

IBM LTO Ultrium Performance Considerations

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Introduction

This paper provides performance information on the IBM LTO Ultrium tape drive. A tape drive's performance is effected by a number of factors. This paper delineates those factors and discusses the impact of each of them. It is intended for use by IBM field personnel and their customers in designing tape solutions for their applications.

Business benefit of improved performance

The IBM LTO Ultrium tape drive provides significantly improved performance compared to the other competitive tape offering available today. This performance improvement provides a number of benefits to the customer.



- **Drive cost savings.** Customers must complete their backups in a given number of hours. To accomplish this, they need a given number of tape drives. When customers use slow tape drives, they need additional drives to make that same backup window.
- **Business savings - Backups.** If the customer has their on-line systems down for backup, their on-line systems can be brought up sooner with faster tape drives.
- **Business savings - Restores.** Similarly, with the faster IBM LTO Ultrium tape drives, a customer system will be up and running sooner after a recover requirement.

Performance Metrics

In the following sections the performance of the IBM LTO Ultrium tape drive is discussed. The primary metric is the sustained transfer rate, sometimes called the effective transfer rate. The sustained transfer rate is the amount of data transferred (backed up or restored) divided by the elapsed time.

There are many factors that effect a tape drive's sustained transfer rate including:

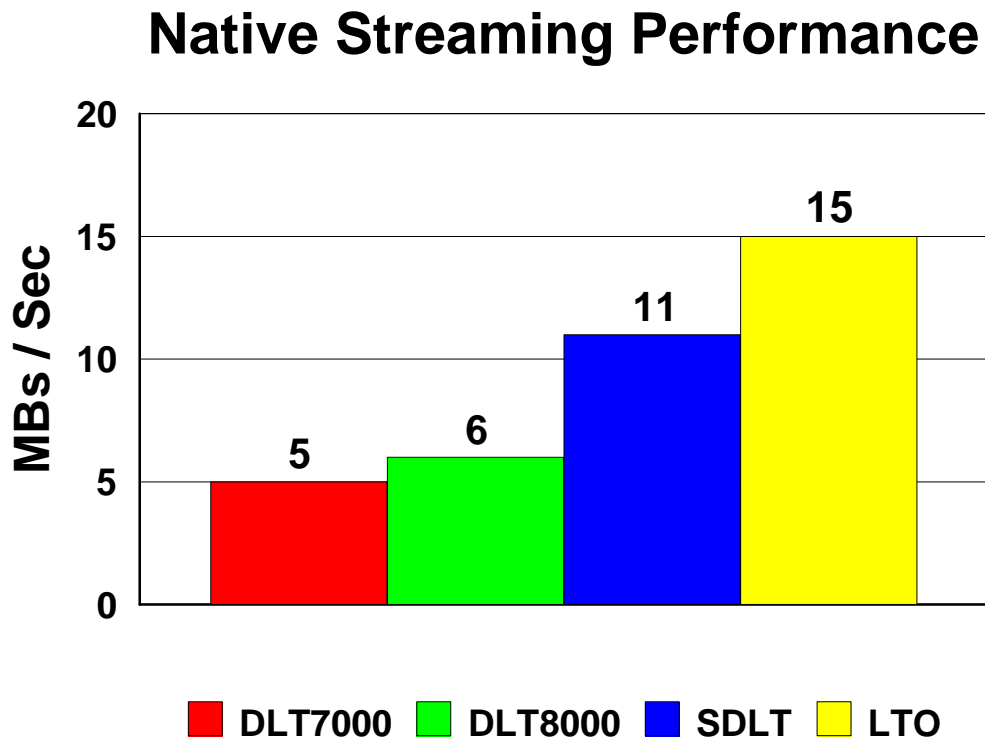
- Native streaming performance
- Compression ratio
- Blocksize
- Disk transfer rate
- File size
- Tape operation
- Application
- Server attachment
 - ◆ HVD, LVD, Fibre Channel
 - ◆ LAN-Free vs LAN
- Start/Stop performance

The sustained transfer rate takes into account the net effect of all these factors. We will look at the effect each of these factors has on LTO performance.

- Performance Problem Determination Tips

If a tape drive is not providing the expected performance, there are a handful of problem determination steps that can be undertaken to help isolate the cause of the performance issue. These problem determination steps are discussed in the last section of this paper.

