International Conference on Internet Science

www.internetscienceconference.eu

Internet • Interdisciplinarity • Innovation

Brussels, April 9-11, 2013

Conference Proceedings

INTERNET-SCIENCE.EU

European Commission

AWKI

Publisher

The FP7 European Network of Excellence in Internet Science (http://internet-science.eu)

eBook and USB produced by Sigma Orionis

1240, route des dolines - BP287 Valbonne - France
Phone: +33 (0) 493 001 550 - Fax: +33 (0) 493 001 560 - http://www.sigma-orionis.com
On behalf of the FP7 European Network of Excellence in Internet Science

Foreword

By Conference General co-Chairs

As co-chairs of the first international Internet Science conference, we are delighted to welcome all Internet scientists to these conference proceedings. This is the first of what we plan to be an annual Internet Science conference series. It starts as an offspring of our network of excellence on Internet Science, following a series of other related events that paved the way including workshops for our eight Joint Research Areas (JRAs), and our annual Internet Science Doctoral Summer School and jointly run Internet Science courses. More details are available on our website www.internet-science.eu and Twitter feed @i_scienceEU – the conference hashtag is #icis2013.

This conference is chaired by a socio-legal scholar (Chris Marsden) and a network scientist (Leandros Tassiulas), with a programme committee chaired by a computer scientist researching the relationship between digital networks and society (Juan Carlos de Martin) and a communications engineer with interests in the geopolitics and geo-economics of Internet effects (Kave Salamatian), with the conference co-ordinated by a nuclear scientist now engaged in exploring the interactions between ICT/Internet and societal developments (Roger Torrenti). The range of disciplines involved is however much broader than that – we include economists, behavioural psychologists, evolutionary biologists, philosophers of science, game theorists, political scientists and several other disciplines in the Technical Program Committee as well as amongst the papers in the Proceedings.

We are delighted to welcome ten keynote speakers, who also give a sense of the range of the international outreach of the conference and the entire Internet Science project. We have three keynotes arriving from the United States, in addition to European speakers. The speakers include computer scientists, biologists, lawyers, political economists and sociologists. Several are academics, several from the corporate environment, three from European institutions and one from a non-governmental organisation. We are therefore both international and multi-stakeholder. It is also noteworthy that we have four women amongst our keynotes, and hope to achieve more geographical, disciplinary and gender inclusion in future conferences.

The Technical Programme has chosen the best 31 papers to be presented in 4 parallel paper sessions and 2 poster sessions. We will also award a Best Student Paper prize at the conference, reinforcing our commitment to mentoring and inspiring the next generation of interdisciplinary Internet scientists.

Our first doctoral summer school in Oxford in August 2012 was a great success (www.internet-science.eu/summer-school-2012), and we look forward to welcoming the next cohort of doctoral Internet scientists to Annecy in August 2013. For more details, please follow @i_scienceEU

Finally, we invite you to get involved by registering and affiliating with the project:

http://www.internet-science.eu/user/register

We wish you a stimulating, thought-provoking but most of all enjoyable Internet Science experience!

Professor Chris Marsden, University of Sussex Law School
Professor Leandros Tassiulas, University of Thessaly and Centre for Research and Technology Hellas

Foreword

By Technical Programme Committee co-Chairs

If performing interdisciplinary research is often challenging, organizing an interdisciplinary conference is arguably even more challenging. Interdisciplinary research, in fact, is performed by a two or more researchers belonging to different disciplines who have made, at some point, the explicit decision to work together.

To propose an interdisciplinary conference, instead, requires not only to address the varying customs and expectations that each discipline cultivate with respect to conferences, but also, and more importantly, to assemble a technical program committee capable of expertly reviewing manuscripts belonging to a wide range of knowledge domains.

This is precisely what we have striven to accomplish for the first edition of the Internet Science International Conference. Our technical program committee, which we wholeheartedly thank for having worked with great dedication under severe time constraints, reviewed over 91 manuscripts belonging to many different disciplines, including anthropology,computer science, law, economics, sociology and philosophy. Each paper received three reviews, and eventually 15 papers were accepted for oral presentation at the conference, and 19 as posters, an acceptance rate of 16% for oral presentations and 20% for posters.

While it is not for us to judge the result of the process, i.e., the final technical program, we take the liberty of stating that the outcome exceed our already fairly optimistic expectations. We knew, in fact, that Internet Science was starting to show signs of maturity, but we did not expect so many submissions of such a high average quality. In particular we were impressed by the signs of the emergence of a new generation of scholars for whom - it is fair to suspect - the words 'Internet Science' already sound mainstream. The future of the discipline clearly belongs to them.

Professor Kavé Salamatian, LISTIC, University of Savoie
Professor Juan Carlos de Martin, Nexa Center for Internet and Society, Politecnico di Torino

Table of contents

Conference organization.....8

Conference agenda.....9

Internet Science and Politics

Chair: Fabrizio Sestini, EINS Scientific Officer, DG CONNECT, European Commission...10

"How useful can web mapping be? Of the relevance of using a cartography tool in order to analyse the political webspheres during the French presidential election in 2012".....11
Authors: Simon Gadras (University of Lorraine, France)

"Common Narrative Divergent Agendas: The Internet and Human Rights in Foreign Policy".....19
Authors: Ben Wagner (European University Institute, Italy), Kirsten Gollatz (Alexander von Humboldt Institute for Internet and Society, Italy), Andrea Calderaro (Center for Media Pluralism and Media Freedom, European University Institute, Italy)

"Equality and civic literacy on parliamentary informatics platforms".....28
Authors: Alina Ostling (European University Institute, Italy)

From Internet to Science and back

Chair: Juan Carlos De Martin, Politecnico di Torino.....36

"A Reflective Examination of a Process for Innovation and Collaboration in Internet Science".....37
Authors: Karmen Guevara, Alan F. Blackwell (University of Cambridge, United Kingdom)

"Science as Social Construction: An InterEpistemological Dialogue between Two Internet Scientists on the InterEpistemological Structure of Internet Science, Part 1".....42
Authors: Paolo Dini (London School of Economics and Political Science, United Kingdom), Laura Sartori (University of Bologna, Italy)

"Digital scholarship: Exploration of strategies and skills for knowledge creation & dissemination"...52
Authors: Cristobal Cobo (1 St Giles & Oxford Internet Institute, United Kingdom), Concepción Naval (Universidad de Navarra, Spain)

Poster session

Chair: Karmen Guevara, Computer Laboratory, University of Cambridge.....60

"Evaluating the Edemocracy Dream: A Case Study on Estonia".....61
Authors: Jian Wen (Sciences Po, France)

"Peerproduction Online Communities Infrastructures".....65
Authors: Melanie Dulong de Rosnay (CNRS & Institut for Communication Sciences, France)

"The Virtual Party Systems Project (ViParSys): Understanding Political Strategy, Party Organizations, and Political Networks, through Hyperlink Analysis".....69
Authors: Antonio Rosas (Universidade Aberta & Technical University of Lisbon, Portugal), Darren Lilleker (Bournemouth University, United Kingdom), Karolina Koc Michalska (Sciences Po, France), Joao Caetano (Universidade Aberta, Portugal)

"Mapping EINS. An exercise in mapping the Network of Excellence in Internet Science".....75
Authors: Almila Akdag Salah (University of Amsterdam, The Netherlands), Sally Wyatt, Samir Passi, Andrea Scharnhorst (Royal Netherlands Academy of Arts and Sciences, The Netherlands)

"Internet voting security in Europe: a process-oriented perspective".....79
Authors: Franco Callegati, Marco Prandini (University of Bologna, Italy)

"Diamond Condition for Commuting Adjacency Matrices of Directed and Undirected Graphs".....88
Authors: Paolo Dini (London School of Economics and Political Science, United Kingdom), Chrystopher L. Nehaniv (University of Hertfordshire, United Kingdom)

"Power relationships embedded in infrastructure governance: Providers versus community".....98
Authors: Mayo Fuster Morell (Berkman Center for Internet and Society, Harvard University, USA)

"Auction Theory meets Collective Intelligence: Towards Designing Next Generation Community Question Answering Systems".....107

Authors: Iordanis Koutsopoulos (Athens University of Economics and Business & CERTH, Greece), George Iosifidis (University of Thessaly, CERTH, Greece), Nicola Barbieri (Yahoo! Research Labs, Barcelona, Spain)

"What's trendy right now? A comparative analysis of Web and Microblogs trending topics".....113
Authors: Dong Wang, Gaogang Xie (Institute of Computing Technology, Chinese Academy of Sciences, China), Mohamed-Ali Kaafar (INRIA, France & National ICT Australia, Australia), Kavé Salamatian (University of Savoie, France)

Governance and Internet Science

Chair: Nicole Dewandre, DG CONNECT, European Commission.....118

"Regulating code: A prosumer law approach to social networking privacy and search market interoperability".....119
Authors: Chris Marsden (University of Sussex, United Kingdom), Ian Brown (University of Oxford, United Kingdom)

"Open Science: One Term, Five Schools of Thought".....123
Authors: Benedikt Fecher (Alexander von Humboldt Institut für Internet und Gesellschaft & Deutsches Institut für Wirtschaftsforschung, Germany), Sascha Friesike (Alexander von Humboldt Institut für Internet und Gesellschaft, Germany)

"Governance of the Top Level Domains: 2013, A failed revolution?".....133
Authors: Dominique Lacroix (Internet European Society & Le Monde en ligne, France)

From Economics and Game Theory to understanding Network Science

Chair: Jonathan Cave, University of Warwick.....142

"Internet Attractors and Repellors: the Role of Asymmetry and Trust in Explaining Connectivity Cycles".....143
Authors: Emanuele Giovannetti (Anglia Ruskin University, United Kingdom), Alessio D'Ignazio (Bank of Italy, Italy)

"The Neighbourhood Game: from Behavioural Economics to Urban Planning".....153
Authors: Panayotis Antoniadis, Ileana Apostol (ETH Zurich, Switzerland)

"On the human-driven decision-making process in competitive environments".....163
Authors: Evangelia Kokolaki, Merkourios Karaliopoulos, Ioannis Stavrakakis (National and Kapodistrian University of Athens, Greece)

"What's your favorite online research tool? Use of and attitude towards Web 2.0 applications among scientists in different academic disciplines".....173
Authors: Daniela Pscheida, Thomas Koehler, Bahaaeldin Mohamed (Technical University Dresden, Germany)

Poster session

Chair: Melanie Dulong de Rosnay, CNRS/ISCC.....180

"Challenges and Opportunities for Integrating Open Energy Data Sources".....181
Authors: Chris Davis, Gerard Dijkema (Delft University of Technology, The Netherlands)

"Reputation based Coordination of Prosumers Communities".....187
Authors: Anna Satsiou (Centre for Research and Technology Hellas, Greece), George Koutitas, Leandros Tassiulas (University of Thessaly, Greece)

"Research Design for the Study of Social Media Use by Dutch Development Organizations".....193
Authors: Anand Sheombar (Manchester Metropolitan University & SURFmarket, The Netherlands)

"Relationships under the Microscope with Interaction Backed Social Networks".....199
Authors: Jeremy Blackburn (University of South Florida, USA), Adriana I. Iamnitchi (University of South Florida, USA)

"The Evolving Dynamics of the Internet Layered Architecture: Innovation, Net Neutrality and the Interdependence of Structure and Function".....203
Authors: Paolo Dini (London School of Economics and Political Science, United Kingdom), Thanassis Tiropanis (University of Southampton, United Kingdom)

"Youth's attitudes and behaviours with respect to online privacy: A conceptual exploration".....209
Authors: Lien Mostmans, Joke Bauwens, Jo Pierson (Vrije Universiteit Brussel, Belgium)

"The evolution of networked communication between patients and clinicians in the UK National Health Service: young people living with long term health conditions".....214
Authors: Frances Griffiths, Jonathan Cave (University of Warwick, United Kingdom), Jackie Sturt (King's College, United Kingdom)

"Evolving Ethnography for Virtual Communities".....219
Authors: Donald McMillan (Mobile Life VINN Excellence Centre at Stockholm University, Sweden), Barry Brown (University of California San Diego, USA)

"Social, Local and Mobile Identity Management. The development of a usercentric open SoLoMo platform".....225
Authors: Paulien Coppens (Vrije Universiteit Brussel & iMindsSMIT, Belgium), Rob Heyman, Jo Pierson (Vrije Universiteit Brussel, Belgium)

About the EINS Network of Excellence.....231

1st International Conference on Internet Science Organization

Conference General Co-chairs

Leandros Tassiulas (Centre for Research and Technology Hellas)
Christopher Marsden (University of Sussex)

Technical Programme Committee Co-chairs

Kavé Salamatian (LISTIC, University of Savoie)
Juan Carlos De Martin (Nexa Center for Internet and Society, Politecnico di Torino)

Conference coordinator

Roger Torrenti (Sigma Orionis)

Technical Programme Committee

Alessandro Mantelero (Nexa Center for Internet and Society, Politecnico di Torino)
Andrea Scharnhorst (Royal Netherland Academy for Arts and Science)
Anna Satsiou (Centre for Research and Technology Hellas)
Bodo Balasz (Berkman Center)
Catharina Maracke (Keio University)
Chris Marsden (University of Sussex)
David Hutchinson (University of Lancaster)
Dirk Trossen (University of Cambridge)
Elena Pavan (University of Trento)
Enrico Bertacchini (Nexa Center for Internet and Society, Politecnico di Torino)
Federico Morando (Nexa Center for Internet and Society, Politecnico di Torino)
Gaogang Xie (Institute of Computing Technology, Chinese Academy of Sciences)
Georg Carle (Technische Universität München)
Hamed Haddadi (Queen Mary, University of London)
Hermann de Meer (University of Passau)
Ian Brown (Oxford Internet Institute)
Jerome Hergueux (Univeristy of Paris)
Jonathan Cave (University of Warwick)
Karmen Guevara (University of Cambridge)
Laura Sartori (University of Bologna)
Leandros Tassulias (Centre for Research and Technology Hellas)
Mayo Fuster Morell (Barcelona and European University Institute)
Mohamed Ali (Dali) Kaafar (INRIA France and National ICT Australia)
Pablo Rodriguez (Telefonica)
Piet Van Mieghem (Delft University)
Robin Dunbar (University of Oxford)
Sandra Cortesi (Berkman Center)
Serge Fdida (Universite Pierre et Marie Curie)
Sue Moon (Korea Advanced Institute of Science and Technology)
Thanassis Tiropanis (University of Southampton)
Thomas Plagemann (University of Oslo)
Timur Friedman (Universite Pierre et Marie Curie)

CONFERENCE AGENDA

TUESDAY, APRIL 9

18:30 *Welcome reception* — MARMERZAAL

WEDNESDAY, APRIL 10

9:30 **OPENING SESSION** — AUDITORIUM ALBERT II
Chair: **Roger Torrenti**, Sigma Orionis, Conference coordinator

Welcome addresses

- **Leandros Tassiulas**, CERTH and **Chris Marsden**, University of Sussex, Conference General co-Chairs
- **Kavé Salamatian**, University of Savoie and **Juan Carlos De Martin**, Politecnico di Torino, Technical Programme Committee co-Chairs

Invited speeches

- **Ziga Turk**, Professor, University of Ljubljana, Former Minister of Science, Slovenia
- **Martin Hynes**, Chief Executive, European Science Foundation
- **Carl-Christian Buhr**, Member of the Cabinet of Ms Neelie Kroes, European Commission VP for the Digital Agenda

11:00 *Coffee-Tea break* — MARMERZAAL

11:30 **SETTING THE SCENE** — AUDITORIUM ALBERT II
Chair: **Leandros Tassiulas**, CERTH, EINS NoE coordinator, Conference General co-Chair

Keynote speeches

- **Urs Gasser**, Executive Director, Berkman Center for Internet & Society, Harvard University
- **Jon Crowcroft**, Professor of Communications Systems, University of Cambridge
- **Andrea Matwyshyn**, Assist. Prof., Department of Legal Studies & Business Ethics, Wharton School

13:00 *Lunch break* — MARMERZAAL

14:30 **INTERNET SCIENCE AND POLITICS** — RUBENS
Chair: **Fabrizio Sestini**, EINS scientific officer, DG CONNECT, European Commission

- *"How useful can web mapping be? Of the relevance of using a cartography tool in order to analyse the political webspheres during the French presidential election in 2012"*, **Simon Gadras** (University of Lorraine, France)
- *"Common Narrative Divergent Agendas: The Internet and Human Rights in Foreign Policy"*, **Ben Wagner** (European University Institute, Italy), **Kirsten Gollatz** (Alexander von Humboldt Institute for Internet and Society, Italy), **Andrea Calderaro** (Center for Media Pluralism and Media Freedom, European University Institute, Italy)
- *"Equality and civic literacy on parliamentary informatics platforms"*, **Alina Ostling** (European University Institute, Italy)

14:30 **FROM INTERNET TO SCIENCE AND BACK** — BOUDEWIJN
Chair: **Juan Carlos De Martin**, Politecnico di Torino, Technical Programme Committee co-Chair

- *"A Reflective Examination of a Process for Innovation and Collaboration in Internet Science"*, **Karmen Guevara**, **Alan F. Blackwell** (University of Cambridge, United Kingdom)
- *"Science as Social Construction: An InterEpistemological Dialogue between Two Internet Scientists on the InterEpistemological Structure of Internet Science, Part 1"*, **Paolo Dini** (London School of Economics and Political Science, United Kingdom), **Laura Sartori** (University of Bologna, Italy)
- *"Digital scholarship: Exploration of strategies and skills for knowledge creation and dissemination"*, **Cristobal Cobo** (1 St Giles & Oxford Internet Institute, United Kingdom), **Concepción Naval** (Universidad de Navarra, Spain)

16:00 *Coffee-Tea break* — MARMERZAAL

16:30 **POSTER SESSION** — AUDITORIUM ALBERT II
Chair: **Karmen Guevara**, Computer Laboratory, University of Cambridge

- *"Evaluating the Edemocracy Dream: A Case Study on Estonia"*, **Jian Wen** (Sciences Po, France)
- *"Peerproduction Online Communities Infrastructures»*, **Melanie Dulong de Rosnay** (CNRS & Institut for Communication Sciences, France)
- *"The Virtual Party Systems Project (ViParSys): Understanding Political Strategy, Party Organizations, and Political Networks, through Hyperlink Analysis"*, **Antonio Rosas** (Universidade Aberta & Technical University of Lisbon, Portugal), **Darren Lilleker** (Bournemouth University, United Kingdom), **Karolina Koc Michalska** (Sciences Po, France), **Joao Caetano** (Universidade Aberta, Portugal)
- *"Mapping EINS. An exercise in mapping the Network of Excellence in Internet Science"*, **Almila Akdag Salah** (University of Amsterdam, The Netherlands), **Sally Wyatt, Samir Passi, Andrea Scharnhorst** (Royal Netherlands Academy of Arts and Sciences, The Netherlands)
- *"Internet voting security in Europe: a process-oriented perspective"*, **Franco Callegati**, **Marco Prandini** (University of Bologna, Italy)
- *"Diamond Condition for Commuting Adjacency Matrices of Directed and Undirected Graphs"*, **Paolo Dini** (London School of Economics and Political Science, United Kingdom), **Chrystopher L. Nehaniv** (University of Hertfordshire, United Kingdom)
- *"Power relationships embedded in infrastructure governance: Providers versus community"*, **Mayo Fuster Morell** (Berkman Center for Internet and Society, Harvard University, USA)
- *"Auction Theory meets Collective Intelligence: Towards Designing Next Generation Community Question Answering Systems"*, **Iordanis Koutsopoulos** (Athens University of Economics and Business & CERTH, Greece), **George Iosifidis** (University of Thessaly, CERTH, Greece), **Nicola Barbieri** (Yahoo! Research Labs, Barcelona, Spain)
- *"What's trendy right now? A comparative analysis of Web and Microblogs trending topics"*, **Dong Wang**, **Gaogang Xie** (Institute of Computing Technology, Chinese Academy of Sciences, China), **Mohamed-Ali Kaafar** (INRIA, France & National ICT Australia, Australia), **Kavé Salamatian** (University of Savoie, France)

18:00 *Break* — MARMERZAAL

19:00 **NETWORKING DINNER** — TROONZAAL

THURSDAY, APRIL 11

9:30 **GOVERNANCE AND INTERNET SCIENCE** — RUBENS
Chair: **Nicole Dewandre**, DG CONNECT, European Commission

- *"Regulating code: A prosumer law approach to social networking privacy and search market interoperability"*, **Chris Marsden** (University of Sussex, United Kingdom), **Ian Brown** (University of Oxford, United Kingdom)
- *"Open Science: One Term, Five Schools of Thought"*, **Benedikt Fecher** (Alexander von Humboldt Institut für Internet und Gesellschaft & Deutsches Institut für Wirtschaftsforschung, Germany), **Sascha Friesike** (Alexander von Humboldt Institut für Internet und Gesellschaft, Germany)
- *"Governance of the Top Level Domains: 2013, A failed revolution?"*, **Dominique Lacroix** (Internet European Society & Le Monde en ligne, France)

9:30 **FROM ECONOMICS AND GAME THEORY TO UNDERSTANDING NETWORK SCIENCE** — BOUDEWIJN
Chair: **Jonathan Cave**, University of Warwick

- *"Internet Attractors and Repellors: the Role of Asymmetry and Trust in Explaining Connectivity Cycles"*, **Emanuele Giovannetti** (Anglia Ruskin University, United Kingdom), **Alessio D'Ignazio** (Bank of Italy, Italy)
- *"The Neighbourhood Game: from Behavioural Economics to Urban Planning"*, **Panayotis Antoniadis**, **Ileana Apostol** (ETH Zurich, Switzerland)
- *"On the human-driven decision-making process in competitive environments"*, **Evangelia Kokolaki**, **Merkourios Karaliopoulos**, **Ioannis Stavrakakis** (National and Kapodistrian University of Athens, Greece)
- *"What's your favourite online research tool? Use of and attitude towards Web 2.0 applications among scientists in different academic disciplines"*, **Daniela Pscheida**, **Thomas Koehler**, **Bahaaeldin Mohamed** (Technical University Dresden, Germany)

11:00 *Coffee-Tea break* — MARMERZAAL

11:30 **POSTER SESSION** — AUDITORIUM ALBERT II
Chair: **Melanie Dulong de Rosnay**, CNRS/ISCC

- *"Challenges and Opportunities for Integrating Open Energy Data Sources"*, **Chris Davis**, **Gerard Dijkema** (Delft University of Technology, The Netherlands)
- *"Reputation based Coordination of Prosumers Communities"*, **Anna Satsiou** (Centre for Research and Technology Hellas, Greece), **George Koutitas**, **Leandros Tassiulas** (University of Thessaly, Greece)
- *"Research Design for the Study of Social Media Use by Dutch Development Organizations"*, **Anand Sheombar** (Manchester Metropolitan University & SURFmarket, The Netherlands)
- *"Relationships under the Microscope with Interaction Backed Social Networks"*, **Jeremy Blackburn** (University of South Florida, USA), **Adriana I. Iamnitchi** (University of South Florida, USA)
- *"The Evolving Dynamics of the Internet Layered Architecture: Innovation, Net Neutrality and the Interdependence of Structure and Function"*, **Paolo Dini** (London School of Economics and Political Science, United Kingdom), **Thanassis Tiropanis** (University of Southampton, United Kingdom)
- *"Youth's attitudes and behaviours with respect to online privacy: A conceptual exploration"*, **Lien Mostmans**, **Joke Bauwens**, **Jo Pierson** (Vrije Universiteit Brussel, Belgium)
- *"The evolution of networked communication between patients and clinicians in the UK National Health Service: young people living with long term health conditions"*, **Frances Griffiths**, **Jonathan Cave** (University of Warwick, United Kingdom), **Jackie Sturt** (King's College, United Kingdom)
- *"Evolving Ethnography for Virtual Communities"*, **Donald McMillan** (Mobile Life VINN Excellence Centre at Stockholm University, Sweden), **Barry Brown** (University of California San Diego, USA)
- *"Social, Local and Mobile Identity Management. The development of a usercentric open SoLoMo platform"*, **Paulien Coppens** (Vrije Universiteit Brussel & iMindsSMIT, Belgium), **Rob Heyman**, **Jo Pierson** (Vrije Universiteit Brussel, Belgium)

13:00 *Lunch break* — MARMERZAAL

14:00 **CLOSING SESSION: FROM RESEARCH TO POLICIES** — AUDITORIUM ALBERT II
Chair: **Chris Marsden**, University of Sussex, Conference General co-Chair

Opening speech

- **Anne Glover**, Chief Scientific Advisor to the President of the European Commission

Best student paper award

Keynote speeches

- **Alissa Cooper**, Chief Computer Scientist, Center for Democracy & Technology
- **Pablo Rodriguez**, Research Director and Head of the Barcelona Lab Telefonica Digital

Policy report

Closing address

- **Mario Campolargo**, Director Net Futures, DG CONNECT, European Commission

16:00 *Open networking*

Internet Science and Politics

Chaired by Fabrizio Sestini, EINS Scientific Officer, DG CONNECT, European Commission

How useful can web mapping be? Of the relevance of using a cartography tool in order to analyse the political webspheres during the French presidential election in 2012

Simon GADRAS
IRENEE, University of Lorraine
Nancy, France
simon.gadras@univ-lorraine.fr

ABSTRACT
This paper discusses the use of a specific mapping tool in order to analyze political webspheres of the electoral campaign for the French presidential election 2012. It underlines some methodological challenges of the use of cartography for information and communication sciences. Being aware of the strength and limits of using of this kind of tool in such a specific context is a condition to make efficient use of these methods, without under- nor over-estimating its technological power.

Keywords
mapping; webspheres; political communication; electoral campaign; information and communication sciences

1. INTRODUCTION
This paper presents a discussion about a mapping tool used to analyze webspheres of the electoral campaign for the French presidential election of 2012. This cartography was built for the *webinpolitics.com* international research project[1], based on a technology developed by *LinkFluence*[2]. The cartography produced by this mapping tool was created in a specific context with two dimensions. Both are to be presented in order to understand the questions raised then discussed in this paper.

The first element is the scientific context. The *webinpolitics.com* project is carried out by a group of several researchers in political science and in information and communication sciences (ICS). These researchers are specialists of online political communication. They are not specialized in web mapping tools or computational treatment of web data. Moreover the web cartography is one among various methods used in the project. These others methods are more classical social sciences tools, such as surveys, interviews or content analysis.

The second element is the political context, which characterizes the object studied. The French presidential election ended on May 6, 2012, as François Hollande was elected. During month before the election, the teams of each of the six main candidates[3] intensively campaigned on the web, even if using various tools (websites, social networks, smartphone apps…) and with unequal means. The webcampaign was then a full part of the electoral campaign. Numerous press articles were published explaining how important the web was for this election and emphasizing on the use of social media, especially Twitter (maybe because it is very used by journalists themselves [1]). Beyond such general observations, we do not have precise knowledge of how the web was used during this campaign by candidates' teams or voters. Researches have been conducted on previous elections in France [2, 3, 4, 5, 6, 7, 8] and in European countries [9, 10, 11, 12]. But a new study for this campaign is useful since technology evolves as well as the way citizens use it.

In order to discuss the use of a web mapping tool and the kind of results it can provide in such a context, this paper is divided in three main parts. First, it details the scientific context and the reasons for this tool to be used in such a research project. Secondly, it describes the main steps of the mapping process, its strengths and limits. The third part briefly presents the cartography while discussing its ability to provide knowledge about how the web was used during the French electoral campaign for the presidential election 2012.

2. WEB, POLITICS AND CARTOGRAPHY IN ICS
A lot of methodologies have been developed in the field of human and social sciences since the first studies on the web. They are mainly based on classic sociological methods such as surveys, interviews, observations... adapted to fit the web. Richard Rogers calls them "digitized methods" [13]. More recently, new sets of methods have been developed in the field of "digital methods" [13] in order to study web native objects through web native tools. Visualization tools such as web mapping technologies represent one of these methods that are getting more and more common.

---

[1] *webinpolitics.com* is an international research project conducted by a team of university researchers in France and Quebec (Canada), funded by the French research agency ANR and the Quebec research agency FQRSC. The project scientific leaders are T.Giasson (University Laval, Quebec) and F.Greffet (University of Lorraine, France). The main researchers are F.Bastien (University of Montreal), G.Blanchard (University of Lille 3), M.Lalancette (University of Québec in Trois-Rivières), G. Le Bars (University Laval) and S.Wojcik (University Paris-Est Créteil). I sincerely thank them for having me included in this ambitious project.

[2] LinkFluence is a company specialized in analyzing digital trends and mapping the web, http://us.linkfluence.net.

[3] The *webinpolitics.com* project focuses on the six main candidates, out of ten official candidates in the presidential election.

These tools are however not yet frequently used in the field of social sciences. It is definitely true in ICS in France even though information and communication technologies (ICTs) are one major concern of this discipline, especially when it comes to their use by citizen or social actors such as politicians. Such little enthusiasm may find its origin in the historically complicated relationship between communication theories and technologies. Several reasons should yet convince researchers of this field to look into these digital methods, by putting their critical point of views to use.

First of all, building a critical thinking on digital objects and linking them to social factors cannot be made without direct confrontation with these tools in various contexts. Moreover, the specificities of ICS approaches on communication objects such as those on the web can be productive. It is based on strong concepts able to question this kind of dispositive. The notion of mediation i.e. the link between individuals and collectiveness is especially efficient as it allows taking into consideration their technical as well as their social dimensions [14]. It is particularly efficient in the political field in order to catch both the technical and strategic sides of actors' practices [15]. Moreover, the concept of public sphere [16] and its evolutions [17], especially related to the use of ICTs in politics [18], underlines the strategies of several categories of actors in order to reinforce the visibility of their opinion in public debates on more or less specific issues. It conduces to consider the political web itself not as a public sphere, but as a part of a wider public sphere happening in the country during the campaign. The web is a way among others to participate in the public sphere and to participate in the structuration of the political mediation process.

Some researches using web mapping tools have been done on very close political issues [19, 20]. They are although not based on those same theoretical bases and stand at the boundaries between ICS and other disciplines. The last years have seen ICS researchers investing the research field of digital methods and building a reflection on the use of these methods in ICS [21]. The idea of this paper is to feed this reflection through the specific case of the 2012 presidential webcampaign. Monnoyer-Smith & Plantin raised several important methodological and epistemic questions on the use of digital methods in ICS [22]. They underline that these tools cannot be used without asking several questions: about the origin and status of data, about the way algorithms gather data on the web and about the way results can be interpreted and linked to actors' strategies and practices.

This paper intends to discuss these issues. The work made by the *webinpolitics.com* team in order to build a cartography of political webspheres during the last French presidential election campaign underlines many methodological questions. These questions appeared for two main reasons. First, because none of the researchers were specialists of web mapping tools or computational treatment. Secondly, because the cartography was build using a preexisting tool provided by web professionals who do not face the same constraints than social sciences researchers.

But why map webspheres? The answer to this question can be found in the starting questions of this research project. It aims at answering three main questions about the online electoral campaign. What are the spaces of political mobilization on the web and what contents can be found in these spaces? What strategies do parties and candidates implement on the web? How do web users feel towards the way the web is used by political actors during the campaign? Mapping webspheres can provide answers to several points of these questions by describing the structures and relationships between campaign websites. The concept of websphere is particularly appropriate for this research because it was first defined for studying electoral campaigns on the web. It designates "a hyperlinked set of dynamically defined digital resources spanning multiple Web sites relevant to a central theme" [23]. In the project, mapping webspheres is therefore a tool designed to monitor the size and diversity of the online spaces of each candidate and party. The aim is to identify the official campaign websites as well as the unofficial or informal online spaces linked with them. This would help decide between two hypothesizes describing how politics is done online during electoral campaigns: one describing political online spaces opened to many different actors, not only members of the political field or highly politicized citizen; and one describing a professionalized online world, with the same actors and the same relationships already existing offline.

3. MAPPING WEBSPHERES

To build the cartography, we chose to work with a private company. *LinkFluence* is a start-up company founded in 2006 by members of a university research group. They built the first maps of the French political blogosphere in 2006, and several others after [19, 20][4]. The system they developed (named mapping system in this paper) is based on a seed of selected websites. A robot *crawls* these websites in order to identify other websites it points out to through hypertext links (named links in this paper). Scores are associated to each website allowing placing it on the cartography. Each website is a node and appears on the map as a point. Links between websites are represented by lines (arcs to be precise).

3.1 Main steps of the mapping process

The process starts with a seed, i.e. a list of websites to be crawled. The first seed was manually built by members of the research project. It includes all official websites of the six main candidates for the election: candidates/campaign/parties corporate websites and all other websites that were published by the campaigns teams and parties during the official campaign[5]. These websites were found by researches through general search engines such as Google, links on the known official websites and press articles[6]. The result was a list of 40 websites. It was completed by an important number of French political websites URLs already identified during previous crawls between 2007 and 2012. Our goal was indeed to identify a community of websites concerning the campaign. It is then much more efficient to start with a larger seed and reduce the result to the effective webspheres of the campaign. The cartography allows visualizing outgoing links i.e.,

[4] A cartography of the French political blogosphere in 2012 was published by *LinkFluence* and *Le Monde* newspaper: http://www.lemonde.fr/politique/visuel_interactif/2012/02/02/cartographie-de-la-blogosphere-politique-en-2012_1635269_823448.html?xtmc=linkfluence&xtcr=8.

[5] The French electoral law defines an official period for each campaign: for the first round of the 2012 presidential campaign, it was between March 20 and April 20.

[6] 370 articles concerning the web campaign and published during three month before the election were consulted.

links that appears on the websites and can be clicked by users to access another webpage, but also incoming links. These incoming links do not appear on the websites, they are representations of outgoing links from others websites pointing out to the visited one. Thus they cannot be all detected from the starting seed. The robot needs to crawl websites that would likely include hypertext links to the webspheres. Using preexisting list of French political websites is also an easier way to reach most of the webspheres. This list was indeed generated from numerous successive crawls. Starting exclusively from our manually built seed would have implied dozens of crawls and reduced the probability to identify most of the nodes of the webspheres. The resulting seed, made of the manually built list of official websites completed by the existing list of websites if called the initial seed. After being completed, it was finally composed with 1,491 URLs.

The crawl of this initial seed generated a list of 31,732 URLs[7]. This list includes all kinds of websites, not only political related ones. A first sorting was automatically made by *LinkFluence* algorithms excluding websites from preexisting lists of thematic website (high-tech for instance), and those having too few links to the seed. After this first sorting, the list included 3,650 websites. A first manual sorting of this list was made in order to exclude URLs that were "obviously" not relevant i.e., websites that can be considered as non-relevant from their URL, without reading their contents (e.g. google.com or paypal.com). 609 URLs were sorted out this way. In the resulting list of 3,041 websites 1,443 came from the initial seed and 1,598 had been crawled.

A second crawl was then applied in order to stabilize the webspheres starting from this list of 3,041 websites. It generated another list of 3,143 websites. Among these websites, many were not about the electoral campaign. Several indicators can help to automatically exclude non relevant websites. The first one is a semantic profile i.e. a selection of key words defined with initial seed. The crawler searches for such word in the content of crawled websites and counts the number of times it appears on each one. The key words selected were the last names of presidential candidates, and the word "presidentielle" (with and without accent). In French this word can indeed be used to designate the electoral campaign alone or in several expressions ("élection présidentielle", "campagne présidentielle"…). The problem is that if the presence of one of these words may assess that the content is at least partially about the election, the opposite is not true: it is possible to refer to the electoral campaign without mentioning the word "presidentielle". A more elaborated set of key words would be able to reduce this problem, but unless working with computational linguistics specialists, it is very hard to avoid such impediments. A manual sorting is then needed, furthermore because one of the goals of the mapping process –in order to fit research questions- is not only to identify nodes and links but also to characterize websites contents.

The two first criteria used to include or exclude websites from the presidential campaign webspheres through manual sorting were:

- Content updates: has the website been updated during the electoral campaign? If no content was published between March 16 and May 6, the website was excluded. March 16 was the last day for candidates' applications to the presidential election[8] and May 6 was the runoff day.
- Content subject: does the website include content about the presidential election? If no content published during the period was about the presidential election, the website was excluded.

1,960 URLs remained after sorting the list using these criteria. They were classified according to two other criteria regarding their contents and the "role" of their author(s) (person or legal entity) during the campaign.

First, they were characterized by their status: were these websites supporting a specific candidate or taking part in the campaign under another form? 15 *categories* were defined:

- 10 categories representing each official candidate: Nathalie Arthaud, François Bayrou, Jacques Cheminade, Nicolas Dupont-Aignan, François Hollande, Eva Joly, Marine Le Pen, Jean-Luc Mélenchon, Philippe Poutou and Nicolas Sarkozy[9]
- No candidate supported;
- Media: the website is a media or the website of a media
- Observer: the author presents himself as a political observer or analyst (and cannot be linked to a media)
- Associations or others: any association, union, think tanks, lobbies… giving its opinion on the election or on specific issues of the campaign
- Anti: the website only contains criticism of one or several candidates (thus no support can be asserted)

As the cartography allows visualizing different sets of classifications, the URLs were also classified on a more general level, through 9 *groups* concerning the political sensibility of their contents:

- Radical Left - Trotskyist
- Radical Left (Communist and allies)
- Social-Democrat (Socialist)
- Greens
- Centre (Modem)
- Conservatives (UMP and allies)
- Radical right (National Front supporters)
- Other radical right
- No clear support of a political force

This classification was chosen because it allows characterizing the websites included in the category "no candidate supported". Some websites indeed present clear political

[7] For more precise explanations on how the crawler operates see [16].

[8] At least 500 support letters from French elected representatives have to be presented to the Constitutional Council in order to run for the presidential election.

[9] We included all official candidates although the study was only about the 6 main candidates because websites supporting every of the 10 candidates were found in the websphere.

sensibilities while rejecting every candidate, especially at the far-left and far-right sides. The category "no candidate supported" regroups websites with very different political sensibilities that can be differentiated through groups.

A last crawl was launched after this manual sorting in order to check the links. This is needed to calculate the sizes and positions of nodes on the cartography according to their actual links. The content of websites may indeed evolve during the mapping process, especially during an electoral campaign. The size of each node is proportional to the number of incoming links of the website: the more there is the bigger is the node. The position of nodes on the map is related to their neighborhood. The algorithm developed by *LinkFluence* regroups websites of the same category; it defines a website's position depending on the number links it has to those of the same category. On the opposite, the links with websites from the same or another group do not interfere into the positioning. When this crawl is done and the scores of URLs are calculated, the cartography can be spatialized i.e. drawn.

A synthetic view of the mapping process through the evolution of the number of identified website along the main steps is presented in Figure 1.

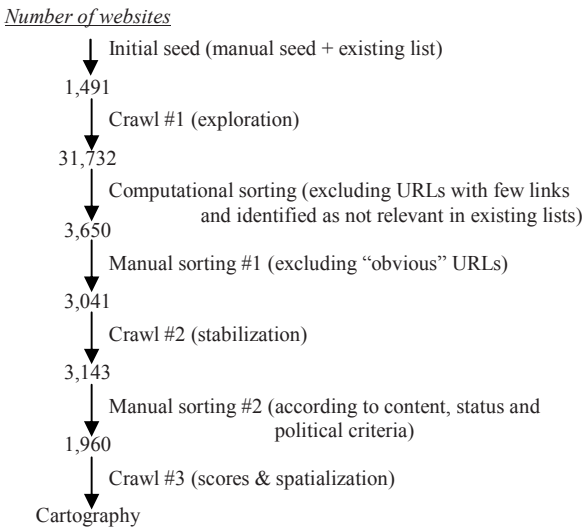


Figure 1. Evolution of the number of URLs in the webspheres during the main steps of the mapping process.

3.2 Strengths and weaknesses of the mapping system

The process described above allowed building a precise cartography of the webcampaign. But it also implies strong constraints and a permanent reflection for the researcher in information and communication science about the best way to build this map in order to achieve the scientific goals. The following paragraphs discuss three of these problems.

3.2.1 The need of manual sorting: human interpretation vs. computational selection

The time needed for the manual sorting of 3,650 websites is huge. Excluding "obvious" URLs can be done in a reasonable amount of time. But the next step implies reading the content, sometimes a lot of contents, of each of the 3,143 left websites. When it appears that no content was published during the period, it can be quite short. When content was published, there can be two kinds of situations: badges, logos or headlines can display very clearly which candidate the website does support. If not the content has to be read until information allowing the website classification can be found. But what kind of information allows that? What if the author hesitates between several candidates, or implicitly expresses his opinion? Only a human person can code content of such a large documentary unit (a website) with this kind of criteria. The unique quality of the manual sorting is the capacity of interpretation of contents. Human coders can identify political opinions and supports from various items, even not explicit ones. This implies letting some leeway to the coder, and rely on his "contextual awareness" [23]. It is indeed essential for the coder to know the general political context and the main issues during the electoral campaign in order to be able to interpret the contents of the websites.

But manual sorting also has disadvantages. This work cannot be done on a much larger data set without huge human resources and/or widely simplifying the classification criteria. In our case, eight people worked at various stages of the sorting process during a period of several weeks to sort these 3,650 websites. Facing this situation, the essential role of computational sorting is even clearer. Sorting by hand the 31,732 websites generated by the crawler is not possible. Once again, it has disadvantages. The number of websites was approximately divided by 10 during the computational sorting. If the lists of thematic URLs can be considered as quite accurate due to *LinkFluence* experience on crawling thematic webspheres, excluding websites with too few links may have lost some nodes that should appear in the webspheres. This is one of the technical limits of the mapping system that cannot pretend to represent full and perfectly delimitated webspheres.

3.2.2 Technological limits: web standards vs. closed networks

Technological limits are not only due to the mapping process and the crawler, but also to the diversity of web spaces it has to face. The crawler was created in 2007 to navigate through "classic" websites. It is then very powerful to *crawl* HTML static pages. It was improved in order to include blogs. Even if the visual structure of blogs pages is specific, the crawling system is about the same: it needs to list every link of every crawled page and follow it to delimitate the website and the links pointing out to another domain name. But the way some nowadays very common social networks (SN) like Facebook or Twitter work challenges this system. This paper is not the place to discuss such technical issues. But the web moved from static websites to flow networks with huge amount of links pointing to the same domain, even if they refer to different items (Facebook pages, Twitter accounts…).

254 listed URLs in the French electoral campaign webspheres we crawled are "web 2.0 spaces": Facebook pages, Twitter accounts and Dailymotion channels. These nodes obviously represent only a part of SN pages that were active on the web during the campaign, even if it is yet hard to estimate their number. But the unsuitability of the crawler for this kind of web pages makes its ability to identify links on these SN unpredictable. This underlines a clear limit of the tool. Furthermore, the sociology of websites and blogs users may not

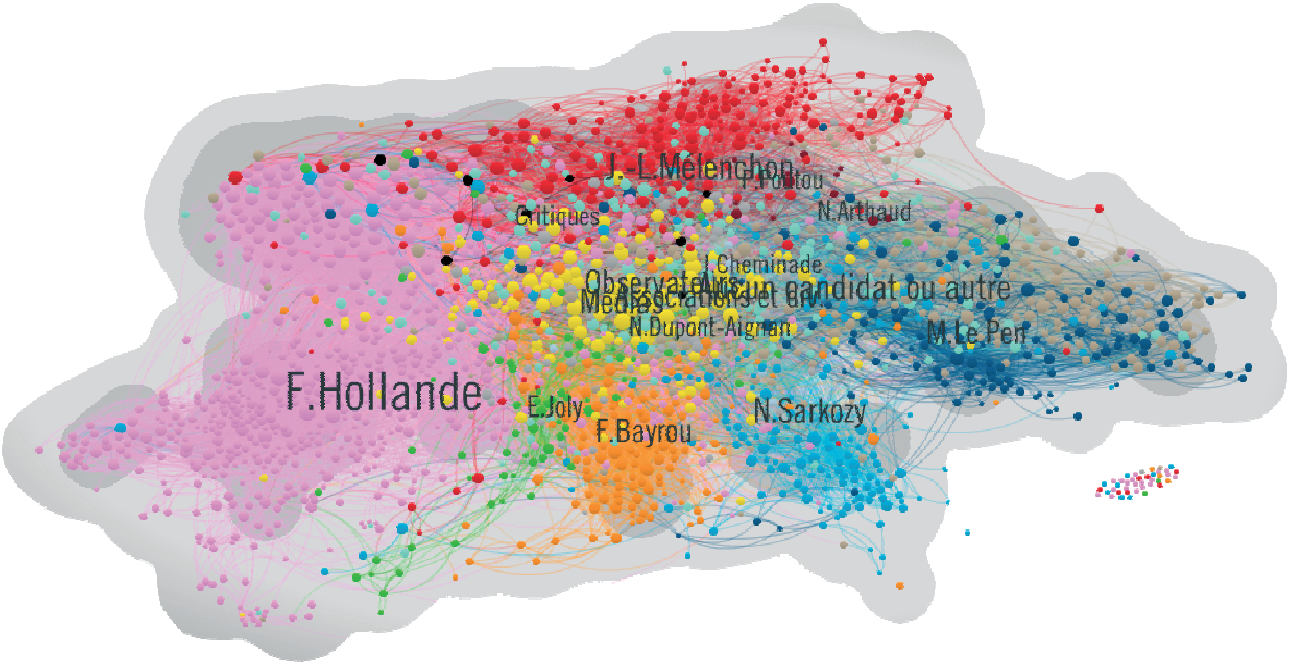


Figure 2. Cartography of the 2012 French presidential electoral campaign webspheres

be the same as SN users, even if this statement still needs to be asserted with rigorous empirical studies. The technical characteristics of webspheres this particular mapping system can reach and visualize may also correspond to sociological characteristics of the users of these webspheres. This enlightens another reason why technical and scientific constraints have to be carefully evaluated before using such digital methods for social sciences purpose.

3.2.3 Working with web professionals: technical expertise vs. research requirements

Working with web mapping professionals is an indisputable asset when it comes to using visualization devices among other methodological tools. Developing a visualization device implies an important and specific job that goes beyond the field of such a research project and beyond ICS research field. The presence of other methods on a research project of this size forbids building a tailor made mapping system, unless devoting all of its human and financial resources to it. Beyond these organizational questions, working with experienced professionals is also an asset for quality and efficiency. Their system was improved during years, their algorithms and robots are reliable. But their main skill goes beyond the technological assets. They already did a lot of this kind of work, they know the problems that can be encountered and they are able to prevent most of them: they know the web and they know how to navigate through websites in order to visualize thematic webspheres.

Working with these professionals on this project did not happen without difficulties. *LinkFluence* is a private company supplying a technological tool. They get to work with private clients who may not have the same need as academics. The focus on methodological issues of the client is not the same. The biggest challenge for a scientific project is however not related to the private status of the company, but shared by any interdisciplinary research project. Computer specialists and social scientists do not focus on the same issues, and do not take into consideration the same epistemological and methodological constraints. Their lack of knowledge of each other's field is the biggest gap to be filled. Even if the algorithms used widely remain a black box for social scientists, the researchers need to understand it as clearly as possible in order to be able to interpret the resulting cartography.

4. FIRST RESULTS AND DISCUSSION: WHAT CAN IT SHOW… AND WHAT CAN IT NOT

The result of this work is the general cartography presented in Figure 2, showing nodes, links and categories. Each category is represented with a color. The name of the categories appears on the middle of the community it represents. This general cartography offers an overview of the repartition of the main categories. Pink dots, representing François Hollande's supporters clearly occupy a larger space on the map. But due to the positioning algorithm, the important criterion to evaluate the strength of a community is the density of the websites more than the space it occupies. A more precise comparison of the size of each category can be made while using another visualization module of the cartography system. N.Sarkozy was the incumbent during this election and according to polls he was going to obtain the second highest number of votes. The community of his supporters is much smaller than François Hollande's and surprisingly even more than Jean-Luc Mélenchon's, a radical left candidate. These comparisons of sizes between the biggest categories can be made from the general map. However in cases like this one, the cartography is

Figure 3. Repartition of websites

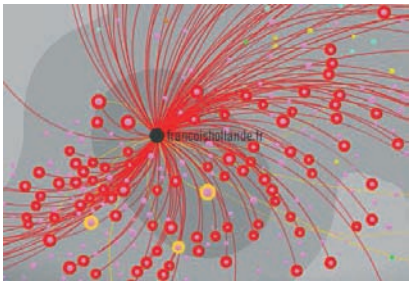


Figure 4. Some ingoing and outcoming links of francoishollande.fr (yellow arcs=outgoing, red arcs=incoming)

not always the best visualization tool: it is more difficult to use it in order to compare smaller and more diffuse communities. For instance, the category "no candidate supported" spreads all over the map and thus cannot be easily compared with others. Only other visualization tools, such as Figure 3, are able to show its size and clearly compare it with others. Even more precise information can be found while using a table listing the number of websites of each category.

These results were produced thanks to the capacity of the system to crawl a very large amount of websites, enabling to see both incoming and outgoing links. That is a very important point which solves a technological gap. Outgoing links, that are visible by users while visiting websites, show only a part of the relationship between websites. It is very hard without such a tool to have an overview of the links and to evaluate the number and strength of these links. Figure 4 focuses on a particular website and its links on the cartography. The yellow links represent outgoing links while red ones incoming links. There clearly are much more incoming links than outgoing ones. This simple example shows that missing incoming links would eliminate meaningful elements of the cartography.

However, this point must not hide two problems. First, the specific situation of this website is not shared by all websites inside the webspheres. The cartography shows 169 incoming and 11 outgoing links for this website. The average is 12.94 incoming links and 53.46 outgoing links. Most importantly, the repartition is not homogenous as shown on Figure 5.

Secondly, what do these links mean from an info-communicational point of view? The manual sorting is here absolutely essential. Categories and by extension political communities cannot be automatically defined based on the number of links without implying that linking means sharing opinions. Quite the opposite: communities have to be manually defined in order to be able to analyze the links inside the communities and between them. Previous studies using cartographies built on the same basis showed that links were used

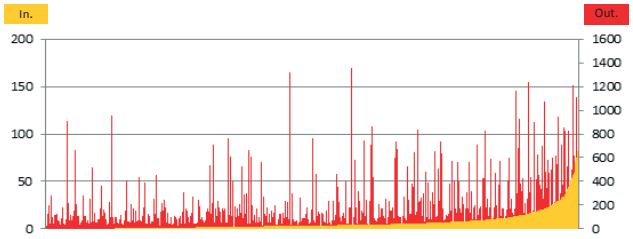


Figure 5. Number of incoming (red) and outgoing (yellow) links on websites of the webspheres (horizontal axis represents each website and vertical axis the number of links; websites are sorted from left to right according to their number of outgoing links).

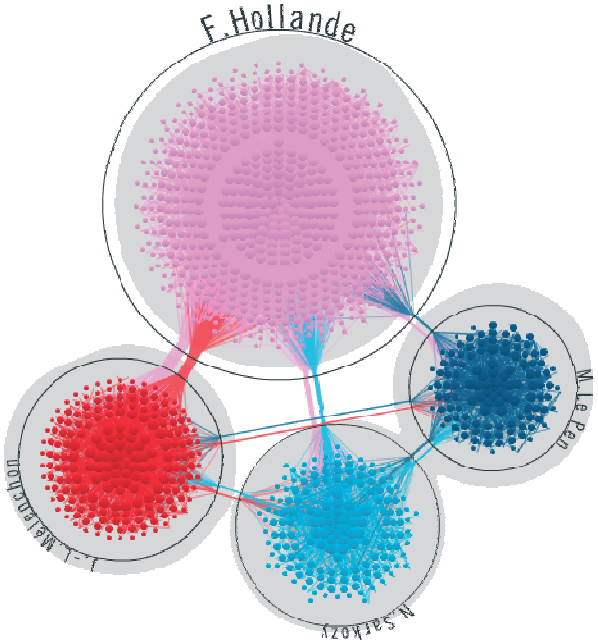


Figure 6. Links between four categories of websites

as an explicit strategy in order to occupy a digital territory [16].

Figure 6 shows an interesting example on how links between categories can be compared. The mapping system allows to regroup categories in circles and to visualize links between these categories. In this figure four categories of supporters are represented (J.-L.Mélenchon far-left, F.Hollande left, N.Sarkozy right, M.Le Pen far-right). There are much more links between left's supporters and far-left's ones than between right's supporters and far-right's ones. This is partly due to the size of the categories, especially the smallness of the websphere of N.Sarkozy's supporters which could explain its few links to other webspheres. But the number of ingoing and outgoing links is about the same in every relationship of this scheme. There is no strong imbalance between incoming and outgoing links that could be implied by a difference of the size of the spheres involved. The weakness of these links is thus not only caused by the size of the communities. It represents a difference of how websites owners link to websites promoting other political opinions. It is however difficult to give a more precise meaning to these links in order to understand the strategies deployed on the web by actors of the campaign without using other classical research methods such as interviews. Also without knowing who is behind these websites: are they published by only a few group of actors multiplying websites? Even if a community is big, it can be built by only a few people.

The question of "who" underlines another aspect of such a system. Who are the people behind these nodes? For instance, the cartography does not differentiate citizens from political leaders. In order to include such characteristics, the map has to be read with some sociological knowledge of users from these webspheres. A survey of political web users conducted shortly after the election [25] showed that the people participating in the webcampaign present a specific sociological profile and are not representative of the whole population. By extension, the hypothesis that people creating and publishing on websites of the campaign webspheres may have an even more specific

sociological profile is worth considering. Once again, only more classical methods such as surveys are able to explain exactly who are the people writing and reading these websites and what they are looking for.

Monnoyer-Smith & Plantin [22] explain that digital methods can be useful to evaluate the forms and evolutions of citizen participation on the web, especially on political issues. The unsuitability of the mapping system to evaluate who is behind the tools limits this possibility. This restriction is also caused by the way the crawler grasp the web: its basic unit is a website. It is not obvious that web users do refer to websites while surfing the web. They more likely access web pages through search engines and hypertext links from other web pages. The unreliability of the system concerning SN pages is also a strong obstacle, as they seem to be more and more used by citizens to keep informed and to express their opinions without referring to political websites. This underlines that online social practices cannot be investigated relying on only one specific digital method.

5. CONCLUSION

In order to understand the strategies developed by actors of the campaign for the presidential election 2012 in France and the relationship that was built through the web between politicians and citizen, we worked with a specialized company that supplied us a technology to map the campaign webspheres. The mapping process is based on a pre-developed technology owned by this service provider. Using this system implied regular coming and going between members of the research project and the company team in order to adapt the data to the research questions. The mix of computational and manual work was necessary to be able to analyzehe amount and diversity of data. Developing a tailor-made mapping system would represent a full research project. Even if using preexisting tools challenges human and social sciences, it allows using that kind of methods among others, even in small or mid-size projects. It was also interesting as these tools were already used in the past years to study various webspheres. It offers relatively strong comparison points representing an important asset for the research.

The resulting cartography enables visualizing the mediation work made by actors and help interpreting it, particularly because it shows links between actors and, with these links, the structuration of the mediation tools that the web can offer. It can help describe how the public sphere is evolving, but other tools have to be added in order to understand the way citizens -can be and effectively- are involved into already existing or emerging public spheres.

Webspheres are abstract constructions built by observers in order to catch a reality, depending on a "socio-technical chain of selection-mechanisms" emphasizing -on a methodological level- the "need to balance machine intelligence and human intuition" [26]. As for public spheres their delimitation depends on the definition of a specific thematic and on the selected criteria. They have to be analyzed as a part of a larger universe made of social actors, communicational strategies and technologies. It cannot be interpreted without it. But as for public spheres webspheres are useful to understand the relationships between actors and the process of mediation between citizen and their political representatives. With this perspective they can help evaluate strategies and understand how these strategies are implemented online and involved in shaping the web.

Digital methods are powerful in order to analyze large amounts of data. The cartography we build provides a clear overview of the main webspheres involved in the French political field during the electoral campaign. It is powerful to evaluate each candidate's extent inside this online political world. But it is not sufficient to produce more precise comparisons. Other types of data presentation such as tables or graphs for instance are needed when it comes to ranking almost same size webspheres or to comparing links between them. They are also helpful to avoid visual misinterpretations. The cartography itself could for instance lead to the conclusion of a relative homogeneity of incoming and outgoing links as it does not present scattered groups of websites. But the graph representing the repartition of links contradicted this statement. Visualization tools are also insufficient for interpreting the social and communicational realities they describe. They can describe the webspheres i.e. websites and their links but they cannot explain who the people behind these websites are and what it means for them to create these websites and their links. That is why classical methodological tools efficiently complete these digital methods. Using them in addition also allows comparisons with offline objects that were already studied through the same methods. This is required in order to understand social evolutions without artificially emphasizing the power of the web transforming modern societies. This is especially true when it comes to the question of the ability of ICTs to improve our democracies, which is more often stated than proved [27]. Anchoring online political practices into "long time" [28] mutations may be necessary to avoid any technological blindness.

Digital cartographies have to be used in such a perspective in order to be useful for ICS. They can be powerful tools if based on methodologies adapted to research questions. Using them implies improving the interdisciplinary work, which characterizes the way ICS were built. They also represent a challenge for researchers who have to build a solid cooperation between disciplines and may have to work with non-academic specialists.

6. REFERENCES

[1] Mercier, A., and Pignard-Cheynel, N. 2012. Enquête sur les usages des réseaux sociaux par les journalistes français, *OBSWEB,* May 15, 2012. http://obsweb.net/2012/05/14/enquete-sur-les-usages-des-reseaux-sociaux-par-les-journalistes-francais/.

[2] Bastien, F., and Greffet, F. 2009. Les campagnes électorales à l'âge d'internet: une comparaison des sites partisans en France et au Québec. *Hermès*, 54, 209-21.

[3] Bousquet, F. 2009. La net-campagne de 2007, entre mobilisation et participation. In *La communication politique de la champagne de 2007. Participation ou representation ?*, P. Maarek, Ed. L'Harmattan, Paris 105-120.

[4] Greffet, F., and Vedel, T. 2011. L'internet ou l'espace des possibles. Les campagnes françaises en ligne depuis 2007. In *Continuerlalutte.com. Les partis politiques sur le web,* F. Greffet, Ed. Les presses de SciencesPo, Paris, 41-57.

[5] Greffet, F., and Wojcik, S. 2010. Opportunities for Political Participation or Pimicry of Political Parties? The Internet Communication of Political Youth Organizations during the EU Election Campaign 2009. In *Proceedings of the International Political Science Association Conference* (Luxembourg, march, 2010).

[6] Ouardi, S. 2004. Internet dans la champagne présidentielle 2002: un pas de plus vers l'appropriation des medias informatisés. In *La Communication politique française après le tournant de 2002*, P. Maarek, Ed. L'Harmattan, Paris, 109-126.

[7] Vedel, T., and Cann, Y.-M. 2008. Internet, une communication électorale de rupture ? In *Le Vote de rupture. Les elections présidentielles et legislatives d'avril-juin 2007*, P. Perrineau, Ed. Presses de Sciences Po, Paris, 51-75.

[8] Yanoshevsky, G. 2009. L'usage des vidéoblogs dans l'élection présidentielle de 2007. Vers une image plurigérée des candidats. *Mots*, 89, 57-68.

[9] Carlson, T., and Strandberg, K. 2008. Riding the Web 2.0 Wave: Candidates on YouTube in the 2007 Finnish National Elections. *Journal of Information Technology & Politics*, 5:2, 159-174.

[10] Coleman, S., and Ward, S. J., Eds. 2005. *Spinning the Web: Online Campaining in the 2005 Election*. Hansard Society, London.

[11] Schweitzer, E. J. 2005. Election Campaining Online: German Party Websites in the 2002 National Elections. *European Journal of Communication*, 20 (3), 327-351.

[12] Hoff, J., Horrocks, I. and Tops, P. Eds. 2000. *Democratic Governance and New Technology: Technologically Mediated Innovations in Political Practice in Western Europe.* Routledge/ECPR Studies in European Political Science, 9. London: Routledge.

[13] Rogers, R. 2010. Internet Research: The Question of Method-A Keynote Address from the YouTube and the 2008 Election Cycle in the United States Conference. *Journal of Information Technology & Politics*, 7, 241–260.

[14] Jouët, J. 2000. Retour critique sur la sociologie des usages. *Réseaux*, 100, 487-521.

[15] Gadras, S. 2010. La médiation politique comme cadre d'analyse de l'évolution des pratiques de communication au sein de l'espace public local. *Les Enjeux de l'information et de la communication*, http://w3.u-grenoble3.fr/les_enjeux/2010-dossier/Gadras/index.html.

[16] Habermas, J. 1989. *The Structural Transformation of the Public Sphere: An Inquiry into a Category of Bourgeois Society*. MIT Press, Cambridge.

[17] Miège, B. 2010. *L'espace public contemporain*, Presses universitaires de Grenoble, Grenoble.

[18] Gadras, S. 2012. Public Sphere and Political Communication. How does the Public Sphere Evolves with the Development of ICTs in French Local Politics? In *The European Public Sphere. From Critical Thinking to Responsible Action*, L. Morganti and L. Bekemans, Eds. PIE Peter Lang, Brussels, 183-196.

[19] Fouetillou, G. 2007. Le web et le traité constitutionnel européen. Écologie d'une localité thématique compétitive. *Réseaux*, 144, 279-304.

[20] Cardon, D., Fouetillou, G., Lerondeau, C., and Prieur, C. 2011. Esquisse de géographie de la blogosphère politique (2007-2009). In *Continuerlalutte.com. Les partis politiques sur le web*, F. Greffet, Ed. Presses de SciencePo, Paris, 73-94.

[21] Plantin, J.-C. 2013. D'une carte à l'autre: le potentiel heuristique de la comparaison entre graphe du web et carte géographique. In *Analyser le Web en sciences humaines et sociales*, C. Barats, Ed. Paris: Armand Colin, 228-243.

[22] Monnoyer-Smith, L., and Plantin, J.-C. 2012. Pour une analyse critique de l'apport heuristique et méthodologique de la recherche numérique pour les SIC. To be published in *Proceedings of the 18ème Congrès de la Société Française des Sciences de l'Information et de la Communication* (Rennes, France, May 30 – June 1, 2012) http://cartonomics.org/wp-content/uploads/2011/09/PLANTIN-MONNOYER-SMITH-SFSIC-20124.pdf. I thank the authors for allowing me to mention their paper before its publication.

[23] Schneider, S. M., and Foot, K. A. 2002. Online Action in Campaign 2000: An Exploratory Analysis of the U.S. Political Web Sphere. *Journal of Broadcasting & Electronic Media*, *46*(2), 222-244.

[24] Moe, H. 2011. Mapping the Norwegian Blogosphere: Methodological Challenges in Internationalizing Internet Research. *Social Science Computer Review*, 29(3), 313-326.

[25] Bastien, F., and Blanchard, G. (unpublished). Les internautes face à la communication électorale à l'ère des campagnes postmodernes. In *La communication politique des Présidentielles de 2012: premières analyses*, P. Maarek Ed.

[26] Madsen, A. K. 2012. Between technical constraints and epistemic assumptions. The socio-technical influences on making web-based visualizations a device of social analytics. In *Proceedings of the Internet, Politics, Policy 2012: Big Data, Big Challenges? Conference*, , (Oxford, UK, September 20-21, 2012). IPP2012, Oxford Internet Institute http://microsites.oii.ox.ac.uk/ipp2012/sites/microsites.oii.ox.ac.uk.ipp2012/files/Between%20technical%20constraints%20and%20epistemic%20assumptions%20-%20Big%20Data%20Big%20Challenges.pdf.

[27] Vedel, T. 2003. L'idée de démocratie électronique : origines, visions, questions. In *Le désenchantement démocratique,* P. Perrineau Ed. Editions de l'Aube, La Tour d'Aigues, 243-266.

[28] Braudel, F. 1969. *Écrits sur l'histoire,* Flammarion, Paris.

Common Narrative - Divergent Agendas:

The Internet and Human Rights in Foreign Policy

Ben Wagner
European University Institute
San Domenico di Fiesole, Italy
Ben.Wagner@eui.eu

Kirsten Gollatz
Alexander von Humboldt Institute
for Internet and Society, Berlin, Germany.

Andrea Calderaro
Center for Media Pluralism and Media Freedom,
European University Institute, San Domenico, Italy.

***Abstract*— The following paper provides an overview of the key conferences on the Internet an human rights and the Internet in the last 3 years. It then proceeds to analyse key narratives, stakeholders and agendas within these conferences, as well as questions of power and legitimacy. It will argue that the conference draw from a common discourse and language but are actually representing divergent agendas between stakeholders and states. This tension will be discussed throughout the article, before the main reasons for this are considered in the conclusion.**

***Index Terms*— Human Rights, Internet Freedom, Foreign Policy, International Relations**

I. Introduction

Although the relation between Internet and Human Rights is widely considered as a key issue in the debate on freedom of expression online, the issue is relatively new in the field of foreign policy. The need to develop policy initiatives able to integrate this debate into actual foreign policy requires an active debate and strengthening of collaborations among multiple actors active in the field of online freedom of expression, including policy makers, international organizations, governments and telecommunication actors. The increasingly frequent policy oriented and academic conferences worldwide addressing the relation between Internet and Human Rights are indicative of the rising relevance of this issue in international politics, and may serve as a vantage point for further inquiry into how this issue area is translated into foreign policy practice.

By focusing on six key international events, this paper explores policy challenges in the debate on freedom of expression online. In particular, the attention to Internet and Human Rights issues among diplomats and MFAs in the past three years would seem to suggest the states in North America and Europe have developed a common foreign policy agenda. Here, it will be argued that while these conferences share a common narrative and use the 'language of rights' (Glendon 1991) within a diplomatic context, this does not signal a common agenda. Rather these conferences draw from a common narrative stemming from global scripts on human rights, national civil society discourses and the foundational narrative of the debate created by the U.S. State Department.

In order to demonstrate this, the article will first provide an overview of the key events that took place in the field of Internet and Human Rights in Foreign Policy from early 2010 until late 2012. While many more conferences were organized in this three-year period, those discussed here will be limited to six international conferences organised by national ministries of foreign affairs (MFAs). It will then proceed to analyse the dominant narratives and stakeholders that were present at these Internet freedom conferences, before looking more closely at the divergent agendas and the power dimension of Internet Freedom. In conclusion a perspective will be provided on how the divergence between discourse and agendas affects policy development before sketching out future policy developments in this area.

II. Summary of Diplomatic Internet and Human Rights Initiatives 2010 – 2012

The "internet freedom debate" (Ross 2010) has become one of the most important international debates on international freedom of expression and foreign policy (McCarthy 2011). One of the most central public statements of such a foreign policy initiative was United States (US) Secretary of State Hillary Clinton's "Remarks on Internet Freedom" (2010) made on 21 January 2010. Despite including other countries, the obvious focus of her statement was China and Iran, which are both mentioned more than any other country. Moreover, within this foundational statement on internet freedom as foreign policy, two key aspects stand out: the assumption that ensuring freedom of expression might serve to foment "US friendly revolutions"(Nye 2009) and the highly ambiguous role of the corporate sector in securing free expression (MacKinnon 2009). Following Clinton's remarks, several European countries began to develop internet freedom initiatives, which were generally understood to be a response to the suppression of mass public protests in Iran in 2009.

The Franco-Dutch initiative which was launched in a joint communiqué by Bernard Kouchner and Maxime Verhagen, then French and Dutch foreign ministers, in May 2010. The initiative culminated in a meeting at ministerial level on "The Internet and Freedom of Expression" in July 2010.[1] Here, too,

[1] de la Chapelle, B. (2010) Remarks by Bertrand de la Chapelle during the Dynamic Coalition on Freedom of Expression and

the key aspects of the meeting agenda were the support of the supposed revolutionary activities of "cyber dissidents" and the ambiguous role of the corporate sector. However, the Franco-Dutch initiative includes significantly stronger references to a human rights framework to guarantee freedom of expression, compared to the US State Department's internet freedom initiative. However the Internet Freedom Initiative led not only to diplomatic but also to corporate responses. With the Internet @ Liberty Conference in Budapest Google also highlighted its agenda in the field of Internet Freedom. Explicitly drawing on existing private and public sector initiatives, such as the Global Network Initiative or the Hillary Clintons Internet Freedom Initiative, the conference was the first clear attempt by a large private corporation to push the Internet Freedom Agenda.

In contrast to many other conferences an attempt had been made to provide a truly global perspective on Internet Freedom, with over 25 countries represented on various panels throughout the three days. At the same time the topics discussed seem relatively narrowly focussed on Freedom of Expression issues rather than broader issues of Human Rights and the Internet. (1)[2] The Freedom Online conference in Den Haag was key in being the first large EU-US event where foreign ministers from both sides of the Atlantic were actively involved in the debate on human rights online. The American, Dutch and Swedish Foreign ministers were all present, bringing together some of the key proponents of Human Rights online in a European context. The elevated role of the U.S. foreign ministry was evident during the conference, with Hillary Clinton invited to make the opening keynote, which was followed by a presentation by Eric Schmidt from Google. The conference itself was focussed explicitly on Freedom of Expression and as a result did not consider many other aspects of Human Rights online such as privacy, protection from surveillance or access to knowledge.

While this focus is typical of both U.S. and Dutch foreign policy in this area, it provides a thin view on potential human rights policy agendas. At the same time the conference was an excellent space to bring together what has become a coalition of states working together to promote internet freedom online. Based on its core values and objectives, namely human rights, a pluralist democracy and the rule of law the Council of Europe (CoE) has also addressed issues with respect to the internet in recent years. The CoE included the issue of Internet Freedom by organizing a major conference in the field in March 2012. Here, the Committee of Ministers which represents 47 member states passed an Internet governance strategy by emphasizing the multi-stakeholder dialog. The preliminary draft was inter alia elaborated at the Internet Governance Forum in Nairobi in September 2011[3] and during the conference (2) "Our Internet – Our Rights, Our Freedoms" organized together with the Federal Ministry for European and International Affairs of Austria in November 2011.[4] As a result, the CoE has developed 40 lines of action integrating a variety of soft law elements, including a "framework of understanding and/or commitments" to protect the Internet's universality, integrity and openness, appropriate human rights-based standards to protect and preserve the unimpeded cross-border flow of legal Internet content, and human rights policy principles on "network neutrality".[5] The strategy also seeks to advance data protection and privacy, the rule of law and co-operation against cybercrime, as well as child protection. The comprehensive declaration that also links previous relevant legislation will be implemented over a period of four years, from 2012 to 2015.

(3) Following the United States and the Dutch diplomatic initiatives, the Swedish Ministry for Foreign Affairs, the Internet Infrastructure Foundation (.SE) and the Swedish International Development Cooperation Agency (Sida) hosted the first Stockholm Internet Forum on "Internet Freedom for Global Development" in April 2012. The focus on human development, digital rights and technologies might have been stated most sharply by Sweden's Development Minister Gunilla Carlson, who drew the analogy "Where there is water, there is life. And where there is the Internet, there is hope. Let's make sure everybody has plenty of both."[6] As second crucial issue on the agenda, one can identify, the responsibility of ICT-corporations combined with the need for exercising due diligence in order to promote human rights. Thereby participants referred to and strongly highlighted the UN Framework and Guiding principles on business and human rights.[7] In the course of the conference, civil society representatives also published new principles for more transparency in policy-making of states: The Stockholm Principles for Governmental Transparency Reporting on Net Freedom are still in beta.[8]

Not surprisingly, Sweden took the initiative within the UN Human Rights Council in fostering freedom online. In July 2012 U.N.'s human rights body endorsed the first ever resolution affirming that the same rights that people have offline must also be protected online, in particular freedom of

Freedom of the Media on the Internet Coalition Meeting, at the 5th Internet Governance Forum, Vilnius, Estonia, 14-17 September.

[2] These six specific conferences form the basis of the analysis conducted in this paper. Why these six were selected in this manner will be explained in section III.B. in greater detail.

[3] http://www.intgovforum.org/cms/2011-igf-nairobi

[4] http://www.coe.int/t/informationsociety/conf2011/

[5] Internet Governance - Council of Europe Strategy 2012 - 2015, CM(2011)175 final, available at https://wcd.coe.int/ViewDoc.jsp?Ref=CM(2011)175&Language=lanEnglish&Ver=final&BackColorInternet=C3C3C3&BackColorIntranet=EDB021&BackColorLogged=F5D383, 15 March 2012.

[6] http://www.stockholminternetforum.se/program/session-1/informal-summary/

[7] On 16 June 2011, the UN Human Rights Council endorsed the "Guiding Principles on Business and Human Rights: Implementing the United Nations 'Protect, Respect and Remedy' Framework" proposed by UN Special Representative John Ruggie, available at: http://www.business-humanrights.org/SpecialRepPortal/Home/Protect-Respect-Remedy-Framework/GuidingPrinciples

[8] http://stockholmprinciples.org/

expression.[9] Together with Sweden, this resolution was presented by Brazil, Nigeria, Tunisia, Turkey and the United States and was supported by over 80 member states and civil society organizations. Sweden's foreign minister Carl Bildt has described this as the beginning of a global alliance for the freedom of the Internet.[10]

(4) Not wanting to be left out, the OSCE also decided to organise an Internet Freedom conference in June 2012. The Organization for Security and Co-operation in Europe (OSCE) representing 56 states from Europe, Central Asia and North America and is thereby the world's largest regional security organization, coordinated a meeting on Internet Freedom in Dublin in June 2012, as Ireland held the OSCE Chairmanship that year. The two OSCE monitoring bodies, the Office for Democratic Institutions and Human Rights and Representative on Freedom of the Media mainly contributed to the conference. As outlined by the organizing committee the Dublin Conference on Internet Freedom first and foremost aimed at moving towards a clearer interpretation of already existing OSCE commitments. In this sense, the working sessions were built around the aim to gain a shared understanding on internet freedom, in particular stressing the role of governments and corporations within international law. However, statements from the audience indicated several conflicting points of views of participating delegations.[11]

(5) Following the first meeting in The Haag, the second Coalition for Freedom Online conference in September 2012 was organized by the Republic of Kenya in partnership with the Dutch government. For the first time Internet freedom policies were broadly discussed on the African continent under the leadership of Kenya. In relation, far more representatives from African and Asian countries attended the conference and participated in the program focusing on entrepreneurship and corporate social responsibility, censorship issues and internet access rights.[12] The Coalition was initiated in 2011 by US and EU governments and seeks to coordinate international diplomatic actions related to Internet freedom. After Kenya and Ghana, Tunisia announced it would join the alliance to become the Coalition's 18th member state and host the next conference in 2013.[13]

(6) Finally the most recent conference in this list was the Berlin Internet and Human Rights Conference in 2012.[14] Looking back on already two years of internet freedom commitments in the US and Europe the Internet and Human Rights Conferences in Berlin attempted to bring together existing initiatives while progressing on the actual implementation of internet freedom. This also included an attempt to develop policy recommendations that were distilled from the recommendations and comments of participants. The conference can to be seen in the context of the German application to become a member of the U.N. Human Rights Council and as an attempt to build capacity on this issue in Berlin. As such the conference was more focused on organising German and European initiatives rather than the global debate on these issues.

III. Analysis: Narrative, Stakeholders and Agendas

The analysis provided in this part applies a mix of qualitative and quantitative methods. Thereby, parts III.A and III.C deploy key elements of a discourse analysis by characterizing, contextualizing and interpreting the debate. The arguments established in Part III.B are based on quantitative measures and are centred on conference participants.

A. Common Narrative? Key Discourses and Questions

Having provided an overview of the most important initiatives, the article will now analyse the key discourses and see whether the suggestion of a common narrative can indeed be substantiated. The following section constitutes a critical analysis of the discourses and language used, based on a repeated reading of programme documents of all six conferences. The method is based on (Jorgensen and Phillips 2002) but also draws heavily from (McCarthy 2011)..

From a sociological perspective, one can consider narratives as effective organizing mechanisms by deploying meaning toward policy issue within institutional contexts. Thus, existing institutional logics might be subject to change and consequently result in alternative settings (Ocasio and Thornton 2008). Notably there is a considerable usage of the words 'Internet', 'Freedom', 'Human' and 'Rights'. However beyond the use of these terms there is little commonality in the substance of what these terms are used to describe (Abraham 2012).[15]

Another aspect that comes out strongly is the lack of legally binding instruments involved in these debates. While there are numerous declarations of principles, statements of Internet and best practise guidelines being developed, parliamentarians or even legislative instruments are only involved in a few cases. While such instruments such as the Global Online Freedom

[9] UN Human Rights Council, Resolution 20/8 on the promotion, protection and enjoyment of human rights: http://www.ohchr.org/Documents/HRBodies/HRCouncil/RegularSession/Session20/A.HRC.20.L.13_en.doc, 5 July 2012

[10] Bildt, C. (2012): A Victory for the Internet, In: New York Times, available at http://www.nytimes.com/2012/07/06/opinion/carl-bildt-a-victory-for-the-internet.html?_r=1, 6 July 2012

[11] http://www.osce.org/cio/91473 (Part 1) & http://www.osce.org/cio/91474 (Part 2)

[12] http://www.freedomonlinekenya.org/programme-1

[13] http://www.state.gov/r/pa/prs/ps/2012/10/198704.htm

[14] In this case the cut-off of the analysis was the end of 2012. While other conferences on this topic have taken place since then they were not considered for the purposes of this analysis,

[15] See also Figure 1. In this quantitative view, the commonly used words "internet", "freedom", "human rights" have been excluded to better illustrate the divergent topics that have been discussed in those six conferences.

Act (GOFA) in the U.S. or demands for stricter export controls on surveillance technologies in Europe do exist, they have not been situated at the core of the conferences nor were they seriously discussed in any of these venues. It seems that these initiatives exist on the fringes of these conferences, while the actual focus of their debates are soft rather than hard policy instruments.

Figure 1. Conference Topics illustrated with wordle.net

A third element that is extremely prevalent in conference debates is that the organisers don't seem to have answers for many of the topics they are discussing. Indeed question marks are so prevalent in many of the internet freedom conferences being organised, that is seems appropriate to consider them collections of open questions rather than attempts at policy implementation or joint action. The role of the multi-stakeholder model is interesting in this context, as it basically evolves into providing new ideas and policies to governments who aren't quite sure what to do about internet freedom. To the invited groups - mainly regional or local civil society but also the private sector and international organisations - a space is offered which is suggested to allow them to upload their ideas and suggestions to government policy in return for innovative ideas and effective analysis. It is however entirely unclear whether this upload ever actually happened.

As such the various conferences serve as a massive free-form public consultation of relevant stakeholder groups. As the consultation process is not formalised, it tends to promote the invitation of the 'usual suspects' and has difficulty challenging basic assumptions about the agenda itself (Barnes et al. 2003). These include narratives about the key role of foreign policy in keeping the Internet open or the fundamental importance of the multi-stakeholder model in Internet governance.

At the same time this flurry of conferences does not mean that there has been a huge amount of policy activity within the field of internet and human rights. For all of the stages that have been built and for all of the public debates that have taken place, this has translated into remarkably little actual activity. On issues such as export controls for technologies, which harm human rights or developing joint declarations or treaties, the development of actual foreign policy has been sluggish at best. The few notable exceptions are the freedom online coalition initiated in Den Haag in 2011, which has since led to a coalition of states working together in this area. This exception notwithstanding, most of the conferences have tended to call for things to be done rather than actually doing things. The impetus of the agenda around internet freedom conferences is more to consider what could be done rather than actually doing it. An alternative interpretation is to see these individuals as 'unelected representatives' (Keane 2009) who still fulfil an important function within the democratic process.[16]

The concept of Internet Freedom has become something of an empty vessel, which is filled by the respective organisers in whatever manner they see fit. However its lack of specificity also makes it difficult to draw together the different aspects of internet freedom around a common set of policy objectives. While all stakeholders draw from the language and narrative of rights, it is difficult to discern a common 'Internet Freedom' or 'Internet and Human Rights' narrative. All of the conferences so far have been held together by a few common terms and a common linguistic framework, within which the debates have taken place. They do not necessarily however suggest a common strategic agenda.

B. Stakeholder Analysis: Key Participants

The starting point for building a database based on the six big international conferences related to freedom online and foreign policy as outlined in the beginning.[17] These are explicitly less than the key events previously mentioned and only include international conferences organised by Ministries of Foreign Affairs. The stakeholder analysis is based on the set of the respective programs which are publicly available on the web. A case is defined as an official speaker, as mentioned in those programs.[18] As a result this quantitative analysis initially aims to identify those individuals and groups who hold some kind of "stake" or interest in the field of Internet and Human Rights. The list of speakers was analysed in order to identify the key actors as well as marginal groups shaping the public debate in the last two years. Following the observations of discourses and questions outlined in the previous section, the following analysis intents to provide further insights into the issues at stake, as well.

Pointing on speakers who attended the conferences follows the assumption that those are perceived as relevant experts in this specific field. They have been invited with the intention to share their knowledge and experiences, and thereby contribute

[16] The authors are grateful to Saskia Sell for this idea and her valuable comments on an earlier version of this article.

[17] The sample includes the following conferences: "Our Internet - Our Rights, Our Freedoms. Towards the Council of Europe Strategy on Internet Governance 2012 - 2015" (Austria, 2011); "Freedom Online. Joint Action for free expression on the internet" (The Netherlands, 2011); "The Stockholm Internet forum on Internet freedom for Global Development" (Sweden, 2012); "Dublin Conference on Internet Freedom" (Ireland, 2012); "The Second Freedom Online Conference" (Kenya, 2012); "The Internet and Human Rights: Building a free, open and secure Internet" (Germany, 2012)

[18] Speakers that were occurring at several conferences each time counted as one case.

to the discussions in plenaries and workshops by providing a specific perspective on the topics linked to Internet and Human Rights. By doing so, experienced speakers shape and frame the public agenda within the field of Internet Foreign Policy to a large extent. They might even shift the attention to alternative problems and solutions, which subsequently might also influence the policy decisions. In order to identify structural patterns and perhaps biases, attributes such as the conferences attended, the organisation, the persons' name and role have also been gathered. Cases have been further categorized according to the stakeholder group, the respective person, or the organization he or she represents.

In the years 2011 and 2012 five out of six conferences were hosted by European governments and as such took place in Europe, one conference was held in Kenya. In total, 245 cases were collected. These cases are clustered into seven stakeholder groups as illustrated in Figure 2.

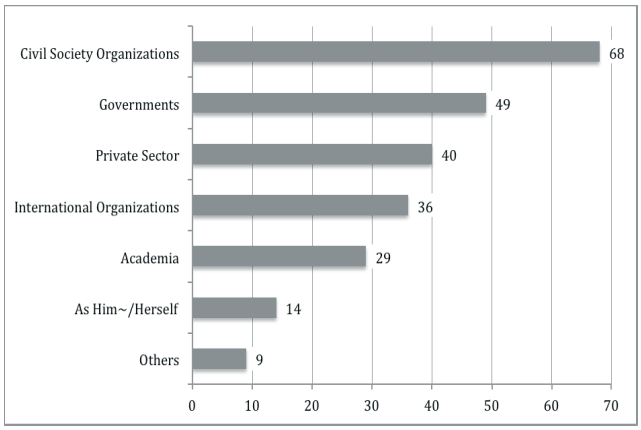


Figure 2. Overall Numbers of Representatives by Stakeholder Group (n=245)

Due to the 'multi-stakeholder' approach that all conference organizers have stressed as very important and applied in the agendas, identifying and dividing different stakeholder groups wasn't a problem. However, while some groups play an outstanding role in contributing to the programs others were completely out of sight. According to their times of appearances, representatives of Civil Society Organizations are the most central actors invited to speak at international conferences on internet freedom. Adding the number of speakers matched under the category "As Him/Herself", mainly represented by bloggers and activists from authoritarian countries, civil society is most active in these conferences and can be identified as the primary stakeholders in the respective field According to their function as organizers and hosts of the meetings, governmental representatives cluster the second largest stakeholder group.[19] These numbers are followed by members from the private sector, first and foremost by officials from Google (9 times) and Facebook (3 times). International Organizations only form the middle field and will be illustrated in detail subsequently. As Figure 1 indicates, academics play a less important role according to the number of times they spoke as experts on panels and workshops.

However, one of the most crucial findings is hidden behind the last category entitled "Others". Quantitatively not enough to form an own category, members of national and the European Parliament represent the most marginal group. The absence of parliamentary representatives becomes even more relevant when looking on how many people exactly have joined the discussions[20]. In sum, in only four out of 245 cases parliamentarians have commented on the issues regarding internet freedom in the realm of international relations. This lack of parliamentary representation within international conferences fits to the aforementioned findings and further exemplifies the absence of hard policy initiatives in the political discourse on internet freedom.

Geographically, speakers from the United States and the UK participated in the conferences most often, though the sample did not include conferences that took place in one of these countries. These are followed by the countries that hosted own conferences, that are Germany, The Netherlands, Sweden, Austria, Kenya and Ireland. Based on our sample of conferences we can state a strong geographical bias towards a Anglo-American and European perspective (See figure 3).

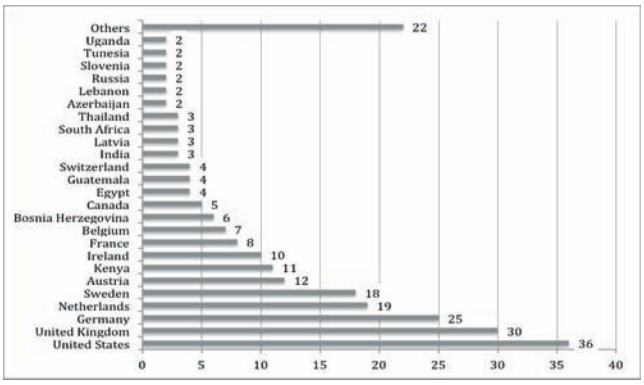


Figure 3. Diversification of speakers by country (n=245)

Detailed findings – 'Levels of stake-holding'

In this section results will be provided in more detail by further elaborating the structure of each conference and within selected stakeholder groups. Figure 4 provides an overarching view on how organizers have interpreted and applied the multi-stakeholder approach. The perceived relevance of one or the other groups results in quite diverge proportional distributions.

[19] The number is based on governmental representatives as they appear in the conference program as speakers in workshops or sessions. The group of governmental actors attending those conferences is much bigger when all country delegations invited are being included.

[20] Easy to count, Marietje Schaake, Dutch Member of the European Parliament officially participated in the sample of conferences three times, and Birgitta Jónsdóttir, Icelandic Member of Parliament for The Movement was active in one conference.

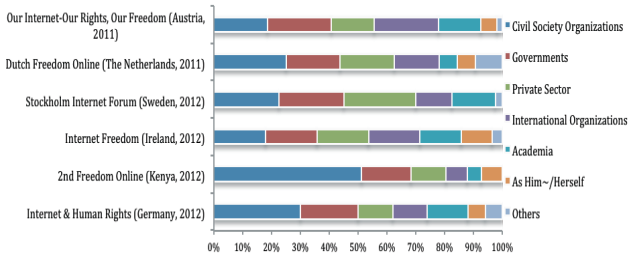


Figure 4. Multi-Stakeholder involvement by Conferences, in percent (n=245)

Most pronounced emerges the 2nd Freedom Online Conference, which was held in Kenya. Whereas strong emphasis was given to Civil Society Organizations – with distinction these were the most represented group – other stakeholders, such as international organisations and academia, were less involved in this conference compared to the conferences hosted by European foreign ministries.

As mentioned before, representatives of Civil Society Organizations participated most often according to the times they gave a talk or joined the discussions. Thereby, the conducted analysis indicates a variety of actors with a civil society background that were involved directly. Members within this category cannot be viewed as a homogeneous stakeholder community, neither in their structure, nor according to their priorities. Within six conferences 48 different organizations were identified. Only a few of them, such as Access Now and The Institute for Human Rights and Business (each 5 times), Freedom House and Hivos (each 3 times) can be named as this category's leaders. However, the majority of CSOs involved participated only once and can be described as smaller groups, rather concerned with national politics. Human Rights Watch as an organization with worldwide branches and a true global outreach only participated twice. Other international CSOs did not contribute to the conferences' agendas.

Even though the conferences dealt with a global topic and were always directed to an international audience, one can also observe a "national framing". This becomes most obvious when we refer to governmental representatives. (See figure 5) The overall result leads to the notion that governments were most active in the conferences they have organized themselves. According to the number of governmental representatives Germany and Austria, as well as Ireland seem to be quite relevant in pushing the agenda forward, but indeed they aren't. All three countries were involved in organizing and hosting an own conference and thereby developed a program involving their own national representatives. By contrast Sweden, The Netherlands and Kenya participated in more than three conferences, as well as The United States and the UK.. The leading role of U.S. foreign policy and the Swedish government can also be confirmed by looking at these numbers.

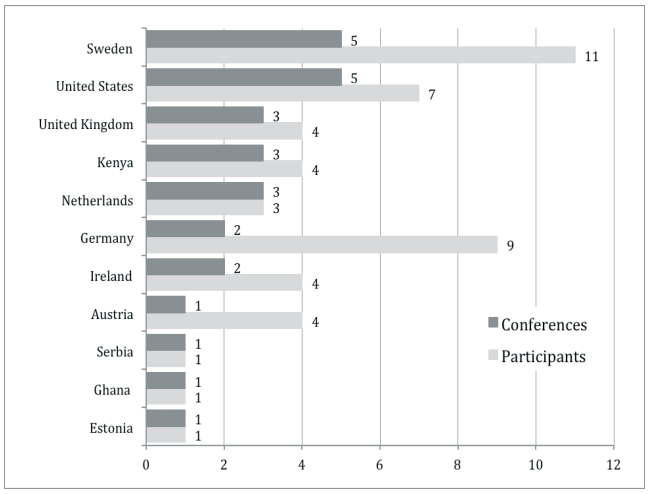


Figure 5. Conferences attended from Governmental Representatives by Country (n=49)

Shifting the attention to International Organizations and how they shape the conferences' agendas, three major actors were found: The Council of Europe, the Organization for Security and Co-operation in Europe (OSCE), both organizers of an own conference and the United Nations (see figure 6).

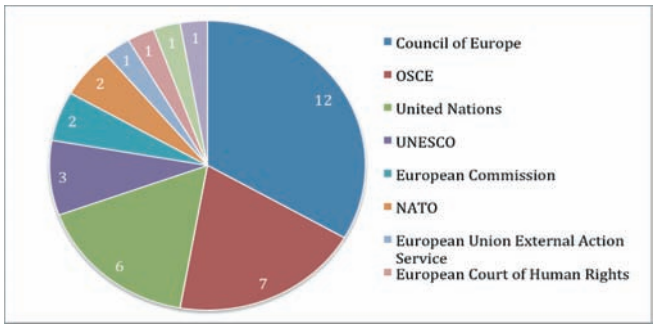


Figure 6. Participation from International Organizations (n=36)

Similarly to parliamentarians, international organizations are mainly represented by a single person. For the OSCE, this is Dunja Mijatovic who was appointed OSCE Representative on Freedom of the Media in 2010. She participated in all six conferences and was thereby the most demanded single person. With regard to the United Nations, Frank La Rue has provided expertise at five conferences in his role as the UN Special Rapporteur on the promotion and protection of the right to freedom of opinion and expression.

Over the course of the last three years the conference analysed above indicate a growing international response to the debate on internet freedom. However, these six single events were mainly framed by national actors and stakeholders. This seems to be contradictory. On the one hand, conferences were initiated by broader coalitions proposing and pushing an agenda on internet freedom principles which are understood as global norms. On the other hand, governments themselves take on the role as conference hosts and organizers to deploy their

domestic and foreign policy interests. Thereby, the vague term of "internet freedom" became a widely used frame for national discourses.

C. Divergent Agendas and Power

Derived from the two sections above that focused on the narratives and key participants, several key drivers could be identified which have led to these conference taking place in this manner over the past three years. There can be split into 1) specific geopolitically relevant events and their framing 2) the role of U.S. foreign policy in framing the debate 3) competition between government ministries at a national level 4) the role of small European countries in framing the debate 5) the role of international organisations and 6) the role of large global corporations.

i) Mass public protests in Iran and during the Arab Spring

The mass public protests on the streets of Tehran in 2009 were widely discussed at a global level. Their role in defining public debate was important, as it led to a close linkage between ICTs, the Internet and the protest movement in Iran. This was perceived to be fuelled, enabled or at very least linked to new ICTs. Particularly the Wall Street Journal story suggesting that Nokia Siemens had supported the Iranian government's suppression of the protests by supplying surveillance technology to Iran (Lake 2009) further focused the debate on the role of ICTs. Although diplomats had been involved in these debates for some time, this was the first time that there was an active search for solutions in this area in response to the widespread public debate. Special advisors were appointed and existing staff with competency in this area were brought together to develop solutions. The result was an explosion of respective foreign policy approaches in late 2009 and early 2010.

ii) The role of U.S. foreign policy in framing the debate

One of the best placed actors in the diplomatic debate on these issues was Hillary Clinton, who had recognised after the presidential elections in 2008 when she became U.S. Secretary of State that she needed to increase the capacity of the state department to deal with online issues. At the same time the historic position of U.S. foreign policy in this area and it's 'open door policy' provided a fertile ground to develop U.S foreign policy in this area (McCarthy 2011). The result were Hillary Clinton's remarks on Internet Freedom, which for all of the legitimate criticism on both their framing and substance of the agenda (Morozov 2011) have been the key starting point of a foreign policy agenda around 'Internet Freedom.' As noted by McCarthy in a seminal article in 2011:

> "The symbolic politics surrounding the Internet are crucial to the future direction of its technological development. The argument of US foreign policy officials, that an Internet characterized by the free flow of information meets international norms of human rights and democracy, is an attempt to steer the development of the technology in a direction that meets its specific vision of how international society should function" (McCarthy 2011: 105).

This analysis is also strongly reflected in the frequent presence of State Department officials speaking at the conferences discussed here. Their prevalence is second only to that of Swedish officials and has been crucial in shaping and framing the global debate on internet freedom beyond the remarks of Hillary Clinton directly.

iii) Competition between government ministries at a national level

Notably pursuing an Internet Freedom agenda allows the state department to get in on a 'hot new policy area' where it previously had little or no political leverage. The 'cyber' policy area had previously been occupied by the Department of Homeland Security and the Intelligence Services as well as the Department of Commerce, with little scope for policy development by the State Department. Engaging in Internet Freedom as a strategic object of U.S. Foreign policy has the effect of 'de-securitising' the agenda - or at very least shifting the discursive frame away from the classic security-oriented 'politics of cyber.' This is not to say that the state department has not shown an appetite for Internet Freedom to become a tool to pursue U.S. strategic interests, but rather that the very consideration of Internet Freedom as an agenda has provoked a shift away from the classic economy and security frame.

Importantly this shifting balance of ministries in the 'cyber' policy can also be observed in other foreign ministries around the world. The opportunity structure for developing Internet Freedom policies is common to many MFAs and the resulting response of foreign ministries around the world - and particularly in Europe - has been to follow suit, if not always with an identical strategic agenda. Apart from divergent European foreign policy interesting, this is also because the issue has historically been framed in terms of Human Rights in several small European countries, particularly Sweden and Estonia.

iv) Small European countries shaping the debate: Sweden and the Netherlands

Indeed it is important to consider the role of both Sweden and the Netherlands in framing the debate on Human Rights and Foreign policy online in Europe. Particularly Swedish Foreign Minister Carl Bildt has been able to make a name for himself, although the process of doing so has led to considerable tensions with other ministries within the Swedish government. The process of Sweden becoming a leading global voice on Internet Freedom has posed some difficulty for larger European countries, as their leadership on a defining future foreign policy issue is called into question. The response by other large European MFAs has been to focus on other aspects of the 'cyber' policy agenda, with President Sarkozy of France organising an unusual e-G8 meeting in 2011 to promote the economic dimension of internet foreign policy, while the

United Kingdom has promoted it's 'London Cyber' process as a means of establishing jointly agreed norms in cyberspace.

Notably the Netherlands have also played an important role in both linking U.S. and European debates on Internet Freedom and spearheading the Freedom Online coalition movement to develop a group of states around an internet freedom agenda. All of the 'usual suspects' in Europe and North America are members of this coalition with one exception: Germany. At the same time both the Netherlands and Sweden are part of an informal G5 group of EU countries which work together on cyber policy issues at a European level.[21] As such it remains to be seen how European foreign policy develops in this area and how the ongoing co-operation of the G5 influences European foreign policy in regards to the internet and human rights.

v) The role of International Organisations

Despite the existence of a European 'No Disconnect Strategy' that was developed by EC VP Neelie Kroes after the Arab Spring, there is a notable absence of EU Commission officials at the internet freedom conferences analysed. Indeed it seems that the institutions of the European Union are also still catching-up with this debate and that there are only very few individuals who are actually considered 'speaker material' from these organisations.

This is not to say that international organisations have not been represented at these conferences. The Council of Europe and the OSCE took over the representation in this case. The CoE has been deeply involved in these debates, yet given the small size and budget of the organisation its purpose is clearly agenda setting rather than policy change. In regards to the OSCE their strong representation stems from the consistent involvement of Dunja Mijatovic, one of the key 'usual suspects who is almost exclusively the sole OSCE speaker represented. The strong presence of the CoE and OSCE in these debates suggests that the agenda is still at a declaratory rather than an operational stage. If it begins to filter into organisations and bureaucracies more strongly, it might be expected that other IOs such as the European Commission or UNDP might be more frequently represented as well.

vi) The interests of large global corporations

Unsurprisingly Internet Freedom policies are also used as a tool to further economic interests. The policies have been particularly relevant for large global corporations wishing to expand their presence across the globe. As such the agenda has been particularly relevant for those companies whose business models depend on global Internet connectivity, particularly Google, Cisco and Facebook. Google has openly and vocally supported the Internet Freedom agenda since it was first announced in 2010, with both Chairman Eric Schmidt and CEO Sergey Brin publicly coming out in favour of the U.S. Internet Freedom agenda. Also Cisco has been particularly concerned with the threat that the breakup of the global internet into different national internets represents for its hardware business. As the development of internet governance policies remains closely entwined with economic and trade policies, the support of private companies for such agendas has become an important factor.

IV. Conclusion and the path ahead

The Internet Freedom agenda has developed and disseminated in manifold ways over the past three years. Although initiated in the U.S., it has quickly gained different dimensions and spaces through its continued use as a highly flexible 'boundary object.'[22] Despite this, each initiative in this area has attempted to carve out a new space and not be seen as a 'me-too' conference, a phenomenon that can be particularly observed in the conferences that took place in 2012. While there is a strong impetus towards taking concrete steps, many of the initiatives and conference left unclear how these policy agendas will be implemented. For the enormous amount of discourse in this space remarkably little has been done.

There are several reasons for this. Public policy is slow to develop and particularly difficult when the empirical basis of the policy making process is unclear. In many cases decision makers lack hard facts about human rights abuses enabled by internet technologies, how governments are censoring and surveilling the internet in different parts of the world and even how online service providers in their own country are filtering news content in crisis situations. Moreover public debates on ACTA, SOPA but also WCIT exemplify the difficulty of developing a public debate on deeply technical material which is formulated following legal and diplomatic conventions. The general lack of public debate, usable expertise and reliable data makes the overall policy process difficult. The general lack of substantive parliamentary debates on these issues - although there are a few notable exceptions – further accentuates this problem.

Of course MFAs also compete on this topic and there is a notable level of PR, public diplomacy and agenda setting taking place during the conference organising process. For the U.S. State department the Internet Freedom agenda has been an important tool to demonstrate the on-going capacity of the U.S. to innovate in the field of diplomacy and to reassert U.S. dominance within this field after the Iraq war. For Sweden and to a lesser extent the Netherlands, Internet Freedom of the Internet and Human Rights has provided a platform which as smaller European countries they would not otherwise have had access to in developing European foreign policy. Germany, which had not previously been particularly active in this field saw the conference as a way to catch up with other actors in this area while promoting its own candidature for the U.N. Human Rights Council.

[21] Bendiek, A., & Wagner, B. (2012). Die Verfassung des Internets. *IP - Die Zeitschrift, Jahrgang 2* (November/December).

[22] This idea initially stems from Jeanette Hofmann, who provided valuable comments on an earlier version of this article.

The analysis above has also identified the disconnection between national debates on the Internet and the global internet freedom agenda. This is reflected both in the speakers invited and in the way the conferences are framed. While there seems to be an overarching discourse, there is little agreement beyond a few common boundary objects. Although the conference in Kenya represents an attempt to remedy the European and North American focus of the Agenda, there is no denying in that the overwhelming number of stakeholders participating comes from North America and Europe. The frequent presence of civil society organisations at these conferences could simply be cosmetic, but the extent to which they are integrated into the debate on these issues suggests that they themselves are one of the key drivers of this agenda. Of course, it is extraordinarily helpful that open networks are also in the interests of large corporations and not just of civil society organisations. But the extent to which foreign ministries use these conferences as a means to 'download' knowledge and build their own capacity in dealing with these topics is notable and considerably shapes the debate as a result.

With Hillary Clinton universally expected to leave the state department at the end of 2012, there is no knowing how her successor will proceed and which strategic objectives he will pick. While the topic has clearly taken root in Europe, the direction and scope of European engagement with the Internet Freedom agenda remains difficult to ascertain. Crucial in this context is the involvement (or lack of it) of the largest European countries: the UK, France and Germany. While all have shown an appetite for integrating the internet into foreign policy, the focus has been on security and norms of behaviour in the UK, on supporting rights-holders and creating economic growth in France. All three countries have their own Cybersecurity strategy that typically includes a foreign policy component, but none has yet developed an overarching strategy for integrating the Internet and human rights or even just 'Internet Freedom' into foreign policy.

References

Abraham, Sunil. 2012. "Open letter to Hillary Clinton on Internet Freedom." *Centre for Internet and Society*. http://cis-india.org/internet-governance/open-letter-to-hillary-clinton

Barnes, Marian et al. 2003. "Constituting 'the public' in public participation." *Public Administration* 81(2): 379–399.

Clinton, Hilary R. 2010. "Remarks on Internet Freedom." http://www.state.gov/secretary/rm/2010/01/135519.htm

Glendon, Mary Ann. 1991. *Rights talk : the impoverishment of political discourse*. New York; Toronto; New York: Free Press ; Collier Macmillan ; Maxwell Macmillan.

Jorgensen, Marianne W, and Louise J Phillips. 2002. *Discourse Analysis as Theory and Method*. SAGE Publications Ltd.

Keane, John. 2009. *The life and death of democracy*. New York: W.W. Norton & Co.

MacKinnon, Rebecca. 2009. *Race to the Bottom-Corporate Complicity in Chinese Internet Censorship*. Human Right Watch.http://dspace.cigilibrary.org/jspui/handle/123456789/20068

McCarthy, D.R. 2011. "Open networks and the open door: American foreign policy and the narration of the internet." *Foreign Policy Anal. Foreign Policy Analysis* 7(1): 89–111.

Nye, Joseph S. Jr. 2009. "Get Smart- Combining Hard and Soft Power." *Foreign Affairs* 88: 160.

Ocasio, W., and P. H. Thornton. 2008. "Institutional logics." In *The SAGE handbook of organizational institutionalism*, ed. Royston Greenwood. Los Angeles, CA: SAGE, p. 99–129.

Ross, Alec. 2010. "Internet Freedom: Historic Roots and the Road Forward." *SAIS Review* 30(2): 3–15.

Equality and civic literacy on parliamentary informatics platforms

- a comparative analysis of three cases in the UK, Italy and France

Alina Ostling
Department of Political & Social Sciences,
European University Institute,
Florence, Italy
alina.ostling@eui.eu

***Abstract*—The past decade has brought a boom of online initiatives that monitor the performance of parliaments – a practice commonly referred to as 'parliamentary informatics'. A recent survey identified 191 organisations monitoring over 80 parliaments worldwide; many of these use digital tools to aggregate information and facilitate citizens' involvement in parliamentary activity (Mandelbaum 2011). At the same time, little is actually known about who uses these platforms and whether they increase the quality of democracy. This paper aims to fill this gap by assessing parliamentary informatics projects in three European countries from the point of view of key democratic dimensions: their inclusiveness of different groups of citizens (equality) and their effects on citizens' knowledge and interest in politics (civic literacy).**

***Index Terms* - e-democracy, e-participation, civic engagement, parliamentary informatics, equality, inclusiveness, civic literacy.**

I. Introduction

Parliamentary informatics is generally defined as the application of information technology to the documentation and dissemination of legislative activity. By using new technologies that enable citizens to participate in democratic processes, parliamentary informatics projects qualify as a manifestation of electronic (e)-democracy.

Parliamentary informatics has become a growing trend over the last decade. Today, there is a myriad of innovative tools and services that make use of parliamentary data in order to better analyse and visualise how parliaments actually work. As a rule, they aim at improving the transparency and accountability of parliaments, and increase citizens' engagement in the legislative process (Dietrich 2011). However, to date, there is a lack of academic research about these initiatives, In particular, it is not clear how they rate on different democratic dimensions and whether they increase the overall quality of democracy.

The theoretical framework of this paper is based on the 'essentialist' and the 'instrumentalist' approaches (Blanco and Lowndes 2011). The former is rooted in Barber's concept of strong democracy and considers public engagement as an essential feature of democracy (Barber 1984). From this perspective, the main challenge is to assess if participation fulfils certain procedural criteria that ensure its democratic legitimacy. From the instrumentalist perspective, the key challenge is to find evidence of the impact of participation. In this paper, the essentialist criterion is operationalised as equality, and the instrumentalist criterion as civic literacy.

The paper examines three parliamentary informatics projects: OpenParlamento (OP) in Italy, TheyWorkForYou (TWFY) in the UK and NosDéputés (ND) in France. Non-profit associations with members who have a prevalently technological background run the projects. They have an overarching aim to provide user-friendly and free access to public data about parliamentary activities. Their mission is in line with the practice of 'open government', which holds that citizens have the right to access government information to allow for effective public oversight and involvement. Open government supporters believe that the processing, aggregation and mashup of data could contribute to these objectives (Blondeau and Allard 2009).

The projects offer information and statistics about parliamentary activities, and the possibility of discussing legislative acts. They help users to keep track of the declarations of their MPs, offer various content management options (e.g. tagging, graphing), and allows users to 'adopt' representatives, i.e. follow their activities and contribute actively by uploading updates on the chosen representative.

The case studies are based on interviews with project stakeholders and the results of online user questionnaires, which originate from the author's surveys of OP and ND (2011); and from Tobias Escher's survey of TWFY, which provided crucial insights and unique comparative data (Escher 2011).

In particular, the paper shows that parliamentary informatics projects achieve both positive and negative results in terms of democratic quality. On the one hand, parliamentary informatics projects seem to boost civic literacy and expand the numbers of the politically active. On the other hand, the data support previous claims in the literature that online participation is even less inclusive than offline engagement (Hindman 2008). Many of the traditionally underrepresented

groups in politics seem to have even more limited presence on parliamentary informatics platforms.

II. Civic Literacy

Civic literacy has many definitions. Generally they refer to civically literate citizens as those who: (i) are interested in, pay attention to and have a reasonable understanding of the contemporary society; (ii) possess knowledge and understanding of civic processes; (iii) engage in civic activities that form a foundation for democracy (Milner 2002). In this paper, civic literacy is defined as increased understanding and interest in politics, which in turn stimulate political participation (Milner 2004).

Not unexpectedly, the more often people engage in politics, the better civic skills they get (Fung and Wright 2001). Knowledgeable individuals can better seize what impact policy has upon their interests and those of their community, as well as increase their influence on political outcomes (Milner 2003). What is more, civic literacy can be considered one of the pillars of democracy. Originally, John Dewey declared: "democracy depends upon the willingness of learned citizens to engage in the public realm for the betterment of the larger social good" (as cited in Rhoads 2003, p. 25). There is a general scholarly consensus that a healthy democracy needs citizens who are competent in civic literacy. Almond and Verba showed the importance of citizens' civic skills for stable and prospering democracies already back in the 1960s (Inglehart and Welzel 2005).

The participatory democracy theorists Pateman (1970) and Barber (1984) argue that positive effects of civic education appear when people have improved opportunities to engage in policy-making. During the past decades, the rise of the Internet has created many of these opportunities, in particular by offering new tools that facilitate political participation. Several studies affirm that e-democracy and the accompanying digital tools promote political knowledge, motivation, discussion and voting (Tolbert and McNeal 2003; Mossberger et al. 2008; Anduiza et al. 2012). The participatory democracy school considers e-democracy as a form of civic training and a fertile ground for cultivating civic activists, which in their turn are able to boost the potential of the civil society (Talpin 2007).

In line with these assumptions about the positive effects of e-democracy, the projects seem to have increased the civic literacy of users. As illustrated by Fig. 1, a large majority of OP and ND respondents (72-83%) have a better understanding of and more interest in politics after having participated in the projects. About one third of OP respondents are even strongly convinced about it. However, only 21%-28% of the respondents believe they have a possibility to impact on Parliament, which is logical since the project platforms do not provide any direct communication channel into the parliament. Analogously, a substantial majority (circa 90%) of TWFY users affirm that they have improved their knowledge about their representatives. Moreover, 60% of TWFY users had never even looked up information about their MPs before they visited the site (Escher 2011, p. 5).

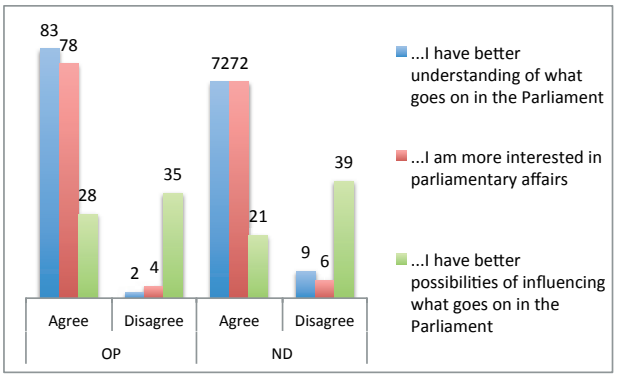


Fig. 1. The OP and ND respondents' expectations regarding the outcomes of their participation (%) (Authors' surveys 2011)[1]

The user surveys also show that parliamentary projects stimulate participation. About a third or more of OP and ND respondents had *never* before engaged in any of the political activities in Table I, except for petitioning in which circa 20% had never participated. What is more, 35% of OP and 42% of ND respondents stated that they would *not* have made their comments/proposals unless on the project sites. This last result should however be taken with caution since the N was very small. [2]

TABLE I. Respondents who never engaged in any of the political activities under consideration (Author's surveys 2011)

	ND		OP	
	(%)	(N)	(%)	(N)
Posted on an online political forum	**43**	39	**40**	158
Contacted politician/media	**41**	38	**44**	176
Demonstrated	**41**	38	**30**	119
Signed petition	**22**	20	**17**	67

Similarly, nearly half of TWFY users have not engaged in any other political activity apart from using the project's website. One in five users (i) has not been politically active within the last year, (ii) has not been part of any political or community groups, and (iii) has tried to find information about representatives for the first time with the help of TWFY (Escher 2011, p. 5). This indicates that the projects have captured the attention of people who are normally politically inactive and enabled them to engage in parliamentary affairs.

The stimulus to participation is unveiled by an overwhelming majority (98% of OP and 79% of ND

[1] See Annex I for further survey details.
[2] OP (N=39); ND (N=10).

respondents) who said they would consider getting involved in the political activities mentioned in Table I in the future. Moreover, a cross tabulation of answers shows that a strong majority of respondents (68%-97%) who had *never* participated in any of these activities were inclined to engage in the future (see Table II). This shows that OP and ND have a potential as catalysts for political participation.

TABLE II. CROSS TABULATION: RESPONDENTS THAT HAVE *NEVER* ENGAGED IN ANY OF THE LISTED POLITICAL ACTIVITIES BUT THAT WOULD CONSIDER PARTICIPATING IN THE FUTURE (AUTHOR'S SURVEYS 2011)

	OP		**ND**	
	N	%	N	%
Contact media/ civil servant/politician	145	**97**	26	**70**
Participate in a demonstration/protest	88	**97**	25	**71**
Sign a petition	51	**96**	15	**75**
Post on an online political forum/discussion group	126	**96**	26	**68**

In sum, a striking majority of respondents seems to have increased their knowledge and interest in politics thanks to the parliamentary informatics projects. A part of the respondents also stated that they would not have made their proposals unless on project platforms, and that they would like to engage politically in the future. This suggests that parliamentary informatics projects boost civic literacy and expand the numbers of the politically active. In line with the previous body for research on the related concept of media literacy, parliamentary informatics could be considered as an 'environmental factor'. Environmental factors consist of media availability and literacy context, and can affect the literacy capabilities of individuals (Celot et al. 2009). From this perspective, parliamentary informatics turns out to be a form of activity that fosters civic literacy capacities.

The next section will examine who is actually present on parliamentary informatics platforms in terms of demographics, political activity and digital skills.

III. EQUALITY: SOCIO-DEMOGRAPHICS OF USERS

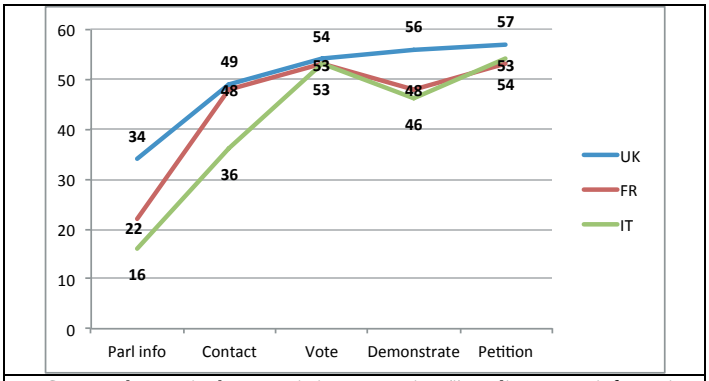
The concept of equality examined in this paper is closely related to Scharpf's notion of input-legitimacy, which is produced by the inclusive involvement of citizens affected by a political outcome (Scharpf 1997; Barber 1984). This means that a lack of equality among participants poses problems of legitimacy to the political outcomes. Who participates in parliamentary informatics projects is important mainly because if certain groups dominate, they might promote issues and policies that are not relevant for the population as a whole.

Moreover, there is a risk that online participation reinforces traditional, offline, political inequalities. The literature on Internet activism is split between the supporters of the mobilization hypothesis, who think that the Internet can give more space to marginalised groups in politics (Gibson et al. 2005) and the reinforcement proponents, who believe that it merely reinforces established patterns of political communication, and widens the gap between elites and non-elites (Norris 2001). The former argue that if there are strong divergences among people participating offline and online new configurations of political influence can emerge (Anduiza et al. 2012, p. 7). The latter believe that those who were politically active before the Internet are the basically same people who are now politically active on the Internet (Bimber 2003).

Previous empirical research mainly shows that political inequalities are perpetuated also online. Privileged groups such as the wealthy and the well educated are engaged online in a disproportionate way (Norris 2000; Pew Internet and American Life Project 2009). However, this pattern may be about to change, at least in some parts of the world. A recent study by the Pew Research Center shows that 73% of adult Internet users in the US (representing more than half of the voting-age population) went online to get news or information about the 2010-midterm elections (Smith 2011). Moreover, as recently as the 2006 election cycle just 16% of American adults were social networkers. Today 60% use online social networking sites and these sites have emerged as a key part of the political landscape in the most recent campaign cycle (Smith et al. 2009; Smith 2011). Moreover, when the younger cohorts, who are more Internet-savvy, get older this trend might grow stronger (Coleman and Blumler 2009).

In theory, many e-democracy projects are intrinsically more inclusive than conventional participation since they give access to groups that are normally excluded from voting, e.g. immigrants that do not have rights to vote in local or national elections, or those who are under-age. But in practice, the user survey results presented in this section show that many of the traditionally underrepresented groups in politics have even more limited presence on parliamentary informatics platforms.

Firstly, as shown by Ostling (2012), women are in minority among respondents. They constitute 16% in OP, 22% in ND and 34% TWFY. Their share among projects users reflects what is happening in terms of political participation of women on country levels: the UK shows the best gender-balance, while France and Italy have inferior scores (see Fig. 2). This implies that the gender inequality pattern discernable in the projects could be influenced by the state of gender equality in national politics. It is also noteworthy that the share of women among survey respondents tends to be much lower with respect to the share of women in other political activities such as contacting politicians, voting, demonstrating, and petitioning.



LEGEND: The X-axis shows statistics concerning (i) parliamentary informatics project ('Parl info'), i.e. TWFY, ND, OP, (ii) people who contacted a politician/government official ('Contact'), (ii) voted in general elections ('Vote'), (iii) took part in demonstrations, and ('Demonstrate'), and (iv) signed a petition ('Petition').

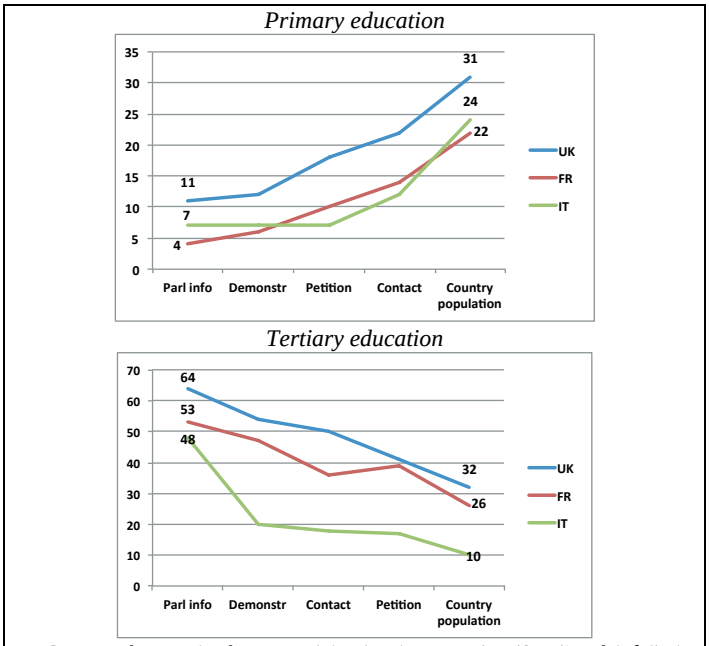
Fig. 2. Percentages of politically active women in Italy, France and the UK (Author's surveys 2011, Escher 2011; European Social Survey (ESS) ESS1-2002[3])

Moreover, the level of education of parliamentary informatics users is well above the national averages (Ostling 2012). Half of the OP respondents (48%) finished university with respect to 10% of Italy's population; and twice as many TWFY and ND respondents have a university degree in comparison to their respective country populations. At the other end, there are few people with lower education among respondents (see Annex I). The difference between project respondents and country populations is three to fivefold for those who only attained primary education (Ostling 2012).

The data where the difference between respondents and the country populations was greatest (tertiary and primary education) was compared with the data on the politically engaged in ESS1-2002 (Ostling 2012). The comparison showed that the survey respondents are more similar to the latter group rather than to the general country population (see Fig. 3). Moreover, the project respondents have even more high-educated and fewer low-educated people among them compared to the politically active citizens. This indicates that parliamentary informatics projects are even less inclusive than other forms of participation such as contacting politicians, petitioning or demonstrating. This could be due to the digital skills required for participation in parliamentary informatics.

The next section will address the digital skills dimension, as well the level of political activity of parliamentary informatics users.

[3] The reason for using such an old round of the ESS (ESS1-2002) is that Italy has not carried out any ESS survey since 2002.



LEGEND: The X-axis shows participation in TWFY/ND/OP ('Parl info'), in taking part in a demonstration ('Demonstrate'), in petitioning ('Petition') and in contacting politician/government officials ('Contact'), and the overall country population ('Country population').

Fig. 3. The share of persons who have engaged in politics in alternative ways in Italy, France and the UK, by educational level (%) (Author's surveys; Escher 2011; ESS1-2002)

IV. Equality: Political Activity of Users and Their Digital Skills

Previous research shows that digital political engagement depends greatly on context. Political environment, experience in Internet use, and the level of digital skills are among the key contextual elements that are believed to affect the modes and levels of engagement (Anduiza et al. 2012). A selection of these indicators, which are assumed to condition the extent of the projects' inclusiveness, is reviewed in this section.

The user surveys show that a clear majority of OP (88%) and ND (78%) respondents use the Internet every day. These levels are much higher with respect to the national averages (51% in Italy and 65% in France) (see Annex I).

Almost all OP and ND respondents are advanced Internet users who get information about politics online. Most of them also use social media. Moreover, they are active participants and content producers; the majority has posted in political forums and made reviews/ratings online (between 51-77%). Somewhat fewer respondents have created their own blogs and uploaded videos (around 30-40%). Strikingly, one fourth of the OP users and 16% of the ND ones have even edited or created a Wiki-type posting (see Annex I).

As illustrated in Fig. 6, the OP and ND project respondents are much more advanced users than their co-nationals, especially regarding getting online news or information, posting on forums and rating/reviewing web content. Moreover, the respondents' Internet skills also exceed those of the overall Internet user population in the EU-27. In fact, the gap between respondents and the national/EU averages

diminishes only when it comes to uploading content, and in the French case in terms of social networking.

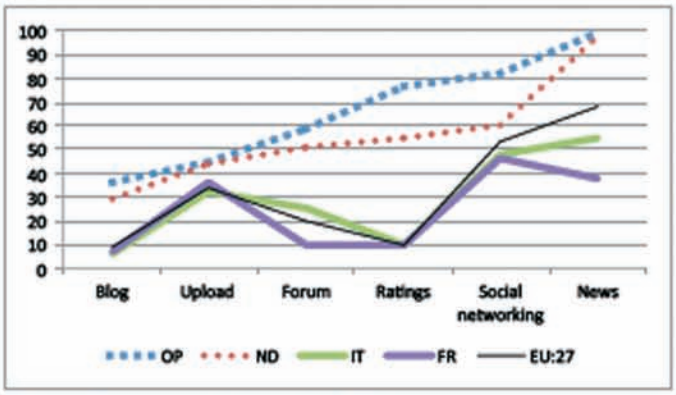


Fig. 4. Comparison of advanced use of the Internet among survey respondents and individuals in their respective country (as percentage of individuals who used Internet in the last 3 months) (Author's surveys and EUROSTAT 2012; Wikipedia Statistics 2011; Pascu 2008)

Turning to political engagement offline, previous survey results (Ostling 2012) indicate that an overwhelming majority voted in the last parliamentary elections: 89% of OP respondents and 98% of ND respondents.[4] These turnout levels are higher compared to the national averages (85% in Italy and 60% in France). A large share (between 51-83%) of respondents was also engaged in unconventional political activities, such as contacting politicians, demonstrating and petitioning. This level of engagement appears especially striking when compared to the much lower – in some cases five or six times lower - national participation rates (see Annex I).

V. Conclusions

Participatory democracy theorists like Pateman (1970) and Barber (1984) argue that if citizens have improved opportunities to engage in policy-making, this brings along positive civic education effects. Nowadays, Internet offers more and more innovative tools that facilitate political participation. These tools allegedly boost the resources and motivations necessary for political involvement (Anduiza et al. 2012). This hypothesis seems to hold also for parliamentary informatics projects examined in this paper.

From the instrumentalist perspective, which is focused on the effects of participation, the projects under study point to strong and positive effects in terms of improved civic literacy. The survey data presented in this paper indicate that they have improved the civic literacy of users and expanded the numbers of the politically active. A substantive majority of survey respondents increased their knowledge and interest in politics. Many also stated that they would be prone to engage politically in the future. Reflecting on this and other pieces of research (Mossberger et al. 2008; Tolbert and McNeal 2003), the actual participation in e-democracy projects - with its user-friendly digital tools that diminish the costs of engagement – could be an important factor for enhancing civic literacy.

Nevertheless, as Diamond and Morlino (2004) hypothesise, even if everyone can participate and improve their civic skills in theory, inequality of political resources can make it harder for lower-status individuals to engage in practice. In fact, the survey results presented in this paper indicate that certain groups that are traditionally less politically active - women, people with lower education and limited digital skills - are even more absent from parliamentary informatics platforms. From the essentialist perspective, the projects fail to fulfil the equality criterion. The lack of inclusiveness poses problems of input-legitimacy to the outcomes of parliamentary informatics projects (Scharpf 1997).

It also appears as if parliamentary informatics users are more similar to their co-nationals who are politically active than to their respective country population. Further corroborating the finding above, the user survey analyses show that the majority of project respondents are already politically active. Moreover, most of them seem to be digitally skilled. The survey results show that the OP and ND respondents are very advanced Internet users (e.g. in blogging, rating content and in social networking), much more so than their co-nationals.

Hence, the equality results mostly support the reinforcement thesis according to which the Internet strengthens established patterns of elite political communication. However, further research with larger user survey samples is needed to establish if parliamentary informatics compensates at least for some of the inequality by raising civic literacy levels also among the groups traditionally side-lined from the political realm. Moreover, to test the findings of this paper, future research on parliamentary informatics should also include cases in other contexts outside Europe, and of different types of organisations running the these platforms (not only those with technological focus but also civil society-based ones). The latter might show to have a stronger appeal for different types of citizens and be more inclusive.

[4] The voting data was not available for TWFY users.

References

[1] Mandelbaum. A. "Strengthening Parliamentary Accountability, Citizen Engagement and Access to Information: A Global Survey of Parliamentary Monitoring Organizations". NDI and the World Bank Institute. Accessed on 29 May 2012 at: http://www.ndi.org/node/18101. 2011.

[2] Dietrich D. "State of Play: Re-use of Parliamentary Data". European Public Sector Information Platform (ePSI). ePSI platform Topic Report No: 2011 / 8.

[3] Blanco I. and Lowndes V. Does community participation improve the quality of policy making? Exploring and explaining the effects of democratic innovations in neighbouring regeneration. Paper presented at the Joint Sessions of Workshops of the ECPR, St. Gallen, 13-17 April 2011.

[4] Barber, B. Strong Democracy: Participatory Politics for a New Age. Berkeley: University of California Press. 1984.

[5] Blondeau O. and Allard L. "nosdeputes.fr: Mr Hacker goes to Parliament". Fondation pour l'innovation politique (Fondapol). Article dated 29 October 2009. Retrieved on 9 January 2013 at: http://www.fondapol.org/debats/1594/

[6] Escher T. Analysis of users and usage for UK Citizens Online Democracy. May 2011. London: mySociety / UK Citizens Online Democracy. 2011.

[7] Hindman M. The myth of digital democracy. New Jersey Princeton University Press. 2008.

[8] Milner. H. "Civic Literacy: How Informed Citizens Make Democracy Work". University Press of New England. 2002.

[9] Milner H. "Compétences Civiques, Croissance Économique et Redistribution Sociale". Policy Options, vol. April, 2004: 73-78. 2004.

[10] Fung A. and Wright E. O. Deepening democracy: institutional innovations in empowered participatory governance. London; New York, Verso. 2003.

[11] Inglehart R. and Welzel C. Modernization, Cultural Change and Democracy. The Human Development Sequence. Cambridge. 2005.

[12] Pateman C. "Participation and Democratic Theory". Cambridge: Cambridge University Press. 1970.

