TECHNOLOGY BRIEF

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Compaq Computer Corporation

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Compaq DLT Library Technology

EXECUTIVE SUMMARY

Recent changes in the handling of business critical data storage have forced companies to search for a high-density, fast storage solution that can perform backups and restores unattended for long periods of time. One of Compaq's solutions is the DLT Library. The Compaq DLT Library offers up to 450 GB (compressed) of storage in a rack-mountable box designed to withstand the rigors of a lights-out environment for weeks at a time. This paper examines the trends that led to the development of the DLT Library, and the technology used to implement Compaq's solution.

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INTRODUCTION

Demands upon information management systems increased significantly in recent years. Consequently, the importance of developing a reliable, large-scale method to back up, store, and restore massive quantities of data increased. As recently as five years ago, paper constituted much of a corporation's archiving. Large quantities of paper were the primary means of preserving data, and warehouses quickly filled to provide this backup. Paper archives prove expensive to maintain, difficult to manage, and a waste of valuable resources. Today's corporations back up their data electronically with tools such as tape drives, optical drives, and floppy drives. One of Compaq's solutions to the problem of managing massive quantities of data is the Compaq DLT Library.

This paper examines the mass storage trends that led to the development of the tape library and key features that Compaq identified as "must haves" in the solution. The design and salient features of the library are discussed in detail.

CURRENT MASS STORAGE AND BACKUP TRENDS

In today's corporate world, the quantity of business critical-data increases constantly. Forecasters see no end to this trend for a number of reasons. As the price of computers drops and performance rises, most companies computerize their businesses. As a result, much of the data formerly archived on paper has transferred to electronic media. The range of companies with large quantities of data has increased as well. Today, small and mid-size companies require sophisticated backup solutions for their swelling volume of data, a need once exclusive to large, multi-billion dollar corporations. In addition, large companies changed their backup philosophies to include departmental and business-critical backups, increasing their information management load.

Compounding the problem of huge quantities of data requiring backup, the time period available for backups is shrinking or has disappeared entirely. As more and more companies move to an international environment, their computer systems' usage increases to 24 hours a day/seven days a week. Prior to globalization, a company based in North America typically had a backup window from close of business on the West coast to start of business on the East Coast – a period of about 12 hours. This was still a respectable time period for performing system backups. Now however, system administrators are forced to juggle users' needs for data with the need for backup.

Despite a wealth of technology, current backup and archival methods remain manpower intensive. The majority of backup methods require an administrator to monitor the backup medium; change tapes, drives, or cartridges; troubleshoot; perform restores; etc. Not only is such hands-on involvement expensive in terms of personnel costs, but many companies fail to account for these costs when calculating total cost of ownership, hiding the true cost of many tape backup systems.

LAYING THE FOUNDATIONS OF A SOLUTION

As a leading provider of enterprise-class computing solutions, Compaq understands companies' needs for reliable, high-density backup systems. Compaq identified three requirements to be addressed in the development of a new storage product:

- Scalable storage capacity. A scalable storage solution includes the ability to store more data, link storage units, or add additional drives to improve throughput capacity within a defined footprint.
- Automated backup management. Fully automated backup management means that backup performance occurs in a lights-out environment, 24 hours a day/seven days a week. Ideally, the library functions in stand-alone status for days or weeks at a time.
- High reliability. A product designed to provide years of reliable service without worry of failure or breakage.

THE COMPAQ SOLUTION

The core of Compaq's philosophy includes providing well-engineered, reliable enterprise class solutions. One of Compaq's solutions for managing expanding quantities of enterprise-critical data consists of the new Compaq DLT Library. It offers scalability and automation in a chassis specified to withstand the rigors of a lights-out environment for weeks at a time. The DLT Library's design is a complete solution encompassing hardware and firmware and the ability to integrate with independent software vendor (ISV) software solutions.

