Faster Simpler NETWORKS

Solving Server Bottlenecks with Intel® Server Adapters

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Contents

Overview

As the sophistication and importance of network-based applications continues to grow, pressures are mounting on network servers. The Internet, corporate intranets, databases, video conferencing and other high-bandwidth applications are placing heavier demands on server performance and network bandwidth. At the same time, more and more users are dependent on these applications to do their work. When a key server fails or slows down, it can hamper productivity for a great many users. In many cases, sales and other customer interactions suffer as well.

This technical brief discusses how advanced server adapter technologies address two key issues of server performance – server bottlenecks and downtime due to link failure (see Table 1). These advanced technologies contribute toward a simple and cost-effective server solution, providing scalable bandwidth and automatic fail-over connections for a faster and more dependable network link.

"The cost of server downtime is staggering." Less than 1% downtime can cost more than $75,000 per year in lost revenues, user salaries and server outage costs for a typical small business. This translates roughly into a loss of $4000 per hour of downtime.*

**Source: Network Server Downtime Cost Analysis, Strategic Research, 1998 (www.networkbuyersguide.com – Online Evaluation Applications). Calculations based on the servers of a 30-employee, $10M business going down six times a year, three hours at a time.*

Problems	Causes	Advanced Feature Solution:
Server bottlenecks	■ Bandwidth-intensive applications (Web, video conferencing, intranet, etc.) ■ More powerful PC network connections (faster bus and technologies – 100Mbps adapters) ■ More high-performance clients attached to the network	Scalable server bandwidth, using: ■ Adaptive Load Balancing (ALB) ■ Link Aggregation ■ Fast EtherChannel* (FEC) ■ Gigabit EtherChannel* (GEC)
Server downtime (due to a failed network connection)	■ Broken/loose cables ■ Hub or switch port failures ■ Adapter hardware breakdown ■ PCI slot malfunction	Automatic redundant backup links and online serviceability, using: ■ Adapter Fault Tolerance (AFT) – Mixed Adapter Teaming – Preferred Primary Technology ■ PCI HotPlug*

Table 1: *Server connectivity problems and their solutions using advanced server adapter features.*

The Problem: Server Bottlenecks

As sophisticated applications and more powerful desktop PCs drive network traffic to new levels, a single 100Mbps channel isn't enough bandwidth for critical server connections – especially as the number of desktops connected at 100Mbps increases.

In the past, server bottlenecks were typically solved by installing an additional Network Interface Card (NIC) in the server, and segmenting the network into two subnetworks (Figure 1). This reduced traffic volume on each network link, eliminates the bottleneck. But segmentation poses a new set of problems, including additional overhead and the need to reassign IP addresses and remap the network. Segmentation generally requires additional hardware, such as switches or routers. Balancing traffic on the two segments can also be difficult, usually requiring repeated reconfiguration. Finally, since the two adapters operate in separate network segments, they don't provide a fail-over connection in the event of a link failure.

The Solution: A Scalable Network Connection

Adaptive Load Balancing

Adaptive Load Balancing (ALB) technology offers a simpler and better way to move more data between the server and the network. ALB can increase server bandwidth up to 400Mbps, by automatically balancing data transmission across as many as four network adapters (Figure 2). Essentially, each additional adapter adds another 100Mbps link to the network. Since the distribution of traffic among the adapters is automatic, there's no need to segment or reconfigure the network. The existing IP address is shared by all adapters, and the traffic is always balanced between them. ALB can also be used over Gigabit Ethernet links, providing throughputs up to 4Gbps.

