ICT BONE views on the Network of the Future: the role of optical networking

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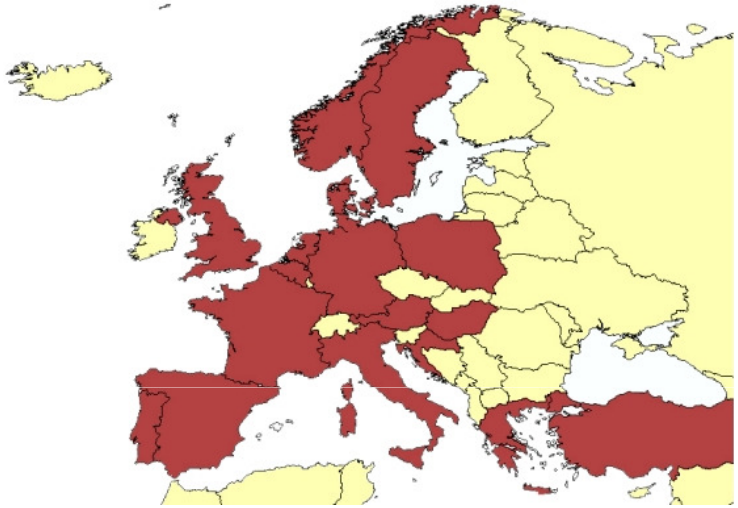
ICT BONE- Building the Future Optical Network in Europe



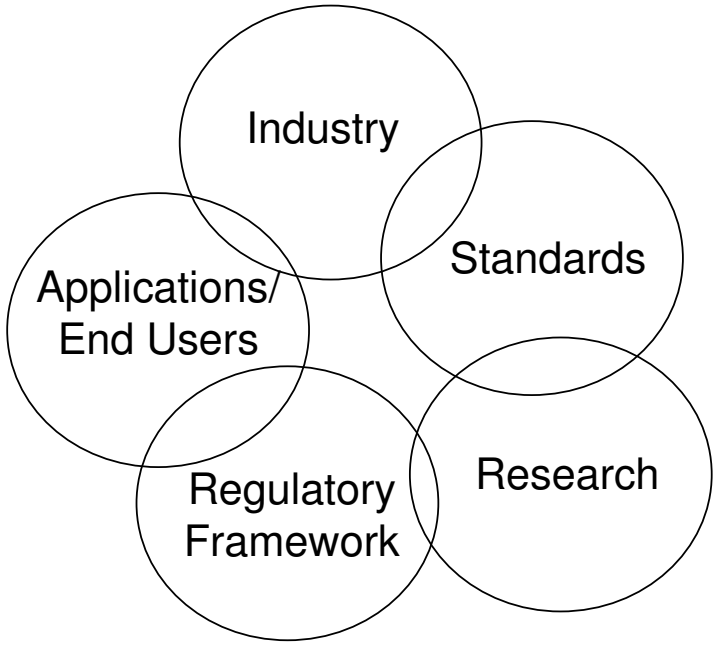
- The core activity of BONE is the stimulation of intensified collaboration, exchange of researchers and integration of activities and know-how of partners.
- The BONE-project is structured in 6 Virtual Centres of Excellence and 7 Topical projects.
  - Centralised activites are grouped in 4 General WPs dealing with management, dissemination, teaching and electronic tools.
- It comprises 49 partners

Part of the activities of BONE is the development of the European Roadmap on Optical Networking in the context of the “Network of the Future”

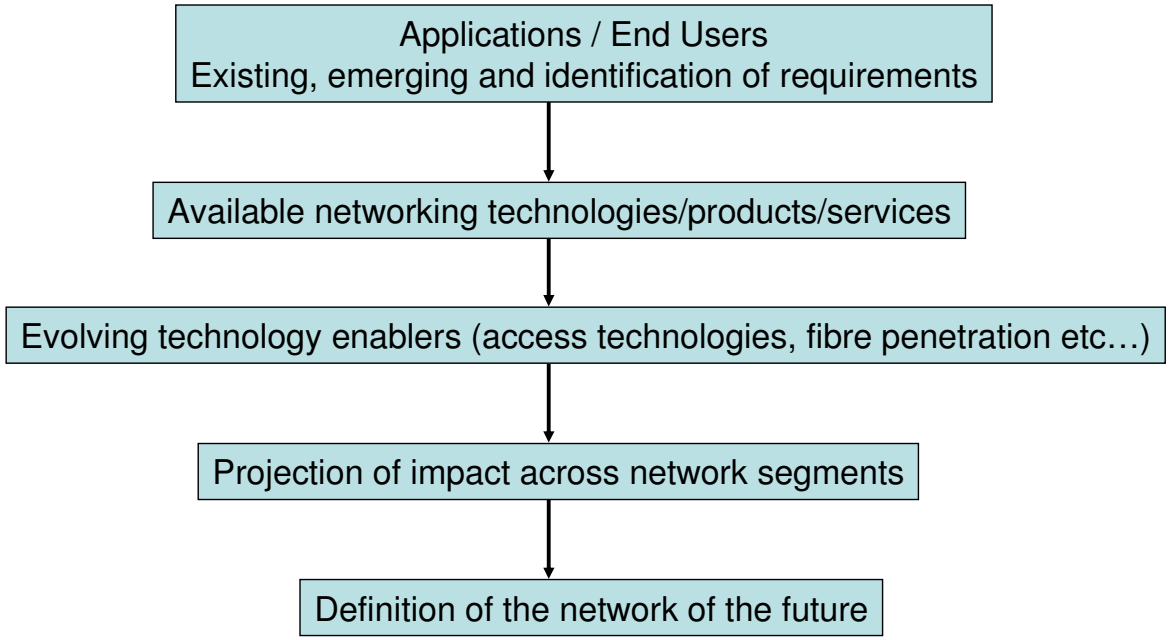
Roadmap Objectives

- To capitalize on the wide expertise and views of the BONE partners
- To develop a realistic view on how network services and applications are evolving and what requirements this may impose on the Network of the Future
- To develop a consolidated view on how optical networking can better help meet those requirements
- To identify the areas of research needed to support this view of the Network of the Future
- To set out the issues and solutions for the development and implementation of future networks, network technologies and define areas for further research activity

