



Precise Time with SDN Whiteboxes

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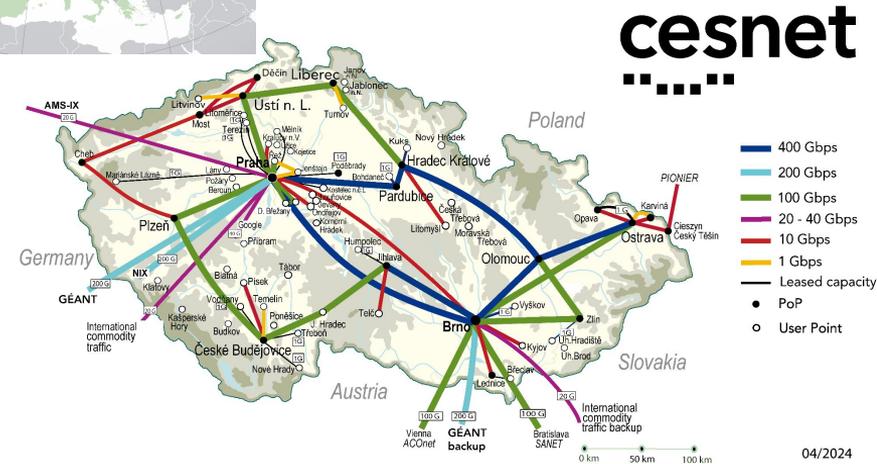
CESNET, a.l.e.

TNC25

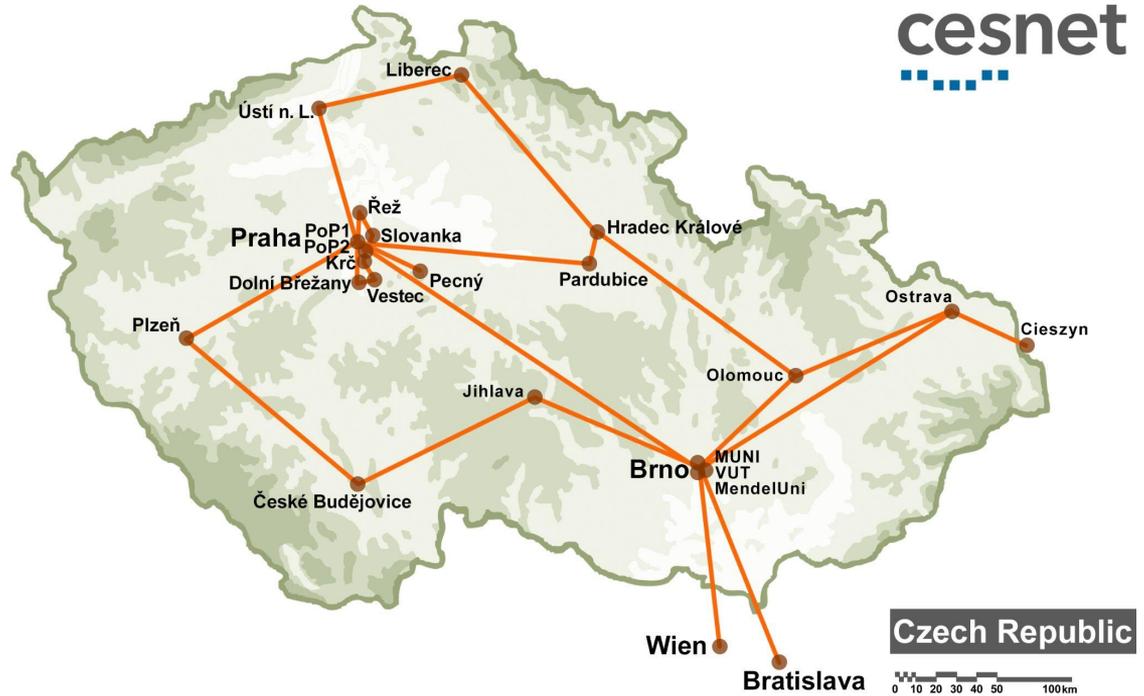
2025-06-10



- E-infrastructure service provider
 - Czechia, EU
 - Science, research & education
 - Services
 - Network
 - Compute
 - Storage
 - Collaborative environment



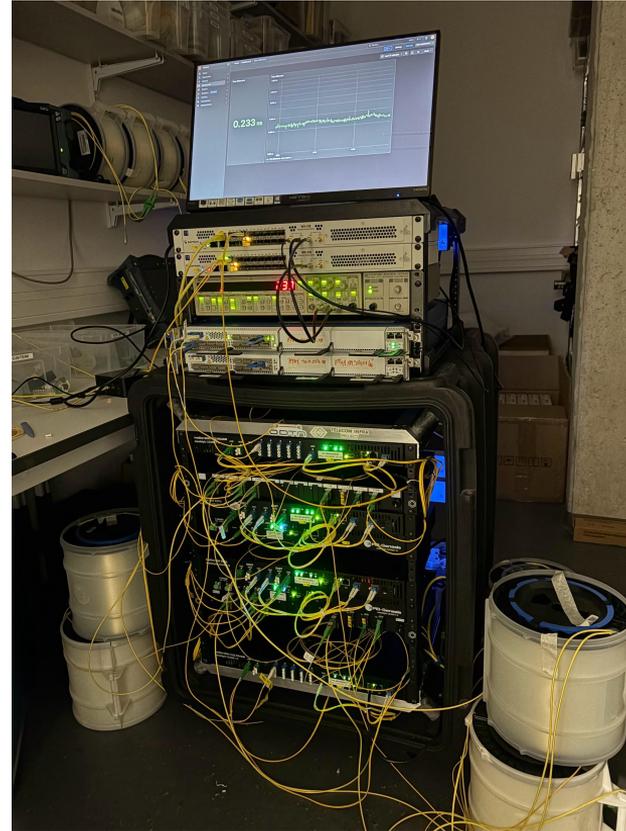
- Nationwide
- Long Haul White Rabbit with bidirectional amplification
- Over 20 PoPs and 40 amplifiers
- Shared fibers with production 400G network for Research and Education
- Integration into management and monitoring tools



