
# SEVENTH FRAMEWORK PROGRAMME

**Project Number:** FP7-ICT-2007-1 216863

**Project Title:** Building the Future Optical Network in Europe (BONE)

**CEC Deliverable Number:** FP7-ICT-216863/IT/D27.1

**Contractual Date of Deliverable:** 31/03/2009

**Actual Date of Delivery:** 24/03/2009

**Title of Deliverable** D27.1: Report on planned activities

**Work package contributing to the Deliverable:** WP27: Physical Impairments constrain based routing in packet switching networks

**Nature of the Deliverable** R (Report)

**Dissemination level of Deliverable** PU (Public)

**Editors:** IT, António Teixeira, D. Fidalgo, R. Dionísio

**Abstract:**

This document is the first deliverable of the WP27 "Physical Impairments constrain based routing in packet switching networks". This report contains a short description of the expertise available in the network and some of the starting planned activities for the WP. It is expected that some of them can evolve into further developments and activities which will be updated in the annual report.

There are nine partners involved in this work package and five joint activities are proposed.

**Keyword list:** monitoring, route, reroute, regenerate, discard, packet, management level, route level.

# 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

# Table of Contents

# 1. JA Contributors

| No. | Partner name | Contact person | e-mail | Comments |
|---|---|---|---|---|
| 2 | TUW | Gerald Franzl | Gerald.Franzl@tuwien.ac.at | Final Edit (03/04/09) |
| 13 | UPC | Jose Lázaro | jose.lazaro@tsc.upc.edu | Final Edit (07/04/09) |
| 15 | UPVLC | Ruth Vilar | rutvima@ntc.upv.es | Final Edit (20/04/09) |
| 19 | AIT | Ioannis Tomkos | itom@ait.edu.gr | Final Edit (02/04/09) |
| 24 | BME | Szilard Zsigmond | zsigmond@tmit.bme.hu | Final Edit (03/04/09) |
| 28 | ISCOM | Giorgio Lavoro | giorgio.tosibeleffi@comunicazioni.it | Final Edit (31/03/09) |
| 37 | IT | António Teixeira | teixeira@ua.pt | Initial release (25/03/09), and Final edit (07/04/09) |
| 42 | BILKENT | Namik Sengezel | namik@ee.bilkent.edu.tr | Final Edit (06/04/09) |
| 48 | USWAN | Karin Ennser | K.Ennser@swansea.ac.uk | Final Edit (06/04/09) |

# 2. Executive Summary

This document is the first deliverable of the work package “Physical Impairments constrain based routing in packet switching networks”. It contains reports on the work carried during first year of the project within proposed joint activities.
There are ten partners involved in this work package participating and five joint activities. The topics covered by this work package address the physical impairments based routing in packet switching networks.

# 3. Introduction

The main objectives of the work package "Physical Impairments constrain based routing in packet switching networks" are to collect monitoring strategies (traffic based ICBR, physical impairments ICBR, possible route parameter monitor, possible packet to packet monitor); collect regenerators (packet by packet regenerators; parameter regenerators) and collect actions (rerouting, signaling, blocking, special fields in the protocols dedicated for the control of the packet passing through the router and controllable at physical layer).
This deliverable describes the work done in this WP and provides an updates on progress of the planned joint activities.
First, we provide a list of the partners involves in the work package as well as the joint activities in which they are involved. Then we focus on the development and next steps of the joint activities. Finally we draw some conclusions.
Huawei was initially involved, however due to main power reallocation has recently quit the activity.

# 4. Participants

There are ten partners collaborating in this work package. Table 1 shows the list of participants and the number of the joint activities, in which they are involved. A detailed description of the partners' expertise and joint activities is provided in the following chapters.

| Partner No | Member | Joint Activities | Country |
|---|---|---|---|
| 2 | TUW | JA1, JA2, JA3 | Austria |
| 13 | UPC | JA1, JA2, JA3, JA4, JA5 | Spain |
| 15 | UPVLC | JA1, JA2, JA3, JA5 | Spain |
| 19 | AIT | JA1, JA4 | Greece |
| 24 | BME | JA1, JA2, JA3, JA4 | Hungary |
| 28 | ISCOM | JA1, JA2, JA3, JA4, JA5 | Italy |
| 37 | IT | JA1, JA2, JA3, JA4, JA5 | Portugal |
| 42 | BILKENT | JA1, JA3, JA4 | Turkey |
| 48 | USWAN | JA1, JA3, JA4 | United Kingdom |
| Collaborating Inst. | NICT | JA1, JA2 | Japan |

