



# **CZECHLIGHT**

## **Open Line System with SDN Control**

Jan Kandrát

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September 2019



- Researcher at CESNET
  - E-infrastructure provider in Czechia, EU
    - Network, cloud infrastructure,...
    - Non-data users – *photonic services*
  - R&D
- Software engineer at Telecom Infra Project
  - Open Optical Packet Transport
  - GNPY [<https://github.com/Telecominfraproject/oopt-gnpy>]

**Disclaimer:** I am not speaking on behalf of TIP today

- In-service since 2004



- In-service since 2004
- EDFA amplifiers
  - In-line
  - Booster/Pre-amp
  - Bidirectional, single-fibre
  - No-lase for precise time & frequency
- Switches
- V-MUXes, fixed-grid legacy ROADMs, WSSes
- Special equipment

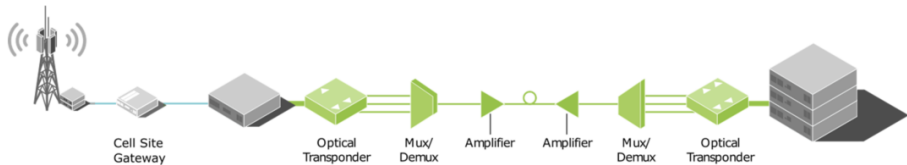


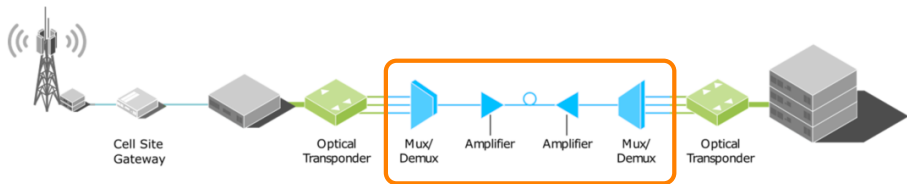


cesnet  
"....."