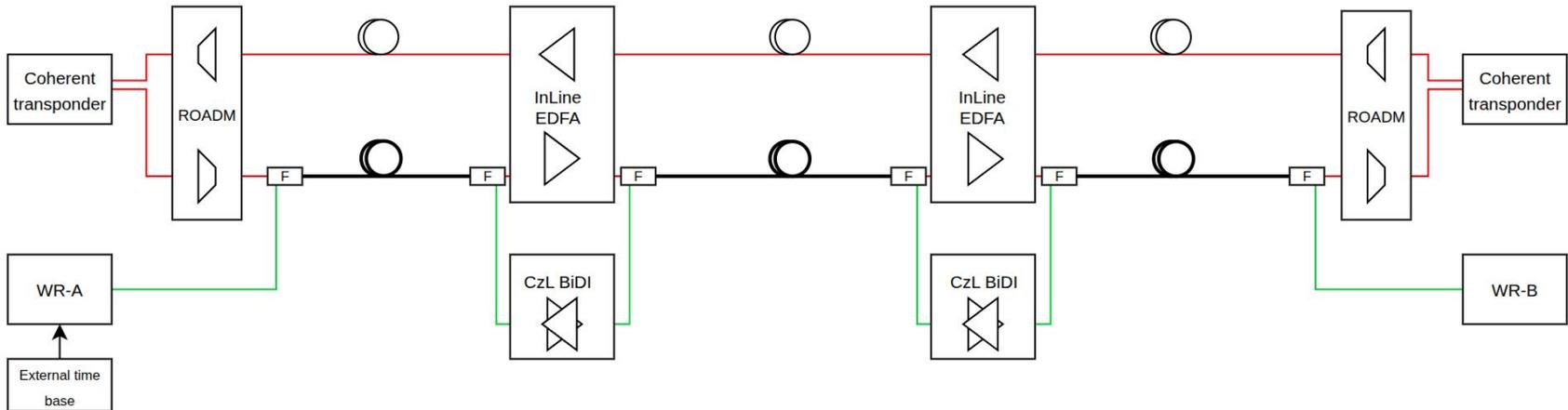
- Bidirectional transmission over existing fibre lines equipped by commodity transmission systems
 - Need to add/drop BiDi channels at each inline node for amplification
 - Filters have already been part of the CESNET3 design (future proof design work)
- Long Haul White Rabbit with L-Band DWDM SFPs
 - There are not many vendors supplying 1GE DWDM transceivers for L-band
 - Compatibility issues
- Integrate the management and monitoring of new equipment into the existing ecosystem
 - SDN driven solution using open source tools and CzechLight amplifiers



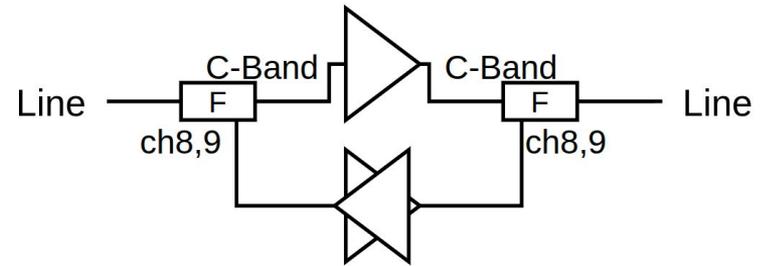
- Fiber line (3 spans)
- Coherent 400G signal via fiber pair
- White Rabbit protocol for precise time transfer over one fiber of the pair
- CzechLight OLS
 - 2x ROADM
 - 2x InLine EDFA
 - 2x BiDi EDFA
 - 6x DWDM filters for BiDi channels
- Rubidium timebase and time interval counter for time comparison

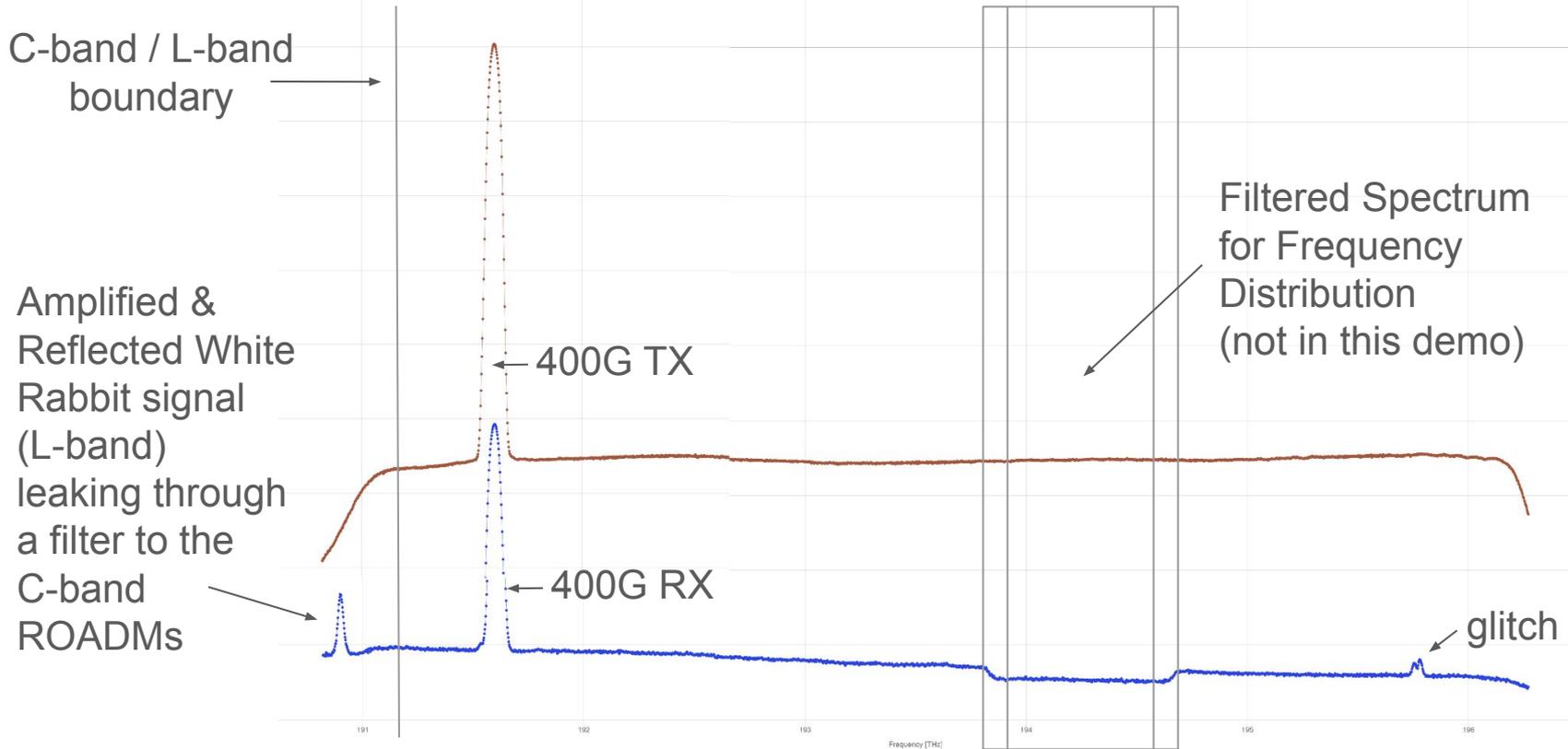


- 300 km fiber line in lab
- 1GE LR DWDM SFPs for L-Band
 - 2 channels 1570 nm and 1571 nm
 - Filters on Tx and Rx side
- 2 Bidirectional amplifiers for time transfer channels
- DWDM filters

