IARIA Work Group Meeting on Future Internet
EXPERT PANEL

Future Internet: Challenges, Perspectives, and Beyond

INTRODUCTION

Eugen Borcoci,
University Politehnica Bucharest

INFOWARE Conference , August 22- 29th, Cannes, France

Panelists

- **Moderator:** Eugen Borcoci, prof., University "Politehnica" of Bucharest (UPB), Romania
- **Expert panelists:**
- Alessandro Bogliolo, prof., Università di Urbino, Italy
- Dr. Gyu Myoung Lee, prof., Institut TELECOM SudParis, France
- William W. Wu, IEEE Fellow / ATMco Founder, USA
- Vladimir Zaborovski, Prof, Technical University/Robotics Institute - Saint-Petersburg, Russia
- **Open discussion: INTERNET's topics, journals, directions**

Panel motivation

- **Future Internet (FI)**
- **Why to discuss, here, again?**
  - **Nowadays the Internet has significant impact on all socio-economic and life aspects of the global society**
  - **Internet – became (some opinions) the 5th power of the society**
  - **Many (int'l) efforts to define/re-define the future directions of FI**
    - **Research groups, academia**
    - **Industry**
    - **Standardization organizations**
    - **Governments**
    - **Users**
    - **….**
  - **Still – there are many open FI issues, including discussion/revision of the fundamental concepts**
  - **FI: very large collection of topics**
  - IEEE Comm Magazine –July 2009:
    - "The term *future Internet* has gained a lot of interest recently"
    - "Several research funding organizations have decided to support the development of the FI; a growing number of research projects are being established."
    - "There is, however, currently no agreement on what the technology of the FI will look like; nor is there agreement on what the goals of the various competing future Internet activities are…"

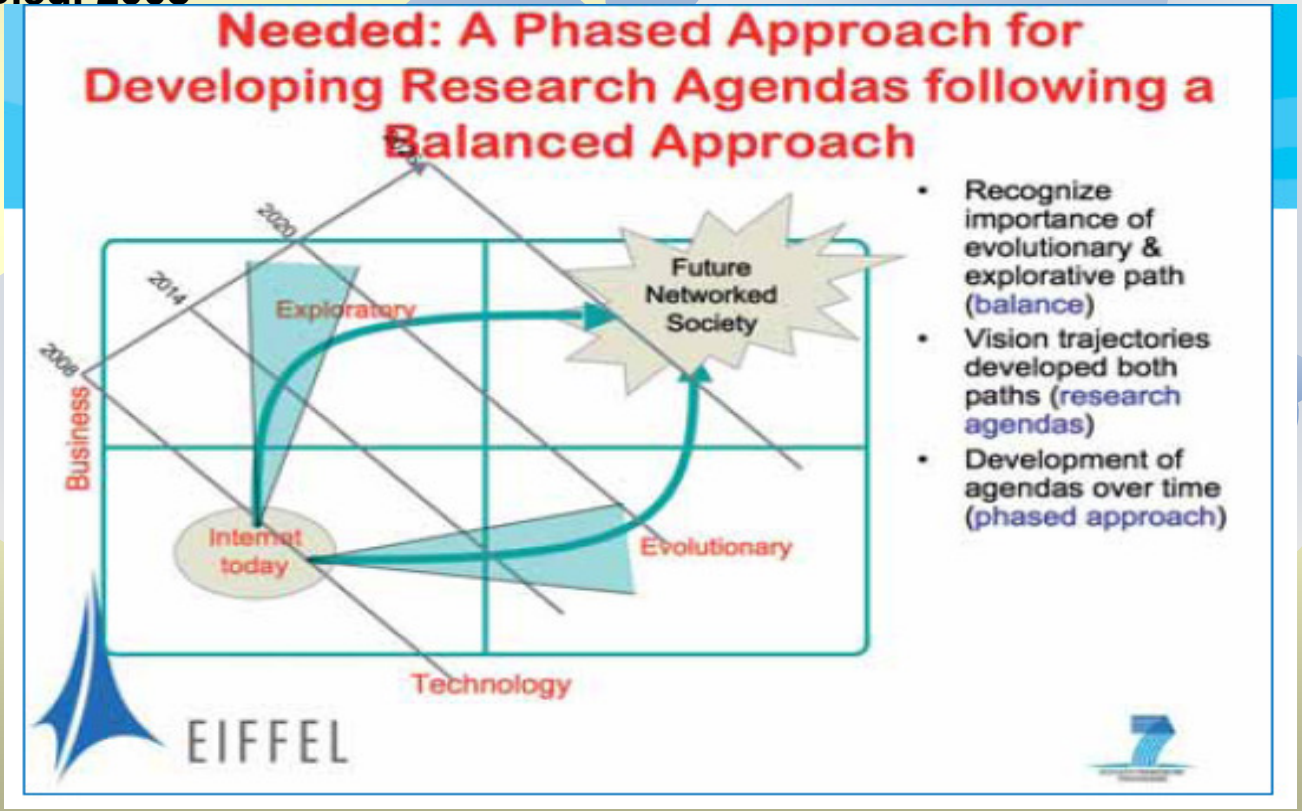
Panel agenda

- **Note: Two hours panel only…**
  - **Short, general introduction and presentation of current Internet limitations and some FI challenges (moderator)**
  - **Specific issues (selection) and possible solutions (panelists)**
  - **Then, the audience is kindly invited to express opinions..**
  - ***KEY issues on FI concepts and design:***
    - ***evolution?***
    - **or *clean slate approach?***
    - **or *something in the middle*?**

FI key issues on approach

KEY issues on FI concepts and design:

- **evolution? or clean slate approach? or something in the middle?**
- **Source:** Petri Mahönen, Project Coordinator, EIFFEL, RWTH Aachen University“ **Evolved Internet Future for European Leadership (EIFFEL)”, FI Conference, Bled, 2008**



CONTENTS

- Summary on Internet Evolution and Status
- Future Internet R&D Challenges
- Future Internet Conceptual Architecture
- Future Internet Initiatives

- Acknowledgment
  - This material is not an original one but a summary of ideas presented in numerous documents, reports and papers (see References) dedicated to *Future Internet*

Summary on Internet Evolution and Status

- *(Partial Sources:*
  - *Report from the National ICT Research Directors Working Group on Future Internet (FI) of the EC on Information Society and Media- Nov. 2008)*
  - *A.Peltomäki, Stimulating an Innovation Ecosystem for Future Internet Technologies, EC Information Society and Media Directorate-General, Lulea, Sweden June 2009,*
  - **Nowadays is a global infrastructure supporting the economy as well as the provision of societal services**
  - **Pervasive /ubiquitous; ~ 25% of the world population - access to Internet**
  - **Mobility and nomadic usages are becoming the norm**
    - **By 2012, at least 1 Bn of Internet users will use mobile as their only access means, adding to the today 1.5 Bn of fixed users**
  - **It has enabled user and consumer empowerment, through the emergence of eCommerce and social networks**
  - **Tool for modernisation of many domains: emerging - eEducation, eGovernment, eHealth, etc.**
  - **Expected to contribute significantly to solve emerging challenges such as climate change and energy efficiency.**

Summary on Internet Evolution and Status (cont'd)

- It has favoured innovation and the emergence of new disruptive business models: in 2008, ~300 million use VoIP Skype
- Software: novel A/V consumption models - e.g. YouTube (global users downloading ~10 hours of video/min from that site
- Web 2.0 and social networks are growing. Popular social sites attract more than 120 million regular users. Web 2.0 apps. will be more and more used by businesses and individuals. The emergence of 'enterprise 2.0' will bring significant benefits to companies and SMEs in particular
- Support for entrepreneurs' creativity: its native openness, made possible thousands of innovation world wide, to develop a huge range of applications
- There is a recognized - clear correlation factor between growth of broadband Internet access and employment growth
- Multiple societal impacts of the Internet are nowadays widely accepted by the policy makers (issue like - "Future of the Internet economy")

Summary on Internet Evolution and Status (cont'd)

- An ever richer content and media environment
  - Content is clearly one of the main drivers of Internet changes
  - Every year, the Internet traffic grows by 60%. This is mainly due to video, and will be further amplified with the advent of on-line 3D content.
- The emergence of an Internet of "things": In the near future, it will be possible to interconnect billions of objects and devices
- New types of applications combining information of the virtual world with
- a perception of the physical world have enormous economic prospects
- **Challenges:**
  - Internet has been designed ~ 30 years ago
  - Numerous technical challenges arise with the expansion of the Internet
  - New usage patterns and requirements not previously foreseen lead to the need of a fresh look at the main Internet architecture itself
  - Trust and security – serious future issues

Summary on Internet Evolution and Status (cont'd)

- **Usage trends versus current Internet limitations**

Usage Trend	Technological limitations of the current Internet	Application enabler
Very high rate throughput E2E	Many protocols not designed for ultra broadband scenarios	Data intensive usage scenarios, e.g. A/V multimedia transfer and processing
Ubiquitous good quality and cheap network access	Limited availability of high-quality optical wired networks and of bandwidth and quality offered by the wireless networks	Data applications Real time A/V and multimedia applications
Increasing mobility needs (micro, macro, terminal/ session, network mobility)	Initial Internet support has been conceived for fixed usages	Open Internet environment and fully available on the move (any-time, any-where, any terminal)
Need for more *security* , and *trust* capabilities	Major limitation of the current Internet. Security and trust mechanism natively supported in service and network infrastructures.	All application involving processing of sensitive data Avoiding/limiting DoS is a must
Neeed for more *privacy* and *anonymity* capabilities	Currently: privacy by design. The awareness of these issues is somewhat underdeveloped in today's Internet users.	There is already a market of specialized companies that offer Internet privacy services to (well known) people; One expects that the sensitivity of ordinary Internet users to privacy and anonymity concerns will increase.
New services: VoIP, P2P, IPTV	Insufficient networking support	VoIP, P2P, IPTV

Summary on Internet Evolution and Status (cont'd)

Current trends versus limitations

Usage Trend	Technological limitations of the current Internet	Application enabler
User generated content and services	Service architecture enabling dynamic, secure and trusted service compositions and mashups- is still in the starting phase. No business models enough flexible	Cloud computing type of applications, (global) appls. requiring massively distributed computing such as multimedia search. Internet of Services. Semantic Web technologies
Novel human-computer interaction techniques	Reduced availability of cheap and compact sensor technology and advanced display technologies Basic Human-computer interaction	Home networking Network of things Business applications Industry, education
Universal connectivity,of devices, coupling of virtual world data with physical world information (RFID, sensors)	Network architecture itself scalability Non existing protocols to support device generated traffic Basic-only service architectures Not enough capability for service discovery	Applications coupling physical world information with data, e.g logistics, transports, environment, energy efficient grids, remote patient monitoring.
3D becoming mainstream	Imposes resource intensive usage of computing and networking platform, standards - - only partially available today	3D virtual environment, possibly coupled with physical world information, beyond games
Negotiated management and control of resources, negotiated SLA's	Dynamic and predictive network management, infrastructure observability and controllability- onbjectives partially fulfilled	Variability of business model, from best effort low level of control towards full real time management of quality of service, security level..