# Open Optical Line System SDN ROADMs







**RF system (195 THz), not a digital network**



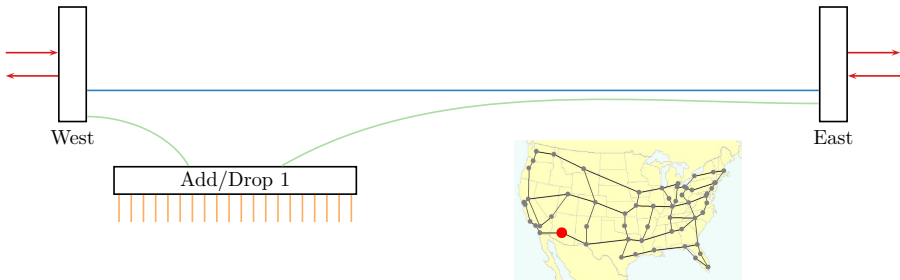


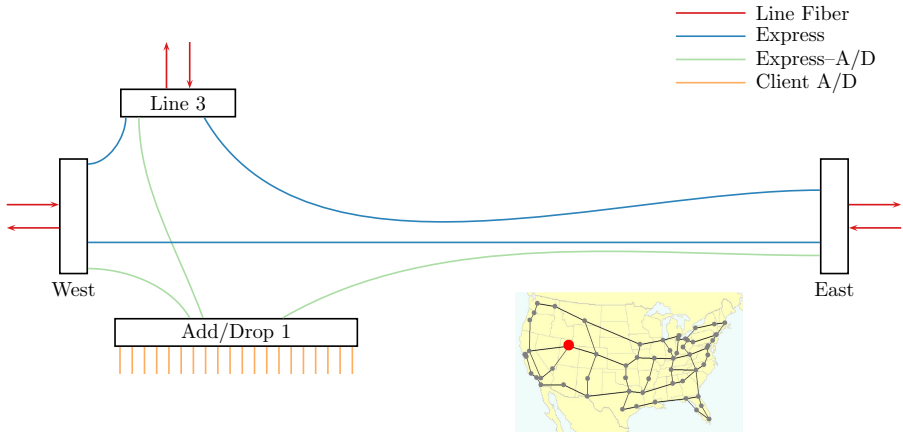


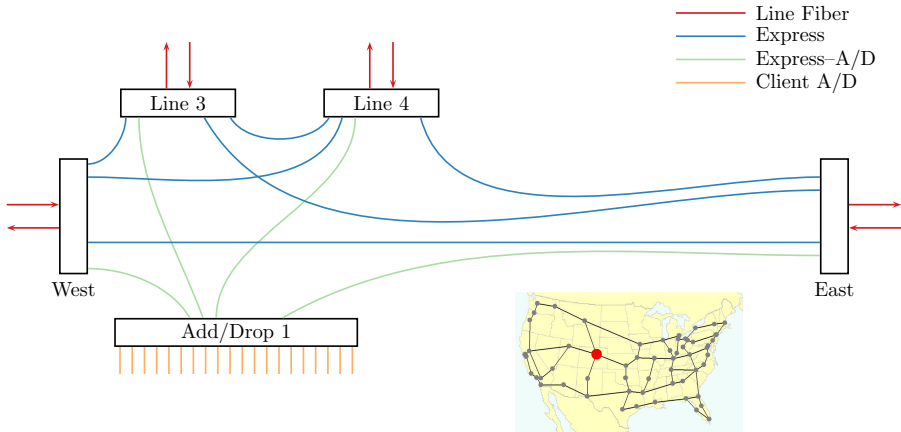
