INSTITUTE OF COMMUNICATION, INFORMATION AND PERCEPTION TECHNOLOGIES

Scuola Superiore Sant'Anna

A monitoring architecture for self-configurable optical networks

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Introduction

- Optical networks are evolving to support ultra-high rate and **self-configurable operations**, e.g. elastic adaptation and optimization of transmission parameters
- The **operation, administration, and maintenance (OAM)** are fundamental functionalities
- **Monitoring** is crucial to verify the actual matching of quality of transmission (QoT) requirements and Service Level Agreements (SLAs) and to **trigger** proper **actions** (e.g., adaptation of transmission parameters, re-routing) to react against link degradations/fault which degrade QoT and, in turn, SLA
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- An emerging candidate for the control and orchestration of next generation optical networks is the **Application-Based Network Operations (ABNO)** architecture which includes the management of monitoring functionalities, through the **OAM Handler**

What we propose within the EU Project ORCHESTRA

- hierarchical monitoring architecture, instead of a centralized OAM Handler, is proposed within the framework of the EU project ORCHESTRA: OAM Handler is the root of the hierarchy
- improved scalability and effective fault management are guaranteed by the hierarchy

ABNO architecture

“Functional components are architectural concepts and have distinct and clear responsibilities” [RFC7491]

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Some of the main functional elements:

ABNO architecture

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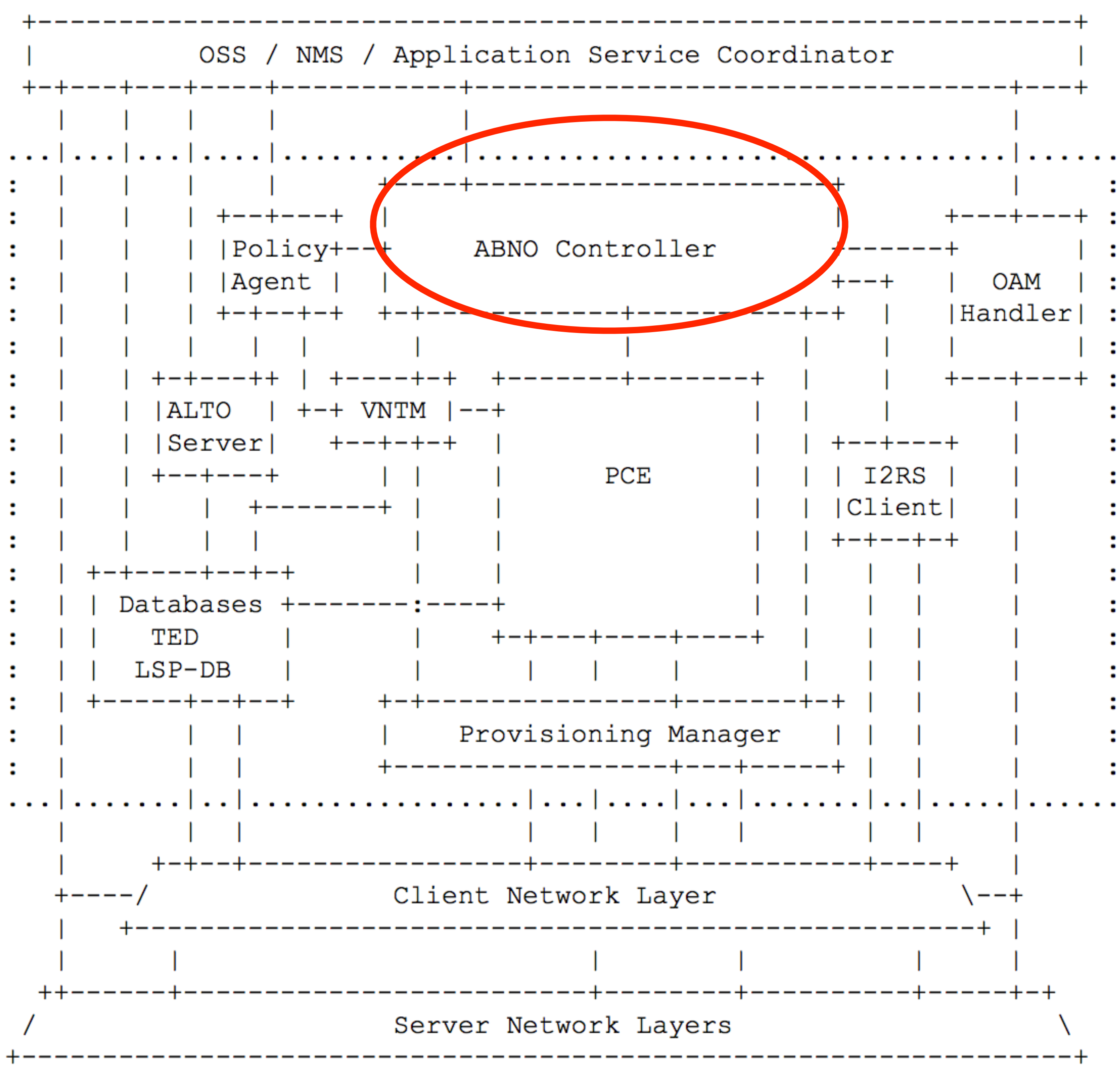

Some of the main functional elements:

- **ABNO controller:** governs the behavior of the network in response to changing conditions and in accordance with application network requirements and policies
- **PCE:** path computation element

ABNO architecture

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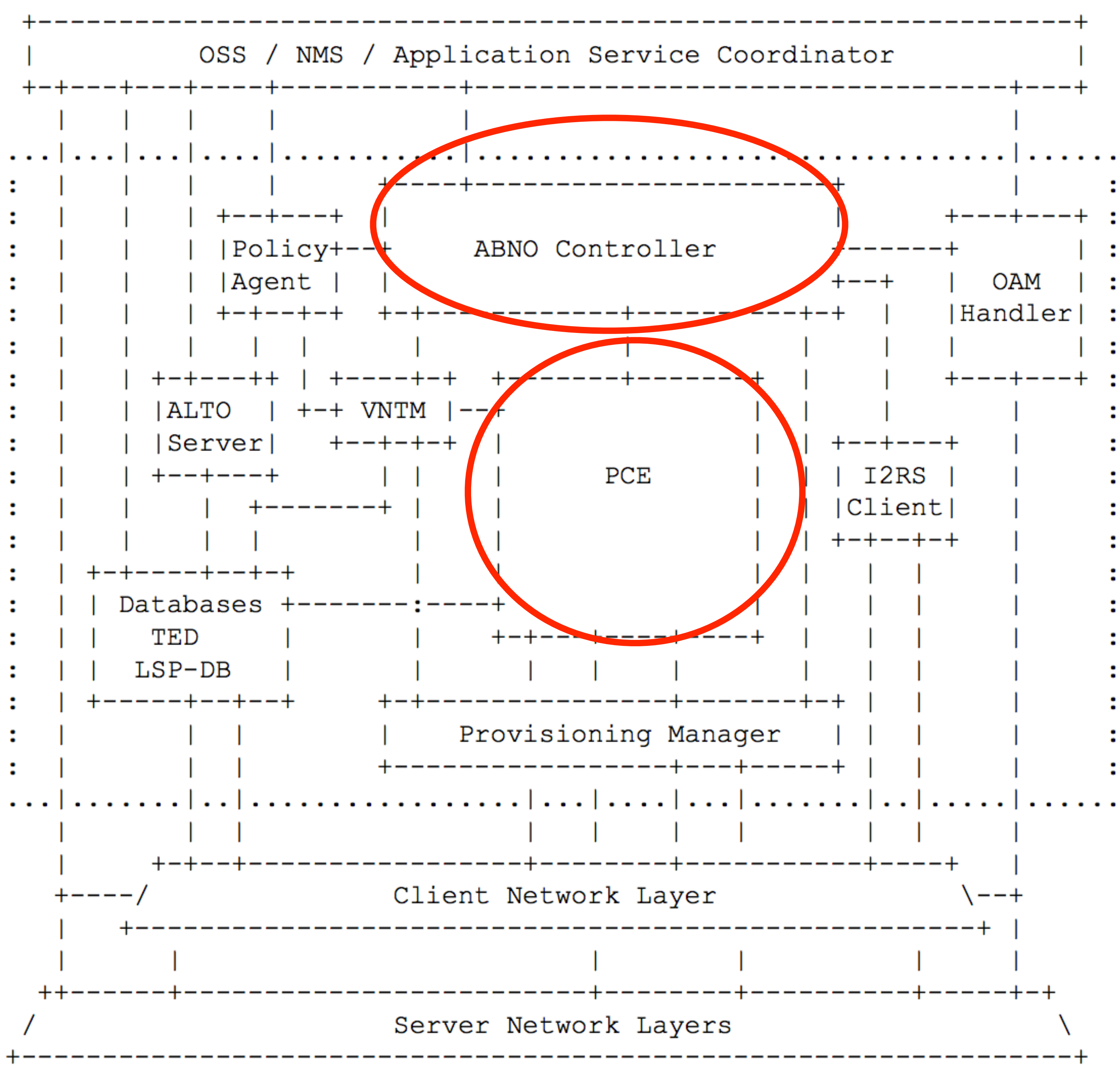

