



What's next for optical?

Experience, Control, and Open

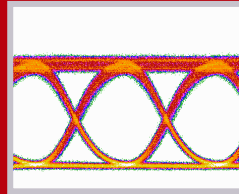
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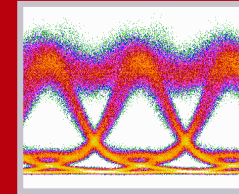


Optical Technology \neq Basic Math

Optical Communications:
It May Be a **Digital** Signal, but It's **Analog** Transmission



Transmitted Data Waveform



Waveform After 1000 Km

TX Shaping

Transponder

Transceiver

CD

TX OSNR

TX Power

Non-Linear
Effects

RX ROSNR

Discrete

RX Sensitivity

Channel Plan

Modulation

Noise
Figure

Coherent

PMD

Bit Rate

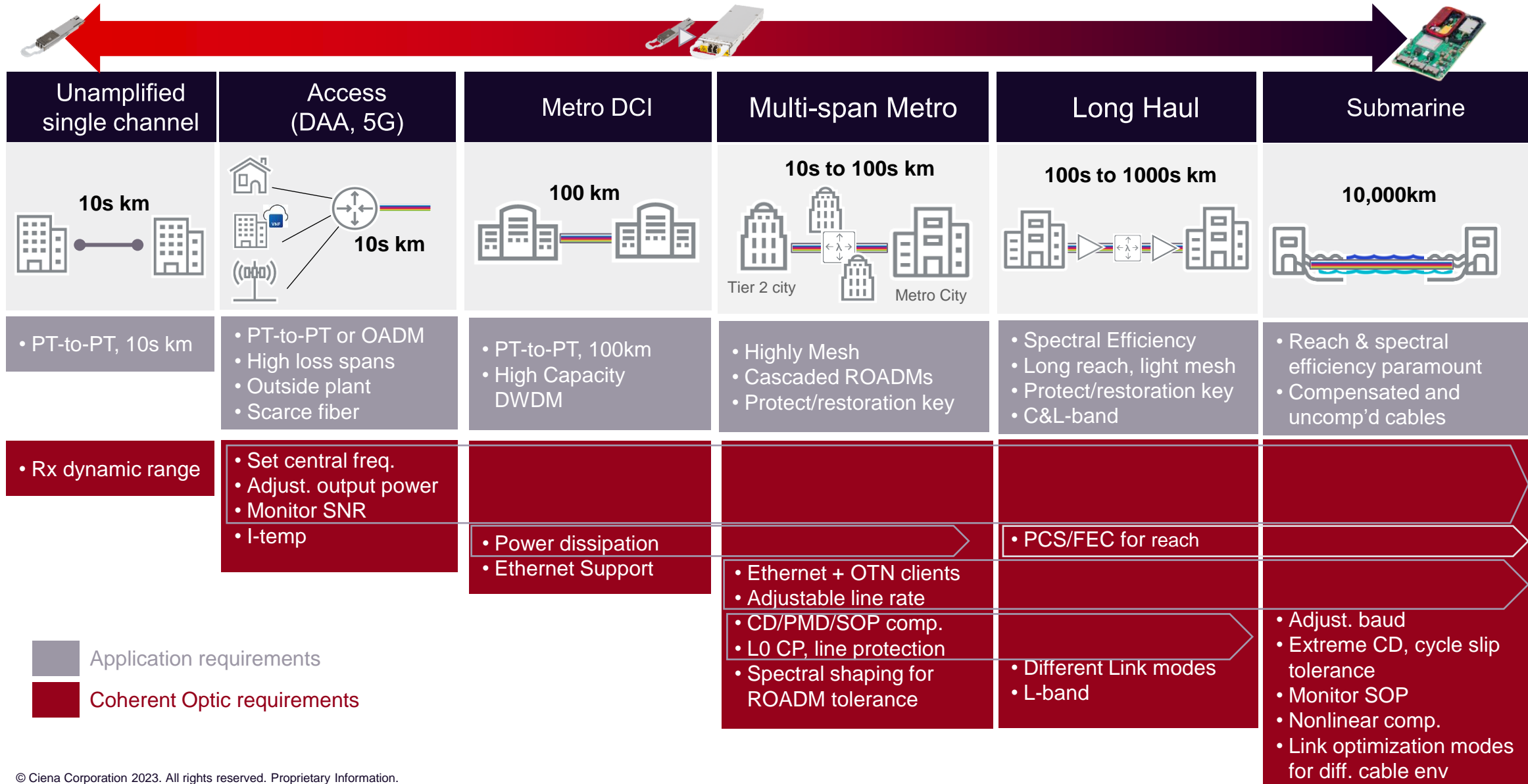
Grid

Baud Rate

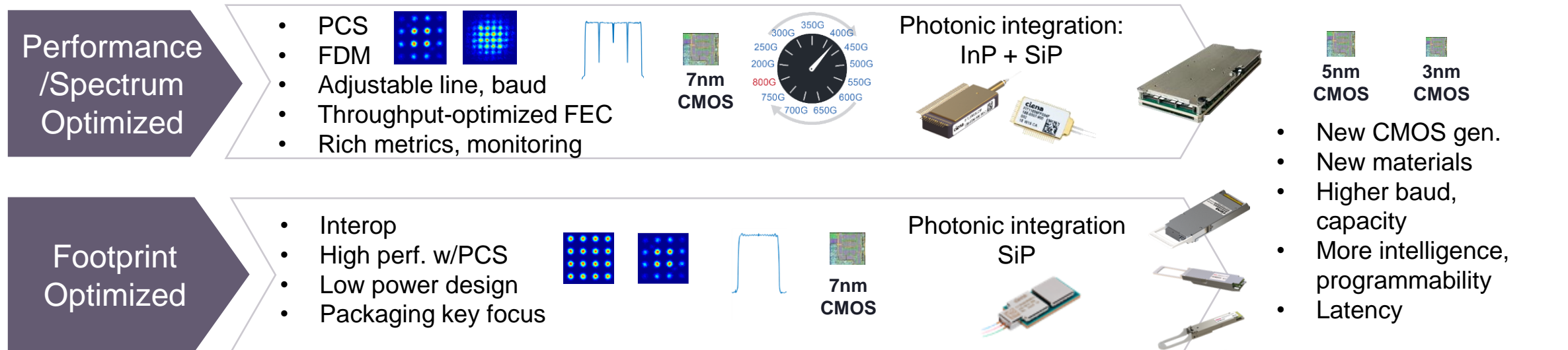
Bandwidth

ORL

Coherent optics becoming ubiquitous choice in transport

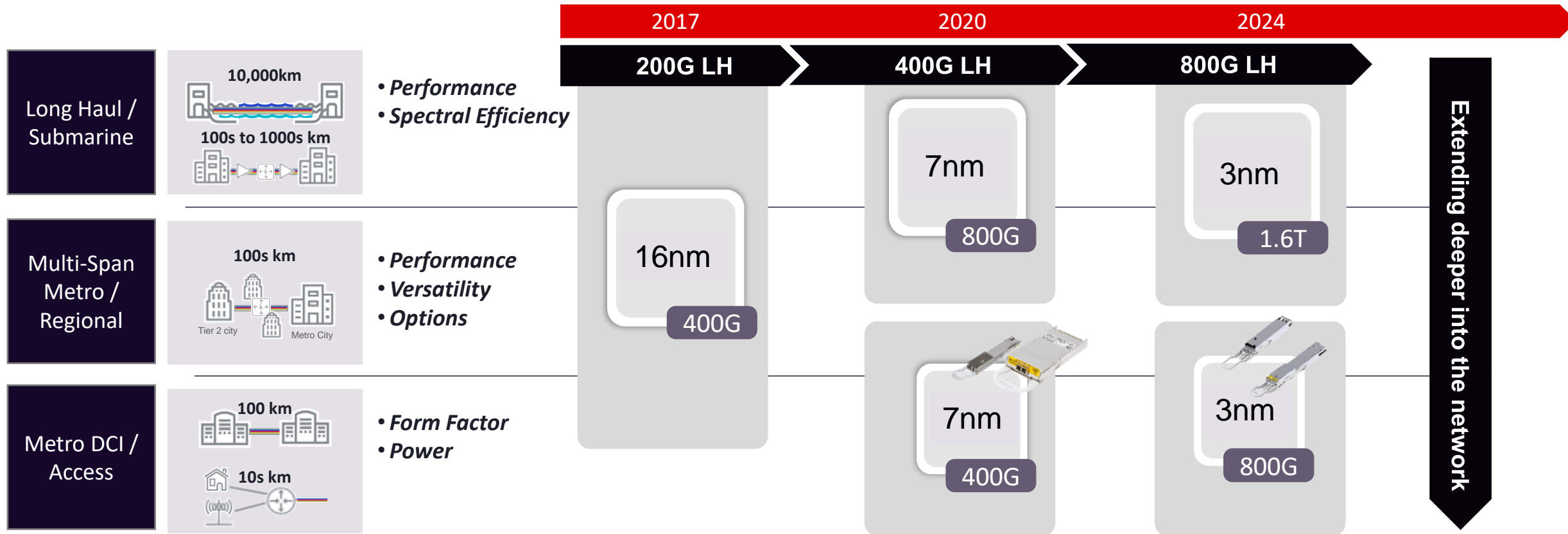


What technology design fits better?

