

European Research on Future Internet Architectures and Technologies

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European Commission
Information Society and Media



Outline

- **Setting the stage: Internet technology reaching its limits**
- Ongoing research activities on Future Internet
 1. In the Memberstates
 2. On European Framework-Program level
- Next opportunities in FP7



Quote

- *A modern maxim says: People tend to overestimate what can be done in one year and to underestimate what can be done in five or ten years, Joseph Licklider; 1965*



Future Networked Society

Accommodation of all user ideas and requirements

Interactive multimedia content everywhere and easy to search

Communications of context-aware autonomic objects

Consumers enjoying permanent, seamless and confident services

Internet by and for People

Internet of Contents and Knowledge

Internet of Things

Internet of Services

Future Network Infrastructure

Scalable and dynamic routing and addressing

Security, privacy, and trust

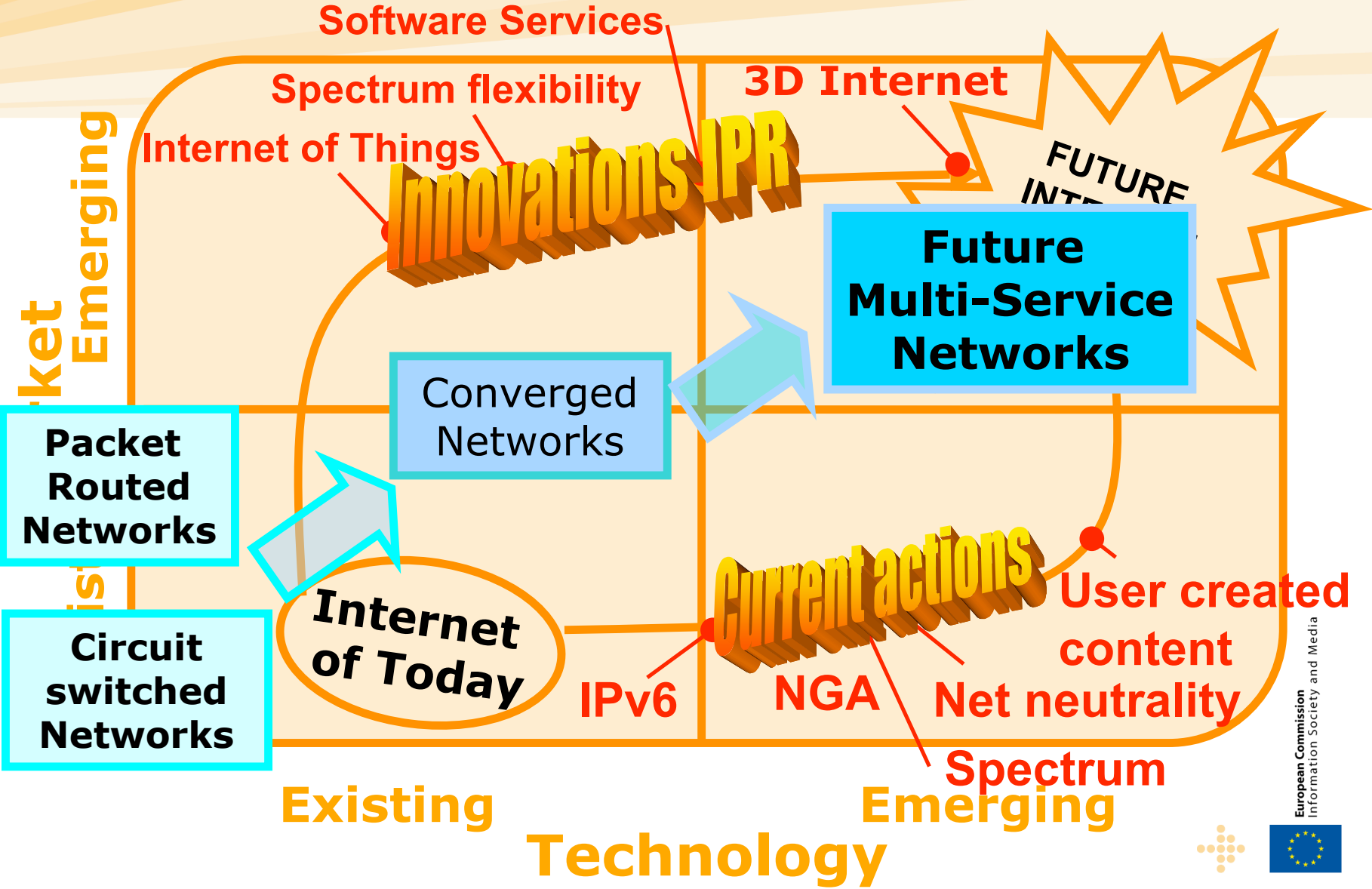
Efficient data and traffic management

Availability, ubiquity, and simplicity

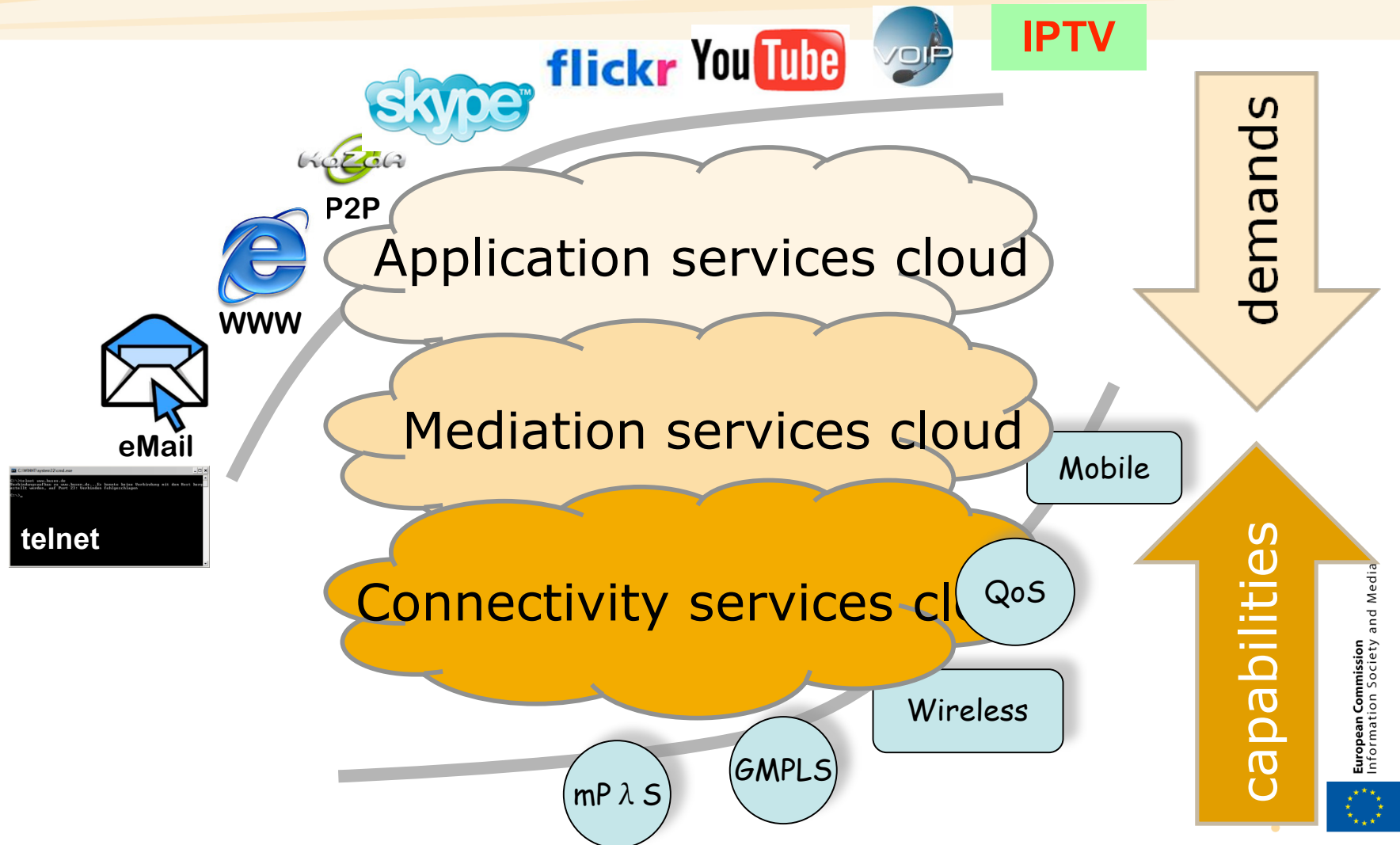
Adaptability to heterogeneous environments