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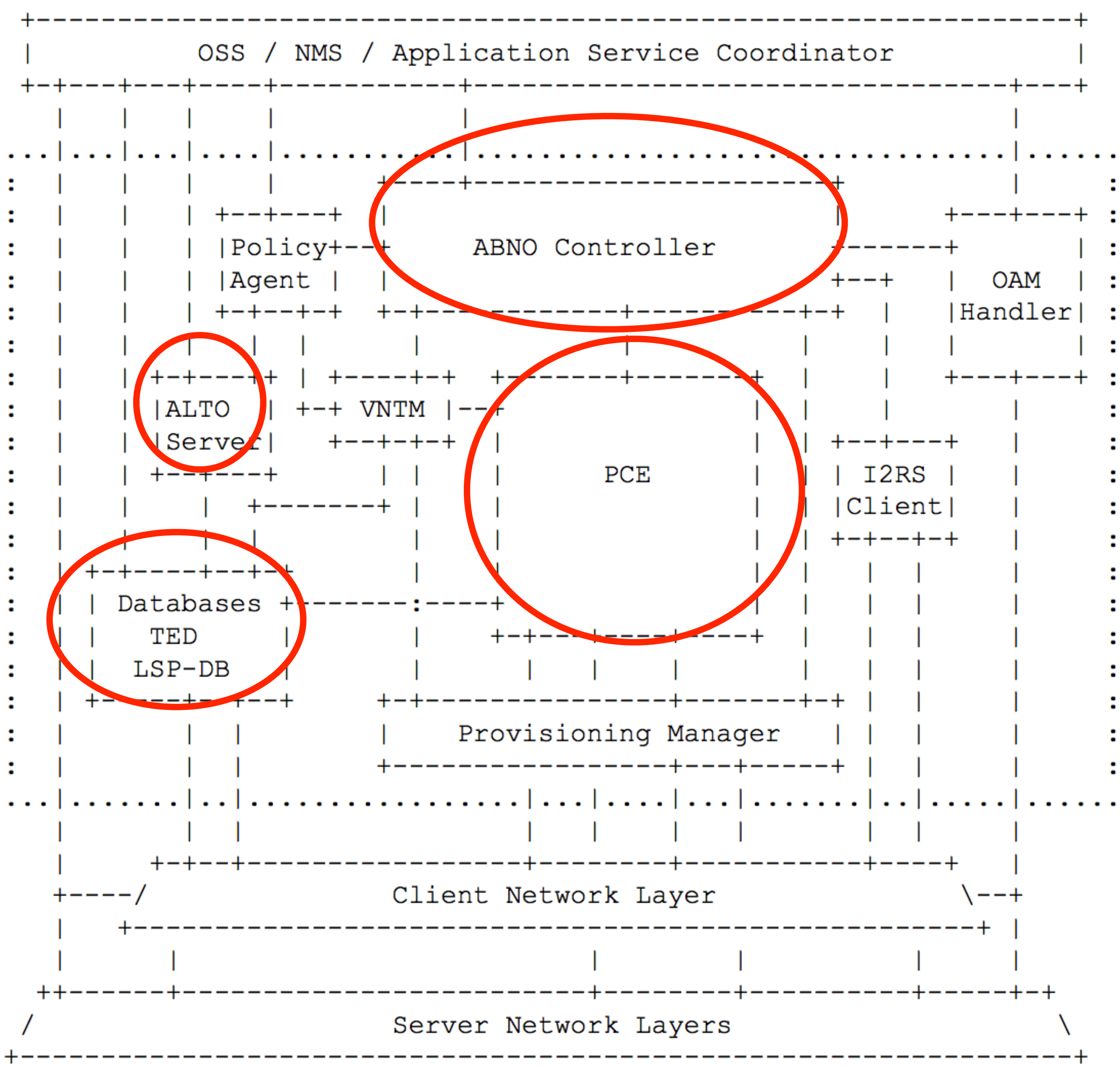

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- **Application-Layer Traffic Optimization (ALTO):** to provide to the application layer a simplified view of the network for optimization (e.g., to better select paths in the network to carry application-layer traffic)

OAM Handler within ABNO architecture

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 |          OSS / NMS / Application Service Coordinator           |
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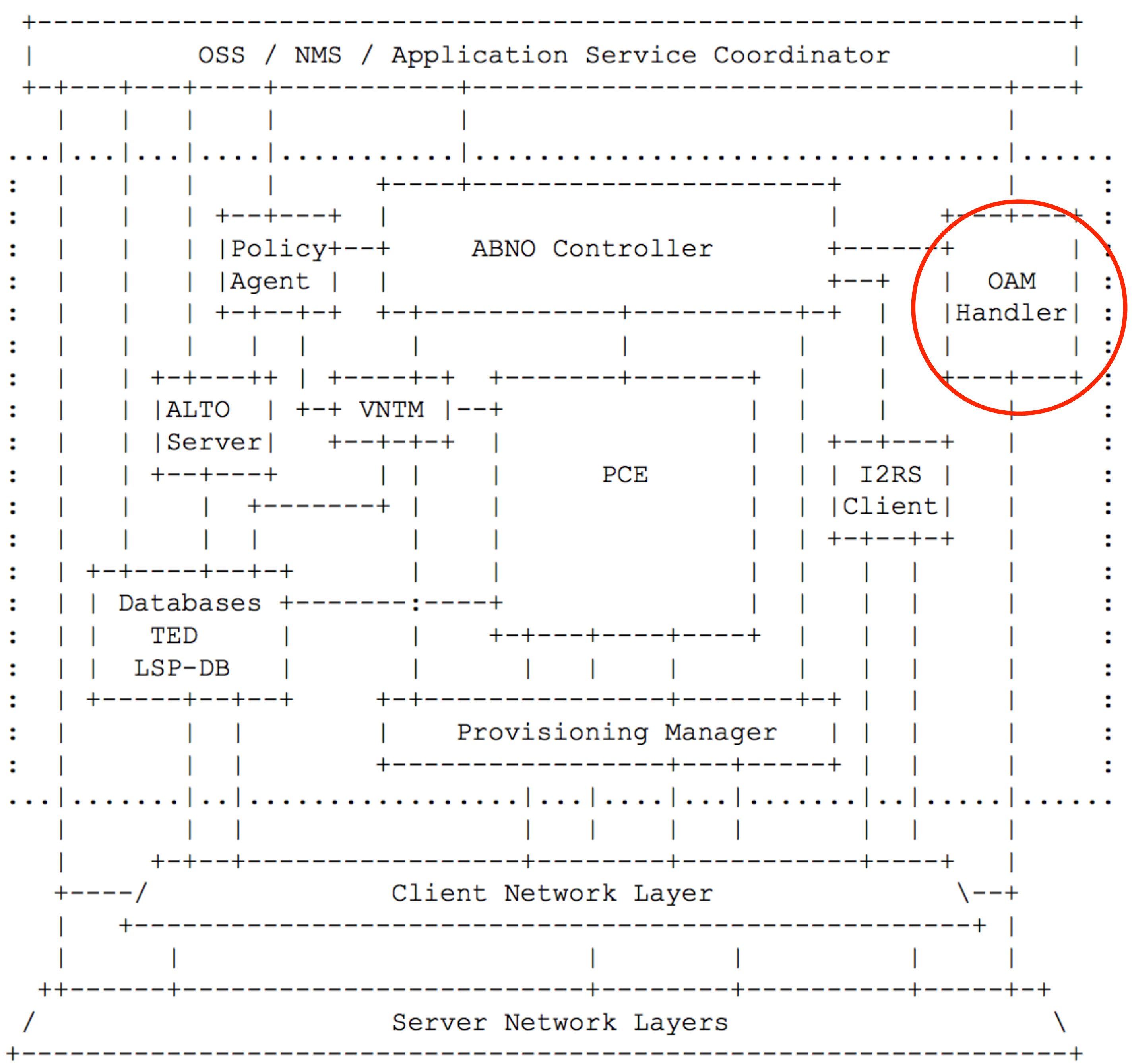
OAM Handler within ABNO architecture



The OAM Handler:

- receives **alerts** about potential problems
- **correlates** them
- **triggers** other components of the ABNO system to take **actions** to preserve or recover the services

The OAM Handler is the root of the proposed hierarchical monitoring architecture

Assumed monitors at the physical layer

We will mainly focus on **LSP monitors** (however hierarchy can be applied to other monitors)

[ONDM2015] G. Meloni, L. Potì, N. Sambo, F. Fresi, F. Cavaliere, "Code-adaptive Transmission Accounting for Filtering Effects in EON", Proc. of ONDM 2015, Pisa, Italy

Assumed monitors at the physical layer

- **link monitors** (e.g., power monitors)
- **node monitors** (e.g., power monitors)
- **LSP monitors** may leverage on digital signal processing (DSP) functionalities installed in coherent receivers: may provide parameters such as pre-forward-error-correction bit error rate, symbol variance [*ONDM2015*], each related to a specific LSP

