Point-to-Point Coherent Optics

Coherent Termination Device Requirements Specification

P2PCO-SP-CTD-I01-210609

ISSUED

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Key to Document Status Codes

Work in Progress An incomplete document, designed to guide discussion and generate feedback that may include several alternative requirements for consideration.

Draft A document in specification format that is considered largely complete, but lacking review by Members and vendors. Drafts are susceptible to substantial change during the review process.

Issued A generally public document that has undergone rigorous Member and Technology Supplier review, cross-vendor interoperability, and is suitable for certification/qualification testing if applicable. Issued Specifications are subject to the Engineering Change Process.

Closed A static document, reviewed, tested, validated, and closed to further engineering change requests to the specification through CableLabs.

Trademarks

Contents

Figures

1 SCOPE

1.1 Introduction and Purpose

This specification is part of the Point-to-Point Coherent Optics suite of specifications developed by Cable Television Laboratories, Inc. (CableLabs). These specifications enable the development of interoperable transceivers using coherent optical technology over point-to-point links. This specification was developed for the benefit of the cable industry and includes contributions by operators and manufacturers from North and South America, Europe, Asia, and other regions.

This specification defines requirements for a coherent termination device (CTD) that resides in an aggregation node (AN) in the field. It is intended to aid manufacturers in developing CTDs that are appropriate for use in the field for a wide range of cable operators.

A CTD supports some type of Ethernet forwarding and/or aggregation, includes one or more coherent optics transceivers compliant with CableLabs specifications to terminate point-to-point (P2P) coherent optics links, includes multiple non-coherent optical transceivers (generally operating at lower data rates than a coherent optics link), and is directly manageable. An aggregation node aggregates multiple fiber endpoints onto a single fiber or fiber pair through one or more mechanisms, is weather hardened to operate outdoors in the field, and can contain a CTD and/or other functions/devices. As such, the scope of this specification is to establish requirements specific to a CTD that resides in an aggregation node; it does not address CTDs that reside at other locations (such as in a hub facility).

Note that with any CableLabs specification, cable operators are not required to purchase devices that are compliant to this specification, nor are manufacturers required to build devices that are compliant to this specification. Rather, the intent of this specification is to define the requirements for a CTD that will meet the needs of a majority of cable operators, thereby expanding the potential market for a compliant device.

1.2 Background

Most operators have a very limited number of fibers available between the headend (HE)/hub and the fiber node used for data and video services; often only one or two fiber strands are available to serve groups of fiber nodes. Operators need a strategy for increasing capacity in the optical access network as end users demand more bandwidth be delivered to the home. One approach is to add more fiber between the HE/hub and the fiber node, but even if possible, retrenching is costly and time consuming, making this option unattractive. A solution that uses the existing infrastructure much more efficiently would be preferred. One such solution is to use coherent optics technology along with wavelength-division multiplexing (WDM) in the optical access network.

Coherent optics technology is common in the submarine, long-haul, and metro networks, but it has not yet been applied to access networks because of the relatively high cost of the technology when used in those applications. However, the cable access network differs from other types of networks in the following ways: (1) the distances from the HE/hub to the fiber node are much shorter, (2) the network consists of P2P links (or a series of P2P links), and (3) it utilizes fixed-wavelength optical passives. With these differences, the capabilities, performance, and features of transceivers can be relaxed in areas such as optical output power level, transmitter wavelength capability, the amount of fiber chromatic dispersion compensation, and transmitter optical signal-to-noise ratio (OSNR), which potentially allows for lower cost designs and the use of lower cost components in cable access networks. The use of coherent optics in the access network opens new possibilities for cable operators and other telecommunication service providers.

1.3 Requirements

Throughout this document, the words that are used to define the significance of particular requirements are capitalized. They are defined below.

"MUST"	This word means that the item is an absolute requirement of this specification.
"MUST NOT"	This phrase means that the item is an absolute prohibition of this specification.
"SHOULD"	This word means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications should be understood, and the case carefully weighed before choosing a different course.

"SHOULD NOT"	This phrase means that there may exist valid reasons in particular circumstances when the listed behavior is acceptable or even useful, but the full implications should be understood, and the case carefully weighed before implementing any behavior described with this label.
"MAY"	This word means that this item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.

1.4 Device Under Test

All requirements in this document are written against a specific device under test (DUT)—a "coherent termination device that resides in an aggregation node." Throughout this specification, the term "CTD" is used to refer to this device, unless specified otherwise.