**Table 1: Work package participants and their joint activities**

# 5. Partners Expertise

| Partner shortname: | | TUW | UPC | UPVLC | AIT | BME | ISCOM | IT | BILKENT | USWAN | NICT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Are you registered in BONE-WP27 Mailing list? | | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| No. | Research Activities Topics | Interested (Y/N/? 'May be')? | | | | | | | | | |
| 1 | Impairment aware routing for burst and packet switching (state of the art observation) | Y | Y | | Y | Y | | Y | Y | | Y |
| 2 | Impairment aware routing for burst and packet switching (Simulation/experiments) | ? | Y | | Y | Y | | ? | Y | | Y |
| 3 | Regeneration for packet and burst (state of the art) | N | Y | | N | | Y | Y | | | |
| 4 | Regeneration for packet and burst (Experiments) | N | Y | | N | | | Y | | | |
| 5 | Paramenter regeneration at burst or packet speed (SoArt) | N | | | N | | | Y | | | |
| 6 | Paramenter regeneration at burst or packet speed (Experiments) | N | | | N | | | Y | | | |
| 7 | Burst or Packet Monitors (SoArt) | N | Y | | N | | | Y | | | |
| 8 | Burst or Packet Monitors (Experients) | N | Y | | N | | Y | Y | | | |
| 9 | Route parameter Monitors (SoArt) (eg. disersion/atenuation) | ? | Y | Y | N | Y | | Y | | | Y |
| 10 | Route parameter Monitors (Exp) (eg. disersion/atenuation) | ? | Y | Y | N | Y | | Y | | | Y |
| 11 | Burst or Packet Rerouting techniques at physical level (SoA) | ? | | Y | N | Y | | Y | | | Y |
| 12 | Burst or packet Rerouting techniques at physical level (Exp) | ? | | Y | N | Y | Y | Y | | | Y |
| 13 | Fast signalling for impairment aware routing (SoArt) | Y | | | N | Y | | ? | | | Y |
| 14 | Fast signalling for impairment aware routing (Exp/sim) | Y | | | N | Y | Y | ? | | | Y |
| 15 | Study of possible fields in protocols which allow packet drop or rerout and can be affected optically (eg. IP TTL) | ? | | Y | N | Y | | Y | | | Y |
| 16 | How to optically block degraded packets | ? | | ? | N | | | Y | | | |
| 17 | When & where to block packets (i.e. admission control) | Y | | | | | | ? | | | |

## *5.1 TUW (P2)*

**Partner organization name: Vienna University of Technology**

**Short name: TUW**

**Areas of expertise:**

Vienna University of Technology (TUW) offers 19 undergraduate and 41 graduate programs, and is strongly involved in basic and applied research. The Institute of Broadband Communications (IBK) covers teaching and research on communication networks, with a strong emphasis on optical networks, next generation networks, and wireless networks. Some of the lectures offered for undergraduate and graduate students are Photonic Network Technologies, Data Communications, Teletraffic Theory and Performance Evaluation. Current research is focused on control, management and traffic engineering concepts and protocols, network architectures, theoretical and simulative investigations in the transport layer, design and validation of new subsystems and techniques for optical signal transmission,

as well as security, location based services, and the IP multimedia subsystem within future Internet and next generation networks research area.

Impairment-aware, respectively constraint-routing is seen as key demand for all optical networks to achieve maturity. In dynamic environments like a packet switched network the common practice of commissioning must fail as all potential network states can be hardly tested in order validate commissioning (complexity O(N!)). Instead, the routing mechanism needs to take the responsibility that a current path along which the packet is forwarded is feasible. Impairment aware routing is assumed mandatory to achieve scalable all-optical networks. Impairment-constraint-routing is a prime step towards impairments awareness in the network layer, respectively in a network's control plane. The special challenge arises from the nature of physical layer impairments: being related to physical (analogous) effects these impairments comprise correlations and in general can not be perfectly compensated in contrast to digital impairments (bit errors), which, with sufficient overhead, in principle can be eliminated.

**Relevant Publications:**

[1] A. Teixeira, L. Nicolau Costa, G. Franzl, S. Azodolmolky, I Tomkos, K. Vlachos, S. Zsigmond, T. Cinkler, G.T. Beleffi, P. Gravey, T. Loukina, J.A. Lazaro, C. Vazquez, J. Montalvo, E. Le Rouzic: "An Integrated View on Dynamic Monitoring and Compensation for Optical Networks: From Management to Physical Layer"; Photonic Network Communications, 2009.

