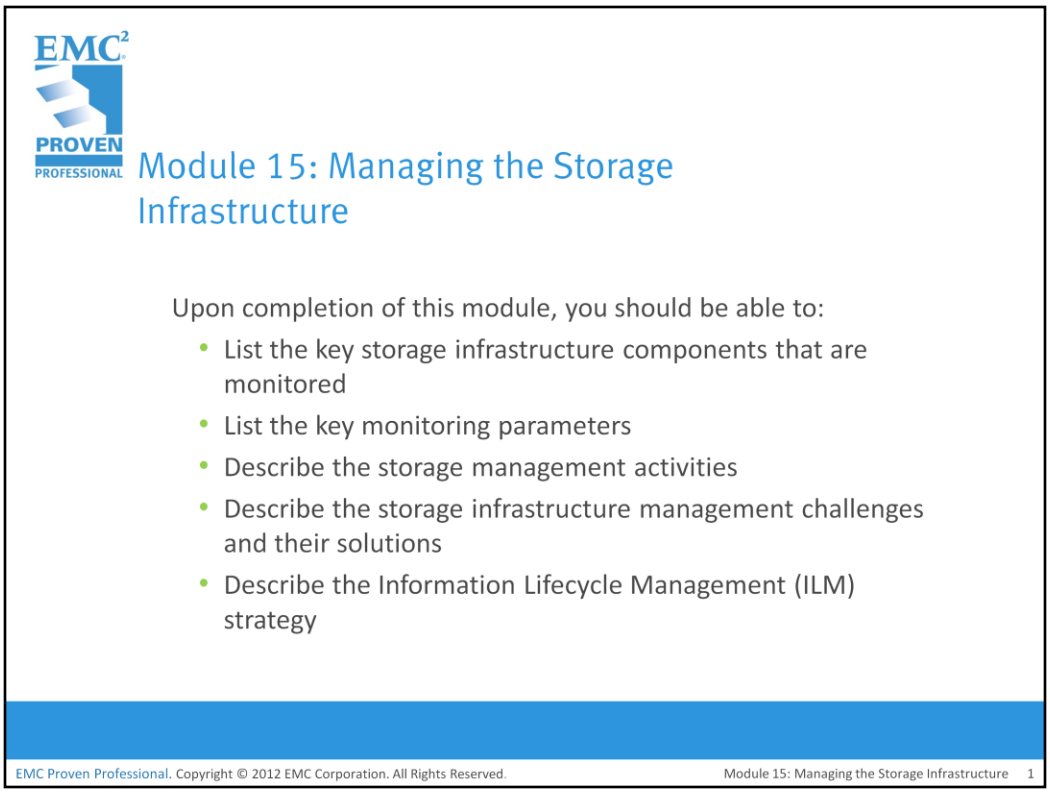
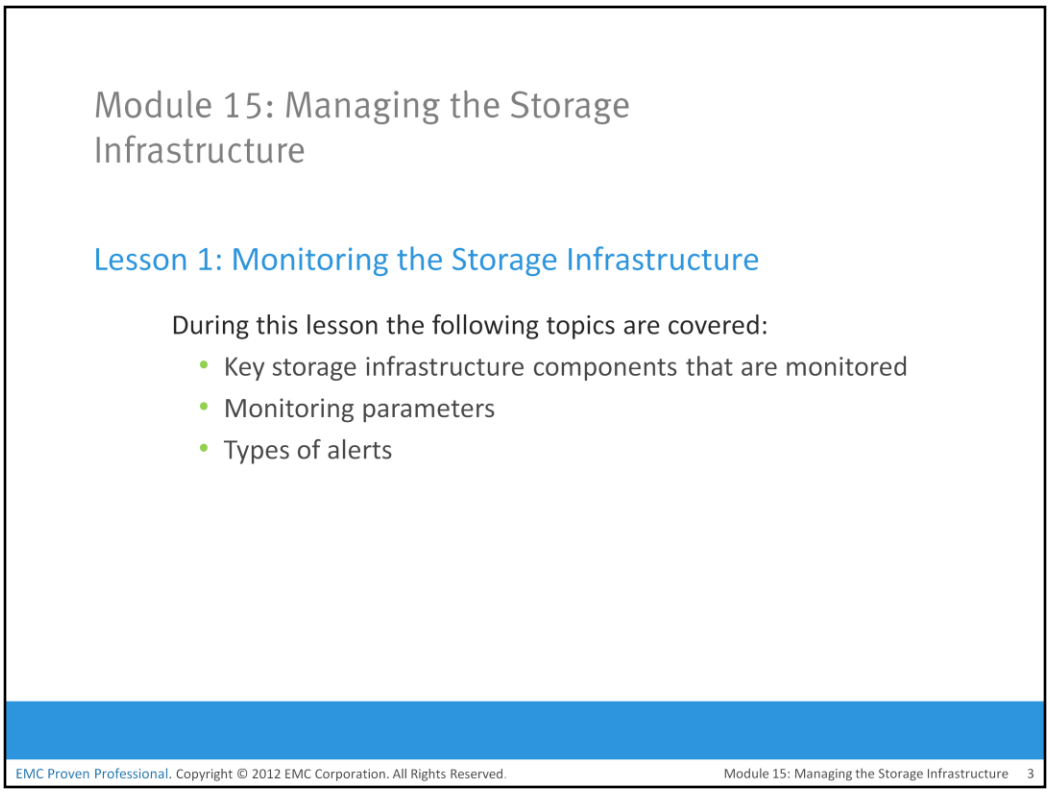
Module – 15

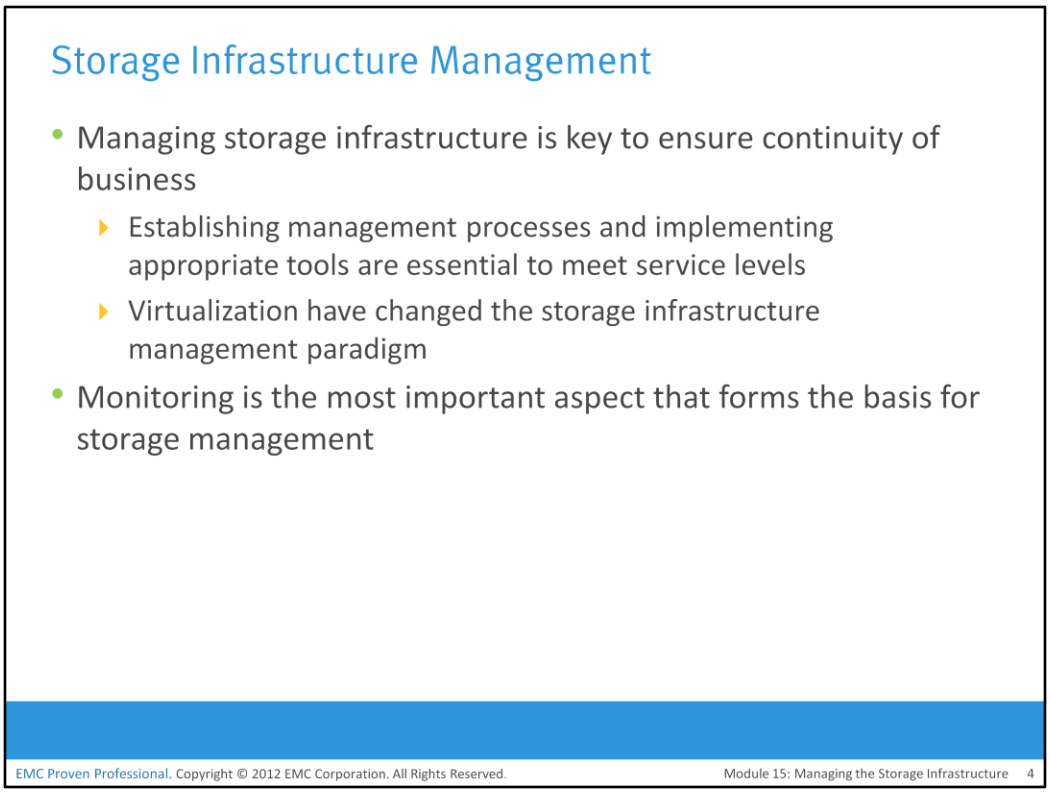
Managing the Storage Infrastructure



This module focuses on the management of storage infrastructure. This module lists the key storage infrastructure components that are monitored. The module also lists the monitoring parameters. Further, the module describes the storage management activities. It also describes the storage infrastructure management challenges and their solutions. Finally, this module describes the Information Lifecycle Management strategy.



This lesson covers the storage infrastructure components that are monitored. It also covers the monitoring parameters for storage infrastructure components. Further, it details the three types of alerts. Finally, the module provides monitoring examples.



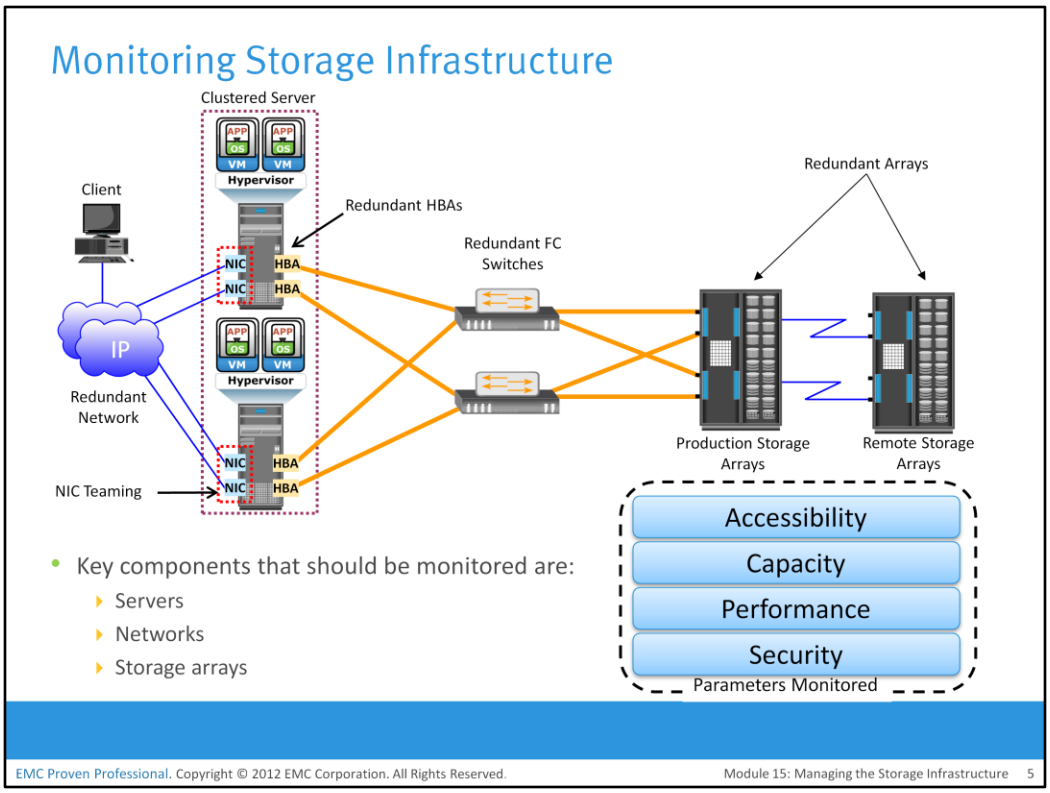
Unprecedented growth of information, proliferation of applications, complexity of business processes, and requirements of 24×7 availability of information have put increasingly higher demands on the IT infrastructure.

Managing storage infrastructure efficiently is a key that enables organizations to address these challenges and ensures continuity of business.

Comprehensive storage infrastructure management requires the implementation of intelligent tools and robust processes to meet the required service levels. These tools enable performance tuning, data protection, access control, centralized auditing, and meeting compliance requirements. They also ensure the consolidation and better utilization of existing resources, thereby limiting the need for excessive ongoing investment on infrastructure. The management process defines procedures for efficient handling of various operations, such as incident, problem, and change requests. It is imperative to manage not just the individual components, but also the infrastructure end to end due to the components' interdependency.

Storage infrastructure management is also composed of strategies, such as *information lifecycle management* (ILM) that optimizes the storage cost while meeting the service levels. ILM helps to manage information based on its value to the business.

Managing the storage infrastructure requires performing various activities, including accessibility, capacity, performance, and security management. All of these activities are interrelated and should be considered to maximize the return on investment. Virtualization technologies have dramatically changed the storage infrastructure management paradigm.

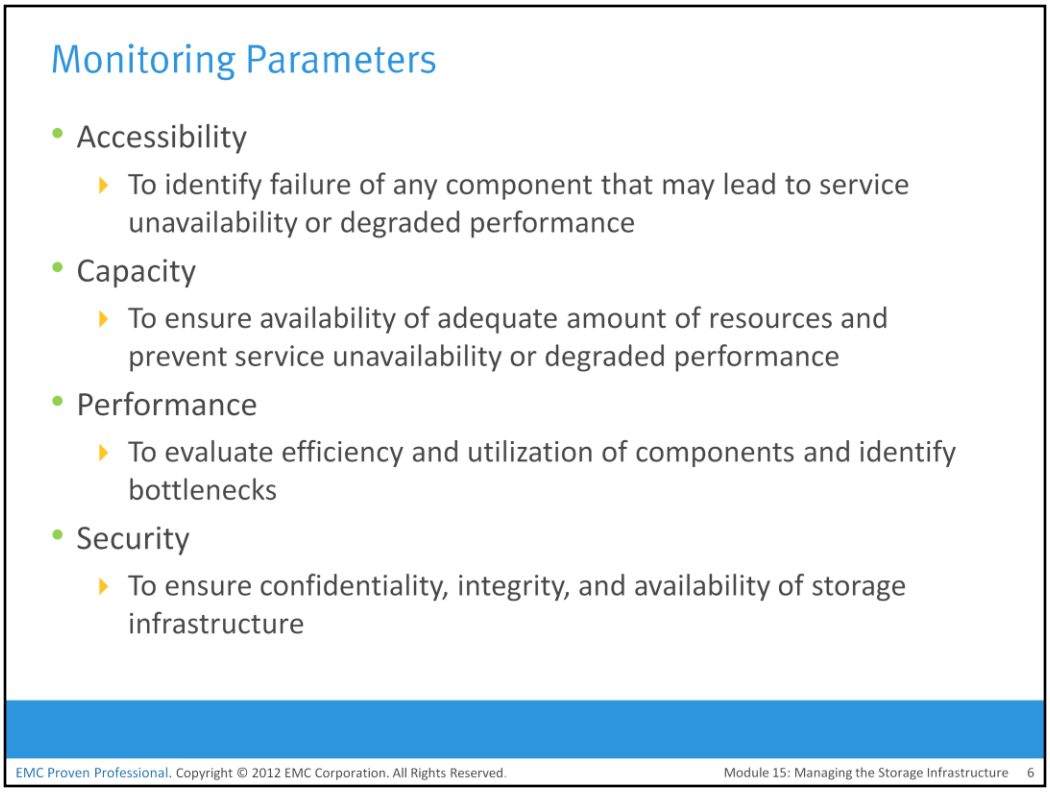


Monitoring is one of the most important aspects that forms the basis for managing storage infrastructure resources. Monitoring provides the performance and accessibility status of various components. It also enables administrators to perform essential management activities. Monitoring also helps to analyze the utilization and consumption of various storage infrastructure resources. This analysis facilitates capacity planning, forecasting, and optimal use of these resources. Storage infrastructure environment parameters such as heating, ventilating and air-conditioning (HVAC) are also monitored.

The key storage infrastructure components that should be monitored are:

- Servers
- Network
- Storage arrays

These components could be physical or virtualized. Each of these components should be monitored for accessibility, capacity, performance and security.



Accessibility refers to the availability of a component to perform its desired operation during a specified time period. Monitoring the accessibility of hardware components (for example, a port, an HBA, or a disk drive) or software component (for example, a database instance) involves checking their availability status by reviewing the alerts generated from the system. For example, a port failure might result in a chain of availability alerts.

A storage infrastructure uses redundant components to avoid a single point of failure. Failure of a component might cause an outage that affects application availability, or it might cause performance degradation even though accessibility is not compromised. Continuously monitoring for expected accessibility of each component and reporting any deviation helps the administrator to identify failing components and plan corrective action to maintain SLA requirements.

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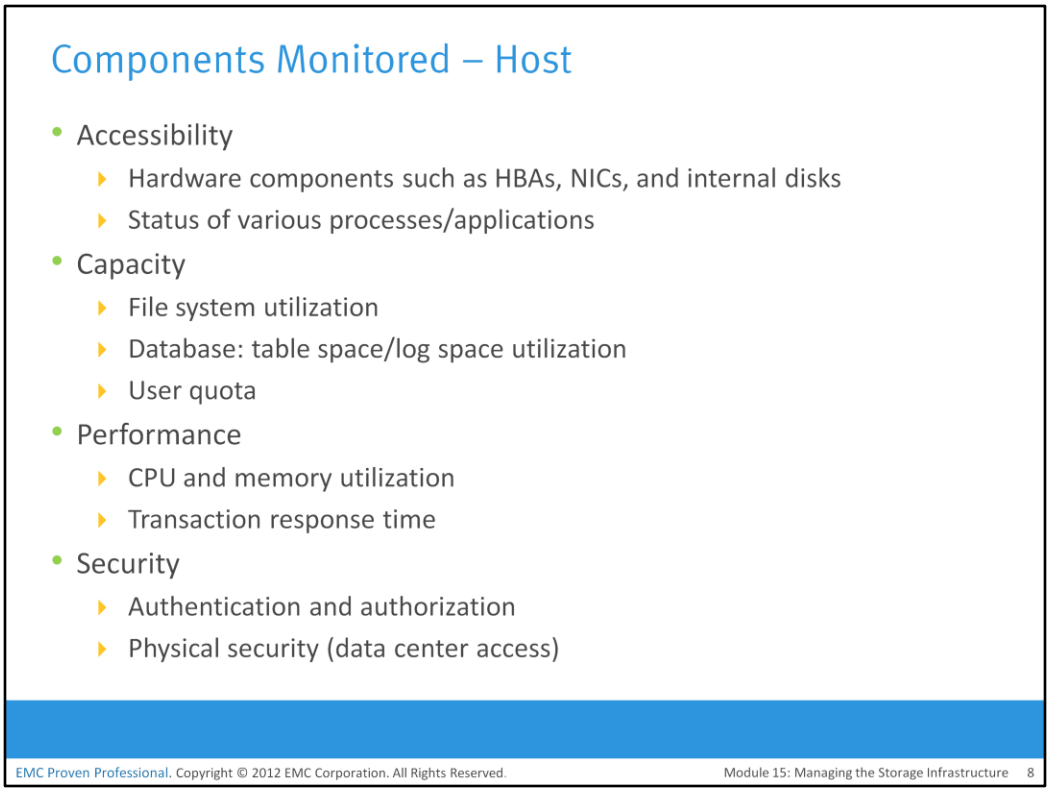
Capacity refers to the amount of storage infrastructure resources available. Examples of capacity monitoring include examining the free space available on a file system or a RAID group, the mailbox quota allocated to users, or the numbers of ports available on a switch. Inadequate capacity leads to degraded performance or even application/service unavailability. Capacity monitoring ensures uninterrupted data availability and scalability by averting outages before they occur. For example, if 90 percent of the ports are utilized in a particular SAN fabric, this could indicate that a new switch might be required if more arrays and servers need to be installed on the same fabric. Capacity monitoring usually leverages analytical tools to perform trend analysis. These trends help to understand future resource requirements and provide an estimation of the time required to deploy them.