1.5 Organization of Document

Section 1 provides an overview of the Point-to-Point Coherent Optics suite of specifications, including background and conventions, and introduces this specification.

Sections 2–4 include the references, terms, acronyms, and symbols used throughout this specification.

Section 5 provides an informative overview of the architecture and context for the CTD requirements.

Section 6 contains the normative requirements for a compliant CTD.

2 REFERENCES

2.1 Normative References

In order to claim compliance with this specification, it is necessary to conform to the following standards and other works as indicated, in addition to the other requirements of this specification. Notwithstanding, intellectual property rights may be required to use or implement such normative references.

All references are subject to revision, and parties to agreement based on this specification are encouraged to investigate the possibility of applying the most recent editions of the documents listed below.

[CFP-MIS]	CFP MSA Management Interface Specification, Revision 2.6, March 24, 2017, http://www.cfp-msa.org/Documents/CFP_MSA_MIS_V2p6r06a.pdf.
[CFP2-HS]	CFP MSA CFP2 Hardware Specification, Revision 1.0, July 31, 2013, http://www.cfp-msa.org/Documents/CFP2_HW-Spec-rev1.0.pdf.
[G.8275.1]	ITU-T Recommendation G.8275.1, Precision Time Protocol Telecom Profile for Phase/Time Synchronization with Full Timing Support from the Network, March 2020.
[SyncE]	ITU-T Recommendation G.8262, Timing Characteristics of a synchronous equipment slave clock, November 2018.
[OPT-CTD-OSSI]	Coherent Optics Termination Device OSSI Specification, P2PCO-SP-CTD-OSSI-I02-200501, May 1, 2020, Cable Television Laboratories, Inc.
[OPT-P2P-PHYv1.0]	P2P Coherent Optics Physical Layer 1.0 Specification, P2PCO-SP-PHYv1.0-I03-200501, May 1, 2020, Cable Television Laboratories, Inc.
[OPT-P2P-PHYv2.0]	P2P Coherent Optics Physical Layer 2.0 Specification, P2PCO-SP-PHYv2.0-I02-200501, May 1, 2020, Cable Television Laboratories, Inc.
[QSFP-DD]	QSFP-DD MSA Hardware Specification, Revision 5.1, August 7, 2020, http://www.qsfp-dd.com/specification/.
[RFC 4604]	IETF RFC 4604, Using Internet Group Management Protocol Version 3 (IGMPv3) and Multicast Listener Discovery Protocol Version 2 (MLDv2) for Source-Specific Multicast, Version 3, August 2006.
[SNIA-SFF]	SNIA SFF Specifications, https://www.snia.org/technology-communities/sff/specifications.

2.2 Reference Acquisition

- Cable Television Laboratories, Inc., 858 Coal Creek Circle, Louisville, CO 80027;
  Phone +1-303-661-9100; Fax +1-303-661-9199; http://www.cablelabs.com
- CFP MSA; http://www.cfp-msa.org/documents.html
- International Telecommunication Union (ITU), Place des Nations, CH-1211, Geneva 20, Switzerland;
  Phone +41-22-730-51-11; Fax +41-22-733-7256; http://www.itu.int
- Internet Engineering Task Force (IETF) Secretariat, 48377 Fremont Blvd., Suite 117, Fremont, CA 94538;
  Phone: +1-510-492-4080; Fax: +1-510-492-4001; http://www.ietf.org
- Storage Networking Industry Association (SNIA), 4360 ArrowsWest Drive, Colorado Springs, CO 80907-3444

3 TERMS AND DEFINITIONS

3.1 Terms and Definitions

This specification uses the following terms.

