SEVENTH FRAMEWORK PROGRAMME

2nd report on dissemination activities including updated roadmap

FP7-ICT-216863/UoP/R/PU/D01.4

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Nature of the Deliverable R

Dissemination level of Deliverable PU

Editors: UoP / Tanya Politi

Abstract:

This deliverable reports on the dissemination activities that took place in the first year of the project as organized by WP01 and also in conjunction with other WPs. There were 5 types of activities that were organized to assist in disseminating information and spreading excellence. 1) Workshops and conferences either supported or organized by the consortium; in this type of activity we include events like exhibition booths and also presentations /tutorials. 2) Preparation of dissemination material to be used in these events but also to other occasions. 3) Organization of the School event at UEssex in order to reach out to young pupils. 4) The development of a Roadmap. 5) The coordination of online dissemination with emphasis on Newsletters.

Keyword list:

Dissemination, roadmap, events, schools event

Clarification:

Nature of the Deliverable

R Report
P Prototype
D Demonstrator
O Other

Dissemination level of Deliverable:

PU Public
PP Restricted to other programme participants (including the Commission Services)
RE Restricted to a group specified by the consortium (including the Commission Services)
CO Confidential, only for members of the consortium (including the Commission Services)

This report was edited by T. Politi- UoP.

Different partners contributed to this report from WP01 (Michael O'Mahony –Uessex, Anna Tzanakaki & Kostas Katrinis– AIT and Gerald Franzl-TUW.

Also the organizers of the specific events/workshops contributed to this deliverables.

The following WP leaders contributed in the formation of the living document that comprises the ICT BONE Roadmap.

Franci Callegatti/UNIBO, WP11: VCE on Network Technologies and Engineering.

Pierro Casoldi/SSSUP, WP12: VCE on Services and Applications

John Mitchell /UCL, WP13: VCE on Access Networks

Kyriakos Vlachos/RACTI, WP14: VCE on Optical Switching Systems

Periklis Petropoulos/ORC, WP15: VCE on Transmission Techniques:

Mario Pickavet/IBBT & Dimitra Simeonidou/UEssex, WP21: TP on Green Optical Networking

Salvatore Spadaro/UPC, WP22: TP on MPLS, GMPLS and routing.

Achille Pattavina/POLIMI, Guido Maier/POLIMI WP25: TP on Optical Interconnects

Many partners completed the questionnaire that depicts the access technologies of their countries.

Disclaimer

The information, documentation and figures available in this deliverable, is written by the BONE ("Building the Future Optical Network in Europe*) – project consortium under EC co-financing contract FP7-ICT-216863 and does not necessarily reflect the views of the European Commission*

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1. Executive Summary :

WP01-Dissemination and Outreach is in charge of disseminating the information, technical results and scientific work progress of the Network of Excellence, both within the consortium and also with external parties involved in the area of optical networking with the objective of facilitating the smooth integration and spreading of excellence.

As mentioned in the first year report (D01.2), the high level of technical excellence of each partner in the consortium, together with the strong collaborating framework that was built during the first year of activities enables WP01 to focus on and support methods for the dissemination of their research, which in turn promotes integration.

The variety of topics covered by the various workpackages make this an interesting and challenging task to accomplish, but the strong interaction that has been established within the consortium, that comprises a community of its own, assists greatly in the dissemination of knowledge across the consortium. The framework that has been built during the first year of the project (task forces etc) has been specially effective. Hence dissemination activities within the consortium are increasingly important due to the increasing technical impact that has taken place during the second year of the project. In particular activities like the Roadmap exercise have gained the interest of different partners, helping to create a consensus on the BONE vision of optical networks on the one hand, while creating a platform to integrate the technical work that takes place in BONE on the other.

As far as external parties are concerned these mainly comprise: a) European institutes outside the consortium where it is felt that contact should be established, b) industry in the area of optical communications where ties for mutual interactions are being established, c) international institutes, d) other IST and ICT projects with similar or complementary scope, and e) outreach to younger generations of pupils/students to raise awareness of optical networking. Special effort has been made in the second year of the project for the younger generations through the successful accomplishment of one of the main deliverables this year: the school event.

In the second year of the project dissemination activities were mainly focused on dissemination and spreading of excellence, reaching out to pupils, and creating a first draft of the roadmap. This mainly comprised activities such as support of workshops and events, interaction with industry, implementation of the BONE roadmap and school event, together with all the typical dissemination events (online dissemination, workshop organisation etc) that are reported in this document.

In the last year greater focus will be given to disseminating the roadmap, repeating the school event in other partner's premises and interacting with external parties to disseminate research results. Emphasis will be given in disseminating the research results to as wide an audience as possible.

1. Introduction

The main core of the BONE NoE activities aims to support the general framework of the project. Specifically three WPs are dedicated to coordinating these activities namely:

- WP01: Dissemination & Outreach
- WP02: Teaching
- WP03: Electronic Communication Aid

In this report the disseminating activities that took place with the support of WP01 are reported and described. The objectives of WP01 activities during the project are the following:

- To disseminate information concerning the expertise, research and integration activities of the Network of Excellence and spread excellence to other European researchers and their institutions.
- To reach out to the European communities and young researchers and explain the purpose and challenges of optical networking and how the Network of Excellence can support local initiatives in this area.
- To facilitate the integration of a strong collaborative institution framework, to allow expert groups to effectively collaborate within the Network on key topics.
- To extend the roadmap [commenced in e-Photon/ONe] into a focused view (roadmap) of the evolution of photonic networks [within Europe] for telecom and non-telecom applications; and bench mark European research activities against international programmes.

2. Dissemination Activities

Dissemination activities in BONE include a variety of events to help the NoE better establish a collaborative framework while disseminating the results outside the consortium.

The events are separated into three categories

- Workshops and Conferences
- Dissemination Material
- Online Dissemination

2.1 Workshops and Conferences

Dissemination & Outreach is closely linked to those public events where BONE partners are present. In these events partners generally not only discuss their work and/or represent their institution but also present:

- the BONE project and how a NoE fosters research,
- the opportunities BONE offers to partners,
- the topics jointly studied by BONE members,
- the BONE view on future ICT.

Support of events is structured into 4 levels:

1. **announced:** insertion in a public calendar on the BONE webpage (if especially requested allowance to use LOGO)
2. **supported:** As in (1) above plus general permission to use LOGO on webpage, handouts, etc. stating 'supported by BONE'. They may also host a BONE organised public workshop in the event's program and recommendations may be made to WP-leaders to co-locate WP-meetings (increase the number of potential attendees by making partners to be at the same place at the same time) with the event.
3. **co-organised:** As in (2) above plus BONE partners are strongly involved in the formation, technical content and added value of the event including (a) running a booth, (b) dissemination of material (flyers etc), and (c) presentation of the BONE project (the NoE project as a whole)
4. **sponsored:** public event with direct financial support from BONE budget, i.e., BONE schools organised under WP02

Hence WP01 supports and promotes events and conferences in the area of optical communications and optical networking.

During the first months of each project year Gerald Franzl (TUW) sends out an email in the BONE list and collates a list of planned events (workshops and conferences) that will seek endorsement from ICT BONE and informs the possible organizers about the procedures. Gerald Franzl (TUW) coordinated discussions on the level of endorsement together with the description and related documents. The different levels of endorsement are listed below. In the duration of the year other event organizers (possibly outside BONE) that wish to have a specific workshop/conference supported by BONE should contact the Advisory Board who makes a decision based on their knowledge and submitted information on the event. This is to ensure the quality of the event and its added value both to the event and the consortium.

Advertised events: These are events that WP01 considers interesting for the partners and have a scope similar to the scope of the project, and hence are advertised on the website and newsletter. They are marked on the public calendar of the BONE website.

Supported Events: These are conferences and events that the NoE has supported with active participation by either contributing a large number of papers or/and by organizing a workshop in conjunction with the event etc. This level of support may also include recommendation to WP-leaders to co-locate WP-meetings. These activities aim at increasing the number of potential attendees by organising BONE partners meet at the same place/time. Organizers may use the NoE logo but have to provide a report on the event (size, program, feedback, etc.).

Co-organised Events: These are workshops/events co-organised by BONE WPs. BONE partners are strongly involved in the formation, technical content and added value of these events that might be (a) workshops (b) running a booth, (b) dissemination of material (flyers etc), and presentation of the BONE project. The organizer must have the NoE logo on their website and provide a report on the event, highlighting the NoE contribution and added value.

Sponsored Events: These are stand alone public events organized by BONE with direct financial support from BONE budget, i.e., Schools event that was organised by Uessex thie last year..

2.2 Advertised events

A number of events were advertised either by email, by posting on the website (Online Calendar) or in the Newsletter. It is noted here that on different occasions WP leaders send emails to disseminate events that are related to their WP and associated activities. Some of the events that were advertised through the BONE website are shown below

- 10th International Conference on Telecommunications (ConTEL 2009)
  08/06/2009 - 10/06/2009, Zagreb, Croatia
- 14th European Conference on Networks and Optical Communications (NOC 2009)
  09/06/2009 - 12/06/2009, Valladolid, SPAIN
- ICT-MobileSummit 2009
  10/06/2009 - 12/06/2009, Santander, Spain
- IEEE International Conference on Communications (ICC 2009)
  14/06/2009 - 18/06/2009, Dresden, Germany
- CLEO®/Europe-EQEC 2009
  14/06/2009 - 19/06/2009, Munich, GERMANY
- EuroFOS Summer School 2009
  08/07/2009 - 10/07/2009, AIT, Athens, Greece
- IEEE LEOS Summer Topicals 2009
  20/07/2009 - 22/07/2009, NewPort Beach, California, USA
- SIGCOMM 2009
  17/08/2009 - 21/08/2009, Barcelona, Spain

- IEEE Hot Interconnects

  25/08/2009 - 27/08/2009, New York, USA
- Third International ICST Conference on Networks for Grid Applications

  07/09/2009 - 09/09/2009, AIT, Athens, Greece
- Sixth International Conference on Broadband Communications, Networks, and Systems (BROADNETS 2009)

  14/09/2009 - 17/09/2009, Madrid, SPAIN
- 21st International Teletraffic Congress (ITC 21)

  15/09/2009 - 21/09/2009, Paris, France
- ICO PHOTONICS DELPHI2009

  07/10/2009 - 09/10/2009, Delphi, Greece
- IEEE International Topical Meeting on Microwave photonics (MWP 2009)

  14/10/2009 - 16/10/2009, Valencia, Spain
- IEEE GLOBAL COMMUNICATIONS CONFERENCE (IEEE GLOBECOM 2009)

  30/11/2009 - 04/12/2009, Honolulu, Hawaii, USA
- 3rd International IEEE Symposium on Advanced Networks and Telecommunication Systems (ANTS)

  14/12/2009 - 16/12/2009, New Delhi, INDIA

These events either involve a number of partners in the TPCs or are considered important for part of the BONE network.

2.3 Supported events

These are events whose scope matches that of BONE. Other than OFC, ECOC and ICT in all other cases one of the organizers should specifically ask for permission from WP01. In this case the conference organizer should contact WP01 leaders with the case for support (focus of the conference, etc). This is forwarded to the advisory board as standard procedure for approval. If approved the conference is advertised on the BONE Calendar as a BONE supported event and announcements are regularly updated on the website together with newsletters. The logo of BONE can then be used by the conference (website advertisements etc) If not approved the conference can still be advertised.

Supported Events in 2009 include:

Title: ICTON 2009 – International Conference on Transparent Optical Networks

Date: 28 June 2009 to 2 of July of 2009

Venue: San Miguel Island, Azores, Portugal

Number of participants: 430

Organiser/Authors:

(From BONE) General conference Chair: António Teixeira

BONE-SARDANA sessions I..V

Josep Prat, Jose Lazaro (UPC)

Peter Van Deale (IBBT)

General Description:

ICTON was, in the 2009 edition, in its 11th successful realization and still is increasing participation and attraction from scientific community. Its structure is based on a set of different thematic workshops and meetings. The topics are , Digital All-Optical Networks, Ultra-dense Wavelength-Division Multiplexing, Ultra-fast Optical Time Domain Multiplexing, Next Generation Networking, Optical switching & routing (WAOR), Optical Packet Networks & Services, Optical memories and data storage, Quality of Service issues, Optical transparency & network scalability, Network reliability & availability (RONEXT), Wireless & Optical Networking (GOWN), Radio-over-fibre transmission, Analogue transmission systems, Broadband metro and access networks, Industry and Standardisation, Photonic Band-Gap structures (ESPC), Photonic crystal fibres, Nonlinear & active PBG devices, Nanoscale & ultrafast photonics (NAON), VCSELs and other novel light sources, Microresonators & Photonic Molecules, New fibre types, Plastic fibres, Novel glasses, New transmission windows, Polarisation Mode Dispersion, Photonic component integration (PICAW), Modelling of optical systems and components, Network planning and design tools, Non-conventional optical communications, Other relevant topics.

The conference was a great success having the record attendance since its existence. Due to this, it was also support for many parallel meetings of several projects and discussions.

Description of BONE participation and added value:

The involvement of the projects BONE and SARDANA was designed to bring together the common thematic issues related to both projects and gather a set of presentations which could help driving the inner research lines as well as see it faced with concurrent solutions and ideas in an open forum. BONE and SARDANA have gathered high attention and had a dedicated set of five sessions of one and a half hour each, with a total of 21 papers (14 invited papers on 7 contributed). The added value for the conference is clear (high interest and participation was raised) and to BONE and SARDANA the interaction with scientist of other fields, projects and activities was very visible.

Title: ONDM 2009- 12th International Conference on Optical Networking Design and Modelling

Date: February 18-20, 2009

Venue: Institut für Datentechnik und Kommunikationsnetze (IDA)
Technische Universität Carolo-Wilhelmina zu Braunschweig
Hans-Sommer-Straße 66
38106 Braunschweig
Germany

General Description:

As it is established practice at ONDM, the 13th installment will focus on cutting-edge, state-of-the-art research in optical networking and newly emerging areas. ONDM also encouraged submissions of the research papers that relate the topics of optical networking to the other areas and disciplines, such as integration of optical and wireless networks or the role of optical network for the future Internet design. Controversial ideas and approaches and their open discussion are strongly encouraged. Moreover, ONDM in Braunschweig will contribute to the community strengthening by inciting interactivity among the senior and junior participants as well as among the industrial and academic participants, in Europe and internationally.

Based on the peer review, the conference will select a Best Paper Award. In addition, authors of selected papers will be invited to submit an extended version of their papers to a special issue of the Optical Switching and Networking journal edited by Elsevier.

Description of BONE participation and added value:

The involvement of the project BONE among other projects that sponsored the event is great through the involvement in the TPC and with regular papers. A special fee was arranged for ICT BONE in order to enhance the partcipation of BONE partners and ensure the dissemination of BONE technical results. The added value for the conference is clear (high interest and participation was raised) as BONE activities were very visible in such an important conference.

Title: Photonics in Switching (PS) 2009

Date: September 15-19, 2009

Venue: Grand Hotel Continental, Tirrenia, Pisa - Italy

Organiser/Authors: SSSUP, Italy

General Description:
Photonics in Switching is a historic conference on optical switching created at the end of the 1980s. Since then, it has represented a valuable forum for the international academic community, manufacturing companies and operators representatives to share technical achievements, ideas and views on the evolution of the application of photonics to the domain of switching.

There is a steady increase in the demand for bandwidth in all segments of telecom networks due to growing number of Internet users and corporate services. Optical networks and photonic technologies can be combined to realize access solutions and scalable transport infrastructures

capable of supporting high-capacity connections.

Photonics in switching addresses all research areas in which photonic technologies are applied to innovate and enhance switching capabilities of the future optical network infrastructures. This area includes integrated photonic devices, high-throughput all-optical nodes, large capacity optical systems, efficient optical network architectures. In particular, developing optical subsystems, optical processors and novel integrated circuit requires proper balancing of photonic and electronic technologies. Optical infrastructures will leverage the opportunities offered by photonics to answer the emerging needs of the next decades such as the realization of all-optical network elements, the reduction of network power consumption and device footprint by integration.

Description of BONE participation and added value:

Photonics in Switching has always been a conference of great value to the BONE consortium due to the very focused objective and the fact that many partners are involved with the specific topic. This year the conference is organized by one of BONE WP leaders and gained a lot of attention from the BONE partners.

2.4 Co-organised events

2.4.1 Workshops

Title: CONTEL 2009 – The 10th International Conference on Telecommunications: Special session on Optical Access

Date: 8 June 2009 to 10 of June of 2009

Venue: Zagreb, Croatia

Number of participants: 60

Organiser/Authors:

(From BONE) Giorgio M. Tosi Beleffi, Italian Ministry of Economic Development - Communication Department (MED), Rome, Italy, and Antonio Teixeira, IT, Aveiro, Portugal;

BONE-SARDANA SS IV- Optical Access

General Description:

Contel was, in the 2009 edition, in its 10th realization. Its structure is based on a set of different thematic workshops and meetings. The topics are among others: Next Generation Networks, Protocols and Services, All-optical networks, Broadband wireless LANs/MANs, Network convergence, Location-based services, Next generation Internet, Multimedia communication, Mobile multimedia, Networked virtual environments, Quality of experience, Mobile agents & multiagent systems, Web services and architectures, Telecom market , Communications Software

and Services, Service architectures, Communications systems software, Software engineering, Software testing and evaluation, Software design for mobile device, Formal methods, Tools, environments and testbeds, Multimedia applications, Information Infrastructure, e-Commerce & e-Government, Information society, Knowledge management, Security & privacy

Description of BONE participation and added value:

The involvement of the projects BONE and SARDANA was in promoting one of the 4 special sessions – Optical Access.

The purpose of the Special Session is to provide a forum for exchange and debate of the latest research topics and developments in optical access systems. Passive Technologies, Green applications, True-Broadband application and services are some of the key concepts that were addressed. The joint organization of this session by two European top level projects such as FP7 NoE BONE and FP7 STREP SARDANA represented an added value since it brought in their view on European broadband & future Internet. The program included 2 sessions and a total of 8 invited papers in the.

The return for BONE was, as in many conferences the discussions in the topics and also the visibility to all scientific communities which in this conference also stemmed from the upper layers.

