Internet of Things: an early reality of the Future Internet

WORKSHOP REPORT

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Information Society and Media

"They say a year in the Internet business is like a dog year, equivalent to seven years in a regular person's life. In other words, it's evolving fast and faster".

Vinton Cerf

Foreword

Ten years ago, Kevin Ashton, then brand manager at Procter & Gamble (P&G), said: "*Adding radio-frequency identification and other sensors to everyday objects will create an Internet of Things, and lay the foundations of a new age of machine perception.*" Today, he goes even further by stating that "*the Internet of Things has the potential to change the world, just as the Internet did; maybe even more so.*" (RFID Journal, June 22nd, 2009.)

In November 2005, a team of nine experts from ITU's Strategic and Policy Unit led by Lara Srivastava, foretold an Internet of Things where "*eventually, it will be feasible to 'tag and track' virtually every object on earth.*"

In June 2009, the European Commission adopted a Communication acknowledging the role of the Internet of Things to address today's societal challenges: "*an ageing society (...), deforestation (...), traffic congestion (...), recyclability (...). This interconnection of physical objects is expected to amplify the profound effects that large-scale networked communications are having on our society, gradually resulting in a genuine paradigm shift.*"

On the industry side, in September 2008 a group of high-tech companies declared its intention to create a new kind of network that would allow sensor-enabled physical objects – appliances in the home, products in a factory, cars in a city – to talk to one another, the same way people communicate over the Internet.

After ten years of academic research and expert insight into the nuances of the Internet of Things, the latter is at last coming. Underwear that measures blood pressure, washing machines that start up only when electricity is cheap, smart meters that provide real-time, two-way communication between customer and electric power company – there are already many examples of real-world objects that eventually may become "*objects that blog*" (Julian Bleecker).

On that day of May 10th, 2009, the European Commission was proud to gather several eminent and internationally well-known experts to debate the main challenges and opportunities of the Internet of Things within the overall context of the Future Internet. It's been a great honour and privilege for me to chair the workshop and welcome these experts, whose command of the issues — and ability to explain those issues in plain language — was a joy to behold.

What was striking was that all the speakers were very proud of the remarkable ties of heritage and destiny that bind them across the different geographical, political, cultural and linguistic boundaries. These ties are strong, deep and enduring, made of a common allegiance to the goal of continually harnessing technologies to enable a dynamic, sustainable and user-friendly information society. In these troubled times, as several world economies are on the brink of depression, the speakers surely offered the hope for a recovery through innovation in the years ahead.

The present report gives the statements and results of this workshop which concludes, among other things, that future networks, network architectures and the Future Internet will be driven by the Internet of Things, and that experts from all over the world should work together to help create a common reference model for the Internet of Things.

Gérald Santucci

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Introduction

European Internet scientific and economic actors, researchers, industrialists, SMEs, users, service and content providers are determined to redesign the Internet, taking a broad multidisciplinary approach and thus shaping the Future Internet.

The European Commission launched a wide ranging consultation of all Internet of Things (further: IoT) stakeholders and adopted on 18th June 2009 a Communication that will give rise to a set of actions, initiatives and policy debates. In this context, an "Internet of Things" means "a world-wide network of interconnected objects uniquely addressable, based on standard communication protocols", or, more widely: "Things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts".

Equally a number of technical and policy challenges like security, privacy and data protection, control of critical global resources and identity management, naming and interoperability will be at the heart of a sustainable Internet of Things approach.

This special workshop was organised within the overall context of the High Level Future Internet Conference 11th May 2009 in Prague, with a view to addressing the Internet of Things as a major likely scenario of the Future Internet, and truly explore what ways forward would be necessary for society to benefit from the opportunities this would bring to society.

João da Silva, Director for Converged Networks and Services in Directorate General (DG) for Information Society and Media, welcomed the participants and underlined the Commission's keen interest in the subject. Key subjects in the newly adopted Communication include awareness, spectrum, standards (global, or at least well beyond Europe), and governance. In addition, Europe wants to be on the forefront of the development of IoT, and is very well placed to be so.

Gérald Santucci, Head of Unit for Networked Enterprise and Radio Frequency Identification (RFID) in DG for Information Society and Media, and Chairman of the meeting, added that the meeting does bring together a good number of people from different sectors to discuss the issues relevant for IoT. There are 27 countries, and this brings opportunities to learn from each other, as some applications will be more advanced in some countries than in others. At the same time it is important to continue to realize that different steps may be needed in different parts of Europe. This meeting was an opportunity to advance the common understanding and raise the awareness on specific developments in the field.

What should be the EU strategy towards the Internet of Things?[1]

It is a pleasure to be able to make a next step in the ongoing activity of discussion of the IoT as it is a very important subject. What has changed already since we begun to discuss the issues, 3 years ago, RFID was mainly considered as a part of logistics, not so much the Internet at large. Nowadays it is clearly connected to the ongoing development of the Internet, mobile Internet, etc. The Internet as we know is 20 years old, RFID is older, and mobile Internet is younger. But now all the technologies come together that allow us to develop all those services that we could only imagine a couple of years ago. We are in a critical moment – not only for technology at large, but also for the European technology. We are moving from an economy of machines to an environment in which many objects will be connected. The Internet is about to leave the computer and become part of the person itself.

The Internet is beginning to be less and less centralized, from big mainframes to microcomputers to mobile to everything. Europe missed in this the first step. While the WWW was developed in Europe by Tim Berners-Lee, we were not present in the development of the big services that have become the face of the Internet today (Yahoo, eBay, Amazon, Google). While we were still focusing on infrastructures, the world moved along in developing services. We need to get back into the game, and come back to the global competition.

We have some unique features that should give us a good start: <1> a very large mobile base (users and producers); <2> cultural and geographical contents that are the biggest source in the world. We should benefit from that. Proximity services are such a clear new opportunity: tourism, sustainability, etc. Development of the smart grid is key in this, including sharing and feeding back energy that is not used, also key in President Obama's programme. Google, for instance, invested heavily in "smart meters" that can help households to spend less.