Energetic and economic sustainability

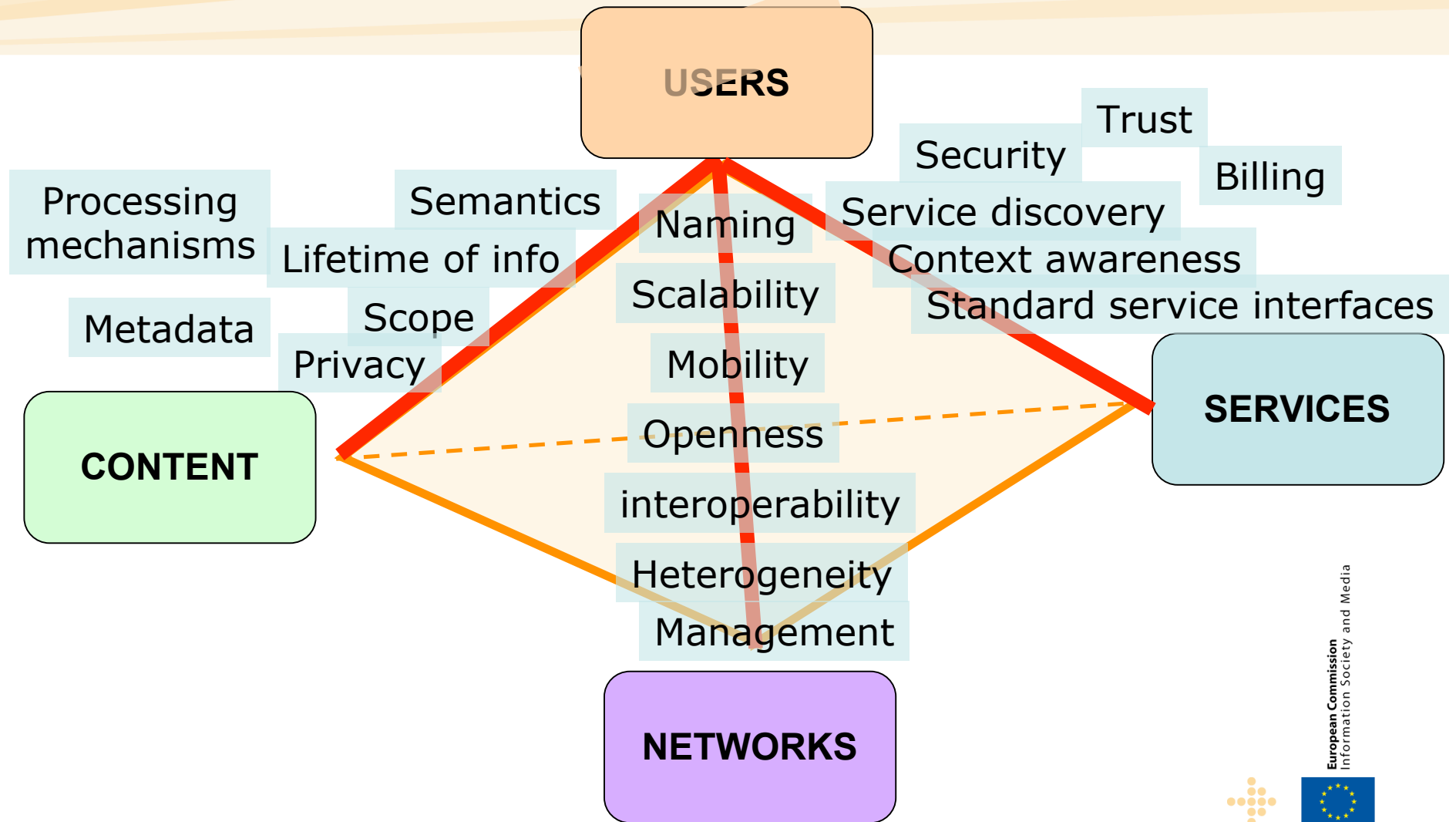
The network revolution



Communication Clouds



Relations

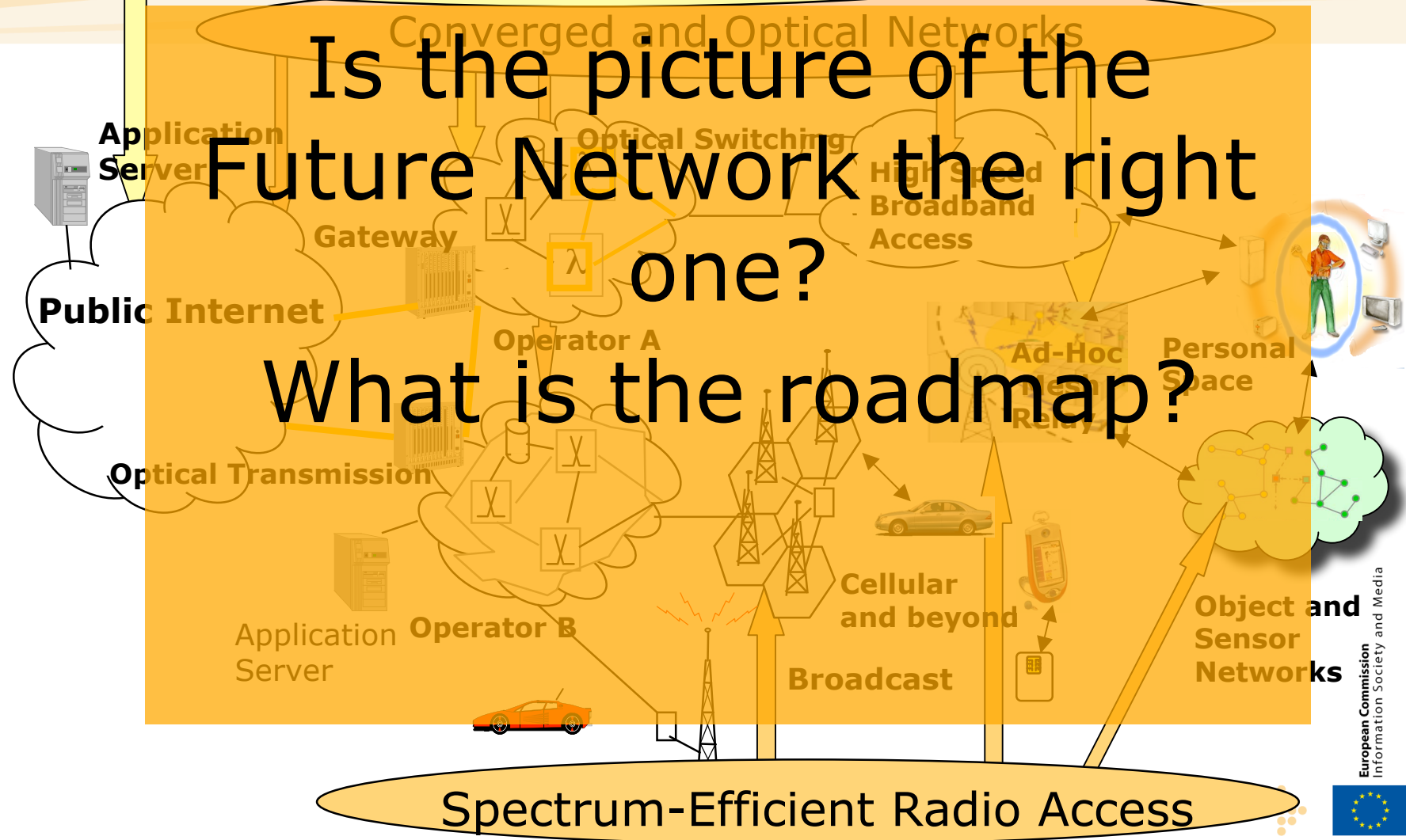


The Network of the Future

Network Architectures and Network Technologies

Is the picture of the
Future Network the right
one?

What is the roadmap?

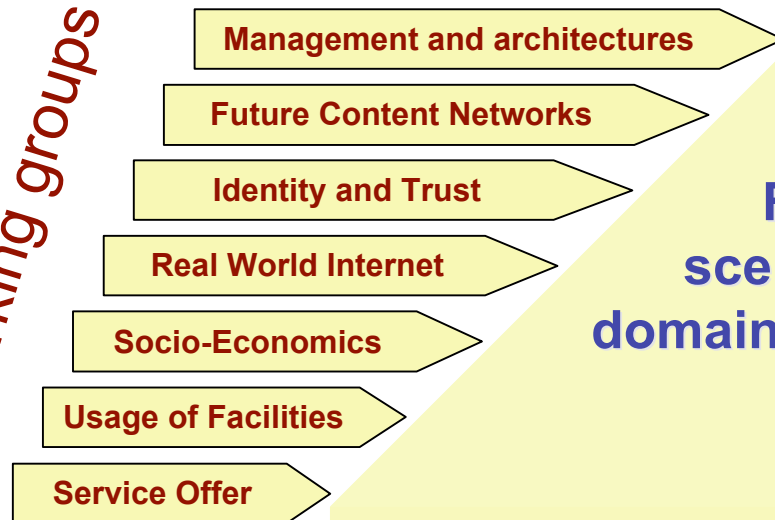


Organisation of the FIA

Work Programme Objectives

- **Open interactions and cross-fertilization**
- **Reducing fragmentation of efforts**
- **Developing common deliverables**
- **Joint strategic research agenda**

Working groups



**Future Internet
scenarios and cross-
domain research challenges**



European Commission
Information Society and Media



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FP: Framework Programme

Preliminary observations

- FI activities strongly intertwined with policies (broadband, IPv6 deployment, accessibility, rural development, ...)
- FI as a critical infrastructure to:
 - drive business and industrial innovation
 - modernise public administration
 - address emerging societal challenges
- Fragmentation in terms of: policy goals, targeted applications, R&D scope, involvement of users, innovation models,...
- Some common structures already emerging

