

Fibre Channel over Ethernet and 10GBASE-T: Do More with Less

What You Will Learn

Over the past decade, data centers have grown both in capacity and capabilities. Moore's Law—which essentially states that the performance of technology doubles every 18 months—is just as true for networks and servers as it has been for CPUs.

Because of these advances, people expect more from their equipment. After all, as the capability of equipment to handle multiple tasks at the same time increases, devices can do more with less.

Today, technology has advanced so that data centers can handle workloads and traffic that would have been impossible only a few years ago. With improvements in networking, servers, cabling, and storage, data centers have better price-to-performance ratios than ever before.

Two crucial technologies that have yielded improvements in both storage and physical-layer devices are Fibre Channel over Ethernet (FCoE) and 10GBASE-T. When these technologies are used together, modern data centers can provide storage, networking, and server connectivity in ways not possible with traditional data center architectures.

What Is FCoE?

Traditionally, data centers had separate networks to handle LAN and SAN. Therefore, independent, dedicated infrastructure devices were required to handle Ethernet and storage traffic.

However, with FCoE, multiprotocol traffic can run on the same physical wire, so now the Fibre Channel part of storage traffic can be placed on the same physical medium as Ethernet LAN traffic. Most important, because it is Fibre Channel, FCoE uses the same well-known management and architectural designs and tools as traditional SAN environments.

In other words, instead of having two switches, you can have one. Instead of two points of management, you can have one. Instead of two different types of cabling infrastructure, you can have one. From the perspective of a host or target, nothing changes because you are still using the same Fibre Channel protocol that the applications have always known.

This advancement was made possible because Ethernet speeds increased to 10 Gbps, providing enough bandwidth to handle multiple protocols at the same time. Improvements in the Ethernet IEEE Data Center Bridging (DCB) standard, most notably Priority Flow Control (PFC) and Enhanced Transmission Selection (ETS), which enabled simultaneous lossy and lossless traffic and the capability to define bandwidth groupings on the same wire, made this consolidation a reality.

Ethernet technology is continuing to advance. New physical attributes for Ethernet, notably 10GBASE-T, have created even more options for lowering the cost of reliable storage connectivity in the data center.

What Is 10GBASE-T?

Since the early days of Ethernet, twisted-pair cabling has been the most common media type for wired LAN communications, and it is found in every data center around the world. The industry has benefited from the advantages of this low cost, simple-to-use cabling for three generations, providing a consistent and comfortable user experience.

As the industry has evolved from lower-rate to higher-rate Ethernet, it has made further use of the available bandwidth of twisted-pair copper cabling. Each generation of Ethernet BASE-T physical-layer (PHY) technology uses more efficient signaling and improved signal processing to mitigate the limitations of twisted-pair cabling at higher transmission frequencies.

The interconnect basics have remained the same, particularly the simplicity of the user experience. 10GBASE-T maintains the structured cabling deployment model of twisted-pair wiring, uses RJ-45 connectors and field-terminated patch panels, provides 100 meters of reach, and offers autonegotiation for backward compatibility with the lower speeds of Ethernet, including 1000BASE-T and 100BASE-TX.

The cabling specifications have also been enhanced as bandwidth requirements have increased for each generation of Ethernet. 10GBASE-T makes greater demands on the interconnect, requiring Category 6A or better cabling and additional complex signal processing technologies to help ensure a reach of 100 meters as defined by the standard. 10GBASE-T approaches the maximum rate at which information can be transmitted over a communications channel of a specified bandwidth in the presence of noise.

As with previous generations, the value proposition of BASE-T continues to be its low cost of deployment, ease of use, and backward compatibility that allows broad distribution of 10 Gigabit Ethernet in the data center and the enterprise. Early adopters of 10 Gigabit Ethernet were limited to optical (10GBASE-SR) or direct-attach copper (10GBASE-CR) through SFP+ form factors), but these solutions are limited in reach, requiring new network infrastructure, or are prohibitively costly to deploy throughout the data center.

With 10GBASE-T, you can also reduce the complexity of your network by replacing multiple Gigabit Ethernet connections with a single 10GBASE-T connection. This consolidation means big savings in adapter, cabling, and switch-port costs. Customers can achieve 45 percent savings in power in each rack, 80 percent reduction in the number of cables and switch ports, and 15 percent reduction in infrastructure costs, and get twice the bandwidth. At the same time, 10GBASE-T provides all the advanced features of virtualization and unified networking for both LAN and storage networks, including support for FCoE.

Why Use FCoE with 10GBASE-T Now?

