Abstract
This white paper highlights the compatibility of the disk-drive Spin Down technology with EMC® Celerra®, to reduce the power consumption for SATA drives. It provides details of the testing performed to verify if the disk-drive Spin Down technology is supported with the EMC NetWorker® backup and restore software. Additionally, this paper also covers the recommendations and best practices to implement the feature.

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Executive summary

Data center managers are increasingly demanding the reduction of total cost of ownership (TCO) as corporations ask information technology (IT) and facilities departments to do more with less each year. With increasing electricity and fuel costs, the operational costs of maintaining a data center are on the rise. Sustainable design, global warming, depleting fuel reserves, energy use, and operating costs are gaining in importance in data centers for the following reasons:

- Large, concentrated use of energy that can be up to 100 times the “watts per square foot” of an office building
- Operations running 24/7 have approximately three times the annual operating hours as other commercial properties

Building towards the suite of power management solutions, EMC introduced the disk-drive Spin Down feature with EMC® CLARiiON® and the EMC Celerra® unified storage platform. With this feature enabled, a spin-down eligible disk-drive motor is spun down when the drive does not receive any I/O activity for a specific duration.

Introduction

This white paper discusses the CLARiiON disk-drive Spin Down technology as it applies to Celerra unified storage platforms.

The objective of the testing described in this paper is to verify whether file systems on Celerra that are placed on CLARiiON RAID groups with the disk-drive Spin Down feature enabled, function as expected. This is tested by creating an EMC NetWorker® backup-to-disk (B2D) target on the RAID group over which the target Celerra file system is placed.

The primary goals of the testing are to:

- Verify that the RAID group used by Celerra for B2D operations can be quieted for a sufficient duration so that the RAID group is spun down by CLARiiON.
- Verify that the CLARiiON array spins up disks quickly enough to avoid invoking file system timeouts on Celerra when data is sent to the spin-down disks through EMC NetWorker.

This paper provides a brief introduction of the disk-drive Spin Down feature and its management using Navisphere® Manager and Navisphere CLI. It also provides detailed test results that show that EMC NetWorker supports the disk-drive Spin Down feature of Celerra, along with recommendations and best practices to implement the feature. The paper provides a detailed description of the test environment, tests performed, observations, and recommended best practices.

The scope of this paper is limited to the verification of the CLARiiON spin-down functionality on Celerra unified storage platforms and the viability of EMC NetWorker support for the CLARiiON disk-drive Spin Down feature. This paper does not discuss the details of backup and recovery procedures with EMC NetWorker. Readers are expected to have a good working knowledge of EMC Celerra unified storage platforms and EMC NetWorker.

Audience

This white paper is intended for EMC customers, partners, and employees who are considering the use of the disk-drive Spin Down feature. It is assumed that the reader is familiar with CLARiiON storage systems, Celerra unified storage platforms, and their management software. It is also assumed that the reader is comfortable with the usage, configuration, and management of the EMC NetWorker software.
**Terminology**

**Celerra unified storage platform:** EMC network-attached storage (NAS) system.

**Common Internet File System (CIFS):** Network file-sharing protocol that is based on Server Messaging Block developed by Microsoft.

**EMC NetWorker:** A client/server software application used for backup, restore, and recovery of data.

**Full power mode:** A drive with its motor spinning and ready to serve the I/O requests.

**Idle time requirement:** Specifies how long the spin-down eligible drives should be idle before the storage system moves them to the standby mode. It is a fixed duration of 30 minutes.

**Low power mode or Standby mode:** A drive with its motor no longer spinning.

**Spin-down capable RAID group:** A RAID group with EMC disk-drive Spin Down feature qualified drives.

**Spin-down eligible drives:** Drives that are qualified for the disk-drive Spin Down feature and that satisfy the configuration criteria for the EMC disk-drive Spin Down feature.

**Spin-down qualified drives:** Drives qualified by EMC to be enabled for the disk-drive Spin Down feature and that can withstand multiple spin ups and spin downs.

**Technology overview**

Energy usage is a significant portion of the facility operating costs of data centers, and hence energy efficiency is an important metric. Data center equipment is supplied power from systems of varying efficiencies and cooling infrastructure is required to support the resulting heat load. Therefore, improving the energy efficiency of data center equipment is a critical step towards achieving an energy-efficient data center because the source heat load and the resulting Heating, Ventilation, and Air conditioning (HVAC) system load are reduced.