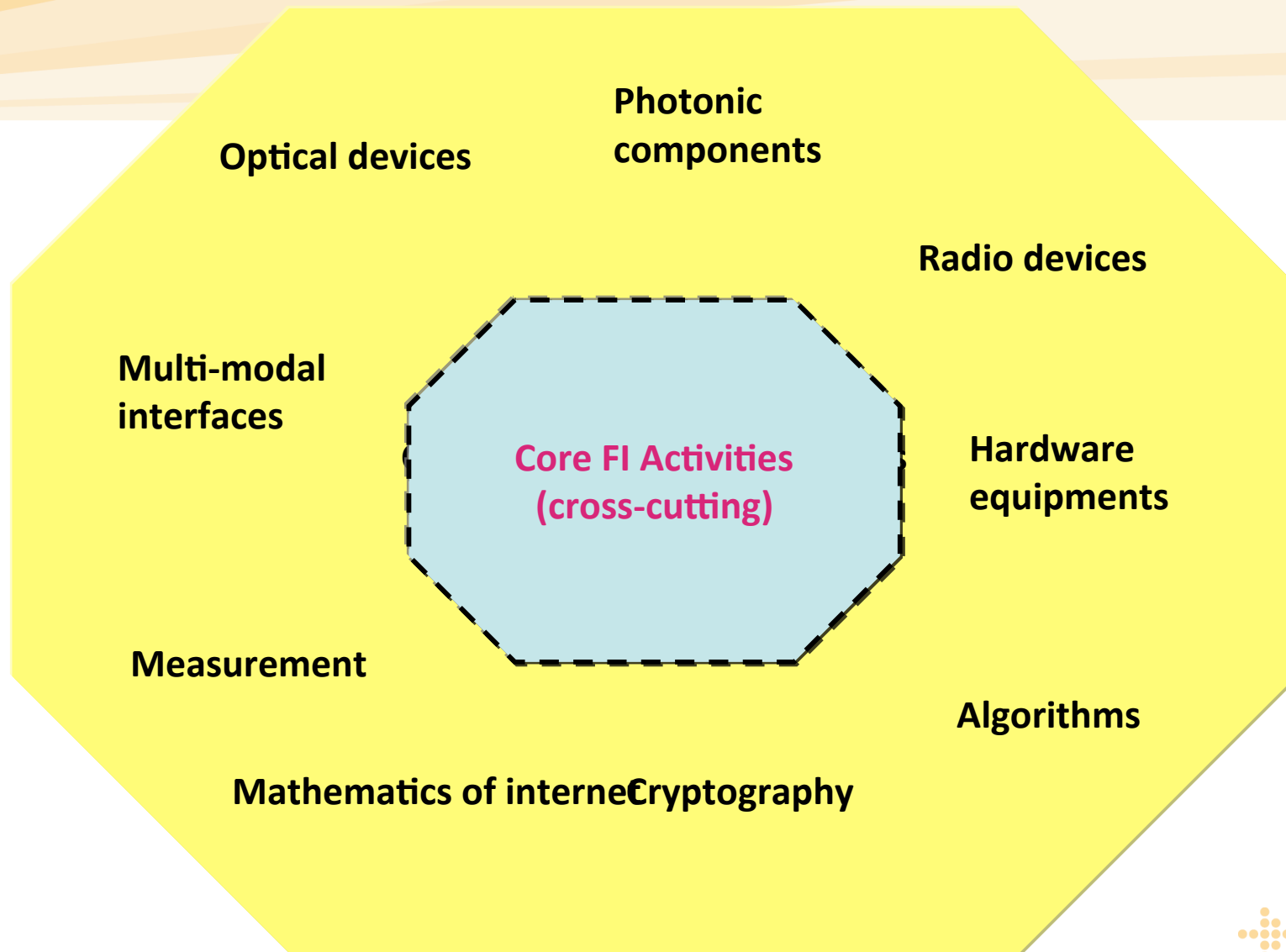


Technical scope (1)

- Different granularities and structures of activities (project, programme, initiative,..)
- Similar structure of topics (ICT WP/CH 1 as a model)
- Combination of incremental & clean-slate approaches
- Applications as strong drivers (health, inclusion, transport, energy,...)
- Some functional blocks identified (e.g. e-ID)
- Need for experimental facilities and test-beds



Technical scope (2)

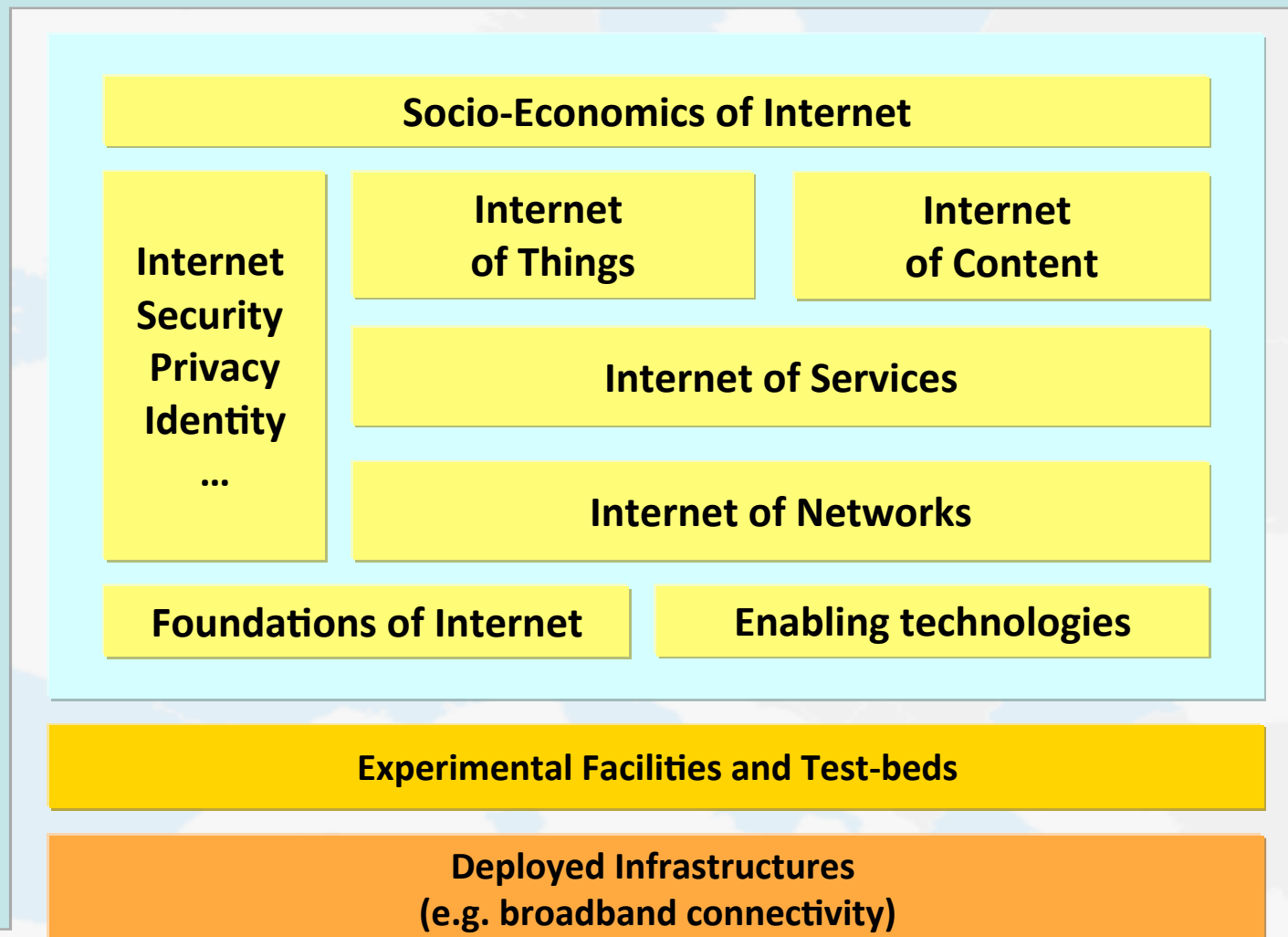


Enabling components & FI foundations



Technical scope (3)

New Application Scenarios (healthcare, transportation, energy, inclusion, ...)



Known Member States FI Initiatives

- ❑ Finland - ICT SHOK - www.futureinternet.fi
- ❑ Spain - Spanish Technology Platform convergent towards Future Internet” - www.idi.aetic.es/esInternet/
- ❑ Germany - G-Lab - www.german-lab.de
- ❑ France - Groupe de Reflexion Internet du Futur - [GRIF](#)
- ❑ Sweden - Ambient Sweden
www.vinnova.se/upload/EPiStorePDF/AmbientSweden.pdf
- ❑ Belgium - www.ibbt.be
- ❑ Luxembourg - www.ipv6council.lu
- ❑ Italy - cit.fbk.eu/future_internet
- ❑ The Netherlands - www.futureinternet.ez.nl
- ❑ Ireland - www.futureinternet.ie
- ❑ UK - www.internetcentre.imperial.ac.uk/about_us



Key objectives identified for the FI

- ***Industrial competitiveness***

- Mastering technologies and building IPR portfolios
- Exploring EU strongholds : mobile, broadband, security
- Shaping the future ahead of our competitors: u-Japan, u-Korea

- ***New economic and social opportunities***

- Innovative applications for enterprises and public authorities
- Economic and social impact beyond ICT sector
- Visible in MS strategies for the FI

→ To be successful both kind of objectives must be considered and interlinked

→ Clean slate and evolutionary approaches needed to go hand in hand



International Co-operation

- Not only valued from a technological perspective: globalization means that tomorrow's players are not necessarily the same as today
- FIRE-GENI Workshops
- EU-Japan symposium, 2nd edition 7-9 July, Tokyo
- EU-South America event envisaged.
- Joint experiments are key focus of work with third countries
- Opportunities in upcoming work program: **CSA:** *“Coordination of research efforts to explore synergies across on-going national initiatives and with third countries -USA and Japan-...” (Networks) international co-operation with other initiatives in industrial and emerging countries (FIRE); Asia and US, (RFID and IoT).*