With this evolution, new companies, new sectors, that were previously completely outside the technology area become now central in technology development. Big businesses in retail will go way beyond the point of sales and become information super centres. We need to create the technological, legal and business conditions in which these new services can emerge. Key in this:

1. Create a trust environment; people have to be in control of those technologies, and should be enabled to do so (e.g. "able to switch off", the right to the silence of the chips, the right not to appear on images). This right is new and necessary in order to enable trust;
2. Need to ensure a European control base on this; we don't want to go to a situation in which all these data would become available to other governments that could use it for electronic surveillance;

[1] Based on a contribution from Bernard BENHAMOU, French Delegate for Internet Usages, Ministry for Research and Higher Education.

3. We need to create projects that are relying on these technologies. In the last years we have started to build a non American root for IoT based on ONS in France.

France is also building a large application for mobile services this year, what will be the first big IoT application built on a root governed by France (Proxima Mobile).

We hope this will be an incentive to our European partners for public sector architects to help build more of these. We need an ecosystem in which small companies can develop innovative services that partly would grow out to the new big applications and un-imaginable services.

Trends and promises in IoT (current developments and possible scenarios)[2]

In order to meaningfully connect things in IoT, getting the semantics right is key. Imagine a parcel, continuously communicating via Twitter on every event on its way, and, when things go wrong, maybe even collaborating with other parcels, correcting the situation that was never intended.

Interesting thoughts, which could be the start of a new movie, yet the point is - it is clear that we are dealing with different domains that speak different languages, for example:

1. User domain - human readable text, e.g. progress, status and delivery estimate on Twitter posted by the parcel;
2. Object domain - machine interpretable data, e.g. record of condition, dropped and damaged, by whom, when and where?;
3. Application (Postal Service) domain - application interpretable data, e.g. meaningful location to the postal infrastructure;
4. Application (Customer Service) domain - application and human interpretable data, e.g. status, location, delay for customer satisfaction analysis and optimisation.

We need to form a link through cyberspace between the physical world and communities to enable innovative un-foreseeable services and applications, and gaining new knowledge about economics, environment and us. Semantic integration can be that link between cyberspace and the physical world and consequently information about the real world can be offered as knowledge (just like documents and websites today) to communities.

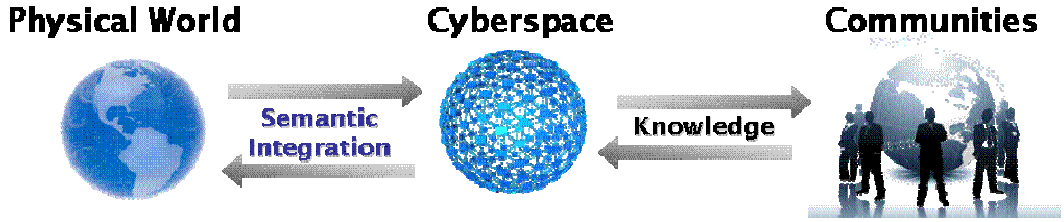


Fig. 1 – using cyberspace to link physical world information to communities

Making sensor-generated information usable as a new and key source of knowledge will require their integration into the (existing) information space of communities, which will lead to semantic integration. For semantic integration, we need to have middleware to which we add a semantic layer that allows different applications to talk with each other and create a mash up of real world knowledge.

2 Based on a contribution from Mirko PRESSER, FP7 SENSEI R&D Project Technical Manager, CCSR Wireless Sensor Network Research Lab, The University of Surrey, UK.

Thinking a bit bigger you can see the world as one big box of knowledge, and the dream would be to access all this knowledge like a database. This requires structured querying; integrated views, and aggregation and analyses leading to reasoning upon the data.

Arguably, today, the core technological building blocks are in place and (widely) available: ontology languages, flexible storage and querying facilities, reasoning engines, etc. Standards and guidelines for best practice are being formulated and disseminated by e.g. the W3C. But it is still difficult to oversee the scale and time dependency of data, and how to deal with storage and querying continuously growing masses of dynamic information. Semantic modelling is a need here, both for sensors, and sensors data; interoperability of domain specific semantics, and integration with the social semantic information spaces. Today, we haven't dealt with the data coming from objects in a useful and horizontal (no application silos) way, yet. How can we deal with an explosion of information?

In conclusion: "By 2015, wireless networked sensors in everything we own will form a new Web. But it will only be of value if the 'terabyte torrent' of data it generates can be collected, analyzed and interpreted." (Quoting Gartner).

Gérald Santucci concluded that the semantic integration is truly at the very heart of IoT, as it is key to know how objects can communicate in a meaningful way.

In addition, via the link http://www.ict-sensei.org/Sensei_090422/ interesting IoT scenarios from the SENSEI project are presented in three languages.

Japan's uID strategy and international cooperation opportunities[3]

Professor Ken Sakamura, who has a long track record in the field, kicked off by explaining that automatic identification was already big in Japan. All together, annual sales in 2008 were in the order of magnitude of 2.15 billion EURO, of which about 14% RFID (~320 million EURO). It is mainly used in Factory Automation (FA; 27%) and Office Automation (OA; 26%).

