Operating System Security

3.3. Outline

- Introduction to Operating System Security
- System Security Planning
- Operating Systems Hardening
- Application Security
- Security Maintenance
- Linux/UNIX Security
- Windows Security
- Virtualization Security

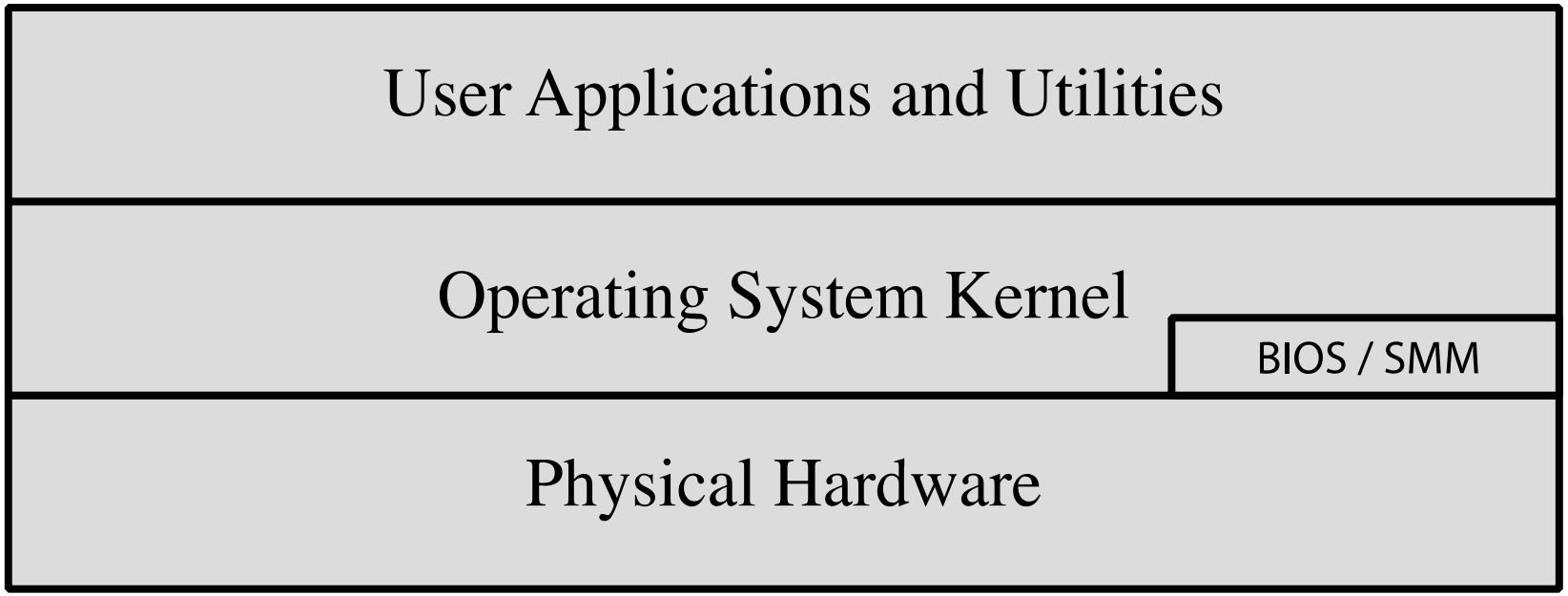


Figure 12.1 Operating System Security Layers

Strategies

- The 2010 Australian Signals Directorate (ASD) lists the "Top 35 Mitigation Strategies"
- Over 85% of the targeted cyber intrusions investigated by ASD in 2009 could have been prevented
- The top four strategies for prevention are:
  - White-list approved applications
  - Patch third-party applications and operating system vulnerabilities
  - Restrict administrative privileges
  - Create a defense-in-depth system
- These strategies largely align with those in the "20 Critical Controls" developed by DHS, NSA, the Department of Energy, SANS, and others in the United States

