Atempo

TIMEnavigator™

Backup and Restore on Storage Area Network

OVERVIEW >>

Companies are entrusting a growing number of applications with an increasing amount of activity-essential data. With the advent of the Internet and greater data sharing in the workplace, the rise in importance of information technology has lead to an exponential growth in data storage management requirements. Information must be rapidly accessible over long distances. These criteria are central to the emergence of new technology and compete to reconcile different points of view and to find solutions to various constraints.

Information systems are currently based on the existence of file servers or applications used by clients to access data or generate results. This solution is suitable as long as number of clients and volumes of data remain manageable. When one criterion exceeds this “safety zone”, difficulties arise in the form of a slow down in exchanges, and network overload. Moreover, difficulties in data transfer have lead to predictable incompatibilities between storage formats.

To solve these kinds of problems and to control growth levels, solutions such as specialized storage servers have been developed with some success. However, over the long term, a more radical architecture based on new concepts needs to be developed and implemented. The association of high flow networks and powerful data administration software will open the door to networks dedicated entirely to data storage. Data security must take advantage of the new technology. Standard local network backup is moving toward more efficient and flexible solutions by revolutionizing traditional set ups. SANs, for example, are comprised of one or several sub-networks with in a larger overall linking application server.

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Introduction to Storage Area Network

Fibre Channel

Fibre Channel is a data transfer technology that can carry different higher-level protocol types (SCSI, IP, HiPPI, etc.). Being multi-protocol means that the same Fibre Channel environment can be used for high data flow input/output operations in addition to dealing with more standard network connections. Distances of around ten kilometers can be achieved with frames of several dozen kilobytes and media of varying kinds. This makes Fibre Channel a powerful tool in the design process of advanced storage and exchange architecture.

Fibre Channel was originally based on optical fibre connections. When metallic connections entered the market, the norm[1] was adapted to meet the requirements of heterogeneous media. Depending on the equipment that is used, exchanges take place at the following speeds: 133 Mb/s, 266 Mb/s, 531 Mb/s, or 1062 Mb/s; with optional flow transfer rate at 100 Mb/s (or 200 Mb/s in full-duplex). For example, we are able to develop Fibre Channel networks with optical fibers (mono-mode and multi-mode), coaxial or twisted pair cables. Depending on the selected media, maximum distances between nodes (for FC-AL) will range from 10m for fine coaxial to 10km for fiber. Exchanges will be established at optimal speeds that vary according to the media selected.

Definition of Fibre Channel layer protocol:

FC-0: Defines physical connections, transmitters, and receivers.

FC-1: Defines 8/10 bit encoding, octet serializing, flow control, communication interface management, and error management.

FC-2: Defines the framing, sequencing, and controls from start to finish.

FC-3: Characterizes shared services on which higher levels are based.

FC-4: Definition of the adaptation of high level services (IP, SCSI) on Fibre Channel layers.

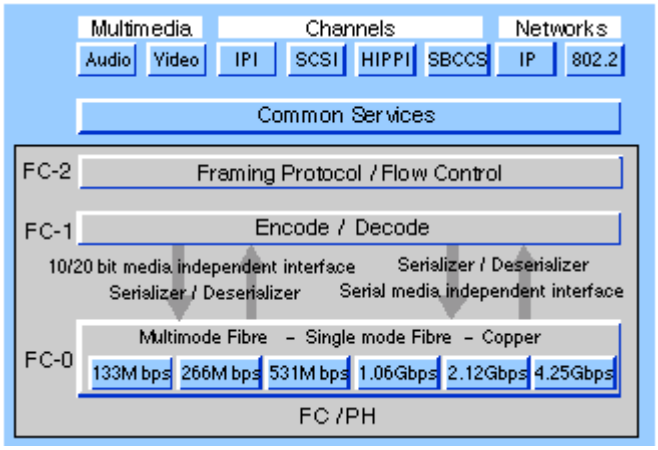


Figure 1. Fibre Channel layer protocol - Fibre Channel Association

Fibre Channel consists of layers as shown in the ISO representation of networks. The MAC (Media Access Control) layer is at the lowest level (FC-0) and allows the interface access to physical communication media to be defined. Subsequent layers define new services and points of access. Most level 2 protocols (IP, SCSI-3, ATM) can be incorporated directly above the lowest layers (cf. Figure 1).