Aggregation node	A device that aggregates multiple client-side interfaces into one or more line-side interfaces. For example, it might aggregate multiple 10 Gbps client-side interfaces into a single 200 Gbps coherent optics line-side interface.
CFP MSA Management Interface	The main communication interface between a host and a CFP module. The host uses this interface to control and monitor the startup, shutdown, and normal operation of the CFP modules it manages. See [CFP-MIS].
Client-side	The side of the CTD that connects the CTD to any child nodes, typically using non-coherent optical links at lower speeds than the P2P coherent optics link.
Coherent termination device	A device that includes one or more coherent transceivers to terminate P2P coherent optics links on line-side interface(s), includes multiple client-side interfaces, and supports some type of Ethernet forwarding or aggregation between those interfaces.
Coherent optics	Encodes information in both the in-phase (I) amplitude and quadrature (Q) amplitude components of a carrier.
Colored optics	An optical device that can share a fiber with other optical devices via DWDM and/or CWDM by operating on specific wavelengths or channels on an established grid.
Data rate	Throughput; data transmitted in units of time, usually bits per second (bps).
Ethernet	Computer networking protocol used to send frames between a source and destination address at OSI Layer 2.
Ethernet switch	A network device used for Ethernet packet switching.
Forward error correction	A method of error detection and correction in which redundant information is sent with a data payload to allow the receiver to reconstruct the original data if an error occurs during transmission.
Grey optics	A low-cost single channel optical device that is not suitable for DWDM or CWDM deployments.
Headend/hub	A central facility used for receiving, processing, and combining broadcast, narrowcast, and other signals to be carried on a cable network (somewhat analogous to a telephone company's central office). A headend typically supports multiple hub facilities.
Hybrid fiber-coaxial (HFC) system	A broadband bidirectional shared-media transmission system using fiber trunks between the headend and the fiber nodes and coaxial distribution from the fiber nodes to the customer locations.
Line-side	The side of the CTD that connects the CTD to a facility like a hub or headend (or another CTD in an Aggregated CTD Architecture) using P2P coherent optics links.
Media access control (MAC)	Layer 2 in the OSI architecture.
Physical layer (PHY)	Layer 1 in the OSI architecture. This layer provides services to transmit bits or groups of bits over a transmission link between open systems; it entails optical, electrical, mechanical, and handshaking procedures.
Transceiver	A transmitter and receiver combined in the same device or component.

4 ABBREVIATIONS AND ACRONYMS

This specification uses the following abbreviations.

5G	Fifth Generation
AN	aggregation node
CFP	C form-factor pluggable
MSA	Multi-Source Agreement
CFP2-DCO	CFP2 Digital Coherent Optics
CTD	coherent termination device
CWDM	coarse wavelength-division multiplexing
DAA	Distributed Access Architecture
DUT	device under test
DWDM	dense wavelength-division multiplexing
GAP	Generic Access Platform
HE	headend
HFC	hybrid fiber-coax
IGMP	Internet Group Management Protocol
IP	Internet Protocol
LTE	Long-Term Evolution
MAC	media access control
MSO	multiple system operator
OLT	optical line terminal
OSI	Open System Interconnection
OSNR	optical signal-to-noise ratio
OSSI	Operations Support System Interface
P2P	point-to-point
PHY	physical layer
PON	Passive Optical Network
QSFP	quad small form-factor pluggable
QSFP-DD	QSFP double density
RMD	Remote MACPHY Device
RPD	Remote PHY Device
SFP	small form-factor pluggable
WDM	wavelength-division multiplexing

5 OVERVIEW

5.1 Introduction

This specification defines a set of common requirements for a coherent termination device (CTD) that resides in an aggregation node (AN). The requirements are based on input from cable operators to enable the development of devices that meet the needs of multiple operators, thereby reducing development risk for manufacturers and encouraging the development of these devices, which are key to the deployment of P2P coherent optics technology.

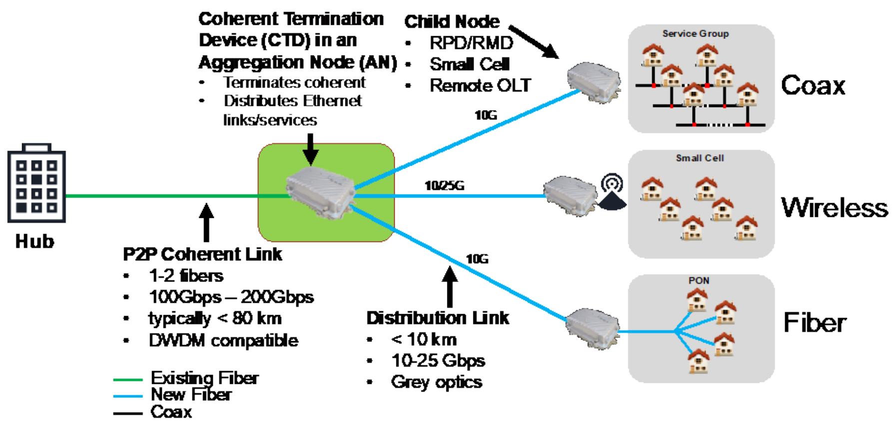

Figure 1 – Overview of a CTD in an AN

As illustrated in Figure 1 above, the AN is a device that aggregates multiple fiber endpoints onto a single fiber or fiber pair and resides in the field (meaning that it is weather hardened in some manner). This could take the form of a clamshell, a street cabinet, or some other form; the most common AN design used in North America is expected to be a clamshell. Nominally, it would sit where a fiber node does in a hybrid fiber-coax (HFC) network. The AN can contain one or more functions or devices, including a CTD.

