Digital coherent optics Deployment and management

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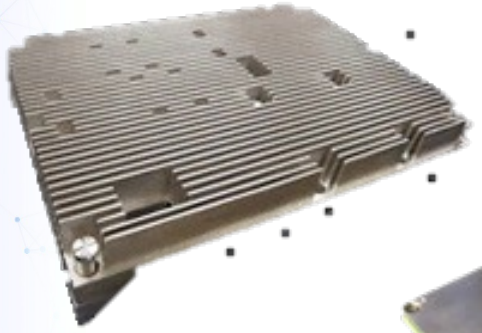
Agenda

- Digital Coherent Optics overview
- Deployment examples
- DCO management

Coherent router optics evolution

2011 2014 2016 2019 2020 2024 2026



5x7 inches

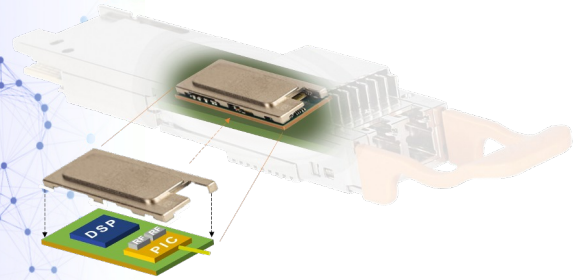
3x6 inches

CFP2-ACO

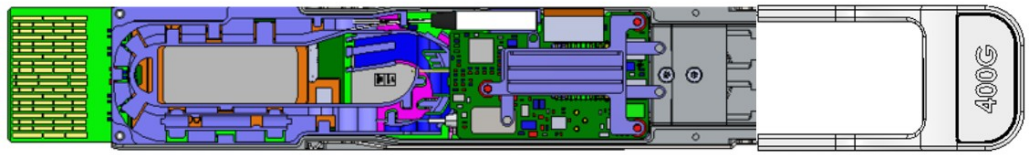
CFP2-DCO

QSFP-DD
OSFP

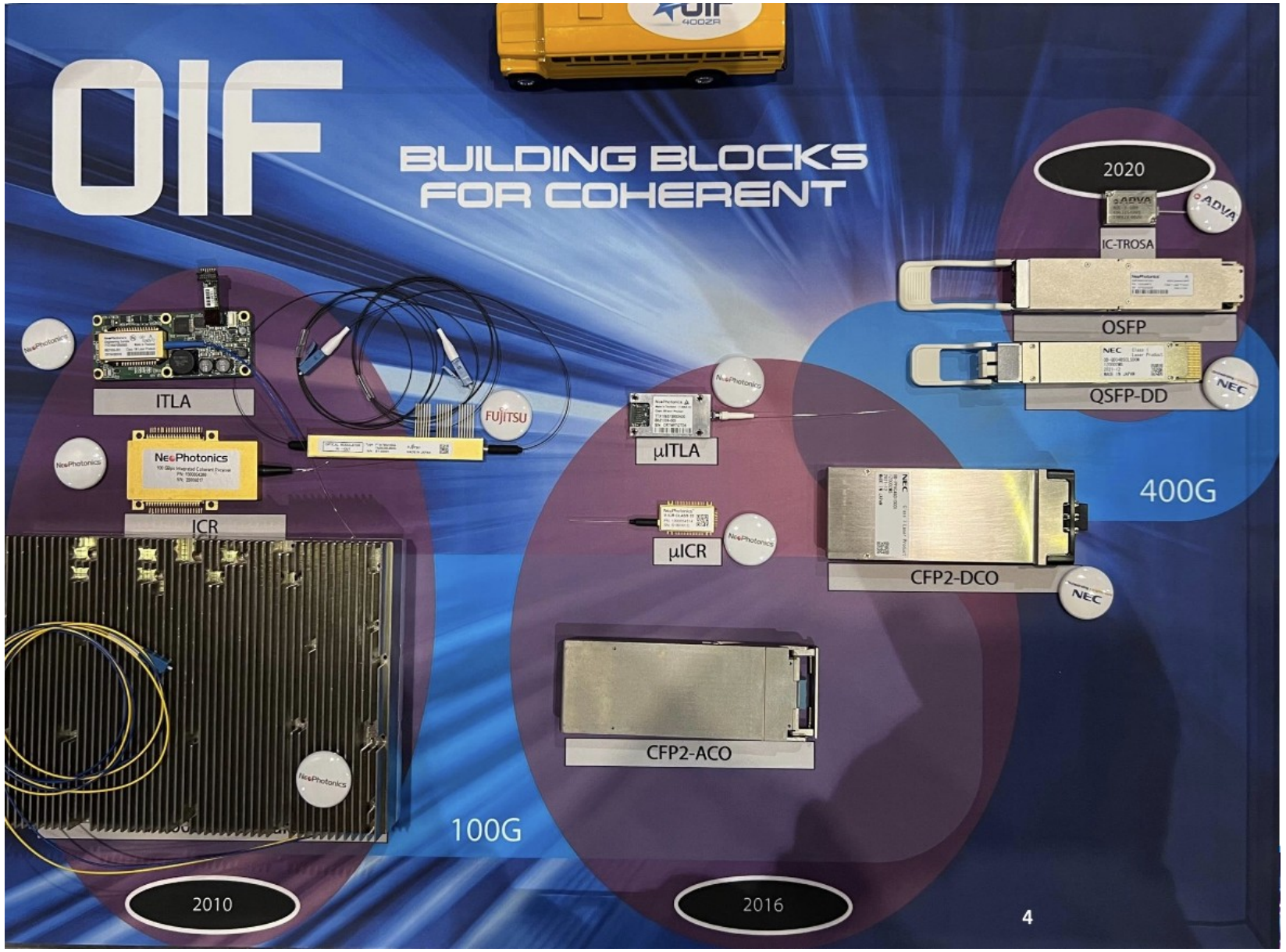
QSFP28



EDFA fiber tray with ~4ft of fiber



Coherent router optics evolution



Picture from Karl Gass (OIF)

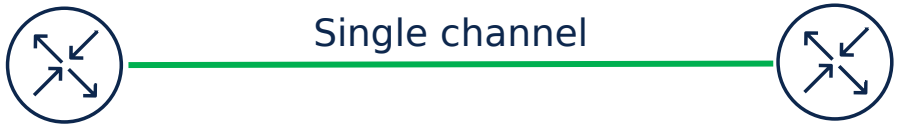
Coherent optics standards

	OIF 400ZR	OIF 800ZR	OpenZR+ 400ZR+	OpenROADM 800G	100G-ZR
Media Rates	400	800	100, 200, 300, 400	400, 600, 800	100
Host Rates (NxMedia)	400	100, 200, 400, 800	100, 200, 400	100, 200, 400, 800	100
Reach	< 120km amplified	< 120km amplified	~1200km amplified	~1000km amplified for 800G	~500km amplified
FEC	cFEC	oFEC	cFEC, oFEC	oFEC	SC-FEC
Modulation	16QAM	16QAM	QPSK, 8QAM,16QAM	QPSK, 16QAM, PCS	QPSK
Baud Rate	60G	~118G	30-61G	60-131G	31G
Power Consumption	15W	30W	15-24W	20-30W	<6W

- OpenZR+ is adopting subset of OpenROADM for 800G
- Most 800G optics are compatible with OIF/OZR+ 400G standards
- 1.6T coherent standards work is well under way in OIF and other groups