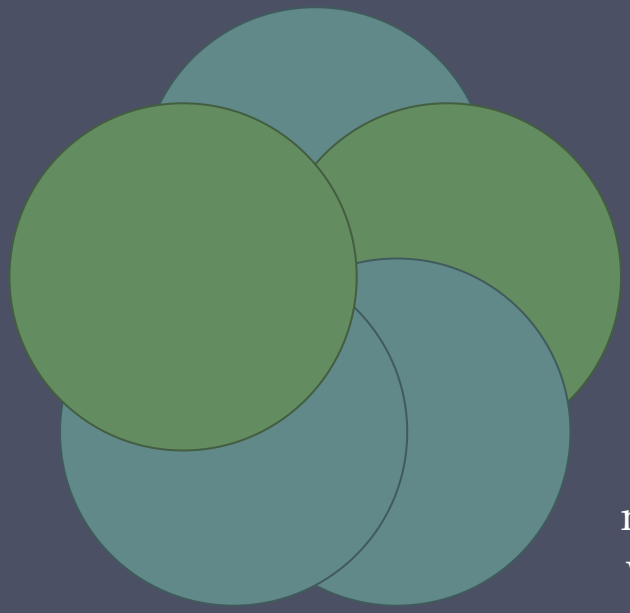
Operating System Security

- Possible for a system to be compromised during the installation process before it can install the latest patches
- Building and deploying a system should be a planned process designed to counter this threat
- Process must:
  - Assess risks and plan the system deployment
  - Secure the underlying operating system and then the key applications
  - Ensure any critical content is secured
  - Ensure appropriate network protection mechanisms are used
  - Ensure appropriate processes are used to maintain security

System Security Planning

The first step in deploying a new system is planning

Plan needs to identify appropriate personnel and training to install and manage the system