Data center equipment has become more energy-efficient through the use of efficient power conditioning equipment, power supplies, lower power processors, and sophisticated power management. The equipment includes computer servers, network switches, and storage equipment.

Energy efficiency can be defined as the ratio of the energy output to the energy input of a process or a machine. There are many factors and components that affect energy efficiency. These include air-moving devices within the equipment, ratio of the load to equipment rating, level of redundancy in the system, level of power management employed, device technologies, and virtualization or consolidation.

Improved energy efficiency may also improve reliability. If the energy efficiency of data center equipment, is improved, it results in less heat being generated within the equipment, and thereby reduces the temperature that components are exposed to. In turn, this improves reliability because the failure rate of electronic components increases with the increase in operating temperatures.

Power management has two distinct roles in improving the energy efficiency of data centers. The first is to scale power consumption to be proportional to its workload, that is, the power is reduced when the equipment is idle. This improves the "performance per watt," which is the ratio of the performance of the equipment measured in operations per second to the average input power of the equipment. Most modern servers have built-in technologies that address this requirement. It is recommended to activate power management features to improve energy efficiency.

**EMC CLARiiON disk-drive Spin Down**

Celerra unified storage platforms have introduced support for the disk-drive Spin Down feature. When this feature is enabled at the storage system level, the storage system keeps track of how long the drives are idle. If a drive has been idle for more than 30 minutes, the array automatically spins down the drive’s motor so that it is no longer spinning. However, the electronics of the drive is still powered up. If there is an I/O request for that drive, the array spins the drive up to its full speed.
With this feature enabled, the disk drives can be in any of the following states at a specific instant:

- Full power — The drive is spinning at a normal rate.
- Low power — The drive is in a standby mode, and hence there might be a delay in accessing the data on the drive.
- Reduced power — The drive is transitioning from one mode to another, and hence data cannot be accessed at this point.

**Support**

The disk-drive Spin Down feature is available with FLARE® release 29. It is not a licensed product and a separate enabler is not required to use this feature.

**Power savings**

The amount of power that the disk-drive Spin Down feature saves is proportional to how much time a disk spends in standby mode. Internal experiments have shown that low-power SATA II drives save approximately 55 percent power in low power mode as compared to full power mode. The following table shows the power savings in both modes.

<table>
<thead>
<tr>
<th>Type of drive</th>
<th>Power consumption in Active state (watts)</th>
<th>Power consumption in Standby state (watts)</th>
<th>Power savings (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5400 rpm SATA II</td>
<td>8.87</td>
<td>4.06</td>
<td>54.23</td>
</tr>
<tr>
<td>7200 rpm SATA II</td>
<td>12.15</td>
<td>4.77</td>
<td>60.74</td>
</tr>
</tbody>
</table>

The actual total power savings depends on how long the drives are allowed to operate in a low power state.

For further details on power savings provided by low-power SATA II drives and the disk-drive Spin Down feature, refer to *An Introduction to EMC CLARiiON CX4 Disk-Drive Spin Down Technology — Applied Technology* white paper.

**Criteria for disk drives to enter the standby mode**

The drives are allowed to enter the standby mode when both storage processors report that the drives have not been accessed for 30 minutes. The array monitors the I/O activity at the RAID group level and not at the LUN level. Therefore, the LUN layout should be designed based on the access profiles of LUNs when using the disk-drive Spin Down feature. With the feature enabled on the storage system, the drives with no RAID group created and the drives in a RAID group with no LUNs created on them move to a standby mode in approximately one to two minutes.

**Criteria for disk drives to exit the standby mode**

When the array receives an I/O request for a drive in standby mode, the I/O operation is kept in a pending state while a request is sent to the drive to exit the standby mode. All further I/O requests to the drive are saved until the drive returns to a ready state. Using drive health check operations, the array ensures at regular intervals that the drive can be moved from the standby to the ready state whenever the need arises.

**Drive spin-up algorithm**

The array allows up to four drives to spin up simultaneously in an enclosure. Also, the array waits for 12 seconds before spinning up the next set of four drives in the same enclosure to ensure that the spin-up operations remain within its power budget.

Internal tests have confirmed that the latency in moving all drives in an enclosure from standby to ready mode is in the tolerance limits of most operating systems. Background health check services of the array ensure that the usage of the disk-drive Spin Down feature does not compromise data integrity or product reliability.
Management

The disk-drive Spin Down feature can be enabled or disabled at the storage system level. By default, this feature is disabled on the storage system. This feature can also be enabled and disabled at the RAID group level for further granular management. The disk-drive Spin Down feature settings are persistent across storage system and storage processor reboot operations.

