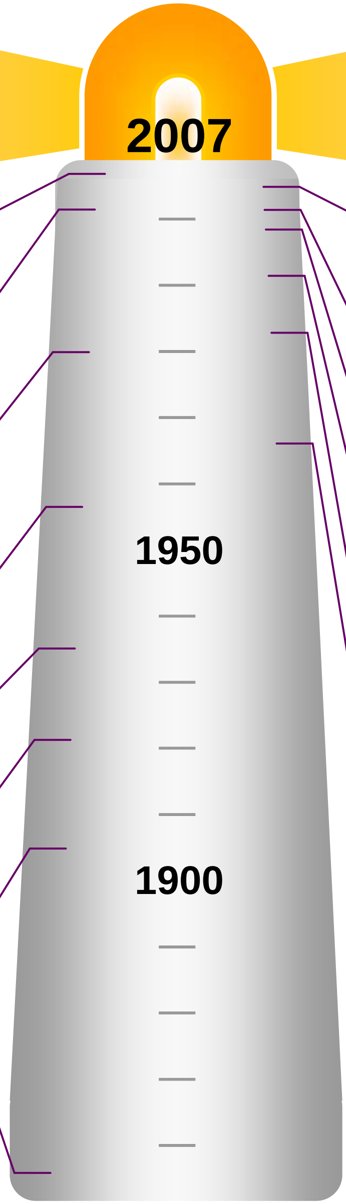
# *Nokia Siemens Networks*

## *Strong Heritage / Facts and Figures*

Overview

# Strong tradition in innovation

## Siemens since 1847




## Nokia since 1865

**Siemens:**

- **2006** Industry first live demonstration of Long Term Evolution
- **2001** Built first UMTS network in Europe
- **1980** The first telephone exchange using the digital electronic switching system EWSD goes into operation
- **1957** The beginning of data processing
- **1935** Construction of Telefunken television set
- **1921** Completion of the Rhineland telephone cable
- **1905** First automatic Telephone exchange
- **1855** Russian long-distance telephony network

**Founded 1847**

**Nokia:**

- **2004** Industry first commercial end-to-end 3GPP IP Multimedia Subsystem
- **2001** World's first Multimedia Messaging Service Center
- **1999** World's first triple-mode (GSM, EDGE, WCDMA) base station
- **1991** World's first GSM call made in Radiolinja's network, supplied by Nokia
- **1982** Europe's first digital exchange, the DX 200
- **1967** Nokia's first generation of manual radio telephone systems

Roots in paper, rubber, and cables, in just over 100 years Nokia becomes a powerful industrial conglomerate....

**Founded 1865**

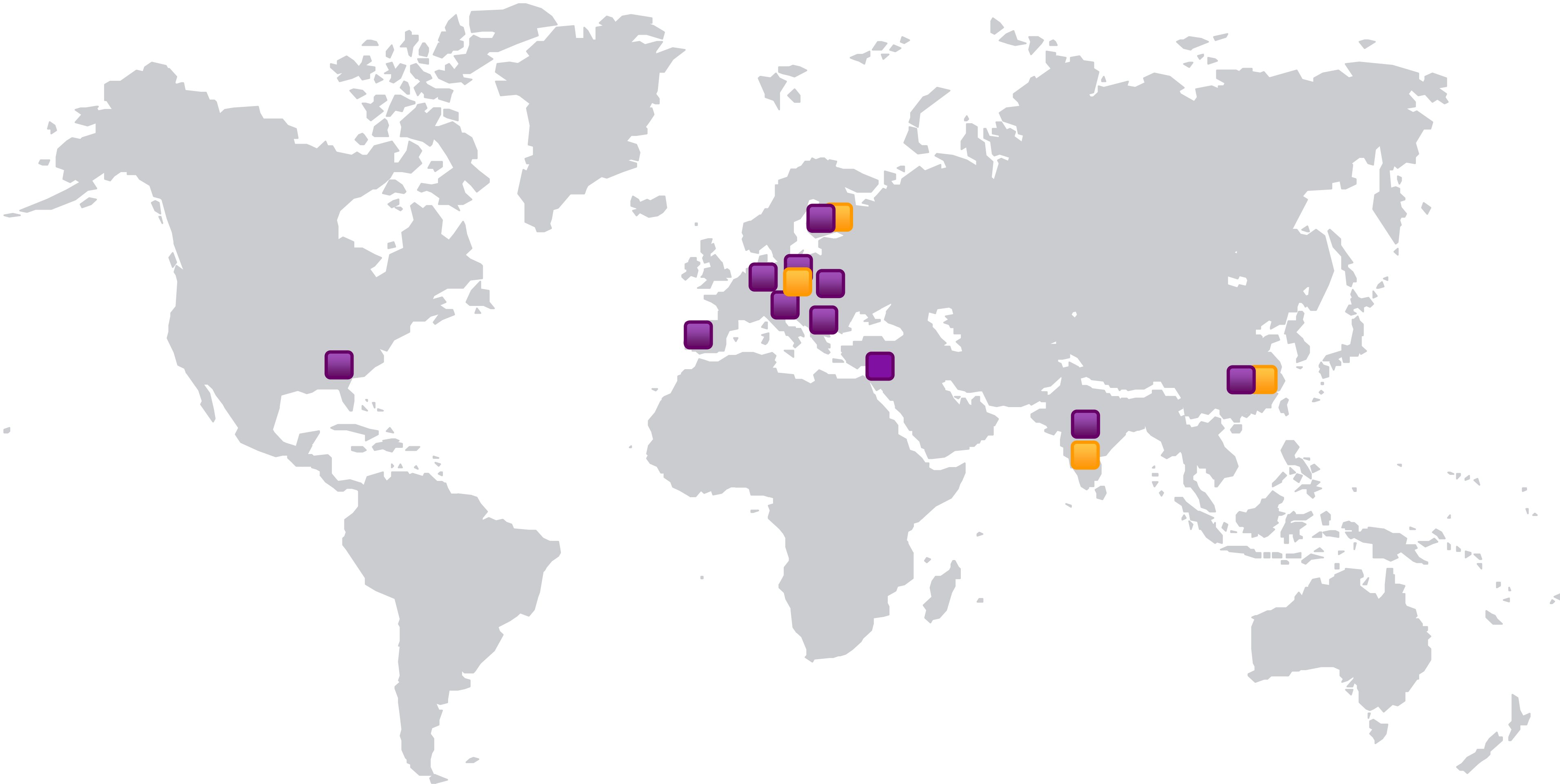
# Strong global market position and customer base

- #2 in wireless networks
- #2 in operator services
- #3 in wireline networks
- More than 600 operator customers in over 150 countries
- Over 1.5 billion people connect through our networks




Nokia Siemens Networks

# Our global R&D and manufacturing footprint – close to key markets and customers



Main R&D development center

Main manufacturing site

Nokia Siemens Networks

# ***Research Activities at Nokia Siemens Networks Portugal***

## Overview



Nokia Siemens Networks

# Framework & Enabling Actions

Close collaboration with the system-engineering and hardware groups

Participating in initiatives of the European Community for research, technological development and demonstration activities

Participating in international and national research projects (FCT, FP7)

Use national-wide research facilities for performing work towards M.Sc and PhD degrees

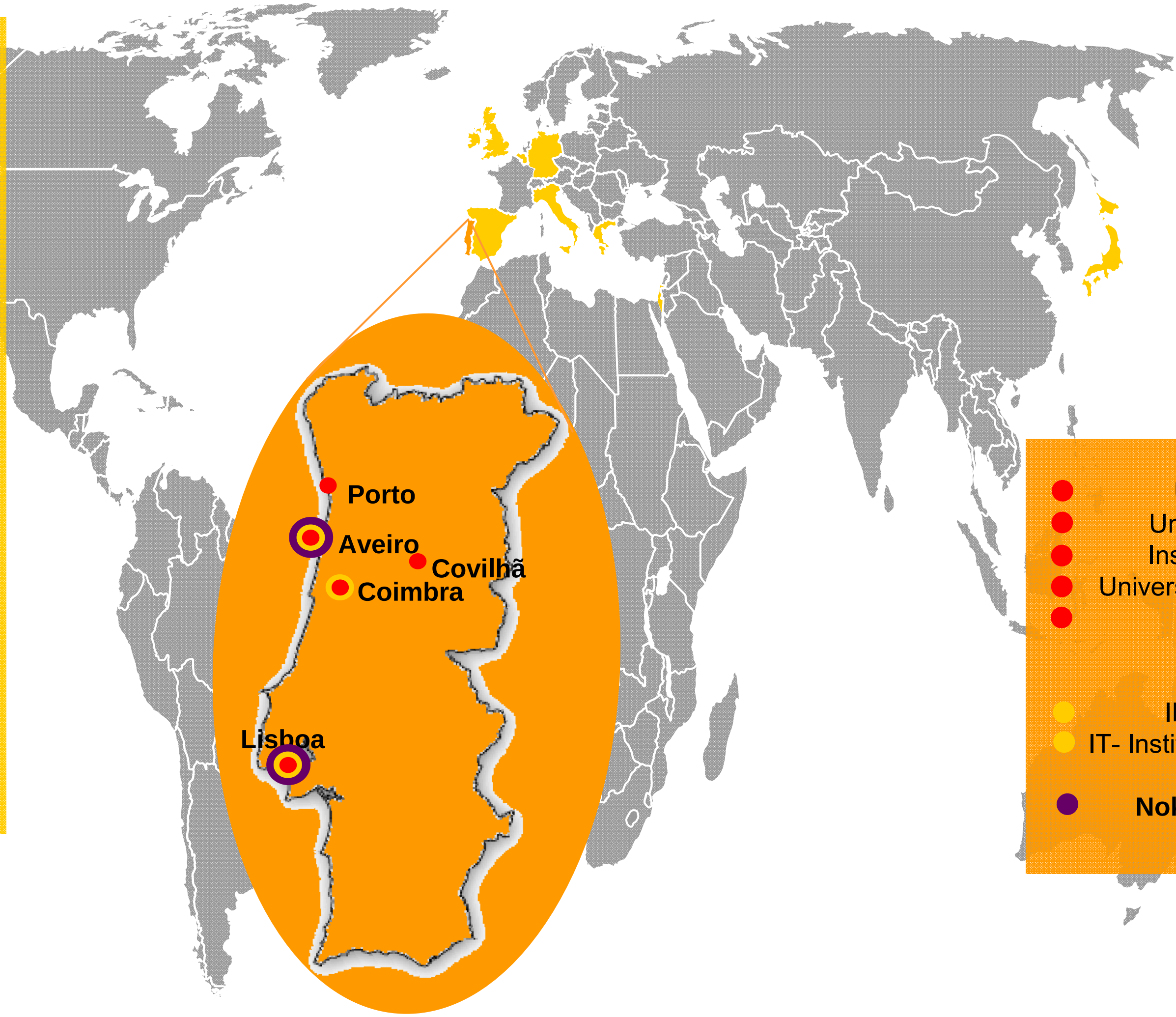
Close cooperation with National and International Universities and research centres for R&D in Consortium and Research Activities

# Research Innovation Network

## International

**Universities:**
University of Kiel (D)
University of Karlsruhe (D)
Technical University of Berlin (D)
University of Essex (UK)
University of Southampton (UK)
University College Cork (IR )
University of Bristol (UK)
University of Glasgow (UK)
Università degli Studi di Pavia (I)
Universidad Islas Baleares (SP)
Universiteit Brussel (B)

