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The Constantly Evolving Wireline Network

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Cable access networks are rapidly evolving to support present and future connectivity needs. As recently as the 1990s, a cable network provided only video entertainment to customers. Today, the cable network provides fundamental connectivity to support a plethora of services including working from home, remote learning, telehealth services and, yes, is still the primary conveyance for video entertainment. The pandemic has only heightened the need to evolve fast, reliable, and secure connectivity to stay well ahead of the demand from these various classes of service. Worldwide, cable networks have excelled in this daunting task.

Cable network operators have never been shy about investing in their networks to stay ahead of the service demand curve. According to the NCTA, U.S. operators have invested over $290 billion in infrastructure and networks over the last two decades—$17 billion in the year 2020 alone.

As a major milestone along this investment continuum, NCTA and CableLabs announced the 10G platform at the 2019 Consumer Electronics Show. While speed is still a central "pillar" of this platform, latency, security, and reliability are also foundational pillars.

In 2021, CableLabs and SCTE merged, creating an ecosystem that delivers research and development, interoperability testing, standardization, training, certification, 67 geographic chapters and an international technical exposition, all dedicated to the furtherance of the cable industry's technological objectives.

To achieve 10G objectives, CableLabs and SCTE manage a vast portfolio of technology projects. This article provides just a sampling of these projects.

Distributed Access Architecture (DAA) and Generic Access Platform (GAP)

DAA moves the physical layer (aka PHY layer), as well as the media access control (MAC) layer in some variants, out of the hub site and into the fiber access node. With the PHY layer (or MAC and PHY layers) moved into the node, fiber connections transition from analog optics technology to digital optics technology, thereby leveraging the ubiquity of optical IP/Ethernet transport between the hub and the node. Since the PHY layer is closer to the customer's home, operators can leverage the lower signal-to-noise ratio to provide higher modulation efficiency, more capacity, and overall faster service tiers and improved network performance.

For operators, significant rack units (RUs) are freed up in the hub site, decreasing space, power, and HVAC costs. Additionally, operational expenses associated with alignment and maintenance are reduced, while network visibility is improved due to the remote device intelligence.

The Generic Access Platform (GAP) is a key component of a DAA solution. GAP is a modular, next-generation access node that standardizes the physical, thermal, mechanical, and electrical interfaces for the internals of a node housing.

It is not unusual for large network operators to have to manage the supply chain of over 40 different node enclosures and their related cards in their network. The supply chain includes initially procuring the parts, keeping sufficient quantities in their warehouses and trucks, and training technicians to work with all these variants. For the most part, none of these enclosures, transmitters, receivers, amplifiers, and power supplies are interchangeable. Standardizing the node enclosure eliminates this logistical headache. It also allows equipment vendors to focus on innovating and developing specific modules within the enclosure. In addition to providing operational efficiency by standardizing the node enclosure, GAP will also support mobility by including LTE and 5G wireless modules.(see figure 1 on next page)

SCTE recently released two GAP standards: SCTE 273-1 outlines the specifications for the GAP enclosure, while SCTE 273-2 details the requirements for interchangeable modules within that GAP enclosure. Use cases envisioned for GAP include cable access, fiber access, wireless access, multi-access edge computing, and future applications.

DOCSIS 4.0 technology

The DOCSIS 4.0 specifications define the requirements for a sixth generation of the broadband solution for hybrid fiber coax (HFC) networks. Two modes of operation are defined, each capable of providing approximately 10 Gbps downstream and 6 Gbps upstream. The full duplex (FDX) DOCSIS mode of operation leverages echo cancellation technology to simultaneously transmit in both upstream and downstream directions in the same spectral region. In essence, FDX DOCSIS increases the upstream spectral region from 42 MHz to 684 Mhz.

For frequency division duplex (FDD) mode of operation, also referred to as Extended Spectrum DOCSIS (ESD), the tradition in previous DOCSIS generations continues with spectrum dedicated to upstream transmission and separate spectrum dedicated to downstream transmission. FDD DOCSIS increases the upper end of upstream spectrum to 684 MHz, while the maximum downstream frequency increases to approximately 1.8 GHz.

This next generation of DOCSIS technology is intended to support multi-gigabit symmetric services, an important objective of the 10G platform.

