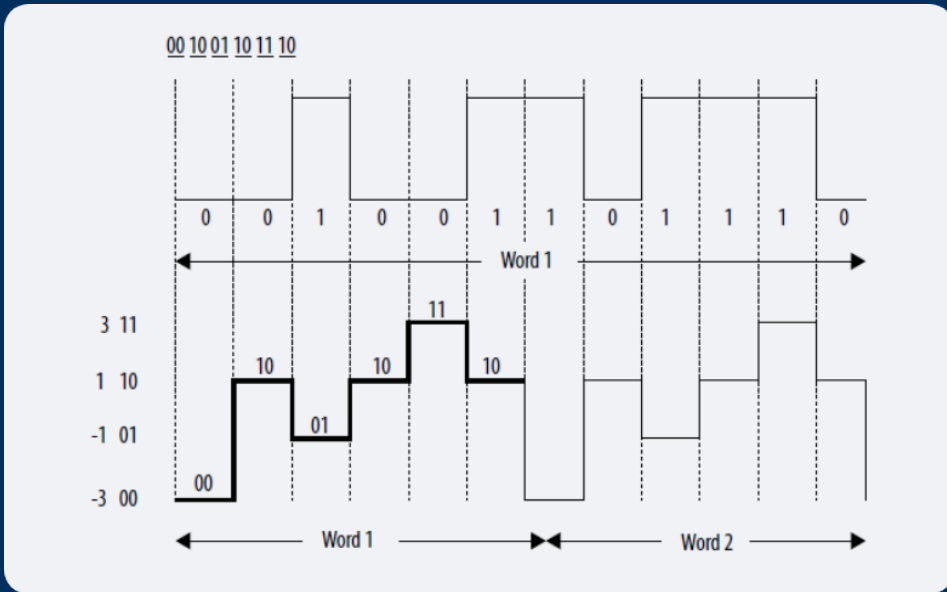


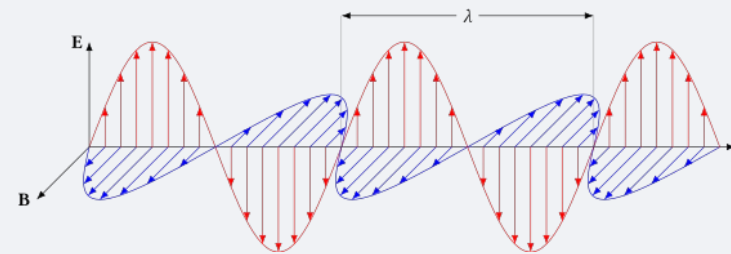
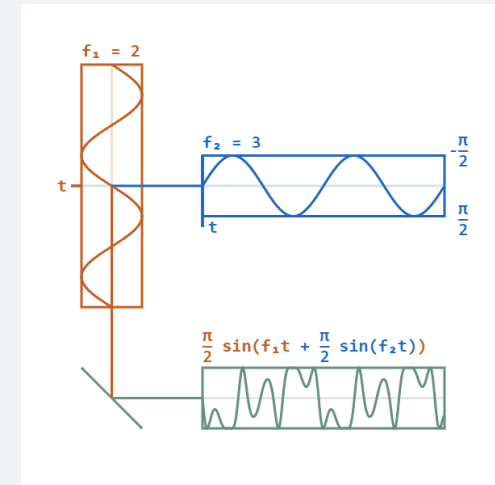
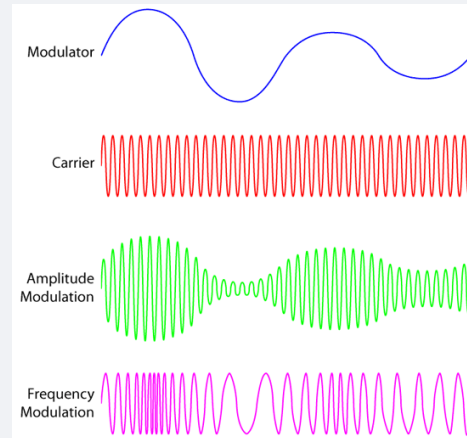
**Efficient and cost-effective
IP-over-DWDM optical networks
based on QSFP28 100G and QSFP-DD
400G coherent optical modules.**



