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White Paper

The Efficient Green Data Center: Delivering IT with Financial and Environmental Consciousness

Technology Concepts and Business Considerations

Abstract

This white paper discusses how to build an efficient green data center for financial and environmental benefits. It describes the short- and long-term financial and environmental impact for an organization, and then explores three key considerations for data center efficiency — equipment placement, power and cooling, and virtualization.

October 2008

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Executive summary

Information is estimated to be growing at about 55 percent[1]. To handle this massive influx of information, organizations are continuously investing in IT resources, both capital as well as human; the net result is that organizations are falling behind the curve and struggling to keep up with IT requirements from the business. This forces organizations to implement tactical strategies rather than building and maintaining broader, visionary strategies for their data centers. The "block and tackle" approach is leading to large-scale inefficiencies across data centers, resulting in financial loss for businesses as well as environmental loss for the earth's ecosystem.

The widening gap between physical and operational assets of a data center and the lack of their optimal use are resulting in higher costs for everything including hardware acquisition and maintenance, energy consumption, data center real estate, infrastructure management, and human resources, along with environmental costs. Organizations have an opportunity to improve their data center operations and reduce cost and environmental impact by better understanding all aspects of an operational data center.

Introduction

This white paper is about building an efficient green data center for financial and environmental benefits. Three key strategies discussed for data center efficiency are equipment placement, power and cooling, and virtualization. This paper is intended to provide the reader the key considerations that organizations need to take into account in transforming their existing data center or building new data centers.

This paper is organized in two sections:

- "Building an efficient green data center" on page 5 – Focusing on financial and environmental impact of inefficient data centers and the case for building efficient and green data centers.
- "Considerations for efficient green data centers" on page 7 – Focusing on high-level data center operating environment, IT process, and technology considerations for data center efficiency.

For more information, read the white paper *The Efficient Green Data Center: Optimizing Your Environment and IT Infrastructure – Best Practices Planning,* also available on EMC.com and Powerlink®.

Audience

This white paper is written for senior-level IT managers (CxO, VP/line-of-business managers) responsible for defining the strategic direction of an organization's data center operations, and middle-level managers (IT directors, operations managers, project and program managers) responsible for the execution and implementation of strategy.

Organizations and individuals who have the following interests should read this paper:

- A desire to better understand areas of opportunity for efficiency in a data center
- Those who have started or are about to start IT and non-IT related data center efficiency projects such as data center consolidation, server virtualization and consolidation, storage virtualization for data migration and mobility, storage consolidation, equipment placement planning for new or existing data centers, and new design and implementation of a cooling system
- Looking for information on important steps to consider prior to and during a project
- Looking to better understand technology requirements and considerations for improving asset efficiency

[1] Compound annual growth rate

Building an efficient green data center

Building an efficient green data center means focusing on increasing the utilization of existing and new IT resources, containing and improving equipment power and cooling usage and requirements, reducing data center footprint of the physical infrastructure, and optimizing IT administrative and maintenance cost and staff productivity.

The two key drivers for organizations to consider for efficient green data centers are:

- The opportunity to realize significant, near- and long-term, financial benefits
- The opportunity to minimize the environmental impact of inefficient data centers

The financial impact

The average utilization of physical IT assets including servers and storage in most data centers remains well below the desired rates of 75 percent to 80 percent. Studies from equipment manufacturers and independent analysts show that the average utilization of servers is around 15 percent to 20 percent while the average utilization of storage is around 35 percent to 40 percent at best in most organizations. On the other end of the spectrum, the amount of new information being created continues to grow at approximately 55 percent (CAGR), requiring organizations to continue to invest in new infrastructure to keep up with growth. This widening gap of inefficiency between the total infrastructure in the data center and the actual used capacities results in far greater dollar-to-value cost for the infrastructure than originally anticipated or desired. Hardware inefficiency also results in inefficiency in energy consumption in the data center and increased management efforts. All of this results in increased operations costs.

