Introduction of pluggable 400G coherent optics, what does it mean for you?

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Agenda

- **DWDM Primer for IP Professionals**
- **Introduction to Coherent 400G**
  - Building concepts
  - Standards
  - Product Availability
- **400 Optical Performance**
- **Case Study**

DWDM Primer for IP Professionals

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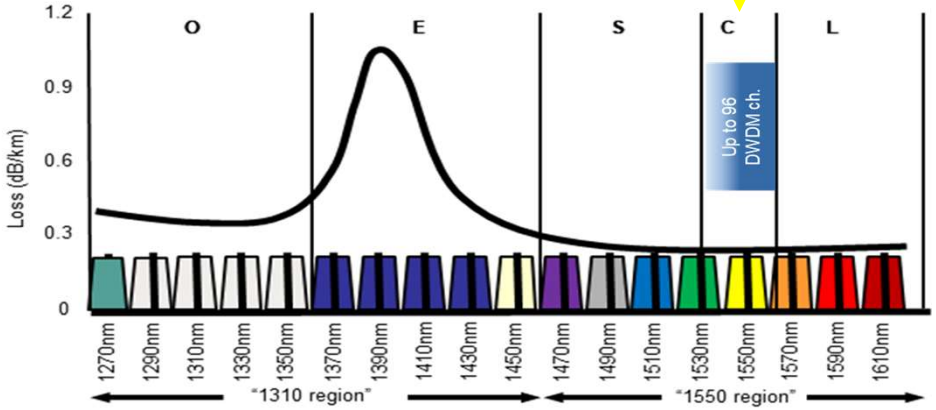
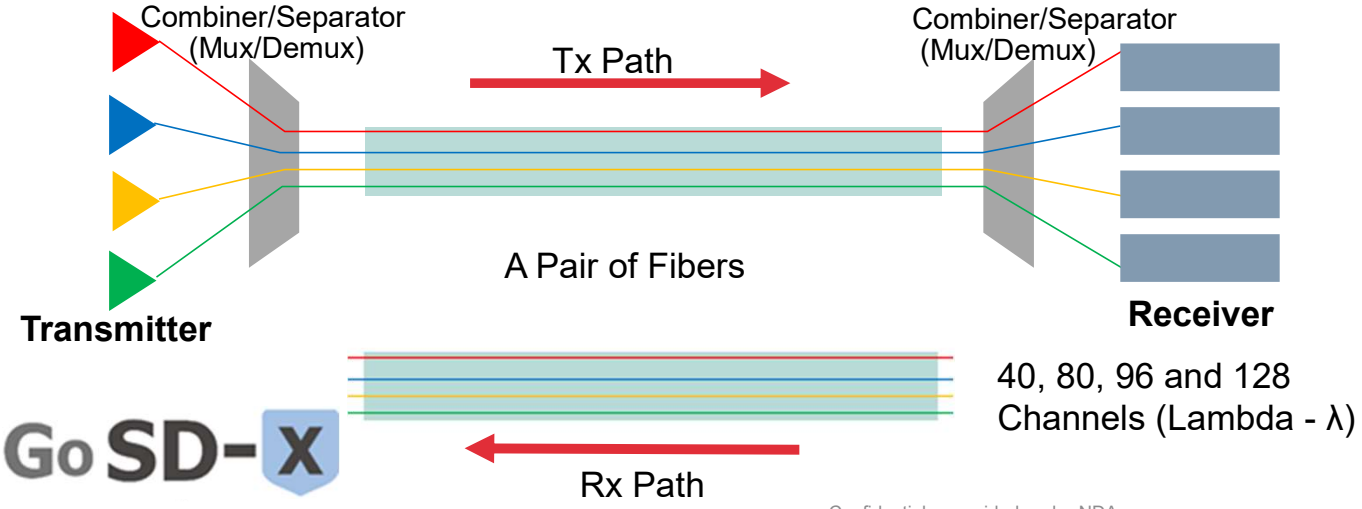
What is Wavelength Division Multiplexing (WDM)?

- A transmission technology that multiplexes multiple optical carrier signals on a single fiber by using different wavelengths (colors) of laser light to carry different signals or frequencies
- The effective capacity of existing fiber plant can be increased by a factor of 40, 80, and 96

Optical Spectrum:
C-Band



WDM turns a single pair of fibers into 96 virtual fibers!