Title: Energy Footprint of ICT: Forecast and Network Solutions

Date: March 22, 2009, 4:30-7:30 PM

Venue: OFC 2009 (San Diego, CA, USA)

Number of participants: about 50

Organiser/Authors: Patrich Leisching (NSN, Germany) and Mario Pickavet (IBBT-UGent)

General Description:

ICT provides many energy-saving solutions, but is also responsible for a considerable and quickly increasing energy footprint on its own. Recent surveys estimate that the complete life cycle of ICT equipment today is responsible for about 4% of the worldwide primary energy consumption. This percentage is expected to double within 10-15 years, if current ICT energy trends are not drastically deviated. Due to these forecasts, the awareness for ICT energy reducing research is rising steeply in the community.

This workshop provided insight in the main ICT energy consumption factors and their expected future evolution in telecommunication transport networks, highlighting access, metro and core networks and server farms. Possible research directions and future network paradigms were outlined, motivated and elaborated by expert speakers from industry and academia. Special attention was paid to the role of optics. A closing panel discussion reflected on similar or deviating approaches and identified the key research challenges and action points.

Description of BONE participation and added value:

The workshop was co-organised by BONE, together with an industrial partner to balance inputs from both academic and industrial background. Also several BONE partners were present in the audience. The topic of this workshop is right in the focus of BONE WP 21 on green optical networking, and yielded many interesting insights that were beneficial for the further development of this workpackage. Moreover, the workshop provided a significant exposure for the BONE project at the renowned OFC conference, one of the key dissemination goals of BONE WP 01. After the workshop, the slides of the workshop were made available to the public via the BONE website www.ict-bone.eu.

Title: The First International Workshop on Network Operation Cost Modeling - In conjunction with IEEE Globecom

Date: 4 December 2009

Venue: Honolulu, Hawaii

Number of participants: 9

Organiser/Authors:

Workshop Chairs

Carmen Mas Machuca Munich University of Technology (TUM), Munich, Germany
Monika Jaeger T-Systems, Berlin, Germany
Sofie Verbrugge IBBT - Ghent University, Ghent, Belgium
Koen Casier IBBT - Ghent University, Ghent, Belgium

General Description:

Description

As network Operational Expenditures (OpEx) have been identified as major factor of the Total Cost of the network Ownership (TCO), network operation cost modeling has increasingly attracted attention in recent years. This workshop aimed at gathering models of network processes and case studies in different states of the network life-cycle. Reducing OpEx involves a good knowledge of the processes to operate the network as well as the services. The study of OpEx has turned to be very challenging due to several reasons such as the lack of models, confidentiality of most of the data, time variance of the parameters, human factors, etc. This workshop aimed at gathering detailed models and data for the different network processes. This included templates or best-practice process descriptions and the associated input data, case study descriptions and results, discussion on methods and tools and the broader context in which this problem resides including the regulatory aspects.

Goal: The workshop aimed to bring together various actors in the world of Network Operational Cost Modeling. Based on discussions useful directions for future research in this field were formulated.

Description of BONE participation and added value:

The activities within BONE WP21 formed a good basis for discussion on the topics related to this workshop. They enabled the right goals for the workshop to be set.

Title: The 2009 International Workshop on Optical Burst/Packet Switching (WOBS 2009)

Date: 14-Sep-2009

Venue: Madrid, Spain

Number of participants: 30

Organiser/Authors: Dr. Reza Nejabati and Prof. Chunming Qiao

General Description:

Optical burst/packet switching (OBS/OPS) has been introduced to combine the advantages of both packet and circuit switching and is considered a promising technology for the next generation optical Internet. The success of OBS technology relies on its small control overhead for a large amount of payload data. Within this context, this workshop seeks to showcase the latest developments in OBS as for example in multi-cost burst scheduling, QoS burst routing, hybrid OBS switch architecture, application-aware OBS architecture, service oriented OBS architecture and OBS experimental test-beds. Since first being held in 2003, the Workshop on Optical Burst/Packet Switching (WOBS) has served as a premier forum for researchers from academia, industry and government to meet, exchange ideas, and discuss the technical and commercial challenges associated with burst-switched and packet-switched optical networks. Note that the OBS workshop is the specific OBS/OPS track in the BROADNETS 2009 conference and OBS/OPS papers should be submitted to the workshop. This workshop solicits original papers related to all aspects of optical burst switching and optical packet switching including but not limited to the following topics:

· OBS/OPS network architectures and technologies suitable for access, metro and core networks

· OBS/OPS and hybrid OCS/OBS/OPS/OTDM sub-systems architectures and technologies

· Application-aware, service-oriented and programmable OBS/OPS networking

· Signaling and control issues in networks supporting OBS technologies

· Burst/Packet scheduling algorithms

· Contention resolution, avoidance and bandwidth scheduling strategies

· QoS and traffic engineering in OBS/OPS networks

- OBS/OPS performance evaluation & modeling
- OBS/OPS experimental test-beds and demonstrators
- Cross Layer optimization in networks supporting OBS/OPS technologies
- Multicast / anycast routing in OBS/OPS

Description of BONE participation and added value:

The WORKSHOP was well attended with more than 50 participants presenting 14 papers. 50% of papers reported result of work, which fully or partially was supported by BONE. The highlight of the WORKSHOP was the strong participation from industry (i.e. operator and vendor). This opened opportunity for participants (from BONE) to disseminate their works and research direction in the area of OBS-OPS to relevant industry for potential future collaboration. Furthermore, there were strong presence from INDIA, CANDA and USA which provided further means of disseminating BONE achievements for finding common ground of collaboration between BONE partners and researchers outside of EU.

Title: European Workshop on photonic solutions for wireless, access, and in-house networks – IPHOBAC

Date: May 18-20, 2009

Venue: inHaus-Zentrum, Forsthausweg 1, 47057 Duisburg, Germany

Number of participants: (estimate) : 70

Programme committee is made up by:

- Jean-Pierre Vilcot
- Mikhail Popov
- Claus Popp Larsen\
- Peter Van Daele
- Michael O Mahony
- Paulo Monteiro
- Nathan Gomes
- André Scavennec
- Urban Westergren
- Josep Prat
- Beatrice Cabon
- Jean-Philippe Javaudin
- Joachim Walewski
- Isabelle Siaud
- Moshe Ran
- Yosef Benezra
- Efstratios Kehayas

General Description:

The aim of the workshop was to provide an overview on actual research activities in Europe in the area of photonic communications (wireline and wireless for access and in-house), to foster European cooperation in that areas and to provide a forum for discussing about future activities at a European level. Technical demonstrations were be organised during the workshop as well as laboratory visits.

The workshop was organised by the following European projects: ALPHA, BONE, euroFOS, FUTON, GIBON, HECTO, IPHOBAC, ISIS, OMEGA, and UROOF. The workshop was also open to participants who are not members of the above mentioned projects.

The workshop was co-organised by IEMN (project coordinator for IPHOBAC) and the University of Duisburg and was supported by OpTechNet and Fraunhofer Geselschaft. It has received also the endorsement of BONE.

Description of BONE participation and added value:

Several BONE members participated at teh workshop and both Peter Van Daele (as BONE project coordinator) and Mike O'Mahony (as WP-leader for WP01 Dissemination) participated in the programme committee.

All projects, including BONE had a project presentation, but participated also in the presentation of contributed papers. The added value for BONE comes from the interaction with other projects working in the fields described in the workshop programme and which interact with BONE., BONE as an NoE does not have the funding and means available for supporting in-depth scientific research, but supports the interaction amongst projects, partners and dissemination activities. BONE-partners had the opportunity at this workshop to interact with colleagues in other projects.

Other projects also learned about BONE and how BONE assist in dissemination and networking.

Title: IEEE High Performance Switching and Routing Workshop (HPSR 2009)

Date: June 22 - 24,2009

Venue: TELECOM ParisTech

General co-Chair/ Authors: Maurice Gagnaire, Telecom ParisTech (ENST), Paris, France

The High Speed Switching and Routing (HPSR) workshop has its roots in the ATM workshop first convened in 1995 in Washington-DC, USA. Subsequent workshops were held in 1996 in San Francisco-CA, USA; 1997 in Lisboa, Portugal; 1998 in Fairfax-VA, USA; 1999 in Kochi, Japan; 2000 in Heidelberg, Germany. The current name HPSR was adopted for subsequent workshops to reflect specifically the focus on the topics of switching and routing. HPER 2001 was held in Dallas-TX, USA; 2002 in Kobe, Japan; 2003 in Torino, Italy; 2004 in Phoenix-AZ, USA; 2005 in Hong-Kong; 2006 in Poznan, Poland; 2007 in New-York-NY, USA; 2008 in Shangai, China.

HPSR 2009 brings together researchers on the forefront topics of switching and routing with associated topics of architecture, performance evaluation, algorithms, traffic control, protection, multi-layer and multi-domain networking and security. We are witnessing important design aspects such as power usage, design efficiency, secure routing, and path

optimization. Presentations of the latest research results provide a unique opportunity at this workshop for discussions and exchange of ideas to further the knowledge base in this field.

2.4.2 Booths at exhibitions

Booths at exhibitions are highly appreciated as important dissemination events. The organization of these events is coordinated by UoPelop, UoEssex and KTH.

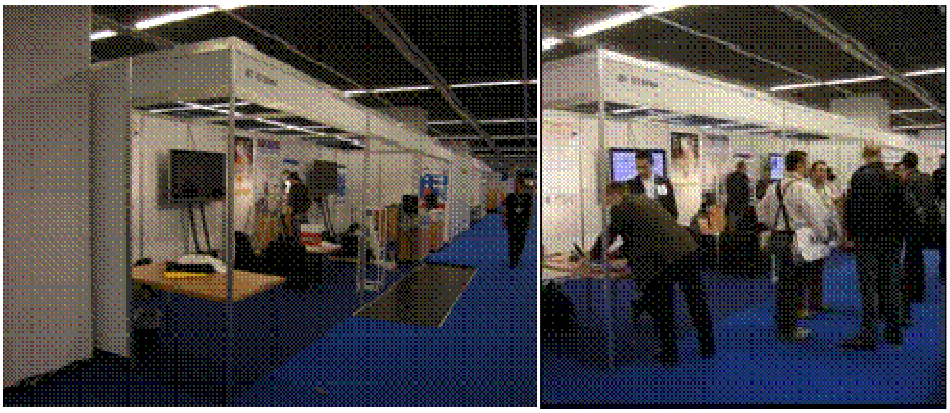
ECOC 2009

As every year ICT BONE had a booth at ECOC 2009. A very successful event took place in Vienna, Austria, on September 20–24; the largest conference on optical communication in Europe. Together with that the largest exhibition in the area of optical communications took place. Stand 267 of the ECOC exhibition was organized by ICT BONE and accommodated dissemination material and demos from different ICT projects. The stand displayed posters and rolling presentation about BONE activities and also posters and demonstrations from other associated European projects. A demonstration of POF-PLUS and of ALPHA projects was taking place at the stand. This year the booth was organized together with NoE Eurofos so the booths from both projects were set up side by side in order to maximize impact.

Specifically this year the booth had a special 'Gender Issues' corner were a poster and a video from the School's event that took place at University of Essex was displayed and Gender Issues questionnaires were distributed to the interested visitors and they were collected back.

The stand was visited by many exhibition visitors. Several other projects were represented with posters including some optical component projects like HECTO. Material and information (flyers etc) was also available from other projects.

C. Matrakidis from UoP, Gerald Franzl from TUW and Lena Wosinska from KTH, and other representatives from other projects attended the event and assisted with the BONE stand.



Pictures from ECOC 2009 booth

2.4.3 Presentations/Posters/Papers at events

Technical papers for all WP:

The large number of **321** papers (journals, magazines, book chapters) of which **134 are joint publications** and a number of accepted papers that will be presented in the next months show the extent of dissemination as all these papers present the acknowledgement to the project.

Tutorials and presentations:

Examples of tutorials/ presentation at events related to BONE and supported by dissemination activities are as follows:

- Presentation by UC3M and dissemination of BONE research activities on optical multicast in the workshop of the national thematic network on multilayer optical networks 23-24 February at UPC.
- David Larrabeiti (UC3M) gave a presentation of BONE activities in a seminar of the Photonics Networking Research Laboratory (PNRL) of Stanford University.
- K.Heggarty (GET Institut Telecom/Telecom Bretagne) was invited to give a presentation by to a Spanish national conference on internationalisation of university education at the Universidad Rovira i Virgili on 12/11/09. Presentation was based on BONE WP02 experience.
- AIT presented an invited presentation in European Workshop on photonic solutions for wireless, access and in-house networks (18-20 May 2009). In this presentation the current activities of BONE WP23 (which AIT is leading it) were presented. AIT also presented the activities of WP26 in the latest plenary in Bologna (8-9 June 2009).
- Fabio Neri (POLITO) presented an invited paper on optical technologies and energy efficiency at ECOC 2009
- Fabio Neri (POLITO) conducted a plenary talk in the 4th International Workshop on OPS & OCDMA (IWOO 2009) in Japan, in November 2009.
- Piero Castoldi (SSSUP) participated to "International Workshop on the Cloud/Grid/Utility Computing over Optical Networks" and he gave the talk "Challenges for enabling Cloud Computing over optical networks" disseminating some results of WP12. The website of the workshop is: http://www.cse.buffalo.edu/Cloud/
- UNIBO made a presentation of the research activities of UNIBO within BONE at Cisco System Photonics in Milan (ITALY).
- **AGH** presented a paper describing BONE project during biggest telecommunication event in Poland: National Telecommunications Conference, KSTiT, "Projekt NoE BONE – postęp prac w tematyce nowoczesnych sieci optycznych"; ("BONE project - the advances in the modern optical networks"), Warsaw, 16-18 September 2009.
- **PUT** made a a presentation to secondary school students on Optical fiber networks.
- PUT made a presentation of the paper during Polish Telecommunication and Teleinformatics Symposium: G. Danilewicz, W. Kabacinski, R. Rajewski, "Nowa architektura pól komutacyjnych zbudowanych z niesymetrycznych komutatorów optycznych", KSTiK, Warsaw, Sep. 2009.

- Peter Van Daele – IBBT represented BONE at FP7 Concertation Meetings and gave Presentation of BONE at various occasions.

In some international events dissemination took place through display of ICT BONE dissemination material.

APOC 2009 (Hangzhou, China): An ICT BONE poster was displayed at APOC 2009 by L. Wosinska- KTH near the entrance of the conference.

An ICT BONE poster was also at the Summers School and Master School in Poland

2.5 Sponsored Events:

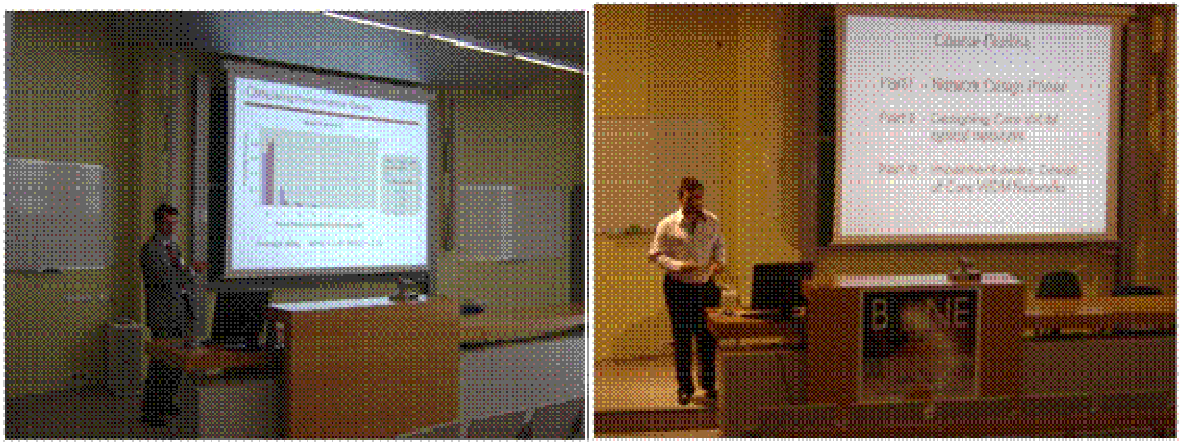
Master School and Summer School

The BONE Summer School 2009 and Master School 2009, hosted by the AGH-UST, took place in the last days of September in Krakow. Specifically, the Summer School takes place 28th - 29th September and the Master School 30st September - 2nd October. The topics were:

Advances in Core Networks for the Summer School

Optical Core Networks - Selected Areas for the Master School

In addition to the lectures prepared by the invited speakers, the students were also offered the possibility to share the results of their research. The events was highly attended by different partners, 64 people coming from 17 partners from 9 different countries were involved in the events. The photos below were taken during the events.



Pictures from BONE Summer School 2009

Pictures from BONE Summer School 2009

School public event

The BONE Schools event was the major BONE sponsored event and a special section is dedicated to this deliverable together – together with the major deliverable D01.3.

2.6 Participation to TPCs and special issues

Another way of disseminating the high quality work that is being carried out at ICT BONE and ensuring excellence is through participation of the partners in Technical Programme Committees (TPCs) of important events and conferences.

Fabio Neri (PoliTo) is the general chair of ECOC 2010 and member of the ECOC Management Committee; also a large number of partners are involved in the associated TPCs. Other events that involve the strong commitment of BONE partners are ONDM, OFC, ICC and Globecom etc that are considered high profile events for the optical networks community.

Involvement in special issues of Journals, with direct mentioning of BONE, is also regarded as an excellent means of spreading knowledge about the project. Examples are:

Maurice Gagnaire (IT/Telecom Paristech) and Dimitra Simonidou (U-ESSEX) are co-chairing a special issue of the Annals of Telecoms published by Springer dedicated to Cloud/Grid networking. The title of this special issue is "Grid/Cloud/Utility Computing: research initiatives, applications and standardization". The reviewing process is under way. and selection of the accepted papers has started.

POLITO has carried out several editorial activities and particularly for the Elsevier Journal on Optical Switching and Networking.

2.7 Dissemination Material

In order to disseminate the integration activities of BONE a variety of dissemination material was developed in the first year of the project, and it was updated and enriched in the second year of the project and these activities are coordinated by UoEssex.

Also a new activity has started during the second year of the project, coordinated by A. Tzanakaki (AIT)) in the form of the preparation of a travelling presentation on BONE. This presentation is aiming at providing a high level introduction of the thematic areas and topics that BONE is dealing with together with a description of the specific activities and output that are produced in the framework of the project.

2.7.1 Posters, presentations and flyers

Two kinds of presentations were developed to be used on different occasions.

In the first a description of the different workpackages and the work that is carried out therein was collated. This presentation is updated every year with new results and input from WPs. WP01 coordinated the collection of the slide show that aimed initially to be presented at exhibition booths (see ECOC 2009) for the visitor that is interested in the technical details of the project. The material in this presentation is used for reference on different occasions.

