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SDN control for disaggregated optical networks

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ORCHESTRA

“SDN/NFV for optical networks” Workshop,
ONDM 2018



Introduction

- Interest of network operators and service providers in pushing vendors to disaggregate networks and to guarantee multi-vendor inter-operability
 - an example is the disaggregation of software from the hardware
- Components of different vendors enable to reduce capital expenditure since not being tied to single-vendor equipment
- **Fully disaggregated white box**: it **separates software from hardware** and can be **composed of devices from different vendors**, possibly **controlled** and managed **by open-source software**
- NETCONF [a] is an emerging SDN protocol expected to be adopted next generation networks
- NETCONF is based on YANG [b] data modeling

- To support control and management of white boxes, standardized data models are required
- YANG is a widely agreed language for enabling interfaces with the control and the management system

In this presentation:

- Review of activities on SDN disaggregated optical networks
- Open issues



Consortiums and projects

- **OpenConfig [a]**: vendor-neutral data models, e.g. on optical amplifiers, ROADMs, and transponders
- **OpenROADM [b]**: models focused on ROADM disaggregation: how different pluggable devices for optical networks (e.g., amplifiers, transponders) can be interconnected
- **Telecom Infra Project (TIP) [c]**: disaggregation, e.g. releasing an open source QoT estimator tool for multi-vendor networks
- **IETF [d,e]**: models for nodes, links, media channels, optical interfaces...
- **ODTN [f]**: ONOS working group dealing with disaggregated optical equipment and open-source software

[a] <http://www.openconfig.net/>

[b] <http://www.openroadm.org/home.html>

[c] <https://telecominfraproject.com/>

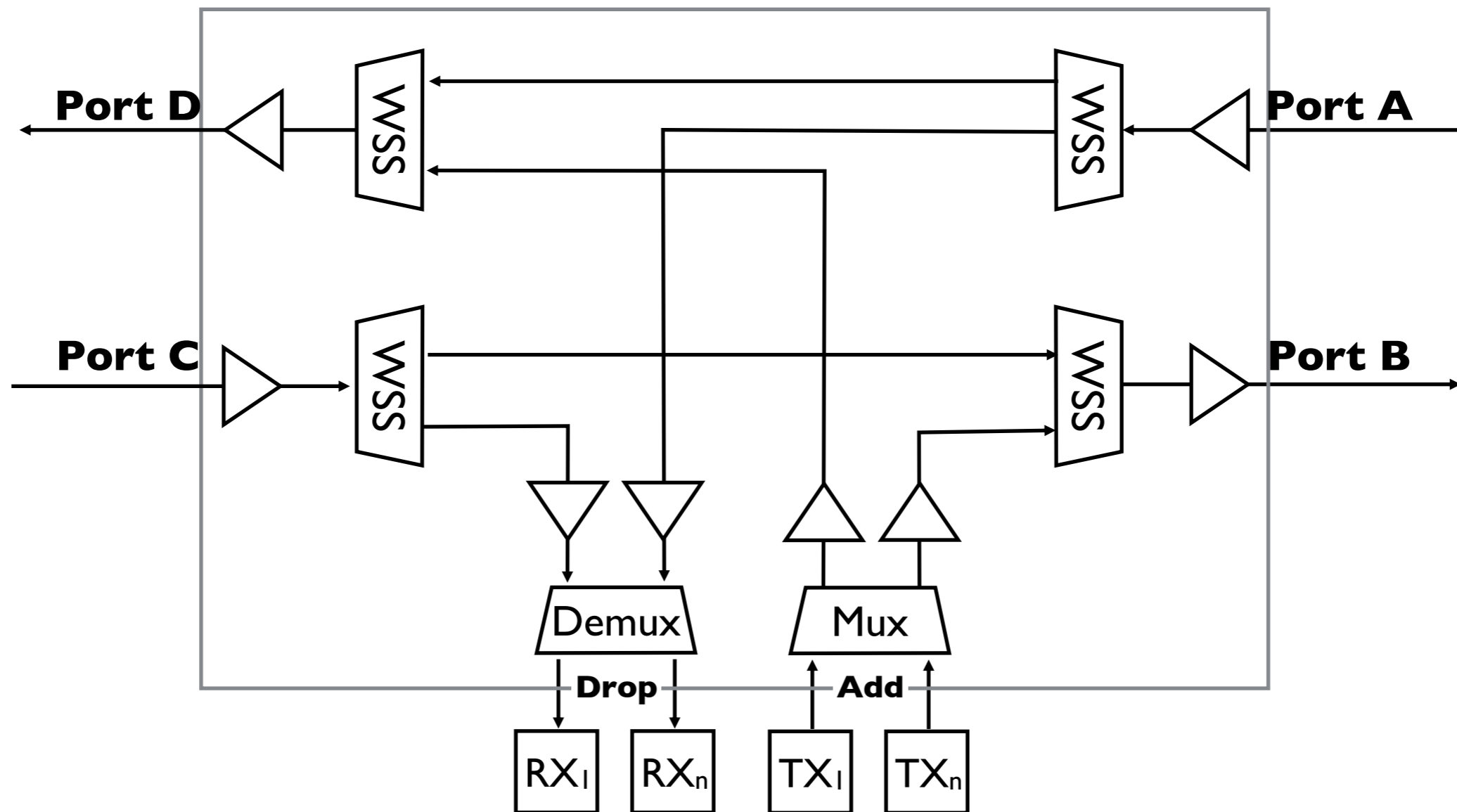
[d] draft-dharini-ccamp-dwdm-if-param-yang-02