[1] Current standardization procedures for protocols including Fibre Channel are under the responsibility of the ANSI X3T11 committee.

Topologies

Fibre Channel is a technological innovation, which, in FC-AL or FC-SW topologies, allows equipment to be connected and disconnected at will and they can also be integrated dynamically into an existing sub-network (hot-plug). Connecting or disconnecting equipment in a sub-network requires a participant rediscovery phase with a possible redistribution of addresses on the FC network, for each SCSI bus, if necessary. This guarantees good extendibility for any system based on Fibre Channel since new resources can be added and removed as required. However, resource management is more complex as addresses are not always variable in time.

The three main topologies based on Fibre Channel are:

- Point-to-point connections.
- Arbitrated loop architecture - FC-AL.
- Switched architecture - FC-SW.

Architecture using Fibre Channel can link unified FC-AL segments to an FC-SW network which combines the advantages of each topology for the price of a more complex total component management (zone definition, private, public loops etc.).

Point-to-Point

In the first case, equipment is connected directly to a machine (with a HBA, Host Bus Adapter) using a Fibre Channel link. If the equipment is not native Fibre Channel (frequently SCSI for disks, tape drives, etc.), it is possible to insert a bridge whose role is to convert Fibre Channel protocol into SCSI and vice versa.

This bridge provides a clear view of SCSI peripherals through a Fibre Channel link by converting SCSI FC addresses. It should be pointed out that using a bridge restricts the granularity of assigned resources located behind this bridge - FC and SCSI peripherals attached to this bridge, which belong to a single SCSI bus that cannot be dissociated. It is theoretically possible to connect a machine (an "initiator") to a SCSI bus and have access to the Fibre Channel via a bridge.

Arbitrated Loop

In this case, equipment to be connected must communicate via the hubs, which enable links (loops) to be defined between certain elements. These routes are usually configured statically and the switch from one route to another requires a new set up to be loaded (definition of a new set of loops).

The hub allows peripheral connections (loops) to be established that the FC-AL protocol then takes charge of (insertion/removal of peripherals, access authorization, etc.). Each loop has 126 FC addresses available.

Switch / Fabric

Switched architecture is the most complex to set up and requires greater intelligence for each piece of equipment to be connected[2]. Equipment designed for FC-AL will not normally be adapted to a FC-SW configuration. Conversely, equipment connected in FC-SW architecture can function in FC-AL mode if the establishment of the FC-SW protocol fails.

The principle is close to FC-AL architecture except that a switch replaces the hub. The role of this switch is to establish a communication path linking two pieces of equipment where communication occurs using routing mechanisms between switches known as fabric.

This route (in network terms) is maintained throughout the exchange and the switch can link both pieces of equipment to others depending on which new exchanges are to be performed. Establishing this routing based on a different protocol (FC-SW) is more complex than FC-AL. Up to 16 million nodes can be interconnected (host, peripherals) as opposed to FC-AL in which all loop element components share the same media and therefore the available bandwidth. Switching ensures a "private" communication between two components to exchange elements at the maximum transfer speed permitted by the physical medium (currently 1062 Mb/s).

Storage Network on FC

In the network sector, there are many other technologies that cater for high flow, long distance, manufacturer independent, etc. but Fibre Channel has the upper hand in terms of uniting most essential characteristics and being able to handle foreign protocols. In addition, advances in manufacturing processes have seen the introduction of high performance components (ASICs). These are the building blocks of emerging hardware architecture and Fibre Channel can, due to these elements, skip certain steps which were, until a few years ago, necessary in the local network sector (switching can replace traditional routing).

From a more technical standpoint, it is a non-collision network (as opposed to Ethernet) in which exchanges are based on sufficiently dimensioned frames guaranteeing adequate use of the available bandwidth. In addition, the data-encoding layer guarantees a level of data protection that is comparable to traditional networks (8b/10b encoding).

In theory, under the control of norm and normalization organizations, this protocol will retain manufacturer independence. However, it has yet to face the test of time in order to be sure that independence does not mean isolation and that all parties can agree on common standards.

Main Advantages

All these characteristics make Fibre Channel an invaluable element in network architecture:

- High bandwidth reduces the time for data transmission.
- Distances of around one kilometer between nodes or between a node and a switch are positive points when considering redundant, accident proof storage architecture.

[2] W*orld Wide Name*, *Simple Name Server*, *zoning, etc.*..

