SEVENTH FRAMEWORK PROGRAMME

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Abstract:

This document is the first deliverable of the WP26 “Topical Project on Alternatives for Multi-layer Networking with Cross-Layer Optimization”. This report contains the participant’s expertise, and also planned activities into the BONE project. There are seventeen partners interested and involved in this work package and five joint activities are proposed. Moreover, three mobility actions are planned during the two years term of this work package.

Keyword list:

Joint Activities, planned activities, inventory of expertise

Disclaimer

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Table of Contents

Executive Summary:

This document is the first deliverable of the work package “Typical Project on Alternatives for multi-layer networking with cross-layer optimization”. The main objectives of this deliverable are to provide and compile the partner expertise and also the planned joint activities so far in the framework of BONE project. According to the Annex I (Description of Work) of BONE project, there are 17 partners interested and involved in this work package. Based on common research topics five (5) joint activities are proposed and planned so far. The topics covered and planned by this work package try to address multi-layer networking and cross-layer optimization including: Multilayer algorithm using Bayesian decision theory, Routing and Wavelength Assignment considering the physical layer impairments, ICBR (Impairment Constraint Based Routing) algorithms considering physical impairments and traffic grooming. Moreover, one joint activity pay attention to the traffic engineering in integrated and interconnected control plane models in the presence of physical impairments.

1. Introduction

Playing the role of a Network of Excellence, BONE project has brought together over several years of research activities in Europe in the field of Optical Networks and it intends to repeat and validate this effort by stimulating a more intensified collaboration, exchange of researchers and building on its centralized activities, Topical Projects (TP), and Virtual Centres of Excellence that can serve to European industry with education and training, research tools and test beds and eventually pave the way toward new technologies and architectures.

This work package, identified as a TP on Alternatives for multi-layer networking with cross-layer optimization, combines a large number of partners currently working on various research fields interoperable to each other. The long term focus is to define the possible future solutions for converged IP/ Ethernet over optical layer and create a common platform for the protocol and algorithm designs that will result in optimised solutions. Future developments in this area could benefit from this as all will have a common approach and work on a well defined target. This will allow optimum converged solutions to be proposed and developed in a more commonly adopted fashion. Therefore, multi-layer as well as multi-domain issues can be handled both faster and in a more efficient way within the European networks.

1.1 TP Objectives

Dynamically reconfigurable optical networks provide the basis of next generation data-centric core networks, which offer cost-efficient use of bandwidth. In general those solutions that provide transportation of data traffic over Optical Transparent Networks (or even futuristic approaches like Optical Burst Switching or Optical Packet Switching) are focusing on methods for converged data traffic (IP, Ethernet) over optical networking solutions, which eventually shape the multi-layer networks.

The various architectures and protocols proposed in this direction should consider networking performance, complexity and implementation cost issues. However, depending on the convergence approach that these solutions try to adopt, networking studies on different multi-layer network architectures and approaches are essential for the identification of optimum solutions in terms of capacity, network topology, traffic model etc. Moreover, a number of architectural and technology challenges associated with the operation of a multi-layer network environments exist, especially when considering new transparency challenges. In such networks guaranteed QoS provisioning becomes very challenging as advanced monitoring techniques are required combined with efficient information dissemination protocols able to handle the rapid traffic variations and meet fast reconfiguration times at the nodes. Therefore, multi-layer transparent optical networks require the examination of novel schemes and the development of certain algorithms that can take into account the characteristics of the underlying layers. Cross-layer optimization methods must take into consideration both higher layer traffic characteristics and lower layer switching capabilities in order to provide efficient solutions and protocols for the realization of multi-layer networks.

Given these two main directions, the targeted focuses of this TP are:

1) Multi-layer approaches (architectures, protocols and network characteristics) for future Internet Protocol (or Ethernet) convergence over optical network solutions.

2) Cross-layer optimization approaches that take into consideration the physical layer, transport/data link layer and network layer characteristics.

The specific objectives for each domain are as follows:

- Objectives of multi-layer approaches:
  - Identification of various solutions for converged IP over optical networks and the networking issues related to each solution.
  - Identification of the networking parameters that must be taken into consideration when examining the performance of multi-layer networks.
  - Examination of modelling challenges related to the multi-layer networking simulations.
  - Development of performance evaluation tools for various multi-layer network solutions.
- Objectives of cross-layer optimization:
  - Identification of the lower layer parameters (e.g. physical impairments, resources availability etc) that can be offered and monitoring methods to collect and disseminate this information to the network.
  - Identification of higher layer parameters (e.g. QoS requirements, traffic demands etc.) and ways that these can be included in the development of fast reconfiguration algorithms
  - Development of cross-layer optimization schemes and routing/decision protocols.
  - Performance evaluation and feasibility studies.

1.2 Deliverable goals

This work package aims at integrating the partners' research activities and expertise on the topic of multi-layer networking and cross-layer optimization and provide a targeted common effort with the following outcomes: a)The development of a knowledge platform on multi-layer networking aspects that will be used to promote new ideas and concepts on future IP network solutions for optical networks and b) The promotion of novel ideas for the cross-layer optimization study of future IP networks which will lead to the development of the appropriate methods and tools to enhance the performance characteristics of such networks.

In order to materialize the objective of this TP, it is essential to compile an inventory of expertise and then based on the common interests of individual participating partners; joint activities will be planned and executed during the running period of this work package. This deliverable presents the inventory of collected expertise of each interested and involved partner in this TP. Furthermore based on the common interests of participants, the proposed joint activities are also covered in the 4th section of this deliverable. Final comments and conclusions are presented at the end of this deliverable.

2. Participants

This section covers the collected expertise of the interested partners and participants in this TP (WP26). The partners and their expertises are presented according to the alphabetical order of their designated short name (or abbreviation). According to the Annex I (Description

of Work), there are (16) partners in total, which are collaborating in this work package. However there are also some additional interested partners, who will collaborate in joint research activates. Table 1 (in alphabetic order of partners short name) provides a list of participant and the code of joint activity(ies), in which they are involved. A detailed description of these joint activities is provided in the next chapter.

Table 1: Participant and their interested joint activity code (see Table 3)

Partner Number	Short Name	Joint Activity Code
P19	AIT	2,3,4
P42	BILKENT	3,5
P24	BME	3,4,5,
P08	COM	N/A[1]
P09	CTTC	3
P01	IBBT	N/A (See note [1])
P37	IT	2, 3
P29	POLIMI	2
P30	POLITO	N/A (See note [1])
P21	RACTI	3
P31	SSSUP	N/A (See note [1])
P10	TID	3
P02	TUW	2
P11	UAM	1,3
P47	UEssex	N/A (See note [1])
P13	UPC	3
P14	UPCT	2, 3
P07	UST-IKR	Left WP26

In the following section an inventory of partner expertise is complied.

1 - Some partners have expressed their interests for some research topics, but they need more time to finalize their Joint Activity proposal(s), the membership of these partners for current joint activities are indicated as “Not Available (N/A)” in this table. Of course during the term of the project, and based on the inventory of expertise, it is possible to plan new proposals for joint activities.

2.1 AIT

Partner organization name: Research and Educational Laboratory in Information Technology

Short name: AIT

Areas of expertise:

AIT is a centre of excellence in ICT research and graduate education. The main role of AIT as a research and educational institute is to provide high quality research in the field of telecoms and IT, as well as training through three post-graduate educational programs and special professional courses focused on the industrial needs. AIT participates in BONE project with its 'Networks and Optical Communications' (NOC) research group. The group maintains a broad range of research activities and technical expertise supported be a state-of-the-art laboratory to that provides innovative research activities on optical communications. The work carried out within the AIT's NOC group is focused on optical network infrastructures for existing and future broadband networks and services in access, metro and wide area networks. Specific areas of interest include novel architectures for circuit-, burst- and packet-switching, optical system and subsystem design, signalling and routing protocols, network resilience, service aware network design and traffic engineering, advanced transmissions and switching techniques, and techno-economic studies.

