

# **FUTURE INTERNET ASSEMBLY 2009**

**Stockholm, Sweden, 23<sup>rd</sup> – 24<sup>th</sup> November 2009**

## **CONFERENCE REPORT**

**DG Information Society and Media - Directorate for Converged Networks and Services**

*"The Internet People"*



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## Glossary

EFII	European Future Internet Initiative
EIT	European Institute of Innovation & Technology
FCN	Future Content Networks (an FIA Working Group)
FIA	Future Internet Assembly
FIRE	Future Internet Research & Experimentation
FISE	Future Internet Socio-Economics (an FIA Working Group)
FISO	Future Internet Service Offer (an FIA Working Group)
KIC	Knowledge & Innovation Community
MANA	Management & Service-aware Networking Architecture (an FIA Working Group)
PPP	public-private partnership
RWI	Real-World Internet (an FIA Working Group)
T&I	Trust and Identity (an FIA Working Group)

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Conference website: [www.fi-stockholm.eu](http://www.fi-stockholm.eu)

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## Executive Summary

The Future Internet Assembly (FIA), held in Stockholm from 23<sup>rd</sup> – 24<sup>th</sup> November 2009, brought together around 400 participants from Europe's Future Internet (FI) community to discuss progress on Future Internet research and to advance the technical debate. This was the fourth FIA, continuing a process begun in Bled, Slovenia in March 2008.

### European Policy for the Future Internet

The Assembly heard that Europe's policy agenda for the Future Internet is moving rapidly. It welcomed, as a very major development, the Commission's Communication on a public-private partnership (PPP) for the Future Internet adopted on 28<sup>th</sup> October 2009. The Communication sets a framework for the creation of a PPP in Europe, providing a holistic perspective on how to leverage the internet infrastructure as an open, secure and trusted platform. Priorities identified include:

- Improving linkages between FI technologies and applications;
- Supporting new business models and making the operation of infrastructures and applications (including those of societal interest) more efficient;
- Fostering cross-sector industry partnerships;
- Maximising societal benefit through stakeholder involvement;
- Addressing relevant regulatory and policy issues.

The Communication provides a roadmap of milestones towards the first projects, starting with the launch of the Future Internet PPP in April 2010. Overall, the Commission has committed to funding of €300M for PPP activities over the period to 2013, with initial contributions under the ICT Work Programme for 2011-12.

The Assembly heard that for Europe to be a knowledge-based society and economy it must have a high-speed internet open to all – people, businesses, schools – while also emphasising green and sustainability aspects. Thus, 'PPP' should stand not only for public-private partnership, but also for 'People, Planet and Profit'. Ensuring Europe delivers on these goals has been a priority of the Swedish Presidency, culminating in the Visby Conference and Declaration in November 2009.

European industry is actively supporting these efforts and has formed the European Future Internet Initiative (EFII) to focus industry's inputs to the planning for a Future Internet PPP. EFII believes it is important that the PPP has the support and involvement of a wide range of industry sectors – not just ICT. Europe can lead by example in proving the scalability and viability of new approaches, for example through large-scale trials and demonstrations.

### Towards a Future Internet Infrastructure

Technical discussions proceeded in a series of Parallel Sessions and Working Groups (WGs). For the first time the Assembly included sessions organised on a thematic basis, as well as around the seven Working Groups.

The discussions stressed that the internet is not centric in any particular respect, and indeed is increasingly 'polymorphic'. As such it has to accommodate an increasingly wide and diverse range of systems: communication-centric systems, information-centric systems, context-centric systems, resource-centric systems, content-centric systems, service/computation-centric systems, device-centric systems, object-centric systems, things-centric systems and management-centric systems. A lot of capabilities and interrelated features are missing, leading to critical ossification of the internet infrastructure.

The sessions discussed the implications of this key technical observation. Their findings are summarised in the session reports, longer versions of which are available online together with background papers and presentations<sup>1</sup>. In brief, for the WGs:

- **Future Content Networks (FCN):** Work is focusing on the most important areas of evolution in both networks (towards content-centric networking) and media (towards enhanced media experiences). At the architectural level ideas are maturing and converging, leading to a federated approach between FCN and other groups, also taking account of socioeconomic considerations.
- **Future Internet Service Offer (FISO):** Services affect many aspects of the Future Internet. With the community now emphasising the polymorphic nature of the Future Internet infrastructure, FISO has adopted a new 'mission statement' reflecting the contribution of service-based interfaces to the integration, interrelationships and interworking of the architectural elements in a polymorphic internet.
- **Future Internet Socio-Economics (FISE):** Socio-economic aspects underlie many areas of Future Internet development. To focus its discussions, FISE has developed a framework categorising technology, economics, social sciences and policies and the interactions between them. As areas for future work participants emphasised in particular: incentives for the digital economy; Europe's response to globalisation; and the need for more sophisticated approaches in user modelling and technical design.
- **Management & Service-aware Networking Architecture:** Discussion within the MANA track emphasised that the Future Internet will be based on cooperating polymorphic infrastructures, where the boundaries between separate/silo systems would change in time and where the glue is represented by the orchestration of vertical and horizontal architectural elements and systems. The MANA community will develop these ideas in a second MANA position paper, "FI Research Road Map", in time for the next FIA in Valencia.
- **Real-World Internet:** The Real-World Internet, or 'Internet of Things', will impact on the Future Internet in a variety of ways and has particular implications at the application level (e.g. new solutions for Smart Cities, enterprises, etc). Building on the work at FIA Stockholm, the RWI WG will initiate a series of white papers focusing on: i) an RWI Reference Model - outlining the development of a common terminology and synthesizing an architecture from results of RWI projects; and ii) defining an RWI problem space and identifying potential solutions based on existing work.
- **Trust and Identity:** T&I is another 'horizontal' issue underlying much of the work of the other WGs. Discussions within this track at FIA Stockholm highlighted three main issues: i) need for continued work on e-identity provisioning, focusing on privacy and ID provisioning across the layers, and looking at the short, medium and long term issues; ii) security for the

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<sup>1</sup> See Conference website: [www.fi-stockholm.eu](http://www.fi-stockholm.eu) and European Future Internet Portal: [www.future-internet.eu](http://www.future-internet.eu)

Future Internet (at a cross-domain level) so as to identify what new threats might emerge and how to counteract them; and iii) the user perspective - how to engender trust for FI systems and services.

- **Usage of Facilities:** Research experimentation and testing will be a crucial element in the development of FI service platforms, services and applications. Discussions at FIA Stockholm focused on explorations of what it means to conduct experimentally-driven research and how to engage directly with users in deploying on FIRE<sup>2</sup> facilities. The community will collaborate in drafting a series of papers dealing with: i) the fundamentals of the methodology and its benefits; and ii) necessary specifications to satisfy deployment requirements on FIRE facilities.

Significant progress was made in all areas, and in particular areas of convergence and overlap between Working Groups have begun to be identified and addressed through inter-WG working. Based on these inputs, the Working Groups are now preparing another round of position papers setting out the communities' thinking.

## Beyond Technology

Among the other activities in the programme at FIA Stockholm:

- In a keynote presentation, Prof. George Stamoulis of the Athens University of Economics and Business, highlighted the importance of **economic incentives** in making the Future Internet a reality. Economic theory asserts that incentive constraints should be considered alongside resource constraints in the formulation of economic problems. Applying such theories to the Future Internet could lead to new traffic management approaches that better meet players' interests, while respecting network neutrality and improving overall performance.
- In a second keynote, Dr. Peter Ljungstrand of the Chalmers University of Technology, contrasted the technology-centric perspective by **alternative perspectives from end-users**. The Future Internet research is ambitious and challenging, and carries high expectations. Realising these ambitions will require inputs from a broad range of disciplines, much wider than at present, including end-user perspectives. To tackle these important challenges, we need truly multi-disciplinary integrative approaches in both research and policy.
- The **Enterprise** session facilitated a first discussion on the implications of the Future Internet for enterprises. Discussions focused on three areas – visions and policy, socio-economics, and technology – and elicited a wide range of issues and opinions. Particular emphasis is required in relation to business models and incentives. Participants agreed to continue consultations beyond the conference, with a view to preparing a position paper on the enterprise topic.
- The **Smart Cities** session concluded that city-based environments would provide an excellent proving ground for the PPP, as they naturally bring together a variety of critical application domains, such as energy, healthcare, transport, and governance. Therefore a Smart City based infrastructure will provide an ideal open platform for the development, experimentation and testing of common FI service enablers required to enable 'smartness' in a variety of application domains.

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<sup>2</sup> Future Internet Research & Experimentation

This Smart Cities session represented the first direct involvement of a user community in FIA activities. Its success highlighted the need to engage with other communities, such as health, energy and transport, in bringing Europe's Future Internet vision to reality.

Finally, in a keynote address to the Closing Plenary, Håkan Eriksson, Ericsson Senior Vice-President and CTO, emphasised that research alone is not enough. Internet traffic is increasing at exponential rates (especially for mobile broadband). A significant funding gap is opening up and it is not clear how this will be filled. For Europe to succeed in the Future Internet somebody has to be prepared to pay for the technology that is developed. This requires a greater willingness by governments and companies to invest in infrastructure and by users to pay for the benefits they receive through added value services.

### **FIA Valencia**

The next FIA will be held in Valencia, Spain, in April 2010. This promises to be a major event which, as well as progressing the technical discussions, is expected to see the launch of the Future Internet PPP. It will be part of a special week of meetings and events focusing on the EU Research Programmes' contributions to European industry sectors.

## Opening Session

### Welcome Message: Prof. Gunnar Landgren, Vice Rector of KTH

*FIA Stockholm was hosted by KTH at Kista Science City, a world-class resource in information technology*

Professor Landgren welcomed Assembly delegates to Stockholm and to KTH, the Royal Institute of Technology, one of the largest technical universities in Europe. KTH was founded in 1827, Prof. Landgren explained, and today accounts for one-third of Sweden's technical research and engineering education capacity at university level. It has over 12,000 undergraduate students, more than 1,400 postgraduates and 2,800 full-time equivalent employees.

KTH was instrumental in bringing the internet to Sweden and therefore it is no surprise that one-third of its activities are in ICT and internet. In Kista, KTH collaborates with Stockholm University, various research institutes and industry within the framework of the IT University – Sweden's largest resource in information technology.

***“Kista is a prime example of the Triple Helix – industry, academia and the public sector in harmony”***

KTH was very proud to be hosting the Future Internet Assembly conference and the ServiceWave event that would follow it, and Prof. Landgren thanked the European Commission for the opportunity to do so. The Electrum Building, where the event was being held, was 25 years old and the result of a long-standing collaboration between Stockholm city and region, academic institutes, research centres and enterprises to establish the Kista Science City with strong industrial involvement. It predates the 'Triple Helix' model of innovation but illustrates that concept very well – industry, academia and the public sector working in harmony. A new phase of development is now underway that will double the size of Kista, bringing new homes, research centres and workplaces.

Prof. Landgren also expressed his thanks to the Swedish Presidency for its support and recognition of the event, and to the entire Future Internet community for their help in the organisation. The one thing they could not avoid was the rather gloomy November weather – for which Prof. Landgren apologised! He wished the meeting every success.

### Welcome Message: Leif Zetterberg, State Secretary to the Minister for Communications, Sweden

*For the EU to be knowledge based it must have a high-speed internet open to all. To this end, the Swedish Presidency has helped lead the debate on a post-i2010 policy for Europe.*

Mr Zetterberg thanked the organisers for the invitation. Having been at the previous Assembly meeting in Prague, it was a pleasure to welcome Europe's Future Internet community to Stockholm.

Since Prague, the significance of the internet for Europe's information society had become even more deeply embedded, Mr Zetterberg maintained. The conference audience knew this all too well but we should do more to communicate that effectively. The Swedish Presidency's priority in this area has been in leading discussions on a post-i2010 policy for Europe. A policy paper had been issued in September 2009, followed by a major conference in early November in Visby. The

conference conclusions – presented as the ‘Visby Declaration’ – placed a high emphasis on the Green Knowledge Society. These debates will lead to a new ICT policy for Europe in early 2010.

The key message, which is supported by other studies, is that for the EU to be knowledge based it must have a high-speed internet open to all – people, businesses, schools – while also emphasising green aspects. ‘PPP’ should stand not only for public-private partnership, but also People, Planet and Profit: it is essential that Europe delivers on all of these.

***“PPP should stand, first and foremost, for ‘People, Planet and Profit’.”***

The European Commission has shown strong support for internet-related initiatives and will continue to do so in the future. The private sector should also play its part, most urgently by improvements in broadband. Meanwhile, public authorities can play a role through public procurement, regulation and harmonisation.

Mr Zetterberg expressed his best wishes for the conference and thanked the audience for their attention.

## European Perspectives on the Future Internet

*Mário Campolargo, Director, Emerging Technologies and Infrastructures, European Commission*

*The Future Internet will be a key enabler for innovation, underpinning EU policies at many levels, and will be a key element in the new Digital Agenda. The recent Communication set a clear framework for the creation of a public-private partnership on the Future Internet that will help focus Europe’s efforts and maximise the benefits.*

Mr Campolargo thanked Prof. Landgren and Minister Zetterberg for their warm welcome to Sweden.

Referring to the evolving policy context, we were witnessing, he explained, a new chapter for Europe. The incoming European Commission has put the digital agenda at the core of Europe’s policy framework for the next five years, with the green economy as an important element. The Future Internet will be a key enabler for innovation, underpinning EU policies<sup>3</sup> at many levels. Turning to the broader EU R&D landscape, the recent communication on ICT R&D<sup>3</sup> has emphasised the need for Europe to bring demand and supply closer together; to shorten the time to market and innovation lifecycles; and to put ICT at the service of citizens. Similar messages are echoed in other policy discussions.

