Storage Area Networks & Return on Investment

White Paper

Product Management
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Introduction

According to the International Data Corporation (IDC), the Random Array of Independent Disks (RAID) shipped in a recent one-year period reached 250 Petabyte ($10^{15}$). Consequently, in data-rich businesses projections show that data continues to grow at a phenomenal pace, driving this issue to the forefront as a discussion along with the need to find effective data storage and management solutions to support this growth. One such solution that would meet this need is the Storage Area Network (SAN). This paper details the many benefits derived from using a SAN to store and manage data along with other issues to think about when considering a SAN implementation.

Discussion details

The purpose of this white paper is as follows:

- To discuss the benefits that can result from SAN implementations
- To discuss SAN technology, security, and implementation
- To present a case study of a Datalink SAN implementation
- To describe various Return on Investment (ROI) methodologies and how to use them in the decision-making process to select an appropriate vendor partner, as well as justify a project such as a SAN, and measure its success

Audience

This white paper is directed toward persons having budgetary responsibility for making decisions about how to store and manage the continuous growth in data and the ever-increasing demand to have that data available nearly 24 hours a day, 7 days a week.
Storage Area Network Benefits

SANs promote high availability

<table>
<thead>
<tr>
<th>High-availability benefits</th>
<th>A SAN implementation provides the following high-availability benefits:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• With certain SAN architectures, data is available <em>(uptime)</em> from 99.99% of the time to 99.999% of the time. This translates to downtime <em>(planned or unplanned)</em> from 53 minutes per year to 5 minutes per year</td>
</tr>
<tr>
<td></td>
<td>• Overall reductions in planned and unplanned downtimes compared with the existing storage topology</td>
</tr>
<tr>
<td></td>
<td>• Perform data replication to remote sights for faster recovery in the event of an unexpected disaster</td>
</tr>
</tbody>
</table>

| Downtime                   | It is estimated that roughly 30% of business-application downtime results from data storage failures. With a SAN implementation, that statistic can be reduced significantly because data storage failures that could impact data availability to that degree are highly unlikely with SAN technology—which features fewer storage devices and improves storage management capabilities. Also, any additional tape or disk storage subsystems can be added to the SAN fabric dynamically. |

| Downtime and revenue losses | Table 1 shows some examples of how much revenue can be lost in one hour due to downtime. When revenue losses accumulate over the course of one year they become very significant. |

*Continued on next page*
**SANs promote high availability, continued**

Table 1: Cost of Downtime (dollar amounts in millions)

<table>
<thead>
<tr>
<th>Business Applications</th>
<th>DT Cost ($M/hr)</th>
<th>99% Uptime (88 hrs/yr DT)</th>
<th>99.5% Uptime (44 hrs/yr DT)</th>
<th>99.9% Uptime (9 hrs/yr DT)</th>
<th>99.99% Uptime (1 hr/yr DT)</th>
<th>99.999% Uptime (5 mins/yr DT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brokerage</td>
<td>$7.80M</td>
<td>$686M</td>
<td>$343M</td>
<td>$70M</td>
<td>$8M</td>
<td>$0.68M</td>
</tr>
<tr>
<td>Phone Company</td>
<td>$5.10M</td>
<td>$449M</td>
<td>$224M</td>
<td>$46M</td>
<td>$5M</td>
<td>$0.45M</td>
</tr>
<tr>
<td>Credit Cards</td>
<td>$3.20M</td>
<td>$282M</td>
<td>$141M</td>
<td>$29M</td>
<td>$3M</td>
<td>$0.28M</td>
</tr>
<tr>
<td>B2B E-commerce Site</td>
<td>$2.50M</td>
<td>$220M</td>
<td>$110M</td>
<td>$23M</td>
<td>$3M</td>
<td>$0.22M</td>
</tr>
<tr>
<td>Home Shopping</td>
<td>$1.10M</td>
<td>$097M</td>
<td>$048M</td>
<td>$10M</td>
<td>$1M</td>
<td>$0.10M</td>
</tr>
<tr>
<td>e-Bay</td>
<td>$0.72M</td>
<td>$063M</td>
<td>$032M</td>
<td>$07M</td>
<td>$0.72M</td>
<td>$0.06M</td>
</tr>
<tr>
<td>Pay Per View</td>
<td>$0.58M</td>
<td>$051M</td>
<td>$026M</td>
<td>$04M</td>
<td>$0.58M</td>
<td>$0.05M</td>
</tr>
<tr>
<td>Catalog Sales</td>
<td>$0.43M</td>
<td>$038M</td>
<td>$019M</td>
<td>$04M</td>
<td>$0.43M</td>
<td>$0.04M</td>
</tr>
<tr>
<td>Hotel/Car Reservations</td>
<td>$0.40M</td>
<td>$035M</td>
<td>$018M</td>
<td>$04M</td>
<td>$0.40M</td>
<td>$0.04M</td>
</tr>
<tr>
<td>Airline Reservations</td>
<td>$0.21M</td>
<td>$019M</td>
<td>$009M</td>
<td>$02M</td>
<td>$0.21M</td>
<td>$0.02M</td>
</tr>
<tr>
<td>Package Shipping</td>
<td>$0.20M</td>
<td>$018M</td>
<td>$009M</td>
<td>$02M</td>
<td>$0.20M</td>
<td>$0.02M</td>
</tr>
<tr>
<td>ATM Service Fees</td>
<td>$0.02M</td>
<td>$002M</td>
<td>$001M</td>
<td>$0.18M</td>
<td>$0.02M</td>
<td>$0.02M</td>
</tr>
</tbody>
</table>

Uptime

The uptimes permitted for various availability environments are shown in Table 2.

Table 2: Uptimes for Various Availability Environments

<table>
<thead>
<tr>
<th>Availability Environments</th>
<th>Downtime Hours /Minutes Per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>99%</td>
<td>87:36</td>
</tr>
<tr>
<td>99.9%</td>
<td>08:45</td>
</tr>
<tr>
<td>99.99%</td>
<td>00:53</td>
</tr>
<tr>
<td>99.999% (5–Nines)</td>
<td>00:05</td>
</tr>
</tbody>
</table>

Data replication and disaster recovery

With SANs, data replication can be applied to storage at the controller, switch, or Operating System (OS) level; this provides the capacity to create multiple copies of critical data, and then move those copies to other parts of the SAN, or over a Wide Area Network (WAN) for remote protection. For disaster planning purposes, the organization needs to consider two things:

1. What would be the cost per hour to the organization while it is without its data?
2. How long can the organization afford to go without its data before revenue losses lead to the very real possibility that the business might not recover?
SANs improve data storage management and reduce costs

**Data storage management benefits**

A SAN implementation can actualize the following data storage management benefits:

- Staffing requirements for storage management can be reduced significantly
- Administrators can support over 40% more storage in a SAN environment than in direct-attached environments
- Fewer tape libraries for backup
- Reduction in application Central Process Unit (CPU) cycles with the process of off-host backups
- Improved server use in terms of server processing cycles
- Data storage costs can be allocated to departments based on need

**SANs permit managing more data with fewer people**

In a Storage Management Solutions article, an organization had two-and-one-half people dedicated to managing backups alone. After implementing a SAN, only one-half person was needed to manage the backups. This actualizes a manpower reduction of 80%.

**Data storage and the IT budget**

Throughout most of the 1990s, storage was a relatively small part of the IT budget and was typically attached directly to servers in the data center. Over the past few years, this has all changed dramatically. Storage growth rates have driven storage to or near the top of the IT capital budget. In fact, by 2004, storage will account for almost half the typical IT budget (*source: CIO Magazine*).

On average, SAN solutions permit managing much larger data volumes per person than is possible with other storage configurations. In addition, under a SAN scenario other resources can be freed up and applied to other areas within the data center.

**Data in distributed islands**

In terms of the overall storage management budget, analysts state that storing given amounts of data in distributed islands throughout the enterprise could well consume more than half the operational management budget. When centralizing those islands of data into a SAN, dramatic management efficiencies result, reducing this expense to less than half the storage management budget.

*Continued on next page*
SANs improve data storage management and reduce costs, continued

**SANs reduce data storage and mgmt. costs**

With such a large part of the budget designated for data storage, any viable strategy to reduce this cost should be considered—making SANs not only viable, but also a proven solution for reducing data storage hardware requirements and management costs.