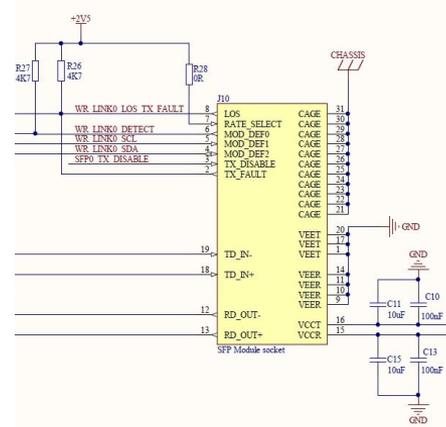
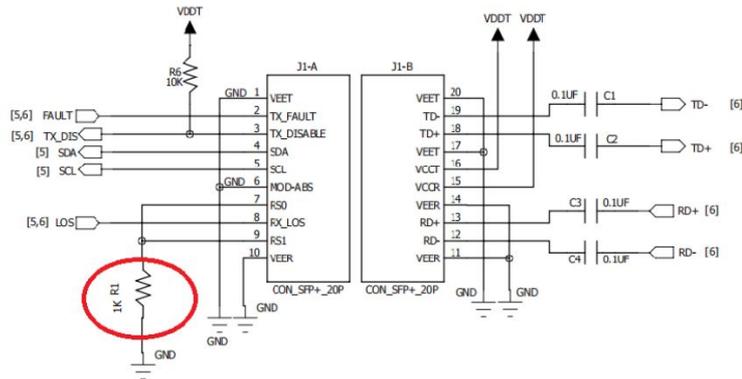


- Passive filters “everywhere”
 - L-band channels 6–9 for WR
 - C-band channels 39–46 for stable frequency (fixed frequency requirement)
 - Rest of the C-band for data channels





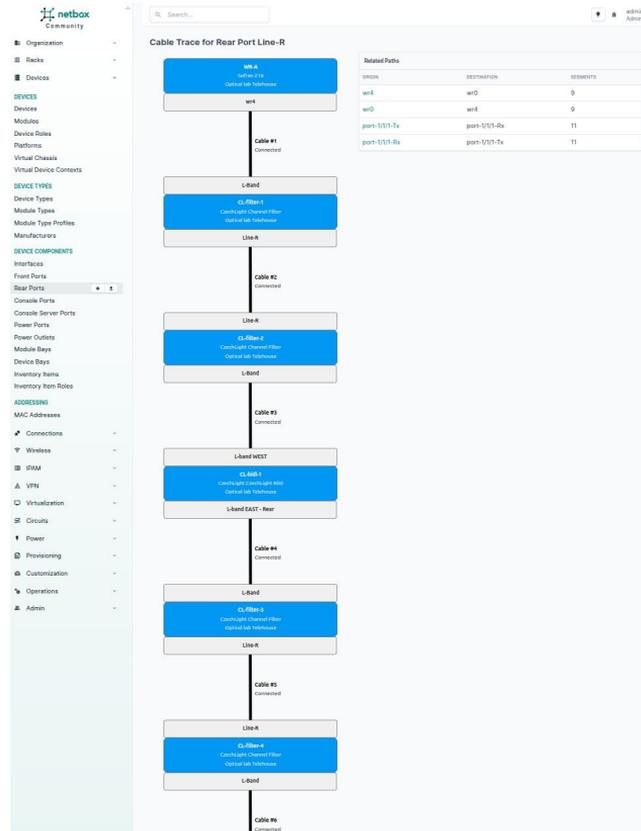
- One manufacturer's mistake meets another manufacturer's mistake during testing of White Rabbit switches.
 - When the transceiver manufacturer saves one resistor and connects two inputs together (the transceiver works normally elsewhere),
 - and the White Rabbit CERN open hardware design has an error in the SFP transceiver connection – a 0 Ohm resistor directly to the +2.5V power supply,
- = a power short circuit in the WR device when the SFP transceiver is inserted.



- Bidirectional optical amplifiers for precise time distribution in CESNET3
- 47 devices delivered by PEI-GENESIS
- Key features
 - Multiband: C-band and L-band
 - Dual power supply AC 230V/DC 48V
 - Hot swap fans
 - Open Source OS - images released by CESNET→full control over the device (security)
 - NETCONF, RESTCONF, local CLI
 - Streaming telemetry



- Already in use in CESNET3 network
- All topology data
- IPAM
- Serve as the Inventory for ansible
- DWDM layer modeling has its limitations with Netbox



- Some impedance mismatch
 - NETBOX started as a datacenter tool
 - WDM was not a native concept
 - “Link”: fiber pair vs. one fiber

Allow Virtual Circuit Termination on All Interface Types and Support Multiple Virtual Circuit Terminations on a Single Interface #19053

Netbox version: v2.2.0

Proposed functionality

Currently, Netbox restricts Virtual Circuit Termination to Virtual Interfaces only. This proposal extends Virtual Circuit Termination to support all interface types, including physical interfaces.

This change would extend Netbox's ability to create virtual circuits of different termination types: Duplex, Bidirectional, and Full Duplex. The Virtual Circuit model has a port GUID attribute, enabling the mapping of physical infrastructure using GUIDs and Cross-Link IDs that referencing to other virtual circuits in Netbox. Netbox is currently lacking the ability to associate link fiber pairs into a virtual network via:

- Ability to create termination model to allow linking any type of interface, not just virtual interfaces.
- Allow an interface to have multiple Virtual Circuit terminations (multi termination support).
- Support GUID and GUIDs to support associating physical and virtual circuits for Virtual Circuit termination.

Use case

This feature would allow Netbox to model any type of connection between devices across all network types, spanning to flexibility in working topology representations.

Database changes

- Optical Transport Networks (OTN) Model (WDM) optical paths between components using Virtual Circuits.
- MPLS & SD-WAN - Representing capabilities over physical infrastructure.
- Service Provider Networks - Representing L2/L3, L4/L5, and bandwidth terminations directly on physical interfaces.

Database changes

- Modify constraints on CircuitTermination to allow linking to any interface type.
- Add multi termination support for interfaces.
- Add necessary migrations to handle existing Virtual Circuit terminations.

Internal dependencies: N/A

Circuit Termination: BiDi Circuit and Interface Support #11865

Netbox version: v4.1.5

Proposed functionality

Provide the ability to light (provision) and test 2 individual circuits. In other words, allow circuit to be provisioned 2 physical interfaces by using 1 fiber. After routing each of 200 links only 100 of the fiber pair is required. However, the circuit provisioner currently requires a single fiber.