[13] Tolbert C. J. and McNeal R. S. Unraveling the Effects of the Internet on Political Participation? Political Research Quarterly June 2003 56: 175-185.

[14] Mossberger K., C. J. Tolbert, et al. "Digital citizenship: the internet, society, and participation". Cambridge, Mass; London, MIT. 2008.

[15] Anduiza E., Jensen M and Jorba L. "Digital Media and Political Engagement Worldwide: A Comparative Study". Cambridge University Press. 2012.

[16] Talpin J. "Schools of Democracy: How ordinary citizens (sometimes) become competent in participatory budgeting institutions". EUI PhD thesis. 2007.

[17] Celot P., Tornero J. M. P., Gonzalz Lopez L. and Thompson N. "Study on the Assessment Criteria of Media Literacy Levels in Europe" for the European Commission, DG Information Society. Final report. Retrieved on 29 March 2013 at: http://www.eavi.eu/joomla/what-we-do/researchpublications/70-study-on-assessment-levels-of-ml-in-europe

[18] Scharpf F.W. "Economic integration, democracy and the welfare state". Journal of European Public Policy, vol. 4, no. 1, 18-36. 1997.

[19] Bimber B. "Information and American Democracy: Technology in the Evolution of Political Power". Cambridge University Press. 2003.

[20] Norris P. "A virtuous circle. Political communications in post-industrial societies". Cambridge university press. Cambridge. 2000.

[21] Pew Internet and American Life Project. "Well-off and well-educated are more likely to engage". p. 25 in "Engaging citizens in government". Intergovernmental solutions newsletter. U.S. General Services Administration (GSA) Office of citizen services and communications. 2009.

[22] Smith A. "The Internet's Role in Campaign 2008", Washington, D.C.: Pew Research Center, 2009.

[23] Smith A. "The Internet and Campaign 2010. Pew Internet & American Life Project". Report retrieved on 31 October 2012 at: http://pewinternet.org/Reports/2011/The-Internet-and-Campaign-2010.aspx

[24] Coleman S. and Blumler J. G. "The Internet and democratic citizenship: theory, practice and policy". Cambridge University Press. 2009.

[25] Ostling A. "Parliamentary informatics projects – who are their users and what is their impact?" eJournal of eDemocracy and Open Government (JeDEM).Vol 4, No 2. 2012.

[26] EUROSTAT. "Internet use and activities" [isoc_bde15cua]. Last updated: 25-06-2012. Retrieved on 15 February 2013 at: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_bde15ei&lang=en . 2012.

[27] Wikipedia. "Wikipedia Statistics". The statistics were accessed on 10 August 2011 at: http://stats.wikimedia.org/EN/ 2011.

[28] Pascu C. "An Empirical Analysis of the Creation, Use and Adoption of Social Computing Applications". IPTS Exploratory Research on the Socio-economic Impact of Social Computing. Institute for Prospective Technological Studies (IPTS), JRC, European Commission. 2008.

[29] IDEA. IDEA's webpage: "Voter Turnout". Accessed in August 2012 at: http://www.idea.int/vt 2008.

[30] Diamond L. J. and Morlino L. " The Quality of Democracy: an overview". Journal of Democracy. Volume 15, Number 4 October 2004.

ANNEX I. SURVEY RESULTS

Annex I presents the detailed survey results from the author's surveys of OP and ND users, Tobias Escher's survey of TWFY users, and comparative country-level data.

All the three user surveys were carried out in 2011. The author's surveys of OP and ND had a response rate of 9% (OP: 4,300 sent and 397 responded, ND: 1,070 sent and 99 responded, at least partially). Tobias Escher's survey had a response rate of 8% (N=903).

The ESS1-2002 round has been used for comparison throughout the paper because this was the last ESS-round carried out in Italy.

A. Civic literacy

Question: "After your participation in OP/ND, how much do you agree or disagree with the following statements? "I now feel that…"

Results OP:
"I have better understanding of what goes on in the Parliament" (N=417), (don't know=3%);
"I am more interested in parliamentary affairs" (N=404), (don't know=2%);
"I have better possibilities of influencing what goes on in the Parliament" (N=406), (don't know=6%).
Results ND:
"I have better understanding of what goes on in the Parliament" (N=92), (don't know=2%);
"I am more interested in parliamentary affairs" (N=93), (don't know=3%);
"I have better possibilities of influencing what goes on in the Parliament" (N=92), (don't know=10%).

B. Socio-demographics

Gender

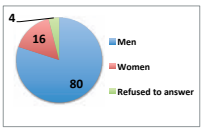
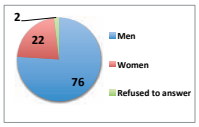
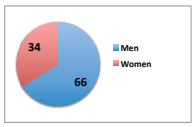
OP respondents (N=403)	ND respondents (N=93)	TWFY respondents (N=838)
		

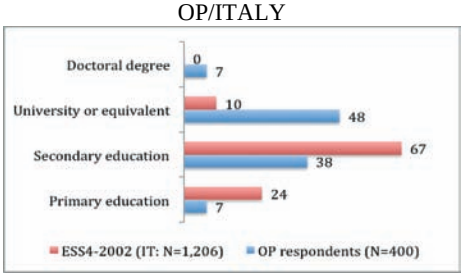
Fig. 5. Gender distribution among respondents (Author's surveys 2011; Escher 2011)

TABLE III. PERCENTAGES OF POLITICALLY ACTIVE WOMEN AS COMPARED TO MEN IN ITALY, FRANCE AND THE UK (EUROPEAN SOCIAL SURVEY (ESS) ESS1-2002, UNITED NATIONS STATISTICS DIVISION 2012)

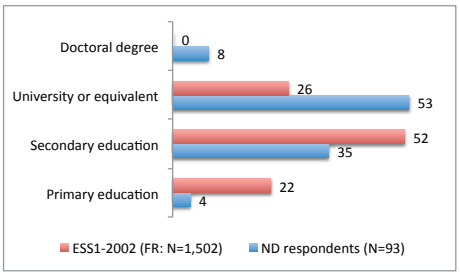
	IT	FR	UK
Contacted politician/government official	36	48	49
Taken part in a lawful demonstration	46	48	56
Signed a petition	54	53	57
Voted in the last national elections	53	53	54
AVERAGE ACROSS INDICATORS	**47**	**51**	**54**

Education

OP/ITALY



ND/FRANCE



TWFY/UK

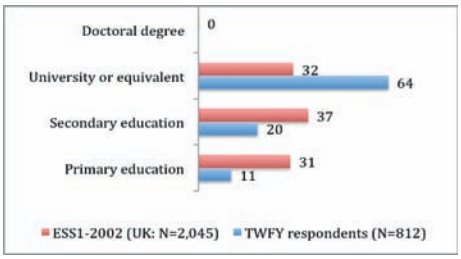


Fig. 6. Educational attainment of respondents vs. their respective country populations (%) (Author's surveys; Escher 2011[5]; ESS1-20026; The Long Term Economy 2009[7])

[5] Escher's survey comprised a category called 'other education' (5% of respondents). Moreover, (i) the 'primary education' category was called 'basic education' and included people with education up to secondary school; and (ii) the category 'doctoral degree' was absent.
6 In the ESS1-2002, the category 'doctoral degree' was not present.
[7] According to an elaboration of the data on the website the Long Term Economy (2009), the rate of researchers as share of the population is 0.002% in Italy, 0.003% in France and 0.004% in the

TABLE IV. THE SHARE OF PERSONS WHO HAVE ENGAGED IN POLITICS IN ALTERNATIVE WAYS IN ITALY, FRANCE AND THE UK, BY EDUCATIONAL LEVEL (%) (AUTHOR'S SURVEYS 2011; ESCHER 2011; ESS1-2002)

	Primary education			Tertiary education		
	IT	**FR**	**UK**	**IT**	**FR**	**UK**
Overall country population	*24*	*22*	*31*	*10*	*26*	*32*
People in the respective country who have:						
Contacted politician/government official	12	14	22	18	36	50
Taken part in a lawful demonstration	7	6	12	20	47	54
Signed a petition	7	10	18	17	39	41
AVERAGE ACROSS THE INDICATORS:	***9***	***10***	***17***	***18***	***41***	***48***
Project respondents	*7*	*4*	*11*	*48*	*53*	*64*

C. Internet use and skills

Note well that concerning users Internet access and skills, the data is available for OP and ND but not for TWFY.

TABLE V. "HOW OFTEN HAVE YOU USED THE INTERNET DURING THE LAST THREE MONTHS?" (%) (AUTHOR'S SURVEYS (2011); EUROSTAT 2012B)

	OP (N=365)	**Italy**	**ND** (N=74)	**France**	EU-27
Every day or almost every day	88	51	78	65	*58*

UK. The country population data was taken from ISTAT (2011b), INSEE (2010e), and the Office for National Statistics (2011).

TABLE VI. ADVANCED USE OF THE INTERNET AMONG SURVEY RESPONDENTS COMPARED TO COUNTRY STATISTICS (AS PERCENTAGE OF INDIVIDUALS WHO USED INTERNET IN THE LAST 3 MONTHS) (AUTHOR'S SURVEYS AND EUROSTAT 2012; WIKIPEDIA STATISTICS 2011; PASCU 2008)

	OP		**IT**	**ND**		**FR**
	(N)	(%)	(%)	(N)	(%)	(%)
Edited any page/created a Wiki						
Edited/created a wiki page	96	**25**	0.004	14	**16**	-
Created your own blog	141	**36**	6	26	**29**	7
Uploaded videos on e.g. YouTube	175	**45**	32	40	**44**	36
Posted on an online political forum	234	**59**	25	46	**51**	10
Provided ratings/reviews of web content	301	**77**	10	50	**55**	10
Used social networking sites	328	**82**	48	56	**60**	46
Obtained news or information about current events/politics	403	**99**	55	91	**98**	38

D. Political participation

The survey results below are based on the following answers to the question "Have you done any of the following activities before or after your participation in OP/ND?" "Yes, before", "Yes, after", Yes, both before and after" and "Yes, but I don't know exactly when".

TABLE VII. PERCENTAGES OF RESPONDENTS AND COUNTRY POPULATIONS INVOLVED IN POLITICAL ACTIVITIES (AUTHORS' SURVEYS; IDEA 2008[8]; ESS1-2002)

	OP		**IT**	**ND**		**FR**
	(N)	(%)	(%)	(N)	(%)	(%)
Voted in the last national elections	341	**89**	85	91	**98**	60
Contacted media	210	**53**	-	52	**57**	-
Contacted civil servant/politician	210	**53**	12	52	**57**	17
Participated in a demonstration	273	**69**	11	51	**55**	17
Signed petition	333	**83**	18	73	**78**	34

[8] Country-level statistics for turnout in parliamentary elections originate from IDEA's website. Statistics for Italy date back to the 2008 elections, and those of France to the 2007 elections.

From Internet to Science and back

Chaired by Juan Carlos De Martin, Politecnico di Torino

A Reflective Examination of a Process for Innovation and Collaboration in Internet Science

Karmen Guevara
Computer Laboratory
University of Cambridge
Karmen.Guevara@cl.cam.ac.uk

Alan Blackwell
Computer Laboratory
University of Cambridge
Alan.Blackwell@cl.cam.ac.uk

***Abstract*— In this paper we explore the challenge of fostering innovative convergence among widely diverse disciplines. The context for this exploration is a study of a recent experimental interdisciplinary EINS workshop. We present empirically grounded reflections drawn from a post-workshop study, leading to a framework for highly collaborative and innovative interdisciplinary workshops.**

Keywords—Interdisciplinary; innovative collaboration; conceptual framing; divergence-convergence; process; group dynamics; facilitation; culture clashes; informal process.

I. INTRODUCTION

"The European Network of Excellence in Internet Science is founded on the philosophy that scientific and technological excellence is strengthened through development of integrated and interdisciplinary scientific understanding." The primary objective of EINS is to foster open and productive dialogues between all disciplines that study Internet systems from any technological or humanistic perspective [1].

The "Internet Science" challenge therefore, is how to foster convergence among widely diverse disciplines.This pivotal question is the focus of this paper and guides our examination of the conditions that influence the process of interdisciplinary innovation and collaboration. This exploration arose from a recent EINS interdisciplinary experimental workshop. The workshop took the form of a self-organising process with an assigned mission to "Think Architecturally" [2].

During the course of the 1½ days the complex nature of the "Internet Science" challenge was demonstrated. This experience contains a rich source of information and insights that can be applied to future EINS workshops. In this paper we present empirically grounded reflections drawn from a post-workshop study, leading to a framework for highly collaborative and innovative interdisciplinary workshops.

II. BACKGROUND

Science policy research often concludes there are major societal challenges requiring interdisciplinary research approaches [3,4]. The problems that challenge social and professional structures do so precisely because they span multiple knowledge boundaries and either are resistant to analysis or are subject to controversy. Programmes like the Network of Excellence in Internet Science demonstrate the way in which applied problems extend beyond the boundaries of the discipline from which they emerge. At this stage, it is necessary for a greater range of disciplinary experts to be assembled in contexts that will allow them to formulate new approaches to significant problems [5].

The need for interdisciplinary approaches is well understood. However, there is less agreement about the form these should take, and the mechanisms most effective in obtaining value from different types of expertise. A better understanding is required of the dynamics of the personal processes that arise from engaging with a wide range of disciplines having complementary theoretical and methodological expertise [6,7]. Ideally, this understanding should be based on evidence, for example, philosophy of science and sociology of knowledge. Further evidence should be drawn from employing empirical and/or experimental studies to identify and validate successful interdisciplinary ways of working [8].

The EINS workshop discussed in this paper is a study of this kind. Our analysis draws on previous experimental workshops in interdisciplinary design, conducted by one of the authors in collaboration with a team of sociologists and anthropologists [9]. However, we do not assume that Internet Science requires the same approach as other problem domains and therefore we have invited the perspectives of those participating in Internet Science as a basis for this reflective analysis.

III. RESEARCH METHOD

The focus of this exploratory post-workshop study was at the *process* level as the objective was to examine the interrelationship between process, collaboration and outcome. Consequently, there were three points to our line of enquiry.

- Experiences of the process of the workshop and the level of contribution;
- Time and space for the exploration of emerging ideas;
- Convergence of understanding.

A questionnaire centred on these three points was sent to all twenty-four participants (excluding the authors), which resulted in an 83% response rate.

A grounded theory approach was applied to the examination of the study results. The grounded theory methodology provided the framework for the data analysis involving the process of data chunking and data naming (coding), analytic memos, development of conceptual categories and a continual comparative analysis of data. This analytical approach leads to findings and theories grounded in the data.

The codes that emerged from the open coding of the data were tested and refined against additional material provided by a few participants and also from the brief survey responses the workshop leader collected on the morning of the second day. These validated codes led to a set of closely interrelated themes. Examples are shown in Table 1.

TABLE I. OPENING CODING - EMERGING THEMES

Clarity	Concreteness	Outcomes	Group Size	Goals
Focus	Competition	Celebrity	Dominance	Represent
Personalities	Change	Flexibility	Balance	Intention
Metaphor	Participation	Dynamics	Clashes	Convergence
Rationalise	Shared Context	Tracking Capturing	Agendas	Definitions

A further analysis of these themes led to a synthesis under three primary headings:

- The process of conceptual framing.
- The process of innovative and collaborative thinking.
- Conducting a collaborative process.

Each of these is examined in the next three sections.

IV. THE PROCESS OF CONCEPTUAL FRAMING

Several factors influenced the process by which the group attempted to develop a conceptual framework for discussions. A dominant theme in the study was the desire to find clarity or focus in the workshop. This presented a challenge for many who were unsure of what was expected from the group or how they could contribute their expertise to the discussions.

This linked to the lack of acknowledgement of a shared trans-disciplinary intention for the workshop. The original intention of the workshop - the exchange and development of ideas across disciplinary boundaries - became obscured in the process. A contributing factor was the predominant agenda of the majority – computer scientists and Internet networking experts. This led to an engineering mind-set – for example in a suggestion that the group focus on a list of standardised objective measures or success criteria on which to base an Internet design process.

Language was a significant factor. EINS described the crux of the challenge for Internet Science as the “inevitability that various disciplines will talk different languages.” This was evident in the group’s struggle to create a basis for discussing the workshop theme, “Thinking Architecturally”. Analysis of the study data pointed to three strategies adopted by participants:

1. *To better understand* the work of Internet "Architects”, those people who most fully understood the related technical problems. In this case, the mastery of the technical language formed the basis of the dominant group, and also of leadership within that group.
2. *To seek clarification* through comparative analysis. Analogies, like the correspondence between buildings and networks, were formed as an aid to finding discipline-spanning definitions of generic architectural concepts.
3. *To treat architecture* as a metaphor. This approach aimed to generate creative seeds for new readings of the problem space that escaped either existing expertise or literal terminology.

It appeared that individual participants had a clear orientation toward the different approaches. It was often asserted in the questionnaire responses that one of the three strategies had been the most necessary.

A conclusion is that the workshop was primarily divergent rather than convergent. Slightly more than half of the respondents to the questionnaire stated a lack of convergence at the end, and the remaining claimed that ‘real’ convergence did not occur, only partially. A functional balance between convergence and divergence is an objective in interdisciplinary collaboration. Nevertheless, a consensus view emerged from the data that overall the workshop was extremely interesting, intellectually stimulating, and for some to have delivered personal knowledge resources (rhetorical or perspectival) that could be drawn on in the future. This appears to have outweighed many of the reported frustrations and limitations experienced during the workshop.

Although these are welcomed outcomes, possibly they are a lowest common denominator. Future EINS collaborative workshops could certainly set higher aspirations. The challenge in that case will be to escape the bounds of the disciplines that may already be starting to calcify as "Internet Science" and to maintain a divergent exploration within a context of deliberate intention.

V. THE PROCESS OF INNOVATIVE AND COLLABORATIVE THINKING

A conclusion drawn from our analysis is that the system dynamics of the group significantly impacted the group’s capacity for innovative and collaborative thinking, and shaped both the process and the outcome.

The core dynamics were rooted in pre-workshop conditions such as group size and composition. Fourteen of the twenty-four participants were from either computer science-engineering, networking and/or networking architecture backgrounds. This led to a domination of Internet architecture discussions, which closed avenues for expansive and exploratory thinking drawn from the other disciplines present. This was strengthened by the presence of a few invited ‘stars’. This shared community formed another axis of dominance complementary to that of expertise in Internet architecture.

This appears to have led to a 'them and us' dynamic in which the 'observers' felt uncertain about their contribution either because of a lack of perceived appropriate expertise and/or a lack of confidence in interjecting in a lively debate.

It was clear for the majority of participants, that personality was significant in creating the dynamics in the group. Members labelled the nature of the conflicts as antagonism, distain, assertiveness, pressure and intimidation. These are socio-psychological dynamics that define systems of collaboration and interactive behaviours. The dynamics of this group were created by a handful of dominant character dispositions, resulting in a closed system that precluded collaboration and interaction. This system had the effect of excluding innovative thinking.

This raises culture as an important consideration, given that the workshop composition was both multi-national and interdisciplinary. Participants were from ten different countries. However, the 'cultural clashes' as they were described, span disciplinary cultures as well as national ones. Each discipline has its own culture (and style), as do countries. It is inevitable that clashes will occur between them. Nevertheless, the interrelationships between character disposition and these different facets of culture add yet another level of complexity. This suggested an area for further enquiry particularly relevant for fostering innovative and collaborative thinking across nations and among diverse disciplines.

VI. CONDUCTING A COLLABORATIVE PROCESS

Key themes relating to the workshop process emerged from the data. One concerned breakout groups. The original intention was to have breakout groups in the workshop, however this was abandoned due to flexibility in the timing of invited presentations. Therefore, one of the study questions asked participants to reflect on whether breakout groups would have been beneficial. More than half of the respondents claimed they would have been, while the remaining stated that very little or nothing at all would have been gained.

An analysis of the 'pro' breakout responses indicated a perception of breakout groups as an enabling mechanism for some of the things that did not occur in the full group. The commonalities in the respondents' statements centred on: an opportunity for small focused discussions; increased participation levels, wider contribution of expertise and to minimise personal inhibitions, like for example, apprehension in speaking out among the pre-dominants, and functioning better in smaller groups or one-to-one.

The issue of breakout groups opens up an interesting line of enquiry regarding both the structure and management of a collaborative process. Determining an optimum frame for a collaborative and innovative interdisciplinary workshop is not straightforward. The difficulty lies in identifying a frame that best supports a particular evolving process. For example, at one end of the spectrum is a fully open structure that is suited to a self-organising process. At the other extreme is a closed structure where rigidity will prevent a process of open, innovative explorations. Finding the right place on the spectrum is a key concern. There is a close interrelationship between the structure and the process that develops in a workshop. Due to the dynamic nature of this relationship, a high level of awareness in directing the process becomes essential.

A further consideration is the value of unstructured time. Many participants highlighted coffee, dinner, and lunch breaks as the most valuable periods of the workshop. These periods facilitate an informal process where personal connections and serendipitous discussions can occur in parallel to the formal workshop process. Ultimately, these benefits strengthen collaboration and innovation among members of a group.

Some participants also valued the free structure in the large group, although it was noted creating a shared representation might have mitigated the disparity in vocabularies. This relates to our earlier point about the dynamism inherent in a process and the implications for the directive style. A good illustration of this relationship is found in the workshop experiment because of its fully open structure and corresponding self-organising process. This was emphasised in the participants' responses, where a desire for facilitation was clearly identified. Among the descriptions provided were: set the direction and goal; guide the process; tame the 'mob'; allow the emergence of participation and contributions of others; capture key insights and lead them to another level of exploration.

This points to an underlying tension between the desire for structure and the desire for freedom. The movement between these two points was evident in the participants' responses – a desire for freedom to have highly stimulating discussions and the desire to bound and represent them in some way. Shared representations within a flexibly coordinated process can enable a greater range of perspectives to be accommodated. This brings in many of the key themes highlighted in our findings for example, focus, shared intent, balance, flexibility, 'right' structure, and perhaps most importantly, a fluid movement of highly dynamic processes.

The person (or persons) who facilitates or 'manages' the workshop process is central. We found it useful in our analysis, to consider this by analogy to the role of an orchestral conductor. Even where a great range of orchestral instruments are playing different themes or counterpoints, a conductor ensures a coordinated focus within the complex score, thus resulting in a communal performance. These processes do not occur by default - imagine a whole orchestra trying to democratically decide when to start playing, at what tempo, and when the piece is over!

Interdisciplinary collaboration and innovation is vital for EINS and the future Internet. Therefore, we recommend in light of our findings from this exploratory study, that a focus be placed on a conductor responsible for the dynamics and the outcome of a "performance."

VII. A COMPARATIVE VALIDATION

We are able to test our findings by a comparison to those of a related study focused on the social processes during forums on Internet governance [10]. The social structure of these workshops differed from the one we are examining, in that they represented two clearly defined groups (advocating

either freedom of speech, or child protection) who despite their different concerns, were motivated by a shared critique of existing policy. Two communities with value-driven motivations have a common basis of dialogue (even though those motivations might lead to directly opposed positions). This is a clear contrast to the findings of our workshop study. However, the facilitation process in their forums placed less emphasis on the articulation of established positions, and instead "destabilised any existing relationships of dominance." Lack of formality was a key advantage, as also noted by many of our respondents reflecting on the productive outcomes of unstructured time. The challenge of establishing a common language for discussion while avoiding premature debates over definition was addressed by setting this ground during informal time, in a dinner for all participants that preceded the main part of the workshop.

VIII. A FRAMEWORK FOR DESIGNING INNOVATIVE AND COLLABORATIVE CONDITIONS

This exploratory study highlights the need for a platform upon which innovative and collaborative thinking can develop across disciplines and cultures. If a high priority is placed on collaboration and innovative outcomes, it is essential that "differing perspectives do not lead to missed opportunities and unanticipated consequences" [11].

We propose an analytic framework for design and implementation of such a platform in interdisciplinary EINS initiatives, where it is important that outcomes are not left to serendipity. This framework builds on a meta-model for socio-psychological dynamics referred to as the 'P' model (Fig. 1) [12,13]. The model consists of four interdependent elements that are fundamental to productive collaborative settings. These elements are: i) *Purpose* - a clear, focused purpose creates a level of unity and coherence above any disparities; ii) *People* - the individual, the collective, and what potentially can be created by the interaction between the two; iii) *Process* – the mechanism by which an optimal outcome is developed; and iv) *Principles*, which underpin the elements of purpose, people and process and provide the foundation from which these evolve.

The 'P' model includes layers within each element that can be applied at different phases. For example, attention to principles includes guiding principles at the design level of an event, principles for conducting the event and principles in navigating an outcome. However, the model emphasises holistic attention to each element, ensuring that all are developed and evolve together throughout the collaboration and innovation process.

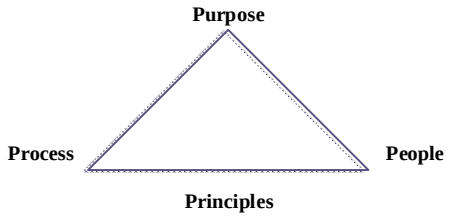


Fig. 1. The 'P' Model

IX. THE WAY FORWARD

It is the quality of collaboration between individuals that leads a group towards innovative convergence. This is the overarching aim of the Network of Excellence in Internet Science. The root of the challenge lies in how to enable the level of cooperation required in interdisciplinary groups so that individuals are able to create something larger than themselves. Here lies the essence of true Internet innovation.

It is highly recommended that the necessary steps be taken for EINS to create a foundation for successful collaborative and innovative events. This can be achieved by drawing on the skills of experts in the design of interdisciplinary collaborative innovation. As specialists in this area we recommend three key steps. The first step is the design and implementation of a workshop process that builds on the findings from our study.

The findings most pertinent to the development of a foundation are:

- Identifying the 'right' point on the spectrum between structure and process;
- Establishing a balance between divergence and convergence;
- Factor socio-personal dynamics into the equation;
- The value of weaving informal processes into formal ones.

This is especially important for events where a high level of interdisciplinary collaboration is desired.

A second step is to bring in an expert to act as a 'conductor' – to guide the workshop process. The skilled navigation of the workshop process will stimulate collaboration and guide it towards convergence and innovation. The third step is to engage in studies of workshop enterprises. These would consist of observations during the workshops, followed by a survey and sample interviews. An objective of these studies is to explore whether the requirements for interdisciplinary innovative collaboration in Internet Science are significantly different from those of other sciences. The overall objective is to develop the optimal process and conditions for EINS interdisciplinary collaborative events.

The benefits derived from this will extend beyond the EINS programme. They will pave the way for high quality collaboration and innovation across all disciplinary boundaries necessary for the holistic design of the future Internet.

REFERENCES

[1] EINS Statement of Goals. http://www.internet-science.eu/network-excellence-internet-science.

[2] EINS JRA2 "Thinking Architecturally" Workshop, 28,29 November 2012, Cambridge University.

[3] National Academies (U.S.). Committee on Facilitating Interdisciplinary Research, Committee on Science, Engineering, and Public Policy (U.S.), National Academy of Sciences (U.S.), National Academy of Engineering, Institute of Medicine (U.S.) (2005). Facilitating Interdisciplinary Research. National Academies Press.

[4] Royal Society 2010. The scientific century: securing our future prosperity. RS Policy document 02/10.

[5] Hirsch Hadorn, G., Pohl, C. and Bammer, G. (2010). Solving problems through transdisciplinary research. In R. Frodeman, J.T. Klein and C. Mitcham (eds), The Oxford Handbook of Interdisciplinarity. Oxford University Press. pp 431-452.

[6] Barry, A., Born, G., and G. Weszkalnys (2008). Logics of Interdisciplinarity. Economy and Society, 37(1): 20-49.

[7] Wilson, L. and Blackwell, A.F. (in press). Interdisciplinarity and Innovation. To appear in N. Seel (ed). Encyclopedia of Creativity, Invention, Innovation and Entrepreneurship

[8] Blackwell, A.F., Wilson, L., Boulton, C. and Knell, J. (2010). Creating value across boundaries: Maximising the return from interdisciplinary innovation. NESTA Research Report CVAB/48, May 2010.

[9] Blackwell, A.F. (2006). Designing knowledge: An interdisciplinary experiment in research infrastructure for shared description. University of Cambridge Computer Laboratory Technical Report UCAM-CL-TR-664.

[10] Powell, Alison and Victoria Nash "The Dissenting Values at the Heart of the Internet: How Child Protection and Freedom of Expression Advocates Negotiate Shared Values and Shape the Future Internet" at the OII/ICS Symposium "A Decade in Internet Time" Oxford, UK September 24, 2011.

[11] EINS Statement of Challenges. http://www.internet-science.eu/network-excellence-internet-science.

[12] The Path of Principles. UK Procurement Executive, Ministry of Defence Technical Report, March 1994.

[13] Creating Organisations Fit For The Human Spirit Through Hakomi," Hakomi Journal, Issue 12, 1996.

Science as Social Construction

An Inter-Epistemological Dialogue between Two Internet Scientists on the Inter-Epistemological Structure of Internet Science, Part 1

Paolo Dini
Department of Media and Communications
London School of Economics and Political Science
Houghton Street, London, UK
p.dini@lse.ac.uk

Laura Sartori
Dipartimento di Scienze Politiche e Sociali
Università di Bologna
l.sartori@unibo.it

***Abstract*— This paper is structured as an informal dialogue between two members of the EINS (www.internet-science.eu) Network of Excellence: a sociologist (Laura Sartori) and an engineer (Paolo Dini). The deck is stacked since the engineer also taught physics for a number of years, has been studying social and economic theory for the past 10 years, and is also currently active in mathematical and theoretical computer science research. The purpose of the paper is to provide an overview of the epistemological bases of different disciplinary perspectives as a first step towards developing a methodology of analysis of the Internet as a scientific object of study. To complement well-established areas of Internet Science such as networking and information theory, the paper regards three areas of social science as particularly important: social constructivism, power and knowledge, and domains of value. Of these, we focus on the first and only touch on the other two. The paper builds on previous research which concluded that it is impossible to develop a unified interdisciplinary theoretical framework due to irreconcilable epistemological differences, but that it is possible and very worthwhile for those adhering to various disciplinary perspectives to collaborate towards the achievement of a practical joint endeavour. In our view the Internet exemplifies the ultimate example of such an endeavour.**

Keywords: epistemology; interdisciplinarity; social constructivism; internet science; methodology

I. Introduction

Laura Sartori: Good morning, what are we talking about today?

Paolo Dini: I would like to discuss the epistemological structure of the EINS project because I find it extremely interesting and potentially transformative for how we do science.

LS: In Italy 'epistemology' carries a connotation of 'history of science'. However, I think you are probably referring to the more Foucauldian meaning of 'construction of knowledge'?

PD: Yes, correct. The Greek root of 'science' means 'knowledge', so we could easily tie ourselves in knots, here, but in today's English this distinction makes sense. In other words, we can take epistemology to mean construction of knowledge, but with an awareness of a deeper set of issues, as encapsulated in this brief quotation:

> The episteme is the 'apparatus' which makes possible the separation, not of the true from the false, but of what may from what may not be characterised as scientific. (Foucault 1980: 197)

LS: Very nice, but why are you introducing the 'apparatus' so soon?

PD: Well, the cognitive landscape we need to explore is multi-dimensional and very complex, so our dialogical narrative can hardly be expected to be linear. I am afraid we will have to jump around a bit and may need to distribute the explaination of concepts at different places in the paper.

LS: Right, so we are writing a paper, and this paper appears to have a distinctive philosophy of science flavour.

PD: Yes, it seems like a good way of making sense of the EINS project, or of the Internet, for that matter.

LS: Where do we start?

PD: From my point of view, this paper builds on a paper I co-wrote with Mehita Iqani and Robin Mansell (Dini et al. 2011) at the end of the radically interdisciplinary EU-funded Network of Excellence OPAALS,[1] which had some similarities with EINS. OPAALS was concerned with digital ecosystems as a socially constructed ecosystem *metaphor* of socio-technical and economic environments of particular relevance to small and medium-sized enterprises (SMEs), and aiming to maximize sustainable development and/or collaborative knowledge construction.[2] OPAALS took the existence of the Internet for granted. In addition to aiming to develop a 'science of digital ecosystems' and a community of practice in this science, it also had the applied aims of sustainable socio-economic development led by SMEs and catalysed by information and communication technologies (ICTs). EINS, by contrast, seems more fundamental to me: it is focused entirely on scientific objectives, i.e. understanding the Internet as a socio-technical-economic phenomenon, on developing a 'science of the Internet', and of course also on the development of an Internet Science community.

LS: Very interesting. So, in EINS we are interested in identifying the concepts and thought processes that enable

[1] Open Philosophies for Associative Autopoietic Digital Ecosystems (2006-10), http://www.opaals.eu

[2] At the same time, digital ecosystems as understood in the OPAALS project and in its precursor DBE (Digital Business Ecosystem, 2003-07, http://files.opaals.eu/DBE) were meant to benefit from a certain level of self-organized and autonomic behaviour in the software itself, i.e. as far as the software is concerned the research attempted to develop an ecosystem *model*, in addition to treating the concept of ecosystem as metaphor. This latter, mathematical, work was pursued also in the BIONETS project (Biologically-Inspired Networks and Services, 2006-10, http://www.bionets.eu) and is still on-going in the currently active BIOMICS project (Biological and Mathematical Basis of Interaction Computing, 2012-15, http://www.biomicsproject.eu).

making sense of the Internet from a social, economic, and technical perspective. Am I right?

PD: Yes, but first we need to define the framework within which we will be working.

LS: In terms of the ontological dimensions and epistemological perspectives for Internet Science?

PD: Precisely. Figure 1 shows the analytical framework I propose we follow. At the top of the figure you can see what I would call the analytical categories that we are going to utilize to orient ourselves in the discussion. The second group of concepts are three themes or dimensions that I consider *necessary* to Internet Science, although clearly not *sufficient*. Since the ground covered by these themes is rather vast, we should focus on social constructivism as a running thread for this paper, touching on the other two dimensions only briefly. We could leave more in-depth discussions of power/ knowledge and value domains to future dialogues. The bottom group of terms lists some of the main pairs of opposite perspectives in how we construct our understanding of society. In this and the following papers I would like to show how

1- each of these viewpoints relies on its own ontological priorities and epistemological machinery;
2- the Internet appears to be bridging several if not all of them, often in surprising ways; and
3- attempts to reconcile these binary opposites often lead to the development of interesting theories

LS: OK, this sounds pretty ambitious, but I guess it's worth a try.

Ontology: *What reality is made of*

Epistemology: *How knowledge is constructed*

Methodology: *How we do science*

Main Dimensions of Discussion

- *Social Constructivism (this paper)*
- *Power and Knowledge*
- *Domains of Value*

Ontological, Epistemological and Methodological Binaries

- *Subjectivist/Hermeneutic -- Objectivist/Positivist*
- *Empiricist/Inductive -- Rationalist/Deductive*
- *Individualist/Constructivist -- Collectivist/Structuralist*
- *Existentialist/Context-Dependent -- Essentialist/Context-Free*
- *Conflict-Based -- Regulation-Based*

Fig. 1. Analytical framework underpinning the dialogue

II. The Methodology of Internet Science

PD: Right, as we were saying, in EINS we are interested in identifying the concepts and thought processes that enable making sense of the Internet also from a political viewpoint, which relates to governance issues.

LS: Of course. But in describing OPAALS you seemed to be mixing social construction with mathematics. Why, and how, do you do that?

PD: That's a scary question. No, in those projects, and also in EINS, I think we can afford to overlook the socially constructed aspects of mathematics and simplify our discussion considerably by treating the hard sciences and mathematics as objectivist. The social sciences…

LS: We will talk about the social aspects of mathematics and informatics (as in coding and programming) another time, but, please, just let me cite this quote by Albert Einstein:

> As far as the laws of mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality. (quoted in Newman 2003[1956])

PD: Ah, nice one! The social sciences can be both objectivist and subjectivist, of course, but in this paper, again for the sake of simplicity, I would like to emphasize the subjectivist perspective in social science and de-emphasize quantitative methods.[3,4] Anyway, before we get to that, let me clarify what I mean by 'socially constructed' through the words of Boghossian:

> To say of something that it is socially constructed is to emphasize its dependence on contingent aspects of our social selves. It is to say: This thing could not have existed had we not built it; and we need not have built it at all, at least not in its present form. Had we been a different kind of society, had we had different needs, values, or interests, we might well have built a different kind of thing, or built this one differently. The inevitable contrast is with a naturally existing object, something that exists independently of us and which we did not have a hand in shaping. There are certainly many things, and facts about them, that are socially constructed in the sense specified by this core idea: money, citizenship and newspapers, for example. None of these things could have existed without society; and each of them could have been constructed differently had we so chosen. (Boghossian, 2001)

LS: I agree entirely. But you seem to like to add more of a philosophical twist to our conversation than some sociologists would! Social construction is one of the most interesting processes to be studied, also because it operates across all disciplines. Not only the social sciences. There are many aspects of the Internet that could be described as socially constructed. In other words, the Internet has become "real" in people's minds and in people's lives, in spite of their ignorance of the "objective" aspects of the Internet. They don't understand its technical structure, but they "use" it, they talk about it, they incorporate it in their daily routines. Yet, the Internet as a technology does not drive what people do, as a technologically deterministic view might suggests. Technology allows for certain activities, and users and actors domesticate and shape it to fit their own goals. Something analogous has happened in the past as well. Take the refrigerator, for example. In the 1950s refrigerators were used to preserve drugs and women tights, not just food. Also the telephone or electricity – whose technical details were largely unknown at the time – were used very differently from today (Fischer 2000; Marvin 1988). The social construction of technology depends on the socio-technical frame (Flichy 1995), reflecting user practices and collective representations in a given historical period.

PD: Very true. This point connects to another disciplinary perspective on the phenomenon, namely anthropology, which views technology as a cultural artefact and/or as an extension of language. As you just said, the Internet has made it much

[3] Social network analysis is an example of an area of social science that has been usefully complemented by mathematical concepts; however, it still leaves most of the questions social scientists are interested in unanswered.
[4] Qualitative methods include questionnaires, participant observation (ethnography), individual interviews, focus groups, etc.

more obvious to most laypersons (and, of course, some computer scientists!) that technology embodies our cultural values (Feenberg 1999, 2001), for example through the Net Neutrality debate. Deep packet inspection can enable the prioritization of certain content streams over others; whereas this is often proposed as a market-driven evolution of the web, it also has implications for freedom of expression. Backing one or the other side (i.e. supporting or not Net Neutrality) has social, political and economic consequences. Another example is provided by centralized architectures, which make top-down control more feasible, versus distributed P2P architectures, which facilitate individual freedom on the web. Although whether or not control or freedom can be justified in some cases very much depends on the point of view, the point is that architectural or technological features embody our social, economic, political and moral values.

LS: Might we say that our actions, decisions, and behaviours are value-oriented and they result in shaping public opinion (or the dominant perception/opinion, as Habermas would say)?

PD: Sure, but the less obvious point here is that the same values influence what technologies we build and how they work.

LS: Just perfect! A sociologist and an engineer that agree on the social construction of technology seems to be a nice start for our Internet Science. For this purpose, we consider the sociological, anthropological, economic, technical, and political dimensions, even though each of these perspectives relies on sometimes slightly different and sometimes radically different ways of analysing and making sense of the object of study, in other words of constructing knowledge. This is what we mean by different epistemologies?

PD: Yes. The incredible thing about the Internet is that it is forcing together areas of science that had previously maintained a "safe" distance from each other. In many cases, however, this still is not sufficient for mutual understanding to emerge, precisely because the ontological and epistemological building blocks are so different, incompatible, and often incommensurate.

LS: This gives a nudge to our conversation. What is science? What is Internet Science? To begin to answer these questions I need to go back to the philosophy (and history) of science, trying to grab some useful concepts for our inter-epistemological effort. By the way, as you will see, I will try to turn epistemological problems into methodological issues.

PD: Is this actually possible?

LS: I believe science is a social construction, as I expressed earlier. Sociology can, thus, try to solve empirical questions that traditionally pertained to the philosophical realm. In my opinion this is the path we have to follow to make different areas of science talk to each other. I will briefly sketch my personal preference in terms of construction of knowledge. Had I lived in the 19th Century (or before), I would have been an empiricist rather than a rationalist. I would have studied social phenomena through inductive methods, not deductive. I am more a fan of Max Weber than Emile Durkheim since Weber considers social action to be oriented by actors' motivations and preferences. By constrast, Durkheim, the value of whose work on statistical and quantitative methods is undeniable, regards actors as powerless and believes general laws to be operating in society exactly as they do in physics. Two threads of research have emerged since the time of this basic dichotomy: Interpretativism and Positivism. Very roughly, we can state that the first (also called Hermeneutics) focused on interpreting social phenomena through the understanding (verstehen) of individual points of view, while the second[5] tried to explain social phenomena through statistical data. We might call these two positions 'paradigms', as Thomas Kuhn would say (1996).

PD: Didn't Kuhn theorize scientific revolutions?

LS: Yes, Kuhn for the first time asserted that knowledge is not cumulative. At a certain point, the paradigm just changes and all assumptions, hypotheses and results with it. When Copernico (or Galileo) was credited for his theories about the solar system, the previous Earth-centred solar system was simply rejected. The same happened with Netwon or Einstein's ideas. All of a sudden paradigms change.

PD: The way I like to put it is that a Kuhnian paradigm is a body of theory combined with a community of practice and a set of methodologies. This is to be contrasted with the use of the term in computer science and in common parlance, which tends to be more limited to a 'model'.

LS: Sure. The very point here is that Kuhn says that different paradigms are incommensurate, because profoundly different in terms of – as Foucault would say – apparatus, as you mentioned earlier. Yet, they can communicate. In other words, they cannot be "measured" by the same unit of measurement, but they can still have a dialogue. And I think this is exactly what you meant in your paper (Dini et al. 2010).

PD: Foucault's apparatus is also closely concerned with the interplay between power and knowledge, but I see what you mean. In any case, when I call for an integration, not a unification, of different sciences, I mean the following. If 'unification' is understood to imply considering two or more apparently unrelated phenomena within the same theory or model, then 'integration' is understood to enable different theories to coexist with a degree of compatibility that does not imply that the same theoretical foundation underpins them. An example of the former is electricity and magnetism which were thought to be different physical phenomena until a single set of equations was derived by Maxwell (1873). An example of the latter is the understanding of computers as media of communications, rooted ultimately in Heidegger's phenomenology, sitting side-by-side the understanding of computers as machines operating on objective data and whose functions can be optimized (Winograd and Flores 1987).

LS: Exactly, we are not looking forward to a new unified single science, but to an integration of different visions of science. Even in the natural (or hard) sciences there are competing views (as well as methods, hypotheses, and values). And, especially in social science, different paradigms and visions co-exist easily, such as qualitative and quantitative methods, post-positivistism and interpretativism, etc. The competition between quantum mechanics and general relativity is a perfect example for the hard sciences. They explain two different aspects of behaviour, one at micro-level and the other at macro-level.

[5] Today we talk more properly of neo-positivism because the search for general laws governing society has shown its weaknesses, leaving an opening to a probabilistic approach through statistics. It is recognized that there are hypotheses to be tested to attain a certain degree of generalization and standardization.

PD: Yes, right, they are incommensurate, although in this specific case there is at least a chance, in principle, of mathematical unification (e.g. string theory). But in general I agree that different paradigms from all the disciplines of the consortium can start dialoguing since there is no competition!

LS: Definitely. One starting assumption we should make and stick to is that coexistence is possible if there are no "imperialistic" tendencies by any one discipline over the others in terms of "superior" techniques or value-production of their own discipline over another.

PD: As Foucault would put it, we should avoid 'the tyranny of globalizing discourses' (1980: 83).

LS: Yes. As I was saying above, I think *methodology* is the key for setting up an Internet Science. Given our differences in ontologies, epistemologies and research techniques, I believe that methodology is the key to our conversation. Methodology could work as a bridge across the different epistemologies at play precisely because Internet Science is a *practice* that straddles all the disciplines we have been discussing.

PD: So, what do you mean by methodology?

LS: Methodology refers to the techniques we choose when facing a cognitive problem, which could be either theoretical or applied. Obviously we will differ because we have different cognitive issues and research problems, not to mention skill-sets. The good news is that we can solve that. As Feyerabend stated, there is no one scientific method better or superior to others (1975).

PD: I agree, although it sounds a bit abstract. As we concluded in the article I mentioned above (Dini et al. 2011), it is possible and very worthwhile for those adhering to various disciplinary perspectives to collaborate towards the achievement of a practical joint endeavour. I think the Internet exemplifies the ultimate example of such an endeavour.

LS: What we can borrow from Feyerabend is the fact that change (in paradigm) at the theoretical level is driven by interests, ideology, and cultural beliefs (convictions), not by a specific method – i.e. by a "more scientific" method.

PD: So… your proposal for the foundations of an Internet Science is…?

LS: Well, I would propose to think in terms of a 'research programme' (Lakatos, 1976). A research programme is not a closed system of a few, measurable and static theories. It is a living, open system where scientists discuss, compare and contrast different ideas or solve problems as they emerge, prioritize or abandon hypotheses, etc. Thus, they contribute to the progress of science. Take Newton's theory of gravitation, Einstein's relativity, Freud's psychoanalysis, or Marx's theory of capital. They all have a core (2-3 definitions) exemplified through auxiliary propositions connected to historical facts. In Marx the theory of surplus value occupies the core, while alienation, revolution and failing profit rate are auxiliary theories. Decades later the Marxist tradition maintained the core but adapted to different contexts and auxiliary propositions.

PD: So, it sounds like you think that Internet science needs a 'research programme', where each discipline maintains its core while adapting to and interacting through auxiliary hypotheses?

LS: Yes. Methodology is the tool, the "practical language" as you would say, to build knowledge. Computer and social science can contribute and interact productively because they both share a scientific method that can solve both applied and philosophical cognitive problems. When you speak of 'practical joint endeavour', I hear 'methodology can translate philosophical problems into practical cognitive problems'. In this sense it can handle both theory and practice. Moreover, our goal is ambitious: we (social scientists) study causal connections between social conditions and knowledge in the information society, in our contemporary society (supporting hypotheses and theories with empirical evidence).

PD: Are you saying that we have to think really "big" in order to understand the causal connections underlying our society? I agree, we have to fly beyond single-discipline boundaries, answering the call for integration that ICTs have implicitly launched.

LS: I really believe that what we need today is new thinkers able to grasp the complexity we are experiencing, as Max Weber did at the dawn of capitalism[6] when he set up the methodological basis for modern sociology. Again, the Internet is calling us to set up a methodology (a 'research programme') for the science of the 21st Century. Each discipline uses different methods because it tries to answer different research questions stemming from alternative cognitive and epistemological problems. Each discipline sheds light on a limited portion of knowledge. Since as we said ICTs serve as a "practical" bridge across disciplines (and across paradigms), we need not only the social sciences to agree and cooperate but also the hard sciences to listen to research questions that have been posed in a different way.

PD: OK, science itself has to be thought of as 'open' to critical thinking, as Popper suggested. Critiques grow out of differences in scientists' certainties and beliefs: as Popper says, this is the only path to knowledge! I see your point: Internet Science has to cross disciplinary fences, exercise critical thinking by encouraging each discipline to borrow from the others and… just build knowledge.

LS: Precisely. Otherwise, we remain stuck in the familiar scenario where computer scientists develop the best-technical-platform-ever for – let's say – participation (by individuals, associations, governments). Yet, if they do not take into considerations, for example, social actors, material and symbolic resources, social and economic values attributed to that specific social action, privacy concerns… in short, if they do not account for social and institutional actors (their preferences, their values, their social relations), the best platform remains a "perfect", yet closed, system.

PD: Yes, I know… we tend to design closed systems because it is easier to define *ceteris paribus* conditions and, from this, test hypotheses and infer some conclusions. It is like economics: it relies heavily on mathematics and modelling, but it often fails because its models do not fully reflect the real world.

LS: Of course, I agree with that. I want to sum up and end this part of the discussion with two points. The first relates to methodology, paradigms, and dialogue while the second to the nature of science:

[6] Weber investigated the conditions upon which the capitalist system grew in his masterpiece *The Protestant Ethic and the Spirit of Capitalism* (Weber, 2012[1905]). More importantly, he also set up the methodological basis for modern sociology.

1. Methodology, thus, is the key to solve epistemological differences that can be still challenged within a single discipline but do not adversely affect Internet Science.
2. By now, it should be clear that science – generally speaking – is a social construction.

PD: True, I acknowledge that even in the hard sciences interests and ideologies can have influences that are more than conceivable or acceptable. Think about the research on stem cells, the battle over IPV6, regulatory standards for Intellectual Property protection, the Net Neutrality debate I mentioned before, SOPA, ACTA,[7] etc. It is clear: dominant opinions shape science, because it is socially constructed in a mutual process where multiple actors play.

LS: Our mission should be, then

1. To establish the (methodological) basis for a dialogue that teases and provokes points of contact.[8] By so doing we will have a higher chance to discover what bases are needed by an Internet science.
2. To understand that our research results can orient and influence the form the Internet (and, consequently, Internet Science) will take.

PD: So, even though straight translation between social science and hard science concepts is often not possible, as long as one keeps in mind the ontological assumptions and the epistemological processes involved an interesting dialogue obtains?

LS: Yes. Each discipline has its own paradigm, which is incommensurate with other paradigms. Yet, they can try to talk to each other without worrying about losing their primacy because they respect each other's epistemological bases. The history of science is full of examples to the contrary, for instance Keynes's and Hayek's ideas in economics, Weber's and Durkheim's, or Parsons and The Frankfurt School in sociology, etc. But in Internet Science we should make an effort to avoid such polarizations.

PD: Not that one should expect communication to be easy, but at least there is a better chance of getting across to each other – and to *learn* from each other.

LS: Yes, if there is no "imperialist" vision (e.g. computer science over social science) I believe that the Internet – as a technical and a social product – can facilitate dialogue and collaborative knowledge construction. Would you bet that in the long run computer scientists will design really usable technologies, for example (how often they realize that outside of the laboratory the 'average user' is not able to use what they invented)? And that social scientists will elaborate hypotheses and narratives that are down-to-earth (that is, that consider technical aspects, actors, and contexts all at the same time)?

[7] SOPA = Stop Online Piracy Act; ACTA = Anti-Counterfeiting Trade Agreement.

[8] For example, for economists consumer decisions are the product of independent evaluations deriving from high-level information and budget constraints (for example, 'I have E30k, I like red cars, so I can afford a red BMW since the latest model costs E29.9k'), whereas for sociologists consumption has a strong relational character (it depends on others' preferences) and on the symbolic value of goods, which can be more important than its use value (for example, 'I want to buy a new car for my second house in the countryside, I like red or blue cars and I like Toyotas, but many friends told me that they don't have reliable 4-wheel drive; my best friend suggested a Range Rover to me, it costs just E2000 more than my budget, I think I'll go for it'). So this would mean making economists look at preferences more closely and making (some) sociologists utilize a higher degree of formalization.

PD: Yes! Nicely put.

III. A System of Epistemological Binaries for Internet Science

PD: Now that we have a better understanding of how to work together, i.e. through a joint applied endeavour and/or by focusing on methodology, we can continue discussing the ontological and methodological, but mainly epistemological, binaries of Figure 1. Paraphrasing Anthony Giddens, the difficult aspect of social science is that, unlike what happens in physics, the object of research has *opinions* about what is being said about them. How many opinions? As many as there are individuals. Clearly it may become too difficult to account for or work with that many, so that is why we engage in dialogue and various kinds of interactions (political, social, economic) to work towards some level of consensus, thereby reducing the number of opinions out there.

LS: I would put it differently. I would say that the social sciences deal with multi-faceted social, economic and political phenomena where actors and institutions play complex and intertwined roles. Since economics and sociology were born, pundits debated about these disciplines' ability to grasp social reality. Far from 19th Century positivist positions,[9] I believe that it is possible to study social, economic and political phenomena by means of Max Weber's Ideal Types. Ideal types are analytical tools for representing the main traits of historically-grounded phenomena. For example, what we generally know as power, (or capitalism or state) has various declinations: charismatic, traditional-bureaucratic or legal-rational. Think of different types of power you encounter in daily life. You recognize somebody as powerful because he is gifted (Julius Ceasar, Napoleon, Hitler had charisma), or you acknowledge beliefs and behaviours as powerful because they are strictly linked to traditions (i.e. religion), or because they originated from a legal framework (i.e. a constitution and democratic structures). It is clear that these ideal types can be encountered in different contexts at different historical moments. Yet, they will help reconcile particular traits within a more general analytical framework.

PD: Trigilia explains ideal types as follows:

> The formulation of generalizations – which Weber called 'ideal types' – has specifc spatial and temporal limitations and essentially aims to improve historical knowledge. (Trigilia 1998: 6)

So perhaps what you mean is that power is an ideal type, but it takes the different forms you list above in the different contexts?

LS: Sure, that's fair.

PD: Since you mention power, let me cite Foucault again:

> It is not possible for power to be exercised without knowledge, it is impossible for knowledge not to engender power. 'Liberate scientific research from the demands of monopoly capitalism': maybe it's a good slogan, but it will never be more than a slogan. (Foucault 1980: 52)

Foucault also addressed the "imperialism" of science that you mentioned earlier, which seems particularly relevant to Internet Science:

[9] The central assumption of positivism in the 19th Century was that the social and natural sciences share a common nomological framework in explaining how single phenomena stem from general laws and in making use of organicist analogies.

> What types of knowledge do you want to disqualify in the very instant of your demand: 'It is a science'? … Which theoretical-political avant garde do you want to enthrone in order to isolate it from all the discontinuous forms of knowledge that circulate about it? … in contrast to the various projects which aim to inscribe knowledges in the hierarchical order of power associated with science, a genealogy should be seen as a kind of attempt to emancipate historical knowledges from that subjection, to render them, that is, capable of opposition and of struggle against the coercion of a theoretical, unitary, formal and scientific discourse. (1980: 85)

What I find interesting about Foucault is that to him power is not just 'oppressive', 'coercive', or 'hegemonic'. Power can also be "horizontal", it can be 'productive' not just destructive. This means that power can sustain and transmit complex relationships among the component parts of society. He captures these ideas through the concept of the apparatus, which I mentioned at the beginning and which seems particularly fitting for how we can think about the Internet:

> …a thoroughly heterogeneous ensemble consisting of discourses, institutions, architectural forms, regulatory decisions, laws, administrative measures, scientific statements, philosophical, moral and philanthropic propositions – in short, the said as much as the unsaid. Such are the elements of the apparatus. The apparatus itself is the system of relations that can be established between these elements. … The apparatus is thus always inscribed in a play of power, but it is also always linked to certain coordinates of knowledge which issue from it but, to an equal degree, condition it. This is what the apparatus consists in: strategies of relations of forces supporting, and supported by, types of knowledge. (1980: 195, 196)

LS: I see, this is interesting. And I agree, it can be useful for us. Anyway, I can see political and social interactions potentially leading to consensus, but how do economic interactions lead to consensus?

PD: This point is tricky to argue. I believe that the degree to which economic interactions can afford to approach the "free market" is proportional to the democratic maturity of the society within which those economic interactions are embedded.[10]

LS: That's an outrageous statement.

PD: Sorry. Probably impossible to prove. But as an Italian that has lived in different democracies (IT, US, IE, UK) it feels right. Of course there is no such thing as a free market. The fact that we may feel more or less free to buy and sell whatever we want does not mean that the market itself is "free".

LS: That's for sure!!!

PD: In order to function properly, in addition to contracts markets need accountability rules, laws, institutions of various kinds and sizes, physical infrastructure, standards, and so forth. So mine is a superficial perception which, however, I believe is echoed by the current Euro/sovereign debt crisis. I wrote a paper on community currencies that discusses this point in more depth (Dini 2012). We can look at the Swiss WIR parallel currency, for example, which has been going strong since 1936. It balances solidarity with trade, entrepreneurship with accountability and banking law, and explicitly protects SMEs from credit fluctuations caused by global market and economic forces. Their example is now being emulated by other parallel currencies, such as the Sardex.[11] I think that when Neoclassical economists were talking about the self-regulating market they had this idyllic picture in mind, but took a huge amount of political, democratic, and institutional infrastructure for granted, which could be argued to have been present in Britain in the second half of the 19th Century to a greater degree than in many other countries at that time. The uncritical application of the 'self-regulating market' in countries that were farther behind in their democratic development – as well as in Britain itself – then led to famine, world wars, etc, as variously argued by Polanyi (2001[1944]) and others.

LS: I like the Polanyi reference, but you are sounding a bit too Euro/Western-centric for my taste.

PD: You are right. My "meta-point" is that it is possible to make sense of rather different positions (e.g. the modern vs. the post-modern), depending on which difficult issues one overlooks. For example, overlooking the power of the IMF (International Monetary Fund) relative to many governments, and the interests of the main private-sector players in the West/North, who have long influenced the WTO (World Trade Organisation), WIPO (World Intellectual Property Organisation), etc, makes it easier to accept a modernist interpretation of recent history. On the other hand, overlooking the unbelievably expensive (in terms of human lives) process through which over the past 300-400 years Western Europe has attempted to develop an understanding – and an acceptable implementation – of democracy makes it easier to embrace the fiercely critical post-modern perspective.

LS: Fine – kind of – but what do we gain from such intellectual exercises?

PD: The ability to see the other person's point of view and to engage in a constructive debate.

LS: I see. Anyway, leaving economics and politics aside for the moment, you mean that there is a middle ground between subjective perception and objective certainty?

PD: Yes, Karl Popper called it 'inter-subjective', which in my mind is more or less the same as 'socially constructed'.

LS: Speaking of Popper, he also proposed a way to resolve the empiricist/inductive vs. rationalist/deductive dichotomy. He said that one could not generalize from a given set of empirical observations to a general law because we never know when an exception to the rule might arise. Similarly, we can't be certain that our starting axioms are always going to be right. So he found a compromise in saying that for a theory to be valid it must be 'falsifiable'.

PD: Very nice. It sounds like a workable position for EINS. It enables us to make some claims, which could be inspired by empirical observations or by leaps of theoretical imagination, as long as we can design tests that could prove them to be false.

LS: Yes, although it's a bit of a trick, because in practical terms we still tend to generalize from experience.

PD: True. And sometimes we make decisions based on axioms as if they were religious dogma.

[10] See Granovetter (1985) for the concept of embeddedness of economic action in social structure.

[11] http://www.sardex.net/

LS: I am glad we are on the same page: the system view that engineers default to is generalizing and objectifying.

PD: Generalizing because the totality and plurality of, for example, a part of a social system are assumed to apply to the whole system; by objectifying I think you mean that we treat the social system as if it were a physical object, that we lose track of the fact that it is made of individual human beings.

LS: We need to go back to individuals, otherwise we can't really talk about social construction. We can refer to social construction as a good compromise between relativism (tendency to acknowledge the co-existence of multiple realities, each of which deserves to be studied depending on the definition of the situation the actor gives) and objectivism (for which reality is like a physical object, a system made of sub-units working together harmoniously, where the paths of individuals are determined by existing structures).

PD: Thankfully we have language, then, which makes it possible to reach some level of consensus over things like money, newspapers, and citizenship, as we were saying above.

LS: I would push it a bit further. The first position holds that social actions refer to multiple realities and specific situations where actors give their own interpretations. The second supports the idea of an objective reality constraining social action within specific paths. Giving credit both to individual interpretations and constraining structures for action, we have ground for backing the idea that from subjective perceptions and definitions of reality individuals engage in social processes within shared norms and values.

PD: And these social constructions are "real", even if invisible, and help build institutions.

LS: Yes. However, more than just language (as a tool) I would use Goffman's frame analysis (1974). It avoids extreme relativism (each actor has its own definition of the situation) while rejecting determinism. Instead, actors use and define multiple situations according to other existing frames (that is to say, institutions). But now let's move the discussion back to politics and economics. So, in political theory we have Habermas (1964) who says that if a group of citizens engage in public and democratic debate in the 'public sphere' they will eventually reach consensus, i.e. a dominant view, on specific issues.

PD: Whereas Chantal Mouffe (2000), on the other hand, says that we might as well accept that some of us will never agree with each other and, therefore, that we should accept a dynamic exchange of positions as part of a healthy political process. She calls it 'agonistic pluralism', which we could regard as some middle ground between Habermasian consensus and the perennial and sterile polarisation we see in some political systems, for example in Italy since the Second War. This reminds me of Siedentop (2000) and the path towards Modernity.

LS: What do you mean?

PD: A central aspect of the modernity discourse is the issue of individual freedom versus allegiance to the group (be it family, tribe, city, or nation). For example, countries like Italy can be seen to be in the middle of a transition from a 'pre-individualist society' (Siedentop 2000: 166–7), where the individual owes allegiance to his/her family before him/herself, to a society where the individual asserts his/her right to individual freedom. Of course the Western discourse of modernity has been amply criticised, for example, by postmodernist philosophers (Lyotard 1979) as being deaf to other paths of cultural evolution and self-discovery.

LS: In other words, the possibility of a 'big narrative' of history for the evolution of different cultures or countries towards Modernity has been discredited.

PD: Exactly. However, the point here is that, with respect to individualism and collectivism, the modernity debate has been appropriated by political currents that are concerned mainly with questions of socio-economic action. This has contributed to further polarisation. For example, individual freedom has been applied to economic action, becoming the cornerstone of neo-liberalism. By contrast, collectivism can be taken as the starting point for new value systems based on social capital, collaboration, and public goods theory. For historical reasons that we cannot consider here, collectivism is also associated with socialism, communism and fascism. These conflations can create significant tension within our fledgling EINS community, so we should probably try to set some boundaries.

LS: Indeed! I see you have started to talk about economics again. Where are we going with that?

PD: Let's see, I happen to be sympathetic to some branches of heterodox economics, in particular Geoffrey Hodgson's institutional economics (1988, 1993) and Stephen Gudeman's economic anthropology (2001). Hodgson defines an institution

> …as a social organization which, through the operation of tradition, custom or legal constraint, tends to create durable and routinized patterns of behaviour. (Hodgson 1993)

So an institution can be seen as a social construction. It is interesting that in Southern European countries the term 'institution' can carry a significant *negative* connotation, whereas in Northern European countries this term is much more neutral, and in some cases it carries *positive* connotations. An example of this can be seen in the difference between the definition of institution by Hogson's, who is English, and Trigilia's, who is Italian:

> One can define institutions as a set of social norms which orient and regulate behavior and which are based on sanctions which seek to guarantee compliance on the part of individuals. (Trigilia 1998: 4)

In Trigilia's definition you can definitely sense the coercive power element, whereas Hogson's is much more neutral and even benign.[12]

LS: Interesting, I see your point, although I am not totally convinced. It can be understood in terms of frame, which I mentioned above. Different frames arise from different individual perceptions and contexts. Contexts are rich historical milieux where the perception of institution is related to the democratic process and to the form modernization took in different countries. We can make a parallel with the Internet. The way the Internet is governed (at a technical, economic, and social level) is a political process, and has to do with how power is exercised at the different scales of the

[12] This comparison between Hodgson and Trigilia is not meant to be "scientific", it is only an informal observation. In fact, in Trigilia's original text in Italian the corresponding quotation places less emphasis on sanctions. Nonetheless, the point remains worth investigating further, perhaps through a comparative study of how institutions are defined by sociologists from many different European and non-European countries.

individual and the institution. It takes us back to the first part of the discussion: decisions (especially policies) are produced through a collective process imbued with images of society, economy, and technology. Therefore, they reflect the positions of the dominant class (or country, like the US in the case of the Internet) on specific issues. Talking about the Internet (or more generally ICTs) it is clear that dominant telcos want to influence regulatory decisions in a way that is opposite to user/citizen preferences. The control of the Internet governance process, which can be heavily influenced by the prevalent view on specific issues by different players, is at stake (the Net Neutrality debate exemplifies this well).

PD: Yes, speaking of scale, we are clearly approaching questions of socio-economic action, in particular juxtaposing structuralism and individualism. I think it may be helpful to refer to Figure 2 at this point. Differing epistemologies are most evident when comparing natural science and social science, but they are also evident within the social sciences. A 'map of social science' proposed by Hollis (1994) can be used to begin making sense of the large number of concepts we are throwing together here. Hollis's map summarises the main analytical traditions in the social sciences divided along two axes: the first a commitment to objectivism or subjectivism, the second a commitment to structure or agency.

As shown in Figure 2, the blue boxes indicate some of the social science epistemologies that we are discussing. A few indicative names are shown to make the table easier to interpret. The left-hand column is generally associated with the rationalist, deterministic tradition. In Western thought it is the older of the two, and grew out of naturalistic philosophy. The right-hand column is more recent, reflecting a greater emphasis on the social world in defining reality (ontology) and construction of knowledge (epistemology). Although interpreting the two columns as an objective-subjective dichotomy risks gross oversimplification, those in the left-hand column can be grouped loosely as sharing a belief in some form of 'objective' reality, whereas a more 'subjective' perspective permeates the ideas of those named in the right column. The column on the left is generally acknowledged to have a much greater constituency (and to attract more funding) within social science than the traditions on the right that are inspired in part by a hermeneutic (i.e. interpretative) philosophy. The table can also be understood in terms of different accounts of social systems and human action. The top row favours a view of society and the economy that is biased toward the importance of structures and systems over individuals, whereas the bottom row represents the opposite emphasis. This distinction is reflected in methodology in the sense that theories in the top row tend to be deductive, deriving behaviour from general principles, whereas the bottom row is associated with the tradition of empiricism and positivism, where general principles are derived from experience through an inductive process.

LS: I don't agree on putting Weber in the upper-right quadrant, because he focuses more on individuals and on action rather than on society and structure.

PD: Well, kind of. As explained by Hollis (1994: 147-151), Weber's starting point is individualist. However, his extension of '*homo economicus*' into '*homo sociologicus*' as rule-following individuals leads to, for example, organizations as 'Weberian machines' whose rational and bureaucratic traits are self-evident. So I think both views of Weber are possible.

LS: I see. We said earlier that Popper provides a plausible way to reconcile the subjectivist-objectivist tension. Can something similar be done with the structure-agency tension?

PD: Indeed! Giddens's theory of Structuration does that very well, in my opinion. Giddens says that institutions provide a structure within which we live our lives. So to some extent they determine many of our actions. However, institutions themselves are the result of social constructivist processes in a specific time- and space-frame. To this I would add also progressive memory-dependent "crystallization", i.e. the same process through which many flexible social norms eventually become rigid laws.[13] In any case, the point is that through language our social interactions provide an upwell of transformative pressure from within institutions, which over longer time-scales are thereby able to renew themselves and evolve.

LS: I understand that you think about language as an explaining category (as power could be). But, please, do not reduce everything to language!

PD: All right, but don't worry: language for me has a more important epistemological function than ontological role. In other words, I do not believe that social systems are made of communications, like – oversimplifying – Niklas Luhmann does. In any case, to me structuration provides a nice balance between top-down structuralism and bottom-up social constructivism. It represents a theoretical approach that tries to solve the macro/micro incommensurability. Again, the important thing to our discussion is that it highlights the dynamic and context-dependent nature of the process we are observing.

LS: You sound like an sociologist! In other words, is Giddens saying that micro- (actors) and macro- (structures) levels influence each other in a long-term process?

PD: Not exactly. Macro-structures influence individuals on *short* time-scales, whereas individuals, through social interactions, generally can influence institutions only over *long* time-scales. Anyway, we have a couple of binaries left to address: essentialist vs. existentialist and context-free vs. context-dependent binaries, which are similar, and the conflict vs. regulation binary.

LS: We have kind of covered the latter.

PD: Yes, but we can say a bit more. Burrell and Morgan (1979) provide a map of sociology that is similar in spirit to Hollis's. It overlaps Hollis's map on the subjective-objective axis, but instead of the structure-agency axis it relies on a conflict-regulation dichotomy. They argue that many works in sociology rely on an assumption that some level or "harmony" is attainable, for example Talcott Parsons's functionalism.

Others, for example Marx, believe that conflict is unavoidable and is intrinsic to human nature. Since I have an engineer's mind, I saw an opportunity for a 3-D diagram, see Figures 3 and 4. Note that in Figure 4 the cube face the stickperson is looking at corresponds to Figure 2. Going onwords, my exposure to physics and my ever-stronger attraction towards mathematics provides a good balance for the social constructivist thinking. I was always partial to

[13] For example, most academics are familiar with the process whereby administrative procedures are communicated and actioned informally, but become progressively more formalized over time, eventually involving many steps, many people, and many written rules, forms, and signatures, which are perceived as exogenous to the community.

structure, and now I can see that this may be nothing more than how our minds are sensitive, to different degrees, to *algebraic* structure.

LS: You lost me.

PD: Algebraic structure is closely related to Platonic essentialism, which in my mind is related to context-free concepts and theories.

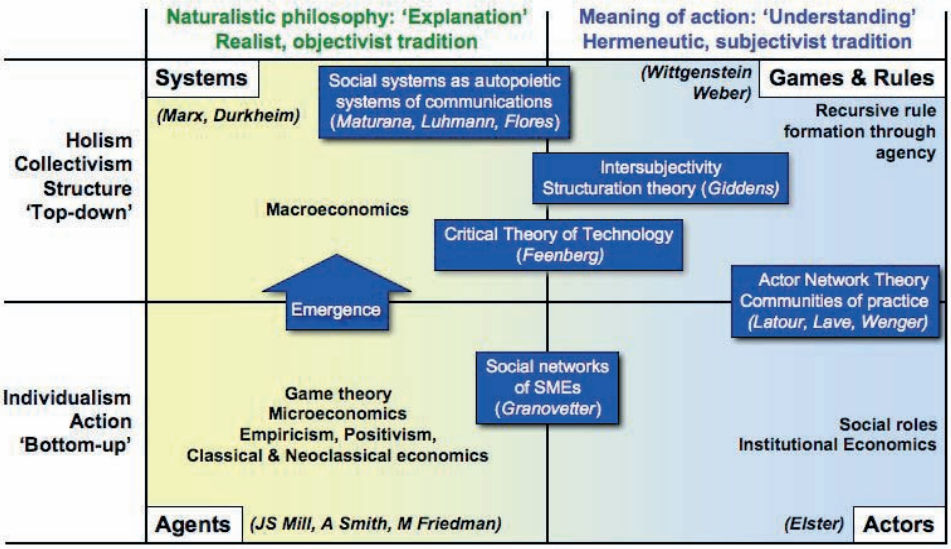


Fig. 2. Map of social science (after Hollis 1994; and Dini et al. 2011)

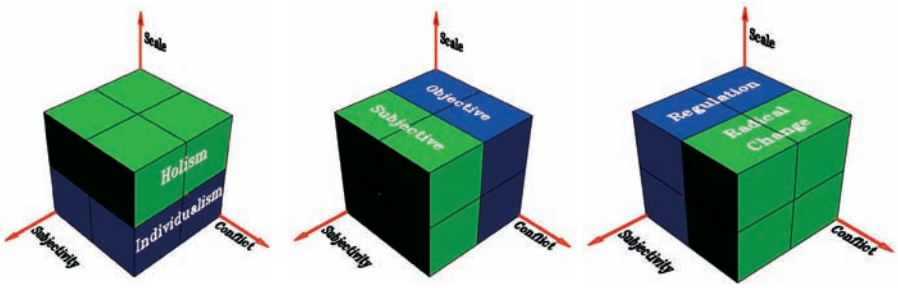


Fig. 3. 3-D view of social science (after Hollis 1994; and Burrell & Morgan 1979)

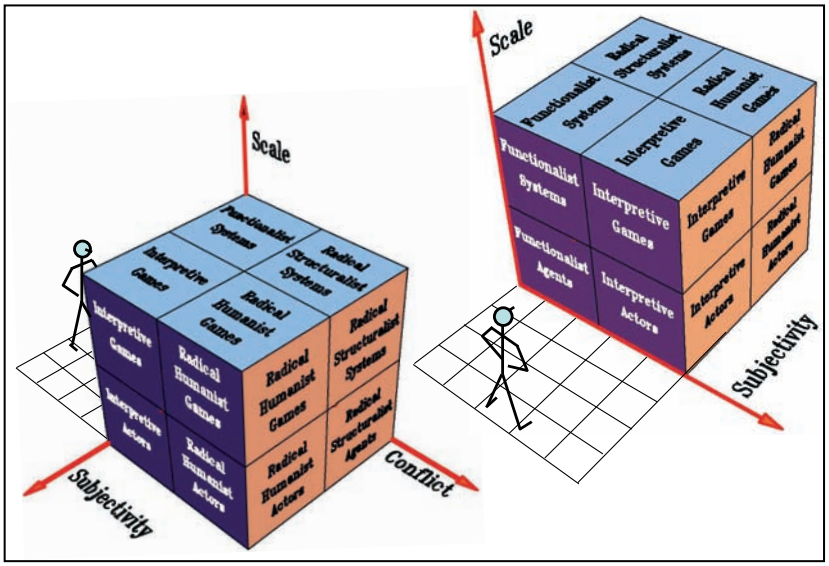


Fig. 4. Social science in a box (after Hollis 1994; and Burrell & Morgan 1979)

LS: Whatever you say! Anyway, where is the context dependence then?

PD: In evolutionary dynamics. The DNA blueprint (genotype) of an individual organism can lead to slightly

different phenotypes depending on the environment the organism develops in, and over many generations a species will adapt to its environment. So the core "design" – a common example is the eye – is fairly stable, but the finer details will change and adapt as the environment changes. An analogous perspective in the social sciences is provided by post-modernism.

LS: You are making big leaps again, but OK. Where do we go from here? Where is the Internet in all this? And can you please provide an example of the parallel between organism and post-modernism. In my understanding, post-modernism opens up multiple paths to knowledge through relativism. Where is the link to the evolutionary dynamic of organisms and phenotypes?

PD: Relativism is the basis of evolution. Natural selection is meaningful only relative to a given environment. In other words, a successful organism is only successful relative to a given environment, not in absolute terms.

IV. Conclusion

PD: If we combine the ideas we have talked about we should be able to start seeing how different disciplines and different individuals approach and relate to the Internet.

LS: I suppose, but we haven't yet arrived at an understanding of what the *structure* of Internet Science might be.

PD: You are right, we have only started to sketch an outline. I believe that, whatever Internet Science might end up being composed of, it will depend to a significant extent on the dimensions I mentioned at the beginning: social constructivism, the interaction between power and knowledge, and some system of value that goes beyond current mainstream understandings of market and exchange economy, without negating either. But in this dialogue we have only touched on the second and we have not discussed the third at all. In any case, the idea is not so much to develop a single and unique view of what the Internet is or what Internet Science should be composed of. The idea we have been developing in our conversation is to set down some principles of interaction and communication for internet scientists, so that they can understand each other better as they work towards a common methodology for *doing* Internet Science, which might eventually lead to some shared understanding of what Internet Science *may become*.

LS: That sounds good to me. 'Til next time then!

V. Acknowledgement

The work reported in this article was funded in part by the EU projects EINS, contract number CNECT-288021, and BIOMICS, contract number CNECT-318202. Their support is gratefully acknowledged.

VI. References

[1] Barnes, B. and Mckenzie D. (1979) "On the role of interests in scientific change", in Wallis, R. (Ed.) On the margin of science: The Social Construction of Rejected Knowledge, Sociological Review, 27, 49-66.

[2] Boghossian, PA (2001). What is social construction? *Times Literary Supplement*, 23 February 2001. http://as.nyu.edu/docs/IO/1153/socialconstruction.pdf.

[3] Breitstein, L and Dini, P (2011). A Social Constructivist Analysis of the 2007 Banking Crisis: Building Trust and Transparency through Community Currencies, *Journal of Banking Regulation*. **13**(1), 36-62.

[4] Burrell, G and Morgan, G (1979). *Sociological Paradigms and Organisational Analysis*, Ashgate.

[5] Dini, P, Iqani, M, and Mansell, RE (2011). The (Im)Possibility of Interdisciplinarity: Lessons from Constructing a Theoretical Framework for Digital Ecosystems, *Journal of Culture, Theory and Critique*, **52**(1), 3-27.

[6] Dini, P (2012). Community Currencies and the Quantification of Social Value in the Digital Economy, Unpublished. Available from: http://eprints.lse.ac.uk/47349/

[7] Feenberg, A (1991). *Critical Theory of Technology*, Oxford: Oxford University Press.

[8] Feenberg, A (2002). *Transforming Technology: A Critical Theory Revisited*, Oxford: Oxford University Press.

[9] Feyerabend, K. (1975) *Against Method: Outline of an Anarchistic Theory of Knowledge*, London , New Left Books.

[10] Fischer, C. 2000. *America Calling. A Social History of the Telephone to 1940*, California University Press.

[11] Flichy, P. (1995) *L'innovation technique*. récents développements en sciences sociales. Vers une nouvelle théorie de *l'innovation*. Paris : La Découverte.

[12] Forman, P. "Weimar Culture, Causality, and Quantum Theory: Adaptation by German Physicists and Mathematicians to a Hostile Environment," *Historical Studies in the Physical Sciences*, Vol. 3, pp 1-115. 1971

[13] Foucault, M (1980). *Power/Knowledge*. London: Longman.

[14] Giddens, A (1984). *The Constitution of Society: Outline of the Theory of Structuration*. Cambridge: Polity.

[15] Goffman, E. (1974) Frame Analysis. New York: Harper and Row.

[16] Granovetter, M (1985). Economic Action and Social Structure: The Problem of Embeddedness, *The American Journal of Sociology*, 91(3):481-510.

[17] Gudeman, S (2001). *The Anthropology of Economy*, Blackwell.

[18] Habermas, J (1964). "The public sphere: An encyclopaedia article" in *New German Critique*, **1**(3).

[19] Hodgson, G (1988). *Economics and Institutions*, Cambridge: Polity Press.

[20] Hodgson, G M (1993). *Economics and Evolution: Bringing Life Back into Economics*, Ann Arbor, MI: The University of Michigan Press.

[21] Holland, J H (1975). *Adaptation in Natural and Artificial Systems*, University of Michigan Press, Ann Arbor.

[22] Hollis, M (1994). *The philosophy of social science: an introduction*, Cambridge.

[23] Jackson, M (1997). The Problem of Over-Accumulation: Examining and Theorising the Structural Form of LETS. *International Journal of Community Currency Research*, Vol 1.

[24] Kuhn, T (1996). *The Structure of Scientific Revolutions*. Chicago, IL: University of Chicago Press.

[25] Lakatos, I (1976). *Proofs and Refutations: The Logic of Mathematical Discovery*, Cambridge: Cambridge University Press.

[26] Lyotard, J-F (1979). *The Postmodern Condition*, Manchester: Manchester University Press.

[27] Marvin, C (1988). *When old Technologies Were New:* Thinking About Electric Communication in the Late Nineteenth Century, New York: Oxford University Press.

[28] Maxwell, J C (1873). *A Treatise on Electricity and Magnetism*. Oxford: Clarendon Press.

[29] Mouffe, C (2000). *The Democratic Paradox*, London: Verso.

[30] Newman, J R (2003[1956]). *The World of Mathematics*, New York: Dover.

[31] Polanyi, K (2001[1944]). *The Great Transformation: the Political and Economic Origins of Our Time*, Boston: Beacon Press.

[32] Popper, K (2002 [1935]). *The Logic of Scientific Discovery*. Translated by Logik der Forschung. London: Routledge.

[33] Siedentop, L (2000). *Democracy in Europe*, London: Penguin.

[34] Weber, M (2012[1905]). *The Protestant Ethic and the Spirit of Capitalism*, CreateSpace Independent Publishing Platform.

[35] Winograd, T and F Flores (1987). *Understanding Computers and Cognition*, Addison-Wesley.

Digital scholarship: Exploration of strategies and skills for knowledge creation and dissemination

Cristobal Cobo
Oxford Internet Institute, Oxford University
Oxford, England
cristobal.cobo@oii.ox.ac.uk

Concepcion Naval
Balliol College, Oxford University. Department of Education, University of Navarra
Pamplona, Spain
cnaval@unav.es

***Abstract*— Widespread access to digital technologies has enabled digital scholars to access, create, share, and disseminate academic contents in innovative and diversified ways. Today academic teams in different places can collaborate in virtual environments by conducting scholarly work on the Internet. Two relevant dimensions that have been deeply affected by the emergence of digital scholarship are new facets of knowledge generation (wikis, e-science, online education, distributed R&D, open innovation, open science, peer-based production, online encyclopaedias, user generated content) and new models of knowledge circulation and distribution (e-journals, open repositories, open licenses, academic podcasting initiatives, etc.). This paper provides a review of existing frameworks which have been proposed so far to get a grip on digital scholarship and address the following questions:**

-What strategies are followed by digital scholars to interdisciplinarily (co)create, curate and translate their ideas on the Internet?
- How do digital scholars spread their ideas on the Internet?
- What set of key skills need to be learned (and updated) by scholars who actively create and/or disseminate academic knowledge through the Internet?

Despite the potential transformation of these novel practices and mechanisms of knowledge production and distribution, some authors suggest that digital scholarship can only be of significance if it marks a radical break in scholarship practices brought about through the possibilities enabled in new technologies. This paper address some of the key challenges and raise a set of recommendations to foster the development of key skills, new models of collaboration and cross-disciplinary cooperation between digital scholars.

***Keywords*: digital scholarship; digital research; knowledge based society; education.**

EINS Topics included: Knowledge, education, and scholarship on and through the Web; Internet, society, and innovation; Analysis of human behavior and social interaction using data from social media & online networks; Collective intelligence, collaborative production, and social computing; Intellectual property and the commons

The analysis described in this study will allow us to complete Table 1.

	Mechanisms (tools and technologies)	Digital Scholarship Practices	Key Skills Required
Knowledge Generation	Open Data, Big Data, Wiki-alike, Interoperability for Scholarly Annotation, Zotero	Peer-production, Content curation, cross-disciplinarily	Self-direction, Collaborativeness, critical assessment (crap detection).
Knowledge Distribution	Data visualization, Rubriq, DOAJ, PLOS, PeerJ, open-source platform.	Openness, open/independent peer review, Open License (Green & Golden route)	Creativity, Practice focus, cross platform literacy, knowledge translation, privacy and digital identity awareness.

***Keywords*— digital technologies, digital scholarship, academic knowledge, Internet**

1. Current Information landscape

The exponential growth of information together with the expansion of digital technologies suggests major changes for a world increasingly shaped by the digital revolution. Hilbert and López (2011) indicate that the world's capacity for bidirectional telecommunication is growing at 28% per year, closely followed by the increase in globally stored information (23%). Machines' application-specific capacity to compute information per capita has roughly doubled every 14 months over the past two decades while the global telecommunication capacity per capita doubled every 34 months. These authors state that the world's technological information processing capacities are quickly growing at clearly exponential rates.
The knowledge economy, highly influenced by the unprecedented volume of information, is a new socio-economic order in which new technologies are the drivers of knowledge production and application. Among other producers of knowledge, universities have become a key part

of the innovation system, in which innovation is understood as "the process-of assembling and maintaining a novel alignment of ideas, practices and actors to respond to site-specific issues and/or to pursue a vision" (Häyrinen-Alestalo and Peltola 2006, 253; Tytler et al., 2011; Lecercle 2011). Hurmelinna, Kyläheiko, and Jauhiainen explain that new 'mechanisms of knowledge creation, integration and transfer, play a central role in the evolutionary economics-based dynamic capability' (2007, 142).

The exponential transformation of information is not only remarkable from the quantitative perspective, but also there is a fragmentation and diversification of communication channels and mechanisms to create, access and distribute information. In academic contexts, these phenomena have deeply changed the way in which people work and collaborate.

Two relevant dimensions that have been deeply affected by the emergence of digital scholarship are new facets of **knowledge generation** (wikis, e-science, online education, distributed R&D, open innovation, open science, peer-based production, online encyclopaedias, user generated content) and new models of **knowledge circulation and distribution** (e-journals, open repositories, open licenses, academic podcasting initiative, etc.). The transformations of these two major dimensions are affecting the traditional role of higher education institutions, expressed in new practices and systems.

In connection with the new mechanisms of knowledge production and distribution Benkler (2006) explains that a radical decentralization is shaping the current network society. According to Benkler (p. 32) this radical decentralization of intelligence in our communications networks and the centrality of information, knowledge, culture and ideas to advancing economic activity are 'leading to a new stage of the information economy – the networked information economy'.

In accordance with Burdick, (et al, 2012, p.112-113) this radical decentralization is providing new alternatives for knowledge generation. The creation of a culture of information exchange has the potential to enhance the quality, depth, and reach of digital scholarship. Here the authors remark on the importance of creating common spaces of knowledge production and knowledge exchange (Jankowski, 2009 and Wouters, 2012).

Nowadays an increasing interest in promoting institutional measures to support and facilitate the access and exchange of academic knowledge is observed. For instance, during 2012 two major announcements were made by European Commission (Kroes, 2012) and the Economic and Social Research Council (ESRC) in the UK. In both cases these initiatives aimed to increase, facilitate and accelerate open access to scientific knowledge.

2. Digital Scholarship

In the current context, the academic community can harness many more of the diverse pathways and mechanisms for scientific transmission that were muted by the economies of scale that led to the rise of the concentrated, controlled forms of mass media, whether commercial or state-run. One of the most important aspects of the networked information economy is the possibility it opens for reversing the control focus of the industrial information economy. From an institutional perspective this radical decentralization is articulated by new knowledge intensive mechanism and transactions.

Borgman (2007, p. xvii) adds, "Today's initiatives in cyber-infrastructure, e-Science, e-Social Science, e-Humanities, e-Research, and e-Learning emerged from a tumultuous period in scholarly communication in which technological advances converged with economic and institutional restructuring".

Digital scholarship is manifested by new modes of scholarship and institutional units for collaborative, transdisciplinary and computationally engaged research, teaching and publication (Burdick, et al, 2012, p.122). According to these authors, digital scholarship communities collaborate in dynamic, flexible, and open-ended networks for knowledge creation and distribution, which actively exchange innovation, creativity and authoring (idem.p.85) Nonetheless, Pearce et al (2011) emphasis that digital scholarship is more than just using information and communication technologies to research, teach and collaborate; it also embraces the open values, ideology and potential of technologies born of peer-to-peer networking and wiki ways of working in order to benefit both academia and society.

Here four dimensions that play a fundamental role among digital scholarship practices are highlighted:

Technology

The openness and flexibility that different new digital platforms and tools offer (i.e. Google Books, Diigo, Scoop.it, Evernote, Google Drive, Wikipedia, Zotero, etc.) provide multiple opportunities to create new types of knowledge and facilitate the development of novel inter- and multi-disciplinary knowledge.

These platforms become coordination mechanisms that support continuous flows of exchange and codification of tacit knowledge, simplifying its translation into more usable, findable and interchangeable resources (Heimeriks & Vasileiadou, 2008). In this context, digital tools are not just tools. They are cognitive interfaces (coordination mechanism) that presuppose forms of mental and physical discipline and organization (Burdick, et al, 2012, p. 105).

The 'open access' movement in digital scholarship can offer diversified possibilities for stimulating scientific work. Consequently, this openness is not only relevant in terms of providing access to research (i.e. open access journals or databases); but also speeding up scholarly communication and scientific dialog between researchers; facilitating new mechanism of open peer revision (broadly adopted in platforms such as Wikipedia or more scholar-oriented ones such as the Public Library of Science) and offering greater visibility and impact opportunities.

Collaboration - co creation

Rheingold (2012) proposed a comprehensive taxonomy that describes different levels of collaborative work. In this case that categorization can be particularly useful in order to understand different levels of digital collaboration. This classification can be summarized as follow:

- First level (Networking) more simple level of collaboration. It implies low risk and low commitment from the participant's perspective.
- Second Level (Coordination). It requires similar level of commitment than as the one observed in the 'networking' level, but the members identify mutual benefits establishing additional incentives.
- Third level (Cooperation). It implies a more active attitude towards sharing and exchanging. Members identify a common purpose and exists a higher level of trust among participants.
- The fourth level (Collaboration). All participants shared goals. It implies all the previous levels, but in addition participants find mutual benefits, share risks, resources, and rewards.

In previous works (McCarthey & McMahon, 1992; Dutton, 2010 or Cobo, 2012) collaboration is not understood as a one-size-fits-all concept but as a dimension that varies at different levels of negotiation. According to these studies, at least three general hierarchies used in collaboration over the Internet can be identified.

- (level 1) "share" by sharing documents, data and other digital resources, for example using hypertext links.
- (Level 2) encourages "contribution generation" through notes and other content produced by different individuals, and
- (level 3) co-creation, for example, by creating active and distributed knowledge (many-to-many) combining the individual contributions.

One type of interaction is not necessarily better than another; the appropriateness of each depends on the individuals' knowledge of the purpose and the nature of the task. However, the higher the level of collaboration, the more complex the set of skills required to achieve successful negotiation among individuals will be. Bulger, et al. (2011) after exploring different case studies found that that researchers are not moving from less complex information uses to more complex ones, but are broadening their information ecosystems.

Authorship and beta version

Just like in the development of open source, in the context where collaborative writing technologies become increasingly adopted among scholars (Bulger, et al., 2011), the idea of authorship as an autonomous work or as the labour of a solitary genius seems to move toward the harnessing and expressiveness of the creative energies of an ever-expanding, virtually boundless community of digital scholars (Burdick, et al, 2012, p.83). Wuchty (et al., 2007) after analysing almost 20 million papers over 5 decades claim that "teams increasingly dominate solo authors in the production of knowledge. Research is increasingly done in teams across nearly all fields. Teams typically produce more frequently cited research than individuals do".

The collectivization of authorships is also trending toward fluid, iterative, and distributive models. Whatever the medium, authorship is increasingly understood as a collaborative process, with individuals creating materials within the setting of a team that merges their identities into a corporate subject (the laboratory, the technology sandbox, the research group) (Burdick, et al, 2012, p. 110).

Crowd-sourced production mechanism for generating and editing scholarly content (i.e. open peer review journals, social bookmarks, wikis, Google Docs, etc.) are transforming both the authorship function and the use of conventional knowledge platforms. Burdick (et al.) explain that nowadays a book is not simply "finished" and "published," but is now part of a much more dynamic, iterative, and dialogical environment that is predicated on versioning, crowd-sourced models of engagement and peer review, and open source knowledge and publication platforms. Publication is not an endpoint or culmination of research, but is something significantly more process-oriented, indeterminate, experimental, and even experiential (Burdick, et al, 2012, pp. 85 and 89).

Dissemination

Traditionally, publishing meant finding a journal or press in order to make academic treatises, arguments, and the results of research public—but this "public" was in reality primarily or even exclusively readers initiated in and defined by the discursive conventions of a given field (Burdick, et al, 2012, 86). Today, that scenario is changing. After the growth of so-called '2.0' technologies (O'Reilly, 2007), the expansion of open repositories (i.e. Social Science Research Network or Directory of Open Access Journals) and particularly the so-called "new open-access policies" (Van Noorden, 2012) almost anyone can publish (in the sense of "make public") anything.

A re-evaluation of the "publish or perish" syndrome can be found in Jenkins et al. (2010) proclamation "If it doesn't spread, it's dead". Nowadays, the alternatives of publication have diversified significantly. More and more scholars consider the possibility of posting early versions of their academic work on blogs or micro-messages, by posting photographs or videos, hosting a website, commenting on other people's blogs, etc. (Nielsen, 2011).

The participatory environment facilitates the creation of new cultural materials through a growing variety of Do-it-yourself publishing mechanisms (i.e. CreateSpace or Blurb are some examples) that offer new possibilities of "radical decentralization". Here, as Burdick (et al, 2012, p. 96) suggested these new distribution mechanisms will need to evolve in ways that recognize the productive distinction between popular work and more specialized scholarship. In addition, the increasing possibilities of digital knowledge dissemination also raise some challenges such as the

principles of intellectual property, licensing, remixed use of materials or open peer review.

New digital publishing models are challenging the long-standing roles and institutional boundaries (Burdick, et al, 2012, p. 87). The '2.0 tools' provide a new ecosystem of creation and dissemination that complement (even replace, in some cases) the traditional practices of peer-review that have been adopted for centuries to assure the quality of the knowledge (i.e. Public Library of Science). Now an active audience also has the possibility of providing feedback, and can call for amendment or other mechanisms of control or quality (in some cases in real time). As is well-known, Creative Commons provide legal tools and platform to make scientific data and databases freely available. These mechanisms, still under a process of consolidation, are acquiring increasing relevance in the digital scholarship environment (Fitzpatrick, 2009).

The dissemination of digital scholarship can be summarized with the 4'R: reuse, revise, remix and redistribute. Wiley (2010) explains that the primary permissions or usage rights for open content are expressed by: *reuse* (the right to reuse the content in its unaltered/verbatim form); *revise* (the right to adapt, adjust, modify or alter the content itself); *remix* (the right to combine the original or revised content with other content to create something new); and *redistribute* (the right to share copies of the original content, your revisions or your remixes with others).

Is the scholar community willing to change their working practices?

Taking into account these novel mechanisms and practice of knowledge generation and distribution, Burdick, et al. (2012, p. 112) enquire: Will our universities and colleges institutionalize approaches to learning and research grounded in collaboration and cooperation instead of celebrity and competition? Or will we continue to allow profit-driven entities to shape the networked environment on which our digital future depends?

In order to address this question, Chesbrough suggest that we live in a new paradigm of knowledge exchange called open innovation, which occurs when organisations and individuals share risks and rewards extensively. This paradigm holds that a field of knowledge must be used readily if it is to provide value to the organisation that creates it. Nevertheless, this author suggest that resistance to change occurs, he suggest that this transition implies potential confrontations when '[t]he shift in knowledge landscape is disturbing to people familiar with the earlier paradigm' (2006, 41). Sohail and Daud noted that 'knowledge sharing is inevitably challenging and an important concept in higher learning institutions' (2009, p.129), and Seonghee and Boryung (2008, p.282) argued that the members of academic organisations often resist knowledge sharing:

> [I]ndividual members of academic institutions place a higher priority on individual scholarly achievement […]. Consequently, there is a relatively weak willingness to share knowledge for achieving common goals in academia compared to in profit-oriented organizations. Due to these unique characteristics of exclusiveness and individualism, knowledge-sharing and knowledge management in academic organizations are often not systematic and may be inefficient.

Menkhoff, Evers, and Wah (2010, 230) noted that while universities have traditionally been viewed as archetypal learning communities, 'where there is substantial knowledge sharing in term of academic knowledge and expertise in the form of journal publication and teaching, these forms of knowledge sharing are paradoxically induced more by peer-competition than altruistic sharing'. Kanwar, Kodhandaraman, and Umar (2010, 73) add that the lack of partnership in a highly competitive environment can also affect the development of open educational or open science initiatives. Researchers and scientists are living in a continue competition ranging from contest for academic positions, research grants, or in order to bringing their academic institution to the top of international rankings. Either for concern of professional development or the risk of being left behind ('stick or the carrot') the academic mechanisms of recognition in many cases are limited to metrics such as the 'h-index' a single-number criterion to evaluate the scientific output of a researcher (Hirsch, 2005). This permanent competition for professional development does not always provide the more appropriate framework to facilitate peers based collaboration. Adler and Harzing (2009) claim that current academic assessment systems reward scholarship are dysfunctional and potentially cause more harm than good.

On the other hand, Kenway, Bullen & Robb (2004, p. 338) emphasize that 'there is considerable pressure on all academics to become particular sorts of networkers'. They stress the importance of exchanging information across disciplinary or institutional borders and spreading knowledge and excellence that foster new connections and relationships.

At this stage is not easy to determine how and to what extent the traditional and the new practices (here described as digital) of scholarship will coexist. Is expected that the scholars' practices might evolve when there is the appropriate institutional recognition (i.e. a tenure evaluation system that recognizes the value of new publication formats but also more flexible mechanisms of knowledge dissemination). A tradeoff between a digital ecosystem that offers unlimited channels of knowledge dissemination and the idea of exclusive excellence where the academic systems encourage publishing only at locations that have the highest impact factor and the best indexing ('h-index'). This mismatch illustrates part of the current digital scholar landscape.

Flanders (2009) states that digital tools are not neutral and remarks a whole new range of challenges (i.e representation, medium, and structures). The author summarizes some of the tensions in this field: digital scholarship is uneasy about the significance of medium; digital scholarship is uneasy about the institutional structures of scholarly communication; and

digital scholarship is uneasy about the significance of representation in forming models of the world.

Additional drawbacks identified in the digital scholarship spectrum are: **dependence on technology** (i.e. 'if it's not on the web, it doesn't exist at all', technological progressivism, broadband divide generating inclusion and exclusion); **tenure evaluation systems** (i.e. current metrics to assess academic value dismiss the new, potentially better digital scholar practices); **information overload** (i.e. intoxication, infobesity, information anxiety); **increasing complexity** (i.e. open dissemination strategies demand increasing awareness, tech savviness, and additional funding in cases like the golden route publication); **publish or perish** (pressure in academia to rapidly and continuously publish academic work in high impact journal, in many cases non-open-access publication); **interdisciplinary boundaries** (i.e. a cross disciplinary science need to overcome divisions between methods, tools, expertise, jargon, etc.)

3. Key skills for digital scholarship

Taking into account the trends and practices of digital scholarship described, how do digital researchers learn and update their knowledge and skills? What are the key skills for academic knowledge creation and dissemination? Where and how can these skills be learned?

The landscape described suggests that one of the central problems in the development of digital scholarship is not the technology per se, nor the role of the user in technological environments, but the cultural and historical specificity of knowledge (Wouters, 2004, p.3). Pearce et al. (2011) acknowledge that the adoption of digital tools cannot be understood or oversimplified as an inevitable change in scholars practices which have remained relatively stable along the years (or if they have changed it has been due to much greater forces, such as the move from elite to mass participation, introduction of fees or economic incentives, etc.).

In order to facilitate the creation of novel disciplinary boundaries which are more permeable to new scholarly practices a whole set of cultural practices will be required: institutional flexibility (i.e. diversifying tenure track, re-understanding concepts such as academic visibility or digital influence) as well as development of the appropriate skills for knowledge production in the new technologically mediated contexts.

From the individual scholar's point of view appropriating (or re-appropriating) these tools requires a new set of skills that lie outside the traditional knowledge-based research practices. Burdick, et al. (2012) suggest that the outside skills—skills in fields such as design, computer science, media practice, curation, or library science—are assuming increasing importance alongside core training in digital scholarship (particularly in humanities). No longer trained for academic careers alone, skilled in practical as well as theoretical domains, they (scholars) are moving more fluidly between institutions of memory, industry, and academia (p. 117). These authors recommend four competences, which are particularly central to contemporary scholar activity: **curation, analysis, editing, and modelling**.

These authors understand these proficiencies as part of an "open source culture" which includes work practices such as: collaborative authoring, multiple versioning, flexible attitudes toward intellectual property, peer contributions, access to multiple and multiplying communities, and overall patterns of distributed knowledge production, review, and use (Burdick, et al, 2012, p. 77).

The reason for suggesting these competencies as "outside" dexterities is attributable the fact that these are not necessarily associated with traditional academic training such as statistical analysis programming and data-mining. These 'outside' skills should be understood as an extension of traditional knowledge skills and methods, not a replacement for them. It will demand that the new generation of digital scholars model new ways of exploiting the digital domain, and look for innovative ways of public engagement and distributed collaboration, as well as novel publishing models.

Some of the abilities and knowledge required to foster this networked scholarship in this digital ecosystem could vary significantly depending on the stakeholder or context. However, it seems important to identify and develop a set of relevant skills to work across this ecosystem where the information intermediaries are notably more diverse than in the last decades.

The Institute for the Future foresees 10 skills considered vital for the workforce in the coming years (2020). The study classified the key proficiencies and abilities required across different jobs and work settings. It is noteworthy that, the skills and expertise described in this study provide a comprehensive 'picture' to better understand (and study) the competence for digital scholarship (Davies, Fidler, and Gorbis, 2011).

- **Sense-making**: the ability to determine the deeper meaning or significance of what is being expressed.
- **Social intelligence**: the ability to connect to others in a deep and direct way, and to sense and stimulate reactions and desired interactions.
- **Novel and adaptive thinking**: proficiency at thinking and coming up with solutions and responses beyond those that are rule-based.
- **Cross-cultural competency:** the ability to operate in different cultural settings in a truly globally connected world.
- **Computational thinking:** the ability to translate vast amounts of data into abstract concepts and to understand data-based reasoning.

- **New Media Literacy:** the ability to critically assess and develop content that uses new media forms, and to leverage these media for persuasive communication.

- **Transdisciplinarity:** literacy in and ability to understand concepts across multiple disciplines.

- **Design mindset:** the ability to represent and develop tasks and work processes for desired outcomes.

- **Cognitive load management:** the ability to discriminate and filter information in terms of importance, and to understand how to maximize cognitive functioning using a variety of tools and techniques.

- **Virtual collaboration:** the ability to work productively, drive engagement, and demonstrate presence as a member of a virtual team.

Borgman (2007) suggests that information literacy and particularly critical thinking skills are an essential part of becoming educated, however these are not skills that are easily taught. The skills described here acknowledge the importance of the informal development of this set of abilities.

The European Centre for the Development of Vocational Training states that *informal learning* results from daily activities related to work, family or leisure. It is not organised or structured in terms of objectives, time or learning support. Informal learning is in most cases unintentional from the learner's perspective (Tissot, 2008).

In this case, it is hypothesized that researchers develop a number of key skills for digital scholarship (particularly in term of novel forms of knowledge creation and dissemination) based on specific, individual or collective needs, without formal instructors or official recognition, that lead them to develop new tacit and explicit theoretical and/or empirical knowledge relevant to work on science in the 21st century.

4. Recommendations and Remarks for future research

- Facilitate the creation of spaces and opportunities, either formal or informal (i.e. re-skilling programmes, mobility initiatives, workshops or summer schools) that stimulate the development of skills for digital scholarship by fostering the combination of different learning styles as well as more diverse formal, non-formal and informal educational environments.

- The integration of disciplines (i.e. cross disciplines, inter-, intra-, trans-, multidiscipline) must be facilitated and consistently promoted. In order to do so, there must be instance and context (i.e. complex problems) which stimulate redefining the boundaries of the humanities, the social sciences, the arts, and the natural sciences in order to study the imminent generation of an Internet Science.

- Development of opportunities to make the most of the digital platforms (i.e. peer based training) allowing exploration and exchange of novel and combined research methods.

- To stimulate and reward the adoption of distributed and collective practices that facilitates the creation and adoption of flexible data sharing practice (i.e. free and open data initiatives).

- To create new metrics assessing how well individual scholars and universities are doing in terms of knowledge dissemination and research impact. Evaluation mechanisms that are not entrapped in simple and reductionist approaches (i.e. metrics based on counting publications or citations).

- To promote the implementation of formal and informal up skilling opportunities, especially in international work environments encouraging researchers to acquire competences for digital scholarship.

- Development of strategies and programmes to increase digital awareness and literacy in order to better understand subjects such as: digital identity (i.e. digital footprint), privacy awareness (i.e. right to delete), more flexible licensing premises (i.e. Creative Commons Science; open journals or open data, etc.), or open-source culture (i.e. collaborative authoring or multiple versioning).

- To consider the importance of bringing open access and new publication formats into the tenure evaluation system. Doing this could not only contribute to the tenure process, but may also serve to promote open access and more efficient knowledge dissemination. Notably, the required mechanisms and technology to promote the change are already available, but cultural and institutional constraints make this transition to opening particularly slow.

References

[1] Adler, N. J., & Harzing, A.-W. (2009). When Knowledge Wins: Transcending the Sense and Nonsense of Academic Rankings. Academy of Management Learning & Education, 8(1), 72–95. doi:10.5465/AMLE.2009.37012181

[2] Benkler, Y. (2006). The Wealth of Networks: How social production transforms markets and freedom. Yale University Press, New Haven, CT.

[3] Borgman, C. L. (2007). Scholarship in the Digital Age: Information, Infrastructure, and the Internet. MIT Press.

[4] Bulger, M., Meyer, E., De la Flor, G., Terras, M., Wyatt, S., Jirotka, M., Eccles, K., et al. (2011). Reinventing research? Information practices in the humanities. Information Practices in the Humanities (March 2011). A Research Information Network Report. Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1859267

[5] Burdick, A., Drucker, J., Lunenfeld, P., Presner, T., & Schnapp, J. (2012). Digital_Humanities. Mit Press.

[6] Chesbrough, Henry William. (2006). Open Innovation: The New Imperative for Creating and Profiting from Technology. Harvard Business Press.

[7] Davies, A., Devin F., and Marina G. 2011.Future work skills 2020. Institute for the Future (for the University of Phoenix Research Institute).http://apolloresearchinstitute.com/sites/default/files/future_work_skills_2020_full_research_report_final_1.pdfFitzpatrick, K. (2009). Planned Obsolescence: Publishing, Technology, and the Future of the Academy, New York University, NYU.

[8] Flanders, J. (2009). The Productive Unease of 21st-century Digital Scholarship, 3(3). Retrieved from http://www.digitalhumanities.org/dhq/vol/3/3/000055/000055.html

[9] Häyrinen-Alestalo, M., and U. Peltola. (2006). "The Problem of a Market-oriented University." Higher Education 52 (2): 251–281.

[10] Heimeriks, G., & Vasileiadou, E. (2008). Changes or transition? Analysing the use of ICTs in the sciences. Social Science Information, vol. 47, no.1, pp. 5-29.

[11] Hirsch, J. E. (2005). An index to quantify an individual's scientific research output. Proceedings of the National Academy of Sciences of the United States of America, 102(46), 16569–16572. doi:10.1073/pnas.0507655102

[12] Hurmelinna, Pia, Kalevi Kyläheiko, and Tiina Jauhiainen. (2007). "The Janus Face of the Appropriability Regime in the Protection of Innovations: Theoretical Re-appraisal and Empirical Analysis." Technovation 27 (3) (March): 133–144. doi:10.1016/j.technovation.2005.09.011.

[13] Institute for the Future (2011) Future Work Skills 2020. University of Phoenix. [Online] Available at: http://www.phoenix.edu/research-institute/publications/2011/04/future-work-skills-2020.html

[14] Jankowski, N. (2009). E-Research: Transformation in Scholarly Practice. NY:Routledge.

[15] Kanwar, Asha, Balasubramanian Kodhandaraman, and Abdurrahman Umar. (2010). "Toward Sustainable Open Education Resources: A Perspective From the Global South." American Journal of Distance Education 24 (2): 65–80. doi:10.1080/08923641003696588.

[16] Kenway, J., Bullen, E. & Robb, S., (2004). The knowledge economy, the techno-preneur and the problematic future of the university. Policy futures in education, vol. 2, no.2, pp.330–349.

[17] Kroes, N. (2012). Scientific data: open access to research results will boost Europe's innovation capacity. Europa Releases Rapid. Brussels. Retrieved from http://europa.eu/rapid/press-release_IP-12-790_en.htm?locale=en

[18] Lecercle, Doranne, ed. (2011). Giving Knowledge for Free: The Emergence of Open Educational Resources. Organisation for Economic Co-operation and Development. http://www.oecd.org/dataoecd/35/7/38654317.pdf.

[19] McCarthey, S. J., & McMahon, S. (1992). From convention to invention: Three approaches to peer interactions during writing. Interaction in cooperative groups: The theoretical anatomy of group learning, 17–35.

[20] Menkhoff, Thomas, Hans-Dieter Evers, and Chay Yue Wah. (2010). Governing and Managing Knowledge in Asia. World Scientific.

[21] Nielsen, M. (2011). Reinventing discovery: the new era of networked science. Princeton University Press.

[22] O'Reilly, T. (2007). What is Web 2.0: Design Patterns and Business Models for the Next Generation of Software (SSRN Scholarly Paper No. ID 1008839). Rochester, NY: Social Science Research Network. Retrieved from http://papers.ssrn.com/abstract=1008839

[23] Pearce, N., Weller, M., Scanlon, E., & Kinsley, S. (2011). Digital scholarship considered: how new technologies could transform academic work. in education, 16(1). Retrieved from http://dro.dur.ac.uk/8072

[24] Rheingold, H., & Weeks, A. (2012). Net Smart: How to Thrive Online. MIT Press (MA). Retrieved from http://books.google.co.uk/books?hl=en&lr=&id=o3EvRkgYv2MC&oi=fnd&pg=PR7&dq=%E2%80%98Net+Smart

%E2%80%98,+Howard+Rheingold+&ots=v27dybezO_&sig=xkDJ5cE2h1pXZZtTJJdiXNG_YDQ
[25] Seonghee, Kim, and Ju Boryung. (2008). "An Analysis of Faculty Perceptions: Attitudes Toward Knowledge Sharing and Collaboration in an Academic Institution." Library & Information Science Research 30 (4) (December): 282–290. doi:10.1016/j.lisr.2008.04.003.
[26] The World's Technological Capacity to Store, Communicate, and Compute Information. Science, 332(6025), 60–65. doi:10.1126/science.1200970
[27] Tissot, P. (2008). Terminology of European education and training policy. CEFEDOP-European Centre fot the Development of Vocational Training.
[28] Tytler, R., Symington, D., Smith, C., (2011). A curriculum innovation framework for science, technology and mathematics education. Research in science education 41, 19–38.
[29] Van Noorden, R. (2012). Europe joins UK open-access bid. Nature, 487(7407), 285–285. doi:10.1038/487285[a]
Jenkins, H., Xiaochang, L., Domb Krauskopf, A. and Green, J., 2010. Spreadability: If it doesn't spread, it's dead. Convergence Culture Consortium 2008 White Paper. Available from: http://convergenceculture.org/research/Spreadability_doublesidedprint_final_063009.pdf
[30] Wouters, P. (2012) Virtual Knowledge: Experimenting in the Humanities and the Social Sciences. MIT Press.
[31] Wouters, P. (2004). The Virtual Knowledge Studio for the Humanities and Social Sciences@ The Royal Netherlands Academy of Arts and Sciences. Program proposal. Amsterdam. Retrieved from http://www.knaw.nl/Content/Internet_KNAW/actueel/bestanden/The%20Virtual%20Knowledge%20Studio%20for%20the%20Humanities%20and%20Social%20Sciences.pdf
[32] Wuchty, S., Jones, B. F., & Uzzi, B. (2007). The Increasing Dominance of Teams in Production of Knowledge. Science, 316(5827), 1036–1039. doi:10.1126/science.1136099

Poster session

Chaired by Karmen Guevara, Computer Laboratory, University of Cambridge

Evaluating the E-democracy Dream:

A Case Study on Estonia

Wen Jian

Sciences Po
Paris, France
jian.wen@sciences-po.org

***Abstract*— This paper lays the groundwork for a comprehensive typology in uncovering the factors influencing the degree of shift towards e-democracy. The paper proposes an interaction model of factors in the analysis of e-democracy by examining the public sector, the private sector and the individuals. This interaction model is then used to discuss pertinent socio-economic and political impacts of e-democracy in Estonia. The discussion hopes to shed light on the obstacles and difficulties of achieving e-democracy and paves the way for future analysis of e-democracy implants in other countries.**

***Keywords*— e-democracy, interaction model, Estonia, e-voting, typology**

I. Introduction

Upon gaining independence in 1991, Estonia showed all signs of becoming a success story: the former Soviet state was rapidly transformed into an independent democratic nation with high rates of economic growth. This achievement is often observed alongside its extraordinary devotion of national resources to Information and Communication Technologies (ICTs). Within the last decade, Internet penetration rate in Estonia has increased from 28.2% in 2000 to 75.1% in 2010 [1], [2]. With a population well versed in Internet usage, many of the public services were then moved online. The entrance of ICTs in the political sphere is a nascent phenomenon that is currently been researched by sociologists and political scientists alike.

This paper makes a distinction between e-government and e-democracy. E-government encompasses the digitization of information related to the functions of the government and also in normal public services such as the filing of tax payments or the registration of a company. In this sense, the Internet becomes a bulletin board for government services and also a sort of "e-commerce" platform where citizens can perform their administrative obligations online [3].

E-democracy, however, refers to the participation of citizens in the governmental decision making process through the Internet. Under the branches of e-democracy, we can find e-rulemaking, where governmental agencies solicit public comments or opinions and take them into account before any decisions are made. Another form of e-democracy can be e-voting where the traditional electoral voting system is replaced by an online system.

E-democracy in this extended sense also means an evolution of representative democracy into participatory democracy whereby citizens' opinions carry weight in the policy formulation process. Representative democracy has been criticized to remain static over the years and the introduction of new ICTs seems to promise a revolutionary change towards a more participatory form of democracy. Frequently cited limitations of the present-day system include the following [4]:

1) The participation of the citizens is limited to the Election Day
2) Dissenting opinions within the parties are restricted or rejected
3) Parties may have hidden interests
4) The public control of parties is very limited.

How the Estonian hybrid model of a representative and participatory democracy can be generalized and studied for its effectiveness will be further discussed.

I will begin with a literature review and proceed on to a section on typology that will help examine the factors affecting the implementation of an e-democracy from the perspectives of the public sector, the private sector and the individual. In the third section, tensions and trade-offs among the aforementioned three groups will be analyzed in order to evaluate the potential benefits and difficulties in the implementation of e-democracy at a national level.

II. Literature Review

By many indices, Estonia is one of most wired countries in the world with high Internet penetration rate and well-serviced ICT infrastructure [5]-[10]. The European Union study of online public e-services ranked Estonia eighth in EU for online sophistication of its public sector services, and fourth for online service availability [11]. Although official statements suggest that the implementation of e-government and e-democracy in Estonia are due to long term planning, many scholars recently have shown that the process is in fact more heterogeneous than previously thought [12], [13]. At the local level, a digital divide, disparities in access to the Internet based on income and education, can be observed as the capital city Tallinn has a larger proportion of sophisticated users [14].

In seeking a more participatory form of democracy, the Estonian government set up the online platform *Tana Otsustan Mina* (Today I Vote - TOM) in 2001. After much media hype but failing to capture local participation, the website was shut down to be succeeded by *Osale.ee* in 2008.

The newer platform has more options of expressing opinions with ways to different between informal "comments" and formal "opinions" [13]. However, by the end of 2008, the response has been lackluster with few or no comments on most of the consultation projects [13].

Estonia also tested electronic voting during elections and has received considerable scholarly attention [15], [16]. It was implemented in 2005 during municipal elections and then for the first time, electronic voting was seen at the national level the same year. The proportion of e-votes increased from five percent in 2005 to about fifteen percent in 2009 national election [17].

The dream of revolutionizing representative democracy is what attracted the attention of many political scientists and scholars, tempted to follow the Estonian model and hoping to implant the same e-seeds in other countries. Some examples are the United States [3], Spain [18]) and, at supra-national level, the European Union's ambition in the construction of Intelcities [19]. Hence, a typology of e-democracy is especially important in understanding the determinants and conditions for the diffusion of e-democracy. Richard Rose did a comprehensive analysis in this respect [20]. However, this paper would like to propose its own set of characterizations in an attempt to improve upon some interactions unforeseen by the diffusion model proposed by Rose.

III. Typology

In order to examine the degree of polarization towards e-democracy, this paper chooses a typology that examines the three principle levels of forces: Public sector, private sector and the individuals.

TABLE I
FACTORS INFLUENCING THE DEGREE OF SHIFT TOWARDS E-DEMOCRACY

Public sector:	
National level:	• National income, • Sophistication of telecommunication infrastructure, • Political openness
Local level :	• Degree of urbanism, • Availability of public ICTs
Private Sector:	• Sensitivity of ICT changes • Sophistication of online services
Individual:	
Human Capital:	• Education level, • Income level, • Age
Social Capital:	• Degree of political involvement and interest • Psychological openness to new technology

A. Public Sector

First of all in the public sector, we examine the factors at a *national level*. With higher levels of national income, the country will have the ability to increase its spending in research and development of new ICTs. For Estonia, this progress came rapidly due to the support given by politicians such as former Prime Minister Mart Laar who were eager to portray themselves as a force of progress [13]. Hence political will must also exist in order to translate high economic growth into better ICT infrastructure. Furthermore, as identified by Richard Rose [20], a certain political openness is essential in allowing the fostering of ICTs. A contrasting example would be China where economic resources were instead being used to block the development of ICTs into tools of political opposition and dissent as exemplified by the "Great Firewall of China". Rose presciently noted that if political openness has not been achieved, ICTs could be used to mobilize political opposition through e-dissent. The recent Arab Spring epitomizes this influence of ICTs in the political sphere.

There are differences on a *local level* as compared to the national level where we examine the issue of the digital divide. The term "digital divide" refers to the gap in opportunities to access ICTs and to their use of Internet. For example between Tallinn and other Estonian cities, there are huge disparities in terms of public Internet access points per head [21]. In terms of impact of e-democracy, there will be huge inequalities when we make inter-city comparisons within the country. Hence the city's degree of urbanism and the availability of access to public Internet facilities is crucial in understanding the underlying inequalities that e-democracy will result in.

B. Private Sector

Kitsing [13] proposed that the private sector played an important role in cultivating the social culture of performing administrative work online through Internet banking. When there is a greater participation rate and closer integration of online services with daily life, people begin to demand more of these efficient services and grow accustomed to the digital life. This gives an impetus for the government to shift its services online. In the case of Estonia, it has been observed that the rate of use of online banking was higher than most European countries in 2005 [13]. In addition, this the *sensitivity of private companies to ICT changes* will influence the velocity of adaptation of technological changes among individuals. For example, with a high level of adoption of the mobile Internet services, more companies are tailoring their services to fit these new technological breakthroughs to help clients access their online services on the move. Private companies in this sense can be seen as a catalyst for an ICT culture to be formed. The level of *sophistication of online services* provided by private companies is hence an important measure of the level of Internet cultural change that citizens have gone through.

C. Individual Level

At the individual level, this paper identifies both human capital and social capital. Human capital relates to the basic characteristics of ICT users such as *education level, age and income level.* Education refers to the general education level of the user. Individuals with higher levels of education are generalized here to be rather sophisticated in their reasoning and critical thinking and understand the legality and boundaries of their opinions and views. Depending on the societal values, culture and degree of freedom of speech, we might observe different amounts of e-outputs from the intellectuals of the society. It is expected that younger citizens are more familiar with ICTs and Internet usage and are hence more inclined to use the online platforms to voice their opinions or to vote. However, an assumption made here is that proficiency in these ICTs will translate to higher accessibility to national politics and hence increase voting turnout and political participation.

This leads us to the point of social capital where the degree of political interest and openness to ICTs are both important factors working hand in hand. A person with high ICT familiarity but zero interest in politics would be indifferent to existing online platforms and the e-voting process. Hence the *impact* of ICTs in creating e-democracies is not by the degree of implementation of these technologies but by how much they can create political interest among those apolitical yet conversant in ICTs.

IV. Interaction Model of E-democracy

A. Individual-Public Sector Interaction in E-rulemaking

1) *Trade-off between national security and individual privacy:* The interaction model is built upon the typology mentioned in the previous section. This interaction framework will allow us to see the many trade-offs and tensions in the process of transformation towards a e-democracy. Between the individual and the public sector, there is a *trade off between national security and individual privacy.* As administrative work, opinions and voting are increasingly being digitized, there will be a proportionate growth in fear of intrusion of privacy or "e-surveillance" [3]. Many times, these data collected on individuals and companies can be used for monitoring of illegal activities such as terrorism. However, security breaches to these information vaults could be potentially dangerous to the individuals. Estonia experienced one of the deadliest cyber attacks on its government servers in 2007 [22]. This could potentially result in loss of faith and trust in the government's ability to keep individual or company sensitive data private.

2) *Trade-off between freedom of speech and legality:* Should anonymity of opinions be kept? If anonymity is allowed, the system will almost certainly fall prey to abuse. In 2001, Estonia set up the well-promoted online platform that allowed Estonians to submit proposed laws and amendments. Initially, anonymity of the user is ensured culminating in the absurd situation whereby Ministers had to start their responses by addressing "Dear Mickey Mouse" [13]. Anonymity was later removed and users had to identify themselves. E-opinion is a relatively new concept and net users might not be trusting enough to reveal their true identity online for fear of leaving ineffaceable digital footprints that might bring about legal issues. Not surprisingly, by 2007, there were only less than 7,000 registered users with a total population size of 1.4 million [13]. To what extent should the online channels be regulated? How can freedom of speech be preserved while not subjecting it to hateful abuses? These are some of the tricky questions that have to be addressed before a hasty launch of such channels.

B. Private Sector-Public Sector Interaction in E-voting

1) *Trade-off between cooperation and checks and balances:*

Should the government invest in its own research and development of its online capabilities or should it outsource to private companies? How can checks and balances exist for governments and private companies alike so that citizens' rights are protected in face of e-surveillance? Examining this interaction allows us to see the complex issues at work here. Cost-benefit analysis of e-democracy often do not take into account these subtle changes in relationships between the principle agents and this is often why e-voting system always seem to fail [14], [23]. The cost of setting up the e-voting system has to include the amount of new checks and balances that the state has to instate so as to ensure its fairness. In the case of Estonia, personal ID chip cards and voting card readers have to be issued to all to minimize fraud. Checks on voting programming systems, and new security measures have to be put in place so that the systems are not subjected to hacks. Furthermore, e-voting do not allow for rechecks that the traditional system would permit hence increasing the risks for error. Taking all these into account, the interaction model offers a better picture of the pros and cons of e-voting than do a simple cost benefit analysis.

V. Conclusions

This paper has paved the ground for a comprehensive typology in understanding the factors influencing the degree of shift towards e-democracy. In its extension, I have proposed an interaction model of viewing the cost and benefits of institutionalizing e-democracy. The introduction of e-rulemaking and e-voting is not merely a policy change but requires a fundamental readjustments in socio-cultural attitudes and psyche towards integrating ICTs into the foundation of the society. The model that this paper proposes does not assume that a democratic society is already in place. It is an objective observation of the interactions that would allow for e-democracy to take root. It, however, does not entitle us to the extended dream of revolutionizing non-democratic societies through ICT proliferations. Although such instances could be a plausible outcome of the model, as exemplified by the recent Arab Spring, it has to be viewed in

its own rights. The model hopes to show that the implantation of e-democracy is a complex maneuver depending on various sociological, cultural, political and economical factors.

The typology outlined in this paper is not exhaustive but should serve as a general outline and encourages interdisciplinary research on the impact of ICTs in the political sphere. Whether e-democracy will eventually remain a dream or reality will depend on our identification of interactions between principal groups and new innovations in satisfying all interests among them.

REFERENCES

[1] ITU. (2000). *ITU Information Society Statistical Profiles 2000*. Available: http://www.itu.int/ITU-D/ict/publications/

[2] ITU. (2010). *ITU Information Society Statistical Profiles 2010: Europe*. Available: *http://www.itu.int/ITU-D/ict/publications/*

[3] J. C. Reitz, "E-government," *The American Journal of Comparative Law*, vol. 54, pp. 733-754, 2006.

[4] J. M. a. Moreno-Jiménez and W. Polasek, "E-Cognocracy and the Participation of Immigrants in E-Governance," *Reihe Ökonomie*, 2005.

[5] United Nations, "Global E-Government Readiness Report 2004: Towards Access for Opportunity," United Nations, New York2004.

[6] United Nations, "Global E-Government Readiness Report 2005: From E- Government to E-Inclusion," United Nations, New York2005.

[7] United Nations, "UN E-Government Survey 2008. From E-Government to Connected Governance," United Nations, New York2008.

[8] United Nations, "United Nations E-Government Survey 2010. Leveraging E-Government at a Time of Economic and Financial Crisis," United Nations, New York2010.

[9] Economist Intelligence Unit, "E-Government in Central Europe. Rethinking Public Administration," Economist Intelligence Unit, London2004.

[10] Economist Intelligence Unit, "E-Readiness Index," Economist Intelligence Unit, London2005.

[11] European Commission, "Online Availability of Public Services: How is Europe Progressing?," European Commission Directorate General for Information Society and Media, Luxembourg2005.

[12] P. Runnel, P. Pruulmann-Vengerfeldt, K. Reinsalu, "The Estonian Tiger Leap from Post-Communism to the Information Society: From Policy to Practice," *Journal of Baltic Studies*, vol. 40, pp. 29-51, 2009.

[13] M. Kitsing, "Success Without Strategy: E-government development in Estonia," *Policy & Internet*, vol. 3, 2011.

[14] K. Vassil and T. Weber, "A bottleneck model of e-voting: Why technology fails to boost turnout," *New Media & Society*, pp. 1336-1354, 2011.

[15] R. M. Alvarez, T.E. Hall, A.H. Trechsel, "Internet Voting in Comparative Perspective: The Case of Estonia," *PS: Political Science and Politics*, vol. 42, pp. 497-505, 2009.

[16] D. Bochsler, "Can Internet Increase Political Participation? Remote Electronic Voting and Turnout in the Estonian 2007 Parliamentary Elections.," presented at the Internet and Voting, Fiesole, Italy, 2010.

[17] Vabariigi Valimiskomisjon. Elektroonilise hääletamise statistika [Online]. Available: http://www.vvk.ee/index.php?id=10610

[18] A. I. Alonso, "E-participation and local governance: A case study," Department of Law and Political Science, University Rey Juan Carlos, Madrid, 2009.

[19] P. Nijkamp and G. Cohen-Blankshtain, "Opportunities and pitfalls of local e-democracy," unpublished.

[20] R. Rose, "A global diffusion model of e-governance," *Journal of Public Policy*, vol. 25, pp. 5-27, 2005.

[21] M. Kalkun and T. Kalvet, "Digital divide in Estonia and how to bridge it," Emor and PRAXIS Center for Policy Studies2002.

[22] R. Vamosi. (2007). *Cyberattack in Estonia-what it really means*. Available: http://news.cnet.com/2008-7349_3-6186751.html

[23] E. Abu-Shanab, *et al.*, "E-voting systems: A tool for e-democracy," *Management Research and Practice*, vol. 2, pp. 264-274, 2010.

Peer-production online communities infrastructures

Melanie Dulong de Rosnay
CNRS Institute for Communication Sciences
20 rue Berbier-du-Mets
75013 Paris, France
melanie.dulong-de-rosnay@iscc.cnrs.fr

***Abstract*—This article analyses peer-production online communities according to their technical and governance architectures level of centralization and decentralization. Peer-production online communities can be defined as projects or platforms distributing or producing digital information based on users' voluntary contributions. The resources technical characteristics, the rules organizing provision of the service, production, access and appropriation of the resources, as well as the platforms design will have an influence on the excludability of the users. The level of decentralization or distribution of the architecture of these platforms will have an impact on governance, exclusion, ownership and reuse of the resources and services developed by communities.**

***Index Terms*—peer production; commons; governance; distributed architectures, access.**

I. Introduction

This article[1] proposes an analytical framework to analyze the provision, production and appropriation (as understood in [1]) characteristics of peer-production online communities understood as forms of collective action. The typology presented in the paper is based on the level of decentralization of the projects' technical, governance and legal framework. Suggesting axes of classification aims at better understanding the impact of platforms design and governance choices on access to digital resources, sustainability of the hosting platforms and of the produced resources and autonomy. Each of the four areas, depending on the level of centralization or decentralization of architecture or governance will be contextualized with examples of platforms and consequences of such infrastructural choices.