The CTD is a device that includes one or more coherent transceivers to terminate P2P coherent optics links (referred to as line-side interfaces), includes multiple optical transceivers (generally non-coherent) operating at the same or lower speeds than the line-side interfaces (referred to as client-side interfaces), and supports some type of Ethernet forwarding and/or aggregation between interfaces. The CTD can be standalone or can be included as a module or logical entity in another device.

The scope of this specification, therefore, is specific to the requirements for a CTD that resides in an AN. As such, it assumes a deployed network architecture that uses digital optical Ethernet links to connect remote distributed devices to a hub or headend facility using P2P coherent optics for some portion of that network path. It is also expected that a CTD could be a part of an AN that is a GAP node, a purpose-built node enclosure, or a street cabinet; as a result, the specific type of enclosure and other details of the AN (beyond weather hardening) were considered out of scope and are not included in this specification.

The requirements for the CTD were derived from the results of a survey of cable operators. The survey collected information on the services and applications that will need to be supported over a network that includes a CTD (including the time frame in which they will be used) and the type of network architecture being planned to support those services/applications.

5.2 Target Services and Applications

In considering the services and applications for a CTD, cable operators preferred a useful lifetime for the device of approximately 10 years. With a 10-year target in mind, they identified several key services that would need to be supported.

- DOCSIS® Distributed Access Architecture (DAA) deployments (including Remote PHY, Remote MAC/PHY, and/or Flexible MAC Architecture approaches)

- Passive Optical Network (PON) deployments, where the optical line terminal (OLT) (or equivalent) would reside in the field
- Business Ethernet using P2P Ethernet links
- Mobile backhaul for LTE and 5G deployments
- Mobile fronthaul for 5G deployments

The requirements for the CTD found in this specification were developed with these applications in mind.

5.3 Target Access Network Architectures

Several network architectures utilizing P2P coherent optics and CTDs were identified during specification development.

Direct Link CTD Architecture—Each CTD connects directly to a hub or headend using P2P coherent optics (either dedicated or shared fiber(s)), and each CTD directly supports multiple child nodes (Figure 2).

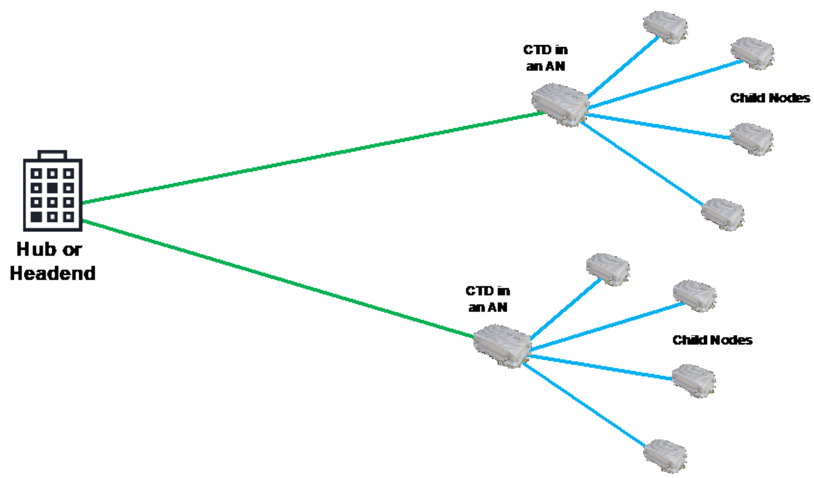

Figure 2 – Direct Link CTD Architecture

Aggregated CTD Architecture—Similar to the direct link architecture, each CTD supports multiple child nodes directly. However, each of those CTDs is connected to an aggregating CTD, which is the only device with a direct connection to the hub or headend (Figure 3).

