COMPAQ

Migrating from a GIGAswitch/FDDI Backbone to a Gigabit Ethernet Environment

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V1.0
This document will continue to be updated with
Recommended Migration Configurations

Abstract:

This paper explains the following:

- The advantages of migrating from FDDI to Gigabit Ethernet.
- The method of migrating to a Gigabit Ethernet environment without interruption to the network.
- The recommended configurations in this document require that you are running V3.5 or greater firmware on the GIGAswitch/FDDI and V2.2 firmware or greater on the GIGAswitch/Router

For more information on the technologies, see the following appendices:

- Appendix A: Overview of GIGAswitch/FDDI
- Appendix B: Overview of the FDDI and Gigabit Ethernet Technologies

Notice

Executive Summary

Currently, many customers who implemented the GIGAswitch/FDDI are reaching the maximum performance capacity of their networks or understand that the FDDI technology will no longer be enhanced or cost reduced.

Compaq has developed a migration vehicle that customers can implement on their existing GIGAswitch/FDDI backbone which will lead to a 10 fold performance increase through a direct connecton to a Gigabit Ethernet network. This networking vechicle is comprised of:

- Fast Ethernet Line Card: Provides ease of migration

- GIGAswitch/Router: Increases networking speed ten-fold and manages high network traffic, through Quality of Service features.

You can add these products to your existing network, without interrupting your network service. This migration vehicle is easy to implement and, with its two-pronged approach, has built-in investment protection. It allows you to maintain the existing network and still enhance network performance by gradually adding on new equipment. No other vendor offers the same ease of migration that Compaq does.

Why Should Customers Migrate to Gigabit Ethernet?

GIGAswitch/FDDI still has many loyal customers, who implemented FDDI because of its performance, redundancy and fault tolerance. However, from an industry perspective, vendors will no longer add features or continue focusing on cost reducing FDDI technology. Compaq recommends that customers upgrade to Gigabit Ethernet to enhance their networks.
Gigabit Ethernet is a new high-performance, cost-effective technology, based on existing, stable, and widely deployed technology (Ethernet). Table 1 compares FDDI and Gigabit Ethernet technologies.

Table 1: Comparison of FDDI and Gigabit Ethernet Technologies

CY 99			
	FDDI	**Gigabit Ethernet**	**Fast Ethernet**
Performance	100 MB/second 200 MB/second full duplex (proprietary implementation)	1,000 MB/second	100 MB/second
Protocol Translation	Required	Not necessary	Not necessary
Price (per adapter)	~$700 for unshielded twisted pair (UTP) ~$1000 for Multi Mode Fiber (MMF)	~$750	~$125

The Solution: New Product Migration Vehicle

The introduction of the Fast Ethernet line card and the GIGAswitch/Router provides a migration vehicle for customers who want ease of implementation and built-in investment protection. Customers can maintain their existing network infrastructure and still enhance network performance by integrating the new equipment.

Definition: GIGAswitch/FDDI Fast Ethernet Line Card

The GIGAswitch FDDI/Fast Ethernet Line Card is a four-port module that offers Fast Ethernet connectivity through modular interfaces that support Multi Mode Fiber (MMF) or unshielded twisted pair (UTP-5) (category 5 cabling). The Fast Ethernet Line Card is a single-slot module that connects to the GIGAswitch FDDI backplane for power and console management.

Definition: GIGAswitch/Router

The GIGAswitch/Router is an enterprise switching router that features the best price and performance in the industry. This chassis-based switch combines full wire-speed performance and superior routing capacity to meet the needs of both today’s and tomorrow’s networks. Equally important, this standards-based switching router provides works seamlessly with previous generations of networking equipment to protect existing network investment.

GIGAswitch/Router’s Features Layers 2, 3, and 4 Switching

In addition to Layer 2 switching and Layer 3 wire-speed full-function routing, the GIGAswitch/Router's can switch Layer 4 application flows to extends its functionality well beyond the boundaries of traditional routers. This capability allows you to manage network traffic through extensive security, port-level accounting, and comprehensive Quality of Service (QoS), necessary for the backbone of an applications-aware network.

