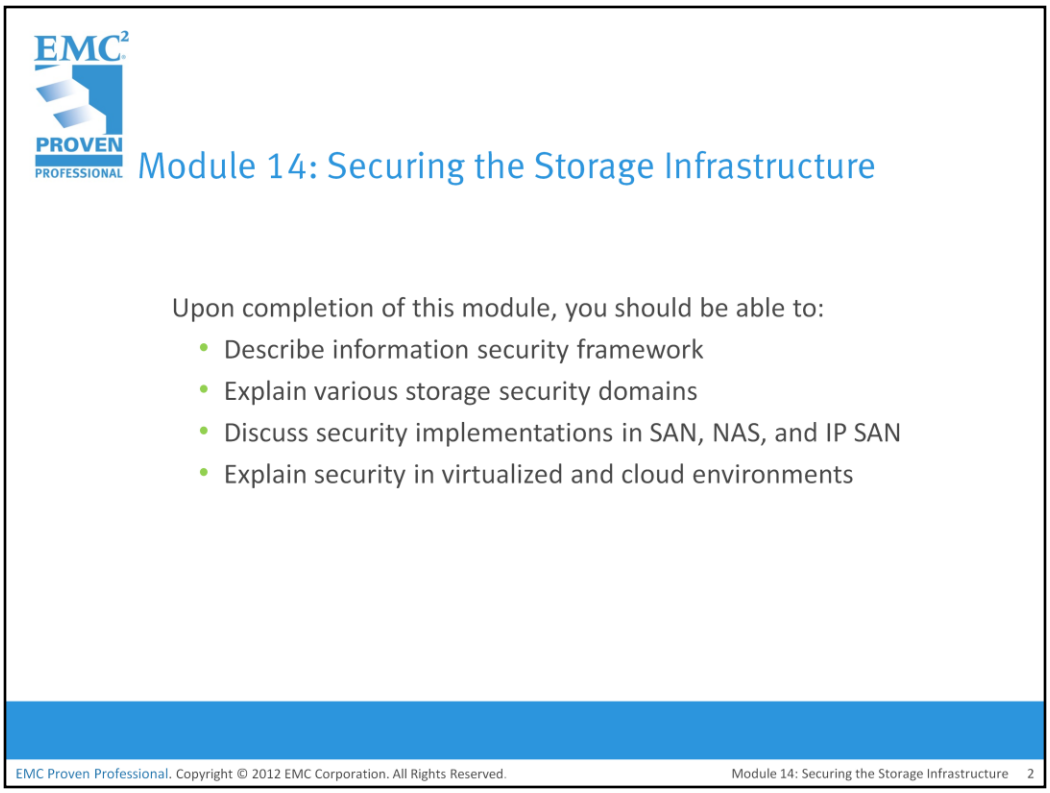
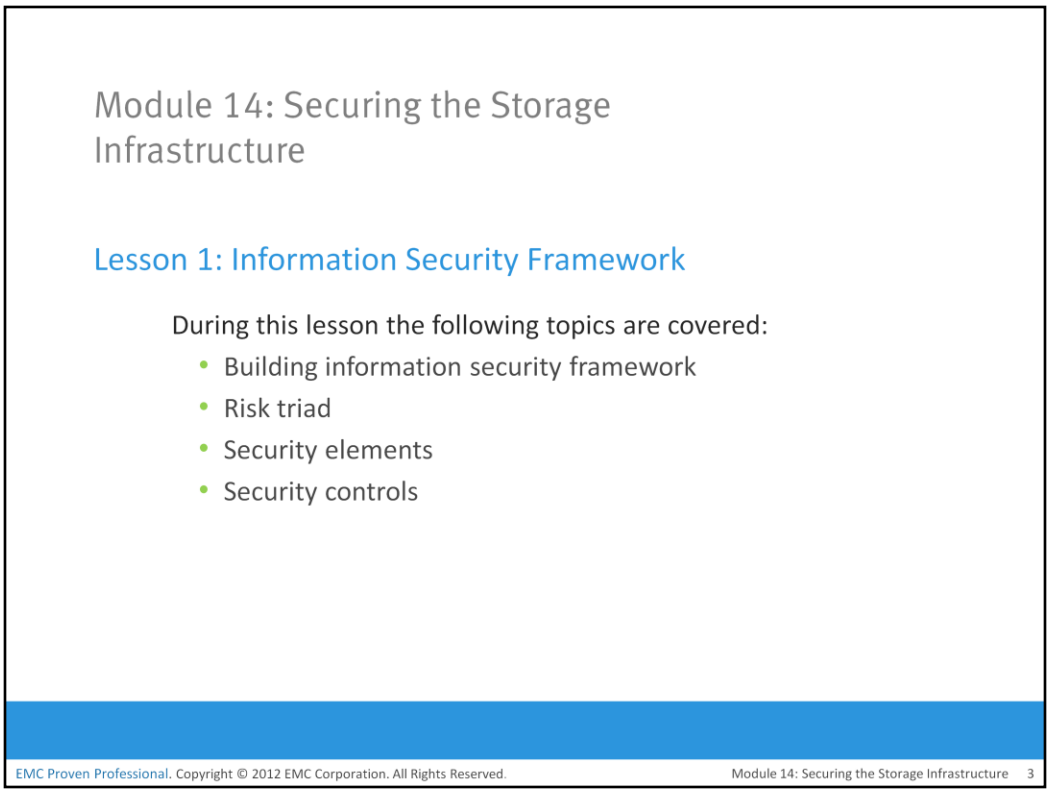
Module – 14

Securing the Storage Infrastructure



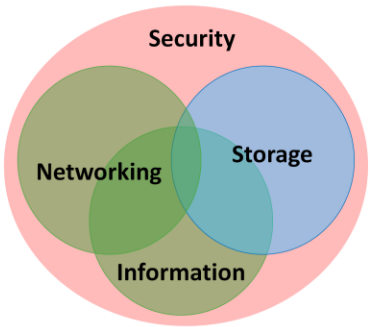
This module focuses on information security framework and various storage security domains. This module also focuses on security implementation in SAN, NAS, and IP SAN. Further, this module focuses on security in virtualized and cloud environments.



This lesson covers building information security framework and risk triad. This lesson also covers security elements such as assets, threats and vulnerabilities. Additionally this lesson also focuses on security controls.

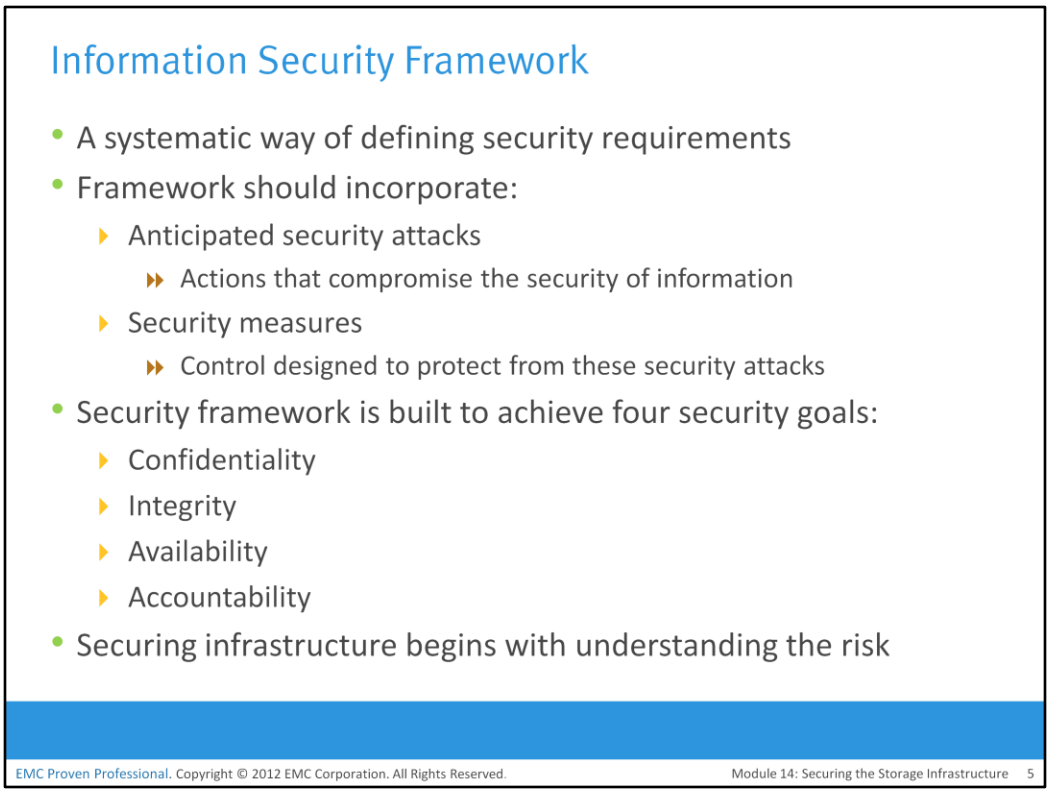
Storage Security

- Process of applying information security principles and practices within the domain of storage networking technologies
- Storage security focuses on securing access to information by implementing safeguards or controls
- Storage security begins with building 'information security framework'



Valuable information, including intellectual property, personal identities, and financial transactions, is routinely processed and stored in storage arrays, which are accessed through the network. As a result, storage is now more exposed to various security threats that can potentially damage business-critical data and disrupt critical services. Securing storage infrastructure has become an integral component of the storage management process in traditional and virtualized data centers. It is an intensive and necessary task, essential to managing and protecting vital information.

Storage security is the process of applying information security principles and practices within the domain of storage networking technologies. Storage security implements various kinds of safeguards or controls, in order to lessen the risk of an exploitation or a vulnerability in the storage network which could otherwise cause a significant impact to organization's business. From this perspective, security is an ongoing process, not static and requires continuing revalidation and modification. Storage security begins with building a framework.



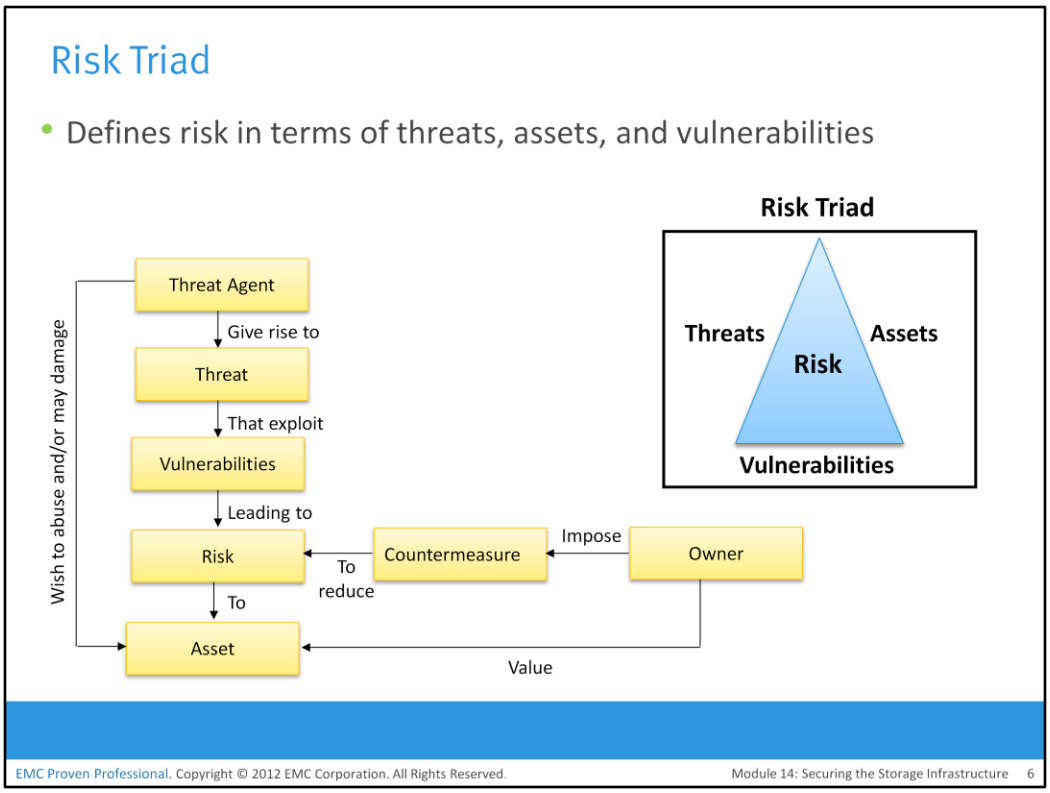
The basic information security framework is built to achieve four security goals, confidentiality, integrity, and availability (CIA) along with accountability. This framework incorporates all security standards, procedures and controls, required to mitigate threats in the storage infrastructure environment.

Confidentiality : Provides the required secrecy of information and ensures that only authorized users have access to data. This requires authentication of users who need to access information. Data in transit (data transmitted over cables) and data at rest (data residing on a primary storage, backup media, or in the archives) can be encrypted to maintain its confidentiality. In addition to restricting unauthorized users from accessing information, confidentiality also requires to implement traffic flow protection measures as part of the security protocol. These protection measures generally include hiding source and destination addresses, frequency of data being sent, and amount of data sent.

Integrity: Ensures that the information is unaltered. Ensuring integrity requires detection and protection against unauthorized alteration or deletion of information. Ensuring integrity stipulate measures such as error detection and correction for both data and systems.

Availability: This ensures that authorized users have reliable and timely access to systems, data and applications residing on these systems. Availability requires protection against unauthorized deletion of data and denial of service. Availability also implies that sufficient resources are available to provide a service.

Accountability: Refers to accounting for all the events and operations that take place in the data center infrastructure. The accountability service maintains a log of events that can be audited or traced later for the purpose of security.

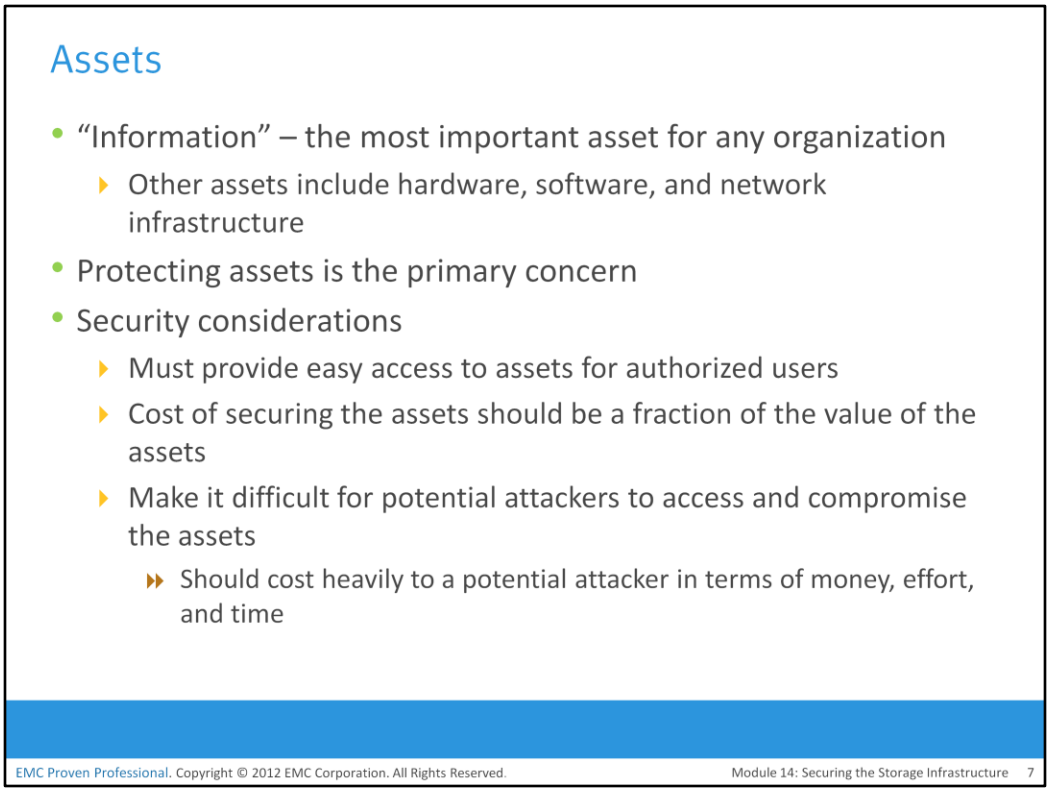


Risk triad defines risk in terms of threats, assets, and vulnerabilities. Risk arises when a threat agent (an attacker) uses an existing vulnerability to compromise the security services of an asset, for example, if a sensitive document is transmitted without any protection over an insecure channel, an attacker might get unauthorized access to the document and may violate its confidentiality and integrity. This may, in turn, result in business loss for the organization. In this scenario potential business loss is the risk, which arises because an attacker uses the vulnerability of the unprotected communication to access the document and tamper with it.

To manage risks, organizations primarily focus on vulnerabilities because they cannot eliminate threat agents that appear in various forms and sources to its assets. Organizations can enforce countermeasures to reduce the possibility of occurrence of attacks and the severity of their impact.