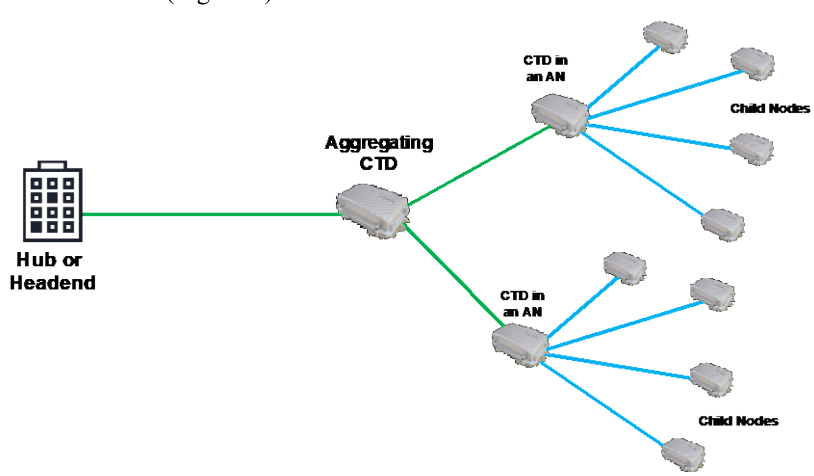

Figure 3 – Aggregated CTD Architecture

Chained CTD Architecture—The CTDs are linked together in a chain using P2P coherent optics links, with at least the first CTD in the chain connected to a hub or headend. Each CTD directly supports multiple child nodes (Figure 4).

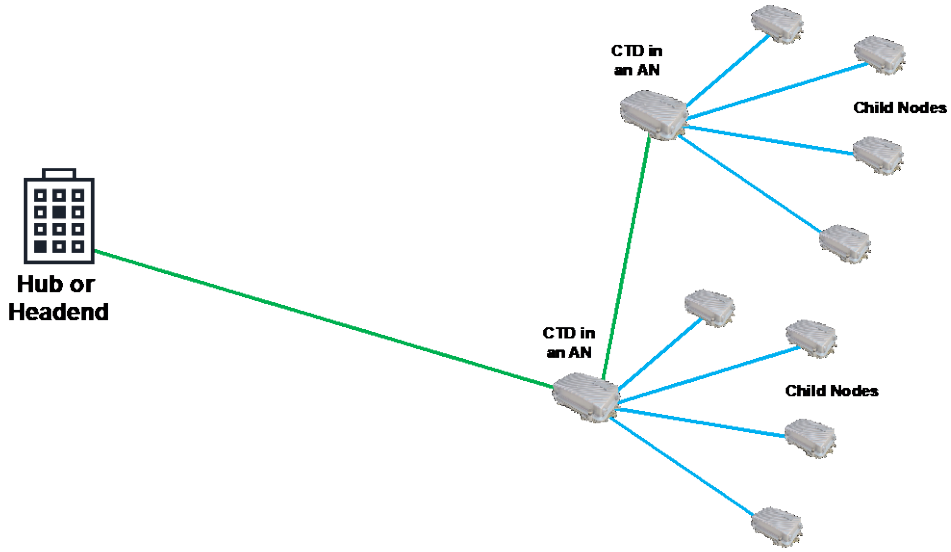

Figure 4 – Chained CTD Architecture

Ring CTD Architecture—Similar to the chained architecture, CTDs are linked, and both the first and last CTDs in the chain are connected to the hub or headend. Each CTD directly supports multiple child nodes (Figure 5).

