

# Combining Gigabit Ethernet and Hyper-Threading Technology in the Desktop for Improved Office Productivity

*Test report prepared under contract from Intel Corporation*

## Executive summary

Intel commissioned VeriTest to examine the performance impact of combining Hyper-Threading Technology found in the Intel® Pentium® 4 processor with Intel® PRO Gigabit Ethernet connections in networked desktop computers under a processor and network intensive office workload. Additionally, we examined the impact Gigabit Ethernet clients have on server resources when compared to Fast Ethernet clients.

The digital office is requiring more resources for network functions like email and file transfers, software and virus definition updates, document collaboration, database queries, and data synchronization, in conjunction with local desktop applications. Intel's desktop Gigabit Ethernet solutions and Hyper-Threading Technology provide a high performance desktop that offers the improvements to office productivity IT managers and end users are looking for in their next PC refresh deployment.

Hyper-Threading Technology in the Intel® Pentium® 4 processor allows the operating system to execute two application threads in parallel, giving nearly equal time to two separate tasks. With networking being the most common background task found in the office today, we set out to see if Hyper-Threading Technology enables Gigabit network performance even under the load of a processor intensive office application.

For our timed multitask scenario, we downloaded files from a network share while converting a PowerPoint presentation to a portable document format (PDF). We combined the Gigabit Ethernet performance of the Intel® PRO/1000 MT Desktop Adapter (1 Gbps) and the Intel® 2.8GHz Pentium® 4 processor with Hyper-Threading Technology and compared it against Fast Ethernet (100 Mbps) in the same desktop. Additionally, we compared similarly outfitted desktops without Hyper-Threading Technology using both Fast Ethernet and Gigabit Ethernet connections. The results of this test scenario showed that the desktop combining Hyper-Threading Technology and the Intel® PRO/1000 MT Desktop Adapter resulted in nearly a 5x performance improvement over our baseline desktop outfitted with a Pentium® III 500 MHz processor with Fast Ethernet.

In our WebBench test, we examined the impact to server resources associated with Gigabit Ethernet desktops versus Fast Ethernet desktops. To insure server efficiency and provide end users a high quality of service, most servers are tuned to support a specific number of maximum active connections. A server that has reached this threshold will handle new requests by either sending an error or "Try Back Later" message

## Key findings

- ❑ Combining the Pentium® 4 processor with Hyper-Threading Technology and the Intel® PRO/1000 MT Desktop Adapter resulted in a 4.9x performance improvement over our Y2K generation desktop.
- ❑ In our WebBench tests, the server showed dramatically fewer active connections as a result of having Gigabit Ethernet clients as compared to Fast Ethernet clients. Because the Gigabit Ethernet clients finished transfers sooner, server resources were made available for other tasks sooner.

to the requestor or redirecting the request to another server. The WebBench test results showed an average of only 18 active connections per second, even though it was handling an average of 1452 connections per second using Gigabit Ethernet desktops. Comparatively, Fast Ethernet desktops resulted in an average of 133 active connections per second on the server, even though the server was handling an average of 569 connections per second. The WebBench test results concluded that servers connected to Gigabit Ethernet desktops had resources for other tasks much sooner because connections closed much more quickly using Gigabit Ethernet desktops.

Based on the tests we conducted in this report, combined with our own everyday work-experience, desktop Gigabit has found its place in the office PC. Today's office user is multitasking with multiple network applications, making Gigabit Ethernet an obvious component in next generation office desktops, like Fast Ethernet was the obvious choice when IT managers rolled out the Pentium® III processor desktops.

### ***Test 1: Networking Multitasking Scenario***

Most office users today have several applications open at a time and continuous networking is happening in the background. The purpose of this test was to determine the impact of processor intensive tasks on networking performance in a multitasking scenario. We used Adobe Distiller 5.0 for the processor intensive task and downloaded files from a server for the network intensive task.

We first began converting a 50 slide (8.42MB) PowerPoint\* presentation to a portable document format (PDF) using Adobe Distiller\* 5.0. Within a second of starting the processor intensive Adobe conversion, we used Windows\* Explorer to download files totaling 1.46GB from a shared volume on the server to the local hard drive in the desktop.

The test required using two stopwatches, each measuring the length of time to complete each of the two processes described above. Each test was completed three times for consistency and the median of the three times was reported. Each test ran a minimum of one minute to reduce the impact of human reflex error at the stop of each test.