40, 80, 96 and 128 Channels (Lambda - λ)

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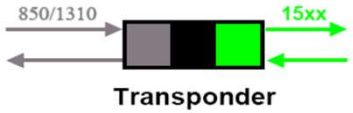
Basic Building Blocks of a DWDM System

Add/Drop Filter
- **Static Optical Multiplexer / Demultiplexer**

Amplifiers
- **Erbium-Doped (EDFA)**
- **Raman**

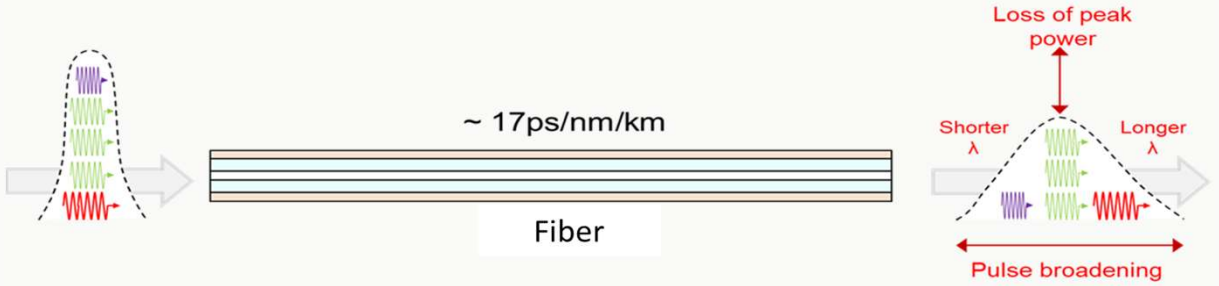
Transponders
- **Client Side**
- **Line Side**

Client Side (Grey)



Line Side (Colored)

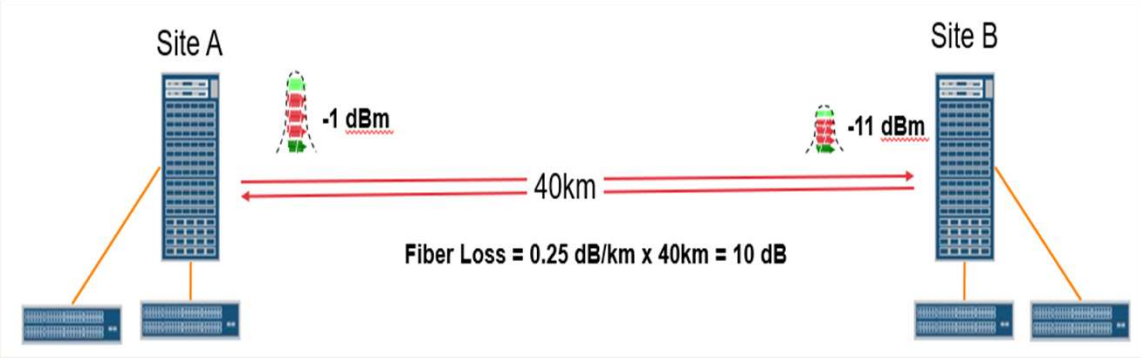
Dispersion Compensation
- **Chromatic Dispersion**



Optical Transmission Challenges and Solutions

#1 Fiber Attenuation

Challenge



Decay of signal strength as the signal propagates through the fiber from Site A to Site B

Solution

The signal is amplified with an EDFA amplifier

The EDFA also adds Amplified Spontaneous Emissions (ASE) noise. This causes another challenge with Optical Signal to Noise Ratio (OSNR)

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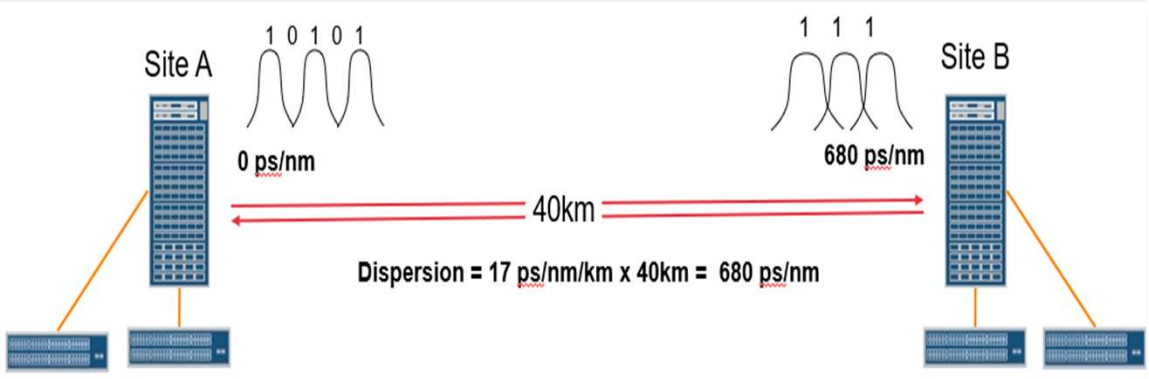
Optical Transmission Challenges and Solutions