Summary on Internet Evolution and Status (cont'd)

- **Current trends versus limitations**

Usage Trend	Technological limitations of the current Internet	Application enabler
User controlled infrastructure	Limitations in the area of Ad hoc network and service composition	User driven deployment scenario and control of connectivity business model
Personalized services will become widespread on the FI.	Limited context awareness, lack of personalization tools, basic search capabilities	Increasing number of media productions targeting special interest groups, and entertainment services with adaptation to user preferences. Social networks will become mobile and also context aware in the near future.
Computing and software as a network-centric service.This frees users from dealing with backups and software updates, etc.	Currently many PCs exist, having installed a large number of different applications. This trend will probably come to an end.	Much simpler clients using network provided storage and SW provided as a service. Computing power can be accessed when needed through dedicated networked servers (called "cloud computing"), reducing costs and system maintenance overhead.
More need for *Availability*, *reliability*, and *dependability*	Limited: various degree of offering these, depending on provider. Not enough maturity of distributed approaches to solve these	The Internet needs to be treated as a critical infrastructure similar to power grids or fresh water supplies

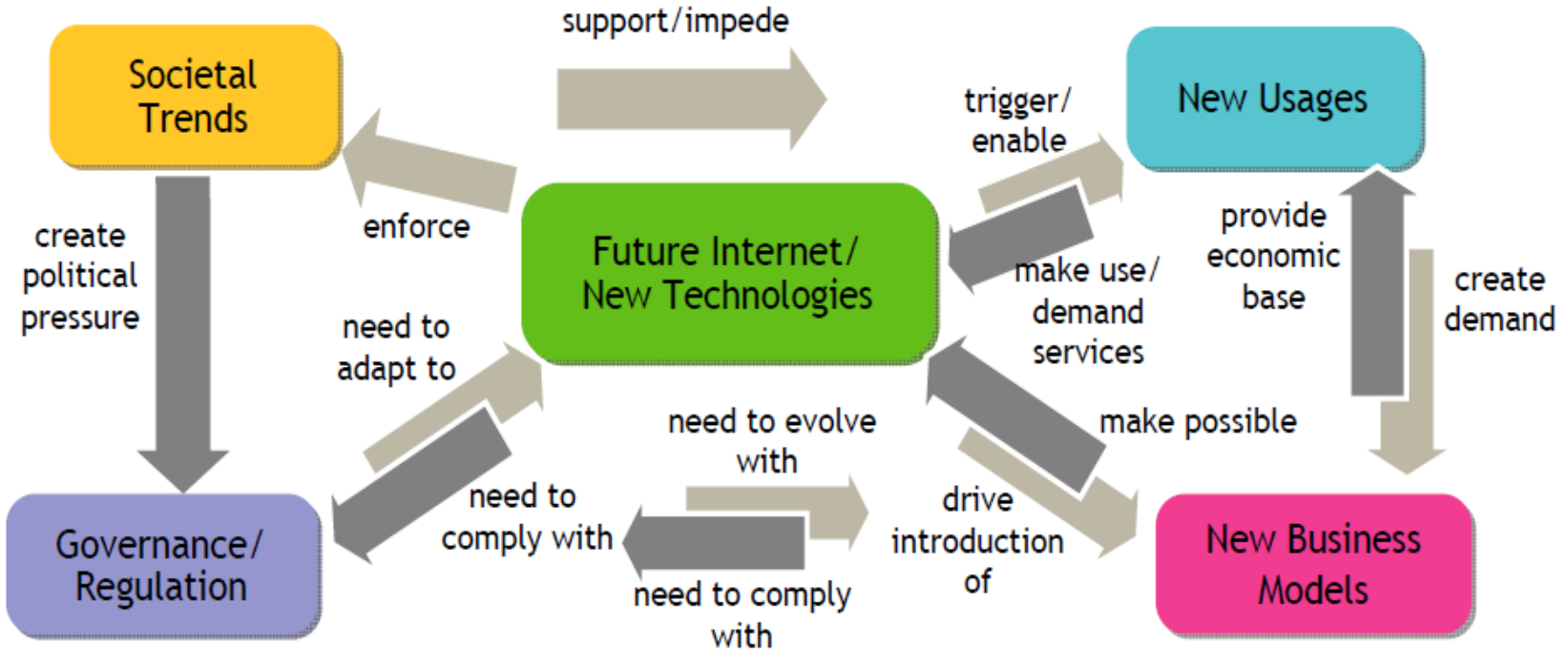
Future Internet R&D Challenges: Social, Economic, ..

FI - Social, Economic and Environmental Challenges

- Major socio-economic factor influencing FI
- New business models, incentive, new usages, etc.
- Governance and regulation
- Network centric versus user centric approaches
- ***FI in the context of economic recession ??***

- Future Internet – Towards Research Challenges – 07 APR 2009, http://www.future-internet.eu/fileadmin/documents/prague_documents/FI

❖ Real world impact of non-technical drivers on Future Internet



Future Internet R&D Challenges : FI Services

- **FI = Content + Services + Management (*Schönwälder* ,j. et al. ,** IEEE Communications Magazine, July 2009)
  - **Management of FI services**
    - **Traditional management**
      - Out-of-band
      - Various solutions from point of view centralization
      - mostly added on later
    - **FI management**
      - management must be designed from start, in-band
      - or out-of-band, or even a mixture of both types
  - **Service management - requirements**
    - Content and context as managed objects
    - Users acting as service providers
    - Personalization of services
    - Seamless access to services and session mobility
    - Enhanced security
    - Privacy of services and content
    - Identity and trust management
    - Distributed management(self-X management)
    - Context-, situation-,location-, aware services

Future Internet R&D Challenges: FI Services (cont'd)

- **Networked European Software and Sevices Initiative**
- **NESSI Strategic Research Agenda, Vol. 3.FP7-2.exec, NESSI Roadmap, (NESSI, Feburary, 2008)**
- **Key areas**
  - **1. Service oriented utility infrastructure:**
    - HW, middleware, programming model
    - Service-aware Networking Architectures
    - Content Networks
    - Web Services issues
  - **2. Service and Systems Engineering**
    - Modelling, construction and management of hybrid service-based
    - systems (situational, spontaneous and goal-based)
    - Mapping QoE of the services to non-functional properties of the components
    - Refining semantics to become appropriate across hybrid service based systems
  - **3. Adaptive Interactions**
    - Collaborative business intelligence for hybrid service-based systems
    - Knowledge- and situational-driven personalization of interfaces and services,
    - Embodiment of educating principles in services

Future Internet R&D Challenges: FI Services (cont'd)

- **NESSI Strategic Research Agenda, Vol. 3.FP7-2.exec, NESSI Roadmap, (NESSI, Feburary, 2008) (cont'd)**
  - **4. Business process modelling**
    - Dynamic formalization, management and interaction of business processes implemented through services
    - Support for long-term and transactional business collaboration
  - **5. Reference Architecture and Implementations**
    - Harmonize service architectures (SOA) and infrastructure architectures (SOI) to support all kinds of BMs , applications and HW environments and provide transparent and integrated access for all relevant stakeholders.
  - **6. Services for the Future Internet**
    - Turn devices into enablers of services by embodying SOA principles into embedded systems and link collaborative devices to services
  - **7. End-to-end Trust, Security and Dependability**
    - Provide a chain of trust across all levels and trust zones
    - End-to-end verification and assurance
    - Identity and trust management challenges
    - New security solutions: Privacy and data-protection mechanisms of distributed data

- **Management and Service-aware Networking Architectures (MANA) for Future Internet (Dec 2008)**
- **Required capabilities**
  - **1. Infrastructures Capabilities**
    - Computing, networking, and storage elements = components of the MANA infrastructure
    - Ubiquitous Connectivity, Computation, Storage and Content infrastructures, together with the architectures, resources, self management, and controls of such resources, including the assessment of infrastructure adaptations based on context-awareness
    - New globally accessible *Infrastructure Services*, including *Information-centric* and *Context-centric networks*.
  - **2. Control and Elasticity Capabilities**
    - New naming frameworks, including Identity / Location splits and support for addressing information or context objects and services
    - New tuneable protocols for different layers of the protocol stack in support of cleaner cross-layer interaction and dynamic service composition
    - Flexible and cost effective operations of service platforms over core and edge transport networks.

- **Management and Service-aware Networking Architectures (MANA) for Future Internet (Dec 2008) (cont'd)**
- **Required capabilities**
  - **3. Accountability Capabilities**
    - *Cross layer optimization* – network, transport and service layers – to enhance session-less application driven QoS approaches
    - *Enhance Information exposure* - Traffic carries info about its resource usage in such a way that the network can monitor the cost (e.g.congestion) of carrying a specific packet but also the application can select the most convenient path to send specific traffic
  - **4. Virtualisation of Resources and Service Computing Clouds Capabilities**
    - *Ubiquitous Virtual Resources* with integrated self-management of those resources
    - *Security concerns* related to the use of virtual resource
    - *Virtual resource-facing services* enabling flexible usage of the physical resources
    - *Real-time service* computing clouds and virtual-private service clouds, integrating the necessary storage, networking and service resources
    - *Ubiquitous light-weight virtual channels* for integrating an Internet of Things into a service-aware network infrastructure

- **Management and Service-aware Networking Architectures (MANA) for Future Internet (Dec 2008)**
- **Required capabilities**
  - **5. Self-management Capabilities**
    - Mechanisms for dynamic deployment of measuring and monitoring probes for services' and network' behaviours, including traffic
    - Increased level of self-awareness, self-knowledge, self-assessment and self-management capabilities for all Future Internet systems, services, and resources
    - Increased level of self-adaptation and self-composition of resources to achieve effective, autonomic and controllable behaviour
    - Increased level of self-contextualisation and context-awareness for network and service systems and resources
    - Self-awareness capabilities to support system-level objectives of minimizing system life-cycle costs and energy footprints.

