ORCHESTRA- Optical performance monitoring enabling flexible networking

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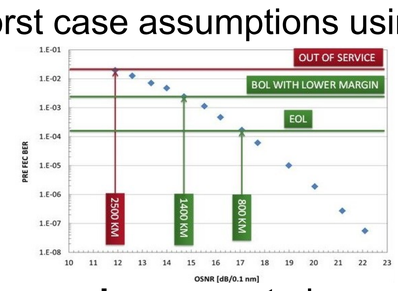
Motivation

ICT 6– 2014: Smart optical and wireless network technologies

"Address the limitations of optical transmission technologies"

☒Optical networks are designed under worst case assumptions using "End-of-life margins"

- Equipment (fibers, amps) ageing
- Interference (nonlinear impairments)
- Anticipated maintenance operations

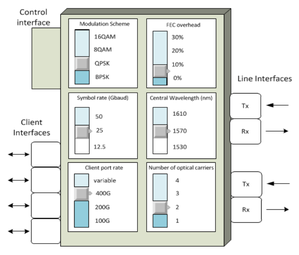


☑ORCHESTRA promises **to lower the margins**, so as to increase the transmission efficiency and reduce or postpone investments

"Address the lack of dynamic control and management of resources for lower cost and more flexible use of resources"

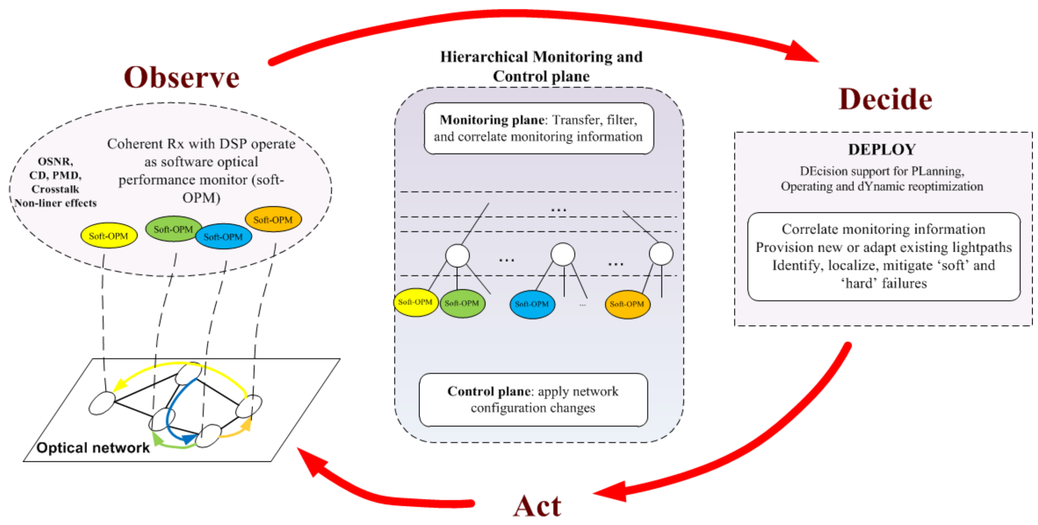
☒Physical layer monitoring information is barely used

- Planning inefficiencies are never corrected
- Soft-failures are treated as black or white
- Tunable transceivers provide vast optimization options, but need feedback from the physical layer to be efficiently used



☑ORCHESTRA proposes to **close the loop** between physical layer and the control plane, enabling a dynamically controlled network that can be used in a more flexible and efficient way

ORCHESTRA closed control loop



- The future of optical networks is **coherent** and **elastic,** operators are deploying DSP enabled coherent transceivers
- ORCHESTRA will take advantage of the evolving trends and develop DSP algorithms that will add **optical performance monitoring** (**soft-OPM**) capability to coherent transceivers
- The ORCHESTRA network will have a **plethora** of soft-OPMs to extract physical-layer information. But we can do even more: **correlate** information from multiple soft-OPMs to
  - Improve estimation accuracy
  - Estimate QoT before lightpath establishment
  - Detect, as well as anticipate, 'hard' and 'soft' failures
- ORCHESTRA will develop a **hierarchical control and monitoring** infrastructure to transfer and manipulate monitoring information, that will have active control functionality
  - Hierarchical: avoid bottleneck issues
- ORCHESTRA will rely on the feedback from the soft-OPMs to develop **true cross-layer optimization algorithms** to achieve unprecedented efficiency for dynamic and offline use cases