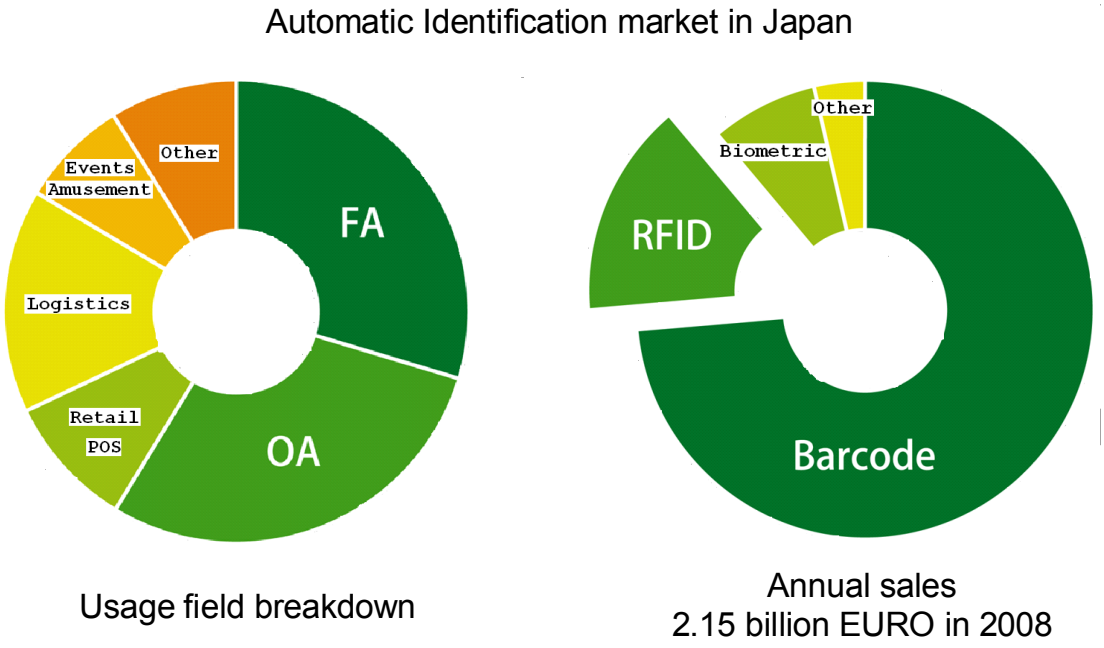


Fig. 2 – automatic identification market in Japan, 2008

Current use is mainly in closed/proprietary systems within organizations; often simply replacing barcodes with RFID tag information on the product it is linked to. RFID usage as such continues to grow by about 10% per year.

A specific development in Japan is the Unique/Universal/Ubiquitous IDentifier (uID) architecture. It is networked based, and it is a response to the reality that most of the use of tags is in closed environments. With closed use of tags, many different tags are added for other closed environments. uID tries to integrate those tags. The uID is simply a number that points at networked information. In that way:

1. The number on the tag finds its meaning in the network, which may be a different meaning for different parties;

[3] Based on a contribution from Professor Ken SAKAMURA, Director, YRP Ubiquitous Networking Laboratory and University of Tokyo, Japan. YRP UNL is a participating member of FP7 EU- funded project CASAGRAS (more on CASAGRAS on page 12). His research and development team also works with TEKES (page 17) on collaborating IT projects.

2. The meaningful information is obtained from servers in computer network;
3. Access restriction to this meaningful information for security and privacy management can be simply based on the network security. If additional cost is not an issue, reading IDs can be restricted from RFID tags. But it adds cost to tags considerably and as a result, such tags look more like expensive security IC cards.

Standardisation takes place on the middleware layer, not on the tag, or even the reader/writer of the tag, like what is currently happening in the EPCglobal environment. This is depicted below.

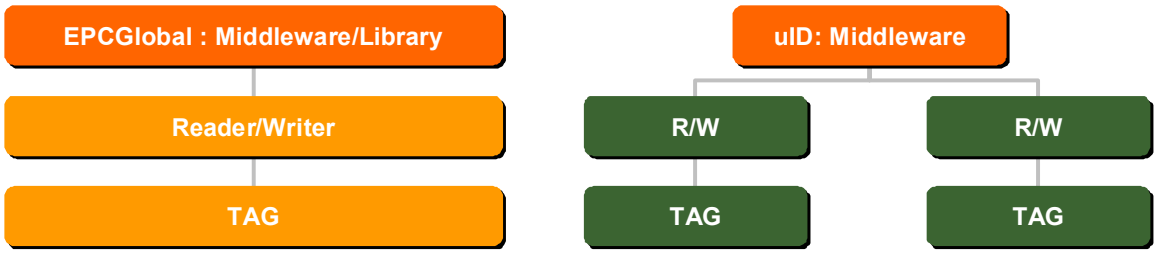


Fig. 3 – interoperability levels with EPCglobal and uID

As ucode is based on 128 bits, there is plenty of address space for many years to come. The memory space, as said, is only needed for storing the number that refers to the data source. In addition, where EPCglobal uses tags at UHF, HF and frequencies for active tags, the uID architecture allows many types of RFID (active and passive) tags to be used, but also optical barcode, sensors etc., according to the needs of applications. Any tag or similar system can be used that can store a number and can be read by networked applications.

Examples of current ucode usage for objects include traceability of fire alarm systems (more than 1 million shipped), food (many experiments have been done) and drugs (including intelligence, i.e. signalling the need to take a drug, the bad combination between drugs, etc).

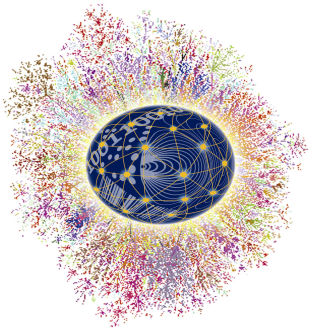
Ucodes for locations have been used, for instance, in Ginza. Many ucode tags, wireless markers and infrared markers help people find their way in personal navigation, also within buildings and underground, as the system is not dependent on GPS. The ucode is seen as a very powerful enabler of systems that can assist elderly and others needing assistance in the normal daily life and/or work environment.

The Japanese uID centre is seeking collaboration with others to create more centres in the world, and talks with EPCglobal about advantages of further cooperation.

Key technological and governance challenges[4]

Dr Furness was introduced as coordinator of the EU-funded project CASAGRAS ('Coordination and support action for global RFID-related activities and standardisation'), which aims to provide a framework of foundation studies to assist the European Commission and the global community in defining and accommodating international issues and developments concerning radio frequency identification (RFID), with particular reference to the emerging 'Internet of Things'.

A first challenge was to create a common understanding of the concept of IoT. This concept is not only about technology, but about a structure, a capability, a value proposition, and a robust, scalable and sustainable development for the future. Despite the fuzziness of definitions ("Internet of Things 2010") IoT is a concept that is now being influenced strongly by developments in computing and network ubiquity and developments in the next generation Internet - and considered at all levels including United Nations (see quote below).



