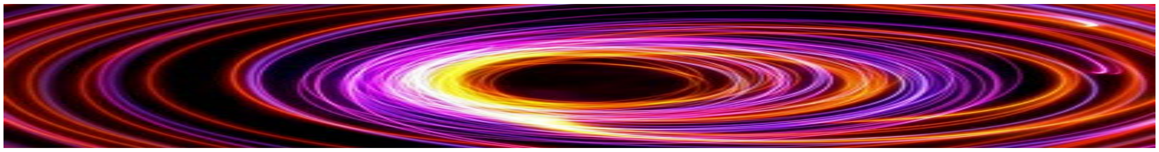

Storage over IP (SoIP)
A Solution for Enterprise Data Storage

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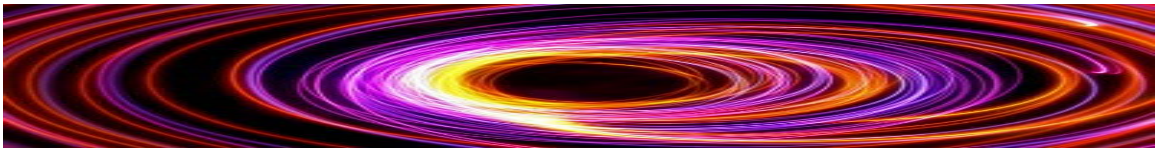


Introduction
This white paper outlines a complete framework for Storage Area Networking (SAN) using Internet Protocol (IP) networks to directly connect servers and storage. This approach is referred to at the Storage over IP, or SoIP Framework. The paper will outline the current state of SANs with Fibre Channel, including implementation hurdles, the recent breakthroughs in IP storage technology, the reasons and benefits to use SoIP products as an alternate approach, and a general outline to implementing SoIP storage networks.

The Rise of SANs

Storage area networks have arrived. This new approach to networking servers and storage provides real solutions to current data center problems with backup, storage management, and scalability of high-end storage systems. The basic premise of a storage area network is to replace the current "point-to-point" infrastructure of server to storage communications with one that allows "any-to-any" communications. In its simplest form, a storage area network provides LAN-like connectivity, scalability, and availability to enterprise storage resources.

Fibre Channel History

Since its initial development in 1988, Fibre Channel has emerged as a means of gigabit communications for both networking and storage. Fibre Channel began as a way to improve the limited performance of 10 Mbps Ethernet. In 1994, the first Fibre Channel standard was approved, and several years later, Fibre Channel gained traction as a medium for building storage area networks. There are numerous Fibre Channel standards today, including specifications for audio and video over Fibre Channel, ATM and HIPPI mappings to Fibre Channel, avionics applications, and more. Many of these standards were initiated and developed well before the emergence of Fast Ethernet or Gigabit Ethernet, which have since become the dominant protocols for networked infrastructures.

Topologies and Protocols for Fibre Channel Storage Area Networks
Current Fibre Channel deployment is based on two primary topologies, Fibre Channel Arbitrated Loop and Switched Fibre Channel. Fibre Channel Arbitrated Loop (FC-AL) creates a storage area network via a physical or logical loop connecting up to 126 devices sharing 100 MB/s of bandwidth. FC-AL simplifies storage cabling and can be used with or without a hub. Based on ports shipped to date, FC-AL is the more widely accepted method of deploying Fibre Channel technology.

Switched Fibre Channel is true "networking" of storage. Switches connect hosts and devices, either directly or on arbitrated loops. Switched Fibre Channel provides the benefits of a switched environment, such as efficient use of bandwidth (i.e. unshared media) and the ability to set up a fabric of server and storage resources. However, the rise in shipments of Fibre Channel switches does not necessarily mean that the fabric features have been fully exploited. The Enterprise Storage Group reports that over 90% of switched Fibre Channel ports are installed in loops, not full fabrics. So while the concept of a switched SAN has led to increases in switched port shipments, the full implementation hasn't been realized due to difficulties in implementing large scale switched Fibre Channel SANs.