We used the following desktops for the multitasking test:

- Client 1: Pentium® 4 processor- 2.8 GHz, 800 MHz front side bus, Hyper-Threading Technology, 512 MB RAM, 865G chipset, ST340016A 37.2GB hard drive, Intel SDG Graphics Controller, Windows XP\* Pro (Service Pack 1), Office XP\* Pro (Service Packs 1 and 2)
- Client 2: Pentium® 4 processor - 2.8 GHz, 533 MHz front side bus, 512 MB RAM, 865G chipset, ST340016A 37.2GB hard drive, Intel SDG Graphics Controller, Windows XP\* Pro (Service Pack 1), Office XP\* Pro (Service Packs 1 and 2)
- Client 3: Pentium® 4 processor - 2.0 GHz, 400 MHz front side bus, 512 MB RAM, 845G chipset, Intel 82845G/GL Graphics Controller, Samsung SP4002H 37.3GB hard drive, Windows XP\* Pro (Service Pack 1), Office XP\* Pro (Service Packs 1 and 2)
- Client 4: Pentium® III processor - 500 MHz, 100 MHz front side bus, 512 MB RAM, 815 chipset, 3D Rage Pro AGP 2X, IBM IC35L040AVVN07-0 40GB hard drive, Windows XP\* Pro (Service Pack 1), Office XP Pro (Service Packs 1 and 2)
- Server: Intel® 2.20 GHz Xeon™ DP, 1 GB RAM, Windows\* 2000 Advanced Server\*, Service Pack 3
- Switch: Intel® NetStructure™ 480T Gigabit Routing Switch (default settings)

### ***Results of Test 1: Networking Multitasking Scenario***

What we found in our tests is that multitasking can take a toll on desktop network performance. While Intel's networking teams have made tremendous steps towards offloading the processor and reducing latency with Gigabit Ethernet, networking has continued to demand more. Processing network packets may not consume a large portion of today's processor's resources, but the processor must still handle each packet, one at a time. With processors over 2 GHz, there certainly is enough power to drive Gigabit Ethernet performance in the desktop, processing thousands of packets per second. However, introduce a CPU intensive task and networking can become painfully slow again. If the network task has to wait a second while the processor is working on a foreground task, those thousands of packets have to wait for their turn.

However, Intel has found a solution to network application latency. In our tests, Hyper-Threading Technology removed the networking bottleneck caused by multitasking through dedicating a virtual processor to each task. This allowed the network task to have instant access to the processor, resulting in Gigabit Ethernet network performance even while converting the presentation to PDF format.

Our baseline is a year 2000 generation desktop with a Pentium® III processor at 500 MHz and yesterday's network connection at 100 Mbps. We added the time to complete the network task to the time to complete the processor intensive task and divided by two to create the average time to complete both tasks, which is shown to the right of each bar in Figure 1 below. The performance improvement over the baseline is represented by the value shown in bold at the top of each bar.

