



# Fibre Channel over Ethernet (FCoE) in the Data Center

Data centers utilize multiple networks that present operational and maintenance issues as each network requires dedicated electronics and cabling infrastructure. Ethernet and Fibre Channel are the typical networks, with Ethernet providing a local area network (LAN) between users and computing infrastructure, while Fibre Channel provides connections between servers and storage to create a storage area network (SAN). Fibre Channel's T11 technical committee and the Institute of Electrical and Electronic Engineer's (IEEE's) Data Center Bridging committee have defined standards to converge the two fabrics into a unified fabric with Fibre Channel over Ethernet (FCoE).

## What is FCoE?

FCoE is simply a transmission method in which the Fibre Channel frame is encapsulated into an Ethernet frame at the server (Figure 1). The server encapsulates Fibre Channel frames into Ethernet frames before sending them over the LAN and de-encapsulates them when FCoE frames are received. Server I/O consolidation combines the NIC and host bus adapter (HBA) cards into a single converged network adapter (CNA), which reduces server cabling and power/cooling needs. At present, the Ethernet frame is removed at the Ethernet edge switch to access the Fibre Channel frame, which is then transported to the SAN. Fibre Channel encapsulation requires use of 10 Gigabit Ethernet transmission electronics as well as provides for increased server to SAN connectivity.



Figure 1 – Ethernet Encapsulated FCoE Frame

FCoE encapsulation standards activity took place at the Fibre Channel T11.3 committee. Fibre Channel is a deterministic protocol that guarantees delivery of information. Native Ethernet has not been deterministic and has relied on transmission control protocol (TCP) to re-transmit dropped frames. With FCoE, the Ethernet transport has been required to be updated to ensure that frames/packets are lossless without using TCP/IP protocol. The new enhanced Ethernet standard is called converged enhanced Ethernet (CEE). CEE standards activity took place at the IEEE 802.1 Data Center Bridging working groups and was completed in 2011.

Table 1 provides the Fibre Channel Industry Association (FCIA) FCoE speed roadmap. Where 10 Gigabit FCoE utilizes serial duplex fiber transmission, 40/100 Gigabit FCoE speeds will require parallel optics. Data centers should install 12-fiber MTP® backbone cables with OM3 or OM4 fiber today that can be used for 10 Gigabit FCoE and to provide an effective migration path to emerging parallel optics that requires an MTP interface into the switch electronics and the server (Figure 2).

Product Naming	Throughput (Mbps)	Equivalent Line Rate (Gbaud)	T11 Spec Technology Completed (Year)	Market Availability (Year)
10GFCoE	2400	10.3125	2008	2009
40GFCoE	9600	41.225	TBD	Market Demand
100GFCoE	24000	103.125	TBD	Market Demand

Table 1 – FCIA FCoE Speed Roadmap

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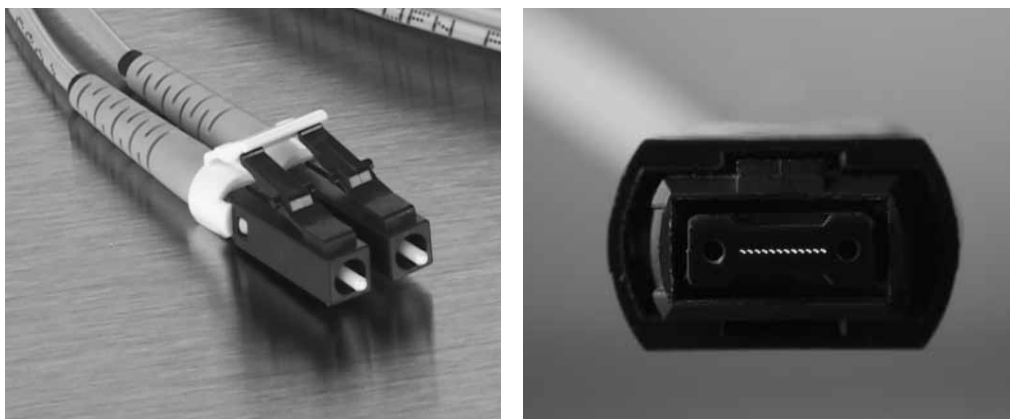


Figure 2 – Migration from Duplex LC (left) to MTP® Connectors (right)

## FCoE Cabling Architecture

Legacy data center cabling infrastructure typically includes an Ethernet optical fiber uplink to the access switches located at the server rack. Copper UTP cables then interconnect to the server NIC. Fibre Channel frames are transmitted from the server HBA to the SAN using optical fiber. Laser-optimized 50 µm multimode fiber (OM3 or OM4) is the default type optical fiber used for Ethernet and Fibre Channel transport. CAT 6 or CAT 5 are the typical copper UTP cables for the edge switch to server interconnect (Figure 3).