The expertise of AIT's NOC group in the field of transparent networks and impairment constraint based routing studies is proven through a number of journal publications as well as invited talks in major international conferences in optical communications. Moreover relative activities in the general field of optical networking studies, design and evaluation are carried out through a number of EU projects where AIT is actively participating, like the DICONET project on Dynamic Impairment Constraint Networking for Transparent Mesh Optical Networks, SARDANA, APACHE, and EUROFOS.

Relevant Publications (OPTIONAL):

[1] Tomkos, I., et al., "Impairment constraint routing in mesh optical networks", (Invited paper), OFC 2007, Anaheim, USA.

[2] G. Markidis, et al., "Impairment Constraint Based routing in Optical Networks Employing 2R Regeneration", ECOC 2006, Cannes, France, September 2006

[3] Tomkos, I., et al., "Benefits from the Use of Impairment Constraint Routing in Optical Networks", International Journal "Annals de Telecommunications", Special issue on "Simulation techniques for optical networks", 2006

[4] Tomkos, I., et al., "Q-factor based Constraint Routing in Optical Networks", SPIE Newsletter, 2006

[5] G. Markidis, et al., "CoS assignment based on physical performance parameters in OBS networks", 8th International Conference on Transparent Optical Networks (ICTON 2006) conference, June 18-22, 2006, Nottingham, United Kingdom.

[6] Tomkos, "Impairment constraint routing in transparent and managed reach optical networks", (Invited paper), APOC 2005.
[7] P. Kalkani, et al., "Benefits of Q-factor based routing in optical networks", ECOC 2005.
[8] C. Mas, et al., "A failure location algorithm for transparent optical networks", IEEE Journal on Selected Areas in Communications, August 2005.
[9] C. Mas, et al., "Comparison of transparent versus opaque interconnecting nodes of OADM rings with respect to failure location", ICTON 2005
[10] Tomkos, I., et al., "Performance Engineering of Metropolitan Area Optical Networks through Impairment Constraint Routing", IEEE Communications Magazine, vol. 42, no. 8, pp. S40 - S47, Aug. 2004.
[11] C. Mas, et al., "Optimal Monitoring Equipment Placement for Fault and Attack Location in Transparent Optical Networks" IFIP Networking 2004.
[12] C. Mas, et al., "Optimal Monitoring Equipment Placement for Fault and Attack Location in Transparent Optical Networks", Lecture Notes in Computer Science, 2004.
[13] C. Mas, et al., "Failure management in optical networks", Invited talk, IEEE ICTON'03, July 2003.
[14] C. Mas, et al., "A framework for failure prevention and management in all-optical networks", ITCOM'03, September 2003, Orlando, USA.

2.2 Bilkent

Partner organization name: Bilkent Universitesi

Short name: BILKENT

Areas of expertise:

Based at the Electrical and Electronics Engineering Department at Bilkent University, Ankara, Turkey, the Bilkent University Information Network Laboratory (BINLAB) performs research on innovative high-performance computer and communication networks, systems, and protocols with a particular emphasis on the design and analysis of Internet Protocol (IP)-based networks. Our research topics include

- Optical network design and planning
- Traffic Engineering
- Performance of optical burst/packet switching networks
- Internet protocols and technologies
- Internet architectures
- QoS routing

Our main focus in the context of WP26 is development of network planning and traffic engineering approaches satisfying physical layer impairment constraints. We are specifically interested in developing multi-layer traffic engineering and logical topology design techniques, considering the physical limitations brought by the optical network infrastructure. Our collaboration with IBBT and BME on multi-layer traffic engineering under the auspices of e-Photon/ONe+, resulted in two conference articles, one submitted to ICTON 2007 [1] and the other submitted to Networks 2008 [2]. In the previous years, under the project e-photon/ONe, we conducted studies on topology design and traffic engineering, wavelength converter sharing and wavelength converter placement in optical networks, the results of which are published in [3], [4] and [5] respectively.

Relevant Publications (OPTIONAL):

[1] N. Sengezer, B. Puype, E. Karasan, M. Pickavet, “A Comparative Study of Single-Layer and Multi-Layer Traffic Engineering Approaches on Transparent Optical Networks,” in the Proceedings of the 9th International Conference on Transparent Optical Networks, ICTON '07, Rome, Italy, July 2007.

[2] P. Hegyi, N. Sengezer, E. Karasan, T. Cinkler, "Traffic Engineering in Case of Interconnected and Integrated Layers", submitted to 13th International Telecommunications Network Strategy and Planning Symposium, Networks 2008.

[3] N. Sengezer, E. Karasan, "An Efficient Virtual Topology Design and Traffic Engineering Scheme for IP/WDM Networks", in Proc. ONDM 2007, Athens, Greece, July 2007.

[4] N. Akar, E. Karasan and K. Dogan, "Wavelength Converter Sharing in Asynchronous Optical Packet/Burst Switching: An Exact Blocking Analysis for Markovian Arrivals," IEEE Journal on Selected Areas in Communications, vol. 24, no. 12, pp. S69-80, December 2006.

[5] N. Sengezer and E. Karasan, "TSCP: A Tabu Search Algorithm for Wavelength Converting Node Placement in WDM Optical Networks", in Proc. ONDM 2005, Milano, Italy, Jan. 2005.

2.3 BME

Partner organization name: Budapest University of Technology and Economics

Short name: BME

Areas of expertise:

In both metropolitan optical networks (MON) and long haul optical networks (LHON) the signal quality is often influenced by the physical impairments, therefore proper impairment constrained routing decisions are needed. Our research is focused on new method that jointly performs, on the one hand, routing and wavelength assignment (RWA) and, on the other hand, tuning the signal power of certain Wavelength Division Multiplexed (WDM) channels. We compare different methods for both, single and multilayer networks. In the first case we assume that no signal regeneration is allowed along the path, while in the more complex two-layer case we assume that 3R signal regeneration, grooming and wavelength conversion can all be done in the electronic layer. Nowadays in nearly all reconfigurable optical add-drop multiplexers (ROADM) the signal power can be tuned by the control plane via variable optical attenuators (VOA). The proposed methods can be used in existing WDM optical networks wherever the nodes support signal power tuning. If there exists a global optimum the algorithm finds it, for any network topology, physical constraint and demand set.

Relevant Publications (OPTIONAL):
[1]

2.4 COM (DTU)

Partner organization name: Technical University of Denmark

Short name: DTU

Areas of expertise:

DTU has experience in long reach PON links that employ distributed Raman amplification over a single fibre, bidirectional links. Studies have been conducted on the effect of burst mode transmission on the gain transient performance in such Raman amplified links.

DTU has expertise in the employment of reflective SOA-EAM for the ONU at PON links. A Raman amplified link to compensate for the transmission and losses at the backhaul links and a SOA-EAM reflective ONU has been proposed and demonstrated experimentally. The use of xPSK modulation for downstream and ASK carrier re-modulation for upstream with Reflective SOA has also be considered.

An optical labelling method for a xPSK modulated burst payload, based on subcarrier tone, has been proposed and demonstrated experimentally. More recently, DTU has started activities on the use of SOA for gain transient suppression in burst mode transmission in PON links.

Therefore, we would like to joint the activity 13: “Analisys of the effects of erbium amplification in burst/packet networks”. Therein we plan to contribute, especially with insights from the physical layer performance, to the study of on the response of amplifiers (SOA, Raman, ..) to burst mode transmission and expand it to the case of labelled burst.

