

## **40 and 100 Gigabit Ethernet:** An Imminent Reality



# 40 and 100 Gigabit Ethernet:

## An Imminent Reality

Many of today's data centers are running 10 Gigabit Ethernet (GbE) over both optical fiber and balanced twisted-pair copper cabling in their backbone infrastructure where large numbers of gigabit links aggregate at core devices. As more edge devices; like servers and storage equipment, continue to move to 10 GbE, the next natural progression is for the network core to require even faster connections within the data center.



Fortunately, there is a solution that is now an imminent reality. Standards have been in development since 2008, and the Institute of Electrical and Electronics Engineers (IEEE) will soon release the 802.3ba standard that will support data rates for 40 and 100 GbE over optical fiber cabling. Both cable and connectivity solutions capable of supporting these speeds already exist, and vendors are in the process of developing active equipment. Now is the time to migrate data center cabling infrastructures to support this imminent technology.

## Key Market Drivers

From storage and IP traffic growth to the advancement of technology across many market sectors, the drivers that moved data transmission speeds from 1 GbE to 10 GbE over the past decade are now expanding as forecasted, creating the need for 40 and 100 GbE.

### 10 GbE Growth

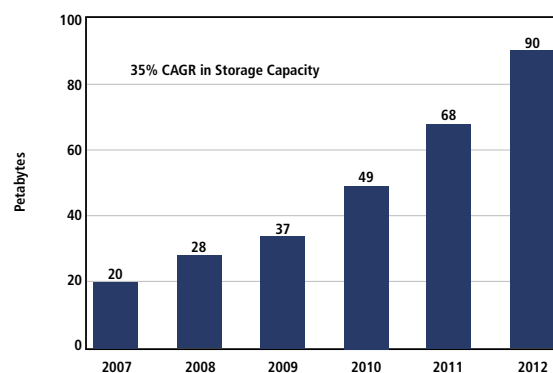
While the global Ethernet switch market experienced overall decline in 2009, the migration from 1 to 10 GbE continued in data centers across the world. As a result, 10 GbE was one of the few market segments to experience growth in an economic downturn with several vendors introducing solutions. And, according to a 2009 CIR market research report, the 10 GbE market will reach \$1.4 billion over the next four years.

This growth in 10 GbE adoption has been a significant driver for creating the next generation of Ethernet. But even as 10 GbE begins to take hold in data centers as the primary protocol, continued growth and new technologies are pushing the envelope. As more edge devices move to 10 GbE, network core devices will need to advance to higher speeds of 40 GbE. Likewise, when edge devices reach 40 GbE, the network core will need even higher speeds. The need exists today as online giants like Google and Amazon are already claiming a need for 40 and 100 GbE in their core networks.

### Storage

As global enterprise requirements continue to evolve, the amount of data needing to be transmitted and stored is growing exponentially. Additionally, many regulatory agencies are demanding more stringent policies on the storage and backup of information, especially in the government, financial and medical sectors.

All data—everything from email and company information to customer accounts, transactions and medical records—must be properly stored and archived. The best approach to accomplish this is by storage area networks (SANs). SANs enable sharing, moving and recovering information during daily operations and disaster recovery. Due to the ever-increasing amount of data, larger capacity storage devices and high-bandwidth, SAN switches are required for faster backup and retrieval. According to International Data Corporation (IDC), storage growth is continuing at a compound annual growth rate of over 35% and storage equipment is now the largest component of IT hardware budgets.



Projected Storage Capacity. Source: IDC

Over the past decade, most data center managers and storage equipment manufacturers have adopted Fibre Channel as a means of transmitting data for SANs. This highly reliable, low-latency technology allows simultaneous high-speed communications among servers and data storage systems via optical fiber cabling. On the other hand, most data centers use Ethernet for transmitting data from client to server or from server to server. To support both Fibre Channel and Ethernet, data center managers have had to deploy parallel infrastructures and interfaces, which increases cost and manageability concerns.