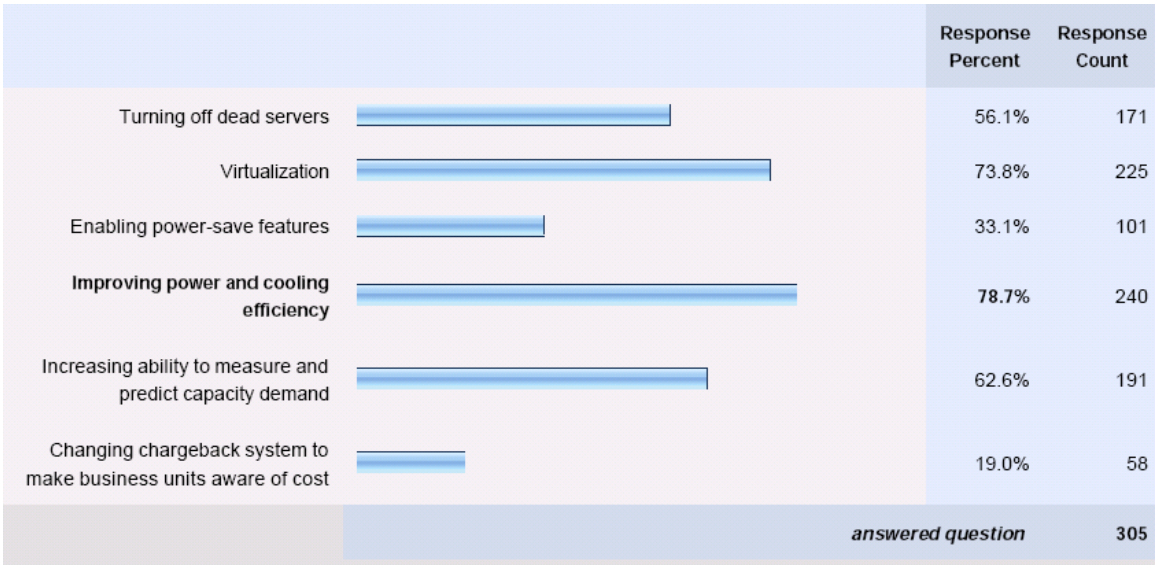
While the initial hardware (server, network, and storage equipment) procurement cost continues to become more affordable, this still remains one of the major expenses in the data center and has a trickle-down effect on other areas of the data center operations that are increasingly becoming less affordable; these new areas of increased cost include data center power and cooling, and data center real estate; infrastructure administration and maintenance remain the top operations expense. The opportunity of realizing financial benefits in building efficient IT exists not only in improving utilization rates of equipment but also in associated resources and activities.

Data center electricity cost, for instance, has risen as the second highest expense in data center operations at 13 percent followed by the cost of data center maintenance and administration, which is about 67 percent of the overall operations expense[2]. Businesses paid about 20 percent more for electricity in 2005 than they did in 2004. It should also be noted that data centers in 2006 used 61 billion kilowatt-hours of electricity — twice the energy they consumed in 2000, and this usage was an output equivalent of about 15 power plants. It is believed that if this trend continues, an additional 10 power plants would be required by 2011 to support data center operations[3].

Focus for many IT organizations is expanding from simply building core information infrastructures that support business operations to building highly optimized, efficient, flexible, and lightweight infrastructures.

Figure 1 shows the results of a data center capacity and energy efficiency survey of over 300 IT professionals including senior and middle managers, technology analysts, and consultants conducted and released by the Uptime Institute in March 2008.

[2] IDC study
[3] EPA study



	Response Percent	Response Count
Turning off dead servers	56.1%	171
Virtualization	73.8%	225
Enabling power-save features	33.1%	101
Improving power and cooling efficiency	**78.7%**	240
Increasing ability to measure and predict capacity demand	62.6%	191
Changing chargeback system to make business units aware of cost	19.0%	58
answered question		**305**

Figure 1. Results of an Uptime Institute survey

The environmental impact

Data centers can impact the environment in two ways:

- Direct generation of heat in operating IT and cooling equipment
- Ongoing process of power generation, supply, and consumption

Figure 2 on page 7 shows how the use of power in data centers impacts the environment.