Netbox circuit is represented for each fiber as a subelement. It would be a Single-Media fiber pair but can run with single GUID type in 1:2:2 mode.

Use case

• Extension of BiDi Termination to connect optical termination models to various WDM (bidirectional multiplexing technology and compliant with the SFP multi source agreement (MSA). Bidirectional technology means a communication model to process data in both directions and receive back 100% of the data, which allows termination models to represent and resolve data within the termination network device like network switches or routers in a single optical fiber.

How Does BiDi Media Work?

BiDi media is an application of WDM technology that enables to transmit and receive data transmitted over a single fiber using different wavelengths of light. Use traditional transmission, BiDi systems typically use 2 different fibers. However, the BiDi, can share one fiber but can be an application of WDM and extend for the transmission of 2-way data streams at an expense of SNR. For example, fiber optic link installed at a customer that transmits TX on 1310nm wavelength and RX on 1550nm. Fiber optic BiDi is implemented that requires 80-100 dB cross-polarization loss to prevent crosstalk on the same fiber. In part 4 of the frequency filtering on 1490nm.

How Does BiDi Media Type?

The current types of BiDi terminations used in today's networks are 1550nm BiDi 50% and the most common optical technology for BiDi terminations are 1310nm/1550nm, 1550nm/1310nm, and 1310nm/1550nm. They are Required by 100%

Ansible project structure for BiDi amplifiers

```

/
├── bidi-configure.yaml
├── inventory/
│   └── netbox-inventory.yaml
├── host_vars/
│   ├── CzechLight-BiDi-A.yaml
│   └── CzechLight-BiDi-B.yaml
├── roles/
│   └── cl-bidi/
│       ├── tasks/
│       │   └── main.yaml
│       ├── templates/
│       │   └── edfa_pump.j2
│       └── defaults/
│           └── main.yaml
└── vault-password.txt
    
```

```

channels:
  narrow-1572:
    edfa_mode: "acc"
    edfa_setting: "84"
  c-band:
    edfa_mode: "off"
    edfa_setting: "0"
  persistent: true
    
```

Configuration play

```

---
- name: "Configure CL BiDi"
  hosts:
    - "CzechLight-BiDi-A"
    - "CzechLight-BiDi-B"
  gather_facts: no
  tasks:
    - name: "Configure CL BiDi using restconf"
      include_role:
        name: "cl-bidi"
  vars:
    channel: "{{ item.key }}"
    edfa_mode: "{{ item.value.edfa_mode }}"
    edfa_setting: "{{ item.value.edfa_setting }}"
    loop: "{{ channels | dict2items }}"
    
```

Netbox names



- Official module for configuring Network Elements
 - NETCONF & RESTCONF
- Sufficient for config distribution
 - Rather coarse features compared to native Linux modules
 - No model-driven knowledge

netcommon.restconf_config doesn't like colon in JSON key names #702 New issue

Open

nleiva opened 2 weeks ago

SUMMARY

Hi team, hope everything is good. netcommon restconf_config module fails when the content argument has a JSON key name with a colon in it, for example Cisco-100-KE-native-native.

Full content is stored in file interfaces.json.

```

{
  "Cisco-100-KE-native-native": {
    "interface": {
      "gigabitEthernet": [
        {
          "ip": {
            "address": {
              "primary": {
                "address": "198.64.8.93",
                "mask": "255.255.255.252"
              }
            }
          }
        }
      ]
    }
  }
}
    
```

ISSUE TYPE

- Bug Report

COMPONENT NAME

ansible.netcommon.restconf_config

ANSIBLE VERSION

```

$ ansible --version
ansible [core 2.18.5]
  config file = None
  configured module search path = ["/root/.ansible/plugins/modules", "/usr/share/ansible/plugins/modules"]
  ansible python module location = /root/.local/lib/python3.13/site-packages/ansible
  ansible collection location = /root/.ansible/collections:/usr/share/ansible/collections
  executable location = /root/.local/bin/ansible
  python version = 3.13.3 (main, Apr 23 2025, 15:03:10) [GCC 12.1.1 20220628 (Red Hat 12.1.1-3)] (/opt/ib/bin/python)
  jinja version = 3.1.6
  libyaml = True
    
```

COLLECTION VERSION

```

$ ansible-galaxy collection list ansible.netcommon
    
```

Assignees

- KB-perByte

Labels

No labels

Type

No type

Projects

No projects

Milestone

No milestone

Relationships

None yet

Development

[Code with Copilot Agent Mode](#)

No branches or pull requests

Notifications Customize

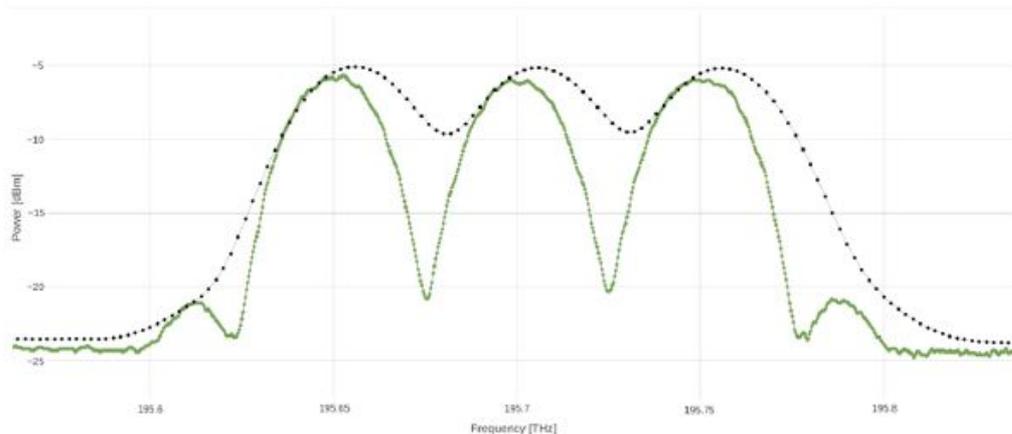
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Participants



- Streaming Telemetry
 - All the metrics
 - Sub-second latencies
- I/O Formats
 - IETF YANG-push
 - OpenMetrics (Prometheus)
 - Grafana