- **Specific areas of FI Architectural and Protocol Approaches**
  - Old TCP/IP stack versus new approaches
  - Network-services coupling: content aware networking and network aware appplications, P2P, P4P
  - Addressing, Identities and network virtualization
  - Cross-layer optimisation (how many levels?)
    - But avoid monolithic implementation
  - Content aware networks (CAN) and network aware application
  - More flexible and reliable routing
    - Multi-path as addition to to current single path, QoS enabled routing
    - Content aware routing (see CAN)?
      - Applications/services can choose the routes based on their requirements
      - User Selectable Routing
    - Better resilience, load balancing / use of resources
    - Edge Controlled Routing, new inter-domain approach
    - Location / ID separation
  - Service aware resource control
    - Service clouds viewing the network as a service
    - Deploy and offer network services in a similar fashion to IT services
  - Home area networking
  - Wireless and mobility aspects in FI
    - Horizontal and vertical seamless handover

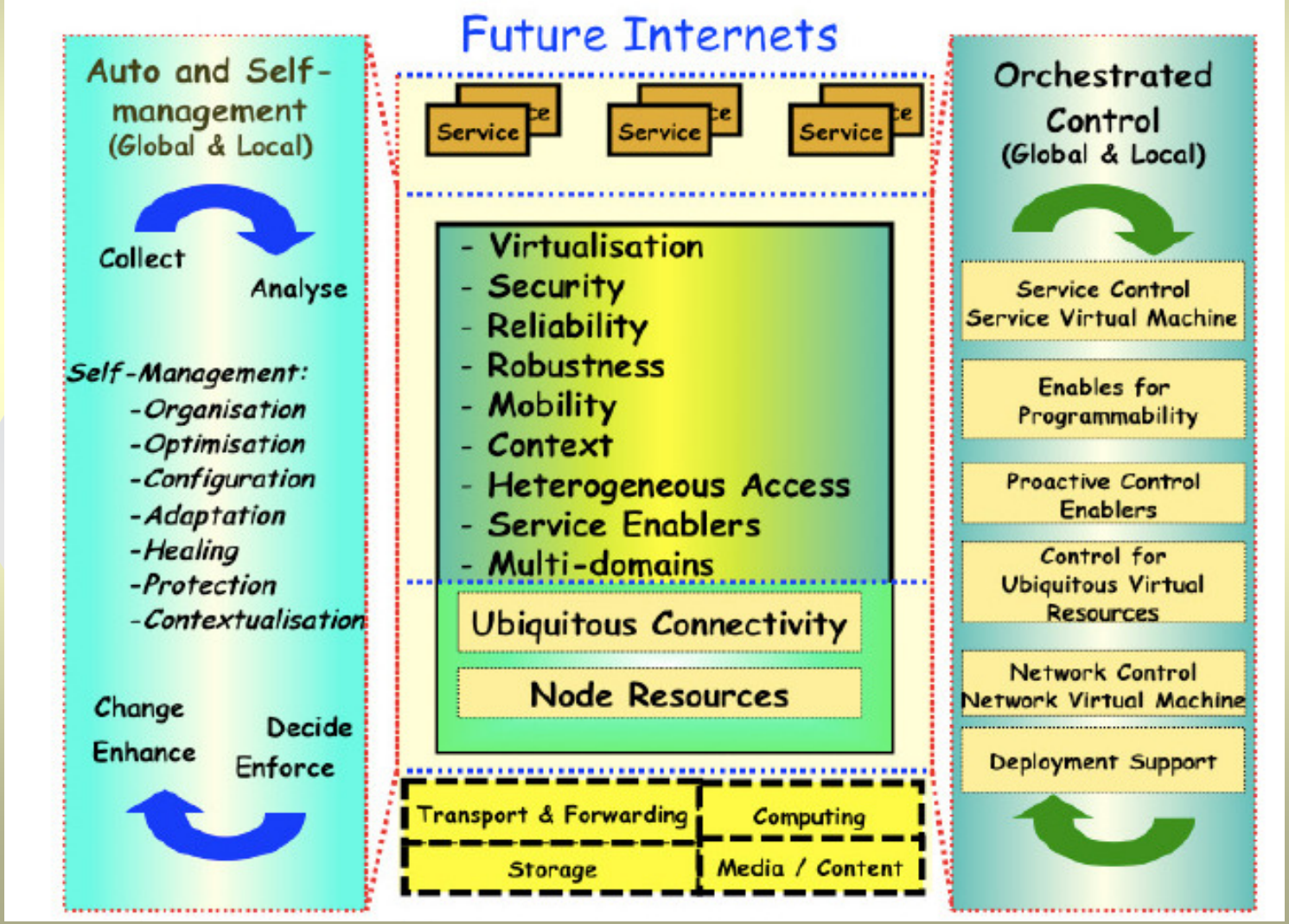
- **Energy awareness (impact on architecture and protocols)**
  - In the network itself
    - Wireless sensor networks
    - Mobile networks
    - Heterogeneous networks
  - Usage of FI applications to save energy in industrial, traffic, etc. systems

- **Solution space**
  - *Evolutionary*
  - *Revolutionary* approaches
    - soft nodes, virtualisation, parallel Internets
      - A Parallel Internet Architecture will allow next generation(s) disruptive approaches to be deployed in parallel to the current (and future) legacy
  - Possible : both *evolutionary* and *revolutionary / disruptive approaches*
    - Examples:Location / ID separation, resource pooling, multi-path routing QoS enabled: *evolutionary*
    - Edge controllable/computable routes, network-level content-based routing: *revolutionary*

Future Internet R&D Challenges: Conceptual Architecture

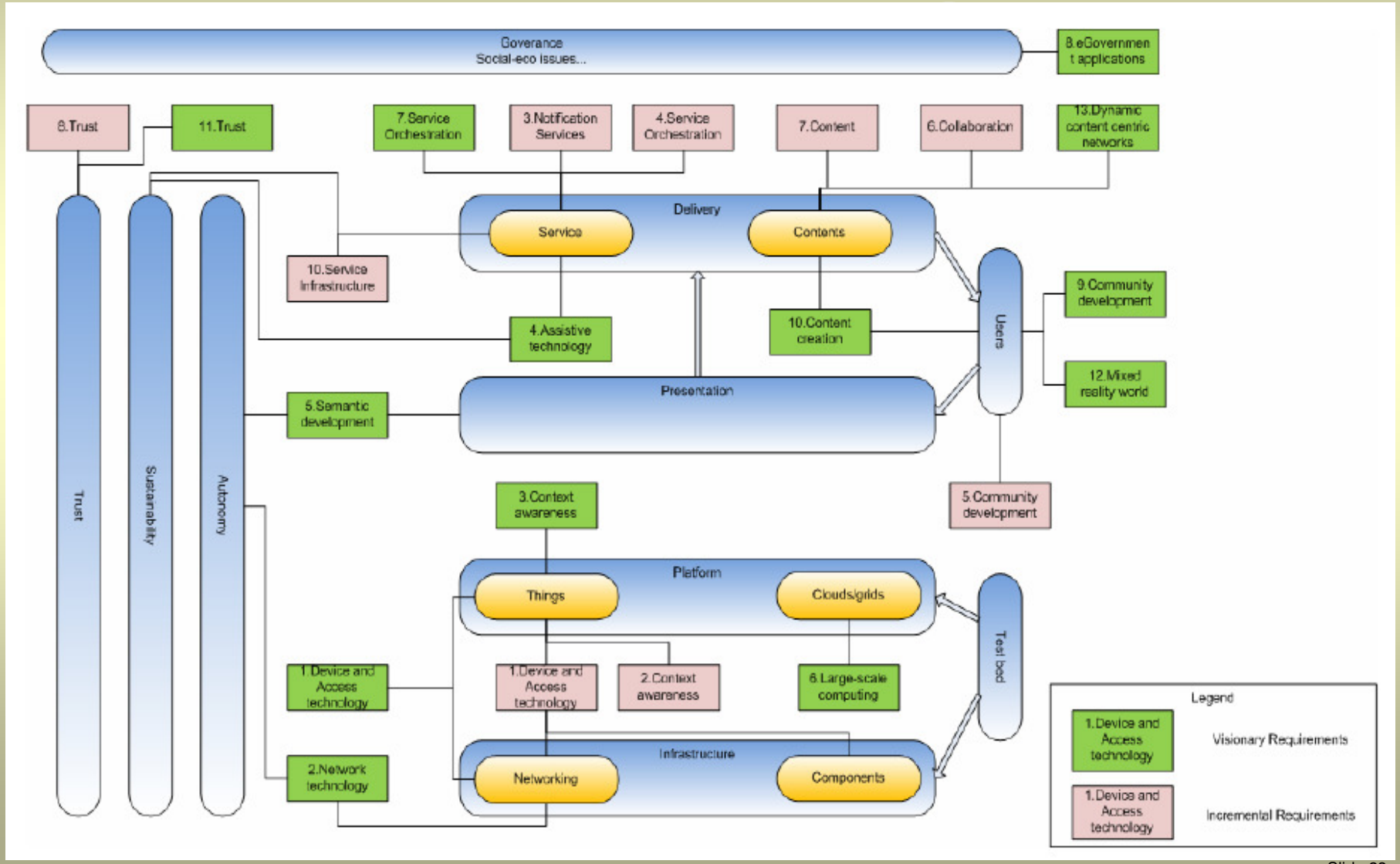
FI R&D open issues – summary

- **Excerpt of 7):** Future Internet – Towards Research Challenges – 07 APR 2009, http://www.future-internet.eu/fileadmin/documents/prague_documents/...