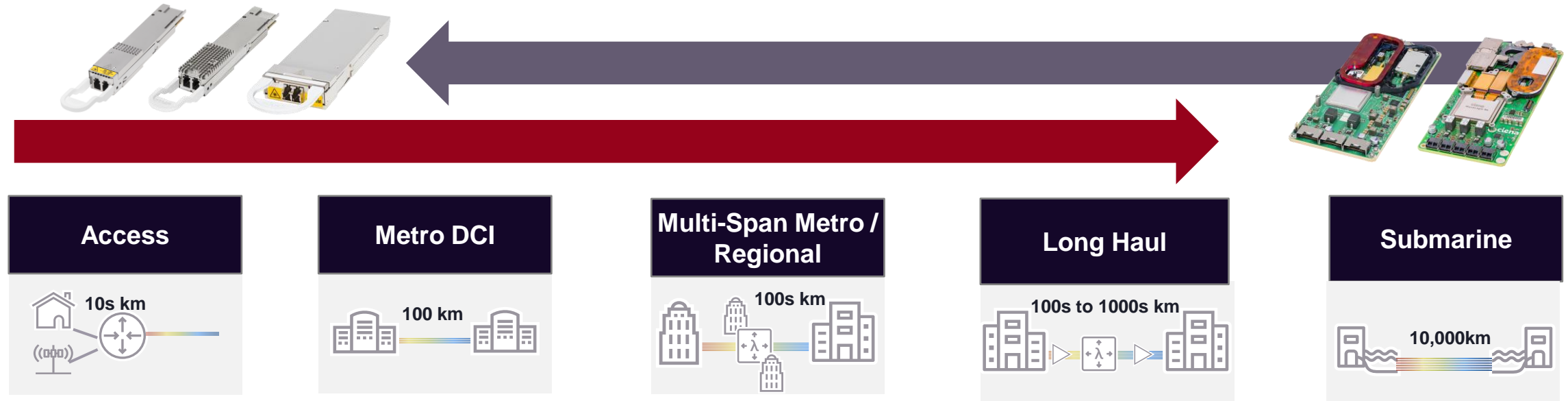


Choice in technology, DSP algorithms and implementation/co-design dictate performance & savings

Decision based on market and network requirements



Embedded transponders versus coherent pluggables



Ability to support both across the network results in lowest TCO

Coherent pluggable transceiver standards evolution

400ZR (OIF) optimized for
12.8 / 25.6T switch

800ZR (OIF) optimized for 51.2T switch

400ZR+ (MSA) for interoperable
converged IP/Optical – metro

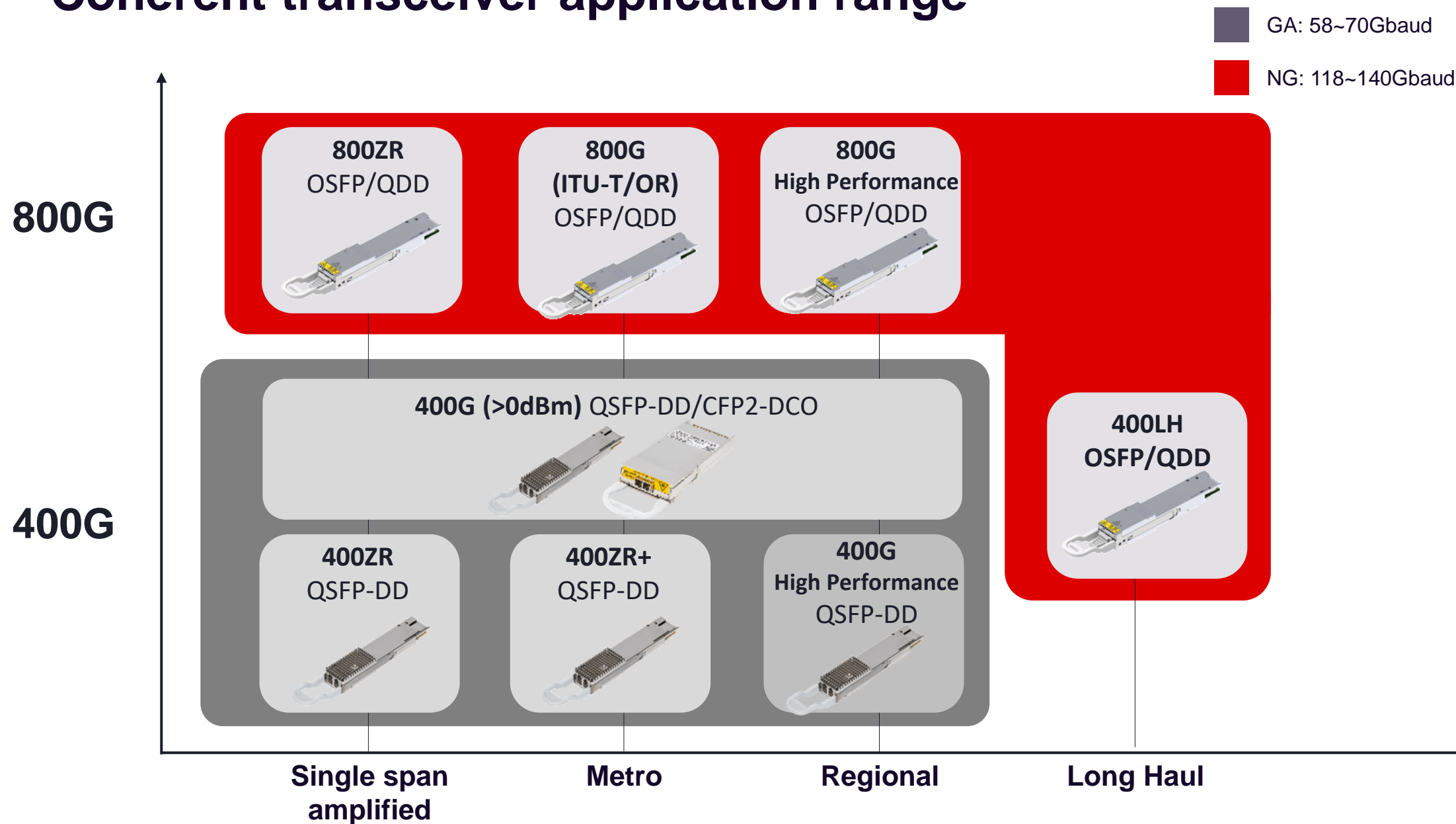
400G (ITU-T / Open ROADM) for
metro transport ROADM networks