II. Digital Informational Resources Governance

Digital information can be considered as a public, non-rival and non-excludable good. After the investment for production of the first unit, it can be distributed through the networks and reproduced by digital technologies for a marginal cost of zero.

Two models of governance have been observed for the production and the distribution of digital informational resources, the market and the commons-based approach [2].

First, information can be treated as a private or club good, and enclosed by providers or producers, for instance by using copyright law, encryption technologies or contracts to restrict access and control reuse. The market approach reestablishes artificial scarcity and excludability by controlling access and reproduction, leading to a “second enclosure movement on the intangible commons” [3].

But because reproduction and distribution can be achieved for free, online communities have also been able to develop other collaboration forms or institutions for collective action, namely “commons-based peer-production” [4], for instance free software. Distributed peer-production has been evaluated as sustainable, people are able to dedicate time to projects and find incentives to participate to communities [5].

It is important to distinguish the property status of the resources, the nature of the resources and the organizational form of production. Peer-production doesn't infer anything about the platform governance and the resources ownership status and it can be distinguished among communities who produce public goods, private goods, club goods and commons pool resources. The architectural design of the infrastructures used by these communities helps identifying the type of institution for collective action. It is claimed that the level of centralization has an effect on the level of excludability.

III. Architecture Models of Peer-Production Online Communities

The level of centralization of the architecture of peer-production online communities can be studied at various levels: the technical infrastructure of the platform, the governance rules of the platform and the ownership of the resources produced by the peers.

A. The Technical Architecture

Online communities, such as applications and networks in general, can be centralized around a server owned and managed by a central authority.

Alternatively to the traditional client-server centralized model, a technical architecture can be called decentralized, distributed, or peer-to-peer, when it works without intermediary or hierarchy, without a central node or centrally-controlled servers. This is the original architecture of the Internet and of peer-to-peer softwares allowing the exchange of files between peers without a central server being responsible or in control of the nodes. Centrally-controlled platforms can also be structured in some decentralized manner, for instance with cloud computing allowing to store resources in external

servers, but for the purpose of the proposed typology, these services will technically be considered as centralized if they are controlled by a central authority. Even if there are no strictly pure decentralized or centralized communities, the use of such models is helpful to characterize tendencies. An interface design giving more control to the platform owner is centralized while an architecture distributing power, responsibility and freedoms among users will be a decentralized infrastructure.

B. The Governance Architecture

Social architecture institutional arrangements will reflect on participation rules applicable to the users. They can also be classified from open to closed governance architectures. Legal rules governing the ownership of the resource, the right to access and reuse it as also set by the platform's terms of use or license agreement, are also part of the governance architecture.

A platform will have a centralized governance if users are excluded from its design and if the participation rules give control to a central authority. Decentralized governance will involve users in some democratic or participatory decision-making process [2] in which peers will have a word or an action on the design and the rules governing the platform, the participation and the resources.

Centralized ownership will concentrate the property of the resources produced by the peers in the hand of the platform owner. Decentralized ownership system will see the resources commonly or individually owned by the peers who are producing them.

Common property, public property and private property rules can be chosen for both the governance (rules of production and maintenance) and for the appropriation (rules of ownership of the resource output).

IV. Analysis of Communities According to their Architecture Models

I evaluate the combined impact of the level of distribution/centralization of the architecture, governance and ownership arrangements on the excludability of those platforms, the potential restrictions on consumers' rights and users' rights to create, access and reuse the resource.

The following table illustrates the models breakdowns as analyzed in the following sections according to the level of centralization/decentralization of the architecture and governance.

TABLE I. Architecture Models

	Centralized Architecture	Decentralized Architecture
Centralized Governance	Flickr Facebook (*section A.*)	Über Skype Wuala 1.0 (*section C.*)
Decentralized Governance	Wikipedia (*section B.*)	Kune Diaspora Faroo (*section D.*)

A. Centralized Architecture and Centralized Governance

Flickr, Facebook or Twitter provide platforms to publish resources produced by peers. They are hosted on central servers controlled by the platform owners. The technical infrastructure embeds the excludability of the user by the platform, allowing arbitrary censorship based on users participation choices and the type of resource.

There is no involvement of the community in the platform design or in the definition of the governance rules. These communities rely on peer production, but the property-regime is not commons-based. The peers can neither control the terms of use of the service, nor retrieve their production from the system and reuse it in another platform.

B. Centralized Architecture and Decentralized Governance

Wikipedia has been studied in the literature as a collective organization for public good provision (e.g. [6]).

Wikipedia has a centralized architecture; the servers are controlled by the Wikimedia Foundation. There is excludability and censorship at the production level for the individual contributor exercised by the peers following the sustainability rules defined by the community. “Without the ability to control the resource provided by a legal right to exclude content, quality could not be maintained” [7]. Governance is distributed among peers, with the re-introduction of a level of centrality through the power of the editors and the administrators.

There is no excludability from the collective contribution because of the copyright institutional arrangement. Open licensing with the use of a copyleft license ensures peer-production will remain commonly owned. The Creative Commons Attribution Share Alike license ensures traceability of the resource and prevents private appropriation or central ownership; no one can restrict others from accessing and reusing the common resource. If a peer wants to reuse and modify the resource, the result should be distributed with the same license, making it available to all. The platform is characterized by:

- A decentralization of the maintenance, the production and the monitoring,
- A relative re-centralization of the excludability of contributions by the administrators and arbitration committee control,
- A centralization of the production servers,
- A relative decentralization of the governance [7]: peers participate to the modification of the rules, the rules can't be modified without a vote,
- A commons-based licensing framework avoiding private/central appropriation of the resource produced by the peers; copyleft can be interpreted as a distributed ownership and a re-introduction of some sort of excludability: the resource is not in the public domain openly accessible for all, but can be used according to some rules aiming at sustainability and availability for the community and everybody. Copyleft property rights are an institutional

arrangement preventing free riders from privatizing resources.

C. Decentralized Architecture and Centralized Governance

Über, Skype, Wuala 1.0 are examples of centrally-controlled platforms using the features of a decentralized technical architecture. Peers are creating information about the localization and the rating of taxis available in the area where the user of the Über mobile phone application is geolocalized. Skype users are becoming nodes for direct communication between peers, and providing online storage for all users of the community. Wuala in its 1.0 version [9] was a peer-to-peer online storage provider coordinating storage of files in the computers of the peers, not only in a central cloud server. Data are fragmented, encrypted and made redundant in order to allow a user to retrieve stored data at any time. There are certain rules and incentives about the amount of time peers have to be online in order to allow the retrieval of data by the other peers at any time.

These services institutions are centralized: governance, terms of use and ownership of the platforms are controlled by central companies. There is excludability in the sense that terms of use are not favorable to users, data security is a black box.

Faroo is a peer-to-peer search engine. The company claims to be a “democratic, attention based ranking search engine”, an “alternative to information monopoly”. Its architecture protects privacy because queries and results are encrypted, and is resistant to censorship and request of public authorities to access users queries or results because the index of the search results is distributed and redundant. The absence of search logs provides privacy as a resource by architecture, not only by policy.

The governance and appropriation of the results of the work produced by peers, the value produced by the collective searches, is unclear. There are no terms of use, but the platforms are not open source and have closed business models.

D. Decentralized architecture and decentralized governance

Kune is a “free distributed web platform for collaborative work” providing service for the collaborative edition of documents (like Google Doc), the production and management of content between peers (like wikis, mailing-lists, calendars), the storage and sharing of resources among communities (like Dropbox). There is no central point of control, no excludability, no censorship. Projects can be hosted on the server of the choice of the users, avoiding problems of interoperability and appropriation of user generated data which is observed in proprietary platforms providing services in centralized architectures [10].

V. The Impact of Distributed Architectures on Users Creativity, Control and Access

The typology proposed to analyze platforms architecture and governance according to their level of decentralization has been illustrated by some examples. Excludability is correlated with the level of centralization.

Centralization characteristics facilitates control, features and terms of use that are not favorable to the user: arbitrary censorship, risk of privatization of the produced resources, restriction to access the platform, to retrieve the production, to reuse it, difficulty to assess privacy and security of the data.

Decentralization features will give more control to the user on its data and on produced resources. The absence of central control system increases robustness and performances as well as resilience against attacks and prevents surveillance [11]. Distributed architecture can be used by projects for privacy and anonymity purposes: Commotion wifi mesh network, Diaspora and Friends of Wikileaks distributed social networks, Tor anonymity peer-to-peer routing project.

Decentralization protects privacy and access to information, but can also facilitate cybercriminality. When data and process are fragmented, it is harder to allocate responsibility and locate actions on one agent. This makes the law apparently more difficult to enforce to peer-to-peer architectures than on centralized platforms that can be controlled and easily closed by public authorities (e.g. Megaupload in 2011).

But some form of decentralized control can be introduced through commons-based peer ownership, with open licensing as a way to reintroduce (decentralized) control on the resources produced by peers in decentralized architectures against exclusion in the form of private appropriation. The effects of the combination of architecture design and policies should be further investigated, in particular to analyze possible forms of regulation in decentralized models, with more systematic and in-depth observation of more platforms.

Acknowledgment

This research benefits from contributions by Primavera De Filippi and Francesca Musiani as part of the ADAM interdisciplinary project on Distributed Architectures and Multimedia Applications (http://adam.hypotheses.org/) supported by a grant from the French ANR (Agency for National Research).

References

[1] E. Ostrom, Governing the Commons. The Evolution of Institutions for Collective Action, Cambridge University Press, 1990

[2] M. Fuster Morell, Governance of online creation communities : Provision of infrastructure for the building of digital commons, PhD thesis, European University Institute, 2010.

[3] J. Boyle, “The second enclosure movement and the construction of the public domain”, Law and Contemporary Problems, Vol. 66, pp. 33-74, Winter-Spring 2003.

[4] Y. Benkler, The Wealth of Networks: How Social Production Transforms Markets and Freedom, Yale University Press, 2006.

[5] C. Shirki, Cognitive Surplus: Creativity and Generosity in a Connected Age, Penguin Group, 2010.

[6] L. F. Heredia, Collective Organization for Public Good Provision: The Case of Wikipedia, University of Victoria bachelor thesis, 2012.

[7] J. Boyle, “Mertonianism Unbound? Imagining Free, Decentralised Access to Most Cultural and Scientific Material”, in E. Ostrom, and C. Hess (ed.), Understanding Knowledge as a Commons From Theory to Practice, The MIT Press, Cambridge, Massachusetts, 2006.

[8] A. Forte Andrea, V. Larco Vanessa, A. Bruckman, “Decentralization in Wikipedia governance”, Journal of Management Information Systems, 26(1), 49-72, 2009.

[9] F. Musiani, Dwarfs without giants. Decentralized architecture and Internet-based services, PhD thesis, Ecole nationale supérieure des Mines de Paris, 2012.

[10] P. De Filippi, M. Said Vieira, The Commodification of Information Commons. Proceedings of the 1st Global Thematic IASC Conference on the Knowledge Commons, Building Institutions for Sustainable Scientific, Cultural and genetic Resources Commons, Université catholique de Louvain, Louvain-la-Neuve, Belgium, 12-14th September 2012.

[11] A. Guadamuz, Networks, Complexity and Internet Regulation, Edward Elgar, 2011.

The Virtual Party Systems Project (*ViParSys*): Understanding Political Strategy, Party Organizations, and Political Networks, through Hyperlink Analysis

António Rosas*, Darren Lilleker†, Karolina Koc-Michalska‡ and João Caetano§
*Universidade Aberta, Lisbon and CAPP–Technical University of Lisbon, Portugal
Corresponding author. Email: anjoserosas@gmail.com; URL: http://antoniorosas.wordpress.com
†Bournemouth University, Bournemouth, United Kingdom
Email: DLilleker@bournemouth.ac.uk
‡SciencesPo., Paris, France
Email: karolina.kocmichalska@sciences-po.org
§ Universidade Aberta, Lisbon and CLEPUL–University of Lisbon, Portugal
Email: Joao.Caetano@uab.pt

***Abstract*—This poster intends to present *ViParSys*, an innovative international and global research project that uses hyperlink analysis to study comparatively and across time virtual political party systems. Based on state-of-the art literature and empirical research on political communications and computer based technologies, *ViParSys* is now completing its pre-launch phase, after which it will go online and start collecting, and analysing, large amounts of hyperlink data from several national virtual party systems, while simultaneously creating a database for researchers and interested publics. In this poster we will briefly contextualize this type of research and the project goals, before presenting some preliminary results of four virtual party systems (Poland, France, Great Britain and Portugal). As it is now and promises to be, *ViParSys* can be an important interdisciplinary tool in the sub-field of empirical and theoretical research on political parties communications online.**

***Keywords*—Political parties, communications, hyperlink analysis, virtual party systems, database**

I. Introduction

HYPERLINKS are widely described as the building blocks of the World Wide Web, "the basic structural elements of the Internet" [1] (see also, in this context, [2], [3]). Hyperlinks connect different web addresses and enable traffic directly from one webpage, document, image, or word, to another resource on the Web. Hyperlinks are thus the basic resources enabling us to "surf", or browse, the WWW, looking for pages and for information quickly and easily.

As structural components of the architecture of the WWW, hyperlinks can, therefore, be intentionally selected in the design of a website, in order to build strategic links between pages of a site, between websites to subsidiary sites, or between websites belonging to different individuals, groups or organisations [4]. As such, it is reasonable to assume that *Hyperlink Analysis* (HA from now on) can inform researchers a lot about political parties online behaviour, namely about their strategy, communication practices, as well as the capacity of the Internet to democratize communications and foster empowerment, equality and visibility to organizations, social groups and individuals.

Having this in mind, *Viparsys* will have a double role. It will provide scholars with exhaustive and regular databases for research, while, at the same time, it will offer national, cross-national and longitudinal studies of its own, based on an empirical and open approach to this sub-field of research. Over the next lines, we will begin by offering *ViParSys* theoretical guidelines, although we must repeat that those are mere baselines for our future research that can be updated or even discarded. After that, we will focus on some arguments for developing this project, develop further over its main characteristics, and present some preliminary results.

Concretely, we argue that within the political context, HA can provide very useful insights into four interrelated elements of political parties' overall online communications: strategy; connectedness; visibility; and the extent to which the World Wide Web is democratising offline party politics and representative democracies.[1]

Firstly, hyperlinks of political parties' websites can be used as proximate proxies for their online communications strategy, especially when looking to which organisations they choose to connect [11]. Outbound links (connections to) can thus indicate what type of network the political organisation wishes to create. Consequently, several conceptualizations are possible to assess strategy, using indicators like geographic

[1]Political parties began using the Internet in the 90s and since then this practice has expanded both rapidly and exponentially. Albeit initial research tended to be speculative and utopian [5], systematic empirical studies began to appear in the late 1990s, focusing mainly on mainstream political parties ([6]–[10], all cited in [3]), although other types of political groups soon began also to attract attention, like social movements and extremist or terrorist groups.

scope (local, national, or transnational), institutional profile (elite, non-elite, partisan, independent, or news media, for example), or ideological profiles [2], [3], [12], just to name a few. Moreover, strategy can be assessed through the analysis of the functions carried out by hyperlinks. For example, hyperlinks can be used to create a brand image [13], to increase credibility – by linking to independent fact checkers, news sites or NGOs [1], etc. –, or to build a network of independent actors and activists [14]. The nature and functions of outbound links can give us, thus, valuable insights regarding the overall online strategy of an organisation.

Additionally, the analysis of the volume of outbound and inbound links (outgoing and incoming connections) can indicate how well connected the organisation is with the other actors that populate the World Wide Web, or how embedded the organisation is, regarding the virtual ecology that surrounds it. Empirical research carried out till now has long noted that relational networks are formed by flows of communication [15]. In network analysis, connectedness can be assessed by examining the number of outbound and inbound links, but also by measuring the level of hyperlinking reciprocity [16] between actors. Studying connectedness and reciprocity can thus help us in determining the extent to which a network is open or self-contained, and this can be done, for example, by analysing the geographic, organisational and ideological homogeneity of organisations that have strong relational ties [17]. These provide indicators of both strategy and connectedness from an internal and external perspective.

Thirdly, the extent of inbound links are generally interpreted as a measure of visibility, or prominence, of pages. This is based on the assumption that the number of connections that an organisation gets provides a good estimate of the amount of its importance in a network and of the amount of traffic that its pages attract. According to Hindman et al. [18], the number of inbound links to a site is a very good predictor of the volume of the traffic to the site (see also [19]). This assertion is based on the way search engine algorithms tend to return heavily-linked sites. Additionally, visibility is also believed to be an important factor for the expansion of a network. This is most visible with links between political organisations and websites that attract a great deal of traffic, such as mainstream news organisations' websites [20].

Finally, hyperlink analysis can measure the extent to which the World Wide Web is democratising political parties and party politics. This can be assessed empirically by examining the extent to which some websites, webpages, weblogs or other sites of non-elite or grassroots organisations, are embedded within a network, or by determining the number of connections that are established to political parties' sites by news sites or high profile political organisations [21]. As we know, the flow of ideas through the Internet can have highly positive impacts for democracy, as it is particularly demonstrated through the number of links distributed via social media or by the degree of interconnectedness between the electoral online public sphere (parties and news media) and the broader political online public sphere [22]. The latter enhances engagement, as it is argued does a heavily hyperlinked online media that facilitates traffic flow across the political online public sphere [23]. On the other hand, it can indicate whether the virtual party system (VPS) is more transparent, participatory and democratic than its offline counterpart, and whether online networking is transforming the party along democratic criteria. Additionally, seeing how offline organizations are networking online can be a very effective way of examining the benefits of being online and how the Internet is affecting these organizations and their strategies. Are Internet communications favouring some parties more than others? Or establishing a new balance of power between them? Are newcomers, fringe parties, or non-conventional political actors, like online social movements and new media social movements, transforming party systems, by gaining visibility and connectedness that are not proportional to their offline power and organizational muscle and status? With the advent, and the growing use, of the Internet for political participation and opposition, are we seeing a new era of party politics or, even, the advent of new organizational forms of conventional politics?

Although HA can perform invaluable services to the study of political parties online communications, there is no project, to our knowledge, that does it in a systematic, comparative and longitudinal way. Moreover, apart from the fact that most studies do limited and *ad hoc* case studies or incidental comparisons between parties' digital networks (and not between complete virtual party systems), we are confronted with the fact that these studies usually advance different theoretical approaches and research techniques. In our perspective, it is, thus, time to engage in a more systematic, sustained and reflexive approach that can gain much from a continued examination of virtual party systems that offers a fresh baseline for researchers while adopting an open perspective that is largely sustained by an inductive approach. Having this in mind, *ViParSys* will try to respond to the above questions in a open and empirically way, reformulating theory from the ground up and employing new methods and techniques for studying medium and large-N samples of virtual party systems and cases. Our theoretical questions will be thus equated as simple guidelines that will be always open to be reformulated or even bypassed, as new data is collected and new insights are gained from familiarity with the data and by analysing deeper and more complete hyperlink databases.

Simultaneously, as it will work as a online platform for researchers and all those interested in the sub-field, *ViParSys* intends to offer a valuable tool for researcher to develop their own theoretical and methodological approaches to the sub-field and thus enrich it with the renewed strength that, in our mind, is even more necessary as the Internet, social media and new media in general, is transforming politics and proving its growing importance in the study of political parties and their post-modern forms of communication. In the following section we will offer some preliminary results coming from the study of four virtual party systems (France, Great Britain, Portugal and Poland). This will be done without having the intention of applying straightforwardly the theoretical scheme delineated above, as we already mentioned, but with the aim of showing in a more linear and schematic way how the data that is available so far can answer to these and other questions, or how new techniques can be called by a systematic and comparative framework in order to enrich our knowledge of this ever growing and important sub-field of political communications. After this brief presentation, we will offer some concluding and additional remarks on new research questions and arguments for continue developing

ViParSys.

II. Research and findings

A. Research

Although *ViParSys* intends to break new ground, its reliance on link analysis is inspired by some prior work done by one of its researchers and by scholars working in the sub-field. A preliminary study serving as a springboard for this project was carried out by Rosas et al. (see [12]), who used *Web Mining* and HA to identify for the first time the Portuguese *virtual party system* and to study it across several dimensions. These had been broadly specified by Robert Ackland and Rachel Gibson, in their seminal paper on "the complex structure of hyperlinks surrounding the far right and other party sites" in six democracies (Austria, France, Germany, Italy, the UK and Australia) [3]. As such, the Portuguese study closely matched the conceptual scheme and their operationalizations as they had been proposed by Ackland and Gibson. Accordingly, the Portuguese *virtual party system* was scraped during September 2011 and studied across three basic dimensions: (1) scope or size; (2) content (2.1 international, national and local focus; 2.2 domain focus (i.e. commercial, educational, or non-governmental); 2.3 ideological insularity) and (3) overall visibility, or prominence. Also, as in [3], [12] constructed a "Political Connectivity Database" (PCD) composed by two rings of unique pages connected with the parties sites. This means that the observations consisted of the parties websites, plus the unique pages connected both directly and indirectly with these.

It must be clear, nonetheless, that either [12] nor [3] used a complete, systematic and longitudinal approach in their work, being in this respect perfectly in line with the vast majority of the studies that we know. While the Portuguese case envisaged for the first time a whole virtual party system, the limited comparative framework proposed by Ackland and Gibson was not directed at studying complete sets of virtual party systems, but some sets of actors and ideological families across countries. This and other studies differ thus much from our standpoint, where complete virtual party systems will be regularly collected, archived, posted in a site for being available to the public and analysed by our team of collaborators.

However, we must notice that for now *ViParSys* will be only looking for proximity networks, i.e., for networks formed by seed sites and first rings, while it equates several alternative methods for looking deeper into the networks, using, for instance, random-walk sampling. As so, the project has began by producing one ring deep network for each of the four countries comprising its initial country set, and has done it using *VOSON* [24] software to crawl the WWW and *Mathematica* [25], *Pajek* [26], *Networkx* (Python) [27] and *Gephi* [28] to prepare, analyse and graph the data. The result was four Political Connectivity Databases formed by pagegroups (*ViParSys* uses aggregated pages, instead of disaggregated ones) and their immediate connections (proximity networks). At the same time, while the seed sites used for web crawling the proximity networks can be selected using different methods, *ViParSys* uses is employing for now only expert judgements. This means that each researcher chooses what parties must be web crawled based on their local knowledge of national party systems (see Table I for details).

TABLE I: Parties used as seed sites - France, Portugal, Great Britain and Poland

Party	Designation
Parti Socialiste	PS
Union Pour Un Mouvement Populaire	UMP
Europe Ecologie Les Verts	EELV
Front de Gauchel	FdG
Centre Pour La France	MoDem
Front National	FN
Parti Radical	UDI
Le Parti Communiste Français	PCF
Debout La République	DR
Mouvement Républicain et Citoyen	MRC
Le Nouveau Centre	NA
République Solidaire	RS
Mouvement Pour La France	MPF
Parti Radical de Gauche	PRG
Parti Chrétien-Démocrate	PCD
Lutte Ouvrière	LO
Nouveau Parti Anticapitaliste	NPA
Solidarité et Progrès	S&P
Chasse, Pêche, Nature, Traditions	CPNT
CAP21	CAP21
Le Mouvement Écologiste Indépendant	MEI
Partido Socialista	PS
Partido Social Democrata	PSD
Partido Popular	CDS-PP
Partido Comunista Português	PCP
Bloco de Esquerda	BE
Conservatives	NA
Labour	NA
Liberal Democrats	NA
Scottish Nationalist Party	NA
Plaid Cymru	NA
Unionist Party	NA
Social & Democratic Labour	NA
Sinn Fein	NA
UK Independence Party	NA
British National Party	NA
Platforma Obywatelska	PA
Prawo i Sprawiedliwosc	PiS
Ruch Palikota	RP
Sojusz Lewicy Demokratycznej	SLD
Polskie Stronnictwo Ludowe	PSL
Kongres Nowej Prawicy	KNP
Polska Partia Pracy	PPP
Polska Jest Najwazniejsza	PJN
Samoobrona	NA
Prawica Rzeczpospolitej	NA
Solidarna Polska	SP
Unia Pracy	UP
Liga Polskich Rodzin	LPR

B. Some inaugural findings

Due to the necessary brevity of this poster, our analysis will cover some macro and meso attributes of four virtual party systems, which will be described using predominantly quantitative criteria. This analysis will be followed by some micro-level descriptions of party connections, based on the edges list included in the database that was created so far.

One of the things that are immediately apparent in the study of virtual party systems is that their size can vary significantly between countries. Even if we control for the number of initial pages used as seeds for the web crawl, it is apparent that European conventional politics online can reveal real world cultural and organizational differences.

Albeit the British and the French party systems stand

up by their own and rank at the top, even controlling for large sets of seeds, the position of Poland and Portugal is interesting, because even taking into account that thirteen parties were web crawled in the case of the first of these two countries, the number of their neighbours is clearly non proportional to that number (Tables II and III).

The same is truth regarding the density of the edges (hyperlinks). While the Polish network has 244 nodes and 356 edges, Portugal, with only five seed sites, has 419 and 581, respectively. This can tell us a lot about how national conventional politics is performing online and how pages are being strategically used (or not) for communications and networking. Apart from the fact that their differences in networking are very significant, we can also use identical layouts to gauge for the types of patterns and their differences (see Figures 1 and 2, showing the proximity networks, or one ring deep networks of Portuguese and Polish virtual party systems). In fact, even using different layout algorithms, each virtual party system can reveal a lot of itself by simply appearing before our eyes in the form of a graph. Certain VPSs have many hubs [29], others are predominantly dominated by authorities, some others have many small and marginal nodes surrounding big clusters, while others are less centralized and more uniformly distributed.

TABLE II: National networks by size of nodes

Countries	Nodes weighted by number of parties
Britain	215.8
France	123.1
Portugal	83.8
Poland	25.4

TABLE III: National networks by size of edges

Countries	Edges weighted by number of parties
Britain	276.2
France	181.0
Portugal	116.2
Poland	17.4

Fig. 1: The Polish proximity network.

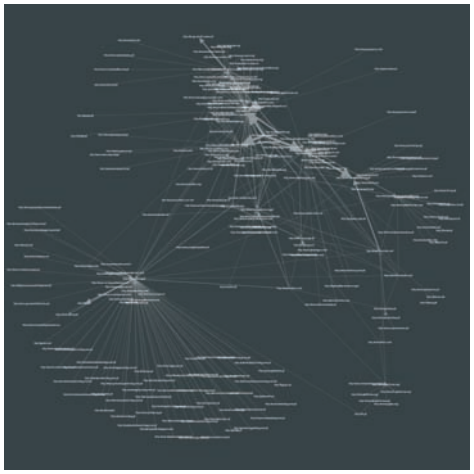


Fig. 2: The Portuguese proximity network.

This can obviously be assessed, for these two cases, by many means. One of these is by looking at tally bar charts representing the distributions of degrees or by looking at the distribution plots of values for hubs and authorities in each network, as these two tasks can be easily performed in an automated way by *ViParSys*. As we can see next page (Figures 3 and 4), although the Portuguese VPS has less political actors, its big players have more densities of connections than the Polish ones, not mentioning the fact that Portuguese secondary players are stronger and more equally distributed than their Polish counterparts. Additionally, regarding hubs and authorities (Figures 5 and 6), it becomes apparent that the Portuguese proximity network is stronger in hubs than the Polish, but that this one competes better regarding authorities, although on a smaller scale of magnitude.

When looking at the micro level of connections, *ViParSys* can also provide useful information as it will offer, for each wave, edge lists per country and per party. This will enable anyone to easily compare and assess who is connected, in each wave, by whom, and to whom it connects. As each VPS will grow deeper, the simple fact that this information is available in a systematized format and can be easily accessed online, will facilitate immensely the ability of analysts in that task, even when working with big chunks of data. Using one of these lists, one can straightforwardly supplement quantitative assessments based on SNA metrics, with qualitative examinations of connections and conclude, for instance, that Portuguese and Polish parties are also much connected to the media (miming more developed and extensive networks, like the French or the British), that left parties are more connected than center and right parties in Portugal (the BE and the PCP), while in Poland the same is truth for the peasant centrist PSL and the post-communist SLD, or that ideological homophily is apparently more praised in Poland than in Portugal. How these insights can relate to certain quantitative attributes or with some contextual variables within each country can be, thus, as interesting as knowing how they evolve over time or how these two VPSs can be compared across time, or across some variables, or as a whole.

Fig. 3: The Polish proximity network - Degrees

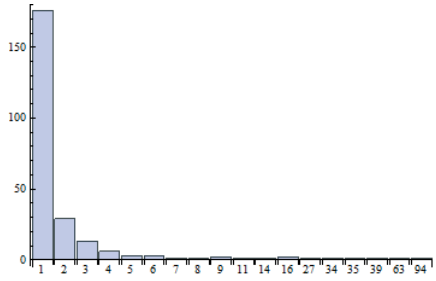


Fig. 4: The Polish proximity network - Hubs and Authorities

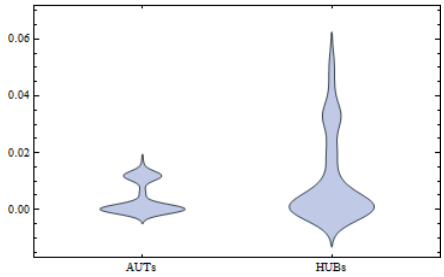


Fig. 5: The Portuguese proximity network - Degrees

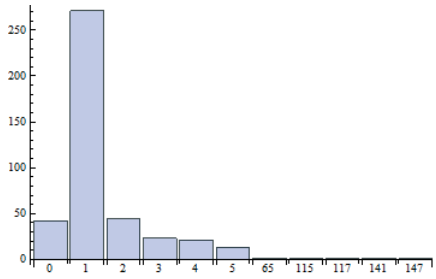
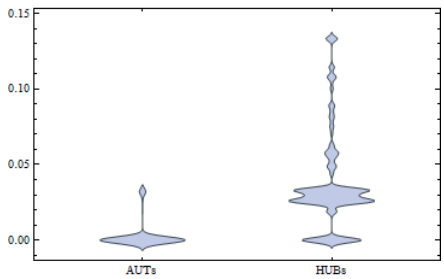


Fig. 6: The Portuguese proximity network - Hubs and Authorities



III. Conclusion – New questions and the rationale for *ViParSys*

Our preliminary study on the Portuguese virtual party system revealed interesting properties that asked for further research. Mainly, they asked for a systematic and regular approach to online political parties communications. In our world where politics is changing enormously because of ICTs, we cannot continue to approach party politics as in the past, or treat the WWW, and especially the Internet and new media, as mere complements to ”real” or ”offline” politics. Due to the Internet, parties are changing, the same way as new actors are surfacing, are getting visibility and power, or are simply using the new resources to compensate for structural or organizational weaknesses. *ViParSys* is a project intended to help understand those changes, offering a new venue venue for researching political communications that is based on the thousands of hyperlinks and pages used by political parties for political competition. It is our conviction that only by offering a systematic, unified, longitudinal and comparative framework for research, we will be able to understand how politics and power networks operate today and how they are affecting our lives.

As this project will offer, together with its database, qualitative and quantitative assessments of VPSs, *ViParSys* will be, also, a platform for autonomous and renovated research. In fact, due to its configuration, it will be so easy to do intra-VPS studies as across-VPS analysis. Regarding the later, one possibility will be to use contextual variables per country to do probability and qualitative comparative studies (QCA). This seems relevant when we want to know if some national patterns or results (both qualitatively or quantitatively inferred) can be associated with cross-national variations in independent variables, like the sizes of Internet national populations, the degree of offline political and institutional democracy, the degree of non-conventional politics, or simply the number of Facebook and Twitter users. In fact, this can be even more important if, after several waves, researchers are able to establish a valid theory regarding the democratic effects of digital communications and formulate several hypotheses associating certain variables with higher levels of democracy.

As a project that is still in its infancy, *ViParSys* is filled with questions and not many answers. Are the characteristics saw in the cases examined so far exclusive or can be found elsewhere? Are they time invariant, or depending with time? Are there also important offline factors to account for when studying national patterns and, if so, which factors are these? Are these factors also relevant across virtual party systems? These will be, in fact, some of the questions that *ViParSys* will need to ask. At the same, although some of the analytical criteria can follow [3] and [12], *ViParSys*, must be open enough to use previous research and results as guidelines and move further, starting with the fact that while more simple concepts as visibility and connectedness will be relatively easy to operationalize, as they are grounded on [3] and [12], the same will not be true, for instance, with strategy and democratizing effects. In fact, one of the biggest challenges will be to come up with a basic and robust analytical framework that can take into account such complex constructs, as they do not exhaust the analytical framework proposed by [3] and used by [12], especially regarding the nature or content dimension. A rigorous and parsimonious grid of indicators must thus be set in place, for each construct. In sum, the new project will need to come up with a robust typology in order to classify and compare within and across virtual party systems different strategic options or to account between different options in different contexts or periods of

time. As we said, assessing strategy and democratizing effects will be for *ViParSys* two big but unavoidable challenges, as the project aims to establish a basic framework for the systematic, comparative and longitudinal study of virtual party systems.

Apart from the need to establish a robust and heuristic battery of indicators for all its dimensions, or to improve qualitative assessments of the networks and of their most important components, *ViParSys* will aim to develop and establish some logistics and capabilities. A website will be needed, together with sophisticated technologies for the periodic retrieval, preparation and analysis of large quantities of data.

References

[1] H. W. Park, "Hyperlink network analysis: A new method for the study of social structure on the web," *Connections* 25(1), 49-61, 2003.

[2] R. Ackland and R. Gibson. "Mapping Political Party Networks on the WWW," Australian Electronic Governance Conference, University of Melbourne, Melbourne, pp. 1-33, 2004.

[3] R. Ackland and R. Gibson, "Mapping Political Party Networks on the WWW: How Active are the Far Right?", Paper, 2005.

[4] M. H. Jackson, "Assessing the structure of communication on the World Wide Web." *Journal of Computer Mediated Communication*, 3(1), 1997.

[5] H. Rheingold, *The Virtual Community: Homesteading on the Electronic Frontier*, 1994. Available http://www.rheingold.com/vc/book/

[6] M. Margolis, D. Resnick, and C. Tu, "Campaigning on the internet: Parties and candidates on the World Wide Web in the 1996 primary season." *Harvard International Journal of Press/Politics*, 2(1): 5978, 1997.

[7] M. Margolis, D. Resnick, and J. Wolfe, "Party competition on the internet: Minor versus major parties in the UK and USA." *Harvard International Journal of Press/Politics* 4(4): 2447, 1999.

[8] R. Davis, *The Web of Politics: The Internet's Impact on the American Political System*. Oxford: Oxford University Press, 1999.

[9] R. Gibson, R. Rommele, and S. Ward, "Parties and campaigning on the WWW," *Party Politics* 9(1), 2003.

[10] R. Gibson, P. Nixon, and S. Ward, *Net Gain?: Political Parties and the Impact of the New Information Communication Technologies*. London: Routledge, 2003.

[11] M. Shumate and M. Lipp, "Connective collective action online: An examination of the hyperlink network structure of an NGO issue network," *Journal of Computer Mediated Communication*, 14(1), 178-201, 2008.

[12] A. Rosas, P. Espírito Santo, and E. Mendes Rodrigues. "On the Online Presences of Portuguese Political Parties — A First Assessment and Prospects for Research." Paper delivered at the Annual Meeting of the International Political Science Association, IPSA, Madrid, 2012.

[13] H. J. Schau and M. C. Gilly, "We are what we post? Self presentation in personal web space," *Journal of consumer research* 30(3), 385-404, 2003.

[14] D. G. Lilleker and K. Koc-Michalska, "Online political communication strategies: MEPs, e-representation and self-representation," *Journal of Information Technology and Politics*, forthcoming, 2013

[15] E. M. Rogers and D. L. Kincaid, *Communication networks: Toward a new paradigm for research.* New York: Free Press, 1981.

[16] D. Lusher and R. Ackland, "A relational hyperlink analysis of an online social movement," *Journal of Social Structure* 11(1), 2010.

[17] D. Zimbra and H. Chen, "Comparing the virtual linkage intensity and real world proximity of social movements. In Intelligence and Security Informatics (ISI)," in *2010 IEEE International Conference on (pp. 144-146). IEEE, 2010.*

[18] M. Hindman, K. Tsioutsiouliklis, and J. A. Johnson, "Googlearchy: How a few heavily-linked sites dominate politics on the web," in *Annual Meeting of the Midwest Political Science Association (Vol. 4, pp. 1-33)*, 2003.

[19] B. A. Huberman, P. Pirolli, J. Pitkow, and R. Lukose, "Strong Regularities in World Wide Web Surfing," *Science* 280:95-97, 1998.

[20] Y. W. Chen, Who Made Uyghurs Visible in the International Arena?: A Hyperlink Analysis," *Global Migration and Transnational Politics (GMTP)*, Working Paper 12, 2010.

[21] P. A. Hepburn, "Local governance and the local online networked public sphere: enhancing local democracy or politics as usual?" Doctoral dissertation, University of Manchester, 2011.

[22] M. Xenos and W .L. Bennett, "The disconnection in online politics: the youth political web sphere and US election sites, 20022004," *Information, Community and Society* 10(4), 443-464, 2007.

[23] K. E. Dalrymple and D. A. Scheufele, "Finally informing the electorate? How the Internet got people thinking about presidential politics in 2004," *The Harvard International Journal of Press/Politics*, 12(3), 96-111, 2007.

[24] The Virtual Observatory for the Study of Online Networks (VOSON) Project. Available: *http://voson.anu.edu.au/.*

[25] Wolfram Research, Inc. Mathematica Edition: Version 9.0 Publisher: Wolfram Research, Inc. Champaign, Illinois, 2013.

[26] V. Batagelj and A. Mrvar, "Pajek Program for Large Network Analysis". Home page: *http://vlado.fmf.uni-lj.si/pub/networks/pajek/.*

[27] Aric A. Hagberg, Daniel A. Schult and Pieter J. Swart, "Exploring network structure, dynamics, and function using NetworkX", in *Proceedings of the 7th Python in Science Conference (SciPy2008)*, Gel Varoquaux, Travis Vaught, and Jarrod Millman (Eds), (Pasadena, CA USA), pp. 1115, Aug 2008.

[28] M. Bastian, S. Heymann and M. Jacomy, "Gephi: an open source software for exploring and manipulating networks." *International AAAI Conference on Weblogs and Social Media*, 2009.

[29] Kleinberg, J. "Hubs, Authorities, and Communities", *ACM Computing Surveys* 31(4), December 1999. Available at http://www.acm.org/surveys/Formatting.html.

Mapping EINS

An exercise in mapping the Network of Excellence in Internet Science

Almila Akdag Sahal
New Media Studies
University of Amsterdam
Amsterdam, The Netherlands
A.A.Akdag@uva.nl

Sally Wyatt / Samir Passi / Andrea Scharnhorst
eHumanities group
Royal Netherlands Academy of Arts and Sciences
Amsterdam, The Netherlands
Andrea.scharnhorst@dans.knaw.nl

***Abstract*—This paper demonstrates the application of bibliometric mapping techniques in the area of funded research networks. We discuss how science maps can be used to facilitate communication inside newly formed communities, but also to account for their activities to funding agencies. We present the mapping of EINS as case – an FP7-funded Network of Excellence. Finally, we discuss how these techniques can be used to serve as knowledge maps for interdisciplinary working experts.**

***Index Terms*—Visualization; science maps; research collaboration**

I. Introduction

The academic world of science and technology represents an ever-changing landscape characterized by the continuous emergence and development of new research directions, funding initiatives, scientific publications, and communication and collaboration networks. One of the ways to represent and analyze this dynamic landscape is through science maps. Science maps are two- or three-dimensional visualizations that represent specific attributes pertaining to particular scientific field(s). These attributes can be related to research themes within disciplines, results of scientific experiments, or the nature of citations within and between disciplines. Examples of science maps include, but are not limited to, maps representing a) bibliometric analysis of scientific publications, b) collaborative research networks, c) nature and quantity of research funding, and d) the trajectory of the evolution of scientific fields. In this paper, we are specifically interested in science maps representing bibliometric analysis of research publications.

Scientific and research publications provide a relevant point of entry to study the nature, trajectory, and structure of scientific fields [9]. Bibliometric records contain a wide array of information such as author name(s), title, year of publication, citations, publication type etc. Each of these elements, or combinations thereof, can be employed to generate unique science maps representing different aspects of the relationships between and within scientific disciplines and research communities. For example, a science map based on publication types (differentiating between types of journals for example) helps showcase the dominant disciplinary and research fields while a map based on co-occurrence of authors (two or more authors co-authoring a publication) represents the formulation and evolution of collaborative networks between disciplines and research communities [6]. Science maps, thus, are useful tools to understand the state-of-the-art and disciplinary structure within an academic field as well as to analyze the emergence of research networks and collaborations. Such an understanding can help provide relevant insights not only into which specific disciplinary areas need more focus and research efforts but also into the ways in which collaborative research networks can be sustained and developed further.

The very first attempts to map science [5] were meant to visualize research fronts and most intriguing new areas in the sciences [13]. Current science maps displayed the structure of academia mining and aggregating millions of links in scholarly communication (such as co-words, citations, co-citations) in a bottom-up approach to identify higher level structures in science such as disciplines [1]. Soon these so-called backbone maps of science were used as reference systems against which the position of a lab, an institute or a whole country could be "science-located". In this function they can be used as a heuristic for studying the sciences; but also as a means for evaluation and science policy advice. Currently, there are a number of tools available, such as Sci2Tool [12], CiteSpace [2], Vosviewer [14] and OverlayToolkit [10]. But, most of the analysis has been done *about* communities, programmes, research trends. The argument we bring forward in this paper is to use science mapping as internal communication tool *by* the communities themselves.

II. The use case – EINS

EINS - **E**xcellence in **IN**ternet **S**cience[1] - is a so-called Network of Excellence (NoE) project funded under the 7th Framework programme. This funding scheme is meant to "contribute to the clarification of the concepts in the covered field"[2] and to coordinate research capacities, rather than directly to fund research. Network activities such as workshops and research mobility are therefore central for this project. EINS started on 1 December 2011 and continues for 42 months. About 5 million euros have been allocated to a consortium formed by 33 research institutes from 16 countries

[1] www.internetscience.eu

[2] http://en.wikipedia.org/wiki/Framework_Programmes_for_Research_and_Technological_Development

(including partners from China, South Korea, Australia and Canada). The main goal is to achieve "a deeper multidisciplinary understanding of the development of the Internet as a societal and technological artifact" [16].

From the kick-off plenary meeting onwards it was obvious that experts in the project come from very different scientific disciplines, and that to exchange, communicate and negotiate notions, concepts, and methods around phenomena as broad as the Internet will become a real challenge [3]. This observation prompted this study in bibliometric mapping of the community.

The research strategy was to "science-locate" the current position of the network of excellence by looking into their publications prior to EINS, to detect the knowledge base of community in terms of most cited literature, and to analyze the co-authorship network. To compare the EINS network with current other research about the Internet, we did a topical search for the term "Internet" and the year 2012 in the Web of Science bibliographic database. Publications from this sample are used to contrast the occupation of the EINS network on a global map of science with an occupation of Internet-related publications on the same map.

III. Data collection and applied tools

A. Data

The data source for this analysis was the Web of Science™ (WoS) – an interdisciplinary and international bibliographic database, which includes mostly journal publications, and with them also the cited references [4]. In October 2012 we retrieved a set of 1353 articles by searching for the names of 118 EINS members, which were listed on the EINS website at that time. We searched for their publications using the author search function. Few of the experts had no publications in the WoS. For most of them the search delivered different listings (pre-aggregated author sets). Those could be sorted out using information about the academic background and therefore the publications venues where we expect them to publish, and/or using institutional information (for the problem of author ambiguity see [11]). One Chinese name could not be retrieved properly, and was excluded from the analysis eventually. After retrieving all articles we used the Sci2Tool to limit the publication years to the five years prior to the start of the EINS.

We collected a second dataset using the topical search function in WoS and "Internet" as search term. The topical search function retrieves publications which contain the search term either in the "Title", "Abstract", "Author Keywords" or "Keywords Plus®" field of the bibliographic record. We restricted our search to the year 2012 only. The search was performed in December 2012 and delivered 1191 records. We would like to emphasise that such a data mining strategy is expected to give only a global and rough impression of the activities related to Internet Science. The internet is not that new any more so authors may no longer feel justified in putting "Internet" in the title of each work which is relevant for the study of the Internet. Consequently we use this dataset as an illustration for the expansion of 'internet' literature across a global map of science, than for an analysis of current Internet Science. The latter would require a much more specifically designed and larger data mining strategy. Both datasets are available from the authors for inspection.

B. Tools

We used the Sci2 Tool of the Cyberinfrastructure for Network Science Center, Indiana University Bloomington for data cleaning, pre-analysis, and the co-authorship network. We used network mapping and analysis tools (including the Overlay toolkit) provided by Loet Leydesdorff for the other maps[3]. We used *Gephi* for the final network layout, and *Adobe Illustrator* for the final design.

IV. Results

In this section we present the maps and discuss them.

A. Distribution of publications of EINS' experts

This map (Fig. 1) displays publications of the EINS community over a general map of science (first dataset of 1353 records). The transparent network structure of the general map of science is colour-coded according to different disciplines. Using the overlay technique developed by Ismael Rafols and others [10], areas in which members publish appear as nodes, colour-coded according to the assigned discipline and size coded.

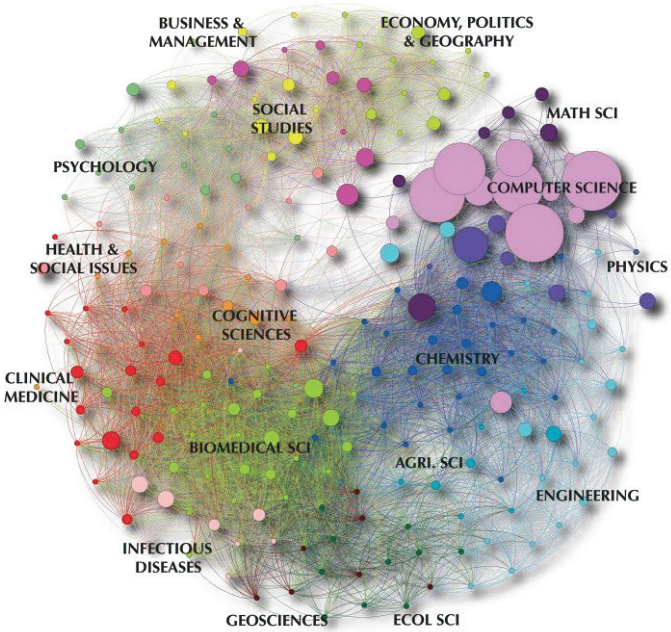


Fig. 1. Publications of EINS experts on the global map of science

The visualization (Fig. 1) shows the main output disciplines of the members: computer science and physics, 1303 of the total of 1353 articles belong to those disciplines. Using an absolute scale of node size coding made the already existing outreach into other areas invisible. We therefore used the

[3] http://www.leydesdorff.net/software.htm

spline-size coding option for node size scales of the visualization software *Gephi*.

B. The knowledge base of EINS

This map confirms the dominance of computer and natural sciences in this expert network and at the same time indicates the challenge for this community. The map uses the set of 1353 articles and displays the network of cited journals – the knowledge base of this community. Whenever two journals appear in the reference list of an article a link is established between them. Apart from the interdisciplinary journals *Science* and *Nature*, the journal landscape of this community, and with it their conceptual frameworks, methods and use of language is dominated by computer sciences, physics and engineering.

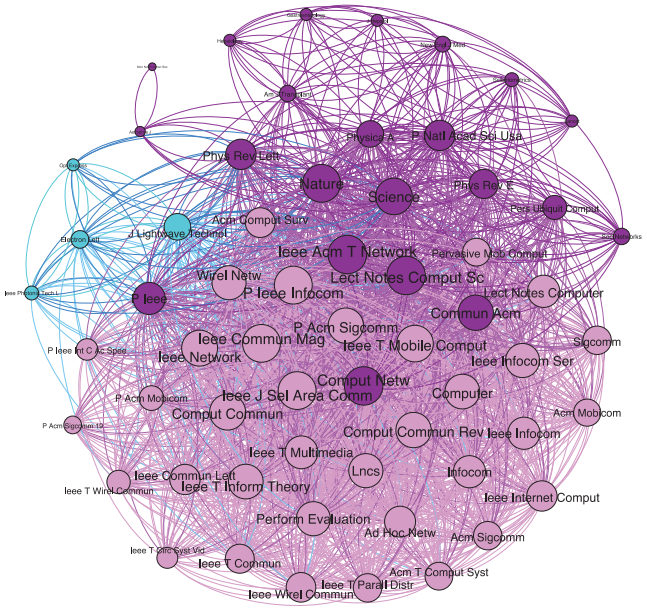


Fig. 2. Network of journals relevant for the EINS community

C. Co-author map of EINS

The map shows the existing co-authorship network based on the same data set of 1353 articles of EINS members. A program (co-author.exe) devised by Loet Leydesdorff has been used for this analysis. The resulting network (threshold value 0.1 %) shows 122 connected authors, 57 of whom are members of EINS. Only the EINS member nodes are coloured (according to the subject categories in which they actively publish), the rest of the nodes are marked with grey. The node sizes correspond to the in-degree parameter, i.e. the more co-authors an author has, the bigger the node size. Naturally EINS members come with their existing collaboration networks. One goal of this Network of Excellence is to sustain and widen those collaborative networks.

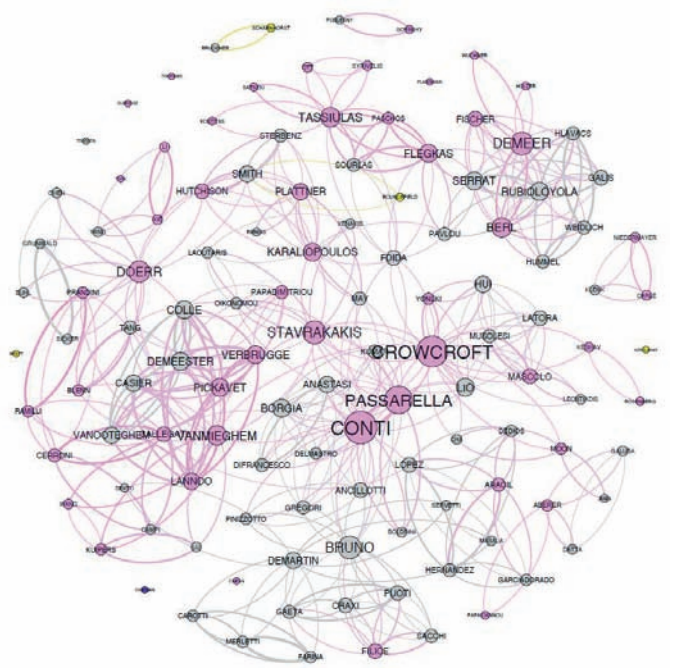


Fig. 3. Existing collaboration network at the start of EINS

D. Overview map of 'Internet Science'

The current world of 'internet science' or 'internet research' encompasses all scientific disciplines. This map shows the overlay map of our second dataset (1191 records), based on a search of the term "Internet" in titles, etc. of articles in the Web of Science for the year 2012 only. Using the same overlay technique as in Fig. 1 this visualization shows that computer science and physics are not the only leading research areas to study the Internet. From anthropology, psychology, economy, politics to medical and cognitive research and public health issues, almost all areas of the science system are concerned with the Internet. One goal of the EINS community is to link its core competences with other Internet Science research threads, to occupy more areas in the overall 'internet science landscape', and to contribute to a consolidation of the knowledge about the Internet.

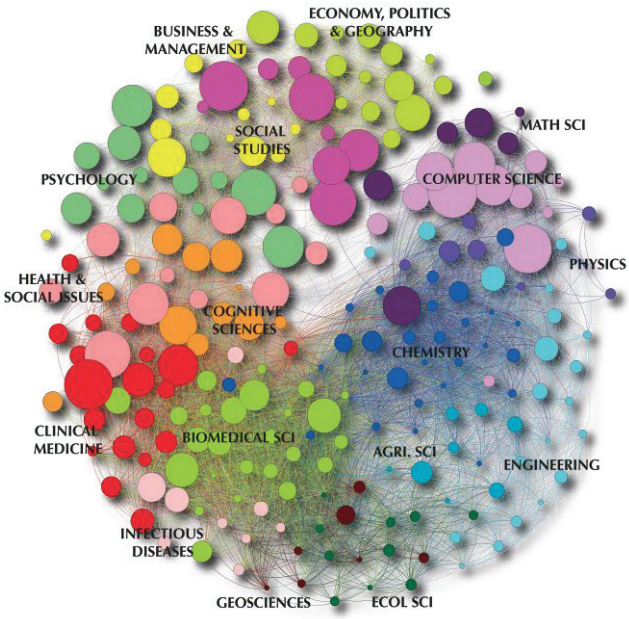


Fig. 4. Internet-related publications at the global map of science in 2012.

V. Conclusions

The exercise described above has implications not only for the EINS community, but also for research agenda setting and evaluation. First, for the EINS community, the results indicate that there is an imbalance between the disciplines predominant in EINS and the full range of scientific and scholarly work being conducted about the 'Internet'. Given the massive diffusion and use of the Internet since it went public and commercial in the mid-1990s, it is not surprising that much academic attention about its effects has come from the full range of disciplines. Understanding the Internet requires input from all. Thus, EINS is correct in its policy of attempting to develop the internet research community and to build bridges between disciplines through its various networking activities. Second, such maps can be used to identify lacunae for further research. However, this would need to be combined with more qualitative approaches. Recently, van Heur, Leydesdorff and Wyatt [8] did something similar, combining the kinds of analyses described above with close reading of texts in order to assess the extent and nature of the ontological turn in science and technology studies. Third, such maps can be used as evaluation tools. After EINS is finished, a similar exercise can be conducted in order to assess whether EINS was successful in promoting interdisciplinary collaboration by examining co-authorship and co-citation patterns in future work [7]. Fourth, science mapping techniques combined with automatic information retrieval allow for a fast and easy overview about future emerging trends, under-occupied research areas and missing links in research collaboration. In this capacity, science maps or more general knowledge maps have potential as visual enhanced navigation tools in large and complex spaces of information [15].

Acknowledgment

This work has been funded by the Network of Excellence for Internet Science, FP7 – 288021.

References

[1] K. Borner, *Atlas of Science*. Cambridge, Mass.: MIT, 2010.

[2] C. Chen, "CiteSpace II: Detecting and visualizing emerging trends and transient patterns in scientific literature" *Journal of the American Society for Information Science and Technology*, vol. 57, no. 3, pp. 359–377, 2006.

[3] P. Galison, *Image & logic: A material culture of microphysics*. Chicago: University of Chicago Press, 1997.

[4] E. Garfield, "Citation indexes for science; a new dimension in documentation through association of ideas" *Science*, vol. 122, no. 3159, pp. 108–111, 1955.

[5] E. Garfield, "Launching the ISI Atlas of Science: for the new year, a new generation of reviews," *Current Contents*, vol. 1, pp. 1–6, 1987.

[6] F. Havemann and A. Scharnhorst, "Bibliometric Networks," *Arxiv preprint: arXiv:1212.5211 [cs.DL]*, p. 20, Dec. 2012.

[7] F. Henwood, S. Wyatt, and J. Eve, "Evaluation of the e-Society Research Programme, Final Report, Report to UK Economic & Social Research Council." London, p. 88, 2009.

[8] B. v. Heur, L. Leydesdorff, and S. Wyatt, "Turning to Ontology in STS? Turning to STS through 'Ontology'," *Social Studies of Science*, Oct. 2012.

[9] R. K. Merton, "Science and technology in a democratic order," *Journal of Legal and Political Sociology*, vol. 1, pp. 115–126, 1942.

[10] I. Rafols, A. L. Porter, and L. Leydesdorff, "Science overlay maps: A new tool for research policy and library management," *Journal of the American Society for Information Science and Technology*, vol. 61, no. 9, pp. 1871–1887, Sep. 2010.

[11] L. Reijnhoudt, R. Costas, E. Noyons, K. Borner, and A. Scharnhorst, "'Seed+Expand': A validated methodology for creating high quality publication oeuvres of individual researchers," *Preprint. Computer Science. Digital Libraries. ArXiv:1301.5177*, Jan. 2013.

[12] Sci2Team, "Science of Science (Sci2) Tool." 2009.

[13] H. Small and B. C. Griffith, "The structure of scientific literatures I: Identifying and graphing specialties," *Science Studies*, vol. 4, no. 1, pp. 17–40, 1974.

[14] N. J. Van Eck and L. Waltman, "Software survey: VOSviewer, a computer program for bibliometric mapping," *Scientometrics*, vol. 84, no. 2, pp. 523–538, 2010.

[15] "Analyzing the dynamics of information and knowledge landscapes - KNOWeSCAPE." COST Action TD1210, MoU, Brussels, 2013.

[16] "Network of Excellence in Internet Science - Factsheet," no. December. pp. 1–3, 2011

Internet voting security in Europe: a process-oriented perspective

Franco Callegati
Department of Electrical, Electronic and Information Engineering "G. Marconi", University of Bologna
Email: franco.callegati@unibo.it

Marco Prandini
Department of Computer Science and Engineering, University of Bologna
Email: marco.prandini@unibo.it

***Abstract*—Electronic and Internet voting provides some significant functional improvements with respect to traditional voting processes, but also put on the floor new important security issues. In this paper we discuss such issues with reference to the current status of development and implementation of electronic and Internet voting in Europe.**

The manuscript discusses the importance to evaluate the security of the entire voting process and not just of the technological building blocks. Then it reviews the current implementations of electronic and Internet based voting processes in several European Countries and provides an example of voting process security analysis using Fault Tree Analysis.

I. Introduction

Voting is a very sensitive process since it may affect entire populations. Nowadays complex devices have appeared to ensure fair and efficient collection of large numbers of ballots, possibly containing votes about many different topics, and their tallying according to various kinds of algorithms. Quite obviously, given the distributed nature of a population over a territory, the latest steps of this evolutionary process involve the usage of the Internet.

The main goal of Electronic and Internet based voting is to rich out those voters that have difficulties in reaching the polling places, speed up the whole voting process and make it less error-prone. The former two goals can be achieved with electronic and Internet based voting. Unfortunately the latter objective has not been centered as much, because there is an intrinsic disadvantage of computer-based systems when compared to traditional ones. Threats against pencil-and-paper procedures were simple and well understood. They were all based on single-ballot manipulation, such as ballot hiding/counterfeiting or voter bribing/blackmailing. These are not necessarily easy-to-solve problems, but there are means to make them stand out in a way that any voter can understand if he/she is called to participate in the verification effort. Computers inevitably process ballots in a way that cannot be kept under the voter's control. Consequently, the voter is forced to surrender a significant part of his/her trust in the voting system to the organizational apparatus that runs the election (the electoral body hereinafter). In order to face this responsibility, the electoral bodies started to develop technical and organizational standards for the verification of voting machines and voting systems.

This paper focus on this issue. In Section II are briefly reviewed the approaches to standardization in the United States of America (USA) and in the European Union (EU) (Subsection II-A) as well as the main security issues still pending and publicly discussed (Subsection II-B). Then it is discussed the importance to adopt a voting process security evaluation rather than a simple security testing of the various technological sub-systems (Subsection II-C). The paper then reviews the electronic voting approaches of the countries in Europe that already choose to adopt it, (Section III) and presents an example of analisys of the Norvegian one performed by means of Fault Tree Analysis (Section IV). Finally in Section V some conclusions are drawn.

II. Security Issues in Voting Systems

A. Current Recommendations and Standards

In the USA the Election Assistance Commission (EAC - http://www.eac.gov) is responsible for developing guidelines for voting systems in conjunction with the National Institute for Standards and Technology (NIST - http://www.nist.gov/). The two entities work to develop technology-assisted voting processes, and define the standards for testing, certification, decertification and recertification of the hardware and software components involved. The resulting guidelines provide a set of specifications and requirements which the voting systems can be tested against, to prove if they actually conform to the expected functional, accessibility and security levels.

The most important document is the "Voluntary Voting System Guidelines" (VVSG) [1] published in 2005 and updated in 2007 with title "Voluntary Voting System Guidelines Recommendations to the Election Assistance Commission" [2]. To gather relevant opinions and information from all the interested parties, the EAC also set up an online commenting system called The VVSG Open Forum (archives at `http://vvsg.org/`).

To obtain the federal electronic voting certification the VVSG specify:

- functional requirements;
- performance characteristics;
- documentation requirements;
- test evaluation criteria.

The document is divided in two volumes, "Voting System Performance Guidelines" and "National Certification Testing

Guidelines", and exhibits a very technical approach, with the goal to be directly usable by developers, producers, voting systems distributors, testing laboratories and government organizations responsible for certifying the systems prior to acquisition.

In the EU the main document which sets out the guidelines for electronic voting systems is the Recommendation Rec(2004)11 [3] issued by the Council of Europe (CoE) and adopted by the "Committee of the Ministers of the CoE" in 2004. It is named "Legal, operational and technical standards for e-voting" and is the result of the Integrated Project "Making Democratic Institutions Work". The Recommendation is a work-in-progress document, which is periodically updated in order to reflect the social changes and technological developments. Rather than opening the document for public, online commenting, the CoE opted for periodic meetings where invited members discuss and integrate suggestions.

Strictly speaking, the Recommendation is a very short document that provides basic definitions and states high-level principles such as (just to give a few examples):

- the e-voting procedures must respect all the democratic principles and be at least reliable and safe as the paper elections.
- the connections between the legal, operational and technical aspects of e-voting procedures must be considered when the Recommendation is applied.
- the Members States should consider a review of their legal rules following this recommendation.

The main document is followed by three slightly broader appendices, which respectively define legal, operational and technical standards. Finally the "Explanatory memorandum" clarifies the concepts synthetically listed in the previous parts, by explaining the intended meaning to be associated to specific terms, by completing the requirements stated in the standards through examples and scenarios, and by providing somewhat detailed templates for the technical analysis of various processes.

B. Standardization does it all?

Unfortunately the answer to the question in the title is no! Notwithstanding the regulatory efforts the criticism against Electronic and Internet based voting systems in terms of lack of security has recently grown [4] [5].

The VVSG is a collection of procedures with the limited scope of verifying the compliance of voting system components and this does not prove enough to ensure the security of the overall process. David Wagner provides a very interesting summary [6] of the shortcomings in the VVSG application scheme, complete with striking examples of the consequences of the separation between the VVSG provisions and their intended context: Independent Testing Authorities (ITAs) certified machines that later lost votes, caused elections disruption, and exhibited almost any kind of security flaw. According to Wagner, the cause is not the technical inadequateness of the VVSG, which contains provisions against these kinds of failures, but the lack of its integration in the federal qualification process. Since the ITAs have no interest in reporting issues that are not explicitly regulated by the VVSG, the certification process is very likely to put the VVSG compliance seal on system affected by critical flaws.

Moreover there are also gaps within the VVSG itself which are to be expected since the 2005 VVSG were developed under a very short deadline (the writing of the draft took only three months). Conversely, the updated version is undergoing a very thorough scrutiny, thus leaving the old one in force for a long time.

Similarly for the EU Rec. Two Irish researchers, Margaret McGaley and J. Paul Gibson, performed a sensible analysis [7] of the Rec. It pointed out some issues regarding the correctness, coherence and consistency of the recommendations. They categorized the main problems found as follows.

- Inconsistent use of the terminology.
- Incomplete coverage of some common scenarios.
- Inclusion of targets out of the scope of this kind of standard.
- Over-specification (indication of specific means to reach some goals instead of the relevant goals themselves).
- Under-specification (indication of goals so general that no testing procedure could ever determine whether a system meets them).
- Redundancy and repetition.
- Problematic maintainability and extensibility.

These weaknesses make a comprehensive understanding of the Rec difficult, and consequently weaken its applicability and effectiveness.

On top of these concerns regarding electronic voting deployed in traditional polling places, Internet voting is open to a wider range of vulnerabilities. It requires that also the voters' terminals are secured; it is subject to denial-of-service attacks, which flood the network preventing the system to work at all; it raises non-technical issues like vote selling, family votes, coercion threats, that are made easier when voting from home.

C. From security of Sub-systems to Security of Processes

The basic issue which gives rise to the problem was well expressed by H. Stephen Berger who says of the VVSG "... the foundational flaw in the document is the separation of the voting system from the election process ..." [8].

In fact the security of an electronic voting system alone does not provide assurance of the security or accuracy of an election, but the whole voting process has to be addressed [9].

In [10] this issue was well addressed and was proposed to analyze the robustness of election processes using fault tree analysis (FTA). The process is modeled in order to identify a fault tree which is then used to study how voting systems (which in fact need not be electronic) are configured, used, and checked, as well as to study other parts of the process such as registering voters and consolidating results from different precincts. The final goal is to illustrate potential problems with the process, including those that an attacker can exploit to break its security.

To follow this approach, each voting process has to be formally modeled using the Little-JIL language [11]. A Little-JIL model breaks down a process into steps, describing their calling order, the resources they require, how they communicate, and the expected output.

Given a specific threat, it is possible to automatically compute a Fault Tree (FT) from the Little-JIL model. Formally, the FT is a tree of events which can be either primary or intermediate. Primary events are placed at the leaves of the tree, and represent a fault in an elementary step of the process. Intermediate events are triggered upon a logic combination of primary or intermediate events, represented by a Boolean gate (AND, OR, NOT). The tree root represents the threat. In this way, the FT describes every possible combination of faults, occurring within the steps, that eventually jeopardize the whole process.

A combination of primary events letting the threatened attack to succeed is called a Cut Set. A Cut Set is minimal if, by removing any event from it, the resulting set is not a Cut Set anymore. Minimal Cut Sets (MCSs) thus represent the smallest sets of actions an attacker would need to perform to successfully cause the intended outcome. The smaller the MCSs in an FT, the simpler the attack (in terms of number of actions, not necessarily of their ease of completion). An MCS of cardinality equal to one is defined a Single Point of Failure. The higher the number of MCSs in an FT, the wider the choice of attack paths.

Given this set of tools, it is possible to analyze the strengths and weaknesses of electoral processes, and also to evaluate the impact of proposed improvements: *any change increasing the size of an MCS makes the corresponding attack more complex to perform, any change decreasing the number of MCSs restricts the attack surface*.

III. The main European e-voting experiences

A. Voting process in Norway

1) Registration: In Norway there is a passive and continuous voter registration system. The voters registry is drawn from the civil registry, which is administered by the Population Registry Authority. The Electoral Committees are responsible for keeping the voters registry once it is created and for distributing polling cards to all eligible voters in the municipality. The voters registry is on display in each municipality, and voters can request corrections until election day.

The deadline to submit candidate list proposals to the county authorities is on March 31st. Each proposal has to list at least as many candidate names as there are mandates in the constituency, with up to an additional six names. Political parties that received at least 500 votes in a county or 5,000 votes nationwide at the previous parliamentary election only need to submit two signatures of members of the local party executive committee on their list proposals. Other political parties and unregistered groups have to collect 500 signatures of registered voters in each constituency where they submit a list proposal. At the municipal level, the number of signatures required is at least 2% of eligible voters during the previous election. Lists can be withdrawn by April 20th, and the County Electoral Committees have to decide by June 1st whether to approve submitted lists proposals.

2) Voting: There are many possibilities to cast a vote: an early voting period (July 1st - August 9th), advance voting period (August 10th - September 9th), out-of-country voting (July 1st - September 2nd, at diplomatic mission or by mail if a voter is in a country without a Norwegian diplomatic mission), internet voting (during advance voting period, 24-hours a day, for voters of the ten municipalities selected for the experiment). On election day, internet voters can also cast paper ballots at polling stations in their municipalities.

During the early voting period, voters can make arrangements for voting by notifying the municipal authorities. Voters are given a unified national ballot paper, as party ballots are not yet printed and distributed, and so they can't express any preferential vote.

During the advance voting period, municipal authorities set up advance voting sites in health and social welfare institutions, universities, high schools and prisons, as well as other convenient locations such as shopping malls and libraries. Some advance voting sites are open for the entire advance voting period, while other sites are open for selected dates only. Voters can participate in advance voting in any constituency. However, those voters voting in a constituency other than where they are registered use a unified national ballot paper rather than party ballots, and so they can't express any preferential vote (like early voting). Similarly, voters voting from abroad at a diplomatic mission or by mail also use the unified ballot. Advance voting ballot boxes are stored in a locked local government office every night. Advance voting ballots are regularly collected during the advance voting period by municipal authorities, forwarded to the municipalities of the voter, and can be checked against the voter lists prior to election day. These names are then marked in the voter list to show they had already voted as a measure to ensure against multiple voting.

To cast a vote during election day, voters enter the polling booth, select a party ballot, express a preferential vote if they wish to do so, and fold the ballot. They then show a photo ID to polling officials, have their ballot stamped and put it into the ballot box.

To cast an electronic vote, a registered voter first open a web page, which loads the required software. The system first authenticates the voter with the same username and password used for any other governmental internet application. Upon successful authentication, a PIN code is sent to the voter's via text message, for him/her to enter In the web application. Next, the electronic ballots are shown and the voter can choose one list of candidates. The voter also has the option of casting a blank ballot. In the background and not visible to the voter, the system then encrypts the ballot and signs it with a unique digital signature assigned to each voter by the system). Finally, the voter transmits the ballot via the server to be stored in the electronic ballot box. In an effort to provide end-to-end verifiability, the pilot project introduce the use of so-called

return codes. Internet voters receive specially-designed and secret return codes that allow voters to verify that his/her cast votes are accurately stored in the electronic ballot box (but not to verify if their votes are counted as cast): when each encrypted ballot is stored, a mathematical function allow the calculation of these return codes without actually decrypting (opening) the ballot. The codes are then sent by text message to the voter, who can compare them with the unique return codes listed on the voter's polling card. Each voter can re-vote over the internet as many times as he wants.

3) Counting: To assure the secrecy of the ballot decryption key, a so-called Electoral Board was formed for the internet voting pilot, comprising ten representatives from different political parties. On August 2nd, each of the ten members publicly receives one section of the secret key. The day after the end of the internet voting period, operators from the ministry download the encrypted votes and perform "vote cleansing". This process eliminates multiple ballots from the same voter, ballots from voters who also voted with a paper ballot, and ballots from voters not on the voter list. The process also includes a check for the validity of voters identities. The ballots are then mixed to eliminate any trace connecting each ballot to the corresponding voter's identity.

On election day, the ministry organizes a counting meeting, during which the Electoral Board assembles the decryption key for the first time. The ballots are decrypted and counted immediately after the polling places close. After the counting, the results are established and published onto the online election administration system. At polling stations, Polling officials count the number of checked names on the voter list and reconcile it with the total number of stamped ballots cast, before counting the ballots by party. A summary is signed by all members of the PC and delivered, together with the election materials, to the municipal level, where the final count of paper ballots takes place. The EC had to decide whether to accept or reject any ballots that were set aside as questionable. All ballots are then counted again. With the exception of very small municipalities, the final count is partially automated by using optical scanners that could also record any preferences marked. The ballots and other election materials are then sent to the County Electoral Committee (CEC), which is responsible for determining the result of the election based on all the municipalities taken together. Separate counting is required to determine the names of elected candidates.

B. Voting process in The Netherlands

1) Registration: In Netherlands there is a passive and continuous voter registration system. The Municipal Electoral Committee is responsible for keeping the voter register once it is created. Voters abroad can opt to use internet voting. If so, they must submit a request no later than 4 weeks before the election. The PEC registers candidates' lists for the district. Each list must be supported by a statement of at least 30 voters residing in the district. Supporting signatures are not required from parties already represented in the Parliament, which can register centrally with the Electoral Council provided that they running with the same list in all districts.

2) Voting: Separate procedures apply for domestic voters and those abroad. Domestic voters are required to present their voter registration cards (issued by municipalities based on civil registers data) to vote in a polling place whether by paper ballot or electronic machine. Voters are permitted to cast their ballot at any polling place within their municipality.

Polling stations are of the Direct Recording Electronic (DRE) kind. In order to vote, a voter touches a candidate name on a paper ballot that covers a touch pad. The tentative vote is displayed on a small screen. To confirm it and cast the ballot, the voter pushes a large red button. At the close of the polling place, the machine prints out vote totals from a small internal printer, on a strip of paper which becomes the official record of results for the polling station. From the time ballots are cast until the moment the paper is printed, the ballots only exist in electronic form within the machine.

In Netherlands there is the so-called proxy voting, by which a voter can authorize voter to cast a vote on his behalf. A voter may only cast up to two proxy votes, and must vote himself. In addition, he has to present at the polling station the voter card of the voter who authorized him, and both voters need to sign the back of the proxy's voter card. A voter may only cast up to two proxy votes.

Voters abroad are registered at the municipality of The Hague. During the last elections, the government implemented an internet voting system known as RIES, as an alternative to the mail-based voting process usually exploited for voters abroad. Voters abroad opting to use RIES had to register their request no later than 4 weeks before the election. They received an instruction booklet and a sealed authorization code by mail. The booklet directed voters to the RIES website, where the authorization code was usable to enter the voting system up to 4 days before the election day. After voting, each voter was given a so-called "technical vote" allowing him/her to verify, after the closure of polls, that their votes were counted. This technical vote did not disclose for whom the voter voted, but it could be decoded by the state to reveal the vote. After the polls closed, the codebook relating technical votes to candidates' names was published, along with all the technical votes received, allowing anyone who cared to independently count the votes.

3) Counting: The totals are printed after the closure of polls and the print-out is then attached to the protocol. The print-out shows the number of votes obtained by each list, the votes cast for each candidate and the number of blank votes. The protocol also contains statistical data such as the numbers of voter cards and proxies. The total number of cards collected should equal the total number of votes recorded by the machine. The chairman of the polling station committee takes the protocol together with the remaining voting material to the municipal electoral committee. The memory cartridges are either delivered to the municipality by the committee chairman or collected by municipal employees. The memory cartridges are read by a computer, and an automatic tabulation

is done. If the cartridge is unreadable, results for the paper printout are manually entered into the computer. Additionally, tabulated results are checked in the corresponding municipality against the print- outs after election day.

The counting and tabulation in polling stations using paper ballots are performed under similar rules, but take substantially longer. Polling station committees initially sort the votes cast by candidate list, and then count the votes for each list. Invalid and blank ballots are counted separately. The ballots for a given list are subdivided by candidates' preferential votes and counted, and the totals entered in the protocol. Each municipality then send the results to the Principal Electoral Committee of its electoral district. The aggregation of results in the Principal Electoral Committees of the electoral districts is carried out on the second morning after the election, and the results passed to the Electoral Council. Three days later the Electoral Council establishes the election results for the entity based on the protocols from the Principal Electoral Committees, and translates the votes into seats.

C. Estonia

The Estonian national parliament elections in 2007 and 2011 are the best-known internet voting experiences in Europe. They were open to every citizen, identified by means of a widely-deployed national electronic identification infrastructure. The election process is managed by a three-layered structure.

- NEC is the central body. Its responsibilities include both defining the election rules (e.g. for candidates registration, ballot counting, results verification) and verifying that every other body operates according to the rules and to the Riigikogu Election Act.
- CEC. There are 17 CECs, one for each county plus the cities of Tallinn and Tartu. They mainly supervise the activities of the DCs and aggregate the results from them.
- DC. The DCs are appointed for each election (whereas the NEC and CECs members hold their positions for four years). Each DC oversees to the operation of a polling precinct.

1) Registration: The voters lists are automatically compiled from the residents registry. No later than a week before the election (when advance voting begins), each DC receives the list of all the voters under its jurisdiction.

2) Voting: Every Estonian citizen holds an ID card, which is both a personal identification document and a device which can perform digital signatures. Voters can cast their ballot trough the Internet during an advance voting window (six to four days before the election day). A voter can cast multiple ballots online, each overriding the previously-cast ones. A voter can also vote with pencil and paper at the assigned polling place: in this case, any vote cast online, both before and after the physical ballot is cast, is discarded.

To be able to access Internet voting, a voter needs a smart card reader for his/her ID card. The voting application uses the ID card to authenticate the voter, who has to enter a PIN number (PIN1) to unlock the process. If the voter is not found in the voters list, he/she is directed to contact the Population Registration Authority, otherwise the application shows the candidates lists. The ballot is encrypted with the Counting Server public key, then signed with the voter's ID card, enabled by entering a second PIN (PIN2).

The Internet Server checks that the signer's identity matches the authenticated internet user identity, verifies that the signature is valid with the voter's public key taken from a certificate provided by the Certificate Server, sends the encrypted ballot to the Vote Storage Server, and finally sends a confirmation message to the voter.

When the window for advance voting closes, the NEC provides every CEC with a list of the voters who cast their ballot online. They could vote at the polling place during the advance voting period, but not on the election day. In turn, the DCs provide the NEC with the list of voters who cast their ballot at polling places during the advance voting period, so that any vote they cast online is discarded.

3) Counting: The NEC president receives an optical media holding the last internet-cast, not paper-overridden ballot for every voter. An hour after polling places close, these ballots are transferred to the Counting Server for decryption and counting. Decryption requires the activation of an Hardware Security Module, involving six keys, two held by the system operators and four out of the seven held by NEC members. The results are loaded into a spreadsheet.

The process guarantees a fair robustness against multiple voting attacks and coercion risks, but the government bodies are ultimately trusted to respect the anonymity and confidentiality of the ballots.

D. Switzerland

The organization of federal elections in Switzerland is regulated by a common standard, but the details about its implementation can vary among the different Cantons. Here is an overview of the main features of the process. The actors are:

- FC The Federal Chancellery coordinates the election, oversees the correct application of the general rules and standards, sets the rules for candidates registration and verifies the compliance of applications. Oversees the internet voting process. Publishes the election results.
- CN In every CaNton civil servants are appointed to prepare the ballots. Every other responsibility is delegated to the townships of the Canton.
- TW The ToWnship is responsible for the distribution of ballots to voters, for the administration of early voting procedures, for the operation of polling places and for finally the counting of votes.

1) Registration: Every citizen is automatically enrolled for vote from the township resident population registers. The registers can be updated until five days before the election. Swiss citizens abroad can enroll at the nearest embassy.

Political parties present their candidates list to the Canton's chancellery, with 100 to 400 support signatures. If the party is

already represented in the National Council, or if it already got more than 3% of the votes in past elections, support signatures are not needed.

2) Voting: The vote casting step is quite complex. Every voter receives a package with a separate ballot for each list, plus a blank ballot. Every voter can cast a number of votes equal to the number of seats his/her Canton holds within the National Council. Different options are available to cast a vote:

- voting for a list as a whole;
- voting for an edited list, by manually erasing some of the pre-written candidates and/or adding candidates from different lists;
- voting for an arbitrary set of candidates writing their names on the blank ballot, up to the available number of votes;
- voting an arbitrary set of candidates on the blank ballot, filling up the places left blank by adding candidates from an indicated list.

Voting by mail is an option available to every voter, and this possibility is widely exploited. A complete package including the voter's card, the ballots, envelopes for returning the cast ballots, and informative material is prepared and sent ten to twenty days before the election. By choosing this option, the voter forfeits confidentiality, since the ballot must be sent back together with the signed voter's card.

Since the townships bear most of the organizational burden, the details of the process for voting at the polling places are often different from town to town: for example, the identity of voters may or may not be checked against a register; ballots may or may not be enclosed by the voter into an envelope before passing it to the employee who stamps it before putting it into the ballot box.

Internet voting is allowed only for citizens of the four Cantons participating to the experimentation (Aargau, Basel-Stadt, Graubünden, St. Gallen) living abroad. The Basel-Stadt Canton tested a process called Geneva System, whereas the other three tested a different one, called Consortium System. Not many details are known, but in both cases the voter is authenticated by means of credentials included in the package sent by mail; he/she can cast the ballot only once (it is not possible to change it afterward); there is no means to check the correct registration of the cast ballot. The two systems differ mainly because in the Consortium System the ballot is encrypted on the server, whereas in the Geneva System it is encrypted on the voter's computer.

3) Counting: Also the counting process can differ from Canton to Canton. Generally speaking, the polling places bring the ballots to an aggregation point, where the unmodified ballots are fed to the electronic counting system as blocks of votes for the corresponding party, while the manually-edited ones are checked for validity before feeding the system with the single votes for each candidate.

In the end, the security of the process lies essentially in the correct behavior of the employees. Key steps like voter identification and confidentiality protection are not performed according to a common procedure, and processes involving remote voting are ridden with weaknesses.

IV. An example of process analysis

As a concrete example of the proposed approach, this section illustrates the analysis of two sub-processes of the Norwegian electoral process. As explained in Section II-C the process is modeled using LittleJIL and is built in a hierarchical way, using the same formalism to show both the relations between sub-processes which compose the complete process (Figure 1) and the details of the selected sub-processes.

The root step is labeled *conduct election*. It coordinates a sequence of five child processes: *pre-polling activity*, *early voting*, *advance voting*, *election day at precinct*, *count votes*.

- *Pre-polling activity* is again a sequence of two steps, representing the registration of voters and the registration of candidates' lists, that are performed before the voting phase begins.
- *Advance voting* models three different ways to cast ballots: from abroad, on advance voting polling stations in towns, and through the Internet.
- The *early voting*, *election day at precinct*, and *count votes* labels should be self-explaining.

The two sub-processes chosen for detailed analysis are: *voting at polling stations on election day*, and *Internet voting*.

A. Voting at the polling station

The Little-JIL to model this sub-process, as shown in Figure 2. Without explaining every single detail, we can see that the process:

- starts with a voter's actions (taking a ballot for a party, and filling it),
- proceeds to voter authentication (involving photo ID and voters registry checks),
- terminates with the ballot being accepted in the ballot box (in case every preceding step yielded positive results).

We chose to study the threat of an unqualified voter being able to cast a ballot. The corresponding FT is composed of 33 nodes connected through 26 gates, and it is too complex to be shown here. The FT has three MCSs of cardinality four, and one MCS of cardinality three. The absence of Single Points of Failure is reassuring. It is not possible to include all the details here but, to summarize, the analysis points out that:

- in one case, corresponding to the MCS shown in Figure 3, the process is moderately vulnerable in the quite uncommon situations involving homonymous voters,
- whereas the other MCSs represent vulnerabilities requiring deep collusion between attackers and polling place officers.

B. Internet Voting

The Little-JIL model for this sub-process is shown in Figure 4. The process starts with voter authentication, which requires the username and password every Norwegian citizen holds for accessing e-government services, plus a specific PIN. The PIN is sent to the voter's mobile phone after verification

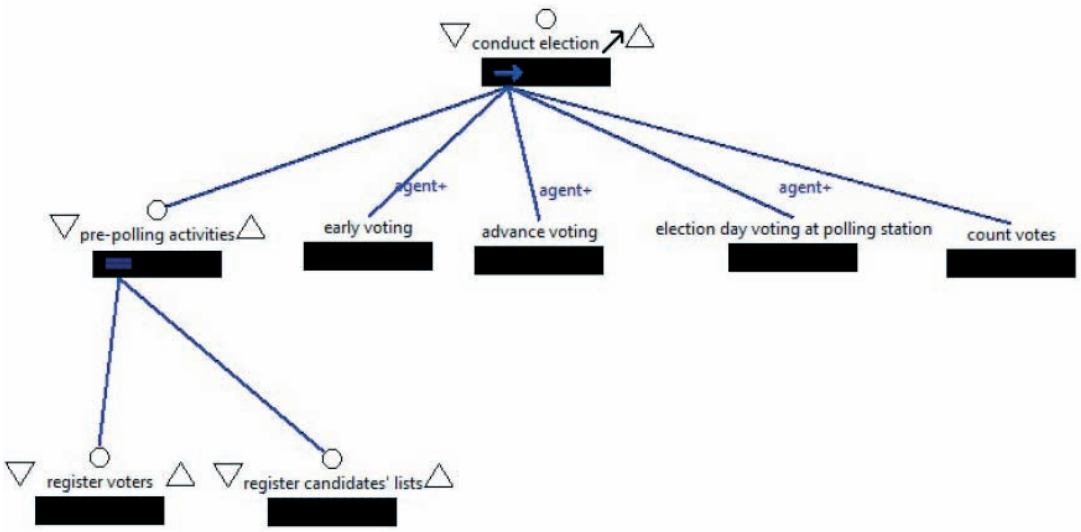


Fig. 1. The LittleJIL overview model of the Norwegian voting process.

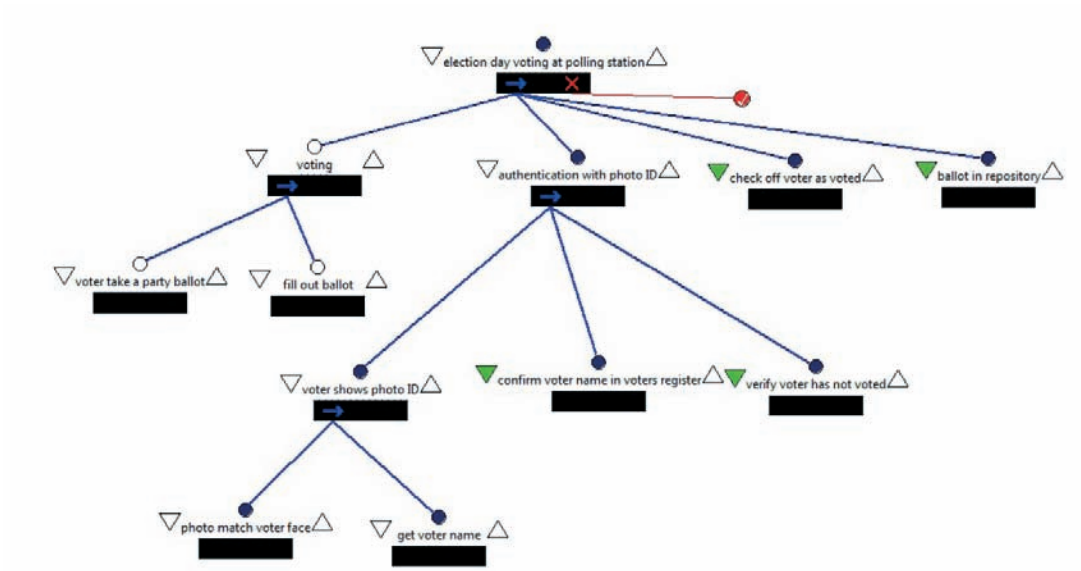


Fig. 2. The Little-JIL model for the polling station voting sub-process.

of the common credentials, and only if the voter resides in one of the ten municipalities chosen for testing the Internet voting process. After successful authentication, the ballot filling and submission steps follow.

The FT representing the same threat of an unqualified voter being able to cast a ballot, for this process, is composed of 54 nodes connected through 44 gates. Again it is not shown here due to its size. There are 6 MCSs, varying in cardinality between three and five. The most understandable one is shown in Figure 5 and from its study we conclude that it represents an attack where the attacker needs to get the username, password and PIN of a voter to vote in his/her place. It is a very unlikely situation, and certainly not one that can scale to massive proportions. Due to lack of details about the process, it is very difficult to give a clear interpretation of the remaining (not shown) MCSs.

V. Conclusions

In this paper we have discussed the importance of evaluating the security of electronic and Internet based voting systems for public elections considering the whole process and not just the various technological building blocks, as suggested by the main standardization documents about the subject.

The paper provides a review of the electronic and Internet based voting systems adopted or experimented to date by european countries and shows an example of application of the process oriented security analysis to the Norvegian process.

The conclusion drawn from such example is that the application of Fault Tree Analysis to the voting process is very

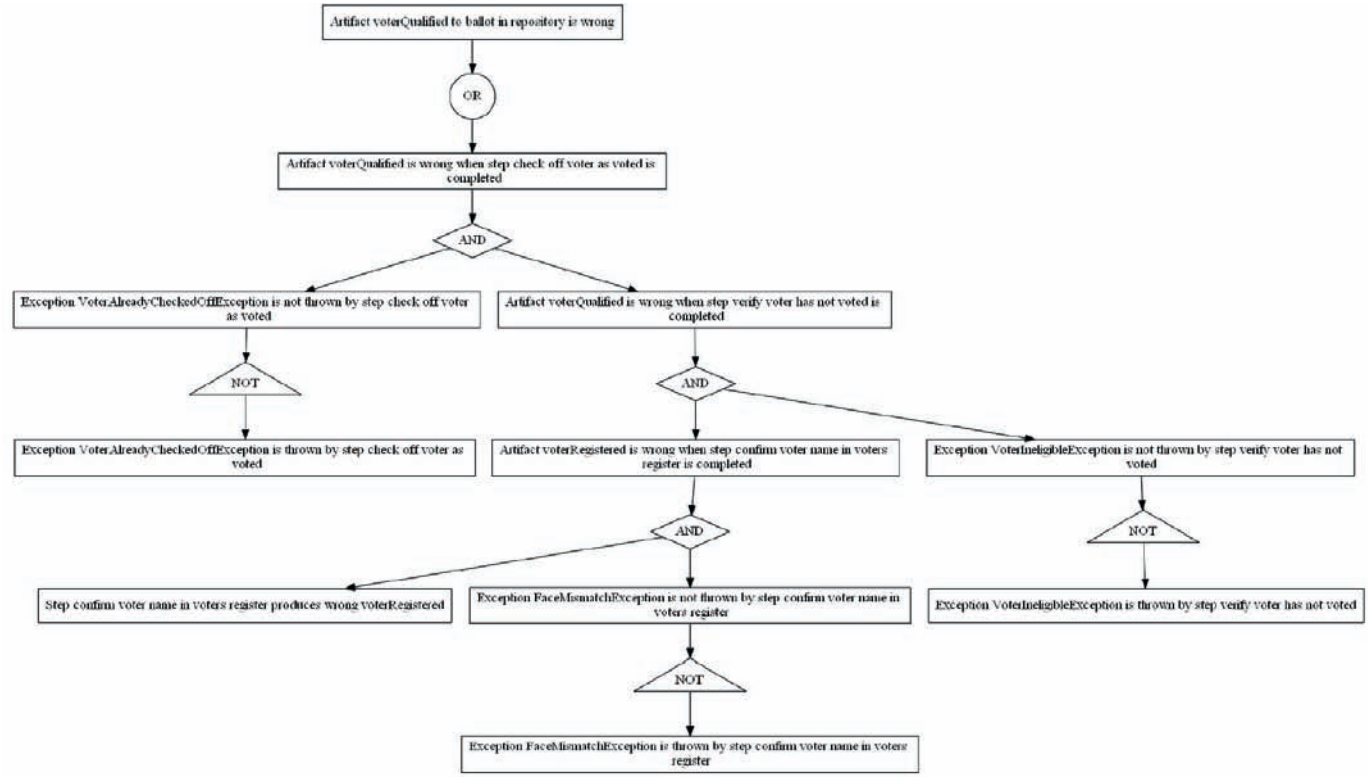


Fig. 3. One of the MCSs of the FT for threat of an unqualified voter being able to cast a ballot at the polling station.

effective to identify the possible threats and can easily lead to suggest viable countermeasures well beyond the analysis of the security of the various technological building blocks that are out in place.

ACKNOWLEDGMENT

This research work has been supported by EINS, the Network of Excellence in Internet Science (www.internet-science.eu/) through European Unions 7th Framework Programme under Communications Networks, Content and Technologies, Grant Agreement #288021.

REFERENCES

[1] U.S. Election Assistance Commission, Ed., *Voluntary Voting System Guidelines*. U.S. Election Assistance Commission, 2005. [Online]. Available: http://www.eac.gov/voting systems/voluntary-voting-guidelines/2005-vvsg

[2] Technical Guidelines Development Committee, Ed., *Voluntary Voting System Guidelines Recommendations to the Election Assistance Commission*. U.S. Election Assistance Commission, Aug. 2007. [Online]. Available: http://www.eac.gov/files/vvsg/Final-TGDC-VVSG-08312007.pdf

[3] Council of Europe, *Recommendation Rec (2004) 11*. Council of Europe, 2004. [Online]. Available: http://www.coe.int/t/dgap/democracy/Activities/GGIS/E-voting/Key_Documents/Rec%282004%2911_Eng_ Evoting_and_Expl_Memo_en.pdf

[4] B. Simons and D. W. Jones, "Internet voting in the u.s." *Commun. ACM*, vol. 55, no. 10, pp. 68–77, Oct. 2012. [Online]. Available: http://doi.acm.org/10.1145/2347736.2347754

[5] M. Prandini and M. Ramilli, "Internet voting: fatally torn between conflicting goals?" in *Proceedings of the 6th International Conference on Theory and Practice of Electronic Governance*, ser. ICEGOV '12. New York, NY, USA: ACM, 2012, pp. 58–61.

[6] D. Wagner, "Joint hearing of the house committee on science and the committee on house administration. testimony on voting system standards. july 19, 2006." [Online]. Available: http://www.votetrustusa.org/index.php ?option=com_content&task=view&id=1554&Itemid=26

[7] M. McGaley and J. P. Gibson, "A critical analysis of the council of europe recommendations on e-voting," in *Proceedings of the 2006 USENIX/Accurate Electronic Voting Technology Workshop*, 2006.

[8] H. S. Berger, "Testimony concerning the tgdc 2007 draft revision of the voluntary voting system guidelines. march 17, 2008." [Online]. Available: http://www.eac.gov/assets/1/Events/testimony h stephen berger public meeting march 19 2008.pdf

[9] E. Barr, M. Bishop, and M. Gondree, "Fixing federal e-voting standards," *Commun. ACM*, vol. 50, pp. 19–24, March 2007. [Online]. Available: http://doi.acm.org/10.1145/1226736.1226754

[10] B. I. Simidchieva, S. J. Engle, M. Clifford, A. C. Jones, S. Peisert, M. Bishop, L. A. Clarke, and L. J. Osterweil, "Modeling and analyzing faults to improve election process robustness," in *Proceedings of the 2010 international conference on Electronic voting technology/workshop on trustworthy elections*, ser. EVT/WOTE'10. Berkeley, CA, USA: USENIX Association, 2010, pp. 1–8. [Online]. Available: http://dl.acm.org/citation.cfm?id=1924892.1924898

[11] A. G. Cass, B. S. Lerner, S. M. S. Jr., E. K. McCall, A. E. Wise, and L. J. Osterweil, "Little-jil/juliette: a process definition language and interpreter," in *ICSE*, C. Ghezzi, M. Jazayeri, and A. L. Wolf, Eds. ACM, 2000, pp. 754–757.

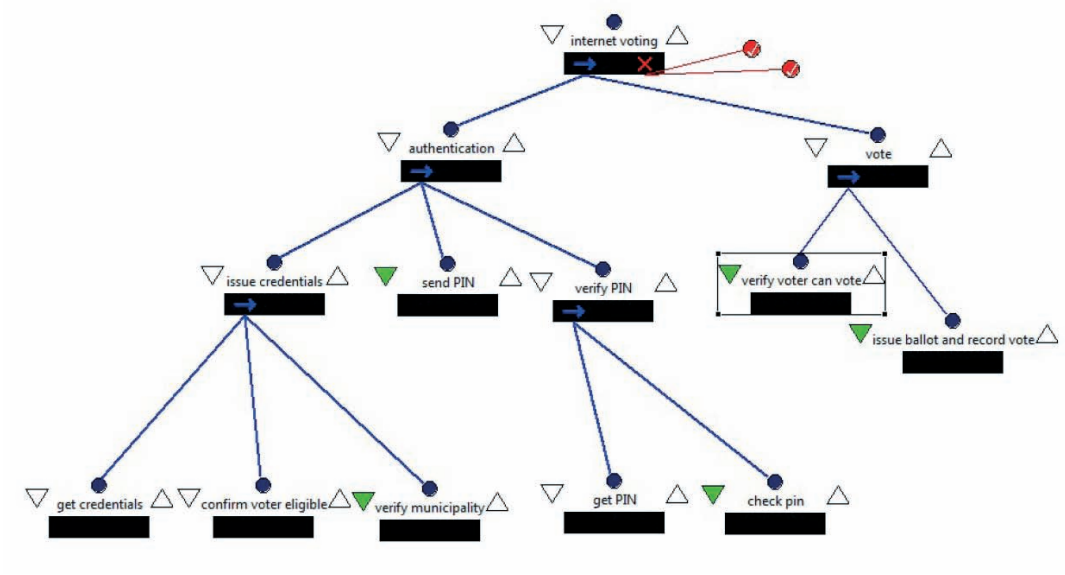


Fig. 4. The Little-JIL model for the Internet voting sub-process.

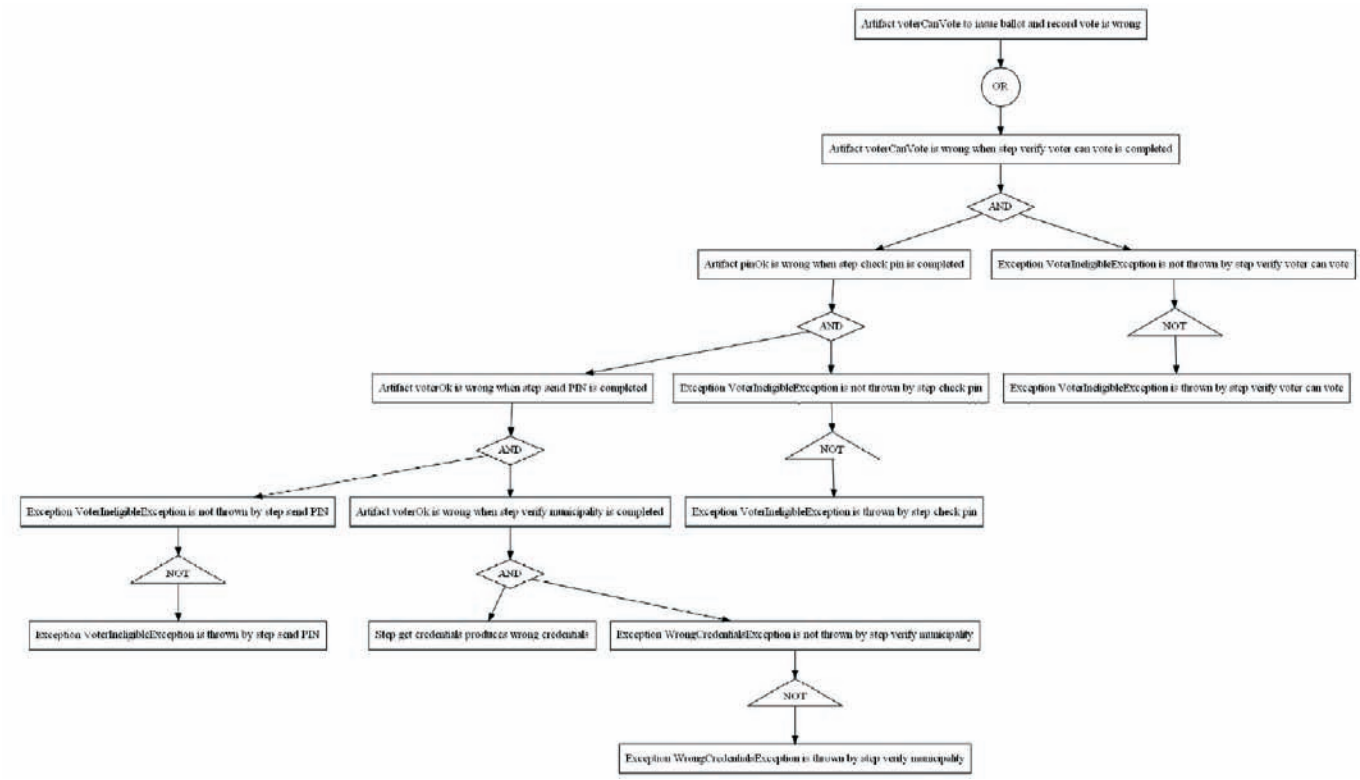


Fig. 5. One of the MCSs of the FT for threat of an unqualified voter being able to cast a ballot through the Internet.

Diamond Condition for Commuting Adjacency Matrices of Directed and Undirected Graphs

Paolo Dini*†
*Department of Media and Communications
London School of Economics and Political Science
London, United Kingdom, WC2A 2AE
Email: p.dini@lse.ac.uk

Chrystopher L. Nehaniv†
†Royal Society Wolfson BioComputation Research Lab
Centre for Computer Science and Informatics Research
University of Hertfordshire, Hatfield, United Kingdom
Email: c.l.nehaniv@herts.ac.uk

***Abstract*—In the context of the stability analysis of interdependent networks through the eigenvalue evaluation of their adjacency matrices, we characterize algebraically and also geometrically necessary and sufficient conditions for the adjacency matrices of directed and undirected graphs to commute. We also discuss the problem of communicating the concepts, the theorems, and the results to a non-mathematical audience, and more generally across different disciplinary domains, as one of the fundamental challenges faced by the Internet Science community. Thus, the paper provides much more background, discussion, and detail than would normally be found in a purely mathematical publication, for which the proof of the diamond condition would require only a few lines. Graphical visualization, examples, discussion of important steps in the proof and of the diamond condition itself as it applies to graphs whose adjacency matrices commute are provided. The paper also discusses interdependent graphs and applies the results on commuting adjacency matrices to study when the interconnection matrix encoding links between two disjoint graphs commutes with the adjacency matrix of the disjoint union of the two graphs. Expected applications are in the design and analysis of interdependent networks.**

Keywords: Commuting adjacency matrices, algebraic graph theory, internet science.

I. Introduction

This paper is motivated by the wish to optimize the efficiency of the mathematical analysis of the stability of interdependent networks. The paper is also concerned with a wider and deeper question of fundamental importance to Internet Science. Namely, given the increasing reliance of every applied and theoretical aspect of the Internet on many and very different disciplines, how can the inevitable disciplinary language barriers that today's Internet scientists face be best addressed? For example, what takes place in the mind of a mathematician when solving a particular problem? And how can such insight be best communicated to a wider audience of applied scientists and engineers? What kind of formalism provides an optimal "user interface" for a given audience?

Some integration with a social science perspective helps in this regard. For example, whereas in computer science and in the hard sciences in general the term 'paradigm' usually means a deeper and more pervasive 'model', but still a model, in social science the dominant definition of paradigm is due to Thomas Kuhn (himself a physicist) as, paraphrasing, a body of theory, a community of practice, and a set of methodologies [1]. For a community of practice to exist, a shared language – or set of languages – is essential. Thus, the development of an Internet Science faces the problem of undoing the effect of the disciplinary Babel tower most of us have been inhabiting.

As discussed in [2], however, one must go beyond "translation" when attempting to communicate across disciplines, and take into account the different epistemologies relied upon in each discipline. Although the analytical tools to effect such a reflexive analysis of one's research are best drawn from social science, at this early stage of Internet Science development an explicit discussion of the epistemologies at play (e.g. integration with [3]) would make this paper too difficult to read. Therefore, we prefer to adopt a tutorial style where the problem at hand is approached from different mathematical points of view, drawing connections between them. Thus, the paper can also be seen as a reflexive account or "case study", in two different mathematical "languages" that tend to be used respectively by engineers and mathematicians, of how a particular mathematical fact, the "diamond condition" for commuting adjacency matrices, was hypothesized, formalized, and proven together with the development of visualization techniques. The two presentations are then related through geometrical visualization.

A. Background and Scope

This work grew out of P. Dini's Research Mobility visit to P. Van Mieghem's Network Architectures and Services group at TU Delft in September 2012, in the context of the EINS Network of Excellence.[1]

The proof of the diamond condition requires only a few lines. In this form, however, it can only be understood and appreciated by mathematicians, or by other scientists equipped with pencil, lots of paper, time and patience, and a strong applied mathematics background. This paper aims to make this important result as accessible and applicable as possible for a wide range of Internet scientists. Therefore, the paper follows a tutorial style that is organized into four main narratives:

- Section II: General facts and some elementary results about commuting matrices, written in mathematical language.

[1] http://www.internet-science.eu

- Section III: A "pedestrian" and "brute force" account of how the commutativity requirement for symmetric adjacency matrices can be expressed most simply in coordinate form, written in a language more common in applied mathematics contexts.
- Section IV: A detailed account of the mathematical facts leading up to the diamond condition, written almost completely in pure maths.
- Section V: A geometrical discussion and visualization of the equivalence of the two previous sections, written in a language more common to engineering contexts.

B. Mathematical Problem Statement

Given two separate undirected networks, for example an electric utility network and the network of computers that controls it, each can be characterized by its adjacency matrix. Call the two matrices A_1 and A_2, both symmetric. Now introduce some links between the networks. These links can be modelled with another matrix B_0, which is not necessarily square or symmetric. The two global matrices, therefore, are:

$$A = \begin{bmatrix} A_1 & 0 \\ 0 & A_2 \end{bmatrix} \qquad B = \begin{bmatrix} 0 & B_0 \\ B_0^T & 0 \end{bmatrix} \tag{1}$$

which are shown here in block form. Note that even when B_0 is neither square nor symmetric B will be both. It turns out that whenever A and B commute the largest eigenvalue of the combined matrix is a linear combination of the largest eigenvalues of the individual matrices, as follows [4]:

$$\lambda_1(A + \alpha B) = \lambda_1(A) + \alpha\lambda_1(B), \tag{2}$$

where α is some real number. This is useful because it speeds up the evaluation of the eigenvalues of the connected network since they are linear combinations of the eigenvalues of A and B. Faster eigenvalue evaluation means more frequent monitoring of the stability of the combined network, enabling quicker intervention if something goes wrong in either network. Thus, the problem we are trying to solve is:

> *Given any two symmetric adjacency matrices A_1 and A_2, what are the constraints on the form B_0 should take so that A and B commute?*

II. Some General Discussion and Results

Before addressing the problem statement we define a few terms and review some known facts about matrices.

Definition 3 (Eigenspace)**.** *An eigenspace of a matrix is the linear subspace consisting of all eigenvectors associated to a given eigenvalue. Its dimensionallity is equal to the multiplicity of the eigenvalue.*

Definition 4 (Simultaneous diagonalization)**.** *If two matrices A and B are diagonalized by the same matrix U then they are simultaneously diagonalizable.*

Explanation: Since U diagonalizes both A and B we can write

$$\left.\begin{matrix} UAU^{-1} \\ UBU^{-1} \end{matrix}\right\} \text{Diagonal.} \tag{5}$$

Conjugation by any invertible U respects addition and multiplication of A and B:

$$UAU^{-1} + UBU^{-1} = U(A+B)U^{-1} \tag{6}$$

$$\begin{aligned}(UAU^{-1})(UBU^{-1}) &= UA(U^{-1}U)BU^{-1} \\ &= UABU^{-1} = U(AB)U^{-1}.\end{aligned} \tag{7}$$

So simultaneous diagonalizability, i.e. that $UA^{-1}U$ and UBU^{-1} are both diagonal, implies that $U(A+B)U^{-1}$ and $U(AB)U^{-1}$ are too. Therefore the eigenvalues of $A+B$ and AB are, respectively, sums and products of those of A and B.

Proposition 1. *If symmetric operators A and B (on a real or complex n-dimensional vector space V) commute, then they are simultaneously diagonalizable by an orthonormal basis.*[2]

Proof: Let A be a symmetric operator on a real or complex n-dimensional vector space V (e.g., one given by an $n \times n$ matrix). Then

$$A\vec{v} = \lambda\vec{v}, \tag{8}$$

where λ is an eigenvalue for some eigenvector $\vec{v} \in V$. Now pre-multiply both sides of (8) by B. Then, since A and B commute, we have:

$$\begin{aligned} BA\vec{v} &= \lambda B\vec{v} \\ A(B\vec{v}) &= \lambda(B\vec{v}), \end{aligned} \tag{9}$$

showing that $B\vec{v}$ is an eigenvector of A that belongs to the *same* λ-eigenspace of A as $\vec{v}$.[3] Let the eigenvalues of A be λ_i $(1 \le i \le k, k \le n)$. Let $W_i \subseteq V$ denote the λ_i-eigenspace of A. Now V is the orthogonal direct sum $\bigoplus_{j=1}^{k} W_i$, of the W_i. Moreover, A acts on each W_i by stretching vectors in W_i by a factor λ_i:

$$W_i = \{\vec{w} : A\vec{w} = \lambda_i\vec{w}\}. \tag{10}$$

For each i, let $d_i = \mathrm{Dim}(W_i) \le n$. By (9), W_i is invariant under B, i.e., $B : W_i \to W_i$ for each i. Therefore, since B is a symmetric operator on V, it is also a symmetric operator on W_i.[4] Hence there exists an orthonormal basis $w_1^{(i)}, \ldots, w_{d_i}^{(i)}$ for W_i that diagonalizes B restricted to W_i.[5] This means that,

[2]Note: this does *not* mean that A and B will have the same (number of distinct) eigenvalues, nor that they will have the same eigenspaces. In general they will not. But all we need to prove is that there exists a basis of V that will diagonalize both operators.

[3]The dimension of an eigenspace equals the number of repeated eigenvalues associated with it. As a reminder of how to visualize an eigenspace, if $n = 3$ and the eigenspace is 2-dimensional, it is a plane embedded in $\mathbb{R}^3$.

[4]For a real matrix, being symmetric as an operator (for example, the inner product $\langle Ax, y\rangle = \langle x, Ay\rangle$ always holds) is equivalent to being symmetric as a matrix ($A = A^T$). Then, since A maps W_i to W_i and the inner product condition holds in V, it must hold in W_i too, so A restricted to W_i is a symmetric operator, which lets us diagonalize A restricted to W_i.

[5]Notice that we are free to choose such a basis since – given that A is a symmetric operator – each eigenspace is orthogonal to all the other eigenvectors. In the example of the plane embedded in $\mathbb{R}^3$, any two mutually perpendicular unit vectors lying in this plane form a valid basis for this W_i, and each will be scaled by λ_i regardless of the choice of their orientation in this plane. However, only *one* orientation of this basis system will diagonalize also d_i dimensions of B.

using this basis for W_i,

$$B\,\vec{w}_j^{(i)} = \mu_j^{(i)}\,\vec{w}_j^{(i)}, \tag{11}$$

where $\mu_j^{(i)}$ is an eigenvalue of B for $\vec{w}_j^{(i)} \in W_i$ $(1 \le j \le d_i)$.[6] Be that as it may, since each $w_j^{(i)}$ lies in W_i, we have by definition of W_i that

$$A\,w_j^{(i)} = \lambda_i w_j^{(i)}, \tag{12}$$

for $1 \le i \le k$ and $1 \le j \le d_i$. Now consider the orthonormal basis for V given by concatenating the bases for the various W_i $(1 \le i \le k)$:

$$w_1^{(1)}, \ldots, w_{d_1}^{(1)}, \ldots, w_1^{(k)}, \ldots, w_{d_k}^{(k)},$$

In this basis, the ith block of B that corresponds to the subspace W_i is diagonal by (11) and the block of A corresponding to W_i is diagonal by (12). Thus A and B are both diagonal in this orthonormal basis. □

In the above basis, it is obvious that the eigenvalues of a linear combination of the commuting symmetric matrices A and B will be a linear combination of the eigenvalues of A and B. A similar statement clearly also holds for the eigenvalues of the product AB.

Proposition 2. *If the block diagonal matrix for the networks is*

$$A = \begin{bmatrix} A_1 & 0 \\ 0 & A_2 \end{bmatrix} \tag{13}$$

and for the interconnection graph one has

$$B = \begin{bmatrix} 0 & B_0 \\ B_0^T & 0 \end{bmatrix}, \tag{14}$$

then commutativity $AB = BA$ is equivalent to requiring

$$A_1 B_0 = B_0 A_2. \tag{15}$$

Proof: From

$$AB = \begin{bmatrix} 0 & A_1 B_0 \\ A_2 B_0^T & 0 \end{bmatrix} \quad \text{and} \tag{16}$$

$$BA = \begin{bmatrix} 0 & B_0 A_2 \\ B_0^T A_1 & 0 \end{bmatrix}, \tag{17}$$

for commutativity $A_1 B_0 = B_0 A_2$ and $A_2 B_0^T = B_0^T A_1$ must be true simultaneously. Conversely, assuming Eq. (15) is true, since A_1 and A_2 are both symmetric,

$$\begin{aligned} A_1^T B_0 &= B_0 A_2^T \\ [A_1^T B_0]^T &= [B_0 A_2^T]^T \\ B_0^T A_1 &= A_2 B_0^T, \end{aligned}$$

thus showing that the other condition is also true. □

The spectrum of a graph is the set of eigenvalues (with multiplicities) of a matrix representation of the graph.

[6] In other words, B may have up to d_i distinct eigenvalues associated with subspace W_i, unlike A which only had 1 eigenvalue associated with W_i (by definition of W_i as an eigenspace of A).

Proposition 3. *If B_0 is invertible and A and B commute, then A_1 and A_2 have the same spectrum. Note that in this case A_1 and A_2 must be of the same size.*

Proof: By Prop. 2, $B_0 A_2 = A_1 B_0$. Hence,

$$\begin{aligned} B_0 A_2 B_0^{-1} &= A_1 B_0 B_0^{-1} \\ B_0 A_2 B_0^{-1} &= A_1, \end{aligned} \tag{18}$$

but conjugation does not change the spectrum of a matrix. □

Unfortunately, although two isomorphic graphs have adjacency matrices with the same spectrum, the converse is not true: two adjacency matrices with the same spectrum need not correspond to two isomorphic graphs. Graphs that have the same spectrum but are not isomorphic are called *cospectral*. The issue of cospectral graphs is likely to play an important role in this problem.

We look at a few more simple cases of solutions to the commutative interconnection problem. We can always take $B_0 = 0$, the $m \times n$ zero matrix, for a trivial example (i.e. no coupling). If the two graphs are isomorphic then we can always take $B_0 = I$ (or a permutation matrix that gives the mapping of the isomorphism on nodes). As a fourth and distinct case,

Proposition 4. *Let A_1 be an $m \times m$ matrix and A_2 $n \times n$. Using an $m \times n$ matrix of all 1s for B_0 works to yield $AB = BA$, with A and B as defined in* (13) *and* (14)*, if and only if all the row sums of A_1 are equal to all the column sums of A_2. In particular this always works if A_1 and A_2 are adjacency matrices of regular graphs of the same degree.*

Proof: Let

$$A_1 = \overbrace{\begin{bmatrix} 0 & a_{12} & \cdots & a_{1m} \\ a_{21} & 0 & \cdots & a_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & 0 \end{bmatrix}}^{m} \Bigg\} m$$

$$B_0 = \overbrace{\begin{bmatrix} 1 & 1 & \cdots & 1 \\ 1 & 1 & \cdots & 1 \\ \vdots & \vdots & \ddots & \vdots \\ 1 & 1 & \cdots & 1 \end{bmatrix}}^{n} \Bigg\} m$$

$$A_2 = \overbrace{\begin{bmatrix} 0 & a^{12} & \cdots & a^{1n} \\ a^{21} & 0 & \cdots & a^{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a^{n1} & a^{n2} & \cdots & 0 \end{bmatrix}}^{n} \Bigg\} n$$

Then,

$$n$$

$$A_1B_0 = \left.\overbrace{\begin{bmatrix} \sum_{j=1}^m a_{1j} & \cdots & \sum_{j=1}^m a_{1j} \\ \sum_{j=1}^m a_{2j} & \cdots & \sum_{j=1}^m a_{2j} \\ \vdots & \ddots & \vdots \\ \sum_{j=1}^m a_{mj} & \cdots & \sum_{j=1}^m a_{mj} \end{bmatrix}}^{n}\right\} m \tag{19}$$

$$B_0A_2 = \left.\overbrace{\begin{bmatrix} \sum_{i=1}^n a^{i1} & \cdots & \sum_{i=1}^n a^{in} \\ \sum_{i=1}^n a^{i1} & \cdots & \sum_{i=1}^n a^{in} \\ \vdots & \ddots & \vdots \\ \sum_{i=1}^n a^{i1} & \cdots & \sum_{i=1}^n a^{in} \end{bmatrix}}^{n}\right\} m \tag{20}$$

Both (19) and (20) are $m \times n$ matrices and they are equal as long as the sums of the rows of A_1 equal the sums of the columns of A_2. In particular, this condition is clearly satisfied in the case of regular graphs of the same degree. □

III. Lie Bracket and the Coordinate Form of the Commutativity Condition for Undirected Graphs

To investigate which matrices commute we can use a Lie algebra approach [5]. Let F be a field. A Lie algebra over F is a vector space L together with a bilinear map called the Lie bracket:

$$L \times L \to L, \qquad (x, y) \to [x, y], \qquad x, y \in L \tag{21}$$

such that

$$[x, x] = 0 \qquad \forall x \in L \tag{22}$$

$$[x, [y, z]] + [y, [z, x]] + [z, [x, y]] = 0. \qquad \forall x, y, z \in L \tag{23}$$

Thus the Lie bracket returns a vector, which can be bracketed recursively with another vector as shown, for example, by the Jacobi identity (23). In $\mathbb{R}^3$, the familiar vector or cross-product satisfies the Lie bracket axioms. Bilinearity implies that

$$\begin{aligned} 0 = [x + y, x + y] &= [x, x] + [x, y] + [y, x] + [y, y] \\ &= [x, y] + [y, x], \end{aligned} \tag{24}$$

from which we find that

$$[x, y] = -[y, x] = 0, \qquad \forall x, y \in L. \tag{25}$$

Now let V be an n-dimensional vector space over F. Let $gl(V)$ be the set of all linear maps $V \to V$, so it can be regarded as a set of matrices. This is itself an n^2-dimensional vector space[7] over F with canonical basis E_{ij}, where E_{ij} is a unit vector since it is an $(n \times n)$ matrix all of whose entries are 0 except for a single 1, for one value of $1 \le i \le n$ and one value of $1 \le j \le n$, which equals 1. It becomes a Lie algebra if we define

$$[A, B] = AB - BA, \qquad \forall A, B \in gl(V), \tag{26}$$

with the usual matrix product.

[7]The axioms of a vector space can indeed be satisfied by a set whose elements are matrices.

Although Erdmann and Wildon (for example) develop the theory of abstract Lie algebras fairly extensively, in this paper we only need to rely on the definition of the Lie bracket. In particular, for the problem at hand we start by asking what conditions $(n \times n)$ symmetric adjacency matrices A and B need to satisfy in order to commute, i.e.,

$$[A, B] = 0. \tag{27}$$

We will later investigate how any such conditions might relate to the interdependent graphs and in particular to the form of the B_0 connecting matrix. We may rewrite A and B as follows:

$$A = \sum_{ij} a_{ij}E_{ij}, \;\; a_{ij} = a_{ji} \in \{0, 1\} \text{ and } 1 \le i, j \le n; \tag{28}$$

$$B = \sum_{ij} b_{ij}E_{ij}, \;\; b_{ij} = b_{ji} \in \{0, 1\} \text{ and } 1 \le i, j \le n, \tag{29}$$

The summation limits on all the indices are always from 1 to n unless underwise stated. Substituting into (27),

$$\begin{aligned} &\left[\sum_i \sum_j a_{ij}E_{ij}, \sum_k \sum_l b_{kl}E_{kl}\right] \\ &\qquad = \sum_i \sum_j \sum_k \sum_l a_{ij}b_{kl}[E_{ij}, E_{kl}] = 0 \end{aligned} \tag{30}$$

An example of this straightforward calculation for $n = 2$ is provided in [6]. The Lie brackets of the unit matrices (basis vectors) follow these easily verifiable rules:

$$\text{Case 1:} \quad j = k, i = l, \quad [E_{ij}, E_{kl}] = E_{il} - E_{kj} \tag{31}$$

$$\text{Case 2:} \quad j = k, i \ne l, \quad [E_{ij}, E_{kl}] = E_{il} \tag{32}$$

$$\text{Case 3:} \quad j \ne k, i = l, \quad [E_{ij}, E_{kl}] = -E_{kj} \tag{33}$$

$$\text{Case 4:} \quad j \ne k, i \ne l, \quad [E_{ij}, E_{kl}] = 0. \tag{34}$$

The four cases can be written more compactly using the Kronecker delta δ_{ij}, which takes values zero and one with $\delta_{ij} = 1$ if and only if $i = j$ (see also [7]):

$$[E_{ij}, E_{kl}] = \delta_{kj}E_{il} - \delta_{il}E_{kj} \tag{35}$$

We now expand $[A, B]$ as in (30), according to which of these cases applies to (i, j, k, l). Full details for the example $n = 3$ are provided in [6]. In the following, we discuss the general case, showing the specialization to $n = 3$ only for the final step of each case.

<u>Case 1:</u> $j = k, i = l$

$$\sum_i \sum_{j \ne i} a_{ij}b_{ji}(E_{ii} - E_{jj}) = 0, \tag{36}$$

since A and B are both symmetric. E.g. for $n = 3$,

$$\begin{aligned} (36) = {} & a_{12}b_{21}(E_{11} - E_{22}) + a_{13}b_{31}(E_{11} - E_{33}) + \\ & a_{21}b_{12}(E_{22} - E_{11}) \;\; + a_{23}b_{32}(E_{22} - E_{33}) + \\ & a_{31}b_{13}(E_{33} - E_{11}) + a_{32}b_{23}(E_{33} - E_{22}) = 0, \end{aligned} \tag{37}$$

<u>Case 2:</u> $j = k, i \ne l$

$$\sum_i \sum_j \sum_{l \ne i} a_{ij}b_{jl}E_{il} = \sum_i \sum_{l \ne i} \left(\sum_j a_{ij}b_{jl}\right) E_{il}. \tag{38}$$

For $n = 3$, taking advantage of the fact that A and B are symmetric adjacency matrices (i.e. with zero diagonal), the above simplifies to:

$$\sum_i \sum_{l \neq i} \left(\sum_j a_{ij} b_{jl} \right) E_{il} = a_{13}b_{32}E_{12} + a_{12}b_{23}E_{13} + a_{23}b_{31}E_{21} + a_{21}b_{13}E_{23} + a_{32}b_{21}E_{31} + a_{31}b_{12}E_{32} \quad (39)$$

We will pair this expression with the analogous result for Case 3, which is calculated next.

Case 3: $j \neq k, i = l$

$$\sum_i \sum_j \sum_{k \neq j} a_{ij} b_{ki} (-E_{kj}) = -\sum_j \sum_{k \neq j} \left(\sum_i a_{ij} b_{ki} \right) E_{kj} \quad (40)$$

For zero diagonals and $n = 3$,

$$-\sum_j \sum_{k \neq j} \left(\sum_i a_{ij} b_{ki} \right) E_{kj} = -a_{31}b_{23}E_{21} - a_{21}b_{32}E_{31} - a_{32}b_{13}E_{12} - a_{12}b_{31}E_{32} - a_{23}b_{12}E_{13} - a_{13}b_{21}E_{23} \quad (41)$$

Adding the two non-zero results for the 3×3 example,

$$\begin{aligned} \sum_i \sum_j \sum_k \sum_l a_{ij} b_{kl} [E_{ij}, E_{kl}] &= a_{13}b_{23}(E_{12} - E_{21}) + a_{12}b_{23}(E_{13} - E_{31}) + \\ &\quad a_{23}b_{13}(E_{21} - E_{12}) + a_{12}b_{13}(E_{23} - E_{32}) + \\ &\quad a_{23}b_{12}(E_{31} - E_{13}) + a_{13}b_{12}(E_{32} - E_{23}) \\ &= (a_{13}b_{23} - a_{23}b_{13})(E_{12} - E_{21}) + \\ &\quad (a_{12}b_{23} - a_{23}b_{12})(E_{13} - E_{31}) + \\ &\quad (a_{12}b_{13} - a_{13}b_{12})(E_{23} - E_{32}) \end{aligned} \quad (42)$$

Setting this equal to zero, therefore, is the condition for two 3×3 symmetric adjacency matrices A and B to commute. The generalization of this expression to $n \times n$ matrices requires a bit of work which, as before, is shown in detail in [6]. What we have shown so far is that the Lie bracket of two arbitrary symmetric matrices A and B is given by the sum of Eqs. (38) and (40). Expansion of these two sums, simplification due to symmetry and zero diagonals, and rearrangement eventually leads to the general commutativity condition:

$$\begin{aligned} &\sum_i \sum_j \sum_k \sum_l a_{ij} b_{kl} [E_{ij}, E_{kl}] \\ &= \sum_i \sum_{l \neq i} \left(\sum_j a_{ij} b_{jl} \right) E_{il} - \sum_j \sum_{k \neq j} \left(\sum_i a_{ij} b_{ki} \right) E_{kj} \\ &= \sum_{i=1}^{n-1} \sum_{k=i+1}^{n} \sum_{\substack{j=1 \\ j \neq i,k}}^{n} (a_{ij}b_{kj} - a_{kj}b_{ij})(E_{ik} - E_{ki}) = 0 \end{aligned} \quad (43)$$

The next section provides a more abstract, more elegant, and more efficient derivation and proof of this condition, along with the analogous one for directed graphs. The much greater insight afforded by this more "mathematical" work then leads naturally to a simple geometrical interpretation for commutativity and to constructive tests that are easily codable for both directed and undirected graphs for any n. The strategy is to work with the simplest possible "unit graphs", i.e. single directed or undirected edges, and to generalize to any digraph or graph by writing it as a linear combination of these with coefficients in $\{0, 1\}$. The geometrical condition for undirected graphs is of course equivalent to the result obtained above.

IV. Diamond Condition for Commuting Directed and Undirected Graphs

A *directed graph* or *digraph* $\Gamma = (V, E)$ is a set V of vertices together with a set of edges $E \subseteq V \times V$. It is called a *graph*, or *undirected graph*, if E is a symmetric relation, i.e. $E = E^{-1} = \{(v_2, v_1) : (v_1, v_2) \in E\}$. If Γ is an undirected graph, we say "$\{v_1, v_2\}$ is an edge of Γ" if either (hence both) of (v_1, v_2) or (v_2, v_1) are edges of Γ. In this paper we shall assume Γ has no self-loops, i.e. $(v, v) \notin E$ for any $v \in V$. Moreover, if we write (i, j) is an edge of Γ, this shall be taken to assume $i \neq j$.[8]

For finite graphs, $|V| = n$ is a natural number and it is convenient to take $V = \{1, \ldots, n\}$. We then denote by E_{ij} the $n \times n$ matrix having zeroes in all positions, except for a 1 in row i, column j. The notation δ_{ij} is the Kronecker delta taking values zero and one with $\delta_{ij} = 1$ if and only if $i = j$.

The *adjacency matrix* of a graph or digraph Γ is defined as

$$A(\Gamma) = \sum_{(i,j) \in E}^{n} E_{ij}. \quad (44)$$

For $n \times n$ square matrices A and B, their *Lie bracket* is $[A, B] = AB - BA$. A and B commute if and only if $[A, B] = 0$.

A. Commuting Digraphs

We study when two digraphs have commuting adjacency matrices. In this case we say that the (di)graphs commute. Note we can do this even if the (di)graphs do not have the same number of nodes: If Γ has vertices V and Γ' has vertices V', possibly $V \cap V' \neq \emptyset$, we enumerate $V \cup V' = \{v_1, \ldots, v_n\}$, and consider, without loss of generality, each of the (di)graphs as having edges connecting nodes amongst the v_i's that belong to them. NB: Whether or not graphs commute does depend on whether and how their nodes are identified, e.g. they always commute if their sets of nodes are disjoint!

