The Internet of the future: What could it be and what are the challenges

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From Internet towards Multiservice IP networks

- First generation, before 1992
  - ⇨ Research network, “nice” users (no major security issues)
  - ⇨ Telnet, Email, File Transfer, no stringent QoS constraints
  - ⇨ Low traffic, low number of users, low socio-economic impact
- Second generation, the ’90s
  - ⇨ Commercial services, ISPs – business stakes
  - ⇨ Web and basic peer-to-peer
  - ⇨ Traffic and number of networks explosion
  - ⇨ Mainly Best Effort approach and simple engineering rules
    - Main issue: capacity (transmission and addressing)

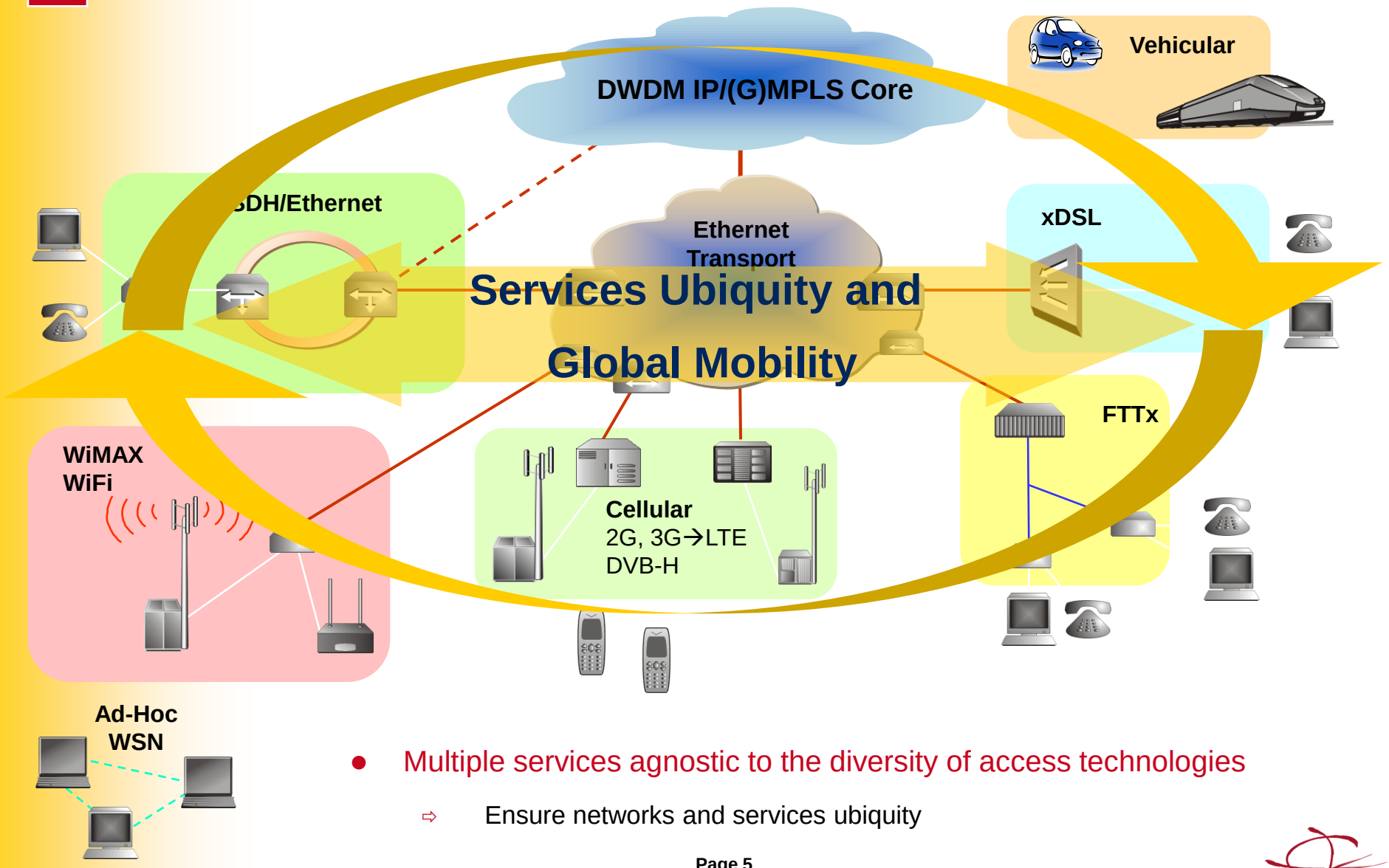
From Internet towards Multiservice IP networks

