CONNECTING AT THE SPEED OF LIGHT

Coherent In Passive Optical Networks

OptiNet 2023

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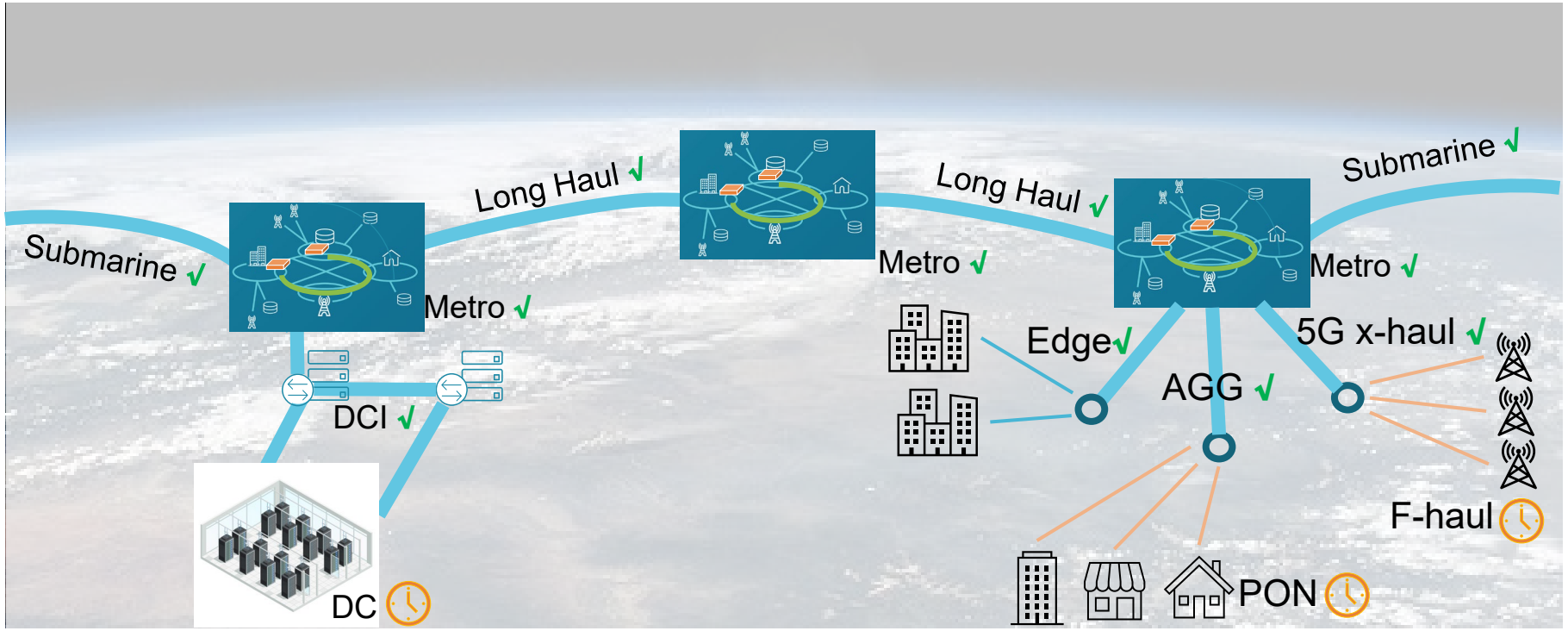
Optical Coherent Networks Continue to Expand



Coherent Successes: Submarine, Long-haul, Metro, DCI
Coherent Penetrations: Edge, AGG, 5G x-haul, Enterprise