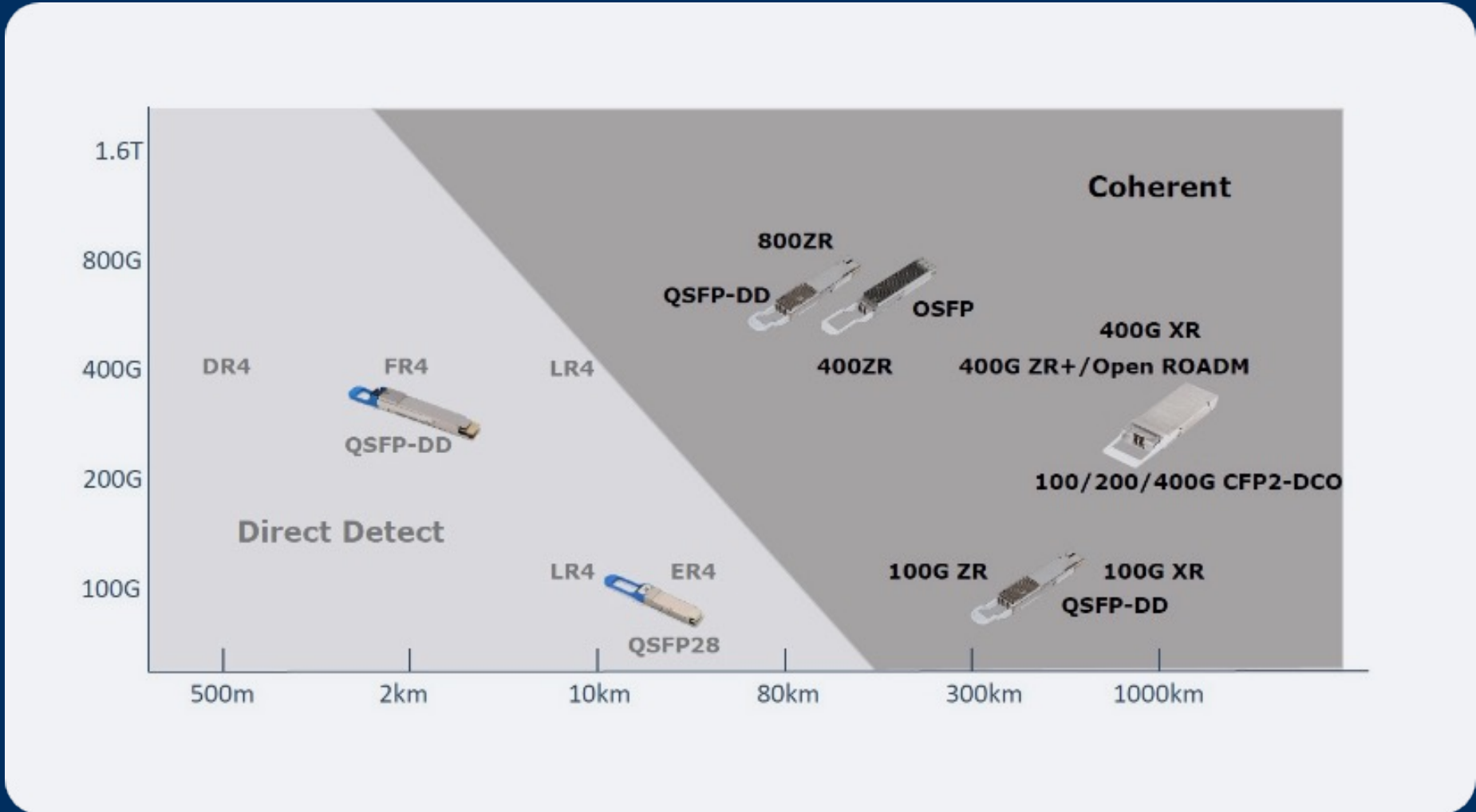
NRZ: The Simple Starter PAM4: Doubling the Data Flow



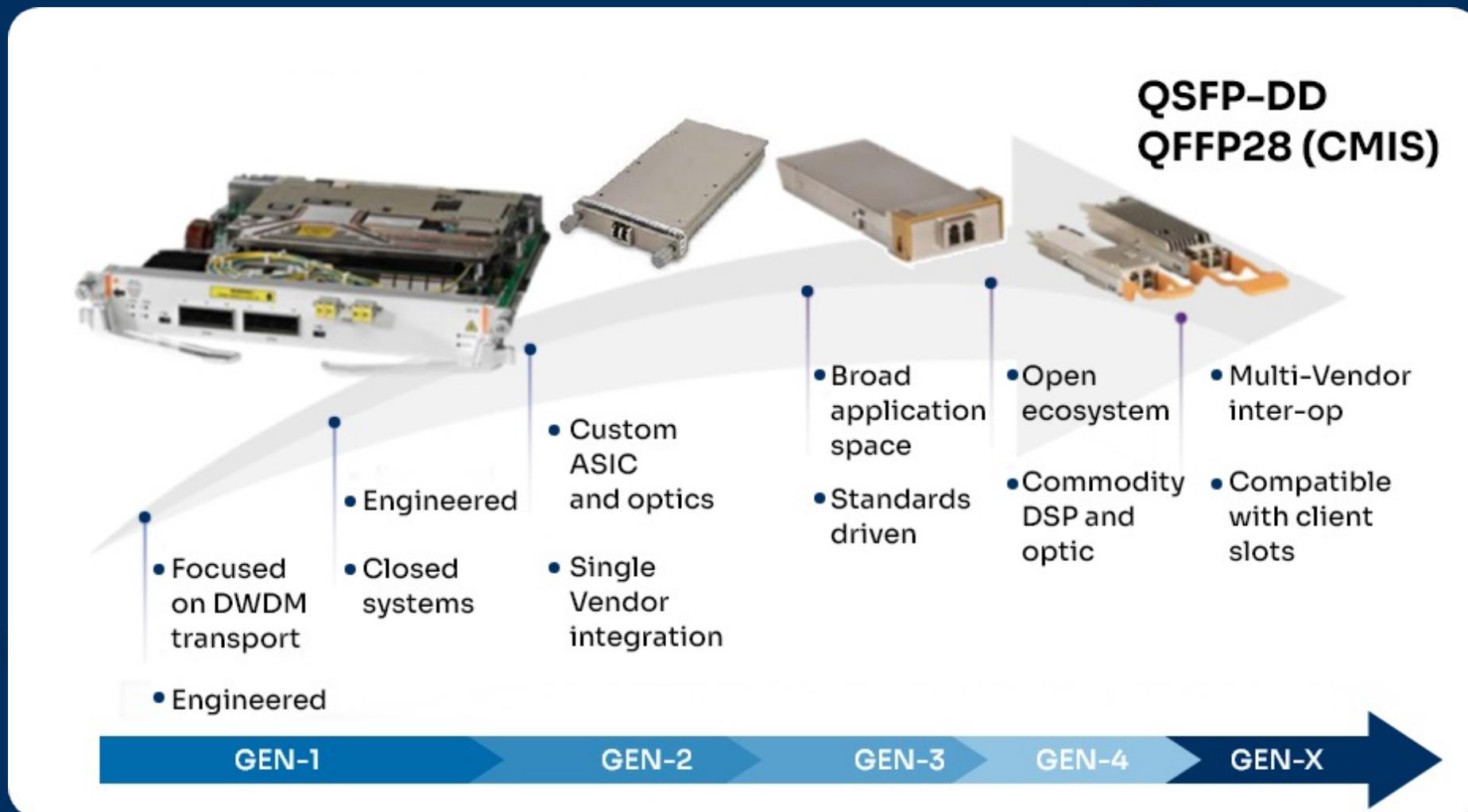
Coherent Modulation: Unveiling a New Realm of Speed