Native Streaming Performance



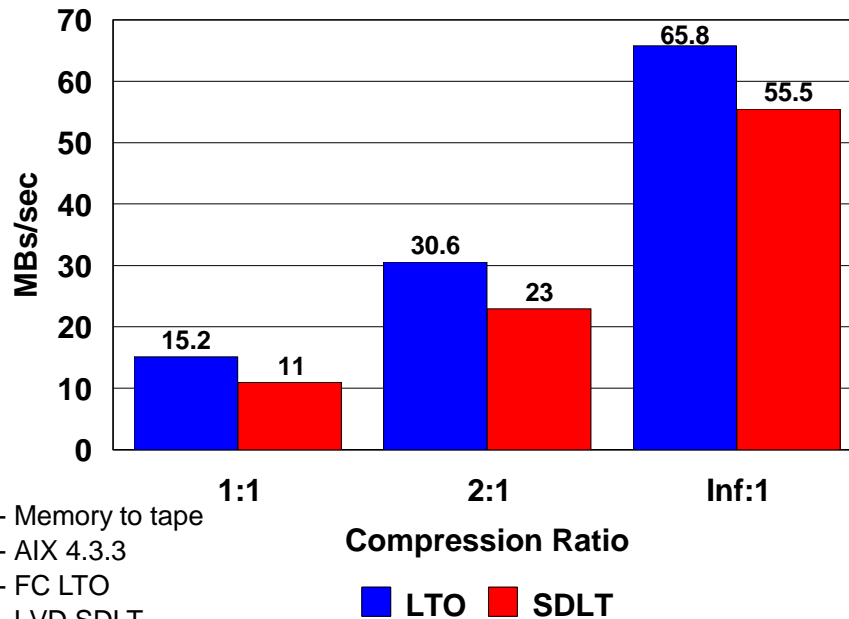
LTO tape drives have a high native streaming transfer rate. The streaming rate is the rate at which the drive transfers data while the tape is moving, that is, while it is actively reading or writing data.

A tape drive's streaming rate is an important factor in determining its overall sustained transfer rate; an important factor, but not the only factor.

If your car can go 70 MPH, that does not mean you can go 7000 miles in 100 hours. Many factors: speed limits, gas, food, sleep, detours, traffic jams will effect your overall speed. And the same is true with tape drives.

Compression Ratio

Sustained Transfer Rate



- Memory to tape
- AIX 4.3.3
- FC LTO
- LVD SDLT
- 256K blksize

Compression Ratio

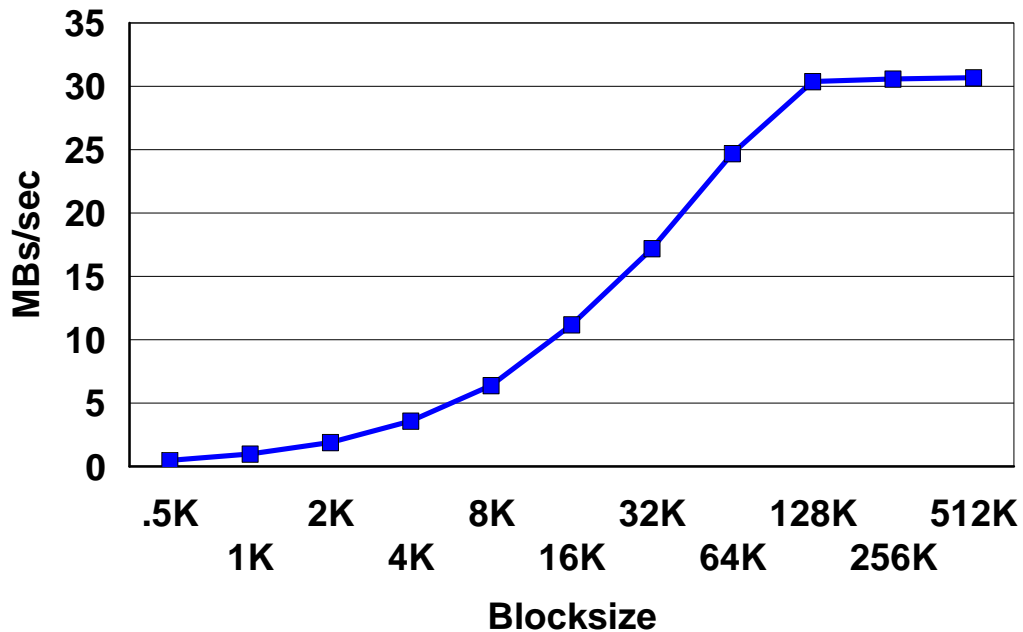
■ LTO ■ SDLT

The above runs were done with a benchmark driver. Common constraining variables; disk, LAN, application, have all been removed. This is a good run to test the performance potential of the tape drive with no other constraining parameters.

