



# Evolution of Gigabit Technology

*From the Server to the Desktop*

## Contents

<a href="#">Executive Summary</a>	2
<a href="#">Standards Evolution</a>	3
<a href="#">The Ongoing Desktop Revolution</a>	3
<a href="#">New Processors and Applications</a>	5
<a href="#">Gigabit to the Desktop: Now Is the Time</a>	6
IT Managers	6
Users on the Network	7
<a href="#">Cabling Considerations</a>	7
<a href="#">Deployment Scenarios</a>	8
Department or Small Business – New	8
Department or Small Business – Upgrade	9
Single-Building or Mid-Size Business	10
Multi-Building Campus	11
<a href="#">Conclusion</a>	11
<a href="#">For More Information</a>	11

## Executive Summary

The need for speed continues to accelerate at all levels of the network, and today's PCs and servers are designed to meet the challenge – but only if they have the right network connections. High-bandwidth applications and high-speed communications have driven major increases in networking speeds from 10Mbps Ethernet to 100Mbps Fast Ethernet, and now to 1000Mbps Gigabit Ethernet (GbE). This means critical connections must be continually re-evaluated.

Many IT managers are deciding the time is ripe for broadly implementing Gigabit Ethernet to the desktop. They are specifying 1000Mbps network adapter cards or LAN-on-Motherboard (LOM) for their desktop systems, and multi-GbE for their servers. Benefits to the IT manager include significant time savings for a myriad of daily tasks ranging from virus protection patches to backups and software pushes. Users on the network gain the ability to download seamlessly without waiting, greatly increasing their productivity.

This paper looks at the ways your network can benefit from GbE implementations and offers a variety of deployment examples using copper and/or fiber-optic cabling. This information is intended to help network managers stay ahead of the demand for bandwidth and get the most performance at a lower cost.

## Standards Evolution

87% of all installed network connections are Ethernet, according to International Data Corporation (IDC, 2000). This is primarily due to the fact that industry standards for Ethernet, over 25 years old, have progressed along with networking requirements. This progression of industry standards provides a clear and easy migration path for companies as their bandwidth requirements increase.

Gigabit Ethernet has evolved from the original industry standards for 10Mbps Ethernet (10BASE-T) and 100Mbps Fast Ethernet (100BASE-TX and 100BASE-FX). When the IEEE approved Gigabit Ethernet over fiber-optic cable in June of 1998, companies were able to rely on a well-known, standards-based approach for improving traffic flow in congested areas.

Gigabit Ethernet began to be used along network backbones and in network servers via GbE adapters to remove traffic bottlenecks in these areas of congestion. As Internet-based activities increased, companies also deployed Gigabit links from workgroups into the data center.

To implement Gigabit Ethernet, however, network managers were often faced with re-wiring their buildings in order to upgrade the infrastructure to fiber-optic cable. This issue was resolved in 1999, when the IEEE adopted an industry standard for GbE over standard Category-5 (Cat-5) copper cabling. Widespread deployment of GbE became possible and more affordable over the existing copper infrastructure. The vast majority of desktop connections are copper, and this industry standard has made the deployment of Gigabit to the desktop possible.

## The Ongoing Desktop Revolution

The revolution in productivity that began with the advent of the desktop computer has never ended. That revolution continues today with the rapid growth of the Internet, which requires desktop PCs to quickly download large files, process rich content, and communicate as well as compute.

Not long ago, desktop connections and PC processing power were considered more than adequate if the user could simultaneously open Microsoft Word\* and an Excel\* spreadsheet. Some wondered if 10Mbps bandwidth would ever be fully utilized. The kind of visually rich multi-tasking that is routine today, such as editing video while downloading photographs or exchanging graphic designs while talking on an Internet phone line, were not part of the equation.

## Advantages of a Gigabit Network

Gigabit Ethernet is 100 times faster than regular 10Mbps Ethernet and 10 times faster than 100Mbps Fast Ethernet. Advantages as a networking technology include:

- Increased bandwidth for higher performance and elimination of bottlenecks
- Power to transfer large amounts of data across a network quickly
- Ability to aggregate network bandwidth to multi-Gigabit speeds using GbE server adapters, link aggregation, and switches
- Quality of Service (QoS) features to help configure network traffic and optimize critical data
- Low cost of acquisition and ownership
- Seamless integrations with Ethernet and Fast Ethernet-installed base

Then, as applications grew more bandwidth-hungry, the view that 10Mbps was adequate for desktops began to change, and the trend to 100Mbps desktops developed. This trend greatly accelerated when the cost of dual-speed 10/100Mbps Ethernet connections approached the cost of regular Ethernet. Network managers could build 100Mbps capability into their new PCs at the time of purchase and avoid the higher costs of retrofitting these desktops in the future.