Observation 1. $E_{ij}E_{kl} = \delta_{jk}E_{il}$

Thus,

Lemma 5 (Lie Bracket of Directed Edges)**.**

$$[E_{ij}, E_{kl}] = \delta_{jk}E_{il} - \delta_{il}E_{kj}. \quad (45)$$

[8]Note that parentheses in (i, j) imply that order matters, whereas curly brackets $\{i, j\}$, which are more generally used to denote a set, imply that either ordering of the indices is equivalent. Thus, parentheses are used for the edges of digraphs and curly brackets for the edges of bidirectional graphs.

Corollary 6. *Distinct E_{ij} and E_{kl} commute unless (and only unless) the directed edges (i,j) and (k,l) are abutting (i.e. $j=k$ or $i=l$, or both).*

Corollary 7. *E_{ij} does not commute with E_{ji}, for any choice of $i,j \in V \cup V'$ $(i \neq j)$.*

Corollary 8. *Disjoint edges always commute. That is, E_{ij} commutes with E_{kl} if the four vertices i, j, k, and l are pairwise distinct.*

Observation 2.

$$[A,B] = \sum_i^n \sum_j^n \sum_k^n \sum_l^n a_{ij} b_{kl} \, [E_{ij}, E_{kl}]. \tag{46}$$

Proposition 9 (Simple Necessary Directed Quadrilateral Condition for Commuting Digraphs)**.** *Let $[A,B]=0$ for adjacency matrices of directed graphs. For each vertex k where an edge (i,k) of Γ meets an edge (k,j) of Γ', there exists a vertex k' such that edge $(i,k') \in \Gamma'$ and edge $(k',j) \in \Gamma$.*

Proof: Abutting edges account for the only way to generate nonzero coefficients in front of E_{ij} and E_{ji} in the expansion of the Lie bracket by Lemma 5. In the expansion of the Lie bracket of A and B (Observation 2), for every k with an edge (i,k) in Γ and an edge (k,j) in Γ', we have

$$[E_{ik}, E_{kj}] = \delta_{kk} E_{ij} - \delta_{ji} E_{kk} = E_{ij}. \tag{47}$$

For every such k, we also have, since (k',j) is in Γ and (i,k') in Γ', the summand

$$[E_{k'j}, E_{ik'}] = \delta_{ji} E_{k'k'} - \delta_{k'k'} E_{ij} = -E_{ij}, \tag{48}$$

which cancels the former. However, there can be no cancellation if there is no k' corresponding to k. □

Visual Interpretation for Digraphs. Each pair of such summands in the proof corresponds to a quadrilateral whose directed edges give two paths from i to j with edges coming alternatingly from the two graphs. Along one of the paths the Γ edge is first and along the other the Γ' edge is first. (Note that $k=k'$ is possible if the two digraphs share a two-step path from i to j. Also $i=j$ can occur.) Moreover, it is easy to give necessary and sufficient conditions for directed graphs to commute:

Theorem 10 (Diamond Condition for Commuting Digraphs). *If Γ and Γ' are directed graphs, with adjacency matrices A and B respectively, then A and B commute if and only if the diamond condition holds: For all nodes i and j, the number of two-step paths from i to j consisting of an edge of Γ followed by an edge of Γ' is equal to the number of two-step paths from i to j consisting of an edge of Γ' followed by an edge of Γ.*

Proof: Since we are multiplying adjacency matrices, the first number mentioned gives the (i,j)-entry of AB, the second number gives (i,j)-entry of BA. Hence $[A,B]=0$ in its (i,j)-entry if and only if these numbers are equal. □

B. Commuting Undirected Graphs

We now characterize when undirected graphs have commuting adjacency matrices. Notation: Let $E_{\{i,j\}} = E_{ij} + E_{ji}$. Obviously $E_{\{i,j\}} = E_{\{j,i\}}$. If Γ is an undirected graph, then A is a symmetric matrix. Clearly in this case

$$A(\Gamma) = \sum_{\{i,j\} \in E}^{n} E_{\{i,j\}}. \tag{49}$$

Observation 3. *For undirected graphs with adjacency matrices A and B,*

$$[A,B] = \sum_{\substack{i<j \\ k<l}}^{n} a_{ij} b_{kl} \, [E_{\{i,j\}}, E_{\{k,l\}}]. \tag{50}$$

Lemma 11 (Lie Bracket of Undirected Edges)**.**

$$\begin{aligned}[E_{\{i,j\}}, E_{\{k,l\}}] = \delta_{jk}(E_{il} - E_{li}) + \delta_{jl}(E_{ik} - E_{ki}) + \\ \delta_{ik}(E_{jl} - E_{lj}) + \delta_{il}(E_{jk} - E_{kj}).\end{aligned} \tag{51}$$

Moreover, at most one of the summands is nonzero. The bracket is zero if and only if $|\{i,j,k,l\}| \neq 3$. Thus an edge commutes with another unless (and only unless) they share a single vertex.

Proof: Using the distributivity of the Lie bracket over sums and the formula for the Lie bracket of directed edges, we see that

$$\begin{aligned}
&[E_{\{i,j\}}, E_{\{k,l\}}] && (52)\\
&\quad = [E_{ij} + E_{ji}, E_{kl} + E_{lk}] \\
&\quad = [E_{ij}, E_{kl} + E_{lk}] + [E_{ji}, E_{kl} + E_{lk}] \\
&\quad = [E_{ij}, E_{kl}] + [E_{ij}, E_{lk}] + [E_{ji}, E_{kl}] + [E_{ji}, E_{lk}] \\
&\quad = \delta_{jk} E_{il} - \delta_{li} E_{kj} + \delta_{jl} E_{ik} - \delta_{ki} E_{lj} + \\
&\qquad \delta_{ik} E_{jl} - \delta_{lj} E_{ki} + \delta_{il} E_{jk} - \delta_{kj} E_{li} && (53)
\end{aligned}$$

Collecting terms multiplied by the same δ's now yields the result. If all of i,j,k and l are distinct then this is zero since all the δ's are zero. If there are only two distinct vertices, it follows that $\{i,j\} = \{k,l\}$; then this Lie bracket is the bracket of a matrix with itself and hence zero. In the case of 3 distinct vertices, we have two undirected edges sharing exactly one vertex, so only the δ corresponding to the unique shared vertex is nonzero. □

Corollary 12. *$E_{\{i,j\}}$ commutes with $E_{\{k,l\}}$ if and only if edges $\{i,j\}$ and $\{k,l\}$ are (1) identical or (2) share no vertex.*

NB: As can be seen from Lemma 11, $[A,B]$ need not be symmetric even if both A and B are symmetric.

Proposition 13 (Simple Necessary Quadrilateral Condition for Commuting Undirected Graphs)**.** *Let $[A,B]=0$ for adjacency matrices of undirected graphs. For each vertex k where an edge $\{i,k\}$ of Γ meets an edge $\{k,j\}$ of Γ' $(i \neq j)$, there is*

a vertex k' so that $\{j, k'\}$ is an edge in Γ and $\{k', i\}$ is an edge in Γ'.[9]

Proof: In the expansion of $[A, B]$ in Observation 3 by Lemma 11, E_{ij} can occur only with a $+1$ coefficient due to summands of the form $[E_{\{i,k\}}, E_{\{k,j\}}]$ ($k \in V \cap V'$) and only with a -1 coefficient due to summands of the form $[E_{\{j,k'\}}, E_{\{k',i\}}]$ ($k' \in V \cap V'$). Hence the number of such summands of each type must be equal. □

Visual Interpretation. Each pair of such summands in the proof corresponds to a quadrilateral comprised of alternating edges from Γ and Γ'. Note that $k = k'$ is possible if the two edges where the graphs meet occur in both graphs.

Similarly, but more simply than in the directed case, it is easy to give necessary and sufficient conditions for directed graphs to commute:

Theorem 14 (Diamond Condition for Commuting Undirected Graphs). *If Γ and Γ' are undirected graphs, with adjacency matrices A and B respectively, then A and B commute if and only if, for all nodes i and j, the number of two-step paths from i to j consisting of an edge of Γ followed by an edge of Γ' is equal to the number of two-step paths from j to i consisting of an edge of Γ followed by an edge of Γ'.*

Proof: This follows from Theorem 10 by noting that the second number in Theorem 10 is equal, for undirected graphs, to the number of two-step paths from j to i consisting of an edge of Γ followed by an edge of Γ'. □

Note that edges in the Diamond Condition comprise (possibly degenerate) quadrilaterals with edges belonging alternatingly to Γ and Γ'.

C. Examples of Commutative Interconnections

We will now develop a geometrical visualization through the corresponding graphs. We recall the motivational problem of connecting two undirected networks in such a way that their adjacency matrices commute, Eq. (1) in Section I-B.

1) Connecting to n-Cycles: We examine the case where the two networks are both simple cycles with n nodes ($n \geq 3$). In this case $A_1 = A_2$ is the $n \times n$ matrix

$$A_1 = A_2 = \sum_{i=1}^{n} E_{\{i,i+1\}}, \tag{54}$$

where the indices are taken modulo n, so $n + 1 \equiv 1$. The two n-cycles can be visualized as straight-line networks with wrap-around (so-called periodic boundary conditions), where the last node connects back to the first. The two cycles are visualized in red as shown in Figure 1 with an example set of blue interconnections given by $B_0 = I$, the identity matrix.

[9]We call an edge *red* if it belongs to Γ and *blue* if it belongs to Γ'. With that, although one can formulate this proposition in terms of coterminous red-blue and blue-read paths from i to j as in Proposition 9, due to undirectedness we can formulate a quadrilateral condition in terms of a closed red-blue-red-blue loop around the perimeter of the quadrilateral i, k, j, k', which is easier to check visually (see next section). An edge is *purple* if it is both red and blue.

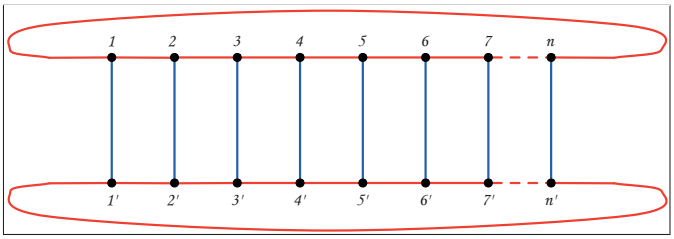


Fig. 1. Two disjoint n-cycle graphs (red) with interconnections (blue), according to the identity matrix I

We already know we can take B_0 to be the zero, identity or all-ones matrices. Regard the above (disconnected, two-component) red graph as Γ. We are interested in finding interconnection graph Γ' with nodes $\{1, 2, \ldots, n, 1', 2', \ldots, n'\}$ and edges of the form $\{i, j'\}$, with i a node of the first cycle and j' a node of the other one.

Blue edges connect each i to i', yielding a graph for which the diamond condition (Theorem 14) obviously holds (Figure 1). We now consider how the resulting graph can be extended minimally with more interconnection edges, while still preserving commutativity. If we want to add $\{1, 2'\}$ to the interconnection edges, the Diamond Condition (Theorem 14) says that we must complete to a quadrilateral the edges $\{1, 2\}$ and $\{1, 2'\}$. We can do this with $\{2, 3'\}$, which together with $\{2', 3'\}$ gives a quadrilateral.[10] The addition of the new edge thus requires another edge. Continuing in this way, we can add all $\{i, (i+1)'\}$ to Γ'. This yields a regular graph of degree 4 consisting of the two cycles and the interconnections, see Figure 2. By Theorem 14, Γ and Γ' commute, giving us a new example. Here B_0 has entry $b_{ij} = 1$ if and only if $i = j$ or $j \equiv i + 1 \mod n$.

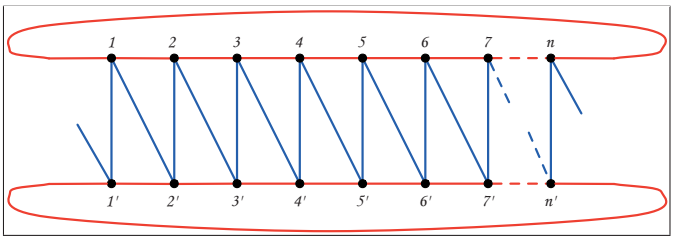


Fig. 2. Example of commuting B_0 interconnection graph with two n-cycle graphs

2) More Examples Connecting Two n-Cycles: Although we constructed the above example using the quadrilateral condition, we can now easily see many similar graphs that will also work (we also get an independent verification of the commutativity of A and the interconnection matrix B just constructed):

Define D_k to be the $n \times n$ matrix with entries $d_{ij}^{(k)} = 1$ if $j = i + k \mod n$ and zero otherwise. D_0 is the identity matrix I and $D_0 + D_1$ is the interconnection matrix B_0 we just constructed above (Figure 2).

[10]Also $\{1, 2'\}$ (blue), $\{2', 3'\}$ (red), $\{3', n\}$ (blue), $\{n, 1\}$ (red) would work, which can be continued to a different solution.

Observation 4. *The graph Γ constructed from the two n-cycles with interconnection matrix D_k is isomorphic to the graph with the two-cycles connected by links $\{i, i'\}$. Note that the latter are encoded by the identity matrix $D_0 = I$. Due to the isomorphism, the diamond condition for the graph with interconnection matrix based on D_k holds since it holds for the graph with interconnection matrix based on $I = D_0$.*

It follows from Proposition 2 that $A_1 D_k = D_k A_1$. Hence we have a commuting interconnection by setting $B_0 = D_k$ for any $1 \leq k \leq n$. Notice that the interconnections encoded by D_k have no edges in common with those encoded by D_m unless $k = m$. It follows that any sum of distinct D_i's is a zero-one matrix.

Let $S \subseteq \{1, 2, \ldots, n\}$. Let Γ' be the interconnection graph with matrix

$$B_S = \sum_{k \in S} \begin{bmatrix} 0 & D_k \\ D_k^T & 0 \end{bmatrix}. \tag{55}$$

Then B_S commutes with A, the matrix of two disjoint n-cycles, since A_1 commutes with each D_k. These yield 2^n examples of commuting interconnection graphs, including our example constructed in this section (taking $S = \{0, 1\}$), the identity ($S = \{0\}$), the zero matrix ($S = \emptyset$), and J, the all-ones matrix for $S = \{0, 1, 2, \ldots, n\}$. Note that each element of S adds one edge at every node to the graph. Thus we have proved the following:

Proposition 15 (Connecting Two n-Cycles via Commutative Interconnection)**.** *Let A be the adjaceny matrix of two disjoint n-cycles ($n \geq 3$) as given above. For any subset S of $\{1, \ldots, n\}$, the interconnection matrix B_S commutes with A. Moreover, including the interconnection links gives a regular graph of degree $|S| + 2$.*

3) Graphs on which Groups Act: We can generalize the results just presented.

Let Δ be any n-node graph with an automorphism group G, which acts[11] *regularly* on Δ: that is, for all $\pi, \pi' \in G$, if $\pi(v) = \pi'(v)$ for some v in the graph then $\pi = \pi'$. Take two disjoint copies of Δ with nodes $\{1, \ldots, n\}$ and $\{1', \ldots, n'\}$, respectively. We can create a commutative interconnection for fixed $\pi \in G$: connect each i in Δ to $\pi(i)'$ in the disjoint copy. For $\pi = e$, the identity automorphism, this is clearly a commutative interconnection. For $\pi \neq e$, the graph with the interconnections constructed according to π is clearly isomorphic to the one with $\pi = e$ since the nodes i' with a prime are simply relabelled by $(\pi(i))'$. Define D_π to be the $n \times n$ matrix of zeros and ones with entries $d_{ij}^{(\pi)} = 1$ if and only if $j = \pi(i)$. If D_π and $D_{\pi'}$ are both 1 at position (i, j), it follows that $j = \pi(i) = \pi'(i)$, whence by regularity $\pi = \pi'$. Interconnecting using the identity matrix yields a graph satisfying the diamond condition, hence so does interconnecting using any $\pi \in G$. And, like before, due to the isomorphism, it follows that $A_1 D_\pi = D_\pi A_1$, where A_1 is the adjacency matrix of Δ.

Let B_π be the symmetric interconnection matrix based on D_π. $AB_\pi = B_\pi A$, where A is the adjacency block diagonal matrix based on $A_1 = A_2$. Then for any subset $S \subseteq G$,

$$B_S = \sum_{\pi \in S} B_\pi \tag{56}$$

commutes with the adjacency matrix A of the two disjoint copies of Δ. This is clear since A commutes with each B_π.

[11] *G acts on $\Delta = (V, E)$* means each $\pi \in G$ permutes V, and for all $v_1, v_2 \in V$, $\{v_1, v_2\} \in E$ iff $\{\pi(v_1), \pi(v_2)\} \in E$.

V. Visualization, Discussion and Conclusion

Figure 3 shows four examples of commuting 6-node graphs that demonstrate the Diamond Condition (Theorem 14). The purple edges indicate overlap between the two graphs Γ and Γ', and the examples were chosen to show the Diamond Condition for different levels of overlap.

Table I shows a visualization of Lemma 5, as the Lie bracket of the four possible combinations of single-edge directed graphs with one vertex in common. Table II, on the other hand, shows a visualization of Lemma 11. The insights encapsulated in these two lemmas and displayed in these tables were the kernel of the proof, in the following sense. Our initial work focused on reviewing background material and rederiving known results, as shown in Section II. The second phase of the work sought to express the commutativity condition through the Lie bracket for A and B matrices of arbitrary size, as shown in Section III. It was at this point that C. L. Nehaniv started to think about when "elemental" graphs of single edges commute, leading to the development presented in Section IV. The two tables then capture all the possible component interactions for the directed and undirected cases, from which the corresponding Diamond Conditions follow naturally for graphs of any size by linear superposition, matching the "brute force" condition (43).

Acknowledgment

The work reported in this article was funded in part by the EU projects EINS, contract number CNECT-288021, and BIOMICS, contract number CNECT-318202. Their support is gratefully acknowledged.

References

[1] T. Kuhn, *The Structure of Scientific Revolutions, 3rd Ed.* University of Chicago Press, 1996.

[2] P. Dini, M. Iqani, and R. E. Mansell, "The (Im)Possibility of Interdisciplinarity: Lessons from Constructing a Theoretical Framework for Digital Ecosystems," *Journal of Culture, Theory and Critique*, vol. 52, no. 1, pp. 3–27, 2011.

[3] P. Dini and L. Sartori, "Science as Social Construction: An Inter-Epistemological Dialogue between Two Internet Scientists on the Inter-Epistemological Structure of Internet Science, Part 1," in *EINS2013: 1st International Conference on Internet Science*, 10-11 April, 2013.

[4] H. Wang, Q. Li, G. D'Agostino, S. Havlin, H. E. Stanley, and P. Van Mieghem, "Effect of Interconnected Network Structure on the Epidemic Threshold," 2013, http://arxiv.org/abs/1303.0781.

[5] K. Erdmann and M. J. Wildon, *Introduction to Lie Algebras*. London: Springer, 2006.

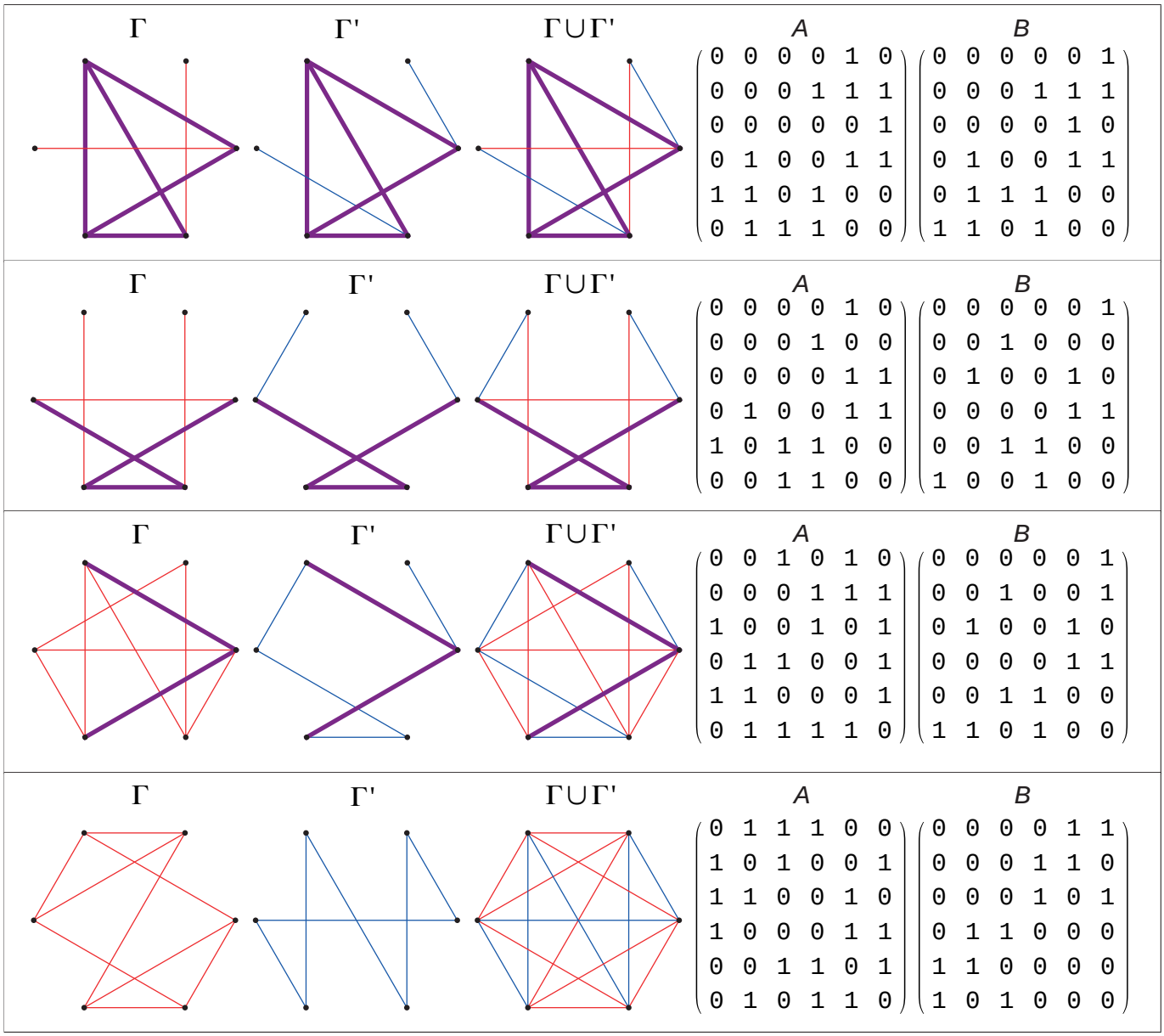


Fig. 3. **Example of Diamond Condition for undirected graphs (Theorem 14) and $n = 6$, verifiable in the $\Gamma \cup \Gamma'$ graph. Purple edges indicate overlap between Γ and Γ'. From the top: large overlap, medium overlap, small overlap, no overlap.**

[6] P. Dini and C. L. Nehaniv, "Notes on Interdependent Networks: Commutativity Conditions for the Adjacency Matrices of Graphs and Digraphs," February 2013, University of Hertfordshire Computer Science Technical Report.

[7] P. V. Mieghem, *Graph Spectra for Complex Networks*. Cambridge, UK: Cambridge University Press, 20122.

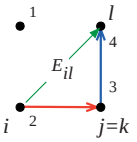
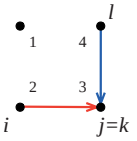
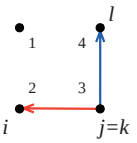
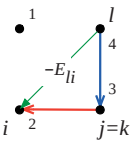
Bracket of Edges	Adjacency Matrix A of Γ	Adjacency Matrix B of Γ'	Lie Bracket	Kronecker δ Notation	Output
	$\begin{bmatrix} 0&0&0&0\\0&0&1&0\\0&0&0&0\\0&0&0&0 \end{bmatrix}$	$\begin{bmatrix} 0&0&0&0\\0&0&0&0\\0&0&0&1\\0&0&0&0 \end{bmatrix}$	$[E_{ij},E_{kl}]=\begin{bmatrix} 0&0&0&0\\0&0&0&1\\0&0&0&0\\0&0&0&0 \end{bmatrix}-\begin{bmatrix} 0&0&0&0\\0&0&0&0\\0&0&0&0\\0&0&0&0 \end{bmatrix}$	$\delta_{jk}E_{il}-\cancel{\delta_{li}}E_{kj}$	E_{il}
	$\begin{bmatrix} 0&0&0&0\\0&0&1&0\\0&0&0&0\\0&0&0&0 \end{bmatrix}$	$\begin{bmatrix} 0&0&0&0\\0&0&0&0\\0&0&0&0\\0&0&1&0 \end{bmatrix}$	$[E_{ij},E_{lk}]=\begin{bmatrix} 0&0&0&0\\0&0&0&0\\0&0&0&0\\0&0&0&0 \end{bmatrix}-\begin{bmatrix} 0&0&0&0\\0&0&0&0\\0&0&0&0\\0&0&0&0 \end{bmatrix}$	$\cancel{\delta_{jl}}E_{ik}-\cancel{\delta_{ki}}E_{lj}$	0
	$\begin{bmatrix} 0&0&0&0\\0&0&0&0\\0&1&0&0\\0&0&0&0 \end{bmatrix}$	$\begin{bmatrix} 0&0&0&0\\0&0&0&0\\0&0&0&1\\0&0&0&0 \end{bmatrix}$	$[E_{ji},E_{kl}]=\begin{bmatrix} 0&0&0&0\\0&0&0&0\\0&0&0&0\\0&0&0&0 \end{bmatrix}-\begin{bmatrix} 0&0&0&0\\0&0&0&0\\0&0&0&0\\0&0&0&0 \end{bmatrix}$	$\cancel{\delta_{ik}}E_{jl}-\cancel{\delta_{lj}}E_{ki}$	0
	$\begin{bmatrix} 0&0&0&0\\0&0&0&0\\0&1&0&0\\0&0&0&0 \end{bmatrix}$	$\begin{bmatrix} 0&0&0&0\\0&0&0&0\\0&0&0&0\\0&0&1&0 \end{bmatrix}$	$[E_{ji},E_{lk}]=\begin{bmatrix} 0&0&0&0\\0&0&0&0\\0&0&0&0\\0&0&0&0 \end{bmatrix}-\begin{bmatrix} 0&0&0&0\\0&0&0&0\\0&0&0&0\\0&1&0&0 \end{bmatrix}$	$\cancel{\delta_{il}}E_{jk}-\delta_{kj}E_{li}$	$-E_{li}$

TABLE I
Visualization of Lemma 5 for $n=4$ example of single-edge digraphs with one common vertex

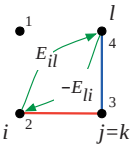
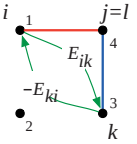
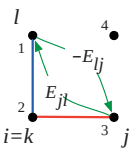
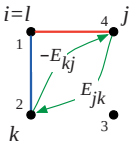
Bracket of Edges	Adjacency Matrix A of Γ	Adjacency Matrix B of Γ'	Lie Bracket $[E_{\{i,j\}},E_{\{k,l\}}]$	Example-Specific Output	General Expression
	$\begin{bmatrix} 0&0&0&0\\0&0&1&0\\0&1&0&0\\0&0&0&0 \end{bmatrix}$	$\begin{bmatrix} 0&0&0&0\\0&0&0&0\\0&0&0&1\\0&0&1&0 \end{bmatrix}$	$\begin{bmatrix} 0&0&0&0\\0&0&0&1\\0&0&0&0\\0&0&0&0 \end{bmatrix}-\begin{bmatrix} 0&0&0&0\\0&0&0&0\\0&0&0&0\\0&1&0&0 \end{bmatrix}$	$E_{24}-E_{42}$	$\delta_{jk}(E_{il}-E_{li})$
	$\begin{bmatrix} 0&0&0&1\\0&0&0&0\\0&0&0&0\\1&0&0&0 \end{bmatrix}$	$\begin{bmatrix} 0&0&0&0\\0&0&0&0\\0&0&0&1\\0&0&1&0 \end{bmatrix}$	$\begin{bmatrix} 0&0&1&0\\0&0&0&0\\0&0&0&0\\0&0&0&0 \end{bmatrix}-\begin{bmatrix} 0&0&0&0\\0&0&0&0\\1&0&0&0\\0&0&0&0 \end{bmatrix}$	$E_{13}-E_{31}$	$\delta_{jl}(E_{ik}-E_{ki})$
	$\begin{bmatrix} 0&0&0&0\\0&0&1&0\\0&1&0&0\\0&0&0&0 \end{bmatrix}$	$\begin{bmatrix} 0&1&0&0\\1&0&0&0\\0&0&0&0\\0&0&0&0 \end{bmatrix}$	$\begin{bmatrix} 0&0&0&0\\0&0&0&0\\1&0&0&0\\0&0&0&0 \end{bmatrix}-\begin{bmatrix} 0&0&1&0\\0&0&0&0\\0&0&0&0\\0&0&0&0 \end{bmatrix}$	$E_{31}-E_{13}$	$\delta_{ik}(E_{jl}-E_{lj})$
	$\begin{bmatrix} 0&0&0&1\\0&0&0&0\\0&0&0&0\\1&0&0&0 \end{bmatrix}$	$\begin{bmatrix} 0&1&0&0\\1&0&0&0\\0&0&0&0\\0&0&0&0 \end{bmatrix}$	$\begin{bmatrix} 0&0&0&0\\0&0&0&0\\0&0&0&0\\0&1&0&0 \end{bmatrix}-\begin{bmatrix} 0&0&0&0\\0&0&0&1\\0&0&0&0\\0&0&0&0 \end{bmatrix}$	$E_{42}-E_{24}$	$\delta_{il}(E_{jk}-E_{kj})$

TABLE II
Visualization of Lemma 11 for $n=4$ example of single-edge undirected graphs with one common vertex

Power relationships embedded in infrastructure governance

Providers versus community

Mayo Fuster Morell

Institute of Government and Public Policies.
Autonomous University of Barcelona

***Abstract*—The paper will address the governance of online creation communities for the building of digital commons. Online Creation Communities (OCCs) are defined as a collective action performed by individuals that, though diverse forms and degrees of participation, cooperate, communicate and interact, mainly via a platform of participation in the Internet, with the goal of knowledge-making and which a resulting informational pool that remains freely accessible and of collective property. The analysis will look to the sources and type of power present at these networked forms of collective action. The methodology is based on triangulation of quantitative and qualitative approaches. The empirical analysis will be based on a large-N statistical analysis and three case studies (Wikimedia Foundation for Wikimedia projects; Yahoo for Flickr; and International Council of the World Social Forum for the Social Forum Memory project). The methods used for the case study are virtual ethnography; participative observation in physical encounters and headquarters; interviews and e-mail interviews; and analysis of participation data.**

Keywords—Online creation communities; power; infrastructure provision

I. INTRODUCTION

First studies on the Internet and politics mainly concentrated on well-established and traditional actors such as parliaments and political parties [1,2,3,4,5,6,7,8]. The debate was followed by an interest in empirical research on interest groups, NGOs and social movements [9,10,11,12,13]. From my point of view, the debate on the Internet and politics could benefit from expanding further to consider actors with mainly an online base. Following this reflection, this paper addresses collective action in the digital era, with the empirical case of online creation communities (OCCs) and among them, those of global scale.

Online creation communities (OCCs) are sets of individuals who communicate, interact and collaborate in several forms and degrees of participation which are eco-systemically integrated, - mainly via a platform of participation on the Internet, on which they depend - and aiming at knowledge-making and sharing.

In order to approach the subject of OCCs it is useful to make an analytical distinction between two spaces. On the one hand, there is a platform of participation where participants interact, and which can grow enormously. On the other, there is a generally small provision body that provides the platform on which the community interacts. For example, the Wikimedia Foundation is the provider of the infrastructure within which the community of participants who build Wikipedia interact. The provision of this infrastructure cannot be seen as a dysfunction or unimportant; instead it solves some of the questions this type of online collective action necessarily raises. Previous analyses of OCCs have dedicated little attention to this, and infrastructure governance is considered a "backstage" question [3,4,6,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27]. In my view, in the analysis of OCCs there is instead a need to look at both spaces (community, around the knowledge-making, and infrastructure provision) and their particular connections, because both are important and have functions in the governing of OCCs.

A part of the interest in the analysis of OCCs is linked to the growing socioeconomic importance of forms of knowledge-making in a knowledge-based society [28]; the analysis of OCCs offers an opportunity to see how various problems of democratic governance evolve and are solved in a digital environment. In other words, OCCs are interesting for what they can tell us about democratization more generally. Furthermore, OCCs can help us to analyze power relationships emerging in online environment.

The paper is organized into two main parts. The first part will introduce the main models and logics of the relationship between providers and the community (that is, models of infrastructure governance) according to previous research. The second part will address the core question of the paper; that is, How does power work in OCCs? How does power frame the relationship between infrastructure providers and the community? A conceptualization of power in OCCs will be presented,

and an empirical analysis based on a comparison of four case studies presented. The four case studies are the Social Forum Memory Project, Wikipedia, Flickr and Wikihow.

In the case of the Social Forum, the platform analyzed was *openesf.net* . This is a platform provided by the European Social Forum (ESF). The ESF is a gathering of social movements in Europe. The social Forum host platforms for archiving information on the forums, developing the forum program, facilitating networking among the forum participants, and allowing the collective (re)construction of the memory of the forums.

Wikipedia is one of the most outstanding examples of OCCs. It is an encyclopedia of free content created in 2001, developed in a collaborative manner with the use of Wiki technology by tens of thousands of volunteers around the world. The infrastructure is provided by the Wikimedia Foundation, a North American non-profit foundation based in San Francisco.

Wikihow is a Wiki collaborative "how to" manual. Founded in 2005, it is provided by Wikihow, a start-up based in Silicon Valley, San Francisco.

Flickr is a platform for sharing and archiving visual materials. As of November 2008, it claimed to host more than three billion images. It is provided by Yahoo!. Particiants interact in order to improve and comment on each other's pictures, collaborate to create "albums" of photos around a particular topic, or create learning groups around photography techniques.

The methods used in the case studies were interviews, participative observation and online ethnography. The data collection on the social Forum was mainly carried out during 2007 and 2008. The Wikipedia data collection was carried out from July 2008 to August 2009, and the Flickr and Wikihow data collection from July 2009 to January 2010.

II. INTRODUCTION TO INFRASTRUCTURE GOVERNANCE

According to previous research, the OCCs can be classified in terms of how their provision spaces function [29][1]. Two main axes concerning the infrastructure provision strategies can be distinguished: open *vs.* closed to community involvement in infrastructure provision, and freedom and autonomy *vs.* dependency on the infrastructure (netenabler *vs.* blackbox).

There is a qualitative difference between, on the one hand, the OCCs where it is possible for participants to present themselves as candidates for, or be part of, the administrative body; and, on the other, those where such options are not available; in other words between "closed" provision spaces and "open" or accessible participative provision spaces.

Participation in the provider space is considered closed where it would require a capital investment or being a member of an institution (such as a university). Participation in the provider space is considered partly open where this depends on the fulfilling of certain criteria related to participation in the platform (such as a number of contributions). It is considered open when participation in the provider space is possible for anyone; that is, participation is regulated through self-selection.

The freedom and autonomy *vs.* dependency on the infrastructure (netenabler versus blackbox) dimension is linked to the knowledge policy - in concrete, to the copyright license and the type of software used. Netenabler conditions are defined by a copyleft license and the use of Free/Libre Open Source Software (FLOSS) code, while blackbox conditions are defined by copyright and proprietary software.[2] On the one hand, the importance of knowledge policy is linked to the observation that knowledge-making is the goal of OCCs. In this regard, the conditions of access and use of the resulting knowledge could be considered as a "right" of the contributors as "authors" and so subject to democratic organizing.

On the other hand, knowledge policy can be understood as referring solely to the conditions of access to the "knowledge outcome" of the community, yet from a broader perspective knowledge policy governs the relationships in online environments.

Firstly, relationships in the online environment are founded upon the exchange of information which is subject to copyright law. The management of the information also governs the relationships that can be established online. In other words, the management of the information dictates the protocols of the relationships. Relationships are "restricted" to a confined copyright regime, but can flow freely if the management of information does not restrict the information flow.

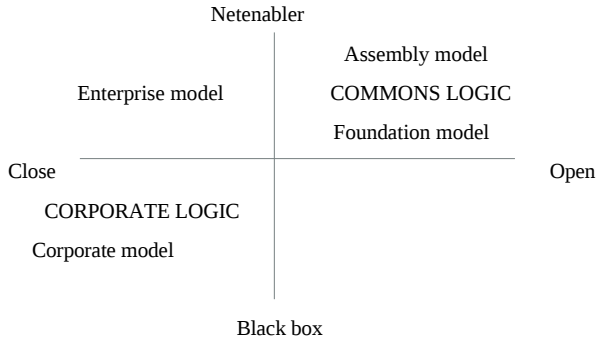
Secondly, in large online interactions, the social contract between the parties is less defined by any direct agreement between them than by the platform's design. The code of the platform regulates the information exchange and the architecture of actions that can be developed [30,31]. Open- code platforms make the regulatory dimension more transparent, but also allow recoding or intervention in the regulatory dimension.

Thirdly, and perhaps most importantly, there is a qualitative difference between relational settings in which the collective action is "locked" into the platform, and those where the collective action is free and autonomous with respect to the platform. If the platform cannot be reproduced, the community relationship is "closed" within the specific platform which is dependent on the provider. If the platform can be replicated, the relationships are free from the specific platform provider. FLOSS and copyleft licensing allow platforms to be replicated, while proprietary software and copyright regimes do not. In other words, the use of FLOSS and a copyleft license creates conditions in which the community can have greater autonomy and freedom from the platform provider, as well as allowing for the possibility of other combinations of collective relationships and interventions in the regulation of those relationships. The role of the provider thus evolves from being there "exclusively" to allow the collective action to happen. This is an essential aspect of community empowerment.

[1] The empirical analysis of this previous research was a large N analysis based on a sample of 50 units, a codebook, the collection of digital data threads, and producing a statistical analysis of the data.

[2] Copyleft [54] refers to the set of licences which favor a less restrictive information regime than traditional copyright.

FIGURE I. Models and logics of infrastructure provision



Concerning, the open *vs.* closed to community involvement in the provision body distinction (axis X in figure I), there is a qualitative difference between OCCs in which it is possible to take part in the provider body, which is the case with the foundation and assembly models, and those in which this is not possible, as is the case with the corporation and enterprise models, as presented in figure I.

Among the open OCCs, there is also a substantial difference in the levels and ways in which the provider body is open in terms of formality *vs.* informality. While the foundation model is based on the formal organization of participation in provision and establishes more, the assembly model is based on informal organization and participation is less restricted. The operationalization of formality is based on the presence or otherwise of a legal entity, and the limitation (or not) of participation to members of a board.On this axis, a distinction can also be established between for-profit strategies *vs.*non-profit strategies. Profit strategies are by definition close to community involvement. Corporation and enterprise models are for-profit, while foundation and assembly models are non-profit. The for-profit *vs.*non-profit characteristic is operationalized by looking at the character of the legal entity of the providers.

The netenabler *vs.* blackbox (axis Y in figure I) refers to knowledge policy. Netenabler conditions are based on a copyleft license and FLOSS code; conversely, blackbox conditions are based on copyright (restrictive access) and proprietary code. Only the corporation model tends to be blackbox. The other cases are netenabler models, albeit to different degrees.

In order to define models of infrastructure provision, the two dimensions of democratic quality linked to infrastructure provision (the open *vs.* closed to community involvement in the provision body distinction (axis X in figure I) and, netenabler versus blackbox (axis Y) were considered [29]. Four main clusters of cases constituted the four models of infrastructure governance: corporate service model, mission enterprise model, representative foundation model, and assemblearian self-provision. Furthermore, according to these two axes, two oppositional logics are defined: common logic based on openness to community involvement in the provision body and netenabler conditions (that is major freedom and autonomy from the infrastructure provider); and corporate logic based on closedness to community involvement in the provision body and black box conditions.

The corporation service model applies to cases of communities owned by communications companies with large pools of technological skills such as Google, the provider of YouTube. Flickr (provided by Yahoo!) is a case of corporate model .

The corporate model of infrastructure governance is characterized by a provider body closed to participant involvement and based on blackbox conditions. It follows a for-profit strategy. Participants are “trapped” in the platform, as the copyright and proprietary software framework restricts the freedom and autonomy of the participants in the platform.

The mission enterprise model is characterized by being for-profit, and hence closed to participant involvement. Importantly, the enterprise model is based on netenabler conditions, which favor the autonomy of collaboration. Furthermore, the enterprise model guarantees more netenabler conditions than the foundation model. The enterprise model is the case for startups, which maintain independence from big communications companies. It is a strategy for developing new business models which are compatible with netenabler conditions. Wikihow is an example of the enterprise model.

The autonomous representational foundation model is characterized by a provider body which is (relatively) open to participant involvement as it uses some formal filters. This model is also characterized by its promoting the freedom and autonomy of collaboration (netenabler). Additionally, they are non-profit. Being relatively open to participant involvement implies that they are formal, and not open in terms of the self-selection of participants, but open in terms of filters of requirement. In this regard it could be considered a hybrid form (partly open, partly closed). OCCs following this model are less open than the assembly model, which is based on total openness of the provision body. They are also less netenabler than the assembly and enterprise models. The foundation model describes the situation of Wikipedia provided by the Wikimedia Foundation. The self-provision assembly model is characterized by being the most open in terms of provision. A self-selected community of participants can be part of the provision body in this model. It follows an informal organizing logic (without a board or legal entity) and is non-profit oriented. Additionally, the assembly model assures the most netenabler conditions. The assembly model applies to the sites linked to the Social Forum process.The previous section introduced the logics and models of infrastructure governance. The next sections will present the conceptualization of power and the empirical analysis of power in OCCs. The final goal of the paper is to address the question: How do the different logics of infrastructure governance (commons logic versus corporate logic) distribute power between the provider and the communities?

III. Conceptualization of power in OCCs

According to Castells [30], in the global network society there are four distinct forms of power: network power (the power of the protocols of communication to impose the rules of inclusion and dialogue); networked power (who has power in the dominant networks); network-making power (the paramount form of power, with reference to programmers and switchers); and networking power (the power of actors and organizations included in the networks that constitute the core of the global network society over human collectives or individuals who are not included in these global networks). In this list, Castells does not mention the importance of infrastructure

providers. In this regard, somewhat in line with and somewhat against Castells, I will argue that the role of the infrastructure provider for network building and collective action is fundamental in the global network society. In addition, there is a need to delve deeper and explore power relations in network forms and extract some commonalities of power in network forms, moving beyond Castells' assumption that "because networks are multiple, power relationships are specific to each network" [30, p.89]. Furthermore, the (emerging) institutional logic that frames the relationship between the infrastructure providers and users (individually, but more importantly, collectively) will be determined by the political shape of the society in the organizational environment.

Within the framework of this research, power is regarded as embedded in the institutional order of the OCCs [30, p.44]. Power refers to a universal dimension present in any social relationship. In Parson's approach, power is the generalized mean of exchange [32]. Power is not seen as an attribute, but as relational and as a reciprocal relationship. In this regard, my analysis distances itself from an approach to the role of platform provider as the holder of some power with meaning or value in itself. Instead, my analysis approaches power in OCCs as being the consented-to, negotiated and/or conflictual relationship between providers and communities embedded in the infrastructure governance of OCCs. On the one hand, power in OCCs, as in any social relationship, involves not only the entity that is the source of power, but also others who obediently consent to, accept or resist that power. On the other hand, social structures are based on power relationships that are embedded in institutions and organizations according to Lukes [33]. In this regard, an analysis of the distribution of sources of power between the platform provider and the community is developed, as they are embedded within infrastructure governance.To map the sources of power, an analysis of the functions, authority and ownership present in OCCs will be carried out. The analysis of the distribution of those sources of power between the actors involved will consider the more or less equal or asymmetric positioning of the provider vis à vis the community. Furthermore, power distribution in OCCs is regarded not only in terms of the distribution of sources of power, but also with regard to typology (power *for vs.* power *over*). Power involves either an action or the possibility to take action. The direction of power in terms of whether it is benevolent and empowering (such as providers defending the legal interests of the community) or malignant and disempowering (such as providers controlling participants' data) will be also considered.

Finally, my approach is distanced from the elitist approach to power which refers to the existence of a unitarian hierarchy with material, symbolic and political resources all converging in the same hands [34]. Instead, in the line of pluralists, a more complex picture is depicted, with polyarchies based on the separation of the different sources and carriers of power in any social relationship. The exercise of power in a network society requires a complex set of joint actions that goes beyond alliances to create a new type of subject [35]. According to Castells: "There is not unified a power elite capable of keeping the programming and switching operations of all important networks under its control that more subtle, complex and negotiated system of power enforcement must be established. For these power relationships to be asserted, the programs of the dominant networks of society need to set compatible goals between these networks. And they must be able, though the switching processes enacted by actors-networks, to communicate with each other, including synergy and limited contradiction" [30, p. 47].

The classical sociological definition of power by Weber understands power as "the probability that one actor within a social relationship will be in a position to carry out his own will despite resistance, regardless of the basis on which this probability rests" [36, ,p.53]. This will be reformulated in order to be applied to my analysis of OCCs. While Weber's definition of power is based on a unilateral relationship, my approach to power is multidimensional and interactive. Furthermore, my approach to power integrates the different directions of power, considering empowering ("power for") and disempowering ("power over") forms. However, contrary to the binary antagonistic approach of Holloway's "power for" and "power over" [37], the possibility for overlap between these two types of power in a relationship will also be considered. This is in line with Foucault's conception of power where the latter is seen as a "multiplicity of relationships of force" [38, p.121]. In conclusion, within the framework of this research, power is regarded as the series of situations in which an actor involved in a social relationship is able to impose his/her will, even in the face of the resistance of other parties and/or over third parties (external world) "for" the benefit of the other party, independently of the sources of such will and as they are embedded in the institutional order.

Power in OCCs can be a source of inspiration for political imagination in terms of rethinking institutional logics for political organizing. Power in OCCs follows an eco-systemic pattern. A major feature of power in OCCs is its distributed character, which creates mutual dependency between the holders of power. In this regard, within the current organizational paradigm change, it could be said that power follows a network logic confirming an eco-systemic, plural, multi-dimensional and interactive network.

In this paper an analysis of the power relationships embedded in infrastructure governance will be presented. Power in OCCs is addressed in terms of the distribution of several sources of power between the provider and the community. Earlier research on OCCs has indicated the particular form of ownership present in these organizations [39]. My analysis builds upon this early research on ownership within OCCs. However, in order to analyze power within OCCs it is relevant to consider not only the distribution of ownership, but also the distribution of functions and authority. In this regard, three aspects will be considered. Firstly, *who does what*; that is, function distribution; secondly, *who has authority over what*; that is, the distribution of authority; and thirdly, *who owns what*; that is, ownership distribution. Once a map of power distribution characteristic of OCCs has been presented, an exploration of the type of powers and asymmetries in terms of the empowerment of providers vis à vis the communities will be presented. Importantly, a sharp distinction in power distribution between commons logics and corporate logic is demonstrated by the analysis.

IV. Prosumers and the change in the media power matrix

In terms of the distribution of functions, a major commonality can be highlighted within the OCCs. The providers take care of the technical infrastructure, its sustainability and the relations between the OCCs and the external world. The relations with the external world refer to the symbolic dimension (trademark and logo management), fund-raising and press and legal issues. The community takes care of developing the content or the work.

Providers not being involved in content creation has occurred since the very beginnings of OCCs. For example, this was the case of the WELL, one of the earliest online communities [40]. In addition, legal regulations tend to reinforce this distribution of functions. Most of the legal regulatory systems do not make providers responsible for the content created by the participants. In this regard, in order to ensure providers hold no liability over content, it is best that providers do not get involved in content creation. It is worth specifying that the issue of the liability of providers is independent of the type of provider. The introduction of provider liability would create prejudice for both for-profit and non-profit providers. Furthermore, it would most likely lead providers to censor some content; and it would make non-profit strategies difficult, as providers would have to meet the costs of liability.

Concerning the distribution of functions, in the four case studies, providers are in charge of infrastructure provision and symbols (trademark and logo), while the work is developed by the community. However, minor differences are present between the cases. There is a sharp distinction between the cases of Flickr and Wikihow in terms of the content being developed only by the community. In Flickr, providers do not get involved in creating content, yet in the case of Wikihow, the provider, particularly through the figure of the founder, is involved in developing the work. This is even more so the case for the Social Forum, where generally the "promoters" of the platforms within the context of the Social Forum are amongst the main generators of content.

According to this function distribution, participants are not "consumers", but "prosumers" [41]. Participants use the work available at the platform, but also create content. This is a major distinction between the "old" media and the "new" media [42]. Importantly, the "prosumer" character of the participants changes the power matrix between the "old" and "new" media providers in the public space. Providers of online infrastructure depend much more on the participants as creators of the content that gives value to the site. Providers depend on the participants to generate the content and to attract more participation and attention; while participants depend on the providers to give the infrastructure that supports their interaction. As a consequence of the function distribution, a mutual dependency between the providers and the community exists.

The dependency of providers on the content created by the participants is illustrated, ironically, by the case of Google. Google's slogan is "Don't be evil" meaning that Google cannot do whatever it wants - it cannot be evil [43].

Kow and Nardis [44] use the term "creative ecology" to refer to the mutually beneficial relationships between companies and communities. According to Kow and Nardis [44] and Tschang and Comas [45], the development of new media co–evolves across three elements: designers, users, and a business rationale. However, as the design of the architecture of participation is controlled by the providers, I do not distinguish designers as a key element distinct from providers. In the words of Wikihow's founder, "You might have some power, but you have to use it carefully because of the mutual dependencies." [46].

It is relevant to mention that fulfilling the function of infrastructure provision is a source of power from a Foucauldian standpoint in two senses [38]. On the one hand, infrastructure design defines linkages between individuals. The guiding and coordination of the interaction between the participants is transferred to the infrastructure design [47]. The "code" in Lessig's terms regulates the cyberspace, just as architecture regulates real spaces. The regulation of the infrastructure limits the freedom of the participants (what they can or cannot do) and disciplines the participants into designed behavior. This form of power over participants is not direct and coercive (such as torture) but a "disciplinary power" in Foucault's terms [38]. On the other hand, in using the infrastructure participants generate digital threads (e.g. from which country the participant is connecting to the site, which topics he or she is interested in, with whom he or she interacts, among others). Providers have access to these digital threads. Adopting Foucault's point of view, the goals of power and knowledge cannot be separated: in knowing, providers control and in controlling, providers know .

The mutual dependency of the distribution functions is characteristic of all the case studies independently of their types of infrastructure governance. However, in terms of distribution of authority and ownership there are differences. There is a qualitative difference between the settings of the corporate logic for the Flickr case and the commons logic of the other cases.

V. Providers versus community: distribution of functions, authority and ownership

As presented in the previous section, the distribution of function is similar in both infrastructure governance logics. However, major differences are present between these two logics in terms of the distribution of authority and ownership of the community vis a vis the provider (see following table on distribution of functions, authority and ownership).

TABLE II. Distribution of functions, authority and ownership among communities and providers: commons logic versus corporate logic

	Provider	Community
Commons		
Functions	Technical infrastructure External relationship. Press and legal matters. Sustainability	Work
Authority	As functions and ownership	As functions and ownership Self-governance
Ownership	As functions and authority	As functions and authority Collective ownership
Corporate		
Functions	Technical infrastructure External relationship. Press and legal matters. Sustainability	Work
Authority	As functions and ownership Plus authority over the community	No self-governance
Ownership	functions and authority	Individually based

In the commons logic, function, authority and ownership follow the same distribution pattern. In corporate logic, function, authority and ownership follow different patterns of distribution. Importantly, these different approaches to the matrix, varying between function, authority and ownership, condition the power distribution in the OCCs following these two logics.

In commons logic, function, authority and ownership are distributed similarly. The provider takes care of the technical infrastructure provision, legal framework and the logo and trademark, and has authority over and ownership of them; while the community develops the work, owns the work, and has authority over the work. In other words, providers take care of certain functions and have authority over and ownership of them; while the communities are self-governed in the sense that they have authority over how the interaction processes between participants building the work will be; in addition communities collectively own the resulting work.

This is the case for Wikihow, Wikipedia and the Social Forums, although with minor differences. The Social Forums have no "formal" organization of ownership. The use of legal frameworks is rare in the context of Social Forums. In this regard, in the Social Forum it is common that the ownership of the work is not established by licenses. However, the informal ownership of the Social Forum follows the same concept of knowledge as the other cases, with privileged access and reuse as well as a collective character. Another contrast between this set of case studies is that, in the cases based on open infrastructure governance (that is Wikipedia and the Social Forum), the participants can get involved in decisions on providers' matters if they wish to a certain degree. This is not the case with Wikihow. Also, Wikihow's providers have more involvement in community matters than in the cases of Wikipedia and the Social Forum.

In conclusion, in commons logic the common infrastructure governance logic creates a dynamic of "doography".-meaning that those who do something have authority over it and ownership of it.

Several aspects of the situation change in the corporate logic, which is the case for Flickr. On the one hand, the distribution of authority is not equal to functions. Flickr has authority and ownership of the infrastructure, but also has authority over the community's functioning as it establishes the policies of behavior for interactions within the infrastructure. In other words, the community is not self-governed. The rules and policies that govern the interaction are established by Yahoo!. Furthermore, those rules and policies establish the tight control of Yahoo! over its participants. For example, Yahoo! can remove material created by a participant if it does not follow the policies that Yahoo! has established.

On the other hand, the ownership of the works is not collective, but individual, and so the community is not empowered in collective terms, but in individual terms with regards to work ownership.

This different matrix in terms of function, authority and ownership in the commons and corporate logics creates a different scheme of dependencies between the provider and the community. In other words, the number and strengths of the sources of power in the corporate logic benefit the provider with regard to the community of participants.

In conclusion, under both logics providers depend on the community to develop the work and content. The "vast majority of the work" is developed by the community. In other words, the participation of the community is the main prerequisite for achieving the stated goals. If there is a decrease in participation in the community, the providers have no way of replicating what the community does. It is worth mentioning that the large N analysis showed that the ratio between the number of people required to create the infrastructure for collective action online, and the total number of people involved in creating the content was small. For each person present at the provision space there is a mean of 55,906 people creating content at the platform. However, the dependency of the community on the provider is more significant in the corporate logic than in the commons logic.

In both logics, the community could find ways to continue acting without the providers. However, the blackbox conditions and the individual basis of the corporate logic disempowers the community. Firstly, the corporate logic is not based on doography. The community does not have authority over its own interaction. The community cannot define the rules and policies of what participants do together. Furthermore, providers have the capacity to control the participants' individual behavior. Providers can block the participation of a certain individual or can remove the content they create if, according to the provider, it does not follow their policies. In other words, the freedom of speech of the participants in corporate platforms is "monitored" by the corporation. It is up to the corporate platform to decide whether to allow the content or not. Secondly, blackbox conditions in corporate models reduce the freedom and autonomy of the community, and reduce the possibility to "replicate" the platform somewhere else and re-start the collective action without the corporation.

There are even cases, such as Facebook, where the provider can request ownership of the content generated by the participants on its site, and create impediments for participants who seek to move their data elsewhere, as well as claiming ownership of data generated by them. In addition, with blackbox conditions, users have no way of knowing what the software they are using is doing; for example if it is collecting their personal data and sending it somewhere else [47]. In this regard, it is frequent that corporations commercialize their participants' behaviour data. This data is useful, for example for building marketing profiles. Participants in these conditions have the option to stop participating, but it becomes difficult to "leave" since the price is to lose one's own data. Furthermore, the individual base of the corporate model makes it even more difficult for the community to collectively declare independence from the provider. As individuals individually own content, they would have to agree in order to migrate the content somewhere else. This is not the case when the works are owned collectively and have a free character. With free collective ownership, there is no need for the entire community to agree on seeking autonomy from the provider. A part of the community can decide to migrate without the rest of the community.

In commons logic, the community is more empowered with regard to the provider in several aspects. On the one hand, the commons base model is based on "doography" principles. The community develops and owns the content, as well as holding authority over it. This implies that communities are self-governed, in the sense that communities define the rules and assign the roles of the interaction process. For the case of open providers, communities can also intervene in and have authority over the provider functions. Secondly, netenabler conditions favor the freedom and autonomy of the community from the infrastructure, as this can be reproduced. The community collectively owns the content, which can be reproduced; the platform software can also be reproduced. This creates the conditions for the community to "leave" and "fork" if the community, or part of it, does not agree with the provider's behavior. As the content is owned collectively, forking is more easily achieved.

The possibility of forking is a major feature in terms of community empowerment. Even if it does not occur, the possibility that it could do so forms a mechanism which empowers with regard to the provider. Actually, forking has only taken place in one of the cases, e.g. Wikipedia; however, forking occurs with a certain regularity in FLOSS communities (Hill, 2005).

It may be worth mentioning that as the community grows larger, the possibility of forking becomes more remote. Forking is more difficult when communities grow larger, because, amongst other issues, the reproducibility of a large and costly infrastructure combined with the network effect inside the community makes it more difficult to fork. In other words, as the communities grow larger, the balance of power tips towards the providers.

In summary, an exploration of the type of powers and asymmetries in terms of the empowerment of the provider vis à vis the community between the corporate and commons logics reveals that there is a sharp distinction in power distribution between commons logics and corporate logics. Commons logic is based on the empowerment of the community in terms of community self-governance, community autonomy and freedom from the infrastructure. Corporate logic is designed to empower the providers. The community is disempowered in corporate governance in several senses: the control of the corporation over participants' behavior at the platform; the dependency of the participant for access and reuse of their works on the platform; and the non-enforcement of a collective frame.

It is worth mentioning that it is common for providers to use a discourse of empowering the community. However, according to the analysis not of the discourses, but of the sources of power, the empowerment of the community within the corporate logic is minor when compared to the commons logic. I suggest the term "Wiki-washing" to refer to the practice of creating "fake" images of commercial providers in order to boost reputation.

Two senses of power are present in OCCs: power "for" and power "over." Power "for" refers to the power to accomplish a mission, a force that supports doing something, or a tool that allows a move. Power "over" refers to the control and domination of someone to direct and force their actions, involving an asymmetry between those with power and those over whom power is exercised.

In both logics, the dependency of the provider on the community as the content generator limits the power of the providers "over" the community. Participants are not employees, and the providers do not have any direct source of power "over" the volunteers to force them to do something. Providers could block the use of their infrastructure, but then they will lose their own role as platform providers.

However, a distinction seems to be present in terms of power "for" versus power "over" in the two logics. In the corporate logic, the provider controls the community and restricts its autonomy from the infrastructure; these constitute two sources of power "over" the community. Instead, in the commons logic, the power that providers hold is more based on being able to accomplish or provide something for the community than a power to force the community to do something. Providers in the commons logic do not have control over the community, as the community is self-governed and can become autonomous from the provider. Additionally, providers depend on the trust of the community to fulfill their role.

In conclusion, in a commons logic, providers have limited power "over" the communities in contrast to the corporate logic, and the power they do have with regards to the community is a power "for" supporting the community to accomplish the mission. The terms of being in parallel with, and not "over and under" a hierarchy (or in the centre) could illustrate this relationship between the providers and the communities in a commons logic. During the interviews for the Wikipedia and ocial Forum cases, interviewees were asked to sketch a map of the relationship between the provider and the community, and most did indeed depict the provider as parallel to the community. Other authors who have studied providers in open-source and free-software projects also suggest a similar argument with the concept of "lateral authority" [48]. Theorists have long predicted that project and networked-based forms will rely less on traditional lines of vertical authority and more on lateral modes of authority in order to achieve collective work outcomes [49,50,51,52,53].

Finally, the distribution of functions, ownership and authority amongst the providers and the participants in a commons

logic generates an eco-systemic mutual dependency between them. The concept of parallel co-governance is appropriate for referring to a form of governance in which both provider and community play a role and a mutual dependency is formed between them.

REFERENCES

[1] S. Coleman, J. Taylor, and W. Van de Donk, Eds. Parliament in the Ageof the Internet. Oxford: Oxford University Press, 1999.

[2] P. Norris, Democratic Phoenix: Reinventing Political Activist. Cambridge, UK: Cambridge University Press, 2002.

[3] A. Trechsel, R. Kies, F. Mendez and P. Schmitter, "Evaluation of the use of new technologies in order to facilitate democracy in Europe: E-democratizing the parliaments and parties of Europe," 2003. Retrieved from http://www.erepresentative.org/docs/6_Main_Report_eDemocracy-inEurope-2004.pdf.

[4] A. Römmele, "Political parties, party communication and new information and communication technologies." Party Politics, vol. 9, 7-20, 2003.

[5] C. Cunha, I. Martin, J. Newell and L. Ramiro, "Southern European parties and party systems, and the new ICTs." In Political Parties and the Internet, R. Gibson, P. Nixon and S. Ward, Eds. London: Routledge, 2003. pp. 70-97.

[6] R. Gibson, P. Nixon and S. Ward, Eds. Political Parties and the Internet - Net Gain? New York and Londres: Routledge, 2003.

[7] R. Gibson and S. Ward, "U.K. Political parties and the Internet: "politics as usual" in the new media?," Harvard International Journal of Press/Politics, vol. 3(3), pp. 14-38, 1998.

[8] M. Margolis and D. Resnick, Politics as Usual: The "Cyberspace Revolution," Thousand Oaks, CA: Sage Publications, 2000.

[9] D. della Porta, D and L. Mosca, "Searching the net. Web sites' qualities in the Global Justice Movement," Information, Communication & Society, vol. 12 (6), pp. 771 - 792, 2009.

[10] G. Navarria, "Reflections on beppegrillo.it: A successful attempt of innovation and active promotion of political participation through the web?" A paper prepared for the 4th ECPR General Conference, Pisa (Italy), 6-8 September, 2007. Section: "Emerging Patterns of Collective Action" Panel: "The use of ICTs for innovative forms of participation," 2007.

[11] M.L. Sudulich, "ICT and SMO: something new?" A paper presented at the "Cortona Colloquium 2006", Cultural Conflicts, Social Movements and New Rights: A European Challenge, Cortona, Italy, 20-22 October 2006,

[12] P. Van Aelst and S. Walgrave, "New Media, new movements? The role of the Internet in shaping the anti globalization movement," in Cyberprotest: New Media, Citizens and Social Movements, W. Van de Donk, B. Loader, D. Rucht, and P. Nixon. London: Routledge,2004.

[13] B. Vedres, L. Bruszt, and D. Stark, "Organizing technologies: Genre forms of online civic association in eastern Europe," The Annals of the American Academy of Political and Social Science, vol. 597, pp. 171-188. doi: 10.1177/0002716204270504, 2005

[14] M. Burke and R. Kraut, "Administrators: Mopping up: modeling Wikipedia promotion decisions," Proceedings of the 2008 ACM conference on computer-supported cooperative work. San Diego, CA, USA, pp. 27-36, 2008.

[15] A. Ciffolilli, "Phantom authority, self-selective recruitment and retention of members in virtual communities: the case of Wikipedia." First Monday, vol. 8 (12), 2003. Retrieved from http://www.firstmonday.org/issues/issue8_12/ciffolilli/

[16] R. Davis, The Web of Politics: The Internet's Impact on the American Political System. Oxford, UK: Oxford University Press, 1999.

[17] C. De Landtsheer, N. Krasnoboka, and C. Neuner, "La facilidad de utilización de los websites de partidos políticos. Estudio de algunos países de Europa del este y occidental," Cuadernos de Información y Comunicación (CIC) vol. 6, pp. 107-140, 2001.

[18] A. Kittur, E.Chi, B. Pendleton, B. Suh, and T. Mytkowicz, "Power of the few vs. wisdom of the crowd: Wikipedia and the rise of the bourgeoisie," Proceedings of the 25th Annual ACM Conference on Human Factors in Computing Systems (CHI 2007), April-May 2007.

[19] T. Kriplean, I. Beschastnikh, D.W. McDonald, and S.A. Golder, Community, Consensus, Coercion, Control: CS*W or How Policy Mediates Mass Participation. GROUP 2007 - ACM Conference on Supporting Group Work. 2007.

[20] M. Loubser and C. Pentzold, "Rule dynamics and rule effects in commons-based peer production." Section: Internet and politics. panel: Contemporary collective action dilemmas. 5th ECPR General Conference, Potsdam/Germany, 10-12 September 2009.

[21] P. Norris, "Preaching to the converted? Pluralism, participation and party websites," Party Politics, vol. 9 (1), pp. 21-45. 2003.

[22] M. O'Neill, Cyberchiefs: Autonomy and Authority in Online Tribes. London, UK: Pluto Press, 2009.

[23] J. Reagle Jr., "Do as I do: Leadership in the Wikipedia," retrieved from: http://reagle.org/joseph/2005/ethno/leadership.html, 2005.

[24] J. Reagle Jr., "Do as I do: Authorial leadership in Wikipedia," in WikiSym '07: Proceedings of the 2007 International Symposium on Wikis., New York, USA: ACM Press, retrieved from http://ws2007.wikisym.org/space/ReaglePaper

[25] F. Stalder and J. Hirsh, "Open source intelligence," First-Monday, vol. 7 (6), 2002. Retrieved from http://www.firstmonday.dk/issues/issue7_6/stalder/

[26] N. Tkacz, "Power, visibility, Wikipedia," Southern Review, vol. 40 (2), pp. 5-19, 2007.

[27] F. Viégas, M. Wattenberg, and M. McKeon, "The hidden order of Wikipedia," EOnline Communities and Social Computing, pp. 445-454, 2007.

[28] M. Castells, The Rise of the Network Society. Malden, MA: Blackwell, 2000.

[29] M. Fuster Morell, "Governance of online creation communities: Provision of infrastructure for the building of digital commons," Doctoral Dissertation. European University Institute, 2010.

[30] M. Castells, Communication Power. Oxford, UK: Oxford University Press, 2009.

[31] L. Lessig, Free Culture: How Big Media Uses Technology and the Law to Lock Down Culture and Control Creativity. New York, NY: Penguin Press, 2004.

[32] T. Parsons, “On the concept of political power," Proceedings of the American Philosophical Society, vol. 107 (1963). Reprinted in Talcott Parsons, Politics and Social Structure. New York: Free Press, 1969.

[33] S. Lukes, Power: a Radical View /Steven Lukes Imprint. London; New York : Macmillan, 1974.

[34] F. Hunter, Community Power Structure: a Study of Decision Makers. Chapel Hill: University of North Carolina Press, 1953.

[35] B. Latour, Reassembling the Social: an Introduction to Actor-Network Theory. Oxford; Oxford University Press, 2005

[36] M. Weber, Economy and Society: An Outline of Interpretive Sociology, Guenther Roth and Claus Wittich, Eds. vol. 1, pp. 100–03. Berkeley: University of California Press, 1978.

[37] J. Holloway, Cambiar el Mundo sin Tomar el Poder: el Significado de la Revolución Hoy. Barcelona: el Viejo Topo, 2002.

[38] M. Foucault, Discipline and Punish : the Birth of the Prison. New York: Pantheon Books, 1977.

[39] S. Weber, The Success of Open Source. Cambridge, MA: Harvard University Press, 2004.

[40] H. Rheingold, The Virtual Community. Homesteading on the Electronic Frontier. Reading, MA: Addison-Wesley, 1993.

[41] A. Toffler, The Third Wave. Bantam Books, 1980.

[42] M. McLuhan and B. Nevitt, Take Today: The Executive as Drop Out. New York: Harcourt Brace Jovanovich, 1972.

[43] D. Vise, and M. Malseed, The Google Story. Delacorte Press, 2005.

[44] Y. M. Kow and B. Lardis,”The creative ecology is one complete whole, and is dependent on User creativity, governance, and the new media: An introduction to the First Monday special issue,” First Monday, 15, (5), retrieved from: http://firstmonday.org/htbin/cgiwrap/bin/ojs/index.php/fm/article/view/2954/2523, 2010

[45] F.T. Tschang and J. Comas, “Developing virtual worlds: the interplay of design, communities and rationality,” First Monday, vol. 15 (5), (2010). Retrieved from http://firstmonday.org/htbin/cgiwrap/bin/ojs/index.php/fm/article/view/2957/2525

[46] J. Herrick. Interview with author, December 4, 2008.

[47] G. Sartor, “Il diritto della rete globale. [Law in the global network],” Ciberspazio e Diritto, vol. 4, pp 67–94, 2003.

[48] S. O’Mahony, “The governance of open source initiatives: what does it mean to be community managed?,” Journal of Management and Governance, vol. 11, pp. 139–150, 2007.

[49] S.R. Barley and G. Kunda, “Bringing work back in,” Organization Science, vol. 12, pp. 76-95. 2001.

[50] R.L. Daft and A. L. Lewin, „Where are the theories for the new organizational forms - an editorial essay,” Organization Science, vol. 4: R1-R6, 1993.

[51] R.E. Miles and C.C. Snow, “Organizations: new concepts for new forms,” California Management Review, vol. 28, pp. 62-73, 1986.

[52] W.W. Powell, “Neither market nor hierarchy: network forms of organization,” Research in Organizational Behavior, vol. 12, pp. 295-336, 1990. Retrieved from http://www.stanford.edu/~woodyp/papers/powell_neither.pdf

[53] E. Romanelli, “The evolution of new organizational forms,” Annual Review of Sociology, vol. 17, pp. 79-103, 1991.

[54] Copyleft, in Wikipedia, the free encyclopedia. Retrieved December 19, 2010 http://en.wikipedia.org/wiki/copyleft

Auction Theory meets Collective Intelligence: Towards Designing Next-Generation Community Question Answering Systems

Iordanis Koutsopoulos
Athens University of Economics and Business and CERTH, Greece
jordan@aueb.gr

George Iosifidis
University of Thessaly and CERTH, Greece
giosifid@inf.uth.gr

Nicola Barbieri
Yahoo! Research Labs
Barcelona, Spain
barbieri@yahoo-inc.com

ABSTRACT

Community Question Answering (CQA) systems are web-based platforms that promote collective (community) intelligence. Users (queriers) place questions about topics they are interested in, and other users (answerers) provide answers to these questions. The queriers evaluate answers and identify the best one, and users who gave these answers are rewarded. In these systems, the objective is to maximize the expected provided utility to queriers, namely the likelihood that they receive "good" answers, by matching queriers to answerers. Current systems attempt to perform this matching without consideration of the different needs of queriers, such as the necessity for receiving good answers to their questions, and as a result the allocation matching does not maximize the sum utility of queriers.

In this work, we put forward auction theory as the mathematical tool to address this challenge. Upon posing a question, a querier declares his necessity for getting an answer to it through a bid. Each answerer has a finite number of bins in his answer list, which captures time or effort limitations in answering questions. We formulate the platform utility maximization problem as one of allocating questions to the bins of answerers. The model may take into account, (i) the relevance of each question for each answerer, (ii) the usefulness of answers provided by answerers based on past experience, (iii) the impact of the position of a question in the answer list of a querier on the chances that it will be answered. We propose meaningful compensation rules for answerers, and we extend the model to cater for the question starvation phenomenon, in which some questions are displayed in the lists of several answerers, while others do not appear at all. The problem turns out to be an extension of the advertisement slot assignment problem in sponsored search auctions. This is work in progress, and as a next step, it will feature validation from publicly available real data.

Categories and Subject Descriptors

H.1 [**Information Systems**]: Models and principles; C.4 [**Performance of systems**]: Modeling techniques; G.1.6 [**Mathematics of Computing**]: Optimization

General Terms

Algorithms, Economics

Keywords

Collective Intelligence, Community Question Answering systems, Auction theory.

1. INTRODUCTION

Web platforms that promote *collective* (or *community*) intelligence have rapidly proliferated. Community knowledge is collectively produced by large, loosely coordinated groups of people, and this systemic intelligence in how the whole system operates would have been impossible to build otherwise. The equivalent term *"social computing"* is attributed precisely to the fact that the community knowledge is generated out of atomic contributions. The proliferation of these platforms is the harbinger of a new, exciting research field, namely that of building the theoretical foundations and fundamental underlying design principles of these systems.

A first instance of social computing is *community* or *participatory sensing* [1]. The goal is to represent an underlying state as accurately as possible and deliver it to interested users. Information providers submit data related to the application at hand (e.g., text, video, photos), usually through mobile devices. Information consumers place queries related to the application (e.g., about the air pollution level or free parking spots) and require to be served. The application service provider aggregates data samples of providers and forwards results to querying users for some price. The most important challenge lies in coordinating the exchange of information and the matching of information supply and demand, while meeting quality of experience constraints for provisioned data for information consumers. A fundamental issue is that the traded good is data, which is reusable, since the same data may be provided to multiple consumers at the same time. Another instance is *collective consumption* [2], namely a model based on sharing, swapping, bartering, trading or renting resources, which is opposed to traditional, ownership-based models. Again the goal is to match resource supply and demand as much as possible.

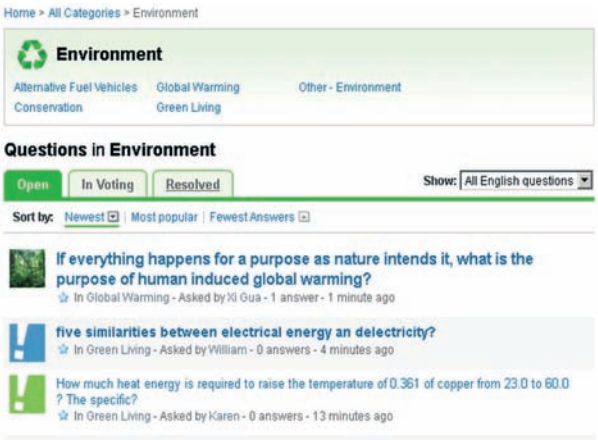


Figure 1: A screenshot of a representative CQA platform, Yahoo! Answers.

A third instance is Community Question Answering (CQA) systems (Fig. 1), such as Yahoo! Answers, Baidu Zhidao, Google Answers, Facebook Questions and Reddit Ask Me Anything (AMA) [3]. There also exist other CQA platforms focused on specific subjects, which operate as forums. In a typical CQA system, a querying user places a question which falls under one of a list of predefined categories. Any user may provide an answer to the question. After an elapsed time interval, which may be set by the system or be determined by the user, the question becomes inactive, and the best answer is selected by the querying user. The user who gave this answer gets rewarded with a credit in terms of a number of points or a direct payment.

The benefits of such a system are fully harvested if the chances that querying users receive "good" answers by other users are maximized. The current practice is that users interested in answering questions need to run down long lists of loosely related questions so as to locate questions they can answer. A basic challenge lies in the fact that querying users have different valuations, which quantify how necessary or important it is for a user to receive an answer. Current systems attempt to perform the matching of questions to answerers without consideration of these different needs of queriers, and as a result the allocation matching does not maximize the sum utility to queriers. In this work, we tackle precisely this challenge.

1.1 Related work

1.1.1 CQA Platforms

There exists a significant body of work on existing CQA systems and on methods for improving them. The main shortcoming is that the potential of harvesting community intelligence by having users answering questions well, is not fully exploited. For example, it is estimated that approximately 15% of submitted questions in the Yahoo! Answers system remain unanswered [4]. Similar conclusions were reached for a Java online forum [5]. Hence, a fundamental challenge is how to incentivize user participation so as to increase the number and quality of provided answers.

A method to achieve this is to route questions to potential answerers. In [6], this matching problem is addressed through multi-channel recommendation systems. The relevance of each question to each user is quantified with multiple criteria based on content (e.g., categories of interest to each user) and social signals (e.g., the querying / answering activity of users, voting, etc). In [7] the authors studied methods for characterizing the expertise of a user based on her answering history. The question-answerer matching problem is also challenging in social search engines [8]. In [9] the authors proposed a reputation-based incentive protocol so as to improve the quality of the answers. This is also studied in [10]. In [11] the authors consider a general model of crowd-sourcing systems and study how incentives affect user participation.

A method to decrease the number of unsatisfied requests and improve performance of CQA platforms is to use previously given answers for recurring questions [4], [12]. In [13], the authors showed that incentives increase quality and quantity of provided answers. Using real data, they demonstrated that users asking factual and difficult questions are more willing to pay for answers. From a different perspective, the authors in [14] considered methods for predicting the quality of a question in CQA systems. These findings provide support to our argument that, appropriately designed incentive mechanisms will improve the performance of CQA platforms.

1.1.2 Auction Mechanisms

Auction mechanisms [15] are most suitable for resource allocation in systems where the demand has unknown parameters such as the form of utility functions of users that request resources. Auctions manage the competition for the limited resources and ensure efficient allocation, in the sense of maximizing social welfare, *despite the unknown parameters* of the demand. The last few years, auctions have attracted increasing interest and have been applied to a variety of problems, ranging from spectrum allocation in wireless networks to sponsored search auctions (SSAs) for allocating advertisement slots.

SSA auctions [16] are used in internet search engines like Google and Yahoo! for selling advertisement slots in web pages that display web search results of internet users. A SSA mechanism determines whether an advertisement will appear in the user page with the search results, out of the multiple competing ones of different advertisers, and if so, in which slot (position) of the page. Advertisements that are displayed higher in the page are expected to attract more users through clicks. Unlike other auctions, the bids of competing advertisers are weighted by a factor which determines their importance and relevance through click probabilities. SSA auctions are of particular interest to our work and, in fact, they are a special case of the class of mechanisms that are discussed here as we will see in the sequel.

1.2 Our contribution

In this paper we propose an auction-based method for improving the performance of CQA systems. The ultimate goal of these platforms is to act as proxies for delivering high-quality answers to querying users. That is, they aim at maximizing the benefit, or *utility* for the querying users. However, current CQA platforms do not provide a scheme for exploiting the full potential of such a system.

There exist several challenges in improving the performance of CQA platforms. First, answerers have limited

time or effort for answering questions. Hence, a sophisticated allocation is needed, which guarantees that appropriate questions are assigned to each answerer. Ideally, each answerer would like to have in his list questions that he feels an expert in answering, so that the possibility that her answer is best is increased, and his credit is also increased. Second, different querying users have different necessity for obtaining an answer. The mechanism should guarantee that the allocation is performed in a way that distinguishes these necessities. Third, these necessities are not known to the system. In fact, these parameters are private information to each user and to the platform. In addition, appropriate incentives for high-quality answers should be given to answerers. The system should apply a question allocation rule to answerers and a payment rule that encourages participation and high-quality answers, while adhering to the assumption that querying user valuations are unknown. The problem turns out to be an extension of the advertisement slot assignment problem in SSAs.

This work attempts to address the problem of efficient allocation of questions to answerers, while taking into account the aforementioned challenges. The proposed model is simple to implement and is amenable to a real-data-driven approach. This allows for fine-tuning of system parameters and for the validation of the solution method through data traces from actual CQA systems that are available in online repositories such as [17]. Our future agenda includes this validation. The contribution of our work to the literature is as follows:

- We provide a model for an enhanced CQA platform that takes into account the time or effort availability constraints of each answerer. These constraints give rise to a competition of questions for the limited time resources of answerers that has not been explicitly discussed in the prior literature.
- We formulate the problem of maximizing the efficiency of the platform as one of placing questions to answering bins of answerers, by taking into account the different necessity of queriers.
- We propose an auction-based mechanism that consists of a question allocation rule and a payment rule, and we extend the model to cater for the question starvation phenomenon, in which some questions are displayed in the lists of several answerers, while others does not appear at all.

2. SYSTEM MODEL

2.1 Description of a typical CQA platform

In a typical CQA platform, each user may ask a question and provide answers to questions submitted by other users. Users may also provide feedback by rating the received answers with positive or negative signals, but this option is not considered in our model. Each question is assigned to a predefined category and remains active for a certain time period. If the querier is satisfied with a given answer, he closes the question and flags it as answered. The question remains active until a satisfactory answer is given.

Users may answer any of the currently active questions. The latter are usually organized (tagged) in categories in order to facilitate search. Each user may browse questions by category (e.g., *Environment*) and subcategory (e.g., *Global Warming*, *Renewable Energy Sources*). Users can see which questions are currently active and which have been answered. Finally, questions can be sorted based on popularity, the number of answers received, and the time they have been submitted. In some cases (e.g., in Reddit AMA) the questions and the answers can be evaluated by all users through voting.

In order to encourage participation and incentivize users toward high quality answers, some CQA platforms have adopted a credit (point) system. For example, in Yahoo! Answers, each new user is initially awarded 100 points. Each submitted question consumes 5 points, while for every answer the user provides, he receives 2 points. Finally, when an answer provided by the user is selected (or, voted) as the *best answer*, the user earns 10 points. Note that these point rewards and penalties are the same for all users and questions.

2.2 Queriers and Answerers

We assume that the system operates in fixed-duration time intervals, the *epochs*. Each epoch may be of the order of some minutes. At the beginning of an epoch, there exist M questions that need to be answered. Without loss of generality, we assume that each question is placed by a distinct user, whom we refer to as the *querier*. The set of M queriers is denoted by $\mathcal{Q}$. We use the same index to refer to the queriers and the questions.

Each question (querier) $j \in \mathcal{Q}$ is associated with a certain value $u_j \geq 0$ units. This captures the utility (or benefit) that the querier will perceive if his question is answered. Equivalently, it quantifies the importance or necessity for the querier to have the question answered. Different questions have different importance for queriers who submit them, and hence different values of u_j. These values are private information for each querier.

There also exist N users that could potentially answer this question. We refer to these users as *answerers* and denote the answerer group by $\mathcal{A}$. We assume that each answerer has T available *bins*, and each bin denotes a position for a question. By introducing the constraint of T bins, we explicitly model the *limited available time* or *limited attention budget* that each answerer has for answering questions. In order to simplify the model, we take this time constraint to be the same across all answerers. We also implicitly assume that the time needed to provide an answer to a question is the same and equal to one time unit. The system is depicted in Fig. 2.

For each potential answerer i and question j we define a coefficient a_{ij} that quantifies the relevance (or appropriateness) of answerer i for question j. This coefficient could be computed from historical data as follows. A correlation metric may be defined among each pair of questions. Questions that answerer i has answered in the past may be correlated with question j, and we can also include a metric denoting the quality of answers provided, based on feedback from queriers. Hence, coefficient a_{ij} may be derived as

$$a_{ij} = \sum_{k \in \mathcal{Q}_i} \rho_{kj} \mu_{ik} \,, \tag{1}$$

where $\mathcal{Q}_i$ is the set of already answered questions by i, $\rho_{kj} \in [0, 1]$ is a correlation metric between questions k and j, and μ_{ik} is the quality of answer by answerer i to question k. Coefficient a_{ij} may be normalized in the interval $[0, 1]$.

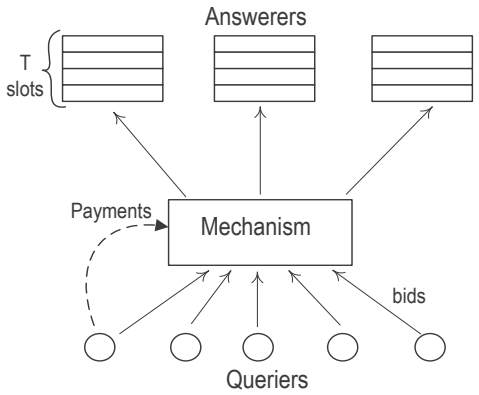


Figure 2: Architecture of an incentive-based CQA platform. Queriers ask questions and submit bids to declare how important the answer is to them. The mechanism allocates questions to bins (slots) of one or more answerers and determines the prices that will be charged to queriers.

Depending on the nature of available data, the following terms could be defined:

- A term specific to position s, q_s. This represents the probability that an answerer will click to answer a question if this is placed in its s-th bin. We assume a decaying probability with the position, so that $q_1 \geq \ldots \geq q_T$, regardless of the answerer.
- A term specific to the degree of matching (relevance) of the question to the interests of the answerer a_{ij}, as the one in (1). Besides giving higher priority to matching users with questions that are highly correlated to past answered ones, this term may justify the assumption that, upon looking at a question, an answerer is more likely to click on it if he feels more confident.
- A term r_i that reflects the overall average quality of answers provided by querier i in the past. This term may be included in the model if some rating feedback from the querier exists, and if some degree of reciprocation is sought, so as to distinguish users that have good track-record in providing answers.

A metric $p_{ij}(s)$ that captures the propensity of an answerer i to give good answers to question j when this is placed in the sth position may consist of the product of the terms above, $p_{ij}(s) = q_s a_{ij} r_i$. Data from online data repositories such as [17] can be used to evaluate coefficients r_i, a_{ij}, $i \in \mathcal{A}$, $j \in \mathcal{Q}$. Depending on data availability, $p_{ij}(s)$ may comprise one, two, or all of the three terms above.

3. THE MECHANISM

An auction-based mechanism consists of an *allocation* and a *payment* rule. The objective of the CQA platform is to increase the benefit for queriers through appropriate assignments of questions to answerer bins.

Upon placing a query, a querier j provides a bid b_j in an effort to implicitly declare to the system the private valuation u_j for the answer, or in other words the necessity to obtain an answer to the question. Namely, the bid denotes the amount of money (or, points) the user is willing to give so as to have his question answered. For each querier j, we define $\mathbf{b}_{-j}$ as the vector of bids of queriers other than j, $\mathbf{b}_{-j} = (b_1, \ldots, b_{j-1}, b_{j+1}, \ldots, b_M)$.

The mechanism performs the allocation of questions to bins of answerers and imposes a payment $h(\cdot)$ per answer, for each querier j. We define the net utility ω_j of querier j as the difference between the derived utility and the total payment,

$$\omega_j = u_j - x_j h(b_j, \mathbf{b}_{-j}) \tag{2}$$

where x_j is the number of answers to question j received by different answerers. Without loss of generality, this is taken to be continuous-valued. The payment $h(b_j, \mathbf{b}_{-j})$ depends on the entire bid vector $\mathbf{b} = (b_j, \mathbf{b}_{-j})$.

3.1 Allocation Rule

At the beginning of each epoch, the platform collects submitted bids. Accordingly, for each question $j \in \mathcal{Q}$, it determines whether it will appear at the bin of an answerer. Clearly, some questions will not appear at all in the answerers, while others may appear at the answering bin of more than one answerer. Let the control variable $x_{ij}(s) \in \{0, 1\}$ indicate whether question j will appear or not at the s-th bin of answerer i. Define vectors $\mathbf{x}_{ij} = (x_{ij}(s) : s = 1, \ldots, T)$ and $\mathbf{x} = (\boldsymbol{x}_{ij} : i \in \mathcal{A}, j \in \mathcal{Q})$.

The objective is to come up with the allocation that maximizes a metric that shows the efficiency of the question-to-answerer assignment. A possibility may be that the allocation is performed so that priority is given to questions with higher declared valuation, and that these questions are assigned to the bin with the highest probability of being answered. Consider the following optimization problem:

$$\max_{\mathbf{x}} \sum_{j=1}^{M} \sum_{i=1}^{N} \sum_{s=1}^{T} b_j p_{ij}(s) x_{ij}(s) \tag{3}$$

subject to:

$$\sum_{s=1}^{T} x_{ij}(s) \leq 1, \forall i \in \mathcal{A}, j \in \mathcal{Q} \tag{4}$$

$$\sum_{j=1}^{M} x_{ij}(s) \leq 1, \forall i \in \mathcal{A}, s = 1, \ldots, T\,. \tag{5}$$

Constraint (4) dictates that each question can be allocated to at most one bin of a specific answerer. However, it may be allocated to bins of more than one answerers. Constraint (5) says that each bin of an answerer should contain at most one question. Thus, two different questions cannot appear in the same bin, while it is possible to have an unoccupied bin.

The optimization problem (3)-(5) can be solved in polynomial time. Specifically, we can map it to a max-weight matching problem and solve it with the Hungarian method [18]. To do so, we create a bipartite graph that contains a set of nodes, one node for each querier, and another set of nodes, where each node represents an answerer.

There is an interesting point to notice here. The dependence of metric $p_{ij}(s)$ on the position s is expected to vary with T. For CQA platforms where each answerer has many answering slots (i.e., T is large) the position is expected to

impact $p_{ij}(\cdot)$ more and hence affect the question assignment (and thus, the solution of the above problem). On the contrary, for CQA platforms with small T (e.g., $T = 2$), the impact of placing a question in different position is very small. For these cases, the problem above is further simplified by omitting the summation over s in (3) and modifying accordingly the constraint set.

3.2 Allocation Rule for Mitigating the Starvation Phenomenon

In the previous allocation rule, we did not impose a limitation on the number of answerer lists on which each question can appear. However, this may result in an assignment where questions with high bids are favored more and are assigned to several bins (of different answerers), while questions with low bids do not appear in any answerer list. In order to ensure that queriers with lower bids will not *starve*, we propose an alternative allocation rule.

The main idea is to gradually discount the bid of each querier as the number of the slots that the question is assigned to increases. First, we define the expander set of queriers $\mathcal{Q}^e$ which stems from $\mathcal{Q}$ by creating K replicas of each question $j \in \mathcal{Q}$. Each one of the different instances of question $j \in \mathcal{Q}$ can be assigned at most to one slot of any answerer. In other words, K is the maximum number of total slots across all answerers that each question j can be assigned to. This is set by the CQA platform.

For each replica $k = 1, 2, \ldots, K$ of question j, we define the bid b_j^k which comes out the initial bid b_j, submitted by querier j, but it is discounted by a certain parameter θ,

$$b_j^k = b_j \cdot (k\theta)^{-1}\,, \tag{6}$$

where $\theta > 1$ is a discount parameter which is tuned by the CQA platform. Clearly, it is $|\mathcal{Q}^e| = MK$. We also define variable $x_{ijk}(s) \in \{0, 1\}$ indicating whether the k-th replica of question j will appear in the s-th position of answerer i or not. As extension of parameter $p_{ij}(s)$ above, we have parameter $p_{ijk}(s)$.

The new allocation rule is derived from the solution of optimization problem:

$$\max_{\mathbf{x}} \sum_{j=1}^{M}\sum_{k=1}^{K}\sum_{i=1}^{N}\sum_{s=1}^{T} b_j^k p_{ijk}(s) x_{ijk}(s)\,, \tag{7}$$

subject to:

$$\sum_{s=1}^{T} x_{ijk}(s) \leq 1,\ \forall i \in \mathcal{A},\ j = 1, \ldots, M,\ k = 1, \ldots, K\,, \tag{8}$$

$$\sum_{j=1}^{M}\sum_{k=1}^{K} x_{ijk}(s) \leq 1,\ \forall i \in \mathcal{A},\ s = 1, \ldots, T\,, \tag{9}$$

$$\sum_{i=1}^{N}\sum_{s=1}^{T} x_{ijk}(s) \leq 1,\ j = 1, \ldots, M,\ k = 1, \ldots, K\,, \tag{10}$$

where the additional constraint (10) dictates that each expanded question must be assigned at most one slot. It is easy to see that with this modified allocation rule, the bid of each question j is artificially discounted as the question is assigned to more answerer bins. This increases the chances that the bids of other question will excced the bid of question j, and will therefore gain priority in being assigned to answerer bins.

Numerical Example. We give a simple example to demonstrate the difference between the allocation rules above. Consider a toy system with 2 answerers ($\mathcal{A} = \{1, 2\}$), and $T = 2$ bind for each. Assume that there are 3 queriers with valuations $u_1 = 10$, $u_2 = 6$ and $u_3 = 4$ units respectively. For simplicity, we consider that parameters $p_{ij}(s)$ are identical for all queriers, answerers and slots. It is easy to see that the first allocation rule assigns the two slots of each answerer to queriers $i = 1$ and $i = 2$. Hence, querier $i = 3$ would not appear in any slot of any answerer. Consider now the second allocation rule with parameters $K = 2$ and $\theta = 2$. According to (6), the discounted bids for querier $i = 1$ are $b_1^1 = 5$ and $b_1^2 = 2.5$, for querier $i = 2$, $b_2^1 = 3$ and $b_2^2 = 1.5$, and for querier $i = 3$, $b_3^1 = 2$ and $b_3^2 = 1$. With these new bids, the slot allocation changes and querier 3 receives one slot.

3.3 Payment Rule

The payment rule determines the price $h(b_j, \boldsymbol{b}_{-j})$ that each user $j \in \mathcal{Q}$ will be charged by the mechanism. This may involve actual monetary, virtual currency or point transfer. There exist various options that yield different prices for queriers and hence have different revenue for the platform. Furthermore, while some payment schemes are simple to implement, others come with high computational complexity, such as the Vickrey Clarke Grooves (VCG) auction [19], [20].

One payment scheme that has been employed in SSAs is that of generalized second price (GSP) auctions [21]. In a very simple version, this rule can be stated as follows. Each querier j pays a total price for all answering bins in which his question appears. That is, for each bin in an answerer, the querier pays a price which is equal to the bid of the querier who is assigned the immediate next slot. If querier j is in the last answering bin of an answerer, he pays the highest bid among queriers that did not appear in this answerer's list [16, Ch.3]. Other versions of GSP payments can also be defined. It has been shown that GSP mechanisms fail to induce bidders to reveal their actual valuations[21]. Actually, the only auction that achieves truthfulness is the VCG mechanism.

Alternatively, a first-price payment rule can be used, where each querier is charged a price equal to his bid. In this case, the price charged to each bidder j depends only on his bid b_j and not on the bids submitted by others. Nevertheless, since the allocation is determined by considering the entire bid vector $\boldsymbol{b}$, the payment, which is charged only to questions that receive answering bins, is indirectly determined by all participants in the auction.

4. DISCUSSION AND FUTURE WORK

4.1 Real Data and Implementation Issues

The proposed scheme can be put in practice and can be incorporated with minor modifications in various existing CQA platforms. The payment rule has been explicitly selected so as to be simple to implement and easy to understand by queriers. In addition, the payments can be mapped to actual or virtual currency transfers ones. Our model emerged after an elaborate studying how different CQA platforms operate. We believe that these parameters can be calculated either directly on the platforms, or by using available online data repositories such as [17].

Besides, previous works have focused exactly on estimating these parameters and using them to identify optimal matchings among questions and answerers [6], [7], [8]. These results are complementary to our work and can be incorporated in the proposed formulations. Unlike the vast majority of the related papers in this area, our focus was to set the stage for the optimal question assignment by taking into account the time and effort limitations of answerers and the different needs of queriers.

4.2 Future Work

The study presented in this paper is a first step towards igniting further studies for designing next-generation CQA platforms. We focused on the proposition of some rules for question allocation and payment. Our model is a non-trivial extension of the one of SSA [16, Ch.3] that are used to allocate advertisements of competing advertisers on different ad slots in the end-user web page. In fact, for the simple case of one answerer, namely if $N = 1$, our model coincides with that of advertisement placement in SSAs. However, for multiple answerers, i.e. $N > 1$, the problem becomes different. The multiple answerers correspond to a hypothetical situation where there are multiple competing web search engines in whose *result pages* the advertisements must be placed.

Besides elaborating more on the model specifics, in the future, we aim at focusing towards rules that ensure incentive compatibility, namely they discourage the misreporting of utility by queriers. Such a property would be prerequisite for sustainable system operation. Additionally, we will investigate methods which provide certain (probability) guarantees that users' questions will receive satisfactory answers. Notice that the presented algorithms maximize the expected utility of the queriers but do not give lower bounds. This is a challenging direction for future work.

Also, our model focused more on the arising competition among queriers for time (bin) resources. It encapsulated only charging rules for queriers and did not include rewards to answerers. Following the current practice, we assumed that rewards to answerers are not part of the model. However, there also exists a tussle among answerers as well–in the sense that they compete for the answers to question. Therefore, answerers should also be awarded for their effort in a dynamic fashion, possibly through a reverse auction. We intend to address this issue and the arising two-sided competition in the future.

5. ACKNOWLEDGMENTS

G. Iosifidis and I. Koutsopoulos acknowledge the support of the European Union through the FP7 NoE project EINS (FP7-288021) and the support of the ERC08- RECITAL project, co-financed by Greece and the European Union (European Social Fund) through the Operational Program "Education and Lifelong Learning" - NCRF 2007-2013.

6. REFERENCES

[1] J. Goldman, K. Shilton, J. Burke, D. Estrin, M. Hansen, N. Ramanathan, S. Reddy, V. Samanta, M. Srivastava, and R. West, "Participatory Sensing: A citizen-powered approach to illuminating the patterns that shape our world", *White Paper,* Center for Embedded Networked Sensing, UCLA, 2008.

[2] http://collaborativeconsumption.com/

[3] http://www.reddit.com/r/AMA/

[4] A. Shtok, G. Dror, Y. Maarek, and I. Szpektor, "Learning From the Past: Answering New Questions with Past Answers", *in Proc. of ACM WWW Conf.*, 2012.

[5] J. Zhang, M. S. Ackerman, and L. Adamic, "Expertise Networks in Online Communities: Structure and Algorithms", *in Proc. of ACM WWW Conf.*, 2007.

[6] G. Dror, Y. Koren, Y. Maarek, and I Szpektor, "I Want to Answer, Who Has a Question? Yahoo! Answers Recommender System", *in Proc. of ACM KDD*, 2011.

[7] F. Riahi, Z. Zolaktaf, M. Shafiei, and E. Milios, "Finding Expert Users in Community Question Answering", *in Proc. of ACM CQA Workshop (in WWW Conf.*, 2012.

[8] D. Horowitz, and S. D. Kamvar, "Searching the Village: Models and Methods for Social Search", *Comm. of the ACM*, vol. 55, no. 4, pp. 111-118, 2012.

[9] Y. Zhang, and M. V. der Schaar, "Reputation-based incentive protocols in crowdsourcing applications", *in Proc. of IEEE INFOCOM*, 2012.

[10] A. Ghosh, and P. McAfee, "Incentivizing High-Quality User-Generated Content", *in Proc. of ACM WWW Conf.*, 2011.

[11] D. DiPalantino, M. Vojnovic, "Crowdsourcing and All-pay Auctions", *in Proc. of ACM Electr. Commerce Conf.*, 2009.

[12] J. Jeon, W. B. Croft, and J. H. Lee, "Finding similar questions in large question and answer archives", *in Proc. of ACM CIKM*, 2005.

[13] G. Hsieh, R. E. Kraut, S. E. Hudson, "Why Pay?: Exploring How Financial Incentives are Used for Question & Answer", *in Proc. of ACM CHI*, 2010.

[14] B. Li, T. Jin, M. R. Lyu, I. King, and B. Mak, "Analyzing and Predicting Question Quality in Community Question Answering Services", *in Proc. of ACM CQA Workshop (in WWW Conf.)*, 2012.

[15] V. Krishna, "Auction Theory", *Academic Press*, 2002.

[16] Y. Narahari, D. Garg, R. Narayanam and H. Prakash, "Game theoretic problems in Network Economics and Mechanism Design Solution", *Springer-Verlag*, 2009.

[17] Yahoo!Answers: http://webscope.sandbox.yahoo.com/

[18] C. H. Papadimitriou, K. Steiglitz, "Combinatorial Optimization: Algorithms and Complexity", *Prentice-Hall*, 1982.

[19] W. Vickrey, "Counterspeculation, Auctions and Competitive Sealed Tenders", *Journal of Finance*, vol. 16, pp. 8-37, 1961.

[20] T. Groves, "Incentives in Teams", *Econometrica*, vol. 41, pp. 617-631, 1973.

[21] M. Ostrovsky, B. Edelman, and M. Schwarz, "Internet advertising and the generalized second price auction: Selling billions of dollars worth of keywords", *In 2nd SSA Workshop*, 2006.

New experiment report

Dong Wang

1. DATASET DESCRIPTION

1.1 Tweets Dataset

We use two Twitter datasets D_7 which contains 46,202,523 tweets published by 4,783,193 users from July 1st-July 31st, 2009, and D_8 which contains 132,210,436 tweets published by 7,404,248 users from August 1st-August 31st, 2009.

1.1.1 Definition of Twitter Trending topics

Trending topic is a key concept for Twitter. A word, phrase or topic that is tagged at a greater rate than other tags is said to be a trending topic. In other words, trending topics are the words, phases or topics which can become immediately popular rather than the ones which have been popular for a while. Trending topics become popular either through a concerted effort by users or because of an event that prompts people to talk about one specific topic. These topics help Twitter and their users to understand what is happening in the world [3, 2].

1.1.2 Extract Trending topics from Twitter Dataset

At first, we divide D_7 and D_8 into subsets S_i in the day scale. And then for each subset S_i, we tokenize all tweets and get the word pool W_i. For each word $w \in W_i$, we extract the term frequency (*i.e.* word frequency) of w in the subset S_i, $TF_i(w)$.

In the process of TF statistic, some measures are taken to enhance the correctness. At first, we ignore the stop words such as "a", "after", "before" which have higher TF but less meanings. Here we use the Google stop words list [1].

Second, for the repeated words in one tweet, we just consider the word once. In this way, we can make sure the fairness for all tweets.

Third, as the number of collected tweets in different subsets are different, in order to avoid the effect of length of documents, we use the relative term frequency instead of the absolute term frequency, $RF_i(w) = TF_i(w)/|S_i|$ where $|S_i|$ is the cardinal number of S_i (*i.e.* the number of tweets in S_i).

Finally, for all $RF_i(w)$, we normalize them in interval [0,100] through $NF_i(w) = RF_i(w)/RF_{max}(w) * 100$.

As stated above, sudden uptrend is the most important character of a trending topic. Here we detect sudden uptrends as follows:

Step1: For all words i extracted from Twitter dataset, we get the Twitter trends $\{Y_i\}$ (the NF in each day)

Step2: Find all uptrends P_i ($P_i = Y_i(t) - Y_i(t-1)$,where $Y_i(t) - Y_i(t-1) > 0$) for each word i. And we get the set $P = \bigcup P_i$ where i is a word extracted from the whole Twitter dataset.

Step3: Find the mean value T for $p \in P$.

Step4: If $p \in P_i$ and $p > T$, then we consider there is a sudden uptrend in i's Twitter trends and i is a trending topic.

Using the above method, we extract 73,722 trending topics from D_7 which composes the trending topic set K.

1.2 Official Twitter trending topics

We collect the trending topics recommended by Twitter per every 5 minutes and from 2012-09-01 to 2012-10-31, where the hot topics for different countries are provided. In order to analyze the geographic popularity of Twitter trending topics, we collect the trending topics for 5 different countries including USA, UK, Canada, France and Australia. There are 6,858 hot Twitter topics crawled totally, which compose a topic set H.

1.3 Google Trends

For each word $w \in K$, we use Google trends to get its Google search history from June 1st to July 31st,2009. And for word $w \in H$, we get the Google search history from September 1st to October 31st,2012. We collect the information from Google trends as follows:

1.Normalized search volumes of word w. Google trends provides the search volumes normalized in the range $0-100$ where the highest search volume $v_{max}(w)$ in the customized time interval is set as 100 and the other search volumes are represented by $v(w)/v_{max}(w) * 100$.

2.Top 10 countries where the word w is searched most frequently in this time interval.

We can find the sudden uptrends of Google through the similar method stated in section 1.1.2 replacing NF with normalized search volumes. The distribution of number of sudden Twitter uptrends and Google uptrends for each topic is shown as figure 1.

From figure 1, we can find that for the 73,722 trending topics extracted from Twitter, there are about 27.5% topics are not trending topics in Google(*i.e.* there are no sudden

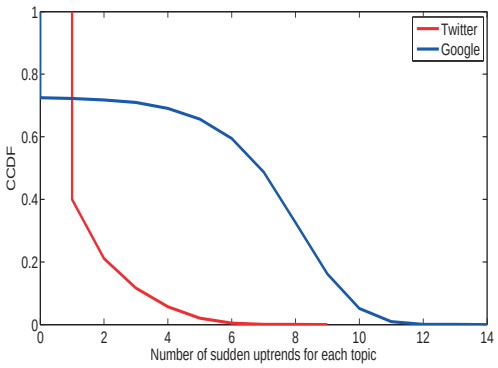


Figure 1: Distribution of number of sudden Twitter uptrends and Google uptrends for each trending topics

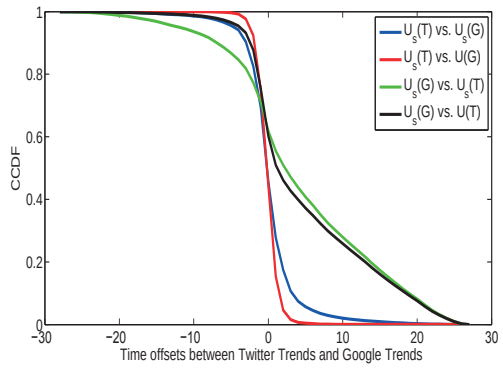


Figure 2: Distribution of difference between Twitter uptrends and Google Uptrends

uptrends for these topics). And for these trending topics in Google, there are always more than one sudden uptrends. On the other hand, for trending topic in Twitter, there are more than 60% topics with only one sudden uptrend.

1.4 Alexa hot topics

The normalized search volumes can't tell us whether this word is popular in Google or not at time T because it provides only normalized search volume but not real one. Fortunately, Alexa can give us this information.

Alexa keeps 10 most popular topics in Internet for any 5 minutes from July 26th,2009 to now. We collect all popular topics of Alexa in hour scale from August 1st to August 31st, 2009. There are 898 unique hot topics totally.

2. IS THERE TIME EFFECT OFFSET BETWEEN TWITTER AND GOOGLE TRENDS?

For the 73,722 trending topics in K, we compare their Twitter trends with the corresponding Google trends at the same time(both of them are from July 1st to July 31st,2009).

In the comparison, we focus on the following four time offsets: the time offsets where sudden uptrends in Twitter $U_s(T)$ effect on sudden uptrends in Google $U_s(G)$ and all uptrends in Google $U(G)$, and on the other hand, the time offsets where sudden uptrends in Google $U_s(G)$ effect on sudden uptrends in Twitter $U_s(T)$ and all uptrends in Twitter $U(T)$. Figure 2 shows the four time offsets distributions, where the value is the difference (take day as a unit) between a Twitter uptrend and a Google uptrend. In the case if one trending topic in Twitter(or Google) with one uptrends but more than one uptrends in Google(or Twitter), we consider the minimum values among these differences. Here the positive value means that Twitter trends is behind Google trends, otherwise, negative means Google Trends is behind Twitter trends and 0 means the two uptrends appear at the same time.

As figure 2 shown, there are 60%-70% Twitter sudden uptrends having a near Google uptrend in interval [-2,2]. However, there are only 30%-40% Google sudden uptrends with a near Twitter uptrend in interval [-2,2]. What's more, for these Google uptrends near by Twitter sudden uptrends, there are 76.3% are sudden trends.

3. IS TIME EFFECT OFFSET RELATED TO POPULARITY?

It is natural to consider the relationship between the popularity of tweets and the difference. Here we use the increasing volume of uptrends to measure the popularity of topics. Figure 3 shows the relationship between the increasing volume of $U_s(T)$ and the difference between $U_s(T)$ and $U(G)$.

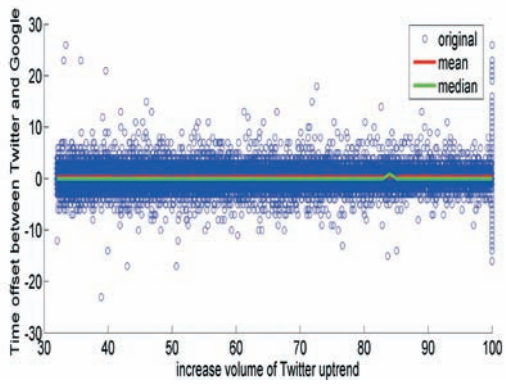


Figure 3: Distribution of topic popularity for different minimum differences

From the above figure, we find that there is no obvious relationship between popularity and time effect offset. What's more, for each popularity, the mean and median of difference between $U_s(T)$ and $U(G)$ are always close to 0, which is another proof of the similarity between Twitter trends and Google trends.

4. GOOGLE POPULAR MEANS TWITTER POPULAR?

As stated in section 1.4, Google trends can't tell us whether this word is popular in Google or not while Alexa dataset provides the hot topics in Internet. In this section, we compare the trending topics extracted from Twitter dataset with the hot topics in Alexa dataset at the same time inter-

val(August 1st-August 31st,2009) and check the similarity between the two.

The method to get similarity is exact match. If the topic of Alexa includes only one word, any tweets mention this word can be seen as related tweets. For the multi-word topics, a tweet can be seen as related only when its content includes all the words(continuous or not). The method for judging a topic is trending or not is stated in section 1.1.2. There are 817 topics of Alexa in August totally and 87.5% (715 topics) are trending topics in Twitter which indicates if a topic is popular in Google, it is likely to be a trending topic in Twitter.

5. TWITTER POPULAR MEANS GOOGLE POPULAR?

From figure 2, we can find that there are 60%-70% Twitter sudden uptrends having a near Google uptrend in interval [-2,2]. And figure 3 tells us for each Twitter popularity, the mean and median of difference between $U_s(T)$ and $U(G)$ are always close to 0. Then we can get the conclusion that the sudden uptrends in Twitter always indicate the uptrends in Google.

6. STABILITY

In this section, we analyze the stability of topics in Google and Twitter. Here we use the *popular duration* to measure the stability. Popularity duration should be based on the method to judge whether a topic is popular or not. Although there is no effective way to get the absolute popularity of a topic, we can use the normalized search volumes provided by Google trends to get popular duration.

Here the popular duration of a topic is defined as follows: At time t_i, the normalized search volumes (or popularity of tweets) is $N(t_i)$. Then we set the popular threshold as the mean value of $\{N(t_i)\}$ where $N(t_i) > 0$. If $N(t_i)$ is larger than the mean value, we say this topic is popular at time t_i. The popular duration is the period when a topic last popular continuously. Should note that for a topic, there may be more than one popular durations. For example, if topic A is popular at $\{t_1, t_2, t_3, t_{10}, t_{11}\}$, then there are two popular durations $\{t_1, t_2, t_3\}$ and $\{t_{10}, t_{11}\}$. In this case, we use the average value of these popular durations as the final answer.

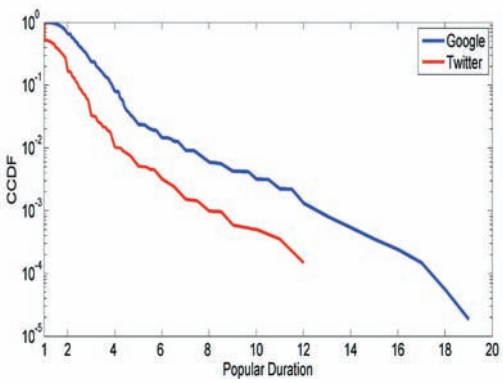


Figure 4: Distribution of popular duration of hot topics in Google Trends and Twitter

Figure 4 shows the distribution of popular duration of 82,687 hot topics both in Google Trends and in Twitter from July 1st to July 31st, 2009.

We can find that in Twitter dataset, for 47.9% topics, the popular duration is only 1 day, while in Google Trends dataset, there are only 0.4% topics whose popular duration is 1 day and almost lie in 2-4 days. This is a proof that topics are more stable in Google than in Twitter.

7. GEOGRAPHIC POPULARITY ANALYSIS

In this section, we analyze the geographic popularity of Twitter trending topics. We compare the interesting rank of these 5 countries(USA, UK, Canada, France and Australia) in Twitter with the corresponding rank in Google Trends.

7.1 Definition of interesting rank

For Google Trends, we focus on the relative popular ranks of the 5 countries(*i.e.* the order of these countries in regional interest list provided by Google Trends). For example, the regional interest list for topic A is as followings:1) Germany; 2) United States; 3) Switzerland; 4) Canada; 5) France, then the relative popular ranks are: $G(US) = 1; G(CA) = 2; G(FR) = 3$. For UK and AU, because they are not in the list, that means topic A is not popular in UK and AU, where we assign 0 to represent. Finally, the relative Google ranks for topic A is:$\{G(US) = 1, G(UK) = 0, G(CA) = 2, G(FR) = 3, G(AU) = 0\}$.

In terms of Twitter, the average ranks of each 5 countries are used. We collect the top 10 hot topics of Twitter per five minutes. In this case, the rank of a topic may be different in different time, then the average Twitter rank of a topic is $\bar{W} = E(\{W_t\})$ where W_t is the rank of this topic at time t when the topic appears in top list. For any topic, we can extract the $\bar{W}$ of the 5 countries from the corresponding country dataset separately.

With the average ranks comparison, the relative Twitter popular ranks of the 5 countries R can be got through the similar method with Google Trends and 0 is assigned for the country datasets where the topic doesn't appear in.

7.2 Geographic popularity similarity between Twitter and Google Trends

If we fix an order {USA, UK, Canada, France, Australia}, then for each topic, there are two relative rank vectors: Google rank vector $V(G) = \{G(US), G(UK), G(CA), G(FR), G(AU)\}$ and Twitter rank vector $V(T) = \{R(US), R(UK), R(CA), R(FR), R(AU)\}$.

We compare the cosine distance D between $V(G)$ and $V(T)$. If D is close to 1, that means the geographic popularity in Twitter is the same as Google, otherwise, the geographic popularity in Twitter is different with Google.

Figure 5 shows the distribution of cosine distances D between $V(G)$ and $V(T)$ for all 6,858 topics in H.

If we only consider the most popular country(*i.e.* relative rank is 1) for each topic, then the cosine similarity must be 1(complete same) or 0(complete different). Figure 6 shows the distribution of cosine distances D between $V(G)$ and $V(T)$ where only the most popular country is considered.

The average of cosine distances in figure 5 is 0.62 and the average value in figure 6 is 0.69, showing the geographic popularity in Twitter is similar with the one in Google.

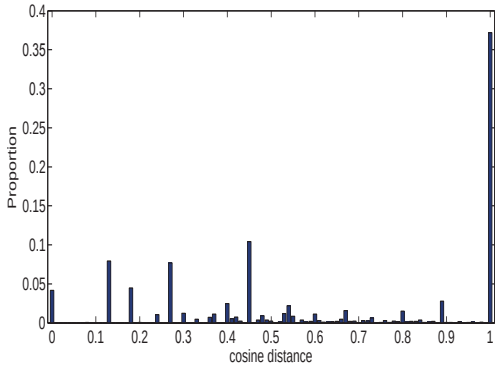


Figure 5: Distribution of cosine distances D between $V(G)$ and $V(T)$

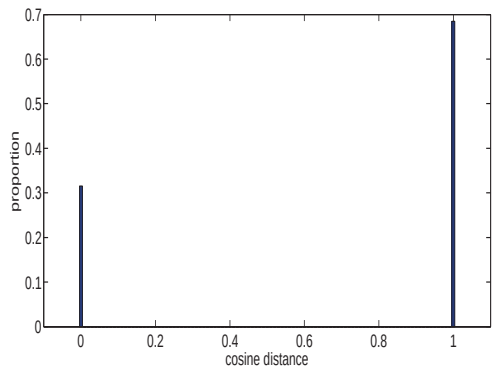


Figure 6: Distribution of cosine distances D between $V(G)$ and $V(T)$ where only the most popular country is considered

8. REFERENCES

[1] Google stop words. http://code.google.com/p/stop-words/downloads/list.

[2] Twitter help center. https://support.twitter.com.

[3] Twitter wikipedia. http://en.wikipedia.org/wiki/Twitter.

9. APPENDIX

Table 9 summarizes the notations used in this paper.

Table 1: Notations and Basic Definitions

D_7	Dataset concluding tweets published in July 2009
D_8	Dataset concluding tweets published in August 2009
S_i	Dataset concluding tweets published in one day
$\|S_i\|$	Cardinal number of S_i (*i.e.* the number of tweets in S_i)
W_i	Words set extracted from S_i
$TF_i(w)$	Word frequency of w in S_i where $w \in W_i$
$RF_i(w)$	Relative word frequency of w in S_i, $RF_i(w) = TF_i(w)/\|S_i\|$
$NF_i(w)$	Normalized word frequency of w in S_i, $NF_i(w) = RF_i(w)/RF_{max}(w) * 100$
$\{Yi\}$	Twitter trends(*i.e.* the set composed by NF in each day)
P	uptrends set for all words extracted
K	Twitter trending topics set extracted from crawled dataset
H	Twitter trending topics set provided by Twitter
$U(T)/U(G)$	Uptrends in Twitter/Google
$U_s(T)/U_s(G)$	Sudden uptrends in Twitter/Google
$G(A)$	Relative popular rank of country A in Google
$W_t(A)$	The topic rank in country A at time t
$W(A)$	Average topic rank in country A
$R(A)$	Relative popular rank of country A in Twitter
$V(T)/V(G)$	Topic rank vector of Twitter/Google
D	Cosine distance between $V(T)$ and $V(G)$ for the same topic

Governance and Internet Science

Chaired by Nicole Dewandre, DG CONNECT, European Commission

Regulating code

A prosumer law approach to social networking privacy and search market interoperability

Ian Brown
Oxford Internet Institute
Oxford University, UK

Christopher T. Marsden
Law School
University of Sussex, UK

***Abstract*— Internet users are all becoming 'prosumers', sharing videos, news, photos and intimate details of their personal lives online. But consumer protections are yet to catch up with this 'prosumer environment', leaving personal information traded enthusiastically as the 'new oil' of the online economy, while some governments have reacted with knee-jerk over-regulation to the free speech enabled by online platforms. This article examines how a prosumer law interoperability framework can meet these challenges, in the context of two recent Internet policy developments. These are the continued competition investigations into Google's dominance of search advertising, and the privacy law reforms designed in response to social networks such as Facebook.**

***Index Terms*— prosumer, law, interoperability, competition**

I. Introduction

Over a billion people now use YouTube to watch and upload videos, Facebook and Instagram to share news, gossip and photos, and Twitter and other blogs to say just about anything. We are all becoming 'prosumers,' sharing intimate details of our personal lives online. But consumer protections are yet to catch up with this 'prosumer environment', leaving personal information traded enthusiastically as the 'new oil' of the online economy, while some governments have reacted with knee-jerk over-regulation to the free speech enabled by online platforms.

Over three years of fieldwork (2009-2011), we have carried out detailed examination of case studies to illustrate the regulatory crisis and 'prosumer law' solution.[1] These included:

- Copyright issues surrounding file sharing;
- Privacy and data protection, including the implications of new EU laws related to social networking;
- State-sponsored censorship of protest such as WikiLeaks;
- Private censorship for commercial gain, breaching network neutrality.

We investigated regulatory solutions that may be effective *ex ante* to ensure the development of technologies that do not act against the public interest, without stifling innovation and introducing bureaucratic interventionist regulation to an area that has blossomed without it. Such a solution would avoid the economic determinism of belief in the invisible hand of the market, and the technological determinism of some that claim that progress all but inevitably results in wider choice and more desirable features, despite public policy concerns.

We have analysed the regulatory shaping of "code"—the technological environment of the Internet comprising hardware, software and their interactions, notably in the protocols and standards used to achieve interoperability — to achieve more economically efficient and socially just regulation [1], including the increasing "multi-stakeholderisation" of Internet governance, in which non-governmental organizations (NGOs) and other prosumer groups from civil society argue for representation in the closed business-government dialogue, seeking to bring in both rights-based and technologically expert perspectives.

Code has continued to morph rapidly even as legislation has tried to adapt. Investor certainty and democratic participation in legislative processes are arguably enhanced by the leisurely speed of legislation, contrasted with the rapid—but slowing—progress of Internet standards in which only technical experts can realistically participate. Most progress has happened with technical protocol development within companies (and, arguably, open source communities), where coordination ("tussle") problems are less complex than in legislatures. IPv6 has been slowly, even glacially, deployed, but a big switch in Facebook design to facilitate the use of Secure Socket Layer connections was possible in a few days, and Windows security updates can be automatically distributed to hundreds of millions of users overnight.

We focus in our 'prosumer law' solution on two main regulatory mechanisms: the use of competition law to engage in predicting and designing prospective markets such as cloud computing and social networking [24], and the widespread adoption of interoperability policies across the European Union, in response to the potential for fragmentation of the single European market and open interoperable Internet. We build on several relevant information regulation precedents:

- Must-carry/must-offer obligations, which are imposed on many market actors, including those obliged to offer Fair Reasonable and Non-Discriminatory (FRAND) terms (including common carriers, broadband access providers, cable broadcasters, electronic program guides);
- Application programming interfaces (API) disclosure requirements, which were placed on Microsoft by a European Commission ruling upheld by the European Court of Justice [6];

[1] We acknowledge our funders for parts of several case studies: EPSRC and the European Commission.

- Interconnection requirements on telecommunications providers, especially those with dominance—already echoed in the AOL/Time Warner merger requirement for instant messaging interoperability [23].

The forces of regulation can be shaped more subtly: forbearance in one dimension enables expansion in others. Where code is slow to evolve, law can assist by removing bottlenecks to innovation. Where law is designed expressly to stymie code innovation, code is likely to spill over any logjam by creating new paths to achieve user goals, as, for instance, in the peer-to-peer solution to friends sharing music files. Accusations of illegality did not serve as a veto on user adoption of peer-to-peer tools.

This article examines how our framework and conclusions can be applied to two recent developments, based on our continued examination of the issues in 2012-13. These are the continued competition investigations into Google's dominance of search advertising, and the privacy law reforms specifically applied to social networks, notably Facebook. We note as background that network neutrality, state censorship and copyright reform all remain mired in exactly the public goods failures that we have extensively documented.

In each case study, we examine whether governments have moved from sledgehammer prohibition-based, enforcement-oriented regulation, to smarter regulation that works technically, with some degree of outcome legitimacy in terms of goals. These might, for instance, support the creation of public goods and disruptive innovation in markets. A smart solution in terms of code and regulation would provide effectiveness in enforcement (whether by law or code), technical efficiency (in an engineering sense) and legitimacy, transparency, and accountability (to allay rights-based concerns). Unsurprisingly, the outcomes are likely to be trade-offs among these goals.

II. Search Markets: Google

Google has faced competition investigations on both sides of the Atlantic since 2010. It settled with the US authorities on 3 January 2013 [2], and sent a settlement proposal to the European Commission on 1 February 2013 [3]. Experts have severely criticized both the timing and content of the Obama Administration's settlement, which they portray as extremely favourable to Google due to the composition of the outgoing Federal Trade Commission (FTC) board, and the decision not to proceed against the company on the main issues raised. Grimmelman argued: "If the final FTC statement had been any more favourable to Google, I'd be checking the file metadata to see whether Google wrote it." [4] The European Commission investigation continues as we write, with the same four principal complaints raised against Google as in the US:

- Search bias – that Google favours its own products in search results over competitors;
- Vertical Search Opt-Out – Google protocols don't let websites opt out of particular uses that Google might make of the pages it indexes. A complete opt-out means giving up all Google traffic, a significant driver of traffic – especially in Europe where Google has almost 90% of the search market in the UK, and over 90% in Netherlands, France and Germany;
- Restrictions on third party use of AdWords in one crucial respect: "The AdWords API Client may not offer a functionality that copies data between Google and a Third Party." Companies can advertise on Google and Bing, but cannot use a program to copy Google AdWords campaigns over to Bing. This was dropped by Google as their token interoperability sop to the FTC's investigation;
- Injunctions against standards-essential patents, including those by Google-acquired Motorola Mobility (and see Posner's now–famous judgment in June 2012 [5]). The FTC concluded (4-1) that the practice is unfair competition, and Google agreed not to engage in it in the future. This fires a shot not just at Google, but also at all its rivals – a clever concession by Google.

While it would be dangerous to speculate whether the European Commission can wring any concessions on the first two points, it is worth noting that on points 3 and 4, it is Google that had claimed the right to regulate others' use of code, to use the AdWords API or to use Motorola Mobility's patents. Google and its competitors routinely privately regulate each other's code.

What we suggest is a "prosumer law" approach where interoperability and content neutrality are taken more seriously by European regulators, as the former Commissioner has continually threatened ever since the brutally extended Microsoft European competition litigation ground to a conclusion [1,6,7]. The first objection can be resolved through forcing Google to reinforce its search neutrality rather than bias results using its search algorithms [8], and the second by a relatively trivial (by Google standards) amendment to its code to allow other websites more flexibility in future listing, rather than the 'nuclear option' of a complete opt-out via the existing robots.txt convention.

We do not adopt a strong normative claim that Google should adopt an entirely neutral perspective (nor do we adopt such an approach to network neutrality), but we do advocate enforcement of truth-in-advertising, that any search engine (or ISP using search) claiming verifiably neutral results produce the same, or else be made to prominently advertise its product as a commercially driven, affiliate-biased selective search engine.

Search neutrality would require that any Internet search engine provide search results that correspond to its mission to search the Internet for relevant products, with any 'promoted' products advertised as such and separated from the search results requested by the user. Note that this is exactly the solution that leading search engines claim to provide, with 'sponsored links' boxes separated from the overall results in either a side-bar or more intrusive text box above the main results [8]. That would not prevent linking to an affiliated maps provider, or shopping engine, as long as these links are not in the main results.

Such a requirement does not impose a significant regulatory burden on a search provider, rather it reinforces the brands of search providers of integrity. It would not apply to selective search providers if labelled as such: 'a search engine which selectively provides you with search results according in part to its commercial affiliations' (or equivalent wording) would need to be prominently displayed above search results if that were the case. In the book, we suggest a similar approach to network neutrality violators, who could not advertise their services as allowing end-users' choice in accessing the 'Internet' when in fact it is a commercial Intranet to which full access is provided [1].

These code-based solutions are lighter touch than multi-billion Euro fines or structural separation of businesses [9].

III. Facebook and Privacy

If Google's flotation took some time to wipe away an idealistic founders' myth of anti-evil cartoon-book coding, Facebook's 2012 flotation required no such adjustment. Facebook's buccaneering attitude to 'monetizing' your personal intimate data, and those of your children and grandchildren, was recognised long ago as requiring greater regulatory action.

The European home of approximately half of its users has 27 national regulators of personal data. Facebook chose the regulator that relocated in 2006 from Dublin to Station Road, Portarlington, Co. Laois, Ireland, resulting in wholesale removal or resignation of its expert staff [10]. Google is also regulated from Portarlington. While German state and federal regulators and others may rattle sabres at Facebook, it is the Irish regulator that took action in auditing Facebook in spring 2012 and insisting on remedial action on at least nine counts [1].

United States corporate-funded trade associations have complained that the proposed new EU Data Protection Regulation will raise their costs of doing business. But it is the US federal and state authorities – and litigants in court – that have far more vigorously pursued Facebook, Google and others for their failures to guarantee users' privacy. In November 2012, Google settled for $22.5m a case brought by the FTC in the case of tracking cookies for Safari browser users [11,12] on top of a 2011 $8.5m settlement for privacy breaches involving Google Buzz. In January 2013, Facebook settled a class action with a $20m payment into a compensation fund that – as with the Google Buzz settlement – will likely result in privacy advocacy and education groups receiving a substantial part of the settlement [13,14]. In 2012, both companies agreed to settle privacy complaints by agreeing to FTC privacy audit of their products for a twenty-year period. Sector-specific regulation of social networking already exists *de facto* in the United States, while Europeans wring their hands on the sidelines. The proposed new European Regulation, for instance, is unlikely to be implemented before 2016.

