IBM

Netfinity *White Paper*

IBM Netfinity Storage Management Using Tape Subsystems

Abstract

Today's applications process business data that must be maintained during system outages. The Tape drive is the industry standard for data backup. IBM's Netfinity product line provides complete application solutions for today's industry-standard, Intel-processor-based server marketplace.

This paper addresses the technologies, performance, and capacity of current tape solutions offered in the Intel processor based server segments.

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[1]Actual storage capacity will vary based upon many factors and may be less than indicated.

[2]MB equals one million bytes and GB equals one billion bytes when referring to hard disk capacity; accessible capacity may be less.

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Executive Overview

IBM Netfinity Storage Management – bringing proven leadership in high availability, power and scalability for storage management to industry-standard, business-critical solutions.

IBM has unparalleled reputation in technology leadership, service and support in the large and midrange systems. It has received numerous patents and awards for its technology and customer solutions over the past 40 years. IBM is adapting this experience to the Netfinity product line to provide complete application solutions for today's industry-standard, Intel-processor-based server marketplace.

IBM's Netfinity Storage Management solution offers the power, scalability, control and service needed for the Intel-processor-based servers. During 1998, IBM plans to announce products that round out the offering portfolio and provide solutions for standalone and clustered servers. These products manage and transfer data from the Intel platform to and from the traditional midrange and large-system environment. IBM will leverage its own technology with those of other alliance partners to provide storage-management solutions that rival today's enterprise offerings.

This paper offers an overview and tutorial on tape technology and discusses current offerings on IBM Netfinity systems.

Tape Technologies

IBM has a long heritage in the development and production of digital data storage. As Netfinity Servers take on more work in the enterprise, the need for robust storage management solutions and support programs in the Windows NT environment becomes a basic requirement.

IBM provides industry-leading tape technology in 4 mm, 8 mm, QIC, DLT and Magstar MP. IBM's tape offerings are manufactured and tested to IBM's standards and specifications and are backed by its worldwide service and support. IBM can provide a total end-to-end storage solution from hardware to financing.

Tape Requirements

Providing a total solution requires attention to today's tape usage requirements, emerging requirements and customer concerns.

Today's Tape Usage Requirements

Today's tape usage requirements are driven by the need to:

- Serve as a distribution media for operating system code, application licenses and information exchange.

- Provide backup and disaster recovery for system data, user data and business data.

- Archive legal, historical or other business data.

- Provide storage management techniques that can help customers reduce cost and meet the need for quick and easy information retrieval from digital libraries.

- Meet application needs, such as providing alternate boot devices, large sequential reads/writes and permanent data storage.

Emerging Requirements

These requirements address customer concerns about explosive growth in data and the need for distributed data management in a constantly changing world. There are four emerging requirements in the tape storage market:

1. Perception of infinite storage

    – Transparent access

    – Archive storage

    – Scalability

    – Network access

    – Built-in storage and hierarchy management

2. Simplicity

    – Multi-platform support

    – Shared storage

    – Simple, familiar interfaces

    – Integrated solutions

    – Ease of Installation

3.	Anxiety-free security and disaster recovery	4	Productivity

3. Anxiety-free security and disaster recovery

    – Reliable, robust backup and restoration

    – Executable in shrinking backup window

    – Automation of disaster recovery

4 Productivity

    – Lower operating costs

    – Platform independence

    – Automated operation, management and maintenance

Customer Concerns

Customer concerns are reflected in today's tape usage requirements and they drive the emerging technologies, too. These concerns include:

- Controlling the use of floor space
- Reducing storage costs
- Preserving disk capacity
- Reducing operator intervention.

As the need for storage management grows, customers want more tape capacity, unattended tape operations and faster access to more data. At the same time, the backup window is shrinking and the need to provide data recovery is expanding.

Tape Storage

Tape storage products are divided into two broad classes: drives and libraries. Tape drives range from those that can accommodate one media cartridge at a time, to those that can accommodate multiple cartridges in sequential access. Tape libraries typically use hardware and software automation to insert multiple media cartridges into one or more drives in sequential or random access. Tape libraries are normally used when a tape drive cannot meet the capacity and/or the management requirements of a particular installation.

Tape Technology

Tape drives use two basic technologies: helical scan and longitudinal recording. Although the packaging may be different, both use essentially the same mechanism for writing and reading data. Regardless of the packaging, tape consists of a long strip of material ranging from 4-mm wide to half-inch wide. The strip is coated with a magnetic material and wound onto spools. A transport mechanism moves the tape past read and write heads that alter or sense the polarity of magnetic domains on the tape, thereby writing or reading data.

Helical Scan

Helical scan technology has its origins in consumer analog audio and video devices and though there are several formats, the basic principles are the same for each.

Figure 1 shows that the tape surface is wound around a large cylindrical head, which is inclined at an angle of four to five degrees.
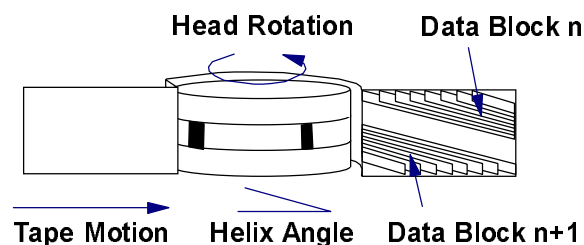

Figure 1. Helical Scan Principles

The tape moves slowly past the angled head that spins at high speed. This movement causes the data tracks to be written at an angle across the tape width so they overlap. This is a very efficient use of the tape surface resulting in high-density recording and good data rates for continuous writing (streaming) of data. However, the increased capacity is offset by synchronization requirements that slow initial access to the data. Since the tape surface is in contact with the read/write head across a relatively large area, the head and tape wear more rapidly.

Figure 2 illustrates the fact that in order to come into contact with the head, the tape must be extracted from the cartridge each time the device is loaded or idles. This extraction process takes time. In addition, the complexity of the transport mechanism lowers overall drive reliability.
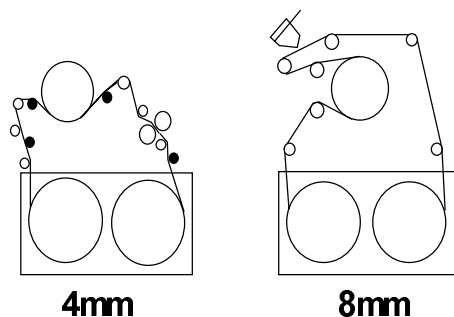

Figure 2. Helical scan tape paths

Longitudinal Recording

Longitudinal recording was specifically designed for computer data storage. There are variations, although all use the same basic concepts. Figure 3 shows that in longitudinal recording the tape moves past stationary read and write heads causing the data tracks to be recorded linearly along the tape's length. In order to make full use of the tape, the heads normally contain multiple elements allowing several tracks to be written or read concurrently.