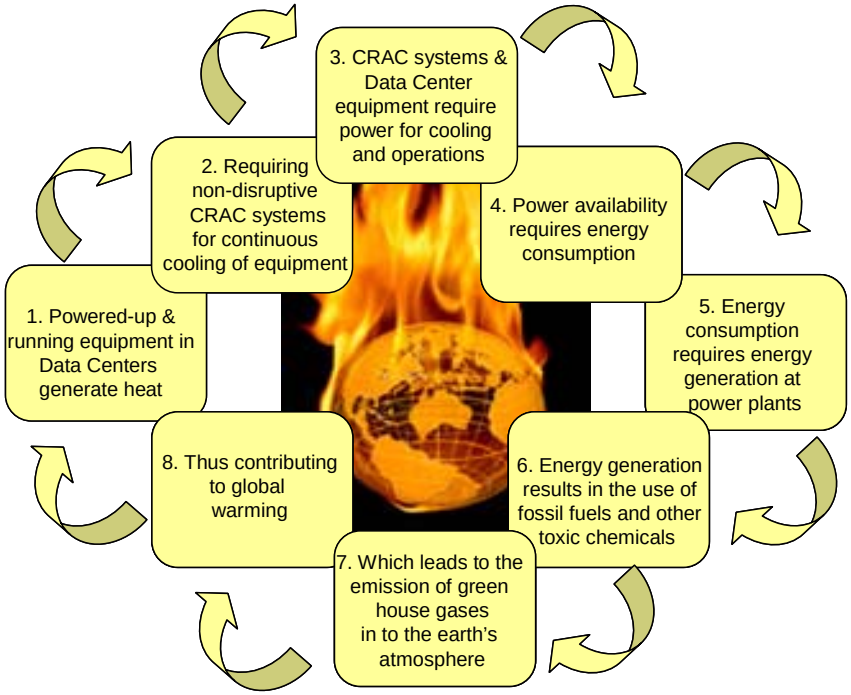


Figure 2. Environmental impact

As seen in Figure 2, powered-up and operating equipment in the data center generates heat. In order to keep equipment from overheating and within normal operating temperatures, cooling is applied through large-scale (commercial use) Computer Room Air Conditioning (CRAC) systems. Both the IT equipment and CRAC systems require power for operations and consume energy; availability of energy requires power generation at power plants. Power plants use fossil fuels and other chemicals resulting in emission of green-house gases in to the earth's atmosphere.

The bottom line

Technology has matured to a point in its lifecycle that by exercising diligence and prudence in technology evaluation, purchase, implementation, and operations & management, organizations can realize near- and long-term financial benefits while being environmentally responsible. Organizations are now in a position to *deliver IT with financial and environmental consciousness*.

Considerations for efficient green data centers

In this section we will discuss some of the key considerations that organizations need to take into account in transforming their existing data center or building new data centers. These data centers should feature elements of efficiency and flexibility, should be designed to make better use of existing and new infrastructure and resources, and should provide headroom to keep up with ongoing growth while minimizing environmental burden.

Equipment placement

Today's high-performance equipment results in densely packed electronics in a compact footprint, leading to greater heat dissipation and higher cooling requirements for the equipment. Hence, it is important to pay close attention to the placement of densely populated racks in the data center. Misplacement of equipment

results in higher power and cooling usage and energy costs of operations. Organizations can take simple steps to cut down the cooling requirements and costs, including creation of hot aisle and cold aisle configuration in equipment placement. This step is discussed in greater detail in the white paper *The Efficient Green Data Center: Optimizing Your Environment and IT Infrastructure – Best Practices Planning*. Similarly, separation of high density equipment across the data center helps prevent the build-up of major hot spots and maintains a relatively even temperature across the data center, which can be cooled with relatively higher room temperature requiring less cooling power. This step is also discussed in *The Efficient Green Data Center: Optimizing Your Environment and IT Infrastructure.*

Power and cooling

Assess requirements

When considering a green data center initiative, start with an inventory of all IT assets in order to assess and understand current power usage patterns. For increased control and accuracy in assessment, consider a logical division of the data center into more than one section, where readings can be made for power and cooling in each section. These logical divisions, for example, can be made along the lines of service to business units where an assessment can be performed for a complete infrastructure serving a given business unit. Similarly, a data center asset division can also be in terms of asset types, such as servers or networks or storage resources. The goal of an assessment should be to identify inefficiencies in existing power and cooling patterns and areas of opportunity for the greatest impact. An assessment can only be as good as the tools used to perform the assessment, hence it is important to use tools that provide granular and detailed information. As an example, a tool that is designed to take vendor specifications of equipment as input will likely lead to inaccuracies in an assessment; it may not be sufficient to capture the total potential power demand of a rack of blade servers and the total potential heat dissipation of the rack in a situation where the actual count of servers in the rack can be different. Similarly using vendor power and cooling specifications for a rack of storage alone in an assessment will likely lead to inaccuracies in the event the actual storage usage within the rack is less than the full rack.

It is also important to project (with a reasonable margin of error) the short- and relatively long-term power and cooling requirements to accommodate for growth and manage the risk of running out of data center power. In this case, assessment tools that perform trend analysis can be useful.

An energy assessment should also be able to clearly identify the energy and cost savings over different periods of time.

Design optimal cooling plans

The key objective in designing an optimal cooling system is to create a clear path for air flow from the source of cooled air to the intake of equipment and from the hot air exhaust of the equipment to the return air duct of the exhaust system. While there are a number of points to consider in designing an optimal cooling system, a large majority of these considerations revolves around the optimal operation of the Computer Room Air Conditioning (CRAC) system.