[2] B. Statovci-Halimi, V. C. Emeakaroha: "Enabling Class-based QoS Commitments through Flow-Aware Admission Control"; International Workshop on Traffic Management and Traffic Engineering for the Future Internet (FITraMEn08), Porto, Portugal; 2008.

[3] S. Aleksic: "Dynamic Optical Packet/Burst-Switched Metropolitan Area Network"; Elektrotechnik und Informationstechnik (e&i), Vol. 125 (2008), 7/8; 290 - 295.

[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.

## 5.2 UPC (P13)

**Partner organization name: Universitat Politècnica de Catalunya**

**Short name: UPC**

**Areas of expertise:**

The **Universitat Politècnica de Catalunya (UPC)** has expertise in several fields related to the WP23. In particular, several publications at IEEE JLT, ICTON and ECOC show the application of transmission techniques based in Burst mode traffic applied mainly to access networks (PON). Both physical and also higher layer are considered either focusing at:

-Transmission and detection impairments of burst or packets

-Developing of Access-Metro interfaces

-Queue management techniques for QoS control in resilient PONs

-Amplification of burst or packets in PONS

**Relevant Publications:**

[1] J. Segarra, V. Sales, J. Prat, "An All-Optical Access-Metro Interface for Hybrid WDM/TDM PON Based on OBS", IEEE J. Lightwave Technology, 25 (4): 1002-1016, April 2007.

[2] J. Segarra, V. Sales, J. Prat, "OLT design approach for resilient extended PON with OBS dynamic bandwidth allocation sharing the OLT optical resources", ICTON 2008, 4, pp: 139-144, 22-26 June 2008.

[3] J. Segarra, V. Sales, J. Prat, "Queue Management and Priority Scheduling Disciplines for QoS Control in Wavelength Routed OBS (WROBS) Access Networks", ICTON 2006, 3, pp: 207-214, June 2006.

[4] A. Baptista, N. B. Pavlović, P. André, D. Forin, G. Tosi Beleffi, J. A. Lázaro, J. Prat, and A. Teixeira, "Improved remote node configuration for passive ring-tree architectures", IEEE ECOC 2008, Bruxelles.

[5] J.A. Lazaro, K. Ennser, G. Della Valle, S. Taccheo, V. Polo, and J. Prat, "Reflective ONUs by integration of Erbium Doped Waveguide Amplifiers", ECOC 2007, pp 644, Berlin, Germany, 16-20 Sept. 2007 , ISBN: 978-3-8007-3042-1

## 5.3 UPVLC (P15)

**Partner organization name: Universidad Politécnica de Valencia**

**Short name: UPVLC**

**Areas of expertise:**

The **UPVLC** research activities are focused on optical performance monitoring in OPS networks. OPS is particularly attractive as a possible technology for future telecommunication networks, due to its compatibility with Internet protocol (IP), and efficient use of the network resources. However, OPS brings about new challenges to the research in optical performance monitoring. In this scenario, each packet follows its own path along the network depending on the routing information contained in the label and thereby packets suffer from different signal degradations. Therefore, a definitive goal for optical performance monitoring is to provide comprehensive signal quality information on packet basis. The traditional monitoring techniques based on BER estimation or Q-factor are not appropriate for the future ultra high-speed optical networks due to the O/E conversions which limit the bitrate unless it is preceeded by optical time demultiplexing. In particular, UPVLC has proposed some all-optical monitoring techniques which assess the signal quality packet by packet. Moreover, we are also interested in integrating monitoring tasks with other functions in the packet switching node to take immediate actions when the signal quality is strongly degraded (e.g. discard, rerouting). Indeed, the quality information obtained from the optical monitor could be included when calculating new routes for data signals or backup routes in order to fast react to network failures and sustain reliability of future networks.

**Relevant Publications:**

[1] R. Vilar, J.M. Martinez, F. Ramos, J. Marti, "All-optical DGD monitor for packet-switched networks based on na integrated active Mach-Zehnder interferometer operating as logic XOR gate", Optics Communications,Vol. 281, July 2008 pp. 5330-5334.

[2] Ruth Vilar, José M. Martínez, Francisco Ramos, and Javier Martí, "All-Optical decrementing of a packet's time-to-live (TTL) field using logic XOR gates", OPTICS EXPRESS, Vol. 16, No. 24, November 2008.

