OPTIMIZING VIRTUAL TAPE PERFORMANCE:
IMPROVING EFFICIENCY WITH DISK STORAGE SYSTEMS

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ABSTRACT

The FastStream™ Virtual Tape appliance is a standalone storage peripheral which emulates a tape library while storing data to a standard SAS, Fibre Channel, SATA or SCSI disk array. The virtual tape appliance is flexible enough to allow you to use existing storage - JBOD or RAID arrays - to create virtual tape libraries. Since the virtual tape has been designed to interoperate with a large number of third party disk arrays, the configuration of both the virtual tape appliance and the drive array can have significant impacts on performance.

This document will present general guidelines for configuring the virtual tape appliance in a wide variety of environments. It will describe the theory of how a virtual tape appliance writes to disks, present guidelines for number of tape volumes and number of drives, then discuss configuration of disk arrays and virtual tape appliances to maximize performance.

While a virtual tape appliance performs quite well when treated like just another tape library, it is important to remember that even greater efficiency can be attained by reconfiguring servers for numerous simultaneous backups. See ATTO’s Tech Brief: Faster backups using Virtual Tape for help in optimizing the backup of an entire data center.
THEORY

Before diving into the format of the virtual tape data, it is helpful to remember how data is stored on a disk drive. A hard drive is made up of a number of spinning platters (disks) covered with magnetic material. These disks are read by a read-head on the end of an actuator arm. Before reading or writing to a specific portion of the disk, the hard drive must move the actuator arm to the proper spot on the disk (known as seek time), then wait for the platter to rotate around to the exact position (known as rotational delay) for the data to be stored. The seek time for a given transfer varies based on how far the actuator arm must move before reading or writing the data. Although modern hard drives are designed to reduce the delays, improperly utilizing the hard drive can cause too much seeking on the disk, seriously degrading performance. If reads or writes to a disk have sequential block addresses, the actuator arm will already be in position, minimizing seek time. If the block addresses used for disk access vary wildly, seek time will go up with a corresponding slump in performance.

Prudent users of virtual tape technology will want to store the virtual tape data with RAID. The algorithms for RAID 0, 5 and 10 use a technique called data striping, in which a single write is segmented into multiple pieces, each written on a separate disk. The size of each piece to be written to disk is called the *interleave*. The group of the interleaved units across all data drives is called a *stripe*, while the size of the stripe is called the *stripe width*. RAID 5 uses one of the disk writes for storing parity information. The parity information is written to different disks for adjacent writes (distributed across the disks) for better failure protection.

![Figure 1](image)

Figure 1 depicts RAID 5 on a four-disk array. There are four different stripes, lettered ‘A’ through ‘D’. Each stripe is composed of three pieces of data, numbered ‘1’-’3’, plus a parity block, labeled with a ‘p’.

The format of the virtual tape data on the disk is relatively straightforward. Each virtual tape volume is allocated a contiguous set of logical block addresses. The virtual tape data is stored in two parts: tape format data, known as *metadata*, and backup data. The metadata describes block lengths, filemarks, etc., and is placed at the beginning of the tape region. Backup data is placed on the volume (logically) after the metadata, in sequential logical block addresses. During a standard backup and restore the
metadata written to the disks is negligible – the real efficiency is gained by writing the backup data as fast as possible.

![Figure 2](image)

Figure 2 diagrams two virtual tape volumes on a disk. Each volume has space set aside for metadata followed by a large logically-contiguous block of backup data.

**NUMBER OF VOLUMES (TAPES)**

The FastStream Virtual Tape appliance lets the user choose the number of volumes created on the disk array. The number and size of tape volumes relies on the backup scenario for your particular installation. Some backup administrators want virtual tapes to closely match the physical tape used for archiving. Other backup administrators want a large number of small virtual tapes for incremental backups, and others want a small number of large virtual tapes for ease of management. Regardless of the usage model, creating the right number of tapes can improve backup performance on a JBOD or RAID 1 (mirrored) array.¹

We’ve seen how virtual tape data is written to the disk: each virtual tape volume gets a contiguous set of logical block addresses. If these volumes are too small, many volumes may fit onto the same physical disk, causing several backup streams to be simultaneously written to the same disk. Writing simultaneous backup streams to the same disk, as we have seen, causes the disk to perform many seeks, seriously degrading backup performance.

If the tape volumes are too large the opposite effect can occur. Volumes which are too large only allow a small number of physical disks to be active at one time. Other disks in the drive array may be idle, wasting disk bandwidth. When backing up to a JBOD or RAID 1 array it is important to use all of the physical disks simultaneously. The best way to use all of the disks while minimizing seek time is to create virtual tapes which are about the same size as each physical disk and assign each virtual tape volume to its own virtual tape drive.

It follows, then, that a JBOD array should be configured so that each LUN presented by the JBOD array is the same size as a physical drive (no drive concatenation). Following this same formula, a RAID 1

¹ If RAID striping is used, the number of volumes does not significantly affect performance.
(mirrored) array should present one LUN for each mirrored pair of disks. This will allow the FastStream Virtual Tape appliance to use all of the available disk bandwidth for a backup.