- It considerably reduces hardware investment costs through improved resource sharing.
- It allows data to be shared more easily as they do not have to be duplicated. It only requires two or more machines to be associated at one given time.
- FC equipment hookup flexibility is a major advantage ensuring that network architecture has high adaptability in terms of growth needs.

With Fibre Channel, we can now design dedicated data storage network, such as with Local Area Networks (LAN), Wide Area Networks (WAN), and storage networks, known as SAN Storage Area Networks.

The SAN concept is not just a compendium of advantages. It is recent technology whose standards have yet to be established. As such, while waiting for the authorities to decide on a stable protocol version, hardware manufacturers need to convince their users of their ideas. Software vendors must have a sufficiently wide product offering of environments that are capable of interfacing with the maximum amount of equipment. Interoperability between different manufacturers has become a sensitive subject with no satisfactory outcome for users on the horizon. Similarly, Fibre Channel represents a new technological advance that must be integrated by information system administrators.

Backup on SAN

LAN Backup

In traditional network based backups with centralized administration, one machine usually has the privileged role of backup server, responsible for executing and checking the work. The local network interconnection and the backup server also serves in transferring backup data.

This method, which has the advantage of using existing resources, has a downside in that it cannot provide optimum performance. Activity peaks, separated by periods of calm, generally characterize traffic on a local network. However, traffic during backup operations is different, made up of rapid exchanges of huge quantities of data. Therefore, since both types of traffic have varied characteristics, all network architectures that need to handle both these activities simultaneously must find a compromise to offset these constraints.

LAN-Free Backup

One can now envisage a specialized network that is dedicated to backup. With SAN, the way to describe this type of architecture is LAN-Free backup. It is a network topology that could be implemented alongside traditional technology (Ethernet, C/FDDI, ATM, etc) but which only comes into its own when associated with Fibre Channel. In fact, duplicating a local network reserving it for backup is an interesting proposition, but one which, except for backup windows, ties up resources unnecessarily. With Fibre Channel, we not only have a powerful network to perform backups, but this very network also enables associated resources (disks, data etc.) to be shared.

SANs are designed to simplify and optimize data administration through resource sharing and optimizing the use of shared equipment. Backup consists of keeping critical data safe. As such, it must be part of operational tasks that use the infrastructure and tools for total network management. To achieve this, backup software must be capable of:

- Communicating with storage resources connected to the network.
- Sharing use with other users and software.
- Taking maximum advantage of the capacity of the network to transfer data rapidly and over distances of up to one kilometer.
- Taking into account network configuration changes, which are liable to happen at any time.

SANs are currently based on either Fibre Channel or SCSI-3 encapsulated in Fibre Channel. To answer the first point, backup software that can handle the SCSI-3 norm will have a transparent access to SCSI peripherals. With regards to native Fibre Channel peripherals, drivers control Fibre Channel machine adapter hosts, whose role is to enable the operating system to access these peripherals. In this case, backup software must be able to reference the correct peripherals by using the logical name given to them by the operating system and control them with system commands.

Library Sharing Module

Resource sharing is harder to manage in a multi-supplier environment. The lack of shared rules means there is no way of knowing whether a resource is being used and therefore if it can be used for another activity. Backup software must not only provide all backup mechanisms that allow it to synchronize competing accesses with a critical resource, but it must also accept that it is the only software which has such a resource. The latter may cause some serious problems for complex networks where several operations might be started up at the same time by software with no means of communicating. Time Navigator, thanks to its Library Sharing Module network, allows competing accesses for several backup servers to be managed and synchronized.

Cartridge movement requests are sent to the host on which the Library Sharing Module is installed. This module controls the robot arm and is responsible for transmitting request findings to the servers. Data to be backed up circulates via the SAN network only, between the machines to back up, the backup server and storage peripherals.