"We are heading into a new era of ubiquity, where the users of the Internet will be counted in billions, and where humans may become the minority as generators and receivers of traffic. Changes brought about by the Internet will be dwarfed by those prompted by the ***networking of everyday objects*** *" – UN report*

Each definition attracts the rhetoric and hype that fuel enthusiasm and dreams of what might be achieved, often without consideration of the practicalities. The vision statement CASAGRAS developed for IoT is "A world where things can automatically communicate to computers and each other providing services to the benefit of the human kind." Based on this vision, CASAGRAS proposes the following definition for IoT:

> *A global network infrastructure, linking physical and virtual objects through the exploitation of data capture and communication capabilities. This infrastructure includes existing and evolving Internet and network developments. It will offer specific object-identification, sensor and connection capability as the basis for the development of independent federated services and applications. These will be characterised by a high degree of autonomous data capture, event transfer, network connectivity and interoperability.*

Actuation and control are further important elements that need to be considered within such a definition. But definition is one thing, reality is

4 Based on a contribution from Anthony FURNESS, Chief Technical Director for the European Centre for Automatic Identification and Data Capture (AIDC), project coordinator of CASAGRAS, European Centre of Excellence, Halifax, UK.

another. It is important to choose a way to explore and explain the nature of objects, and how to link these objects in meaningful ways to human kind. Having a structure and a methodology is invaluable in moving forward in the understanding and development of the IoT. A model depicting the domain could be:

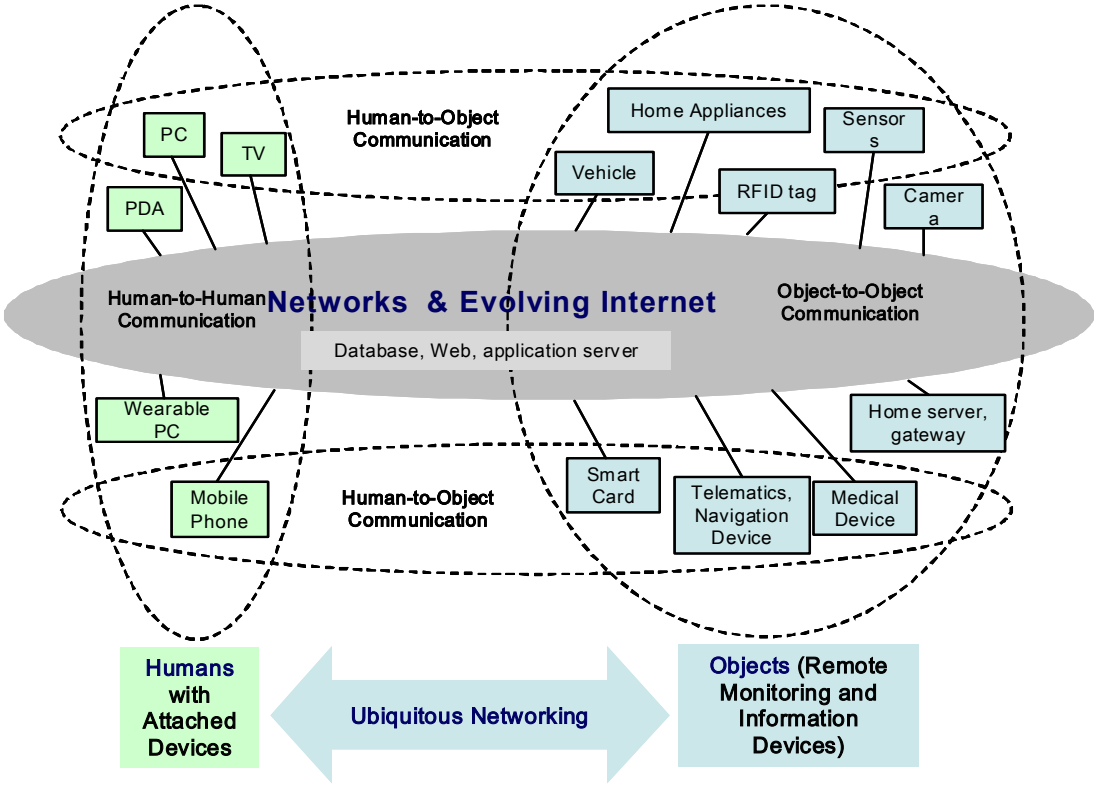


Fig. 4 - Internet of Things environment

The principal challenges, representative of the wide ranging practicalities required to engineer an IoT, include:

- **Interfacing with the physical world** – accommodating the capacity and transfer needs (of an estimated 50,000 billion objects) – also data, information and knowledge management and handling the obsolete;
- **Communications and connectivity** – wireless (radio platforms integration), spectrum usage – software and cognitive radio – tag pollution?;
- **Exploiting developments in ubiquitous computing and networks** – embedded platform needs – nano-tube radio and sensor platforms;
- **Global identification** - connection and integration with the evolving Internet – IPv6, accommodating legacy systems (EPC, ucode, etc.);
- **Security of data and systems and against attack** – particularly issues with respect to autonomous networks and protection against malware;
- **Reliability** – self-diagnosis and repair – including sensory, actuation and control systems;
- **Standards and needs for interoperability;**
- **Governance.**

The more inclusive the IoT is, the more complex the demands and challenges. Global identification is important, yet there is a wealth of legacy systems in commerce and services as well as systems currently emerging in the Internet world.

CASAGRAS[5] is to provide recommendations, and proposes a new approach using Object Identifiers and exploiting Unique Item Identifier (UII) concepts and namespace resolver to accommodate legacy coding schemes for identification. It is also considering a range of standards, including those from ISO, IEC and EPCglobal[6]. These standards need to support a value proposition that exploits a defined infrastructure and provides scope for commercial venture – federated services and applications. They need to support scalability, security and structures to accommodate failure in functionality. Currently CASAGRAS is considering the importance of a dedicated top-level domain to address issues and support the development of IoT and associated services.

Governance is a big issue. Issues like dealing with coding and legacy systems need to be resolved, and standards need to be set, if we want to have a model of IoT that is inclusive. Dr Furness concludes with the remark that there is still a long way to go in exploiting the full potential of object connectivity – and that we are on our way. RFID is only part of that equation.

5 CASAGRAS website: http://www.rfidglobal.eu
6 GRIFS Report on standards - http://www.grifs-project.eu/data/File/GRIFS%20D1_3%20State%20of%20the%20Art%20Report.pdf

Potential applications in the enterprise world[7]

Stephan Haller focused on the introduction of the IoT approach into the business process. He emphasized that he saw IoT as an integral part of the whole future Internet, enabling the establishment of service platforms that provide insight in the developments of the "real world" through collection of information from sensors, and allow a reaction from that understanding towards the complex reality. This is depicted in the picture below.