Ongoing health check inspection and maintenance of the cooling system

A regular health check inspection will ensure that the cooling demands in the data center are sufficiently met through full potential output utilization of the CRAC system. The inspection and maintenance need to include the entire CRAC system, including chillers and condensers, pumping systems, cooling loops, and Direct Expansion (DX) systems. The subfloor condition in the case of raised-floor cooling needs to be inspected to make sure that there is no obstruction to air circulation due to improper equipment cabling and wiring. Also, dirt and dust in the subfloor area will blow up into the equipment. Dirty and blocked coils and air filters impact cooling performance as well.

CRAC positioning with IT equipment

Positioning of CRAC units in the data center needs to align with equipment placement. Once equipment aisle (hot aisle/cold aisle) configurations have been worked out, plan the placement of CRAC units inline with and on both sides of hot aisles since, by design, we have a greater concentration of heat in these aisles. Also ensure that blank panels are installed in all racks for any unused and blank space in racks. Missing blank panels create openings in the rack and allow hot air from the back end of the equipment (from hot aisles) to enter the cool air intake system of the equipment (in the cold aisles) and adversely impact the cool air circulation.

IT infrastructure virtualization

When it comes to the implementation and use of IT infrastructure, virtualization is the single most important consideration in truly making a data center efficient and green. Virtualization addresses the core and most chronic issue of inefficiency in the data – the low utilization rates of equipment and assets that consume power and generate heat. Virtualization enables consolidation of infrastructure, provides flexibility in resource provisioning, and yields tremendous increase in resource utilization. This allows IT to meet business requirements with fewer resources, which is good for the business and the environment. Being able to do more with less equipment means less power consumption, which in turn means reduction in operating cost of the data center; less power consumption also means lower heat dissipation. This in turn means lower burden on power grids and power plants, which in turn means reduction in greenhouse gas emission and impact on the earth's ecological system.

Following are some of the areas of consideration in IT infrastructure virtualization. IT infrastructure virtualization is discussed more in the white paper *The Efficient Green Data Center: Optimizing Your Environment and IT Infrastructure - Best Practices Planning* on EMC.com and Powerlink.

Start with analysis

When virtualizing infrastructure, consider performing a detailed technical, operational, and business analysis at the start of the initiative. As an example, create a map of business users and their applications along with the usage pattern at a departmental or a business unit level. This will help define the functional and operational requirements of virtualization solutions. The analysis should focus on discovery of information such as performance, availability, and growth requirements under normal and special conditions. A special condition for an application can be a particular time of the day, week, month, or year where it requires increased availability and/or performance. Once this level of information has been gathered, it can be mapped against the available IT infrastructure to identify how best to meet these requirements with all available resources. This mapping can be used later to build a chargeback model.

Criteria	Tier Storage Considerations						
	Symmetrix (Tier 1)	CX-FC (Tier1/2)	CX-ATA (Tier2/3)	NS I/G/X (Tier 1)	Centera (Tier 2/3/4)	EDL (Tier 3/4/5)	Tape (Tier 4/5/6)
Application Performance (Block Level)	X	X					
Application Performance (File Level)				X			
Application Availablity	X	X	X	X			
RAID Protection	X	X	X	X	X	X	
HA Capabilities	X	X	X	X	X	X	
Security	X	X	X	X	X	X	
R.P.O.	X	X	X	X			
R.T.O.		X	X			X	X
Disk to DiskBackup			X			X	
De-duplicated Disk-based Backup						X	
Disk to Disk to Tape			X			X	X
Tape Consolidation with Emulation						X	
Regulatory Compliance					X	X	X
Infrequent Data Access Management			X		X		
Inactive Data Management			X		X	X	X
Data Vaulting					X	X	X
Replication Capabilities	X	X	X	X	X	X	
Disaster Recovery Requirements	X	X	X	X	X	X	X

Figure 3. A sample of mapping between business criteria and the use of EMC tiered storage to align storage use with business requirements. Similar mappings for other components of infrastructure such as servers and networks can assist in building an efficient and well-leveraged virtualized infrastructure

Plan for future requirements

Including future growth requirements in a virtualization plan is essential for building an infrastructure with sustainable efficiency. An application that becomes increasingly important in the day-to-day operations of a company may require additional server resources and/or higher storage performance over time. Investment in server and storage virtualization technology that features flexibility to scale and seamlessly adapt to evolving business requirements without disruption helps achieve greatest efficiencies. The as-needed scaling of existing infrastructure will ensure that the ratios of efficiency for power, cooling, and utilization derived in the initial deployment can be retained in the expanding infrastructure and that growth occurs in a controlled and accountable manner.