The second presentation is focused on the integration activities within the project and is updated with recent data on integration activities (like mobility actions, joint papers etc). It is also aimed at being used as a stand alone rolling presentation at events where the project wishes to show a presence.

Two kinds of posters were developed in the same philosophy as above in order to capture the eye of visitors at exhibition booths. The first is simpler and portrays BONE as a network of research centres and a platform for collaboration. It was presented at ECOC 2009 (to capture the attention of the passer by) together with the detailed technical rolling presentation for the interested conference attendees. This poster has been displayed at different conferences that are sponsored by BONE and also at Summer Schools and BONE plenary meeting.

The second was created during the first year of the project. In the scond year a third poster was developed that highlights the Schools event that took place in Uessex.

A flyer following the guidelines of the first poster was developed and distributed at booths and events and also by partners.

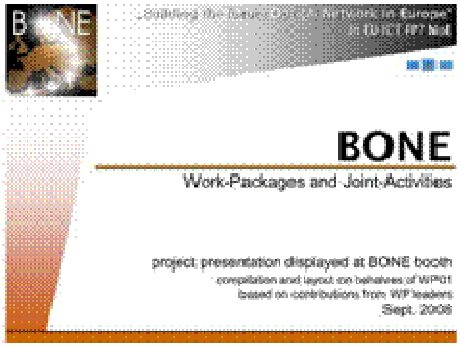
BONE poster 1

BONE poster 2

BONE poster 3

BONE Flyer can also be found *here*

BONE rolling presentation



BONE information presentation

2.7.2 Travelling presentation

As mentioned above the travelling presentation aims at setting the framework of activities supported within BONE offering a high level description of the project thematic areas and topics. In addition and more importantly, this presentation will provide information on the various activities carried out within the framework of the project and the relevant output and results produced.

The presentation includes a general introduction on Optical Networking sketching the project theme and then focuses on the specific activities carried out within BONE organized in the form of Virtual Centres corresponding to the project WPs. The first version of this presentation has been based on the BONE presentation prepared to be used at the exhibition booths (ECOC 2009).

In this context, the topics around which the presentation is organized are the following:

- Network Technologies and Engineering (WP11)
- Services and Applications (WP12)
- Access Networks (WP13)
- Optical Switching Systems (WP14)
- Transmission techniques (WP15)
- In-building Networks (WP16)

A list and some information on the joint activities between BONE partners in the context of the corresponding WPs will be also provided.

2.8 Online Dissemination

WP01 (and specifically TUW and UoPelop) is responsible for the update of the public part of the ICT BONE electronic platform and ICT BONE website with respect to events and Calendar. This activity is coordinated with the endorsement of the events and the Newsletter.

WP01 (UoPelop) is also responsible for the definition of the layout, the collection of information the write up and the distribution of a bi-monthly Newsletter.

In the figure the first page of one of the newsletters is shown. Nine volumes have been distributed to the BONE-news@mail.tlc.polito.it mailing list. This mailing list is designated for distribution of news and newsletter.

Newsletters are also uploaded on the public part of the website: http://www.ict-bone.eu/portal/landing_pages/bone_newsletter.html


ICT BONE Newsletter

NEWS ROUNDUP

ICT BONE Newsletter: past and upcoming activities

Xmas Wishes

ICT BONE News

Past Events

FIA Contribution /Trust & Identity Session

Upcoming Events

BONE December 2008 newsletter

3. Public Event (see also D01.3)

The Technical Annex states that "a high level public lecture will be organised which will address the general public and schoolchildren to explain the role of optics in telecommunications with the aim of promoting understanding and enthusing teenagers to think about a career in telecommunication. Specifically this will be done by designing a day event that combines explanations with simple demonstrations; then the event format [together with material used] would be available for other partners to stage in the local language at an appropriate venue of their choice".

To organise the event several conference calls and meetings were held as necessary. A group of interested partners committed to participate in the event was established: Mike O'Mahony (UoEssex) led the activity, together with B. Mikac (TelFer), F. Neri (Polito), T.Politi (UoP), P. Van Daele (IBBT), A. Tzanakaki (AIT) and L. Wosinska (KTH). A WP01 meeting in Athens was organised to address key issues, for example age group of the children, structure of the event, content etc. Following this, M. O'Mahony (UoEssex) coordinated discussions with a local girls school [close to the University of Essex where the event would be held] to understand the schools view of how such an event might best be organized and to try and ensure that the proposed content fitted with the schools curriculum and syllabus. Similar discussions were held by B. Mikac (Telfer). In this way a rough outline of the event was agreed as follows.

1) The event would focus on 14/15 yr female students [it is a girls school]. Attending numbers would be 120 children (all studying physics) plus adults (15). From a schools perspective it would need to be a full day visit [9:30 am-3 pm].

2) The agreed programme would involve a 2 hr core lecture [Telecommunications using Light] in the morning, followed by lunch, then three afternoon events, namely (a) a quiz , with questions based on the morning lecture (b) video links to other partners in France, Greece & Croatia so the girls had a chance to understand about European collaborations and (c) a presentation about the University and its research.

The actual event was held on the 1st July, with a total audience of about 125; 110 girls + 15 adults and it was judged a very successful day. The main lecture [Telecommunications using Light] comprised a 2 hr presentation (with break) followed by 30 min Q&A session. The talk was interspersed with a number of demonstrations illustrating the applications of optical fibres to telecommunications, for example a basic transmission system was demonstrated [with girls helping] and a demonstration of how a broken fibre is repaired through fusion splicing. MEMs switching was also demonstrated through large scale models and also the real thing was shown through microscopes and cameras. The talk followed the history of telecommunications from early semaphore systems to modern day networks. This format fitted well with a video on semaphore systems developed by the University of Zagreb in conjunction with a local school.

The afternoon events went smoothly and the quiz was a great success; the girls were very competitive and I think this event was the highlight of their day.

A questionnaire was distributed by the school (and results presented in D01.3) and showed that generally it was a good day enjoyed by all (with quiz most popular). As the girls had only

studied optical fibres theoretically, the experimental flavour of the day was greatly enjoyed (very much so by the accompanying teachers).

The events of the day were recorded on video and through stills and available if requested; the slide material is also available. Deliverable D01.3 [Staging the Public Event] gives a more complete discussion on the days activities.

Pictures from the Schools Event

4. Roadmap

The term “roadmap” describes a generic direction for technology development or usage. However, a standard definition of technology roadmapping does not exist, and a survey on technology roadmaps that have been created indicates that there is considerable diversity as to what constitutes a roadmap. In its broadest context, a technology roadmap provides a consensus view or vision of the future technological landscape for decision makers. The roadmapping process provides a way to identify, evaluate, and select strategic alternatives that can be used to achieve a desired technology or business objective. Robert Galvin[1], former Chairman of the Board of Directors for Motorola, offered this definition of roadmapping:

> "A 'roadmap' is an extended look at the future of a chosen field of inquiry composed from the collective knowledge and imagination of the brightest drivers of change in that field."

In e-Photon/ONe+ a Roadmap on Optical Communications has been developed and the objective of WP01 is to extend the Roadmap in order to understand the role of optical networking in the Network of the Future.

The aims of this specific Road Map are the following:

- To understand the situation in Europe as it is formed from the expertise and views of the BONE partners and representatives regarding the availability of specific network and IT technologies at different areas of Europe combined. This information will put together the idea of what is the situation today form the network/service access point of view what are the different capacity prospects in different parts of Europe.
- To gather an idea of how the network services and applications will evolve in the future and what requirements this may impose in the Network of the Future. This will be built upon the expertise of BONE WP leaders and will set out the desired requirements for the Network of the Future. For example we will investigate what may be the new video based services beyond high definition TV such as cinema services for example as they are a strong driver for network bandwidth together with the growth of established ‘narrow bandwidth’ services such as VOIP, messaging which are significant drivers for core bandwidth are because they are more ubiquitous and they result in less efficient use of transmission bandwidth. These future services will assist us set the requirements on the network.
- To extrapolate these requirements in order to understand how the network is required to be involved. For example as services must be delivered more efficiently, with assured quality and high security better and efficient ways to organise and deliver services may be required including more automation in the service provisioning processes. We will analyse the limits of today’s network as it stands and we will establish a picture for the Network of the Future. This procedure will be base upon the broad spectrum of views

[1] Science. Volume 280, Number 5365, Issue of 8 May 1998, p. 803

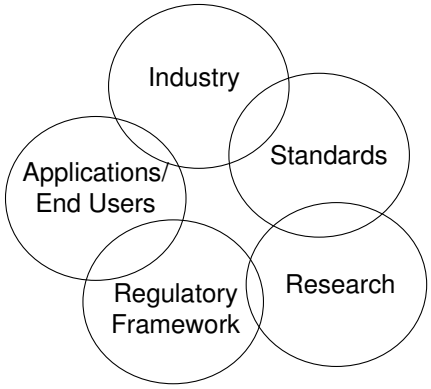
about the trends and directions in optical transport network technologies that was developed in the e-photon/One+ Roadmap.

- To investigate what is missing in research and development to cover this picture of the Network of the Future
- To set out the issues and solutions in a way that will provide options to those people who have the responsibility to develop and implement future networks the technologies and the required areas for further research activity.

The audience for the *Road Map* is those people are involved in the process of developing future commercial networks and technologies and who are concerned with prioritising further research activity. This includes booth people from industry and academia but also those with the responsibility to direct the future research programme (funding bodies).

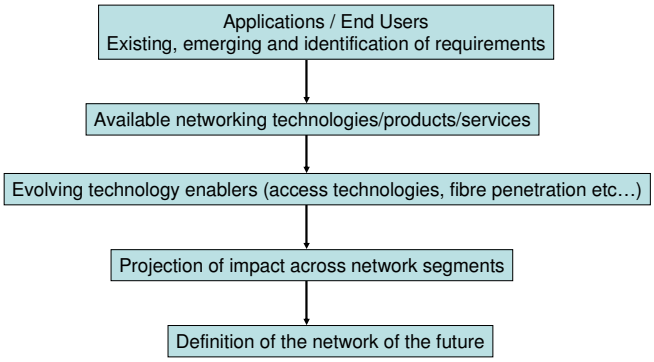
4.1 Methodology

For the roadmap a short methodology was developed by UoPelop, UEssex and AIT. The main idea is based on the figure below that illustrates the factors influencing the evolution of scientific sectors and their interrelation:



Networking Evolution Drivers

The roadmap methodology was developed in the first year of the project based on previous experience and a number of documents that can be found on the e-Documents area of the Roadmap subgroup. The methodology is described below:



Roadmap Methodology

To describe the effort of WP01 one can say that a description of the situation in networking as is today should be defined together with the 'momentum' that is gained from technology in order to chart an overall direction for Network of the Future, while identifying the missing elements for this procedure.

The first steps for the definition of the Roadmap are shown below:

1. **Collect data on existing/emerging services at European Level**

For the description of the Market pull- Technology push situation (as defined by the first three steps in the figure above) we needed to collect data on existing/emerging services in Europe and also collect data on access technologies in Europe. This meant that a taskforce was set up and at the Plenary meeting from a group of people with diverse backgrounds and nationalities. They put together a questionnaire (see Annex I) that was used to collect pilot information from BONE partners. The task force comprises the following group

John Mitchell (UCL), WP leader of the Access Technologies, is involved in order to assist with the definition of the picture of technology push situation.

Fabio Neri (PoliTo) is involved in order to assist as contact point for the Italian case study for the access network evolution.

Lena Wosinska (KTH) is involved in order to assist as contact point for the Sewdish model as a case study for the access network evolution

A. Tzanakaki (AIT) and T. Politi (UoPelop) were coordinating this effort with iterations of the questionnaire draft and also helped with the Greek case study etc.

Mike O'Mahony (UEssex) distributed the BREAD roadmap where a methodology was developed for a relevant issue. Also T. Politi (UoPelop) and Mike O'Mahony (UEssex) will build on the previously developed Roadmap.

2. **Collect data on access technologies in Europe Roadmap taskforce**

After the pilot questionnaire, a first version of the questionnaire was prepared and distributed to the Roadmap Taskforce and then to all partners (see Appendix). The data were processed so that the European situation on existing access network technologies and services was depicted.

3. **Process data to evaluate the impact on the Network**

From the first round of results, data were processed and a first version of the roadmap was released.

4. **Projection of impact on the various network segments.**

A workshop was organized within BONE during the plenary meeting in Poznan and the Roadmap was discussed. A second version of the questionnaire was released and more data was collected and processed.

5. **Build the converged image of the Network of the future**

A first release of the BONE vision of the Network of the Future is released and discussed separately with some WP leaders. The first draft of the Roadmap is collated in a long presentation that describes the vision and the summary is presented here.

6. **Evaluate key challenges to close the gap between the situation as is today and the Vision**

   Currently discussion is focused is evaluation of the key challenges with all WP leaders. Key challenges for all network segments and different network planes were discussed and collected. The summary is presented here.

The current version of the Roadmap is a living document that is being updated in the form of a PowerPoint presentation that comprises two parts. The first describes and extrapolates the situation in Europe for emerging services and access technologies. The second part presents the vision of the BONE NoE. The current version of this presentation is shown in Annex III and is uploaded on the BONE website.

4.2 Roadmap Data- Existing/Emerging services at European Level

The first part of the Roadmap concerns mainly the understanding of existing and Emerging Services at European level. In order to understand the key challenges for the Network of the Future, one has to extrapolate todays existing services and evaluate todays access technologies in order to examine whether they will be sufficient and to project their impact on the core Network of the future.

Through the questionnaire, filled in by the ICT BONE partners, data on existing and emerging, services and Access Technologies were collected from different countries in Europe. Some Examples are shown below:

Case Studies of Access Technologies in Europe

UK

- BT is currently deploying a GPON system to a 1,000 acre new build in Ebbsfleet, Kent. This will be approximately 10,000 homes and will offer speeds up to 100Mbit/s symmetrical. First customers were connected at the end of 2008.
- Virgin media (Cable operator) is upgrading its network to DOCSIS 3 and advertising 50Mbit/s “Fibre optic broadband” to the 9 million homes passed.
- H20 Networks has announced plans to building fibre to the home networks in in Bournemouth and Dundee using fibre layed in sewers.

Greece

- In the 99.5% of broadband access is xDSL and more specifically is only 27.1% >10Mb/s

Belgium

Technologies and market share (Belgium - Q2 2009)

The fixed broadband market in Belgium consists of DSL and Cable. There is no FTTH available in Belgium, only FTTC (FTTCabinet) or FTTN (FTTNode).

Using VDSL2+ (Belgacom), where the optical fiber is extended from the local exchange to a remote optical platform (ROP) located next to the street cabinet. From the ROP to the

customer, twisted pair copper is used, but in this way, the copper distance can be limited to ca. 300-500m.

Using HFC (Telenet), where the optical fiber reaches the optical nodes. From this point, a shared coax cable is used to connect the customer. The average distance between the optical node and customer is 1.5 km. Currently, Telenet is reducing the number of customers connected to one optical node from 1400 (2008) to 500 (by 2013).

Poland

Considering the broadband Internet offer, Poland occupies the very last positions in Europe. Moreover, in the West the term “broadband” is used usually in case of bandwidth from 1 Mbps , while European Commission (so also Poland) has not yet changed the definition and assumes the speed of 144 kbit/s and more as broadband Internet service.

Broadband access to Internet is offered by 13 operators (3 typical operators, 4 mobile and 6 cable TV operators).

Facts about broadband technologies (source , January 2009):

xDSL 58,16 %

Cable TV 21 %

Mobile modems 15%

LAN Ethernet 11,16 %

WiFi, HiS 1,68 %

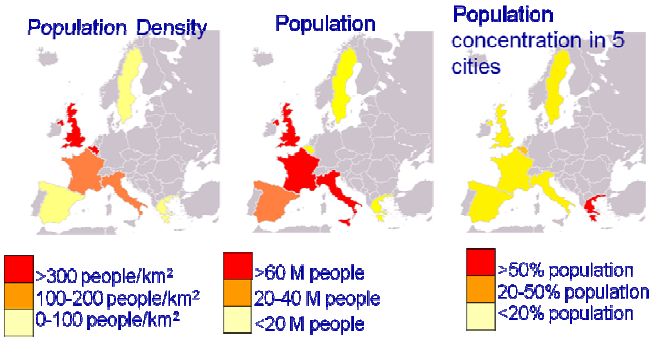
Leased lines 0,04 %

FTTx 0,03 % (* FTTx is point to point Ethernet)

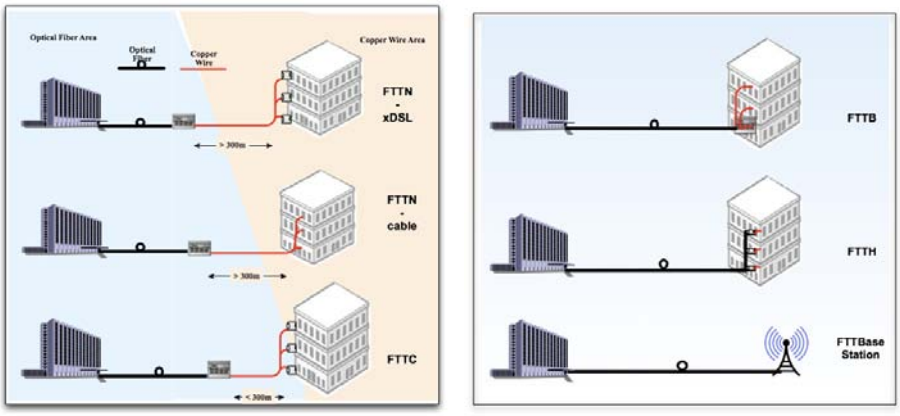
European Diversity in Demographics

In order to understand the impact that the different technologies and access rates would make to the core network one had to take under consideration the European diversity in demographics. European distribution of the population and population density will play a very important role in the deployment of different new services or technologies, as critical user mass has to be guaranteed for service providers and network operators to proceed with such new technology deployments.

In the BONE roadmap the European diversity was considered in the future prediction of service and technology deployment and also in the relative population percentage, as densely populated counties are most probable to take on new technologies in an accelerated way. Also densely populated areas even in countries that lack specific technology deployment will be more likely to be deploying some new services. The figure below illustrates the diversity in European demographics that is considered in the roadmap development.