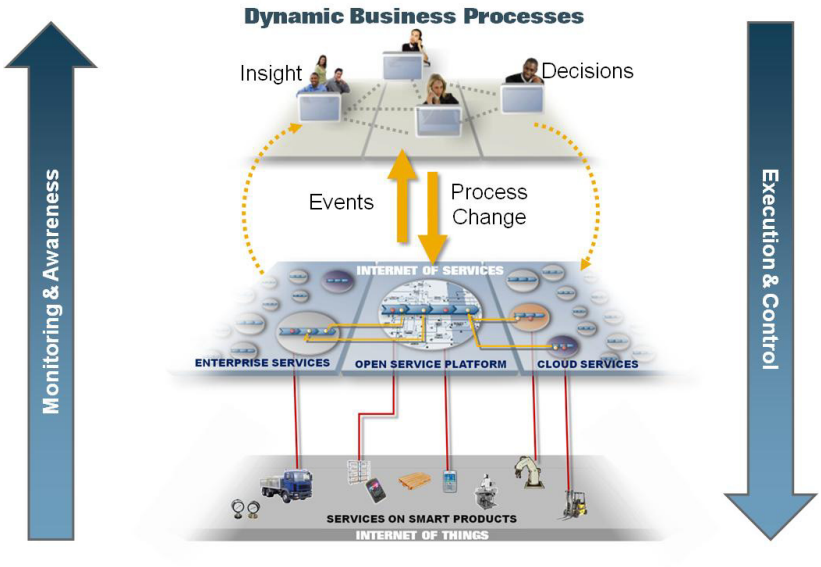


Fig. 5 – IoT and real world Internet. Source: SAP, Haller, 2009

For IoT RFID is most talked about, but there are many more technologies contributing to that understanding. SAP is coordinating a project called ADiWa ("Allianz Digitaler Warenfluss", Alliance Digital Product Flow) which aims to research technologies for enterprise applications, used to plan, control, and execute complex and dynamic business processes involving IoT. Important subareas to consider when realizing such an environment include IoT and logistics, but also security; analysis, modelling and simulation of business processes; modelling and processing of complex events; and finally application and evaluation.

New developments (beyond the "traditional" areas of logistics and retail) include Dynamic Service products, and "lean and green manufacturing". Dynamic Service products are products for which the care by the provider is moving well beyond the point of sales: the provider is no longer selling a machine, but a service, which may well include just in time maintenance and insurance of service continuity. These systems would also allow the provider to

7 Based on a contribution from Stephan HALLER, Senior Researcher, SAP Research, CEC Zürich, Switzerland.

follow and understand usage patterns by clients. "Green" services are services that optimize environmental impacts of production and logistics – making best use of natural resources.

ADiWa (http://www.adiwa.net/index.php?id=108&L=0) builds on the projects SemProM (http://www.semprom.org/semprom_engl/) and Aletheia (http://www.aletheia-projekt.de/index.php?id=79&L=0) and adds the ability to manage the processes in integrated environments. Crucially, IoT will lead to better informed and potentially automatically interactive business processes.

Potential applications for society[8]

In business environments things are much more straightforward. There can be measuring of costs and benefits, performance, etc, and decisions can be taken based on this knowledge. Societal applications have to be built much more solid, robust, and in a way that they are accepted. There are no killer applications yet, but one would expect them to come, like: transportation, energy and resources environment monitoring, safety and security, healthcare. Monitoring and increase of efficiency should well be possible. Another application is asset management (expensive instruments, public owned; nothing should be lost, or used in areas where it is not proprietary; we need to know the status of maintenance). Also for smaller things like medicine: where is it, what is its status, what are the used dates, how many have been used by whom?

The challenge is that we have many solutions that are merely technical, and these need to be translated into solutions towards users and markets (and therefore requires participation of users and testing in markets). Two of these are:

<1> creation of solid implementation backbone/future Internet;

<2> adapting societal backbone (legislative and regulatory measures to back this up).

We are on a slippery road with the Internet currently. There is too much unwanted traffic, and issues like privacy and reputation arise, scalable routing is just becoming to be possible, mobility and multi-homing are growing from incidental to mainstream, and it is not clear yet where resources for investment will come from, and how these will be compensated.

Yet dealing with these issues in itself is not enough, as new future Internet challenges are already arising. Changing usage patterns need to be convened, socio-economic impacts need to be considered, autonomous use and resilience become crucial, and bottlenecks like energy consumption, limited computer power, and the length of technical lifetime of the installed base need to be addressed.

On the way to societal IoT applications it is important to perform many feasibility study experiments and pilot implementations, to really meet and weed out potential problems that lie ahead. It is important to learn from potential bottlenecks and problems including non-technological such as security and privacy issues and come up with solutions BEFORE a wide deployment is pursued. Cooperation, in order to be able to conduct large-scale real-world feasibility study experiments to identity such problems, is crucial.

Finland truly looks across the border for cooperation with USA and Japan, as well as European collaboration through FP7, as it sees cooperation as essential.

[8] Based on a contribution from Kimmo AHOLA, Chief Technology Adviser, Tekes – Finnish Funding Agency for Technology and Innovation.

Mr Ahola concluded that:

- The future information society will be based on IoT, ubiquitous computing devices, networks and their novel solutions.
- When handing over IoT from engineers and designers to users and markets solid backbones are needed, including Internet, and a legislative backbone.
- To find possible bottlenecks early enough many feasibility studies should be carried out as cooperative national and international efforts of companies, research groups and public sector stakeholders.

Gaining visibility: towards the Internet of Things[9]

GS1 EPCglobal standards are designed to improve visibility. Visibility is one of the key components of the roadmap towards the creation of the Internet of Things vision. When we talk about visibility we talk about what is happening with an object. Knowing where things are or have been in time, and why, and not just within your own four walls, but also within supply chain partners' walls. It is all about understanding the processes that affect the life of an object and its usage, and thus providing the ability to answer a broad range of questions, i.e. status, current location, change of custody, etc. In this way, IoT brings awareness of the physical world through supporting standards and systems. This also allows, for instance, transformation of business processes through global visibility of products, assets and other "things".

GS1 is an independent non-for-profit organization that develops visibility standards, and it is neutral towards the interest of particular groups and sectors. It provides a natural platform enabling organisations with different interests to collaborate. User companies and solution providers are deeply involved in the GS1/EPCglobal standards development processes and in governance. This ensures that GS1's developments respond to real business needs. GS1 has an alliance with universities through the Auto-ID Labs. Some MOs have close relations with universities at local level. These links provide critical input from independent research into the work of GS1. In addition, GS1 has collaboration with a selected number of external standard bodies (e.g. ISO, UN-CEFACT, IETF, IEEE, ETSI) to ensure the interoperability of its standards.