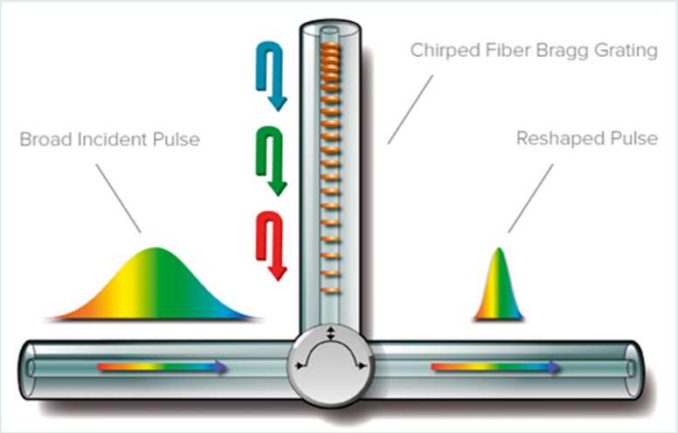
#2 Chromatic Dispersion

Challenge



Wavelengths arrive at different times causing the signal to spread as it travels through the fiber

Solution



The signal is dispersion compensated via a Dispersion Compensation Device

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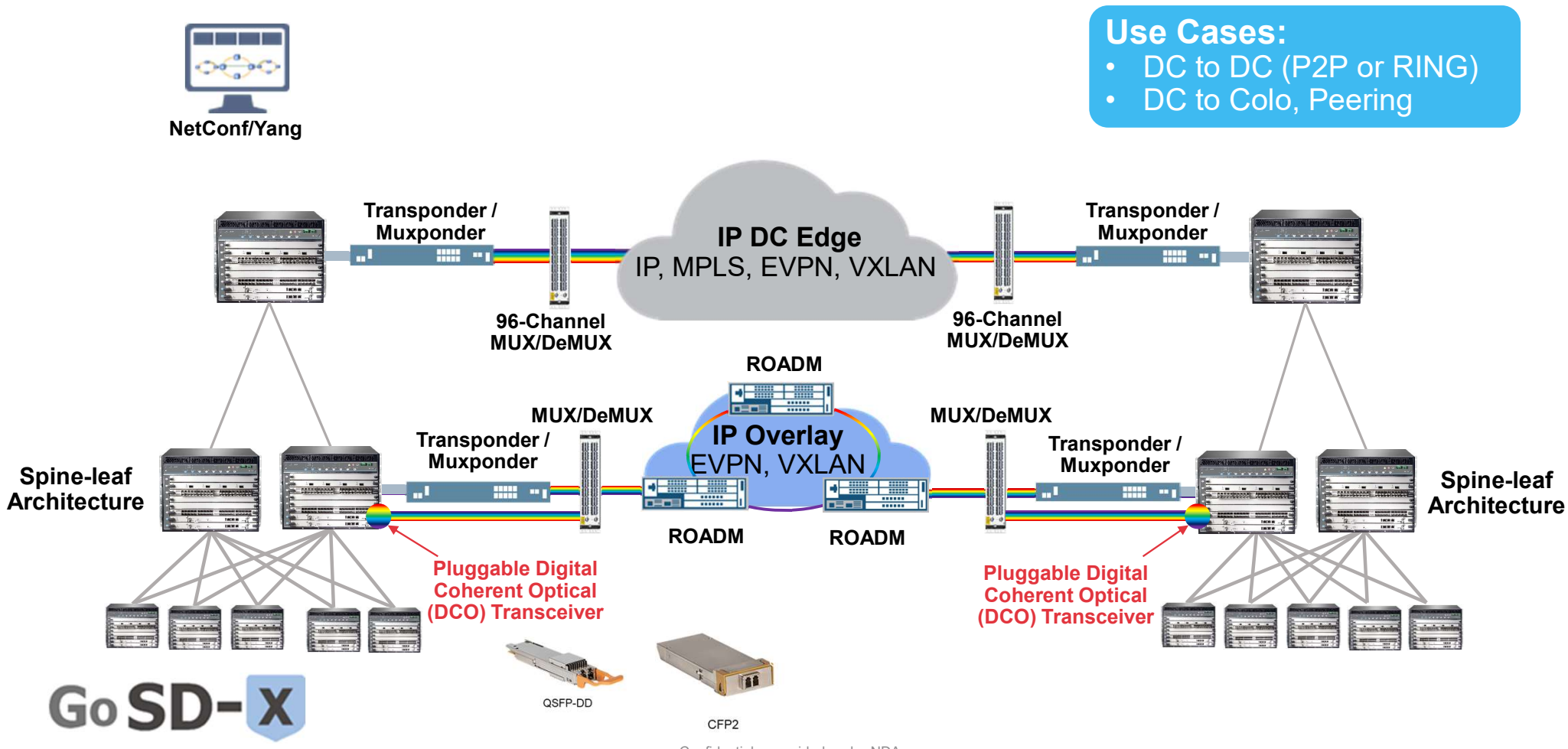
Data Center Interconnect (DCI) Architecture



You may Google the DWDM Terminologies below when you have time – Enjoy your reading!