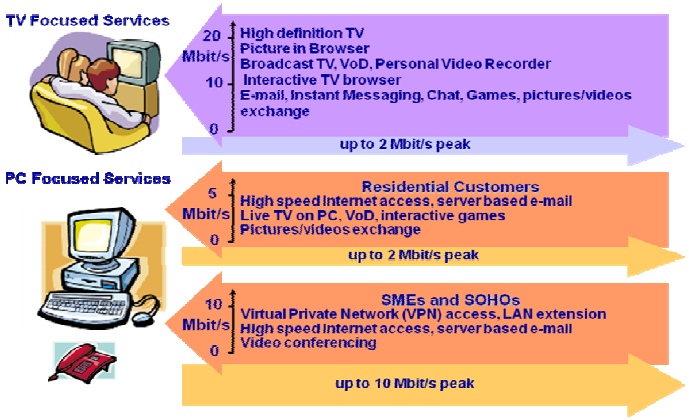
Today's access and service rates



The figure above illustrates all current Access technologies that are available in different percentages in the various European countries. Similarly the figure below shows some of today's emerging services across Europe, a wider deployment of which may dictate higher access rates in many European households, SOHOs and SMEs for both upstream and downstream traffic. In order to understand how these services may dictate higher Access rates one has to take under consideration that the same platform will be used for a variety of services like for example: It is expected that penetration of HDTV in Western Europe has reached 20%, compared to 36% in North America and that European penetration should reach from 75% to 100% by 2012. At the same time new services may emerge that will push this further such as considering that Super Hi-Vision service by the Japanese broadcasting corporation NHK will begin in 2025 hence similar developments are expected in Europe as well.

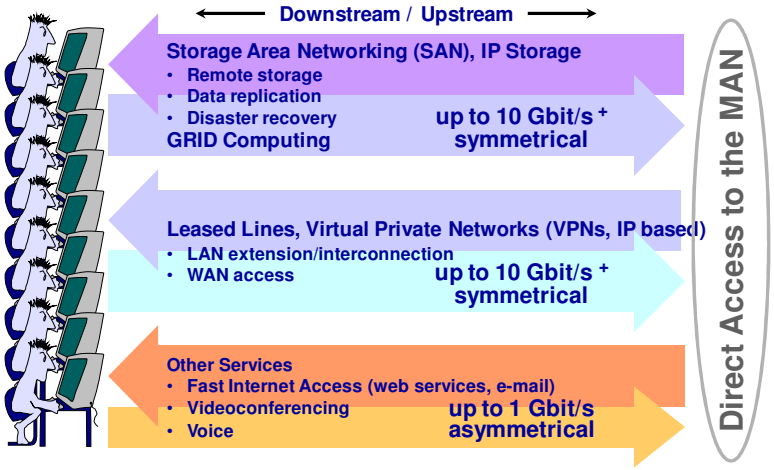
Again here different countries may have different rodamaps for the services and applications that are national plan targets. Digital Britain focuses on near-future applications like transportation control, energy/smart-grids, home-based telehealth, andeducation, as well as smoother high capacity to download music, video, and texts. The French ARCEP Annual Report notes similar target applications, adding the possibility that the relevant applications could be video-calls integrated into social networking or location-specific access to cultural content (such as in a museum). A current communiqué about intended stimulus investments also identifies as targets the development of Web 2.0 applications and "serious games": or

video-game-like experience software environments applied to more functional applications like health or language instruction[2].



Services & Bitrates for Residential Customers, SOHOs and SMEs

Today's Services & Bitrates for Large Enterprises



Services & Bitrates for Large Enterprises today that have a direct impact on the MAN

Similarly to the above the figure illustrates the different services for Large Enterprises and the bandwidth that they may require. There different services like for example SANs and GRID computing that impose strict requirements on the MAN and core network not only because of the high capacity that they may require but because of the levels of Quality fo Service that they may require.

2 http://www.fcc.gov/stage/pdf/Berkman_Center_Broadband_Study_13Oct09.pdf

Medium Term Access Requirements

Private and business customers make up two market segments for more and more data and therefore IP oriented telecommunications services with enormous potentials but quite different specific requirements.

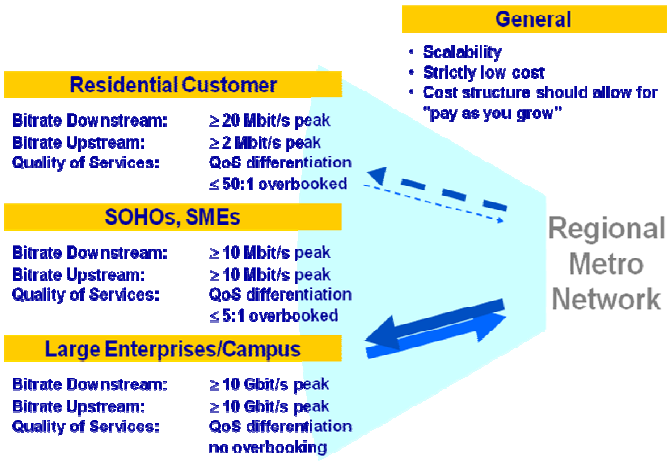
Attractive services for the private customer are very multimedia (video) oriented and require large and low cost transport capacities, which are for most of the customers strongly downstream emphasized. For most of the traffic best effort service quality is sufficient.

Business customers typically require quality oriented services defined by individual Service Level Agreements (SLAs).

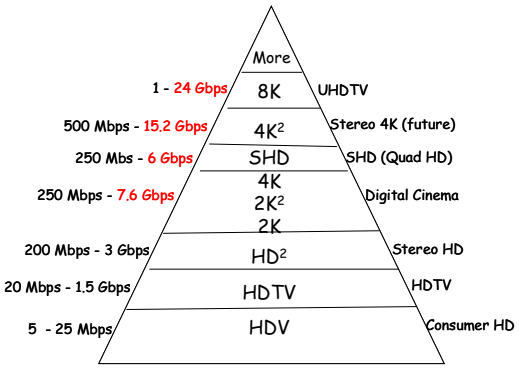
For both categories voice services play an important role and the tendency is clear, also the voice services are becoming more and more applications on top of the IP protocol. Transport of IP packages for advanced data services over Metro/Access network infrastructures, which are originally designed and optimized for voice services, finally led to low performance, high costs and small revenues.

Classical SONET/SDH Transport networks which are relatively marginally adapted for IP based services are not suited to improve sufficiently and sustainable the revenue situation. In order to meet the following general requirements new concepts optimized for IP based data services are necessary.

The way that these services are driving the access technologies in the medium term are shown below and this is expected to be the situation in the most densely populates areas in the medium term. Households will be provided with 20 Mbps peak downstream access but with low QoS with respect to large enterprises that will require 10 Gbps dedicated bandwidth.



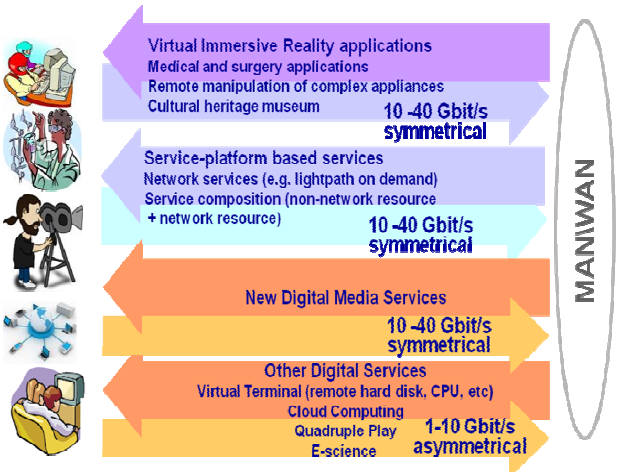
New Media Services



To gather an idea of how the network services and applications will evolve in the future and what requirements this may impose in the Network of the Future we investigate the different future applications. This built upon the expertise of BONE WP leaders and will set out the desired requirements for the Network of the Future. For example they are investigating what may be the new video based services beyond high definition TV such as cinema services for example as they are a strong driver for network bandwidth together with the growth of established 'narrow bandwidth' services such as VOIP, messaging which are significant drivers for core bandwidth are because they are more ubiquitous and they result in less efficient use of transmission bandwidth. These future services will assist us set the requirements on the network.

In the figure taken from D. Simeonidou (WP21- TP on Green Optical Networking) different digital media formats impose different requirements on the transmission rates. The pyramid shows how "popular" these applications will be. If the different formats are translated into transport bitrates , it is very interesting to see that although only few cases for example the transport of an 8K video requires huge amount of bandwidth as in most cases this should be tranferred uncompressed (in order to be processed etc). WP21 for example sees that these will be major applications. Other future Services and applications are discussed below.

Future Services & Bitrates for new Digital Services

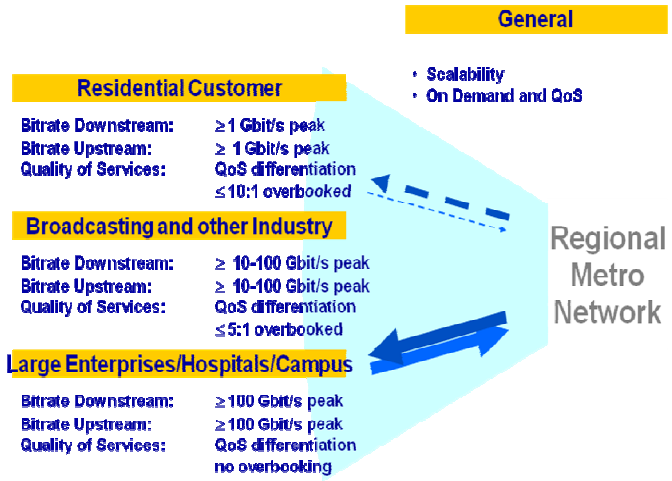


WP12 (VCE on Services and Applications) that's is the WP that works on new services and applications and contributed in enlisting the future services and the bitrates of these new

services, which combined with the access rates, will give us an idea of the users requirements. It becomes evident that private/household related services are becoming more bandwidth demanding and that large enterprises now comprise different industrial sectors from hospitals and campuses and museums to broadcasting industry.

Future Access Requirements

The figure of the access requirements in bandwidth per user is changed according to the above predictions and the results are shown below. The specific applications impose stringent criteria not only on the bandwith of the application but the quality of the service, service delivery time and the flexibility that they may require. All these will be discussed in the second part of the roadmap.



Evolution and Public Networking

In spite of our belief in shorter and shorter development cycles, evolution in public networking takes its time[3]. Based on these development cycles we have based our assumptions on the BONE roadmap of new access technologies and services. It takes:

- A 10 to 20 years period of time from Emerging (potentially disruptive) component technologies to broadly installed equipment (new system concepts and standards)
- A 5 to 10 years period of time is typical to get from lab prototype based on new technologies to broadly installed equipment.
- 2 to 5 years elapse typically from startup's first offerings to broadly installed equipment based on not traditional architectures and technologies.

Due to diversity in Access Technology deployment in the different countries of Europe and according to our survey we have assumed that countries in Europe have ***two speeds*** in FttX deployment per country:

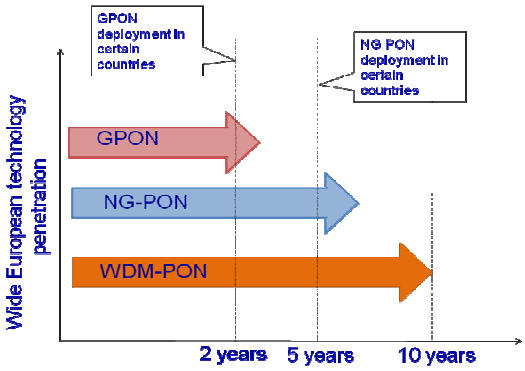
- 2 years → In *selection* of countries xPON technology and NGN services will be available in most urban areas (for 'fast' technology deployers)
- 2-5 years → In the rest of countries xPON technology will be available in densely populated urban areas (for 'slow' technology deployers)

[3] IST OPTIMIST Roadmap

- 5-10 years → differentiated NGN services will be available in most areas (urban & rural) (for 'fast' technology deployers)
- >10 years?- 100M/1G access services will be available in most areas (urban & rural)

The criteria which categorized the countries in Europe as 'fast' or 'slow' deployers are among others: the situation and technology deployment today according to survey, the population density and the business model applied for Fttx deployment (contribution of public funding is assumed to accelerate deployment) and the opinion of the ICT BONE partners that replied to our survey from each specific country.

The figure below illustrates the deployment of Access technologies in Europe as seen in BONE consortium.



The Impact of future access technologies in the Core Network

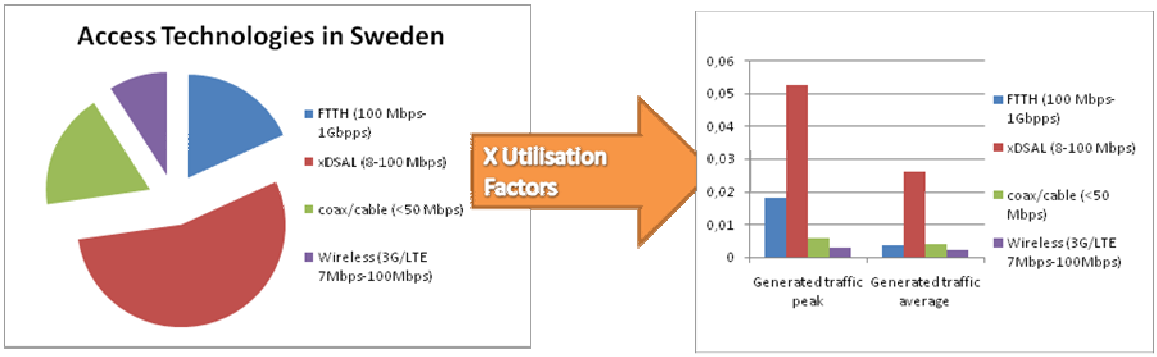
The target of this excercise is to project the traffic that will be generated in Future Network by the Eurpean access networks coming from households and SOHOs and understand the impact that this traffic may have on the core Notwork. Hence through this excercise we will understand the challenges that such an evolution of access techlogies may have on the Core Network.

The Swedish Case Study

We show below the Case Study of the Swedish Network, but we have done a similar extrapolation for all European Networks where information has been collected through the questionnaire. For the other European countries we have assummed that they follow the Broadband penetration behaviour of their region and we have made assumptions on the evolution of such services.

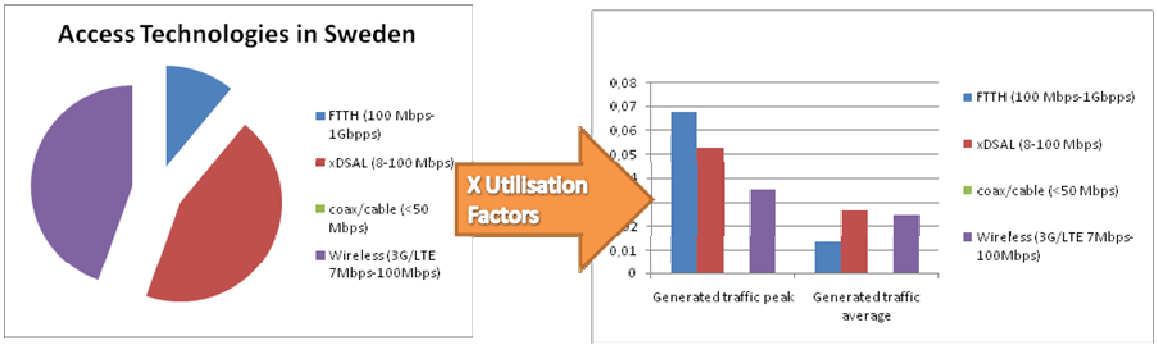
In all cases we combine the results on the Access technology that we have for each country with the demographics and we can make some assumptions on the size of the traffic in the national network. To achieve this we have to assume specific utilisation factors for all access users and we then calculate the average traffic in each national Network. We then assume that 10% of the traffic is conveyed in a Pan-European Network. Each country has one PoP in this Pan-European network and from these data we extract an actual Traffic Matrix on the Pan-European network. By extrapolating the future generated traffic from each country we get an idea about the growth of traffic that FttX deployment will bring about in the future.

Figures below illustrate the Sweden Case Study.



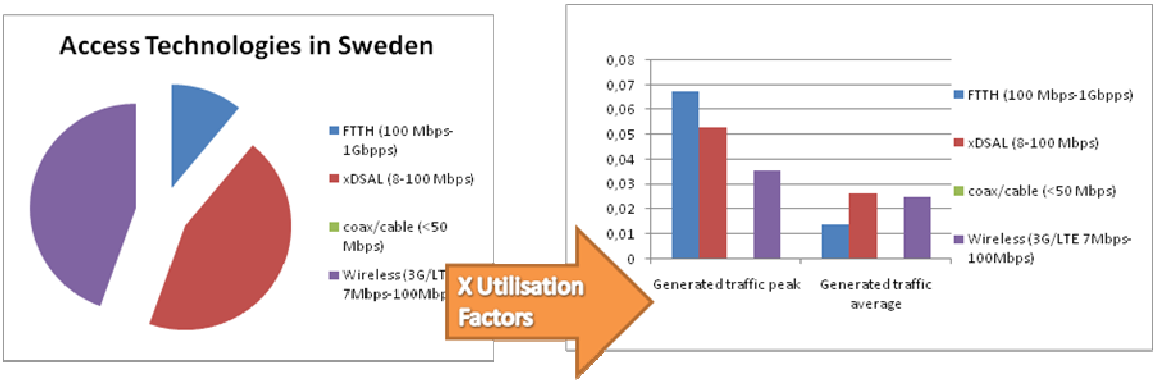
Access technology penetration in Sweden today translated into traffic volume (Tb/sec)

The average generated traffic from Sweden that is conveyed to the Pan-European Network is calculated to be of the order of 3.5 Tb/sec. By assuming that that all densely populated big cities in Sweden with be connected through FttH (GPON) in 2 years, as Sweden is assumed to be a fast technology deployer and with similar rationale as before the numbers become as shown in the figure below. The overall traffic that is conveyed from Sweden is now 5.6 Tb/sec



Access technology penetration in Sweden as expected to be in two years translated into traffic volume (Tb/sec)

By assuming that in 5 years time all densely populated big cities in Sweden will have access through FttH (but now through 10 Gbps PON/NGPON) the numbers change slightly (see below) but the overall amount of traffic that will be generated from the Swedish PoP to Europe will be 13.14 Tb/sec.