ALB is implemented by installing a team of server adapters in the server. The adapters can be quickly configured to run ALB using the Intel® PROSet utility. No client configuration is required, and clients don't have to be routed to communicate with each other. Moreover, the multiple adapters provide automatic emergency backup links to

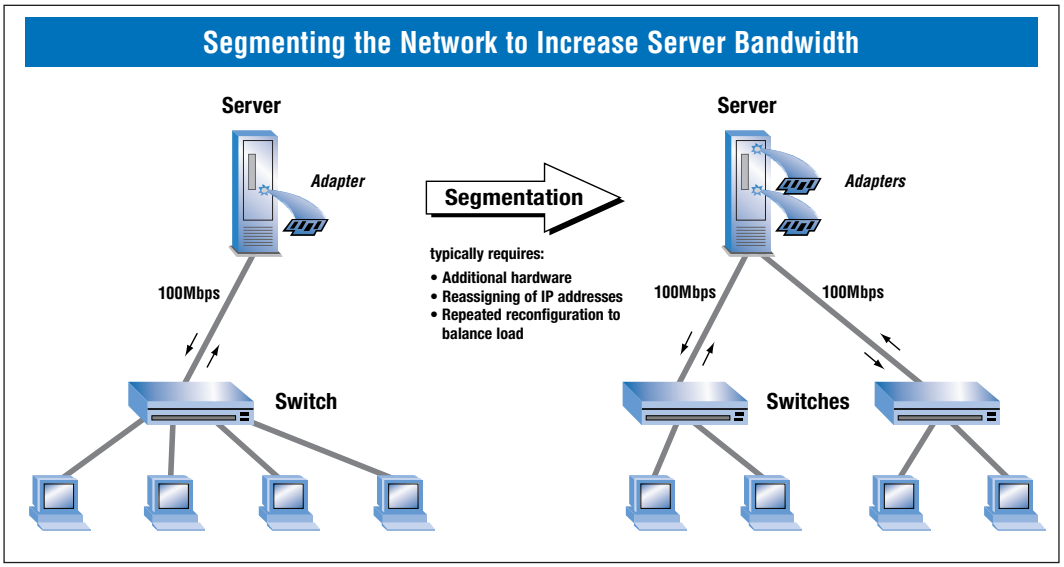
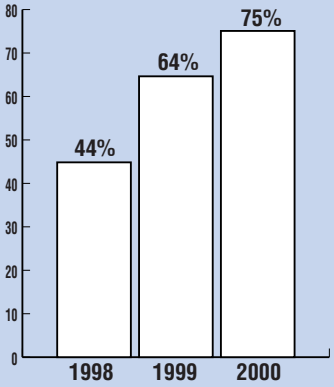


Figure 1: *Segmentation increases server bandwidth, but typically requires additional hardware and management overhead – including repeated reconfiguration to balance the traffic load.*

10/100Mbps Desktops Running at 100Mbps



Source: Infonetics 1999

Server Bandwidth – A Growing Need

A 1999 study by Infonetics reveals that more than half of all 10/100Mbps desktops are already running at 100Mbps, and the percentage is rapidly increasing. That same study sited server bottlenecks as the number one reason that businesses are migrating to higher performance networking technologies. Clearly, there's a need for significant increases in server bandwidth to match the growing power and demands of networked clients.

Fortunately, it's possible to significantly increase server bandwidth without a major network overhaul. Load balancing across multiple Fast Ethernet or Gigabit Ethernet server adapters, using the technologies discussed in this technical brief, provides a simple and scalable solution. And since these load-balancing technologies automatically support redundant network links, they increase server availability as well as performance.

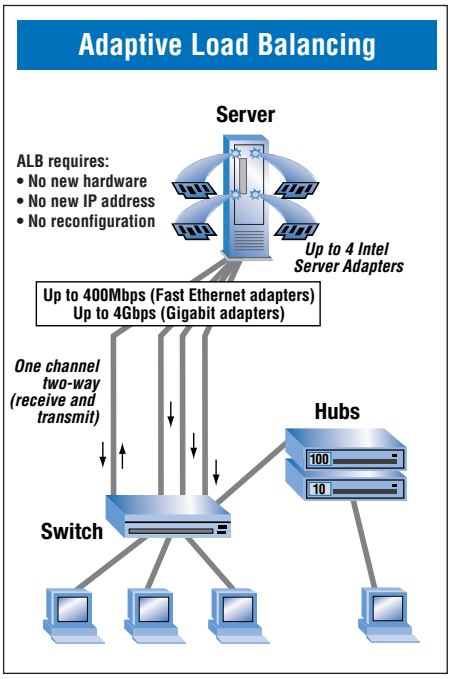


Figure 2: *With Adaptive Load Balancing, all traffic traveling from the server is automatically balanced between as many as four network adapters. This assures fast throughput with no need to restructure or reconfigure the network.*