Start with the easiest resources to virtualize and consolidate

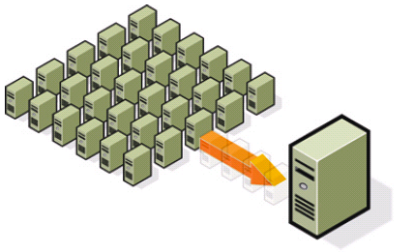
The most prominent IT assets with highest power consumption and lowest utilization rates include servers and storage. Servers and storage consume approximately 50 percent of the overall data center power, however, the average server utilization is below 20 percent and the average direct-attached storage utilization remains below 40 percent. Virtualization and consolidation of these resources to increase utilization can have a dramatic savings impact in the cost of energy consumption, data center real estate, procurement of additional hardware, and management of infrastructure. The spare energy found in the new efficient virtualized infrastructure can be conserved and used for future growth without new (additional) power requirements.

Figure 4 gives a three-year breakdown of financial savings in power and cooling of servers by consolidating on VMware server virtualization infrastructure and compares these savings against continuation of operations without consolidation.

Power and Cooling

With the proposed VMware solution, servers can be consolidated helping to significantly reduce the power and cooling requirements and costs.

Power and Cooling Savings	Year 1	Year 2	Year 3
Current (As Is)	$ 291,435	$ 320,579	$ 352,637
With VMware (Projected)	$ 19,705	$ 21,676	$ 23,844
Total savings	$ 271,730	$ 298,903	$ 328,793



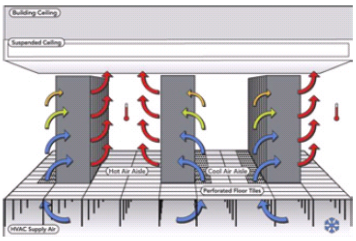


Figure 4. Savings from using a VMware virtualization solution

Use energy efficient/green equipment in the data center

For new equipment, consider energy-efficient hardware. All major server and some storage vendors are manufacturing energy-efficient hardware. These systems features components such as low voltage CPUs designed to deliver more performance per watt of power, adaptive cooling fans that automatically throttle fan speed based on workloads, and high efficiency power supplies that draw significantly less energy and help lower internal temperatures of the equipment. In addition, the use of high capacity, low power disk drives along with medium to high performance disk drives in tiered storage subsystems and the use of disk drive spin-down features in some storage subsystems reduce power and cooling requirements and drive up the overall efficiency.

Optimize infrastructure through Information Lifecycle Management

Perform ongoing Information Lifecycle Management by leveraging “tiered storage” capabilities of storage arrays. By classifying information and identifying information value to business, information can be stored in the appropriate type and class of storage device within a given storage array. As storage subsystems consume a significant footprint and power in the data center, mixing different types and classes (high, medium, and lower performance) of disk drives in single storage frame offers efficiency in data center floor space consumption, and power and cooling, as well as the management of the storage infrastructure. This concept of tiered storage must not be limited to a given storage array but needs to be applied across the broader horizontal storage infrastructure to fully materialize storage efficiency gains.

Figure 5 shows a horizontal EMC tiered storage deployment with built-in tiered storage capabilities for vertical storage tiering inside of each storage device. This model yields maximum, inside-the-box (vertical), and across-the-storage-infrastructure (horizontal) efficiency for power, cooling, and management.