When a continuous series of tracks has been written along the length of the tape, the direction of motion can be switched. The heads move perpendicularly to the movement of the tape to a clear area where they can write another series of tracks.

This process, which can be repeated until the entire width and length of the tape is used, is known as serpentine track interleaving.
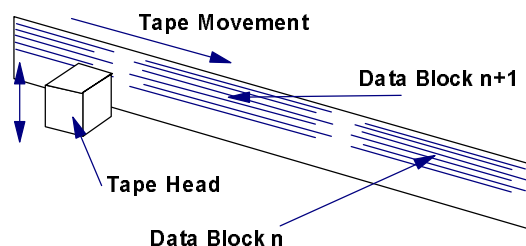

Figure 3. Longitudinal recording principles

Longitudinal recording is a nondestructive process, and so typically provides longer media life than helical scan recording. Performance is good for both streaming and start/stop activity. Figure 4 shows that the tape transport path and mechanism are less complex then in helical scan. Maintenance is therefore easier.
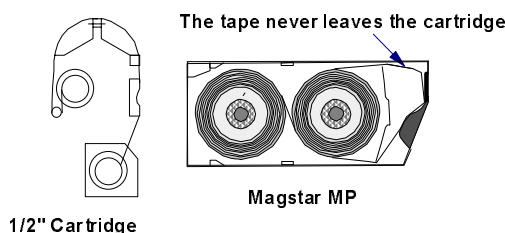

Figure 4. Longitudinal recording tape paths

With longitudinal recording, the tape-transport path can remain entirely within the cartridge. The IBM Magstar MP uses this method and employs a dual hub, midpoint load and a self-enclosed tape path. This allows the Magstar MP to load and unload faster, and keeps the entire design much simpler.

Other designs employ a single reel within the cartridge, requiring the free end of the tape to be threaded onto a spool within the tape device itself. This results in a slightly more complex design, leading to longer load/unload time.

The simpler design of longitudinal devices generally results in greater reliability and faster load/unload time. Helical scan technology provides greater capacity for a given media size and data cartridge costs are generally lower.

Both helical scan and longitudinal recording devices can make use of hardware compression before writing data to the tape. The resulting capacity depends on the characteristics of the data to be compressed. Depending on the algorithms used and the hardware implementation, data compression typically doubles a tape's capacity.

Tape Storage Device Selection Criteria

When selecting a tape storage device, there are four primary things to consider: capacity, performance, data reliability and availability.

- Capacity

The capacity of a tape drive refers to how much information can be stored on the media it uses. This varies as a function of the tape drive technology.

A tape library is needed if the required capacity exceeds that of any single tape available or there is a requirement for automated storage management.

Most tape drives support some form of compression, either hardware or software, which can increase the amount of data that can be stored on a tape. When compression is used, the tape device automatically decompresses the data when reading back from tape. Most devices allow compression to be turned off. Generally, it is better to leave compression enabled.

- Performance

In the case of tape drives, performance refers to the data rates to and from the device. Performance can also be affected by channel speed, the compression scheme used, data type, nature of the application and processor performance. Another measure of performance is data access time. When applications using tape require quick retrieval of data, then the time to load, thread and search the tape must be considered. In the case of tape libraries, the time it takes to read the first byte of data is usually also a performance measurement. This includes the time it takes to load and unload tapes to or from the library.

- Data Reliability

The reliability of various tape technologies depends upon the recording technique, redundancy capabilities and quality of the media.

- Availability

Availability usually refers to drive reliability and tape-cartridge shelf life. A device is reliable when it is up and running properly. The mean time between failures (MTBF) for a device is a common measurement for reliability, but different vendors may calculate this figure in different ways. Devices with simpler transport mechanisms usually have greater reliability.

Typical tape-cartridge shelf life depends on the type of tape used, the storage environmental conditions and several other factors. Half-inch and quarter-inch tape lasts longer than 4-mm and 8-mm tape, primarily due to the type of scanning employed – longitudinal versus helical.

Tape Storage Media

The more popular tape storage media technologies used in today's Netfinity servers are Digital Linear Tape (DLT), 8-mm and 4-mm Digital Audio Tape (DAT) and Quarter-inch (Travan).

Digital Linear Tape (DLT)

Digital Equipment Corporation developed DLT. It was based on existing half-inch magnetic tape. The essential difference was the elimination of the take-up reel within the tape cartridge. This permitted the speed and capacity of the half-inch, reel-to-reel tape subsystems in a smaller form factor more suited to Intel-processor based servers.

Although DLT does not have the installed base of the other tape technologies, it is the fastest growing tape technology in the middle to high-end Netfinity Server market segments.

Strengths

DLT has the highest capacity and fastest transfer rate of any other tape technology. It provides very high reliability, hardware data compression and the read-while-write standard.

Other Considerations

DLT has a relatively large (5.25-inch, full-height, extended length) form factor with a higher cost than competing technologies.

Summary

DLT is a prime technology to use as a network-based tape backup for multiple servers that have large amounts of data or for local use with digital video, photo editing and other applications that produce large files.

The IBM 35/70[1] GB Digital Linear Tape drives deliver the power, performance and capacity needed in network business environments.

8-mm Tape

The 8-mm tape has its origins in the video (camcorder) market.

Strengths

Reliability has improved considerably over earlier models. Enhanced 8-mm Mammoth reliability is provided through:

- A streamlined rugged design with fewer moving parts
- An improved capstan-removed tape path
- A dynamic built-in head cleaner
- An extensive parametric monitoring of tape and cartridge load motions

Hardware for 8-mm tape features data compression and a read-while-write standard. It has high capacity and a fast transfer rate for a relatively small 5.25-inch, half-high form factor and provides faster drive performance than 4-mm and quarter-inch tape drive offerings.

Data cartridge cost is low and has downward-read capability compatible with older 8-mm formats.

Other Considerations

Although 8-mm tape has a lower cost than half-inch technology, it does not have the capacity or extendibility of the DLT technology at this time. Exabyte has recently announced a road map that may extend the technology.

Overall, performance of 8-mm tape is slower than half-inch tape technology.

Summary

The 8-mm technology provides good capacity and performance at a moderate price within an attractive form factor. It is a good choice for those Netfinity Server customers with price and performance requirements or space constraints, as well as for those who have invested in the 8-mm technology.

The 8-mm technology may provide a better price and performance than DLT, depending on the customer's application requirements.

IBM 20/40 GB 8-mm tape drive delivers price, performance, and compatibility, and provides investment protection for those who have chosen to standardize on 8-mm technology.