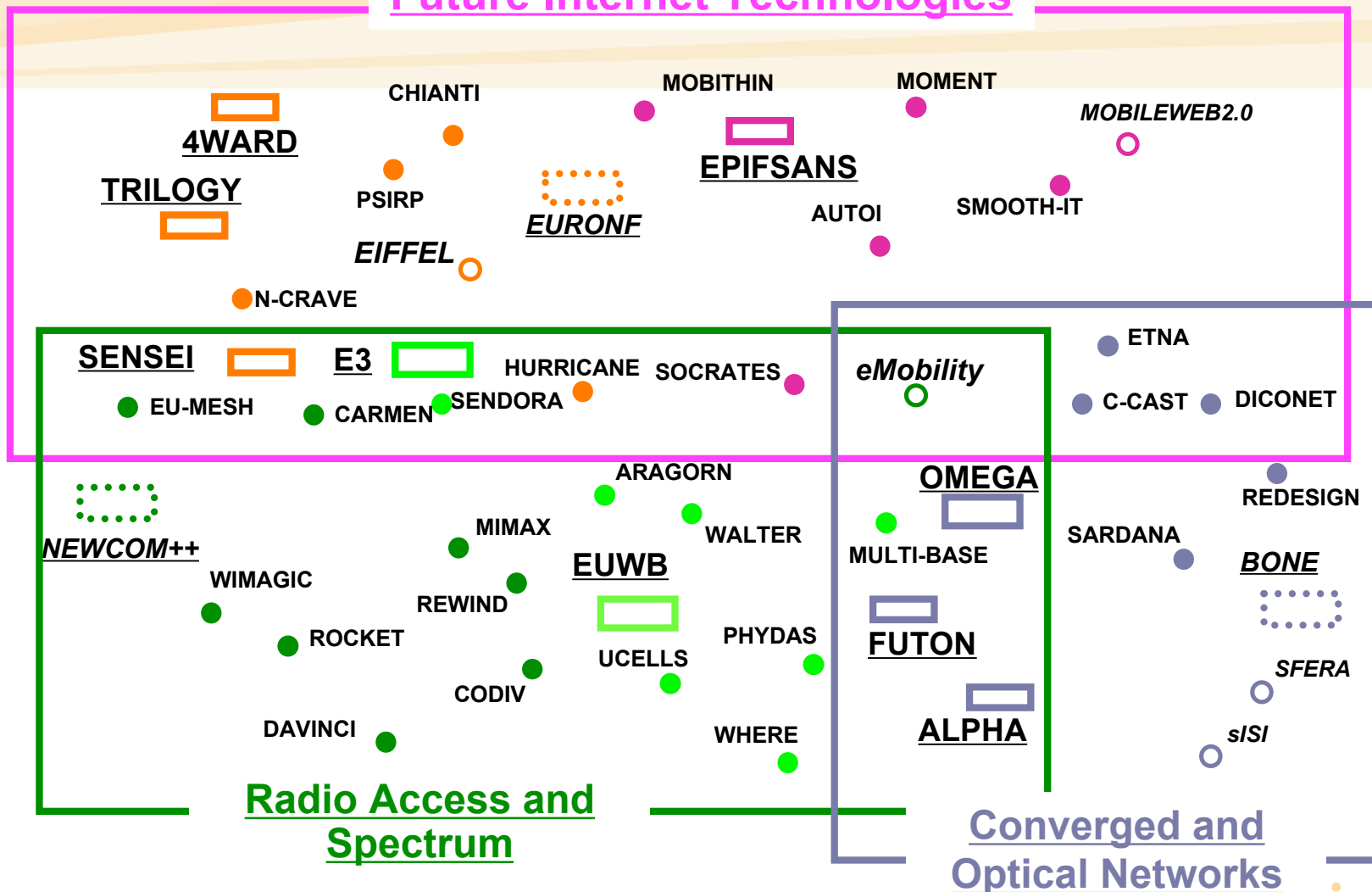


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Future Networks Project Portfolio & Clusters

Future Internet Technologies



Current State of the Art Research in the Cluster: Future Internet

- Both academically-driven and industry-led projects
- Example long-term topics covered:
 - post TCP/IP protocol research (new approaches to inter-domain routing, high-speed congestion control, load balancing, etc.)
 - radical architectural approaches built on strong mobile and wireless background
 - virtualization for networking resources
 - information-centric paradigm in place of the old host-centric approach



FP7 Research Approaches: Disruptive Paradigms

- Leverage Network Coding in architecting and controlling wireless networks in performance-challenged and resource-constrained environments (N-CRAVE)
- Implement an internetworked Publish-Subscribe Internet Routing architecture that restores balance of *network economics incentives* between sender and receiver (PSIRP)
- Integrate wireless sensor and actuator networks (physical world) efficiently into the future internet (digital world) (SENSEI, SENDORA)



FP7 Research Approaches: Compatible with existing Internet infrastructure

- Develop disruption-tolerant architectures that enable seamless service perception in challenging mobile scenarios (CHIANTI, MobiThin)
- Create a communication resource overlay with autonomic characteristics for the purposes of fast and guaranteed service delivery (EFIPSANS, AUTOI, SOCRATES)
- Develop efficient and fair resource control techniques allowing behavioural flexibility for different technical, social and economic outcomes (TRILOGY, Euro-NF)



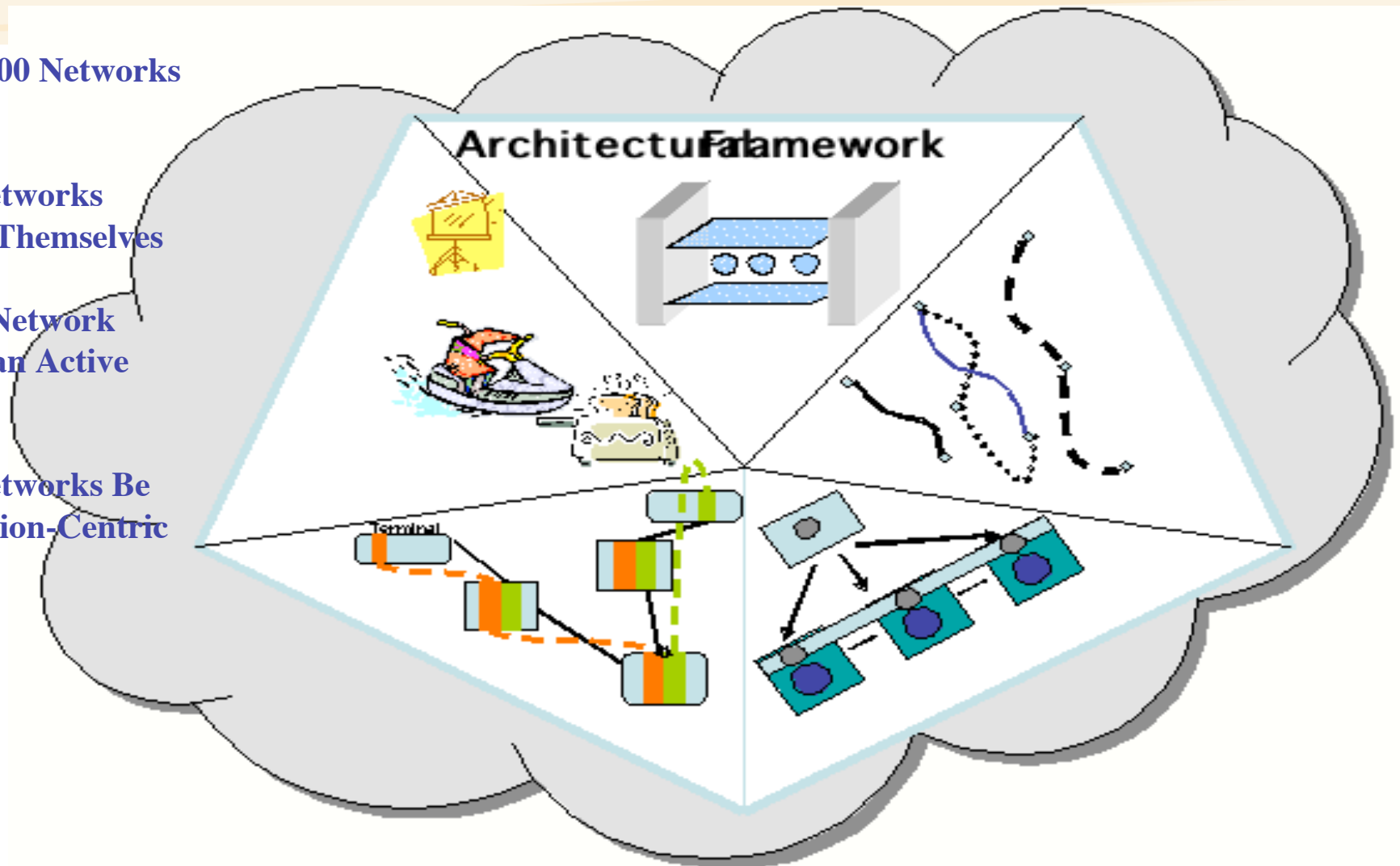
EU project **4WARD**, 10 M€

1: Let 1000 Networks Bloom

2: Let Networks Manage Themselves

3: Let a Network Path Be an Active Unit

4: Let Networks Be Information-Centric



4WARD

- Moving from node-centric architecture to info-centric: connecting objects of information, not connecting hosts
- Info as a routable object, routing on the information
- Based on “dissemination architecture” of Van Jacobson
- Split between identification and localization
- Persistent info id (no more error 404, object not found)
- Info objects could add more abstraction (they can represent a service, a real-world object,...)

