EDISON Group

89 Fifth Avenue, 7th Floor
New York, NY 10003
www.TheEdison.com
212.367.7400

TCO White Paper

EMC, NetApp, and HP Midrange Storage Arrays

November 2007

First Publication: November 2007
Produced by: Kalicharan Rakam, Analyst; Barry Cohen, Author and Editor-in-Chief, Craig Norris, Editor

4AA1-6634ENW

Table of Contents

Executive Summary

Many factors contribute to the ownership cost for enterprise storage. These include (but are not limited to): physical capacity relative to physical space requirements, performance capacity for data transfer and system reaction time, software maintenance and updates, expandability and flexibility, hardware purchase price, software licensing costs, hardware expansion or upgrade costs, administrator training, power utilization, day-to-day management costs, and third-party costs for installation, configuration, and integration. Three of these factors — training, power utilization and day-to-day management — have a large and increasingly critical impact on Total Cost of Ownership (TCO) today.

Edison has developed an approach to TCO analysis that recognizes the need for all companies to more easily manage the increasing rate at which change takes place in their data center environment. The approach focuses on day-to-day management, based on our belief that a user-friendly storage management interface, in conjunction with a virtualized array architecture, can lower administrative training costs and dramatically improve administrator efficiency in that area. Edison's approach also takes into account the trend in which lower-skilled, lower cost IT generalists are used for most day-to-day storage management tasks, thereby reserving specialists and highly paid staff for mission-critical tasks and more complex challenges. Finally, Edison's approach recognizes that customers are increasingly using mid-range storage such as the HP EVA to meet their expanding storage needs with an easily administered system.

This study demonstrates how the superior user interface and virtualization offered by the HP EVA storage system can provide organizations with the benefits of higher administrative efficiency combined with the potential ability to utilize less expensive human resources. Edison analysts put the management software of an HP EVA system through a series of typical day-to-day storage management tasks. The same tasks were also evaluated on similar systems from NetApp and EMC.

Edison's analysis shows that, when performing the list of tasks, the HP EVA required 70 percent fewer steps than EMC and 82 percent fewer steps than NetApp, with 79 percent less time than EMC and 76 percent less time than NetApp for performing a series of standard administrative tasks. Depending on the operation performed, the EVA demonstrated up to 5 times the management efficiency of EMC and NetApp.

These average savings can be interpreted in several ways, depending upon the nature of an organization's IT infrastructure. For example, using the popular metric of TB/FTE (Terabytes per Full Time Employee), an organization can conservatively expect an

administrator to manage at least twice and possibly three times the terabytes of storage than with the other platforms.

Our research demonstrates that this greater administrative efficiency, realized through a superior user interface and virtualization architecture, make the HP EVA storage solution a preferred storage choice with lower overall cost of ownership than other systems on the market.

About This Report

This report is based on a combination of hands-on evaluation, review of relevant published documents on storage cost of ownership, and reports on data center and storage administrator salaries.

Who Should Read This Report

This report should be read by anyone responsible for choosing storage solutions for their organizations or for making administrative personnel decisions in the data center.

Methodology Overview

Edison analysts performed the series of tasks described in this white paper on storage systems from EMC, HP, and NetApp. The hardware and software evaluated are listed within the document and in the appendices.

Contents of this Report

The report consists of the following sections:

- **Storage Management Costs in the Enterprise**
  - *Cost Factor* — This section discusses the drivers affecting storage expansion and cost of ownership.
  - *Edison's Approach to Measuring Management Costs* – this section describes the Edison approach to measuring and comparing management costs.
- **Methodology for this Study** — This section describes the specific methodologies utilized in developing this report. It describes the products being compared, the management tasks evaluated, and other aspects of the research.
- **Results of this Study**
  - *Overall Results* — This section summarizes the results of Edison's research.
  - *Results Details* — This section describes the results for each of the management task categories evaluated.
- **Conclusions** — This section presents Edison's conclusions based upon the research results. It briefly discusses other TCO factors that should be taken into consideration.
- **Appendices** — This section contains several appendices detailing the platforms compared, the results of the evaluations, and a table of comparable terminology.

Storage Management Costs in the Enterprise

Storage Cost Factors

Growth

Exponential growth of data storage requirements has been reported every year since the commercial emergence of the World Wide Web and rich media content.[1] Even the dot.com bust of 2000 did little to disrupt this trend. Organizations of all sizes have had to invest in ever larger and more complex storage systems. Storage Area Networks (SANs) and Network Attached Storage (NAS) solutions have emerged as the leading hardware approaches to meeting this exponential growth in capacity requirements.

Virtualization

Adding more hardware, however, has not sufficed in addressing the need for ever more storage capacity. The data center space available for storage systems has not kept pace with this need. The rapid increase in drive capacity has helped; but even with this growth, real estate remains a limiting factor. Storage virtualization has emerged as an important strategy in addressing this problem. Such technologies abstract the logical storage of data from its physical location. The available space on physical storage devices in a system can thereby be assigned to abstracted, or virtual, pools to which hosts (or servers) can be attached. Virtualization can result in much more efficient and flexible usage of storage capacity; it can, for example, enable such capabilities as adding capacity on the fly and changing the allocation of storage capacity to computing device on an as-needed basis.

Facilities Costs

Storage arrays take up space. Fortunately, data density on hard disks keeps increasing, allowing greater volumes of data to be stored in the same physical space. As with servers, however, greater device density can result in greater consumption of electricity. Therefore, storage management systems that enable greater efficiency in the use of physical storage capacity can affect power consumption. At the consumption levels now being seen, even incremental reductions in consumption can have a strong effect on total data center power costs.

---

[1] A Google search on the topic (Reports: "Data Storage" "Capacity Growth" 2007) returned 534 English pages on August 2, 2007. This is undoubtedly the tip of the iceberg for this topic. The topic has become so ubiquitous as to be common knowledge.

Storage Administration

Besides the use of electricity, the boom in storage growth presents another challenge: management. Managing the storage systems in a data center can be a complex process comprising several elements. The list below just touches on the range of tasks involved in storage management:

- Installation and configuration of the physical devices themselves — the drives, controllers, connections, and other components. Tasks here include such activities as building arrays, formatting disks, making connections to the SAN, and so forth.
- Storage virtualization tasks that include the creation of storage pools and virtual volumes, the assignment of pools to devices, the monitoring of pool utilization, and the management of utilization quotas and capacity.
- Monitoring and management of the physical devices — for example, their health and utilization levels, and their available capacity.
- Backup and disaster recovery — these tasks include making snapshots of live data for later archiving to tape or other disks, data replication to off-site locations, running backups, replacing failed disks, and restoring data lost due to hardware failure or the more prevalent accidental deletion.

A review of IT salaries over the past several years reveals that storage administration is emerging as a separate and highly valued discipline, spreading from the largest organizations down through the whole gamut of enterprise IT. Storage management tasks are quickly becoming an issue in mid-sized and even smaller organizations as these organizations address exponential storage growth using network storage solutions of the same type (though of lesser scale). The annual salary figures from the most recent reports [2] show that Storage Administrators are being paid approximately $100,000 in salary and bonuses as compared to approximately $65,000 for general IT operations staff. It is within this salary delta where the TCO savings identified in this study emerge.

TCO studies are generally used to reveal the true costs of IT investments beyond acquisition price. The factors considered in this study include costs incurred in the use and maintenance of the equipment and software going forward. The management tasks discussed herein are related to other ownership cost factors, such as failure or outage (planned and unplanned), diminished performance events (i.e., where users are kept waiting), costs of disaster preparedness and recovery, and managing incremental growth (the introduction of additional capacity to the system). Other factors affecting cost of ownership that are not included in this report are acquisition costs for equipment

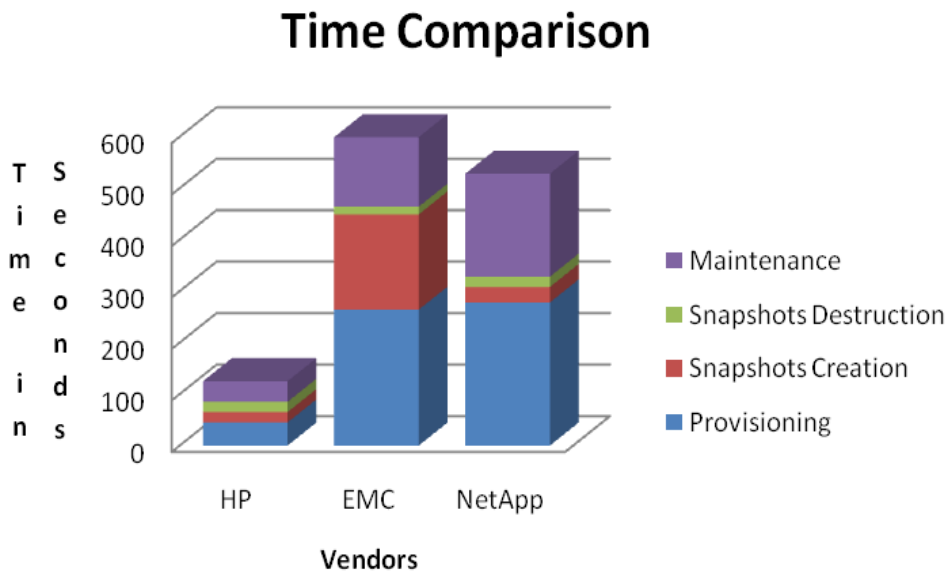
[2] *Network World Salary Survey 2007* http://www.networkworld.com/salary/2007/092407-total-job-title.html

and software, floor space, and power consumption. Decommissioning, e-waste handling, and other factors — while important to the overall total cost of ownership — are also not considered in this study.

