



## **IBM Netfinity Fibre Channel Solutions for Enterprise Storage**

*Bringing proven leadership in high availability, performance and scalability to industry-standard, business-critical solutions*

### **Executive Summary**

Today's information technology customers need expandable, high-speed networked systems that support business-critical applications including database applications, enterprise resource planning, business intelligence and e-commerce, for users in diverse locations. Customers running these applications need to be able to take advantage of the information they have stored on hard disk drives and tape, and to share resources as part of efforts to lower their total cost of ownership.

Fibre Channel is a new technology, similar to a high-speed network, that can be used to connect large amounts of disk storage to a server or cluster of servers. Fibre Channel technology supports increased performance, scalability, availability and distance for attaching storage subsystems to network servers. IBM's Netfinity® Fibre Channel products provide this technology and the benefits it offers to businesses requiring enterprise server solutions.

Drawing on decades of experience and expertise that helped build our midrange and mainframe systems, IBM has developed a blueprint to bring the reliability, availability and scalability of our mainframe servers to the Netfinity family of products. This blueprint is called *X-architecture* and was designed to include advances in technologies needed to implement business-critical core business, e-business and deep computing applications. IBM is adapting this experience to the Netfinity Fibre Channel product line to provide complete application solutions for today's industry-standard storage marketplace.

In September of 1998, IBM announced and delivered hardware and software products that use Fibre Channel technology, and that provide complete application solutions for standalone and clustered servers. In 1999 and beyond, when Fibre Channel will be the basis for the expected development of storage area networks or SANs, IBM will continue to enhance the Netfinity product line and its associated storage systems. IBM's focus will be on all aspects of computing to further improve performance and help reduce the total cost of ownership.

This paper offers a brief tutorial on Fibre Channel technology and describes the new products IBM has announced and their roles in enterprise storage solutions. Because of the dynamic nature of the computer industry, changes may occur in IBM's actual implementations and timing of product announcements.

## **What is Fibre Channel?**

Fibre Channel is the new generation in high-performance storage interface technology. It consists of an integrated set of standards that defines new protocols for flexible information transfer using several interconnection topologies. These standards have been created by the American National Standards Institute (ANSI) committee, with IBM playing a leadership role as it has done before in the development of many new industry-standard technologies.

IBM engineers worked on the ANSI committee and helped establish the three basic Fibre Channel topologies: fabric, point-to-point and arbitrated loop (FC-AL). Each topology contains nodes and ports, which consist of transceivers and receivers connected together by copper wiring or optical fiber cable.

In a fabric topology, the flow of information is controlled by the fabric (routers or switches) instead of by the ports. In a point-to-point topology, two ports of the same type are connected to each other. In an arbitrated loop, up to 126 ports can be interconnected. An arbitration protocol is used to allow one device port on the loop to send messages at a time. Messages not intended for a particular port are passed around the loop until they reach their designated destinations.

Fibre Channel combines the standard SCSI command set and protocol used by storage devices with the flexibility and connectivity of networks. Its ability to attach large numbers of devices using physically longer and smaller cables than traditional SCSI, combined with its ability to transmit data at up to 100MBps, makes it an attractive alternative to SCSI in many cases. Its architectural flexibility enables it to handle different protocols simultaneously. This allows a Fibre Channel network to serve as a high-speed LAN supporting network protocols such as TCP/IP and to support attachment of storage devices simultaneously.

And, as was mentioned previously, Fibre Channel is the basis of storage area networks (SANs). Over time, IBM's deployment of Fibre Channel SAN technology and products is expected to allow interoperability and data sharing among all IBM server platforms—Netfinity, AS/400®, RS/6000® and S/390®.

## **Advantages of Fibre Channel**

Fibre Channel technology supports applications that require very large amounts of disk storage or clustered storage shared by two or more servers. IBM's X-architecture, which brings the high availability, reliability, scalability and performance of our midrange and mainframe systems to our industry-standard Netfinity family of products, makes this possible.

Key elements of the Netfinity X-architecture include powerful processors, reliable and highly available memory systems, scalable I/O, world-class silicon and module technology and advanced caching software. Also included are clustered systems featuring technology derived from IBM's industry-leading AS/400®, RS/6000® and S/390® products, as well as interoperability with existing mainframe and midrange systems.

Because of this, Fibre Channel is an excellent technology for clustering, enterprise resource planning (ERP), business intelligence, multimedia and disaster recovery applications. With Fibre Channel, you can see a higher throughput rate over longer

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distances than is possible with SCSI or serial storage architecture (SSA). These differences are illustrated in the following table.