Pluggable modules division



Coherent solutions evolution



Coherent optical modules QSFP-DD 400G



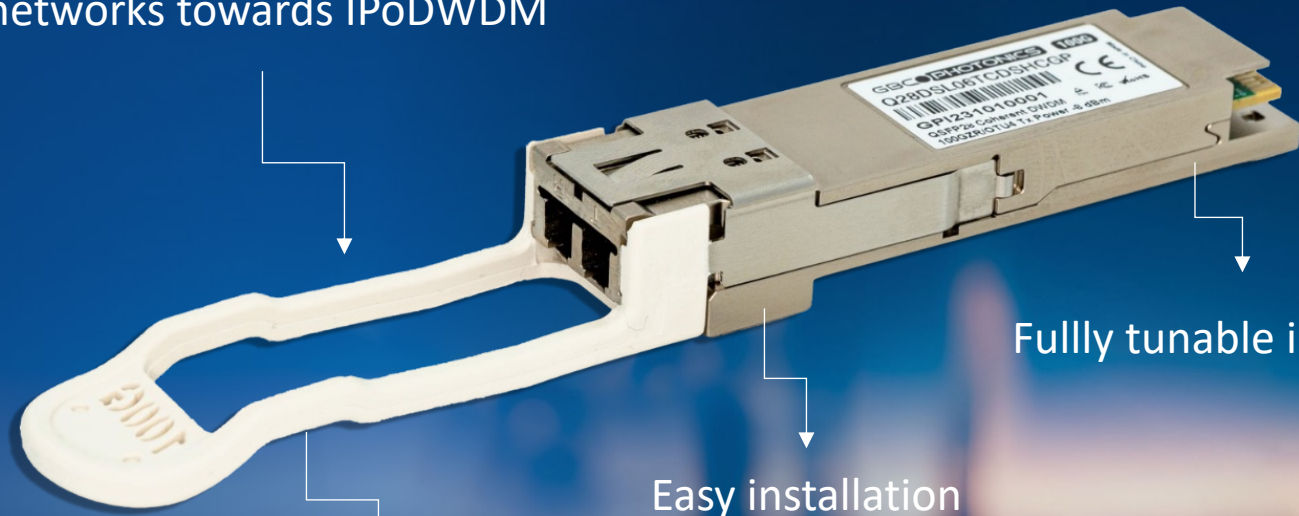
Standardization

Reach	< 120 km	> 120 km
Client	400GbE Only	100-400GbE
Application	DCI, Campus, Metro	DCI, Metro, Regional, Long haul
FEC	C-FEC	O-FEC
Power Consumption	15W	20W
Multi-vendor Interoperability	Yes	Yes
Standards	OIF	OpenZR + MSA

Coherent Transceiver QSFP-DD 400 ZR+ 0dBm.

Ideal for optimizing DWDM
networks towards IPoDWDM

Low power consumption

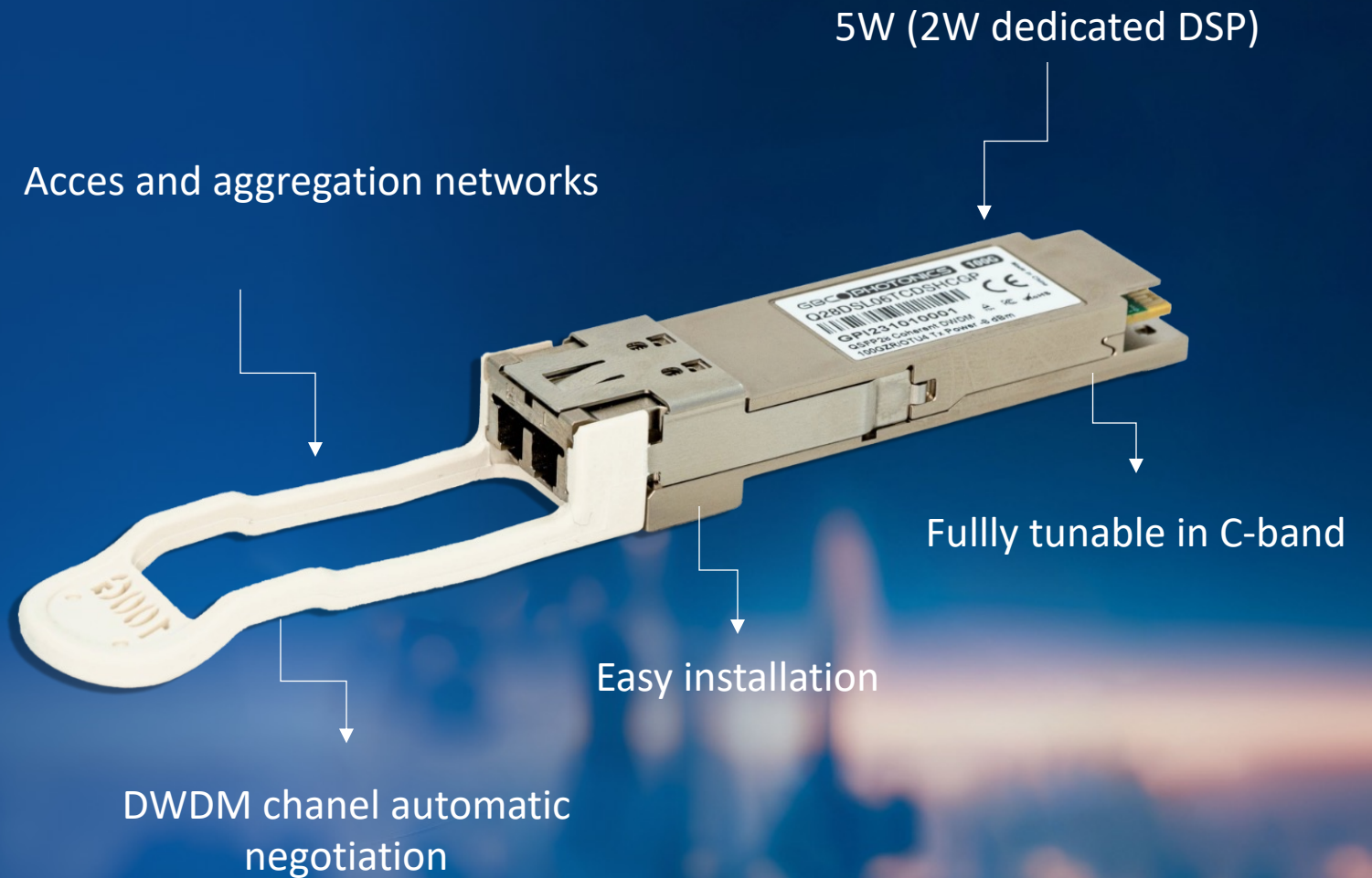


Fully tunable in C-band

Easy installation

High signal quality

Coherent Transceiver QSFP28 100G.



