DATACOM CABLE SOLUTIONS

10 Gigabit Ethernet in the Marketplace:
When Gigabit Ethernet is Just Not Enough

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INTRODUCTION

Ethernet technology is currently the most deployed technology for high-performance network environments. Enterprises around the world have invested cabling, equipment, processes, and training in Ethernet. In addition, the ubiquity of Ethernet keeps its costs low, and with each deployment of next-generation Ethernet technology, deployment costs have trended downward. In networks today, the increase in worldwide network traffic is driving service providers, enterprise network managers and architects to look to faster network technologies to solve increased bandwidth demands.

As enterprise applications converge on the common Ethernet backbone, the network must be able to gracefully support a new array of bandwidth-hungry applications such as storage (NAS and SAN), streaming media, digital imaging, video and others. To effectively deal with this onslaught of bandwidth demand, forward-thinking network architects are designing enterprise networks with 10 Gigabit Ethernet to meet current and future needs.

In general, 10 Gigabit Ethernet links are deployed in parts of an enterprise or service provider network where large numbers of Gigabit Ethernet links are being aggregated. This most frequently occurs in the network core, but as Gigabit-to-the-desktop deployments continue to grow, the need for 10 Gigabit Ethernet uplinks from the network edge will emerge. The following are some common uses or applications for 10 Gigabit Ethernet.

ENTERPRISE NETWORKING

Starting from the edge of the network, as Gigabit-to-the-desktop deployments continue to grow, the need for 10 Gigabit uplinks from a wiring closet switch to handle the performance demands of power users will emerge. Backbone links to entire floors or buildings may run over optical fibers at Gigabit rates, while drops to desktop workstations may need to be no faster than 100 Mbps. Naturally, with this upsurge in bandwidth demand, 10 Gigabit Ethernet will be used as a high-speed interconnection between multiple buildings. These buildings could be in close proximity on a self-contained "campus," or could be many miles apart and connected by dark fiber provided by a local service provider or municipality. Due to the limited distance of 10 Gigabit Ethernet on Multimode fiber (MMF), Singlemode fiber (SMF) must be deployed to support 10 Gigabit building interconnects. In an enterprise data center, 10 Gigabit Ethernet can be utilized in a variety of applications such as cluster computing, server attachment and storage interconnect.

Server clusters are a group of tens, hundreds or even thousands of relatively inexpensive (e.g., 1U Linux servers) computers (referred to as nodes) connected in parallel to cooperatively solve large, complex problems. Cluster computing has become a mainstream technological tool for research, financial modeling, digital image rendering and scientific applications. The connection between the various computers in the cluster is typically an Ethernet switch.

10 Gigabit Ethernet has 10 times the performance over Gigabit Ethernet today. With the addition of 10 Gigabit Ethernet to the Ethernet technology family, a local network now can reach further distances and support even more bandwidth-hungry applications. A natural choice for expanding,

extending, and upgrading existing Ethernet networks, 10 Gigabit Ethernet also meets several criteria for efficient and effective high-speed network performance such as:

- A customer's existing Ethernet infrastructure is easily interoperable with 10 Gigabit Ethernet. The new technology provides lower cost of ownership including both acquisition and support costs versus current alternative technologies

- Uses processes, protocols and management tools already deployed in the management infrastructure, 10 Gigabit Ethernet draws on familiar management tools and a common skills base

- Flexibility in network design with server, switch and router connections

- Multiple vendor sourcing of standards-based products provides proven interoperability

- Provides much needed scalability for Next-Generation technologies

As 10 Gigabit Ethernet continues to grow in the market, and equipment vendors deliver 10 Gigabit Ethernet network devices, the next step for enterprise and service provider networks is the combination of multi-Gigabit bandwidth with intelligent services, which leads to scaled, intelligent, multi-Gigabit networks with backbone and server connections ranging up to 10 Gbps for copper cabling. Convergence of voice and data networks running over Ethernet is now a very real option. And, as TCP/IP incorporates enhanced services and features, such as packetized voice and video, the underlying Ethernet can also carry these services without modification.

APPLICATIONS FOR 10 GIGABIT ETHERNET

Manufacturers and end users generally agree that Ethernet is inexpensive, well understood, widely deployed and backwards compatible in today's enterprise networks. Currently, a packet can leave a server on a short-haul optic Gigabit Ethernet port, move cross-country via a DWDM (dense-wave division multiplexing) network, and find its way down to a PC attached to a Gigabit copper port, all without any re-framing or protocol conversion. Ethernet is literally everywhere, and 10 Gigabit Ethernet maintains this seamless migration in functionality for any application in which Ethernet can be applied.