**Fibre Channel compared with other interface technologies:**

	<b>Fibre Channel</b>	<b>Fast/Wide SCSI</b>	<b>Ultra/Wide SCSI</b>	<b>Ultra2 SCSI</b>	<b>SSA</b>
<b>Distance</b>	Up to 10km (6mi.) with optical cable Up to 25m (80ft) with copper	Up to 6m (20ft) with copper	Up to 3m (10ft) with copper	Up to 15m (50ft) with copper	Up to 2.4km (1.5mi.) with optical extensions
<b>Speed (data transfer rate)</b>	100MBps	20MBps	40MBps	80MBps	20-40MBps
<b>Host systems per connection</b>	1-126	1-2	1-2	1-2	1-126
<b>Devices per connection</b>	126 (FC-AL) 16 million (fabric)	15	15	15	126

Combining Fibre Channel technology with Netfinity systems and SCSI storage expansion enclosures (EXP10s and 15s) makes the possibilities for scalable, high-performance solutions almost endless.

The advantages of Fibre Channel include distance, performance, availability and scalability.

- **Distance and Performance.** With Fibre Channel, greater distances (up to 10km [6mi.]) can be supported. This means that your servers and the people who use them can be located miles apart and still share the same storage devices. And Fibre Channel can transfer data at speeds up to 100MBps, giving you high performance over distance for your business-critical applications.
- **Availability.** Businesses can face failures of operating systems or applications. Disaster recovery can be better managed through the use of Fibre Channel combined with the appropriate cluster software. For example, should a failure occur in a clustered environment, work can be transferred to another location without interruption.
- **Scalability.** As businesses grow and become more complex, so do systems. The flexibility and scalability of Fibre Channel technology enable you to manage this increased complexity and expand your current system while protecting your base investment. This is possible because Fibre Channel technology allows for system expansion by increasing the number of devices that can be attached per PCI slot. Another key point is that you can easily connect more than two host systems to a Fibre Channel arbitrated loop or fabric; SCSI cable lengths limit the number of host systems that can attach to a single SCSI bus to two.

This is not intended to suggest that IBM believes Fibre Channel to be preferable to SCSI and SSA in all environments. All three technologies have advantages and disadvantages. SCSI enables customers to leverage their existing investments. There is an abundant supply of SCSI devices of many types available from numerous vendors. SCSI has lower power requirements and hence needs smaller power supplies and fewer cooling fans than Fibre Channel, both factors that make SCSI less expensive.

SSA is highly fault-tolerant; in a single-loop configuration the system does not go down with a single point of failure, because SSA can bypass a failed component and data can be transferred in either direction on the loop.

Fibre Channel, on the other hand, enables simpler cabling over much greater distances, allows more devices to be attached, and when redundant loops are used it can provide higher availability than SCSI in certain configurations.

## **IBM Netfinity Fibre Channel Strategy**

Today's networked business solutions must be able to grow exponentially through scalable I/O devices. IBM's Netfinity strategy and products support this growth requirement.

IBM began demonstrating Netfinity Fibre Channel hardware solutions to customers in the fourth quarter of 1997. Today IBM has developed hardware and software Fibre Channel products as part of comprehensive computing solutions that meet IBM's requirements for quality, reliability, availability and performance. Over time, it is anticipated that the benefits to be gained by customers from the new Fibre Channel solutions will increase. They will include the capability for tape backup pooling, disk-to-tape backup over Fibre Channel with its accompanying speed and savings in time and money, disk pooling, data mirroring and data sharing between multiple host systems.

For solutions requiring extremely high bandwidth, cabling distance and high availability, Netfinity Fibre Channel subsystems provide scalability to hundreds of terabytes (TB<sup>1</sup>) of storage, 100MBps throughput and distances of up to 10km (6mi.) between the server and external disk storage to provide additional protection of data. Implementations support host-attached Fibre Channels solutions which leverage existing investments in SCSI disks and products such as the EXP15. Solutions that utilize Fibre Channel-attached hard disk drives (HDDs) will be offered in the future.

Netfinity Fibre Channel subsystems and Netfinity EXP15 storage expansion units can be used to attach up to 72TB of disk storage to a single PCI expansion slot. Using Netfinity Fibre Channel subsystems, which support single server or N-node cluster configurations, over 864TB can be attached to a single Netfinity 7000 M10 server or cluster.