Powered by custom ASICs, the GIGAswitch/Router routes packets at wire speed based on conventional source-destination data and/or application-level information. These ASICs also store QoS policies and security filters, providing wire-speed performance even when all functions are enabled. This provides users with the performance and functionality needed without compromise, while extending their control to the application level. Table 2 lists some of the features of the GIGAswitch/Router:

Table 2: Features of the GIGAswitch/Router

Unique Features	8-Slot Chassis	16-Slot Chassis
Full function routing		
Wire-speed, standards-based, IP/IPX routing (Unicast & Multicast)	Yes	Yes
Industry-leading performance	16 Gbps (Non blocking)	32 Gbps (Non blocking)
High-density configurations –10/100 ports	56 Ports	120 ports
Gigabit Ethernet ports	14 ports	30 ports
HSSI WAN ports 8 slot	14 ports	30 ports
SLI WAN ports	28 ports	60 ports
Up to 250,000 Layer 3 routes	Yes	Yes
Layer 4 Application Flows	2,000,000	4,000,000
MAC Addresses	400.000	800,000
Security/access filters	20,000	20,000
Extensive QoS support		
Allocate bandwidth or assign Priority based on application	Yes	Yes
Unique WAN capabilities	Yes	Yes
Comprehensive Web-based management	Yes	Yes

GIGAswitch/Router Maximum Configuration(s)

For large networks, the GIGAswitch/Router offers table capacities that are an order of magnitude greater than any other solution available today, thus allowing it to scale seamlessly as the network evolves. With a switching fabric up to 32 Gb/s, this chassis-based switch/router can be configured with up to 120 10/100 ports, or up to 30 Gigabit Ethernet ports, depending on the number of slots. The GIGAswitch/Router provides the capacity to handle peak traffic across even the largest enterprise backbones, because of the following features:

- Support for up to 250 ,000 routes
- Support for up to 2,000,000 or 4,000,000 application flows
- Ability to handle more than 400,000 or 800,000 Layer-2 MAC addresses

Capacity for more than 4,000 VLANs, 20,000 security filters, and large per-port buffers,.

GIGAswitch/Router Redundancy Capabilities

Built on a foundation of fault tolerance and redundancy, the GIGAswitch/Router offers redundant CPUs, hot-swappable modules, power supplies, and fans, as well as the ability to add a redundant switching fabric module to the 16-slot chassis. The result is the stability and reliability users require in an enterprise-level, high-speed, network backbone.

Note: Redundancy for the GIGAswitch/Router is not the same as redundancy for the GIGAswitch/FDDI. See Appendix A: Overview of GIGAswitch/FDDI for the differences in technologies between the GIGAswitch/Router and the GIGAswitch/FDDI.

For more information about the GIGAswitch/Router product, see the following web site: http://www.networks.digital.com/dr/npg/dgsra-mn.html

Topologies: Typical Customer Configurations and Problems

The majority of GIGAswitch/FDDI systems are installed as building or campus backbone switches connecting departmental switches and servers via switched FDDI uplinks. The GIGAswitches typically have many servers, routers, concentrators and workstations connected to them using FDDI connections. Such networks have continuing requirements to add more clients and servers, in addition to bandwidth-intensive intranet and internet applications. The overwhelming popular choice for client connectivity is Ethernet and Fast Ethernet, primarily due to cost, ease of management, flexibility of media and simplicity. In many cases the network traffic and connectivity demands are now approaching or soon expected to exceed the capacity of the GIGAswitch fabric. The next-generation architecture, such as the GIGAswitch/Router, provides nearly an order of magnitude more backbone bandwidth to satisfy these demands.

This presents network managers with questions as to how to proceed. The network managers need to integrate Ethernet into the FDDI environment, while expanding the network beyond the limitations of FDDI. Should they overhaul the network, and replace the costly and proven FDDI connections with a total Ethernet solution? Or, should they keep what is in place, and add to it? Compaq provides the opportunity to preserve the GIGAswitch/FDDI environment and to integrate to Ethernet through the GIGAswitch/Router.

No major enterprise can tolerate any extended outage of its network, or even a significant interruption in service. Customers do not want the risks of a wholesale replacement and upgrade of existing networks without providing a fall-back path in case of unexpected trouble. Customers prefer a planned migration that gradually updates the environment, providing improvement while limiting interruption of service. For this reason especially, the majority of installed FDDI equipment is likely to remain in place for some time, while new equipment is gradually phased-in, or added above it. This provides investment protection, continuing to use current GIGAswitch FDDI, but placing an umbrella Gigabit (GS/R) above it.

Let’s take a look at several specific types of GIGAswitch/FDDI configurations, and examine the recommended upgrade paths for each case in question.

Configuration 1: Switched FDDI Building Backbone

Problems:

1. Need to increase backbone capacity for current and expected future demand.
2. Need more ports to add additional servers and workgroups.
3. Cost to deploy additional FDDI connections is high.

Solution:

1. Leaving the existing FDDI equipment in place, add a Fast Ethernet line card to the GIGAswitch/FDDI and a GIGAswitch/Router (GS/R) to the network.

2. To provide the additional ports needed, at a reasonable cost, use 8-port 10/100 Ethernet line cards in the GS/R; up to (120) 10/100 ports can be installed in a single chassis.

