iSCSI: The Future of Network Storage
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Storage Basics

The Internet and related activities continue to expand, increasing the amount of data that needs to be stored. Businesses and other organizations require effective ways to store and maintain this data. Today’s technology market offers three basic options: Direct Attached Storage (DAS), Network Attached Storage (NAS) and Storage Area Networks (SANs).

Direct Attached Storage (DAS)

In its simplest form, DAS consists of a disk drive attached directly to a server. Data is transferred using SCSI (Small Computer System Interface) commands, the most common means of I/O communication between a computer and a hard drive. SCSI commands transfer data as blocks – low-level, granular units used by storage devices – as opposed to files, the most common means of transferring data over Local Area Networks (LANs).

There are a number of disadvantages to the DAS approach including high cost of management, distance limitations and limited scalability. In particular, in order to increase storage capacity, enterprises must purchase more servers. Furthermore, storage devices must be located close to the server since SCSI devices are designed to work over parallel cable with a maximum length of 12 meters. These limitations have driven the need for network storage.

Network Attached Storage (NAS)

NAS is a file-based storage architecture with resources attached directly to the LAN. Storage traffic is transmitted over the LAN as well. Since it uses a familiar technology, NAS resources can be managed by existing IT staff with minimal training in storage management, which may reduce IT costs. Another benefit of NAS is flexibility – since the storage units (NAS) can easily be attached to the network. However, this is not a highly scalable option, since storage traffic can become very heavy and decrease the performance of the LAN.

Storage Area Networks (SANs)

SANs are dedicated networks that connect servers to storage devices and transport storage traffic without burdening the enterprise LAN (Figure 1). Several factors help make SANs attractive, including performance, reliability, availability, scalability and ease of management.

Without the potential for centralized data management provided by SANs,
redundant file copies can rapidly consume disk space, while multiple file versions cause reconciliation problems. In the absence of mature management tools, servers with high-demand applications and often-used data can become overloaded while others remain relatively idle. SANs, used in conjunction with management tools, help reduce these problems.

SANs are also highly scalable. Growing storage demands can be met by simply installing more storage and network resources.

Switches and other equipment in a SAN have historically communicated via a network protocol suite called Fibre Channel which allows SCSI commands to be transmitted via serial, rather than parallel, connections. The protocol also allows for relatively high throughput, transmitting data at 700 to 800Mbps in first-generation products and approximately twice that in second-generation products.

A Host Bus Adapter (HBA) connects the server to devices in the SAN. Typically, the server will have Ethernet and Fibre Channel connections to communicate with both the Ethernet LAN and the Fibre Channel SAN. The HBA serves the same purpose on the SAN side as a Network Interface Card (NIC) or network adapter servers on the LAN side.

Current Limitations

While Fibre Channel is a high-performance transmission technology optimized for the same block storage format that storage devices use, it does have drawbacks:

- **Total Cost of Ownership (TCO)**
  The Total Cost of Ownership (TCO) for operating a Fibre Channel SAN, while lower than the DAS model, is still high. Since organizations vary widely in their storage needs, it is difficult to develop a set of assumptions for generating average cost figures. Still, Fibre Channel is a fairly new technology and many IT staffs have limited, Fibre Channel expertise. Finding the necessary specialized personnel can be challenging and training is often not readily available. As a result, installing and maintaining a Fibre Channel network is typically difficult and expensive.

- **Operating Distance**
  Although the theoretical limit for Fibre Channel is 10km, individual multi-mode fiber links used in Fibre Channel SANs may have a practical limitation of 250 to 500 meters. The storage ecosystem is evolving to where large organizations often have SANs located far from the LAN, to provide geographical redundancy as part of disaster planning. This means even 10km may be increasingly inadequate.

The Need for IP Storage

Several factors are rapidly expanding worldwide storage requirements:

- **E-mail**
- **E-Commerce**
- A pervasive global economy

Over the past decade, many enterprises have seen a significant increase in the volume of data produced. The amount of data continues to increase, particularly in Web-based and E-Commerce environments.

E-mail impacts worldwide storage by producing more data than is generated by new Web pages. These types of traffic are typically multimedia-intensive. E-mail and Internet-related business/commercial transactions combined have caused a dramatic increase in storable data moving across Internet Protocol (IP) networks. This traffic can potentially overwhelm existing backup methods.

A new method is needed to bring improved storage capabilities to IP networks and reduce limitations associated with Fibre Channel SANs. A rapidly emerging technology solution is Internet SCSI (iSCSI) or SCSI over IP.