[e] draft-vergara-ccamp-flexigrid-yang-03

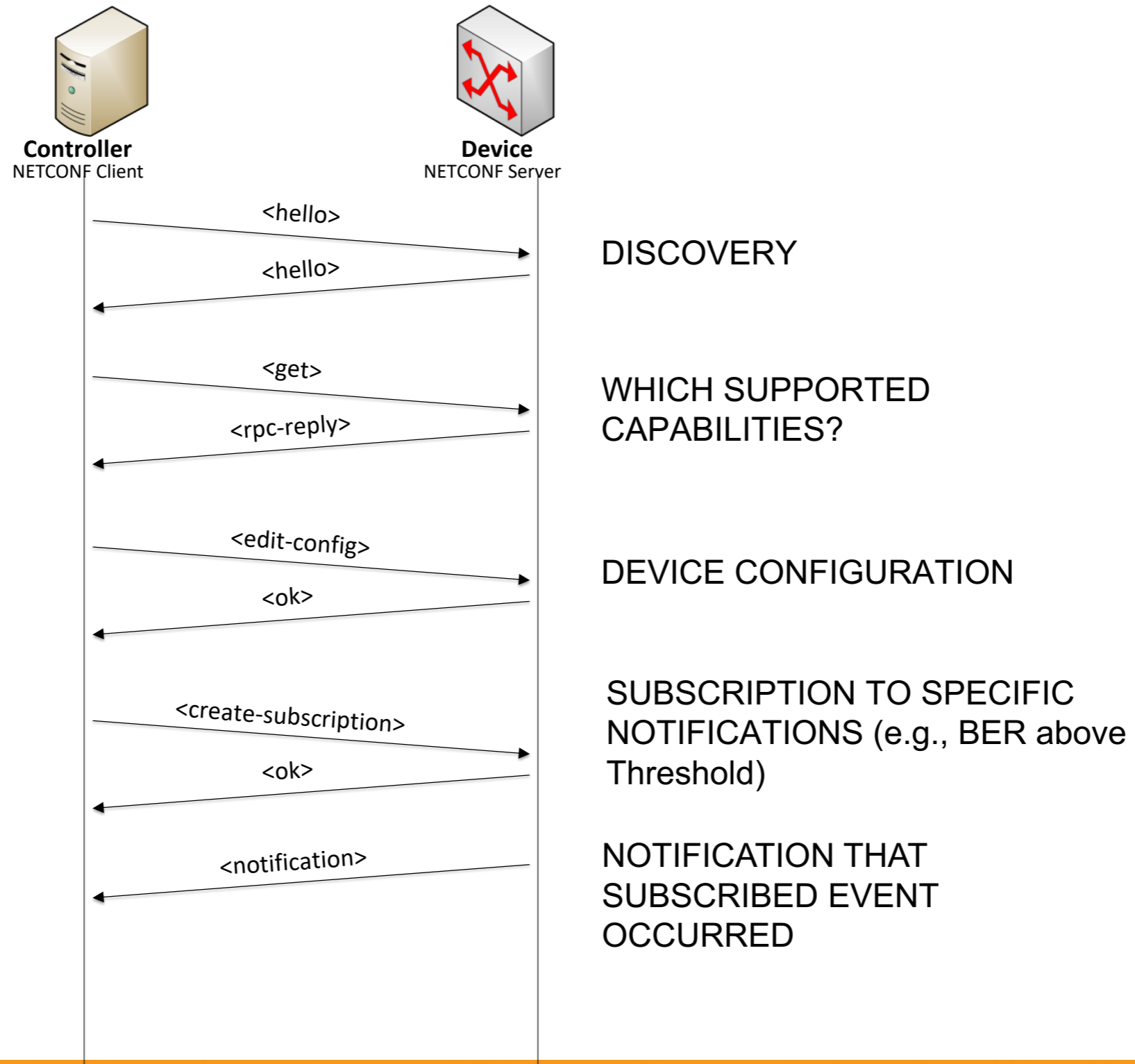
[f] opennetworking.org/solutions/odtn



OpenROADM: node architecture



NETCONF SDN protocol



OpenROADM: YANG models

```
+--rw och
  +--rw rate?          identityref
  +--rw frequency?    org-openroadm-common-types:frequency-THz
  +--ro width?        org-openroadm-common-types:frequency-GHz
  +--rw modulation-format? org-openroadm-common-types:modulation-format
  +--rw transmit-power? org-openroadm-common-types:power-dBm
```

Optical channel

```
+--rw xpdr-port-attributes
| +--rw local-lgx?    string
| +--rw rate?        identityref
| +--rw modulation-format? org-openroadm-common-optical-channel-types:modulation-format
| +--rw optic?       org-openroadm-common-equipment-types:optic-types
| +--rw state?       org-openroadm-common-state-types:state
| +--rw wavelength
| | +--rw frequency?  org-openroadm-common-optical-channel-types:frequency-THz
| | +--rw width?     org-openroadm-common-optical-channel-types:frequency-GHz
```