3. By establishing a trunk of full-duplex Fast Ethernet links between the GIGAswitch/FDDI and the GS/R, hundreds of Megabits per second of data can pass between the existing FDDI and new Ethernet devices attached to the GS/R. The Fast Ethernet line card in the GIGAswitch/FDDI translates FDDI and Ethernet packets, when necessary, for all inter-switch communication. Figure 1 depicts a four-member full-duplex Fast Ethernet Trunk between the two switches, providing an aggregated capacity of 800 Mbps.

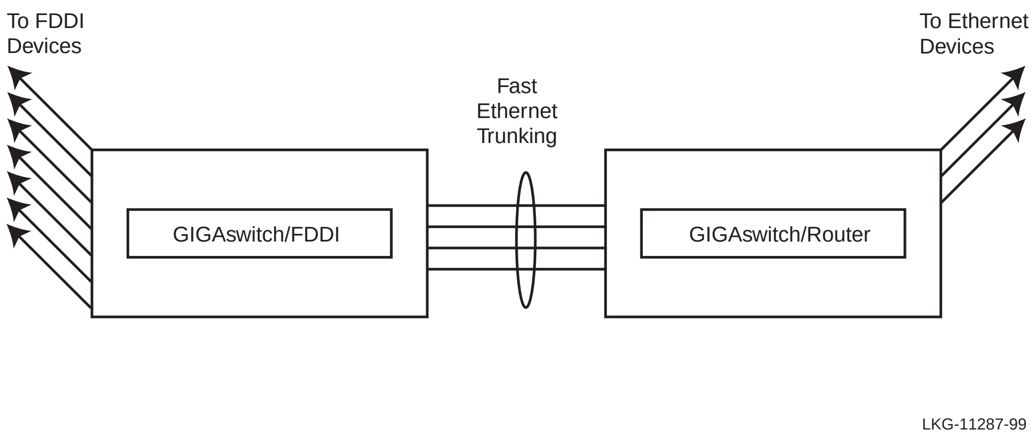

Figure 1: Four-Member, Full-Duplex Ethernet Trunk Between Switches

Configuration 2: Campus Backbone, with GIGAswitch/FDDI Systems in Larger Buildings

Problems:

1. Need to increase backbone capacity for current and expected future demand.
2. Need redundant data paths between buildings, but cost of FDDI equipment is too high.
3. Need to increase bandwidth between backbone switch(s) and WAN

Solution:

1. Leaving the existing FDDI equipment in place, add a Fast Ethernet line card to the GIGAswitch/FDDI and a GIGAswitch/Router (GS/R) to the network.

2. To provide the additional ports needed, at a reasonable cost, use 8-port 10/100 Ethernet line cards in the GS/R; up to (120) 10/100 ports can be installed in a single chassis.

3. By establishing a multi-member Trunk of full-duplex Fast Ethernet links from the GIGAswitch/FDDI to the GS/R, hundreds of megabits per second of data can flow between the existing FDDI and new Ethernet devices attached to the GS/R. The Fast Ethernet line card in the GIGAswitch/FDDI provides translates FDDI and Ethernet packets, when necessary, for all traffic passing between the switches.

4. Add Gigabit Ethernet (GIGAswitch/Routers) at each building, providing Gigabit bandwidth between buildings using existing fiber connections, and a choice of high speed port types (T1/E1,T3/E3) for WAN connections.

Figure 2 depicts a campus with Gigabit Ethernet running between the GS/R's, and full-duplex Fast Ethernet Trunks between the older FDDI switches and the newer GS/R. FDDI to FDDI allows 200 Mbytes/sec. GSR to GSR allows thousands of gigabytes of added bandwidth and functionality.