## 5.4 AIT

**Partner organization name: Athens Information Technology**

**Short name: AIT**

**Areas of expertise:**

AIT has a strong experience in cross-layer design of transparent networks, in particular, with circuit-switched and OBS networks. AIT is leading the FP7 "DICONET" STREP dealing with this very topic. In particular, AIT has performed studies on the related topics:

- monitoring in transparent optical networks;

- routing and wavelength assignment accounting for physical impairments;

- control plane requirements for optical transparent networks;

- techno-economic studies.

Some of the techniques could be applicable to packet switching.

**Relevant Publications:**

[1] Siamak Azodolmolky**,** Yvan Pointurier, Marianna Angelou, Josep Sole Pareta, and Ioannis Tomkos, "An Offline Impairment Aware RWA Algorithm with Dedicated Path Protection Consideration", OFC/NFOEC 2009, OWI1, 22-26 March 2009, San Diego, California, USA.

[2] I. Tomkos, S. Azodolmolky**,** M. Angelou, D. Klonidis, Y. Ye, C. Saradhi, E. Salvadori, A. Zanardi, "Impairment Aware Networking and Relevant Resilience Issues in All-Optical Networks", ECOC 2008, Brussels, Belgium.

[3] Pablo Pavon-Mariño, Siamak Azodolmolky**,** Ramon Aparicio-Pardo, Belen Garcia-Manrubia, Yvan Pointurier, Marianna Angelou, Josep Solé Pareta, J. Garcia-Haro, Ioannis Tomkos, "Offline Impairment Aware RWA Algorithms for Cross-Layer Planning of Optical Networks", IEEE Journal of Lightwave Technologies, Accepted for publication.

[4] S. Azodolmolky**,** M. Klinkowski, E. Marin, D. Careglio, J. Sole Pareta, I. Tomkos, "A Survey on Physical Layer Impairments Aware Routing and Wavelength Assignment Algorithms in Optical Networks", Computer Networks (Elsevier) (ISSN: 1389-1286), accepted for publication.

## 5.5 BME (P24)

**Partner organization name: Budapest University of Technology and Economics**

**Short name: BME**

**Areas of expertise:**

BME research is focused on impairment based routing, the simulation of multilayer networks considering the physical impairments. We compare different methods for both, single and multilayer networks. We also developed models where 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.

Recently in collaboration with National Institute of Information and Communication technology (NICT) Japan, Photonic Network Group we extended our research to optical packet switch (OPS) systems. Here we investigated the by extensive simulations the performance of OPS systems, based on different modulation formats or component parameters.

**Relevant Publications:**

[1] Sz. Zsigmond, M. Perényi, T. Cinkler, "ILP formulation of Signal Power Based Routing for Single and Multilayer Optical Networks", BROADNETS 2008 September 8-11 2008 London.
[2] Sz. Zsigmond, G. Németh, T. Cinkler, "Mutual Impact of Physical Impairments and Grooming in Multilayer Networks", ONDM 2007 Greece.
[3] Sz. Zsigmond, H. Furukawa, N. Wada, T. Miyazaki, "Scalability Study of 640Gbit/s/port Optical Packet Switched Prototype", under publish.
[4] Sz. Zsigmond, H. Furukawa, N. Wada, T. Miyazaki, "Modulation Formats Comparison in a Prototype 640Gbit/s/port Optical Packet Switching System", under publish.

## 5.6 ISCOM (P28)

**Partner organization name: Superior Institute of Communications and Information Technologies**

**Short name: ISCOM**

**Areas of expertise:**

The key research topics at ISCOM, Ministry of Economic Development Communication Department, in the area of WP27 FP7 NoE BONe are focused monitoring and physical impairments detection in packet switched networks. In particular several experiments have been carried out on packet based infrastructures in the area of all optical monitoring and signalling. Experimental joint activities are planned to be performed with IT, AIT and all the other partners involved in the WP27 area partners.

**Relevant Publications:**

[1] A. Baptista, N. B. Pavlović, P. André, D. Forin, G. Tosi Beleffi, J. A. Lázaro, J. Prat, and A. Teixeira, "Improved remote node configuration for passive ring-tree architectures", IEEE ECOC 2008, Bruxelles.