**Institutes:**
Cork Institute of Technology (IR)
Research Academic
Computer Technology (GR)
RESIT- Athens Information
Technology (GR)
Heinrich-Hertz Institute (D)
NICT (JP)




## National

**Universities:**
- Universidade de Aveiro
- Universidade de Coimbra
- Instituto Superior Técnico
- Universidade da Beira Interior
- Universidade do Porto

**Research Institutes:**
- INESC Porto; INESC-ID
- IT- Instituto Telecomunicações

**Nokia Siemens Premises**

# Research Activities at NSN – Facts and Numbers

| NUMBER OF PATENTS | | |
|---|---|---|
| **Inventions** | **Since April 2007** | **Last 5 years** |
| Invention Disclosures submitted | **17** | **46** |
| Approved for Patent | **11** | **32** |

| Scientific Production | | | |
|---|---|---|---|
| Type | Technological Area | | |
| | Access | Transport | Networks |
| Scientific Publications | 7 | 24 | 2 |
| International Conferences | 12 | 66 | 24 |
| Book chapters | 2 | 1 | 3 |

**Conferences:**

- European Conference on Optical Communications (ECOC): 2005/2006/2007/2008
- Optical Fiber Communication Conference (OFC): 2006/2007/2008
- Globecom 2006 /2008
-

**Scientific Publications:**

- IEEE Journal of Lightwave Telecommunications:
- IEEE Photonic Technology Letters:
- IET Electronic Letters
- OSA Optics Letters
- OSA Journal of Optical Networking
- IET Optoelectronics

# Transport

# 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 network design**

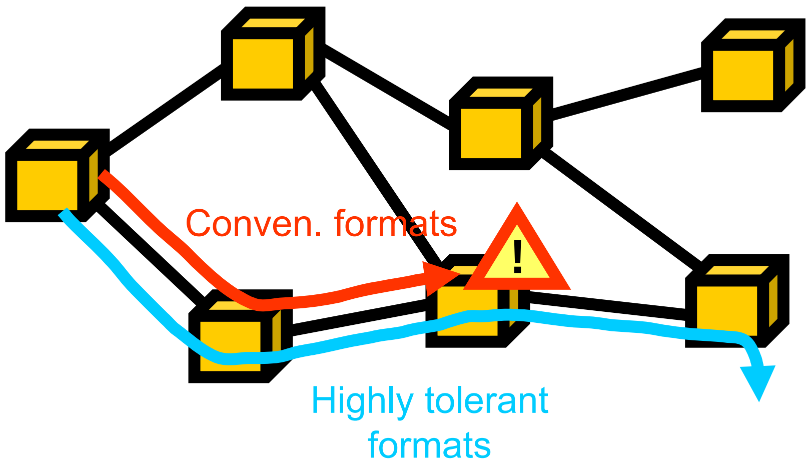
# Areas of research

## Modulation formats

-**Increase tolerance to optical impairments**

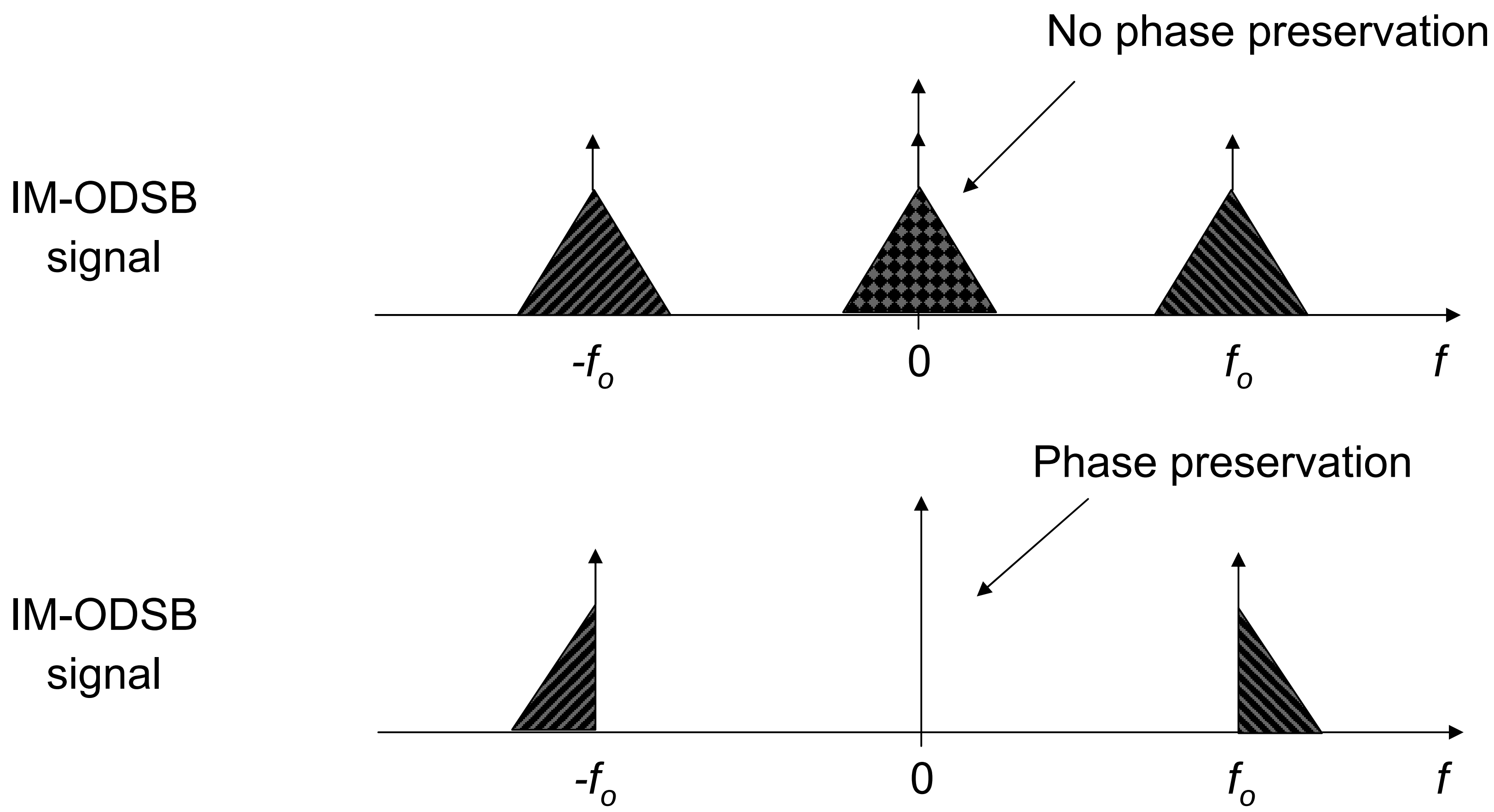
- -fibre dispersion
- -optical filtering
- -PMD
- -nonlinear effects