As one can see from the above chart, compression ratio, has a significant effect on a tape drive's sustained transfer rate. Compressibility is very data dependent. Data Bases often compress around 2:1. Video, audio, or image data around 1:1.

Blocksize

LTO Write Throughput at Various Blocksizes

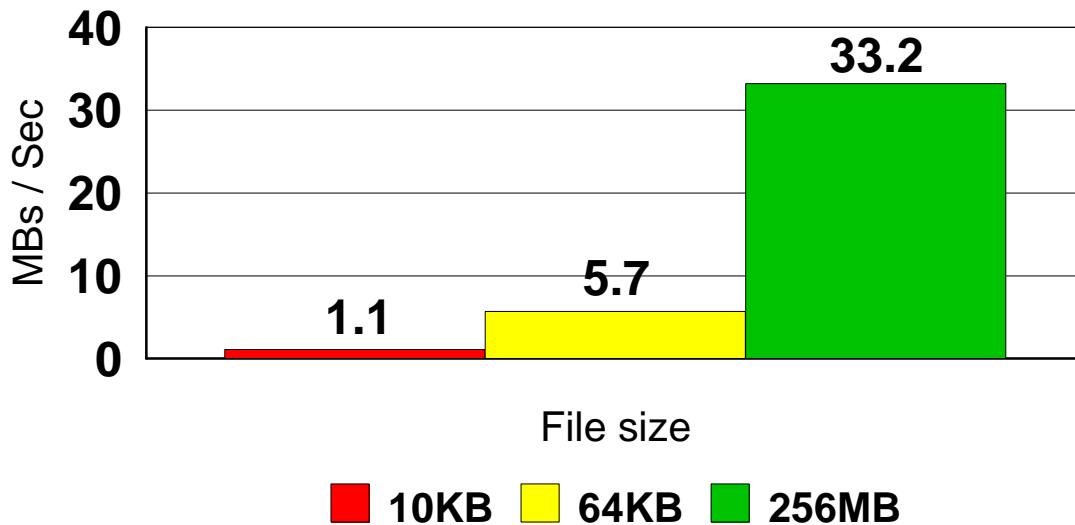


2:1 Compression Ratio

At any blocksize greater than or equal to 128K, the LTO tape drive can be written to at 30MBs/sec. At smaller blocksizes, SCSI overhead relative to the amount of data transferred increases, decreasing the effective data rate.

Small blocksizes significantly reduce the performance a tape drive can sustain. Fortunately, all major ISVs (IBM TSM, Veritas NetBackup, Legato Networker, etc.) use large blocksizes. Blocksize can be a constraining factor when using native OS commands, e.g.. Unix TAR, Windows BACKUP.

LTO TSM Backup Throughput



- RS/6000 H70 4way
- Shared Memory
- LTO Fibre

Disk performance and file size are combined because for backup operations, they are closely related. Assume you are backing up very small files, 10KB. If your disk drive transfers at 10MBs/sec, it would take 1ms to transfer the 16KB file. Then the disk drive would do a multi-millisecond search and a multi-millisecond seek before it was ready to read the next file. The disk drive would be spending 80 - 90% of its time moving the drive actuator, and a very small percentage of time actually reading data. And as one would expect, data cannot be written to tape any faster than it can be read from disk.

