



SEVENTH FRAMEWORK PROGRAMME

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Abstract:

This deliverable describes organization end execution of BONE schools 2009 (Summer and Master school) that took place at AGH University of Science and Technology (al. Mickiewicza 30, 30-059 Kraków, Poland) in the week of September 28 - October 2, 2009.

Success indicators are also briefly reported.



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)



Disclaimer

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1. Executive Summary :

Two co-located events have been organized by WP02 in the period from 28^{th} September tol 2^{nd} October 2009 at AGHs (partner 38) premises (AGH University of Science and Technology, al. Mickiewicza 30, 30-059 Kraków, Poland): the second BONE **'Summer' School** and the second BONE **Master School**. On Wednesday the 30th September 2009 afternoon took place the **WP02 meeting**.

The **Summer school**, that took place September 28-29, 2009, was dedicated to the theme **'Advances in Core Networks'**. This theme is linked with the WP11 (Virtual Centre of Excellence on Network Technologies and Engineering), and WP22 (TP MPLS, GMPLS and routing) workpackages. Lecturers coming from the BONE NoE proposed in-depth tutorials on several aspects linked to this very hot topic. Time slots have also been allocated to give the opportunity to PhD students and researchers attending the Summer school to present their preliminary or final work results in oral sessions. The number of registered participants to the **Summer school** is 59. They came from 8 different countries and from 13 BONE partners. There were two participants coming from 2 external institutions to BONE project.

The **Master school** consisted in three intensive days (September 30 and October 1-2, 2009) of tutorials (12 hours) devoted to core networks, switching and network optimization. Organization of Master school is in line with fulfilling one of the main objectives in BONE/WP02 "spreading excellence within and outside the project through the organization and execution of common Master study in Optical Communications and Networks combining benefits of teaching in situ, teleteaching or application of learning tools". Selected topic is a part of Master study course curriculum. Participants had the opportunity to optionally extend the Master school on September 30 with a program of practical classes (3 hours).

Some tutorials of Master school were transmitted in real time to TELECOM-Bretagne and FER, enabling interactive teaching. Also all tutorials were stored on server of BONE Directory service enabling delayed video-streaming for all BONE users.

The number of registered participants to the **Master school**, meaning that they were physically present in AGH premises, is 53. They came from 9 different countries and from 10 BONE partners. There were also 2 participants coming from 2 external institutions. On the top of those 53 participants, must be added the 25 TELECOM-Bretagne Master students and 10 from FER who were participating using videoconferencing. This raises the total number of participants to 88, which is a success indicator for such an event. Among the participants, 32 followed only the theoretical courses (September 30 and October 1-2,) and 21 followed the laboratory exercises.



2. General introduction

Through its WP02 teaching activities, as described in Part B of BONE proposal, the BONE project set as one of its major goals the dissemination of its expertise and know-how to the wider audience possible, noticeably by the way of specific courses and workshops.

In this frame, two co-located events have been organized by WP02 in the period 28^{th} September – 2^{nd} October 2009 at AGHs (partner 38) premises (AGH University of Science and Technology, al. Mickiewicza 30, 30-059 Kraków, Poland): the second BONE Master School and the second BONE Summer school.



Figure 1: BONE schools venue

The Summer school, that took place on September 28-29, 2009, was dedicated to the theme 'Advances in Core networks'. This theme is linked with the WP11 (Virtual Center of Excellence on Transmission Techniques) workpackage. Lecturers coming from the BONE NoE proposed in-depth tutorials on several aspects linked to this very hot topic. Time slots have also been allocated to give the opportunity to PhD students attending the Summer school to present their preliminary or final work results in oral sessions.

The **Master school** consisted in three intensive days (September 30 and October 1-2, 2009) of tutorials (12 hours) devoted to '**Optical Core Networks - Selected Areas**'. Organization of Master school is in line with fulfilling one of the main objectives in BONE/WP02 "spreading excellence within and outside the project through the organization and execution of common Master study in Optical Communications and Networks combining benefits of teaching in situ, teleteaching or application of learning tools". Selected topic is a part of Master study course curriculum No.3 *Optical Core Networks (1st coordinator Piero Castoldi and 2nd coordinator Josep sole Pareta) and* No.5 *Photonics in Switching (1st coordinator Lena Wosińska and 2nd coordinator Carla Rafaelli)*. Participants had the opportunity to optionally extend the Master school on September 30 with a program of practical classes (3 hours) in network optimization and planning.

Most tutorials of Master school were transmitted in real time to TELECOM-Bretagne and FER enabling interactive teaching. Also all tutorials were stored on server of BONE Directory service enabling delayed video-streaming for all BONE users.



A dedicated web site (<u>http://bone-school.kt.agh.edu.pl/</u>) has been developed by local organizers to disseminate all information related to both BONE schools and to allow on-line registration.