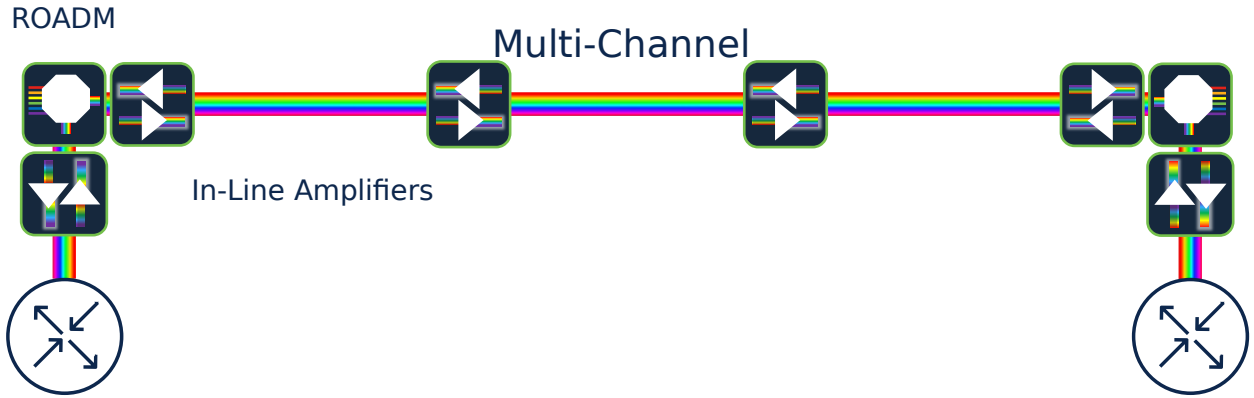
Common Deployment Types

Dark fiber
Unamplified



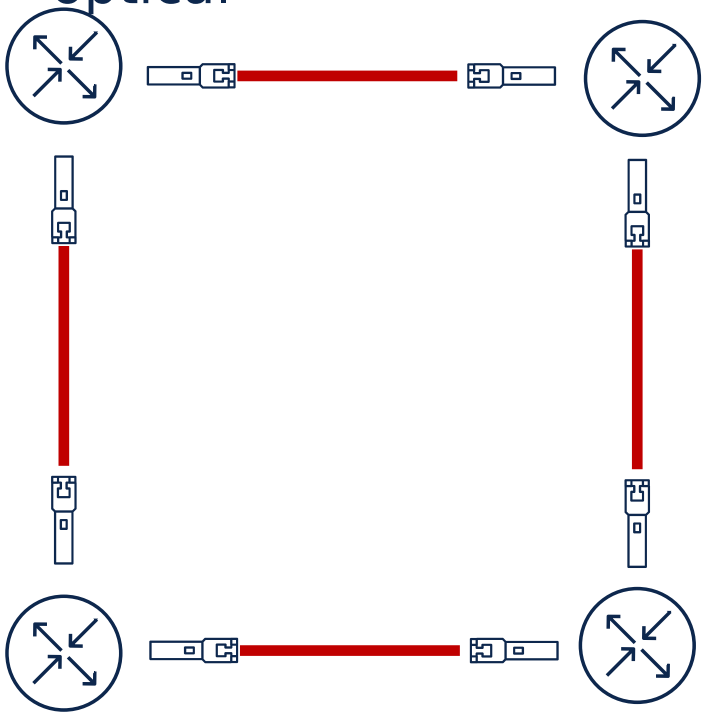
Point-to-point DWDM
Amplified

Multi-degree DWDM
(ROADMs, ILAs)