Scalability

Because of how the DLT Library was specified and designed, scalability takes several forms. First, one library was designed to hold up to 15 DLT cartridges, providing a storage capacity of up to 225 gigabytes (GB) (native) or 450 GB (compressed). Second, a single Compaq 42U rack holds five DLT Libraries for a total storage capacity of 1.125/2.25 terabytes (TB). Third, multiple racks of libraries can be deployed in a centralized location. Finally, the customer can purchase extra magazines of cartridges and rotate the magazines to provide additional storage or for archival purposes.

Scalability of the DLT Library makes it possible to condense secondary storage to a more centralized location. For example, if there were five servers in a department, each with its own tape drive, it would be manpower intensive to backup and manage each server individually. However, one DLT Library in a centralized location can handle the backup for all five servers. By centralizing the department's secondary storage, the system administrator effectively manages the backup needs of the department. This method includes one caveat, however. The system administrator must evaluate the constraints of the network. If the backup is going to be performed over the network, the network must be fast enough to handle the data transfer without negating the speed of the tape drives and slowing down the backup significantly.

Hardware Architecture

In defining the DLT Library to meet customers' needs, Compaq subjected multiple DLT Libraries to more than 100,000 hours of intensive stress and qualifications testing in the areas of temperature, humidity, robustness, tape drives, tapes, shock and vibration, and regulatory agency. The following paragraphs outline the engineering that went into producing the DLT Library.

Robot and Mechanics

The Compaq DLT Library's design allows for a highly automated solution for secondary storage. The robot used within the library was leveraged from a proven large-scale library system and re-engineered to compress the large-scale technology into a relatively small space. Figure 1 illustrates the relative compactness of the DLT Library and shows the interior of the unit. In the qualification of the DLT Library, Compaq selected the picker mechanism for its reliability, low wear, and proven track record to insert and remove cartridges from the tape drive. This design reduces wear on the cartridge and minimizes the chances of contaminating the cartridge in the drive.

The material used to make the robot mechanism is a Teflon impregnated polycarbonate. This material has proven to be extremely tough and durable, with minimal wear characteristics. All other materials were also chosen for their robustness and abrasion resistance. Because of the wear inherent to moving mechanical parts, the robot and barcode reader self-align at boot-up to ensure proper operation. Maintaining proper alignment reduces and overcomes mechanical wear and failures and extends the life of the library.

