

# Optical Networks and Future Internet Research in the European Framework Program 7

Symposium on the Future Internet and Its  
Impact on Next-Generation Optical Networks  
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Andrew Houghton

Future Networks Unit  
Information Society and Media DG  
European Commission  
Brussels, Belgium

The views expressed in this presentation are those of the author and do not necessarily  
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# Content Summary

- Research on Inter(net)works: the European Union policy/economic context
- Ne(w/xt) Generation Networks: technology and concept issues
- Optical Network Research in the EU Framework Projects: connecting the Future Internet

# Framework Research in the ICT Policy and Economic Context

## Research & Development

- IST Programme in the FP6
- ICT Programme in the FP7

Policy for wider adoption, best use  
of ICT: i2010 Programme

## Regulatory Framework

- ensuring fair competition
- and the rights of citizens and businesses

# Lisbon Strategy and the i2010 initiative

- The Lisbon European Council (3/2000) emphasized
  - the potential for growth, competitiveness and job creation of the shift to a digital, knowledge-based economy
  - the importance of the access to an inexpensive communications infrastructure and a wide range of services for Europe's businesses and citizens
- i2010 initiative
  - Objective: to ensure that Europe's citizens, businesses and governments make the best use of ICTs in order to
    - improve industrial competitiveness
    - support growth and the creation of jobs
    - help address key societal challenges

# The European Union

- 27 Member States
- 500 million population
- 320 Billion Euro Telecoms market
- 120 million homes with broadband access
- 100 mobile telecoms operators

# European Mobile and Broadband Market: €293 billion in revenues in 2007

## **European Mobile markets are maturing:**

Revenue growth was 3.8% in 2007, to €137B

With 550+ million mobile phones in use (Oct 2007), penetration is now at a notional 112% of population (up from 103% in 2006).

SMS=14% of revenue, other data= 7% of revenue.

3G subscriptions at end of 2007 were 88 million.

## **Competition drives fast broadband growth:**

Revenues from fixed (broadband) data grew to €62B (from €58,5B).

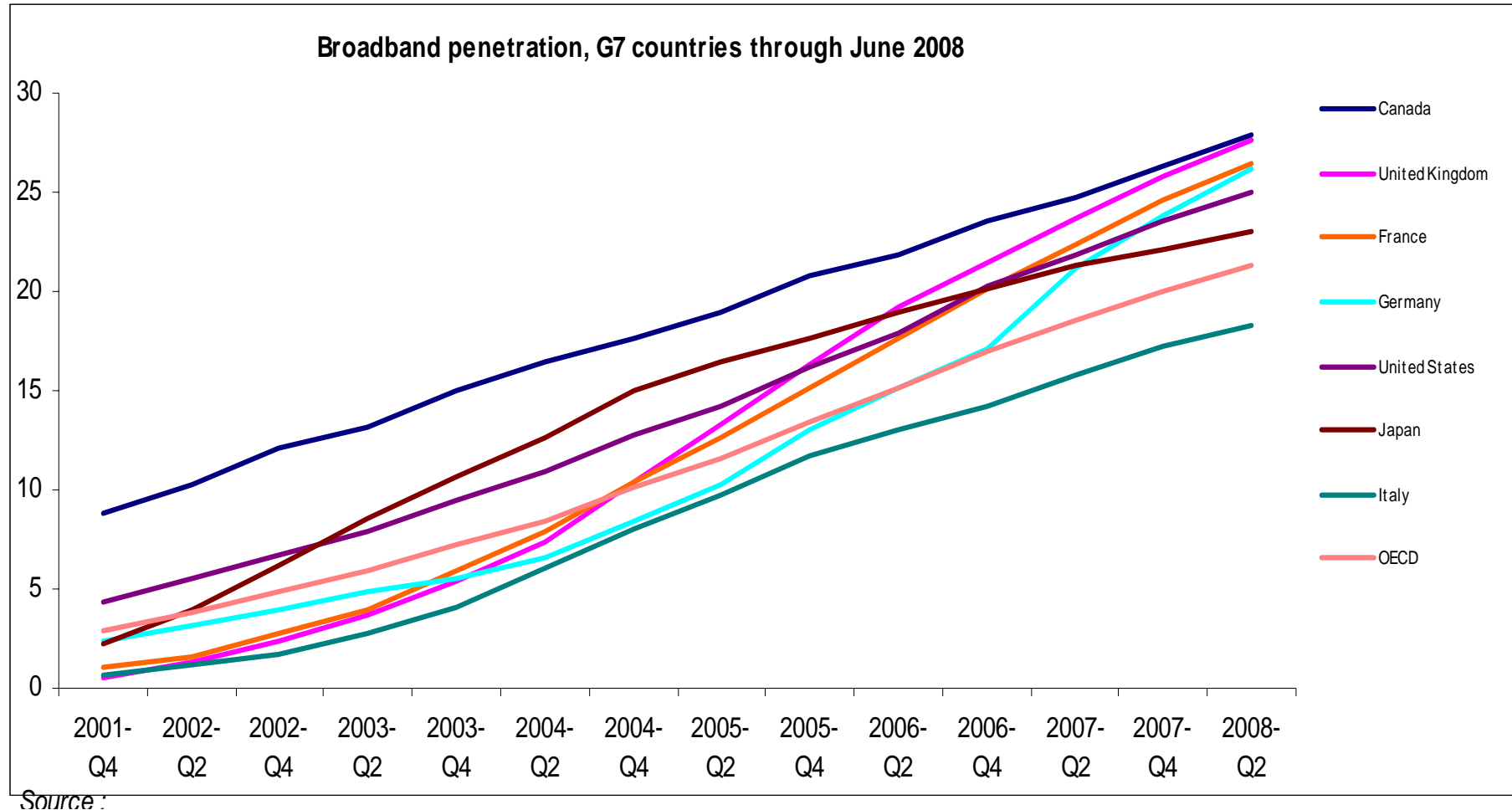
19 million broadband lines were added in 2007, bringing the total to 99M, and penetration in the EU27 to 50% of households.

The Netherlands and Denmark now have the highest broadband penetration rates (>30% per capita) in the world. Eight Member States have higher broadband penetration rates than the US.

Source: *European Commission's 13th report on the EU telecom markets, Comm(2008) 153, 19 March 2008*