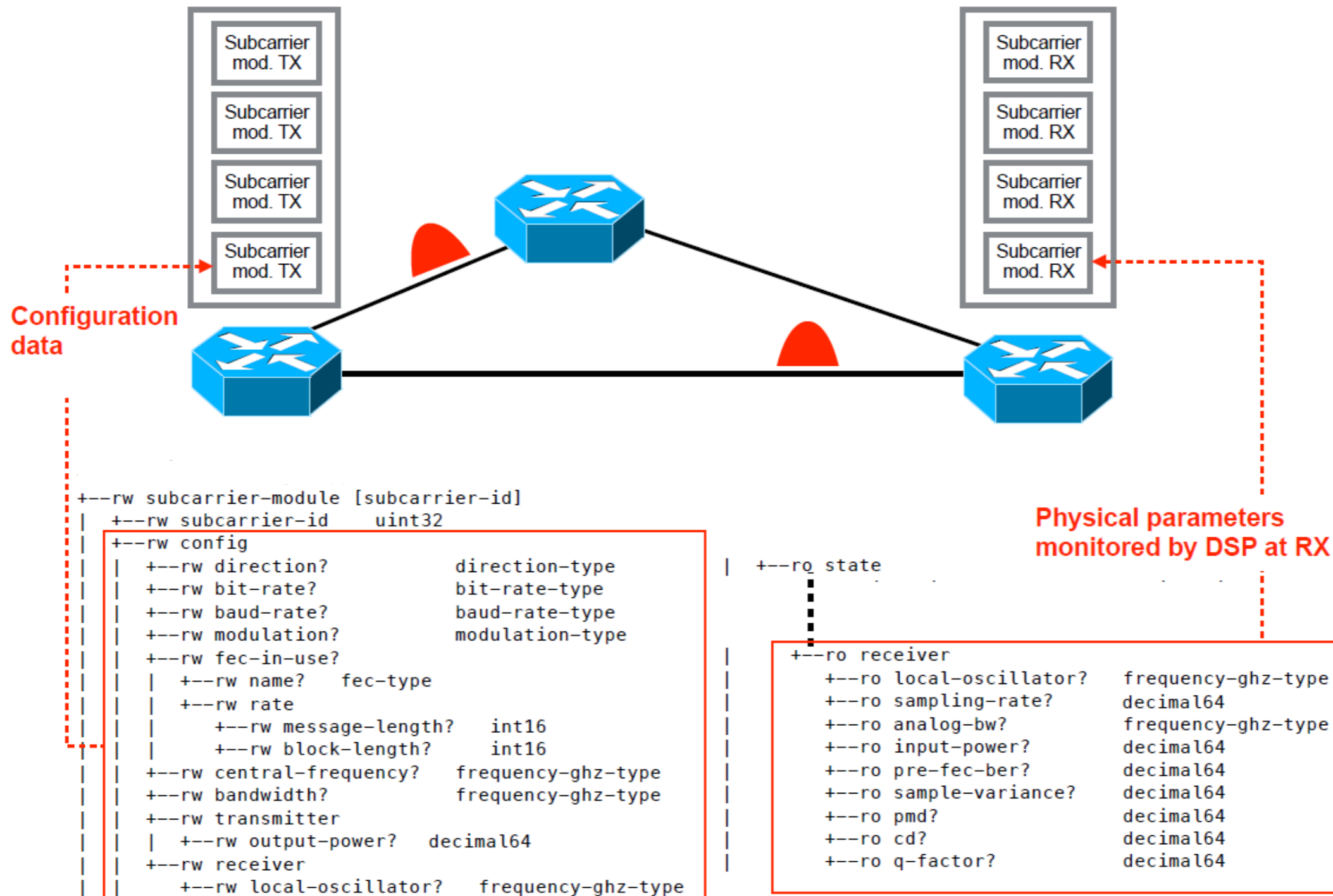
xponder

```
+--rw line-amplifier* [amp-number]
| +--rw amp-number    uint8
| +--ro amp-type      org-openroadm-common-amplifier-types:amplifier-types
| +--rw control-mode? org-openroadm-common-amplifier-types:line-amplifier-control-mode
| +--ro amp-gain-range? org-openroadm-common-amplifier-types:amplifier-gain-range
| +--rw target-gain?  org-openroadm-common-link-types:ratio-dB
| +--rw target-tilt?  org-openroadm-common-link-types:ratio-dB
| +--rw egress-average-channel-power? org-openroadm-common-link-types:power-dBm
| +--ro out-voa-att?  org-openroadm-common-link-types:ratio-dB
```