The industry is now in a similar circumstance with 1000Mbps Gigabit Ethernet connections (Figure 1).

The availability of multi-speed, auto-sensing adapter cards and LOM technology has made it easy for network managers to future-proof new PCs and increase bandwidth as needed. A manager can deploy GbE to the workgroup or segment switches in the wiring closet, and auto-sensing connections on the desktops will adjust accordingly.

Once multi-speed adapters are deployed, use of the higher speed inevitably becomes necessary over time. For example, of the 10/100Mbps desktops deployed beginning in the mid-1990s, an estimated 86% were running at 100Mbps by the year 2000 (Infonetics, 2000). Similar trends can be expected for 10/100/1000Mbps connections as bandwidth requirements increase.

Behind the growth in bandwidth requirements has been a revolutionary change in the way people get their work done. Several years ago, people relied on the network mainly to deliver productivity applications such as file and print. Most network activity took place on the local network segment, not on the WAN (Wide Area Network).

A tremendous shift in this dynamic has occurred with the advent of the Internet, intranets, and the widespread use of workgroup applications such as Microsoft NetMeeting\* (collaboration meeting tool) (Figure 2). IT managers have redesigned the network to accommodate this shift, and most network traffic is now routed TCP/IP data. Desktops are being used to download massive amounts of data from the Internet and intranets, and networks are far busier.

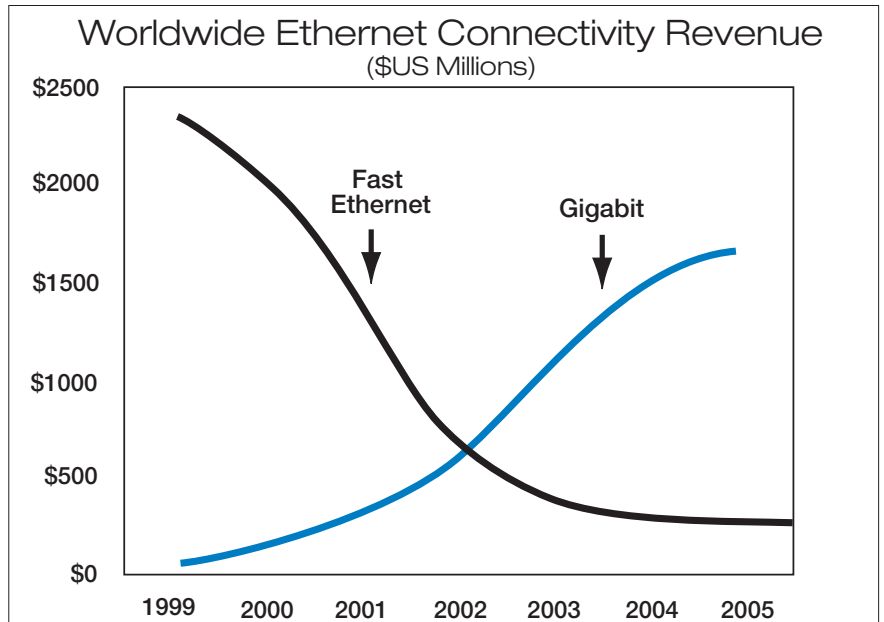


Figure 1 - Shrinking price deltas are ramping the growth of desktop Gigabit connections and continuing a now-familiar pattern as 1000Mbps replaces 100Mbps. It is estimated that by the middle of 2002, over 50% of worldwide NIC revenues will come from GbE products (Cahners In-Stat, 2001).