Work to be Done: Front-haul, Intra-DC, PON

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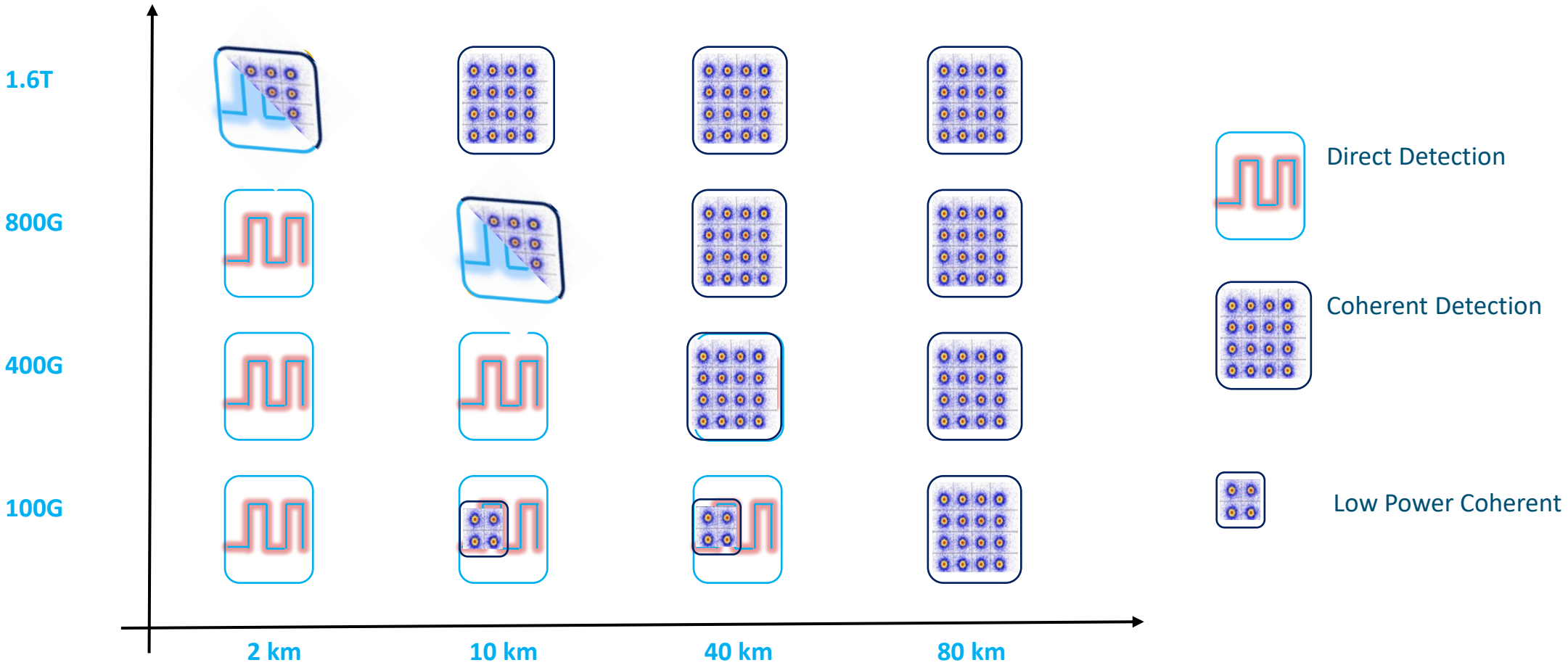
IM-DD vs. Coherent Implementations