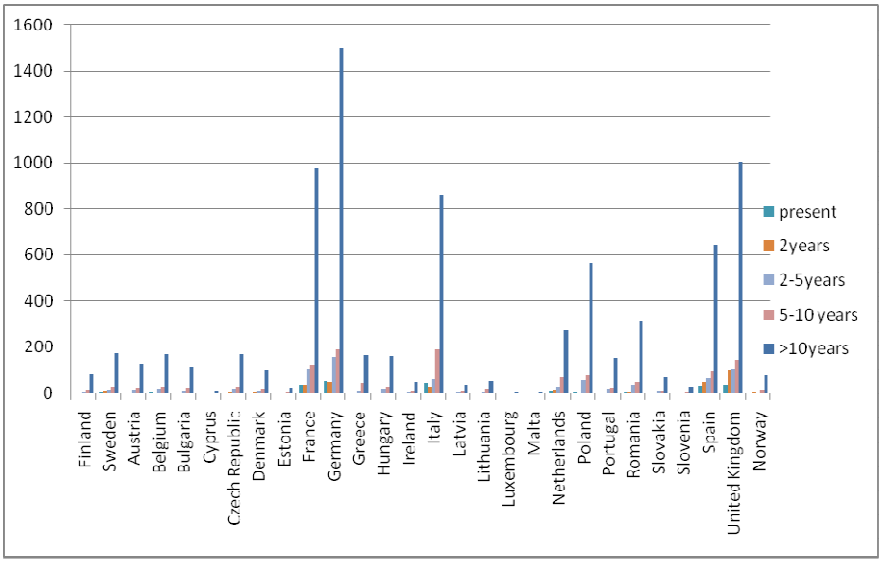


Access technology penetration in Sweden as expected to be in five years translated into traffic volume (Tb/sec)

The final assumption concerns an extreme case that is used here for reference, assuming that in more than 10 years time all Swedish inhabitants will have access to applications and services with a 1Gbps connection each and by using similar utilization factors as before the amount of traffic that is generated grows in orders of magnitude and becomes 87.5 Tb/sec.

All European Countries

By making similar assumptions and projection for all European countries, similar results are drawn. It is evident that not all countries will have the same phase in the FttX deployment. Also Sweden, although a fast deployer, is a very small country in population hence the impact of 1Gbps deployment may not be so huge as in the case of Germany for example. In the figure below we have the traffic generated- remember that only 10% of the generated traffic is assumed to be conveyed in the PanEurpean Network. There are some interesting results: Although average Traffic coming out of all countries is ~283 Tbps the maximum from some countries is more than 1000 Tbps. Remembering that this corresponds to the add/drop traffic and not to the by- pass traffic this will put a lot of burden on the Future Optical Network



Calculated TrafficVollume (in Tb/sec) predicted for all European countries

Next Steps-Dimensioning the PanEuropean Network

The projection of the dimensions of the European network to the near- and mid-term future is performed through solving an instance of the network dimensioning problem termed "Brownfield Network Dimensioning". In this version of the problem, the geographical location of nodes is given together with the set of trenched physical links (ducts) connecting neighbouring nodes. The output of the dimensioning process is the *optimal number of fibres per link* and *wavelengths per fibre* that need to be installed to serve the input traffic matrix at minimum cost, as well as *the optimal dimensions of optical switches* required to transparently route the input traffic.

The adopted method employs a linear cost model incorporating fibre cost (fixed and length-dependent components), wavelength cost and switch size cost. In addition, all flow constraints are linear, thus admitting the formulation of the problem as a linear programming problem with integer solutions. Each source-destination demand is served by k=3 candidate lightpaths using standard k-shortest path routing, whereby physical distance is used for assigning link weights during the routing process. The traffic matrix used as input has been obtained from the in-/outbound traffic projections per site, assuming wavelength granularity of demands and uniform distribution of traffic to/from a node to all other nodes, using 40 wavelengths per fibre at 10Gbps per wavelength. Since the goal of the dimensioning study is to capture future trends rather than specify exact quantitative requirements, we consider only a subset of all potential European source/sinks of core traffic. Specifically, we consider the Pan-European test network topology proposed by the COST 239 action ("Zurich" site excluded).

Using the method outlined above and the described input, we create instances of Integer Linear Programs for each traffic matrix corresponding to present and projected future and solve each instance to optimality using the Gurobi solver.

4.3 ICT BONE on the Network of the Future

In order to facilitate the penetration of new services and applications the access bandwidth rates should be upgraded accordingly. It inevitably concerns Metropolitan networks as they 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. In this part of the Roadmap exercise we seek to understand the limitations of current technologies under the possible penetration of services and the expected access rate growths that was predicted through our first Roadmap part.

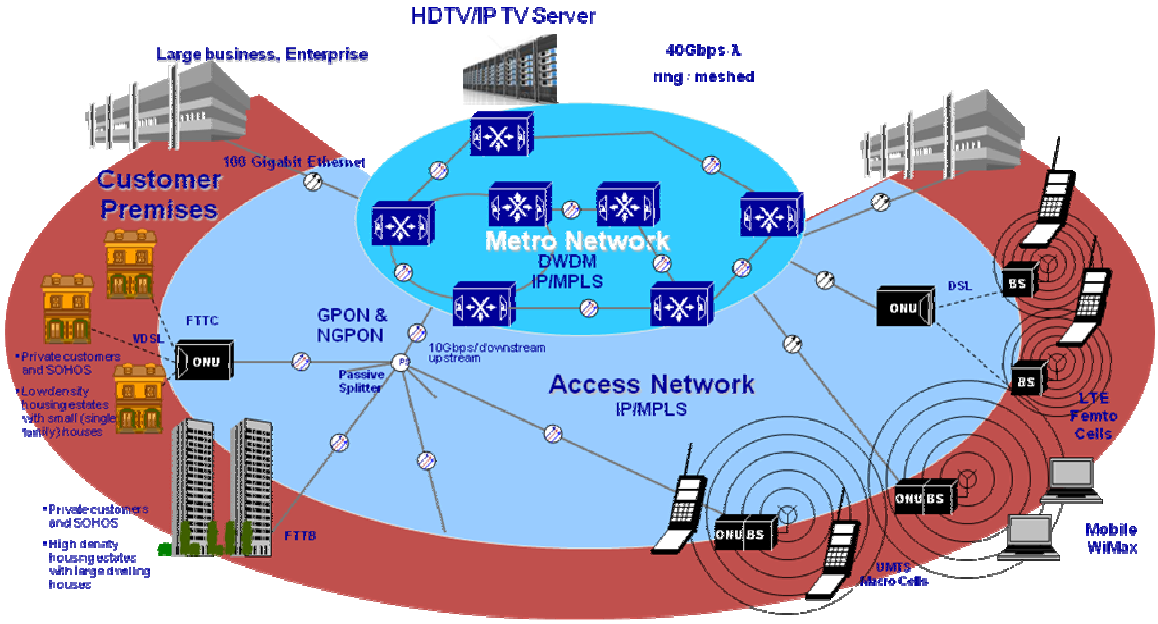
Limitations of Current Access Metro Networks

The main limitations of current access and metro networks are listed here:

- Copper still dominant in the access network of most countries.
- Optical fiber replicating the last mile of the network to replace copper without impacting the metro network
- Asymmetric services still dominant
- Issues of unbundling not universally resolved
- Evolution paths only just becoming clearer
- Differentiating services between users still difficult

Medium Term Vision for Metro/Access Network<5 year

The figure shows the medium term ICT BONE vision for the Metro and Access networks. As bit rate per household and SOHO (customer) increases, remaining copper links to the customer access has to become shorter and shorter. Minimum per customer bit rate is 10 Mbps which limits copper links to typically maximum 500m for VDSL symmetrical (13/13 Mbps d/u) and 1km for VDSL asymmetrical (26/2 Mbps d/u). Fiber to the home (FTTH) is affordable in some cases and fiber to the building (FTTB) is an economic solution for high density housing estates with large dwelling houses.



Medium Term Vision Metro/Access Network<5 year

The PON and particularly GPON is widely used as the most economical solution for feeding the optical network terminations (ONTs). In some countries NGPON technologies are expected to be available in 5 years time as discussed before. ONTs are numerous and widespread in the field and must therefore meet a number of obvious requirements as high reliability, small volumes, low power consumption (power backup).

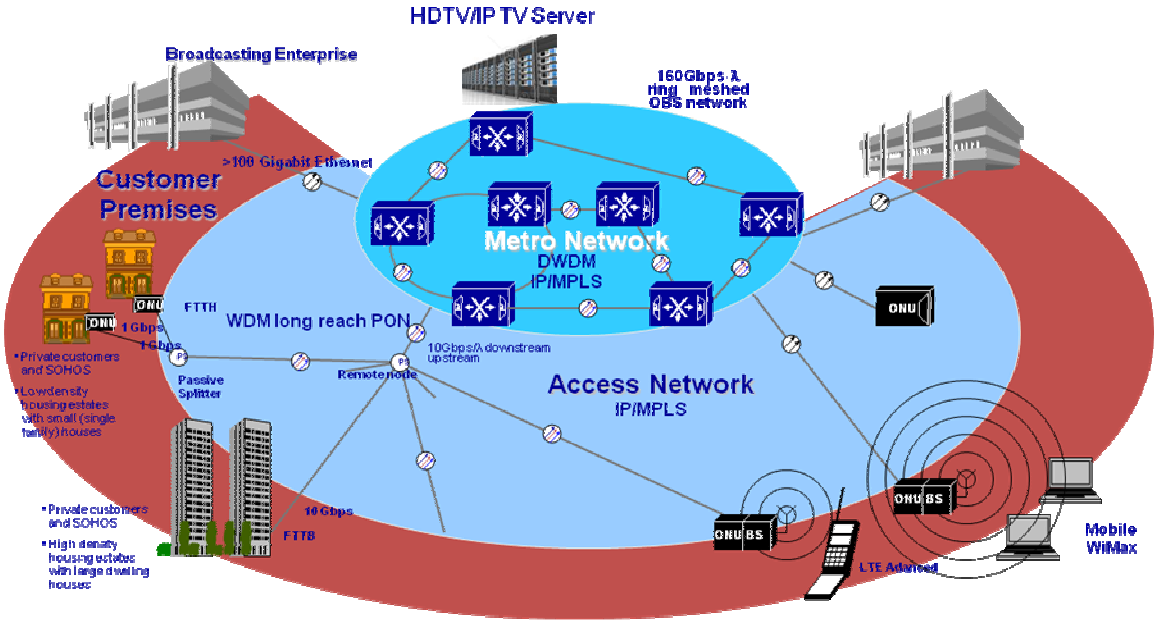
As in the metro and core network domain IP/MPLS is the dominant protocol. MPLS is important for QoS differentiation. MPLS allows to realise SLAs and VPNs for business customers and real time services as VoIP.

Wireless is ubiquitous in the public access network (UMTS) and in the customer premises domain (WLANs). Also in the whole wireless world the IP/MPLS protocol is predominant for the same reasons as in the wired network. LTE will become a deployed technology.

As far as the metro is concerned for the next years to come legacy still plays an important role. The potential capacity of the fiber has to be more exploited other that changing the transport technology and this means (D)WDM also in the metro domain. Costs is a critical point also in the metro domain because the degree of sharing the resources by many customers is somewhat limited compared with the WAN. For this reason optical channel switching and add/drop multiplexing nodes for ring and mesh networks will come up first. The main goals regarding the protocol stack, control and management functions are:

- QoS differentiation for any private and business application (with SLAs),
- low cost OAM and
- fast provisioning of any l-channel or MPLS/IP virtual path and virtual private network (VPN).

Long Term Vision for Metro/Access Network<10 year



Long Term Vision for Metro/Access Network<10 year

Regarding the long term vision (>10 years), as shown in the figure above, fiber will be the dominant transmission medium in the access domain for most European countries. Typically the fiber goes up to the buildings for all kind of household and business customers. Within the buildings wireless (WLANs) will play the dominant role for bitrates of some 10s up to 100 Mbps. In big business and enterprise buildings fiber will typically be used for very high speed access (100 GEthernet).

Point-to-point links and typically meshed networks connect large enterprise buildings (FTTB) and also large buildings for private households/customers and SOHOs directly with the metro network. PONs will be further developed concentrating traffic from small to medium size buildings for private customers, SOHOs and small to medium businesses and from a lot of densely distributed radio base stations. ICT BONE foresees a different FttX scenario in order to overcome the limitations of medium term TDMA PONs, which are among others:

- Contended bandwidth,
- Security
- TDM based protocols require flexibility
- Upgradability

In ICT BONE different long reach WDM architectures are discussed which are seen as a long term solution. The immense transport capacity of future long reach WDM PONs make demands for challenging components. So the open issues for Access in the next >10 years

- Long Reach availability in WDM PON
- Availability of low cost WDM equipment
- Scalability in terms of growth
- Flexibility to support Mobility

- Optical technology needs further research[4]
    - Reflective SOAs
    - Low cost stable multi-wavelength sources (OLT)
    - Athermal array waveguide devices
    - Coherent optical modulation schemes

As far as the Metro segment is concerned, there is a long debate regarding mesh and ring topologies in the Metro network. On one hand mesh networks will outperform rings because of their advantages regarding flexibility, capacity, scalability and survivability. On the other hand the simplicity of ring topology, availability of well established protocols make them a very interesting and cost efficient choice. The compatibility of the proposed solution with access optical technology and core networks for end-to-end service delivery will play an important role in this choice.

It should be remembered that even if it is assumed that the critical technologies are mature and stable an intensive and time consuming standardization activity is necessary before equipment will be industrialized .

The metro network can support large numbers of high speed wavelength channels, because of the limited distance span. It is in this region of the network that ultra high-speed is possible, eg more that 160 Gb/sec.

Optical packet/burst switching will be possible, although unlikely to be at the highest bit rates. It is likely that in this time period the WAN network will comprise a small number of high throughput nodes interconnected by high capacity links. Most of the switching/routing will take place in the MAN, for example through the use of optical packet switching. Within the long term time scenario for the Metro network, technologies for optical solutions may become mature and industrialized. Just to give some examples for key technologies:

- large space and wavelength switches for packet/burst transport
- tunable optical transmitters and receivers

Limitations of Current Wide Area and Global Area Networks

Limitations on these networks are identified at different levels. For example

Regarding the Service plane (WP12)

- Reduced QoE due to core resource exhaustion for bulk multimedia applications
- Increased service block due to lack of dynamicity in core networks
- Lack of service platforms for core networks
- Proprietary web-based provisioning of lightpaths
- No valid standard framework to supply end-user configurable optical carriers

Regarding the Control Plane (WP22)

- Architectures/protocols to support ASON are in place but there is still lack of interest of the industry for global deployment

[4] KTN consortium, UK

  - GMPLS only partial support and in high-end nodes,
  - Lack of a multi-domain interoperability framework
- Weak integration IP-DWDM
- Inefficient/static protection mechanisms
- No Control Plane extensions for QoT-aware lightpaths provisioning

As far as the Data Plane is concerned (WP11 and WP)

- Lack of multi-vendor compatibility at the physical layer prevents full optical backbone interconnection
- Optical Burst/Packet Multiplexing/switching technology unavailable at WAN
- Lack of support of carriers above 40Gb/s

There serious issues however that should be resolved at the system level in order overcome important technology issues for the realization next generation systems

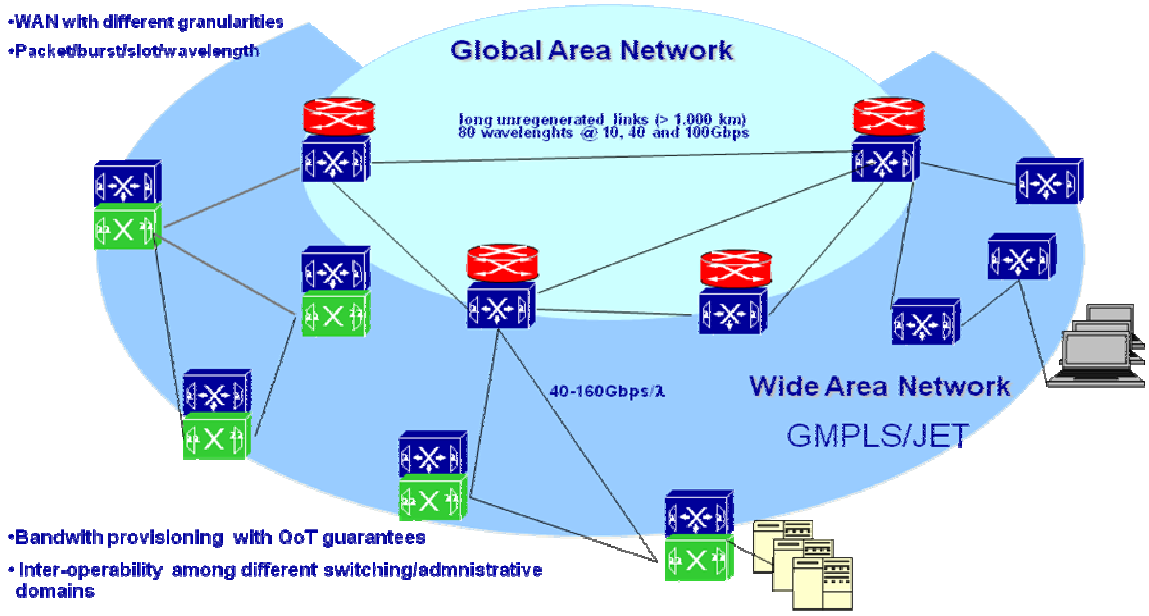
- Power consumption a very important issue in ICT
- Optical Switching still an open issue
- Optical Technology not mature
- Transmission >40 Gb/sec requires different modulation formats

Medium Term Vision GAN/WAN Network

In future years Wide Area Networks (WANs) will evolve to well meshed optical networks providing optical switching at wavelength granularities and possibly other levels of granularity as well, i.e. optical burst switching or generally sub-wavelength granularities will be implemented at the end of this timeframe. WDM with hundreds wavelengths will be implemented, whereas other optical multiplex techniques like OTDM are still too immature. Probably the maximum single channel bit rate will be not more than 100 Gbit/s.

As far as transport layer is concerned, it is expected that since wavelength and subwavelength swithing will be in place by this time and hence corresponding transport issues should have been resolved by then at both commercialisation and standardisation level. For real optical networking to take place however bandwidth provisioning should take place with real Quality of Tranmission guarantees. Furthermore interoperability between different administrative or technological domains should be achieved. These are expected to be resolved within the GMPLS protocol stack that will possibly be the main platform for control plane functionalities. All the above are illustrated in the figure below.