The Communication<sup>4</sup> on a public-private partnership (PPP) for the Future Internet – adopted on 28<sup>th</sup> Oct 2009 - represented a very important development. It sets a framework for the creation of a PPP on the Future Internet in Europe, providing a holistic perspective on how to leverage the internet infrastructure as an open, secure and trusted platform. Priorities identified in the Communication include: improving linkages between technologies and applications; supporting new business models and making the operation of infrastructures and applications (including those of social interest) more efficient; and fostering cross-sector industry partnerships. Important regulatory and policy issues will also need to be addressed. And to maximise societal benefit it will be essential to involve end-users, civil society and consumer organisations at local, regional and national levels. A PPP will

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<sup>3</sup> “A Strategy for ICT R&D and Innovation in Europe: Raising the Game”, COM(2009) 116 final

<sup>4</sup> “A Public-Private Partnership on the Future Internet”, COM(2009) 479 final

provide a strong focus for a smarter world: smarter energy, smarter health, smarter transport, smarter cities, and smarter living.

The milestones to the creation of such a PPP are fairly well defined. The Communication has committed to funding of €300M over the period to 2013, with initial contributions under the ICT Work Programme for 2011-12. At the next Assembly meeting in Valencia (April 2010) an announcement is expected regarding the launch of a PPP, alongside Council Conclusions on Europe's Future Internet policy. The first call for proposals under the PPP is expected in July 2010 and will be subject to specific evaluation criteria. Initial projects are expected to begin in early 2011. A further FIA meeting would be held in Gent, Belgium in late 2010.

***“Milestones for the creation of a PPP on the Future Internet are now well defined.”***

The Future Internet Assembly was a growing family, Mr Campolargo observed, with nearly 100 projects now participating – twice the number at the time of the launch of the FIA 18 months ago in Bled. Coordination had improved significantly during this time, primarily through the efforts of the Working Groups which have provided a focus for common research agendas. Member States are an increasingly important part of this picture. The Future Internet Forum – which brings together Member States' representatives with relevant interests – met for the first time in Prague and would hold its second meeting during FIA Stockholm.

In conclusion, Europe was making good progress in its Future Internet efforts. The ICT Call 5, which had recently closed, would result in a new wave of FI projects, adding a further €250-300 million of new funding to Future Internet activities. Planning for a PPP was well advanced and would further improve coordination by identifying strategies, aligning projects' roadmaps, and identifying new avenues for research. As matters become more mature, it is clear that issues such as standards, regulations and governance also require more attention. With proper articulation, the proposed PPP would surely be about People, Planet and Profit, as Minister Zetterberg had foreseen.

## **Industry Preparations for a Future Internet PPP**

*David Kennedy on behalf of the European Future Internet Initiative*

*From an industry perspective, it is essential that Europe's efforts in relation to the Future Internet are both cross-sector and sustainable. A core platform based on existing infrastructures will be preferable to building new infrastructures. Europe can lead by example here in proving scalability and viability, for example through large-scale testbeds and demos.*

Mr Kennedy provided an update on the European Future Internet Initiative (EFII), an industry-led grouping involved in the planning for a Future Internet PPP. “Industry's vision”, Mr Kennedy explained, “was to get everyone working in the same direction in a reasonable timescale”, which meant bringing solutions to market relatively quickly.

From an industry perspective, it was essential that activities were both cross-sector and sustainable. Stand-alone solutions developed in any one sector would not provide the efficiency and productivity gains that a networked solution would be able to provide and that the market could support. Similarly, a multidisciplinary and integrated approach, where massively distributed services and applications are run over large-scale and secure internet infrastructures, is the only means to deal with the increasing complexity of intertwined application and service demands.

Building new infrastructure would be very costly and take a long time. Instead we need to look at what is available and build on that. We have to determine the common enablers in each area and work out how to provide a core platform that supports them. Then we need to build the platform and use it in large-scale trials and tests, using existing advanced infrastructures to test Future Internet functionality.

Thus, the structure foreseen is based on a series of large-scale testbeds on which applications are built. This will require inter-related projects, which is likely to be very complicated in terms of administration and intellectual property. The Commission has looked at a wide range of implementation options, including the legal structure known as a 'joint technology initiative' (JTI). A series of dedicated calls is now seen as the best option in the short term, possibly with revisions under the next Framework Programme (FP8).

***"The Future Internet is a hard target to follow,  
so we need flexibility at every stage"***

"To make this happen we need many brave steps", Mr Kennedy noted. Integration will not happen in many small projects, so we have to be prepared to cede territory within large-scale projects and see our efforts as contributing to a programme. The Future Internet is a hard target to follow, so we need to show flexibility at every stage. A systematic approach to project selection is required, ensuring that those chosen contribute to the programme overall and address unique aspects, rather than being just the best proposal. IPR issues should not hinder collaboration, so we need to find ways to facilitate open sharing of projects' foreground results.

The PPP aims to enhance all sectors with the Future Internet: we must find ways to integrate sector competence with the ICT competence. Europe can lead by example here in proving scalability and viability, for example through large-scale trials and demos. Finally, time and scale dictate using what we have already achieved in Europe. This requires that we exploit synergies by building on existing results and resources. The European Future Internet Initiative will be developing these ideas further in a series of position papers and workshops in 2010.<sup>5</sup>

"The time for Europe to act is now", Mr Kennedy implored. We need to try something different and Europe can lead through an integrated approach. With strong partnership between the public and private sectors, we can support tomorrow's services and accelerate take-up through demonstration.

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<sup>5</sup> [www.future-internet.eu](http://www.future-internet.eu)

## Socio-economic Views on the Future Internet

*Chair: Burkhard Stiller, University of Zürich*

Dr Stiller introduced the Session looking at socio-economic issues. The Future Internet is a complicated landscape, Dr Stiller observed, with a very wide range of stakeholders. These include business and service providers, researchers and funding bodies, citizens and end-users, and policy-makers and regulators. Bringing all these viewpoints together is a huge challenge, requiring input from technology, economics, social sciences, policies and interactions between them.

The keynote presentations explored these issues and the discussions were taken further in the parallel session organised by the Future Internet Socio-economics (FISE) Working Group on Day 2 of the conference.

### Keynote: Serving the Incentives of Users and Providers

*George D. Stamoulis, Athens University of Economics and Business*

*Economic theory asserts that incentive constraints should be considered alongside resource constraints in the formulation of economic problems. Applying such theories to the Future Internet could lead to new traffic management approaches that better meet players' interests, while respecting network neutrality and improving overall performance.*

The internet ecosystem involves many players acting simultaneously, Prof. Stamoulis explained. For example, a simple transaction such as booking a hotel or an airline flight may require an internet service provider, an overlay application provider (a broker or aggregator), content providers (the hotel or airline) and, of course, the customer or end-user. We are aiming for an all-win situation, where traffic is optimised for all players.

In practice, the present – and probably the future – internet is characterised by tussles. There are self-interested players with conflicting interests who substitute or offer complementary functionalities. Tussles lead the system to equilibrium operating points but these are not necessarily global optima.

Conventional traffic management aims at achieving a global optimum for a single criterion by a central entity with full information. Tussles mean such an approach can no longer be relied on. Traffic management in the Future Internet should take into account the interests of individual players and the distribution of information among them. This new approach is known as Economic Traffic Management (ETM).

***“Tussles mean conventional traffic management approaches can no longer be relied on”***

Recent thinking in economics asserts that **incentive constraints should be considered coequally with resource constraints in the formulation of economic problems**. This axiom derives from the work of R.Myerson and E.Maskin who shared the Nobel Prize in Economics in 2007 for their work on what has become known as Mechanism Design Theory.

Translating this to the transaction example described above means, firstly, that the overlays should be built independently of physical topology, and secondly that the underlay network need not be aware of overlay requirements.

ETM mechanisms are based on economic incentives such as providers' revenue/cost and performance, and promote compatibility for all players. They can influence overlay traffic patterns by users' individually optimal choices and stimulate information sharing among players. The mechanisms are highly scalable and take advantage of the distributed nature of overlays. ISPs shape users' behaviour by providing users with extra underlay information and offering extra resources in the overlay to "help" local users.

Summarising, Prof. Stamoulis explained ETM mechanisms could lead to triple-win, although no ETM approach can fit all cases/applications. In addition, ETM should not affect adversely other applications and is compatible with the principle of network neutrality. It should help to improve overall performance and would be applicable under flat-rate pricing and for multiple applications.

Further information on the approaches described are available via the SmoothIT project<sup>6</sup>.

## Keynote: Future Internet and Multidisciplinary Research

*Peter Ljungstrand, Chalmers University of Technology, Sweden*

*Future Internet research is ambitious and challenging, and carries high expectations. Realising these ambitions will require inputs from a broad range of disciplines, much wider than at present, including end-user perspectives. We need truly multi-disciplinary integrative approaches to tackle these important challenges.*

Dr Ljungstrand's presentation contrasted the technology-centric perspective by alternative perspectives from end-users.

The Future Internet is based on bold ambitions, Dr Ljungstrand stated, namely that the internet will be fundamental to tomorrow's economy and society and must be supported by multidisciplinary approaches in both research and policy. These ideas are reflected in numerous documents and policy statements, such as the Bled Declaration. For instance, in its recent report on "a New Renaissance", the European Research Area Board noted<sup>7</sup>:

*"Research in the social sciences and the humanities will be at least as important to our future as the physical or engineering sciences. ...A new, holistic way of thinking is required as technological answers alone are not the end-solution to a given problem."*

Are we living up to these expectations regarding multidisciplinary?, Dr Ljungstrand asked.

At present, the technical research is at the core, since it is enabling everything else. This should not change: indeed, even more funding is needed for "FI basic research" given the ambitions set. However, this technical research needs to be complemented by a thorough understanding – drawn from other disciplines - of basic human, organisational and societal behaviour. Socio-economics is being partly addressed, but the focus is on business and society needs rather than on "real people".

***"Are we living up to our own expectations regarding multidisciplinary?"***

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<sup>6</sup> See [www.smoothit.org](http://www.smoothit.org)

<sup>7</sup> "Preparing Europe for a New Renaissance: A Strategic View of the European Research Area", First Report of the European Research Advisory Board, 2009

Many technical innovations have had a much wider adoption than anticipated by their inventors: the telephone, email, SMS, to name just a few. Others (such as mobile video telephony, MMS) have done less well than their inventors expected. "Could things have been different if social science had been applied?", Dr Ljungstrand wondered.

One area where social sciences could contribute is identity and authentication. In social science, identity is a very complex concept, with strong underpinnings in sociology and social psychology. Technical approaches are much more simplistic, often equating identity with the authentication of an individual; similarly in legal approaches. Yet, even the most cursory look at the online world shows that the approach to identity is unsatisfactory. For example, many online services equate a user's email address with their (single) identity, which is used as a login name. As a workaround solution, many people adopt several email addresses associated with different roles. Would we accept such a situation with physical postal addresses? In other areas, such as healthcare, an alternative situation pertains: people share login accounts and passwords which are supposed to be private. Clearly, Dr Ljungstrand concluded, there is a mismatch between people's real world behaviour and concepts and systems for identification/authentication as used online.

At present, much of the social science research in this area focuses on how people use the internet and other mediated communications technologies. Relatively little of this is future- or design-oriented, and overall social sciences are not well represented in the FIA community at present. In the United States, an NSF Panel has recently recommended security as a core focus for Future Internet activities, as well as looking at user behaviour and incentives for all stakeholders. Europe should follow this approach.

Summing up, Dr Ljungstrand noted that there is a discrepancy between the bold statements in research programmes and political visions and the actual research carried out. There is also a mismatch between some of the concepts and models that underpin current and future technical infrastructure and the everyday reality of ordinary people. Research on Future Internet is vital, and technology research is at the core. The ambitions and expectations are high and broad but appear insufficient to live up to the expectations being placed on them. We need truly multi-disciplinary, integrative approaches to tackle these important challenges.

## **Discussion**

Addressing Mr Kennedy, one delegate expressed concern about the timeframe. The actions proposed would not bear on the market for many years, could something not be achieved more quickly? Mr Kennedy replied that it was the Commission's programme and he could not comment on how public money was spent. The EFII was trying to identify areas it could work on and progress in a relatively short time. Mr Campolargo added that innovation would be a core feature of the proposed PPP. Large-scale trials were not about the market but they would offer proof that a market is viable, which is the best that could be achieved under a public research programme.

Another participant asked Mr Kennedy how industry could work together to get around the IPR problems: what are the real obstacles? Mr Kennedy reiterated that under current approaches such issues would require discussions with each consortium and partner. Under the PPP three instruments would be available: the call text (where inter-working and sharing could be made an obligatory requirement); the project contract (ditto); and possibly a large-scale consortium agreement (i.e. one spanning multiple consortia). All three could be used to shape the IP regime. "Companies will invest for profit", Mr Kennedy observed, "so the key point is it has to lead somewhere. If you can predict it, it's not the Future Internet".

Reflecting on Prof. Stamoulis's presentation, a delegate commented that most applications bring new elements in the economics that were not understood sufficiently to make them work. In the environment, for example, where is the benefit for each individual? Economic and business models do not match the ambition of the technological solutions. Prof. Stamoulis agreed that business models were important and further work is required on this. There may be cases where current models are not enough, while with others existing approaches may be sustainable.

One delegate commented that the speakers appeared to be offering conflicting messages. Some were saying "slice and dice" whereas others were calling for totally new approaches. Dr Ljungstrand agreed that the way forward was unclear. He was just pointing out that current approaches might not get us where we want to go and we had to be prepared to be flexible.

Jacques Bus, of the European Commission, agreed that trust and security issues was an important focus for future work and one where the social sciences could make a major contribution. The FIDIS Network of Excellence had recently finished its work in this area and had produced a book on its findings, including legal issues<sup>8</sup>. The Commission was supporting many similar efforts and much of this work tries to take account of social factors. "We can't engineer the social world, but we can take account of such factors in our technology programmes", Mr Bus observed.