- Line Fiber
- Express
- Express-A/D
- Client A/D

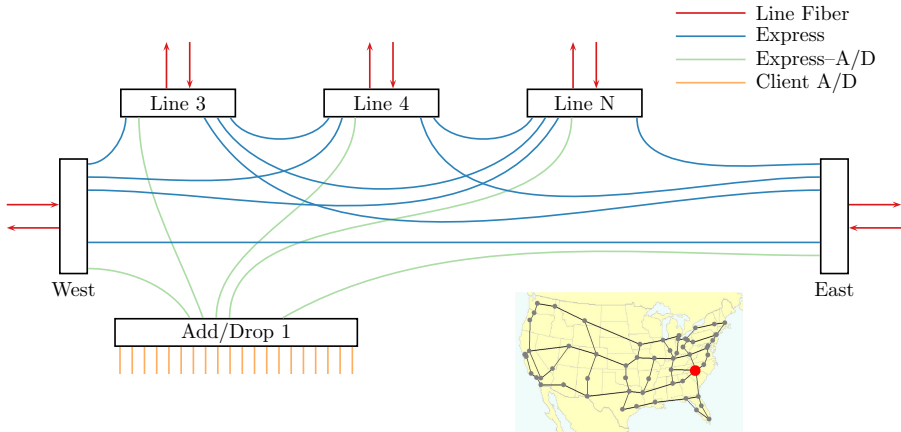


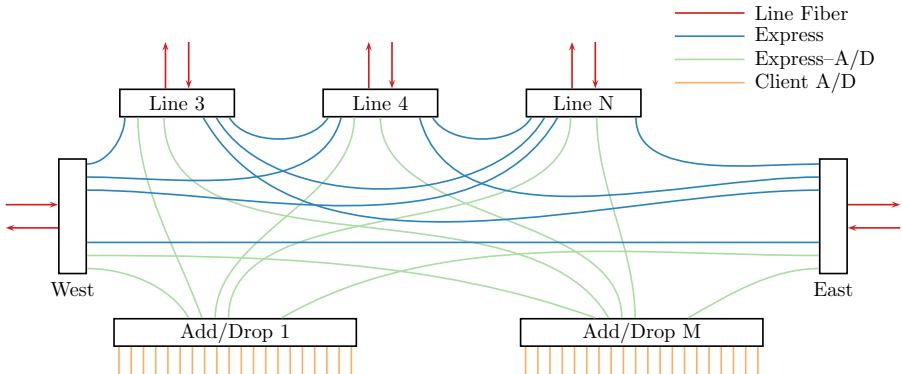
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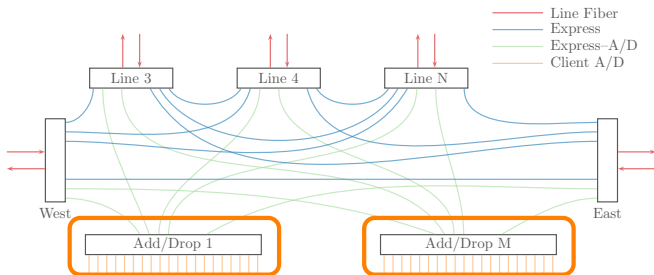