Methodology



Networking Evolution Drivers

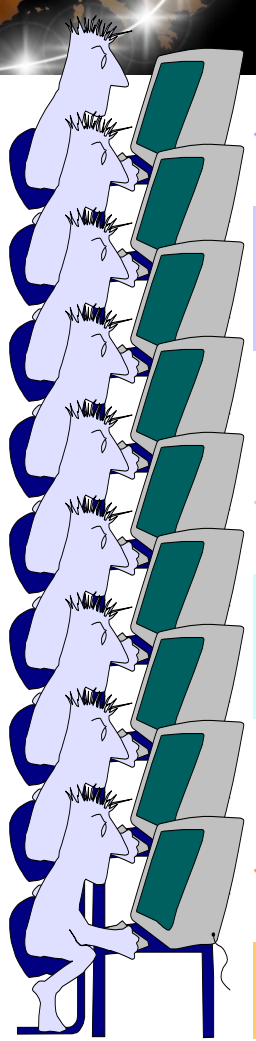


Roadmap Methodology

Survey

- Collection of information from various European countries through BONE partners on:
  - existing and emerging applications and services
    - definition of services & bitrates for residential customers and large enterprises today, in the near (~ 5 years) and in the long term future (>10 years from now)
    - Special emphasis was paid on the evolving applications and new digital services and their impact on the network
  - broadband penetration
  - existing and upcoming access technologies

Services & Bitrates for Large Enterprises



Downstream / Upstream

Storage Area Networking (SAN), IP Storage
- Remote storage
- Data replication
- Disaster recovery

GRID Computing

up to 10 Gbit/s + symmetrical

Leased Lines, Virtual Private Networks (VPNs, IP based)
- LAN extension/interconnection
- WAN access

up to 10 Gbit/s + symmetrical

Other Services
- Fast Internet Access (web services, e-mail)
- Videoconferencing
- Voice

up to 1 Gbit/s asymmetrical

Direct Access to the MAN

Medium Term Access Requirements

General

- Scalability
- Strictly low cost
- Cost structure should allow for "pay as you grow"

Residential Customer

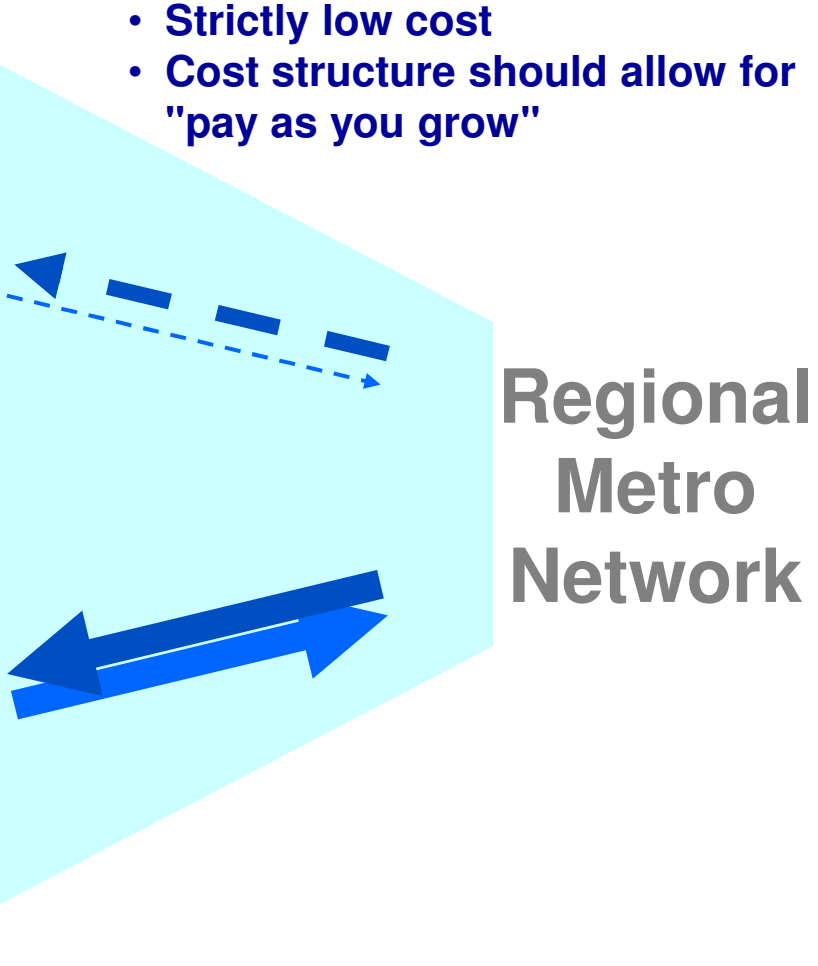
Bitrate Downstream:	≥ 20 Mbit/s peak
Bitrate Upstream:	≥ 2 Mbit/s peak
Quality of Services:	QoS differentiation ≤ 50:1 overbooked