-**Increase spectral efficiency of optical systems**

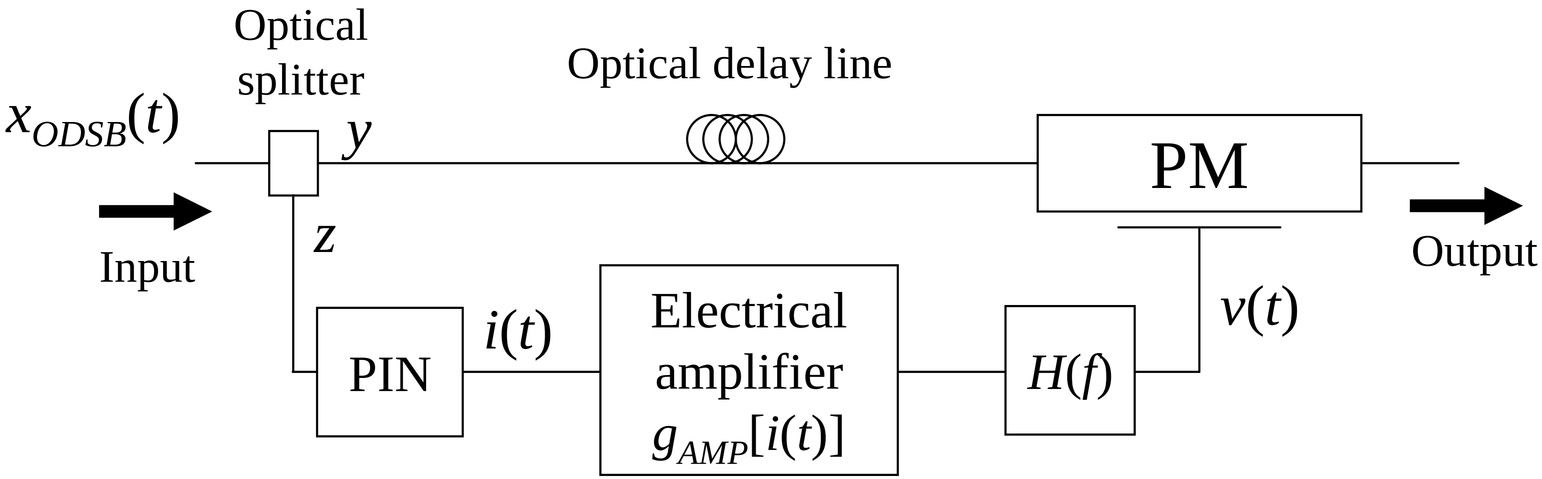


# Spectrally efficient optical modulation
## Electrical Dispersion Compensation with OSSB signals

### Phase preservation after direct detection



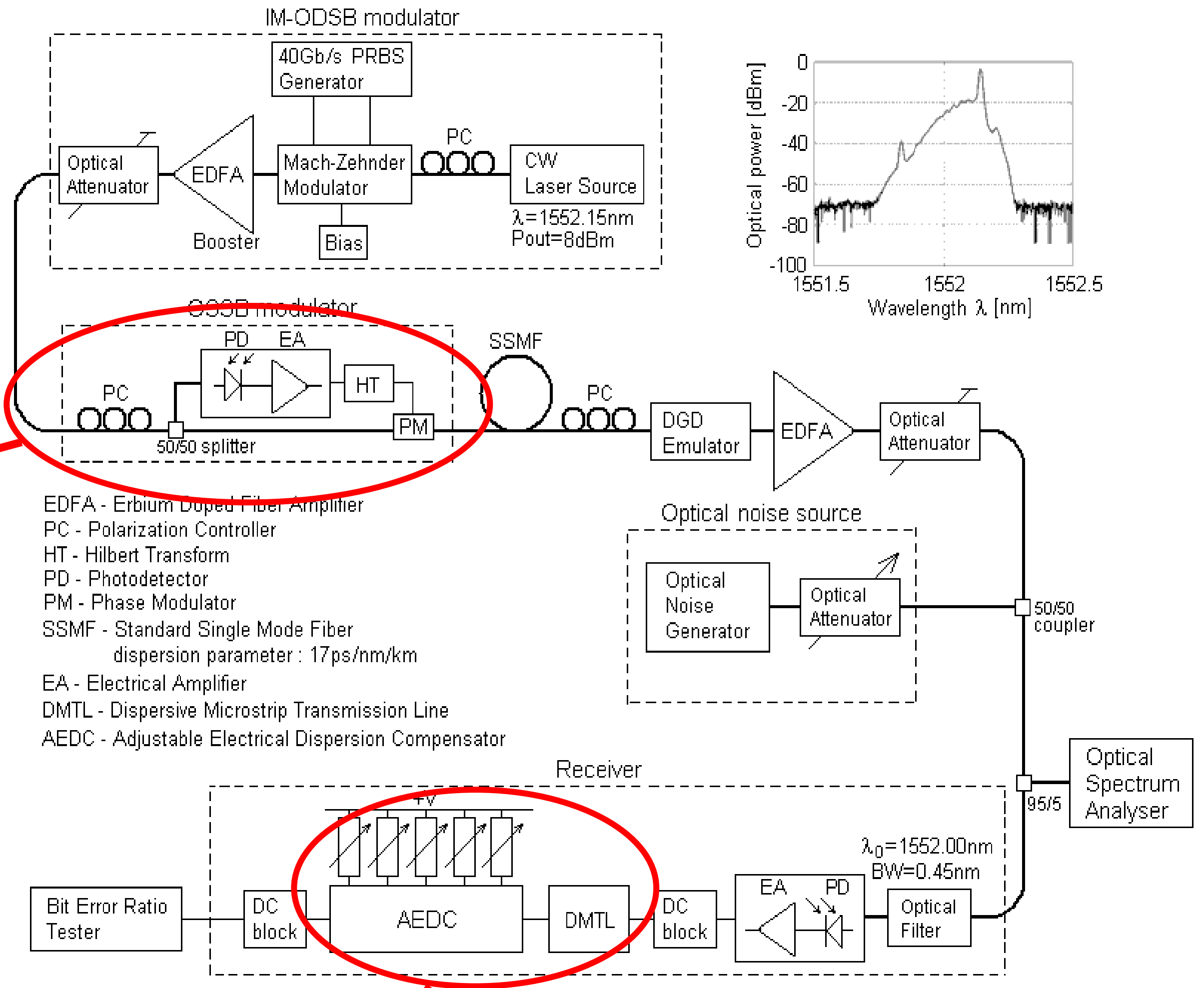
# Opto-electronic OSSB filter




- Wavelength independent operation
- Null intensity distortion
- Significant sideband suppression

**Adaptive opto-electronic OSSB filter based on phase modulator**, patent WO2374856A1,

# 40 Gb/s Experimental system

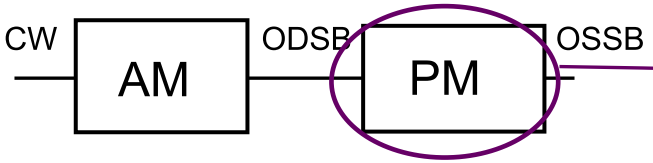



**Opto-electrical filter to generate OSSB signal**

**EDC**

# All-Optical DSB to VSB/SSB converter using SOA

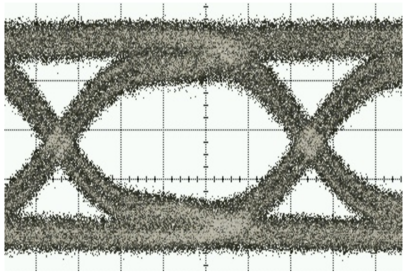
- OSSB signals can be generated using a two stage configuration: AM+PM



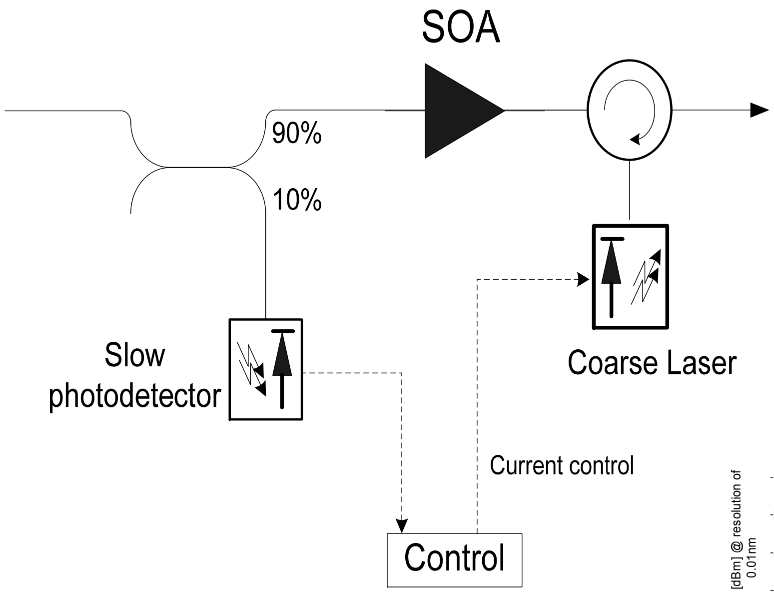

- Semiconductor Optical Amplifiers (SOA) are highly non-linear devices, which induce Self-Phase Modulation when an Optical Signal is being amplified

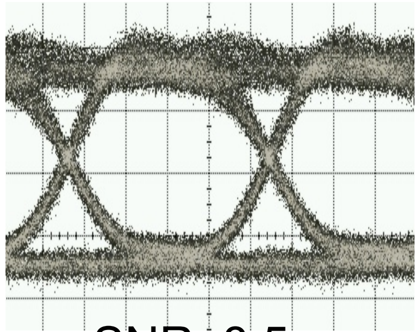

  

# All-Optical DSB to VSB/SSB converter using SOA (cont)

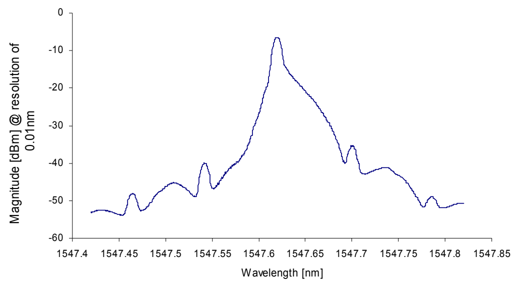


SNR=5.7
(ER=5dB)



SNR=8.5

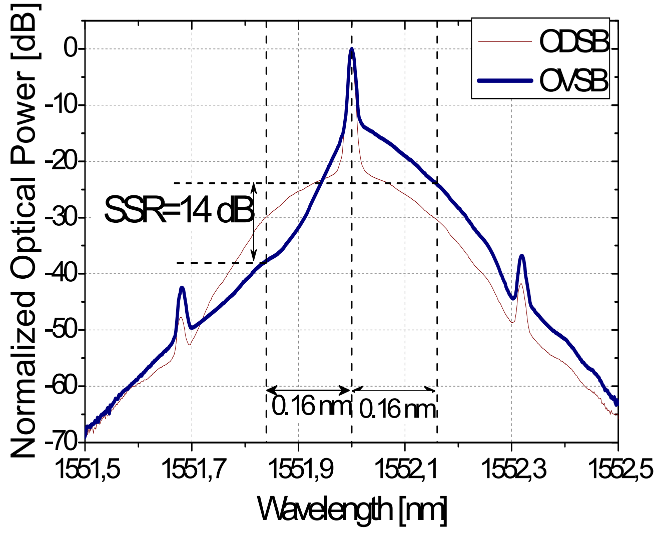



SBS=15.0dB

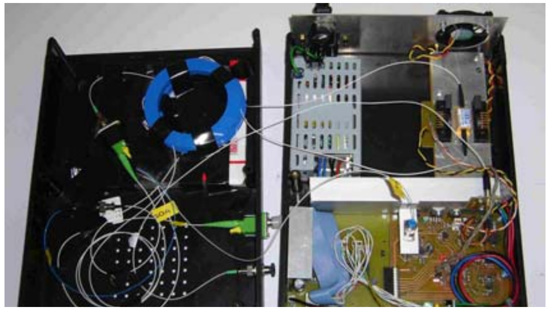
A SNR higher than 7.5 (input SNR=5.7) and a SBS higher than 14 dB for a range of 10dB of the input power (ER=5dB).

# 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



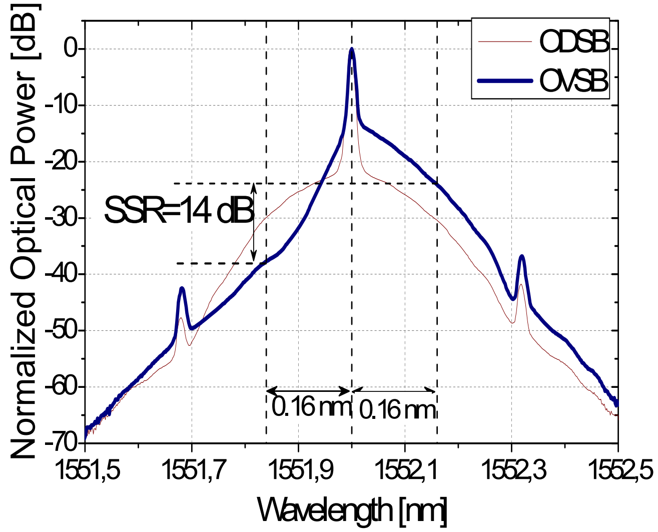

T. Silveira, et al, *Photonics Technology Letters*, vol. 18, n. 21, pp. 2212-2214, 2006.

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

# Prototype of 40 Gb/s OVSB Generator using SOA

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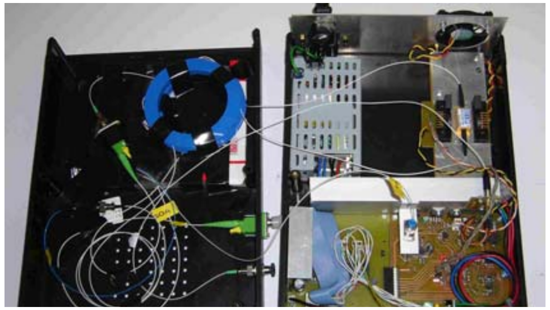