- 1U pizza-boxes

- Add/Drop for client connections**





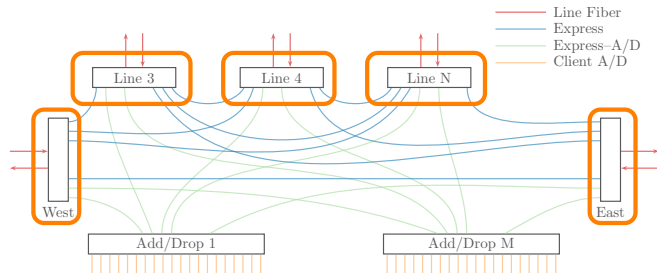
- 1U pizza-boxes

- **Add/Drop** for client connections

- **Line Degree** for long-haul links

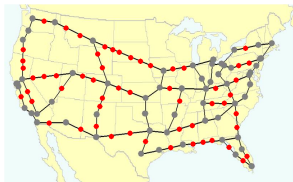
- Up to **8-degree** ROADM

- 25 dB reach with no additional amplification

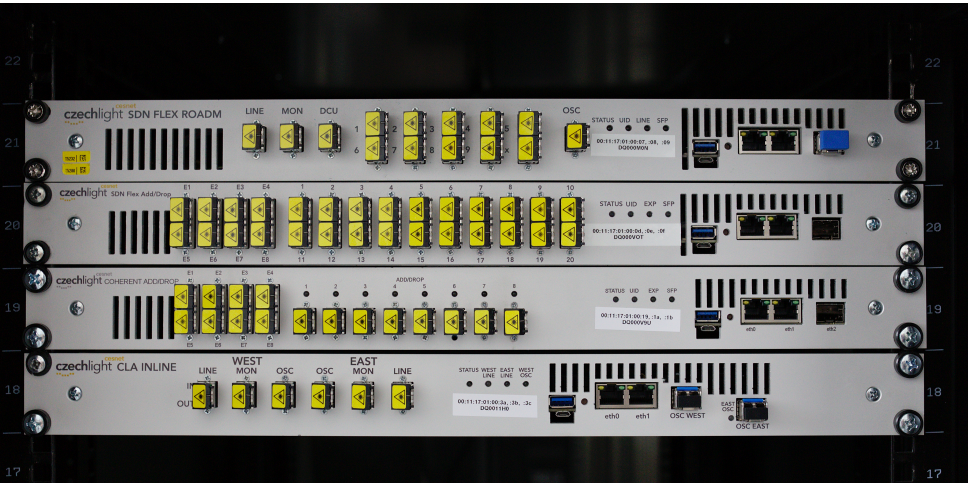


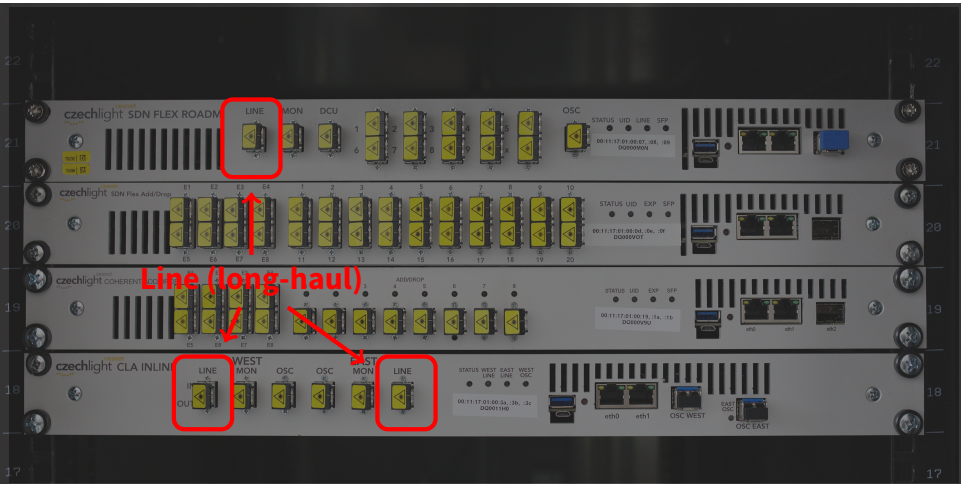
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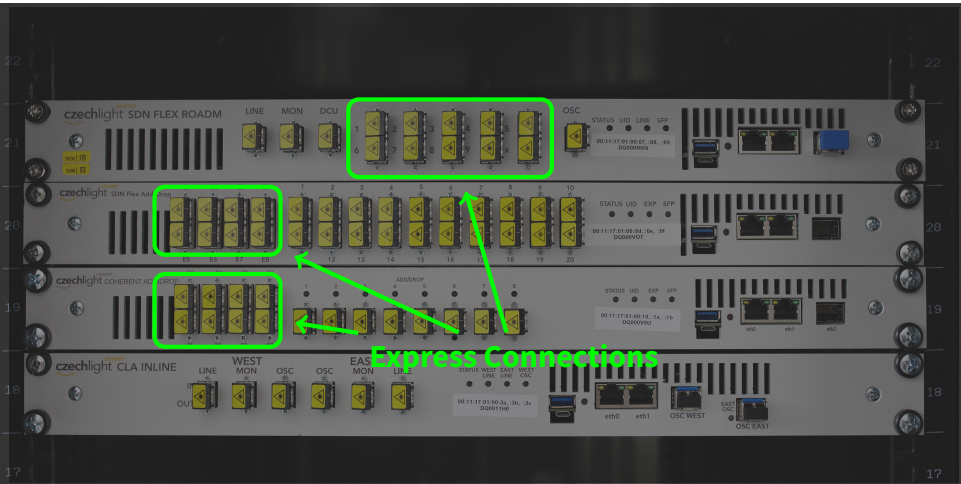
- **Add/Drop** for client connections
- **Line Degree** for long-haul links
  - Up to **8-degree** ROADM
  - 25 dB reach with no additional amplification
- **Inline Amplifiers for long spans**