[2] M. Tobia, S. Taccheo,K. Ennser,D. Forin, G. Tosi-Beleffi, M. Guglielminucci, F. Curti, A. Teixeira, "Implementation of in line first-order PMD monitoring in high-bit-rate links based on supercontinuum generation in normal dispersion regime", IEEE/LEOS CLEO EUROPE 2007, Conference, June 2007.

[3] F. Di Vincenzo, G. Cincotti, G. M. Tosi Beleffi, D. M. Forin, F. Curti, A. Teixeira, "Remote inline all optical signalling and monitoring in passive optical network scenarios by means of erbium doped fiber amplifier pump modulation", Conference on Laser and Electrooptics (CLEO) and Quantum Electronics and Laser Science Conference (QELS), San Jose, California, May 2008.

[4] G. Incerti, F. Incerti, F. Di Vicenzo, D. Forin, G. Tosi Beleffi, F. Curti, A. Teixeira, J. Prat, "Remote Pumping and Signalling in a Passive Optical Network Scenario", ICTON 08 Proceedings, Vol. 1, No. 1, pp. 312-315, ATHENS, July 2008.

## 5.7 IT (P37)

**Partner organization name: Instituto de Telecomunicações**

**Short name: IT**

**Areas of expertise:**

**Insituto de Telecomunicações** has expertise in several fields related to the WP27. It has been leading several initiatives in the field of optical monitoring in networks (eg. A topical project in the former e-Photon ONe on dynamic monitoring). It has promoted several joint activities which lead to several papers in the field.

It has worked for long time in:

- asynchronous performance monitoring.

- all-optical pre-processing for optical monitoring (RF tone analysis)

- Burst mode operation of optical amplifiers.

- all-optical packet routing

- all-optical regeneration

IT has top level equipped labs available for sharing inside the WP.

**Relevant Publications:**

[1] Luis, R.S.; Teixeira, A.; Monteiro, P., "Optical signal-to-noise ratio estimation using reference asynchronous histograms", IEEE/OSA Journal of Lightwave Tech., Vol.1, No.1, pp.1-1, Jun 2008.
[2] V. Di Vicenszo; G. C. Cincotti; G. Tosi-Beleffi; D. Forin; F. Curti; Teixeira, A.T.; "Remote inline all optical signalling and monitoring in passive optical network scenarios by means of erbium doped fiber amplifier pump modulation", Proc Conf. on Lasers and Electro-optic - CLEO, San José, United States, Vol. CD, pp. JWA106, May, 2008.
[3] Andre, P; Neto, B; Teixeira, A; Wada, N., "Raman amplification impact in packet base networks", Microwave and Optical Tech. Letters, Vol. 50, No. 12, pp. 3083 - 3085, December, 2008.
[4] Author(s): A. Teixeira, L. Costa, G. Franzl, S. Azodolmolky, I. Tomkos, K. Vlachos, S. Zsigmond, T. Cinkler, G. Tosi Beleffi, P. Gravey, T. Loukina, J.A. Lázaro, C. Vazquez, J. Montalvo, E.L. Rouzic, "An Integrated View on Monitoring and Compensation for Dynamic Optical Networks: From Management to Physical Layer", Photonics Network communications, in publication phase (20 pages), 2009.

## 5.8 BILKENT (P42)

**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.

We are currently conducting a joint study with Budapest University of Technology and Economics on development of traffic engineering approaches satisfying physical layer impairment constraints in the scope of WP26.

We are also conducting studies on physical layer impairment aware virtual topology design. In the context of these studies, we develop ILP formulations and also heuristic approaches for the problem. The heuristics we develop include application of various routing and wavelength assignment strategies with the aim of providing a maximum BER threshold or minimizing the BER of the established lightpaths. The considered physical layer impairments include PMD, fiber attenuation, ASE noise and crosstalk. We are also working on introduction of the effects of four-wave mixing to our model.

In the context of WP27, we are planning to make use of our current experience from the aforementioned studies and develop impairment aware routing algorithms for optical packet switching networks.

**Relevant Publications:**

[1] P. Hegyi, N. Sengezer, E. Karasan, T. Cinkler, "Traffic Engineering in Case of Interconnected and Integrated Layers", Networks 2008, Budapest, Hungary, Oct. 2008.
[2] 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.
[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.