3. BONE schools organization committees

3.1 Summer school committee

Academic people of AGH as well as some BONE Summer school lecturers, together with some very active WP11 and WP22 partners constituted the Summer school committee:

- Franco Callegati, UniBo, Italy
- Tibor Cinkler, BME, Hungary
- Kevin Heggarty, WP02 co-leader, TELECOM-Bretagne, France
- Andrzej Jajszczyk, AGH-UST, Poland
- Wojciech Kabaciński, PUT, Poland
- Branko Mikac, WP02 leader, FER, Croatia
- Véronique Moeyaert, FPMs, Belgium
- Josep Sole-Pareta, UPC, Spain
- Andrzej Staniszewski, Deputy Dean, EE Faculty, AGH-UST, Poland
- Krzysztof Wajda, chairman, AGH-UST, Poland

3.2 Master school committee

Academic people of AGH as well as all BONE Master school teachers constituted the Master school committee:

- Franco Callegati, UniBO, Italy
- Tibor Cinkler, BME, Hungary
- Kevin Heggarty, WP02 co-leader, TELECOM-Bretagne, France
- Wojciech Kabaciński, PUT, Poland
- Branko Mikac, WP02 leader, FER, Croatia
- Véronique Moeyaert, FPMs, Belgium
- Michel Morvan, TELECOM-Bretagne, France
- Andrzej R. Pach, AGH-UST, Poland
- Salvatore Spadaro, UPC, Spain
- Andrzej Staniszewski, Deputy Dean, EE Faculty, AGH-UST, Poland
- Krzysztof Wajda, chairman, AGH-UST, Poland
- Lena Wosińska, KTH, Sweden



Local organizing committee (AGH-UST):

- Jerzy Domżał
- Mirosław Kantor
- Paweł Korus (webmaster)
- Krzysztof Monist
- Marcin Niemiec
- Joanna Putała
- Jacek Rząsa
- Dorota Tischner
- Krzysztof Wajda
- Robert Wójcik

4. BONE Summer school

4.1 Goal of BONE Summer school and targeted audience

The general goal of BONE schools is to disseminate the Network of Excellence knowledge. Particularly, **BONE Summer schools**, should accelerate the training of PhD students as well as to give them opportunity to present research results. In this purpose, in-depth tutorials on a subject related to one of the BONE WP are proposed, as well as special session for PhD students.

In this particular case, the second BONE Summer school, that took place on September 28-29 2009, was dedicated to the theme 'Advances in Core Networks' that is linked with WP11-Virtual Centre of Excellence on Transmission Techniques and also with WP22 activities. In this frame, lecturers coming from our BONE NoE proposed tutorials on several aspects linked to this very hot topic. Namely, they are: Prof. Andrzej Jajszczyk (AGH, Poland), Prof. Franco Callegati (UniBO, Italy), Prof. Josep Sole Pareta (UPC, Spain), Prof. Chris Develder (IBBT, Belgium), Prof. Lena Wosińska (KTH, Sweden).

In addition to the lectures prepared by the invited speakers, the students were also offered a possibility to share the effects of their research. There was an opportunity to submit an article published in the proceedings. All submitted papers were briefly reviewed by Members of Committee.

The targeted audience was mainly BONE PhD students and BONE senior researchers, although the event was also open to non-BONE members, mainly staff and students of AGH.

The second BONE Summer school encountered some success with more than 59 participants coming from 9 different countries and 13 institutions (plus 2 external institutions).

Pdf versions of presentation files have been stored on the private part of the general BONE website <u>www.ict-bone.eu</u>.



4.2 BONE Summer school schedule

Paragraph 4.2 describes precisely the schedule of the first BONE Summer school. As shown, get-together events were also organized in order to improve social aspects and to facilitate technical discussions among participants.



Monday September 28th 2009

Day 1 - Monday September 28th 2009		
08h30	09h30	Registration
09h30	09h45	Welcome address by AGH-UST authorities (Professor Andrzej Pach, Head of Telecommunications Department) and BONE representative (Professor Branko Mikac)
09h45	10h45	Multilayer resilience (Professor Andrzej Jajszczyk - AGH-UST, Poland))
10h45	11h15	Break
11h15	12h15	Congestion Resolution in Optical Packet Switching - PART 1 (Professor Franco Callegati - UniBO, Italy)
12h15	13h45	Lunch break
13h45	14h45	Congestion Resolution in Optical Packet Switching - PART 2 (Professor Franco Callegati - UniBO, Italy)
14h45	15h30	From Interoperable OBS-GMPLS Networks to Optical MPLS - PART 1 (Professor Josep Sole Pareta - UPC, Spain)
15h30	16h00	Break
16h00	16h30	From Interoperable OBS-GMPLS Networks to Optical MPLS - PART 2 (Professor Josep Sole Pareta - UPC, Spain)
16h30	17h30	Presentation of papers by school participants
17h30	18h15	Break
18h15		End of DAY 1 - departure for social event
19h00	22h00	Visit to Salt Mine in Wieliczka and Welcome dinner

4.2.2

Thursday September 29th 2009

Program

Day 2 - Tuesday September 29th 2009		
09h00	10h30	Optical grids (Professor Chris Develder - IBBT, Belgium)
11h00	12h30	Photonics in Switching (Professor Lena Wosinska - KTH, Sweden)
12h30	14h00	Lunch break
14h00	16h00	Presentation of papers by school participants
16h45		End of DAY 2







4.3 BONE Summer school tutorial program and lecturers

Five in-depth tutorials were proposed to the BONE Summer school attendees on subjects related to the theme 'Advances in Core Networks'.

The content of each tutorial, as well as the lecturer biography, are detailed below.

Multilayer resilience

Professor Andrzej Jajszczyk

AGH-UST, Poland

Abstract: Networks have a layered structure in the sense that different transmission technologies offer services that are used by others, providing different granularities and a more sophisticated functionality. The talk presents recovery provisioning methods for such networks. First, a brief outline of terminology related to network resilience is given. Then, an overview of basic recovery methods is presented. Next, multilayer networking concepts are outlined and discussed. The talk is focused on two-layer networks where an IP layer is placed on top of the optical layer. However, most of the presented concepts can be easily extended to networks containing more than two layers. It will be shown that in multilayer networks approaches to resilience focusing on a single layer only may lead to limited or even unsuccessful recovery. Therefore, some mechanisms are needed that enable using recovery procedures at more than one layer. The proper operation of recovery mechanisms at several layers requires some coordination between layers to avoid contention between these mechanisms. The relevant approaches including escalation strategies, integrated multilayer recovery, the common pool survivability, and the dynamic multilayer recovery will be presented and discussed. The talk will be concluded by a brief overview of enabling technologies for multilayer recovery.