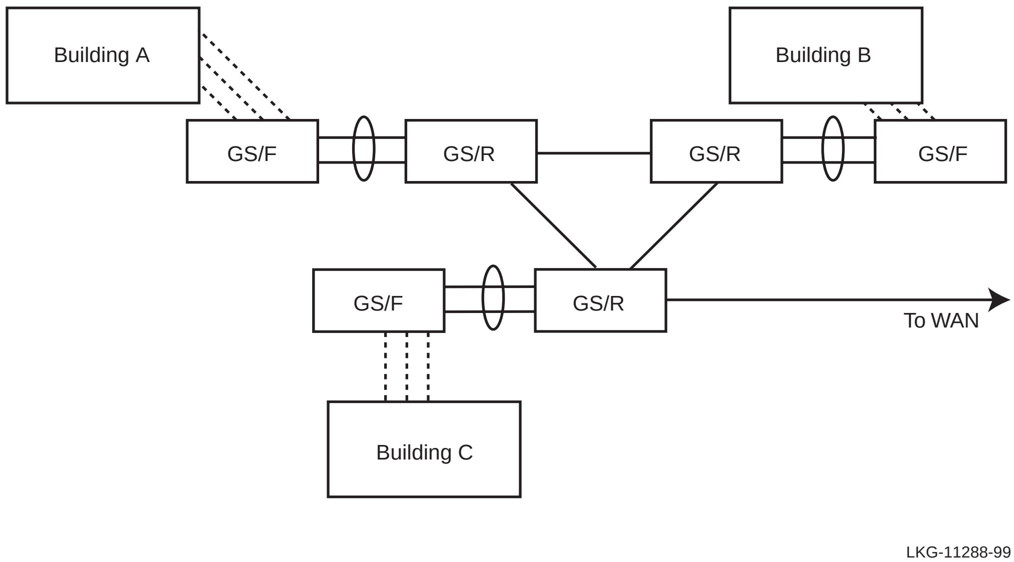

Figure 2: Campus Environments with Gigabit Ethernet and Fast Ethernet Trunks

Points to consider for Figure 2:

1. If the buildings were connected with FDDI or fiber Fast Ethernet Trunk before installing the GS/R's, the network manager could remove a single fiber from each Trunk and use it as the Gigabit Ethernet link (shown). The remaining lines can remain for redundancy (in case of failure on the Ethernet link). Figure 2 does not show these pre-existing links, for simplicity.

2. On a campus with more buildings, the network manager might want to connect the buildings in a matrix, instead of a "ring", as shown. Then, all IP and/or IPX (routed protocol) traffic can be routed, avoiding *Spanning Tree restrictions between the switches. At the same time, non-routed traffic can continue to use any pre-existing fiber between the buildings.

*The logical topology of an extended LAN must be loop-free. That is their should be a single, clearly defined path among all attached stations. To prevent logical loops on the extended network, bridges/switches form a logical configuration called Spanning Tree. Formation of a spanning tree is done based on an industry standard Spanning Tree algorithm defined by IEEE.802.1d.
-The creation of only one logical path between any two bridges
-The proper connection of all LANs into a single extended LAN with no active duplicate paths formed among connected bridges/switches.

The dual ring implemented at the root of the tree delivers high availability by providing a redundant transmission path to the attached concentrators, bridges/switches and routers. To optimize network availability, the recommended solution is to only attach network backbone devices such as concentrators, bridges/switches and routers directly to the dual ring. All other devices should connect to the FDDI network through concentrators.

Configuration 3: Collapsed Backbone

A second major usage of GIGAswitch/FDDI has been in a collapsed backbone, as a “switch of switches.” Large sites that are configured this way want to gain additional backbone capacity by using the latest generation of switch products.

Problems:

1. Need a multi-Gigabit backbone of 10 or more Mbps
2. Need redundant connection options
3. Need to integrate existing FDDI connections, and/or migrate away from FDDI

Solution:

Use 4-port Fast Ethernet (up to two line cards can be used for up to 1.66bps) in the GIGAswitch/FDDI systems, with trunking to the multi-Gigabit GIGAswitch/Router at the logical center of the backbone. This will provide connectivity from the existing FDDI switches to the central Ethernet switch, with additional capacity for increased connections. See Figure 3.

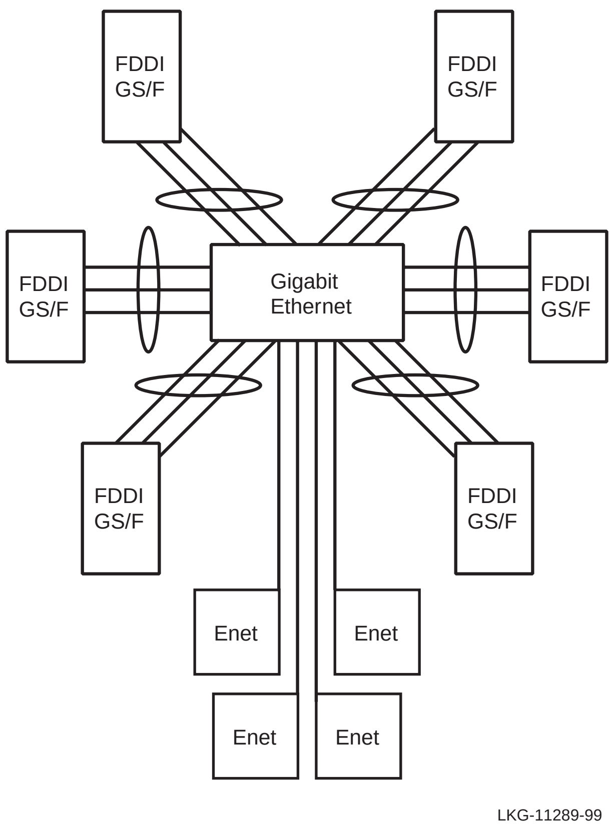

Figure 3: Gigabit Ethernet Used in a Collapsed Backbone Environment

Figure 4 depicts a collapsed backbone configuration in which **all** slot capacity has been utilized in creating the backbone switch fabric The customer is migrating over to Gigabit Ethernet/Fast Ethernet. The VNswitch 900FX, an FDDI to Fast Ethernet switch, connects the individual GIGAswitch/FDDIs to the Gigabit Switch by providing FDDI to Fast Ethernet translation (over a 100-Mb link).