SOHOs, SMEs

Bitrate Downstream:	≥ 10 Mbit/s peak
Bitrate Upstream:	≥ 10 Mbit/s peak
Quality of Services:	QoS differentiation ≤ 5:1 overbooked

Large Enterprises/Campus

Bitrate Downstream:	≥ 10 Gbit/s peak
Bitrate Upstream:	≥ 10 Gbit/s peak
Quality of Services:	QoS differentiation no overbooking



Future Services & Bitrates for new Digital Services

Downstream / Upstream

Virtual Immersive Reality applications
Medical and surgery applications
Remote manipulation of complex appliances
Cultural heritage museum

10 -40 Gbit/s symmetrical

Service-platform based services
Network services (e.g. lightpath on demand)
Service composition (non-network resource + network resource)

10 -40 Gbit/s symmetrical

New Digital Media Services

10 -40 Gbit/s symmetrical

Other Digital Services
Virtual Terminal (remote hard disk, CPU, etc)
Cloud Computing
Quadruple Play
E-science

1-10 Gbit/s asymmetrical

MAN\WAN

Future Access Requirements

General

- Scalability
- On Demand and QoS

Residential Customer

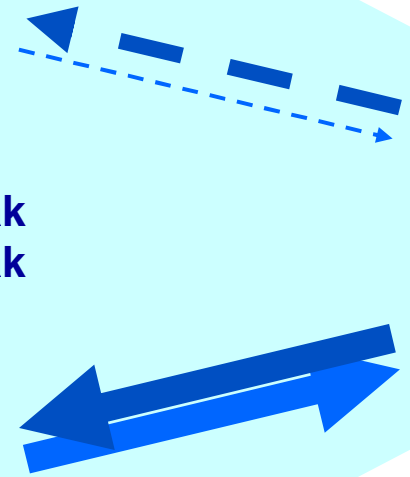
Bitrate Downstream:	≥ 1 Gbit/s peak
Bitrate Upstream:	≥ 1 Gbit/s peak
Quality of Services:	QoS differentiation ≤ 10:1 overbooked

Broadcasting and other Industry

Bitrate Downstream:	≥ 10-100 Gbit/s peak
Bitrate Upstream:	≥ 10-100 Gbit/s peak
Quality of Services:	QoS differentiation ≤ 5:1 overbooked

Large Enterprises/Hospitals/Campus

Bitrate Downstream:	≥ 100 Gbit/s peak
Bitrate Upstream:	≥ 100 Gbit/s peak
Quality of Services:	QoS differentiation no overbooking



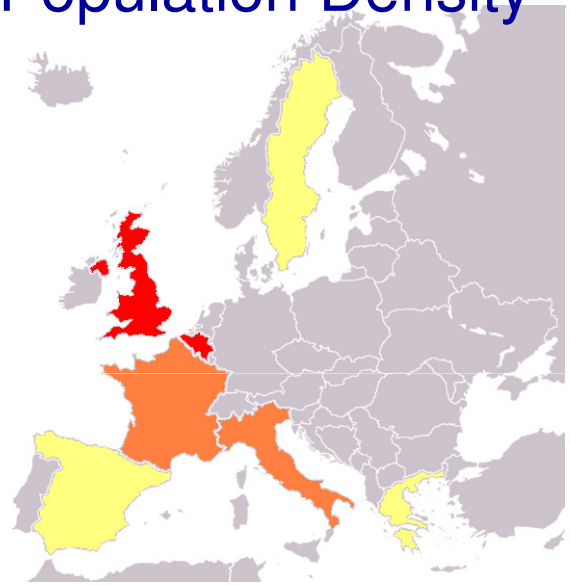
Regional Metro Network

General Remarks

- Private/household related services are becoming bandwidth demanding and large enterprises comprise different industrial sectors from hospitals, campuses and museums to broadcasting industry.
- The specific applications impose stringent requirements not only on the bandwidth but also the quality of the service, the service delivery time and the level of flexibility that they may require.

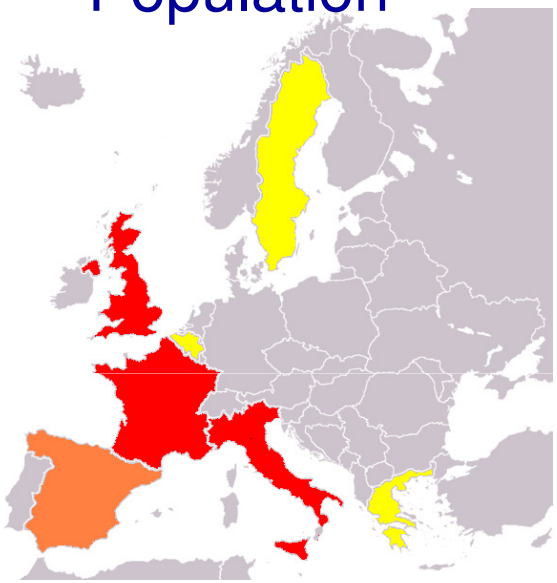
European Diversity ….