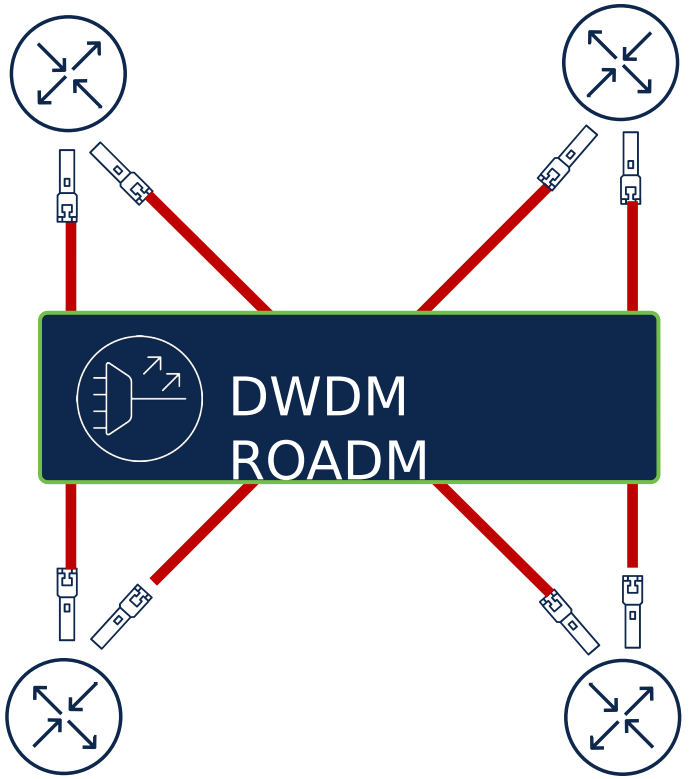


Topology flexibility

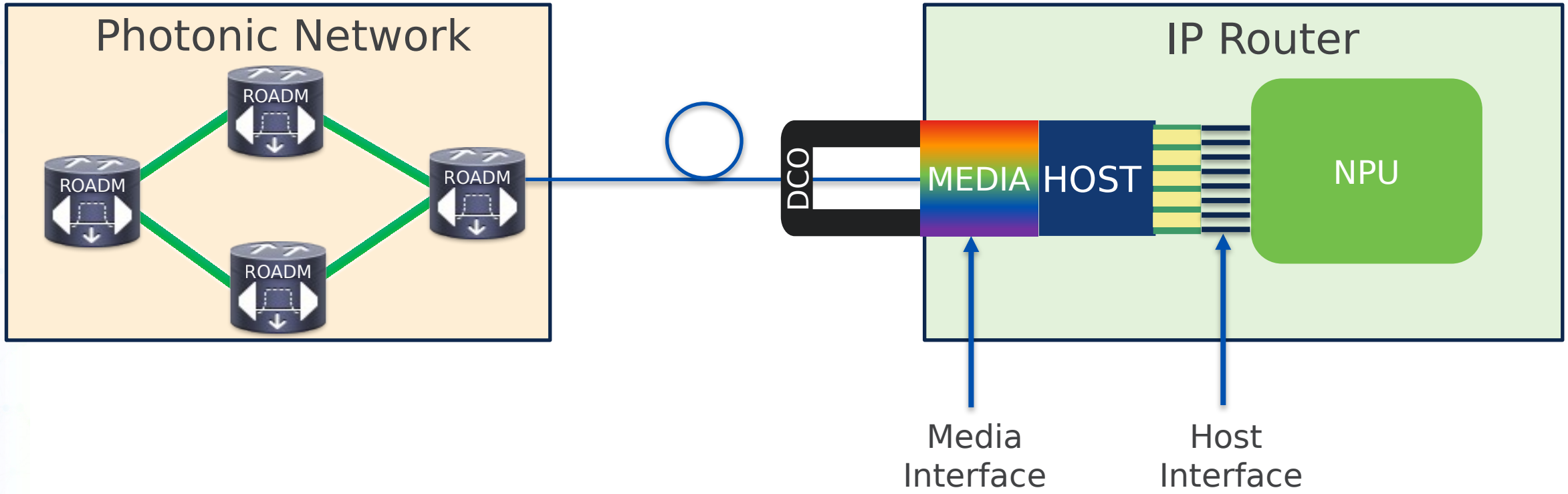
P2P with simplified optical



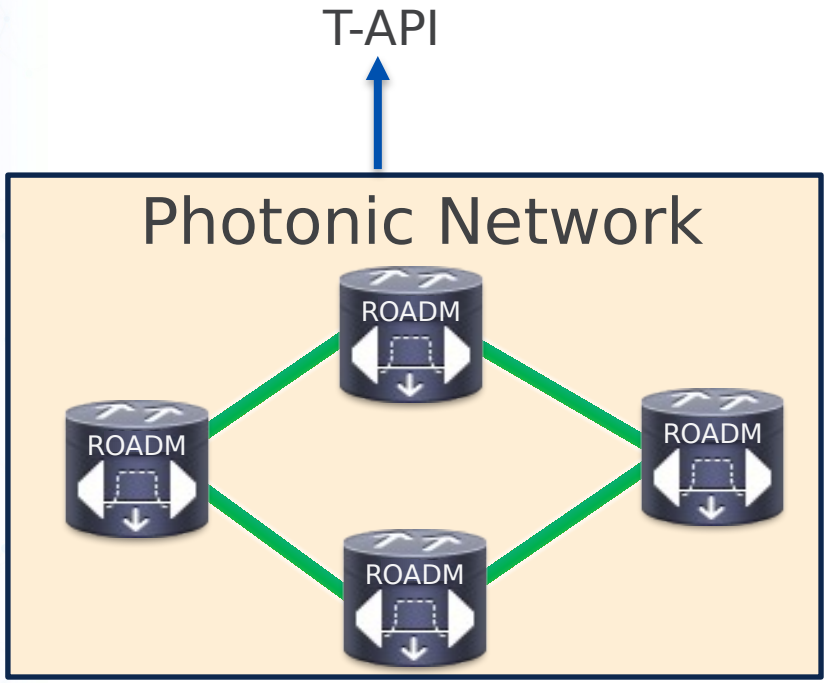
Multi-degree ROADM, photonic bypass



Network Management Domains



Network Management Domains - Photonic



- Photonic network open management is primarily performed using Linux Foundation OMNI (previously ONF) T-API
- Covers most required areas such as physical inventory, circuit management, and performance
- May undergo some changes to adopt IETF hardware inventory model schema
- Current version is 2.5.2 / 2.6 in development

https://github.com/Open-Network-Models-and-Interfaces-ONMI/TAPI/tree/develop/YANG

Router host to coherent pluggable standards

Optical Interworking Forum
CMIS – Common Management Interface Specification
C-CMIS – Coherent CMIS

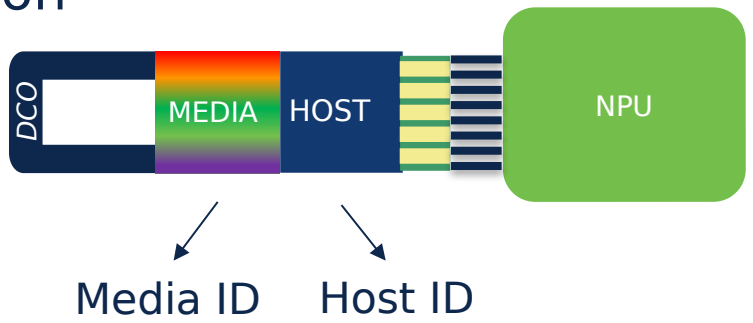
Storage Networking Industry Association
Small Form Factor Technical Working Group
SFF-8024 – SFF Module Management Reference Code Table

Router host to coherent pluggable standards

SFF-8024 – SFF Module Management Reference Code Tables

This specification provides codes for module identifiers, encoding values, connector types, extended compliance codes, host electrical interfaces and module media interfaces.