Edison's Approach to Measuring Management Costs

Edison has developed an approach to measuring management efficiency and costs that draws upon the time-motion studies of the mid twentieth century. The process involves identifying a set of regularly performed tasks, counting the number of steps, and measuring the time spent in performing them. To make the metric more easily comparable between different solutions, a measurement of complexity — usually based on the number of mouse clicks (or choices available) for any one step — has been added. For this study, Edison has added additional granularity by tracking the number of operations required to perform a task, such as provisioning. Provisioning — preparing and attaching the storage in storage system to one or more hosts – requires a different number of discreet operations for each vendor's product. These can include such operations as identifying and assembling the disks in the system into a storage pool, partitioning that pool into logical units (LUNs), identifying the hosts that are to be attached and attaching the hosts to the LUNs.

The analysis of administrative efficiency in this study cannot be reduced to a single number. Rather, the cumulative affect can be readily visualized when the results are compared globally and for task category, especially when viewed in a chart. The sample below illustrates the effect:



Methodology for this Study

Edison's focus for this study limits the analysis to the software used for administering the storage arrays from three vendors: EMC, HP, and NetApp. The choice of hardware was therefore less critical than it might be for a pure performance test. The software from all three vendors is standardized across the models chosen: all the models in a given product line use the same software. The hardware chosen was from similarly targeted product families, so the time comparisons for the management tasks are reasonably comparable. The brand and product families used [3] were:

- HP StorageWorks EVA 6100
- EMC CLARiion CX3-80
- NetApp FAS6070

The criteria used for measurement began with the identification of a set of day-to-day tasks, with an emphasis on those commonly required in a virtualized storage environment. The task categories were:

- **Provisioning** – setting up and configuring new systems and arrays, including configuration of RAID settings, volumes, or LUNs, and connecting to hosts.
- **Storage Management** – a selected range of regularly performed tasks that include changing storage capacity settings (both physical and virtual), changing cache and other configuration settings, adding, removing, and migrating LUNs or volumes, and so forth.
- **Snapshots** – the tasks involved in the creation and deletion of data snapshots. The capability for creating snapshots of data at a point in time is a significant factor in providing data integrity, especially for large mission-critical systems.

The tasks were performed by Edison analysts. The number of operations and steps, as well as their complexity in mouse clicks, was counted. The time required was measured using a stop watch and an analysis of system logs. The results were compiled and compared for all three vendors' offerings. These results are reported in the Results Summary section of this report and in the appendices.

[3] Full details are in the appendix.

The day-to-day task categories identified for this evaluation consist of a series of specific operations, themselves divided into steps with click counts. The specific tasks vary between the vendors by task name, description, and necessity. In other words, the specific operations required to perform a task vary considerably from product to product. These operations may have the same goal — such as provisioning — but may be called a different thing by each vendor. In addition, each vendor has differences in the degree of automation, eliminating the need to perform some tasks. Edison considers the different specific tasks as operations within the task categories, and considers the differences between the platforms as factors affecting the complexity and time metrics. A table correlating the vendors' different names for features, tasks, and operations is included in the appendices.

Application-Specific Storage Management

All three platforms under evaluation offer add-on software packages that let organizations leverage the storage solution's inherent data protection capabilities with many popular business applications. Edison evaluated add-on packages for the three platforms under consideration for Microsoft Exchange and Oracle databases. The focus of the evaluation was on the tasks required for creating and managing data snapshots and restoring the data from running Oracle and Exchange systems.

For the HP EVA 6100, Edison tested HP StorageWorks Continuous Access EVA Software and Business Copy EVA Software. For the EMC CLARiion CX-3, Edison tested EMC Replication Manager SE for Exchange and EMC Replication Manager 5.0 for Oracle. For NetApp, Edison tested Snap Manager for Exchange and Snap Manager for Oracle.

These add-on software products are all intended to provide similar functionalities: the brief suspension of the respective programs so that data can be replicated or protected with a snapshot. While the three vendor's solutions vary in the details of how they deliver these functionalities, the end results are similar: successful snapshots of Exchange and Oracle databases, backup or replication of the databases, and the ability to restore that data.

GUI vs. CLI

Edison believes that well-designed Graphical User Interfaces or GUIs can greatly improve the quality of system management as compared to the exclusive use of a command line interface (CLI) or scripting. This is especially true for the less skilled staff usually tasked with day-to-day management.

Edison does not oppose the use the CLI or scripts, but we believe that for the majority of day-to-day tasks, a Graphical User Interface can lower training and task-oriented support costs and prevent operator error: both significant factors in administrative efficiency, and thus cost. In fact, a good GUI should streamline the use of scripts by providing an interface for running and creating scripts through learning or similar capabilities. By enabling the use of scripts for the performance of repetitive tasks while providing access through a GUI, the best features of both approaches can be utilized.

Dick Benton, principle consultant at GlassHouse Technologies Inc., recently wrote an article published by SearchStorage on storage staffing. The theme of the article is that a traditional measure of storage administrator staffing needs — Terabytes per Full Time Employee — is almost meaningless. This is because the metric can only be calculated within the context of each individual organization. As a practical matter, TB/FTE can only be used after acquisition and implementation, and then only for analysis of staffing requirements for future expansion of the existing infrastructure. Changing the infrastructure to a different platform changes the basis for TB/FTE calculations.

The article lists three things to consider when calculating storage management staffing requirements. The first factor is called "technology factors" which are the technologies (hardware and software) that require significant training or experience for use. The other two factors, "transaction factors" (the day-to-day tasks performed by storage administrators) and "complexity factors" ("factors that impact a storage administrator's need for skills and the time needed to execute a task") have a major influence on the technology factor; the easier a technology is to use, the less training or experience is required for its use. These are the same criteria Edison employs in comparing storage administrator costs in this study.

Other Considerations

As mentioned above, this study only considers the effect of greater administrative efficiency on ownership costs. Other factors, such as acquisition costs, space and power utilization, third-party installation, decommissioning and so forth are not considered. There is one other ownership cost factor that is not being directly analyzed but which has a bearing on this study: the importance and nature of planning in implementing complex IT infrastructures.

Planning for a SAN implementation requires an analysis not only of how much storage is required (including projected expansion), but also of the nature of what is being stored. Such considerations include the existence of Microsoft Exchange, SQL Server, or Oracle databases, how much capacity they require, and what data protection policies are needed for operational and regulatory reasons. At a minimum, SAN planning requires

the identification of the hosts to be attached to the system, operating systems and application data to be stored, and any data retention and protection policies that are in place. Installing any of the arrays Edison evaluated requires these minimum planning steps.

In the modern organization there is one constant for storage utilization: the storage capacity required and the hosts and applications to which it is attached will change rapidly and in often unanticipated ways. If a storage system offers insufficient flexibility to accommodate the rapidly changing environment into which it is placed, the costs of administration can grow very quickly. A system that requires adherence to an overly structured planning process and storage schema can prove very difficult to adapt to changing circumstances. A highly flexible system will enable rapid IT responsiveness to business changes and lower the costs accrued from those changes.

This study consists of hands-on evaluation of the management software for three vendors' storage systems. While the methodology utilized was objective, Edison's analysis of the results must be to some extent subjective. We use a gestalt overview of the operations, steps, clicks, and time required to perform a category of tasks. Edison recognizes that not all of the operations are performed for every activity within a task category. As we have no agreed-upon weighting factors for the tasks, we feel that our high-level view would reflect the reality of weighted analysis over time.

How to Use These Results

TCO whitepapers such as this one are intended to help you make product acquisition decisions. For midmarket storage arrays, the purchase decision must include many factors. Mid-size organizations often have relatively smaller IT organizations, with administrators wearing many hats. The more efficient the administrator's toolset, the more productive the administrative staff can be.

When reviewing these results, take your organization's file storage and application integration requirements into consideration. Review your staffing policies, as well, including training program and other factors. You should also evaluate the skill levels of your existing staff. If your team has great skills and deep knowledge of storage management issues, the choice of storage array management tools may seem moot; but a more efficient platform can enable your team to make better use of their time.

Results Summary

Overall Results

The overall results of this study demonstrates that the HP Command View EVA software enables storage administrators to perform their tasks with significantly fewer steps, less complexity, and in less time than the competing systems evaluated. The table below summarizes our finding for all three task categories using all of the systems tested.

Tasks	HP	EMC	NetApp
Provisioning			
Operations	3	5	5
Steps	6	17	39
Clicks	26	37	48
Time (seconds)	45	264	278
Snapshots			
Creation			
Operations	1	3	2
Steps	2	15	3
Clicks	6	35	8
Time	20	185	30
Destruction			
Operations	1	1	1
Steps	3	2	3
Clicks	8	7	6
Time	20	15	20
Maintenance			
Expansion - Adding Disks and Expanding LUNs			
Operations	2	2	2
Steps	6	15	14
Clicks	12	28	21
Time	40	135	200

It is important to recognize that while each of the task categories (Provisioning, Snapshots, and Maintenance) can be considered common to all network storage solutions, the number of operations required depends on how each vendor approaches administration. For example, HP offers a much greater degree of automation, eliminating the need to perform several operations that are mandatory for other vendors' solutions.

Edison characterizes the three vendors' approaches as follows:

- HP offers the most automated approach to management, with all of the standard GUI tasks accessible through one application: HP Command View EVA. Tasks that are required for the other vendors' solutions are not required because the embedded virtualization of the EVA takes care of these tasks. The HP solution demonstrates the most adaptability in organizational approach to storage management, enabling more *ad hoc* changes and configuration flexibility than what is provided by EMC or NetApp. This is important because change is the reality in today's rapidly evolving data center environment.
- EMC takes a very different methodology. EMC expects a very structured approach to architecting, configuring, and managing their system. The design and features of the array and the management software reflect that expectation. Every operation that can be performed with the main GUI management software, Navisphere Management Suite, assumes this structured approach. This can be seen in the number of operations required for performing our set of compared tasks and in all of the other tasks evaluated during our research. In addition, there is an assumption that careful planning has been performed and that there will be little need to modify the organizational scheme used in configuring and maintaining the system. Changes — whether as basic as deleting a snapshot or as complex as expanding available storage to a host — require careful consideration and, often, numerous steps.
- NetApp approaches the administration of its devices from yet another perspective. The NetApp filers started life as Network Attached Storage (NAS) devices and the configuration — and to some extent the maintenance operations — reflect that origin. The need to create a LUN on top of a Flexible Volume (FlexVol) clearly demonstrates this point (see below).