# 6. List of Joint Activities

This chapter describes the joint activities that will be carried out in this work package. Following, Table 2 shows key information about these joint activities:

| No | Joint Activity Title | Responsible person | Participants | Mobility Action | Deadline |
|---|---|---|---|---|---|
| 1 | Impairment aware algorithms for optical packet switching (OPS) networks | Ioannis Tomkos | TUW, UPC, UPVLC, AIT, ISCOM, IT, USWAN, BME, BILKENT, NICT | Not yet planned | M33 |
| 2 | Monitoring strategies for OBS and OPS networks | Rogério Dionísio | TUW, UPC, UPVLC, ISCOM, IT, BME, NICT | Not yet planned | M33 |
| 3 | Decision mechanisms for packet transit in OPS networks | António Teixeira | TUW, UPC, UPVLC, ISCOM, IT, USWAN, BME, BILKENT | *planned | M33 |
| 4 | Techno-economic study of monitoring techniques in OPS networks | Giorgio Tosi Beleffi | UPC, AIT, ISCOM, IT, USWAN, BME, BILKEN | Not yet planned | M33 |
| 5 | SOA Spectral Red-shift and Blue-shift for Chromatic Dispersion and OSNR Monitoring in Packets | Diana Fidalgo | UPC, UPVLC ISCOM, IT | *Planned | M33 |

* # to be estimated with the evolution of the work

**Table 2: Summary list of the planned joint activities**

As it is depicted in previous table, five joint activities are planned for this work package.

## 6.1 JA-1 - Impairment aware algorithms for optical packet switching (OPS) networks

**Participants**: G. Franzl, J.A. Lázaro, R. Vilar, I. Tomkos, G. Tosi-Beleffi, A. Teixeira, K. Ennser, Szilard Zsigmond, Namik Sengezel

**Responsible person**: G. Franzl

**Description:**

While attenuation can be assumed to be compensated hop by hop using all optical amplifiers other physical layer impairments (degrading the optical signal quality) accumulate hop by hop. In all-optical networks the routing mechanisms therefore shall consider the degradation of the optical signal to avoid paths delivering optical signals not receivable with an acceptable bit error rate (BER).

A distinction needs to be made among two types of impairments: a) the load independent physical layer impairments – these limit the maximum path length, and b) the load dependent, which should be considered in short term routing decisions, e.g., load balancing and hop-by-hop admission control, to assure that the remaining packets on a hop are not unacceptably degraded along their individual paths. Latter causes an NP hard optimization problem and likely heuristics need to be found in order to define viable (fast enough) routing mechanisms.

**Objectives:**

The aim of this JA is to collect routing algorithms to implement traffic decisions in packet switched networks, based on impairment present in optical systems (PMD, noise, and crosstalk).

**Mobility actions:**

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

**Requirements**:

Expected Duration: 17 months

Type of work: Theoretical, simulation

Skills/facilities required:

Skills /facilities available: TUW: experience with multi-constraint routing problems

**If interested, contact:**

António Teixeira (teixeira@ua.pt)

**Meetings:**

One midterm meeting with the BONE´s annual
One final meeting around M14

**Papers:**

[1] I. Tomkos, S. Sygletos, A. Tzanakaki, and G. Markidis, "Impairment Constraint Based Routing in Mesh Optical Networks," in Optical Fiber Communication and the National Fiber Optic Engineers Conference, 2007. OFC/NFOEC 2007. Conference on, 2007, pp. 1-3.

**Other information:**

Possible partners: TUW, UPC, UPVLC AIT, ISCOM, IT, USWAN, BME, BILKENT, NICT

## 6.2 JA-2 - Monitoring strategies for OBS and OPS networks

**Participants**: G. Franzl, J.A. Lázaro, R. Vilar, G. Tosi-Beleffi, A. Teixeira, Szilard Zsigmond

**Responsible person**: Rogério Dionísio

**Objectives:**

The aim of this JA is to collect monitoring techniques to detect physical impairments, and investigate their effectiveness in optical packet switched (OPS) networks.

**Description:**

Two distinct scenarios are possible:

Monitoring at the router level: The techniques to be implemented must be fast enough to detect physical constraints packet by packet, eventually supported by an all-optical structure.

Monitoring at the management level: For a long-term evaluation of the network impairments, the mitigation techniques used should be route oriented, with a larger time scale.

The individual effectiveness and potential gain from combined consideration shall be investigated to outline close-to-optimal strategies given the monitoring options considered available for different scenarios.