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<sup>8</sup> *The Future of Identity in the Information Society: Challenges and Opportunities*, K.Rannenber, D.Royer, A.Deuker (Eds.), ISBN: 978-3-540-88480-4. [www.springer.com](http://www.springer.com)

## Parallel Sessions

### Session I.1. Different Architectures for Different Business Models?

*Session Report by: Henrik Abramowicz, Ericsson*

#### Scope and Objectives

The session aimed to get an initial understanding of:

- Requirements of the future network architectures (auto-configuration, dynamic self-adapting, etc.);
- Agreement and initial description of the system interfaces and architectures enabling integration of polymorphic faces of the Internet;
- Initial description of the milestones and roadmap of research results.

The agenda comprised a series of presentations and discussion, although the discussion element had to be cut short due to lack of time.

#### Presentations and Discussion

In the introduction **Henrik Abramowicz** (Ericsson,4WARD, MANA) gave an overview of the problem statement relating to this topic. Today we are seeing the merger of business segments with different architectures and business models. In addition, consumers and producers are taking on different roles dependent on the situation, so-called 'prosumers' for networking, services and content. Vertically-oriented business models are becoming more horizontal and operators are moving up the value chain. This begs the question: who will invest in infrastructure and how should it be paid for? On the one hand, facilitating usage of the Net and on the other hand the cost for handling huge data volumes. Should there be revenue sharing between actors? Openness of the current Internet vs. privacy and accountability is also an important issue.

Issues that need to be addressed here include:

- Can a single scalable architecture support the different applications and business models to emerge?
- Organisational & federated domains vs the end-to-end principle
- Diverse user/consumer-facing functionality
- Polymorphic facets of the Internet
- Distributed architectures and resources
- How to manage change: migration; evolvability; programmability.

**Alex Galis** (UCL), representing MANA, outlined why the Internet needed to change – in terms of the tremendous growth in traffic and nodes - and continued with an overview of the MANA position paper. Salient points were:

- Hourglass model/layering works well in creating a data plane but without the management mechanisms for different prosumers to influence or control what is inside the networks and how to deploy services. It has faded away and needs to be buried; it would be replaced with resource-centric services and prosumer-centric services.

- Prosumers' control / responsibility on route selection & sent /receive packets;
- Virtualisation of system facilities resulting in ease of deployment and isolation of different Internets; programmability as software defined / triggered / managed networking systems.
- Identifiers (resources, virtual resources, users, services entities, network entities, machines, things) instead of addressing; Decoupling of identity from trust and identity from addressing; Identity Management as a Global Service.
- In-systems autonomous capabilities as the norm.

**Simon Delaere** (IBBT/VUB), representing FISE, stated the following key messages:

- Moving from one to many internets, **a generic, extendable and adaptable core architecture remains important.**
- New horizontal business models require new generic representations; **ontologies** will be important for this.
- We are moving from vertical to horizontal models, but not just dumb/smart pipes, hence the importance of **platforms.**
- Complex architectures require adherence, hence the importance (and business impact) of **trust and certification.**
- Business models do not exist in a vacuum, hence the importance of **socio-economic experimentation.**

**Volkmar Lotz** (SAP, ThinkTrust), representing the Trust and Identity stream, stated that different applications and stakeholders have differing protection needs. Implications of this were that:

- Build trusted environments on-demand based on risk analysis and a toolbox of enforcement and control mechanisms;
- The toolbox needs to serve different "deployment" models, taking ownership, trust relations and technology into account;
- Controls, i.e., mechanisms that mitigate risk rather than eliminating it, are of specific importance ("incentives");
- Security mechanisms and controls as well as guidance (e.g., risk analysis) and deployment support need to be available through all layers ("framework");
- Design the architecture so that this model is supported (and, most important, usable).

Thus, we should talk about different architectural instances rather than different architectures.

**Fredric Gittler** (HP), representing FISO, stated that the FI architecture should be a polymorphic infrastructure, where the boundaries between silo systems are changing and blending. The emphasis should be on the integration, interrelationships and interworking of the architectural elements through new service-based interfaces. Reference architecture is important to help the designers and should also work for the actual product development.

**Theodore Zahariadis** (Synelixis), representing FCN, gave a talk on Future Media Internet Architecture. New media will give new experiences supported by mobility and the FI will be a federation of networks, services and applications. The design principles should be simplicity, robustness and support of new business models. He argued that the Internet would gain more efficiency through content centricity. There are two approaches, one that is evolutionary based on content-centric internet, and another that is revolutionary, where the object is defined by media,

rules, behaviour, relations, and characteristics and can be manipulated separately. He further described how FCN is mapped to objects and conceptual architecture.

### **Conclusions and Next Steps**

As discussion time was limited, the issues were taken up at the MANA session where the discussion focused on orchestration and architecture. It is apparent that metrics for evaluation of architecture is a key omission at present.

We should still focus on having a common understanding and possibly an agreement and initial description of the system interfaces and architectures for the overall Future Internet, as well as an initial description of the milestones and roadmap of research results.

## Session I.2. eID Management in the Future Internet

Session Report by: *Jim Clarke (WIT), Volkmar Lotz (SAP), Nick Wainwright (HP)*

### Objectives

Previous FIA events in Madrid (Dec 2008) and Prague (May 2009) addressed identity (ID) management and identity provisioning in the Future Internet (FI). FIA Stockholm (Nov 2009), building on the Preparation Workshop, focused on cross-domain topics, recognising that all layers in the Future Internet stack – networks, services, applications, devices and terminals (sets of devices), and content – make use of identifiers and identifiable information.

The objective of the FIA Stockholm session was to provide an opportunity for the networks and the services/applications communities to lay out their motivation and challenges associated with their approaches to eID provisioning in the FI. It also provided an opportunity for the communities to start discussing and debating their approaches with the aim of establishing a common ground for the evolution and broadening the scope of eID provisioning across the layers.

All of the presentations and background papers are available online<sup>9</sup>.

### Presentations and Discussion

Marcus Brunner, NEC Labs Europe, chaired a panel discussion based on a series of presentations. The panellists and their presentations were:

- **Ricardo Azevedo Pereira** (Portugal Telecom) - the motivation for a networks-based or converged approach to eID for the Future Internet.
- **Simone Fischer-Hübner** (Karlstad University) - the motivation for Services/Applications approaches for eID.
- **Kai Rannenberg** (Goethe University Frankfurt) (and also on behalf of Jan Camenisch, IBM Zurich) - privacy enhancing technology (PETs) from the perspectives of the PrimeLife and PICOS projects.
- **Amardeo Sarma** (NEC Labs Europe) - research challenges associated with the networks approach to eID in the Future Internet.

Key points from the discussion were:

- **The need for more focused research on accountability:** We need to look at the underlying assumption that ‘whatever is stored, or can be stored, needs to be provided to law enforcement’ as a social issue. Another issue now is that there is a significant change in the cost paradigms of capture/store/use of information; in the past, it was hard to capture and retain information. Conversely, nowadays, it is hard to discard information.
- **Need for cross-layer ID due to the thrust from business interests rather than technology.** There are real problems and issues in the network today that need to be addressed by the research communities. For example, it is possible to link data across layers (Mac, IP, application). The idea of drawing up a linkages matrix for identity/identifiers/attributes spread across the layers was discussed and it was agreed the networking and services/applications research communities could come together and look at each and every

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<sup>9</sup> [http://security.future-internet.eu/index.php/Stockholm\\_Public\\_page](http://security.future-internet.eu/index.php/Stockholm_Public_page)

element and discuss what is needed and why. Some of these issues are already being addressed by the cluster group PrimCluster.

- **What is meant by “maximum of privacy or appropriate amount of privacy”:** The response was that it means the minimum amount of information flowing to the network layers to achieve what is required. This also depends on certain things, e.g. context of the situation and the desired applications. It refers to the data of overall intention and only pieces needed to set up a services and connection. It has to be noted that there are also costs involved – how far are we prepared to re-engineer the Internet to provide more privacy? For example, it will cost to have ‘anonymous routers’ and new overlays, underlays, etc will be needed. At the application layer, the extra costs will depend on the application and the context.

## Conclusions and Next Steps

The session identified the following challenges based on the presentations and the resulting discussion:

- The need for **embedded security and privacy** at all network levels, and in every operation – discovery, identity validation, session setup and management, routing, network transport, signalling.
- **Identity and entity based routing** and **symmetrical relations between users and providers** enabling entities to communicate across different domains using locator-independent identifiers, without being subject to limitations of IP, and ensuring a proper treatment of mobility, multi-homing, and multi-domain policy negotiation. This would require trustworthy identity discovery and validation mechanisms that use the identity of the entity (and not the machine and/or network point-of-attachment/interface) to address as the communication endpoint.
- **Future network architectures** with communication setup and routing that are **identity-data-aware only as necessary for the functions of the network without making the related users identifiable**, coping with “Identity” data in the network in such a way that there is an increase in functionality and associated usability while increasing privacy and security, in particular, managing identification across the layers. Some approaches to discuss and compare as starting points could be an evolution of the Host Identity Protocol and/or creation of Communication Sessions in the network, amongst others.
- **A coherent and comprehensive framework** for handling all aspects of usage and management of eID from the bottom to the top of the stacks. This should include administrative aspects (creation, provision/registration, revocation of identities, and the management of attributes); operational aspects (how eIDs and their attributes are used, controlled, protected, and monitored - including accountabilities – paying particular attention to the need for interoperability on the widest scale; the supporting abstract services to provide interoperability; and the access controls by (productive) networked services based on eID.
- **Close collaboration between researchers to maximise integration and consistency of approach.** The panellists recommended working together to develop a matrix of identity, identifiers, attributes and linkages information at each level, and identify what is needed.
- **Global cooperation** in line with the recommendations in the RISEPTIS report<sup>10</sup>.

It was recommended that the research communities continue to focus on achieving short, medium and longer term concrete results in these challenges / approaches highlighted above. The short term, in particular, should be a focus for ongoing work to be presented at FIA Valencia.

<sup>10</sup> [http://security.future-internet.eu/images/7/7e/RISEPTIS\\_Report.pdf](http://security.future-internet.eu/images/7/7e/RISEPTIS_Report.pdf)

## Session I.3. What Does it Mean to Conduct Experimentally Driven Research?

Session Report by: Anastasius Gavras, Eurescom GmbH

### Background and Rationale

The internet has been the ICT success story for many decades, having great impact in everyday life as well. Economic as well as societal aspects have been greatly affected by the emergence and proliferation of internet technologies. The support of internet communication and the great number of novel services over heterogeneous systems has boosted new forms of communication schemes, collaboration possibilities, services, education, knowledge and information propagation as well as innovation. The fast grow of the internet points to the need for broader experimentation capabilities for future technologies.

Theoretical models in the context of Future Internet, emerging communications and services, are usually validated through dedicated prototyping activities. The testbeds used in these activities are usually focused in terms of testing capabilities and fragmented in terms of validation capabilities. Therefore, the need to evolve the testbeds into coherent experimentation facilities, enabling broader scope experimentation and validation of theoretical approaches, becomes apparent. This will engage the federation of multi-scope platforms under a common framework.

Experimentally-driven research, based on large-scale federated experimental infrastructures, is quite a challenge. The benefits appear to be the engagement in a validation and assessment loop early in the R&D process. In this way, in complex systems experimentation could be the key for discovery and validation throughout the research process. There is a lot of value in putting end-users participating as active testers at an early stage of the R&D cycle. They could become key indicators of several metrics related to the realization of theoretical approaches in tangible real-life scenarios. Indicative metrics that could be assessed would be the scalability of solutions, performance, usability, robustness and security of the tested functionality. Reduced time-to-market of tested products could be the imminent outcome of the whole process.

Relevant topics to be addressed:

- Experimentation as a methodology to achieve concrete results: where, how, when?
- The experimentation facilities as a service offered to R&D
- What are the metrics relevant to experimentations?
- The impact to standardization
- Large scale experimentation: requirements and limitations

### Presentations and Discussion

These issues were addressed through a series of presentations entitled<sup>11</sup>:

- *Introduction on Experimentation Methodology*, Nancy Alonistioti, Univ. of Athens
- *Necessity for Experimentation from the PPP Point of View*, Didier Bourse, Alcatel-Lucent
- *Methodology Issues and How to Experiment*, Martin May, Thomson
- *How the methodology could facilitate the shorter time to product development*, Vania Conan, Thales

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<sup>11</sup> Available at <http://www.ict-fireworks.eu/events/fire-events/fia-stockholm/experimentally-driven-research.html>

- *Experimentation as a methodology to achieve concrete results: where, how, when*, Dimitri Papadimitriou, Alcatel-Lucent

During a panel discussion the following topics were discussed:

- A structure of FI research which may be too strict and inhibit research (forced division in many areas). Need for a frequent interaction between the areas and harmonization and cross-validation of activities/ideas.
- Experimentation is a mandatory step in the validation of new ideas. FIRE facilities offer the bridge between tests in a lab and in a very large scale.
- Migration strategies and coexistence testing are as much important as models validation. FIRE facilities offer also such capabilities.
- International collaboration and concertation, also at the technical level, is of utmost importance, in particular standardization.

### **Conclusions and Next Steps**

- There is a need to pin down the fundamentals: definitions, concepts, nomenclature, and characterisation and classification of use cases.
- Segments of users and how the FIRE area relates to user-driven innovation and living labs.
- How to do performance monitoring in a generic way and how does a monitoring framework relate to the experimental facilities and the experimental driven research?

The FIRE community will start developing a document to address these issues, which may need several versions or iterations.

