At the start of 2019, the cable industry announced its vision for delivering 10 gigabit networks, or 10G; ramping-up from 1 gigabit service offerings today to symmetrical speeds of 10 Gb/s and beyond while enhancing the customer experience and achieving operational efficiencies. Cable MSOs will achieve 10G with a collection of architectures and technologies including Distributed Access Architectures (DAA), Converged Interconnect Networks (CIN), full duplex DOCSIS, digital fiber in the HFC (extending fiber deep), and coherent optics. Ciena builds the Adaptive Network™ for cable MSOs, supporting their DAA strategies and CIN deployments.

DAA is based on distributing functions traditionally done in the headend and paves the way for virtualization. The CIN is a packet-based network within DAA that connects service cores such as the Converged Cable Access Platform (CCAP) in the headend to remote PHY and MACPHY devices in the access network that are used to distribute physical (PHY) layer functions and Medium Access Control (MAC) functions. Remote PHY (R-PHY) nodes and Remote MACPHY (R-MACPHY) nodes used in Flexible MAC Architectures (FMA) will be generally referred to as Distributed CCAP Architecture (DCA) nodes throughout this document.

What is a Converged Interconnect Network? Read blog

This paper provides an overview of the CIN and introduces the Ciena Fiber Deep Solution for the Converged Interconnect Network.

Converged – This originally referred to just CCAP services, which included CMTS and video functions. However, cable MSOs are now looking to use the CIN to achieve greater operational efficiencies. For example, the CIN can (and should) support multiple services – residential, enterprise, Mobile Backhaul (MBH), and Passive Optical Network (PON) for fiber to the premises.

From an architecture perspective, the CIN can be built to support a mix of DCA nodes, PON endpoints, mobile fronthaul and backhaul (macro and small cell), and point-to-point Ethernet. In the services realm, the CIN will likely need to support video (multicast and unicast), residential broadband, LTE/5G, enterprise services, and future services.

Interconnect – The transition to DAA is dramatic, not only because each outside plant endpoint changes, but also the extensive coaxial-RF interconnect network in hubs or headends transforms to digital-fiber networked endpoints as well. Pair this with the need for the CIN to support not only legacy packet core boxes, but also cloud-based packet cores and their data center fabrics, and the connectivity aspects can become complex very quickly. This creates a need for automation in provisioning and ongoing lifecycle management. Automation is key to manage the scale and complexity of the CIN.

Network – The transmission tools useful for the CIN are collective and can include Ethernet, IP, OTN, WDM, Common Public Radio Interface (CPRI), eCPRI, or other packet-centric protocols. Ultimately, the architectures and services mentioned above could coincide at different networking layers in the CIN to support service convergence: Layer 0 with wavelength multiplexing, Layer 1 with OTN framing, Layer 2 with Ethernet,
and Layer 3 with IP. Further granularity includes pseudowires, an emulation of a point-to-point connection over a packet network, that are already part of DAA specifications. Figure 1 shows the scope of the CIN within a DAA reference architecture.

The CIN is comprised of packet, optical, and automation technologies; interoperability is important, as these all need to work together.

Packet technologies comprise the hardware and software that will frame optical packets, switch Ethernet frames, and route IP packets. Packet solutions allow for convergence of different signals enabling end-to-end flexibility, from DCA nodes in the access network to/from the headend.

Optical technologies provide the physical connectivity: 10G digital optics to the DCA nodes, 100-200G optics for backhauling traffic aggregated in the access network to hub sites, and 100-800G optics for metro networks between the hub sites and headends. Different optical solutions are needed for the traffic aggregated in the access network (e.g. traffic from DCA nodes, PON Optical Line Terminals (OLTs), MBH) versus metro networks. The access network requires optical solutions with smaller footprints and lower power consumption, designed to operate in outside plant environments (i.e. temperature-hardened). Metro networks will require integrated, high-capacity coherent optics and the flexibility to throttle bandwidth, or liquidity of spectrum, given the dynamic nature of network traffic.