Relevant Publications (OPTIONAL):

[1] Tafur Monroy, R. Kjær, F. Öhman, K. Yvind, and P. Jeppesen, Distributed Raman amplification in long reach PON bidirectional access links, Journal of Optical Fiber Technology, Volume 14, Issue 1, January 2008, Pages 41-44.

[2] R. Kjær, I. Tafur Monroy, L. K. Oxenløwe, P. Jeppesen, and B. Palsdottir, Impairments due to Burst-Mode Transmission in a Raman-based Long Reach PON Link, IEEE Photonics Technol. Lett., Volume: 19, Issue: 19, pp. : 1490-1492, 2007.

[3] J. B. Jensen, I. Tafur Monroy, R. Kjær, and P. Jeppesen, "Reflective SOA re-modulated 20 Gbit/s RZ-DQPSK over distributed Raman amplified 80 km long reach PON link," Opt. Express 15, 5376-5381, 2007.

[4] Tafur Monroy, F. Öhman, K. Yvind, L. J. Christiansen, J. Mørk, C. Peucheret, and P. Jeppesen, "Monolithically integrated reflective SOA-EA carrier re-modulator for broadband access nodes," Opt. Express 14, pp. 8060-8064, 2006.

2.5 CTTC

Partner organization name: Centre Tecnològic de Telecomunicacions de Catalunya

Short name: CTTC

Areas of expertise:

CTTC's area of expertise within WP26 is defined by the recent evolution of the ADRENALINE+ test-bed, aiming at jointly address the ever-growing and bursty bandwidth demands of IP data traffic, replacing the SONET/SDH nodes by Ethernet based circuit-oriented technologies (enabling flexible packet aggregation and grooming) along with the high-bandwidth offered by the reconfigurable wavelength-routed network functionality (providing end-to-end all-optical connections), controlled by the intelligence provided by the unified GMPLS architecture. In the ADRENALINE+ testbed, we experimentally assess the application of a unified GMPLS control plane, in which Ethernet and optical layers are controlled by a single instance of the control plane. To this end, two approaches for configuring a legacy Ethernet switch to support both VLAN cross-connect and VLAN/MAC forwarding are being implemented and deployed, in order to provide GMPLS Ethernet LSPs over the dynamically reconfigurable impairment-aware wavelength-routed network of the ADRENALINE testbed. Especially, these two topics are being addressed:

Impairment-Aware GMPLS-based Control (traffic engineering) and Management (monitoring) of transparent optical networks with QoS. A very interesting approach to match QoS requirements along with the performance of optical signals is to design intelligent mechanisms that consider physical-layer information when provisioning connections. By doing so, the GMPLS control plane, embedded at each network node, is aware not only of the resource state (i.e., wavelength availability) and traffic engineering attributes (e.g., bandwidth and protection capabilities) over each ongoing data link (i.e., optical fiber), but also of the optical signal degradations introduced by physical impairments such as ASE noise due to amplification spans, PMD, losses, homodyne crosstalk, etc.

GMPLS-based dynamic provisioning and restoration over Multi-Layer networks (Ethernet over wavelength-routed networks) with QoS. In order to provide a finer bandwidth granularity, a good strategy is a combination of electrical grooming with the transparent optical network functionality based on the unified GMPLS architecture. Nevertheless, the application of a unified control plane, in which different layers (e.g. IP, Ethernet and optical) are controlled by a single instance of the control plane raises new issues that need to be investigated. Note that the electrical regeneration of the optical signals is required in the traffic grooming points, therefore layer 2 (Ethernet) and layer 3 (IP) performance parameters, such as bit error checks or packet loss rates, can be integrated into the monitoring system of a multi-layer, all-optical network to increase the efficiency of fault and performance management.

Relevant Publications (OPTIONAL):

[1] C. Pinart, Relation of OSNR and PLR for nonintrusive fault detection in all-optical IP–Ethernet–WDM networks, in OSA Journal of Optical Networking, vol. 7, no. 4, pp. 256-265, April 2008.

[2] R. Muñoz, R. Martínez, R. Casellas, R. Morro, C. Cavazzoni, S. Pizzaja, M. Jaeger, H.-M. Foisel, J. Jiménez, C. García, H. Dentler, Experimental demonstration of ASON-GMPLS signaling interworking in the NOBEL2 Multi-domain Multi-Layer Control Plane Emulator, in Proc. 12th International Conference on Optical Network Design and Modelling (ONDM 2008). Vilanova i la Geltrú, Spain, March 12-14 2008.

[3] R. Muñoz, R. Martínez, G. Junyent, An experimental switching-aware GMPLS-based lightpath provisioning protocol in wavelength-routed network, Published in Photonic Network Communications, Vol. 14, No. 3, pp. 253-264, December 2007.

[4] R. Muñoz, R. Martínez, F. Galán, R. Morro, H.M. Foisel, S. Szuppa, J. Jiménez, O. González, H. Dentler, E. Escalona, F.Agraz, S. Spadaro, B. Berde, Experimental interconnection and interworking of the multi-domain (ASON-GMPLS) and multi-layer (TDM-LSC) NOBEL2 Test-beds, in Proc. 33rd European Conference and Exhibition on Optical Communication (ECOC), Berlin (Germany), September 16-20 2007.

[5] C. Pinart, H. Harai, On using optical-layer link information parameters in distributed impairment constraint-based routing, in Proc. Optical Fiber Communications Conference/National Fiber Optic Engineers Conference (OFC/NFOEC 2007). Anaheim (USA), March 25-29 2007.

[6] R. Martínez, C. Pinart, F. Cugini, N. Andriolli, L. Valcarenghi, P. Castoldi, L. Wosinska, J. Comellas, G. Junyent, Challenges and requirements for introducing impairment-awareness into the management and control planes of ASON/GMPLS WDM networks, in IEEE Communications Magazine, special issue “Advances in Control and Management of Connection-Oriented Networks”, Vol. 44, No. 12, pp. 76-85, December 2006.

[7] R. Casellas, I. Martínez, C. Pinart, R. Muñoz, R. Martínez, F. Galán, G. Junyent, On-demand uncompressed HDTV Transmission over a GMPLS controlled Service-Aware all-optical network, in Proc. 33rd European Conference and Exhibition on Optical Communication (ECOC 2007). Berlin (Germany), September 16-20, 2007.

[8] C. Pinart, Alternatives for in-service BER estimation in all-optical networks: towards minimum intrusion, in Academy Publishers Journal of Computers, Vol. 2, No. 3, pp. 56-63, May 2007.

[9] R. Martínez, C. Pinart, J. Comellas, G. Junyent, Routing issues in transparent optical networks, (Invited Paper) 8th International Conference on Transparent Optical Networks (ICTON 2006). Nottingham (UK). June 18-22, 2006.

2.6 IBBT

Partner organization name: Interdisciplinair Instituut voor Breedbandtechnologie

Short name: IBBT

Areas of expertise:

The expertise of the IBBT-UGent research group Intec Broadband Communication Networks (IBCN) with respect to this workpackage is mostly on routing algorithms taking into account multiple layers, and rerouting algorithms to provide protection or restoration capabilities in a multi-layer environment.

Relevant Publications (OPTIONAL):
[1]

2.7 IT

Partner organization name: Instituto de Telecomuinicações

Short name: IT

Areas of expertise:

IT is working for several years on the gathering and quantification of monitoring strategies. Within the studies the works performed resulted in several new approaches for monitoring and compensation of physical impairments.

It has run the Joint project T, on dynamic networks based on constrains in E-Photon ONe +. With this several expertises were gathered in the topic of physical layer optimization having in mind networking problems.