Regardless of the topology implemented for Fibre Channel, both methods use the same core protocol. This is known as the Fibre Channel Protocol (FCP), which is an approved ANSI standard that defines a Fibre Channel layer (FC-4) to transmit SCSI commands, data, and status information between a SCSI initiator and SCSI target.

FCP is implemented in all Fibre Channel devices, both host and storage devices, and is the only layer 4 standard for Fibre Channel being deployed today. It represents a clear, consistent way to take SCSI commands, convert them to serial format, and then send those commands on a network.

Fibre Channel Implementation

As Fibre Channel solutions have only been shipping for the past few years, implementation requires a significant overhaul for existing computing environments as illustrated in the following steps:

1. Buy and install a stand-alone Fibre Channel network (i.e. switches and cabling)
2. Install and deploy new (SAN) network management tools
3. Buy Fibre Channel-SCSI Routers for all non-native Fibre Channel devices (i.e. SCSI based tape libraries) and replace server host bus adapters with Fibre Channel host bus adapters

This upgrade can be a costly and time-consuming process. It also raises questions about IT managers committing resources to isolated technologies. For example, installing a Fibre Channel fabric requires a second network based on a new, unfamiliar technology. Enterprise backbones based on IP and Ethernet already exist in every corporate data center, metropolitan area network, and soon, wide area network. Deploying a second network using a new, different type of technology adds significant cost, particularly due to the need for separate network management systems, new training and education for IT personnel, and separate sourcing of new networking equipment.

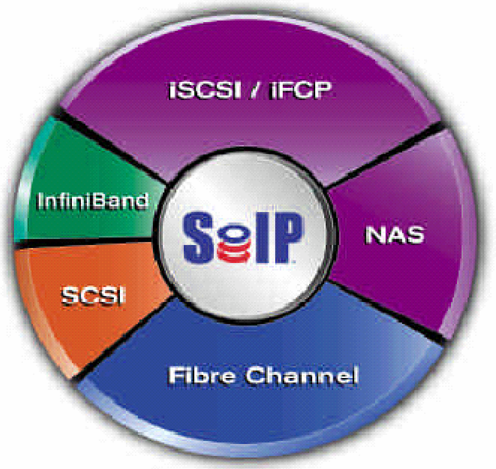
Given the costs of a separate networking technology for storage, and the overwhelming preference among the IT community for IP and Ethernet solutions, many have asked about using IP and Gigabit Ethernet for storage networking. Previously, the answer has been that IP and Gigabit Ethernet were not capable of carrying storage traffic. That has changed.

Storage over IP Framework

An Open Standards-based Architecture for IP Storage

The SoIP Framework is an open, standards-based architecture for deploying native IP storage solutions using the IP Storage standards within the IETF IP Storage Working Group such as iSCSI, iFCP and iSNS1. SoIP products are designed to support transparent interoperability of storage devices based on Fibre Channel, SCSI, and a new class of Gigabit Ethernet storage devices using iSCSI and iFCP. This means that any existing Fibre Channel or SCSI devices, such servers with host bus adapters (HBAs) or storage sub-systems can be included in an SoIP storage network without modification. Additionally, native IP Gigabit Ethernet storage devices using iSCSI or iFCP will seamlessly fit with SoIP products. This design blueprint is highlighted in Figure 1: SoIP Framework Vision.

Interfaces and Connectivity



iSCSI / iFCP using IP and Ethernet
- SAN, LAN, MAN, WAN
- IP Routers and Gigabit Ethernet Switches
- 10 Gigabit Ethernet

Network Attached Storage

Fibre Channel
- FC Host Bus Adapters
- FC Disk, RAID, Tape
- FC SANs

SCSI
- SCSI Disk, RAID, Tape
- SCSI Host Bus Adapters

InfiniBand
- Future Interfaces

Figure 1: SoIP Framework Vision

With all current storage interfaces included in the solution, SoIP products leverage the standards based IP network as the transport network for connectivity. For example, Fibre Channel servers and storage devices can be connected locally with Fibre Channel, but for fabric, campus, or longer distance connectivity, SoIP products use standard IP and Gigabit Ethernet. Additionally, native SoIP devices such as SoIP Adapters based on iSCSI can access any other device on the network using a Gigabit Ethernet connection.