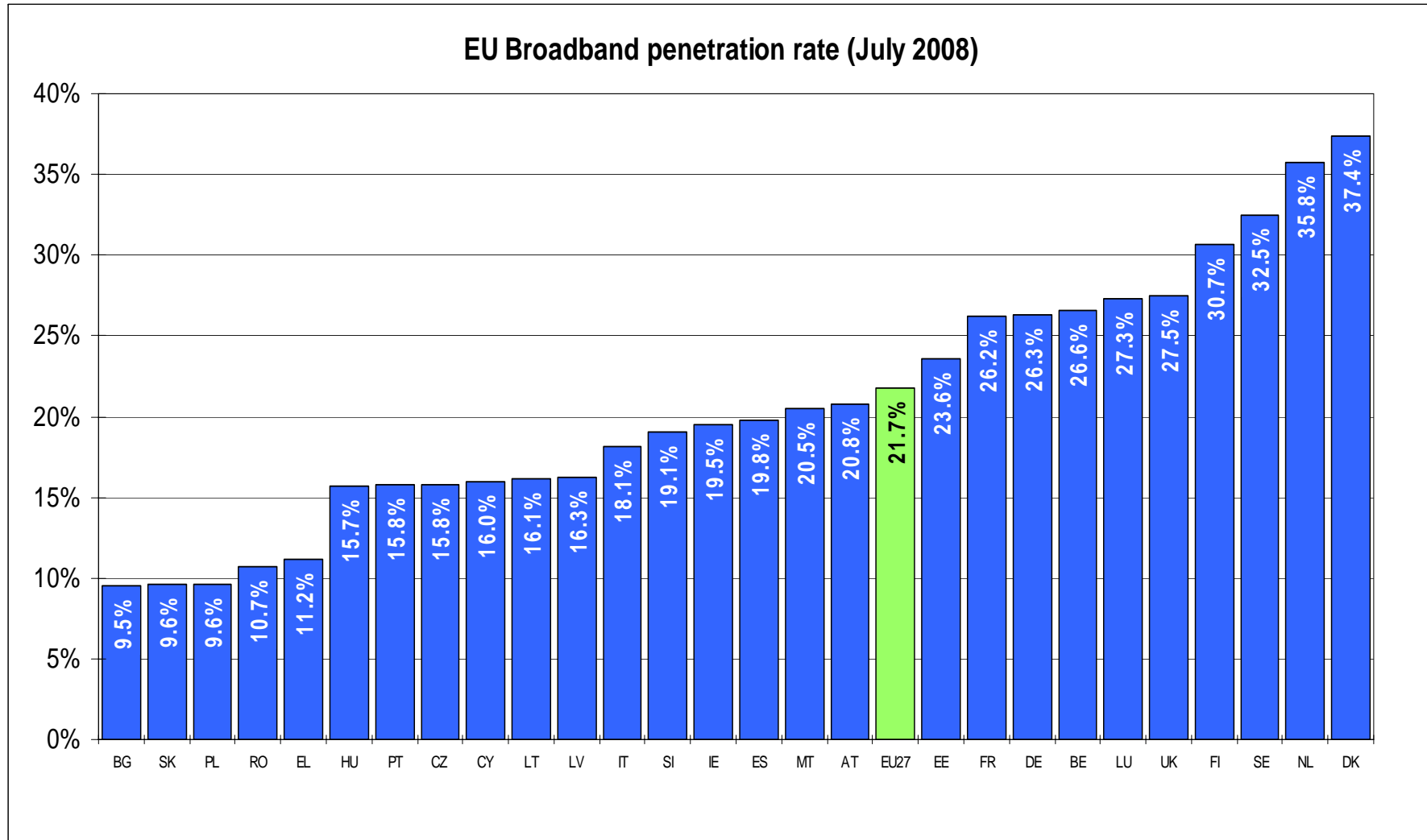
# Growth in Broadband Access

G7 Countries, June 2008 Source: OECD



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# EU Broadband Internet Access



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# What IS the Future Internet?

Today's Internet/Tomorrow's Internet is ....

- A physical entity
- Routers, switches, ...
- A critical infrastructure
- A communication medium
- A Service
  - Web, email, news, SMS, telephony, P2P, ...
- The foundation of someone's business
- Social phenomena
  - Cyperspace: redefined communication
- Human to human, human to computer, ....

> "Whatever you want it to be"

# Future Inter(Net)work: Policy Drivers

- Support for “eGovernment”:
  - Education, learning , training
  - Healthcare, personal health systems
  - Care for the elderly
  - Energy efficiency and environmental sustainability
- Future Internet: scalable, reliable, secure
  - High bandwidth, low latency, mobile
  - Broadband for all, everywhere
- Support for European network equipment industry

# Regulatory Framework for Electronic Communications: Principles

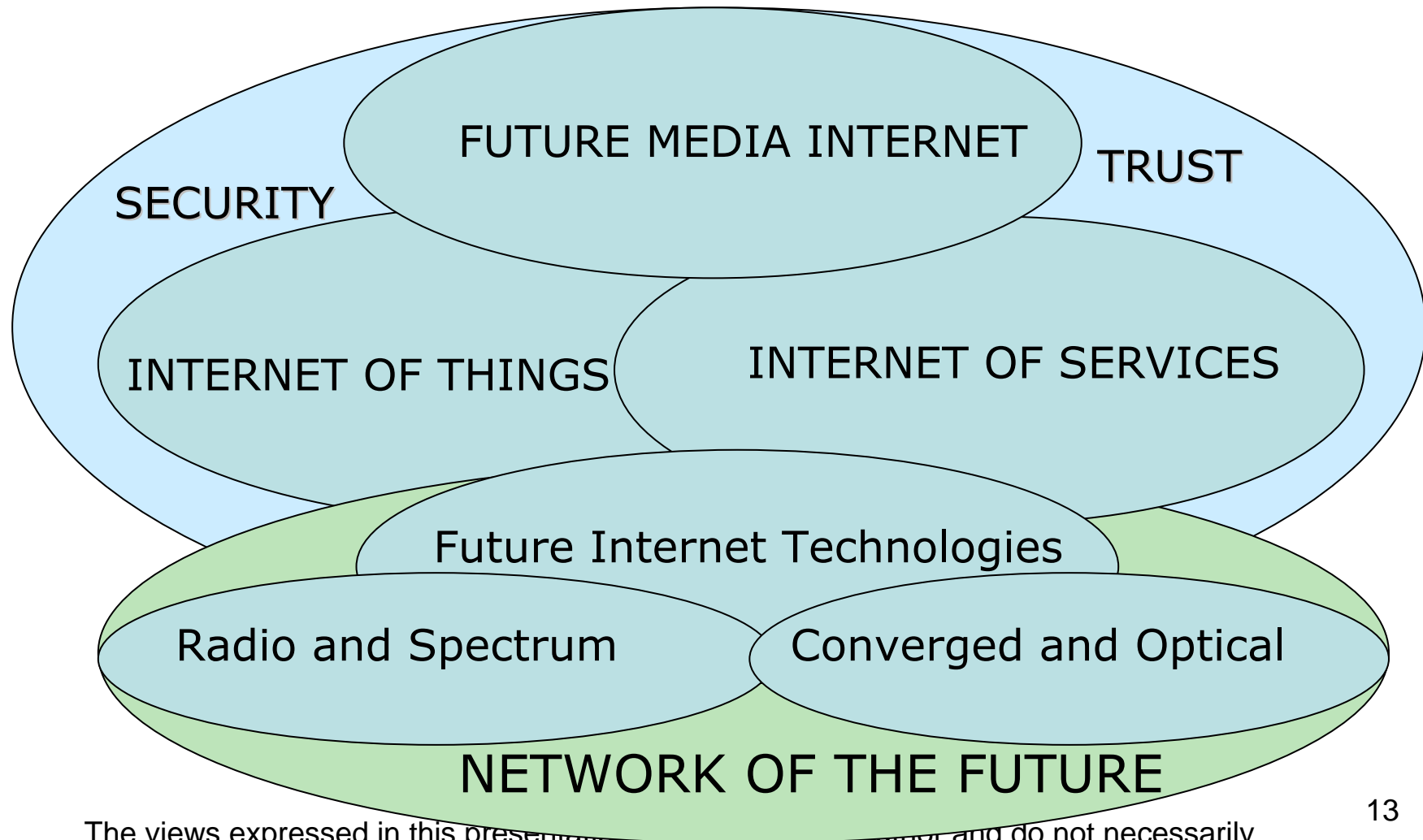
- From July 2003 (and now in first review):
- Based on clearly defined policy objectives (e.g. to ensure that a minimum of services are available to all users at an affordable price, that the basic rights of consumers continue to be protected).
- Keep regulation to the minimum necessary (markets are more competitive)
- Enhance legal certainty in a dynamic market
- Be technologically neutral
- Be enforced as closely as possible to the activities being regulated (globally, regionally or nationally)

# The (Inter)Net(work) of the Future

## Broadband, wireless and optical

- Increasing dependence of society and economy on network infrastructures and Internet/Web applications;
  - 2 billion mobile terminals in commercial operation, 1 billion Internet users, 400 million internet enabled devices
- Limitations of current Internet architecture:
  - Security, robustness, manageability, QoS,
  - At the limit of its scalability?
  - Mobility is a big challenge
- New opportunities will be driven by:
  - New applications and services, in all areas of economic and social activity
  - Disruptive technologies: mobile, radio, photonics, sensors,
    - for increasing user control of content/services; for networking 'things' - TV/PC/phone/sensors/tags ...
- Europe is well-positioned: industry, technology and use
  - networks equipment and services, business software, middleware, security, home systems ...

