

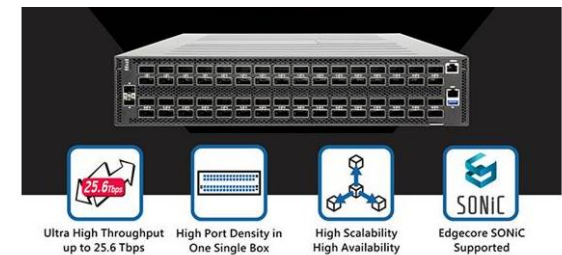
Using Standards to Control of Disaggregated IPoWDM Solutions

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Coherent pluggable technology



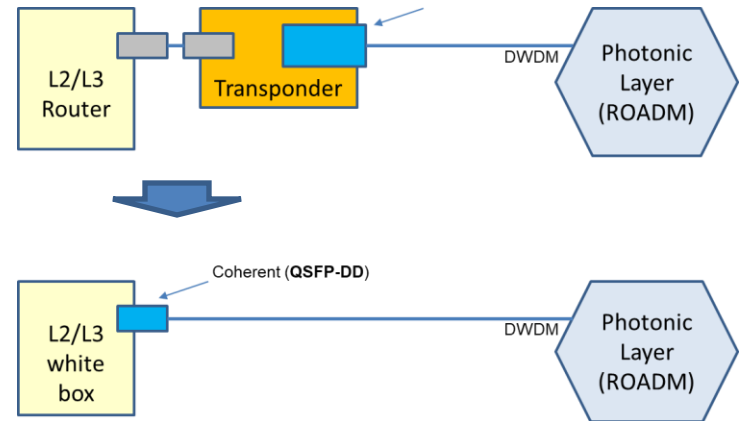
- **QSPF-DD** form factor
 - 400G (e.g., 400 ZR+) standardized with relevant multi-vendor ecosystem
 - 0dBm transmit optical power
 - small form factor fitting existing 400G packet switches/routers designed for DC
 - Cost-effective
 - Open solutions (e.g., SONiC)



IP over WDM with QSFP-DD

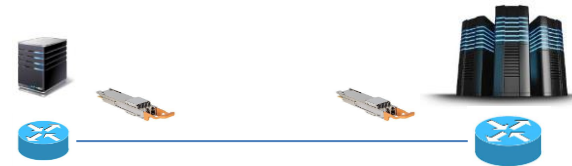
- Benefits

- Removal of transponders as standalone network elements
- Tight integration with IP layer
- Savings in power consumption and space in central office
- Savings in CAPEX, leveraging on white box for Data Centers



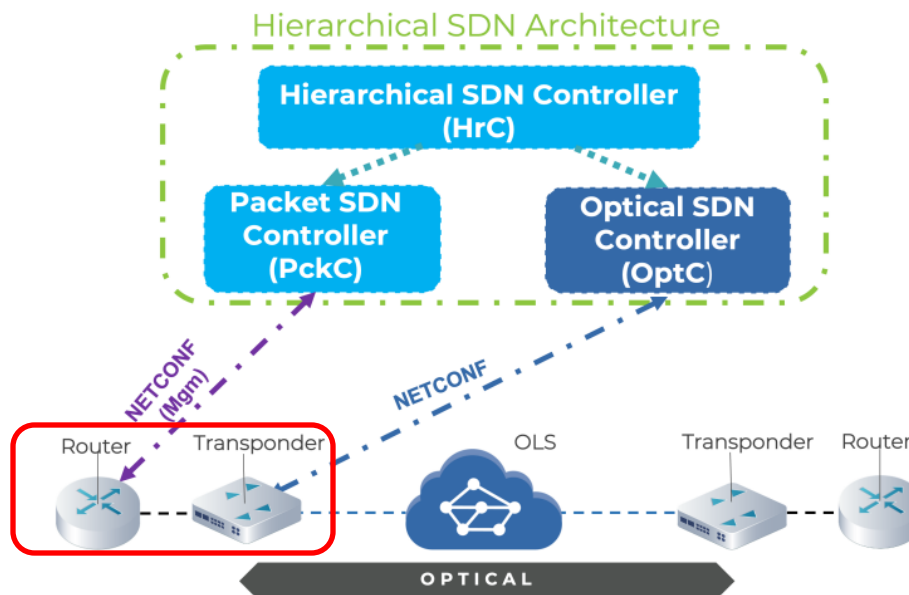
- Use cases:

- a single switch serving for both intra-DC aggregation (leaf) and inter-DC interconnection
- IPoWDM metro/aggregation



IPoWDM Control problem

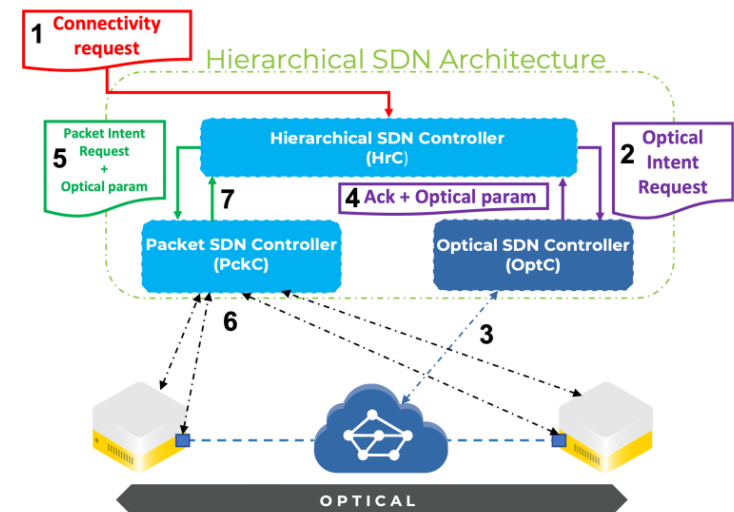
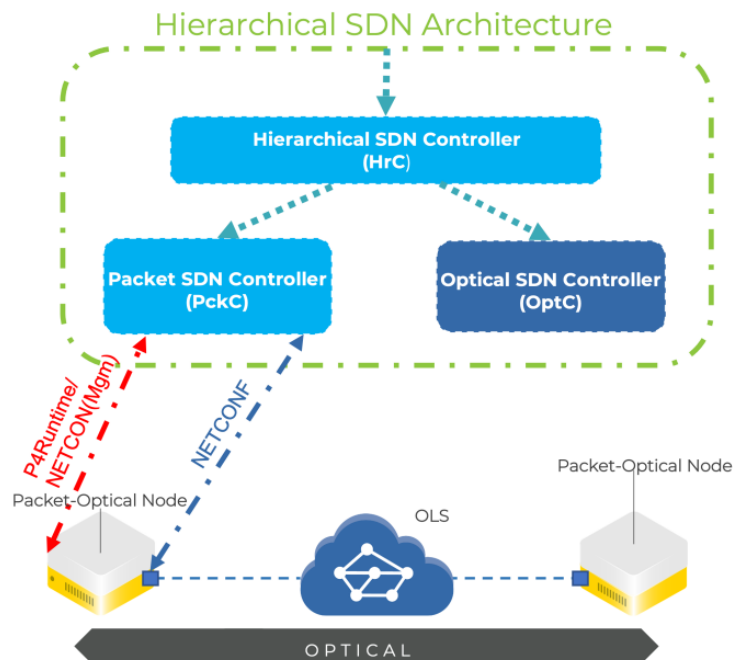
- Traditionally, the SDN Optical Controller controls the transport network
 - ROADM configurations, impairment-aware computation
 - Identifies the most suitable configuration for transceivers (e.g., mod format, FEC, operational mode..)
- Traditionally, only the SDN Packet controller has the capability to configure resources within the packet node, including its pluggables
- How to control pluggable modules?