Performance monitoring evaluates how efficiently different storage infrastructure components are performing and helps to identify bottlenecks. Performance monitoring measures and analyzes behavior in terms of response time or the capability to perform at a certain predefined level. It also deals with the utilization of resources, which affects the way resources behave and respond. Performance measurement is a complex task that involves assessing various components on several interrelated parameters. The number of I/Os performed by a disk, application response time, network utilization, and server-CPU utilization are examples of performance parameters that are monitored.

Monitoring a storage infrastructure for security helps to track and prevent unauthorized access, whether accidental or malicious. *Security monitoring* helps to track unauthorized configuration changes of storage infrastructure elements. For example, security monitoring tracks and reports the initial zoning configuration performed and all the subsequent changes. Security monitoring also detects unavailability of information to authorized users due to security breach. Physical security of a storage infrastructure can also be continuously monitored using badge readers, biometric scans, or video cameras.



Hosts, networks, and storage are the components within the storage environment that should be monitored for accessibility, capacity, performance, and security.

The accessibility of a host depends on the availability status of the hardware components and the software processes running on it. For example, a host's NIC failure might cause inaccessibility of the host to its user. Server clustering is a mechanism that provides high availability if a server failure occurs. In a server virtualization environment, multiple virtual machines (VMs) share a pool of resources. These resources are dynamically reallocated, which ensures better accessibility and utilization of the resources.

Monitoring the file system utilization of a host is important to ensure that sufficient storage capacity is available to the applications. Running out of file system space disrupts application availability. Monitoring helps estimate the file system's growth rate and predict when it will reach 100 percent. Accordingly, the administrator can extend (manually or automatically) the file system's space proactively to prevent application outage. Use of virtual provisioning technology enables efficient management of storage capacity requirements but is highly dependent on capacity monitoring.

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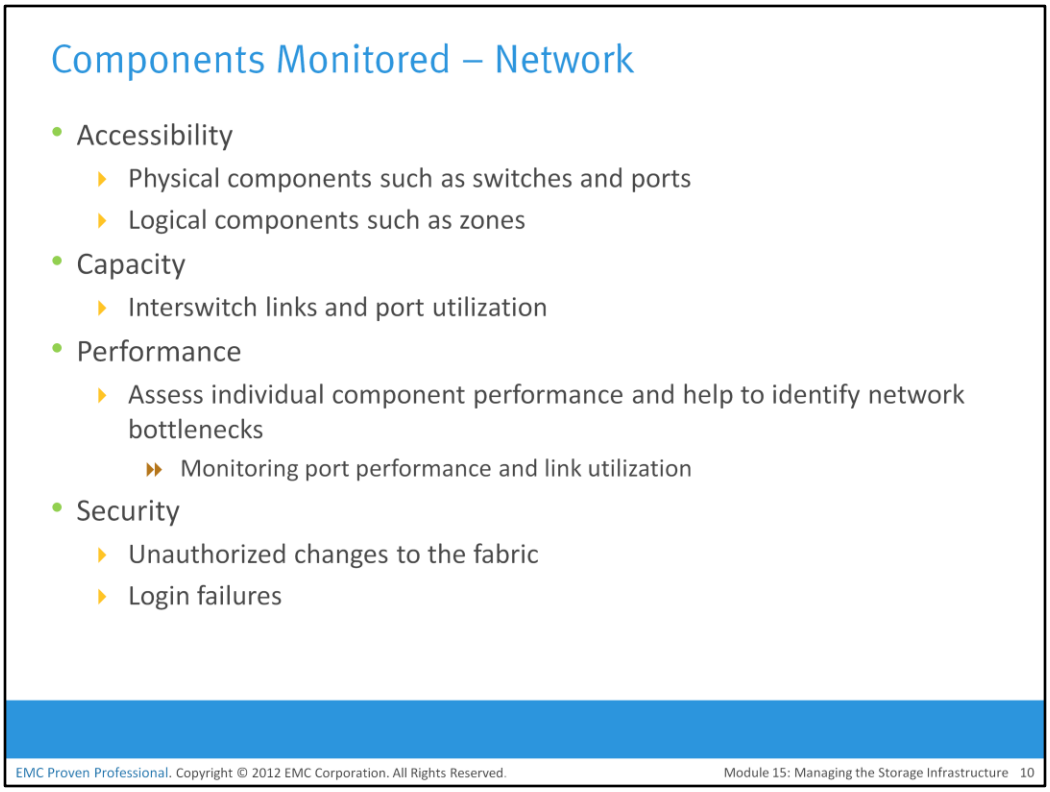
Host performance monitoring mainly involves a status check on the utilization of various server resources, such as CPU and memory. For example, if a server running an application is experiencing 80 percent of CPU utilization continuously, it suggests that the server may be running out of processing power, which can lead to degraded performance and slower response time. Administrators can take several actions to correct the problem, such as upgrading or adding more processors, shifting the workload to different servers, and restricting the number of simultaneous client access. In a virtualized environment, additional CPU and memory may be allocated dynamically from the pool, if available, to meet performance requirements.

Security monitoring on servers involves tracking of login failures and execution of unauthorized applications or software processes. Proactive measures against unauthorized access to the servers are based on the threat identified. For example, an administrator can block user access if multiple login failures are logged.



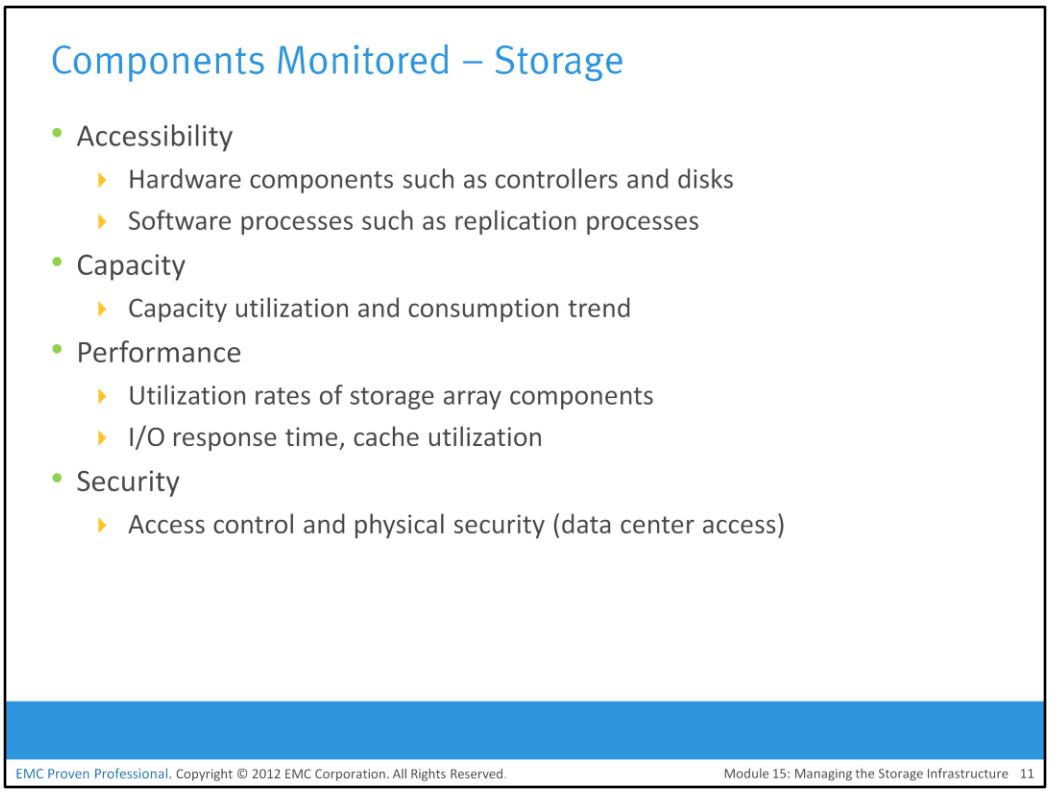
Storage networks need to be monitored to ensure proper communication between the server and the storage array. Uninterrupted access to data over the storage network depends on the accessibility of the physical and logical components in the storage network. The physical components of a storage network include switches, ports, cables, and power supplies. The logical components include constructs, such as zones. Any failure in the physical or logical components causes data unavailability. For example, errors in zoning, such as specifying the wrong WWN of a port, result in failure to access that port, which potentially prevents access from a host to its storage.

Capacity monitoring in a storage network involves monitoring the availability of ports on a switch, the number of available ports in the entire fabric, the utilization of the interswitch links, individual ports, and each interconnect device in the fabric. Capacity monitoring provides all the required inputs for future planning and optimization of fabric resources.

Monitoring the performance of the storage network is useful in assessing individual component performance and helps to identify network bottlenecks. For example, monitoring port performance involves measuring the receive or transmit link utilization metrics, which indicates how busy the switch port is. Heavily used ports can cause queuing of I/Os on the server, which results in poor performance.

For IP networks, monitoring the performance includes monitoring network latency, packet loss, bandwidth utilization for I/O, network errors, packet retransmission rates and collisions.

Storage network security monitoring provides information about any unauthorized change to the configuration of the fabric—for example, changes to the zone policies that can affect data security. Login failures and unauthorized access to switches for performing administrative changes should be logged and monitored continuously.

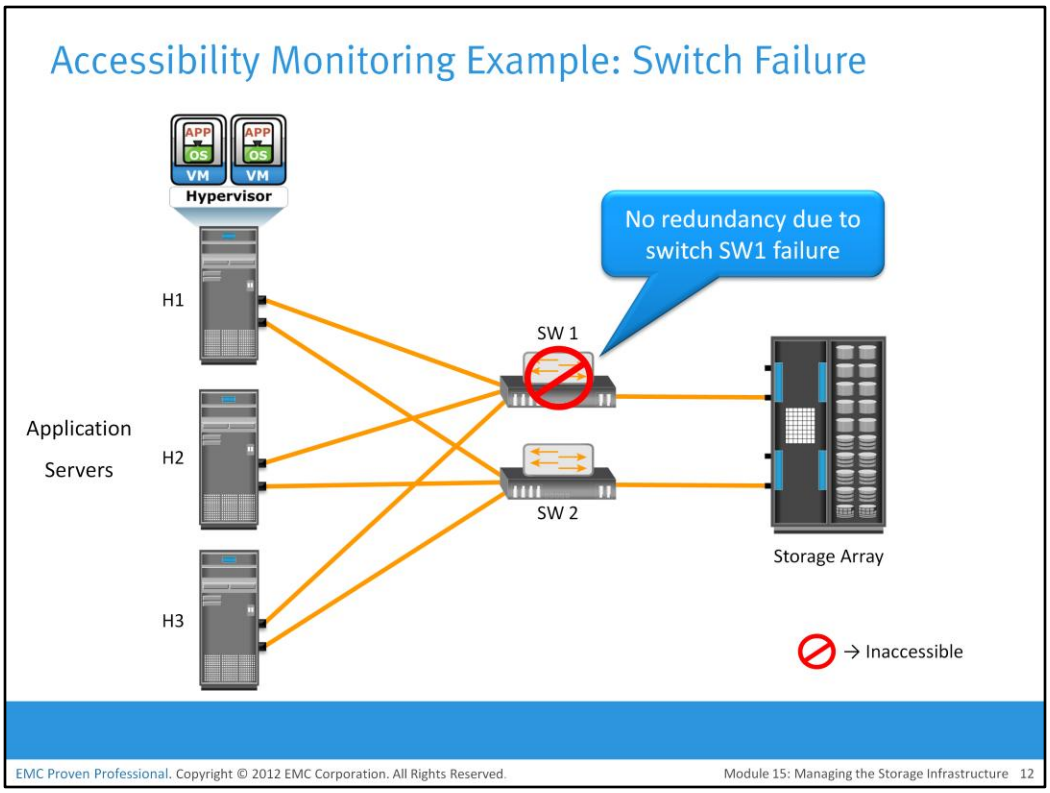


The accessibility of the storage array should be monitored for its hardware components and various processes. Storage arrays are typically configured with redundant components and therefore individual component failure does not usually affect their accessibility. However, failure of any process in the storage array can disrupt or compromise business continuity operations. For example, the failure of a replication task affects disaster recovery capabilities. Some storage arrays provide the capability to send messages to the vendor's support center if hardware or process failures occur, referred to as a *call home*.

Capacity monitoring of a storage array enables the administrator to respond to storage needs preemptively based on capacity utilization and consumption trends. Information about unconfigured and unallocated storage space is also required to decide whether a new server can be allocated storage capacity from the array.

A storage array can be monitored using a number of performance metrics, such as utilization rates of the various storage array components, I/O response time, and cache utilization. For example, an over utilized storage array component might lead to performance degradation.

A storage array is usually a shared resource, which may be exposed to security threats. Monitoring security helps to track unauthorized configuration of the storage array and ensures that only authorized users are allowed to access it.

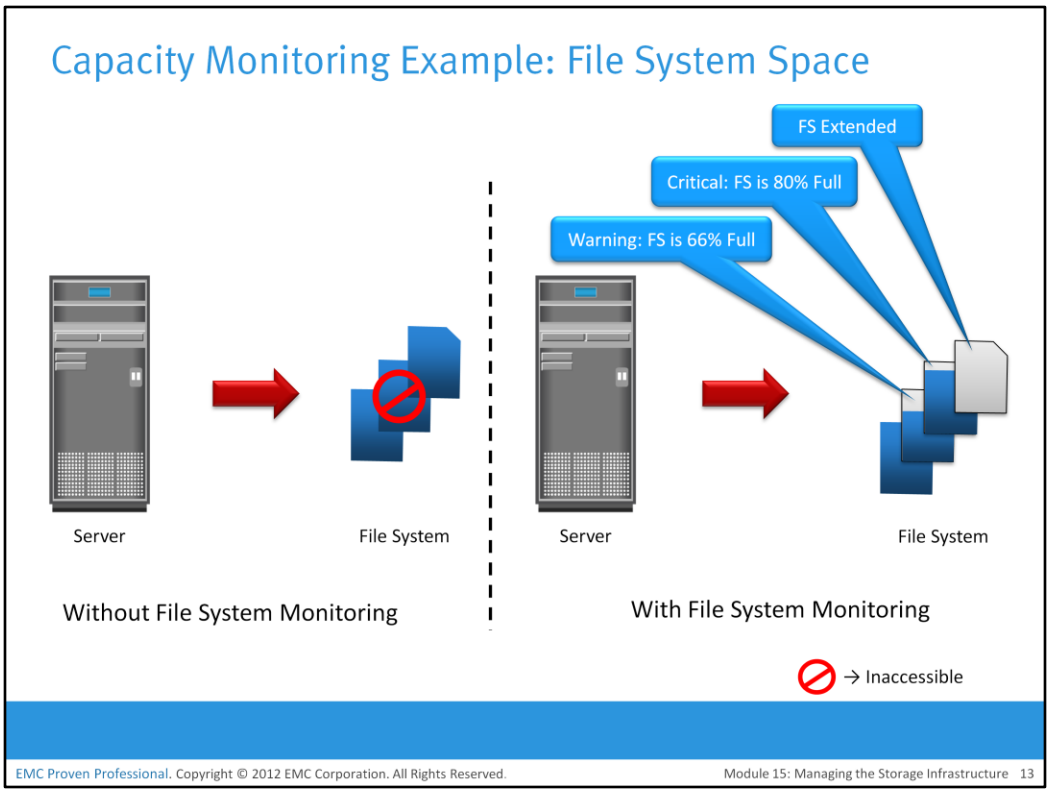


A storage infrastructure requires implementation of an end-to-end solution to actively monitor all the parameters of its critical components. Early detection and preemptive alerting ensure uninterrupted services from critical assets. In addition, the monitoring tool should analyze the impact of a failure and deduce the root cause of symptoms. Next few slides illustrates examples of monitoring storage infrastructure components for accessibility, capacity, performance, and security.

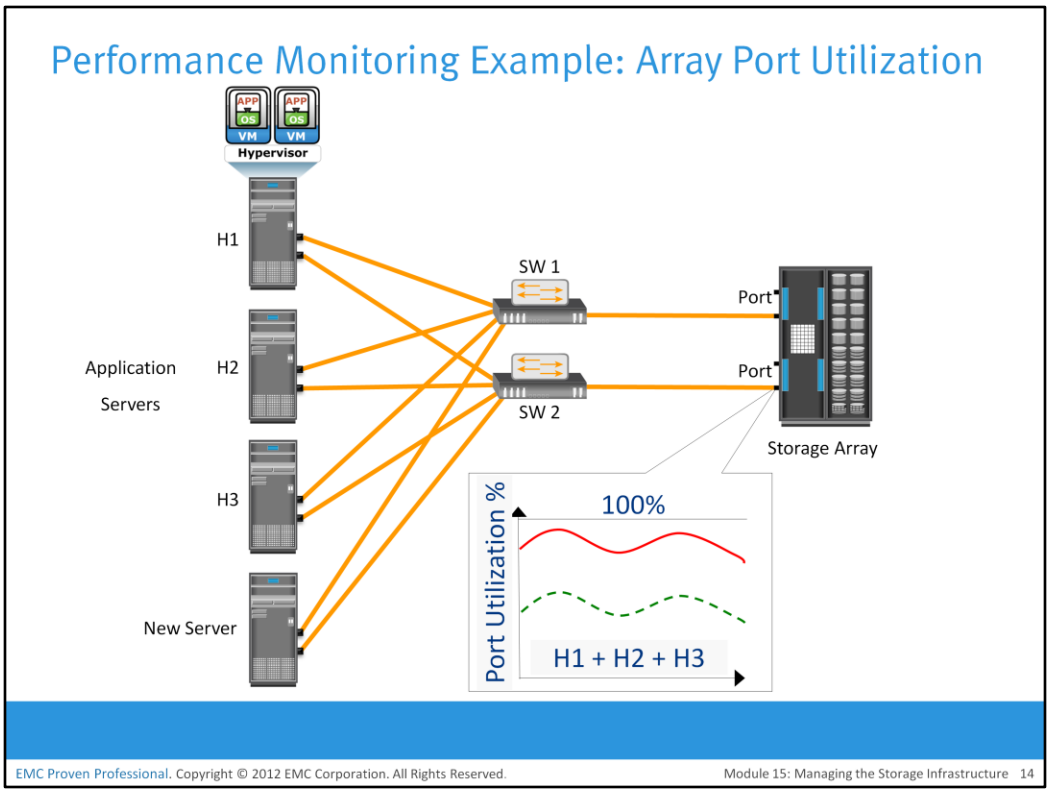
Failure of any component might affect the accessibility of one or more components due to their interconnections and dependencies. Consider an implementation in a storage infrastructure with three servers: H1, H2, and H3. All the servers are configured with two HBAs, each connected to the production storage array through two switches, SW1 and SW2, as shown on slide. All the servers share two storage ports on the storage array. Multipathing software has also been installed on all the three servers.

If one of the switches, SW1 fails, the multipathing software initiates a path failover, and all the servers continue to access data through the other switch, SW2. However, due to absence of redundant switch, a second switch failure could result in inaccessibility of the array. Monitoring for accessibility enables detecting the switch failure and helps administrator to take corrective action before another failure occurs.

In most cases, the administrator receives symptom alerts for a failing component and can initiate actions before the component fails.