Population Density



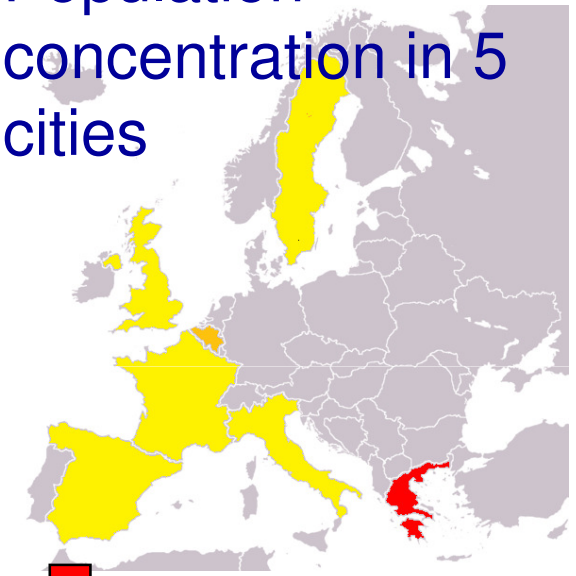
>300 people/km²
100-200 people/km²
0-100 people/km²

Population



>60 M people
20-40 M people
<20 M people

Population concentration in 5 cities



>50% population
20-50% population
<20% population

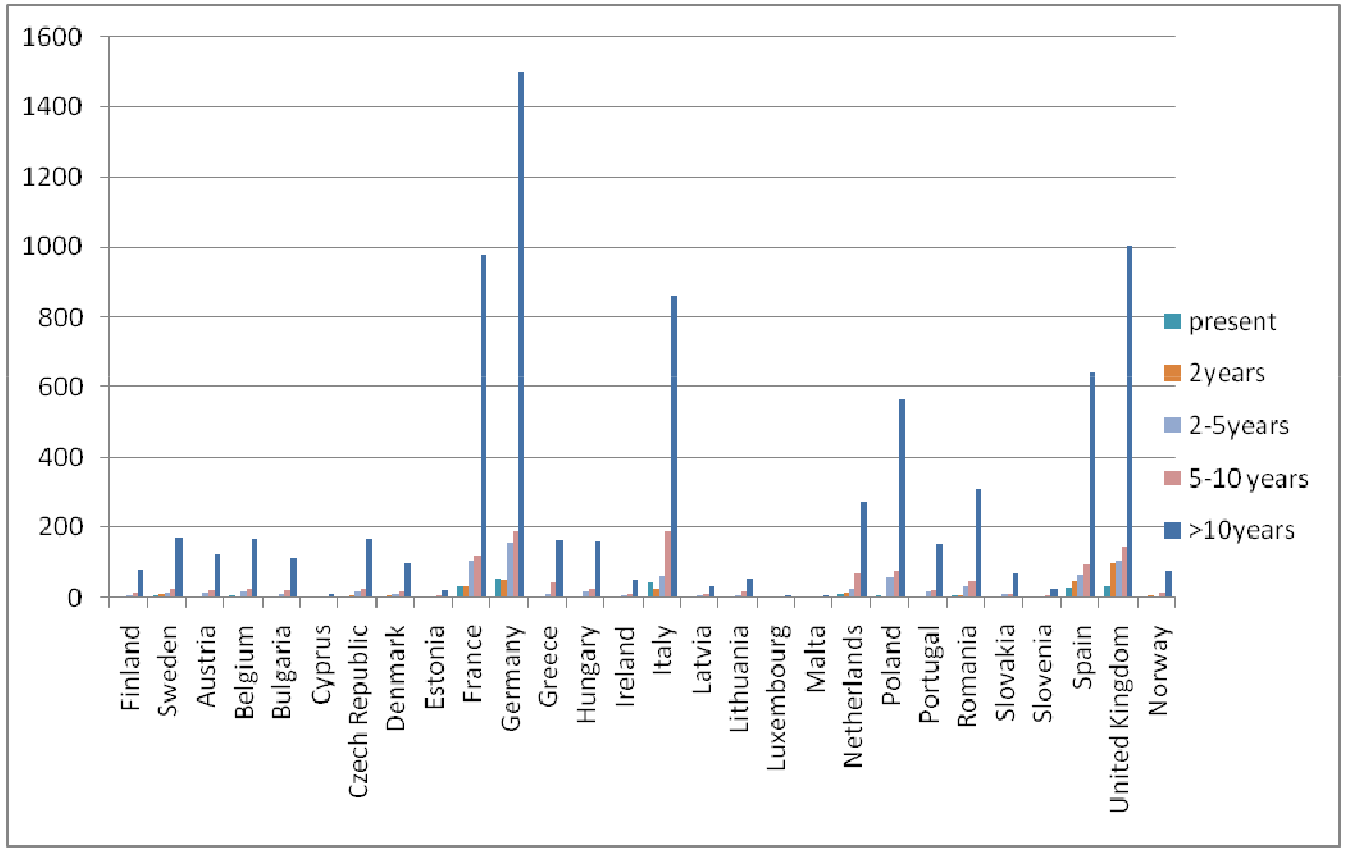
European population distribution and population density plays an important role in the deployment of different new services or technologies

A critical user mass has to be guaranteed for service providers and network operators to proceed with the economic deployment of new technology

European Diversity…

- Due to diversity in Access Technology deployment and according to our survey we have assumed that there are ***very fast, fast and slow deployers*** in FttX among the EU countries
- This is due to their current technology deployment and the business model applied for these deployments
  - e.g. public funding may accelerate specific technology uptake in certain regions