4-mm Digital Audio Tape (DAT)

The 4-mm DAT evolved from the consumer audio market, and added such features as ECC (error correction code), read-after-write, and multi-partitions for use in the digital world. It uses helical scan recording.

There are several generations of 4-mm drives, including DDS-1, DDS-2 and DDS-3.

DDS-1 is the first generation 4-mm drive with 2.0 GB native capacity and 183-KB/second transfer rate. It supports either 60-m or 90-m data cartridges.

DDS-2 increased capacity to 4.0 GB native capacity and 500-KB/second transfer rate. It supports either 60-m, 90-m, or 120-m data cartridges and it is downward compatible with the DDS-1 format.

DDS-3 is the current generation drive with 12.0 GB native capacity and 1-MB/second transfer rate. It supports 60-m, 90-m, 120-m and 125-m data cartridges and is downward compatible with DDS-1 and DDS-2 formats.

Today, 4 mm DAT is the most popular tape backup choice for low to midrange Netfinity servers.

Strengths

The 4-mm DAT format is very popular for the midrange Netfinity server market, and it has a large installed base.

The 4-mm DAT format is a mid-capacity and mid-performance solution, in a compact 3.5-inch, half-high form factor. It is significantly lower priced than DLT and 8 mm. The data cartridges have a relatively low price. It is downward read/write compatible with older 4-mm DAT formats.

Other Considerations

Popularity may be peaking, receiving performance pressure from DLT and 8 mm from the high end and price pressures from mini-QIC (Travan) at the low end.

Helical Scan technology (8 mm and 4 mm) is not as reliable historically as linear technology (DLT and Travan).

Summary

The 4-mm DAT technology is a good choice for those Netfinity Server customers who want midrange capacity and performance at costs below DLT or 8 mm. It is also a good choice for customers who have already invested in 4-mm technology.

The IBM 12/24 GB 4-mm DAT tape drive offers investment protection for customers standardizing on 4-mm media and compatibility with previous versions of the DDS family of drives.

Travan Quarter Inch Cartridge (mini-QIC)

Mini-QIC has emerged from the desktop market. Early products were floppy interface drives with limited Netfinity Server features. Early mini-QIC drives had capacities of 100 to 200 MB.

The initial Travan class mini-QIC drives allowed use of a larger capacity data cartridge and extended capacities to 400 MB and more.

TR-1, TR-2 and TR-3 use a floppy interface. The TR-1 has a 400-MB capacity, the TR-2 capacity is doubled to 800 MB and the TR-3 capacity is doubled to 1.6 GB. The TR-4 has an enhanced interface with both SCSI and ATAPI models and a 4 GB capacity with a transfer rate of approximately 30 MB/minute

The TR-5 drives (renamed NS20) are being introduced. These drives offer 10 GB capacity, 1-MB/second transfer rates and added Netfinity Server features (read-while-write and hardware data compression) which help NS20 bridge the gap from being a desktop-backup device to a true server-class backup option.

Strengths

Low tape drive costs, and a compact (3.5-inch, 1-inch high) form factor are strong points of the mini-QIC.

Interchange capability with installed base of lower quarter-inch tape drives.

Other Considerations

The data cartridge cost is higher than 4-mm and 8-mm tape. It still carries a reputation as a desktop option.

In addition, for greater reliability, all quarter-inch drives re-tension the tape every time the cartridge is inserted into the drive. This process requires the tape to be unwound to the end and wound back and this process can take up to 4.5 minutes. This can be a problem for customers doing a backup of many cartridges.

Summary

Travan makes an excellent choice for low-end Netfinity Servers. Its very low cost, compact form factor and high reliability make it a good solution for those who have not standardized on a competing technology or who are looking for cost-effective alternatives to their present backup solutions.

The IBM TR-4 tape drives deliver a cost-effective solution for the entry market segment.

Autoloaders & Libraries

Today there are a wide range of tape autoloaders and libraries, varying in size, price and physical appearance. The more popular autoloaders and libraries use the 4-mm and 8-mm tape technologies, but it is also easy to find autoloaders and libraries based on DLT, Magstar MP and Travan technologies.

Autoloaders were developed as an extension to the basic tape drive, enabling customers to extend the capacities by adding multiple data cartridges. The early autoloaders and libraries consisted of a single tape drive and 4 to 10 data cartridges manipulated within the assembly by a robotic arm or picker.

Autoloaders and libraries are sometimes confused, but an easy way to distinguish them is to think of the autoloaders as a single tape drive and multiple (usually 6 or less) data cartridges. Libraries can have multiple tape drives and multiple data cartridges (10 or more).

Autoloaders and libraries have gained popularity as a means to automate large backup jobs. The library, with the proper application software, can change daily backup tapes and find the proper tape for a given backup sequence, freeing operators to perform other tasks.

Strengths

Autoloaders and libraries have very large capacities (up to several terabytes). They offer faster performance in multiple drive models. They can be standalone or rack mounted and they enable automation of complex backup jobs.

The 4-mm tape libraries support high capacities but have relatively slow data rates compared to half-inch tape cartridge libraries. It is therefore recommended that the 4-mm libraries be used in incremental backup/restore, archive or hierarchical applications.

The 8-mm tape libraries support high capacities and now have improved data rates and reliability with the 8-mm Mammoth technology that can be utilized in backup/restore, archive or hierarchical applications.

The DLT libraries incorporate the latest drive technology for save/restore, data interchange and migration applications. High capacity, performance and reliability are its strong points.

The Magstar MP connotes multipurpose, providing highly reliable backup/restore, archive or hierarchical applications as well as fast access to data.

Other Considerations

Autoloaders and libraries provide a level of redundancy and availability that can surpass a single drive application when contained in a storage management environment with the appropriate Redundant Array of Independent Tape (RAIT) software or hardware.

Summary

Due to their size and price, autoloaders and libraries are not for everyone. However, if higher capacities and/or backup rates than can be provided by individual tape drives are needed, or if automation of complex backup schemes is wanted, a tape autoloader or library should be considered. Storage libraries start at a higher price/performance curve than single drive solutions.

The IBM 3449 8-mm Tape library and the 3447 Digital Linear Tape library deliver on the price, performance, capacity and automation solutions required by the mainstream and high-end market segments.

Tape Software

Tape drives differ from disk and CD-ROM in that additional application software is required to effectively use the tape hardware. Relatively simple tape utilities are provided in some of the major server operating systems today. Selections from a variety of more robust tape backup applications are available in the open market from industry-standard ISVs. In either case, a plan must be developed for software as part of a Netfinity Server backup strategy.

A brief discussion of the tape backup software currently available in the Netfinity Server market follows:

Available Operating Systems Applets

Some of the major operating systems include integrated tape backup applications (or applets). These applets provide simple backup/restore functions and do not include features such as scheduling that are normally found in the more robust application software. Examples of these applets include the backup features in Microsoft Windows NT 3.51 and 4.0.