B400G (ITU-T / Open ROADM)
800G packet-optimized metro
800G transport ROADM metro networks
400G, 600G long haul transport

400G high performance for
metro/regional ROADM networks

800G high performance for metro/regional
ROADM and converged IP/Optical transport

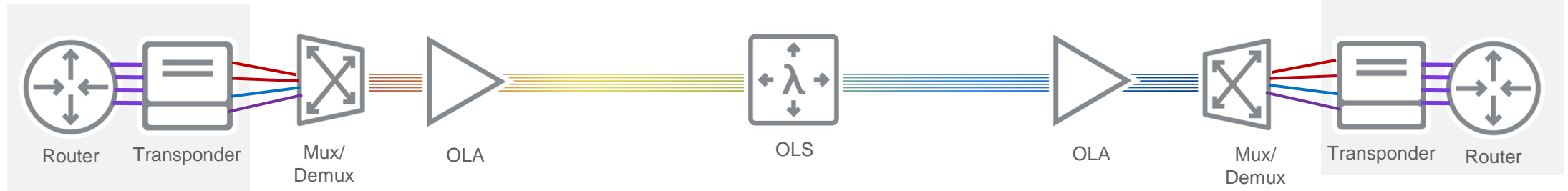
Coherent transceiver application range



New consumption models

How to add bits/Hz in the cost/bit equation?

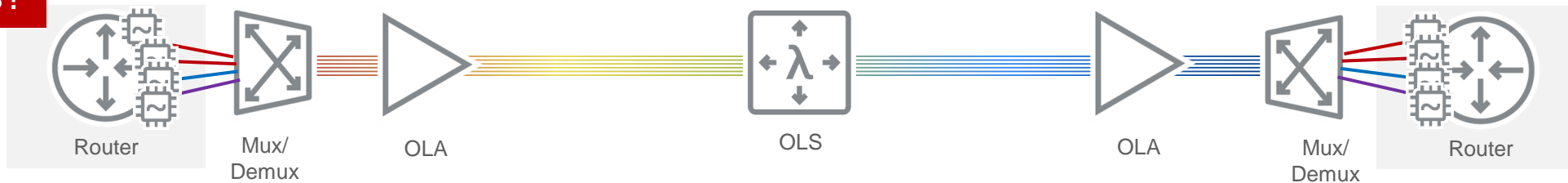
What performance do I need?



How to maintain multiple vendors?

How to manage?

Are there line system implications?



How to keep router ports at maximum rate?

Engineering considerations to support multi-generational technologies?

Four Types of Interoperability in an Open System

Domain Controller Interoperability

The 3rd party host must provide an open and standard domain controller interface for control, management, and monitoring functions.

Host to Plug Interoperability

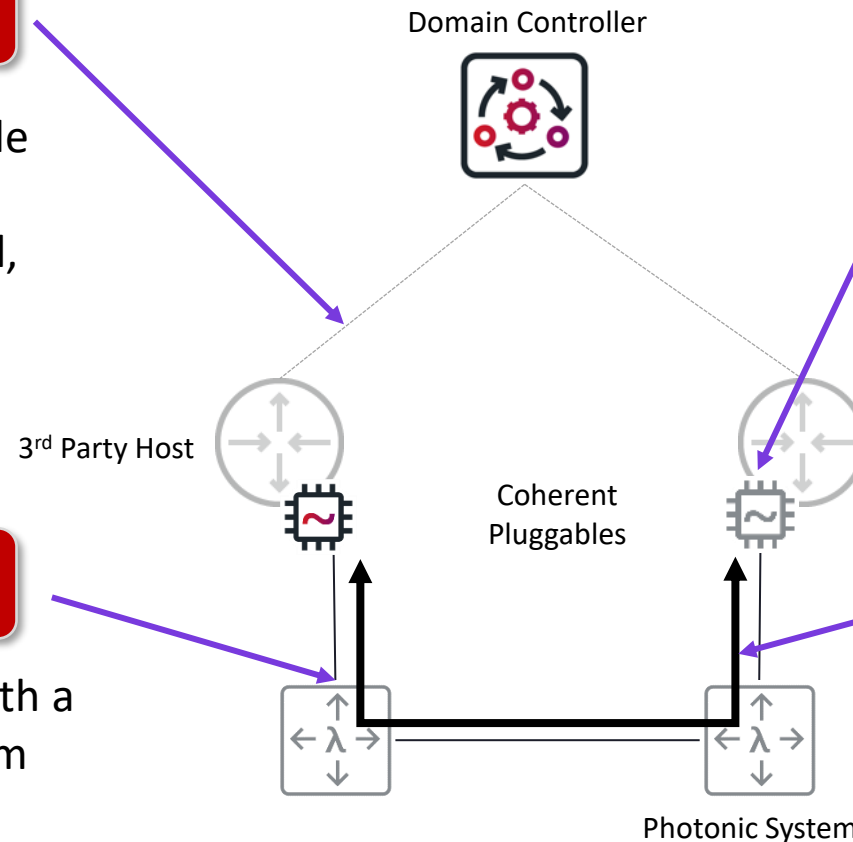
The 3rd party host must assure interoperability via CMIS with multiple vendor coherent pluggables to avoid vendor lock-in