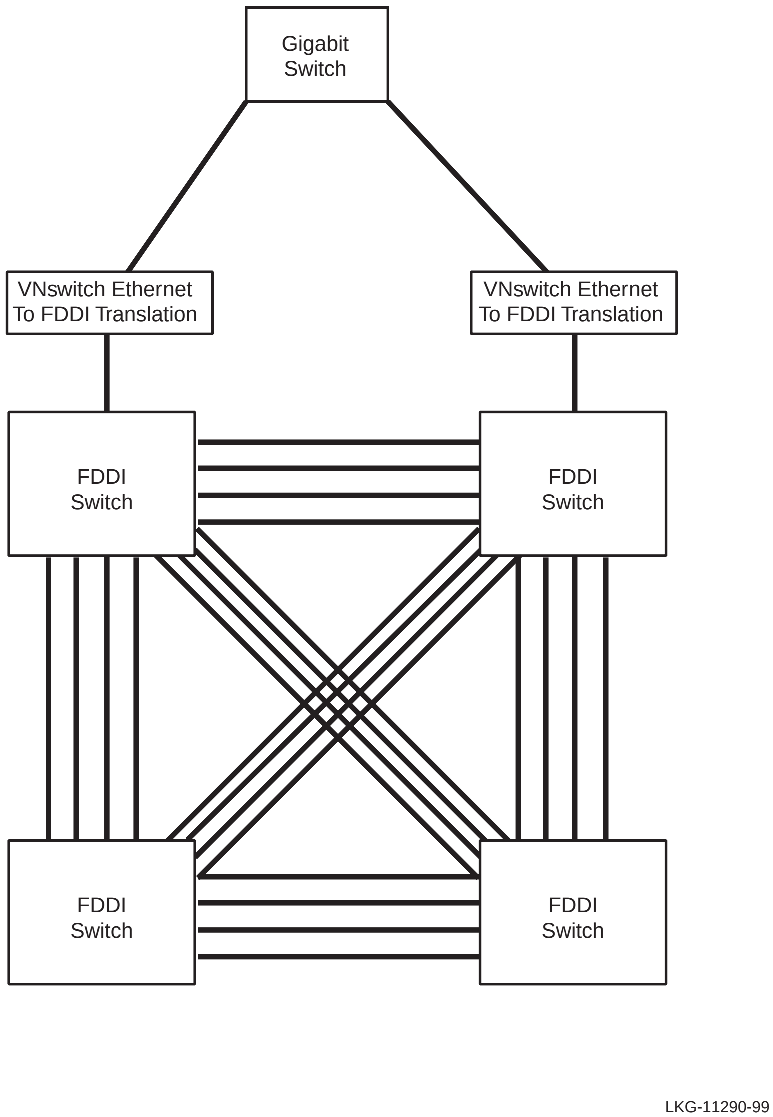

Figure 4: Collapsed Backbone Where All the Slots Are Used

This diagram depicts a FDDI customer with a collapsed backbone configuration in which **all Slot** Capacity has been utilized to build the backbone infrastructure, and the customer is left with not available slot capacity to connect to the GIGAswitch/Router. We still have a solution for your customer.

THE VNFX switches can connect the individual GIGAswitch/FDDIs to the Gigabit Switch by providing FDDI to Fast Ethernet translation (over a 100 Mb. Link).

Network Management Systems

Network Managers can manage GIGAswitch/Router through the CoreWatch element manger. They can manage the GIGAswitch FDDI through clearVISN. Both element mangers work with the Spectrum

Enterprise Management (which is supported on NT and Sun Solaris platforms) and HP Openview Enterprise Management (which is supported on UNIX and NT platforms).

Appendix A: Overview of GIGAswitch/FDDI

The GIGAswitch/FDDI is a robust multi-technology switch for enterprise networks and heavy-duty FDDI switching data centers. The GIGAswitch/FDDI has a non-blocking cross-bar backplane design that can sustain 3.4 Gigabits per second throughput at very low latency (average of 15 microseconds), with support for up to 34 switched FDDI LANs.