**Mobility actions:**

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

**Requirements**:

Expected Duration: 17 month

Type of work: Theoretical, simulation

Skills/facilities required:

Skills /facilities available: simulation tools (VPI, Matlab)

**If interested, contact:**

António Teixeira (teixeira@ua.pt

**Meetings:**

One midterm meeting with the BONE´s annual
One final meeting around M14

**Papers:**

[1] A. Teixeira et al, "An integrated view on monitoring and compensation for dynamic optical networks: from management to physical layer", Photonic Network Communications, 2009 (to be published).
[2] Luis, R., Teixeira, A., Andre, P., Monteiro, P. "Novel distortion resilient OSNR monitoring technique based on evaluation of asynchronous histograms", Microwave and Optical Technology Letters, vol. 48, pp. 1369-1372, 2006.
[3] S. Pachnicke and P. M. Krummrich, "Constraint-Based Routing in Path-Protected Translucent Optical Networks Considering Fiber Nonlinearities and Polarization Mode Dispersion", in APOC2008, 2008.

**Other information:**

Possible partners: TUW, UPC, UPVLC, ISCOM, IT, BME, NICT

## 6.3 JA-3 - Decision mechanisms for packet transit in OPS networks

**Participants**: G. Franzl, J.A. Lázaro, R. Vilar, G. Tosi-Beleffi, A. Teixeira, K. Ennser, Szilard Zsigmond, Namik Sengezel

**Responsible person**: António Teixeira

**Objectives:**

The aim of this JA is to collect actions to be implemented on the reception of optical packets, prior routing to an out-port, depending on the information supplied by the monitoring system. Operations like re-routing, signaling, blocking and discard of packet are among the objectives of study.

Moreover, special fields of the communication protocol, dedicated for the control of packet routing, potentially controllable at the physical layer (e.g. TTL in the IP protocol), shall be considered and their usage studied.

**Mobility actions:**

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

**Requirements**:

Expected Duration: 17 months

Type of work: Simulation, experimental

Skills/facilities required:

Skills /facilities available: simulation tools (VPI, Matlab, optisystem), optical laboratory

**If interested, contact:**

António Teixeira (teixeira@ua.pt)

**Meetings:**

One midterm meeting with the BONE´s annual
One final meeting around M14

**Papers:**

[1] I. Papagiannakis, D. Klonidis, V. Curri, P. Poggiolini, G. Bosco, R.I. Killey, M. Omella, J.Prat, D. Fonseca, A. Teixeira, A. Cartaxo, R. Freund, E. Grivas, A. Bogris, A.N. Birbas, and I. Tomkos., "Electronic Distortion Compensation in the Mitigation of Optical Transmission Impairments: The view of JP-E ePhoton/ONe+ project", IET of

Optoelectronics, (in publication phase), 2009.
[2] A. Teixeira, P. Andre, R. Nogueira, P. Monteiro, J. da Rocha, "All-optical routing limitations due to semiconductor optical amplifliers dynamics", Lecture Notes in Computer Science, 3124:766-771, 2004.
[3] S. Pachnicke, T. Paschenda, and P. M. Krummrich, "Physical impairment based regenerator placement and routing in translucent optical networks", 2008 Conference on Optical Fiber Communication/National Fiber Optic Engineers Conference, Vols 1-8, pp. 2535-2537 3037, 2008.

**Other information:**

Possible partners: TUW, UPC, UPVLC, ISCOM, IT, USWAN, BME, BILKENT

## 6.4 JA-4 - Techno-economic study of monitoring techniques in OPS networks

**Participants**: J.A. Lázaro, I. Tomkos, G. Tosi-Beleffi, A. Teixeira, K. Ennser, Szilard Zsigmond, Namik Sengezel

**Responsible person**: Giorgio Tosi-Beleffi

**Objectives:**

The aim of this JA is carrying out OPS network studies in different scenarios, depending on the monitoring level (flow, packet combined) and ICBR techniques to be integrated in the short/long term.

Where monitoring on flow level is assumed to be performed at optical signal destinations determining the end-to-end signal degradation along an entire route (path), and monitoring on packet level at every node, realizing the common hop-by-hop scheme of today's digital networks.

Monitoring flows end-to-end is assumed least costly as at destinations optical signals are assumed to be converted to electrical domain anyhow and therefore techniques requiring O/E conversion do not require additional O/E converters. Monitoring packets individually at every node (per hop) is assumed the most equipment intensive approach. The decision complexity opposes that; i.e., end-to-end information on signal degradation first needs to be correlated in order to identify the responsible source and thereby the actions required to solve a problem.

The economic impact of monitoring devices shall be compared to the economic impact of imperfectly delivered optical signals using extreme examples, a private customer (IP-TV) and a security/health relevant application (remote control of a power distribution network).