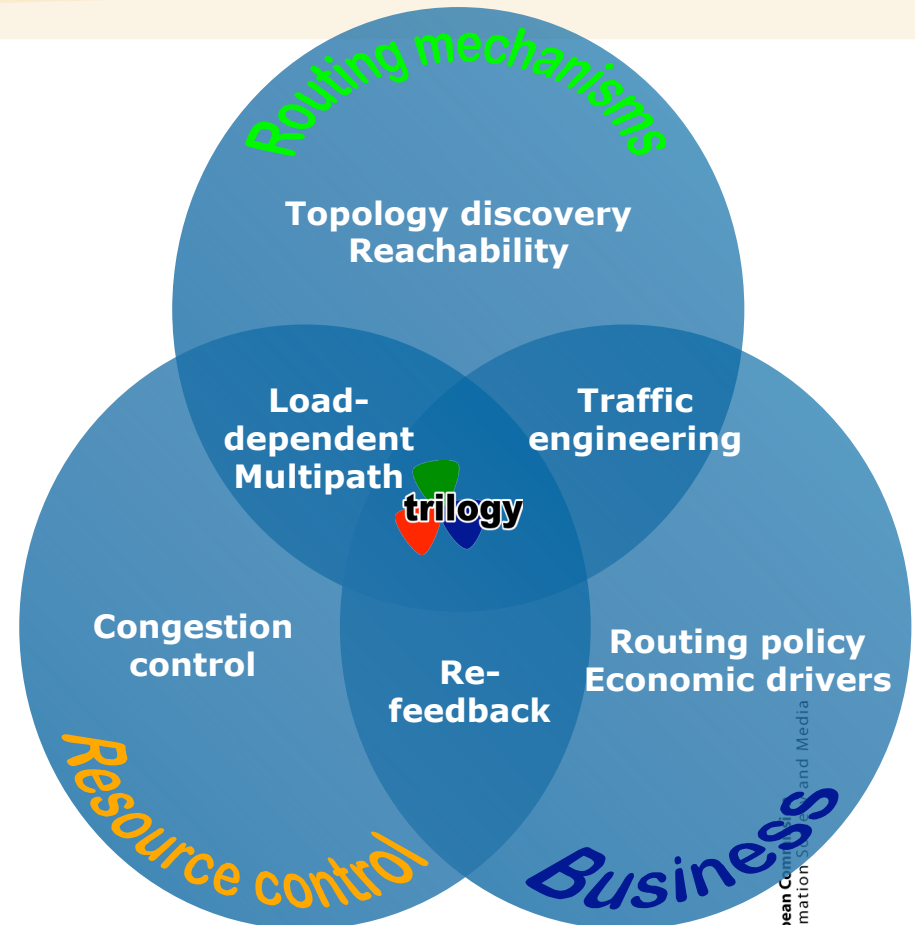


Trilogy – An Architecture for Change

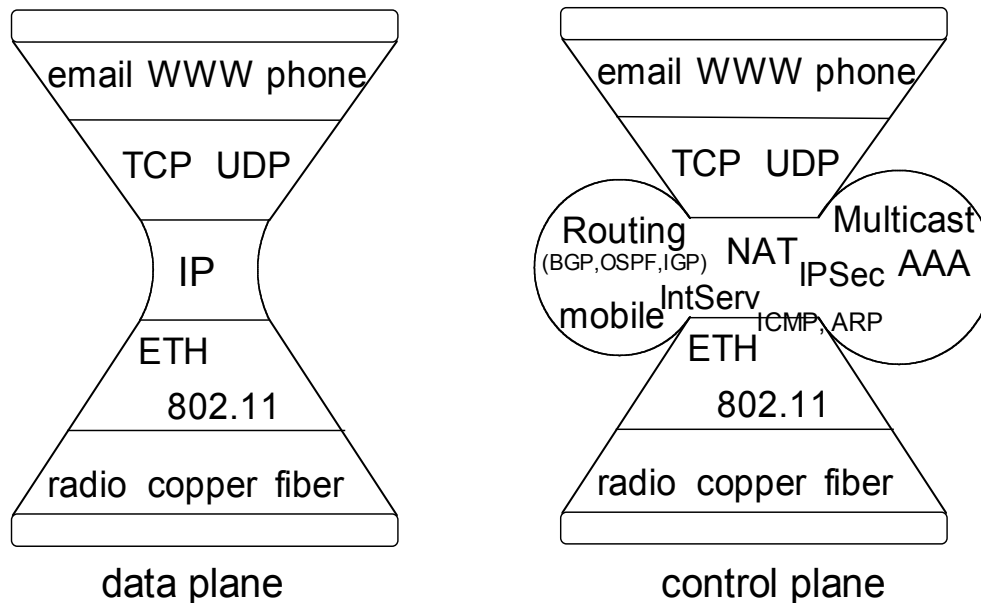
Main Objectives

- Develop a **unified control architecture for the Future Internet** that can adapt to local operational and business requirements
- Develop and evaluate **new technical solutions for key Internet control elements**: reachability & resource control
- Assess **commercial and social control aspects** of the architecture

Trilogy Concept



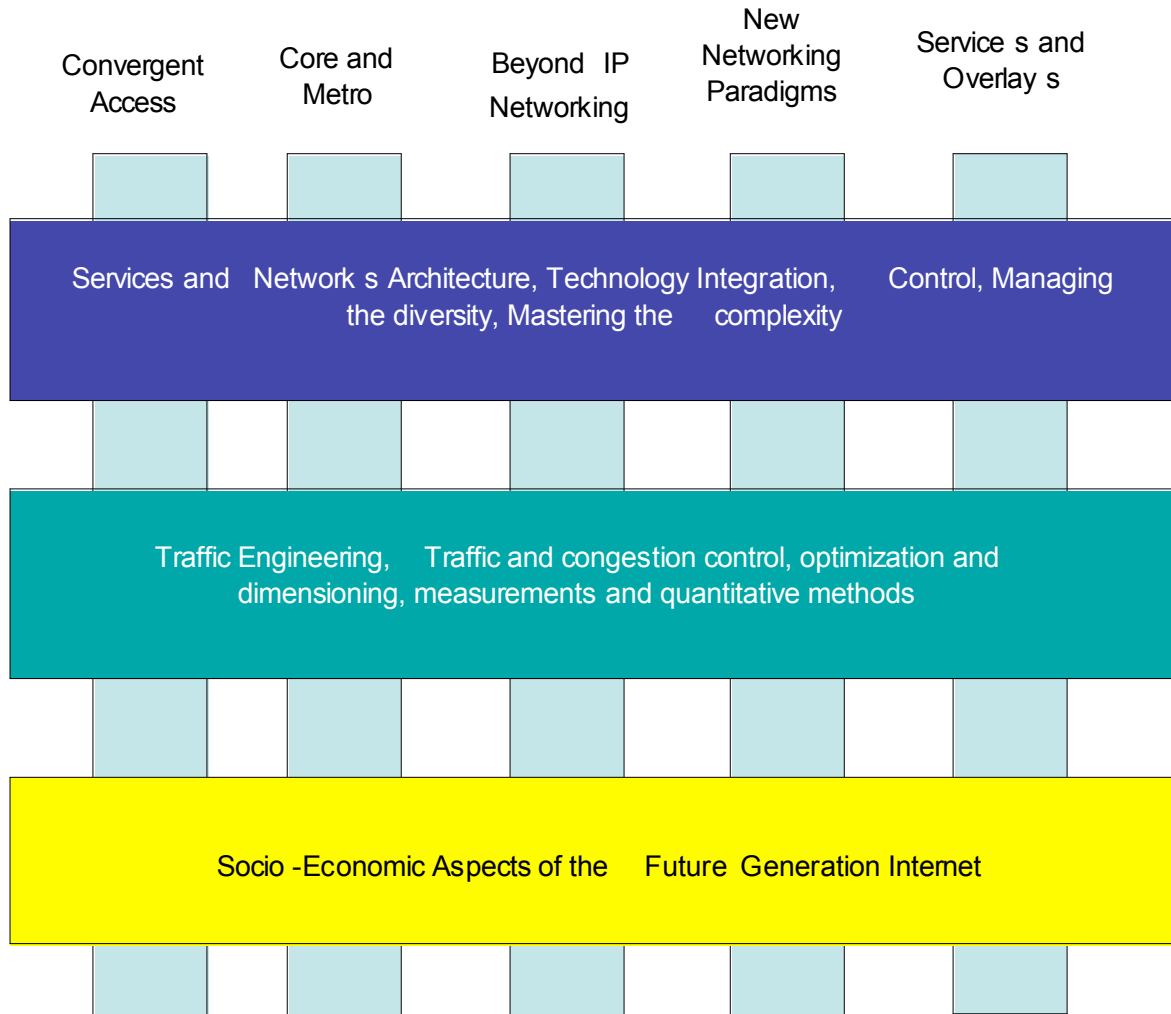
Trilogy goal



- Our ambition is to narrow the waist again
- By developing a **unified control architecture for the Future Internet**
 - & developing Routing & Resource control solutions that fit into it
- so getting back the beautiful properties of the Internet hourglass



Architectural Domains



Research Domains



PSIRP Hypothesis: Clean-Slate Design Required

- What stood at the beginning
 - Collaboration
 - Cooperation
 - Endpoint-centric servicesdoes not seem enough

- What about:
 - Trust?
 - Information centrim?
 - Legitimacy of E2E?
 - Role of overlays?

Clean-slate design...

- Question ALL fundamentals
- Challenge our thinking
- Take nothing for granted, including industry structures
- Clear vision

...with late binding (to reality)

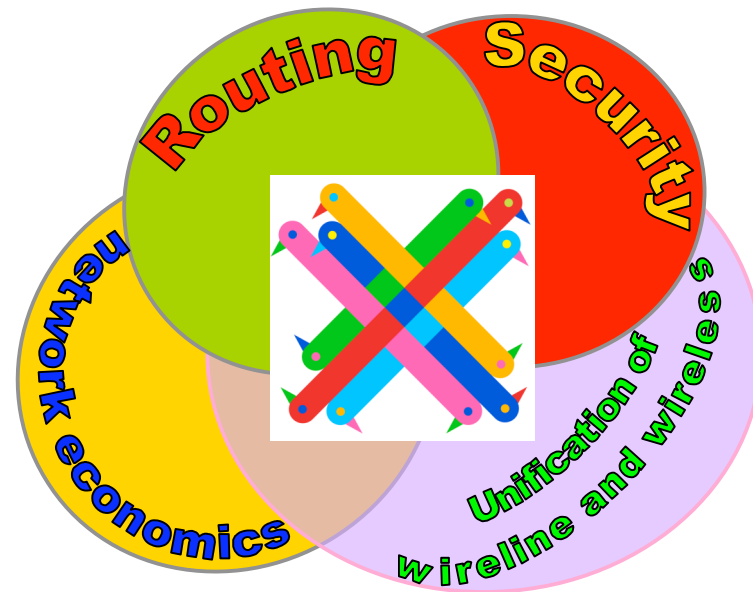
- Consider migration and evolvability in separate work items
 - How to get our design into real deployments, e.g., overlay vs. IP replacement?
- Consider necessary evolution of industry (and regulatory) structures
 - How do industries need to evolve in certain scenarios?



PSIRP Vision

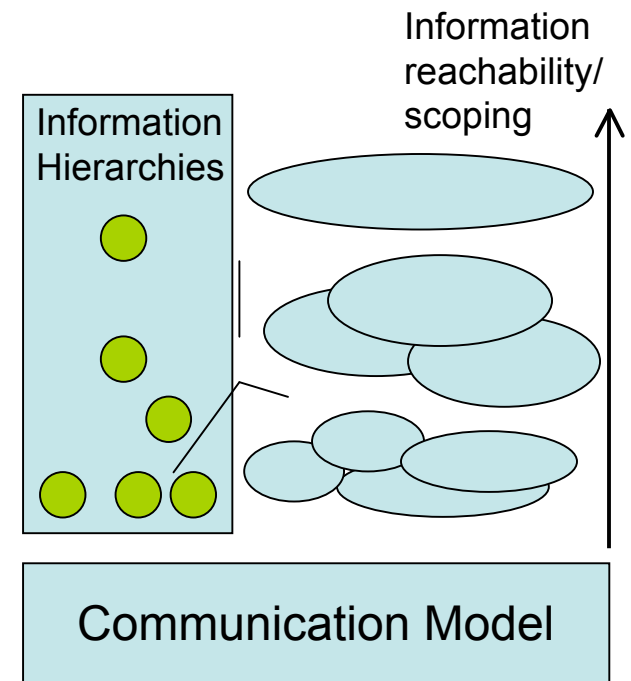
Envision a system that dynamically adapts to evolving concerns and needs of their participating users

- Publish–subscribe based internetworking architecture restores the balance of network economics incentives between the sender and the receiver
- Recursive use of publish-subscribe paradigm enables dynamic change of roles between actors



Main PSIRP design principles

- Information is multi-hierarchically organised
 - Higher-level information semantics are constructed in the form of directed acyclic graphs (DAGs), starting with meaningless forwarding labels towards higher level concepts (e.g., ontologies).
- Information scoping
 - Mechanisms are provided that allow for limiting the reachability of information to the parties having access to the particular mechanism that implements the scoping.
- Scoped information neutrality
 - Within each scope of information, data is only forwarded based on the given (scoped) identifier.
- The architecture is receiver-driven
 - No entity shall be delivered data unless it has agreed to receive those beforehand, through appropriate signalling methods.