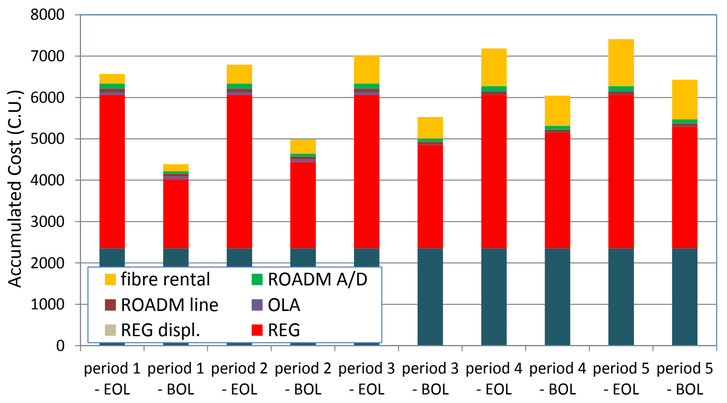
Use Cases

- **Lightpaths provisioning with reduced margins**: during an upgrade or the addition of new lightpaths, decisions on equipment purchase are taken. QoT estimates are typically done using high margins due to lack of physical feedback. ORCHESTRA proposes to provision the lightpaths with reduced margins, based on the actual network conditions as observed through the soft-OPMs.
- **Dynamic network adaptation**: ORCHESTRA develops mechanisms for dynamic network re-optimization based on actual conditions as opposed to current overprovisioning practice.
- **Hard-/soft-failure localization and hard-failure prediction**: Currently upon failure a huge number of alarms are generated while alarm suppression mechanism are quite slow. ORCHESTRA's hierarchical monitoring plane provides an efficient and scalable infrastructure to filter and correlate alarms to suppress them and localize the hard but also soft failures.
- **Optimize transmission during upgrade or maintenance tasks**: During such stepwise procedures the network remains in operation but is vastly un-optimized. ORCHESTRA can optimize the network even during the upgrade/ maintenance processes.
- **Alien lightpaths support**: Aliens are lightpaths for which we do not have knowledge on their transmission parameters, and might cause soft-failures. It is also hard for aliens to obtain good performance over an unknown domain. ORCHESTRA advanced monitoring functions provide solutions to support the aliens.

Cost Benefits

- Accumulated cost of a network incrementally planned for 5 periods (10 years), in which lightpaths are provisioned with
  - End-of-life (EOL) margins – current practice
  - Begin-of-life (BOL) margins- ORCHESTRA approach
- SPARKLE Pan-European topology
- Traffic 100 Gbps between all nodes, traffic not increase over time
- Physical layer: 100 km spans, span margin BOL:3 and EOL:4dB, fiber attenuation BOL:0.22 and EOL: 0.24 dB/km, span budget BOL: 25 and EOL: 28 dB, worst interference (all channels active)
- 10% equipment depreciation per year

Network equipment	Unit price (C.U.)
TR 100G (DP-QPSK or DP-BPSK)	1
REG 100G (DP-QPSK or DP-BPSK)	2
REG displacement cost	0.1
OLA EDFA	0.15
WSS 1x20 96 ch 50 GHz fix (incl. OA)	0.3
WSS CD A/D submodule with 24 ports fix grid (incl. OA)	0.4
Fiber rental (SSMF per km per period)	0.005 (annual)



EOL: the cost of equipment is paid upfront, at period 1, and does not change (except for fiber rental), since no new equipment is added later

BOL: the cost is lower at period 1 and equipment is added later, but at lower prices

☑ At the end of the 5 periods we had 13.7% savings

Note that in this study we did not take into account the reduction of interference margins, which were show to have additive effect.
The savings enabled by ORCHESTRA will be even higher (double)

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