Visibility standards are needed to exchange information along broader and different pathways than traditional ecommerce. Visibility is knowing exactly where a given asset is at any point in time, and why. It may also include physical condition of the asset, physical relationship to other assets, other information. Global visibility is not just having visibility within a company's own four walls, but everywhere in the supply chain where a company has a legitimate interest and right to know.

GS1 developed EPCIS as the first building block of the framework of standards for exchanging event related information: what/when/where/why about an object as it moves through supply chains. Example: where is my product now, where was it last seen, who had the ownership of it at a particular time, etc. Each company keeps its own data, and chooses who to share it with.

EPCIS can enable companies or entities to collect information from a single company or across multiple companies, and make it available to those parties that have an interest in the data and are authorized to receive it. A fundamental principle is that each user that captures data owns that data, and has full control over what other parties have access to that data. EPCIS is one of the standards that enable visibility.

[9] Based on a contribution from Mrs. Elizabeth BOARD, Executive Director Public Policy Steering Committee (PPSC) at GS1 EPCglobal. The PPSC addresses public policy issues for the GS1 EPCglobal community at a global level.

The Discovery Services Standard currently under development will enable trading partners to discover all of the resources who may have information about things (who has data about this object? Where is their EPCIS located so I can ask about this data about this object?). In addition, it will enable trading partners to exchange data in a secure way with parties that may not have a prior direct business relationship, warrants that each party retains rights of ownership of its visibility data, and ensure that queries are authorized and authenticated.

ONS is a lookup service that locates the EPCIS of the trading partner that commissioned the EPC (usually a manufacturer).

GS1 EPCglobal's focus is to ensure that information can be effectively collected and shared across complex supply chains. This visibility is needed to enable companies to support ever increasing complexity in supply chains with more integrity and transparency.

All the GS1 and EPCglobal standards are open and come together to provide visibility, enabling an interconnected world for the benefit of all. At the moment, over 1.2 million companies, the majority of them being SMEs, are using these standards through GS1 Member Organizations in 108 countries (39 in Europe).

Conclusions and suggestions for further action

Following the succinct presentations, that together cover pretty much the issues at hand, a discussion took place, moderated by Gérald Santucci, focusing on what needs to be done, today, in order to make this vision of IoT come true, and what role government is to play in that. This resulted in the following conclusions, leading to proposed actions by governments, business and the research community.

Public sector: EU and Member States

Implementation of the Internet of Things has clear advantages at societal level, up and beyond the purely commercial business case. Bernard Benhamou, French Delegate for Internet Usage, Ministry for Research and Higher Education, emphasized that IoT is of crucial interest to his government, as it is seen closely related to where the Internet goes and thus will have substantial socio-economic impact. Bernd Weismann, National IT Strategy responsible, and Media and Creative industry responsible at the German Ministry of Economics and Technology, underlined that it is now particularly important to make full use of the great technological potential of the IoT, with innovative applications and business models which can boost economic growth and prosperity in Europe. In this respect Germany welcomes the Commission's initiative to set up an EU-wide network, the "RACE network RFID" (Raising Awareness and Competitiveness in Europe), as this project brings together a lot of relevant players and very much enables collaboration on a cross-border basis.

Government involvement in Internet developments is not new: at some stage of development of new technologies, government has always played a role, often in collaboration with industry. DARPA played a big role in the early Internet development. CERN was the home of WWW. And there are many more examples of useful public-private partnerships in development of new societal impact matters. The main reasons for governments to get involved in IoT are:

1. Enabling innovation and competitiveness;
2. Dealing with upcoming societal challenges like ageing, energy crisis, etc.;
3. Being able to meet new challenges arising from the emergence of IoT and the evolution of Internet.

In order to make room for innovation, it is important that unnecessary legislative and political blocks are taken out of the way. While the government should step up when needed, no overhasty solutions should be provided to problems that are not clear yet. It is important to first create and develop new services, prior to shutting doors, which we still can do when issues come up that may need to have regulation, rather than regulating beforehand. This requires the willingness to take a certain level of risk. Monitoring and

experimenting in order to be able to determine those risks and the need to take measures are important.

As real life pilots are very useful in gaining experience, the European Commission as part of the ICT Policy Support Programme (CIP) will support the launch of advanced RFID pilots in 2010 and following years. Pilots also help in creating interest from the media, from all over, thus bringing people together. Yet, nobody can predict where the real innovation will come from.

Governments can also play a role by creating the conditions for a sustainable ecosystem for small and medium businesses to function and contribute:

Create an environment at regional, national and European level in which innovations can thrive. This requires:

- *Raising awareness about business opportunities and collecting and sharing business cases, thus getting businesses to be interested to invest;*
- *Taking away unnecessary legislative blocks from the past, that stand in the way of innovation while specific threats to people and/or society-at-large are not clear and/or experienced, yet;*
- *Leaving regulation of new developments to the sector itself as long as possible, while monitoring developments, thus being able to act when necessary in order to protect the public interest;*
- *Stimulating (precompetitive) collaboration and exchanging knowledge in development of IoT, within the EU, and internationally;*
- *Fostering federated approaches among European Member States to avoid isolated solutions;*
- *Providing encouragement and support for education and training to ensure qualified workforce and users.*

It should be understood that, while technology may make some jobs obsolete, or enable some jobs to move towards other areas in the world, new jobs are created through the Internet that are heavily localized, and this is exactly where IoT plays a role: proximity of services etc., requires local jobs.

As was explained during the presentations, IoT enables the emergence of interactive environments that can assist people in independent living, as well as place independent interaction. In this way, it will be easier to support an ageing population in continuing to live their own life, and continue to contribute to economic as well as societal processes well beyond what would otherwise be possible.

Green IT, or the use of ICT to support the best possible use of our eco-environment, can also be enhanced by the use of IoT in terms of monitoring and warning, as well as in optimizing the use of energy, etc.

Mobile Internet is coming up, and, hand in hand with the development of IoT, offers new opportunities for parts of the population that are currently much less using the Internet. This will not only impact our countries in terms of access for all, but also needs to be expanded to the developing countries that have no alternative than going mobile.

These specific societal challenges were brought up, to which development and deployment of the IoT will make a difference. This leads to the following recommendations:

Support R&D:

- *Foster academic research on IoT, especially for societal challenges;*
- *Support industrial research to address specific challenges for making IoT environments affordable and easy to create and use;*
- *Create awareness with businesses about emerging business opportunities in national and international markets.*

It is crucial to keep people informed and aware of developing opportunities. Mediators, like VTT Technical Research Centre of Finland, play an important role in that, by putting effort in keeping the right players involved at the right time.