Now Fibre Channel over Ethernet (FCoE) aims to consolidate both SAN and Ethernet data transmission onto one common network interface, enabling the use of the same cable for both purposes and greatly reducing costs. As a result, the Fibre Channel market is expected to reach \$1.7 billion by 2014. [With Fibre Channel already operating at speeds of 1 to 4 Gbs, 10 GbE is the next logical step for FCoE from both a value and performance standpoint.] Increasing storage will continue to demand even higher speeds, and SAN equipment and FCoE will likely be the leading drivers for 40 GbE in edge devices over the next five years.

### Server Virtualization

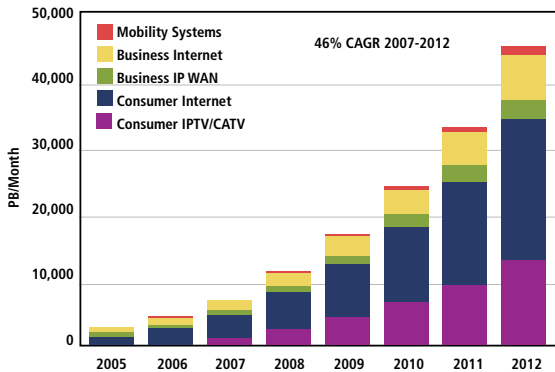
Server virtualization involves running multiple virtual operating systems on one physical server. This practice is increasingly being deployed to address the amount of equipment and space constraints in the data center. Server virtualization reduces capital expenditure and aids in disaster recovery due to the fewer number of servers needed to host all of an organization's required applications. Deploying fewer servers also maximizes resources and space availability, improves server utilization and helps to reduce power and cooling.

Most enterprises deploying server virtualization are consolidating applications on one physical server at a ratio of 4:1. As data centers become more comfortable with the technology, experts predict that the ratio could grow to as much as 20:1. With so many

applications running on one physical server, higher bandwidth capacity is required to support increased data transmission to and from servers. Increased services, such as firewalls, are also required with server virtualization, placing additional demands on capacity. This is yet another reason why 40 and 100 GbE protocols are being developed and why 40 GbE servers are expected to be one of the first technologies available following ratification of the IEEE standard.

## IP Traffic and Convergence

High-speed links in the data center are becoming more vital than ever for transmitting an increased amount of information to and from a greater number of sources. Data transmission is growing so significantly that it is expected to be six times larger in 2012 than it was in 2007. As shown below, overall IP traffic is expected to grow to over 45,000 petabytes (PB) per month by 2012—that's more than 45 billion gigabytes of information.



**Cisco Forecasts Over 45 Petabytes per Month of IP Traffic in 2012**

Technological advancements in transmitting information via Internet protocol (IP) also means that more devices and applications reside on the network, further increasing the amount of data transmission. Voice, data, video, security, and building management systems that once operated as separate analog systems have now become digitally based, allowing all forms of communication traffic to converge over a common infrastructure using IP technology. As IP convergence and the number of networked devices continues to grow, data centers will see a rapid increase in the amount of cabling and equipment needed to support new applications, as well as the need for faster speeds like 40 and 100 GbE.

## Video-Centric Applications

The entertainment industry is one of the most significant drivers for 40 and 100 GbE. Triple-play service is the fastest growing segment with customers seeking personalized content, video-on-demand, high-definition viewing, on-line gaming and Internet video like YouTube and IPTV. According to studies from CISCO, Internet video traffic will be 400 times the amount of traffic carried by the Internet in 2000. Video-on-demand, IPTV, peer-to-peer video, and Internet video are forecasted to account for nearly 90 percent of all consumer IP traffic by 2012.

In other markets, video-centric applications are also significant drivers such as telemedicine in healthcare, distance e-learning in education and virtual meetings across all business segments. The growth of video-centric applications in both the consumer and business environment is putting a strain on service providers, Internet providers and high-performance computing in data centers. These are key applications demanding 40 and 100 GbE transmission speed.