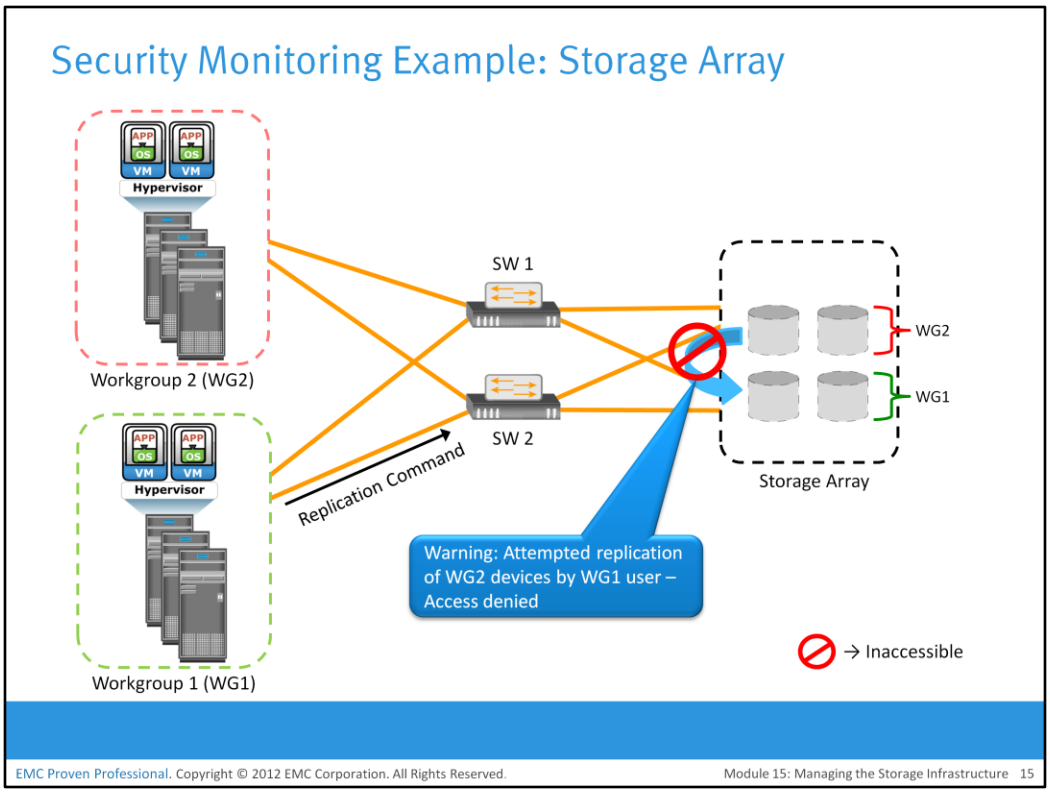


This example illustrates the importance of monitoring the file system capacity on file servers. Figure on the slide illustrates the environment of a file system when full and that results in application outage when no capacity monitoring is implemented. Monitoring can be configured to issue a message when thresholds are reached on the file system capacity. For example, when the file system reaches 66 percent of its capacity, a warning message is issued, and a critical message is issued when the file system reaches 80 percent of its capacity. This enables the administrator to take action to extend the file system before it runs out of capacity. Proactively monitoring the file system can prevent application outages caused due to lack of file system space.

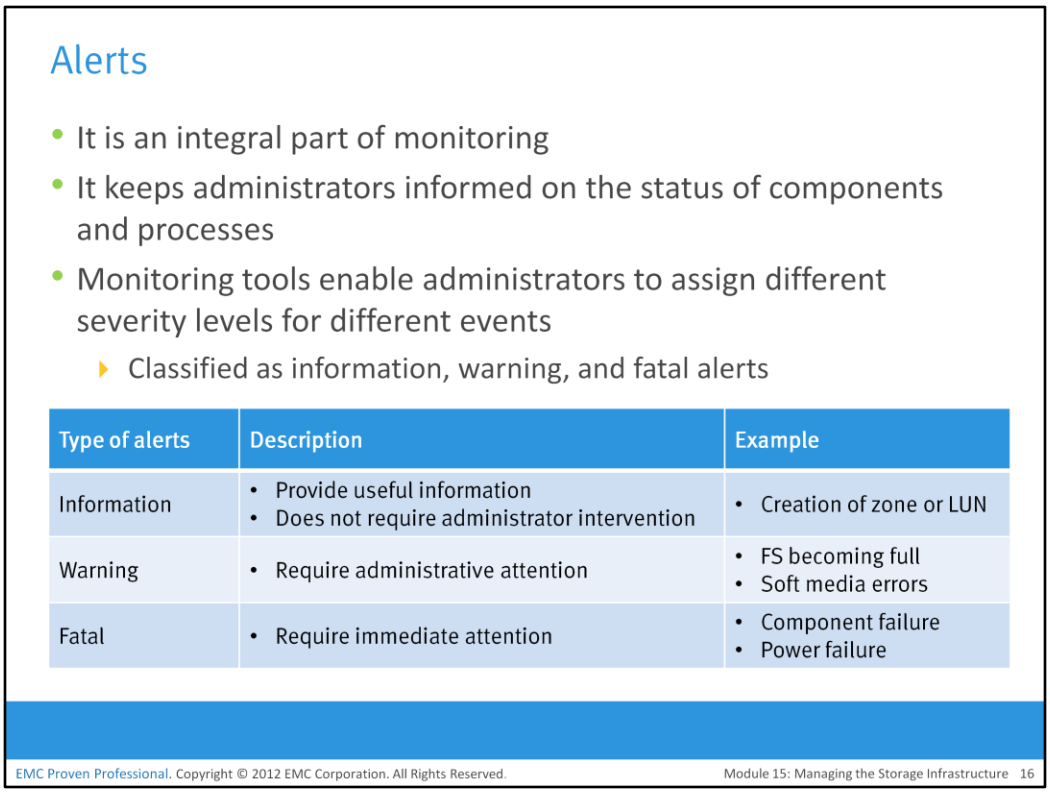


This example illustrates the importance of monitoring performance on storage arrays. In this example, servers H1, H2, and H3 (with two HBAs each) are connected to the storage array through switch SW1. The three servers share the same storage ports on the storage array to access LUNs. A new server running an application with a high work load must be deployed to share the same storage port as H1, H2, and H3.

Monitoring array port utilization ensures that the new server does not adversely affect the performance of the other servers. In this example, utilization of the shared storage port is shown by the solid and dotted lines in the graph. If the port utilization prior to deploying the new server is close to 100 percent, then deploying the new server is not recommended because it might impact the performance of the other servers. However, if the utilization of the port prior to deploying the new server is closer to the dotted line, then there is room to add a new server.



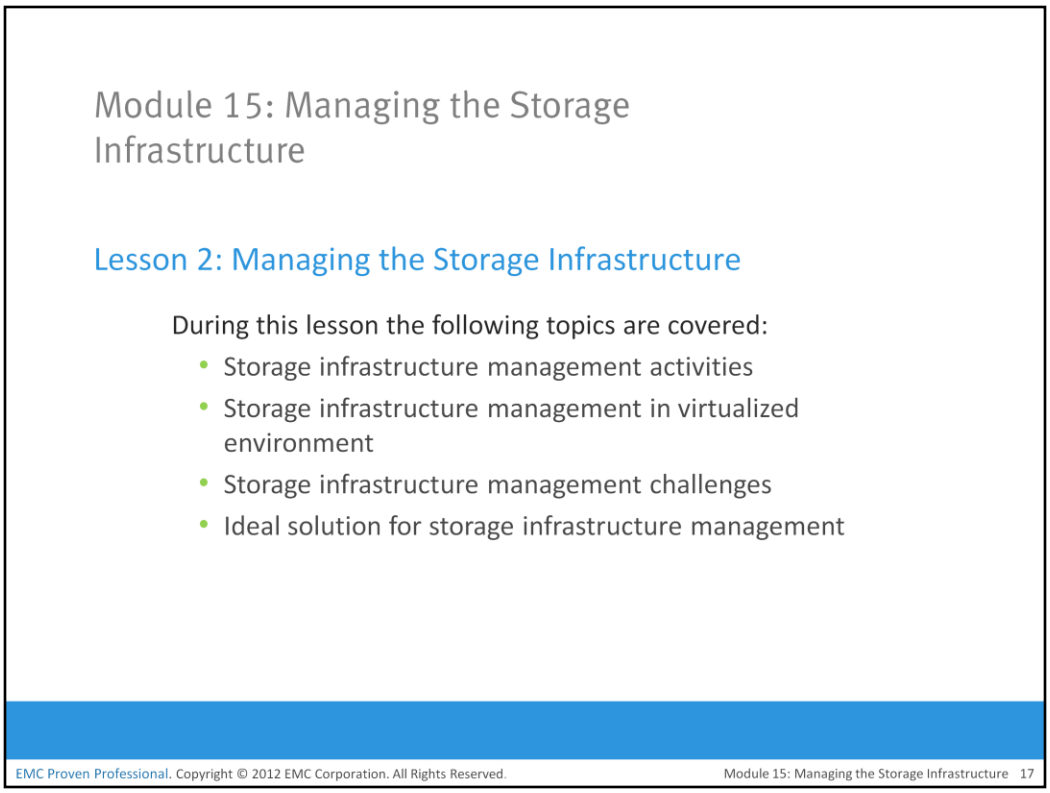
This slide illustrates the importance of monitoring security in a storage array. In this example, the storage array is shared between two workgroups, WG1 and WG2. The data of WG1 should not be accessible by WG2 and vice versa. A user from WG1 might try to make a local replica of the data that belongs to WG2. If this action is not monitored or recorded, it is difficult to track such a violation of security protocols. Conversely, if this action is monitored, a warning message can be sent to prompt a corrective action or at least enable discovery as part of regular auditing operations.



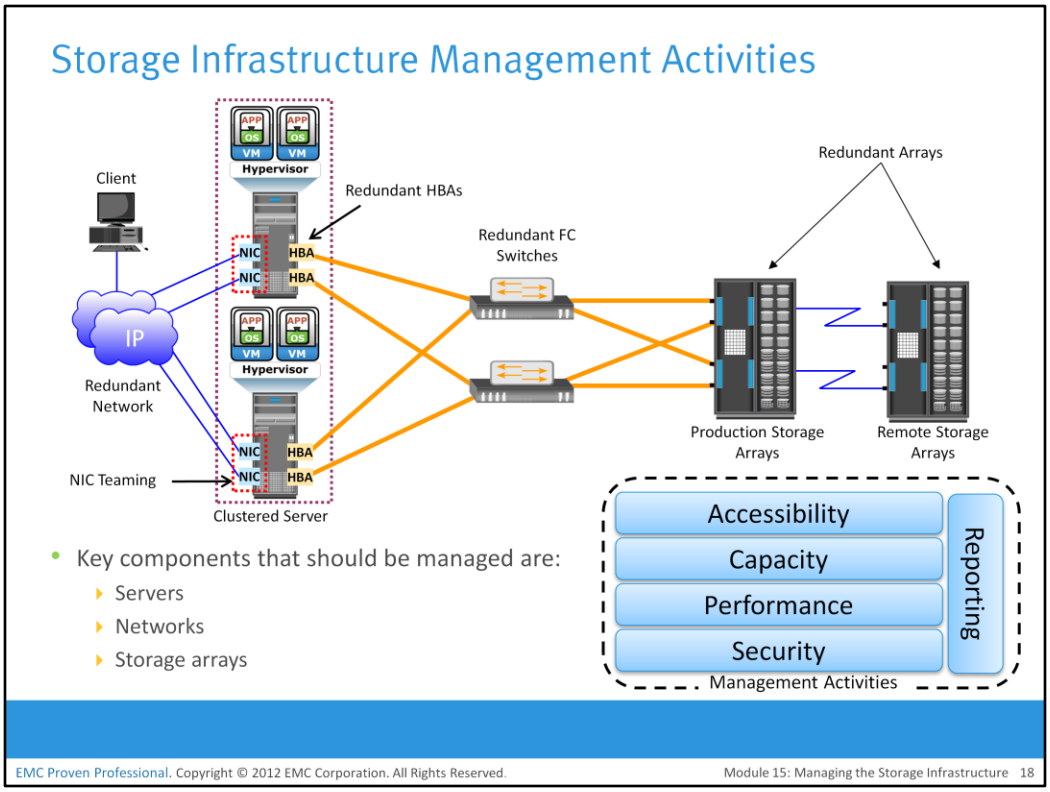
Alerting of events is an integral part of monitoring. Alerting keeps administrators informed about the status of various components and processes—for example, conditions such as failure of power, disks, memory, or switches, which can impact the availability of services and require immediate administrative attention. Other conditions, such as a file system reaching a capacity threshold or a soft media error on disks, are considered warning signs and may also require administrative attention.

Monitoring tools enable administrators to assign different severity levels for different conditions based on the impact of the alerted condition. Whenever a condition with a particular severity level occurs, an alert is sent to the administrator, a script is triggered, or an incident ticket is opened to initiate a corrective action. Alert classifications can range from information alerts to fatal alerts. *Information alerts* provide useful information but do not require any intervention by the administrator. The creation of a zone or LUN is an example of an information alert. *Warning alerts* require administrative attention so that the alerted condition is contained and does not affect accessibility. For example, if an alert indicates that the number of soft media errors on a disk is approaching a predefined threshold value, the administrator can decide whether the disk needs to be replaced. *Fatal alerts* require immediate attention because the condition might affect overall performance or availability. For example, if a disk fails, the administrator must ensure that it is replaced quickly.

Continuous monitoring, with automated alerting, enables administrators to respond to failures quickly and proactively. Alerting provides information that helps administrators prioritize their response to events.

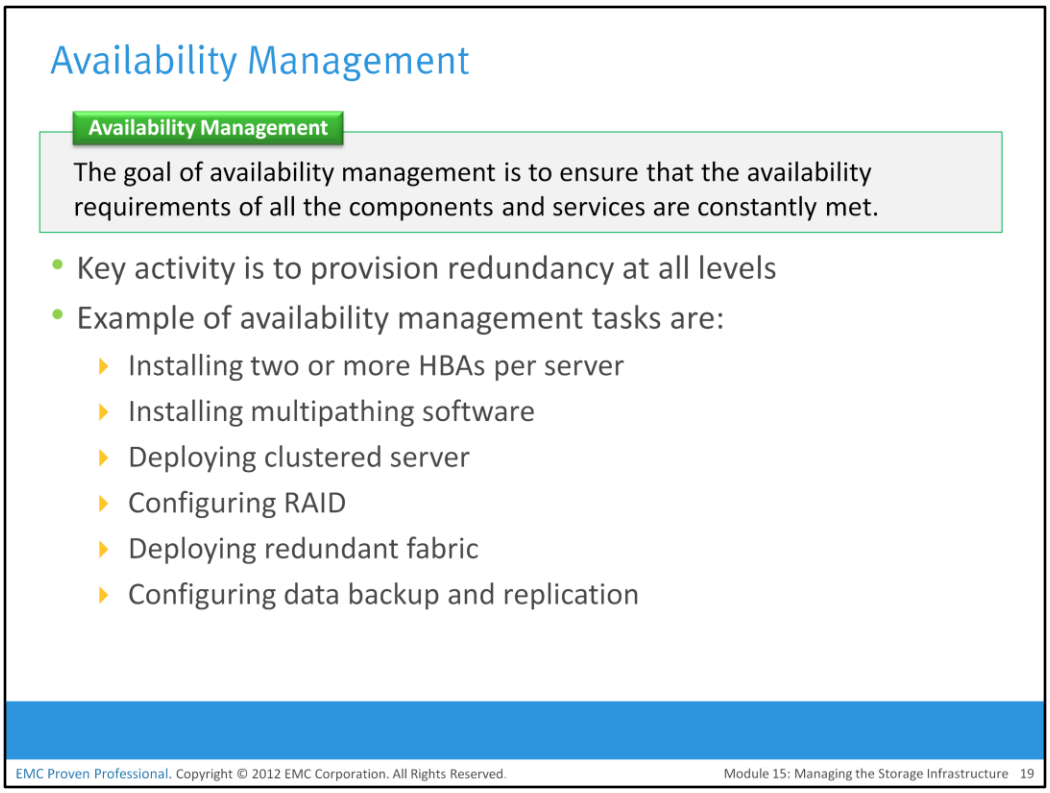


This lesson details storage infrastructure management activities, and management in virtualized environment. It covers storage management examples and challenges. Finally, it describes the ideal solution for storage infrastructure management.

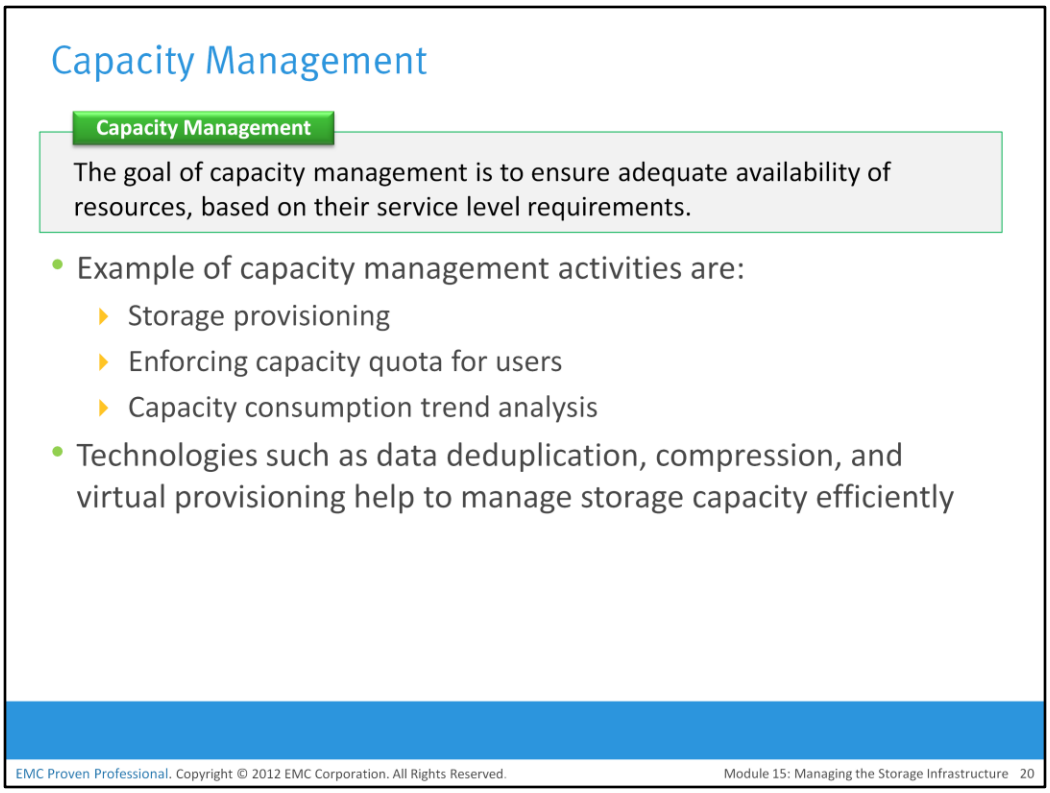


The pace of information growth, proliferation of applications, heterogeneous infrastructure, and stringent service-level requirements have resulted in increased complexity of managing storage infrastructures. However, the emergence of storage virtualization and other technologies, such as data deduplication and compression, thin provisioning, federated storage access, and storage tiering, have enabled administrators efficiently manage storage resources.