These operating system applets are not as robust as the software offered by storage-management software vendors or from operating-system vendors that specialize in backup software for the Intel space.

Bundled Applications

Some operating systems provide separate backup software as part of their basic package. This backup software normally provides as much function as the simpler backup applications available in the market. Examples of these are SBACKUP within NetWare and PSNS within OS/2 Warp Server.

OEM Software

Applications can be purchased to provide a more robust backup solution. The applications range in complexity from those used for simple backup/restore, to those used for backup, archival and overall data-storage management. Seagate, Cheyenne and Legato are three of the ISVs that provide a range of storage-management software products for the Intel-processor based market.

IBM Software

IBM's ADSTAR Distributed Storage Manager (ADSM) is used by major corporations around the world. The award winning ADSM software is an enterprise-wide storage management solution. It includes unattended network backup and archive, hierarchical storage management (HSM) and disaster recovery management (DRM) designed to support business continuance while implementing disaster-recovery operations.

ADSM offers a complete, scaleable storage-management solution for today with the performance, control and usability features to grow with user needs well into the future.

Highlights

- ADSM automates the backup, restoration and archiving of critical data for multi-vendor platforms, helping safeguard business assets.

- A single solution backs up and restores data, industry applications and databases.

- Server-to-server communication enhances storage sharing and disaster protection.

- Media flexibility backs up to disk, optical or tape.

Choices Available

This choice should really be based on individual requirements. For a simple backup/restore process, without many extras, the operating system tape applets are best. More complicated needs require a tape drive that includes a bundled software solution.

If neither of these choices meet the requirements, then the alternative is to pick from a large array of backup applications from IBM or ISVs such as Seagate Software, Computer Associates, and Legato.

IBM Tape Solution Product Line

The following section describes the tape options currently available from IBM for the Netfinity Server and PC Server products.

IBM 35/70 GB Digital Linear Tape Drive (DLT)

Part numbers: 04K0149 (Internal) or 01K1174 (External)

Highlights

- 5.25-inch, full-high form factor

- Single DLT-7000 drive

- High capacity, high performance

- Digital linear tape media

- Backward read/write compatible DLT I, II, III

- Software NOS
  Windows NT, NetWare, SCO, OS/2

- SCSI fast/wide interface

Features

- Capacity
  35 GB (native capacity); up to 70 GB (with hardware data compression)

- Data rate (native) 5 MB/second[1]

- Data rate (compressed) 10 MB/second [1]

- 8-MB cache to improve start/stop performance

- Data and cleaning cartridge included

- SCSI cable included

- Software shipped with options:

  - Seagate Backup Exec V6.11 or higher for windows NT standard

  - Seagate Backup Exec V7.11 or higher for NetWare standard

  - Seagate Sytos Premium V2.2 or higher for OS/2

- Other leading industry ISVs. See Web site http://www.pc.ibm.com/us/options/family

> **High Performance Drive for Mainstream and High-End Server Segments**

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[1] Per drive unit

IBM 20/40 GB 8-mm Tape Drive

Part Number: 01K1325

Highlights

- Single 5.25-inch, half-high form factor

- 8-mm media

- LCD display for usability

- Software NOS
  Windows NT, OS/2, NetWare, SCO

- SCSI fast/wide interface

Features

- Capacity
  20-GB (native capacity)
  Up to 40 GB (with hardware data compression)

- Data rate (native) 3 MB/second [1]

- Data rate (compressed) 6 MB/second [1]

- Data and cleaning cartridge included

- Software included with options:

  - Seagate Backup Exec V6.11 or higher for Windows NT

  - Seagate Backup Exec V7.11 or higher for NetWare

  - Seagate Sytos Premium V2.2. or higher for OS/2

- Other leading industry ISVs. See Web site http://www.pc.ibm.com/us/options/family

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> ### Economical 8-mm Drive for Mainstream and High-End Segments

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[1] Per drive unit

IBM 12/24 GB 4-mm DAT Tape Drive

Part Number: 01K1282

Highlights

- 3.5-inch, half-high form factor

- 4-mm media

- Compatible with DDS-1 and DDS-2 formats

- Software NOS
  Windows NT, OS/2, NetWare, SCO

- SCSI fast/narrow interface

Features

- Capacity
  12-GB (native capacity)
  Up to 24 GB (with hardware data compression)

- Data rate (native) 1 MB/second[1]

- Data rate (compressed) 2 MB/second [1]

- Data and cleaning cartridge included

- 5.25-inch, half-high mounting kit included

- Software included with options:

  - Seagate Backup Exec V6.11 or higher for Windows NT

  - Seagate Backup Exec V7.11 or higher for NetWare

  - Seagate Sytos Premium V2.2. or higher for OS/2

- Other leading industry ISVs. See Web site http://www.pc.ibm.com/us/options/family

> **Price/Performance Drive for
> Mainstream Segment
> Preserves Legacy (DAT) Investment**

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[1] Per drive unit

IBM 4/8 GB Travan TR-4 SCSI Tape Drive

Part Number: 06H9716

Highlights

- 3.5-inch, half-high form factor

- Travan media

- Software NOS
  Windows NT, OS/2, NetWare, SCO

- SCSI fast/narrow interface

Features

- Capacity
  4 GB (native capacity)
  Up to 8 GB (with software data compression)

- Data rate (native) 0.6 MB/second [1]

- Data rate (compressed) 1 MB/second [1]

- Data cartridge included

- 5.25-inch, half-high mounting kit included

- Software included with options:

  - Seagate Backup Exec V6.11 or higher for Windows NT

  - Seagate Backup Exec V7.11 or higher for NetWare

  - Seagate Sytos Premium V2.2. or higher for OS/2

- Other leading industry ISVs. See Web site http://www.pc.ibm.com/us/options/family

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Cost Effective Drive for Entry Server Segment

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[1] Per drive unit

IBM 4/8 GB Travan TR-4 IDE Tape Drive

Part Number: 06H9720

Highlights

- 3.5-inch, 1-inch-high form factor

- Travan media

- Software NOS
  Windows NT, OS/2

- EIDE interface

Features

- Capacity
  4 GB (native capacity)
  Up to 8 GB (with software data compression)

- Data rate (native) 0.6 MB/second [1]

- Data rate (compressed) 1 MB/second [1]

- Data cartridge included

- 5.25-inch, half-high mounting kit included

- Software included with options:

  - Seagate Backup Exec V2.0 for Windows

  - Seagate Backup Exec V5.6 for Windows 3.1

  - Seagate Backup Exec V2.0 or higher for Windows NT 4.0

  - Seagate Sytos Premium V2.2. or higher for OS/2

- Other leading industry ISVs. See Web site http://www.pc.ibm.com/us/options/family