Risk assessment is the first step to determine the extent of potential threats and risks in an IT infrastructure. The process assesses risk and helps to identify appropriate controls to mitigate or eliminate risks. Based on value of assets, risk assessment helps to prioritize the investment and provisioning of security measures. To determine the probability of an adverse event occurring, threats to an IT system must be analyzed with the potential vulnerabilities and the existing security controls.

The severity of an adverse event is estimated by the impact that it may have on critical business activities. Based on this analysis, a relative value of criticality and sensitivity can be assigned to IT assets and resources. For example, a particular IT system component may be assigned a high-criticality value if an attack on this particular component can cause a complete termination of mission-critical services.

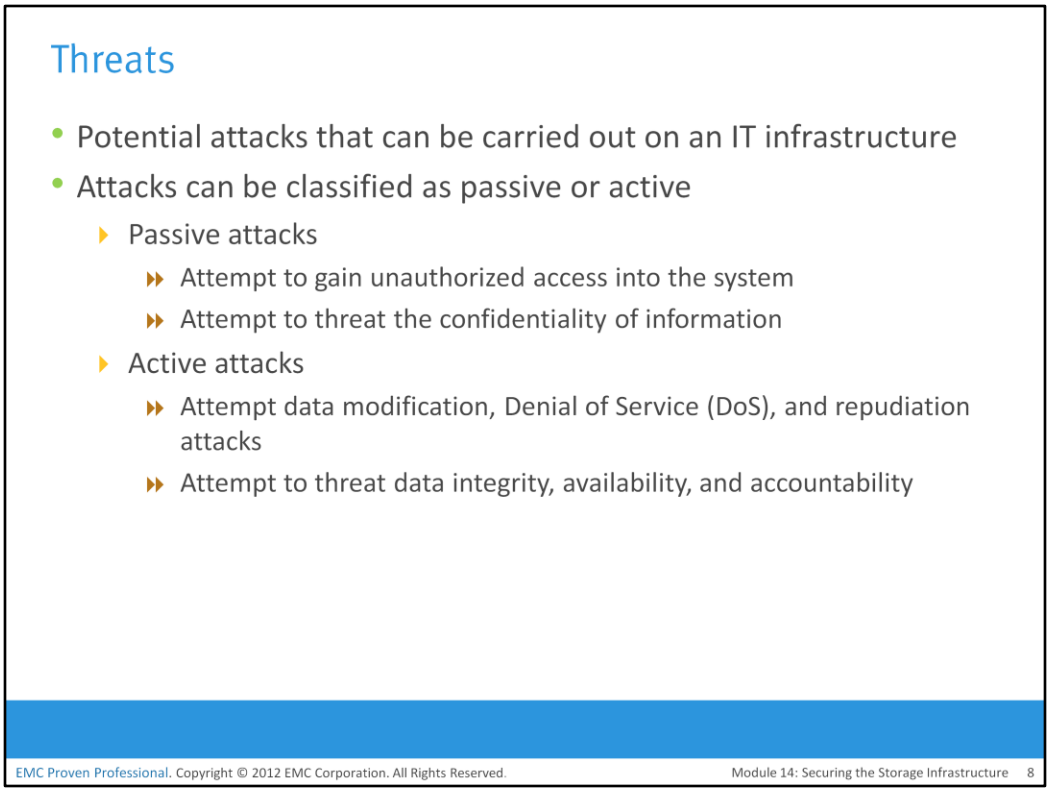


Information is one of the most important *assets* for any organization. Other assets include hardware, software, and other infrastructure components required to access the information. To protect these assets, organizations must develop a set of parameters to ensure the availability of the resources to authorized users and trusted networks. These parameters apply to storage resources, network infrastructure, and organizational policies.

Security methods have two objectives. The first objective is to ensure that the network is easily accessible to authorized users. It should also be reliable and stable under disparate environmental conditions and volumes of usage. The second objective is to make it difficult for potential attackers to access and compromise the system.

The security methods should provide adequate protection against unauthorized access, viruses, worms, trojans, and other malicious software programs. Security measures should also include options to encrypt critical data and disable unused services to minimize the number of potential security gaps. The security method must ensure that updates to the operating system and other software are installed regularly. At the same time, it must provide adequate redundancy in the form of replication and mirroring of the production data to prevent catastrophic data loss if there is an unexpected data compromise. For the security system to function smoothly, all users are informed about the policies governing the use of the network.

The effectiveness of a storage security methodology can be measured by two key criteria. One, the cost of implementing the system should be a fraction of the value of the protected data. Two, it should cost heavily to a potential attacker, in terms of money, effort, and time.

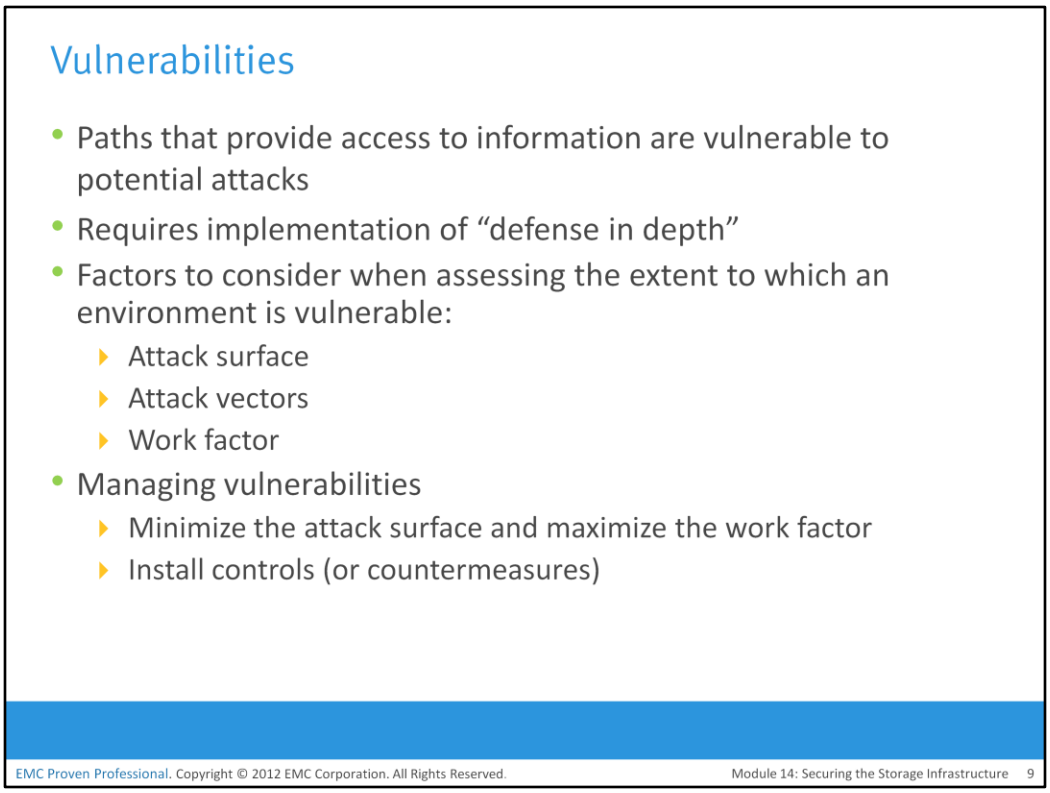


Threats are the potential attacks that can be carried out on an IT infrastructure. These attacks can be classified as active or passive. Passive attacks are attempts to gain unauthorized access into the system. They pose threats to confidentiality of information. Active attacks include data modification, denial of service (DoS), and repudiation attacks. They pose threats to data integrity, availability, and accountability.

In a data modification attack, the unauthorized user attempts to modify information for malicious purposes. A modification attack can target the data at rest or the data in transit. These attacks pose a threat to data integrity.

Denial of service (DoS) attacks prevent legitimate users from accessing resources and services. These attacks generally do not involve access to or modification of information. Instead, they pose a threat to data availability. The intentional flooding of a network or website to prevent legitimate access to authorized users is one example of a DoS attack.

Repudiation is an attack against the accountability of information. It attempts to provide false information by either impersonating someone's identity or denying that an event or a transaction has taken place. For example, a repudiation attack may involve performing an action and eliminating any evidence that could prove the identity of the user (attacker) who performed that action. Repudiation attacks include circumventing the logging of security events or tampering with the security log to conceal the identity of the attacker.



The paths that provide access to information are vulnerable to potential attacks. Each of the paths may contain various access points, which provide different levels of access to the storage resources. It is important to implement adequate security controls at all the access points on an access path. Implementing security controls at each access point of every access path is known as *defense in depth*. Defense in depth recommends using multiple security measures to reduce the risk of security threats if one component of the protection is compromised. It is also known as a "layered approach to security". Because there are multiple measures for security at different levels and defense in depth gives additional time to detect and respond to an attack. This can reduce the scope or impact of a security breach. *Attack surface*, *attack vector*, and *work factor* are the three factors to consider when assessing the extent to which an environment is vulnerable to security threats. *Attack surface* refers to the various entry points that an attacker can use to launch an attack. Each component of a storage network is a source of potential vulnerability. An attacker can use all the external interfaces supported by that component, such as the hardware and the management interfaces, to execute various attacks. These interfaces form the attack surface for the attacker. Even unused network services, if enabled, can become a part of the attack surface.

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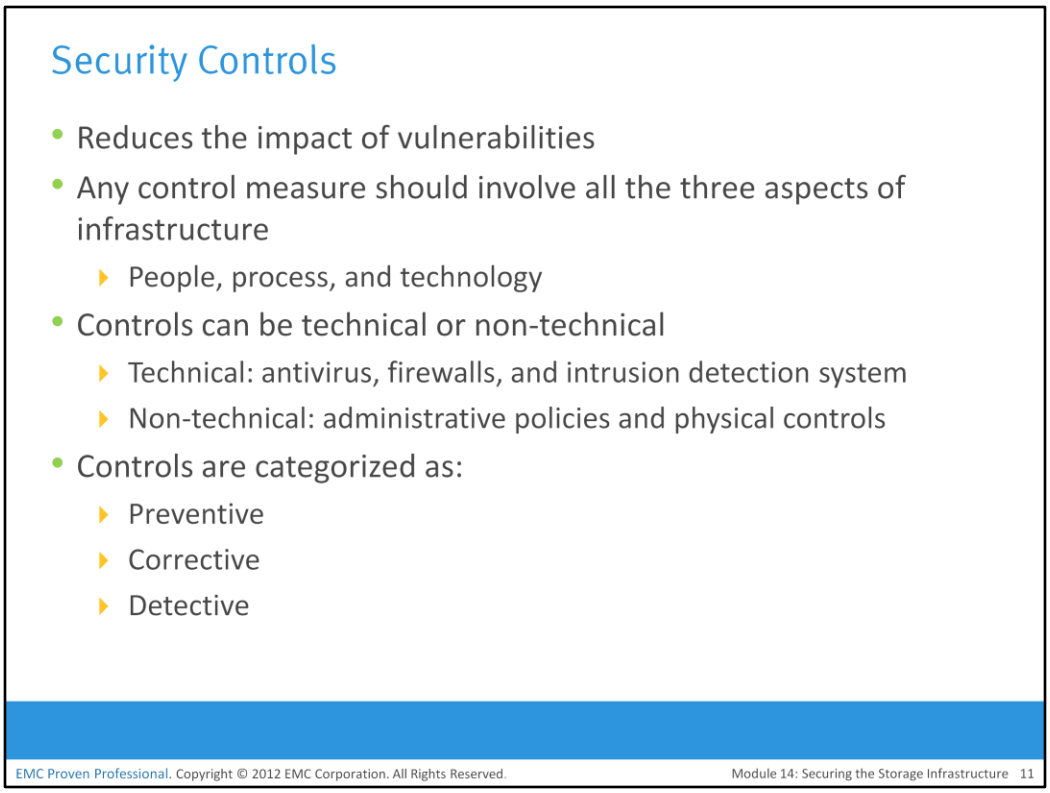
An *attack vector* is a step or a series of steps necessary to complete an attack. For example, an attacker might exploit a bug in the management interface to execute a snoop attack whereby the attacker can modify the configuration of the storage device to allow the traffic to be accessed from one more host. This redirected traffic can be used to snoop the data in transit. *Work factor* refers to the amount of time and effort required to exploit an attack vector. For example, if attackers attempt to retrieve sensitive information, they consider the time and effort that would be required for executing an attack on a database. This may include determining privileged accounts, determining the database schema, and writing SQL queries. Instead, based on the work factor, they may consider a less effort-intensive way to exploit the storage array by attaching to it directly and reading from the raw disk blocks.



Having assessed the vulnerability of the environment, organizations can deploy specific control measures. Any control measures should involve all the three aspects of infrastructure: people, process and technology, and their relationship. To secure people, first step is to establish and assure their identity. Based on their identity, selective controls can be implemented for their access to data and resources. The effectiveness of any security measure is primarily governed by the process and policies. The processes should be based on a thorough understanding of risks in the environment and recognize the relative sensitivity of different types of data, the needs of various stakeholders to access the data. Without an effective process, the deployment of technology is neither cost-effective nor aligned to organizations' priorities. And finally, the technologies or controls that are deployed should ensure compliance with the processes, policies, and people for its effectiveness. These security technologies are directed at reducing vulnerability by minimizing attack surfaces and maximizing the work factors. These controls can be technical or nontechnical. Technical controls are usually implemented through computer systems, whereas nontechnical controls are implemented through administrative and physical controls. Administrative controls include security and personnel policies or standard procedures to direct the safe execution of various operations. Physical controls include setting up physical barriers, such as security guards, fences, or locks.