## Session II.1. Orchestration Across Networks, Services, Things and Content

*Session Report by: Alex Galis, University College London*

### Objectives

In today's internet some orchestration capabilities are embedded for enabling network-of-networks to grow organically, to operate and interwork. The scope of the session was to review the research challenges in Future Internet orchestration. It addressed the following key questions:

- What are the orchestration capabilities needed to integrate and govern the complete behaviour and operations of the 'system-of-systems' (i.e. communication-centric systems, information-centric systems, context-centric systems, resource-centric systems, content-centric systems, service/computation-centric systems, device-centric systems, object-centric systems, things-centric systems and management-centric systems)?
- What are the capabilities needed to dynamically grow, adapt and optimize infrastructure (network, computation, storage, content) resources in response to changing context and in accordance with applicable business goals and governance policies?
- What are the capabilities needed to dynamically grow, adapt and optimize (user-generated) content (stored or live content) in response to changing user and application needs, devices and context and in accordance with applicable business goals and governance policies?
- What are the capabilities needed to dynamically grow, adapt and optimize services resources (service components and mash-ups) in response to changing user and application needs, context and in accordance with applicable business goals and governance policies? How efficient may be (semi-)automatic annotation and reasoning? How efficient and realistic is the automatic orchestration and composition of new user generated services?
- How Services and Content can be seamlessly integrated in a new environment? Can we define a polymorphic object that will be morphed to thing, service or content according to the user needs? Which is the role of annotation and reasoning to that? Which is the role of the environment (network, service, context)?
- What are the supervisory and interworking capabilities that integrate all other system behaviour insuring integrity of the FI operations? What are the capabilities supporting the simple and fast merging different Internet business segments into new forms?

### Presentations and Discussion

**Alex Galis** (UCL) made an introductory presentation on "Orchestration Research Challenges". The following key challenges were identified for defining/designing orchestration mechanisms and capabilities: controlling workflow for all systems of all FI system-of-systems, ensuring bootstrapping, initialisation, dynamic reconfiguration, federation, adaptation and contextualisation, optimisation, organisation, and closing down of system components, which represents one facet of the FI Orchestration Plane; allowing heterogeneous systems to interwork (i.e. polymorphic facets of the Internet); Orchestration Plane architectures and its interfaces to the Infrastructure (network, computation, storage, content) resources, to the Self-Management functionality and to the Service functions; controlling co-existence of multiple and parallel FI(s) based on multiple socio-economies matrices and measures; distributed governance.; negotiation in order to solve conflicts among FI systems; dissemination of knowledge regarding the Orchestration Plane- Publish/push/subscribe; cognitive control; dynamically reconfiguring and adapting of other systems under supervision;

supervision of QoS controllers, triggering an instantaneous modification of the configuration; supervision of resource allocation in several virtual; virtualisation of resources (hardware resource, software resources, networks, services, service components/mash-ups, content). How can we create a holistic system view from separate views of the elements in all system level and in all virtualization levels; nesting and cooperation of different control loops with respects to the same objective or the same set of resources.

**Martin Vigoureux** (Alcatel-Lucent - *“Orchestration: Networks and Network Management Viewpoints”*) focused on the two radically different roles with one common objective with an analogy to orchestra and conductor: Systems and Networks (‘the orchestra’) with limited cross-function collaboration, and limited knowledge and understanding of the objectives Vs Network Control Centres (‘the conductor’) with system focus, top-down commands and information pull. Orchestration implies ‘autonomics’, which have well understood principles, however some solutions have no overall solution – time to bring it to maturity. Substantial changes are needed in operational models: from command & control to monitor & guide; from system view to service view; and all these changes would require trust capabilities as a precondition of wide adoption.

**Jean-Dominique Meunier** (Thomson - *“Orchestration Content Networks View Point”*) focused on introducing the NEM technology platform with the key message that ‘a network without content and users is nothing’ and that content fuels the Internet evolution. Key research challenges identified relate to: search and access content, delivery of content on any devices everywhere with the view of creating a Content-centric Future Internet.

**Stefan Schuster** (ESI - *“Orchestration System of Systems Viewpoint”*) focused on Internet Scale Systems of Systems (ISSoS) as a paradigm that describes systems assembled of many autonomous systems that collaborate in order to attain a common goal. He presented the ISSoS in terms of interoperability requirements, engineering and deployment requirements, governance requirements, and orchestration requirements.

**Joe Butler** (Intel - *“Implication of Service Level Agreements for Orchestration”*) focused on SLA in the ‘real world’ (i.e. multiple service types hosted; heterogeneous infrastructure; diversity of customer expectations and satisfaction requirements) and in particular on SLA agreements, service provisioning and adjustment, negotiation of the provisioning phase and service run time phase.

**Dimka Karastoyanova** (University of Stuttgart -*“Service Orchestration”*) focused on service composition and the S-Cube model. Identified challenges were: virtualization of resources, applications and networks; tackling vertical vs. horizontal orchestration; provisioning of services and resources; trust and governance; service orchestration for networks to improve coordination and manageability; service composition models and infrastructure; cloud computing, architecture of infrastructure for FI orchestration; programmability of service orchestrations.

## Conclusions and Next Steps

The main conclusions from the Orchestration session were:

- **The Internet is becoming increasingly polymorphic** (i.e. communication-centric systems, information-centric systems, context-centric systems, resource-centric systems, content-centric systems, service/computation-centric systems, device-centric systems, object-centric systems, things-centric systems and management-centric systems).
- **Future Internet would be based on cooperating polymorphic infrastructures**, where the boundaries between separate/silo systems would change in time and where the glue is

represented by the orchestration of vertical and horizontal architectural elements and systems.

- **Orchestration implies cooperative autonomics**, which have well understood principles, and silo solutions however they would need to be brought to maturity.
- **New mechanisms for orchestration and control are needed to manage a “system of systems”** (i.e. system of networking platforms: coordinated service networks, coordinated content networks).
- **Virtualisation of resources** (computation, networking, storage, content) **and systems is a promising approach**. Amongst other benefits, it offers the advantage of being able to separate a single physical infrastructure into a “network of coordinated infrastructures”. It could therefore enable ‘parallel internets’ and ‘polymorphic internets’.

Orchestration Plane definition and design is proposed as part of Future Internet research challenges for the next FIA Valencia conference.

## Session II.2. How to Measure Trust?

*Session Report by FIA T&I Caretakers: Jim Clarke (WIT), Volkmar Lotz (SAP), Nick Wainwright (HP)*

### Objectives

While the question of how to measure security- and trust-related properties for networked systems and services, and how to build and adapt security and trust solutions based on risk considerations and economic aspects has frequently been touched in discussions at previous FIA events, this was the first time that a dedicated session on the topic had been arranged. Taking its truly cross-domain nature into account, the objective of the session was to explore the various dimensions of trust and security measurements and related metrics, in order to identify the scope, the relevant research challenges and the path towards meeting them. The importance of measurements arise from the fact that the Future Internet is unlikely to be a perfectly secure and trustworthy place everywhere and anytime, and that users will need to make trust decisions based on incomplete and uncertain information, including an assessment and prediction of current and future risks.

### Presentations and Discussion

The session focused on questions of what can and needs to be measured, how social- and economic-based models of trust will scale, and what can be the targets of measurement. Presentations were made by<sup>12</sup>:

- **Claudia Keser** (University of Goettingen) - demonstrated how game-theory based economic experimentation can be effectively used to measure how reputation systems influence trust decisions and trustworthiness of people conducting transactions over a network.
- **Stephan Neuhaus** (University of Trento) – discussed the importance of security and vulnerability predictions.

The presentations showed promising results on various aspects of security and trust measurements in focused research efforts. This immediately raised questions on how this research could be scaled to Future Internet dimensions in order to exploit the approaches for FI networks, services and applications.

To do so, three essential points related to the presented results were addressed in the discussions:

- Do results on trust experiments scale from the laboratory environment to the real worlds of the Future Internet?
- Can security predictions be generalised across different software components, programming languages, systems, environments?
- How to collect and share security-related data for experimental research in the line of the work presented?

### Conclusions and Next Steps

To have solid grounds for building advanced theories, future work is needed to address the challenges related to publishing data in a transparent way while preserving privacy and confidentiality. The discussions showed the interest in the topic as well as consensus on

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<sup>12</sup> [http://security.future-internet.eu/index.php/Stockholm\\_Public\\_page](http://security.future-internet.eu/index.php/Stockholm_Public_page)

measurements being the basis for an economically-based approach to a trusted and trustworthy Future Internet. **The conclusion was that the major challenges that should be addressed by a Future Internet Research agenda are scalability and the provision of a sound database for experimental evaluation.** It is suggested to continue the discussion along these lines, preferably with a stronger integration of the socio-economics and experimental facilities communities.

## Session II.3. What does Future Internet Mean for Smart Cities?

*Session report by: Alex Gluhak, University of Surrey*

### Objectives

The session aimed to foster an understanding on what Smart Cities can expect from the Future Internet and how they can benefit from it, as well as how Future Internet research can benefit from Smart City environments.

### Presentations and Discussion

The programme consisted of the following presentations:

- **Soft Infrastructure - Duncan Wilson, Arup Foresight Innovation & Incubation:** Urbanisation is a major challenge, with the highest growth being in cities in the developing world. In China, for example, a further 600 million people are expected to move from rural living to urban living by 2050. Cities rely on technology – many back-end systems are fundamentally a part of the city infrastructure. Technology plays a role in developing a sense of community in cities and places. The relationship between technology - community – value is a key link. Cities such as Manchester have followed a top-down approach, building models of how we can design cities, and using models to understand the different aspects of cities (e.g. noise planning, etc.). Others believe the best approach is ‘bottom up’: “the next generation of urban resilience relies on citizens and communities, not the institutions of state”. Urban informatics (a layer of information in a city that would enable planning, short term, longer term models, citizen centric) and Sustainable ICT (ICT applied to sustainability) were identified as key themes going forward. Further information on Arup’s work is available at: [www.driversofchange.com/projects](http://www.driversofchange.com/projects).
- **Smart City Technologies - Fiona Williams, Ericsson Research:** People mean different things when they say ‘smart cities’. At network infrastructure level it means ‘fibre infrastructure’. Sensor technology linked by networks – e.g. SmartSantander in Spain is a good example. Key ICT building blocks of a smart cities are: i) an underlying ubiquitous ICT infrastructure; ii) high speed internet access; iii) sensor and actuator deployments; and iv) an ICT service enablement suite (Smart media service enablers). Smart cities need city-wide open access to sensor and actuator services (taking into account appropriate access). At present, there are not many ‘holistic’ approaches in cities, but rather are focused on various different topics partly because of the lack of city-wide standards or frameworks for city-wide access to data and information from sensors and actuators. Is this a technical or business model issue? The way forward should include: horizontalisation of the ICT infrastructure; cross-industry meeting points; standardisation across industries; and showcases and pilots. Ericsson would like to see a programme in this area in the PPP. The biggest impact would be for standard ways of interfacing to the various applications, services and interfaces.
- **Smart Cities - Urban Living Labs Supporting Regeneration Through Creativity and Innovation - Dave Carter, Manchester Digital Development Agency:** A reality check is required. Many cities have aspirations to be ‘smart cities’, but very few are taking it seriously. But now this is being recognised as mainstream, rather than fringe, it creates opportunities for smart cities to become a reality. ‘Smart citizens’ and ‘smart communities’ are an important part of this, alongside technology push. The idea of smart cities has a long history, starting with the Telecities project in 1993. In those days, the idea that the internet

and ICT would be important to cities was seen as 'science fiction'. Smart cities will be 'fully wireless and fully fibred', so we can take connectivity out of the equation. They will rely on digital industries, in particular SMEs (there are 300 in Manchester's digital trade association, most under 10 employees).

Open innovation will be important for smart cities as a means of creating new innovation ecosystems. This will require multi-level partnerships between cities, industry and the research community, e.g. regarding open data. Cities don't adapt well to innovation because they don't understand it, and innovators don't understand cities. User-driven innovation is more than just 'having consumers involved'. Living lab projects, such as those supported under FP7, could be a way forward: cities leading FP7 bids with some businesses and researchers. This will help innovators and technologists to understand cities and vice versa. Applications are very important – e-health, smart energy, tele-work, these are the things that will drive it. We have to use cities as a catalyst. Associations such as Eurocities could help develop the interface with the FI community in building creative cities.

The speakers, together with Timo Ojala of the University of Oulu then joined a short panel discussion, with Nick Wainwright of HP as moderator.

### **Conclusions and Next Steps**

Speakers uniformly emphasised that digital technologies should be deployed to solve real problems and were wary of 'technology push'. Nevertheless, there was a hint that horizontal platforms had potential benefits in smart city environments, as many sectors addressed have some common needs. Applications spanned community building, transportation, digital industries, energy, buildings, and urban planning. Fiona Williams presented a perspective on infrastructure for smart cities that would be a platform for connectivity and interoperability. Nick Wainwright observed that trustworthiness should be considered at the heart of smart city infrastructure and services and that this could provide valuable use cases and scenarios to explore in the future.

Looking at the PPP, Smart Cities will provide an excellent experimental environment as they naturally bring together a variety of critical application domains, ranging from energy, healthcare, transport, governance, etc. Therefore a SmartCity based infrastructure will provide an ideal open platform for the development, experimentation and testing of common FI service enablers required to enable 'smartness' in a variety of application domains.

The Smart City topic has been well received by many FIA communities and hence will be part of the programme for FIA Valencia. Application domains of high interest in the community are Smart Environment/Energy and Smart Health. An initial link to the Eurocities community has been established, which should be more actively developed in the preparation process towards Valencia.

## Session III.1. The Question of Discovery and Search in the Future Internet

Session Report by: Graham Hench, John Domingue and Petros Daras

### Objectives

Search is concerned with making the best use of available (human or machine generated) knowledge to provide the user with meaningful information even if his/her request might be poorly formulated and typically unanticipated. The value of a search engine depends on how efficiently the knowledge is managed (automatically acquired, enriched, structured, retrieved, filtered, interpreted) and how easily the information is accessed and understood by the end-user.

Search involves a number of different disciplines within the FI, including:

- **FCNs:** a) content as the main ingredient of media, and b), networks in terms of improving the user's experience and satisfaction;
- **IoT:** resource and information discovery from a sea of heterogeneous devices and sensors;
- **IoSs:** service discovery approaches range from keyword search over service directories to semantic approaches which delineate between a service capability (what the service does), non-functional properties, and descriptions of service behaviour.

