Nokia Siemens Networks

Research Activities at Nokia Siemens Networks Portugal

Overview

Nokia Siemens Networks

Research Group in Portugal

- 2002 - Start of activities
- 2002 - Acknowledgement from FCT as Shelter Institution for Scholarships.
- 2003 - Contest for Siemens Doctorships and selection of first candidates.
- 2004 - Siemens/NSN Portugal joins Institute of Telecommunications.
- 2005 - Siemens/NSN Connects Research Lab to a Research Network
- 2006 - NSN builds National Consortium of Excellence for Telecommunications (Telesal).

Research Group NSN Portugal Overview

Advanced Research Centre

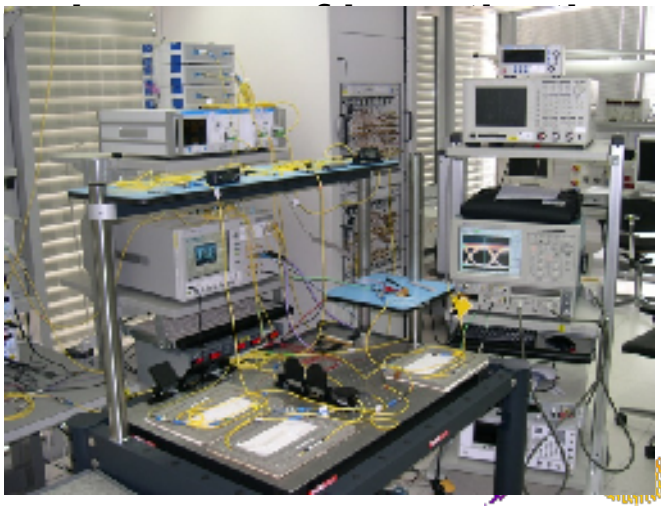
Currently has 20 PhD students and two PhDs;

-Paulo Monteiro
-Daniel Fonseca
-Rui Meleiro
-Lara Pellegrino
-Carlos Santiago
-João Santos
-Catarina Francisco

- Marek Hajduczenia
-Jorge Castro
-Rui Morais
-Silvia Pato
-João Gomes
-Tiago Silveira
-João Redol

-Nuno Garcia
-João Pedro
-José Pina
-Ruben Luis
-Pedro Inácio
-Rui Luis
-Pan Jieke

Three



Lab Infrastructures

- Lab plant over 2000 sqm for **Three State of the art labs**: Multimedia, Network Management, Optical Networks. Together they represent a truly **end-to-end Carrier solutions lab**.
- Lab Data Center with 300 servers, storage and Backup facilities.
- Over 250 installed Network Elements **(WDM, NG-SDH ADMs, xDSL, xPON,…)**.
- Over 200 Gb/s stream traffic generation capability for packet oriented System Testing and traffic engineering.



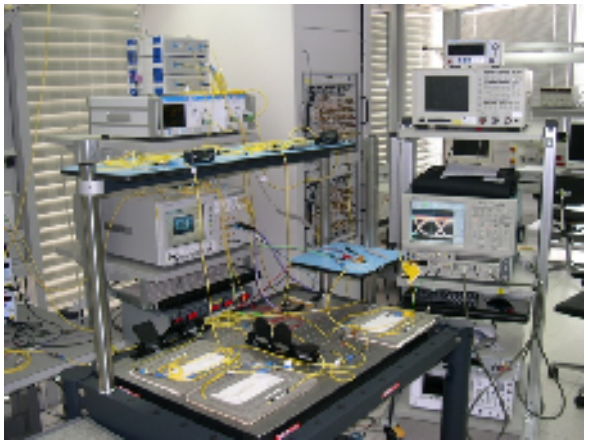

Lab Infrastructures (Research)

- 43Gb/s, 13Gb/s and 10Gb/s BER testers
- EO transmitter for various formats, for BERT
- Optical Spectrum Analyzers, 0.01nm max. resolution
- Oscilloscopes with: 65, 55 GHz and optical sampling head

  12Gb/s optical sampling head with CDR

  50, 70 GHz electrical sampling heads

  Phase reference module for low jitter measurements
- 40GHz ultra short pulse generator (< 1ps)
- Optical bit rate interleavers (2x and 4x) for 80 Gbit/s and 160 Gbit/s
- Several medium power and low noise EDFAs (up to 2W)
- Tunable lasers and optical filters; CD and PMD emulators
- Up to 50 GHz synthesized signal generator
- 40Gb/s MZ modulators, optical phase modulator, 40GHz electrical driver,



Research Activities at NSN Portugal

Participation in Research Projects :

- **National:** ARPA; SHOTS; Oreo; CONDENSA; CONPAC; SUPRESSOR
- **International (FP6,Celtic):** MUFINS; TRIUMPH; IOLOS, Optronet

Scientific Actions:

- COST (**Co**operation in the field of **S**cientific and **T**echnical Research)
- ISIS (Industry Board Member)
- ePIXnet (affiliate member)

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Networks

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Areas of research

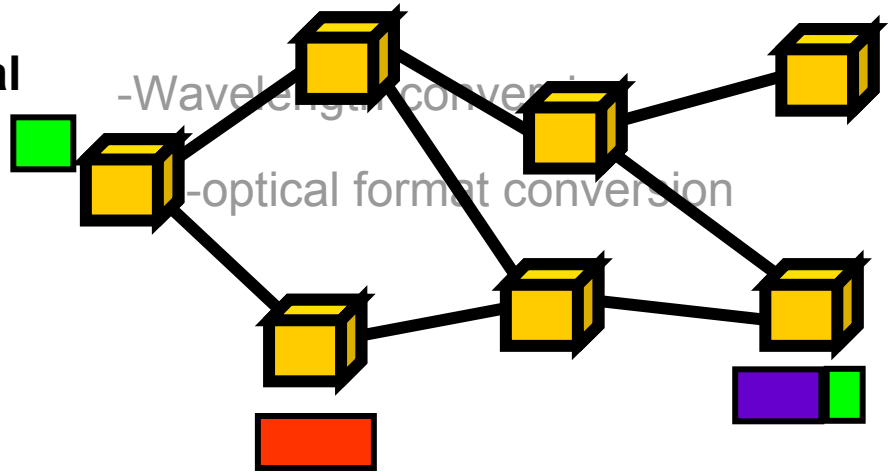
- Architectures and algorithms for optical burst/packet networks
- Traffic monitoring, measurement, classification, etc
- Intrusion detection systems
- Advanced frameworks and active defence mechanisms
- Advanced frameworks for distributive and inteligent network management
- Quality of service (QoS)
- IP traffic aggregation and burst assembly evaluation

Areas of research

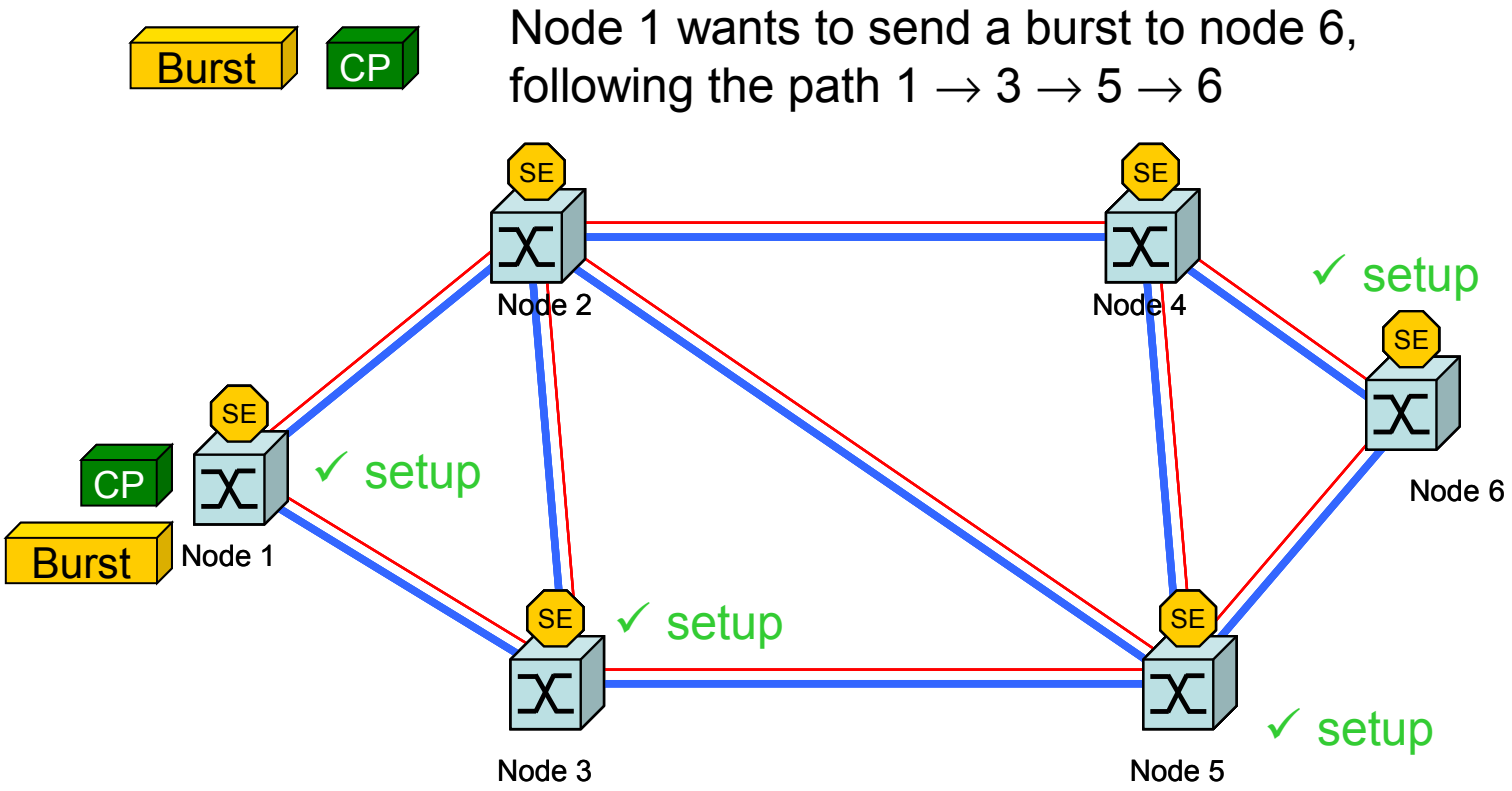
- Optical integration
- Modulation formats
- Optical processing
- Regeneration
- Wavelength conversion
- Time-slot processing
- optical format conversion
- dynamic
- Optical Switching Node
- automatic adaptation to IP traffic
- Optical burst switching
- Optical monitoring
- Optical network planning
- Minimization of expensive optical componentes

Objectives:

- **Implementation of an efficient optical layer**
- **Optical burst switching**
- **Cost-effective network architectures**