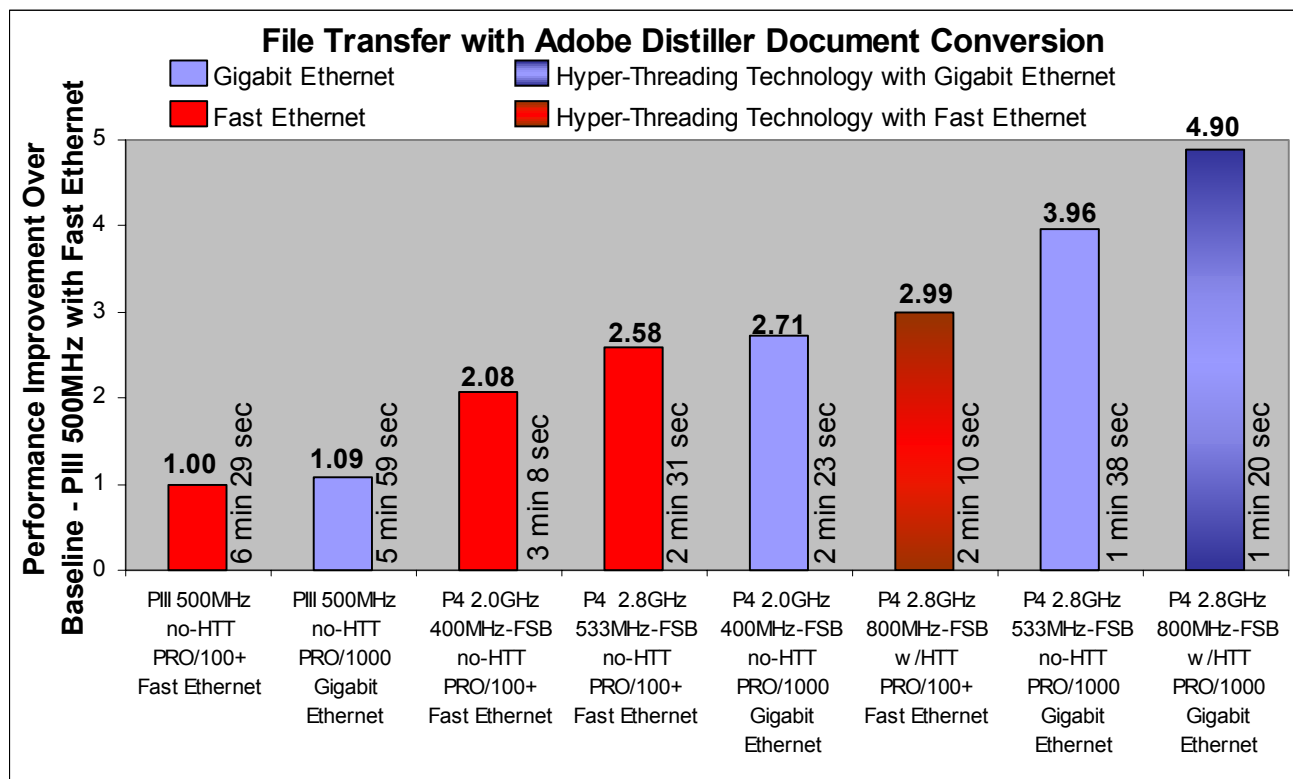


Figure 1: File Transfer with Adobe Distiller Document Conversion

As shown above in Figure 1, adding Gigabit Ethernet to each desktop resulted in overall performance improvements when compared to the same desktop with Fast Ethernet. On the 500 MHz Pentium® III processor desktop, the performance improvement associated with Gigabit Ethernet was 9%. The 2.0 GHz Pentium® 4 processor desktop realized a 30% improvement using Gigabit Ethernet instead of Fast Ethernet. On the 2.8 GHz Pentium® 4 processor desktop without Hyper-Threading Technology, Gigabit Ethernet provided a 53% performance improvement over Fast Ethernet. And finally, when Gigabit Ethernet was compared to Fast Ethernet in our 2.8 GHz Pentium® 4 processor with Hyper-Threading Technology, the performance improvement was 64%.

While adding processing power and networking power helped get the multitasking job done sooner, it was the combined power of our 2.8 GHz Pentium® 4 processor with Hyper-Threading Technology and Gigabit Ethernet that gave us the nearly 5x performance increase over the baseline.

## Test 2: Impact to Server Resources – Fast Ethernet versus Gigabit Ethernet Clients

The WebBench test was performed to determine the amount of resources used on our Windows 2000\* Advanced Server when using a Gigabit network connection versus a Fast Ethernet connection in the desktops. To generate the HTTP activity, we used Ziff Davis Media's WebBench, Version 4.1.

We installed the WebBench controller on an 866 MHz Pentium® III processor system and the WebBench clients on each of the three client systems. We placed the workload from the WebBench 4.1 CD on the shared directory of the Windows 2000 Advanced Server. Figure 3 below shows the script details as modified from the default:

File name	File Size	Percentage Requested
223.gif	223 bytes	1
735.gif	735 bytes	1
1522.gif	1.5 KB	1
2895.gif	2.9 KB	6
6040.htm	6 KB	10
11426.htm	11.4 KB	10
22132.htm	22.1 KB	10
Fractional class		60
41518.htm	41.5 KB	
87360.htm	87.4 KB	
529k.ex	529 KB	
(404 errors)	N/A	1

Figure 2: Modified WebBench script details

We used the same HTTP web script in both Fast Ethernet and Gigabit Ethernet test cases. We monitored and captured log records of each test run using Windows\* Performance Monitor and averaged the results to calculate the final results. The primary field of concern was the Web Service Object's Current Connections counter. The comparisons will show the impact to the average number of open connections on the web server using Gigabit Ethernet clients compared to Fast Ethernet clients.

We used the following systems for the WebBench test:

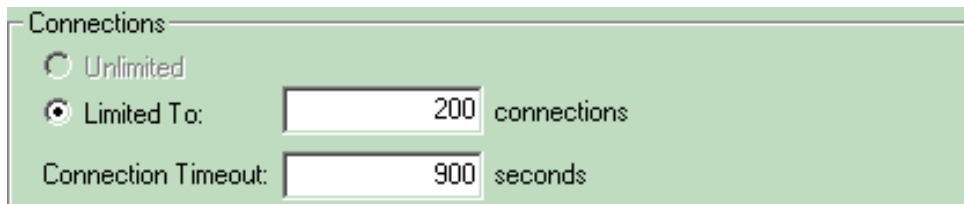
- Server: Intel® 2.20 GHz Xeon™ DP, 1 GB RAM, Windows\* 2000 Advanced Server\*, Service Pack 3
- Client 1: Intel® 2.8 GHz Pentium® 4 processor desktop, 512 MB RAM, Windows XP Pro, SP1
- Client 2: Intel® 1.7 GHz Pentium® 4 processor desktop, 512 MB of RAM, Windows XP Pro, SP1
- Client 3: Intel® 733 MHz Pentium® III processor desktop, 512 MB of RAM, Windows XP Pro, SP1
- Switch: Intel® NetStructure™ 480T Gigabit Routing Switch (default settings)
- WebBench controller: 866 MHz Pentium® III processor, 1 GB RAM, Windows\* 2000 Server, SP2