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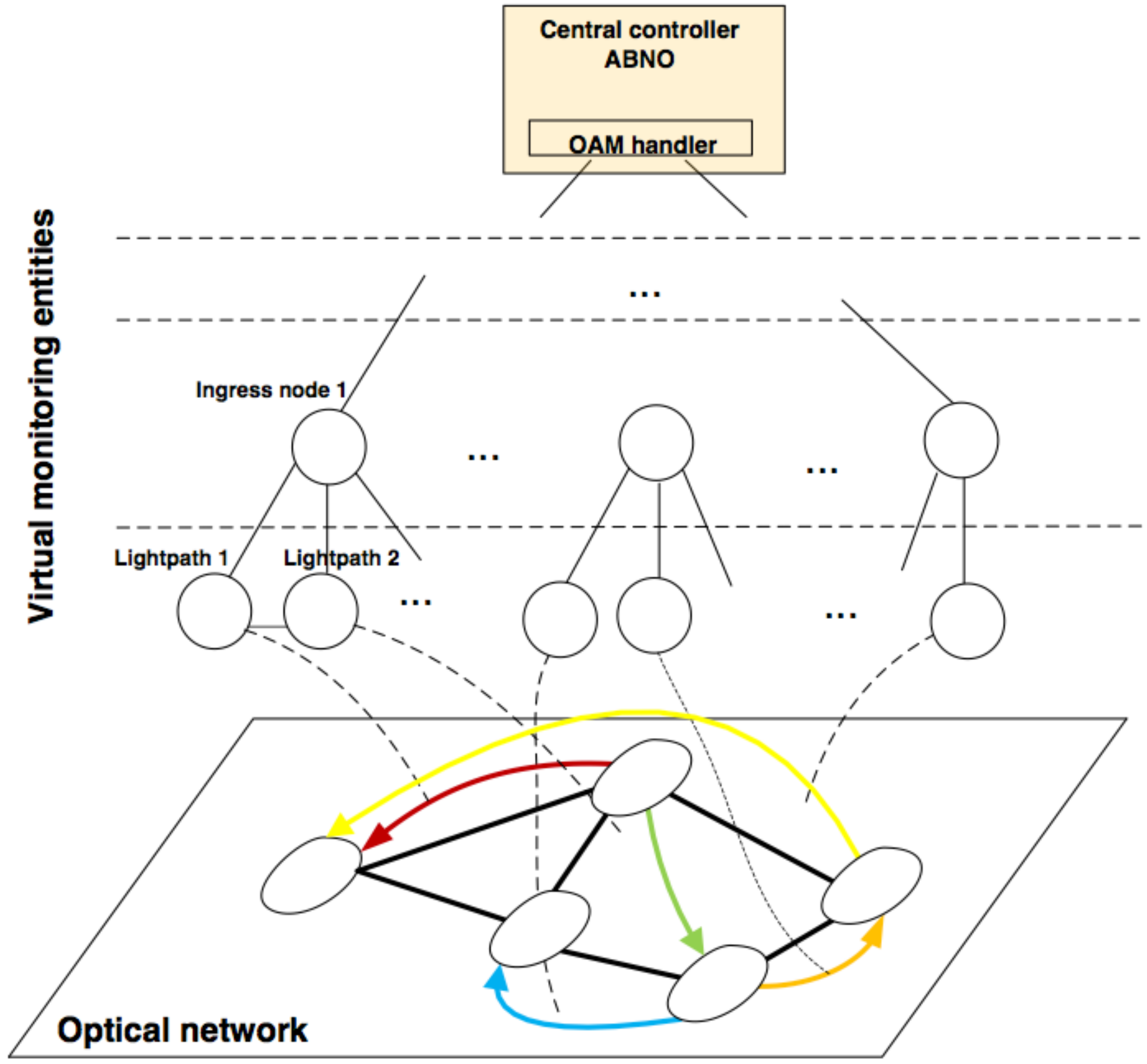
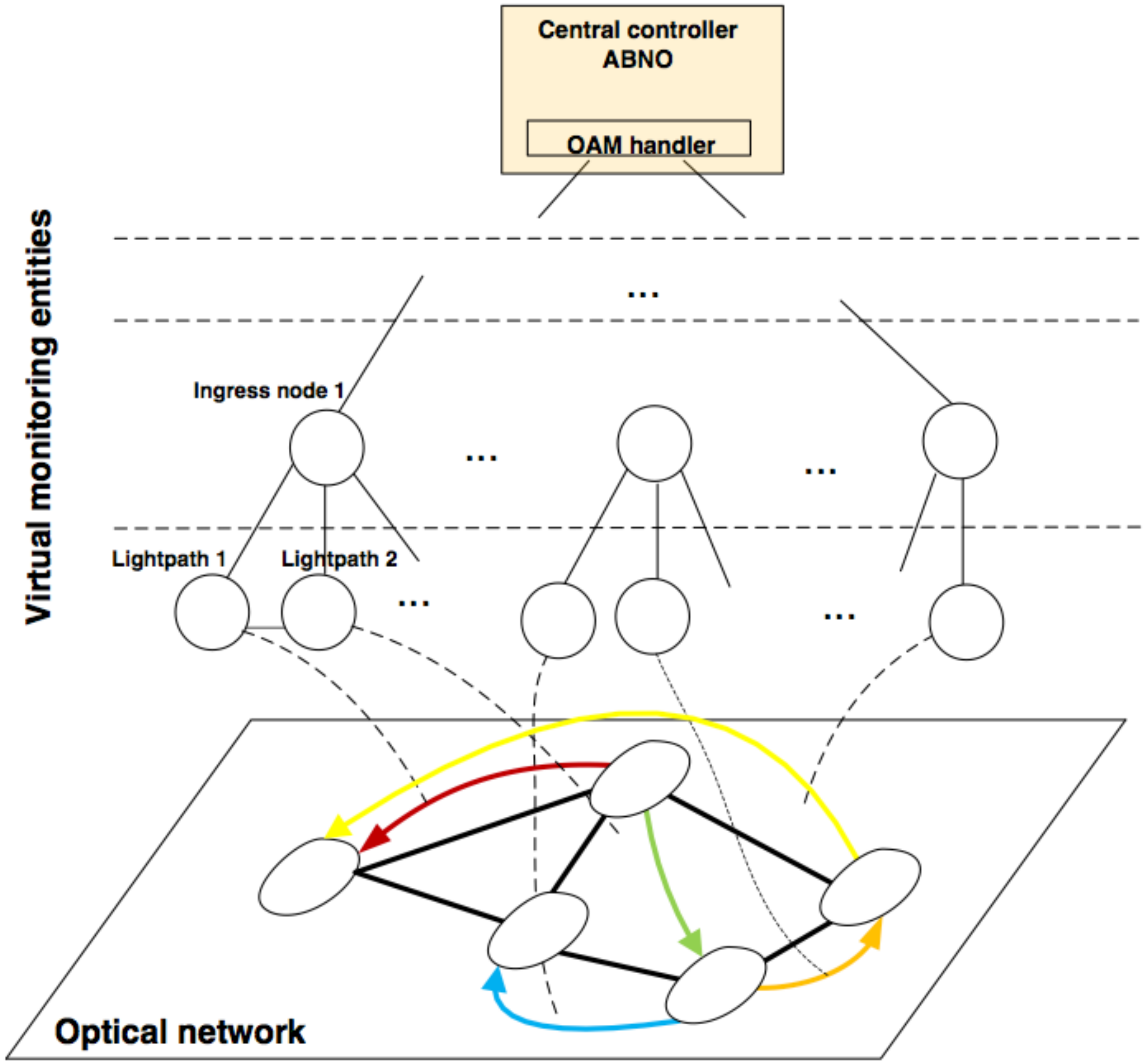
Hierarchical monitoring architecture