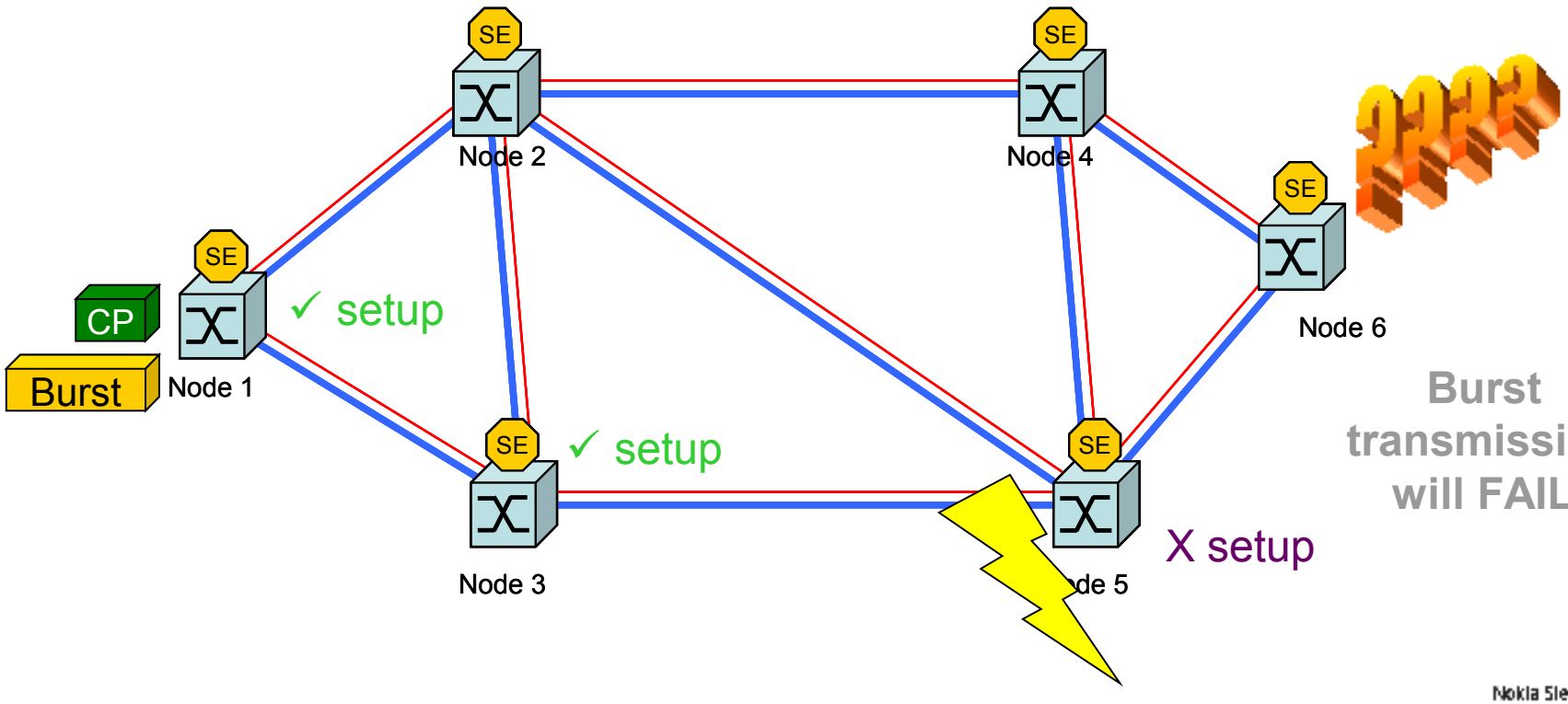
OBS Architecture



- Data and respective control packet are separated by a time delay
- Network intelligence at the edge

OBS Architecture

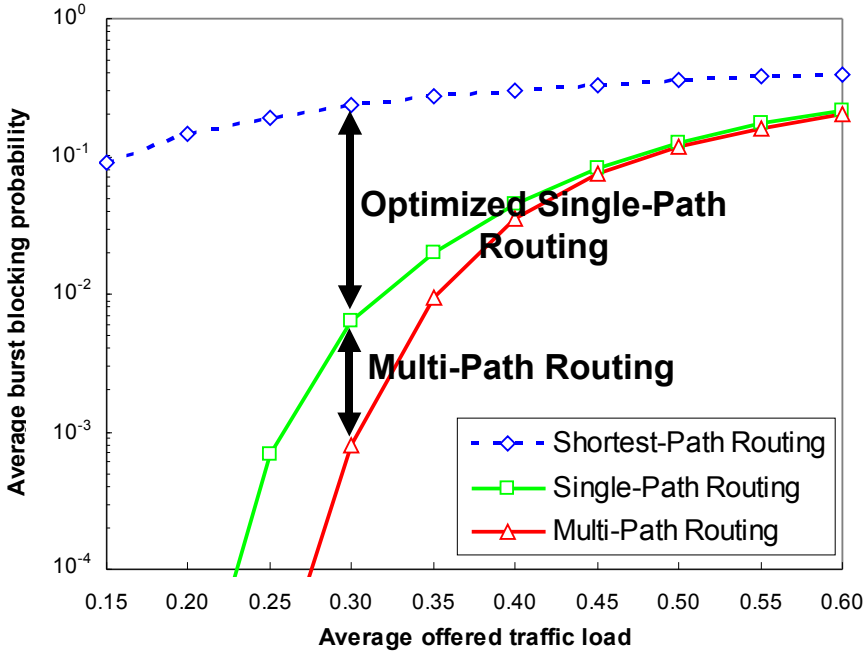
Node 1 wants to send a burst to node 6,
following the path 1 → 3 → 5 → 6
but node 5 has no free resources

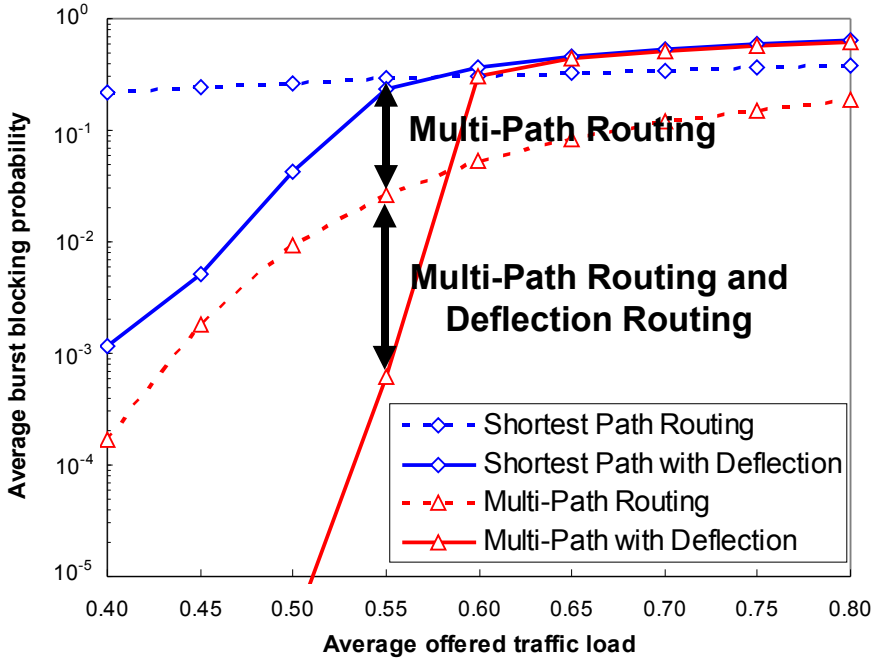


Contention Minimization/Resolution in the Space Domain

Motivation: proactively reducing the impact of burst losses at the bottleneck links and exploiting the capacity available at the least congested links to resolve contention

Proposal: combine a novel proactive Multi-Path Routing (MPR) strategy with deflection routing





- With multi-path routing it is possible to support **20% more traffic load** for an **objective average burst loss of 10^{-3}** than that supported with a known optimized single-path routing strategy

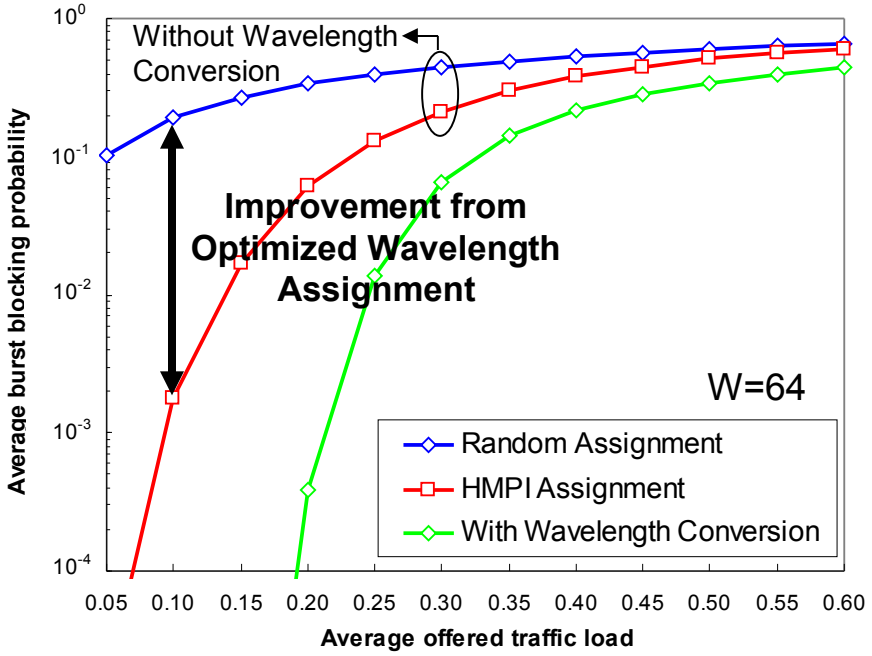
- Combining multi-path routing with deflection routing enables to support **38% more traffic load** for an **objective average burst loss of 10^{-3}**

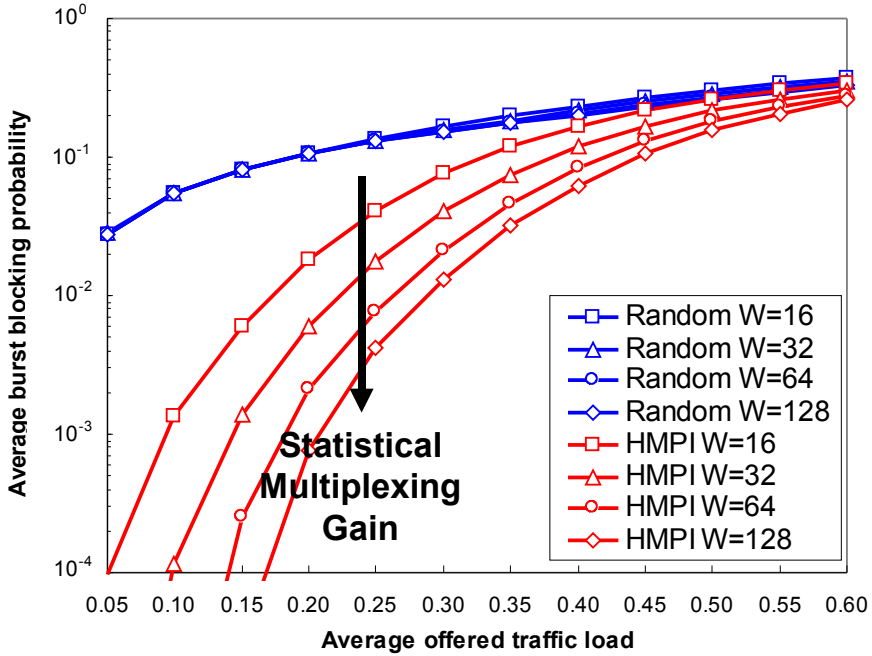
Publications: ConfTele 2007 and IEEE ICTON 2007

Contention Minimization in the Wavelength Domain

Motivation: improve the performance of OBS networks without wavelength converters by exploiting the wavelength domain to minimize the probability of contention.