- **Decibels (dB)** - for relative measurements, like 'half' or 'double'
  - Gain and Attenuation/Loss are in dB
- **Decibels-milliwatt (dBm)** - an absolute value based on 0dBm=1mW
  - Output power and Receiver sensitivity are in dBm
- **Grey** (850nm/1310nm/1550nm) vs **Colored Optics** (DWDM: 15xx nm)
- **Wavelength** (λ in nm) - distance from one peak to the next
- **Frequency** (f in THz) - inverse relationship to wavelength $f=c/\lambda$
- **Dispersion** - spreading of the light pulse (Modal/CD/PMD)
- **Optical Signal to Noise Ratio (OSNR) -** ratio of optical signal power to noise power for the receiver
- **Bit Error Rate (BER)** - typical acceptable rate is 10^{-12}
- **ITU Grid Wavelength** - standard for DWDM systems
- **ROADM** - Reconfigurable Optical Add/Drop Multiplexer
- **Open Pluggable Transceivers** - OpenZR+ (http://openzrplus.org/) and Open XR Forum (https://www.openxrforum.org/)

Open Pluggable Coherent Optics – A Game Changer for the industry!!!

Introduction to Coherent 400G

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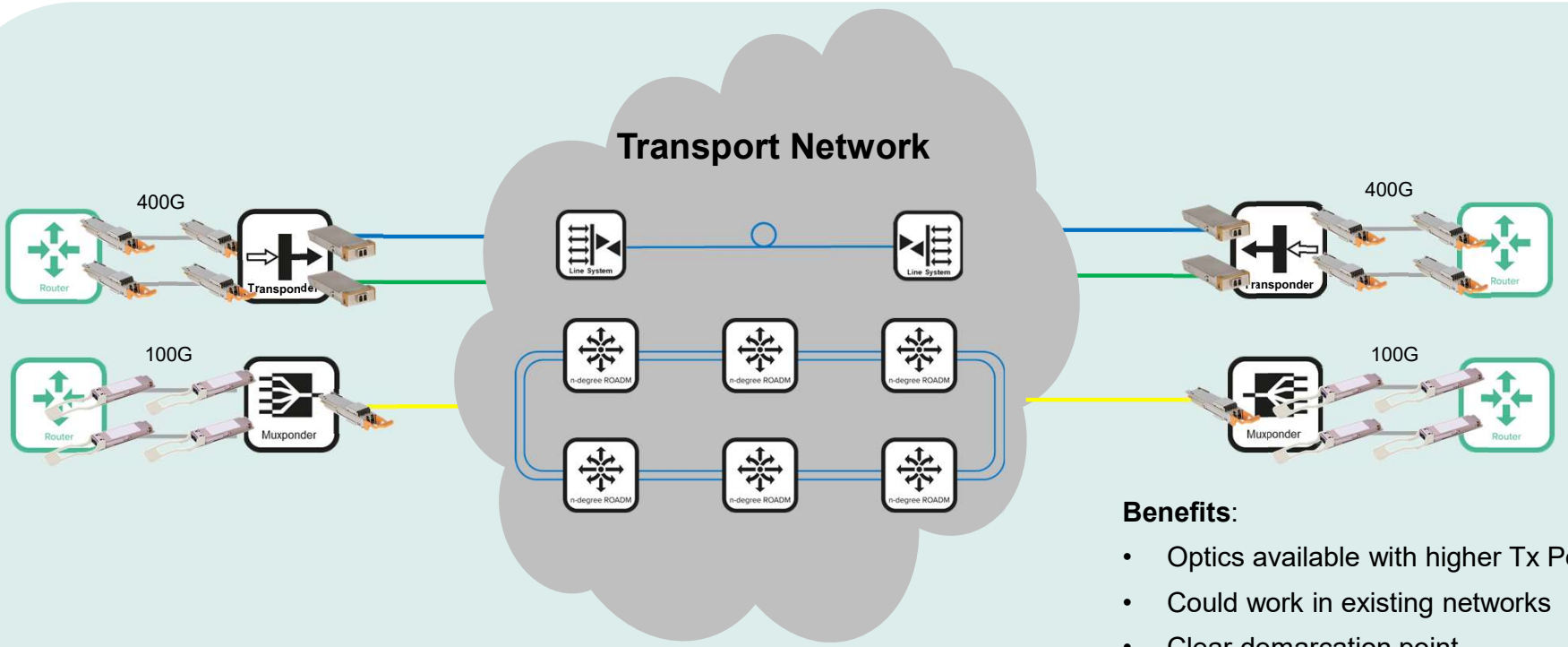
400G in Metro Networks – Traditional building concept



Benefits:

- Optics available with higher Tx Power
- Could work in existing networks
- Clear demarcation point
- End-to-end optical management in traditional management systems