Storage networks have been extremely beneficial to users by allowing them to separate local area network traffic from storage traffic. SoIP storage networks continue this flexibility, by allowing

iSCSI: Internet SCSI; iFCP: Internet Fibre Channel Protocol; iSNS: Internet Storage Name Service

The Charter for the IETF Working Group is at http://www.ietf.org/html.charters/ips-charter.html

storage traffic to be routed over a separate network. However, the second network can now be built with the same, universally familiar, existing IP and Ethernet technology.

Maintaining a “minimum disruption” design philosophy, SoIP products enable transparent use of existing and future SAN-aware host applications by adopting all existing storage network management services. SoIP products also fit as is with all existing operating systems and host applications. Most important in the design philosophy of the SoIP framework is that it meets the high performance requirements for storage. With an architectural model vastly different from networking, storage traffic has typically been deployed in dedicated point-to-point connections where speed and latency were minimized. On the other hand, most networking architectures have been designed with resiliency, error recovery, and scalability in mind. SoIP products have taken a best of both worlds approach and designed a storage networking solution that does not compromise the typical expectations for storage performance.

Benefits of an IP storage solution using the SoIP framework

SoIP products provide a range of benefits that stem from the ability to use proven, widespread networking technologies like IP and Gigabit Ethernet for storage solutions. Users can rapidly deploy storage for new business applications by using technologies they know and trust.
With wider connectivity options, SoIP SANs provide improved access to business-critical information. The physical storage equipment can now be placed anywhere on an IP and Gigabit Ethernet network. Investment protection and reduced training costs follow naturally by using existing network and storage expertise and common technology infrastructure. Specifically, common IP management tools can help drastically reduce the cost of storage and data management through consolidated and shared SoIP SANs.

Storage Traffic with SoIP Products

The SoIP framework is implemented through a family of networking products that link existing Fibre Channel, SCSI and Ethernet end devices with Gigabit Ethernet backbone networks. The end devices can be servers or storage devices with Fibre Channel, SCSI or Ethernet interfaces.
This allows for the integration of all existing storage equipment into an SoIP solution, and, the for direct incorporation of SoIP devices to the Gigabit Ethernet network.
Figure 2: SoIP Switch Traffic Flow, labels the directional mechanisms for SoIP products. Flow 1 represents intra-switch Fibre Channel traffic. When Fibre Channel servers and Fibre Channel storage devices are connected to the same switch, the traffic between them is handled just as it is in any Fibre Channel switch. Again, the “minimal disruption” design philosophy provides for immediate interoperability with current storage and SAN environments.
However, when storage traffic travels between switches, or over any distance, the power of SoIP storage networks is unleashed. In these cases, such as traffic flows 2 and 3 in Figure 2, SoIP products seamlessly and transparently map the Fibre Channel or SCSI traffic to IP and Gigabit Ethernet. Once the traffic is on Gigabit Ethernet, it can be carried through any standard Gigabit Ethernet equipment, and extended to metropolitan and wide area networks.
Traffic flows 4 and 5 represent provisions for new end devices. With IP storage in the data center, expect to see both Gigabit Ethernet adapter cards and Gigabit Ethernet storage subsystem device controllers that carry storage traffic. Additionally, devices based on the forthcoming InfiniBand interface are expected. Both of these developments can make use of the SoIP infrastructure.