Future Internet R&D Challenges: Conceptual Architecture

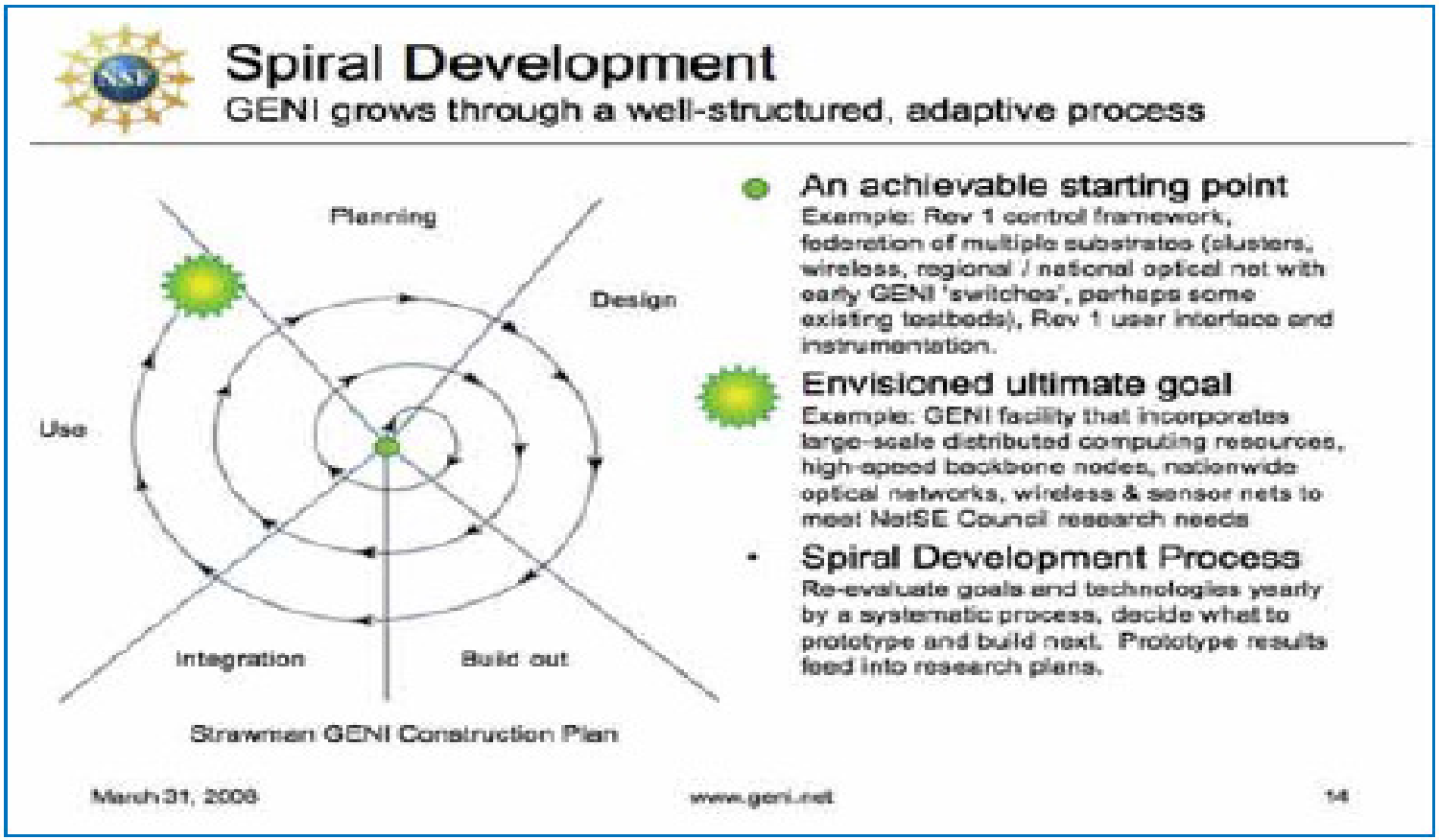
- Future Internet – Towards Research Challenges – 07 APR 2009, http://www.future-internet.eu/fileadmin/documents/prague_documents/FI..



- **Example 1: US**
- GENI/FIND - of the NSF (originated ~10 years ago)
  - GENI - Global Environment for Network Innovation
  - GENI umbrella provides the experimental research and testbeds facilities FIND – Future Internet Design
  - FIND umbrella providing support to research
  - .
  - FIND will be replaced by the new initiative NetSE, Network Science and Engineering, launched in Sept. 2008
    - It includes support to PlanetLab
  - GPO (GENI Project Office) - established in May 2007
    - It supports 5 different approaches to future networks (not disclosed)
    - A new research agenda - delivered in December 2008, in partnership with NetSE

Future Internet Initiatives

- GENI/FIND (cont'd)
  - **Source: Heidi Dempsey, Office Operations and Integration Manager, GENI Project" The Path to the Future Internet,the US Approach" , The Future of the Internet Conference, Bled ,Slovenia March 2008**



Future Internet Initiatives

- **Example 2: Japan**
- **"New Generation Network" initiative (NWGN) complemented with the creation of the NWGN promotion forum (2004)**
  - **NWGN is supported by the AKARI initiative, a couple of research projects exploring Future Research paths including today more than 200 members from industry and academia**
  - **Source: Fumito Kubota, Executive Director,Japanese New Generation Network Research Centre, " The Path to the Future Internet, the Japanese Approach", The Future of the Internet Conference, Bled ,Slovenia March 2008 :**
    - ***"AKARI follows a 'clean slate' approach rather than extending the existing internet"***
    - **Principles of NWGN**
      - **KISS (Kep it Simple, Stupid)**
      - **Sustainable and evolutionary principle**
      - **REalitry connection Principle**
    - **Examples of key technologies for NGN:**
      - **Photonics Network Project**
      - **Overlay Network Research and Environment**

- **Example 3: Europe**
  - *EU level activities*: mainly through a set of ~80 FI related projects (result of the first calls of the ICT Thematic priority of FP7)
  - These actions are currently being consolidated through the setting up of the "Future Internet Assembly" kicked off on the occasion of the Bled/Slovenia Conference of March 2008
    - The main goal of the FIA is to confront the various technological and architectural approaches deriving from the multiplicity of usage scenarios and requirements applying to a FI
    - this will help the emergence of cross sector consensus and pave the way towards the later emergence of common architectural approaches and standards
    - National intiatives and programs oriented for FI (not complete list): Belgium, France, Finland, Germany, Italy, Nederland, Spain, Sweden, UK, etc.

Future Internet Initiatives (cont'd)

Europe (cont'd)

- ***National level initiatives*** and programs oriented for FI (not complete list): Belgium, France, Finland, Germany, Italy, Nederland, Spain, Sweden, UK, etc.
- ***EU level activities*:** mainly through a set of ~90 FI related projects (result of the first calls of the ICT Thematic priority of FP7)
- These actions are currently being consolidated through the setting up of the "Future Internet Assembly" kicked off on the occasion of the Bled/Slovenia Conference of March 2008
  - The main goal of the FIA is to confront the various technological and architectural approaches deriving from the multiplicity of usage scenarios and requirements applying to a FI
  - this will help the emergence of cross sector consensus and pave the way towards the later emergence of common architectural approaches and standards

Future Internet Initiatives (cont'd)

- **Europe (cont'd)**
  - *EU level activities*:
  - European holistic approach one: all network and service platforms technologies to constitute the FI are looked upon as part of a single complex system.
  - FIRE (Future Internet Research and Experimentation)
    - the European research actors have access to an experimental facility required by such a complex research domain
    - possibility for large scale experimentation
      - as the glue between different FI research domains
      - means to early assess the potential impact of changes to the current Internet in technical as well as socio-economic terms.
    - FIRE Research complements this cross-domain approach by supporting visionary, multidisciplinary and experimentally-driven research

Future Internet Initiatives (cont'd)

- **Europe (cont'd)**
- *EU level activities*:
  - Near term : couple the FI technology research with applications of high societal value such as health, urban mobility, energy grids or smart cities.
    - Expectation to provide an early "Internet response" to the societal challenges mentioned earlier.
    - Establish a Public Private Partnership with industry to complement our longer term FI research of the FP7 ICT Work Programme
  - Joint work is done with industry to define the content and structure of this PPP, towards an operational start in 2011
  - A Forum of Member States, the "Future Internet Forum" supports Europe in better federating our Internet research in Europe and overcoming fragmentation by sharing the know-how

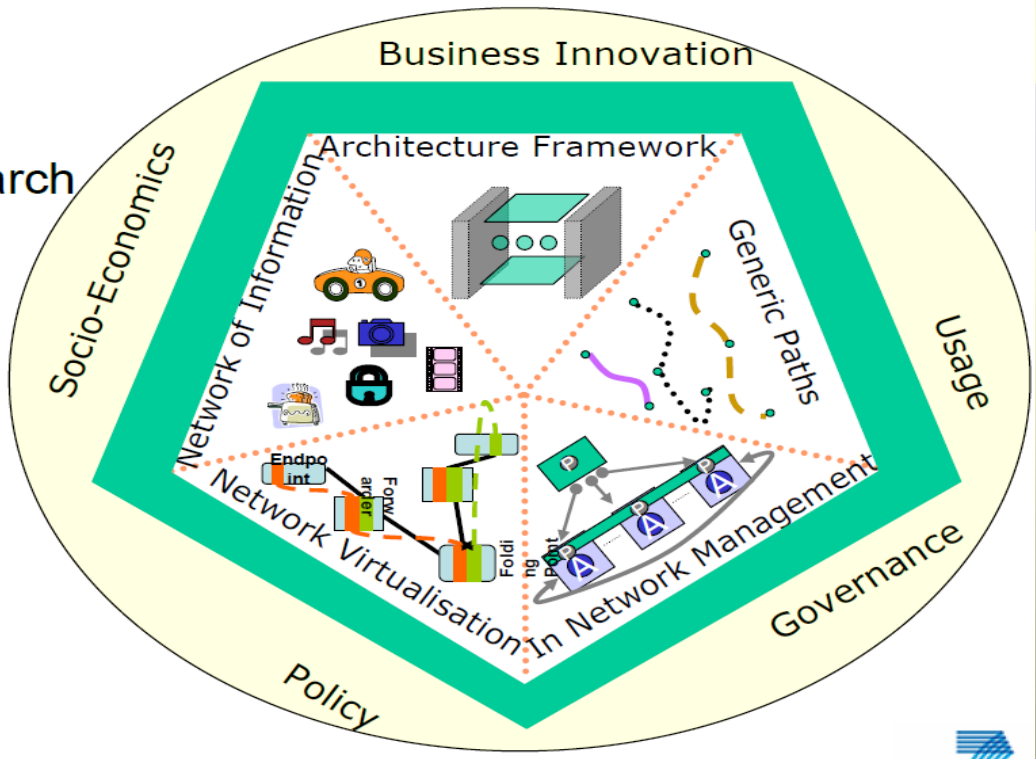
Future Internet Initiatives (cont'd)

- **Europe (cont'd)**
- *EU level activities*:
  - Near term : couple the FI technology research with applications of high societal value such as health, urban mobility, energy grids or smart cities.
    - Expectation to provide an early "Internet response" to the societal challenges mentioned earlier.
    - Establish a Public Private Partnership with industry to complement our longer term FI research of the FP7 ICT Work Programme
  - Joint work is done with industry to define the content and structure of this PPP, towards an operational start in 2011
  - A Forum of Member States, the "Future Internet Forum" supports Europe in better federating our Internet research in Europe and overcoming fragmentation by sharing the know-how

Future Internet Initiatives (cont'd)