The disk-drive Spin Down feature can be managed from Navisphere Manager and Navisphere CLI commands. For further details on configuration settings and management of the disk-drive Spin Down feature, refer to the An Introduction to EMC CLARiiON CX4 Disk-Drive Spin Down Technology — Applied Technology white paper.

Monitoring

In the Navisphere Manager GUI, special icons are used to represent RAID groups with drives eligible for the disk-drive Spin Down feature and for drives that are in low power and in reduced power mode.

The array maintains a disk-drive Spin Down log on the storage system when “power saving statistics logging” is enabled. “Power saving statistics logging” helps in evaluating the system performance and the impact of the spin-down feature. Counters are maintained at the drive level such as the instant when statistics were retrieved last time, time in minutes spent by the drive in spinning state (spinning ticks), time in minutes spent by the drive in standby mode (standby ticks), the number of drive spin ups from the standby mode, and the instant at which power saving statistics logging is enabled.

Limitations

The limitations of the disk-drive Spin Down feature are:

- Disk-drive Spin Down is supported on CLARiiON CX4 storage systems only, and hence only on Celerra platforms with a CX4 back end.
- The drives in vault locations are not eligible for spin down.
- Unless all drives in a RAID group are eligible for spin down and satisfy the idle time criteria, none of the drives will enter the standby mode.
- The RAID group that is used for layered applications such as MirrorView™, SnapView™, MetaLUNs™, or Virtual Provisioning™ cannot use the disk-drive Spin Down feature.
- In FLARE 29, only 1 TB SATA II drives are qualified for spin down.

How EMC tested this technology

A Celerra NS40G was used to provide storage to EMC NetWorker, which was used as a B2D target. Manual Volume Management (MVM) was used to configure Celerra file systems from CLARiiON 4+1 RAID 5 groups that have the power savings feature enabled. Standard best practices were followed for Celerra Data Mover and network configurations.

Several tests have been performed to verify the viability of the disk-drive Spin Down feature of the FLARE release (R29). The following section provides the details of system configurations, tests performed, and observations.

Setup details

This section provides the details of the hardware and software used to perform the testing discussed in this paper along with a description of the test environment.

The test bed setup consists of a virtual machine created on a Dell 1850 server configured as an EMC NetWorker server using a Celerra NS40G for a B2D target.
**Hardware requirement**

The following table lists the hardware components used to perform this testing.

**Table 2  Hardware configuration**

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Celerra NS40G</td>
<td>Gateway system with 2 Data Movers</td>
<td>NAS for NetWorker B2D target</td>
</tr>
<tr>
<td>CLARiiON CX4-480</td>
<td>3 shelves of SATA II drives</td>
<td>Back-end storage</td>
</tr>
<tr>
<td>Dell PowerEdge 2950</td>
<td>Two dual-core CPUs, 3.00 GHz, 16 GB memory</td>
<td>vSphere ESX Server 4.0</td>
</tr>
<tr>
<td>Dell PowerEdge 1850</td>
<td>Two single-core CPUs, 3.00 GHz, 4 GB memory</td>
<td>vCenter Management Server 4.0</td>
</tr>
<tr>
<td>Virtual machine</td>
<td>One CPU, 3.00 GHz, 1 GB memory</td>
<td>EMC NetWorker backup server</td>
</tr>
</tbody>
</table>

**Software requirement**

The following table lists the software components used to perform this testing.

**Table 3  Software configuration**

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Celerra DART</td>
<td>5.6.47.11</td>
<td>CMR 10</td>
</tr>
<tr>
<td>CLARiiON FLARE</td>
<td>04.29.000.5.003 Release 29</td>
<td>(Includes support for disk-drive Spin Down)</td>
</tr>
<tr>
<td>vSphere ESX</td>
<td>4.0</td>
<td>Virtual machine for the EMC NetWorker backup server</td>
</tr>
<tr>
<td>vCenter Server</td>
<td>4.0</td>
<td>Management server</td>
</tr>
<tr>
<td>Operating system</td>
<td>Windows 2003 Enterprise Edition</td>
<td>Virtual machine guest OS</td>
</tr>
<tr>
<td>EMC NetWorker</td>
<td>Version 7.5 SP1</td>
<td>EMC NetWorker server</td>
</tr>
</tbody>
</table>