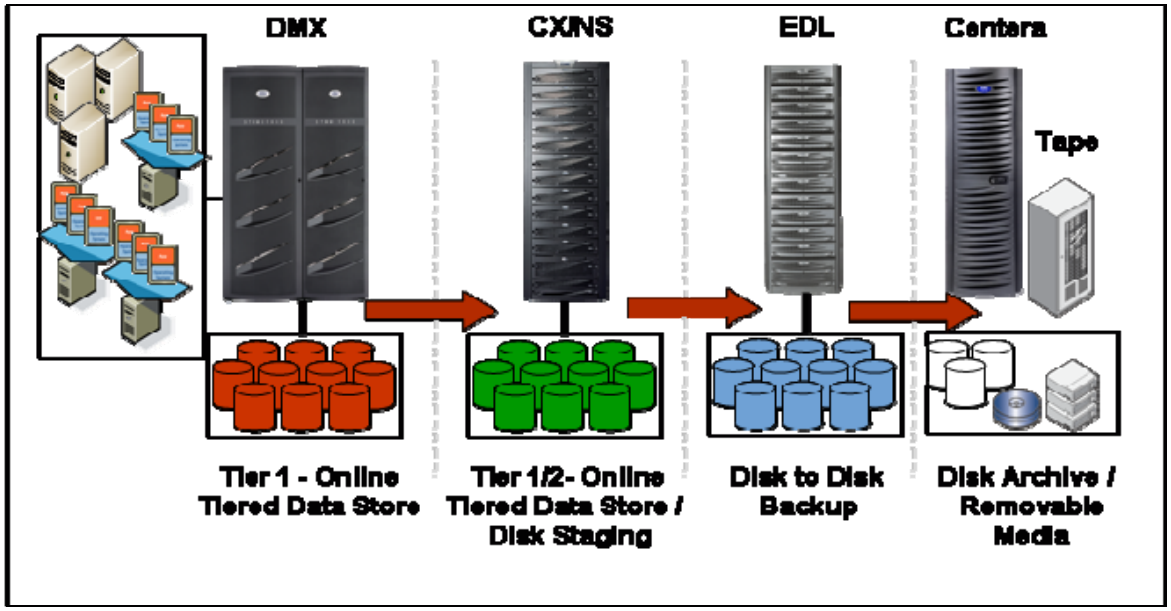


Figure 5. Model of horizontal EMC tiered storage deployment

Optimize information archiving and backup data management

By storing less frequently accessed information, referred to as static or reference information, on lower powered, higher capacity, and low cost storage such as an online disk archive, organizations can achieve operational, financial, and environmental efficiencies.

Online disk archiving of reference information also improves backup and recovery operations across the data center. Since all reference information can be safely protected and made available through the online archive, organizations can eliminate a large chuck of overall information, at times as large as 60 percent or more, from their active backup cycles. This reduction in the total amount of data with active data protection requirements improves backup and recovery windows, requires fewer physical resources, consumes less floor space, and results in lower power and cooling for the backup and recovery infrastructure.

To improve backup and recovery efficiency of the infrastructure, data de-duplication technology requires consideration. This technique is particularly useful for medium-size to large-size organizations with multiple operation centers and branch offices. Data de-duplication ensures that only unique elements of information are protected and there is no redundancy in the backup cycle. If a set of information has already been protected in a backup cycle and only a small portion of this information set changes after the completion of a given backup cycle, then during the next backup cycle only new elements of the information set that do not already exist in the back image of the information will be protected. Data de-duplication can significantly shrink the total amount of data requiring backup and can drastically drive up the overall efficiency of the infrastructure. There are a few different implementation techniques available. One is de-duplication of information at the source, meaning de-duplicating information at the location where the information is being picked up from; another is de-duplicating at the destination, meaning de-duplication of information before placing it in the backup repository. Understanding and knowledge of business requirements are important in making the correct implementation choice; for example, is the backup required for single or multiple sites? Does each site perform its own backup or is there a centralized backup model in place? Do remote offices require backup over the wide area network? If so, how many remote offices are there and what type of WAN bandwidth is available? Having answers to these types of questions will assist in making an investment decision in technology that delivers the most efficiency.

Figure 6 shows how EMC® Avamar® de-duplication identifies and protects only unique information. The total data requiring backup is significantly reduced and major operational and financial efficiencies are achieved.