**SANs enable enhanced cost allocation capability**

Within a SAN, capacity can be added as needed, enabling on-demand scalability and continuous availability. Many organizations have capitalized on those SAN benefits by separating storage purchasing decisions from server and application purchasing decisions. This radical shift in procurement has led to storage consolidation as well as unique cost allocation capabilities for IT managers. This enhanced cost allocation capability provides IT managers with the ability to calculate the cost of storage per managed gigabyte within a SAN, which can be applied to any project or application requiring storage. This fixed cost could include disk and tape hardware, software, and any labor dollars linked to managing the data storage (source: Accenture). This also gives IT managers the ability to evaluate and allocate storage based on departmental needs, which improves managing the cost of storing the data.
### SANs enable efficient hardware deployment and utilization

**SAN hardware deployment and utilization benefits**

SANs promote efficient use of hardware, actualizing the following benefits:

- Better use of hard disk and tape drives, thereby reducing the number of tape drives required
- Fewer servers purchased for storage, especially in an NT environment
- Fewer backup servers required
- Centralizing or pooling storage will free data-center floor space; this is especially critical if floor space is completely used up and the organization is considering a move, building a new data center, or leasing co-location space
- With reductions in hardware and software there will be a reduction in annual maintenance costs
- Reduction in power and cooling requirements

**Disk capacity utilization**

With a SAN implementation, disk space utilization will increase significantly. Businesses often see disk space utilization improve from 35% – 40%, up to 80% after storage consolidation, using SAN technology. This reduces acquisition, floor space, and power costs.

**Declining disk drive costs**

Another point to consider is the declining cost of disk drives. The disk drives purchased today will have less capacity and will cost more than those purchased tomorrow. Disk drives will continue a significant decline in price due to advances in disk-drive technology. As a result, higher utilization allows the deferment of capacity upgrades, taking full advantage of declining prices.

**Tape storage subsystems in direct-attached environments**

In a direct-attach environment, the tape storage subsystem connects directly to the server through the Host Bus Adapter (HBA). When the server is not using this storage resource, it remains in an idle state; hence, some tape drives endure heavy use while others do not. If all tape drives were used to their maximum capacity, fewer would be required. In a SAN, tape drives can be dynamically allocated so that the tape storage subsystem performs more efficiently by maximizing tape drive utilization.

*Continued on next page*
SANs enable efficient hardware deployment and utilization, continued

**Tape drive utilization and purchases**

In a SAN environment, the tape library subsystem connects to the SAN fabric where multiple servers can share its tape drives. Backups can occur more frequently because drive availability increases. This reduces the cost of tape drives and possibly the number of libraries and autoloaders required, especially when a centralized library can handle all backups. See Figure 1. When there is a need for more capacity, additional tape drives can be added, rather than purchasing additional tape library subsystems. With the implementation of a SAN solution and depending on the number of tape drives, tape-drive utilization could increase to nearly 100%.

Additionally, there are two other cost considerations:

1. Cost estimates for a tape drive
2. Cost estimates for a library slot

Obviously, any reduction in tape drives or library slots will also lead to additional cost savings.

![Figure 1: Tape Library Subsystem with Shared Tape Drives on a SAN](image-url)
**SANs enable efficient hardware deployment and utilization, continued**

**Server utilization and purchases**

With a SAN implementation, the organization can expect the following efficiencies and improvements associated with servers:

- A reduction in the number of servers purchased strictly for storage purposes
- A reduction in the number of backup servers
- The implementation of off-host backups (*new software technology*)

**Rack and floor space reductions**

By pooling data there is the potential to save floor space, using storage subsystems with more utilized GB per square foot. Some organizations could experience additional savings, especially if there is little room in an existing data center, and the cost of moving or building a new data center would be significant. The organization would have to calculate the cost per square foot and the potential savings based on the particular configuration of their data center. This may be especially significant in high-availability environments where redundant systems are placed in leased, co-location facilities. This improvement in utilization extends to power and cooling requirements as well.

**SANs and interoperability**

Taking full advantage of the SAN infrastructure, storage subsystems purchased today can operate seamlessly with those purchased in the future, leading to extended life cycles for all storage subsystems.

**SANs support maintenance cost reductions**

With reductions in hardware (*disk drives, tape drives, servers, etc.*), the overall cost of maintenance contracts will go down, offset somewhat by added storage networking hardware and software. Moreover, with this reduction should come a proportional reduction in manpower time spent working on failed hardware; conversely, as the amount of hardware increases so does the possibility of mechanical failures.
### SANs enable storage virtualization

<table>
<thead>
<tr>
<th>SAN storage virtualization benefits</th>
<th>SANs actualize the following storage virtualization benefits:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Non-disruptive growth, eliminating server downtime when adding storage hardware</td>
</tr>
<tr>
<td></td>
<td>• Extending expected life of servers and storage subsystem hardware</td>
</tr>
<tr>
<td></td>
<td>• Storage pooling</td>
</tr>
<tr>
<td></td>
<td>• Same class of service</td>
</tr>
<tr>
<td></td>
<td>• Same environment</td>
</tr>
<tr>
<td></td>
<td>• Flexibility and efficiency</td>
</tr>
</tbody>
</table>

| What is storage virtualization? | Storage virtualization is taking RAID storage subsystems and pooling their disk capacities. In a SAN, all RAID storage subsystems are connected to the fabric and used as one large storage pool. This optimizes disk capacity, allowing multiple servers to use the pooled disks regardless of the operating system or manufacturer. You can also use multiple servers in direct-attached environments, but there are limited numbers of ports available on RAID storage subsystems. |

| Storage virtualization efficiencies | Storage virtualization flexibility and efficiencies are dependent upon criteria such as the number of storage subsystems being consolidated, their heterogeneous availability, and future RAID storage-subsystem purchases. |

<table>
<thead>
<tr>
<th>SANs and direct-attached storage</th>
<th>Typically, with Direct-Attached Storage (DAS) there are issues concerning:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Data storage management</td>
</tr>
<tr>
<td></td>
<td>• Storage allocation</td>
</tr>
<tr>
<td></td>
<td>• Availability</td>
</tr>
<tr>
<td></td>
<td>• Cost</td>
</tr>
<tr>
<td></td>
<td>• Data recovery</td>
</tr>
<tr>
<td></td>
<td>After implementing a SAN, the existing DAS can be used for other purposes such as:</td>
</tr>
<tr>
<td></td>
<td>• Third copy mirrors</td>
</tr>
<tr>
<td></td>
<td>• Disaster recovery</td>
</tr>
<tr>
<td></td>
<td>• Operating system migration</td>
</tr>
</tbody>
</table>
SANs improve data backup efficiency and accessibility

<table>
<thead>
<tr>
<th>SAN data backup and access benefits</th>
<th>SANs promote the following benefits:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Improved data availability and performance speed</td>
</tr>
<tr>
<td></td>
<td>• Number of connections to storage subsystems can be easily scaled for both availability and performance</td>
</tr>
<tr>
<td></td>
<td>• Access to data is faster, easier, and more reliable</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data backup methods</th>
<th>There are three effective methods used to backup data:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Distributed</td>
</tr>
<tr>
<td></td>
<td>• Centralized <em>(conventional)</em></td>
</tr>
<tr>
<td></td>
<td>• SAN</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Backups in distributed environments</th>
<th>In distributed environments, storage subsystems are directly attached to servers. See Figure 2. Distributed backups require IT personnel to touch each system physically <em>(i.e., handling tapes)</em> to perform backup operations. If the server data exceeds the tape capacity <em>(which is usually the case)</em>, the IT person must monitor the operation and reload new tapes at the proper time.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Distributed environments are fragmented in the following circumstances:</td>
</tr>
<tr>
<td></td>
<td>• When storage is isolated on individual servers <em>(storage islands)</em></td>
</tr>
<tr>
<td></td>
<td>• When there are point-to-point SCSI connections only</td>
</tr>
<tr>
<td></td>
<td>• When there is a one-to-one relationship between servers and storage subsystems, creating storage islands, which scale poorly and are difficult to centrally manage</td>
</tr>
</tbody>
</table>

![Figure 2: Distributed Backup Environment](chart)

*Continued on next page*
SANs improve data backup efficiency and accessibility, continued

In conventional-centralized environments, a storage subsystem is attached to one server, and all other systems are backed up to that storage subsystem through the server and over the Local Area Network (LAN). See Figure 3. Conventional-centralized backups limit management overhead to a single storage subsystem. The challenge is not managing the storage subsystem, but getting the data to it. Conventional-centralized backup solutions rely on an Internet Protocol (IP) network as the data path. The problem with this is that the Transmission Control Protocol/Internet Protocol (TCP/IP) processing associated with transporting the sheer volume of data can adversely impact server CPU cycles. This results in long-backup cycles that exceed the scheduled backup window. Therefore, conventional-centralized backups often overflow into user uptime, resulting in poor network response and generally unacceptable server performance. This method is an improvement over the distributed method, but it still has inefficiencies:

Pros:
- Centralizes the storage in fewer locations and on fewer platforms
- Requires fewer backup servers and software packages
- Uses centralized administration
- Results in fewer human errors

Cons:
- Backup bottlenecks develop on the LAN
- Bottlenecks become more frequent as storage needs grow
- Still managing multiple separate backup servers
- Typically uses the same LAN for production and data backups
- Many-to-one relationship between servers and the storage subsystem

Figure 3: Conventional-Centralized Backup Environment
SANs improve data backup efficiency and accessibility, continued

**Backups in SAN environments**
In SAN environments, storage subsystems are attached to the SAN fabric where all servers potentially have equal access to them. See Figure 4 on the next page. SANs offer the following efficiencies and advantages over conventional-centralized and distributed backup methods:

- The entire storage-network infrastructure can be off-loaded from the LAN, promoting LAN-free backups—20% or more of LAN traffic can be due to backups
- Significant improvements in backup times, since data is moved at Fibre Channel (FC) speeds over dedicated storage networks, rather than at Ethernet speeds over a shared network
- Fewer network interruptions when adding incremental storage hardware
- Reduces or eliminates backup windows
- Promotes on-the-fly scaling (*non-disruptive*) rather than set-planned downtime windows
- Extends the life expectancy of servers
- Enables off-host backups where data transfers directly from storage disks to tape libraries, bypassing the server, and reducing server loads

**Configuration of the network and backups**
The network’s configuration will be a factor also. If some servers are distributed, expect heavy LAN traffic during backups and restores. If backups for remote systems without high availability occur overnight then network use should not be a major concern.
SAN Architectures

SAN technology

What is a SAN?  In its purest sense, a SAN is a separate computer network typically based on a 'fabric' of fibre channel switches and hubs, connecting storage subsystems to a heterogeneous set of servers on an any-to-any basis. A SAN enables direct storage-to-storage interconnectivity and lends itself to exploiting new breeds of clustering technology. See Figure 4. SANs can also get the best out of Network-Attached Storage (NAS) subsystems that can intelligently provide disk and tape capabilities to one or more servers.

Figure 4: Storage Area Network

Continued on next page
**SAN technology, continued**

| **Fibre channel and SCSI connectivity** | FC technology links network devices such as standard and director-class switches, and HBAs within the SAN. FC interfaces link large disk and tape storage subsystems similar to that of HBAs. In addition, legacy SCSI devices integrate within the SAN fabric using SCSI-to-fibre bridging devices. Manufacturers of large disk and tape storage subsystems also integrate bridging technology to enable SAN attachment for those storage subsystems that use SCSI-based back ends. |
| **Redundant data paths and true five-nines** | Robust SAN designs include at least two data paths between any server and disk storage subsystem, such as a RAID. By using redundant data paths in concert with FC director switches, a true five-nines environment can be achieved. Additionally, the any-to-any connectivity of SAN devices gives IT departments the flexibility and portability for data requirements in dynamic environments. |
| **Proprietary and open SAN architectures** | SAN architectures range from those that are “proprietary” to those that are “open.”
- Proprietary SAN architectures are sourced from a single manufacturer who serves as the single point of contact for SAN hardware, software, and services. These architectures are usually limited in flexibility for two reasons:
  1. Hardware manufacturers traditionally specialize in one area such as enterprise storage subsystems, and could have limited experience in areas such as tape, software configuration, and overall storage management.
  2. A limited suite of technologies is at their disposal, inhibiting their ability to tailor their architecture to the business needs of the organization. However, these single-source solutions can be effective for organizations that have limited staff expertise, and can adapt their business needs to the vendor’s specialized architecture.
- Conversely, open-SAN architectures typically consist of hardware and software from more than one manufacturer. More flexible in nature, this approach leverages best-of-breed technologies and services to meet specific business needs. The storage architect’s integration experience with multi-vendor technologies is critical to ensure interoperability, optimal performance, and functionality. |
| **Environments suitable for a SAN** | Environments that are suitable for a SAN are those that require highly sustained throughput and high availability, with continuously growing data. |
SAN security

When the word “security” is used in association with a SAN, thoughts can easily lead to computer hackers infiltrating the network and causing havoc. Although hacker invasions are a concern, there is another security issue associated with a SAN that must be addressed, and that is the issue of technology containment. For example, Windows NT servers would naturally claim every available Logical Unit Number (LUN) visible to them. In brief, technology containment keeps servers from gaining unauthorized or accidental access to undesignated areas within the SAN. The two major areas of concern with SAN implementations are data access and fabric management security.

Open systems security

Open systems offer many different file systems, volume and disk management formats and software requiring that security issues be considered and then implemented during the SAN design and development phase, for the following reasons:

- Data access and security
- Fabric management and security (protection from outside threats)
- Higher levels of availability to data and the applications that use the data

Data access and security methodologies

The following are data access and security methodologies:

- **Fabric zoning is fabric-centric enforcement**: It provides a fabric port-and-host/storage-level point of logical partitioning and can help ensure that different OS types or applications are partitioned on the SAN. Fabric zoning is managed and enforced on the SAN fabric. Fabric zoning cannot mask individual LUNs that sit behind a port. All hosts connected to the same port will see all the LUNs addressed through that port.

- **LUN Masking is RAID storage subsystem-centric enforcement**: LUN Masking is configured at the RAID storage subsystem level; this helps ensure that only designated hosts assigned to that single storage port could access the specified RAID LUN.

- **Persistent Binding is host-centric enforcement**: This consistently forces a host to see a specific storage-subsystem port as a particular SCSI target. Persistent binding also helps ensure that a specific storage-subsystem port on the SAN is always seen as the same SCSI Target ID on the host, across the host and fabric, and throughout storage configuration changes. OS and upper-level applications (such as LAN-free backup software) typically require a static or predictable SCSI Target ID for storage and reliability purposes.

Continued on next page
**SAN security, continued**

### Data access and security methodologies (continued)

- LUN Mapping, in addition to persistent binding, is another host-centric method of storage visibility management. LUN Mapping selectively allows a system administrator to scan for specified SCSI targets and LUNs at storage-driver boot time and to ignore selectively non-specified SCSI targets and LUNs. The advantage of LUN Mapping is that it provides a level of security management in SANs where LUN Masking is not an option, perhaps because it is not supported on the storage hardware. The disadvantage is that LUN Mapping is configured and enabled on a host-by-host basis. It requires good coordination among the administrators of the systems sharing the storage, which ensures that only one host sees certain storage unless planned, as in a clustered server configuration.

### Fabric management and security technologies

The following technologies protect and manage the fabric:

- **Fabric-to-Fabric Security** technologies allow Access Control Lists (ACLs) to allow or deny the addition of new switches to the fabric. Public Key Infrastructure (PKI) technology may be applied as a mechanism for validating the identity of the new switch. Also, fabric-wide security databases help ensure that all new authorized switches added to the fabric inherit fabric-wide security policies, so that a new out-of-the-box switch does not become a non-secured access point.

- **Host-to-Fabric Security** technologies can apply ACLs at the port-level on the fabric, and allow or deny a particular host’s FC HBA to attach to that port. This would prevent an unauthorized intruder host from attaching to the fabric via any port. The host’s ability to log into the fabric is clearly defined and is allowed with this model.

- **Management-to-Fabric** technologies can use PKI and other encryption (*such as MD5*) technologies to ensure a trusted and secure management console-to-fabric communication layer exists. This will help ensure that the management console or framework used to control the SAN fabric is valid and authorized.

- **Configuration Integrity** technologies ensure that propagated fabric configuration changes only come from one location at a time, and are correctly propagated to all switches on the SAN fabric with integrity. Distributed lock managers can ensure that only serial and valid configuration changes are enabled on the fabric.

### SAN security white paper

Implementing a SAN

When an organization wants to implement a SAN, it needs to consider the following questions concerning its existing storage infrastructure:

- Can we afford to continue with the existing storage infrastructure, if so, for how long?
- What would be the costs related to scaling the existing storage infrastructure?
- What would be some of the other associated and intangible costs associated with the existing storage infrastructure?
- What would be the cost projections when a SAN or some other storage solution becomes a feasible alternative?
- What are the inherent risks associated with continuing to use the existing storage infrastructure versus moving to a SAN?
- What would be an appropriate exit strategy?
- Should we use in-house IT resources, or develop a partnership with a storage architect to implement the SAN?