**Process overview**

Tests were performed to verify the feasibility of the CLARiiON disk-drive Spin Down feature with EMC Celerra. Along with the functional verification, testing was done to verify the support of this feature with EMC NetWorker. Tests were performed with one to nine RAID groups of spin-down eligible SATA II drives. For all tests executed, the following statistics were recorded for analysis and documentation purposes:

- Backup time with disks in full power mode
- Backup time with disks in low power mode
- Restore time with disks in full power mode
- Restore time with disks in low power mode

Tests were conducted with disk drives in low power and full power modes to find out the amount of additional delay in backup and restore operations.
**Assumptions**

The assumptions for the test were:

- Before the backup or restore operation was initiated, all selected test drives were in low or full power mode.
- During the backup or restore operation, all selected test drives were moved to full power mode from low power mode.

**Detailed procedure**

The procedure to verify the disk-drive Spin Down feature support for EMC NetWorker is described in this section.

**Low power mode backup test**

- Halt I/O activity to allow drives to move to low power mode
- Allow the drives to be in low power mode for 10 minutes
- Perform a backup in low power mode
- Record the time taken for the backup operation to complete in low power mode
- Wait for 10 minutes before continuing

**Full power mode restore test**

- Perform a restore in full power mode
- Record the time taken for restore operation to complete in full power mode
- Wait for 10 minutes before continuing

**Full power mode backup test**

- Perform a backup in full power mode
- Record the time taken for the backup operation to complete in full power mode
- Halt I/O activity to allow drives to move to low power mode
- Allow the drives to be in low power mode for 10 minutes

**Low power mode restore test**

- Perform a restore in low power mode
- Record the time taken for the restore operation to complete in low power mode

**Test details**

The following section provides details and observations of the various tests that were performed.

**Spin down the CLARiiON**

**Objective**

The objective of this test is to verify that Celerra allows a CLARiiON RAID group to achieve low power mode when the Celerra file system placed on the RAID group is not being accessed by any client.

**Details**

The procedure that was followed:

1. A 4+1 RAID 5 group was created on spin-down eligible SATA II drives.
2. A CLARiiON LUN was created on the RAID group.
3. A 1 TB file system was created using the MVM configuration.
4. The file system creation was allowed to complete.
5. The “power savings” option was enabled for the CLARiiON storage system and the RAID group.
6. The “disk power savings statistics logging” option was enabled.
7. Within 30 minutes, the RAID group moved to low power mode.

Observation
Because there were no users accessing the file system and thereby the drives in the RAID group, it was observed that the RAID group moved to low power mode within 30 minutes of the completion of the file system creation process.

Spin down the file system

Objective
The objective of this test is to verify that Celerra allows the drives to move to the low power state when the Celerra file system is mounted on a client host.

Details
The procedure that was followed:
1. The file system was created as described in the spin-down CLARiiON test.
2. A CIFS share was configured on the Celerra file system.
3. The file system share was mounted on the EMC NetWorker server.
4. The RAID group moved to low power mode within 30 minutes.

Observation
Because there were no I/O operations performed on the file system though it was mounted on the NetWorker server, it was observed that the RAID group moved to low power mode after 30 minutes of I/O inactivity on the file system.

Backup/Restore with spin down

Objective
The objective of this test case is to verify the following:
- NetWorker allows the Celerra file system, which is configured as the backup target, to quiet down.
- Backup and recovery operations can be performed on a file system created over a RAID group with the “power savings” option enabled and the RAID group moved to low power mode.

Details
The procedure that was followed:
1. Forty-five spin-down eligible SATA II drives were configured with 4+1 RAID 5 groups.
2. The “power savings” option was enabled on all RAID groups.
3. A single LUN of 1 TB in size was created from each RAID group.
4. LUNs were made accessible to Celerra and marked as disk volumes.
5. A single slice volume of 20 GB was created from each disk volume.
6. Based on the test requirement, multiple slice volumes were striped across with a 64 KB stripe element size to create a stripe volume over which a metavolume was created.
7. A file system was created from the metavolume.
8. A CIFS share was configured over the file system.
9. A NetWorker backup target was created on the CIFS share.
10. A single source file of 4 GB in size was used to perform the backup and restore operations.
11. Backup and restore tests were performed using the EMC NetWorker application as discussed in the “Detailed procedure” section.
12. Statistics were collected as discussed in the “Process overview” section.
13. The RAID groups moved to low power mode after 30 minutes of backup or restore completion.