GIGAswitch/FDDI's Redundancy

From its initial design, the GIGAswitch/FDDI is highly redundant, to ensure against any single point of failure. As such, nearly every functional component of the system can be backed-up by a secondary (standby) device, including:

- The system power supply
- The control processor module that is the heart or brains of the switch
- The cooling fans
- The line cards and physical ports.
- For the ultimate in protection, two GIGAswitch/FDDI systems can be interconnected to provide completely redundant paths and guaranteed availability.

GIGAswitch/FDDI's Full Duplex Technology

The GIGAswitch/FDDI features the proprietary FDDI Full Duplex Technology (FFDT, originally patented by DIGITAL). Through the use of FFDT, the GIGAswitch is capable of point-to-point connections with nearly double the data transfer rate of standard FDDI switches, which only operate in half-duplex mode. This additional bandwidth, which is available simultaneously for transmitting and receiving, makes the GIGAswitch an excellent choice for connections to servers and workstation farms where two-way network traffic is critical. By comparison, the need for individual stations to be connected in full duplex mode is usually less critical, since the data transfers here are more likely to be query and response oriented.

GIGAswitch/FDDI's Trunking

Another unique feature of the GIGAswitch/FDDI, which will also be available on other switch products from Compaq and Cabletron in 1999, is Trunking, a proprietary method of aggregating two or more ports into a single logical port for greater bandwidth and resiliency. Using Trunking, the GIGAswitch/FDDI can create connections to servers, switches, and routers with much greater capacity than a single connection; allowing far greater network performance. The ability to aggregate switch ports into Trunks is not restricted to just FDDI links; Trunks can also include Fast Ethernet.

To illustrate the usefulness of Trunks, consider a three-building campus with a FDDI backbone. With standard FDDI, the connections between buildings are each limited to a maximum of 100 Mbps, in half-duplex mode. There is network congestion and resulting delays caused by many users attempting to move files over the backbone at the same time across these limited links.

Now, consider the performance improvement made by the use of a four-member FDDI or Fast Ethernet trunk between the switches in each building:

- The maximum inter-switch throughput is increased eight-fold, to a theoretical 800 Mbps, since Full Duplex connections are established at each port.
- The congestion previously experienced between the switches (when linked by a single 100-Mbps connection) is eliminated

Additional data paths are provided, which remain available if one of the participating links is lost. For example, if one of the link connections is lost, automatic failure recovery is available on the three remaining connections, providing a continued data path, which is still three times as great as the original single connection. The network manager can identify which data paths have the highest levels of traffic, and add trunk members incrementally. Configuration of trunks is easily managed with any standard SNMP management software, such as clearVISN.

Trunking Versus Spanning Tree for Redundancy

Although FDDI is well known for using redundant data paths when Spanning Tree Protocol is enabled, you can obtain a higher degree of network redundancy and continuous availability of the data paths when you use Trunks. Plus, the failover time from one data path to a redundant path under Spanning Tree Protocol could be too slow for time-critical protocols. The time to fall-back from one active connection to the next depends on:

- The size of the network
- The number of participating devices in the spanning tree domain
- The link speed of the interconnects
- The location of the “root” of the tree.

In worst-case scenarios (usually where the root bridge in the tree is located at a remote site via low bandwidth bridged WAN links), this fallback time can exceed 5 minutes – a disaster for even the most resilient non-time critical protocols. In a spanning tree configuration, the switches must exchange configuration information after a network topology change; whereas a configuration based on Trunks requires only ~ 1.5 seconds before the two directly connected switches confirm the loss of a link member and begin distributing all traffic over the remaining links.

Note: Only switches with directly attached trunking where the failure is involved participate in this algorithm. Failover is transparent to all other network devices and switches.

With Trunking, it is clear that the users on the network benefit, and the network manager will be able to offer increased availability and better throughput at all times.

Using Fast Ethernet Line Cards with GIGAswitch/FDDI

With the recent introduction of a 4-port Fast Ethernet line card for the GIGAswitch/FDDI, network managers can integrate FDDI and Ethernet LANs seamlessly and cost-effectively. They can manage both through a single switch. (Two Fast Ethernet line cards provide up to 8 ports, 2 cards can be grouped together) The Fast Ethernet line card provides line-speed translation of FDDI and Ethernet packets for all the standard protocols, as well as IP packet fragmentation, and translation and *fragmentation of packets which have been encapsulated according to 802.1q VLAN trunk encapsulation rules.