CHIANTI

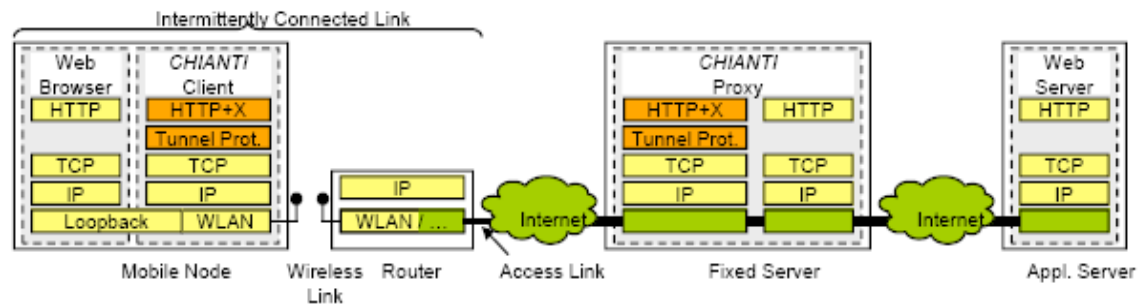
Objectives



CHIANTI

- Improving the experience for mobile users
- Hiding disruptions from the application layer
- Developing
 - a system architecture providing optimal disruption tolerance
 - prototype implementations for user devices and infrastructure components
 - service platforms and middleware components

Compatible with existing Internet infrastructure and applications!



ETNA

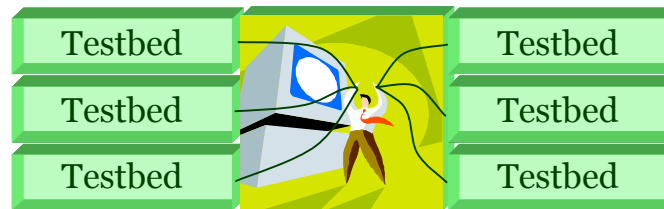
MAIN IDEAS:

- Ethernet as the basic transport technology, even inter-domain transport.
- Flatten the current model, simplifying the current “N” layers (including IP) to an only-Ethernet model
- Routed Ethernet with a new MAC address scheme, the BRIDGED-MAC address, which is dynamic according to host location (so location inferred from the MAC address)
 - Inter Domain Transport Network (now, inter-carrier is based on IP)
 - End-to-end Ethernet Transport (connection-oriented end-to-end Ethernet)
 - Routed Ethernet for Intra domain
 - Carrier Ethernet Transport QoS

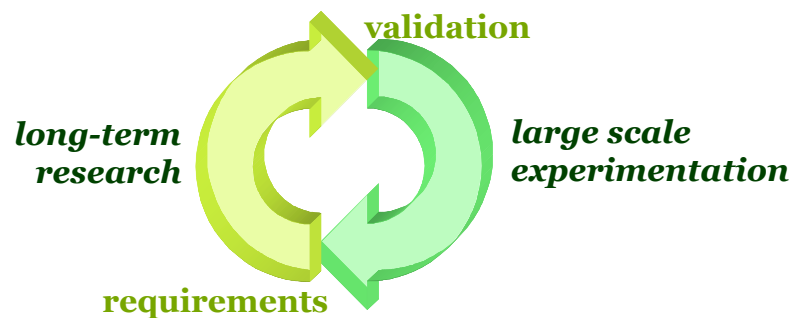


Future Internet Research and Experimentation (FIRE)

- Allowing European researchers to test new paradigms at large scale, including interactions with end users and communities

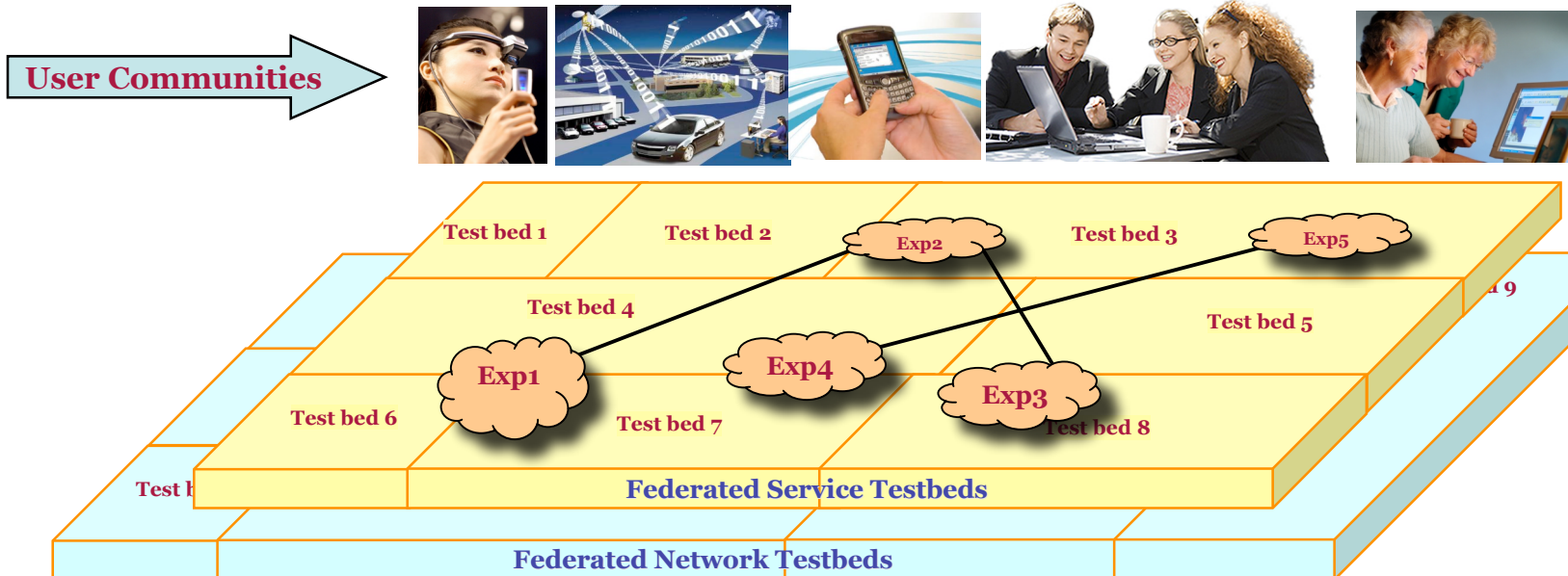


- Internet as a complex system: need to promote strategic, long-term, multi-disciplinary research on new internet concepts



Future Internet Research and Experimentation (FIRE)

- Anticipating technology trends
- Assessing business models
- Evaluating societal impact
- User-centric development



FIRE Experimental Facility



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Recommendations

1. *Keeping and strengthening the competitiveness of EU ICT sector in this area is key*

1. Technological and services competitiveness

2. *Evolutionary and disruptive approaches must go hand in hand*

3. *The time to market horizon should be 2015-2020*

4. *Networking of actors, knowledge, skills & users required*

- PPP (Public Private Partnership) preparation is in motion.
- Establishment of a Future Internet Forum composed of National representatives (related to FIA).



Recommendations - II

- 5. *Experimental research facilities and testbeds*** are needed at national and pan-European level to facilitate user involvement and application developments
- 6. *Driver role of public administrations*** for the development and take-up of innovative applications
- 7. *Involvement of local innovation actors*** helps FI to enable local innovation systems
- 8. *International collaboration*** is a key issue: a shared strategy at EU level will allow to achieve a great impact