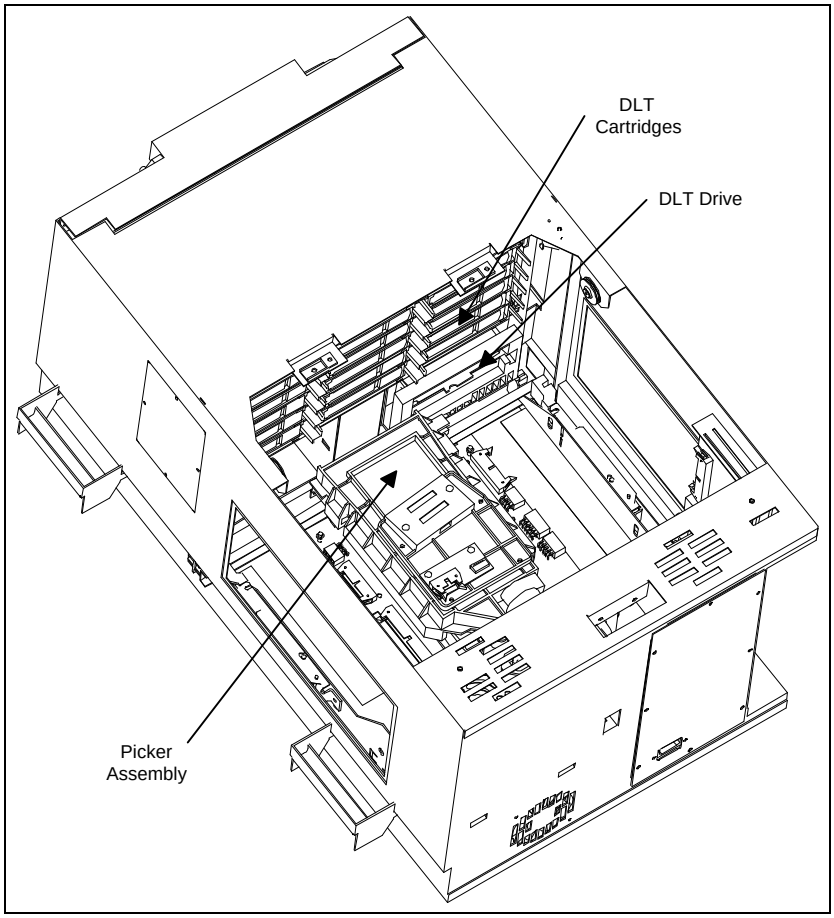

Figure 1: Interior of the DLT Library showing the robot and magazines with tapes.

Rack and Chassis Modifications

Compaq plans for the DLT Library to have a long product life, and defined the chassis accordingly. The DLT Library is a compact storage solution given all the functionality it contains. Nevertheless, it is a large chassis weighing close to 100 pounds (44 kg). To simplify handling for the customer, Compaq engineered the unit to be as user-friendly as possible by adding the following features:

- Side handles for lifting and mounting the unit in a rack.
- Mounting rails specified for a Compaq library rack environment.
    - Small détentes at the back of the rails, to keep the unit from rolling out unless approximately one pound of force is applied.
- Door access to the tape magazines specified to open to 120 degrees for easy access when mounted high in a rack.
- Customized cable management arm, shown in Figure 2, to accommodate the 29-inch depth of the library, minimizes interference of cables with the back of the cabinet and prevents damage, crimping or disconnection of the cables.
- Repeater board to "zero-out" the SCSI cabling within the cabinet. The repeater board allows the 12 foot external SCSI cables to provide maximum signal integrity with regards to operation.
- Robust fans to cool the drives and robotic mechanisms providing more than adequate cooling at the upper specified operating parameters. Keeping the box cool prevents the media (the most sensitive component) from overheating and failing.

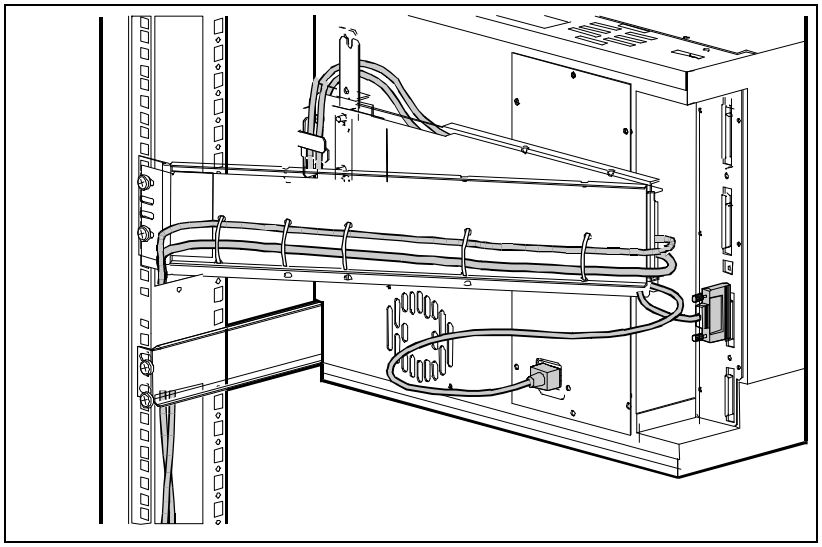

Figure 2: Rear view of the DLT Library with the cable management arm in place.