Professor Andrzej Jajszczyk is a Professor at AGH University of Science and Technology in Krakow, Poland. He received M.S., Ph.D., and Dr Hab. degrees from Poznan University of Technology in 1974, 1979 and 1986, respectively. He spent a year at the University of Adelaide in Australia and two years at Queen's University in Kingston, Ontario, Canada as a visiting scientist. He is the author or co-author of six books and more than 250 papers, as well as 19 patents in the areas of telecommunications switching, high-speed networking, and network management. His current research interests focus on control plane architectures for transport networks, quality of service and network reliability. He has been a consultant to industry, telecommunications operators, and government agencies in several countries. Since January 2008 he is Vice-President of IEEE Communications Society.





Congestion Resolution in Optical Packet Switching

Franco Callegati

UniBO, Italy

Abstract: The talk will address the issue of congestion resolution in Optical burst/packet switching. It will discuss the various strategies that are available and focus on the use of the time and channel domain. The first part will address the issue of congestion resolution in the time domain with delay lines, providing an overview of the performance evaluation tools available. Then congestion resolution algorithm using time and channel domain to enhance performance will be discussed, proposing an original comparison framework to evaluate the cost/performance trade-off of the various solutions. Finally a possible implementation in dedicated hardware will be presented addressing the main problems and features.

Professor Franco Callegati is Assoc. Prof. of Telecommunication Networks at DEIS. His research interests are in the field of teletraffic modelling and performance evaluation of telecommunication networks. He is currently working on optical packet and burst switching. He has been active in several UE funded research projects. For furher details please refer to:

http://www.unibo.it/docenti/franco.callegati

From Interoperable OBS-GMPLS Networks to Optical MPLS

Josep Sole Pareta

UPC, Spain

Abstract: This talk will start reviewing some key conceptual aspects of the Optical Packet Switching (OPS) networks based on the Virtual Circuits scheme. In particular it will refer to the, so called, Optical MPLS (OMPLS). Nevertheless, since the current status of the optical technology is far to can provide what OMPLS requires to be deployed, the second part of the talk will rely on Optical Burst Switching (OBS) as a shorter-term available technology. Here two issues will be addressed, namely a proper OBS node architecture to be implemented, and the design of an interoperable GMPLS/OBS Control Plane. The former aiming to make possible the coexistence between OBS and OPS, and the latter to allow the migration from the Optical Circuit Switching (OCS) networks, currently under deployment, to the OBS networks.

Professor Josep Sole Pareta (pareta@ac.upc.edu) obtained his M.Sc. degree in Telecom Engineering in 1984, and his Ph.D. in Computer Science in 1991, both from the Technical University of Catalonia (UPC). In 1984 he joined the Computer Architecture Department of UPC. Currently he is Full Professor with this department. He did a Postdoc stage (summers of 1993 and 1994) at the Georgia



ofTechnology. He is co-founder of the UPC-CCABA Institute (http://www.ccaba.upc.edu/). His publications include several book chapters and more than 100 papers in relevant research journals (> 25), and refereed international conferences. His current research interests are in Nanonetworking Communications, Traffic Monitoring and Analysis and High Speed and Optical Networking, with emphasis on traffic engineering, traffic characterization, MAC protocols and QoS provisioning. He has participated in many European projects dealing with Computer Networking topics.

Photonics in Switching

Professor Lena Wosinska KTH, Sweden

Abstract: The concept of optical transparency refers to the property of an optical network to show independence with respect to a number of characteristics, such as bit rate, protocol, modulation format. Optical transparent networks, based on WDM technology, seem to be the most promising candidates for future high capacity backbone networks. In such networks, switching functions will be carried out directly in the optical domain so that high speed optical signals can travel through the network without any optical-to-electrical conversion. Different switching paradigms can be applied to exploit the optical technology in terms of different switching granularities. These are: optical circuit switching OCS (referred to as wavelength routed optical networks), optical burst switching OBS and optical packet switching OPS. The optical circuit switching (OCS) paradigm (mostly at wavelength level) is a technique to offer huge bandwidth in the backbone network. This approach provides access to bandwidth with a coarse granularity. It provides end-to-end optical channels (lightpaths) between source and destination nodes. Lightpath can be set up and torn down on request. One of the most important challenges in OCS networks is solving routing and wavelength assignment (RWA) problem, which consists of finding a suitable physical route for each lightpath request, and assigning an available wavelength to that route. Demands to set up lightpaths may be known in advance and set up semi-permanently (static or off-line), or can arrive in a random manner with random holding times (dynamic or on-line). In the static case, the common objective of RWA is to minimize the resources (such as number of wavelengths or number of fibers) that will be needed to support all the lightpaths in the network, while in the dynamic scenario lightpath blocking probability is a major performance characteristic. A suitable OCS node architecture (referred to as optical cross connect OXC) can significantly improve the blocking performance. In contrast to OCS, optical burst switching (OBS) is based on statistical multiplexing, which can increase the efficiency of network resource utilization. OBS networks mainly consist of two types of switching nodes, namely edge and core nodes. The edge node can aggregate client data (e.g., IP packets) into bursts. Each burst has an associated control header. Usually, a burst is separated from the control header by the interval of offset time. This characteristic is helpful to overcome the infancy of optical