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Lowest-Cost Drive for Entry Server Segment

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[1] Per drive unit

IBM 3449 8-mm Mammoth Library

Highlights

- One or two, half-high 20-GB Mammoth tape drives

- 20 cartridges in 2 removable magazines

- 2 Bonus slots [1]

    - Cleaning slot
    - Customer slot

- Deskside or rack mount

- Barcode reader

- Shell design picker [1]

- Three modes of operation

    - Manual
    - Sequential
    - Random

- Graphics display

    - Gas gauge [1]
    - Inventory [1]

- Automatic drive cleaning [1]

- Read compatibility with 2.3 GB, 5 GB, 7 GB

- Software NOS
  Windows NT, NetWare

- SCSI 2 fast/narrow interface

Features

- Capacity

    - Number of cartridges - 20
    - Library uncompressed - 400 GB
    - Library compressed - up to 800 GB

- Data rate (uncompressed) 3 MB/second [2]

- Data rate (compressed) 6 MB/second [2]

- Cartridge average - 6 seconds access time

- Supported by:

    - ADSM

    - Industry ISVs

- See Web site
  http://www.pc.ibm.com/us/options/family

> **High Capacity and
> Price/Performance Storage
> Management System for Mainstream
> and High-end Segments**

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[1] IBM exclusive
[2] Per drive unit

IBM 3447 Digital Linear Tape (DLT) Library

Highlights

- One or two DLT-7000 drives

- IBM Digital Linear Tape media - 35/70 GB

- Backward read/write compatible: DLT I, II, III

- 15-cartridge capacity - 5 fixed, one 10-cartridge removable magazine

- Deskside or rack mount

- LCD display

- Software NOS
  Windows NT, NetWare

- SCSI 2 fast/narrow interface

Features

- Capacity

  - Library uncompressed - 525 GB
  - Library compressed - up to 1.05 TB

- Data rate (native) 5 MB/second [1]

- Data rate (compressed) 10 MB/second [1]

- Supported by:

  - ADSM

  - Industry ISVs

- See Web site
  http://www.pc.ibm.com/us/options/family

High Capacity and Performance Storage Management System for Large Multi-user and Enterprise Networks

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[1] Per drive unit

Other Tape Products from IBM

IBM Magstar MP 3570 Tape Subsystem

The IBM Magstar MP 3570 Tape Subsystem is being tested on the Netfinity platform for compatibility. Results of this testing will be posted on the World Wide Web, as they become available, at http://www.pc.com/us/compat.

Highlights

- Breakthrough IBM technology

- One or two Magstar MP drives

- IBM Magstar MP media

- 20-cartridge capacity

- Fast access to data

- Midpoint load for faster access

- High reliability

- Standalone or rack mount

- Pre-imbedded servo tracks

- SCSI fast/wide interface

Features

- Capacity

  - 5 GB (native)
  - up to 15 GB (with hardware data compression)
  - 300 GB (library)

- Data rate (native) 2.2 MB/second [1]

- Data rate (compressed) 6.6 MB/second [1]

- Supported by:

  - ADSM

  - Industry ISVs

- See Web site http://www.pc.ibm.com/us/options/family

Ensures Compatibility of Enterprise Storage-Management Tape Solutions for Netfinity Server Platforms

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[1] Per drive unit

More on Magstar

IBM Magstar MP 3570 Tape Subsystem is a revolutionary new multipurpose (MP) SCSI attachment tape technology designed for automation. Traditionally, tape has been used to perform write-intensive operations like backup and data interchange. The Magstar MP is a compact, integrated storage device that functionally expands the capability of tape to optimize both read- and write-intensive operations. It provides the characteristics of high performance, high reliability, a new cartridge and a new library subsystem.

High Performance

The IBM Magstar MP has been designed to provide fast access to data. The drive and cartridge have been uniquely designed to allow fast cartridge insertion, almost instantaneous head/tape contact at load time and midpoint load. In this case, the tape is already positioned to achieve fast data access by quickly fast-forwarding to data in either direction. The drive time to read/write data is about 8 seconds from the time of cartridge insertion. The tape drive can read/write data at a sustained data rate of 2.2 MB/second (uncompacted) with a 20-MB/second burst data rate. The sustained data rate with maximum compression is 14 MB/second. Automatic caching of data enables balancing system read/write speed and the drive is designed to provide high performance in both streaming and start/stop operations. These characteristics are exciting new technical breakthroughs in an industry that has only historically seen innovation in the form of increased cartridge capacity and data rates.

High Reliability

The IBM Magstar MP provides outstanding reliability. IBM provides leading-edge technology in the area of reading and writing data. Data write is provided by an exclusive thin-film write module that is designed for extremely accurate recording. IBM's leading magneto-resistive (MR) head technology that is based on IBM Magstar provides data read. The head is a highly tuned 4-track MR head that is designed for high read reliability, long life and future growth. In addition, the 4-track head provides data redundancy and servo tracking for superior data integrity in the midrange tape marketplace. It offers technology that was previously only affordable in the large-systems environment.

A New Cartridge

IBM has been awarded numerous patents for its innovative new cartridge technology. It features two tape spools with the tape load point positioned at the midpoint of the tape to provide fast access to data, while still providing matched capacity for backup needs. The Magstar MP Fast Access Linear Tape cartridge has a native capacity of 5 GB (up to 15 GB with 3:1 Lempel-Ziv compression). It contains major enhancements over conventional data-recording cartridges. It has a rugged case designed for repetitive handling by automated pickers and for protection in an enclosed environment. The cartridge contains advanced metal-particle tape media developed for high capacity and durability. The tape never leaves the cartridge because the cartridge contains the tape path within itself. Thus, the tape media is protected from being harshly handled by external pickers, rollers or external guides. The unique path eliminates tape thread time, reduces complexity and enables higher reliability. The internal tape path also allows quick load time and combined with the midpoint load, provides unparalleled tape performance. Along with the Magstar MP Fast Access Linear Tape Cartridge, IBM is announcing a Magstar MP Cleaning Cartridge and a Magstar MP Cartridge Magazine.

The Magstar MP significantly expands the functional utility of tape storage with its revolutionary data-recall performance that supports both current and emerging tape applications. In addition, the Magstar MP tape subsystem addresses the growing storage needs of midrange customers by offering a more durable technology that is designed to meet the tougher demands of automation.

Backup Solutions

This section deals with the integration of the hardware (tape drives) and the software to implement a total backup solution. First is a definition of three generic environments to be backed up. Following that, is a discussion of the methods for accomplishing the backup for each of those categories.