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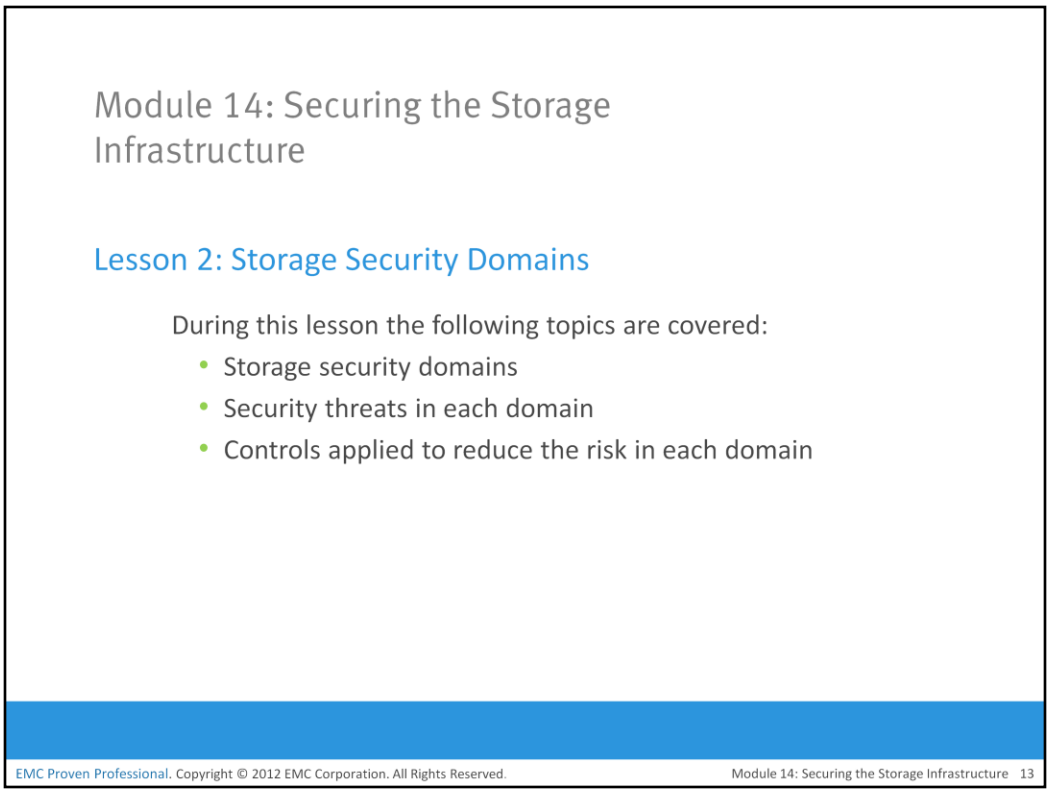
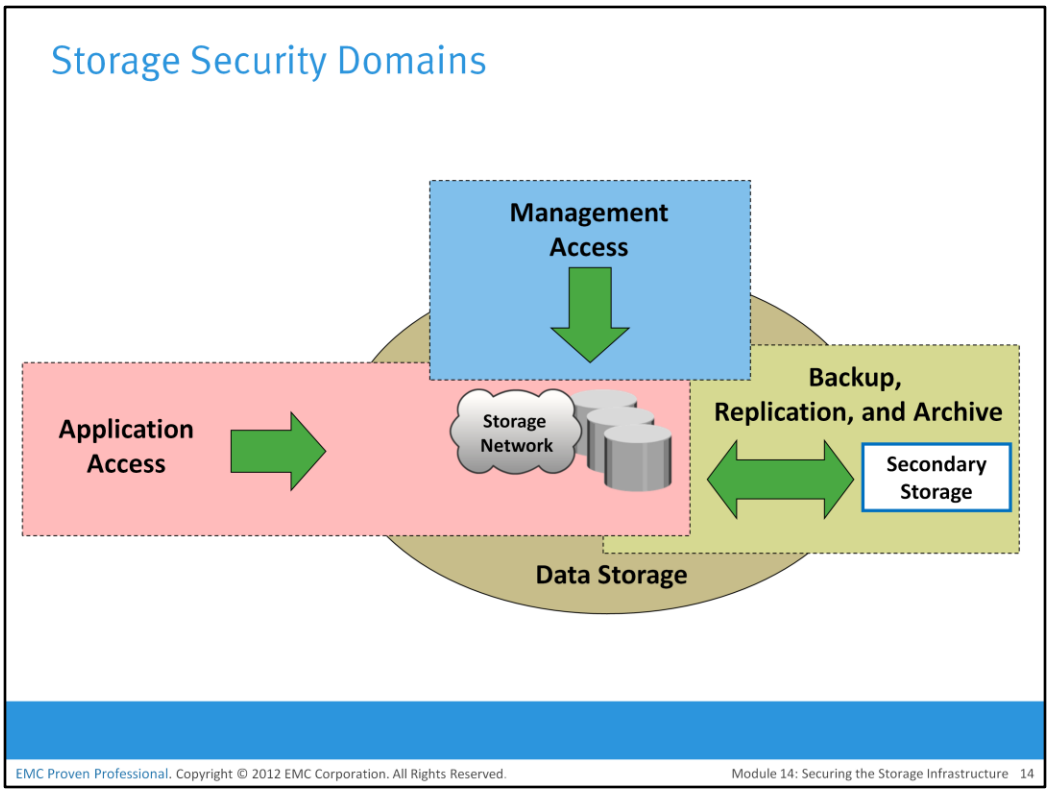
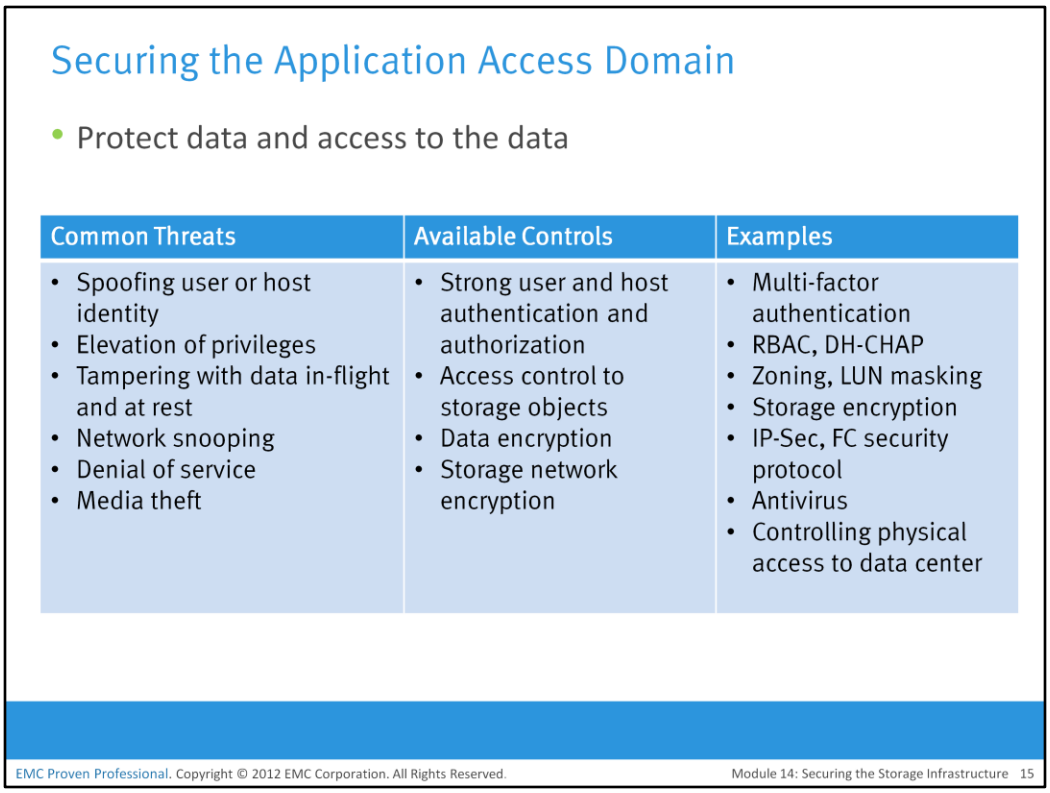
Based on the roles they play, controls are categorized as preventive, detective, and corrective. The preventive control attempts to prevent an attack; the detective control detects whether an attack is in progress; and after an attack is discovered, the corrective controls are implemented. *Preventive controls* avert the vulnerabilities from being exploited and prevent an attack or reduce its impact. *Corrective controls* reduce the effect of an attack, whereas *detective controls* discover attacks and trigger preventive or corrective controls. For example, an Intrusion Detection/Intrusion Prevention System (IDS/IPS) is a detective control that determines whether an attack is underway and then attempts to stop it by terminating a network connection or invoking a firewall rule to block traffic.



This lesson covers various storage security domains such as application access, management access, and back, replication, and archive. This lesson also covers security threats and control in each domain.



Storage devices connected to a network raises the risk level and more exposed to security threats via networks. However, with increasing use of networking in storage environments, storage devices are becoming highly exposed to security threats from a variety of sources. Specific controls must be implemented to secure a storage networking environment. This requires a closer look at storage networking security and a clear understanding of the access paths leading to storage resources. If a particular path is unauthorized and needs to be prohibited by technical controls, ensure that these controls are not compromised. If each component within the storage network is considered a potential access point, the attack surface of all these access points must be analyzed to identify the associated vulnerabilities. To identify the threats that apply to a storage network, access paths to data storage can be categorized into three security domains: *application access*, *management access*, and *backup, replication, and archive*. Figure on the slide depicts the three security domains of a storage system environment. The first security domain involves application access to the stored data through the storage network. The second security domain includes management access to storage and interconnect devices and to the data residing on those devices. This domain is primarily accessed by storage administrators who configure and manage the environment. The third domain consists of backup, replication, and archive access. Along with the access points in this domain, the backup media also needs to be secured. To secure the storage networking environment, identify the existing threats within each of the security domains and classify the threats based on the type of security services—availability, confidentiality, integrity, and accountability. The next step is to select and implement various controls as countermeasures to the threats.



Access control services regulate user and host access to data. These services mitigate the threats of spoofing user identity and elevating their privileges. Both these threats affect data integrity and confidentiality. Access control mechanisms used in application access domain are user and host authentication (technical control) and authorization (administrative control). These mechanisms may lie outside the boundaries of the storage network and require various systems to interconnect with other enterprise identity management and authentication systems. NAS devices support the creation of *access control lists* that regulates user access to specific files. The Enterprise Content Management application enforces access to data by using Information Rights Management (IRM) that specifies which users have what rights to a document.

Restricting access at the host level starts with authenticating a node when it tries to connect to a network. Different storage networking technologies, such as iSCSI, FC, and IP-based storage, use various authentication mechanisms, such as Challenge-Handshake Authentication Protocol (CHAP), Fibre Channel Security Protocol (FC-SP), and IPSec, respectively, to authenticate host access. After a host has been authenticated, the next step is to specify security controls for the storage resources, such as ports, volumes, or storage pools, that the host is authorized to access. *Zoning* is a control mechanism on the switches that segments the network into specific paths to be used for data traffic; *LUN masking* determines which hosts can access which storage devices.

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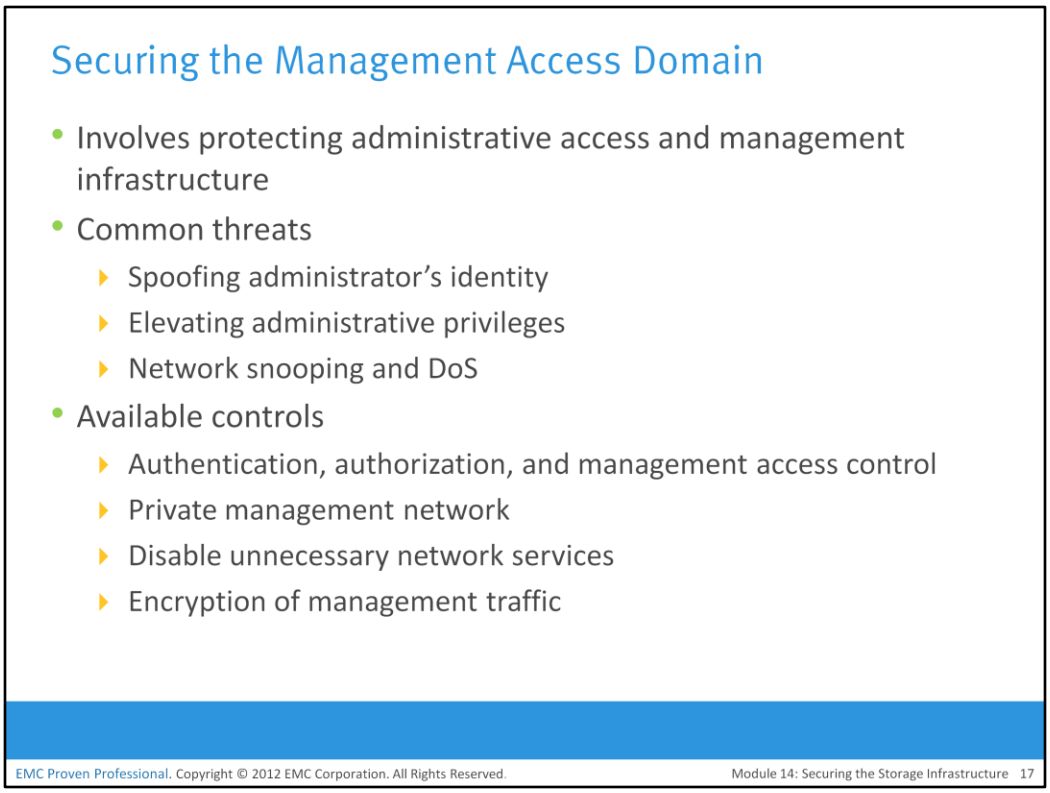
It is also important to ensure that administrative controls are implemented. Regular auditing is required to ensure proper functioning of administrative controls. This is enabled by logging significant events on all participating devices. Event logs should also be protected from unauthorized access because they may fail to achieve their goals if the logged content is exposed to unauthorized modifications by an attacker.

Security controls for protecting the storage infrastructure address the threats of unauthorized tampering of data in transit that leads to a loss of data integrity, denial of service that compromises availability, and network snooping that may result in loss of confidentiality.

The security controls for protecting the network fall into two general categories: network infrastructure integrity and storage network encryption. Controls for ensuring the infrastructure integrity include a fabric switch function that ensures fabric integrity. This is achieved by preventing a host from being added to the SAN fabric without proper authorization. Storage network encryption methods include the use of IPSec for protecting IP-based storage networks, and FC-SP for protecting FC networks. In secure storage environments, root or administrator privileges for a specific device are not granted to every user. Instead, *role-based access control* (RBAC) is deployed to assign necessary privileges to users, enabling them to perform their roles. A role may represent a job function, for example, an administrator. Privileges are associated with the roles and users acquire these privileges based upon their roles. It is also advisable to consider administrative controls, such as "separation of duties," when defining data center procedures. Management networks for storage systems should be logically separate from other enterprise networks. Finally, physical access to the device console and the cabling of FC switches must be controlled to ensure protection of the storage infrastructure.

The most important aspect of securing data is protecting data held inside the storage arrays. Threats at this level include tampering with data, which violates data integrity, and media theft, which compromises data availability and confidentiality. To protect against these threats, encrypt the data held on the storage media or encrypt the data prior to being transferred to the disk. Data should be encrypted as close to its origin as possible. If it is not possible to perform encryption on the host device, an encryption appliance can be used for encrypting data at the point of entry into the storage network. It is also critical to decide upon a method for ensuring that data deleted at the end of its lifecycle has been completely erased from the disks and cannot be reconstructed for malicious purposes. On NAS devices, adding antivirus checks and file extension controls can further enhance data integrity. In the case of CAS, use of MD5 or SHA-256 cryptographic algorithms guarantees data integrity by detecting any change in content bit patterns. In addition, the data erasure service ensures that the data has been completely over written by bit sequence before the disk is discarded.



Management access, whether monitoring, provisioning, or managing storage resources, is associated with every device within the storage network. Implementing appropriate controls for securing storage management applications is important because the damage that can be caused by using these applications can be far more extensive.

Controlling administrative access to storage aims to safeguard against the threats of an attacker spoofing an administrator's identity or elevating privileges to gain administrative access. To protect against these threats, administrative access regulation and various auditing techniques are used to enforce accountability of users and processes. Access control should be enforced for each storage component. In some storage environments, it may be necessary to integrate storage devices with third-party authentication directories, such as Lightweight Directory Access Protocol (LDAP) or Active Directory. Security best practices stipulate that no single user should have ultimate control over all aspects of the system. It is better to assign various administrative functions by using RBAC. Auditing logged events is a critical control measure to track the activities of an administrator. However, access to administrative log files and their content must be protected. In addition, having a Security Information Management (SIM) solution supports effective analysis of the event log files.

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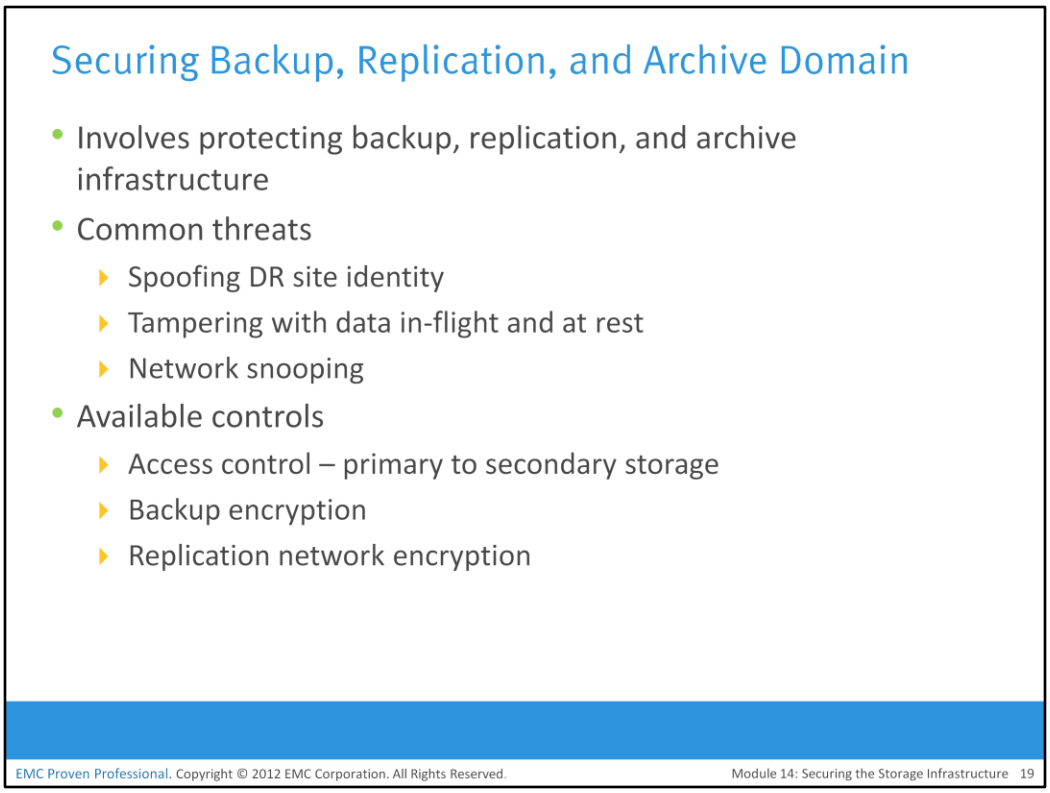
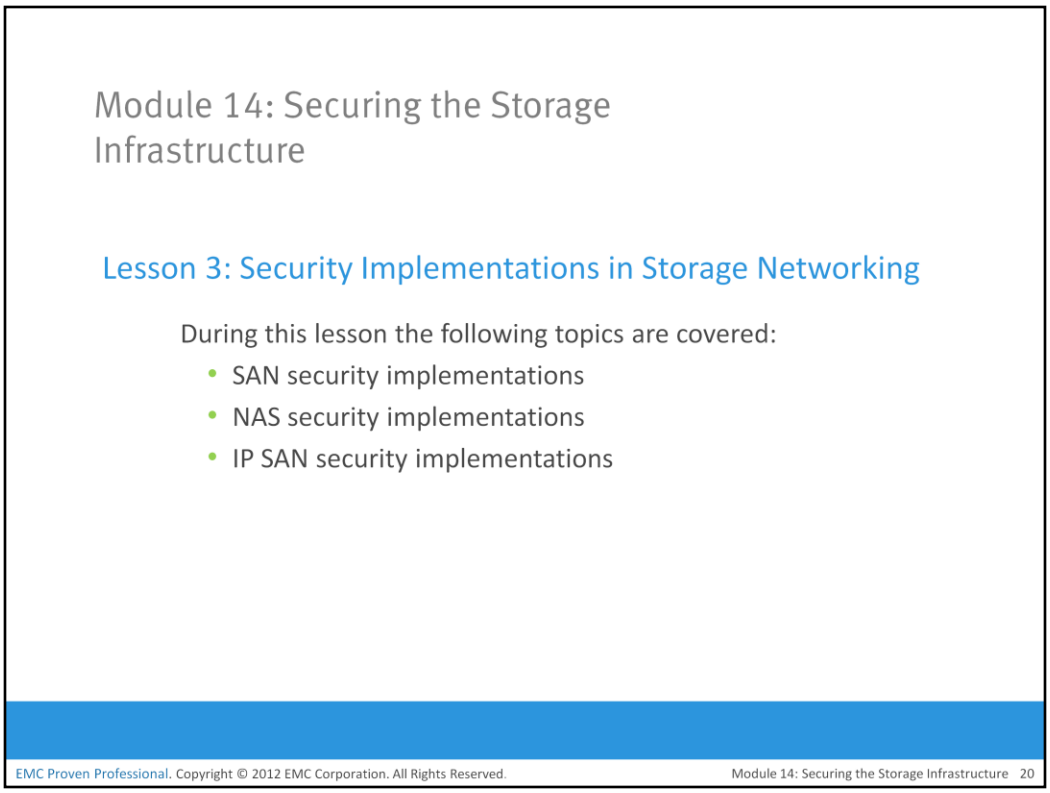
Mechanisms to protect the management network infrastructure include encrypting management traffic, enforcing management access controls, and applying IP network security best practices. Restricting network activity and access to a limited set of hosts minimizes the threat of an unauthorized device attaching to the network and gaining access to the management interfaces. Access controls need to be enforced at the storage-array level to specify which host has management access to which array. A separate private management network is highly recommended for the management traffic. If possible, management traffic should not be mixed with either production data traffic or other LAN traffic used in the enterprise. Unused network services must be disabled on every device within the storage network. This decreases the attack surface for that device by minimizing the number of interfaces through which the device can be accessed.