When the decision is made to implement a SAN, the organization needs to develop a solid SAN implementation strategy to ensure that a measurable return on the investment can be shown.

Continued on next page
Implementing a SAN, continued

Most IT departments do not have the expertise with SAN technology to make an informed assessment of the various available options or to calculate a return on the investment as it concerns SANs. The cost to develop this expertise could be significant, both in actual dollars spent and in opportunity costs related to deployment of scarce IT resources. The costs could literally range from a few thousand to millions of dollars, depending on the size and complexity of the proposed SAN.

Areas of potential cost consideration when analyzing, designing, and implementing a SAN solution with in-house IT resources doing the work are the following:

Educating IT employees:
- Training costs
- Time

Testing the interoperability of the various components:
- Time
- Determining component costs
- Determining which equipment to test
- Determining best-of-breed products

Sorting of vendors:
- Determining the best vendor for each product

Developing the expertise for the SAN implementation:
- Developing the design methodology
- Installing the SAN
- Testing the SAN implementation
- Identifying problems
- Providing technical support

Staying current with evolving technology:
- Storage roadmaps
- Incorporating future products

Those are all potential areas of cost that an organization must consider when planning to implement a SAN with in-house IT personnel doing the work. Given that, perhaps the best strategy would be to form a partnership with a SAN integration vendor. There are many SAN vendors to choose from, including storage technology manufacturers, platform providers, and independent storage architects.

Continued on next page
Implementing a SAN, continued

**Choosing a SAN vendor partner**
SAN integration vendor partners can play a critical role in analyzing, designing, implementing, and supporting the implemented SAN infrastructure. Largely, a measurable ROI is dependent upon the chosen SAN integration vendor partner. The organization should consider the following when choosing a vendor partner:

- The vendor’s experience and expertise with implementing enterprise storage solutions in heterogeneous environments
- The vendor’s ability to ask the right questions and gather the right data to analyze the present and future data storage management needs of the organization
- The vendor’s grasp and ability to communicate and use quantitative analysis methodologies to calculate returns on investments
- The vendor’s organizational fit, qualitatively *(reputation, technology, references, etc.)*

**Independent storage architects as partners**
Independent storage architects *(such as Datalink)* are not tied to one particular platform or technology. They have the flexibility to build solutions using best-of-breed technologies. Their independence affords them access to technologies from a variety of vendors, enabling them to test and certify all components of the proposed storage architecture.

Additionally, storage architects have direct access to key contacts at most top-tier storage technology manufacturers; as a result, they are privy to technology roadmaps and are well positioned to build and integrate scalable products for the future.

Notably, storage architects have a considerable advantage due to their expertise in analyzing, designing, implementing, and supporting multi-vendor technologies in heterogeneous environments—which is not true for storage technology manufacturers and platform providers.

**Storage technology manufacturers as partners**
Storage technology manufacturers also offer SAN solutions, but their specialty lies in their own technologies; as such, their solutions are most often positioned as "SAN In A Can." While this approach minimizes the vendor’s role, it does not offer the customer best-of-breed technologies.

**Platform providers as partners**
Platform providers also offer SAN solutions, but their specialty is mainly in supporting SAN solutions in homogeneous environments featuring their own platform. However, they are not as well informed working in heterogeneous environments where NT, UNIX, and Linux platforms could be operating.
Justifying a SAN

In today’s business climate, project justification is a necessary part of the business culture. It would be ludicrous to consider doing a project that could cost hundreds of thousands or even millions of dollars without calculating the potential return on that investment. It is simply good business fundamentals to qualify and quantify the justification used to determine project feasibility and success, especially when a SAN is being considered.

The organization’s questions of concern when considering a SAN implementation should be the following:

• Will the SAN help actualize the executive team’s vision for the organization?
• Will the SAN help move the organization toward its goals?

Each executive team has a vision and a set of goals that they want the organization to embrace and to achieve. Obviously, the funds to achieve those goals are limited, so maximizing those funds is critical for all businesses. An ROI analysis can give some insight into which projects should be prioritized for implementation. All organizations that practice good business fundamentals will require not just a slanted ROI analysis, but one that is impartial and equates with different ROI methodologies.

Without doing a quantitative ROI analysis decisions will be made with limited scope and understanding, i.e., qualitatively. A quantitative analysis defines and sets expectations for the project’s success or failure, which is essential when considering a SAN. A quantitative analysis permits evaluating the project’s overall impact on the organization, answering the question: Is the cost of doing this project worthwhile, or should the dollars be spent on another project or venture?

Again, without an ROI analysis, decisions would be arrived at by a qualitative assessment alone, forcing the following concerns:

• Can the so-called subject-matter expert be trusted?
• Is the vendor reputable?
• Is the technology a good fit for the organization?
• Will the hardware be compatible with tomorrow’s technologies?

While those questions should be asked in any case, an ROI analysis will present a quantitative assessment of the project, leading to concrete answers to some of those questions and many others, if done correctly.
Understanding the variables used in the vendor’s ROI analysis

One of the most abused analysis methodologies in business currently is ROI analysis. It is very easy to mislead the organization with high expectations. It is possible to justify any project quantitatively. Vendors will sometimes slant their ROI analysis using data that will make the project appear feasible and some will intentionally distort the analysis results to benefit themselves. The key for the organization is to understand the variables being used to construct the ROI analysis tool and the data used to justify the results.

Data quality and the ROI tool

Along with the variables or parameters associated with the ROI tool, the actual data being used must be as honest and accurate as possible. It is not always the integrity of the ROI tool in question, but the quality of the data being processed. The most refined tool in the industry could be rendered useless without good data. The phrase “Garbage In Garbage Out” is very appropriate when using an ROI tool; hence, make sure that the data is the best available. Taking the time to collect the proper data and correctly using the selected ROI tool will yield the best possible results. Additionally, any time a vendor becomes uncomfortable with the organization’s desire to use their ROI tool to input the data it wants, a red flag should go up. The organization should be able to use the tool and view multiple scenarios if need be. It is critical to look at the parameters used, and then test the tool to ensure that the data is valid.

Vendor’s role in the ROI analysis

For the vendor, a big concern is the knowledge level of the organization using the proposed ROI tool. Vendors should have the following concerns when exporting their ROI methodology to an organization:

- Does the organization understand ROI analysis and the many methods used to obtain results?
- Does the organization understand Net Present Value, Internal Rate of Return, Payback, and Discounted Payback analysis methodologies?
- Does the organization understand the ROI tool that will be used?

It may be necessary for the vendor to educate or re-educate the organization in some or all those areas.

Continued on next page
**Justifying a SAN, continued**

**ROI checklist**

Keep these points in mind when performing an ROI analysis:

- Do not manipulate the input numbers to achieve a specific outcome
- Consider all costs associated with the SAN implementation
- If you guess or adjust the input numbers, make sure that there is some rationale behind your numbers and assumptions
- Make sure that the costs and benefits match within the same scope associated with the SAN implementation
- Consider indirect areas that can incur costs
- Consider the indirect benefits of a SAN
- Give the business aspects of a SAN implementation the correct level of attention, and do not just focus on the technology
- Do not assume that since you are going to do the project anyway, that there is no need to measure the ROI

**Measuring project success requires both qualitative and quantitative methodologies**

In the world of statistical magic, theory and reality can lead an organization to very different conclusions when it comes to analyzing project successes. In theory, some important characteristics can be learned from a qualitative assessment; but with many unknown variables to consider when the attempt is to validate the worth of a project, a qualitative assessment alone would render inconclusive results. Additionally, with the potential costs of implementing a project on the scale of a SAN, results based on qualitative factors alone (no quantitative analysis) will not give an accurate return on the investment. Keep in mind, variables can and most likely will change over the proposed timeframe for the project, developing the real need for effective quantitative analysis methodologies. Therefore, in reality, organizations must use both qualitative and quantitative methodologies if the outcome is to result in a good business decision and to actualize an accurate and measurable return on an investment.

**Case study**

The next section presents a case study of a Datalink SAN implementation at a customer site, which will actualize the discussion to this point.
SAN Implementation Case Study

Environment before the SAN implementation

Introduction

This customer is having critical issues with system failures, data backups, and network bandwidth problems. The environment is heterogeneous. Datalink’s task was to analyze, design, implement, and support a storage solution that would address the organization’s current and future data storage and management needs. The analysis revealed that a SAN solution would make good sense financially and operationally for this organization. This case study presents SAN phases one and two of the implementation and the resulting ROI.