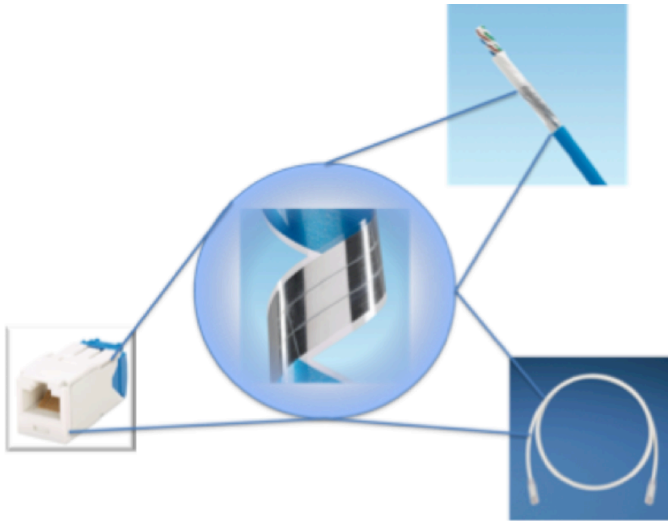
FCoE is a demanding application that requires cable built to demanding specifications. To meet these bit error rate (BER) needs of FCoE, the cabling must be designed to mitigate problems such as *alien crosstalk*.

Alien crosstalk refers to noise between neighboring channels, such as between adjacent jacks in a patch panel or adjacent cables in a pathway or bundle. It is a critical concern in 10GBASE-T systems because alien crosstalk is noise that the equipment cannot cancel, so the cabling system itself must mitigate it by design. Only cabling and components rated for Category 6A or higher have been designed with sufficient alien crosstalk mitigation for the needs of FCoE. Therefore, only Category 6A or higher cabling is recommended for FCoE.

Newer Unshielded Twisted-Pair (UTP) technologies such as Panduit TX6A 10Gig UTP (0.300-inch cable diameter) and TX6A-SD 10Gig UTP (0.240-inch cable diameter) use patented Panduit MaTriX Technology to exceed all Category 6A and Panduit 10Gig alien crosstalk requirements by design. Discontinuous metallic elements on both

the cables and connectors (Figure 1) provide sufficient alien crosstalk mitigation in a small cable diameter without requiring any grounding mechanism. Note that any properly grounded shielded Category 6A or higher cabling such as Panduit TX6A 10Gig shielded copper cables will also provide sufficient alien crosstalk mitigation for FCoE.