Hierarchical monitoring architecture

- Monitoring plane organized as a **hierarchy** of virtual monitoring entities



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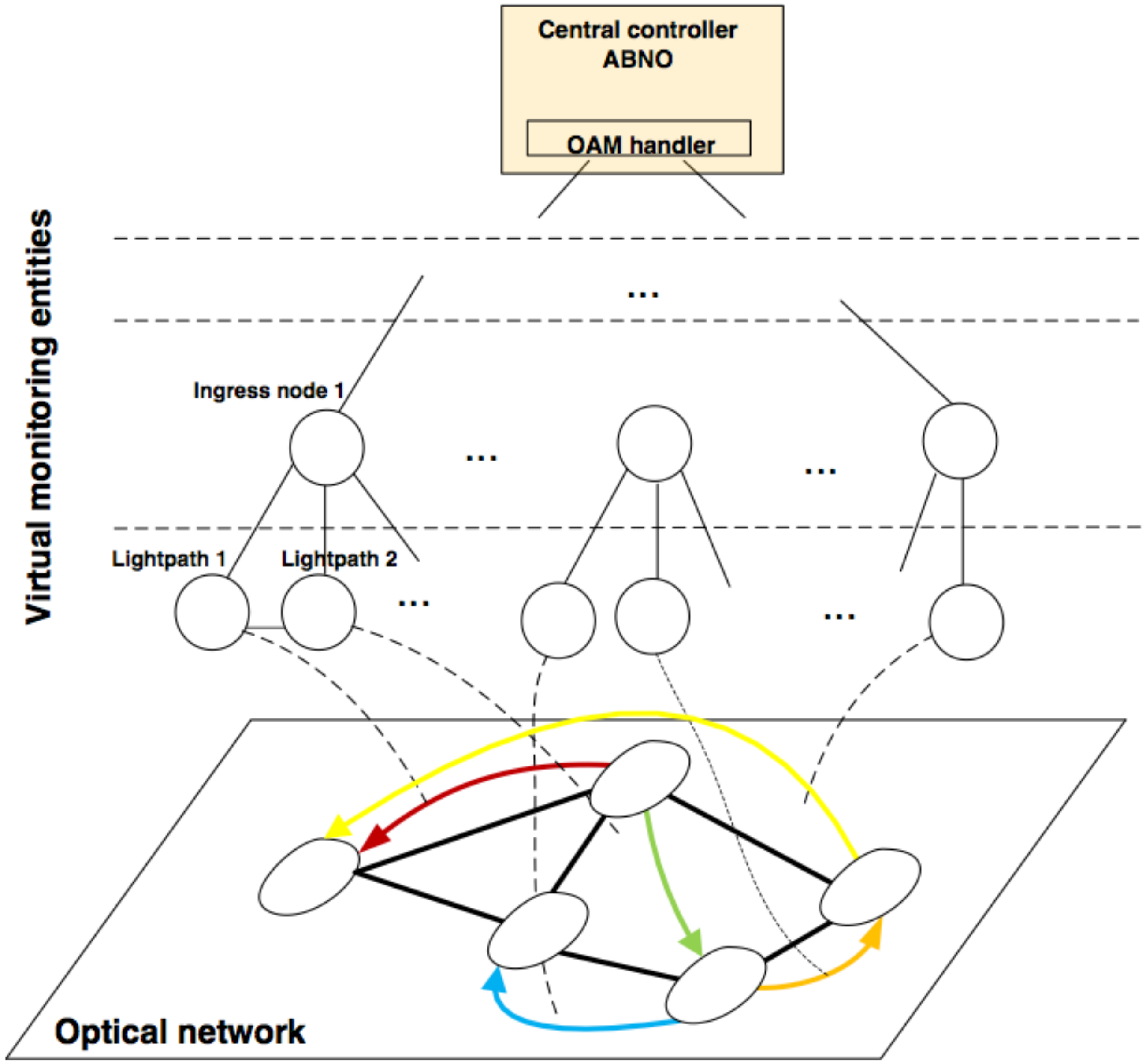

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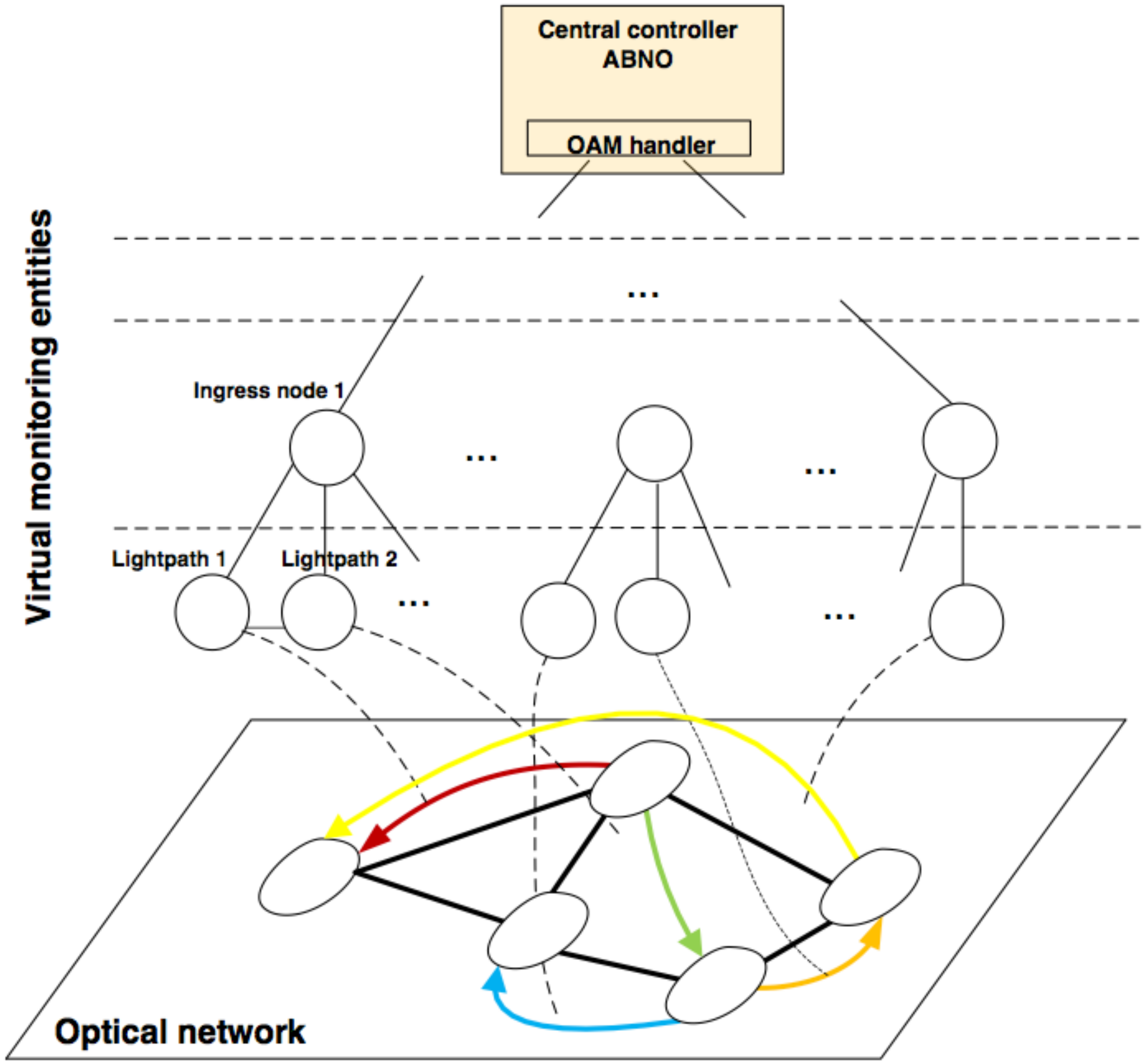

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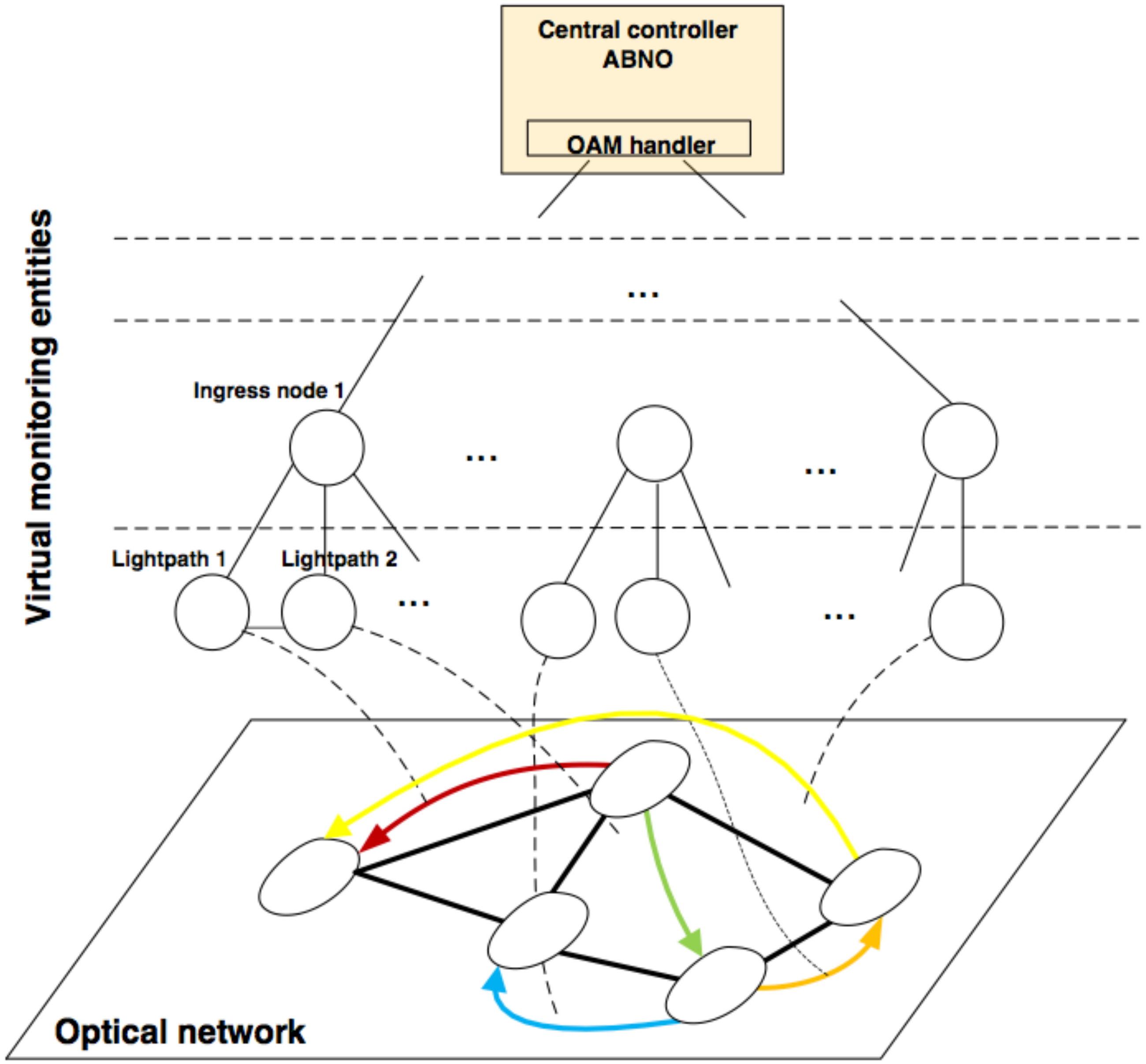