The key storage infrastructure management activities performed in a data center can be broadly categorized into availability management, capacity management, performance management, security management, and reporting.

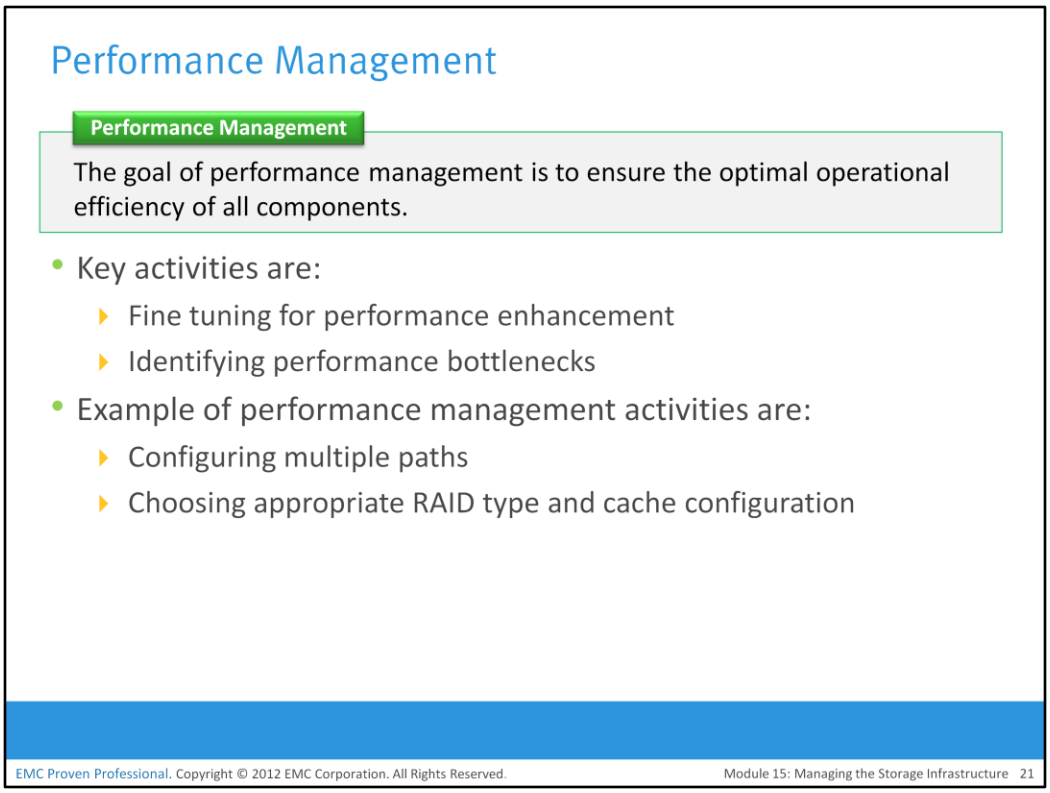


A critical task in availability management is establishing a proper guideline based on defined service levels to ensure availability. *Availability management* involves all availability-related issues for components or services to ensure that service levels are met. A key activity in availability management is to provision redundancy at all levels, including components, data, or even site levels. For example, when a server is deployed to support a critical business function, it requires high availability. This is generally accomplished by deploying two or more HBAs, multipathing software, and server clustering. The server must be connected to the storage array using at least two independent fabrics and switches that have built-in redundancy. Provision RAID-protected LUNs to the server using at least two front-end ports. In addition, the storage arrays should have built-in redundancy for various components and should support local and remote replication.



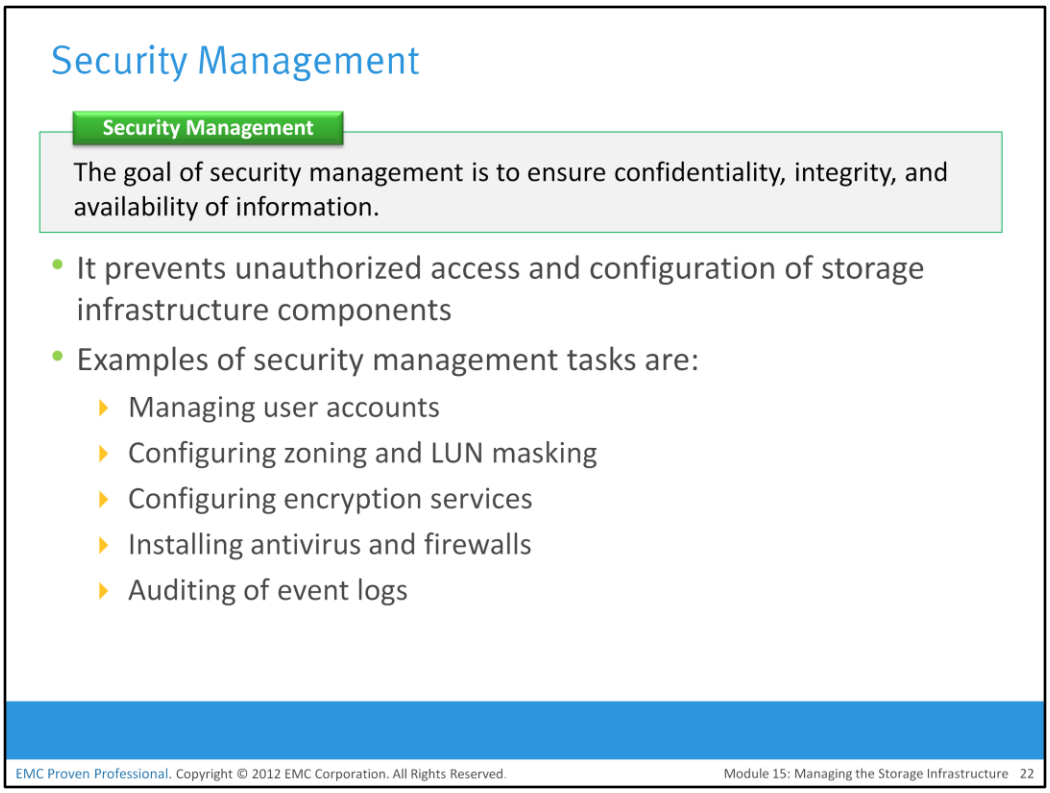
The goal of *capacity management* is to ensure adequate availability of resources based on their service level requirements. Capacity management also involves optimization of capacity based on the cost and future needs. Capacity management provides capacity analysis that compares allocated storage to forecasted storage on a regular basis. It also provides trend analysis based on the rate of consumption, which must be rationalized against storage acquisition and deployment timetables. Storage provisioning is an example of capacity management. It involves activities, such as creating RAID sets and LUNs, and allocating them to the host. Enforcing capacity quotas for users is another example of capacity management. Provisioning a fixed amount of space for their files restricts users from exceeding the allocated capacity.

Technologies, such as data deduplication and compression, have reduced the amount of data to be backed up and thereby reduced the amount of storage capacity to be managed.

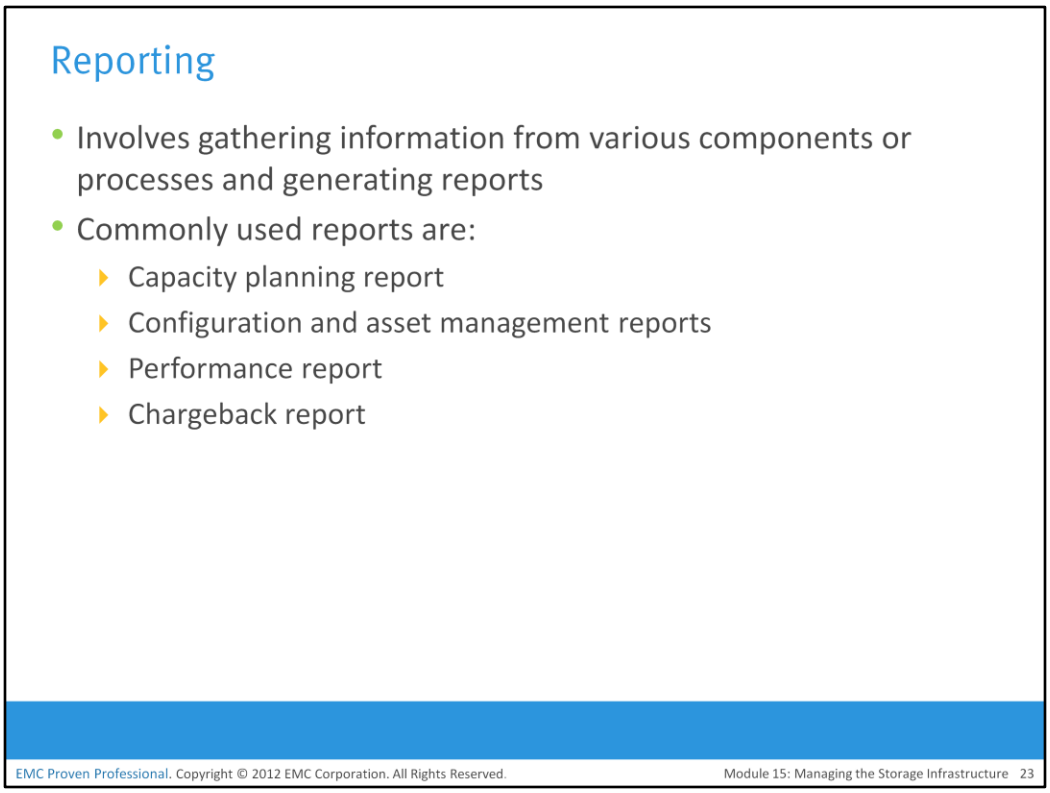


Performance management ensures the optimal operational efficiency of all components. Performance analysis is an important activity that helps to identify the performance of storage infrastructure components. This analysis provides information on whether a component meets expected performance levels.

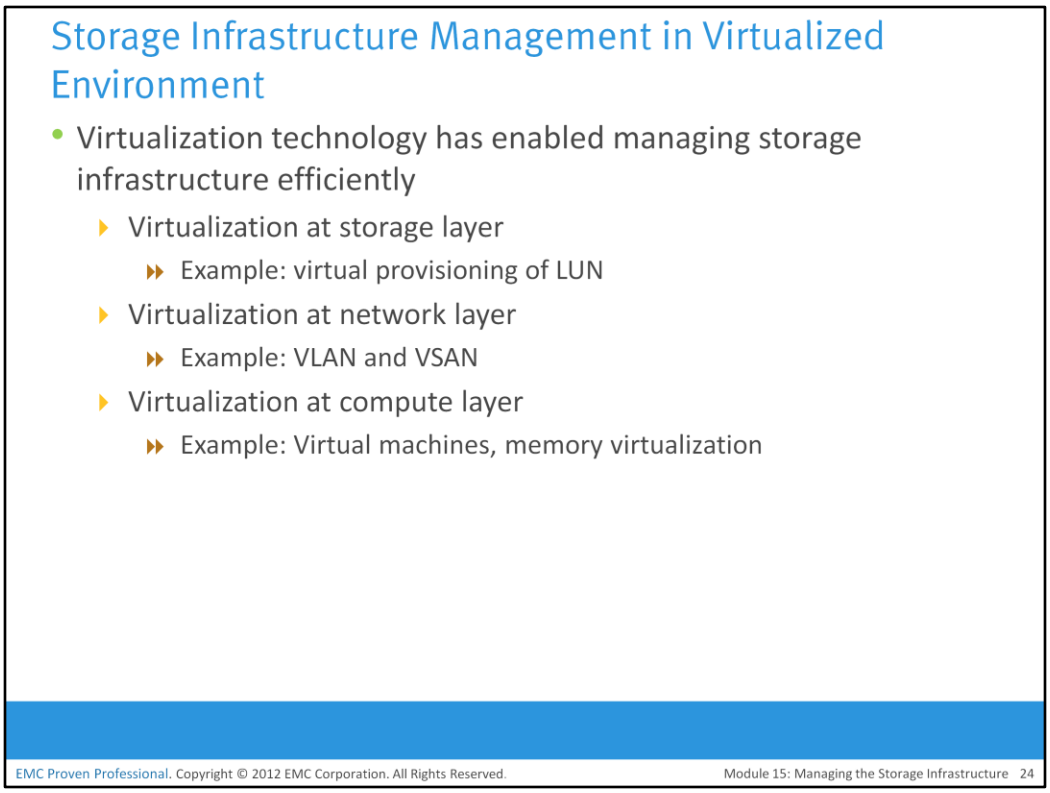
Several performance management activities need to be performed when deploying a new application or server in the existing storage infrastructure. Every component must be validated for adequate performance capabilities as defined by the service levels. For example, to optimize the expected performance levels, activities on the server, such as the volume configuration, database design or application layout, configuration of multiple HBAs, and intelligent multipathing software, must be fine-tuned. The performance management tasks on a SAN include designing and implementing sufficient ISLs in a multiswitch fabric with adequate bandwidth to support the required performance levels. The storage array configuration tasks include selecting the appropriate RAID type, LUN layout, front-end ports, back-end ports, and cache configuration, when considering the end-to-end performance.



The key objective of the *security management* activity is to ensure confidentiality, integrity, and availability of information in both virtualized and nonvirtualized environments. Security management prevents unauthorized access and configuration of storage infrastructure components. For example, while deploying an application or a server, the security management tasks include managing the user accounts and access policies that authorize users to perform role-based activities. The security management tasks in a SAN environment include configuration of zoning to restrict an unauthorized HBA from accessing specific storage array ports. Similarly, the security management task on a storage array includes LUN masking that restricts a host from accessing a defined set of LUNs.

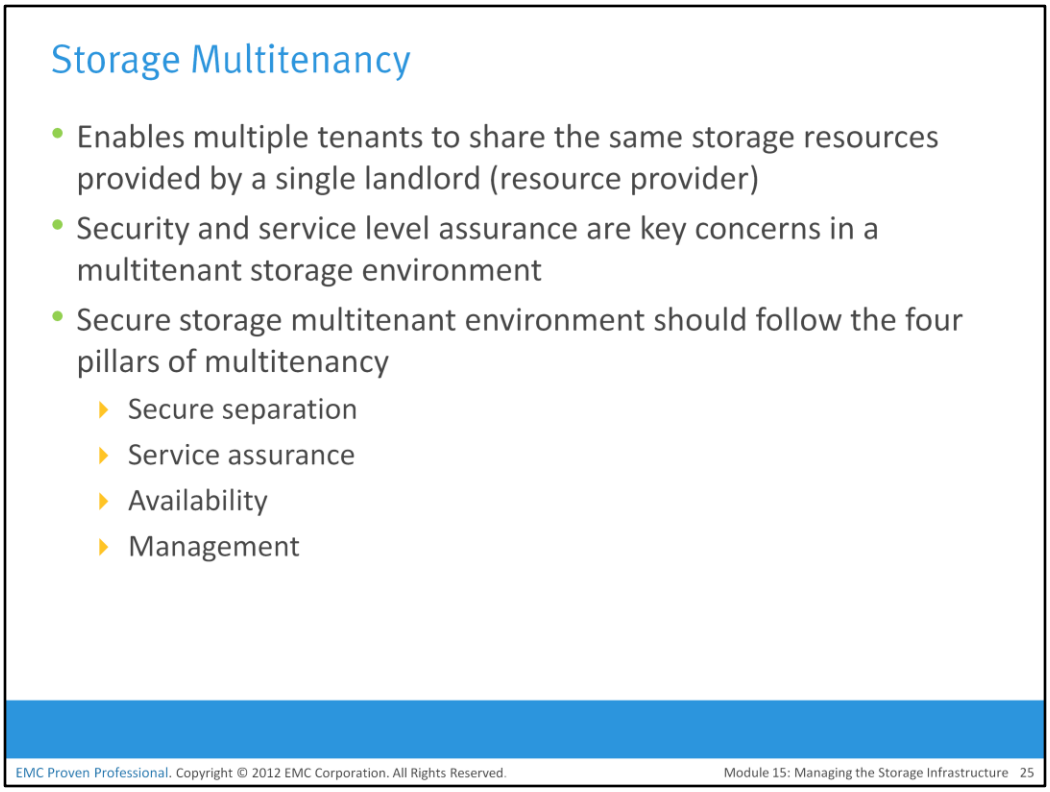


Reporting on a storage infrastructure involves keeping track and gathering information from various components/processes. This information is compiled to generate reports for trend analysis, capacity planning, chargeback, and performance. Capacity planning reports contain current and historic information about the utilization of storage, file systems, database tablespace, ports, and so on. Configuration and asset management reports include details about device allocation, local or remote replicas, and fabric configuration. This report also lists all the equipment, with details, such as their purchase date, lease status, and maintenance records. Chargeback reports contain information about the allocation or utilization of storage infrastructure components by various departments or user groups. Performance reports provide details about the performance of various storage infrastructure components.



Virtualization technology has dramatically changed the complexity of storage infrastructure management. In fact, flexibility and ease of management is one of the key drivers for wide adoption of virtualization at all layers of the IT infrastructure.

At the storage layer, storage virtualization has enabled dynamic migration of data and extension of storage volumes. Due to dynamic extension, storage volumes can be expanded nondisruptively to meet both capacity and performance requirements. Because virtualization breaks the bond between the storage volumes presented to the host and its physical storage, data can be migrated both within and across data centers without any downtime. This has made the administrators' tasks easier while reconfiguring the physical environment. Virtual storage provisioning is another tool that has changed the infrastructure management cost and complexity scenario. In conventional provisioning, storage capacity is provisioned upfront in anticipation of future growth. Because growth is uneven, some users or applications find themselves running out of capacity, whereas others have excess capacity that remains underutilized. Use of virtual provisioning can address this challenge and make capacity management less challenging. In virtual provisioning, storage is allocated from the shared pool to hosts on-demand. This improves the available capacity utilization, and thereby reduces capacity management complexities. Virtualization has also contributed to network management efficiency. VSANs and VLANs made the administrators' job easier, by isolating different networks logically using management tools rather than physically separating them. Disparate virtual networks can be created on a single physical network, and reconfiguration of nodes can be done quickly without any physical changes. It has also addressed some of the security issues that might exist in a conventional environment. On the host side, compute virtualization has made host deployment, reconfiguration, and migration easier than physical environment. Compute, application, and memory virtualization have not only improved the provisioning, but also contributed to the high availability of resources.



Multiple tenants sharing the same resources provided by a single landlord (resource provider) is called multitenancy. Two common examples of multitenancy are multiple virtual machines sharing the same server hardware through the use of hypervisor running on the server, and multiple user applications using the same storage platform. Multitenancy is not a new concept; however, it has become a topic of much discussion due to the rise in popularity of cloud deployments as shared infrastructure is a core component of any cloud strategy.

As with any shared services, security and service level assurance are key concern in a multitenant storage environment. Secure multitenancy means that no tenant can access another tenant's data. To achieve this, any storage deployment should follow the four pillars of multitenancy:

- Secure Separation: This enables data path separation across various tenants in a multitenant environment. At the storage layer, this pillar can be divided into four basic requirements: separation of data at rest, address space separation, authentication and name service separation, and separation of data access.
- Service Assurance: Consistent and reliable service levels are integral to storage multitenancy. Service assurance plays an important role in providing service levels that can be unique to each tenant.
- Availability: High availability ensures a resilient architecture that provides fault tolerance and redundancy. This is even more critical when IT infrastructure is shared by multiple tenants – as the impact of any outage is magnified.
- Management: This includes provisions that allow a landlord to manage basic infrastructure while delegating management responsibilities to tenants for the resources that they interact with day to day. This concept is known as balancing the provider (landlord) in- control with the tenant in-control capabilities.