Defines standardized numerical identifiers for pluggable transceiver host and media configuration



https://members.snia.org/document/dl/26423&ved=2ahUKEwj2-9LO9KSUAxWDNWIAHfLNOocQFnoECBgQAQ&usg=AOvVaw27sCzSpuARNpQxHGRDCd23 for latest published standard (4.13)

https://members.snia.org/document/dl/26714 for 4.13.2 draft version

Router host to coherent pluggable standards

SNIA SFF TWG Technology Affiliate

SFF-8024 – Media ID table 4-7 for Single Mode optics

ID	ID (Hex)	SM Media Interface (Specification Reference)	Application Bit Rate, Gb/s	Lane Count	Lane Signaling Rate, GBd	Modula-tion	b/UI
		OIF					
62	3E	400ZR (0x01-0x03), DWDM, amplified	478.75	1	59.84375	DP-16QAM	8
63	3F	400ZR (0x02), Single Wavelength, Unamplified	478.75	1	59.84375	DP-16QAM	8
108	6C	800ZR-A (0x01), 150 GHz DWDM, Tx Output Range A, placeholder	945.626,804, 824	1	118.203,350, 603	DP-16QAM	8
109	6D	800ZR-B (0x02), 150 GHz DWDM, Tx Output Range B, placeholder	945.626,804, 824	1	118.203,350, 603	DP-16QAM	8
110	6E	800ZR-C (0x03), 150 GHz DWDM, Tx Output Range C, placeholder	945.626,804, 824	1	118.203,350, 603	DP-16QAM	8
		OpenZR+					
70	46	ZR400-OFEC-16QAM	481.108374	1	60.1385468	DP-16QAM	8
53	35	ZR400-OFEC-16QAM-HA	481.108374	1	60.1385468	DP-16QAM	8