# A Map Of The Network of the Future and the Future Internet *(not to scale)*



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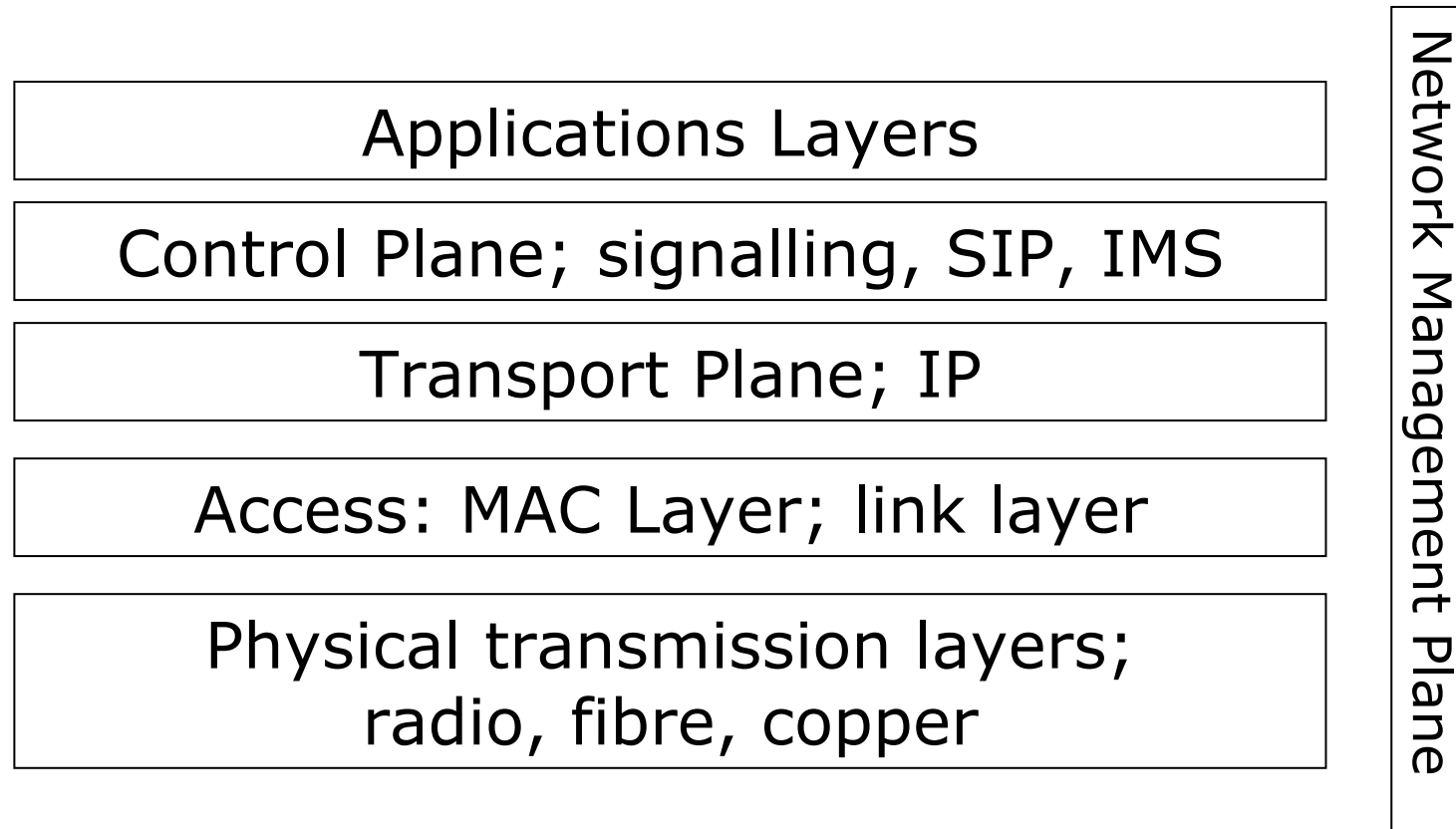
# Internet Architectural Issues

- Solving architectural limitations between physical and higher layers
- Decoupling location/identifier from network address
- Solving scalability of routing tables and protocols;
- From reactive network management to active network management.
- From co-existence of different networks/domains to virtualisation
- From fixed to mobile; Access and routers
- From security as an add-on to built-in security
- Reconfigurability- cater for changing and unexpected traffic patterns and behaviours
- QoS...cost...trust...video...competing services...

# Optical Networks: Who is the “User”?

- Layer 2? Gigabit Ethernet?
- IP packets?
- Service providers?
- The Future Internet?
- Core/Metro/Access network operators?
- Mobile Network operators?
- HFC Cable networks?
- Home/LANs?
- NRENS?

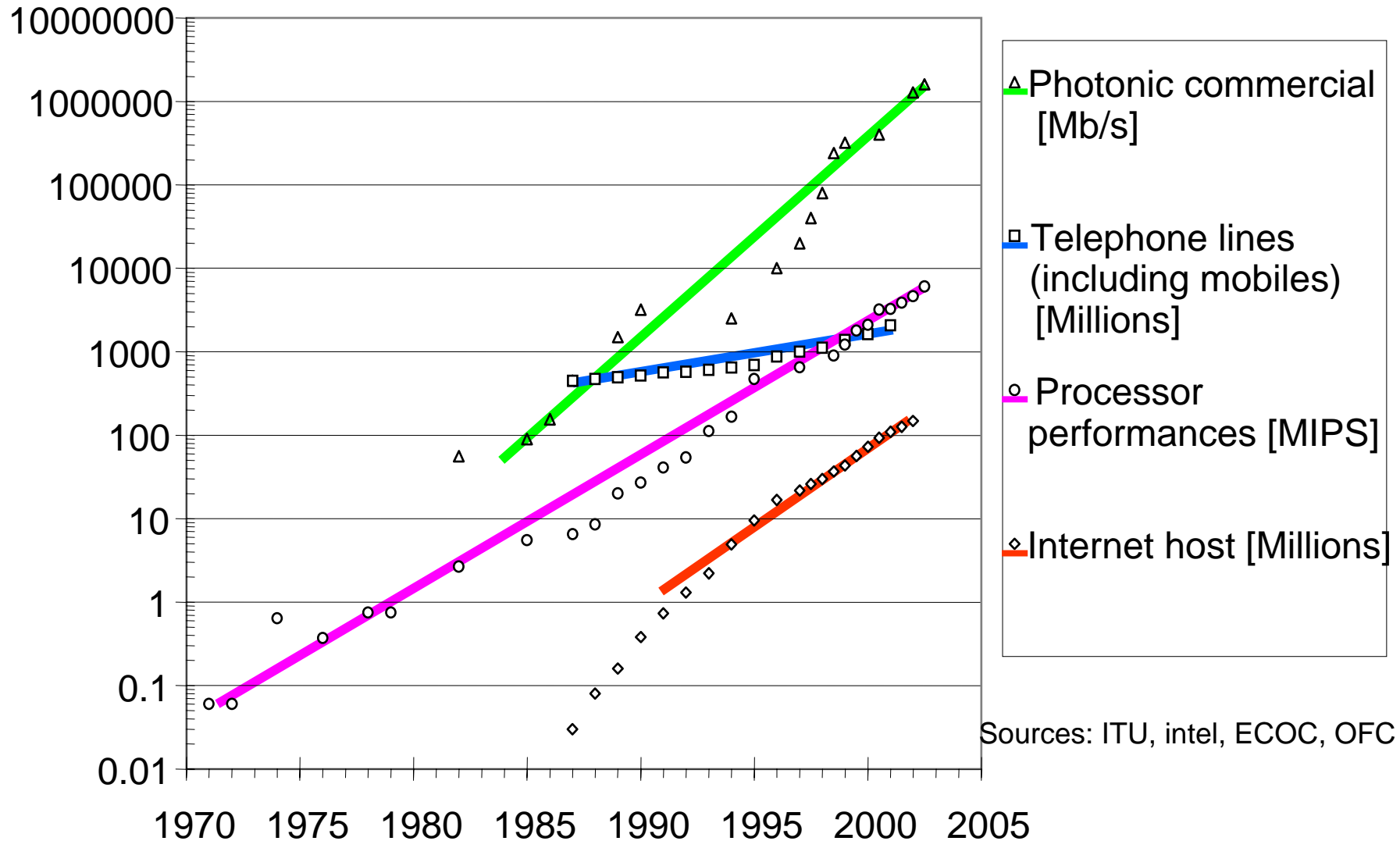
# “Converged” Network Structure



All types of wide-area IP (access) networks are following the same structure/layers:

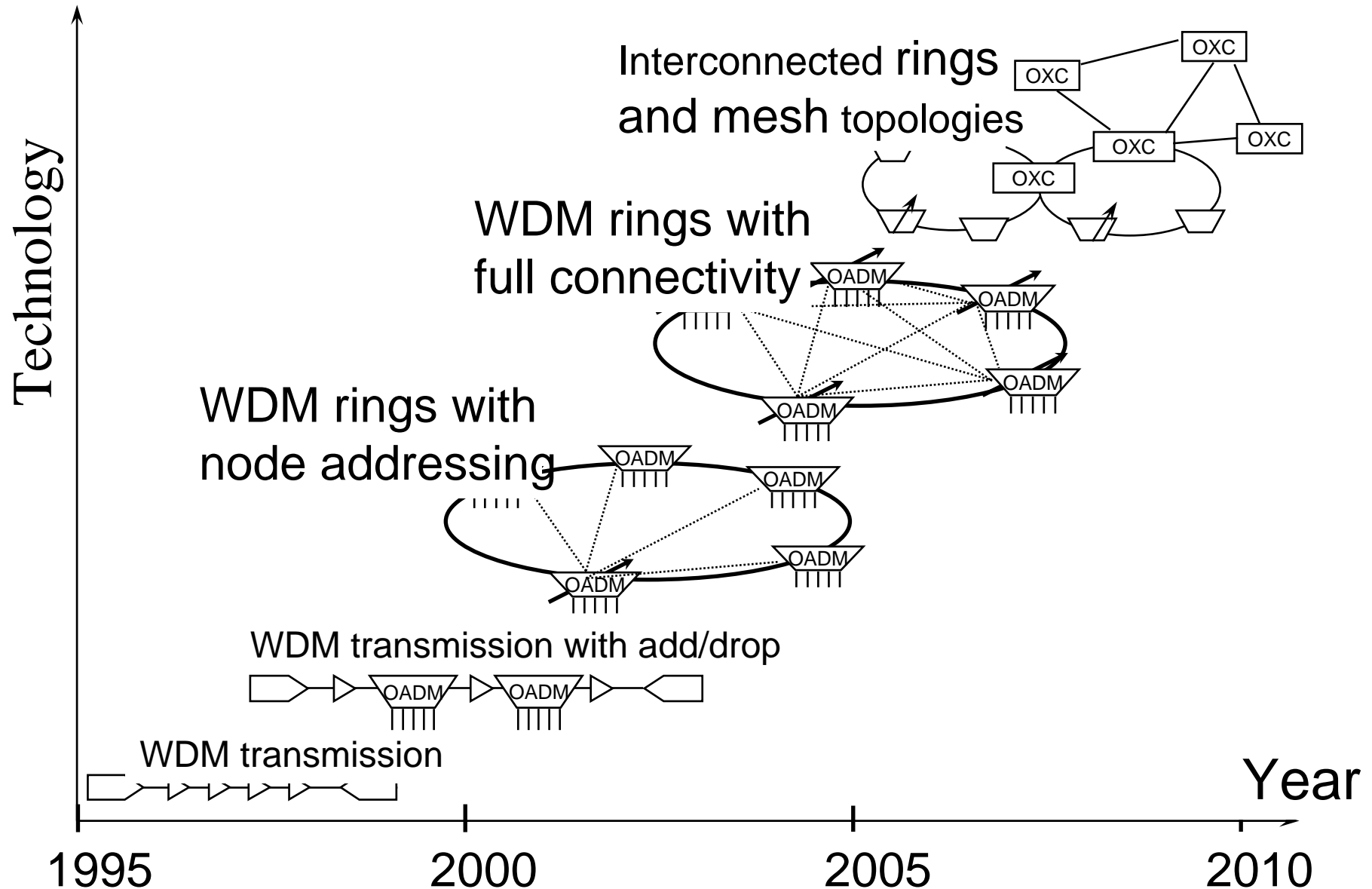
- Plain link-layer infrastructure for concentrating traffic of individual users (most economic)
- An entity providing an IP address to the UE for access to IP based applications/services
- Applications being agnostic to the particular infrastructure based on plain IP connectivity

# Moore's Law for Telecoms



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# Photonic Networking Evolution



# Connectivity- Delivering the packets

- Analogue/digital; circuit/packet
- Are all (IP) packets the same?
- IP Protocol: Glue or Fuse?
- QoS: Latency- the big issue?
- How to put the packets into the fibre?
  - Cells, packets or frames?
- How to pass packets seamlessly from a radio link into a fibre?
- Radio Spectrum scarcity? -fibre?!

# EU Research Framework Programmes

A key role in the history of optical network (and broadband access) technology research and development over the past 20 years-