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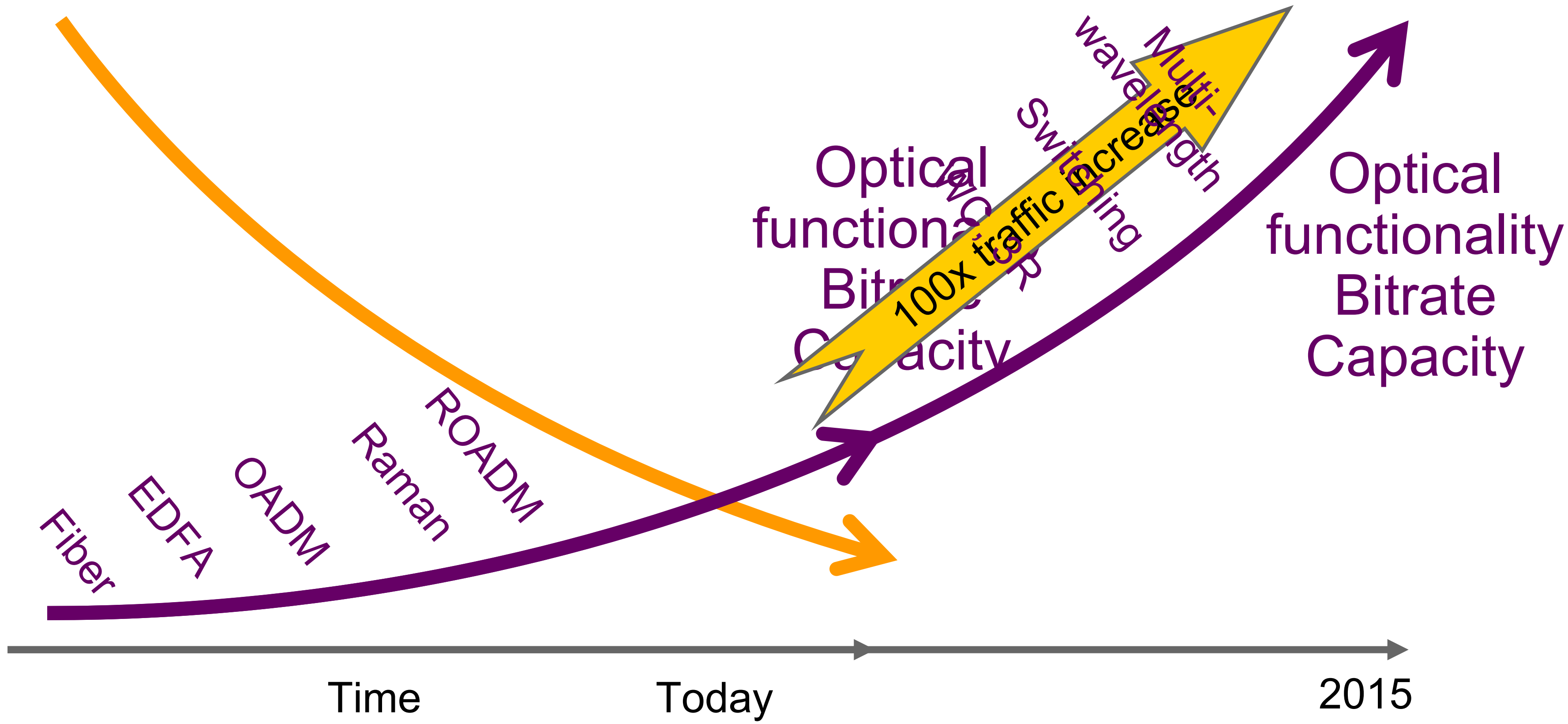
# All-Optical Processing

# All-Optical Processing

## The route to all-optical



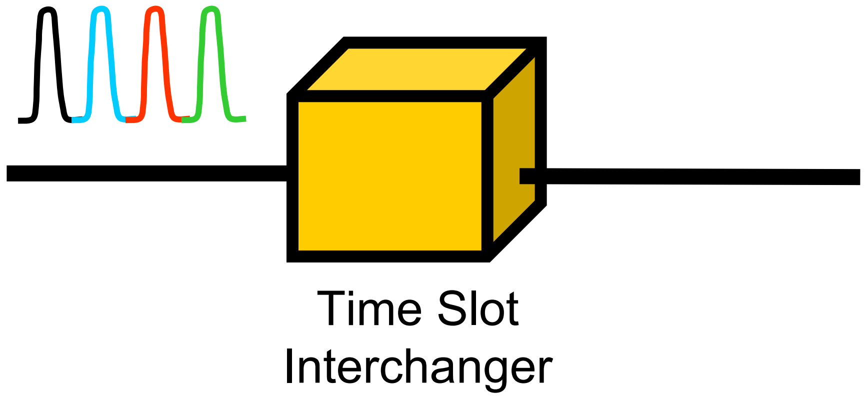
# Areas of investigation

## Time-slot processing

**Objectives:**

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

What is the best way of building a TSI?



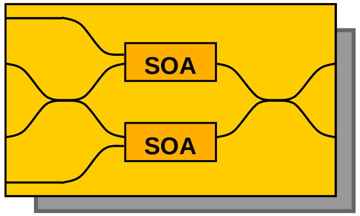

Rui Meleiro, et al., ICTON 2007, Rome, Italy

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

# MUFINS platform

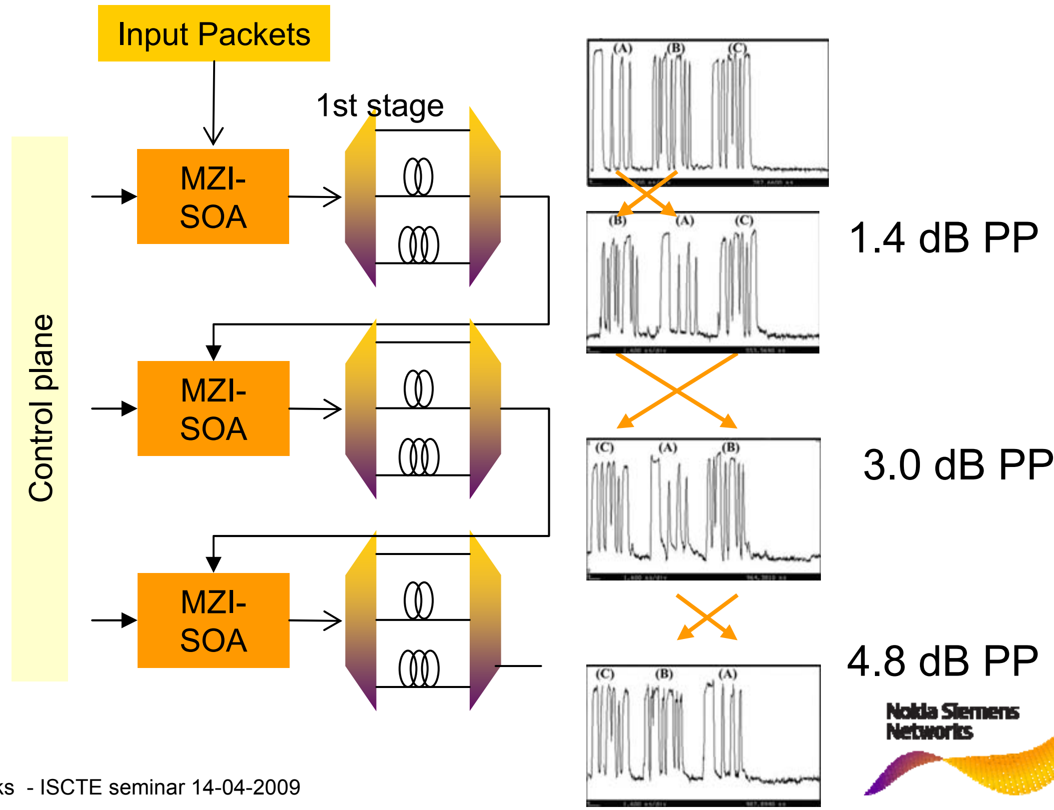
## Multi-Functional INtegrated arrays of interferometric Switches

**Base platform for building advanced all-optical processing sub-systems**




MZI-SOA: Mach-Zehnder interferometer
with Semiconductor optical amplifiers

- 3R 4-λ burst mode regenerator
- Label swapping front end
- Contention resolution
- Time Slot Interchanger




Zouraraki, OFC2007 OTuB3

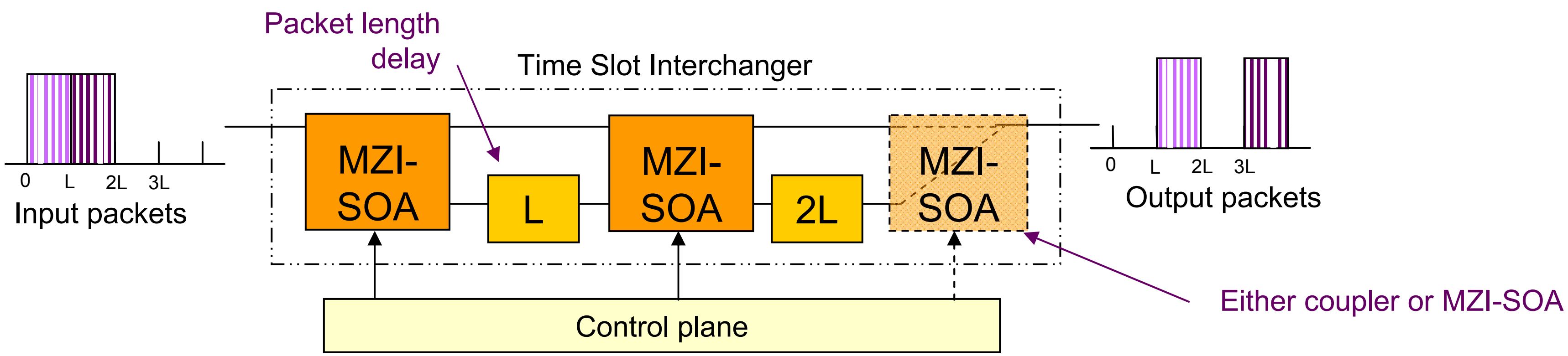
# Analytical study of switch based Time Slot Interchanger

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.



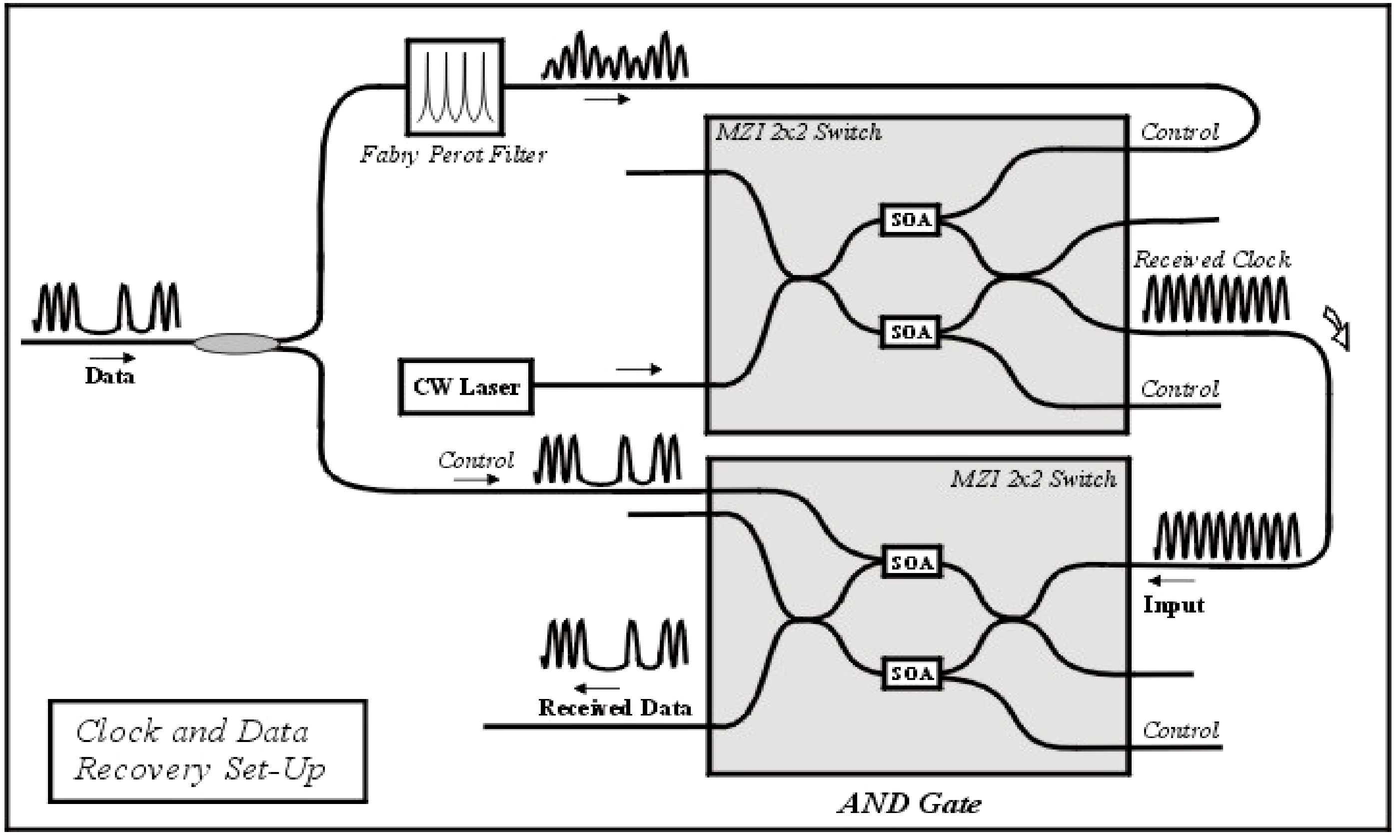

With the output MZI-SOA 3 stages are achievable for a power penalty lower than 3 dB.