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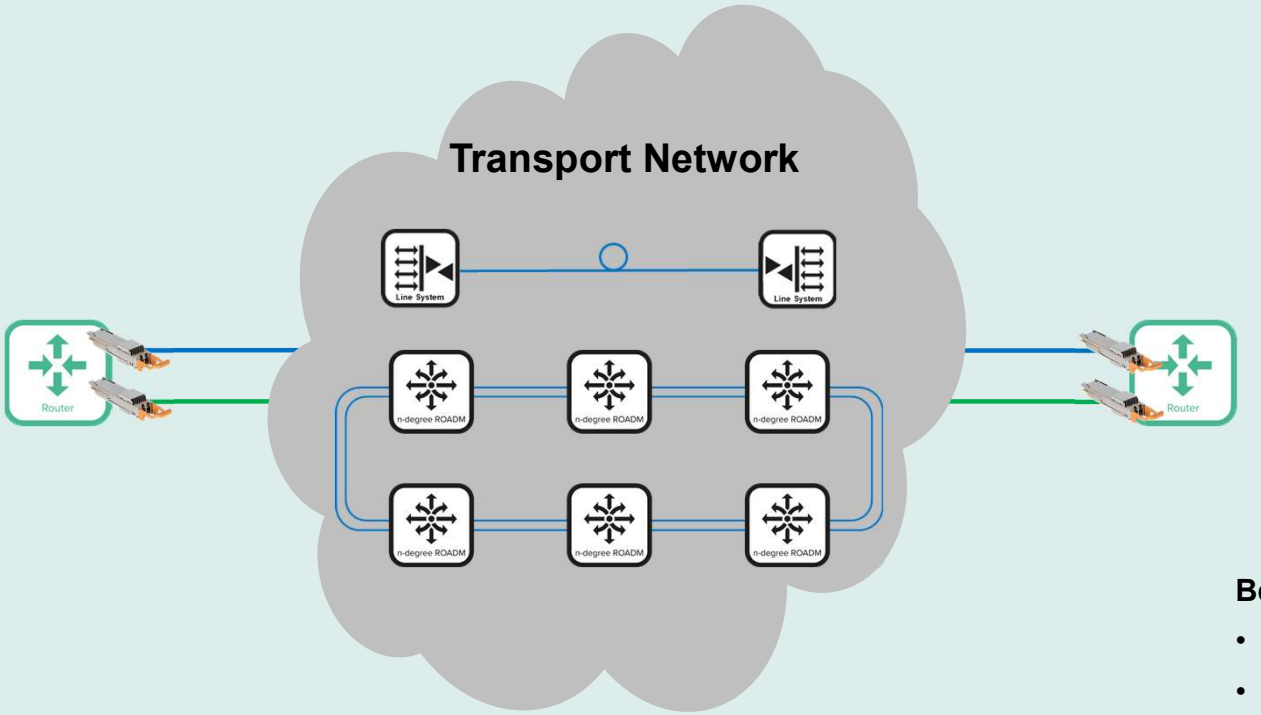
400G in Metro Networks – Embedded building concept



Benefits:

- Low cost
- Lower Power Consumption
- Smaller Foot-print
- Lower Latency

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400G Industry Standards

There are three principal initiatives to provide standardized 400G solutions.

	OIF 400ZR	OpenZR+ MSA	Open ROADM
Target application	Edge DCI/Campus	Metro/Regional DCI	Metro/Regional DCI
Reach	80 – 120km / 11dB	>120km	>120km
Line capacity	400G	100G/200G/300G/400G	200G/300G/400G
Client formats	400GE	100GE/200GE/400GE	100GE-400GE + OTN
FEC	CFEC	oFEC	oFEC
Line modulation	16QAM	QPSK/8QAM/16QAM	QPSK/8QAM/16QAM