Snapshot of media ID values for standard/MSA based coherent modes

Host ID values for Ethernet are based on IEEE / MSA standards

What does the “Media” code represent?

SNIA SFF TWG Technology Affiliate

SFF-8024 – SFF Module Management Reference Code Tables

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109	6D	800ZR-B (0x02), 150 GHz DWDM, Tx Output Range B, placeholder	945.626,804, 824	1	118.203,350, 603	DP-16QAM	8
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Snapshot of media ID values for standard/MSA based coherent modes

Host ID values (not shown) for Ethernet are based on IEEE and MSA
Media ID values for coherent optics based on standards (OIF) and MSA

Router host to coherent pluggable standards

CMIS – Common Management Interface Specification

- CMIS Implementation Agreement defines a set of functions for the management of pluggable optical modules. Provisioning of optical parameters, security, monitoring, firmware management, etc.
- Current CMIS version is 5.3 with 5.4 being released shortly
- CMIS defines optics “applications” and codes to select specific applications and through an abstracted value configure parameters like modulation and baud rate

https://www.oiforum.com/wp-content/uploads/OIF-CMIS-05.3.pdf
https://www.oiforum.com/wp-content/uploads/OIF-CMIS-Plug-and-Play-01.0.pdf

Router host to coherent pluggable standards

CMIS – Common Management Interface Specification

CMIS defines a set of functions for the management of pluggable optical modules. Provisioning of optical parameters, monitoring, firmware management, and provisioning using Application Codes.

*An **application** is a mode of operation for a module, defined by a specific combination of an industry standard host electrical interface and an industry standard media interface*

```
RP/0/RP0/CPU0:ron-8711-32fh-1#show controllers optics 0/0/0/0 appsel advertised
-------------------------------------------------------------------------------------------------------------------
-----------
  App-ID  |  Host-ID                       |  Media-ID                       |  Standard                |  Host     |  Power
         |                                |                                 |                          |  Supported|
Consumption(W)  |
-------------------------------------------------------------------------------------------------------------------
-----------
  1       |  81    ETH 800GAUI-8 S C2M     |  108   OIF 800ZR-A (0x01) 150GH |  OIF                     |  Yes      |  n/a
         |
  2       |  82    ETH 800GAUI-8 L C2M     |  108   OIF 800ZR-A (0x01) 150GH |  OIF                     |  Yes      |  n/a
         |
  3       |  79    ETH 400GAUI-4-S C2M (Ann |  108   OIF 800ZR-A (0x01) 150GH |  OIF                     |  Yes      |  n/a
         |

  1       |  81          |  108         |  8         |  1         |  0x1         |  0x1         |  Yes       |
  2       |  82          |  108         |  8         |  1         |  0x1         |  0x1         |  Yes       |
  3       |  79          |  108         |  4         |  1         |  0x11        |  0x1         |  Yes       |
```

CMIS < 5.3 = 15 codes
CMIS >= 5.3 = 240 codes
Cisco 800G-ZR has 128 modes

Router host to coherent pluggable standards

```
RP/0/RP0/CPU0:ron-8711-32fh-1#show controllers optics 0/0/0/0 appsel detailed
-------------------------------------------------------------------------------------------------------
  App-ID  |  Host-ID     |  Media-ID    |  Host Lane |  Media Lane|  Host Lane   |  Media Lane  |  Host      |
          |              |              |  Count     |  Count     |  Assign      |  Assign      |  Supported |
-------------------------------------------------------------------------------------------------------
  1       |  81          |  108         |  8         |  1         |  0x1         |  0x1         |  Yes       |
  3       |  79          |  108         |  4         |  1         |  0x11        |  0x1         |  Yes
```

App-ID 1 example

- 1x800G lane
- ~945 Gbit/s w/FEC
- 118Gbaud
- 16QAM modulation
- 8 bits/symbol

- IEEE 800GAUI-8 C2M standard
- 8 electrical lanes at 53.125 Gb/s
- PAM4 modulation, 2 bits/symbol
- Results in 1x800G Ethernet interface

Media ID	108	6C	800ZR-A (0x01), 150 GHz DWDM, Tx Output Range A	945.626,804,824	1	118.203,350,603	DP-16QAM	8
Host ID	81	51	800GAUI-8 S C2M (Annex 120G)	850.00	8	53.125	PAM4	2