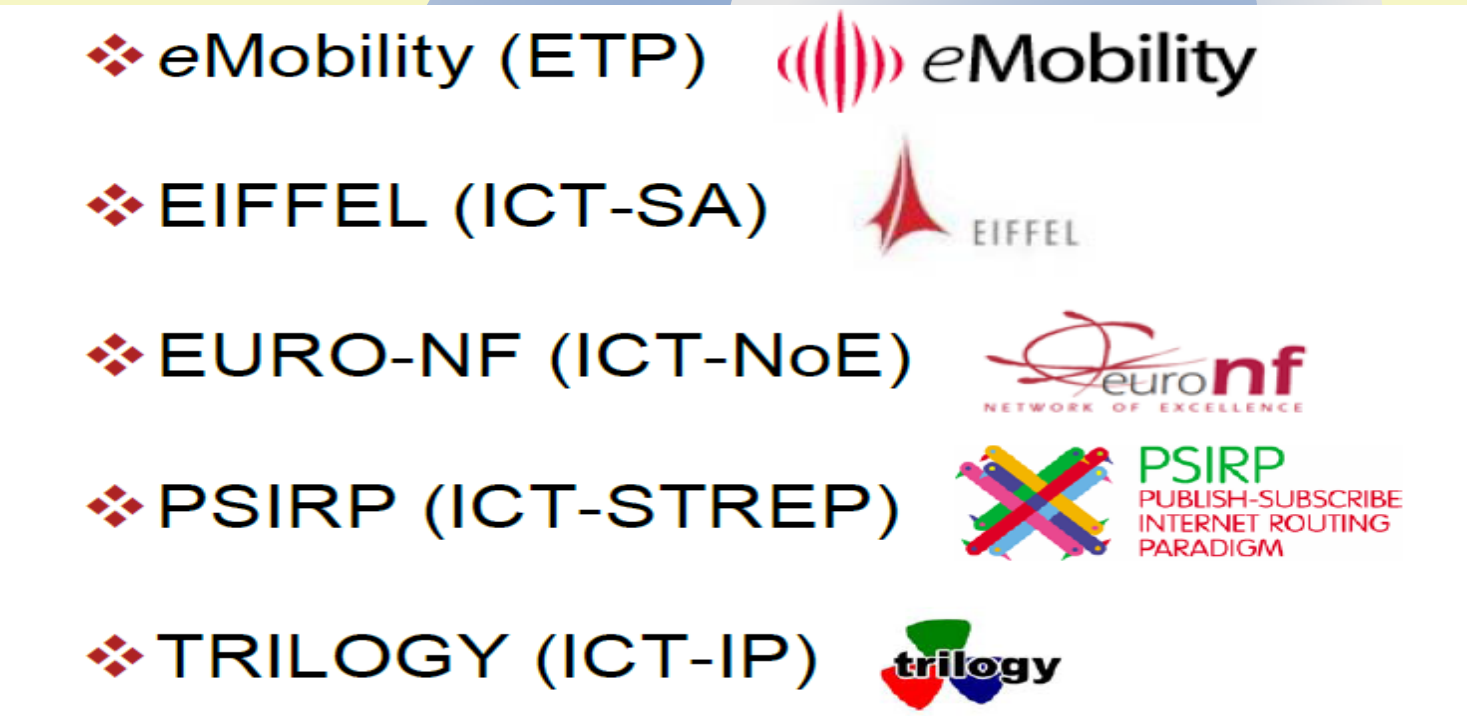
- **Europe (cont'd)**
- *EU level activities*:
  - Examples of FP7 ICT project on FI: 4WARD, http://www.4ward-project.eu/

- Combination of clean-slate research approaches to address the **Network of the Future**
- Size: Roughly 23 M€
- Time 2 years



Future Internet Initiatives (cont'd)

- **Europe (cont'd)**
- *EU level activities*:
  - Other examples of FP7 ICT projects on FI



References

- **References (partial list)**

1) Report from the National ICT Research Directors Working Group on Future Internet (FI) of the EC on Information Society and Media- Nov. 2008)
2) A.Peltomäki, Stimulating an Innovation Ecosystem for Future Internet Technologies, EC Information Society and Media Directorate-General, Lulea, Sweden June 2009
3) Schönwälder ,j. et al. , Future Internet = Content + Services + Management, IEEE Communications Magazine, July 2009
4) FUTURE INTERNET ASSEMBLY, Madrid, Spain, 9th – 10th December 2008, MEETING REPORT, December 2008
5) DG Information Society and Media Directorate, for Converged Networks and ServiceFuture Internet 2020, VISIONS OF AN INDUSTRY EXPERT GROUP, May 2009
6) G. Tselentis et al. (Eds.), Towards the Future Internet, IOS Press, 2009
7) Future Internet – Towards Research Challenges – 07 APR 2009, http://www.future-internet.eu/fileadmin/documents/prague_documents/FI_-_From_Functionalities2Challenges-09_04_08.pdf
8) Future Internet Initiatives, http://www.nessi-europe.com/Nessi/ (Networked European Software and sevices initiative)
9) Pavlou G., Towards a Service-aware Future Internet Architecture, Future Internet Assembly – Madrid, Dec 2008
10) The FP7 4WARD Project , http://www.4ward-project.eu/
11) Luis M. Correia, An Academic View on Business and Regulatory Issues on the Future Internet, http://www.4ward-project.eu/
12) Abramowicz,H. Introduction to BIRD WS, http://www.4ward-project.eu/
13) www.cordis.lu/FP7/

Concept, Key Characteristics and Requirements of Future Networks in ITU-T perspectives