hardware logic. The main functions of the edge nodes are optical burst assembly/disassembly, offset time and burst size decision. The OBS core nodes perform control header lookup, optical cross-connecting and data burst monitoring. Compared with the edge nodes, the core nodes can have relatively simple structure. In optical packet switching (OPS), packets are buffered and routed in the optical domain. In contrast to OCS and OBS, OPS networks have the switching granularity on the packets level. The functionality of OPS node should include: decoding packet header, (can be electronic if the packet header is encoded at lower bit rates), configuring a switch fabric (the reconfiguration needs to be performed very fast in nanosecond range), synchronization (for synchronous OPS nodes), multiplexing, and contention resolution. The lack of flexible optical buffers makes the contention resolution in optical domain very difficult.

Professor Lena Wosinska received her M. Sc. degree in Electrical Engineering from the Warsaw Institute of Technology, Poland, Ph.D. degree in Photonics and Docent degree in Optical Networking from the Royal Institute of Technology (KTH) in Stockholm, Sweden. She joined the Royal Institute of Technology in 1986 where she is currently an Associate Professor in the School of Communication and Information Technology (ICT) heading a research group working on optical networking and teaching courses on optical networking and queuing theory. She is currently coordinating projects on All-optical Overlay Network and Next-generation Fiber Access Networks as well as Swedish part of Eureka/Celtic project on Management Platform for Next Generation Optical Networks. She is an Associate Editor of IEEE/OSA Journal of Optical Communications and Networking JOCN. Her research interests include optical network management, reliability and survivability of optical networks, photonics in switching and fiber access networks.

Optical grids

Professor Chris Develder IBBT, Belgium

Abstract: This talk will briefly introduce the origin and concepts of Grids and their relation to optical networking. Optical network architectures will be discussed with respect to their suitability to support Grid applications, covering both optical circuit switching (OCS) and optical burst switching (OBS) as well as hybrids. Subsequently, Grid routing and scheduling challenges will be outlined, highlighting the difference with classical routing and scheduling approaches. Next, the Grid dimensioning problem will be addressed, explaining how it differs from classical optical network dimensioning problem. All these issues will be illustrated with relevant case studies.

Professor Chris Develder received the M.Sc. degree in computer science engineering and a Ph.D. in electrical engineering from Ghent University (Ghent, Belgium), in July 1999 and December 2003 respectively. From October 1999 on, he has been working in the Department of Information Technology (INTEC), at the same university, as a Researcher for the Research Foundation—Flanders (FWO), in the field of network design and planning, mainly focusing on optical packet switched



networks. In January 2004, he left University to join OPNET Technologies, working on transport network design and planning. In September 2005, he re-joined INTEC at Ghent University as a post-doctoral researcher, and as a post-doctoral fellow of the FWO since October 2006. In July-October 2007 he enjoyed a post-doctoral internship at UC Davis, CA, with prof. Biswanath Mukherjee. Since October 2007 he holds a part-time professor position at Ghent University. He was and is involved in multiple national and EU-funded research projects. His current research focuses on dimensioning, modeling and optimizing optical Grid networks and their control and management, as well as multimedia and home network software and technologies.

4.4 BONE Summer school PhD program

BONE PhD students had the opportunity to present their preliminary or final thesis results to their peers during the Summer school. The aim of this initiative was two-folds: to stimulate interactions between participants (either PhD students or senior researchers) and to train PhD students to English oral scientific communications.

Following paragraph lists the oral presentations proposed and given by the participants.

4.4.1

Oral presentations

Day 1 - Monday September 28th 2009

- **16h30** Analysis and Modeling of Multipath Resilient Ad-hoc Network Gerson Rodríguez de los Santos Lópe, José Alberto Hernández
- **16h50** Experimental Characterization of the Noise Power Spectral Density of Slow Light SOA-based Microwave Photonic Phase Shifters Juan Lloret, Francisco Ramos, Juan Sancho, Ivana Gasulla, Salvador Sales, José Capmany
- **17h10** Application Support for Core Networks in Business Company Rafał Watza
- Day 2 Tuesday September 29th 2009
- **14h00** Harmonic Distortion in SOA based Slow Light Microwave Photonic Phase Shifters

Juan Sancho, Ivana Gasulla, Juan LLoret, Salvador Sales, José Capmany

- **14h20** Wavelength Assignment for Minimizing Intra-Channel Crosstalk Attack Propagation in Optical Networks Marija Furdek, Nina Skorin-Kapov
- 14h40 Advantages of Batch Service Interconnection Request Provisioning in PCE-based Grid Networks – An Overview Paweł Korus, Mirosław Kantor
- **15h00** *Parallel in-band OSNR monitoring of DWDM channels in ROADM-based networks* Mervin Obeegadoo, Philippe Gravey, Tatiana Loukina
- 15h20 Non-shortest Path Routing Schemes for the Construction of Memory Efficient Routing Tables in Core Networks Przemysław Bereski, Piotr Pacyna



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15h40 Security requirements in quantum cryptography Marcin Niemiec



Figure 2: M. Furdek (FER, Croatia) giving presentation during PhD students slot).

4.5 BONE Summer school participation

Figure 3 shows the repartition table of Summer school participants depending on their provenance and their participation to the content of the school.