Evaluation parameters

An effective way to evaluate the ROI value of a SAN implementation is the following:

1. Take an existing environment (before the SAN implementation) and forecast the associated costs (people, equipment, etc.) to maintain that environment in a one-, two-, or three-year timeframe. Some important measurement criteria would be:
   - Scalability
   - Manageability
   - Human resources
   - Hardware utilization

2. Then take the actual or projected costs (people, equipment, etc.) after the SAN implementation, and compare the before and after scenarios.

In this Case Study, the results were assessed within a two-year period.

Continued on next page
Environment before the SAN implementation, continued

The original environment
- Servers, 150 (NT and Netware) and 75-mid-range RAID storage subsystems (30 Bay) – 45% disk utilization
- Seven admin people (six for server applications and disk management, and one for tape backup)
- Maintenance upgrades – take six weeks
- Break/fix (mid-range, 10-12 hours/per unit/per year)
- More people involved and inconsistent administration
- Administration from multiple locations
- LAN backup only
- Exchange server backups – 28 hours
- Not able to allocate storage costs to corporate departments if desired
- Adding new capacity (three weeks – buy and install)
- Migration of servers
- 9 TB managed
- Each server had a direct-attached tape subsystem (drive, autoloader, etc.)
- All backups were performed individually and averaged about a 60% completion rate

Data-management challenges
With this organization’s data requirements continuing to grow rapidly, it was a challenge to figure out how to manage this growth. The data-management issues and associated costs looked like this:
- Six people were required to manage 9 TB of stored data (1.5 TB per person), where it cost approximately $67K to manage a terabyte of data (6 people at $100K salary divided by 9 TB, equals approximately $67K).
- The analysis showed that the organization’s data would grow to about 35 TB in the near future, which is an increase in data by an approximate factor of four. This translates to an additional 18 people needed to manage that growth in data. Hence, the organization would need to add an additional 18 people to manage the data growth: Currently 6 + 18 = 24 people—which would mean an additional $1.8M (18 people at $100K each) in salary.

Continued on next page
Environment before the SAN implementation, continued

**Downtime challenges of the existing environment**

This organization receives orders online; consequently, downtime becomes a costly event. The organization was experiencing approximately 12 hours of unplanned downtime per year for each of the 75 disk subsystems—although not all of the subsystems failed at the same time. Further analysis showed that within two years, the downtime would be approximately 24 hours per disk subsystem.

**Downtime analysis of the existing environment**

The downtime costs were estimated from $200K to many millions in lost revenue per hour. The conservative estimate showed that the organization was losing about $500K per hour due to downtime. When applying that figure to the downtime of the existing environment over the next two years, the cost would be $12M in lost revenue at the end of the two-year timeframe.

If you divide $500K across 75 disk-array subsystems, the total would be about $6.7K cost per hour of downtime per disk subsystem. Additionally, considering the downtime for the servers attached to the disk subsystems as well as maintenance costs, IT resources, and testing for corrupt data, the $6.7K per hour cost can be easily actualized; in fact, it could be significantly higher.

Those numbers are based on quantitative estimates. The numbers in each environment will vary due to the environment’s size, complexity, etc. The key point is to make realistic assumptions and estimates.
# Environment after the SAN implementation

<table>
<thead>
<tr>
<th>The SAN environment</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>62 servers, 12 switches (16 Port), three enterprise RAID storage subsystems, one single console</td>
<td></td>
</tr>
<tr>
<td>Disk utilization 80% (less disk, same amount of data)</td>
<td></td>
</tr>
<tr>
<td>80 fewer file and print servers</td>
<td></td>
</tr>
<tr>
<td>Seven administrative people (five for server applications and 2 for disk management and tape backup)</td>
<td></td>
</tr>
<tr>
<td>Maintenance upgrades – takes 6 hours</td>
<td></td>
</tr>
<tr>
<td>Break/Fix (no failures)</td>
<td></td>
</tr>
<tr>
<td>One occurrence of downtime (60 minutes due to human error)</td>
<td></td>
</tr>
<tr>
<td>Less people and more consistent administration</td>
<td></td>
</tr>
<tr>
<td>Administration from one location if desired</td>
<td></td>
</tr>
<tr>
<td>LAN-free backups</td>
<td></td>
</tr>
<tr>
<td>Exchange server backups – six to eight hours</td>
<td></td>
</tr>
<tr>
<td>Can allocate costs to departments if desired – cost per GB used</td>
<td></td>
</tr>
<tr>
<td>Adding new capacity (disk) – on-demand storage</td>
<td></td>
</tr>
<tr>
<td>Migration of servers</td>
<td></td>
</tr>
<tr>
<td>23 TB managed (35 TB in the SAN environment)</td>
<td></td>
</tr>
<tr>
<td>Tape libraries – four independent tape libraries (better tape drive utilization)</td>
<td></td>
</tr>
</tbody>
</table>

The implemented SAN solution is shown in Figure 5, on the next page.

*Continued on next page*
Environment after the SAN implementation, continued

Figure 5: Environment after the SAN Implementation

Continued on next page
Environment after the SAN implementation, continued

Environment comparisons

Table 3 shows the SAN implementation results within two years; it compares IT resource deployment, the downtime, and the disk space utilization before and after the SAN implementation.

Table 3: Environment Comparisons Before and After the SAN Implementation

<table>
<thead>
<tr>
<th>Item</th>
<th>Before SAN</th>
<th>After SAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT resources to manage the 35 TB of data</td>
<td>• Took six people to manage 9 TB of data</td>
<td>• Currently, two people are needed, since four fewer people are required</td>
</tr>
<tr>
<td></td>
<td>• There were 35 TB of data to be managed, or four times as much; hence,</td>
<td>(four were redeployed to other areas in the IT department, saving another</td>
</tr>
<tr>
<td></td>
<td>the need for four times as many people, or 24 total</td>
<td>$400K (4 x $100K)</td>
</tr>
<tr>
<td></td>
<td>• 24 – 6 existing = 18 additional people needed, $18 x $100K = $1.8M in</td>
<td>• Total human resource cost savings is $2.2M (due to the previous need for 24</td>
</tr>
<tr>
<td></td>
<td>salaries/year</td>
<td>people total, while only two actually needed)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downtime</td>
<td>• Averaged 12 hours per year or 24 hours every two years for each of the</td>
<td>• One hour of downtime in approximately two years</td>
</tr>
<tr>
<td></td>
<td>75 disk-array subsystems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Conservative estimates for the cost of downtime – $500K (revenue and</td>
<td>• Total benefit (revenue and cost) is $11.5M (24 x 500k = 12M – 1 x 500k = 0.5M, equals 11.5M)</td>
</tr>
<tr>
<td></td>
<td>employee productivity losses, etc.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• $500K/hr. entire environment = $6.7k/hr. per disk-array subsystem</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disk utilization</td>
<td>• Disk space utilization was 45%</td>
<td>• Disk utilization is now 80%.</td>
</tr>
<tr>
<td></td>
<td>• Estimated cost per Megabyte was approximately 10 cents</td>
<td>• SAN Implementation – 35 TB needs only 44 TB raw capacity (35 TB divided</td>
</tr>
<tr>
<td></td>
<td>• 9 TB usable disk capacity requiring 20 TB raw capacity (9 divided by</td>
<td>by 0.80% utilization = 44 TB)</td>
</tr>
<tr>
<td></td>
<td>0.45% utilization = 20 TB)</td>
<td>• Difference in capacity from old environment to the SAN is 34 TB (78 TB</td>
</tr>
<tr>
<td></td>
<td>• Projected need was 35 TB usable disk space, which requires 78 TB of</td>
<td>– 44 TB = 34 TB)</td>
</tr>
<tr>
<td></td>
<td>raw disk capacity (35 TB divided by 0.45% utilization = 78 TB)</td>
<td>• Assume $100K for each Terabyte purchased (10 cents per Megabyte)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Total cost savings is $3.4M</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Continued on next page
Environment after the SAN implementation, continued

Comparison chart

The following chart compares costs for the environment before and after the SAN implementation.

![Comparison chart](chart.png)

Savings

There was a dollar cost savings of $17.1M within the two-year timeframe. The specific-savings breakdown is shown in Table 4.