### WebBench Active Connections Test Results:

Consider what happens in a typical client to server request. First, the client issues a request from the server. The server retrieves the data from a local or network database or storage device and places the data in server memory. Next, the server begins delivering the data to the client. Until the request is fully transferred back to the client, the data must continue to occupy memory space in the server. If the server memory resources become saturated, the server will not be able to accept new requests. When the transaction is complete, the server can close the connection and purge the data from server memory to fulfill other requests. With Fast Ethernet clients, these connections are held open much longer than Gigabit Ethernet clients, tying up server resources longer.

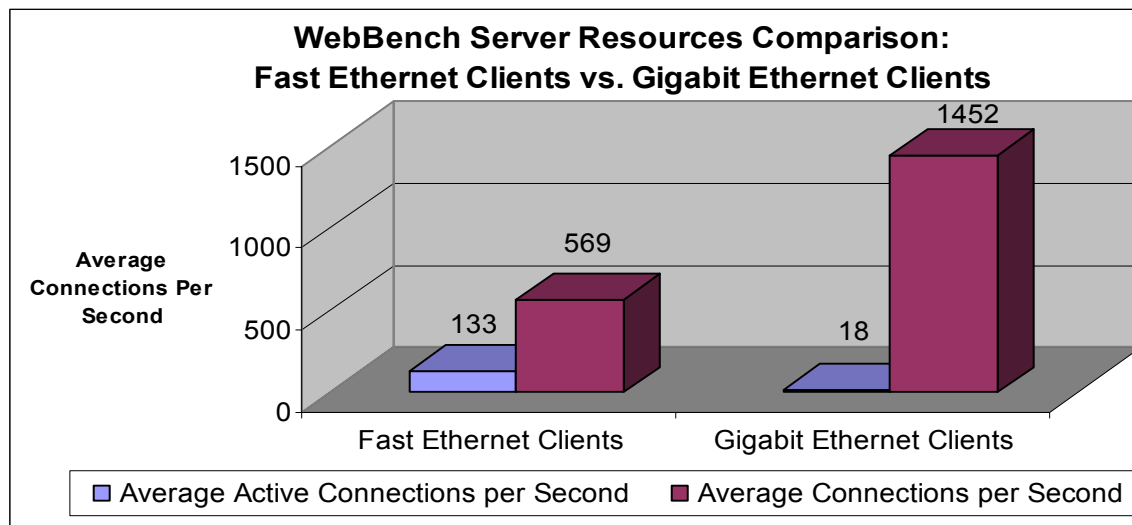
Depending on the service hosted by the server, there are varying limits of how many active connections a server can host. "Server Busy" error messages sent to the client are often the result of the server reaching its maximum number of active connections. Limiting the number of connections a server will allow open at a time helps provide a quality of service to the connections already begun, rather than dropping those connections to allow resources for new requests. Because of the quicker transfer rate in each Gigabit

Ethernet client request when compared to Fast Ethernet client requests, the client access time is decreased significantly, closing connections sooner, leaving more resources on the server available for other requests sooner.



**Figure 3: Example of server connections limit settings from Internet Information Services properties**

Figure 4 below provides the detailed results of the server resources test while using Ziff Davis Media's Web Bench. The blue bars represent the average number of active connections per second over the course of the test (smaller is better) and the dark red bars represent the average number of connections per second the web server delivered to the test clients (larger is better).



**Figure 4: Active and average connections per second comparisons between Fast Ethernet clients and Gigabit Ethernet client generated WebBench workloads**

Even though the server was under a load of 1452 average connections per second with Gigabit Ethernet clients requesting web pages, there were only 18 average active connections per second, as reported by Performance Monitor. Comparatively, the Fast Ethernet clients generated only 569 average connections per second, but there were an average of 133 active connections per second shown on the server.

With migrations to Gigabit Ethernet well under way as the Y2K generation desktops are refreshed, IT managers will benefit from better-utilized servers, getting mission critical client tasks like virus patch distributions and hard drive backups done sooner.

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