The global area network spans large distances, typified by undersea systems. Thus very large unregenerated distances are required. In the medium term WDM transmission will continue with greater numbers of wavelengths, possibly combined with non-linear techniques (eg using RZ transmission). Because of the long distances and associated non-linear problems very large numbers of wavelengths are unlikely. Key technologies are ultra-wideband optical amplifiers, for example hybrids using distributed Raman amplification combined with doped fibre amplifiers. Wideband dispersion compensation (chromatic and PMD) subsystems are also important.



Medium Term Vision GAN/WAN Network

Long Term Term Vision GAN/WAN Network

The long term ICT BONE vision on the GAN and WAN networks are illustrated in the figure below. In order to overcome the limitations of current networks and the limitations of the medium term vision ICT BONE is working the different planes of the network and foresees different technological evolutions that will drive this scenario forward.

It is expected both from historical perspective but also from the Roadmap excercise that was performed that in the WAN, that is of the size of a PanEuropean Network, the characteristic data like bit rate per channel, total bit rate per fiber and number of channels per fibre will be further increased. Due to that development multi-granularity in the transport domain is expected to be evolved in other levels of granularity like for example waveband and fibre. Technology should be evolved accordingly and so should standardisaion activities.

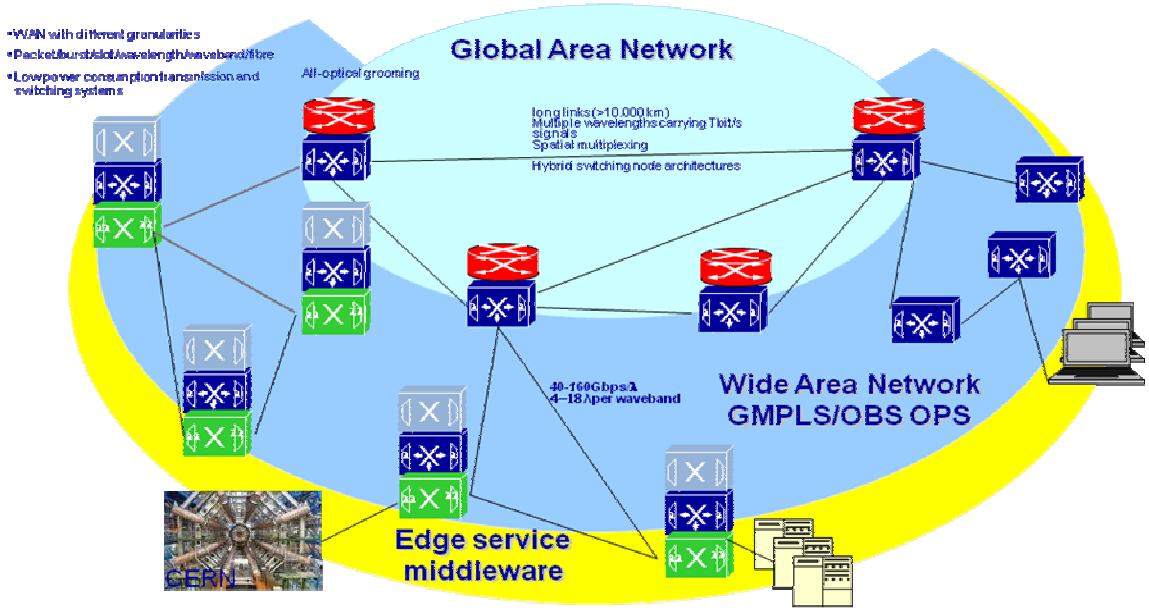
However the main issue in the long term evolution of the WAN is the power consumption and the energy efficiency of the switching and tranmission systems. It is expected that multi-granularity in switching will assist towards the specific direction as node cosnolidation and traffic grooming should be designed accroding to this.

In the system level, that new technologies will be mature to be introduced in practical networks. The single channel bitrate can be further increased fare above 40 Gbit/s. Using more sophisticated modulation formats and coding schemes the spectral efficiency will be increased to values above 1 bit/s/Hz in the long haul links in the WANs.

WP12 envisages a Service Plane that will be facilitated by an Edge Service Middleware and will obtain the external coordination needed by the UNI/NNI implementations.

As far as the control plane is concerned WP22 is working towards the directions that will overcome limitations like lack of a multi-domain interoperability framework, lack of QoT awareness in the control plane, extensions of the GMPLS paradigm for hybrid OCS/OBS

network scenarios, is also dealing with strategies for combating weak IP and WDM integration, and also studies protection mechanisms for efficent recovery of opticla networks.



Long Term Term Vision GAN/WAN Network

Specifically for switching systems, other than the issues of multi-granularity and power efficiency, WP14 and WP25 are investigating ways of achieving power and cost efficient optical switching with advanced performance.

Transmission issues are more related to the GAN. For efficient advanced modulation high speed modulations formats, together with spatial multiplexing in multi-core fibers are considered as the solution for the transmission into the ultra long haul links, while phase sensitive amplifiers and new amplifiers for other transmission bands are envisaged as the key technology for the future GN.

Conclusions and Challenges for the WAN

According to the research developments in BONE, there are still some issues that need to be resolved in order to bridge the network as it stands today with the network of the future, i.e. the outlook that ICT BONE is envisaging.

According to WP22 the key challenges that are discussed in the framework of this WP but remain an issue for the long term visions are the following:

- Multi-domain interoperation framework
- Resilience Mechanisms
- Intelligent Traffic Distribution
- QoT-aware bandwidth provisioning

- IP/MPLS-ASON/GMPLS integration
- Switching paradigms inter-operability

According to the WP12, Service Plane Issues can be summarized as follows:

- New applications are characterized by dynamicity and need for connectivity with strict requirements (e.g. bandwidth, delay and jitter)
- Applications may benefit from custom and advanced network services (e.g. VPN, QoS-awareness, traffic policing).
- Node configuration points and applications exhibit different "grain" in service description
  → direct triggering of network services via service platforms in metro/core Network is highly desirable

WP15, WP14 , WP25 and WP21 have reached the following consensus regarding the issues that will effect the development of systems.

- Increased Capacity in the Optical Links will drive the development of both transmission and switching systems
- Increased capacity needs and flexibility bring about new requirements for ultra-high throughput on internal backplanes of switches/routers
- Multigranularity in optical transport is a requirement for optical transport for efficient traffic grooming and switching

Power consumption of ICT equipment in general and network equipment in general is becoming larger and larger:

- Large OpEx costs for network operators
- Resulting Green House Gas Emissions severe thread (Eur. Comm. 20/20/2020 directives)
- Rising power density (Watt per square meter) requires more sophisticated and more expensive cooling systems

So power efficiency in future networks is crucial challenge for the coming decade

In each part of the ICT BONE Roadmap, which is a living document there are different pointers that identify the contribution of the BONE integrated work towards solutions to these challenges. This work that is highlighted there is described in full detail in different deliverable so detailed presentation is avoided here.

5. Impact & Conclusions

The BONE NoE provides a European-wide technical and social platform for research and researchers involved in the study of optical networking and its application to the general field of communications. Its partners are increasingly in demand for invited talks at prestigious events and as members of TPCs, and the BONE Logo is valued as a mark of quality on meetings and conferences. Individual partners are involved with national industry providing insight into future directions of networking and networking technologies. Collaboration between partners is providing educational material for the training of future engineers and a great strength of the Network is enabling transfers for doctoral students between laboratories. This year also the Network is moving towards the involvement of schools to try and stimulate an interest for science and technology and to show that engineering is a discipline which has high quality content both technically and also socially. Thus we believe the BONE NoE has a wide and deep impact on society.

This specific report described the dissemination activities organised during the second year of the project. As it is shown in here there are major deliverables of the project that were finalized during this year and their impact will be evident in the years to come.

Five types of activity were discussed, namely:

1. Workshops and conferences and events either supported or organized by the consortium; exhibition booths are also included. During the period, for example, ++
2. Preparation of dissemination material (posters, presentations and flyers). Other than the update of the existing material a new Travelling presentation has been put together in order to be available to be presented by partners at different occasions
3. The organization of a Schools public event. A very successful event was organized on the 1st of July by the University of Essex. This was considered a major event for the Outreach to younger generations
4. The development of a Roadmap. During the second year the roadmap exercise was finalized and the first roadmap vision was put together
5. Online dissemination with emphasis to Newsletters

6. Annex I

BONE WP01

Roadmap of Optical Networking

1st version of Questionnaire

1. What is the population in your country and the population density? Indicate whether there are major cities with very high population density?

2. What are the geographical dimensions of the country?

3. What is the percentage of the population using computers in your country?

4. What is the percentage of the population having Internet access in your country?

5. What is the percentage of the internet users that have broadband access? Can you identify specific percentages for businesses and households?

6. What type of broadband access technologies are used and in what percentage? What are the line rates available to the end users?

7. What are the type of services that the users access and in what percentage?

8. What is the cost of broadband connections per bit?

9. Is FTTX available in your country, if yes identify:

    a. Type of FTTX variant
    b. Numbers of FTTx subscribers
    c. Investment on FTTx/country/population
    d. Number of FTTx providers
    e. Available bandwidth to the end users
    f. Price/bps

10. What type of services do broadband users access in your country?
    a. Voice
    b. Data
    c. Video
    d. TV
    e. other

11. Your comments on the future outlook:

7. Annex II

2nd version of Questionnaire

Questionnaire 2nd edition

12. What is the percentage of households that have broadband access?

13. What type of broadband access technologies are used and in what percentage? What are the line rates available to the end users?

14. Is FTTX available in your country, if yes identify:

    a. Type of FTTX variant
    b. Numbers of FTTx subscribers
    c. Available bandwidth to end users
    d. Price/bps

15. Which funding model best describes the FTTX installation funding in your country:

    a. Public funding

    b. Private funding

    c. Public-private partnerships

16. Which business model best describes the FTTx providers in your country:

a. Infrastructure provider

b. Infrastructure and network provider

c. End to end network and service provider

6. What type of services do broadband users access in your country?
   a. Voice
   b. Data
   c. Video
   d. TV
   e. Other…

7. Your comments on the future outlook about services:

8. Annex III- The Roadmap

The Roadmap is a living document that is being contantly updated

WP-01
Roadmap

Objectives

One of the activities within WP01 has an objective to :

To extend the roadmap [commenced in e-Photon/ONe] into a focused view (roadmap) of the evolution of photonic networks [within Europe] for telecom and non-telecom applications; and bench mark European research activities against international programmes.

Contents of the Roadmap

- Roadmaps of the … past
- Methodology

PART I

- European network and diversity
- Access bandwidth growth and New Services – Impact on the Core European Network
- New Media Services – Impact on Core
- Business Access rates – Impact on Core
- Pan European Network capacity growth

Contents of the Roadmap

PART II

- Access/Metro Networks
- WAN/GAN Networks
- Optical Networking Systems
- Key Challenges and Open Issues

Contents of the Roadmap

- Roadmaps of the … past
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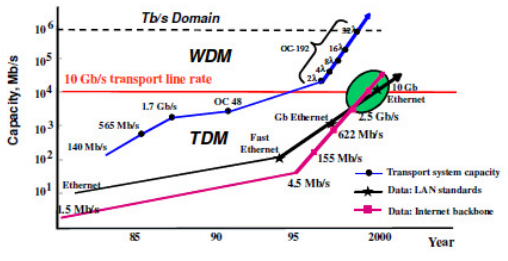
Service and Transport Rates
The role of optical Networking since 2000



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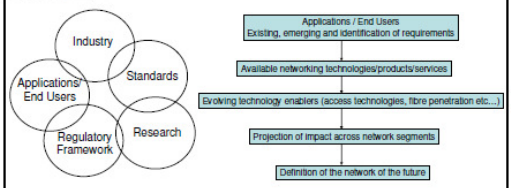
- Pan European Network capacity growth

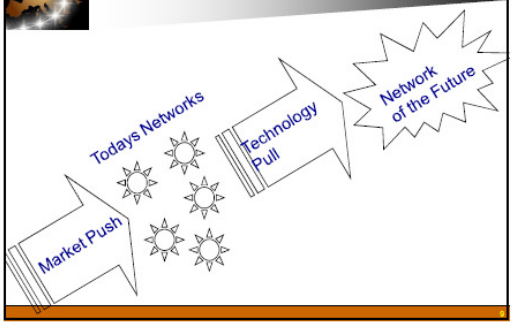
Methodology



Networking Evolution Drivers

Roadmap Methodology

Market pull- Technology push



BONE Roadmap Methodology

- **Collect data on existing/emerging services at European Level**
  - Through Roadmap Taskforce
- **Collect data on access technologies in Europe**
  - A questionnaire was distributed in order to collect the data on existing access network technologies and services
- **Process data to evaluate the impact on the Network**
- **Discuss at Roadmap meeting-Projection of impact on the various network segments.**
  - This took place by Roadmap taskforce together with WP leaders
- **Collect data on existing/emerging services at European Level (2nd round)**
- **Build the converged image of the Network of the future**
- **Evaluate key challenges to close the gap between the situation as is today and the Vision**

Contents of the Roadmap

- Roadmaps of the … past
- Methodology
- European network and diversity
- Access bandwidth growth and New Services – Impact on the Core European Network
- New Media Services – Impact on Core
- Business Access rates – Impact on Core
- Pan European Network capacity growth

Accessible Access Network Technologies in Europe

UK
BT is currently deploying a GPON system to a 1,000 acre new build in Ebbsfleet, Kent. This will be approximately 10,000 homes and will offer speeds up to 100Mbit/s symmetrical. First customers were connected at the end of 2008.
Virgin media (Cable operator) is upgrading its network to DOCSIS 3 and advertising 50Mbit/s "Fibre optic broadband" to the 9 million homes passed.
H20 Networks has announced plans to building fibre to the home networks in in Bournemouth and Dundee using fibre layed in sewers.

Greece
In the 99.5% of broadband access is xDSL and more specifically is only 27.1% >10Mb/s

Available Access Network Technologies in Europe

Belgium

Technologies and market share (Belgium - Q2 2009)

The fixed broadband market in Belgium consists of DSL and Cable. There is no FTTH available in Belgium, only FTTC (FTTCabinet) or FTTN (FTTNode).

Using VDSL2+ (Belgacom), where the optical fiber is extended from the local exchange to a remote optical platform (ROP) located next to the street cabinet. From the ROP to the customer, twisted pair copper is used, but in this way, the copper distance can be limited to ca. 300-500m.

Using HFC (Telenet), where the optical fiber reaches the optical nodes. From this point, a shared coax cable is used to connect the customer. The average distance between the optical node and customer is 1.5 km. Currently, Telenet is reducing the number of customers connected to one optical node from 1400 (2008) to 500 (by 2013).

Available Access Network Technologies in Europe

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Available Access Network Technologies in Europe

Poland

Considering the broadband Internet offer, Poland occupies the very last positions in Europe. Moreover, in the West the term "broadband" is used usually in case of bandwidth from 1 Mbps , while European Commission (so also Poland) has not yet changed the definition and assumes the speed of 144 kbit/s and more as broadband Internet service.

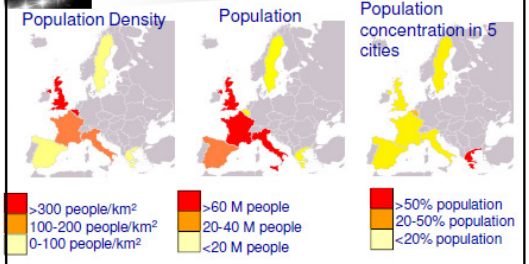
Broadband access to Internet is offered by 13 operators (3 typical operators, 4 mobile and 6 cable TV operators).

Facts about broadband technologies (source , January 2009):

xDSL 58,16 %
Cable TV 21 %
Mobile modems 15%
LAN Ethernet 11,16 %
WiFi, HiS 1,68 %
Leased lines 0,04 %
FTTx 0,00 %

* FTTx is point to point Ethernet

European Diversity ....

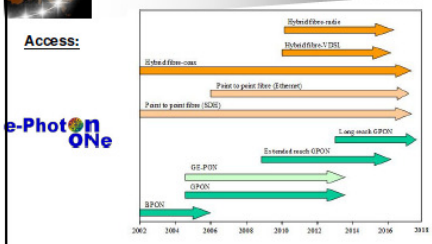


Contents of the Roadmap

- Roadmaps of the … past
- Methodology
- European network and diversity
- Access bandwidth growth and New Services
  - Todays access and service rates
  - What is FttH going to bring about
  - New Services
  - Mobile/Wireless Users
  - Impact on the Core European Network in numbers
-

Key Outcomes-Access

Access:



e-Photon ONe

- GE (Gigabit Ethernet)-PON widely deployed in Japan, G (Gigabit)PON in Europe
- Extension of GPON standard in 2008 with range extension to 60 km and 128-way split
- Long term target eg (PIEMAN) 32 channels x 10Gbps over 100 km with split ratio of 1024

Speed of Evolution in Public Networking

In spite of our belief in shorter and shorter development cycles, evolution in public networking takes its time.

- A 10 to 20 years period of time from Emerging (potentially disruptive) component technologies to broadly installed equipment (new system concepts and standards)
- A 5 to 10 years period of time is typical to get from lab prototype based on new technologies to broadly installed equipment.
- 2 to 5 years elapse typically from startup's first offerings to broadly installed equipment based on not traditional architectures and technologies.