European Traffic Demands



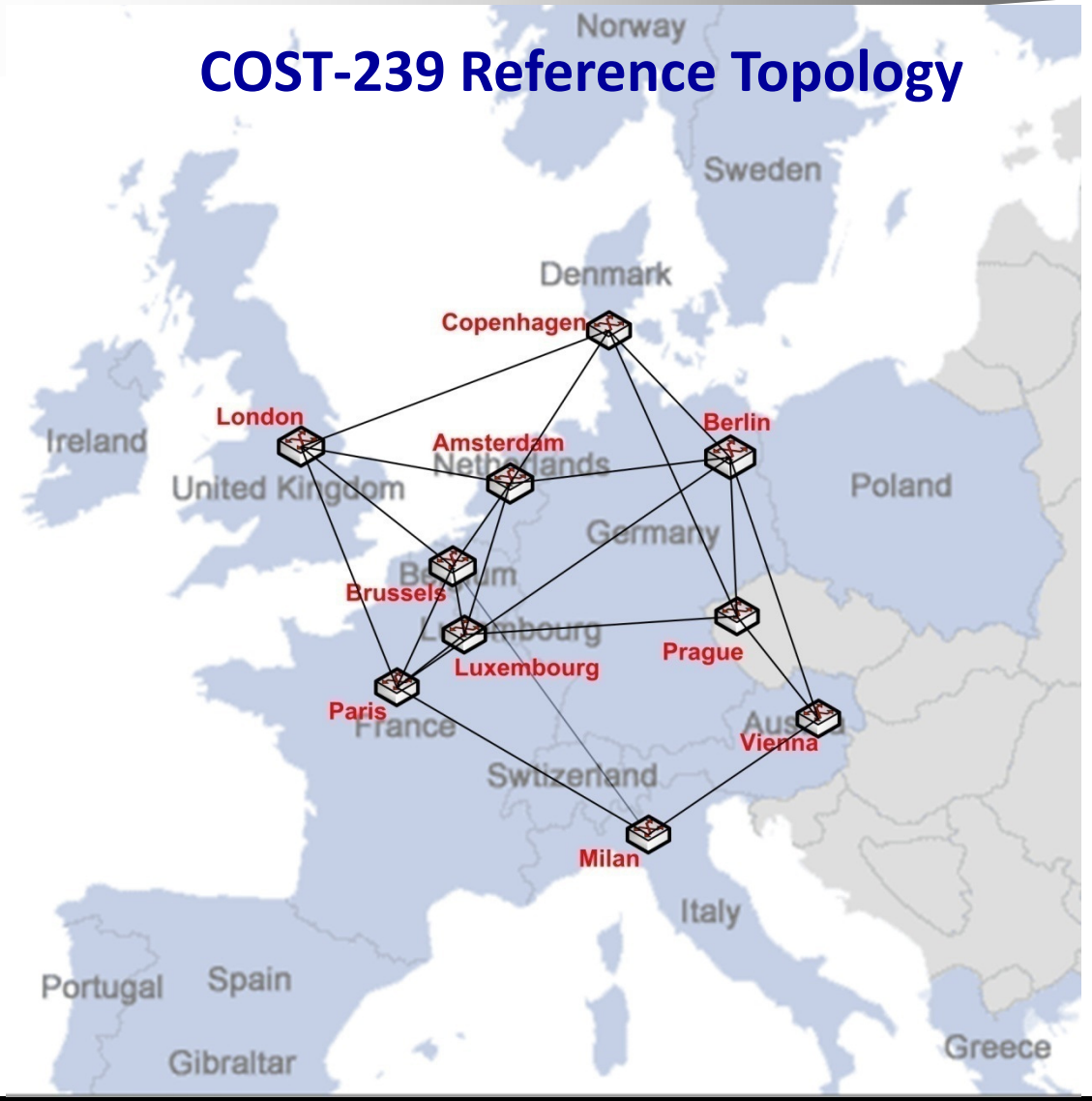
- Projection of the traffic volume coming from each PoP in the Pan-European network

Pan-European Network Dimensioning

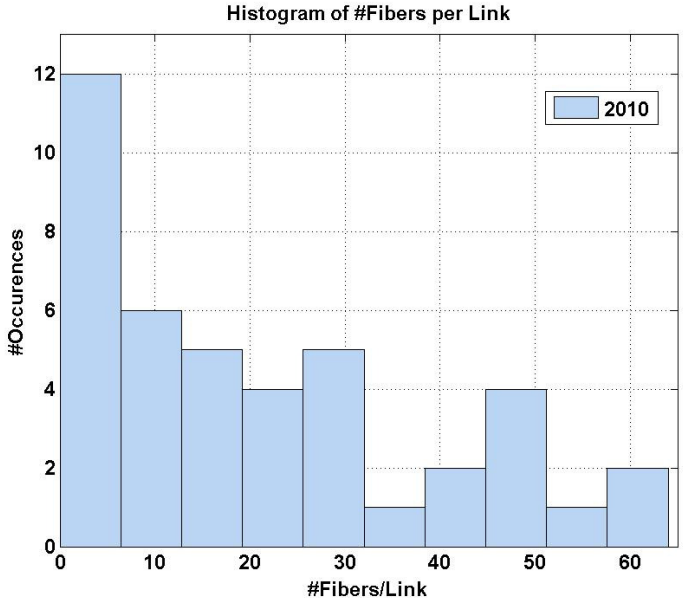
- The output of this specific part of the Roadmap produced a traffic matrix
- Pan-European etwork dimensioning study
  - realistic predictions of capacity requirements, in the network of the future
  - identification of limitations in today's networks
  - identification of suitable architectural approaches and technology solutions optimised for the network of the future
- Each country has one PoP in the Pan-European network
- The projection of the dimensions of the European network to the mid- and long-term future is performed through solving an instance of the network dimensioning problem