**NUMBER OF VIRTUAL DRIVES**

For best performance the number of virtual tape drives should be configured to maximize the number of disks being used at once, without performing too many simultaneous backups to the same disk drive. This needs to be balanced with the number of servers which being backed up at your installation. As a rule of thumb, if the virtual tape and disk array are JBOD or RAID 1, there should be one virtual drive for each LUN presented to the virtual tape appliance. The disk array should be configured so that each LUN corresponds to a drive (JBOD) or pair of drives (RAID 1). Some recommended configurations are presented below.

**RECOMMENDED CONFIGURATIONS**

<table>
<thead>
<tr>
<th>Reference</th>
<th>Performance Level</th>
<th>Disk Array Configuration</th>
<th>ATTO Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>High</td>
<td>JBOD – No Drive Concatenation</td>
<td>RAID 5</td>
</tr>
<tr>
<td>A</td>
<td>High</td>
<td>JBOD – No Drive Concatenation</td>
<td>RAID 10</td>
</tr>
<tr>
<td>B</td>
<td>Medium-High</td>
<td>RAID 1 (Mirrored)</td>
<td>RAID 0</td>
</tr>
<tr>
<td>C</td>
<td>Medium</td>
<td>RAID 10 (Mirrored + Striped)</td>
<td>RAID 0</td>
</tr>
<tr>
<td>D</td>
<td>Medium</td>
<td>RAID 5</td>
<td>JBOD</td>
</tr>
<tr>
<td>D</td>
<td>Medium</td>
<td>RAID 6</td>
<td>JBOD</td>
</tr>
</tbody>
</table>

Note: The ATTO virtual tape RAID 0/5/10 interleave will be 128 Ki bytes (128 * 1024 bytes).

**A - Use 3rd Party Disk Array as JBOD – ATTO RAID 5, RAID 10**

This scenario will typically yield the best performance, since the ATTO RAID algorithms and the FastStream Virtual Tape were designed to work together. When configuring the disk array, create a single JBOD partition for each disk drive and map each JBOD partition as a separate Logical Unit (LUN). Do not concatenate the drives in the disk array. Configure the virtual tape as RAID 5 or RAID 10.

**B - Use 3rd Party Disk Array as RAID 1 – ATTO RAID 0**

Some disk arrays cannot be configured in JBOD mode. If RAID 1 (mirroring) is available on the disk array, configure the mirroring so that each mirrored volume is the size of a single disk drive. Map each mirrored volume to a separate Logical Unit (LUN), which will effectively match LUNs to mirrored pairs of drives. Configure the virtual tape as RAID 0 (striped). This allows the virtual tape to maximize the number of active disks at a single time.

**C - Use 3rd Party Disk Array as RAID 10 – ATTO RAID 0**

In this scenario, the disk array is configured as RAID 10 (mirrored + striped). If the stripe width is configurable, set it to an even multiple of 128 Ki bytes times the number of drive mirrors. Create stripe partitions equal to the number of drive mirrors, each mapped to a separate Logical Unit (LUN). For
example, in a disk array with 16 drives: configure the stripe width to 512 Ki bytes (128 Ki bytes * 4), and split the array into four striped partitions, each mapped to its own LUN. Configure the virtual tape as RAID 0 (striped).

D - Use 3rd Party Disk Array as RAID 5 or RAID 6 – ATTO JBOD
This scenario is useful since it provides RAID 5/6 parity protection on the disk array but it may incur the penalty of reduced virtual tape performance. To maximize performance in this setup, it is useful to know the data block size of the backup software package. These block sizes are typically around 64Ki (65536) bytes, although many packages use 63 Ki (64512) bytes. Set the RAID interleave to approximately twice the backup software block size². Partition the RAID 5/6 array to equal the number of data drives (\([\text{total number of drives}] - 1\) for RAID 5, \([\text{total number}] - 2\) for RAID 6), with each partition mapped to a separate LUN. Configure the ATTO Virtual Tape in JBOD mode.

² Some disk arrays do not allow a user-configured interleave size. In this case, it may be advantageous to use ATTO RAID 0 instead of JBOD. The ATTO RAID 0 interleave will be 128Ki bytes.
CONCLUSION

ATTO Technology’s RAID functionality was developed for use in demanding digital video and audio applications. These applications, by definition, read and write large chunks of sequential data. The ATTO Virtual Tape solution was designed to take advantage of ATTO Technology’s RAID algorithms, coupling the streaming nature of tape reads and writes with ATTO’s best-in-class streaming RAID solution. The end result is a virtual tape solution with most consistent performance when the external disk array can be configured as just a bunch of disks (JBOD) with the ATTO FastStream providing RAID protection. If this is not desirable, it is essential to choose a FastStream-to-disk array pairing which reduces disk seek time while keeping all of the disk drives busy. The configuration will take into account the number of disk array LUNs, virtual tape volumes, and virtual tape drives to achieve the best performance from the ATTO FastStream Virtual Tape appliance.