Coherent optics in access

With the evolution toward DAA, edge devices such as remote PHY devices, remote MACPHY devices, and even remote OLT modules will each be capable of providing 10 Gbps peak symmetric capacity to consumers. As there are a multitude of edge devices connected to the optical distribution network, the aggregate capacity of the fiber network is potentially orders of magnitude higher than today's fiber network requirements. To meet the increasing capacity requirements, CableLabs has defined specifications for coherent optical transceivers in a point-to-point fiber topology. The 100 Gbps and 200 Gbps PHY layer specifications, used in conjunction with the Coherent Termination Device specification, provide the requirements for an end-to-end access network aggregation solution.

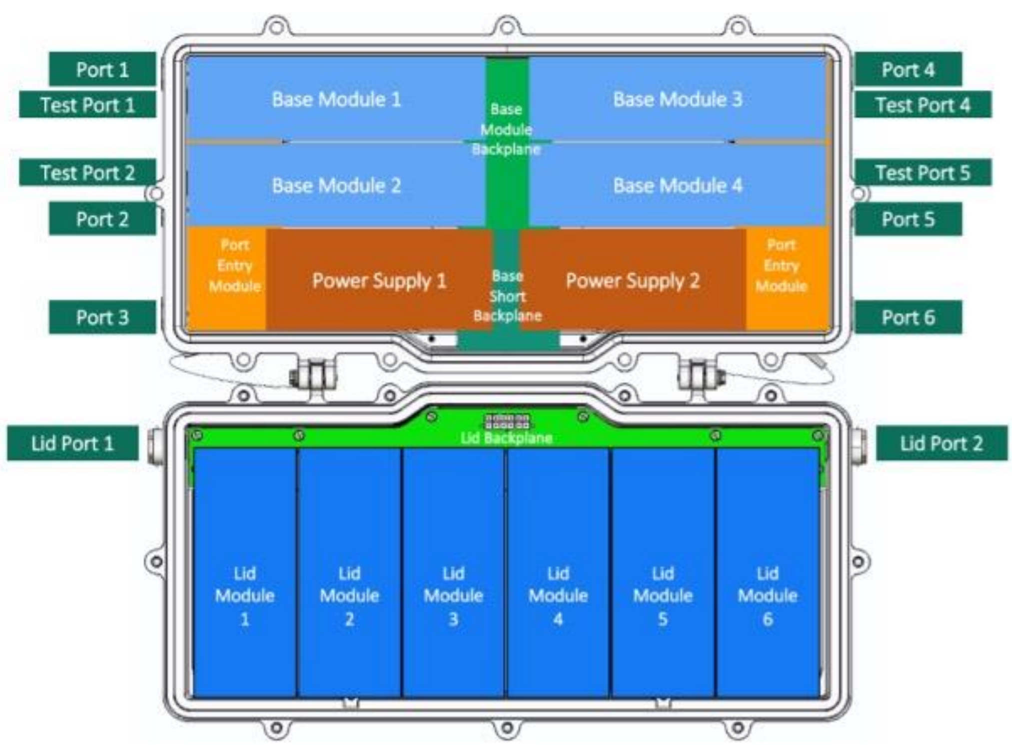

Figure 1 – GAP Reference Architecture

click to enlarge

100G Coherent PON

Equally important for the access network and the 10G platform, ensuring future service tiers are supported in a completely passive manner is also a focus of the cable industry. Fiber to the home (FTTH) using passive optical networking (PON) technology continues to gain momentum and, like past generations of PON technology that leveraged point-to-point technology to create a solution for a passive point-to-multipoint topology, CableLabs has started developing specifications for a single-wavelength, 100 Gbps PON solution based on coherent optics. Aside from the significant increase in peak capacity, the 100G Coherent PON solution will be able to extend up to 80 km (versus the traditional 20 km) and split up to 512 subscribers (versus the traditional 32 to 64).

Low latency

Lowering latency in access networks has been a focus for the cable industry for several years now. Experts are recognizing that along with speed, latency plays an important part in improving overall quality of experience for high-speed data customers. Working toward this goal, CableLabs and industry partners have defined solutions to lower the latency on DOCSIS access networks to be as low as 1ms to 5 ms. This solution, referred to as Low Latency DOCSIS, has already been implemented in cable modems and cable modem termination systems. Additionally, CableLabs and industry partners are developing a framework for measuring end-to-end latency in networks.

DAA, GAP, DOCSIS 4.0, 100G Coherent PON, and low latency are just a sampling of the vast breadth of technology projects that CableLabs and SCTE are working on. We look forward to sharing updates on other projects in future articles.