Country	Entity	Number of participants	Presentation of one
			(or several) course(s),
			paper(s) or poster(s)
Belgium	IBBT	1	Yes
Croatia	FER	8	Yes
France	TELECOM-Bretagne	3	Yes
Hungary	BUTE	1	Yes
Italy	POLIMI	1	
	FUB	1	
Poland	AGH (2 ext.)	17	Yes
	ComArch (external)	1	
	PUT	2	
Spain	UPV	2	Yes
	UPC	1	Yes



	UC3M	1	
Sweden	KTH	4	
Countries 8	Institutions 13 (2ext.)	59	

Figure 3: Repartition of Summer school participants.

The number of registered participants to the Summer school is 59. They came from 8 different countries and from 11 BONE partners. There were also two participants coming from WUT and ComArch (Poland).

A certificate of participation was distributed to each participant at the end of the Summer school. An example can be found at Annex 2.

5. BONE Master school

5.1 Goal of first BONE Master school and targeted audience

The general goal of BONE schools is to disseminate the Network of Excellence knowledge. Particularly, BONE Master schools are aimed to propose and test the courses that were developed by within teaching working packages in the frame of e-Photon/ONe and e-Photon/ONe+ NoEs (2004-2008)

(see <u>- https://www.e-photon-one.org/ephotonplus/intranet/Intranet.Generar?seccio=1_1_16_3_2</u>).

In the frame of second BONE Master School, WP02 decided to test the slides of e-Photon/ONe+ course $n^{\circ}3$ and $n^{\circ}5$:

https://www.e-photon-one.org/ephotonplus/intranet/Intranet.Generar?seccio=1_1_16_3_2_2).

Among the available set of slides belonging to course $n^{\circ}3$ and $n^{\circ}5$, 17 hours of theoretical courses have been selected. Teachers from the BONE community have accepted to give the courses, using and improving the set of slides that were previously developed (cf. paragraph 5.3):

Moreover practical classes (3 hours) related to the theoretical courses were especially developed at this occasion under the responsibility of Dr. Pablo Pavon Marino from UPCT. The title of the practical class is '**Optimization and planning in optical networks**'. Participants were free to choose those complementary hours and were divided into different groups to facilitate the learning.

The targeted audience was mainly two-folds, although the event was also open to non-BONE members:

- 1. Master school students of BONE Universities;
- 2. PhD students willing to improve their knowledge in the Master school theme and/or to collect ECTS in the frame of their doctoral training.



The first BONE school encountered some success with more than 65 participants coming from 9 different countries. Particularly, FER and TELECOM-Bretagne (by videoconferencing) enrolled their respective regular Master students to this BONE event.

5.2 Master school schedule

Below is included the schedule of the second BONE Master School, with or without the complementary practical classes. As shown, get-together events were also organized in order to improve social aspects and facilitate technical discussions among participants.

Program

Day 1 -	Day 1 - Wednesday September 30 th 2009		
08h30	09h30	Registration	
09h30	09h45	Welcome address by AGH-UST authorities (Prof. Tomasz Szmuc, Deputy Rector for Science and BONE representative (Prof. Branko Mikac)	
09h45	10h45	ILP (Integer Linear Programming) for Optimising Operation of Optical Networks (Professor Tibor Cinkler - BME, Hungary)	
10h45	11h15	Break	
11h15	12h30	Optimization and planning in optical networks - PART 1 (Dr Pablo Pavon Marino - UPCT, Spain)	
12h30	13h15	Lunch break	
13h15	14h00	Optimization and planning in optical networks - PART 2 (Dr Pablo Pavon Marino - UPCT, Spain) Optimization and planning in optical networks - practical exercises (Dr Pablo Pavon Marino - UPCT,	
14h00	16h45	Spain)	
15h30	15h40	Break	
16h45		End of DAY 1 - departure for social event	
16h45	20h00	Guided tour	
15n30 16h45 16h45	15h40 20h00	Break End of DAY 1 - departure for social event Guided tour	

Day 2 - Thursday October 1st 2009

-		
09h00	10h30	Multilayer traffic engineering (Professor Tibor Cinkler - BME, Hungary)
10h30	11h00	Break
11h00	12h30	ASON/GMPLS (Dr Salvatore Spadaro - UPC, Spain)
12h30	14h00	Lunch break
14h00	15h30	Physical impairments in GMPLS networks (Professor Piero Castoldi - SSSUP, Italy)
15h30	16h00	Break
16h30	18h00	The impact of optics on networking (Dr Michel Morvan - FT, France)
18h00		End of DAY 2
20h00	22h30	Dinner in Kraków city center



Day 3 - Friday October 2 nd 2009		
09h00	10h30	Impairment-aware Design of Core Optical Networks (Dr Kostas Katrinis - AIT, Greece))
10h30	11h00	Break
11h00	12h30	Switching technologies - PART 1 (Professor Wojciech Kabaciński - PUT, Poland)
12h30	14h00	Lunch break
14h00	15h30	Switching technologies - PART 2 (Professor Wojciech Kabaciński - PUT, Poland)
15h30		End of DAY 3
20h00	22h30	Social event - bowling

5.3 Master school teachers

Master school teachers were exclusively coming from the BONE community, with a majority of courses endorsed by teachers who were part of e-Photon/ONe+ course $n^{\circ}3$ and $n^{\circ}5$. All names and biographies are listed below.

Multilayer traffic engineering

Professor Tibor Cinkler

BME, Hungary

Abstract (**MTE**): The simplest definition of TE (Traffic Engineering) is to put the traffic, where enough resources are available. However, in a multi-layer network there arises the question at what level should the actions be performed? In this course a few 'a priori' and 'a posteriori' approaches will be shown that distribute the traffic in the network with TE-objectives as well as they help the network to adapt to traffic conditions.