Automation technologies are very important given the significantly increased scale of network elements—DAA and extending fiber deep result in many more networking endpoints—nodes in the outside plant will increase eight to 12 times as DCA nodes replace existing analog nodes and devices. Automation for provisioning and management of DCA nodes and CIN elements is necessary, not only for Day One provisioning but, equally important, for ongoing lifecycle management. Network elements in the CIN will provide robust telemetry information; tools or an orchestration framework will be necessary to extract, analyze, and visualize information and automate the appropriate action or policy.

The Ciena Fiber Deep Solution for the Converged Interconnect Network

Ciena is a leader in the cable industry for packet, optical, and intelligent automation solutions and is uniquely positioned to provide a comprehensive solution for the CIN as cable MSOs pursue DAA strategies and extend fiber deep. Ciena builds the Adaptive Network for cable MSOs, supporting their DAA strategies and CIN deployments - including a roadmap that provides architectural options for cable MSOs on their DAA journey. Figure 2 provides a reference architecture for Ciena’s Fiber Deep solution.
Packet solutions

Cable MSOs can maximize operational efficiencies of their CIN with Ciena’s high-density packet aggregation/switching with integrated coherent optics, reducing space, power, and complexity. Operational efficiencies will be further enhanced with the cost and time benefits of Ciena’s wire-once philosophy and zero-touch provisioning.

The Ciena Fiber Deep Solution for the Converged Interconnect Network enables edge aggregation of 10GbE traffic from DCA nodes, business services, and PON OLTs. In temperature-controlled environments such as a hub site, 10GbE traffic from DCA nodes is aggregated with Ciena’s 5170 Service Aggregation Platform to 100GbE to a local CCAP, or backhauled over a metro network to a headend.

Traffic from DCA nodes, PON OLTs and MBH can be aggregated in the outside plant for backhaul to hub sites or a headend for efficient utilization of scarce fiber resources in the access network. 10GbE DCA node and business services traffic can be converted to 100/200G coherent optics for backhaul to a hub site or headend with Ciena’s 5171 Service Aggregation Switch or 5171 Service Aggregation Platform along with the WaveLogic™ 5 Nano CFP2-DCO, which can operate over an extended temperature range so aggregation can happen in the outside plant. The 5171 can also be used at the headend or primary hub site for low fan-in aggregation applications.

Ciena’s 8180 Coherent Networking Platform with the CFP2-DCO field replaceable unit (FRU) can be used to provide secondary aggregation of 100/200G signals from the 5170/5171 within a hub site, or higher fan-in aggregation as required. With a 6.4 Tb/s switching fabric, the 8180 alleviates fiber congestion by providing an efficient mechanism to aggregate multiple 100Gb/s connections from the access network into 400 Gb/s wavelengths for transport across the metro network.

Optical solutions

Ciena’s 6500 Reconfigurable Line System (RLS) is an ultra-dense photonic line system that reduces footprint and expands fiber capacity between the hub and the headend for efficient wavelength transport. The 6500 RLS can utilize WaveLogic 5 Extreme coherent technology.

Ciena’s Waveserver® receives wavelengths from the 6500 RLS and converts them back to Ethernet traffic within the headend. The Waveserver has a compact footprint and consumes low power—ideal for space constrained environments.

Coherent optics

Optics for the CIN need to go beyond capacity—small footprint and ruggedness are essential in the access network. Ciena leads the optical industry by making solutions specifically for the access and metro networks of the CIN. Ciena offers WaveLogic coherent optics across both optical and packet networking products to power seamless interworking 100G–800G solutions driving scalability, intelligence, and programmability. Ciena’s WaveLogic Ai is the industry’s first programmable 400G solution, offering tunable capacity from 100G to 400G to optimize capacity across any path and flexibly throttle or move bandwidth as needed. WaveLogic Ai is used on the 8180 and Waveserver Ai platforms.
WaveLogic 5 Nano CFP2-DCO is a 100G/200G coherent solution available as an extended temperature range pluggable, with a small footprint and reduced power consumption for transporting aggregated DCA node and business services traffic to a hub site or headend. Ciena is an active participant in the CableLabs Point-to-Point (P2P) Coherent Optics Working Group, supporting the industry’s 100G coherent optics standard for the access network. WaveLogic 5 Nano supports 100G interoperability as defined by CableLabs and is used in Ciena’s 5171 and 8180.