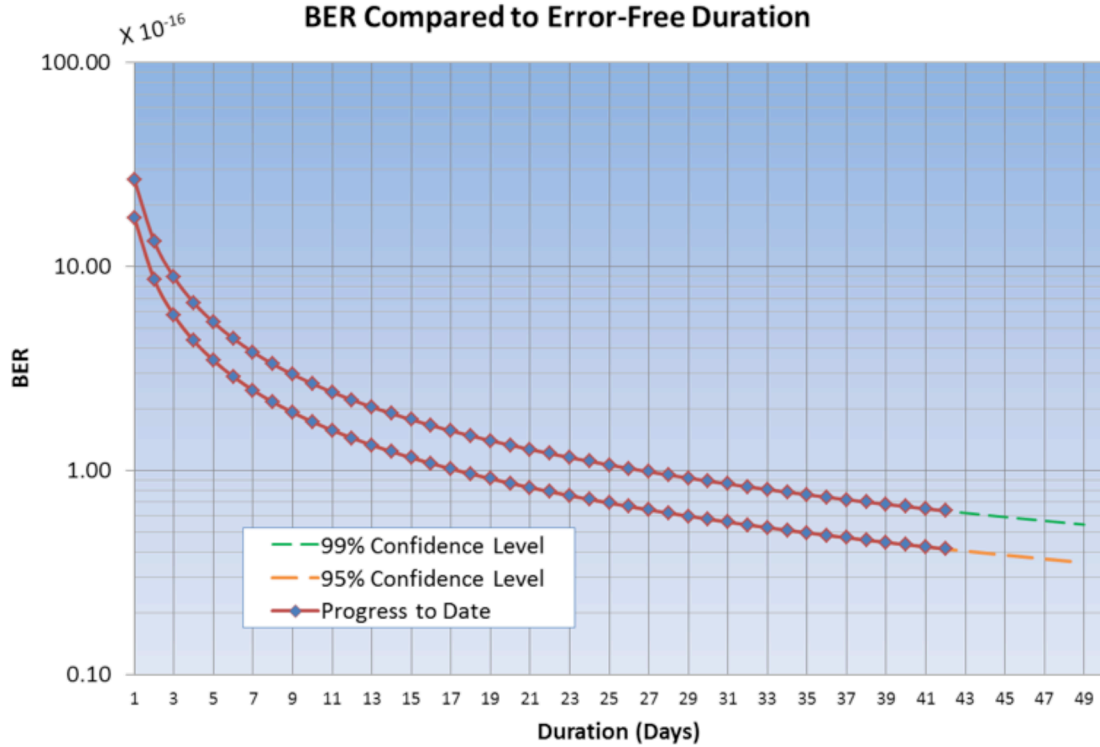
Figure 1. Panduit MaTriX Technology



Bit-Error Rate

Panduit has performed extensive testing on the Panduit MaTriX cabling to show that UTP cabling can meet demanding BER needs for applications such as FCoE. Panduit conducted a 42-day test with a 50-meter link with 3- and 5-meter patch cords on each end. This test was conducted in a worst-case “six around one” scenario in which 10GBASE-T data was transmitted on seven cables, six of which were surrounding a middle cable. The BER was then monitored on the middle cable. In total, Panduit transmitted 7.26^{E16} bits with no errors, yielding 99.9 percent confidence that the BER is less than 9.52^{E-17} , which is more than sufficient for FCoE. The BER results over time are shown in Figure 2.

Figure 2. BER Results over the Error-Free Duration



Cost Savings with FCoE over 10GBASE-T

The growth in server virtualization and other bandwidth-intensive applications has led to increased demands on data center networks, including LANs and SANs. Meeting these bandwidth requirements has increased infrastructure cost and complexity—a challenge compounded by the fact that LANs and storage networks rely on separate server adapters, switches, and even management staffs.

In environments that rely on separate SANs, for example, connecting more servers to the SAN means purchasing additional, and often costly, Fibre Channel Host Bus Adapters (HBAs) and cabling. This increase in servers, in turn, creates a need for additional Fibre Channel switches.

Consolidation with FCoE over 10 Gigabit Ethernet

As shown in Table 1, transitioning to a unified or converged fabric using FCoE can significantly reduce the cost of connecting servers to the SAN.

Table 1. Comparison of Network Costs

	Separate Networks		Ethernet LAN and SAN		Converged Fabric	
	Ports	Cost (US\$)	Ports	Cost (US\$)	Ports	Cost (US\$)
10GBASE-T CNA	2	\$500	4	\$1000	2	\$500
8-Gbps Fibre Channel HBA	2	\$1200	0	\$0	0	\$0
10GBASE-T cabling cost (US\$5 per port)	2	\$10	4	\$20	2	\$10
Fibre channel cabling cost (US\$150 per port)	2	\$300	0	\$0	0	\$0
Total	4	\$2010	4	\$1020	2	\$510

Based on Cisco and Intel estimates, with convergence you reduce the amount of equipment you need to operate your LAN and SANs. Table 1 shows that you can reduce the number of ports and consolidate them with FCoE and 10GBASE-T.

The Separate Networks column lists the costs associated with a server using two 10GBASE-T ports to connect to the LAN and two Fibre Channel ports to connect to the SAN. With cable prices included, connectivity costs are more than US\$2000.

In the Ethernet LAN and SAN column, the two Fibre Channel HBA ports have been replaced by two 10GBASE-T ports that pass FCoE traffic, for a total of four 10GBASE-T ports. In this scenario, combined LAN and SAN connectivity costs have fallen to US\$1020. In some cases, IT may want to separate LAN and SAN traffic onto separate Ethernet networks. Doing so still results in server connectivity costs that are nearly half the cost of using dedicated Fibre Channel HBAs.

In the Converged Fabric column, consolidation has been taken a step farther, with LAN and SAN traffic sharing two 10GBASE-T ports. Costs have fallen as well, to just US\$510, significantly lower than the US\$2010 for the Separate Networks model.

Moreover, as true 10GBASE-T LOM integration increases, connectivity costs will fall significantly, because add-on PCI Express (PCIe) adapters will no longer be required, and 10 Gigabit Ethernet connections will be included in the price of the server.

Customer Proof Point

A recent proof-of-concept (PoC) deployment by the city of Pforzheim, Germany, demonstrated the viability of 10GBASE-T in a converged fabric environment.

The Pforzheim IT department had already deployed a 10-Gbps converged infrastructure using Enhanced Small Form-Factor Pluggable (SFP+) adapters and switches. Adding FCoE support allowed this network to deliver dependable, high-performance access to storage for virtualized use models while reducing equipment costs by eliminating Fibre Channel HBAs.