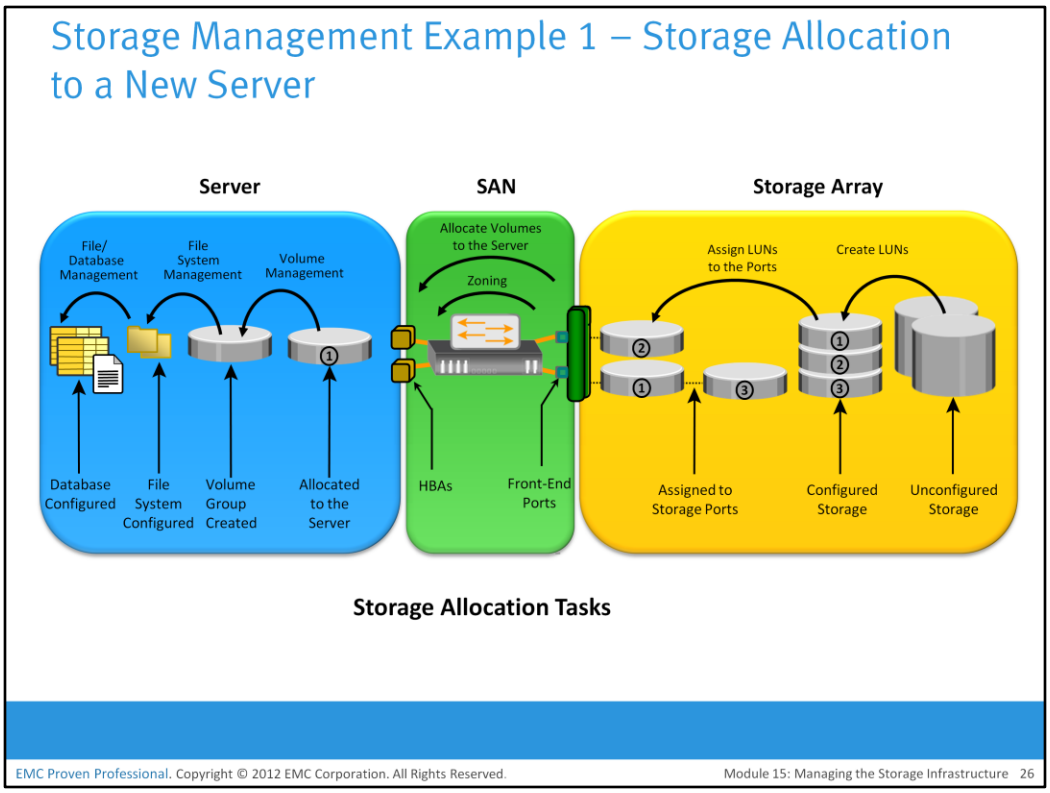


Figure on the slide illustrates the activities performed on server, SAN, and storage array while allocating storage to a new server.

Consider the deployment of a new RDBMS server to the existing nonvirtualized storage infrastructure. As a part of storage management activities, first, the administrator needs to install and configure the HBAs and device drivers on the server before it is physically connected to the SAN. Optionally, multipathing software can be installed on the server, which might require additional configuration. Further, storage array ports should be connected to the SAN.

As the next step, the administrator needs to perform zoning on the SAN switches to allow the new server access to the storage array ports via its HBAs. To ensure redundant paths between the server and the storage array, the HBAs of the new server should be connected to different switches and zoned with different array ports.

Further, the administrator needs to configure LUNs on the array and assign these LUNs to the storage array front-end ports. In addition, LUN masking configuration is performed on the storage array, which restricts access to LUNs by a specific server.

Cont..

The server then discovers the LUNs assigned to it by either a *bus rescan* process or sometimes through a server reboot, depending upon the operating system installed. A volume manager may be used to configure the logical volumes and file systems on the host. The number of logical volumes or file systems to be created depends on how a database or an application is expected to use the storage.

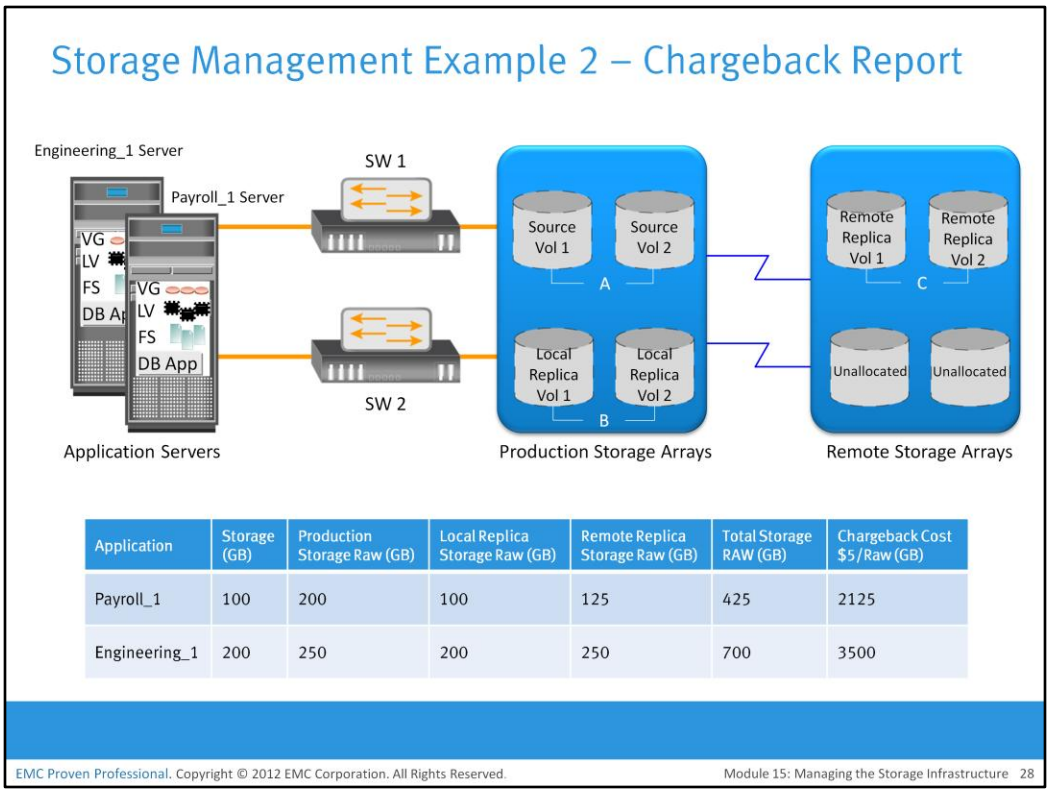
On the application side, the administrator's task includes installation of a database or an application on the logical volumes or file systems that were created. The last step is to make the database or application capable of using the new file system space.

In a virtualized environment, provisioning storage to a VM that runs an RDBMS requires different administrative tasks.

Similar to a nonvirtualized environment, a physical connection must be established between the physical server, which hosts the VMs, and the storage array through the SAN. At the SAN level, a VSAN can be configured to transfer data between the physical server and the storage array. The VSAN isolates this storage traffic from any other traffic in the SAN. Further, the administrator can configure zoning within the VSAN.

At the storage side, administrators need to create thin LUNs from the shared storage pool and assign these thin LUNs to the storage array front-end ports. Similar to a physical environment, LUN masking needs to be carried out on the storage array.

At the physical server side, the hypervisor discovers the assigned LUNs. The hypervisor creates a logical volume and file system to store and manage VM files. Then, the administrator creates a VM and installs the OS and RDBMS on the VM. While creating the VM, the hypervisor creates a virtual disk file and other VM files in the hypervisor file system. The virtual disk file appears to the VM as a SCSI disk and is used to store the RDBMS data. Alternatively, the hypervisor enables virtual provisioning to create a thin virtual disk and assigns it to the VM. Hypervisors usually have native multipathing capabilities. Optionally, a third-party multipathing software may be installed on the hypervisor.



This example explores the storage infrastructure management tasks necessary to create a chargeback report. Figure on the slide shows a configuration deployed in a storage infrastructure. Three servers with two HBAs each connect to a storage array via two switches, SW1 and SW2. Individual departmental applications run on each of the servers. Array replication technology is used to create local and remote replicas. The production volume is represented as A, the local replica volume as B, and the remote replica volume as C.

A report documenting the exact amount of storage resources used by each application is created using a chargeback analysis for each department. If the unit for billing is based on the amount of raw storage (usable capacity plus protection provided) configured for an application used by a department, the exact amount of raw space configured must be reported for each application. Slide shows a sample report. The report shows the information for two applications, Payroll_1 and Engineering_1.

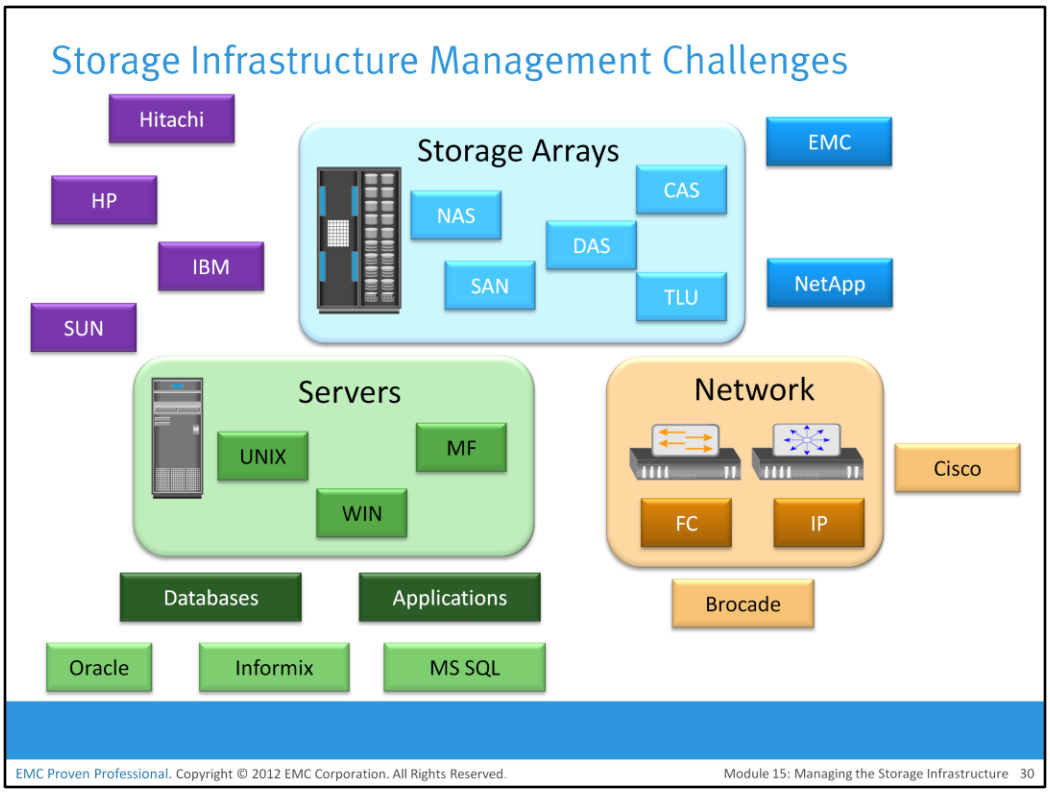
The first step to determine chargeback costs is to correlate the application with the exact amount of raw storage configured for that application. The Payroll_1 application storage space is traced from file systems to logical volumes to volume groups and to the LUNs on the array. When the applications are replicated, the storage space used for local replication and remote replication is also identified. In the example shown, the application is using Source Vol 1 and Vol 2 (in the production array). The replication volumes are Local Replica Vol 1 and Vol 2 (in the production array) and Remote Replica Vol 1 and Vol 2 (in the remote array).

Cont..

The amount of storage allocated to the application can be easily computed after the array devices are identified. In this example, consider that Source Vol 1 and Vol 2 are each 50 GB in size, the storage allocated to the application is 100 GB (50 + 50). The allocated storage for replication is 100 GB for local replication and 100 GB for remote replication. From the allocated storage, the raw storage configured for the application is determined based on the RAID protection that is used for various array devices.

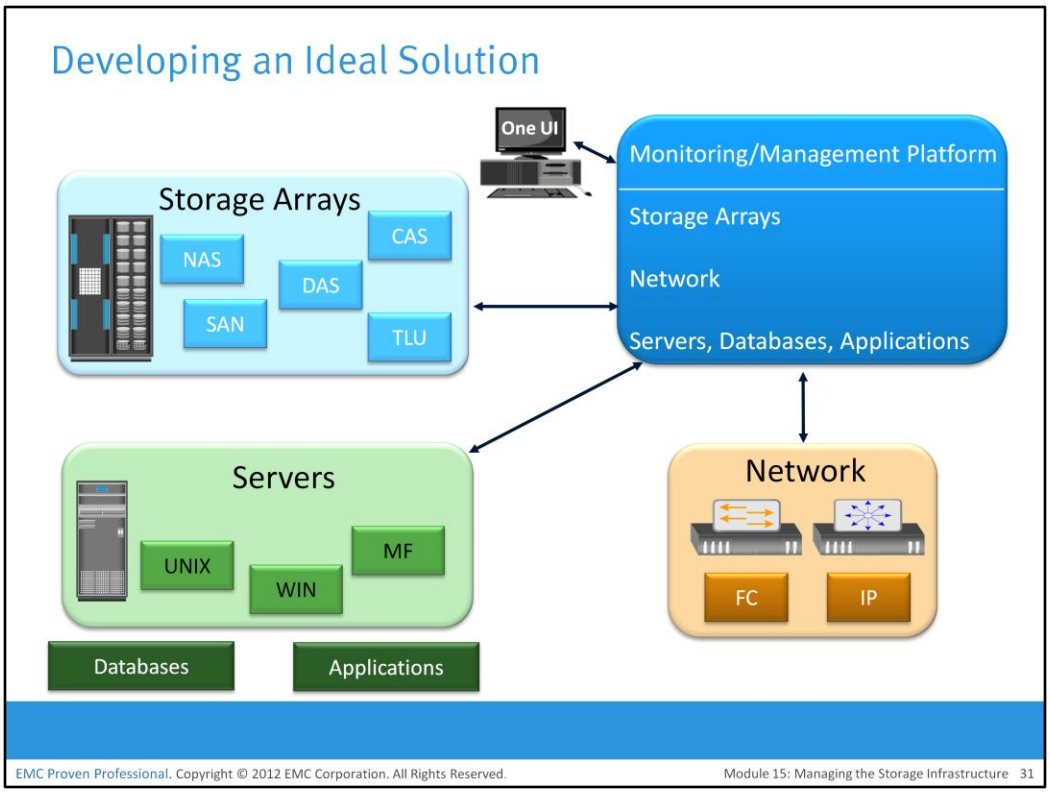
If the Payroll_1 application's production volumes are RAID 1-protected, the raw space used by the production volumes is 200 GB. Assume that the local replicas are on unprotected volumes, and the remote replicas are protected with a RAID 5 configuration, then 100 GB of raw space is used by the local replica and 125 GB by the remote replica. Therefore, the total raw capacity used by the Payroll_1 application is 425 GB. The total cost of storage provisioned for Payroll_1 application will be $2,125 (assume cost per GB of storage is $5). This exercise must be repeated for each application in the enterprise to generate the chargeback report.

Chargeback reports can be extended to include a pre-established cost of other resources, such as the number of switch ports, HBAs, and array ports in the configuration. Chargeback reports are used by data center administrators to ensure that storage consumers are well aware of the costs of the service levels they have requested.



Monitoring and managing today's complex storage infrastructure is challenging. This is due to the heterogeneity of storage arrays, networks, servers, databases, and applications in the environment. For example, heterogeneous storage arrays vary in their capacity, performance, protection, and architectures.

Each of the components in a data center typically comes with vendor-specific tools for management. An environment with multiple tools makes understanding the overall status of the environment challenging because the tools might not be interoperable. Ideally, management tools should correlate information from all components in one place. Such tools provide an end-to-end view of the environment, and a quicker root cause analysis for faster resolution to alerts.

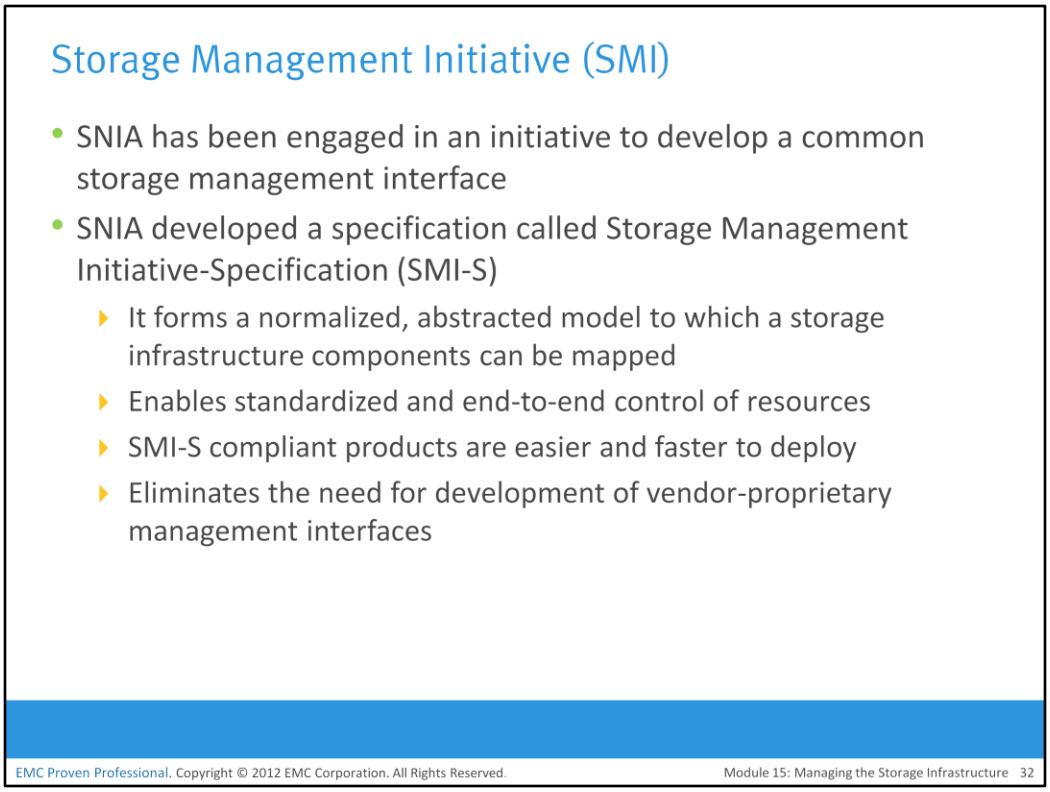


An ideal solution should offer meaningful insight into the status of the overall infrastructure and provide root cause analysis for each failure. This solution should also provide central monitoring and management in a multivendor storage environment and create an end-to-end view of the storage infrastructure.

The benefit of end-to-end monitoring is the ability to correlate one component's behavior with the other. This is helpful to debug or analyze a problem, when looking at each component individually might not be sufficient to reveal the actual cause of the problem. The central monitoring and management system should gather information from all the components and manage them through a single-user interface. In addition, it must provide a mechanism to notify administrators about various events using methods, such as e-mail and Simple Network Management Protocol (SNMP) traps. It should also have the capability to generate monitoring reports and run automated scripts for task automation.