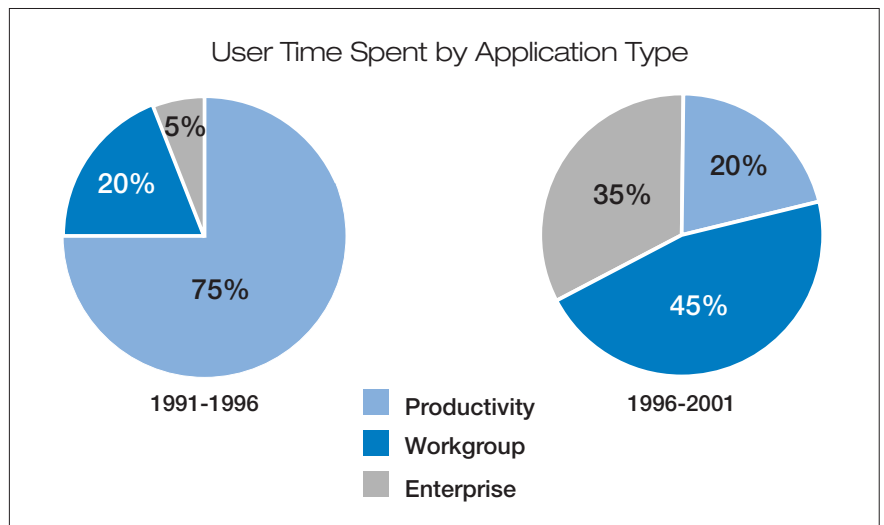


Figure 2 - User Time Spent by Application Type

## New Processors and Applications

In addition to the new work model that has emerged along with the Internet, the move to Gigabit-enabled desktops is being driven by several other factors, including:

- High-performance desktop processors
- Faster architectures, with 2 to 3 times the transfer speed between CPU and RAM
- Converged voice and data applications
- Collaborative work environments involving the sharing of large files
- Multi-tasking, where multiple applications are open simultaneously

Increases in desktop computing power are not only continuing as they have in the past, but are actually accelerating (Figure 3). As of this year, with the Intel® Pentium® 4 Processor, speeds are exceeding 2GHz. In addition, desktop hard drives of 60GB are typical. Gigabit connections provide the bandwidth to handle the increased processing power of today's high-end PCs, as well as processors of the future.

Taking full advantage of desktop processing power is increasingly important as the move to converged networking picks up speed. Along with infrastructure changes, a variety of new, bandwidth-intensive multimedia applications are being introduced encompassing voice, data, video and long-distance Storage Area Networks (SANS) – applications that are used down to the desktop level.

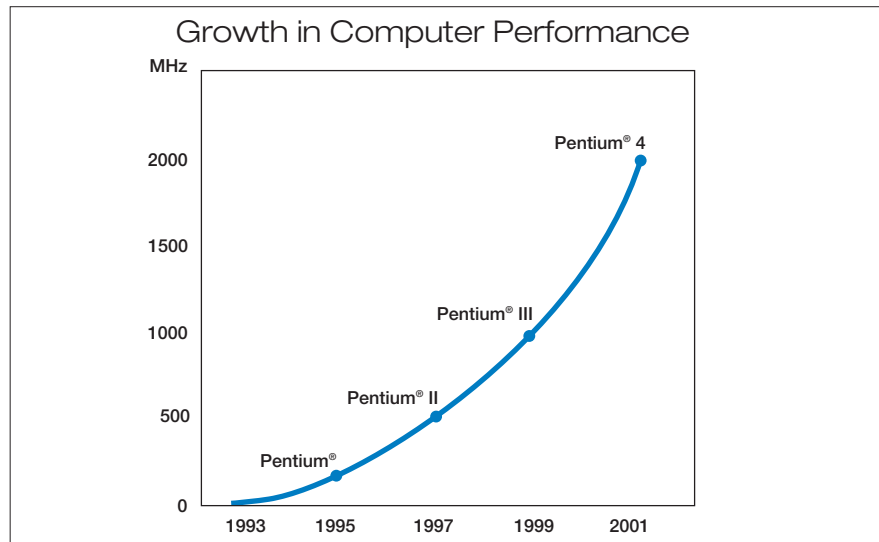


Figure 3 - Growth in Computer Performance

Desktop PCs not only need to compute today, but also communicate – via e-mail, instant messaging, Internet telephone and more. E-mail, often involving large attachments, is the most widely used application on the Internet. Attachment file sizes have been growing rapidly in the last few years, putting increased strain on the desktop and the entire network. Now instant visual messaging is integrated into Microsoft's new Windows\* XP operating system, and Network World predicts this capability will be an important driver of bandwidth increases (Network World Fusion, 2001).