QSFP-DD

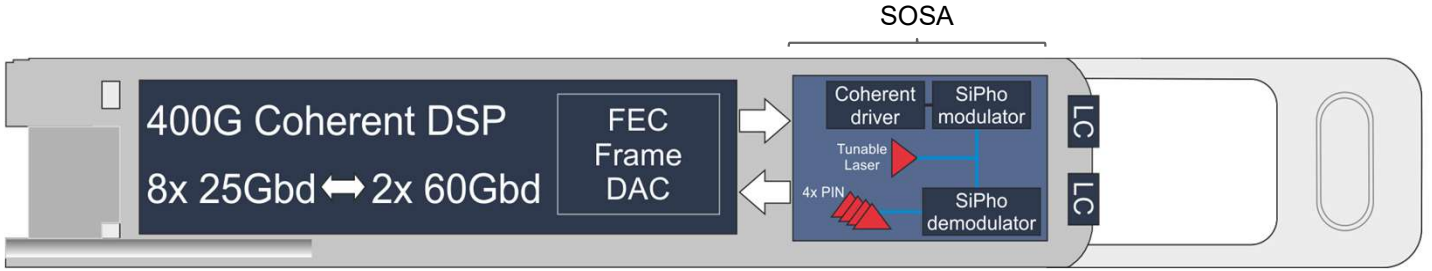
OSFP

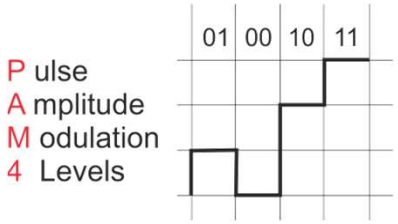
Typical combinations for Embedded

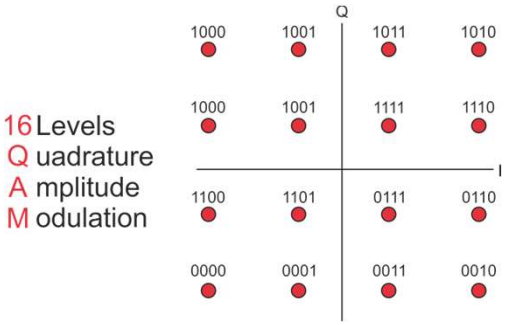
CFP2

Typical combination for Traditional

Extreme complexity







DP-16QAM (DP = Dual Polarization)
4 bits per symbol (x2)

DSP: Digital Signaling Processor

SOSA: Silicon Optical Sub-Assembly

It's a combination of complex transceiver technology and transceiver management.

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Where are the modules?

We have today shipped OIF 400ZR transceivers to a customer in Europe.

SO-TQSFP-DD-4CC-ZR

Application mode	Host format	Electrical interface	Payload	FEC	Modulation	Operating reach	MSA format
1	400GBASE-R	1x 400GAUI-8 (8x 50G)	400G	CFEC	DP-16QAM	80km	OIF 400ZR app code 0x01
2	400GBASE-R	1x 400GAUI-8 (8x 50G)	400G	CFEC	DP-16QAM	25km	OIF 400ZR app code 0x02

The OIF 400ZR transceiver is released but with limited availability.

The OpenZR+ transceiver has been generally available since Q2.

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Where are the 400G systems?

- System vendors have already released products that support 400G, but lack SW to support these modules.

- Expect OIF 400ZR and OpenZR+ support
  roll-out during 2021.

- Will system vendors block OIF 400ZR and OpenZR+ 3rd party transceivers?

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400G Optical Performance

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Optical challenges using 400ZR in passive networks

TTF Filter Bandwidth

Typical bandwidth of 8ch DWDM filter: ~30 (<60)GHz

Typical bandwidth of a 400ZR signal: ~63GHz

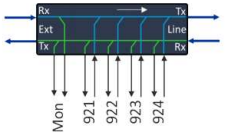
AWG Filter Loss

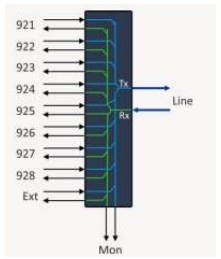
40ch Mux/Demux have sufficient bandwidth

