

# Gigabit Network Backbones

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Network bandwidth requirements continue to rise. As users spend more of their time accessing resources beyond the LAN, the demand for ATM and Gigabit Ethernet backbones will continue to increase. Today's network backbones now require gigabit speeds to carry the increasing traffic between LANs and to connect users to remote servers. Backbone technologies such as Fast Ethernet and Fiber Distributed Data Interface (FDDI) are currently being displaced by two newer technologies - Gigabit Ethernet (GE) and Asynchronous Transfer Mode (ATM). In the following pages, this paper provided a brief description of these new (and competing) high-speed network technologies. In addition, the strengths and weaknesses of ATM and Gigabit Ethernet were explored in order to determine which would become the dominant backbone technology. Included in the analysis were quality of service (QoS), integration with existing networks, cost of implementation, and configuration and administration.

## Gigabit Network Backbones

Network bandwidth requirements continue to rise. Driven by users' needs to access resources outside their LAN, the demand for high-speed network backbones has increased more rapidly than other segments of the network (Harbaugh, 1998). Today's network backbones now require gigabit speeds to carry the increasing traffic between LANs and to connect users to remote servers. Backbone technologies such as Fast Ethernet and Fiber Distributed Data Interface (FDDI) are currently being displaced by two newer technologies - Gigabit Ethernet (GE) and Asynchronous Transfer Mode (ATM).

In the following pages, this paper provides a brief description of these new (and competing) high-speed network technologies. In addition, the strengths and weaknesses of ATM and Gigabit Ethernet are explored in order to determine which will become the dominant backbone technology.

### ATM

ATM is a network technology used for both LANs and WANs. It supports realtime voice, video, and data. ATM topology uses switches to establish logical circuits from end to end. Since ATM was introduced in the early 1990s, the technology has had some growing pains. ATM did not evolve as quickly as expected for a couple of reasons. First, large numbers of Ethernets and Token Rings were in place. Second, faster versions of Ethernet, coupled with Ethernet switches provided a simpler way to increase bandwidth.

In spite of its slow start, ATM is finally reaching maturity. This is in large part due to its wide adoption by telecommunications and service provider networks. "ATM is really beginning to happen more widely and broadly," said George Dobrowski, president of the [ATM Forum](#) and director of switching and signaling at [Bellcore](#) (Heskett, June 2, 1998). One example is Sprint's new [Integrated On-Demand Network](#) (ION) service. ION integrates voice, video, and data over one line. In the last few years, Sprint has spent \$2 billion quietly building its network in preparation for the launch of its new ION service (Luening, 1998).

Sprint's long distance network covers the United States. This allows Sprint ION to pass through 70 percent of large businesses without having to use digital subscriber lines. [Cisco Systems](#) ATM equipment will provide ION customers voice-over-ATM capability along with the ability to connect to other carriers' legacy circuit-switched networks. In addition, Sprint will be one of the first to use the Directory Enable Networks (DEN) standard. DEN will allow Sprint to manage the ION network from a central depository of information about users, applications and network resources (Luening, 1998). Bellcore will provide the software that will serve as the core intelligence for ION.

Sprint is currently leading the effort toward a "one-pipe" converged network. [AT&T](#) and [MCI WorldCom](#) are not far behind. AT&T plans to handle voice and data via an ATM device on the business customers' premises (Gerwig, 1998). This ATM switch will take

different customer protocols and send them through AT&T's network as ATM protocol. Sprint, on the other hand, plans to use an integrated service hub device developed jointly by Cisco Systems and Bellcore. Also, ATM technology received a boost recently when [Intel](#) announced its partnership with [FORE Systems](#) (worldwide leader in ATM technology) (Heskett, 1998). Intel will add ATM technology to its lineup of networking products.

## Gigabit Ethernet

Ethernet is currently the dominant network technology and the most widely used LAN access method (Token Ring is the next most popular). According to [International Data Corporation](#) (IDC), more than 85 percent of all installed network connections were Ethernet at the end of 1997. Ethernet is defined by the [IEEE](#) 802.3 standard and is normally a shared media LAN. All stations on the segment share the total bandwidth, which is either 10 Mbps (Ethernet), 100 Mbps (Fast Ethernet) or 1000 Mbps (Gigabit Ethernet).

In contrast, switched Ethernet improves network performance because instead of sharing 10 Mbps for Ethernet or 100 Mbps for Fast Ethernet among all users on a network segment, the full bandwidth is available to each user. If the switch and network adapters provide full-duplex operation, the total bandwidth is 20 Mbps or 200 Mbps between nodes. A major advantage of migrating to switched Ethernet is that the existing network interface cards (NICs) are still used.

Gigabit Ethernet is the Ethernet technology that raises transmission rates to one Gbps. The IEEE Standard (802.3z) for Gigabit Ethernet defines its operation over multimode optical fiber. This standard provides for full-duplex transmission from switch to end station or to another switch and half-duplex over a shared channel using the CSMA/CD access method. The IEEE 802.3ab is the counterpart standard for Gigabit Ethernet over Category 5 copper wiring.