Abstract (**ILP**): Integer Linear Programming became a popular tool for solving various optimisation problems. Although it is typically a brute force approach, as the computation capacity of computers grows and the parallel ILP solvers evolve its importance grows. Often we use ILP as a reference in evaluating various faster and more scalable heuristics or we use various heuristics and tricks to make ILP feasible. In this short course examples will be shown, that explain how ILP works, how can it be applied to various problems, what are the obstacles, and what the strengths of using ILP, heristics and modelling tricks. The examples include the following:

- * TE formulations and polytope representation
- * Resilience



- * Multicast
- * Routing with Physical Impairments

Professor Tibor Cinkler has received M.Sc.('94) and Ph.D.('99) degrees from the Budapest University of Technology and Economics (BME), Hungary, where he is currently associate professor at the Department of Telecommunications and Media Informatics (TMIT). His research interests focus on optimisation of routing, traffic engineering, design, configuration, dimensioning and resilience of IP, Ethernet, MPLS, ngSDH, OTN and particularly of heterogeneous GMPLS-controlled WDMbased multilayer networks. He is co-author or author of over 180 refereed scientific publications and of 4 patents. He has been involved in numerous related European and Hungarian projects and he has been member of Scientific and Programm Committees of numerous conferences. He teaches related graduate and postgraduate (BSc, MSc, PhD) courses and he gave tutorials at ICC and ITC conferences and at the e-Photon/ONe Winter School.

Physical impairments in GMPLS networks

Professor Piero Castoldi

SSSUP, Italy

Abstract: Nowadays, the automatic end-to-end lightpath provisioning is based on Generalized MultiProtocol Label Switching (GMPLS) protocols and it assumes that every route, eligible by the routing protocol, is characterized by a satisfactory optical signal quality, i.e., quality of transmission (QoT). This talk will review recent approaches for inclusion within the GMPLS protocol suite at the routing protocol or signaling protocol level of (i) Quality of Transmission (QoT) information for transparent optical networks and (ii) regenerator awareness for translucent networks. Simple and accurate models for describing optical propagation and regeneration are considered and the relevant extensions for inclusions within GMPLS are presented.

Professor Piero Castoldi (SSSUP, Italy) received his Master Degree from the University of Bologna, Italy, in 1991 and the PhD degree in Information technology from the University of Parma, Italy in 1996. He is currently Associate Professor at Scuola Superiore Sant'Anna, Pisa, Italy, where he is Area Leader of the "Networks and Services" area. Since January 2005 he has been also Director of the CNIT National Laboratory of Photonic Networks. His recent research interests cover reliability, switching paradigms and control of optical networks, including application-network cooperation mechanisms. He is author of more than 150 publications in international journals and conference proceedings.



ASON/GMPLS

Dr Salvatore Spadaro

UPC, Spain

Abstract: Legacy Time Division Multiplexing-based networking architecture was basically designed to transport symmetric voice traffic. However, the volume of data traffic is increasing at explosive rate and already dominates the voice traffic. The current transport networks (both SONET/SDH and Optical Transport Networks (OTN)) tend to be static, which means that connections are provided manually through the Network Management System (NMS). However, the bandwidth provisioning through the NMS is time consuming. The advent of reconfigurable optical systems, such as the Reconfigurable OADMs (ROADMs), open the possibility for the reconfiguribility of optical networks, providing therefore the possibility of implementing a network architecture where the optical layer is able to react to dynamic changes in the traffic and lightpath requests. The introduction of the ASON/GMPLS paradigm is recognized as the enabling solution to allow fast and flexible end-to-end bandwidth provisioning.

Dr Salvatore Spadaro (UPC, Spain) received the M.Sc. (2000) and the Ph.D. (2005) degrees in telecommunications engineering from Universitat Politècnica de Catalunya (UPC). He also received the Dr.Ing. degree in electrical engineering from Politecnico di Torino (2000). He is currently an Associate Professor in the Optical Communications Group of the Signal Theory and Communications Department of UPC. Since 2000 he has been a staff member of the Advanced Broadband Communications Center (CCABA) of UPC, and he is currently participating in the DICONET and BONE FP7 EU projects. He has coauthored about 80 papers in international journals and conferences. His research interests are in the field of all-optical networks with emphasis on traffic engineering and resilience.

Optimization and planning in optical networks

Dr Pablo Pavon Mariño

UPCT, Spain

Abstract: The "Optimization and planning in optical networks" course is focused on optimization and planning problems that arise in optical network, with special focus on the transparent/translucent optical WDM (Wavelength Division Multiplexing) networks. This network paradigm is expected to be the infrastructure of the Future Internet. In the first section, some relevant optimization techniques involved in optical network optimization will be reviewed and categorized. In the second section, a categorization of optical network planning problems will be presented. In the third section, a comprehensive set of examples will be provided. Each example should apply one or more of the categorized optimization techniques, into some of the categorized optical network planning problems. Finally, lab work is proposed for exemplifying the optimization and planning of multilayer transparent optical