Low Power Coherent 100G Replacing Nx10G in Short Reaches

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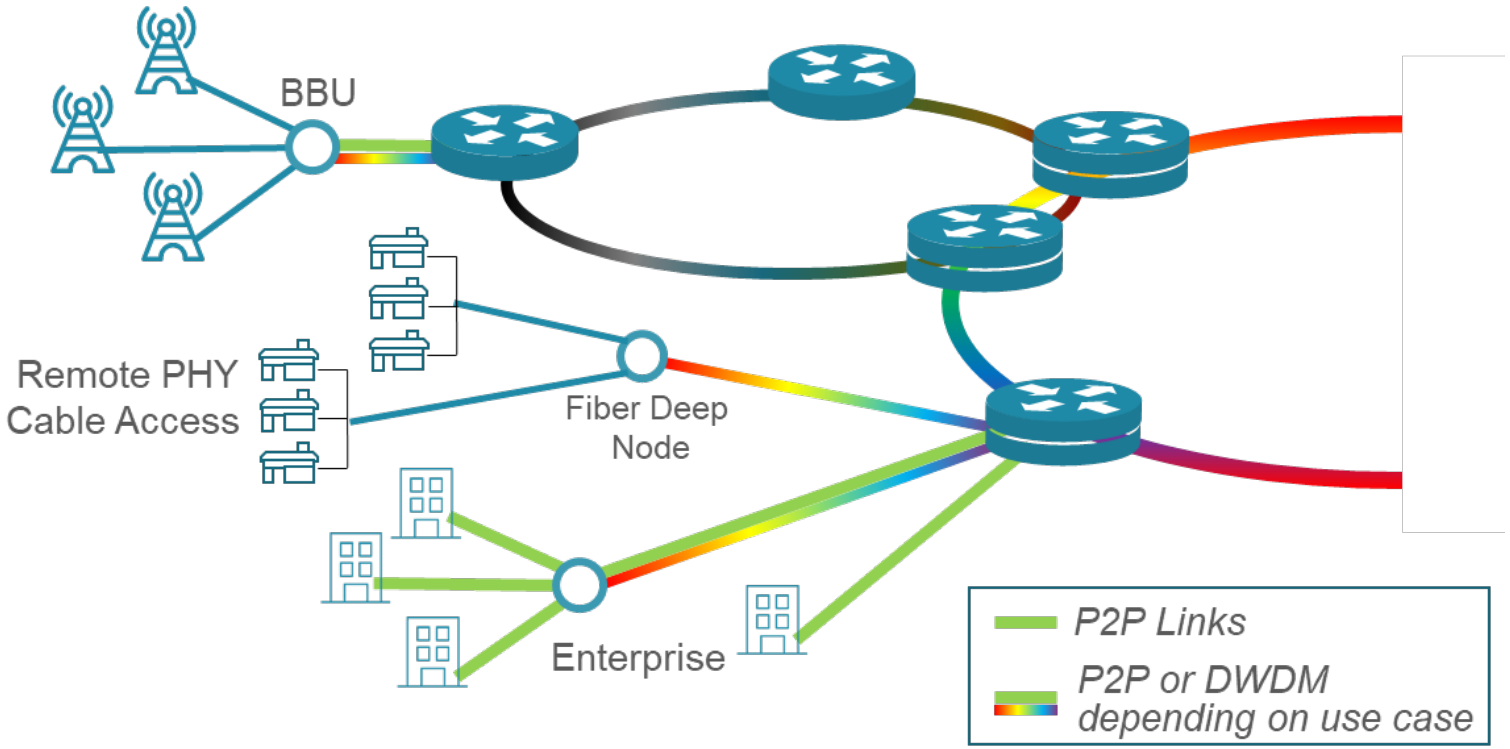
Edge & Access Network – Wireless Backhaul/Aggregation