### ***Hard Disk Drives***

Most server-class hard disk drives are attached to servers or RAID controllers via some version of SCSI, SSA or Fibre Channel interfaces. All disk drives use the same basic components such as magnetic disk platters, read/write heads, seek actuators, and most of the electronics needed to control access to data. These basic components are usually the parts that limit the performance of the disks regardless of which interface is used to

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<sup>1</sup> When referring to hard drive capacity, TB means one trillion bytes. Total user-accessibility may vary depending on operating environments.

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connect the disks to the server or RAID controller. Rarely is the bandwidth of the disk interface a limiting factor in system-level performance.

The choice of which interface is best suited for a given application depends on a number of factors such as availability of supply, cost, scalability and performance. Of these three interfaces, SCSI disks are used most widely, are the simplest to design, cost the least to implement and are readily available from a number of suppliers. SSA and Fibre Channel disk drives are not as widely used, are generally available from only a single supplier (IBM for SSA and Seagate for Fibre Channel), are more complex in design, and generally have higher power requirements and higher costs than SCSI drives. Even if the disk drives were the same price, the cost of other components that support SSA or Fibre Channel disk drives such as hot-swap disk enclosures and RAID controllers generally are more expensive than their SCSI equivalents.

Even with these known limitations, there are configurations where SSA and Fibre Channel disk drives are preferable to SCSI disk drives. In cases where the number of disks that need to be attached to a system or RAID controller is very large, SSA and Fibre Channel disks can provide significant advantages. Up to 126 disks can be connected to an SSA or Fibre Channel interface, whereas a maximum of 15 disks can be connected to a SCSI interface. SCSI also has the limitation of a maximum of several meters of cabling used to connect the disks to the systems or RAID controllers compared to several thousand meters of optical fiber cabling allowed by SSA and Fibre Channel. SCSI cables are also very bulky, containing 68 wires, and are expensive compared with SSA and Fibre Channel cables, which usually contain 4 to 6 wires or 2 optical fibers. SSA and Fibre Channel disks support dual-interface circuits, which provide fault tolerance for some types of failures. However, SCSI RAID adapters or Fibre Channel-attached RAID subsystems that use SCSI disks attached to multiple SCSI buses can typically be configured to tolerate failures of a SCSI bus as well.

Because of its longer distance support, the capability to support large numbers of devices, and the ability to support switched fabric topologies, Fibre Channel has been selected overwhelmingly by the computer industry as the interface of choice for connecting multiple servers to storage subsystems. The attachment of multiple storage devices to multiple servers is typically called a Storage Area Network. The use of Fibre Channel for this purpose should be distinguished from the use of Fibre Channel to attach disk drives to a server or RAID controller. For example, the current Netfinity Fibre Channel RAID subsystem uses 6 independent Ultra2 SCSI buses for attaching up to 60 Ultra or Ultra2 SCSI disk drives to a server or cluster of servers. This allows the reuse of existing investments in SCSI disks and enclosures while still getting the benefits of Fibre Channel technology. By using RAID-1 or RAID-5 disk arrays that span across two or more of these SCSI buses, a SCSI bus failure can be eliminated as a single point of failure. This is sometimes referred to as *orthogonal RAID* technology.

For attaching disks drives, the majority of customers' needs today are easily met with SCSI disk technology and with the consistent improvements that have been made to SCSI technology such as Ultra, Ultra2 and most recently the announcement of Ultra3 SCSI; SCSI disks will likely remain the most popular type of disks installed in servers in the foreseeable future. Netfinity servers support a wide variety of disk and RAID adapters and controllers that can use the same SCSI disks from the low end to the high end of the Netfinity product line. This strategy protects the investment in SCSI disks and allows scalability to many TB of capacity in standalone or clustered server applications. IBM intends to continue to support SCSI-disk-based solutions into the foreseeable future, as well as offer newer generations of SSA and Fibre Channel disks in situations where SCSI may become a limiting factor in the total enterprise storage solution.

## **Enterprise Storage**

IBM Netfinity Fibre Channel storage solutions can support the massive data storage requirements of business-critical applications and provide the scalability needed to meet the increased demands of a growing enterprise. For example, because Netfinity Fibre Channel storage solutions can support distances between the server and storage subsystems up to 10km (6mi.), companies can more easily configure off-site server and storage systems to keep critical data available around the clock—even in the event of a catastrophe.

An excellent example of the use of a highly available enterprise storage subsystem is for clustering, which permits the partnering of several servers and their fault-tolerant systems to keep up with end-user demand for data. Utilizing Netfinity Fibre Channel storage solutions in this scenario provides high-bandwidth, high-performance interconnectivity links between servers and external storage. Netfinity Fibre Channel storage solutions' high-speed data transfer also helps eliminate storage bottlenecks, so clustering in the enterprise is more powerful, and more flexible, than ever before.

