100G Single-Wavelength Passive Optical Network
Coherent PON (CPON)

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Evolution to 100G TDM-PON

Max DS Data Rates (Gbps)

- **IEEE 802.3**
- **ITU-T SG15**

100G PON
Coherent PON

>10G per λ

10G per λ

- **10G-EPON**
  - 10/10G
  - 802.3av
  - G.987.x
- **XG-PON**
  - 10/2.5G
  - G.987.1
- **NG-PON2**
  - TWDM-PON
  - 4λ, 10/10G
  - G.9807.1
- **XGS-PON**
  - 10/10G
  - G.9807.1

<10G per λ

- **GPON**
  - 2.5/1.25G
  - G.984.x
- **EPON**
  - 1/1G
  - 802.3ah

- **NG-EPON**
  - 802.3ca
  - 50/50G
  - G.Hsp.x
- **HSP-PON**
  - 50/50G

- **B-PON**
  - 622/155M
  - G.983.x
- **EPON**
  - 1/1G
  - 802.3ah

- **2000**
- **2005**
- **2010**
- **2015**
- **2020**
- **2025**

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IM-DD to the Limit

Coexistence with legacy PON Objective: meeting 29dB and higher (32dB) optical power budget

25 Gbps

- A power penalty of ~5 dB relative to 10G PON
  - 1-2 dB from FEC (Reed–Solomon (RS) code used in XG(S)-PON at 1E-3, the low-density parity check (LDPC) code at 1E-2)
  - 1 dB from improved receiver sensitivity (PIN to APD)
  - 2-3 dB from an increase in launch power (4-5dBmEML)

50 Gbps

- A power penalty of minimum ~4 dB relative to 25G PON
  - 1dB from FEC (soft-decision LDPC to replace hard-decision LDPC)
  - Improved receiver sensitivity (DAC/ADC/DSP, SOA + PIN, no 50G APD available)
  - Increase in launch power (SOA)
  - Challenges of burst mode reception

100 Gbps?

Coexistence with legacy PON

- TWDM approach
  - Challenges in frequency drift (especially in burst mode)
  - Inter-channel crosstalk
  - Complexed control of channel bonding
- Revolutionary technology (Coherent Solution)

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1 Gbps (aka Gigabit Ethernet)
- 1G-EPON
  - GPON
    - DS: 2.5G/1G
    - US: 1.25G/1G

10 Gbps (aka 10G Ethernet)
- 10G-EPON
  - XGS-PON
    - DS: 10G
    - US: 10G

25 Gbps (aka 25G Ethernet)
- 25G-EPON
  - 50G-EPON
    - DS: 50G/25G
    - US: 50G/25G

100G Gbps (P2P coherent)
- 100G PON Coherent
  - DS: 100G (75G/50G/25G)
  - US: 100G (75G/50G/25G)
Extended PON Application Scenarios

- Higher Density Support
- Larger Coverage Extended Reach
- Higher Capacity
- Business
- DAA/PON Aggregation
- Mobile Transport
- Typical PON Deployment

OLT - 32 ONUs - 20 km

Even PON to Data Center …
Coherent PON and Use Cases
What is Coherent PON?

• Coherent PON is like traditional PON:
  • Passive optical distribution network
  • Point-to-multipoint topology

• Yet, Coherent PON is different:
  • Uses coherent modulation and detection instead of IM-DD
  • Optimizes optical power distribution
  • Provides longer reach & higher split ratio with improved power budget
  • Enables 100 Gbps and beyond data rate (per lambda)
Ten 10G PONs for 100 Gbps capacity

IM-DD Passive Optical Network (PON)
Up to 20 km reach

Up to 64 split ratio

10 Gbps capacity
Coherent PON (CPON)

- Up to 80 km reach
- 100 Gbps capacity
- Up to 512 split ratio
What use cases will require:

100 Gbps Capacity?
80 KM Reach?
512:1 Split Ratio?

Coherent PON
Use Cases for Coherent PON

100 Gbps Network Aggregation

Optical Access Networks: Residential Broadband

Wireless Transport: Mid-Haul & Fronthaul

Fiber to Businesses and Multi-Dwelling Units
Use Case: Residential Broadband

Optical Access Networks: Residential Broadband

Digital Hub

CCAP Core

CPON OLT

100G

Existing Fiber Optics

Optical Splitter

1.2 GHz FDD

1.8 GHz FDD

DOCSIS® 4.0 Extended Spectrum (Remote PHY)