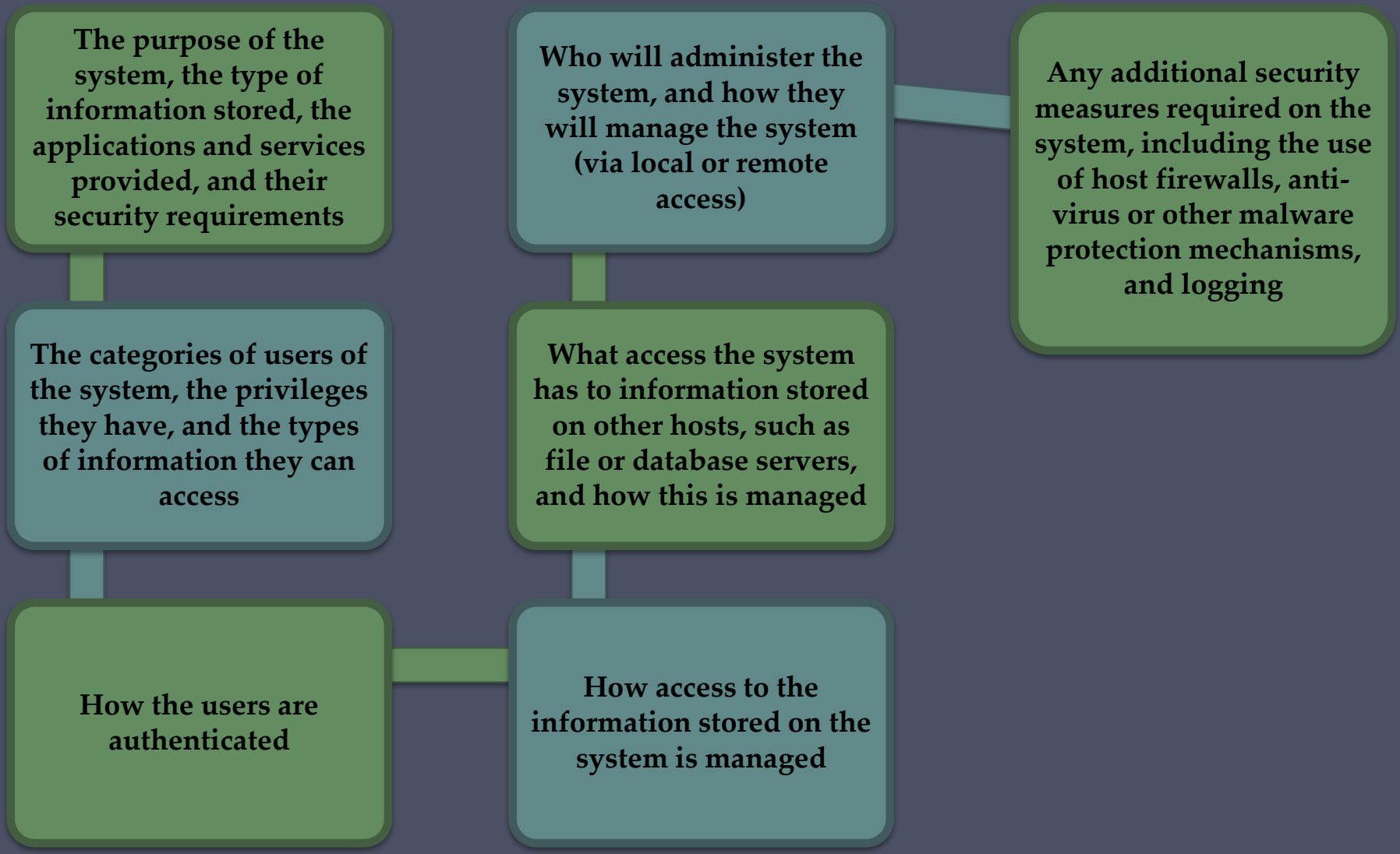


Planning should include a wide security assessment of the organization

Planning process needs to determine security requirements for the system, applications, data, and users