Enterprise Network Categories

Enterprise backup requirements can be divided into three generalized categories. The line between each of the three categories is not clearly defined. It is possible, even probable, that any particular enterprise's network will fit into more than one of these categories.

Category 1 defines an enterprise with a small number of file servers, usually less than two or three. An important characteristic of this category is that each server will have a single tape drive capable of performing a complete backup of the hard disk space to a single tape. Routine (nightly) periods of network downtime are normal. Unscheduled downtime, although critical, is usually not catastrophic to the organization. The goal of backing up data on this size network is to provide protection against loss of individual files, as well as ensuring that the organization can recover from a complete loss of a file server (disaster recovery).

Category 2 defines an enterprise with many file servers—possibly more than one hundred—and total hard drive capacity in terabytes. An organization with a network this large will most likely have critical database applications as well as general file storage. The file and print sharing requirements are complex with differing levels of security within the organization. While this category has the same requirements as the first category (file recovery and disaster recovery), there are added constraints. There is much less time the network can be unavailable on a regular basis—four to five hours (or less) per day as opposed to nine to ten hours in Category 1. It is possible to have tape drives in each server in this environment, although it is not required.

Category 3 is the most complex of the three defined here. Hard disk capacities are measured in terabytes and there are many file servers. A single server can control more than one terabyte. This organization might have different platforms, such as Netfinity Servers, AS/400s, RS/6000s and mainframes. This category has the same constraints as in Category 2. The principle difference between Category 2 and Category 3 is the platforms.

These three categories have similarities. They all require the ability to recover files, from one that has been accidentally erased, up to recovery from a natural disaster such as a fire or flood. Categories 2 and 3 are orders of magnitude more complex than Category 1. They have the problem of more data to backup and less time to do it.

Enterprise Backup Solutions

A backup solution for each of the three categories described above will be discussed here. Although there will be specific hardware and software combinations used in the examples, these are not the only solutions. This section will describe one of many ways to have the data on the file servers protected in each category.

Category 1 example

This is the easiest to back up, given the small number of file servers and the relatively small amount of hard drive capacity. In this example, assume the following configuration:

File Servers   1

Network Operating System   Microsoft Windows NT 4.0

Total Disk Capacity   9 GB (2 x 4.5 GB)

Tape Drive   DDS-3 (4-mm DAT 12/24)

Tape Backup Software   Seagate backup Exec
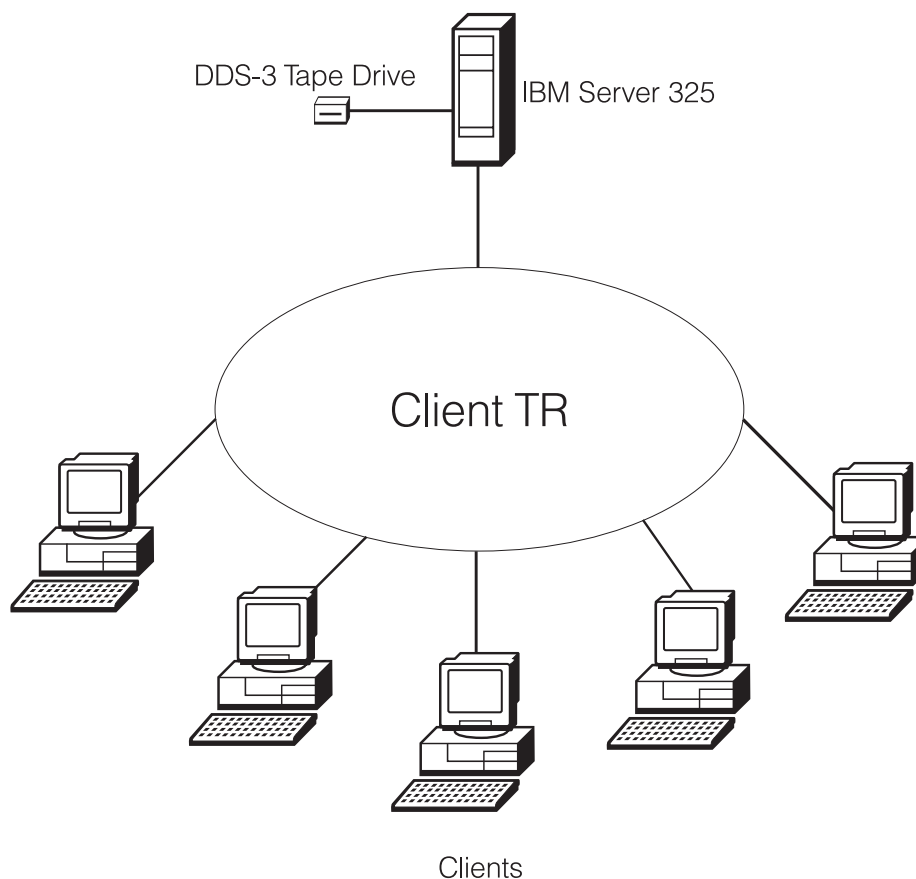
The file server is an IBM PC Server 325 with two internal 4.5 GB[2] hard drives for 9.0 GB of disk space. The tape drive is a DDS-3 tape drive, which has a capacity of 12 GB (uncompressed) on a single tape. The operating system in this example is Microsoft Windows NT v4.0 although it could easily be NetWare or OS/2. A good LAN installation allows room for growth of data and, therefore, it is assumed the entire 9 GB disk capacity is not entirely used up. Chart 1 shows theoretical backup times for a given amount of data using a DDS-3 tape drive.

Chart 1. DDS-3 Backup Times

Many small offices do not have a network specialist on staff, therefore, an easily administered backup solution is required. A good backup solution for this office might work as follows:

- Perform full backup of the entire server at the end of *each business day* on separate tapes, Monday through Thursday. This requires 4 tapes. (Monday's tape will be reused each Monday, etc.)

- Friday night's full backup will be the *weekly* backup with each Friday of a given month using a different tape. This requires 4 more tapes (one for each Friday of the month).

- On the last day of the month, instead of the normal daily or weekly backup, a *month-end* backup is performed (12 tapes). The backup scenario described here will allow data to be easily recovered for up to *one year*. It provides a good balance between the need to keep costs down (it only requires 20 tapes), the need to have old data available and ease of data recovery.