- From ITU-T 1st Focus Group on Future Networks (FG-FN) meeting -

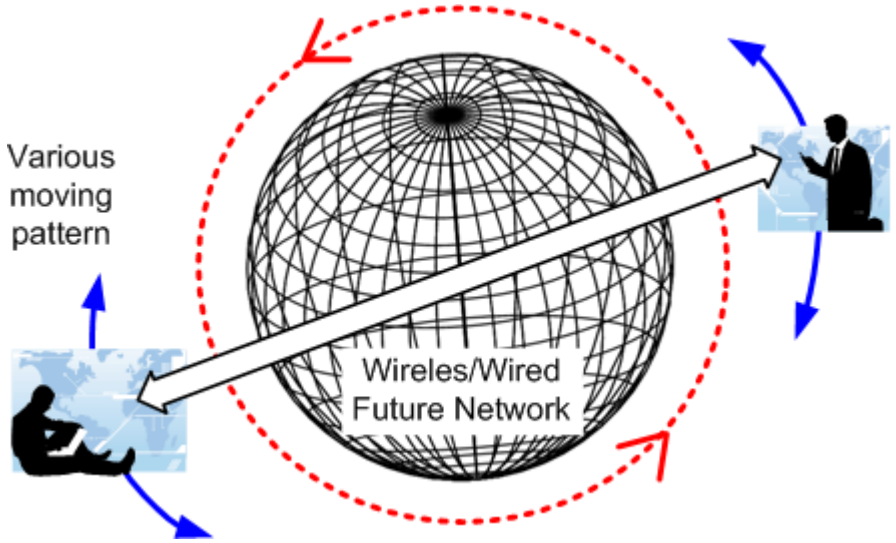
Gyu Myoung Lee

26th August, 2009

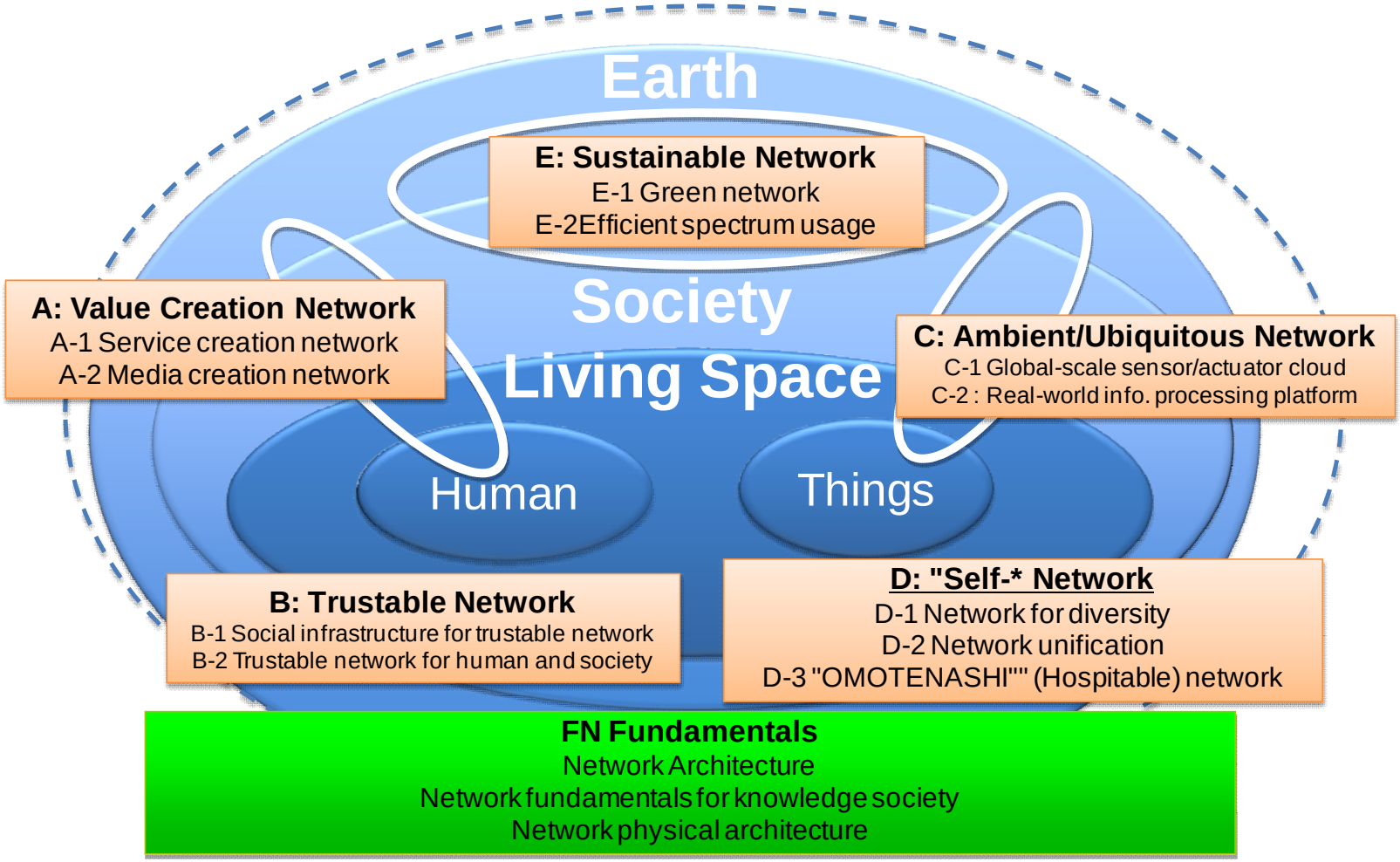
Institut TELECOM, TELECOM SudParis

gm.lee@it-sudparis.eu

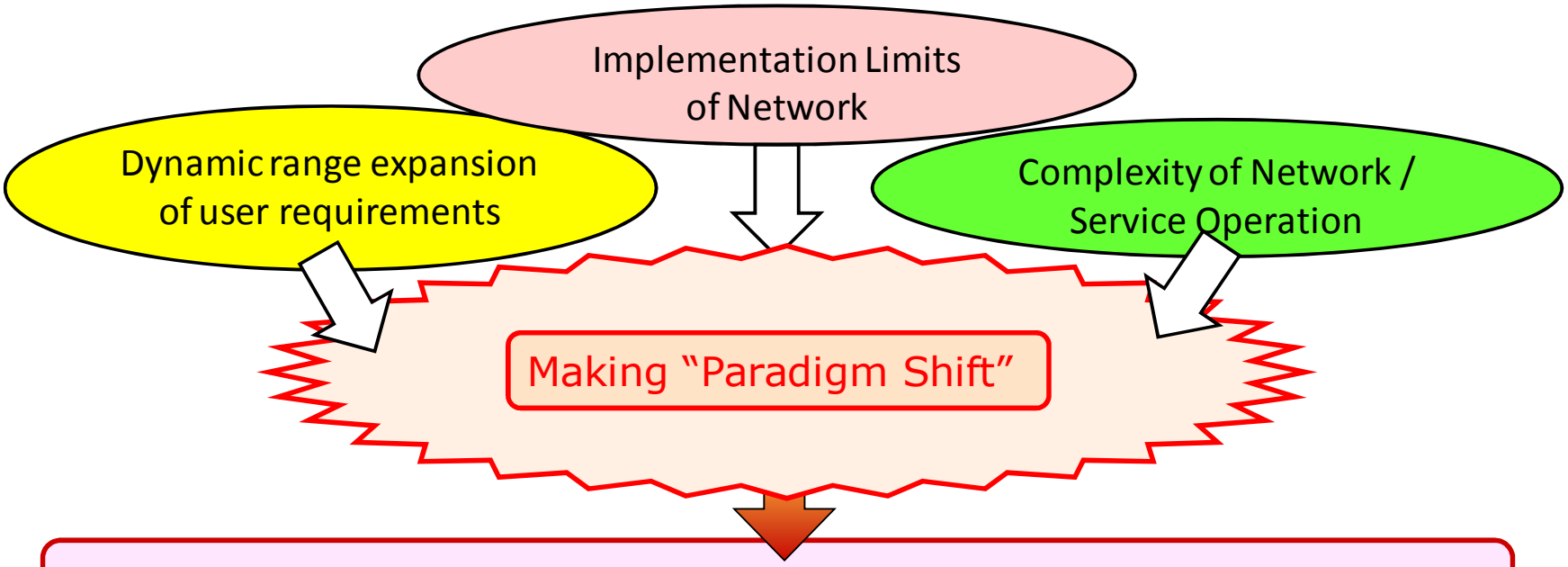
Abstraction of communication sphere



High level vision of Future Networks



Paradigm shift towards Future Networks



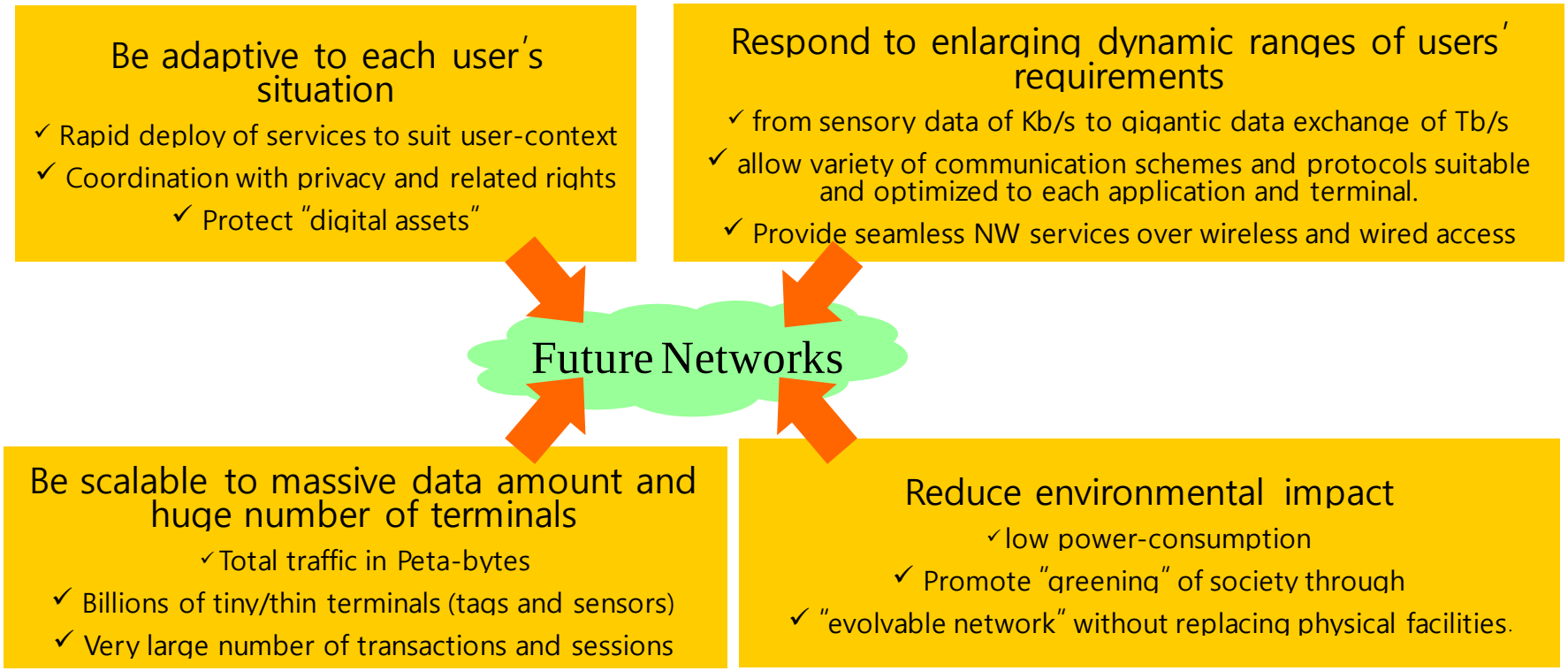
Every network user can get customized services for his/her needs.

Customer requirements is dynamically reflected in network.

Static or dynamic optimization strategies are provided in any levels of network.

Green (Environmental issues) & Security (Social issues)

High level requirements of Future Networks

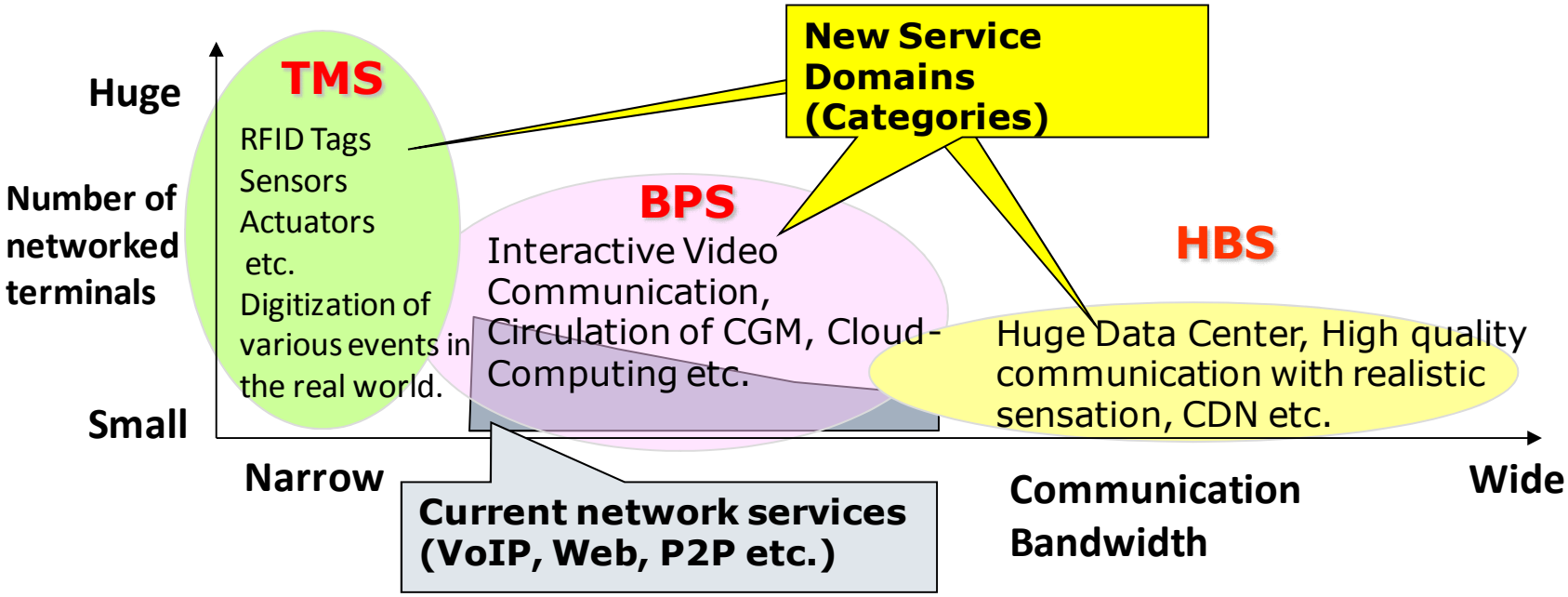


High level view of new services domains

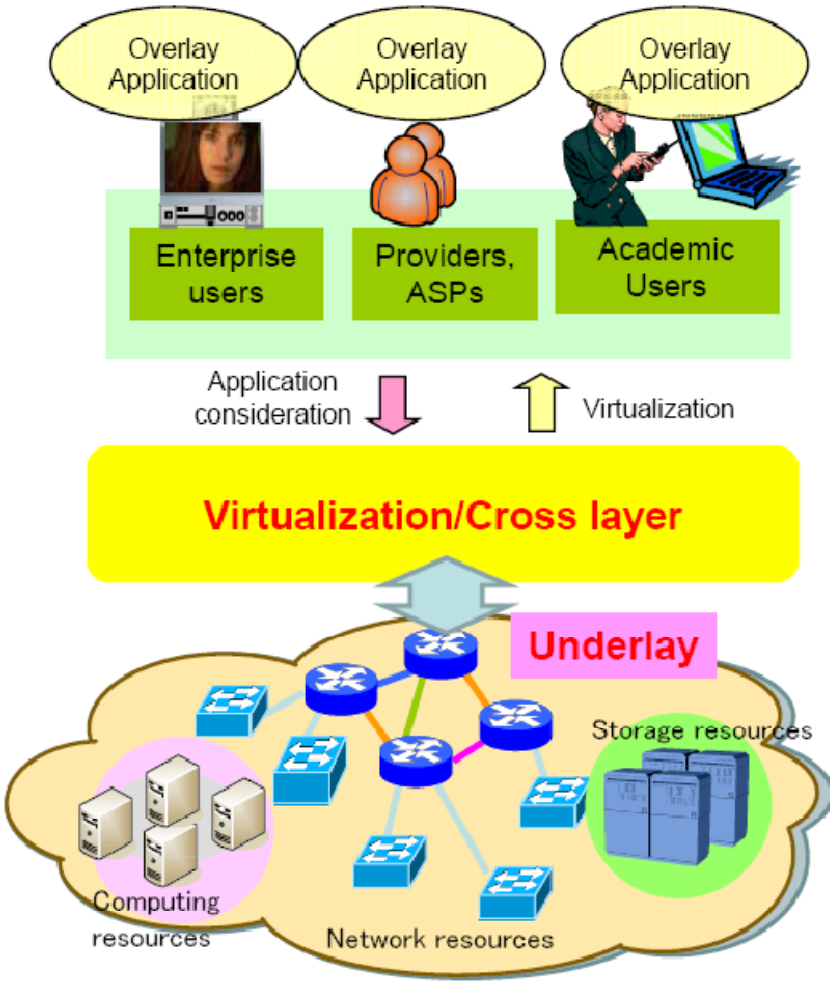
HBS : Huge Band Service — **Transparency, ultra wide bandwidth, low latency …**