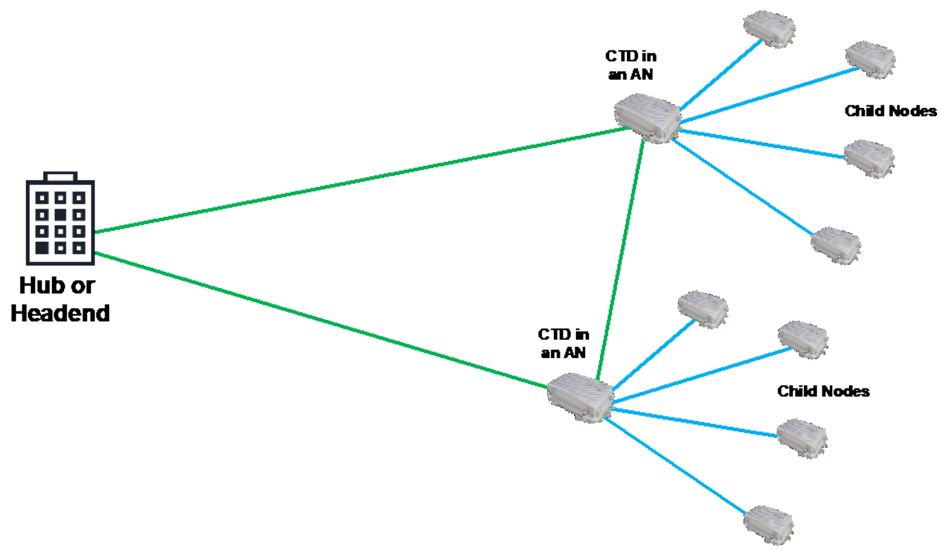

Figure 5 – Ring CTD Architecture

Based on the feedback from cable operators, it is expected that most will use a direct link architecture in at least some of their CTD deployments. However, a substantial portion also indicated that they would likely use a ring architecture in at least some deployments. Others expressed plans for or interest in aggregated and/or chained architectures. The requirements in this specification, therefore, were designed to support all of these architecture approaches.

In looking at the child nodes connected to the CTD, cable operators indicated that they expected an average of 5–12 child nodes connected to a single CTD, with maximum numbers in excess of 20 child nodes in some cases. In general, they expected the connections to the child nodes would use grey optics connections over a dedicated fiber, although there may be some use cases where a fiber or fiber pair would be shared among multiple child nodes, necessitating the use of a technology such as coarse wavelength-division multiplexing (CWDM) or dense wavelength-division multiplexing (DWDM).

Several cable operators also indicated that they intended to implement some sort of redundancy in the link from the CTD to the hub, such as by using a separate fiber on a different route or by using the Ring CTD Architecture.

With regard to fiber availability, cable operators indicated that at least some portion of their deployments would use a single fiber instead of a fiber pair, which will require support for dual-laser transceivers and/or full duplex coherent optics.

The requirements on the CTD defined in this specification were crafted to address these operational requirements.

6 CTD REQUIREMENTS

6.1 Physical Connection Port Requirements

This section defines requirements for the physical connection ports on the CTD, divided into two parts.

- Line-side ports, which connect the CTD to a facility like a hub or headend (or another CTD in an aggregated CTD architecture) by using P2P coherent optics links
- Client-side ports, which connect the CTD to child nodes, typically by using non-coherent optical links at lower speeds than P2P coherent optics links

6.1.1 Line-Side Ports

Based on the service and architecture requirements identified by cable operators, each CTD will need a minimum of two line-side ports. This permits a single CTD design to support multiple different network architecture design approaches. Specifically, including two line-side ports enables the following:

- Redundant architectures by using one port for an alternate connection,
- Support for Ring or Chained CTD Architectures by using both ports to interlink multiple CTDs, or
- Future capacity grown by reserving one of the ports.

Each line-side port is expected to support coherent optics transceivers that are compliant to one or both of the CableLabs Coherent Optics PHY specifications, [OPT-P2P-PHYv1.0] or [OPT-P2P-PHYv2.0]. As a result, support for both 100 Gbps and 200 Gbps on each line-side port is required.

In order for coherent optics transceivers from different manufacturers to be used interchangeably, operators have settled on the use of pluggable transceiver modules using one of two form factors: (1) CFP2-DCO, as per the CFP MSA, and (2) QSFP-DD, as per the QSFP-DD MSA. CFP2-DCO is a form factor that is currently available with support for the full I-Temp temperature range required by a CTD operating in an outdoor environment; it can also support dual-laser transceivers. QSFP-DD is an emerging form factor that is smaller than CFP2-DCO, which allows transceivers to be packed into a smaller space, but might not be capable of supporting dual-laser transceivers. Note that this requirement could be updated to include additional options as new form factors are developed.

In order to support both deployments on a single fiber or a fiber pair, the CTD is also required to support the use of both single-laser and dual-laser pluggable transceiver modules. Note that this specification does not place requirements on the transceiver itself; rather, the requirement enables an operator who purchases a dual-laser transceiver module for a specific application to also purchase and use single-laser transceivers without having to purchase separate CTDs.

The CTD MUST support a minimum of 2 line-side ports to support pluggable coherent optics transceiver modules.

The CTD MUST support either CFP2-DCO pluggable optics as per [CFP2-HS] or QSFP-DD pluggable optics as per [QSFP-DD] in its line-side ports.

The CTD MUST support pluggable optics that comply with [OPT-P2P-PHYv1.0] for 100G per wavelength operation and [OPT-P2P-PHYv2.0] for 200G per wavelength operation in its line-side ports.

The CTD MUST support the use of at least one of its line-side ports as a redundant connection.