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

# MUFINS platform

## Multi-Functional INtegrated arrays of interferometric Switches

### All Optical Regeneration



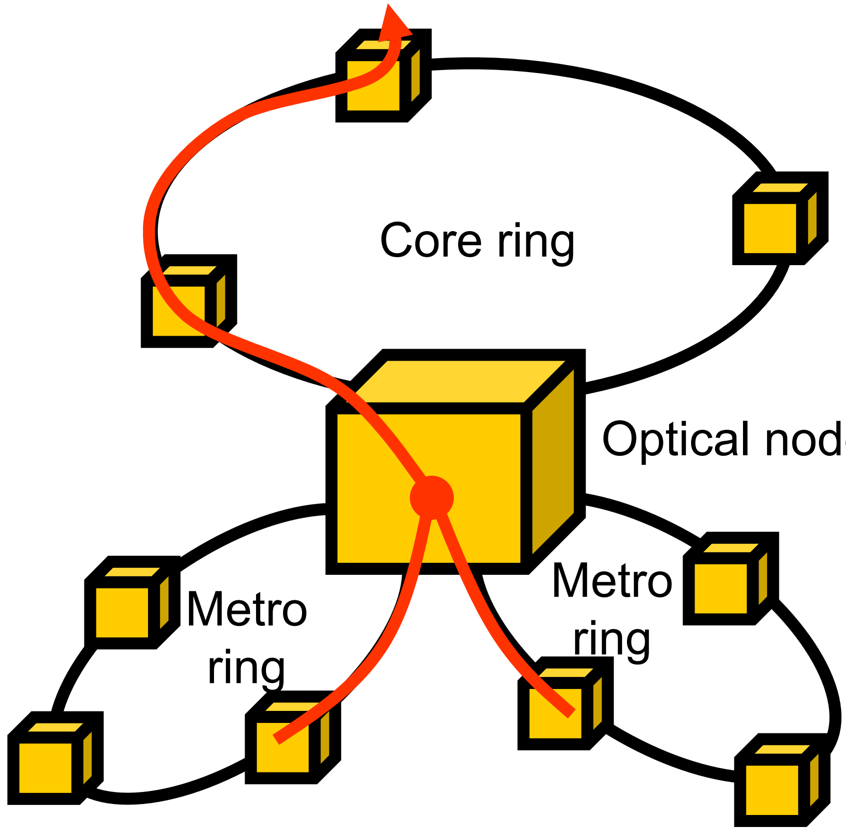
# TRIUMPH

## Transparent Ring Interconnection Using Multi-wavelength PHotonic switches

**Objectives:**

-**Adapt signals between different ring hierarchies**

- -Bit-rate adaption
- -Format adaption
- -Synchronization



# TRIUMPH

## Transparent Ring Interconnection Using Multi-wavelength PHotonic switches

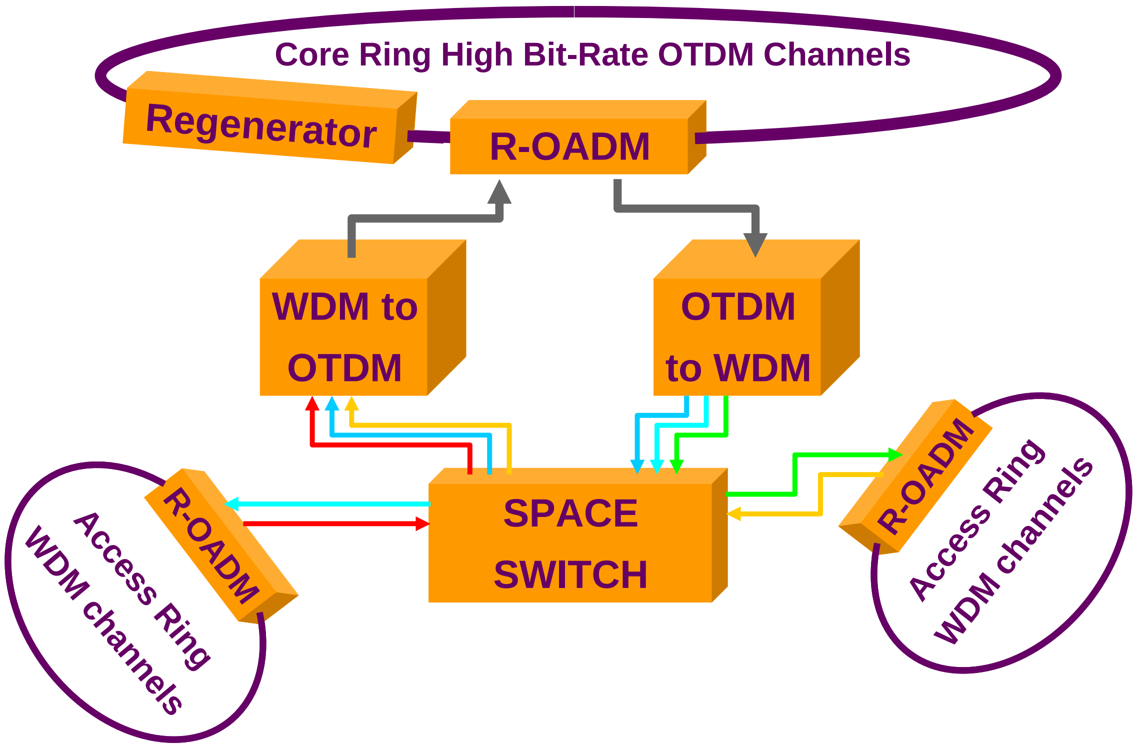
### Transparent OCS Node

**Core Ring @ 130 Gbit/s**

**Access Ring @ 40 Gbit/s**

**Adapt signals between different ring hierarchies**

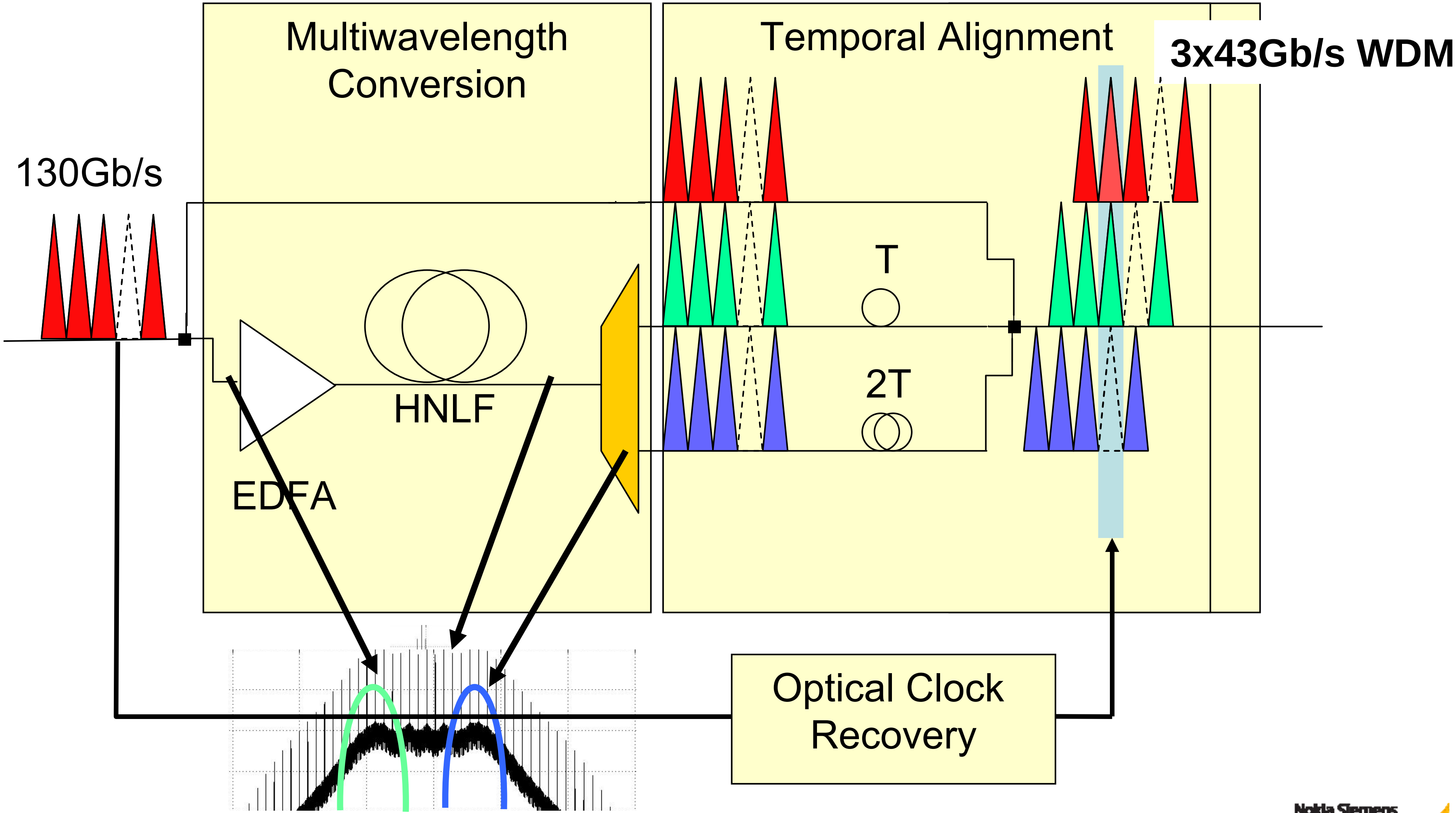
- Bit-rate adaption
- Format adaption
- Synchronization




### 3 basic functions with disruptive technology:

- **2R- Multiwavelength Regenerator (passive based on HNLF or active based on QD-SOAs)**
- **OTDM to WDM converter (based on HNLF, R. Morais et al, OFC (2007), OTuD5)**
- **WDM to OTDM converter – Synchronization, reshaping (ADORE – Asynchronous Digital Optical Regenerator, S. Ibrahim et al, ECOC (2008), Tu.4.D.3.)**

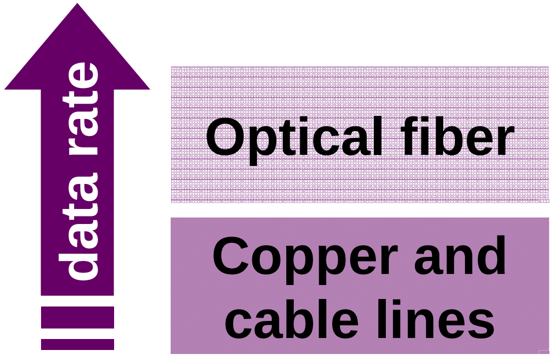
# TDM-to-WDM Conversion




Reference: R. Morais et al., OFC (2007), OTuD5.
NOLM based: P. Vorreau et al., ICTON (2008), Th.PD.2.