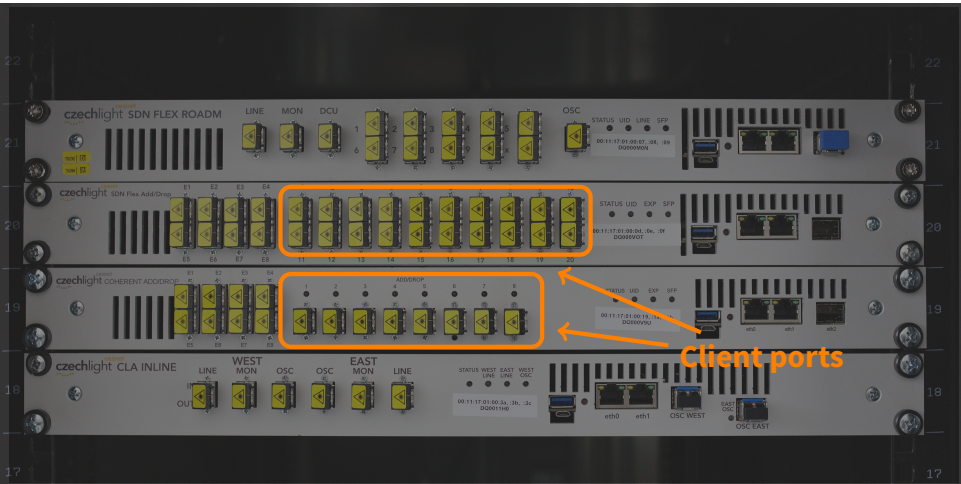


Note: Amplifier placement not to scale

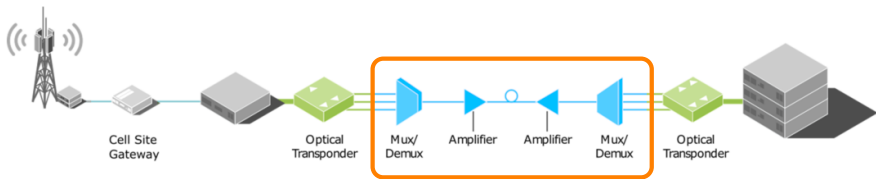








- A complete Open Line System
  - Everything below transponders



■ Modern Features

■ Flexgrid

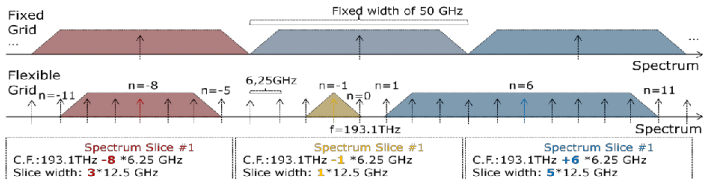
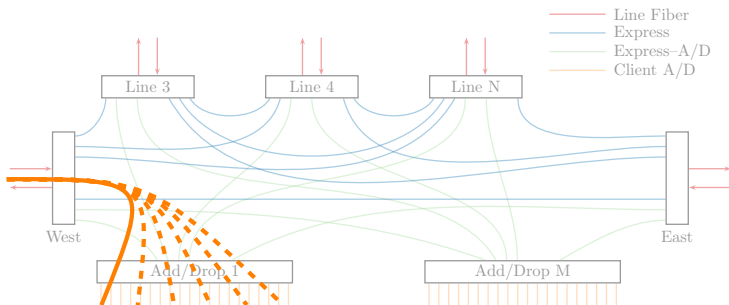


Image credit: TNC 2014, Ioan Torus, Josva Kleist, Anna Manolova Fagertun



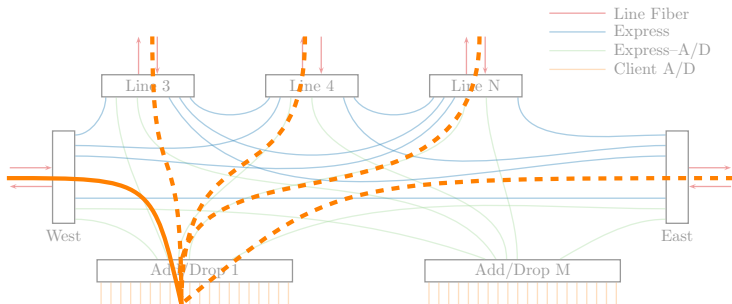
## ■ Modern Features

- Flexgrid
- **Colorless**



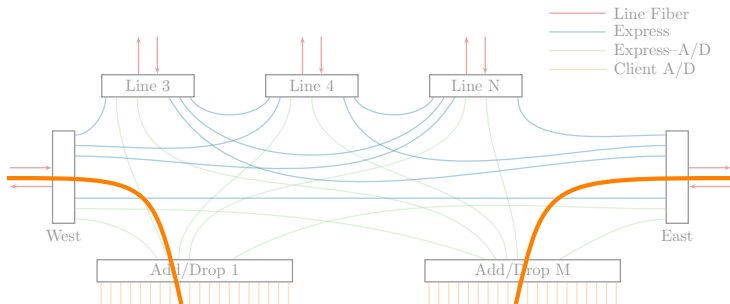
## Modern Features

- Flexgrid
- Colorless
- **Directionless**



## ■ Modern Features

- Flexgrid
- Colorless
- Directionless
- **Contentionless**



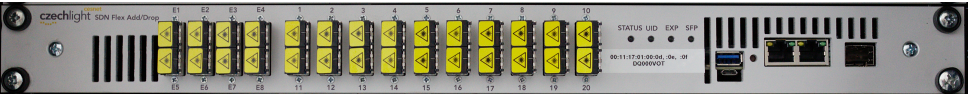
- Multiple Add/Drop boxes for redundancy
  - Contentionless feature
  - Blocks of up to 20 client ports per Add/Drop

An MD-ROADM with a contention-less local add/drop feature is able to add or drop more than one optical channel with the same wavelength to/from different optical line ports.

Rec. ITU-T G.672 (10/2012)



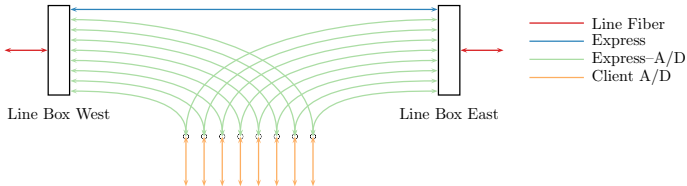
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  - Contentionless feature
  - Blocks of up to 20 client ports per Add/Drop
- Active and passive Add/Drop
  - **WSS-based for Alien Wavelengths**



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- Active and passive Add/Drop
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  - **Cost-optimized for coherent signals**