According to Tam Dell'Oro of the [Dell'Oro Group](#), the Gigabit Ethernet switch market will grow to \$1 billion by the year 2000 (Axner, 1997). The Gigabit Ethernet market (like the ATM market) is driven by user needs for faster response times, increased segment capacity, and significant improvements in backbone bandwidth and server performance. Growth potential of this magnitude has motivated than 80 companies to form the [Gigabit Ethernet Alliance](#) (GEA). The mission of the GEA (formed in May 1996) is to assist the 802.3z Task Force in developing standards and to educate users with Gigabit Ethernet solutions.

The Gigabit Ethernet market has grown from the technology development stage in 1996, the hype stage in 1997, and finally the beta testing and "ready for sale" equipment deployment phase in 1998 (Heskett, March 19, 1998). Even ATM leaders such as FORE Systems recognize the potential for Gigabit Ethernet. FORE recently demonstrated this with its purchase of Gigabit Ethernet equipment manufacturer [Berkeley Networks](#) (Heskett, August 27, 1998).

There is a common misconception that Gigabit Ethernet is just an upgraded version of Fast Ethernet. This is not the case. Although Gigabit Ethernet is interoperable with other Ethernet technologies, its physical layer is different. Gigabit Ethernet uses a modified version of the ANSI X3T11 Fibre Channel standard physical layer (FC-0). [The Fibre Channel standard](#) was chosen because it is currently the only technology that supports gigabit speeds up to 4.268 Gbps. The current ATM OC-48 standard supports rates up to 2.5 Gbps.

Like Fast Ethernet, Gigabit Ethernet operates in either half- or full-duplex mode. Full-duplex Gigabit Ethernet connections yield a total of 2.0 Gbps, but can only be used for point-to-point connections. Initially, Gigabit Ethernet technology will be deployed in campus and building environments where bandwidth performance problems exist. Gigabit Ethernet to the desktop is not expected until later phases in its deployment. Initial deployments will replace Fast Ethernet and FDDI backbones.

## Strengths and Weaknesses

Currently the biggest long-term difference between Gigabit Ethernet and ATM is quality of service (QoS). Important short-term issues include cost, integration with existing networks, and ease of configuration and administration.

### Quality of Service

QoS defines a level of performance in a data communications system. QoS has become a major issue on the Internet as well as in enterprise networks, because video is increasingly traversing IP-based data networks. QoS is extremely important for applications supporting video over the network as well as for allocating bandwidth to priority WAN traffic over relatively slow WAN links. The growing popularity of voice traffic on the network, including voice over IP, is also putting QoS in the spotlight.

ATM networks have established QoS features and modes of service that ensure optimum performance for traffic such as realtime voice and video. ATM's constant bit rate (CBR) level of service guarantees bandwidth while its available bit rate (ABR) service level adjusts bandwidth according to congestion levels for LAN traffic. Unspecified bit rate (UBR) service provides best effort for remote users. Interactive multimedia that requires minimal delays uses realtime variable bit rate (rt-VBR). Non-realtime variable bit rate (nrt-VBR) is used for bursty traffic.

In contrast to ATM, Gigabit Ethernet does not have an established standard for QoS. Until recently, Ethernet did not have the ability to handle high-priority traffic such as a video feed. However, Gigabit Ethernet switch manufacturers are beginning to support the IEEE 802.1q standard (Rash, 1998). IEEE 802.1q is the standard for providing VLAN identification and quality of service (QoS) levels. Four bytes are added to an Ethernet frame, increasing the maximum frame size from 1518 to 1522 bytes. Three bits are used to allow eight priority levels (QoS) and 12 bits are used to identify up to 4096 VLANs.

Until the 802.1q standard is ratified and implemented by all vendors, there is very little chance that the Gigabit Ethernet equipment from different vendors will interoperate and provide quality of service guarantees (Harbaugh, 1998).

## **Integration**

ATM and Ethernet both integrate well with existing networks. ATM integrates very simply with token-ring networks and ATM-based carrier networks. ATM uses an ATM Forum standard to route legacy protocols (IP, IPX, etc.) over ATM networks. This standard, Multiple Protocol Over ATM (MPOA), separates the routing processing from the forwarding. ATM also uses LAN Emulation (LANE) to interconnect legacy LANs. LANE encapsulates Ethernet and Token Ring frames into LANE packets and then converts them to ATM cells.

Most phone companies and other telecommunication companies use ATM to carry data. This means that ATM networks can be connected over a WAN link with little overhead or translation. In contrast, Gigabit Ethernet networks require considerable overhead to be linked over an ATM network. It takes a considerable amount of work for a router to divide Ethernet's large (1,518 to 8,000 byte) packets into 53-byte ATM packets.