Because of the potential of 10GBASE-T for cost savings and ease of deployment, the Pforzheim IT department decided to undertake a PoC study to determine whether 10GBASE-T could offer the performance and reliability required for deployment in a production environment.

Working closely with Intel and Cisco, the Pforzheim IT department conducted extensive tests using Cisco Nexus® 2232TM-E 10GE Fabric Extenders and adapters based on the Intel Ethernet Controller X540. The results of these tests demonstrated that FCoE performance met requirements across a range of packet sizes without any errors. As a result, Pforzheim is planning a phased migration to 10GBASE-T that will replace some of the existing Fibre Channel infrastructure with simple and more cost-effective 10GBASE-T.

Joint Products and Solutions

Intel Ethernet Controller X540 and Intel Ethernet Converged Network Adapter X540

The Intel Ethernet Controller X540 (Figure 3) is the industry's first single-chip 10GBASE-T controller, combining the media access controller (MAC) and physical layer controller (PHY) into a single package. This controller is designed for low-cost, low-power LAN-on-motherboard (LOM) and converged network adapter (CNA) solutions.

Figure 3. Intel Ethernet Controller X540



The main features of the Intel Ethernet Controller X540 include the following:

- **The virtual machine device queue (VMDq) and support for PCI-SIG Single-Root I/O Virtualization (SR-IOV)** provide optimized I/O virtualization for virtualized and nonvirtualized servers.
- **Unified networking** delivers LAN, NFS, iSCSI, and FCoE in a single, low-cost adapter, eliminating the need for dedicated storage adapters.
- **Power-efficient 10GBASE-T performance** offers cost, power, and server-slot savings compared to the performance of multiple Gigabit Ethernet adapters.
- **Backward compatibility with 1000BASE-T infrastructure** helps ensure easy deployment and upgrading.
- **The dual-port design** provides redundancy and greater throughput.
- **Reliable, consistent performance is provided** across a broad range of operating systems and hypervisors.

The Intel Ethernet CNA X540-T2 and T1 are powered by the Intel Ethernet Controller X540 and are Intel's fourth-generation 10GBASE-T adapters (Figure 4).

Figure 4. Intel Ethernet CNA X540-T2









Cables and Connectors

Panduit offers a comprehensive line of Category 6A cables and connectors that provide industry-leading performance to support high-end applications such as 10GBASE-T and FCoE. Panduit’s Category 6A offerings are available in unshielded and shielded versions to match the requirements for any region or application (Table 2).

Panduit’s unshielded solution uses Panduit MaTriX technology, which places discontinuous metallic elements on the cabling and connector to mitigate alien crosstalk without requiring any grounding mechanism. Panduit offers both a 100-meter solution with the Panduit TX6A 10Gig UTP 0.300-inch diameter cable, and a 70-meter solution with the Panduit TX6A-SD 10Gig UTP 0.240-inch diameter cable.

Table 2. Panduit Cabling and Connector Solutions

Panduit TX6A 10Gig UTP Solution		
	Panduit TX6A 10Gig and TX6A-SD 10Gig UTP with MaTriX technology	Panduit TX6A has a 0.300-inch diameter, and Panduit TX6A-SD has a 0.240-inch diameter.
	Panduit Mini-Com TX6A 10Gig UTP jack modules with MaTriX technology	The modules are available in a variety of colors.
	Panduit TX6A 10Gig TX6A 10Gig-SD UTP patch cords with MaTriX technology	Panduit TX6A has a 0.275-inch cable diameter, and Panduit TX6A-SD has a 0.240-inch diameter.
	Panduit TX6A 10Gig Shielded Solution	
	Panduit TX6A 10Gig U/FTP or F/UTP shielded copper cable	The cable is available in U/FTP and F/UTP versions.
	Panduit Mini-Com TX6A 10Gig shielded jack modules	There is a 360-degree termination to the cable shield.

Switches

Cisco's next generation of 10GBASE-T equipment has improved performance and reliability characteristics, creating a solid foundation for multiprotocol traffic environments, including FCoE.