Table 4: Cost Saving Breakdown After SAN Implementation

<table>
<thead>
<tr>
<th>Item</th>
<th>Dollars in Millions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Resources</td>
<td>$2.2</td>
</tr>
<tr>
<td>Downtime</td>
<td>$11.5</td>
</tr>
<tr>
<td>Disk Utilization</td>
<td>$3.4</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td><strong>$17.1</strong></td>
</tr>
<tr>
<td><strong>Total Cost of Project</strong></td>
<td><strong>$10.0</strong></td>
</tr>
<tr>
<td><strong>Savings Grand Total</strong></td>
<td><strong>$7.1</strong></td>
</tr>
</tbody>
</table>
Other benefits after the SAN implementation

Improved Administration

The administration of the environment is critical. The SAN will allow the administration of the entire environment from a single location, if desired. In addition, that location has flexibility, which promotes remote administration. In the previous direct-attached environment, it was necessary to administer the RAID storage subsystems from multiple locations. In addition, with a reduction in the number of IT-admin personnel, a more consistent policy of data administration was developed and deployed.

Maintenance upgrades and backup efficiencies

Maintenance upgrades have been reduced from six weeks across 75 disk subsystems to six hours across three enterprise-level disk storage subsystems. In addition, the backup of the exchange server that previously took 28 hours now takes only six hours. Part of the reason for the reduction is that the SAN can administer some of the backups LAN free.

In the previous environment, each server had its own tape drive; with the SAN, the drives are shared by multiple servers. The number of tape drives declined from 150 (one per server) to four centralized tape library subsystems (10 drives each). This is a reduction of 110 tape drives. Cost estimates for tape drives range from $50 to $75 per month. This saves the organization an additional $60−$70K per year. This does not even address the additional flexibility and restorability benefits.

Adding capacity

A critical piece of the SAN implementation is adding capacity. In the original environment, it would take three weeks to order and install new equipment. In the SAN environment, a new disk drive is installed, the solution is reconfigured, and the IT resource moves on to the next project—it is now essentially a “storage-on-demand” scenario—all done without downtime.

Cost allocation

In the SAN environment, costs can be allocated to each department. The allocation can be measured strictly by the storage needs of each department. This is critical for future projects, because instead of the IT department needing the money exclusively, the required funding determination will be based on departmental needs. IT expenses will not be just “sunk costs,” as in the previous environment because the costs are distributed throughout the organization and are based strictly on departmental needs.

Continued on next page
**Other benefits after the SAN implementation, continued**

**Floor space and electricity usage**

An additional benefit of a SAN implementation is usually a reduction in floor space; in this case study, the floor space utilization improved by a factor of four (*floor space requirement for 9 TB is now being used for 35 TB*). There was also a major reduction in the use of electricity.
Case study: payback analysis ROI methodology

Payback analysis method
The data from the Payback analysis methodology justified the project as a worthwhile venture. Ideally, the preferred method for calculating the ROI, in this case study, would have been Net Present Value or Internal Rate of Return analysis because they are more comprehensive (See the ROI Methodologies section). The organization’s cost-saving projections are internally confidential. Given the client’s concern for confidentiality, the Payback analysis method was used to analyze the return.

What this method considered
Payback analysis considers the initial cost of the venture and then projects a payback within a specific timeframe—in this case study, within the two-year timeframe. The payback period for the project is calculated by counting the number of months/years it takes before the cumulative forecasted cash flows, or the cost savings equals the initial investment.

Was the project worthwhile?
Most organizations would deem a project worthwhile using one-to-three year payback timeframes. In this case study, the initial cost was approximately $10M—the return was $17.1M within two years. Whether you use Payback or Discounted analysis, the project easily justified itself within the two-year timeframe, which demonstrates the effectiveness of the initial analysis. In addition, the Payback analysis method does not consider future savings after the project has paid for itself, so the SAN implementation is still reaping additional returns.

For an additional explanation of ROI methodologies and their application to SANs, see the ROI Methodologies section.
Return on Investment

ROI an essential measure of project justification and success

Assessment and analysis
In today’s IT environments, enterprise storage solutions must deliver measurable returns on investments, making qualitative assessments and quantitative analysis methodologies essential business tools. One of the most commonly used quantitative evaluation methodologies is ROI analysis. With the size, complexity, and dollar value of proposed enterprise storage solutions such as a SAN, an ROI analysis becomes a critical factor in justifying, predicting, and measuring project success.

ROI analysis tool
An ROI analysis tool is used to measure the expected return on a project or venture. ROI analysis tools can be very basic with just a few parameters, or very complex. It also can be designed, built, and oriented towards a specific industry or niche.

The following ROI basic formula is defined for a project as:

\[
\text{Return} = \frac{\text{Profit}}{\text{Investment}} - 1
\]

This formula seems simple enough, but there are additional questions that need to be answered such as:

- What constitutes profit (cost savings)?
- Are all savings being attributed to the project?
- How accurate are the cost savings?
- What are the critical project elements, and how do you measure them?
- Is there a stream of cost savings over some timeframe?
- Is the time value of money being considered in the project?

Continued on next page
Measuring the returns and tools

The storage side of the IT budget is continuously growing, which makes ROI analysis a critical factor in justifying an enterprise storage solution. With the SAN becoming an increasingly popular data storage solution with its wide array of integrated components, getting a feel for how to actualize the return on the investment for a SAN can be a daunting task. With storage consolidation, shared tape drives, and LAN-free backups, the questions that need answering are the following:

- How is the return on the investment for the SAN measured?
- What are the critical elements in developing an ROI tool that will effectively measure the impact of a SAN on the data center and the organization, financially and operationally?

Why is an ROI analysis needed?

As projects escalate in dollar value, quantitative analysis is usually required to show the expected return for expensive investments, especially in today’s business climate. Most decisions are generally made in the qualitative mode (intuition, sales-person influence, vendor of choice, technology, etc.), but with large amounts of money at stake, some objective analysis is needed to justify the large initial cost. Usually, a quantitative analysis is used at the executive level to set expectations and to effectively measure the success of the project. This analysis will also help position the cost of acquisition versus the cost of ownership, over the useful life of the project.

What about returns and costs savings

The ROI will come in either cost savings or expected revenue streams from the investment. The expected revenue return is a tangible number used extensively in the financial world. For example, the expected return on an investment of $1000 will be $1100 in one year at 10%. The accumulated cash investment will increase 10% over the specified timeframe of one year. The question then becomes: Is this investment worthwhile, or would the money be better spent invested in other ventures?

Another form of return is cost savings. With an initial cash investment (in hardware, programs, networks, etc.) there will be a return actualized by the organization. The difference in this scenario is the investment of the original $1000 (as stated in the previous example), which must return at least that amount or the project would not be worthwhile. To realize a 10% return, there must be a cost savings of $1100. In both examples, there is a 10% ROI, but with the revenue stream, those funds are still available for the organization to use. However, in terms of cost savings alone, once the dollars are invested those funds are not usually retrievable in the form of cash.

Continued on next page
Lease or buy option

Another reason to do an ROI analysis is to determine if the organization should lease or buy hardware. While purchasing the hardware will provide ownership, it is not necessarily the best option in all cases; the technology could change significantly, or the organization’s cash may be limited presently. A lease could be the best option, but along with a qualitative assessment, an ROI analysis will provide the best analytical tool to help answer the lease or buy question.

There are many factors to consider when deciding which option best suits the organization for both the short and long terms. For example, the organization may not want to lock into a particular technology, especially if a new and more efficient and effective technology is just around the corner; or it may be just personal preference—the list is open ended.

Regardless of the relevancy of the quantitative or qualitative reason, the issue that seems to be constantly overlooked is an exit strategy. In the lease versus buy scenario, once the contract is finished or the technology becomes obsolete, the question becomes: How does the organization exit the existing scenario and smoothly transition to a new one?

Seeking input from subject-matter experts

With accurate data and the correct ROI tool, the decision maker can select the best options for the organization. When it comes to making decisions about large projects with diverse technologies such as a SAN, which will impact the entire enterprise, the decision maker would be wise to seek assistance from a subject-matter expert vendor. Many vendors use ROI analysis as a part of their sales process.
ROI an essential measure of project justification and success, continued

Vendor’s ROI tool
When selecting a vendor to assist with an ROI analysis, the decision maker must be careful because on many occasions the vendor’s ROI tool may be biased toward its products. When that occurs, other critical variables will be left out, which will skew the data and could result in a bad decision. Many articles and books have been published about the abuse of statistics, so to help facilitate good decision making, here are some additional questions to asked about the vendor’s ROI tool:

• Does the tool take into account the time value of money?
• Can the organization manipulate the ROI tool with the quantitative data that it wants to have analyzed?
• Does it provide an answer with only one kind of analysis?
• What parameters are being considered for the ROI conclusion?
• Can additional costs be added if necessary?

By using the right criteria, the analysis will be very insightful and contribute significantly to the decision-making process.