Powerful processors and high-speed connections are needed to ensure the performance of these and other applications. The relationship between processors and applications is clear. Recent third-party tests by CSA Research (Figure 4) show that GbE at the desktop can significantly boost application performance. Testing a Gigabit over copper solution, CSA was able to measure up to 47% performance gains over traditional 10/100Mbps deployment.

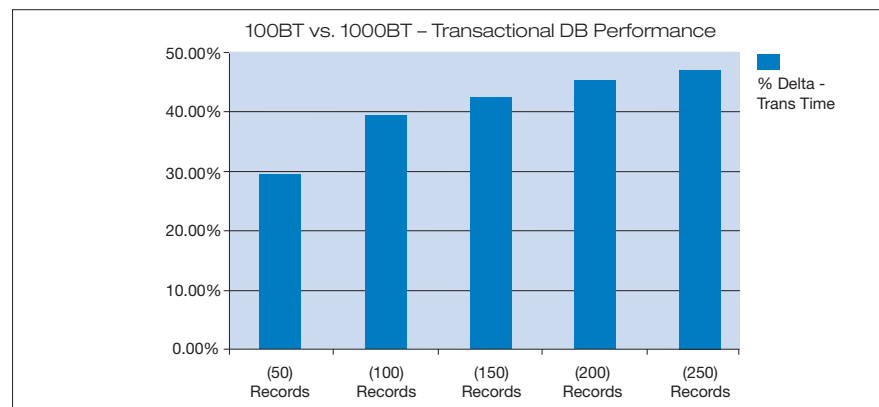


Figure 4 - Mainstream applications such as client/server database tasks (above) and messaging workloads were tested while running Microsoft SQL Server\* and Exchange Server\*.

Historically, specialized application users such as R&D or engineering departments have been the first to adopt high-speed connectivity. As bandwidth requirements increase for mainstream applications, high-speed connections become more widely deployed. Today, adoption of Gigabit connectivity has moved past early adopters and into mainstream adoption.

## Gigabit to the Desktop: Now Is the Time

To get full value from high-performance PCs running Intel® Pentium® 4 Processors, companies should be specifying Gigabit connectivity today.

From e-Commerce and Customer Relationship Management (CRM) to entertainment, businesses are finding they need Gigabit desktop connections to:

- Enable emerging desktop-centric technologies such as streaming video, MP3 audio and digital photography
- Support specialized applications such as computer aided design (CAD), 3D modeling or high-resolution imaging
- Attract and retain new business with more effective e-Communications to customers and suppliers
- Create professional-quality content and customer communications more quickly
- Perform real-time file transfers

At the same time, the cost differences between 10/100Mbps connectivity and 10/100/1000Mbps connectivity have now narrowed significantly. According to International Data Corporation, rapidly declining price points and the advent of Gigabit over copper are adding fuel to the migration from 10/100Mbps to Gigabit networks (IDC, 2001).

These marketplace conditions give network managers an ideal opportunity for desktop future-proofing. Along with GbE adapter cards and LOM, related equipment has also become more affordable. For example, the cost of a Gigabit switch per-port has dropped significantly over the last twelve months.

The deployment of Gigabit connections to the desktop not only benefits end users, but also IT organizations. These benefits can be immediate.

## IT Managers

Benefits to the IT manager include significant time savings for the myriad of tasks that must be performed every day – tasks ranging from virus protection patches to backups to operating system upgrades. Gigabit connections make it much easier and faster to push software changes to client PCs. Many other tasks important to IT, such as real-time virus checking, security encryption and e-mail synchronization, take place in the background in today's desktop environment. This new desktop paradigm can increase uptime and boost productivity, all the while keeping a large portion of network bandwidth available for user network traffic demands.

## Users on the Network

Users on the network gain the ability to download seamlessly without waiting, greatly increasing the amount of work they can perform in today's demanding desktop environment. As Forrester Research puts it, "When PowerPoint\* attachments take more than 8 seconds to detach from an e-mail message, users lose productivity" (Forrester, 2000). Conversely, when they are able to take full advantage of high-bandwidth applications, productivity increases dramatically.

## Cabling Considerations

Approximately 90% of organizations will be able to run Gigabit Ethernet over the same Cat-5 copper wiring that is presently installed in most buildings. According to Sage Research, 87% of companies are running their networks on Cat-5 cable (Sage Research, 2000), and it is estimated that 90% of these existing installations already meet the requirements for Gigabit throughput (Gigabit Ethernet Alliance, 2000). Installations that do not support GbE would also not support Fast Ethernet.