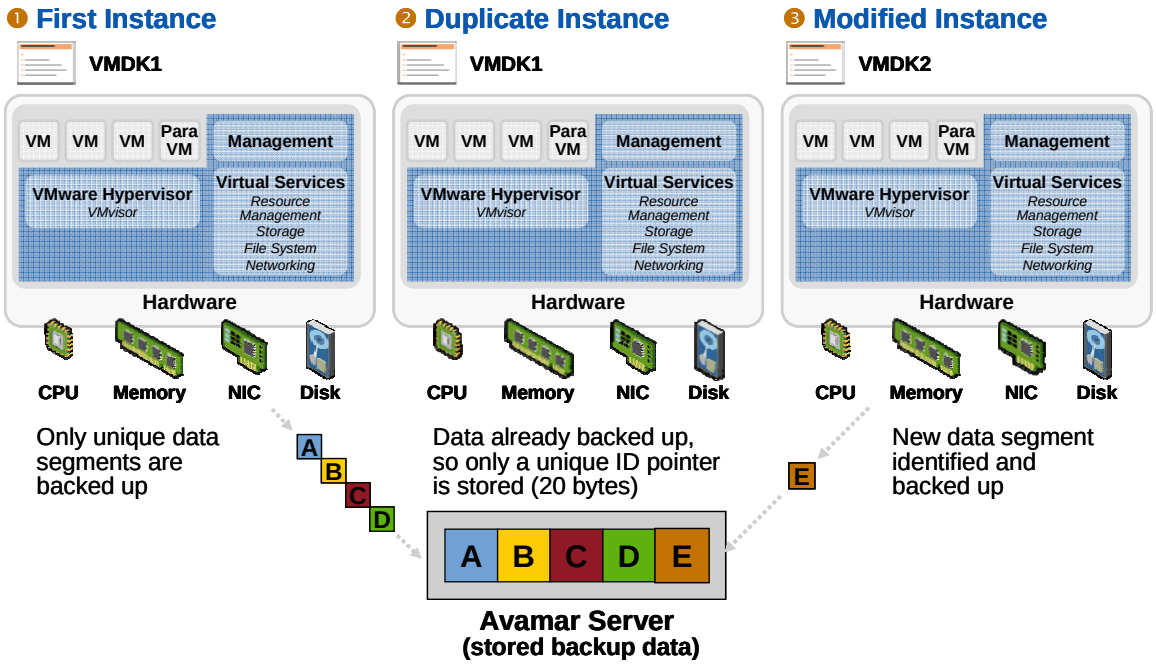


Figure 6. EMC Avamar de-duplication

Secure virtual infrastructure management

In addition to securing perimeters of the data center and user access to information with various hardware and software solutions such as firewalls, filters, antivirus software, VPN, and authentication systems, it is important to pay very close attention to who has direct access to the management of data center resources such as servers, networks, storage, applications, and databases. Only role-based access needs be granted to data center operations staff. Access needs to be designed and restricted/controlled in a manner that no single individual has enough data center resource access to single-handedly impact the overall operations.

Also, logically separate the user network (LAN) from the management network by creating isolated management VLANs. This not only ensures greater security in access to IT assets but also ensures availability of deterministic network resources (bandwidth) to IT staff for management functions and to users for application functions.

Set appropriate expectations with your customers – the users of technology

Setting realistic expectations in the delivery of IT services to users is critical in building an efficient data center. Not every user application or environment is of the absolute criticality and importance in a company's day-to-day and strategic business operations. Hence, over provisioning of resources in general or provisioning of expensive resources to operate less demanding parts of business is an entry point for inefficiency in a data center. Implementing chargeback systems, where departments are required to pay for used services, can help prioritize the use of infrastructure and can be a method of quality control in service delivery.

Service Level: Platinum	Service Number: 10060781
Subscriber Organization: OTD -- Online Trading Department	Cost Center: 20070
Subscription Type: Monthly	Start Date: 8/28/2008
Service Description:	**Service Charge**
Primary Trading DB Storage -- Grade A+ -- EMC Symmterix DMX	
Tier 0 -- Flash/Solid State Drive Storage	$10/GB
Tier 1 -- Fibre Channel (15K RPM) Storage	$5/GB
Priamry ORACLE Stoage -- Grade A -- EMC Clariion CX4	
Tier 1 -- Fibre Channel (15K RPM) Storage	$5/GB
Tier 2 -- Fibre Channel (10K RPM) Storage	$4/GB
Tier 4 -- Low Power Serial-ATA (5.4K RPM) Storage	$2.50/GB
Microsoft Exchange Operations	
200 Accounts	
Grade A Storage (CX4-240)	$100/Account
Backup to Disk -- EMC Networker/EDL	
Standard Data Protection	$2/GB
- Recoverfy Point Objective (R.P.O)	< 4 Hrs.
- Recovery Time Objective (R.T.O)	< 8 Hrs.
Continuous Data Protection	$4/GB
- Recovery Point Objective	< 2 Minutes
- Recovery Time Objective (R.T.O)	< 1 Hr.
Active Archive using EMC Centera	$1.50/GB
Replication - Local	
For Trading DB Multi-application Processing using DMX TimeFinder Mirror	$4/GB
For ORACLE Multi-application Processing CX4 SnapView Clone	$3/GB
Replication - Remote	
SRDF/ S	$10/GB
MirrorView/A	$7/GB
RecoverPoint - CRR	$7/GB

Figure 7. An example of an IT service delivery charge rate report to an organization with varied IT services created using various EMC technologies

Continuously strive to optimize IT operations

An ongoing review of IT requirements and services with functional departments and business units will ensure continuous alignment with business requirements. A quarterly review of delivered services over the previous term and requirements of future terms will not only build confidence and trust but will be an opportunity to educate other organizations on how IT requirements are delivered while at the same time better understand how requirements are generated. Engagement with business owners can help fine-tune and make IT more efficient by identifying areas where higher service levels are required or where the existing quality of service is higher than required and can be dialed down for increased IT efficiency.