Photonic Layer Interoperability

Coherent plugs must work with a wide range of photonic system configurations

Modem Line Side Interoperability

Multiple coherent pluggable vendors must support interoperability when using interoperable transmission modes



Two main challenges observed in the industry today

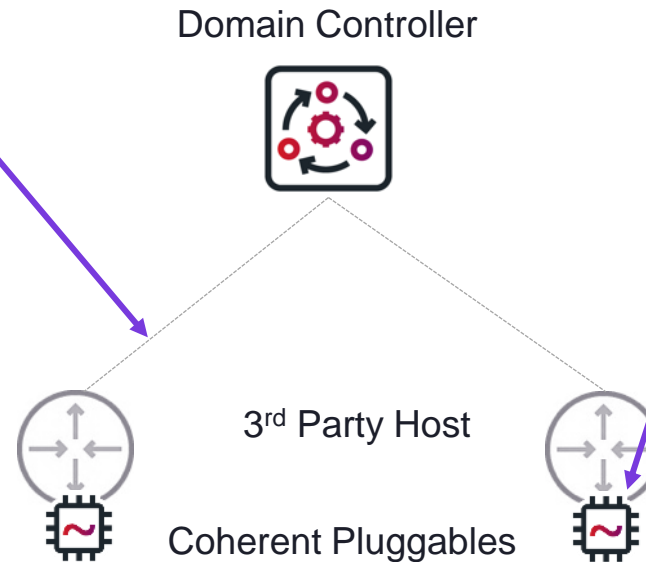
Domain Controller Interoperability

The 3rd party host must provide an open and standard domain controller interface for control, management, and monitoring functions.

Opportunity:

Implement a multi vendor and multi-layer management system

Risk if not supported: Degrade the optical management capability due to the lack of wavelength to photonic layer correlation for both provisioning and fault management.



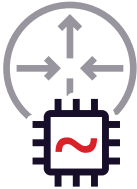
Host to Plug Interoperability

The 3rd party host must assure interoperability via CMIS with multiple vendor coherent pluggables to avoid vendor lock-in

Opportunity: Ensure diversity of supply, select the plug according to your performance objective

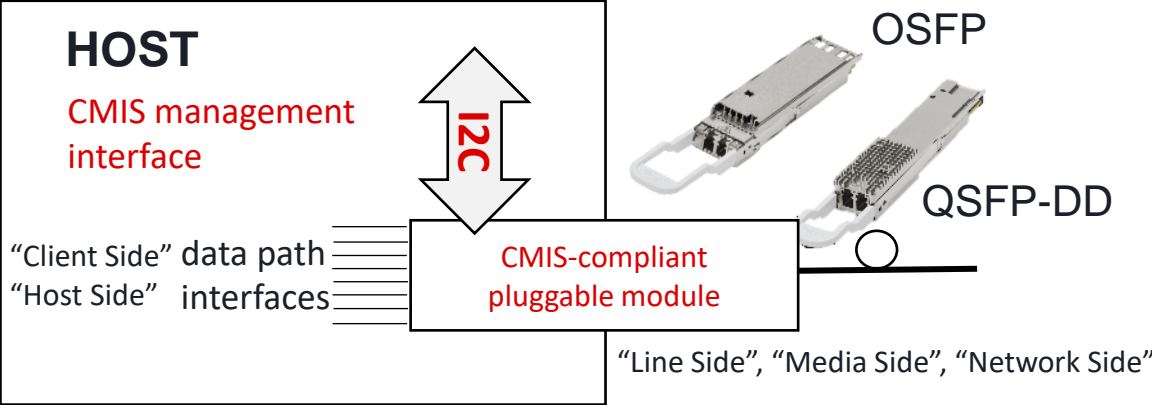
Risk if not supported: Vendor lock-in, take a step back in optical openness

Multiple industry forums and projects underway to improve over today's abilities to manage coherent pluggable optics in routers



What is CMIS ? How is it supported today ?