Library Sizing based upon Sustained Backup

Example:

Assume 20MBs/sec

1 Drive at 20MBs/sec = 72GBs / Hr

Requirement: 2TBs / 4 Hrs or 500GBs / Hr

$500 / 72 = 6.9$ LTO Tape drives

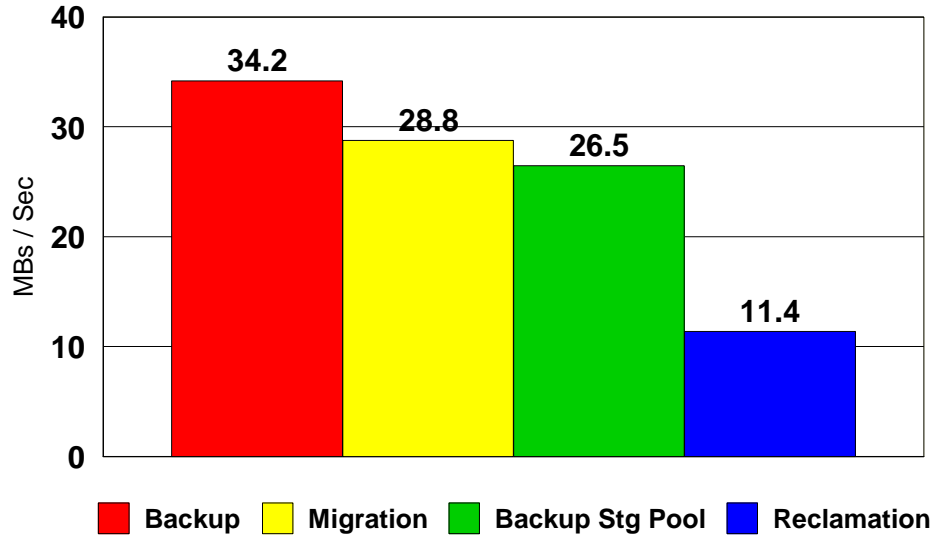
This approach is valid ASSUMING the sustained throughput used is valid and ASSUMING sustained throughput scales with the number of tape drives.

Just because one tape drive can do 20MBs/sec, does not mean that seven tape drives can do 7X that. Other constraints; server utilization, server PCI bus utilization, SCSI or FC path utilization, disk subsystem throughput, will often limit overall throughput from scaling with the number of tape drives.

The best way to determine what sustained throughput a tape subsystem will provide in a given customer environment is to install and test it. If this is not possible, be conservative. Do not assume all files are large, and that there will be no performance constraints unless you are certain that is the case.

Tape Operation

LTO TSM Throughput

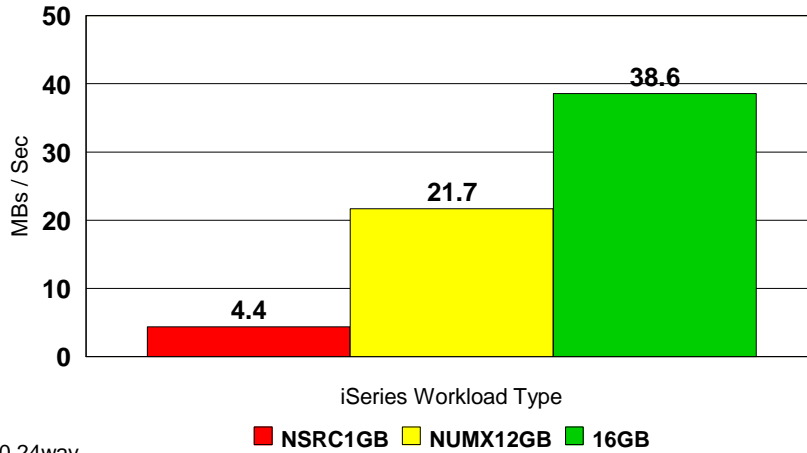


- * RS/6000 H70 4way
- * Shared Memory
- * LTO Fibre
- * 256MB file size

Different tape operations have different performance characteristics. On IBM tape drives, backup and recovery normally perform similarly. Reclamation will be slower than large file backup because of the substantial amount of tape movement involved.