Coherent modules QSFP28 100G - variants

CMIS based:

1. Standard Tx output power -8dBm, 100GE & OTU4
2. High Tx output power 0dBm, 100GE & OTU4

SFF-8636 based:

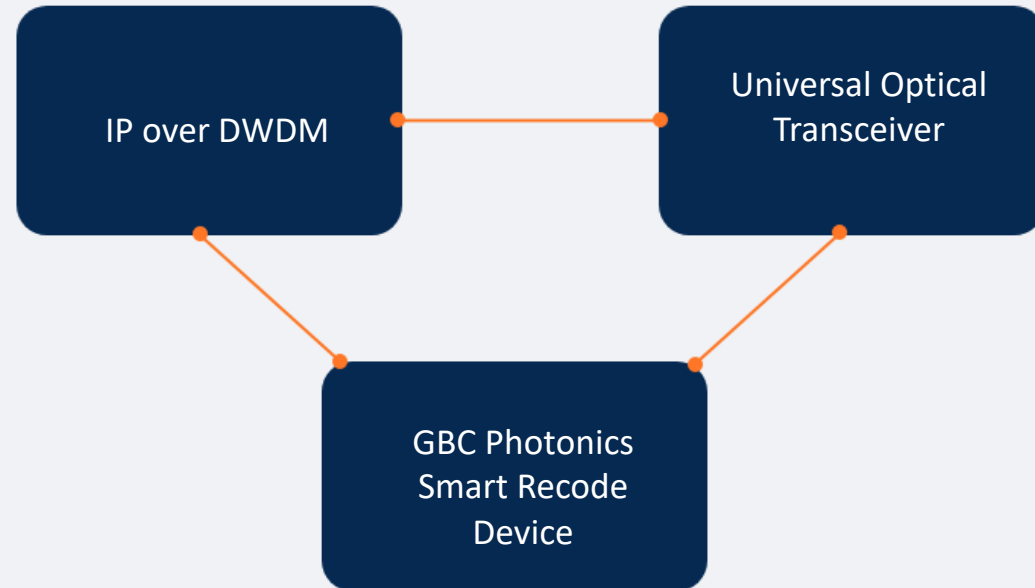
3. Standard Tx output power -8dBm, 100GE
4. High Tx output power 0dBm, 100GE



Coherent modules QSFP28 100G - roadmap



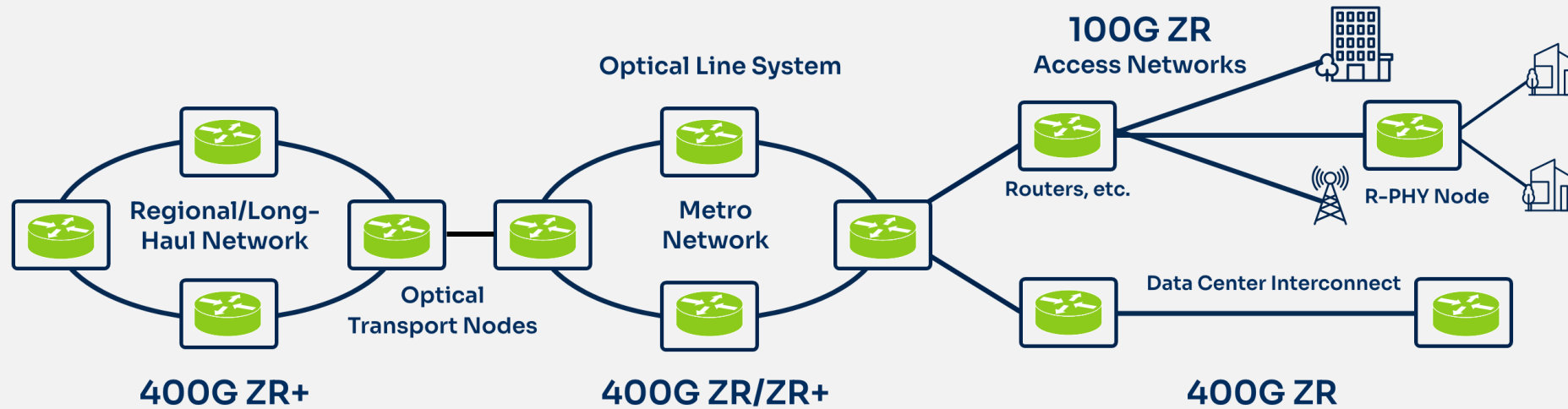
Business advantages



Business advantages

Optic	Reach	Cost (CAPEX)	Power	Space
	km	per 400GE port		
Transponder@800G	150/60	87	140 W	0,17 RU
Transponder@600G	1000/700	100	168 W	0,20 RU
Transponder@400G	2000	121	188 W	0,23 RU
OpenZR+@400G	1040/480	59	58 W	0,11 RU
OpenZR+@300G	2300/1600	92	78 W	0,16 RU
400ZR DCI	120/80	47	58 W	0,11 RU

Business advantages



Current 400G ZR, ZR+ compatibility:

1. Nokia (tested on 7750 SR, OS 22.10.R5, 23.3.R2)
2. Juniper (tested on PTX 10008, OS 23.1R1.8)
3. Cisco (8201, OS 7.9.1)
4. UfiSpace (IP Infusion 6.4.2, DriveNets 18.0.0)
5. Edgecore (IP Infusion 6.4.2, DriveNets 18.0.0)