RPD_N

RPD_1

= 100G CPON Optical Network Unit (ONU)

DOCSIS 4.0 Full Duplex DOCSIS (Remote PHY)
Use Case: Wireless Transport

Wireless Transport: Mid-Haul & Fronthaul

### Mid-Haul Aggregated Bandwidth for D-RAN

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Mid-Haul Bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-Band 64T64R Massive MIMO Radio 3Cell (100M D16L/U8L)</td>
<td>10 Gbps</td>
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</tbody>
</table>

### Fronthaul Aggregated Bandwidth for C-RAN

<table>
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<th>Configuration</th>
<th>Fronthaul Bandwidth</th>
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</thead>
<tbody>
<tr>
<td>C-Band 64T64R Massive MIMO Radio 3Cell (100M D16L/U8L)</td>
<td>62 Gbps</td>
</tr>
</tbody>
</table>

Source: VRAN Cost Modeling and Value Proposition, Samsung, 2020

Optical Fronthaul Architecture will determine placement of ONUs
Use Case: Fiber to the Building

Optical Access Networks: Fiber to the Building

Digital Hub

CPON OLT

100G

Fiber to Businesses and Multi-Dwelling Units

Existing Fiber Optics

Optical Splitter

100G CPON Optical Network Unit (ONU)
Edge Aggregation: 100G Coherent PON

- Optical power splitter/combiner
- 100G CPON Optical Network Unit (ONU)

Digital Hub

CCAP Core

Core Network vEPC

100G CPON OLT

1.2 GHz FDX

1.8 GHz FDD

RPD

RAN

DU

CU

OLT

CPON

Core Network

Network
Use Case: Rural (Long Reach) FTTH
Use Case: Urban (High Density) FTTH
Coherent PON Advantages vs. EPON and GPON Technologies

**Features:**
- Higher Capacity (100 Gbps per single λ)
- Longer Reach (up to 80 KM)
- Higher Density (up to 512 end points)

**Benefits:**
- Efficient Sharing of Optical Power
- Scalability to 100 Gbps and Beyond
- Flexibility of High- and Low- Density Deployments
- Single Platform for Network Aggregation and FTTH
Key Enabling Technologies
Transmitter Burst Frame Structure

Pol. X

Pol. Y

Clock Sync/FOE/Pol DeMux Ch EQ Payload

~100ns ~1.3us
Receiver Burst Processing

Burst Waveform

ONU1

ONU2

Sync. Peaks Detected

One Frame Abstracted

Pols. Recovered

Ch. Equalization

Carrier Phase Recovered
Rate-Flexible Symmetric 100G Coherent PON

Digital subcarrier multiplexing in both time and frequency domain over a single optical wavelength, enabling 25G, 50G, 75G, and 100G flexible data rate.
Focus Area for Cost Reduction

Traditional Coherent Optics

Access Optimized Coherent Optics

P2MP CPON

- DSP
- Rx
- Modulator
- Laser

- DSP
- Rx
- Modulator
- Laser

- DSP
- Rx
- Modulator
- Laser
CPON Project Launch
Project Objectives

• Develop specifications for Coherent Passive Optical Network solution for the Access Network
  • Specs will support cable applications, and also could be applicable to other applications (e.g., cellular, telco, data center, etc.).
  • Specs will ensure PON systems coexist on deployed infrastructure and enable interoperability, creating volumes to drive down cost.
Launching a Working Group (WG) to develop the specifications
Looking for companies with relevant experience to participate
Optical Project Charter

- Provides governance for CableLabs Optical Project
- Covers following topics (among others):
  - Scope
  - Conditions for Participation
  - Confidentiality
  - Intellectual Property Terms
WG Kickoff Meeting

• Date: May 27, 2021
• Time: 9:00-11:00 am (Mountain Time)
• Location: Virtual web meeting

• Note: you **MUST** provide a signed Participation Agreement in order to receive the invitation of WG kickoff meeting and participate in any project activities
How to Participate

1. Review Project Charter
2. Sign Participation Agreement
   • One per company
   • Commits each company to Project Charter
3. Identify Contributing Engineers (CEs)
   • Up to 2 per company
   • Must have relevant experience
   • Sign CE agreement, committing ~50% of engineer’s time to project
4. Attend meetings and actively participate
How to Participate

Send email to workinggroups@cablelabs.com
Coherent PON

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