Data accuracy leads to meaningful results
Keep in mind that a quantitative calculation of a project does not guarantee a meaningful return. The actual return could be more or less than the original calculations; thus, the more accurate the data the greater the potential for meaningful results. However, rarely does an environment remain the same over a one- to five-year timeframe. As the time from the initial project implementation extends, the potential for unknown variables or unforeseen circumstances to adversely impact the originally calculated ROI will increase.

Qualitative assessment
Do not base the decision solely on the calculated ROI. Other important factors of the decision-making process are qualitative considerations. Although quantitative analysis factors are major, they should not be the only considerations. Some qualitative factors to consider are the following:

• Vendor’s reputation
• Vendor’s service offerings
• Vendor’s organizational fit
• Technology being considered

The qualitative factors could vary widely among individuals, vendors, or industries. The problem is that qualitative criteria cannot be quantified and hence are not easily measured. Obviously, using only qualitative factors it would be difficult to set expectations and determine the impact on the organization.

Continued on next page
Decision making

When making a qualitative assessment, the decision maker must remain as objective as possible. Too often, critical decisions are made based on friendship, nepotism, or other non-analytical criteria; when this occurs, the decision-making process is faulty at best. To guard against this, try the following:

- Have another individual from the organization who would not be emotionally tied to a particular individual/vendor assist in the decision-making process. At least then, the decision maker has someone who is objective and can be used as a sounding board.

- Give the decision-making task to someone else completely. This individual could present their decision based on the criteria they have accumulated. The decision then becomes the decision-maker’s to accept or reject. Again, objectivity is the main consideration when assigning the task to someone else.

The key is to maintain objectivity throughout the entire decision-making process, both qualitatively and quantitatively. Ultimately, the goal is to make the best possible decision for the organization.
ROI Analysis Methodologies

Net present value analysis

Net present value

Net Present Value (NPV) analysis is the present value of a stream of net returns (revenues less cost) from the investment minus the initial cost, or the present cost of making the investment. NPV is also the most widely used method for calculating ROI because it takes into consideration all the necessary variables when calculating returns; variables such as initial costs, all cost savings, cash streams, and the time value of money.

NPV of money

The NPV of money is critical when developing an ROI tool or performing an ROI analysis. Why? Because it takes into consideration the time value of money. What is the time value of money? It is simply this: A dollar today is worth more than a dollar tomorrow because the dollar today can be invested to start earning interest immediately. If you project cost savings into the future using today’s dollars, the analysis will be skewed—how much is dependent upon a personal assessment of the potential return.

NPV and the future value of money

Given that NPV calculates the ROI based on the future value of money, the value of that money or future buying power is determined by a personal analysis of risk, which considers these questions:

- What would be the return on the money if it were invested in a different venture?
- How much risk can be comfortably tolerated?

Usually, the analysis is compared to something relatively safe, such as money market accounts, interest at banks, etc. For this type of analysis, one could look at indicators such as inflation, or prime or historical interest rates.

Purchasing power

In general, most experts use 6% as a marker for purchasing power. Obviously, this could change during high inflation and recession periods. For example, a straightforward way to envision this is that $1 in the year 2002 has roughly the same purchasing power as $1.06 in the year 2003. Keep that in mind when doing an ROI analysis, because the goal is accuracy, and the time value of money is critical to obtain meaningful results.

Continued on next page
Net present value analysis, continued

Delayed payoff
The present value of a delayed payoff may be found by multiplying the payoff by a discount factor, which is less than “one.” If the discount factor exceeds an index of “one,” a dollar today would be less than a dollar tomorrow.

Calculating NPV
There are two methods of calculating NPV:

- Net present value
- Profitability index

To calculate NPV, do the following:

Discount the expected future payoffs by the rates of return offered by a comparable alternative; for example, in the case of a SAN, it could be versus a general market investment or compared to a continual investment of monies into an existing environment. The formula would be the following:

\[
NPV = \text{Projected Value} - \text{Required Investment}
\]

Where:

\[
NPV = -C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \ldots + \frac{C_t}{(1+r)^t}
\]

- \(C_0\) = Initial Investment
- \(C_1\) = Cash flows at the end of the first period
- \(C_2\) = Cash flows at the end of the second period
- \(C_t\) = Number of project years
- \(r\) = Opportunity cost of investing in the market

Continued on next page
**Net present value analysis, continued**

<table>
<thead>
<tr>
<th>Profitability index</th>
<th>The Profitability Index is the present value of forecasted future cash flows/cost savings divided by the initial investment, where:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Profitability Index = ( \frac{PV}{Co} )</td>
</tr>
<tr>
<td></td>
<td>PV = Present Value</td>
</tr>
<tr>
<td></td>
<td>Co = Initial Investment</td>
</tr>
</tbody>
</table>

The Profitability Index rule shows that all projects with an index greater than “one” should be pursued. When the profitability index is greater than “one,” the present value (PV) is greater than the initial investment (Co), so the project must have a positive NPV. The Profitability Index leads to exactly the same conclusion as revealed by the NPV method.

| Cost streams or cost savings | When assessing the value of a project, all benefits must be measured. Net Present Value takes into consideration all cash streams or cost savings for the entire life of the project. Other methods are not as encompassing and are only measured for specified timeframes. If you choose only one method in which to measure overall project success, choose Net Present Value if possible. |
Payback analysis

Payback analysis determines that the initial cash outlay for a project should be recoverable within some specified timeframe. The payback period for a project is found by counting the number of months/years it takes before cumulative forecasted cash flows equal the initial investment.

Things to consider when using the Payback analysis method:

- It ignores the order in which the cash flows come within the specified payback period
- It ignores any subsequent cash flows, entirely, once the payback period has expired, and it does not take into account the total value of the project
- It also does not consider the time value of money

Payback analysis is a simple methodology that shows the revenue streams *(payout or cost savings)* and the time it takes to recover the initial investment. The money streams coming in are subtracted from the initial investment until the balance descends to zero. See Table 5 for an example of a five-year return on an investment.

### Table 5: ROI over Five-Year Period

<table>
<thead>
<tr>
<th>Year</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment</td>
<td>$5000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROI</td>
<td>$1000</td>
<td>$1000</td>
<td>$1000</td>
<td>$1000</td>
<td>$1000</td>
<td>$1000</td>
</tr>
<tr>
<td>Balance</td>
<td>$4000</td>
<td>$3000</td>
<td>$2000</td>
<td>$1000</td>
<td>$0</td>
<td></td>
</tr>
</tbody>
</table>

In the above example, it took five years for the return to cover the initial investment. This is a very simple analysis, but it will give a general idea about the basic return on an investment. This method also does not assume salvage or residual value for the equipment at the end of the analysis period.
Discount payback period analysis

Discount payback period

The Discount Period is the amount of time over which the discounted present value of cash flows in; or the cost savings from a project to equal the initial cost, or cash outlay.

Discount payback period and the time value of money

The Discount Payback Period is a more encompassing analysis than Payback analysis because it considers the time value of money. Hence, it will always take longer (if the analysis extends beyond one period) to pay back the investment than the Payback analysis method would. See Table 6 for an example.

Table 6: Payback Analysis over a Six-Year Period

<table>
<thead>
<tr>
<th>Year</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment</td>
<td>$5000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROI</td>
<td>$1000</td>
<td>$1000</td>
<td>$1000</td>
<td>$1000</td>
<td>$1000</td>
<td>$1000</td>
<td>$1000</td>
</tr>
<tr>
<td>NPV (6%)</td>
<td>$943.40</td>
<td>$890.00</td>
<td>$839.62</td>
<td>$792.09</td>
<td>$747.26</td>
<td>$704.96</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>$056.60</td>
<td>$110.00</td>
<td>$160.38</td>
<td>$207.91</td>
<td>$252.74</td>
<td>$295.04</td>
<td></td>
</tr>
</tbody>
</table>

The payback period

As shown in Table 6, and given the same scenario, if you consider the time value of money, the actual payback period is just over six years (at six years - $4917.33). Some organizations will not entertain projects greater than 6 years, so the payback period is within the requirement (see the example in the Payback Analysis section), but the discounted payback period is not. Obviously, the critical factor is the time value of money in the payback period. The difference in the examples is that it took a full-year longer to recover the initial investment for the project. In this scenario, there is no residual or salvage value associated with hardware at the end of the analysis period. This analysis does not take into account any subsequent cash flows or cost savings once the project cost has been recouped.
Internal rate of return (IRR) analysis

**IRR analysis**

The IRR analysis from a particular investment is the discount rate that brings the net present value of an investment balance to zero.