HP's approach with Command View EVA and the virtualization architecture of the EVA array has two advantages:

1. Administrative tasks are easier to perform and generally take less time.
2. Since it is not unusual for an organization's storage needs to change quickly even while a system is being configured for the first time, the flexibility offered by the

EVA gives administrators the freedom to adjust their configuration plans to reflect those changes as they happen.

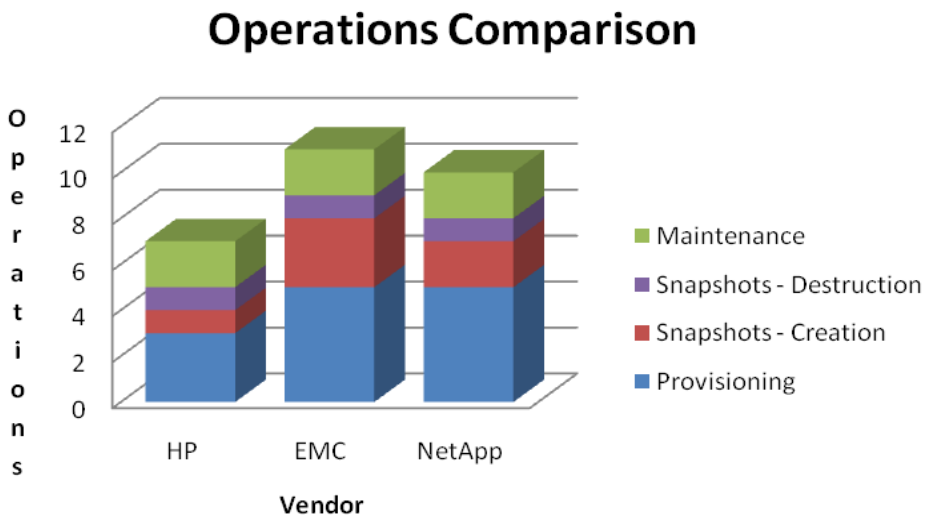
In addition, HP EVA is unique in the industry in that it is based on an architecture that virtualizes the array at system initialization. An administrator of an EVA array does not need to worry about data placement when provisioning the array in order to achieve best performance or best use of available capacity. When application loads increase and more disks are added to provide more I/O, the array is able to automatically re-apportion the data across the available disks to deliver best performance.

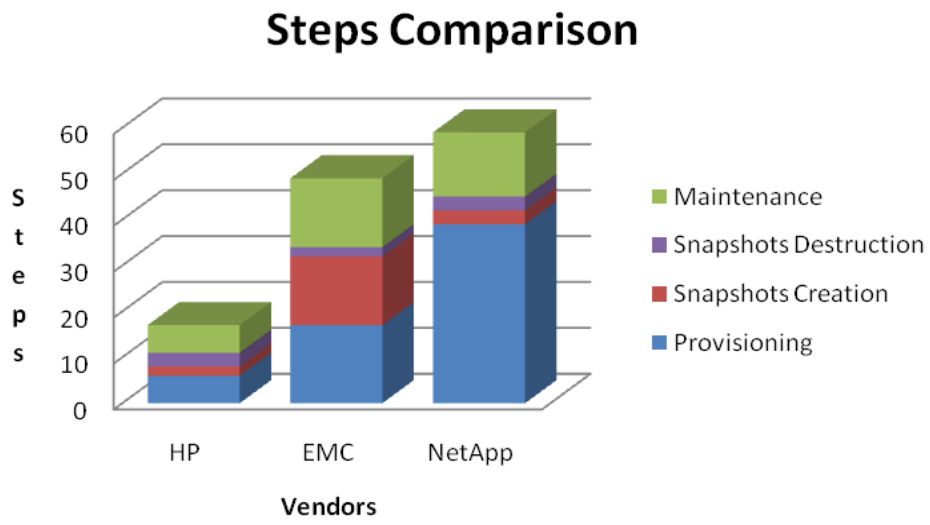
An additional point needs to be made. All three vendors offer the use of a command line interface (CLI) for performing administrative functions. It is recommended for some operations and required for a number of others. Some storage administrators prefer using a CLI exclusively for the vast majority of their work. Comparison of CLIs is not a practical endeavor — the operational similarities between systems are extensive, the differences in syntax can best be termed idiosyncratic, and they can only be evaluated from the perspective of personal experience and predilection.

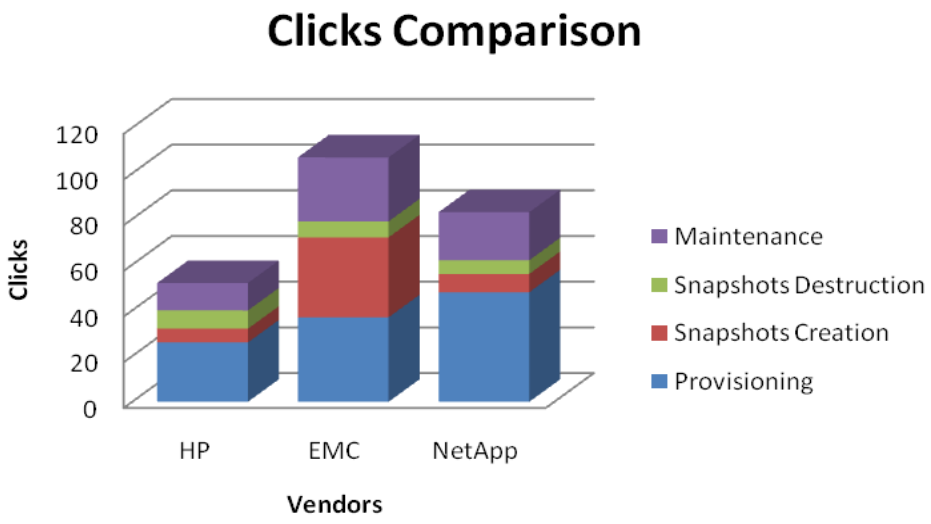
Comparisons for Task Categories

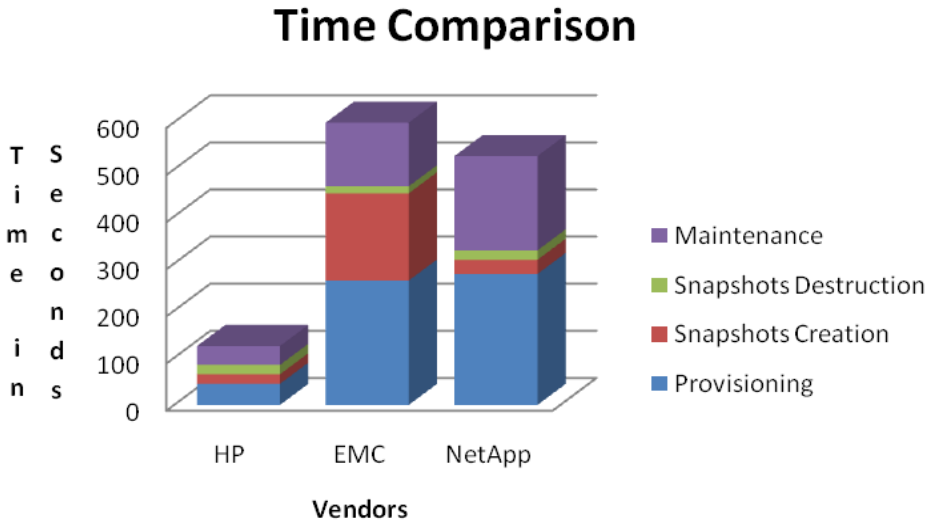
As the charts on the following pages show, HP came out ahead for all measurements of complexity or time. HP's greatest advantages were for storage provisioning and maintenance. In these two areas HP Command View EVA was significantly more efficient than either EMC Navisphere or NetApp's Data ONTAP. It was only in the area of snapshots that NetApp challenges the EVA results. Despite NetApp snapshot capabilities being inherent in NetApp's WAFL[4] file system, the HP EVA still tested with slightly better results than NetApp in regards to snapshot management. Both the HP EVA and NetApp saw significant snapshot advantages over EMC.

[4] WAFL is NetApp's Write Anywhere File Layout. It is an approach to writing data to disk locations that minimizes the conventional parity RAID write penalty. WAFL is the core technology for enabling snapshots and making the capability simpler to implement on NetApp than on almost any other storage solution. For more information, visit: http://www.netapp.com.


Operations Comparison
Operations
12
10
8
6
4
2
0
HP
EMC
NetApp
Vendor
Maintenance
Snapshots - Destruction
Snapshots - Creation
Provisioning


Steps Comparison
Steps
60
50
40
30
20
10
0
HP
EMC
NetApp
Vendors
Maintenance
Snapshots Destruction
Snapshots Creation
Provisioning


Clicks Comparison
120
100
80
60
40
20
0
Clicks
HP
EMC
NetApp
Vendors
Maintenance
Snapshots Destruction
Snapshots Creation
Provisioning


Time Comparison
600
500
400
300
200
100
0
Time in Seconds
HP
EMC
NetApp
Vendors
Maintenance
Snapshots Destruction
Snapshots Creation
Provisioning

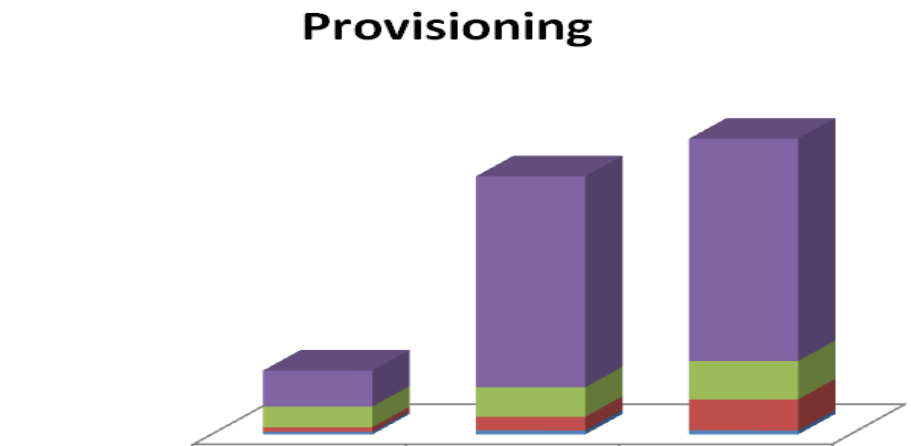
Results Details

The following sections detail our findings for each task category.