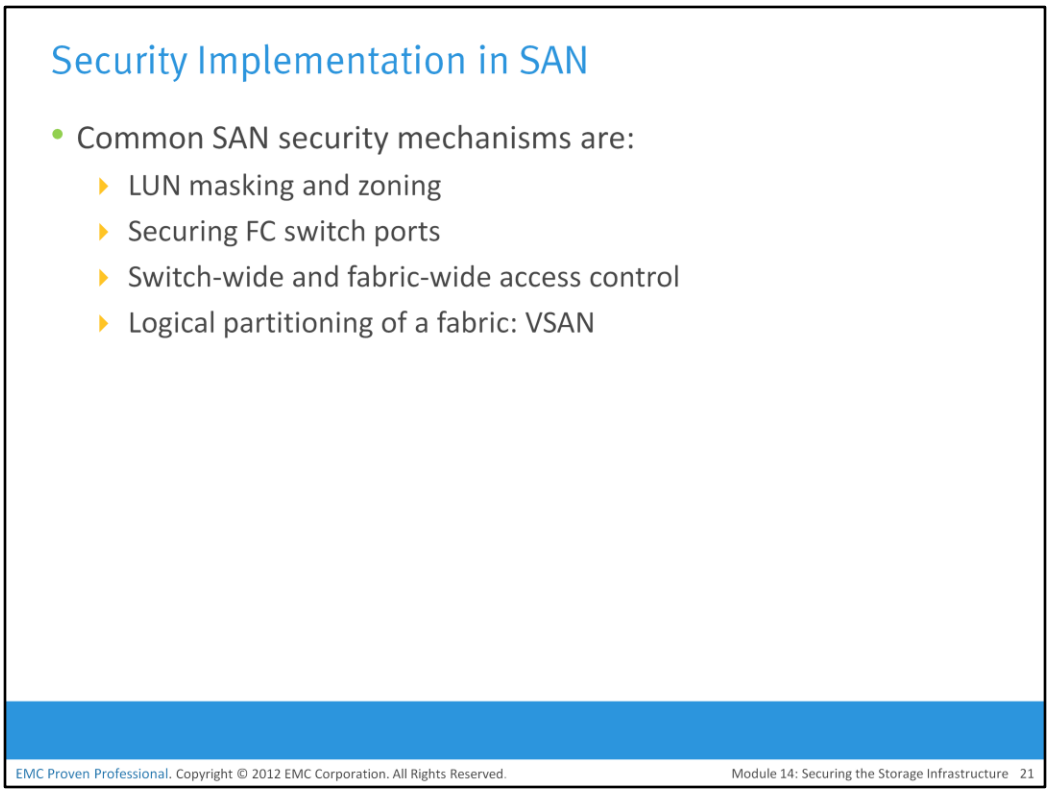
Backup, replication, and archive is the third domain that needs to be secured against an attack. A backup involves copying the data from a storage array to backup media, such as tapes or disks. Securing backup is complex and is based on the backup software that accesses the storage arrays. It also depends on the configuration of the storage environments at the primary and secondary sites, especially with remote backup solutions performed directly on a remote tape device or using array-based remote replication.

Organizations must ensure that the disaster recovery (DR) site maintains the same level of security for the backed up data. Protecting the backup, replication, and archive infrastructure requires addressing several threats, including spoofing the legitimate identity of a DR site, tampering with data, network snooping, DoS attacks, and media theft. Such threats represent potential violations of integrity, confidentiality, and availability. In a remote backup solution where the storage components are separated by a network, the threats at the transmission layer need to be countered. Otherwise, an attacker can spoof the identity of the backup server and request the host to send its data. The unauthorized host claiming to be the backup server may lead to a remote backup being performed to an unauthorized and unknown site. In addition, attackers can use the DR network connection to tamper with data, snoop the network, and create a DoS attack against the storage devices.

The physical threat of a backup tape being lost, stolen, or misplaced, especially if the tapes contain highly confidential information, is another type of threat. Backup-to-tape applications are vulnerable to severe security implications if they do not encrypt data while backing it up.



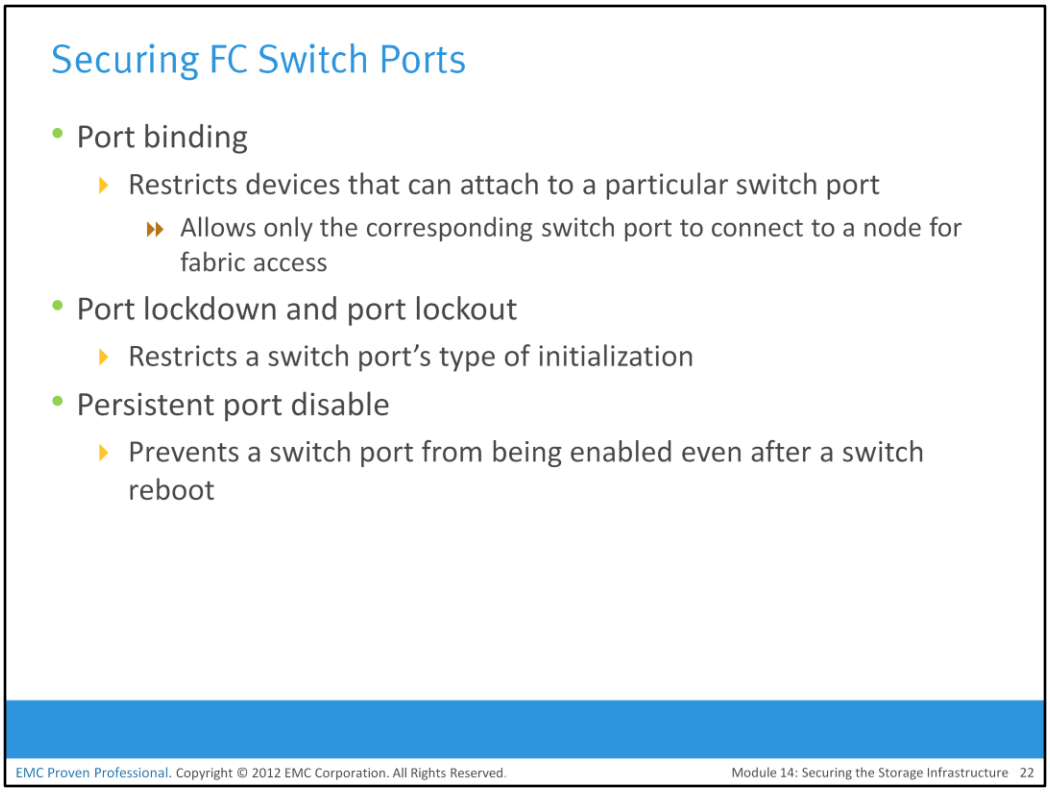
This lesson covers various security implementation in SAN, NAS and IP SAN environment.



Traditional FC SANs enjoy an inherent security advantage over IP-based networks. An FC SAN is configured as an isolated private environment with fewer nodes than an IP network. Consequently, FC SANs impose fewer security threats. However, this scenario has changed with converged network, storage consolidation, driving rapid growth and necessitating designs for large, complex SANs that span multiple sites across the enterprise. Today, no single comprehensive security solution is available for FC SANs. Many FC SAN security mechanisms have evolved from their counterpart in IP networking, thereby bringing in matured security solutions.

Fibre Channel Security Protocol (FC-SP*)* standards (T11 standards), published in 2006, align security mechanisms and algorithms between IP and FC interconnects. These standards describe protocols used to implement security measures in a FC fabric, among fabric elements and N_Ports within the fabric. They also include guidelines for authenticating FC entities, setting up session keys, negotiating the parameters required to ensure frame-by-frame integrity and confidentiality, and establishing and distributing policies across an FC fabric.

LUN masking and zoning, security in FC switch port, switch-wide and fabric-wide access control, and logical partitioning of a fabric (Virtual SAN) are the most commonly used SAN security methods. A stronger variant of LUN masking may sometimes be offered whereby masking can be done on the basis of source FC address. It offers a mechanism to lock down the FC address of a given node port to its WWN.

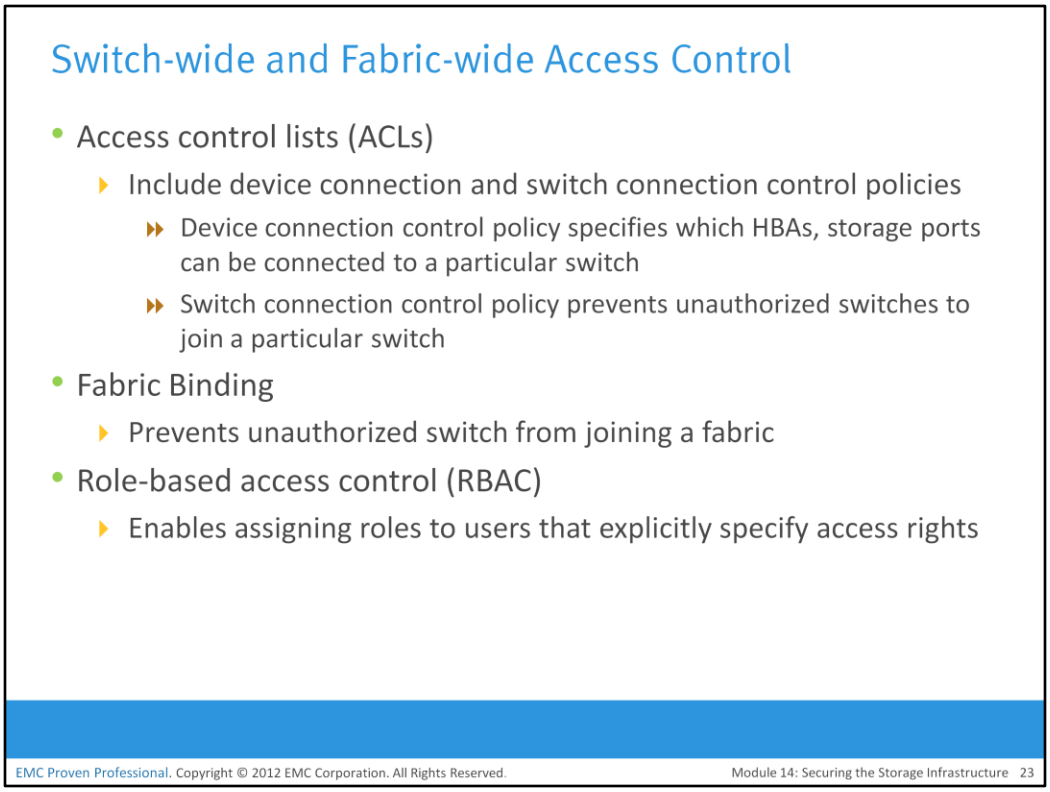


Apart from zoning and LUN masking, additional security mechanisms, such as port binding, port lockdown, port lockout, and persistent port disable, can be implemented on switch ports.

Port binding : Limits the devices that can attach to a particular switch port and allows only the corresponding switch port to connect to a node for fabric access. Port binding mitigates but does not eliminate WWPN spoofing.

Port lockdown and *port lockout:* Restrict a switch port's type of initialization. Typical variants of port lockout ensure that the switch port cannot function as an E-Port and cannot be used to create an ISL, such as a rogue switch. Some variants ensure that the port role is restricted to only F-Port, E-Port, or a combination of these.

Persistent port disable: Prevents a switch port from being enabled even after a switch reboot.

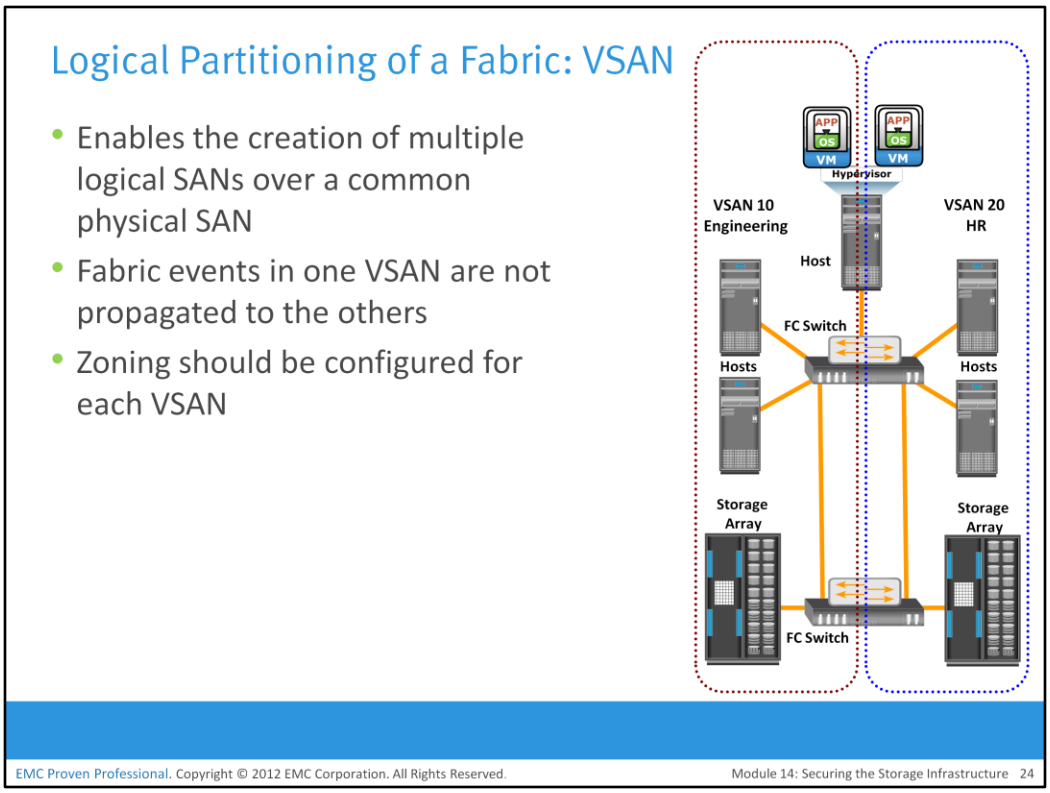


As organizations grow their SANs locally or over longer distances, there is a greater need to effectively manage SAN security. Network security can be configured on the FC switch by using access control lists (ACLs) and on the fabric by using fabric binding.

ACLs incorporate the device connection control and switch connection control policies. The device connection control policy specifies which HBAs and storage ports can be connected to a particular switch, preventing unauthorized devices from accessing it. Similarly, the switch connection control policy specifies which switches are allowed to be connected to a particular switch, preventing unauthorized switches from joining it.

Fabric binding prevents an unauthorized switch from joining any existing switch in the fabric. It ensures that authorized membership data exists on every switch and any attempt to connect any switch in the fabric by using an ISL causes the fabric to segment.