Proposal: novel Heuristic Minimum Priority Interference (HMPI) strategy for proactively minimize the probability of contention for the same wavelength by bursts going through overlapping paths





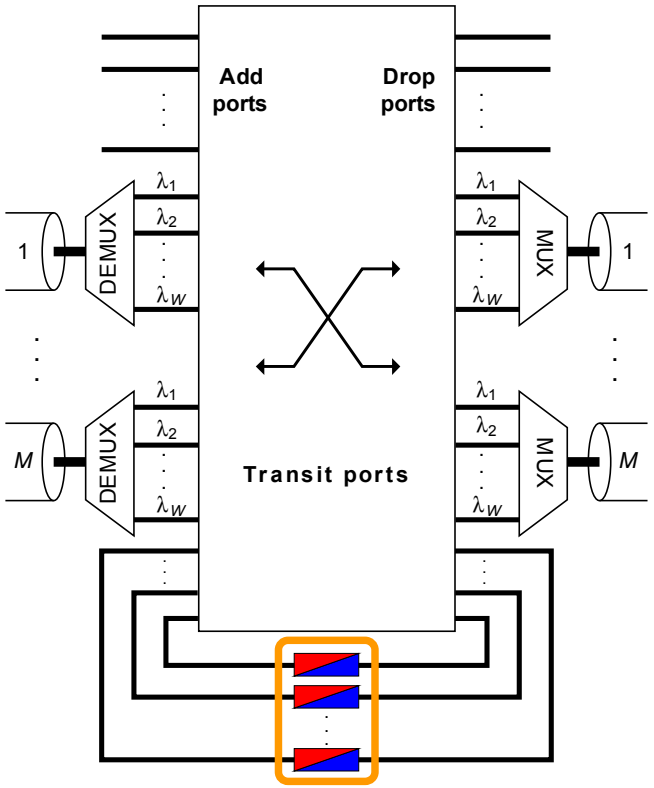
- The HMPI strategy can greatly contribute to the feasibility of deploying OBS networks without complex and expensive all-optical wavelength converters
- With the HMPI strategy the OBS network without wavelength converters can also benefit from the statistical multiplexing gain due to increasing the number of wavelengths per link

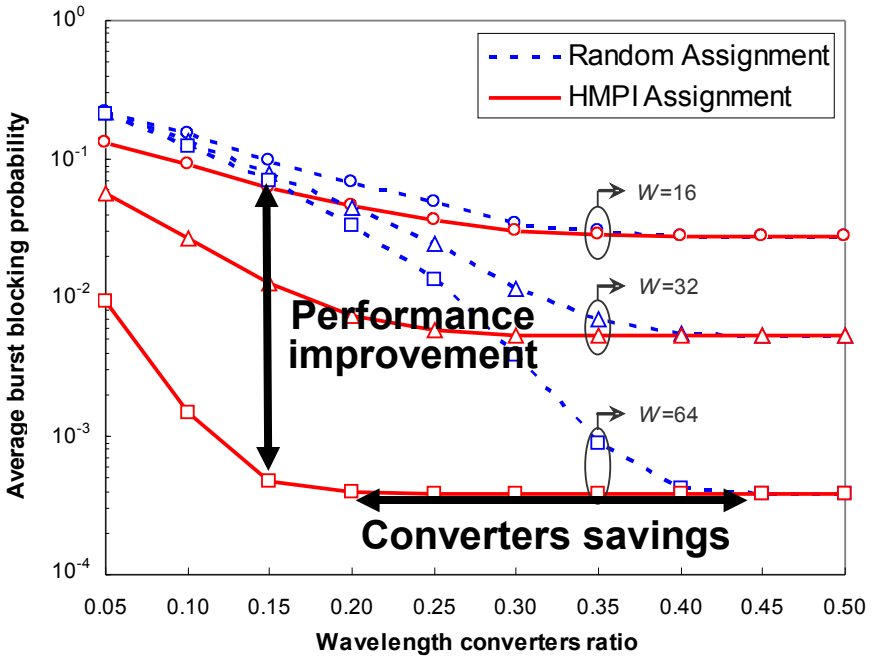
Publications: IEEE GLOBECOM 2006 and SPIE ITCOM 2006

Cost-Effective OBS Networks with Shared Converters

Motivation: reduce the number of wavelength converters deployed at the core nodes of an OBS network without degrading the network performance

Proposal: combine the use of the HMPI strategy to minimize contention in advance with the use of shared wavelength converters to resolve contention





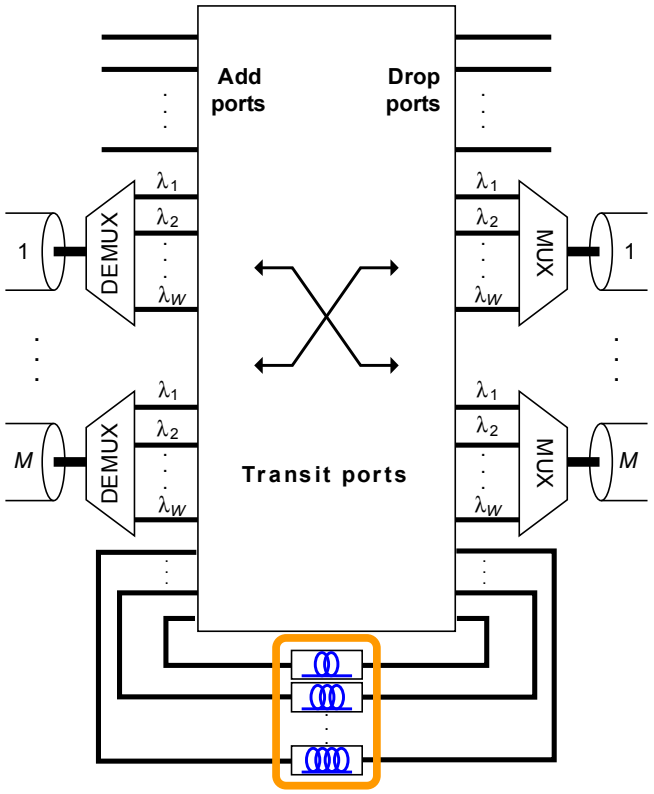
- With the proposed approach the number of wavelength converters can be reduced in some cases to less than 20% of their original number without degrading the network performance

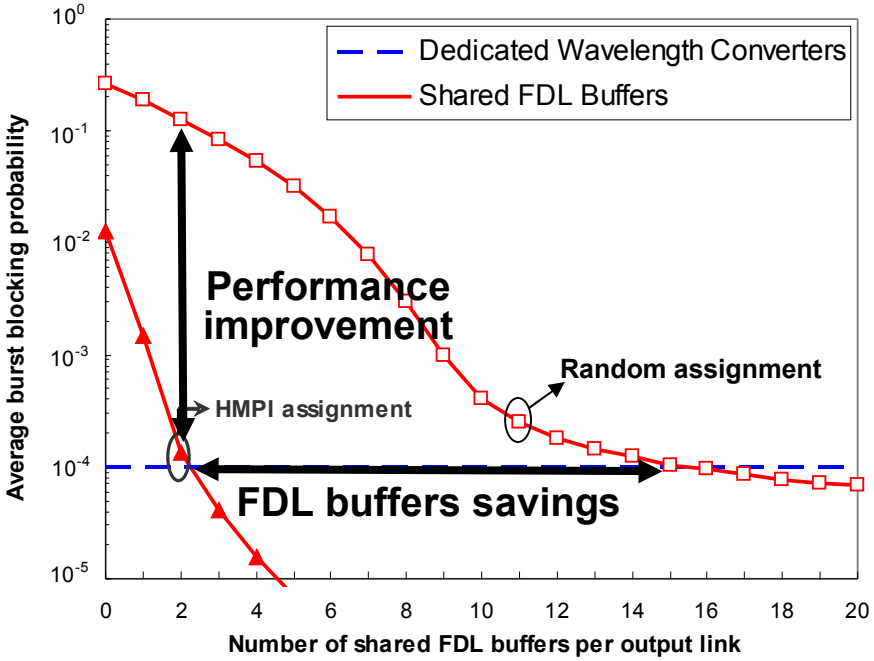
Publications: IEEE ICC 2007

Cost-Effective OBS Networks with Shared FDL Buffers

Motivation: replace the dedicated wavelength converters by simple FDL buffers without degrading the network performance

Proposal: combine the use of the HMPI strategy to minimize contention in advance with the use of shared FDL buffers to resolve contention



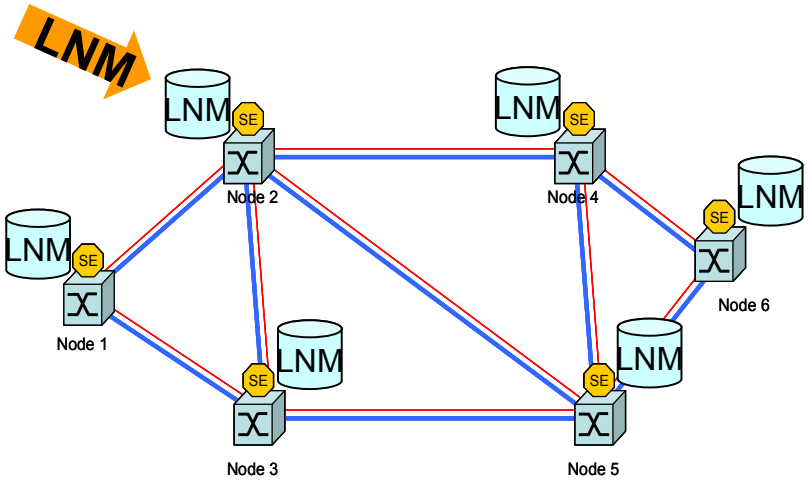


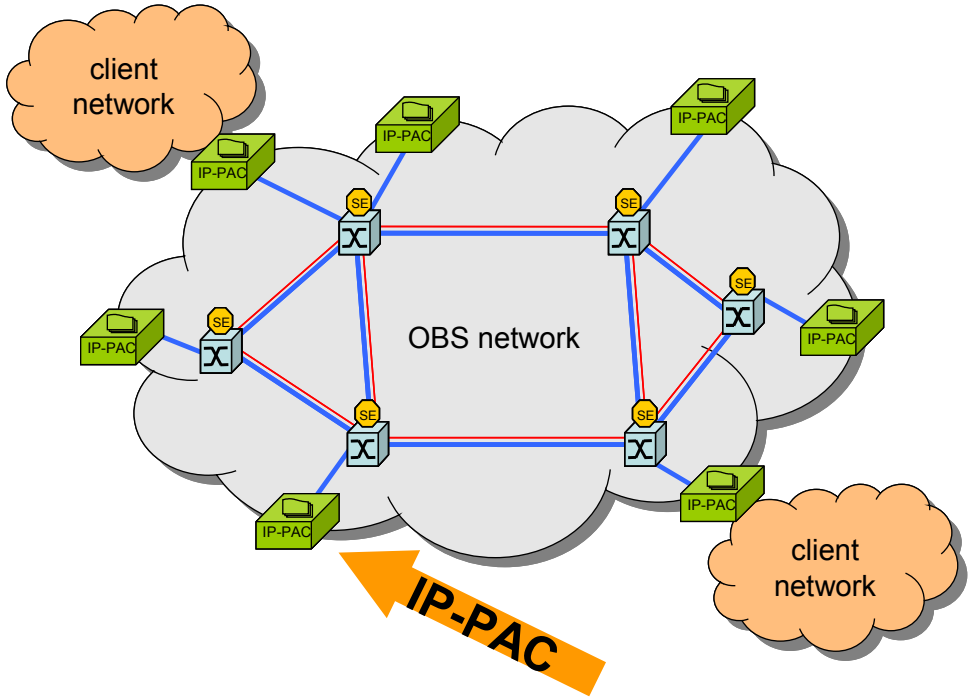
- With the HMPI strategy the OBS network with only a small number of simple FDL buffers can achieve the performance of the same network using a large number of expensive wavelength converters