Provisioning - From Initialization through Host Attachment

For this study, provisioning is the creation of an accessible storage space, as well as the division of that space and its attachment to a host or server. Provisioning begins once the storage system has been physically installed, connected to the storage and management networks, and initialized.

The following chart shows the relative cumulative results for all three vendors. As you can see, the HP EVA system is clearly more efficient by all four measurement criteria. While the cumulative results are based on different criteria, this representation shows how all four factors interact for administrative complexity and time spent.



	HP	EMC	Netapp
Time	45	264	278
Clicks	26	37	48
Steps	6	17	39
Operations	3	5	5

HP

- **Create Disk Groups** — On initialization, the HP EVA system creates a default Disk Group comprised of all the active disks on the system. This Disk Group is ready for use immediately, though it can be reconfigured if desired. Among the reasons for multiple disk groups is the need to keep similarly performing disks together — i.e.,

15 K disks in their own group and 10 K disks in another. The EVA recognizes the different disk types and creates separate disk groups automatically. If disk groups are to be created manually, it takes 2 steps with about 10 clicks and only 10 seconds for each group created.

- **Adding hosts** — Hosts are discovered and identified by the World Wide Name (WWN) and are added to the Hosts Group and presented to the VDisk. This takes 2 steps with 7 clicks and about 10 seconds.
- **Create VDisk** — This task creates the virtual disk and assigns it to a host. When creating a VDisk, RAID level, Size (capacity), and so forth are configured within a single interface. All other functions required for attaching the storage to the host are automatic. Creating a VDisk takes 2 steps with 12 clicks and takes about 25 seconds.

  Totals:
  - Three operations comprising 6 steps, 26 clicks, and about 45 seconds. In real time — counting pauses between tasks provisioning storage and attaching it to a host — this task takes about a minute.

EMC

- **Create RAID groups** — A RAID group is defined by choosing the RAID type (RAID 5 or RAID 1/0) and the amount of space to set aside. The RAID group becomes the pool of physical storage, from which the virtual storage to be used by hosts will be created. EMC requires that many RAID groups be created for performance and other reasons. The reality, therefore, is that our measurement for the creation of a single RAID Group needs to be multiplied by the number of groups created. This takes 4 steps with 8 clicks and about 95 seconds
- **Define and create LUNs** — Defining sets the parameters for a LUN. Once the parameters are set a LUN can be created. This takes 3 steps, 5 clicks and 54 seconds.
- **Create storage groups** — A storage group is the location to which hosts are attached and where the LUNs that the hosts connect to reside. Creating storage groups takes 3 steps with 5 clicks and about 35 seconds.
- **Assign LUNs to storage group** — The LUNs previously defined need to be assigned to a storage group before a host can be attached to it. This takes 4 steps with 10 clicks and about 45 seconds.
- **Assign hosts to storage group** — The hosts for which the effort of the previous tasks are intended need to be assigned to the storage group where they can then access and be attached to the LUNs. This takes 3 steps with 9 clicks and about 35 seconds.

  Totals:
  - Five operations consisting of 17 steps, 37 clicks, and about 264 seconds, or 4 1/2 to five minutes.

NetApp

- **Create Aggregate** — The aggregate is the collection of disks into allocatable space on the system to be used. This can be comprised of all or some of the disks on the system. The task takes 9 steps with 10 clicks and 28 seconds.
- **Create Volumes (Flexible)** — Flexible Volumes, or FlexVols are the virtual storage spaces which provide an adjustable storage space (up or down) for the hosts attached. A FlexVol can be accessed via NAS directly. To be accessed on a Fibre Channel or iSCSI SAN, a LUN must be created. Creating a FlexVol requires 8 steps with 9 clicks and about 25 seconds.
- **Create a LUN** — This is required for accessing storage on a FC SAN. It takes 6 steps with 7 clicks and about 140 seconds — mostly wait time.
- Once a LUN is created an Initiator Group must be defined. This takes 1 step and 4 clicks and 25 seconds.
- Once you have an initiator group, you can map the LUN to the initiator group and your hosts are assigned. The operation requires 6 steps, 7 clicks, and 35 seconds.

  Totals:
  - Five operations consisting of 39 steps, 48 clicks, and 278 seconds, or about 4 1/2 to 5 minutes.

Conclusion

Configuring an HP EVA solution from initiation to host attachment is as much as five times faster than that of the competing systems. Even if configuration were to occur only once in the system lifecycle, the less time spent performing this activity, the sooner the servers can access the storage space provided. In an actual data center, the time saved here can immediately be seen in IT productivity. For example, EMC requires provisioning of multiple RAID groups for a system, while HP requires that only a single group be created and recommends that only one or two groups be created. This means that EMC RAID group provisioning, here timed at 95 seconds, must be performed multiple times greatly increasing the complexity and total time required to provision the system.

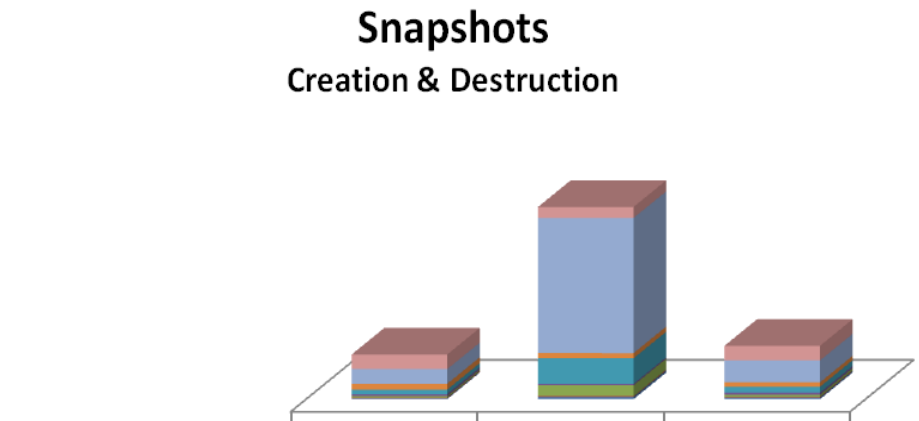
Snapshots

The ability to create snapshots of live data is an important data protection capability for enterprise storage systems. All three vendors support point-in-time snapshots of data in various configurations. These snapshots can be used to restore data to the state it was in at any specific time within the capabilities of each platform. With the use of additional

purpose-specific software, snapshots of application data from such programs as Oracle or Microsoft Exchange (see below) can also be created.

The chart below shows the cumulative results for both the creation and destruction of snapshots for all three platforms. Edison acknowledges that the two operations — creation and destruction — are not performed with equal frequency. Since the research also shows that the effort required for destroying a snapshot is fairly equal for all three platforms, it was felt that combining the two operations for this task would provide a reasonable perspective.

The results show a small advantage for HP over NetApp and a much larger advantage for both HP and NetApp over EMC for all aspects of Snapshot creation and destruction.



	HP	EMC	NetApp
Time- Destuction	20	15	20
Time - Creation	20	185	30
Clicks - Destruction	8	7	6
Clicks - Creation	6	35	8
Steps - Destuction	3	2	3
Steps - Creation	2	15	3
Operations - Destruction	1	1	1
Operations - Creation	1	3	2

HP

- **Create Snapshot** — HP EVA (through HP Command View EVA and HP Business Copy EVA) supports two types of snapshots: full allocation and demand allocation. Full allocation sets aside all the space required and makes a snapshot of the whole LUN, while a demand allocation sets aside only the space required and adjusts the space allocated as needed within the capacity of the system. There is a single

interface for creating either kind of snapshot. Creating the snapshot takes 2 steps with 6 clicks and about 20 seconds.

- Snapshots can be deleted if needed in 3 steps with 8 clicks and 20 seconds.

  Totals:
  - Creation is one operation with 2 steps, 6 clicks, and 20 seconds.
  - Destruction is one operation with 3 steps, 8 clicks, and 20 seconds.

EMC

- **Create Snapshot** — Creating snapshot requires the use of Navisphere SnapView software. It takes 10 steps, 15 clicks, and about 95 seconds.
- Once the snapshot has been created, the administrator needs to switch to Navisphere Storage Management, where it is added to a storage group. This takes 3 steps, 11 clicks, and about 40 seconds.
- Once added to a storage group, the Snapshot needs to be activated. To do this, the administrator must switch back to SnapView. Scheduling can also be configured at this time. This requires 2 steps with 9 clicks and about 50 seconds.
- Destroying a snapshot is performed in SnapView and takes 2 steps, 7 clicks, and about 15 seconds.

  Totals:
  - Creation takes three operations comprising 15 steps with 35 clicks and about 185 seconds, or just over 3 minutes.
  - Destruction takes 2 steps, 7 clicks, and 15 seconds.

NetApp

- **Create Snapshot** — Creation to defaults takes 2 steps with 3 clicks and about 5 seconds.
- **Configuring Snapshots** — This optional task can also be perceived as a maintenance task. This operation is for customizing settings for a specific snapshot or for changing system wide snapshot defaults. While the operation is optional, it is being included here because customization of snapshot settings is a commonly performed task. There are two steps with 5 clicks, and the process takes about 25 seconds.

  Totals:
  - Creation is one operation with 2 steps, 3 clicks, and only five seconds.
  - The optional "Configuring Snapshots" is a single operation with only 2 steps, 5 clicks, and a duration of 25 seconds.