## 40 and 100 GbE Standards

The IEEE802.3ba 40 and 100 GbE standards will address:

- short reach transmission using parallel transmission over multimode optical fiber cabling,
- longer reach transmission using coarse wavelength division multiplexing (WDM) and LAN WDM technology over singlemode optical fiber cabling,
- and extremely short distances over multiple lanes of parallel coaxial copper cabling.

This standard is expected to be ratified in mid 2010.

In addition to the IEEE standard, both the Telecommunications Industry Association (TIA) and International Electrotechnical Commission (IEC) have standardized OM4, a new type of laser-optimized multimode fiber optic cable (TIA-492AAAD and IEC 60793-2-10, optical fiber type A1a.3). OM4 fiber is a 50  $\mu$ m laser-optimized multimode optical fiber with extended bandwidth capabilities. It offers an effective modal bandwidth (EMB) of 4700 MHz•km based upon the IEEE 802.3 link budget model, as compared to OM3, which offers an EMB of 2000 MHz•km. OM4 optical fiber also offers more headroom, with an additional 1.9 dB of insertion loss over OM3 optical fiber running 10 Gbps at a distance of 300 meters. OM4 has already been in use to extend 10 GbE multimode applications to distances of up to 550 meters.

When the IEEE first set out to develop standards for 40 and 100 GbE, they set an objective to reach 100 meters on existing OM3 optical fiber cabling. However, because 100 meters only encompassed approximately 85 percent of data center link lengths, OM4 was adopted due to its

capability of reaching 125 meters and supporting the majority of data center links. The following table demonstrates the designation, speed, wavelength, media, technology type and distance currently specified in the IEEE802.3ba draft standard for 40 and 100 GbE. OM3 optical fiber cabling can also be used for 40 and 100 GbE, but it will only support a distance of 100 meters. Previous generations of multimode optical fiber cabling (OM1 and OM2) will not be supported by the 40 and 100 GbE standards.

Designation	Speed	Wavelength	Media	Technology	Distance
40GBASE-LR4	40 Gbps	1310 nm	Singlemode	2 Fibers Using WDM	10 km
40GBASE-SR4	40 Gbps	850 nm	LO 50 μm Multimode (OM4)	8 Fibers (Tx & Rx) @ 10 Gbps	125 m
40GBASE-CR4	40 Gbps	NA	Parallel Coaxial Copper (Twinax) Cabling	8 Pairs 4 Tx & 4 Rx @ 10 Gbps	7 m
100GBASE-ER4	100 Gbps	1310 nm	Singlemode	2 Fibers Using WDM	40 km
100GBASE-LR4	100 Gbps	1310 nm	Singlemode	2 Fibers Using WDM	10 km
100GBASE-SR10	100 Gbps	850 nm	LO 50 μm Multimode (OM4)	20 Fibers (Tx & Rx) @ 10Gbps	125 m
100GBASE-CR10	100 Gbps	NA	Parallel Coaxial Copper (Twinax) Cabling	20 Pairs 10 Tx & 10 Rx @ 10 Gbps	7 m

IEEE802.3ba Draft Standard for 40 and 100 GbE

### Media and Interface Options

**Copper** – Transmitting 40 GbE over short distances of parallel coaxial copper cabling (also referred to as twinax cabling) is accomplished using a special cabling assembly with four lanes of coaxial cabling (eight pairs). Four pairs each transmit 10 Gbps in one direction and four transmit 10 Gbps in the other direction for a total data rate of 40 Gbps. For 100 GbE, a cabling assembly with 10 lanes of coaxial cabling (20 pairs) will be required with 10 pairs transmitting 10 Gbps in one direction and 10 transmitting 10 Gbps in the other direction. There is currently no physical layer specification under development by IEEE for running 40 or 100 GbE over balanced twisted-pair cabling.