educational version of the MatPlanWDM v0.51 tool networks with an (http://www.matlabcentral.com). The lecturing of the "Optimization and planning in optical networks" course in the BONE Master School will be adapted to the time availability. The first part of the course will be devoted to a short introduction with the main links to major optimization techniques for network planning. The second part will make a brief description of some of the "classical" network planning problems in optical networks. Then, a case study will be proposed, in which a planning problem will be more intensely described. The students are then intended to implement their own heuristic algorithms applying one or more of the optimization techniques suggested by them and/or by the lecturers, using the MatPlanWDM tool. Finally, the algorithms created by the students will be compared in different problem instances, using the MatPlanWDM v0.51 tool "what-if" functionality. These will automate the creation of a ranking of results, and should motivate a discussion on the merits of each algorithm. Required material: MatPlanWDM v0.51 tool, which runs on MATLAB 7.0 or higher version. The public version of the tool (to be used in the course) can be downloaded in

http://www.mathworks.com/matlabcentral/fileexchange/13791

Dr Pablo Pavon Mariño (UPCT, Spain) was born in Ourense (Spain). He received his Telecommunications Engineering degree from the University of Vigo (Spain) in 1999. In 2000 he joined the Polytechnic University of Cartagena (Spain), where he received his Ph.D. degree in Telecommunications in 2004. Currently, he is an Associate Professor in the Department of Information Technologies and Communications. He is involved in teaching BSc, MSc and doctorate degree courses in the fields of network planning and optimization. His research interests include optimization and planning of optical networks, and performance evaluation of optical switching systems.

Switching technologies

Professor Wojciech Kabaciński PUT, Poland

Abstract: The aim of the lecture is to provide basic knowledge about switching architectures and implementations. Firstly, what is switching and where it is used will be presented, followed by notations used in the lecture. Basic taxonomy and switching fabric classification will be given. Than photonic switching technologies will be presented and switching fabric architectures and their characteristics will be discussed and compared. Control algorithms for different architectures will be also considered.

Professor Wojciech Kabaciński (PUT, Poland) Professor Wojciech Kabaciński (PUT, Poland) has received M.Sc. (83) and PhD (88) degrees from the Poznan University of Technology, Poland, where he is currently the full professor at the Chair of Communication and Computer Networks. His research interests focus on



switching fabric architectures, control algorithm, broadband and photonic switching, and also signaling in telecommunication networks. He co-authored several books (some in Polish) on switching, signaling and telecommunication networks and over 150 papers on switching and control algorithms. In 2005-2009 he was the chair of Communications Switching and Routing Technical Committee of IEEE Communication Society. He is also the TPC member of many international conferences and the editorial board member of IEEE Communication Magazine and IEEE Communications Survey and Tutorial.

Impairment-aware Design of Core Optical Networks

Dr Kostas Katrinis AIT, Greece

Abstract: At the phase of planning a new network deployment, telecom providers are confronted with devising a topological design and placement of capacity on network machinery so as for the network to be able to sustain an anticipated volume of traffic, while minimizing total expenditure costs. Similar questions arise when a deployed network infrastructure undergoes growth cycles. All these create interesting optimization problems that depending on the particularities of the problem definition are either known to be solved to optimality or otherwise can be only solved approximately within polynomial time bounds. In this course, we will formalize the problem of designing/dimensioning optical core networks, using realistic design constraints and cost-modelling factors. Special focus will be given on cross-layer design methods, i.e. methods that incorporate physical-layer awareness into the design process, specifically through the consideration of the effects of physical impairments along with conventional network design constraints.

Dr Kostas Katrinis (AIT, Greece) Kostas Katrinis is a post-doctoral researcher at the Athens Information Technology (AIT), pursuing research on the design and optimization of dependable and sustainable communication systems, with emphasis on next-generation optical transport networks. He holds a PhD degree from the ETH Zurich and a Diploma in Computer Engineering from the University of Patras (Greece). In the past, he has conducted research on group communication in the Internet, multimedia communication and overlay networks.

The impact of optics on networking

Dr Michel Morvan

Telecom Bretagne, France

Abstract: Since the early days of optical fibre in the 70's; Optical Networking has been evolving from simple point to point Mbit/s transmission systems to sophisticated and advanced Tbit/s optical transport networks based on a



comprehensive body of international standards. This amazingly successful evolution is mainly due to the huge progress accomplished at the physical layer. Hence; the links between the physical aspects of optical transmission and network considerations are exposed and explicated. On one side, technologies such as single mode fiber optics, fiber amplifiers, tunable optical devices and ultra high speed digital processing, have all opened new networking possibilities. Hence, the different generations of optical transmission systems are presented not only from an historical perspective but also from a functional point of view. On the other side, client networks and new services constantly demand for more flexibility, reliability, bandwidth efficiency, ease of operation and cost reduction and pose new challenges to optical transport networks. Finally, we conclude by exposing the possible future of optical networking.

Dr Michel Morvan (TELECOM-Bretagne, France) Michel Morvan received his engineering degree from the Ecole Nationale Supérieure de Télécommunications de Bretagne in 1988. He started his career in 1989 as a research engineer at France Telecom R&D (formerly CNET) in Lannion (France) where he successively worked on optical coherent detection systems, PMD line characterization for high bit rate transmission networks, SDH//WDM equipment evaluation and network architectures. He then occupied a senior network architect position at Sycamore Networks where he designed SDH/WDM backbone and metro networks. In October 2002, he joined the optics department of TELECOM Bretagne, part of the "Institut TELECOM", as a senior lecturer and researcher. He lectures on optical components and transmission systems, system design and simulation as well as optical networking. His current research activities are focused on the evolution of both access and metro networks architectures.

5.4 On the use of Communication Technologies at the Master school

The AGH local organization has realized:

- 1. A two days-long videoconference connection between AGHs and TELECOM-Bretagne (France) and FER premises to allow Master school students to follow and participate to the courses located in Mons;
- 2. An 'on-fly' synchronization between the video and the slides presentation that allowed AGH to diffuse by video streaming, from the password protected BONE directory service, each Master school course right from its end;
- 3. The storage of all teachers slides presentations.