Business advantages – coherent QSFP-DD 400G on Nokia 7750 SR

```
[/]  
A:admin@prod-lab03c-ral# show vershow version  
TiMOS-C-22.10.R5 cpm/hops64 Nokia 7750 SR Copyright (c) 2000-2023 Nokia.
```

```
[/]  
A:admin@prod-lab03c-ral# show chassisshow chassis  
=====  
System Information  
=====  
Name : prod-lab03c-ral  
Type : 7750 SR-7s  
Chassis Topology : Standalone  
Location : (Not Specified)  
Coordinates : (Not Specified)  
CLLI code :  
Number of slots : 8  
Oper number of slots : 8  
Num of faceplate ports/connectors : 36  
Num of physical ports : 29  
Critical LED state : Off  
Major LED state : Off  
Minor LED state : Amber  
Over Temperature state : OK  
Base MAC address : 10:e8:78:00:b0:01  
FP Generations : FP4  
System Profile : profile-a
```

Coherent Optical Module

```
=====  
Cfg Tx Target Power: -6.00 dBm  
Cfg Rx LOS Thresh : -23.00 dBm  
  
Disp Control Mode : automatic  
Cfg Dispersion : 0 ps/nm  
CPR Window Size : 32 symbols  
Compatibility : longHaul  
Cfg Tx Power Min : -6.00 dBm  
Cfg Tx Power Max : 1.00 dBm  
  
Cfg Alarms : modflt mod netrx nettx hosttx  
Alarm Status :  
Defect Points :  
  
Rx Q Margin : 4.6 dB  
SNR/OSNR X Polar : 17.8 dB / 29.7 dB  
SNR/OSNR Y Polar : 17.8 dB / 29.7 dB  
  
Sweep Start Disp : -25500 ps/nm  
Sweep End Disp : 2000 ps/nm  
Rx LOS Reaction : squelch  
  
Chromatic Disp : 0 ps/nm  
Diff Group Delay : 1 ps  
Pre-FEC BER : 2.540E-04  
  
Module State : ready
```

```
[/]  
A:admin@prod-lab03c-ral# show port 1/1/c25 detail  
=====  
QSFP-DD Connector  
=====  
Description : ** In use for OpenZR+ testing **  
Interface : 1/1/c25  
FP Number : 3  
Licensed : Yes  
Admin State : up  
Oper State : up  
IfIndex : 1610901056  
Last State Change : 09/14/2023 16:48:22  
Last Cleared Time : N/A  
Breakout : c1-400g  
RS-FEC Config Mode : None  
MAC Chip Number : 9  
DDM Events : Enabled  
  
Transceiver Data  
  
Transceiver Status : operational  
Transceiver Type : QSFP-DD  
Model Number : 3HE18360AARA01 NOK INUIAYLGAA  
TX Laser Wavelength: 1553.328 nm  
Laser Tunability : flex-tunable  
Config Freq (MHz) : 193000000  
Oper Freq (MHz) : 193000000  
Fine Tune Range : 6250 MHz  
Supported Grids : 100GHz 75GHz 50GHz 25GHz 12.5GHz 6.25GHz  
Diag Capable : yes  
Number of Lanes : 1  
Connector Code : LC  
Manufacture date : 2023/05/11  
Serial Number : GPI221222014  
Part Number : QDDMSL06THDLHCGP  
Optical Compliance : ZR400-OFEC-16QAM ZR300-OFEC-8QAM ZR200-OFEC-QPSK ZR100-O*  
Link Length support: Unknown  
DCO : Enabled  
Min Freq (MHz) : 191300000  
Max Freq (MHz) : 196100000  
Fine Tune Resolu*: 100 MHz  
Vendor OUI : 00:90:65  
Media : Ethernet
```