**What Is Gigabit iSCSI?**

**iSCSI Defined**

Internet SCSI (iSCSI) is a draft standard protocol for encapsulating SCSI command into TCP/IP packets and enabling I/O block data transport over IP networks. iSCSI can be used to build IP-based SANs. The simple, yet powerful technology can help provide a high-speed, low-cost, long-distance storage solution for Web sites, service providers, enterprises and other organizations.

An iSCSI HBA, or storage NIC, connects storage resources over Ethernet. As a result, core transport layers can be managed using existing network management applications. High-level management activities of the iSCSI protocol – such as
permissions, device information and configuration – can easily be layered over or built into these applications. For this reason, the deployment of interoperable, robust enterprise management solutions for iSCSI devices is expected to occur quickly.

First-generation iSCSI HBA performance is expected to be well-suited for the workgroup or departmental storage requirements of medium- and large-sized businesses. The expected availability of TCP/IP Offload Engines in 2002 will significantly improve the performance of iSCSI products. Performance comparable to Fibre Channel is expected when vendors begin shipping 10 Gigabit Ethernet iSCSI products in 2003.

**Benefits**

- **Builds on stable and familiar standards** – many IT staffs are familiar with the technologies
- **Creates a SAN with a reduced TCO** – installation and maintenance costs are low since the TCP/IP suite reduces the need for hiring specialized personnel
- **Provides a high degree of interoperability** – reduces disparate networks and cabling, and uses regular Ethernet switches instead of special Fibre Channel switches
- **Ethernet transmissions can travel over the Global IP Network and therefore have no practical distance limitations**
- **Scales to 10 Gigabit** – comparable to OC-192 SONET (Synchronous Optical Network) rates in Metropolitan Area Networks (MANs) and Wide Area Networks (WANs)

**Who Can Use It**

iSCSI SANs are most suitable for organizations with a need for streaming data and/or large amounts of data to store and transmit over the network. This includes:

- Internet Service Providers (ISPs)
- Storage Service Providers (SSPs)
- Organizations that need remote data replication and disaster recovery. For example, a high-technology company in San Jose remains susceptible to disaster if it uses a Fibre Channel SAN. Original and backup data copies could be lost in the same earthquake due to distance limitations.
- Geographically distributed organizations that require access to the same data on a real-time basis. For example, work team members who need the latest project data without waiting 24 hours for traditional replication/backup/reconciliation procedures.
- Businesses and institutions with limited IT resources, infrastructure and budget. These organizations should look for iSCSI equipment that functions over standard Gigabit Ethernet Cat-5 copper cabling already in place in most buildings today.
Deployment Examples

Network Storage Services via iSCSI

Two iSCSI HBAs can be used in conjunction with standard Ethernet NICs through a Gigabit-capable switch connected to an iSCSI-capable RAID Array (Figure 3). This configuration is appropriate as either the next step in transitioning to an iSCSI-exclusive SAN or as an initial iSCSI SAN configuration.

Multiple Cards to Single iSCSI Router

Multiple HBAs in separate servers can be used in conjunction with a Gigabit-capable switch connected to an iSCSI-capable router with Fibre Channel ports. This is then connected directly.
to a native Fibre Channel RAID Array (Figure 4). This configuration is appropriate as the next step in transitioning to an iSCSI front-end SAN with Fibre Channel storage devices.

**iSCSI HBA and Fibre Channel Tape Backup**

An iSCSI HBA can be used in conjunction with a Gigabit-capable switch connected to an iSCSI-capable router with Fibre Channel ports connected to a Fibre Channel tape drive (Figure 5). This configuration can be used as a means to perform backup and recovery using existing Ethernet infrastructure.

**Conclusion**

Organizations with changing data requirements, especially those requiring data storage security or disaster recovery, will benefit most from the introduction of IP storage and iSCSI. As performance increases and iSCSI SANs become ubiquitous, they will gradually be integrated into enterprise TCP/IP networks. Distributed intelligent services and automated allocation of storage resources via virtualization will become an integral part of the future evolution of iSCSI SANs.

Intel is actively involved in the advancement of iSCSI solutions. It is in the process of developing an iSCSI storage NIC – the Intel® PRO/1000 T IP Storage Adapter. Other involvement includes open software development and participation in standards efforts through membership in the Storage Network Industry Association* (SNIA). Intel is also a key group member of the SNIA subcommittee on iSCSI.

**For More Information**

Intel® PRO/1000 T IP Storage Adapter:

The Storage Networking Industry Association* (SNIA):
http://www.snia.org

The Internet Engineering Task Force* (IETF):
http://www.ietf.org