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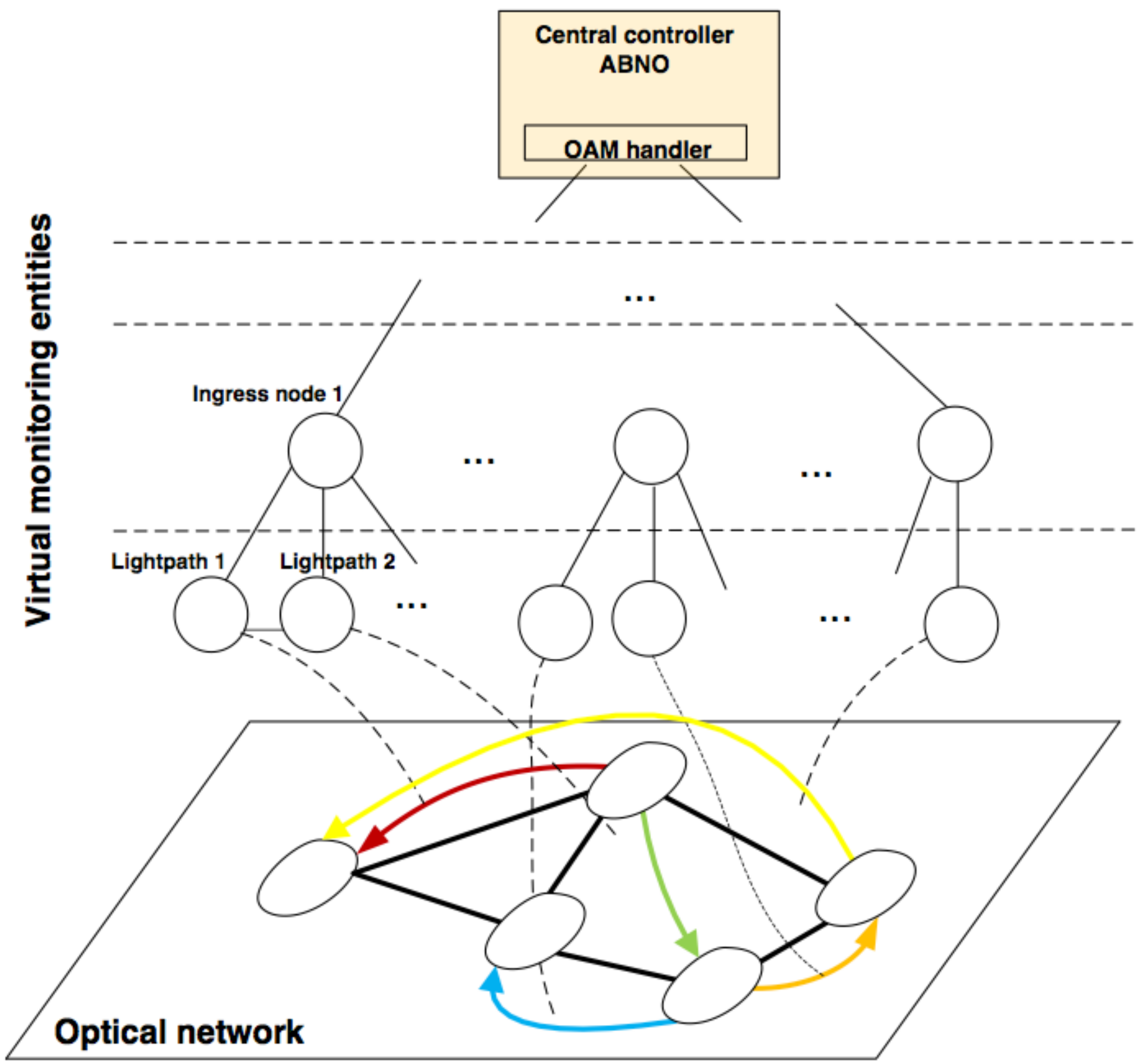

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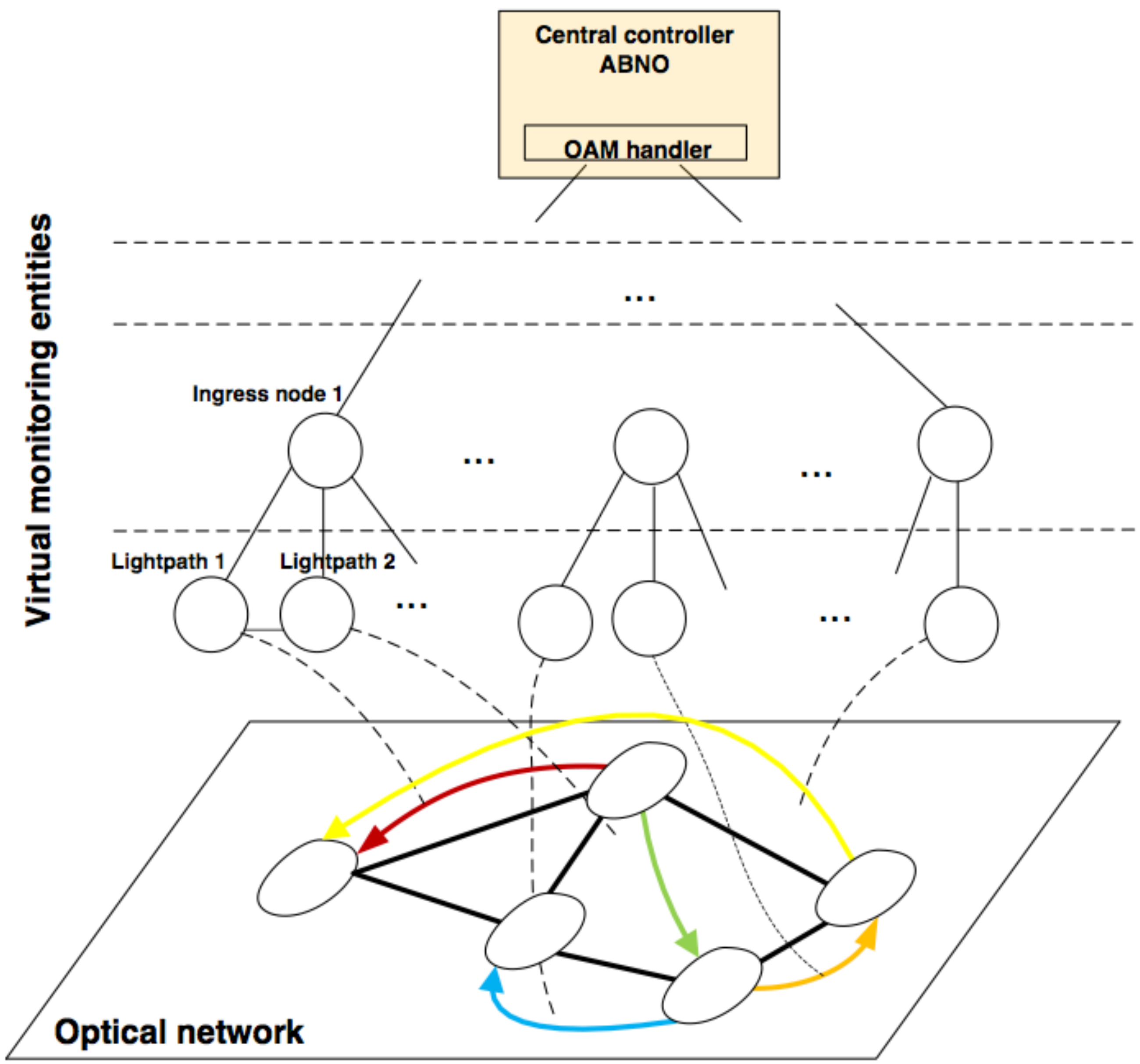