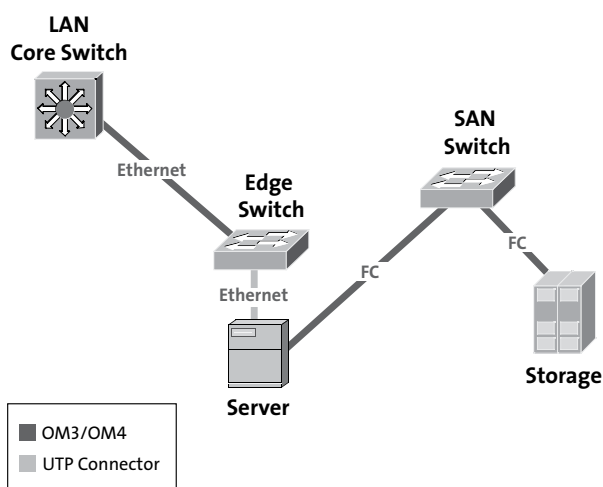
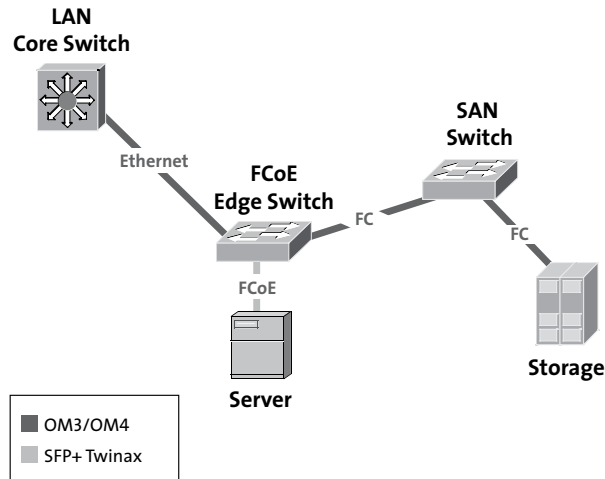


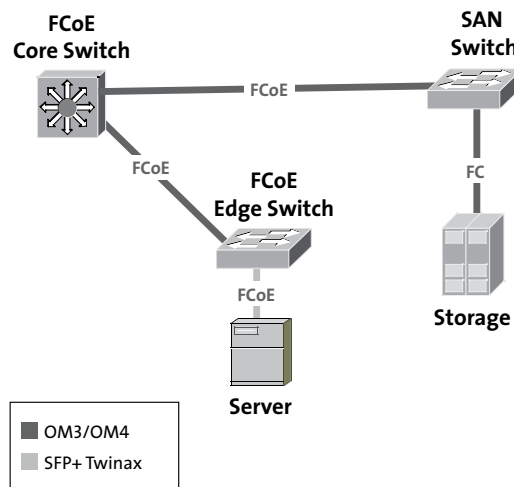
Figure 3 – Typical Data Center Infrastructure

First generation FCoE implementation is focused on the edge switch and server. Ethernet OM3 or OM4 fiber optical uplinks are received into the FCoE enabled edge switch and then interconnected to the server CNA. Instead of copper UTP interconnects, SFP+ direct-attached twinaxial copper cable is now used as the media offers significantly lower power and latency performance. The twinax copper cable is used for distances up to 7 to 10 m. Beyond that distance, low cost, ultra short reach (USR) SFP+ modules and OM3 or OM4 optical fiber is used. The encapsulated Fibre Channel frame is returned to the edge switch where the Ethernet frame is removed to access the Fibre Channel frame. The Fibre Channel frame is then transmitted to the SAN network (Figure 4). This architecture solution reduces the server interconnect cabling and adapter card number by at least 50 percent.



**Figure 4 – First Generation FCoE Infrastructure**

Second generation FCoE deployments are expected to use FCoE enabled core switches and edge switches. This architecture will continue to use basic Ethernet optical uplinks from the core switch to the edge switch and SFP+ twinax interconnects into the server. The difference occurs when the FCoE frame is transmitted back through the edge switch to the core switch over the same optical fiber previously used as the uplink to the server. At the core switch, the FCoE frame is forwarded to the SAN director where



**Figure 5 – Second Generation FCoE Infrastructure**

the Ethernet frame is removed and the Fibre Channel frame is then transmitted to the storage devices. This architecture solution reduces the server interconnect cabling and adapter card number by at least 50 percent and eliminates the Fibre Channel HBA to SAN optical fiber trunk cable (Figure 5).

Third generation FCoE architecture mirrors the second generation with the exception that the core switch now forwards the FCoE frame directly to storage where the Fibre Channel frame is accessed. This architecture solution reduces the server interconnect cabling and adapter card number by at least 50 percent, eliminates the Fibre Channel HBA to SAN optical fiber trunk cable and eliminates the core switch to SAN director fiber trunk cable (Figure 6).

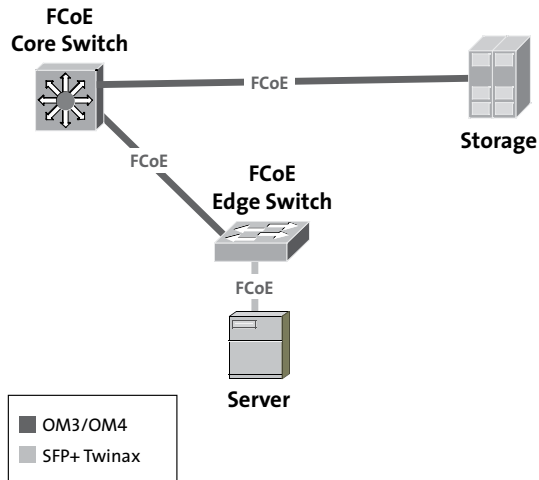


Figure 6 – Third Generation FCoE Infrastructure

The FCIA has adopted specific guidance relative to the cabling physical layer. Optical connectivity shall be in accordance with IEEE 802.3ae (10GBASE-SR) utilizing OM3 optical fiber. In addition, new installs are recommended to be = < 100 m to be compatible with emerging 40/100 Gigabit Ethernet and 16/32 Gigabit Fibre Channel. SFP+ is the preferred connector for twinaxial and optical cable. This eliminates use of 10GBASE-T copper UTP/STP cable.

### Summary

FCoE offers a data center unified fabric solution that simplifies operational and maintenance of the cabling infrastructure. FCoE facilitates utilization of low-cost Ethernet electronics and OM3 or OM4 optical connectivity to support 10, 40 and 100 Gigabit data rates.