Competition between social networking sites may have been an effective mechanism for promoting user privacy while the market was developing in the mid-2000s (although Preibusch and Bonneau suggest that networks primarily driven by customer recruitment had strong incentives to encourage maximum data sharing [14]). A period of rapid growth has been followed by market maturation in most advanced economies, tipping towards Facebook as the eventual winner. While social networking had relatively low entry barriers in the past, as did search engines, the advertising-dominated mass-market model that currently applies is inimical to the successful overturning of Facebook's dominance. Internet markets are not in continuous 'Schumpeterian emergency' [15].

Facebook in January 2013 enforced its ban on exporting data for use in social networks, by blocking Russian search engine Yandex's new social search mobile app API calls within three hours of launch. It also cut off two apps from 'Find Friends' (Facebook's API): Twitter's photo app Vine and messaging app Voxer. This sounds remarkably like many recent reports of blocking of APIs and content by telecoms companies in breach of network neutrality law.

As Constine argues, Facebook could find its actions backfiring for its platform supporters: "Facebook is playing with fire. It could use policy enforcement to cook competitors and shine a light on its dominance of social networking. But if this enforcement scares off developers whose apps might otherwise provide content that could be shown next to ads in the news feed and piped into Graph Search, Facebook could get burned badly" [17]. It will be more badly burnt if – like Google and Microsoft before it – it is found in abuse of a dominant position. It should be required to remedy its failure to follow our prosumer law principles: to permit interoperability rather than harming smaller competitors, and to protect user data by granting full data protection rights as guided by the guardians in Portarlington.

IV. Towards Prosumer Law?

The market and information failures of the network effects pervading the Internet were noted by the chair of the FTC as early as 1998 [22] and have been in evidence throughout its development. As the technology stabilizes and matures, it may be that less radical innovation lies ahead, but we see no reason for policymakers to surrender entirely to an oligopolized model for the Internet in copyright, carriage, search or social networking. Therefore, solutions that maintain interoperability and open standards, which drove Internet, World Wide Web, mobile, and computer innovation in the 1990s and 2000s, should be maintained against the passive comfort of a largely walled-garden intranet future.

Governments, users, and better functioning markets need a smarter "prosumer law" approach to Internet regulation. Prosumer law would be designed to enhance the competitive production of public goods, including innovation, public safety, and fundamental democratic rights. Prosumer law suggests a more directed intervention to prevent Facebook or Google or any other network from erecting a fence around its piece of the information commons: to ensure interoperability with open standards.

The notion that communications policy introduces certain rights and duties is as old as electrical and electronic communications media. There is an extensive history of competition policy in favour of open technology standards that long predates the Internet [18], but the evidence of extensive network effects and innovation that can rapidly tip markets has helped focus policymakers' attention on the potential for using interoperability as a solution to the online competition and innovation problems that have emerged.

Prosumerism should be a declared policy of the European Commission alongside the European interoperability framework (EIF). In fact, the Commission on 17 December 2012 launched its *Code of European Union Online Rights* for European citizens using the Internet [19]. The UK government has made a giant rhetorical stride towards embracing interoperability in its open data purchasing principles of November 2012, a surprisingly strong statement of belief in interoperability as sound economics as well as normative policy [20] – although this will not be trivial to put into practice [21].

European electronic commerce consumer law is a marked departure from consumer protection in European contract law. It would therefore not be difficult to extend the European interoperability framework and legal protection for prosumers in this direction in law, though implementation requires all member states to commit to such a step in practice as well as theory.

This is a less radical proposal than the separations principle of Wu [9], who proposes a rigid separation between carriers and content and applications providers, based on historical analysis of previous communications industries—including the FCC's 1970 Financial Interest and Syndication Rules in cinematic production and distribution, as well as the concentration in the telecommunications industry resulting from the 1996 Telecommunications Act. Our analysis is similar but suggests that effective enforcement of interoperability for prosumer benefit is possible, even in the face of vertical integration by incumbents.

Strengthened data protection rules and a "right to be forgotten" are important steps towards prosumer law. But interoperability is needed as well as data portability, to permit exit to more prosumer-friendly products than Google and Facebook, should prosumers wish to switch. It requires a combination of interconnection and interoperability more than transparency and the theoretical possibility to move data. Only then will information markets become more competitive, and prosumers have the luxury of real choice between very different standards offered by their hosts. The prosumer is the provider of 'new oil' to the digital economy, from whom their data is currently extracted and traded for private profit by oligopolists. The prosumer should be empowered to protect and enjoy their data through European prosumer law.

REFERENCES

[1] Brown, I. and C. Marsden, *Regulating Code*, Cambridge: MIT Press, 2013.

[2] Federal Trade Commission, *Google Agrees to Change Its Business Practices to Resolve FTC Competition Concerns In the Markets for Devices Like Smart Phones, Games and Tablets, and in Online Search*, 1 Mar. 2013.

[3] Brunsden, J. & A. White, 'Google Submits Settlement Offer, EU Antitrust Chief Says', Bloomberg News, 1 Feb. 2013.

[4] Grimmelman, J. 'Not with a Bang', *Laboratorium*, 3 Jan 2013.

[5] Posner, R., *Apple, Inc. & Next Software Inc. V. Motorola, Inc. & Motorola Mobility, Inc., Opinion And Order of 22 June 2012*, Illinois Dist. Ct. No. 1:11-cv-08540.

[6] Coates, K., *Competition law and regulation of technology markets*, New York: Oxford University Press, 2013, Ch. 6.

[7] European Parliament Internal Market Committee, Dossier IMCO/7/06240, OD/2011/0150 *European standardisation.*

[8] Bracha, O. and Pasquale, F. (2008) Federal Search Commission? Access, Fairness, and Accountability in the Law of Search, 93 *Cornell L. Rev*. 1149.

[9] Wu, T., *The master switch: The rise and fall of digital empires*, New York: Knopf, 2010.

[10] Department of Justice and Equality, *Address by the Tanaiste at the official opening of the newly decentralised Office of the Data Protection Commissioner*, 11 Dec. 2006.

[11] *U.S. v. Google*, 3:12-cv-04177, U.S. District Court, Northern District of California (San Francisco).

[12] Devine, Lauren-Kelly, 'Court Approves Google's Privacy Settlement', *RegBlog*, 27 Nov. 2012.

[13] *Fraley v. Facebook*, Case No. CV-11-01726 RS.

[14] Preibusch, S. and J. Bonneau, 'The privacy landscape: product differentiation on data collection', Workshop on the Economics of Information Security, Washington DC, 14 Jun. 2011.

[15] Bresnahan, T., S. Greenstein, and R. Hendersen, *Schumpeterian competition and diseconomies of scope: Illustrations from the histories of Microsoft and IBM*, Cambridge, MA: National Bureau of Economic Research, 2011.

[16] Marsden, C., 'Fraley v. Facebook, Inc. - $20m settlement for private education/research of social media users', *Regulating Code Blog*, 26 Jan. 2013.

[17] Constine, J., 'Facebook Is Done Giving Its Precious Social Graph To Competitors', *TechCrunch*, 24 Jan. 2013.

[18] Kahin, B., and J. Abbate, eds, *Standards policy for information infrastructure*, Cambridge, MA: MIT Press, 1995.

[19] European Commission, 'Code of EU online rights published', *Digital Agenda for Europe Blog*, 17 Dec. 2012.

[20] Cabinet Office, *Government bodies must comply with Open Standards Principles*, 1 Nov. 2012.

[21] Moody, G., 'UK Government Fails Its First Big Procurement Test', *ComputerWorld*, 1 Feb. 2013.

[22] Pitofsky, Robert. 1998. Self regulation and antitrust. Prepared remarks of the chairman, Federal Trade Commission, D.C. Bar Association Symposium, February. http://www.ftc.gov/speeches/pitofsky/self4.shtm.

[23] Faulhaber, Gerald R. 2002. Network effects and merger analysis: Instant messaging and the AOL–Time Warner case. Telecommunications Policy 26 (5–6): 311–333

[24] Cowen, Tim (2013) Competition Law Issues in Cloud Computing, *Computers and Law*, forthcoming, 10 Februar

Open Science: One Term, Five Schools of Thought

Benedikt Fecher, Sascha Friesike
Alexander von Humboldt Institute for Internet and Society
Berlin, Germany
fecher@hiig, friesike@hiig.de

Open Science is an umbrella term that encompasses a multitude of assumptions about the future of knowledge creation and dissemination. Based on a literature review, this paper aims at structuring the overall discourse by proposing five Open Science schools of thought: The *infrastructure school* (which is concerned with the technological architecture), the *public school* (which is concerned with the accessibility of knowledge creation), the *measurement school* (which is concerned with alternative impact measurement), the *democratic school* (which is concerned with access to knowledge) and the *pragmatic school* (which is concerned with collaborative research).

Open Science, assessment and review, science 2.0, open access, open data, citizen science, science communication, altmetrics

I. Introduction

'Open Science' is one of the buzzwords in the scientific community. It is accompanied by a vivid discourse that apparently just grasps any kind of change in relation to the future of knowledge creation and dissemination; a discourse whose lowest common denominator is perhaps that academic research somehow needs to open up more. The very same term however evokes quite different understandings about how science could open up, ranging from the democratic right to access knowledge (e.g. open access to publications), the demand for including the public in the research (e.g. citizen science) to the use of tools for collaboration and sharing. It appears that the 'open' in Open Science can refer to pretty much anything: The process of knowledge creation, its result, the researching individual, or the relationship between research and the rest of society.

We aim to offer an overview of the multiple directions of development of the still young discourse, its main arguments and common catchphrases. Looking thoroughly at the relevant literature on Open Science, one can indeed recognize iterative motives and patterns of argumentation that, in our opinion, form more or less distinct streams. We allowed ourselves to call these streams schools of thought.

After dutifully combing through the literature on Open Science, we identified five schools of thought. We do not claim a consistently clear-cut distinction between these schools (in fact some share certain ontological principles). We do however believe that our compilation can give a comprehensible overview of the predominant thought patterns in the current discourse and point towards new directions in research on Open Science. In terms of a literature review, we believe that this paper identified some of the leading scholars and thinkers within the five schools.

The following table comprises the five identified schools together with their central assumptions, the involved stakeholder groups, their aims and the tools and methods to achieve and promote these aims.

TABLE 1

It has to be said that our review is not solely built on traditional scholarly publications but, due to the nature of the topic, also includes scientific blogs and newspaper articles. It is our aim in this paper to present a concise picture of the ongoing discussion rather than a complete list of peer-reviewed articles on the topic.

II. The Public School

In a nutshell, advocates of the public school argue that science needs to be accessible for a wider audience. The basic assumption herein is that the social web and Web 2.0 technologies allow and urge scientists on the one hand to open up the research process and, on the other hand, to prepare the research product for interested non-experts.

Accordingly, we recognize two sub-streams within the public school—the first is concerned with the accessibility of the research process (the production); the second with the comprehensibility of the research result (the product). Both streams involve the relation between the scientists and the public and define openness as a form of devotion to a wider audience. In the following section we will elaborate more on both streams in reference to relevant literature.

TABLE 2

A. Accessibility of Non-experts to the Research Process

It sounds like a romantic blueprint of doing science that the formerly hidden research process becomes not only visible but also accessible to the common man. Yet, coming from the stance that communication technology not only allows to document research constantly but also to include external dispersed individuals (as supposed in the pragmatic school), an obvious inference is that the formerly excluded public can now play an active role in research. A pervasive catchphrase in this relation is the so-called citizen science which, put simply, describes the participation of non-scientists and amateurs in research.

Hand refers, for instance, to Rosetta@home, a distributed-computing project in which volunteer users provide their computing power (while it is not in use) to virtually fold proteins [1]. The necessary software for this allowed users to watch how their computer tugged and twisted the protein in search of a suitable configuration. Watching this, numerous users came up with suggestions to speed up the folding process. Reacting to the unexpected user involvement, the research team applied a new interface to the program that enabled users to assist in the folding in form of an online game called Foldit. Hand states: "*By harnessing human brains for problem solving, Foldit takes BOINC's distributed-computing concept to a whole new level*" [1]. In this case, citizen science depicts a promising strategy to 'harness' volunteer workforce. One can however arguably question the actual quality of the amateur influence on the analytical part of the research. Catlin-Groves takes the same line as the Rosetta@Home project. She expects citizen science's greatest potential in the monitoring of ecology or biodiversity [2]. The specific fields possibly issue from the author's area of research (natural sciences) and the journal in which the review article was published (International Journal of Zoology). Nonetheless, in the two delineated examples, citizens can be rather considered a mass volunteer workforce instead of actual scientists with analytical or heuristic capacity.

Most citizen science projects follow indeed a certain top-down logic, in which professional scientists give impetuses, take on leading roles in the process and analysis and use amateurs not as partners but rather as free workforce. Irwin even claims, that most citizen science projects are not likely to provide amateurs with the skills and capacities to significantly affect research in meaningful ways [3]. Powell and Colin also criticize the lack of meaningful impact of non-experts in the research: "*Most participatory exercises do not engage citizens beyond an event or a few weeks/months, and they do not build citizens' participatory skills in ways that would help them engage with scientists or policy makers independently*" [4, p327].

The authors further present their own citizen science project, the Nanoscale Science & Engineering Center (NSEC), which at first also started as a onetime event. After the project was finished however, the university engaged a citizen scientist group that is in frequent dialogue with field experts. The authors do not outlay in detail the group's role in research and its influence on research policies; yet points at a perspective for a bottom-up involvement of interested amateurs and professionals. There is still a lack of research when it comes to models of active involvement of citizens in the research process beyond feeder services. Future research could therefore focus on emerging areas of citizen participation or alternative organizational models for citizen science (e.g. how much top-down organization is necessary?).

B. Comprehensibility of the Research Result

The second stream of the public school refers to the comprehensibility of science for a wider audience. Whereas citizen science concerns the public engagement in research, this sub-stream concerns the scientists' obligation to make research understandable for—a demand that Tacke, in an entry on his blog, provocatively entitled "*Come out of the ivory tower*" [5].

Cribb and Sari demand a change in the scientific writing style: "*Science is by nature complicated, making it all the more important that good science writing should be simple, clean and clear*" [6]. The authors' credo is that when the audience becomes broader and the topics more specific, then the academic dissemination of knowledge needs to adapt.

On a more applied level, numerous authors suggest specific tools for science communication. Puschmann and Weller for instance, describe the microblogging service Twitter as a suitable tool to direct users to, for example, relevant literature and as a source for alternative impact factors (as expressed in the measurement school) [7]. Grand argues that by using Web 2.0 tools and committing to public interaction, a researcher can become a public figure and honest broker of his or her information [8].

While numerous researchers already focus on the new tools and formats of science communication and the audience's expectations, there is still a need for research on the changing role of a researcher in a digital society, that is for instance the dealings with a new form of public pressure to justify the need for instant communication and the ability to format one's research for the public. A tenable question is thus also if a researcher can actually meet the challenge to, on the one hand, do research on highly complex issues and, on the other hand, prepare these in digestible bits of information. Or is there rather an emerging market for brokers and mediators of academic knowledge?

III. The Democratic School

The democratic school is concerned with the access to knowledge. The reason we refer to the discourse about free access to research products as the democratic school issues from its inherent rationale that everyone should have the same right to access knowledge, especially when its state funded. This concerns mostly research publications and scientific data, but also source materials, digital representations of pictorial and graphical materials or multimedia material.

In the following, we will discuss open access to research publications and open data.

A. Open Data

Regarding open data in science, Murray-Rust relates the meaning of the prefix 'open' to the common definition of open source software. In that understanding, the right of usage of scientific data does not demise to a journal but remains in the scientific community: "*I felt strongly that data of this sort should by right belong to the community and not to the publisher and started to draw attention to the problem*" [9, p52]. According to Murray-Rust, it is obstructive that journals claim copyright for supporting information (often research data) of an article and thereby prevent the potential re-use of data. He argues that "*(it) is important to realize that SI is almost always completely produced by the original authors and, in many cases, is a direct output from a computer. The reviewers may use the data for assessing the validity of the*

science in the publication but I know of no cases where an editor has required the editing of (supporting information)" [9, p54]. The author endorses that text, data or meta-data can be re-used for whatever purpose without further explicit permission from a journal. He assumes that, other than validating research, journals have no use from claiming possession over supporting information—other researchers however do.

According to Murray-Rust's, data should not be 'free' (as in free beer), but open for re-use in studies foreseen or not foreseen by the original creator. The rationale behind open data in science is in this case researcher-centric; it is a conjuncture that fosters meaningful data mining and aggregation of data from multiple papers. Put more simply, open data allows research synergies and prevents duplication in the collection of data. In this regard, Murray-Rust does not only criticize the current journal system and the withholding of supporting information but also implies a productive potential of practicing open data. It has to be said though, that the synergy potentials that Rust describes mostly apply to natural sciences (or at least research fields in which data is more or less standardized) or at least fields in which intermediate research product (e.g. data) can be of productive use for others.

Similar to Murray-Rust, Molloy criticizes the current journal system, which works against the maximum dissemination of scientific data that underlies publications. She elaborates on the barriers inherent in the current journal system: "*Barriers include inability to access data, restrictions on usage applied by publishers or data providers, and publication of data that is difficult to reuse, for example, because it is poorly annotated or 'hidden' in unmodifiable tables like PDF documents*" [10, p1]. She suggests a handling with data that follows the Open Knowledge Foundation's definition of openness, which means that data should be available as a whole, at no more than a reasonable reproduction cost (preferably through download) and in a convenient and modifiable form.

Other than Murray-Rust and Molloy, Vision [11] and Boulton [12] first of all hold the researchers liable for practicing open data. Vision refers to a study by Campbell et al. (2002), after which only one quarter of scientists share their research data—even upon request. According to that study, the most common reason for denying requests was the amount of effort required for compliance. Vision presents disciplinary data repositories that are maintained by the data creators themselves as an appropriate solution to the problem. This way, scientists would only need to upload their data once instead of complying with requests. Although Vision emphasizes the necessity to minimize the submission burden for the author, he does not suggest concrete inducements for scientists to upload their data (for instance forms of recognition or another a material reward). In an empirical study about the sharing behavior among scientists, Haeussler found out that the sharing of data is indeed closely related to a form of counter-value [13, p117].

The apparent divergence regarding the impediments of open data demonstrate the need for further empirical research on that issue. Future studies could address the researcher reluctance to practice open data, the role of journals and supporting material, the design of an appropriate online data repository or meta-data structures for research data. The implied multitude of obstacles for practicing open data also illustrates that research on that issue needs to be holistic.

TABLE 3

B. Open Access to Research Publications

When it comes the open access of research publications, the argument is often less researcher-centric. Cribb and Sari make the case for the open access to scientific knowledge as a human right [6]. According to them, there is a gap between the creation and the sharing of knowledge: While scientific knowledge doubles every 5 years, the access to this knowledge remains limited—leaving parts of the world in the dark: "*As humanity progresses through the 21st century (...) many scholars point to the emergence of a disturbing trend: the world is dividing into those with ready access to knowledge and its fruit, and those without.*" [6, p3]. For them, free access to knowledge is a necessity for human development. In a study on open access in library and information science, Rufai et al. take the same line. They assume that countries "*falling in the low-income economic zones have to come on open access canvas*" [14]. In times of financial crises, open journal systems and consequently equal access to knowledge could be an appropriate solution. Also Phelps et al. regard open access to research publications as a catalyst for development. Consistently, they define open access as "*the widest possible dissemination of information*" [15, p1].

Apart from the developmental justification, Phelps et al. mention another, quite common, logic for open access to research publications: "*It is argued (...) that research funded by tax-payers should be made available to the public free of charge so that the tax-payer does not in effect pay twice for the research (...)*" [15, p1]. 'Paying twice for research' refers to the fact that citizens do not only indirectly finance government-funded research but also the subsequent acquisition of publications from public libraries. Carroll also criticizes the inefficiency of traditional, subscription-financed scientific journals in times of growth in digital technologies and networks [16]. He argues that prices should drive down in the light of the Internet—instead they have increased drastically. He further argues that the open access model would shift the balance of power in journal publishing and greatly enhances the efficiency and efficacy of scientific communication [16]. By shifting the financing away from subscriptions, the open-access model re-aligns copyright and enables broad re-use of publications while at the same time assuring authors and publishers that they receive credit for their effort (e.g. through open licensing).

TABLE 4

I. The Pragmatic School

Advocates of the pragmatic school regard Open Science as a method to make research and knowledge dissemination more efficient. It thereby considers science as a process that can be optimized by, for instance, modularizing the process of knowledge creation, opening the scientific value chain, including external knowledge and allowing collaboration through online tools. The notion of 'open' follows in this regard very much the disclosed production process known from open innovation concepts.

Tacke for instance builds upon the connection between open innovation and Open Science. Similar to open innovation, the author applies the outside-in (including external knowledge to the production process) and inside-out (spillovers from the formerly closed production process) principles to science [17]. He regards the Web 2.0 in this regard as a fertile ground for practicing collaborative research and emphasizes the 'wisdom of the crowds' as a necessity to solve today's scientific problems: "*Taking a closer look at science reveals a similar situation: problems have become more complex and often require a joint effort in order to find a solution*" [17, p37].

Tacke refers to Hunter and Leahey who examined trends in collaboration over a 70 years period [18]. They found out that between 1935 and 1940 only 11 % of the observed articles were co-authored, whereas between 2000 and 2005 almost 50 % were coauthored—a significant increase that according to Tacke issues from the increasing complexity of research problems over time; research problems that apparently can only be solved through multi-expert consideration. Indeed, Bozeman and Corley, in an empirical study on researcher collaboration, found out that some of the most frequent reasons for collaborative research are the access to expertise, the aggregation of different kinds of knowledge and productivity [19]. Apart from the assumed increasing complexity of today's research problems and the researcher's pursue of productivity, Tacke also points at the technical progress that enables and fosters collaboration in the first place. The Web 2.0 allows virtually anyone to participate in the process of knowledge creation. It is thus tenable to consider, besides striving for productivity and the increasing complexity of research process, also the emerging communication and collaboration technology as a solid reason for collaborative research.

Nielsen argues accordingly. He proceeds from the assumption that openness indicates a pivotal shift in the scientific practice in the near future—namely from closed to collaborative. By reference to numerous examples of collective intelligence, such as the Polymath Project (in which Tim Gower posted a mathematical problem on his blog that was then solved by a few experts) or the Galaxy Zoo Project (an online astronomy project which amateurs can join to assist morphological classification), he emphasizes the crucial role of online tools in this development: "*Superficially, the idea that online tools can make us collectively smarter contradicts the idea, currently fashionable in some circles, that the Internet is reducing our intelligence*" [20, p26].

Nielsen's presentation of examples for collaborative knowledge discoveries allow to conjecture the wide variety of collaborative research when it comes to scale and quality—may it be a rather-small scale expert collaboration as in the Polymath project or large-scale amateur collaboration as in the Galaxy Zoo project. Nielsen also points towards the importance of open data and promotes comprehensive scientific commons: "*We need to imagine a world where the construction of the scientific information commons has come to fruition. This is a world where all scientific knowledge has been made available online, and is expressed in a way that can be understood by computers*" [20, p111]. It becomes obvious that Nielsen's vision of Open Science is based on vesting conditions like the enhanced use of online platforms, the inclusion of non-experts in the discovery process and, not least, the willingness to share on the part of scientists; all of which show that Nielsen's notion of collective research is also bound to numerous profound changes in the scientific practice—not to mention the technological ability to understand all formats of knowledge by computers.

Haeussler addresses the sharing behaviour of researchers in an empirical study [13]. She uses arguments from social capital theory in order to explain why individuals share information even at (temporary) personal costs. One of Haeussler's results concerns the competitive value of information. She concludes: "*My study showed that factors related to social capital influence the impact of the competitive value of the requested information on a scientist's decision to share or withhold information*" [17, p117]. If academic scientists expect the inquirer to be able to return the favor, they are much more likely to share information. Haeussler's study shows that the scientist's sharing behaviour is not per se altruistic—which is often taken for granted in texts on Open Science. Instead, it is rather built on an, even non-monetary, return system. The findings raise the question how the sharing of information and thus, at least according to Nielsen and Haeussler, a basic requirement for Open Science could be expedited. It implies that a change in scientific practice comes with fundamental changes in the scientific culture (e.g. community recognition for sharing information).

Neylon and Wu elaborate more on Web 2.0 tools that facilitate and accelerate scientific discovery. According to them, tools "*whether they be social networking sites, electronic laboratory notebooks, or controlled vocabularies, must be built to help scientists do what they are already doing, not what the tool designer feels they should be doing*" [21, p543]. The authors regard the implementation of Web 2.0 tools in close relation to the existing scientific practice. Following this, scientific tools can only foster scientific discovery if they tie in with existing research practice. The most obvious target, according to the authors, is in this regard *"tools that make it easier to capture the research record so that it can be incorporated into and linked from papers"* [21, p543]. Unfortunately the authors do not further elaborate on how potential tools could be integrated in the researchers' workflows. Nonetheless, they take a new point of view when

it comes to the role of Web 2.0 tools and the necessity to integrate these into an existing research practice.
Future research must focus on the structural parameters for Open Science, the incentives for scientists to share knowledge or the inclusion of software tools in the existing practice.

TABLE 5

IV. The Infrastructure School

The infrastructure school is concerned with the technical infrastructure that enables emerging research practices on the Internet. That concerns mainly software tools and applications as well as computing networks. In a nutshell, the infrastructure school regards Open Science as a technological challenge. Literature on this matter is often case-specific; it focuses on the technological requirements for particular projects (e.g. the Open Science Grid).

The technical infrastructure is a cyclic element for almost all identified schools in this paper (e.g. imagine open data without online data repositories). It is the new technological possibilities that change established scientific practices or constitute new ones, as in the case of altmetrics or scientific blogging. Still, we decided to include the infrastructure school as a separate and superordinate school of thought due to discernible infrastructure trends in the context of Open Science; trends that in our eyes enable research on a different scale.
We will therefore not list the multitude of Open Science projects and their technological infrastructure but instead dwell on two infrastructure trends and selected examples that signify a sever change in the scientific practice.
It has to be said that these trends are not mutually exclusive but often interwoven. The trends are:

- Distributed computing: Using the computing power of many users for research
- Social and collaboration networks for scientists: Enabling researcher interaction and collaboration

A. Distributed Computing

A striking example for distributed computing in science is the Open Science Grid, *"a large distributed computational infrastructure in the United States, which supports many different high-throughput scientific applications (...) to form multi-domain integrated distributed systems for science."* [22, p202]. Put simply, the Open Science Grid enables large-scale, data-intensive research projects by connecting multiple computers to a high-performance computer network. Autonomous computers are interconnected in order to achieve high throughput research goals. The Open Science Grid provides a collaborative research environment for communities of scientists and researchers to work together on distributed computing problems [22].

It is thus not completely accurate to confine the Open Science Grid to its computational power alone as it also provides access to storage resources, offers a software stack and uses common operational services. Nonetheless, its core strength resides in the computational power of many single computers which allows scientists to realize data-intensive research projects, high throughput processing and shared storage. Typical projects that use the Open Science Grid are therefore CPU-intensive, comprise a large number of independent jobs, demand a significant amount of database-access and/or implicate large input and output data from remote servers.

Foster encapsulates the increasing importance of grids as an essential computing infrastructure: "*Driven by increasingly complex problems and by advances in understanding and technique, and powered by the emergence of the Internet (...),today's science is as much based on computation, data analysis, and collaboration as on the efforts of individual experimentalists and theorists"* [23, p52]. He further emphasizes the potential to enable large-scale sharing of resources within distributed, often loosely coordinated and virtual groups—an idea that according to the author is not all new. He refers to a case from 1968, when designers of the Multics operating system envisioned a computer facility operating as a utility [23]. What is new though, according to Foster is the performance of such network utilities in the light of the technological progress [23].

Distributed computing allows scientists to realize research almost independently from the individual computing resources. It is thereby an opportunity to untie a researcher from locally available resources by providing a highly efficient computer network. Considering the importance of big data, scientific computing will be an essential research infrastructure in the near future. One could say the objective of scientific computing is the increase of performance by interconnecting many autonomous and dispersed computers.

B. Social And Collaboration Networks

A second, more researcher-centric, infrastructure trend focuses on platforms that foster interaction between locally dispersed individuals and allow collaboration by implementing Web 2.0 tools. Drawing on the example of myExperiment, De Roure et al. propose four key capabilities of what they consider a Social Virtual Research Environment (SVRE) [24]:

- According to the authors, a SVRE should *firstly* facilitate the management and sharing of research objects. These can be any digital commodities that are used and reused by researchers (e.g. methods and data).
- *Secondly*, it should have incentives for researchers to make their research objects available.
- *Thirdly*, the environment should be open and extensible—meaning that software, tools and services can be easily integrated.
- *Fourthly*, it should provide a platform to action research. Actioning research is, in the authors' understanding, what makes a platform an actual research environment. Research objects are in this regard not just stored and exchanged but they are used in the conduct of research (De Roure, 2008, p. 182).

This depiction of a SVRE does of course not exclude, mass computation (the third capability in fact endorses the integration of additional services)—it does however clearly focus on the interaction and collaboration between researchers. Further, it becomes apparent that the authors' notion of 'virtual social research' involves a multitude of additional tools and services enabling collaborative research. It implies (directly or indirectly) integrated large-scale data repositories that allow researchers to make their data publicly available in the first place.

Nentwich and König [25] point towards other social networks for scientists, such as ResearchGate, Mendeley, Nature Networks, Vivo or Academia.edu. The authors state that present academic social networks are principally functional for scientists and do not (yet) feature a convergence towards one provider. They point towards the use of multi-purpose social networks (such as Facebook, LinkedIN or Xing) among scientists. These are used for thematic expert groups (not only scientists), self-marketing or job exchange.

TABLE 6

V. The Measurement School

The measurement school is concerned with alternative standards to ascertain scientific impact. Inarguably, the impact factor, which measures the average number of citations to an article in a journal, has a decisive influence on a researcher's reputation and thereby his/her funding and career opportunities. It is therefore hardly surprising that a discourse about Open Science is accompanied by the crucial question of how scientific impact can be measured in the digital age.

Advocates of the measurement school express the following concerns about the current impact factor:

- The peer review is time-consuming ([26] [27]).
- The impact is linked to a journal rather than directly to an article [26].
- New publishing formats (e.g. online open access journals, blogs) are seldom in a journal format to which an impact factor can be assigned to ([07], [28], [29]).

Accordingly, this school argues the case for an alternative and faster impact measurement that includes other forms of publication and the social web coverage of a scientific contribution. The general credo is: As the scholarly workflow is increasingly migrating to the web, formerly hidden uses like reading, bookmarking, sharing, discussing and rating are leaving traces online and offer a new ground to measure scientific impact. The umbrella term for these new impact measurements is altmetrics.

Yeong and Abdullah state that altmetrics differ from webometrics, which are, as the authors argue, relatively slow, unstructured and closed [29]. Altmetrics instead rely on a wider set of measures that include tweets, blog, discussions and bookmarks. Altmetrics measure different forms of significance and usage patterns by looking not just at the end publication but also the process of research and collaboration [29]. As a possible basis for altmetrics, Priem et al. mention web pages, blogs, downloads but also social media like Twitter or social reference managers like CiteULike, Mendeley and Zotero [28]. As a result of a case study with 214 articles, they present the two open-source online tools CitedIn and total-impact as potential alternatives to measure scientific impact as they are based on a meaningful amount of data from more diverse academic publications. At the same time, they emphasize that there is still a need for research regarding the comparability of altmetrics, which is difficult due to the high dimensionality of altmetrics data.

While many authors already recognize the need for new metrics in the digital age and a more structured and rapid alternative to webometrics, research on this matter is still in its infancy [29]. There is scarcely research on the comparability of altmetrics and virtually no research on their potential manipulations and network effects. Furthermore, altmetrics does not yet broadly applied in the scientific community; raising the question what hinders their broad implementation. A possible reason is the tight coupling of the existing journal system and its essential functions of archiving, registration, dissemination, and certification of scholarly knowledge [30]. All the more, it appears that future research should also focus on the overall process of science, its transformative powers and, likewise, restrainers

TABLE 7

VI. Discussion

Even though the paper implies a certain lack of conceptual clarity of the term Open Science, we do not promote a precisely defined concept. We aimed at offering an overview of the leading discourses by suggesting five (more or less) distinct schools of thought, their core aims and argumentations. We suggest that this classification can be a starting point for structuring the overall discourse and locating its common catchphrases and argumentations.

Although Open Science covers in the broadest sense anything about the opening of knowledge creation and dissemination, not necessarily all developments described in this paper are novel. In fact core demands and argumentations existed long before the dawn of the Internet and the digital age. Some would even argue that science is per definition open since the aim of research is, after all, to publish its results, and as such *to make knowledge public*. Nonetheless, science certainly experiences a new dynamic in the light of modern communication technology. Collaborative forms of research, the increasing number of co-authored scientific articles, new publication formats in the social web, the wide range of online research tools or the increasing emergence of open access journals bear witness to the dawn of a new era of science.

The entirety of the outlined developments in this paper marks a profound change of the scientific environment. And even if the most prominent accompaniments of this change (be it Open Access, Open Data, citizen science or collaborative research) are possibly overdue for a knowledge industry in the digital age and welcomed by most people who work in it, they

still depend on comprehensive implementation. They depend on elaborate research policies, convenient research tools and, not least, the participation and devotion of the researchers themselves. In many instances Open Science appears to be somewhat like the proverbial electric car—an indeed sensible but expenseful thing that better parks in the neighbor's garage; a great idea that everybody agrees upon but urges the others to take the first step.

REFERENCES

[1] E. Hand, "Citizen science: People power," *Nature*, vol. 466, no. 7307, pp. 685-687, Aug. 2010. [Online]. Available: http://dx.doi.org/10.1038/466685a

[2] Christina L. Catlin-Groves, "The Citizen Science Landscape: From Volunteers to Citizen Sensors and Beyond," International Journal of Zoology, vol. 2012, Article ID 349630, 14 pages, 2012.

[3] A. Irwin, "Constructing the scientific citizen: Science and democracy in the biosciences," *Public Understanding of Science*, vol. 10, no. 1, pp. 1-18, Jan. 2001.

[4] M. C. Powell and M. Colin, "Participatory paradoxes: Facilitating citizen engagement in science and technology from the Top-Down?" *Bulletin of Science Technology Society*, vol. 29, no. 4, pp. 325-342, Aug. 2009.

[5] O. Tacke, "Raus aus dem Elfenbeinturm: Open Science," blog, 23 November 2012; http://www.olivertacke.de/2011/10/23/raus-aus-dem-elfenbeinturm-open-science/

[6] J. Cribb and T. Sari. Open Science: Sharing Knowledge in the Global Century. Collingwood, 2010, pp. 1-20.

[7] C. Puschmann and K. Weller, "Twitter for Scientific Communication: How can Citations/References be Identified and Measured?", unpublished.

[8] A. Grand, C. Wilkinson, K. Bultitude and A.F.T. Winfield (2012, Sept.). "Open Science. A New "Trust Technology?"". Science Communication. 34(5), pp. 679-689.

[9] P. Murray-Rust (2008, March). "Open Data in Science". 34(1), pp. 52-64.

[10] J. C. Molloy, "The open knowledge foundation: Open data means better science," *PLoS Biol*, vol. 9, no. 12, pp. e1 001 195+, Dec. 2011. [Online]. Available: http://dx.doi.org/10.1371/journal.pbio.1001195

[11] T. J. Vision, "Open data and the social contract of scientific publishing," *BioScience*, vol. 60, no. 5, p. 330, May 2010. [Online]. Available: http://dx.doi.org/10.1525/bio.2010.60.5.2

[12] G. Boulton, M. Rawlins, P. Vallance, and M. Walport, "Science as a public enterprise: the case for open data." *Lancet*, vol. 377, no. 9778, pp. 1633-1635, May 2011.

[13] C. Haeussler, "Information-sharing in academia and the industry: A comparative study," *Research Policy*, vol. 40, no. 1, pp. 105-122, Feb. 2011. [Online]. Available: http://dx.doi.org/10.1016/j.respol.2010.08.007

[14] R. Reyaz, G. Sumeer and S. Tariq-Ahmad. (2011, July). "Open Access Journals in Library and Information Science: The Story so Far." 7(2)

[15] L. Phelps, B. Fox, and F. Marincola, "Supporting the advancement of science: Open access publishing and the role of mandates," *Journal of Translational Medicine*, vol. 10, no. 1, pp. 13+, Jan. 2012. [Online]. Available: http://dx.doi.org/10.1186/1479-5876-10-13

[16] M. W. Carroll, "Why full open access matters," *PLoS Biol*, vol. 9, no. 11, pp. e1 001 210+, Nov. 2011. [Online]. Available: http://dx.doi.org/10.1371/journal.pbio.1001210

[17] O. Tacke, "Open science 2.0: How research and education can benefit from open innovation and web 2.0," in *On Collective Intelligence*, ser. Advances in Soft Computing, T. Bastiaens, U. Baumöl, and B. Krämer, Eds. Berlin, Heidelberg: Springer Berlin / Heidelberg, 2011, vol. 76, ch. 4, pp. 37-48. [Online]. Available: http://dx.doi.org/10.1007/978-3-642-14481-3_4

[18] L. Hunter and E. Leahey, "Collaborative research in sociology: Trends and contributing factors," *The American Sociologist*, vol. 39, no. 4, pp. 290-306, Dec. 2008. [Online]. Available: http://dx.doi.org/10.1007/s12108-008-9042-1

[19] B. Bozeman and E. Corley, "Scientists' collaboration strategies: implications for scientific and technical human capital," *Research Policy*, vol. 33, no. 4, pp. 599-616, May 2004. [Online]. Available: http://dx.doi.org/10.1016/j.respol.2004.01.008

[20] M. Nielsen, *Reinventing Discovery: The New Era of Networked Science*. Princeton University Press, Oct. 2011. [Online]. Available: http://www.worldcat.org/isbn/0691148902

[21] C. Neylon and S. Wu, "Open science: tools, approaches, and implications." *Pacific Symposium on Biocomputing. Pacific Symposium on Biocomputing*, pp. 540-544, 2009.

[22] M. Altunay, P. Avery, K. Blackburn, B. Bockelman, M. Ernst, D. Fraser, R. Quick, R. Gardner, S. Goasguen, T. Levshina, M. Livny, J. McGee, D. Olson, R. Pordes, M. Potekhin, A. Rana, A. Roy, C. Sehgal, I. Sfiligoi, and F. Wuerthwein, "A science driven production cyberinfrastructure—the open science grid," *Journal of Grid Computing*, vol. 9, no. 2, pp. 201-218, Jun. 2011.

[23] I. Foster, "The grid: A new infrastructure for 21st century science," pp. 51-63, 2003. [Online].

[24] D. De Roure and C. Goble, "Software design for empowering scientists," *IEEE Software*, vol. 26, no. 1, pp. 88-95, Jan. 2009.

[25] M. Nentwich and R. König"Cyberscience 2.0: Research in the Age of Digital Social Networks." Frankfurt. Campus, June. 2012.

[26] M. McVeigh, "Open Access Journals in the ISI Citation Databases: Analysis of Impact Factors and Citation Patterns. A citation study from Thomson Scientific" Internet: http://ip-science.thomsonreuters.com/m/pdfs/openaccesscitations2.pdf [Jan. 29, 2013]

[27] J. Priem and K. L. Costello, "How and why scholars cite on twitter," in *Proceedings of the 73rd ASIS&T Annual Meeting on Navigating Streams in an Information Ecosystem - Volume 47*, ser. ASIS&T '10. Silver Springs, MD, USA: American Society for Information Science, 2010.

[28] J. Priem, D. Taraborelli, P. Groth and C. Neylon. "altmetrics: a manifesto" Internet: http://altmetrics.org/manifesto/, Oct. 26, 2010 [Jan. 29, 2013]

[30] C. H. Yeong and B. J. J. Abdullah, "Altmetrics: the right step forward," *Biomedical Imaging and Intervention Journal*, vol. 8, no. 3, pp. 1-2, 2012. [Online]. Available: http://www.biij.org/2012/3/e15/e15.pdf

[31] J. Priem and B. H. Hemminger, "Scientometrics 2.0: New metrics of scholarly impact on the social web," *First Monday*, vol. 15, no. 7, Jul. 2010.

[32] P. Miller, R. Styles and T. Heath. "Open Data Commons. A License for Open Data." Internet: http://events.linkeddata.org/ldow2008/papers/08-miller-styles-open-data-commons.pdf, April 22, 2008 [Feb. 12, 2013]

[33] A. Löh and R. Hinze, "Open data types and open functions," in *Proceedings of the 8th ACM SIGPLAN international conference on Principles and practice of declarative programming*, ser. PPDP '06. New York, NY, USA: ACM, 2006, pp. 133-144.

[34] S. Auer, C. Bizer, G. Kobilarov, J. Lehmann, R. Cyganiak, and Z. Ives, "DBpedia: A nucleus for a web of open data the semantic web", in *The Semantic Web*, ser. Lecture Notes in Computer Science, K. Aberer, K.-S. Choi, N. Noy, D. Allemang, K.-I. Lee, L. Nixon,

J. Golbeck, P. Mika, D. Maynard, R. Mizoguchi, G. Schreiber, and P. Cudré-Mauroux, Eds. Berlin, Heidelberg: Springer Berlin / Heidelberg, 2007, vol. 4825, ch. 52, pp. 722-735.
[35] K. Antelman, "Do Open-Access articles have a greater research impact?" *College & Research Libraries*, vol. 65, no. 5, pp. 372-382, Sep. 2004.
[36] S. Harnad, T. Brody, F. Vallières, L. Carr, S. Hitchcock, Y. Gingras, C. Oppenheim, H. Stamerjohanns, and E. R. Hilf, "The Access/Impact problem and the green and gold roads to open access," *Serials Review*, vol. 30, no. 4, pp. 310-314, Jan. 2004.
[37] S. Harnad and T. Brody, “Comparing the Impact of Open Access (OA) vs. Non-OA Articles in the Same Journals.” Internet: http://www.dlib.org/dlib/june04/harnad/06harnad.html, 10 June 2004 [Feb. 12, 2013]
[38] T. Gowers and M. Nielsen, "Massively collaborative mathematics." *Nature*, vol. 461, no. 7266, pp. 879-881, Oct. 2009.
[39] O. F. E. R. Arazy, W. Morgan, and R. Patterson, "Wisdom of the crowds: Decentralized knowledge construction in wikipedia," *Social Science Research Network Working Paper Series*, Dec. 2006.
[40] A. Weiss, "The power of collective intelligence," *netWorker*, vol. 9, no. 3, pp. 16-23, Sep. 2005.
[41] T. Hey and A. E. Trefethen, "Cyberinfrastructure for e-Science," *Science*, vol. 308, no. 5723, pp. 817-821, May 2005.
[42] L. Björneborn and P. Ingwersen, "Perspective of webometrics," *Scientometrics*, vol. 50, no. 1, pp. 65-82, Jan. 2001.

Table 1: Five Open Science Schools of Thought

School of thought	Central assumption	Involved groups	Central Aim	Tools & Methods
Democratic	The access to knowledge is unequally distributed.	Scientists, polititians, citizens	Making knowledge freely available for everyone.	Open access, intellectual property rights, Open data, Open code
Pragmatic	Knowledge-creation could be more efficient if scientists collaborated.	Scientists	Opening up the process of knowledge creation.	Wisdom of the crowds, network effects, Open Data, Open Code
Infrastructure	Efficient research depends on the available tools and applications.	Scientists & platform providers	Creating openly available platforms, tools and services for scientists.	Collaboration platforms and tools
Public	Science needs to be made accessible to the public.	Scientists & citizens	Making science accessible for citizens.	Citizen Science, Science PR, Science Blogging
Measurement	Scientific contributions today need alternative impact measurements.	Scientists & politicians	Developing an altemative metric system for scientific impact.	Altmetrics, peer review, citation, impact factors

Table 2: The Public School

Author (Year) Type of Publication	Title	Content
Cribb & Sari (2010) Monograph	*Open Science - Sharing Knowledge in the digital age*	The accessibility of scientific knowledge is a matter of its presentation. *"Science is by nature complicated, making it all the more important that good science writing should be simple, clean and clear." (p. 15)*
Grand et al (2012) Journal Article	*Open Science: A New "Trust Technology"?*	Scientists can raise public trust by using web 2.0 tools *"As mainstream science—and comment on science— follows the pioneers into the realm of Web 2.0, to be able to navigate the currents of the information flow in this relatively unmapped territory, scientists and members of the public will all need reliable and robust tools." (p. 685)*
Morris & Mietchen (2010) Proceedings	*Collaborative Structuring of Knowledge by Experts and the Public*	Using web 2.0 tools to make knowledge production accessible for the public. *"(...) there is still plenty of opportunities for reinventing and experimenting with new ways to render and collaborate on knowledge production and to see if we can build a more stable, sustainable and collegial atmosphere (...) for experts and the public to work together." (p. 32)*
Tacke (2012) Blog entry	*Out of the Ivory Tower: Open Science.*	The Web 2.0 gives scientists new opportunities to spread scientific knowledge to a wider public. *"Im einfachsten Fall können Wissenschaftler etwa in Blogs über Themen aus ihrem Fachgebiet berichten und Fragen von interessierten dazu beantworten." (p. 2)*
Irwin (2006) Monograph	*The politics of talk*	Due to modern technology, citizens can participate in scientific knowledge creation. *"(...) this book is committed both to an improved understanding of 'science, technology and citizenship' and to better social practice in this area (...)" (p. 8)*
Hand (2010) Article	*Citizen science: People power*	Citizens possess valuable knowledge from which science can benefit. *"By harnessing human brains for problem solving, Foldit takes BOINC's distributed-computing concept to a whole new level." (p. 2)*
Ehner & Maurer (2009) Article	*Can microblogs and weblogs change traditional scientific writing?*	Blogs can contribute to make research more accessible to the public. Yet they cannot replace articles and essays in scholarly communication. *"Weblogs and microblogs can enhance lectures by bringing the resources of the WorldWideWeb to the course and making them discussable. Both new technologies, however, cannot replace writing essays and articles, because of their different nature." (p. 55)*
Catlin-Groves (2012) Review article	*The Citizen Science Landscape: From Volunteers to Citizen Sensors and Beyond*	Citizens can help monitoring on a large scale. *"The areas in which it [citizen science] has, and most probably will continue to have, the greatest impact and potential are that of monitoring ecology or biodiversity at large geographic scales." (p. 2)*
Powell & Colin (2009) Article	*Participatory paradoxes: Facilitating citizen engagement in science and technology from the Top-Down?*	Citizen science projects are often short-lived "Most participatory exercises do not engage citizens beyond an event or a few weeks/months, and they do not build citizens' participatory skills in ways that would help them engage with scientists or policy makers independently." (p. 327)

Table 3: The Democratic School: Open Data

Author (Year) Type of Publication	Title	Content
Murray-Rust (2008) Preceedings	*Open data in science*	Open data depends on a change of the joournal practice regarding the witholding of supporting information. *"The general realization of the value of reuse will create strong pressure for more and better data. If publishers do not gladly accept this challenge, then scientists will rapidly find other ways of publishing data, probably through institutional, departmental, national or international subject repositories. In any case the community will rapidly move to Open Data and publishers resisting this will be seen as a problem to be circumvented." (p. 64)*
Vision (2010) Journal Article	*Open Data and the Social Contract of Scientific Publishing*	Data is a commodity. The sharing of data enables benefits other researchers. *"Data are a classic example of a public good, in that shared data do not diminish in value. To the contrary, shared data can serve as a benchmark that allows others to study and refine methods of analysis, and once collected, they can be creatively repurposed by many hands and in many ways, indefinitely." (p. 330)*
Boulton et al. (2011) Comment	*Science as a public enterprise: the case for open data*	Data needs to be prepared in a usable format. *"Conventional peer-reviewed publications generally provide summaries of the available data, but not effective access to data in a usable format." (p. 1634)*
Molloy (2011) Open Access Article	*The open knowledge foundation: Open data means better science*	Data should be free to reuse and redsitribute without restrictions. *"The definition of "open", crystellised in the OKD, means the freedom to use, reuse, and redistribute without restrictions beyond a requirement for attribution and share-alike. Any further restrictions make an item closed knowledge." (p. 1)*
Auer et al. (2007)	*DBpedia: A nucleus for a web of open data the semantic web*	Open Data is a major challenge for computer scientists in future. *"It is now almost universally acknowledged that stitching together the world's structured information and knowledge to answer semantically rich queries is one of the key challenges of computer science, and one that is likely to have tremendous impact on the world as a whole." (p. 1)*
Löh & Hinze (2006)	*Open Data types and open functions*	The problem of supporting the modular extensibility of both data and functions in one programming language (known as expression problem) *"The intended semantics is as follows: the program should behave as if the data types and functions were closed, defined in one place." (p.1)*
Miller et al. (2008)	*Open Data Commons, A Licence for Open Data*	Practicing open data is a question of appropriate licencing of data. *"Instead, licenses are required that make explicit the terms under which data can be used. By explicitly granting permissions, the grantor reassures those who may wish to use their data, and takes a conscious step to increase the pool of Open Data available to the web." (p. 1)*

Table 4: The Democratic School: Open Access to Research Publications

Author (Year) Type of Publication	Title	Content
Cribb & Sari (2010) Monograph	*Open Science - Sharing Knowledge in the Global Century*	Open access to knowledge is a tool for development. *"As humanity progresses the 21st century (...) many scholars point to the emergence of a disturbing trend: the world is dividing into those with ready access to knowledge and its fruit, and those without." (p. 3)*
Rufai et al. (2012) Journal Article	*Open Access Journals in Library and Information Science: The Story so Far.*	Open access helps underdeveloped countries to bridge the gap between them and developed countries. *"The sustainability of open access journals in the field of LIS is evident from the study. Countries falling in the low-income economic zones have to come on open access canvas." (p. 225)*
Phelps, Fox & Marincola (2012) Journal Article	*Supporting the advancement of science: Open access publishing and the role of mandates*	Open access increases the dissemination of a scholar's work *"Maybe one of the reasons that open access is an increasingly popular choice for society journals is that it fits well with many society missions to encourage the advancement of knowledge by providing the widest possible dissemination with no barriers to access." (p. 3)*
Carrol (2011) Journal Article	*Why full open access matters*	Open access helps overcoming the inefficiancy of traditional peer-review journals *"Pricing of traditional, subscription-financed scientific journals is highly inefficient. The growth in digital technologies and in digital networks should be driving down the price of access to the scholarly journal literature, but instead prices have increased at a rate greatly in excess of inflation" (p. 1)*
Harnad & Brody (2004)	*Comparing the Impact of Open Access (OA) vs. Non-OA Articles in the Same Journals*	Open access can increase the number of citations and helps skirting the high access tolls of journals. *"Access is not a sufficient condition for citation, but it is a necessary one. OA dramatically increases the number of potential users of any given article by adding those users who would otherwise have been unable to access it because their institution could not afford the access-tolls of the journal in which it appeared; therefore, it stands to reason that OA can only increase both usage and impact."*
Harnad et al. (2004)	*The Access/Impact Problem and the Green and Gold Roads to Open Access*	Only 5% of journals are gold, but over 90% are already green (i.e., they have given their authors the green light to self-archive); yet only about 10-20% of articles have been self-archived. *"Along with the substantial recent rise in OA consciousness worldwide, there has also been an unfortunate tendency to equate OA exclusively with OA journal publishing (i.e., the golden road to OA) and to overlook the faster, surer, and already more heavily traveled green road of OA self-archiving." (p. 314)*
Antelmann (2004)	*Do Open-Access Articles Have a Greater Research Impact?*	Open access articles have a higher research impact than not freely available articles. *"This study indicates that, across a variety of disciplines, open-access articles have a greater research impact than articles that are not freely available."* (p. 379)

Table 5: The Pragmatic School

Author (Year) Type of Publication	Title	Content
Tacke (2008) Proceedings	*Open science 2.0: How research and education can benefit from open innovation and web 2.0*	Complex situations can be better judged by the collective wisdom of the crowds. *"However, several critics emphasize that one person can never possess enough knowledge in order to judge complex situations expediently, and that it may more appropriate to use the collective wisdom of crowds." (p. 37)*
Haeussler (2011) Journal Article	*Information-sharing, social capital, open science*	Scientists expect a benefit from sharing information. *"My study showed that factors related to social capital influence the impact of the competitive value of the requested information on a scientist's decision to share or withhold information." (p. 117)*
Neylon & Wu (2009) Symposium Workshop	*Open science: tools, approaches, and implications*	Open science tools need to fit to the scientific practice of researchers. *"Tools whether they be social networking sites, electronic laboratory notebooks, or controlled vocabularies, must be built to help scientists do what they are already doing, not what the tool designer feels they should be doing" (p. 543)*
Nielsen (2012) Monograph	*Reinventing Discovery: The New Era of Networked Science*	*"We need to imagine a world where the construction of the scientific information commons has come to fruition. This is a world where all scientific knowledge has been made available online, and is expressed in a way that can be understood by computers" (ibid., p. 111)*
Weiss (2005)	*The Power of Collective Intelligence*	Participation in collective knowledge-creation depends on the tools and services available. *"With ever more sophisticated APIs and Web services being shared, attracting a critical mass of developers to build tools on those services, and a critical mass of users contributing to the services' value by aggregating shared knowledge and content, we have the makings of a truly collaborative, self-organizing platform." (p. 4)*
Arazy et al. (2006)	*Wisdom of the Crowds: Decentralized Knowledge Construction in Wikipedia*	Participation in the co-creation of knowledge depends on the entry barriers *"To entice participation, organizations using wikis should strive to eliminate barriers (e.g. allow users to post anonymously) and provide incentives for contributions." (p. 5)*
Gowers & Nielsen (2009)	*Massively Collaborative Mathematics*	Natural sciences can profit from collaboration of researchers. *"But open sharing of experimental data does at least allow open data analysis. The widespread adoption of such open-source techniques will require significant cultural changes in science, as well as the development of new online tools. We believe that this will lead to the widespread use of mass collaboration in many fields of science, and that mass collaboration will extend the limits of human problem-solving ability." (p. 881)*

Table 6: The Infrastructure School

Author (Year) Type of Publication	Title	Content
Altunay et all. (2011) Article	*A Science Driven Production Cyberinfrastructure—the Open Science Grid*	Science grid can be used for high-throughput research projects. *"This article describes the Open Science Grid, a large distributed computational infrastructure in the United States which supports many different high-troughput scientific applications (...) to form multi-domain integrated distributed systems for science." (p. 201)*
De Roure et al. (2010) Conference Paper	*Towards open science: the myExperiment approach*	*"myExperiment is the first repository of methods which majors on the social dimension, and we have demonstrated that an online community and workflow collection has been established and is now growing around it." (p. 2350)*
Foster (2003) Journal Article	*The grid: A new infrastructure for 21st century science*	Computation is a major challenge for scientific collaboration in future. *"Driven by increasingly complex problems and by advances in understanding and technique, and powered by the emergence of the Internet (...), today's science is as much based on computation, data analysis, and collaboration as on the efforts of individual experimentalists and theorists." (p. 52)*
De Roure et al. (2003) Book Chapter	*The Semantic Grid: A Future e-Science Infrastructure*	Knowledge layer services are necessary for seamlessly automatiing a significant range of actions *"While there are still many open problems concerned with managing massively distributed computations in an efficient manner and in accessing and sharing information from heterogenous sources (...), we believe the full potential of Grid computing can only be realised by fully exploiting the functionality and capabilities provided by knowledge layer services." (p. 432)*
Hey & Trefethen (2005) Article	*Cyberinfrastructure for e-Science*	Service-oriented science has the potential to increase individual and collective scientific productivity by making powerful information tools available to all, and thus enabling the widespread automation of data analysis and computation *"Although there is currently much focus in the Grid community on the lowlevel middleware, there are substantial research challenges for computer scientists to develop high-level intelligent middleware services that genuinely support the needs of scientists and allow them to routinely construct secure VOs and manage the veritable deluge of scientific data that will be generated in the next few years." (p. 820)*

Table 7: The Measurement School

Author (Year) Type of Publication	Title	Content
Priem & Light Costello (2010) Proceedings	*How and why scholars cite on twitter*	Tweets can be used as an alternative basis to measure scientific impact. *"Twitter citations are much faster than traditional citations, with 40% occurring within one week of the cited resource's publication. Finally, while Twitter citations are different from traditional citations, our participants suggest that they still represent and transmit scholarly impact."*
Weller & Puschmann (2011) Poster	*Twitter for Scientific Communication: How Can Citations/References be Identified and Measured?*	Scientific tweets can be identified in numerous ways
Priem et al. (2012) Proceedings	*Uncovering impacts: CitedIn and total-impact, two new tools for gethering altmetrics*	CitedIn and total-impact are tools that can measure scientific impact. *"CitedIn and total-impact are two tools in early development that aim to gather altmetrics. A test of these tools using a real-life dataset shows that they work, and that there is a meaningful amount of altmetrics data available"*
McVeigh (2012) News paper article	*Twitter, peer review and altmetrics: the future of research impact assessment*	*"So why is a revolution needed? Because long before the tools even existed to do anything about it, many in the research community have bemoaned the stranglehold the impact factor of a research paper has held over research funding, careers and reputations."*
Priem & Hemminger (2012) Journal article	*Decoupling the scholarly journal*	*"This tight coupling [of the journal system] makes it difficult to change any one aspect of the system, choking out innovation."*
Yeong & Abdullah (2012) Position paper	*Altmetrics: the right step forward*	Altmetrics are an alternative metric for analysing and informing scholarship about impact. *"Altmetrics rely on a wider set of measures [than webometrics] (...) are focused on the creation and study of new metrics based on the social web for analysing and informing scholarship."*
Björneborn & Ingwerson (2001) Journal article	*Perspectives of webometrics*	The lack of metadata attached to web documents and links <s> and the lack of search engines exploiting metadata <s> affects filtering options, and thus knowledge discovery options, whereas field codes in traditional databases support KDD (Knowledge Discovery in Databases). *"As stated above, the feasibility of using bibliometric methods on the Web is highly affected by the distributed, diverse and dynamical nature of the Web <s>and by the deficiencies of search engines. That is the reason that so far the Web Impact Factor investigations based on secondary data from search engines cannot be carried out." (p. 78)*

GOVERNANCE OF TOP LEVEL DOMAINS (TLDS): 2013, A FAILED REVOLUTION?

Dominique Lacroix
Internet European Society
Paris, France, +33 6 63 24 39 14
dominique.lacroix@ies-france.eu

***Abstract* — On June 13rd, 2012 in London, ICANN unveiled the first results of a major reform of the governance of Top Level Domains (TLDs). This reform that was prepared since 2005, was supposed to reduce the criticisms toward ICANN. Public interest, fair distribution, trust and diversity were the ambitions set in the slogan "One world, one Internet" that was tirelessly repeated by ICANN for its reform. The aim of this paper is to do a retrospective analysis of the outcomes of this reform and to evaluate empirically if the reform achieved its goals. We achieve this by an in-depth analysis of the outcomes of the new gTLD extensions campaign as publicized on the ICANN website since June 2012. This analysis shows that the reform is far from having hit its goals. In particular we show that while most of the criticisms have not been resolved some issues have even deepen.**

Index Terms* —Governance, ICANN, naming, TLDs, namespace, root zone, monopolies, tax havens, cultural diversity, trust, inclusiveness, economic development, surveillance, data.*

I. INTRODUCTION

On the June 13rd, 2012, in London, the former CEO of ICANN solemnly announced the initial outcomes of a great reform of the governance of Top Level Domains (TLDs), prepared since 2005. This reform is about to be implemented from mid-2013, under the direction of a new CEO for Internet Corporation for Assigned Names and Numbers (ICANN),

The Domain Names System (DNS) is at the very heart of Internet Governance as it has unique worldwide power on the way Internet resource are named. The namespace represents a cognitive power, that similarly to a town map that is recognized by its street names, structures the mental representation of cyberspace as well.

The namespace is also a great set of places of possible data capture. So the organization of registries is a sensitive issue for civil liberties as well as for business competition and public policy. It's a collective self-definition of humanity.

Last but not least, as a result, the namespace is the theatre of great competition between linguistic and ethico-juridical areas.

A. Basics we need about the namespace

The DNS is a system of correspondence between names and numbers. However it is noteworthy that while the numbers are attributed for free, the names are sold. So DNS is the base of a naming industry, with new job descriptions playing different roles in the hierarchical organization of the namespace.

At the top level, the root zone is controlled by the Department of Commerce, managed by ICANN through the Internet Assigned Numbers Authority IANA contract allocated by the National Telecommunication and Information Administration of the federal US Government, and operated technically by Verisign an US company [3].

At the first level, the ICANN attributes TLDs to registries through contracts. Till now, two main categories of TLDs have been initiated: ccTLDs (country code Top Level Domains) category, defined with two letters code for each country (following the ISO 3166 list); the other category contains generic TLDs where second level registrations are widely open (as *.com*, *.org*, etc.*)* and sponsored TLDs, used exclusively by professional groups (as *.museum*, *.tel .coop*, or *.mil*) or cultural communities (*.cat*).

As the major part of ccTLDs began running before ICANN's creation (1998), some of them never accepted to contract with ICANN but nevertheless still run as well as others. Some organizations also run "alternative roots", completely ignored by ICANN. The latest, Open root (http://www.open-root.eu/?lang=en), was initiated by Louis Pouzin, who invented the datagram, the basic mode for the transmission of packets in a network.

At the second level of the hierarchy are registrars that are either accredited by ccTLDs registries for commercialising domain with a country TLD extension, or by ICANN for selling all other extensions. The list of commercial TLDs lists has changed slowly in from 1998 to 2013. Currently there are around 20 gTLDs and 250 ccTLDs.

Five Regional Internet Registries (RIRs) manage the numbers resource (like IP addresses, AS numbers, *etc.*) and the relations with the technical networks [19].

B. Main criticisms against ICANN

The main disagreement about DNS architecture is about the uniqueness of the root and consequently the uniqueness of each TLD in the whole world. Milton Mueller analyzed economical concerns — artificial scarcity, monopolies and speculation —, political concerns — mean of surveillance of users and control of access — and institutional deadlock in the line of Douglas North's theories. But Milton Mueller believed that adding new resources in the technical system could operate a disruptive change. [16] That's a result we are searching for.

The naming industry that is dealing with large amount of money and power is also confronted with great struggles. ICANN has been the subject of many criticisms. Beyond the ccTLDs, the major part of the registers are under U.S. actors controls through US technical operators: Verisign (*.com*, *.net*, *.name*, *.edu*, *.gov*, *.jobs*), Neustar (*.biz*, *.travel*) and PIR (*.org*). Some recently created extensions have escaped from this domination, *e.g.*, *.eu*, *.asia*., *.cat*, *.tel* and *.museum* while some other like *.info* and the *.mobi* are still in the same situation as the technical operator is Afilias, an "Irish-US" company. However these new TLDs that arrived after the first wave of major TLDs, have only a small market share compared to first generation TLDs, and especially *.com* that regrouped in 2012 alone one hundred million domain names. The second rank in number of registered domains is the German ccTLD *.de*, followed by the generic *.net*, each one with around 14 million registries. Even *.ru*, *.cn* and *.in* have each about 3.5 million entries [5].

The same concentration phenomenon has been observed in non-ccTLD registrars. The largest registrar GoDaddy, manages three times more domains than the number two, eNom [2]. The registrars business is also dominated by US companies: out of 966 registrars recorded by ICANN, 604 are US companies [2].

While one can generally expect the prices to decline with market size increase, concentration on the *.com* domain, and Verisign monopoly has resulted into price increases on the grounds of increased insecurity. Finally ICANN had to stop the price inflation of Verisign through a new agreement. [11]

If we accept the concept that the management of a registry is a serious technical and financial responsibility that need regulations, we can expect that the regulators will try to ensure that large parts of the naming space are not becoming excluded from public resources and converted into annuities (parkings) or speculative investments (domainers). The ICANN reform aimed into dealing with the above issues by expanding consumer choice and strengthening naming trust.

We should add to the above issues, some criticisms targeting the ASCII bias in naming, that has been repeatedly denounced as contradictory with a linguistic and cultural diversity and going against a universal and multicultural Internet. Since 1996, Martin Dürst, Tan Tin Wee Seng and James proposed the IDNA (*Internationalizing Domain Names in Applications*) [6][7] and IDNAbis (2008) [13] protocols that converted strings using different scripts (Arabic, Chinese, Russian, Hindi, and accented Latin etc.) into ASCII strings and vice versa.

C. The ICANN reform with TLDs

The new ICANN reform was also designed to address concerns of diversity by operating in an inclusive way and helping to put an end to vast Internet "dead zones" that are observed in yet densely populated regions. The reform was also aimed to boost the economy by creating new opportunities for Western SMEs and for companies in developing and emerging countries.

Public interest, competition, trust and diversity were ambitious keywords defined in the slogan "*One world, one Internet*" of the ICANN reform. "*Competition, Consumer Trust and Consumer Choice Review*" were in every speech and every leaflet. ICANN was introduced as "*…a multi-national institution bringing the World Online with Internationalized Domain Names*".[9] Those principles were also reiterated in ICANN's *Affirmation of commitments* [4].

D. The aims of the paper

The aim of this paper is to do a retrospective analysis of the outcomes of the ICANN reform and to evaluate empirically if it achieved its goals. We achieve this by an in-depth analysis of the outcomes of the new gTLD extensions campaign as publicized on the ICANN website since June 2012.

The paper would like also to contribute a reflexion about building a monitoring tool for Internet governance. It could be interesting to analyze the structure of the core of power in the namespace (and other parts of governance) for example in the way performed by the Systems Design team of ETH Design about the *network of global corporate control* [24]. All stakeholders could have an interest in having such tools, at least civil society and all the governments. But secrete information harbors such as tax havens may be obstacles. The present study emphasizes areas of opacity and perhaps clustered interests. For the whole paper, mentions of tax havens refer to the recent report for US Congress prepared by Jane G. Gravelle, in Jan. 2013 [26].

This analysis shows that the reform is far from having hit its goals. In particular we show that while most of the criticisms have not been resolved some issues have even deepen. In particular we show that in contradiction with the announced goals of increased cultural diversity, economic development and worldwide inclusion, a dozen U.S companies have pre-empted up to 3/4 of the new TLD extensions sometimes indirectly and using proxies. Moreover we observed that out of the 1930 candidates TLDs at least 870 candidates proposed by 10 companies are located in tax havens. This is also in contradiction with the notion of public interest and trust. These observations lead us to state that the announced ICANN revolution is a failure that will not reduce the existing criticisms and issues that ICANN have to deal with. We believe that these issues might also deepen.

II. METHODOLOGY

A. Building two indexes

Let's call the dataset, objet of the study, the public part of the 1930 TLDs applications as they are displayed by ICANN [8] and, in complement, another display by the .Nxt magazine [17].

We gathered first figures about the new TLDs for a conference in the frame of the 2100 Foresight Association, on the June 19th 2012 [*2100.org*]. These first observations lead us to define a methodology in order to conduct a more precise analysis. Our attention was drawn to the three Caribbean Islands because of the contrast between the small size of the countries and the high number of applications they host. We therefore build an objective index to analyze the localization of the applications.

Let's call the "Icannian engagement index" the number of candidate TLDs in a country as presented by ICANN (Table 1) reported to the country's population. The population criterion is not perfect but it takes in account that the purpose of the namespace should be the public interest. So it's a way of surveying this achievement. The location criterion may also be discussed in a cross-border matter, but the tax collection as well as the corporations legal registers are still at the national level. The reason we observe locations is probably the same reason why some companies don't register themselves in the location of their actual business.

The unit will be the number of TLDs per million inhabitants. The number of applications is divided by the population of the country (location field) and multiplied by one million. The location field is defined by ICANN's table as "*Indicated by applicant as principal place of business*". The population recent figures are found in Wikipedia. The focus on the location field was chosen in consideration of three concerns: the ICANN's outreach goal and internationalization process, cultural diversity and properly distributed economic benefits and leverage.

We show in Table 2 the resulting index for each one of the ICANN regions.

As the first index reveals some clusters, it led to built a second index, for the concentration: the ratio applications upon actors. In order to approach an actual number of actors, when obvious, we aggregated the serial applications done by a company or its group or its holding.

B. The ICANN's table

ICANN displays a two dimensions table [8]: 1930 rows, one for each TLD proposal. On June 2012, nine columns and a small search engine allowed queries by Applicant (area with predictive input and clickable list), Region (pop up with 5 choices if any), String (area with predictive input and clickable list) and three fields with Boolean choice if any: IDN, Community, Geographic, that are not exclusive. Then were added two search options: application status ("IE complete", "In IE" or "Withdrawn" where IE means Initial evaluation) and IE result ("pass" or "-") that permit to follow the selection

process in real time. The search answers can be displayed on several numbered pages and the total count of answers is written on the left bottom of the screen. Other fields are not searchable but are all sortable: Primary contact, Contact email (both alphanumeric strings), Application ID (formatted number), Application updates, Objections, GAC early warnings, String similarity and Public Interest Commitments (all Booleans). The latest field added is the Prioritization Number that shows the order of examination of the applications.

A lot of data can be interpreted by directly reading the table. But it's more comfortable to import the table in a spreadsheet.

Both fields with strings and their applicants are linked to download public portions of application. The Boolean fields concerning the IE process are linked to official documents related to the examination process of the applications.

The public portion of application is a rich form with 30 fields and some sub-fields. Five fields were the most useful for our analysis:

- ✓ *2. Address of the principal place of business*
- ✓ *8(b). State the specific national or other jursidiction* [sic] *that defines the type of entity identified in 8(a).*
- ✓ *9(a). Legal form of the Applicant*
- ✓ *9(b). If the applying entity is a subsidiary, provide the parent company*
- ✓ *11(c). Name(s) and position(s) of all shareholders holding at least 15% of shares*

They can be reached either manually (long) or by some scripts. Nevertheless, it's quite uneasy to extract from the form a valuable information: the technical operator of the registry. It may be either the applicant itself or an external partner.

Another site, *dot-nxt.com*, displays also the new TLDs applications, since mid-June 2012 [17]. They chose to display the back-end supplier as a visible and searchable column with a pop-up choice containing the 41 actors for that part, only two applications staying mute on that point. So it's easy to import also these data in one's spreadsheet.

C. Calculating the two ratios

The calculating part is also simple: a rule of three for the "engagement index".

For the secondary index, trying to see the concentration by place, its the ratio number of bids upon number of applicants. This ratio is approximate, because some actors used several companies for their bids. The links are not always obvious. The main capital links (parent company and shares above 15% were asked for in the ICANN's form. But one cannot know if the informations are complete and what could be sanctions in case it's forgotten or false.

The number of bids by applicant as they are displayed by ICANN was corrected only for the biggest subsets of applications. Nevertheless, it's a first approach. The actual concentration must be equal or higher. The advantage of this second index is to be neutral regarding to the population and the great variance of Internet penetration.

D. Difficult points

As we deal with a cross-border process and as some companies are already global actors, its sometimes uneasy to decide the "place" of a company, above all when the companies declared themselves in an against intuitive country. But, finally, only two real dilemmas stood up.

Afilias, a top class domain services provider, the second one after Verisign [5], is often cited as an Irish company. The site Afilias.info explains that the headquarters is located in Dublin and "*maintains administrative and operational offices in the U.S. near Philadelphia, PA*". Actually, Afilias USA Inc. was registered in Pennsylvania some days before Afilias Limited in Ireland [*cro.ie*], and it is filed in Delaware [*dos.state.pa.us*]. When the company hired a data analyst in Feb 2013 [simplyhired.com], it was in Montgomery, PA. So it reasonably may be counted as a US company in the scope of a data travels study, even if there is an Afilias group with a lot of entities.

Uniregistry Corp, created in 2012, applied for 54 TLDs. It's owned by Frank Schilling, a great domainer. He likes to show that he lives in the Cayman Islands in the real life. Beyond the unusual personal story of the manager [http://www.dnjournal.com/cover/2007/december.htm], the team described on the company's site [*http://uniregistry.com*] seems to be mostly outsourced in US and the back-end operator is ISC, a US actor. That's why it could be also reasonable to count Uniregistry Corp in the US.

Nevertheless, if one disagree with those both choices, the difference is not important: Europe could be increased with 85 applications without changing the main structure of the process described hereunder.

The aggregation of clusters is sometimes difficult because of the question of delegation. In each case, we evaluated whether the serial applicant was registering for himself or acting for clients. On one hand, it seems quite usual that, when acting for clients, the managers of the applications declared their clients as the applicants. On the other hand, serial applications often follow a unique pattern. In case of doubt, we were careful and didn't aggregate. So, even approximate, the result would not be exaggerated.

Neither the engagement index nor the concentration index permits to distinguish, in a location, the local companies and the foreign ones. Such observations were done case by case.

This paper must not be understood as suspicious or fearful towards the United States. We know that the history of innovations dig furrows. Institutions and structures are also heavy to move. We try to understand what sort of tools could help change and solve societal issues. In the namespace, we face a huge information gap. Now, only a few global companies probably can get these data — and surely the FBI and NSA in the Name of the Patriot Act [*aclu.org*] as the major part of the namespace are still managed by US companies.

III. THE ICANN'S CYBERGEOGRAPHY

The great day of the “Big Thing” was emblematic. At the moment when was released the list of candidate TLDs in London, widely broadcasted, all Arabic strings were posted written backwards on the big public screen.

Let’s note that the ICANN table uses the GB code for the United Kingdom while that code was abandoned in 2006 in favor of the UK.

We also observed some entry errors. *.broadway*, *.bway*, *.theatre* and *.theater*, filed by the Company GTLD Key Holding Inc. (based in New York and declared in the Delaware), were located with the code UA (Ukraine) instead of US. We therefore transferred these four candidates from Europe to the United States. ICANN's explanation was: the location inputs was operated online directly by the applicants. It was impossible to change them, because of the risks of trials. [interview with Stéphane Van Gelder, former GNSO chair, Feb. 2013, inter alia].

We can object that in database techniques, the input filters are very usual. And with a small database of 1930 records, an email exchange with the applicant in case of doubt could be imagined, in the sake of the quality of public information.

Nevertheless, the definition of the five great regions is built in the original database and unambiguously an ICANN's work. Usually, ICANN mapping of the world lies upon the 5 RIRs areas [19]. It's unclear why two great changes appear in the ICANN dataset, about the Middle East and the Caribbean Islands.

We show in the first column of Table I the distribution of the candidate as announced by ICANN [8].

Table 1: ICANN's display
Corrections applied in the categorization of the applications regarding to US-EU relations

Regions *A-H letters refer to the subtables hereunder*	**Strings counted by ICANN**	**After « area based »** corrections (a)	**After « tax based »** corrections in EU (b)
Africa *(D)*	**17**	17	**17**
Asia/Australia/Pacific *hereunder, split into: Asia (F) Australia (G] and Middle East (H]*	**303**	303	303 – 2 = **301**
Europe *(E)* *hereunder, 167 bids of Caribbean Islands located in Europe by ICANN are transferred into a separated group.*	**675**	675 – 4 –167 = 504	504 – 76 – 12 – 61 – 31 = **324**
Latin America/ Caribbean Islands *(A)*	**24**	24	**24**
North America *(B)* *(without US actors operating in Asia)*	**911**	911 + 4 + 167 = 1082	1082 + 2 + 76 + 12 + 61 +31 = **1264**

(a) 4 = the “Ukrainian from Broadway“ TLDs
167 : the "European Caribbean"
(b) 2: Cyprus, 76: Amazon Eu sarl, 12: Verisign sarl, 61: Famous Four Medias, 31: Afilias

The Middle East is usually attached to the European RIR, RIPE NCC, as well as Russia [19]. But here, ICANN attached it to Asia/Australia/Pacific group. One can imagine that the ICANN designers, according to a strictly territorial view, considered that Asia begins in Istanbul. This vision included Russia in Europe, but not Cyprus that was also attached to Asia without any consideration of that Cyprus is a member of the European Union and also under the management of the RIPE NCC.

Within a territorial and apolitical vision, often hostile to governments and states, that many ICANN actors have, one might wonder why Cayman Islands, British Virgin Islands and Bermuda are all located in Europe by the ICANN table and are not appearing in the ad hoc Caribbean Islands region. The only plausible justification could be that those islands are under British dependency. So a political criteria have been introduced here while it is evacuated elsewhere, for example for Cyprus. This decision is far from neutral since those three islands hold together 167 applications [table 5].

We therefore have to apply an initial correction to the ICANN provided table. A first "territorial" correction inspires to subtract those Caribbean applications from the numbers of Europe. The question is where could we locate those 167 applications? A closer view shows that they are actually held by United States companies. Moreover, these three Caribbean Islands are usually under the jurisdiction of ARIN, the North American RIR. So we could transfer them from Europe to a Caribbean account.

An analysis of Cyprus shows that beyond the issue with Cyprus being in Europe, the both Cypriot applications are also held by a U.S. company from the State of Indiana. So, in the table 1 (b), this application has been transferred from Asia to North American.

NB. In the hereunder other tables, only the 4 "Ukrainian" TLDs are reallocated to the US category. Other concerns with locations are solved by splitting the regions into several groups.

The table 1. col. b shows new ratios we shall obtain after analysis: US applicants bid for at least 1264 strings, that is 65,49% of the total. EU applications are 16,79%. Asia + Australia + Pacific all together gets almost the same ratio as EU: 15,6%. But Asia alone gets 10,10%, including US companies target there the Asian markets.

These figures are quite different from those announced by ICANN in London [8].

IV. The Revolution announced in June 2012

Of the 1930 candidates [8] announced in London in June 2012, only 17 were withdrawn at the date of mid-February 2013 [8]. This difference appears to be negligible for our investigation. Our analysis will therefore be based on the applications as they are publicized on the ICANN website since June 2012.

All the history of the Internet shows a significant commitment of United State based companies. This is confirmed in the table by a strong commitment index for US companies that can be considered as a benchmark. The overall world index of global engagement, counting only countries in which at least one candidate TLD was filed, is 0.4. Surprisingly, the index of the three Caribbean Islands is dramatically higher than USA index.

V. Strange engagements

The table 2 summarizes the global engagement indexes for each region.

Table 2: Regional indexes of engagement
in ICANN's process, based on ICANN 2012 figures

A. Latin America/Caribbean Islands	0,1386
B. North America	**2,6217**
C. Caribbean Islands placed in Europe by ICANN	1136,4719
D. Africa	0,0013
E. Europe, Russia included	0,8835
F. Asia	0,0658
G. Australia/Pacific	1,5717
H. Middle East	0,4151
World	**0,4413**

Now let’s observe with more details each one of the above regions. All indices higher than the US index need more scrutiny. We draw a thick horizontal line separating the locations into two sets: lower than the US benchmark index — that is 2,8 — and, if any, equal to or greater than it.

We can observe strange aggregations.

A. *Latin America*

Table 3: Latin America
based on ICANN 2012 figures
NB. Act. is for enterprises

Code	TLDs	Act.	Country	Index	Population
BR	11	10	Brazil	2,6829	4 100 000
UY	6	2	Uruguay	1,8080	3 318 535
PA	3	1	Panama	0,7317	4 100 000
MX	3	1	Mexico	0,0260	115 296 767
CO	1	1	Colombia	0,0216	46 366 364
Total	**24**	**15**	**LAT. AM.**	0,1386	**173 181 666**

In Latin America, Brazil is leading. Its Internet policy is known to be very dynamic. It is noteworthy that Brazil voted for the World Telecom treaty in Dubai [25]. So this ICANN commitment should not be interpreted as an alignment with the United States in Internet governance.

In Uruguay, the US company FairWinds Partners won contracts with the great travel group Despegar for 5 bids. Uruguay is a tax haven within Mercosur.

The table shows that three US actors successful promoted the new TLDs program: Gretchen Olive (CSI info), Joshua Bourne (FairWinds Partners) and John Kane (Afilias) made together the third part of the applications. Centralnic, an atypical and pioneer global registry acting from London, United Kingdom, holds 3 bids (bar, cafe, rest).

Other South American countries observe the processes. Peru joined Brazil in the opposition [10] expressed against the bid of the company Amazon for the string *.amazon* which is also the name of their common river. Argentina opposed [10] the deposit of the TLD *.patagonia* by the company Patagonia Inc., proprietor of the sportswear mark with the same name.

B. *North America*

Table 4: North America
based on ICANN 2012 figures

Code	TLDs	Act.	Country	Index	Population
US	888	288	USA	2,8143	315 527 000
CA	27	14	Canada	0,8065	33 476 688
Total	**915**	**302**	**NORTH AM.**	**2,6217**	**349 003 688**
US: 594 applicants => 288 actors					

594 different applicants (adding Broadway theater) appear for the United States. We left the applications counted as different when they are borne by one company in portfolios (ex. Minds+Machines, WhatBox? etc.) or when the manager of the application apparently represents clients (ex. 65 bids borne by Gretchen Olive of CSC, 91 by Josh Bourne or Philip Lodico of FairWinds Partners). Only Donuts, who created 307 serial companies, will be counted for one.

So the 594 different applicants become 288 actors in US.

Let's note also that North America doesn't appear to be a destination for non-American investors.

The total commitment index of the United States stood at 2.8, based on the raw data table ICANN (except for 4 TLDs "Ukrainian" from Broadway). Reincorporating in the "escaped" from Table 1, the total US index could amount up to 4.

A major phenomenon in the United States is the location of high tech companies in tax havens as the Delaware state. So it was a mandatory verification here, to get the location at least of the major registrants in the U.S. It requires to open one application folder for each applicant and read the 8(b) field in the form. Google: 101 strings, Delaware. Donuts: 307 strings, Delaware. CSC: 90 strings, Delaware.

C. *Caribbean Island*

Table 5: Caribbean Island placed in Europe
based on ICANN 2012 figures

Code	TLDs		Country	Index	Population
KY	91	5	Cayman Islands	1 658,2237	54 878
VG	72	2	British Virgin Islands	2 589,9281	27 800
BM	4	1	Bermuda	62,2394	64 268
Total	**167**	**8**	**CARIBBEANS**	**1 136,4719**	**146 946**
VG: 3 applicants => 2 actors					

Those three islands form a strange "Bermuda Triangle" around Cuba, embargoed United States and connected to the Internet thanks to Venezuela [15].

Three major registrants:

Top Level Domain Holdings-Minds+Machines: 80 bids, VG.

Uniregistry, 54 bids, KY.

Afilias, has 3 applications in Cayman Islands.

United TLD, subsidiary of Demand Media (NYSE), 80 bids, KY

Let's note the presence of the Chinese group Alibaba with 4 bids located in Cayman Islands.

Zodiac Holdings Limited, also, holds 4 bids in KY. It's a domain portfolio company created by James Seng, the inventor of IDN, and Eugene Li, the former Deputy Director of China Network Information Center (CNNIC).

The 4 bids in Bermuda are for Vistaprint, the famous innovative printer created in France by Robert Keane.

In the VG, there are actually 2 actors, as Minds+ Machines holds two companies there.

At the first glance, it's uneasy to find any local actor, except Frank Schilling who is living now in KY (see hereabove, in Difficult points). It's an important point, because it's often argued that offshore localizations benefit the local populations. So the point deserves more observations.

D. *Africa*

Table 6: Africa
based on ICANN 2012 figures

Code	TLDs	Act.	Country	Index	Population
MU	1	1	Mauritius	0,0077	1 291 456
GM	1	1	The Gambia	0,0056	1 782 893
ZA	13	5	South Africa	0,0025	51 770 560
EG	2	1	Egypt	0,0003	79 602 000
Total	**17**	**8**	**AFRICA**	**0,0013**	**134 446 909**

A big struggle fired between two registrants for *.africa*, the manager of ZA registry, a South African attorney expert in domains dispute resolution and an Ethiopian-Californian ICT expert (MU), ICT business woman in California and a very active member of several ICANN groups. [*icannwiki.com*] An early warning of the African Union Commission showed a support for the former.

A notable point is the absence of Northern Africa, where Internet is quite present: Morocco (51% of Internet users), Tunisia (39.1%) [12].

In Egypt, both bids come from the League of Arab States.

In South Africa, Gretchen Olive of CSC won commercial results with 9 bids for 4 clients.

E. *Europe*

Two engineering French researchers at INRIA, Stéphane Grumbach and Stéphane Frénot published an opinion paper in the journal *Le Monde*, on the Jan. 13rd 2013, about big data. [27] This op ed is based upon their research. They mention that US and China have their data exploited by their national industries. At the contrary, Europe is widely open and European are exploited by US companies.

Table 7: Europe based on ICANN 2012 figures					
Code	**TLDs**	**Act.**	**Country**	**Index**	**Population**
VA	*4*	*1*	*Vatican City*	*4 784,6890*	*836*
GI	62	2	Gibraltar	2 083,8935	29 752
LU	85	8	Luxembourg	161,9501	524 853
LI	3	1	Liechtenstein	82,6879	36 281
MC	1	1	Monaco	27,4944	36 371
IM	1	1	Isle of Man	11,8127	84 655
CH	51	21	Switzerland	6,3750	8 000 000
IE	36	8	Ireland	5,6258	6 399 115
DK	10	7	Denmark	1,7920	5 580 413
SE	11	9	Sweden	1,1530	9 540 065
NL	19	15	Netherlands	1,1342	16 751 323
FI	5	4	Finland	0,9222	5 421 827
DE	**70**	**49**	**Germany**	**0,8557**	**81 799 600**
FR	54	37	France	0,8263	65 350 000
UK-GB	40	26	Un. Kingdom	0,6331	63 181 775
NO	3	2	Norway	0,5960	5 033 675
AT	3	3	Austria	0,3565	8 414 638
ES	15	12	Spain	0,3174	47 265 321
BE	3	2	Belgium	0,2717	11 041 266
IT	16	7	Italy	0,2631	60 813 326
PT	2	2	Portugal	0,1890	10 581 949
CZ	1	1	Czech Rep.	0,0951	10 513 209
GR	1	1	Greece	0,0925	10 815 197
RU	8	7	Russia	0,0558	143 300 000
Total	**504**	**227**	**EUROPE**	**0,8835**	**570 479 076**
IT: 2 Fiat comp => 1, GI: 62 => 2, DE: Afilias 6 bids => 2					

On November 2012, the European Commission wrote to ICANN an Interim position saying that it "*does not consider itself legally bound to the processes*".

The German index is interesting because it is a country that has withstood the quite pervasive ASCII naming. The *.de* is the second TLDs for the number of domain names registered, after *.com* and it's the first ccTLDs. The German index may be a good European benchmark.

In the Vatican City (VA), the Pontificium Consilium de Comunicationibus Socialibus (PCCS) follows a development policy of the Catholic community whose presence on all continents has been attested for a long time. They bid for *.catholic* and the equivalent in Arabic, Chinese, and Cyrillic. The Saudi Communication and Information Technology Commission objected that the PCCS should not monopoly the Catholic name in the whole world.

The VA index is exceptionally high because the population is rare. Tax avoidance doesn't seem to be a relevant subject here. For the other locations with high indexes, Gibraltar, Luxembourg, Liechtenstein, Monaco, Isle of Man, Switzerland and Ireland, the tax aspect may be a hypothesis deserving further observation.

Ireland can be considered as a great aircraft carrier and tax low cost for US high tech companies targeting the European markets.

The Netherlands are famous with the "Dutch sandwich", a tax transit facility.

An Amazon subsidiary is located in Luxembourg for 80 TLDs. 60 strings in Gibraltar are filed by Famous Four Media with 60 new ad hoc companies.

Switzerland is often considered as a safe harbor as well as an advanced base for worldwide operations in an International City. Verisign, the worldwide greatest cybersecurity US company, located there a new subsidiary, Verisign sarl, for 12 strings, .com and .net in several scripts.

Other high index countries, higher than Germany, are the Northern Europe countries through which Internet connections with US came to Europe.

Afilias bids for LLC, LLP, LTD, SARL, SRL (with 5 new companies) and Web in Germany.

Other highly engaged actors in Europe are the luxury group Richemont, 14 bids, CH (Cartier, Montblanc, Piaget etc.), l'Oréal, 14 bids, FR (Lancome, Garnier, hair etc.), IG Group, the worldwide financial services Londonian company, 7 bids, GB, the Guardian media group, 5 bids, GB (Guardian, Observer etc.) and the Fiat group, 10 bids with 2 enterprises, IT (Lancia, Maserati, Alfaromeo etc.). The Saudi Olayan Group is the unique actor in Liechtenstein, backed by the Austrian AusRegistry.

Russia has some candidates. But the *.ru* is quite popular in Russia [5] and the government has some projects for a more "Russian Internet" as it still opposes to ICANN as one could see in Dubai WCIT-12 meeting [25]. The Russian language and the Cyrillic script are strong cultural links for the Russian community and it's a political power. A few actors try to enter the Cyrillic area with Cyrillic transcriptions of ASCII strings: Vatican (*.catholic*), Verisign (*.com*), PIR (*.org*) and CORE Association (*.online*).

F. Asia

Table 8: Asia based on ICANN 2012 figures					
Code	**TLDs**		**Country**	**Index**	**Population**
HK	42	24	Hong Kong	5,9480	7 061 200
SG	5	4	Singapore	0,9412	5 312 400
JP	71	19	Japan	0,5606	126 659 683
TW	4	4	Taiwan	0,1716	23 315 822
MY	3	3	Malaysia	0,1059	28 334 135
KR	5	4	South Korea	0,1000	50 004 441
CN	41	25	China	0,0303	1 353 821 000
TH	2	2	Thailand	0,0300	66 720 153
IN	21	17	India	0,0174	1 210 193 422
PH	1	1	Philippines	0,0108	92 337 852
Total	**195**	**103**	**ASIA**	**0,0658**	**2 963 760 108**

Japan, an ally of the historical development of the Internet and host of the W3C, with 71 candidates, has a quite mediocre index: 0.56. Here also, the Japanese language and culture creates strong community feelings. Google, Amazon and Verisign target the Japanese market in katakana.

China (0.03) takes some positions, a little less than Russia (0.05). But they both openly disagree with this system of naming and governance and they are allies in the Shanghai Cooperation Organization (SCO, *sectsco.org*). China also has a Chinese Internet independent of ICANN.

The phenomenon to be observed here will be the relations in the Chinese language area, for example, between mainland China, Hong Kong, Singapore and Taiwan.

The major Chinese actors in Asia are Zodiac Corp (4 bids in CN, 5 in HK), who is also in Cayman Islands, HiChina a leading Internet services provider, subsidiary of Alabama, often partner with Afilias, Qihoo 360 (4 bids, CN), an Internet and mobile provider of security products and services, the Kuok Group, great actor in Asian hotels (6 bids with Kerry Trading and 5 bids with Shangri-La in HK), and Edmon Chung, the founding CEO of *.asia* (9 bids for his own or for clients, HK).

Hong Kong and Singapore are both listed as tax havens.
Some non-Chinese actors targets China market: the only IDN candidate held by a Japanese company is Bridgestone written in han script. Main others are the Richemont group (*.jewelry* and *.watches*), Wal-Mart, Amazon, Afilias, Donuts, Verisign, PIR, Volkswagen and the Vatican.
Let's note that Verisign bids for both *.com* and *.net* in hangul targeting the Korean market.

India (0.01) does not seem to feel at ease in the ICANN system. Indian actors limited their bids: 3 for Reliance Group, 2 for the State Bank of India, 2 for the Tata Group, 2 for Infosys. Radix registry, the major Indian registrar, holds only 1 bid in India (*.ping*) but 25 in United Arab Emirates (see hereunder).
Only two global actors try to enter the hindi area: Verisign and the PIR, with *.com* and *.org* written in devanagari.

G. Australia/Pacific

Table 9: Australia/Pacific
based on ICANN 2012 figures

Code	TLDs		Country	Index	Population
AU	41	34	Australia	1,7898	22 907 678
NZ	2	2	New Zealand	0,4493	4 451 017
Total	**43**	**36**	**OCEANIA**	**1,5717**	**27 358 695**

In the Australia and New Zealand, not any actor invested massively, the maximum number of bids seems to be 3: Commonwealth Bank of Australia, iSelect Limited (*.compare*, *iselect*, *.select*), 2 bids is met thrice: Motion Picture Domain Registry (*.film*, *.movie*), National Australia Bank Limited. and Open Universities Australia (*courses*, *study*).

Let's note one bid in Arabic script (meaning *.network)*, held by an affiliate of AusRegistry Group. The group hosts the Omani registry (*.om*) [see *iana.org*] and runs as the technical operator of the 3 bids of the Saudi conglomerate of the Olayan family in Lichtenstein.

H. *Middle East*

Table 10: Middle East
based on ICANN 2012 figures

Code	TLDs	Act.	Country	Index	Population
AE	36	5	United Arab Emirates	4,3562	8 264 070
QA	5	2	Qatar	2,6268	1 903 447
BH	3	2	Bahrain	2,4300	1 234 571
CY	***2***	***2***	***Cyprus***	*1,8193*	***1 099 341***
KW	2	1	Kuwait	0,7097	2 818 042
SA	5	2	Saudi Arabia	0,1884	26 534 504
TR	10	2	Turkey	0,1322	75 627 384
IL	1	1	Israel	0,1253	7 980 900
IQ	1	1	Iraq	0,0321	31 129 225
Total	**65**	**18**	**MIDDLE EAST**	0,4151	**156 591 484**
AE: 34 companies => 5 actors					

The major event here is the great investment in the Emirates from the Indian registry operator Radix, subsidiary of Directi Group: 36 strings in ASCII, with a new company for each one. Directi is a global Indian domain company, leader in India. The others applicants are Abu Dhabi Systems and Information Centre (2 bids), Dubai eGovernment Department (1 bid), Emirates Telecommunications Corporation (trading as Etisalat) (2 bids) and MTN Dubai Limited (1 bid).

In Qatar, two actors, Qatar Telecom (Qtel), technically backed upon CentralNic (4 bids) and the The Supreme Council of Information and Communication Technology “ictQATAR”, operated by Afilias.

In Bahrain, the Belgian company Sedari operates for the interconnection cables company GCCIX (1 bid). The Bahraini company GreenTech Consultancy runs for 2 bids *.mobily* in ASCII and in Arabic. Bahrain is listed as a tax haven.

Asia Green IT System (AgitSys), located in Turkey, tries to get 8 strings (*.halal*, *.islam*, *.nowruz*, *.persiangulf* etc.). Some people objected.

An interesting phenomena will be interesting to observe: the transformative power of Internet acting in some countries of the Arabic peninsula, where small minorities lead great populations, are tempted to modernize the country with Internet and try to find alternative resources to oil.

In Cyprus, Constantinos Roussos, a US domain small investor, runs for *.home* and *.music*.

The Kuwait Finance House runs for 2 strings, their acronym KFT in ASCII and in Arabic script, backed upon CentralNic.

CentralNic and Afilias are the two technical operators in Saudi Arabia: the former for the 4 bids of Saudi Telecom Company (all in ASCII) and the later for Suhub Electronic Establishment (*.site* in Arabic script).
In Iraqui, the only one bid is for *.krd*, held by KRG Department of Information Technology, an Information Technology agency in the Kurdistan Regional Government of Iraq. The mission of "*the .krd TLD is to promote the Kurdistan region of Iraq and elevate the people of Kurdistan onto the international stage*".

The abstention of Israel, very high Internet skilled, is astonishing, maybe related to the hard cyberwar in the region [*aljazeera.com*, tags cyber-war, Israel]. Only Verisign bid for *.com* in Hebrew script.

VI. Global observations

Let's now sum up our findings about actors.

Table 11: Global figures
based on ICANN 2012 figures

NB. compared to ICANN's table cf. Table 1):
- 4 Broadway bids are transferred from EU to US
- "European Caribbean Islands" are separated from EU
- Asia is split into 3 areas: Oceania, Middle East, Asia

	Engagement	Bids	Actors	Concentration
B. North America	**2,6217**	**915**	**302**	**3,03**
C. Caribbean Islands placed in Europe	1136,4719	167	8	20,88
E. Europe, Russia included	0,8835	504	227	2,22
(total so called Europe)		*671*	*235*	
G. Australia/Pacific	1,5717	43	36	1,19
H. Middle East	0,4151	65	18	3,50
F. Asia	0,0658	195	103	1,89
(total so called Asia)		*303*	*157*	
A. Latin America /Caribbean Islands	0,1386	24	15	1,60
D. Africa	0,0013	17	8	2,13
World	**0,4413**		717	

After analysis, in Table 1, column (b), it seems appropriate to put in the account of the United States series of applications from U.S. companies registered in Europe, possibly for tax reasons: Gibraltar, Luxembourg, Switzerland. We cannot find

anything as massive in another regions. Europe seems to have some weakness here widely exploited by aggressive commercial US companies.

After tax corrections, the promised global Revolution is more than for a half a U.S. Revolution: 64% of candidates TLDs must be added to the existing U.S. TLDs.

We must add also to that landscape a big offensive in terms of registry back-end operators for third parties: Neustar for 344 TLDs, Demand Media for 329 TLDs via a European subsidiary, Verisign for 250 TLDs, Minds + Machines and ISC (Internet Systems Consortium).

The German KSregistry (26 TLDs) and AFNIC (18 TLDs) were able to sell their good skills. The techniques for registry operations are therefore present in Europe.

Overall, we can classify the states into three groups:

Those whose commitment index is higher than the U.S. index: Vatican City, British Virgin Islands, Gibraltar, Cayman Islands, Luxembourg, Liechtenstein, Bermuda, Isle of Man, Switzerland, Hong Kong, Ireland, United Arab Emirates. The Vatican City aside, these countries where chosen as legal locations by U.S. great companies (like Amazon in Luxembourg) and TLDs brokers, a new profession which may be developed as it did for the second-level domains.

The second group could be the countries noted between the indices of the U.S. and Germany. There are Brazil, Qatar, Bahrain, Cyprus, Uruguay, Denmark, Australia, Netherlands, Sweden, Singapore, Finland.

We can find Australia (it's unclear if it could exist a link with the statute of a historic ally of the USA in the UKUSA treaty, 1956, [23]), historical places of the expansion of the Internet (Northern Europe) and emerging countries whose Internet strategies are well asserted (Brazil, Singapore, Qatar and Bahrain).

The third group, a great number of states, can be described as a group of skeptics. They are not all poor countries. In a great majority of countries of the third group, the reason of their weak engagement seems to be neither a lack of skills nor a lack of money. And the most active US companies were not very interested by those countries: New Zealand, Canada, Norway, Belgium etc.

Let's also consider the "no group", the absent. The poor countries, with the OECD meaning, are not present at all: 2,6 billion people are so far removed from this "Revolution" that not even one domain name has been proposed in their country.

VII. Conclusions

Regarding to the objectives of the Reform — public interest, fair distribution, diversity and trust — one may be doubtful.

The allocation of global monopolies for the use of names of common language is a recurring criticism expressed in the public comments, and by voices from the Government Advisory Committee [GAC] : *Restricting common generic strings for the exclusive use of a single entity could have unintended consequences, including a negative impact on competition*. [8, ex. in Australia EW about several strings, see *.hoteles*]

Some strings, without being well formed names strictly speaking, have nevertheless identifiable semantic content, for example *.bio* or *.archi*. Their semantics are precisely the reason for filing them as candidate TLDs. Without very specific commitments, they may be risky regarding to consumer protection. This is also a point expressed by France [10].

Great brands might seem legitimate, at first glance, for becoming TLDs. But first, some of them are names of common language or acronyms that were not originally protectable by trademark laws. Their existence is already a drift. Why Apple could confiscate the word *apple*, to the detriment of apple growers and cider manufacturers all around the world? Moreover, a global monopoly on certain brands creates a worldclass brands that may almost oblige other brands to defensive TLDs deposits. This drift, quasi rackets, was widely denounced even by the U.S. Department of Commerce, restless recalling that companies must not be obliged to expensive defensive registrations [20].

The public interest is also threatened by the fact that many applicants are expected to use their TLD for their own needs, without opening the possibility to reserve second-level names and therefore without enriching the registrars market. The incompatibility registrar-registry was recently abolished, paving the way for name captures or vertical integrations and data collections.

In terms of distribution, we see professional depositors try to capture dozens, even hundreds of TLDs (307 deposits Donuts, founded by the CEO of eNom, the second top registrar [2]). It is doubtful that a great care can be provided simultaneously to so many TLDs with numerous clients. Some brokers created as many companies as the strings they bid, one llc for each string, all in a tax haven. Companies that are exposed, they, with their names, do not have this escape from responsibilities. This looks like competition distortion. These operations show a high risk to see reproduced the speculative mechanisms observed in the second-level domains markets. Here, its worst, because the level his higher in the naming hierarchy.

In another style, the companies Google and Amazon are competing about many strings. They bid respectively 101 and 76 candidate TLDs. Both will have new temptations to abuse of dominant position if they get those tools of vertical integration.

Trust in naming, as well as public interest, seem hardly compatible with companies who behave as wholesalers or brokers and escape taxes. A large number of US candidates (Google, Donuts, CSC) are declared in the State of Delaware, also well known for its low taxes and information secrecy.

At least 870 applications were registered in tax havens by only 10 companies.

116 new TLDs were expressed in IDNs. But this represents only 6% of the total. And of these, half are Western entities who go to attack distant markets, such as Verisign inc. who candidates for the *.com* and *.net* written in 12 different scripts.

U.S. companies preempted ¾ of the new cyberspace, including a great part of IDNs.

The magazine *.Nxt* titled on the 20th June 2012, "*A Very American Revolution*" [17] Finally, in terms of cultural and linguistic diversity, and in term of international balance, the change is not so obvious in spite of a great expansion of the namespace.

The naming seems to suffer from two original design errors. As detailed in the *Towards a Future Internet Report* [22] Internet was influenced by the technical community in its first age. And then, for the current period, major Internet commercial players became the strongest influencers. The technical community had a lot of difficulties to consider some linguistic aspects of domain names.

Some IDNAbis discussions can illustrate it: "*Domain names are names, but they're not names in any language except "the Internet". They "use words" in the same sense that companies use words when naming their products (tell me: was "Pepsi" a word before the cola company used it? What about "Viagra" before the little blue pill was invented?) They are not words in any language, they never were, and they've never obeyed the spelling rules of any natural language on Earth.*"[21]

Since 1998, under the direction of a mainly self-regulatory regime headed by ICANN came a purely commercial vision, where everything, including words of languages, can be sold either to the first in (rush) or to the highest bidder (the second auction market).

This approach has led to gross negligence in the management of the organization, beset by conflicts of interest. We understand that the technical and procedural aspects of the operation of naming cause difficulties to recruit directors outside of the professionals. But the confined aspect of the group, its secrets and its Western folklore does not give much of a serious image capable of seducing the world.

It is unclear how the recruitment as the new ICANN CEO of an outstanding manager, Fadi Chehadé, with true multicultural skills and mind and the best will in the world, could reverse the logic embodied in the policy of ICANN since its inception, rooted in the economic environment that supports it and already engaged in a program for more than seven years. It could be very hard to resist hungry companies who paid 185 K$ each application and that are surrounded by trial consulting groups. The great challenge may be in the manner of taking a real shift towards a multicultural and diverse Internet through real cooperation with diverse regions in the world.

An example already exists in the cyberspace. In matter of Internet of things, the naming space, ruled by an Object Naming Service, is being structured upon a multiple root system organizing the worldwide cooperation [1]. The moment perhaps came for the exploration of a real Big Thing in ICANN affairs.

REFERENCES

[1] Balakrichenan S. , Kin-Foo A., Souissi M., WINGS 2009, *Experimental Evaluation of a Proposed Federated Object Naming Service Architecture*
http://cse.stfx.ca/~iThings2011/sub//CheckPaper.php?idPaper=154&password=693ab2

[2] Directi, *Top Global ICANN accredited registrars*, 2013
http://www.webhosting.info/registrars/top-registrars/global/

[3] doc.gov, *DNS Current Process Flow Diagram*, 2011
http://www.ntia.doc.gov/legacy/DNS/CurrentProcessFlow.pdf
in *Federal Register* Volume 76, Number 38 (Friday, February 25, 2011)] [Notices] [Pages 10569-10571] From the Federal Register Online]
http://www.gpo.gov/fdsys/pkg/FR-2011-02-25/html/2011-4240.htm

[4] DOC-ICANN: *Affirmation of commitments*, 2009
http://www.icann.org/en/news/announcements/announcement-30sep09-en.htm

[5] Domaines info, *Worldwide TLDs stats*, Feb. 2012
http://www.domainesinfo.fr/statistiques.php

[6] Dürst, Martin J., *Internationalizing Domain Names in Applications (IDNA*), IETF Draft 3940, Internet Engineering Task Force (IETF), 2003

[7] Falstrom P., Hoffman P. Costello A., March 2003, *Internationalizing Domain Names in Applications (IDNA)*, IETF Draft 3940

[8] ICANN, *New GTLD current application status*, June 2012
http://gtldresult.icann.org/application-result/applicationstatus/viewstat
and London announcement
http://www.icann.org/en/news/announcements/announcement-13jun12-en.htm

[9] ICANN, *2010 Report*
http://www.icann.org/en/about/annual-report/annual-report-2010-en.pdf

[10]ICANN GAC, *New TLDs Early warnings*, 2013
https://gacweb.icann.org/display/gacweb/GAC+Early+Warnings

[11] ICANN - Verisign: *.com registry agreement*
http://www.icann.org/en/about/agreements/registries/com

[12] Internet World Stats: *Africa*
http://www.internetworldstats.com/stats1.ht

[13] Klensin, John, January, 6, 2010
International Domain Names in Application (IDNA): Protocol, IETF IDNAbis WG, 2008
http://tools.ietf.org/html/draft-ietf-idnabis-protocol-18

[14] Mandel Michael, *Beyond Goods and Services: The (Unmeasured) Rise of the Data-Driven Economy*, October 2012, http://www.progressivepolicy.org/2012/10/beyond-goods-and-services-the-unmeasured-rise-of-the-data-driven-economy/

[15] Mendes-Franco, Janine, *Cuba, USA: Blogger Perspectives on the Embargo's 50th Anniversary*, Feb. 2012
http://globalvoicesonline.org/2012/02/29/cuba-u-s-a-blogger-perspectives-on-the-embargos-50th-anniversary-part-1/

[16] Mueller Milton, *Ruling the Root: Internet governance and the taming of cyberspace*, MIT Press, July 2002

[17] *Nxt*: the 1930 TLDs: http://news.dot-nxt.com/gtld/all
and
an analysis, June 21st 2012, *A Very American Revolution*
http://news.dot-nxt.com/2012/06/21/very-american-revolution

[18] OECD (2013), *Addressing Base Erosion and Profit Shifting*, OECD Publishing,
http://dx.doi.org/10.1787/9789264192744-en

[19] RIPE, *The RIR system*,
http://www.ripe.net/internet-coordination/internet-governance/internet-technical-community/the-rir-system

[20] Strickling Lawrence, NTIA, letter to ICANN, Oct. 2012
http://www.icann.org/en/news/correspondence/strickling-to-crocker-04oct12-en

[21] Sullivan, Andrew, Forum IDNAbis, Sep 24 2009.
http://www.alvestrand.no/pipermail/idna-update/2009-September/005543.html

[22] *Towards a Future Internet*, Final Report, p.10
http://cordis.europa.eu/fp7/ict/fire/docs/**tafi**-final-report_en.pdf

[23] UKUSA: Australia's participation
http://www.defence.gov.au/minister/90tpl.cfm?CurrentId=10513

[24] Vitali Stefania, Glattfelder James B., Battiston Stefano, *The Network of global corporate control*, ETH Zurich, Sept 2011
http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0025995

[25] WCIT-12, votes on the ITU site
http://www.itu.int/osg/wcit-12/highlights/signatories.html

[26] ABOUT TAX AVOIDANCE: generic reference for the whole paper:
Gravelle Jane G., *Tax Havens: International Tax Avoidance and Evasion* Jane G. January 23, 2013, Congressional Research Service,
http://www.fas.org/sgp/crs/misc/R40623.pdf

[27] ABOUT DATA: Grumbach Stéphane, Frénot Stéphane, *Les données, puissance du futur*, Le Monde, Jan. 13rd 2013
http://www.lemonde.fr/idees/article/2013/01/07/les-donnees-puissance-du-futur_1813693_3232.html

~ ~ ~

From Economics and Game Theory to understanding Network Science

Chaired by Jonathan Cave, University of Warwick

" Internet Attractors and Repellors: the Role of Asymmetry and Trust in Explaining Connectivity Cycles"

Alessio D'Ignazio, Bank of Italy

Emanuele Giovannetti, IIMP, Anglia Ruskin University, Cambridge UK

Abstract

Recent studies on the evolution of the Internet found evidence of cycles in connectivity between operators. In this paper, we use a repeated game setting to explain these cycles as resulting from the imperfect ability of Internet connectivity Providers to monitor their Customers' actions. In equilibrium Providers introduce temporary spells of disconnection, to reduce their Customers' incentives to free ride on connectivity. We estimate two econometric models focussing both on the probability and on the length of these punishment phases, both necessary elements to ensure that connectivity, although discontinuously, remains a feature of the Internet ecosystem. We find that asymmetry between Customer and Providers, shaping the Customers' period incentives to deviate, and the history of past connectivity, affecting mutual trust and information asymmetries, are the main factors in determining both the length and the probability of the occurrence of the disconnection phases and, consequently, the evolution of the Internet connectivity.

1. INTRODUCTION

The early debate on the evolution of the Internet focussed on the choice of appropriate metrics to synthesize and represent it (Vespignani and Satorras 2004). Interestingly, the technical analysis of the topological structures of the Internet has often led to relevant, though sometime implicit, economic questions. These questions emerged, from otherwise mainly physical analyses, as the Internet is the resulting configuration of an enormous number of micro-business decisions on whether to establish bilateral interconnections between independent providers, and these decisions shape the evolution and future morphology of the Internet ecosystem.

Following a seminal contribution by Gao (2000), the focus on Internet metrics extended to their semantic interpretation in terms of their commercial nature. The main idea is that as ISPs' commercial bilateral relationships determine their policies for routing traffic, these policies can be inferred back through the *imprint* left in the routes advertised between Internet Service Providers (ISPs). The economic nature of these inferences is very important, as the interpretation of the underlying commercial relations is derived from the properties of paths that minimise techno-economic costs. Gao (2000) classified four types of business relationships: Customer-Provider, Provider-Customer, Peer-Peer, and Sibling. D'Ignazio and Giovannetti (2006a) used these inferred relations in an antitrust framework, measuring the extent of market power in the Internet upstream access in Europe and capturing the presence of *essential facilities*, often the root cause of Market power, through the *degree of unavoidability* of Autonomous System (AS). D'Ignazio and Giovannetti (2009) used these connectivity data to investigate whether asymmetry between a pair of providers may explain interconnection quality degradation.From a theoretical perspective, the economic literature has produced increasingly sophisticated models focussing on the incentives to interconnect in the Internet. The actual interconnection regime between a pair of operators is usually analysed as the result of a strategic game capturing both a relationship of complementarity (each network must be able to access each other in order to assure the Internet universal connectivity) and competitiveness (they compete over downstream customers). These two opposite forces shape the complex incentives to interconnect. Different *game theoretical* models provide contrasting answers to these trade-offs[1] motivating the need for more empirical research. Recent empirical evidence presented by Dhamdhere and Dovrolis (2011) focussed on the analysis of "rewiring" activity, as it is captured in the Border Gateway Protocol (BGP) data on Internet connectivity. *Rewiring* is measured by these authors, by taking successive *snapshots* of existing *Customer to Provider* links, recording both births and deaths of these links and their possible change of business relation.

This evidence shows that the largest number of new links, defined as *births*, is associated with existing providers rewiring activity, i.e. with a change of the nature of their previous economic relation. The authors also found that some large transit providers act as *"attractors"* or *"repellers"* of customers, where the *attractiveness* of a provider is calculated as the fraction of newly established *Customer to Provider* links appearing in a new connectivity *snapshot,* while its *repulsiveness* is given by the fraction of *Customer to Provider* links that disappeared in the new connectivity *snapshot.* Dhamdhere and Dovrolis (2011) also showed that, for many providers, strong attractiveness precedes strong repulsiveness by 3-9 months. Hence, *connectivity* seems to be characterised by intermitting cycles of *wiring* and *dewiring activities*. Inter-AS links, captured in the different *snapshots* of the Internet topology, transfer both traffic and economic value. Alternative link typologies are characterised by different combinations of the *benefits of complementarity* and *risks of free riding*, however, given the instantaneous nature of traffic exchanges and their dynamic routing features, monitoring the implicit or explicit exchange contracts can be difficult. This paper interprets the evidence on rewiring frequencies and on the alternating *attractor/ repellent* role played by major providers, from a *repeated games* perspective. In particular, we focus on results derived in the literature on *price wars*, whereby

spells characterised by the breaking of implicitly cooperative agreements, alternate with periods of implicit collusion. The main point of these results shows the necessity of these alternating patterns of cooperation and punishment to sustain collusion among competitors when their actions are private information because of imperfect monitoring[2]. According to this literature, intermitting price wars emerge as the equilibrium outcome of strategy profiles, explicitly including temporary punishments to deter deviations from an otherwise cooperative strategy[3]. After describing the model we focus on its main testable implications, analysing them in relation to the connectivity data collected from Caida[4], a database of more than twelve years of observations on Provider Customer relations, discussed in Dhamdhere and Dovrolis (2011). In particular, we estimate an econometric model, focussing on the determinants of the length of the punishment phases and on the probability of their occurrence, both necessary features to ensure that connectivity, although discontinuously, remains a feature along the equilibrium path of the repeated connectivity game. We assess the role played by two main explanatory variables: the asymmetry in market shares, between Customer and Providers, shaping their period incentives to deviate, and the history of past connectivity, affecting trust and the information asymmetries. We find that these two variables are the main factors in determining the length and occurrence of the Repellence phases and the overall evolution of the Internet ecosystem connectivity. The remainder of the paper is organised as follows, Section two introduces a static model of connectivity, Section three discusses the repeated game focussing on the equilibrium strategy under asymmetric information that leads to the emergence of connectivity wars. Section four introduces an econometric model focussing on the main determinants of these connectivity wars. Finally, Section fives concludes the paper.

2. A SIMPLE CONNECTIVITY MODEL

Consider two different types of ASes, a *Provider* (P) of Internet connectivity and its *Customer* (C). We focus on the *Provider-Customer* (PC) relations, again following GAO's classification as used in the empirical analysis of Dhamdhere and Dovrolis (2011). P has two available actions deciding whether or not to sell C direct access to its networks. While C decides whether to *free-ride* by abusing the contractual terms of this access. The strategy space, of the component game played by P and C, is chosen to focus specifically on interconnection decisions. As discussed in the early peering literature, decisions on interconnection provide plenty of opportunities for free riding as there are many ways in which *Moral hazard,* due to informational problems, may arise between ASes. PC *agreements* can be abused, for example when the customer uses more capacity than agreed in advance, or if it accesses the provider's network at a specific convenient point, a techniques known as *hot potato routing*[5]. These abuses often lead to *business stealing* of, other, final customers of P by C, or may induce extra *costs,* for P, due to increased congestion of its network, or to the routing the extra traffic. Table 1 formalises the tradeoffs between the mutual benefits of interconnection and the incentives to *free-ride*, describing a stage game whereby P and C decide about period interconnection and its potential use or abuse.

In the stage game, P decides whether to Link (L) or dewire (D) with C and C decides whether use (U) or abuse (A) the possibly existing link.The main idea is that at the stage game, P would prefer to link (L) if C does not abuse (U), as it receives access revenues for the agreed capacity K at unit price *a*. C, however, prefers to abuse the link if P provides the connection.If C abuses the link, P prefers to *dewire*, (D), as the costs from business stealing and the extra costs of carrying the increased traffic are greater than the benefits obtained from the access revenue.

Provider\Customer	Use (U)		Abuse (A)	
Link (L)	$\pi_{P,(L,U)}$	$\pi_{C,(L,U)}$	$\pi_{P,(L,A)}$	$\pi_{C,(L,A)}$
Dewrire (D)	$\pi_{P(D,U)}$	$\pi_{C,(D,U)}$	$\pi_{P,(D,A)}$	$\pi_{C,(D,A)}$

Table 1 The Payoffs of The Static Game

The characteristic of the period's payoffs[6], as discussed above are such that:

1. $\pi_{P,(L,U)} \geq \pi_{P,(D,U)} = \pi_{P,(D,A)} \geq \pi_{P,(L,A)}$

2. $\pi_{C,(L,A)} \geq \pi_{C,(L,U)} \geq \pi_{C,(D,U)} = \pi_{C,(D,A)}$

This payoff matrix describes a typical *Prisoners' Dilemma* whereby both P and C would prefer to be linked but C's incentives to deviate do not allow cooperation to emerge leading to a Pareto-inferior *Nash Equilibrium*, given by the strategy combination: (Dewire/ Abuse) leading to the *collapse* of PC connectivity.

Differently from the standard *Prisoners' Dilemma*, the incentives to cooperate in our Connectivity Game are asymmetric. This is due to the payoffs asymmetry between customer and providers. Indeed, only the Customer has an incentive to deviate from the cooperative outcome (L,U), as $\pi_{C,(L,A)} \geq \pi_{C,(L,U)}$ while the provider does not as: $\pi_{P,(L,U)} \geq \pi_{P,(D,U)}$. This implies that when studying the equilibrium conditions required for cooperation we will only need to focus on C's Incentive Compatibility Constraint (ICC). Finally, for simplicity, in the following we assume that

the payoff obtained by C when *dewired* equals zero, $\pi_{C,(D,A)} = 0$

3. Repeated interaction

It is a standard textbook result that perfect observability of the customer's actions could make cooperation sustainable, as a Nash Equilibrium of the infinitely repeated game, if the players are sufficiently patient. This can be achieved with the provider choosing a *trigger strategy*, stating that P will start by playing the cooperative action, L, and, in any future period, P will keep playing this action unless, in the previous period, C played A, in which case P will play D forever.

In particular, if we focus on C's incentives, we have that the value from cooperating under complete information is given by the infinite sum of discounted cooperation payoffs, obtained when the P plays L and the customer plays U:

$$V_{C,CI}{}^{C} = \frac{\pi_{C,(L,U)}}{1-\delta} \quad .$$

If, on the contrary, C deviates from the cooperative strategy it will obtain higher period deviation payoffs, $\pi_{C,(L,A)}$, followed by an infinite discounted sequence of punishment ones: $\pi_{C,(D,A)} = 0$

$$V_{C,CI}{}^{A} = \pi_{C,(L,A)} + \frac{\delta \pi_{C,(D,A)}}{1-\delta} = \pi_{C,(L,A)} \quad .$$

This implies that under complete information, cooperation, i.e. maintaining a stable wired status between C and P, is an equilibrium outcome of the repeated game provided that C's discount rate is sufficiently high.

$$ICC_{C,CI} = \frac{\pi_{C,(L,U)}}{1-\delta} > \pi_{C,(L,A)} \;\; i.e.$$

$$\delta > \frac{\pi_{C,(L,A)} - \pi_{C,(L,U)}}{\pi_{C,(L,A)}}$$

Clearly, the critical discount rate after which cooperation and stable interconnection are observed in equilibrium is increasing in the period profits differential obtained from abusing the link: $\pi_{C,(L,A)} - \pi_{C,(L,U)}$.

3.1 Asymmetric information

Cycles of attractiveness and repulsiveness, as those described in Dhamdhere and Dovrolis (2011), do not appear as an equilibrium outcome in the perfect information repeated game, when P adopts a *trigger strategy*. Similarly, more sophisticated temporary punishment strategies under complete information, while envisaging the possibility of temporary punishments followed by resumed cooperation, will not produce temporary wars as observed outcomes on the equilibrium paths as they would only be counterfactual threats describing *out of equilibrium behaviour.* However, by considering the presence of asymmetric information about the modalities in which C uses P's connection, it is easy to show that cycles of *wiring* and *dewiring* become possible equilibrium outcomes of the infinitely repeated interconnection game. The main idea behind this result is that asymmetric information provides C with the incentives to abuse the link without P being able to observe this action with certainty. This situation will typically arise when a random variable is jointly determined by an exogenous random shock and the Customer's unobserved behaviour, and the Provider is unable to distinguish between these two possible causes of variability[7]. In this setting, if P is never punishing C then C will respond to the *moral hazard* incentive and will abuse the link. If, on the contrary, P decides to always punish the customer there is no scope for cooperation in equilibrium. The literature on *price wars* and on *repeated agency*[8]in the context of repeated games with asymmetric information provides a modelling strategy that we apply to the connectivity game to explain the observed empirical evidence on *dewiring*. In a repeated connectivity game, the Provider, P, will need to introduce some periods of temporary punishments, *dewiring*, D, to reduce the Customer's incentives to *free-ride*. These punishment periods are triggered by some observable variable, correlated to the action of the Customer. More formally: connectivity is modelled as an infinitely repeated game. Firms discount future periods profits with a common discount factor (δ), where 0 < δ < 1.

We assume that, in each period, P observes the realization of a signal about the customer choice: if P observes A, P is sure about the deviation; but if P observes U, P will not be sure whether C has deviated. If P wants to achieve cooperation, it will need to formulate a punishment strategy that will satisfy C's incentive compatibility constraints to cooperate. In the following, we consider a possible candidate equilibrium strategy leading to an outcome path characterised by alternating periods of *dewiring and rewiring*. We will see that, along the equilibrium outcome path, the length of these punishment periods is endogenously determined by the incentive compatibility constraints of the Customer, the only player who may potentially derive short period gains from deviation.

3.1.1 The equilibrium strategy under asymmetric information

Let us assume that the Provider will play the "*Dewire with probability B for T periods" (DBT)* strategy described below. The only constraint for this strategy to be an equilibrium is given by the Customer's ICC, as, given the payoffs

structure described in Table 1, there is no need to check for the Provider's incentives to deviate.

The Provider's strategy *"Dewire with probability B for T periods (DBT)"*:

"Start by playing L, then, if you observe that the customer plays U, switch from L to D with probability B, and keep playing D for the next T periods and, after T+1 periods, revert to play L. If you observe that the customer plays A, then switch from L to D, with probability 1, if so, play D for T of periods and then revert to L".

The main intuition underlying this strategy is that: when P observes A as a signal of C's choice, P will know with certainty that C deviated and, in the next period, will start with probability one a punishment phase. When, on the contrary, P observes U as a signal of C's choice, P will not be sure whether an abuse has taken place. In this case, according to the *DBT* strategy, P will start a punishment phase[9] with probability B. The value of this probability, B will reflect the uncertainty about the received signal, U, or the amount of asymmetric information. Given the DBT strategy, the critical question is whether this is sustainable in equilibrium and, if yes, to determine the appropriate length for the punishment phases to ensure that actual deviations from collusive behaviour do not occur.

The second, relevant, question concerns the assessment of the main factors affecting both the duration and probability of starting a punishment phase. Clearly, providing answers to these questions would improve both the prediction of the probability of the start of a connectivity war, the duration of these *punishment* phases and the resulting cycles of *attractiveness* and *repulsiveness* characterising the evolution of the Internet morphology.

Following[10] the standard repeated games approach, *C's* expected discounted profit from cooperating, by playing U, ($V_C{}^C$), taking into account that cooperation may break down with probability B, even when C cooperates, can be written as:

$$V_C{}^C = \pi_{C,(L,U)} + (1-B)\left(\delta V_C{}^C\right) + B\left[\left(\delta + \ldots + \delta^{T_i}\right)\pi_{C,(D,U)} + \left(\delta^{T_i+1} V_C{}^C\right)\right]$$

$$\text{or, assuming that } \pi_{C,(D,U)} = 0$$

$$V_C{}^C = \pi_{C,(L,U)} + (1-B)\left(\delta V_C{}^C\right) + B\left(\delta^{T_i+1} V_C{}^C\right)$$

This condition states that the value of C's discounted profits when cooperating, choosing U, under asymmetric information, and assuming that $\pi_{C,(D,U)} = 0$, is given by the sum of the period profits from cooperation, $\pi_{C,(L,U)}$, plus the discounted profits from cooperating in the next period, obtained with the probability that *dewiring* does not start, $(1-B)\left(\delta V_C{}^C\right)$, plus the T+1 periods discounted values of the cooperation profits arising after T periods of punishment, due to the probability B event that a punishment phase had started at period t+1: $B\left(\delta^{T_i+1} V_C{}^C\right)$.

With this notation, the value, V_c ,obtained by the Customer, C, from cooperating when the Provider P follows the DBT strategy defined above is given by:

$$V_C{}^C = \frac{\pi_{C,(L,U)} + B^*\left(\delta + \ldots + \delta^{T_i}\right)\pi_{C,(D,U)}}{1-\left(1-B^*\right)\delta - B^*\delta^{T_i+1}}$$

$$\text{or, assuming that } \pi_{C,(D,U)} = 0 \qquad (1)$$

$$V_C{}^C = \frac{\pi_{C,(L,U)}}{1-\left(1-B^*\right)\delta - B^*\delta^{T_i+1}}$$

The deviation value, V_d, induced by the DBT strategy following C's deviation, playing A, is such that C will first obtain, once, the period payoff for deviating and abusing the link, $\pi_{C,(L,A)}$, after which C will receive T periods of *zero punishment payoffs, from* being dewired: $\pi_{C,(D,U)} = 0$ and, starting from the T+1th period, after P following the DBT strategy will have reverted to L, C will receive, again, the discounted value for cooperating, $\delta^{T+1} V_c$. Hence, the value of the infinite stream of discounted payoffs, received by C when deviating and playing A, is given by:

$$V_d = \pi_{C,(L,A)} + \delta^{T+1} V_c \qquad (2)$$

This allows to specify the Customer's ICC when the Provider P adopts the DBT strategy:
When P plays the DBT, C will play "Always U", only if

$$V_c > V_d \rightarrow \frac{\pi_{C,(L,U)}}{1-(1-B)\delta - B\delta^{T+1}} > \pi_{C,(L,A)} + \delta^{T+1} V_c \rightarrow V_c > \frac{\pi_{C,(L,A)}}{1-\delta^{T+1}}$$

(3)

Having characterised the Customer's ICC when the Provider adopts the DBT strategy, we are now able to discuss three lemmas, providing the main testable implications of the Model.

In the first lemma, we show that there is an upper limit for the value of the probability B of starting the *dewiring* phase after which the DBT strategy is no longer and equilibrium.

Lemma 1

The DBT strategy is an equilibrium for the infinitely

repeated game of Table (2) if

$$\delta^{T+1} < \frac{(1-(1-B)\delta)\pi_{C,(L,A)} - \pi_{C,(L,U)}}{(By - \pi_{C,(L,U)})} \quad \textit{and}$$

$$B < \frac{\pi_{C,(L,U)}}{\pi_{C,(L,A)}} \quad (4)$$

The next lemma focuses, instead, on the required *duration* of the punishment phase, for the DBT strategy to be an equilibrium.