Confidence & security in RFID and Internet technologies remains an important point, in which governments play necessarily a role. While governance of the Internet has been left to other players, mostly, it becomes more important that governments start playing a role, too, in the Internet of the Future. In this a careful balance needs to be found in not stopping further developments and at the same time assuring a justified confidence in using the Internet.

In order to protect public safety and the public interest, while at the same time not unnecessarily stopping new developments, the following recommendations came up:

Stimulate self-regulation of the sector while developing new applications and technologies, thus to ensure a conscious behaviour vis-à-vis risks for the public;

Monitor new developments and their impact in order to be able to act when necessary. This requires:

- *Thinking ahead. By thinking ahead about possible risks and opportunities, as well as ways to address these, risks of uncertain developments can be reduced. Ex ante exercises and scenario based workshops involving multidisciplinary groups of experts and stakeholders can help;*
- *Measure and relate. Measure specific developments including uptake, impact, etc., in order to be able to witness trend developments in an early phase, thus being able to act when necessary. Many of those measures can be taken.*

Business and industries

While government, at different levels, can create an environment in which the Internet of Things can thrive, it will only do so when businesses see business opportunities, and are willing to pursue those. While business cases for RFID as such already exist, and more emerge, business cases for creating the Internet of Things as part of a value proposition are still rare, and IoT has not developed yet as a commercial proposition in the market apart from isolated applications.

There are several factors that will make business move towards investing in IoT, of which the most important are: perceived opportunity, and perceived risk. Today, uncertainty prevails among the business stakeholders, and perceived opportunity is considered much less than the real opportunity, as there is relatively little known about IoT.

At the same time it is clear that market situations are changing already today. Twenty years ago, pre-IoT was seen as possibly interesting, but it was not really relevant, yet. Now the basic technologies are in place, and the first companies like Wal-Mart started to really use basic RFID technologies a couple of years ago, which really got the ball to start rolling. Today the technologies are there, and it is time to implement them, and again companies in the informatics, energy, construction and health sectors are at the forefront. In addition, many applications are expected in the areas of social networking and trend industries. In this it should be noted that <1>RFID is important, but not the only answer; <2> deployment is often underestimated (maintenance and management); <3> interoperability is key. Standards provide a basis for interoperability, and as such they are very important, but standards alone are not sufficient. Furthermore, standards need to be established at the right time: not too late, but also not too early.

IoT offers opportunities for creating a clear competitive edge, and the time to start developing (and sharing) business cases is now. The following action was generally seen as a key next step in deployment:

Raise awareness on IoT opportunities and business issues. What are the real opportunities and possible risks, and how can companies benefit most from IoT applications and services? Important in this are:

- *collecting and sharing real life business cases;*
- *development and sharing of scenarios of IoT applications;*
- *development of IoT pilot environments;*
- *creation of business alliances and public-private partnerships;*
- *getting a good understanding of user behaviour.*

Key in an IoT environment is that all data collected from sensors and applications are put in context, in order to get meaning. As presented earlier, semantics are crucial, and it is important to be able to bring all data relevant together in a meaningful way. In this, EPCglobal plays an important role by creating an environment in which data can be captured and related in a logical way.

Two components are critical to data exchange amongst entities that may not have a trading relationship – ONS and Discovery. These two interface standards provide an approach to finding information across the Internet of Things. ONS (ONS – Object Name Server) will not be required but can allow for information to be found across parties involved in the IoT.

However, several things were revealed up during the meeting:

1 – ONS and its governance

2 – EPC identifier (URI – Uniform Resource Identifier[10]) and/or uID?

ONS and other identifying systems used widely today in the Internet communication are based on DNS. ONS 1.0 is the first version and relying on DNS (has been subscribed as subset of DNS).

Currently, EPCglobal has a community effort to evaluate the requirements to have a distributed ONS approach and how that can be best structured to meet the usage that is defined. In order to develop the most effective approach to enabling distributed data to be managed locally, GS1 has set up an *ad hoc* committee to develop the requirements for a distributed approach to ONS. In the understanding that the future of this architecture may be updated, there is a need for more research to make it more secure, adapted and scalable. A participant mentioned that a mobile service pilot is crucial in this.

The uID concept, which has been developed in Japan and is now well known in Southeast Asia, has its origins in a market focused on small home users and consumer appliances, but it is now equally used in the enterprise context. This market is quite different than, for instance, the U.S. one, where many real time, large scale systems are used, which is underlying the difference in architecture, as explained above.

EPCglobal has been focusing on the 900 MHz tag, but has started to address different frequencies. The EPCglobal Architecture Framework was designed to enable various air interface tagging to be supported and defines standardized interfaces to identify, capture and share data. These standards are componentized specifically so that companies and technology providers can use them interchangeably and as needed.

The model of ucode, which is based on 128 bits, and storing the information itself on the network, allows combination of many different automatic identification systems and would in fact even be able to include EPCglobal tags and readers in its environment.

It was also said that the ucode development has a strong emphasis on security, both at the level of data protection and also in the communicator itself. In its concept it offers a lot of benefits, both from a security and data protection point of view, (non-centralized) governance approach. Data protection and security are also addressed at several levels in the EPCglobal architecture but it would be interesting to provide an analysis on the data protection and security approaches currently available.

Regarding identification, industry representatives indicated that they did not expect global identification to become prevalent, as industry wants to keep the identification they have, as long as it continues to serve its needs. Whereas the meeting was not conclusive on this, there was a feeling that ucode has a lot to

[10] A URI is a character string representation that is commonly used to exchange identity data between software components of a larger system.

offer, next to EPCglobal, and that it would be worthwhile exploring this further.