Legacy Cat-5 cable destined for 1000BASE-T use should be tested for far-end crosstalk and return loss, and corrected if necessary. If the cabling link doesn't pass, ANSTI/TIA/EIA industry-standard TSB-95 (1998)

defines five relatively simple options for correcting performance. For new cable installations, network designers might want to consider the enhanced Cat-5 cable (Cat 5e) to gain extra signal margin. However, this is not a requirement for Gigabit throughput.

Network managers deploying Gigabit Ethernet have a choice of copper or fiber to match different situations. For example, fiber is typically reserved for situations that require cabling distances greater than the 100-meter copper limit – such as between buildings. Copper is most widely deployed for horizontal applications in walls and ceilings. Both copper and fiber are used in vertical risers between floors throughout office buildings.

## Phased Gigabit Migration Strategy

For many organizations, the most cost-effective way to go to Gigabit speed is by migrating in several phases.

- Specify 10/100/100Mbps network connections on all new server, workstation and desktop purchases to future-proof your network
- Implement GbE network adapters and switches to high-traffic servers; team multiple GbE adapters for multi-Gigabit connections
- Deploy GbE switches in the backbone to aggregate Fast Ethernet switches
- Upgrade wiring closet switches to provide GbE connectivity to work-group servers and high-need users
- Retrofit desktops and workstations of power users/segments with GbE network adapters, as needed

## Deployment Scenarios

The following examples show how Gigabit Ethernet can be deployed in a variety of situations using Intel® connections on server and desktop platforms.

### Department or Small Business – New

100% new Gigabit deployment for department or small business (Figure 5).

#### Profile

- 0-200 employees
- 1 or 2 departmental servers
- Frequently send, print and download large files
- Using bandwidth-intensive software and applications such as graphic design programs, CAD/CAM, medical imaging, database management
- Cat-5 cabling installed

#### Gigabit Deployment Strategy

- Take advantage of low-cost Gigabit solutions for entire department/business
- Deploy new servers with redundant Gigabit connections
- Specify PCs with Gigabit-ready 10/100/1000Mbps adapters or LOM