Traditional SDN architecture for transponder-based optical networks

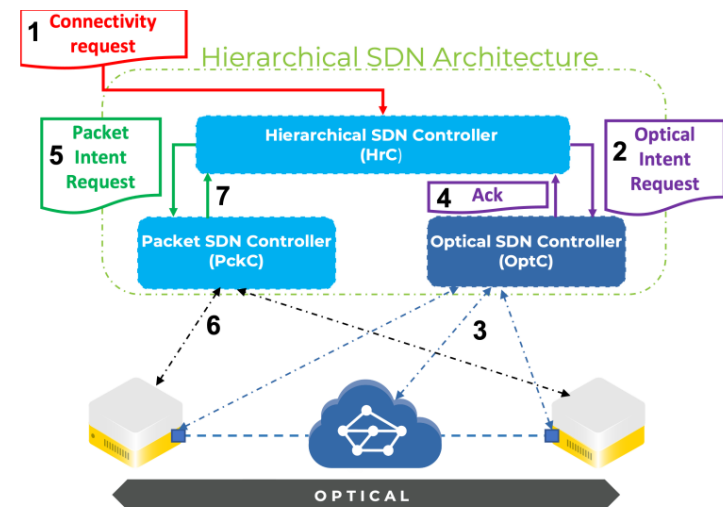
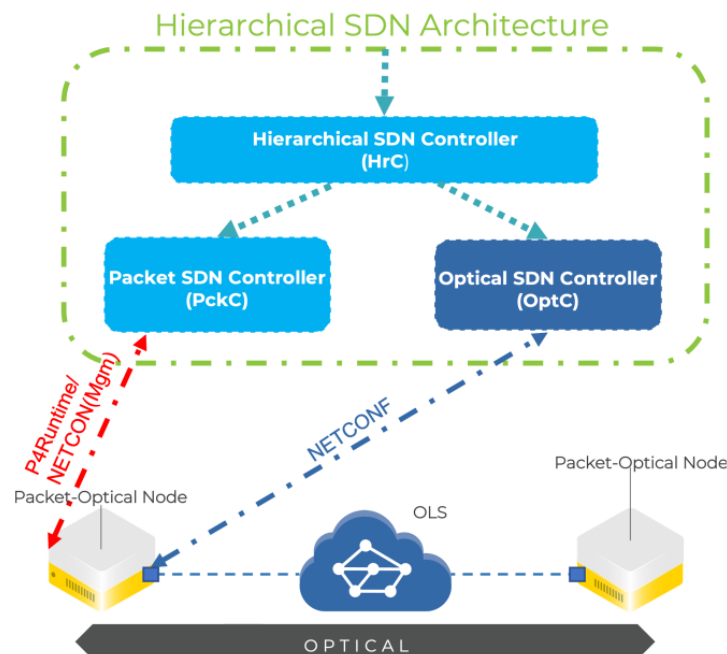
“Single” IPoWDM

- IP SDN Controller
 - is the only entity directly interfaced with the IPoWDM routers
 - Optical parameters received via Hierc. Controller



“Dual” + (r/w) IPoWDM

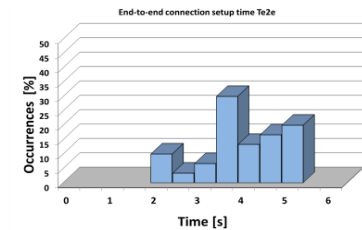
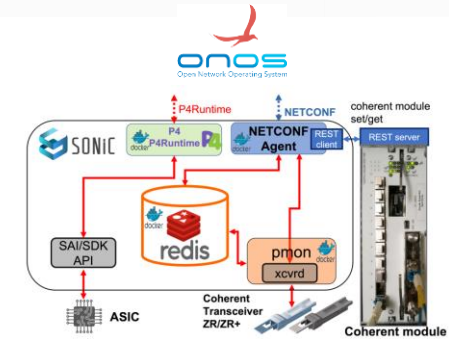
- Network Configuration Access Control Model (NCACM, RFC 8341) to implement controlled access and avoid misconfigurations
- OptC is provided with write rights on the optical parameters and read-only rights on packet parameters



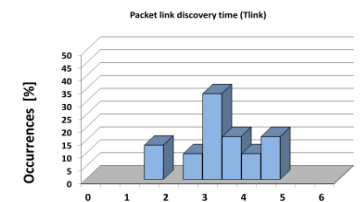
IPoWDM Implementation



- Implementation in SONiC-based OS, augmented with NETCONF agent
- Experimental results shown that the Dual (Concurrent) workflow is faster, mainly due to a simpler coordination between the two controllers.
- Management/maintenance procedures appear to be more complex in the Dual case. For example:
 - NOS versioning/updates with compatibility to be guaranteed toward two controllers, which are typically provided by different vendors.
 - proprietary development of the controllers, which might include specific features that facilitate the management of one of the two solutions.
 - How to estimate the actual impact of such issues?
 - How standardization could help mitigating such issues?