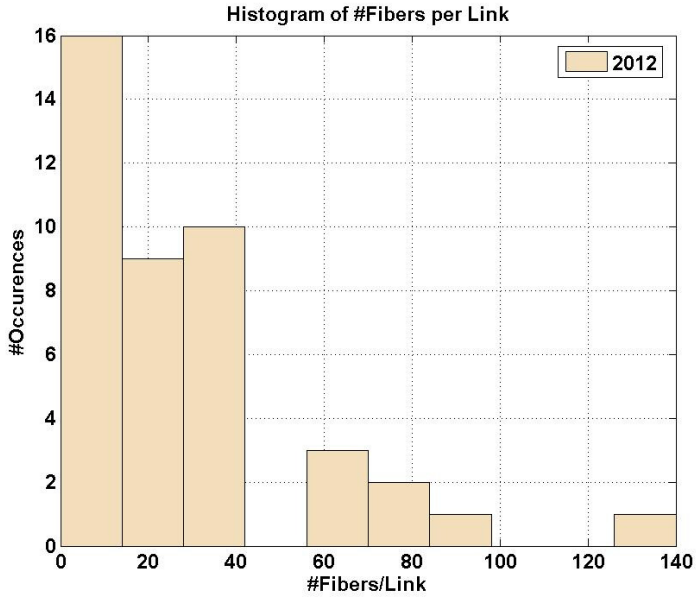
Dimensioning Method: Topology

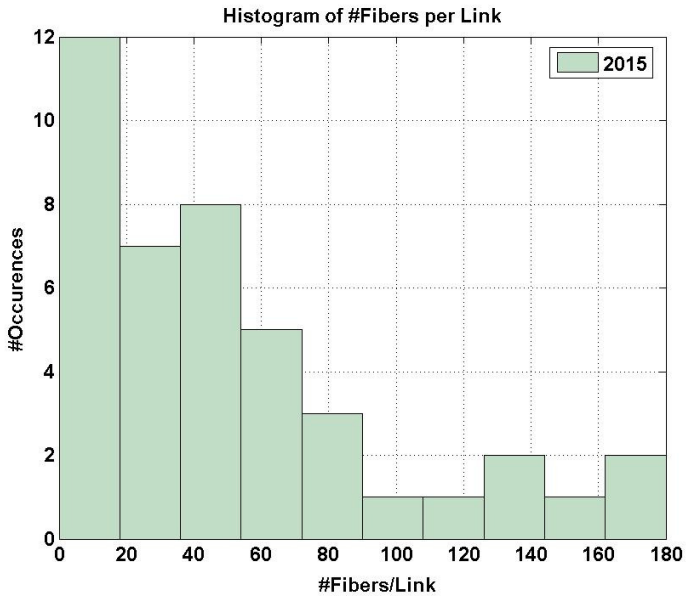
COST-239 Reference Topology

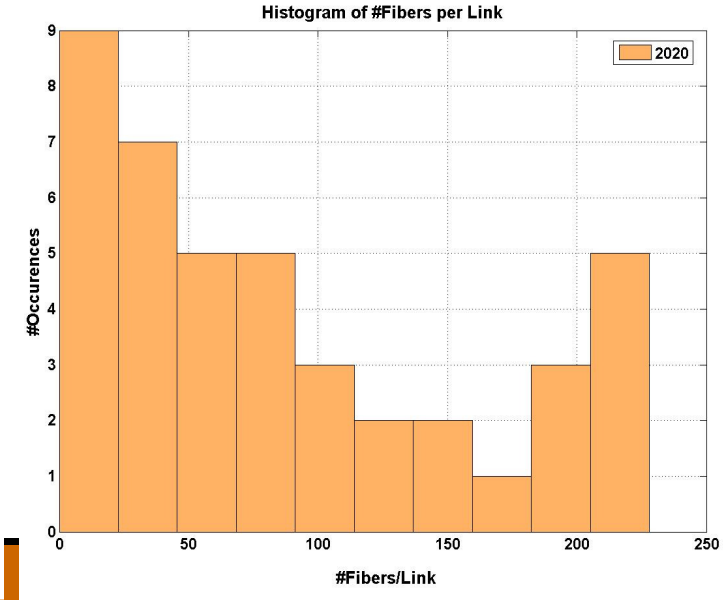


Fiber Capacity Per Link

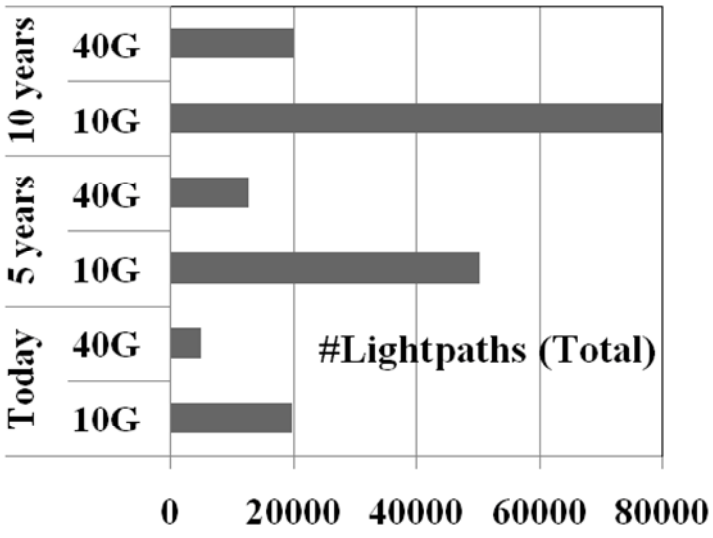


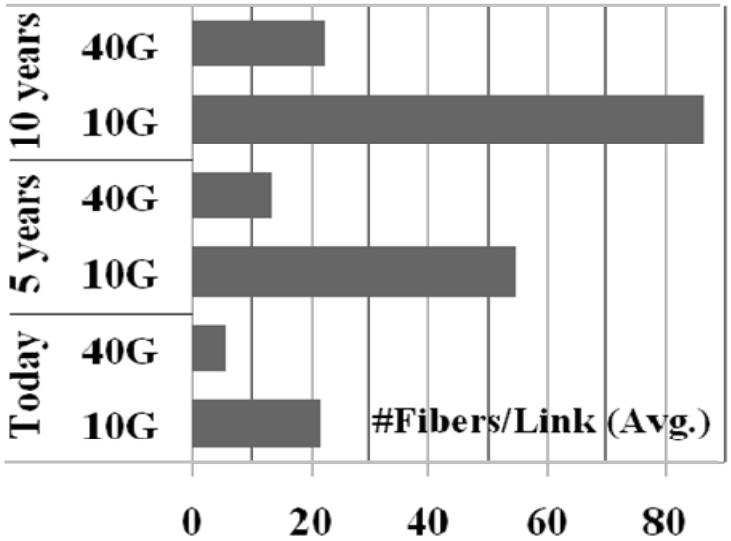






European optical backbone dimensions





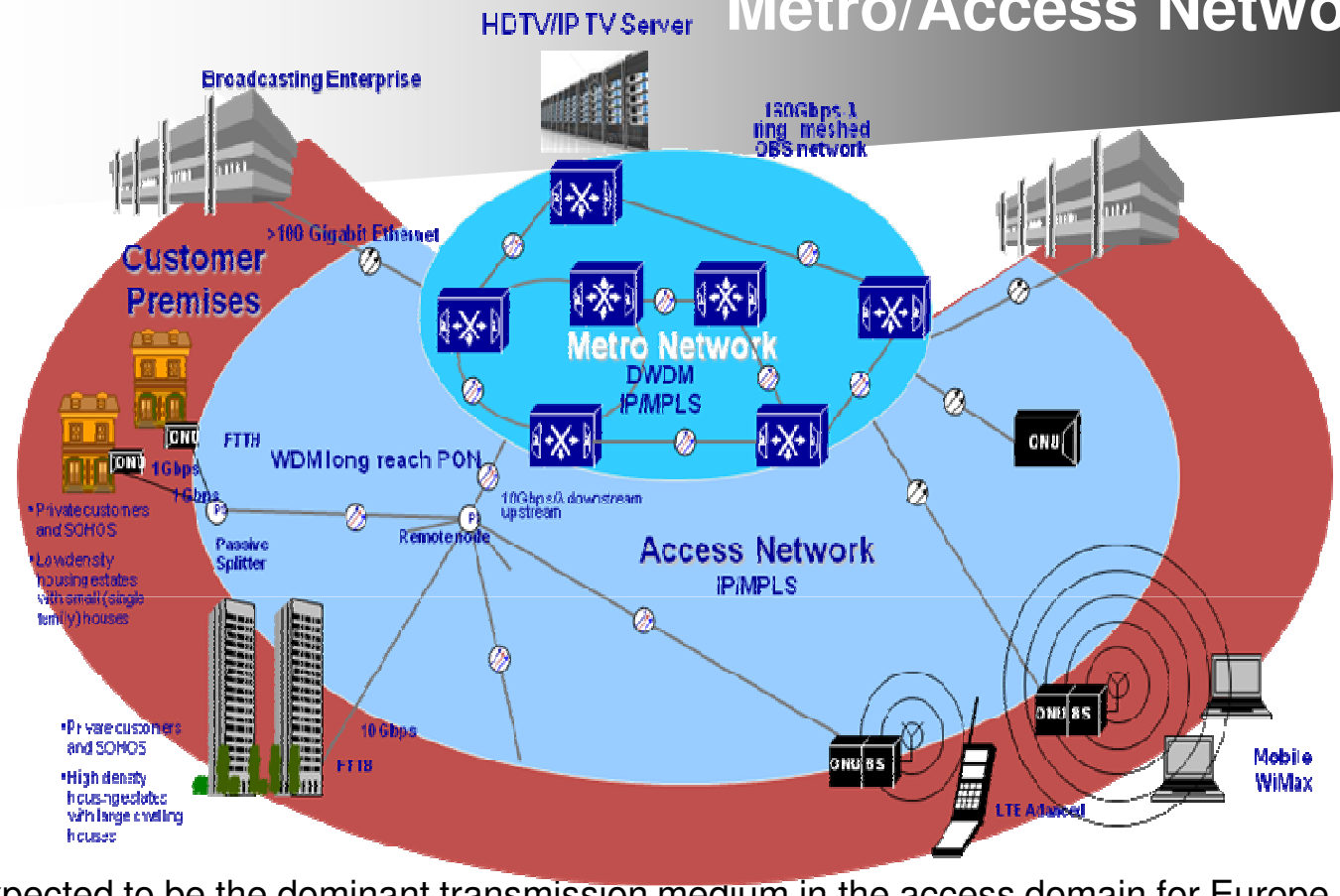
European optical backbone dimensions and number of fibres per link

Need to address: scalability, power efficiency…

Limitations of current networks based on roadmap results

- In order to facilitate the penetration of new services and applications the access bandwidth rates should be upgraded accordingly- This concerns all types of access networks
- It inevitably concerns Metropolitan networks as may emerge as the main bottleneck in network upgradability and efficient end-to-end service delivery
- As far as the core network is concerned important changes should be proposed in order to eliminate the scalability, Power Consumption, flexibility and Reconfiguration issues that characterizes today's networks

Long Term Vision for Metro/Access Networks (I)