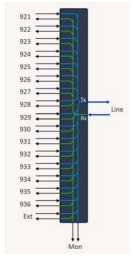
40ch Mux/Demux loss: 12dB

400ZR Optical Budget: 11 dB

Solution: New filters with higher bandwidth







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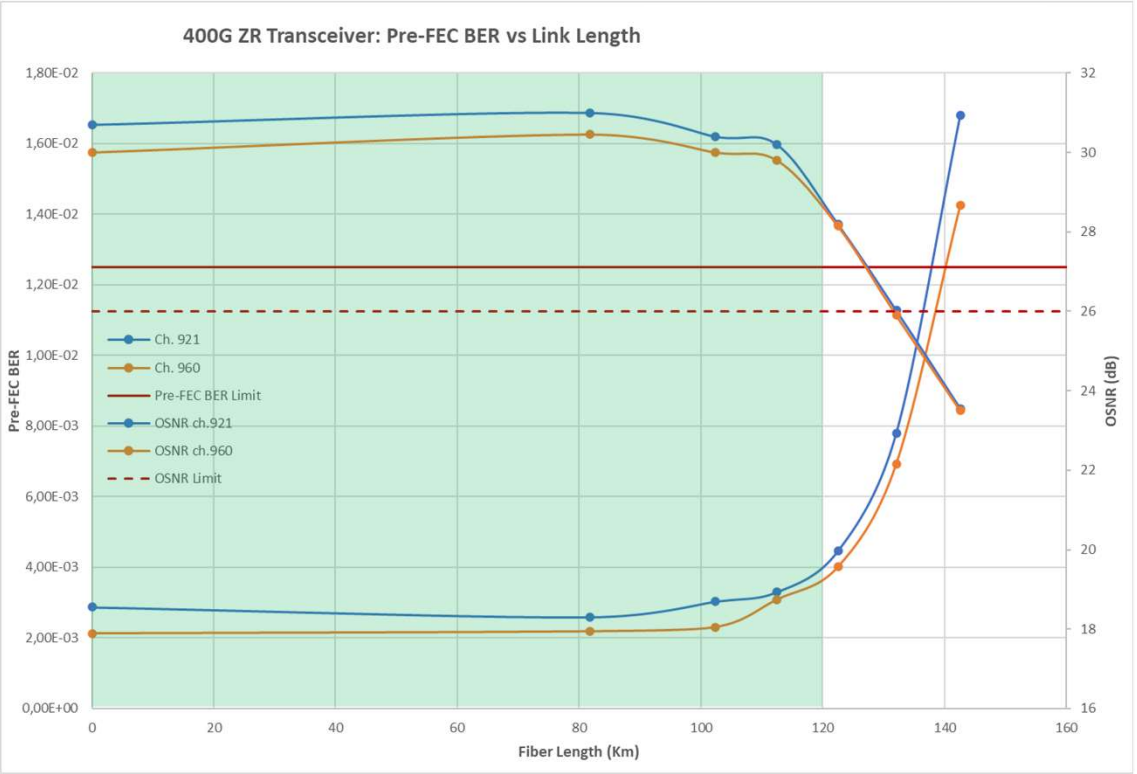
400ZR Optical Performance over Open Line Systems

Pre-FEC BER & OSNR vs Link Length

- No optical penalty for distances below 100km (~22 dB)
- Well within specification up to 120km fibre distance (~26 dB)



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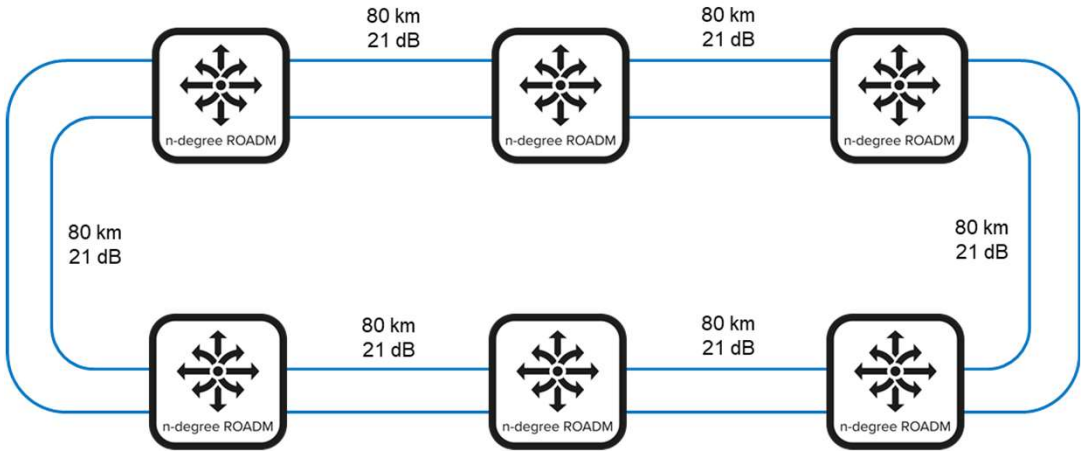
400ZR optical performance for in ROADM networks

OSNR performance 21 dB Link Span

Name	Span no	OSNR (dB)
Tx OSNR	0	33,4
Span 1	1	30,4
Span 2	2	27,9
Span 3	3	26,3
Span 4	4	25,1
Span 5	5	24,2
Span 6	6	23,5
Span 7	7	22,8
Span 8	8	22,3
Span 9	9	21,8
Span 10	10	21,3
Span 11	11	20,9
Span 12	12	20,6
Span 13	13	20,2
Span 20	20	18,3

Traffic format	OSNR tolerance (dB)	CD Tolerance (ps/nm)	ROADM Hops
OIF 400ZR	26	2,400	3
OpenZR+ 400G	24	20,000	5
OpenZR+ 300G	21	40,000	10
OpenZR+ 200G	16	50,000	20+
OpenZR+ 100G	12.5	100,000	20++