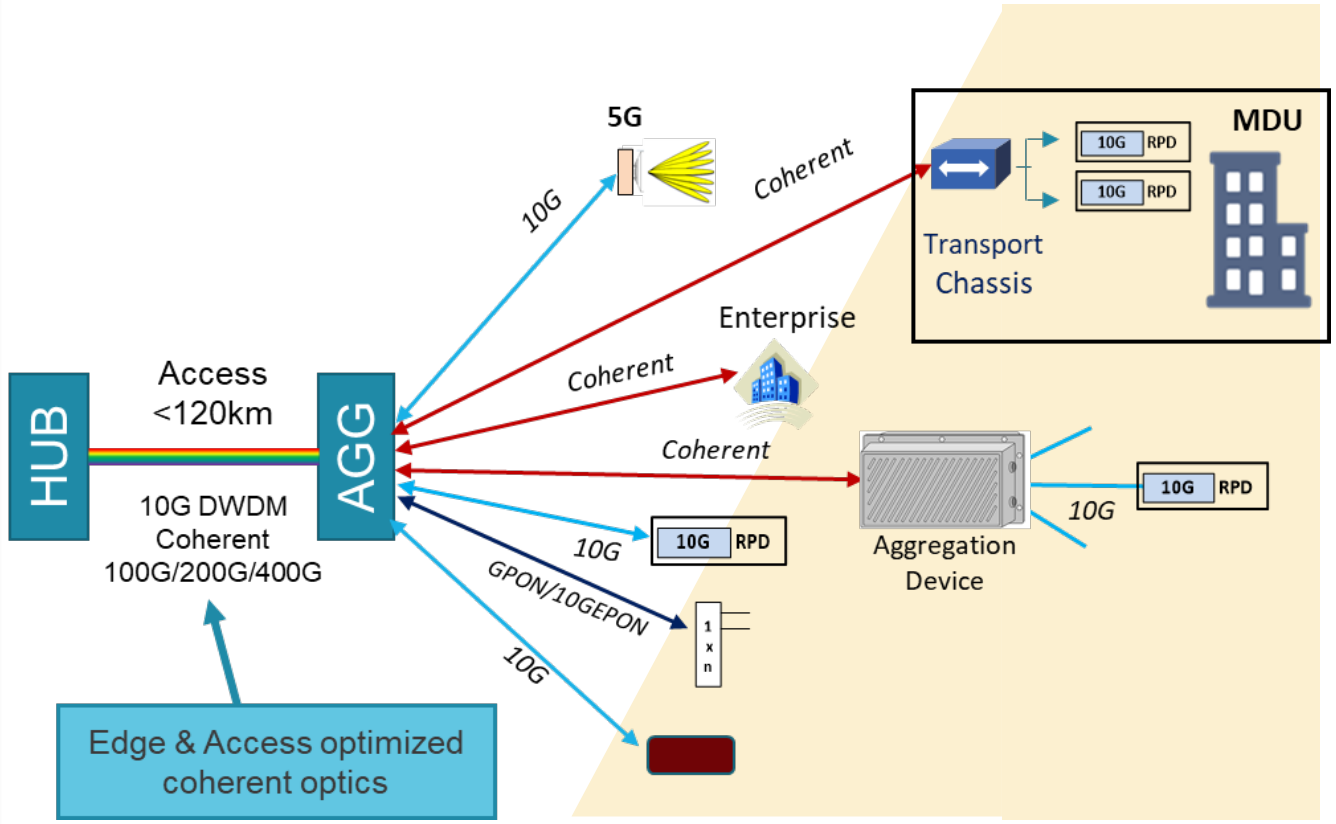
- Existing solutions
  - 100G LR4/ER4/ZR4
  - Nx10G DWDM
- Coherent solutions
  - Hot Pluggable
  - Fixed Wavelength or DWDM
  - 100G/200G/400G



Coherent Deployment in Transponders or Direct in IP

Converged Edge Using Coherent Optical Solutions

- Converged Interconnect Networks
  - Wireless backhaul services
  - Enterprise/Private network services
  - Residential Internet services
    - Data/Video/Voice
  - Most of links between hub and AGG are <120km
- Existing solutions
  - Nx10G DWDM
- Coherent solutions
  - Significant boost of capacity
  - N x 100G/200G/300G/400G



- Diagram based on SCTE-ISBE contributed paper by Cox Communications

PONs: Dominated by IM-DD (10G/25G/50G)