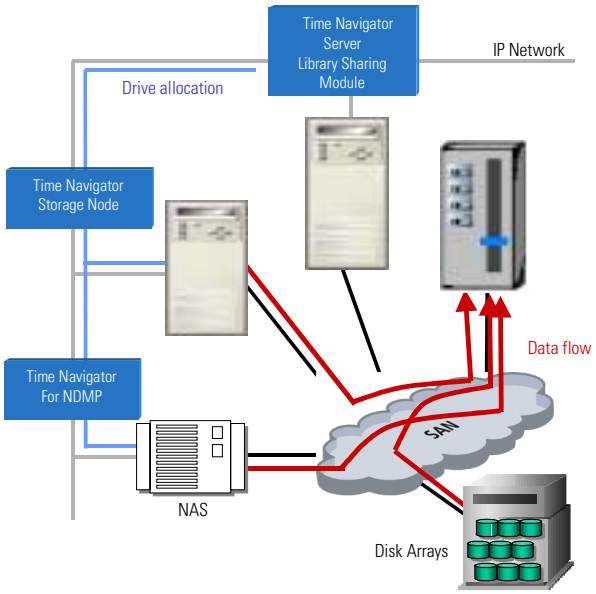


Figure 2. SAN Backup solution with Time Navigator

Time Navigator's Library Sharing Module will include the ability to share tape drives between servers. This solution will give maximum flexibility for the backup system administrator who will be able to allocate these drives dynamically to servers that need one to backup or restore, even during an operation. For example, the backup of a server can start up by using only one tape drive because only one is available at that time. As competing operations free up other resources, backup software can be attributed to the first server to accelerate the flow by aligning data speed.

Replication and Disaster Recovery

A Fibre Channel network is a gigabit network in the Metropolitan Area Networks (MAN) class. This will open the door for backup system architecture that is based not only on data duplication on magnetic tape or optical disks, but also data replication. In all cases, a backup represents a still photograph of the system storage space at a particular moment in time. To obtain a clear

image, we need to freeze the system status during the time it takes to carry out the backup, which means we have to regularly suspend system activity.

For a major total application server backup for example (RDBMS, ERP), this operation could last several hours, which is of course far too long within a working environment. High levels of data flow using Fibre Channel mean it is possible to make mirror sites, which duplicate, either continuously or on request, data from the central site to a secondary site (the mirror). Being recopied from the mirror site via the Fibre Channel network restores data. In addition, since the duplication site may be several kilometers from the main site, this architecture is well suited to serve as a base for Disaster Recovery Procedures.

Actual data backup can be carried out on the secondary site without disturbing what is happening on the production site, by temporarily suspending data duplication until the operation is complete. Updating the mirror site can be rapid if only modified data is exchanged. In order to minimize the length of synchronization between systems even further, mechanisms have been developed that save modifications to a file or application system (snapshots, etc.).

Server-Free Backup

At this point it might be of interest to ask if it is possible to go a step further in the quest for greater performances and for optimal backup system flexibility. In other words, after designing high performance storage architecture, shared storage libraries and tape drives to optimize data transfer, there is one remaining hurdle to ensure data security, which is the backup server. By using SAN functions, will designing server free backup architectures become a possibility?

What makes a company turn to SAN solutions is the realization that client–central storage server exchanges are increasingly bottlenecked. For shared data backup, shorter available time slots and the risk of production downtime make this situation even more critical. The SAN solution stands out because connection points are spread out thus reducing or wiping out bottlenecks. The question remains: What is needed for SAN to win over, once and for all, the world of storage and network data backup? The good news is that for dedicated storage networks, the foundation stones are in place and appear to be reliable. The downside is that there is a vital missing link needed to ensure immediate SAN success.

The flip side is "Who develops, provides and maintains the 'cloud', which keeps all the different SAN elements together?" SAN is a puzzle made up of applications and file systems in disk bays, machine clusters, backup equipment, etc. each differing in their capacity to read and write managed data. As a result, in an SAN we need to know who is in charge of data and how it is presented in a coherent and homogeneous manner to the users. In reality, there is no simple answer since neither the different file systems [3], nor applications or disk bays have been designed to be interfaced with external elements that are part of the SAN. Without the 'cloud' concept, the SAN can only be perceived as an *evolution* in SCSI based storage and not a *revolution*.

[3] This incompatibility also exists within products from the same firm: file systems were created for the traditional single-terminal and NFS is a move towards wider data sharing.

SAN and Virtualization concept

Storage virtualization concept is not considered to be the implementation of hardware mirroring or RAID by the storage vendor. Virtualization tricks the operating system and the applications by presenting it with an abstraction it can understand, when in fact, the content comes from many sources and there may be something completely different and more complex behind that abstraction. Several companies, like DataCore or FalconStor, offer one solution to manage large disk volumes from different manufacturers. SN6000 product, StorageTek offers a different way. Their virtualization concept works with tape drives, but StorageTek is also planning to support disk virtualization.