Time difference

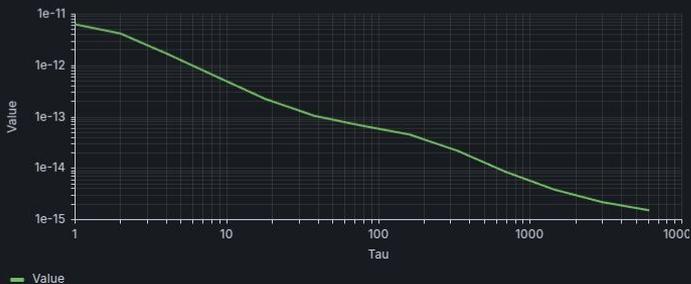


Line view



Grafana

Service Quality - MDEV for last 6h



Time difference



VICTORIA METRICS

■ Data model

- Tree structure
- Configuration vs. State
- "Leaf" data types

■ Defines Data Semantics

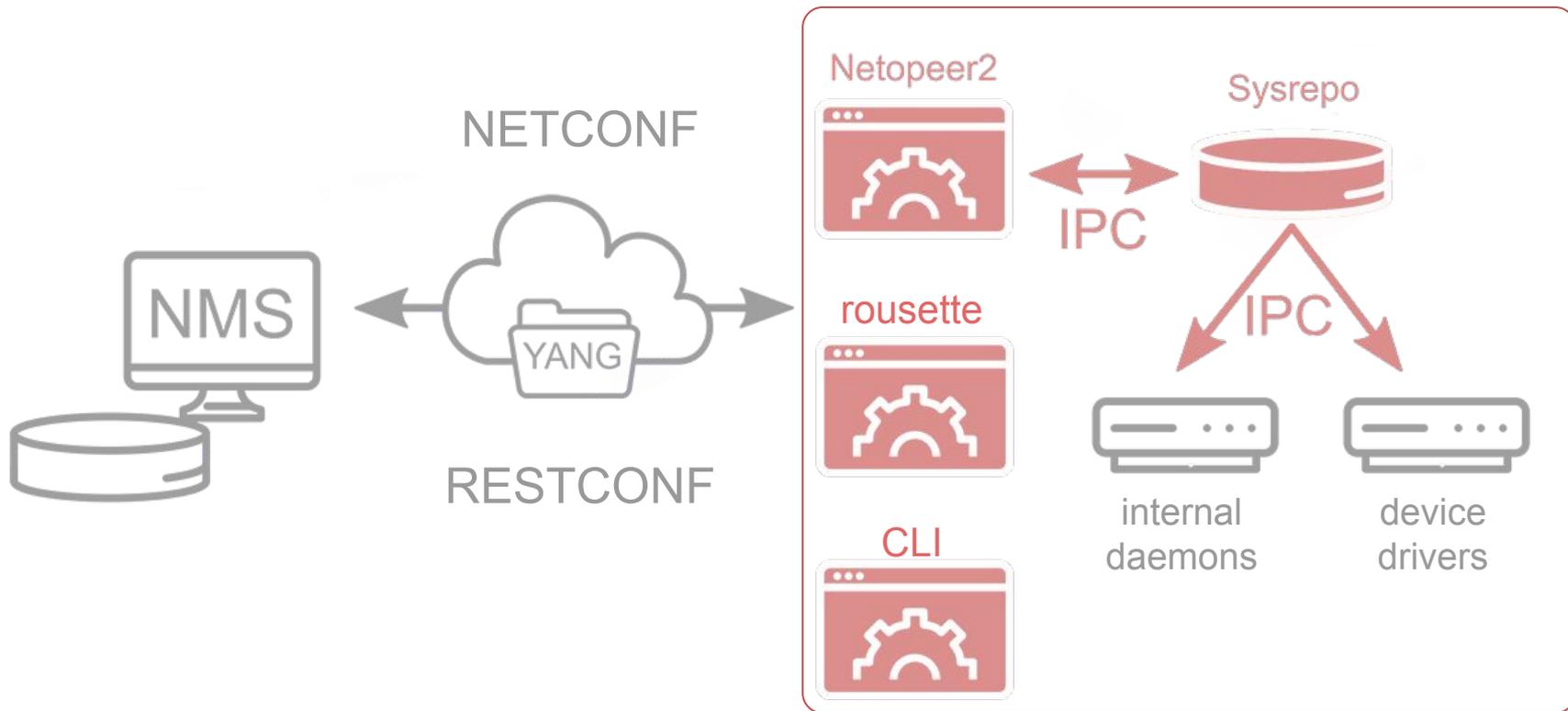
■ Machine Validation

- Bjorklund, Martin. "YANG-a data modeling language for the network configuration protocol (NETCONF)." RFC 6020, 2010.
- Bjorklund, Martin. "The YANG 1.1 data modeling language." RFC 7950, 2016.

```

module: czechlight-bidi-amp
  +---rw c-band {dualband-c-plus-1572}?
  |   +---rw pump
  |   |   +---rw (control)?
  |   |   |   +---:(disabled)
  |   |   |   |   +---rw disabled?   empty
  |   |   |   +---:(agc)
  |   |   |   +---rw agc             gain-dB
  |   |   +---:(manual-current)
  |   |   +---rw manual-current     laser-current-mA
  |   +---ro measured-current?     laser-current-mA
  +---ro east-to-west
  |   +---ro input-power            odt:optical-power-dBm
  |   +---ro output-power           odt:optical-power-dBm
  |   +---ro output-spectrum (c-band-ocm)?
  |   |   +---ro lowest-frequency   frequency-ghz
  |   |   +---ro step               frequency-ghz
  |   |   +---ro p?                anyxml
  +---ro west-to-east
  |   +---ro input-power            odt:optical-power-dBm
  |   +---ro output-power           odt:optical-power-dBm
  |   +---ro output-spectrum (c-band-ocm)?
  |   |   +---ro lowest-frequency   frequency-ghz
  |   |   +---ro step               frequency-ghz
  |   |   +---ro p?                anyxml
  +---rw ocm-period?               cla-common:spectral-scan-frequency (c-band-ocm)?
  [...]

```

- czechlight-firewall
- czechlight-inline-amp
- czechlight-lldp
- czechlight-netconf-server
- czechlight-network
- czechlight-roadm-common
- czechlight-system
- iana-afn-safi
- iana-crypt-hash
- iana-hardware
- iana-if-type
- iana-ssh-encryption-algs
- iana-ssh-key-exchange-algs
- iana-ssh-mac-algs
- iana-ssh-public-key-algs
- iana-tls-cipher-suite-algs
- ietf-access-control-list
- ietf-alarms
- ietf-crypto-types
- ietf-datastores
- ietf-ethertypes
- ietf-factory-default
- ietf-hardware
- ietf-interfaces
- ietf-ip
- ietf-ipv4-unicast-routing
- ietf-ipv6-unicast-routing
- ietf-keystore
- ietf-netconf-acm
- ietf-netconf-monitoring
- ietf-netconf-nmda
- ietf-netconf-notifications
- ietf-netconf-server
- ietf-netconf-with-defaults
- ietf-netconf
- ietf-network-instance
- ietf-notification-capabilities
- ietf-origin
- ietf-packet-fields
- ietf-restconf-monitoring
- ietf-restconf-subscribed-notifications
- ietf-restconf
- ietf-routing
- ietf-ssh-common
- ietf-ssh-server
- ietf-subscribed-notifications
- ietf-system-capabilities
- ietf-system
- ietf-tcp-client
- ietf-tcp-common
- ietf-tcp-server
- ietf-tls-common
- ietf-tls-server
- ietf-truststore
- ietf-x509-cert-to-name
- ietf-yang-library
- ietf-yang-patch
- ietf-yang-push
- ietf-yang-schema-mount
- libnetconf2-netconf-server
- nc-notifications
- netopeer-notifications
- notifications
- opendevise-types
- sysrepo-factory-default
- sysrepo-ietf-alarms
- sysrepo-monitoring
- sysrepo-notifications
- sysrepo-plugind
- sysrepo
- velia-alarms
- yang