Category 2 example

This example is significantly more complex than the previous example. In this example, assume the following hardware configuration:

File Servers	IBM PC Server Model 704 (total of 3)
Network Operating System	Microsoft Windows NT 4.0
Total Disk Capacity	54 GB (7 x 9.2 GB per server in RAID 5)
Tape Drive	DLT-7000 (35/70) in each server
Tape Backup Software	Seagate Backup Exec, Cheyenne ARCServe or IBM ADSM

File Servers	IBM PC Server Model 330 (total of 7)
Network Operating System	Microsoft Windows NT 4.0
Total Disk Capacity	36 GB (5 x 9.1 GB per server in RAID 5)
Tape Drive	DLT-7000 (35/70) in each server
Tape Backup Software	Seagate Backup Exec, Cheyenne ARCServe or IBM ADSM

This scenario would be in use in a medium-size business where there is a need for applications servers running larger databases, some file and print sharing, an interoffice mail system, as well as office management such as accounting and payroll systems, and world wide web (WWW) services. There is a higher need for server availability than in the first example.

Usually this environment has a mixture of file servers since the company will probably have grown the servers over time through a series of upgrades. This example assumes a tape drive in each server. As in the first example, it is assumed that each server's disk capacity is not completely filled — a well-functioning network environment does not have all available disk capacity used. The tape drives used in this example have enough capacity (35 GB uncompressed) to handle a full backup on a single tape for the IBM PC Server Model 330. However, for the larger capacity IBM PC Server 704, a single tape might not be able to hold a full server backup. Therefore, in this scenario, an incremental backup solution will be used.

Incremental backups have proven to be a good method for backing up large amounts of data onto smaller tapes in less time than full-system backups. Incremental backups will only copy the fields that have changed since the last backup. Since, for example, a database application does not change very often (the database itself changes, the program files do not) there is no need to write those files to tape every time a backup is done. An incremental backup solution has a more demanding tape management requirement than the full daily backup solution. Since all the files making up a complete file server are spread across multiple tapes, the location of these files must be managed. The three backup software applications listed above for this example all perform incremental backups as well as cataloging file location. If a single file needs to be restored, the backup software will prompt for the tape that holds the most up-to-date copy of it. In the case of a full system restore, the backup application will prompt for each tape it needs in order to rebuild the complete system.

Chart 2 shows theoretical backup times for a given amount of data on a DLT-7000 tape drive.

Chart 2. DLT-7000 Backup Times

Many studies have shown that less than 30% of the data on a typical server changes in a single day. The rest of the data, for example, old work processing files, spreadsheets, operating system files and so on, remain untouched. Using this estimate, the largest server in this example, even if the disk drives were completely full, would easily be backed up in less than one hour (30% of 54 GB = 16 GB).

Category 3 example

For Category 3, assume the following hardware configurations of the network file servers:

File Servers	IBM Netfinity 7000 (total of 5)
Network Operating System	Microsoft Windows NT, UNIX, NetWare
Disk Capacity	163.8 GB per Netfinity 7000 (2 IBM EXP10s fully populated 10 x 9.1 GB = 82 GB)
File Servers	IBM PC Server Model 704 (total of 3)
Network Operating System	Microsoft Windows NT, NetWare, UNIX
Total Disk Capacity	54.6 GB (7 x 9.1 GB per server in RAID 5)
File Server	IBM PC Server Model 330 (total of 7)
Network Operating System	Microsoft Windows NT, NetWare
Total Disk Capacity	36.4 GB (5 x 9.1 GB per server in RAID5)
Other network servers	IBM AS/400, IBM RS/6000, mainframe
ADSM Backup Server	IBM PC Server Model 325
Network Operating System	Microsoft Windows NT 4.0
Disk Capacity	36.4 GB (5 x 9.1 GB per server in RAID 5)
Tape Libraries	3 DLT-7000 (35/70) Libraries (2 drives per library)
Tape Backup Software	IBM ADSM
Total Network Disk Capacity	1.2 terabytes (Intel Servers only)

This is the most complex of the three examples. It assumes there are many Intel-processor-based file servers configured with higher amounts of disk drive space. In an organization this large there will probably be larger servers such as an IBM AS/400 as well as IBM RS/6000. There likely will be a mainframe in the enterprise as well. The servers will be on their own server backbone as well as each being connected to the user environment—each server has dual network adapter cards. This prevents inter-server communications from competing with user communication.

In this example, the backup solution will be centralized to a single backup server. This server will be an IBM PC Server Model 325 running IBM's ADSM Server software. ADSM Client software will be running on the other IBM file server as well as the AS/400 and RS/6000 computers to provide the necessary backup services for the ADSM server. In an environment with the backup storage requirements as complex and demanding as this, tape libraries will be required and will be attached to the backup server.

ADSM functions as two separate pieces, the backup server and the backup clients. The backup server is any computer running the server software. Although the server software is not required to be on a dedicated computer, in this example it is. The backup clients are not required to be file servers—any computer (file server or workstation) can run the client software. The ADSM Server communicating with the backup clients performs the backups.

Although a detailed explanation as to the workings of ADSM is available from IBM's ADSM World Wide Web site, this paragraph will provide a very brief overview. When ADSM copies data from a network file server (any computer running ADSM client software), it is first stored in a backup pool on the disk drive. This is an area on the backup server dedicated for this pool (analogous to a disk cache). Once this has filled to a preset threshold, ADSM will begin actually writing data to tape. Since there are six tape drives available in this example—each of the three libraries holds two tape drives—ADSM will utilize each by writing to the drive that is available at any given time. This provides many benefits. The backup continues even when a tape drive fails; multiple drives are utilized at once giving a higher overall performance. ADSM Server will also manage the location of data across the tapes and will automatically have the library load the required tape by using the bar-code readers in each library.

Chart 3 shows theoretical backup times required for a given amount of data. It assumes the use of 6 DLT-7000 tape drives.

Chart 3. DLT-7000 Backup Times using 3 DLT Libraries

The backup times shown in Chart 3 only indicate the amount of time it takes to get data written to the tape, not the total backup time required by ADSM. The chart does not take into account the effect the backup pool has on the total backup.

Although the backup scenario is significantly more complex given the amount of data, the different server platforms and the tape libraries, it is no more difficult to manage than the first two examples. ADSM provides a centralized point of administration that allows the backup administrator to run the entire process from a single location.

Buyer Considerations

IBM delivers the total solution and brings power and scalability with key IBM strengths to this product area:

IBM is the only company providing complete solutions, including systems, software, disk, tapes, RACLs, tape libraries, storage management software, and systems and network software.

IBM provides a unique level of integration — testing the whole system working together, not just a peripheral in isolation.

IBM's native mode attach provides ongoing testing of microcode levels, PTFs and new software releases for compatibility.

IBM systems provide integrated error correction and recovery routines including predictive failure-analysis routines, self-diagnosis and correction.

Failing-component identification facilitates fast repair times.

IBM's inventors and manufacturers are continually making advances in tape technology, keeping IBM as the leading-edge, storage-solution provider.

Tape storage management is evolving rapidly on the Intel-processor-based platform. IBM continues to provide leadership technology across multi-server platforms and is poised to do the same for this platform with the total solution.