Gigabit Ethernet integrates smoothly into existing Ethernet networks. This is an important quality since more than 85 percent of the networks in the U.S. are Ethernet. No conversion is required since all types of Ethernet use the same packet size, structure, and protocol. In addition most Gigabit Ethernet switches include 10/100 Mbps Ethernet ports.

## **Cost**

One of Gigabit Ethernet's biggest selling points is that it is less expensive than ATM. Both ATM network interface cards and network infrastructure equipment (i.e. switches and routers) are considerably more expensive than Gigabit Ethernet. For instance a gigabit-speed Ethernet connection costs about the same as a 155 Mbps ATM connection according to Menachem Abraham, president of Lucent Technologies Inc.'s enterprise infrastructure products group (Higgins, 1998). Also Gigabit Ethernet prices are dropping rapidly while ATM prices are only moving slowly downward due ATM's relative complexity.

## **Configuration and Administration**

Issues regarding configuration and administration may be more significant than the cost of acquisition. For instance, retraining a large network support staff may end up costing more than the equipment when training fees and lost worker hours are factored in. There is a significant difference between ATM and Gigabit Ethernet when it comes to configuration and administration.

ATM products are complex and often only have a text-based, non-intuitive interface for configuration. In contrast, Ethernet cards and switches do not require manual

configuration and need only to be plugged in to start working. Currently, ports that automatically sense Gigabit, in addition to 10 Mbps and 100 Mbps Ethernet, are available (Harbaugh, 1998). Also, most network technicians are familiar with Ethernet and unfamiliar with ATM's underlying format and operation.

In addition to the above differences, ATM is a more mature technology than Gigabit Ethernet. Currently, second and third generation ATM hardware is available, while Gigabit Ethernet hardware is still waiting for a full set of standards to be ratified.

## Conclusion

Gigabit network backbones will soon replace the existing 100 Mbps Fast Ethernet and FDDI varieties. As users spend more of their time accessing resources beyond the LAN, the demand for ATM and Gigabit Ethernet backbones will continue to rise. This paper provided a brief description of these competing technologies along with an analysis of their strengths and weaknesses (i.e. quality of service, integration, cost, and configuration/administration).

In conclusion, ATM is a good fit for large enterprises linked over a WAN and when quality of service is a major consideration. It is even more applicable when different divisions are using different network hardware. Gigabit Ethernet is simpler and cheaper, with limited QoS features. However, current solutions are limited to a single vendor environment. This limitation should go away when Gigabit vendors standardize on 802.1q. Competition between the two technologies will become fierce in 1999. The outcome will most likely be determined by Gigabit Ethernet's ability to standardize and provide promised QoS guarantees.

## Reference List

- ATM Forum Web Site: <http://www.atmforum.com>
- AT&T Web Site: <http://www.att.com>
- Axner, D. (1997, March). Gigabit Ethernet: A technical assessment. *Telecommunications*. <http://www.telecoms-mag.com/issues/199703/tcs/anxer.html>
- Bellcore Web Site: <http://www.bellcore.com>
- Cisco Systems Web Site: <http://www.cisco.com>
- Dell'Oro Group Web Site: <http://www.delloro.com>
- FORE Systems Web Site: <http://www.fore.com>
- Gerwig, K. (1998, October 5). The one-pipe approach gains momentum. *InternetWeek*. <http://www.techweb.com/se/directlink.cgi?INW19981005S0039>
- Harbaugh, L. (1998, October 12). Strengthen your backbone. *InformationWeek*. <http://www.techweb.com/se/directlink.cgi?IWK19981019S0050>
- Heskett, B. (1998, March 19). Gigabit Ethernet shakedown. *CNET News.com*. <http://www.news.com/News/Item/0,4,20260,00.html>
- Heskett, B. (1998, June 2). ATM catches up with hype. *CNET News.com*. <http://www.news.com/News/Item/0,4,22675,00.html>
- Heskett, B. (1998, August 27). FORE makes gigabit bet. *CNET News.com*. <http://www.news.com/News/Item/0,4,25759,00.html>
- Higgins, K. (1998, August 1). Gigabit Ethernet hits the fast track. *Tele.com*. <http://www.techweb.com/se/directlink.cgi?TLC19980801S0016>
- IEEE Web Site: <http://www.ieee.org>
- Intel Web Site: <http://www.intel.com>
- International Data Corporation Web Site: <http://www.idc.com>
- Luening, E. (1998, June 2). Sprint aims to ease congestion. *CNET News.com*. <http://www.news.com/News/Item/0,4,22667,00.html>
- MCI Worldcom Web Site: <http://www.mciworldcom.com>

Rash, W. (1998, October 5). Jerky video be gone: QoS for Ethernet is here.  
*InternetWeek*. <http://www.techweb.com/se/directlink.cgi?INW19981005S0063>