Router host to coherent pluggable standards

C-CMIS – Coherent Common Management Interface Specification

- C-CMIS (Coherent CMIS) is a companion specification to extend CMIS to better manage coherent optics. Key component is standardized registers, data types, and units for performance data.
- Key component is standardized registers, data types, and units for performance data.
- Current version is 1.4 with 1.5 to be published shortly

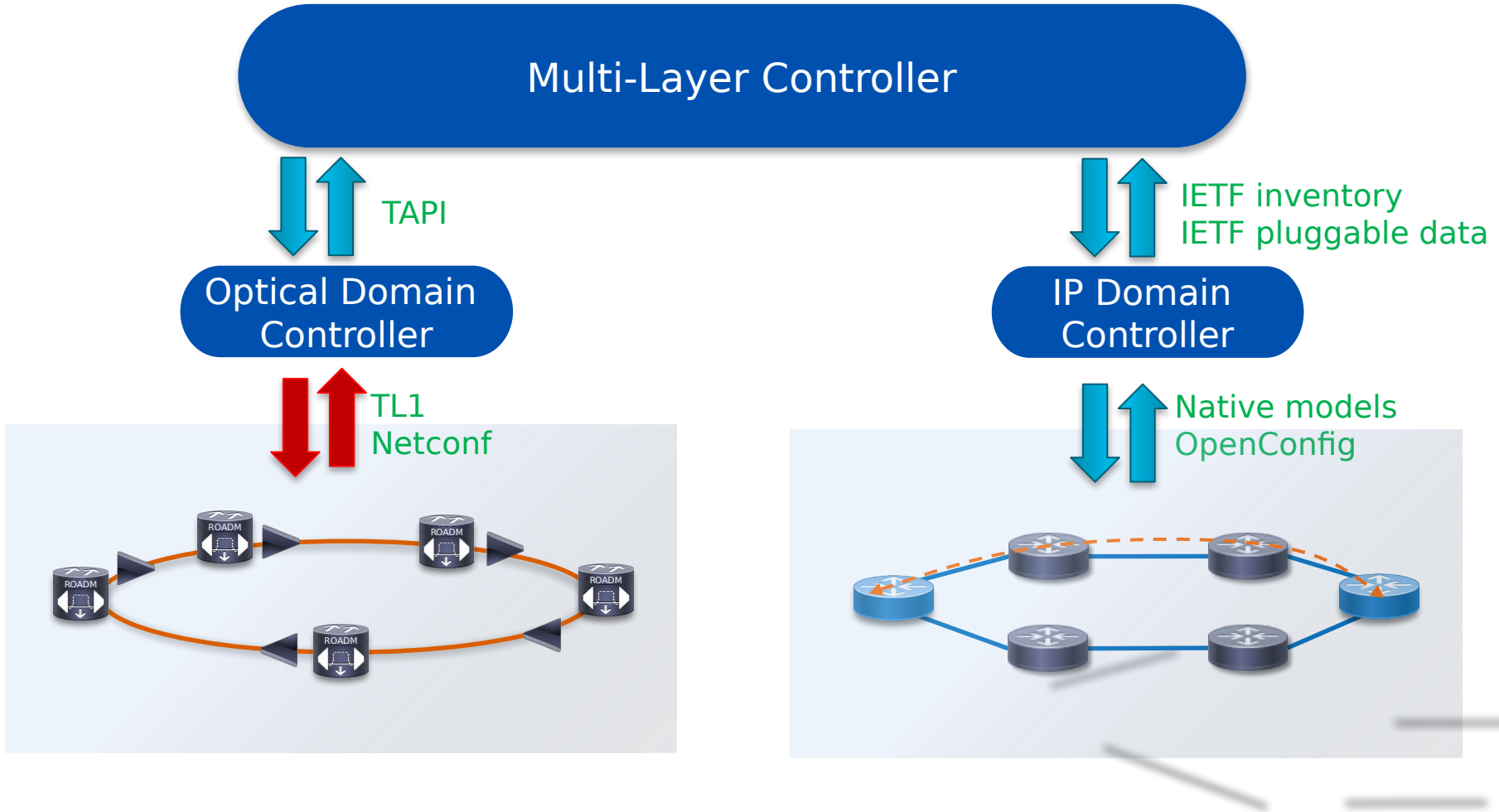
https://www.oiforum.com/wp-content/uploads/OIF-C-CMIS-01.4.pdf