Publications: IFIP ONDM 2007

OBS Architectures
Common Control Channel OBS – C³-OBS

OBS	vs.	C³-OBS
•**Network decisions at the edge nodes**		•**Network decisions at each node**



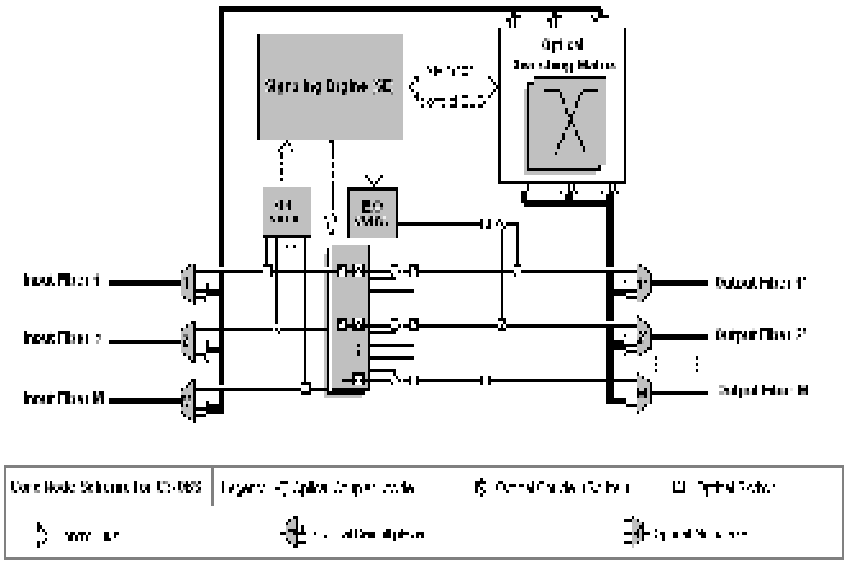


LNM - Local Network Model
SE - Signaling Engine

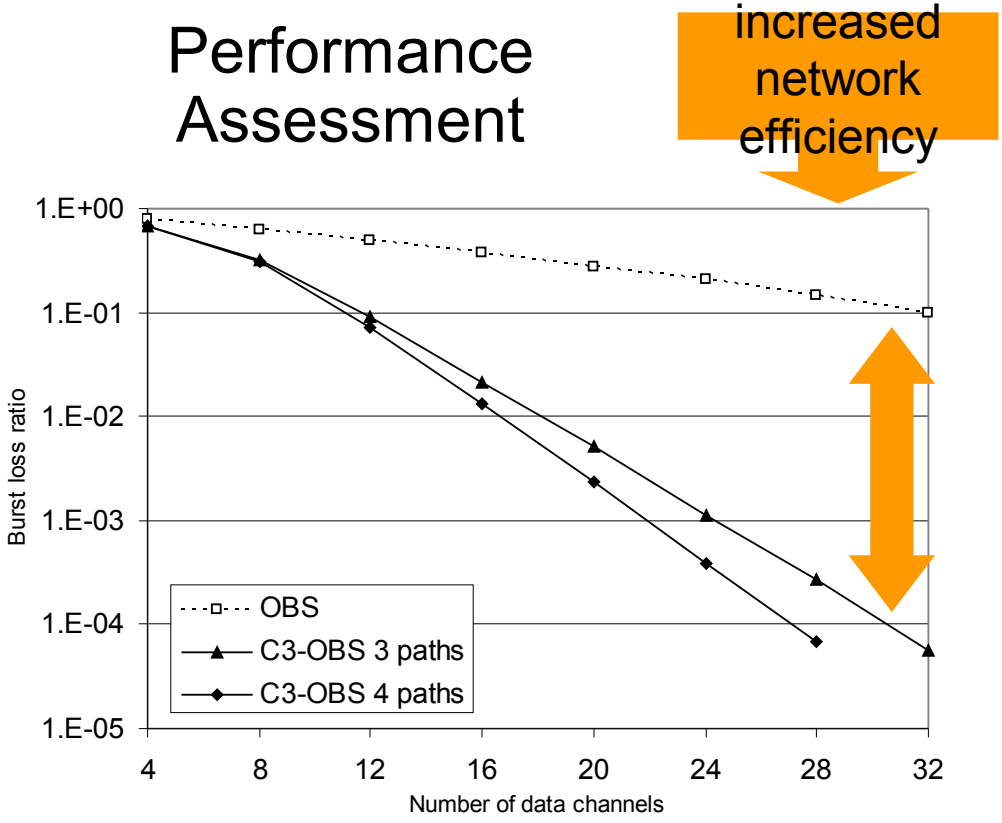
(International Patent – Europe + USA + Asia + …)

OBS Architectures for IPv4/v6
C³-OBS

Functional Scheme of a C³-OBS node



Performance Assessment

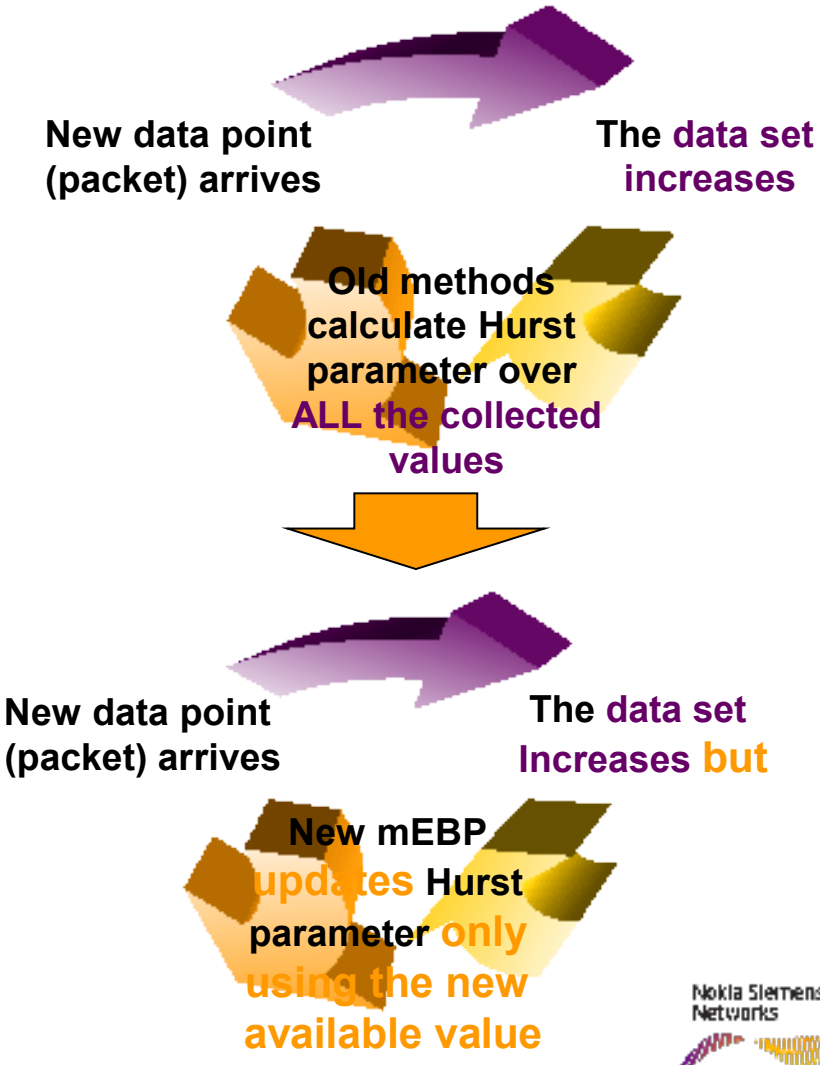


Real Time Evaluation of Self-Similarity Degree through Hurst Parameter Estimation using modified Embedded Branching Process (mEBP)

Hurst Parameter was never used on IDS until now, because:

- **there were no means to calculate the HParam**
  - packet-by-packet
  - in real time
- **consequently, there were no practical means,**
  - to explore the self-similar property of the network traffic
  - to distinguish normal/abnormal traffic;

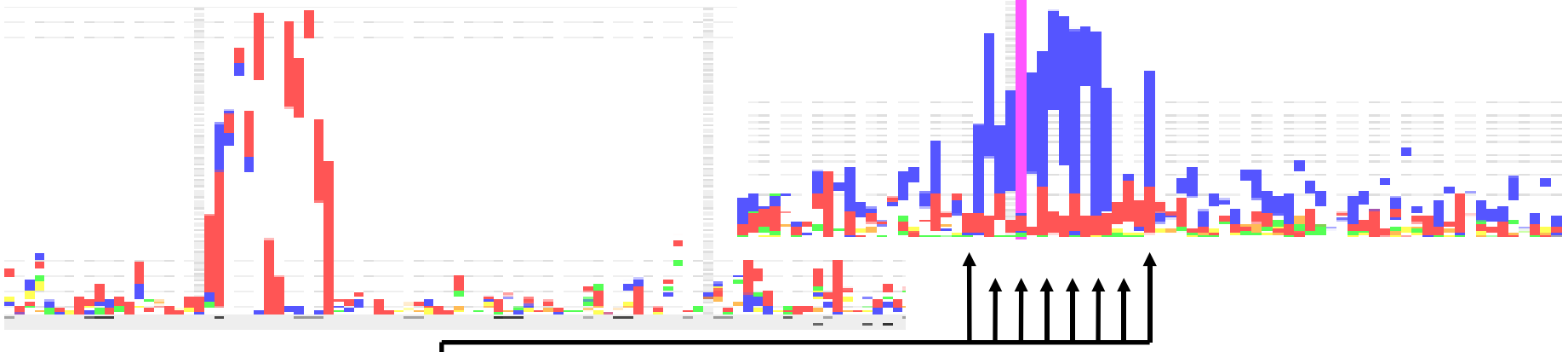
(International Patent)