The ideal solution must be based on industry standards, by leveraging common APIs, data model terminology, and taxonomy. This enables the implementation of policy-based management across heterogeneous devices, services, applications, and deployed topologies.

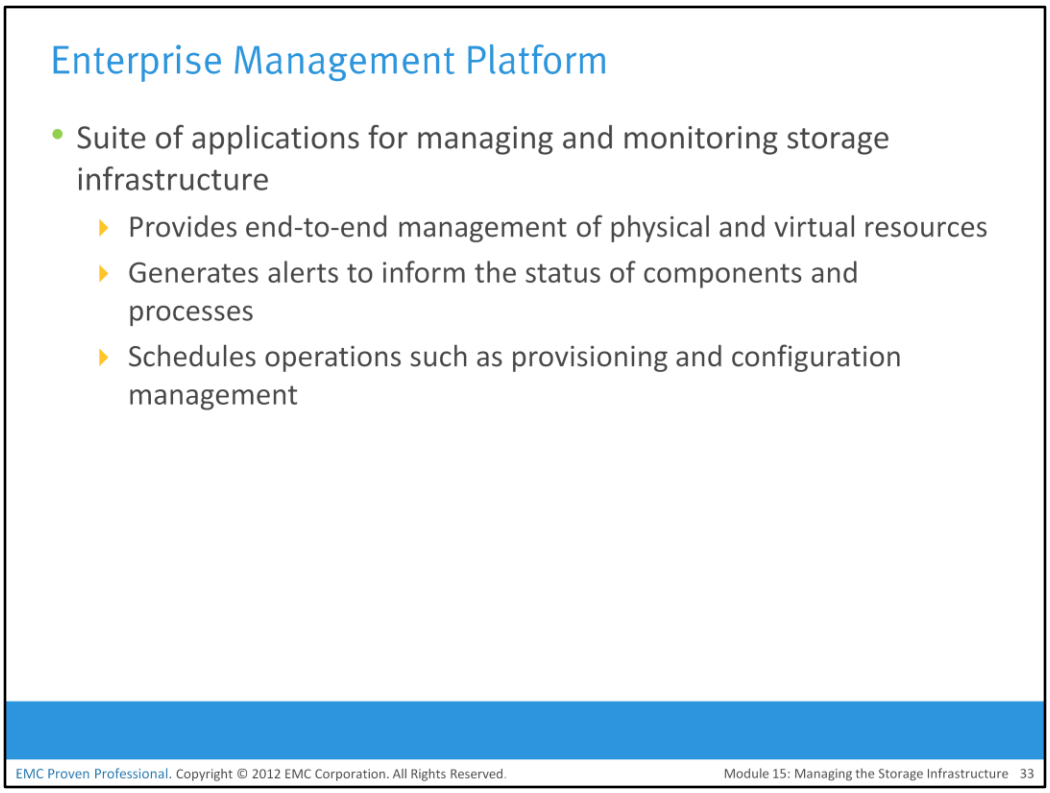
Traditionally, SNMP protocol was the standard used to manage multivendor SAN environments. However, SNMP was primarily a network management protocol and was inadequate for providing the detailed information required to manage the SAN environment. The unavailability of automatic discovery functions and weak modeling constructs are some inadequacies of SNMP in a SAN environment. Even with these limitations, SNMP still holds a predominant role in SAN management, although newer open storage SAN management standards have emerged to monitor and manage storage environments more effectively.



The Storage Networking Industry Association (SNIA) has been engaged in an initiative to develop a common storage management interface. SNIA has developed a specification called Storage Management Initiative-Specification (SMI-S). This specification is based on the Web-Based Enterprise Management (WBEM) technology, and Distributed Management Task Force's (DMTF) Common Information Model (CIM). The initiative was formally created to enable broad interoperability and management among heterogeneous storage and SAN components. For more information, see www.snia.org.

SMI-S offers substantial benefits to users and vendors. It forms a normalized, abstracted model to which a storage infrastructure's physical and logical components can be mapped. This model is used by management applications, such as storage resource management, device management, and data management, for standardized, end-to-end control of storage resources.

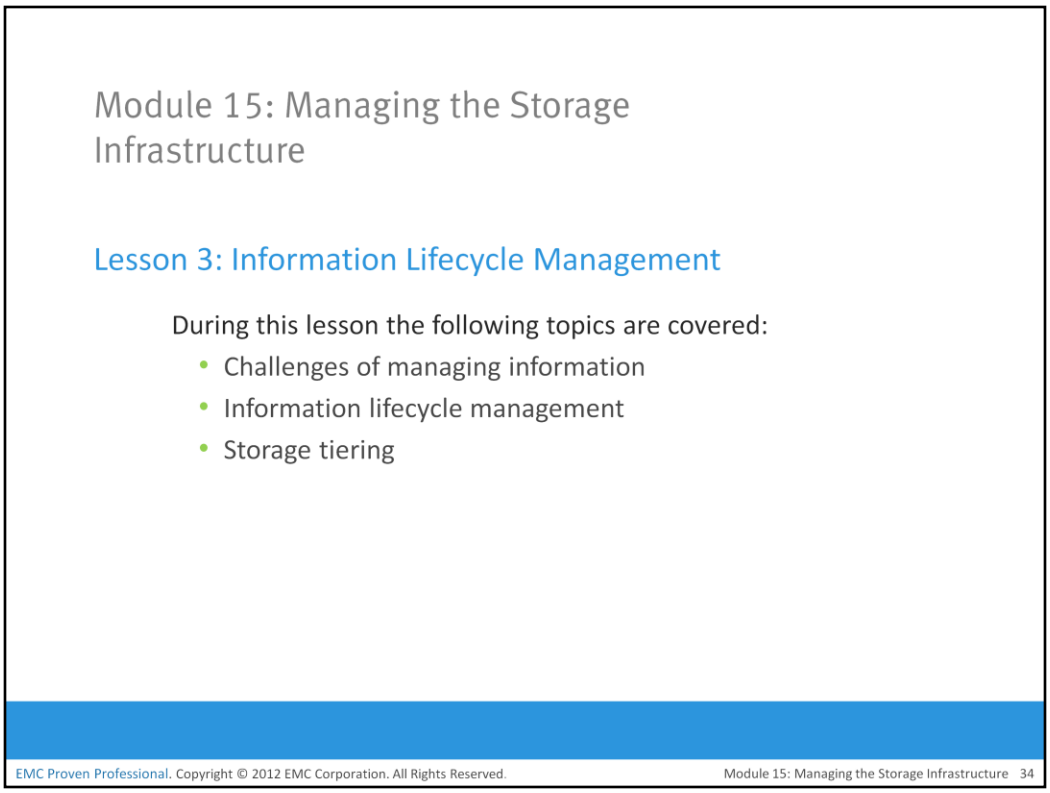
Using SMI-S, device software developers have a unified object model with details about managing the breadth of storage and SAN components. SMI-S-compliant products lead to easier, faster deployment and accelerated adoption of policy-based storage management frameworks. Moreover, SMI-S eliminates the need for the development of vendor-proprietary management interfaces and enables vendors to focus on value-added features.



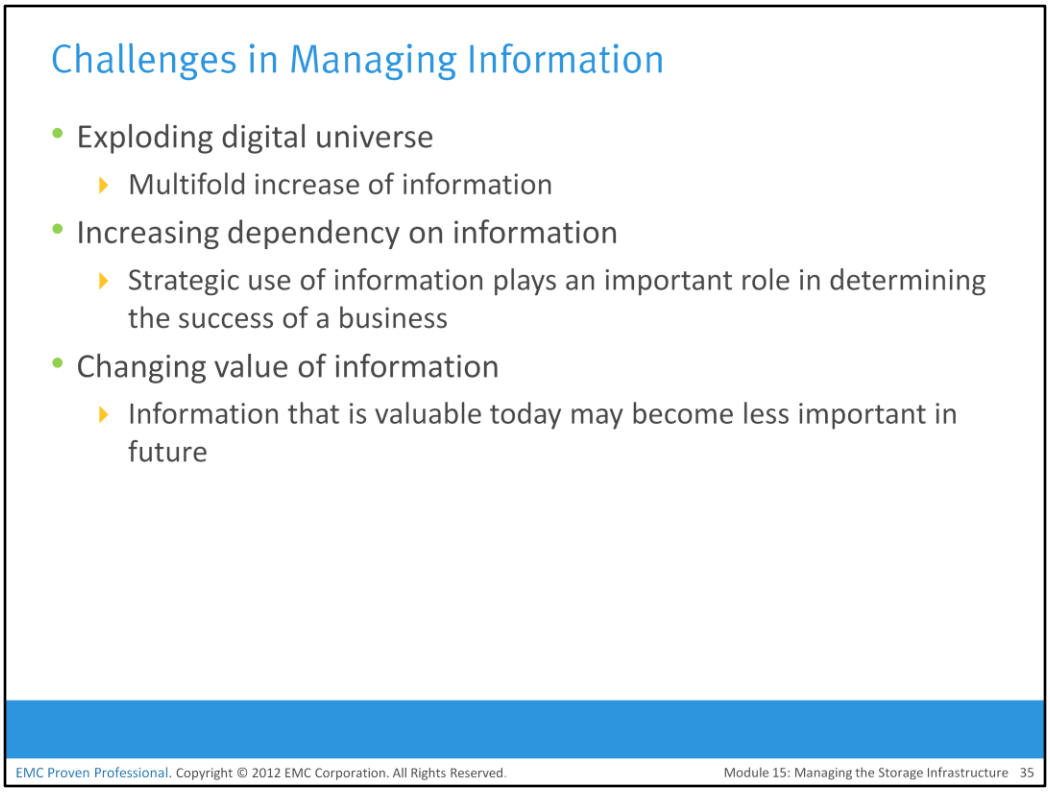
An enterprise management platform (EMP) is a suite of applications that provides an integrated solution for managing and monitoring an enterprise storage infrastructure. These applications have powerful, flexible, unified frameworks that provide end-to-end management of both physical and virtual resources. EMP provides a centrally managed, single point of control for resources throughout the storage environment.

These applications can proactively monitor storage infrastructure components and alert users about events. These alerts are either shown on a console depicting the faulty component in a different color, or they can be configured to send the alert by e-mail. In addition to monitoring, an EMP provides the necessary management functionality, which can be natively implemented into the EMP or can launch the proprietary management utility supplied by the component manufacturer.

An EMP also enables easy scheduling of operations that must be performed regularly, such as the provisioning of resources, configuration management, and fault investigation. These platforms also provide extensive analytical, remedial, and reporting capabilities to ease storage infrastructure management. EMC ControlCenter and EMC Prosphere described in this chapter are examples of an EMP.

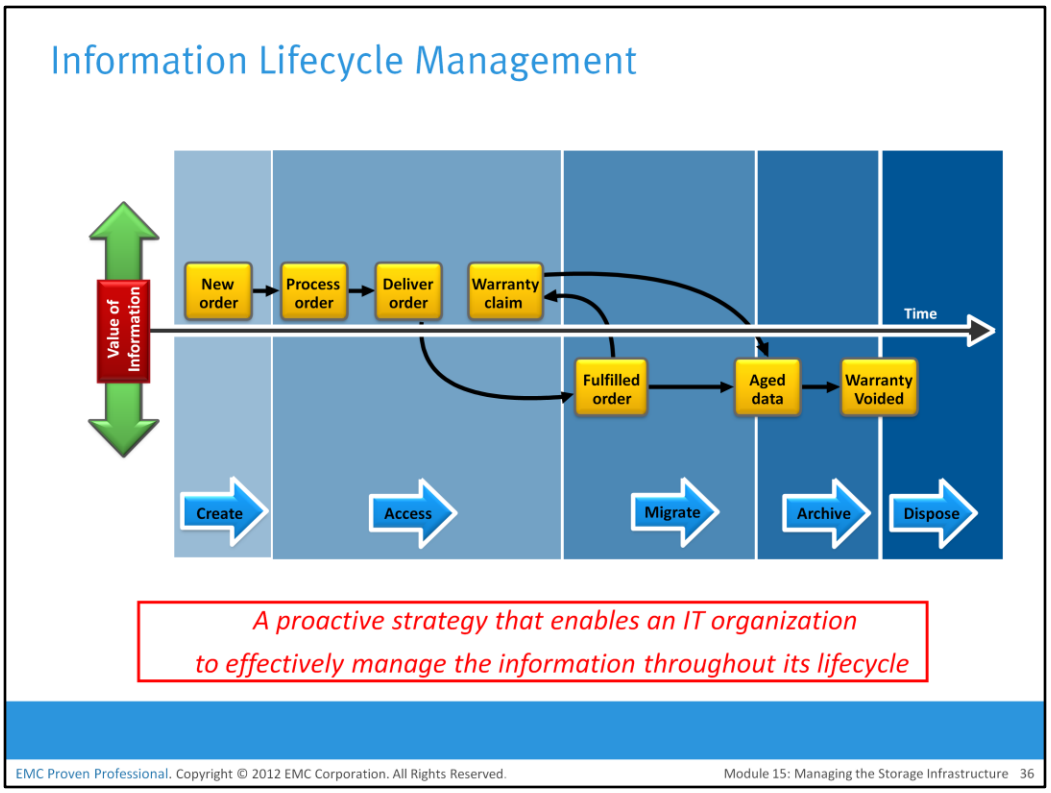


This lesson describes the challenges of managing information. It also describes information lifecycle management strategy. Finally, the lesson explains storage tiering.



In both traditional data center and virtualized environments, managing information can be expensive if not managed appropriately. Along with the tools, an effective management strategy is also required to manage information efficiently. This strategy should address the following key challenges that exist in today's data centers:

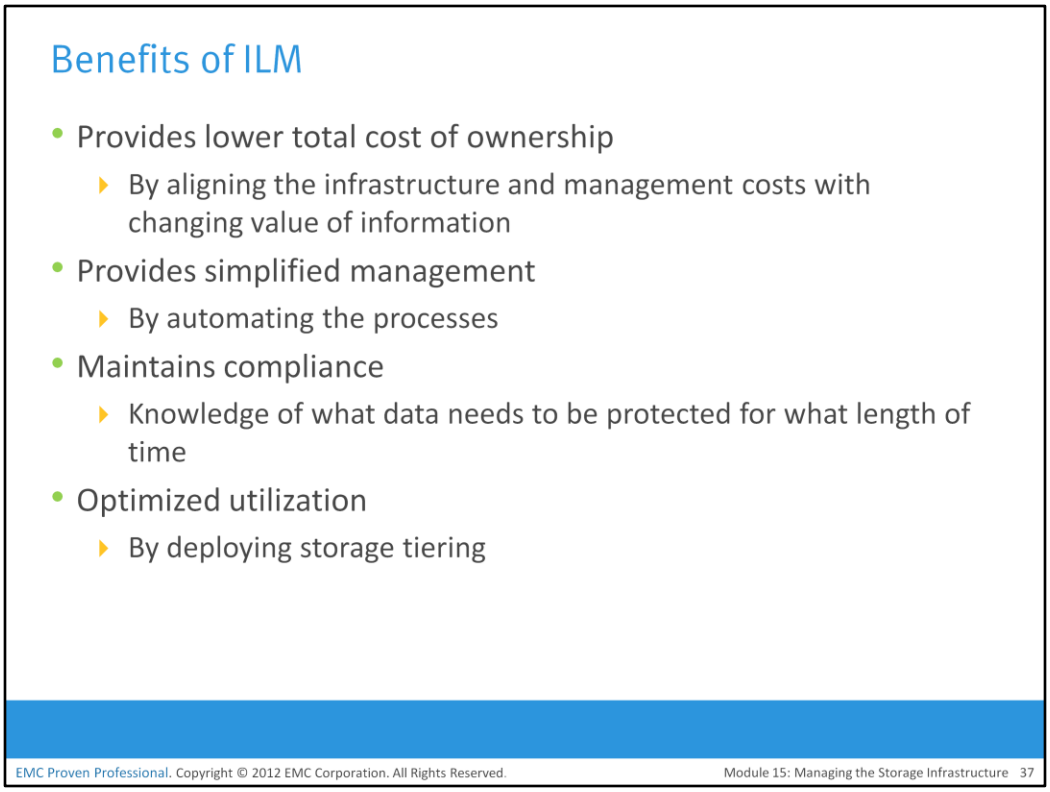
- Exploding digital universe: The rate of information growth is increasing exponentially. Creating copies of data to ensure high availability and repurposing has contributed to the multifold increase of information growth.
- Increasing dependency on information: The strategic use of information plays an important role in determining the success of a business and provides competitive advantages in the marketplace.
- Changing value of information: Information that is valuable today might become less important tomorrow. The value of information often changes over time.



Framing a strategy to meet these challenges involves understanding the value of information over its life cycle. When information is first created, it often has the highest value and is accessed frequently. As the information ages, it is accessed less frequently and is of less value to the organization. Understanding the value of information helps to deploy the appropriate infrastructure according to the changing value of information.

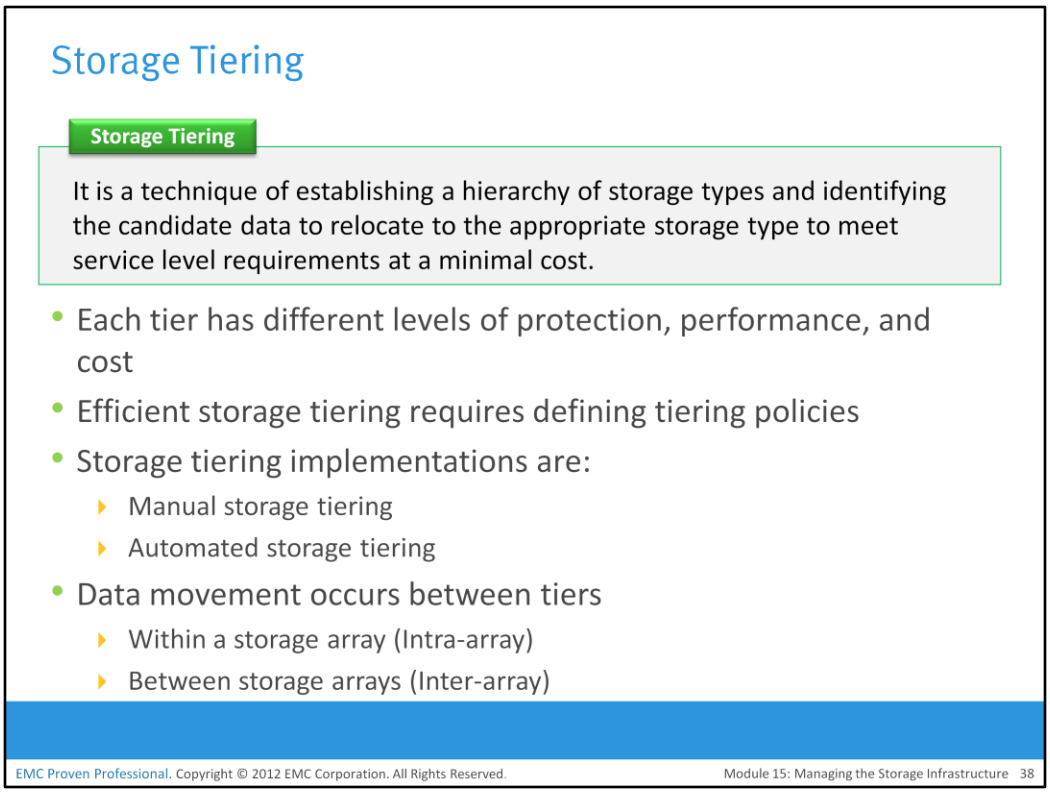
For example, in a sales order application, the value of the information (customer data) changes from the time the order is placed until the time that the warranty becomes void. The value of the information is highest when a company receives a new sales order and processes it to deliver the product. After the order fulfillment, the customer data does not need to be available for real-time access. The company can transfer this data to less expensive secondary storage with lower performance until a warranty claim or another event triggers its need. After the warranty becomes void, the company can dispose of the information.