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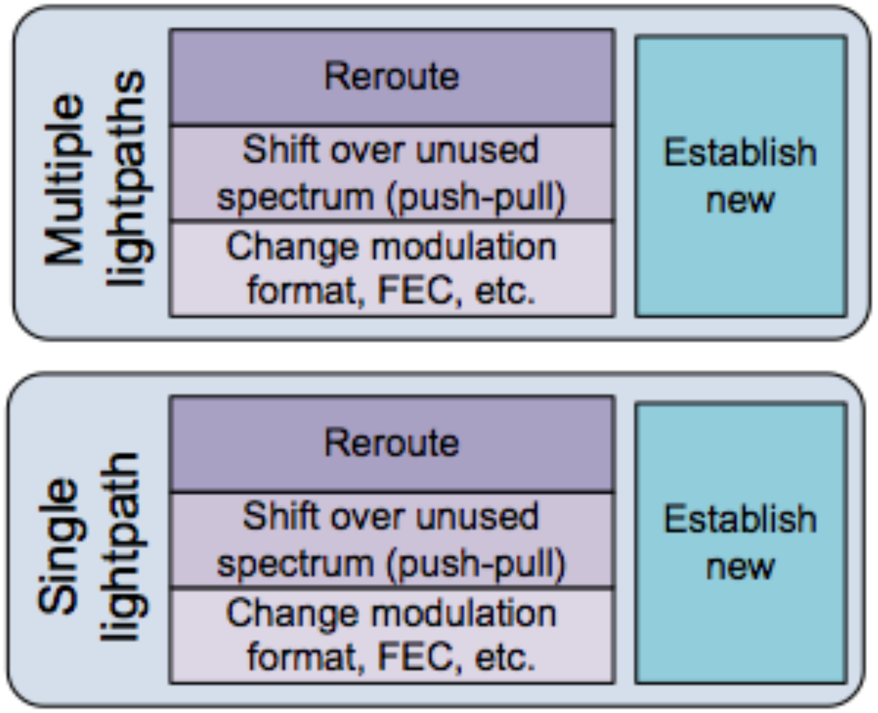
- Each monitoring entity correlates received monitoring information and **passes "filtered" monitored information** to the upper-layers monitoring entities —> **HIGH SCALABILITY**

Actions upon degradation/failure notification

Library of Control Primitives

Control actions that can be applied by each virtual entity



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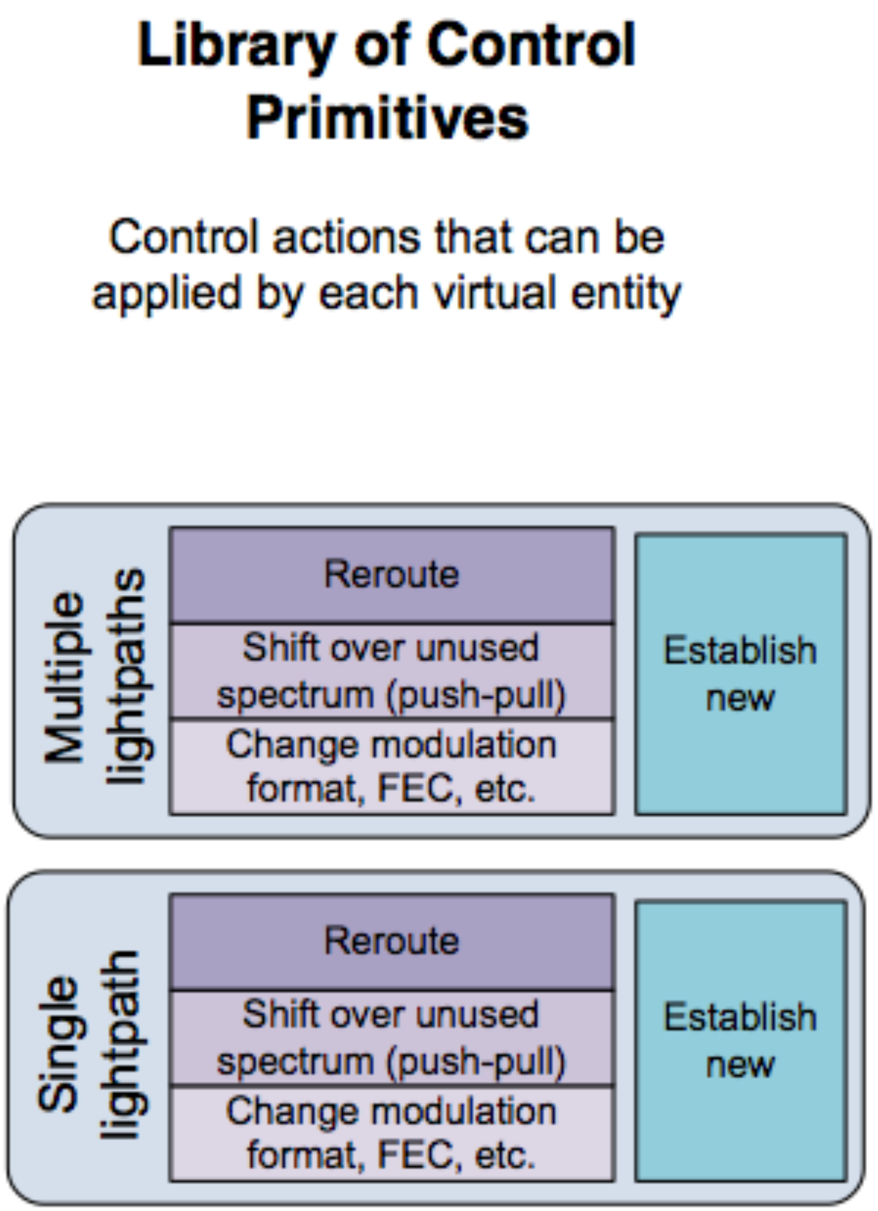

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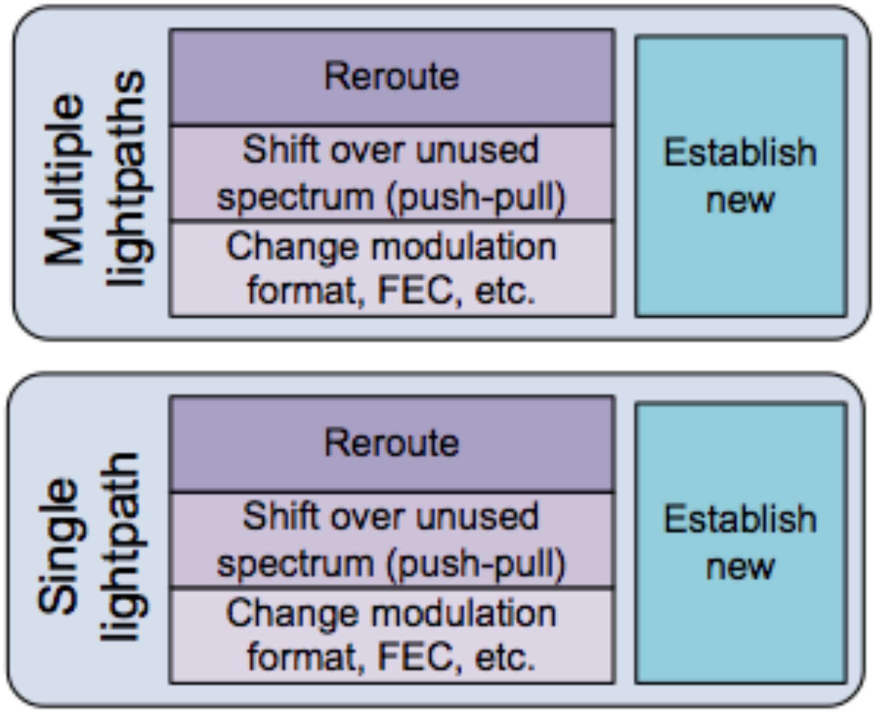

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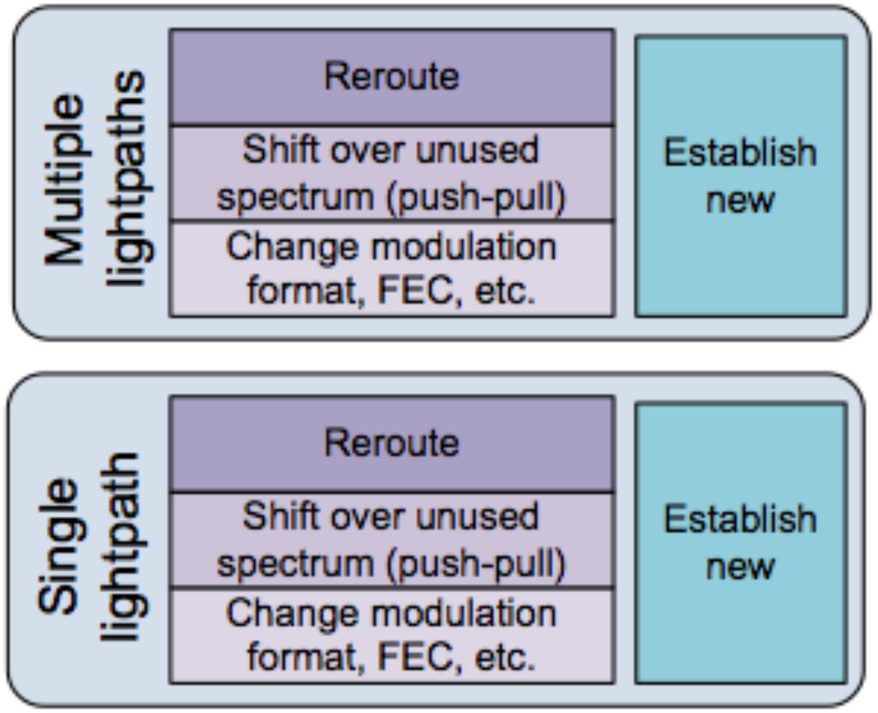