Business advantages – coherent QSFP-DD 400G on Juniper PTX

```
lab@prod-lab03d-rc1-rel> show chassis hardware
version
Hostname: prod-lab03d-rc1-rel
Model: ptx10008
Junos: 23.1R1.8-EVO
Yocto: 3.0.2
Linux Kernel: 5.2.60-yocto-standard-g3549735
JUNOS-EVO OS 64-bit [junos-evo-install-ptx-x86-64-23.1R1.8-EVO]
```

```
lab@prod-lab03d-rc1-rel> show chassis hardware
Hardware inventory:
Item          Version  Part number  Serial number  Description
Chassis                               EQ720         JNP10008 [PTX10008]
Midplane 0    REV 16    750-086802   BCBS8342      Midplane 8
FPM 0         REV 02    711-086964   BCBS8168      Front Panel Display
PSM 0         Rev 03    740-069994   1F21A420137   JNP10K 5500W AC/HVDC
Power Supply Unit
Routing Engine 0  BUILTIN  BUILTIN      JNP10K-RE1-E
Routing Engine 1  BUILTIN  BUILTIN      JNP10K-RE1-E
CB 0           REV 07    750-101345   BCBS9671      Control Board
CB 1           REV 07    750-101345   BCBT1261      Control Board
FPC 0          REV 40    750-093524   BCBT4433      JNP10K-LC1201
  CPU          REV 11    750-087304   BCBS8992      JNP10K-LC1201 PMB
Board
  PIC 0        BUILTIN  BUILTIN      JNP10K-36QDD-LC-PIC
    Xcvr 16    REV PW 740-0_ZR+ GPI221222016 QSFP56-DD-400G-ZR-M
  MEZZ 0       REV 11    711-084968   BCBT6069      JNP10K-LC1201 MEZZ
Board
SIB 0         REV 30    750-083423   BCBR9885      SIB-JNP10008
FTC 0         REV 18    750-083435   BCBT1968      Fan Controller 8
FTC 1         REV 18    750-083435   BCBT1967      Fan Controller 8
Fan Tray 0    REV 09    750-103312   BCBS7884      Fan tray 8
Fan Tray 1    REV 09    750-103312   BCBS7878      Fan tray 8
```

```
lab@prod-lab03d-rc1-rel> show interfaces et-0/0/16 detail
Physical interface: et-0/0/16, Enabled, Physical link is Up
  Interface index: 1057, SNMP ifIndex: 521, Generation: 657129997758
  Link-level type: Ethernet, MTU: 1514, LAN-PHY mode, Speed: 400Gbps, BPDU Error: None, Loop Detect PDU Error:
None,
  Ethernet-Switching Error: None, MAC-REWRITE Error: None, Loopback: Disabled, Source filtering: Disabled, Flow
control: Enabled,
  Auto-negotiation: Disabled, Media type: Fiber
  Wavelength      : 1550.12 nm, Frequency: 193.40 THz
  Optic-loopback  : Disabled , Optic-loopbacktype : nil
Media Code      : ZR-400-OFEC-16QAM
Host Code       : 400GAUI-8 C2M (Annex 120E)
  Device flags    : Present Running
  Interface flags : SNMP-Traps
  CoS queues      : 8 supported, 8 maximum usable queues
  Hold-times      : Up 0 ms, Down 0 ms
  Damping         : half-life: 0 sec, max-suppress: 0 sec, reuse: 0, suppress: 0, state: unsuppressed
  Current address : fc:96:43:aa:70:52, Hardware address: fc:96:43:aa:70:52
  Last flapped   : 2023-05-22 17:03:15 CEST (00:17:00 ago)
  Statistics last cleared: Never
  Traffic statistics:
    Input bytes : 48480      0 bps
    Output bytes : 47874     0 bps
    Input packets: 160       0 pps
    Output packets: 158     0 pps
  Egress queues: 8 supported, 8 in use
  Queue counters:
    Queued packets  Transmitted packets  Dropped packets
    0                0                    0
    1                0                    0
    2                0                    0
    3                158                   158
    4                0                    0
    5                0                    0
    6                0                    0
    7                0                    0
```

```
OpenXR1# sh system version
```

```
System Name: OpenXR1
```

```
Version: DNOS [18.0.0] build [5], Copyright 2023 DRIVENETS LTD.
```

```
OpenXR1# show config interfaces ge400-0/0/2
```

```
# OpenXR1 config-start [27-Jan-2022 06:30:03 UTC]
```

```
interfaces
  ge400-0/0/2
    admin-state enabled
    transceiver
      application 400ZR-amplified
      optical-transport
        center-frequency 194300 ghz
        grid-spacing 100GHz
        target-output-power 1
    !
  !
!
```

```
OpenXR1# show config interfaces ge400-0/0/6
```

```
Interface ge400-0/0/2
Identifier                : QSFP_DD
Connector                 : 0x7 (LC type fiber
connector)
Length (SMF,km)           : 12km
Length (OM3 50um)         : 0m
Length (OM2 50um)         : 0m
Length (OM1 62.5um)       : 0m
Length (Copper or Active cable) : 0m
Transmitter technology    : 0x10 C-band tunable
laser
Optical transport info    : Grid 100GHz,
Frequency 194.3 THz
Configured Tx Power       : 1.0 dBm
Laser wavelength          : 1547 nm
Laser wavelength tolerance : 0 nm
Vendor name                : GBC PHOTONICS
Vendor OUI                 : 00:00:00
Vendor PN                  : QDSSL75THDSHCGP
Vendor rev                 : 11
Vendor SN                  : GPI230512002
Firmware version          : 2.8
Revision compliance        : QSFP-DD or QSFP-DD
CMIS Rev 5.1
Module temperature        : 47.0 degrees C /
116.5 degrees F
Module voltage             : 3.3 V
Alarm/warning flags implemented : Yes
Laser tx bias current (Channel 0) : 100.0 mA
Transmit avg optical power (Channel 0) : 1.0 dBm / 1.3 mW
Rcvr signal avg optical power (Channel 0) : 0.6 dBm / 1.2 mW
Laser bias current high alarm (Chan 0) : off
Laser bias current low alarm (Chan 0) : off
Laser bias current high warning (Chan 0) : off
Laser bias current low warning (Chan 0) : off
```

Business advantages – coherent QSFP-DD 400G on UfiSpace with DriveNets

```
Laser rx power high warning (Channel 0) : off
Laser rx power low warning (Channel 0) : off
Laser bias current high alarm threshold : 120.0 mA
Laser bias current low alarm threshold : 80.0 mA
Laser bias current high warning threshold : 110.0 mA
Laser bias current low warning threshold : 90.0 mA
Laser output power high alarm threshold : 4.0 dBm / 2.5 mW
Laser output power low alarm threshold : -9.0 dBm / 0.1 mW
Laser output power high warning threshold : 3.0 dBm / 2.0 mW
Laser output power low warning threshold : -8.0 dBm / 0.2 mW
Module temperature high alarm threshold : 75.0 degrees C / 167.0 degrees F
Module temperature low alarm threshold : -5.0 degrees C / 23.0 degrees F
Module temperature high warning threshold : 70.0 degrees C / 158.0 degrees F
Module temperature low warning threshold : 0.0 degrees C / 32.0 degrees F
Module voltage high alarm threshold : 3.6 V
Module voltage low alarm threshold : 3.0 V
Module voltage high warning threshold : 3.5 V
Module voltage low warning threshold : 3.1 V
Laser rx power high alarm threshold : 4.0 dBm / 2.5 mW
Laser rx power low alarm threshold : -23.0 dBm / 0.0 mW
Laser rx power high warning threshold : 3.0 dBm / 2.0 mW
Laser rx power low warning threshold : -22.0 dBm / 0.0 mW
Chromatic dispersion (min / avg / max) : -93 / -93 / -93 ps/nm
Pre-fec-ber (curr / min / avg / max) : 1.500e-03 / 1.370e-02 / 1.390e-03 /
1.000e+00
Post-fec-ber (FERC) (curr / min / avg / max) : 0.000e+00 / 1.530e-02 / 0.000e+00 /
1.000e+00
Osnr (min / avg / max) : 317.000 / 317.000 / 317.000 dB
```

```
Active application : 400ZR-amplified
Supported applications:
1. 400ZR-amplified
2. 400ZR-unamplified
```

```
Configuration:
Application : 400ZR-amplified
Frequency : 194.3 THz
Grid spacing : 100GHz
Target output power : 1.0 dBm
```

```
UFISPACE#show version
Software version: UFI_S9510-28DC-OcNOS-SP-PLUS-6.4.2-MR 01/29/2024
04:30:33
Copyright (C) 2024 IP Infusion. All rights reserved
```