Amplifier



YANG model for sliceable transponder

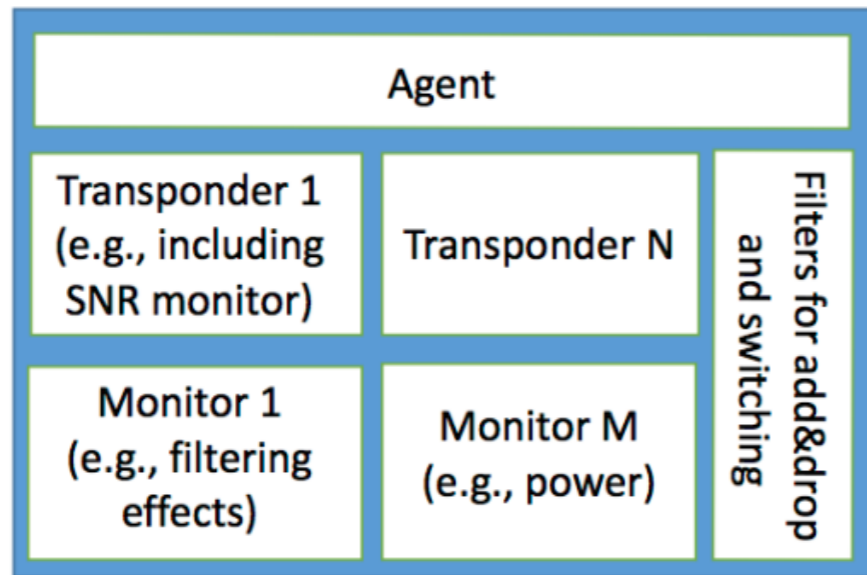


- M. Dallaglio, et al. "YANG model and NETCONF protocol for control and management of elastic optical networks", OFC 2016

- N. Sambo, et al., "Sliceable Transponders: Pre-Programmed OAM, Control, and Management," in *JLT*, vol. 36, no. 7, pp. 1403-1410, April 1, 2018



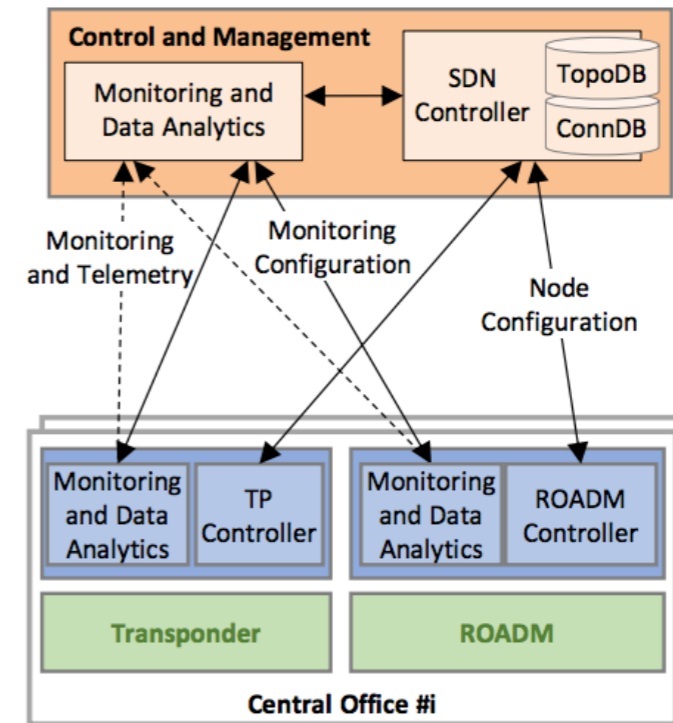
Some experimental demonstrations



Experimental demonstration of fully disaggregated white box including different types of transponders and monitors, controlled by NETCONF and YANG

N. Sambo¹, K. Christodoulopoulos², N. Argyris³, P. Giardina⁴, C. Delezoide⁵, A. Sgambelluri¹, A. Kretsis², G. Kanakis³, F. Fresi¹, G. Bernini⁴, H. Avramopoulos³, E. Varvarigos², P. Castoldi¹
 (1) Scuola Superiore Sant'Anna, Pisa, Italy; (2) CTI, Patras, Greece; (3) NTUA, Athens, Greece; (4) Nextworks, Pisa, Italy; (5) Nokia bell labs, Paris, France; email: nicola.sambo@sss.up.it