**IRR and project feasibility**

IRR is another way to determine if a project is feasible for the organization to invest in. It determines the rate of return for the project. Most organizations have a standard return level before they will deem a project feasible. For example, when an organization has a minimum standard of 15% expected return on an investment, it would not entertain projects with a calculated return less than 15%. In determining IRR, care must be taken when projecting the actual amount of IRR savings because the amount can be set at any value, due to hidden dollar savings projections that cannot be actualized. This is where caution is advised, considering what is being evaluated and the reasonableness of the return on the investment. When vendors know where the bar has been set, they will certainly project their solutions above that bar. IRR is very similar to Discounted Payback except that it takes all cost savings into account and not just those at the cutoff point where the project breaks even, but beyond.

**IRR formula**

Again, IRR is defined as the rate of discount, which makes the NPV = 0. The formula is as follows:

\[
NPV = -C_0 + \frac{C_1}{1+IRR} + \frac{C_2}{(1+IRR)^2} + \ldots + \frac{C_t}{(1+IRR)^t} = 0
\]

- \(C_0\) = Initial investment
- \(C_1\) = Cost savings - year one
- \(C_2\) = Cost savings - year two
- \(C_t\) = Number of years of the project

Continued on next page
**Internal rate of return (IRR) analysis, continued**

### Calculating IRR

An example, cash flow dollars:

\[
\begin{align*}
\text{Co} & = -4000 \text{ (initial investment)} \\
\text{C1} & = +2000 \text{ (cost savings - year one)} \\
\text{C2} & = +4000 \text{ (cost savings - year two)} \\
\end{align*}
\]

\[
\text{NPV} = -4000 + \frac{2000}{(1 + \text{IRR})} + \frac{4000}{(1 + \text{IRR})^2} = 0
\]

Unfortunately, unless there is a computer or calculator programmed to determine the IRR, the answer will be arrived at through trial and error. In this case, the IRR is 28%. Hence, when the Opportunity Cost of Capital is compared to the IRR for the project, the question becomes: Is the project’s return above what the organization considers the minimum for deeming the project worthwhile? In this case, the IRR is 28%, which is well above the minimum standard of 15%.

### IRR considerations

The following is a list of considerations when using IRR analysis:

- If a project offers positive cash flows followed by negative cash flows, the NPV will increase as the discount rate increases. These projects are feasible if the IRR is less than the opportunity cost of capital. This is highly unlikely in a SAN implementation.

- Multiple rates of return – if there is more than one change in the size of the cash flow, the project may have several IRRs or no IRR at all; again, this is highly unlikely for SAN implementations.

- Mutually exclusive projects – unlike NPV, rates of return do not add up. If a bad project is coupled to a good project, the combination of both projects could have a lower or higher IRR than the good project on its own. In either case, make sure that the IRR on each additional investment is considered. In addition, that IRR rule could give the wrong ranking to mutually exclusive projects that differ in economic life or in the scale of the required investment—could be applicable if the SAN implementation is piggybacked with future projects and purchases.

- Short-term interest rates might be different from long-term interest rates. The IRR rule requires comparing the project’s IRR with the opportunity cost of capital. However, sometimes there is an opportunity cost of capital for cash flows in year one, with a different cost of capital for cash flows in year two, and so on. In those cases, there is no simple standard for evaluating the IRR of the project. When doing a SAN analysis, it is best to stay with a single cost of capital factor.
Salvage/residual value and depreciation analysis

Salvage/residual value

Salvage/Residual Value is the actual or estimated selling price, net of removal, or disposal cost of used plant equipment sold or retired. Residual value may be a better term because the equipment does not necessarily need to be scrapped or sold, but could still be used.

SAN fabric salvage/residual value

One outstanding element of a SAN implementation is that the SAN is designed for scalability. As the demand for storage increases, the SAN infrastructure can absorb the additional needs by adding additional devices to the SAN fabric. Hence, the salvage or residual value of a SAN fabric will be quite high. This element is crucial in the analysis because the majority of standard ROI analysis methods assume no or a very small value at the end of the analysis period. Since SANs are relatively recent, a general quantitative salvage value (amount or percentage) is yet to be identified.

Depreciation

Depreciation is the reduction in the book or market value of an asset; the portion of an investment that can be deducted from taxable income—sales revenue before the operating income is taxed.

ROI measurement types

In an ROI analysis, two types of measurements can be used:
1. The upfront cash amount for the project/equipment being considered
2. Depreciation, which reduces the amount of operating income at scheduled intervals

Depreciation is considered a debit—the entire cost can be absorbed initially or depreciated for a specific timeframe.
## Opportunity cost and cost of capital analysis

<table>
<thead>
<tr>
<th>Opportunity cost</th>
<th>Opportunity Cost is the present value of income or cost savings that could be earned or saved from using an asset in its best alternative use to the one being considered.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparing and selecting projects using opportunity cost analysis</td>
<td>Opportunity Cost analysis can be crucial in that it compares one project to another and then selects the best project based on the potential quantitative return on each project. In the financial world, you would pit the ROI of a project against what those monies could earn by investing in other financial vehicles (<em>money markets, stocks, bonds, etc.</em>). This is also referred to as the Cost of Capital. With SANs, the true opportunity cost would be the relationship between implementing the SAN solution versus continuing with the existing environment and its associated and future-related costs. With SAN fabrics being more scalable, available, and offering better use of equipment, the SAN ROI will be more than the initial investment.</td>
</tr>
<tr>
<td>Cost of capital</td>
<td>The Cost of Capital analysis is the money that could be earned in the market or some other investment opportunity; in other words, the required rate of return on an asset before the owner will devote that asset to a particular purpose.</td>
</tr>
<tr>
<td>Comparative investments</td>
<td>For Cost of Capital, as with Opportunity Cost, a comparative investment is the amount of money that could be earned if invested in stocks, bonds, or money market vehicles. If there were no projects to compare to the current project, comparative investments would be measured to determine if the current project is worthwhile. In addition, the NPV of the project must be greater than the Cost of Capital to justify the project’s worth.</td>
</tr>
</tbody>
</table>
Risk analysis

Risk analysis is a measure of the potential variability of the ROI. For a given expected amount of return, there is a correlated amount of risk. In rational markets, investments with more risk usually promise or are expected to yield a higher rate of return than investments with lower risk.

Risky investments

Generally, a safe dollar is worth more than a risky one. Most investors avoid risk when they can do so without sacrificing returns. However, the concepts of present value and the opportunity cost of capital still make sense when analyzing risky investments. It is still proper to discount the payoff by the rate of return offered by a comparable investment. Overall, thought must be given to the expected payoff and the expected rate of return on other investments when comparing them to the proposed project.

Risk tolerance

Risk is a relative term and is different for each individual. The tolerance or threshold of risk an organization is willing to take is dependent upon its current situation and the current timeframe. Four questions must be answered when an organization plans to implement a SAN:

1. Will the SAN solve the technology problems?
2. Will the investment in a SAN return the calculated ROI?
3. Will the SAN scale with future technologies?
4. How cost effective is it to continue with the existing environment before things start to breakdown or before managing the data growth becomes a problem (hardware, meeting backup schedules, disk capacity, etc.)?

Many times the environment’s hardware and software need major upgrades, or there are insufficient IT personnel to continue with the existing environment—both are solid reasons to consider a SAN.
### Interrelationship among ROI analysis methodologies

<table>
<thead>
<tr>
<th>Project feasibility and expectations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Each ROI analysis methodology gives some insight into the feasibility of a proposed project. Each method looks at returns in a slightly different manner, but they are all interrelated to some degree. The key is that an ROI analysis determines not only the viability of a project, but also sets expectations for the project. If the return is less than what was calculated, the project could be considered a failure even though it met the organization’s standard for returns on investments. An effective ROI analysis should present any number of scenarios for the decision maker to consider, which in turn should facilitate good decision-making.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ROI analysis facilitates good decision-making</th>
</tr>
</thead>
<tbody>
<tr>
<td>One final point concerning vendors and ROI; if the equipment, SAN fabric, or project were truly a worthwhile venture, a vendor should be more than willing to perform an in-depth, non-slanted, impartial ROI analysis. SAN fabrics offer better availability, increased performance, improved hardware use, simplified management, and utilization of IT personnel over traditional storage architectures. With those potential benefits, an in-depth, non-slanted, and impartial ROI analysis would only help make the decision to invest in a SAN, not dissuade the organization from that decision.</td>
</tr>
</tbody>
</table>
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