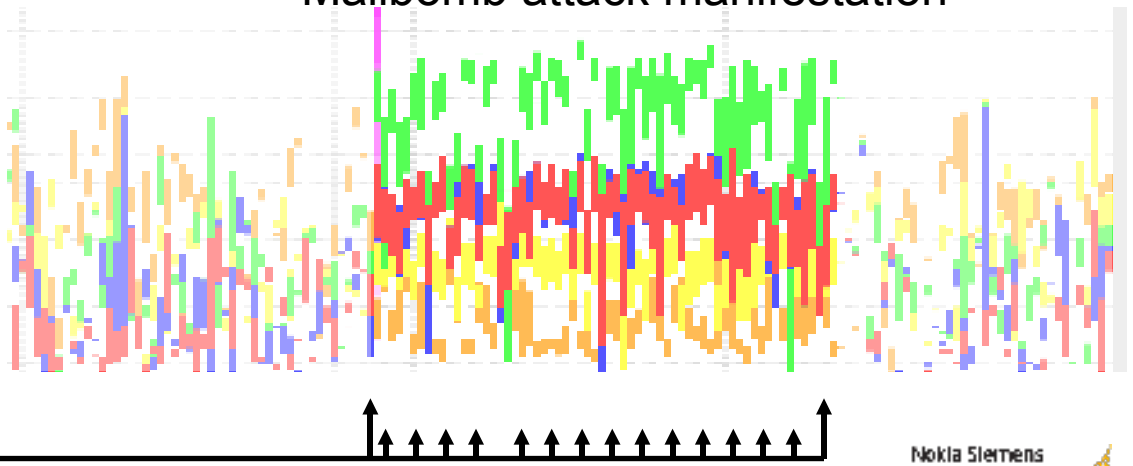
Results – Denial of Service attacks

SATAN attack manifestation

Neptune attack manifestation



Mailbomb attack manifestation



non fractal influences of three different attacks on a sample data trace containing labeled attacks

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Transport

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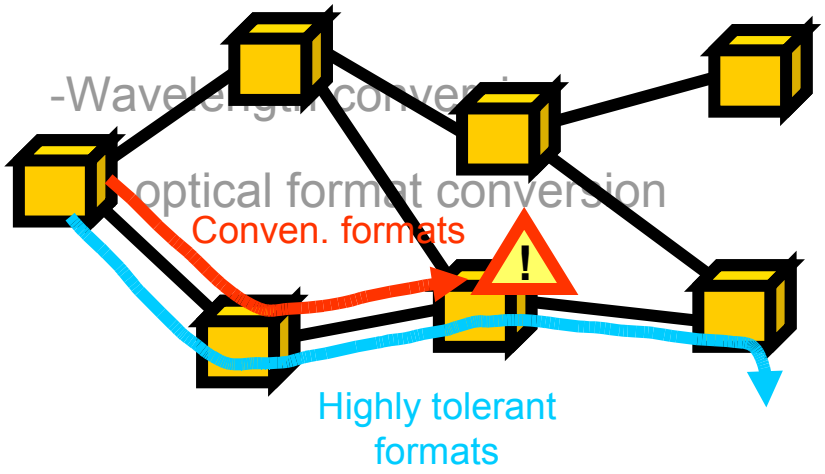
Areas of research

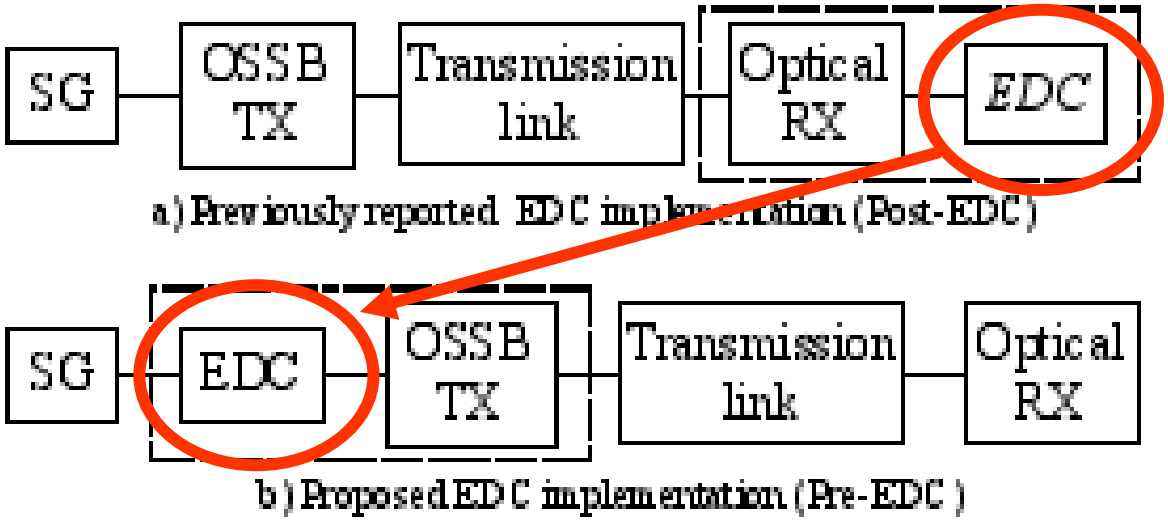
- **Modulation formats**
- **Optical monitoring**
- **Optical processing**
  - -Regeneration
  - -Time-slot processing
  - -Optical Switching Node
  - -Wavelength conversion
  - -All-optical format conversion
- **Optical burst switching**
- **Optical integration**
- **Optical network design**

Areas of research

- **Modulation formats**
- Optical monitoring
- **Objectives:**
- Optical processing
- **Increase tolerance to optical impairments**
  - -Regeneration
  - -fibre dispersion
  - -Time-slot processing
  - -optical filtering
  - -Optical Switching Node
  - -PMD
- Optical burst switching
  - -nonlinear effects
- Optical integration
- **Increase spectral efficiency of optical systems**
- Optical network planning



EDC enhancement using OSSB modulation, EP 1739865, ID level 5



- **Simple EDC** (Electrical Dispersion Compensation) – electrical dispersive line

- **Transmission performance independent** of the amount of accumulated optical dispersion (considering linear transmission)

- Launch of a **distorted signal** into the transmission link – undistorted eye pattern is obtained at the input of the Optical RX

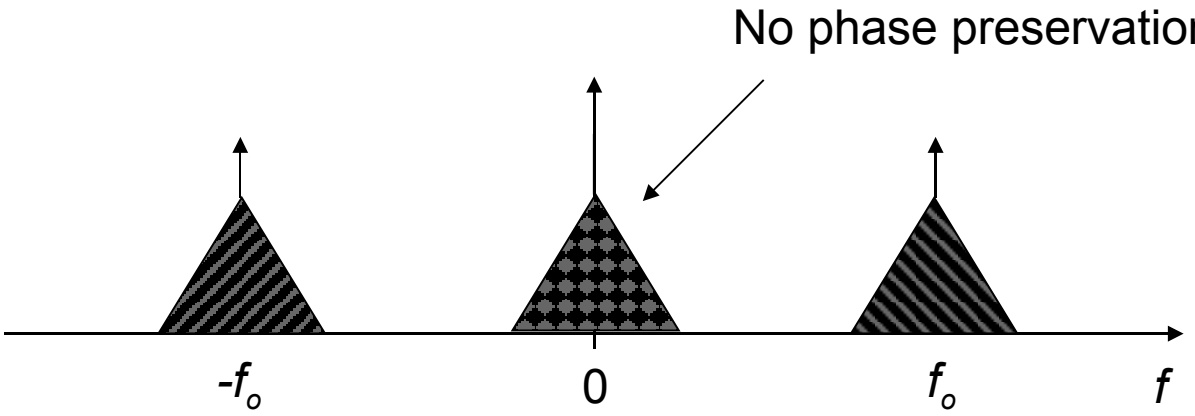
D. Fonseca, et al, *IEEE Selective Topics in Quantum Electronics*, vol. 12, n. 4, pp. 603-614, 2006.

D. Fonseca, et al, *LEOS 2005*, pp. 898-899, 2005.

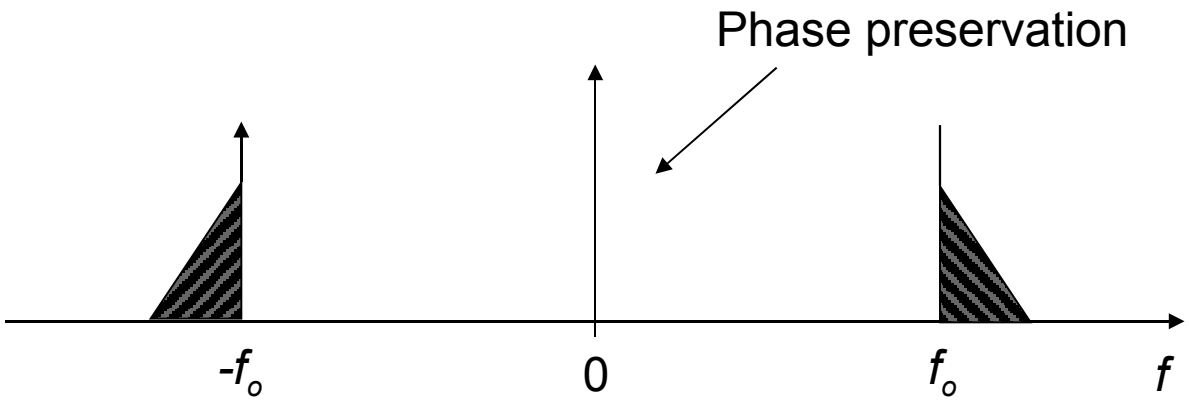
Spectrally efficient optical modulation
Electrical Dispersion Compensation with OSSB signals

Phase preservation after direct detection

IM-ODSB signal

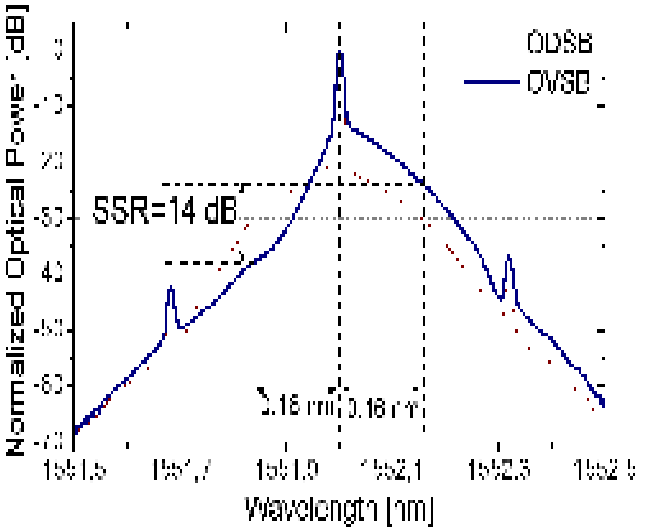


IM-ODSB signal

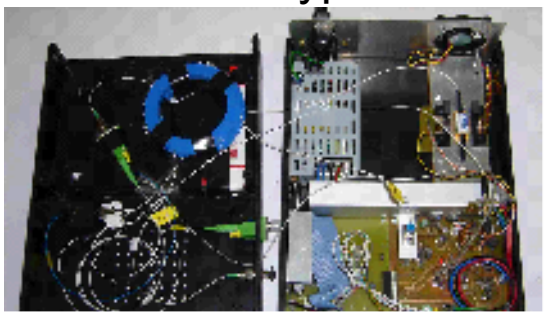


Prototype of 40 Gb/s OVSB Generator using SOA

- Development of pre-commercial prototype to evaluate implementation feasibility
  - SSR higher than 12 dB for an input power range higher than 10 dB.
- Without the use of ODC, error free transmission over 170 ps/nm of dispersion was obtained without EDC and over 238 ps/nm with EDC.
- Enhancement of short-reach 40 Gb/s transmitters



