



# On the Internet of the Future

**Grif**

**Groupe de Reflexion sur l'Internet du Futur**

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# Outline

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- The Network of the Future
  - ⇒ A vision and related challenges
- The Underlying Research Challenges
- Standardization Bodies
- The Initiatives on the Future Internet
- How to Favor the Creation of Value in Networking
- How to Meet the Scientific Challenges}

# Groupe de Réflexion Internet du Futur

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- **Steering Committee**

- ⇒ F. Jutand, Institut Telecom

- ⇒ J.P. Verjus, INRIA

- **Members**

- ⇒ F. Baccelli, INRIA-ENS

- ⇒ V. Badrinath, Orange

- ⇒ F. Bourdoncle, Exalead

- ⇒ C. Diot, Thomson

- ⇒ S. Fdida, Paris 6

- ⇒ D. Kofman, Institut Telecom

# The present situation

- **Triple play, Quad play**
  - ⇒ Internet access, Telephony, IPTV, Mobile convergence,...
  - ⇒ Fix and mobile broadband connectivity increasing fast
- **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 as a critical infrastructure for the economy, the society, etc.
- **Major investments on the Internet of the Future**
  - ⇒ Evolutive and disruptive approaches

# Core and access evolution

- Network and services ubiquity

- ⇒ Ubiquity of personalized services based on a large diversity of access technologies
- ⇒ Location and Context Awareness
- ⇒ Services composition, services networking

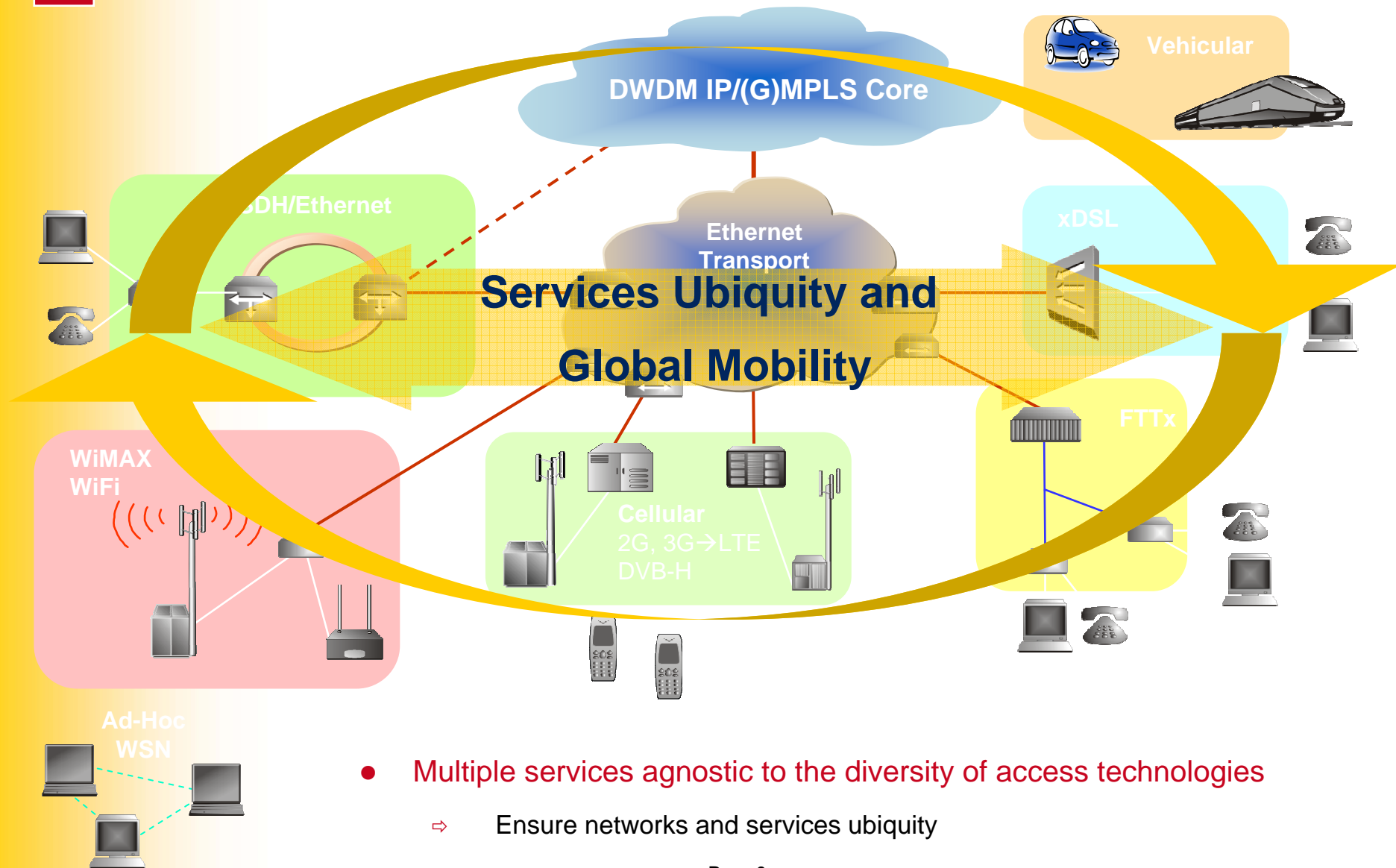
- Global Mobility

- ⇒ Services Mobility across terminals, technologies and administrative domains
- ⇒ Always Best Connected
- ⇒ Any terminal is your terminal (bio identification, ...)