Discussion was invited around the following premises:

- Internet evolution: rich content, immersive experiences, interaction, networked sensors, services, new applications...
- Text-based search is not any more the best choice...
- Content/context-based search seems to be a solution...
- Future Internet search can be considered from the viewpoint of media, physical objects and/or services.
- Need to move towards a common understanding between the different communities.

### Presentations and Discussion

Ralph Traphoener's (EMPOLIS) presentation entitled *An FCN Perspective on Search and Discovery*<sup>13</sup> highlighted the need for data (re-) structuring, and solutions which are high-speed, systematic, dynamic, and require convergence between new and old media formats and content generation techniques and methodologies. The FISO perspective was covered in Dieter Fensel's (University of Innsbruck) presentation<sup>14</sup>, focusing on the current state of the Web of Services, the involved processes of Service Discovery, such as service mediation and composition, and the challenges of combining online services and Linked Open Data. Finally, the perspective from the IoT/RWI group was presented by Neeli Prasad (University of Aalborg)<sup>15</sup>, expanding upon the content/service focus to include search and discovery of networks, devices, applications, etc.

The session discussed a range of issues related to heterogeneity and diversity. Among the key issues highlighted were:

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<sup>13</sup> <http://www.fi-stockholm.eu/getfile.ashx?cid=58719&cc=3&refid=27>

<sup>14</sup> <http://www.fi-stockholm.eu/getfile.ashx?cid=58719&cc=3&refid=25>

<sup>15</sup> <http://www.fi-stockholm.eu/getfile.ashx?cid=58719&cc=3&refid=25>

- **Given the polymorphic facets of the Internet, what should a search environment look like? Are the open, federated search services a/the solution?** Since services are often abstractions, a refinement process is needed for accurate/specific queries - approximation and incompleteness are part of this process. SPARQL should be considered to eventually provide uniform query access for the FI. Interaction/assistance is needed for efficient search. The goal has often been to connect *what is stored* with *what is queried*; this translation and/or bridge must be further developed. Technical standards and user-level guidance are important but distinct issues. Search systems often emerge rather than being developed, hence user-generated data/user groups often provide sought answers far quicker.

Machine-to-machine query/search should also be considered, not just human-based queries/search, as is noted within the preliminary definition: *Search is the best use of available (human or machine generated) knowledge to provide the user with meaningful information even if his/her request might be poorly formulated and typically unanticipated.*

Other methodologies include the overlaps of target search and mental image search whereby query resolution are estimations which are based upon the user, rather than traditional search methodologies. Search also includes device search, network search, as well as actually tracking objects (e.g. RFID Tags).

- **How can we implement/architect search and discovery over a range of information artefacts including services, sensor networks and rich multimedia content? What types of indexing/caching could support FI search and discovery?** Semantic technologies provide a solution for interoperation between search and discovery engines. Services can be viewed as abstractions of entire sets of data, which can be searched and discovered semantically. Meta search and combined search methodologies do not allow two agents with the same query, searching over the same space, to derive different results. Improved representations are needed to describe search engines and allow for interoperation. Currently, search engines face the standard inter-agent communication challenges (i.e. trust, validity, verifiability). While queries within Amazon, or confined query/search systems with structured/organized space, are quite efficient, “grey” queries, e.g. “I’m searching for the song which sounds like...” require improved systems. Creating and populating a search engine both require economic incentives. Discovery could be a business model in itself - but does it make sense to have another Google?
- **What types of representations (meta-data) could we use to support Future Internet search across the heterogeneous resources? How would these be created and maintained?** E.g. “Query by Humming”. Google currently leads because it has the largest database and infrastructure. Enterprise, domain-specific, and content-based search are areas where Google does not lead.

The final wrap up part of the session emphasized the willingness of those present to continue discussing search and discovery in the FIA Valencia.

## Session III.2 What does Future Internet Mean for Enterprise?

Session Report by: Man-Sze Li, IC Focus

### Objectives

This session was the first opportunity for an open discussion dedicated to the topic of “enterprises” in the FIA setting. It focused on the problem statement: *What will the Future Internet deliver for Enterprises?*

The aim was to elicit opinions from a broad spectrum of FIA stakeholders, with a view to creating a common baseline for identifying and prioritising issues in research. Building on that, the intention was also to determine, where possible, what needs to be done to ensure that European enterprises, including SMEs, would benefit from Future Internet research and its outcomes. Thus, the emphasis was on the **application** of Future Internet technologies in support of business innovation and enterprise transformation. Preparation of the session involved the Future Internet Enterprise Systems (FInES) Cluster<sup>16</sup>, which has over 600 registrants to its activities.

The session was divided into two parts<sup>17</sup>. The first included position statements from representatives of initiatives and stakeholders in the field. The second included three parallel knowledge cafes (covering visions & policy, socio-economics, and technology) which actively engaged the participants.

### Presentations and Discussion

#### *Visions & Policy aspects*

Discussion in this knowledge cafe centred around a series of questions:

- *Question 1: In Europe, only 13% of enterprises use ICT for inter-enterprise collaboration. The figure for SMEs is still less. What can be done to improve this situation?* Compared to large enterprises, SMEs have huge barriers in ICT adoption: awareness problems (SMEs are not aware of what is available in the “technology/application basket”), resource problems (e.g. technology watch), ICT skills problems. Critical mass is key. Targeted measures for SMEs are needed in: education, knowledge dissemination and knowledge exchange; greater involvement in research. There should be a clear value proposition for collaboration with others. Greater attention should be trust issues (e.g. hosting data in cloud, remote backup of sensitive data). Public availability of data (e.g. address databases) would benefit SMEs.
- *Question 2: Commoditisation is a key trend in the ICT landscape. How can ICT providers benefit in providing (low to zero cost) commodities/utilities?* This issue – which is not specific to FI - is about motivating infrastructure investments; it is about return-on-investment and rules. This will be a trial and error process and solutions will emerge organically. Market dynamics will define the solution and we should not try to anticipate market changes. How important is the public ICT infrastructure? Is it in the public interest to be supported/provided by government? Low to zero cost utility provision requires relevant

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<sup>16</sup> [http://cordis.europa.eu/fp7/ict/enet/ei\\_en.html](http://cordis.europa.eu/fp7/ict/enet/ei_en.html)

<sup>17</sup> Slides and other materials relating to the session are at <http://services.future-internet.eu/index.php/Enterprises>

policy decisions (e.g. deregulation and market dynamics) to enable the development of appropriate business models under market conditions.

- *Question 3: People, Things, Services and Content are currently four fairly self-standing research streams. Is it an issue?* Up to now, FI discussion goes largely in the direction of how to develop technology rather than how to apply it. The pillars do not mix very well and hence they lack business relevance. This is partly due to ‘silo thinking’: the EC has been too silo oriented up to now in terms of research policy. Collaboration between the pillars needs to be looked for and motivated, it cannot be assumed. Finally, SMEs need to be encouraged to cover the entire innovation lifecycle (idea, opportunity, research, experimentation, development, commercialisation).
- *Question 4: “European way to the Future Internet” - What are the specific European issues we are looking for and how can we leverage them to develop a key position?* Culture, language and value systems are key differentiating factors. The European enterprise landscape is based more on SMEs than, for example, the US economy; this should be turned into an advantage. In some countries, it is difficult for SMEs to adopt new technologies. Regulation can also be a hindering factor. Ultimately, however, the Internet is a worldwide issue, not specifically a European one.
- *Question 5: What are we waiting for? What are enterprises waiting for? Do enterprises really care about FI?* Points noted here were: We need more business from FI and we need more concrete description of what the FI is all about. We cannot sell the advantages of FI if it is still not deployed. We have to approach FI development from both ends: studying people and what they want, and also studying what possible usage patterns we could imagine for the technology available. This is the essence of serendipitous innovation.

### **Social-Economic aspects**

The approach in this area should be set by the enterprises. We need to solve concrete real problems and not a technological proof of concept. The innovation should not only be technological. We need to establish examples of how FI can improve the way enterprises work, including examples of new emerging business models, concerning both big enterprises and SMEs.

**Internal structure vs. External Relationships of enterprises:** The former is more important; the latter comes as a second step. The (expected) changes will lead to more “fluid” structures and the boundaries between the “inside” and “outside” of a company will become increasingly blurred. The enterprise may become less structured but needs the capability to restructure itself in response to business development. There is a need to focus on collaboration among enterprises and SMEs that will allow them to be more competitive.

**Nature of Work:** We need to study the new forms/ways of work that (will) emerge, how they evolve and how FI technologies can help towards this direction. **Trust & privacy** are very important issues, and not only from the technology perspective.

Internet technology adoption by enterprises is still low. **Reasons for non-adoption** include:

- Lack of awareness of available technological solutions, particularly by smaller companies;
- Profit-driven decisions by enterprises impede initial investments, e.g. IPv6 and PKI are not (fully) used;
- High costs on operation and maintenance (here, cloud computing can potentially offer solutions);
- Long term goals of FI vs. short-term objectives of enterprises;
- Constantly changing technological landscape does not provide any assurance.

The main question is whether the adoption of technologies will lead to financial success. We need to come up with examples of new business models that will make FI technologies viable.

Additional issues requiring further discussions were: IPR, the role of users in the overall picture, new contracts and governance system to manage relationships, evaluation methods of enterprise adoption of (Future) Internet technologies.

### **Technology aspects**

**Use of social networking tools in the enterprise** requires a clearer elaboration of benefits and risks. These will differ for internal vs external (open) use. We consider employees in a broad sense, but in an open scenario there is a problem of trust & security. The value of data held in social networks needs to be better understood, as well as the significance of cultural differences. Means of measuring and compensating people's productivity should also be investigated.

**The Internet of Content & Knowledge** is bringing dramatic changes in intellectual property rights in the corporate sphere. There will be a gap in terms of the technology used by individuals (e.g. at home) and in the enterprise. Who holds the knowledge: employees or the employers? There is a divergence here between the legal position (enterprise owns) and reality (employee owns) situation for IPR. Enterprise of experience: it is a form of content / knowledge.

**Internet of Things and distributed knowledge / decision making:** Sources for business intelligence are increasing rapidly with sensor networks, process traces, etc. Intelligence is being built into machines that contributes to decision making. What about things that start to behave differently from the expected pattern? One view is that increasing the number of intelligent entities will not increase the global intelligence of the enterprise. Another view is that smart devices can reduce the amount of information flowing when something goes wrong, for instance reducing message traffic to alarms (pre-processing is performed locally).

**Enterprise in the Cloud:** Under what conditions would enterprises migrate into the Cloud? We need better definitions of what constitutes a 'cloud' and what the benefits are both for large enterprises and SMEs. Quality and accountability are needed. Migration will be application dependent; non-critical apps are more promising for clouds.

**An FI universal business infrastructure:** The current infrastructure will still be relevant in 20 years' time, because it requires big investment that will not be "thrown away". Some innovative enterprises, e.g. eBay, will base their full business on FI but enterprises still run legacy systems because it is too costly to change. There are divergent views on the role of government here which require further discussion.

### **Conclusions and Next Steps**

Discussions at the three knowledge cafes elicited a wide range of issues and opinions. Further discussion involving even more stakeholders in an open setting is needed.

It was agreed to continue the discussion via the session wiki and engage all interested stakeholders in the discussion, including Open Consultation. The possibility of preparing a Position Paper on the enterprise topic in the FI context is to be investigated. In addition, support was expressed for continuing the debate in a dedicated session in FIA Valencia.

## Session III.3: Deploying on "Future Internet Research & Experimentation" (FIRE)

Session Report by: Anastasius Gavras, Eurescom GmbH

### Objectives

To date several EC and national projects are offering and further deploying facilities for supporting research and experimentation for the Future Internet. In past FIAs the so-called FIRE cluster (Future Internet Research and Experimentation) provided information and demonstrated the possibilities of using the FIRE facilities for research experimentation and testing.

For example at the FIA Madrid, the FIRE cluster collected use cases that illustrated how the facilities are being used and how potential users of the facilities intend or plan to use them. Likewise at the FIA Prague, the FIRE cluster exhibited a number of facilities and provided live demonstrations of how these facilities can be used and what features were available.

In this context not only the main projects like Onelab2, PII, Federica, Wisebed and Vital++ should be seen, but also activities that fall in the area of the Living Labs and focus on the user experience and user-driven innovation.

The logical evolution of the current state of affairs is to discuss directly with the potential users of the facilities in concrete terms how to deploy service platforms, services and applications on the available facilities. Thus the FIA Stockholm was used by the FIRE facilities providers to discuss with the prospective users the details of "how to deploy on FIRE".

### Presentations and Discussion<sup>18</sup>

The FIRE experimental facilities let us explore whether Future Internet systems operating at scale exhibit the properties and behaviours that we intended when we designed them and tested in the lab, whether systems constructed independently can be integrated together and whether they function as we expect when they are integrated. If we are able to make facilities available for others to use we can also look for emergent properties and emergent usage of systems (e.g. creative use of facilities by users who discover different ways). A fuller treatment of the role of experimental facilities has been explored by the working group on modular federation of FIRE facilities<sup>19</sup>.

### *Specific focus on Trust and Identity*

At the Prague FIA meeting some of the experimental approaches to Trust in Future Internet were explored. These can be broadly characterised as:

- Observing and monitoring attacks on systems in the public internet (e.g. Honeynets)
- Experimental work with 'real' end users (e.g. living labs)
- Provision of 'trust services' e.g. eID on which more trustworthy services can be constructed
- Experimental identification of technical vulnerabilities in systems

**Providing quarantine areas of the testbed.** There will be vulnerabilities at all levels in the systems and components of the Future Internet. Can we create isolated (quarantined) experimental facilities in which one could run experiments that explore the robustness of systems and components against

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<sup>18</sup> Available at: <http://www.ict-fireworks.eu/events/fire-events/fia-stockholm/deploying-on-fire.html>

<sup>19</sup> [http://www.ict-fireworks.eu/fileadmin/documents/Wise-men\\_final.pdf](http://www.ict-fireworks.eu/fileadmin/documents/Wise-men_final.pdf)

attack? For example, can we launch a distributed denial of service attack on services without bringing down the whole FIRE facility, or even worse impacting the entire internet?