- The whole process of creating customized snapshots therefore consists of two operations with 3 steps, 8 clicks, and about 30 seconds.
- Destroying a snapshot takes 3 steps, 6 clicks, and 20 seconds.

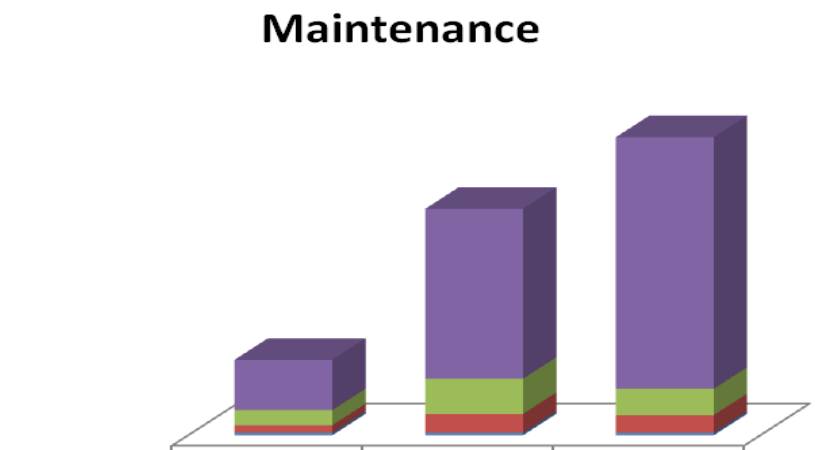
Conclusions

Performing snapshots is NetApp's forte, as the capability is inherent in its underlying file system, WAFL. Creating a snapshot on HP EVA is as simple as with NetApp — requiring the same two steps; but the time required to actually perform the operation is faster for NetApp. EMC's more structured approach is more complex and takes significantly more time than the other two vendors' solutions.

Maintenance

Maintaining any data center system is a major component of ownership cost accounting. More time is spent maintaining a system and re-provisioning it than installing and configuring it. Increasing capacity by adding disks to an array is one of the most common maintenance tasks, and the ability to do so with little or no disruption to existing operations is a primary reason for using a SAN.

The chart below shows the cumulative results using all three platforms for the maintenance tasks compared in this white paper.



	HP	EMC	NetApp
Time	40	135	200
Clicks	12	28	21
Steps	6	15	14
Operations	2	2	2

HP

- **Adding Disks** — Once the disks are inserted into the system, the administrator has the option of adding them to an existing Disk Group or creating a new one for the new disks. Adding disks to an HP EVA array requires 3 software steps with 6 clicks and about 20 seconds.
- Once the disks are added to a storage group, the newly introduced space must be made available to the VDisks. This task takes 3 steps with 6 clicks and 20 seconds duration for each VDisk.

  Totals:
  - Adding new disks to a Disk Group and expanding a VDisk requires two operations with 6 steps, 12 clicks, and about 40 seconds. It takes about another 20 seconds to expand each additional VDisk.

EMC

- **Expanding Raid Groups** — Once the disks are inserted, the targeted RAID groups must be expanded. This requires 4 steps with 13 clicks and about 40 seconds.
- **Expanding LUNs** — Once the RAID Groups have been expanded, the LUNs can be expanded. This requires the creation of a LUN from the new drives within the RAID group. This new LUN can then be added to an existing LUN by Concatenation or by striping the data across the drives. Either method requires 11 steps, 15 or 16 clicks, and about 90 or 95 seconds.

  Totals:
  - Adding capacity requires two operations, totaling 15 steps, 28 or 29 clicks and up to 135 seconds or about 2 1/4 minutes.

NetApp

- Once new disks are inserted, adding disks to Aggregate takes 8 steps with 11 clicks and about 95 seconds.
- Increasing the size of the volumes requires 6 steps, 10 clicks, and about 105 seconds. LUNs automatically expand to available space in the volume, depending on their configuration settings.

  Totals:
  - Adding disks requires two operations, totaling 14 steps, 21 clicks, and about 200 seconds or a bit over 3 minutes.

Conclusions

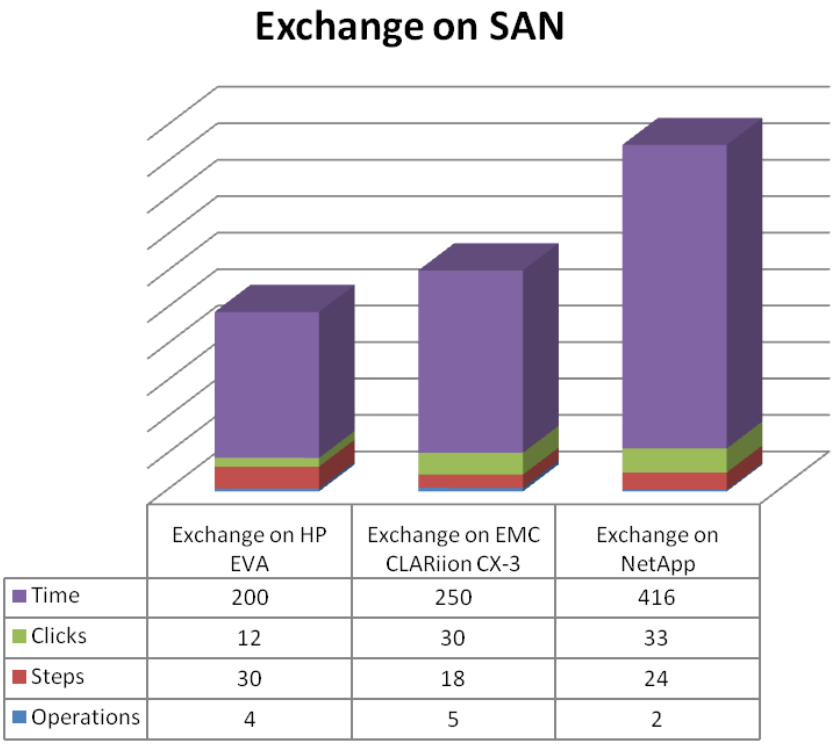
The only maintenance tasks readily comparable between all three platforms were for adding physical storage capacity through the introduction of additional disks. Many of the other maintenance tasks available on the EMC and NetApp platforms are fully automated on the HP EVA, so there are no equivalent operations to perform. For the tasks covered, once again the EMC solution is much more complex though NetApp is a close second; however, these tasks take longer to perform on the NetApp platform than on EMC. HP EVA stands out for being less complex and much faster. While it does not take enormous amounts of time to add to the capacity available to hosts on any of these platforms, the difference between 20 to 40 seconds to provide a host with more capacity on HP is significantly less than the two and one quarter to three and one quarter minutes required for the other two systems.

In addition, because HP EVA defaults to (and recommends) creating the fewest disk groups possible (each with the most disks possible), adding disks and other expansion tasks occur less often. This presents a striking contrast to EMC's best practice recommendation of RAID 5 groups of 16 disks or less. The resulting effect is that EMC's relative complexity may be compounded 30, 40 or even 60 times as administrators manage numerous small disk groups rather the one or two large ones in HP's approach.

Exchange Storage Management Tasks

Microsoft Exchange is the leading e-mail and communications platform on the market. Most organizations using it find that managing the explosive growth of Exchange-related data a major challenge, for which a SAN is the ideal solution. Recognizing the opportunity, all three vendors in this evaluation offer add-on software for their arrays that enables better management of Exchange data storage. The nature and degree of Exchange integration varies from vendor to vendor and is evolving along with the updates to Microsoft Exchange. For this study, we focused on the operation most common to all three vendors: backing up and restoring Exchange data with full backups and snapshots.

Since the three vendors' approaches are different, the operations required for performing these basic tasks vary as well. The overall results are presented in the following chart.



	Exchange on HP EVA	Exchange on EMC CLARiion CX-3	Exchange on NetApp
Time	200	250	416
Clicks	12	30	33
Steps	30	18	24
Operations	4	5	2

HP

For this evaluation, Edison utilized the Replication Solutions Manager (RSM) component of the Business Copy EVA program. RSM is based on a simple "one click, no manual" premise where users can quickly and easily use advanced replication functionality with little more than a few clicks.

Four operations were required for performing backup and restoration tasks. For Exchange, HP EVA uses the snapshot functionality to create a full backup (also called a SnapClone), or incremental point-in-time snapshots.

- **Create Snapshot** — This consisted of identifying the Exchange storage group to backup, entering credentials for access, and accepting the settings. Storage space for the snapshot is automatically assigned. Upon completion of the wizard, the snapshot or clone is created as a background process. Creating the snapshot takes only 2 steps with only 6 clicks or choices to make, taking 40 seconds
- Scheduling backup jobs is a separate operation accomplished from the scheduling interface, requiring 4 steps and 70 seconds.
- Restoring an Exchange database from the local snapshot (we did not evaluate remote arrays) required only 3 steps and 8 click, taking only 45 seconds.

- **Deleting Snapshots/SnapClones** — On systems using regular schedule snapshots and snap clones, a large quantity of old data can quickly accumulate. Regularly deleting these old snapshots is an important maintenance task. An administrator can do so in three steps taking 45 seconds.

  Totals:
  - Performing the set of Exchange operations on HP EVA consists of 4 operations, consisting of 30 steps over 200 seconds, or 3 and 1/3 minutes.

EMC

Edison used the EMC Replication Manager SE software for the Exchange-related tasks. Quoting EMC, "EMC Replication Manager/SE was designed specifically for Microsoft Exchange and SQL Server. It is intended to simplify management of EMC SnapView, EMC SnapSure … and EMC SAN Copy software." As with the HP EVA, backing up Exchange utilizes the snapshot functions of the system.

The backup and restore tasks on the EMC CLARiion required 5 operations to complete:

- **Creating the Snap job** — This consists of identifying the Exchange Storage Group, selecting the RAID Group for storing the snapshot, and setting the other parameters appropriate to the job. This operation required 8 steps and 90 seconds. There were 11 increments among the steps.
- **Running the Snap job** — Unlike with the EVA, running the newly created Snap job is a separate operation. This took 3 steps and about 50 seconds.
- Snap jobs are scheduled separately. It is a 1-step process taking only 20 seconds.
- **Restoring** — Restoration requires 5 steps and 70 seconds.
- **Deleting Jobs** — Old snapshots and jobs can be deleted in a single step, requiring 20 seconds.