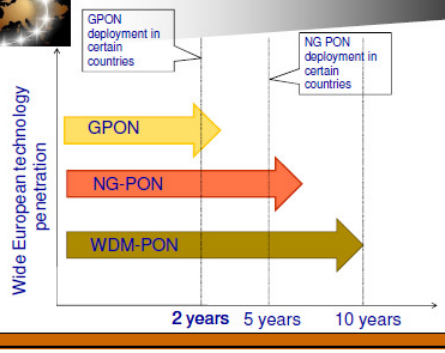
European Diversity

- Due to diversity in Access Technology deployment and according to our survey we have assumed that there are ***two speeds*** in FttX deployment per country:
  - 2 years → In *selection* of countries xPON technology and NGN services will be available in most urban areas
  - 2-5 years → In the rest of countries xPON technology will be available in densely populated urban areas
  - 5-10 years → differentiated NGN services will be available in most areas (urban & rural)
  - >10 years?- 100M/1G access services will be available in most areas (urban & rural)

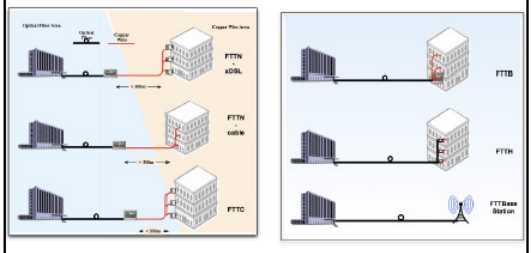
Criteria

- Situation today according to survey
- Population Density
- Business model applied for Fttx deployment (contribution of public funding is assumed to accelerate deployment)
-

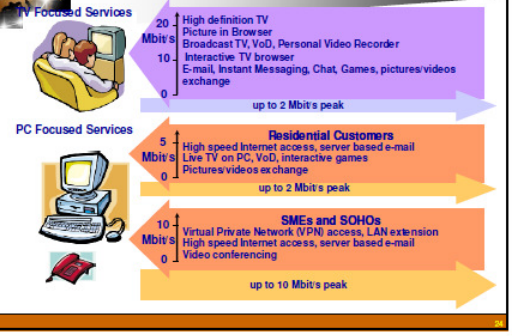
What does this mean for Europe



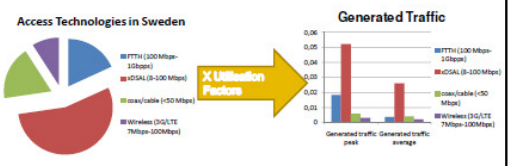
Available Access Technologies



Services & Bitrates for Residential Customers, SOHOs and SMEs



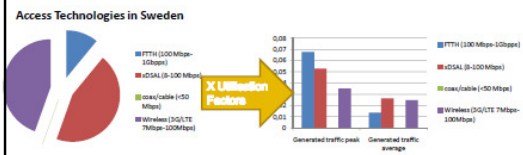
Sweden Case study Today's technology



<Amount of Traffic Generated from Sweden>
3.5 Tb/sec
Assuming 10% of the traffic generated in Sweden is conveyed to PanEuropean Network with one PoP

Sweden: Future Household Traffic Prediction (2 years)

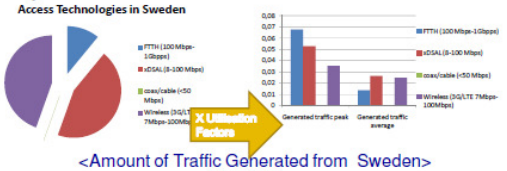
- By assuming that all densely populated big cities will be accessed through FttH (GPON)



<Amount of Traffic Generated from Sweden>
5.6 Tb/sec
Assuming 10% of the traffic generated in Sweden is conveyed to PanEuropean Network with one PoP

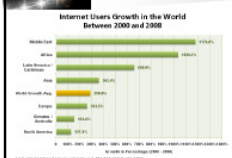
Future Household Traffic Prediction (5 years)

- By assuming that all densely populated big cities will be accessed through FttH (10 Gbps PON/NGPON)



<Amount of Traffic Generated from Sweden>
13.14 Tb/sec
Assuming 10% of the traffic generated in Sweden is conveyed to PanEuropean Network with one PoP

Extreme Case: PC users/Mobile Users/TV Users should be taken into account



Penetration of HDTV in Western Europe has reached 20%, compared to 36% in North America. European penetration should reach from 75% to 100% by 2012.
Super Hi-Vision service by the Japanese broadcasting corporation NHK will begin in 2025

Monthly TV time in Q3 2008 (hh:mm) www.nielsen-online.com	A18-24	A25-34	A35-44	A45-54	A55-64	A65+
On Traditional TV	108:36:00	133:00:00	134:51:00	159:23:00	175:18:00	196:23:00
Watching Timeshifted TV	4:36	10:04	8:15	7:15	6:35	3:44
Using the Internet	12:59	26:40:00	37:56:00	35:24:00	35:05:00	26:39:00
Watching Video on internet	3:52	3:21	2:44	2:13	1:20	1:02
Mobile Subscribers Watching Video on a Mobile Phone	3:15	4:26	3:37	2:15	2:55	n/a

Extreme Case > 10 years

- By assuming that all households in Sweden will have access via FttH (32G (eg WDM PON)) in Sweden with similar methodology
- <Amount of Traffic Generated from Sweden>
- 87.5 Tb/sec
- Assuming 10% of the traffic generated in Sweden is conveyed to PanEuropean Network with one PoP

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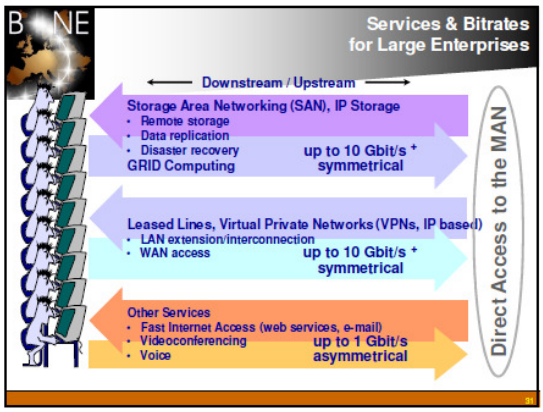
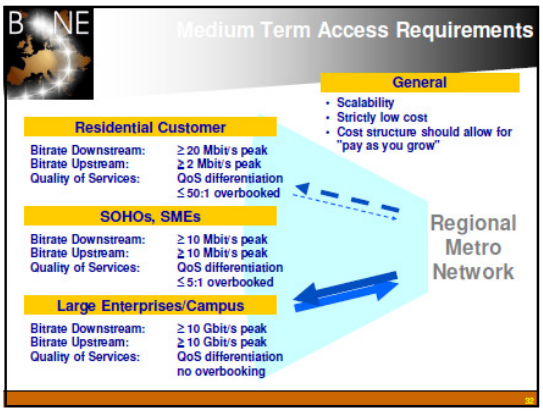
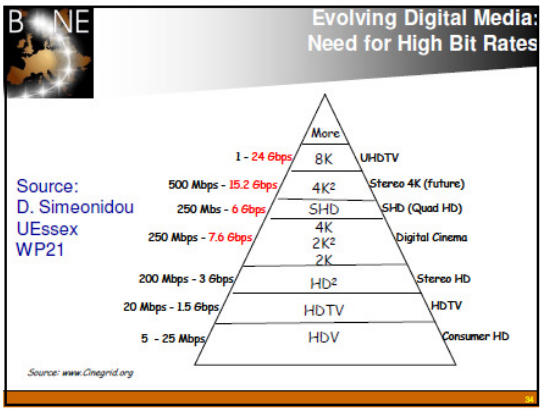
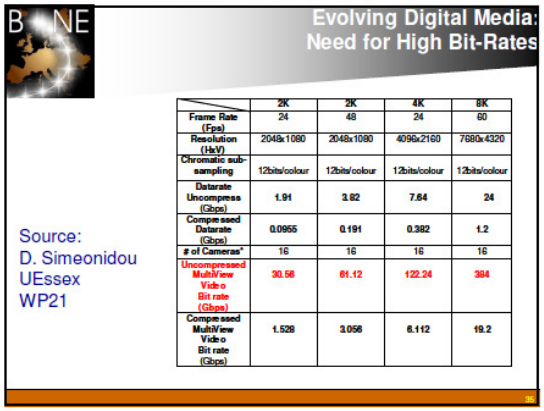
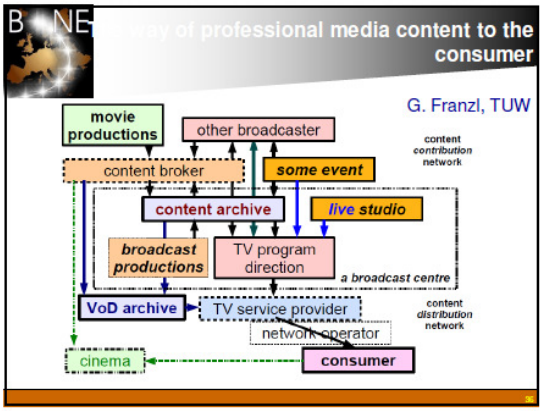








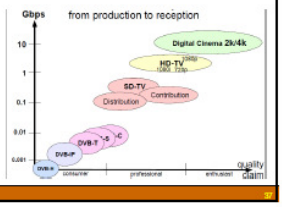
	2K	2K	4K	8K
Frame Rate (Fps)	24	48	24	60
Resolution (HxV)	2048x1080	2048x1080	4096x2160	7680x4320
Chromatic sub-sampling	12bits/colour	12bits/colour	12bits/colour	12bits/colour
Datarate Uncompress (Gbps)	1.91	3.82	7.64	24
Compressed Datarate (Gbps)	0.0955	0.191	0.382	1.2
# of Cameras*	16	16	16	16
Uncompressed MultiView Video Bit rate (Gbps)	30.56	61.12	122.24	384
Compressed MultiView Video Bit rate (Gbps)	1.528	3.056	6.112	19.2



Typical Formats used -Bandwidth & Quality Claim

G. Franzl, TUW

- Content production
  - Capture raw content
  - Direct / Mix content
  - File content
- Handle content
  - Contribution
  - Distribution
- Deliver content
  - Analogous
  - DVB-x
  - IP-TV
  - Internet-TV



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

Contents of the Roadmap

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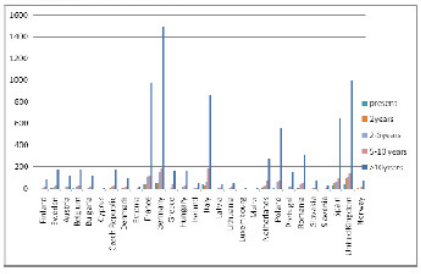
Pan European Network capacity growth

- By making similar assumptions and projection for all European countries, similar results are drawn
- In the figure below a projection on the traffic volume coming from each PoP in the PanEuropean network is illustrated
- The first results assumes only household traffic

Order of Magnitude Traffic Increase in Tbps



Impact on Core Network

- Although average Traffic coming out of all countries is ~283 Tbps the maximum from some countries is >1000 Tbps
- This corresponds to the add/drop traffic and not to the by-pass traffic
- All these assuming one PoP and 10% of the traffic to be conveyed in the European backbone
- Different types of services will be conveyed through to the core
- Mobility is a very important issue

Next Steps

- We will make similar assumptions for business cases
- We will included those assumption is the initial results
- We will come up with numbers on the capacity/size of the network and capacity/size of routers/switches (similar to slide 29)
- Understand limitations
- Suggest solutions

Limitations of current networks

- 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

General conclusions from traffic/capacity projections

- Evidently both access and core networks require higher bandwidth – hence optical networking is the way forward!
- This network should provide end-to-end connectivity, should be highly dynamic
- This network should be simple with low CAPEX and power efficient
- It should provide the common infrastructure for all the available services and should provision for mobile and fixed access
- It should be flexible and should provide a variety of services that each user can choose
- It should be scaleable flexible and interoperable
- It should be controlled in an efficient and uniform way

Convergence:

Service Convergence: Web-based service provisioning
Network Convergence: IP over high speed transport network

Contents of the Roadmap

PART II

- Access/Metro Networks
- WAN/GAN Networks
- Optical Networking Systems
- Key Challenges and Open Issues

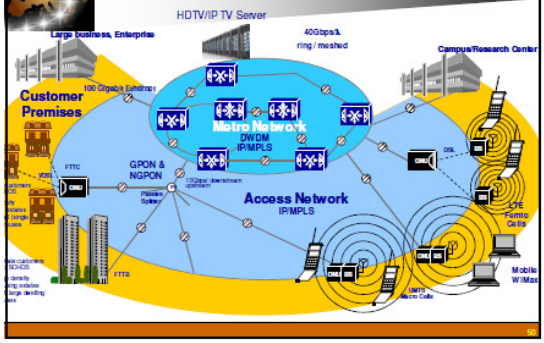
Contents of the Roadmap

- Access/Metro Networks
  - Limitations of current Networks
  - Medium Term Vision for Access/Metro Networks
  - Long Term Vision for Access/Metro Networks
  - What we do in BONE
  - Key Challenges to bridge the gap
- WAN/GAN Networks
- Optical Networking Systems
- Key Challenges and Open Issues

Limitations of Current Access Metro Networks

- Copper still dominant in the access network of most countries.
- Optical fiber replicating the last mile of the network to replace copper without impacting the metro network
- Asymmetric services still dominant
- Issues of unbundling not universally resolved
- Evolution paths only just becoming clearer
- Differentiating services between users still difficult
- Bring real broadband inside the user premises
  - Wi-fi will be the answer? the re-use of the spectrum will be more and more difficult with a very dense deployment
  - Copper ethernet? Integration into existing buildings not easy, no deployment into power ducts etc.
  - Plastic optical fiber can be a very important breakthrough

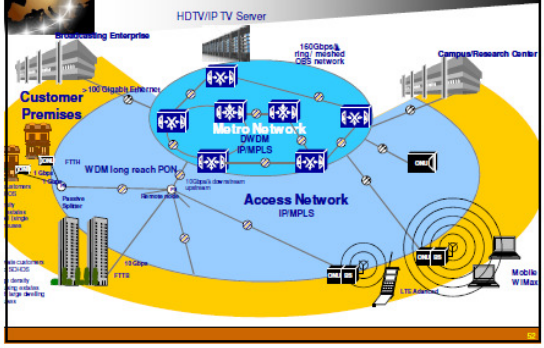
Short Term Vision Metro/Access Network <5 year



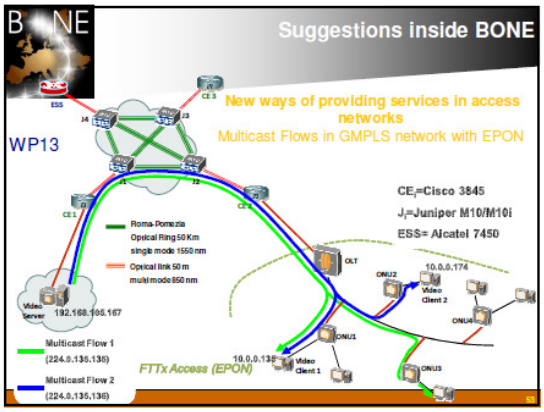
Limitations of Medium vision

- Network Level- PONs
  - Contended bandwidth,
  - Security
  - TDM based protocols require flexibility
  - Upgradability
- Network Level- Metro
  - QoS differentiation for any private and business application
  - low cost OAM and DWDM equipment
  - fast provisioning of any λ-channel or MPLS/IP virtual path and virtual private network (VPN).
- System/Subsystems PONs
  - Low cost optical equipment for Access Network
  - Complex technology for both electronics and optics

Long Term Vision Metro/Access Network <10 year

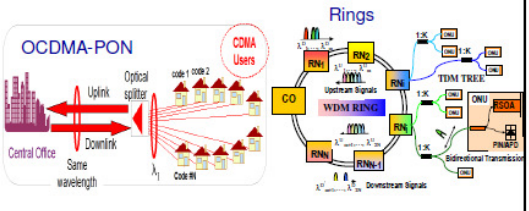


Suggestions inside BONE



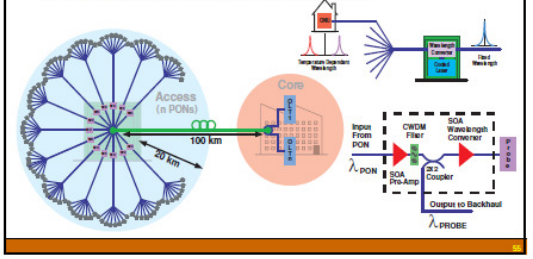
Suggestions inside BONE

WP13: VCE on Access Networks
New Network Architectures



Suggestions inside BONE

Access Technologies →WP13: **VCE on Access Networks Consolidation and Long Reach Access**



Suggestions inside BONE

Metro Transport Technologies→ **WP11: VCE on Network Technologies and Engineering.**

Long Term Vision Access Network Key Challenges

- Open Issues for Access in the next >10 years
  - Long Reach availability in WDM PON
  - Availability of low cost WDM equipment
  - Scalability in terms of growth
  - Flexibility to support Mobility
  - Optical technology needs further research (*)
    - Reflective SOAs
    - Low cost stable multi-wavelength sources (OLT)
    - Athermal array waveguide devices
    - Coherent optical modulation schemes
- Shared network planning and traffic engineering tools for PONs
  - A deployment not wisely made is of a little use and can be detrimental

(*) KTN – UK

Long Term Vision Metro Network Key Challenges

- Critical Issues for Metro
  - The critical issue is whether FTTH will happen or not
  - Metro networks evolution will depend on FTTH penetration
    - Public support likely to be uneven (metropolitan/regional/national)
- Open Issues for Metro in the next >10 years
  - Flexibility
  - Statistical Multiplexing
  - Service differentiation

Contents of the Roadmap

- Access/Metro Networks
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  - Limitations of current Networks
  - Medium Term Vision for WAN/GAN Networks
  - Long Term Vision for WAN/GAN Networks
  - What we do in BONE
  - Key Challenges to bridge the gap
- Optical Networking Systems
- Optical Networking Systems
- Key Challenges and Open Issues

Limitations of existing Technology

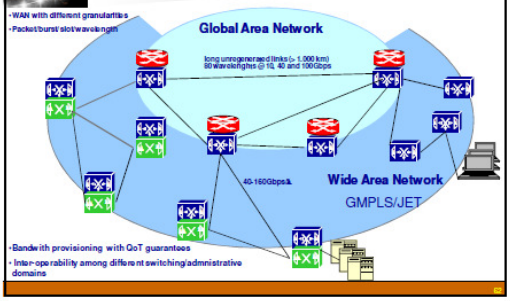
Networking Issues
- Scalability
- Power Consumption
- Flexibility and Reconfiguration
- Quality of Service
- Interoperability
- Management Issues
- Intelligent Self-healing capability
- Limited integration with IP
- No valid framework for Optical Internet eXchanges
- Centralised Control

SERVICE related Issues
- Increased volume of traffic (multimedia and p2p)
- Demand by applications for dynamic end-to-end wavelength services
- Demand by applications for IP connection-oriented services
- Demand for reliable services

Limitations of existing Technology

- Many network layers; which effects on resource allocation and bandwidth provisioning,
  - Signalling delay on routing
  - RWA considering fault tolerance ecc.
- Flow routing and flow networking
  - Will it be feasable at optical speed
  - Control plane issues
- Traffic engineering
  - Still no consolidate traffic engineering strategies
    - Interaction with CAPEX/OPEX effectiveness
- Packet switching at optical speed, will it be 100G ethernet
  - Do we need new technologies and optics in the switching