**Providing e-Identity facilities.** Can FIRE provide a comprehensive electronic ID facility as a FIRE offering, so that it is used by all experimental activities using FIRE? How do FIRE users access and use such systems?

### ***Specific focus on Software and Services***

In the area of services and software, it is proposed to explore the installation and deployment of solutions from the Open Nebula/Reservoir projects for managing clouds onto the current FIRE facilities. The intention is to explore the application of the Infrastructure as a Service (IaaS) cloud paradigm on the FIRE testbeds. This undertaking requires a discussion on how the Open Nebula/Reservoir stack can be deployed in some of the current FIRE facilities.

In view of the above, the following presentations were made during the session:

- Introduction, Anastasius Gavras, Eurescom GmbH
- *Deploying Service Experiments on FIRE: An OpenNebula/RESERVOIR Perspective*, Philippe Massonet, CETIC
- *Federated Clouds*, Sebastian Wahle, Fraunhofer FOKUS
- *Providing Quarantine Areas of the Testbed*, Nick Wainwright, HP Labs
- *Deploying Isolated Testbeds*, Mauro Campanella, GARR

### **Conclusions and Next Steps**

There is a need to kick-off working groups or task forces to elaborate and possibly agree among the FIRE projects on:

- A common language for resource descriptions
- A common language to describe experiments
- A common language to describe results
- Standardized APIs to access resources
- Single sign-on / one-stop shop - i.e., a common approach for managing user credentials
- Action point to kick-off one or more of the above working groups.

## FI Working Groups

### Future Content Networks

*Session Report by: Theodore Zahariadis (Synelixis)*

#### Objectives

The session covered the most important areas of evolution in both networks (towards content-centric networking) and media (towards enhanced media experiences). As well as three invited speakers, two panels were organised: one focused on Content Centric Networking and one focused on Quality of Experience.

#### Presentations and Discussion

**Rosalia Lloret, TVE**, made a presentation entitled "Broadcasting and the Future Internet"<sup>20</sup>. She presented new interactive forms of media distribution, the competition battlefield and new services currently considered by TVE. Main points were:

- Professional content providers, huge and small aggregators are complemented by the emerging prosumers.
- Content needs to be available everywhere, seamlessly streamed to every screen, adapted and personalised.
- New services should give more insightful information and better quality of experience.
- Main challenges include (but are not limited to): bandwidth, interoperability, standards, brand/business role, findability ("let's make video the new text!") and rights.

**George Pavlou, UCL** gave a comprehensive presentation on the "Evolutionary, Innovative and Revolutionary Approach on Content Centric Network". The vast majority of interactions relate to content access: e.g. media aggregators (e.g. YouTube, GoogleVideo), P2P overlays (e.g. BitTorrent, eMule), content delivery networks (e.g. Akamai, Limelight), social networks (e.g. Facebook, MySpace), and photo sharing sites (e.g. Picasa, Flickr). Emerging interactive applications are immersive. User-generated content is expected to proliferate and new approaches are required to cater for the explosion of video-based content and for creating novel user experiences. Given the massive emergence of video content, for which the internet was not originally designed, new architectural approaches are being investigated, both evolutionary and visionary. Content Distribution Network (CDN) approaches support an 'anycast' model by choosing the most appropriate content replica to maximise QoS/QoE. Peer-to-Peer (P2P) started from file sharing, to evolve into video streaming through network overlays. Visionary CCN approaches have originated from the fact that most internet interactions are user-to-content instead of host-to-host. The content mediation plane can be implemented in a revolutionary manner in network routers. In summary, Content-Centric Networks + Future Internet => Future Media Internet.

**Federico Alvarez, UPM** presented the nextMEDIA Coordination Action on "Future Media Internet". nextMedia will create a new "Future Media Internet Architecture" Think Tank to reinforce the leadership of the EU. It will:

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<sup>20</sup> Presentations available at: <http://www.future-internet.eu/home/future-internet-assembly/stockholm-november-2009/cluster-sessions.html#c198>

- Support the work of the initiatives “Future Media & 3D Internet Task Force” and the “Future Content Networks” groups.
- Coordinate the efforts of the projects on Future Media Internet: by collecting and analysing the short term (commercial/business) and the longer term (academic) research priorities; and by coordinating the Future Media projects with the FIA groups and promote a coordinated approach between activities.
- Structure the Future Media Internet research evolution path by: organising the existing knowledge in a unified form; and comparing the research situation in Europe with other areas of the world.
- Maximise the impact of the European positioning at scientific & industrial levels, by promotion at high-quality conferences and events and coordinating exchanges of ideas with key players from third countries (mainly from USA and Japan).
- Facilitate collaboration with third countries in relation to standardisation on Future Media Internet. Examples include: promoting the standardisation of EU research results; launching an Industry Specification Group (ISG) on Future Media Internet (inside ETSI); dissemination in exhibition events; and creation of online course materials.

The Content-Centric Networks panel, chaired by Norbert Niebert (Ericsson), covered areas related to evolutionary network architectures. Main questions that were discussed in the panel included:

- Is it really needed to touch the network for this? Could it not just be another Web-service?
- Will there be a visible difference to content services today?
- How will a content centric network support prosumers, aggregators etc.
- What is the main innovation from a Content Centric Network?
- What is the main driving force for a Content Centric Network? Where could it start?
- Is this a new hope for rights enforcement?

Vali Lalioti, BBC and NEM Vice-Chair Liaison, chaired the Quality of Experience panel. The main issue and question was: “What is QoE for the user/consumer and how do we measure it?”. An informal definition was: “QoE is whatever is perceived by the user, who will consider it together with the price in evaluating the value of the service.” Some of the metrics of QoE are:

- For the Network operators: QoS bit-error ratio, delay, maximum throughput and service availability
- For the Content Providers: IPTV artefact free, no picture freezing, fast zapping times
- For the service providers new features and applications for growth (interactivity, immersion, time-shifted TV, access to more content, 3DTV with feeling of presence)
- For the users... ???

Other key topics included:

- How can QoE be measured, to give results that are helpful in service development?
- How do we use these to create holistic, consistent and engaging experiences across platforms and services?
- How do we measure QoE for the new services of the FI and create consistent engaging experiences (e.g. contribution, interaction, immersion)?

## Conclusions and Next Steps

At the architectural level different ideas are maturing and converging. This will lead to a federated approach between the FCN, FISO, MANA and IoT groups, also taking account of socioeconomic considerations:

- Simplicity, federation – Interoperability and backwards compatibility are and will be key parameters;
- Trust, reputation and privacy should be inherent in the network architecture;
- Objects and components' polymorphism may boost Future Internet;
- Evolution architectures are closer to what we may expect in the next few years;
- Innovation architectures could be the Internet Revolution.

Other areas of interest for the FCN groups include:

- Converged network architecture
- Emphasis in home networks
- Push/pop paradigms for content delivery
- Content identification and packet inspection
- Immersive media experiences & quality of experience
- Content streaming.

## Future Internet Service Offer

*Session Report by: Graham Hench and John Domingue*

### Objectives

The session aimed to understand the implications for the FISO group of the cross-domain sessions of November 23<sup>rd</sup> and to identify possible topics and format for FIA Valencia.

### Presentations and Discussions

FISO rapporteurs provided feedback on the various FIA sessions from the first day of the Assembly:

- **Session I.1 - Different architectures for different business models?** Sergio Gusmeroli's (TXT) presentation highlighted six different architectures for different business models based upon the work of other FIA working groups (including perspectives from MANA, FISE, FCN).
- **Session I.2 - eID management and provisioning in the Future Internet infrastructures** including routing, services, and content. Patrick Hayden's (TSSG) presentation summarized possible networking approaches, whereby: 1) all layers require authentication (application, service/content, network); 2) avoid personally identifiable data at network level (IP and MAC address); and 3) communications setup and routing should be identity aware – but without making users identifiable. Primary objectives for possible service/application approaches include: 1) re-establish control over our personal identities; 2) provide data minimization, assurance and lifecycle management, and transparency tools to allow users to keep control of what aspects of identity are released and to whom; 3) implement measures of multilateral security, including partial identities, community privacy management, partial disclosure.
- **Session I.3. What does it Mean to Conduct Experimentally Driven Research?**  
Klaus Tochtermann's (Know-Center) presentation included the following recommendations:
  - Make sure that FI Services meet the future European societal needs (green, ehealth, smart cities, transport...)
  - Bridge between existing network-focused testbeds and user-focused living labs for evaluations
  - Bring together the network community with the service/software community
  - Need for tools and languages to describe and automatically set up experiments in served experiment facilities
  - Need of a model for standardised and service-based access to testbeds and experimental facilities (Testbed-as-a-Service) => comparable results of experiments.
- **Session II.1. Orchestration Across Networks, Services, Things and Content**  
Nuria De Lama's (ATOS) presentation highlighted the identified orchestration challenges as such:
  - Mechanism for controlling the workflow associated to many heterogeneous systems
  - Mechanisms to control the co-existence of parallel FI(s)
  - Mechanisms for distributed governance
  - Mechanisms to control the sequence and conditions of service invocation, supervision of QoS, etc

- **Session II.3 - What does Future Internet mean for Smart Cities?**

Marco Pistore's (Fondazione Bruno Kessler) presentation concluded with the following key messages:

- System of systems = cross-industry, cross-domain
- Smart-city >> smart-transport + smart-hospital + smart-\*
- Entire ICT infrastructure must be evaluated; application/service layer plays a key role
- The "soft" aspects should not be ignored: new businesses, innovation, creativity

- **Session III.1 - The Question of Discovery and Search in the Future Internet**

John Domingue's (OU) presentation summarized the RWI/IoT, FCN, and FISO perspectives on discovery and search in the Future Internet, and then presented the Heterogeneity and Diversity questions discussed in Session III.1:

- **Session III.2 - What does Future Internet mean for Enterprise?**

Stefan Schuster's (ESI-Tecnalía) presentation included a summary of visions and policies as such:

- SMEs are not aware what's available in the "technology/application basket"
- Market dynamics will define business models, but need policy involvement
- Silo thinking is not the right way (FI pillars)
- Culture, languages and value systems key differentiating factors of a European FI
- Need more concrete description of what the FI is all about to make it compelling for SME uptake

- **Session III.3 - Deploying on "Future Internet Research & Experimentation" (FIRE)**

Ricardo Jimenez-Peris's (UPM) presentation conclusively listed the following requirements to deploy on FIRE:

- A common language for resource descriptions
- A common language to describe experiments
- A common language to describe results
- Standardized APIs to access resources
- Single sign-on access to the testbed.

## Conclusions and Next Steps

FISO adopted the following new 'slogan' or mission statement (from Federic Gittler, HP):

*The Future Internet is polymorphic infrastructure, where the boundaries between silo systems are changing and blending and where the emphasis is on the integration, interrelationships and interworking of the architectural elements through **new service-based interfaces**.*

FISO is concerned with the service aspects associated with this vision.

With respect to FIA Valencia, FISO would support an agenda where we move from cross-domain to cross-community discussions. We advocate including representatives from the vertical sectors as currently associated with the PPP. In particular, from eHealth, Smart Energy, and Smart Cities.

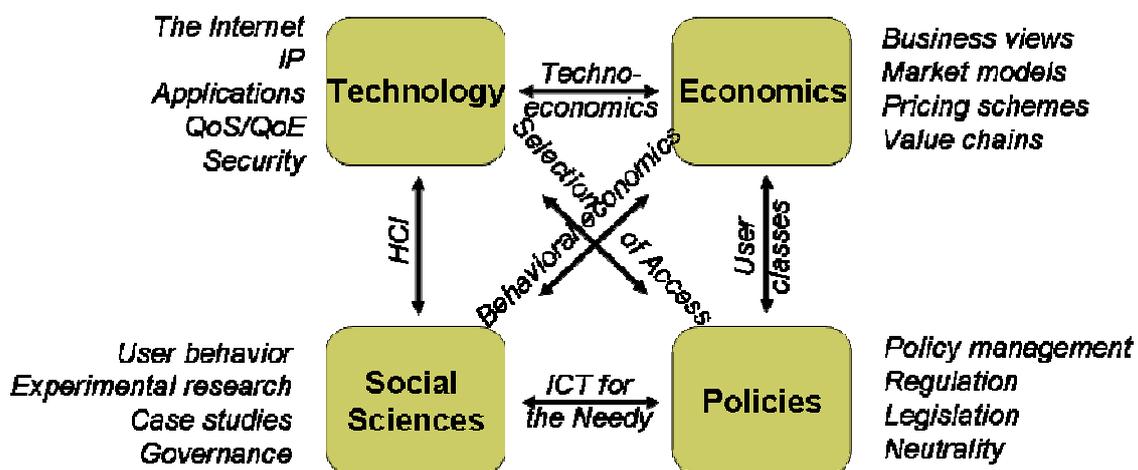
## Future Internet Socio-Economics

Session Report by: Michael Boniface, IT Innovation Centre, Sergios Soursos, Intracom, Burkhard Stiller, University of Zurich

### Objectives

In preparation for FIA Stockholm, the FISE group assessed the proposed topics and selected thoughts most appropriate to socio-economics. This included architectures and business models, smart cities, smart enterprises and how to measure trust. A representative from FISE attended each of the selected groups, either as a presenter or an observer during the topic sessions on 23 Nov 2009 to provide socio-economic viewpoints during discussions. Each representative summarised the outcome of topic sessions during the FISE working group meeting on 24 Nov.