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  - Blocks of up to 20 client ports per Add/Drop
- Active and passive Add/Drop
  - WSS-based for Alien Wavelengths
  - Cost-optimized for coherent signals
  - **Y-cables for 2-deg ROADMs**



- Optical Supervisory Channel (OSC)
  - Overlay network
  - Laser safety
  - Neighbor discovery
- Integrated line-facing bidirectional OTDR
  - Via the OSC SFP slot
  - Optional feature



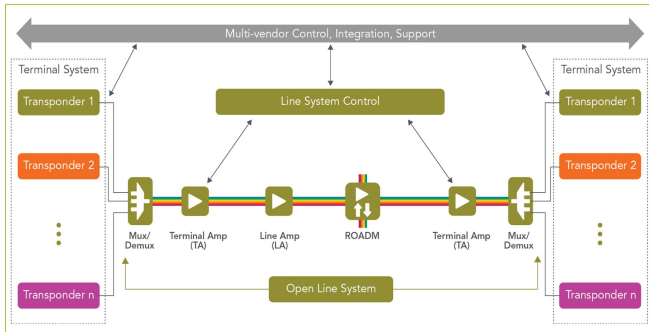
**cesnet**  
"....."

**Management**



# cesnet SDN: Software Defined Network

- SDN Operation and Management
  - Everything is remotely configurable
  - Native Alien Wavelengths
  - Telemetry, performance monitoring



## ■ Configuration

- NETCONF control
- YANG data model
- Interactive CLI console
  - SSH
  - microUSB port

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## ■ YANG fragmentation

- OpenROADM
- OpenConfig
- TIP OpenDevice
- T-API
- IETF TE-topology, IETF CCAMP impairment-aware

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## ■ Configuration

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```
module: czechlight-roadm-device
  +--rw channel-plan ← List of recognized Media Channels (MCs)
  | +--rw channel* [name]
  |   +--rw name string
  |   +--rw lower-frequency opendevicetypes:dwdm-frequency-mhz
  |   +--rw upper-frequency opendevicetypes:dwdm-frequency-mhz
  +--rw connections* [channel]
  | +--rw channel -> /channel-plan/channel/name
  | +--rw description? string
  | +--rw add!
  | | +--rw port device-dependent-port-type
  | | +--rw (mode)
  | |   +--:(attenuation)
  | |   +--rw attenuation czechlight-roadm-common:attenuation-type
  | +--rw drop!
  |   +--rw port device-dependent-port-type
  |   +--rw (mode)
  |   +--:(attenuation)
  |   +--rw attenuation czechlight-roadm-common:attenuation-type
  +--ro channel-power* [channel]
  | +--ro channel -> /channel-plan/channel/name
  | +--ro power* [location]
  |   +--ro location string
  |   +--ro optical-power opendevicetypes:optical-power-dBm
  +--ro aggregate-power* [location]
  | +--ro location string
  | +--ro optical-power opendevicetypes:optical-power-dBm
```

```
module: czechlight-roadm-device
  +--rw channel-plan
  |   +--rw channel* [name]
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```

## Routing of MCs



```
module: czechlight-roadm-device
  +--rw channel-plan
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  |   +--rw add!
  |   |   +--rw port device-dependent-port-type
  |   |   +--rw (mode)
  |   |   +--:(attenuation)
  |   |   +--rw attenuation czechlight-roadm-common:attenuation-type
  |   +--rw drop!
  |   |   +--rw port device-dependent-port-type
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  |   |   +--ro location string
  |   |   +--ro optical-power opendevicetypes:optical-power-dBm
  +--ro aggregate-power* [location]
  |   +--ro location string
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```

Independent **Add/Drop** MC paths



