Rising energy prices and increases in density and power requirements for enterprise servers and storage have made controlling energy use a key part of data center management. According to the U.S. Department of Energy, the average cost of electricity in the United States increased 36 percent between August 2000 and August 2007, from US$0.0691/kWh to US$0.0968/kWh, with costs typically highest for regions along the densely populated coasts and in Alaska and Hawaii. Enterprises in other parts of the world, including Europe and Asia, may face even greater challenges than those in the United States in terms of energy costs as well as limited power availability and floor space.

The high cost of energy is only one of the factors contributing to rising operational costs. The amount of power and cooling needed for each square foot of data center floor space is also increasing, as racks are filled with increasingly powerful systems designed for the same footprint as their predecessors. And while IT managers have typically welcomed increases in processor speeds, they may now be concerned about the increased power and cooling requirements that future acceleration could bring. An IDC study, for example, has found that both servers and storage can be major contributors to energy demand and to rising power and cooling costs, a trend that will likely continue increasing in the future (see Figure 1). Enterprises can take a variety of approaches to help address energy use. This article focuses on how data centers built on Dell™ hardware can use the advanced energy-efficient features of Dell/EMC CX3 series storage to help optimize storage performance, reduce energy use, and ultimately reduce ongoing operational costs.

MULTITIERED STORAGE DESIGN

The Dell/EMC CX3 UltraScale™ architecture allows administrators to deploy a wide variety of disk drive types within a single array. Dell/EMC CX3 disk array enclosures support simultaneous use of Serial ATA (SATA), 2 Gbps Fibre Channel, and 4 Gbps Fibre Channel drives to help increase flexibility within each storage array, particularly when combined with virtual logical unit (LUN) technology (see the “Virtual LUN technology” section in this article).

Because most disk drive technologies use a similar electromechanical design, drives with the same rotational speed often have similar power usage. Dell/EMC CX3 1 TB, 7,200 rpm SATA II disk drives can help dramatically...
increase storage system capacity. These high-capacity drives offer a 50 percent increase in capacity per spindle over previous-generation 500 GB drives and can provide comparable performance in large-block, sequential I/O environments—without requiring increased power consumption.

Dell/EMC CX3 10,000 rpm 4 Gbps Fibre Channel drives, available in 146 GB, 300 GB, and 400 GB sizes, are designed to increase storage system capacity through enhancements to linear and area densities and tracks per inch—the key factors affecting overall drive capacity per spindle. The 400 GB drives offer more than twice as much capacity per spindle as previous-generation 146 GB drives while providing equivalent or improved power usage and increased performance per spindle. Meanwhile, Dell/EMC CX3 15,000 rpm 4 Gbps Fibre Channel drives, available in 73 GB, 146 GB, and 300 GB sizes, are designed to increase performance through enhancements to disk operations such as rotational latency and seek rates—the key factors affecting access times.

The flexibility offered by Dell/EMC CX3 drives enables administrators to deploy drives of different capacities and performance levels to meet the needs of different applications within their environment. And because these drives have different power profiles, administrators can move data dynamically between drive types as needed to help control and manage energy use.

### Table 1: Typical Energy Costs and Heat Dissipation for Different Dell/EMC CX3 Drive Types

<table>
<thead>
<tr>
<th>Drive Type</th>
<th>Number of Drives</th>
<th>Line Current</th>
<th>Typical Power Consumption*</th>
<th>Annual Energy Costs**</th>
<th>Typical Heat Dissipation</th>
</tr>
</thead>
<tbody>
<tr>
<td>7,200 rpm SATA II</td>
<td>15</td>
<td>1.4 A</td>
<td>0.29 kVA</td>
<td>US$726</td>
<td>900 Btu/hour</td>
</tr>
<tr>
<td>10,000 rpm 4 Gbps Fibre Channel</td>
<td>15</td>
<td>1.5 A</td>
<td>0.31 kVA</td>
<td>US$794</td>
<td>1,000 Btu/hour</td>
</tr>
<tr>
<td>15,000 rpm 4 Gbps Fibre Channel</td>
<td>15</td>
<td>1.6 A</td>
<td>0.32 kVA</td>
<td>US$821</td>
<td>1,100 Btu/hour</td>
</tr>
</tbody>
</table>

*Based on drive specifications. Actual power consumption will vary based on configuration, usage, and manufacturing variability.

Figure 2, which compares typical annual energy costs and heat dissipation for various Dell/EMC CX3 disk drives, illustrates typical differences between these drives. (Note that these figures compare only the drive type, not their relative power consumption per gigabyte.)

Based on the differences shown in Figure 2, administrators could set up a tiered structure for different types of data in their environment. Because each storage tier has different information and power requirements throughout its life cycle, administrators should ensure that they have an appropriate configuration when designing a specific storage environment.

### Flexible RAID Configuration

Choosing the appropriate RAID configuration for particular applications can be key to maximizing performance and data protection while optimizing energy use. For example, although RAID-0 typically uses less power than other RAID types of the same capacity, it does not include safeguards against drive failures. And while RAID-1 provides high levels of availability, it is not well suited for writing large I/O sizes; in addition, because it is designed to duplicate all data, it can also double storage and energy costs.