CMIS: Common Management Interface Specification



OIF - CMIS

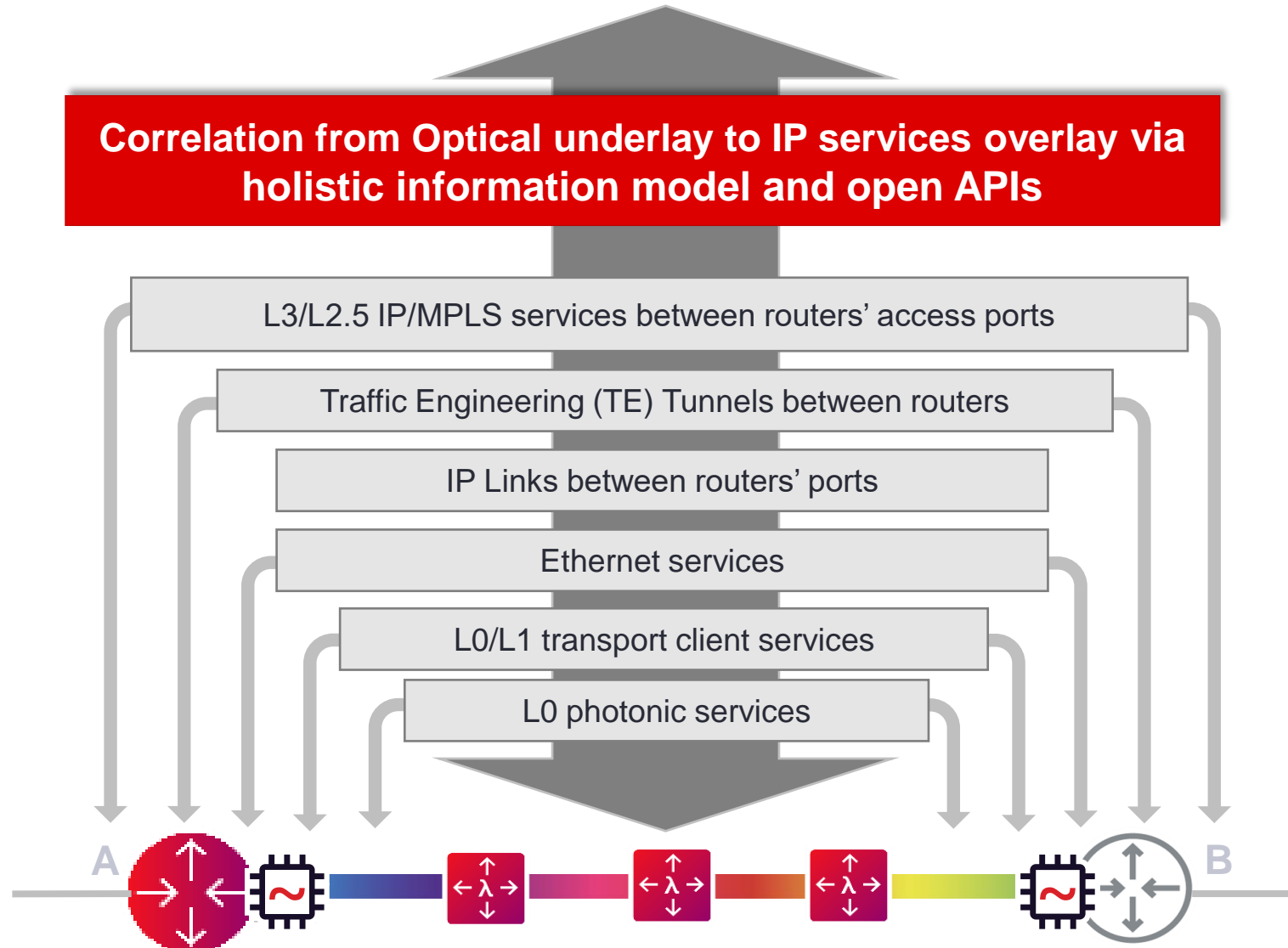
- CMIS is a management interface specification for optical modules
- CMIS provides a defined set of registers for standard module management including inventory data, module alarms, module monitoring, capability advertising, traffic configuration
- CMIS is intended to manage a wide range of optical modules
- C-CMIS is an additional document that augments CMIS to provide management support for coherent modules

Plug	TV1	TV2	RV1	RV2	RV3	RV4	RV5	RV6
400ZR	GUI	GUI	CLI	CLI	CLI	CLI	CLI	CLI
400G ZR+	GUI	GUI	CLI	CLI	CLI	CLI	TBD	Not supported with current OS
Proprietary	GUI	GUI	CLI	TBD	TBD	TBD	TBD	TBD

Router vendor support for 3rd party pluggables is an evolving landscape.