**Backup results**
The following figure shows the time taken by backup operations with drives in low and full power modes and with varying number of 4+1 RAID 5 groups.

![Backup duration with varying number of RAID groups](image)

**Figure 1**  **Backup duration with varying number of RAID groups**
The figure shows that the backup operations were successfully completed with nine RAID groups, that is, 45 SATA II drives placed in low power mode. EMC NetWorker was able to sustain the latency caused by spinning up the 45 drives before performing the write operations during the backup operation.

An approximately similar latency overhead was observed with the increasing number of RAID groups placed in low power mode. This behavior can be explained from the fact that the Celerra file system was mounted with the default options (cached and prefetch), and the write I/Os may have been cached while drives in low power mode were spinning up their motors.

**Restore results**
The following figure shows the time taken by restore operations with drives in low and full power modes and with varying number of 4+1 RAID 5 groups.
Figure 2  Restore duration with a varying number of RAID groups

The figure shows that the restore operations were successfully completed with nine RAID groups, that is, 45 SATA II drives placed in low power mode. EMC NetWorker was able to sustain the latency caused by spinning up the 45 drives before performing the read operations during the backup operation.

A continually increasing latency overhead was observed with the increasing number of RAID groups placed in low power mode. The reason for this behavior can be explained as follows. Irrespective of the number of drives in low power mode, the array spins up only four drives at a time from low power to full power mode. The array waits for 12 seconds before spinning up the next set of four drives. Hence, it takes longer to spin up a greater number of drives from low power mode. In the current environment, as the SATA drives over which the file system was placed were inactive for at least 30 minutes before the backup/restore operation, the I/O request cannot be served from the Data Mover cache, and thereby forces all drives to spin up before the NetWorker restore operation can be performed.

Observations

The observations from the tests performed with EMC NetWorker are:

- NetWorker allows spin-down eligible drives to quiet down after approximately 30 minutes of inactivity on drives.
- NetWorker was able to sustain the latency overhead while spinning-up to 45 drives during backup / restore operations.
- Latency overhead during backup operations was nearly stable with the increasing number of drives in low power mode.
- Latency overhead during restore operations was directly proportional to the number of drives to spin up.

Best practices

The array monitors the I/O activity at the RAID group level and not at the LUN level. Therefore, the LUN layout should be designed based on the access profiles of LUNs when using the disk-drive Spin Down feature.

No Initial Verify

LUN Initial Verify is an array background service that helps to detect and correct potential disk media errors before they become unrecoverable. This feature can be configured on individual LUNs during...
creation, that is, the LUN binding process. This option, when set, initiates a background process to check all parity sectors in the LUN for any inconsistencies.

It was observed that when LUNs are created without the “No Initial Verify” option selected, the Initial Verify background service caused a low bandwidth read activity on the disk drives over which the LUN was created. It takes a couple of days to complete this initial verify operation even on a reasonably sized RAID group, for example, a 4+1 RAID 5 group. Due to this ongoing background I/O on the drives, the RAID groups created on them were not moved to low power mode until the Initial Verify operation was completed in spite of not receiving any I/O activity from user applications. After the Initial Verify operation is completed, this option has no effect on the LUNs and the switching process of RAID groups between full power mode and low power mode.

If the “No Initial Verify” option is selected during the LUN creation, after 30 minutes of I/O inactivity on the drives, the RAID groups enabled for the disk-drive Spin Down feature move to low power mode immediately.

Hence, it is recommended that the “No Initial Verify” option should not be selected during the LUN creation, keeping in mind the long-term perspective of data accessibility and correctness.

**Conclusion**

This white paper provides a brief overview of the EMC CLARiiON disk-drive Spin Down feature and its support on EMC Celerra unified storage platforms. Testing was performed to verify that the feature is supported by EMC NetWorker and that backup and restore operations can be successfully performed on EMC Celerra spin-down enabled drives both in full power mode and in low power mode.

**References**

The following white papers provide additional information about EMC NetWorker and CLARiiON disk-drive Spin Down:

- *An Introduction to EMC CLARiiON CX4 Disk-Drive Spin Down Technology — Applied Technology*
- *EMC NetWorker Fast Start Integration with EMC Celerra — Applied Technology*