- Read-only Linux rootfs via **buildroot**

- Stateless system
- R/W config with YANG data

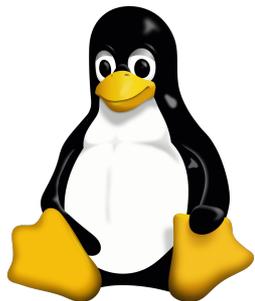
- Userland based on **systemd**

- A/B software slots via **rauc**

- Integrated with HW watchdog
- Atomic system updates



Open Source



- Open Source SW
 - One closed part due to NDAs
- github.com/CESNET
- CI/CD: gerrit.cesnet.cz



The screenshot shows the GitHub profile for CESNET (Czech Educational and Research Network). The profile includes a search bar, navigation tabs for Overview, Repositories (329), Projects (4), Packages, Teams (17), and People (131). A list of repositories is displayed, including:

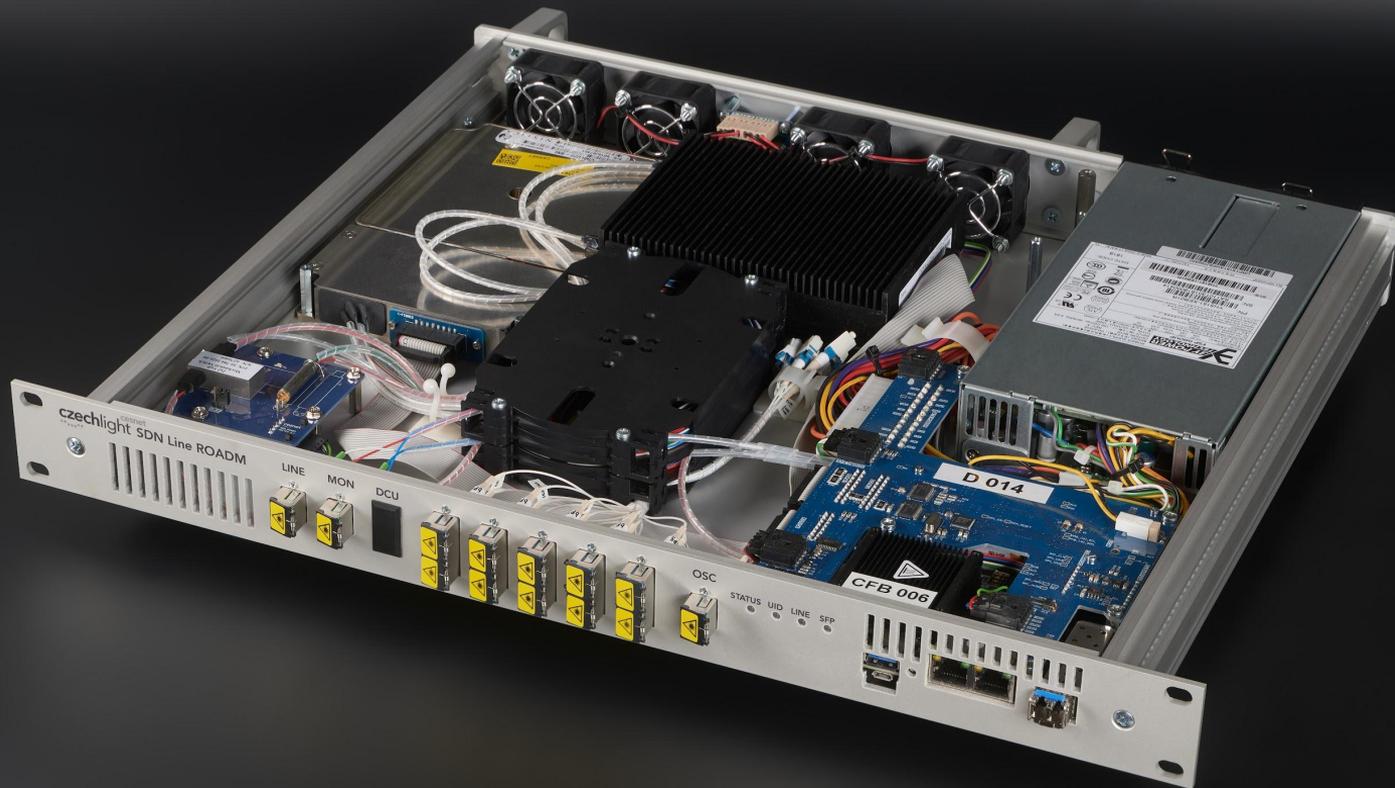
- CzechLight-br2-external** (Public): CzechLight-specific bits for Buildroot. Updated 31 minutes ago.
- CzechLight-yang** (Public): YANG models used by CzechLight devices. Updated 2 hours ago.
- rousette** (Public): RESTCONF server for sysrepo. Updated 3 hours ago.
- sysrepo-ietf-alarms** (Public): Alarm management (ietf-alarms) YANG module for sysrepo. Updated 3 hours ago.
- velia** (Public): YANG System management for embedded devices running Linux. Updated 3 hours ago.
- libyang-cpp** (Public): C++ bindings for the libyang library. Updated 4 hours ago.

Additional features visible include a 'Follow' button, a 'View as: Public' dropdown, a 'People' section with avatars, and a 'Top languages' section showing Python, PHP, C, Shell, and C++.

Hotswap
AC & DC PSUs

Redundant fans

HW health
telemetry & alarms



Scalable,
Modular,
Open

ROADMs,
EDFAs,
BiDi EDFAs

SDN Control
& Monitoring



IntelDat

OPTOKON[®]
FIBER OPTIC TECHNOLOGY
CALIBRATION LABORATORY

CZECHOS
Czech Optical Solutions

 **PEI-Genesis**[™]

 **Photonic
Technologies**



- CESNET's upcoming production service
 - Bringing precise time to existing users
- Reusing Existing Fiber Footprint
 - Multiband & BiDi is possible
 - ...but some aspects are "tricky"
- DevOps Approach
 - Treating Network Elements as "servers with an API"
 - High-quality telemetry as a key for successful deployment
- Open Hardware
 - With open source software and commercial support
 - Not just the BiDi amplifiers



Come see the demonstration
at our stand



cesnet
.....