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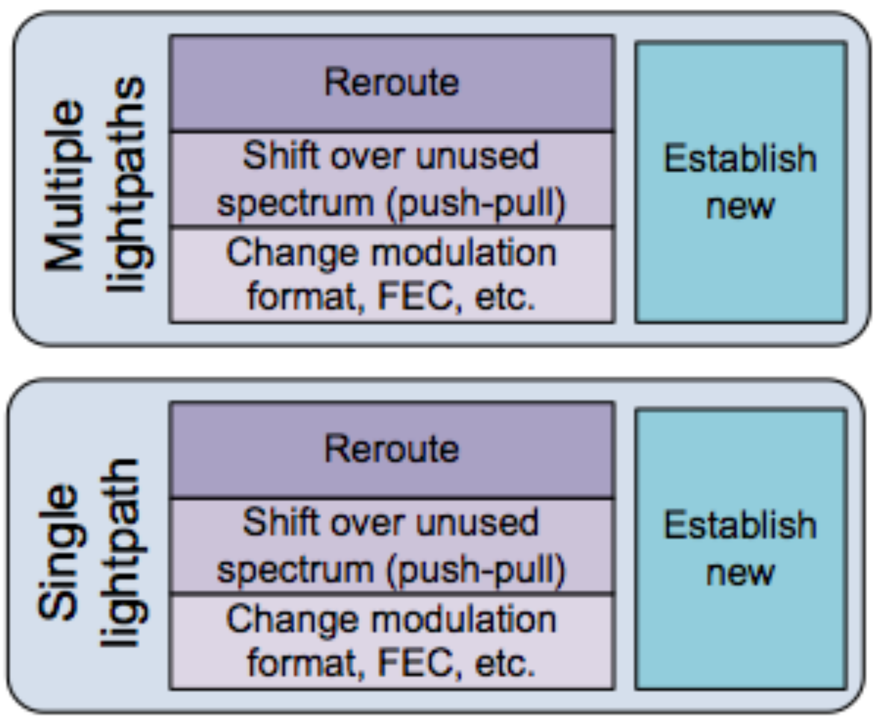

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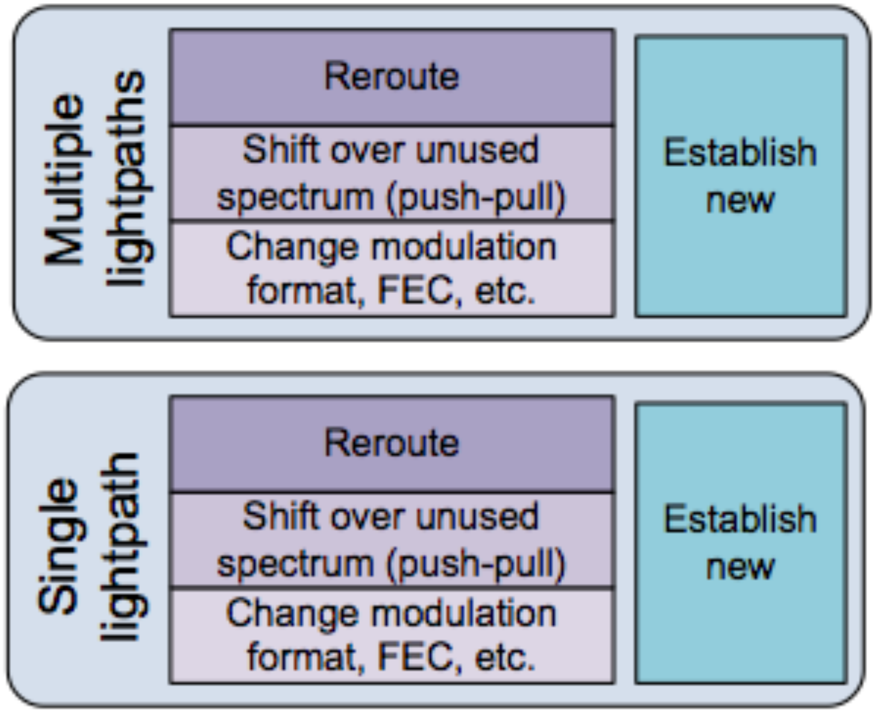

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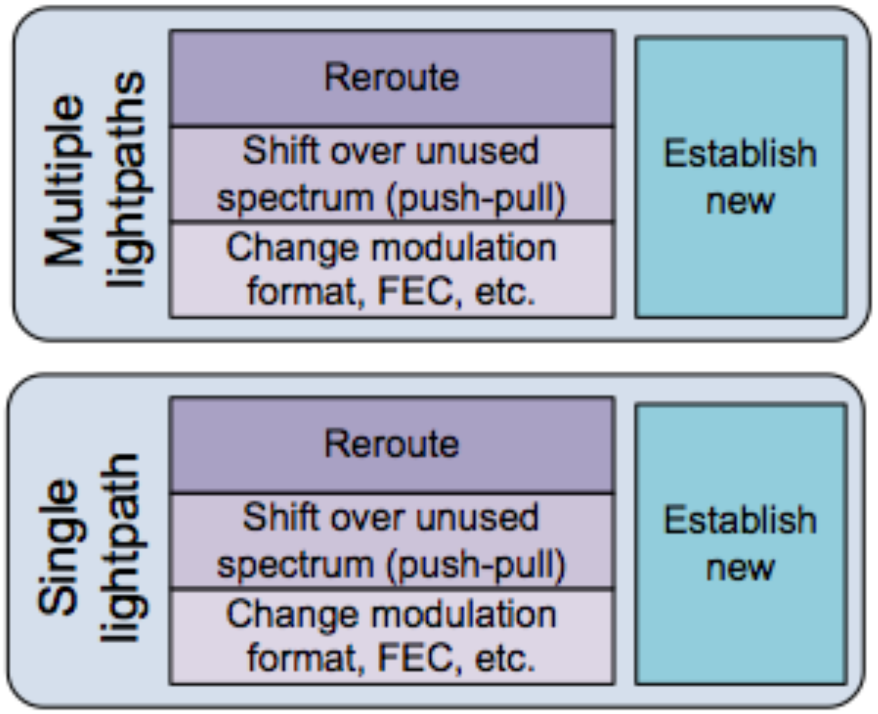

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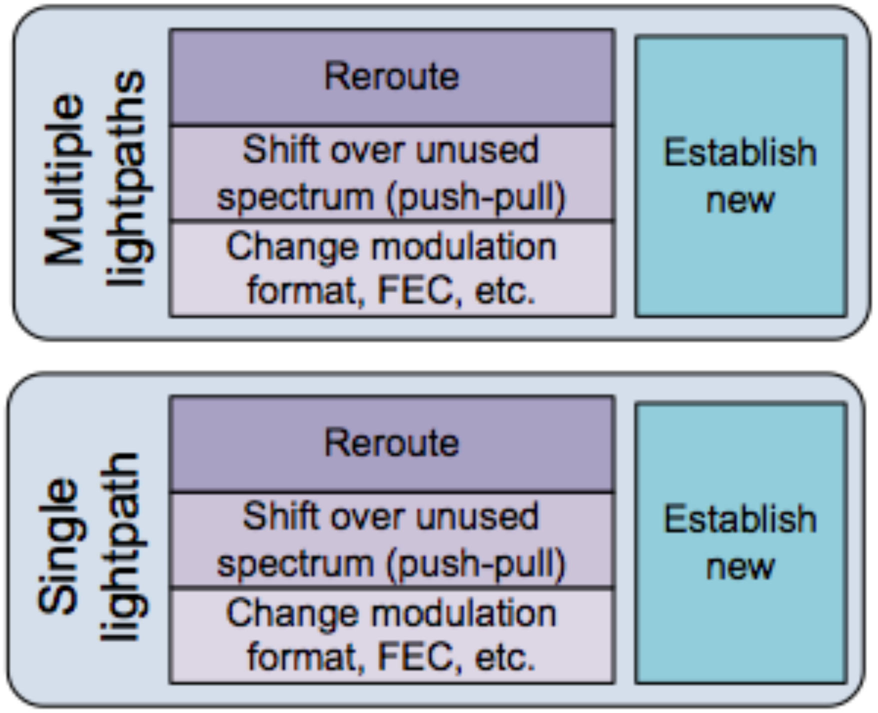

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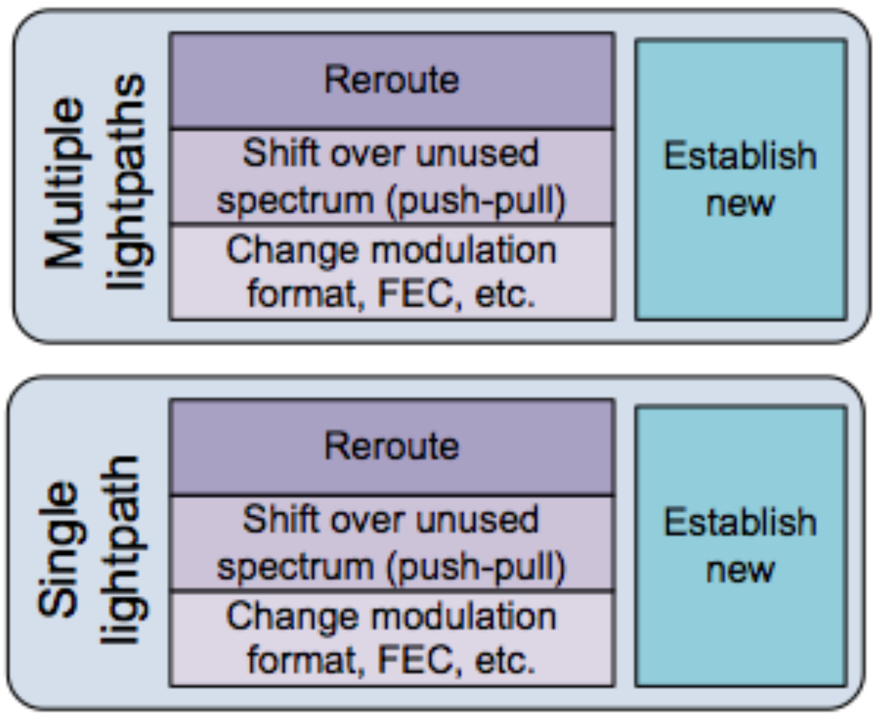