For more information about the Fast Ethernet Line card, see the following web site: http://www.networks.digital.com/dr/npg/defga-mn.html

*IP packet fragmentation, FDDI permits the creation of frames up to 4500 byes in length. Sub LANs such as Ethernet do not have that capability to handle large size frames. Common communication protocols such as Internet Protocol (IP), define a method for handling such frame size differences known as frame fragmentation. Fragmentation breaks up large frames into smaller frames, each of which contains control information for re-assembly by the end station.

Appendix B: Overview of the FDDI and Gigabit Ethernet Technologies

FDDI

FDDI is a dual-ring architecture, which provides built-in redundancy and superior fault tolerance. It is based on the use of counter-rotating rings: the primary ring used for data transfer and the secondary ring reserved for backup. When a station or cable segment fails, the dual-ring architecture automatically reconfigures to form one complete ring with no interruption of service to the application.

FDDI/Copper Distributed Data Interface (CDDI) (ANSI X3T9.5) delivers 100 Mbps over Category 5 Unshielded twisted pair (UTP), multimode fiber single-mode fiber optic cable.

FDDI employs a token passing scheme as its network access method. When this scheme is combined with the dual ring architecture, FDDI is a self healing (with a single fault) LAN Technology. FDDI supports frame lengths up to 4500 bytes (vs 1500 frame length for Ethernet) for greater throughput. Data can be switched and routed from Ethernet and Fast Ethernet networks once the frame format and lengths are translated.

FDDI supports single attachment station (SAS) to one ring for connectivity. Redundant connections are obtained with a dual attachment station (DAS) connection. In addition, FDDI has a Station Management Layer which defines an extensive set of statistics designed for trouble shooting the LAN.

The FDDI connection rules allow for several redundant topologies. A redundant topology provides for several logical paths for connecting to the network. The FDDI standard allows for redundant paths in tree topologies as well as in the dual ring topology. This redundancy is provided by a mechanism known as Dual Homing. Dual homing a redundant tree topology provides protection where network uptime is critical.

Where is FDDI Used?

Built-in redundancy, topological flexibility, and extensive distances made FDDI an ideal choice for use as a high speed backbone supporting applications sensitive to network downtime. FDDI can also be used as a high speed workgroup LAN to connect servers or desktops requiring high performance and exceptional reliability.

Gigabit Ethernet

Gigabit Ethernet 802.3z adds native Ethernet backbone technology to the huge installed base of Ethernet network nodes. This capability moves network traffic at one billion bits-per second, a tenfold increase in speed for campus networks. Gigabit Ethernet provides the simplicity of Ethernet at a lower cost than other technologies of comparable speed.

Gigabit Ethernet employs the same Carrier Sense Multiple Access with Collision Detection/CSMA/CD protocol, same frame format and same frame size as its Ethernet technology predecessors.

Because Gigabit Ethernet operates in full duplex it is ideal as a backbone interconnect technology for use between Fast Ethernet switches, as a connection to high performance servers. Gigabit uses the same management objects defined by the IEEE 802.3 group.

Gigabit Ethernet uses the same variable-length (64-1514 byte packets) IEEE 802.3 standards frame format and size found in all Ethernet technologies.

Gigabit Ethernet provides high-speed connectivity, but does not by itself provide a full set of services such as Quality of Service (QOS), Automatic Redundant fail-over or higher level routing services, is defined at the network layer to work alongside of IP (TCP provides retransmission). 802.1p and 802.1Q to facilitate quality of service over Ethernet by providing a means for tagging packets with an indication of the priority class of service desired for the packet.

Quality of Service has become increasingly important to network managers, In June 1998 the IEEE 802.p committee standardized a means of individual end station requesting a particular QoS of the network and network being able to respond accordingly.

A new protocol is defined in 802.1p, Generic Attribute Registration Protocol (GARP), GARP is a generic protocol that will be used by specific GARP applications, for example, GARP multicast Registration Protocol (GRMP) and GARP VLAN Registration Protocol (GVRP), GMRP is defined in 802.1p; GMRP provides registration services for multicast MAC addresses.

Just as the evolutionary nature of Gigabit Ethernet enables its integration with existing Ethernet and fast Ethernet networks, the technology also preserves and optimizes company investments in network hardware, applications and administration resources. Networked applications need not be rewritten to work with, or take advantage of, Gigabit Ethernet features.

Table 3 shows the differences between the two technologies, as well as how to attain comparable features in Gigabit Ethernet as you have in GIGAswitch/FDDI.