Relevant Publications (OPTIONAL):
[1]

2.8 Polimi

Partner organization name: Politecnico di Milano

Short name: POLIMI

Areas of expertise:

Our research group on Optical Networking is active in the Department of Electronics and Information of the Politecnico di Milano. The group has been developing expertise for more than ten years on: design and simulation of optical transport networks, routing and wavelength-assignment (RWA) algorithms, ASON/GMPLS control plane, evaluation of the physical impairments on the transport-network performance. The group has also expertise on optical-packet- and burst-switching networks. Recently our interest shifted towards RWA taking into account multiple physical constraints or impairments. Our main objective is then, to design a whole multi-layer RWA mechanism able to deal with inter and intra-domain routing and taking into account the physical impairments. We are also interested to observe the behaviour of the RWA algorithms proposed in condition of uncertainty on the actual values of the parameters describing the physical impairments. More specifically, we are interested in developing new RWA algorithms and methods that are resilient to the mismatching between actual and calculated or measured values of the physical parameters.
We have two publications proposing new RWA schemes for intra and inter-domain routing deriving from the collaboration with UPC, Pirelli, CoreCom and Telecom Italia in the Nobel 2 project.

Relevant Publications (OPTIONAL):

[1] Eva Marín Tordera,Sergio Sánchez López, Xavier Masip Bruin, Josep Solé Pareta, Walter Erangoli, Stefano Santoni, Guido Maier,Marco Quagliotti, Applying Prediction Concepts to routing on semi-transparent optical transport networks, ICTON 2007.

[2] Eva Marín Tordera,Sergio Sánchez López, Xavier Masip Bruin, Josep Solé Pareta, Walter Erangoli, Stefano Santoni, Guido Maier,Marco Quagliotti, A RWA Algorithm in Semi-Transparent Optical Networks, ECOC 2007.

2.9 POLITO

Partner organization name: Politecnico di Torino

Short name: PoliTO

Areas of expertise:

Politecnico di Torino is one of the leading Italian technical universities. PoliTO staff involved in BONE has a strong background in research and educational activities in the area of optical communications systems and networks. The the optical networks group, led by F. Neri at the Electronics Department, focussed its research on different aspects related to optical networking: algorithms for logical topology design, access protocols for metropolitan optical networks, scheduling algorithms for broadcast and select networks, and experiments on optical packet-switched metropolitan rings.

PoliTO has been active in the past in two main areas covered by this TP.

1) Routing and Wavelength Assignment (RWA) with physical layer constraints

Some new models for taking into account non-linear physical layer impairments in the RWA problems were proposed, and RWA heuristics accounting for these constraints were devised and compared by simulation. See [1] for details.

2) Multilayer fault protection schemes

The cost of protecting faults at the IP layer and at the WDM layer in an overlay configuration were compared over selected network scenarios. See [2] for details.

Relevant Publications (OPTIONAL):

[1] G. Bogliolo, V. Curri, M. Mellia, “Considering Transmission Impairments in RWA Problem: Greedy and Metaheuristic solutions”, OFC 2007, Anaheim, CA, USA

[2] M. Cuna. M. Mellia, “Comparison of Protection Capacity Cost at IP or WDM Layer,” HPSR 2006 (IEEE Workshop on High Performance Switching and Routing), Poznan, Poland

2.10 RACTI

Partner organization name: Research Academic Computer Technology Institute

Short name: RACTI

Areas of expertise:

The Research Academic Computer Technology Institute (RACTI) is a non-profit Research Organization, closely affiliated to academia. RACTI constitutes an integrated environment of scientific research, design and development of products and solutions. In continuous interaction with the academic community the national and European informatics industry, the international scientific community and the public sector, RACTI has evolved to an internationally renowned research institution in Information and Network Technologies.

Our group performs research on various fields of optical communications such as

- Control protocols and traffic engineering in optical networks
- QoS routing
- Optical Burst Switching (OBS) and Optical Packet Switching (OPS) architectures
- Routing and scheduling in Optical Grid Networks
- Routing and wavelength assignment (RWA) algorithms for WDM networks
- Impairment aware RWA algorithms for transparent WDM networks

Our main focus in the context of WP26 is the development of impairment aware routing and wavelength (RWA) algorithms. The effect of physical impairments in transparent optical networks has received increasing attention from the research community lately. In most cases, the proposed algorithms compute the lightpaths in a network layer module and then the verification of the quality of transmission is performed by a physical layer module. We plan to examine the feasibility and applicability of algorithms that consider jointly the RWA problem and the impairment constraints. Moreover, the great majority of the proposed RWA algorithms consider only static traffic scenarios, in the form of permanent lightpaths demands, and static network conditions, that is time invariant physical impairments. We plan to design algorithms that address dynamic traffic and dynamic impairments scenarios. For the dynamic traffic scenarios, apart from typical scalar algorithms, we plan to examine the applicability of multi-cost algorithms with impairment related costs.

Relevant Publications (OPTIONAL):

[3] I. Tomkos, D. Vogiatzis, C. Mas, I. Zacharopoulos, A. Tzanakaki, and E. Varvarigos, Performance Engineering of Metropolitan Area Optical Networks through Impairment Constraint Routing, IEEE Communications Magazine, special issue on metro optical networks, pp. 40-47, August 2004.

[4] R. Van Caenegem, D. Colle, M. Pickavet, P. Demeester, K. Christodoulopoulos, K. Vlachos, E. Varvarigos, L. Stampoulidis, D. Roccato, R. Vilar, The design of an all-optical packet-switching network, IEEE Communications Magazine, pp. 52-61, Nov. 2007.

[5] P. Kokkinos, K. Christodoulopoulos, N. Doulamis, E. Varvarigos, Quality of Service Scheduling of Computation and Communication Resources in Grid Networks, to appear in "Grid Computing Research Progress." Nova publishers (invited).

[6] A. Sideri and E. A. Varvarigos, New Assembly Techniques for Optical Burst Switched Networks Based on Traffic Prediction, Proc. 11th Conference on Optical Network Design and Modelling (ONDM 2007), LCNS Volume 4534, pp. 358-367, June 2007.

[7] K. Seklou, E. Varvarigos, Burst Assembly Policies for Latency Reduction in Optical Burst-Switched Networks Based on Predictions, to appear in ICN 2008.

[8] K. Christodoulopoulos, E. Varvarigos and K. Vlachos, A new Burst Assembly Scheme based on the Average Packet Delay and its Performance for TCP Traffic, Optical Switching and Networking, Elsevier, 2007.

[9] K. Manousakis, V. Sourlas, K. Christodoulopoulos, E. A. Varvarigos, K. Vlachos, A Bandwidth Monitoring Mechanism Enhancing SNMP to Record Timed Resource Reservations, Journal of Network and Systems Management, Vol. 14, No. 4, pp. 583-597, 2006.

[10] E. Varvarigos, V. Sourlas, K. Christodoulopoulos, Routing and Scheduling Connections in Networks that Support Advance Reservations, pending 2nd review, Computer Networks journal, Elsevier

[11] K. Christodoulopoulos, K. Vlachos, E. Varvarigos, Stampoulidis L. Kehayas, E., EBRP: An Efficient burst reservation protocol for QoS provision in Optical Burst Switching networks, Journal Optical Networking, 5, 147-158, 2006

[12] N. Doulamis, T. Doulamis, E. Varvarigos, and T. Varvarigou, Fair QoS Resource Management in Grids, IEEE Transactions on Parallel and Distributed Systems, 18 (11): 1630-1648, 2007.