Backup and Snapshot

Through API or script mode, Time Navigator supports backup volume of virtual disks manager. Like SANsymphony example, the classical way is to create a snapshot volume to back it up later. This method is called Server-less backup. The Application server does not run the data Backup or the data Restore process, only backup server mounts a snapshot volume, backs it up or restores it. This process needs only a few moments to suspend the application and to perform the snapshot. Once the snapshot is done, the resulting volume is mountable and can be accessed as a standard volume.

The snapshot is the ability of making a logical copy of an original volume copying only references to each block. If one of these references is read, the original volume is read instead. In order to maintain the snapshot consistency, each time a block is modified on the original volume, it is physically copied on the snapshot before it is written on the original volume. So, changing all the blocks of the original volume results in a physical duplication in the end.

SANsymphony

Time Navigator is officially certified and tested solution with SANsymphony product (cf. World Wide Press Release - 09/26/2001). DataCore and Atempo announced their joint efforts on developing an enhanced backup integration solution.

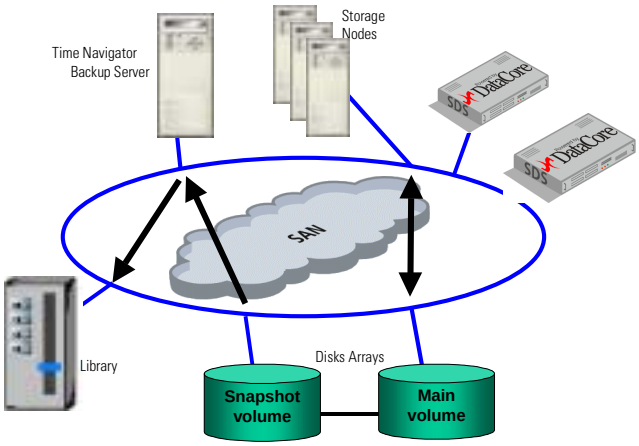


Figure 3. Backup example using SANsynphony solution

The first result of the relationship between DataCore and Atempo is full data protection and recovery architecture for Windows platforms. Figure 3 shows one example of volume Backup with DataCore snapshot solution:

1. SANsymphony manages the main volumes for Storage Node that is connected to the SAN.
2. Time Navigator manages the library and tape drives connected to the SAN.
3. Time Navigator launches a Snapshot through SANsymphony API, mounts the new volume and backs it up directly to the tape drives.

Time Navigator uses SANsymphony API to back up data within SAN (LAN-free backup and restore) and to limit CPU use of Storage Nodes (Server-less backup and restore).

IPStor

IPStor is a disk virtualization product of FalconStor Company. Atempo and FalconStor have integrated and tested Time Navigator Backup and Restore solution on an IPStor environment. The main difference with SANsymphony is the final user. FalconStor hardware and software export SAN volume directly to the IP network. Each computer is installed with one FalconStor agent who virtualizes some data volumes and tape drive devices through a dedicated IP network.