  Totals:
  - Performing the set of Exchange operations on EMC CLARiion consists of 5 operations, consisting of 30 steps over 250 seconds, or just over 4 minutes.

NetApp

For NetApp, Edison utilized Snap Manager for Exchange. According to NetApp literature, Snap Manager for Exchange is intended to speed and simplify application data management. It automates the complex, manual, time-consuming processes associated with backup, recovery, and verification of Exchange databases.

In Edison's tests, NetApp Snap Manager for Exchange only required two operations for backup and restoration.

- **Exchange Storage Group backup** — Within this operation are all the steps required to identify an Exchange Storage Group, define and schedule the snapshots, and verify the data. The process requires 14 steps and took 196 seconds.
- **Exchange Storage Group restore** — This operation mirrors the backup one, consisting of all the steps required to restore Exchange data. In our tests, restoration required 10 steps and 220 seconds

  Totals:
  - Backup and restore on NetApp with Snap Manager for Exchange required 24 steps and 416 seconds, or almost 7 minutes.

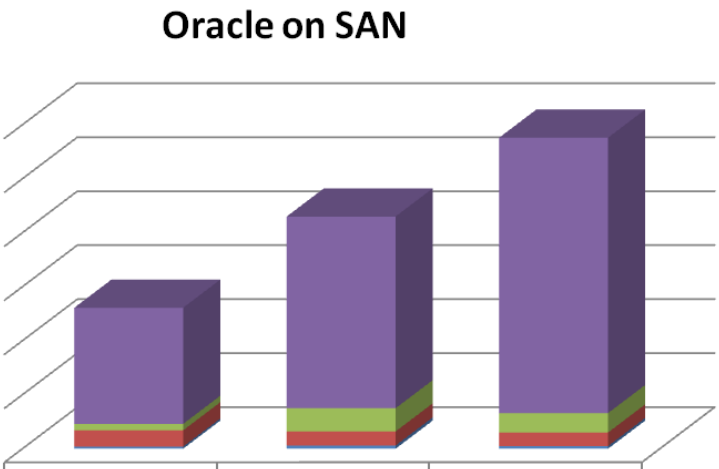
Conclusions

Over all, HP EVA has an advantage over the other platforms, though the advantage in simplicity is not as great as for some other operations. The greater number of clicks counted for EMC and NetApp demonstrates that there are more choices that need to be decided and acted upon when configuring and managing Exchange-related tasks than for the HP EVA. The most significant advantage is in the time required to perform Exchange storage management tasks, taking from one fifth to about one half the time required for the other products.

Oracle Storage Management Tasks

Oracle databases exist in most organizations. Managing Oracle's storage requirements can be a very time-consuming and complex task. While Oracle's own utilities enable the performance of many storage management tasks, when Oracle database files are stored on a SAN, use of the SAN vendor's management tools can greatly simplify and improve the process. Transferring storage management tasks from the Oracle DBA team to the storage management team can also result in better use of IT resources.

Edison evaluated Oracle storage add-on software from all three vendors. The results of the evaluation are presented in the table on the following page.



	Oracle on HP EVA	Oracle on EMC CLARiion CX-3	Oracle on NetApp
Time	215	355	510
Clicks	12	43	36
Steps	30	26	25
Operations	4	6	5

HP

Edison used the same RSM software for managing Oracle storage that was used for managing Exchange storage. This means that a storage administrator who can manage Exchange data has the required EVA skills to also manage Oracle (though dba provided documentation or knowledge of Oracle is still needed).

Managing Oracle storage on HP EVA required the same four operations that were required for Exchange.

- **Create Snapshot** — This consisted of identifying the Oracle database to backup, entering credentials for access, and accepting the settings. Storage space for the snapshot is automatically assigned. Upon completion of the wizard, the snapshot or clone is created as a background process. Creating the snapshot takes only two steps with only 6 clicks or choices to make, taking 40 seconds
- Scheduling backup jobs is a separate operation accomplished from the scheduling interface, requiring 4 steps and 70 seconds
- Restoring an Oracle database from the local snapshot (we did not evaluate remote arrays) required only 3 steps, taking 45 seconds.
- **Deleting Snapshots/SnapClones** — On systems using regular schedule snapshots and snap clones, a large quantity of old data can quickly accumulate. Regularly

deleting these old snapshots is an important maintenance task. An administrator can accomplish it in 3 steps taking 45 seconds.

Totals:

- Performing the set of Oracle storage operations on HP EVA consists of four operations, consisting of 30 steps over 200, seconds or 3 1/3 minutes.

EMC

For EMC, Edison used EMC Replication Manager 5.0 which is a more complete offering than Replication Manager SE. With Replication Manager 5.0, one can manage the entire information replication process through a single interface — from discovery and configuration to multiple-disk replication.

Performance of the Oracle storage management tasks in this evaluation required 6 operations:

- **Add Storage to Replication Manager** — Before a replication job can be created or run, space on the array needs to be set aside by identifying or creating a RAID Group for the purpose. This requires 6 steps and took 95 seconds to complete.
- **Creating Application Set** — This consisted of identifying the Oracle databases and which aspects of those databases to back up, and the creation of the Application Set which acts as a container for the settings. An Application Set can be created in 3 steps and took our analyst 60 seconds.
- **Validating the Application Set** — Technically, this is optional, as validation occurs whenever a replication or backup job is run. It is good practice to validate the job before running it, so Edison considers this a mandatory operation before scheduling or running the job. Validation requires 3 steps and takes 15 seconds.
- **Creating the Replication Job** — Unlike the SE version, this operation enables scheduling and running of the replication job from the same operation interface. Once the job is defined it can be run immediately, scheduled to run at a later time, or both. This operation consists of 8 steps requiring 95 seconds.
- **Restoring Database Job** — A restoration job is the mirror of the replication job. It requires 5 steps and 70 seconds
- **Deleting Jobs** — Old jobs and snapshots can be deleted in a single step requiring 20 seconds.

Totals:

- The Oracle storage management tasks on EMC CLARiion consisted of 6 operations, requiring 26 steps with 43 clicks or increments, and 355 seconds, or almost 6 minutes.

NetApp

Edison used NetApp Snap Manager for Oracle (SMO) to run the Oracle storage management tasks in this evaluation. As with the Exchange version, NetApp Snap Manager for Oracle is designed to automate and simplify complex, manual tasks associated with backup, restore, recovery, and cloning of Oracle databases. It leverages the NetApp technology stack to create near instantaneous and space-efficient snapshot copies.

Performing the Oracle storage management tasks with NetApp required five operations:

- **Creating Repository** — The location where snapshots are to be stored must be identified and created. This required 4 steps and took 30 seconds.
- **Creating SMO Profile** — The profile is the container for all the parameters used in managing storage for an Oracle database. The database, control files, and so forth that will be managed in the profile are discovered, credentials are applied, and so forth. Subsequent operations are performed from within an SMO profile. Creation of the profile requires 8 steps and takes about 75 seconds.
- **Oracle Backup Wizard** — The Oracle Backup Wizard creates the backup job. This operation includes the selection of Oracle objects in a Profile, setting the schedule and other parameters, and running the job immediately or on schedule. Running the Backup Wizard required 6 steps and took 180 seconds. Part of the longer duration consists of the initial backup run.
- **Oracle Restore Wizard** — The Oracle Restore Wizard mirrors the backup process. Running it requires 5 steps and up to 190 seconds.
- **Oracle SMO Profile Delete Wizard** — Oracle profiles and the snapshots they contain need to be maintained. The Profile delete wizard enables granular deletion of snapshots or the profiles themselves. Running the wizard takes 2 steps and about 35 seconds.

  Totals:
  - Performance of the Oracle Storage Management tasks with NetApp Snap Manager for Oracle required 5 operations consisting of 25 steps with a duration of 510 seconds, or 8 ½ minutes.

Conclusions

Managing Oracle storage requirements from the storage array can help an organization manage its IT human resources by assigning these storage management tasks to the storage array administrator team. All three vendors' solutions can enable that resource reallocation. The less complex solution can provide further advantage by lowering the skill level threshold for performing these basic storage management tasks.

Edison's analysis shows that, once again, the HP EVA is the less complex product to use. Backup and restoration requires only four operations over just over 2 minutes to complete. This means that these operations on HP take almost 40 percent less time than on EMC and almost 60 percent less time than on NetApp.

Conclusions

There are two ways of analyzing the results of this study from a cost perspective. The first is the effect of time savings on administrative costs. Simply put: HP EVA's 76 percent time savings over NetApp and 79 percent time savings over EMC mean that highly paid storage administrators are going to be more productive. Put in different terms, the EVA provides Storage Administrators up to 5 times the management efficiency. This translates into less time spent on managing the storage and more time spent on more critical IT activities. Attaching a cash savings to this added efficiency is difficult, and probably irrelevant. It is difficult because there are not, as yet, any agreed upon weighting factors for the various day-to-day administrative tasks performed by a storage administrator with which to calculate day-to-day savings. Calculating day-to-day savings is irrelevant because $100,000 per annum employees are usually not paid by the hour, so saving their time does not matter on a direct cost basis. What does matter is that saving from 76 percent to 79 percent of the time required for day-to-day tasks means an administrator has more time for their more complex management undertakings.

A second way of analyzing these results is through a comparison of complexity. The less complex the interface for performing day-to-day tasks, the easier it is to train administrators and the less skilled they need to be. The results show that, for the number of operations and steps required to perform the set of administrative tasks evaluated in this study, HP is 60 percent less complex to administer than EMC and 75 percent less complex than NetApp. Lower complexity can therefore be directly translated into cost savings because general network operations staff can be quickly and economically trained to take on day-to-day storage administration tasks, while saving about 30 percent in salary costs.