Software Product: OcNOS-SP, Version: 6.4.2

```
Build Number: 49
Release: MR
Hardware Model: Ufi Space S9510-28DC-B
Software Feature Code: PLUS
Software Baseline Version: 6.4.1.28
```

```
UFISPACE#show qsfp-dd 1 eeprom
```

```
Port Number           : 1
Identifier            : QSFP-DD Double Density 8X Pluggable
Transceiver          :
Name                 : GBC PHOTONICS
OUI                  : 0x0 0x53 0x4F
Part No              : QDDMSL06THDLHCGP
Revision Level       : A
Serial Number        : GPI221222020
Manufacturing Date   : 220930 (yyymmddvv, v=vendor specific)
CLEI Code            : INUIANYEAA
Module Power Class   : 8
Module Max Power     : 22.50 Watt
Cooling Implemented  : Yes
Module Temperature Max : 70 Celsius
Module Temperature Min : 0 Celsius
Operating Voltage Min : 3.14 Volt
Optical Detector     : PIN
Rx Power Measurement : Average Power
Tx Disable Module Wide : Yes
Cable Assembly Link Length : Separable Media
Connector Type       : LC (Lucent Connector)
Media Interface Technology : C-band Tunable Laser
CMIS Revision        : 5.1
Memory Model         : Paged
MCI Max Speed        : 1000 kHz
Active Firmware Revision : 2.8
Inactive Firmware Revision : 2.8
Hardware Revision    : 1.0
Media Type           : Optical SMF
Max SMF Link Length  : 600.0 Kilometer
Wavelength Nominal   : 1547.70 nm
Wavelength Tolerance : 0.01 nm
```

```
UFISPACE#conf t
Enter configuration commands, one per line. End with
CNTL/Z.
UFISPACE(config)#inter cd0/1
UFISPACE(config-if)#mtu 9200
UFISPACE(config-if)#commit
UFISPACE(config-if)#exit
UFISPACE(config)#interface cd0/1.1 switchport
UFISPACE(config-if)#encapsulation default
UFISPACE(config-if)#commit
UFISPACE(config-if)#exit
UFISPACE(config)#interface cd1/1
UFISPACE(config-if)#mtu 9200
UFISPACE(config-if)#commit
UFISPACE(config-if)#exit
UFISPACE(config)#interface cd1/1.1 switchport
UFISPACE(config-if)#encapsulation default
UFISPACE(config-if)#commit
UFISPACE(config-if)#exit
UFISPACE(config)#cross-connect 400G_UFI_400G
UFISPACE(config-xc)#interface cd0/1.1
UFISPACE(config-xc)#interface cd1/1.1
UFISPACE(config-xc)#commit
UFISPACE(config-xc)#end
```

Business advantages – coherent QSFP-DD 400G on UfiSpace with IP Infusion

salumanus.com

```
UFISPACE#show qsfp-dd 1 advertisement applications
```

```
Port Number           : 1
> Application 1:
  | Host |
    Interface           : 400GAUI-8 C2M
    Application BR      : 425.00
    Lane Count          : 8
    Lane Sig BR         : 26.5625
    Modulation Format    : PAM4
    Bits Per Unit Intvl : 2.000000
    Lane Assigned       : Lane-1
  | Media |
    Interface           : ZR400-OFEC-16QAM
    Application BR      : 481.108374
    Lane Count          : 1
    Lane Sig BR         : 60.1385468
    Modulation Format    : DP-16QAM
    Bits Per Unit Intvl : 8.000000
    Lane Assigned       : Lane-1
```

```
UFISPACE#show qsfp-dd 1 laser status
```

```
Port Number           : 1
```

Attribute	Lane	Value	Unit
Grid Spacing	1	50.000	GHz
Laser Frequency	1	192.600000	THz
Channel Number	1	-10	--
Wavelength	1	1556.55	nm

```
-----
```

Flag	Lane	Status
Tuning in progress	1	No
Wavelength locked	1	Yes

```
-----
```

Flag	Lane	Status (L)
Target output power OOR	1	No
Fine tuning out of range	1	No
Tuning accepted	1	Yes
Channel number valid	1	Yes