Lemma 2

If, $B < \frac{\pi_{C,(L,U)}}{\pi_{C,(L,A)}}$ *there is a positive number T+1 such that, after T punishment periods, cooperation, (L,U), resumes and the DBT strategy is an equilibrium for the infinitely repeated game of Table (2). The optimal length, producing the smallest required sacrifice in terms of lost profits due to the necessary punishments is given by the smallest value of T satisfying the inequality:*

$$(T+1) > \left(\frac{1}{\ln\delta} \ln \frac{1}{\pi_{C,(L,U)} - B\pi_{C,(L,A)}} \right) \quad (5)$$
$$\left(\pi_{C,(L,U)} - \pi_{C,(L,A)}(\delta(B-1)+1)\right)$$

Finally, the last lemma describes the effects of a change in the customer's period payoffs from deviation, playing A instead than U, $\pi_{C,(L,A)}$ - $\pi_{C,(L,U)}$, on the duration of the punishment phase.

Lemma 3

If, $B < \frac{\pi_{C,(L,U)}}{\pi_{C,(L,A)}}$*, the duration of the punishment phase is increasing in the customer's period incentives to deviate,* $\pi_{C,(L,A)}$ - $\pi_{C,(L,U)}$.

A crucial constraint for the DBT strategy to be an equilibrium is provided by the value of the upper bound of the probability of *dewiring*, B, after observing U. We have seen in Lemma 1 that this *upperbound* is decreasing in the customer's period incentives to deviate $\pi_{C,(L,A)}$ - $\pi_{C,(L,U)}$, as $B < \frac{\pi_{C,(L,U)}}{\pi_{C,(L,A)}}$.

The empirical analysis presented in the next Section, will focus on these testable implications of the model.

4. Empirical Analysis

The primary objective of this paper is to interpret and explain the empirical evidence on the cycles of connectivity in the Internet, a building block of the evolution of the entire Internet ecosystem. After introducing the model of repeated connectivity under asymmetric information our next step is to empirically assess its testable implications. Specifically, we want to focus on the main factors affecting both the probability of *dewiring* of Provider-Customer relations and the *duration* of the related punishment phases.

4.1 The Data

The data used for the econometric estimation were collected from CAIDA as discussed in Dhamdhere and Dovrolis (2011)[11]. These authors produced a twelve years sequence of quarterly "topology snapshots" describing inter-AS connectivity, based on the publicly available BGP *dumps*, in turn provided by Routeviews and RIPE NCC's collectors. The original BGP data were classified by CAIDA, to define the underlying inter-AS business relationships using Gao's (2000) algorithm. Each individual AS was further categorised based on its average number of customer and peers.

4.2 Capturing the period incentives to deviate through the Provider-Customer Asymmetry in their customer bases

In Section three, describing the DBT strategy, we have seen from the customer's ICC, that C's period's incentive to deviate, by choosing A instead than U, $\pi_{C,(L,A)}$ - $\pi_{C,(L,U)}$, played a crucial role in determining both the *duration* and the probability of starting a *dewiring* phase. In the following, we assume that C's period incentives to deviate, $\pi_{C,(L,A)}$ - $\pi_{C,(L,U)}$, are increasing in the asymmetry in the customer bases between C and P. These customer bases, or in CAIDA's terms *customer cones*, are defined as the set of other Internet ASes that can be reached starting from an AS and only following its customer links[12]. Our assumption, on the relation between period incentives to deviate and the asymmetry in customer cones between Provider and Customer, means that the larger the PC *customer cones'* differential the higher will be C's increase in period profit from an unilateral deviation. This is because by abusing the link, more of P's customers advertised IP routes, become reachable by C so that, there are more opportunities for C to steal business from P.

4.3 The econometric model

We are now ready to introduce a *Panel Probit Model* to estimate the different factors affecting the probability of disconnection, at any given date, for a pair of connected PC.

Formally we have

$$Y^* = X'\beta + \varepsilon$$

where the dependent variable, for each pair/date (i,t), $Y^*_{i,t}$ is such that: if $Y^*_{i,t} > 0$, the PC pair, *i,* becomes disconnected (P dewires C) at time t, and the binary outcome equals one, $Y_{i,t}=1$, while, if $Y^*_{i,t} \leq 0$, the PC pair *i,* at time t, remains connected (P does not *dewire* C) so that the binary variable $Y_{i,t}=0$. The matrix *X* describes the L explanatory variables. This representation implies that, by using the symmetry of the distribution of *ε*, the probability that $Y_{i,t} = 1$ is given by :

$$Prob(Y_{i,t}=1) = Prob(Y_{i,t}^*>0) = Prob(\varepsilon > -X'\beta) = \Phi(X'\beta)$$

where Φ is the cumulative distribution function of the standardized normal (with mean zero and variance 1).The vector $x_{j,i,t}$ is a Lx1 vector of independent variables, affecting the connectivity of the PC pair *i*, at time t. The coefficients β capture the sign of the individual/time specific effects of the independent variables on the probability of *dewiring* for the PC pair *i* at time t.

4.3.1 Variables description

1. The dependent binary variable, $Y_{i,t}$, assumes value one, at any time that, a previously connected pair Provider/Customer, breaks its connection in period t (variable short-name used: dew).

The independent variables are chosen considering both the data availability and the elements that play a relevant role in the model of repeated connectivity under asymmetric information discussed in Section 3. These include relevant measures of the asymmetry between the Provider and the Customer, as these are crucial in defining the period incentive to deviate from the cooperative strategy. The full list of the independent variables, considered in the two models we present, is given below.

1. The *growth rate* of C's customer's cone in the period preceding the present decision date (variable short-name used: delta). This variable is relevant as a signal, for P, about the possibility that the C has increased its customer cone in the preceding period by stealing some of P's other customers, abusing the existing PC link.

2. The *duration*, in number of periods, of the uninterrupted interconnection between P and C, up to period, t (variable short-name used: conncum).

3. The asymmetry in customer base between P and C, measured as the difference in their respective *customer cones* (variable short-name used: custconegap and L. custconegap when lagged).

4. The number of previous *dewirings* already inflicted by P to C, i.e. the number of previous times that the PC pair disconnected (variable short-name used: L.dewcum). This variable is relevant as it may capture the instability of the existing connectivity relation for the PC pair *i* at time *t-1*, reflecting the lack of an established relation of trust, or a volatile environment characterised by higher information asymmetry.

4.3.2 Results

Table 3, below, provides the results of three estimated models, assessing the effects on the probability of *dewiring* between connected PC pairs, exerted by different combinations of covariates.

Dependent binary variable Y_i=1 if dewiring at t for pair i			
	(1)	(3)	(5)
Independent Variables	dew	dew	dew
delta *Rate of growth at t-1 of C's customer cone*	1.84e-05** (8.88e-06)	1.88e-05** (8.34e-06)	1.69e-05** (8.09e-06)
L.custconegap *Lagged difference in the PC customer cones*		-7.91e-07*** (2.31e-07)	-3.84e-08 (2.01e-07)
conncum *Number of cumulated connection periods*		-0.0272*** (0.000663)	-0.0367*** (0.000550)
L.dewcum *Number of times there have been prior dewiring for the same pair*			0.266*** (0.00605)
Constant	-1.272*** (0.00489)	-1.025*** (0.00710)	-1.003*** (0.00605)
Original Observations	259,221	259,221	259,221
Number of pairid	38,988	38,988	38,988

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2. Model 1 Estimating the Probability of Starting Disconnection for a Pair *i* at time *t*.

The first relevant observation, emerging from the results presented in Table 2, is that the probability of disconnecting, for a previously connected PC pair *i* at time *t*, is significantly increasing if, at time (t-1), C experiences an increase in its *customer cone* (if *delta* >0).

This result is interesting as C's customers cone is an *observable* signal for P, a possible indication, that C might have abused the connectivity link. It is therefore reassuring that this covariate has a positive impact on the probability of *dewiring* observed in the actual data as it would be efficient for P to increase the probability of disconnection following an unexpected increase in C's customer base. A second, interesting, result relates to the effects played by the duration of the present connectivity period on the probability of disconnection. Our estimates show that, when the PC pairs have been interconnected for longer periods (independent variable conncum), the likelihood of becoming disconnected decreases. This, again, reinforces the intuition underlying our model. Longer periods of interconnection are essential in establishing reputation and trust in a *partnership* characterised by asymmetric information and exposed to the risk of moral hazard. In this case, trust, linked to the length of the existing PC relation, becomes a substitute for observability, it reduces asymmetric information and induces a more efficient outcome by reducing the, still necessary, probability of starting a *connectivity war*. Further evidence on the relation between previous connectivity and trust is captured by the positive and significant effect on the probability of disconnection played by the number of previous *dewiring* episodes inflicted in the past by P to C (independent variable L.dewcum). This variable indicates a volatile connectivity environment and proxies the lack of trust, usually built on an established PC relation. Hence, the positive impact of this variable confirms our expectations that past *dewiring* episodes increase the chance of current disconnection for the PC pair *i* at time *t.* Asymmetry in the PC pair *i at time t*, is captured by the gap in their customer cones, (independent variable L.custconegap). This variable has a significant and negative effect on the probability of disconnection. This result confirms the implication of Lemma 1. In particular following the DBT strategy, the probability, B, of P choosing D, to *dewire* C, after observing U, only enters in the equation (1) defining C's value from cooperation: $V_C{}^C = \frac{\pi_{C,(L,U)}}{1-\left(1-B^*\right)\delta - B^*\delta^{T_i+1}}$ and, clearly, an increase in this probability, B reduces the incentive to cooperate for C.

On the other hand, C's incentive to deviate, by playing A, seen in equation (2), $V_d = \pi_{C,(L,A)} + \delta^{T+1}V_c$, is independent of B, since when P adopts the DBT strategy, C is punished with probability one, after choosing A.
We have also assumed that C's period's incentive to deviate, by playing A: $\pi_{C,(L,A)} - \pi_{C,(L,U)}$ is increasing in the asymmetry between P and C, as C, by deviating, can benefits from *stealing or just reaching* more business (other customers) from P. Hence, with higher asymmetry, a lower value of the *disconnection probability* B, is required for the incentives to cooperate, V_c, to dominate the incentive to deviate, V_d.
This means that: in order to satisfy the Customer's ICC for the DBT to be an equilibrium and observing alternating connectivity cycles, the higher the PC gap, and V_d, the lower has to be the probability B.
To conclude, we estimated a second model focussing on the main determinants of the duration of the punishment phases. This model focuses on the probability of reconnecting, for a PC pair, *i*, at time t, starting from a state of disconnection. Now, the dependent variable is a binary variable that equals one, $Y_{i,t}$ =1, if rewiring takes place for the pair PC *i,* at time *t*, while they were disconnected at time t-1; and equals zero, $Y_{i,t}$=0,if the pair remains disconnected at time t. The independent variables analysed in this case are: the number of cumulated connection periods before the last disconnection phase had started (conncum); the total number of previous dewiring episodes for the pair *i,* having taken place at any previous date (dewcum) and the gap between the customer cones of the provider and customer (custconegap).

PUNISHMENT DURATION:
Probability of RE-WIRING

VARIABLES	(1) re-wire	(2) re-wire	(3) re-wire
conncum *The number of cumulated connection periods before the dewring phase started*	0.0300*** (0.00127)	0.0183*** (0.00133)	0.0189*** (0.00133)
dewcum *Total number of previous dewirings*		-1.226*** (0.0281)	-1.233*** (0.0282)
custconegap *gap between customer cones of the provider and customer*			-1.84e-06*** (4.69e-07)
Constant	-1.938** (0.887)	0.112 (0.881)	0.122 (0.881)
Observations	52,656	52,656	52,656

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3 Model 2. Estimating the Probability of Reconnecting after a Punishment Phase.

From Table 3 we can see that the number of cumulated connection periods, conncum, experienced before the start of the last *dewiring* phase, has a positive and significant effect on the probability of terminating a punishment phase and consequently to reduce its duration. This result indicates that the increased knowledge between P and C due to previous cumulated periods of connectivity, reduces the *duration* of the punishment phases. In accordance with the previous finding, Table 3 also shows us that the cumulated number of previous *dewirings* (dewcum) has a negative and significant impact on the probability of termination of a punishment phase. As noticed earlier, also this result confirms the relevance of the relation between trust and the length of the punishment phases. Clearly, a high number of previous dewiring episodes indicates a more volatile PC relation, characterised by higher degree of asymmetric information. Finally, we consider, the asymmetry between P and C, measured as the gap between their customer cones (custconegap). Table 4 shows that this variable also has a highly significant and negative impact on the probability of reconnecting during a punishment phase. Hence higher asymmetry, inducing a larger period incentive to deviate $\pi_{C,(L,A)} - \pi_{C,(L,U)}$, will increase the duration of the punishment phase by reducing the probability of reconnecting during the time the pair was disconnected. This confirms the implication of lemma 3 stating that when $B < \frac{\pi_{C,(L,U)}}{\pi_{C,(L,A)}}$, the length of the punishment phase is increasing in the period incentives to deviate.

5 Conclusions

This paper provides an interpretation of recent empirical evidence on the regularity of cycles of attraction and repulsion, in Internet connectivity between providers and customers. We considered a repeated game under asymmetric information, taking into account the possibility that customers have an incentive to abuse providers' connectivity, to gain more customers for themselves, and that providers may need to initiate regular but limited periods of disconnection to deter customers *free-riding* otherwise leading to a permanent collapse in PC connectivity.

We then looked at the testable implications of this model. We introduced two separate econometric models, based on a large dataset *dewiring* and *rewiring* episodes for Cutomer/Providers pairs, collected over twelve years based on the CAIDA data used by Dhamdhere and Dovrolis (2011) to show evidence of the alternating role of *attractors* and *repellors* played by the main providers of Internet connectivity.

The empirical results from the two econometric models confirmed the testable implications of the DBT strategy, emphasizing the role played by asymmetry, in *customer cones*, on the probability of starting a disconnectivity war, and confirming the relevance of trust and reputation built throughout the previous connectivity spells, in reducing both the likelihood and the duration of the punishment phases.

REFERENCES

- Abreu, D., Pearce, D. and E, Stacchetti (1990) "Toward a Theory of Discounted Repeated Games with Imperfect Monitoring" *Econometrica* , Vol. 58, No. 5 , pp. 1041-1063.
- Constantiou, I. and Courcoubetis, C. (2002). Information asymmetry models in the Internet connectivity market. In Proceedings of IEW 2001, Berlin, Germany
- D'Ignazio, A. and Giovannetti, E., "Antitrust Analysis for the Internet Upstream Market: A Border Gateway Protocol Approach" *Journal of Competition Law & Economics,* Vol 2-1, (2006a), pp 43-69.
- D'Ignazio, A. and Giovannetti, E., "Asymmetry and Discrimination in Internet Peering. Evidence from the LINX" *International Journal of Industrial Organization*, (2009) Vol.27, pp. 441- 448
- D'Ignazio, A., and Giovannetti, E. (2006b), "From Exogenous to Endogenous Economic Networks: Internet Applications", *Journal of Economic Surveys*, (2006b) Vol. 20, No. 5, pp. 757-796
- Dhamdhere, A.; Dovrolis, C.; , "Twelve Years in the Evolution of the Internet Ecosystem," *Networking, IEEE/ACM Transactions on* , vol.19, no.5, pp.1420-1433, Oct. 2011
- Economides, N. The Economics of the Internet Backbone. *Handbook of Telecommunications Economics. Elsevier Publishers*, 2006.
- Faloutsos, M., P. Faloutsos, and C. Faloutsos. **"**On power law relationships of the internet topology**"**, *ACM SIGCOMM*, (1999)
- Gao,L. (2000), "On Inferring Automonous System Relationships in the Internet", *IEEE Global Internet*, Nov 2000.
- Green, E. J. and Porter, R. H. "Noncooperative Collusion under Imperfect Price Information", *Econometrica*, 52, pp. 87–100. (1984).
- Lippert, S.,and G. Spagnolo, "Internet peering as a network of relations", *Telecommunications Policy*, v.32 n.1, p.33-49, (2008)

- Kende, M. (2000). The digital handshake: Connecting Internet backbones. OPP Working Paper No. 32. Washington, DC: Federal Communications Commission.

- Laffont, J.-J., Marcus, S., Rey, P., & Tirole, J. (2003). Internet interconnection and the off-net-cost pricing principle. RAND Journal of Economics, 34(2), 370–390.

- Olczak, Matt (2009) "Unilateral Versus Coordinated Effects: Comparing the Impact on Consumer Welfare of Alternative Merger Outcomes". ESRC Centre for Competition Policy Working Paper 10-3. Available at SSRN: http://ssrn.com/abstract=1543750 or http://dx.doi.org/10.2139/ssrn.1543750

- Norton, William B., (2012) "The Internet Peering Playbook: Connecting to the Core of the Internet" DrPeering Press

- Pastor-Satorras R., and A. Vespignani. *Evolution and Structure of the Internet: A Statistical Physics Approach*. Cambridge University Press, Cambridge (2004).

- Phan, K. T., J. Park, and M. van der Schaar, (2012) "Near-Optimal Deviation-Proof Medium Access Control Designs in Wireless Networks," in *IEEE/ACM Trans. Networking,* vol. 20, no. 5, pp. 1581-1594, Oct. 2012

- Porter, R. H. (1983), "A Study of Cartel Stability: The Joint Executive Committee, 1880–1886", *Bell Journal of Economics*, 14, pp.301–314.

- Shrimali, G. "Competitive resource sharing by Internet Service Providers", *Netnomics* , Volume 11 Issue 2 (2010)

- Stigler G.J. (1964) "A theory of oligopoly". The Journal of Political Economy vol. 72: pp.44-61

- Tirole, J. (1988). The Theory of Industrial Organisation. MIT Press.

- Vazquez, A. , R. Pastor-Satorras, and A. Vespignani. "Large-scale topological and dynamical properties of the Internet." *Phys. Rev. E* 65, 066130, (2002)

Proofs of the Lemmas are Available from the Authors

[1]See for example Economides (2006), Laffont, et al. (2003) and Lippert and Spagnolo (2008).

[2] See Porter (1983) and Green and Porter (1984).

[3] For example under Cournot competition and demand uncertainty, collusion may breakdown as firms are unable to differentiate the effects of a rival's deviation from those of an exogenous shock lowering industry demand. Temporary price wars deter deviations from collusive behaviour as, without them, unmonitored deviations remain unpunished and may become profitable (Abreu et al., 1986).

[4] See the CAIDA website at www.caida.org.

[5] ISPs often have multiple points of interconnection and it is common practice to pass traffic off to another network as quickly as possible. This practice is called Hot Potato Routing (see Kende 2000 for a discussion of this practice in peering and Laffont, et al. 2003 for Internet backbones).See also Norton (2012) for the modalities of Connectivity charging and Constantiou and Courcoubetis (2002)) for the possibilities of abusing the connectivity contractual terms.

[6] Where:

- $\pi_{P,(L,U)}$ gives the Provider's period profits when P chooses to supply a link (L), and the customer C use the link as for the agreement (U), does not cheat.

- $\pi_{P,(D,U)}$, gives the Provider's period profits when P chooses disconnect, to cut a link (D), and the customer C use the link as for the agreement (U), does not cheat.

- $\pi_{P,(D,A)}$ the Provider's period profits when P chooses disconnect, to cut a link (D), and the customer C abuses the link (A) and cheats.

- $\pi_{P,(L,A)}$ …. And so on.

[7] See Phan, Park, and van der Schaar (2012) for an application to wireless protocols, where nodes collect signals about the actions of other nodes use a statistical test to infer whether or not other nodes are following the prescribed strategy , and trigger a punishment if a deviation is perceived.

[8] See Radner et al . (1986) for a model of *repeated agency*. Green and Porter (1984) introduced the *price wars* model in a *Quantity setting* framework, Tirole (1988) provides a detailed introduction on the model in terms of secret *Price cuts*, Olczak (2009) introduces firms' capacity constraints, so that price wars maybe triggered also when there is positive but low demand. The original ideas of the role of asymmetric information and price wars can be traced back to the seminal paper by Stigler (1964).

[9] Let B be this probability, reflecting the degree of P's ignorance about C's past move, then we have that the *DBT* strategy generates the following distribution over the P's period actions f:

$P(D_t/ L_{t-1}, U_{t-1})= B$ and $P(L_t/ L_{t-1}, U_{t-1})= 1-B$, while

$P(D_t/ L_{t-1}, A_{t-1})= 1$ and $P(L_t/ L_{t-1}, A_{t-1})= 0$

During the punishment phase of course the Provider will keep punishing for T periods, after its first punishment period his action will be (both if the customer played U_{t-2} and the punishment started with Probability B in period t-1, D_{t-1},or if the customer played A_{t-2} and the punishment started with Probability 1 in period t-1, D_{t-1}):

$$P(D_t/ D_{t-1}, L_{t-2...} L_{t-T-2} L_{t-T-1}, L_{t-T} U_{t-1}), = 1, P(D_t/ D_{t-1}, L_{t-2...} L_{t-T-2} L_{t-T-1}, L_{t-T} A_{t-1}), = 1$$

and

$$P(L_t/ D_{t-1}, L_{t-2...} L_{t-T-2} L_{t-T-1}, L_{t-T} U_{t-1}), = 0, P(L_t/ D_{t-1}, L_{t-2...} L_{t-T-2} L_{t-T-1}, L_{t-T} A_{t-1}), = 0$$

This says that whatever the action chosen by the C during the punishment phase, the punishment will continue with probability one to the next period... untill the number of periods of punishments, T, stipulated in the DBT strategy has elapsed so that the Provider will resume the the link by playing L again. So,for example in the second period of punishment we will have the provider choosing his actions with the following probabilities

$$P(D_t/ D_{t-1}, D_{t-2...} L_{t-T-2}, L_{t-T-1} L_{t-T}, U_{t-1}), = 1, P(D_t/ D_{t-1}, D_{t-2...} L_{t-T-2}, L_{t-T-1} L_{t-T}, A_{t-1}), = 1$$

and

$$P(L_t/ D_{t-1}, D_{t-2...} L_{t-T-2}, L_{t-T-1} L_{t-T}, U_{t-1}), = 0, P(L_t/ D_{t-1}, D_{t-2...} L_{t-T-2}, L_{t-T-1} L_{t-T}, A_{t-1}), = 0$$

This will continue for T periods after the provider will be choosing his actions with the following probabilities

$$P(D_t/ D_{t-1}, D_{t-2...} D_{t-T}, U_{t-1}), = B \text{ and } P(L_t/ D_{t-1}, D_{t-2...} D_{t-T}, U_{t-1}), = 1-B$$

If the cusomer C cooperated in the last period choosing U, or

$$P(D_t/ D_{t-1}, D_{t-2...} D_{t-T}, A_{t-1}), = 1 \text{ and } P(L_t/ D_{t-1}, D_{t-2...} D_{t-T}, A_{t-1}), = 0$$

If the customer did not cooperate in the last period of the punishemnt phase.

[10] See Tirole (2008 pag. 263)

[11] The data and a relevant discussion is are available at http://www.caida.org/publications/papers/2011/twelve_years_evolution/supplement/

[12] The size of the *customer cone* of an AS reflects the number of ASes that pay, directly or indirectly for transit, and provides a better metric of the size of an AS than its degree. See more details from CAIDA at http://www.caida.org/data/active/as-relationships/".

The Neighbourhood Game

From Behavioural Economics to Urban Planning

Panayotis Antoniadis
Department of Information Technology and Electrical Engineering, ETH Zurich
Zurich, Switzerland

Ileana Apostol
Department of Civil, Environmental and Geomatic Engineering, ETH Zurich
Zurich, Switzerland

***Abstract*—The rapid advances of information and communication technologies (or ICTs) and the mass online participation have increased the expectations for the long awaited visions of e-participation and e-democracy. However, there are still many challenges that need to be addressed related to privacy, data ownership and control, and various types of digital divides. Perhaps the most fundamental requirement is the need for information exchange between parties that do not necessarily share common interests, education, and cultural backgrounds. To achieve this, ICT could significantly help if designers understand in depth the way technology affects behaviour in the evolving hybrid (virtual and physical) space of modern cities, and communities are empowered to choose the tools that are most suitable for their environment and configure them according to their own values and objectives. In this paper we introduce a research framework connecting two relatively remote until today disciplines, namely behavioural economics and urban planning, through the mediation of computer science. More specifically, we describe a long-term social learning process evolved around a configurable ICT framework, the NetHood Toolkit, which will support a wide variety of hybrid interactions between people in physical proximity. The definition of a specific set of information sharing games with various configuration options can then form the basis for a real life experimentation process with potential benefits both for understanding human behaviour and for reaching important social objectives.**

Keywords—Interdisciplinary research; hybrid realm; social software; information sharing; behavioural economics; urban planning; civic engagement.

I. Introduction

Today the information and communication technology (or ICT henceforth) is creating a rich virtual space that overlays our physical world. The numerous individual decisions of people residing this hybrid space influence its morphology. Thus social sciences, in particular those aiming to understand human behaviour, need to study this new *hybrid realm*, i.e., virtual and physical, and especially how the new institutions and design options introduced by technology can contribute to, or also may hinder, the construction of a democratic society. The key premise of this paper is that, to build an understanding of this new environment, appropriate research needs to integrate interdisciplinary knowledge from behavioural and social sciences, and to structure a learning process between theory and practice that is adapted to the new requirements.

Panayotis Antoniadis was supported by EINS, the Network of Excellence in Internet Science, FP7 grant 288021.
Ileana Apostol was supported by PORTA, a Marie Curie Intra European Fellowship, FP7 grant IEF-275197.

Behavioural (or experimental) economics[1] and urban planning are two concerned disciplines that perhaps lie at the two extremes in the spectrum of possible methodologies and objectives. On the one extreme, behavioural economists are very ambitious amongst scientists in trying to identify the most fundamental aspects of human behaviour, precisely those that are the most independent of culture, education, and other contextual variables. To achieve this end, they employ statistical arguments based on data produced through reiterations of carefully designed, but mostly artificial, experiments applied in different settings. This process has led recently to some robust results, although there is still some scepticism and debates on their level of generality (see for example the debate between Binmore and Shaked [12] with Fehr and Schmidt [25]). On the other extreme, amongst social sciences urban planning is one of the tightest to the practical world. Planners are often asked to propose solutions, here and now, for real problems whose implementation can affect dramatically the future [29]. Decision-making processes are subject to numerous hard constraints, conflicting objectives, the challenge to aggregate individual choices into collective decisions, the unpredictable role of nature, and so forth.

The contribution of this paper is a description of an interdisciplinary experimentation framework where these two disciplines of social sciences can interact in a productive way, and contribute together to the materialization of the promises of a more democratic and inclusive society, that ICT may facilitate with its immense capabilities in collecting, aggregating, and filtering information.

According to John Dewey, "Democracy must begin at home, and its home is the neighborly community" (cited in [29], p. 193). Indeed it is the hybrid space of modern neighbourhoods that we propose as the common living laboratory where experimental economics, urban planning, and computer science can interact toward the establishment of a social learning approach for bringing knowledge to action, and vice versa, under the premises of an informed practice; Fig. 1 (p.3) depicts a simplified view of the interactions envisioned, analysed in more detail in Section IV. Here, a neighbourhood is defined as a specific geographic location where a limited number of people are in close physical proximity but not

1 Camerer and Loewenstein [13] describe the differences between the fields of behavioural and experimental economics as far as their experimental methodologies are concerned. For the level of discussion in this paper these differences are minor and in the following we will use both terms interchangeably.

necessarily sharing the same interests, culture or even language. This definition includes both traditional city neighbourhoods but also "ad-hoc" neighbourhoods of people in-habiting the same public space for a certain period of time like a train, a public square or a park.

The core characteristic of social learning, according to John Dewey and others, is the continuous feedback loop between knowledge and practice. For this, the main criticism of Friedmann (see [29], Chapter 5) refers to the inherent assumption of a benevolent "Administrator of Social Change", to the natural social friction that resists change, as well as the material and psychological investments required to circumvent that, and finally to the power of expertise that could be used to manipulate decision-making. We propose to address these valid challenges by building a flexible ICT framework, which will support different variations of a *neighbourhood game,* and allow local communities to choose the configuration options that match their values, requirements, and objectives. This framework, as a product of the novel available technology acting in an evolving hybrid social realm, gives a new opportunity to address Friedmann's critique through spontaneous, flexible, and bottom-up uses of the conceptual and practical tools to be provided. It could play the role of a global shared laboratory for learning to exchange information, accept diversity, deliberate and produce knowledge at the local level, which can then form the basis for addressing more complex problems at higher levels.

To increase the chances for success it is important to build an environment that allows the exchange of experiences and best practices. This paper describes a methodology for studying human behaviour in various scenarios, by comparing the outcomes of simple, but real, ICT-mediated information sharing and other *games* to be played in different neighbourhoods across the world. Similar games, such as the public good provision, have been extensively studied in the field of experimental economics to verify (or not) some fundamental assumptions, like this of rationality and self-regarding preferences, made by models of human behaviour used in various disciplines [13][31]. But the neighbourhood game is not an artificial game. It is a *real life* game whose properties are encoded in the design options of a dedicated ICT framework, the *NetHood ToolKit*, which will be extended according to the outcome of different game instantiations.

Computer scientists from the networking field have been trained to bridge gaps between theory and practice using a sort of social learning process around the design of the most influential artefact produced by this field, the Internet. Clark et al. [16] argued eloquently in favour of the "design for tussle" principle, responsible for the distributed Internet architecture, according to which network designers should avoid to implement hard decisions in the network core, allowing it to adapt according to different social or economic conditions, and other forces (see also [45]). As this new complex organism is growing practically uncontrolled, new theories are required to understand the laws of the Net, and the behaviour of people while interacting with it and through it [66]. Especially in the case of peer-to-peer networks formed as Internet overlays, like in file sharing, and wireless technology, which enables self-organized user owned networks (e.g., wireless community networks [15][69]), the concepts of rationality, altruism and cooperation are central since the very existence of the network depends on individual contributions in terms of computing resources, time, and content. There is a constantly growing literature on the economics of networks and the required incentive mechanisms for encouraging cooperation, most of which follow the rationality assumptions of the neoclassical economics (see [3][4][5] and references therein).

When one wishes to stimulate more intrinsic, social, motivations for participation and collaboration the role of the user interface becomes critical. Then research disciplines like Human-Computer Interaction (HCI), Computer-Human Interaction (CHI), Computer-Mediated Communication (CMC), and Computer Supported Collaborative Work (CSCW) take over the task of understanding and influencing human behaviour in online environments (e.g., [10][70][71]). But as the ICT technology advances and the virtual space overlays more closely the physical one, these disciplines are becoming more and more interdisciplinary in nature and play an important role in new emerging fields like urban informatics, community informatics, and ubiquitous computing (e.g., [21][28][9][15]).

Our core objective is to encourage members of diverse local communities to share information, and participate in activities toward achieving common goods, which may range from service exchanges to deliberations about important issues and shared concerns. We wish to follow the "design for tussle approach" followed in the case of the Internet itself but this time putting in the centre of the socio-economic tussles our NetHood Toolkit, which will be able to adapt to the specific environment and selected social objectives. As Hal Varian suggests [77], we intend to start with the simplest possible game: the one that invites people in proximity to "meet their neighbours", which is a fundamental requirement and the very first step toward more ambitious interactions related to consensus-building and decision making.

In the following we argue that bringing together knowledge and methodologies from the field of experimental economics and urban planning can help us to achieve this social objective (in practice), and at the same time provide invaluable data for understanding and modelling some fundamental aspects of human behaviour (in theory). We build our argument in steps, going first through the different veins of research involved in our framework and addressing the open challenges and opportunities that these scientific fields are facing today. We then describe how computer science can mediate between these two highly diverse research disciplines toward high-level scientific objectives, such as the understanding of human behaviour when exchanging information in hybrid environments, and traditional social objectives, such as the increase of social capital and civic engagement.

Note that our "real life experimentation" methodology shares some of the characteristics of similar approaches like the action research paradigm [37], living labs [61], and other co-creation models [58]. But it has also some unique elements, such as the selected combination of scientific and social objectives, and the empowerment of the users, which we further discuss in Section IV.

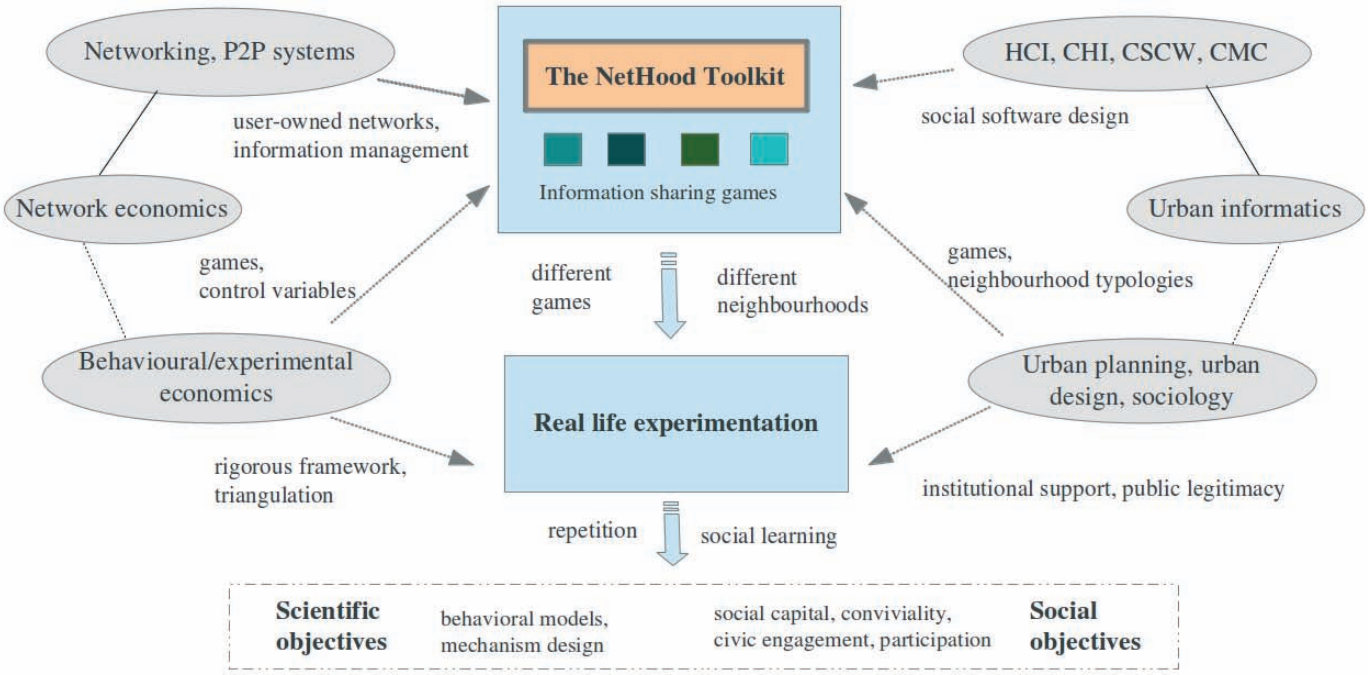


Figure 1. The NetHood interdisciplinary research framework (simplified view)

II. BEHAVIOURAL ECONOMICS

Behavioural and experimental economics are relatively new disciplines that build on concepts from game theory and, with the help of a rigorous experimental methodology, study the fundamentals of human behaviour in situations of conflict between personal and social benefits. For example, such experiments wish to test whether in a public goods scenario, in the absence of any external mechanism all participants will choose to “free-ride” [48] or in a common-pool scenario they will choose to overutilize the common resource [63]. The ultimatum game is an interesting artificial game which captures the notion of “altruistic” punishment, the desire of people to punish non-cooperative, selfish, users at their own cost [24].

After numerous experiments around the world, researchers in this area have managed to demonstrate through strong statistical evidence that people have “other-regarding preferences” built in their decision making process, challenging the widespread assumption of the inherently self-interested *homo economicus* [31]. By varying carefully the institutional environment, they can study in isolation the effect of different factors, e.g., communication, trust, and social norms, on the emergence of altruistic behaviour. In this manner experimental economics studies produce invaluable insights of the nature of human behaviour, but also regarding the direction of action to be taken to improve the level of cooperation in our societies. For instance, the 2009 Nobel Prize winner Elinor Ostrom and her colleagues [64] have identified the conditions under which certain institutions can help communities to employ a sustainable use of their common-pool resources, defying Hardin’s pessimistic prediction of the "tragedy of the commons." [34]

A. ICT-based Experimentation

The main weaknesses of the experimental economics methods relate to the fact that most experiments are based on artificial games played in the laboratory, typically by students offered monetary incentives. The careful definition of these games, their continuous repetition in different environments, and in some cases the availability of funding, have helped this research community to produce robust results for certain games, such as the ultimatum and the voluntary provision of public goods. But there is still significant room for improvement especially for more complicated games.

The ICT revolution brings today the potential for more realistic and low-cost experimentations. On the one hand, researchers have access to a much wider population of potential subjects for their experiments, either on custom experimental sites or using sites like the Amazon's Mechanical Turk, games-with-a-purpose, or in general what has been recently called "technology-mediated social participation systems" [71]. Such online behavioural experimentation suffers from limited control over the attention of the subjects, but minimizes the contextual factors that affect behaviour. Nevertheless these are still artificial environments, which are not adequate to study more complicated cooperation problems like public deliberations over the common good.

Another attractive option is the deployment of *real* web sites. The fact that online interactions can be recorded while users are often behaving unbiased, and actually unaware of

being observed, has indeed offered a great new opportunity for researchers who can try to set up sites that can offer value to Internet users and attract a critical mass. Today there are many research groups that create such websites with real value for users, with the goal to study their behaviour online. For example, the *GroupLens* group has built the *MovieLens* recommendation site, in order to experiment with strategies for motivating contributions studied in the field of social psychology, e.g., goal setting and self-efficacy [10]. To perform in a more controlled experimental environment, other researchers have built a successful website on health issues [14], which was purposefully designed to study the role of the network of ties structure in information dissemination, ensuring the anonymity of users and forbidding any additional social interaction that could influence the results.

Note that in principle every successful website can be used as an invaluable source of data for studying human behaviour, like the numerous studies on the motivations behind the contributions to *Wikipedia* based on the history of the articles (e.g., [47]). This is especially so for the site owner, who has access to the exact information of all activity performed on the site and thus, if there is enough activity, can easily measure the effect of small variations in design choices (what is often called A/B testing). If carefully done, such studies could lead to very robust causal relationships between design choices and behaviour. Here lies the tremendous power of corporations like *Amazon*, *Facebook*, and *Google*, which can perform studies on human behaviour of unprecedented scale and realism. However, this knowledge is today kept private and is already being used for commercial objectives or even political ones.

Nevertheless, this raises some important concerns related to privacy (we return to this later in Section III.A) but also to the openness of the acquired knowledge. Although there are voices from scientists requesting access to this information [39], it is unlikely that this will happen soon, not only because it is against the commercial interests of these corporations, but also because there are serious privacy issues at play [19]. Nevertheless, even if this huge amount of data were publicly available for researchers, the object of study would be limited to the people's behaviour in the specific virtual environment created by the professional software designers of *Facebook* and *Google*. This means that there would be no opportunity to try alternative options, a necessary process to make scientific sense out of this huge amount of information and design space.

So a big challenge is to provide online systems that generate real value for its users, and are transparent regarding the type of data collection, while they allow users to easily opt out and, most importantly, guarantee the privacy conditions for the shared information and the data collected. Of course, this sounds like a utopian objective, and for such a website or group of websites to acquire the necessary critical mass of users, while competing with corporations like *Facebook* and *Google* seems like a lost battle. However, we have many examples of grassroots initiatives that managed to design highly competitive products, for instance the *Linux* operating system, which prove the possibility of open and safe collective endeavours. Moreover, despite the numerous efforts in the past (*i-neighbors*, *Everyblock*) and more recent dynamic initiatives like *NextDoor*, which on February 12th 2013 announced that it has raised $21.6 million (www.reuters.com), there is still a lot of room for innovation in the area of hybrid neighbourhood communities.

In context, our strategy in producing an ICT framework for research purposes is to follow an incremental approach within a long-term not-for-profit project, and to make sure that each of the individual efforts will be designed in ways that produce value for a community, even if this group of people is the only one having access to the deployed system. The experimentation methodology proposed here brings a novel aspect, which could have significant impact over time. For local communities at different scales, urban planners, public authorities, even researchers who want to do artificial experiments with real users, the experience gained from our experimental efforts can add to the improvement of our NetHood Toolkit, which will then offer a low-cost solution to build and operate local hybrid communities. Then the willingness of these groups to partly share the data produced in a common repository would provide an invaluable source of information for our understanding of the social impact of social software and its informed design. It is very likely that this information will respect the privacy requirements of its producers, and will be freely available to the scientific community, unlike the datasets analysed internally by corporations like *Facebook* and *Google*.

B. *Information sharing*

The majority of cooperation games studied in the experimental economics literature concern the provision and allocation of *resources.* Today information is one of the most valuable resources but the underlying incentives for producing, sharing, and consuming are much more difficult to model and analyse. For that we witness a fierce battle between the market and the "commons" for the rights to own and share it (see Benkler 2006). While the Internet community has some notable successes in collaborating toward a common outcome at a global scale under the peer-to-peer paradigm, this is not the case at the more local levels. The extreme capabilities of ICT to bring together people living in distanced locations, based on a common interest, reduce significantly the motivation to face and deal with diversity in physical proximity. However, sharing information with neighbours is a critical requirement for creating convivial physical, and not virtual, communities [76] and for a more informed and cohesive participation in public affairs [6].

In our view, this situation brings the game of information sharing at the local level in the front-line of the challenging cooperation problems that western liberal democracies face today. The flexibility of ICT to employ a wide variety of information management rules, and to mediate in different ways between the game players, creates a novel environment with new rules and potential "strategies." Hence one of our objectives is to study in a rigorous way this new *neighbourhood game* that can shed light to the fundamental aspects of human behaviour in the hybrid realm, which was previously impossible to achieve due to the complexity of the involved contextual variables. In addition, and in parallel, it can help the achievement of social objectives discussed in the next section.

The idea here is to extend the notion of the standard public good provision game studied extensively in the experimental economics literature, and adapt it to a simple information-sharing scenario. Of course, the analogy is interesting when there are no network effects [43], and when information revelation is not strategic [17] as in the case of consensus-building and/or decision-making scenarios. Otherwise the resulting game becomes much more complex and difficult to analyse using simple models. For non-experts in the vast field of information economics, Lord [53] provides a nice overview of such strategic information games, seen from the point of view of an urban planner and thus very relevant to our interdisciplinary perspective.

The model that we will use as our starting point assumes that information sharing incurs a certain cost only because of the effort required to generate information or due to privacy concerns regarding its exposure to third parties. In this sense our take is closer to work on privacy economics; see [1] for a short overview on the behavioural economics of privacy, and [50] for a related experiment. What makes the game different than the simple public good provision one is that in reality there exist people who derive significant value from self-exposure, and ignore the corresponding costs. When there are numerous such people in the game, instead of leading to a more desirable equilibrium, information revelation can lead to a ”parallel” common-pool game [64], due to information overloading.

The most obvious information sharing activity of this type in a traditional or ad-hoc neighbourhood is the simple “meet your neighbour” game, in which people are invited to contribute personal information to the “community identity pool,” to introduce themselves to their neighbours, and so the outcome being a collection of local identities as a public good or a shared collective identity. Additionally, the information sharing game could refer to the collection of information about a set of external elements. For instance, the neighbours may be asked for reviews of neighbourhood places, or for more sophisticated data including the collection of information about the social life in the neighbourhood, while respecting others' privacy [6]. New elements brought by technology include, among many others, the possibility for anonymous communication, the rich multimedia options and the ability to rate and designate artificial constraints, but also, in our scenario, the presence of hybrid elements connecting the virtual with the physical space.

How can one characterize the “selfishness” and “altruism” in this context? Is there any general lesson that one can learn to design social software that can improve cooperation in such simple scenarios? Can we devise a formal definition of self-interest and altruism in the game of information sharing, and the identification of the contextual variables and institutions (i.e., the rules of the game) that could lead, or not, to increased levels of “cooperation”? Answering these simple questions will provide a basis for building an understanding of more complicated and competitive games related to conflicting interests in decision-making processes that are central to the e-democracy project.

To simplify the social exchanges and isolate the most important factors that influence behaviour in the neighbourhood are among the most important challenges. However, this may be a long process, and its success will depend on the number of different experiments that the research community will be able to perform in a coordinated fashion. For instance, Levitt and List [52] show how the experimental research community slowly achieved today's level of formalization and collaboration, yet over time enabling some robust results and interesting cross-cultural comparisons across the world. In the case of information sharing rigorous experimentation is more difficult to achieve and most efforts today are not based on formal models; see for example the work of Leslie et al. [50], for the context-specific privacy concerns and Rains [72], on the effect of anonymity.

Note that although we do not share the ambition of experimental economists whose ultimate goal is to identify a universal equation that captures human motivations, even if it is for a specific scenario like the ultimatum game (e.g., [24]), we do believe that it is very valuable to pursue such objectives. The reason is that even if the outcome may not qualify as the absolute truth, in trying to eliminate contextual variables that can hide what is general and universal one can identify important variables and causal relationships, revealing shared preferences, which become potential targets of design decisions and institutions building toward the common good. In this sense, economic models may be regarded as a formal way to improve the methods of action, and produce convincing and valid arguments within a social learning process.

III. URBAN PLANNING

Urban planning generates guiding knowledge for concrete visions of the future through the integration of various schools of thought in the social sciences and design disciplines. The planning expertise concentrates on practical challenges, and for instance, one of its constant focuses is to accommodate the growing urban population, together with the increasing diversity of interests, lifestyles and cultures in one locality. For that, the core “resource” is information, which becomes relevant for action if particularized within the local context. More importantly, the distribution of power and control over this information is a decisive factor within the planning process in general, and in particular, for beneficial outcomes in terms of quality of life and spatial appropriation at the community level. To address the increasing level of complexity and demand for engagement of citizens in decision-making processes, the concepts of participatory democracy and public deliberation at scale are in the front line (see for example [26][27][41][36]). Nonetheless, planning research requires appropriate ways to apply the existing methods of spatial investigation, as well as imagination in translating theoretical insights into action, and in designing empirical inquiry that can engage with the practical world.

A. Participatory planning and civic engagement

The tremendous capabilities of ICT for collecting, filtering, and processing information have generated many possibilities and promises toward the materialization of on-going planning objectives such as civic engagement and deliberations of public concerns. The concept of e-democracy, and visions of

augmented, smart or intelligent future cities dominate today the ICT-related research agendas of top universities across the world, as well as those of major national and international funding agencies.

To materialize this potential, numerous efforts are underway. Citizens' online interventions could influence governmental decisions of broad interest (e.g., change.gov, gopetition.com, zebralog.eu), as well as signal local problems concerning their everyday life in the neighbourhoods (e.g. sourcewatch.org, fixmystreet.com). The opening of the available government data around the world (data.gov), a part of the so called "open data initiative", is providing an additional degree of transparency, and is creating many opportunities for interesting services and applications.

In a decision making process, although such ICT infrastructures facilitate the information flow with the grassroots, they fail to provide either direct connections of these platforms with the physical settings or virtual spaces for social activities that are an important complement to user participation in the debates (see [15] for some exceptions). At present there are e-planning initiatives, which use privately owned and operated global online social networks like *Facebook* (see [23] and the example of Plaza Diaz Vélez in [6]) or *Twitter* (for example dis.urbaninformatics.net) and try to take advantage of their popularity as platforms for social exchanges to engage citizens in participatory processes.

In parallel, there are many practical efforts for bridging the virtual and the physical and enable neighbours to meet, create social capital, and exchange services. For instance, generic platforms like *i-neighbors* in the US, or *peuplade* in France promote district-wide networking by inviting people to join a specific virtual neighbourhood of their city. Research work related to such communities is concerned mainly with the social impact in the neighbourhood in terms of social capital following on earlier experiments (e.g., [32] [33]). In practice, these platforms and many other proprietary small scale solutions mostly serve mainstream uses as announcement boards by a minority of enthusiasts, local advertising, or in the best case informal discussions about local issues. The result is that dominant social networks like *Facebook* and *Twitter* make these local sites appear as redundant today. However, we believe that they are not the right platforms to mediate for such sensitive, context-aware and inherently local activities. First, because of the tremendous power acquired over the hosted content raising significant concerns related to privacy and control [19][42], but also because of the uniformity of their design, which sacrifices diversity and identity for simplicity and efficiency.

So, even ignoring the issues of privacy and manipulation, the role of the social software in mediating democratic processes can be subtle yet critical, thus requiring informed and responsive design, adapted to the specificities of each environment. For instance, cyberspace places were imagined twenty years ago by William Mitchell as being constructed "virtually by software instead of physically from stones and timbers, and they will be connected by logical linkages rather than by doors, passageways, and streets", with the help of "bitsphere planners" ([57], p.24). Since then many studies (such as [51][11][75], among many others) have highlighted the inherently interdisciplinary nature of software design, and its importance in shaping our society.

Today the "bitsphere planners" of our time are researchers of disciplines like HCI, CMC, and CSCW who have produced very helpful guidelines for building better systems, from virtual communities [70] to technology-mediated social participation sites [71], but also specific HCI artefacts, like the visualization of group participation based on the level of activity [22]. Until now planning experts have not been involved closely with the development of place-based social software. Although there is some research targeted to the specificities of the design of *place-based* virtual communities it originates mainly from fields closer to computer science (see [21][28]). However, the very idea of democracy depends on the exposure of people to other opinions and their ability to deliberate and make decisions, at least at a local scale. Systems like *Facebook* and *Twitter* owe part of their success exactly to their ability to facilitate interconnections of common interests across the world. Despite its importance, this capability generates the danger of creating virtual silos that reinforce disparities, and hinder people's disposition to accept and embrace diversity (see [59][65][2][18] for the importance of diversity and the possible positive and negative role of the Internet)

As Apostol, Antoniadis and Banerjee have recently argued [6][7], the collaboration between planning and computer science can be fruitful in both directions. First, planners could participate actively in cyberspace design, and evaluate its use and quality employing planning methods like Lynch's taxonomy of images [54], and Whyte's observations of social behaviour in public spaces [78]. Then, they could identify spatial elements through analogies between the virtual and the physical social environments, in order to derive alternatives for future (hybrid) spatial design [7]. Second, planners can collaborate with computer scientists to build intelligent social software that can contribute significantly toward improving the quality of the information from and to citizens. For example, the practice of flânerie in the physical and virtual space could be encouraged as a method to produce representative images of contemporary social life [6].

B. Conviviality and breaking the ice

In a multicultural city there are issues related to the limited choice of neighbours and possible cultural, ethnic, or ideological differences, which may lead to social exclusion or create tensions when it comes to sharing values and preferences. How can scientific knowledge, as well as researchers' engagement in practical activities in the city, work toward shaping convivial communities? Lisa Peattie defined conviviality as "small-group rituals and social bonding in serious collective action, from barn raisings and neighbourhood cleanups to civil disobedience that blocks the streets or invades the missile site" ([68], p. 246). To fulfil "the search for a space to deliberate about the common good" ([73], p. 341), and to accommodate civil and convivial diverse communities, planning practice must encourage deliberation of public concerns also in the hybrid environments.

The ICT can add to this practice by providing an online space for communication, information exchanges, and

ultimately deliberations of public concerns. The possibility to make contacts and engage in dialogue in the online neighbourhood community can motivate citizens to be more active in their neighbourhood (see the study by Harris and Flouch study that reports that "conversational democracy" in neighbourhood online networks may lead to civic action [35]). Seen from this perspective, online activity may help build social capital and add "eyes on the street" [44] toward enhancing neighbourhood conviviality, and that has become a reality in some hybrid spatial practices (Peuplade in Paris).

Moreover, within urban studies on spatial exploration, Kevin Lynch believed that the method to elicit personal spatial information from citizens through asking them to draw their own cognitive maps of the city has a principal value: to "break the ice" [55], in other words to engage people to talk about their environments in the context of their everyday urban spatial practice. Hence simple research inquiries on the neighbourhood "imageability" [54] are capable also to open communication processes that can strengthen social ties and neighbourhood conviviality, and further build a sense of shared urban community. It is possible that the same or similar effect would have the launching of a neighbourhood game as a scientific experiment inviting the residents of a small neighbourhood to participate, perhaps with the support of the municipality, acting this way as a "triangulation" element [78].

IV. AN INTERDISCPLINARY RESEARCH FRAMEWORK

Playing with the title of a well-known work by Schelling [74], experimental economics study the "micro-motives" of humans while planning studies the "macro-behaviour" of complex ecosystems. In addition to the positive role of ICT in the independent agendas of these two fields, our proposed research framework can enable further productive interactions. First, behavioural economists can build on the institutional support of planners to produce a realistic experimental environment and use their experience in public deliberations to model interesting information sharing games. On the other hand, urban planners can benefit from the analysis of such models to build hybrid spaces that encourage people to participate and share information and treat behavioural experiments as effective "ice breakers" to transform today's apathetic neighbourhoods into places of conviviality and deliberation. In the following, we describe briefly four main components of our proposed research framework (see Fig. 1).

A. The NetHood Toolkit

Rather than performing bilateral interactions between different disciplines raising competition and often-questionable results (see [21], p.65-74), we propose to concentrate all the intended collaboration into a single artefact –the NetHood Toolkit– that allows its software and underlying network rules and functionality to be customized to a specific scenario. The exchanges across the different disciplines will then be mediated through this ICT framework.

The NetHood Toolkit is being developed as an ICT framework offering a rich set of configuration options at different levels. It will extend its functionality in a continuous loop between theoretical analysis, software design, experimentation, and data analysis based on a) suggestions for appropriate configuration variables, b) the identification of trade-offs of possible values with respect to a list of evaluation metrics, and c) the definition of different neighbourhood games. We follow the Free and Open Source Software (FOSS) paradigm, which is transparent, and thus can build trust and prevent manipulative practices from authorities, provides cost-efficient customized solution for local communities, and enables a global social learning process based on experiences across the world.

Some important variables for which we wish to allow flexible customization options include the following:

1) **Context setup**: The type of place, location, number of people, demographics, time horizon.
2) **Framing**: The objectives of the game, its rules and process, use appropriate wording (templates will be available, which will be updated as more and more people get involved and share their experiences).
3) **Identity management**: User profile, representation, different levels of anonymity, roles.
4) **Content management**: Input constraints (e.g., size, rate, type of content), rating, filtering, and visibility of activity).
5) **Data gathering**: Information to be stored and shared for scientific or other purposes (with a selected aggregation level).
6) **Hybrid interactions**: Entry and exit points, templates for flyers and posters, functionality for organizing and reporting on physical meetings.

A key feature of NetHood is its capability to be run locally through the use of wireless technology, in isolation from the Internet, either as a dedicated infrastructure [69] or through ad hoc interactions [40]. This communication option can create feelings of ownership and independence, and ensure privacy and *de facto* physical proximity of participants [3]. Moreover it allows for cost-free solutions and immediate deployment, which is a critical requirement for most local communities. Finally, it enables the ubiquitous participation of all people in physical proximity through whatever device they carry, without the need to install a certain application, provide any credentials, or even have access to the Internet. They can just join the local wireless network and get redirected automatically to a local web service supporting the neighbourhood game selected and configured by an individual, a group of residents, or even a local authority (the municipality or even a railway company for the ad hoc scenario). This gives the ability to citizens to freely define their own neighbourhood games and, if they wish, become experimenters themselves, instead of simple subjects of experimentation, as in the case of living labs [61], or of information sources as in the case of citizen science [67]. As a result, the amount and the quality of data that can be collected over time may multiply significantly.

B. Economic Modelling

In order to be able to produce robust theoretical results from the experimentation process one needs to formulate

economic models that are simple enough to be studied analytically but expressive enough to give us some useful insights for the problem under consideration. These models will form the basis of the game theoretic analysis and verification through the statistical analysis of the data made available during the different experimentation phases. More specifically, we can use as a starting point an analogy with the public goods game studied extensively in the experimental economics literature, as discussed above. For example, we can assume that information contributed during a game incurs a personal cost (e.g., privacy) or benefit (e.g., self-exposure) with different weights for different people, while the collected information is valuable for everyone. More complicated games could also take into account the information overloading effects and try to capture this interesting difference between our information sharing with standard resource provision games.

Then, we can build on the idea of mechanism design for classic economic models [62] but extend them to include in the utility functions considered "other-regarding" preferences like in the experimental economics literature. To escape from the restrictions of the classic mechanism design we consider preferences as dynamic, subject to social or other motivations that in our case can be stimulated by specific design variables (a sort of "social mechanism design"). Then how different variables affect the outcome, and how generic the causal relationships are, should be studied through experimentation.

C. *Qualitative analysis*

An important contribution of urban planning is a comprehensive analysis of the conditions under which specific neighbourhood games can have positive social, political, or psychological impacts in different types of neighbourhoods. A first step toward this direction is to study the history of hybrid neighbourhoods around the world, and identify some important types of target neighbourhoods for NetHood experiments based on their size, diversity, existing institutions, pace of residence change etc. By analysing available data sets, personal online participation, and field research, we can draw insights on the online behaviour of users in this context in terms of anonymity, leadership, the formation of clusters, and the like.

The urban planning practical perspective on places and communities is also instrumental in defining appropriately the neighbourhoods and their limits, in the description of the environment and contextual elements that would characterize a certain game. In this context, it is important to study possible evolution paths for advancing from simple neighbourhood games to more sophisticated setups that encourage public deliberation respecting diversity and allowing all voices to be heard. For this, we will compare and contrast theoretical work on citizen participation (e.g., [73]) and deliberative planning (e.g., [27][41]) with the design and performance of various e-democracy and e-participation platforms (see objective II.A). This is meant to identify potential gaps between theory and practice, and possibilities for improvement in the context of the neighbourhood game.

Finally, analytic narratives, a rational-choice approach to explain political outcomes [9], will connect the outcomes of the games with knowledge from archival research and from various field observations (it may be also information from written field notes, visual and audio records, cognitive mapping etc.). By employing rational-choice and game theory, the method proposes a way of extracting empirically testable, general hypotheses from particular cases. The results can then be both empirically relevant and theoretically sophisticated.

D. *Real-life experimentation*

The scientific objective through the interaction of the experimental economics and the urban planning disciplines is to build a conceptual framework used to help the selection amongst different versions of the neighbourhood game at a high-level, aiming to reduce the design space and the possibilities of success. It will include a functional classification of variables, their possible values in different real scenarios, and causal relationships between them, and evaluation metrics (e.g., [64], Chapter 12). The role of social learning is then to contrast and integrate the insights from qualitative analyses, the experimental results, and the economic models, and transform them to guidelines for design and experiment configurations.

Previous experience has shown that behaviour can differ significantly in different cultural and political environments (e.g., [38]), no matter how simple is the game to be played. In addition to the selected configuration of the NetHood Toolkit, and the definition of the high-level neighbourhood game, the "administrator" of a specific instantiation of NetHood needs to decide the duration, the bootstrapping strategy (i.e., how people will be invited to participate), and most importantly the "framing", which has shown to play an important role in behavioural experiments (see [52]). Such decisions, some of which are listed above, will affect people's participation in the experiment, while others might be found to influence their behaviour during the game; in the latter case, they will be included in the variables that need to be taken into account during the design of the neighbourhood game itself and the corresponding economic models.

A particularly interesting framing option is whether people will be invited to participate in a scientific experiment, from a simple questionnaire to a hypothetical scenario of social exchange, or just to play a real social game. In the latter case, it is more difficult to constrain the free variables and draw safe conclusions while it is not sure that the participants will be willing to share the data generated for scientific purposes. In the former case, it is more difficult to encourage participation unless if there is some external motivation provided by a local authority, which would play the role of the monetary rewards that are given to the subjects of behavioural economics experiments. Equally important is the decision on the level of anonymity. More anonymity can address issues of timidity and elicit more genuine behaviour, but at the same can also raise the feelings of insecurity and attract inappropriate content.

V. CONCLUSION

In this paper, we introduced a novel interdisciplinary research framework, responsible for supporting a wide variety of local interactions between neighbours. We are aware of the important difficulties that such an endeavour might face both in theory and in practice (see also [20]). However, the tremendous power of corporations such as Facebook and Google, that own

the software and the information exchanged online, while mainly commercial objectives orientate their action, make the "right to the hybrid city" advocated in this paper an urgent objective.

There are some new developments that make us optimistic. First, the experimental and behavioural economics methodologies have matured, and can be applied to model and analyse more sophisticated collaboration games, including the voluntary sharing of information, as a basis for more democratic and bottom-up decision making processes. Second, the technological digital divide is being closed in many areas of the world forming a hybrid space where we can explore real life case studies, and bridge the virtual with the physical space. Finally, the FOSS and creative commons paradigms are producing today impressive results in terms of information collection, knowledge, and tools that exploit efficiently our collective intelligence. It is critical to engage in this effort scientists from different research disciplines and address the important challenges through repetition, knowledge sharing, and collaboration.

VI. ACKNOWLEDGEMENTS

We are grateful to the anonymous reviewers for their insightful comments and very useful pointers to related literature.

REFERENCES

[1] Acquisti, A. 2010. From the Economics to the Behavioral Economics of Privacy: A Note. In Proceedings of ICEB.

[2] An, J., M. Cha, K. Gummadi, and J. Crowcroft. 2011. Media Landscape in Twitter: A World of New Conventions and Political Diversity. In Proceedings of the Fifth International AAAI Conference on Weblogs and Social Media.

[3] Antoniadis, P., B. Le Grand, A. Satsiou, L. Tassiulas, R. Aguiar, J. Barraca, and S. Sargento. 2008. Community building over Neighborhood Wireless Mesh Networks. IEEE Society& Technology, 27 (1): 48-56.

[4] Antoniadis, P., S. Fdida, C.H. Griffin, Y. Jin, and G. Kesidis. 2012. Distributed Medium Access Control with Dynamic Altruism. In Proceedings of ADHOCNETS.

[5] Antoniadis, P. 2009. Incentives for resource sharing in ad hoc networks: going beyond rationality. In Boon-Chong Seet (ed.), Moblie Peer-to-Peer Computing for Next Generation Distributed Environments: Advancing Conceptual and Algorithmic Applications. IGI Global Publishing.

[6] Apostol, I., P. Antoniadis and T. Banerjee. 2013. Flanerie between Net and Place: Promises and Possibilities for Partici-pation in Planning. Journal of Planning Education and Research (SAGE), 33 (1): 20-33.

[7] Apostol, I., P. Antoniadis and T. Banerjee. 2013. Cyberspace design: a new challenge for planners. ICE Journal of Urban Design and Planning. DOI:10.1680/udap.11.00004.

[8] Aurigi, A. and F. De Cindio (eds). 2008. Augmented Urban Spaces: Articulating the Physical and Electronic City. Aldershot, UK: Ashgate.

[9] Bates et al. 1998. Analytic Narratives. Princeton University Press.

[10] Beenen, G. et al. 2004. Using Social Psyhcology to Motivate Contributions to Online Communities. In Proceedings of CSCW.

[11] Benkler, Y. 2006. The Wealth of Networks: How Social Production Transforms Markets and Freedom. Yale Univ. Press.

[12] Binmore, K. and A. Shaked. 2009. Experimental Economics: Where Next?. Journal of Economic Behavior and Organization.

[13] Camerer, C. and G. Loewenstein. 2003. Behavioural Economics: Past, Present, Future. In Advances in Behavioural Economics, C.F. Camerer et al. (Eds.), Princeton Univ. Press.

[14] Centola, D. 2010. The Spread of Behaviour in an Online Social Network Experiment. Science 329: 1194-7.

[15] De Cindio, F., Schuler, D. 2012. Beyond Community Networks: From Local to Global, from Participation to Deliberation. The Journal of Community Informatics, 8(3).

[16] Clark, D., J. Wroclawski, K. Sollins, and R. Braden. 2005. Tussle in Cyberspace: Defining Tomorrow's Internet. IEEE ACM Transactions on Networking 13(3): 462–475.

[17] Crawford, V., and J. Sobel. 1982. Strategic Information Transmission. Econometrica 50: 1431-1451.

[18] Davies, T. and S. Gangadharan (eds.). 2009. Online Deliberation: Design, Research, and Practice. CSLI Lecture Notes.

[19] Debatin, B., J. Lovejoy, A. Horn, and B. Hughes. 2009. Facebook and Online Privacy: Attitudes, Behaviors, and Unintended Consequences. Journal of Computer-Mediated Communication, 15(1): 83–108.

[20] Dini, P., M. Iqani, and R. Mansell. 2011. The (im)possibility of interdisciplinarity: lessons from constructing a theoretical frame-work for digital ecosystems. Culture, theory and critique, 52 (1).

[21] Dourish, P., and G. Bell. 2011. Divining a Digital Future: Mess and Mythology in Ubiquitous Computing. MIT Press.

[22] Erickson T. and W. Kellogg. 2000. Social translucence: Using minimalist visualizations of social activity to support collective interaction. ACM Transactions on Computer-Human Interaction.

[23] Evans-Cowley, J. 2010. Planning in the age of Facebook: the role of social networking in planning processes. GeoJournal 75 (5).

[24] Fehr, E. and K. Schmidt. 1999. A theory of fairness, competition, and cooperation. Quarterly Journal of Economics 114 (3).

[25] Fehr, E. and K. Schmidt. 2010. On Equity Aversion: A Reply to Binmore and Shaked. Journal of Economic Behavior and Organization.

[26] Forester, J. 1989. Planning in The Face of Power. Berkeley: University of California Press.

[27] Forester, J. 1999. The Deliberative Practitioner: encouraging participatory planning processes. MIT Press.

[28] Foth, M., L. Forlano, C. Satchell, and M. Gibbs, eds. 2012. From Social Butterfly to Engaged Citizen: Urban Informatics, Social Media, Ubiquitous Computing, and Mobile Technology to Support Citizen Engagement. Cambridge, MA: MIT Press.

[29] Friedmann, J. 1987. Planning in the Public Domain: From knowledge to action. Princeton University Press.

[30] Gächter, S. and B. Herrmann. 2009. Reciprocity, culture and human cooperation: previous insights and a new cross-cultural experiment. Phil. (Trans.) R. Soc. B 364: 791-806.

[31] Gindis, H. 2009. The Bounds of Reason: Game theory and the Unification of the Behavioural Sciences. Princeton Univ. Press.

[32] Hampton, K., C.-j. Lee, E. Her. 2011. How new media affords network diversity: Direct and mediated access to social capital through participation in local social settings. New Media & Society.

[33] Hampton, K., and B. Wellman. 2003. Neighboring in Netville: How the Internet Supports Community and Social Capital in a Wired Suburb. City and Community 2 (4): 277-311.

[34] Hardin, G. 1968. The tragedy of the commons. Science 162 (3859): 1243-48.

[35] Harris, K., and H. Flouch. 2010. *Online Neighborhood Networks Study*. Available at http://networkedneighbourhoods.com/?page_id=409.

[36] Healey, P. 2010. Making Better Places: The Planning Project in the Twenty-First Century. Palgrave.

[37] Hearn, G. and A. Tacchi, M. Foth, and J. Lennie,. 2008. Action Research and New Media: Concepts, Methods and Cases. Hampton Press.

[38] Henrich, J. et al. 2005. "Economic man" in cross-cultural perspective: Behavioural experiments in 15 small-scale societies. Behavioural and Brain Sciences, 28: 795–855.

[39] Huberman, B. 2012. Sociology of science: Big data deserve a bigger audience. Nature 482.

[40] Hui, P., A. Chaintreau, J. Scott, R. Gass, J. Crowcroft, and C. Diot. 2005. Pocket switched networks and human mobility in conference environments. In Proceedings of WDTN.

[41] Innes, J., and D. Booher. 2004. Reframing public participation: strategies for the 21st century. Planning Theory & Practice, 5(4).

[42] Introna, L., and H. Nissenbaum. 2000. Shaping the Web: Why the Politics of Search Engines Matters. Information Society, 16(3): 169–85

[43] Jackson, M. 2008. Social and economic networks. Princeton University Press.

[44] Jacobs, J. 1961. *The Death and Life of Great American Cities*. NY: Random House.

[45] Kalogiros, C. A. Kostopoulos, and A. Ford, 2009. On Designing for Tussle: Future Internet in Retrospect". EUNICE 2009 – The Internet of the Future, LNCS 5733.

[46] Klein, M. 2012. Enabling Large-Scale Deliberation Using Attention-Mediation Metrics. Computer Supported Cooperative Work, Springer.

[47] Kriplean, T., I. Beschastnikh, D. McDonald, and S. Golder. 2007. Community, Consensus, Coercion, Control: CS*W or How Policy Mediates Mass Participation. In Proceedings of ACM GROUP.

[48] Ledyard, J.O. 1994. Public goods: A Survey of Experimental Research. Social Science Working Paper 861.

[49] Lee, J., P. Antoniadis, and K. Salamatian. 2010. Faving Reciprocity in Content Sharing Communities (A Comparative Analysis of Flickr and Twitter). In Proceedings of ASONAM.

[50] Leslie, J., A. Acquisti, and G. Loewenstein. 2011. Strangers on a Plane: Context-Dependent Willingness to Divulge Sensitive Information Journal of Consumer Research, 37(5): 858-873.

[51] Lessig, L. 2006. Code, Version 2.0. New York: Basic Books.

[52] Levitt, S., and J. List. 2007. What Do Laboratory Experiments Measuring Social Preferences Reveal about the Real World? The Journal of Economic Perspectives 21(2): 153-174.

[53] Lord, A. 2012. The Planning Game: An information economics approach to understanding urban and environmental management. Routledge.

[54] Lynch, K. 1960. The Image of the City. MIT Press.

[55] Lynch, K. 1984. Reconsidering The Image of the City. In Cities of the Mind, ed. L. Rodwin and R. Hollister, 151-162, NY: Plenum.

[56] Mason, W., and S. Siddharth. 2011. Conducting behavioural research on Amazon's Mechanical Turk. Behav. Res. Psychono-mic Society, Inc.

[57] Mitchell, W. J. 1995. City of Bits: Space, Place and the Infobahn. Cambridge, MA: MIT Press.

[58] Mukhtar, M., M. Ismail, and Y. Yahya. 2012. A hierarchical classification of co-creation models and techniques to aid in product or service design. Computers in Industry, 63(4): 289-297.

[59] Munson, S. and P. Resnick. 2010. Presenting Diverse Political Opinions: How and How Much. In Proceedings of CHI 2010.

[60] Mutz, D. 2002. Cross-cutting Social Networks: Testing Democratic Theory in Practice. American Political Science Review 96(1): 111-126.

[61] Niitamo, V-P., S. Kulkki, M. Eriksson, and K. Hribernik. 2006. State-of-the-Art and Good Practice in the Field of Living Labs. In Proceedings of the 12th International Conference on Concurrent Enterprising Innovative Products and Services through Collaborative Networks.

[62] Nisan, N., T. Roughgarden, E. Tardos, V. Vazirani. 2007. Algorithmic Game Theory. Cambridge Univ. Press.

[63] Ostrom, E. 1990. Governing the Commons: The evolution of institutions for collective action. Cambridge University Press.

[64] Ostrom, E. et al. (eds). 2002. The Drama of the Commons. Washington, DC: National Academy Press.

[65] Page, S. 2007. The Difference: How the power of diversity creates better groups, firms, schools, and societies. Princeton University Press.

[66] Papadimitriou, C. 2001. Algorithms, Games, and the Internet. In Proceedings of STOC.

[67] Paulos, E, R. Honicky, and B. Hooker. 2008. Citizen Science: Enabling Participatory Urbanism. In Foth, M. (ed), Urban Informatics: Community Integration and Implementation.

[68] Peattie, L. 1998. Convivial Cities. In Cities for Citizens, 247-253, ed. J. Friedmann and M. Douglass, John Wiley & Sons.

[69] Powell, A. 2011. Metaphors, Models and Communicative Spaces: Designing local wireless infrastructure. *Canadian Journal of Communication*.

[70] Preece, J. 2000. Online communities: Designing usability and supporting sociability. John Wiley & Sons.

[71] Preece, J. and B. Shneiderman. 2009. The Reader-to-Leader Framework: Motivating Technology-Mediated Social Participation. AIS Transactions on Human-Computer Interaction (1)1: 13-32.

[72] Rains, S. 2007. The Impact of Anonymity on Perceptions of Source Credibility and Influence in Computer-Mediated Group Communication. Communication Research February, 34 (1).

[73] Roberts, N. 2004. Public Deliberation in an Age of Direct Citizen Participation. The American Review of Public Administration 34.

[74] Schelling, T. 1978. Micromotives and Macrobehavior. NY: W.W. Norton & Company.

[75] Shirky, C. 2008. Here Comes Everybody: The Power of Organizing Without Organizations. Penguin Press.

[76] Turkle, Sherry. 2011. Alone Together: Why We Expect More from Technology and Less from Each Other. NY: Basic Books.

[77] Varian, H. 1997. How to build an economic model in your spare time. In, M. Szenberg (ed.), Passion and Craft. Economists at Work. University of Michigan Press.

[78] Whyte, W. 1980. The Social Life of Small Urban Spaces. Washington, D.C.: The Conservation Foundation.

On the human-driven decision-making process in competitive environments

Evangelia Kokolaki Merkourios Karaliopoulos Ioannis Stavrakakis
Department of Informatics and Telecommunications
National & Kapodistrian University of Athens
Ilissia, 157 84 Athens, Greece
{evako, mkaralio, ioannis}@di.uoa.gr

ABSTRACT

The emergence of intelligent sensing and communication technologies fosters the generation and dissemination of huge amounts of information that collectively enriches people's awareness about their environment and its resources. With this information at hand, users then decide how to access these resources to best serve their interests. However, situations repeatedly emerge where the users' welfare is better satisfied by the same finite set of resources and the uncoordinated access to them gives rise to tragedy of commons effects and serious congestion problems.

In this paper, we study generic scenarios, where some non-excludable finite resource is of interest to a population of distributed users with variable perceptions about the resource supply and demand for it. The high-level question we address is how efficiently the competition about the resources is resolved under different assumptions about the way the users make their decisions. The users are first viewed as strategic perfectly informed software agents that make fully rational decisions attempting to minimize the cost of accessing the acquired resource. We then exploit insights from experimental economics and cognitive psychology to model agents of bounded rationality who either do not possess perfect information or cannot exploit all the available information due to time restrictions and computational limitations. We derive the operational states in which the competing influences are balanced (*i.e.*, equilibria) and compare them against the Nash equilibria that emerge under full rationality and the optimum resource assignment that could be determined by a centralized entity. Our results provide useful insights to the dynamics emerging from the agents' behavior as well as theoretical support for the practical management of limited-capacity resources.

1. INTRODUCTION

The advances in the broader information and communication technologies (ICT) sector have dramatically changed the role of end users and resulted in unprecedented rates of information generation and diffusion. The integration of sensing devices of various sizes, scope and capabilities with mobile communication devices, on the one hand, and the wide proliferation of online social applications, on the other, leverage the heterogeneity of users in terms of interests, preferences, and mobility, and enable the collection of huge amounts of information with very different spatial and temporal context. When shared, this information can enrich people's awareness about and foster more efficient management of a broad range of resources, ranging from natural goods such as water and electricity, to human artefacts such as urban space and transportation networks.

Besides generating information, the end users may be actively involved in its dissemination, and even make use of it for their own good and benefit. In this paper, we study generic scenarios, where some *non-excludable finite resource* is of interest to a population of distributed users and the information that is generated and may be shared concerns the *resource demand* and *supply*. When the amount of resource is large and the interested user population is small, users can readily opt for using it. When, however, the resource's supply cannot satisfy the demand for it, an inherent competition for the resource emerges that should be factored by users in their decision to opt for accessing this resource or not. The underlying assumption here is that the decision to opt for the finite resource under high competition bears the risk of an excess cost in case of a failure (*i.e.*, go for the limited resource but find it unavailable). This cost captures the impact of congestion phenomena that appear in various ICT sectors when distributed and uncoordinated high volume demand appears for some limited service. Examples include congestion phenomena that emerge on a toll-free road that is advertised as the best alternative to a blocked main road due to an accident (*e.g.*, Google Maps with Traffic Layer); long car cruising when searching for cheap on-street parking spots in busy urban environment (*e.g.*, [1], [2]); or high access delays when users associate with low-cost wireless access points in hotspot areas (*e.g.*, [14]).

In such settings, various critical decisions need to be taken by the entities that are involved in the production, dissemination and consumption of information. Hence, the decision to acquire and distribute the information or not, may account for own-interest priorities, such as preserving own resources or hiding information from potential competitors. In this paper, we focus on the way the entities make use of the accumulated knowledge. Essentially, the main dilemma faced by the end user possessing resource information is *whether to compete or not* for using these resources.

Internet Science Conference'13, April 10-11, 2013, Brussels.
.

This very fundamental question is investigated in this paper by factoring cognitive heuristics/biases in the human-driven decision-making process. Overall, the high-level question that we address is how efficiently the competition about the resources is resolved under different assumptions about the way the agents make their decisions. In essence, we are more concerned with the comparison of the decision-making under *full* and *bounded rationality* conditions. The key assumption is that human activity takes place within a fairly autonomic networking environment, where each agent runs a service resource selection task and seeks to maximize her benefit, driven by self-oriented interests and biases. As the full rationality reference, we frame the case where the agents (typically software engines) avail all the information they need to reach decisions and, most importantly, are capable of exploiting all information they have at hand; whereas users of bounded rationality either possess partial information about the resources or they are totally aware of them but it might be too complex in time and computational resources to exploit all the available information. Typically, decision-makers respond to these complexity constraints by acting heuristically. At the same time, their behavior is prone to case-sensitive biases that may lead to perceptual variations or distortions and inaccurate/not rational judgments that shape their competitiveness.

We introduce key concepts and present the assumptions for the environment under consideration in Section 2. The prescriptions of the full rational decision-making are defined in 3. In Section 4, we outline and implement four different models of bounded rationality within the particular environment, drawing on the Cumulative Prospect Theory, the Rosenthal and Quantal Response Equilibria concepts as well as the heuristic reasoning. Numerical results that are obtained employing these models are then presented in Section 5. The conclusions of the study are outlined in Section 6.

2. THE RESOURCE SELECTION TASK

We apply the general concept introduced in Section 1 to scenarios whereby the agents make their decision independently within a particular time window over which they start the resource selection task. In essence, we consider settings where N agents are called to decide between two alternative set of resources. The first set consists of R low-cost resources while the second one is unlimited but with more expensive items. Those who manage to use the low-cost resources pay $c_{l,s}$ cost units, whereas those heading directly for the safer, but more expensive option pay $c_u = \beta \cdot c_{l,s}, \beta > 1$, cost units. However, agents that first decide to compete for the low-cost resources but fail to acquire one suffering the results of congestion, pay $c_{l,f} = \gamma \cdot c_{l,s}, \gamma > \beta$ cost units. The excess penalty cost $\delta \cdot c_{l,s}$, with $\delta = \gamma - \beta > 0$, reflects the "virtual" cost of wasted time till eventually being served by the more expensive option.

In the following sections, we describe (qualitatively) the scenario of the ideal full rational and strategic cost-minimizing engines against four scenarios, consisting in imperfect information availability and behavioral biases, whereby the agents' decisions are made under bounded rationality conditions. We present how these four bounded rationality expressions can be modelled in a way that enables their analysis and the quantitative assessment of their impact on the efficiency of the resource selection task.

3. FULL RATIONAL DECISION-MAKING

In the ideal reference model of the perfectly or fully rational decision-making, the main assumption is that the decision-maker is a software engine that in the absence of central coordination, acts as rational strategic agent that explicitly considers the presence of identical counter-actors to make rational, yet selfish decisions aiming at minimizing what *it* will pay for a single resource. The intuitive tendency to head for the low-cost resources, combined with their scarcity in the considered environments, give rise to *tragedy of commons* effects [13] and highlight the game-theoretic dynamics behind the resource selection task.

Indeed, the collective full-rational decision-making can be formulated as an instance of *resource selection games*, whereby N players compete against each other for a finite number R of common resources [3]. In [16] we have analyzed the strategic resource selection game in the context of parking search application whereby drivers are faced with a decision as to whether to compete for the low-cost but scarce on-street parking space or directly head for the typically over-dimensioned but more expensive parking lots. An assistance service announces information of perfect accuracy about the demand (number of users interested in the resources/parking spots), supply (number of low-cost resources/on-street parking spots) and pricing policy, that eventually, manages to steer drivers' decisions. We derive the equilibrium behaviors of the drivers and compare the costs paid at the equilibrium against those induced by the ideal centralized system that optimally assigns the low-cost resources and minimizes the social cost. We quantify the efficiency of the service using the Price of Anarchy (PoA) metric, computed as the ratio of the two costs (*i.e.*, worst-case equilibrium cost over optimal cost).

In general, we show that PoA deviates from one, implying that, at equilibrium, the number of user nodes choosing to compete for the low-cost resources exceeds their supply. The PoA can be reduced by properly manipulating the price differentials between the two types of resources. Notably, our results are inline with earlier findings about *congestion pricing* (*i.e.*, imposition of a usage fee on a limited-capacity resource set during times of high demand), in a work with different scope and modelling approach [18]. The results of this study will serve as a benchmark for assessing the impact of different rationality levels and cognitive biases on the efficiency of the resource selection process.

4. DEVIATIONS FROM FULL RATIONALITY

In this section we study the decision-making process under four levels of agents' rationality which result in difference degrees of responsiveness to specific price differentials between low-cost and expensive resources. In all cases, we derive the agents' choices in the stable operational conditions in which all competing influences are balanced.

4.1 Motivation

The maximization of user benefit under perfect and real-time information about the dynamic characteristics of the environments described in Sections 1, 2, is a clearly unrealistic assumption for individuals' decision-making. In this section, we iterate on several expressions of *bounded rationality* in decision-making. This is an umbrella term for dif-

ferent deviations from the fully rational paradigm: incomplete information about environment and other people's behavior, time, computational and processing constraints, and cognitive biases in assessing/comparing alternatives. Experimental work shows that, practically, people exhibit such bounded rationality symptoms and rely on simple rules of thumb (heuristic cues) to reach their decisions in various occasions and tasks. Overall, we have identified the following instances of bounded rationality as worth exploring and assessing in the context of the resource selection task:

Incomplete information about the demand - The most apparent deviation from the perfect information norm relates to the amount of information agents have at their disposal. As two distinct variations hereby, we consider probabilistic (stochastic) information and full uncertainty.

The four-fold pattern of risk aversion - Particular experimental data show that human decisions exhibit biases of different kinds, in comparing alternatives. For instance, a huge volume of experimental evidence confirms the fourfold pattern of risk attitudes, namely, people's tendency to be risk-averse for alternatives that bring gains and risk-prone for alternatives that cost losses, when these alternatives occur with high probability; and the opposite risk attitudes for alternatives of low probability [25].

Own-payoff effects - This is another type of bias that was spotted in the context of experimentation with even simple two-person games, such as the generalized matching pennies game. Theoretically, in these matching pennies games, a change in a player's own payoff that comes with a particular strategy/choice, must not affect that player's choice probability. However, people's interest for a particular strategy/choice is shown to increase as the corresponding payoff gets higher values. This behavior makes choice probabilities range continuously within 0 and 1 and not jump from 0 to 1 as soon as the corresponding choice gives the highest payoff. This bias gives further credit to Simon's early arguments ([22], [23]) that humans are satisficers rather than maximizers, *i.e.*, that they are more likely to select better choices than worse choices, in terms of the utility that comes with them, but do not necessarily succeed in selecting the very best choice.

Cognitive heuristics - Cognitive science suggests that people draw inferences (*i.e.*, predict probabilities of an uncertain event, assess the relevance or value of incoming information *etc.*), exploiting heuristic principles. The cognitive heuristics could be defined as fast, frugal, adaptive strategies that allow humans (organisms, in general) to reduce complex decision tasks of predicting, assessing, computing to simpler reasoning processes. In the salient of heuristic-based decision theory, notions such as recognition, priority, availability, fluency, familiarity, accessibility, representativeness and adjustment - and - anchoring stand out. One of the simplest and well - studied heuristic is the recognition heuristic [9]. It is applied as follows: "If there are N alternatives, then rank all n recognized alternatives higher on the criterion under consideration than the $N - n$ unrecognized ones". The order at which different reasons are examined to make a final decision is defined by the priority heuristic [6]. The availability heuristic is stated as "a graded distinction among items in memory, measured by the order or speed with which they come to mind or the number of instances of categories one can generate". Cognitive researchers have conceptualized a distinct version of availability heuristic, named as fluency heuristic. In particular, the authors in [21] give the definition: "a strategy that artfully probes memory for encapsulated frequency information that can veridically reflect statistical regularities in the world". What is more, "the degree of knowledge a person has of a task or object" is termed as familiarity [12]. The accessibility heuristic [17] argues that "feeling - of - knowing judgments are based on the amount and intensity of partial information that rememberers retrieve when they cannot recall a target answer". Following the representativeness heuristic, people answer probabilistic questions by evaluating the degree to which a given event/object resembles/is highly representative of another one. When people adjust a given initial value to yield a numerical prediction, they devise the adjustment - and - anchoring heuristic. Tversky and Kahneman in [26] discuss biases to which some of the abovementioned heuristics could lead, digging people's responses that are in favor of or against a specific set of alternative choices.

In the following sections, all these effects are incorporated in distinct decision-making analytical models. We account for symmetric scenarios whereby the entire population exhibits the same instance of bounded rationality and the knowledge of this deviation from full rationality is common among individuals. In a more advanced modelling effort [7], the "cognitive hierarchy" approach assumes a distribution of cognitive steps of iterated reasoning, where the zero-step agents just randomize over their strategy space while higher-step agents take account of the intelligence and complexity of others' reasoning.

4.2 Bayesian and pre-Bayesian models

Practically, within a dynamic and complex environment, perfectly accurate information about the resource demand is hard to obtain. For instance, the resource operator may, depending on the network and information sensing infrastructure at her disposal, provide the competing agents with different amounts of information about the demand for resources; for example, historical statistical data about the utilization of the low-cost resources. Thus, in this case, the information is impaired in accuracy since it contains only some estimates on the parameters of the environment.

In the same vein, in [15], we assume a more realistic realization of the parking assistance service where drivers have only knowledge constraints, while they satisfy all other criteria of full rationality, *i.e.*, they are selfish agents who are capable of defining their actions in order to minimize the cost of occupying a parking spot. That is, no computational or time constraints deteriorate the quality of their decisions. However, they either share common probabilistic information about the overall parking demand or are totally uncertain about it[1]. From a modelling point of view, we extend the game formulation for the full rationality case (ref. Section 3) to accommodate the two expressions of uncertainty. In particular, we formulate this type of bounded rationality drawing on Bayesian and pre-Bayesian models and prescriptions of the classical Game Theory.

In the Bayesian model of the game, the agents determine their actions on the basis of private information, their types.

[1]Since the supply of parking space is static information that can be broadcast to the drivers or be known through offline media (website, news), the assumption is that drivers have knowledge of the parking capacity.

The type in this game is a binary variable indicating whether an agent is in search of resources (active player). Every agent knows her own type, yet she ignores the real state at a particular moment in time, as expressed by the types of the other players, and, hence, she cannot deterministically reason out the actions being played. Instead, she draws on common prior probabilistic information about the activity of agents to derive estimates about the expected cost of her actions. Thus, now, the agents try to minimize the expected cost, instead of the pure cost that comes with a strategy, and play/act accordingly. Similarly to the full rationality case, we derive our conclusions drawing on the equilibrium states. In particular, we end up with the Bayesian Nash equilibrium, whereby no agent can further lower her expected cost by unilaterally changing her strategy.

In the worst-case scenario (strictly incomplete information/full uncertainty), the agents may avail some knowledge about the upper limit of the potential competitors for the resources (*i.e.*, drivers in search of on-street parking space or spots in parking lots), yet their actual number is not known, not even probabilistically. This time, we see the resulting agents' interactions as an instance of pre-Bayesian games and build the discussion in terms of safety-level equilibria; namely, operational states whereby every player minimizes over her strategy set the worst-case (maximum) expected cost she may suffer over all possible types and actions of her competitors. Interestingly enough, we show less-is-more phenomena under uncertainty, whereby more information does not necessarily improve the efficiency of service delivery but, even worse, may hamstring users' efforts to minimize the cost incurred by them.

For years, the main approaches to collective decision-making, whereby the decisions of one agent affect the gain/cost experienced by others, draw on Expected Utility Theory (EUT). Agents are considered as strategic and fully rational, namely, they can compute the expected utility of all possible action profiles exploiting all available information about their own and the others' utilities (*i.e.*, the expected utility of one's action equals the sum of her utilities for all possible opponents' actions times the probabilities of their occurrence). In such setting, the classical solution concept of the game is embodied by the Nash Equilibrium (NE), the action profile that no agent would like to unilaterally deviate from. Essentially, the NE captures the agents' best responses in terms of expected utility maximization.

However, experimental data suggest that human decisions reflect certain limitations, that is, they exhibit biases of different kinds in comparing alternatives and maximizing their welfare in terms of the expected utility that comes with an alternative (ref. Section 4.1). To accommodate the empirical findings, researchers from economics, sociology and cognitive psychology, have tried either to expand/adapt the Expected Utility framework or completely depart from it and devise alternative theories as to how decision alternatives are assessed and decisions are eventually taken.

In the following sections we first give the general analytical framework of the decision-making model and then its application to the resource selection task as outlined in Section 2.

4.3 Cumulative Prospect Theory

Tversky and Kahneman in [25] proposed the Cumulative Prospect Theory (CPT) framework to explain, among others, why people buy lottery tickets and insurance policies at the same time or the fourfold pattern of risk attitude (ref. Section 4.1). According to EUT, if X denotes the set of possible outcomes of a lottery, its expected utility equals the sum of the outcomes' utilities, $U(x), x \in X$, times the probabilities of their occurrence, $pr(x)$, that is, $EU = \sum_{x \in X} pr(x)U(x)$. In CPT, the desirability of the alternatives-lotteries (now termed prospects) is still given by a weighted sum of prospect utilities, only now both components of the EUT (*i.e.*, outcomes and probabilities) are modified. However, agents are still maximizers, *i.e.*, they try to maximize the expected utilities of their prospects.

The CPT value for prospect X is given by

$$CPT_X = \sum_{i=1}^{k} \pi_i^- u(x_i) + \sum_{i=k+1}^{n} \pi_i^+ u(x_i) \tag{1}$$

where $x_1 \leq ... \leq x_k$ are negative outcomes/losses and $x_{k+1} \leq ... \leq x_n$ positive outcomes/gains.

In particular, the decision weights π_i^-, π_i^+ are functions of the cumulative probabilities of obtaining an outcome x or anything better (for positive outcomes) or worse (negative outcomes) than x. They are defined as follows:

$$\begin{aligned} \pi_1^- &= w^-(pr_1) \\ \pi_i^- &= w^-(pr_1 + ... + pr_i) - w^-(pr_1 + ... + pr_{i-1}), \quad 2 \leq i \leq k \end{aligned} \tag{2}$$

$$\begin{aligned} \pi_n^+ &= w^+(pr_n) \\ \pi_i^+ &= w^+(pr_i + ... + pr_n) - w^+(pr_{i+1} + ... + pr_n), \quad k+1 \leq i \leq n-1 \end{aligned} \tag{3}$$

In [25], the authors propose concrete functions for both weighting and utility functions,

$$u(x_i) = \begin{cases} x_i^a, \text{ if } x_i \geq 0 \\ -\lambda(-x_i)^b, \text{ if } x_i < 0 \end{cases} \tag{4}$$

$$w^+(p) = p^c / [p^c + (1-p)^c]^{1/c} \tag{5}$$

$$w^-(p) = p^d / \left[p^d + (1-p)^d\right]^{1/d} \tag{6}$$

$$w^+(0) = w^-(0) = 0 \tag{7}$$

$$w^+(1) = w^-(1) = 1 \tag{8}$$

Both functions are consistent with experimental evidence on risk preferences. Indeed, empirical measurements reveal a particular pattern of behavior, termed as loss aversion and diminishing sensitivity. Loss aversion refers to the fact that people tend to be more sensitive to decreases than to increases in their wealth (*i.e.*, a loss of 80 is felt more that a gain of 80); whereas diminishing sensitivity (appeared in both the value and the weighting function) argues that people are more sensitive to extreme outcomes and less in intermediate ones.

The parameter $\lambda \geq 1$ measures the degree of loss aversion, while the parameters $a, b \leq 1$ the degree of diminishing sensitivity. The curvature of the weighting function as well as the point where it crosses the 45° line are modulated by the parameters c and d. Tversky and Kahneman estimated the parametric values that best fit their experimental data at $\lambda = 2.25, a = b = 0.88, c = 0.61, d = 0.69$.

4.3.1 Applying Cumulative Prospect Theory to the resource selection task

In the uncoordinated resource selection problem, the decisions are made on two alternatives/prospects: the low-cost, limited-capacity resource set, on one side and the more expensive but unlimited resource set, on the other side. In addition, both prospects consist only of negative outcomes/costs.

The CPT value for the low-cost prospect is given by

$$CPT_l = \sum_{n=1}^{N} \pi_n^- u(g_l(n)) \tag{9}$$

where $g_l(k)$, with $g_l(1) \leq ... \leq g_l(N)$, is the expected cost for an agent that plays the action "low-cost/limited-capacity resource set". It is a function of the number of agents k taking this action, and is given by

$$g_l(k) = min(1, R/k)c_{l,s} + (1 - min(1, R/k))c_{l,f} \tag{10}$$

The decision weights and utility functions are defined by (2)-(8). The possible $n \leq N$ outcomes, for the number n of agents choosing the low-cost resources, occur with probability $pr(n)$ that follows the Binomial probability distribution $B(n; N, p_l^{CPT})$, with parameters the total number of agents, N, and the probability to compete for the low-cost resources, p_l^{CPT}.

The CPT value for the certain prospect "expensive/unlimited resource set" is given by (4) and equals

$$CPT_u = u(c_u) \tag{11}$$

It is possible to extend the equilibrium concept inline with the principles of CPT. Namely, under an equilibrium state, no agent has the incentive to deviate from this unilaterally because by changing her decision, she will only find herself with more expected cost. Thus, the symmetric mixed-action equilibrium strategy $p^{CPT} = (p_l^{CPT}, p_u^{CPT})$, $p_u^{CPT} = 1 - p_l^{CPT}$, is derived when equalizing the CPT values of the two prospects, $CPT_l = CPT_u$.

4.4 Rosenthal and Quantal Response Equilibria and their application to the resource selection task

Both casual empiricism as well as experimental work suggested systematic deviations from the prescriptions of EUT and hence, classical Game Theory (Nash Equilibrium predictions). In Section 4.1 we briefly present the own-payoff effects that constitute the most common pattern of deviations from Nash predictions in matching pennies games. Triggered by this kind of observations, Rosenthal in [20] and, later, McKelvey and Palfrey in [19], propose alternative solution concepts to the Nash equilibrium. The underlying idea in both proposals is that "individuals are more likely to select better choices than worse choices, but do not necessarily succeed in selecting the very best choice". Rosenthal argued that "the difference in probabilities with which two actions x and y are played is proportional to the difference of the corresponding expected gains (costs)". For the actions "low-cost/limited-capacity resource set" and "expensive/unlimited resource set", the Rosenthal equilibrium strategy $p^{RE} = (p_l^{RE}, p_u^{RE})$, $p_u^{RE} = 1 - p_l^{RE}$ is given as a fixed-point solution of the equation

$$p_l^{RE} - p_u^{RE} = -t(c(l, p^{RE}) - c(u, p^{RE})) \tag{12}$$

where $c(l, p)$ and $c(u, p)$ are the expected costs for choosing "low-cost/limited-capacity resource set" and "expensive/unlimited resource set", when all other agents play the mixed-action $p = (p_l, p_u)$, namely,

$$c(l, p) = \sum_{n=0}^{N-1} g_l(n+1)B(n; N-1, p_l) \tag{13}$$

and

$$c(u, p) = c_u \tag{14}$$

The degree of freedom $t \in [0, \infty]$[2] quantifies the rationality of agents, here seen as a synonym of the knowledge they possess and, primarily, their capacity to assess the difference in the utilities between two outcomes. Thus, the model's solution converges to the Nash equilibrium as parameter t goes to infinity.

In a similar view of people's rationality, McKelvey and Palfrey have shown that these "own-payoff effects", *i.e.*, people's inability to play always the strategy that maximizes (minimizes) the expected utility (cost), can be explained by introducing some randomness into the decision-making process. Actually, one can think this kind of randomness and, ultimately, these inaccurate/not rational judgments with respect to cost minimization, as reflecting the effects of estimation/computational errors, individual's mood, perceptual variations or cognitive biases. McKelvey and Palfrey implement these effects into a new equilibrium concept, the Quantal Response equilibrium. For instance, if the randomness follows an exponential distribution (*i.e.*, *logistic errors*, iid mistakes with an extreme value distribution, smaller mistakes are more likely to occur that more serious ones), the response function/probability to play the action "low-cost/limited-capacity resource set" in this equilibrium state $p^{QRE} = (p_l^{QRE}, p_u^{QRE})$, $p_u^{QRE} = 1 - p_l^{QRE}$ is given using (13) and (14) by,

$$p_l^{QRE} = \frac{e^{-tc(l, p^{QRE})}}{e^{-tc(l, p^{QRE})} + e^{-tc(u, p^{QRE})}} \tag{15}$$

Likewise, the free parameter t plays the same role, abstracting the rationality level.

Addressing human behavior in real-life choice problems by using alternative equilibrium solutions emerges as a typical approach for analytical investigations. In a similar study in [8], a capacity-constrained supplier divides the limited supply among prospective retailers. The latter are assigned quantities proportional to their orders, so they have an incentive to inflate their orders to secure more favorable allocated quantities (when facing capacity constraints). They choose their orders strategically but not always perfectly rationally; the optimization of individual payoffs is prone to errors inline with the quantal response model. Other studies, take explicitly into account similar deviations from perfect rationality in attackers' behavior to improve security systems. In [27], the defender has a limited number of resources to protect a set of targets (*i.e.*, flights) and selects

[2] In the Rosenthal equilibrium the rationality parameter t is subject to the constraint that the resulting probabilities range in [0,1].

the optimal mixed strategy, which describes the probability that each target will be protected by a resource. The attacker chooses a target to attack after observing this mixed strategy. This context can be encountered in selective checking applications where the (human) adversaries monitor and exploit the checking patterns to launch an attack on a single target.

4.5 Heuristic decision-making and its application to the resource selection task

A criticism against analytic models of bounded rationality, such as the CPT or the alternative equilibria concepts, is that they do not describe the processes (cognitive, neural, or hormonal) underlying a decision but just predict it. Furthermore, they give no insight as to how should the corresponding models be parameterized each time. On the other hand, models that rely on cognitive heuristics constitute more radical approaches to the decision-making task that originate from the cognitive psychology domain and specify the underlying cognitive processes while they make quantitative predictions. Indeed, heuristic decision-making reflects better Simon's early arguments in [22], [23] that humans are satisficers rather than maximizers.

Todd *et al.* in [24] list and discuss a number of simple heuristic approaches for a particular instance of the resource selection task, namely, the parking search in the simple context of a long dead-end street, with two one-directional lanes leading to (approach lane) and away from (return lane) a destination and a parking strip between the two lanes. One of the simplest example is the "fixed-distance" heuristic that ignores all spaces in the approach lane until the car reaches D places from the destination and then takes the first vacancy (in the approach or the return lane). If none leaves his/her parking place before the last arrival and the first vacancy is not detected during the trip in the approach lane, the driver pays an extra cost that penalizes the travel along the return lane. Overall, all these heuristics rely on related rules for search that have been suggested from other domains (*i.e.*, psychology, economics) and criteria that have been identified as important for drivers such as the parking fee, parking time limits, distance from drivers' travel destination, accessibility and security level [11], [10].

In an effort to get the satisficing notion in our resource selection setting, we came up with a simple kind of heuristic rule in competitive resource selection tasks, arguing that instead of computing/comparing the expected costs of choices, individuals estimate the probability to get one of the "popular" resources and play according to this. In essence, as common sense suggests, agents appear overconfident under low demand for the scarce low-cost resources and underconfident otherwise. Similar to equilibrium solutions in Section 4.4, we define the equilibrium heuristic strategy $p^{HE} = (p_l^{HE}, p_u^{HE})$, $p_u^{HE} = 1 - p_l^{HE}$, by the fixed-point equation

$$p_l^{HE} = \sum_{n=0}^{R-1} B(n; N-1, p_l^{HE}) \quad (16)$$

where $B(n; N-1, p_l^{HE})$ is the Binomial probability distribution with parameters $N-1$ and p_l^{HE}, for n agents competing for the low-cost resources.

5. NUMERICAL RESULTS

Table 1: Sensitivity analysis of the CPT parameter b: $N = 100, R = 50, \beta = 4, \gamma = 8$

b **value**	0.616 (−30%)	0.704 (−20%)	0.792 (−10%)	0.88 (0%)	0.968 (+10%)
p_l^{CPT}	0.8837	0.8836	0.8835	0.8834	0.8834

Table 2: Sensitivity analysis of the CPT parameter d: $N = 100, R = 50, \beta = 4, \gamma = 8$

d **value**	0.552 (−20%)	0.621 (−10%)	0.69 (0%)	0.7590 (+10%)	0.828 (+20%)
p_l^{CPT}	0.8934	0.8876	0.8834	0.8805	0.8786

In Sections 3 and 4, we iterate on decision-making models for full rational agents and individuals that exhibit systematically deviations from the full rational behavior and show how the agents resolve in distributed manner the problem of coordinating, that is, which partition of agents will gain the low-cost resources and which will pay the service more expensively. In this section, we consider the resource selection task described in Section 2 and plot the derived agents' choices along with the associated per-user costs incurred in the equilibrium states of the system, under different charging schemes for the two resource sets. The average per-user cost in the symmetric case where every agent performs the mixed-action $p = (p_l, p_u)$ is given by (13) and (14), as follows

$$C(p) = p_l c(l, p) + p_u c(u, p) \quad (17)$$

Ultimately, we compare the Cumulative Prospect Theory decision-making model, the Rosenthal and Quantal Response equilibria as well as the heuristic reasoning against what the full rational decision-making yields ([16], Theorem 2). Interested readers are referred to [15] for a similar discussion on the Bayesian and pre-Bayesian models in the context of the parking search application.

In addition, we plot the different types of equilibria against the optimal/ideal centralized resource allocation, where the full information processing and decision-making tasks lie with a central entity. Agents issue their requests to a central server, which monitors the limited-capacity resource set, possesses precise information about its availability, and assigns it so that the overall cost paid by agents is minimized. Thus, in an environment with R low-cost resources, whereby such an ideal centralized system serves the requests of $N(\geq R)$ agents, exactly R $(N - R)$ agents would be directed to the low-cost (resp. more expensive) option and no one would pay the excess penalty cost.

For the numerical results, usage of the limited resources costs $c_{l,s} = 1$ unit whereas the cost of the more expensive resources β and the excess penalty cost parameter δ range in $[3, 12]$ and $[1, 16]$ units, respectively.

5.1 Cumulative Prospect Theory

Although the CPT model was originally suggested to rationalize empirical findings in financial lottery experiments, it has been successfully exploited to accommodate data sets for different decision-making models. In [5], the authors review empirical estimates of prospect theory under different (parametric) assumptions, incentives, tasks and samples. In a transportation paradigm more similar to our

Table 3: Sensitivity analysis of the CPT parameter λ: $N = 100, R = 50, \beta = 4, \gamma = 8$

λ **value**	1.8 (−20%)	2.025 (−10%)	2.25 (0%)	2.475 (+10%)	2.7 (+20%)
p_l^{CPT}	0.8834	0.8834	0.8834	0.8834	0.8834

setting, Avineri *et al.* in [4] first conduct a route-choice stated-preference experiment and then explain the results parametrizing their route choice model with values similar to the ones that Tversky and Kahneman found for their archetypal model in [25]. In the absence of proper experiment measurements on the particular resource selection paradigm that could validate this theory, it is not suggested that the parameter set $b = 0.88, d = 0.69, \lambda = 2.25$, as was introduced in Section 4.3, reflects the actual agents' choices. Thus, we use the default parametric values to explore the existence (or not) of the same risk attitudes towards losses in the particular environment (ref. Section 2) and conduct a sensitivity analysis on the parameters b, d, λ in the end of the section to address these concerns.

Motivated by the simple experiments on preferences about positive and negative prospects that, eventually, reveal the four-fold pattern of risk attitude [25], we iterate on the most interesting case studies for the cost differentials between the certain prospect (*i.e.*, c_u for the expensive/unlimited resource set) and the best or worst outcome of the risky one (*i.e.*, $c_{l,s}$ or $c_{l,f}$ for the low-cost/limited-capacity resource set). As Figures 1a, 1b suggest, when the agents have the opportunity to experience a marginally or significantly lower charging cost at low or high risk, respectively, their biased risk-seeking behavior turns to be full rational, and thus, minimizes the expected cost over others' preferences. On the contrary, in the face of a highly risky option reflected in significant extra penalty cost (Fig. 1c), the risk attitude under the two types of rationality starts to differ, yet both suggest being more conservative. For instance, when $N = 100$ agents compete for $R = 50$ low-cost resources, the expected utility maximization framework results in the Nash equilibrium $p_l^{NE} = \frac{R(\gamma-1)}{\delta N} = 0.59$, with expected cost values $c(l, p^{NE}) = c(u, p^{NE}) = c_u$ whereas the CPT suggests playing with $p_l^{CPT} = 0.61$ that equalizes the relevant values $CPT_l = CPT_u = -7.62$. Under the prescriptions of CPT, at the mixed-action $p^{NE} = (0.59, 0.41)$, the cumulative prospect values become $CPT_l = -6.74$ and $CPT_u = -7.62$ which leads to a risk-prone behavior, inline with the theory for losses: an agent may decrease the prospect cost by switching her decision from the certain more expensive resource set to the risky low-cost one. On the other hand, at the mixed-action p^{CPT} the expected costs for the two options differ, namely, $c(l, p^{CPT}) = 4.49$ and $c(u, p^{CPT}) = c_u = 4$.

Overall and as Figure 2 implies, both the full rational and the biased practice are more risk-seeking than they should be, increasing the actual per-user cost (or equivalently, the social cost) over the optimal levels. As a result, being prone to biased behaviors cannot score better than acting full rationally[3].

The sensitivity of these results to the particular CPT parametric values $b = 0.88, d = 0.69, \lambda = 2.25$, can be drawn from Tables 1, 2 and 3, respectively. The CPT model evolves to the expected utility maximization one that gives $p_l^{NE} = 0.875$, as the parameters go to one. In general, although we admit that the ultimate validation of our analytical results would come out of real, yet costly and difficult experimentation with in-field measurements, the effect of the parameters is shown to be limited.

5.2 Rosenthal and Quantal Response Equilibria

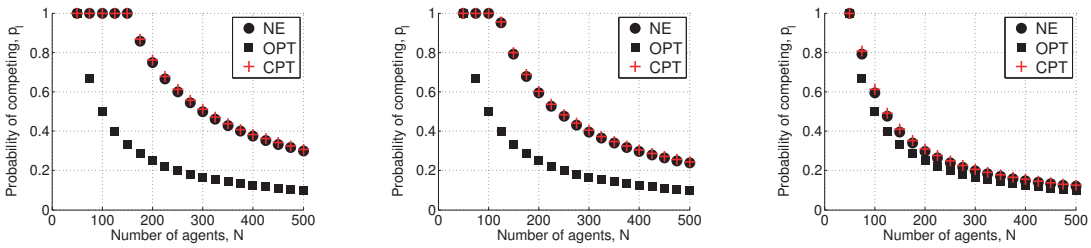
Within the typical game-theoretic setting, the agents' expected costs from different strategies are determined by their beliefs about others' preferences. Eventually, these beliefs may generate choice probabilities according to a particular response function that is not necessarily *best*, inline with the expected utility maximization norms. Yet under this kind of response functions, such as those in the form of (12) or (15), the resulting - Rosenthal and Quantal Response - equilibria impose the requirement that the beliefs match the equilibrium choice probabilities, as in the Nash equilibrium solutions.

Figure 3 plots these two alternative types of equilibrium strategies and the resulting per-user costs when individuals cannot always choose the actions that best satisfy their preferences, that is when the rationality parameter t is 3. First, the implementation of bounded rationality increases randomness into agents' choices and hence, draws choice probabilities towards 0.5. As a result, when competition exceeds the capacity of the low-cost resources, computational limitations lead to more conservative actions comparing to the Nash equilibrium competing probabilities when $N < \frac{2R(\gamma-1)}{\delta}$ and less, otherwise. Second, the more different the - expected - costs of the two options are, the less the Rosenthal and Quantal Response equilibrium differ from the Nash one, since the identification of the best action becomes easier. Thus, we notice almost no or limited difference when the risk to compete for a very small benefit is high due to the significant extra penalty cost δ (Fig. 3c) or the high demand for the resources (Fig. 3a, $N > 300$). The same reason underlies the differences between the Rosenthal and the Quantal Response equilibrium. Essentially, the three types of equilibrium form a three-level hierarchy with respect to their capacity to identify the less costly resource option, with the Quantal Response equilibrium at the bottom level and the Nash one at the top level.

Since the per-user cost is minimized at lower competing probabilities, the inaccurate but frugal computation of the best action saves not only time and computational resources but also, usage cost when $N < \frac{2R(\gamma-1)}{\delta}$ (Fig. 3b).

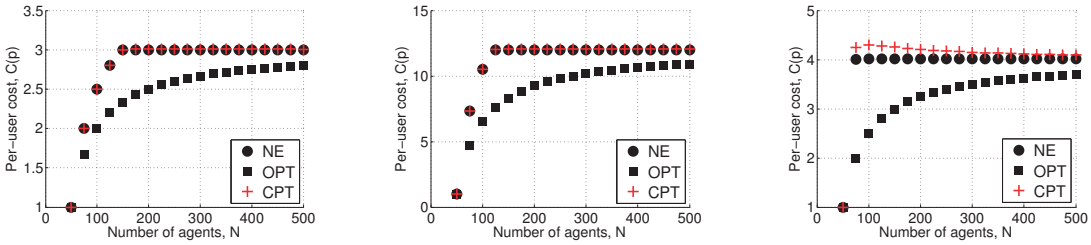
The impact of computational limitations becomes more sharp at even lower values of the rationality parameter. In Figure 4, we plot the probability of competing for the low-cost resources and the resulting per-user cost, when $t = 0.2$. Again higher differences in behavior are observed in settings where it is not clear which of the two resource options costs less. This is the case of Figure 4a, where the choices are decided almost randomly. On the other hand, when the risk is high when choosing the limited resources, as in Figure 4c,

[3]In [16], we investigate the game-theoretic equilibrium strategies and the resulting Price of Anarchy metric, which compares the induced social cost at equilibrium states against the optimal one, to quantify the inefficiency of equilibria for a wide range of charging schemes.



a. $\beta = 3, \gamma = 4$ b. $\beta = 12, \gamma = 20$ c. $\beta = 4, \gamma = 20$

Figure 1: Probability of competing in CPT equilibrium, for $R = 50$, under different charging schemes.



a. $\beta = 3, \gamma = 4$ b. $\beta = 12, \gamma = 20$ c. $\beta = 4, \gamma = 20$

Figure 2: Per-user cost in CPT equilibrium, for $R = 50$, under different charging schemes.

even that low rationality level generates decisions similar to the full rational ones.

Interestingly, when $\beta = 3$, $\gamma = 4$ and $N < \frac{2R(\gamma-1)}{\delta}$, the decrease in competing probability that comes with imperfect rationality, draws the per-user cost to near-optimal levels (Fig. 4b). However, when the penalty cost is high, any - limited - increase in competitiveness due to inaccurate cost discrimination causes significant overhead (Fig. 4d).

As a last note, Figure 5 illustrates the impact of the rationality parameter t on the equilibrium choice probabilities. Starting with a difference $\delta_{prob,t\sim 0} = p_l^{QRE,RE} - p_l^{NE} = 1/2 - \frac{R(\gamma-1)}{\delta N}$ under a pure stochastic decision-making model, the bounded rational reasoning approximates the full rational practice, as t goes to infinity. When $N \sim (N-1)$, as in our setting, this difference in competing probability can be translated in gains (less cost) or losses (more cost) in the ultimate per-user cost, by (17), as follows:

$$\begin{aligned}
\delta_{cost,t} &= C(p^{QRE,RE}) - C(p^{NE}) \\
&\approx \delta_{prob,t} \cdot \delta c_{l,s}, \quad \text{if } R/((N-1)(p_l^{NE} + \delta_{prob,t})) < 1 \\
&\approx c_{l,s}(p_l^{NE} + \delta_{prob,t} - R/(N-1)) - \\
&\quad c_{l,f}(p_l^{NE} - R/(N-1)) - \delta_{prob,t} c_{pl}, \quad \text{o/w}
\end{aligned}$$

5.3 Heuristic decision-making

Typically, under time and processing limitations, the fast and frugal reasoning approaches emerge as the only solution. In fact, the cognitive heuristics operate as adaptive strategies that allow agents to turn complex decision tasks of predicting others' preferences, assessing corresponding utilities or costs, determining best or better actions, to simpler decision-making tasks. Within a highly competitive environment and in the face of a penalty cost ($\delta c_{l,s}$), the heuristic reasoning just estimates the competition levels (*i.e.*, according to (16)) and plays according to this. At equilibrium,

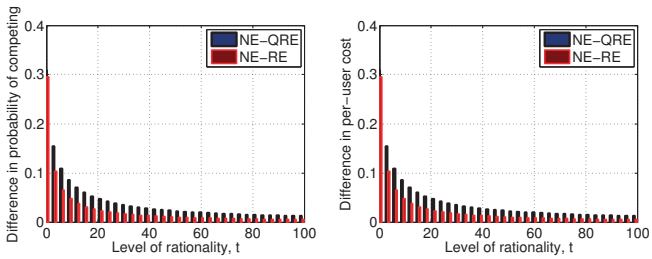


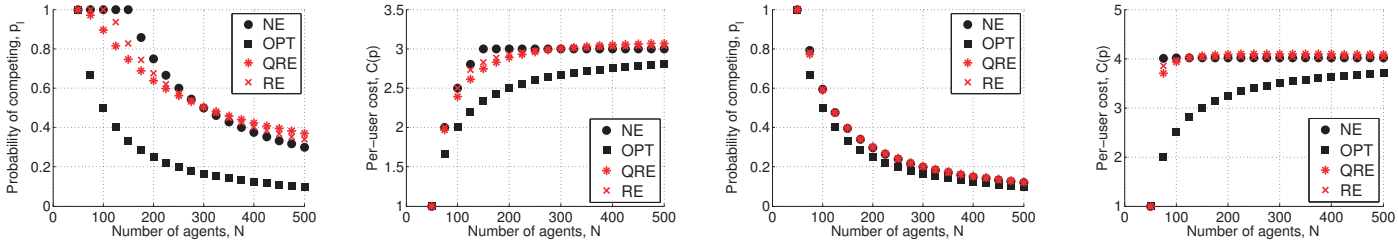
Figure 5: Difference between the probability of competing in the Quantal Response, Rosenthal equilibria and that in Nash equilibrium (left) and the resulting per-user cost difference (right), for $R = 50, N = 180$, under fixed charging scheme $\beta = 3, \gamma = 4$ and $t = [0.1, 100]$ (from imperfect to perfect rationality).

the beliefs that formulate the competition level match the actual choice probabilities, as in Section 5.2.

Interestingly, this trivial modelling approach leads to near-optimal results. Unlike CPT or the alternative equilibrium solutions, it does not take into account the charging costs. Yet, this reasoning mode expresses a pessimistic attitude that takes for granted the failure in a possible competition with competitors that outnumber the resources. As a result, it implicitly seeks to avoid the tragedy of common effects and hence, eventually, yields a socially beneficial solution.

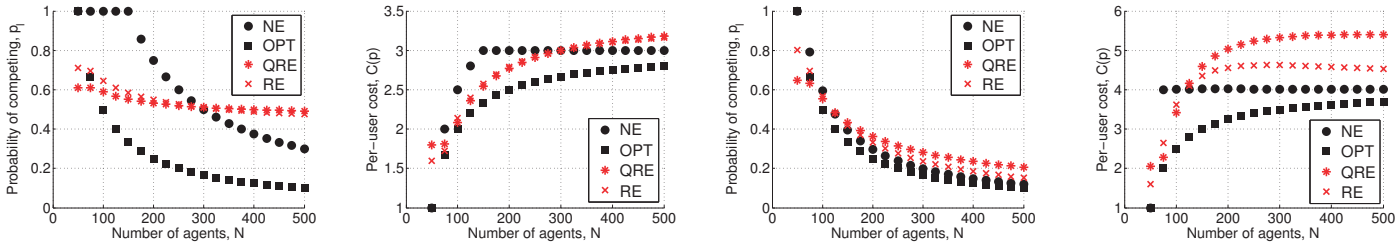
6. CONCLUSIONS

In this study, we consider environments where the tragedy of commons effects emerge on a limited-capacity set of inexpensive resources. Agents choose independently to either compete for these resources running the risk of failing the competition and having to take an unlimited, yet more ex-



a. $\beta = 3, \gamma = 4$ b. $\beta = 3, \gamma = 4$ c. $\beta = 4, \gamma = 20$ d. $\beta = 4, \gamma = 20$

Figure 3: Probability of competing in the Quantal Response and Rosenthal equilibria and the resulting per-user cost, for $R = 50$, $t = 3$.



a. $\beta = 3, \gamma = 4$ b. $\beta = 3, \gamma = 4$ c. $\beta = 4, \gamma = 20$ d. $\beta = 4, \gamma = 20$

Figure 4: Probability of competing in the Quantal Response and Rosenthal equilibria and the resulting per-user cost, for $R = 50$, $t = 0.2$.

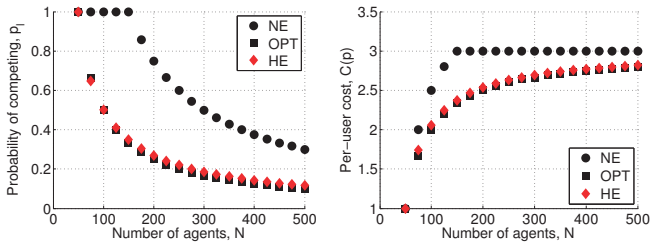


Figure 6: Probability of competing in heuristic equilibrium (left) and the resulting per-user cost (right), for $R = 50$, under fixed charging scheme $\beta = 3, \gamma = 4$.

pensive option after paying a penalty cost, or prefer from the beginning the more secure but expensive option. In their decisions, they consult (or not) information about the competition level (*i.e.*, demand), the supply (*i.e.*, capacity) and the employed pricing policy on the resources. This content might be available through ad-hoc/opportunistic interaction or broadcast from the resource operators, through information assistance systems.

Drawing insights from cognitive science, we assess how cognitive heuristics/biases affect the efficiency of real-life resource selection applications, yet without assessing the exact relevance of the heuristics/biases in particular application paradigms. Bayesian and pre-Bayesian variants of the strategic resource selection game are investigated to express incompleteness in agents' knowledge, while people's biased behavior within the particular competitive environment is captured via the Cumulative Prospect Theory framework. We view the two resource alternatives, in particular, as prospects and verify numerically the agents' risk-prone attitude under particular charging schemes on the resources. Alternative equilibria solutions (Rosenthal and Quantal Response) model the impact of people's time-processing limitations on their decisions, inline with Simon's argument that humans are satisficers rather than maximizers. We tune the rationality parameter in the Rosenthal and Quantal Response equilibria, to model agents of different rationality levels and thus, different degrees of responsiveness to various cost differentials between the two resource options, ranging from pure guessing to perfectly rational reasoning (Nash equilibrium). We identify environments where the impaired reasoning, as expressed by the two alterative equilibrium concepts, leads to less costly choices compared to the Nash solutions. In the more radical approach, the agents decide heuristically based on the estimated probability to win the competition for the low-cost resources. Interestingly and unlike the other models, the heuristic decision-making results in near-optimal per-user/social cost, albeit far from what the perfect rationality yields. Starting from these results, our intention is to explore scenarios with a richer mix of agent behaviors, catering for various expressions of rationality that interact with each other. This takes us to more advanced models such as the "cognitive hierarchy" in [7] with different distributions for the complexity level of agents' reasoning.

7. ACKNOWLEDGEMENTS

This work has been supported in part by the European Commission IST-FET project RECOGNITION (FP7-IST-257756) and the European Commission under the Network of Excellence in Internet Science project EINS (FP7-ICT-288021).

8. REFERENCES

[1] http://sfpark.org/.

[2] Parkomotivo: parking system for the city of Lugano, available online in http://www.bmob-park.com.

[3] I. Ashlagi, D. Monderer, and M. Tennenholtz. Resource selection games with unknown number of players. In *Proc. AAMAS '06*, Hakodate, Japan, 2006.

[4] E. Avineri and J. Prashker. Violations of expected utility theory in route-choice stated preferences: The certainty effect and inflating of small probabilities. *Transportation Research Record*, 2004.

[5] A. S. Booij, B. M. V. Praag, and G. V. D. Kuilen. A parametric analysis of prospect theory's functionals for the general population. *Theory and Decision*, 68, 2010.

[6] E. Brandstätter, G. Gigerenzer, and R. Hertwig. The priority heuristic: Making choices without trade-offs. *Psychological Review*, 113, 2006.

[7] C. F. Camerer and E. Fehr. When does "economic man" dominate social behavior? *Science*, 2006.

[8] Y. Chen, X. Su, and X. Zhao. Modeling bounded rationality in capacity allocation games with the quantal response equilibrium. *Management Science*, 58, 2012.

[9] D. G. Goldstein and G. Gigerenzer. Models of ecological rationality: The recognition heuristic. *Psychological Review*, 109(1):75–90, 2002.

[10] J. Golias, G. Yannis, and M. Harvatis. Off-street parking choice sensitivity. *Transportation Planning and Technology*, 25, 2002.

[11] D. V. D. Goot. A model to describe the choice of parking places. *Transportation Research Part A: General*, 1982.

[12] R. A. Griggs and J. R. Cox. The elusive thematic-materials effect in Wason's selection task. *British Journal of Psychology*, 73, 1982.

[13] G. Hardin. The tragedy of the commons. *Science, New Series*, 162(3859):1243–1248, 1968.

[14] C. Hasan, E. Altman, J.-M. Gorce, and M. Haddad. Non-cooperative association of mobiles to access points revisited. In *Proc. 10th Inter. Symposium on Modeling and Optimization in Mobile, Ad Hoc and Wireless Networks (WiOpt)*, Paderborn, Germany, 2012.

[15] E. Kokolaki, M. Karaliopoulos, and I. Stavrakakis. Leveraging information in vehicular parking games. Technical report, Dept. of Informatics and Telecommunications, Univ. of Athens, 2012. `http://cgi.di.uoa.gr/~evako/tr1.pdf`.

[16] E. Kokolaki, M. Karaliopoulos, and I. Stavrakakis. On the efficiency of information-assisted search for parking space: a game-theoretic approach. In *Proc. 7th International Workshop on Self-Organizing Systems*, IFIP IWSOS'13, Palma de Mallorca, 2013.

[17] A. Koriat. Dissociating knowing and the feeling of knowing: Further evidence for the accessibility model. *Journal of Experimental Psychology: General*, 124, September 1995.

[18] R. C. Larson and K. Sasanuma. Congestion pricing: A parking queue model. *Journal of Industrial and Systems Engineering*, 4(1):1–17, 2010.

[19] R. McKelvey and T. Palfrey. Quantal response equilibria for normal form games. *Games and Economic Behavior*, 1995.

[20] R. Rosenthal. A bounded-rationality approach to the study of noncooperative games. *Int. J. Game Theory*, 1989.

[21] L. J. Schooler and R. Hertwig. How forgetting aids heuristic inference. *Psychological Review*, 112(3), July 2005.

[22] H. A. Simon. A behavioral model of rational choice. *The Quarterly Journal of Economics*, 69(1), 1955.

[23] H. A. Simon. Rational choice and the structure of the environment. *Psychological Review*, 63, 1956.

[24] P. M. Todd, G. Gigerenzer, and the ABC Research Group. *Ecological Rationality: Intelligence in the World*. New York: Oxford University Press, 2012.

[25] A. Tversky and D. Kahneman. Advances in prospect theory: cumulative representation of uncertainty. *Journal of Risk and Uncertainty*, 5, 1992.

[26] A. Tversky and D. Kahneman. *Judgment under Uncertainty: Heuristics and Biases, Science, New Series*, 185, September 1974.

[27] R. Yang, C. Kiekintveld, F. Ordonez, M. Tambe, and R. John. Improving resource allocation strategy against human adversaries in security games. In *Proc. of the 22th Inter. Joint Conference on Artificial Intelligence*, IJCAI'11, 2011.

What's your favourite online research tool?

Use of and attitude towards Web 2.0 applications among scientists in different academic disciplines

Daniela Pscheida, Thomas Köhler & Bahaaeldin Mohamed
Media Center, Dresden University of Technology
Dresden, Germany
Daniela.Pscheida@tu-dresden.de / Thomas.Koehler@tu-dresden.de /
Bahaaeldin_Khairy_Farag.Mohamed@tu-dresden.de

***Abstract*— Web 2.0 and digital online technologies have and will change the practice of academic work by allowing multi-faceted cooperation among scientists. However, we neither know in detail how exactly to design such academic collaboration, nor what changes result for scientific workflows. We also know very little about the actual extent of Web 2.0 applications' usage among scientists in different academic disciplines. Yet only dedicated knowledge of the status quo can be a suitable basis for further analysis and the development of appropriate support services. The paper presents empirical results of a recent online survey of scientists at Saxon universities and colleges. The analysis particularly covers interdisciplinary differences in the use of various applications, as well as in attitudes toward the use of Internet and Web 2.0 in the context of science.**

***Index Terms*— e-science, e-research, Web 2.0 applications, online tools, usage behaviour, attitude, academic cooperation, research network**

I. Introduction

Over the past few years, Web 2.0 and digital online technologies have penetrated more and more into the realm of academic work. Even if most of the professionals in academia are still far from the mode of 'Cyberscience' [3], the increasing importance of new ways of communication and social networking within the scientific community are already obvious [4]. Still, we know very little, however, about which online tools are adopted by scholars in the context of their work for different purposes. Recent studies have repeatedly pointed to several reservations, such as high 'adoption costs' like time investment, a lack of information, or unclear recognition mechanisms, when it comes to the use of blogs, wikis or other collaborative formats [1]; and therefore state a rather low-key image in this respect. Nor do we know how the use of Web 2.0 applications is changing existing practices and processes of scientific research or how to develop entirely new usage patterns [6]. The aspect of increased cooperation between scientists in this context is certainly an important key [7]. While a close collaboration between several researchers is quite common in some disciplines, the increasing need to provide networked collaborative research in other subjects still represent a major challenge [8]. A study published by Harley et al. in 2010 points to the discipline-specific needs and practices of science communication in seven selected disciplines and shows relevant differences between history and astrophysics for example [2].