Other Factors Affecting TCO

The concept behind Total Cost of Ownership rests upon identifying the costs of owning something independent of acquisition costs. In addition, technical support costs and the human costs for administration, the costs for electricity, real estate (the space occupied by the systems and their support equipment), cables, and additional devices such as backup equipment capable of working with the arrays, and so forth — all contribute to the TCO of a storage system.

The raising of Green Consciousness deserves mention. There is a well-documented emerging crisis concerning the availability of power for the data center. Curiously, one

of the contributing causes of this increasing power drain is the same growth in storage and server density in the data center that is discussed in this report. Constantly adding more servers and storage systems, all at higher capacity densities, results in the consumption of more and more electrical power for the devices themselves, as well as the air flow and cooling systems they require.

Storage Area Networks have helped with power consumption by consolidating storage into fewer arrays as well as by virtualizing to provide greater efficiency in disk utilization. The next frontier, as data centers reach their space and power capacity limits, will be lowering the power utilization footprint of the storage systems themselves. This will involve the use of such technologies as reduced power microprocessors in storage controllers, more power efficient disks (including the new hybrid disk drives), and new controller software algorithms designed to minimize drive utilization when no data is being transferred.

HP is taking a leadership role within the industry by incorporating a range of software, administration, and hardware features into the EVA storage systems that are designed specifically to lower energy utilization or otherwise lessen the carbon emissions footprint of their products. The other major storage vendors are also starting to focus their efforts on lowering their energy footprints. There have not been, at this time, independent studies performed and published that demonstrate and verify the differences in energy utilization for enterprise-class storage systems, but in the coming years this information will become increasingly important in data center planning.

Appendices

Appendix One

Storage Platforms Evaluated

The product specifications in this appendix include the hardware and software used for the evaluation. The hardware platforms are not directly comparable in terms of performance and capacity. Since only the software that is required for managing the systems and its usability was evaluated, the differences in physical specifications were considered irrelevant to the analysis. The specifications are only provided for reference and to give the reader an appreciation of the systems evaluated.

Storage Specifications	EMC Clariion CX 3-80	NetApp FAS 6070	HP EVA6100
SAN MGMT Software	Navisphere Manager	NetApp Storage/ Application/Server/ Data Suite	HP Storage Works Command View EVA
SAN Snapshot and Application Specific Software	SNAP View, Replication Manager RM for Exchange, RM version 5 for Oracle	Snap Drive for Windows/Oracle, Snap Manager for Exchange/Oracle	Business Copy EVA with Replications Solutions Manager (RSM)
Other Misc Software	Powerpath, Navisphere QOS	FlexVol	
Host Type	MS Windows 2003, Sun Solaris10	MS Windows 2003, Sun Solaris10	MS Windows 2003 Sun Solaris 10
Application Software	MS Exchange 2003, Oracle 10g	MS Exchange 2003, Oracle 10g	MS Exchange 2003, Oracle 10g

Appendix Two

The tables below show the results of all the tests run on the platforms, including those not included in the TCO analysis. The results selected for the analysis in this paper reflect those tests for which reasonable equivalents could be identified. The full set of results below support the conclusions arrived at by Edison but may not be uniformly comparable between platforms.

Test Results

HP EVA 6100						
Tasks Performed & Requirements	**Steps**	**Clicks**	**Time (Seconds)**	**Hardware/Software Requirements**	**Special Configuration Requirements**	**Comments**
Provisioning						
Creating Disk Groups	2	7	10	Command View EVA	None	Not Mandatory, Default Disk Group can be used to create VDisk
Adding Hosts	2	7	10	Command View EVA	None	
Creating VDisk (Raid 5)	2	12	25	Command View EVA	None	
Creating VDisk (Raid 1/0)	2	12	25	Command View EVA	None	
Create Container	2	7	20	Command View EVA	None	
Creating DR Groups	4	7	30	Command View EVA	None	
Totals for Storage Configuration	**14**	**52**	**120**			
Application Configuration						
Oracle						
Creating Snapshot/Snapclone	6	2	40	Replication Solutions Manager	None	

HP EVA 6100						
Tasks Performed & Requirements	**Steps**	**Clicks**	**Time (Seconds)**	**Hardware/Software Requirements**	**Special Configuration Requirements**	**Comments**
Replicate Database Snapshot/Snapclone	7	3	60	Replication Solutions Manager	None	
Scheduling Job	10	4	70	Replication Solutions Manager	None	
Deleting Snapshot/SnapClone	6	3	45	Replication Solutions Manager	None	
Totals for Oracle	**29**	**12**	**215**			
Exchange						
Creating Snapshot using RSM	6	2	40	Replication Solutions Manager	None	
Restoring Local Replica	8	3	45	Replication Solutions Manager	None	
Scheduling Job	10	4	70	Replication Solutions Manager	None	
Deleting Snapshot/SnapClone	6	3	45	Replication Solutions Manager	None	
Totals for Exchange	**30**	**12**	**200**			
Snap & Mirror Configuration						
Creating a Snapshot (Demand Allocation)	2	6	20	Command View EVA & Business Copy EVA	none	
Creating a Snapshot (Full Allocation)	2	8	20	Command View EVA & Business Copy EVA	none	
Deleting Snapshots	3	8	20	Command View EVA & Business Copy EVA	none	

HP EVA 6100						
Tasks Performed & Requirements	**Steps**	**Clicks**	**Time (Seconds)**	**Hardware/Software Requirements**	**Special Configuration Requirements**	**Comments**
Restoring Snapshot Copies	4	8	25	Command View EVA & Business Copy EVA	none	
Creating Snap Clone	4	9	30	Command View EVA & Business Copy EVA	none	
Creating Mirror Clone	3	8	30	Command View EVA & Business Copy EVA	none	
Mirror Fracturing	2	6	20	Command View EVA & Business Copy EVA	none	
Re-sync Mirror	2	6	20	Command View EVA & Business Copy EVA	none	
Detach Mirror	2	6	20	Command View EVA & Business Copy EVA	none	
Totals for Snap & Mirror Configuration	**24**	**65**	**205**			
Maintenance & Change Configuration						
Adding Disks	3	6	20	Command View EVA		
Expanding VDISKS	3	6	20	Command View EVA		
Change to Read/Write Cache configuration	2	7	15	Command View EVA		
Destroying VDISKS/Cloned VDisks	2	7	20	Command View EVA		
Destroying Containers	2	6	20	Command View EVA		
Totals for Storage Maintenance & Change Configuration	**12**	**32**	**95**			

EMC CLARiion CX 3-80							
Tasks Performed & Requirements	**Steps**	**Clicks**	**Time (Seconds)**	**Hardware/Software Requirements**	**Special Configuration Requirements**	**Comments**	**Notes**
Provisioning							
Create Raid Groups (RAID 5)	4	8	95	Navisphere/Storage Management	Physical Disks/Navisphere	None	
Create Raid Groups (RAID 0/1)	4	8	95	Navisphere/Storage Management	Physical Disks/Navisphere	None	
Creating Individual Disks	3	7	90	Navisphere/Storage Management	Physical Disks/Navisphere	None	
Creating HOT SPARE	3	8	90	Navisphere/Storage Management	Physical Disks/Navisphere	None	
Defining, Creating & Binding Luns	3	5	54	Navisphere/Storage Management	Defined Raid Group	None	
Creating Storage Groups	3	5	35	Navisphere/Storage Management	Navisphere	None	
Assigning LUNS to Storage Groups	4	10	45	Navisphere/Storage Management	Defined LUNS/Navisphere	None	
Assigning Hosts to Storage Groups	3	9	35	Navisphere/Storage Management	Physical Host connectivity/Navisphere	None	
Totals Storage Configuration	**27**	**60**	**539**				
Application Configuration							
Oracle							
Adding Storage to Replication Manager	6	11	95	Replication Manager for Oracle	Oracle Application and RM installed	Pre-configuring the Raid Groups/LUNS and Clones	

EMC CLARiion CX 3-80							
Tasks Performed & Requirements	**Steps**	**Clicks**	**Time (Seconds)**	**Hardware/Software Requirements**	**Special Configuration Requirements**	**Comments**	**Notes**
Creating Application Set	3	7	60	Replication Manager for Oracle	Oracle Application and RM installed	Pre-configuring the Raid Groups/LUNS and Clones	
Validating Application Set	3	2	15	Replication Manager for Oracle	Oracle Application and RM installed	Pre-configuring the Raid Groups/LUNS and Clones	
Creating Replication Job	8	12	95	Replication Manager for Oracle	Oracle Application and RM installed	Pre-configuring the Raid Groups/LUNS and Clones	
Total Oracle	**14**	**21**	**170**				
Exchange							
Creating Snap job using RM/SE	8	11	90	Replication Manager SE	Exchange Server and RM installed	Pre-configuring the Raid Groups/LUNS and Clones	
Running Snap job using RM/SE	3	3	50	Replication Manager SE	Exchange Server and RM installed	Pre-configuring the Raid Groups/LUNS and Clones	
Scheduling Job	1	5	20	Replication Manager SE	Exchange Server and RM installed	Pre-configuring the Raid Groups/LUNS and Clones	

EMC CLARiion CX 3-80							
Tasks Performed & Requirements	**Steps**	**Clicks**	**Time (Seconds)**	**Hardware/Software Requirements**	**Special Configuration Requirements**	**Comments**	**Notes**
Restoring	5	7	70	Replication Manager SE	Exchange Server and RM installed	Pre-configuring the Raid Groups/LUNS and Clones	
Deleting Jobs	1	4	20	Replication Manager SE	Exchange Server and RM installed	Pre-configuring the Raid Groups/LUNS and Clones	
Total Exchange	**18**	**30**	**250**				
Snap Configuration							
Creating a Snapshot (SnapView)	10	15	95	Navisphere/SnapView	Defined LUNS	None	
Adding Snapshots to Storage Groups	3	11	40	Navisphere/Storage Management	Defined snapshots	None	
Activating Snapshots	2	9	50	Navisphere/SnapView	Defined Snapshots	None	
Destroying snapshots	2	7	15	Navisphere/SnapView	Defined snapshots	None	Need to remove from Storage Groups
Creating LUN Clones	9	14	95	Navisphere/SnapView	Defined LUNS	None	Cloning multiple LUNS requires creating RAID Groups
Starting SnapView sessions	3	11	35	Navisphere/Storage Management	Defined Snapshot Groups	None	
Restoring Snapshot Copies	3	12	90	Navisphere/SnapView	Defined LUNS	None	
Total SNAP configuration	**32**	**79**	**420**				