Fabric interconnects, whether they are for server area networks or storage area networks, have traditionally been the domain of dedicated, often proprietary, networks with relatively small user bases when compared to Ethernet. These server area networks include InfiniBand*, Server net*, Myranet* and various other technologies, offer excellent bandwidth and latency performance for very short-haul networks. However, with the exception of InfiniBand, these are proprietary networks that can be difficult to deploy and maintain due to the small number of experienced IT professionals familiar with the technology. The small volumes also result in higher costs for server adapters and switches. And, as with any proprietary solution, they are not interoperable with other technologies without the appropriate routers and switches.

In storage area networks, the lack of standards and a slew of interoperability problems plagued the early Fibre Channel deployments. However, these technologies also suffer similar problems as those seen by proprietary server area networks in that they are considered difficult to deploy and require specialized IT Skills. Hence they are relatively expensive at the adapter and switch port and are still not directly interoperable with other network technologies without expensive routers or switching devices, and generally focus on short-haul deployments. For both server and

storage-area networks, 10 Gigabit Ethernet is in a position to replace these proprietary technologies as a next-generation interconnect for several reasons, including:

- **10 Gigabit Ethernet Offers Necessary Bandwidth**
  - InfiniBand and Fibre Channel have also begun mass deployments of 10 Gigabit technologies—indicating a convergence on 10 Gigabit throughput
  - Medical Radiology and Imaging requirements based upon file size and urgency
  - Operational Convergence
  - Video Streaming, etc.
- **Cost-Saving Server Consolidation**
  - 10 Gigabit Ethernet grants a single server the bandwidth needed to replace several servers that were doing different jobs
  - Centralization of management is also a major benefit of server consolidation. With a single powerful server, IT managers can monitor, manage, and tune servers and application resources from a single console, which saves time and maximizes IT resources
  - According to industry experts, companies realize a seven-to-one savings in management when processes and servers are consolidated
- **Planned Growth of 10 Gigabit Network Features**
  - For the first time ever, Ethernet can be a low-latency network due to RDMA (Remote Direct Memory Access) support, which is critical in the server-to-server communication typically associated with clustering and server area networks
  - Scalable infrastructure

In addition, the expected universal deployment of TOE (TCP/IP Offload Engine) technology in 10 Gigabit Ethernet adapters may make it extremely efficient on host systems with expected CPU utilization well below anything seen on today's systems deploying Gigabit Ethernet. Due to the wide adoption rate of Ethernet, TOE technology will become extremely cost efficient compared to the lower volume, niche alternatives.

10 GIGABIT ETHERNET OVERVIEW

10 GbE is the latest speed phenomena in Ethernet's ongoing evolution. Ratified in June 2006 as IEEE 802.3an, February 2008 as ANSI/TIA 568B.2-10 and ANSI/TIA 568-C.2 in August of 2009, it is, in every aspect, fully compatible with previous versions of Ethernet. 10 GbE uses the same frame format, Media Access Control (MAC) protocol and frame size. Thus, network managers can retain existing management tools and operational procedures as they introduce 10 GbE into their network. The differences between 10 GbE and previous versions of Ethernet are inconsequential as it pertains to compatibility. First of all, unlike its predecessors, 10 GbE only operates in full-duplex mode. This attribute is a benefit rather than disadvantage since full-duplex operation provides faster, lower-latency responses to network transmissions. Second, the IEEE 802.3ae standard defines two different types of PHYs—LAN PHY and WAN PHY. The LAN PHY transmits Ethernet frames directly over a 10 GbE serial interface. LAN PHY is for standard 10 Gigabit per second transmission within an enterprise or local area-network (LAN) environment. The WAN PHY encapsulates Ethernet packets in SONET, OC-192c frames and provides a rate matching mechanism of 9.953 Gigabits per second. This SONET-compatible interface allows native 10 Gigabit Ethernet to be transported directly over an existing service provider SONET/SDH network.