OFC 2018



Building Autonomic Optical Whitebox-based Networks

L. Velasco, A. Sgambelluri, R. Casellas, Ll. Gifre, J.-L. Izquierdo-Zaragoza, F. Fresi, F. Paolucci, R. Martínez, and E. Riccardi

JLT 2018: Special Issue on Interoperability and white boxes

Others:

- N.A. Robinson et al., Tu3E, OFC2018
- A. Sgambelluri et al., "Fully Disaggregated ROADM White Box with NETCONF/YANG Control, Telemetry, and Machine Learning-based Monitoring", OFC 2018
- M. Shiraiwa et al., in "Experimental Demonstration of Disaggregated Emergency Optical System for Quick Disaster Recovery", JLT 2018
- J. Kandrát et al. "YANG/NETCONF Whitebox ROADM: Evolving Open DWDM towards SDN Applications", JLT 2018



QoT tool for multi-vendor networks

- An SDN controller has also to evaluate the Quality of Transmission
- How is the quality of transmission in multi-vendor networks?
- The Physical Simulation Environment (PSE) Group of the **Telecom Infra Project** is studying this topic
- **Objective:** deliver an **open-source** and **vendor-agnostic tool** for QoT estimation
- The tool is based on the GN model
- It has been tested for long haul (e.g., DC-DC communications) with commercial transponders from 8 vendors
- Accuracy: ± 0.75 dB
- Speed: order of milliseconds

Multi-vendor Experimental Validation of an Open Source QoT Estimator for Optical Networks

Mark Filer, *Member, IEEE, OSA*, Mattia Cantono, *Student Member, OSA*, Alessio Ferrari, *Student Member, OSA*, Gert Grammel, *Member, VDE*, Gabriele Galimberti, and Vittorio Curri, *Member, IEEE*