FP2/3: RACE 1987-1994

FP4: ACTS 1995-1998

FP5: IST 1999-2002

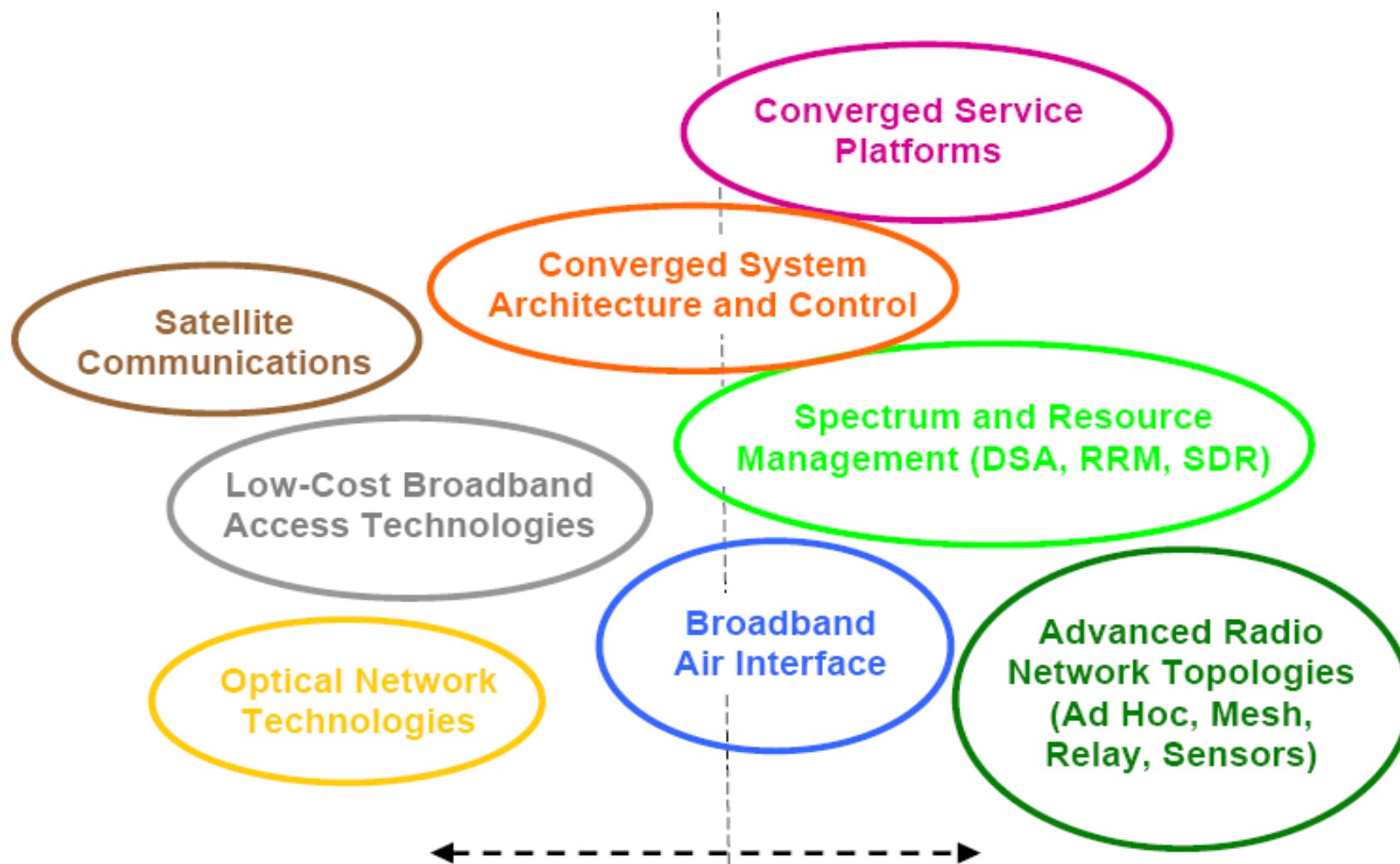
FP6: IST 2002-2006

FP7: ICT 2006-2013

# EU Research Framework Programmes

- R+D+I which has added value at the European level, (within the European Research Area)
- FP6: 2002-2006. FP7: 2007-2013
- Cost-shared RTD:
  - Industry: 50%
  - Academia/research/SMEs: 75% (in FP7)
- Collaborative Projects: IP, STREP, NoE, CSA
- Information and Communication Technologies
  - Network of the Future: FP7 Call 1; 200MEuro
    - Call 4: 110MEuro, Call 5: 80MEuro

# FP6 Project Portfolio: Mobile and Broadband

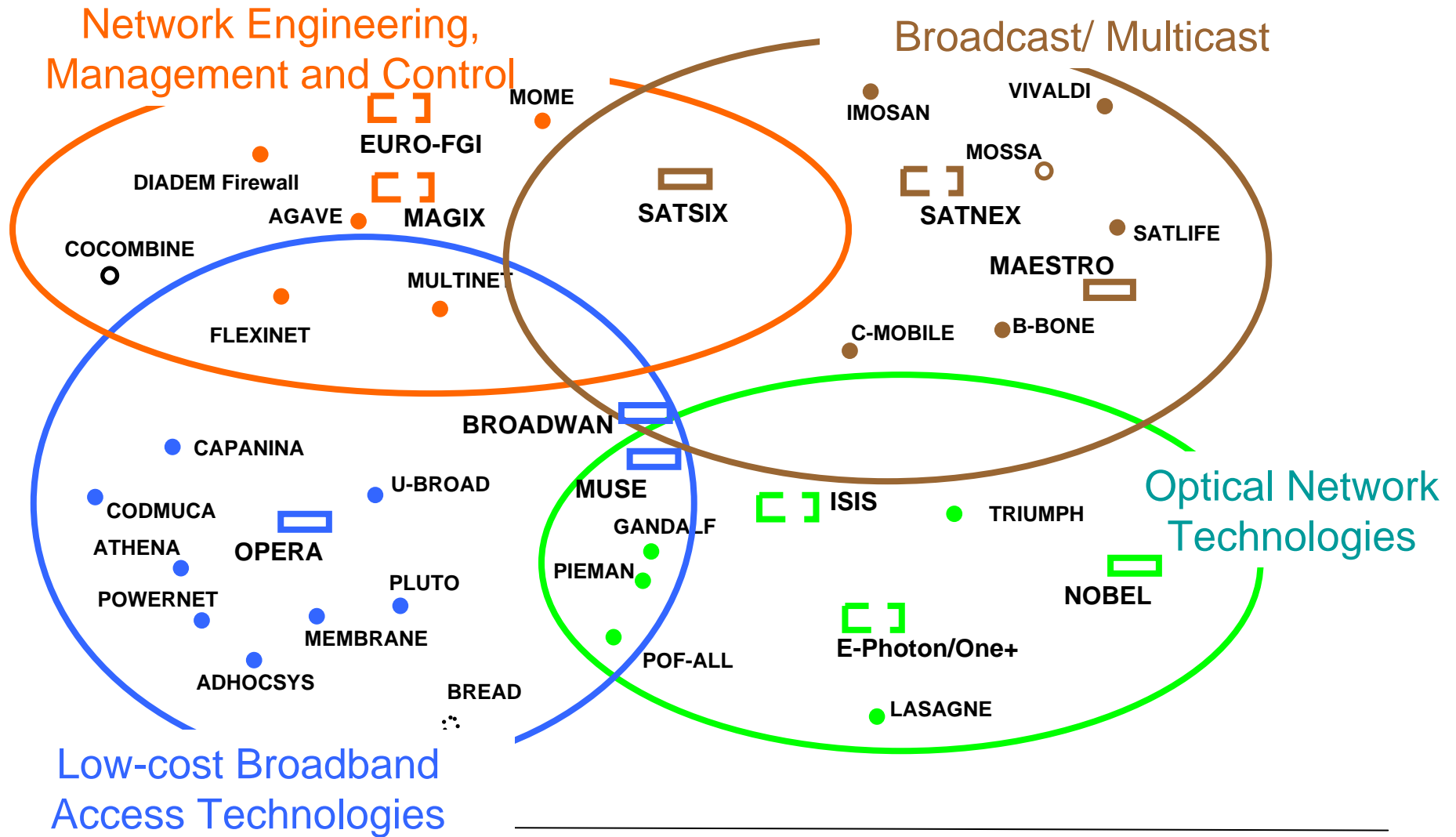


DSA: Dynamic Spectrum Allocation  
RRM: Radio Resource Management  
SDR: Software Defined Radio

Broadband for All | Mobile and Wireless Systems Beyond 3G

reflect those of the European Commission

# FP6 Project Clustering – Broadband For All



Instruments :