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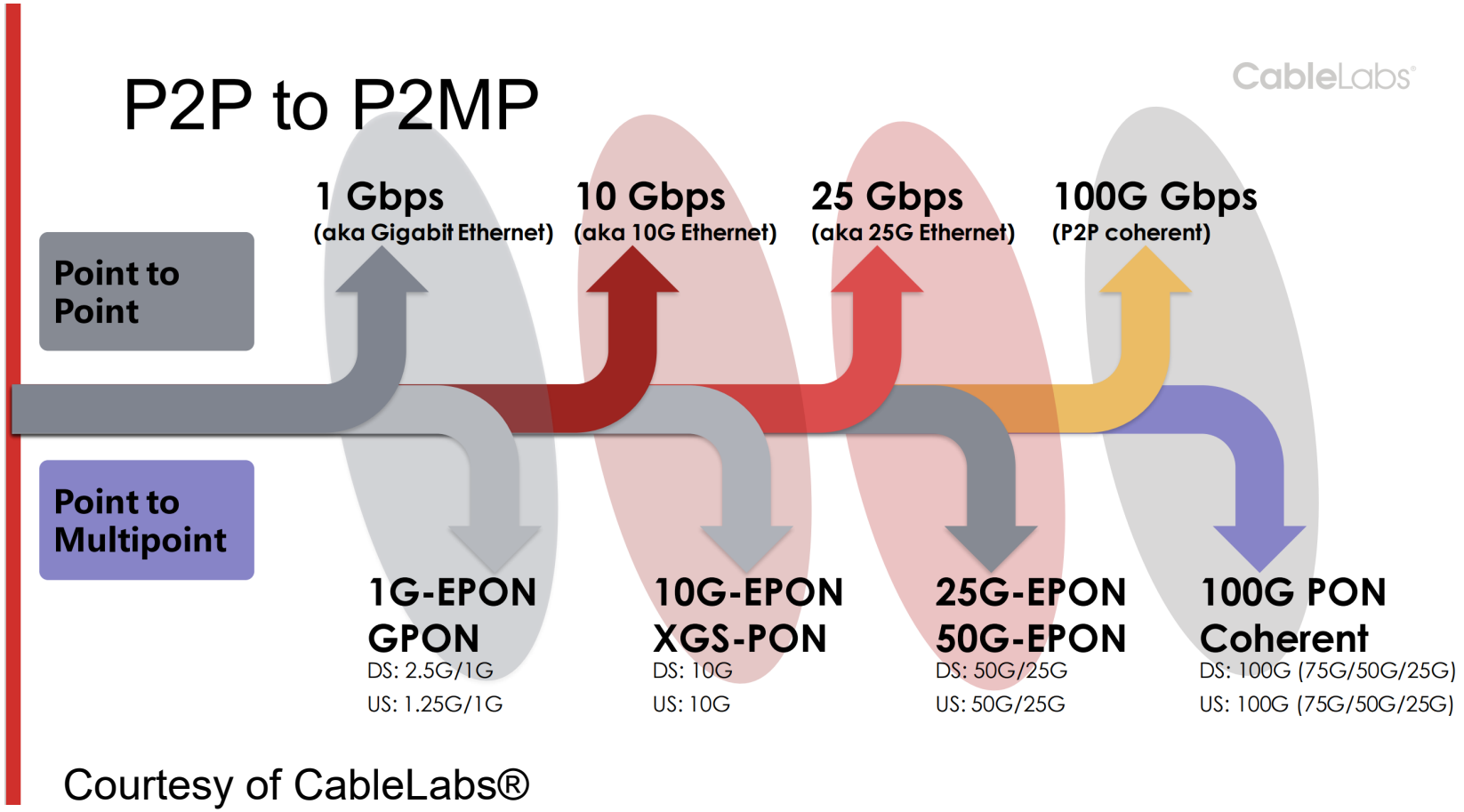
Trend of Passive Optical Network Technologies