**Multimode Optical Fiber** – To run 40 GbE over multimode optical fiber, the IEEE standard will require parallel optics with a total of 8 fibers of multimode optical fiber transmitting and receiving at 10 Gbps using an MPO style connector. The MPO connector is a high-density, multi-fiber connector that terminates up to 12 optical fibers in one connector. MPO connectors are typically preterminated in the factory to multi-fiber cables that are purchased in predetermined lengths. Because only 8 optical fibers are required for 40 GbE, the 4 left and 4 right optical fibers of the connector will be used while the other inner 4 optical fibers will not.



40 GbE over Multimode Optical Fibers using 12-position MPO Style Connector (40GBASE-SR4)

Running 100 GbE over multimode optical fiber will require 20 fibers transmitting and receiving at 10 Gbps within a single 24-position MPO style connector (recommended) or two 12-position MPO style connectors, with 4 optical fibers unused.



100 GbE over Multimode Optical Fibers using 24-position MPO Style Connector (100GBASE-SR10)

**Singlemode Optical Fiber** – Running 40 GbE over singlemode optical fiber will require 2 optical fibers transmitting 10 Gbps over 4 channels using WDM technology. Running 100 GbE with singlemode fiber will require 2 optical fibers transmitting at 25 Gbps over 4 channels using WDM. WDM technology combines multiple signals on a single optical fiber using different wavelengths (colors) of light. Multiple signals, each with its own wavelength, are transmitted on the optical fiber using separate lasers. The signals are combined by a multiplexer at the source end, then separated (de-multiplexed) at the destination end. This provides a scalable way to increase the capacity of an existing singlemode optical fiber infrastructure. WDM technology for running 40 and 100 GbE over singlemode optical fiber is ideal for long reach (up to 10 km) and extended reach (up to 40 km) distances.



**WDM Technology Using Different Wavelengths (colors) of Light on a Single Optical Fiber (40GBASE-LR4, 100GBASE-LR4, and 100GBASE-ER4)**

### Implications and Applications

Each media type capable of supporting 40 and 100 GbE has specific implications and applications and should be carefully considered. These include distance limitations, density, cable management and cost—both deployment and lifecycle costs.

#### Distance

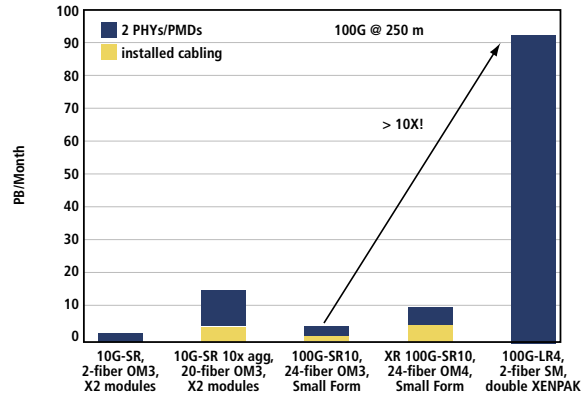
With a distance of just 7 meters, 40 and 100 GbE over parallel coaxial copper cabling will be limited to very short distances for equipment-to-equipment connections. This cabling features a significantly larger outer diameter and will not be intended for any backbone and horizontal cabling. On the opposite extreme, singlemode optical fiber is intended for much longer reach applications such as long haul and multi-facility campus applications. As stated previously, OM4 optical fiber cabling with an EMB of 4700 MHz•km will support a distance of 125 m for 40 and 100GbE, which covers the majority of data center link lengths.

### Density and Cable Management

40 and 100 GbE over multimode optical fiber will require MPO-style connectors and a significant increase in the amount of optical fiber that is currently used for 10 GbE—six times more for 40 GbE and twelve times more for 100 GbE. With up to 12 times the amount of optical fiber needed to support 40 and 100 GbE, managing optical fiber density will be a key consideration. This includes properly managing and routing large amounts of optical fiber cabling in and above racks.