the network. If one server link goes down, due to a broken cable, a bad switch port, or a failed adapter, the other adapter(s) automatically accepts the additional load (see Adapter Fault Tolerance). There's no interruption in server operation, and a network alert is generated to inform IT staff of the problem.

Two, three or four Intel® Server Adapters can be configured to work together as an Adaptive Load Balancing team. All of the adapters in a team must be connected to a switch. They can be connected to a single switch, or to two or more switches, as long as all the switches are on the same network segment (they can't be separated by a router).

Once ALB is configured, all outgoing server traffic will be balanced across the adapter team. Incoming traffic is carried by a single adapter. In most environments, this is a highly effective solution, since server traffic is primarily outbound – from the server to the clients.

Link Aggregation/Fast EtherChannel/ Gigabit EtherChannel* Technology*

Link Aggregation and Fast EtherChannel* (FEC) are other technologies that can be used to increase server bandwidth. Like Adaptive Load Balancing, they automatically balance server traffic among as many as four network adapters and require no network reconfiguration. Unlike ALB, they enable full-duplex transmission on all adapters as long as the switch supports this advanced feature. Both incoming and outgoing server traffic are balanced, and can be scaled in increments of 200Mbps. Total throughputs of up to 800Mbps are possible in Fast Ethernet environments (Figure 3). Link Aggregation can also be used to aggregate traffic across multiple Gigabit server adapters, for throughputs of up

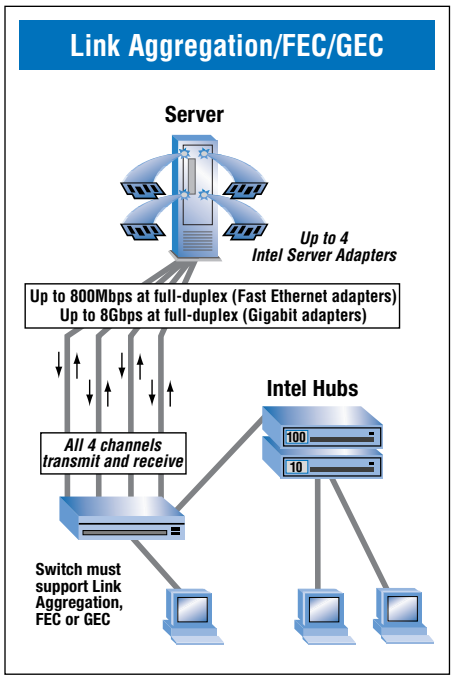


Figure 3: *With Link Aggregation, Fast EtherChannel* or Gigabit EtherChannel* network traffic traveling to the server as well as from the server is automatically balanced between as many as four server adapters.*

Advanced Server Adapter Technologies

These technologies provide scalable server bandwidth through load-balancing, as well as automatic redundant connections for increased server availability. They are not generally supported in desktop adapters.

Adapter Fault Tolerance (AFT) – Developed by Intel, AFT monitors the server connection to the network and automatically switches traffic to a redundant link in the event of a failure.

Mixed Adapter Teaming – Enables one kind of server adapter to be used as a redundant backup link for a different kind of server adapter.

Mixed Speed Teaming – Enables a 100Mbps server adapter to be used as a backup link for a Gigabit server adapter.

PCI HotPlug* – Developed by Compaq, PCI HotPlug is now an industry standard that enables a failed network adapter to be replaced without taking the server offline.

Adaptive Load Balancing (ALB) – Developed by Intel, ALB supports scalable bandwidth up to 400Mbps, or 4Gbps in a Gigabit Ethernet environment.