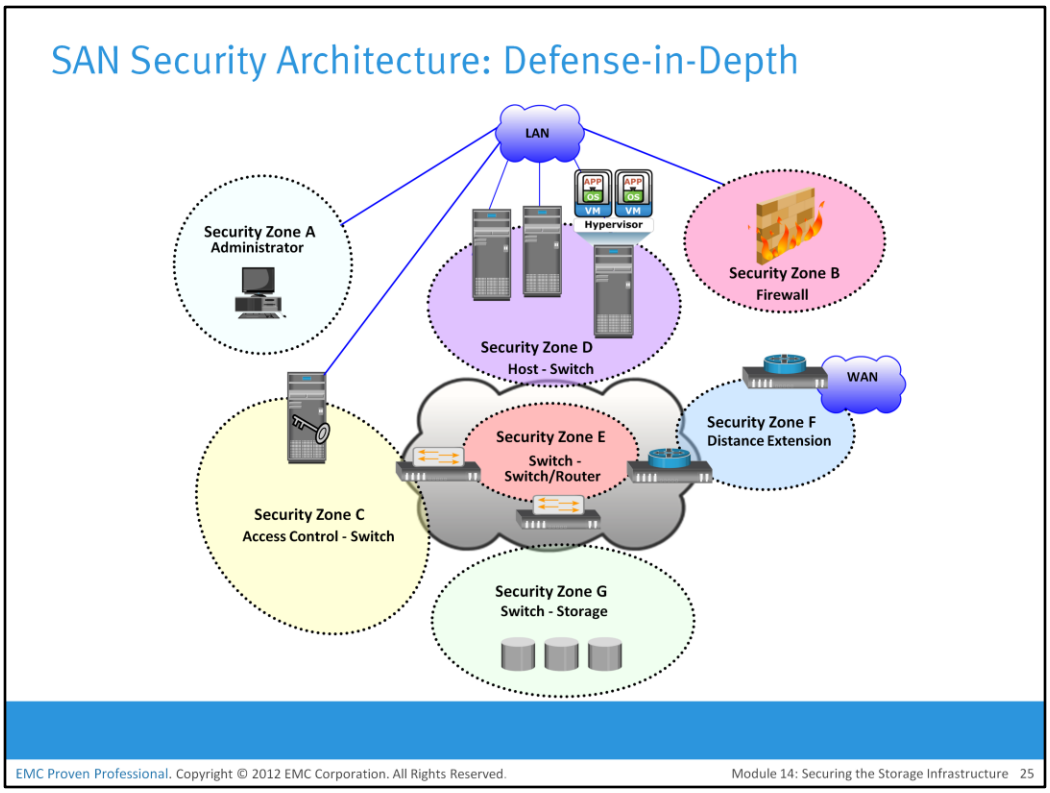
Role-based access control provides additional security to a SAN by preventing unauthorized activity on the fabric for management operations. It enables the security administrator to assign roles to users that explicitly specify privileges or access rights after logging into the fabric. For example, the zone admin role can modify the zones on the fabric, whereas a basic user may view only fabric-related information, such as port types and logged-in nodes.



VSANs enable the creation of multiple logical SANs over a common physical SAN. They provide the capability to build larger consolidated fabrics and still maintain the required security and isolation between them. Figure on the slide depicts logical partitioning of a fabric using VSAN.

The SAN administrator can create distinct VSANs by populating each of them with switch ports. In the example, the switch ports are distributed over two VSANs: 10 and 20—for the Engineering and HR divisions, respectively. Although they share physical switching gear with other divisions, they can be managed individually as standalone fabrics. Zoning should be done for each VSAN to secure the entire physical SAN. Each managed VSAN can have only one active zone set at a time.

VSANs minimize the impact of fabric wide disruptive events because management and control traffic on the SAN—which may include RSCNs, zone set activation events, and more—does not traverse VSAN boundaries. Therefore, VSANs are a cost-effective alternative for building isolated physical fabrics. They contribute to information availability and security by isolating fabric events and providing authorization control within a single fabric.



Storage networking environments are a potential target for unauthorized access, theft, and misuse because of the vastness and complexity of these environments. Therefore, security strategies are based on the *defense in depth* concept, which recommends multiple integrated layers of security. This ensures that the failure of one security control will not compromise the assets under protection. Figure on the slide illustrates various levels (zones) of a storage networking environment that must be secured. FC SANs not only suffer from certain risks and vulnerabilities that are unique, but also share common security problems associated with physical security and remote administrative access. In addition to implementing SAN-specific security measures, organizations must simultaneously leverage other security implementations in the enterprise.

Comprehensive list of protection strategies that must be implemented in various security zones are listed below:

Zone A (Authentication at the Management Console):

(a) Restrict management LAN access to authorized users (lock down MAC addresses) (b) implement VPN tunneling for secure remote access to the management LAN and (c) use two-factor authentication for network access

Zone B (Firewall)

Block inappropriate traffic by (a) filtering out addresses that should not be allowed on your LAN, and (b) screening for allowable protocols block ports that are not in use

Cont..

Zone C (Access Control-Switch)

Authenticate users/administrators of FC switches using Remote Authentication Dial In User Service (RADIUS) and DH-CHAP (Diffie-Hellman Challenge Handshake Authentication Protocol)

Zone D (Host to switch)

Restrict Fabric access to legitimate hosts by implementing (a) ACLs: Known HBAs can connect on specific switch ports only; and (b) a secure zoning method, such as port zoning (also known as hard zoning)

Zone E (Switch to Switch/Switch to Router)

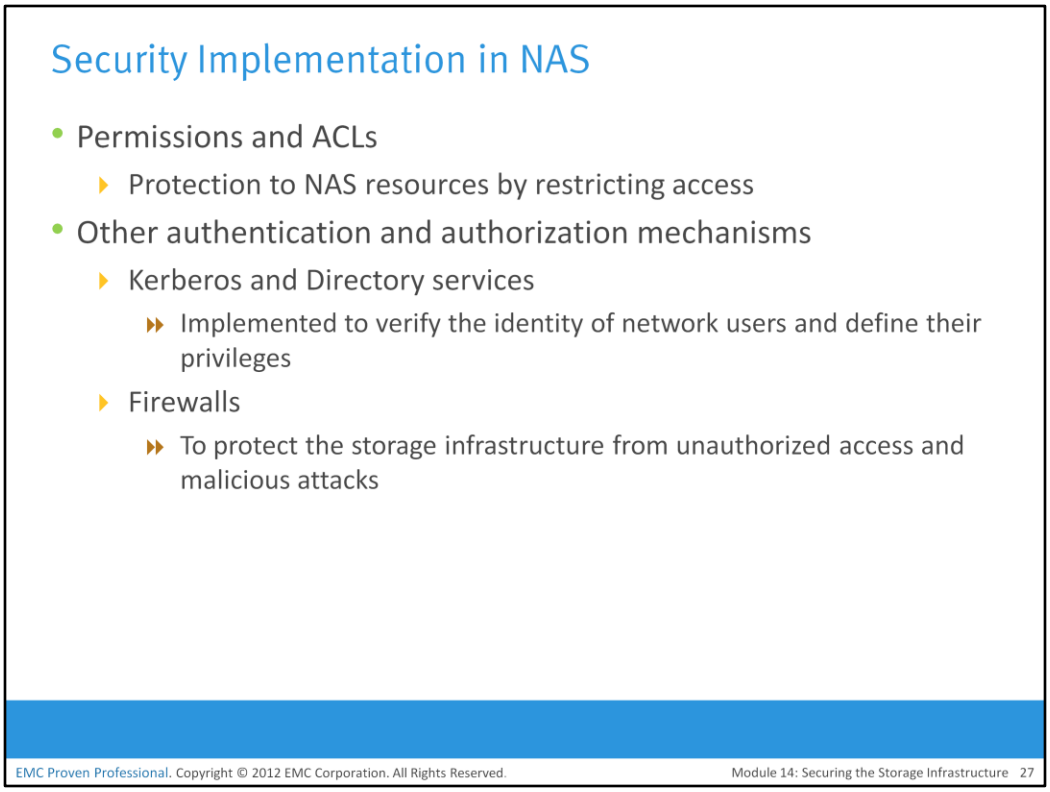
Protect traffic on fabric by (a) using E_Port authentication; (b) encrypting the traffic in transit; and (c) implementing FC switch controls and port controls

Zone F (Distance Extension)

Implement encryption for in-flight data (a) FC-SP for long-distance FC extension, and (b) IPSec for SAN extension via FCIP

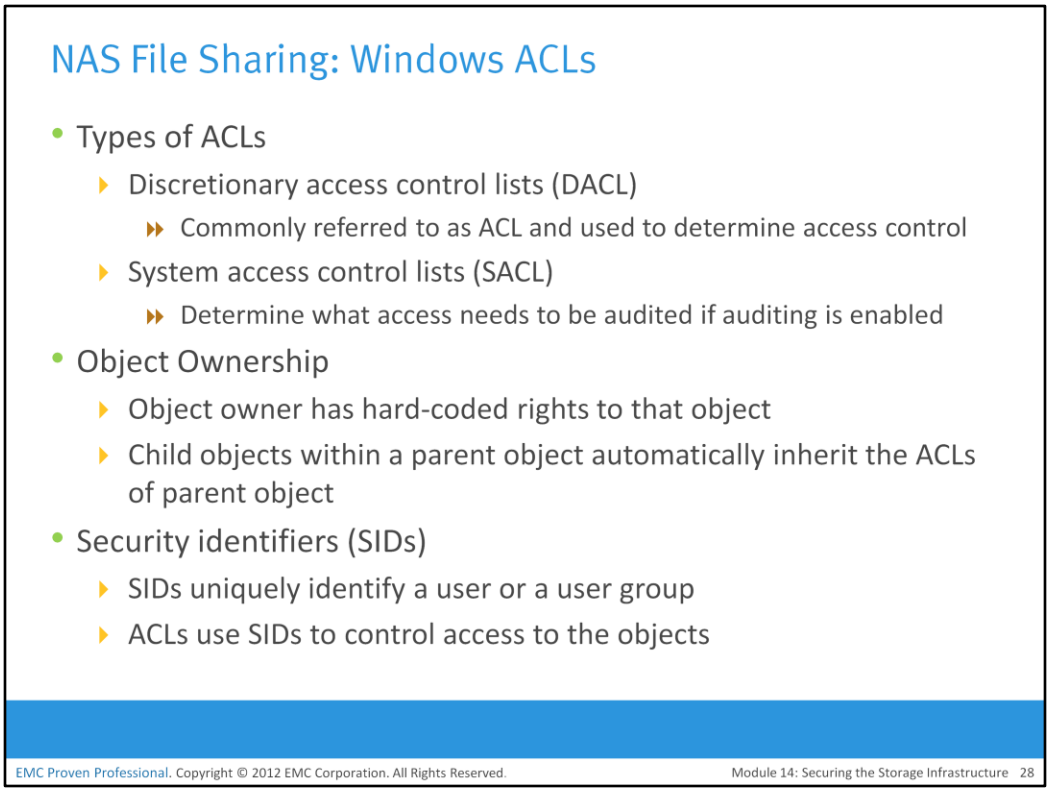
Zone G (Switch to Storage)

Protect the storage arrays on your SAN via (a) WWPN-based LUN masking and (b) S_ID locking: masking based on source Fibre Channel address



NAS is open to multiple exploits, including viruses, worms, unauthorized access, snooping, and data tampering. Various security mechanisms are implemented in NAS to secure data and the storage networking infrastructure.

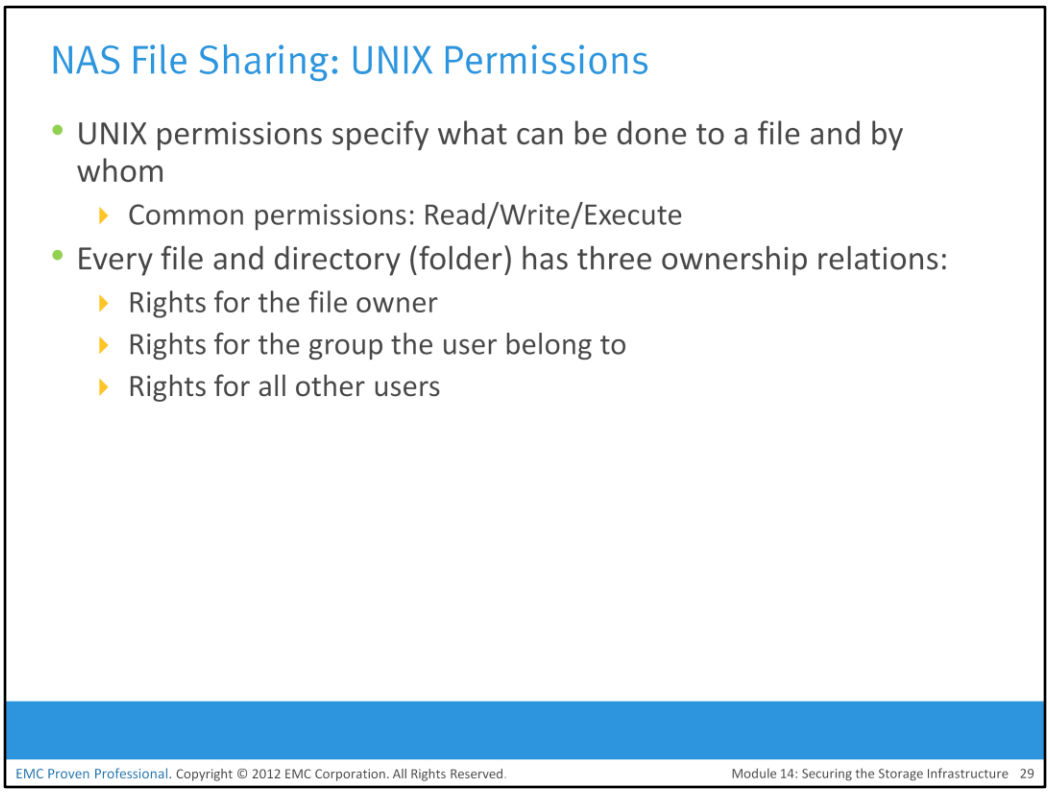
Permissions and ACLs form the first level of protection to NAS resources by restricting accessibility and sharing. These permissions are deployed over and above the default behaviors and attributes associated with files and folders. In addition, various other authentication and authorization mechanisms, such as Kerberos and directory services, are implemented to verify the identity of network users and define their privileges. Similarly, firewalls protect the storage infrastructure from unauthorized access and malicious attacks.



Windows supports two types of ACLs: *discretionary access control lists* (DACLs) and *system access control lists* (SACLs). The DACL, commonly referred to as the ACL, that determines access control. The SACL determines what accesses need to be audited if auditing is enabled.

In addition to these ACLs, Windows also supports the concept of object ownership. The owner of an object has hard-coded rights to that object, and these rights do not need to be explicitly granted in the SACL. The owner, SACL, and DACL are all statically held as attributes of each object. Windows also offers the functionality to inherit permissions, which allows the child objects existing within a parent object to automatically inherit the ACLs of the parent object.

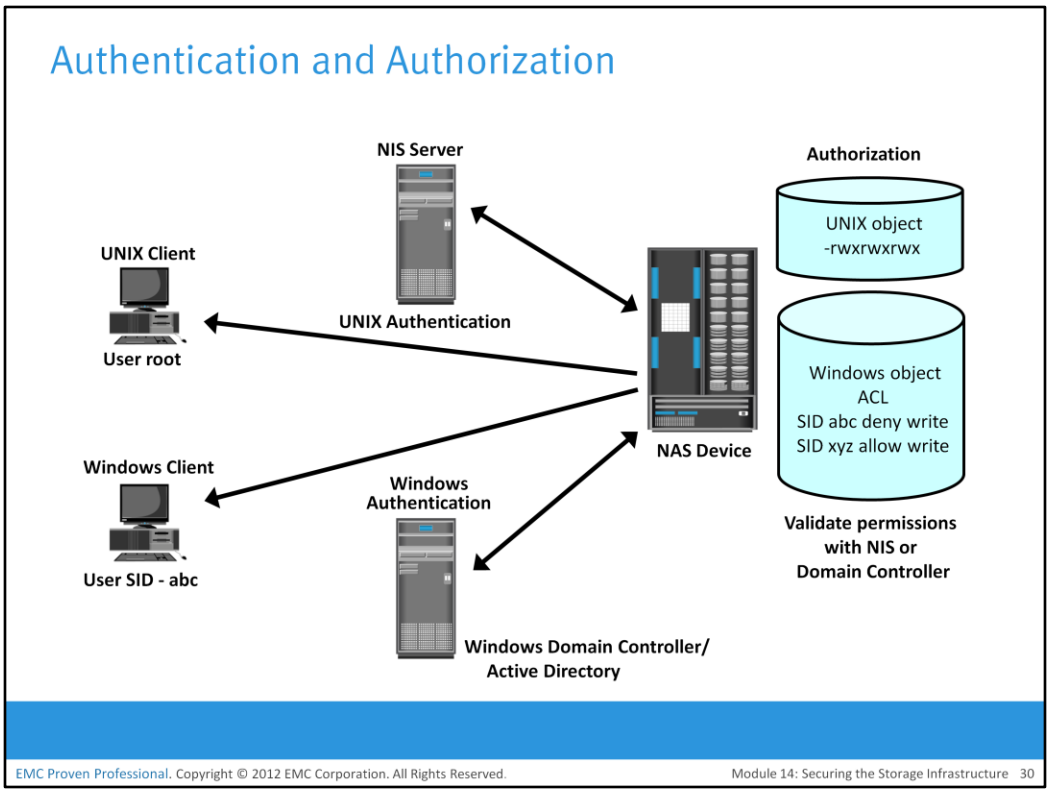
ACLs are also applied to directory objects known as security identifiers (SIDs). These are automatically generated by a Windows server or domain when a user or group is created, and they are abstracted from the user. In this way, though a user may identify his login ID as "User1," it is simply a textual representation of the true SID, which is used by the underlying operating system. Internal processes in Windows refer to an account's SID rather than the account's username or group name while granting access to an object. ACLs are set by using the standard Windows Explorer GUI but can also be configured with CLI commands or other third-party tools.