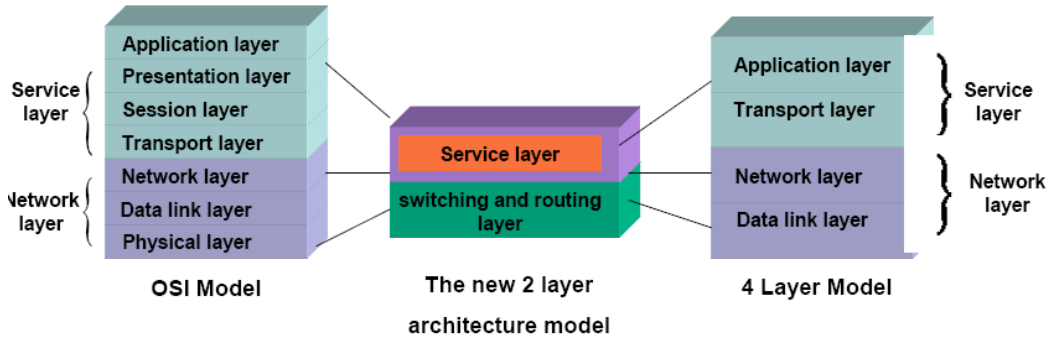
BPS : Broadband Packet Service — **Packet-based network which aggregates wide variety of services.**

TMS : Tiny-band Mass Service — **Service platform for data sensing and mining of real-world and machine-to-machine communication.**

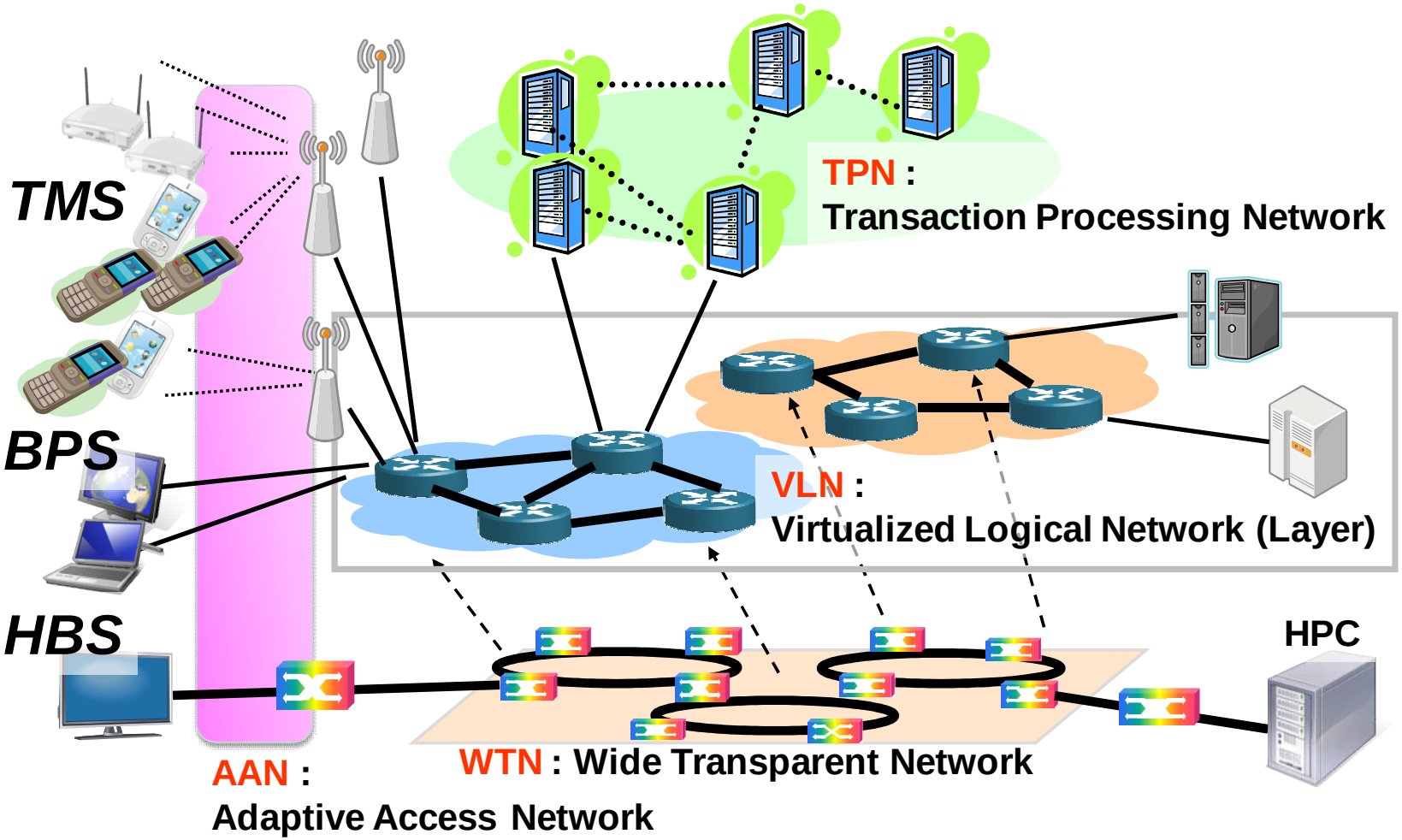


High level view of Future Networks





Rough Sketch of Future Networks



Future Internet:
Challenges, Perspectives, and Beyond

Economic Sustainability of Internet Access Networks

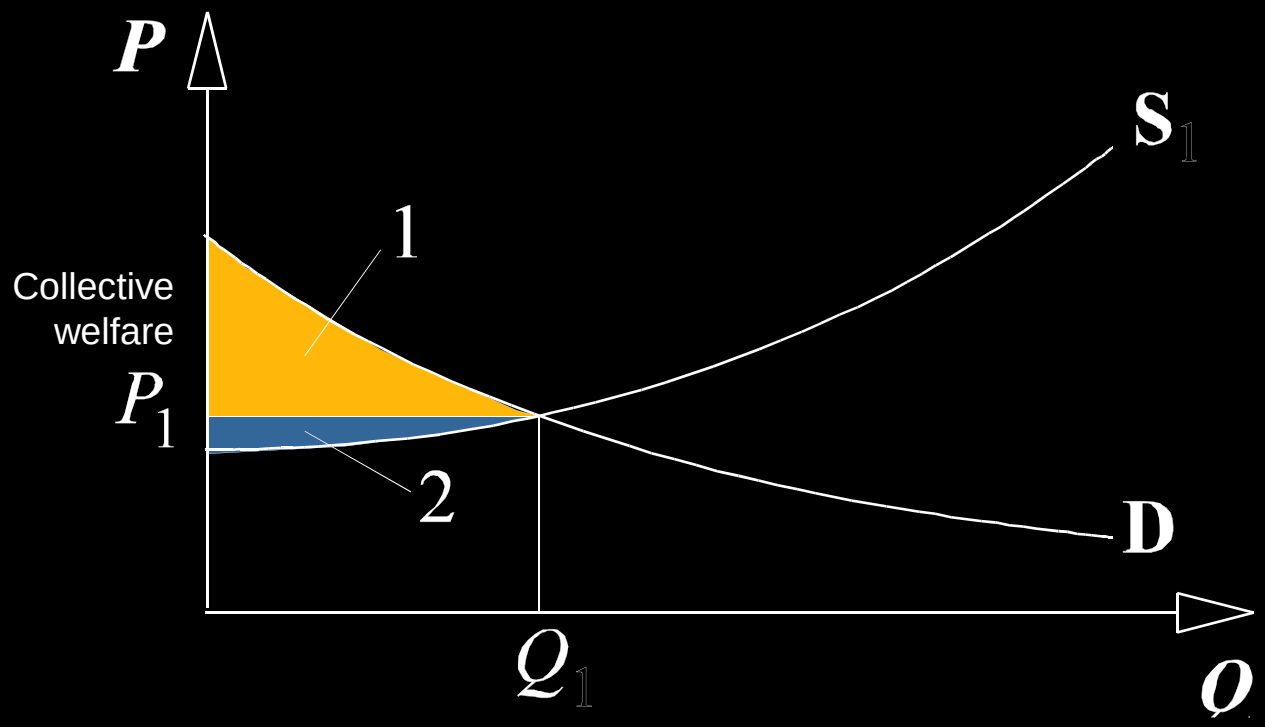
Alessandro Bogliolo

Information Science and technology Institute
University of Urbino
alessandro.bogliolo@uniurb.it
blog.neutralaccess.net