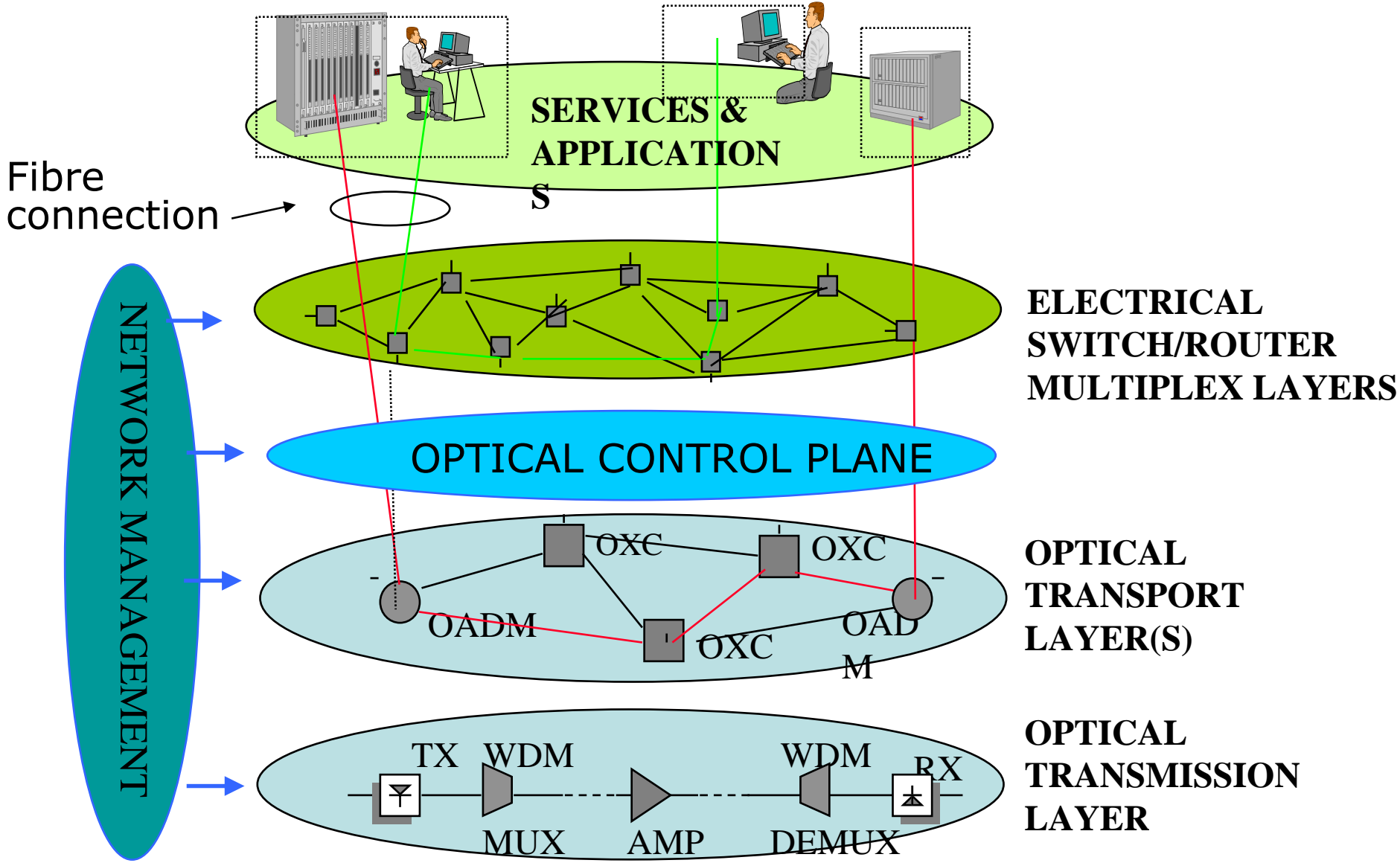
Integrated Projects (IP)
Network of Excellence (NoE)
 Specific Targeted Research Action (STRA)
  Specific Support Action (SSA)
  Coordination Action (CA)

The projects represented by the symbols are those of the author and do not necessarily reflect those of the European Commission

# OPTICAL NETWORK MANAGEMENT AND THE OPTICAL LAYER CONTROL PLANE

- CALL/CIRCUIT SET-UP
- PROTECTION
- RESTORATION
- ADDRESSING
- SIGNALLING
- ROUTING

# NETWORK LAYER MODEL



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# OPTICAL CONTROL PLANE (2)

## STANDARDISATION ACTIVITIES

ITU: ASON Automatically Switched Optical Network  
G.astn, G.ason, SG13, SG15

IETF: GMPLS Generalised Multi-Protocol Label  
(Lambda) Switching IP-Optical WG

OIF- Optical Internetworking Forum: UNI Signalling

OIDF- Optical Domain Service Interconnect:

ANSI T1X1

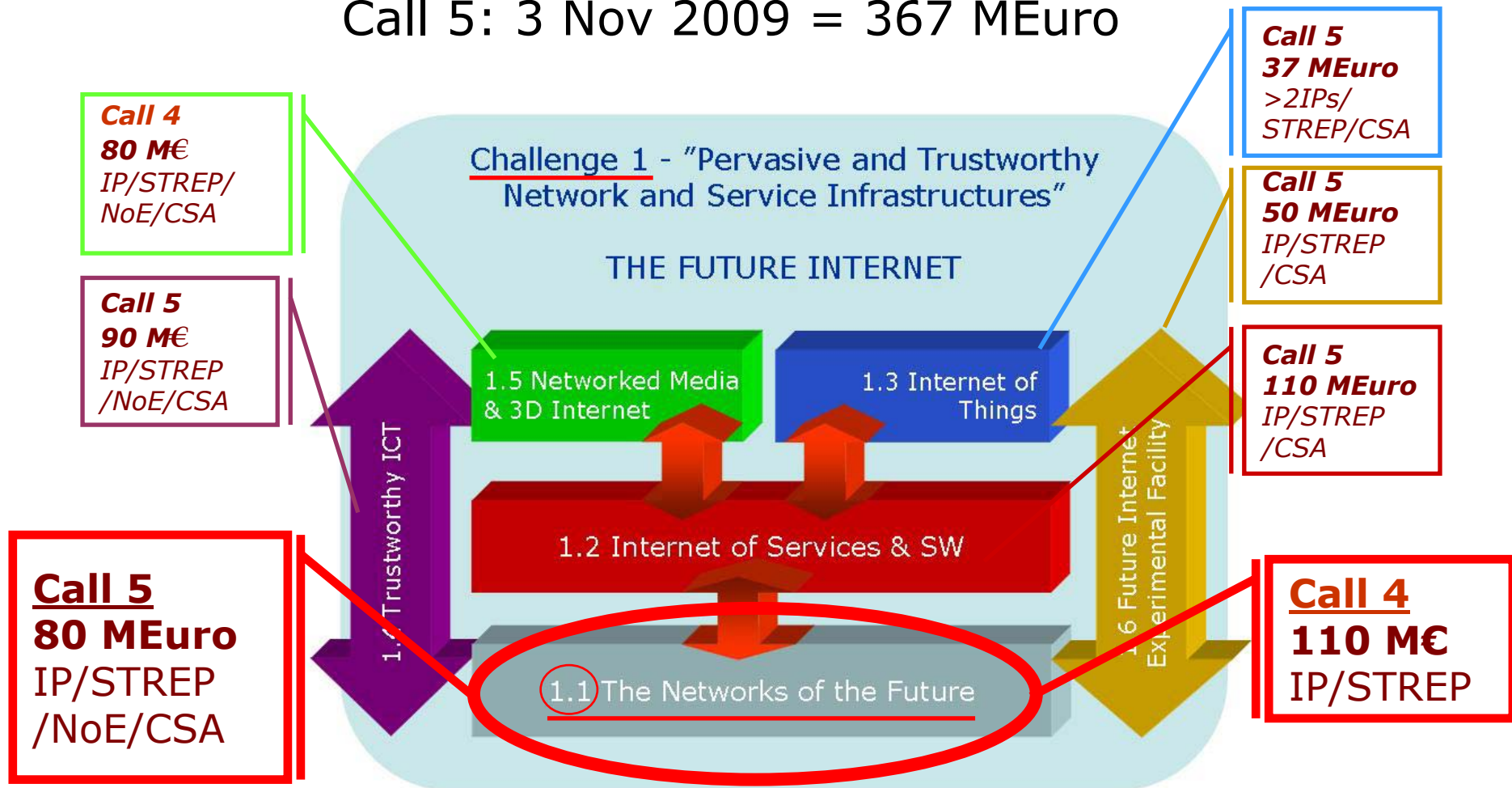
# IST Projects: OPTICAL CONTROL PLANE

LION:	Layers Internetworking in Optical Networks
HARMONICS:	Hybrid Access Reconfigurable Multi-Wavelength Optical Networks for IP-based Communications Systems
DAVID:	Data and Voice Integration over WDM
WINMAN:	WDM and IP Network Management
STOLAS:	Switching Technologies for Optically Labeled Signals
CAPRICORN:	Call Processing in Optical Core Networks
NOBEL:	Next Generation Optical Networks for Broadband European Leadership

# Challenge 1: Future Internet

Call 4: 1 April 2009 = 190 MEuro

Call 5: 3 Nov 2009 = 367 MEuro



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# Challenge 1, Future Internet:

## Challenge

- Making the Internet
  - mobile/broadband
  - manageable/scalable/QoS/QoE
  - secure, and trustworthy
  - 3D/Media enabled
- Virtualised resource, ad-hoc application design
- Enabling novel applications (RFID/sensor based)
- Social Internet, Net is the database, search
- Understand Internet "behaviours" (federated testbeds)
- Standards, International Co-operation...