Information lifecycle management (ILM) is a proactive strategy that enables an IT organization to effectively manage information throughout its life cycle based on predefined business policies. From data creation to data deletion, ILM aligns the business requirements and processes with service levels in an automated fashion. This allows an IT organization to optimize the storage infrastructure for maximum return on investment.



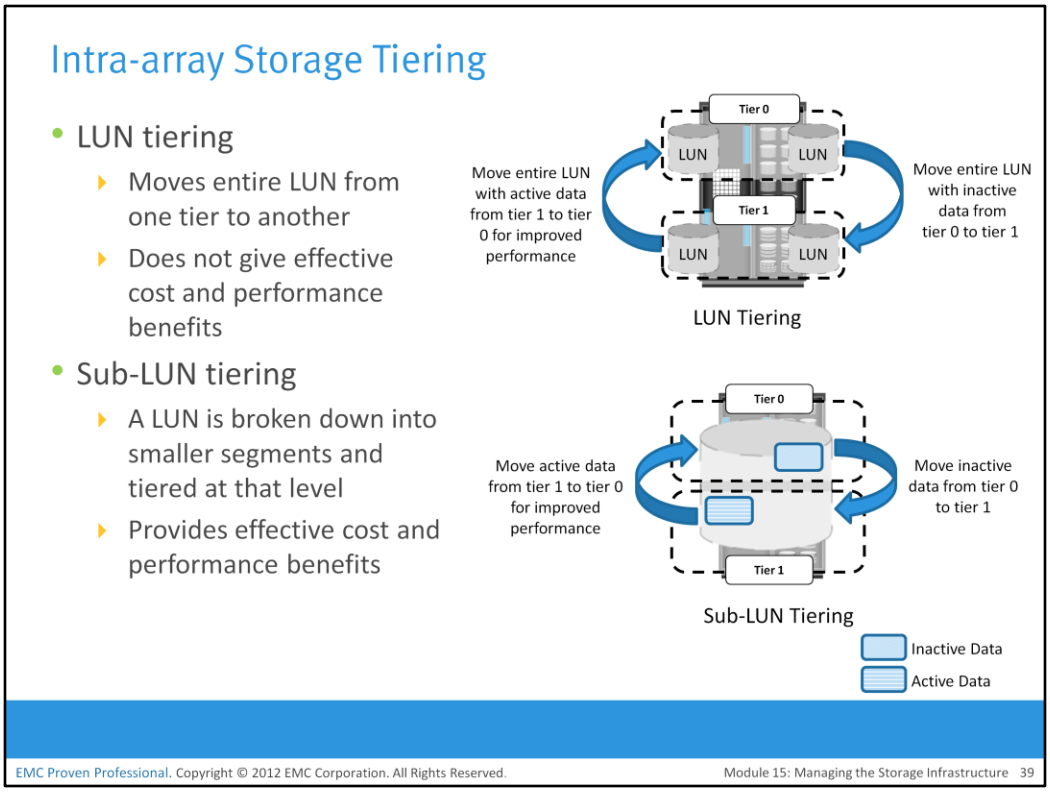
Implementing an ILM strategy has the following key benefits that directly address the challenges of information management:

- Simplified management: By integrating process steps and interfaces with individual tools and by increasing automation.
- Maintaining compliance: By knowing what data needs to be protected for what length of time.
- Lower Total Cost of Ownership (TCO): By aligning the infrastructure and management costs with information value. As a result, resources are not wasted, and complexity is not introduced by managing low-value data at the expense of high-value data.
- Optimized utilization: By deploying storage tiering.



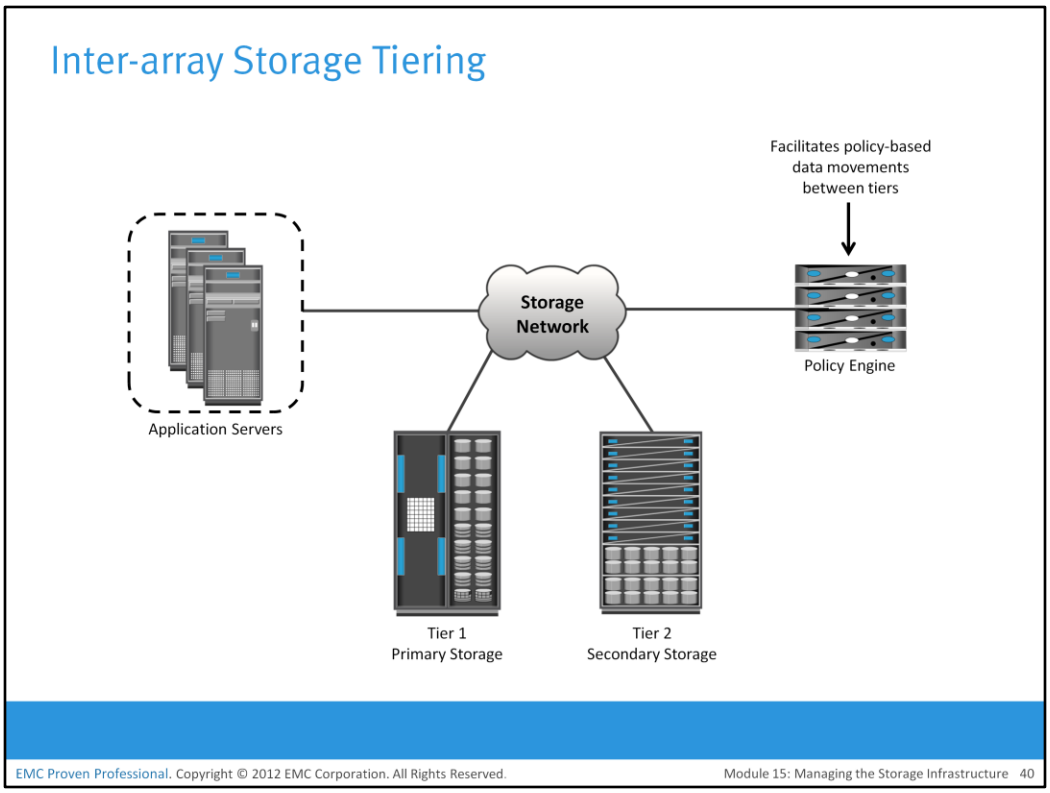
Storage tiering is a technique of establishing a hierarchy of different storage types (tiers). This enables storing the right data to the right tier, based on service level requirements, at a minimal cost. Each tier has different levels of protection, performance, and cost. For example, high performance solid-state drives (SSDs) or FC drives can be configured as tier 1 storage to keep frequently accessed data and low cost SATA drives as tier 2 storage to keep the less frequently accessed data. Keeping frequently used data in SSD or FC improves application performance. Moving less-frequently accessed data to SATA can free up storage capacity in high performance drives and reduce the cost of storage. This movement of data happens based on defined tiering policies. The tiering policy might be based on parameters, such as file type, size, frequency of access, and so on. For example, if a policy states "Move the files that are not accessed for the last 30 days to the lower tier," then all the files matching this condition are moved to the lower tier.

Storage tiering can be implemented as a manual or an automated process. *Manual storage tiering* is the traditional method where the storage administrator monitors the storage workloads periodically and moves the data between the tiers. Manual storage tiering is complex and time-consuming. *Automated storage tiering* automates the storage tiering process, in which data movement between the tiers is performed nondisruptively. In automated storage tiering, the application workload is proactively monitored; the active data is automatically moved to a higher performance tier and inactive data to higher capacity, lower performance tier. Data movements between various tiers can happen within (intra-array) or between (inter-array) storage arrays.



The process of storage tiering within a storage array is called *intra-array storage tiering*. It enables the efficient use of SSD, FC, and SATA drives within an array and provides performance and cost optimization. The goal is to keep the SSDs busy by storing the most frequently accessed data on them, while moving out the less frequently accessed data to the SATA drives. Data movements executed between tiers can be performed at the LUN level or at the sub-LUN level. The performance can be further improved by implementing tiered cache.

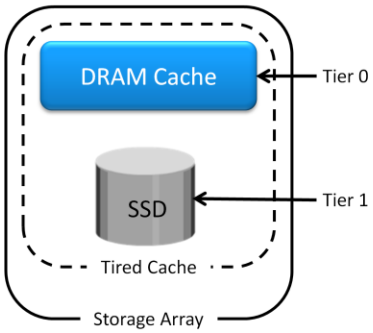
Traditionally, storage tiering is operated at the LUN level that moves an entire LUN from one tier of storage to another. This movement includes both active and inactive data in that LUN. This method does not give effective cost and performance benefits. Today, storage tiering can be implemented at the sub-LUN level. In sub-LUN level tiering, a LUN is broken down into smaller segments and tiered at that level. Movement of data with much finer granularity, for example 8 MB, greatly enhances the value proposition of automated storage tiering. Tiering at the sub-LUN level effectively moves active data to faster drives and less active data to slower drives.



The process of storage tiering between storage arrays is called *inter-array storage tiering*. Inter-array storage tiering automates the identification of active or inactive data to relocate them to different performance or capacity tiers between the arrays. Figure on the slide illustrates an example of a two-tiered storage environment. This environment optimizes the primary storage for performance and the secondary storage for capacity and cost. The policy engine, which can be software or hardware where policies are configured, facilitates moving inactive or infrequently accessed data from the primary to the secondary storage. Some prevalent reasons to tier data across arrays is archival or to meet compliance requirements. As an example, the policy engine might be configured to relocate all the files in the primary storage that have not been accessed in one month and archive those files to the secondary storage. For each archived file, the policy engine creates a small space-saving stub file in the primary storage that points to the data on the secondary storage. When a user tries to access the file at its original location on the primary storage, the user is transparently provided with the actual file from the secondary storage.

Cache Tiering

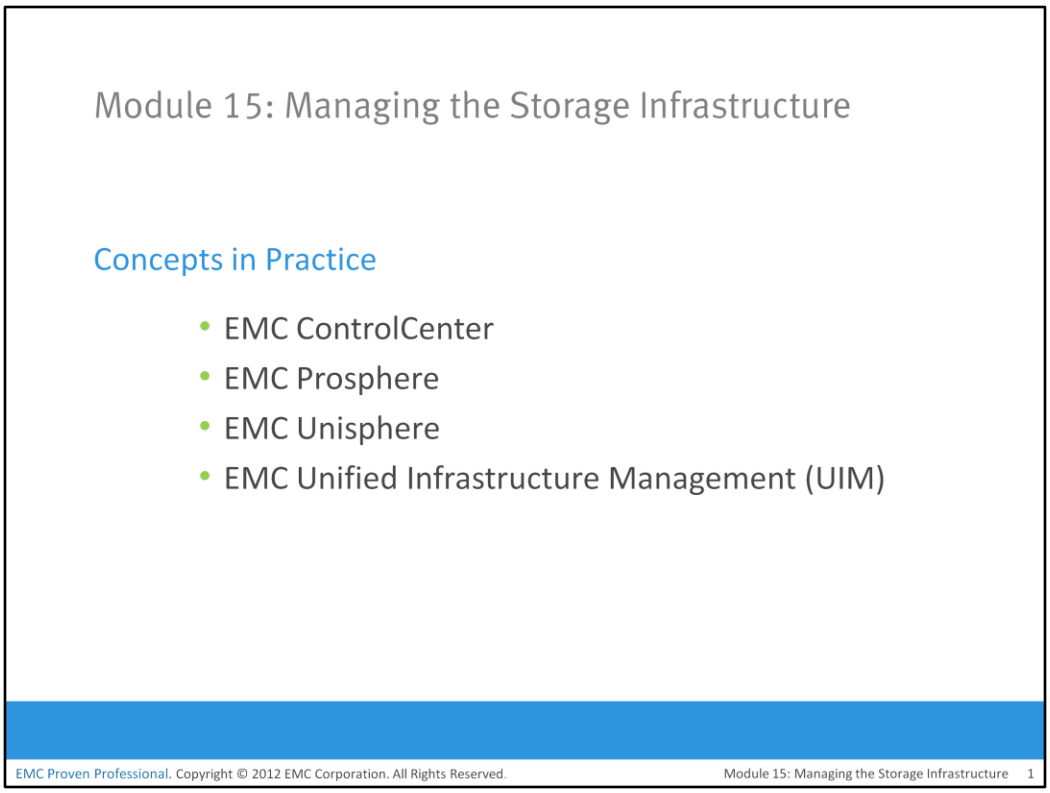
- Enables creation of a large capacity secondary cache using SSDs
- Enables tiering between DRAM cache and SSDs (secondary cache)
- Most reads are served directly from high performance tiered cache



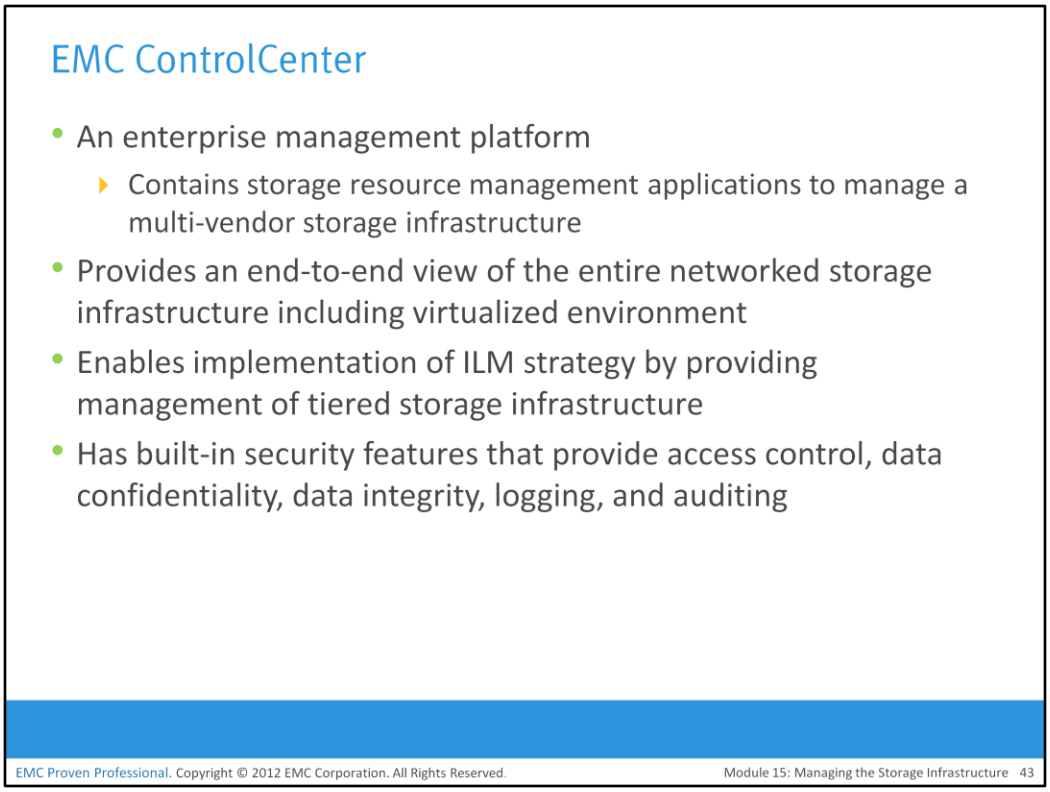
Benefits

- Enhances performance during peak workload
- Non-disruptive and transparent to applications

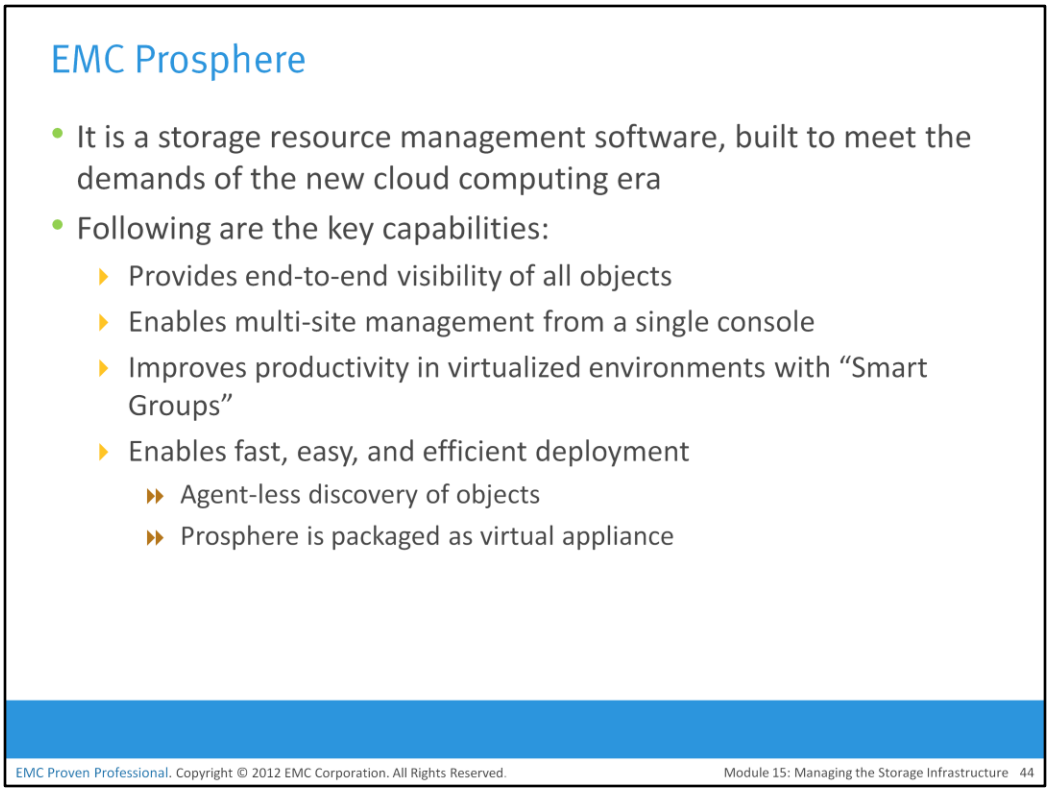
Tiering is also implemented at the cache level. A large cache in a storage array improves performance by retaining large amount of frequently accessed data in a cache, so most reads are served directly from the cache. However, configuring a large cache in the storage array involves more cost. An alternative way to increase the size of the cache is by utilizing the SSDs on the storage array. In cache tiering, SSDs are used to create a large capacity secondary cache and to enable tiering between DRAM (primary cache) and SSDs (secondary cache). Server flash-caching is another tier of cache in which flash-cache card is installed in the server to further enhance the application performance.



These Concepts in Practice cover the product example of storage infrastructure management software. They cover four products: EMC ControlCenter, EMC Prosphere, EMC Unisphere, and EMC Unified Infrastructure Management.