For the UNIX operating system, a *user* is an abstraction that denotes a logical entity for assignment of ownership and operation privileges for the system. A user can be either a person or a system operation. A UNIX system is only aware of the privileges of the user to perform specific operations on the system and identifies each user by a user ID (UID) and a username, regardless of whether it is a person, a system operation, or a device.

In UNIX, users can be organized into one or more groups. The concept of group serves the purpose to assign sets of privileges for a given resource and sharing them among many users that need them. For example, a group of people working on one project may need the same permissions for a set of files.

UNIX permissions specify the operations that can be performed by any ownership relation with respect to a file. In simpler terms, these permissions specify what the owner can do, what the owner group can do, and what everyone else can do with the file. For any given ownership relation, three bits are used to specify access permissions. The first bit denotes read (r) access, the second bit denotes write (w) access, and the third bit denotes execute (x) access. Because UNIX defines three ownership relations (Owner, Group, and All), a triplet (defining the access permission) is required for each ownership relationship, resulting in nine bits. Each bit can be either set or clear. When displayed, a set bit is marked by its corresponding operation letter (r, w, or x), a clear bit is denoted by a dash (-), and all are put in a row, such as rwxr-xr-x. In this example, the owner can do anything with the file, but group owners and the rest of the world can read or execute only. When displayed, a character denoting the mode of the file may precede this nine-bit pattern. For example, if the file is a directory, it is denoted as “d”; and if it is a link, it is denoted as “l.”

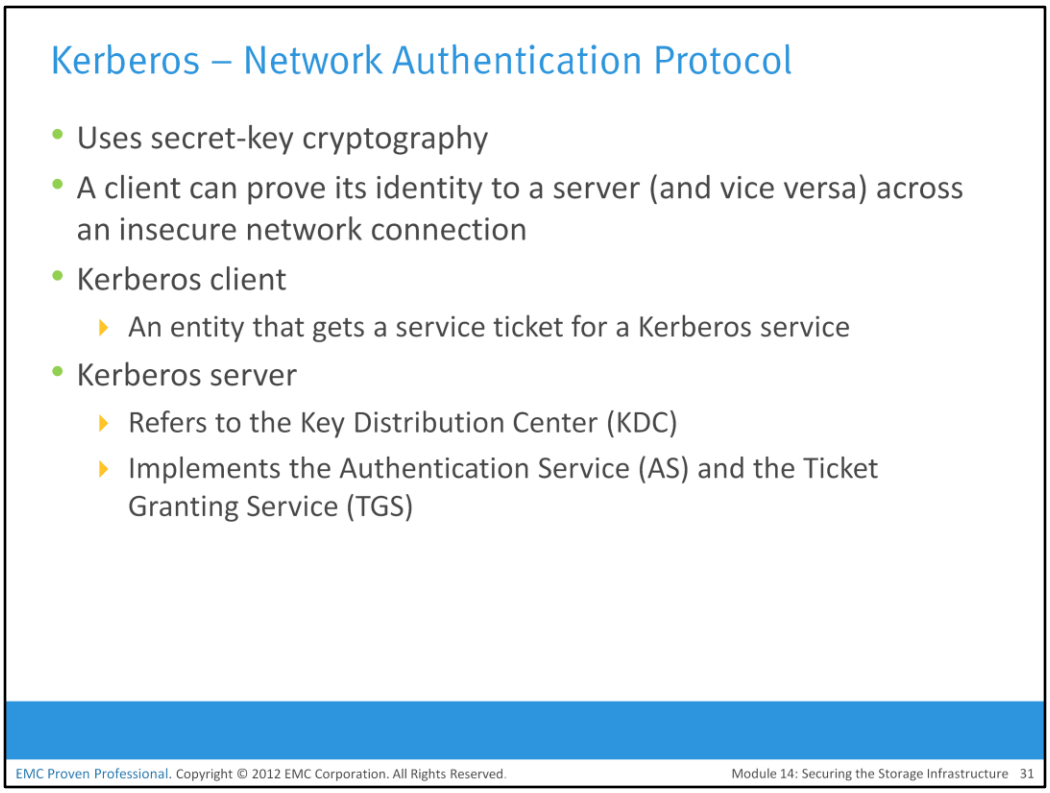


In a file-sharing environment, NAS devices use standard file-sharing protocols, NFS and CIFS. Therefore, authentication and authorization are implemented and supported on NAS devices in the same way as in a UNIX or Windows file-sharing environment.

Authentication requires verifying the identity of a network user and therefore involves a login credential lookup on a Network Information System (NIS) server in a UNIX environment. Similarly, a Windows client is authenticated by a Windows domain controller that houses the Active Directory. The Active Directory uses LDAP to access information about network objects in the directory and Kerberos for network security. NAS devices use the same authentication techniques to validate network user credentials. Figure on the slide depicts the authentication process in a NAS environment.

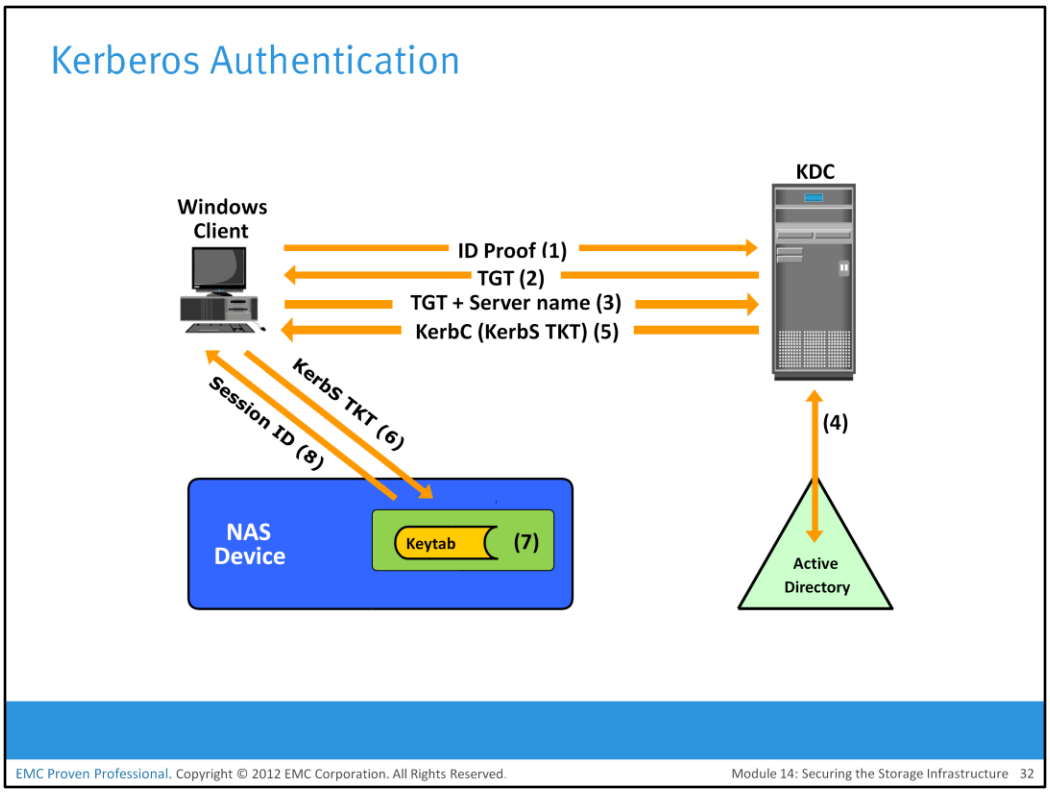
Authorization defines user privileges in a network. The authorization techniques for UNIX users and Windows users are quite different. UNIX files use mode bits to define access rights granted to owners, groups, and other users, whereas Windows uses an ACL to allow or deny specific rights to a particular user for a particular file.

Although NAS devices support both of these methodologies for UNIX and Windows users, complexities arise when UNIX and Windows users access and share the same data. If the NAS device supports multiple protocols, the integrity of both permission methodologies must be maintained. NAS device vendors provide a method of mapping UNIX permissions to Windows and vice versa, so a multiprotocol environment can be supported.



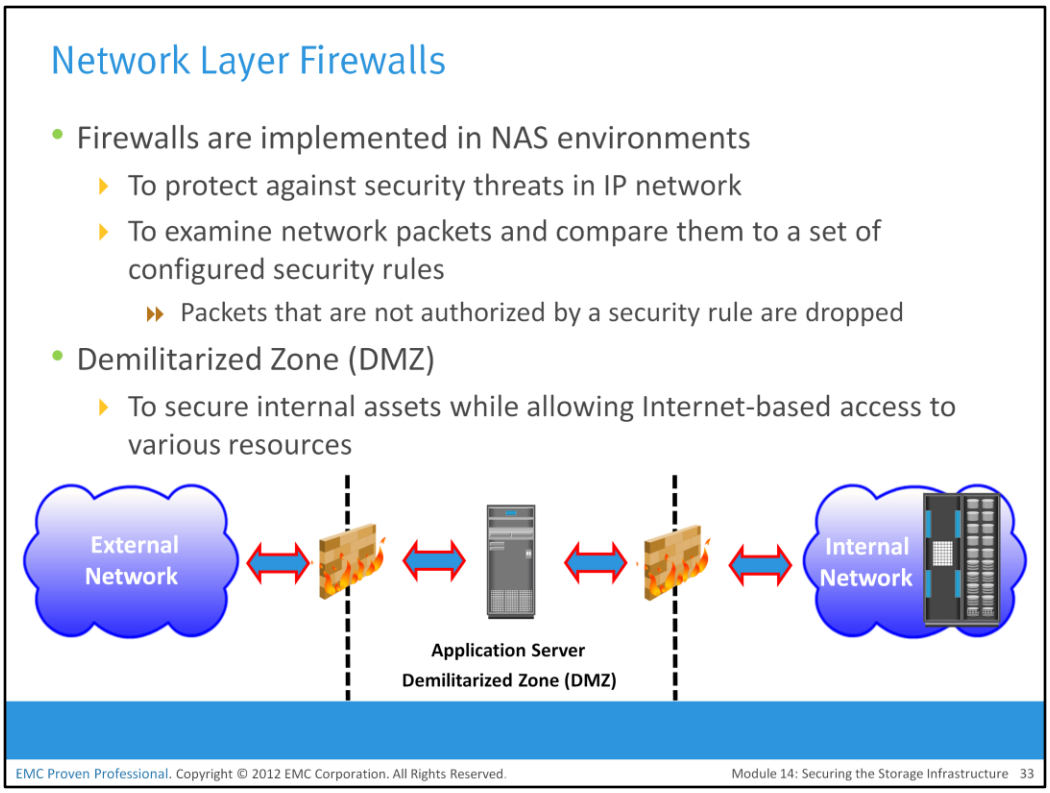
Kerberos is a network authentication protocol, which is designed to provide strong authentication for client/server applications by using secret-key cryptography. It uses cryptography so that a client and server can prove their identity to each other across an insecure network connection. After the client and server have proven their identities, they can choose to encrypt all their communications to ensure privacy and data integrity.

In Kerberos, authentications occur between clients and servers. The client gets a ticket for a service and the server decrypts this ticket by using its secret key. Any entity, user, or host that gets a service ticket for a Kerberos service is called a *Kerberos client*. The term *Kerberos server* generally refers to the Key Distribution Center (KDC). The KDC implements the Authentication Service (AS) and the Ticket Granting Service (TGS). The KDC has a copy of every password associated with every principal, so it is absolutely vital that the KDC remain secure. In Kerberos, users and servers for which a secret key is stored in the KDC database are known as *principals*.



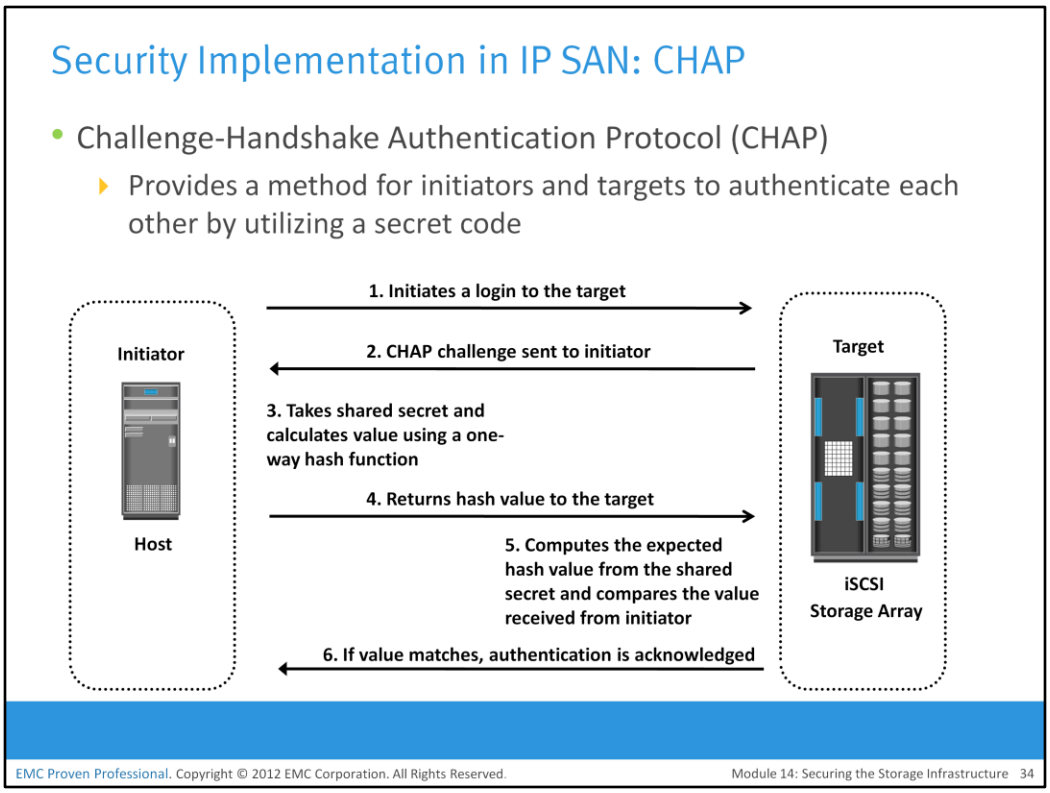
The Kerberos authentication process shown in figure on the slide includes the following steps:

1. The user logs on to the workstation in the Active Directory domain (or forest) using an ID and a password. The client computer sends a request to the AS running on the KDC for a Kerberos ticket. The KDC verifies the user's login information from Active Directory.
2. The KDC responds with an encrypted Ticket Granting Ticket (TGT) and an encrypted session key. TGT has a limited validity period. TGT can be decrypted only by the KDC, and the client can decrypt only the session key.
3. When the client requests a service from a server, it sends a request, consisting of the previously generated TGT, encrypted with the session key and the resource information to the KDC.
4. The KDC checks the permissions in Active Directory and ensures that the user is authorized to use that service.
5. The KDC returns a service ticket to the client. This service ticket contains fields addressed to the client and to the server hosting the service.
6. The client then sends the service ticket to the server that houses the required resources.
7. The server, in this case the NAS device, decrypts the server portion of the ticket and stores the information in a keytab file. As long as the client's Kerberos ticket is valid, this authorization process does not need to be repeated. The server automatically allows the client to access the appropriate resources.
8. A client-server session is now established. The server returns a session ID to the client, which tracks the client activity, such as file locking, as long as the session is active.



Because NAS devices utilize the IP protocol stack, they are vulnerable to various attacks initiated through the public IP network. Network layer firewalls are implemented in NAS environments to protect the NAS devices from these security threats. These network-layer firewalls can examine network packets and compare them to a set of configured security rules. Packets that are not authorized by a security rule are dropped and not allowed to continue to the destination. Rules can be established based on a source address (network or host), a destination address (network or host), a port, or a combination of those factors (source IP, destination IP, and port number). The effectiveness of a firewall depends on how robust and extensive the security rules are. A loosely defined rule set can increase the probability of a security breach.

