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The future internet - Future Internet Assembly 2011: Achievements and technological promises

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Abstract: Irrespective of whether we use economic or societal metrics, the Internet is one of the most important technical infrastructures in existence today. It will be a catalyst for much of our innovation and prosperity in the future. A competitive Europe will require Internet connectivity and services beyond the capabilities offered by current technologies. Future Internet research is therefore a must. This book is published in full compliance with the Open Access publishing initiative; it is based on the research carried out within the Future Internet Assembly (FIA). It contains a sample of representative results from the recent FIA meetings spanning a broad range of topics, all being of crucial importance for the future Internet. The book includes 32 contributions and has been structured into the following sections, each of which is preceded by a short introduction: Foundations: architectural issues; socio-economic issues; security and trust; and experiments and experimental design. Future Internet Areas: networks, services, and content; and applications.

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The Future Internet

Future Internet Assembly 2011:
Achievements and Technological Promises

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Foreword

The Internet will be a catalyst for much of our innovation and prosperity in the future. It has enormous potential to underpin the smart, sustainable and inclusive growth objectives of the EU2020 policy framework and is the linchpin of the Digital Agenda for Europe. A competitive Europe will require Internet connectivity and services beyond the capabilities offered by current technologies. Future Internet research is therefore a must.

Since the signing of the Bled declaration in 2008, European research projects are developing new technologies that can be used for the Internet of the Future. At the moment around 128 ongoing projects are being conducted in the field of networks, trustworthy ICT, Future Internet research and experimentation, services and cloud computing, networked media and Internet of things. In total they represent an investment in research of almost 870 million euro, of which the European Commission funds 570 million euro.

This large-scale research undertaking involves around 690 different organizations from all over Europe, with a well-balanced blend of 50% private industries (SMEs and big companies with equal share), and 50% academic partners or research institutes. It is worth noting that it is a well-coordinated initiative, as these projects meet twice a year during the Future Internet Assembly, where they discuss research issues covering several of the domains mentioned above, in order to get a multidisciplinary viewpoint on proposed solutions.

Apart from the Future Internet Assembly, the European Commission has also launched a Public Private Partnership program on the Future Internet. This 300-million-euro program is focused on short- to middle-term research and runs from 2011 to 2014. The core of this program will be a platform that implements and integrates new generic but fundamental capabilities of the Future Internet, such as interactions with the real world through sensor/actuator networks, network virtualization and cloud computing, enhanced privacy and security features and advanced multimedia capabilities. This core platform will be based on integration of already existing research results developed over the past few years, and will be tested on large-scale use cases. The use cases that are part of the Public Private Partnership all have the potential to optimize large-scale business processes, using the properties of the core Future Internet platform. Examples of these use cases are a smarter electricity grid, a more efficient international logistics chain, a more intelligent food value chain, smart mobility, safer and smarter cities and a smarter content creation system for professional and non-professional users.

Future Internet research is an important cornerstone for a competitive Europe. We believe that all these efforts will help European organizations to be in the driving seat of many developments of the Future Internet. This book, already the third in this series, presents some of the results of this endeavor. The uniqueness of this book lies in the breadth of the topics, all of them of crucial importance for the Future Internet.

We sincerely hope that reading it will provide you with a broader view on the Future Internet efforts and achievements in Europe!

Budapest, May 2011

Luis Rodríguez-Roselló
Mário Campolargo

Preface

1 The Internet Today

Whether we use economic or societal metrics, the Internet is one of the most important technical infrastructures in existence today. One easy measure of the Internet's impact and importance is the number of Internet users which as of June 2010 was 2 billion¹. But of course, this does not give one the full picture. From an economic viewpoint, in 2010 the revenue of Internet companies in the US alone was over \$70 billion². In Europe, IDC estimated that in 2009 the broader Internet revenues (taking business usage into account) amounted to €159 billion and that this is projected to grow to €229 billion by 2014³.

The recent political protests in Egypt give us an indication of the impact the Internet has in societal terms. At the start of the demonstrations in Egypt the Internet was closed down by the ruling government to hinder the activities of opposition groups. Later, as the protests were having an effect, a picture emerged in the world's media of a protester holding up a placard saying in Arabic "Thank You Facebook⁴." Protesters in Egypt used social media to support communication and the associated Facebook page had over 80,000 followers at its peak. It is interesting to note that here we are talking about the power of the Internet in a country where currently Internet penetration is 21%⁵ compared to say 79% for Germany⁶.

2 Current Issues

The Internet has recently been in the news with stories covering two main issues which are commonly known in the Internet research community. Firstly, recent stories have highlighted the issue of the lack of address space associated with IPV4, which can cater for 4 billion IP addresses⁷. Some headlines claim that the IPV4 address space has already run out⁸. Technically, the issue has been solved through IPV6 although there is still the matter of encouraging take up.

¹ <http://www.internetworldstats.com/stats.htm>

² <http://money.cnn.com/magazines/fortune/fortune500/2010/industries/225/index.html>

³ <http://www.fi3p.eu>

⁴ <http://www.mediaite.com/tv/picture-of-the-day-cairo-protester-holds-sign-that-says-thank-you-facebook/>

⁵ <http://www.internetworldstats.com/africa.htm#eg>

⁶ <http://www.internetworldstats.com/europa.htm#de>

⁷ <http://www.bbc.co.uk/news/10105978>

⁸ <http://www.ndtv.com/article/technology/internet-will-run-out-of-ip-addresses-by-friday-83244>

A second major news item has been on net neutrality, specifically, on legislation on net neutrality in the US and UK, which take differing views. At the time of writing the US House of Representatives voted to block a proposal from the Federal Communications Commission to partially enforce net neutrality⁹. In the UK at the end of 2010 the Culture Minister, Ed Vaizey, backed a proposal to allow ISPs to manage traffic, which advocates of net neutrality argued would lead to a “two-speed Internet”¹⁰. Vint Cerf, Sir Tim Berners-Lee and Steve Wozniak (one of the founders of Apple) have argued in favor of retaining net neutrality¹¹.