Link Aggregation – Link Aggregation supports scalable bandwidth up to 800Mbps full-duplex; or up to 8Gbps in a Gigabit Ethernet environment. Link Aggregation requires support in the NIC and the switch.

Fast EtherChannel* (FEC) – Developed by Cisco, FEC supports scalable bandwidth up to 800Mbps at full-duplex. Fast EtherChannel requires support in the NIC and the switch.

Gigabit EtherChannel* (GEC) – Developed by Cisco, GEC supports scalable bandwidth up to 8Gbps at full-duplex. Gigabit EtherChannel requires support in the NIC and the switch.

to 8Gbps at full-duplex. Gigabit EtherChannel* (GEC) is another emerging technology that will provide similar, full-duplex load-balancing if connected to supporting GEC switches.

Because of their ability to handle high-bandwidth, full-duplex traffic loads, Link Aggregation, FEC and GEC are ideally suited to high-performance environments running especially demanding applications such as, enterprise servers, Web servers, intranet servers and high-end graphics imaging and rendering servers. In addition to scalable server bandwidth, these technologies provide reliable fault tolerance. If one link fails, the other adapters in the team automatically accept the full traffic load, and an alert is generated to notify IT staff of the problem (see Adapter Fault Tolerance).

Whereas ALB works when the Intel Server Adapters are connected to the network via any switch, these full-duplex technologies require that the adapters be connected to switches that support whichever scalable bandwidth technology is configured in the adapter. Link Aggregation is supported by all Intel® Express 500 Series Switches and the Intel® Express Gigabit Switch, as well as by an increasing number of other vendors' switch products. Fast EtherChannel works with any FEC-enabled switch.

The Problem: Server Downtime

Almost every company that depends on networked computers has a nightmare story of server failure. As a result, a variety of mechanisms have been implemented by server manufacturers to improve the reliability of servers. However, a broken or loose network cable, a faulty switch or hub port, or a failed adapter can shut down server operation just as easily as a server malfunction.

The Solution: Resilience and Online Serviceability

Adapter Fault Tolerance – Redundant Network Links

Adapter Fault Tolerance (AFT) provides a simple, effective and fail-safe method for increasing the availability of server connections (Figure 4). With two or more server adapters installed in a server, AFT can be configured to establish an automatic backup link between the server and the network. Should the primary link fail, the secondary link kicks in within seconds, in a manner that is transparent to applications and users.

The redundant link that AFT establishes between the server and the network includes a redundant adapter, a cable, and hub or switch port connection. If there is any problem along the primary link, the secondary link immediately takes over. AFT also initiates a network alert. The server remains online so technicians can take corrective measures when appropriate – during off-business hours, for example.

AFT can be implemented in a server using only two server adapters, one as the primary connection and the second as a backup. AFT is also supported when server adapter teams are configured for Adaptive Load Balancing, Link Aggregation, Fast EtherChannel* or Gigabit EtherChannel*. In those cases, if any of the server links fail, for whatever reason, the remaining links automatically take over to share the traffic load.

Mixed Speed and Preferred Primary Teaming

Unlike most redundant link technologies, AFT supports mixed-speed teaming using any combination of Intel Server Adapters.

