Lighting Up Coherent Optics

LiveLearning Webinars™ For Professionals

Thursday, Oct. 21, 2021
11:00 am – 12:00 pm ET
Today’s Speakers

Alan Breznick
Cable/Video Practice Leader
Light Reading

Zhensheng (Steve) Jia
Ph.D., Distinguished Technologist
CableLabs
Agenda

• **Light Reading**—Coherent Optics Overview
• **CableLabs**—Coherent Optical Technology Evolution
• Coherent Optics for P2P Connections
• Coherent Optics for P2MP Access Connections
• Explaining Coherent PON
• Key Enabling Technologies
• CableLabs’ CPON Project
• **Audience Q&A**
Full Duplex Coherent Optics

Hub

Laser
Transmitter
Receiver

Electrical Downlink Signal
Optical Mux/Demux
Electrical Uplink Signal

Circulator
Optical Fiber

Fiber Node

Laser
Transmitter
Receiver

Electrical Downlink Signal
Electrical Uplink Signal
Evolution to Fiber Deeper

N+2
4-8
Child Nodes

N+0
10-18
Child Nodes
If you are a service provider, how much aggregate capacity do you need (1-3 years) for optical access/edge networks in support of coax, fiber and mobile services?

- <= 100G
- 200G
- 400G
- >400G
If you are a vendor, which PON technologies are part of your product portfolio?

- ITU-T PON (GPON, XGS-PON…)
- IEEE PON (EPON, 10GEPON, 25GEPON…)
- both PONs
- none of them
Zhensheng (Steve) Jia
Ph.D. Distinguished Technologist
CableLabs
Outline

• Coherent Optical Technology Evolution
• P2P Coherent Optics for Access Networks
  • Access Environment Considerations
• P2MP Coherent Optics for Access Networks
  • Coherent Passive Optical Network
Coherent Optics Technology Development

1. 2010
   100G - 32GBaud QPSK
   40nm CMOS

2. 2013/14
   200G - 8QAM/16QAM

3. 2015
   400G - Flex rate

4. 2017
   600G - 64GBaud 64QAM

5. 2019/2020
   800G - >90GBaud

6. 2020/2021
   400G Pluggable
   7nm CMOS

7. 2022/2023
   800G Pluggable
   5/3nm CMOS
Why Coherent Solves (almost) Everything?

- Linear optical field conversion
  Enabling modulation and detection for four independent degrees of freedom with powerful Digital Signal Processing
- Coherent gain and inherent wavelength tunability
  Local Oscillator serving as a clean signal amplifier and synchronizing the desired wavelength channel
- No power fading and no powerful information-less carrier
Coherent Optics Technology – DSP Flow

1. Correction  
2. CD comp.  
3. Timing recovery  
4. Polarization Demux  
5. Freq. offset comp.  
6. Phase comp.

QPSK

8QAM

16QAM

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Coherent Optics Evolution

Access/Edge Aggregation Node

Passive Optical Network
Enterprise
5G xHaul!

Metro Network
Core Network
Metro Network

Hybrid Fiber Coax
Data Centers
Business

Coherent Dominant

High-End Coherent Optics
Higher spectral efficiency, higher modulation format, higher Baud rate (800G+ per wavelength)

Low-Cost Coherent Optics
Ultra-compact footprint, ultra-low power consumption

Low-Cost Coherent Optics
multi-vendor interoperability
Coherent Optics for P2P Connections
Adaptation and Optimization of Coherent Optics for Access Networks

Distribution analysis of the ASIC power consumption

Example: number of digital filter taps for different distance introduced chromatic dispersion

The number of required digital taps increases with the transmission distance.
Signal Coexistence Over Fiber

- Analog Channels
- 10G Digital Channels
- Coherent CFP2 100G
- Coherent 400G
Full Duplex Coherent Optical System
The 10G Converged Optical Network

- Network provides high bandwidth Ethernet services deep into the field
- Supports numerous applications in addition to residential broadband over coax, such as wireless xhaul, remote PON, P2P fiber services, etc.
CableLabs’ P2P Coherent Optics Specifications

**1. Architecture**
- 100G: DP-DQPSK, SD-FEC

**2. 100G**
- Application Scenarios: DP-DQPSK, SD-FEC

**3. 200G**
- DP-QPSK, open FEC

**4. OSSI**
- Management & Control

**Incorporated Full Duplex Coherent Optics into specs**

**2 successful Interops for 100G** (December 4-6, 2018, April 23-25, 2019)
Coherent Optics for P2MP Access Connections
Evolution to 100G TDM-PON

Max DS Data Rates (Gbps)

- 10G per λ
  - 10G-EPON: 10/10G, 802.3av, G.987.x
  - XG-PON: 10/2.5G, G.987.x
  - XGS-PON: 10/10G, G.9807.1

- <10G per λ
  - B-PON: 622/155M, G.984.x
  - EPON: 1/1G, 802.3ah

- 100G PON
  - Coherent PON
  - NG-EPON: 802.3ca, 25/25G
  - HSP-PON: 50/50G, G.Hsp.x

Timeline:
- 2000
- 2005
- 2010
- 2015
- 2020
- 2025

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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)
Traditionally, PON technology does not reach approximately 50% of homes from the cable hub without an intermediate active component.
Extended PON Application Scenarios

• R-PHY/RMP Connectivity & Backhaul
• Mobile Backhaul
• Mobile Fronthaul
• Remote OLTs
• WiFi Backhaul
• Fixed Wireless Backhaul
• Residential/FTTH MDU
• Residential/FTTH SFU
• Deep Diversity (Equipment and Path)
• Edge Computing
• Network as a Platform
Use Case: Rural (Long Reach) FTTH
Use Case: Urban (High Density) FTTH
Key Enabling Technologies
Transmitter Burst Frame Structure

- Clock
- Sync/FOE/Pol DeMux
- Ch EQ
- Payload

Pol. X

Pol. Y

~100ns

~1.3us
Receiver Burst Processing

Burst Waveform

ONU1

ONU2

Sync. Peaks Detected

One Frame Abstracted

Pols.Recovered

Ch. Equalization

Carrier Phase Recovered

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Digital subcarrier multiplexing in both time and frequency domain over a single optical wavelength, enabling 25G, 50G, 75G, and 100G flexible data rate.
CableLabs’ CPON Project
Project Objectives

- Develop specifications for Coherent Passive Optical networks and devices that:
  - Are multi-vendor interoperable
  - Can be developed and deployed at scale at reasonable cost
  - Support a wide range of applications and use cases, including cable operators and others such as mobile operators, telcos, etc.
  - Coexist with existing infrastructure
CPON Specifications

1. ARCHITECTURE (ARCH)
   Use Cases and General Requirements.

2. PHYSICAL LAYER (PHY)
   Both Downstream (CM) and Upstream (BM).

3. MEDIA ACCESS CONTROL (MAC)
   Transmission Scheduling, Quality of Service, Auto-Discovery.

4. SECURITY (SEC)
   Authentication, Access Control, Data Integrity.

5. MANAGEMENT (OSSI)
   Fault/Configuration/Performance Management.
Coherent Optics

CableLabs

Steve Jia, Ph.D.
s.jia@cablelabs.com

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Audience Q & A

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Next Months Webinar

How to Test the Next-Gen Cable Network

11/18/2021 11:00 am New York / 8:00 am Los Angeles

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