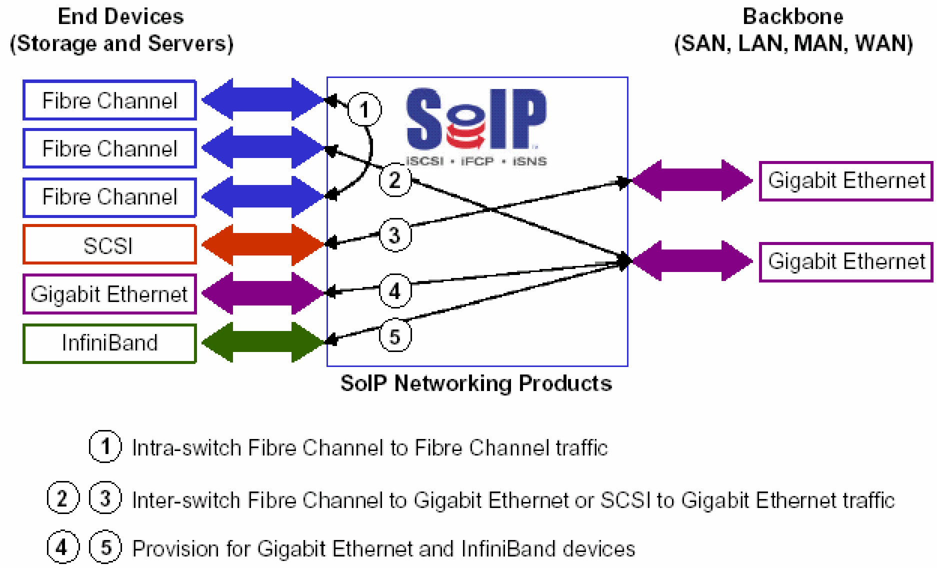


Figure 2: SoIP Switch Traffic Flow

Implementing SoIP Storage Networks

For enterprises that have chosen to implement SANs using Fibre Channel, SoIP storage networks provide an elegant solution to connect disparate SAN "islands" using standard IP and Gigabit Ethernet. Current Fibre Channel-only solutions require the use of a dedicated dark fiber optic cable to link over distance. Now, using SoIP networking products, storage configurations can be easily integrated. This example is highlighted in Figure 3: Linking Fibre Channel "Islands" with IP and Gigabit Ethernet.

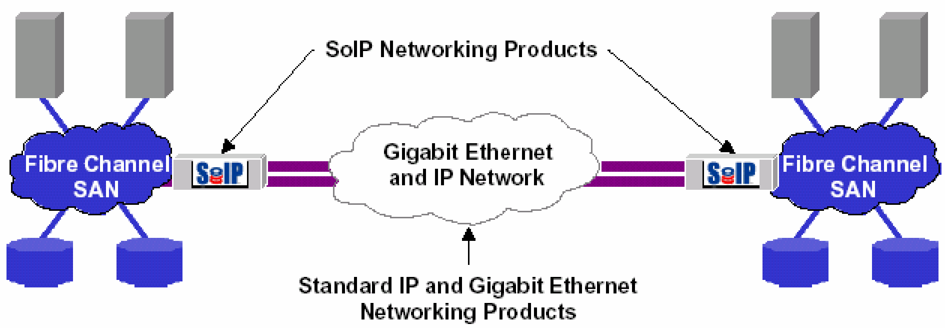


Figure 3: Linking Fibre Channel "Islands" with IP and Gigabit Ethernet

Far more interesting than linking Fibre Channel "islands" is the ability to deploy SoIP products directly in the SANs. This implementation allows users to maximize IP and Gigabit Ethernet networking capabilities, while making use of Fibre Channel and SCSI interfaces on servers or storage devices. The example in Figure 4 demonstrates this type of configuration. The key difference is that in the SoIP SAN configurations, all inter-switch links are built with standard IP and Gigabit Ethernet. This mirrors the networking implementation model deployed in the enterprise backbone. Through the use of this common infrastructure, deployment time and costs are significantly reduced.