A conclusion following this discussion was:

Explore which standards for data exchange would function best in a global environment where many applications will be local and at the same time much less bound to geographic locations. In this it is important to:

Develop concepts that allow ambient environments to emerge as open, interoperable environments in which it is not necessary to commit to one single standard in order to be able to benefit from the information collected in the IoT environment. Important steps in this:

- *Consider the pros and cons of the main systems in use today, and generate a vision on how objects could interact in an open standard environment;*
- *Develop (pilot) environments that allow experimenting and testing with different elements composing an interactive IoT;*
- *Systems need to be designed for heterogeneity of technologies and identification schemes.*

Research and academia

Whereas IoT technologies are in place and a better picture emerges about what it means and how it could work, much more needs to be done to make it easier, and more affordable. There is a general recognition that, in addition to the areas mentioned by CASAGRAS, the following areas need focused action for research:

Basic challenges, standards and needs for interoperability and governance

- *Interfacing with the physical world – accommodating the capacity and transfer needs (of an estimated 50,000 billion objects). This includes:*
  - *Data, information and knowledge management and handling the obsolete;*
  - *Semantics, and semantic modeling to keep and use all data that come up in an IoT environment in their correct context;*
  - *Deal with scale and time dependency of data, and with storage and querying masses of dynamic information;*
- *Communications and connectivity – wireless (radio platforms integration), spectrum usage – software and cognitive radio – tag pollution: how are we going to make sure all data exchange will remain reliable and not harmful to people?*
- *Exploiting developments in ubiquitous computing and networks – embedded platform needs – nano-tube radio and sensor platforms: how will it all interconnect?*
- *Global identification and management of identification - connection and integration with the evolving Internet – IPv6, accommodating legacy systems (EPC, ucode, etc): what way ahead?*
- *Provision of approaches and models of governance to cope with the complexity and societal values.*

Security and resilience of systems

- *Security of data and systems and against attack: with increasing dependence on ambient environments and many ways of interconnecting and transmitting of information how can we protect the system?*
- *Reliability and robustness – self-diagnosis and repair – including sensory, actuation and control systems;*

Specific applications

- *Development of smart environments that support location dependent services in dense environments;*
- *Development of smart (electricity) grid that allows feedback of energy that is not used into the network.*

Last but not least

- *Collect and share a knowledge base of proven cases from practice to learn from and be inspired by: we need to see IoT in practice.*

In summary:

At some point there will be a need to take the step from supporting single business processes towards being able to deal with a freely flowing mash of information and things that interact, and we are not there, yet. The subjects of Future of Internet and IoT provide useful ground to bring these disciplines together in a useful way, rather than stay in the stovepipes they have been used to work in over the last decennia. The motto towards the research community is: educate, and bring together. Networks, network architecture, and the future Internet will be driven by IoT. This will raise new management issues with the new masses of information and users.

Working internationally, with people from Japan, USA, China and other globally important players will help create a better understanding of what IoT could be at a global level, as an inclusive model. We also learned to appreciate a dynamic responsive research agenda, appreciating the wealth of research that has already been carried out and is going on in other countries. There is a future in which the progression of a project like CASAGRAS could help keeping such a global research agenda on the table, by monitoring research and initiate research towards problems identified, from a dynamic model perspective on IoT.

Annex 1 – List of workshop participants

The following persons participated to the IoT workshop on 10th May 2009, Prague, Czech Republic:

Abramowicz Henrik	Ericsson
Accordino Franco	European Commission
Ahola Kimmo	Tekes
Alvarez Federico	UPM
Babot Jacques	European Commission
Baker Nigel	UWE Bristol
Bassi Alessandro	Hitachi Europe SAS
Bauer Martin	NEC Europe Ltd.
Benhamou Bernard	French Ministry of Research
Board Elizabeth	EPCglobal
Botterman Maarten	GNKS Consult
Campolargo Mário	European Commission
Daskala Barbara	EC - ENISA
Deraymaeker Didier	European Commission
Fatelnig Peter	European Commission
Figuerola Sergi	i2CAT Foundation
Fitzpatrick John	University College Dublin
Foley Brian	Waterford Institute of Technology
Friess Peter	European Commission
Furness Anthony	AIDC UK Ltd
Gluhak Alexander	University of Surrey
Gruntorád Jan	CESNET
Gusmeroli Sergio	TXT e-solutions SPA
Haller Stephan	SAP (Schweiz) AG
Hans Carl	BIBA GmbH
Herault Laurent	CEA LETI
Imura Ryo	Hitachi Ltd. & Univ. of Tokyo
Jimenez Marisa	GS1
Kia Ng ICSRiM -	University of Leeds
Kleinwaechter Wolfgang	University of Aarhus
Knebel Thomas	Bundesministerium f. Wirtschaft u. Technologie
Krco Srdjan	Ericsson
Ladid Latif	University of Luxembourg, IPv6 Forum
Lach Hong-Yon	Alcatel-Lucent Bell Labs France
Li Hong	Internet Society of China
Lopour Daniel	GS1 Czech Republic
Ma Ning	Internet Society of China
Magalhães Luís	Ministry of Science & Tech & Higher Education
Majos Wieslaw	Ministry of Science and Higher Education
Martoch Tomas	GS1 Czech Republic
Mateo Manuel	European Commission
Mikkonen Tomi	Nokia Oyj
Mulligan Ultan	ETSI

Neves Ana	Ministry of Science & Tech & Higher Education
Oddi Guido	CRAT
Paindaveine Yves	European Commission
Passen Ludwig	Generali Informatik Service
Persi Stefano	Atos Origin SAE
Platte Klaus-Dieter	Platte Consult
Pleckaitis Andrius	Association "INFOBALT"
Presser Mirko	The University of Surrey
Prevost Jean	Groupe Casino
Reddick Andrew	National Research Council Canada
Ristol Santi	ATOS ORIGIN
Sakamura Ken	YRP
Santucci Gérald	European Commission
Sestini Fabrizio	European Commission
Sharpe Mike	MS Consulting & Research Ltd
Schwarz da Silva João	European Commission
Soler Ignacio	Atos Origin
Sun Yongge	Internet Society of China
Sundmaeker Harald	ATB Institute for Applied Systems Technology
Uckelmann Dieter	LogDynamics Lab c/o BIBA - Bremer Institut für Produktion
van der Vleuten Joost	Ministry of Economic Affairs
van Rhijn Arnold	Ministry of Economic Affairs
Weismann Bernd-Wolfgang	Bundesministerium f. Wirtschaft u. Technologie
Wu Bo	Ministry of Commerce of P.R.China
Yu Hong Miao	Ministry of Commerce of P.R.China
Zhao Faru	Internet Society of China
Zhao Yao	Internet Society of China
Zheng Li-Rong	Swedish iPack VINNOVA Excellence Centre, Royal Institute
Zorc Samo	Ministry of Higher Education, Science and Technology