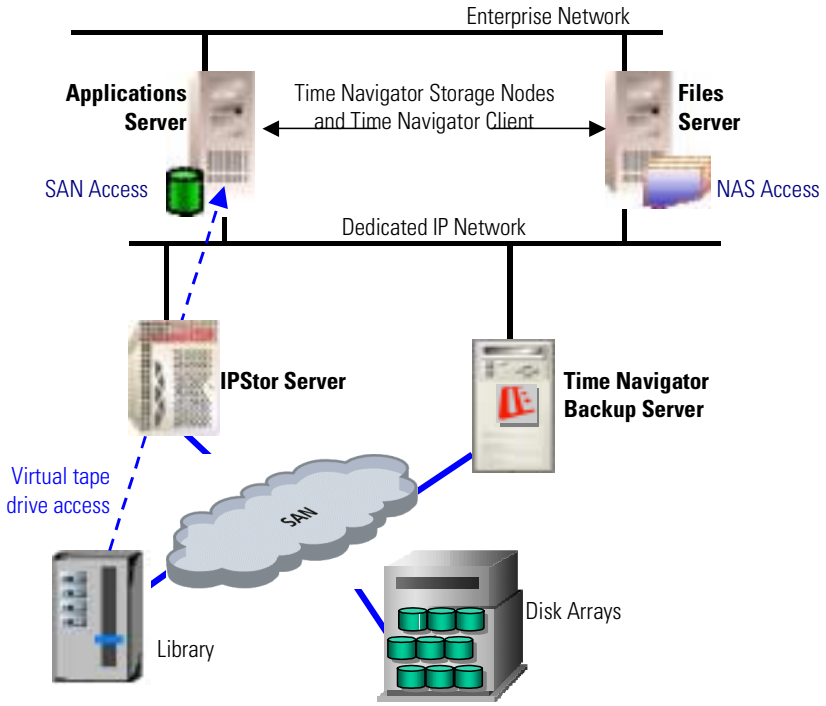


Figure 4. Time Navigator supports IPStor solution

IPStor offers two data access types, NAS access with NFS (classical export method on LAN) and SAN access (need IPStor agent). Data volume is exported through an IP network and it recognizes it as a local disk drive by the operating system. Time Navigator supports the Backup and Restore of this "IPStor" local disk drives as well as virtual tape drive devices.

Tape Drive Virtualization

StorageNet 6000 series is a unique product within the SAN world. This Storagetek box gives capabilities to support the virtualization of devices through SAN architecture. SN6000 is efficient product with the SAN architecture that needs large tape drive connectivity and an important scalability, with a high backup performance.

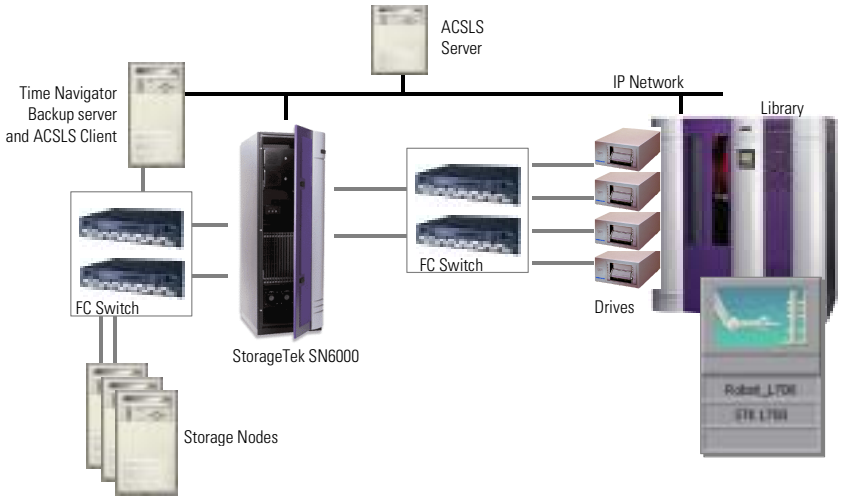


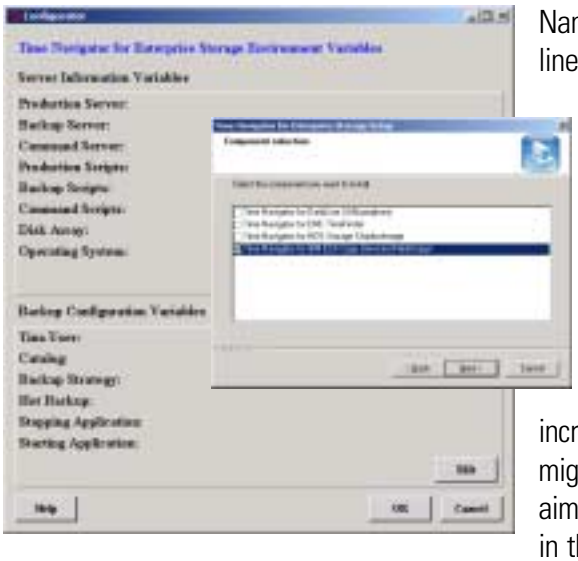
Figure 5. A Time Navigator architecture example with a StorageTek solution

In Figure 5, Time Navigator is a certified and tested solution working with SN6000:

- Time Navigator works with ACSLS product.
- Mixed physical and logical tape drive types are supported.
- Physical drive oversubscription is supported.

Point-In-Time Backup for Disk Array

Main disk array manufacturers supply a software tool that provides a method of creating instant point-in-time copies of disk array based storage volumes. These copies can be migrated to and mounted on other supported host in the SAN. With Time Navigator, one advantage of this feature is the ability to perform backup operations on a copy of the production data and to do so on a completely different host. This offloads the sometimes-significant CPU overhead associated with the backup process from the database server to a dedicated Backup Server.