CHALLENGE 1: Pervasive and Trustworthy Network and Service Infrastructures

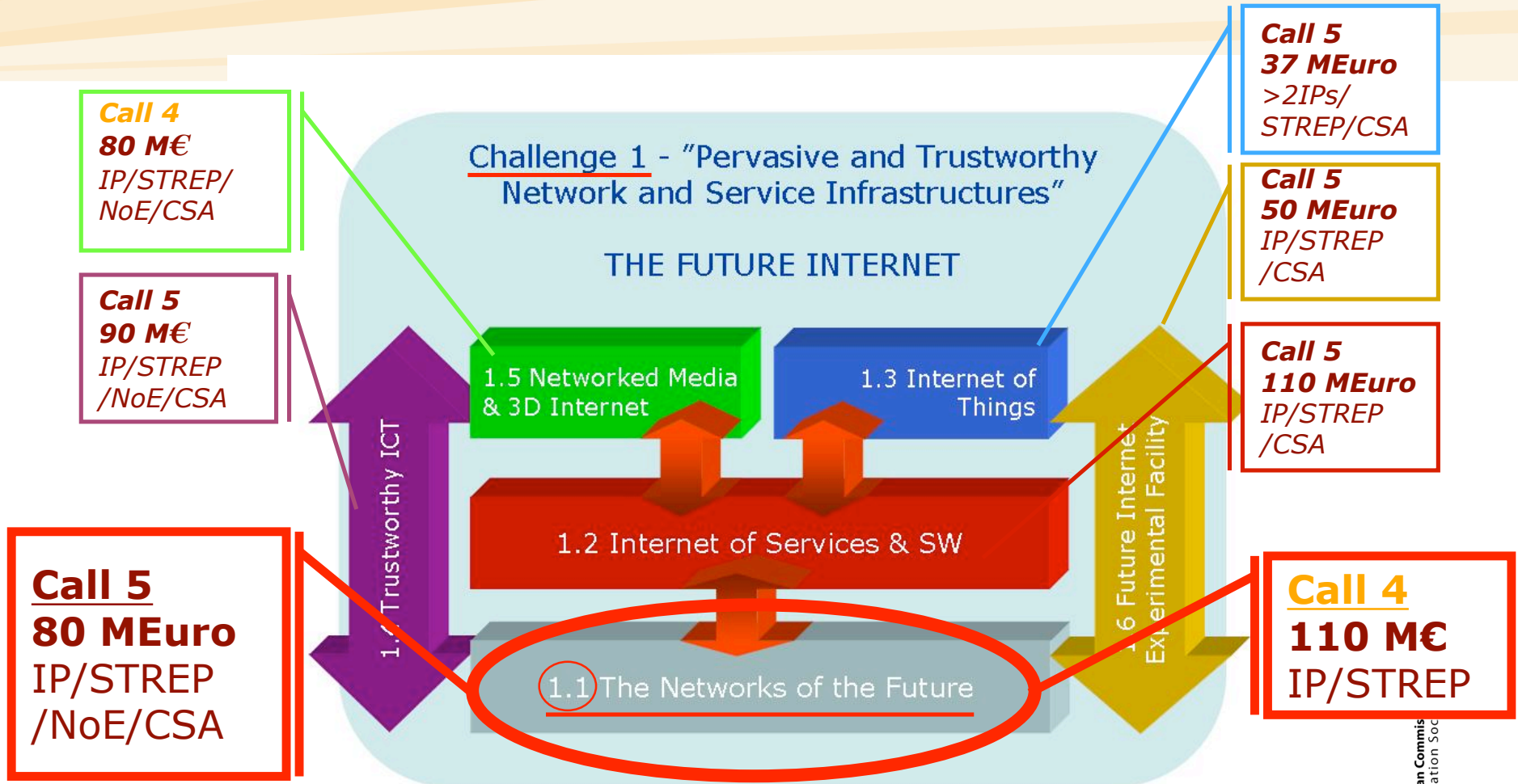
The 'Future Internet' is emerging globally as a federating research theme. The current Internet architecture was not designed to cope with the wide variety of networked applications, business models, edge devices, networks and environments that it has now to support. Its structural limitations in terms of scalability, mobility, flexibility, security, trust and robustness are now recognised. The challenge is to address the multiple facets of a Future Internet. Clean slate or evolutionary approaches or a mix of those can be equally considered.

From a networking perspective, this entails a rethink of architectures such that performance bottlenecks are overcome, novel types of edge networks may be integrated, and new types of media applications such as 3D can be supported. Mobility and ever higher end to end data rates also emerge as important design drivers. At the network level, a clear challenge will be to provide the Internet with flexible management capabilities beyond the original 'best effort' paradigm.

Novel radio and optical systems are important components of this overall network perspective.



Pervasive and Trustworthy Network and Service Infrastructures Σ 557 M€



Expected Research Advances for Call 5 Projects in: Future Internet Architectures and Network Technologies

- **Novel Internet architectures and technologies**
 - IPs expected to take architectural views on Future Internet
 - Even in clean-slate approaches, concrete deliverables to be specified
 - STREPS expected to identify specific key challenges and opportunities in the Future Internet
- **Flexible and cognitive network management and operation frameworks**
 - IPs expected to co-design management frameworks with network architecture
 - STREPS and IPs to couple new concepts with proof-of-concept
 - Step-change beyond state-of-the-art and past activities expected

Agenda

- WP 2009-2010 for Future Networks
 - Call 4
 - Call 5
- Technical Review
- Events
 - Prague
 - Stockholm
 - ICT Mobile Summit 2009
 - ICC 2009 Dresden
- Future Internet JTI





Conference & Exhibition

ICT-MobileSummit 2009

Call for Papers

Santander - Spain

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Thematic Priorities

10 - 12 June 2009



IEEE ICC 2009, Dresden



- June 14-18 2009
- Chance to show European leadership in network & communication research after ICC'2008 success in Beijing
- Presence of Commissioner Reding planned
- <http://www.comsoc.org/confs/icc/2009/>



Future Internet Assembly

- Czech EU Presidency Conference, Prague 11–13 May 2009
- Conference during Swedish Presidency to be defined
- <http://www.future-internet.eu>



EU2009.CZ



More Information

- The ICT Future Networks web site:
<http://cordis.europa.eu/fp7/ict/future-networks/>
- Future Networks Newsletter and Newsflash:
 - Distributed via email (by subscription - free of charge);
 - Contains info on all activities in the field including calls for proposals, conferences, publications, etc.)
- Mailbox for Call4+5 Queries and Pre-Proposal Check forms:
 - Deadline March 11th for call 4
 - [INFSO FUTURE-NETWORKS-CALLS@ec.europa.eu](mailto:INFSO_FUTURE-NETWORKS-CALLS@ec.europa.eu)



Dimensions of the Future Internet

Technological

- Fast optical networks
- Mobility
- Internet of things
- Complex system
- ...

Socio - Economic

- Changes to the Internet not neutral to societal / economic structures
- Preserve innovative force / support investment in Infrastr & Services
- Social responsibility
- Balance Security / Accountability / Trust / Privacy
- ...

Regulatory / Political

- Act where market forces fail
- Consumer protection / empowerment
- National security
- Protection of the private sphere
- OECD process on the future of the internet economy
- ...

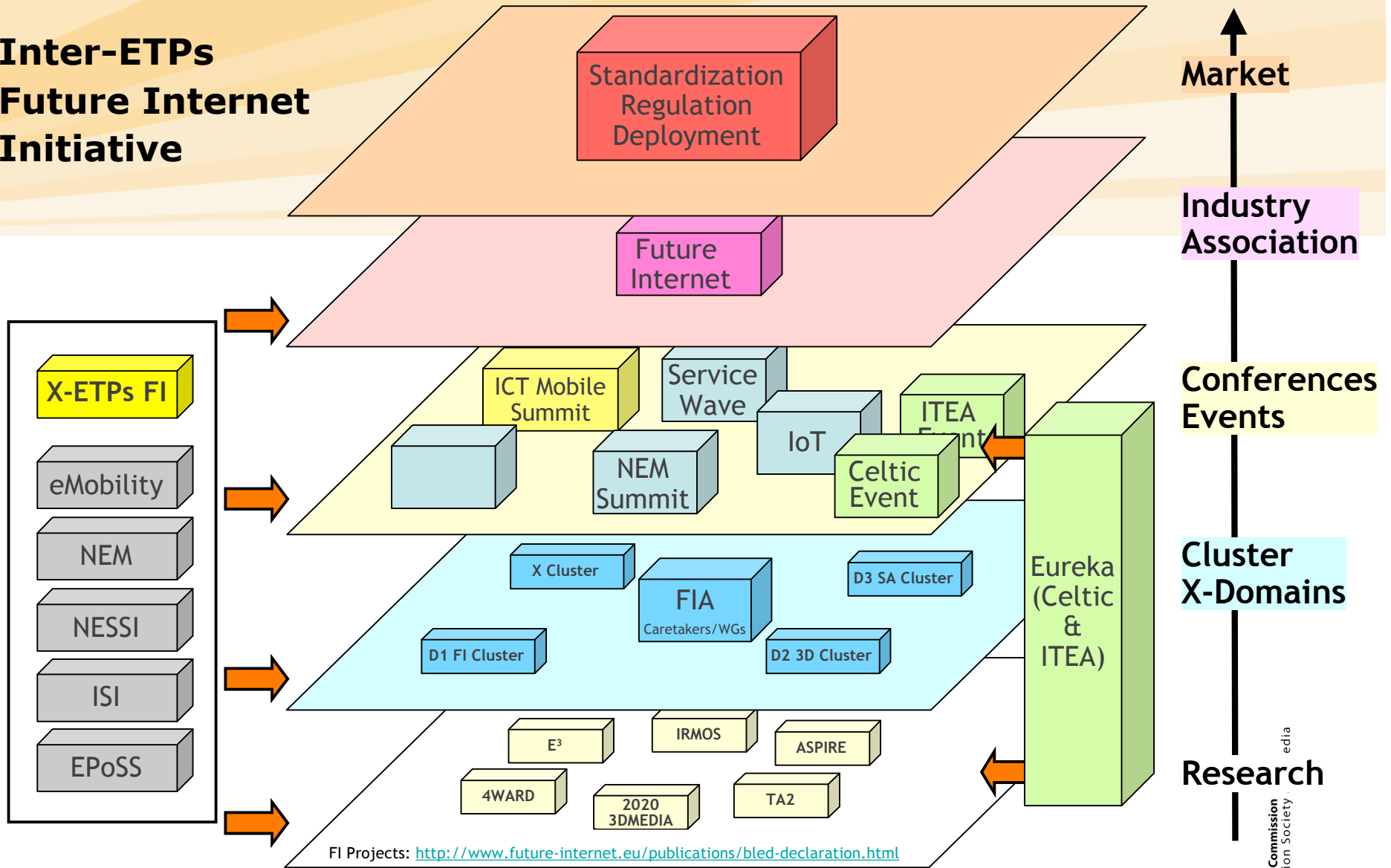
Evolution of the Internet

- The Internet has become a critical part of an economy's infrastructure
- Net-delivered services are reshaping the world (search, media, games etc.)
- Tripling the number of people connected
- Creative flow of content and processes, increasingly generated by users, not just consumers
- Balance the need for control with the creativity that spawns innovation—and profit?
- “Net Neutrality”