<https://ces.net/tnc25>





Q&A

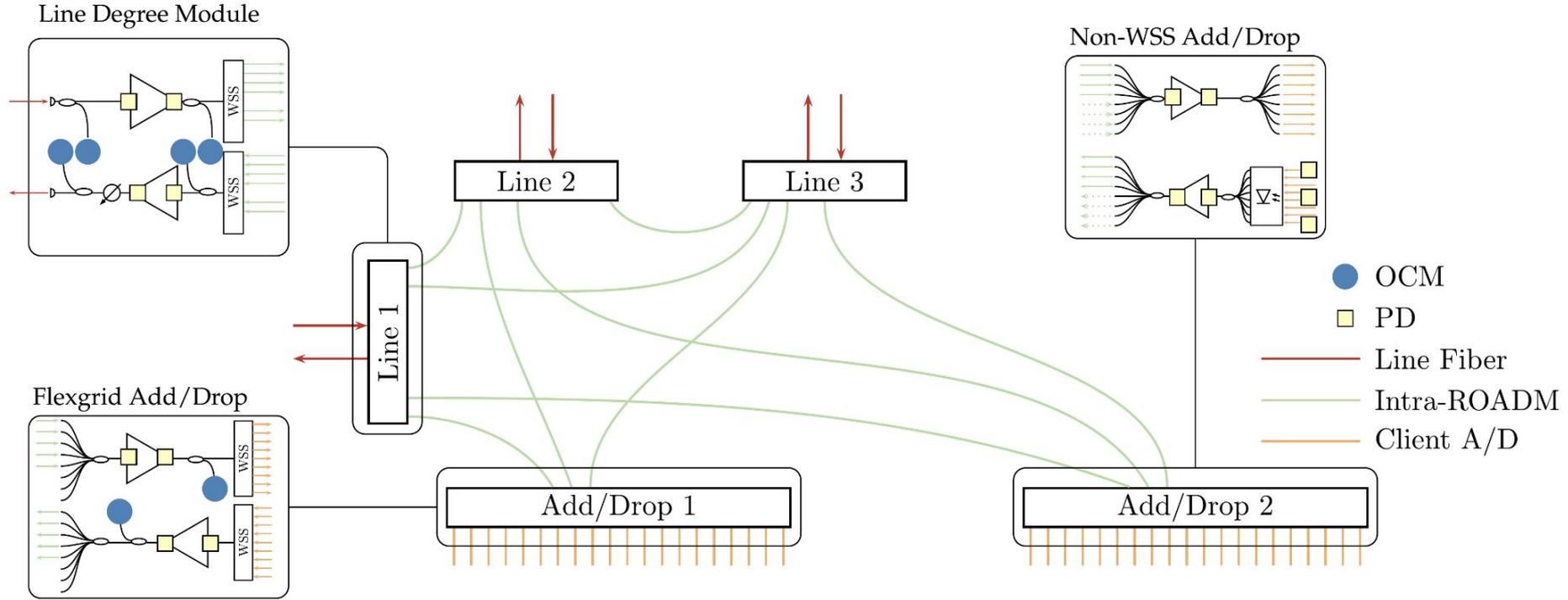
michal.hazlinsky@cesnet.cz





Slides for Offline Reading





■ Long-haul connection

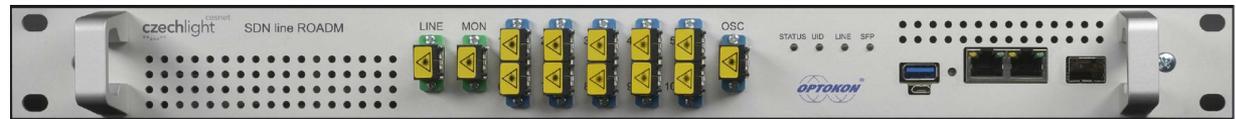
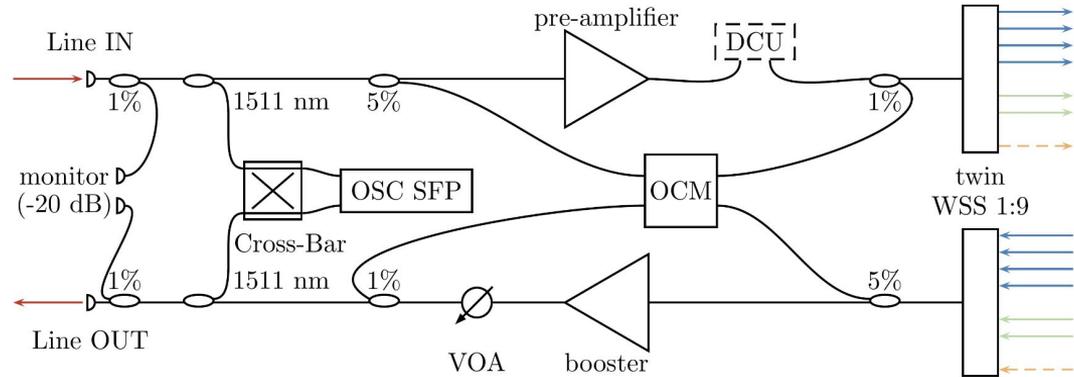
- Internal amplification, up to 25 dB spans (VOA)
- 0 dBm/ch typ. TX power
- Integrated OSC
- OTDR option via SFP