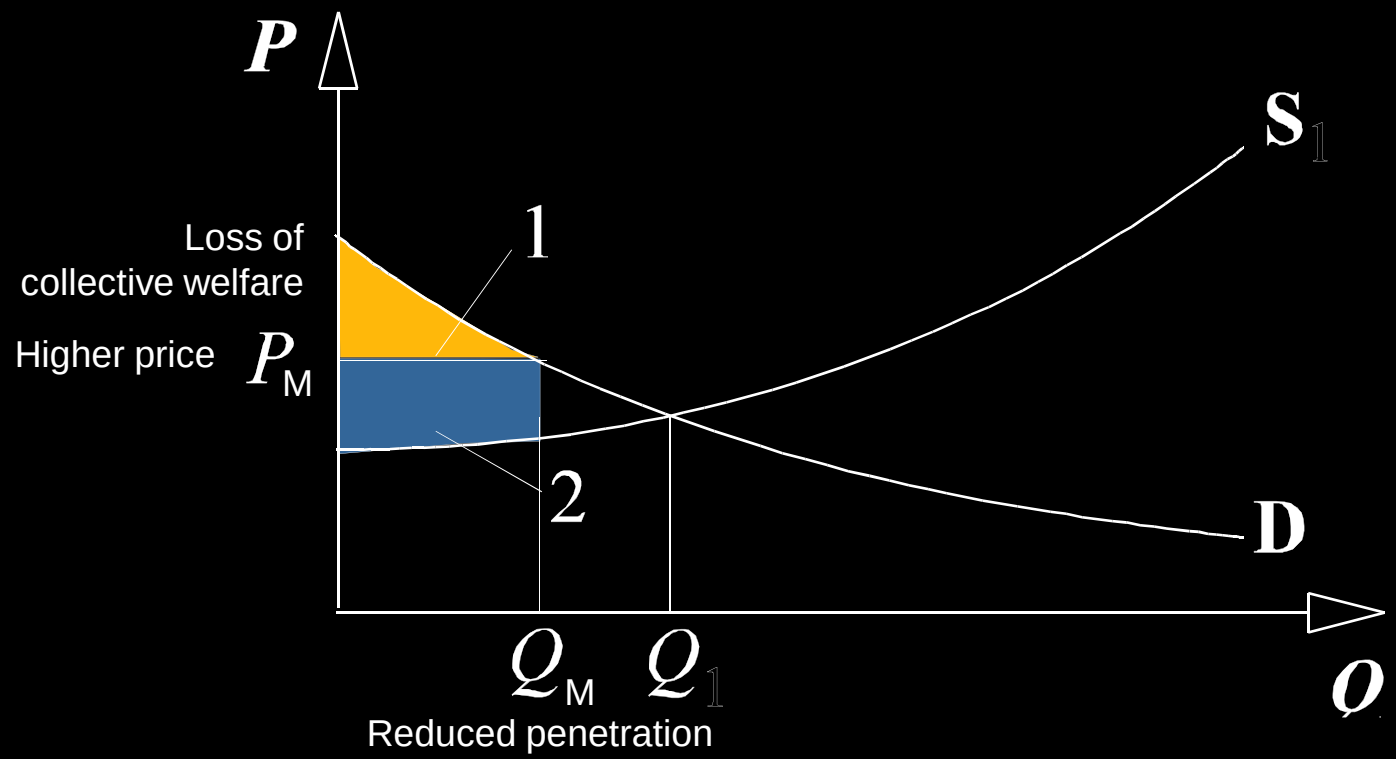
Facts

- Flat-fee access-oriented business models
- Limited broadband penetration
- Unreachable breakeven
- Residual digital divide (infrastructural/cultural)
- Lack of motivation
  - Investments
  - Competition
  - Innovation
  - Demand
- Under-provisioning
- Neutrality issues
- QoS concerns

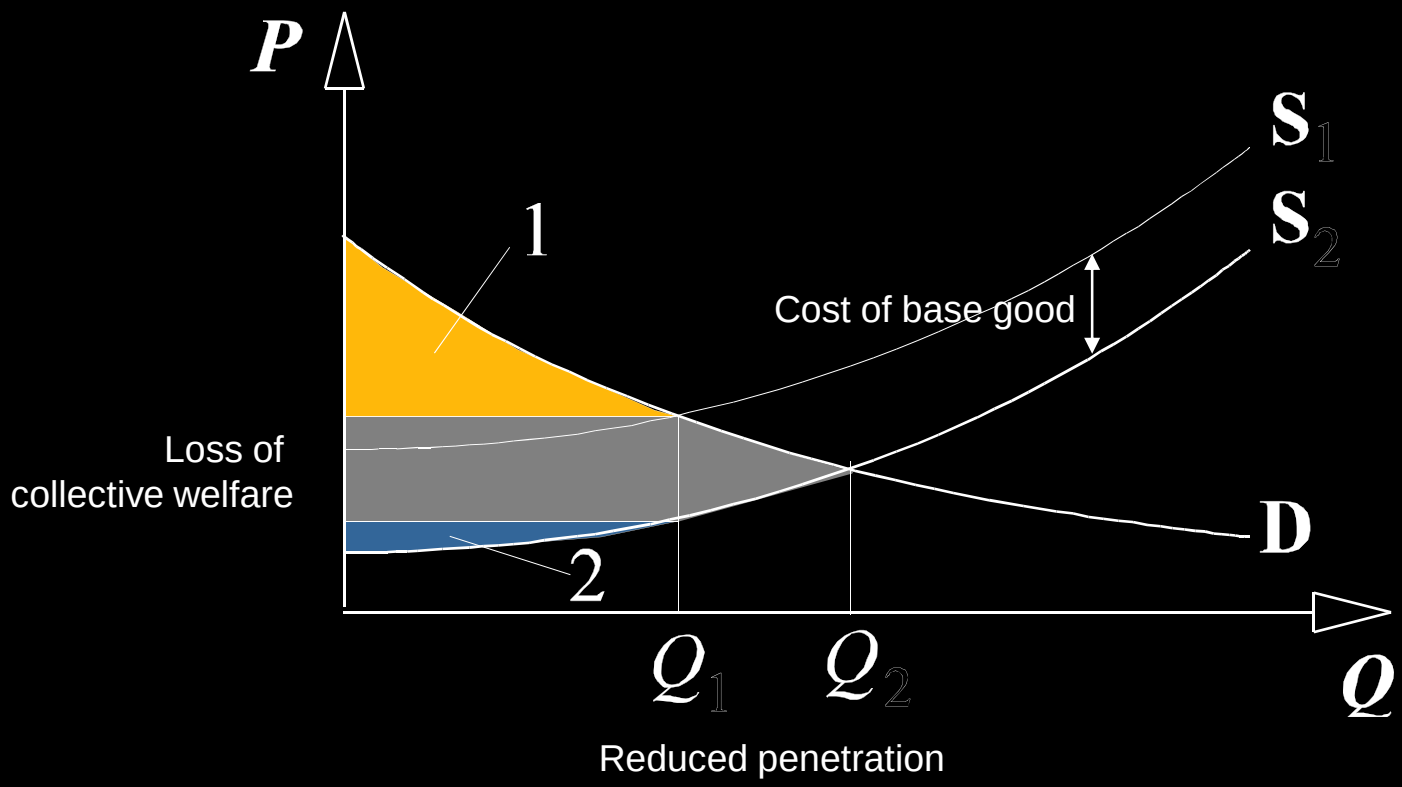
Price-Quantity Equilibrium



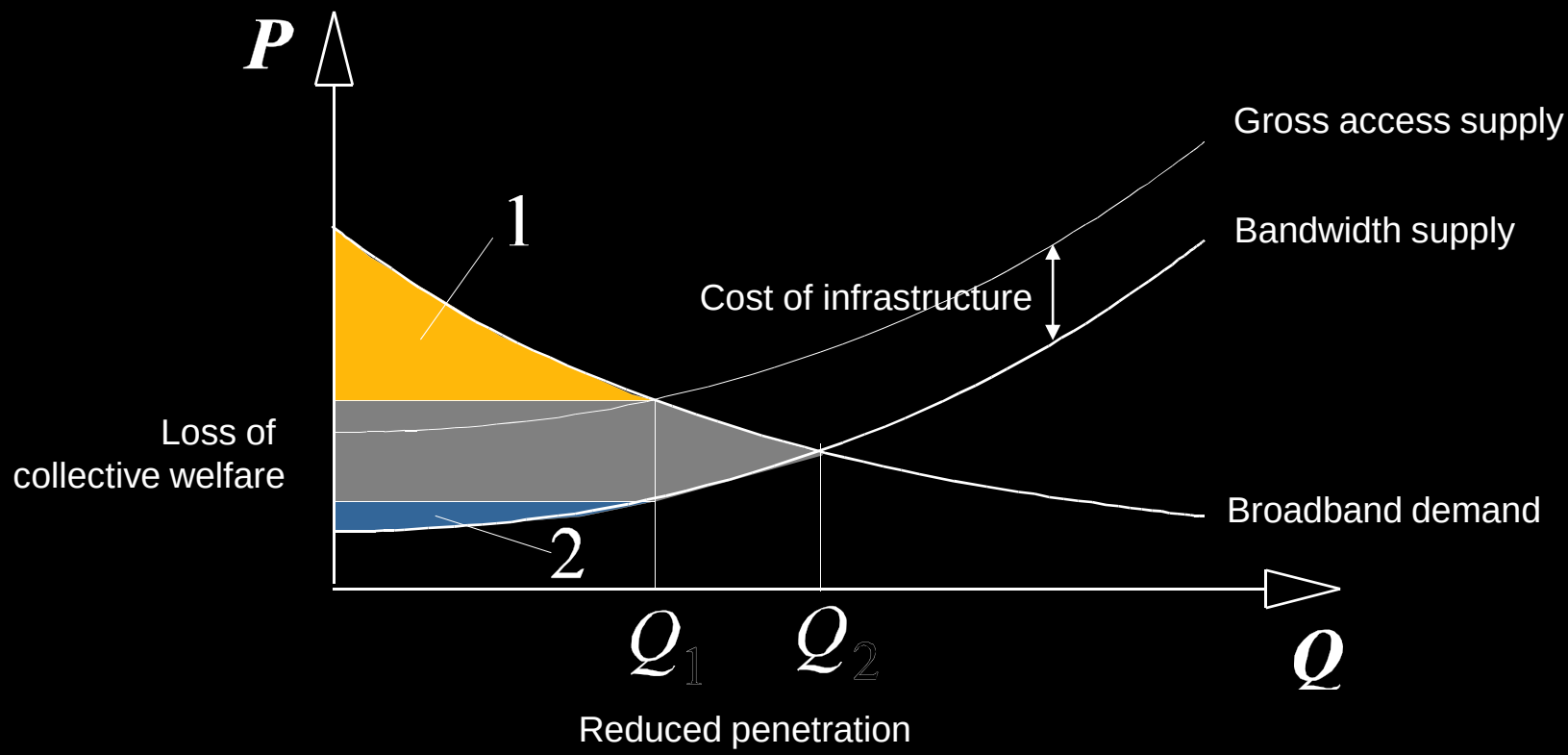
Effect of Monopoly



Effect of a *Hidden Base Good*



Broadband market



Susteinability hints

- Competition
- Convergence
- Accessibility
- Network-service separation
  - Unvealed base good
- Service-oriented business models
- Neutrality
- Externality
- Simplicity (best effort?)