Courtesy of CableLabs®

P2MP Following the Technologies Matured in P2P

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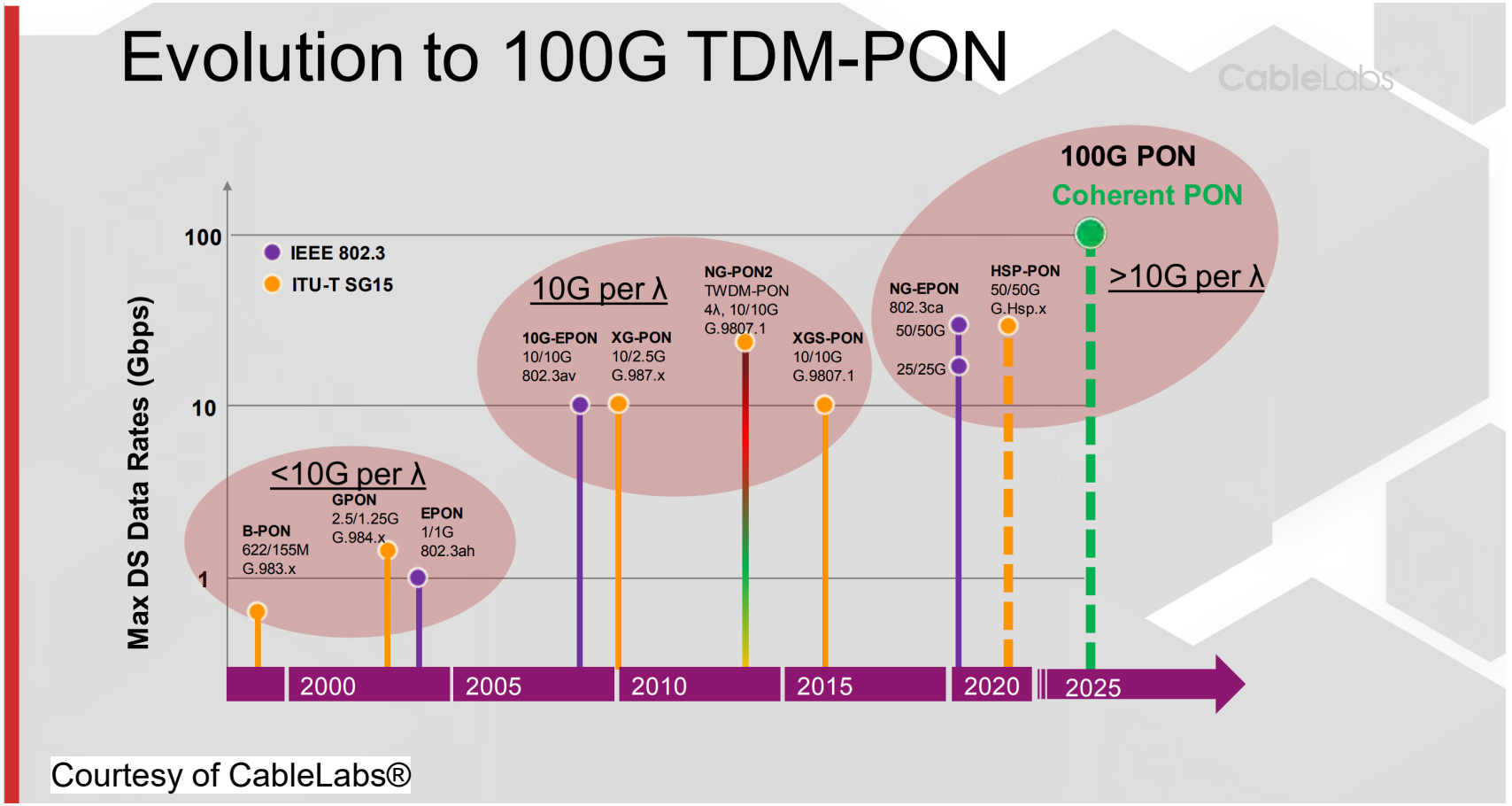
Evolution to 100G TDM-PON



Courtesy of CableLabs®

Coherent PON (CPON) Project Launched!

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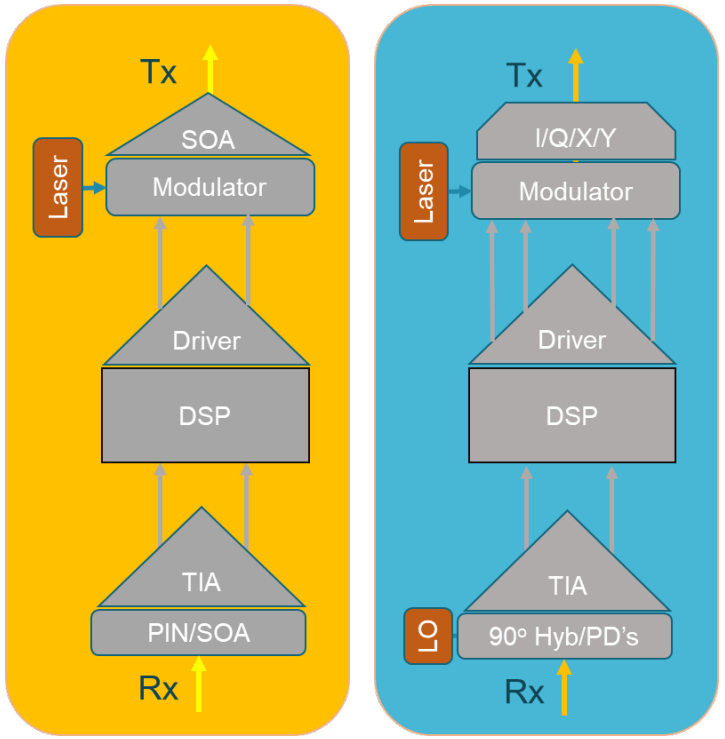
IM-DD vs Coherent for 100G TDM PON