Magazine Storage Units

The magazine design includes features so that cartridges can be inserted one way only. This prevents possible fatal conditions that might occur when a cartridge is improperly inserted into the drive. Magazine design also includes features that allow single-hand removal and transportation, thereby simplifying handling and storage issues. Figure 3 contains an illustration of the magazine, showing insertion of a cartridge into the magazine. A cartridge release/locking button prevents loss of the cartridges during transport. Pressing down the button allows for cartridge removal. The library holds three magazines with five cartridges each for a total of 15 cartridges. This maximizes the configuration for one cleaning cartridge and 14 data cartridges resulting in two weeks of uninterrupted backup solution. Figure 4 illustrates the insertion of a magazine into the library.

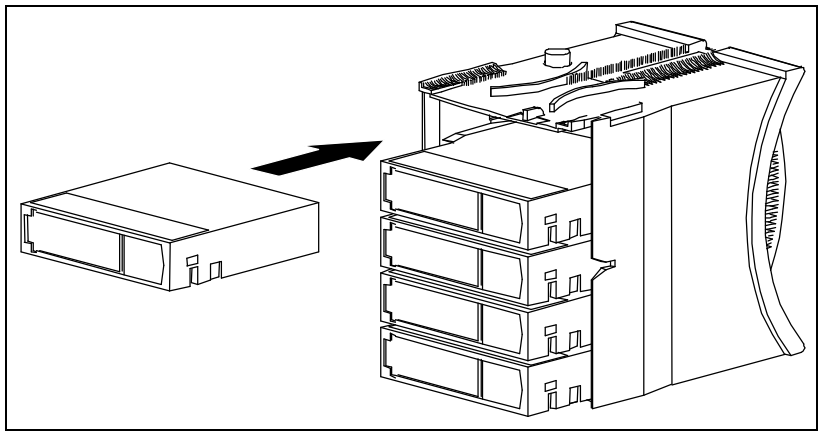

Figure 3: DLT Library magazine and cartridge showing insertion of the cartridge.

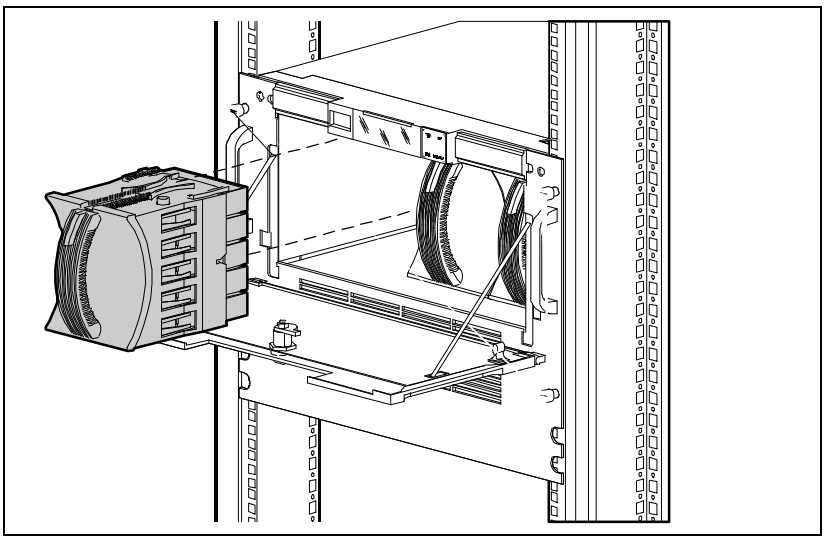

Figure 4: Magazine loading into DLT Library.

As a result of the engineering and testing, the Compaq DLT Library supports a mean swaps between failure (MSBF) of 1,000,000. A swap is one complete cycle of moving a cartridge from a magazine slot to the drive, then removing the cartridge from the drive and putting it back into the magazine slot. In addition, the DLT Library has a mean time between failure (MTBF) of 100,000 hours, and the DLT tape drives have an MTBF of 80,000 hours. This translates into years of use before failure is expected.