Make assessments a routine activity

Perform asset utilization assessments on a regular and ongoing basis to ensure that all assets are being appropriately and fully utilized. A server assessment over a period of time can provide practical and

actionable information on average, peak, and low utilization and can help make necessary adjustments. Similarly a file system assessment for an application can help identify certain patterns for use of primary storage such as the type of data, number of duplicate copies of files, and when a given file was created, modified, and last accessed.

Conclusion

In order to build efficient green data centers, organizations need to take a holistic view of their data center operations including people, process, and infrastructure. Organizations need staff with business process and technical expertise. Definition, creation, and implementation of operational processes in IT projects are fundamental for data center efficiency. Awareness, understanding, and effort in optimizing all aspects of a data center are required in building an efficient green data center that has lower operational cost and greenhouse gas emission and higher value to the business.

With electricity becoming the second largest financial expense in data center operations and the risk of data centers running out of required total power for operations, organizations need to pay close attention to power and cooling infrastructure and power consumption of resources. Through formal assessments, organizations need to understand existing data center power and cooling designs, power consumption and cooling requirements of equipment, and resources' utilization of equipment to identify areas of opportunity for optimization.

To optimize the use of IT equipment and reduce the power burden on the data center, organizations need to use virtualization as the core enabler. Virtualization enables and complements important IT initiatives such as data migration, consolidation, and automation. Virtualization forms the basis for boarder efficiency realization across all functional aspects of IT. With virtualization at the heart of IT infrastructure, organizations build data centers that are financially efficient and environmentally safer.

Next steps

Power and cooling, and IT asset assessment with EMC and VMware Services

Organizations should perform power and cooling and server and storage utilization assessments. EMC and VMware offer a number of assessment services to help organization in the process. Once existing and future power and cooling requirements have been identified and inefficiencies in resources utilization have been accounted for, the next step is to formulate a plan for specific infrastructure optimization to be performed. By leveraging the expertise of EMC and VMware professional and education services, organization can create and implement a comprehensive infrastructure optimization plan to meet unique requirements of every organization.

EMC and VMware data center efficiency solutions

To help organizations build efficient green data centers, EMC and VMware offer a broad set of hardware and software products and services. The use of EMC Information Lifecycle Management and VMware server virtualization platforms results in improved and consistent processes and procedures for server and storage operations and management, optimization of power and cooling usage, and better utilization of server and storage resources. Organizations also achieve adequately protected information with recovery policies inline with business requirements, and compelling return on IT infrastructure investments.

EMC Education Services

To promote awareness and education of storage technology for building efficient green data centers, EMC offers a comprehensive portfolio of educational services programs. These programs are designed to help storage professionals (managers and administrators) develop storage competency. The knowledge gained helps organizations improve day-to-day IT operations and staff productivity. Also, storage professionals develop expertise required to successfully plan, design, implement, and manage strategic IT initiatives. Some EMC Education Services programs include:

- **EMC Technology Curriculum:** Suitable for EMC users, aligned with core technology areas and job roles/responsibilities.

- **Storage Administrator Certification:** Suitable for EMC users, part of the EMC Proven™ Professional framework, aligned with key technology specialties and job roles (storage administrator, storage manager, and storage architect).
- **Storage Technologist Curriculum:** Suitable for EMC users and the overall IT industry; this "open" curriculum focuses on concepts, principles, and core skills, not on products.
- **EMC Storage Technologist Certification:** Suitable for EMC users and the overall IT industry, part of the EMC Proven Professional framework; this "open" curriculum focuses on concepts, principles, and core skills, not on products.
- **EMC Academy Program:** "Open" storage technology curriculum for technology majors in colleges and universities; targeted to help build a highly skilled pool of future storage managers and professionals.
- **EMC Learning Partner Program:** "Open" storage technology curriculum, offered by leading, independent training companies, targeted at building or improving storage technology skills leading to better design and management of efficient storage infrastructures.

VMware Education Services

VMware Education Services provides a strong foundation and advanced training on the VMware infrastructure in instructor-led courses with hands-on exercises

- **VMware Certified Professional**: The VMware Certified Professional Program is designed for any technical individual — partners, end users, resellers, and consultants

References

For more information, contact your local EMC and VMware sales representative or visit EMC.com or VMware.com.

Read the following EMC white paper for more information on efficient green data centers:

The Efficient Green Data Center: Optimizing Your Environment and IT Infrastructure – Best Practices Planning

The following white papers from American Power Conversion can also provide more information:

- *Electrical Efficiency Measurement for Data Centers* (APC white paper #154)
- *Ten Cooling Solutions to Support High Density Server Deployment* (APC white paper #42)