JLT 2018



Advanced programmability

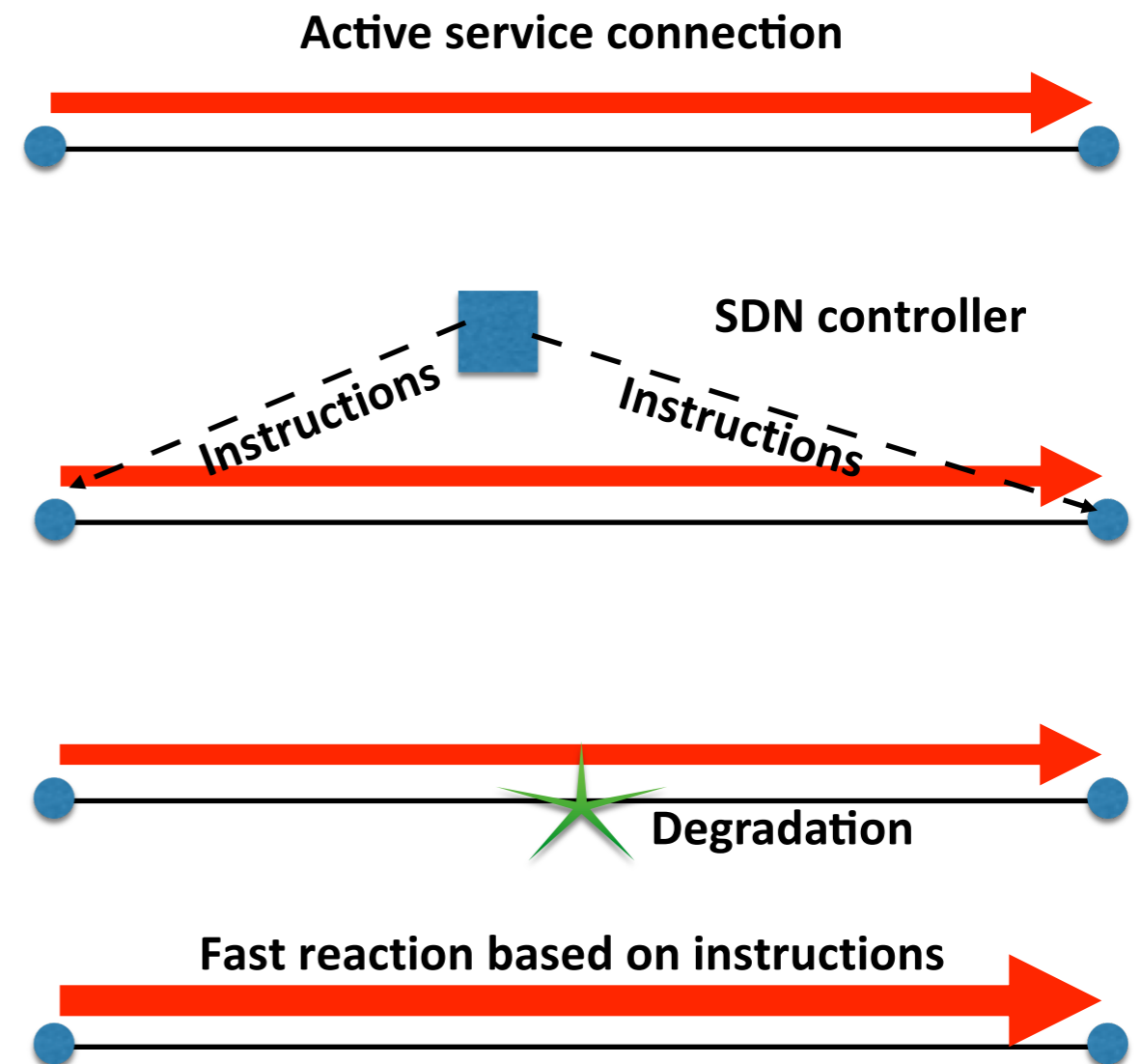
- Should all the configurations or reconfigurations performed by the SDN controller?
- If so, SDN controller may suffer from scalability issues and (re)configuration could suffer from delays: for example in case of failures or degradations
- We proposed a novel approach for programmability based on finite state machine (FSM):

NETMOD Working Group
Internet-Draft
Intended status: Standards Track
Expires: September 3, 2018

