Higher Ethernet Speed, Smoother Data Transfer, and Increased Range

New IEEE 802.3 Standards ~~Define~~Specify 100 Gb/s Signaling over Cable and Fiber, and an Extended-Reach Super-PON

Digital connectivity is fundamental to modern life, and Ethernet networking technology is a major enabler of that connectivity.

Ethernet is a continuously evolving set of standards-~~driven~~based networking protocols that enable manufacturers and providers of a wide variety of devices to focus on developing new products and services that address market opportunities, without having to devote time, attention, and resources to solving connectivity challenges.

The continuing development of new Ethernet technical standards over nearly four decades, while maintaining backward compatibility with existing devices, has led to Ethernet's growing use in diverse applications including local area networks, metropolitan area networks, wide area networks, telecommunications infrastructure, automotive systems, and operational technology (OT) settings.

A Constantly Growing, Evolving Family of IEEE 802.3™ Standards

Beginning in 1985 with IEEE 802.3~~™,~~™-1985, the ~~world's~~ first published ~~Ethernet~~IEEE standard for Ethernet, the IEEE 802 family of standards has helped to advance Ethernet technology through many different Ethernet standards development projects and related activities.

The IEEE 802.3™ Ethernet Working Group has developed more than 75 Ethernet standards, helping to make ~~it~~Ethernet one of the most widely used networking technologies invented. IEEE 802.3 is part of a broad range of technical networking standards developed by the IEEE 802 LAN/MAN Standards Committee (LMSC), comprising ~~thousands~~hundreds of technical experts.

Three ~~recent amendments to~~recently-standardized IEEE 802.3 ~~standards~~amendments reflect ~~attempts to meet~~ the evolving needs of various Ethernet stakeholders.

IEEE 802.3ck™, Physical Layer Specifications and Management Parameters for 100 Gb/s, 200 Gb/s, and 400 Gb/s Electrical Interfaces Based on 100 Gb/s Signaling

Continually growing bandwidth demand has driven the evolution of higher Ethernet speeds. Today, 100 Gb/s, 200 Gb/s, and 400 Gb/s Ethernet networks are used in data centers, telecommunications networks, servers, network storage, and other high-performance computing and data-intensive applications.

IEEE 802.3ck was developed to address the need for data transfer at 100 Gb/s per electrical lane, leading to lower cost/bit and power/bit than is attainable now. It will help reduce costs for developers and users of this equipment and will support the development of next-generation 800 Gb/s and 1.6 Tb/s Ethernet systems for these use cases.

Chips known as application-specific integrated circuits (ASICs) control the movement of data in Ethernet equipment. At higher data transfer rates, it becomes more difficult to get data into and out of an ASIC. A SerDes (serializer/deserializer) circuit is the interface between the ASIC and the data flowing over the network, and helps to minimize the number of I/O pins and electrical connections required. These connections are a limiting factor as Ethernet speeds increase.

For example, at a 25 Gb/s signaling rate it takes four electrical connections, or differential pairs, to every port in the system to transmit 100 GB of data, and another four to receive the data. That's a total of 16 traces for a single port. For 400 GB of data, at the same 25 Gb/s signaling rate the number would grow to 64 traces. This extensive amount of wiring leads to electrical losses; also, it is difficult to find the physical space to connect all of these traces to equipment faceplates, wire the entire system, and cool these traces adequately.

IEEE 802.3ck defines how to simplify these interfaces to support a 100 Gb/s signaling rate, thereby maximizing SerDes performance, improving overall system economics, and enhancing power effectiveness.

IEEE 802.3db™, Physical Layer Specifications and Management Parameters for 100 Gb/s, 200 Gb/s, and 400 Gb/s Operation over Optical Fiber using 100 Gb/s Signaling

While IEEE 802.3ck ~~defines~~specifies Ethernet operation at 100 Gb/s in copper cable, IEEE 802.~~db~~3db does so over multimode optical fiber.

Optical fiber links are needed in data centers because direct-attach copper cabling is limited to just two meters for 100 Gb/s signaling. ~~At lengths~~For longer ~~than that~~links, passive copper becomes impractical because of reduced performance, increased energy consumption, and the need for thicker cables, which are more difficult to route in tight spaces. Instead, optical fiber is used to make the lowest-cost and most energy-efficient ~~short-reach~~ data center links. ~~Up to 100 meters~~In such cases, it is advantageous to pair a type of laser transmitter called a VCSEL with multimode optical fiber.

IEEE 802.3db addresses multiple aspects of 100 Gb/s signaling over multimode fiber. ~~One is that some~~Some emerging architectures in hyperscale data centers will have fewer servers in one rack, leading to the need for fiber connections that are tens of meters in length across multiple racks. IEEE 802.3db ~~defines~~specifies the use of 100 Gb/s wavelengths over multimode fiber ~~at distances up to 50 meters,~~ for server attachment and ~~ML~~machine learning clusters.

IEEE 802.3db also enables users to take advantage of the massive installed base of multimode fiber in enterprise data centers, ~~which is continually being upgraded~~supporting upgrade to higher Ethernet speeds. The new standard specifies optics that will give these large enterprise data centers the opportunity to re-use their existing multimode cabling infrastructure, at distances up to 100 meters, for another five to ~~10~~ten years.

~~Finally, the high-performance computing industry is starting to leverage the VCSELs and photodiodes developed for IEEE 802.3db for use in active optical cables for up to ~30m links. IEEE 802.3db enables this part of the market as well.~~

IEEE 802.3cs™, Physical Layers and Management Parameters for Increased-Reach Point-to-Multipoint Ethernet Optical Subscriber Access (Super-PON)

Passive optical networks (PONs) are increasingly the “last-mile” network infrastructure connecting service providers with their internet and voice customers. They are more cost-effective to build and operate than other technologies because their multi-access nature enables them to serve many customers with a single fiber coming from a central office.

They also provide high-burst bandwidth to customers, enabling high perceived speeds~~;~~, and are a future-proof way to build infrastructure, given their ability to carry ever-higher data rates as technology evolves.

However, a limitation of traditional PONs is that they can effectively serve with one fiber exiting the central office only up to 64 customers within a 20 km radius, which is inadequate for large urban areas and for underserved rural/suburban areas or geographies.

To overcome this limitation, IEEE 802.3cs defines Super-PON, which is a PON optical layer that supports an increased optical reach of up to 50 km, along with an increased customer coverage of up to 1,024 customers per fiber exiting the central office. The standard specifies how to use wavelength-division multiplexing (WDM) to achieve 16 PON channels per fiber exiting the central office; how to amplify all those channels in the central office, for both downstream and upstream wavelengths; and how to make use of a passive wavelength splitter in the field to distribute those channels to more customers.

By increasing the reach of each fiber and the number of customers it can serve, IEEE 802.3cs will enable operators to dramatically reduce the time and cost needed to extend the reach of their networks. Much less trenching will be needed to bury cables because fewer ~~cables~~fibers will be needed, and fewer central offices will be required as well.

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