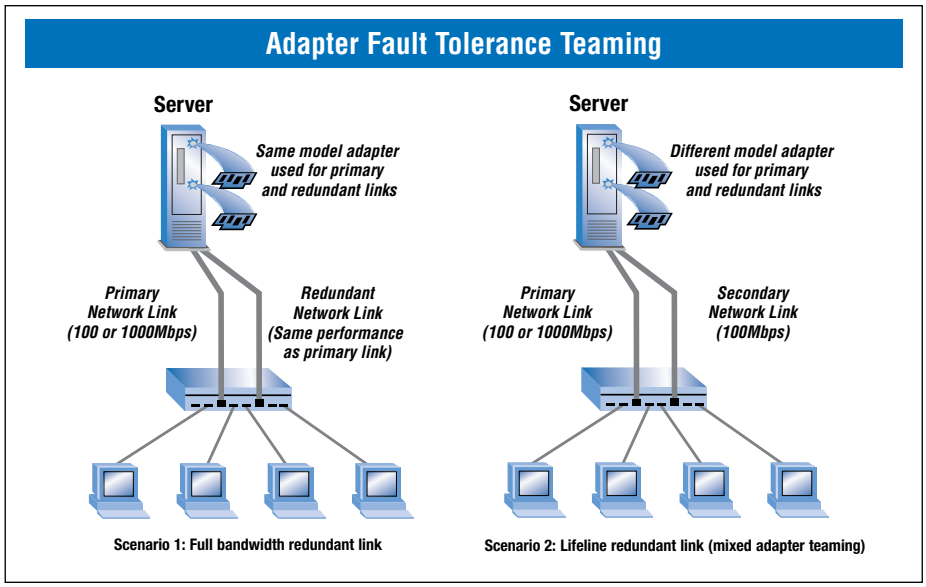


Figure 4: *Adapter Fault Tolerance and PCI HotPlug**
If the primary network link fails: ***1.*** *The failure is immediately detected and the back-up link activated.* ***2.*** *A network alert is generated to notify IT staff.* ***3.*** *The problem can be fixed with the server still online.* ***4.*** *If the failed link was the primary link, it automatically re-establishes itself as the primary link once it is fixed.*

For example, a Gigabit server adapter could be used as the primary network link. The backup link could be another Gigabit server adapter, or a Fast Ethernet server adapter. With this capability, a relatively inexpensive, 100Mbps backup link can be used to safeguard a high-speed Gigabit Ethernet connection. The inexpensive backup may not be able to support the full traffic load as effectively, but it can allow business critical applications to stay online until the higher speed link is fixed.

When configuring AFT, a preferred primary adapter can be specified. If the primary link fails, it will automatically be reinstated as the primary link once it is fixed. For example, if a Gigabit server adapter is being used for specialized, high-demand applications, a less expensive backup link can be installed using a Fast Ethernet server adapter. If the primary link fails and is then fixed, traffic will automatically revert back to the higher performance link.

PCI HotPlug – Online Serviceability*

PCI HotPlug* enables a failed adapter to be replaced without taking the server offline. The technology was developed by Compaq, but has since been established as an industry standard, supported in most new servers.

When used in conjunction with AFT, PCI HotPlug allows an adapter to be replaced without interrupting network service. If an adapter fails, AFT automatically moves server traffic onto the redundant link and generates a network alert. PCI HotPlug enables IT staff to replace the failed adapter without bringing down the server.

Configuration Considerations Using Intel® Server Adapters

A single driver provides the software agent that supports Adapter Fault Tolerance, Adaptive Load Balancing, Link Aggregation, Fast EtherChannel, Gigabit EtherChannel and PCI HotPlug. How the agent is configured in a particular environment determines which of the advanced features is enabled. However, all the scalable bandwidth technologies supported by Intel Server Adapters include built-in support for Adapter Fault Tolerance and PCI HotPlug. So, if Adaptive Load Balancing, Link Aggregation or Fast EtherChannel is configured, AFT and PCI HotPlug are automatically activated.

All the advanced server adapter features supported by Intel Server Adapters integrate seamlessly into Novell NetWare* and Microsoft Windows NT* operating system-based servers. The advanced features are management-ready and simple to use, with intuitive interfaces for quick setup and ease-of-use. Standard operating system interfaces are used for NetWare, and Windows NT uses PROSet, Intel's intuitive Windows* OS-based configuration utility.

Network alerts for failed links are operating system-based for compatibility with management applications. Specifically, NetWare alerts are generated for NetWare servers and event logs for Windows NT servers. A management application, such as Intel® LANDesk® Management Suite, can detect these alerts and trigger an appropriate action. For example, a network manager could choose to be notified of a failure via an email message, a fax or a call to his pager or cellular phone.

All Intel Fast Ethernet and Gigabit Ethernet Server Adapters can also be configured to work in servers equipped with the Intel® 82558 or Intel® 82559 Onboard LAN controller. This enables AFT, ALB, Link Aggregation or FEC to be configured using fewer PCI slots, by teaming the onboard LAN controller with add-in Intel Server Adapters.