As stated in the BONE project WP02 activities description, 'at least two distance teaching experiments, as teleconferences, of selected module will be performed in the period of project'. This has already been realized in the frame of the first BONE Master School. Indeed, 25 Master students from TELECOM-Bretagne (Brest, France) and FER (Zagreb, Croatia) were fully connected by videoconferencing during the two days of theoretical courses (see **Figure** 4).



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Figure 4: Prof. M. Morvan (TELECOM Bretagne) teaching his course. TELECOM-Bretagne and FER Master students projected on the right handside blackboard.

5.4.1

Video courses streaming and storage

During each course, the synchronization between the respective audio track and slides presentation has been realized by AGH technical staff. It allowed diffusing the contents by recorded lectures after each course.

At the time of writing this deliverable, courses storage is still on the internal AGH-BONE directory service but will be transferred as soon as possible on the private part of the general BONE website <u>www.ict-bone.eu</u>.

5.4.2

Storage of presentation files

Each course presentation file in power point and/or pdf format has been stored on the private part of the general BONE website <u>www.ict-bone.eu</u>, as well as the practical classes' protocols.



5.5 Master school official documents

The certificate of participation have been distributed in the frame of the first BONE Master School (see an example in Annex 1) This certificate describing the content of the theoretical courses was distributed to all Master school participants. Depending on local ECTS evaluation rules, this is sometime sufficient to allow participants to collect ECTS for their doctoral training.

5.6 Master school participation

Figure shows the repartition table of Master School participants depending on their provenance and on the program they followed.

Country	Entity	Total number of participants
Austria	TUW	1
Croatia	FER	7
France	TELECOM- Bretagne	2 = 27
Greece	AIT	1
Hungary	BUTE	1
Italy	POLIMI	2
	SSSUP	1
	FUB	1
Poland	AGH	19
	ComArch (ext.)	1
	PUT	5
	WUT (ext.)	1
Spain	UPV	2
	UPC	1
	UPCT	1
	UC3M	1
Sweden	KTH	5
9	10 + 2(*)external	53 + 25 + 10 = 88

Figure 5: Repartition of the Master school audience among partners.

The number of registered participants to the Master school, meaning that they were physically present in AGH premises, is 53. They came from 9 different countries and from 10 BONE partners. There were also two participants coming from outside of BONE. On the top of those 53 participants, must be added the 25 TELECOM-Bretagne Master students plus 10 from FER who were participating to the event **using videoconferencing**. This raises the total number of participants to 88, which is a success indicator for such an event.



Among the participants, 37 followed only the theoretical courses (September 30 and October 1-2, 2009) and 21 followed laboratory exercises.

6. Co-located event: WP02 meeting

On Wednesday the 30th September 2009 afternoon took place the WP02 meeting in parallel with the Master school courses. It was chaired by the WP02 leader, Branko Mikac (FER, Croatia).

The agenda was the following:

- 1. Deliverables and milestones;
- 2. Curriculum and teaching materials of BONE Master Study;
- 3. Scoring system for evaluation of WP02 activities;
- 4. Draft presentation for plenary session in October 2009.

Results of discussions were presented by Kevin Heggarty (TELECOM-Bretagne, France), WP02 co-leader, at the BONE plenary session in Poznań, the 5th of October 2009.

7. Conclusions

As conclusion, we would like to state that WP02 fully completed its task foreseen for the D02.3 deliverable and reported 5-day event held in AGH premises was successfully accomplished.

Following achievements should be itemized:

- 1. 12 lectures by experts from NoE BONE;
- 2. Distance learning by videoconferencing;
- 3. Video streaming and video courses storage;
- 4. Practical exercises devoted to network planning;
- 5. A co-located event, called BONE 'Summer' school, devoted to PhD student training and interactions.



Annex 1: Example of Summer School certificate of participation

Faculty of Electrical Engineering, Automatics, Computer Science and Electronics



CERTIFICATE of PARTICIPATION

This document is to state that

Marija FURDEK (University of Zagreb – Croatia)

has attended the SUMMER SCHOOL 2009 of the BONE European Network of Excellence, which was held the 28th and 29th of September 2009 at the Department of Telecommunications, AGH University of Science and Technology, Krakow, Poland.

Krakow, the 28th of September 2009

U. Woje

Krzysztof WAJDA Local Organizing Committee



http://www.kt.agh.edu.pl tel.: +48 12 617 39 37, fax: +48 12 634 23 72

AGH University of Science and Technology, al. Mickiewicza 30, 30-059 Kraków, Poland



Annex 2: Example of Master School certificate of participation



Faculty of Electrical Engineering, Automatics, Computer Science and Electronics

CERTIFICATE of PARTICIPATION

This document is to state that

Jawwad AHMED (KTH Royal Institute of Technology - Sweden)

has attended the MASTER SCHOOL 2009 of the BONE European Network of Excellence, which was held the 30th of September – 2nd of October 2009 at the Department of Telecommunications, AGH University of Science and Technology, Krakow, Poland.

Krakow, the 30th of September 2009

U. Wy-

Krzysztof WAJDA Local Organizing Committee



http://www.kt.agh.edu.pl tel.: +48 12 617 39 37, fax: +48 12 634 23 72

AGH University of Science and Technology, al. Mickiewicza 30, 30-059 Kraków, Poland



Annex 3: Summer School and Master School dedicated web page