- Simple Superfast Core Networks

- ⇒ IP networks over superfast optical core networks
- ⇒ Beyond IP and new routing paradigms: e.g. Semantic routing
- ⇒ Virtualization: optimized virtual networks answering specific needs
  - Service and application enablers move into the network
    - Storage, caching, transcoding, etc.

# Multi-Network Services



- Multiple services agnostic to the diversity of access technologies

⇒ Ensure networks and services ubiquity

# Examples of challenges

- Europe is not well positioned in present core IP routers market
  - ⇒ The evolution towards the cited new paradigms open new opportunities
- Europe has a leadership on Mobile Networking (GSM and then UMTS)
  - ⇒ Trend towards 4th generation (e.g. LTE) and beyond requires specific efforts to keep the leadership
    - See LTE deployment announcements in the USA
    - Vendors competition (impact of China)
- Requirement for new radio technologies and mobile networking paradigms for spectrum optimization

# Spontaneous and opportunistic networking

- A ring of spontaneous and opportunistic networking
  - ⇒ From terminals to networking capable devices
    - Operator-less networks (e.g. ad-hoc, MANETs)
  - ⇒ Self-organized mesh networks
    - Last mile under the control of the end users or new players?
  - ⇒ Opportunistic networking in operator networks
    - E.g. Mobile terminals behaving as relays for a global spectrum optimization
  - ⇒ Vehicular networks
  - ⇒ Random Connectivity may behave as permanent connectivity depending on the density of communicating devices
    - Keyword: self-organization

# Examples of challenges

- **New business models**
  - ⇒ Shared role of infrastructure based and opportunistic networks
  - ⇒ Control on the last mile
- **Future generation of smart terminals**
  - ⇒ An opportunity to increase competitiveness?
- **Penetration of specific markets**
  - ⇒ Vehicular and navigation systems
  - ⇒ Emergency and military applications

# Networking will reach every electronic device

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- **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

# Examples of challenges

- Positioning in the Internet of things
  - ⇒ E.g. The EPC global network, RFIDs and beyond
- An immense range of applications in health, environment, transport, energy, security, home, etc.
  - ⇒ Facilitate a faster adoption of these new technologies for the benefit of the future networked society
  - ⇒ Understand and lead the various potential vertical markets
- Deal with new complex governance issues
  - ⇒ In particular with related privacy issues
- Requirement for innovative networking architectures, security paradigms, naming approaches, information search and maintenance, etc.

# Services evolution

- Ubiquity of personalized services, Location and Context Awareness, Services composition, services networking
- From web of documents towards the web of services (web 2.0), knowledge, things, semantic web (web 3.0), sites personalization (intelligent marketplace), etc.
- The central role of end users
  - ⇒ Secondlife, Face Book, etc.
- Merging with the real world
  - ⇒ Augmented reality, virtual worlds and the 3G Internet, real time games, telepresence
- Business Aware carrier services enabling new business processes

# Examples of challenges

- Which pertinent markets?
  - ⇒ See Google
- New business models
  - ⇒ Active role of end users
    - Content, Infrastructure-less communications, Last hop
  - ⇒ Added value corporate services
- Governance, Regulation, ...

# New paradigms for content distribution

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- Diversification of the nature of transported contents
  - ⇒ Data, Telephony, Music, Video (TV, VoD, interactive video), real time games, etc.
- Users become content producers and providers
  - ⇒ Increasing role of Peer-to-peer applications
- New approaches for content consumption
  - ⇒ Podcasting

# Examples of challenges

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- Content protection (IPR) and respect of individual freedom
- Control of forbidden content distribution
- The neutrality issue
- Maintenance of digital content
- Impact of increasing volume and diversity on investment requirements

# Summary of the first part

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- An holistic approach of the Future Internet requires dealing simultaneously with
  - ⇒ Future core networks
  - ⇒ Future convergent access networks
  - ⇒ A first ring of self-organized opportunistic networks
  - ⇒ A second ring of communicating devices allowing for merging the physical and digital worlds
  - ⇒ A new generation of services infrastructures, services production and consumption approaches
  - ⇒ New paradigms for content production and distribution