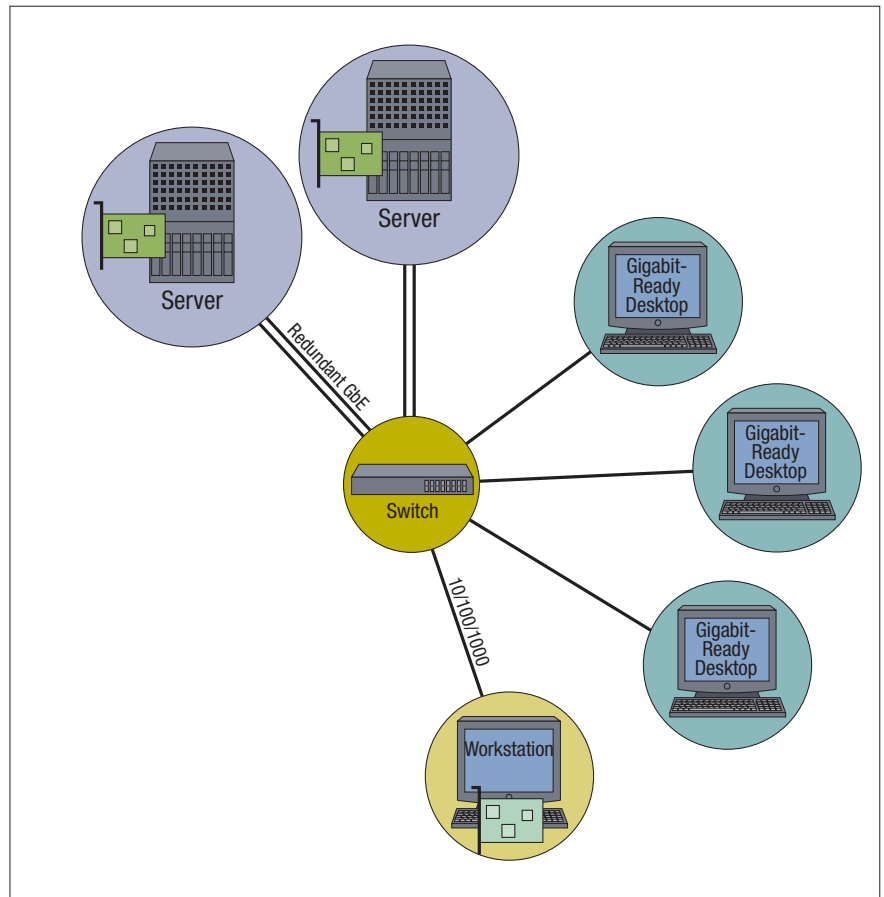


Figure 5 - 100% new Gigabit deployment for department or small business

#### Benefits

- Best ROI for new hardware today
- Prepare for future applications and user demands
- Manufacturer-installed Gigabit adapters in workstations and servers minimize maintenance
- Utilize existing Cat-5 infrastructure

#### Solutions

- Gigabit copper-enabled servers
- Intel® PRO/1000 MT Server Adapters with teaming software
- Workstations upgraded with Intel® PRO/1000 MT Desktop Adapters
- Gigabit-enabled client PC
- Gigabit switches



## Department or Small Business – Upgrade

Gigabit upgrade for department or small business (Figure 6).

### Profile

- 0-200 employees
- 1 or 2 departmental servers
- Bandwidth-intensive users requiring 24x7 uptime
- Cat-5 cabling installed
- Existing 10/100Mbps PCs and servers

### Gigabit Deployment Strategy

- Deploy Gigabit switches
- Upgrade departmental servers with GbE server adapters
- Upgrade PCs with GbE desktop adapters for bandwidth-intensive users and applications
- Spec in Gigabit adapter upgrade for future PC and workstation purchases

### Benefits

- Maximize existing hardware infrastructure
- Alleviate server bottlenecks
- Provide redundant links to servers
- Help ensure high-bandwidth availability for key systems

### Solutions

- Upgrade servers with at least two Intel® PRO/1000 MT Server Adapters
- Upgrade power-user PCs with Intel® PRO/1000 MT Desktop Adapters
- Gigabit switches