Co-existence with legacy PON Objective: meeting 29dB and higher optical power budget

100Gbps IM-DD

- ~7dB penalty relative to 25Gbps
- 4x of component BW
  - Higher power and cost
- No APD => PIN+SOA
  - Higher power and cost
- @ HD-FEC limit
- Operating in O-band (CD limit)
  - >2dB more loss for 20km
- Challenges of burst mode reception
- Need significant increase launch power (feasible?)
  - High power EML +SOA
  - Laser safety issue
  - Reliability issue

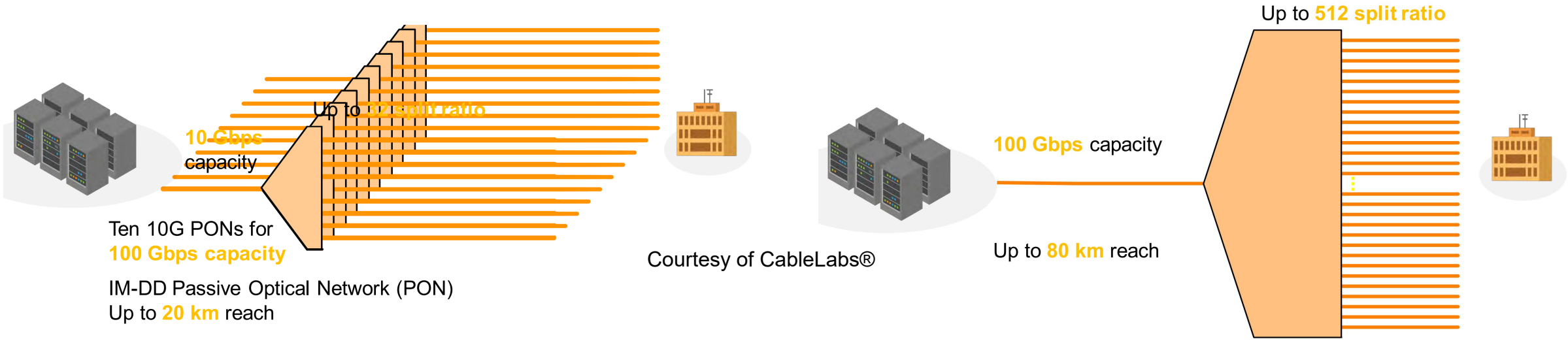


100Gbps QPSK

- Coherent detection: >29dB budget
- 30GB components
  - High volume production for >10yrs
- Hybrid Rx with coherent detection
  - High volume production for >10yrs
- SD-FEC higher coding gain
- Operating in C-band
  - Extend reach >80km applications
- Challenges of burst mode reception
- Need Rx LO work on different frequency than Tx
  - For single fiber BiDi
  - Technology available
- Further capacity increase through DMDM

New Applications Opened by Coherent PON

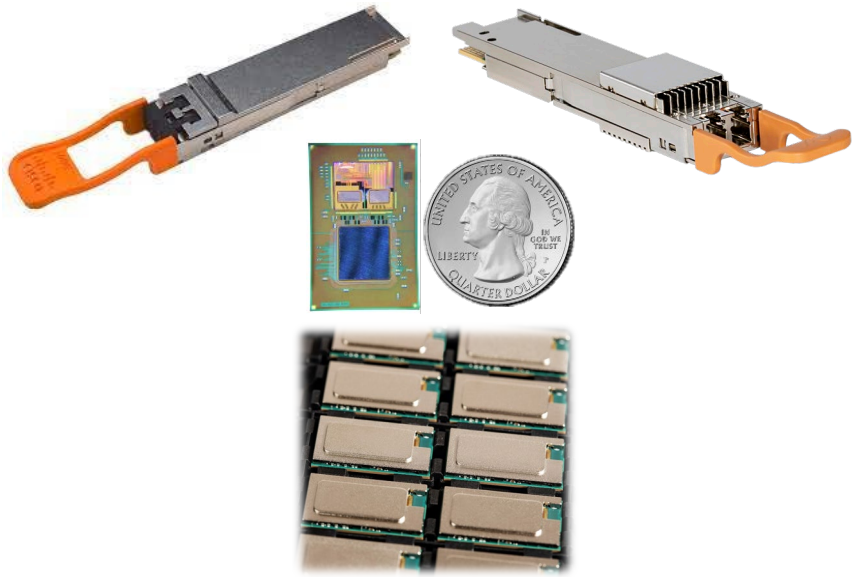
- 100G based on 10x10G PONs
- 100G based on 1x100G CPON