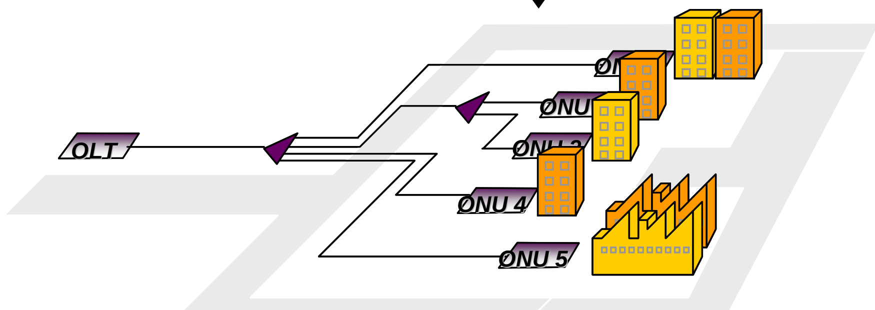
# Access

# Passive Optical Networks
## Motivation and drivers




cost-effective solution to extend the fibre reach to access

**PON systems**




Residential and business customers are **demanding more bandwidth**

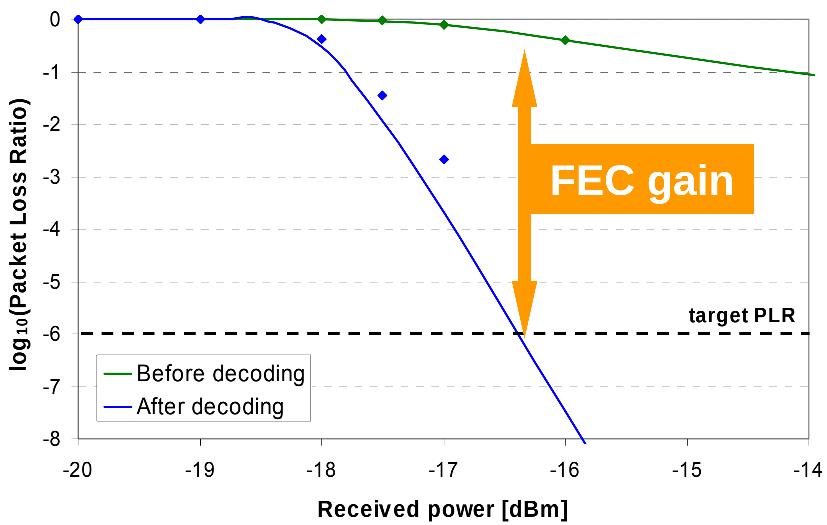
Currently available

Available in 2009/2010

# Passive Optical Networks
## Improvements in future high data rate TDM-PON systems

- **Forward Error Correction** (FEC)
  - Electrical process only (transparent to the underlying physical layer)
  - High coding gains (minimization of SNR-independent impairments)
- **Regeneration**
  - Electrical processing required
  - Single wavelength support
  - Bit-rate dependent
- **Optical Amplification**
  - Transparent (all-optical)
  - Several wavelengths support
  - Bit-rate agnostic




Sílvia Pato, et al, "Forward error correction in 10 Gbits/s Ethernet passive optical networks," J. Opt. Netw. **8**, 84-94 (2009).

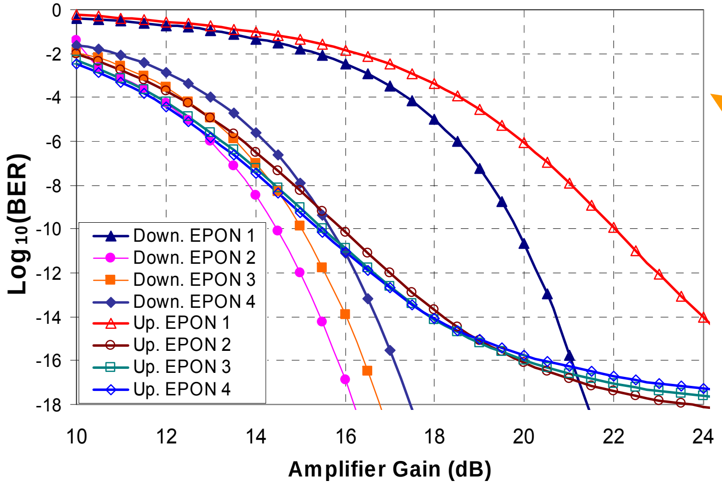
Sílvia Pato, et al, "All-Optical Burst-Mode Power Equalizer Based on Cascaded SOAs for 10-Gbps EPONs" , IEEE Photonics Technology Letters, Vol. 20, No. 24, pp. 2078-2080, December 2008.

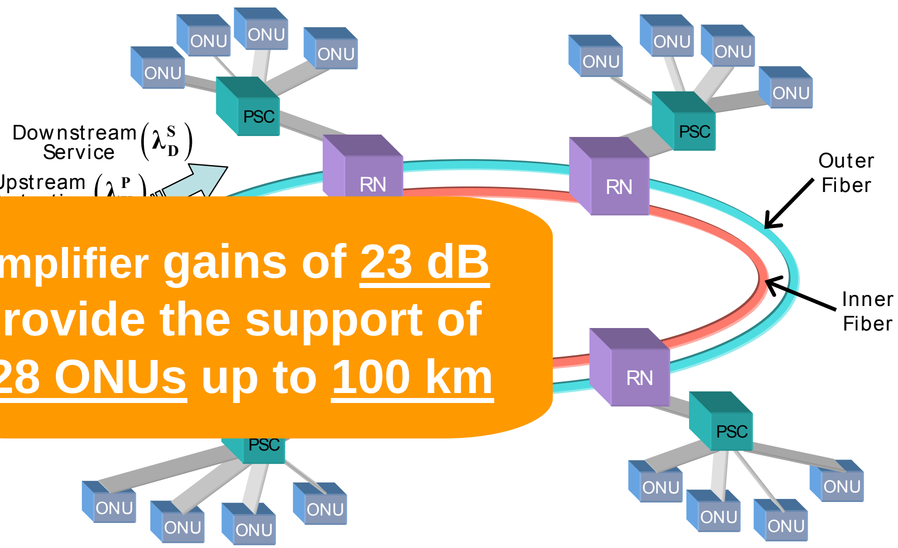
# Next-Generation Optical Access (NGOA)

**Next-generation PON architectures** will evolve to:

- Support hundreds of clients
- Incorporate WDM-PON features to further boost the capacity
- Extend backward into the metropolitan segment (→ access/metro convergence)
- Apply protection schemes to avoid service disruptions

**Example:** Long-reach 10 Gbit/s EPON with survivable double-fiber ring feeder and 4 tree-shaped fiber drops




**Amplifier gains of 23 dB provide the support of 128 ONUs up to 100 km**

J. Santos *et al.*; "Self-Protected Long-Reach 10 Gbit/s EPONs based on a Ring Architecture", Journal of Optical Networking, Vol. 7, No. 5, pp. 1 - 20, May, 2008.
J. Santos *et al.*; "Long-Reach 10 Gbps Ethernet Passive Optical Network Based on a Protected Ring Architecture", Proc OSA Optical Fiber Communications - OFC, san Diego, United States, Vol. OTuI, pp. 1 - 3, February, 2008

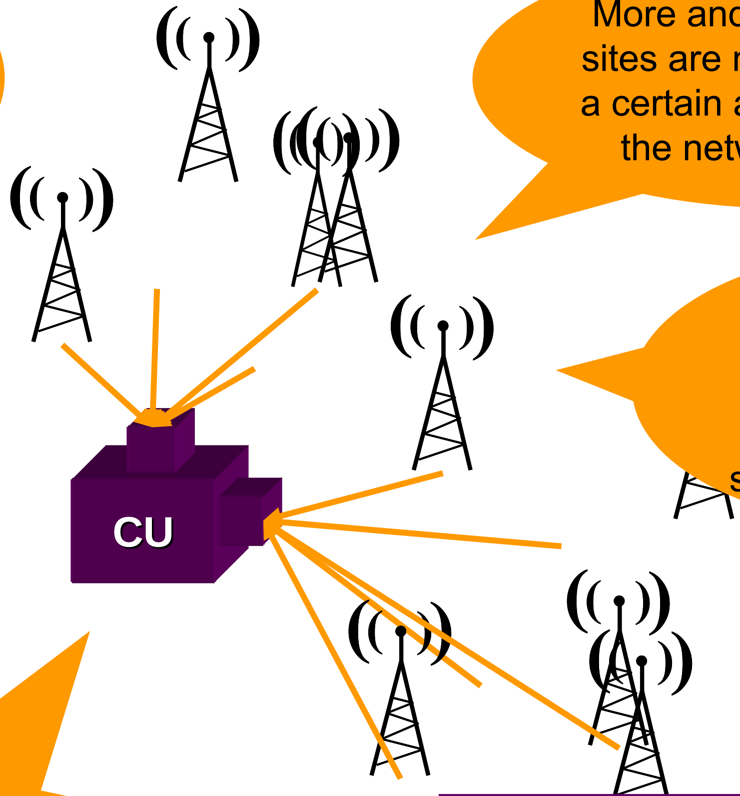
# Optical-Wireless Convergence

Wireless services should provide high capacity to cope with bandwidth-hungry and sophisticated future services

More and more antenna sites are needed to cover a certain area to increase the network capacity

The support of more users at higher data rates results in smaller radio cells

Optical fiber is a suitable transmission medium for transporting radio signals to/from the CU