Aim is to maximize security while minimizing costs

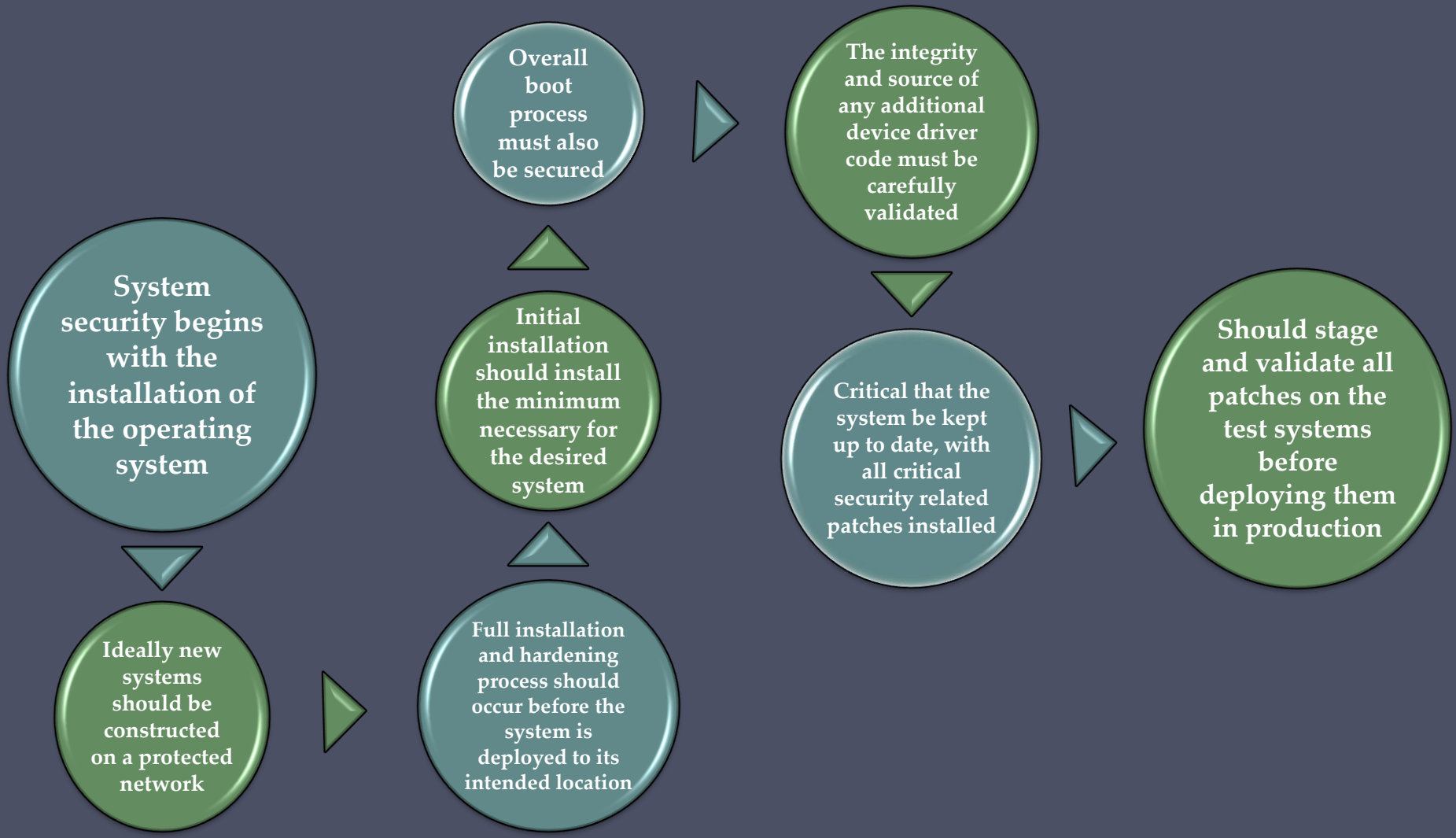
System Security Planning Process



Operating Systems Hardening

- First critical step in securing a system is to secure the base operating system
- Basic steps
  - Install and patch the operating system
  - Harden and configure the operating system to adequately address the indentified security needs of the system by:
    - Removing unnecessary services, applications, and protocols
    - Configuring users, groups, and permissions
    - Configuring resource controls
  - Install and configure additional security controls, such as anti-virus, host-based firewalls, and intrusion detection system (IDS)
  - Test the security of the basic operating system to ensure that the steps taken adequately address its security needs

Initial Setup and Patching



- If fewer software packages are available to run the risk is reduced
- System planning process should identify what is actually required for a given system

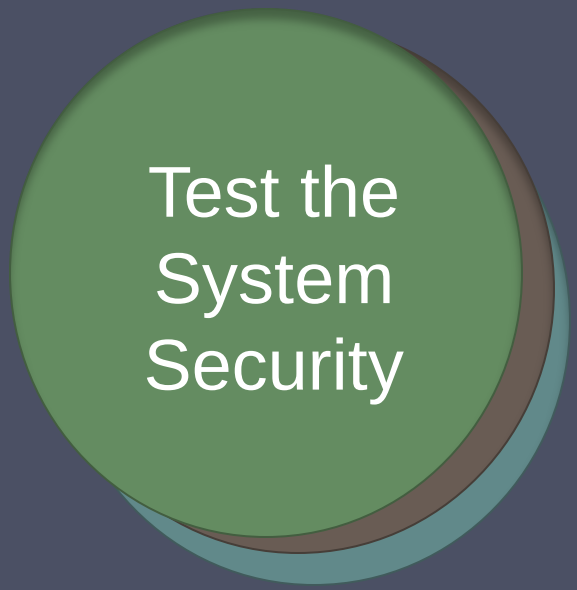
- When performing the initial installation the supplied defaults should not be used
  - Default configuration is set to maximize ease of use and functionality rather than security
  - If additional packages are needed later they can be installed when they are required

- Not all users with access to a system will have the same access to all data and resources on that system
- Elevated privileges should be restricted to only those users that require them, and then only when they are needed to perform a task

- System planning process should consider:
  - Categories of users on the system
  - Privileges they have
  - Types of information they can access
  - How and where they are defined and authenticated
- Default accounts included as part of the system installation should be secured
  - Those that are not required should be either removed or disabled
  - Policies that apply to authentication credentials configured

- Once the users and groups are defined, appropriate permissions can be set on data and resources
- Many of the security hardening guides provide lists of recommended changes to the default access configuration

- Further security possible by installing and configuring additional security tools:
  - Anti-virus software
  - Host-based firewalls
  - IDS or IPS software
  - Application white-listing