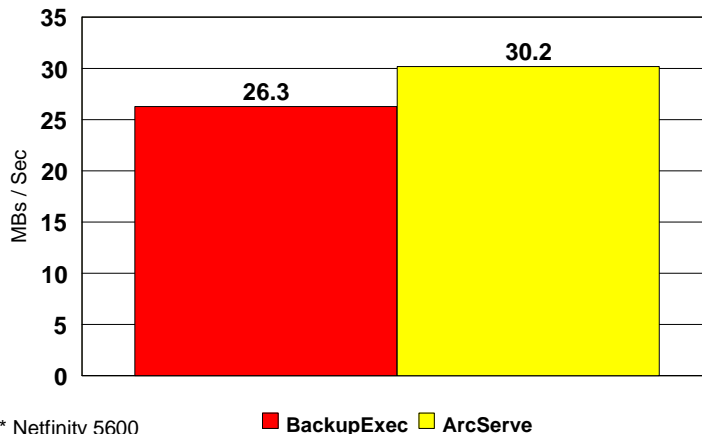
Application

LTO BRMS Backup Throughput



- * 840 24way
- * OS/400 V5.R1
- * LTO Fibre

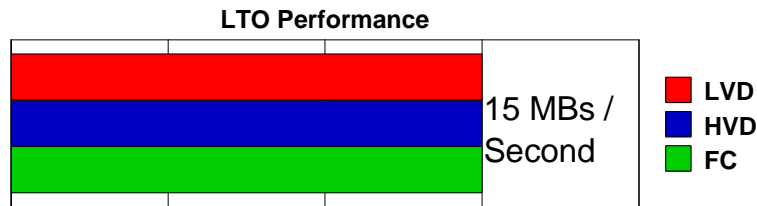
LTO W2K Backup Throughput



- * Netfinity 5600
- * LVD SCSI LTO
- * Veritas BackupExec 8.6
- * CA ArcServe2000 V7.0
- * 1GB Text file

As one can see from the above charts, and the previous TSM charts, all major backup applications provide good performance for large file backups. Different applications have different mechanisms to mitigate the performance impact of backing up small files. TSM, for example, recommends sending small file (less than 100MBs) to a disk storage pool, and then migrating the data to tape. Veritas has a multiplexing capability that allows the user to write multiple concurrent backup streams to a single tape drive. This capability improves the Veritas NetBackup backup throughput, but has a negative impact on restore throughput.

Server Attachment



LVD - Ultra2 SCSI (80MBs/sec)

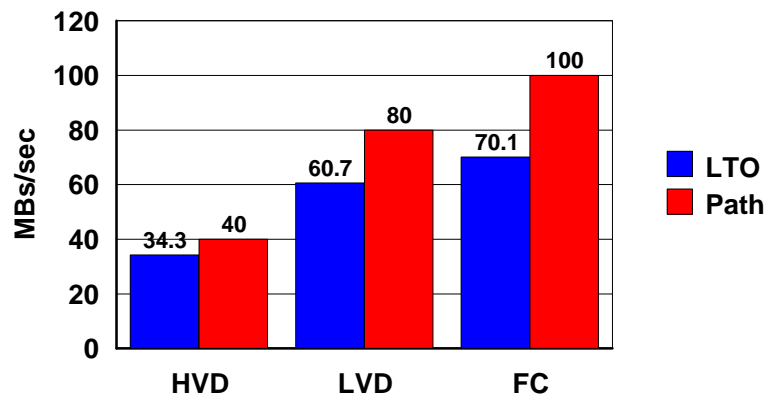


HVD - Ultra SCSI (40MBs/sec)



LTO HVD, LVD, and Fibre Channel tape drives all have the same native streaming data rate, 15MB/sec. The HVD drives attach to a 40MB/sec Ultra SCSI bus. The LVD drives attach to a 80MB/sec Ultra2 SCSI bus. The Fibre Channel drives attach to a 100MB/sec Full Duplex FC path. All of these paths are fast enough to carry a single backup operation without significant performance degradation. A backup involving a very fast disk subsystem, large files, 3:1 compression, with the wind at its back, will just start to be constrained by the 40MB/sec HVD ceiling. A faster path allows more concurrent backups to be run, but will have little impact on the throughput of a single backup.