Single
Avg: 3.5s

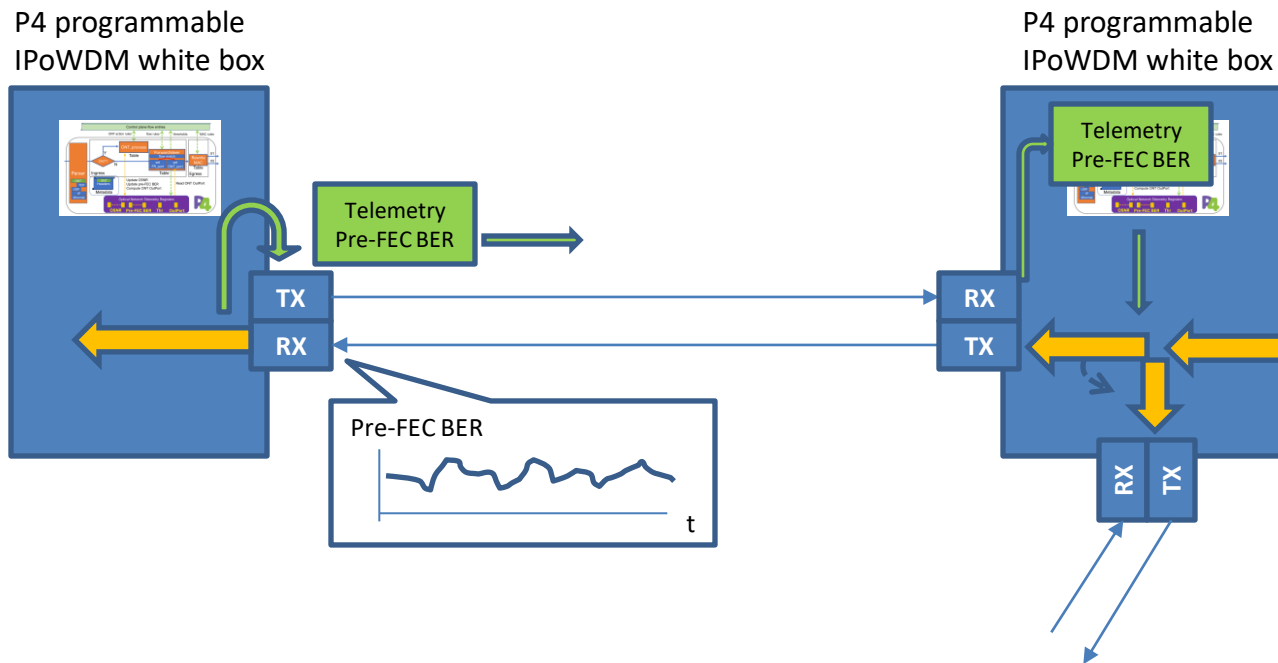


Dual
Avg: 2.9s

A. Giorgetti; D. Scano; A. Sgambelluri; F. Paolucci; E. Riccardi; R. Morro; P. Castoldi; F. Cugini
"Enabling Hierarchical Control of Coherent Pluggable Transceivers in SONiC Packet-Optical Nodes"
Journal of Optical Communications and Networking, 2023

In-band optical monitoring

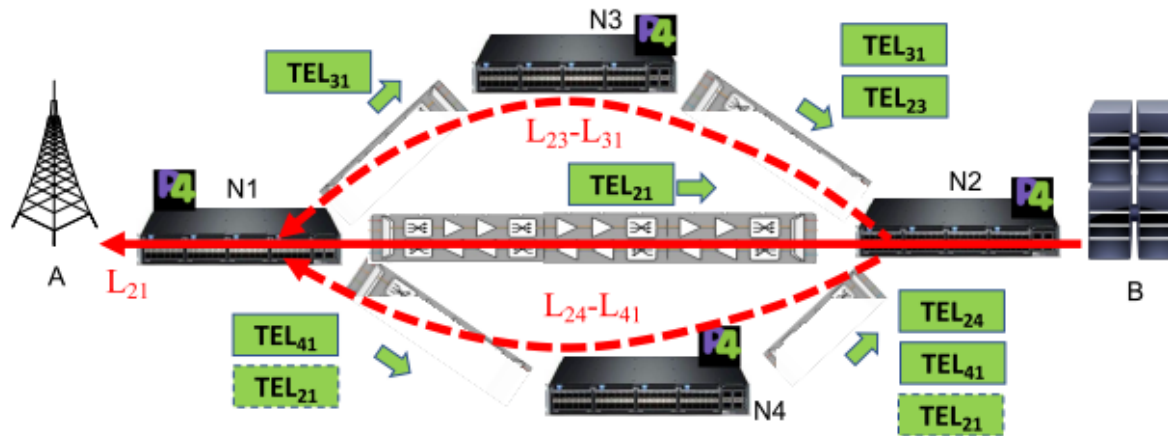
- Monitoring and processing of optical telemetry data/metadata directly in the packet forwarding plane