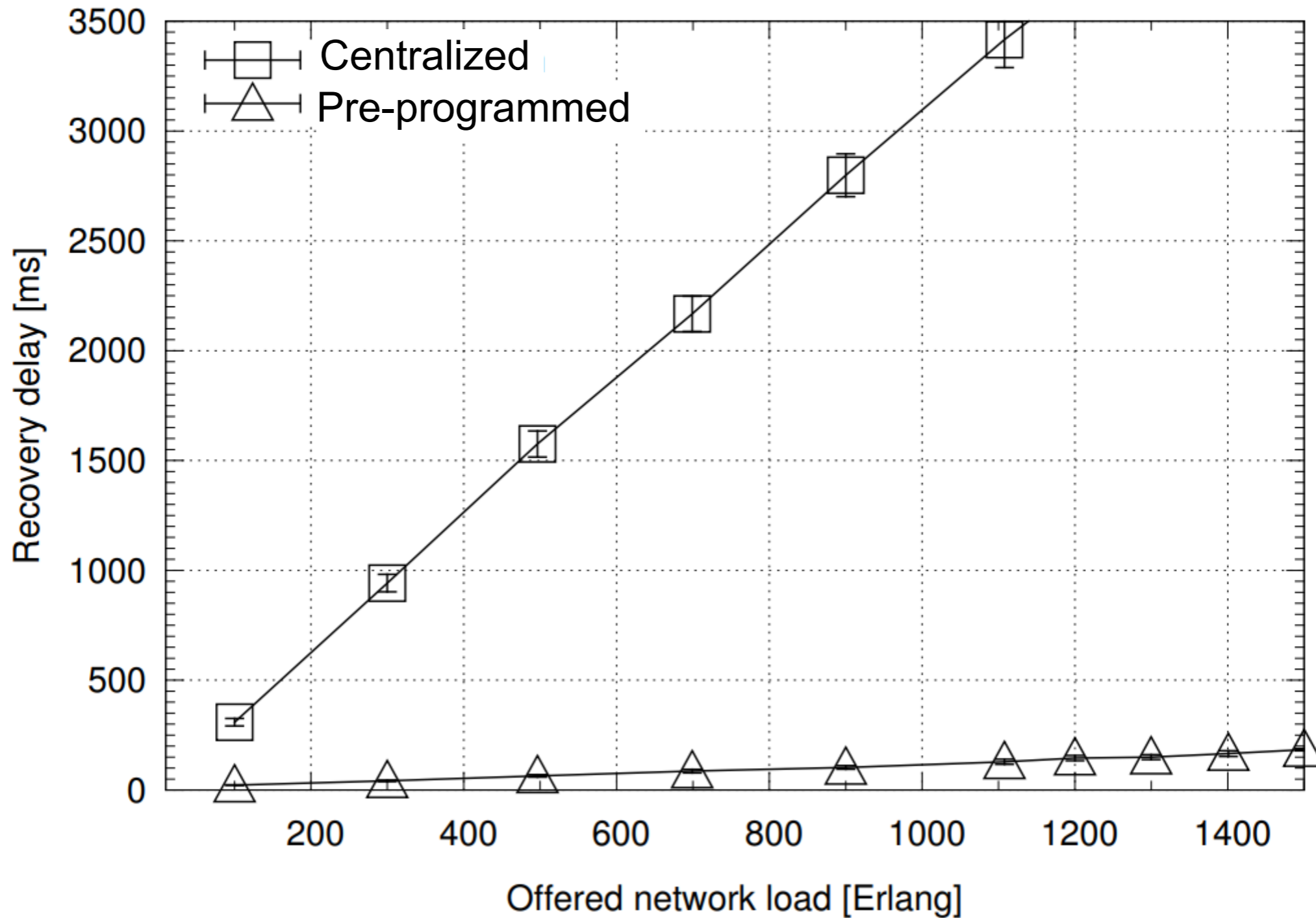
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Huawei
March 2, 2018

YANG model for finite state machine
draft-sambo-netmod-yang-fsm-02

- A YANG model for FSM is proposed to program YANG-described devices



Simulations for advanced programmability



Open issues

- How does the role of network operators will change in disaggregated networks?
- Consolidated procedures (previously in charge of the vendor, such as OAM) might be in charge of the operators, maybe relying on third parties
- Operators might have to deal with:
 - system integration
 - software for control
 - Operation Administration and Maintenance
 - channel power equalization procedures
 - hardware cost will decrease due to the removal of vendor lock-in, but costs will be driven by the costs of system integration and software implementation

An Operator's view on introduction of White Boxes in Optical Networks

Emilio Riccardi, Paul Gunning, Óscar González de Dios, Marco Quagliotti,
Víctor López, *Member, IEEE* and Andrew Lord, *Member, IEEE*

JLT 2018



Conclusions

- Some experimental demonstrations have been presented in the literature, despite commercial White Boxes (e.g., Lumentum, which presents disaggregation of software from the hardware, or Fujitsu)
- There is still a lack of maturity in standardization of YANG data models
- There is a lack of standard procedures for OAM, equalization, etc. in a vendor-agnostic way
- Hardware cost will decrease due to the removal of vendor lock-in
- Costs of software implementation (e.g., SDN) and system integration will be fundamental for the network costs
- Should all the (re)configurations be done by the SDN controller?

ACK: The work has been partially supported by **H2020 MetroHaul** and **ORCHESTRA projects**



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