Barcode Design and Features

In defining and qualifying the inner workings of the library, Compaq examined such things as placement of the barcode reader. Attaching the reader to the transport mechanism instead of placing the reader on the side of the box resulted in a shorter inventory. If the barcode reader is attached to an internal fixed location, the tape has to be removed from the magazine, read, and returned to its original slot. By incorporating the barcode reader on to the transport mechanism, typical inventory time is less than four minutes.[1] The shortest inventory time is achieved by applying barcodes to all cartridges in the library.

Compaq chose DLT cartridges that contain a slot for an industry-standard 3x9-format barcode label. Cartridge barcodes provide accurate inventory information to the application software. In addition, the magazines come with a label pouch which can hold a 3x9 barcode tag or user-selected inventory information for on-the-shelf inventory. The barcode labels shown in Figures 5 and 6 can be placed on either the cartridge or in the label pouch on the magazine.

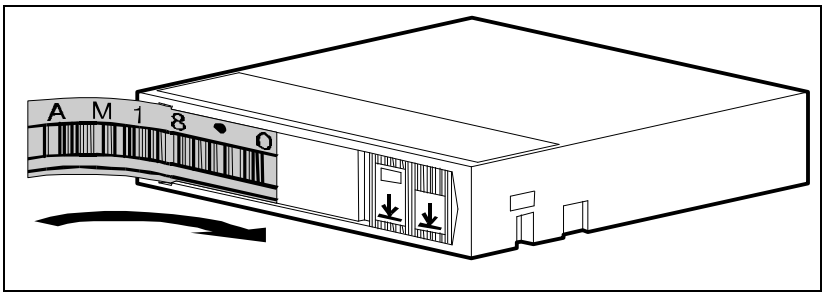

Figure 5: Barcode label location on DLT cartridge.

[1] This assumes that all cartridges have barcodes. Inventory time will increase without barcodes; but will not exceed eight minutes.

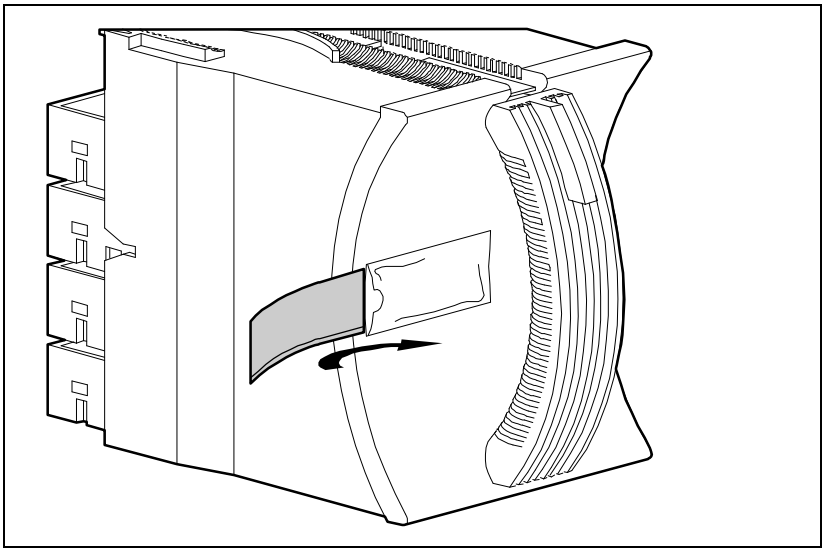

Figure 6: Barcode label location on magazine.

DLT Tapes and Drives

The Compaq DLT Library comes equipped with one 15/30 DLT tape drive standard and a second drive available as an option. The DLT drive used in the Compaq DLT Library is specifically designed for a library environment. The material originally used for the DLT drive faceplates does not stand up to the repeated stresses of an automatic loader. To minimize abrasion problems from contact with the transport mechanism, the drive's faceplate material is made of the same Teflon impregnated polycarbonate used in the transport mechanism. In addition, the drive door was modified to work with the robot picker.