Table 3: Comparison of Gigabit Ethernet and GIGAbit/FDDI

	FDDI	**Gigabit**
Performanc e	100 Mbytes/second Full duplex when connected point to point. Half duplex when connected in a ring configuration. (Originally DIGITAL-Patented Implementation)	1000 Mbytes/second Full Duplex
Fault Tolerance	Double Ring Auto Fail-over Self Healing	Dual Ethernet Rails or the use of External Fault-Tolerant Transceiver Multiple simultaneous Ethernet connections Trunking
Auto Fail-over/ Dual Homing	Dual Ring backup	Fast Ethernet Hunt Groups Dual Ethernet Rails
Distance	Dual ring 200 KM	70 KM (Non Standard), using either: (1000BASE-SX 850nm mmf) (1000BASE-LX 1300nm) (1000BASE-CX 1300nm)

Why is Gigabit Ethernet Important?

Applications such as the Internet/Intranet, Enterprise Backbones, and Video conferencing require large amounts of bandwidth.. Consequently, pressure is growing for increased bandwidth as large amounts of data are more frequently transferred over the network from the desktop to the server. Gigabit Ethernet provides a simple solution by using a stable and widely deployed technology.

Because of these attributes, as well as the support for full-duplex operation, Gigabit Ethernet is an ideal backbone interconnect technology for use between 10/100 Fast Ethernet switches, as a connection to high-performance servers, and as an upgrade path for future high-end desktop computers requiring more bandwidth.

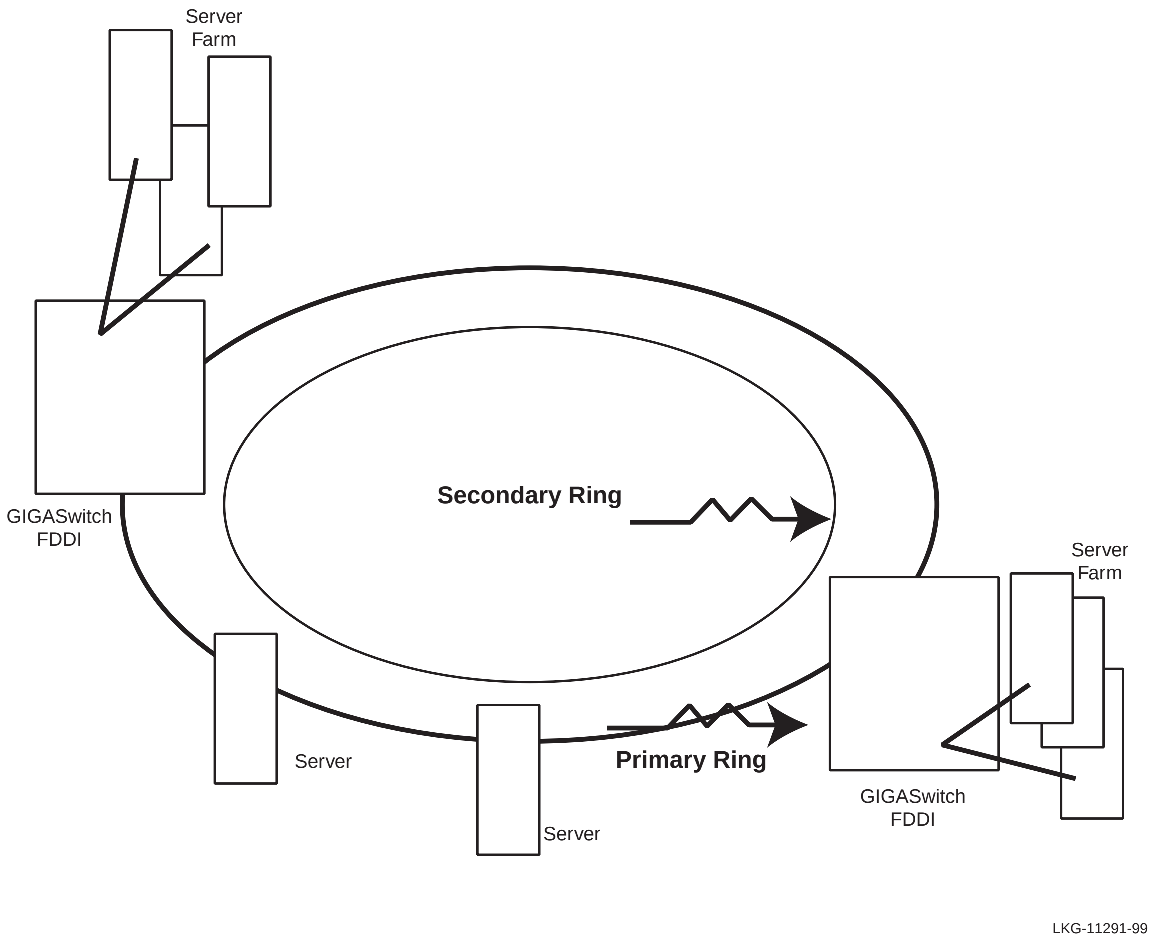

Figure 5: Today's FDDI Ring Architecture