[13] K. Yiannopoulos, E. Varvarigos, K. Vlachos, Multiple-Input Buffer and Shared Buffer Architectures for Asynchronous Optical Burst Switching Networks, Journal of Lightwave Technology, Vol. 25 (6), pp. 1379-1389, 2007.

[14] K. Christodoulopoulos, N. Doulamis, E. Varvarigos, Joint Communication and Computation Scheduling in Grids, to appear CCGrid 2008.

[15] P. Kokkinos, K. Christodoulopoulos, A. Kretsis, E. Varvarigos, Data Consolidation: A Task Scheduling and Data Migration Technique for Grid Networks, accepted HPNG workshop of CCGrid 2008.

2.11 SSSUP

Partner organization name: Scuola Superiore Sant'Anna

Short name: SSSUP

Areas of expertise:

SSSUP expertise focuses on cross-layer approaches for WDM optical networks with GMPLS/MPLS control plane. Cross-layer optimization approaches that take into account the physical layer information are being investigated. In particular, SSSUP evaluated the challenges and requirements for introducing impairment-awareness into the management and control plane of GMPLS WDM networks [1] and proposed centralized and distributed approaches to encompass the physical layer impairments. Currently, SSSUP is active in proposing and evaluating centralized approaches to be implemented at the Path Computation Element (PCE) [2,3] and distributed approaches that extend the signaling protocol (i.e., resource reservation protocol with traffic engineering extensions, RSVP-TE) [4,5]. The approaches aim to guarantee the Quality of Transmission (QoT) requested by the label-switched paths (LSP), by taking into account the physical layer design [4] and the estimation of the physical layer performance [5], during the computation of routing and wavelength assignment for the LSP.

Performance evaluation carried out by SSSUP is based on simulation analysis. A simulation platform implementing GMPLS control plane functionalities (e.g., RSVP-TE, OSPF-TE, PCE) is available at SSSUP and was used to evaluate and compare [6] the performance of the previously proposed approaches.

SSSUP is currently carrying out research activities on this topic within BONE research activities. In particular, SSSUP is actively involved in evaluating approaches for encompassing node impairments and capabilities in GMPLS control plane (WP14), QoT-aware GMPLS control plane (WP11), enhancements of GMPLS signaling protocol for encompassing QoT (WP22).

Relevant Publications (OPTIONAL):

- R. Martínez, C. Pinart, F. Cugini, N. Andriolli, L. Valcarenghi, P. Castoldi, L. Wosinska, J. Comellas and G. Junyent, “Challenges and requirements for introducing impairment-awareness into the management and control planes of ASON/GMPLS WDM networks”, IEEE Communication Magazine, December 2006/Advances in Control and Management of Connection-Oriented Networks.

- F. Cugini, A. Giorgetti, N. Andriolli, F. Paolucci, L. Valcarenghi, P. Castoldi, "Multiple Path Computation Element (PCE) Cooperation for Multi-layer Traffic Engineering", Proc. of OFC/NFOEC 2007, Anaheim (USA), March 25-29, 2007.
- F. Cugini, F. Paolucci, L. Valcarenghi, P. Castoldi, "Implementing a Path Computation Element (PCE) to encompass physical impairments in transparent networks", OFC/NFOEC, Anaheim (USA), March 25-29, 2007.
- F. Cugini, N. Sambo, N. Andriolli, A. Giorgetti, L. Valcarenghi, and P. Castoldi, “GMPLS extensions to encompass shared regenerators in transparent optical networks,” in Proc. ECOC 2007. Berlin, Germany, Sep. 2007.
- N. Sambo, A. Giorgetti, N. Andriolli, F. Cugini, L. Valcarenghi, P. Castoldi, "GMPLS Signalling Feedback for Encompassing Physical Impairments in Transparent Optical Networks", IEEE Globecom 2006 - Advanced Technologies and Protocols for Optical Networks, 27 Nov. - 1 Dec. 2006, S. Francisco, USA.
- P. Castoldi, F. Cugini, L. Valcarenghi, N. Sambo, E. Le Rouzic, M. J. Poirrier, N. Andriolli, F. Paolucci, A. Giorgetti, "Centralized vs. Distributed Approaches for Encompassing Physical Impairments in Transparent Optical Networks" (invited paper), Proc. of ONDM 2007, Athens, Greece, May 29-31, 2007.

2.12 TID

Partner organization name: Telefonica I+D

Short name: TID

Areas of expertise:

One of TID interests is related to multilayer Traffic Engineering mechanisms for Delay Constrained Transport Services. An extended trend in convergent transport architectures today is based on IP/MPLS routers connected by means of direct fibres or lambdas without any additional transport layer in between. However, these architectures may present problems in order to meet the strict delay requirements for real time applications due to the delay introduced by optoelectronic processing and queuing required in each hop. Currently, the commercial availability of OCS architectures allows network operators to reduce the end to end delay by transporting the transit traffic at the optical layer. TID researches in multilayer mechanisms that allows inter-layer communication (from/to the optical layer to the IP layer) in order to assure the end to end delay of a given connection.

The other interest in Telefonica I+D is in addressing the multi-layer network optimization problems that appear in OCS networks with impairment constraints (ICBR). TID is performing studies on the maximum reach of different modulation formats for 40 Gbps and 100 Gbps considering filtering concatenation and PMD effects.

Relevant Publications (OPTIONAL):

[1] V. López, J.A. Hernández, J. Aracil, J.P. Fernández Palacios and O. González de Dios: **A Bayesian decision theory approach for the techno-economic analysis of an all-optical router (extended version)**, in Computer Networks, to appear.

[2] V. López, J.A. Hernández, J. Aracil, J. P. Fernández Palacios O. González de Dios: **A Bayesian decision theory approach for the techno-economic analysis of an all-optical router**, in Optical Networking Design and Modeling (ONDM), May 2007. Published in Lecture Notes in Computer Science (LNCS).

2.13 TUW

Partner organization name:

Vienna University of Technology, Institute of Broadband Communications

Short name: TUW

Areas of expertise:

1) Traffic Engineering: One relevant aspect concerning network dimensioning/optimization in broadband communication networks is "traffic engineering". The primary motivation behind applying traffic engineering in modern communication networks lies in the performance optimization of operational (transport) networks. Its main objectives are made up of optimizing resource utilization across the network's layers by controlling traffic distribution under several constraints (e.g., QoS), bypassing potential congestion hot spots, limiting packet delays, and reducing packet-loss probability in respect to a service's needs.

Research activities: Theoretical, simulative, and experimental investigations according to protocol/algorithm proposals and control plane extension recommendations.

2) Optical Packet Switching: In optical packet-switched networks, the payload is transmitted in packets of fixed or variable length direct on the optical medium (fibre). Optical Packet Switching allows efficient statistical bandwidth utilization, however, demands the implementation of Quality of Service (QoS). Because the switching is to be implemented in the photonic layer, the optical components have to meet high technical requirements.

Research activities: Theoretical, simulative, and experimental investigations in the optical layer, as well as design and validation of new subsystems and techniques for optical signal transmission. I.e., new access node architectures, MAC-protocols, and MUX hierarchies.

3) Optical LANs/MANs: Bandwidth-intensive applications render effective bandwidth allocation in Local Area Networks (LANs) and Metropolitan Area Networks (MANs) an increasingly important issue. To exploit the bandwidth of the optical fibre and to support IP (Internet Protocol) services, packet transport where transmission, switching and routing are performed in a packet-by-packet manner while keeping at least the packet's payload entirely in the optical domain, has to be preferred over the conventional opaque optical circuit switching approach, where every packet needs to be processed in every trespassed node. Medium Access Control (MAC) arbitrates the access to the available bandwidth of the considered transport resource, i.e., light-path, wavelength-group, fibre, according to criteria such as network throughput, packet delays and access fairness. They have to take the physical properties of the resource and the node equipment adequately into account.