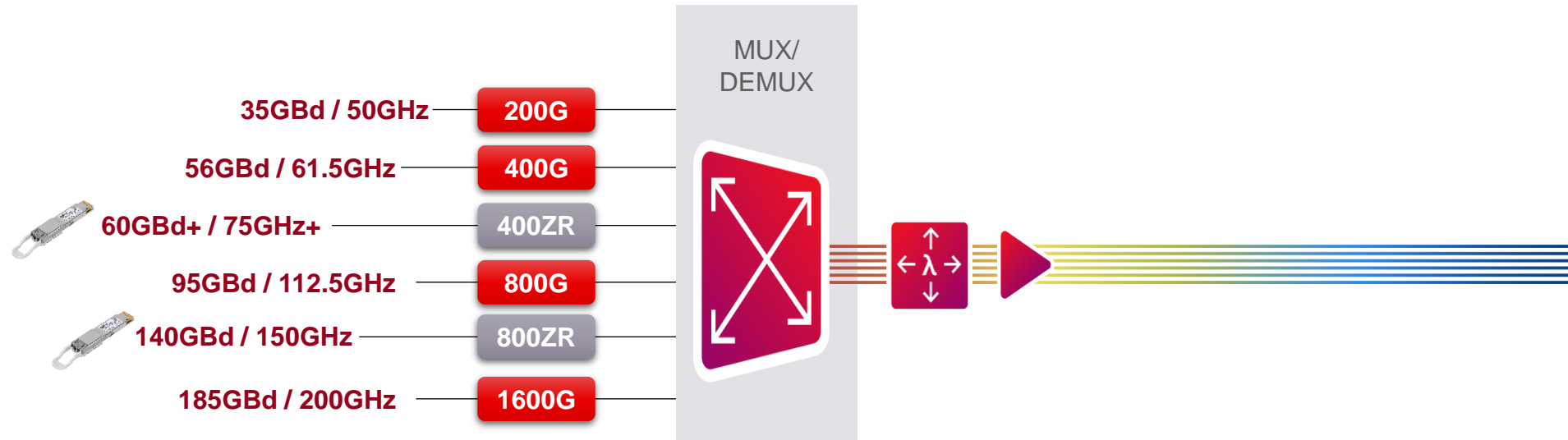
TV: Tester vendor
RV: Router vendor

Holistic information model is needed for multi layer management

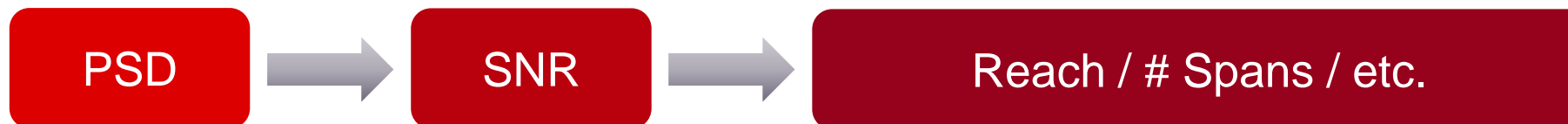


Implications of Multi-Gen Technologies at the photonic layer

The greenfield of today is the brownfield of tomorrow...

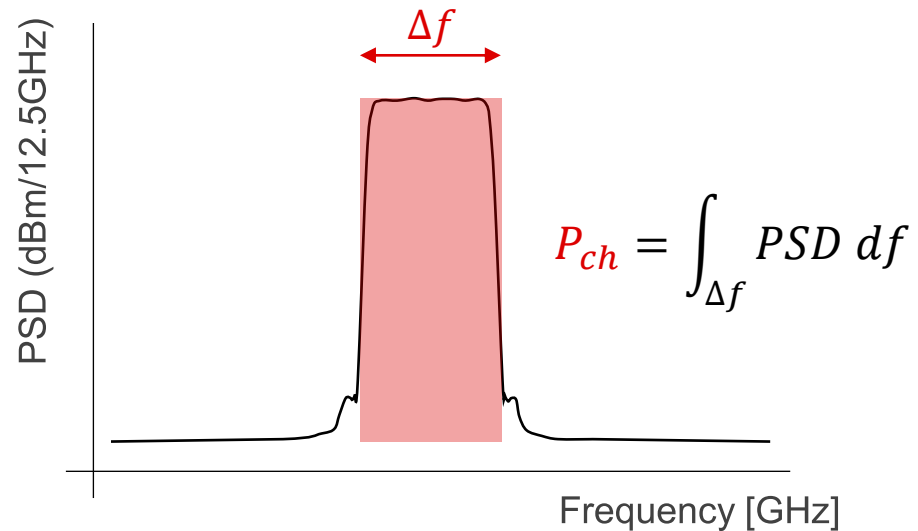


- Why can't I simply mix high and low power plugs? And what about larger and smaller channels?
 - The short answer is "PSD" (Power Spectral Density)

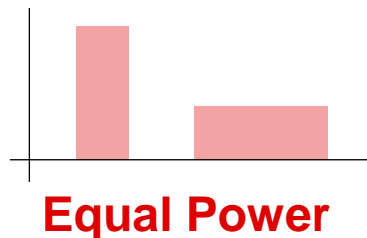


Channel Power vs PSD

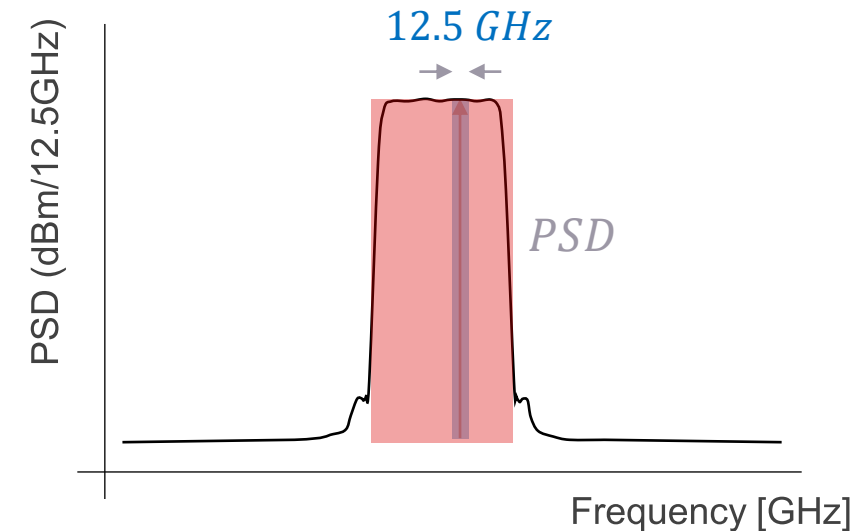
- **Channel Power** is the optical power integrated over the entire channel bandwidth.