■ Flexgrid

- 12.5 GHz granularity
- min. 50 GHz MCs

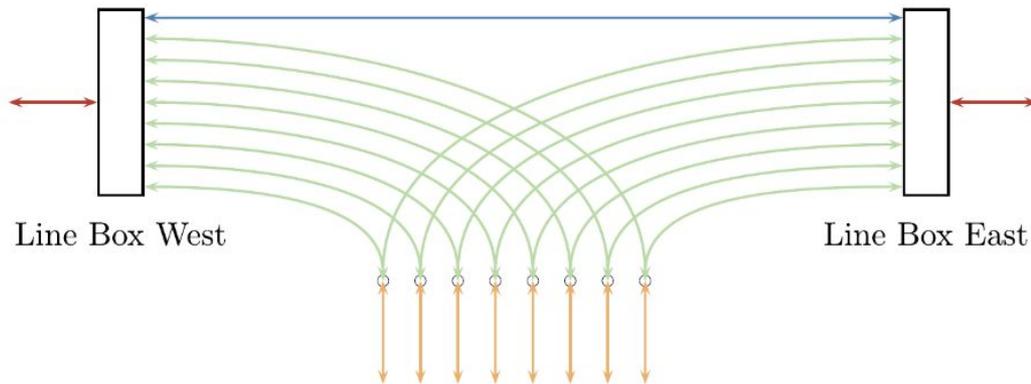
■ 9 Express ports

- -12 dBm/ch TX
- -15..+5 dBm/ch RX



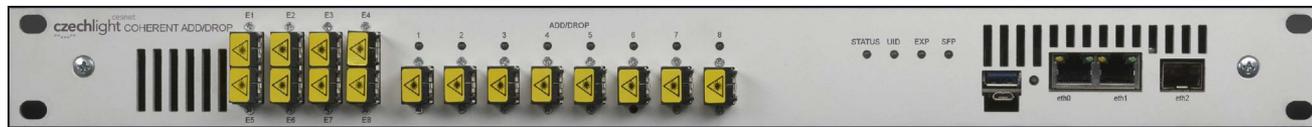
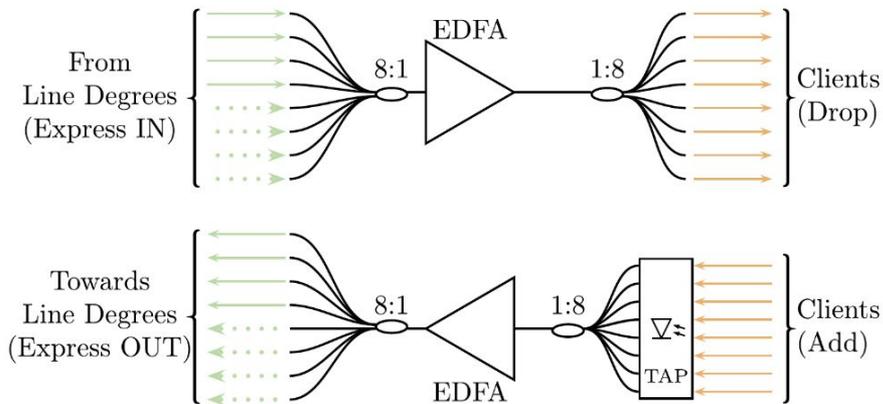
■ Passive

- Direct-connection to Express ports
- 2-deg only
- 8 client ports
- Spectrum control via Line Degrees
- -12 dBm/ch



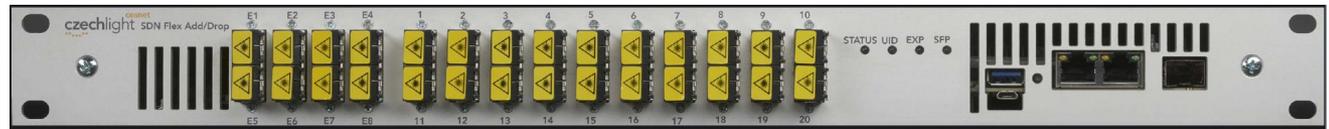
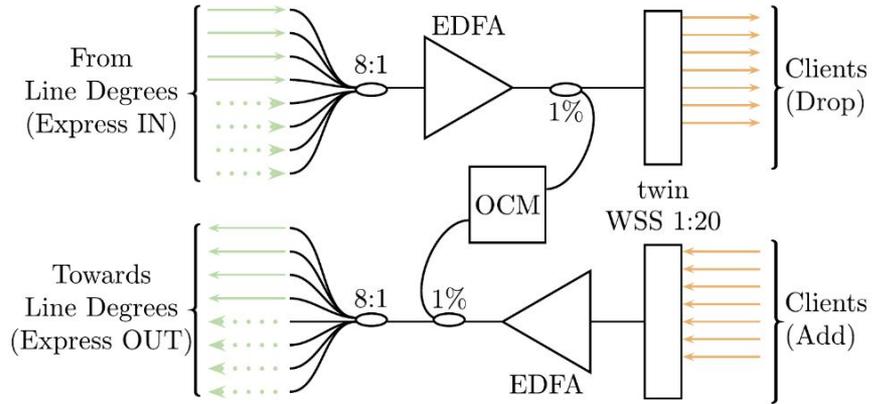
■ Coherent Signals

- 8ch/1U
- Per-port power monitoring
- Power equalization via Line Degree ROADMs



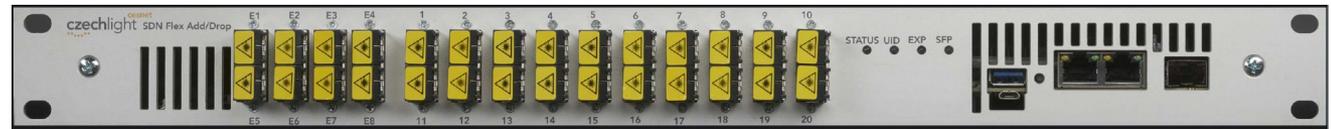
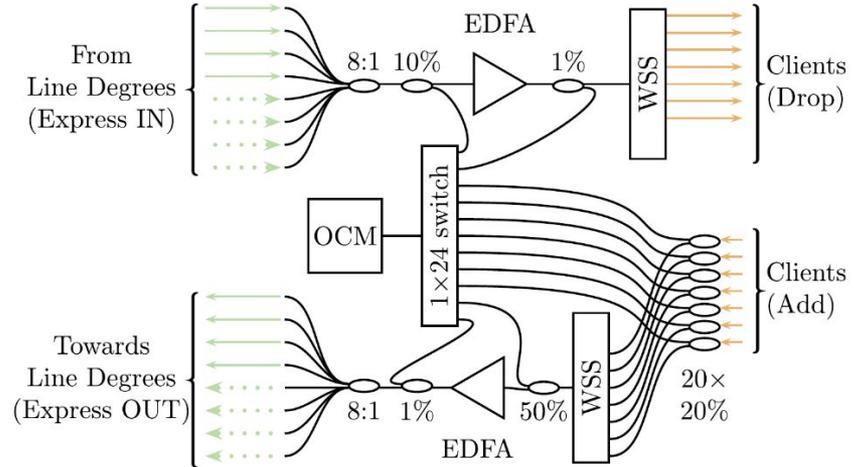
■ WSS-based

- 20ch/1U
- 12.5 GHz routing (min. 37.5 GHz per MC)
- 12.5/6.25 GHz monitoring
- Indirect client-port monitoring



■ Alien Wavelength

- 20ch/1U
- 3.25 GHz routing
- 0.3125 GHz monitoring (2.5 pm)
- Direct client-port spectrum monitoring



■ Dual EDFA

- Flat gain, 27 dB
- $NF \leq 5.5$
- No tilt control
- Up to 25 dB spans,
output VOA in both directions
- Class-1M product

■ OTS

- Power monitoring
- Integrated OSC
- OTDR option via SFP



- EDFA
 - Dual-band by default
 - C-band: 1540 – 1547 nm
 - L-band: 1572 nm
 - Other options possible on request
 - Optional built-in OCM
 - Auto Gain Control, 23 dB
 - Auto Current Control,
Manual pump setting