The session was introduced through an overview of the socio-economic-technical interactions as outlined in Figure 1.



**Examples**

Figure 1: Socio-economic areas and interactions

### Presentations and Discussion

#### Cross-topic Feedback

**Simon Delaere (IBBT-SMIT)** reported on the session on **Architectures and Business Models**. FISE gave a presentation based on a position statement, as summarised under Session I.1. The resulting discussion raised the following research issues:

- Bringing economic reasoning into traffic management (AUEB)
- Need to bring other types of research into technology development (Chalmers)
- Need for self-managing, programmable core networks as well as control/responsibility/intelligence in the edges (prosumers) (how transparent will it be, and what are the incentives for users, potential consequences for liability etc). (UCL)

- Virtualization/identifier based addressing/interfaces/system oriented cloud infrastructures/composable resources (UCL) - radical reshaping of roles, including business roles
- Multi-purpose value of a reference architecture (NEXOF) - how does it influence the business architecture?
- Nuancing of security: what is needed in what context, and what are the business trade-offs? - related to FISE's views on trust and certification (SAP)
- Future media internet architecture: importance of simplicity (system complexity), sustainability, scalability, robustness; dynamic composition points to a potential reconfiguration of business roles; need to think about the value proposition behind - underlines need for user oriented research; fit between new, dynamic architectures and dynamic business architectures; need to introduce user and business oriented variables in technical design; impact on business models of security and trust; and continuous attention for the value proposition: what is it that we want to offer?

**Michael Boniface (IT Innovation Centre)** reported on the **Smart Cities** session. As reported under Session II.3, the Smart Cities topic was driven by three motivating presentations covering different stakeholder perspectives.

The presentations emphasised the concept of urban spaces and why they are important to citizens and the economy. The key message was that around the world the urban space today is extremely diverse, ranging from the suburban sprawl of industrial economies to well established affluent cities with combinations of new builds and legacy. The drive for sustainability of our modern cities has brought discussion of the use of IT as an enabler into the mainstream. This is nothing new as there have been many smart city initiatives over the last 15 years. The challenge is that there are smart buildings, transport and other systems but today they are disparate and largely closed.

Cities promise to offer citizens wealth, health and economic opportunities and these are the major incentives why people collect together. Typically, urban communities have shared economic and social aspirations and it is critical that cities maintain the engagement of people and create desirable living spaces. The engagement model between citizens and city infrastructure is essential to shape social behaviour and achieve social targets for objectives such as inclusion and security. The key here is individual engagement models that ensure everyone knows that their actions can make a difference and also carry responsibility for the community as a whole. This is the essence of citizenship, and personalised interaction and monitoring can help ensure this is achieved. Of course this raises important questions about the balance between citizenship and privacy, topics that have been highlighted for discussion during the next FIA meeting in Valencia.

In terms of technical outcomes, key research areas identified included the following:

- Community planning and forecasting, risk management, real-time analysis, handling large data volumes.
- Quantitative large-scale analysis of human behaviour in the context of converged real-world and digital systems.
- Economic aspects of horizontal integration between multi-level and multi-party services.

**Sergios Sourso (Intracom)** reported on the **Smart Enterprises** session. We must first understand the needs of enterprises and then consider how FI technologies can be used to satisfy them. Based on these needs, the logical structure of SMEs may need to be changed. So, it is the enterprises that should set the questions. We need to address concrete real problems and not a technological proof of concept. The innovation should not only be technological. We must establish examples of how FI

can improve the way the enterprises work (with the focus on SMEs and not just big enterprises). New emerging business models with real examples should be discussed.

Other aspects covered, as reported under Session III.2, were:

- Internal structure vs External Relationships – with boundaries between organisations becoming more blurred and collaboration among enterprises and SMEs becoming the norm.
- Changing nature of work - we need to study the new forms/ways of work that emerge, how they evolve and how FI technologies can help towards this direction.
- Trust & privacy – from a variety of perspectives, not just technology.
- Reasons for non-adoption of FI technologies.

**Burkhard Stiller (University of Zurich)** reported on the session **How to Measure Trust?** In the first presentation, Claudia Keser, University of Goettingen, described game theoretical application in a buyer/seller scenario and results obtained in controlled laboratory environments. Reputation increases trust and trustworthiness, more equitable outcome, may play an important role in the Internet of Things. In a second presentation, Stephan Heuhaus, University of Trento, described security as a science for the Future Internet. This will only be possible if applicable measurements are done to find good theories and to turn them into science. Evaluations of software will also be an important aspects. At present we are in an intermediate stage of reaching secure theory and in the process of developing measurements.

### ***Brainstorm and Discussion***

The brainstorm and discussion session focused on identifying and exploring socio-economic topics. The following list outlines the areas and observations aired by participants.

- **Incentives for the digital economy:** There is an need to understand the structure of the current and future ecosystems and the changing balance of power between providers, users, and prosumers considering the complex burring between all stakeholders.

There are complex issues due to the interaction between traditional and user-driven economics, e.g. user-provided networks (WLAN, etc.) and open source. The contradiction between the perception of “free” internet and sustainability will need to be addressed. These changes affect investment and shift the balance of power significantly to different parts of the ecosystem. The challenge here is then how to support investment in large-scale platforms due to the high costs and risks involved and government backed investments may be necessary.

Protection of interests can also be achieved using copyright and patents. Business models have been patented in the US, although to date there has been no successful litigation against infringement of a business model patent. Other mechanisms may be necessary to protect investment in innovation but it is not clear how this can be achieved currently.

- **Europe’s response to globalisation:** Some members of the audience asserted that Europe does have differential strength in terms of the global economy in terms of culture, languages in Europe and societal effects. The ability to deal with this diversity through infrastructure maybe attractive but does come at a cost in comparison to example the American and Chinese markets who are large are homogeneous.. Another challenge for culture is that it is difficult to commoditise in a global market place.

- **User modelling and technical design:** There was an observation that the nature of social science needed to shift from largely empirical studies to analysis that can affect and link in with technological design. Socio-economic analysis is largely disconnected from the technological innovation and this can also be observed through the interaction between FISE and other FIA groups.

There is a need for qualitative research of users' expectation along with quantitative analysis of large scale social data currently being captured as a result of mobile and social networking. Qualitative research was seen as particularly hard to deal with as defining indicators for wealth beyond economic wealth will be difficult to measure. However, research does need to occur in these areas so that a wider range of metrics can be combined that cover technical, business and social aspects of Future Internet systems. This all links to identity, accountability and transparency for socio-technical interaction.

It was observed that trust in information sources is now a critical issue especially when information is used as the basis for statistical studies. Today, such studies rely on third party authorities to approve data but for the Future Internet this will not be possible and new techniques will be necessary to track the provenance of information used as the basis for statistical analysis. It was also noted that current reports such as the Stiglitz report, which calls for measure of 'well-being' alongside growth, do not cover FISE sufficiently and there is an opportunity to address some of the objectives outlined through specific technological innovation.

## Management & Service-aware Networking Architecture

Session Report by: Alex Galis, University College London

### Objectives

The scope of the session was to review and brainstorm the priorities and research challenges in Future Internet and in particular:

- Preparation for the second MANA position paper “Future Internet Research Road Map”;
- Key FI research milestones for the next 5 years;
- Technical approaches to the design of the Future Internet (FI):
  - What are the ideas/means/ priorities related to the analysed capabilities that will drive the new architecture? How will these ideas be synthesized into an overarching architecture?
  - What are the building blocks and interactions related to the analysed capabilities
  - Review research priorities identified in the 1st MANA position paper

Inputs were the MANA and other position papers<sup>21</sup>.

### Presentations and Discussion

Short presentations of the results from the previous day's sessions were made: Architecture – presentation made by Henrik Abramowicz (Ericsson, Sweden), eID – presentation made by Markus Brunner (NEC, Germany) and Orchestration – presentation made by Alex Galis (UCL, UK).

Alex Galis (UCL) continued with an introductory talk on “*Future Internet Research Challenges – 1<sup>st</sup> MANA position paper*”. This outlined some of the drivers in the current internet and the rationale for change:

- $N \times 10^9$  connectivity points - status: reaching maturity and maybe some limits
- $N \times 10^5$  services/ applications- status: fast growing;
- $N \times 10^3$  exabytes of content - status: fast growing;
- 80 → 90% of lifecycle costs are operational and management - status: reaching crisis level;
- Consumers are becoming prosumers (i.e. producers and consumers).

Furthermore, the internet is not centric and it is increasingly polymorphic. As such it has to accommodate an increasingly wide and diverse range of systems: communication-centric systems, information-centric systems, context-centric systems, resource-centric systems, content-centric systems, service/computation-centric systems, device-centric systems, object-centric systems, things-centric systems and management-centric systems. A lot of capabilities and interrelated features are missing, leading to ossification reaching critical level. Some of the approaches enabling changes include:

1. Parallel Internets Progressive changes vs “Cleaner” slate and evolutionary;
2. Network of networks: system of coordinated → service networks/ polymorphic infrastructures;

<sup>21</sup> Available at: <http://www.future-internet.eu/home/future-internet-assembly/prague-may-2009/management-and-service-aware-networking-architectures.html>

3. Virtualization of resources (networks, services, content, storage);
4. Programmability;
5. Increased self-manageability as the means of controlling the complexity and the lifecycle costs.

The 1<sup>st</sup> MANA position paper had identified approximately 140 research challenges grouped as follows: I. General Capabilities; II. Infrastructure Capabilities; III. Control and Elasticity Capabilities; IV. Accountability Capabilities; V. Virtualization Capabilities; VI. Self-management Capabilities; VII. Service Enablement Capabilities; VIII. Orchestration Capabilities; IX. Overall Capabilities and as liked with an initial MANA architectural model.

The MANA session then organised into two brainstorming groups, which reported to the full session.

### **Conclusions and Next Steps**

The internet is becoming increasingly polymorphic. The Future Internet will be based on cooperating polymorphic infrastructures, where the boundaries between separate/silo systems would change in time and where the glue is represented by the orchestration of vertical and horizontal architectural elements and systems.

Top research priorities leading towards a research roadmap include:

- Open & standard languages/tools/models/APIs for groups/composition of resources description and use (for management and virtualisation); instantiated in different areas; extensibility of the languages; assurable capabilities; programmability of resources.
- In-system self-management (coordination of run-time different management control loops: service-nets-resources loops: dependency; stateful, service view, all operations; multi-domain, federation; integration).
- Mechanisms for orchestrations of different systems; stability & integrity guarantees; orchestration APIs; operation APIs).
- System-oriented cloud infrastructures: rethink and redesign networking, computing, storage, resource and content as planetary scale infrastructures/fabrics of FI: Convergence of Internet.
- Integrate general capabilities in the design of FI (identifiers, security, dependability, ... ).
- Methodology to define architecture.
- How to evaluate an architecture: What are the metrics? (meeting the requirements, what are the constraints); Might help the comparison of given architecture; How to evaluate the value of an architecture (apply different metrics).
- Restructure/Evolution the traditional plane (services, data, control, management) approaches.
- How to fit all the above into an overall picture – input from the 1<sup>st</sup> MANA architectural model.

The MANA community will prepare the second MANA position paper, “FI Research Road Map”, in time for the next FIA in Valencia.

## Real-World Internet

*Session report by: Alex Gluhak, University of Surrey*

### Objectives

The objectives of the session were to:

- Reflect upon the discussions in the various cross-domain topics and their significance for the RWI community<sup>22</sup>.
- Discuss about new ways forward for work on the core pillars of RWI.
- Discuss an initial approach for the RWI community towards Valencia.

### Presentations and Discussion

#### *Analysis of Cross-domain Sessions with Respect To RWI*

The RWI rapporteurs provided report backs on the various cross-domain sessions held the previous day. The following cross-domains topics were covered:

- **Discovery and search (Manfred Hauswirth):** The session presented interesting insights into current problems the different communities work on with respect to search and discovery (content-based search, non-text search, unstructured => structured search, service discovery, semantic issues and mediation, linked data, discovery of devices, etc.). In the panel discussion that followed, there was no discussion of search and discovery problems relevant to RWI which was felt to be a significant gap. We have to distinguish between searching for devices, services or for information.
- **Smart City (Mirko Presser):** The session consisted of three speakers and a panel discussion. The overall perception was that the city is a very good incubator for Future Internet technology, in particular the Real World Internet/Internet of Things. However technology is not the solution, but part of the solution to making a city smarter. Overall, the smart city would also be a very good environment for a Public Private Partnership in relation to the FIA, due to its relatively independent administration and governance as well as its incubator function and access to the public sphere.
- **Business architectures/Enterprise (Srdjan Krco):** The session Different Architectures For Different Business Models gave views in relation to architecture from networking, services, content, security and socio-economic perspectives. A common view was that a generic architecture is required that will be instantiated with different configuration settings depending on the business model requirements. A further session, FI and Enterprise, started with several short presentations that were followed by 3 knowledge cafes that were held in parallel. The topics of the cafes were: Visions and policies aspects, Socio-economic aspects and Technology aspects.
- Other sessions discussed included Identity and Trust.