Model driven management

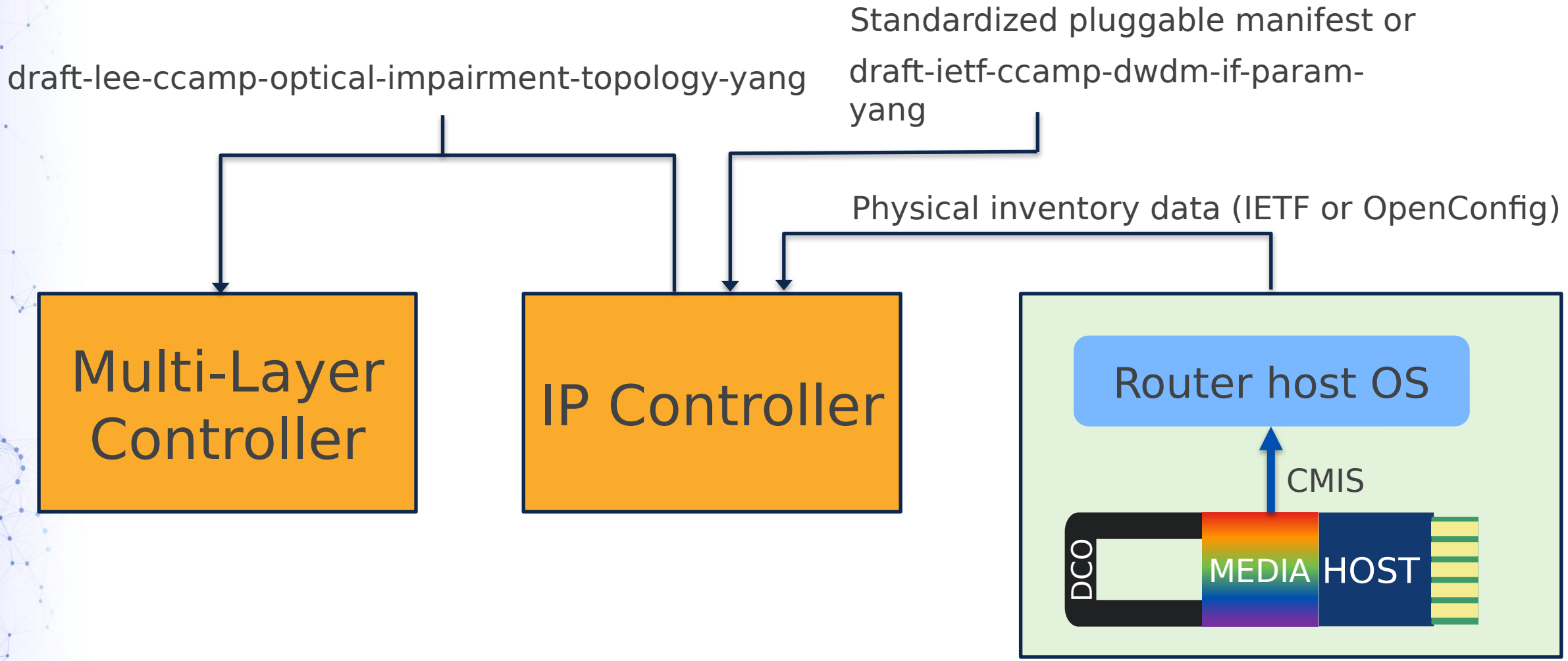
Multi-Domain

Domain

Device

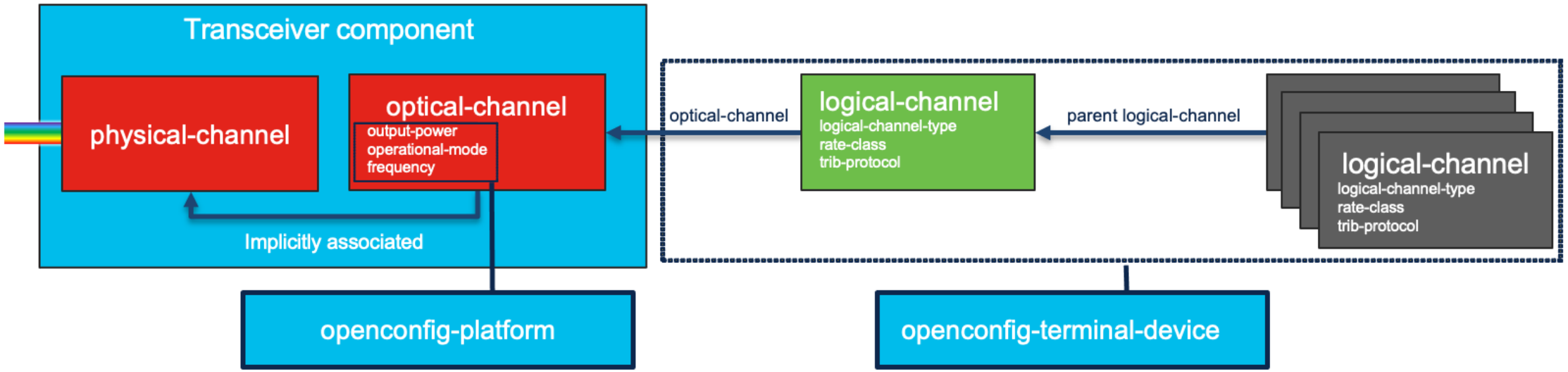


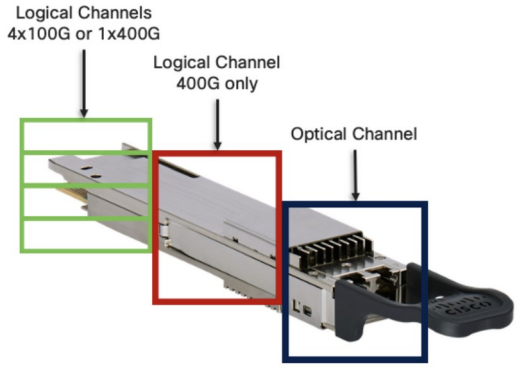
Model-driven dynamic DCO AppSel Discovery