- Third generation: today
  - ⇨ Triple play, Quad play
    - Internet access, Telephony, IPTV, Mobile convergence,…
    - Fix and mobile broadband connectivity increasing fast
      - 1 Billion broadband mobile users by 2011
  - ⇨ Service overlays
    - Skype,…
  - ⇨ Multimedia digital content and end user empowerment
    - YouTube, Daily Motion, Facebook, MySpace…
  - ⇨ Coexistence of two models
    - NGI, NGN
    - The question of neutrality
  - ⇨ The Internet plays today a major socio-economic role
    - It was not designed, for witch it was not designed for.

The Future Networked Society

- Third generation, from now on: Services evolution and global convergence
  - ⇨ Network and services ubiquity
    - Personalized services
    - Location and Context Awareness
    - Services composition, services networking (new BM, new SLAs)
  - ⇨ Global Mobility
    - Services Mobility across terminals, technologies and administrative domains
    - Vertical Handover, Always Best Connected
    - Any terminal is your terminal (bio identification, ...)
  - ⇨ Community services, spontaneous and opportunistic networking
    - Random Connectivity may behave as permanent connectivity depending on the density of communicating devices
    - Last mile under the control of the end users?

Multi-Network Services



- Multiple services agnostic to the diversity of access technologies
  - ⇨ Ensure networks and services ubiquity

The Future Networked Society

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    - Last mile under the control of the end users? (Mesh, Ad-hoc, etc)
    - Random Connectivity may behave as permanent connectivity depending on the density of communicating devices

The Future Networked Society

- Third generation, from now on: Services evolution and global convergence
  - ⇨ Merging the real/physical and digital worlds
    - Wireless Sensor Networks (WSNs) and Actuators
    - Augmented reality, Virtual reality environments (3D Internet)
    - Network transparency
  - ⇨ Machine to machine and ambient intelligence
    - Beyond RFIDs
    - Towards the Internet of things
    - Providing integrated experience
  - ⇨ Autonomous Networking, Cognitive networks and self management, etc.
    - Mastering the complexity

The Future Networked Society

- Third generation, from now on: Services evolution and global convergence
  - ⇨ Network Virtualization and Programmability
    - Service and application enablers move into the network
      - Storage, caching, transcoding, etc,
    - Application awareness, Semantic routing
      - from nice to have functionality towards a networking paradigm that may challenge the supremacy of IP networking
  - ⇨ Home networking: beyond “just” networking
    - Convergence of: Communication, Information, Entertainment, Home automation and Persons and goods security
  - ⇨ Infrastructure services: virtualization (beyond VPNs), services overlays, etc.
    - Support new business processes and new business models between operators, service providers and other players.

New requirements for the network of the future

- Well adapted to the explosion of the number and diversity of connected devices
  - ⇨ From hundreds of millions of wired devices towards tens of billions of wireless devices (trillions?)
  - ⇨ Urbanization: granularity (nano robots) + extension (planetary networks)
- An architecture that deals natively with mobility and infrastructure less systems
  - ⇨ Contribute to ABC solutions, deals with networks of variable topology, with large terminals and technology heterogeneity
- The core concepts of the Internet architecture are challenged : Addressing and routing
  - ⇨ Addressing capacity and structure, Separation of identification and location, New routing paradigms
  - ⇨ Identification management
    - A large diversity of entities to identify: devices, applications, things, programs, ...