Ciena's WaveLogic 5 Extreme supports high-capacity 400–800G signals between hub sites and the headend using the 8180 and Waveserver, and the compact, simple-to-deploy 6500 RLS as the optical line system for transport. Ciena’s Waveserver family of high-capacity packet-to-optical interconnect platforms convert the optical wavelengths to Ethernet for connecting to network elements and packet cores within the headend.

**Intelligent automation products**

Ciena’s Blue Planet Manage, Control and Plan (MCP) software provides multi-layer management, provisioning, assurance, control and planning for Ciena’s packet and optical products within its Fiber Deep solution. MCP includes online planning based on real-time capacity and utilization data along with advanced visualization of the CIN and associated services. Blue Planet MCP enables cable MSOs with service agility in their CIN, along with an open architecture for operations modernization and associated benefits.

Blue Planet intelligent automation and lifecycle management software enables cable MSOs to efficiently manage the CIN, the proliferation of digital end-points and the complexities of having multiple services over a common CIN infrastructure as DAA is deployed. Additionally, Blue Planet intelligent automation will help cable MSOs manage their hybrid network environments that will last for years as DAA is deployed and older network assets and processes are phased out.

Blue Planet Inventory (BPI) provides dynamic federation of legacy inventory and assurance systems, and synchronization with the actual state of the network. BPI presents a single, dynamic view for existing network elements (e.g. analog nodes, CCAP, CMTS) as well as new DAA and CIN elements (e.g. DCA nodes, PON OLts, virtual CMTS, packet and optical devices) accurately reflecting the end-to-end state of network and service resources. BPI enables streamlined capacity reporting, trending and forecasting for the CIN that reduces operational costs and decreases the time to rollout new services.

Blue Planet Multi-Domain Service Orchestration (MDSO) is an open and vendor-agnostic software solution that allows cable MSOs to rapidly create, deploy, and automate the end-to-end delivery of services on both physical and virtual networks as they transition to DAA. MDSO provides an open software layer that enables seamless service automation across any mix of vendors and network layers in the CIN, allowing MSOs to simplify network operations and rapidly incorporate new networking resources to bring compelling services to market.

Blue Planet Route Optimization and Assurance (ROA) provides real-time visibility into how routing behavior affects service delivery. This is important for visualizing the state of the CIN, particularly between hub sites and the headend. ROA is a Layer 3 solution; it does not create or impact any networking activity. ROA captures real-time telemetry from network devices as well as from domain controllers and service orchestrators such as Blue Planet MDSO. ROA has a DVR Playback function that enables cable MSOs to ‘go back in time’ to see the actual state of their CIN at a point in time—which is very helpful when doing root cause analysis of network issues.

**A unique value proposition**

Ciena builds the Adaptive Network for cable MSOs, supporting their DAA strategies and CIN deployments to support the constantly changing demands of their customers.

Ciena offers the most comprehensive solution in the industry for the CIN: high-density packet aggregation with integrated optics, industry-leading coherent optical solutions, and intelligent automation. The solution’s high capacity and performance provide architectural options for DAA, including virtualization, disaggregation, and centralization.

Ciena’s Fiber Deep Solution for the Converged Interconnect Network enables architectural and service convergence over a common CIN infrastructure. Maximizing fiber utilization with industry-leading coherent technology—while reducing transport costs, space and power with high-density aggregation and integrated optics—generates significant operational efficiencies. Blue Planet’s intelligent automation and lifecycle management provides the tools for MSOs to effectively manage multiple services over a common CIN, the proliferation of new DAA network devices, and existing HFC network equipment that will exist for many years as MSOs roll out their DAA strategies.

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