Prototype



T. Silveira, et al, *Photonics Technology Letters*, vol. 18, n. 21, pp. 2212-2214, 2006.

T. Silveira, et al., *in proc. ECOC 2006*, Cannes, France, vol.3, pp. 305-306.

T. Silveira, et al., *accepted for CLEO europe 2007*, Munich

Optical Vestigial Sideband converter based an a SOA"; 2005P17680EP, ID level 4

Areas of research

-Modulation formats

Objectives:

-Optical monitoring

- Effective evaluation of quality parameters using asynchronous histograms

-Optical processing

-Regeneration

- Q-factor

- Time-slot processing

- Optical Signal-to-Noise Ratio

- Interferometric Crosstalk

-Optical Switching Node

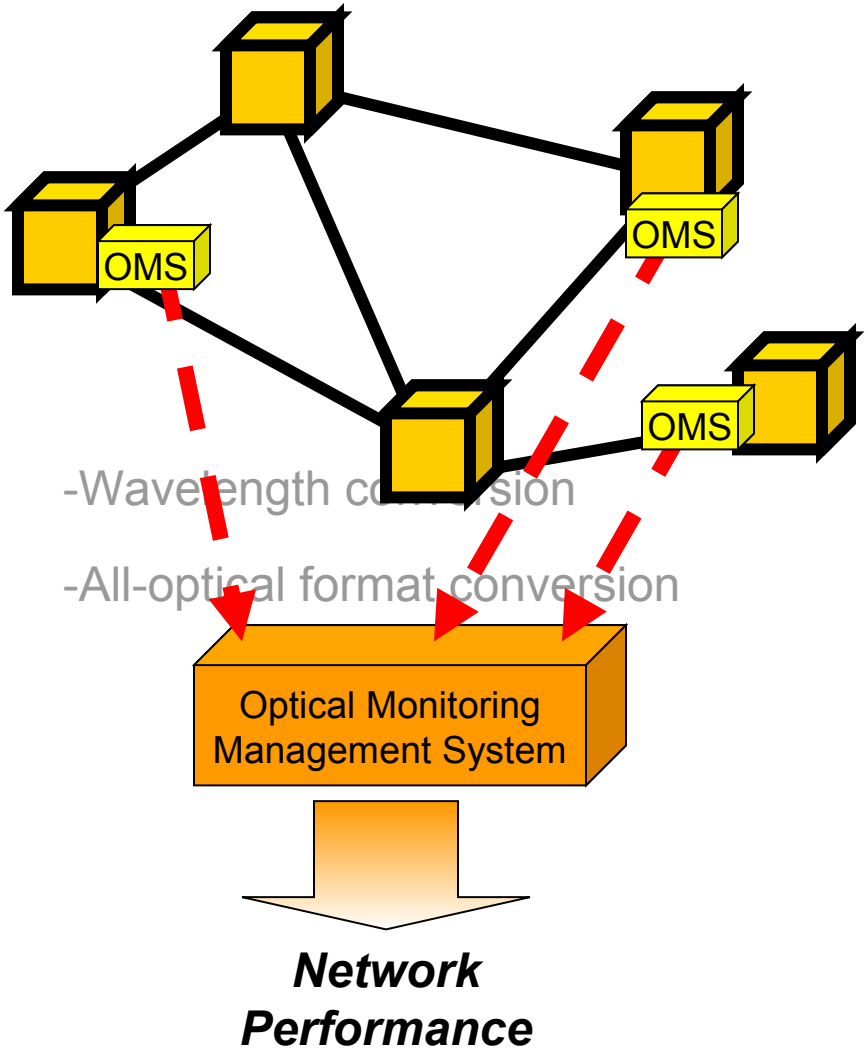
-Transparent monitoring

-Optical burst switching

-Monitoring system must be independent of signal bit-rate, and pulse shape

-Optical integration

-Optical network planning



R. Luís, et al., *J. Lightwave Technol.*, vol. 22, no. 11, pp. 2452-2459, 2004.

R. Luís, et al., in *Proc. 9th European Conference on Networks & Optical Communications* (NOC2004), vol. 1, pp. 374-381, 2004.

R. Luís, et al., *Microwave and Optical Technol. Lett.*, vol. 48, no. 7, pp. 1369-1372, 2006.

Areas of research

-Optical integration

-Modulation formats

Objectives:

-Optical processing

-Avoid electronic traffic bottleneck

-Regeneration

-Extend network reach

-Time-slot processing

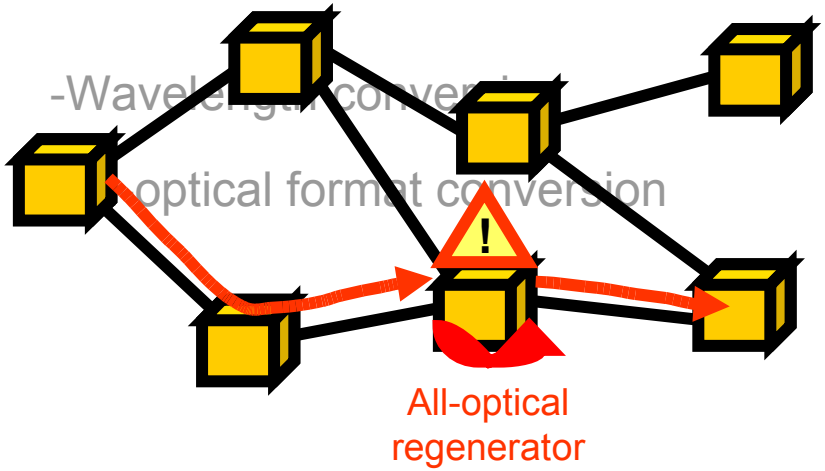
-Ultra-high operation speeds

-Optical Switching Node

-Optical burst switching

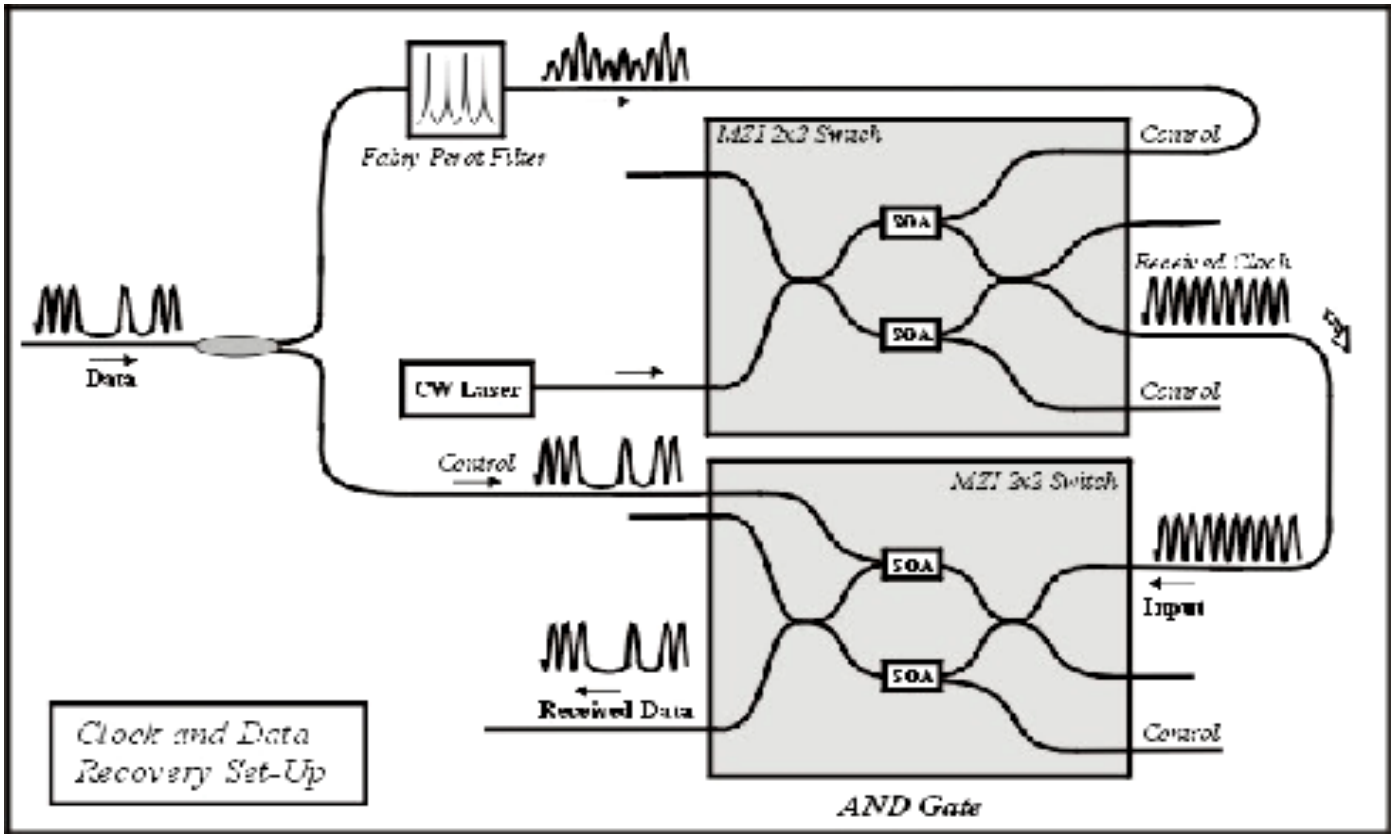
-Optical monitoring

-Optical network planning



All-optical regeneration

- MUFINS project
  - Integrated high speed all-optical circuits for optical signal processing

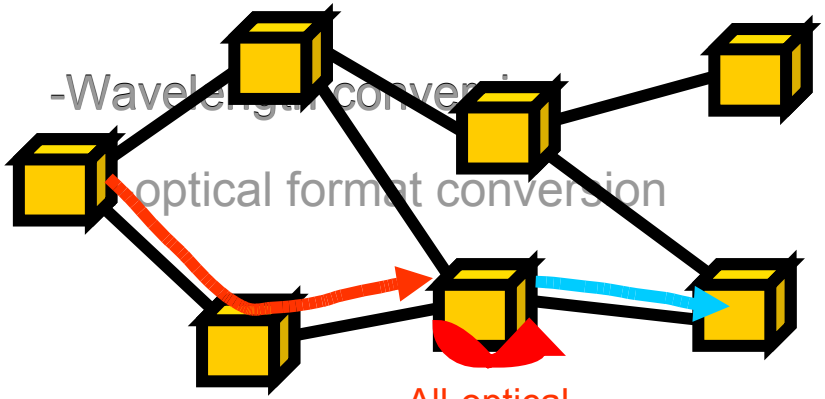


Areas of research

- Optical integration
- Modulation formats
- Regeneration
- Time-slot processing
- Optical Switching Node
- Optical burst switching
- Optical monitoring
- Optical network planning