Dell/EMC CX3 storage is designed to support multiple RAID types within each array and storage group, helping increase flexibility when designing a storage environment that can meet specific performance, data protection, and energy requirements. Figure 3 compares typical annual energy costs and heat dissipation for different RAID configurations in arrays using 300 GB, 15,000 rpm 4 Gbps Fibre Channel drives. Figure 4 compares these same elements for a Dell/EMC CX3-80 configured with ninety 300 GB, 15,000 rpm 4 Gbps Fibre Channel drives with one configured with fifteen of these Fibre Channel drives and seventy-five 750 GB, 7,200 rpm SATA II drives.

As these figures illustrate, using multiple tiers within a given Dell/EMC CX3 array can have a significant impact on storage power and cooling characteristics. Administrators can, for example, move aging data from high-performance Fibre Channel drives to high-capacity SATA II drives in a RAID-5 configuration to help...
reduce power and cooling requirements for that system. As Figure 4 shows, this approach can also help increase overall storage capacity in a given array.

**STORAGE CONSOLIDATION AND EFFICIENT UTILIZATION**
Consolidating storage by migrating from direct attach storage to a storage area network (SAN) can help significantly increase hardware utilization and energy efficiency while helping simplify management, reduce maintenance costs, and increase availability. Dell/EMC CX3 storage is designed to support the high utilization rates of SAN environments without sacrificing performance. However, administrators should be sure to take both the utilization and performance levels required by their environment into account when planning this type of consolidation to help ensure the design meets their needs.

**METALUN TECHNOLOGY**
MetaLUN technology is designed to allow administrators to expand the capacity of RAID groups and individual LUNs as needed to help accommodate growing storage requirements, without reducing application performance and availability. This technology allows administrators to deploy storage without needing to build in extra LUN capacity to accommodate future growth. By helping avoid the need to supply power to disks that may not be used right away, metaLUN technology can help increase utilization and reduce operating costs. MetaLUN technology is built into the EMC® FLARE® operating environment used by Dell/EMC CX3 storage, and does not require additional licenses or installation.

Figure 5 illustrates the impact metaLUN technology can have on energy costs and heat dissipation. When not using this feature, administrators would typically need to provision all of the capacity during deployment whether they need it or not. As shown in Figure 5, the total power and cooling requirements of a 32 TB RAID-5 configuration are considerably higher than those of a 16 TB RAID-5 configuration. By using metaLUN technology, however, administrators could initially provision the 16 TB configuration, then expand it as their storage requirements increase, helping avoid the operating costs of the 32 TB configuration until they require that level of capacity.

**VIRTUAL LUN TECHNOLOGY**
Virtual LUN technology enables administrators to seamlessly migrate data between LUNs in an array without requiring application downtime, providing increased flexibility and control over the storage environment. It also enables them to transparently change characteristics such as RAID configuration, number of disk spindles, alignment offset, stripe element size, and LUN size, as well as to change drive types from SATA II to Fibre Channel and vice versa. Like metaLUN technology, virtual LUN technology is built into the EMC FLARE operating environment used by Dell/EMC storage, and does not require additional licenses or installation.

As shown in Figure 6, using this capacity to migrate aging or archival data from a 16-drive RAID-5 Fibre Channel array to a 7-drive RAID-5 SATA II array can significantly reduce annual energy costs while providing a comparable level of storage capacity.

**EMC NAVISPHERE QUALITY OF SERVICE MANAGER**
The EMC Navisphere® Quality of Service Manager (NQM) software available as an option with Dell/EMC CX3 storage systems enables administrators to monitor...
and manage application performance. Administrators can use the NQM monitoring features to obtain a logical view of system performance, both for the entire storage system and for specific applications, to help them evaluate current service levels and determine what service levels are possible in specific environments. The NQM management features, meanwhile, enable them to set performance targets for high-priority applications and performance limits for low-priority applications to help reduce overall operational costs.

Performance targets and limits are based on one of three key performance characteristics: response time, bandwidth, and throughput. Administrators can give a high-priority application utilizing a Dell/EMC CX3 storage system a target-specific response time, and limit the bandwidth available to a noncritical application to help ensure that the storage system has resources available for critical applications. Administrators can then use the NQM scheduling feature to dynamically adjust these targets based on enterprise requirements, automatically giving priority to specific applications during specific times. For example, they could give the e-mail application a certain performance target during the day, during its peak hours of operation, then create an overnight performance target for the backup application to help ensure that the e-mail data is backed up in a timely way (see Figure 7).

Because energy costs in industrial and commercial environments rise during peak hours, and because active disks consume more energy than inactive disks, managing application access to avoid highly disk-active tasks such as backup-to-disk operations during peak hours can help reduce overall energy costs. In addition, because NQM directly links application policies with specific LUNs, enforcing explicit application policy criteria can reserve active disk use for those LUNs for off-peak times to help reduce energy costs.

**ENERGY-EFFICIENT DELL/EMC CX3 STORAGE**

Dell/EMC CX3 series storage systems provide an extensive feature set designed to optimize energy efficiency. Combining options such as multitiered storage design, flexible RAID configuration, and SAN consolidation with intelligent management features such as metaLUN technology, virtual LUN technology, and EMC Navisphere Quality of Service Manager can help enterprises optimize storage performance while reducing energy use and maintaining control of overall energy costs.

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