It is therefore necessary to understand, first of all, how scientists from different academic disciplines use Web 2.0 and digital online technologies in their everyday work and how this use shapes the scientific work and the process of doing research. That seems to be the only way to make reasonable predictions about the future development of the scientific system in the digital age and to derive recommendations and provide support for its adoption. However, the basis of all these investigations and considerations must be initially a detailed analysis of the current use of various applications by scientists. The research presented in this paper is only the first step of further quantitative and qualitative research in that field currently done in Saxony.

II. The eScience – Research Network Saxony

Digital publications, online repositories and virtual collaboration are just a few examples of topics that stepwise shape the present and future activities of scientists. The 'e' in front of more and more concepts especially in the academic context is not only for its simplicity, speed, and efficiency through the strategic use of ICT; it stands more and more often for a continuing transformation of these terms and associated concepts and processes. To support the modified working- and knowledge society of the 21st century and to strengthen the international competitiveness of Saxony's research community in the long term, the *eScience – Research Network Saxony* was founded in October 2011.

The *eScience – Research Network Saxony* is a joint project of all universities and colleges in the German federal state Saxony, funded by the European Commission together with the local Ministry of Science. The goal is to trigger both, basic research on differentiated approaches and methods of e-science plus the development of appropriate tools and practices among scientists. Therefore the concept of e-science is used in a broad understanding.

In more detail, the term e-science can be understood both as ‚electronic science' as well as ‚enhanced science' and goes back to John Taylor, former Director General of the UK Research Council, who thereby described an emerging revolution in science in 1999. Even though the term e-science

primarily aimed at the natural and technical sciences (data-intensive science) [9], the *eScience – Research Network Saxony* also explicitly addresses the social sciences and humanities. And it also includes changes coming up through new possibilities of communication, interaction and collaboration on the Internet [4]. E-science thus describes the expansion of academic activities through the integration of information and communication technologies in all areas and disciplines of scientific research, communication and dissemination of knowledge.

The project *eScience – Research Network Saxony* has two central concerns: The first goal is about bringing together qualified scientists that conduct cooperative research on the topic of e-science. This is done by specifying three thematically different research clusters focusing on the topics e-business, e-learning and e-systems. In each of the three clusters several smaller, mainly individual research projects are processed, which merge at the level of the overall network including a broad portfolio of relevant issues (including modelling and visualization of research processes, knowledge representation and management, mash-ups and security systems, collaboration and cooperation strategies, adoption, accessibility, e-assessment and e-portfolios) as shown in figure 1. While some of the issues are closely linked to a certain cluster perspective, other topics are in the focus of several projects coming from different clusters.

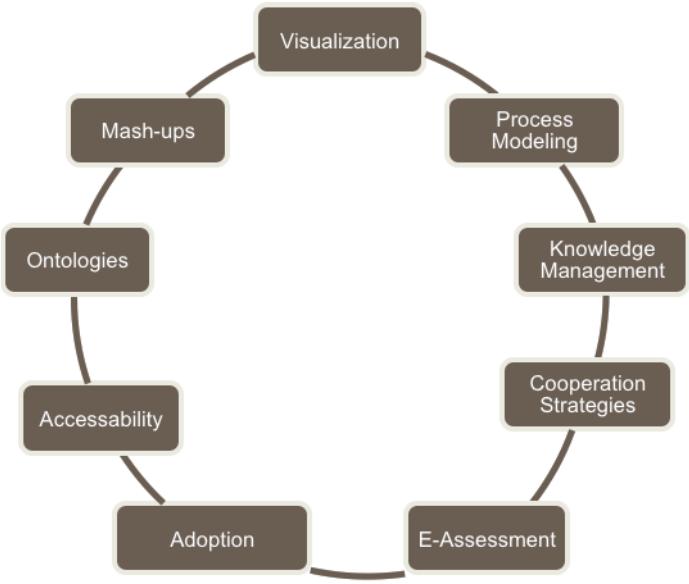


Fig. 1. Principal research topics of the eScience – Research Network Saxony

The cluster e-business (lead by the Technical University of Freiberg) focuses on distributed problem solving and decision support. Core subject of the cluster is to investigate collaborative (research) processes as well as analytical methods and tools. Based on the findings the cluster wants to deduce scientifically generalized explanation patterns and to give recommendations for the economic and scientific realm.

The cluster e-learning (led by the Technical University of Dresden) discusses the role of electronically supported teaching and learning processes in the context of digitization of science. The focus is on the further development of higher education through a tighter coupling between research and knowledge transfer. In addition, the e-learning cluster deals with general aspects of current shifts in academic practices, skills and structures across all academic disciplines.

The cluster e-systems (led by the University of Technology, Economy and Culture in Leipzig) connects scientists and researchers in the fields of ICT and digital media. The focus is on the selection and development of Web 2.0 technologies and applications for the creation of virtual research groups, the planning and execution of experiments and collaborative data analysis, the development of searchable knowledge bases, the joint production of reviews and publications, and to perform calculations, simulations, and demonstrations in cluster clouds.

A second concern of the *eScience – Research Network Saxony* is the sustainable development of a platform for academic working. The prototype of this platform is online since late June 2012 and has been continuously improved. The eScience-platform should become both a work and documentation platform and will provide relevant data for the analysis of activities and processes taking place within interdisciplinary collaborative work. However, as it is planned to provide the platform later on not only for the participating cluster projects but for all interested researchers from all academic disciplines, it is important to learn more about the daily online-routines and experiences of scientists and to find out what is influencing their digital behaviour and interests. Moreover it is interesting looking at possible differences between academic disciplines.

III. Methodology

This paper deals with the first results of a multi-method study run by the coordination of the *eScience –Research Network Saxony*: In the context of the network, a survey of Saxon researchers to measure the use of various digital online tools was completed in May 2012. The survey was conducted using an online questionnaire programmed in Unipark and consisted of two main question areas as well as a demographic section.

In the first part respondents were interviewed about their usage of various Web 2.0 applications and some other digital online technologies. As to assure a consistent understanding of the terms we mentioned two well-known examples for each application. Besides the general frequency of use, the purpose and context of use were also requested.

The second part measured the attitude towards the use of Web 2.0 in academic work. Four scales of an existing questionnaire for the assessment of computer-related attitudes (FIDEC) have been adapted and adjusted to the topic of Internet/Web 2.0 applications. The FIDEC questionnaire is part of the revised inventory to computer literacy (INCOBI-R), which was developed by Naumann, Richter, and Horz in 2010 and consists of eight different scales built by a combination of three dichotomous distinctions. The scales differentiate their content from each other using 8-10 items, which are collected for each. Thus, a so-called facet design is created on the

aspects of (I) computer as an object of personal experiences vs. social implications of computer, (II) computer for learning and work vs. computer for entertainment and communication, and (III) computer as useful tool vs. computer as tease machine [5]. For the survey conducted in the *eScience – Research Network Saxony*, however, we used only the four scales of the aspect of "computer as an object of personal experiences", which include a total of 38 items. All the items were adjusted to the terminology "Web 2.0" or "Internet", which replaced the concept of "computer", and the scales were adopted accordingly. The result of a pre-test showed that this adaption was possible without losing consistency within the scale of the measuring instrument. Table 2 shows some examples of the scale items. Participants were asked on a five-tiered Likert scale (from 1=agree to 5=disagree) to measure their level of agreement of an item indicated.

TABLE I. SCALE NAMES AND ITEM EXAMPLES OF THE FIDEC ATTITUDE MEASUREMENT

Scale name	Item example
I: Learning and work/ useful tool	*There are many tasks that I can solve easier and perform faster with the use of Web 2.0 applications.*
II: Learning and work/ tease machine	*Web 2.0 applications are too unreliable to use them as aids in my academic work.*
III: Entertainment and communication/ useful tool	*Web 2.0 applications offer varied opportunities for communication and scientific exchange.*
IV: Entertainment and communication/ tease machine	*I think it's dangerous to present me and my scientific work on the Internet.*

The questionnaire was given to scientists operating at all state universities, colleges, and academies of art and music in Saxony. The sample consists of an estimated 16.000 subjects, though certainly not all scientists had been reached. 1.178 persons attended the survey, while a total of 765 respondents finally completed the questionnaire.

IV. EMPIRICAL FINDINGS

The vast majority of the survey participants belong to the four academic sections[1] Engineering (41.4%), Social Sciences/Economics/Law (17.8%), Mathematics/Natural Sciences (14.2%) and Arts and Humanities (11.9%), which are therefore considered specifically as shown below in table II.

Particularly striking is the especially high number of respondents from the Engineering, which is typical of the range of subjects of the scientific profile in Saxony. Similarly the majority of academic staff across all disciplines belongs to the status group of research fellows (70.2%) and doctoral scholars (35.9%). The overlap is explained by some multiple answers because in the German academic system scholars may belong to both groups. Additionally, a greater proportion of the respondents belong to the group of professors, with 12.7 percent.

A. Usage of Web 2.0 tools

The analysis of the use of Web 2.0 tools in the context of science as already mentioned often ignores how often an application is actually used in practice. In many cases an application runs without the knowledge of such information about potential considerations and possible changes of academic procedures. In the case of the *eScience – Research Network Saxony*, the data collection also serves as the first step to learn about the usage patterns in the Saxon scientific community.

TABLE II. SAMPLE OF THE ONLINE SURVEY

	Engineering		Social Sciences/ Economics/Law		Mathematics/ Natural Sciences		Arts and Humanities		Total	
	Num.	%	Num.	%	Num.	%	Num.	%	Num.	%
Gender										
Male	241	31.5	70	9.2	72	9.4	35	4.6	**473**	**61.8**
Female	70	9.2	66	8.6	35	4.6	54	7.1	**275**	**35.9**
Not specified	6	0.8	0	0.0	2	0.3	2	0.3	**17**	**2.2**
Average	**317**	**41.4**	**136**	**17.8**	**109**	**14.2**	**91**	**11.9**	**765**	**100**
Academic status*										
Research assistant	2	0.3	7	0.9	2	0.3	8	1.0	31	4.1
Research fellow	253	33.1	93	12.2	65	8.5	61	8.0	537	70.2
PhD student	118	15.4	57	7.5	34	4.5	32	4.2	275	35.9
Post Doc	26	3.4	13	1.7	13	1.7	4	0.5	64	8.4
Assistant professor	4	0.5	2	0.3	1	0.1	1	0.1	11	1.4
Associate professor	2	0.3	1	0.1	3	0.4	2	0.3	9	1.2
Professor	30	3.9	20	2.6	19	2.5	13	1.7	97	12.7
Emeritus	0	0.0	0	0.0	0	0.0	1	0.1	1	0.1
Other	10	1.3	7	0.9	8	1.0	10	1.3	42	5.5
Not specified	0	0.0	0	0.0	0	0.0	0	0.0	4	0.5

* Multiple answers possible

[1] Classification follows the guidelines of the Federal Statistical Office Germany.

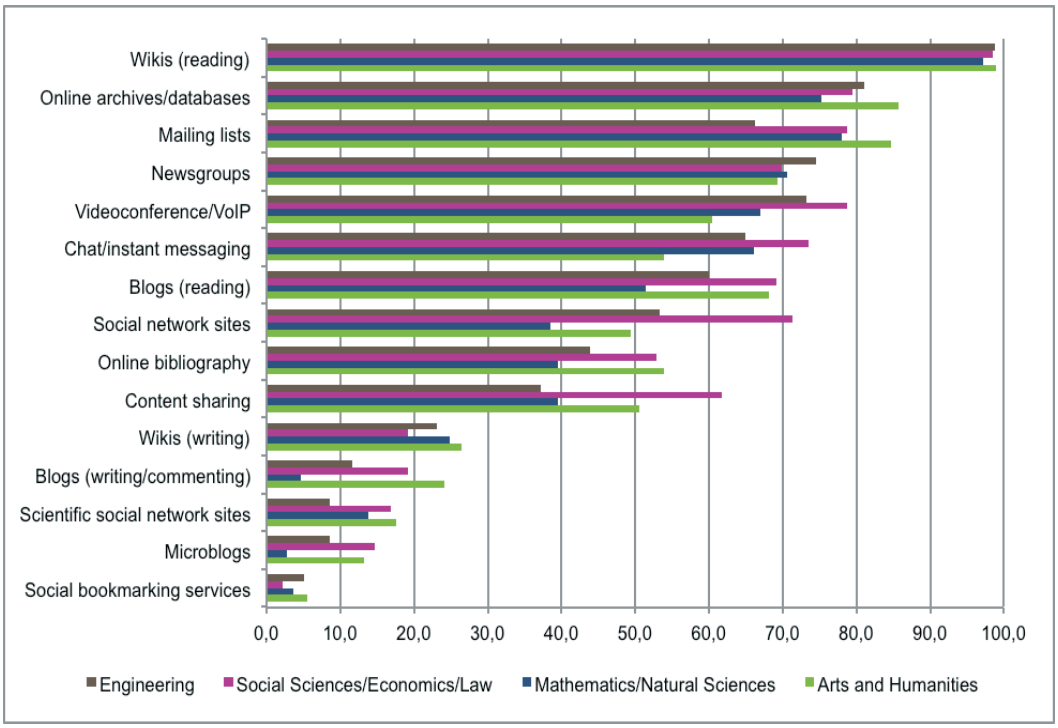


Fig. 2. Usage of Web 2.0 applications

Regarding the use of various Web 2.0 applications as a whole, the favourite is clear: Almost all of the surveyed scientists (98.3%) report the reception of wikis. The next most popular applications are, with some distance, the use of online archives and databases, which are used by 81 percent of respondents. Also popular are mailing lists (72.8%), the use of newsgroups (72%), and the ability to telephone and videoconference via the Internet (71.8%). Microblogs (9.9%) and social bookmarking services (4.6%), or even academic social network sites (12.4%) still play a much more minor role.

It is also striking that, in the strict sense, most collaborative applications - except the reading of blogs and social network sites - are actually used by less than half of respondents, with notable differences between the disciplines.

The subject group of Social Sciences/Economics/Law can be described as zealous users of Web 2.0 applications when looking at the diversity of applications being used (see Fig. 2). There are ten of the applications being used by more than 50 percent of respondents in this group of subjects. The bottom is, on the other hand, the Mathematics and Natural Sciences, with only seven applications with a user base of over 50 percent of respondents. The favourite applications themselves do not differ significantly between the disciplines. Wikis and online archives/databases are preferred applications in all four groups, while mailing lists seem to be not as popular in Engineering as in other subjects.

Moreover, strongly collaborative tools like videoconference/VoIP, chat/instant messaging, social network sites and content sharing are predominantly used by Social Sciences/Economics/Law. While social networking sites are here used by 71.3% of the respondents, in Mathematics/Natural Sciences only 38.5% utilize those services. Regarding the use of social network sites and content sharing by Social Sciences/Economics/Law there is also a positive statistical correlation with high significance (while there is a negative one for Mathematics/Natural Sciences in the first case and for Engineering in the second case) – although all correlations have to me regarded as weak ones (values between -0.126 and 0.159). Furthermore, there is a striking discrepancy with respect to the active use of blogs (commenting and writing) in Arts and Humanities (24.2%) and in Mathematics/Natural Sciences (4.6%). Here, as well, another weak but statistically high significant positive correlation for the Arts and Humanities (0.113) and negative correlation for Mathematics and Natural Sciences (-0.107) could be found.

Looking at the frequency of Web 2.0 applications use, further differences between the four considered disciplines become clear: Table III gives an overview concerning the high intensive (daily or several times weekly) use of different tools (related to those respondents using the tool at all). Again it's content sharing that is used above average by Social Sciences/Economics/Law (53.6%), compared with Engineering (38.1%). Online archives/databases and online bibliography is used with high intense above average by Arts and Humanities (53.8% and 65.3%), compared with Engineering (32.3% and 38.8%). In contrast, the highest intense of the usage of newsgroups can be found in Engineering (50.0%), while in Arts and Humanities only 34.9 percent use newsgroups daily or several times a week.

TABLE III. HIGH INTENSIVE USE OF WEB 2.0 APPLICATIONS BY DISCIPLINES (DAILY AND SEVERAL TIMES WEEKLY)

	Engineering	Social Sciences/ Economics/Law	Mathematics/ Natural Sciences	Arts and Humanities	Average
Wikis (reading)	76.7	66.4	76.4	75.6	73.3
Online archives/databases	32.3	41.7	30.5	53.8	37.6
Mailing lists	46.7	49.5	50.6	53.2	50.4
Newsgroups	50.0	46.3	37.7	34.9	44.1
Videoconference/VoIP	30.2	34.6	32.9	30.9	31.5
Chat/instant messaging	59.2	58.0	48.6	55.1	56.6
Blogs (reading)	48.4	47.9	42.9	41.9	45.7
Social network sites	63.3	69.1	59.5	64.4	65.0
Online bibliography	38.8	40.3	44.2	65.3	43.6
Content sharing	38.1	53.6	51.2	41.3	43.9
Wikis (writing)	17.8	23.1	7.4	16.7	17.0
Weblogs (writing/commenting)	29.7	23.1	20.0	22.7	22.1
Scientific social network sites	25.9	13.0	13.3	31.3	18.9
Microblogs	37.0	75.0	33.3	66.7	55.1
Social bookmarking services	68.8	66.7	75.0	20.0	60.0

A somewhat different picture of the usage preferences results from the comparative analysis of the use of various Web 2.0 applications especially in the scientific context (to support the scientific work, see Fig. 3). The favourite applications continue to be the reception of wikis (83.9% average) and the use of online archives and databases (76.7% average). Additionally, mailing lists are gaining more relevance (58.3% average). These applications are now the only three, which are used in all subject groups by more than 50 percent of respondents. In Engineering, additionally newsgroups are a fourth application used by more than 50 percent in that group (57.1%). In contrast, online bibliography is used especially in Arts and Humanities (52.7%) as well as in Social Sciences/Economics/Law (52.9%). It is likely that there is a connection to the working methods of these disciplines.

Interesting is to compare the data obtained by using an early 2012 study published by Bader, Fritz, and Gloning titled "Digital Science Communication 2010-2012" [1]. The authors present the results of a Germany-wide online survey of n=1.053 scientists from different disciplines, but with a clear focus in the Humanities and Cultural Studies (41%). Also, they come to the conclusion that mailing lists are a very popular tool in science. A total of 64 percent of the survey respondents use, as part of their scientific activity, mailing lists, including 73 percent in the Humanities and Social Sciences, 53 percent in the Natural Sciences, and 48 percent in the Life Sciences (cf. ibid., pp. 40f). The type of use varies greatly. 56 percent of the respondents used mailing lists to provide information on upcoming events, while only 24 percent of respondents also use this to communicate with colleagues.

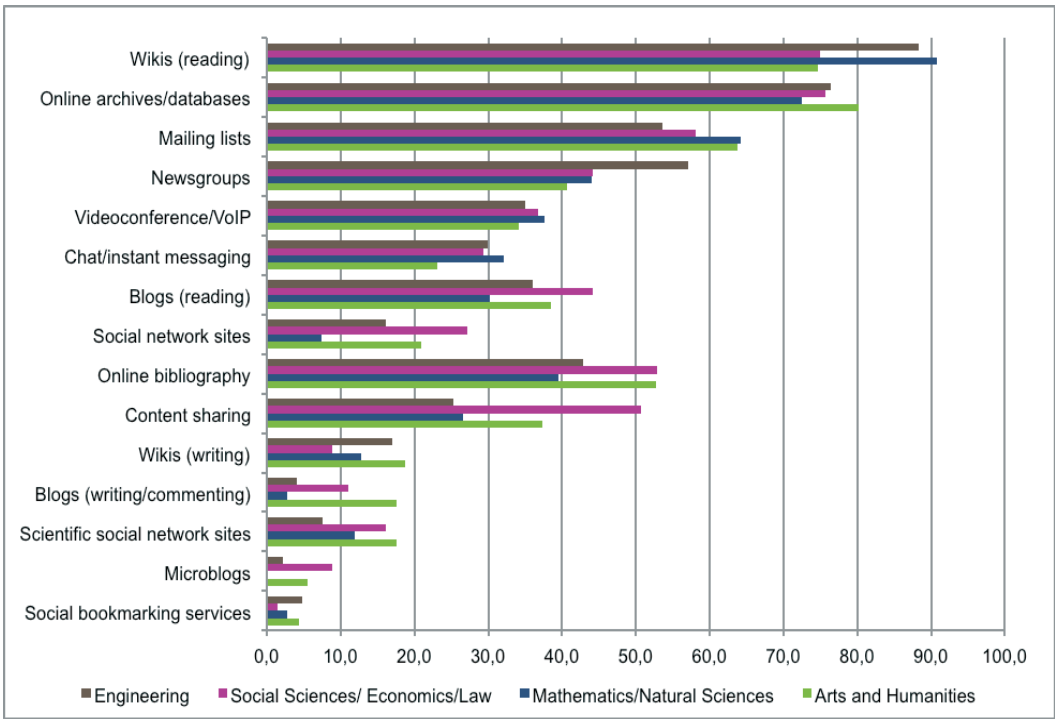


Fig. 3. Usage of Web 2.0 applications for academic purpose

For a discussion of scientific theories or research results before publication, just three percent of respondents use mailing lists (ibid, pp. 42ff.). While these results largely coincide with those of our survey, in terms of the scientific use of blogs significant differences are to detect. Consequently Bader, Fritz and Gloning (p. 68) note that "blogs only play a marginal role in the German science communication". In fact, in their survey, only 8 percent of the sample makes use of blogs in any way as part of their scientific activity (cf. ibid.). In our sample, however, up to 37.5 percent of respondents made use of blogs – at least concerning the passive use of blogs – which signifies a much more intensive use. For the question of the active use we get a comparable value (7.2%), albeit with significant differences between the subject groups. The differences measured also confirm something similar to our study: 26 percent of scientists coming from Philosophy are blog users, while among Natural and Social Scientists only 14 percent report using blogs (p. 70).

B. Attitude towards Web 2.0 in academic work

The mean values of the four scales compared between the four disciplines considered here show, at first glance, only a few differences. The values are essentially in the middle range between 2=tend to agree and 4=tend to disagree (see Fig. 4).

The graph with low values at the positive connotations of scale and high values for the two scales referring to negative connotations shows a tendency to have a positive attitude towards the use of Web 2.0 applications in academic work. This is the same in all four disciplines considered here. In comparing the four groups, one can account for a slightly more positive view of the subject areas Social Sciences/Economics/Law and Arts and Humanities as compared to the Mathematics/Natural Sciences and Engineering, especially in the two positive connotations scales. An ANOVA test here also revealed that the differences in responses of these two scales (Web 2.0 for learning and work as a useful tool/ Web 2.0 for entertainment and communication as a useful tool) are highly statistically significant. This fits with the total of more intensive use of Web 2.0 applications.

II. Conclusions

Even though the measures described are based on the academic situation in Saxony, due to the representativeness of the data also further conclusions concerning German science can be drawn. Nevertheless, international comparisons would be interesting and fruitful. Moreover, a closer look to what is done (e.g. what tool is used for what task) and what is demanded by scientists is needed. The “eScience – Research Network Saxony” with its field sample of R&D projects may deliver a deepened understanding to these questions.

To develop a more detailed insight, in a next step it is planned to examine which factors play a key role by using guided interviews. Discipline might be one, but – as shown here – probably not the most important. What impact, for example, has the frequency of cooperative project work and to what extent do personal career aspirations influence the usage of certain online tools?

Acknowledgment

We thank the central development agency of the Free State Saxony (SAB) and the Saxon State Ministry of Science and Art (SMWK) as well as the European Union for the generous financial support of the “eScience – Research Network Saxony”.

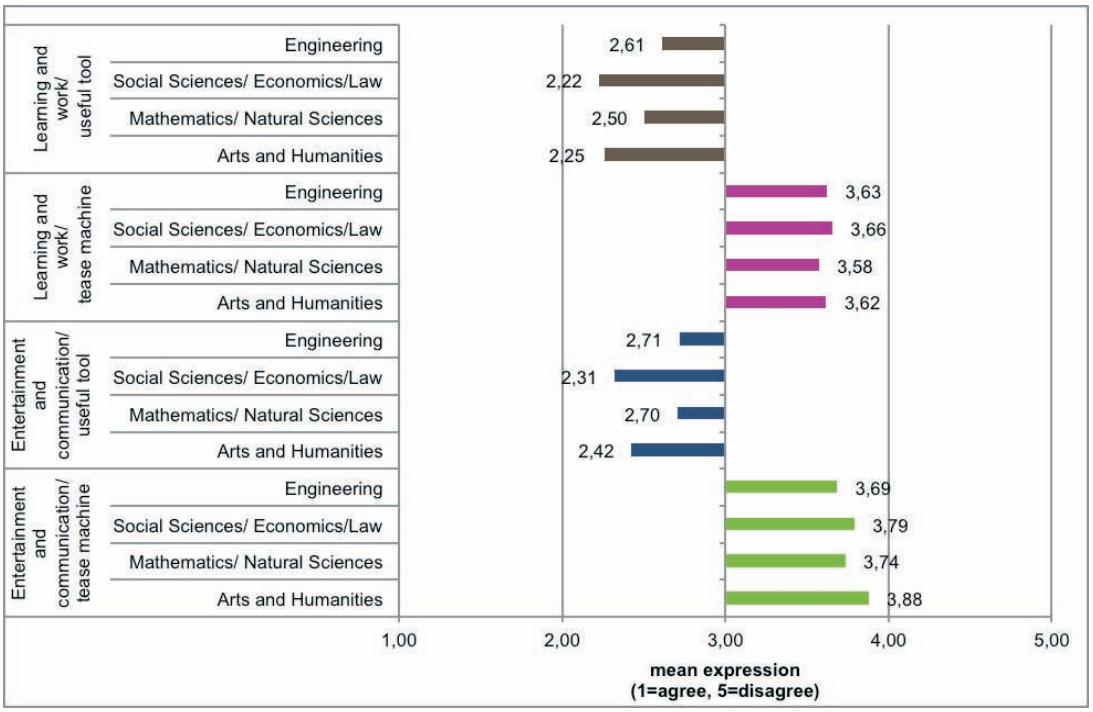


Fig. 4. Attitude towards Web 2.0 usage in academia by discipline

References

[1] A. Bader, G. Fritz and T. Gloning, Digitale Wissenschaftskommunikation 2010-2011, Eine Online-Befragung, Gießener Elektronische Bibliothek, 2012, online: http://geb.uni-giessen.de/geb/volltexte/2012/8539/

[2] D. Harley, S.K. Acord, S. Earl-Novell, S. Lawrence, C.J. King, Assessing the Future Landscape of Scholarly Communication, An Exploration of Faculty Values and Needs in Seven Disciplines, Center for Studies in Higher Education, University of California Berkeley, 2010, online: http://escholarship.org/uc/item/15x7385g

[3] M. Nentwich, Cyberscience, Research in the Age of the Internet, Wien: Austrian Academy of Sciences Press, 2003.

[4] M. Nentwich and R. König, Cyberscience 2.0. Research in the Age of Digital Social Networks, Frankfurt a.M.; New York: Campus, 2010.

[5] T. Richter, J. Naumann and H. Horz, Eine revidierte Fassung des Inventars zur Computerbildung (INCOBI-R) 2010, Pre-Print, online: http://www.uni-kassel.de/fb01/fileadmin/groups/w_270518/pub_richter/Richter_Naumann_Horz_inDruck.pdf

[6] M. Weller, The Digital Scholar, How Technology is Transforming Scholarly Practice, London: Bloomsbury Academic, 2011.

[7] T. Köhler and N. Kahnwald, Virtual Enterprises, Research Communities & Social Media Networks, Dresden: TUDpress. 2012.

[8] B. Mohamed and T. Köhler. The effect of project based web2.0 learning on student outcomes. In: Sampson et al.: Towards Learning and Instruction in Web 3.0. Advances in Cognitive and Educational Psychology, New York: Springer, 2011.

[9] T. Hey, S. Tansley and K. Tolle, The Fourth Paradigm. Data-intensive Scientific Discovery, Redmond: Microsoft Research, 2009.

[10] Pscheida, D. and T. Köhler (unter Mitarbeit von Steve Federow und Selina Hohenstatt). Wissenschaftsbezogene Nutzung von Web 2.0 und Online-Werkzeugen in Sachsen 2012. Dresden: TUDpress, 2013.

Poster session

Chaired by Melanie Dulong de Rosnay, CNRS/ISCC

Challenges and Opportunities for Integrating Open Energy Data Sources

Chris Davis*, Gerard P.J. Dijkema*
*Faculty of Technology, Policy and Management, Delft University of Technology
{c.b.davis, g.p.j.dijkema}@tudelft.nl

***Index Terms*—Open Data, Energy, Linked Open Data, Entity Matching**

***Abstract*—There is growing interest in the topic of Open Data as many governments are taking steps to increase the availability of datasets whose collection the public has already paid for. Aside from the value of simply having the data available, further value can be realized by combining data from multiple sources that contain different facts about the same topics or entities, thus allowing us to gain a more comprehensive view. This vision is being realized with efforts on creating Linked Open Data. In our work on trying to achieve this vision within the energy domain, we have found that the way in which many data sets are managed leads to difficulties in matching the entities described. Unique identifiers are frequently lacking, radically different names may exist for the same entity, and different levels of abstraction or aggregation may be employed.**

Issues such as these lead to fundamental inefficiencies in the life cycle of data. This likely directly effects the organizations responsible for compiling the data, as they also must deal with disambiguating the various sources they use in their own work. This also has implications for the accuracy of the data as it is it can be very tedious to perform an independent verification. The ability to perform quality control checks involving cross-comparison of datasets could aid this, but requires significant preparation and cleanup work. While we support the vision of Linked Open Data and find the tools supporting it to be very powerful, in practice, we have found significant issues with data sets that need to be addressed for this vision to be realized for energy data.

In this paper we outline our experiences in trying to link together data about European power stations and discuss various strategies that can enable us to address the issue of improving our ability to link these datasets via both automation and crowdsourcing techniques.

I. Introduction

Concerns about climate change, the costs and availability of fuel sources, and a resulting desire to utilize more renewable energy are several factors that are driving change within the large scale electricity infrastructure that powers society. Having accurate and comprehensive data about this system is important since infrastructure such as power stations is often in service for several decades due to the significant sunk costs and the major financial resources needed for new development. As a result, changing the ways in which we power society can take decades.

If we want to understand the ways in which we could achieve a transition, it is useful to first have information about several aspects of the system that allow us to infer which types of interventions may be most effective. For example, if one wants to see a shift in the types of fuels used for electricity production, it is useful to know how old the existing power plants are. If most of the portfolio is several decades old, then it is quite likely that numerous plans are being created to build new ones. It is also useful to be able to examine the growth of distributed power generation and understand the degree to which this is linked to particular policies and incentives. Additionally, information about the efficiency by which a power station is able to convert the energy contained in fuel to electrical energy is rarely found in a single data source. Even if the actual number is not published, a range of plausible values can be determined by gathering data from multiple sources which document aspects such as the construction year and fuel type.

The ability to integrate together data from multiple sources can also enable us to more easily perform quality control checks. If we are able to see that certain facts agree, then there is a reasonable chance that the data may be accurate, while if they disagree, this event can be used to raise flags that direct people to understand the source of the discrepancy. More sophisticated checks can be performed based on certain aspects that can be inferred from other properties.

We believe that part of the challenge is that there appears to be a disconnect between the reasons for which the data is published and the reasons for which it is used. The majority of information is in the private domain (i.e. known by the operators of the facilities), and it takes government initiatives that aim to solve a policy problem to bring this data into the public domain. In other words, data is often gathered and published for a single use case, but arguably the ways in which the data can be used are not limited to a single use case. Information about the power industry is not just useful to a single party, but to multiple groups such as investors, academics, policy makers and consultants. Increasing the value of the data for society also means enabling consumers of data to link it in ways in which they see fit based on their own needs and interests. The

impression we have from our experience in working with open energy data is that there seems to be more of a focus on complying with a mandate to collect and publish the data, and not enough attention on how to enable the creation of additional value for purposes the data publishers may not have been thought of.

II. Example Difficulties in Linking Data

A primary difficulty faced is that for power plants, there are often no standard identifiers or even naming conventions, leading to situations where a single plant may commonly be referred to by multiple names. Furthermore, within a single power plant, old units may be decommissioned and new units can be built over time, meaning that the exact definition of an entity can change. It can also be difficult to figure out what is actually included in the definition of an entity, and whether different entities consist of different types of overlap or subsets. For example, one dataset may count all CO_2 emissions, while another may only count CO_2 emissions from fossil fuel sources, meaning that units that burn biomass for fuel may be left out of one dataset.

A useful example of the difficulties encountered is the Wilton Power Station owned by the UK company Sembcorp Utilities. Built in 1952 and with a total electrical capacity of 360 MW, it has been operating long enough and is of a large enough capacity that it will show up in any database on power stations in the UK. Depending on the dataset that one is looking at, Wilton Power Station may refer to a group of power stations at the same industrial site, or it may refer to the original (and largest) power station which was built on the site in 1952. Already, we see that this can lead to confusion about the level of aggregation that is used.

Figure 1 gives a brief overview of the nature of the data on this plant contained within different data sources. The top part of the image shows what we actually know about the composition of the site through researching it. The boxes shown below this indicate whether each of the different data sources investigated contains aggregated data about the entire site, or if it contains data that can be traced to the individual units on the site. Some of the sources shown are not discussed below. In particular, DECC refers to the UK's Department of Energy and Climate Change DUKES (Digest of UK Energy Statistics)[1] data. Carma.org[2] is a project documenting global power plants, which uses a stripped-down subset of the commercial Platt's UDI World Electric Power Plants Database[3], combined with data from several public sources. It is interesting to note that Wikipedia is the only source that mentions that a new unit is being planned, and links to a news articles about the proposed plant. This figure was created after going through all the different data sources, and as will be described, figuring out what was described by each source was not always straightforward.

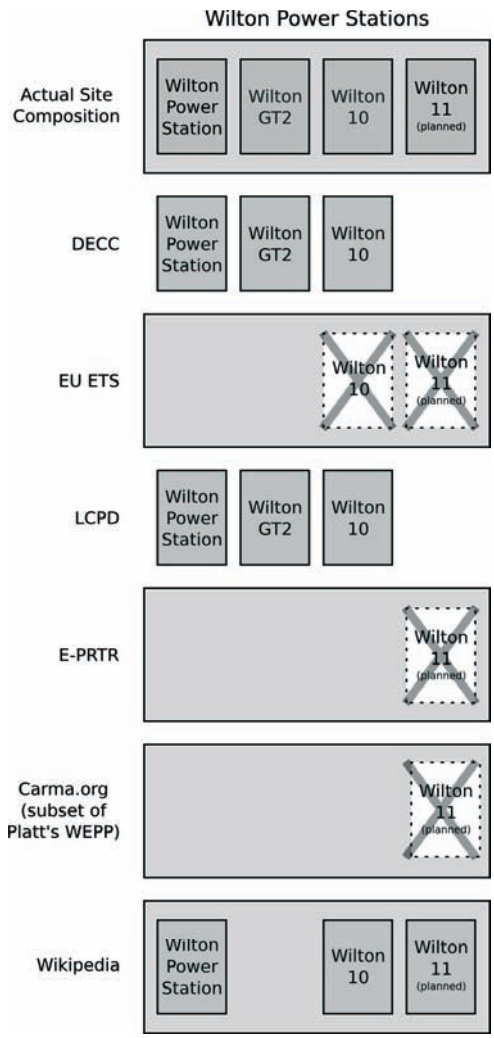


Figure 1. Representation of the Wilton Power Stations site found in different data sources. The large rectangle indicates that aggregated data is available describing the whole site. Smaller rectangles indicate that data is available for that particular unit, while smaller rectangles with an "X" through them indicate that the aggregated data is known to not include data on that unit.

The data sourced from the Large Combustion Plant (LCP) Directive[4] uses a naming scheme that does not match any of the other data sources located, and alignment can only be achieved by looking at the fuel consumption of the different units. For example, what is commonly referred to as "Wilton GT2" is listed in the LCP data as "Sembcorp Utilities U.K Ltd Wilton 3", while the biomass station "Wilton 10" is listed as "Sembcorp Utilities U.K Ltd Wilton 2". The numbers

[1] https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/electricity-statistics

[2] http://carma.org

[3] http://www.platts.com/Products/worldelectricpowerplantsdatabase

[4] http://ec.europa.eu/environment/air/pollutants/stationary/lcp/legislation.htm

in use seem more related to the row numbers in the spreadsheet rather than to the units on the ground. Additionally, the LCP does provide a plant number for each entry, but this changes every year, often along with the name of the plant.

The EU Emissions Trading System (EU ETS)[5] contains aggregated data on CO_2 emissions from the entire site, but this does not include the station burning biomass as it only documents CO_2 emissions from fossil fuel sources. Additionally, the fact that they refer to it as "SembCorp Utlilities [sic] Teesside Power Station" could lead to additional confusion as none of the other data sources located refer to it as "Teesside", and there is another larger power station nearby that is commonly referred to as "Teesside Power Station". The owner name must be used in order to disambiguate it.

The European Pollutant Release and Transfer Register (E-PRTR)[6] also lists the same entity with several different names that change over time. These changes are traceable as they do use unique identifiers for facilities. Two of the names in use are "Sembcorp Utilities (uk) Ltd Wilton Power Station" and "Sembcorp Utilities (uk) Ltd Wilton 10". The latest reporting year (2010) labels identifies this as Wilton 10, which is likely incorrect as we have been able to find no indication that the main plant (commonly referred to as simply "Wilton Power Station") has shut down. Furthermore, the CO_2 emissions estimated in 2010 for this facility in the E-PRTR (791,000 tons) is remarkably close to those recorded in the EU ETS (790,657 tons). The fact that these numbers nearly match is not necessarily a sign of accuracy, as the EU ETS does not record biogenic CO_2 emissions from power plants, and Wilton 10 uses biomass as its primary fuel.

This example is not meant to criticize the people who collect and verify the data, as this task is very tedious and requires large resources and expansive domain knowledge in order to perform correctly. Simply put, it is not an easy task. We also do not want to provoke people to not make data public in order to avoid criticism, as this reaction does nothing to increase the underlying quality of the data and simply perpetuates the problem. Rather, we aim to encourage a discussion and exploration about the practices and tools that can be used to help improve data quality and enable the public at large to gain more value from the open data that is already existing. We want to make it easier for people to spot errors, so that the maintainers are able to leverage a larger population of users who are able to find problems and give feedback on where they exist.

These types of issues are by no means unknown, as work contracted by the UK Department for Environment, Food and Rural Affairs (Defra) on mapping emissions in the UK notes that multiple data sources may record different emissions for the same facility. They note that part of this is due to the different scopes of the permits in each dataset, as there are differences in aspects such as whether they exclude emissions from biofuels or from particular types of installations. Even given this, there is not always a clear reason for why all discrepancies occur, and they note that fully understanding how the scopes of different permits relate to each other "is a major task which would require significant resources to do fully"[1, p. 7].

III. Resource Efficiency of Information

Clearly from this example, the people who collect the data are having difficulties themselves, which has cascading effects as it leads to further difficulties for those who wish to reuse the data. This can be seen as an issue of resource efficiency. While much attention is given to the study of how to manage physical resources, there seems to be much less attention devoted to understanding more efficient ways to manage information resources.

This requires a different mindset as information has different properties than physical resources, in the sense that it does not degrade or diminish as more that people use it. Rather, the more that information is used, the more possibilities it has to improve in quality and comprehensiveness, provided that feedback mechanisms are in place which connect the consumers of the information to those who compile it.

The challenge is that we are trying to centralize information that is naturally distributed. Furthermore, in the case of the electricity system, the knowledge that can detect if information is correct or not is often distributed as well among different parties that have knowledge about the situation on the ground.

IV. Experiences

In our experiences with trying to link together different datasets, there are several commonly encountered issues:

- Names may be misspelled, have completely wrong labeling, or be present in an alternative form.
- Different names may be listed for the owner, due to either a parent company or subsidiary being listed, a change in ownership, or a joint partnership.
- The same name may be used for completely different entities. This can occur if two power stations are in the same general location.
- There may exist different conceptualizations of the same entity. These conceptualizations may be

[5] http://ec.europa.eu/clima/policies/ets/index_en.htm
[6] http://prtr.ec.europa.eu/

subsets or intersections of each other and not a one-to-one matching.

- Entities may split, merge, or mutate over time. This is commonly seen with wind parks, where different sections are built up over time, and may have different names than the name used to describe the collection of parks.

There are several approaches that can be employed to deal with these types of issues. While it is certainly possible to go through the data by hand, this is very time consuming, and it is more efficient to employ some type of automation that can identify possible linkages and areas that need further attention.

The simplest approach is to employ approximate string matching techniques that are able to identify misspellings and measure the similarity between strings. Two string metrics that are commonly employed for this purpose are the Levenshtein and Jaro-Winkler distances. For this technique, all entities from one dataset are compared with all the other entities in another dataset, with comparisons based on their corresponding data fields such as name and owner, etc. The highest scoring comparisons are then recorded and returned to the user to indicate the top candidates for an actual match. For large datasets, the requirement to match all permutations of entities contained in the different sources can lead to a combinatorial explosion, which can be managed by only comparing entities within the same country or within a specified geographic radius.

V. Platform & Implementation

This work on linking datasets is part of our larger effort in developing Enipedia.tudelft.nl[7]. This site is an ongoing exploration of the opportunities that are arising around open data. In particular, we aim to leverage the convergence of several trends: an increasing amount of open data, and the increasing sophistication of interactive data visualization tools and collaborative tools such as semantic wikis. The background and implementation of this project is described further in [2, Chapter 9][8]. The overall guiding vision has been to create an open online collaborative platform for energy data and encourage a larger ongoing discussion about how to best take advantage of these trends.

While the software for working with data is quite well developed, the major obstacle we have faced is what some have called the Knowledge Reengineering Bottleneck, which has been described as "the general difficulty of the correct and continuous reuse of preexisting knowledge for a new task"[3]. In other words, each of these datasets is collected for a very specific purpose, and they are not by default designed to be integrated together, as has been shown in the previous section.

The first step in addressing this bottleneck is to narrow down the search space by matching entities that are either the same or related in some way. Once this is done, values can be checked to see if they match, and investigations can be done to try to understand the underlying causes behind any discrepancies. To facilitate this process, we have set up a system that allows for users from their own computers to take a dataset, and for each entity, find a set of candidate matches of entities contained on Enipedia. With this system, their computer sends requests to our server which is running custom entity matching code[9,10] that we have developed to follow the Reconciliation Service API (Application Programming Interface) specification[11] in use by OpenRefine[12] (formerly Google Refine).

The OpenRefine project describes itself as a "free, open source power tool for working with messy data and improving it"[13], and we have found that it has several features that make it attractive for this particular task. First, the software is cross-platform and runs on Windows, Mac and Linux and is easy for users to install. Secondly, it is able to read a variety of file formats such as Excel spreadsheets, CSV, and XML. Thirdly, it has numerous functions allow users to easily clean up commonly encountered data issues. Fourthly, and most important for the matching process, it allows for communication with a server that is running the API standard that they define, so that users are able to reconcile instances in their own data with data stored on a central server. This particular setup is already used by other groups who wish to manage and integrate government data[4], urban information[5] and data on cultural heritage[6].

When the user starts OpenRefine, the program opens up a window in a web browser. With this interface, the user is able to create a new project and load in a file. Once they do this, a dialog is presented to allow the user to ensure that the data has been parsed correctly. This means that they can check details such as the column headers being identified and the correct column delimiters being used. The user can then alter the import settings to deal with any issues such as these that arise. Once they import the data, they are then presented with a type of spreadsheet interface, and can select the column containing the entities that they wish to match with another data set. The user

[7] http://enipedia.tudelft.nl

[8] http://enipedia.tudelft.nl/thesis/ChrisDavisPhD_MakingSenseOfOpenData.pdf

[9] https://github.com/cbdavis/enipedia-openrefine-reconcile

[10] http://enipedia.tudelft.nl/wiki/Enipedia_Power_Plant_Dataset_Reconciliation_API

[11] https://github.com/OpenRefine/OpenRefine/wiki/Reconciliation-Service-Api

[12] http://code.google.com/p/google-refine/

[13] https://github.com/OpenRefine/OpenRefine#readme

can then start reconciling the data via a dialog that allows them to enter in the URL of the reconciliation API and specify additional columns in their own data and the corresponding entity properties in the other data set that they map to (i.e. city, owner, geographic coordinates, etc). After this, OpenRefine then sends the user data out to the reconciliation API, and the matching candidates are returned to the user as shown in Figure 2.

Figure 2. Google Refine Results

VI. Limitations and Future Work

We believe that the work discussed above is a very important first step for energy data. Aside from our work on Enipedia, we are not aware of any public lookup tables that allow for people to link between entities in different data sets on energy systems. While the approach we have currently employed has proven to be helpful and is able to identify possible matches much faster than can be done by hand, the current implementation still has several limitations, as the methods are only based on string similarity metrics. The primary limitation of this approach is that it does not incorporate any knowledge of what the strings actually mean or how much their presence contributes to the certainty of having found a match. For example, for German data, these string metrics will indicate that two entities are similar if they both contain the term "kraftwerk". However, if one data set contains the term "power station" instead of "kraftwerk", these entities will be seen as being less similar even though these words mean the same thing in different languages. Another issue is that company names may be listed in either full or in abbreviated form. Alternatively, the name of a subsidiary or joint partnership entity may be listed. If we have information about these relationships and alternative forms, then it is possible to expand the amount of information that is available to match on. What is somewhat reassuring is that the issues we face are not new, and there are multiple techniques which have been developed to deal with them[7]. The problem is that there is not a one-size-fits-all solution. The nature of the solution that works best ultimately depends on the nature of the data itself.

A way to make the current approach more sophisticated is through the creation of lookup tables that allow us to find for a particular term the other terms that we should be using for matching as well. However, this does not address the issue of understanding how much the presence of a term indicates a positive match. As mentioned, the existence of the terms "power station" or "kraftwerk" does not give us much additional information. A way to measure the significance of terms is to use the concept of self-information[14] from Information Theory, as it roughly states that the less a particular term is used, the higher information content it has.

Another challenge as mentioned previously is that even if we are able to match two different entities, we are not always sure if the data recorded employs the same level of overlap. It is not always possible to simply merge data, as we have to explicitly check for conflicting values and not overwrite or ignore existing data.

An ideal development direction would be to create systems that get smarter the more that you feed them. For example, if the owners listed for a power plant conflict, then this may indicate the presence of a joint partnership, an ownership change, or a subsidiary. If the system is able to raise a flag in this situation and ask the user to clarify what is happening, then additional information can be added. If the information added is that one company is actually the subsidiary of another company, then this makes the matching process smarter as it now knows that any plant with either of these owners listed is probably the same. As a more extreme example, consider the case where two entities being compared have two different names, two different owners, but the same city. If we know that one owner is the subsidiary of another, then there is a chance that this may in fact be the same plant.

What has been discussed is essentially a techno-fix, and would not be necessary to such an extreme extent if data publishers were to (re)use standard identifiers. An example of what we would consider to be a "gold standard" is the eGRID[15] data set published by the U.S. Environmental Protection Agency, which uses standard identifiers for both plants and owners. While published in Excel, they also use a controlled set of terms to indicate facts such as fuel types. The practices that they use in managing the data are essentially the same that would be found within a proper database.

As part of our work on Enipedia, we convert open energy data from formats such as Excel, CSV, XML and MS Access into formats that make it much easier for the public to run sophisticated queries over[16]. For

[14] http://en.wikipedia.org/wiki/Self-information
[15] http://www.epa.gov/egrid/
[16] http://enipedia.tudelft.nl/wiki/EGRID_Linked_Data

example, with the eGRID data, it is so well structured that we can run queries that can perform actions such as finding all the power plants who have had one fuel source go from under 25% utilization to over 75% utilization. In other words, we can locate all the power plants that have significantly changed the primary fuel type in use over time. The results of the query show that this had occurred in nearly 10% of the data (623 of 6301 plants). If we want to group the results by state to see if certain states are seeing more plants converted than others, then this is possible by modifying the existing query. These types of actions are simply not possible with the current European data.

VII. Conclusion

What we have seen in this paper is that the current situation with European energy data could be significantly better and that there are fundamental issues which hinder our ability to link datasets and gain a more comprehensive view of the systems they describe. For the examples given, we have not found any evidence that the organizations collecting the data are coordinating among themselves, and there seems to be more of a focus on meeting reporting obligations and collecting the data for a single purpose, rather than considering how their efforts could gain much more value by making it easier for people to use the data for multiple purposes.

While we have discussed the types of tools that we are developing to address the issues of linking data, a more diverse type of solution would be desirable, where the data publishers would also adopt better data management practices. Data sets such as eGRID give a very good example of how this could look. The need for software matching techniques will never entirely go away, but better data management practices would at least make the process of working with data more efficient. This would also enable larger gains for data quality by allowing for cross-correlation across data sets and making it easier for others to perform their own independent reviews. The task of collecting distributed data is not easy and mistakes will always be made, but we should at least be more systematic in thinking about how data publishing is an activity embedded within a much larger system, and how the value that it adds to the larger system can then be harvested to in turn increase its own value.

Acknowledgment

This work was funded in part by Energy Delta Gas Research (EDGaR, http://www.edgar-program.com) – project A1, whose support is gratefully acknowledged.

References

[1] I. Tsagatakis, T. Bush, N. Passant, and N. Brophy, "UK emission mapping methodology 2008," Tech. Rep. AEAT/ENV/R/3105, 2010. [Online]. Available: http://uk-air.defra.gov.uk/reports/cat07/1207021214_UK_Emission_Mapping_Methodology_2008.pdf

[2] C. Davis, "Making sense of open data: From raw data to actionable insight," Ph.D. dissertation, Delft University of Technology, Delft, Netherlands, Nov. 2012. [Online]. Available: http://repository.tudelft.nl/view/ir/uuid%3A88c3c6f9-d6a2-4a82-9353-884a3b77b6ed/

[3] R. Hoekstra, "The knowledge reengineering bottleneck," *Semantic Web*, vol. 1, no. 1, pp. 111–115, Jan. 2010. [Online]. Available: http://dx.doi.org/10.3233/SW-2010-0004

[4] F. Maali, R. Cyganiak, and V. Peristeras, "A publishing pipeline for linked government data," *The Semantic Web: Research and Applications*, p. 778–792, 2012. [Online]. Available: http://www.springerlink.com/index/V45X551323V21536.pdf

[5] V. Lopez, S. Kotoulas, M. Sbodio, M. Stephenson, A. Gkoulalas-Divanis, and P. Aonghusa, "Queriocity: A linked data platform for urban information management," *The Semantic Web–ISWC 2012*, p. 148–163, 2012. [Online]. Available: http://www.springerlink.com/index/E00H7J6273018222.pdf

[6] S. van Hooland, R. Verborgh, M. De Wilde, J. Hercher, E. Mannens, and R. Van de Walle, "Evaluating the success of vocabulary reconciliation for cultural heritage collections," *Journal of the American Society for Information Science and Technology, To be published*, 2012. [Online]. Available: http://freeyourmetadata.org/publications/freeyourmetadata.pdf

[7] H. Köpcke and E. Rahm, "Frameworks for entity matching: A comparison," *Data & Knowledge Engineering*, vol. 69, no. 2, p. 197–210, 2010. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0169023X09001451

Reputation-based Coordination of Prosumers Communities

Anna Satsiou
Information Technologies Institute
Centre for Research and Technology Hellas
Thessaloniki, Greece
Email: satsiou@iti.gr

George Koutitas
Dpt. of Electrical and Computer Eng.
Univ. of Thessaly, Volos, Greece
& International Hellenic University
Email: g.koutitas@ihu.edu.gr

Leandros Tassiulas
Information Technologies Institute
Centre for Research and Technology Hellas
Thessaloniki, Greece
Email: leandros@iti.gr

***Abstract*—This paper investigates prosumers' cooperation and coordination in the smart grid. To sustain a well organized bilateral collaboration we emphasize our research on the reputation aspects of virtual prosumer communities. We introduce the concept of condumer, that is a collaborative community of prosumers. The condumer is regarded as a single entity and the aggregated energy production is used one one hand to satisfy the energy needs of its members (prosumers) and on the other hand for participation to the energy market to increase profits and provide sustainability. The paper explores the main characteristics to define the reputation of the condumer and its members, and determines a reputation-based coordination and payment scheme to motivate cooperation and promote reliability among the members of the condumer. We take into account the produced and offered energy, the degrees of freedom that the prosumer offers to the smart grid for demand response and the reliability of the forecasted values of production and consumption to define this heuristic.**

I. Introduction

Smart Grid is a promising new concept to efficiently use all available energy resources in order to accommodate energy demands in a reliable uninterrupted manner. The integration of renewable and other non-carbon decentralized energy resources to the grid will not only increase the capabilities of the grid, but significantly reduce carbon emissions as well, supporting planetary sustainability.

The penetration of smart grid technologies have brought up a lot of new entities like Distributed Energy Resources (DERs) or Distributed Generators (DG), microgrids, Virtual Power Plants (VPPs), Renewable Energy Resources (RES), etc, as well as new terms like Market Participation (MP), Power Quality (PQ), Demand Response (DR), etc. The Information and Communication Technology sector (ICT) holds a significant role to the operation of the smart grid since it provides important end user applications for network management under the general term of Meter Data Management (MDM) but also critical infrastructure for command and data flow in the network such as Advanced metering infrastructure (AMI) and Home Area Networks (HAN) of smart meters and actuators [1], [2]. These networks support functionalities for energy management of individual appliances under direct switch on/off schemes or under indirect approachs such as gamification/incentives to the users. As a result, mechanisms of vital importance for the efficient operation of the smart grid can be developed such as Demand Response (DR) and Supply Load Control (SLC) for load shaping and off grid network operation.

One of the key aspects of the smart grid is the participatory role of the users. Users can have both the role of producer and consumer of energy, given the general term "prosumer". A prosumer may create a certain amount of load in the network (operation of appliances, lighting, heat, etc) and may create a certain amount of capacity (local storage such as electric vehicles, CHPs in homes or utility buildings, gas/diesel generators, bio gas plants, and/or renewable in the form of small wind and solar), also known as distributed energy sources (DERs). For the purpose of our investigation we focus on electric energy only. The prosumer may face the following three modes during his lifetime in the smart grid:

- **Stand-alone mode**: Prosumer balances the energy produced by the DERs he owns and the energy he consumes in a virtual or island mode approach. In this mode, the prosumer neither buys nor has redundant energy to sell to the grid,
- **Consumer mode**: Prosumer consumes more energy than what he produces,
- **Producer mode**: Prosumer produces more energy than what he consumes.

The cooperation between prosumers could lead to a community of collaborative prosumers and a new term "Condumers" as the combination of the words **Co**llaborative Commu**n**ity of pro**du**cers/consu**mers**. Such cooperative community would provide many advantages to its members; they could balance their production and consumption during the day in order to meet one anothers needs. For example, members with orthogonal power curves could collaborate to form a condumer with net zero characteristics (members with peak time consumptions at the evening with those with peak time consumptions during the morning).

Furthermore, members could aggregate their energy production. Although relatively small in capacities, DERs can be in very high numbers. The aggregated energy production can be sold to the grid at competitive rates through a Virtual Power Plant (VPP), which is actually the virtual equivalent of a large power station. Condumers can thus be regarded as a special formation of a VPP that can support dynamic

The authors acknowledge the support of this work by the EU project EINS, Contract number FP7-ICT-288021.

coordination of its members (prosumers) and support load shaping and control. With the use of condumers, the grid will not need to interact with all producers (which may be millions) but only with certain condumers which may be utility companies or prosumers associations, simplifying the coordination. Condumers can alleviate the load on power plants, especially during high-demand periods and can achieve better prices in the energy market due to adaptive and dynamic control of the resources.

The behaviour of prosumers can play a significant role in the smart grid performance; this paper deals with reputation-based mechanisms to steer a prosumer behaviour that would improve the smart grid performance. We introduce the basic system architecture and investigate reputation-based cooperation and payment schemes to motivate prosumers contributions, cooperation, truthful and reliable reporting of energy production predictions and compliance to demand response techniques when necessary.

II. Related Work

To our knowledge, no previous work has ever proposed a reputation-based framework to control the operation of what we call "condumers". Work in [3] brings up the idea of collaborative VPPs, namely CVPPs, referring to coalitions of power-producing DERs integrated into the Grid and striking profitable deals with it, through a Virtual Power plan. The authors further propose a payment scheme and cooperative game theory concepts to allocate payments within the cooperative in a way that motivates CVPPs to provide as accurate estimations of their production as possible. An improved policy is proposed in [4] where members of a CVPP express not only their energy production prediction but also the confidence over this prediction, based on the collection and analysis of historical data. In contrast to these schemes where a CVPP is a collaborative VPP of DERs, in our scheme a condumer is a *collaborative VPP of prosumers* and our proposed reputation-based framework determines not only the payment scheme but also the relationships (i) between prosumers, (ii) between prosumers and the condumer agent and (iii) between condumers and the grid in a way to motivate the cooperation between prosumers and adaptation to demand/response techniques when needed. Other related papers are [5] which proposes a method for congregating the smart-grid actors to approximate micro-grid coalitions, having the ability of providing power even in a case of an outage, [6] which addresses a multi agent system to control a Virtual Power Plant and the way it takes decisions through a pilot Virtual plant in the region of Athens, [7] which proposes a methodology to model the behaviour of electricity prosumers in order to support the power system planning and [8] which presents the role of prosumers in the deregulated energy market. A large scientific collaboration under this field is investigated in the IMProsume project [9]. Finally, it must be mentioned that an important factor for the efficient modeling of prosumers in the smart grid is user behaviour. Based on machine learning techniques and ontologies the authors in [10] and [11] propose algorithms and techniques to categorize user behaviour. However, none of aforementioned works look into the holistic treatment of collaborative prosumers under a reputation framework.

III. System Architecture & Model

This section describes the architecture and model of the envisioned condumer-based smart grid system.

A. The Smart Grid

The basic architecture of the smart grid that considers data and command flow is described in [12]. The basic elements are (i) the smart house/building (known as user) that is either a consumer or prosumer in the network, (ii) the controllers of the smart buildings, (iii) the energy provider and (iv) the service provider. Based on these elements different formations in the smart grid arise and these are the microgrid and the VPPs (discussed earlier). Microgrids are a subset of the network operating at medium or low voltage incorporating DERs and can be in island mode [13]. The controller is responsible to manage and shape the load according to the available energy or even electricity price from the market and might be the control unit of a microgrid or a VPP.

The smart building's intelligent unit is a CPU that is known as "agent". The agent is the coordinator of a home area network (HAN) usually formed in a wireless mesh network of smart meters (deployed in plugs or RES if available), sensors and actuators (Fig. 1). The agent has access to the internet usually over TCP or GPRS. Data flow in the network is mainly related to energy (or power) values and environmental parameters. The agent aggregates data and transmit them to the external controller. In addition the agent receives pricing signals and commands to support switch on/off activation of the appliances according to user or operator centric objectives. The controllers aggregate data and communicates with the service and the energy provider. They manage the command and data flow in a large geographical area according to operator centric objectives, taking into account thresholds imposed by the users [14]. The operator is the energy provider and the service provider supports services and business models, such as smart billing, demand response, etc.

B. The Prosumer

The prosumer is a smart building that produces and consumes energy at the same time (see Fig. 1) and has all the required ICT infrastructure to support data and command flow. In the most general form we assume that the prosumer *i* requires instantaneous power due to the operation of a set of home appliances and devices, a_j, modeled as $c_i(t) = \sum_{j \in A} a_j(t)$ in Watts and produces instantaneous capacity due to RES r_j, modeled as $p_i(t) = \sum_{j \in R} r_j(t)$ in Watts, where *A* and *R* are the sets of appliances and RES at prosumer *i*. The prosumer might also have a given storage of some capacity in Whrs which, in this paper, is incorporated within the offered capacity term. The storage is not assumed as an always available energy source since it can be related to an EV that might be unplugged. Over a limited time horizon *T* the consumed and produced energy are equal to:

$$E^c_{i,T} = \int_0^T c_i(t) \cdot dt \text{ and } E^p_{i,T} = \int_0^T p_i(t) \cdot dt \qquad (1)$$

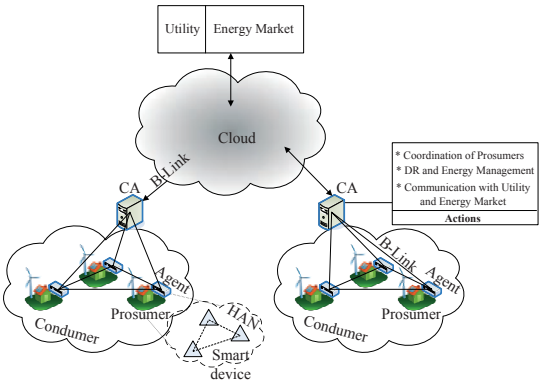


Fig. 1: Condumer-based Grid Architecture.

Over a time horizon T, if $p_i \geq c_i$ or $E^p_{i,T} \geq E^c_{i,T}$ the prosumer is regarded as a producer whereas if $p_i < c_i$ or $E^p_{i,T} < E^c_{i,T}$ the prosumer is a consumer in the network.

The power needs of the prosumer are related to the operation of home appliances and devices. We categorize the appliances into two types. The *standard* or background loads of the user like the standby mode operation of specific devices, the lights etc, and the *flexible* loads that are usually thermostatic or delay tolerant loads like the air conditioning units, the ovens, the heat water devices, the washing machine, etc [12], [15], [16]. These type of devices provide the ability to manage the instantaneous power loads of the prosumer according to given objectives imposed either from the operator or the user itself [16], [17].

C. The Condumer

The condumer is a set of prosumers that cooperate in the smart grid as shown in Fig. 1 and the condumer agent (CA) is responsible to manage and shape the load inside the condumer and handle any communication and transactions (energy purchase or sale) with the grid utility. In other words, we treat condumers as a collaborative community of prosumers. Characteristic examples of such condumers could be:

a) Socially connected groups, e.g., members of a family, owners of smart buildings/houses who wish to collaborate in order to cover their energy needs at different times of the day and aggressively enter the energy market,

b) Owners of smart buildings/houses being neighbors in a close proximity area that are served from the same medium-voltage station cooperating to satisfy their energy needs and avoid transport losses by producing electricity in the vicinity of the consumption area,

c) Group of users with orthogonal needs, i.e., some of them consuming more during the morning and some consuming more on the evening.

e) Group of users who tend to have comparable average residual energy per day, i.e., $E^p_{i,day} - E^c_{i,day}$.

The aggregated energy/power consumption/production of the condumer is regarded as the outcome of the cooperation. By setting as M the set of prosumers-members in the condumer (where $i \in M$ denotes the identifier of prosumer) the aggregated power needs of the condumer environment are $C_C(t) = \sum_{i \in M} c_i(t)$, while the total produced capacity is $P_C(t) = \sum_{i \in M} p_i(t)$. In the rest of the paper we will refer to the prosumers belonging to a paricular condumer as its *members*. Over a limited time horizon T, the energy consumption and the energy production of the condumer can be modeled as:

$$E^c_{C,T} = \int_0^T C_C(t) \cdot dt \text{ and } E^p_{C,T} = \int_0^T P_C(t) \cdot dt \qquad (2)$$

D. Load Shaping Techniques

One of the most important characteristics of the smart grid is the ability to adapt to sudden changes. These can be time variant energy production of RES or unpredictable power spikes in the system. The most important technique to face this issue is demand response (DR) or demand side management (DSM). The main mechanisms behind DR is direct load control [12], load shifting [16] and gamification [18] that control the flexible loads of the procumer, as described in III-B. The objective is to reduce peak loads in the network, flatten the power curve and reduce energy consumption.

E. Model

As it is reported in [3], most countries use the 48 half-hour electricity trading intervals to set the prices in the market and determine the requested energy by the various generators, given the predicted supply and demand the day before. Inside a condumer we consider that in the closing of a day, each member reports to the CA the amount of energy he predicts that he can offer $\widetilde{E^o_{m,t}}$, or that he will demand $\widetilde{E^d_{m,t}}$ for each half-hour time interval of the next day. The prediction can be related to RES production based on time series analysis of past or weather data or it can be related to adaptation of the user to energy management mechanisms, such as DR. Let's suppose that a member m for a given half-hour time interval t predicts that he will produce $\widetilde{E^p_{m,t}}$ and will consume $\widetilde{E^c_{m,t}}$ energy. As already explained, he can act either as consumer or producer. When acting as consumer:

$$\widetilde{E^d_{m,t}} = \widetilde{E^c_{m,t}} - \widetilde{E^p_{m,t}} \text{ and } \widetilde{E^o_{m,t}} = 0, \qquad (3)$$

while, when acting as producer:

$$\widetilde{E^o_{m,t}} = \widetilde{E^p_{m,t}} - \widetilde{E^c_{m,t}} \text{ and } \widetilde{E^d_{m,t}} = 0 \qquad (4)$$

When the total predicted offered energy inside the condumer is more than the total demanded, the condumer can sell the residual energy to the grid at that particular half-time period. The condumer based on its members predictions will report to the grid the predicted energy $\widetilde{E^g_{C,t}}$ it can sell at each time interval t of the next day, according to:

$$\widetilde{E^g_{C,t}} = \sum_{m\in M} \widetilde{E^o_{m,t}} - \sum_{m\in M} \widetilde{E^d_{m,t}}, \text{ if } \sum_{m\in M} \widetilde{E^o_{m,t}} > \sum_{m\in M} \widetilde{E^d_{m,t}}$$
$$\text{or } \widetilde{E^g_{C,t}} = 0, \text{ if } \sum_{m\in M} \widetilde{E^o_{m,t}} < \sum_{m\in M} \widetilde{E^d_{m,t}} \quad (5)$$

In the following section we describe the reputation-based policies that will determine the coordination of the energy resources inside the condumer and a payment scheme.

IV. Reputation-based Policies

For the determination of following reputation metrics and policies we apply concepts that proved to motivate cooperation in various systems (e.g., p2p networks and grids [19], [20], internet sharing and wireless communities [21], [22]).

A. Reputation Metrics

Each member m of the condumer is characterised by two reputation metrics, the one reflecting the cooperation/energy contributions of the user $R^c_{m,t}$ and the one reflecting his reliability in terms of accurate energy predictions $R^r_{m,t}$. Both are updated during time according to the behaviour of the member. The condumer agent keeps these reputation values for each one of the members, based on how much each one of them satisfies the energy needs of the condumer and how close their energy predictions are to the actual ones, respectively.

Cooperation-based Reputation of a member, $R^c_{m,t}$:

If in a given half-hour interval t a member m has offered $E^o_{m,t}$ while the total demands of all members inside the condumer were $E^d_{C,t} = \sum_{i\in M} E^d_{i,t}$ at that time, then the ratio $E^o_{m,t}/\sum_{i\in M} E^d_{i,t}$ represents how much member m satisfied the needs of the condumer in this time period and accounts for m's cooperation-based reputation. At each new time interval the reputation of member m is updated. So, the cooperation-based reputation of member m to the condumer at a given time period t is given by:

$$R^c_{m,t} = \frac{1}{T} min(1, \sum_{t=1}^{T} \frac{E^o_{m,t}}{\sum_{i\in M} E^d_{i,t}}), \quad (6)$$

where T is the total number of half-time intervals during which the cooperation-based reputation of the member is calculated. Under this setup it is meaningful to consider that T is equal to 48, i.e., the period of a day. We consider that the condumer starts replacing the oldest rating transactions $min(1, \frac{E^o_{m,t}}{\sum_{i\in M} E^d_{i,t}})$ with newer ones, always keeping a history of 48 most recent transactions with each member, maintaining the overhead low. In this way the system removes age-bias and quickly adapts to member behavior changes, e.g., when members strategically vary their contributions through time. The cooperation-based reputation of each member can take any value from 0 to 1 and expresses the average energy demands satisfaction that he has offered to the condumer. Any residual contributions are sold to the grid utility and awarded by the payment mechanism as described in later section.

Reliability-based Reputation of a member, $R^r_{m,t}$:

Reliability-based reputation of a member m defines how reliable energy predictions he makes under a half-hour time interval t. If in a given interval t, member m has predicted that he can offer $\widetilde{E^o_{m,t}}$ and he actually offered $E^o_{m,t}$, then the ratio $\frac{E^o_{m,t}}{\widetilde{E^o_{m,t}}}$ represents the accuracy of his prediction in this period. We should note that a member can always have the ability to conform to his initial predictions (that might have been wrong due to vulnerability of some DERs) by following DR or DSM commands. As we shall describe in section IV-C, the reliability of the members' predictions is an important factor for the successful operation of the grid. Reliability-based reputation is updated in a similar way as the cooperation-based reputation and can also take values between [0,1]:

$$R^r_{m,t} = \frac{1}{T} min(1, \sum_{t=1}^{T} \frac{E^o_{m,t}}{\widetilde{E^o_{m,t}}}) \quad (7)$$

In case the predicted energy is less than the actual one, we update the reputation by a ratio of 1, because the residual energy cannot be sold to the grid utility (since the latter has agreed upon a specific amount for this time period), and thus the residual energy does not account for even higher reputation.

We consider that new members in the condumer are awarded initial small contribution-based and reliability-based reputations. If newcomers prove to be collaborative enough, their reputations will quickly increase, providing them certain payment and other benefits as described in later sections.

Reliability-based Reputation of a condumer, $R^r_{C,t}$:

The reputation of the condumer in the eyes of the grid utility takes values between [0,1] and is calculated as follows:

$$R^r_{C,t} = \frac{1}{Trans} min(1, \sum_{\tau=1}^{Trans} \frac{E^g_{C,\tau}}{\widetilde{E^g_{C,\tau}}}), \quad (8)$$

where $Trans$ is the total number of condumer transactions with the grid utility, selling it energy. We keep $Trans$ equal to 48 and keep the most recent ratio values in a similar way and for the reasons described in aforementioned reputation metrics.

B. Reputation-based Coordination of the Condumer

In the closing of a day, the condumer agent will collect the predicted energy demands and offers of the various members and check the following for each time period t:

if the total demands equal or exceed the total offers....

In that case, the condumer has to allocate the available energy $E_{C,t} = \sum_{m\in M} E^o_{m,t}$ to the demanders and buy the rest from the grid utility to accommodate all needs. The proposed reputation-based allocation policy seeks to prioritize most contributive members according to:

$$max \sum_{m\in M} R^c_{m,t} \frac{x_{m,t}}{E^d_{m,t}},$$
$$\text{s.t.} \sum_{m\in M} x_{m,t} \leq E_{C,t} \quad \text{and} \quad x_{m,t} \leq E^d_{m,t} \ \forall m \in M \quad (9)$$

Both the objective function and the constraints in the maximization problem (9) are linear, so the solution can be easily found by sorting members in decreasing order according to their reputation to demands ratio $\frac{R^c_{m,t}}{E^d_{m,t}}$. The condumer agent will satisfy the needs of the members starting from the first one in the order satisfying all his demands, as soon as they do not exceed condumer's total available energy and continuing with the rest of members till all energy is exhausted or all members are completely satisfied. If two or more members have the same reputation to demands ratio and the residual energy of the condumer is not enough to accommodate all of their demands, it will be equally split among them. Our policy maximizes the satisfactions $St_{m,t} = x_{m,t}/E^d_{m,t}$ of the competing members, according to their contribution-based reputations. The satisfaction of a member is expressed by the amount of energy he took over what he has asked from condumer during time period t.

It is obvious from the solution of (9) that for $E_{C,t} < \sum_{m \in M} E^d_{m,t}$ and for any two competing members i and j with $\frac{R^c_{i,t}}{E^c_{i,t}} < \frac{R^c_{j,t}}{E^c_{j,t}}$, their satisfactions from their energy requests will satisfy $\frac{x_{i,t}}{E^d_{i,t}} < \frac{x_{j,t}}{E^d_{j,t}} \Rightarrow St_{i,t} < St_{j,t}$.

The above statement proves that when the resources of a given condumer C cannot satisfy the demands of all of its competing members, the ones with the highest contribution level per unit resource request will perceive the highest satisfaction, providing incentives for cooperation and contributions. Actually, the higher energy demands a member has, the more contributive/reputed he has to be, in order to satisfy them, without having to pay.

The rest of the members that will not be satisfied by the condumer based on the proposed allocation policy, will have to pay the grid utility in order to cover their needs. This scheme motivates members to offer their energy to the condumer in time periods that they do not need it, in order to gain reputation and use it in other time periods to receive energy without having to buy it from the grid utility.

if the total demands are less than the total offers....

In that case, the condumer can sell the remaining energy to the grid utility. It will inform the grid authority of its estimated available for selling energy $\widetilde{E^g_{C,t}}$ for each day-ahead half-hour time period t. In the following subsection we describe a reputation-based payment scheme of the condumer for the amount of energy it sells to the grid utility.

C. Reputation-based Payment of the Condumer

We consider that the payment $P_{C,t}$ that the grid utility will give to a condumer C for the amount of energy sold $E^g_{C,t}$ at a given time interval t is given by the following equation:

$$P_{C,t} = R^r_{C,t} * logE^g_{C,t} * price * E^g_{C,t}, \qquad (10)$$

where $price$ is the electricity base price (per kWh). Therefore, the first three factors represent the actual price being offered by the grid to the condumer, which multiplied with the actual condumer production provides the actual payment to C. This payment mechanism has the following properties:

(a) The actual price offered by the grid to the condumer depends on the latter's reliability reputation $R^r_{C,t}$, i.e. how reliable production estimates the condumer makes. The role of the grid is to schedule the aggregated energy production over the large power plants based on the predicted demand, incorporating the energy production of individual producers or condumers; therefore, the energy predicted production should be as accurate as possible and condumers should comply to any provision agreement of a specific amount of energy in order for the grid operators to determine an efficient scheduling process.

Proposed mechanism motivates condumers and their members to provide truthful and as accurate predictions as possible about their energy production by awarding the most reliable ones with higher revenues. Even when this is not such an easy task, e.g., accurately predicting the produced energy of wind turbines due to the vulnerability of this RES, condumers can always apply DR techniques to its members in order to provide the "promised" amount of energy to the grid and increase their reliability.

Please note that a condumer is somehow "punished", only when the estimated produced energy is less than the one "promised". We consider that the grid buys only the predetermined energy amount and thus if the actual one proves to be higher, it does not affect the performance of the grid. That is why the reputation of the condumer cannot exceed 1, as reported in section IV-A.

The reliability-based reputation of the condumer expresses its overall reliability behaviour over a short amount of transactions with the grid; not too low in order to capture its overall performance and avoid unfair punishments and not too high in order to keep only the most recent record and avoid strategic condumers who might build an initial high reputation and then exploit it by repeatedly providing inaccurate predictions without being punished.

(b) The actual price also depends on the factor $logE^g_{C,t}$ which increases with the amount of energy sold but flattens at very high energy amounts. In this way, the formation of condumers with many members (but not too many in order to increase the complexities of their coordination) generating a higher amount of energy, is motivated. The idea behind is that in this way the role of the grid operators in managing and settling accounts is facilitated by having to interact with specific large-enough condumers than with a vast amount of individual producers. This fosters our initial idea of the "condumer" entity and a decentralised management process where the grid utility communicates with particular condumers and each condumer with its members.

(c) Last, the actual price depends on the price that the grid offers per KWh determined by it (e.g., based on the supply and demand in the energy market) and is fixed for all condumers.

D. Reputation-based Allocation of Payments

As explained above, the payment of the condumer is affected by its reliability in predicting its available energy for the grid utility, which is also dependent on members' reliability on predicting their production. In order to provide the appropriate incentives for each member to provide as accurate estimations as possible, we propose their following

payment mechanism. Every time the condumer is being paid by the grid utility for an amount of energy provided in a certain time period t , the condumer shares this payment $P_{C,t}$ among its members according to:

$$P_{m,t} = \frac{R^r_{m,t} * E_{m,t}}{\sum\limits_{i \in M} (R^r_{i,t} * E_{i,t})} P_{C,t} \tag{11}$$

From above, we can see that the sum of the members' payments equals the payment of the condumer, i.e., $\sum\limits_{m \in M} P_{m,t} = P_{C,t}$. Each member is paid in proportion to the (a) amount of energy offered at that particular time period and (b) its reliability-based reputation in providing accurate estimations of its available energy. This mechanism in combination with the reputation-based payment scheme of the condumer motivate the condumer's members to truthfully and accurately report their available energy and also incentivise them to conform to a DR policy from the condumer, when their actual production falls below their initial predictions.

E. Reputation-based Selection of Condumer

In this section we propose a reputation-based condumer selection policy in order to help the grid utility avoid requesting service from unreliable condumers, which would hamper the energy production scheduling strategy. We consider that the probability with which the grid utility agrees a certain transaction with a condumer C at a given period t, is directly proportional to C's reliability-based reputation, as:

$$p_{C,t} = R^r_{C,t} / \sum_{s \in S_t} R^r_{s,t}, \tag{12}$$

where S_t is the set of all condumers at time period t. In a similar way the grid makes agreements with as much condumers as needed to satisfy its energy demands. New condumers are awarded a small initial reputation and are "tested" by the grid utility till the latter builds their reputation (2-3 transactions are enough; if their behaviour deteriorate, this is quickly captured by the reputation update mechanism as described in IV-A). This mechanism in combination with all aforemenioned ones, incentivise condumers to provide reliable estimations of their production in order to be selected by the grid utility.

V. Conclusions and Future Work

In this paper we introduced the concept of condumer, which is a collaborative community of prosumers who can share their residual produced energy and also dynamically enter the energy market by selling it in the grid utility. In order to efficiently coordinate such communities we proposed simple reputation-based policies which determine the energy allocation process and payment mechanisms in a way to motivate (i) the participation of prosumers in condumer communities (ii) the collaboration of the condumer members, (iii) the compliance to DR policies and (iii) members' reliability in energy production estimations. To the best of our knowledge this is the first attempt to provide a holistic reputation-based coordination framework of prosumers communities and can serve as a framework for efficient establishment of bilateral contracts in the future energy market between prosumers, condumers and the grid. Future work will investigate in depth the creation criteria of condumers and their dynamic formation, as well as the evaluation of the proposed reputation-based schemes over real data from energy production farms.

References

[1] S. Keshav and C. Rosenberg, "How internet concepts and technologies can help green and smarten the electrical grid," *Proc. ACM SIGCOMM Green Networking Workshop*, 2010.

[2] Z. M. F. *et al.*, "Toward intelligent machine-to-machine communications in smart grid," *IEEE Communication Magazine*, Apr. 2011.

[3] G. C. *et al.*, "Cooperatives of distributed energy resources for efficient virtual power plants," *The Tenth International Conference on Autonomous Agents and Multiagent Systems*, pp. 787–794, May 2011.

[4] V. R. *et al.*, "Cooperative virtual power plant formation using scoring rules," *Proc. of the 11th Int. Conf. on Autonomous Agents and Multiagent Systems*, pp. 1165–1166, 2012.

[5] R. Mihailescu, M. Vasirani, and S. Ossowski, "Towards agent-based virtual power stations via multi-level coalition formation," *In Proc. of the 1st Int. Workshop on Agent Technologies for Energy Systems*, pp. 107–108, 2010.

[6] A. Dimeas and N. Hatziargyriou, "Agent based control of virtual power plants," *Int. Conf. on Intelligent Systems Applications to Power Systems*, pp. 1 –6, nov. 2007.

[7] I. Lampropoulos, G. Vanalme, and W. Kling, "A methodology for modeling the behavior of electricity prosumers within the smart grid," *Innovative Smart Grid Technologies Conference*, pp. 1 –8, oct. 2010.

[8] N. Capodieci, "Adaptive game-based agent negotiation in deregulated energy markets," *Collaboration Technologies and Systems (CTS), 2012 International Conference on*, 2012.

[9] I. S. *et al.*, "A prosumer oriented energy market," *IMProsume Publication Series*, 2012.

[10] N. Hatziargyriou, "Machine learning applications to power systems," *Machine Learning and Its Applications, Lecture Notes in Computer Science*, pp. 308–317, 2001.

[11] D. V. T. Stavropoulos, D.Vrakas and N. Bassiliades, "Bonsai: a smart building ontology for ambient intelligence," *Proc. of WIMS*, 2012.

[12] G. Koutitas, "Control of flexible smart devices in the smart grid," *IEEE Trans. on Smart Grid*, vol. 3, no. 3, 2012.

[13] Y. Xu and W. Liu, "Novel multiagent based load restoration algorithms for microgrids," *IEEE Trans. on Smart Grid*, pp. 152–161, 2011.

[14] openADR, http://www.openadr.org/.

[15] G. Koutitas and L. Tassiulas, "Periodic flexible demand: Optimization and phase management in the smart grid," *IEEE Trans. on Smart Grid*, vol. in press, 2013.

[16] I. Koutsopoulos and L. Tassiulas, "Challenges in demand load control for the smart grid," *Network, IEEE*, vol. 25, no. 5, 2011.

[17] J.-Y. L. Boudec and D. C. Tomozei, "Satisfiability of elastic demand in the smart grid," *in Proc. Int. Conf. on Smart Grids, Green Communications and IT Energy-aware Technologies, ENERGY*, 2011.

[18] B. G. *et al.*, "Leveraging gamification in demand dispatch systems," *EDBT-ICDT Proceedings of the Joint EDBT/ICDT Workshops*, 2012.

[19] A. Satsiou and L. Tassiulas, "Trust-Based Exchange of Services to Motivate Cooperation in P2P Networks," *Peer-to-Peer Networking and Applications Journal, Springer*, pp. 122–145, 2011.

[20] A.Satsiou and L. Tassiulas, "Reputation-based Resource Allocation in P2P Systems of Rational Users," *IEEE Transactions on Parallel and Distributed Systems*, Apr. 2010.

[21] A. Satsiou and L. Tassiulas, "Reputation-based Internet Sharing in Wireless Neighborhood Community Networks," *Proc. of the IEEE International Conference on Communications*, May 2010.

[22] P. A. *et al.*, "Community Building over Neighbourhood Wireless Mesh Networks," *IEEE Technology and Society, special issue on Potential and Limits of Cooperation in Wireless Communications*, pp. 48–56, 2008.

Research Design for the Study of Social Media Use by Dutch Development Organizations

Anand Sheombar
Manchester Metropolitan University &
Utrecht University of Applied Sciences
anand.sheombar@gmail.com

ABSTRACT
This research project aims at examining social media potential in the sector of Dutch aid & development organizations. The research question is formulated as: what (issues and opportunities) do the major Dutch development organizations encounter when using social media to engage their stakeholders with their projects? Five Dutch Development organizations active with social media have been analyzed. The research design is a combination of an interpretive and critical research study. A qualitative research approach is adopted. The methodology of Grounded Theory combined with a multiple case study is applied and a combination of methods is used for data collection (semi-structured interviews, social media and reports) The data is analyzed using Grounded Theory method. The findings reveal a preliminary framework for relationships between the concepts related to presumed risks and barriers, the definition of social media and the actual use of social media by the aforementioned organizations

Categories and Subject Descriptors
K.4.3 **[Organizational Impacts]**: Computer-supported collaborative work

General Terms
Human Factors.

Keywords
Information & Communication Technology, ICT for Development (ICT4D), social media, qualitative research; Grounded Theory, case study, research design.

1. INTRODUCTION
Recent years the usage of social media has grown dramatically [1]. The terms social media, social networks (SNSs) and web 2.0 are often interchanged in usage [2, 3]. All definitions for social media share at least the characteristics openness, participation, connectedness and community [4]. The idea for this research on the role of social media as Information & Communication Technology (ICT) instrument for development arose when I observed the intensive usage of social media at an annual meeting of Dutch international aid and development agencies in 2009. However the impact is not clear. The relevance of social media in the context of aid and development covers four broad areas Zuniga and White [5] argue, namely connecting with other, collaborating with other people, creating and sharing content, and lastly finding, using, organizing and reusing content. Thompson [6] and Heeks [7] urge for more research including empirical examples of attempts to introduce social media to serve developmental aims. Information and Communication Technology (ICT) can be a powerful enabler of development goals because its unique characteristics improve communication and the exchange of information to strengthen and create new economic and social networks [8]. Summarized the reasons for this potential are: faster and easier information delivery. dissemination of information and knowledge, connectivity and network creation, efficiency and transparency gains, transformation of people's lives and lastly decentralization & empowerment [8-11]. In this context ICT as an enabler of development is also referred to as ICT for Development (ICT4D or ICTD). ICT for development is aimed at bridging the digital divide and aiding economic development by ensuring equitable access to up-to-date communications technologies [12]. Thompson and Heeks urge for further research including empirical examples of attempts to introduce Web 2.0 (social media) models to serve developmental aims [6, 7]. This pilot study serves as a particular example to that aim.

2. RESEARCH AIMS
This research project aims at examining social media potential in the sector of Dutch aid & development organizations. The research question is formulated as:

What (issues and opportunities) do the major Dutch development organizations encounter when using social media to engage their stakeholders with their projects?

By stakeholders I mean the donors, fellow non-profit organizations, the organizations own staff, the local organizations in developing regions and the aid receiving communities in developing countries. This study presents 5 case studies of Dutch Development organizations perceptions of social media and its opportunities.

A conceptual framework is used as lens for this research. The idea is that social media as an ICT-instrument act as an intervention on the institution, the development agency. The effect of social media is influenced by the skills and knowledge of the individuals, represented by human capital [13]. The "aggregated" (accumulative) effect of the individuals forming a group with its group interactions is represented by social capital [14-17]. Knowledge is passed throughout the group. The cultural context and the individuals social identity may influence the knowledge creation and dissemination between the various stakeholders [18]. Cultural capital is incorporated in the native knowledge and exchange of knowledge [16].

3. RESEARCH METHODS
Given the exploratory nature of this research, a qualitative research was adopted. The methodology of Grounded Theory combined with a multiple case study was applied. Case studies are particularly valuable for understanding complex phenomena in context [19, 20]. A combination of methods was used for data collection (semi-structured interviews, social media and web pages and reports). The data was analyzed using Grounded Theory method.

3.1 Using Grounded Theory Method & Multiple Case Studies

The main purpose of the Grounded Theory method is theory building. In their seminal work The Discovery of Grounded Theory, the originators of Grounded Theory, Barony Glaser and Anselm Strauss [21], described the research process as the discovery of theory through the rigors of social research.

Grounded theory approaches are becoming increasingly common in the Information Science (IS) research literature because the method is extremely useful in developing context-based, process-oriented descriptions and explanations of the phenomenon [22]. A more detailed work definition for Grounded Theory can be found in [23]. Data analysis proceeds from open coding (identifying categories, properties and dimensions) through selective coding (clustering around categories), to theoretical coding [24, 25]. Two distinguishing features of Grounded Theory are that '*the researcher has to set aside theoretical ideas'* and the idea of concepts being developed through '*constant comparison*' [25]. The first feature actually means that the "research does not *start* with a theory to prove or disprove" and tells us that avoiding presumptions is key while doing Grounded Theory [26]. It demands a more inductive than a deductive starting point from the researcher. It does not mean the researcher is not connecting with the literature. Glaser and Strauss [21] did stress the importance of 'theoretical sensitivity' in Grounded Theory. The researcher establishes emerging impressions from the evidence, conceptualizes the data, and then analyses emerging relationships between concepts. A suitable research method supporting the aforementioned methodology is a multiple-case study [20, 27]. Eisenhardt [28] describes how to build theories in case study research, where she explicitly advocates Yin's [20] case study method and Glaser and Strauss's Grounded Theory. Case studies are an established way of theory building [28, 29]. The case study strategy is useful to gain a rich understanding of the context. When combining methods like case study and Grounded Theory, care must be taken to ensure that the principles of case study research do not distort true emergence for theory generation [30]. Evidence suggests that the combination of case studies and Grounded Theory has been rewarding for Information Science researchers [31]. Urquhart et al. [32] show that the social capital lens has occasionally been used as a method to study the effects of ICT intervention in communities. The context of development organization particularly suits the application of the social capital lens Cummings et al. [33] suggest. Thapa and Sein [34] subscribe to this view: "*Social capital perspective is a promising lens to explore the relationship between ICT4D projects and socio-economic development.*"

3.2 Data Sources and Collection Method

Data was retrieved from the segmented group that is the first adopting social media usage in their organization. A selected target group of aid & development organizations in the Netherlands who are already quite actively using social media has been identified by desk research, an online survey I conducted and consulting some experts in the aid & development field, is chosen as sample group for the this a pilot study. Interviews provide a good way of collecting data form the decision makers in these organizations and capturing their perception on the use of social media. Social media is about perception too. Interviews are one of the most important sources of case study information [20]. They may propose solutions or provide insight into events. They may also confirm evidence obtained from other sources [35]. Respondents of the selected development organizations were approached and asked to be interviewed. The interviews were in Dutch and after transcribing I coded in English and translated excerpts of the data.

3.3 Context and Characteristics of Analyzed Organizations

To sketch the context of the findings, some of the characteristics of the aid and development organizations that have been examined for this pilot study are summarized in the following table.

Table 1. Characteristics of the development organizations.

ID	Development organization pseudonym	Age Organization	Staff size.	Single-issue vs. Multi-issue	Organization -wide/Dept. Focused use of social media
A	Crowdsourcing	1-5 years	Mid-size	Multi-issue (*)	Organization-wide
B	Water & platform	6-15 years	Mid-size	Single-issue	Organization-wide
C	Mobile phone focused	1-5 years	Mid-size	Multi-issue (*)	Organization-wide
D	Confederated	> 15 years	Large	Multi-issue	Department-focused
E	Traumatized children	6-15 years	Large	Single-issue	Department-focused

Some (arbitrary) distinctions in age and staff size are made. Age is arranged in tiers of 1 to 5 years, 6 to 15 years, and older than 15 years. Staff size is broken down to 'Small' for less than 11, 'Mid-size' for 11 till 75, and 'Large for more than 75 people. Furthermore I have looked whether the organization focuses on one or more areas of interest, for example only healthcare or a broad range of themes like education and poverty reduction. This is labeled 'Single-issue' respectively 'Multi-issue'. Two organizations are also labeled with the asterisk sign (*). These organizations do cover a broad range of areas but in their operations they focus on small-scale projects (case A) or deployment via mobile phones (case C). Finally I have looked whether social media use is mainly located in one department or observable across the whole organization. The data collection spanned the time period of November 2010 till October 2012.

4. FINDINGS

4.1 Social Capital findings

Social capital is a multidimensional concept [36, 37]. Common dimension in definitions of social capital are: trust, rules and norms governing social action, types of social interaction, network resources and other network characteristics [36]. Waters and Burnet et. al argue that development organizations generate social capital [38]. Looking at the literature of social capital one can distinguish bridging', 'bonding' and 'linking' social capital like Field [39] does. Hean et al. [36] asserts that common dimensions in the definition of social capital include trust, rules and norms governing social action, types of social interaction, network resources and other network characteristics. In table 2 some occurrences of these 'dimensions' of social capital are illustrated by excerpts of the case reports. I consider 'types of social interaction' to overlap with bridging', 'bonding' and 'linking' forms of social capital.

Table 2. Social Capital findings.

Social Capital Aspect	Example
Bridging	development organization C puts effort in reaching out to illiterate people by using voice based messaging next to text based messaging. Social inclusion of women is also acknowledged in the activities of the development organization: *"Mobile phones are not only for men, but also for women [in Kenya]"*
Bonding	Social networks are being used for boding with volunteers by multiple development organizations. In Case the respondent said: *"If I tell you that we have so many people to bind to us, then social media is a very promising channel, a medium. Because of the ability to communicate very quickly."*
Linking	One could identify 'linking' social capital in the connection that has been established between communities in developing countries and crowdsourcing, particularly crowd funding activities. .
Trust	Respondent in case A explains their strategy from *"Trust me, via Tell me and Show me to Involve me".* The respondent in case A said that that he felt that little mistakes while using social media are permitted if you stay honest and transparent: *"In the [web] 2.0 world you should not hide. It is better to admit your mistake directly and discuss openly."*
Rules and norms	*The [text message] code 666 does not work in a Christian country like Uganda "where* that is negatively associated due to religious motives (i.e. the number of the Beast)
Network resources	In developing countries the organization relies on mobile phone communication said responded in case C. *"in Africa Internet [connectivity] is bad and too expensive for the poor whereas mobile phones are they only way to reach out to this group"* The respondent in case B argued that social media can't be considered separate from the 'offline' activities, the 'Online vs. offline' dichotomy: *"You actually have two worlds; you have the old one, that's all large organizations. And then you have social media which is a very open network, but I don't believe that the one can do without the other…you can achieve most success by joining the two worlds. The 'old world' is needed to achieve things and is sometimes underexposed."*
Other network characteristics	'Tone of voice' aspect of communication was mentioned in case C: *"We communicate differently to East-Africans than to Dutch people"* Regarding the use of various types of social media, respondent in case D said: *"The message is adapted to the medium"*

4.2 Preliminary Diagram with Relationships between the Themes

The occurrences of the open codes in the cases show the emerging pattern of the identified selective codes. The selective codes reveal the themes that are apparent in the data. The selective codes (i.e. categories) were identified after grouping the 80 open codes and finding close conceptual relation among the open codes that were clustered. Under 'Perception of social media' I understand the respondents' notion of what social media is. It does not necessarily mean this defines social media, but it tells how the respondents in the context of their work and organization perceive what social media means to them. The selective code 'Applying to social media practice' shows the social media activities undertaken by the examined organization. 'Identifying barriers/risks of social media' reveals the barriers or risks that respondents mentioned and they are recognize while using social media for their organization. The three themes that have been found in the data of this pilot study are assessed on their interrelation. I have found the following preliminary diagram of the emergent themes and their relationships. The ideas that international development organizations and their staff have of the risk of social media use, the threats it brings of the hurdles that have to be crossed, influence the way they perceive the concept of social media. The characteristics that are attributed to social media including the by the organizations and their staff identified barriers and risks of social media motivate how social media is used in practice by the organizations. To illustrate the emerging relationships I will provide some examples from the analyzed cases. The first relationship I'd like to discuss is that between 'Identifying barriers / risks of social media' and 'Characterizing social media'. This relationship I have characterized with the word "Determines" where the first-mentioned theme determines the latter

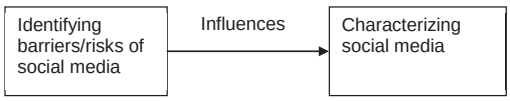


Figure 1. Relationship between 'Identifying barriers/risks of social media' and 'Characterizing social media'.

An example how a barrier influences how social media is characterized is:

"The problem is explaining complex abstract bigger stories, whereas a small story or project is easier to show online and to get support for. See for example [name of development organization Case A] with only projects. My organization struggles with this."

This I have identified as 'Issue with (over)simplification' of the message on social media. This barrier explains the way the respondent told his particular organization characterizes social media. The concept of 'Development 2.0'(or International Cooperation 2.0) was mentioned by several organizations where international cooperation 2.0 (or Development 2.0) is characterized by massive online collaboration, self-organization, open-source marketing, collective intelligence and crowd sourcing [40] and aimed at achieving development goals [41].

"The website combines Web 2.0 elements with the rise of people and organizations who want to contribute to development cooperation and is therefore really in itself a form of International Cooperation 2.0", one respondent commented about his organization.

The second relationship that I identified between the emerging themes is between how the development organizations are 'Characterizing social media' and their 'Social media practice' (figure 2).

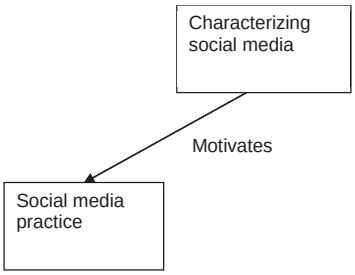


Figure 2. Relationship between 'Characterizing social media' and 'Social media practice'.

An example of this relationship is: *"And if there is a new medium/social media platform we will claim the account and see later if it is useful."* This excerpt exemplifies what I coded as 'Experimenting' and wanting to be front-runner behavior where news social media is typified as innovative and motivates the organization to jump on board.

Another respondent claims his organization's development follows social media developments:

"[development organization A] is completely integrated with social media; we grew together to the current level."

Another fragment shows that the respondent of case E treats social media as just another communication channel:

"Social media is one of the channels that you have in a whole range of channels."

The third relationship that I identified between the emerging themes is between 'Identifying barriers/risks of social media' and 'Social media practice'.

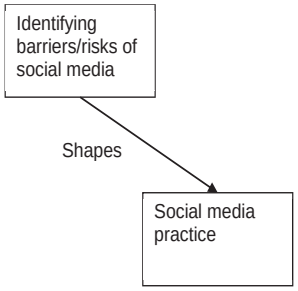


Figure 3. Relationship between 'Identifying barriers/risks of social media' and 'Social media practice'.

An example of this relationship is:

"Social media is not holy; it should be a part of your communication strategy. One cannot solely depend on social media, because what you are left with then is what Facebook, Twitter and the other platforms have to offer."

In this excerpt exemplifies what I coded as the respondent of case A cautioned about the use of social media, remarking that instead of what I coded as 'Overreliance on social media' one should use social media as part of the whole communication strategy of the organization. This idea of the limitations of social media shapes his organizations' use of social media as part of a broader strategy. The respondent of case D told me:

"We work with organizations that cannot put everything online, such as human right organizations. Choices need to be made and discussed before material is put online."

The barrier observed by the respondent concerns about material that may harm it local stakeholders and shapes the way the organizations uses social media.

The findings of this pilot study reveal a preliminary diagram of the emergent themes and the relationships between presumed risks and barriers, the definition of social media and the actual use of social media by the development organizations. The ideas that organizations and their staff have of the risk of social media use, the threats it brings of the hurdles that have to be crossed, influence the way they perceive the concept of social media. The characteristics that are attributed to social media including the by the organizations and their staff identified barriers and risks of social media motivate how social media is used in practice by the organizations. The three themes combine into a diagram that shows the emergent themes and their relations.

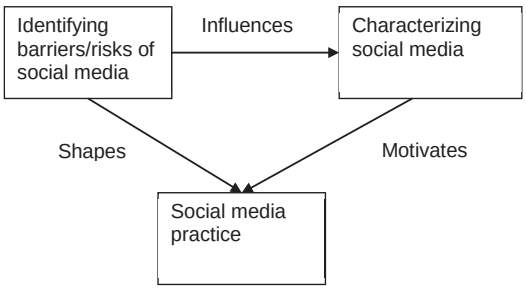


Figure 4. Preliminary framework of emerging themes.

From this diagram it becomes apparent that barriers and risks associated with social media influence the way a development organization thinks of social media. Risks may stimulate education and training of staff to understand how to use social media wisely. This could stimulate knowledge transfer in the organization and influence both human capital and social capital. Risks and barriers may prevent the development organization to use social media or to disseminate certain information or engage via social media. This could mean that weak ties in the social networks are not improved nor deteriorated, but also may prevent potential negative impact on the relationship with strong ties in the social network (i.e. stakeholders that are closely known), c. f. Phulari et al. [42]. The collective of human capital in the development organization influences the ideas one has about social media and how it has been characterized. Furthermore it influences the practical use of social media. The potential social media creates to engage with stakeholders may enhance social capital by improving the ties with other stakeholders. However, if reputation is affected that may have a negative effect on social capital. The findings reveal various ways social capital occurs in the analyzed cases covering the dimensions of social capital suggested by various scholars. Most suggest a positive impact. However the findings are preliminary and more data is needed to corroborate this view. The diagram of the 'Preliminary framework of emerging themes' will aid me for further development of the doctoral research in the subject-matter.

5. RELEVANCE

There is not much literature on the subject of social media in the context of socio-economic development. Few examples are [43], [44] and [45]. Therefore the first stage of this research project focusses at theory building. This study will act as a foundation for my PhD studies. The Grounded Theory analysis will produce some constructs around which further literature reviewing can be done, and from this foundation the PhD research design will be commenced. In terms of knowledge produced, this is the first study to my knowledge that has looked at social media in the context of development organizations in the Netherlands

6. REFERENCES

[1] Kaplan, A.M. and M. Haenlein, *Users of the world, unite! The challenges and opportunities of Social Media.* Business Horizons, 2010. **53**(1): p. 59-68.

[2] Parameswaran, M., *Social computing: an overview*. Communications of the Association for Information Systems, 2007. **19**: p. 762-780.

[3] Iriberri, A. and G. Leroy, *A life-cycle perspective on online community success.* ACM Computing Surveys, 2009. **41**(2): p. 1-29.

[4] Mayfield, A. *What is Social Media?* icrossing, 2008.

[5] Zuniga, L. and N. White, *Module Web 2.0 and Social Media for Development*, in *Information Management Resource Kit (IMARK)*2009, FAO.

[6] Thompson, M., *ICT and development studies: Towards development 2.0.* Journal of International Development, 2008. **20**(6): p. 821-835.

[7] Heeks, R. *ICT4D 2.0: The Next Phase of Applying ICT for International Development.* Computer, 2008. **41**, 26-33.

[8] UNDP, *Creating a Development Dynamic*, in *Final Report of the Digital Opportunity Initiative*2001, United Nations Development Programme.

[9] McNamara, K.S., *Information and Communication Technologies, Poverty and Development: Learning from Experience.*, in *infoDev Annual Symposium*2003: Geneva, Switzerland.

[10] Sachs, J., *Sustainable development in a networked age.*, in *Common Wealth: Economics for a Crowded Planet.*2008, Penguin Books. p. 307-308.

[11] Yamamichi, M., *The Role of Mobile-Enabled Social Media in Social Development*, I.S.U. World Bank, Editor 2011.

[12] UNDP-APDIP, *Information and Communications Technology for Development - A Sourcebook for Parliamentarians*, ed. D.B.K. GAIROLA, et al.2004: United Nations Development Programme - Asia Pacific Development Information Programme (UNDP-APDIP).

[13] Coleman, J.S., *Social Capital in the Creation of Human Capital*. The American Journal of Sociology, 1988. **Vol. 94**(Supplement: Organizations and Institutions: Sociological and Economic Approaches to the Analysis of Social Structure): p. S95-S120.

[14] Putnam, R.D., *Bowling alone : the collapse and revival of American community*2000, New York: Simon & Schuster. 541 p.

[15] Ferlander, S., *The Internet, Social Capital And Local Community*, in *Department of Psychology*2003, University of Stirling.

[16] Scott, J.K. and T.G. Johnson, *Bowling Alone but Online Together: Social Capital in E-Communities.* Community Development, 2005. **36**(1): p. 9 - 27.

[17] Widén-Wulff, G., et al., *Information behaviour meets social capital: a conceptual model.* Journal of Information Science, 2008. **34**(3): p. 346-355.

[18] Chiu, C.-M., M.-H. Hsu, and E.T.G. Wang, *Understanding knowledge sharing in virtual communities: An integration of social capital and social cognitive theories.* Decision Support Systems, 2006. **42**(3): p. 1872-1888.

[19] Crotty, M., *The Foundations of Social Research*1998: Sage.

[20] Yin, R.K., *Case study research: design and methods*. 3rd ed. Applied social research methods series2003, Thousand Oaks, Calif.: Sage Publications. xvi, 181 p.

[21] Glaser, B.G. and A.L. Strauss, *The discovery of grounded theory: strategies for qualitative research*1967: AldineTransaction.

[22] Orlikowski, W.J. and J.J. Baroudi, *Studying Information Technology in Organizations: Research Approaches and Assumptions.* Information Systems Research, 1991. **2**(1): p. 1-28.

[23] Urquhart, C., *An Encounter with Grounded Theory: Tackling the Practical and Philosophical Issues.* Qualitative Research in Information Systems: Issues and Trends, 2001: p. 104-140.

[24] Trochim, W.M.K. *Qualitative Methods*. Research Methods Knowledge Base 2006 10/20/2006; Available from: http://www.socialresearchmethods.net/kb/qualmeth.php.

[25] Urquhart, C., ed. *An Encounter with Grounded Theory: Tackling the Practical and Philosophical Issues*. Qualitative Research in Information Systems: Issues and Trends, ed. E. Trauth2001, Idea Group Publishing. 104-140.

[26] Fernández, W.D., *The grounded theory method and case study data in IS research: issues and design*, 2005, ANU E Press.

[27] Scholz, R.W. and O. Tietje, *Embedded case study methods : integrating quantitative and qualitative knowledge*2002, Thousand Oaks, Calif.: Sage Publications. 392 p.

[28] Eisenhardt, K.M., *Building Theories from Case Study Research.* The Academy of Management Review, 1989. **4**(4): p. 532-550.

[29] Eisenhardt, K.M. and M.E. Graebner, *Theory building from cases: opportunities and challenges.* Academy of Management Journal, 2007. **50**(1).

[30] Fernández, W.D., *Metateams in Major Information Technology Projects: A Grounded Theory on Conflict,Trust, Communication, and Cost*, in *School of Information Systems*2003, Queensland University of Technology.

[31] Lehmann, H.P., *A Grounded Theory of International Information Systems*, 2001, University of Auckland: Auckland, New Zealand.

[32] Urquhart, C., S. Liyanage, and M.M.O. Kah, *ICTs and poverty reduction: a social capital and knowledge perspective.* J Inf technol, 2007. **23**(3): p. 203-213.

[33] Cummings, S., R. Heeks, and M. Huysman, *Knowledge and learning in online networks in*

development: a social-capital perspective. Development in Practice, 2006. **16**(6): p. 570-586.
[34] Thapa, D. and M.K. Sein. *ICT, Social Capital And Development: The Case Of A Mountain Region In Nepal*. in *Third Annual SIG GlobDev Workshop*. 2010.
[35] Tellis, W. *Introduction to case study*. The Qualitative Report [On-line serial], An online journal dedicated to qualitative research and critical inquiry, 1997. **3**.
[36] Hean, S., et al., *The M–C–M' cycle and social capital.* Social Science & Medicine, 2003. **56**(5): p. 1061-1072.
[37] Huysman, M. and V. Wulf, *Social Capital and Information Technology: Current Debates and Research*, in *Social capital and information technology*2004, MIT Press: Cambridge, Mass.
[38] Waters, R.D., et al., *Engaging stakeholders through social networking: How nonprofit organizations are using Facebook.* Public Relations Review, 2009. **35**(2): p. 102-106.
[39] Field, J., *Social Capital*2003: Routledge.
[40] Jansen, N. *LinkedIn Group: International Co-Operation 2.0*. 2009 [cited 2013 4 January]; Available from: http://www.linkedin.com/groups/International-CoOperation-20-2035922/about.
[41] Kirstein Junge, S., *UNDP's Use of Social Media*, in *Social Media in Development Cooperation*, R.S. Braskov, Editor 2012, Ørecomm at Malmö University and Roskilde University
[42] Phulari, S., et al. *Understanding Formulation of Social Capital in Online Social Network Sites (SNS).* International Journal of Computer Science Issues, IJCSI, 2010. **7**, 92-96.
[43] Hellsten, I., *Focus On Metaphors: The Case Of "Frankenfood" On The Web.* Journal of Computer-Mediated Communication, 2003. **8**(4): p. 0-0.
[44] Nugroho, Y., *Opening the black box: Adoption of innovations in voluntary organisations*, in *Manchester Business School working paper*2009.
[45] Bach, J. and D. Stark, *Link, Search, Interact: The Co-Evolution of NGOs and Interactive Technology.* Theory, Culture & Society, 2004. **21**(3): p. 101-117.

Relationships under the Microscope with Interaction-Backed Social Networks

Jeremy Blackburn and Adriana Iamnitchi
Department of Computer Science & Engineering
University of South Florida, Tampa, FL, USA
Email: jhblackb@mail.usf.edu, anda@cse.usf.edu

***Abstract*—Binary friendship declarations typical of online social networks have been shown inadequate to properly capture dynamic and meaningful social relationships between users. Interaction networks, on the other hand, rely on statistical inference and assumptions on the nature of what "friendship" means.**

This paper analyzes an *interaction-backed social network*, where an interaction network and a declared social network coexist without constraining each other. We show quantitatively how many interactions take place within a declared relationship, but also that there are interactions between users without a declared relationship. By measuring interactions between declared and non-declared pairs of users, we can discover how levels of interaction wax and wane, and how attention is diverted from existing relationships to forming new ones. Our quantitative analysis can also serve scientists to create interaction workloads from declared social networks or infer social networks from interaction traces.

I. Introduction

The abundance of social information exposed by online social networks (OSNs) and Web 2.0 applications has enabled the mining of declared social relationships to unprecedented degree. Unfortunately, the ease of relationship creation and hidden incentives to declare many "friends" lead to significant concerns about how findings from OSNs might transfer to real world situations [1]. Moreover, declaration-based OSNs provide little insight into interactions between pairs *without* a declared relationship.

An alternative data source for exploring relationships are interaction networks. For example, data traces from cellular networks [2] have been used as empirical evidence for theories on tie strength, and traces of email chain letters have shown the existence of small world effects in digital communication [3]. However, although interaction-based networks alleviate the questions of relationship meaning, they fail to capture the significance of *explicitly declared* relationships. Instead, researchers must rely on statistical inference and make assumptions on the correlation between interactions and relationships.

One way to mitigate these concerns is to examine *interaction-backed* OSNs, which we define as Internet-mediated communities where declared relationships and interactions can be independent. (Facebook, for example, is not interaction-backed, because two unconnected users cannot interact within the application.) Interaction-backed OSNs more accurately portray real-world relationships where relationships form over time due to extended, meaningful contact between individuals and interactions are possible without the responsibility of a formally declared relationship. Interaction-backed OSNs thus bridge the gap between interactions and explicitly declared relationships.

In this paper, we study such an interaction-backed OSN formed of online game players. Gamers relationships are compelling for several reasons. First, gaming is a very popular activity, with multiplayer games breaking historical records for entertainment sales [4], pushing cutting edge consumer hardware [5], and attracting hundreds of thousands of viewers in live events and millions of dollars in prize money [6]. Second, in-game interactions are considered to mirror real-world interactions [7]. And finally, gaming platforms are built to support gaming interactions and often have a separate, optional, declarative OSN. Gaming interactions do not require the functionality of the OSN, but the OSN facilitates out-of-game interactions (such as chat, announcements, etc).

For these reasons, we analyze a 10-month data trace from a community-owned and operated game server for one of the world's most popular multiplayer games and the corresponding set of players' declared friendships. We analyze the correlation between the two graphs: the in-game interaction network and the declarative OSN. Our analysis captures quantified differences between interactivity along declared relationships in comparison to undeclared relationships.

The remainder of the paper is organized as follows. Section II describes our dataset. The results of our analysis are presented inSection III. Related work is discussed in Section IV. Finally, we conclude in Section V.

II. Dataset

Our dataset consists of in-game events from a popular *Team Fortress 2* (TF2) server and of the corresponding declared social ties in *Steam Community*, an online social network of gamers maintained by Steam, the dominant digital game distribution platform on PCs. We crawled the Steam Community to collect the profiles of the players in our logs [8].

A. Team Fortress 2

TF2 is a team- and class-based, objective-oriented first person shooter game released in 2007. Game sessions in TF2 are hosted by individual servers, most often owned and operated by independent gaming communities. Gameplay pits two teams, Red and Blue, against each other on a variety of maps. Some maps are symetrical, with both Red and Blue attempting to complete the same objective, and others are asymmetrical, with Blue attacking and Red defending the objective.

Once players join a game they must choose a team. After choosing a team, players choose to play as one of 9 classes. Players are allowed to switch classes at any point of the game, and while certain team compositions might be more or less viable, players can choose a class independent of the choices made by the rest of their team. A regular stream of free content updates (335 as of January 2013 [9]) has kept TF2 popular since its release.

B. The Server

We obtained just over 10 months of gameplay traces (from April 1 to February 3, 2012) from "The Slaughterhouse" (SH), one of several TF2 servers operated by the "Brotherhood of Slaughter" (BoS) gaming community. The server, located in Los Angeles, California, hosts up to 30 players simultaneously, costs approximately $250.00 a month to operate, and is completely funded by donations from the BoS community.

SH has been customized with a variety settings. Of note is the `alltalk` setting, which broadcasts all voice communications to both teams, chosen by the BoS server administrators to foster a fun, social atmosphere, as opposed to a purely competitive environment. As voice communication in games like TF2 both influences, and is influenced by, gameplay [10], a server like SH can produce an intense social gaming experience when filled with a talkative crowd.

The logs contain information such as gameplay events, in-game team and server-wide text chat, and map nomination and votes. We extracted 12,621,543 gameplay events. Such events include, for example, one or more players capturing territory together, or two players on the same team working together to "kill" a player on the opposing team.

From the extracted events, we created an undirected *interaction graph* where an edge exists between two players if there was at least one event that involved both players. Each edge is annotated with a time series corresponding to the times of the extracted event between the players. In total there were 18,743,644 pairwise interactions, i.e., the sum of the length of all edges' annotated time series.

C. The Steam Community

Steam Community is an OSN of Steam users, i.e., people who buy and play games on Steam, a digital distribution platform. A Steam profile includes a nickname, a privacy setting (public, private, or friends only), set of friends (identified by SteamIDs), group memberships, list of games owned, gameplay statistics for the past two weeks, a user-selected geographical location, albums of posted screenshots and videos, and even a portfolio of user-created modifications to games. Ties in Steam Community can be declared totally independent of gaming interactions: they are not required to play games together, but they provide a persistent, game-independent contact channel.

Table I presents the size of our dataset. There are 33,546 players on the server who are part of the Steam Community OSN, involved in over 1 million relationships. Of them, 22,099 have 50,522 friendships where both friends played on the server. Of these, 7,701 friends interacted on the server during our observations, forming 13,270 interactive pairs.

Graph	*# Players*	*# Edges*
Steam Friends	33,546 (620,789 non-players)	1,038,133
Server Friends	22,099	50,522
Interaction	33,546	1,768,528
Interacting Friends	7,501	13,270

TABLE I. DETAILS OF OUR DATASET.

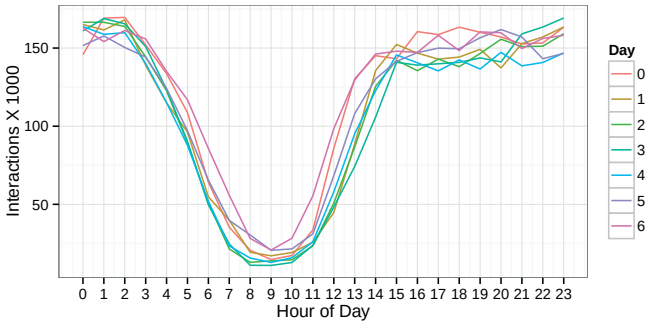


Fig. 1. Number of interactions per-hour, per-day of the week (from Sunday).

III. DATA ANALYSIS: WHAT'S IN A RELATIONSHIP

A. General Server Characterization

We begin with a general characterization of the SH community. Like any community, the social environment of a virtual community helps shape the interactions that occur.

Fig. 1 shows that the community is quite active on any given day of the week. On all days, activity levels are the highest in the afternoon, and begin to fall off around midnight Pacific Time. We note that Saturday, a "pure" weekend day, has a relatively higher level of activity during normal working hours, with Sunday having the second highest level.

This sustained activity during non-working hours drastically differentiates this dataset from interactions in declarative OSNs such as Facebook. Gaming is a leisure activity that requires adequate, and often specialized, hardware, and more importantly, significant focus and concentration. Unlike other online social activities such as instant messaging or browsing Facebook profiles, gaming sessions are continuous and preclude multitasking. Hence, activity levels correlate to the times of day that gamers are not encumbered with the distractions of work or school.

B. Declared Relationships

Fig. 2 plots the degree distributions of the players on the server. The Steam Community degree distribution is based off the entire friends list of players, while the Server Friends degree distribution is based off the subset of a player's friends that also played on the server. The interaction distribution portrays the number of interaction partners each player had.

From the plot we first observe that Steam Friends distribution of players is the same as the degree distribution of Steam Community as a whole observed in [8]. We also see that players have many more interaction partners than they do declared friends, and tend to have fewer friends that play on the server than they do overall. Both of these results mirror real-life experiences that are not captured by interaction graphs or declarative OSNs alone: not everyone we interact with

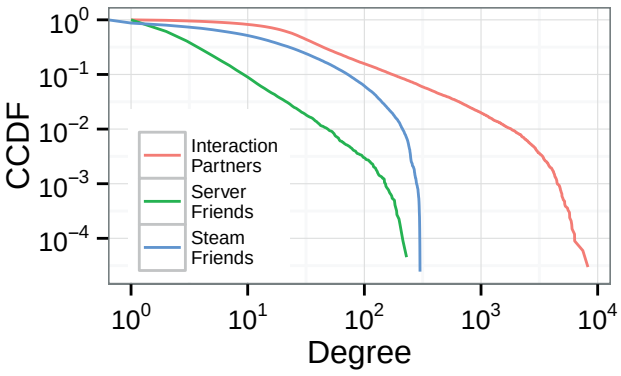


Fig. 2. Degree distributions for SH players.

becomes a friend, and we interact with a subset of our friends depending on the venue.

What is not necessarily intuitive is the shape of the server friends curve. While we might expect the server friends curve to have the same shape (yet shifted) as the Steam friends curve, this is not the case. Instead, the shape mimics that of the interaction partners curve, giving us our first indication that interaction and declared friendships are related.

C. Interactions and Declarations

Having established the activity level of the server community and the engagement of its players in the online social network of Steam, we next examine the relationship between the two. Ultimately, we find that declared pairs have *many* more interactions than undeclared pairs.

There is a striking difference between the interaction patterns of declared pairs and non-declared pairs of players, lending credence to the strength of declared relationships in an interaction-backed OSN like Steam Community. Fig. 3 plots the average number of events per hour of the week for interacting pairs, differentiated by the existence of a declared relationship, across the entire span of our log files. Friends averaged several orders of magnitude more interactions than pairs without a declared friendship.

One unexpected finding is that the peaks in Fig. 3 for declared pairs are during the week. This is in contrast to Fig. 1 which shows higher levels of activity during the weekends. One possible explanation for this difference is that the server population skews towards "regulars" during the week and includes more "randoms" during the weekends. This hypothesis fits well with the concept of an interaction-backed OSN: regulars are more likely to interact more, and their interactions are more likely to spawn declared relationships in the OSN.

IV. Related Work

Wilson et al. [1] questioned the meaning of friendships in declared OSNs by examining interactions between users on Facebook. They define an interaction graph to be a subset of the Facebook social graph (since Facebook interactions are limited to individuals with declared friendship) where the two end points had n interactions over a time interval t, and show that users only interacted with a small subset of their friends, that interaction degree is not correlated with social degree, and that small-world clustering decreased as the interaction graph becomes more restrictive. One aspect they leave open for future work is the construction of interaction graphs that are *not* a strict subset of the social graph. The work in this paper is a first step towards filling that gap since our interactions exist in a separate, although related, context than the OSN they back.

Xu et al. [11] interviewed 14 *Halo 3* players to study the meaning of relationships within an online gaming context. They found evidence of in-game relationships supported by real-world relationships, triadic closure of relationships making use of both real and virtual relationships as a bridge, and in-game interactions strengthening ties in the real world. Mason and Clauset [12] investigated the behavior of *Halo: Reach* players combining gameplay summaries with pyschometrics and a social network constructed from survey data. They find that gamers preferred to play with friends, and that the duration of time played together was a useful predictor for a friendship.

A major difference with our work is the use of surveys vs. an OSN as ground truth for a friendship existing. Considered together, our work and theirs, particularly Mason and Clauset's results that playing together is a useful proxy for friendship and our results that declared friends have orders of magnitude more interactions than non-declared friends can be taken as evidence that declared relationships in gaming related OSNs might very well represent real "friendships."

There is an additional subtle, yet important difference between these works though: the mechanism for finding play partners. In Halo, the primary mechanism is a skill-based matchmaking service [13], which places groups of players of similar skill into a peer-to-peer gaming session. To play with the same teammates, players must explicitly choose to "party up", and anecdotal evidence suggests that most players back out of the party up option after games with random players. In contrast, the mechanism in TF2 relies on players explicitly choosing a particular community owned and operated server, each with their own unique personalities and atmospheres, for play. This makes the selection of a virtual environment an analogue to the selection of a real world environment. For example, the frequenting of a particular pool hall, chosen not just for the competition but also for the camaraderie exhibited by the community. This easily accessible metaphor hints at the applicability of our results to real world scenarios.

Our previous works were the earliest studies of gamers in the Steam Community OSN [14], [8]. The dataset we analyzed comprised over 10 million friends lists and a small sample of the log files used in this paper. The work included a cursory investigation of gamers activity levels and socio-gaming characteristics, however, the focus was on the position of unethical actors (cheaters) in a planetary scale social network. In addition to the above, we proposed a distributed social infrastructure in [15]. We again used a small sample of the logs used in this work to build a proof-of-concept social sensor which produced a weighted social graph based on player interactions.

This paper compliments our previous work by providing a more intimate view of declared relationships. Our new findings indicate a high degree of correlation between declared relationships and interactions. This strengthens the hypothesis

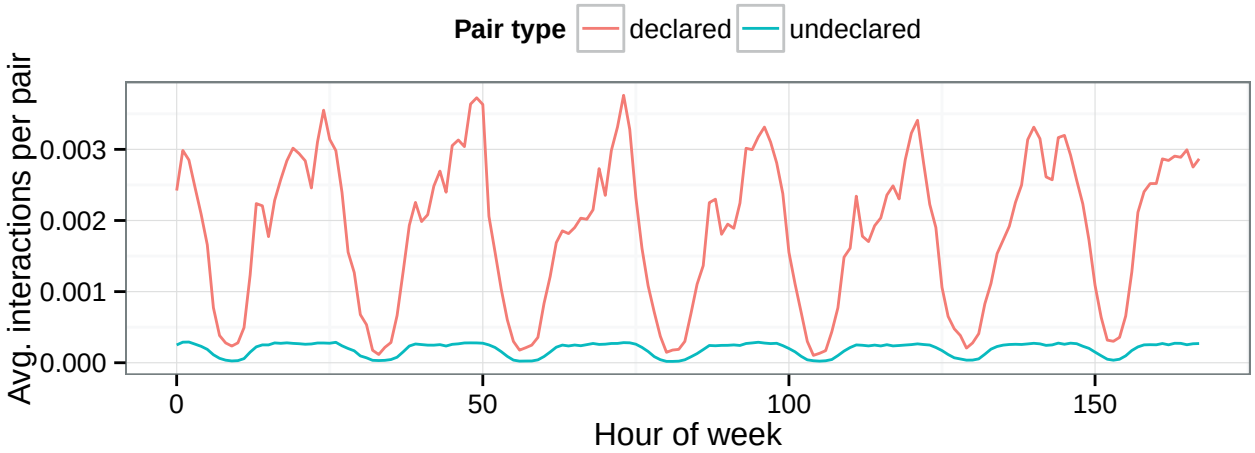


Fig. 3. The average number of interactions per hour of the week for interacting pairs. Hour 0 is Sunday midnight (0:00)

that declared relationships are meaningful enough to allow for the diffusion of innovation, and suggests a possible mapping to interaction-based contagion models [16].

V. Summary

While declarative OSNs have been the focal point of a new understanding of human relations, concerns about the validity of the relationships they describe remain. The implications for researchers is that while declarative OSNs provide a model for human relationships, they might fail to provide a full view of what differentiates a friend from a non-friend.

This paper explored the link between interactions and declared friendships of gamers in the interaction-backed OSN Steam Community. From detailed gameplay logs of an active community-owned and operated server, we examined the interaction patterns of both players with a declared relationship and those without one. We discovered that player pairs with a declared relationship had orders of magnitude more interactions than those without a declared relationship, even though there were multiple orders of magnitude more interactions in total between non-declared pairs than declared pairs.

This suggests a new direction for researchers interested in moving past the simple relationships exposed by OSNs like Facebook. Instead of examining services whose utility is derived solely from declared ties in the OSN, thus obscuring interactions between non-friends, a more enlightening approach is to seek out and investigate interaction-backed OSNs. Studies of interaction-backed OSNs could elucidate, for example, the interactions preceding the creation of a friendship, or how attention is diverted from existing friends to a new contact prior to the next contact being declared a friend. In other words, not only what it means to be friends, but, what it means to *not* be friends.

Acknowledgements The US National Science Foundation supported this research under grant CNS 0952420.

References

[1] C. Wilson, A. Sala, K. P. N. Puttaswamy, and B. Y. Zhao, "Beyond Social Graphs: User Interactions in Online Social Networks and their Implications," *ACM Trans. Web*, vol. 6, no. 4, pp. 17:1–17:31, 2012.

[2] J. Onnela, J. Saramäki, J. Hyvönen, G. Szabó, D. Lazer, K. Kaski, J. Kertész, and A. Barabási, "Structure and tie strengths in mobile communication networks," in *Proceedings of the National Academy of Sciences*, 2007.

[3] D. Liben-Nowell and J. Kleinberg, "Tracing information flow on a global scale using Internet chain-letter data," *Proceedings of the National Academy of Sciences*, vol. 105, no. 12, p. 4633, 2008.

[4] T. Cross, "All the world's a game," 2011. [Online]. Available: http://www.economist.com/node/21541164

[5] J. Giles, "Inside the race to hack the kinect," *New Scientist*, vol. 208, no. 2789, pp. 22 – 23, 2010.

[6] Valve, "The international - dota 2," 2012. [Online]. Available: http://www.dota2.com/international

[7] M. Szell and S. Thurner, "Measuring social dynamics in a massive multiplayer online game," *Social Networks*, vol. 32, no. 4, pp. 313–329, Oct. 2010.

[8] J. Blackburn, R. Simha, N. Kourtellis, X. Zuo, M. Ripeanu, J. Skvoretz, and A. Iamnitchi, "Branded with a scarlet "C": cheaters in a gaming social network," in *Proceedings of the 21st international conference on World Wide Web*, 2012, pp. 81–90.

[9] Team Fortress 2, "Team Fortress 2 History," 2013. [Online]. Available: http://tf2.com/history.php

[10] A. Tang, J. Massey, N. Wong, D. Reilly, and W. K. Edwards, "Verbal coordination in first person shooter games," in *Proceedings of the ACM 2012 conference on Computer Supported Cooperative Work*, 2012, pp. 579–582.

[11] Y. Xu, X. Cao, A. Sellen, R. Herbrich, and T. Graepel, "Sociable killers: understanding social relationships in an online first-person shooter game," in *Proceedings of the ACM 2011 conference on Computer supported cooperative work*, 2011, pp. 197–206.

[12] W. Mason and A. Clauset, "Friends FTW! Friendship and competition in Halo: Reach," *arXiv.org*, vol. cs.SI, Mar. 2012. [Online]. Available: http://arxiv.org/abs/1203.2268v1

[13] R. Herbrich, T. Minka, and T. Graepel, "Trueskill™: A Bayesian skill rating system," *Advances in Neural Information Processing Systems*, vol. 19, p. 569, 2007.