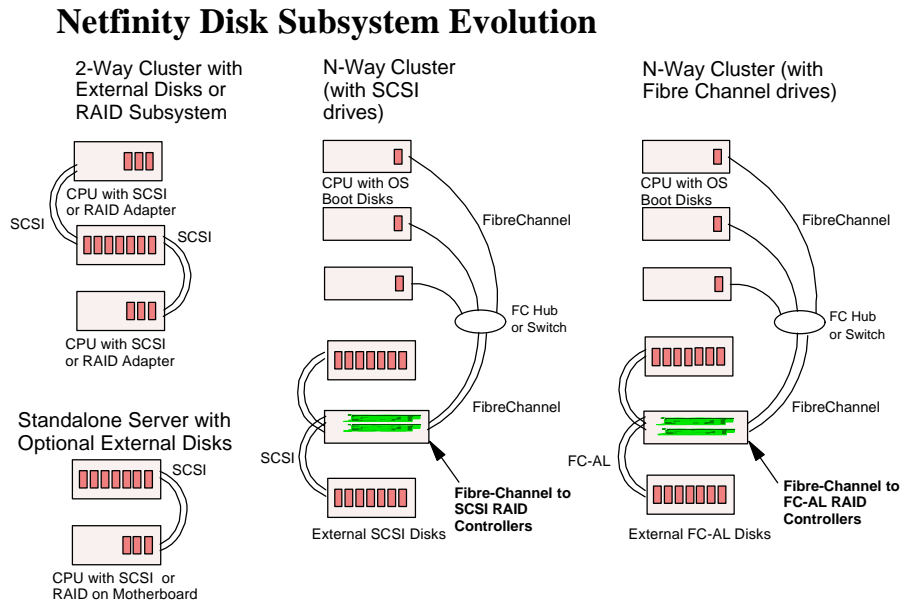
Available IBM Netfinity Fibre Channel enterprise storage products include the following:

- **Failsafe RAID Controller Units:** a single hot-pluggable RAID controller standard; dual active redundant controller as an option, thus eliminating a controller as a single point of failure; RAID levels 0, 1, 3, 5 and 10; 128MB battery-backed cache; 6 Ultra2 SCSI (also known as low voltage differential SCSI or LVDS) drive channels supporting capacity scalability up to 60 HDDs, which allows striping of RAID data across the channels to eliminate the SCSI as a single point of failure (orthogonal RAID); redundant, hot-pluggable power supplies and fans
- **PCI Adapters:** 100MBps speed; Fibre Channel direct drive short-wave optical to 500m (1640ft) rather than the 25m (82ft) limitation imposed by copper cable, also thereby eliminating electrical interference and ground shift problems caused by copper cable; 64-bit PCI bus master data transfers up to 264MBps; compatible with 32-bit PCI
- **Hubs:** 7 ports for short- or long-wave optical connections provided by optional hot-pluggable short- and long-wave gigabit interface converters (GBICs); supports N-way clustering; 4 short-wave GBICs included as standard

As enterprise storage requirements continue to increase—especially as more companies compete in the ever-growing, high-demand, no-room-for-errors arena of worldwide e-business—IBM intends to continue to enhance the performance, capacity and reliability of IBM Netfinity Fibre Channel storage solutions to help businesses keep up with information demand.

## SCSI to Fibre Channel: Storage Subsystem Evolution

The following diagram illustrates how a typical transition from a SCSI-based storage system to a Fibre Channel-based system could take place over time.



Prior to 1997, customer solutions were based primarily on standalone servers with internal SCSI disks and/or a single, nearby SCSI storage expansion enclosure. Then the introduction of the IBM EXP10 in November 1997 made 2-way clustering possible, allowing two servers to share external storage devices.

In 1998 IBM announced new hardware and software products that allow more advanced "N-way" clustering solutions to be configured. Initially this was done primarily with Fibre Channel RAID subsystems that supported attachment of SCSI disk drives and allowed multiple servers to share multiple expansion enclosures. Fibre Channel is an excellent technology solution for such applications, offering the following advantages:

- Users and servers no longer need to be near their shared storage devices.
- Solutions for disaster recovery can be provided more easily because redundant failover elements of the system can be located miles apart.

In late 1999, the migration from SCSI to Fibre Channel disk drives will gain momentum as multiple vendors begin to offer Fibre Channel drives.