## Approach

- Developing the technological and architectural foundations of the FI
- Further building the Future Internet Assembly and FIRE
- Support to reinforced co-operation with EU national initiatives
- International co-operation with regions having FI initiatives
- Leveraging EU assets, industrial drive
- Standards

# Future Network Research In FP7

## Background

- The Challenge is to deliver the next generation of ubiquitous and converged network and service infrastructures for communication, computing and media.
- From “Mobile and Wireless Systems” and “Broadband for All” in FP6, to a converged Objective 1.1 “The Network of the Future” in FP7

## Main Drivers and Objectives (Call 1)

- Ubiquitous network infrastructures and architectures
  - Convergence of mobile, fixed telecom and Internet network infrastructures
- Optimised control, management and flexibility of the future network infrastructure
  - Towards mobile broadband and efficient/dynamic spectrum usage
- Technologies and system architectures for the Future Internet

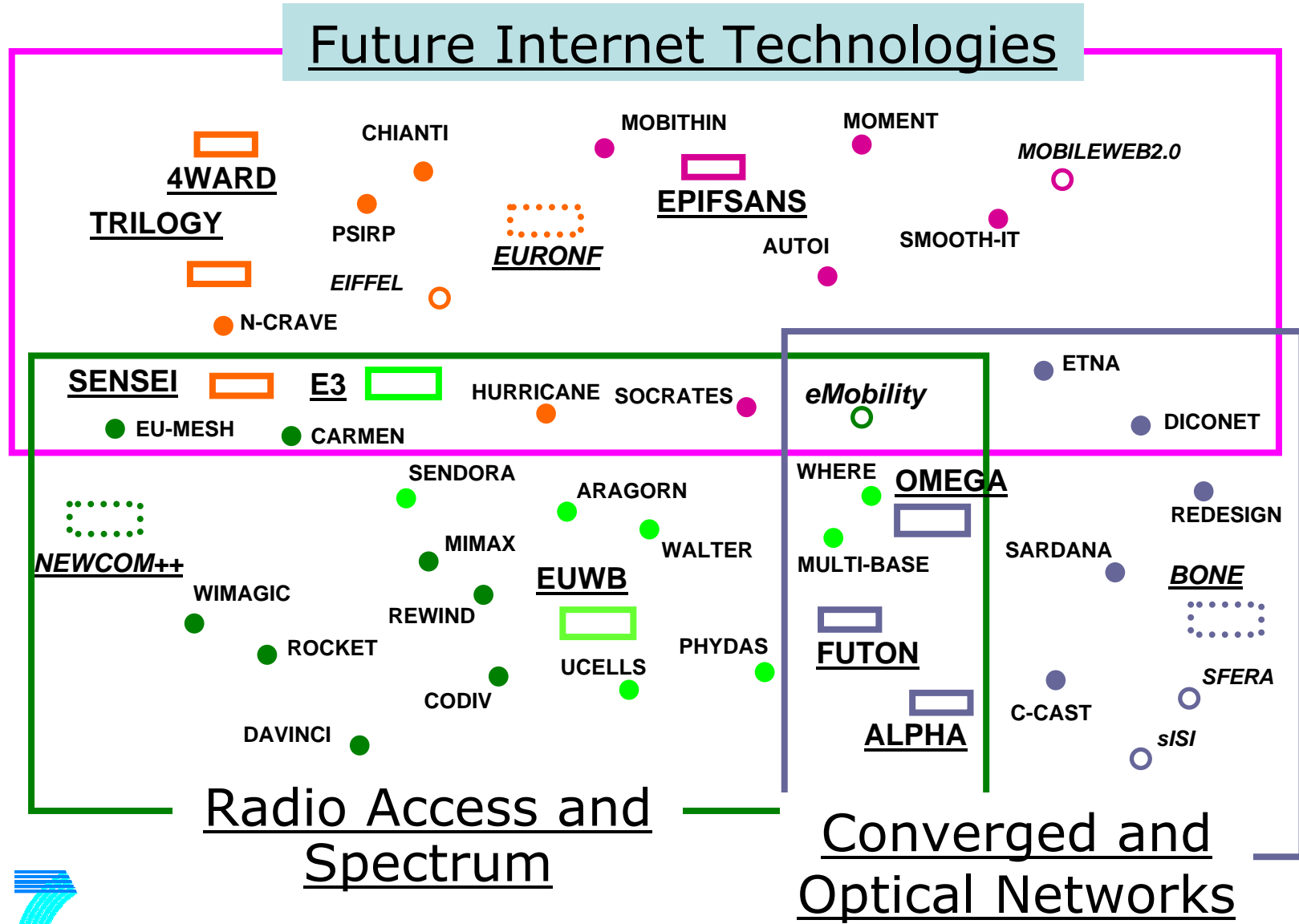
# Future Internet and Future Networks: Is there a “best” research strategy?

- “Clean-slate” versus evolutionary?
- Top-down or bottom-up? Chicken or egg?
- Whatever and whenever the “Future” is, we need to get to there from “here and now”
- We will need a roadmap!

# Objective 1.1 The Network of the Future

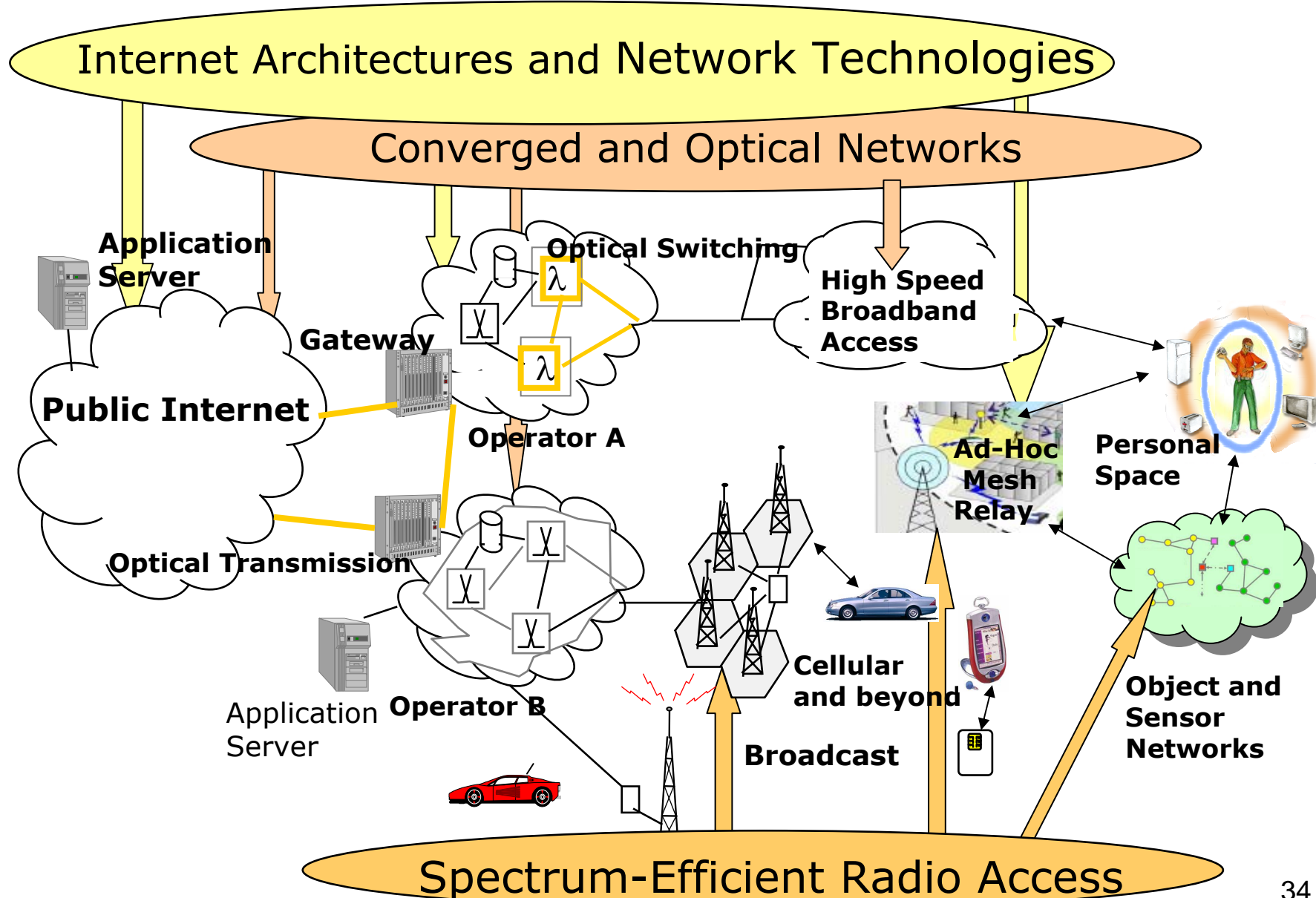
- **Future Internet Architectures and Network Technologies**
  - Novel Internet architectures and technologies
  - Flexible and cognitive network management and operation frameworks
- **Spectrum-efficient radio access to Future Networks**
  - Next-generation mobile radio technologies
  - Cognitive radio and network technologies
  - Novel radio network architectures
- **Converged infrastructures in support of Future Networks**
  - Ultra high capacity optical transport/access networks
  - Converged service capability across heterogeneous access