New requirements for the network of the future

- Security and privacy in the network of the future (Michel Riguidel)
  - ⇨ New threats, examples
    - Computers talking each other never killed a man, what will happen once the physical and digital worlds will be merged?
    - What are the consequences of the mass of Mips that will be available to any citizen?
  - ⇨ New security technologies and architectures
    - Requirement for a joint protection of a large diversity of heterogeneous technologies, a “system approach” is required.
    - Signatures: how can they be guaranteed over long time periods (a contract may be for 99 years, digital signatures are not well suited for such large time scales)
    - Does cryptography scale to the capacity of the networks of the future?
  - ⇨ Who are the major defenders of privacy?
    - Identity management, accountability, responsibility (persons, objects, “virtual entities”), protection of private sphere
- Contribute to the global privacysecurity/trust/ architecture
  - ⇨ Allow for a configurable trade off between security and privacy
  - ⇨ In a very dynamic environment

New requirements for the network of the future

- Easy to use, cheap to operate: Self configuration and self organization
- Dependability: Provide various levels of robustness, including those required for critical services
- Transparency: Contribute to QoS provisioning, merged with the physical world
- Efficient transport: Resources virtualization, Facilitate multicast (e.g. for IPTV), Evolved traffic engineering and traffic control

New requirements for the network of the future

- Flexible to deal with the increase of capacity of devices interfaces and access networks
- Introduce new networking paradigms: challenged networks (delay tolerant networks, disruption tolerant networks, etc.), coding networks, quantic networks, etc…
- Designed considering socio-economical issues related with governance, neutrality, privacy, security, IPRs, spam, viruses, advertisement, …

Internet of the Future, Overview

- Evolution of present Internet core and convergent access
- The Internet of “networking capable” edge devices
- The Internet of WSNs, actuators, things
- The “basic” overlays, virtualization and programmability
  - ⇨ Service enablers
  - ⇨ Session stratum and other control facilities
  - ⇨ Joint network/overlay design
    - Additional functionality moving into the network

Challenges Overview

- Technical
  - ⇨ Technologies
    - High capacity, efficient, flexible and cognitive radio
    - Flexible and reconfigurable optical networking (e.g. OFS)
    - Energy provisioning and consumption
      - E.g. MIT chips operating at 0.3 volts..., targeting devices powered by “ambient energy”
    - Miniaturization (nano technologies)
    - Interfacing with the living world (biotechnologies)
  - ⇨ Network and Service Architectures
    - Global convergence
    - Network transparency
    - Services evolutionarily
    - Dependability, security, trust, privacy
    - Cross-stratum, cross-layer, cross-technology, cross-terminal, cross-generation design
    - New networking paradigms
    - Evolutionary vs. Disruptive; Right question?

Challenges overview

- Technical
  - ⇨ Experimental platforms for
    - Removing any imitation in future networks design
    - Allowing end users to keep contributing on services and applications innovation
  - ⇨ Indeed, Future Internet Services may be Designed by End Users
    - It happened in the past: web, chat, peer-to-peer, social networks, etc.
    - It was possible because the Internet was available and open
    - Extrapolation: if new network solutions based on new technologies are made available, new services and usages will emerge
    - Let’s design and prototype the future Internet, integrating the previously cited concepts and being flexible for future evolutions

Challenges overview

- Economical
  - ⇨ Which pertinent markets?
    - See Google
  - ⇨ New business models
    - Active role of end users
      - Content, Infrastructure-less communications, Last hop
    - Added value corporate services
- Political
  - ⇨ Governance, Regulation, ...
  - ⇨ Promote innovation
  - ⇨ Promote productive collaboration between the industry and academic worlds
  - ⇨ Promote the required synergies between public and private investments in R&D

To conclude

- A strategic domain
  - ⇨ Core of the future networked society
- With a very strong international competition
  - ⇨ And a pertinent market that is broadening
- Requiring advance multidisciplinary research and innovation
  - ⇨ To maintain a leadership
  - ⇨ With a strong requirement of international collaboration
    - Being a leading voice in the international arena
- Euro-NGI/NF: a set of research projects, a think tank and a set of tools to contribute developing a leadership, creating synergies and developing international collaboration.

Thank you for your attention

Discussion
Questions