The CTD MUST support the use of its line-side ports for connections to other CTDs.

The CTD MUST support the simultaneous use of both line-side ports as connections to the same device in order to add additional capacity.

The CTD MUST support the use of both single-laser and dual-laser transceiver modules in its line-side ports.

6.1.2 Client-Side Ports

Based on the service requirements identified by operators and on the anticipated density of child nodes needed to support those services for their specific network deployment scenarios, it is expected that, over the long term, a CTD will be required to support at least 16 client-side ports. This approach will address the requirements of the vast majority of use cases within the target lifetime of the CTD, thereby limiting the need for special devices with more ports. However, in the short term, a CTD that supports at least 12 client-side ports may prove sufficient and may enable faster development and deployment of compliant CTDs. For that reason, this specification requires support for at least 12 client-side ports and strongly recommends support for at least 16 client-side ports.

Additionally, each client-side port is required to support optical transceivers operating at 1 Gbps, 10 Gbps, and 25 Gbps, utilizing the SFP, SFP+, and SFP28 form factors, respectively. Meeting this requirement will support the needs of multiple applications, including but not limited to P2P business Ethernet services, DOCSIS DAA deployments, and mobile backhaul and/or fronthaul. In addition, the client-side ports on the CTD can optionally support optical transceivers operating at 40 Gbps and/or 100 Gbps, utilizing the QSFP and QSFP28 form factors, respectively.

Although the majority of deployments are expected to use dedicated fibers to connect the CTD to any child nodes—thereby utilizing low-cost "grey" optics—some deployments may require the use of shared fiber(s) and, therefore, tunable or "colored" optical transceivers. Based on an assumption that this use case adds minimal cost to the CTD, the client-side ports are also required to support both grey and colored optical transceivers.

The CTD SHOULD support a minimum of 16 client-side ports for connections to other devices in the field via Ethernet.

The CTD MUST support a minimum of 12 client-side ports for connections to other devices in the field via Ethernet.

The CTD MUST support SFP (1 Gbps), SFP+ (10Gbps), and SFP28 (25 Gbps) pluggable transceiver modules as per [SNIA-SFF] in its client-side ports.

The CTD MAY support QSFP (40 Gbps) and/or QSFP28 (100 Gbps) pluggable transceiver modules as per [SNIA-SFF] in its client-side ports.

The CTD MUST support the use of both grey optics transceivers and colored optics transceivers in its client-side ports.

6.2 Network Forwarding Requirements

In examining the type of network forwarding that would work for their specific network environment, some cable operators indicated that they would prefer to deploy a solution that performs layer-3 forwarding (such as in a router), whereas others would prefer a solution that performs layer-2 forwarding (such as in a switch), ideally with some layer-3 awareness (such as for handing multicast). Feedback from manufacturers indicated that, from a hardware point of view, there is very little difference between devices that perform layer-2 or layer-3 forwarding because both generally use the same silicon.

Therefore, in order to meet the needs of as wide a customer base as possible, a CTD is required to have hardware that supports both layer-2 and layer-3 forwarding. A single device does not have to support both at the same time, nor is a single software load required to support both forwarding modes. However, the underlying hardware is expected to be capable of supporting both forwarding modes given the installation of an appropriate software load.

In all cases, the CTD is expected to support multicast; therefore, it will need to be at least partially layer-3 aware.

Further, in order to support certain services and applications, it is required to support [SyncE] and [G.8275.1] boundary clock functionality.

Given the increasing usage of IPv6—combined with the existing usage of IPv4—it is important that the CTD supports both versions of the IP protocol. This requirement applies to both the CTD itself (which needs to be able to accept an assigned IP address so it can be directly managed) and to the CTD's forwarding capability.

Additionally, it is important that the CTD have sufficient forwarding capacity such that all of its interfaces can operate at line rate. Because the CTD is required to support two 200 Gbps line-side interfaces, it should, therefore, have sufficient capacity to support 400 Gbps of forwarding between the line-side and client-side interfaces.

The CTD MUST have hardware capable of forwarding data based on layer-2 forwarding criteria (switching) and on layer-3 forwarding criteria (routing).

The CTD MAY support the ability to change forwarding modes via configuration.

The CTD MUST support IGMP snooping and multicast forwarding per [RFC 4604] to control which client-side ports are members of a multicast group.

The CTD MUST support [SyncE] and [G.8275.1] boundary clock functionality.

The CTD MUST support both IPv4 and IPv6, both for itself and for any connected devices.