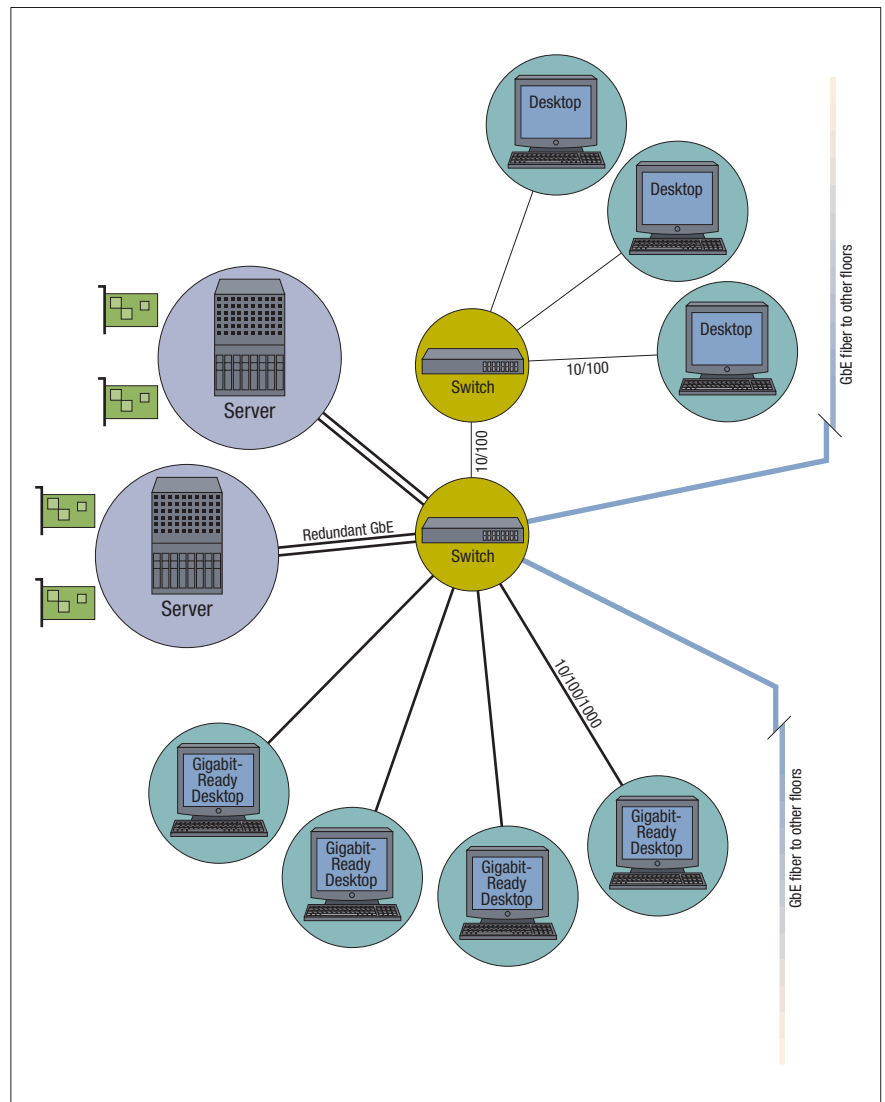


Figure 6 - Gigabit upgrade for department or small business

### Single-Building or Mid-Size Business

100% new Gigabit installation for one building or mid-size business (Figure 7).

**Profile**

- 200-3500 employees in one building
- Server farm/HPC Cluster
- Departmental servers on each floor
- Fiber backbone and Cat-5 throughout building

**Gigabit Deployment Strategy**

- Take advantage of Gigabit solutions for entire building or business
- Deploy new server blades with redundant Gigabit connections
- Specify PCs with Gigabit-ready 10/100/1000Mbps adapters

**Benefits**

- Best ROI for new hardware today
- Prepare for future applications and user demands
- Manufacturer-installed GbE adapters in workstations and servers minimize maintenance
- Extend product lifecycle

**Solutions**

- Gigabit-enabled, rack-mounted, high-density servers
- Additional Intel® PRO/1000 MT Server Adapters with teaming software
- Workstations upgraded with Intel® PRO/1000 MT Desktop Adapters
- Gigabit-enabled PCs with built-in GbE LOM technology from Intel
- Gigabit switches