- **For equal power**, wider channels (higher baud) must have a **lower PSD**.



- **PSD** is the power measured in a specified frequency range, typically 12.5GHz.

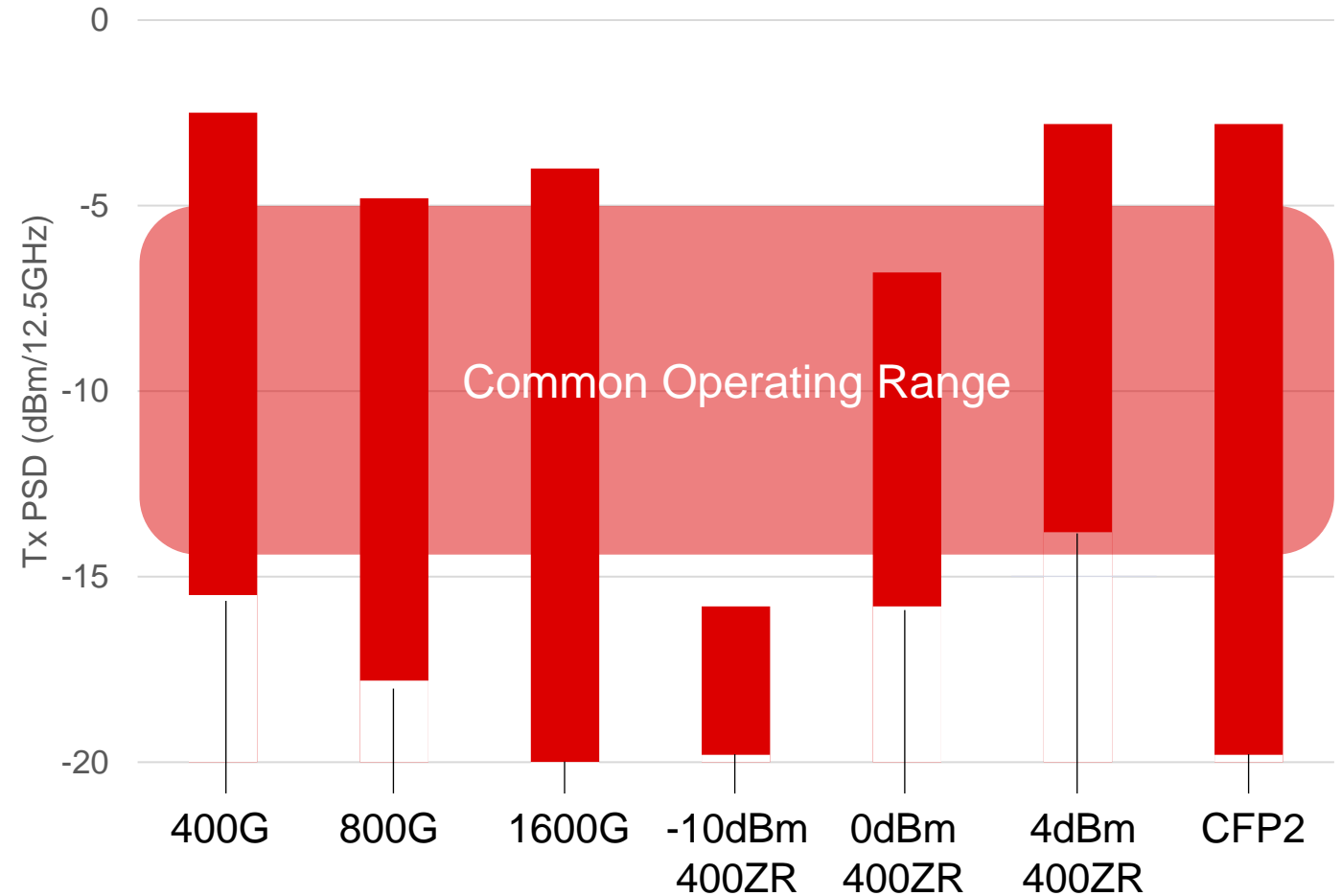


- **For equal PSD**, wider channels (higher baud) must have a **higher channel power**.



Mixing Technologies with Different Powers and PSDs

- Large Tx PSD deltas are undesirable:
 - All Max → Increased Xtalk, WDM for low-power modems
 - All Low → Reduced SNR for high-power modems
- Thus, it is good to match PSD ranges when deploying in brownfield networks.



Key Takeaways

- “Plan twice, execute once” – Don’t compromise working waves
- Optical Line Systems and Multi-Gen coherent technology must match
- Economics of Coherent Pluggables are directly related to its achievable performance
- Openness and Multi-Vendor integration is a must to Converge IP and Optical Networks
- Streamlined multi-layer management is a key objective
- Next-Gen Coherent Pluggables will address a wider application range



Obrigado!
Thank you!

Décio Coraça

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