COMPARISON BETWEEN 1 GIGABIT AND 10 GIGABIT ETHERNET

1 Gigabit Ethernet   **10 Gigabit Ethernet**

CSMA/CD and Full Duplex   Full Duplex only
Leveraged Fiber Channel PMDs   New Optical PMDs
8B/10B PAM 5 Coding   64B/66B PAM 16 Coding

Performance

- **10 Gigabit Ethernet offers:**

    o Same familiar operating environment
    o Ease of use, debug and management
    o No more CSMA/CD issues
    o 10x bandwidth and 8x latency vs. Gigabit Ethernet for the Channel

WHY INVEST IN 10 GIGABIT CABLING NOW?

Some things to think about…

- How often does a company get a chance to rewire?
- Can you be assured that money to retrofit will be there when needed?
- Will other parts of the infrastructure, like conduit, tray, and raceways be suitable for retrofitting?
- What if you have to pull out the old cable? (add 2x labor)
- Would you really want your cabling infrastructure to be the bottle neck?
- Installing technology that has "dead end" implications is counter intuitive
- What about costly downtime associated with retrofit?
- There are no standards on the horizon that will make Category 5e or Category 6 work to 100 meters for 10G Ethernet
- 10 Gig is backward compatible – no fork lift upgrades needed!
- Immediate benefits like reduced power usage for PoE (+) devices, enhanced throughput, and higher versatility with applications like security will be immediately relevant
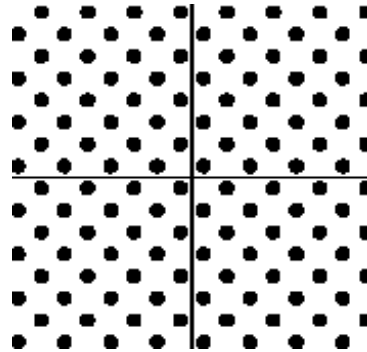- Better bandwidth and support for impending applications like 802.11AC for 1G Wireless/Wi-Fi

WHY IS ANEXT AN ISSUE FOR GIGABIT ETHERNET?

10/100/1000 Base T = 5 PAM
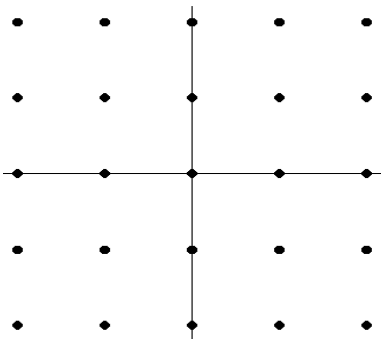
10G Base T = 16 PAM

4-prs running @   25 mega-pulses/sec ----100Base T
4-prs running @ 125 mega-pulses/sec ---1000Base T

Tomlinson-Harashima Precoded (THP)
16 discrete levels: 2-dimensional latticed pattern
16 voltage levels coupled w/ 16 time intervals on
each pair

GIGABIT ETHERNET VS 10 GIGABIT ETHERNET

(Category 5e/6 vs. Category 6A)

10 Gigabit Ethernet creates new issues that were not relevant at speeds of 1 Gigabit Ethernet and below.

(This is due to two major effects that make the difference between 1 and 10 Gb/s)

Higher Noise Emission:

Every transmitting line emits noise by itself.
- Since 10 Gig uses a much higher transmitting power (e.g. power consumption per 10G port is up to 15W compared to 0.5W for 1G) it emits much more – specifically in the relevant bandwidth from 250 to 500 MHz
- All of a sudden, 10 Gig impacts itself because neighboring cables interfere with each other, (via like pairs) an effect called "Alien Crosstalk" or ANEXT.

Reduced Signal Levels:

- Due to its complex encoding scheme (PAM 16), 10G BASE-T functions with significantly reduced signal levels per symbol than slower protocols.

- While Gigabit Ethernet sends with initial symbol amplitude of 0.5 V, 10G Ethernet only uses 0.13 V – which is further attenuated over the length of the cable.

Such lower level signals are more likely to be interfered with by external influences such as background noise, power coupling, etc.

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CONCLUSION

In summary, 10 Gigabit Ethernet empowers companies to expand application capabilities, reduce time to solve complex financial and scientific applications, as well as quickly respond to changing customer needs and market conditions. Unprecedented high bandwidth, low-latency, and energy efficiency are a few key differentiators of General Cable's 10 gigabit cabling products which are designed for horizontal, as well as backbone media; with a strategic emphasis for data centers—implementing high-performance computer clusters, and enterprise networks—consolidating disparate SAN solutions into a common low-cost and high-speed 10 GbE IP storage network.