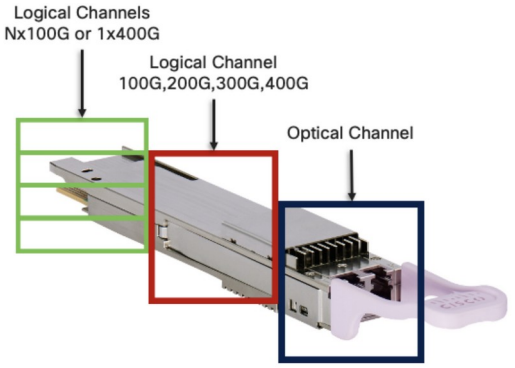
OpenConfig device provisioning

openconfig-terminal-device supports pluggable optics and traditional xponders





OIF 400ZR



OpenZR+

OpenConfig provisioning

The “operational-mode” in OpenConfig is a numeric identifier to provision additional line-side properties such as modulation and FEC. Not standardized.

5003 used below is a Cisco assigned operational-mode for OIF 400G ZR AppSel 1
6xxx going forward is being used to represent actual AppSel value

```
5003  NONE      16QAM                              OIF400ZR:C_FEC:Modulation_16QAM
```

```
<components xmlns="http://openconfig.net/yang/platform">
            <component>
                <name>OpticalChannel0/0/0/10</name>
                <optical-channel xmlns="http://openconfig.net/yang/terminal-device">
                    <config>
                        <target-output-power>-10.00</target-output-power>
                        <operational-mode>5003</operational-mode>
                        <frequency>194300000</frequency>
                    </config>
                </optical-channel>
            </component>
        </components>
```

OpenConfig monitoring

```
gnmic -a 172.21.23.28 --port 57733 -u * -p * --encoding json_ietf --insecure subscribe --path
"components/component[name=OpticalChannel0/0/0/10]/optical-channel/state" --mode once
```

Pre-FEC BER


```
{
  "source": "172.21.23.28:57733",
  "subscription-name": "default-1741915818",
  "timestamp": 1741915812525455104,
  "time": "2025-03-13T20:30:12.525455104-05:00",
  "prefix": "openconfig-platform:",
  "updates": [
    {
      "Path":
"components/component[name=OpticalChannel0/0/0/16]",
      "values": {
        "components/component": {
          "openconfig-terminal-device:optical-channel": {
            "state": {
              "pre-fec-ber": {
                "avg": "2.0E-09",
                "instant": "2.4E-09",
                "interval": "5000000000",
                "max": "3.8E-08",
                "max-time": "1741915811",
                "min": "0.0E+00",
                "min-time": "1741915811"
              }
```


TX Power


```
{
  "source": "172.21.23.28:57733",
  "subscription-name": "default-1741916595",
  "timestamp": 1741916594370587910,
  "time": "2025-03-13T20:43:14.37058791-05:00",
  "prefix": "openconfig-platform:",
   "updates": [
    {
      "Path":
"components/component[name=OpticalChannel0/0/0/16]",
      "values": {
        "components/component": {
          "openconfig-terminal-device:optical-channel": {
            "state": {
              "output-power": {
                "avg": "2.01",
                "instant": "2.02",
                "interval": "5000000000",
                "max": "2.04",
                "max-time": "1741916591",
                "min": "1.98",
                "min-time": "1741916591"
              }
```

How are operators bridging the gap?

- Combined IP and Optical teams are more common even at large operators and especially smaller operators
- The cost savings have been enough to drive collaboration or combination of teams where there were typically silos
- Workflow hasn’t changed much but more coordination for planning to relay wavelengths to turn-up team

Thank You

Q&A

TIG stack monitoring of DCO

- Cisco gNMI plugin works across vendors
- ”Dial-in” telemetry meaning the collector subscribes to telemetry paths, dial-out is also available but is not as widely deployed

```
[[inputs.gnmi]]
  addresses = ["172.29.11.20:57733"]

  username = "admin"
  password = ”****"
  redial = "10s"


  [[inputs.gnmi.subscription]]
    name = "Lab-Cisco-IOS-XR-controller-optics-oper:/optics-oper/optics-ports/optics-port/optics-info"
    origin = "Cisco-IOS-XR-controller-optics-oper"
    path = "/optics-oper/optics-ports/optics-port/optics-info"
    subscription_mode = "sample"
    sample_interval = "60s"

  [[inputs.gnmi.subscription]]
    name = "Lab-Cisco-IOS-XR-controller-otu-oper:/otu/controllers/controller/info"
    origin = "Cisco-IOS-XR-controller-otu-oper"
    path = "/otu/controllers/controller/info"
    subscription_mode = "sample"
    sample_interval = "60s"
```