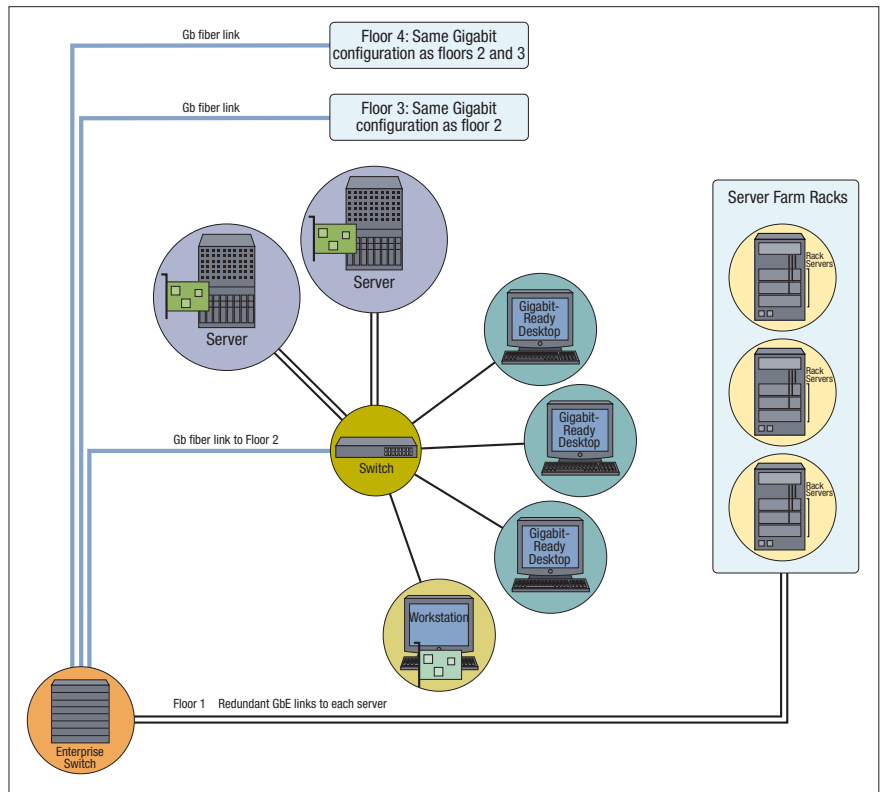


Figure 7 - 100% new Gigabit installation for one building or mid-size business

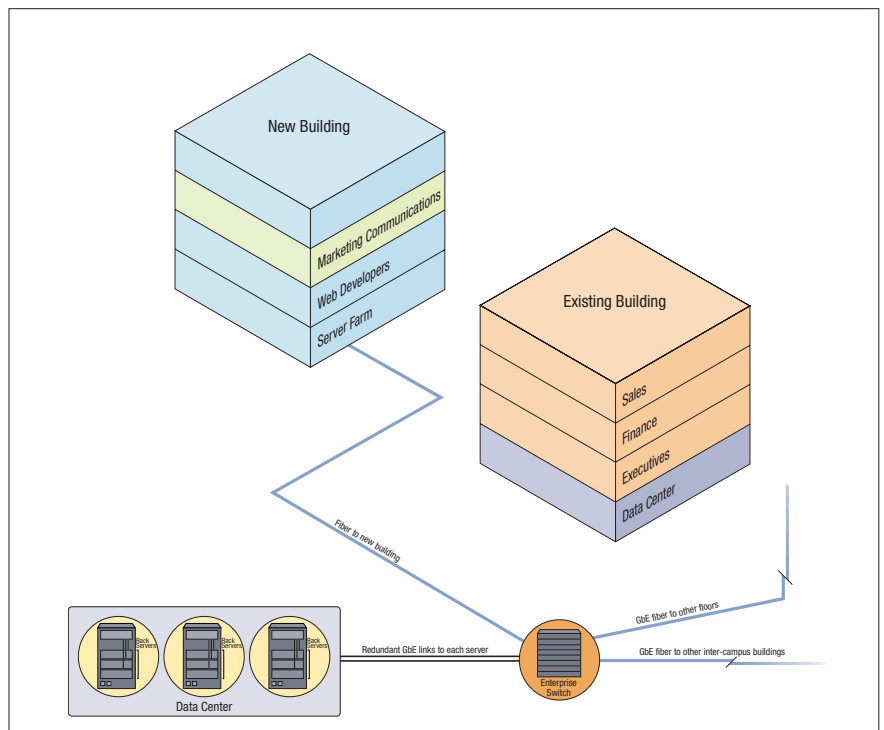


Figure 8 - Gigabit deployment for multi-building campus

## Multi-Building Campus

Gigabit deployment for multi-building campus (Figure 8).

### Profile

- 3500+ employees in multiple work sites
- Data center
- Supporting enterprise servers in multiple buildings
- Connecting floors and buildings via fiber cabling

### Gigabit Deployment Strategy

- Deploy GbE enterprise switches throughout campus
- Upgrade existing 10/100Mbps servers to copper Gigabit in data center
- Start deploying Gigabit switches on floors
- Configure all new servers with Gigabit connections

### Benefits

- Alleviate server bottlenecks while maximizing uptime
- Provide redundant links for critical data center servers

### Solutions

- Gigabit-enabled servers
- Upgrade servers with at least two Intel® PRO/1000 MT or F Server Adapters
- Gigabit switches

## Conclusion

Deployment of bandwidth-hungry applications and more powerful processors is likely to continue for the foreseeable future, requiring faster network connections. Network managers should now be specifying Gigabit connections for all new desktop PCs, especially those equipped with Intel® Pentium® 4 Processors.

Future-proofing new desktops with 10/100/1000Mbps copper connections is the most economical way to prepare for rapid increases in bandwidth requirements. Organizations want to avoid being “blind-sided” by the new wave of applications. Network managers should also think through the network environment to identify power users/segments, and retrofit them with Gigabit connections without waiting for the normal cycle of PC replacement.

For anyone who depends on the fast, efficient flow of information, Intel and its leadership in advanced networking technology to provide solutions that take Gigabit performance from the backbone to the server and to the desktop. Intel® PRO Network Connections on high-performance platforms provide ideal solutions for new GbE deployments.

## For More Information

For product information and case studies about Intel’s Gigabit solutions, please see: <http://www.intel.com/network/connectivity>

For more about Gigabit Ethernet standards, visit: <http://Standards.ieee.org/catalog> and <http://grouper.ieee.org/groups/802/3>

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