Research activities: Novel access protocols for WDM-based LANs/MANs shall be proposed and analysed. Main target is efficient integration of delay-sensitive real-time services associated with stringent delay requirements, loss-sensitive high priority data services, and

best-effort traffic generally not subject to bandwidth grants. I.e., solutions for efficient support of Quality-of-Service (QoS) classes across the layers of WDM infrastructures are studied.

Relevant Publications (OPTIONAL):

Complete List can be found at: **http://www.ikn.tuwien.ac.at,** here find a selection of most relevant publications.

[1] B. Statovci-Halimi: "*A Resource Provisioning Scheme for Multiservice IP Networks*"; Broadband Europe 2007, Antwerp, Belgium; 12-03-2007 - 12-06-2007; in: "*BroadBand Europe 2007*", (2007), ISBN: 9789076546094.

[2] S. Aleksic: "*Transmission Performance of Optically Transparent Metro Edge Nodes*"; 9th International Conference on Transparent Optical Networks, Rome, Italy (invited); 07-01-2007 - 07-05-2007; in: "*ICTON 2007*", IEEE, Volume 3, Rome, Italy (2007), ISBN: 1-4244-1248-x; 289 - 293.

[3] K. Aziz, S. Sarwar, S. Aleksic: "*Analytical Model for Performance Evaluation of a Novel Optical Packet/Burst Switch*"; 9th International Conference on Transparent Optical Networks, Rome, Italy; 07-01-2007 - 07-05-2007; in: "*ICTON 2007*", IEEE, Volume 4, Rome, Italy (2007), ISBN: 1-4244-1248-x; 92 - 95.

[4] A. Jukan, G. Franzl: "*Path Selection Methods With Multiple Constraints in Service-Guaranteed WDM Networks*"; IEEE-ACM Transactions on Networking, Vol. 12 (2004), No. 1; 59 - 72.

[5] S. Tomic, B. Statovci-Halimi, A. Halimi, W. Müllner, J. Frühwirth: "*ASON and GMPLS--Overview and Comparison*"; Photonic Network Communications, Vol. 7 (2004), No. 2; 111 - 130.

[6] S. Tomic: "*Issues of Resource Management in Two-Layer GMPLS Networks with Virtual Network Services*"; 47th Annual IEEE Global Telecommunications Conference 2004, Dallas, TX, USA; 11-29-2004 - 12-03-2004; in: "*Proceedings of GLOBECOM'04*", (2004), ISBN: 0-7803-8794-5; 5 pages.

[7] K. Hendling, G. Franzl, B. Statovci-Halimi, A. Halimi: "*IMRA -- A Fast and Non-greedy Interference Minimizing On-Line Routing Algorithm for Bandwidth Guaranteed Flows*"; 7th IEEE International Conference on High Speed Networks and Multimedia Communications HSNMC'04, Toulouse, France; 06-30-2004 - 07-02-2004; in: "*Proceedings of HSNMC'04*", (2004), ISBN: 3-540-22262-6; 336 - 347.

[8] G. Franzl: "*WDM Path Provisioning on Monitored Interference Probabilities*"; 8th IFIP Working Conference on Optical Network Design & Modelling 2004, Gent, Belgium; 02-02-2004 - 02-04-2004; in: "*Proceedings of ONDM'04*", (2004), ISBN: 9076546029; 635 - 648.

[9] S. Aleksic: "*Packet-Switched OTDM Networks Employing the Packet Compression/Expansion Technique*"; Photonic Network Communications, Vol. 5 (2003), No. 3; 273 - 288.

[10] K. Hendling, G. Franzl, B. Statovci-Halimi, A. Halimi: "*Residual Network and Link Capacity Weighting for Efficient Traffic Engineering in MPLS Networks*"; 18th International TELETRAFFIC CONGRESS 2003 (ITC'03), Berlin, Germany; 08-31-2003 - 09-05-2003; in: "*Proceedings of ITC'03*", (2003), ISBN: 0-444-51455-4; 51 - 60.

[11] K. Bengi, H.R. van As: "*Efficient QoS support in a Slotted Multi-Hop WDM Metro Ring*"; IEEE Journal on Selected Areas in Communications, 20 (2002), 1; 216 - 227.

[12] A. Jukan, G. Franzl: "*Distributed provisioning of wavelength channels in WDM networks with selective electronic regeneration*"; Journal of Optical Networking (JON), 1 (2002), 1; 43 - 55.

[13] K. Bengi: "*Medium access control protocols for passive-star WDM single-hop networks efficiently integrating real-time and data services*"; Optical Networks Magazine, Vol. 2 (2001), 4 July/August; 88 - 100.

[14] G. Remsak, J. Schuringa: "*A Multi-Hop Packet-Switched AWGM-Star-Network Realized with TX/RX Arrays*"; Photonic Network Communications, Vol. 3 (2001), No. 1/2; 147 - 160.

[15] A. Jukan, H.R. van As: "*Service-Specific Resource Allocation in WDM Networks with Quality Constraints*"; IEEE Journal on Selected Areas in Communications, Vol. 18 (2000), No. 10; 2051 - 2061.

2.14 UAM

Partner organization name: Universidad Autónoma de Madrid

Short name: UAM

Areas of expertise:

The Networking Research Group at Universidad Autónoma de Madrid is devoted to research in development in networking and telematic services, with special emphasis in traffic analysis, capacity planning, network management, mediation and optical and high-speed networking. Our main research topics are:

- Optical Burst Switching
- IP over WDM scenarios
- Polymorphic networks: hybrid circuit/burst switching networks
- Performance evaluation
- Traffic models for optical networks
- Simulation
- Network management
- Mediation systems
- Inteligent systems: ontologies

As we are focus in optical networks, interaction problems between IP and the optical layer is one of our topics of interest. Last year we collaborate with Telefónica I+D in the definition of a Bayesian decisor to deal with the routing problem of the incoming flows into the IP or the optical layer. Thanks to this collaboration a conference article ("A Bayesian decision theory approach for the techno-economic analysis of an all-optical router") was submitted to the conference "Optical Networking Design and Modelling" (ONDM), where the article was within the top five papers award. This collaboration continued and an extension of this work has been accepted into the Springer journal "Computer Networks".

Besides, thanks to the mobility actions of the ePhoton/One + project, an internship was carried out in ENST Paris. We submitted an article called "Extension of the Flow-Aware Networking (FAN) architecture to the IP over WDM environments" to the IT-NEWS QoS in Multiservice IP Networks, 2008. This article was within the top ten papers award. This collaboration continues and in the BONE NoE we will improve the research of "Multi-layer Flow-Aware Networking".

Relevant Publications (OPTIONAL):

[1] V. López, J.A. Hernández, J. Aracil, J.P. Fernández Palacios and O. González de Dios: **A Bayesian decision theory approach for the techno-economic analysis of an all-optical router (extended version)**, in Computer Networks, to appear.

[2] V. López, C. Cárdenas, J. A. Hernández, J. Aracil and M. Gagnaire: **Extension of the Flow-Aware Networking (FAN) architecture to the IP over WDM environment**, in IT-NEWS QoS in Multiservice IP Networks, February 2008. Within the top ten papers award.

[3] V. López, J.A. Hernández, J. Aracil, J. P. Fernández Palacios O. González de Dios: **A Bayesian decision theory approach for the techno-economic analysis of an all-optical router**, in Optical Networking Design and Modeling (ONDM), May 2007. Published in Lecture Notes in Computer Science (LNCS).