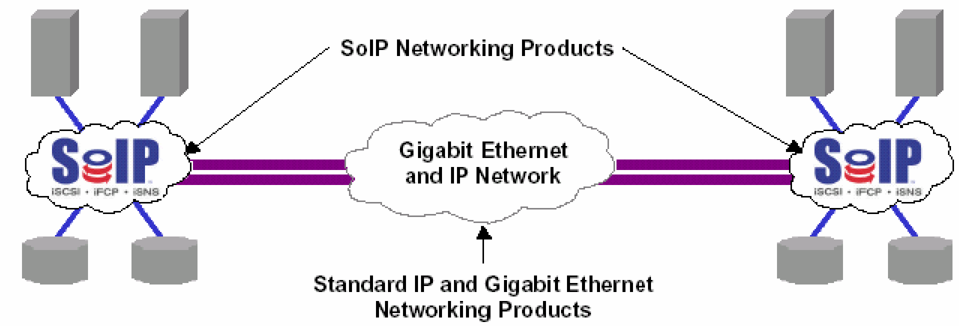


Figure 4: Native IP SANs linked via Standard IP and Gigabit Ethernet Networks

With a native IP SAN solution in place, IT managers can now rapidly deploy applications such as remote backup, mirroring and disaster recovery. The ability to develop highly scalable storage configurations is added through the reach and ubiquity of IP and Ethernet. And storage can be easily consolidated across hosts with an SoIP storage network.

Extending Storage to Metropolitan Area Networks with SoIP Storage Networks

Once storage traffic is on a Gigabit Ethernet and IP network, it can be easily extended to a metropolitan area network to connect to additional sites or service providers, such as storage service providers (SSPs). The example is highlighted in Figure 5: Extending Native IP SANs to MANs and SSPs. With SoIP storage networks, this link is completely transparent across the customer premises, the metropolitan area network, and the storage service provider. Each location can make use of the IP and Gigabit Ethernet features of SoIP products for a completely integrated solution.

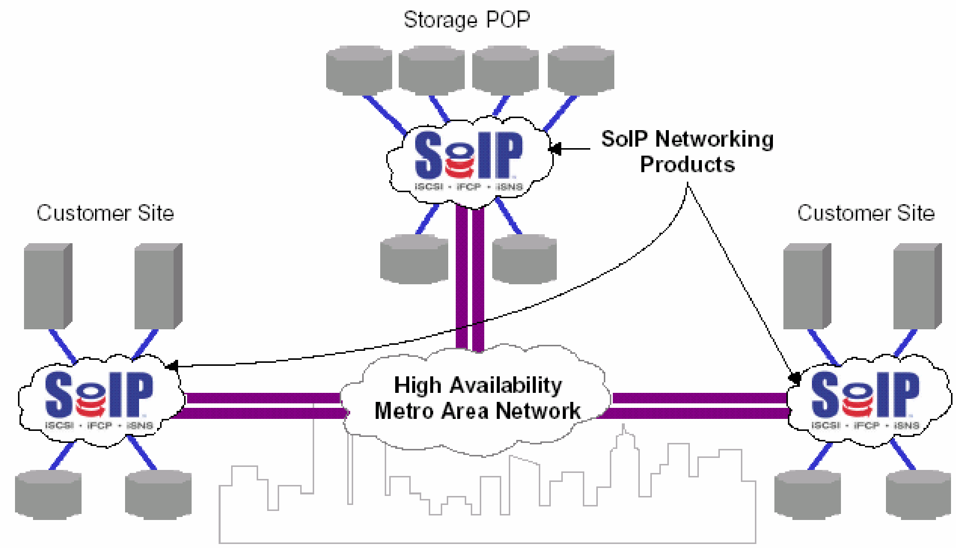


Figure 5: Extending Native IP SANs to MANs and SSPs

Storage over IP Framework — Vision and Implementation

Few doubt the dominance of IP and Ethernet in the networking world. Recently, the Enterprise Storage Group reported that assuming similar performance, 76% of senior IT executives believe IP will make it easier to implement large-scale storage networks. Rising to meet the expectations of the storage, computing and networking industries, the SoIP framework has answered the call of a vision dominated by IP networking, along with a logical, easy to implement strategy to get there. By combining best-of-breed approaches from the storage and networking industries, SoIP products allow customers to use existing infrastructure technology, then build upon it to develop an integrated, native IP storage network that works in local, metropolitan and wide area environments.