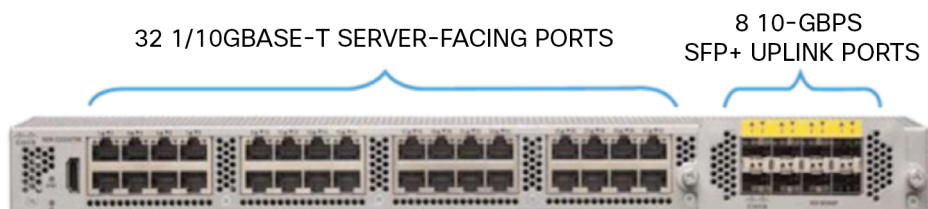
Cisco Nexus 2232TM-E 10GE Fabric Extender

The Cisco Nexus 2232TM-E fabric extender (Figure 5) has 32 ports of 1/10GBASE-T and 8 SFP+ ports and behaves like a remote I/O module for a parent Cisco Nexus 5500 platform or Cisco Nexus 7000 Series Switch. These newer-generation 10GBASE-T PHYs (40 nanometers [nm]) have improved BER characteristics and consume less power (about 210 watts [W] at 30m and 240W at 100m). The fabric extender, essentially a line-card extension of the Cisco Nexus switch fabric, works together with the Cisco Nexus parent switch to simplify operation management, with all ports managed like a local interface.

The Cisco Nexus 2232TM-E forwards all traffic to the parent switch over 10 Gigabit Ethernet SFP+ uplinks. Passing all traffic to the parent switch allows traffic to be shaped according to homogeneous policies established on the parent switch with a single point of management. This distributed modular architecture offers the following benefits:

- Architectural flexibility
- Highly scalable server access (ready for 1/10 Gigabit Ethernet at any time)
- Simplified operations and management
- Increased business benefits (Fabric Extender Transceiver [FET] for cost-effective uplinking to the fabric)

Figure 5. Cisco Nexus 2232TM-E



Cisco Nexus 5596T Switch

The Cisco Nexus 5500 platform switches have always been able to deliver FCoE, the newest addition, the Cisco Nexus 5596T Switch (Figure 6), is the first that is compatible with 10GBASE-T. Now 10GBASE-T LOM connections are being integrated into mainstream server boards, and these new 10GBASE-T ports need a high-performance, high-density switch like the Cisco Nexus 5596T to take advantage of the simplicity, speed, and design flexibility of 10GBASE-T technology.

The Cisco Nexus 5596T is based on the same application-specific integrated circuit (ASIC) and chassis as the Cisco Nexus 5596UP Switch, but the Cisco Nexus 5596T provides 32 fixed 1/10GBASE-T ports, and through the addition of the new 12-port 10GBASE-T Cisco® Generic Expansion Modules (GEMs), it can support up to 68 10GBASE-T ports in a two-rack-unit (2RU) design. In addition, customers can deploy any of the GEMs in any of the Cisco Nexus 5596T Switch's three GEM slots.

The Cisco Nexus 5596T also includes 16 fixed 10-Gbps SFP+ ports, which customers can use to connect to aggregation-layer switches, servers, or Cisco Nexus 2000 Series Fabric Extenders such as the Cisco Nexus 2232TM-E. The switch supports 10 Gigabit Ethernet (fiber and copper), Fibre Channel, and FCoE, offering up to 1920 Gbps of throughput and up to 96 ports. In addition to three expansion modules, the Cisco Nexus 5596T supports a Layer 3 module that provides up to 160 Gbps of Layer 3 forwarding capability (240 million packets per second [mpps]) that can be shared by all the I/O ports in the chassis.

Figure 6. Cisco Nexus 5596T Switch



In conjunction with the Cisco Nexus 2232TM-E fabric extender, the Cisco Nexus 5596T can be used as a high-density 1/10 Gigabit Ethernet switching system, consolidating hundreds of 10 Gigabit Ethernet connections in a single management plane. The highly scalable distributed modular system scales up to 768 1/10GBASE-T ports (24 fabric extenders are currently supported on each Cisco Nexus 5500 platform), making the combination optimal for the bare-metal and virtualized server edge.

Conclusion

Innovations in the data center promote ongoing improvement and help data centers get more out of their equipment. By doing more with less, data centers can drastically reduce capital expenses because less equipment is needed and provide the long-term benefits of a flexible system in which dynamic multiprotocol traffic can easily be allocated using a unified wire and common equipment.

By using 10GBASE-T solutions and FCoE, modern data centers can get more use from less physical equipment at much lower cost than with traditional methods. Intel, Cisco, and Panduit together can provide the next-generation data center with increased capabilities without sacrificing performance or reliability.

For More Information

Please visit the following web pages for additional information on 10GBase-T and FCoE technologies.

<http://www.cisco.com/go/intel>

<http://www.intel.com/go/ethernet>

<http://www.panduit.com>



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