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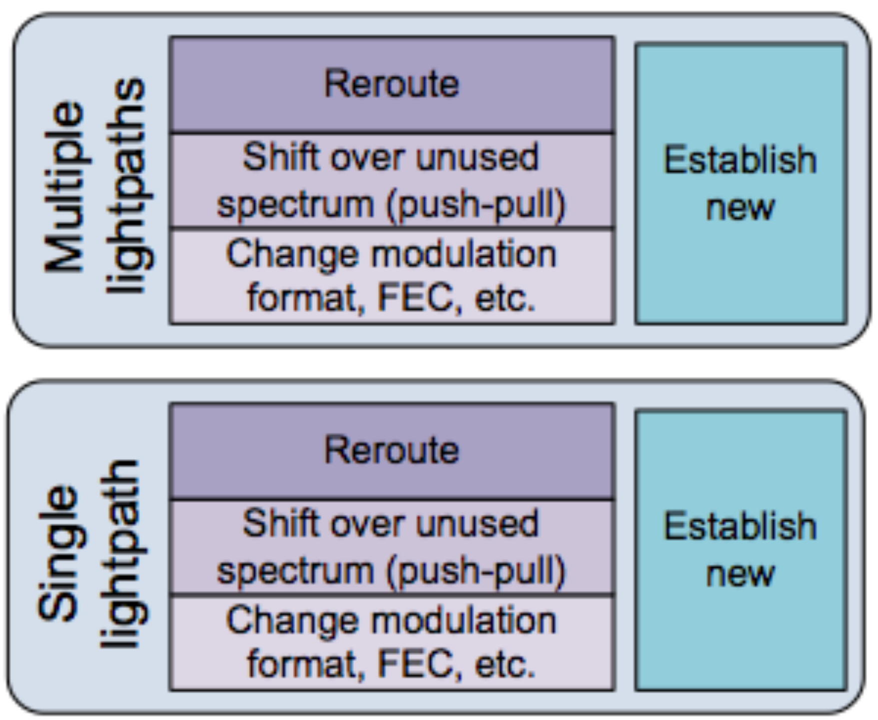

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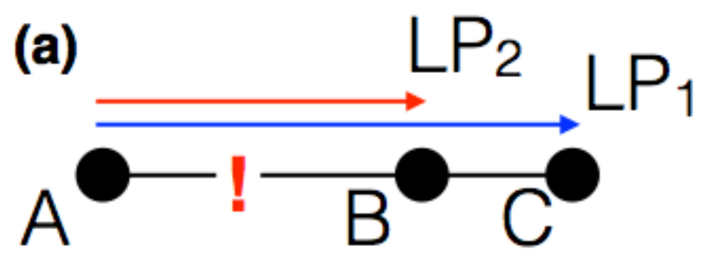
  - <u>more complex actions are taken at high levels in the hierarchy:</u> e.g., on-line restoration is triggered by the OAM Handler since it has the general view of the network
- **OAM Handler must be notified** about actions to keep an overall up to date view

Use cases for the hierarchical monitoring architecture

Use cases for the proposed hierarchical architecture are presented concerning:

- **The monitoring information correlation:** with emphasis on when correlation solves fault localization or not. In the latter case, fault localization is delegated to higher hierarchical layers
- The possible **actions** that can be taken depending on the type of degradation/fault.

Use case: monitoring information correlation (1/2)



- two lightpaths active
- common link A-B is degraded
- lightpath monitors can be assumed in the DSP of receivers placed at node B and C, respectively, for LP_2 and LP_1
- Such monitors are related to the leaf level of the monitoring hierarchy
- Degradation is detected
  - A reaction can be locally taken, such as Forward Error Correction (FEC) adaptation. Indeed, if FEC does not require an increase of the occupied ITU-T *frequency slot* (i.e., the portion of spectrum associated with the LP that is switched), such operation can be immediately performed at the lightpath level
- monitoring entities (of LP_1 and LP_2) at the lightpath level send alarm to the upper monitoring layer, i.e. the one associated with the Ingress node (in this case A)
- such level **identifies link A as degraded link** (i.e., the only link in common), so that such "filtered" monitored information is sent to the OAM Handler without sending to the OAM Handler all the alarms

Use case: monitoring information correlation (2/2)

- two lightpaths active
- common link E-F is degraded
- monitors at the lightpath levels reveal a degradation and send alarm to the Ingress node monitoring layer (in this case D).
- monitoring entity associated with node D is not able to identify the degraded link, being unable to discern between links D-E and E-F
- this monitoring layer communicates with an upper layer (e.g., associated with a group of ingress nodes) that becomes in charge of fault localization. This layer can **correlate more alarm information** coming from different ingress nodes, thus having more chances to identify the degraded link.

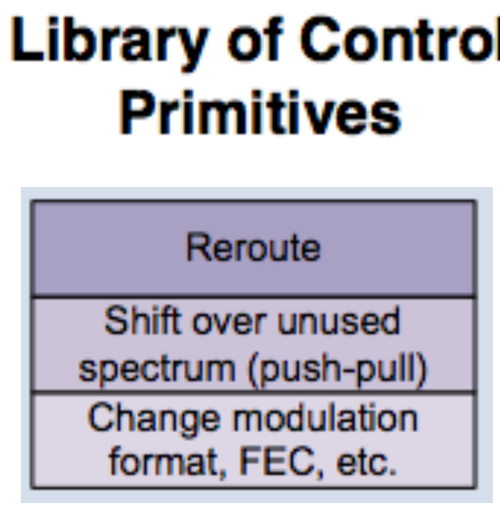
Use case: monitoring information correlation (2/2)

- two lightpaths active
- common link E-F is degraded
- monitors at the lightpath levels reveal a degradation and send alarm to the Ingress node monitoring layer (in this case D).
- monitoring entity associated with node D is not able to identify the degraded link, being unable to discern between links D-E and E-F
- this monitoring layer communicates with an upper layer (e.g., associated with a group of ingress nodes) that becomes in charge of fault localization. This layer can **correlate more alarm information** coming from different ingress nodes, thus having more chances to identify the degraded link.

The proposed architecture **increases the scalability** of next generation optical networks while **guaranteeing reliability**

- a single link degradation (e.g., amplifier mulfunction) affects tens of lightpaths and generates a **huge amount of alarms per lightpaths**
- sending **all the alarms to the OAM Handler** is **NOT SCALABLE**
- the hierarchical architecture filters monitoring information without overloading monitoring entities and OAM Handler

Use case: fault and actions



- **Failure:** connectivity not permitted.
  ACTION: **re-routing** (e.g., on the protection path)
- **Network element degradation/aging:** performance degradation (e.g., BER increase).
  ACTION: **transmission parameter adaptation** to provide more robustness: e.g., lower-order modulation format or more redundancy through FEC adaptation.
- **Undesired degradations on specific frequencies:** this typically occurs due to interference between channels (e.g., XPM).
  ACTION: **shift of lightpath in the spectrum** to reduce the interference

Simulations on increased scalability

The proposed hierarchical architecture permits to correlate and filter monitoring information before passing it to an upper layer —> this increases the scalability of the monitoring plane

- Simulations have been carried out to evaluate the number of received alarms by each monitoring entity
- The **hierarchical architecture** and a **centralized OAM Handler** solution are **compared**
- Link cut is randomly generated in links of a Spanish national backbone networks
- The number of **generated alarms** by the DSP of an affected lightpath is **taken by a commercial system (13 alarms)**
- Assumed hierarchy:
  - Level 0: composed of lightpath monitors sending to
    - Level 1: composed of functional entities, each one correlating monitoring information of lightpaths starting from the same ingress node. Thus, at level 1, there is a monitoring entity for each network node
    - Level 2: single entity correlating all ingress nodes alarms
    - OAM Handler receiving the info coming from Level 2

Tab. 1: Number of received alarms per monitoring entity at each *Level* in case of link hard failure.

	Level 1	Level 2	OAM Handler
Centralized	not present	not present	420.03
Hierarchical	47.97	9.2	1

hierarchical architecture: high scalability

Further results at ECOC 2015…

Conclusions

ACK: This work was supported by the EC through the Horizon 2020 ORCHESTRA project (grant agreement 645360).

Conclusions

- This paper presented the hierarchical monitoring architecture proposed within the EU ORCHESTRA project
- OAM Handler functionalities of ABNO architecture are spread into several layers following a hierarchical approach, enabling to confine sets of monitored physical parameters within specific levels in the hierarchy
- This approach brings a limitation of the OAM Handler overload
- Monitored information can be correlated at each level of the hierarchy in an efficient way, and adaptation of transmission parameters (e.g., FEC) or re-routing are automatically triggered in case of physical layer degradations or faults

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Thank you!

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