Objectives:

- **Optical processing**
- **Develop models to perform design and planning of wavelength converters**
  - Characterize fiber and SOA nonlinearities
  - Develop models for leading wavelength conversion techniques
- **Development of multiwavelength conversion techniques at bit-rates equal or above 40Gbps**



R. Luís, et al., Optics Letters, vol. 31, no. 23, pp.3408-3410, 2006.

R. Luís, et al., *Optics Communications*, no. 271, pp. 100-104, 2007.

R. Luís, et al., *in Proc. International Conf. Transparent Optical Networks* (ICTON2005), vol. 1, pp. 1-4, 2005

N. Yan, T. Silveira, et al, accepted for OECC 2007, Japan.

Areas of investigation

- Optical integration
- Modulation formats

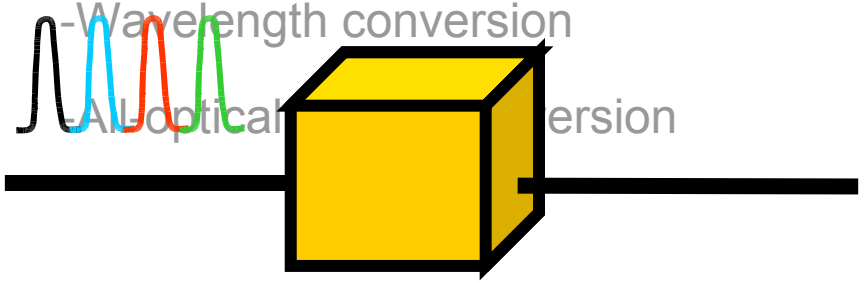
Objectives:

- **Optical processing**

The TSI is a fundamental device in OPS networks. It rearranges the time frames of incoming packets to resolve contention, improving network perfomance.

-Regeneration
-Wavelength conversion
-Time slot processing
-All-optical [illegible] ersion
-Optical Switching Node

What is the best way of building a TSI?



Time Slot Interchanger

- **Optical burst switching**
- **Optical monitoring**
- **Optical network planning**

Rui Meleiro, et al., accepted for ICTON 2007, Rome, Italy

Olga Zouraraki, Rui Meleiro, et al., Proc. of OFC 2007, Anahaiem, USA, paper OTuB3

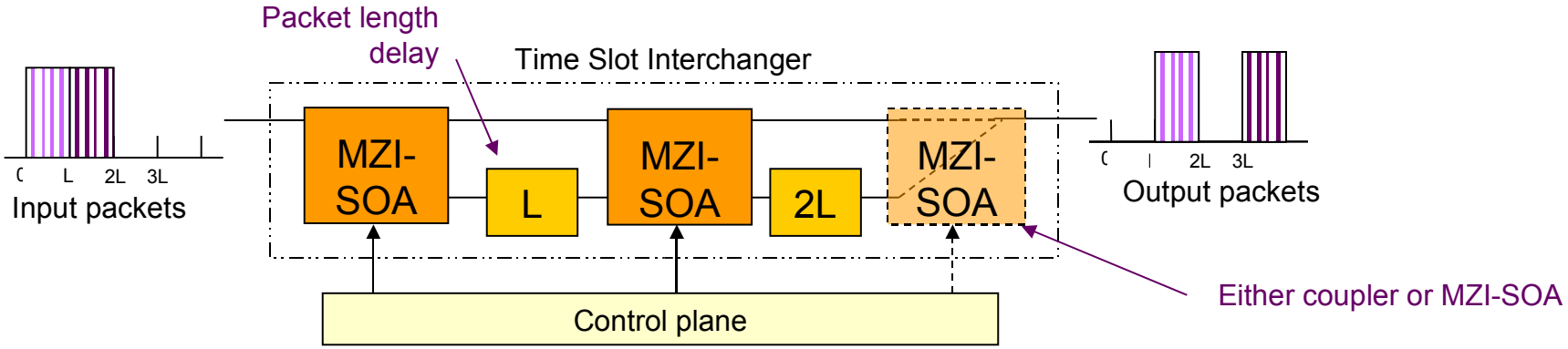
Analytical study of switch based Time Slot Interchanger

Motivation:

The switch based TSI has the simplest architecture and control needs.

Objective:

Study the performance and scalability of the MZI-SOA switch based TSI.



Conclusion:

With the output coupler, only one stage is possible due to crosstalk.
With the output MZI-SOA 3 stages are achievable for a power penalty lower than 3 dB.

Rui Meleiro, et al., accepted for ICTON 2007, Rome, Italy

Experimental 10 Gb/s 3-stage WC based Time Slot Interchanger

Motivation:

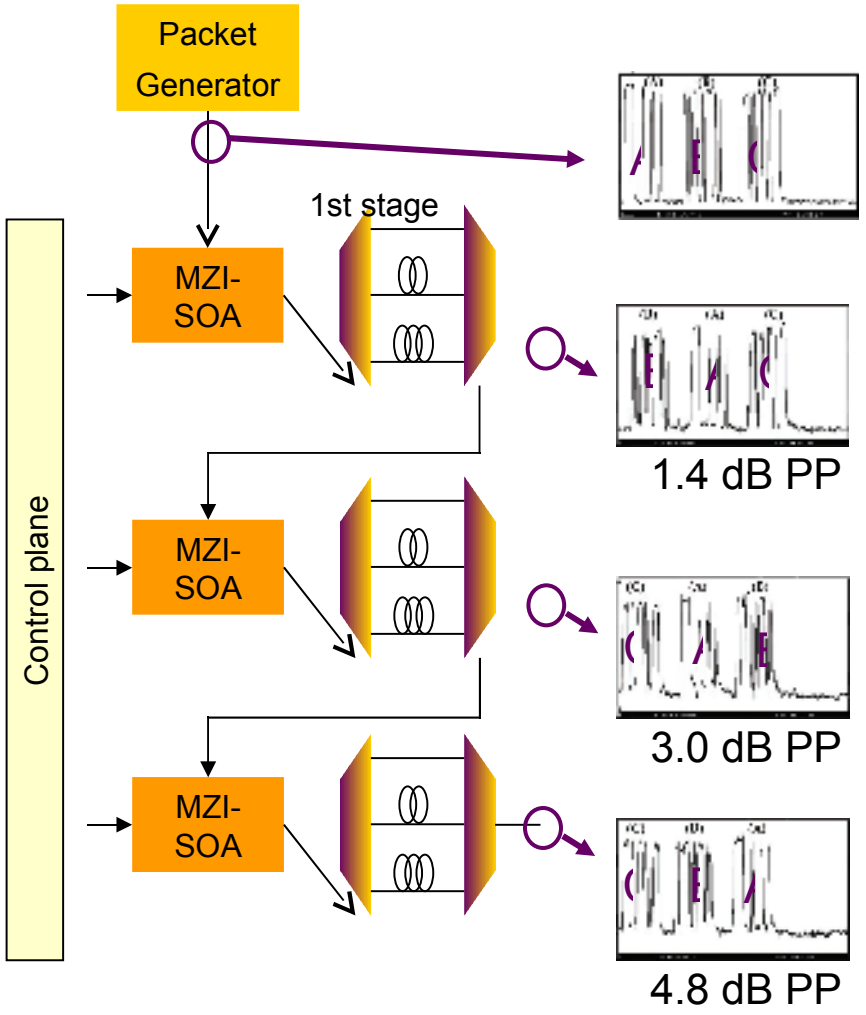
WC based TSI provides larger ranges of delays than the switch based TSI. Moreover, there is no inband crosstalk.

Objective:

Study the performance and scalability of the MZI-SOA wavelength conversion based TSI.

Conclusion:

The WC based TSI has ~1.5 dB power penalty per stage. Each stage can have a large number of delays, without increased power penalty, therefore is more scalable than the switch based TSI.



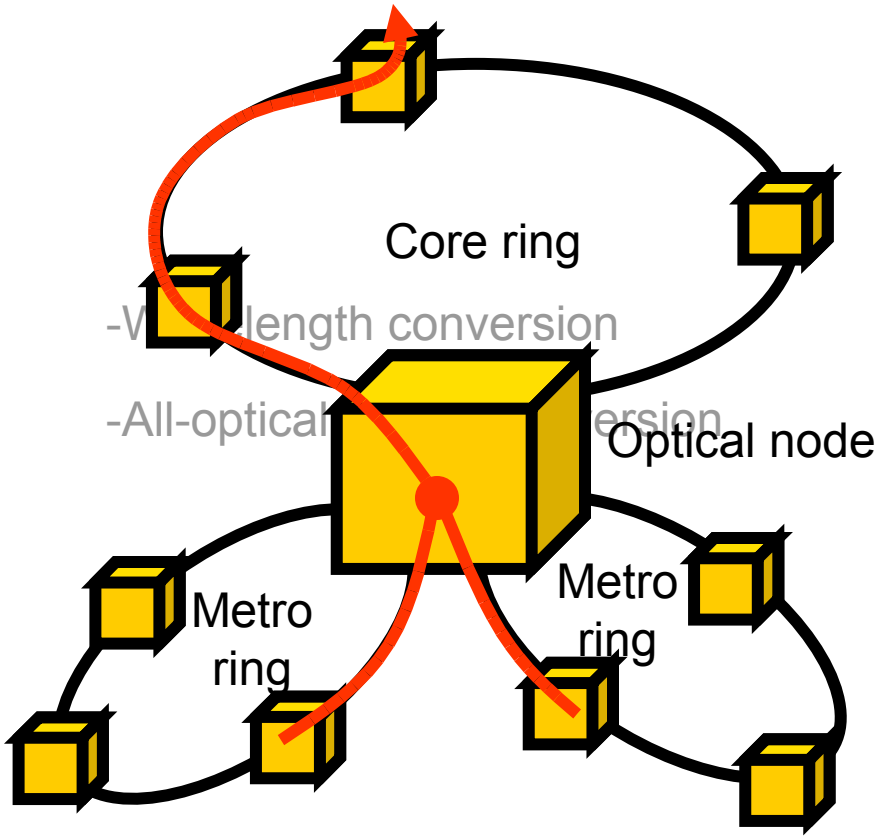
Olga Zouraraki, Rui Meleiro, et al., Proc. of OFC 2007, Anahaiem, USA, paper OTuB3