The Right Tape

The Right Software

The Right Service

The Right Company

The Right Time

IBM <=> TOTAL SOLUTION

Industry Trends and Future Directions

All of the major technologies (DLT, Magstar MP, 4 mm, 8 mm, QIC) have plans for future products with higher capacities, faster backup rates, and added features and functions. It is expected that mainframe-like storage-management software will increase in popularity as customers try to reduce administrative costs and more effectively manage their growing storage requirements.

Advanced optical technologies (DVD) and high-end, removable-disk technologies (Syquest and Iomega) may start to encroach on the low-end tape backup technologies.

For now, the trends seem to indicate QIC is growing in popularity in the entry-to-mid-range level at the expense of 4-mm technology, and DLT is growing in popularity in the high-end server market at the expense of 8-mm technology.

According to recent research reported by International Data Corporation (IDC), the worldwide tape drives storage market reached revenues of $2.9 billion in 1997. The tape-drive market totaled 5.56 million units in 1997. The 4-mm drive market will account for 33 percent of tape storage revenues in 1998; while, DLT shipments will grow 27 percent to 418 thousand units in 1998.

The world tape-drive market went through some fundamental changes in 1997 that will continue into 1998. A new set of technologies is now making its way to the forefront and is positioned to solidify tape as a viable storage solution. Fueling this growth are the high-growth market segments: automation, storage management and digital library systems.

Appendix

Operational Guidelines

Environmental considerations are of paramount importance to the extended life of tape media. The nature of magnetic-tape media requires user awareness of the special limitations and the requirements for operation, handling, storage and usage for reliable backup of critical customer data files.

Cleaning of magnetic Tape drives

Unlike most other options that can be attached to a PC or to an Intel-based processor server, such as fixed disks, magnetic tape drives do require periodic cleaning by the user. It is the user's responsibility to be aware of this requirement and to provide the necessary supplies to perform the required cleaning. Cleaning is not difficult, however, failure to perform this simple task will cause tape backup failures and possible loss of critical customer data. The documentation provided with the specific tape drive provides the necessary information about cleaning and obtaining the required cleaning supplies.

The frequency of cleaning will vary depending upon local environmental conditions, age, quality of the tape media and other factors. For example, a dusty warehouse environment or locations with heavy pedestrian traffic may require cleaning more often than office environments with minimum pedestrian traffic and a well-filtered air-conditioning system.

Proper cleaning is a major factor for reliable tape operation.

Magnetic fields

As in all other magnetic media, magnetic tape cartridges are susceptible to inadvertent data loss if they are placed too close to magnetic fields, such as florescent desk lamps, small appliances, electric clocks or computer monitors (displays). Because monitors are usually placed in close proximity to PCs and servers, it is easy to forget the magnetic field they generate. The larger the monitor is, the larger the magnetic field is. Regardless of the size of the monitor, a large magnetic field is generated during the power-on cycle. When powered-on, most monitors will initiate a degaussing cycle in which a very large magnetic field is briefly applied to the front screen for a few seconds. If a tape cartridge containing valuable data is left lying near a monitor during power-on or power-off cycles, it could be affected by the magnetic field of the monitor and rendered difficult or impossible to read.

Quality of the magnetic media

Only tape media of the type specified by the tape drive vendor should be used. Do not substitute media. Refer to the documentation provided by the vendor for guidance and for the specifications of the tape required for their specific tape drive. Choosing a brand of tape media can be confusing because prices and quality vary from brand to brand. This decision should be given as much consideration as the decision for the brand of tape drive. To protect sensitive financial data, or other critical business data, it is recommended that you choose a brand based on durability and consistent quality. Remember that a slightly higher purchase price could result in lower overall operational costs and higher reliability.

Pre-formatted Tape Media

Pre-formatted media is a popular choice in the marketplace. Usually, this works quite well, however, intermittent tape backup errors have been experienced when using pre-formatted media directly from the box. Therefore, for critical backup applications, the media should be formatted before being used. This only takes a few minutes per cartridge and can be done ahead of time. This provides a ready-to-go tape cartridge that has been formatted on the same drive on which it will be used to store the critical data.

Software considerations

There is no BIOS interface for magnetic tape drives in any Netfinity Server product. These devices require a device driver to control their operations. The device driver varies depending upon the operating system and the specific tape drive being used. To minimize problems, the most recent software application versions should be used and recent fixes or patches for it should be researched to determine their applicability to the configuration. One of the most common causes of backup and recovery errors is related to not having the most recent software versions and fixes from the applicable vendors.

Data Compression

Most magnetic tape drives available to the market today incorporate some type of built-in hardware data compression. Usually, this option is turned on as the default setting by the manufacturer in order to obtain maximum storage capacity per tape cartridge. This works quite well, as long as the data being backed up was not compressed by the operating system or application software. Double compression, which results under these conditions, is a source of difficult-to-diagnose tape backup/restore failures and is not supported or recommended.

Tape Library Management

Correct management of the tape library (tape data cartridge inventory) is a very important factor in a trouble-free tape backup environment. Organization of the library should be based on business needs and unique operational situations. Some of the factors to be considered are as follows:

1. Ease of use – Can a specific back up tape be located for use?

2. Tape identification – What is on the tape and when was it created?

3. Order – In what sequence are the tapes to be used?

4. Time – How long must a specific backup tape be kept for archival purposes?

5. Security – Is the tape library located in a safe place, protected from fire, water damage and magnetic fields?

6. Location – Are all the backup tapes in one location or are there other locations that must maintain a library?

7. Maintenance – Do all responsible personnel understand the importance of correct tape maintenance and the requirements for maintaining library integrity at each location?

Compatibility Matrix

The Compatibility Matrix is on the Internet to assist the user in the selection of a tape solution. See Web site http://www.pc.ibm.com/us/options/family.

Tape Terminology

4-mm tape   Digital Audio Tape, 4 mm in height, helical scan

8-mm tape   8 mm in height, helical scan

DDS   Digital Data Storage, data format for 4-mm tape (DDS IIII 2 GB, DDS-2 4 GB)

DLT   Digital Linear Tape, half-inch height, longitudinal serpentine scan

Helical scan   Recording technique that writes data to tape at a 5-degree angle from top to bottom of the tape

Longitudinal or linear   Recording technique that writes data to tape from end to end.

Mini QIC or QIC mini tape   Shorter length than QIC, called DC2000, longitudinal scan (Sony introduced MQIC – Travan)

QIC tape   Quarter Inch Cartridge, called DC6000, quarter-inch height, longitudinal scan

RAIT   Redundant Array of Independent Tape

Serpentine   Writing data from end to end and back again (used in longitudinal recording)

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