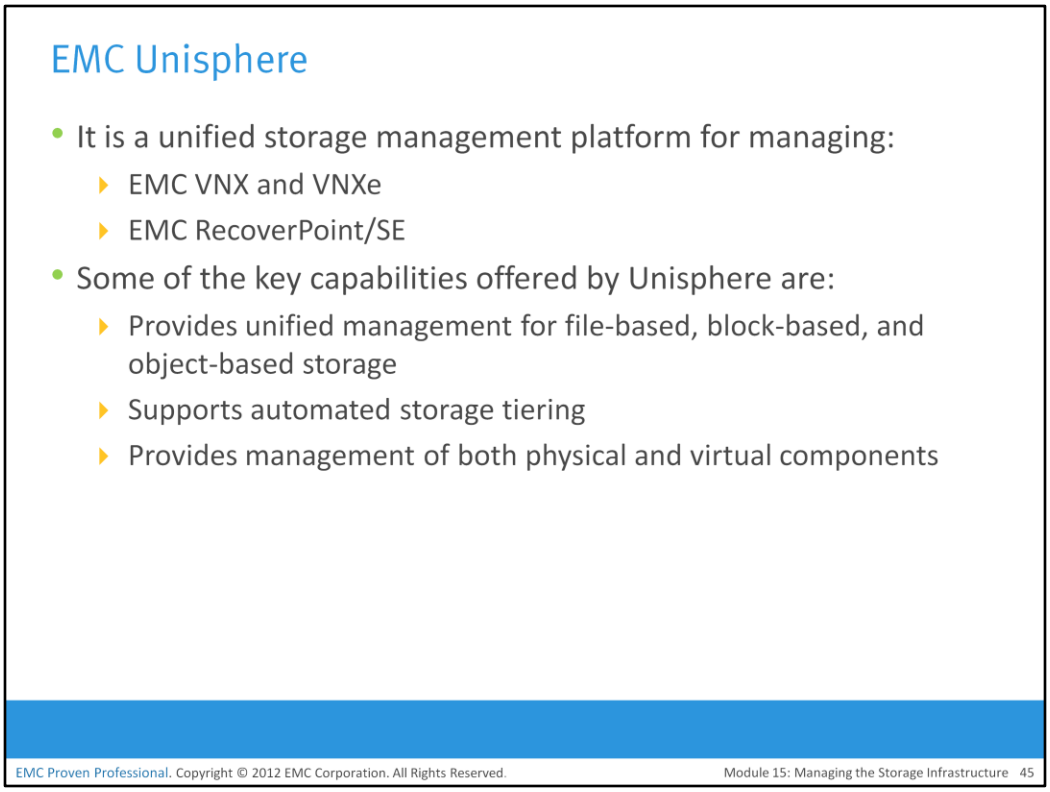


EMC ControlCenter is a family of storage resource management (SRM) applications that provide a unified solution to manage a multivendor storage infrastructure. It helps address the challenges to manage a large, complex storage environment that includes hosts, storage networks, storage, and virtualization across all the layers. ControlCenter provides capabilities, such as storage planning, provisioning, monitoring, and reporting. It enables implementing an ILM strategy by providing comprehensive management of tiered storage infrastructure. It also provides an end-to-end view of the entire networked storage infrastructure that includes SAN, NAS, and host storage resources, including virtualized environment. It provides a central administrative console, discovery of new components, quota management, event management, root cause analysis, and chargeback. ControlCenter comes with built-in security features that provide access control, data confidentiality, data integrity, logging, and auditing. It offers an intuitive, easy-to-use interface that provides insight into the complex relationships of the environment. ControlCenter uses an agent to discover the components in the environment.



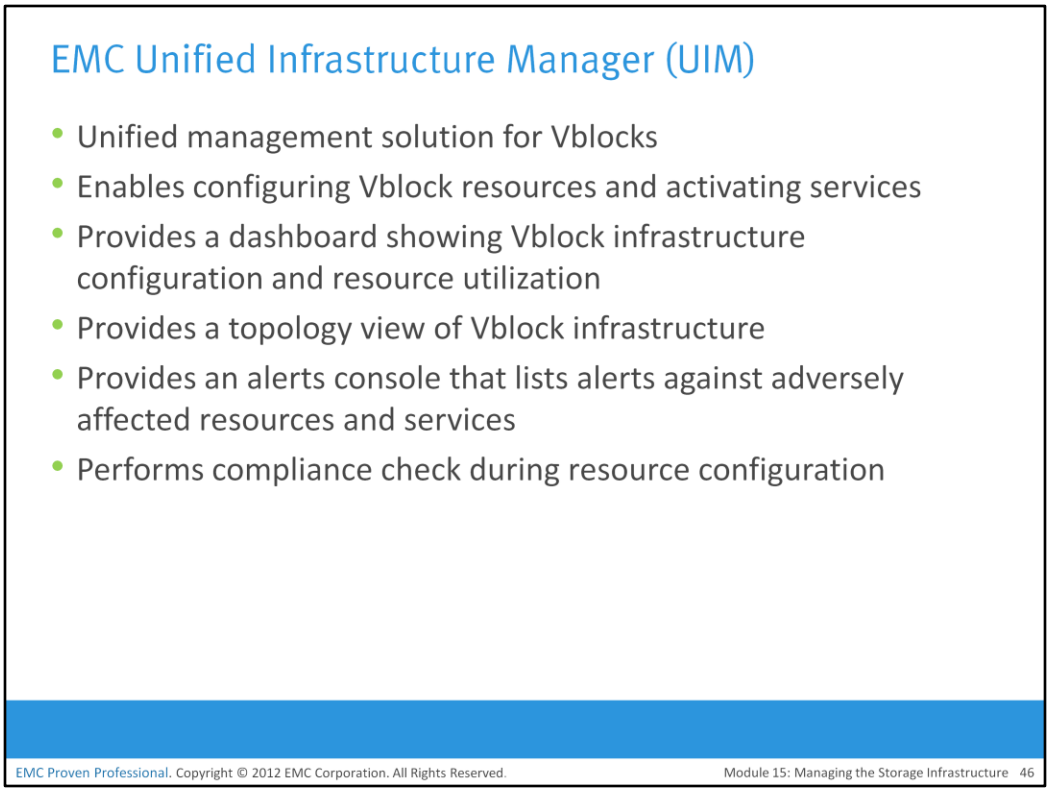
EMC ProSphere is also storage resource management software built to meet the demands of the new cloud computing era. EMC ProSphere improves productivity and service levels in the virtualized and cloud environment. ProSphere includes the following key capabilities:

- End-to-end visibility: It offers an intuitive, easy-to-use interface that provides insight into the complex relationships between objects in large, virtualized environments.
- Multi-site management: From a single console, ProSphere's federated architecture aggregates information from across sites and simplifies information management between data centers. ProSphere is managed from a web browser to allow easy access over the Internet for remote management.
- Improved productivity in growing virtualized environments: ProSphere introduces an innovative technology called Smart Groups, which groups objects with similar characteristics into a user-defined group for performing management tasks. This enables IT to take a policy-based approach to manage objects or to set data collection policies.
- Fast, easy, and efficient deployment: Agent-less discovery eliminates the burden of deploying and managing host agents. ProSphere is packaged as a virtual appliance that can be installed in a short time.
- Delivery of IT as a service: With ProSphere, service levels can now be monitored from host-to-storage layers. This allows organizations to maintain consistent service levels at an optimal price-performance ratio to meet business objectives to delivering IT-as-a-service.



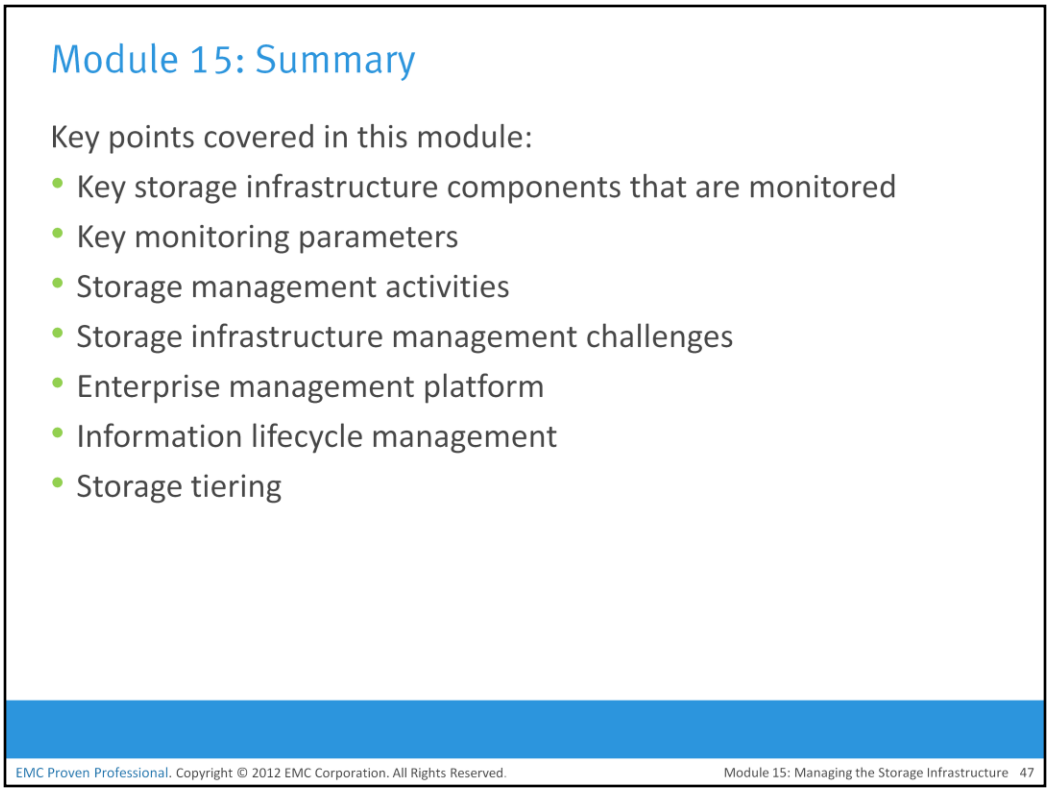
EMC Unisphere is a unified storage management platform that provides intuitive user interfaces for managing EMC RecoverPoint SE, and EMC VNX and VNXe storage arrays. Unisphere is web-enabled and supports remote management of storage arrays. Some of the key capabilities offered by Unisphere follow:

- Provides unified management for file, block, and object storage
- Provides single sign-on for all devices in a management domain
- Supports automated storage tiering and ensures that data is stored in the correct tier to meet performance and cost
- Provides management of both physical and virtual components



EMC Unified Infrastructure Manager is a unified management solution for Vblocks. (Vblock is covered in module 13.) It enables configuring the Vblock infrastructure resources and activating cloud services. It provides a single user interface to manage multiple Vblocks and eliminates the need for configuring compute, network, and storage separately using different virtual infrastructure management tools.

UIM provides a dashboard that shows how the Vblock infrastructure is configured and how the resources are used. This enables an administrator to monitor the configuration and utilization of the Vblock infrastructure resources and to plan for capacity requirements. UIM also provides a topology or a map view of the Vblock infrastructure, which enables an administrator to quickly locate and understand the interconnections of the Vblock infrastructure components and services. It provides an alerts console, which allows an administrator to see the alerts against the Vblock infrastructure resources and the associated services affected by problems. UIM performs a compliance check during resource configuration. It validates compliance with configuration best practices. It also prevents conflicting resource identity assignments, for example, accidentally assigning a MAC address to more than one virtual NIC.



This module covered the key storage infrastructure management components that should be monitored such as servers, network, storage arrays, and environmental controls.

These key components should be monitored for accessibility, capacity, performance, and security.

This module also covered the key management activities such as availability management, capacity management, performance management, security management, and reporting.

This module also covered the key infrastructure management challenges and the ideal solution.

Further, this module covered information lifecycle management (ILM) which is a proactive strategy that enables an IT organization to effectively manage information throughout its lifecycle, based on predefined business policies.

Finally, this module detailed storage tiering techniques which identifies the candidate data and relocate them to the appropriate storage type to meet service level requirements at a minimal cost.

Check Your Knowledge – 1

- Which type of alert is generated if soft media errors on a disk drive approaches its pre-defined threshold value?
  - A. Fatal
  - B. Warning
  - C. Information
  - D. Watermark

- What is a purpose of chargeback report?
  - A. Reports investment in managing infrastructure
  - B. Reports cost of decommissioning infrastructure components
  - C. Reports utilization of infrastructure components by various users
  - D. Reports charges for SLA breach

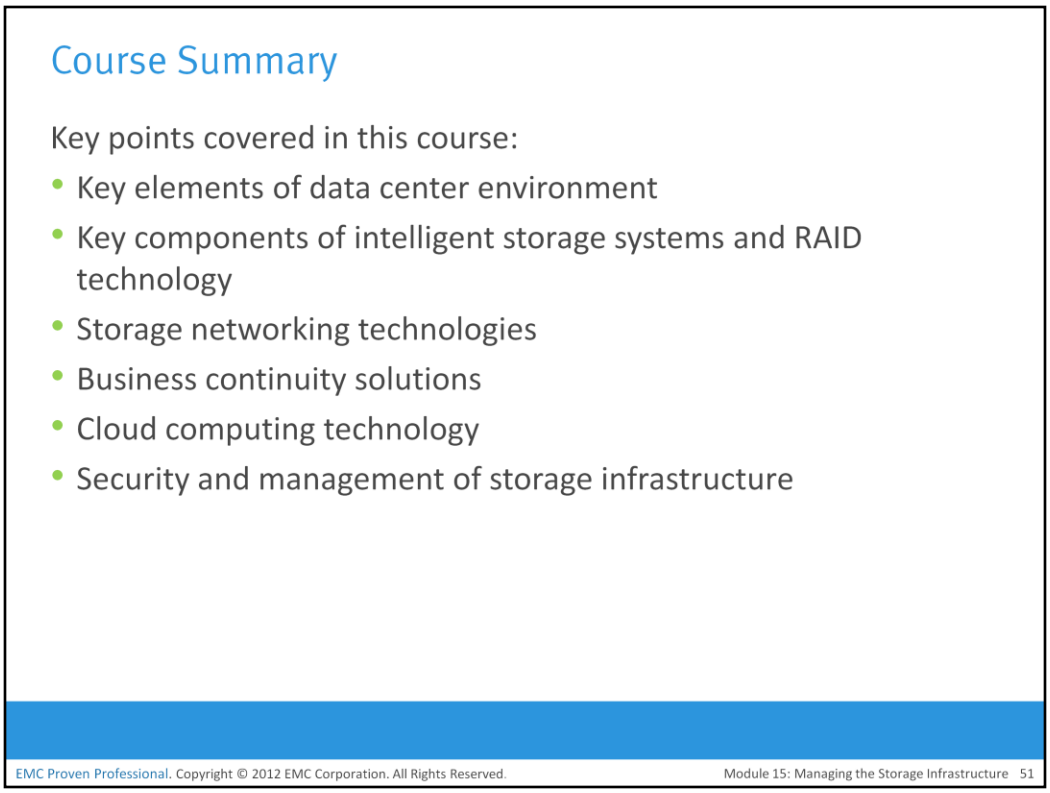
Check Your Knowledge – 2

- Which monitoring parameter helps ensuring availability of adequate amount of resources and prevents service unavailability?
  - A. Availability
  - B. Capacity
  - C. Performance
  - D. Security

- Which pillar of multitenancy ensures consistent and reliable service levels in a multitenant storage environment?
  - A. Secure separation
  - B. Service assurance
  - C. Service availability
  - D. Storage tiering

Check Your Knowledge – 3

- What best describes the SMI specification?
  - A. Restricts vendors to build new features and functions to manage storage subsystems
  - B. Eliminates the need for development of vendor-proprietary management interfaces
  - C. Prevents interoperability among multi-vendor resources
  - D. Enable deploying ILM supported infrastructure



This course covered the importance of information in our daily lives. The increasing dependency of information to the businesses has amplified the challenges in storing, protecting, and managing data.

The course also detailed the five core elements of data center that are essential for its functionality such as application, database management system , host or compute, network, and storage.

The course also covered RAID which is a technique of combining multiple disk drives into a logical unit and provide protection, performance, or both.

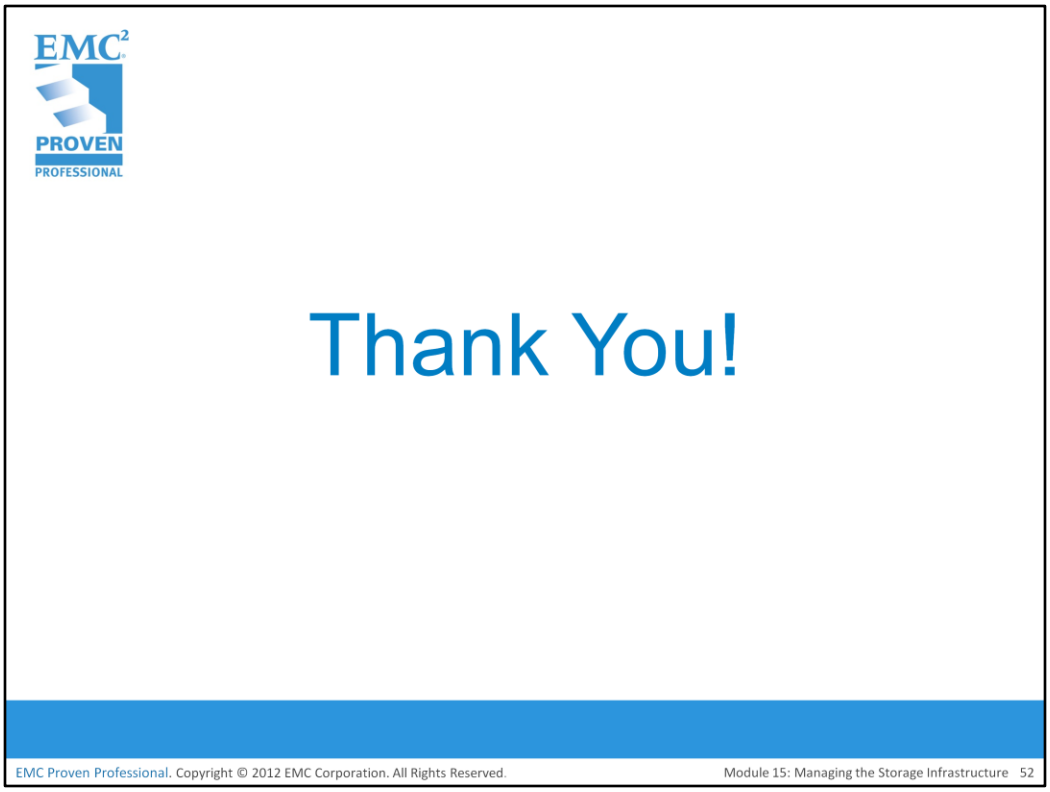
This course also covered intelligent storage systems which are feature-rich RAID arrays that provide highly-optimized I/O processing capabilities.

Further, this course detailed storage networking technologies such as FC SAN, IP SAN, and FCoE that provide block access to storage. The course also covered NAS which is a dedicated, high-performance file sharing and storage device that enables its clients to share files over an IP network. This module covered object-based and unified storage.

Besides this, the course also covered business continuity solutions such as backup and replication. It also covered data archiving solutions that enable to meet compliance.

It also covered cloud computing which is a next generation style of computing that provides highly scalable and flexible computing that is available on demand.

Finally, this module covered security of storage infrastructure that is essential to ensure confidentiality, integrity, and availability. It also covered the management activities in storage environment.



This concludes the training. Thank you for your participation.