#### Cost

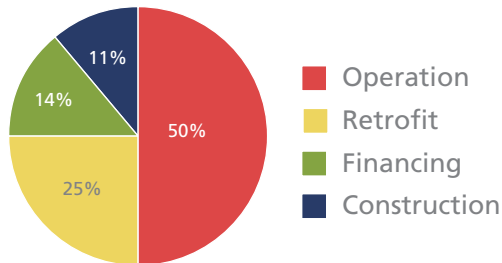
There has been much discussion regarding the cost comparison between singlemode and multimode optical fiber systems for 40 and 100 GbE. While a multimode optical fiber system requires more fiber and typically carries a higher cabling cost, the optical transceiver costs for a singlemode system operating at the 1310 nm wavelength is significantly more expensive than the lower-cost 850 nm VCSEL technology used with multimode optical fiber. In fact, recent studies show that total link cost (cabling and equipment) for 40 GbE systems using singlemode cabling can cost three times more than a multimode system. For 100 GbE, a singlemode system can cost nearly 10 times more than a multimode system.



**Cost Comparison between Singlemode and Multimode Optical Fiber 100 GbE Systems. Source: OFS**



The need to reduce total cost of ownership (TCO) is also a concern among today's enterprise businesses. Over the lifecycle of a typical enterprise, retrofit costs alone can account for 25% of total costs. The longer the data center cabling infrastructure can support changing technology needs, the lower the life cycle cost of the components. Ensuring scalability and reliability across all components in the data center is therefore becoming paramount. While singlemode may be considered the ultimate future-proof technology, the deployment costs for singlemode makes OM4 multimode optical fiber cabling with an EMB of 4700 MHz•km a much more cost-effective option. Multimode optical fiber offers reduced initial costs while providing enough bandwidth to support 40 and 100 GbE for the majority of links in the data center.



**A Building's Lifecycle Costs over 40 Years.**  
Source: ASHRAE

## Summary

Both 40 and 100 GbE will likely be initially deployed in data center high-bandwidth switching, routing and aggregation points for service provider backbones, interconnections in server and SAN devices, and high-performance computing in research, university and medical facilities. According to the CIR report, the first 40 GbE high-end servers are expected to hit the market in 2010, and 100 GbE sales are expected to start up in 2012. With network cabling infrastructure typically designed to last for 15 years and being the most expensive network component to upgrade, it only makes sense for anyone implementing or upgrading their network to ensure support for these imminent technologies.

In recent years, data center managers have become increasingly comfortable purchasing predetermined lengths of multi-fiber cables preterminated with MPO connectors, and some high-performance computing companies are already running 40 GbE using link aggregation with four 10 GbE circuits. With the IEEE802.3ba standard soon to be released, and bandwidth demand continuing to increase, today's data center managers would be wise to implement solutions and strategies that will allow easy migration from 10 GbE to 40 or even 100 GbE as needed. Thankfully, the cable and connectors to support 40 and 100 GbE are available now.

- ADC offers several MPO solutions including trunk cables, array cables, and plug-and-play cassettes. ADC's TrueNet® Optical Fiber Panel and high-density Optical Distribution Frame (ODF) are also designed to easily accommodate MPO connectors at interconnects and crossconnects in the data center.
- ADC also offers TrueNet Ultra 550, an enhanced grade of OM4 laser-optimized multimode optical fiber cable, which is required for supporting 40 and 100 GbE to 125 meters. Because optical fiber cabling is backwards compatible, not forwards, it's critical to choose this optical fiber category today. If singlemode is needed for longer-length 40 and 100 GbE applications, ADC also offers a variety of high-performance singlemode optical fiber cabling components.
- As data center managers migrate to 40 and 100 GbE and find that they need to manage 6 to 12 times the amount of cabling, high-density cable management solutions will be critical. ADC offers a variety of cable management solutions specifically designed to handle the increased amount of optical fiber in 40 and 100 GbE applications.

Preparing the data center for 40 and 100 GbE is much more cost effective than trying to unsystematically and randomly deploy solutions at a later date. Data center managers who are upgrading or deploying their data centers today should consider MPO solutions and higher-bandwidth OM4 multimode optical fiber cabling. The need for 40 and 100 GbE may be closer than they think.

WHITE PAPER



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