The CTD MUST have sufficient bi-directional network forwarding capacity to fully utilize at least 400 Gbps of line-side capacity.

6.3 CTD Power Requirements

When considering the powering requirements for the CTD, there are several factors that have to be considered.

- The power consumption of a CTD will vary depending on of the number and types of pluggable optical transceivers installed.
- The total number of pluggable optical transceiver ports can be greater than the minimums established by this specification.
- Cable systems generally have a limited amount of power available to devices in the field, which varies based on operator and location.
- Manufacturers need to correctly size the power supplies they build into the CTD in order to support a variety of MSO applications.

These factors show that requirements will need to ensure that with a reasonable configuration, the CTD will still be able to fit within a reasonable power envelope. These factors also show the need to establish a maximum that is required when the CTD is fully populated (i.e., all ports are populated with pluggable modules that are connected and operating). Additionally, the requirements will need to account for the varying power draw of optical transceivers from different suppliers and of different data rates.

To meet those needs, this specification establishes two sets of requirements.

The first set establishes the maximum power that the CTD can draw for all components other than pluggable modules while under load. It is impossible to test the CTD under load without any pluggable modules, so this specification calculates the power draw by first measuring the power consumption of the CTD while operating under load with the modules installed and operating, then subtracting the power consumption of those modules (based on manufacturer specifications). The result of that calculation provides the power draw of the CTD without any pluggable modules, which is required to be 70 W or less.

The second set establishes a minimum requirement on the CTD's power supply, based on the power requirements of a fully loaded CTD. Because the power draws of different pluggable modules may vary, this specification establishes a set of assumed power levels for the optical transceiver modules that could be plugged into the CTD, which—in combination with some overhead margin—establishes a minimum requirement for the power supply in a CTD.

The CTD MUST have a total power consumption of 70 W or less under the following conditions:

- it is passing 100 Gbps of traffic and
- the power draw of any pluggable modules being used is subtracted from the total power draw of the CTD with the modules installed and operating.

The CTD MUST have a power supply rated to support a fully loaded configuration (modules plugged in and operating on all ports) using the following assumptions:

- the CFP2-DCO modules each consume 22 W of power,
- the SFP+ modules each consume 3.5 W of power,
- there is a 10% overhead margin, and
- the device is operating at full line rate.

6.4 CTD Environmental Requirements

As noted previously, a CTD will operate in an outdoor environment, so it needs to be inside a sealed enclosure that will keep out dust and water, and it will need to operate in a variety of temperature extremes from very cold to very hot.

For the purpose of sealing out dust and water, this specification requires the CTD to be inside an enclosure that meets the requirements of an IP66 rating, i.e., the device is completely dust tight and is protected against direct high-pressure jets of water.

For operating in cold environments, the CTD is required to cold-start and operate when the outside temperature is as low as -40 °C. Note that it is permissible for the CTD to require a warm-up time prior to becoming fully operational if it is cold-starting from -40 °C, so long as it can reach and maintain a proper operating temperature when the outside air temperature remains at -40 °C.

For operating in warm environments, the CTD is required to be capable of full, normal operation when the ambient air outside of the AN is up to 60 °C. Additionally, because many pluggable optical transceivers are rated for operation at a maximum temperature of 85 °C, it is mandatory that the CTD be capable of keeping any pluggable modules at a temperature of 85 °C or less. Additionally, for the purposes of reliability, the CTD is required to meet this requirement without the use of mechanical cooling, such as fans.

The CTD MUST be capable of operating in an aggregation node enclosure that meets the requirements of an IP66 rating.

The CTD MUST be capable of full, normal operation when the ambient temperature outside the aggregation node is -40 °C.

The CTD MUST be capable of a cold start, after being given sufficient warm-up time, when the temperature outside the aggregation node is -40 °C.

The CTD MUST be capable of full, normal operation when the ambient temperature outside the aggregation node is 60 °C.

When within the aggregation node, the CTD MUST ensure that any pluggable optics remain at a temperature of 85 °C or less when the external ambient temperature is 60 °C, without the use of mechanical cooling (fans).

6.5 CTD Management Requirements

In order to manage the CTD directly, it will be required to support a full IP and management stacks. Key requirements for the management of a CTD can be found in the CableLabs CTD OSSI specification, [OPT-CTD-OSSI].

The CTD MUST support the management requirements defined in [OPT-CTD-OSSI].

Appendix I Acknowledgements

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