**Mobility actions:**

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

**Requirements**:

Expected Duration: 17 months

Type of work: workshop or special session integrated on a conference, where a panel of experts could gather around the subject.

**If interested, contact:**

António Teixeira (teixeira@ua.pt)

**Meetings:**

One midterm meeting with the BONE´s annual
One final meeting around M14

**Papers:**

[1]

**Other information:**

Possible partners: UPC, AIT, ISCOM, IT, USWAN, BME, BILKENT

## 6.5 JA-5 - SOA Spectral Red-shift and Blue-shift for Chromatic Dispersion and OSNR Monitoring in Packets

**Participants**: R. Vilar, G. Tosi-Beleffi, Diana Fidalgo, António Teixeira, J.A. Lázaro

**Responsible person**: Diana Fidalgo

**Objectives:**

The aim of this JA is monitoring CD and OSNR in packets. The main goal is to determine the packet parameters, to which, it can be applied the CD and OSNR monitoring based on non linear spectral reshaping.

**Description**:

Optical performance monitoring is essential in high-bit-rate transparent networks in order to provide, for instance, quality of service, fault management (protection switching), information about the signal quality, dynamic provisioning, and restoration. High speed conversions to enable measurements on the RF electrical signal is the most straightforward way of achieving the ability to monitor time-domain process necessary to assess information about the transmission impairments, like polarization mode dispersion (PMD), Chromatic Dispersion (CD) and Optical-Signal-to-Noise Ratio (OSNR).

Optical packet routing/switching has received much attention, as it is generally considered as one of the key elements for the next generation Internet in order to support the rapidly growing Internet traffic as well as high-bandwidth demands within Next Generation Network core. It could provide for great flexibility, capacity, efficiency and bandwidth utilization that current switching strategies are not capable of providing. Optical packet switching, allows converging optical networks with packets protocols, e.g. IP and Ethernet. Thus, it allows the same data path to be shared by many users in the network as well as simplify the electronic interfaces.

The activities plan includes tests to determine several packets parameters, such as, the packet length and inter-packet spacing. It is also intended to analyze the effects of optical amplification (e.g. EDFA, SOA and Raman) on OSNR and CD monitoring in packets.

**Mobility actions:**

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

**Requirements**:

Expected Duration: 17 months

Type of work: Simulation, experimental

Skills/facilities required:

Skills /facilities available: Simulation tools (VPI, Matlab), optical laboratory

**If interested, contact:**

António Teixeira (teixeira@ua.pt)

**Meetings:**

One midterm meeting with the BONE´s annual
One final meeting around M14

**Papers:**

[1] D. S. Fidalgo, L. N. Costa, R. Nogueira and A. L. J. Teixeira, "SOA spectral red-shift and blue-shift for OSNR monitoring", SEON 2008.
[2] P. Vorreau, D. C. Kilper, J. Leuthold, "Optical Noise and Dispersion Monitoring with SOA-Based Optical 2R Regenerator", IEEE Photon. Technol. Lett., Vol. 17, No. 1, Jan. 2005.
[3] Y. Shi, M. Chen, S. Xie, "A novel low power chromatic dispersion monitoring technique employing SOA spectral shift", Optics Communications, Vol. 230, pp. 297-300, Nov. 2003.

**Other information:**

Possible partners: UPVLC, ISCOM, IT

# 7. Conclusions

The number of joint activities is adequate with respect to the number of partners involved in this work package. If all the planned activities follow the steps described in their proposal, this work package will fulfill the objectives defined in the project's technical annex.
Publications in international conferences and journals are almost assured thanks to the amount of partners and their expertise. Moreover, mobility actions, which will be carried out within this work package, will increase the interaction among the research groups involved in the work package, which is an objective of this Network of Excellence.
In addition to the currently running JAs, the following list of proposed research topic will be also repeatedly circulated among the participants in order to communicate state of work and to start new joint activities during runtime of the project.

| No. | Description | Status |
|---|---|---|
| 1 | Impairment aware algorithms for optical packet switching (OPS) networks | To be started |
| 2 | Monitoring strategies for OBS and OPS networks | To be started |
| 3 | Decision mechanisms for packet transit in OPS networks | To be started |
| 4 | Techno-economic study of monitoring techniques in OPS networks | To be started |
| 5 | SOA spectral Red-shift and Blue-shift for Chromatic Dispersion and OSNR Monitoring in Packets. | Active |