[14] J. Blackburn, R. Simha, C. Long, X. Zou, N. Kourtellis, J. Skvoretz, and A. Iamnitchi, "Cheaters in a Gaming Social Network," *ACM Performance Evaluation Review (PER)*, pp. 1–3, 2011.

[15] A. Iamnitchi, J. Blackburn, and N. Kourtellis, "The social hourglass: An infrastructure for socially aware applications and services," *IEEE Internet Computing*, vol. 16, pp. 13–23, 2012.

[16] P. S. Dodds and D. J. Watts, "A generalized model of social and biological contagion," *Journal of Theoretical Biology*, vol. 232, no. 4, pp. 587–604, Feb. 2005.

The Evolving Dynamics of the Internet Layered Architecture

Innovation, Net Neutrality and the Interdependence of Structure and Function

Paolo Dini
Department of Media and Communications
London School of Economics and Political Science
Houghton Street, London, UK
p.dini@lse.ac.uk

Thanassis Tiropanis
Electronics and Computer Science
University of Southampton
tt2@ecs.soton.ac.uk

In this extended abstract we discuss the infrastructure of the Internet as two distinct layers that are increasingly interdependent: the network layer, below, and the Web, above. The network layer is responsible for the structural properties of the Internet, while the top layer is where the Web content is consumed through Web applications and communications. We argue that the principle of independence between the layers, which guided the early design of the Internet, has enabled an environment conducive to innovation pursued by different communities: networking technologists primarily below, and business, application developers, and humanists/artists above. The innovations in each layer, however, are increasingly influencing design criteria and choices in the other, suggesting that the Internet architecture is evolving towards greater interdependence between the layers. For example, this is explicitly sought in some cases for wireless networks for efficiency optimization. Tight coupling between structural and functional properties is one of the fundamental "architectural" principles of biological organisms, which have evolved to optimize energy efficiency as a requirement for survival and procreation. This view, which mixes strictly functionalist concerns with creative and opportunistic behaviour, suggests that the Internet may be evolving towards an increasingly complex structure and dynamic. The paper argues that an environment in which the two layers are increasingly interdependent can still sustain a high level of innovation as long as no entity has full control of both, and as long as the design principles on each layer, which can be argued to have been fostering innovation, are not changed. We argue that the original Internet has fostered a number of innovations including the Web, P2P applications, and the Cloud and that its potential for innovation could be compromised if the importance of net neutrality and its infrastructural characteristics are undermined.

Keywords: Innovation, net neutrality, layered architecture, tight coupling

I. Introduction

The idea of this paper originated from a conversation between the authors over the course of several meetings of the EINS project.[1] Both authors come from engineering, albeit of different kinds,[2] are still active in the hard sciences, and have been studying social science for the past several years. Our conversations, therefore, have been refreshingly free from the problem usually encountered when speaking with someone whose work is rooted in "the other" disciplinary domain: this is the problem of not being able to find the right words to express an important concept because the other person lacks the ontological, epistemological, and methodological framework to decode and understand the points being made. It is fortunate that since the emergence of Web 2.0 phenomena this problem has been gradually dissipating, as far as the socio-technical interface of interdisciplinary science is concerned, with the result that computer scientists and software engineers are well ahead of the other "hard" sciences in understanding and relating to social phenomena. For example, unlike 10-15 years ago, most computer scientists today are familiar with the concept of social construction. But there are still many opportunities for diverging views in economic and political discussions.

In this extended abstract we begin to sketch the main points of a long-term study of some of the "interdisciplinary entanglements" that increasingly characterize the Internet and an emerging Internet Science. The points raised are meant only as signposts of more in-depth and more nuanced discussions to be pursued during the course of this study. We will analyse the Internet from two viewpoints that for convenience we can associate with the terms "Innovation" and "Net Neutrality".

The first entanglement involves the interaction between the Internet's architecture and socio-technical innovation dynamics. Simplifying the 7-layer OSI stack model or the 4-layer TCP/IP stack model to just 2 layers – network below and Web above – we argue that the original engineering criterion of independence and modularity between the layers facilitated innovation dynamics in the early Internet; but that, ironically, the same innovation dynamics are leading to a progressively *greater interdependence* between the two layers. When interdependence takes the form of interaction only through an agreed interface between otherwise separate modules it is termed 'loose coupling'. This is one of the building blocks of object-oriented software engineering and of its online extension to service-oriented computing or architecture (SOC/SOA) (Papazoglou 2003). Biological systems, by contrast, have evolved opportunistically to optimize their efficiency under scarse energy resources (food), leading to multifunctionality and tight functional interdependence,[3]

[1] http://www.internet-science.eu

[2] Paolo Dini's original background is in aerospace engineering and physics, Thanassis Tiropanis's background is in software engineering and computer science.

[3] The specific functional interdependence we are referring to here goes well beyond function calls to and from inside given modules. In biology the temporal evolution of a given subunit viewed as a discrete and finite state machine depends entirely on the other subunits it is coupled to *themselves* transitioning to new states (there is no CPU). Depending on the interconnection topology and the number of such interdependent modules one

which we can term 'tight coupling'. In this paper we argue that in some respects the evolution of the Internet towards greater interdependence between the layers reflects some aspects of the functional interdependence or tight coupling of biological systems. Although this is an interesting development from a purely technical viewpoint, it comes with some dangers that we would like to analyse in more depth.

For example, the second entanglement we study, which has been and continues to be widely discussed in the literature, concerns what could be regarded as the most important issue in Internet governance: net neutrality. Net neutrality involves the interaction between the technical management of information and content and the political and market forces that are vying to influence or control the technical design of the Internet (Lessig 2006). The main point the paper argues is that as the interdependence between the two layers of the Internet increases it becomes increasingly important to maintain net neutrality if we wish to retain the ability to innovate.

The points outlined above are linked to some ideas the first author started to work on some years ago but never published beyond the stage of a EU project deliverable (Berdou and Dini 2005), except for Figure 3 which has appeared, through a different argument, also in Dini et al. (2011). In reference to the concepts discussed in Dini & Sartori (2013), the interdependence between the two layers of the Internet can be conceptualized either from a systemic point of view, where an emphasis on language overshadows the role of the individual, or from a more empirical and case study-oriented perspective, which necessarily depends on the analysis of individual initiatives, interests, and motivations.

To argue our point we therefore follow two strategies. First, in Section II we develop a language-based systemic model of the socio-technical Internet phenomenon as a self-reinforcing feedback loop that transcends disciplinary boundaries and offers a possible synthesis of very different disciplinary perspectives. This model spans both the loose coupling and the tight coupling scenarios. Second, in Section III we discuss examples of how innovation in the early Internet was made possible by the modularity and independence between the layers. And in Section IV we discuss examples that show that recent innovation trends are pushing the layers towards ever-greater interdependence. Finally, In Section V we use these different perspectives to argue that net neutrality remains one of the most important architectural principles of the Internet and that the infrastructural nature of the Internet and of the Web needs to be safeguarded to foster further innovation in each of these layers.

II. The Media Stack

The nested media of the OSI stack are layered in order of increasing abstraction (see Figure 1). Although each layer is not in general a formal transformation of the layers adjacent to it, it certainly can be, as exemplified by software radio or by ASICs (application-specific integrated circuits), which are first implemented as programs and then transposed to logic gates on silicon. This transformational property of ICTs is a consequence of their being formal systems ultimately equivalent to the same abstract machine (the most general for the currently accepted computing paradigm being the Turing machine[4]).

As shown in Figure 2, if we turn the media stack on its side we can arrange different technologies from most concrete to most abstract right to left, culminating with formal languages. As we approach natural languages two interesting things happen: we encounter a boundary beyond which we cannot develop a formal model, and the medium and content converge. Furthermore, as we approach natural language it becomes increasingly difficult to commodify the technology. This becomes clear through the simple observation that society could not function if every spoken utterance were copyrighted and money were exchanged between listener and speaker according to some contract.

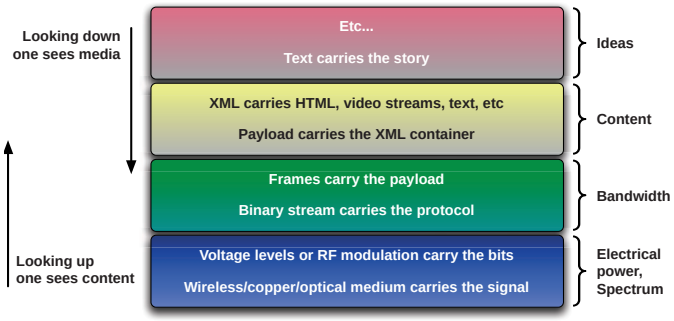


Fig 1. The media stack

Figure 2 also highlights how difficult it is to separate the factors underpinning the co-evolution of technology with socio-economic systems. For example, it is far from clear whether principles such as decentralized architectures or P2P networks were derived from a particular social theory, or whether instead the converse applies. In general, it seems more accurate to state that socio-economic and technical systems are interdependent and tightly intertwined, that socio-technical and socio-economic phenomena appear to emerge spontaneously from their interaction, and that social theory then tries to explain them. This state of affairs can be interpreted as evidence that it is not so easy to make a clear separation between the 'objective' technology we build and our 'subjective' or 'intersubjective' human experience (Ciborra & Hanseth 1998).

As discussed in Feenberg (2005), in Heidegger's early writings 'Aristotle's conception of being in general is derived from the Greek practice of technical making, from τέχνη. τέχνη realizes the inherent potentialities of things rather than violating them as does modern technology' (ibid, xiv). Compatibly with this position, according to Marcuse '…the task of a post-Heideggerian philosophy is to conceive a technology based on respect for nature and incorporating life-affirming values in its very structure, the machines themselves' (ibid, 4). This utopian demand can be understood as 'an implicit recovery of Aristotle's idea of τέχνη in a modern context, freed from the limitations of ancient Greek thought and available as a basis for a reconstructed modernity'

obtains, for example, autocatalytic cycles, which are generally designed out of networking and computer systems as undesirable loops. This form of tight coupling is the basis for emerging models of 'unconventional computing', see for example http://www.biomicsproject.eu.

[4] In his original paper, Turing (1936) introduced also the concept of the 'choice machine' which, unlike what then became known as the Turing machine, could be interrupted during the evaluation of a mathematical function. This is the theoretical starting point of unconventional computing initiatives such as interaction computing (www.biomicsproject.eu), which aim to mimic the tight coupling found within biological systems as well as, at much larger scales, ecosystems.

(ibid, 4). Making things (i.e. engineering) can then be recovered as a life-affirming, deeply human activity, as long as we are not blinded by the myth of the neutrality of technology in an objective world. Feenberg's critical theory of technology (Feenberg 1991, 2002) shows how technology embodies our cultural values and is in fact an extension of our human languages that necessarily generalizes the concept of symbol. It then contributes to the construction of our understanding of reality and in particular of our social reality.

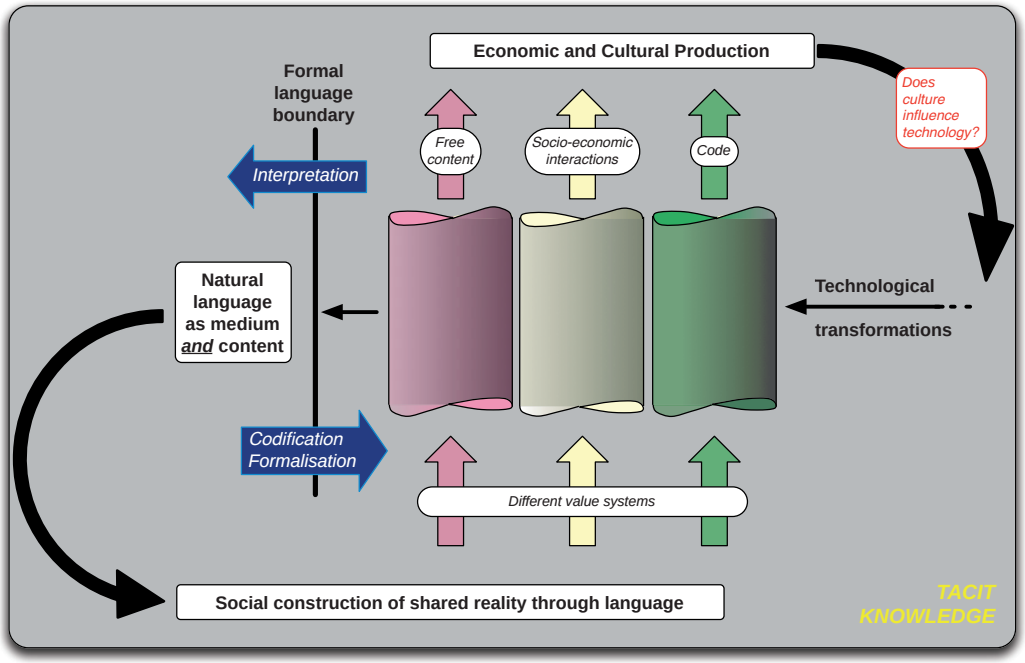


Fig 2. Language, technology and culture

In this panorama of technology recast as an extension of human cultures and languages the Internet plays a unique role because, not only does it share with other kinds of technology this cultural and expressive valence, it *mediates* the very communications that construct the social and cultural systems that created it. It is not clear what the effect of this tight feedback loop might be, but it is pretty clear that it is likely to be a strong one, and perhaps not so easy to control. When looked at through a social science "lens", therefore, the hybrid role of computer science is perhaps best captured by Winograd and Flores's view of computers as communication media (1987). Because communications, in turn, carry commitments (Austin 1962; Flores & Spinosa 1998; Searle 1979), it becomes easier to accept that the Internet has the potential to become a catalyst of social constructivist processes. For example, we can point to the role played by the Web in the formation of the identity of social groups, as discussed by Flores and Spinosa well before Facebook. Figure 3 completes the thought process around the concept of mediation developed in the previous two figures and gives a high-level Escher-like graphical rendition of the feedback loops generated by the interaction of the Internet and media content.

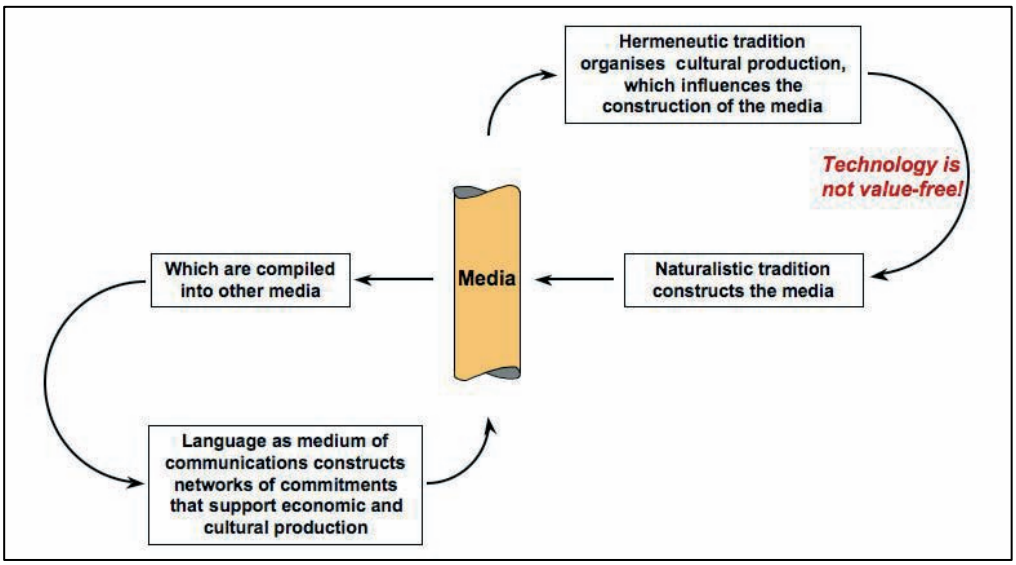


Figure 3: The self-reinforcing cycle at the heart of the Internet (Dini et al. 2011)

This model, although useful for discriminating between how ICTs interact with society and other kinds of technologies (think tractors or container ships), is too abstract to analyse the differences in the innovation dynamics of the Internet under loose coupling vs. tight coupling between its two layers. We need to complement it with an empirical and case study-oriented perspective that examines the Internet as an infrastructure.

III. Infrastructures and Innovation

So far we have been discussing the network layer and the Web as two parts of the same overall infrastructure, the Internet. Whereas this is conceptually correct, the everyday use of these terms by practitioners from each layer is slightly different: the network layer itself tends to be referred to as the Internet – consistently with how things stood before the Web – while use of the Web as the top layer is the same as we have used in this extended abstract so far. As from this section we are shifting the discussion from a model-based, systemic and deductive approach to an empirical, individualist, and inductive perspective, we see no harm in switching the convention for the associated terminology as well.

It appears that both the Internet and the Web can be seen as two distinct infrastructures which have been fostering innovation. However, many people perceive the Web and the Internet infrastructure as a single artefact, especially considering that their individual roles are not easily distinguishable when examined in the context of social construction through language, as discussed in the previous section. For this reason, that view of the Internet and the Web could be complemented by approaching them as two distinct layered and interdependent infrastructures. The Internet itself is based on the telecommunication infrastructure, and supports the Web. More recently, the global deployment of Cloud services could be seen as another infrastructural layer on top of the Internet.

In economic terms, infrastructures have a number of characteristics (Frischmann 2012): (i) governments played an important role in the deployment of those networks, (ii) they were managed on an egalitarian, non-discriminatory basis, and (iii) they generated spillovers (positive externalities) that resulted in social gains. Telecommunication networks had all the characteristics of infrastructure, as summarised by Frischmann (2012), and they led to significant spillovers, e.g. telephone sales or communication among family and social groups. It was on this telecom infrastructure that the Internet was deployed as part of those externalities. One could say that, initially, it may have been viewed as another service, but a retrospective account of its evolution could classify it as another layer of infrastructure deployed on a global scale over those telecommunication networks and as a consequence of the increasingly deregulated telecoms market. Many of the tussles that are currently fought on the Internet, as discussed by Clark et al. (2005), especially those around principles such as the end-to-end argument and openness, are exactly about ensuring that the character of the Internet remain that of an infrastructure instead of just an application. Discussions on Internet governance and on equitable access to it are indeed emerging because the Internet has been established as infrastructure. But when it comes to examining the positive externalities that the Internet has to show, that's when the topic of discussion shifts to the Web.

In a similar fashion, the Web can be viewed as something that initially appeared to be a service based on the Internet. In technical terms, it is based on a protocol that was deployed in the *Application Layer* of the Internet. In the 90s one could view the Web as yet another application offered with a package of Internet applications including *EMAIL* and *FTP*. Nevertheless, the Web was able to leverage direct network effects on a large scale and grew to become a global resource for information publication and discovery in the first instance, and, later, for communication, collaboration and knowledge construction. The peer organisation of the Internet and its support for easy information sharing has led to the success of the Web but also to surprising outcomes ranging from the support for social movements to trading in Wall street (Johnson 2012). Thus, one can now see that the Web evolved to become an infrastructure itself, which is based on the Internet, and which enabled new social architectures and human interaction, such as Wikipedia (Johnson 2012).

In that light, the Internet appears to provide the means for access to Web servers, databases, people and devices, while the Web provides ways of publishing and linking information based on new innovative social structures. Ensuring equitable and fast access to the Internet and the Web is in the programme of many governments in the world, given the promise of the Web as an infrastructure that will lead to significant spillovers and new waves of innovation.

However, apart from the Web, the Internet has fostered further innovation in terms of teleconferencing applications, the Cloud, and interaction with devices. At the same time, the Web has fostered significant innovation with a wave of collaboration and online social networking services. The emergence of the Internet and subsequently of the Web as infrastructures on which ecosystems of innovation flourished has established a precedent that has been followed in online services such as online social networks; these services facilitated the emergence of ecosystems by leveraging network effects and global reach. For example, Facebook fostered the evolution of an application ecosystem that is specific to Facebook. Could these emerging services be seen as an extra layer of infrastructure on top of the Web and the Internet? Do they have the characteristics of an infrastructure in terms of governance, equitable access and the potential for positive externalities? The fact that Google and Facebook are not open platforms in the same sense of the Internet or the Web suggests that they may evolve differently.[5] These are topics for discussion in the future. Nevertheless, it appears that this two-layered infrastructure of the Internet and the Web is characterized by a high and increasing degree of interdependence between the layers, which presents a challenge when considering changes on a technological or policy level.

IV. Interdependence between the Internet and the Web

The growth of the Web has had an impact on the Internet in both technological and policy terms. The growth of the Web as a global infrastructure based on the Internet has had an impact on the Internet itself. ISPs had to optimize their routers to cope with Web traffic. Initially, this involved small-sized Web objects which gradually became larger (Brownlee et al. 2002). In its early years the Web contributed significantly to Internet traffic, followed, later, by peer-to-peer (P2P) applications (Odlyzko 2003). Recently, Web, P2P and Web-

[5] We are indebted to an anonymous referee for pointing this out.

based video-on-demand services were estimated to comprise 85% of Internet traffic (Berl et al. 2010), with Cloud computing adding to that.

Applying law enforcement for content on offshore websites has led to considerations of changes in the domain name system (DNS) in the US under the SOPA act; however, it was argued in a petition to the White House that such changes in the DNS could compromise the openness of the Internet and its potential for innovation.[6] The discussion on net neutrality could be seen as a reflection of the tussle between the stakeholders involved in the deployment of services on the Web and in the provision of Internet access. The significance of open standards as a driver for innovation, the risks of 'Web islands' built around online social networks and application ecosystems, and the need to keep the Web and the Internet as two separate layers have been argued by the inventor of the Web, Tim Berners-Lee (Berners-Lee 2010).

Keeping the Internet and the Web as separate, identifiable (although interdependent) infrastructures can indeed continue to foster innovation. Since the emergence of the Web, the governance model of the Internet and its end-to-end design made new innovation possible. For example, cloud services could be seen as innovation on the Internet driven partly by thriving Web-based services and partly by the widespread use of a variety of networked devices for domestic and industrial applications (including home routers, smartphones, utility usage monitors and media devices). Could it be that the pressure on Internet Service Providers (ISPs) for Cloud access will be increasing, leading to a "flatter" structure of the Internet and making it gradually indistinguishable from the Cloud? Could such developments pose a threat to the potential of the Internet for innovation?

V. Conclusion and Outlook: Net Neutrality and Internet Innovation

The relative roles of infrastructures and applications discussed in the second part of the paper mirror the relationship between media and content discussed in the first part, but add a dynamic element whereby applications and services – under certain conditions that we have only hinted at here – have the potential to evolve gradually into infrastructures which, in turn, can engender more applications, and so on in an apparently never-ending process. Further, the empirical perspective on infrastructures captures elements such as political economy and an analysis of individual interests that are absent from the functionalist and systemic language-based media-stack model. It suggests that the viability of the latter may depend to a significant extent upon characteristics such as openness, democratic values, and market vs. monopolistic behaviour. In other words, embracing both the systemic and individualist epistemological perspectives captures a richer picture of the various layers of the Internet and of some of the factors that drive their evolving dynamics.

In this extended abstract, so far we have argued that the pressure of Web traffic, then P2P traffic and, more recently, of Cloud traffic on the Internet as infrastructure suggests that the Internet with its governance model and its design principles has been fostering innovation with a high impact. The Internet is increasingly supporting interaction among devices, and the distribution of entertainment content is bringing increasing demands for quality of service. The multitude of users engaging with the Internet via devices, the Cloud, or the Web is shaping its evolution. To understand how people engage with the Internet could help us ensure its sustainability and improve it further. Mixed research methods can provide us with new insights on how to improve the Internet – and its continually emerging new layers of applications – as infrastructure to ensure its continuing contribution to innovation. Internet Science will be providing the interdisciplinary methods, the best practices and the research momentum in the study of the Internet as a techno-social phenomenon in this context.

As this is an extended abstract, we now include a critique in the form of a list of points that will be explored in greater depth in our future work:[7]

- As it is known that the Internet net neutrality does not always hold today, its relationship to innovation needs to be investigated further.
- The increasing interdependence between the two layers discussed deserves a more formal analysis: Why? How? What is the impact if any? Why does this limit innovation?
- Is the principle about the separation of layers a necessary condition to support open innovation, or is this just related to the necessity to expose APIs naturally required to support new services from third parties? What does it mean that two layers are more dependent without either having control of both?
- The concept of architecture could usefully be clarified to draw out the roles of design and praxis, especially given the genesis of the Internet from an experiment among a closed and cohesive group with largely shared perspectives and objectives and the distance from 'then' till 'now'.
- The concept of independence needs greater definition; there are many senses in which the Internet and the Web can be said to be independent, but in relation to choice and behaviour, or the interpretation of observations or stylised facts, or the construction of an analytic framework for deriving and testing hypotheses (in the face of endogeneity and unobservability) something more concrete is needed.
- It is not clear why the feedback loop between innovation and independence/modularity should be seen as ironic, but it points out a possibly useful standpoint: the Internet as a complex system, characterized by emergent behaviours and self-organization. The existence of transitory, context- and path-dependent, multiply-directed and (inter-)subjective feedback loops is expected and may represent the true 'genius' of the system as a whole. It also allows the artificially simplified view of the linked systems to be enlarged to track the way human beings individually and in networked association have evolved with the Internet.

[6] whitehouse.gov. Available from: http://www.whitehouse.gov/blog/2012/01/13/obama-administration-responds-we-people-petitions-sopa-and-online-piracy

[7] These points and observations were provided by the anonymous referees, to whom we are grateful for the constructive input.

- The tight vs. loose characterisation is a bit forced. Common knowledge – and typically formalised – hardly seem loose in the intuitive sense, and linkages in even modestly complex food webs (at least under conditions of relative abundance or evolutionary slack) are hardly tight in the manner defined. This is the source of resilience in such systems.
- The definition of net neutrality will need to be made more explicit, and its virtues will need to be derived more carefully. The issue is not innovation per se, but which kind of innovation. There are both good and bad types of innovation, just as there are good (even essential) and bad departures from neutrality (e.g. Ramsey pricing).
- The discussion of language and communication will need to be extended: not all exchanges involve a single listener and a single hearer and not all impediments to the free, easy and potentially pre-emptive flow of communication bear positive fruit. Transaction costs do get in the way, but the communication observed in computer-based financial trading shows that it may be useful to slow things down enough to permit reflection (e.g. learning together how to use what we have 'innovated') or to introduce impediments that we have to innovate around, producing profound improvements and disrupting entrenched power and control (tipping and persistence of power being problems that the current Internet has yet to surmount). An example relevant to this context is structural holes (e.g. extensive literature from theory to empirics).
- The potential of complexity to produce useful plasticity and variable geometries that usurp and refresh the presumed layered structure – if only by emergence – should be addressed (e.g. Arthur 2009).
- The infrastructure vs. service discussion could be improved by relating it to the model of intensive vs. extensive competition, and to the metaphor of services competing on platforms, using relationships between service providers and users on one side and the platform or infrastructure on the other, or end-to-end relations as suggested by the 2-sided market model.

VI. Acknowledgement

The work reported in this article was funded in part by the EU projects EINS, contract number CNECT-288021, and BIOMICS, contract number CNECT-318202. Their support is gratefully acknowledged.

VII. References

[1] Austin, J L (1962). *How to do Things with Words*, Oxford: Oxford University Press.

[2] Arthur, B (2009). *The Nature of Technology: What it is and How it Evolves*. Penguin.

[3] Berdou, E and Dini, P (2005). D18.3: Report on the Socio-Economics of Free/Open Source, DBE Deliverable, European Commission. Available at http://files.opaals.eu/DBE/

[4] Berl, A, Gelenbe, E, Di Girolamo, M, Giuliani, G, De Meer, H, Dang, MQ & Pentikousis, K (2010). Energy-efficient cloud computing. *The Computer Journal*, **53**(7):1045–1051.

[5] Berners-Lee, T (2010). Long Live the Web. *Scientific American Magazine*.

[6] Brownlee, N & Claffy, KCCMI (2002). Understanding Internet traffic streams: dragonflies and tortoises. *Communications Magazine*, IEEE. **40**(10).

[7] Ciborra, CU & O Hanseth (1998). From tool to Gestell: agendas for managing the information infrastructure. *Information Technology & People*, **11**(4):305-327.

[8] Clark, DD, Wroclawski, J, Sollins, KR & Braden, R (2005). Tussle in cyberspace: defining tomorrow's Internet. Networking, *IEEE/ACM Transactions*. **13**(3):462–475.

[9] Clark, DD, Wroclawski, J, Sollins, KR & Braden, R (2002). Tussle in cyberspace: defining tomorrow's internet. In: August 2002, ACM.

[10] Dini, P, Iqani, M, and Mansell, RE (2011). The (Im)Possibility of Interdisciplinarity: Lessons from Constructing a Theoretical Framework for Digital Ecosystems, *Journal of Culture, Theory and Critique*, **52**(1): 3-27.

[11] Dini, P & Sartori, L (2013). Science as Social Construction: An Inter-Epistemological Dialogue between Two Internet Scientists on the Inter-Epistemological Structure of Internet Science, Part 1, in EINS2013: 1st International Conference on Internet Science, 10-11 April.

[12] Espinel, V, Chopra, A & Schmidt, H (n.d.). Combating Online Piracy while Protecting an Open and Innovative Internet | We the People: Your Voice in Our Government. [Online]. petitions.whitehouse.gov. Available from: https://petitions.whitehouse.gov/response/combating-online-piracy-while-protecting-open-and-innovative-internet. [Accessed: 18 /02/13].

[13] Feenberg, A (1991). *Critical Theory of Technology*, Oxford: Oxford University Press.

[14] Feenberg, A (2002). *Transforming Technology: A Critical Theory Revisited*, Oxford: Oxford University Press.

[15] Feenberg, A (2005). *Heidegger and Marcuse: The Catastrophe and Redemption of History*, Routledge.

[16] Flores, F and C Spinosa (1998). Information technology and the institution of identity: reflections since *Understanding Computers and Cognition*. *Information Technology & People*, 11(4): 351-372.

[17] Frischmann, BM (2012). *Infrastructure*. Oxford: Oxford University Press.

[18] Johnson, S (2012). *Future Perfect*. Penguin.

[19] Lessig, L (2006). *Code Version 2.0*, Basic Books.

[20] Odlyzko, AM (2003). Internet traffic growth: Sources and implications, in *Optical Transmission Systems and Equipment for WDM Networking II*, B. B. Dingel, W. Weiershausen, A. K. Dutta, and K.-I. Sato, eds., Proc. SPIE, **5247**:1-15.

[21] Papazoglou, M (2003). 'Service-oriented computing: concepts, characteristics and directions', *Proceedings WISE'03*, IEEE, pp. 3–12.

[22] Searle, JR (1979). *Expression and Meaning*, Cambridge, UK: Cambridge University Press.

[23] Turing, A (1936). On Computable Numbers, with an Application to the Entscheidungsproblem, *Proceedings of the London Mathematical Society*, **42**(2):230-265; A correction, ibid., 1937, **43**:544-546.

[24] Winograd, T, & Flores, T (1987). *Understanding Computers and Cognition*, Addison Wesley.

Youth's attitudes and behaviours with respect to online privacy

A conceptual exploration

Lien Mostmans
iMinds – SMIT
Vrije Universiteit Brussel
Brussels, Belgium
Lien.mostmans@vub.ac.be

prof. dr. Joke Bauwens
iMinds – SMIT
Vrije Universiteit Brussel
Brussels, Belgium
jbauwens@vub.ac.be

prof. dr. Jo Pierson
iMinds – SMIT
Vrije Universiteit Brussel
Brussels, Belgium
Jo.pierson@vub.ac.be

***Abstract*—This paper gives an exploratory overview of topical research on the privacy-related attitude-behaviour dichotomy among youth. It aims to highlight gaps, research challenges and suggest further research while taking into account the primary focus of the doctoral research project inspiring this paper, i.e., young people's moral attitudes regarding online privacy. In particular it argues for (1) a grounded and detailed conceptualization of privacy literacy within Internet literacy debates, (2) further in-depth research into emotional and attitudinal aspects of online privacy-related practices, especially (3) amongst very young Internet users, an age group that has remained empirically under-examined in communications studies.**

***Index Terms*—online privacy, Internet literacy, privacy attitudes, youth**

I. Introduction

Throughout recent decades a multidisciplinary body of scholars has widely documented and analysed young people's online practices [7, 26, 45]. Communications scholars have identified various practices, strategies and skills youth employ and develop to access, analyse, understand and create complex streams of online information [28, 39]. Mirrored by public debate over Internet safety, scholarly attention has growingly included youth's online privacy-related behaviours and attitudes, in particular on widespread and popular social network sites (SNSs) such as Facebook and MySpace.

Parallel, communications scholars have emphasised the complexities and ambiguity of much contemporary mediated culture and computer-mediated social interaction [31, 33, 49]. In privacy research many have pointed to the complex, paradoxical relationship between self-perceived or reported *concerns* and actual *behaviours* when it comes to disclosing information [5]. This often-stated dichotomy lies at the heart of this paper: how do young people's disclosure behaviours relate to their attitudes and concerns about online privacy?

This paper draws on recent and pivotal research about the privacy-related behaviours and attitudes of children and young people throughout their online activities.[1] In analysing the research about attitudinal aspects of youth's online practices and privacy, it aims to complement the extensive body of research and insights into online privacy *behavioural practices*. An extensive review of theoretical and empirical research is beyond the scope of this paper. Rather, it intends to present topical privacy-related discussions on the attitude-behaviour dichotomy among (very) young people and suggest further research. Specifically, it argues for further research into the attitudinal aspects regarding youth's privacy-related choices, taking into account the various challenges such research can entail.

II. The attitude-behaviour dichotomy

The relationship between attitudes and behaviour is a widely examined phenomenon throughout disciplines, most notably within social psychology [21, 23]. In communications research about privacy many studies have pointed to the paradoxical relationship between reported or perceived privacy concerns and actual disclosure behaviours, suggesting that people with negative attitudes toward disclosing personal information share this information for no apparent benefit [1, 5, 15, 43]. Others have challenged this paradox by referring to, amongst others, an elevated awareness of social privacy aspects on Facebook [9], the dissociation between privacy concerns and negative personal experiences [51] and the negative impact of privacy policy consumption on disclosure on SNSs [53]. Interpreting this often-stated dichotomy thus

[1] For readability purposes, this paper will further use the term 'youth' to refer to children, teenagers and persons currently in their twenties. Delineating childhood and youth remains an intricate matter that requires a careful approach as definitions and perceptions can vary according to context [52].

requires a careful approach that takes into account both the social complexities of disclosure behaviours and privacy attitudes.

III. Online Disclosure and Privacy Protection Behaviours

"Online disclosure behaviours" in this article refers to the uses, activities and practices of youth when they post, share and exchange information online, in particular on SNSs. "Privacy protection behaviours" in this paper refers to the various acts and strategies they display to handle, manage and control personal information online. Thus, although SNS users have been categorised based on the content they disclose [34], the key in this paper is not the type or amount of information per se, but rather the use of information control they exert, both deliberately and implicitly, in the process of disclosing.

The online disclosure behaviours of young people have been widely examined and theorised. In particular, SNSs have been emphasised as interactive enablers of digital representations of the self [11, 57]. While some have scrutinised the various multimedia artefacts (photographs, videos, etc.) and practices (friending, swearing; [7, 55]) on SNSs, others have described the various types of personal information youth disclose online (birthday, school information, e-mail address, etc.) [13, 27, 47].

At the same time, it has become clear that youth have developed particular behaviours and strategies to manage and protect personal information online. These include providing inaccurate and/or incomplete information, informing Internet Service Providers and requesting name removal from marketing lists [40, 59]. Moreover, the complex nature of privacy protection behaviours has been emphasised. [50], for example, has discussed privacy control in terms of granular degree, rather than in absolute terms. Interpreting both disclosure and protection behaviours, therefore, requires a careful approach. For example, scholars have found that despite reporting *knowing how to* use privacy settings, youth are less likely to *actually use* them [13]. Many have addressed this discrepancy. Some have pointed to cognitive-developmental factors. It has been argued that children may not yet be able to evaluate the social consequences of Internet use. As a result, assessing and coping with online risks, such as managing personal information online, may be problematic due partially because their limited cognitive abilities [12]. Others have postulated digital literacy-related rationalizations, emphasising the function of knowledge, e.g., about privacy policies and settings, in information privacy behaviour [2, 25]. Moreover, it has been argued that common privacy options (e.g., privacy settings for photographs on SNSs) fail to address (young) user's privacy concerns, needs and expectations [37]. Furthermore, young Internet users have displayed other, alternative strategies in managing their privacy online. For instance, [8] have used the term "social steganography" to describe a common cryptographic privacy strategy amongst teens on SNSs. The term refers to the exclusive reciprocity between communicators in understanding the intended meaning of a message, while communicating to different audience members simultaneously. Thus, messages posted online, such as song lyrics, can be meaningless to some (e.g., adults) and valuable and insightful for others (e.g., peers).

While covert and encoded communication is not novel in history, social steganography is an interesting example of privacy protection behaviour as it points to a shared and specific understanding regarding *online* privacy amongst young people. Furthermore, it suggests that the act of disclosing personal information online involves a complex process of considering, evaluating and balancing various related opportunities, risks and consequences.

IV. Privacy attitudes

"Privacy attitudes" in this paper refer to the set of beliefs, emotions and judgments youth have and formulate about the disclosure, distribution and manipulation of personal information online by or about themselves or others. The key is the emotional, motivational dimension of privacy-related decisions online *underlying* actual behaviours and practices.

Attitude research constitutes a vast body of research within the field of social psychology [17, 54]. Particularly, research efforts into the structure, formation, attribution and change of attitudes offer an interesting analytical backdrop for understanding the underlying processes of decision-making and behaviours, i.c. related to online privacy. Attitudes have been classified ranging from non-existent over weak to strongly held. They obtain structure and shape in a complex manner, involving the effects of source reliance (i.e., first-hand experience versus secondary information access), valence of information (i.e., neutral, positive versus negative information) and the relevance of the attitude to a specific behavioural situation [3, 6, 19]. In short, the stronger the attitudes, the more predicative they are of behaviour [20, 22, 30].

In communications research, privacy attitudes have been examined throughout a wide range of studies about, but not exclusively, Internet literacy, privacy concerns and awareness, intensions and willingness to disclose personal information, (perception of) privacy risks, trust and respond/coping strategies [2, 24, 26, 43].

Privacy attitudes emerge as intricately layered, mutually entangled and variable composites. For example, marketing and consumer research has indicated that trust is strongly related to information disclosure [41]. Trust has been widely examined throughout communications research and generally refers to "the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party" [40]. [16] found that trust may influence what users are willing to share on SNSs, with users being more willing to share information on Facebook than on MySpace. Others have also found these differences in levels of trust between different SNSs, with Facebook receiving higher trust than Myspace [2]. Insights into the grounds of these differences remain scarce. Moreover, privacy is often discussed as one of the various online risks youth are bound to experience. As such, privacy

risks are considered "negative (…) experiences that might result from transactions between communicators, the content/services they provide and the user" [26]. In analysing the various ways in which children respond to or cope with 'risky' situations online, most notably coming about inappropriate content (e.g., pornography), contacts (e.g., grooming) and conducts (e.g., bullying), some scholars have discussed online attitudes and skills. Explicitly, attitudinal factors such as inquisitiveness (attitudes to learning), confidence and judgement (e.g., self-perception of expertise) have been identified as mediating self-protection behaviours and strategies [26]. Furthermore, an extensive stream of research has examined the relation between awareness levels of privacy-related policy, terms and conditions and instruments, such as procedural knowledge of privacy settings and disclosure behaviours. While some have reported negative correlations between awareness of privacy policies, settings and instruments and disclosure [29, 44], others have found that privacy concerns do not affect disclosure behaviours [39, 56]. It has to be noted that research evidence in this field remains ambivalent for various reasons, e.g., because of the measurement of single variables (such as cookies) as proxies for user knowledge.

V. Conclusion and further research

Privacy protection behaviours and strategies such as social steganography generate many questions about the fundamental understandings and attitudes that underlie the decision-making processes in online disclosure behaviours of young people. Certainly, research involving older teens and adults has reported parallel inconsistencies between stated privacy concerns and online disclosure behaviours [31]. However, the psycho-social developmental specificity of youth suggests the need for a unique framework for studying this phenomenon amongst (very) young people.

In particular, in-depth, media sociological research into the underlying psycho-social considerations about online (self-) disclosure could complement the vast body of empirical Internet research. Participatory research methods that take into account the digital lives and cultures of contemporary youth may include visual probing methods such as interactive, co-creative focus group sessions, card sorting and 'creative' photographic/screenshot diaries. This paper closes with a number of specific research suggestions and related methodologies.

Moreover, while it appears many have examined privacy attitudes *a posteriori* or secondarily, i.e., following, or in analysing, disclosure practices and behaviours, less is known about the formation, structure and attribution of online privacy attitudes. Nonetheless, such insights may further reinforce caregivers and policy-makers in understanding and supporting youth's online (privacy-related) endeavours. Besides stimulating further empirical research, this paper thus argues for a theoretical elaboration of *online* privacy attitudes.

Furthermore, while some have emphasised the critical role of user knowledge in undertaking privacy-related actions and have argued to contextualize online privacy in the digital divide debate [44], theoretical conceptualizations of privacy within Internet literacy debates, remain scarce. Nonetheless, *privacy literacy* has been rarely and broadly defined as "the understanding that consumers have of the information landscape with which they interact and their responsibilities within that landscape" [37]. This paper argues for more elaborate, in-depth conceptualizations of online privacy literacy, that take into account the various and often-cited dimensions of digital and Internet literacy – access, analysis, understanding, creation. As such, it may offer valuable, specific contributions to evaluating and guiding the full scope of privacy decisions and trade-offs youth make and experience online.

In addition, this definition implicitly raises an interesting, yet under-examined, aspect of Internet privacy and literacy debates: by referring to the "responsibilities" of Internet consumers, it implies ethical decision-making processes and, hence, hints at the moral dimensions of Internet literacy in general, and privacy-related behaviours in particular. In the past, [33] referred to the ethical responsibilities and complexities in the new media landscape, for example in negotiating between identities when managing social relationships. Insights in the *reflection* of youth upon their disclosure attitudes and behaviours may prove to be key for a deep understanding and accurate interpretation of disclosure behaviours and protection strategies.

Lastly, this paper argues for further privacy research concerning very young Internet users. Firstly, in the groups around ages 10-12 – typically considered a turning point in child development – both media use and moral competences, i.e., the strategies youth develop and use to make ethical decisions when confronted with a moral dilemma, increasingly develop [4, 14, 18, 35, 36, 46, 48, 58]. Nonetheless, this group has remained empirically under-examined, in particular in media research [10]. Secondly, although this group finds itself under the minimum required age limit on many SNSs (mostly set at the age of 13, e.g., Facebook, YouTube, MySpace), it is widely assumed that they are present on SNSs, as restrictions for registration can be bypassed straightforwardly (e.g., by giving a false date of birth). Consequently, it can be argued that their 'clandestine' presence on SNSs leaves young SNS users vulnerable to various online risks. Further research into the online behaviours and attitudes of this age group, particularly on SNSs, is necessary in order to be able to gain insights in the shaping of the mental models youth develop of online privacy.

Researching young people produces various methodological challenges and ethical issues, such as obtaining informed consent from children (in addition to parental consent), anonymity and confidentiality of data treatment and debriefing young participants about the research. Moreover, visual research methods, such as image-based observations (photo, video) in the private and intimate sphere of the home, transgresses the distinction between public and private bodies, and can thus be morally charged. For researchers, ethical dilemmas may be connected to, amongst other, general cultural norms, one's relationship to the participants, and expectations from the research community. Therefore, addressing the

various ethical considerations in privacy research and further developing and refining existing research methods and instruments remains essential in this continually evolving research domain.

REFERENCES

[1] A. Acquisti, Grossklags, J., "Privacy Attitudes and Privacy Behavior: Losses, Gains, and Hyperbolic Discounting," in The Economics of Information Security, S. L. Jean Camp, Ed., Boston/Dordrecht/London: Kluwer Academic Publishers, 2004, pp. pp. 165-178.

[2] A. Acquisti, Gross, R., "Imagined Communities: Awareness, Information Sharing, and Privacy on the Facebook," in Proceedings of 6th Workshop on Privacy Enhancing Technologies., P.D. Golle, G, Ed., Cambridge: Robinson College, 2006, pp. 36-58.

[3] I. Ajzen, "Nature and Operation of Attitudes," Annual Review of Psychology, vol. 52, pp. 27-58, 2001.

[4] A. Bandura, "Social cognitive theory of mass communication," Media Psychology, vol. 3, pp. 265-299, 2001.

[5] S. B. Barnes, "A privacy paradox: social networking in the United States," First Monday, vol. 11, 2006.

[6] J. N. Bassili, "Meta-judgmental versus operative indexes of psychological attributes: The case of measures of attitude strength," Journal of Personality and Social Psychology, vol. 71, pp. 637-653, 1996.

[7] D. boyd, "Why Youth (Heart) Social Network Sites: The Role of Networked Publics in Teenage Social Life," in MacArthur Foundation Series on Digital Learning - Youth, Identity, and Digital Media Volume D. Buckingham, Ed., ed Cambridge: MIT Press, 2007, pp. 119-142.

[8] D. boyd, Marwick, A., "Social Privacy in Networked Publics: Teens Attitudes, Practices, and Strategies," in Symposium on the dynamics of the Internet and society, University of Oxford, 2011, pp. 1-29.

[9] P. B. Brandtzæg, Lüders, M., Skjetne, J. H. , "Too many Facebook “friends”? Content sharing and sociability versus the need for privacy in social network sites," International Journal of Human-Computer Interaction., vol. 26, pp. 1006-1030, 2010.

[10] D. Buckingham, The Media Literacy of Children and Young People: A Review of the Research Literature. London: Ofcom, 2005.

[11] S. Calvert, "Identity construction on the internet," in Children in the Digital Age: Influences of Electronic Media on Development A. B. J. S. L. Calvert, R. R. Cocking, Ed., Westport: Praeger, 2002, pp. 57-70.

[12] L. Camp, "Mental models of privacy and security," IEEE Technology & Society, vol. 28, pp. 37-46, 2009.

[13] E. Christofides, Muise, A., Desmarais, S., "Privacy and Disclosure on Facebook: Youth and Adults’ Information Disclosure and Perceptions of Privacy Risks," The Office of the Privacy Commissioner of Canada, Guelp, 2010.

[14] J. Day, Tappan, M., "The narrative approach to moral development: From the epistemic subject to dialogical selves," Human Development, vol. 32, pp. 67-82, 1996.

[15] B. Debatin, Lovejoy, J. P., Horn, A.-K., Hughes, B.N. , "Facebook and Online Privacy: Attitudes, Behaviors, and Unintended Consequences," Journal of Computer-Mediated Communication, vol. 15, pp. 83-108, 2009.

[16] C. Dwyer, Hiltz, S. R., Passerini, K, "Trust and privacy concern within social networking sites: A comparison of Facebook and MySpace," in AMCIS, Keystone, 2007.

[17] A. H. Eagly, Chaiken, S., The psychology of attitudes. Forth Worth: Harcourt Brace Jovanovich, 1993.

[18] N. Eisenberg, Altruistic emotion, cognition and behavior. Hillsdale: Lawrence Erlbaum, 1993.

[19] R. Fazio, "How do attitudes guide behavior?," in Handbook of motivation and cognition: Foundations of social behavior E. T. H. R.M. Sorrentino, Ed., New York: Guilford Press, 1986, pp. 204-243.

[20] R. Fazio, "On the power and functionality of attitudes: The role of attitude accessibility," in Attitude structure andfunction, A. Pratkanis, Breckler, S., Greenwald, A. , Ed., Hillsdale: Erlbaum, 1989, pp. 153-179.

[21] R. Fazio, "Multiple processes by which attitudes guide behavior: The MODE model as an integrative framework.," in Advances in experimental social psychology. vol. 23, M. P. Zanna, Ed., New York: Academic Press, 1990, pp. 75-109.

[22] R. H. Fazio, Powell, M. C., Williams, C. J., "The role of attitude accessibility in the attitude-to-behavior process. ," Journal of Consumer Research, vol. 16, pp. 280-288, 1989.

[23] M. Fishbein, Ajzen, I., Belief, attitude, intention, and behavior: An introduction to theory and research. Reading: Addison-Wesley, 1975.

[24] J. Fogel, Nehmad, E., "Internet social network communities: Risk taking, trust, and privacy concerns," Computers in Human Behaviour, vol. 25, pp. 153-160, 2009.

[25] E. Hargittai, "Whose space? Differences among users and non-users of social network sites," Journal of Computer-Mediated Communication, vol. 13, pp. 276-297, 2007.

[26] U. Hasebrink, Livingstone, S., Haddon, L., Ólafsson, K., "Comparing children’s online opportunities and risks across Europe: Cross-national comparisons for EU Kids Online " LSE, EU Kids Online, London, 2009.

[27] S. Hinduja, Patchin, J. W., "Personal Information of Adolescents on the Internet: A Quantitative Content Analysis of MySpace," Journal of Adolescence, vol. 31, pp. 125-146, 2008.

[28] R. Hobbs, "Debates and challenges facing new literacies in the 21st century " in International Handbook of Children, Media and Culture, K. Drotner, Livingstone, S., Ed., London: Sage, 2008, pp. 431-447.

[29] D. L. Hoffman, T.P. Novak, Peralta, M.A., "Information Privacy in the Marketspace: Implications for the Commercial Uses of Anonymity on the Web," The Information Society, vol. 25, pp. 129-140, 1999.

[30] R. W. Holland, Verplanken, B., van Knippenberg, A., , "On the nature of attitude-behavior relations: The strong guide, the weak follow," European Journal of Social Psychology, vol. 32, pp. 869-876, 2002.

[31] C. Hoofnagle, J. King, S. Li, en J. Turow, “How different are young adults from older adults when it comes to information privacy attitudes and policies?”, 2010.

[32] C. James, Davis, K., Flores, A., Francis, J.M., Pettingill, L., Rundle, M., Gardner, H., Young people, ethics, and the new digital media: A synthesis from the GoodPlay Project, 2008.

[33] H. Jenkins, Confronting the challenges of participatory culture: Media education for the 21st century. Chicago: MacArthur Foundation, 2006.

[34] B. Knijnenburg, A. Kobsa, Jin, H., "Dimensionality of Information Disclosure Behavior. International Journal of Human-Computer Studies," Special Issue on Privacy Methodologies in HCI, in press.

[35] L. Kohlberg, "Moral stage and moralization: The cognitive-developmental ap- proach," in Moral development and behavior: Theory, research, and social issues, L. Lickona Ed., 1976, pp. 84-107.

[36] M. Krcmar, Cooke, M. C., "Children's moral reasoning and their perceptions of television violence," Journal of Communication, vol. 51, pp. 300-316, 2001.

[37] J. Langenderfer, Miyazaki, A.D., "Privacy in the Information Economy," The Journal of Consumer Affairs, vol. 43, 2009.

[38] Y. Liu, Gummadi, K.P., Krishnamurthy, B., Mislove, A. , "Analyzing Facebook privacy settings: User expectations vs. reality," presented at the IMC 2011, Berlin, Germany, 2011.

[39] S. Livingstone, "Internet literacy: young people's negotiation of new online opportunities.," in Digital youth, innovation, and the unexpected, T. McPherson, Ed., ed Cambridge: MIT Press, 2008, pp. 101-121.

[40] R. C. Mayer, Davis, J. H., Schoorman, F. D., "An integrative model of organizational trust," Academy of Management Review, vol. 20, pp. 709-734, 1995.

[41] M. J. Metzger, "Privacy, trust and disclosure: Exploring barriers to electronic commerce," Journal of Computer-Mediated Communication vol. 9, 2004.

[42] D. M. Moscardelli, Divine, R., "Adolescents' Concern for Privacy When Using the Internet: An Empirical Analysis of Predictors and Relationships With Privacy-Protecting Behaviors," Family and Consumer Sciences Research Journal, vol. 35, pp. 232-252, 2007.

[43] P. A. Norberg, Horne, D.R., Horne, D.A., "The privacy paradox: personal information disclosure intentions versus behaviors," The Journal of Consumer Affairs, vol. 41, pp. 100-126, 2007.

[44] J. Park, "Digital Literacy and Privacy Behavior Online," Communication Research, 2011.

[45] J. Parker, Teaching Tech-Savvy Kids: Bringing Digital Media into the Classroom, Grades 5-12. Thousand Oaks: Corwin Press, 2010.

[46] J. Piaget, The moral judgment of the child. London: Kegan Paul, 1965.

[47] T. A. Pierce, "Talking to Strangers on MySpace: Teens' Use of Internet Social Networking Sites," Journal of Media Psychology vol. 11, 2006.

[48] B. Rogoff, Apprenticeship in thinking: cognitive development in social context. New York: Oxford University Press, 1990.

[49] R. Silverstone, Media and Morality: on the rise of the mediapolis. Cambridge: Polity Press, 2007.

[50] D. Solove, "Media and Morality: on the rise of the mediapolis," San Diego Law Review, vol. 44, 2007.

[51] J. Staddon, Huffaker, D., Brown, L., Sedley, A., "Are privacy concerns a turn-off? Engagement and privacy in social networks," presented at the Symposium on Usable Privacy and Security (SOUPS) Washington DC, 2012.

[52] E. Staksrud, Livingstone, S., Haddon, L., Ólafsson, K., "What Do We Know About Children's Use of Online Technologies? A Report on Data Availability and Research Gaps in Europe (2nd edition)," LSE, London2009.

[53] F. Stutzman, Capra, R., Thompson, J., "Factors mediating disclosure in social network sites," Computers in Human Behavior, vol. 27, pp. 590-598, 2011.

[54] A. Tesser, "On the importance of heritability in psychological research: The case of attitudes," Psychological Review, vol. 100, pp. 129-142, 1993.

[55] M. Thelwall, "Fk yea I swear: cursing and gender in MySpace," Corpora, vol. 3, pp. 83-107, 2008.

[56] Z. Tufekci, "Can you see me now? Audience and disclosure regulation in online social network sites," Bulletin of Science and Technology Studies, vol. 11, pp. 544-564, 2008.

[57] S. Turkle, Life on the Screen: Identity in the Age of the Internet. New York: Simon and Schuster, 1995.

[58] L. S. Vygotsky, Mind in society: The development of higher psychological processes. Cambridge: Harvard University Press, 1978.

[59] S. Youn, "Teenagers' perceptions of online privacy and coping behaviours: A risk- benefit appraisal approach," Journal of Broadcasting & Electronic Media, vol. 49, pp. 86-110, 2005.

The evolution of networked communication between patients and clinicians in the UK National Health Service: young people living with long term health conditions

Frances Griffiths, Warwick Medical School, University of Warwick, UK
Jackie Sturt, Florence Nightingale School of Nursing and Midwifery, King's College London, UK
Jonathan Cave, Department of Economics, University of Warwick, UK

Abstract

Clinical communication between patient and their clinician is confidential. However, there are many young people living with long term health conditions who are accustomed to using digital networked communication, including communicating about their health, with their peers. In the UK the National Health Service provides the health care for nearly all young people with long term health conditions. The NHS has robust Information Governance regulations which are currently acting as a barrier to the use of digital networked communication between patients and clinicians. Young people tend to disengage from health care and there is evidence those that do disengage are at risk of adverse health outcomes. Informally, clinicians are starting to use e-mail and similar means of communication to keep in touch with their young patients, although there are risks to patient confidentiality and safety. Our research is concerned with providing the NHS with guidance on future policy and practice. Further, it considers questions related to the structure and salience of communication links, the influence of pre-existing communication channels on the topology of patient-clinician communication networks, the uptake and evolution of the network and how issues such as security and reliability impact on this. Our preliminary research indicates there is a need for social research in the field, including case studies and economic evaluation, to inform the development of the use of digital networked communication between clinicians and young people with long term health conditions, alongside technical developments. We report these preliminary results and seek feedback to inform our study design.

Introduction

The question considered here is "What is the safe, effective and cost-effective role of digital networked clinical communications for young people living with long term conditions and engaging with UK National Health Service (NHS) providers?" Our concern is with young people with long term health conditions as they tend to disengage from health services resulting in poor health outcomes. Examples of long term health conditions are diabetes, asthma, cystic fibrosis, epilepsy. In the UK almost all young people with long term health conditions receive their health care from the NHS. There is evidence that their health outcome is improved if they engage more with health care. We consider whether this can be improved through digital networked clinical communication. By clinical communication we mean communication about a patient's health, which would normally be considered confidential to the patient and their clinical team. Examples include: adjustment of medication, monitoring health conditions and providing test results. Communications may be routine or triggered by the young person's need for advice to avert an adverse event. For example, a young person with diabetes may need to make a complex decision about their insulin dose: 'It's bed time, Since dinner, I've been in the pub and had five pints and my glucose is 10.5mmol. I have just eaten two slices of buttered toast. How much insulin should I take?' Too much insulin can be life threatening but too little insulin also has adverse consequences. Young people (including those using the NHS) are prolific users of digital networked communications and thus provide the best current opportunity for understanding how, why and with what effect digital networked clinical communication can be used by NHS providers whilst maintaining NHS clinical, and information governance standards. The preliminary results to be presented are part of a research agenda that seeks to inform the policy, planning, provision and commissioning of NHS services for young people with long term conditions and to guide the deployment of digital networked clinical communication across specialist NHS care more widely. It will also contribute to understanding wider issues for applied internet science including:

1. The decision to connect, which happens over an extended timescale. What are the 'transition costs' of moving to or adopting another platform (dedicated to a narrow purpose albeit with high value links) which may act as a barrier to young people moving onto a new platform? Conversely, what are the institutional and functional costs and benefits involved in migrating clinical communication to existing platforms?
2. The decision to forward information over established links which is a short time frame

decision. What prompts or hinders sending information – patient to clinician and vice versa? What information exchange is or can be sustained, by what routes, and with what gain to patient, clinician and the NHS?

3. The integration (or lack of it) for patients between peer support networks, for example via social media, and the patient-clinician network and the degree to which this will be affected by participant self-organisation.

4. The potential for clinicians to learn from engaging with patients through networked communication, both idiosyncratic learning from engagement with individuals or specific groups of patients and systematic learning from systematic audit or research.

5. How does the advent of networked communication technologies and their integration with clinical interaction, modify the need for and optimal forms of Information Governance policy and guidelines? Is their potential for a different *modus vivendi* between praxis and governance?

Policy developments and digital networked clinical communication

Our research is timely in relation to the EU and UK policy agenda. In 2012 the European Commission announced their 'Action Plan to address barriers to the full use of digital solutions in Europe's healthcare systems' (1). Nationally, government policy on clinical information is to improve access to information (2) and the on-going Caldiott 2 review is seeking the appropriate balance between protection of personal information and sharing of information to improve care (3). The vision of the NHSmail 2 project that is developing the specification for the replacement of the current NHS email system, suggests that clinician-patient communication and data exchange will become possible soon (4). However, the NHS is underserved in terms of research evidence to implement current and future policy recommendations. Systematic review evidence (5, 6, 7) suggests that little experimental research has been undertaken and what exists has a high risk of bias and qualitative research has not been reviewed nor undertaken.

The health of young people with long term conditions

Young people living with long term conditions are vulnerable to service disengagement and this endangers their long term adult health. One in five children under 16 years of age, have to take medicines on a long term basis (8). It is possible to extrapolate this to those beyond 16 years on the basis that many long term conditions do not go away (e.g. diabetes) and those that do may take some time to resolve (e.g. anxiety). There are 25,000 under 25's living with Type 1 diabetes in the UK (9). Approximately 20% of children will have a mental health problem, most commonly anxiety and depression, in any given year (10). There are 9,000 people living with cystic fibrosis in the UK (11) and many of these will be under 25yrs old. Transition from paediatric to adult services has become an increasing focus for the NHS in recent years with Department of Health guidance published in 2008 (12). Poor transition can lead to disengagement in health services and poorer health outcomes (13, 14). There is evidence that 35% of young renal transplant recipients had lost their transplants by 36 months after transfer to adult renal care and there is a large peak of graft loss between the ages of 20-24 years (15). The National paediatric diabetes audit report 2010-11 (16) found that in England and Wales, the number of 20-24 year olds having their HbA1c measured (an assessment of the level of control of the blood sugar of a diabetic which is important for health) dropped by >5% compared to the number of 10-19 year olds suggesting the 20-24 year olds were not engaging with the health service. The health outcomes for young people compare poorly with those for an adult population with the same condition (17). This represents a substantial health burden for young people and their families and an economic burden for the NHS. Reasons for disengagement with health services include psychosocial factors and, for some conditions, the impact of hormonal changes on the condition itself. Service level factors affecting young peoples' engagement include poor patient-clinician communication, inflexible access to people and information, lack of person-centred health care and the need for continuity and relationship development (18, 19, 20, 21). Several studies report requests for email, text and social media communications with their health care team (18, 22). Digital networked clinical communications are being embraced by clinicians working with teenagers and young adults (8) but there are questions emerging from patients, clinicians, Caldicott Guardians and NHS IT systems managers, about patient safety, medico-legal issues, health care costs and clinical and organisational impacts of these new types of clinical communication. The NHS is currently underserved by research evidence in preparing it for this development. People are using these technologies in their healthcare (23-27). The "digital native" generation of young people who have grown up with digital technology expect to communicate in a way distinct from their parent's generation. This

expectation is also found to extend to their healthcare (18). There has been little evaluation of the facilitators and barriers to implementation of digital networked clinical communication and the legal and ethical framework for their use is unclear (19). Professional regulating bodies have issued cautious guidance to their members on its use (e.g. Royal College of Nursing & British Medical Association) (28-31). The NHS has a robust information governance structure and processes and this currently acts as a barrier to integration of non-NHS digital networked communication systems with NHS communication systems. There is an acknowledged need for the NHS to understand whether and how these systems need to be integrated which goes beyond technological issues. There is currently no nationally agreed guidance for the use of digital networked clinical communication.

National Health Service specialist clinical services out of step with how young people communicate

Digital communication is becoming almost ubiquitous and is part of everyday life for young people -text messages, email, social media. NHS Trusts, the organisations that run NHS hospitals and community health services, use digital networked communication infrastructures such as NHSnet email (a secure email system for NHS staff), send appointment reminders by text message, and run websites and social media for providing information. The use of digital networked clinical communication, that is between patient and clinician, is increasing albeit most often under the radar of NHS Trust IT regulators (personal communications). Press reports suggest the NHS should be providing this form of communication (32). Organisations such as the Medical Protection Society, which is concerned with medical negligence and litigation, are cautious about the use of digital networked clinical communication and advises clinicians to check with their employer about safeguards (33). Clinicians have expressed interest in web portals for patients but integration of these into NHS Trust IT systems and day to day clinic activity is not straightforward. Solutions also need to be flexible to the changing technologies available and their uptake in the population served by the NHS.

The research

Methods

Our applied research includes systematic literature review, and case studies of NHS clinics serving patients aged 16-25 years with long term health conditions, along with embedded health economic evaluation. We have undertaken preliminary research to inform the design of our field work. This includes literature review, an informal survey at a regional meeting of NHS Information Governance officers, an informal web-based survey (34) to identify NHS Trust public policies on the use of email, and key informant interviews with three NHS Information Governance officers and five clinicians working with young people in NHS Trusts.

Results

We have identified three established systems for digital networked clinical communication for young people in the NHS which function as standalone projects. Commonly there is also informal, unregulated development of email communication between clinician and patient. The survey indicated that of 30 NHS Trusts in the West Midlands of the UK, none has a policy for clinician-patient email, and only three such policies were publically available from NHS Trusts in England. The few NHS Trusts that provide information about how patients can email staff require consent process for email communication (35). The interviews indicate that in NHS Trusts there have been critical incidents related to digital networked clinical communications that had the potential to compromise patient care and safety. Emails are not routinely stored unless a clinician specifically takes action to store them so records of patient-clinician interaction may be incomplete. Clinicians vary in the reasons for engaging in networked clinical communication with young people. Examples include: encouraging patients with TB to comply with medication regimes; providing a way for patients to contact their clinical team when anxious; monitoring mood to detect early episodes of hypomania among people living with bipolar disorder; and providing support and education for young people living with haemoglobin disorders.

Conclusions

Our preliminary results suggest that further work is urgently needed to understand the use and potential use of digital networked clinical communication in NHS specialist care. Issues of data security, patient safety, ethics and the cost-effectiveness of digital networked clinical communication require social investigation in the field alongside technological innovation. We suggest a case study approach to the use of digital networked communication, including cases where it is apparently successful and sustainable others where success is partial or temporary. Each case study should include the perspectives of young people with long term health conditions, clinicians,

policy makers and managers, and include observation of actual use of the digital networked clinical communication.

References

1. European Commission. Press Release: putting patients in the driving seat: a digital future for healthcare. Brussels: European Commission; 2012.
2. Department. of Health. The power of information: putting all of us in control of the health and care information we need. London: Department of Health; 2012.
3. Department of Health. Information: to share or not to share? [Internet]. 2012 [cited Jan 18 2013]. Available from: http://caldicott2.dh.gov.uk/.
4. NHS Connecting for Health. Vision. [Internet]. 2013 [cited Jan 18 2013]. Available from: http://www.connectingforhealth.nhs.uk/systemsandservices/nhsmail/nhsmail2/vision
5. Martin S, Sutcliffe P, Griffiths F et al. Effectiveness and impact of networked communication interventions in young people with mental health conditions: a systematic review. Patient Educ & Couns. 2011;85:e108-e119.
6. Sutcliffe P, Martin S, Sturt J et al. Systematic review of communication technologies to promote access and engagement of young people with diabetes into healthcare. BMC Endocrine Disorders. 2011;11:1.
7. Atherton H, Sawmynaden P, Sheikh A et al. Email for clinical communication between patients/caregivers and healthcare professionals (Review). Cochrane Library. 2012;11.
8. Elliott R, Conroy S, Avery A et al. Promoting partnerships with children and adolescents in medicine-taking (Talking About medicines; TABS) [Internet]. 2013 [cited Jan 25 2013]. Available from: http://www.nottingham.ac.uk/~pazpps/
9. Diabetes UK. Diabetes in the UK 2010: key statistics on diabetes [Internet]. London: Diabetes UK; 2010.
10. World Health Organization. Young people: health risks and solutions (factsheet) [Internet]. Geneva: World Health Organization; 2011.
11. Cystic Fibrosis Trust. Frequently Asked Questions [Internet]. 2013 [cited Jan 25 2013]. Available from: www.cftrust.org.uk/aboutcf/faqs#life
12. Department of Health. Transition: moving on well. London: Department of Health; 2008.
13. Dobbels F, Van-Damme-Lombarert R, Van Haecke J et al. Growing pains, non-adherence with the immunosuppressive regimen in adolescent transplant recipients. Pediatr Transplant. 2005;9:381-390.
14. Annunziato R, Emre S, Shneider B et al. Adherence and medical outcomes in pediatric liver transplant recipients with transition to adult services. Pediatr Transplant. 2007;11:608-614.
15. Watson A. Non –compliance and transfer from paediatric to adult transplant unit. Paediatric nephrology. 2000;14:469-472.
16. Royal College Paediatrics & Child Health. National Paediatric Diabetes Audit 2010-11. London: Royal College Paediatrics & Child Health; 2012.
17. Health & Social Care Information Centre. National Diabetes Audit 2010-2011 Report 1: care processes and treatment targets. Leeds: The Health & Social Care Information Centre, 2012.
18. Dovey-Pearce G, Hurrell R, May C et al. Young adults' (16-25 years) suggestions for providing developmentally appropriate diabetes services: a qualitative study. Health Soc Care Comm 2005: 13(5): 409-419.
19. Kennedy A, Sloman F; Douglass J et al. Young people with chronic illness: the approach to transition. Internal Med J. 2007;37:550-60
20. Kreyenbuhl J, Nossel I, Dixon L. Disengagement from mental health treatment among individuals with schizophrenia and strategies for facilitating connections to care: A review of the literature. Schizophrenia Bull. 2009;35(4):696-703.
21. Bell L, Sawyer S. Transition of care to adult services for pediatric solid-organ transplant recipients. Ped Clin N.Am. 2010;57(2):593.
22. Van Walleghem N, Macdonald C, Dean H. Evaluation of a systems navigator model for transition from pediatric to adult care for young adults with type 1 diabetes. Diabetes Care. 2008; 31:1529-1530.
23. Atkinson N, Saperstein S, Pleis J. Using the internet for health-related activities: findings from a national probability sample. J Med Internet Res. 2009;11(1):e4.
24. Liederman E, Lee J, Baquero V et al. Patient-physician web messaging: The impact on message volume and satisfaction. J Gen Intern Med. 2005;20(1):52-57.
25. Nilsson C, Ohman M, Soderberg S. Information and communication technology in supporting people with serious chronic illness living at home: an intervention study. JTelemed Telecare. 2006;12(4):198-202.
26. Sittig D. Results of a content analysis of electronic messages (email) sent between patients and their physicians. BMC Medical Informatics & Decision Making. 2003;3:11.
27. Department of Health. Research evidence on the effectiveness of self-care support. London: Department of Health; 2007.
28. Pinnock H, Slack R, Sheikh A. Misconnecting for health: (lack of) advice for professionals on the

safe use of mobile phone technology. Quality Safe Health Care. 2007;16(3):162-163.
29. British Medical Association, GPs Committee. Consulting in the modern world: guidance for GPs. London: BMA; 2001.
30. Royal College of Nursing. Use of text-messaging: guidance for nurses working with children and young people. London: RCN; 2006.
31. Mansfield S, Bonning M, Morrison S et al. Social networking and health. Lancet. 2011;377(9783):2083.
32. Vinegar D. When will the NHS start using email to contact patients? Guardian Professional [Internet]. 2012 [cited Jan 23 2012]. Available from: http://www.guardian.co.uk/healthcare-network/2012/jan/23/nhs-email-patients
33. Medical Protection Society. Communicating with patients by fax or email. London: Medical Protection Society; 2012.
34. Matharu, H. Informal web-based survey of NHS Trust information policies. 2013.
35. Cambridge University Hospitals NHS Foundation Trust. Emailing Trust staff [Internet]. 2013 [cited Jan 18 2013]. Available from: http://www.cuh.org.uk/addenbrookes/contact/email_add.html

Evolving Ethnography for Virtual Communities

Anonymous and Anonymous
Anonymous
Anonymous

***Abstract*—*In this paper we provide an introduction to ethnography and its use for studying virtual communities. We chart the historical roots of ethnography and explain some of the practical methods and analytical tools used in this field to understand and study the social world. We review some important ethnographic work in human computer interaction and research on virtual communities. We then discuss some of the challenges of ethnographic work, and in particular challenges of conducting ethnography online.*

***Index Terms*—Ethnography, Virtual Communities, Methods.**

I. Introduction

Ethnography presents a certain analytic attitude to its work: it focuses on getting as close to people as possible, understanding how they see the world, working through their problems and with their ideas. This attitude has become a pervasive one in analysis of technology where the ethos of understanding users has moved, as the other chapters in this book demonstrate, beyond seeing users as measurable units of information processing. Social, cultural and bodily experiences have become much more central, at least in research, to studying users.

In this paper we give an outline of what ethnography is, and a little of its history. We draw specifically on the role of ethnography in the development of human computer interaction (HCI) - one field which has drawn on ethnography to deepen its accounts and design of new technology. In closing we contrast this with the development of ethnography into virtual ethnography.

II. Ethnographic History

Ethnography has its roots in anthropology and sociology and has, in some forms, become a popular model for researching online communication and activity [1], [2]. In particular, ethnography has been widely used within human computer interaction (HCI) and computer supported collaborative work (CSCW), two fields which experiment with designing online activity, and more broadly within cultural studies of internet use. Ethnographic research methods have been applied to projects as diverse as the evaluation of mind map software [3], a proximity based mobile game [4], the working practice of nightclub DJs [5], the results of severing IT workers from their email [6] or the analysis of a mobile, interactive performance [7] – selected from the 2012 Computer Human Interaction (CHI) conference.

Unlike many other scientific research strategies, the ethnographer as researcher is not typically a detached or uninvolved observer. The ethnographer collects data and gains insight through first-hand involvement with research subjects or informants. From the standpoint of ethnography, the only plausible way to study social and cultural phenomena is to study them in action [8]. The formalised ethnography in anthropology is generally seen to have grown from the foundations of the then mainstream practice of ethnology, comparative analysis of different cultures using observational data, in the late 1910's [9] along with the rise in modern fieldwork.

Where previous ethnographic researchers relied on pidgin or interpreters and augmented their data sets with third party accounts from sailors and travellers the new wave guided by Boas, like Malinowski and Radcliffe-Brown, lived among their subjects for extended periods of time. They learned the local language, recorded local myths, customs and ceremonies is much greater detail than had been done before [9]. Although it has been argued [10] that earlier ‘travel writing’ such as Fanny Wright's ‘View of society and manners in America’ published in 1821 and Harriet Martineau's ‘Society in America’ study from 1837 should be considered ethnography as they side-stepped these barriers by focusing on America – living as part of their new culture using a language they already understood after emigration from Europe.

The influence of Boas, Malinowski and Radcliffe-Brown led to this sort of intensive fieldwork being viewed as a ‘right of passage’ for subsequent generations of anthropologists [11]. It must be noted that the desire to follow in the footsteps of Malinowski, Radcliffe-Brown and their contemporaries was not the only driving force behind the move from the practice of explaining the difference between cultures and to documenting and understanding a culture from within – “to grasp the native's point of view, his relation to life, to realize his vision of his world” [12].

The values of an incumbent theory, determining if it will be embraced by a research community, can be seen to be either epistemic or non-epistemic values. Epistemic values are those related to the theory as a means towards greater understanding and the advancement of research, such as simplicity [13] or predictive power [14]. Non-epistemic values are those connected with the scientific context in which the theory evolves, for example its alignment to current moral [15] or political values [16].

Boas challenged the basis of the evolutionary ethnology of the time on the premise that it was based upon a moral foundation, not a scientific one – the progressivist belief that human groups evolved at different rates and that cultures which were at a higher ‘phase of development’ achieved this as a result of the superior inventiveness of the race, or by borrowing

the inventions of others [9]. The move of such a politically influential figure – Boas was key to anthropology being recognized as a field in its own right – away from ethnology to align with his own morality [17] and the concurrent rise of political egalitarianism helped align the context in which new research was being done more closely with the non-epistemic values of ethnography than ethnology. With its solid epistemic values, ethnography was in fertile ground that lead to its swift adoption in the UK and with Boas' former students in American universities.

Ethnography developed as the study of cultures. Originally, the idea of a culture was tied to the notion of ethnicity and geographic location, the culture of the Trobriand Islands in [12] for example, but the areas in which ethnography has been applied has broadened this definition to include virtually any group or organisation. Using ethnographic methods researchers are able to study the 'culture' of a business, a club or the users of a particular system. As explained by Reason and Rowan {reason1981human}, the strengths of ethnography stem from the fact that good research of this sort is involved, committed, relevant and intuitive.

Ethnography must go beyond mere storytelling, it must encompass the elicitation and documentation of cultural knowledge. Seminal examples of ethnography such as Clifford Geertz's 'Deep Play: Notes on a Balinese Cockfight.' [18], the detailed investigation of patterns of interaction of football hooligans in Marsh et. al.'s 'The Rules of Disorder' [19] and the analysis of life within the Moonies by Barker in 'The Making of a Moonie: Choice or Brainwashing?' [20] all demonstrate the vitally important principle, as argued by Glaser and Strauss [21], that in ethnographic research theories must be developed and tested during the process of the research itself.

III. Ethnography in HCI

The emergence of ethnographic enquiry as a method of choice within HCI can be attributed to the fields of Computer Supported Cooperative Work (CSCW) and Participatory Design (PD), which imported ethnographic methods from anthropology and sociology to study the use of technology in situ. The use of ethnographic enquiry within HCI has been argued to be a method of rich requirements capture [1], [22], [23]. Apart from the insight gained into social practice, its merits with respect to the design process include providing "a useful contrast to traditional methods of requirements capture" [22] and the engagement of users in the design process [23].

The difficulty ethnography faced when attempting to influence design has been highlighted [1], [22], and the suitability of ethnography for the task of generating implications for design has been questioned [1], [22], [23]. It is not suggested that this in unobtainable, but simply that implications for design don't necessarily follow from ethnographic findings [23], or that ethnographic findings are more suited to identifying how people cope with existing technologies rather than inventing new ones [22], [24]. The most influential ethnographic studies in CSCW did not provide design recommendations "but instead tried to uncover, in minute detail, the ways in which social order is produced in cooperative work settings." [25]

More recently the notion of evaluating the merit of ethnographic work carried out within HCI by the presence or absence of implications for design has been challenged [1], [24]. Dourish [1] suggests that HCI needs to distinguish between ethnography to inform system design and ethnography to study human computer interaction.

While ethnography purists argue that employing methods such as quasi-experimental statistical tests or dependent and independent variables results in 'dead knowledge' [26] and that 'it is much better to be deeply interesting than accurately boring' [26] when human action and interaction are the subject of the research these tools are often employed in HCI research to support the claims of ethnographic enquiry and add confidence to claims of generalisability.

An ethnographic description may contain a large amount of information with direct value to design and evaluation but it is still a largely unconstrained and personal narrative account. This raises problems of abstraction, generalisation and comparison and leads to a lack of cumulative research results [27].

Ethnomethodology [28] (EM) has also been used in the analysis of ethnographic data. EM is a particular analytic orientation to the practical study of social order, which can be seen woven through the fabric of everyday activity. Ethnomethodologists view human social action as something that is reflexively accountable.

Accountability here means the way the action is observable and reportable – in other words, the very way in which the action is orchestrated by the actor or actors provides others the means to recognise it as what it is. It is seen to be reflectively so in that it is accountable through its own production rather than within a frame of a set of predefined, global social rules.

Although there is some resistance to the evolution of EM-inspired ethnography [29] there have been attempts to move forward with hybrid approaches such as Technomethodology [28]. This methodology has the goal "to understand how ethnomethodological understanding of human social action and interaction can be used, directly, in designing interactive technologies." looking at an implementation practice called "Open Implementation" that aims to change the standard abstractions used in all programming languages for ones where the relationship between "what is done (the implementation behaviour), and what is done by what is done (the achievement of application ends)" is articulated in such away that it is accountable. By providing a development and design space that ties in with ethnomethodological understanding of action, then that understanding can be directly applied to design without being translated, as it were, by the ethnomethodologist.

MUST [30] is another child of EM, although firmly in the camp of Participatory Design, providing a framework for the design process and combining ethnography with intervention, intervention meaning to deliberately set up activities that change the norm in order to learn from the actors' reactions to that change – as opposed to ethnography, where ethnographers strive not to change what they are studying. MUST provides

guidelines for iterative ethnographies and interventions, allowing for interventions that happen "in the mind of the designer or though conversations among designers" [30] to some extent but stressing the importance of 'real' interventions in cases where the imagination is not enough.

A. Online Ethnography

One recent and interesting twist in ethnography and technology has been the growing interest in online ethnography – labeled with titles such as 'virtual ethnography', or 'netography' [31]. This is a form of ethnography that takes its subject communities where the predominant, or at times only, contact is online. While only recently such communities were considered marginal, with the spread of online social networks and the like, not to mention the increasing thicket of forms of online communication, these communities have come to the fore. Indeed, until recently some were doubtful as to whether online communities were themselves possible. Online forums present a range of different social collectives of differing intensities and connections [32]. For example, we might think of the editors of Wikipedia, the online encyclopaedia, as a community. While we will find "legitimate peripheral participation", more central participation and the like, there is also some sort of common orientation to a set of rules, a common space and a common set of skills and abilities. It might be harder to argue that the non-authoring users of Wikipedia are similarly a community. After all, their is little direct communication between them. Yet we might still find collaboration of a sort - the reading of different pages effecting their popularity, donating money, referencing Wikipedia in student essays or simply propagating ideas and arguments from the pages of Wikipedia.

The question of whether a virtual ethnography can be carried out would seem to depend to an extent on the closeness of the community to determine if there is a 'what' to be studied. In terms of methods, the lack of physical contact can cause problems not so much in understanding individual informants, or those being investigated, but rather in how one might pick up on the ambiance of a place - what the walls are covered with, who sits where, the temporal rhythms that can be obvious at a glance to a intimate, yet harder to see when one only has a slowly updating list of forum posts.

One of the more productive areas for virtual ethnography has been online games. Through offering a non-textual virtual environment, one where avatars move and engage, it seems that the possibility of an ethnography is much enhanced. Recent ethnographies of Everquest and second life, for example, have been notable [33]. Perhaps though, in terms of ethnographic study it has been World of Warcraft - that has been the most productive [34]. Perhaps one of the most successful online communities ever, Warcraft peaked at around 12 million subscriptions, and has around 10 million currently. While these are segmented more or less by region, this seems more than enough (and with enough of a world in common) for virtual ethnographers to work in. Yet, there can be few communities that develop and change as quickly as those online, so one can expect methods and approaches here also to be somewhat in flux.

IV. Doing Ethnography

The formalised multi-method form of ethnographical research used today reduces the risks stemming from reliance on a single kind of data and makes triangulation possible, allowing the researcher to compare data collected by different methods to aid understanding [35].

This type of research is concerned with the interaction of events, actors and system – the study of any one of these hold very little meaning without the others, and the research itself is embedded in the social, interconnected world under investigation. Researchers practicing ethnography therefore recognise that they are part of the world they are studying, and that they will have an effect on the subjects under investigation.

Two key issues in any ethnographic study are those of access and of field relations [36]. Blomberg et al. [37] characterise ethnography with four principles and three main techniques: it takes place in natural settings; it is based on the principle of holism, that is, particular behaviours must be understood in their respective contexts; it develops descriptive understanding; and it is grounded in a member's point of view. The main techniques they use are observation, video analysis and interviews.

A. Observation

Observation is the primary means by which a researcher can examine the actions of a participant and the broader context in which the actions take place. In purely observational studies the actions can be open to possible misinterpretation by the researcher, a risk reduced in ethnographic studies by the researcher's long-term immersion in the environment.

There are two modes of observation, direct and indirect. In direct observation, the researcher is present in the subject's environment and watches the subject go about their everyday routine or perform a particular task. With no mode of recording the events that are being observed, one limitation is that events of interest may be missed by the researcher [23] and that there is no way to revisit the data [38].

The most commonly stated limitation of observational studies is the Hawthorne effect.

Proponents of the Hawthorne effect say that people who are singled out for a study of any kind may improve their performance or behaviour not because of any specific condition being tested, but simply because of all the attention they receive [39].

Such a view seems to indicate that the degree of attention paid to those participating in a study is positively correlated with any subsequent Hawthorne effect; a commonly held assumption being that no human-centred study is completely free from the Hawthorne effect [40]. However, the generalisability of the Hawthorne effect has recently been called into question [39], [40]. Macefield [40] presents a full discussion on the limitations of such a generalisation with respect to usability evaluations. Similarly, Crabtree and Rodden propose that the Hawthorne effect is often

overestimated when considering ethnographic studies in the workplace and home, simply because when in these environments people "have better things to do than impress or worry about the ethnographer" [41].

B. Interviews

There are many limitations to interviewing as an investigative technique, the most obvious being the widely acknowledged discrepancy between what people do and what people say they do. Interviewees may also tailor their answers to suit what they think the interviewer wants to hear [38] or to maintain their presentation of self to the interviewer [42].

A less obvious limitation is that interviewing relies on a degree of reflective expertise on the part of the subject, and the ability to articulate their thoughts, feelings, and experiences even though one purpose of interviews is to gain insight into the thoughts, feelings, and experiences of subjects that may not otherwise be easily observed [38].

Additionally, the questions that are asked are limited by the assumptions of the researcher. While this may be useful in situations where the research question has a narrow focus, in more exploratory studies this may delimit the subsequent scope for potential and valuable findings. The implication of incorrect assumptions is most damaging in structured interviews, in which the researcher follows a script predetermined questions with no opportunity for deviation, clarification or explanation. Semi-structured interviews offer some purchase on this problem in that the researcher enters the interview with a loosely defined schedule and willingness to let the course of the interview be guided by issues that are raised as relevant by the subject.

C. Analysis

We now move on to consider the different analytic stages. On the whole we agree with Randall et al; it is the analysis which is particularly challenging in empirical work, much more so than fieldwork or fieldnotes. Of course, the fieldwork can seem most like work, particularly if you are the sort of person (as most of us are) who has some discomfort in launching into conversation with complete strangers. Moreover, in any project it materially takes up most of the time as well as being the most memorable. It is during fieldwork that we approach something for the first time and its strangeness, but also its order, starts to be apparent. Analysis, however, is the crucible of participant observation. It is where observations and participation can be transformed into something that somebody else could understand and make sense of - loosing some of their personal weight in the process, of course, but becoming potentially powerful for helping others understanding what is involved in a family of different activities.

As with fieldwork we can loosely divide up analysis into two parts – a retrospective phase where one attempts to document what you have done and seen, and a prospective phase where you try and work out what relevance that might have for anybody else, or for those attempting to understand the activity in itself. In the retrospective phase we attempt to document and note all the things we have experienced. Here the focus is on documentation, on thinking back to different parts of the experiences and in particular aspects that we did not reflect on at the time. Analysis often involves redescription of previous situations and observations, rewriting and bringing together separate points – transforming your field notes into richer more inter-threaded documents.

It can be confusing to work out what are the important parts that are worth writing down – this is particularly difficult if it is the 'first time through' at doing participant observation. Indeed, the first time one writes down experiences from participant observation it is unlikely that we will be successful. Working out what is important is something that comes from the later stages of the undertaking. Essentially, what is important later impacts on what can be useful to focus on when retrospectively reviewing ones activity. Yet there are some rough guidelines that can help the endeavor. Be careful to document all the different processes and parts of your study, including gaining access and travel to and from the particular field site. Document your own feelings and experiences, and what you can grasp of others perspectives. Be careful to write down what actually people do and where they do it. At the beginning of fieldwork the challenge is that nothing really seems to make any sense so the details can be overwhelming. In contrast when you have a sense of what is happening and how this are done it can be tempting to 'gloss' – to simply write down what an expert would see about a setting. Remember a goal of the analysis is to get at what it is to be an expert. So if you start to use any jargon explain when and how you would know where to use that jargon. It is the 'taken for granted' that you are trying to extract as your data so the challenge is getting yourself to stop seeing what an expert would see and try and understand how an expert.

It is perhaps the prospective analytic phase though that is the hardest of all. The prospective phase is about moving from descriptions of what happened to analytic findings that could be used to understand future activity. This is why we call it prospective – trying to find out what is done in a setting so that if you were to know that you could be quicker to understand what is going on there, how it is organized and so on. In a sense this is about finding generalities, but ones very much tied to the particular setting or activity that one is researching. In many ways these are the sorts of typificiations that we commonly draw all the time – e.g. 'the bakery runs out of bread after about 2pm', 'the project is much smoother if the boss doesn't get involved', 'its easier to apply for research funding if you have a track record'. Finding good prospective analysis comes from understanding what is going on in a setting to the point where one can make predictions, of a sort, about what will happen after what one has seen.

So if one is interested in something analytically, one should be able to detect what it is that will be regularly done. Moreover, if one can understand what motivates particular events or occasions one can predict what changes might take place. Small changes, perhaps, but the sorts of local innovations that can enhance or detract from a particular activity. The power of prospective analysis comes from being able to learn from what goes on in one situation or activity and

to use it to understand other activities or settings. That is to say, to move from understanding something here, to understanding something 'there'. This can be a narrow comparison – such as drawing on lessons from looking at one sort of sports spectating to understand another, to more general comparisons – say between sport participation and video game playing. In each case there is no general or strong rule that says that something in one forum should take the same form as something in another, but rather that contrasts and comparisons can help us learn broadly about how activities are arranged.

The challenge of prospective analysis is keeping it sufficiently open that one does not fall into over generalizations or that one stops documenting any specific cases. Always make sure that you document actual cases and use them in trying to make any sort of prospective analysis. If something didn't happen once, its unlikely to be a general feature of any setting.

D. Ethnography and virtual communities

So far we have provided a general overview of ethnographic methods and its use in human computer interaction. Studying virtual online communites presents some special challenges, however. Yet we are broadly skeptical about the 'newness' of virtual ethnography.

Firstly, it can be extremely tempting to think of the 'virtual' as a place where an ethnography is conducted, and as anthropologists went to particular 'remote' parts of the world, so a study of virtual communities takes place 'online'. Now this way of speaking is quite useful, and does talk to a truth in the sense of the richness of online communication. Yet it is important to underline that whatever the value of this way of speaking it is a metaphor - online work still takes place in the physical world through the manipulation of a tool - through the tangible engagement with technology. If we look at or study online interaction we can see that they are replete with discussion of 'RL'. While many scholars in the past conducted much of their affairs through letters, they did not 'enter letter space', any more than we do when playing world of warcraft. Ethnographies have also always made extensive use of documents - particular studies of work environments. So the first point to make is that the 'virtual' is not itself a place or domain where ethnography is conducted.

This said virtual communities, by their very nature, communicate predominately through online means. This uniquely provides a set of challenges and opportunities for ethnographic work. Yet the first thing to acknowledge is that the existing methods - interviews, participant observation, are still valid. Some of the best virtual ethnographies have spent considerable time 'offline' – Senft's ethnography of Camgirls, for example.

Yet the sense of 'hanging about' does take on different features if that 'hanging about' is being done predominately online. Most importantly, one has to deal with the issues of the media itself. If one is playing a game, much of the communication mechanisms is poised towards the game itself. This can lead to problems for getting an understanding from just looking at the game itself. Fortunately, these issues exist for participants too – they have 'work to do' which can be difficult to arrange simply in he game, and so complex virtual communities often make use of a variety of media – internet forums, IRC conversations, facebook groups and so on.

Yet the key point is to acknowledge the nature of the different media being used. Just as an ethnographer is well aware of the participation frameworks involved in being physically present, so an ethnographer of virtual communities need be aware of the properties of the different media being deployed. This also means that an ethnographer should be active in using different media to get 'closer' to the community being studied. This can mean actually breaking through the constraints of the online and going to physically meet and talk to those involved. One can also hunt out particular physical sites where those involved get together – conventions, internet cafes, gaming events and so on.

A second point concerns the use of recording tools, and more broadly the 'recorded' nature of online communication. Ethnographers have made extensive use of video and audio recording, alongside the trusty notepad and fieldnote, and so in some ways the nature of online communication is a natural extension. Yet the automatic recording of all written online communication, and the opportunities for different analysis, are only beginning to be explored. Note here though that as an ethnographic account recordings lack the opportunity for participation. The involvement of the ethnographer – physically, empathically – "in real time", is limited. The opportunities are here balanced by the issue of participation.

What actually participation is presents its own challenges. For Reagle's study of Wikipedia, to understand the phenomena he actually needed to participate – and participate to a quite considerable level – in Wikipedia. At the heart of participation there is the active involvement of the investigator in becoming like those you are studying, "coming to see the world through their eyes". As Goffman put it: "You should feel like you could settle down and forget about being a sociologist" [43]. That involves a level of participation that goes beyond reading to acting and participating.

V. Conclusion

This paper gives a broad introduction to ethnography and its use for studying virtual communites. We covered the historical roots of ethnography and its distinctive approach to understanding and studying the social world. We reviewed some important ethnographic work in human computer interaction, and more the smaller body of work that research virtual communities. Lastly, we discussed some of the broad methods issues with ethnographic work, and the particular challenges of online ethnography.

We can hardly give a full description of ethnography as a method, but hopefully this chapter gives a little of the flavour of the goals, theories and methods that make up its use. Even for those that do not deploy ethnography themselves, there is much to be learnt in its broad approach: its emphasis on understanding other's worldview, how technology is threaded into situations and communities distant from those we are most familiar.

References

[1] P. Dourish, “Implications for Design,” presented at the Proceedings of the 24th international conference on Human factors in computing systems, 2006, pp. 541–550.

[2] J. Hughes, V. King, T. Rodden, and H. Andersen, “The role of ethnography in interactive systems design,” *interactions*, vol. 2, no. 2, pp. 56–65, 1995.

[3] H. Faste and H. Lin, “The untapped promise of digital mind maps,” presented at the Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems, 2012, pp. 1017–1026.

[4] C. Licoppe and Y. Inada, “‘Timid encounters’: a case study in the use of proximity-based mobile technologies,” presented at the Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems, 2012.

[5] A. Ahmed, S. Benford, and A. Crabtree, “Digging in the crates: an ethnographic study of DJS' work,” presented at the Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems, 2012.

[6] G. Mark and S. Voida, “‘A Pace Not Dictated by Electrons’: An Empirical Study of Work Without Email,” presented at the Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems, 2012, pp. 555–564.

[7] P. Tolmie, S. Benford, and M. Flintham, “Act natural: instructions, compliance and accountability in ambulatory experiences,” presented at the Proceedings of the 2012 ACM annual conference extended abstracts on Human Factors in Computing Systems, 2012, pp. 1519–1528.

[8] J. Murchison, *Ethnography Essentials*. Jossey-Bass, 2010.

[9] M. Risjord, “The politics of explanation and the origins of ethnography,” *Perspectives on Science*, vol. 8, no. 1, pp. 29–52, 2000.

[10] S. Reinharz and L. Davidman, *Feminist methods in social research*. Oxford University Press, 1992.

[11] B. Tedlock, “From participant observation to the observation of participation: The emergence of narrative ethnography,” *Journal of Anthropological Research*, vol. 47, no. 1, pp. 69–94, 1991.

[12] B. Malinowski, *Argonauts of the Western Pacific: An account of native enterprise and adventure in the archipelagoes of Melanesian New Guinea*, no. 65. Routlege, 2002.

[13] K. B. Wray, “A defense of Longino's social epistemology,” *Philosophy of Science*, pp. 538–552, 1999.

[14] W. C. Salmon, “Carl G. Hempel on the rationality of science,” *The Journal of Philosophy*, vol. 80, no. 10, pp. 555–562, 1983.

[15] E. McMullin, “Values in science,” presented at the Proceedings Of The Biennial Meeting Of The Philosophy Of Science Association, 1982, vol. 2, pp. 3–28.

[16] G. C. Homans, “Anxiety And Ritual: The Theories Of Malinowski And Radcliffe‐Brown,” *American Anthropologist*, vol. 43, no. 2, pp. 164–172, 1941.

[17] G. W. Stocking Jr, “Special review: Empathy and antipathy in the Heart of Darkness: An essay review of Malinowski's field diaries,” *Journal of the History of the Behavioral Sciences*, vol. 4, no. 2, pp. 189–194, 1968.

[18] C. Geertz, *Deep play: notes on the Balinese cockfight*. American Academy of Arts and Sciences, 1972.

[19] P. Marsh, E. Rosser, and R. Harré, *The Rules of Disorder*. Routledge, 1980.

[20] E. Barker, *The making of a Moonie: choice or brainwashing?* Gregg Revivals, 1993.

[21] B. G. Glaser and A. L. Strauss, *The Discovery of Grounded Theory: Strategies for Qualitative Research*. Aldine de Gruyter, 1967.

[22] D. Shapiro, “The Limits of Ethnography: Combining Social Sciences for CSCW,” presented at the Proceedings of the 1994 ACM conference on Computer supported cooperative work, 1994, pp. 417–428.

[23] W. Sharrock and J. A. Hughes, “Ethnography in the workplace: Remarks on its theoretical bases,” *Team Ethno Online*, vol. 1, no. 1, pp. 1–21, 2001.

[24] P. Dourish, “Responsibilities and implications: further thoughts on ethnography and design,” presented at the Proceedings of the 2007 conference on Designing for User eXperiences, 2007.

[25] A. Schmidt, M. Beigl, and H. Gellersen, “There is more to context than location,” *Computers & Graphics*, 1999.

[26] P. Reason and J. Rowan, *Human inquiry: a sourcebook of new paradigm research*. J. Wiley, 1981.

[27] B. A. Nardi, “Activity Theory and Human-Computer Interaction,” in *Context and Consciousness: Activity Theory and Human-Computer Interaction*, no. 1, B. A. Nardi, Ed. The MIT Press, 1996, pp. 7–16.

[28] P. Dourish and G. Button, “On ‘Technomethodology’,” *HCI*, vol. 13, no. 4, pp. 395–432, 1998.

[29] A. Crabtree, T. Rodden, P. Tolmie, and G. Button, “Ethnography considered harmful,” presented at the Proceedings of the 27th international conference on Human factors in computing systems, 2009, pp. 879–888.

[30] F. Kensing and J. Simonsen, “MUST: A method for participatory design,” *HCI*, vol. 13, no. 2, pp. 167–198, 1998.

[31] R. V. Kozinets, K. De Valck, A. C. Wojnicki, and S. J. S. Wilner, “Networked narratives: Understanding word-of-mouth marketing in online communities,” *Journal of marketing*, vol. 74, no. 2, pp. 71–89, 2010.

[32] R. Kraut and P. Resnick, *Building successful online communities: Evidence-based social design*. MIT Press, 2012.

[33] E. Castronova, *Synthetic Worlds: The Buisness and Culture of Online Games*. University Of Chicago Press, 2005.

[34] T. Pace, S. Bardzell, and J. Bardzell, “The rogue in the lovely black dress: intimacy in world of warcraft,” presented at the Proceedings of the 28th international conference on Human factors in computing systems, 2010, pp. 233–242.

[35] L. A. Suchman, *Plans and situated actions: the problem of human-machine communication*. Cambridge University Press, 1987.

[36] P. Banister, *Qualitative methods in psychology: a research guide*. Open University Press, 1994.

[37] J. Bloomberg, J. Giacomi, A. Mosher, and P. Swenton-Wall, “Ethnographic field methods and their relation to design,” no. 7, D. Schuler and A. Namioka, Eds. Participatory design: Principles and practices, 1993.

[38] J. Preece, T. Carey, Y. Rogers, S. Holland, H. Sharp, and D. Benyon, *Human-Computer Interaction*. Addison Wesley Publishing Company, 1994.

[39] B. Rice, “The Hawthorne effect: Persistence of a flawed theory,” *Psychology Today*, vol. 16, no. 2, pp. 70–74, 1982.

[40] R. Macefield, “Usability studies and the Hawthorne Effect,” *Journal of Usability Studies*, vol. 2, no. 3, pp. 145–154, 2007.

[41] A. Crabtree and T. Rodden, “Domestic routines and design for the home,” *Computer Supported Cooperative Work*, vol. 13, no. 2, pp. 191–220, 2004.

[42] E. E. Jones, F. Rhodewalt, S. Berglas, and J. A. Skelton, “Effects of strategic self-presentation on subsequent self-esteem.,” *Journal of Personality and Social Psychology*, vol. 41, no. 3, pp. 407–421, 1981.

[43] E. Goffman, “On Fieldwork,” *Journal of Contemporary Ethnography*, vol. 18, no. 2, pp. 123–132, Jul. 1989.

Social, Local and Mobile Identity Management

The development of a user-centric open SoLoMo platform.

Paulien Coppens
iMinds-SMIT
Vrije Universiteit Brussel (VUB)
Belgium
Paulien.coppens@iminds.com

Rob Heyman
iMinds-SMIT
Vrije Universiteit Brussel (VUB)
Belgium
Rob.heyman@vub.ac.be

Jo Pierson
Iminds-SMIT
Vrije Universiteit Brussel (VUB)
Belgium
Jo.Pierson@vub.ac.be

***Abstract*— A popular buzzword these days is SoLoMo, as the contraction of Social, Local and Mobile. This refers to the convergence between social, local and mobile services and platforms. The combination of these three attributes responds to the always connected and interactive modern consumer, but also often leads to privacy concerns. Users, mobile operators, application providers and other third parties can access huge amounts of personal data for different purposes. The myriad of potential uses for personal data and the obscurity thereof increases consumers' reluctancy to fully adopt SoLoMo services. SoLoMo technology providers are challenged to balance between giving users more control over their mobile identity, but at the same time they also have to offer access to service providers and third parties to guarantee a working service and revenue. There is a need for a solution that can find a balance between privacy protection for users and the amount of information third parties need. The SoLoMIDEM project aims at developing a multi-layered open SoLoMo platform, in which an optimal exploitation of big data is possible for each of its stakeholders, with the end user as primary stakeholder. For this we discuss the meaning of (location) privacy and identity in relation to privacy awareness, attitudes, capabilities and practices of users. We also elaborate on the key concepts of Location Based Services (LBS), providing a brief overview of relevant literature. In a next phase our empirical user research will deepen our understanding of the specificities of user privacy in a SoLoMo context.**

Keywords—SoLoMo; Location Based Services; Location privacy; Identity management; Mobile platform; User-centric

I. INTRODUCTION

In today's digital society, an enormous amount of personal data are created, shared and collected by users everyday. Mobile data subscriptions in Flanders (Northern part of Belgium) have tripled between 2009 and 2012 (11,5% to 35,7%) and the adoption of smartphones also rose from 23,5% to 38,5% between 2010 and 2012 [1]. Next to the adoption of smart phones, the use of social network sites on these devices is now 70,1% and 55,4% of smart phone users visit social network sites daily. Third parties can gather, analyze and monetize personal data to offer personalized services. Some companies are even built "on the economics of personal data" (e.g. Google) [2, p.7]. These practices make consumers concerned about their privacy. In addition to this concern, users are also aware of the threats stemming from their social environment [3]. Privacy issues are not a recent development, but they become more pronounced in the SoLoMo environment. These services and platforms can be very useful, entertaining and interesting, but they also lead to an even higher amount of personal information accessible to other parties. Users carry their smartphone with them at all time, making this a highly personal device. Application providers and other third parties now can access even more personal data such as location, contact lists and pictures. This substantially increases the amount of personal data being gathered in comparison to for example the use of Internet on a fixed computer.

This myriad of possibilities increases privacy breaches and also increases distrust, which may be bad for adoption of new services. Several studies however prove that if users have more control over the disclosure of their personal information, they are less concerned about their privacy and they might even share more information [4, 5, 6, 7]. The SoLoMIDEM project (Social, Local and Mobile Identity Management) wishes to bridge the privacy issues through a user-centric platform, which offers enough benefit to provider, advertiser and user. Identity management and location privacy techniques will be integrated to make this a highly trusted platform. Or as Kölsch, Fritsch, Kohlweiss and Kesdogan put it: "As location data is the essential input for LBS {Location Based Services}, protection of privacy in LBS is not a problem of providing anonymity by suppressing data release, but a problem of identity management and control over information handling" [8, p.1]. This balance is not limited to

SoLoMIDEM is 2 year ICON project (01/01/13 - 31/12/14). In an ICON research project, iMinds (an independent Flemish research institute) brings together different partners for an ICT-related need detected by companies, governments or organizations. The SoLoMIDEM research partners are iMinds-SMIT (VUB), iMinds-MICT (UGent), iMinds-COSIC (K.U.Leuven) and iMinds-ICRI (K.U.Leuven). Industry partners are City Live, Enqio nv, LIN.K, Cultuurnet Vlaanderen and iRail.

what information can be shared to whom, but also to usability issues, as privacy management can be very complex and demanding.

An important first step is to better understand the meaning of (location) privacy and identity in relation to privacy awareness, attitudes, capabilities and practices of users. We will elaborate on the key concepts of Location Based Services in relation to location privacy, providing a brief overview of relevant literature. In next phase our empirical user studies will deepen our understanding of the specificities of user privacy in a SoLoMo context.

II. FRAMING KEY CONCEPTS

A. Location Based Services

Smartphones are often equipped with a GPS system, which enables the location tracking of smartphone users. This leads to an increasing popularity of LBS applications that make use of the location of the user to offer a specific service. A wide variety of LBS exists. Examples are check-in services (e.g. Foursquare), way-finding services (e.g. Google Maps) or location based daily deal services (e.g. Groupon Now). In general, a distinction can be made between push-based and pull-based applications. Xu, Gupta and Shi describe pull-based LBS as applications "in which individuals request information and services based on their locations" and push-based LBS as applications "in which location-sensitive content is automatically sent to individuals based on tracking their locations" [9, p.1]. A popular type of LBS are Location Sharing Applications (LSA). These applications focus on sharing locations between users. Some applications focus on location sharing with one or a few persons e.g. Glympse, which enables to share your location with others for a user-defined amount of time. Other applications, such as Foursquare or Facebook check-in, support location sharing with a large group of people [10]. A distinction needs to made between the sharing of exact geo-referenced locations and user-entered place names or community-named locations [11]. When studying users' location sharing behavior, it is important to take that difference into consideration since the desired privacy settings might differ depending on the shared type of location information.

B. Location Privacy

The most commonly used definition of privacy is Warren and Brandeis' right to be left alone [12], which has been called the *privacy as confidentiality* paradigm [13, 14]. Within this paradigm as little information as possible is shared because it becomes uncontrollable once it enters the world. This paradigm is too narrow to describe services build for sharing information. The paradigm of *privacy as control* is more adapted to our purpose [13, 14]. Here information is shared and controlled through tools such as privacy agreements and privacy settings, which are respected by all parties. Commercial companies such as Facebook do not offer enough settings to control all flows of personal information. The selection of controllable options imposes a disclosure behavior on users. The third paradigm, *privacy as practice*, addresses this issue by raising users' awareness through tools [13, 14]. By raising awareness and transparency users can start to think about their own privacy preferences. Although no technologies are suggested to enforce these preferences, the paradigm overcomes the issues in the previously mentioned paradigm by allowing users to think for themselves. We will make use of privacy as control and practice in the SoLoMIDEM project to inform users and offer them settings based on their preferences. In line with these two paradigms, Ardagna, Cremonini, Damiani, De Capitani di Vimercati and Samarati define location privacy as "the right of the users to decide how, when and for which purposes their location information could be released to other counterparts" [15, p.313]. They identify different categories of location privacy:

- Identity privacy: the protection of the user's identity
- Position privacy: the protection of the user's position
- Path privacy: the protection of the location movement of a user that has been monitored for a longer period of time.

C. The privacy decision-making process

To study the privacy decision-making process users face when disclosing personal information, we draw on the theories of Altman [16] and Petronio [17]. Altman's privacy regulation theory introduced the concept of *privacy as boundary regulation* [16]. When disclosing personal information, an individual weighs the goals of disclosure and the boundaries of the disclosures to preserve privacy. Therefore, it is important to be aware of the reach of the information. An individual strives to achieve an optimal level of privacy. Boundary regulation is also central in Petronio's [17] *Communication Privacy Management* theory. To manage information disclosure, individuals develop rules to reveal or conceal private information. The concept of *knowledge informing boundaries* is supported by both theories. The knowledge an individual has of the context for disclosure, influences the rules and the privacy strategy that will be used [7]. To prove the importance of context in forming an identity and managing privacy, De Wolf and Pierson developed the *contextualized identity and privacy* (CIP) model [3]. They draw on the theory of Goffman [18]. Goffman compares the everyday life of individuals with a performance on stage. He distinguishes a front stage, where individuals try to portray themselves the best they can, and a back stage, where one wants hide certain facts. De Wolf and Pierson assume every context can function as a front stage and as a back stage, which facilitates the boundary control process [3]. "The existence of an alternation of a context being a front and back stage facilitates the process of keeping control over how an identity gets displayed (and placed) and what information is disclosed (and withdrawn)" [3, p.12]. We will use the theories of Altman, Petronio and De Wolf et al. to frame the decision process users face when deciding to disclose location information.

First, the research here needs to draw upon the privacy as practice paradigm as more awareness is needed before we can map users' privacy decision-making process. Location based services are advertised as free to users, although users 'pay' with their attention, UGC and personal information. Contrary to privacy as boundary regulation or the formation of an identity, users transmit information implicitly while using the service for other purposes. Transparency is not only an issue in the stage of gathering information, the obscurity problem persists in processing of information and lastly using it as input in services. It is impossible for users to predict what will be inferred from their location-based data as qualitatively new data is generated out of other data [19]. The uses or the purpose limitation is also obscured or hard to predict because the data can be used for unintended purposes. A clear example here is the application 'Girls around me' where Foursquare's API was used to develop an application to find spots with a higher concentration of girls and what is more, enabled users to see their public Facebook profiles [20]. The obscurity surrounding the collection, processing and use of personal and location-based information are not limited to third parties only, Eli Pariser's Filter bubble illustrates how algorithms such as Google search and Facebook's pagerank have become gatekeepers that decide what users should see and should not see [21]. The research here will first map the current awareness of users and will than have to address this obscurity problem in order to understand user preferences.

III. LITERATURE REVIEW

A. Privacy concerns

Privacy concerns influence the intention to use LBS [9, 22, 23]. It is thus important to gain deeper knowledge in users' privacy concerns. Several studies have already been conducted to explore users' (location) privacy concerns. In 1996, the CFIP scale (Concern for Information Privacy) was developed to measure users' privacy concerns about the privacy intruding practices of organizations [24]. Malhotra, Kim and Agarwal adjusted this model to measure privacy concerns in an Internet environment [25]. They developed the 10-item scale IUIPC (Internet Users Information Privacy Concerns) and identified three dimensions of users' privacy concerns: inappropriate collection of personal information, lack of control over personal information, and lack of awareness of organizational privacy practices. But the rise of smartphones and mobile Internet access and services lead to new privacy concerns. Xu, Rosson, Gupta and Carroll study mobile users information privacy concerns (MUIPC) [22]. They drew on the Communication Privacy Management theory of Petronio [17] to develop a framework (MUIPC) in which three factors specify the privacy concerns of mobile users: perceived surveillance, perceived intrusion and secondary use of personal information. These three dimensions accord with the three boundary coordination rules in the CPM theory of Petronio (respectively the permeability rules, the ownership rules and the linkage rules). Privacy concerns when using LBS, also differ among the different types of LBS [9]. Earlier research already found out location-tracking services cause higher privacy concerns than position-aware services. Location-tracking services rely on third parties tracking the location of individuals. Position-aware services rely on the knowledge of the apparatus and the application of its own position [26].

B. Factors affecting location sharing behavior

The willingness of users to disclose their location information, depends on a variety of factors. A lot of research has been conducted to explore *when, where and with whom* users are comfortable sharing their location.

The preferred privacy settings for location sharing depend on the *time* of the day and the day of the week. Research shows that people are more willing to share their location during the day on weekdays, than at night and on weekends [4].

The *specific location* to be shared is also an important element. The exact place a user is at a certain moment, is an important element in deciding whether or not to share the location [27]. When users are at places visited by a lot of people, they are more comfortable sharing that location [28, 29]. The concept of *location entropy* is used to measure the diversity of people on a specific location. People prefer sharing locations with a high entropy. When being in a specific place, users sometimes prefer to share a more abstract location description (e.g. 'grocery store') instead of the exact geographic coordinates [28, 29]. Users also feel more comfortable if they can control the level of location granularity when disclosing location information. LBS should integrate the possibility of choosing the level of granularity when sharing location [28, 29].

Consolvo et al. [27] find that the willingness of users of LBS to disclose their location to social relations depends on *who* is requesting the location and how they feel about that person. They are most willing to share their locations with family or friends. When sharing location with less intimate social groups, users have higher location blurring intentions [28]. A lot of research focuses on users and whether they are willing to share their location with family, friends and other social network members. Kelley, Benisch, Cranor and Sadeh study how comfortable users are sharing their location with advertisers [6]. They find that users have strong privacy concerns with regard to advertisers, but more control over the privacy settings can alleviate these concerns. Another important factor is the amount of people the location is shared with. Research shows that the goal of people who use applications that support location sharing with one or a few persons is purpose-driven, while the goal of users of applications that support locations sharing with a large group of people is often social-driven (e.g. impression management) [10]. Location sharing behaviour and privacy concerns are different for those two groups.

C. The importance of control over personal information

The control perspective is widely used within privacy research [13, 14, 30]. In this perspective it is assumed that a loss of control over personal information, results in a higher feeling of privacy intrusion. If consumers perceive a higher level of control, the feeling of privacy invasion will be lower. Xu [30] identifies three mechanisms that increase the perceived control over personal information: privacy-enhancing technologies, industry self-regulation and government legislation. Giving users more control over their privacy settings can mitigate privacy concerns [4, 5, 6, 7, 28, 30, 31]. A higher perceived control might lead to a higher amount of sharing.

D. The role of feedback

A lot of the existing mobile location-sharing applications do not give information on who has viewed or requested your location. Several researchers study the importance of feedback on users' behaviour in such applications. Jedrzejczyk, Price, Bandara and Nuseibeh explore the impact of real-time feedback [32]. Participants received a notification every time their location is checked. They report real-time feedback can be useful, but it is also highly intrusive. Frequent messages can be annoying for the data owner and the transparency can scare off the data requesters. A positive side of this is that real-time feedback makes people more accountable for their actions. The result is a lower amount of unreasonable location requests, since it makes users think they should have a good reason for requesting a location.

Tsai et al. developed Locyoution, a mobile location sharing system [33]. In their 4-week study, one group of participants received feedback on who had requested their location and a second group received no feedback. They find that the users who received feedback, were much more comfortable after the study with their location being shared with friends and strangers. Those users reported being much less concerned about their privacy after the field deployment of Locyoution. Feeling more comfortable can lead to a larger amount of locations being shared. These findings are important for Location Sharing Applications to take into consideration.

IV. RESEARCH OUTLINE

A. Goals

The goal of the SoLoMIDEM research project is the development of a user-centric and multi-layered open SoLoMo platform. Social, local and mobile platforms are converging at high speed, leading to new business opportunities. Privacy concerns, the fear of being tracked by commercial enterprises and the possible commodification of personal data make many users rather reluctant to use SoLoMo services. Therefore, the aim of SoLoMIDEM is to build a user-centric platform. To create a trusted SoLoMo platform with targeted and context-rich communication, end-users must be given the possibility to manage their mobile identity and privacy. The development of a federated identity management system will give users the possibility to decide when, how and with whom to share the personal mobile identity. Cryptographic techniques will guarantee the desired level of location-privacy. A challenge here is finding the right balance between a desired level of privacy, while at the same time ensuring an optimal Quality of Experience (QoE). Users should have a high level of control, but the service providers also need to be able to use the technology in an efficient and beneficial way. SoLoMIDEM aims for an optimal exploitation of big data for all the stakeholders. The platform will have open APIs so third party application providers will be able to easily integrate their mobile services.

B. Methods

In general, most of the studies focusing on location privacy concerns and location-sharing practices can be divided into two groups [11]. In the first group LBS and privacy are studied by making use of scenarios. Respondents are asked what location information they would be comfortable sharing in different hypothetical situations and with who. This is often measured using survey instruments. In a second group of studies, participants are asked to use an existing LBS during a well-defined period of time. This can be a self-developed application (e.g. Locaccino in [29]) or an already commercialized application (e.g. Foursquare). The behavior of the respondents is monitored and studied, often in combination with additional surveys and interviews to get deeper understanding. Within the SoLoMIDEM project, before a tangible demonstrator is developed, we will apply a combination of quantitative and qualitative methods to get a deeper understanding of the meaning of location privacy and identity in relation to privacy awareness, attitudes, skills and practices of users. To make the platform as user-centric and open as possible, the data gathering will be done by way of a large-scale panel of mobile Internet users (>11,500 users) for constant feedback. An important element is the recurring online survey (every 6 months) with our panel to gather insights on a variety of relevant issues. Besides general topics such as smartphone usage, mobile surfing behavior and the usage of mobile applications, we will also inquire (location) privacy-related topics. Although a survey is a widely used and valuable instrument to study privacy concerns and practices, it also has its limitations. Surveys are less suitable in capturing actual privacy practices, since they rely on users' self-reported behavior. Many surveys also have a rather abstract view of privacy as a 'societally beneficial but abstract good' [34, p.49], which increases the risk of socially acceptable answers. The economics of privacy research field, for example, applies a more concrete view on the privacy concept studies in which circumstances people are willing to trade their privacy to receive direct benefits [34, 35]. The approach used to study the concept of privacy, might have an influence on consumer valuations of privacy. Therefore it is important to combine several research methods. In combination with our recurring survey, we will apply the Proxy Technology Assessment (PTA) technique to study the use of existing LBS in the everyday life of users. The goal of PTA is to reflect on the usage of the technology under development in a natural environment [36]. By means of existing technologies that show as much similarities as possible with the functionalities of the SoLoMo platform that will be developed (proxy

technologies), we will explore how users engage with location privacy. The PTA technique can provide valuable insights to improve the design of the technology. We will select two existing LBS to study users' privacy concerns and practices: a LBS with advanced privacy settings and one with very limited settings. Participants will be asked to use the two LBS during a well-defined period of time, during which they will have to execute specific tasks. As well users of LBS, as users not familiar with LBS will be questioned. Past research already found out it is important to study the use and the non-use of the technology [37]. Semi-structured interviews in the beginning and at the ending of the test periode, will deepen our understanding of the privacy experiences. Since the SoLoMIDEM platform will still be under development in the first phase of the project, this technique is very valuable in eliciting qualitative feedback on privacy concerns and practices, without already have a tangible demonstrator.

V. Conclusion

The converging of social, local and mobile services and platforms leads to an enormous amount of personal data that are being created, shared and collected every day. This leads to major new challenges for privacy and data protection, which requires a deeper understanding of the awareness, attitudes, capabilities and practices of users regarding location privacy. Nowadays, it is mostly only the service providers, mobile operators and other third parties that benefit from the exploitation of these 'big data'. There is too little transparency of these practices, leading to a lack of trust on consumer side and possible several missed opportunities. The mobile platform that will be created within the SoLoMIDEM project, aims at empowering the users by giving them more control over the disclosure of their personal data and identity. We introduce user-centric data mining. Instead of traditional data mining practices, where operators exploit personal data for their own commercial purposes, users will keep full control. It is the responsibility of the users to ask the system to perform data mining practices on their own personal data, in order to get certain recommendations. We believe this will lead to more transparent data collection practices, in which all the stakeholders will benefit.

References

[1] iMinds-iLab.o. (2012). *Digimeter Report 5 - Adoption and usage of Media & ICT in Flanders wave 5 (Aug - Sept 2012)*. Gent, iMinds.

[2] World Economic Forum. (2011). *Personal data: the emergence of a new asset class*. Cologny.

[3] De wolf Ralf, & Pierson, J. (2012). Privacy beyond the individual: analysing group based access control models on social network sites from a user perspective. Presented at the IAMCR, Durban.

[4] Benisch, M., Kelley, P. G., Sadeh, N., & Cranor, L. F. (2011). Capturing location-privacy preferences: Quantifying accuracy and user-burden tradeoffs. *Personal and Ubiquitous Computing*, *15*(7), 679–694.

[5] Brandimarte, L., Acquisti, A., & Loewenstein, G. (2012). Misplaced Confidences: Privacy and the Control Paradox. *Social Psychological and Personality Science*.

[6] Kelley, P. G., Benisch, M., Cranor, L. F., & Sadeh, N. (2011). When are users comfortable sharing locations with advertisers? *Proceedings of the 2011 annual conference on Human factors in computing systems* (pp. 2449–2452).

[7] Stutzman, F., Capra, R., & Thompson, J. (2011). Factors mediating disclosure in social network sites. *Computers in Human Behavior*, *27*(1), 590–598.

[8] Kölsch, T., Fritsch, L., Kohlweiss, M., & Kesdogan, D. (2005). Privacy for profitable location based services. *Security in Pervasive Computing*, 164–178.

[9] Xu, H., Gupta, S., & Shi, S. (2009). Balancing User Privacy Concerns in the Adoption of Location-Based Services: An Empirical Analysis across Pull-Based and Push-Based Applications. Presented at the iConference.

[10] Tang, K. P., Lin, J., Hong, J. I., Siewiorek, D. P., & Sadeh, N. (2010). Rethinking location sharing: exploring the implications of social-driven vs. purpose-driven location sharing. *Proceedings of the 12th ACM international conference on Ubiquitous computing* (pp. 85–94).

[11] Barkhuus, Louise. (2012). The mismeasurement of privacy: Using contextual integrity to reconsider privacy in HCI. *Proceedings of the ACM Annual Conference on Human Factors in Computing Systems* (pp. 367–376).

[12] Warren, S., & Brandeis, L. (1890). The right to privacy. *Harvard Law Review*, *4*(5), 193–220.

[13] Danezis, G., & Gürses, S. (2010). A critical review of 10 years of Privacy Technology. *Proceedings of Surveillance Cultures: A Global Surveillance Society*.

[14] Diaz, C., & Gürses, S. (2012). Understanding the landscape of privacy technologies. *Proceedings of the Information Security Summit*, 58–63.

[15] Ardagna, C. A., Cremonini, M., Damiani, E., De Capitani di Vimercati, S., & Samarati, P. (2008). Privacy-enhanced location services information. In A. Acquisti, S. Gritzalis, C. Lambrinoudakis, & S. De Capitani di Vimercati (Eds.), *Digital privacy. Theory, technologies, and practices.* (pp. 307–326). Boca Raton: Auerbach Publications (Taylor & Francis group).

[16] Altman, I. (1975). *The environment and social behavior.* Monterey, CA: Brooks/Cole.

[17] Petronio, S. (2002). *Boundaries of privacy: dialectics of disclosure.* Albany, NY: State University of New York Press.

[18] Goffman, E. (1959). *Presentation of self in everyday life.* London: Penguin books.

[19] Fayyad, U., Piatetsky-Shapiro, G., & Smyth, P. (1996). From data mining to knowledge discovery in databases. *AI magazine*, *17*(3), 37-54.

[20] Fox, Z. (2012, December 4). "Girls around me" app developer: Foursquare used as a scapegoat. *Mashable*. Retrieved February 15, 2013, from http://mashable.com/2012/04/02/girls-around-me-defense/

[21] Pariser, E. (2011). The Filter Bubble: What the Internet Is Hiding from You. New York: The Penguin Press.

[22] Xu, Heng, Gupta, S., Rosson, M. B., & Carroll, J. M. (2012). Measuring mobile users' concerns for information privacy. *Proceedings of 33rd Annual International Conference on Information Systems (ICIS)*. Orlando.

[23] Zhou, T. (2011). The impact of privacy concern on user adoption of location-based services. *Industrial Management & Data Systems*, *111*(2), 212–226.

[24] Smith, H. J., Milberg, S. J., & Burke, S. J. (1996). Information Privacy: Measuring Individuals' Concerns about Organizational Practices. *MIS Quarterly*, *20*(2), 167 – 196.

[25] Malhotra, N. K., Kim, S. S., & Agarwal, J. (2004). Internet Users' Information Privacy Concerns (IUIPC): The Construct, the Scale, and a Causal Model. *Information Systems Research*, *15*(4), 336–355.

[26] Barkhuus, L., & Dey, A. (2003). Location-based services for mobile telephony: a study of users' privacy concerns. *Proc. Interact* (Vol. 2003, pp. 709–712).

[27] Consolvo, S., Smith, I. E., Matthews, T., LaMarca, A., Tabert, J., & Powledge, P. (2005). Location disclosure to social relations: why, when, & what people want to share. *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 81–90).

[28] Lin, J., Xiang, G., Hong, J. I., & Sadeh, N. (2010). Modeling people's place naming preferences in location sharing. *Proceedings of the 12th ACM international conference on Ubiquitous computing* (pp. 75–84).

[29] Toch, E., Cranshaw, J., Drielsma, P. H., Tsai, J. Y., Kelley, P. G., Springfield, J., Cranor, L., Hong, J., & Sadeh, N. (2010). Empirical models of privacy in location sharing. *Proceedings of the 12th ACM international conference on Ubiquitous computing* (pp. 129–138).

[30] Xu, H. (2007). The effects of self-construal and perceived control on privacy concerns. *Proceedings of the 28th Annual International Conference on Information Systems (ICIS 2007)* (Vol. 20078).

[31] Tang, K., Hong, J., & Siewiorek, D. (2012). The implications of offering more disclosure choices for social location sharing. *Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems* (pp. 391–394).

[32] Jedrzejczyk, L., Price, B. A., Bandara, A. K., & Nuseibeh, B. (2010). On the impact of real-time feedback on users' behaviour in mobile location-sharing applications. *Proceedings of the Sixth Symposium on Usable Privacy and Security* (article 14).

[33] Tsai, J. Y., Kelley, P., Drielsma, P., Cranor, L. F., Hong, J., & Sadeh, N. (2009). Who's viewed you?: the impact of feedback in a mobile location-sharing application. *Proceedings of the 27th international conference on Human factors in computing systems* (pp. 2003–2012).

[34] Directorate-General for Internal Policies, European Parliament. (2011). Does it help or hinder? Promotion of Innovation on the Internet and Citizens' Right to Privacy. Brussels.

[35] Acquisti, A. (n.d.). The economics of privacy. Retrieved from http://www.heinz.cmu.edu/~acquisti/economics-privacy.htm

[36] Bleumers, L., Naessens, C., & Jacobs, A. (2010). How to approach a many splendored thing: Proxy Technology Assessment as a methodological praxis to study virtual experience. *Journal of Virtual Worlds Research*, *3*(1), 3–24.

[37] Page, X., Knijnenburg, B. P., & Kobsa, A. (2013). What a tangled web we weave: lying backfires in location-sharing social media. *Proceedings of the 2013 conference on Computer supported cooperative work* (pp. 273–284).

The 1st international conference on Internet Science, has been organized from April 10 to 11 in Brussels, under the aegis of the European Commission, by the EINS project, the FP7 European Network of Excellence in Internet Science (http://www.internet-science.eu), with the support of KVAB.

About the EINS Network of Excellence

What is the network of excellence? www.internet-science.eu/network-excellence-internet-science The Network of Excellence in Internet Science aims to strengthen scientific and technological excellence by developing an integrated and interdisciplinary scientific understanding of Internet networks and their co-evolution with society. Its main objective is to enable an open and productive dialogue between all disciplines which study Internet systems from any technological or humanistic perspective, and which in turn are being transformed by continuous advances in Internet functionality. The network brings together over 30 research institutions across Europe that are focusing on network engineering, computation, complexity, networking, security, mathematics, physics, sociology, game theory, economics, political sciences, humanities, and law, as well as other relevant social and life sciences.

The network's main deliverable will be a durable shaping and structuring of the way that this research is carried out, by gathering together a critical mass of resources, gathering the expertise needed to provide European leadership in this area, and by spreading excellence beyond the partnership. The network is funded by the EC 7th Framework Programme: ICTs, and is operational until 2015.

Project partners

CERTH
Consiglio Nazionale delle Ricerche
Alma Mater Studiorum Università di Bologna
U1O University of Oslo
institute imdea networks
iMinds Connect.Innovate.Create
Universität Passau
Technische Universität
University of Cambridge
Lancaster University
The University of Warwick
oiioiioii
TU Delft Delft University of Technology
US University of Sussex
Universidad Autonoma de Madrid
Université Savoie Chambery Annecy
EPFL
technicolor
Hellenic Republic National and Kapodistrian University of Athens
ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich
UPMC Paris Universitas
Alcatel·Lucent
University of Waterloo
NICTA
中国科学院 Chinese Academy of Sciences
KAIST
sigma orionis
Nexa Center for Internet & Society Politecnico di Torino
Univerza v Ljubljani
LSE The London School of Economics and Political Science
Universitet Stockholms
Koninklijke Nederlandse Akademie van Wetenschappen
University of Southampton