Named Enterprise Storage, Atempo defines a dedicated product line to use the third software capabilities to back up and to restore data of disk array manufacturers.

Atempo's product is based on an application installing from a specific CD-ROM. The Time Navigator program makes the point-in-time configuration through a graphical user interface for the offline backup and recovery process using a split-mirror technology.

With the Oracle database, Time Navigator can significantly increase the efficiency of an online backup, restoring and migration operations. Time Navigator for Enterprise Storage is aimed at IT environment seeking to protect the critical data stored in their disk arrays and to reduce their Application Server offload. As with any change to the database configuration or back up plan it is vitally important to understand all aspects of the backup and restore operations.

Time Navigator for Enterprise Storage backs up and restores data volume through technologies from the main famous company like EMC with Time Finder, IBM with ESS Copy Services (FlashCopy), HDS with Shadow Image, Compaq with SANworks EVM, StorageTek with SVA, etc.

Conclusion

Data storage is a sector where security is of the utmost importance. To optimize the use of resources and improve processing efficiency, data sharing between different environments is an absolute necessity. Network Attached Storage (NAS) and Storage Area Networks (SAN) enable new architectures to be designed and produced that are adapted for the user's and administrator's requirements.

It would be unwise to let ourselves be drawn to a system just because it is new and innovative. SAN is not the only solution to all data storage problems. It is suited to data sharing within a limited scope. A company whose computer systems are geographically far apart that cannot isolate more restricted sub-systems will probably not be able to use SAN efficiently.

In addition, architectures will evolve in line with more powerful hardware and more "intelligent" software. Today, most SAN implementations are based on FC-AL (Fibre Channel Arbitrated Loop). This topology is easy to set up as it uses concepts that are similar to classic backup systems. However, FC-SW is likely to take off as a recent Gartner Group study indicates.

Fibre Channel is currently the most widely used SAN equipment interconnection. It is also possible to adapt traditional data network transport layers providing the distinct advantage of existing experience, established standards and the functional diversity of management environments. For instance, ATM (Asynchronous Transfer Mode) is a plausible alternative that could be a serious competitor for Fibre Channel since it has similar characteristics (high band width, good service quality, high node separation distances, etc.). Fibre Channel is only used today as a means of transporting rapidly and over long distances SCSI-3 commands for previous generation equipment. Conversely, ATM has already proved itself with WAN backbone interconnections in transporting heterogeneous protocol data, underlining its validity, reliability and its excellent interoperability. Fibre Channel, however, has a significant advantage when storage equipment, that can handle Fibre Channel locally (disks, drives, etc.), is used in a storage system.

The new architecture involves a natural data source circulation**.** This strengthens the need for a backup architecture adapted to this constraint, which enables both weak coupled environments to be managed efficiently, and different storage network elements to be managed homogeneously.

Whatever the future holds for network data storage, it is clear that traditional Network Based backups will continue to have complementary fields of applications in LAN Free Backup and Server Free Backup. However IP networks are always the main way to data exchange and the iSCSI protocol emerged as a potential long-solution. It could be the next technology for the enterprise storage networking.

SAN Hardware support

All SAN architectures need real hardware tests before one final installation. This point is important and Atempo works with all major SAN hardware vendors to check the use of Time Navigator within different architectures.

	Vendor	Product
Host Adapters	Emulex	LP6000, LP7000E and LP8000
	HP	HPHBA and HP5101 BKSP
	ATTO	Express PCI FC
	JNI	FCE 3210 and 6410
Hubs Compatibility	Gadzoox	Gibraltar
	Vixel	2100
Fibre Channel Switches	ANCOR	SANBOX-8
	Brocade	Silkworm 2100, 2400 and 2800
	Compaq	StorageWorks SAN Switch 8/16
	Gadzoox	Capellix
	INRANGE	FC/9000 Series (8-port to 256-port)
	QLogic	SANBox (8-port to 256-port)
	Vixel	7100, 7200 and 8100
Routers and Bridges (FC/SCSI)	ATTO	FiberBridge 3200R
	Chaparral	FS1310 Router
	Compaq	StorageWorks Modular Data Router
	CrossRoads	CP4100 and CP4200

The above table represents only a few of the SAN hardware components supported by Time Navigator. For more specific details, see the compatibility guide document available on the Atempo Website: www.atempo.com.