These two problems have gained prominence in the world’s media since they are most directly linked to the political and regulatory spheres. Other issues are centered on the fact that the Internet was originally designed in a very different context and for different purposes than it is used today. Of the changes that have occurred in the decades since the Internet’s inception, the main alterations which are of concern are:

- **Volume and nature of data** – the sheer volume of Internet traffic and the change from simple text characters to audio and video and also the demand for very immediate responses. For example, Cisco’s latest forecast predicts that global data traffic on the Internet will exceed 767 Exabytes by 2014. Online video and high-definition TV services are expected to dominate this growth. Cisco state that the average monthly traffic in 2014 will be equivalent to 32 million people continuously streaming the 2009 Avatar film in 3D¹².
- **Mobile devices** – the Internet can now be accessed from a wide variety of mobile devices including smart phones, Internet radios, and vehicle navigation systems, which is a radically different environment from the initial Internet based on physical links. Data traffic for mobile broadband will double every year until 2014, increasing 39 times between 2009 and 2014¹³.
- **Physical objects on the net** – small devices enable the emergence of the “Internet of Things” where practically any physical object can now be on the net sending location and local context data when requested.
- **Commercial services** – as mentioned above the Internet is now a conduit for a wide variety of commercial services. These business services rely on platforms which can support a wide variety of business transactions and business processes.
- **Societal expectations** – in moving from an obscure technology to a fundamental part of human communication, societal expectations have grown. The general population demand that the Internet is at least: secure, trustworthy, ubiquitous, robust, responsive and also upholds privacy.

⁹ <http://online.wsj.com/article/BT-CO-20110217-718244.html>

¹⁰ <http://www.bbc.co.uk/news/uk-politics-11773574>

¹¹ See <http://googleblog.blogspot.com/2005/11/vint-cerf-speaks-out-on-net-neutrality.html>,
<http://www.scientificamerican.com/article.cfm?id=long-live-the-web>,
<http://www.theatlantic.com/technology/archive/2010/12/steve-wozniak-to-the-fcc-keep-the-internet-free/68294/>

¹² <http://www.ispreview.co.uk/story/2010/06/10/cisco-forecasts-quadruple-jump-in-global-internet-traffic-by-2014.html>

¹³ <http://www.ispreview.co.uk/story/2010/06/10/cisco-forecasts-quadruple-jump-in-global-internet-traffic-by-2014.html>

3 FIA Overview

This book is based on the research that is carried out within the Future Internet Assembly (FIA). FIA is part of the European response to the problems outlined above. In short, FIAs bring together over 150 research projects that are part of the FP7 Challenge 1 ICT Programme to strengthen Europe's Future Internet research activities and also to maintain the EU's global competitiveness in the space. The projects are situated within established units which cover the following areas:

- The network of the future
- Cloud computing, Internet of services and advanced software engineering
- Internet-connected objects
- Trustworthy ICT
- Networked media and search systems
- Socio-economic considerations for the Future Internet
- Application domains for the Future Internet
- Future Internet research and experimentation (FIRE)

Researchers and practitioners associated with the Future Internet gather at the FIAs every six months for a dialogue and interaction on topics which cross the above areas. In conjunction with the meetings the FIA Working Groups sustain activity throughout the year working toward a common vision for the Future Internet based on scenarios and roadmaps. Since the opening FIA in the spring of 2008, we have now held FIAs in the following cities: Bled, Madrid, Prague, Stockholm, Valencia and Ghent, with the next meetings scheduled for Budapest and Poznan. An overview of FIAs and the FIA working groups can be found at the EU Future Internet portal: <http://www.future-internet.eu/>.

4 Book Overview

This book, the third in the series, contains a sample of the results from the recent FIAs. Our goal throughout the series has been to support the dissemination of results to all researchers as widely as possible. Therefore, as with the previous two books, the content is freely available online as well as in print form¹⁴.

The selection process for the chapters in this text was as follows. In the middle of 2010 a call was issued for abstracts of up to 2 pages covering a relevant Future Internet topic. Accompanying this was a description of the authors indicating their experience and expertise related to FIA and Challenge 1 projects. Of the 67 abstracts submitted a subset were selected after each was reviewed by at least two editors, and the authors were then asked to produce a full chapter. A second reviewing process on the

¹⁴ The previous two FIA books can be found online at <http://www.booksonline.iospress.nl/Content/View.aspx?piid=12006> and <http://www.booksonline.iospress.nl/Content/View.aspx?piid=16465>.

full papers, where each chapter was subjected to at least two reviews, resulted in a final set of 32 chapters being selected.

The book is structured into the following sections each of which is preceded by a short introduction.

- Foundations
 - Architectural Issues
 - Socio-economic Issues
 - Security and Trust
 - Experiments and Experimental Design
- Future Internet Areas
 - Networks
 - Services
 - Content
- Applications

FIA Budapest will be the seventh FIA since the kickoff in Bled and in that time a community has emerged which continues to collaborate across specific topic areas with the common goal of investigating the issues related to the creation of a new global communications platform within a European context. This text holds a sample of the latest results of these endeavors. We hope that you find the contents valuable.

Budapest, May 2011

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Alex Galis
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Theodore Zahariadis
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