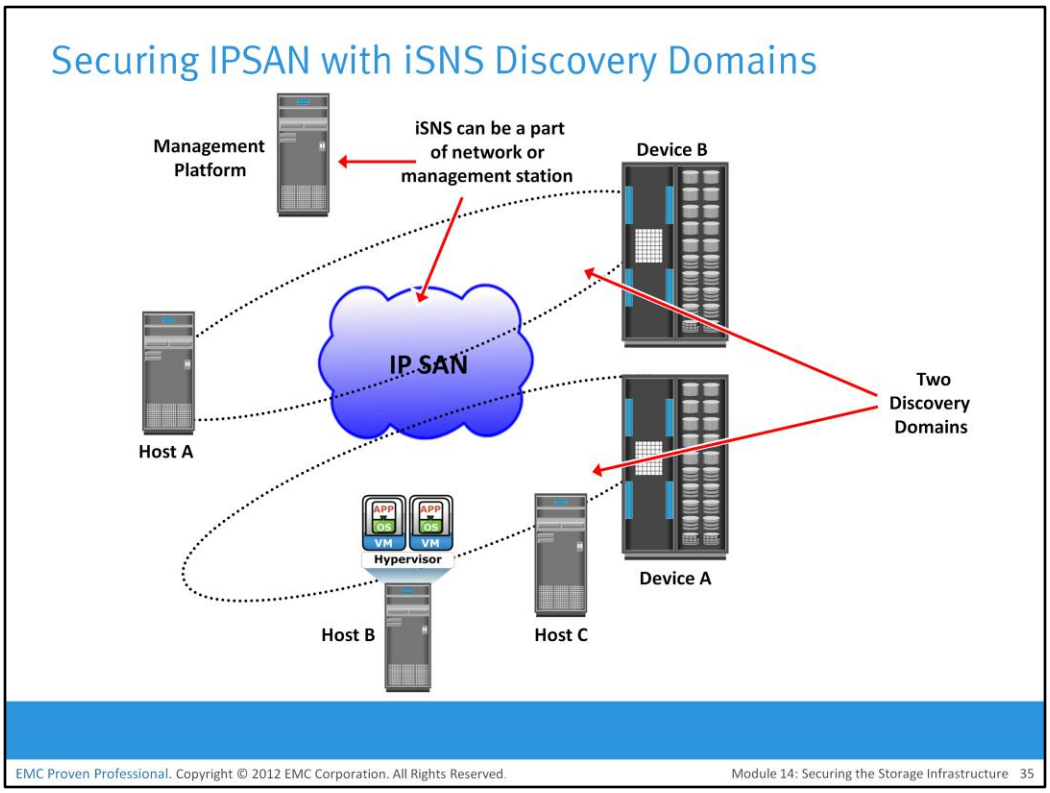
A demilitarized zone (DMZ) is commonly used in networking environments. A DMZ provides a means to secure internal assets while allowing Internet-based access to various resources. In a DMZ environment, servers that need to be accessed through the Internet are placed between two sets of firewalls. Application-specific ports, such as HTTP or FTP, are allowed through the firewall to the DMZ servers. However, no Internet-based traffic is allowed to penetrate the second set of firewalls and gain access to the internal network. The servers in the DMZ may or may not be allowed to communicate with internal resources. In such a setup, the server in the DMZ is an Internet-facing web application accessing data stored on a NAS device, which may be located on the internal private network. A secure design would serve only data to internal and external applications through the DMZ.



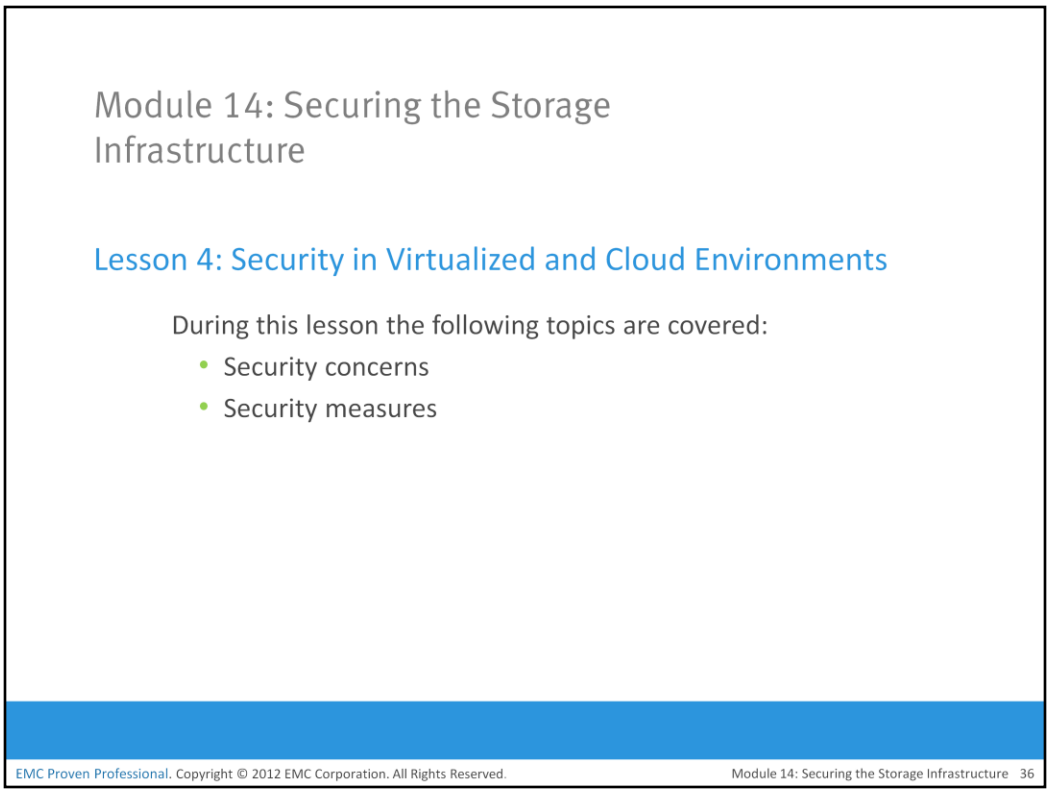
The *Challenge-Handshake Authentication Protocol* (CHAP) is a basic authentication mechanism that has been widely adopted by network devices and hosts. CHAP provides a method for initiators and targets to authenticate each other by utilizing a secret code or password. CHAP secrets are usually random secrets of 12 to 128 characters. The secret is never exchanged directly over the communication channel; rather, a one-way hash function converts it into a hash value, which is then exchanged. A hash function, using the MD5 algorithm, transforms data in such a way that the result is unique and cannot be changed back to its original form. Figure on the slide depicts the CHAP authentication process.

If the initiator requires reverse CHAP authentication, the initiator authenticates the target by using the same procedure. The CHAP secret must be configured on the initiator and the target. A CHAP entry, composed of the name of a node and the secret associated with the node, is maintained by the target and the initiator.

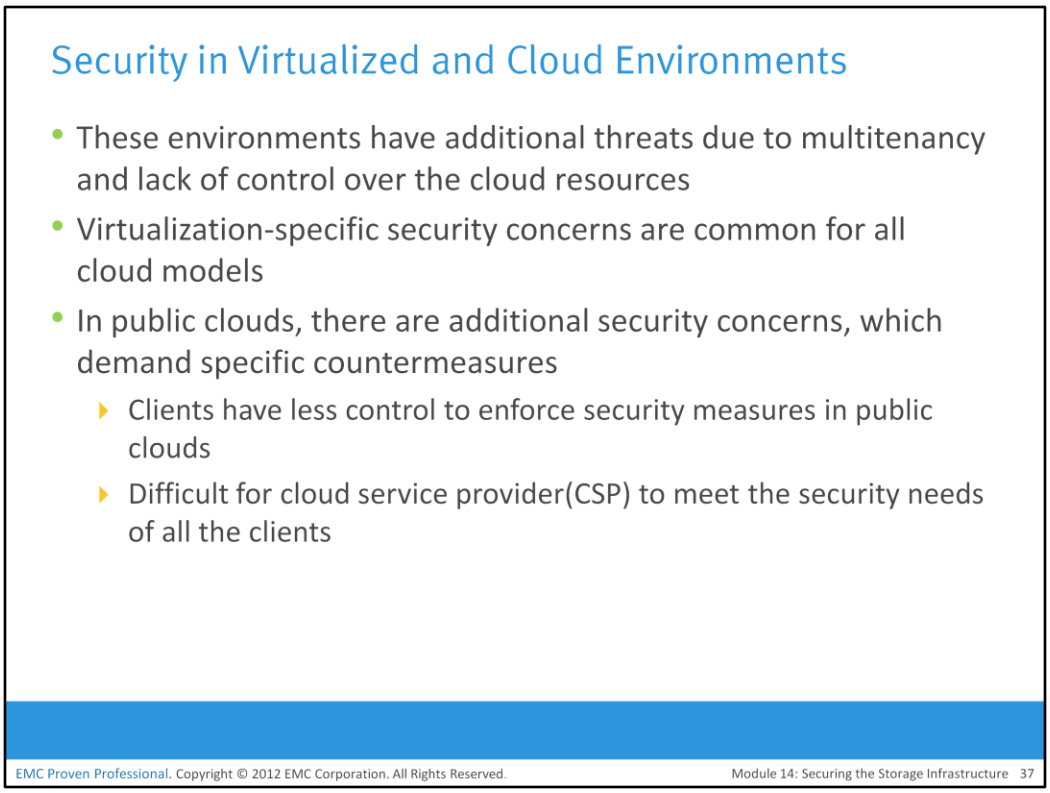
The same steps are executed in a two-way CHAP authentication scenario. After these steps are completed, the initiator authenticates the target. If both authentication steps succeed, then data access is allowed. CHAP is often used because it is a fairly simple protocol to implement and can be implemented across a number of disparate systems.



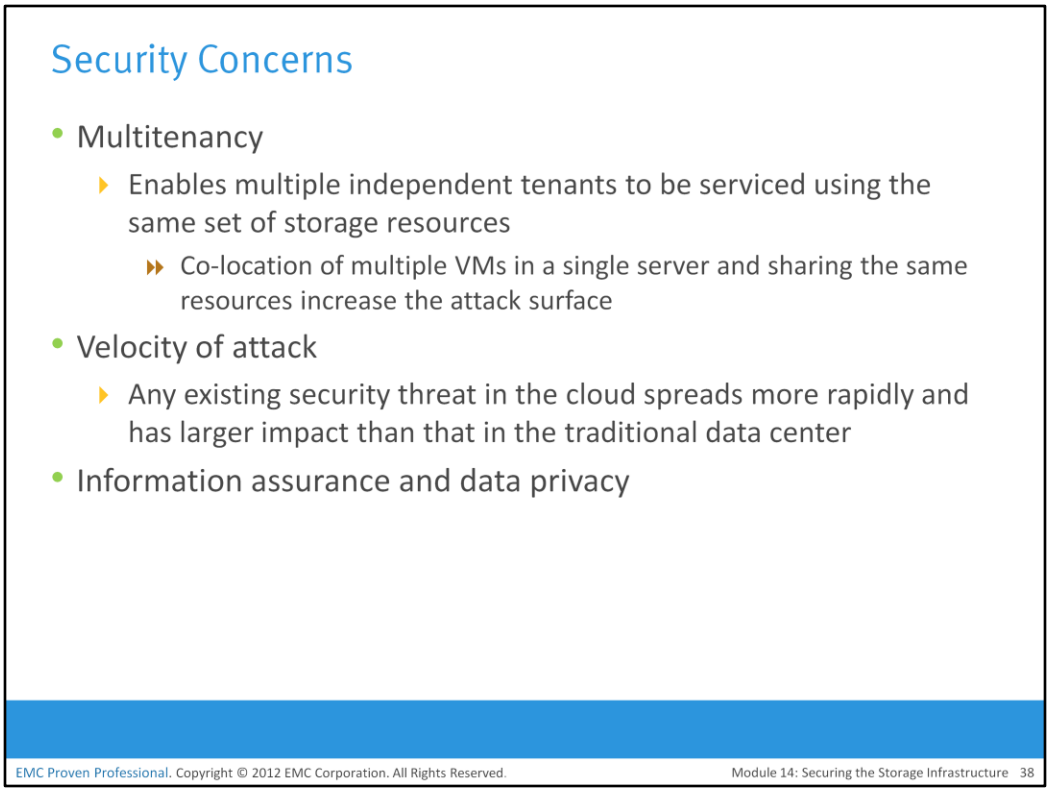
iSNS discovery domains function in the same way as FC zones. Discovery domains provide functional groupings of devices in an IP-SAN. For devices to communicate with one another, they must be configured in the same discovery domain. State change notifications (SCNs) inform the iSNS server when devices are added to or removed from a discovery domain.



This lesson covers an overview of security in virtualized and cloud environment. This lesson also covers security concerns and measures in virtualized and cloud environment.



This module, so far, focused only on the security threats and measures in a traditional data center. These threats and measures are also applicable to information storage in virtualized and cloud environments. However, virtualized and cloud computing environments pose additional threats to an organization's data due to multitenancy and lack of control over the cloud resources. A public cloud has more security concerns compared to a private cloud and demands additional counter measures. This is because in a public cloud, cloud users (consumers) usually have limited control over resources, and therefore, enforcement of security mechanisms for consumers is comparatively difficult. From a security perspective, both consumers and cloud service providers (CSP) have several security concerns and face multiple threats.

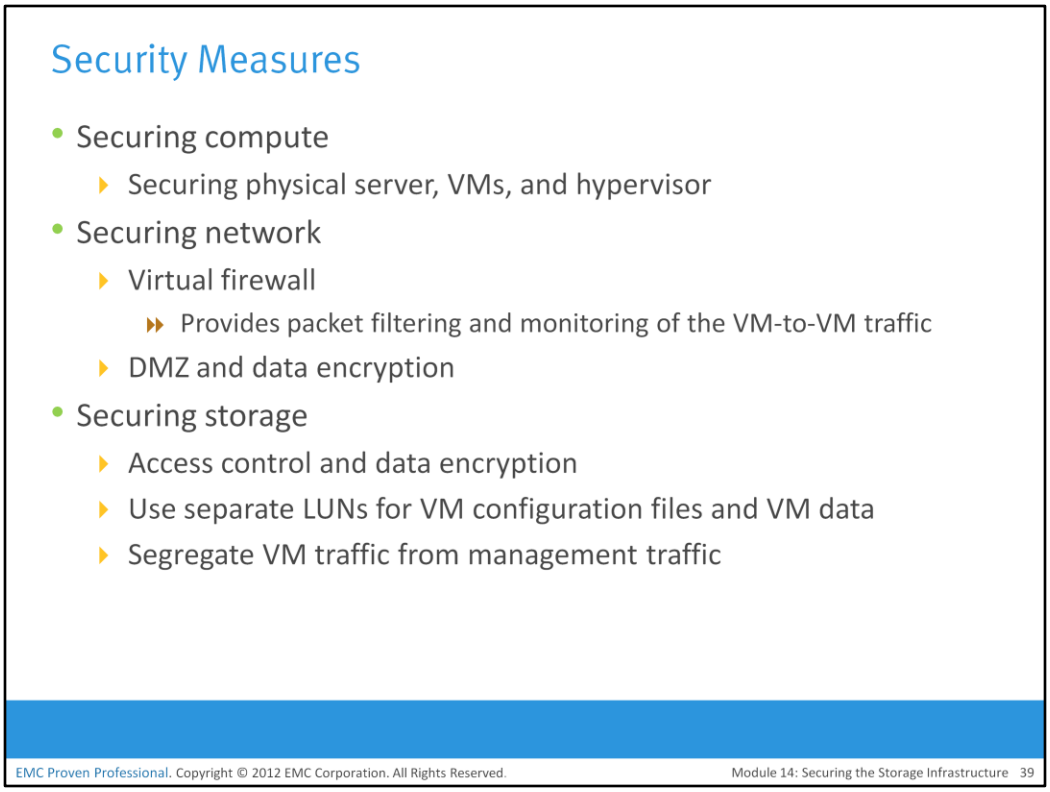


Organizations are rapidly adopting virtualization and cloud computing, however they have some security concerns. These key security concerns are multitenancy, velocity of attack, information assurance, and data privacy.

Multitenancy, by virtue of virtualization, enables multiple independent tenants to be serviced using the same set of storage resources. In spite of the benefits offered by multitenancy, it is still a key security concern for users and service providers. Colocation of multiple VMs in a single server and sharing the same resources increase the attack surface. It may happen that business critical data of one tenant is accessed by other competing tenants who run applications using the same resources.

Velocity-of-attack refers to a situation in which any existing security threat in the cloud spreads more rapidly and has a larger impact than that in the traditional data center environments. *Information assurance* for users ensures confidentiality, integrity, and availability of data in the cloud. Also the cloud user needs assurance that all the users operating on the cloud are genuine and access the data only with legitimate rights and scope.

Data privacy is also a major concern in a virtualized and cloud environment. A CSP needs to ensure that Personally Identifiable Information (PII) about its clients is legally protected from any unauthorized disclosure.



Major threats to storage systems in virtualized and cloud environments arise due to compromises at compute, network, and physical security levels. This is because access to storage systems is provided by using compute and network infrastructure. Therefore, adequate security measures should be in place at the compute and network levels to ensure storage security.

Securing a compute infrastructure includes enforcing the security of the physical server, hypervisor, VM, and guest OS (OS running within a virtual machine). Physical server security involves implementing user authentication and authorization mechanisms. These mechanisms identify users and provide access privileges on the server. To minimize the attack surface on the server, unused hardware components, such as NICs, USB ports, or drives, should be removed or disabled.

A *hypervisor* is a single point of security failure for all the VMs running on it. Rootkits and malware installed on a hypervisor make detection difficult for the antivirus software installed on the guest OS. To protect against attacks, security-critical hypervisor updates should be installed regularly. Further, the hypervisor management system must also be protected. Malicious attacks and infiltration to the management system can impact all the existing VMs and allow attackers to create new VMs. Access to the management system should be restricted to authorized administrators. Furthermore, there must be a separate firewall installed between the management system and the rest of the network.