Areas of research

- Optical integration
- Modulation formats

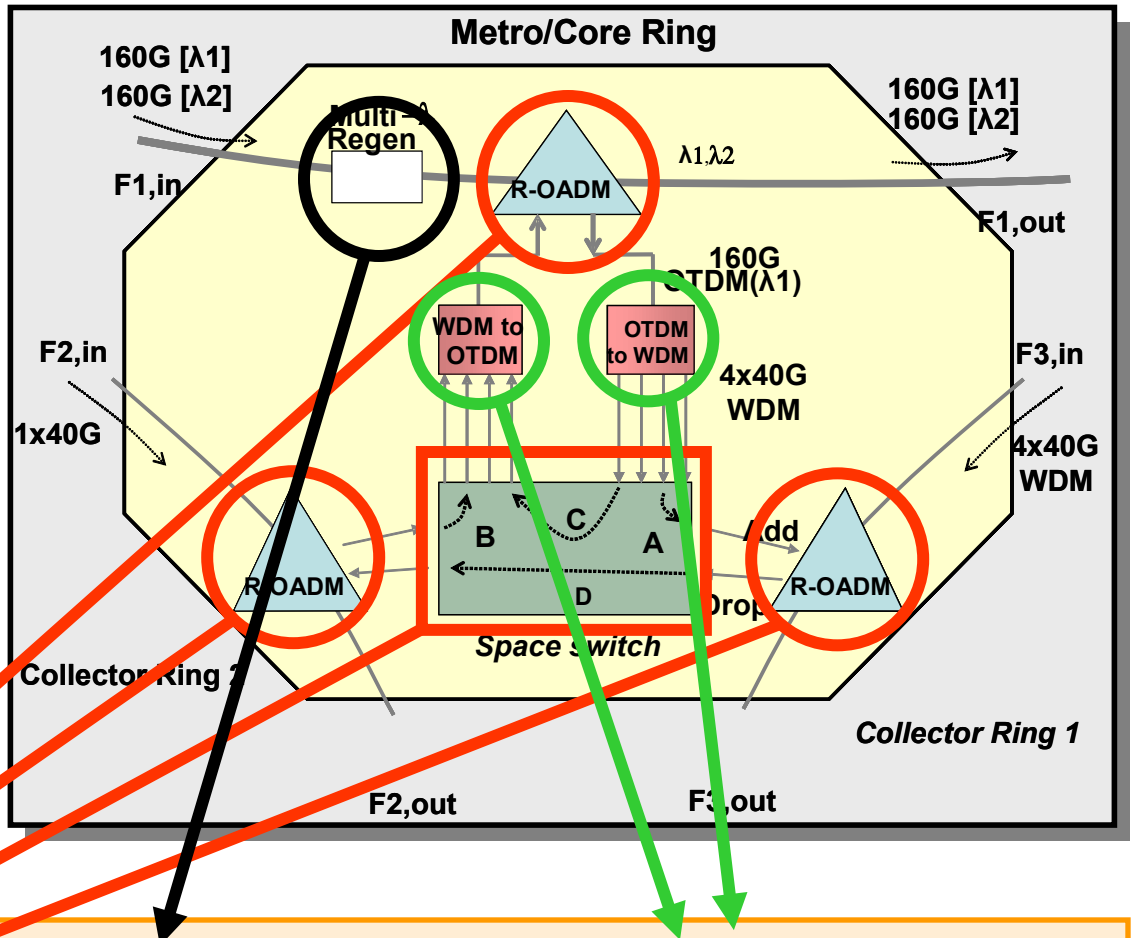
Objectives:

- **Optical processing**
- **Adapt signals between different ring hierarchies**
  - Regeneration
  - Time-slot processing
  - Bit-rate adaption
  - Optical Switching Node
  - Synchronization
- Optical burst switching
- Optical monitoring
- Optical network planning



Optical Switching Node

- *Key system is an optical switching node providing transparent interface between* metro-core/regional *and* metro access networks
- *Functionalities :*
  - Multi-λ regeneration
  - Traffic grooming/aggregation
  - Optical switching



- *Based on the use of existing ROADM and OXC architectures*
- *Optical 2R –regeneration is based on active (QD-SOAs) or passive (HNLF) technologies*
- *Grooming/Aggregation through WDM to OTDM and OTDM to WDM conversion*

http://www.ihq.uni-karlsruhe.de/research/projects/TRIUMPH/

Areas of research

-Optical integration

-Modulation formats

-Optical processing

-Regeneration

-Time-slot processing

-Optical Switching Node

-Optical burst switching

-Optical monitoring

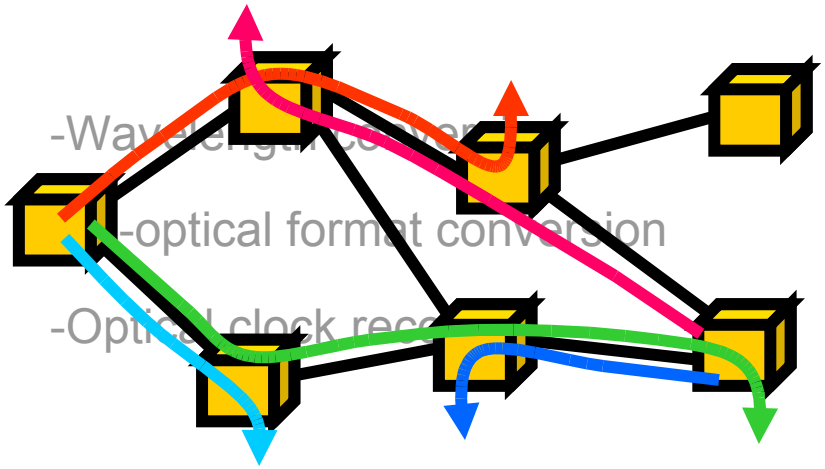
-Optical network planning

Objectives:

-**Modeling optical impairments**

-**Improve dispersion management of instaled networks**

-**Optimzed physical design of optical networks**



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Access

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Next-Generation Optical Access Networks

Study goals:

- R&D on increase in data rate, application of DWDM, CWDM and OCDMA and study of FEC mechanisms for next generation PON systems;
- **Nonlinear effects**: high launched power into the fiber to support extended power budgets and/or higher data rates may result in nonlinear effects i.e. Self-Phase Modulation (SPM) (negligible), Stimulated Raman Scattering (SRS) (negligible) and Stimulated Brillouin Scattering (SBS) – critical for next-gen PON systems.
- **Power equalization**: the near-far-effect on upstream degraded OLT receiver performance, due to the large required dynamic range / decision threshold settling. Power equalization can be achieved with a saturated SOA / MZI-SOA.
- **Forward Error Correction (FEC)**: reduced 10 Gbit/s Rx sensitivity and the required power budgets for the network may require FEC … what is the most appropriate FEC code to be used by e.g. 10G EPONs ? Issues which must be examined in more detail include: network specifications, net coding gain (NCG), overhead, random and burst correcting capability, encoding/decoding complexity.

Current work:

- Study of alternative solutions for optical interfaces of OLT and ONU with FEC and/or increased data rate and/or multiple wavelength channels;
- Laboratory tests of the most promising solutions for handling the requirements of next generation optical access networks

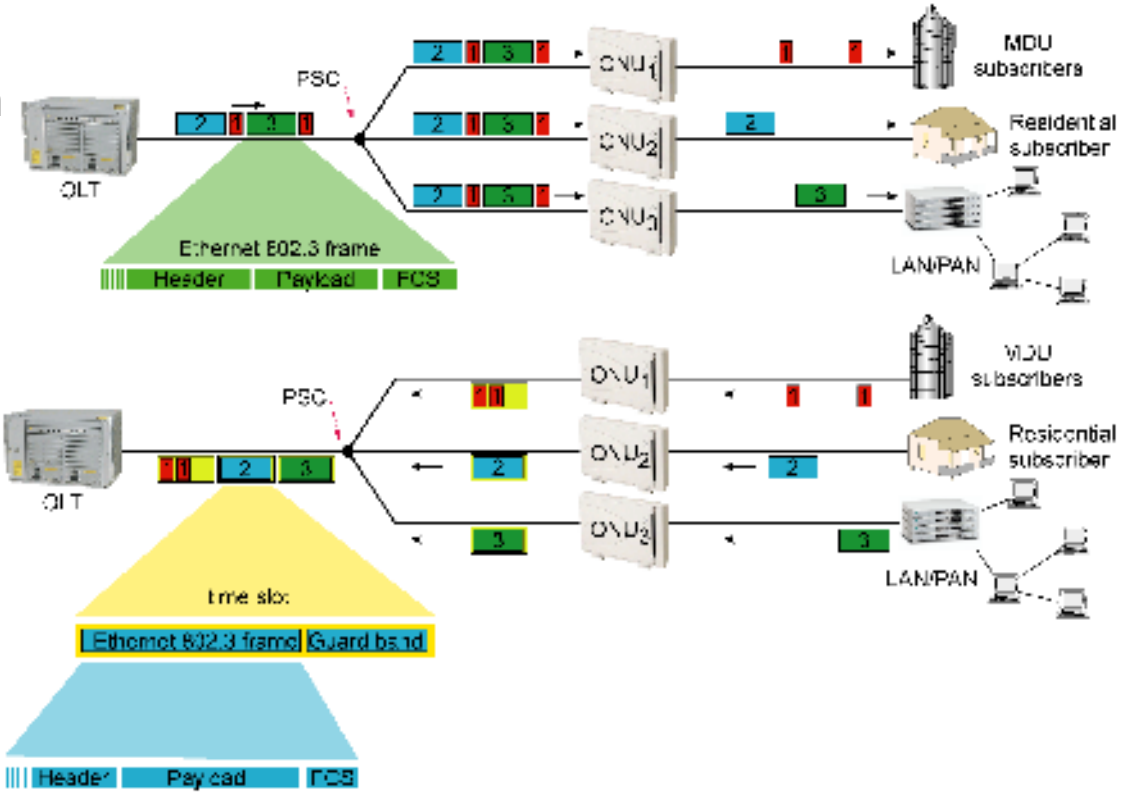
xPON systems – architecture overview

Downstream channel in xPON:

- all data is broadcast to all ONUs in the system via passive fibre plant,
- all ONUs receive the same data at PHY level - P2P links have to be logically emulated at L2;
- in EPON, link emulation via 16 bit LLID (per ONU port); in GPON – via TCON number
- ONUs filter received frames based on logical port number

Upstream channel in EPON:

- a unicast data channel thanks to directional coupler properties,
- shared among a number of ONUs – media access control (MAC) is thus needed (e.g. MPCP in EPONs)
- upstream and downstream traffic is in general case uncorrelated
- channel sharing via TDMA protocol with e.g. interleaved hub polling scheme implemented to maximize bandwidth utilization / ONU count



Bandwidth allocation:

- can be static (SBA) or dynamic (DBA);
- DBA can be either statistical (based on traffic model) or request driven (ONUs report bandwidth demand and OLT allocates channel capacity to meet demand) – second model is commonly used in EPON with the aid of MPCP control plane

IEEE802.3av TF - 10G EPON timeline

- **November 2005**: initial exchange of ideas on the next generation EPON system (system vendors, chip vendors, carriers etc.)
- **March 2006**: following a successful Call For Interest (CFI), the IEEE approves creation of the 10GEPON Study Group. More than 30 companies and 60 individuals expressed their support.
- **September 2006**: following 2 successful Study Group meetings, the IEEE approves creation of the 10GEPON Task Force (802.3av).
- **Currently**:
  - 300+ subscribers to the 10G EPON email reflector (and growing)
  - Task Force is selecting the initial baseline proposals
  - creation of standard draft version 0.8 was approved (to be presented during the July plenary meeting in San Francisco)
- **July/September 2007**: Draft version 0.8 and 0.9 are expected
- **1st half of 2009**: the 802.3av standard is expected (we are right on track at the moment)

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UBI

Thank you!

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