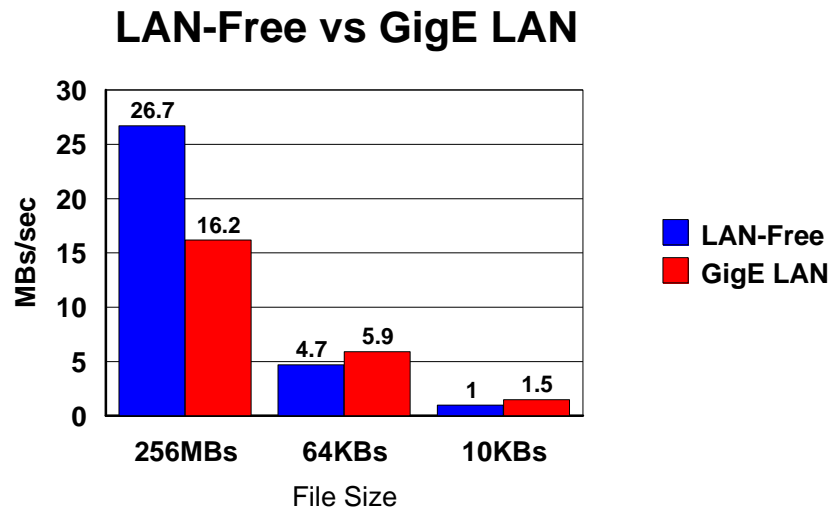
LTO Tape Drive vs Path



- Memory to Tape
- 256K blksize
- Inf:1 compression

The maximum sustained throughput of a path is typically 70 - 75% of the paths rated rate.

LAN-Free vs LAN



- TSM 4.2.1
- Windows 2000 TSM Client and Server
- 3590 Tape Pool

Moving from a LAN based backup to a LAN-Free backup can provide a performance improvement. The magnitude of the improvement depends upon the LAN type and the file size.

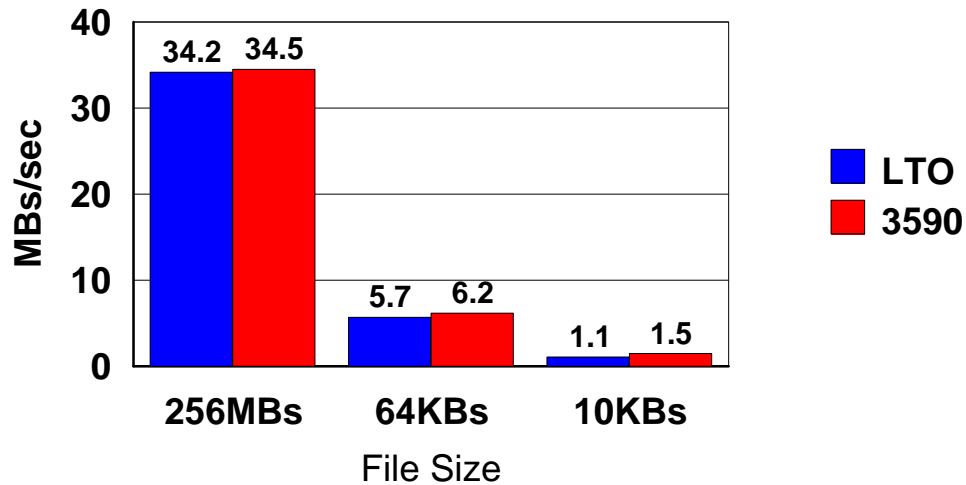
If the customer is backing up over a 100Mb BaseT ethernet LAN today, then their maximum throughput will be in the 5 to 6 MB/sec range. (100 megabits equates to 10 megabytes assuming 8B/10B encoding. With IP overhead, the 10MB path typically tops out in the 5 to 6 MB/sec range) Moving from this environment to a LAN-Free configuration will provide a performance improvement for large files. Small files will see little performance improvement unless the LAN has very high utilization and is a bottleneck.

The performance change between LAN-Free and Gigabit Ethernet LAN based backups depends upon the file size being backed up. We saw a 25-30% degradation with LAN-Free for small (10KBs) to medium (64KBs) size files. This is caused by the significant amount of handshaking necessary between the TSM Storage Agent and the TSM Server. LAN-Free is best suited for large files. The TSM large file (256MB) run showed a 65% performance improvement when moved from GigE to LAN-Free.

The above runs were done with Magstar tape drives. LTO drives will provide similar performance for large files, and slightly lower performance for small files.

Start / Stop Performance

Sustained Transfer Rate



- TSM/AIX Backup
- Shared Memory
- FC Tape Drives

The IBM LTO Ultrium tape drive has a native streaming data rate of 15MBs/sec, 30MBs/sec with 2:1 compression. Streaming rate is the rate at which a tape drive can read/write, not including any start/stop operation. Most uses of tape do include some start/stop which slows down the sustained rate at which the drive operates.