Medium Term Vision GAN/WAN Network



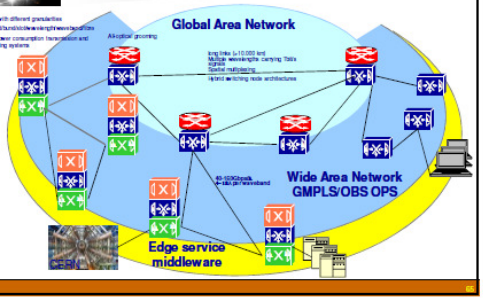
Limitations of current Vision

- Services
  - Reduced QoE due to core resource exhaustion for bulk multimedia applications
  - Increased service block due to lack of dynamicity in core networks
  - Lack of service platforms for core networks
  - Proprietary web-based provisioning of lightpaths
  - No valid standard framework to supply end-user configurable optical carriers
- Control Plane
  - Architectures/protocols to support ASON are in place but there is still lack of interest of the industry for global deployment
  - GMPLS only partial support and in high-end nodes,
  - Lack of a multi-domain interoperability framework
  - Weak integration IP-DWDM
  - Inefficient/static protection mechanisms
  - No Control Plane extensions for QoT-aware lightpaths provisioning

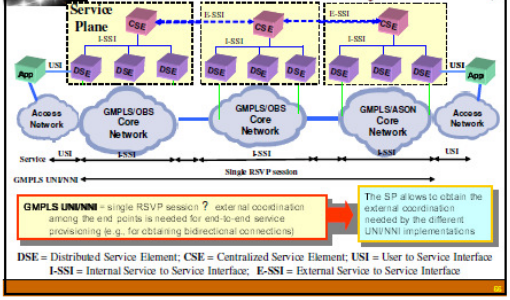
Limitations of current Vision

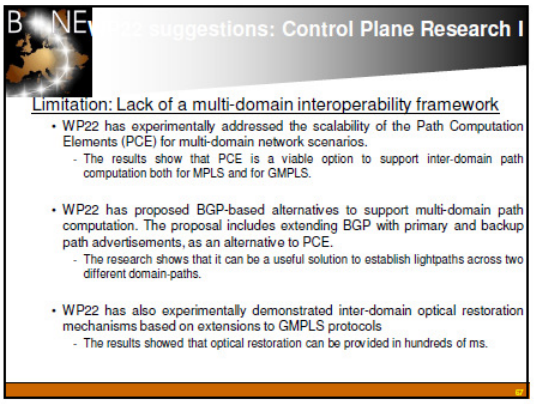
- Data Plane
  - Lack of multi-vendor compatibility at the physical layer prevents full optical backbone interconnection
  - Optical Burst/Packet Multiplexing/switching technology unavailable at WAN
  - Lack of support of carriers above 40Gb/s
- System Issues
  - Optical Switching still an open issue
  - Optical Technology not mature
  - Transmission >40 Gb/sec requires different modulation formats

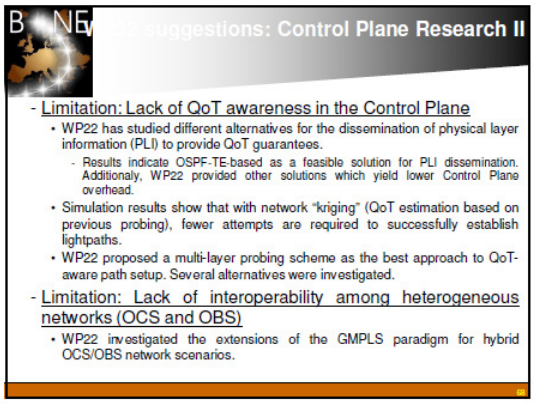
Long Term Vision GAN/WAN Network

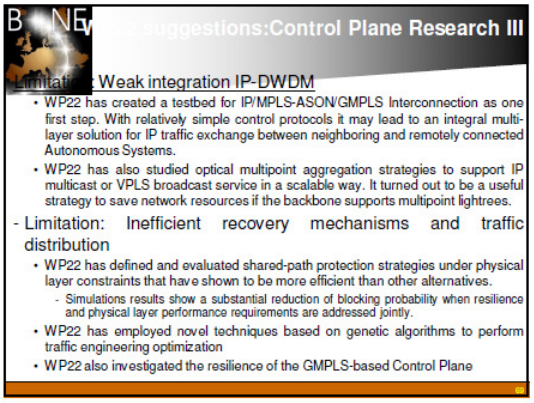


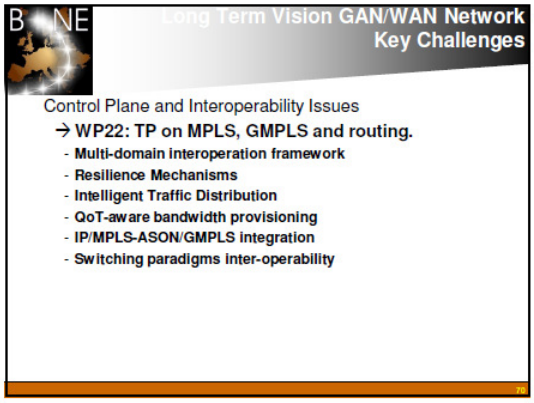
Suggestions inside BONE
WP12 : Inter-domain SP-based network

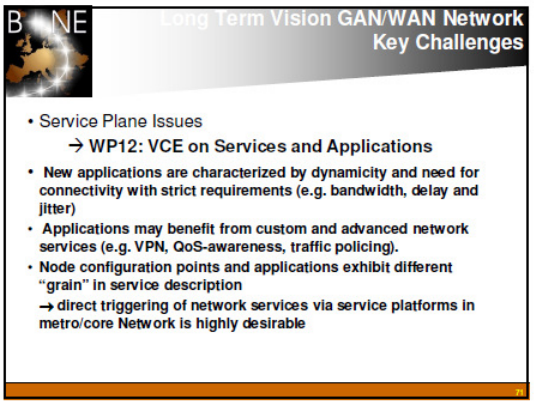


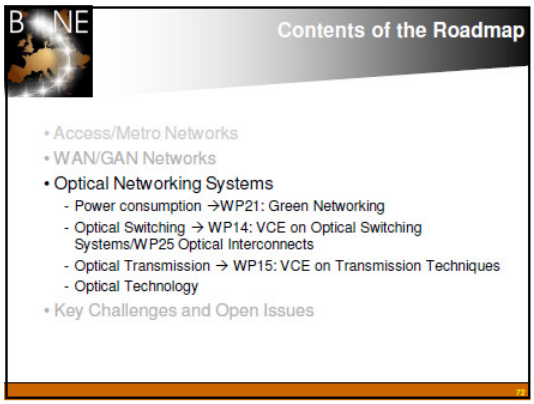

WP22 suggestions: Control Plane Research I
Limitation: Lack of a multi-domain interoperability framework
• WP22 has experimentally addressed the scalability of the Path Computation Elements (PCE) for multi-domain network scenarios.
- The results show that PCE is a viable option to support inter-domain path computation both for MPLS and for GMPLS.
• WP22 has proposed BGP-based alternatives to support multi-domain path computation. The proposal includes extending BGP with primary and backup path advertisements, as an alternative to PCE.
- The research shows that it can be a useful solution to establish lightpaths across two different domain-paths.
• WP22 has also experimentally demonstrated inter-domain optical restoration mechanisms based on extensions to GMPLS protocols
- The results showed that optical restoration can be provided in hundreds of ms.


WP22 suggestions: Control Plane Research II
- Limitation: Lack of QoT awareness in the Control Plane
• WP22 has studied different alternatives for the dissemination of physical layer information (PLI) to provide QoT guarantees.
- Results indicate OSPF-TE-based as a feasible solution for PLI dissemination. Additionaly, WP22 provided other solutions which yield lower Control Plane overhead.
• Simulation results show that with network "kriging" (QoT estimation based on previous probing), fewer attempts are required to successfully establish lightpaths.
• WP22 proposed a multi-layer probing scheme as the best approach to QoT-aware path setup. Several alternatives were investigated.
- Limitation: Lack of interoperability among heterogeneous networks (OCS and OBS)
• WP22 investigated the extensions of the GMPLS paradigm for hybrid OCS/OBS network scenarios.


WP22 suggestions:Control Plane Research III
Limitation: Weak integration IP-DWDM
• WP22 has created a testbed for IP/MPLS-ASON/GMPLS Interconnection as one first step. With relatively simple control protocols it may lead to an integral multi-layer solution for IP traffic exchange between neighboring and remotely connected Autonomous Systems.
• WP22 has also studied optical multipoint aggregation strategies to support IP multicast or VPLS broadcast service in a scalable way. It turned out to be a useful strategy to save network resources if the backbone supports multipoint lightrees.
- Limitation: Inefficient recovery mechanisms and traffic distribution
• WP22 has defined and evaluated shared-path protection strategies under physical layer constraints that have shown to be more efficient than other alternatives.
- Simulations results show a substantial reduction of blocking probability when resilience and physical layer performance requirements are addressed jointly.
• WP22 has employed novel techniques based on genetic algorithms to perform traffic engineering optimization
• WP22 also investigated the resilience of the GMPLS-based Control Plane


Long Term Vision GAN/WAN Network
Key Challenges
Control Plane and Interoperability Issues
→ WP22: TP on MPLS, GMPLS and routing.
- Multi-domain interoperation framework
- Resilience Mechanisms
- Intelligent Traffic Distribution
- QoT-aware bandwidth provisioning
- IP/MPLS-ASON/GMPLS integration
- Switching paradigms inter-operability


Long Term Vision GAN/WAN Network
Key Challenges
• Service Plane Issues
→ WP12: VCE on Services and Applications
• New applications are characterized by dynamicity and need for connectivity with strict requirements (e.g. bandwidth, delay and jitter)
• Applications may benefit from custom and advanced network services (e.g. VPN, QoS-awareness, traffic policing).
• Node configuration points and applications exhibit different "grain" in service description
→ direct triggering of network services via service platforms in metro/core Network is highly desirable


Contents of the Roadmap
• Access/Metro Networks
• WAN/GAN Networks
• Optical Networking Systems
- Power consumption →WP21: Green Networking
- Optical Switching → WP14: VCE on Optical Switching Systems/WP25 Optical Interconnects
- Optical Transmission → WP15: VCE on Transmission Techniques
- Optical Technology
• Key Challenges and Open Issues

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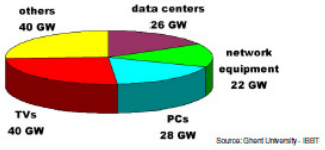
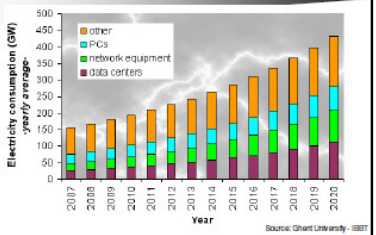
ICT use phase: worldwide 2007



Conclusions:
- Total ICT = 156 GW = 8% of global electricity consumption
- Network equipment = 22 GW = 1% of global electricity consumption

Future estimations ($B_{usiness}A_sU_{sual}$ scenario)



Conclusions:
- 15% of electricity goes to ICT use phase in 2020
- 3 % of electricity goes to network equipment use phase in 2020

Key challenges

Power consumption of ICT equipment in general and network equipment in general is becoming larger and larger:
- Large OpEx costs for network operators
- Resulting Green House Gas Emissions severe thread (↔ Eur. Comm. 20/20/2020 directives)
- Rising power density (Watt per square meter) requires more sophisticated and more expensive cooling systems

So: power efficiency in future networks is crucial challenge for the coming decade.

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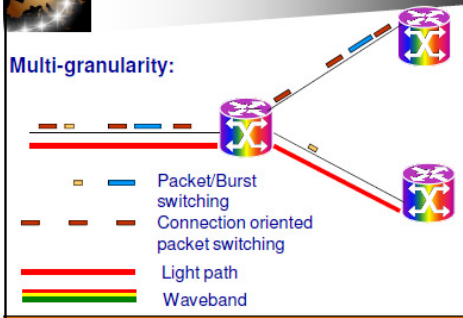
Systems should support multigranularity

Multi-granularity:



WP14: Suggestions inside BONE

- Optical Switching and other Technologies→WP14: VCE on Optical Switching Systems
  - Power-Cost-Effective Node designs for Multicast services
  - Share of resources like Wavelength Converters that are still
  - Code-based optical nodes
  - Employ All-optical switches utilizing for example microring resonators
  - Further improve performance and scalability using wavelength-switching and wavelength-sensitive devices

WP25: Suggestions inside BONE

- Optical Switching and other Technologies
  → WP25: Optical Interconnects
  - Switching fabric architectures relying upon an optical backplane with high-scalability figures in terms of maximum throughput, relative cost/complexity, power consumption
  - Hardware-efficient optical backplanes utilizing advanced optoelectronic and optical switching components
    - E.g. microring resonators, new quantum dot materials, advanced integration technologies
  - Scheduling and routing algorithms for a power-efficient operation of optical interconnection systems
  - On-chip optical switching networks for realising increasing functionality on monolithic multi-processor opto-electronic circuits

Key Challenges– Switching Technologies

- Chip size/footprint must be reduced
- Fast/integratable space switching fabrics exhibit high loss
- Switching for different granularities is required→ different switching speeds
- Power consumption must me reduced
- Loss must be optimized.
- Photonic Integration allows improved performance combined with advantages in development
- Scalability with respect to ports
- Scalability with respect to flows/services

Key Challenges– Switching Technologies

- "Photonics inside the box" can overcome bottlenecks of electrical interconnection backplanes, improving scalability of switches/routers and super-computing systems

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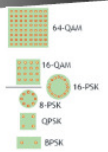
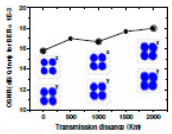
Limitations of Currents TranmissionSystems

- Advances in transmission systems will be required in the following areas:
- Transmission techniques
- Processing systems
- Fibre technology

WP15: Suggestions inside BONE Transmission Techniques

- Advanced modulation techniques
  - Adoption of techniques which are commonplace in RF communications to increase the number of bits per symbol
  - Modulation in amplitude as well as in phase
- Beyond 100GbE
  - Optical frequency division multiplexing
    - Trading complexity in the electronics for capacity in the link
  - Revival of serial techniques
    - OTDM for ultra-high capacity short links





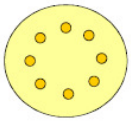
Study on a 100Gb/s DQPSK signal over an uncompensated installed link (Collaboration between PoliTo-UCL-Fraunhofer, BONE WP15)

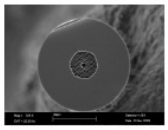
WP15: Suggestions inside BONE Processing systems

- Wavelength converters operating at ultra-high speeds
  - Minimise power x length product of optical switches
    - Short-length soft-glass nonlinear fibres
    - Periodically poled lithium niobate devices for telecommunications applications
    - Silicon and silicon-organic hybrid chips
- Phase sensitive amplification and processing
  - Optical parametric devices
  - Phase locking of optical carriers
- Multi-wavelength ultra-high speed processing systems and regenerators
  - Coherent manipulation of optical waveforms

WP15: Suggestions inside BONE Fibre technology

- Amplifiers for new transmission bands
- Multicore fibres for spatial multiplexing
- Photonic bandgap fibres in transmission systems





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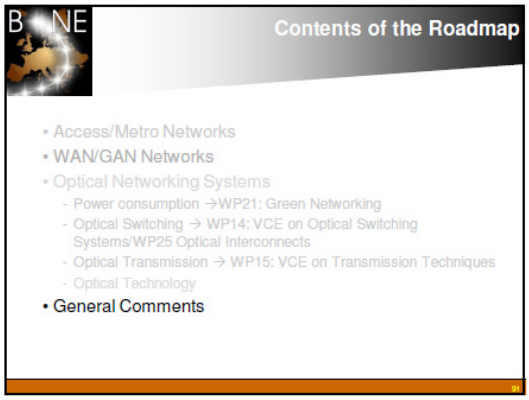
Other Significant Optical Technology Amplification/Regeneration/Wavelength Conversion

- Multi-wavelength Amplifications/Regeneration and Wavelength Conversion
- Phase sensitive / Transparent to modulation format
- High bit rate – wide band
- Reduced power consumption
- Integratable on common platform
- Remotely powered devices

Optical Technology Open issues

	>100 Gb/sec Modulation	Low power consumption	Multi-wavelength	Footprint	
Switching	+++	+++	+++	++	?
Amplification	++	++	++	+++	√
Regeneration/ Conversion	++	+++	+++	++	?
Laser/Receiver	+++	+++	+++	+++	√
Waveguides	+++	+++	+++	+++	?
Fibres					√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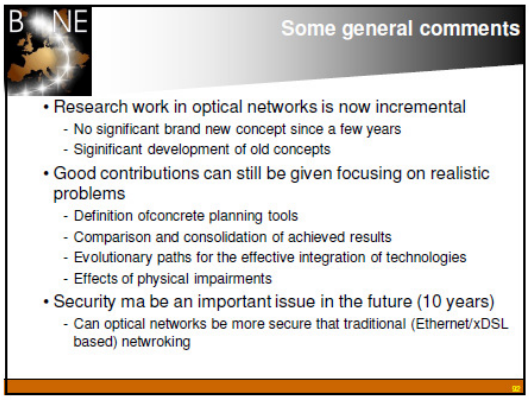
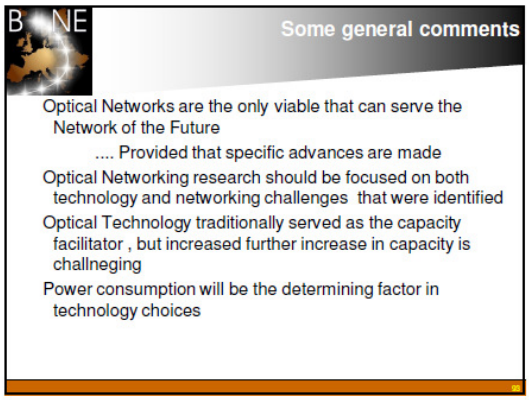
• General Comments


Some general comments
• Research work in optical networks is now incremental
- No significant brand new concept since a few years
- Siginificant development of old concepts
• Good contributions can still be given focusing on realistic problems
- Definition ofconcrete planning tools
- Comparison and consolidation of achieved results
- Evolutionary paths for the effective integration of technologies
- Effects of physical impairments
• Security ma be an important issue in the future (10 years)
- Can optical networks be more secure that traditional (Ethernet/xDSL based) netwroking


Some general comments
Optical Networks are the only viable that can serve the Network of the Future
.... Provided that specific advances are made
Optical Networking research should be focused on both technology and networking challenges that were identified
Optical Technology traditionally served as the capacity facilitator , but increased further increase in capacity is challneging
Power consumption will be the determining factor in technology choices