Cont..

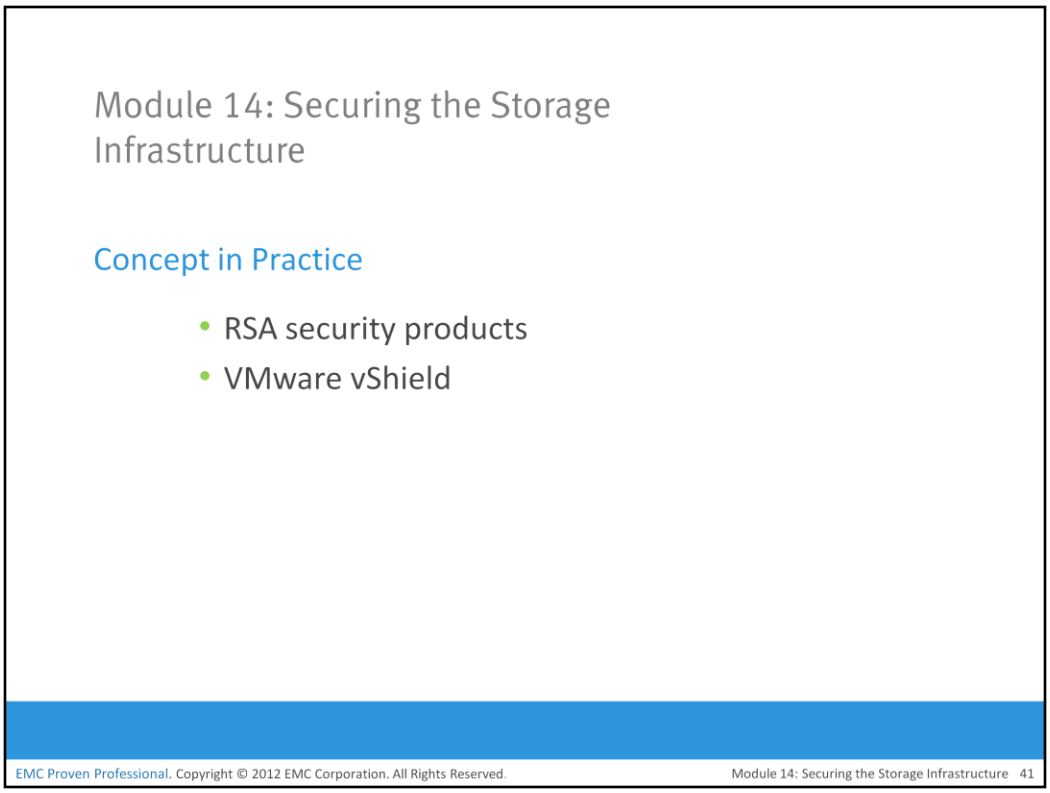
VM isolation and *hardening* are some of the common security mechanisms to effectively safeguard a VM from an attack. VM isolation helps to prevent a compromised guest OS from impacting other guest OSs. VM isolation is implemented at the hypervisor level. Apart from isolation, VMs should be hardened against security threats. Hardening is a process to change the default configuration to achieve greater security.

The key security measures that minimize vulnerabilities at the network layer are firewall, intrusion detection, demilitarized zone (DMZ), and encryption of data-in-flight. In a virtualized and cloud environment, a firewall can also protect hypervisors and VMs. For example, if remote administration is enabled on a hypervisor, access to all the remote administration interfaces should be restricted by a firewall. A firewall also secure VM-to-VM traffic. This firewall service can be provided using a *Virtual Firewall* (VF) running on the hypervisor. VF gives visibility and control over the VM traffic and enforces policies at the VM level. DMZ and data encryption are also deployed as security measures in the virtualized and cloud environments. However, these deployments work in the same way as in the traditional data center.

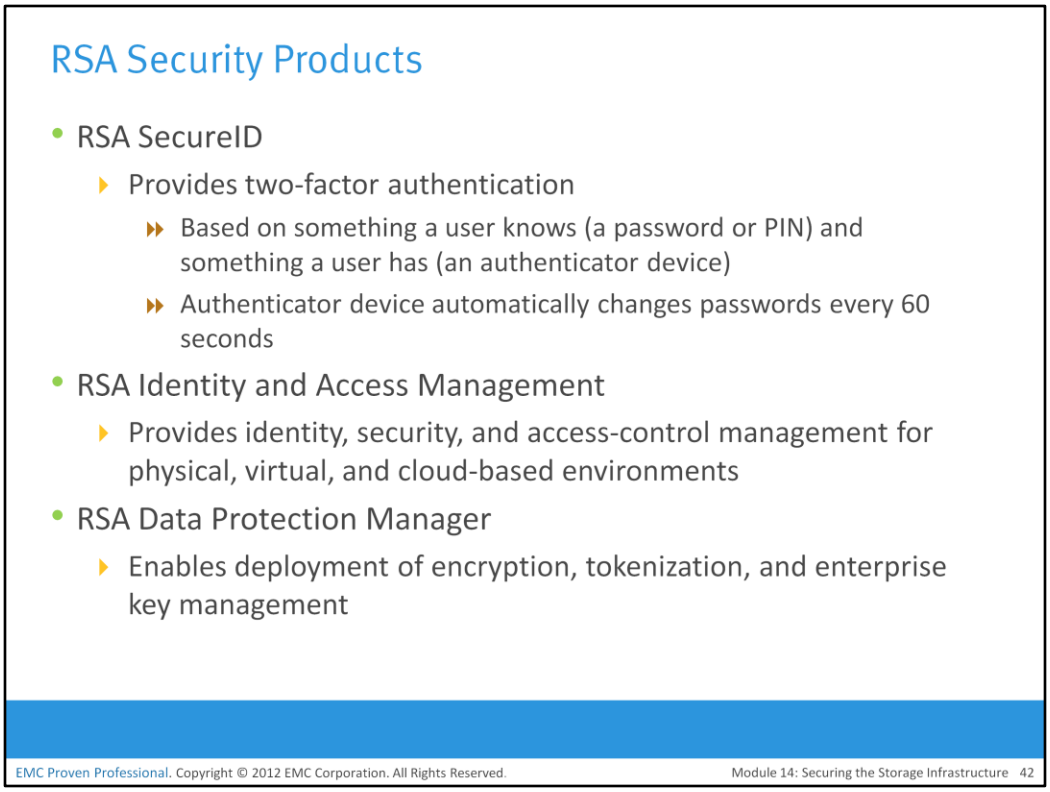
Common security mechanisms that protect storage include the following:

- Access control methods to regulate which users and processes access the data on the storage systems
- Zoning and LUN masking
- Encryption of data-at-rest (on the storage system) and data-in-transit. Data encryption should also include encrypting backups and storing encryption keys separately from the data.
- Data shredding that removes the traces of the deleted data

Apart from these mechanisms, isolation of different types of traffic using VSANs further enhances the security of storage systems. In the case of storage utilized by hypervisors, additional security steps are required to protect the storage. Storage for hypervisors using clustered file systems supporting multiple VMs may require separate LUNs for VM components and VM data.



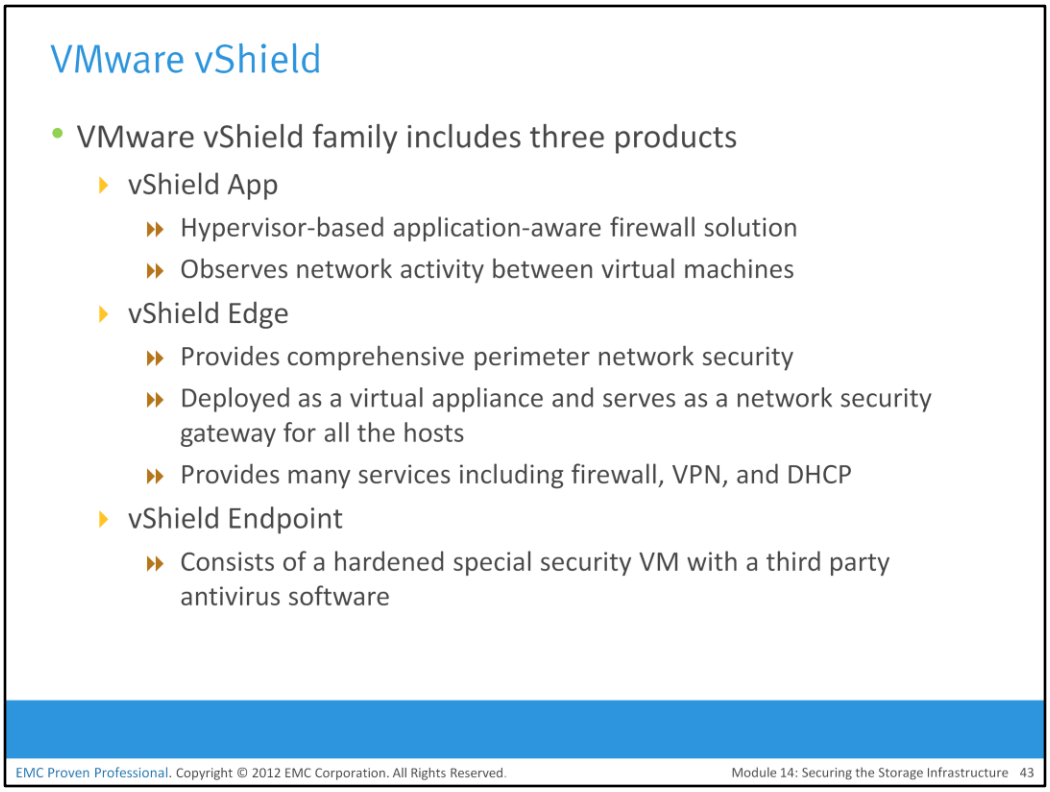
The concepts in practice section covers various security products of RSA and VMware. The product includes RSA SecureID, RSA Identity and Access Management, RSA Data Protection Manager, and VMware vShield.



RSA SecurID two-factor authentication provides an added layer of security to ensure that only valid users have access to systems and data. RSA SecurID is based on something a user knows (a password or PIN) and something a user has (an authenticator device). It generates a new one-time password code every 60 seconds, making it difficult for anyone other than the genuine user to input the correct token code at any given time. To access their resources, users combine their secret Personal Identification Number (PIN) with the token code that appears on their SecurID authenticator display at that given time. The result is a unique, one-time password used to assure a user's identity.

The RSA Identity and Access Management product provides identity, security, and access-control management for physical, virtual, and cloud-based environments through access management. It enables trusted identities to freely and securely interact with systems and access. The RSA Identity and Access Management family has two products: *RSA Access Manager* and *RSA Federated Identity Manager*. RSA Access Manager enables organizations to centrally manage authentication and authorization policies for a large number of users, online web portals, and application resources. RSA Federated Identity Manager enables end users to collaborate with business partners, outsourced service providers, and supply-chain partners or across multiple offices or agencies all with a single identity and logon.

RSA Data Protection Manager enables deployment of encryption, tokenization, and enterprise key management simply and affordably. RSA Data Protection Manager family is composed of two products: *Application Encryption and Tokenization* and *Enterprise Key Management.* Application Encryption and Tokenization with RSA Data Protection Manager helps to achieve compliance with regulations related to PII. Enterprise key management is an easy-to-use management tool for encrypting keys at the database, file server and storage layers.

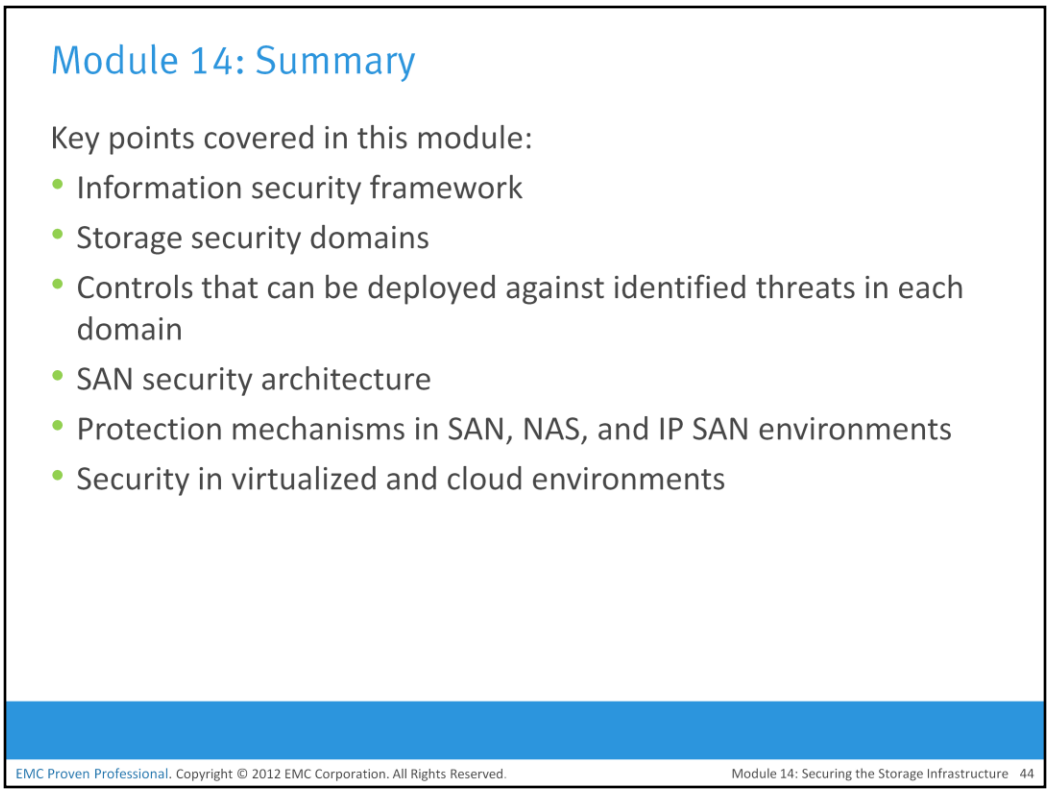


The VMware vShield family includes three products: *vShield App, vShield Edge,* and *vShield Endpoint*.

VMware vShield App is a hypervisor-based application-aware firewall solution. It protects applications in a virtualized environment from network-based threats by providing visibility into network communications and enforcing granular policies with security groups. VMware vShield App observes network activity between virtual machines to define and refine firewall policies and secure business processes through detailed reporting of application traffic.

VMware vShield Edge provides comprehensive perimeter network security for a virtualized environment. It is deployed as a virtual appliance and serves as a network security gateway for all the hosts within the virtualized environment. It provides many services including firewall, VPN, and Dynamic Host Configuration Protocol (DHCP) services.

VMware vShield Endpoint consists of a hardened special security VM with a third party antivirus software. VMware vShield Endpoint streamlines and accelerates antivirus and antimalware deployment because antivirus engine and signature files are updated only within the special security VM. VMware vShield Endpoint improves VM performance by offloading file scanning and other tasks from VMs to the security VM. It prevents antivirus storms and bottlenecks associated with multiple simultaneous antivirus and antimalware scans and updates. It also satisfies audit requirements with detailed logging of antivirus and antimalware activities.



This module covered information security framework and various storage security domains. This module also covered security implementation in SAN, NAS, and IP SAN. Further this module covered security in virtualized and cloud environment.

The basic security framework for storage is built around the four primary services of security: confidentiality, integrity, availability, and accountability.

To identify the threats that apply to a storage network, access paths to data storage can be categorized into three security domains: *application access*, *management access*, and *backup, replication, and archive*.

Storage networking environments are potential target for unauthorized access, theft, and misuse because of the vastness and complexity of these environments. Therefore, security strategies are based on the *defense-in-depth* concept, which recommends multiple integrated layers of security.

LUN masking and zoning, security in FC switch port, switch-wide and fabric-wide access control, and logical partitioning of a fabric (Virtual SAN) are the most commonly used SAN security methods. Permissions and ACLs, Kerberos and directory services, and firewalls are the common security mechanisms implemented in NAS. CHAP and iSNS discovery domain are the security measures implemented in IP SAN environment.

Virtualized and cloud computing environments pose additional threats to an organization's data due to multitenancy and lack of control over the cloud resources.

Check Your Knowledge – 1

- Which attack involves performing an action and eliminating evidence that could prove the identity of the attacker?
  - A. Denial of service
  - B. Eavesdropping
  - C. Repudiation
  - D. Snooping

- What is a role of Active Directory in Kerberos authentication?
  - A. Implements the authentication service and ticket granting service
  - B. Verifies the session ID when the client-server session is established
  - C. Verifies user's login information
  - D. Maintains the security key for the servers

Check Your Knowledge – 2

- How vulnerabilities can be reduced in an IT environment?
  - A. By maximizing attack surface and minimizing work factor
  - B. By minimizing attack surface and maximizing work factor
  - C. By maximizing both attack surface and work factor
  - D. By minimizing both attack surface and work factor

- Which SAN security mechanism prevents a switch port from being enabled even after a switch reboot?
  - A. Port lockdown
  - B. Persistent port disable
  - C. Port binding
  - D. Port zoning

Check Your Knowledge – 3

- Which security mechanism ensures that a port can only be initialized with a specific port type?
  - A. Port lockdown
  - B. Persistent port disable
  - C. Port binding
  - D. Port zoning