Two events commonly cause a tape drive to start/stop; the drive buffer becoming empty or the attached server issuing a filemark command.

The drive buffer becomes empty when the tape drive empties it (writes data) faster than it can be filled. This could occur with slow disk drives / small files, slow network, slow server, etc.

A filemark delay is significantly longer than just the backhitch time.

A common use of the filemark command is to flush the tape drive buffer. When writing to a tape drive, normally the drive returns control to the application when the data is in the tape drive's buffer, but before the data has actually been written to tape. This mode of operation provides all tape drives a significant performance improvement. However, the drive's buffer is volatile. If the application wants to be absolutely sure the write makes it to tape, the application needs to flush the buffer. Flushing the buffer causes the tape drive to backhitch(start/stop).

The TSM parameters TXNBytelimit and TXNGroupmax control how frequently TSM does a buffer flush.

TSM Transaction Size

- **Tivoli Storage Manager Backup**

	TSM 3.7	TSM 4.2
	<u>Default / Max</u>	<u>Default / Max</u>
TXNBytelimit	2MB / 25MB	2MB / 2GB
TXNGroupmax	40 / 256	40 / 256

- **Eg. 64K file X 256 TXNGroup = 16MB Transaction**

For best TSM backup throughput, make sure the TXNBytelimit and TXNGroupmax are set to their maximum values

The Magstar 3590 tape drive has a significantly faster start/stop than the LTO tape drive. This difference allowed the 3590 to have a large performance advantage over the initial models of the LTO tape drive. Subsequent enhancements to the LTO drive and microcode have minimized this performance difference. The chart on the previous page shows the current TSM backup performance for the LTO and Magstar tape drives for different file sizes.

Note: The medium and small file runs are included for your information. These files would normally be backed up to the TSM disk storage pool and then migrated to tape. TSM migration performance is very good on both the Magstar and LTO tape drives.

Tape Performance Problem Determination Checklist

- Is the current configuration supported?
- Do you have current Operating System / Application Software / Device Drivers / Microcode levels?
- Is your performance out of line with known benchmarks?
- Test large file (200MB to 1GB) backup straight to tape.
- Test large file backup to disk storage pool.
- Test large file backup without network.
- Test large file "memory to tape".

As we have seen from the previous pages, many factors can effect tape performance. Fortunately, a few factors are the culprits the majority of the time. If your customer is experiencing a tape performance issue, the tips discussed below may help determine the cause.

- **Check that configuration is supported.** Look at the Supported Configuration website, url:

<http://www.storage.ibm.com/hardsoft/tape/3584/3584opn.html>

<http://www.storage.ibm.com/hardsoft/tape/3583/3583opn.html>

An unsupported configuration could cause a performance problem, but the OS not being able to see the tape drive would be a more common symptom of an unsupported configuration.

- **Check that Operating System / Application Software / Device Drivers / Microcode levels are current.**

Same as above. Could cause performance problem, but other symptoms more likely. For currently tested levels, see url:

<http://w3-1.ibm.com/instaweb/storage/iot>

<http://www.storage.ibm.com/hardsoft/tape/conntrix/index.html>

- **Performance out of line?** Is the customer's current performance out of line with what one would expect given their configuration. We have seen some cases where a customer's performance was exactly what they should be seeing, but performance expectations had been mistakenly set too high.
- **Test large file (200MB to 1GB) backup straight to tape.** A common performance constraint point is disk performance / file size as discussed earlier in this paper. If small file size is the culprit, backing up a large file straight to tape should provide good performance.

- **Test large file backup to disk storage pool.** If performance to disk provides the same performance as tape, you have eliminated the tape drive as the cause of the performance bottleneck.
- **Test large file backup without network.** If you suspect the network, there are many approaches you can take that eliminate the network.
 - ◆ Put TSM client and server on the same server
 - With Windows, used NAMED PIPES to communicate
 - With Unix, use SHARED MEMORY to communicate
 - ◆ Use TSM LAN-Free
 - ◆ Do a disk to disk copy
- **Test large file "memory to tape".** A number of utilities are available that will write data straight from memory to the tape drive. This eliminates disk, network, and application bottlenecks.

Disclaimer

The performance data contained in this document was measured in a controlled environment. Results obtained in other operating environments may vary significantly depending on factors such as system workload and configuration.

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