#### *Knowledge Cafe*

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<sup>22</sup> The agenda and all presentations are available at [http://rwi.future-internet.eu/index.php/RWISession\\_Stockholm](http://rwi.future-internet.eu/index.php/RWISession_Stockholm)

Two 'knowledge cafe' sessions were held:

- **Internet of Things / NoF and Security, Trust and Identity:** The following topics were discussed:
  - Trust in an enterprise.
  - The (lack of) willingness of enterprises to invest in new technology due to high cost of replacing legacy systems that are working well.
  - The role of social networking in enterprises and whether it can improve efficiency.
  - Who holds and owns knowledge in enterprises, legal (companies) and factual (people).
  - Content – who holds the knowledge, legal and factual situation.
  - IoT – intelligent entities may reduce the amount of data exchanged, but not for sure. IoT is important as an input to improvement of work processes and decision making.
  - Cloud – private clouds will take off; will be used by large companies. Public clouds viable solution for SMEs.
- **Real world knowledge and service layer integration:** The following topics were discussed:
  - Modelling approaches for business processes which take into account devices are missing.
  - RWI involves event-driven / ad-hoc business processes, but the modelling of business / higher-level events out of real-world events is difficult and it is unclear if existing SOA software is ready for this.
  - “Filtering at the edges”, i.e., is highly relevant to prevent network / information overload. How can we provide mechanisms that support the extraction of knowledge but do not overload the network, nor drain devices too quickly (energy efficiency)?
  - There is a GAP between IoT and the Cloud (for example, using the Cloud for processing large amounts of IoT generated data).
  - There is a disconnect in the assumptions made at the various layers (services, discovery, middleware, networks, etc.) in respect to device capabilities, energy, reliability, location, etc. which hinders progress.
  - RWI calls for a “continuous” knowledge management approach which does not exist yet.

When reflecting upon the discussion in the different cross-domain topics with respect to the RWI agenda, a set of following observations has been made:

- How to handle exceptions (detect and manage it), when things go wrong
- Common FIA reference model and taxonomy: Issues include reconciling assumptions, gap identification, convergence of ideas. Consider CERP-IoT / Casagras work here as well.
- Event based communication: Publish subscribe based communication; synergies with FI community activities; general purpose software landscape is not ready yet.
- Internet as a system-of-systems: One size does not fit all; pluralism of architecture and solution (how to support this).
- Bring Internet closer to the people / the real world not only integrating the real world into the Internet.
- Control of services and applications is becoming increasingly if they rely on highly distributed real world services spread across different administrative domains.
- There is no consistent set of functional requirements for the Real World Internet.

### Conclusions and Next Steps

It was noted that while RWI community meetings are excellent, there is too little activity between the events. Therefore, in future the focus will be on joint undertakings within the RWI community

such as white papers, recommendations to other FIA communities and interactions with the CERP-IoT cluster.

Work towards Valencia will focus on the synthesis of ideas from the project part of the RWI community. Two working documents will be initiated, resulting in white papers that will be shared with the broader FIA community.

- 1) **White paper on RWI Reference Model.** This will outline the development of a Common Terminology, and synthesize an architecture from results of different projects in the RWI community.
- 2) **White Paper on RWI Problem Space And Current Solutions:** This will define the RWI research problem space; assess existing solutions coming from the RWI community, and identify solutions from related areas that are applicable to the problem space.

## Trust and Identity

*Session Report by FIA T&I Caretakers: Jim Clarke (WIT), Volkmar Lotz (SAP), Nick Wainwright (HP)*

### Objectives

The Trust and Identity 'plenary' brought together the T&I research community to discuss and review the FIA T&I tracks that we have been participating in, to review the FIA processes and consider what actions and steps should be taken to further improve the effectiveness of participation in FIA, and to consider what activities should be scheduled for FIA Valencia and beyond.

### Presentations and Discussion

The session received report-backs from the two parallel sessions organised by the T&I track – e-ID provisioning and How to Measure Trust – as well as the FIRE session at which the use of experimental facilities for trust and security were explored, and the Smart Cities session.

In general, it was felt that the cross-domain interactions were valuable, and that this should be emphasized with more opportunity for this kind of interaction. The session structure created by the caretakers for the T&I sessions for FIA Stockholm enabled a wide range of researchers from both the T&I field and other research domains to contribute and interact. It was noted that maintaining momentum would require follow-up after the FIA events, for example through collaboration on position papers, and that the opportunity to submit papers to FIA would be valuable.

It was felt that there is a need for more information about FIA, the Commission's expectations for FIA, and goals that it has for FIA to be communicated to the FIA signatory project communities and also to communities outside.

### Conclusions and Next Steps

Discussion of the upcoming topics for FIA Valencia concluded by identifying three topics that are priorities for the Future Internet and which would benefit from cross-domain attention through the Future Internet Assembly:

- 1) There should be continued work on **e-Identity provisioning**, focusing on privacy and ID provisioning across the layers, and looking at the short, medium and long term issues, including considering how network infrastructure evolves and their impacts on the topics;
- 2) In the Future Internet, it is important to consider what new threats will emerge that will demand new and different security approaches. Therefore, **Security for the Future Internet** is a topic that should be addressed through a cross-domain approach in FIA;
- 3) The user perspective and how to engender **Trust for the Future Internet** in the user of the systems and services was considered to be an important topic for Valencia, building on the work in FIA Stockholm.

The opportunity to have less formal working sessions in between the FIA events has contributed to ensuring that the T&I research community works well together. The T&I caretakers held a preparatory workshop on 7 Oct. 09, which had helped considerably to plan for and create worthwhile sessions and real progress at FIA Stockholm. It was agreed to hold another interim preparation event before FIA Valencia (during February 2010) to address these topics, and that planning for this event would start right away.

## Usage of Facilities

Session Report by: Anastasius Gavras, Eurescom GmbH

### Objectives

The objective of this session was to understand the results and conclusions of the cross-topic sessions held on 23 November and to develop a roadmap for further work in the area of “Usage of FIRE facilities and experimentally driven research” Working Group.

### Presentations and Discussion

The following presentations were made<sup>23</sup>:

- *Doing Experimentally-driven Research on WISEBED – Preparations, Deployment, Evaluation*, Mesut Günes, Freie Universität Berlin
- *Future P2P Systems and Experiments*, Charalabos Skianis, Aegean Univ.
- *Experimentation Experiences in N4C*, Maria Uden, Lulea University of Technology, Sweden
- *Towards being Always Best Connected – the PERIMETER Way*, Markus Fiedler, Blekinge Institute of Technology, Sweden
- *Experimentation Process for the Assessment of Self-management Behaviour in FI*, Nancy Alonistioti, Univ. of Athens
- *Experimentation-driven Traffic Monitoring and Engineering Research*, Amir Krifa, INRIA.

The session also received conclusions from the sessions “*Deploying on FIRE*” by Anastasius Gavras, Eurescom GmbH, and “*What does it mean to conduct experimentally driven research?*”, by Nancy Alonistioti, Univ. of Athens.

### Conclusions and Next Steps

The following actions were identified based on the two FIRE cross-topic sessions (*Methodology – How to apply experimentally driven research?* and *Deploying on the FIRE facilities*).

- 1) Action to draft a paper elaborating on the fundamentals of the methodology and its benefits:
  - The terms used for the methodology formulation should be elaborated and clearly specified – contribute to the experimentation vocabulary
  - The user selection process for the involvement in the experimentation should be addressed per use case class
  - The methodology will encompass several iterations
  - The methodology will be complementary to benchmarking, prototyping, etc.
  - Develop a position paper to reach consensus on the above
- 2) Action for creating necessary specifications to satisfy deployment requirements on FIRE facilities:
  - A common language for resource descriptions
  - A common language to describe experiments
  - A common language to describe results

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<sup>23</sup> Available at <http://www.ict-fireworks.eu/events/fire-events/fia-stockholm/fire-plenary-session.html>

- Standardized APIs to access resources
- Single sign-on / one-stop shop – i.e., a common approach for managing user credentials

The session concluded with the identification of topics and session formats for the next FIA to be held in April 2010 in Valencia, Spain. These included:

- 1) Cross-topic on virtualisation
- 2) Create European market for testing and experimentation facilities
- 3) Organise a cross-project test session.

## Closing Plenary

### Future Internet as Seen by Ericsson

*Håkan Eriksson, Senior Vice President & Chief Technology Officer, Ericsson*

*Broadband internet underpins our digital society and is central to becoming more sustainable. Much of the future internet growth will be in mobile broadband, but important questions remain about how this expansion is to be financed. Finding investors with the necessary resources will be a real challenge.*

As academics such as Carlota Perez have observed, IT & telecommunications is just the latest in a wave of technological revolutions experienced over the last 250 years. Such revolutions propagate in two stages: an initial installation phase where the focus is primarily on more efficient solutions to existing problems; and a second deployment phase, where the focus shifts to applying the new paradigm to innovate across society. The first phase tends to benefit existing incumbents, whereas the second opens the market to new players. The transition or turning point between the two is typically 20-30 years.

Broadband internet is at such a turning point now, Mr Eriksson observed. Some 40 years after the invention of the internet and 20 years after the invention of the worldwide web, we are now becoming a digital society – with smart media, smart homes, smart utilities, smart travel, etc.

In recent years, important questions have begun to be asked about the sustainability potential of ICT. Currently, the ICT sector itself accounts for only 2% of global emissions; this is very minor in view of the policy commitments to reduce emissions by 50-80% by 2050, during which time global GDP will triple. For instance, charging and using a mobile phone for a year produces around 23 kg of CO<sub>2</sub>, which is equivalent to driving an average car for just one hour.

“So ICT is part of the solution rather than a major part of the problem”, Mr Eriksson observed. Creating a sustainable society will require substantial investment in technology and it is estimated that ICT can contribute between 15-20% of the necessary savings.

Turning to the internet in more detail, Mr Eriksson noted that the growth in broadband was truly staggering. Already today around 400 million households worldwide have fixed broadband (around 1 billion subscribers), while there are 1.5 billion mobile subscribers (up from 700m in 2003). Tomorrow’s market will encompass full service broadband covering many billions of devices – potentially up to 50 billion. Over the last twenty years, bandwidth in the last mile has gone up by a factor of 2000, and in edge routers by a factor of 50. Similar growth is seen in the capacity of mobile networks, although this tends to lag fixed networks by around seven years. By 2013/14, around 80% of broadband subscribers will be mobile.

***“We should not assume that sufficient connectivity for everybody to use will just appear”***

All of this has huge implications for mobile access networks. At present only 1% of internet traffic is carried over mobile networks, but already this comprises more data than voice. Between 2007-09, 3G traffic grew by a factor of five (around 12% per month). If this continues total traffic over mobile networks will increase by a factor of 1000 by 2014. Can we handle such growth?, Mr Eriksson asked. It ought to be possible, but we need appropriate spectrum allocation as well as new ways of financing network development.

Usage patterns in mobile networks vary significantly throughout the day: voice traffic tends to peak in the early evening while the majority of data is sent in the small hours (by automated systems). A possible solution is to introduce a traffic handling strategy, prioritising non-p2p users during busy times of the day.

The 'capacity versus revenue challenge' is another important issue. If we continue on the current trajectory, we will, potentially, have to accommodate a thousand-fold increase in capacity within the next few years. Upgrading all voice users to broadband users would, at most, only double the network operators' revenues. Other options will need to be investigated such as: charging for micro devices like sensors; and differentiated tariffs where the value of connectivity is much higher than is charged at present. Alternative revenues from new communication and information services will also be an important area.

Summing up, Mr Eriksson emphasised we should not assume that sufficient connectivity for everybody to use would just appear. Finding investors willing to put up the necessary resources will be a real challenge. Yet, this is absolutely necessary for the Future Internet to become a reality and policy-makers and consumers should not expect industry to make such investments for free. A strong dose of commercial realism is required.

## Feedback from Parallel Sessions

The Session Caretakers presented summaries of the discussions in the parallel sessions and the seven FIA Working Groups, as reported in the main body of this report.

## The Future Internet Conference in Valencia

*Jésus Canadas-Fernandez, Ministry of Industry, Spain*

*The fifth Future Internet Assembly meeting will be held in Valencia, Spain, in April 2010 as part of a series of events focusing on the future context of European innovation and research programmes.*

Mr Canadas-Fernandez announced that the next Future Internet Assembly would be held in Valencia under the Spanish Presidency, as part of a week of events entitled *FP7: European Innovation and RTD Transforming Sectors*.

The Conference "*The European Framework Programmes: From Economic Recovery to Sustainability*" will be the key public event, launching a series of new PPPs – including the Future Internet PPP - as the cornerstone of the smart investments under the European Economic Recovery Plan. Side events will be held on green cars, factories of the future, and energy-efficient buildings. The FIA and FI Forum meetings will take place on 15<sup>th</sup> and 16<sup>th</sup> April. In total, around 1000 people are expected for the FIA and the co-located events.

The programme will also provide opportunities to investigate the heritage of the ancient city of Valencia. Further details will be posted on the website [www.r2sconference.eu](http://www.r2sconference.eu) as they become available<sup>24</sup>.

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<sup>24</sup> Voting on FIA conference topics for Valencia is also available via [www.fi-internet.eu](http://www.fi-internet.eu)

## Closing Messages

*Gunnar Landgren and Mário Campolargo*

Returning to the podium, Prof. Landgren observed that the Future Internet community was now two years into the process that had begun at Bled. The successes achieved since then clearly showed that the European Commission took the right decision in initiating such an Assembly and that the initiative was on the right track. The PPP Communication was a major milestone and it was gratifying to see these ideas being taken forward. The seven working groups were also valuable, as was the FI Forum. All of these would take further steps in the run-up to the next Assembly meeting in Valencia. At the same time, it would be important to consider the political priorities under the new Digital Agenda, where Future Internet was sure to loom large. Finally, it was necessary to take due consideration of the Work Programme for 2011/12 and of the EIT's Knowledge and Innovation Communities (KICs), one of which was likely to relate to the FI<sup>25</sup>; both of these would create needs for further coordination. Prof. Landgren thanked all of the organisers involved in the meeting, including for the excellent gala dinner held the night before.

***“The successes achieved since Bled clearly show Europe’s Future Internet initiative is on the right track”***

Mr Campolargo observed that with the PPP coming to maturity and new calls coming up, Europe's FI efforts were moving forward at an accelerated pace. He reiterated his thanks to Prof. Landgren and his team, and to the event's sponsors. Special thanks were due to the caretakers for their efforts in organising the sessions, and to representatives from industry, the Member States and colleagues in the Commission. Finally, he thanked delegates for their support for the Assembly and looked forward to continuing the discussions in Valencia.

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<sup>25</sup> <http://eit.europa.eu/kics1/eit-ict-labs.html>