EMC CLARiion CX 3-80							
Tasks Performed & Requirements	**Steps**	**Clicks**	**Time (Seconds)**	**Hardware/Software Requirements**	**Special Configuration Requirements**	**Comments**	**Notes**
Storage Maintenance & Change Configuration							
Expanding LUNS (Concatenation)	11	16	95	Navisphere/Storage Management	Non Allocated Defined LUNS	None	
Expanding LUNS (Striping)	11	15	90	Navisphere/Storage Management	Non Allocated Defined LUNS	None	
Expanding Raid Groups	4	13	11	Navisphere/Storage Management	Unbound LUNS	None	
Expansion/Defrag Raid Groups	2	9	40	Navisphere/Storage Management	None	None	
Destroying Storage Groups	2	6	20	Navisphere/Storage Management	None	None	
Destroying LUNS	2	7	25	Navisphere/Storage Management	LUNS needed to be unbound	None	
Removing LUNS/Clones from storage groups	3	10	45	Navisphere/Storage Management	Defined LUNS/Storage Group	None	
Destroying RAID Groups	2	5	25	Navisphere/Storage Management	Unbind the LUNS	None	
LUN Trespassing	2	7	20	Navisphere/Storage Management	Defined LUN	None	
Migrating LUNS	4	10	70	Navisphere/Storage Management	Defined LUN	None	
Creating METALUNS	10	12	70	Navisphere/Storage Management	Defined LUN	None	
Total Storage Maintenance and Change Configuration	**53**	**110**	**511**				

NetApp FAS 6070							
Tasks Performed & Requirements	**Steps**	**Clicks**	**Time (Seconds)**	**Hardware/Software Requirements**	**Special Configuration Requirements**	**Comments**	**Notes**
Provisioning							
Creating Aggregate	9	10	28	ONTAP Management Software	16 Disks of 66 GB / NTAP	None	
Creating Volumes (Flexible)	8	9	25	ONTAP Management Software	20 GB Volume (edisongrvol1)/NTAP	None	
Creating Volumes (Traditional)	9	11	25	ONTAP Management Software	Volume created with 2 Disks	None	
Creating LUN	6	7	140	ONTAP Management Software	10 GB Standard LUN	None	
Creating Initiator Groups	1	4	25	ONTAP Management Software	Requires WWN for FC and iSCSI group name of Nodes	None	Requires manually entering the WWN number of the Host
Assigning LUNS to Initiator Groups	6	7	35	ONTAP Management Software	Requires Initiator Group created prior	None	None
Total Storage Configuration	**39**	**48**	**278**				
Application Configuration							
Oracle							
Creating Repository	4	6	30	Snap Manager for Oracle	Requires connection details to the Oracle Database	None	None
Creating SMO Profile	8	10	75	Snap Manager for Oracle	Requires connection details to the Oracle Database	None	None

NetApp FAS 6070							
Tasks Performed & Requirements	**Steps**	**Clicks**	**Time (Seconds)**	**Hardware/Software Requirements**	**Special Configuration Requirements**	**Comments**	**Notes**
Oracle Backup Wizard from SMO	6	9	180	Snap Manager for Oracle	Requires connection details to the Oracle Database	None	None
Oracle Restore Wizard from SMO	5	7	190	Snap Manager for Oracle	Requires connection details to the Oracle Database	Restore time depends on the Database	None
Oracle SMO Profile Delete Wizard	2	4	35	Snap Manager for Oracle	Requires connection details to the Oracle Database	None	None
Total Oracle	**25**	**36**	**510**				
Exchange							
Exchange Storage group backup	14	18	196	Snap Manager for Exchange	Standard Snapshot backup using Snap Manager	None	None
Exchange Storage group restore	10	15	220	Snap Manager for Exchange	Database and Transactional Logs Restore using Snap Manager	None	None
Total Exchange	**24**	**33**	**416**				
Snap Configuration							
Creating a Snapshot (Storage)	2	4	5	ONTAP Management Software	Nightly and Hourly (2/6) Snapshots	None	
configuring Snapshots (Storage)	2	5	25	ONTAP Management Software	Nightly and Hourly (2/6) Snapshots	None	

NetApp FAS 6070							
Tasks Performed & Requirements	**Steps**	**Clicks**	**Time (Seconds)**	**Hardware/Software Requirements**	**Special Configuration Requirements**	**Comments**	**Notes**
Creating Snapshots of Virtual Disks (Host)	2	6	10	Snap Drive for Windows	Nightly and Hourly (2/6) Snapshots	Creating snapshots of virtual disks from Host using Snap drive	
Creating Flex Clones	4	5	15	Flex Clone	20 GB Volume (edisongrvol1)/NTAP	None	
Deleting snapshots	3	6	20	ONTAP Management Software	None	None	
Restoring Snapshot Copies	2	6	25	Snap Drive for Windows	None	Restoring snapshot from host using Snap drive	
Total Snap Configuration	**15**	**32**	**100**				
Storage Maintenance & Change Configuration							
Adding Disks to Aggregate with various sizes	8	11	95	ONTAP Management Software	Expanding Aggregate with 3 addition disks of different sizes	None	
Increasing the Size of Volume/Clones	6	10	105	ONTAP Management Software	Resizing the Current Volume by adding 20 GB to existing 20 GB	None	
Creating Raid 4 Aggregate/Volume	8	11	45	ONTAP Management Software	Raid 4 (Non RaidDP) Aggregate created with 2 Disks	None	
Removing LUNS from Initiator groups	4	6	30	ONTAP Management Software	Unmapping the LUNS from Initiator Group	Ns	

NetApp FAS 6070							
Tasks Performed & Requirements	**Steps**	**Clicks**	**Time (Seconds)**	**Hardware/Software Requirements**	**Special Configuration Requirements**	**Comments**	**Notes**
Destroying LUNS	3	5	30	ONTAP Management Software	Taking LUN offline and Deleting	None	
Destroying Volumes/Clones	3	5	40	ONTAP Management Software	Taking Volume offline and Deleting	None	
Destroying Aggregates	5	8	40	ONTAP Management Software	Taking Aggregate offline and Destroying	None	
Creating Virtual Disks	7	11	70	Snap Drive for Windows	Creating Virtual Disk on the Host using Snap Drive for Windows	Automatically creates LUNS, maps to the Initiator group from the host using Snap Drive	
Expanding Virtual Disks using Snap Drive	4	6	25	Snap Drive for Windows	Expanding the Virtual Disks using Snap Drive for Windows	Need SnapDrive Installed on the Host	
Migrating LUNS using Snap Drive	9	15	90	Snap Drive for Windows	Migrating VD or LUN from one host to another using Snap Drive	Need SnapDrive Installed on the Host	
Total Storage Maintenance & Change Configuration	**57**	**88**	**570**				

Appendix Three

This table lists the equivalent feature nomenclature for the operations and tasks evaluated in this white paper. The list covers the three vendors with a brief description of the core functionality and descriptions for each vendor's implementation of that functionality. The cell will be blank if the vendor lacks an equivalent feature.

HP	EMC	NetApp	Description
Disk Group A virtualized storage pool automatically created on system initialization. By default it is comprised of all of the disks in the system, but customization is possible if required.	**RAID Group** A collection of disks, defined by the administrator at initial configuration. The RAID group will contain the virtualized storage space after the performance of additional configuration tasks.	**Aggregate** A collection of disks in the system, defined by the administrator on initial configuration. The aggregate will contain the virtualized storage space after the performance of additional configuration tasks.	Some or all of disks in a system, collected into a unit of or for virtual space. (The state of the collections varies with vendor).
VDisk The VDisk is defined and assigned to a host during configuration from the virtual space created in the Disk Group.	**LUN** A LUN is defined during configuration, but additional operations must be performed before the LUN can be assigned to a host.	**LUN** The LUN is a storage attribute assigned to a virtual space created on a NetApp filer specifically for use by iSCSI and FC SANS.	The Virtual Disk drive or Logical Unit to which a host (usually a server) is attached in a storage area network. In addition to the terminology differences between the storage vendors, different operating systems also use different terminology to describe the storage thus made available.

HP	EMC	NetApp	Description
		Volume NetApp currently has two types of volumes. The traditional volume (on which a file system sits that contains data) can be created on top of one or more RAID groups and is directly related to the underlying disk drives. With Data ONTAP 7G, NetApp introduced the concept of Aggregates (see above) on which can be created something called flexible volumes or FlexVols. Because a FlexVol volume is abstracted from the underlying disk, you can create a volume to meet your capacity needs without regard for physical layout. A NetApp Volume or FlexVol can be directly accessed by hosts in a NAS environment. For FC and iSCSI SAN environments, a LUN must be created.	In traditional storage management nomenclature, a volume is an identifiable unit of data storage that is sometimes (but not always) physically removable from the computer or storage system. The usage of the term varies somewhat with the computer operating system in use. When used in the context of network storage, the term can be used to define a storage space set aside for a specific host's access. This space is often directly related to a set of physical devices though it can also refer to a virtualized storage space. For this study, the term relates to a specific usage, unique to NetApp.
Host Group The Host Group is automatically discovered, though manual identification is possible and occasionally required.	**Storage Group** Storage Groups are created during configuration from the collection of discovered or manually identified hosts.	**Initiator Group** The Initiator Group is created from the collection of discovered or manually identified hosts. The term initiator label is based on iSCSI terminology.	The collection of hosts identified (in a SAN) by WWN identities that can access the storage system. All three vendors are similar in the functionality with slight variations appropriate to their platforms.