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Case Study

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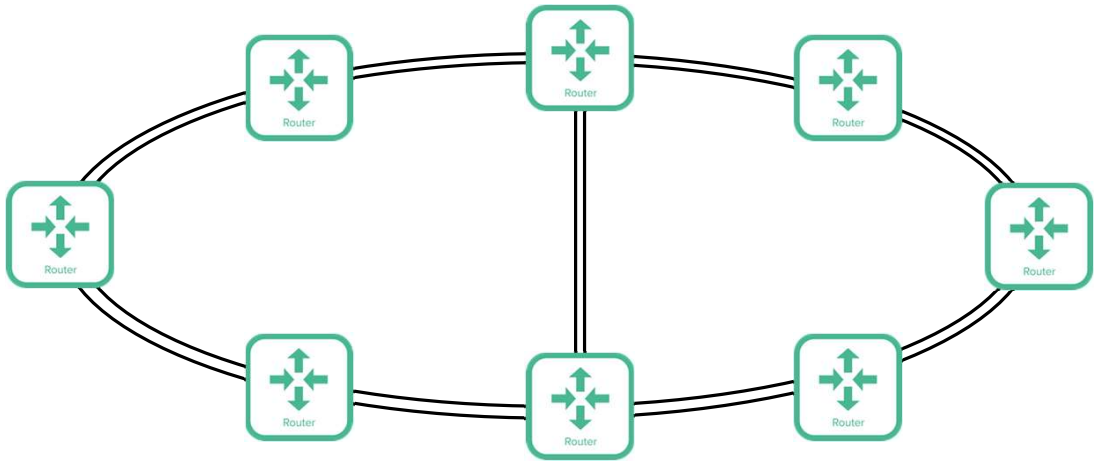
The Network

Network

- The operator built dedicated rings
- Each ring consists of 6-8 nodes
- Decision was made to select 400G technology due to very attractive cost per bit
- Different Applications
  - Passive on some of the links
  - OLS on some
  - Fiber directly connected on dark fiber

Benefits:

- Reduced amount of network equipment
  - Lower power consumption
  - Smaller footprint
- Protection provided by packet layer
- Lowest cost per bit



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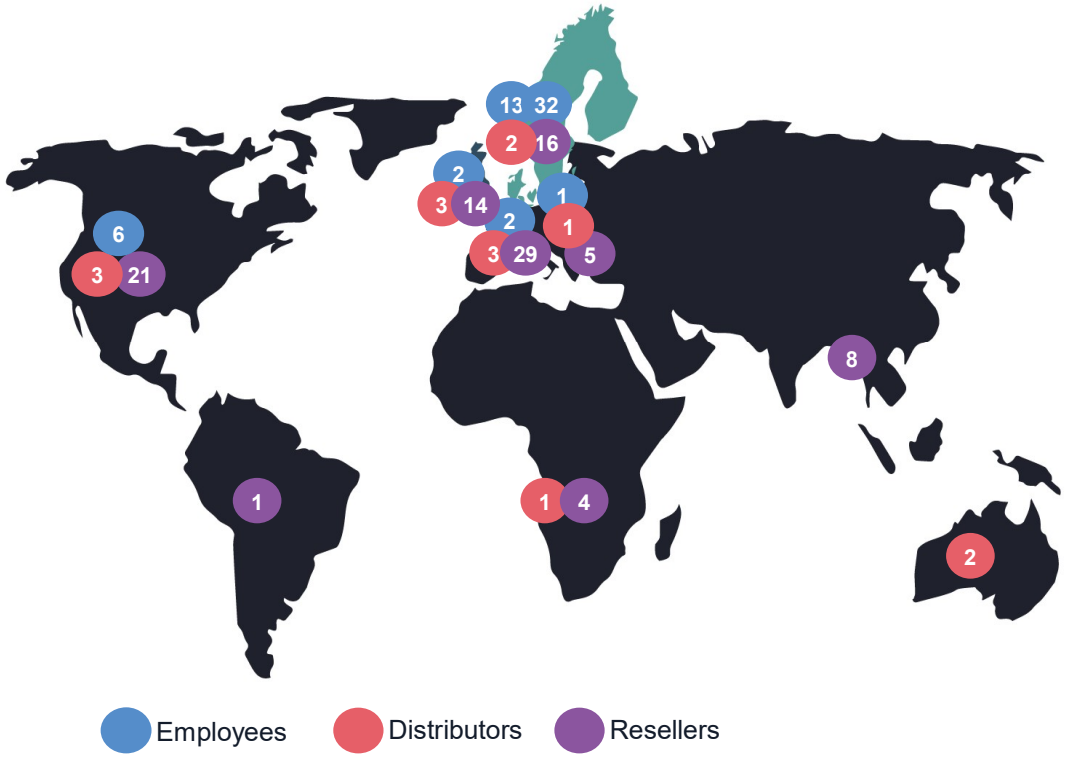
Overview of Smartoptics

Smartoptics at a glance

Founded		2006
CEO		Magnus Grenfeldt
Products		Optical solutions & services Optical devices (transceivers)
Locations	**Norway**	Operations (devices), sales
	Sweden	R&D, production, sales, pre-sales, services and management
	UK	Sales
	Germany	Sales, pre-sales
	US	Sales, pre-sales, operations, services
	Poland	Sales

Geographical footprint



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Thank you!

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