2.15 UEssex

Partner organization name: University of Essex

Short name: UEssex

Areas of expertise:

The Photonic Networks Lab in UEssex specializes in the application of optical technologies to future communication network infrastructures, together with the study of associated issues such as control & signalling, the impact of traffic profiles on network and node architectures, and understanding the network technologies (for example burst and packet switching) best suited for future requirements. Relevant research activities for this WP include:

GMPLS control protocol extension to support advanced network functionality as well as service layer functionality such as: constraint based routing and Grid Service Centric Frameworks and Architectures Wavelength routing: optical cross-connects (OXCs) and reconfigurable optical add/drop multiplexers 40 Gb/sec variable length and asynchronous OPS test-bed including core and edge OPS routers Fast, agile edge interfaces for the OPS/OBS/OWS - 160 Gb/sec OTDM - Nanosecond space switches.

Relevant Publications (OPTIONAL):
[1]

2.16 UPC

Partner organization name: Universitat Politènica de Catalunya

Short name: UPC

Areas of expertise:

The CBA group of the Universitat Politènica de Catalunya is currently doing research in different optical networking areas, such as Wavelength Switching networks, Traffic Monitoring and Analysis, Optical Burst Switching networks, Optical Packet Switching networks, etc.

In the Wavelength Switching networks field, our group is especially interested in new solutions for Routing and Wavelength Assignment (RWA) Mechanisms. The new proposed RWA mechanisms are developed for intra and inter-domain routing, computing the whole path in a hierarchical or multi-layer structure. Moreover, our research is also focussed on RWA taking into account multiple physical constraints or impairments. Our main objective is then, to design a whole multi-layer RWA mechanism able to deal with inter and intra-domain routing and taking into account the physical impairments.

We have different publications proposing new RWA schemes for intra and inter-domain routing (see the list of publications below). Besides, thanks to the collaboration with Pirelli, CoreCom and Telecom Italia in the Nobel 2 project, we have published two papers (ICTON 2007 and ECOC 2007) dealing with the RWA problem taking into account the physical impairments.

Relevant Publications (OPTIONAL):

[1] Eva Marín Tordera, Xavier Masip Bruin, Sergio Sánchez López, Josep Solé Pareta, Jordi Domingo Pascual , **A Hierarchical Routing Approach for Optical Transport Networks** ,Computers Networks Journal (Elsevier), 50(2), 2006.

[2] Marcelo Yannuzzi, Xavier Masip, Sergio Sanchez, Eva Marin, Josep Sole, Jordi Domingo, **RWA Based on stochastic estimation methods and adaptive filtering for optical networks**, Globecom 2006.

[3] Eva Marín Tordera,Sergio Sánchez López, Xavier Masip Bruin, Josep Solé Pareta, Walter Erangoli, Stefano Santoni, Guido Maier,Marco Quagliotti, **Applying Prediction Concepts to routing on semi-transparent optical transport networks**, ICTON 2007.

[4] Eva Marín Tordera,Sergio Sánchez López, Xavier Masip Bruin, Josep Solé Pareta, Walter Erangoli, Stefano Santoni, Guido Maier,Marco Quagliotti, **A RWA Algorithm in Semi-Transparent Optical Networks**, ECOC 2007.

2.17 UPCT

Partner organization name: Polytechnic University of Cartagena

Short name: UPCT

Areas of expertise:

Our key research areas in the field of WP26 are:

- Network planning and traffic engineering in lightpath-based networks.

- Development of planning tools for the topic. Focus on algorithmic issues in the field.

- Study of the mathematical structure of the planning optimization problems in the topic, and their impact on heuristic design.

Relevant Publications (OPTIONAL):
[1]

2.18 Summary of research topics

In order to identify the common interests of partners and in order to materialize the initial setup of joint activities three calls (WP26 mailing list) were announced, in which each partner was requested to express its interest on already proposed research topics and/or proposing new topics in order to seek possible partners for planning joint activities. The results of these three calls are summarized in Table 2. As indicated in this table, there are some research topics in this table with one interested partner, but given the inventory of expertise it will be possible to plan further joint activities during the running period of this TP and these projects will be reported in next deliverable (D26.2: Report on Year 1 and updated plan for activities).

Table 2: Research topics and interested partners

Research Topic	Interested Partner(s)[1, 2]
Algorithms for multi-layer optimization with ICBR constraints	CTTC, TID, UAM, AIT, RACTI, **BME**, BILKENT, **UPCT**, TUW, UPC, IT
Physical Impairment Aware Network Planning/Engineering	BME, SSSUP,BILKENT, IT
Performance Evaluation of IP over optical networks	TUW
Performance evaluation of Optical Performance/Impairment monitoring Techniques	AIT, SSSUP, IT
Performance Evaluation of Impairment Aware Control Plane (GMPLS-based and/or PCE-based)	CTTC, SSSUP, UEssex, TUW
Multi constraint and dynamic lightpath routing in translucent optical networks	IBBT, AIT, BME, SSSUP, TUW, IT
Integration of Ethernet-based access and aggregation networks with the optical domain using and unified and integrated control plane	CTTC,
Performance evaluation of physical information dissemination techniques on routing protocols	CTTC, SSSUP, UEssex, IT
The impact of modulation formats on physical impairments	AIT,
Dynamic bandwidth allocation and MAC layer consideration for overlaid services in PON networks	---
Impact of cross-layer optimization on power consumption	---

1 - In order to save the space, partners are mentioned in this table with their short names.
2 - The partner who has proposed a JA proposal is presented in Bold typeface.

Research Topic	Interested Partner(s)[1, 2]
Impact of grooming and physical impairments on routing/traffic engineering and resilience actions	IBBT, BME, SSSUP, BILKENT, IT
Multi-layer algorithm using Bayesian decision theory	TID, **UAM**
RWA (Routing and Wavelength Assignment) and RP (Regenerator Placement) in semi-transparent networks	CTTC, AIT, SSSUP, TUW, **UPC**, POLIMI, IT, UPCT
Traffic Engineering in Integrated and Interconnected Control Plane Models in the Presence of Physical Impairments	**BILKENT**, BME

1 - In order to save the space, partners are mentioned in this table with their short names.
2 - The partner who has proposed a JA proposal is presented in Bold typeface.

3. Proposals for Joint Activities

Based on common interests of partners the following joint activities are planned. Given the inventory of expertise, which is also circulated among the partners, it is possible to have more joint activities during the term of this TP. These activities will be reported in the next deliverable of this TP (D26.2).

3.1 Multi-layer algorithm using Bayesian decision theory

Partner number and short name: UAM – TID
Title: Multi-layer algorithm using Bayesian decision theory
Description: Current backbone networks are migrating to an IP over WDM architecture. In such scenario, it is necessary to manage both optical and electronic physical layers. However, traditional transport functionalities, such as traffic engineering, switching and restoration, are carried in the IP/MPLS layer. In the light of this, we defined a multilayer mechanism that trades off a QoS metric (delay) and techno-economic aspects. Such mechanism follows the Bayesian decision theory, and was tested with a set of representative case scenarios. This joint activity will continue the research in this topic to define such algorithm in a whole network. We will use the risk definition of the Bayesian decision to provide a metric, which it will help to choose where to route the incoming flows using the electrical or optical layer. This activity must define the Bayesian decisor algorithm in such scenario and evaluate the routing algorithms to send the traffic over the IP over WDM network.
Requirements: *Expected Duration:* December 2009 *Type of work:* Theoretical and simulation. *Skills/facilities required:* *Skills /facilities available:*
If interested, contact: Víctor López (UAM) victor.lopez@uam.es Juan Fernandez Palacios (TID) jpfp@tid.es
Other comments: {optional}

3.2 RWA (Routing and Wavelength Assignment) and Regenerator Placement (RP) in semi-transparent networks

Partner number and short name: UPC, AIT, TUW, POLIMI, UPCT

Title: RWA (routing and wavelength assignment) and regenerator placement (RP) in semi-transparent networks.