Today IBM's Fibre Channel solutions are able to use today's SCSI disks, storage expansion enclosures and servers. This protects your current SCSI hardware investments, which often constitute a high percentage of your total system cost. Native Fibre Channel-attached disk drives are not readily available today from multiple suppliers and are incompatible with existing SCSI adapters, enclosures and cables. This has limited market acceptance of these drives, but we expect market acceptance to increase in late 1999 and beyond.

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As the number of vendors producing Fibre Channel hard-disk drives and other system components (such as Fibre Channel adapters, RAID controllers and backplanes) increases, these new devices should also become more cost-effective. This will allow solutions based entirely on Fibre Channel to become more prevalent. In fact, it is possible that Fibre Channel will eventually replace SCSI as the most popular server storage technology. Given this technology trend, the IBM Netfinity Fibre Channel strategy will allow you to:

- Start your migration to Fibre Channel with IBM's new, complete hardware and software solutions (and still protect your existing SCSI disk investments)
- Migrate to solutions based entirely on Fibre Channel in late 1999 and beyond, when it is cost-effective and appropriate for your business needs

Also in the second half of 1999 and beyond, we expect the announcement of Fibre Channel switches and bridges to tape libraries that will make the SAN vision a reality. IBM's SAN initiative has been designed to help organizations manage, track and more easily share the complex and ever-increasing volume of data created by the Internet and e-commerce applications. IBM's initiative has also been designed to help customers create and extract value from their business information by enabling IT resource management and information sharing any time, anywhere across storage networks.

## **Summary**

Fibre Channel is an emerging, powerful technology for businesses that need available, reliable, high-speed storage interconnected over long distances. Its high bandwidth, flexibility and connectivity, coupled with its ability to handle multiple protocols simultaneously, make it a wise choice for the new generation in storage interface technology. Ease of use is improved because of the need for fewer cables and controllers, which makes it attractive to network planners and administrators. Its scalability allows you to add more devices per system PCI slot and thus protect and expand your current SCSI investments. Its ability to transmit data at up to 100MBps makes it an outstanding alternative to traditional SCSI connections. And it allows you to locate your storage subsystem as far as 10km (6mi.) away from your servers and, in the case of a server failure, work can be transferred to the backup server without interruption.

As in the past, IBM is again playing a leadership role in the development of a new industry-standard technology. Fibre Channel is another step in the migration of IBM's mainframe strengths to industry-standard computing platforms and to SANs. Netfinity X-architecture has brought the high availability, reliability, scalability and performance of our AS/400, S/390 and RS/6000 technology to the Netfinity family of products. By offering Netfinity Fibre Channel software and hardware solutions, IBM continues to be the only vendor to offer a complete range of solutions for your business-critical needs.

IBM's heritage with campus and enterprise computing, our leadership role in the development and implementation of new technologies, and IBM Netfinity products give you the confidence to run your business-critical systems today and in the future. And with our worldwide service and support, we'll help you keep your business up and running when you need it.



### **Additional Information**

For more information on IBM Netfinity direction, products and services, refer to the following white papers, available from our Web site at [www.pc.ibm.com/netfinity](http://www.pc.ibm.com/netfinity).

#### Management

*Implementing IBM Netfinity Server Management*  
*Integrating IBM Netfinity Manager with Microsoft System Management Server*  
*Integrating IBM Netfinity Manager with Intel LANDesk Server Manager*  
*IBM Netfinity Manager 5.2*  
*IBM Netfinity Manager Plus for Tivoli Enterprise Overview*  
*IBM Netfinity Advanced Systems Management*  
*IBM Netfinity Advanced Systems Management for Servers*  
*IBM ServerGuide for Netfinity and PC Server Systems*  
*IBM Netfinity Storage Management Solutions Using Tape Subsystems*

#### Other Topics

*Enterprise Storage Solutions*  
*IBM Chipkill Memory*  
*IBM Netfinity X-architecture*  
*IBM Netfinity ClusterProven Program*  
*IBM Netfinity Predictive Failure Analysis*  
*IBM Netfinity Cluster Directions*  
*IBM Netfinity Web Server Accelerator*  
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*Implementing Microsoft IIS on Netfinity 5500 M10*  
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*IBM Netfinity Server Quality*  
*IBM Netfinity 5000 Server*  
*IBM Netfinity 5500 Server Family*  
*IBM Netfinity 7000 M10 Server*  
*Achieving Remote Access Using Microsoft Virtual Private Networking*  
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