Filippo Cugini, Carlos Natalino, Davide Scano, Francesco Paolucci, Paolo Monti, "P4-based Telemetry Processing for Fast Soft Failure Recovery in Packet-Optical Networks" OFC 2023

In-band optical monitoring

- The processing of the telemetry stream is fast (1us) and scalable, done by the P4 ASIC
- However, feeding the telemetry packet with monitoring info is currently slow, >1sec

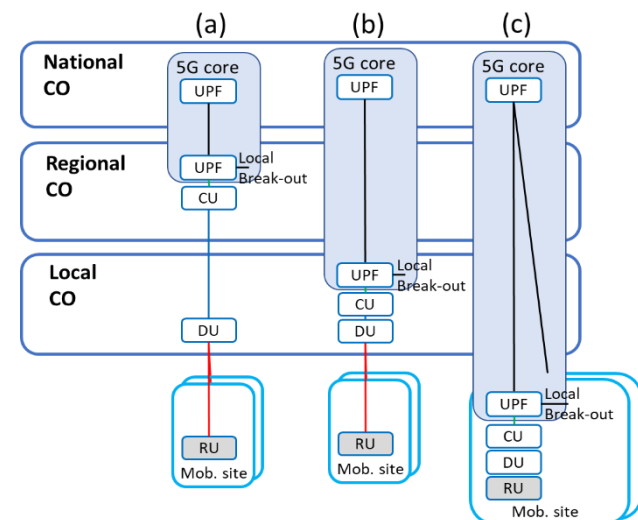
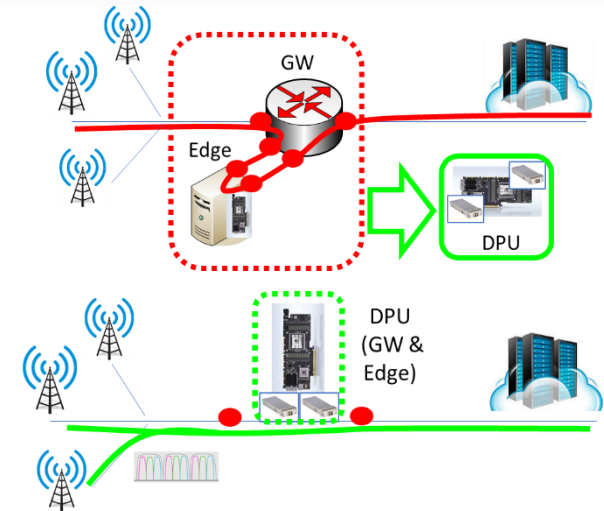


Filippo Cugini, Carlos Natalino, Davide Scano,
Francesco Paolucci, Paolo Monti,
"P4-based Telemetry Processing for Fast Soft Failure
Recovery in Packet-Optical Networks"
OFC 2023

Data Processing Units (DPU)



- Converged packet-optical transport solution based on coherent pluggable modules directly inserted into computing resources
 - drastically reducing O/E/O conversions
 - removing boundaries between networks and edge computing resources,
- Decentralize the implementation of UPF-DU-CU (-RU) functions closer to the cell site
 - Reduce latency (user traffic handled at the local CO or at the cell site)
 - Elimination of some GTP interconnects (F1-U, N3, N9) to be bypassed
 - HW acceleration to reduce energy consumption
- However, current DPU do not support coherent pluggable modules (yet)



Luca Barsellotti, Faris Alhamed, Juan Jose Vegas Olmos, Francesco Paolucci, Piero Castoldi, Filippo Cugini
Introducing Data Processing Units (DPU) at the Edge [Invited]
ICCCN Conf 2022



thank you!

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