# Future Networks Project Portfolio & Clusters



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# The Network of the Future



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# Converged and Optical Networks Cluster (CaON) Projects (1)

- 212352 ALPHA: Architectures for fLexible Photonic Home and Access networks *IP*
- 215533 FUTON: Fibre Optic Networks for Distributed and Extendible Heterogeneous Radio Architectures *IP*
- 213311 OMEGA: Home Gigabit Access *IP*
- 217014 ReDeSign: Research for Development of Future Interactive Generations of Hybrid Fibre Coax Networks: *STREP*
- 215462 ETNA: Ethernet Transport Networks, Architectures of Networking *STREP*
- 216462 C-CAST: Context Casting *STREP*

# Converged and Optical Networks Cluster

## CaON Projects (2)

- 216338 DICONET: Dynamic Impairment Constraint Networking for Transparent Mesh Optical Networks *STREP*
- 217122 SARDANA: Scalable Advanced Ring-based passive Dense Access Network Architecture *STREP*
- 216785 UCELLS: Ultra-wide band real-time interference monitoring and CELLular management Strategies *STREP*
- 216863 BONE: Building the Future Optical Network in Europe: The e-Photon/ONe Network *NoE*
- 216104 SFERA: Structural Funds for European Regional Research Advancement *CSA*
- 215134 sISI Support action to the Integral Satcom Initiative (ISI) *CSA*
- 214089 eMobility CA: eMobility Coordination Action *CSA*

# 216338 DICONET: Dynamic Impairment Constraint Networking for Transparent Mesh Optical Networks *[STREP]*

**The key innovation of DICONET:** The development of a dynamic network planning and routing tool residing in the core network nodes, incorporating real-time measurements of optical layer performance into IA-RWA algorithms, and which is integrated into a unified control plane, is the key enabler for networks capable of automated, rapid network reconfiguration. This feature of fast dynamic reconfiguration upon user or network request is fundamentally different from slow, planned provisioning and reconfiguration used today.

# 217122 SARDANA: Scalable Advanced Ring-based Passive Dense Access Network Architecture [*STREP*]

Sardana is able to serve more than 1000 users with symmetrical 300 Mbit/s per user, spread along distances up to 100 km, at 10Gbit/s, in a flexible way.

-***new technologies***: adoption and adaptation of new opto-electronic technologies, like reflective semiconductor optical amplifier, remotely pumped fiber amplification, wavelength shifting, etc.

-***Signal processing and communication techniques***: orthogonal optical modulation formats to reuse the same wavelength in down- and up-stream, non-linear electronic equalization of the different optical impairments present, and hybrid domain signal multiplexing (wavelength and time domain, routing the optical packets without collisions or delays).

***Ring-based passive***: the network topology is hybrid with a central WDM ring, to offer instant communication protection in case of fiber cut, plus TDM single-fiber trees to the homes. In between, the Remote Nodes perform wavelength add&drop routing and optical amplification, although being fully passive. Strict passiveness is preserved in the external fiber plant.

***Dense Access Network Architecture***: related to the concept of the user density in an area; it can range from a rural scenario at one hundred Km to an urban scenario with several thousand homes.

## 217014 ReDeSign: Research for Development of Future Interactive Generations of Hybrid Fibre Coax Networks [*STREP*]

The aim of the ReDeSign project is to further evolve Hybrid Fibre Coaxial (HFC) network architectures and transmission technologies used in these networks by creating a smooth migration path towards future infrastructure concepts. The project addresses in a first scenario the evolution of the current HFC access network with state-of-the-art RF radio transmission technology. The development of related technologies will be performed through a liaison with the Digital Video Broadcasting (DVB) project, for the second generation DVB for cable (DVB-C2) system.

In a second scenario ReDeSign researches transmission techniques which accelerate the deployment of HFC bidirectional network investments towards more cost efficient, robust, and high quality HFC networks with higher orders of bandwidth capacity including deep fibre architectures where economically feasible.

# 212352 ALPHA: Architectures for fLexible Photonic Home and Access networks *IP*

- Access networks based on optical fibre (FTTH/FTTx):
  - *Point-to-point and Passive Optical Networks and all that...*
- Home (in-building) networks using optical fibre (FITH)
  - *Single-mode and plastic optical fibre versus CAT-5*
- How to achieve 1 Gb/s (and above) per end-user in these domains
- How to provide “transport” for 3G/Beyond 3G in these domains (convergence)
- Techno-economics/politics for all the above.
- *Can we deliver 1 Gb/s to the end-user TODAY?*  
*The short answer is “Yes”. But...*

# 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

# Future Networks: Next Calls

## Future Internet Architectures and Network Technologies

**ICT Call 5  
Closing: 3 Nov 2009**

- *Novel Internet architectures and technologies*
- *Cognitive network management and operation*

- *Next-generation mobile radio technologies*
- *Cognitive radio*
- *Novel radio network architectures*

**ICT Call 4  
Closing 1 April 2009**

## Spectrum-efficient Radio Access to Future Networks

- *Ultra high capacity optical transport/access networks*
- *Converged service capability across heterogeneous access*

**ICT Call 4  
Closing 1 April 2009**

## Converged infrastructures in support of Future Net

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## Network of the Future- Call 4+5: Expected Impact

- Strengthened positioning of European industry in the field of Future Internet technologies
- Reinforced European leadership in mobile and wireless broadband systems, optical networks, cognitive network management technologies.
- Increased economic efficiency of access/transport infrastructures (cost/bit)
- Global standards and European IPRs reflecting federated and coherent roadmaps.
- Wider market opportunities from new classes of applications taking advantage of convergence.
- Accelerated uptake of the next generation of network and service infrastructures.

## Call 4: Converged infrastructures in support of Future Networks

- Ultra high capacity optical transport/access networks
  - Transparent core-access integration, optical flow/packet transport, dynamic wavelength allocation and end-to-end service delivery capability, overcoming the limitations of segmentation between access, metro and core networks and domains
  - Lower cost optical access and the need for energy efficiency
  - IPs are expected to address also a network control plane, supporting flexible management capability of multi-domain and multi-operator contexts with end-to-end carrier grade performance

# More Information

- [http://ec.europa.eu/information\\_society/index\\_en.htm](http://ec.europa.eu/information_society/index_en.htm)
- [http://ec.europa.eu/research/future/index\\_en.cfm](http://ec.europa.eu/research/future/index_en.cfm)
- <http://cordis.europa.eu/fp7/ict/future-networks/>
- [http://ec.europa.eu/information\\_society/policy/ecommm/library/public\\_consult/nga/index\\_en.htm](http://ec.europa.eu/information_society/policy/ecommm/library/public_consult/nga/index_en.htm)
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