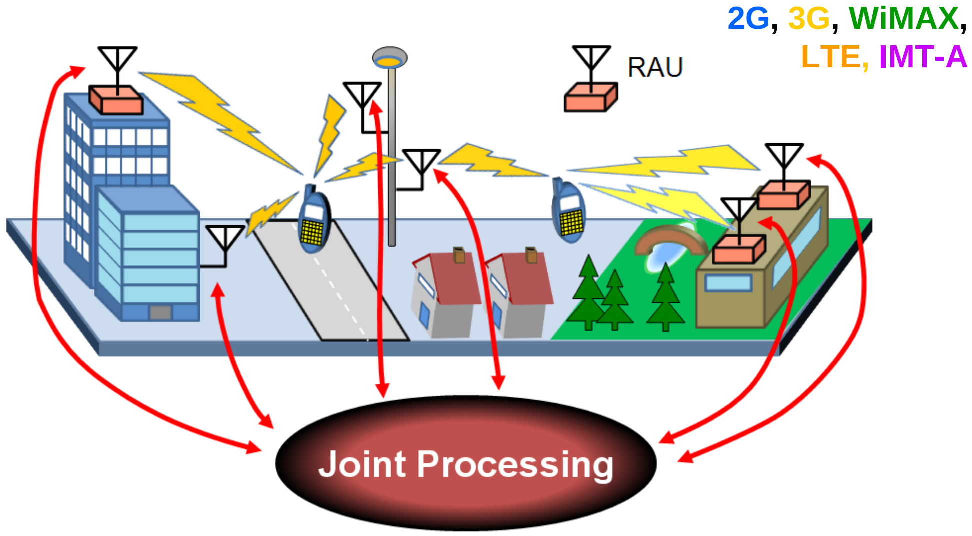

The complexity/cost of the antenna sites is decreased by providing radio signals from a central unit, where all processing functions occur

**Radio over Fiber (RoF) networks allows for the convergence of wireless and optical access systems**

# FUTON Concept

- Development of a hybrid optical-radio infrastructure, where simplified Remote Antenna Units (RAU) are transparently connected to a central unit, and exploiting the potentialities provide by such infrastructure.
- Transparent support the legacy (2G, 3G) and the future high capacity RATs (4G) over a single infrastructure
- Facilitate the implementation of Cooperative MIMO
- Ease vertical handover

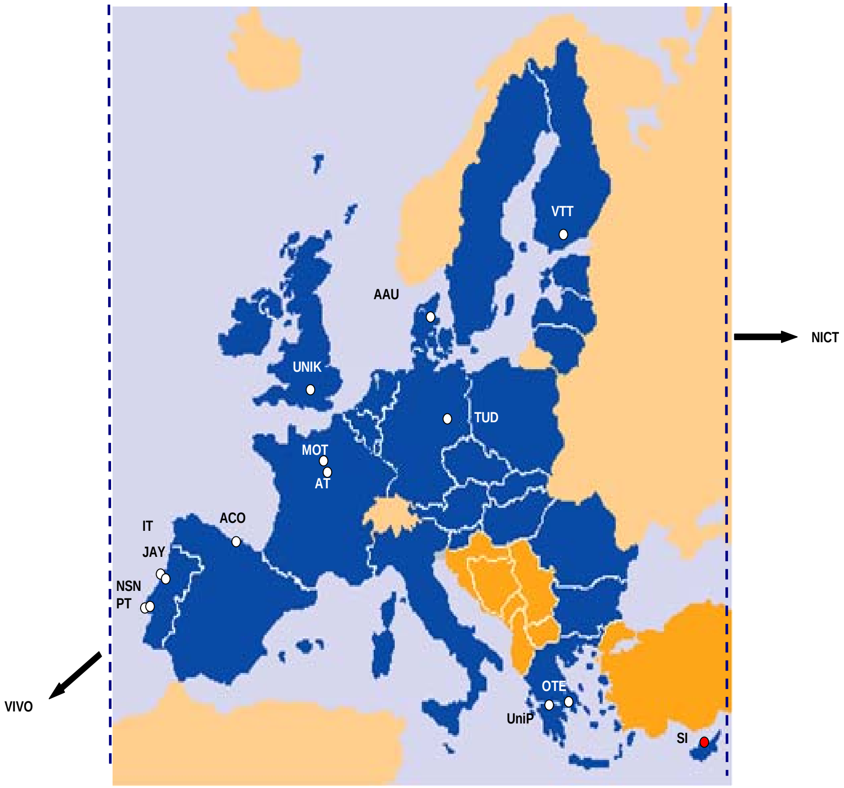



- Deployment of multiband / low cost antennas in a distributed antenna system (DAS)
- Transfer the processing functionalities upstream to a central unit (CU)
- Co-located processing of the radio signals from multiple antenna sites

# FUTON in a Nutshell

## Partners and calendar

✓ **FUTON consortium balanced between academy / research institutes, manufacturers and operators**




**Duration:** January 2008 – June 2010

**Consortium**

**Large Industrial**

- Nokia Siemens Networks (P)
- Alcatel-Thales III-V Labs (F)

**Operators**

- Portugal Telecom (P)
- Hellenic Telecommunications (Gr)
- VIVO (Br)

**Small and Medium Enterprises**

- Wavecom (P)
- Acorde (E)
- Sigint (Cy)

**Research Centres**

- Instituto de Telecomunicações (P)
- CEA
- VTT (Fi)
- NICT (Jp)

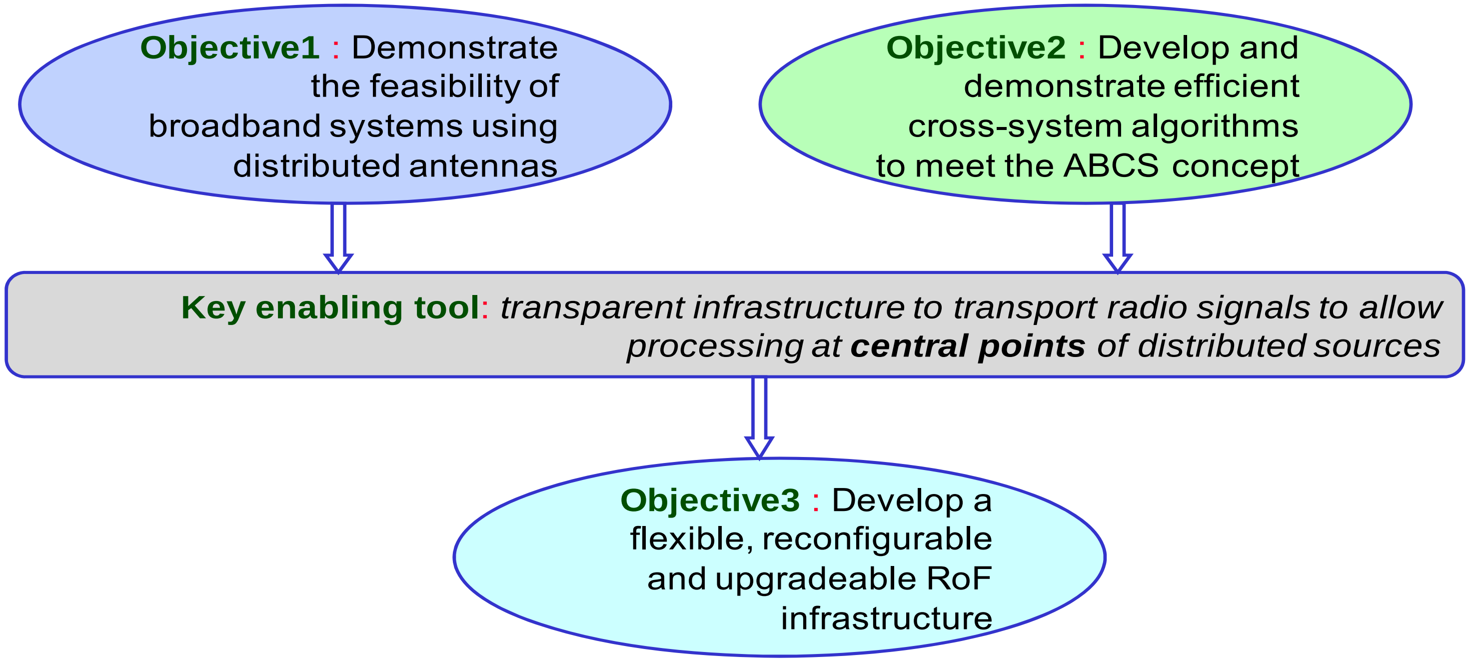
**Universities**

- Technical University of Dresden (D)
- University of Aalborg (Dn)
- University of Kent (UK)
- University of Patras (Gr)

# Objectives Summary

## Technical level

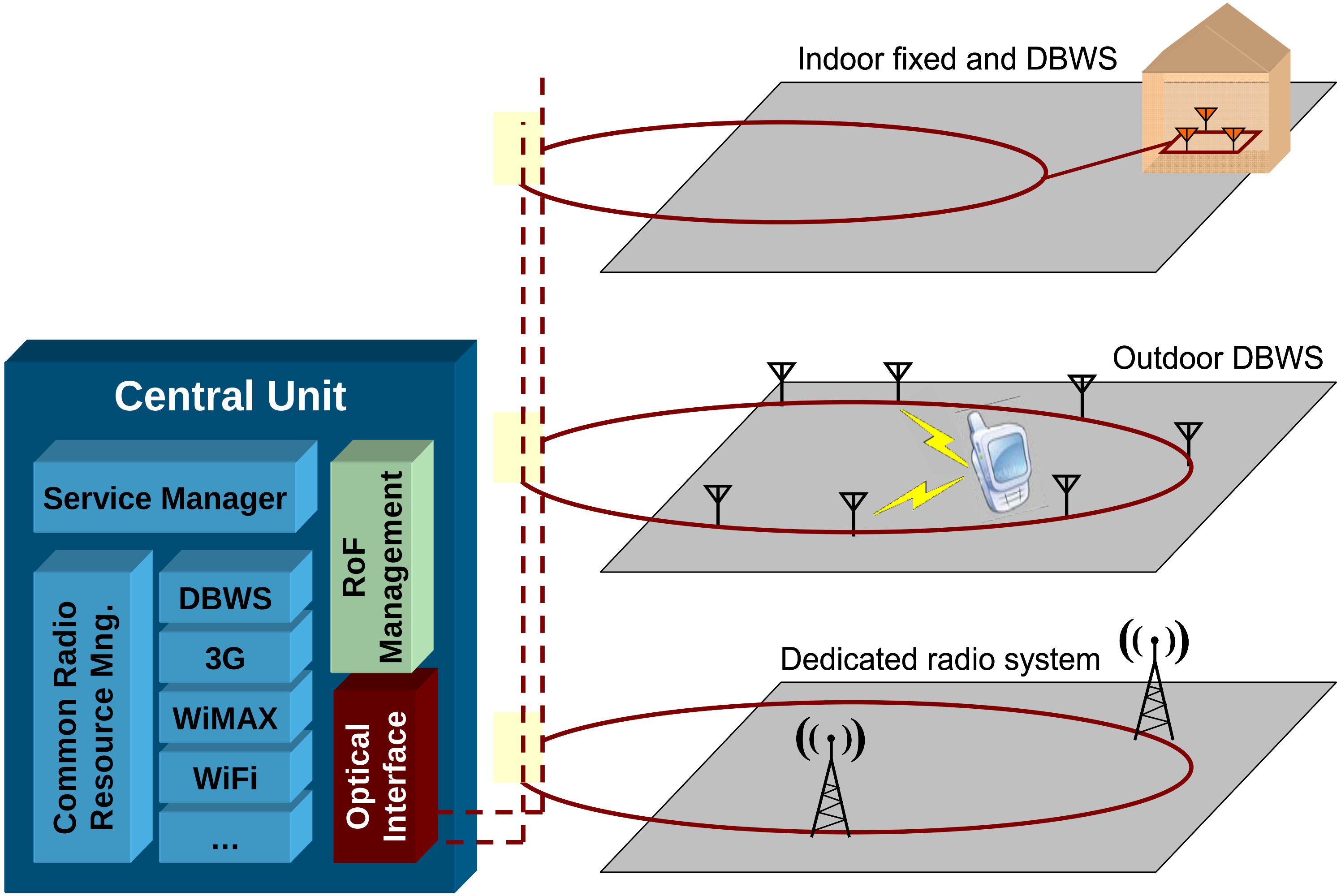



## Deployment/ business level

- *Evaluate the implications on the current wireless architecture models of the FUTON concept, determine cost models for upgradeability / replacement and provide roadmaps for evolution.*