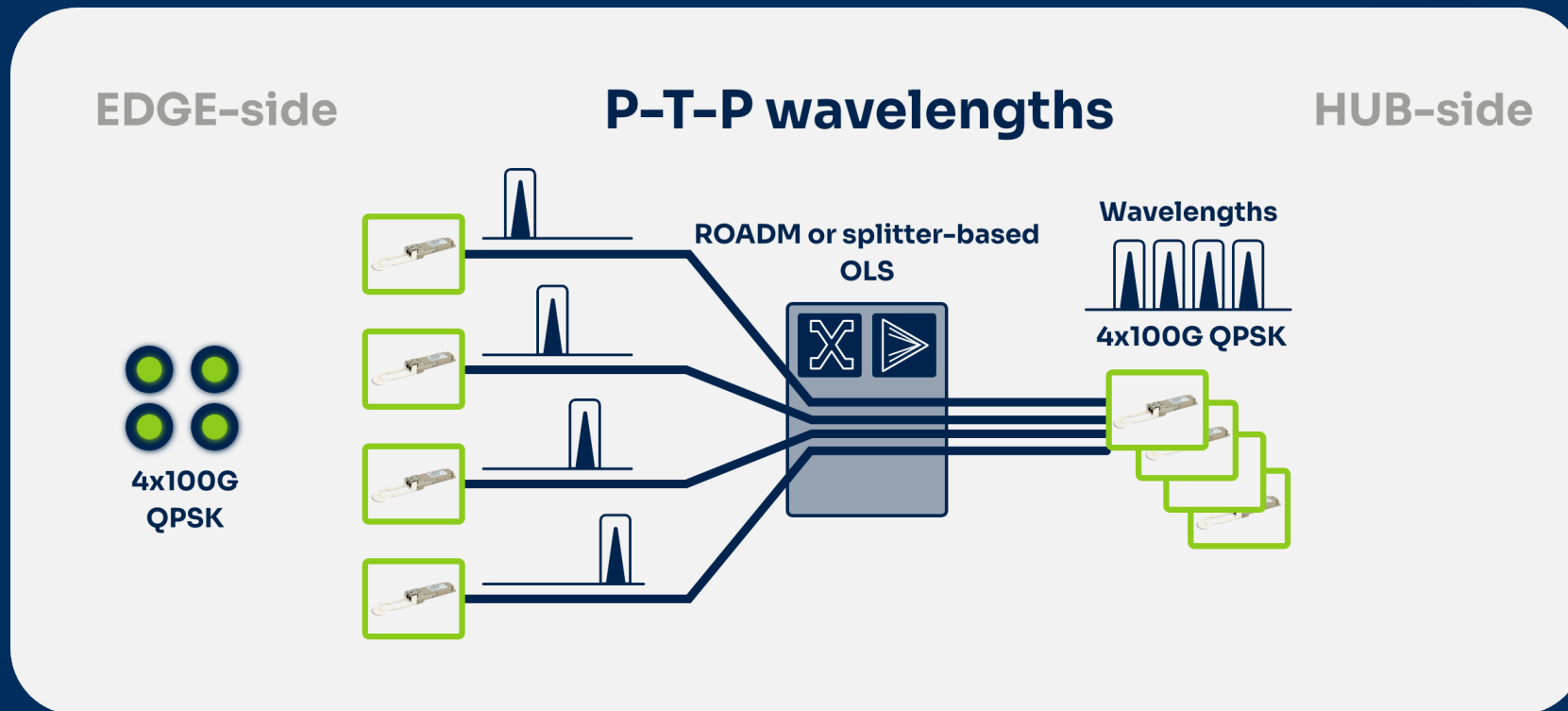
Usage scenarios - coherent QSFP28 100G

P-T-P dark fiber



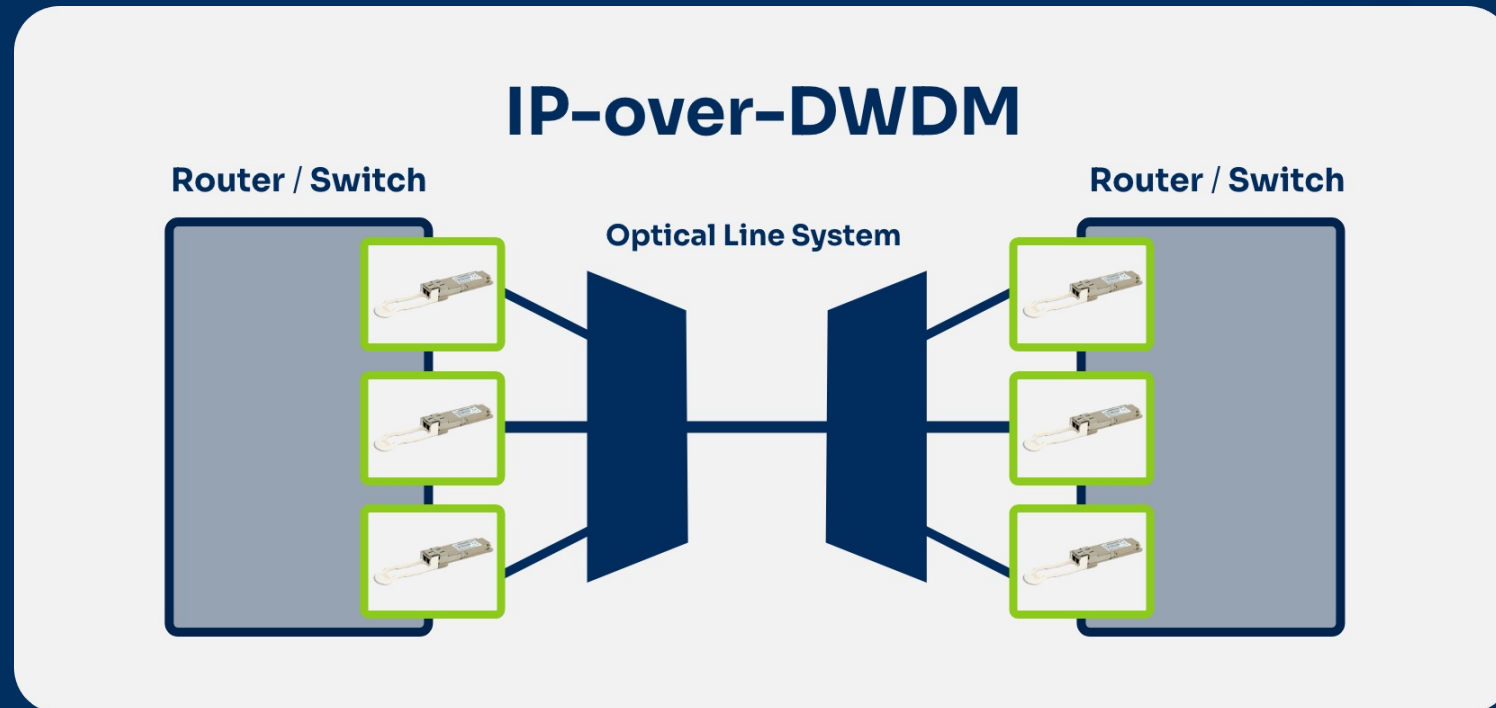
- 80 km or 120 km range (-8dBm or 0dBm)
- Wavelength selected by SRD or the host
- Optional enhanced mode 300 km (0.2-0.3 W higher power consumption)

Usage scenarios - coherent QSFP28 100G



- Tunable selective receiver
- No mux/demux needed

Usage scenarios - coherent QSFP28 100G



- CMIS or SFF-8636 versions
- Tuned from host or SRD
- In amplified links the range limited only with ONSR (min 16.5 dB)

Challenges



Distance

1000km and longer links



Automation

Across IP and Optical Layers



Management

Cross domain management

Thank you for your attention.



Marcin Bała
CEO
Salumanus



Andrzej Wojnar
Solutions Architect
Salumanus