```
module: czechlight-roadm-device
  +--rw channel-plan
  |   +--rw channel* [name]
  |   |   +--rw name
  |   |   |   +--rw lower-frequency
  |   |   |   +--rw upper-frequency
  |   |   +--rw connections* [channel]
  |   |   |   +--rw channel
  |   |   |   |   +--rw description?
  |   |   |   |   |   +--rw add!
  |   |   |   |   |   |   +--rw port
  |   |   |   |   |   |   |   +--rw (mode)
  |   |   |   |   |   |   |   |   +--:(attenuation)
  |   |   |   |   |   |   |   |   +--rw attenuation
  |   |   |   |   |   |   |   |   |   +--rw drop!
  |   |   |   |   |   |   |   |   |   |   +--rw port
  |   |   |   |   |   |   |   |   |   |   |   +--rw (mode)
  |   |   |   |   |   |   |   |   |   |   |   +--:(attenuation)
  |   |   |   |   |   |   |   |   |   |   |   +--rw attenuation
  |   |   |   |   |   |   |   |   |   |   |   |   +--ro channel-power* [channel]
  |   |   |   |   |   |   |   |   |   |   |   |   |   +--ro channel
  |   |   |   |   |   |   |   |   |   |   |   |   |   |   +--ro power* [location]
  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   +--ro location
  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   +--ro optical-power
  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   +--ro aggregate-power* [location]
  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   +--ro location
  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   +--ro optical-power
```

**Optical Performance Monitoring**

string  
opendevicetypes:dwdm-frequency-mhz  
opendevicetypes:dwdm-frequency-mhz

-> /channel-plan/channel/name  
string

device-dependent-port-type  
(mode)  
(attenuation)  
czechlight-roadm-common:attenuation-type  
device-dependent-port-type  
(mode)  
(attenuation)  
czechlight-roadm-common:attenuation-type

[channel]  
-> /channel-plan/channel/name

[location]  
string  
opendevicetypes:optical-power-dBm

[location]  
string  
opendevicetypes:optical-power-dBm

## ■ Linux

- systemd
- glibc
- Buildroot
- RAUC

## ■ NETCONF/YANG stack

- sysrepo
- Netopeer2-server
- libyang