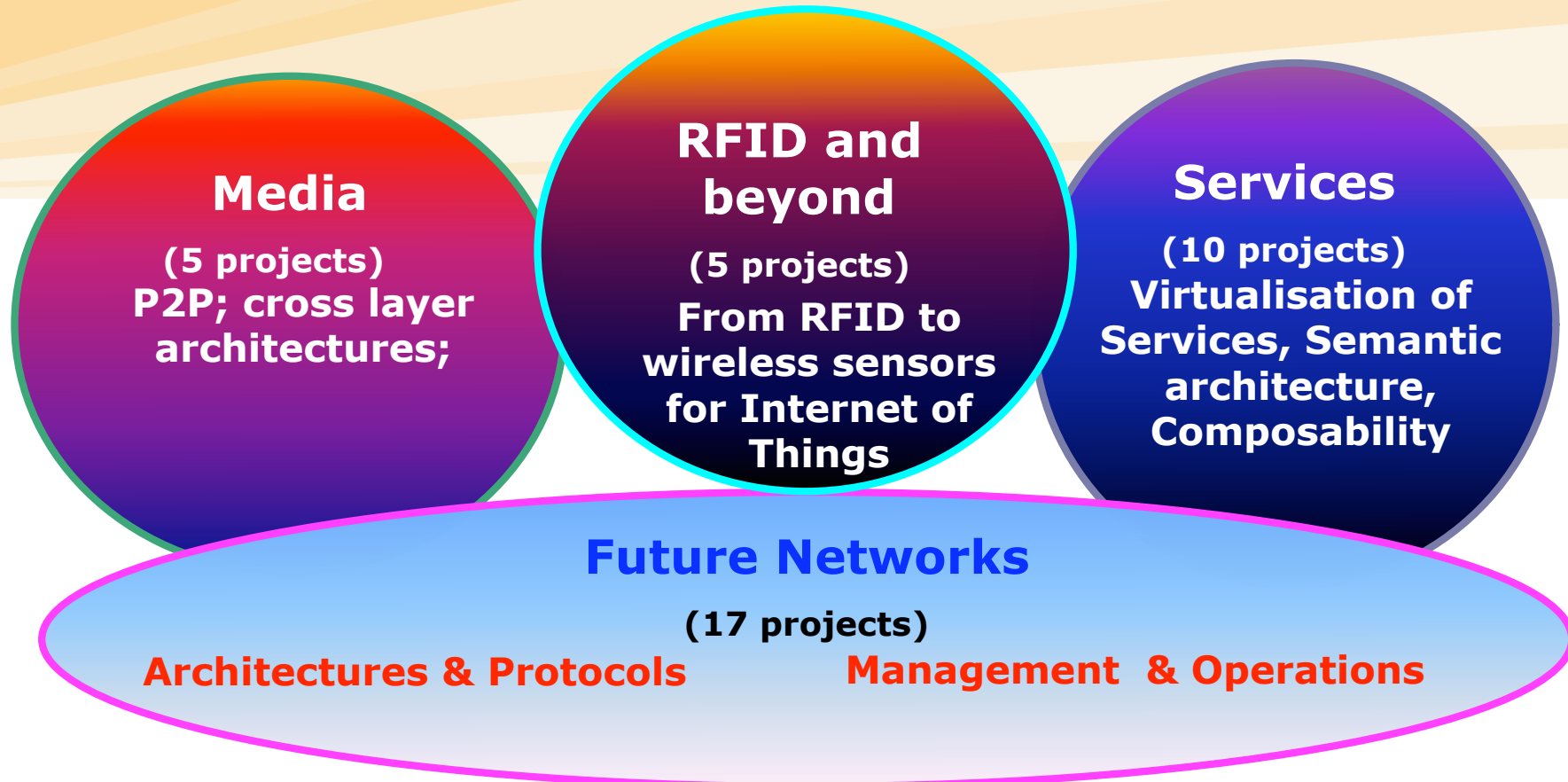
- *Before this can happen, the Internet must undergo important changes. Designed in the seventies, it is starting to face technical limitations which hamper its potential.*



Inter-ETPs Future Internet Initiative



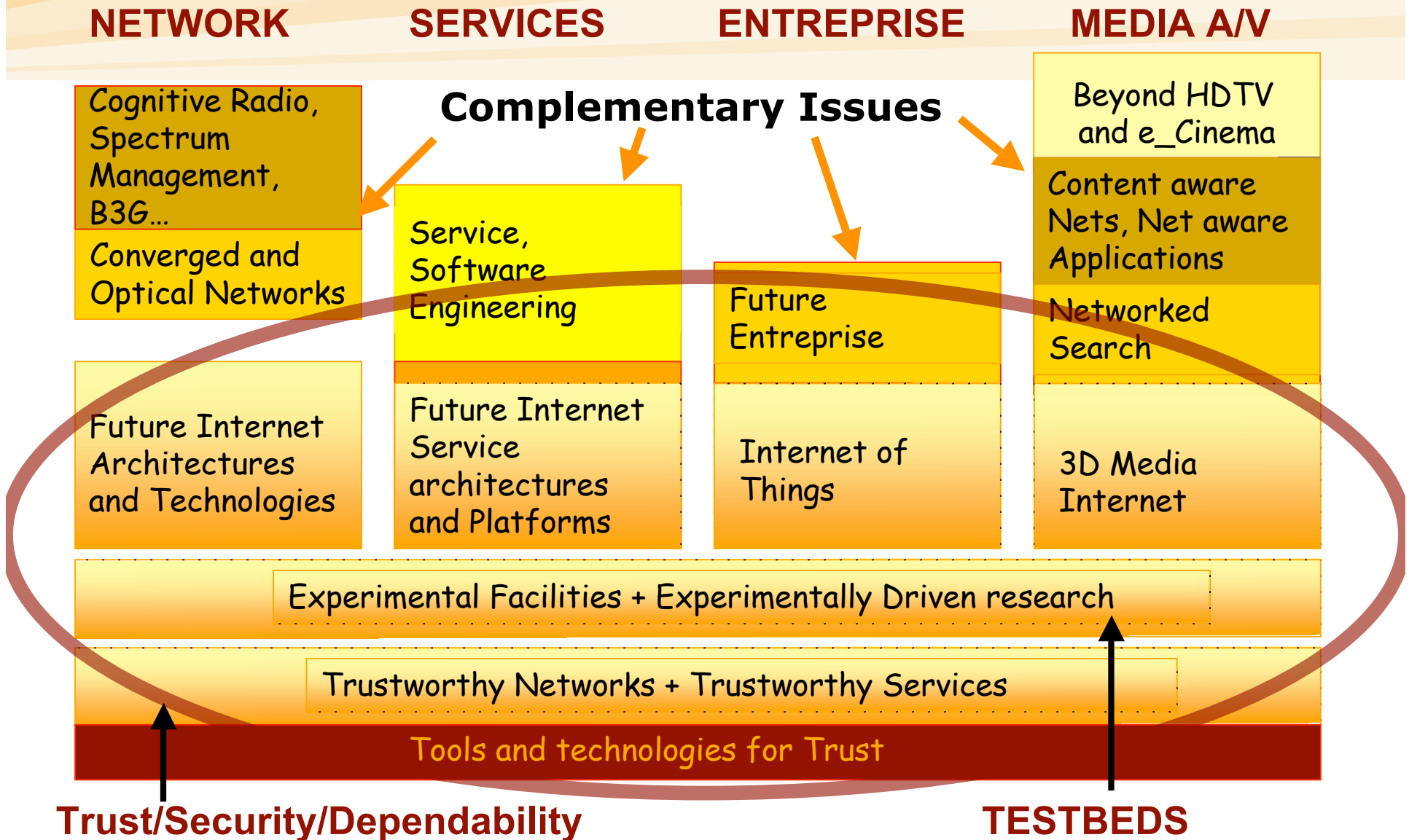
Future Internet in FP7



37 proposals, budget >150M€

System approach including networks, services, devices and content aspects

Future Internet R&D, Holistic view



Experimental Facilities Example

The United States

FIND

- NSF's ambitious program to develop the future Internet architecture through a clean slate approach.
- Make a small-scale, but large number of projects converging into a fewer number of full-scale architectures, and verify using GENI
- A total of 1,200 million dollars to 26 projects by 2006

GENI

- Aimed at developing a testbed organization to succeed Planet Lab's development.
- Aimed at a large-scale facility development's budget in NSF. International cooperation is also included as a target. Project Bureau (GPO) is BBN. Planning to offer prototype, 1,500 million dollars in December 2007 over a two-year period.
- A scale of construction budget is 367 million dollars, but it has already been delayed for more than two years.

Europe

FP7

- EC's Funding structure towards the total fields of science and technology
- >70 Projects
-
- Network of the Future
- Net Media
- Security
- IoT
- Services
- (Call 1,) 485 M€
- FIRE (Call2,) 40 M€

GÉANT2

- EC's research network
- The EC Budget for GÉANT was 9,300 million Euros over 4 years since 2004.
- It is in the middle of preparations for upgrading and for greater capacity by transforming it into GEANT3 from 2008.

Japan

NWGN development projects

- NWGN AKARI architecture development project (Official announcement of concept's specification in April 2007)
- R&D on evaluation and establishment in the structure of NWGN) (NICT commitment, up to 20 million Yen times 2 years, plural cases)
- R&D for dynamic network technology (NICT commitment, 4 years, plural cases)

NWGN research development promoting structure

- "The headquarter of NWGN Research Development Strategy" in October, 2007, NICT.
- "NWGN Promoting Forum," established in November, 2007 Working in 4 WGs Ministry of International Affairs and Communications and NICT are co-secretariat.

Testbed NW「JGN2」

- NICT's Testbed network for research development
- To provide "JGN2plus" from 2008 – 2010.

➔ International cooperation for not federated Testbeds



**- EC -
European Future Internet**

**Science
&
Scientific
Approach**

EIFFEL
(with links
to FIRE,
FIND/GENI,...)

**Projects
Based
Approach**

**EU
Projects
Assembly
on
Future
Internet**

**Industrial
&
Commercial
Relevance**

ETPs

Science based approach
Peer-review and peer-discussion
Long-Term, High-Risk, Exploratory
Advice & Challenge

Gather Projects Together,
Exchange Ideas, Voluntary
Coordination on Message
and Cooperation, Disseminate
Project centric

Provide larger view on
the stakeholders view,
Gather larger view,
Commercial reality, Industrial
Opportunities and Requirements

Horizontal Interaction: data delivery, opinion delivery