Intel® Server Adapters – Support for Advanced Features

Intel® Server Adapter	*Application*	*AFT*	*HotPlug**	*ALB*	*Link Agg.*	*FEC**	*GEC**
PRO/1000 Gigabit Server Adapter	High-traffic backbone servers	✔	✔	✔	✔	N/A	✔
PRO/100 Intelligent Server Adapter	High-traffic web servers or file servers	✔	✔	✔	✔	✔	N/A
PRO/100+ Dual Port Server Adapter	Departmental servers with limited PCI slots	✔	✔	✔	✔	✔	N/A
PRO/100+ Server Adapter	Departmental or workgroup servers	✔	✔	✔	✔	✔	N/A

Table 2: *Intel Server Adapters – support for advanced features: AFT – Adapter Fault Tolerance; ALB – Adaptive Load Balancing; Link Agg. – Link Aggregation; FEC – Fast EtherChannel; GEC – Gigabit EtherChannel*

Reliable, Scalable and Easy-to-Configure

Scalable bandwidth technologies, along with Adapter Fault Tolerance and PCI HotPlug, make the Intel Server Adapter family an ideal solution for fast network connectivity with enhanced server availability. Table 2 shows which advanced features are supported by which Intel Server Adapters.

In practice, each business can choose to configure the adapter software to use the technologies best suited to the demands of their server environment and their existing infrastructure. Each technology builds on the preceding one, so nothing is lost as higher-bandwidth load balancing technologies are employed (Table 3).

By providing scalable bandwidth and increased availability at a crucial point in the network, Intel Server Adapters can help to revive network infrastructures that are otherwise straining under increased traffic loads. They also enable a more affordable server solution for high-demand networks. By integrating high-availability server links and load balancing into the network adapter, they eliminate the need for specialized server hardware and other expensive infrastructure components.

Advanced Feature	Connection Requirements	Benefits
Adapter Fault Tolerance with: – Mixed Speed Teaming – Preferred Primary	When connected to any hub or switch	■ High Server Availability – Transparent backup connections using any combination of Intel® Server Adapters
PCI HotPlug	When connected to any hub or switch and supported in the server	■ Online Serviceability – Adapters can be replaced with the server online
Adaptive Load Balancing	When connected to any switch	■ High Server Availability ■ Load balancing of outgoing server traffic for increased throughputs up to 400Mbps (4Gbps in Gigabit Ethernet environments)
Link Aggregation, Fast EtherChannel* (FEC), or Gigabit EtherChannel* (GEC)	When connected to a switch that supports Link Aggregation, FEC or GEC	■ High Server Availability ■ Load balancing of outgoing and incoming server traffic, for throughputs up to 800Mbps (8Gbps in Gigabit Ethernet environments)

Table 3: *By configuring the adapter for the desired advanced feature support, companies can match the needs and resources of their particular server environment.*

As the number one supplier of Fast Ethernet and Gigabit Ethernet connectivity solutions,† Intel has played a leading role in the development of advanced technologies for server connectivity. Through the effective integration of emerging technologies, Intel® Server Adapters have won 11 out of 11 industry awards,†† and are now being shipped as pre-installed components by top server manufacturers. To help drive the next phase of high-bandwidth connectivity, Intel is working with other major vendors to establish an IEEE standard for Gigabit connectivity over Category 5 copper cabling.

For more information on Intel® Server Adapters:

■ Product information and third-party reviews http://www.intel.com/network/products/server_adapters.htm

■ NOS support for advanced server adapter technologies http://www.intel.com/network/technologies/advanced_features.htm

Related Intel White Papers:

■ Layer 2 Network Prioritization http://www.intel.com/network/white_papers/priority_packet.htm

■ Building a Managed Computing Environment http://www.intel.com/network/white_papers/managed_environment.htm

† Source: Dell'Oro Group, February 1999
†† As of March 1999

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