- libnetconf2

## ■ Interactive CLI console

- netconf-cli

[<https://gerrit.cesnet.cz/plugins/gitiles/CzechLight/netconf-cli/>]

## ■ Redundancy

- Failsafe in-the-field updates
- A/B firmware slots
- HW watchdog
- Hot-swap fans + server-grade PSUs



- Prototypes are ready

- **Opening up ROADMs: Let's Build a Disaggregated Open Optical Line System**

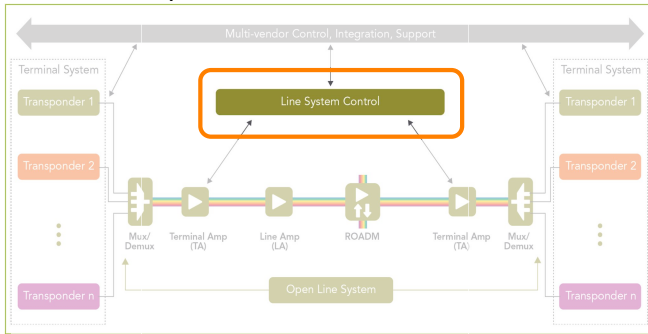
DOI: 10.1109/JLT.2019.2906620

<https://ieeexplore.ieee.org/document/8675347>

- Do you want to start building this?



- Prototypes are ready
- **OLS Controller**
  - ODTN
  - T-API implementation



- Prototypes are ready
- OLS Controller
- **Looking for collaboration**
  - Telecom Infra Project
  - OpenROADM
  - IETF CCAMP

cesnet  
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TIP Summit 2018, London



cesnet  
.....



we are a provider of national e-infrastructure  
for science, research and education

Innovative approach to optical networking:  
SDN, Czechlight™, no more vendor lock-in.

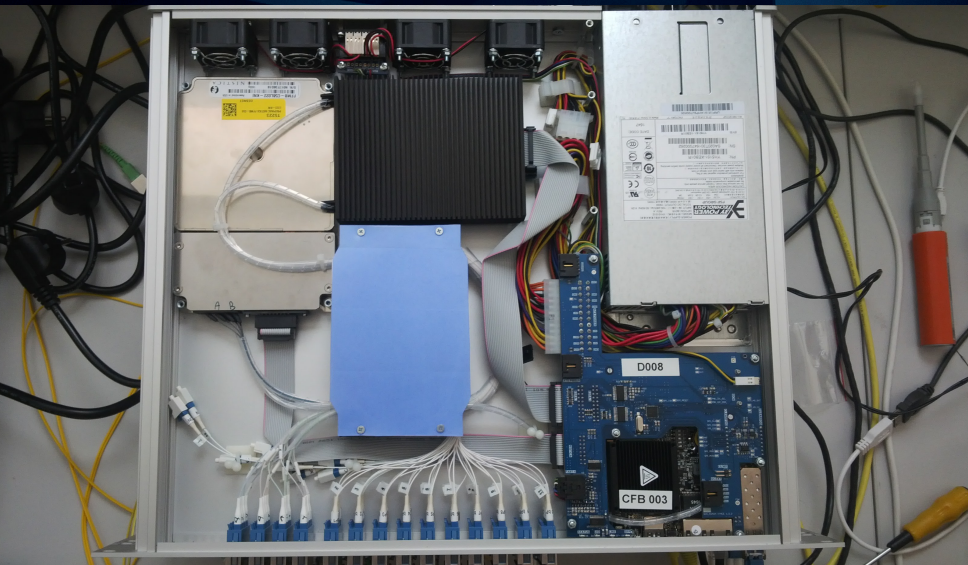
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czechlight  
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SDN at Layer 0

open-line system

cesnet  
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# Peek Inside the Add/Drop Box







Q & A

jan.kundrat@cesnet.cz  
<https://czechlight.cesnet.cz/>

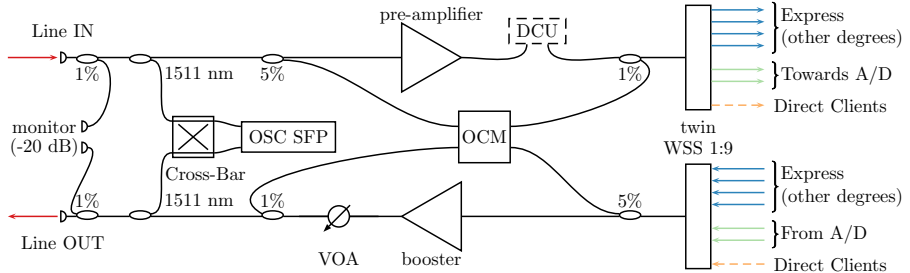


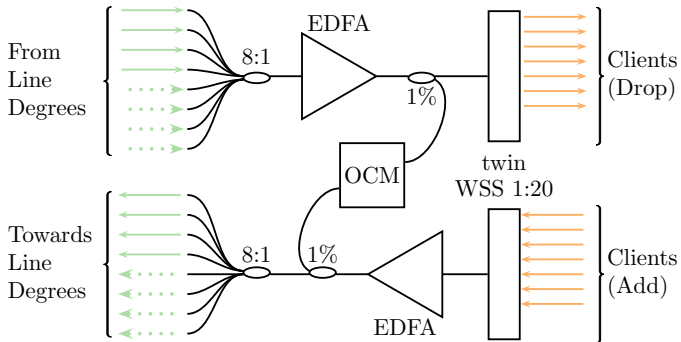


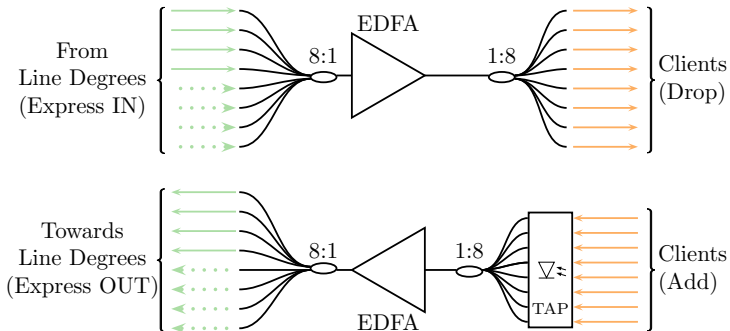
cesnet  
"...."

## Schematics and Optical Performance









## ■ Power Budget

- Integrated EDFA+VOA, span loss 0 — 25 dB
- Line IN: -25 dBm/channel
- Line OUT: target 0 dBm/channel
- Add: -15 — +5 dBm/channel

- Line Degree and WSS Add/Drop
  - Optical Channel Monitor
  - Resolution: 6.25 GHz
  - Refresh rate: 3 Hz
- Coherent Add/Drop
  - Power Monitoring (no spectrum)
  - Refresh rate: 20 Hz
- Amplifiers
  - EDFA's PD
- 1% Integrated Taps
  - Line TX, RX



Q & A

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<https://czechlight.cesnet.cz/>