A single DLT tape is capable of storing 15/30 (native/compressed) GB of data and is reliable for a number of reasons related to technology, drive design, and tape media.[2] This allows for hands-off management of the backup/restore process. Table 1 shows the backup and restore speeds possible with the DLT drives based upon varying compression rates.[3] These figures translate to an average backup speed of 2.16 megabytes/second (MB/s) or 7.78 GB/hr per tape and an average restore speed of 2.08 MB/s or 7.49 GB/hr per tape.

TABLE 1: COMPRESSION RATIOS, BACKUP AND RESTORE SPEEDS FOR THE DLT LIBRARY

Compression Ratio	Backup Speed (MB/m)	Restore Speed (MB/m)
1:1	65.08	65.47
2:1	125.16	116.23
4:1	161.27	155.75
8:1	166.43	163.26

[2] For a detailed discussion of DLT tape technology, refer to the white paper "DLT Hardware Technology," document

[3] Backup data was created using Diskfill at compression ratios of 1, 2, 4, and 8. These compression ratios are based on a PKZIP compression. Also, these numbers are based off of a single 2GB backup and restore.

On-Line Drive Repair

There are benefits to equipping a library with two drives. First, the customer gains a measure of redundancy should one drive fail. Second, there is no need to power down the entire library to replace a failed drive. While the failed drive is replaced, the other drive can continue to perform backup or restore operations. Safety regulations require that the robotics and barcode reader be inactivated while the library faceplate is removed, but the drives will continue to operate. It is also important to note that during a drive replacement, the server attached to a DLT Library does not need to be powered down.

Low Power Mode

The library was designed with a low power mode feature. After 30 minutes of robotic inactivity, the transport mechanism is placed in the lower left corner of the unit to reduce excessive strain and wear and tear on the robotic motors. The robotics reactivate on the next issuance of a robotic move command. This results in power/cost savings for the unit and also serves to extend the life of the unit.

Controller and Drive Firmware

Compaq believes that comprehensive firmware is important to the DLT Library. The drive firmware has been customized per Compaq's requirements for a high-reliability library environment. The front panel diagnostics and onboard testing are designed to be as comprehensive as possible. For example, if a problem with the robot occurs, such as an incomplete operation, a hex code dump can provide significant information about the location of the failure, what parameters failed, etc. Should a move be incomplete, the firmware recalibrates and retries three times to complete the operation. This self-correction feature minimizes human intervention.

The onboard diagnostics design produces a user-friendly environment. The diagnostics will isolate problems to a specific Field Replaceable Unit (FRU)/Service Spares (SS) to allow service personnel to quickly replace only those parts needed. Both the drive and controller firmware contain Compaq specific ID string information to support the library within Compaq's software solutions such as Compaq Insight Manager and User Diagnostics.

Software Architecture

Compaq initially chose to optimize automation of the DLT Library using Cheyenne ARCserve v. 6.0. In the future, Compaq will expand its support of other independent software vendors, so customers will have several software options. Seagate and approximately 20 other software vendors have tested their software for compatibility with the DLT Library, but Compaq has tested only with Cheyenne ARCserve.

Faster backups can also be achieved by using multiple libraries in a rack with dual tape drives performing write operations simultaneously. In particular, ARCserve can support concurrent backups, one to each tape in the library.

CONCLUSION

As companies face the problem of archiving and restoring increasing quantities of mission critical data, they require a reliable, fast, and cost-effective means of doing so. The Compaq DLT Library solves these problems and provides added value because of the extensive engineering and testing involved in its design. Compaq thoroughly examined storage problems that companies face and developed a scaleable, fast storage solution that performs reliably with minimal intervention. Compaq understands that technology evolves quickly and designed the DLT Library to take advantage of advances in DLT drive technology. The DLT Library offers exceptional value and performance for customers' needs today and easily meets customers' needs in the future.