# FUTON Architecture



# FUTON Architecture

With multiband RAU, the capacity of optical fiber allows:

- **The RoF infrastructure to be shared by different systems / operators**

*Potentialities to exploit either at the technical or business levels*

- **Technical level**
  - Processing of multisystems at a single location ➔ facilitate the design of efficient cross-system algorithms / protocols
  - Interoperability
- **Business level**
  - Owner of the RoF can be third party
  - Existence of an infrastructure that can be rented will facilitate the entrance of new service providers

# The optical transmission infrastructure I

## Key design aspects for the optical infrastrucuture

- **Should be easy to support new wireless systems**
- **Should be easy to add new RAU’s, without need for a complete replanning**

*Key aspects*

## Flexibility, Reconfigurability

**The issue - transport of analog radio waveforms or digitized radio over the fiber?**

# The optical transmission infrastructure II

## Digital Transport

Offers noise immunity and protection against component impairments

Specific design for each radio system

Synchronization issues

Very high bandwidth required

## Analog Transport

With combination of subcarrier multiplexing and WDM

→ **high flexibility, transparency**

***Drawbacks***

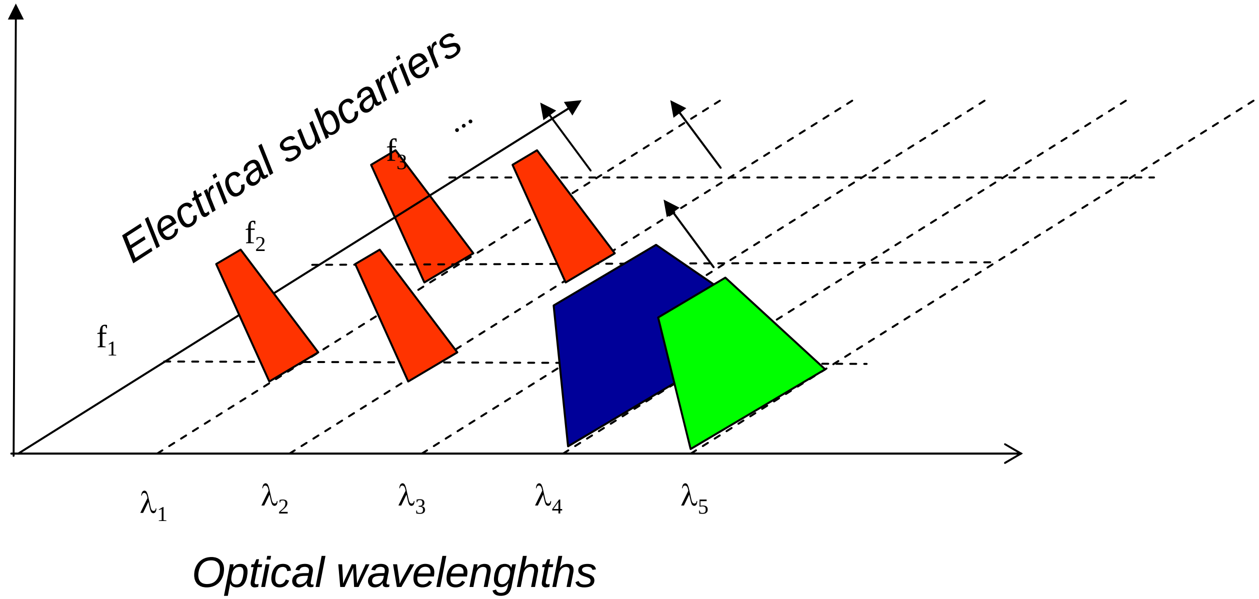
- Dynamic range of optical links

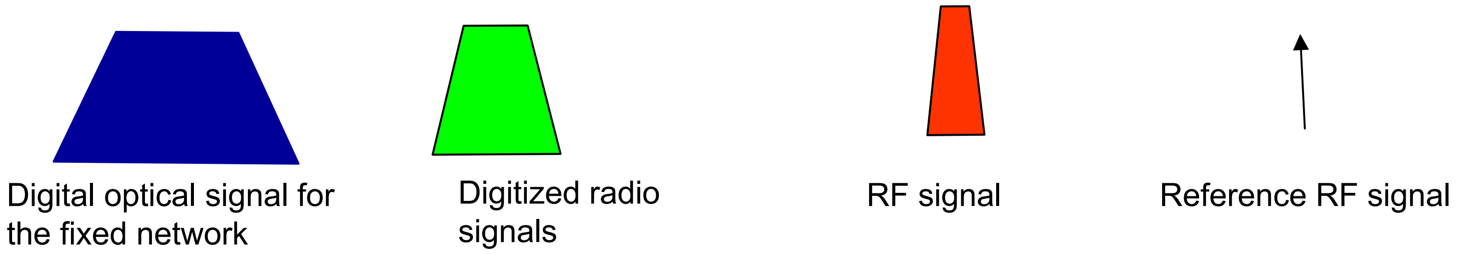
**Furthermore if signal are in digital format → can be transported like analog waveforms**

→ provide easy integration of existing digital interfaces

# The optical transport infrastructure III

- **Resources of the optical infrastructure**
  - Optical wavelengths
  - Electrical subcarriers



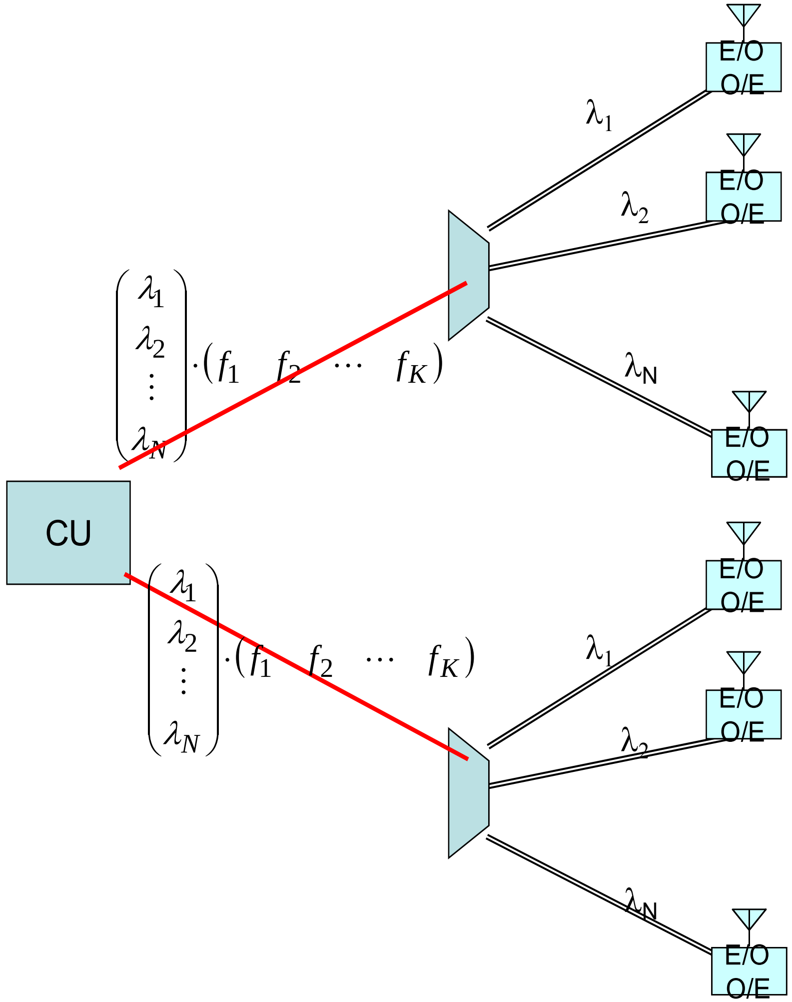
# The optical transport infrastructure IV

Optical wavelength address the RAU's

Electrical subcarriers, separate different systems / sectors / antennas at each RAU

Up and down converters

➔ transport of signals in the range less than 10GHz where optical components with low cost and good linearity characteristics can be developed



# Networks

# 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

# Optical Burst Switching

## Contention in OBS networks

- Contention arises from asynchronous burst transmission and lack of optical RAM
- The use of multiple contention resolution mechanisms (wavelength conversion, FDL buffering, burst segmentation) increases the complexity/cost of core nodes

## Proactive contention minimization strategies

- Exploit the inexpensive electronic buffers at the ingress nodes to reduce the number of contention resolution mechanisms used at the core nodes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## Challenges and Trends in Optical Networking: A Bottom-Up Approach

# Traffic Monitoring and Analysis

# Traffic Monitoring and Analysis
## The Network Management

### Motivation:

- **Quality of Service** (QoS) assurance for new or future services requires strong knowledge about the **traffic behaviour and its patterns**
- Predict and satisfy user **requests in the near future**
- **Separate** the traffic into **different classes**, giving each class the amount of resources needed by its services
- Identify different **threats to network security** (e.g. intrusion and denial of service attacks, )

### Challenges:

Heterogeneity of services

Evasive techniques for undetected applications

Payload encryption

### Approaches:

**Deep Packet Inspection (DPI):**

Analysis of the **data carried in packets payload**

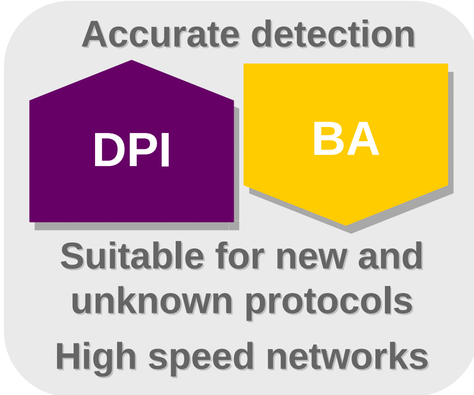
Search for known data signatures within the packets

**Behavioural Analysis (BA):**

Based in **information gathered in the intermediate protocol layers**, typically the data-link, network and transport layers

Usually, the information is correlated using statistical measures

# Traffic Monitoring and Analysis
## Traffic Analysis




### Deep Packet Inspection (DPI):

- ✓ Typically, the **most accurate** approach
- × Requires **high computation power** to analyse huge amounts of traffic over high speed links
- × Unable to deal with **new or unknown protocols or encrypted payloads**

### Behavioural Analysis (BA):

- ✓ Even for new or unknown protocols and encrypted payloads it may give a **strong suspicion about the traffic nature**
- ✓ **Fast and light** mechanisms
- × Only gives strong suspicion: **less accurate** than DPI methods

P. Inácio, *et al*, “Analysis of the Impact of Intensive Attacks on the Self-Similarity Degree of the Network Traffic,” SECURWARE 2008 pp. 107–113, 2008.

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## Thank you!

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