Description:

Transparent optical networks do not convert the signal to the electrical domain in the intermediate nodes but rather keep the signal in the optical domain from source to destination. Full transparency is not always achievable in long distance networks, due to the degradation an optical signal accumulates in propagation. In semi-transparent optical networks regenerators are employed when the quality of the signal falls below the level required for an acceptably correct detection. When for a given lightpath, the signal cannot be detected at the destination node a regenerator has to be installed in an intermediate node. The regenerator breaks up the optical continuity and the optical network becomes a semi-transparent optical network.

This JA will be focussed on RWA (routing and wavelength assignment) and regenerator placement (RP) in semi-transparent networks. This work will continue developing different topics such as, Routing, Wavelength Assignment and Regenerator Placement (RWARP) and simple Routing and Wavelength Assignment (RWA) without regenerator placement (i.e. assuming regenerators have already been placed in prefixed locations) Moreover we will introduce new concepts such as the physical impairment inaccuracy.

Due to this inaccuracy on the physical parameters, new RWA algorithms taking into account this source of inaccuracy in the network state information will be developed. And finally, our objective will be to design a whole RWA mechanism that takes into account so much the physical parameters inaccuracy as the inaccuracy in the information about wavelength availability. This latter source of inaccuracy can be due to different causes, one of them is the use of aggregated information in intra-domain or hierarchical routing. Thus, the whole RWA mechanism will be able to deal with inter and intra-domain RWA and take into account the physical impairments.

Expected Outcome: joint paper to be decided with the other partners in this task.

Deadline: M24

Planning mobility actions: Preferable hosting researchers from others partners in this task.

3.3 Algorithms for multi-layer optimization with ICBR constraints

Partner number and short name: UPCT, TID, AIT, RACTI, BME, UPC, CCTC, UAM, BILKENT, IT

Title: Algorithms for multi-layer optimization with ICBR constraints.

Description:

The aim of this JA is addressing the multi-layer network optimization problems that appear in OCS networks with impairment constraints (ICBR), from an algorithmic point of view. A tentative set of milestones would be:

- Collect and characterize different network scenarios (i.e. metro vs core, 2.5/10/40/100 Gbps) as different impairment constraints appear (and disappear).

- Take a (small) set of relevant multi-layer planning problems: i.e. joint flow routing and virtual topology optimization, converter placement, etc. and study them in network scenarios with impairment constraints.

- For the chosen ICBR + multi-layer problems, study the asymptotic bounds, known inequalities, suboptimization algorithms etc.

- Finally, devise, implement and compare polynomial heuristics which make something better than an intuitive attempt of approaching to the optimum solutions.

Deadline: M24

Planed mobility actions: to be estimated (depending on interested partners)

Requirements:
Expected Duration: {How many months, continuous, sporadic, etc}

Type of work: {Theoritical, experimental, simulation, other…}

Skills/facilities required:

Skils /facilities available:

3.4 ICBR Algorithm taking into account traffic grooming

Partner number and short name: BME, AIT, IT
Title: ICBR algorithm taking into account traffic grooming
Description: The aim of this JA is the joint optimization of traffic grooming and ICBR. In both, metropolitan optical networks (MON) and long haul optical networks (LHON) the signal quality is often influenced by the physical impairments, therefore a proper impairment based routing decision is needed. In the absence of all-optical 3R regenerators, the quality of transmission has a strong impact on the feasibility of all-optical transmission. It is assumed that signal regeneration can be done only in electrical layer. Once the signal is in electrical layer there are some features supported e.g. the traffic grooming. The idea is to take into account both, the physical impairments, and the features of the electrical layer e.g. traffic grooming. Recently it was shown that traffic grooming can also be done all-optically. The other goal of this JA is to develop new algorithms which can handle both the ICBR and all-optical traffic grooming. Deadline: M24 Planed mobility actions: to be estimated (depending on interested partners)
Requirements: Expected Duration: {How many months, continuous, sporadic, etc} Type of work: {Theoritical, experimental, simulation, other…} Skills/facilities required: Skils /facilities available:
If interested, contact: {Szilárd Zsigmond}and {zsigmond@tmit.bme.hu}
Other comments: {optional}

3.5 Traffic Engineering in Integrated and Interconnected Control Plane Models in the Presence of Physical Impairments

Partner number and short name: BILKENT – BME
Title: Traffic Engineering in Integrated and Interconnected Control Plane Models in the Presence of Physical Impairments
Description: The control plane architectures proposed for interaction of the electronic and optical layers can be categorized in two different models. The first one is the vertical interconnection model where the electronic and optical layers are controlled by separate control planes and the interaction between the control planes is provided through interfaces. Three classes of integration model are defined depending on the interaction between the control planes: overlay, peer and augmented. The second approach is the vertical integration approach, in which a unified integrated control plane is used to control both layers. The control plane treats both layers as a single integrated network. In the context of e-Photon/ONe and e-Photon/ONe+, Traffic Engineering (TE) is investigated for the integration and interconnection models. TE mechanisms are proposed for each model and compared in a common scenario. The aim of this JA is to develop TE mechanisms considering the physical impairment constraints along with the throughput and resource utilization of the network, for the separate models. A detailed and comparative study of these models and TE mechanisms in the presence of physical impairments will be carried out.
Requirements: Expected Duration: 12 months Type of work: simulation Skills/facilities required: Skils /facilities available:
If interested, contact: Namik Sengezer (namik@ee.bilkent.edu.tr)
Other comments: {optional}

3.6 Summary of joint activities

Table 3 contains the key information regarding the Joint Activities that are planned so far. In addition to the current planned activities, and given the inventory of partner expertise; it is possible for all participants in this TP (WP26) to plan other new activities during the term of this project. As it is presented in this table, five joint activities with three mobility actions are planned for this work package. The duration of most of the joint activities covers the two years of the project.

Table 3: Summary of planned joint activities

No.	JA Title	Contact Person	Participants	Mobility Action	Deadline
1	Multi-layer algorithm using Bayesian decision theory	Víctor López (UAM) victor.lopez@uam.es Juan Fernandez Palacios (TID) jpfp@tid.es	**UAM**, TID		M24
2	RWA (routing and wavelength assignment) and regenerator placement (RP) in semi-transparent networks.	Eva Marin (UPC) eva@ac.upc.edu	**UPC**, AIT, TUW, POLIMI, IT, UPCT	Yes	M24
3	Algorithms for multi-layer optimization with ICBR constraints.	Pablo Pavon Pablo.pavon@upct.es	**UPCT**, TID, AIT, RACTI, BME, UPC,CCTC, UAM, BILKENT,	Yes	M24
4	ICBR algorithm taking into account traffic grooming	Szilárd Zsigmond zsigmond@tmit.bme.hu	**BME**, AIT, IT	Yes	M24
5	Traffic Engineering in Integrated and Interconnected Control Plane Models in the Presence of Physical Impairments	Namik Sengezer namik@ee.bilkent.edu.tr	**BILKENT**, BME		M12

4. Conclusions

The proposal of joint activities and their research criteria adequately cover almost all the planned research objectives of this work package as indicated in the BONE Annex I (Description of Work). Publications in international conferences and journals are almost assured thanks to the amount of partners and their expertise. Moreover, mobility actions, which will be performed in this work package, will increase the interaction among the research groups, which are participating in this work package, which is a secondary objective of this Network of Excellence. Furthermore the inventory of expertise enables the partners to initiate more joint activities during the term of this TP (WP26).