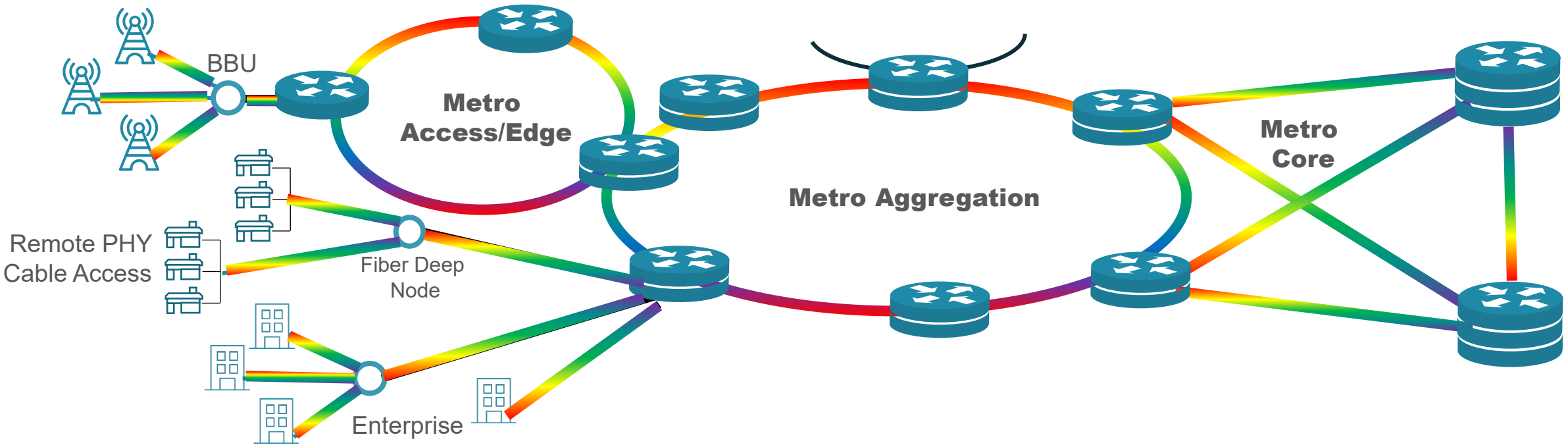
Coherent PON: Higher Capacity, Longer Reach, Greener

Moving into PON: Coherent Ready?

- Fits into small hot pluggable module
  - Innovations from high-density photonic integration (SiP and InP)
  - Innovations from advanced packaging (3D OE-MCM, ICTROSA)
- Low power consumption
  - Smaller CMOS node: 4nm/3nm
  - Low power Driver/TIA and laser designs
  - Co-design on RF signal paths
- Cost competitive
  - High level of vertical integration
  - High-volume packaging
  - Low-cost laser (fixed or narrow tuning range)
- Single fiber Bi-directional transmission
  - Tunable Coherent BiDi DCO available today
  - Need further cost/size reduction
- Operation in I-temp outdoor environment
  - Coherent DCO available today
  - Need further cost/size/power reduction
- Burst mode reception
  - Standardization and Implementation



Light Up the Last Miles of Fiber with Coherent



PON	Edge/Access	Metro Aggregation	Metro Core
• Point – Multi-Point • 10G grey • **Need Coherent at 100G**	• Ring, Point-Point • 10G color & 100G grey • **Coherent replacing DD**	• DWDM Ring • 10G =>100/200G • **Coherent replacing DD**	• DWDM Mesh • 10/40G=>100/200/400G • **Coherent Dominant**

Thank You