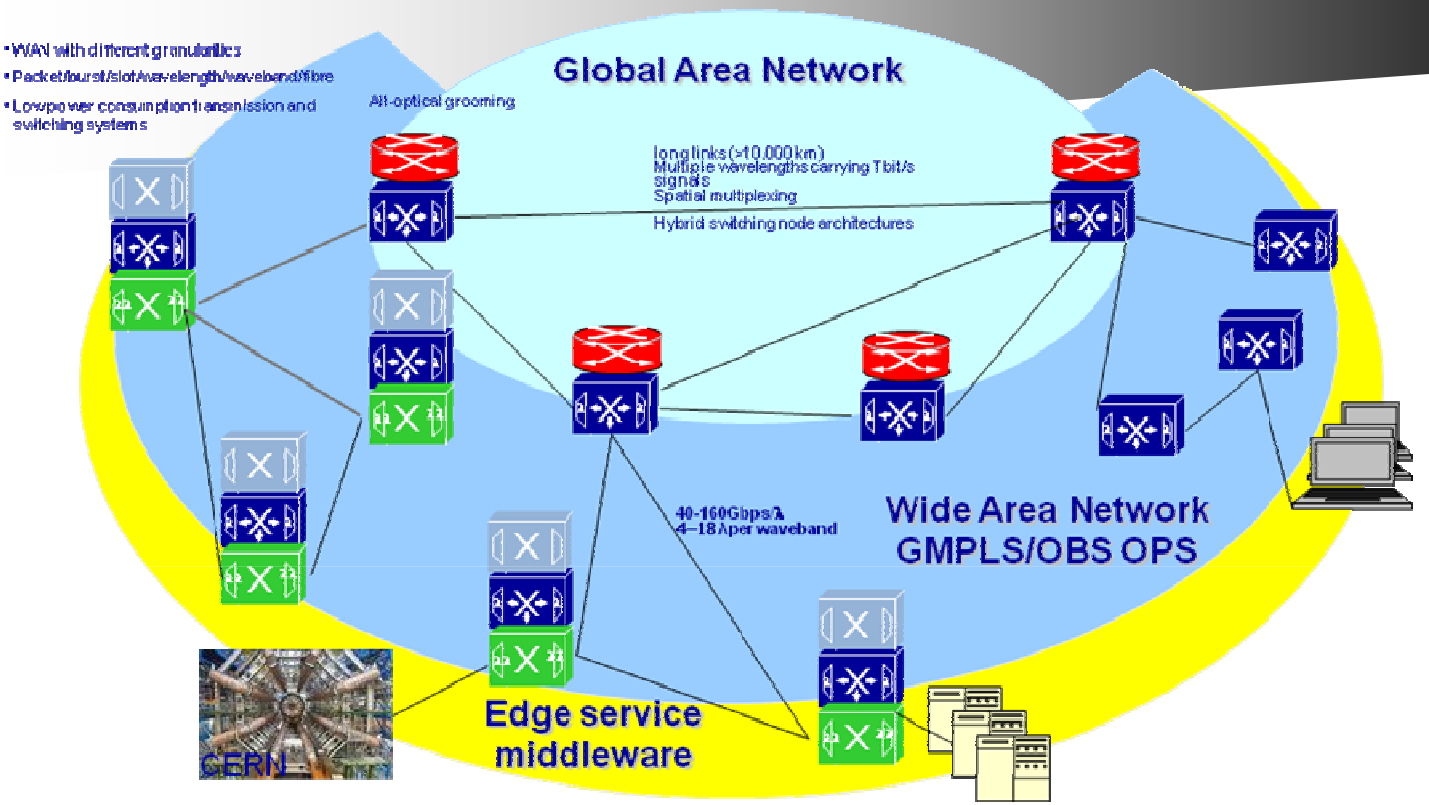


- Fiber is expected to be the dominant transmission medium in the access domain for Europe
- Fiber is expected to reach the building for all kind of household and business customers
- Within the buildings wireless will play the dominant role (bitrates spanning from 10s to 100 Mbps)
- In large business/enterprise buildings fiber will be used for very high speed access (100 GEthernet)
- p2p links and meshed networks will connect large enterprise buildings and also large buildings for private households/customers directly to the metro network
- PONs will be further developed concentrating traffic originating from small to medium size buildings for private customers

Long Term Vision for Metro/Access Networks (II)

- Metro segment: Mesh networks outperform rings because of their advantages regarding flexibility, capacity, efficiency, scalability and survivability
- The control simplicity of ring topology and the availability of well established protocols make them a very appealing choice
- The compatibility of the proposed solution with optical access technology and core networks for end-to-end service delivery will play an important role in this choice
- Metro networks can support large numbers of high speed channels as the transmission distances they support are limited and ultra high-speed is possible
- Metro networks are likely to employ optical burst/packet switching
  - offering improved bandwidth efficiency and tolerance to the burstiness of the input traffic
  - It is not anticipated that these solutions will support very high data rates

Long Term Vision for GAN/WAN Networks (I)



- Multi-granularity transport supporting switching granularities spanning from sub-wavelength to wavelength bands or even fibers while facilitating node consolidation and traffic grooming
- Single channel bit rate exceeding 40 Gbit/s
  - more sophisticated modulation formats and coding schemes increasing the spectral efficiency beyond 1 bit/s/Hz
- Advanced technology deployment and the need for standardisation
- Overall network power consumption of central interest

Long Term Vision for GAN/WAN Networks (II)

- Introduction of a Service Plane to enable decoupling of services and the network infrastructure facilitated by an Edge Service Middleware
- The Control Plane will incorporate cross-layer optimization mechanisms to take into consideration physical layer performance issues
  - GMPLS will facilitate network performance optimization & optimal use of available equipment to extend the transparency domain
- Overcoming the lack of a multi-domain interoperability framework, developing extensions of the GMPLS paradigm for hybrid OCS/OBS network scenarios
- Strategies for combating weak IP and WDM integration
- Mechanisms for efficient protection and failure recovery in dynamic optical networks