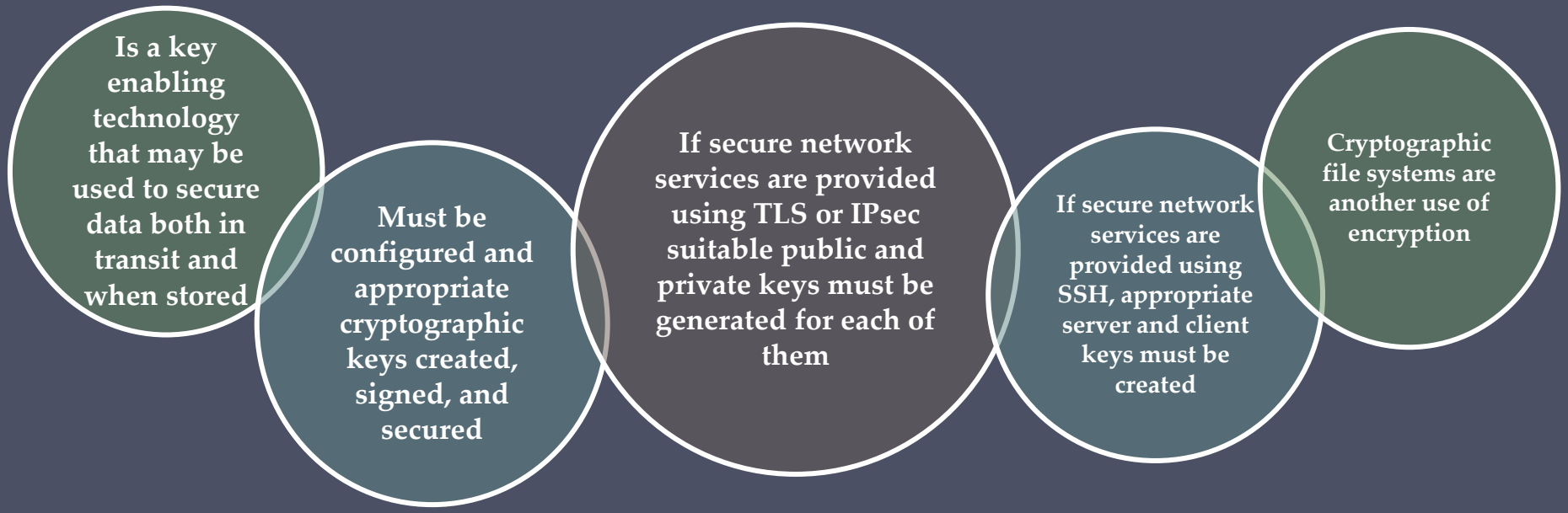
- Final step in the process of initially securing the base operating system is security testing
- Goal:
  - Ensure the previous security configuration steps are correctly implemented
  - Identify any possible vulnerabilities

- Checklists are included in security hardening guides
- There are programs specifically designed to:
  - Review a system to ensure that a system meets the basic security requirements
  - Scan for known vulnerabilities and poor configuration practices
- Should be done following the initial hardening of the system
- Repeated periodically as part of the security maintenance process

Application Configuration

- May include:
  - Creating and specifying appropriate data storage areas for application
  - Making appropriate changes to the application or service default configuration details
- Some applications or services may include:
  - Default data
  - Scripts
  - User accounts
- Of particular concern with remotely accessed services such as Web and file transfer services
  - Risk from this form of attack is reduced by ensuring that most of the files can only be read, but not written, by the server

Encryption Technology



Security Maintenance

- Process of maintaining security is continuous
- Security maintenance includes:
  - Monitoring and analyzing logging information
  - Performing regular backups
  - Recovering from security compromises
  - Regularly testing system security
  - Using appropriate software maintenance processes to patch and update all critical software, and to monitor and revise configuration as needed

Logging

Can only inform you about bad things that have already happened

In the event of a system breach or failure, system administrators can more quickly identify what happened

Key is to ensure you capture the correct data and then appropriately monitor and analyze this data

Information can be generated by the system, network and applications

Range of data acquired should be determined during the system planning stage

Generates significant volumes of information and it is important that sufficient space is allocated for them

Automated analysis is preferred

Data Backup and Archive

Performing regular backups of data is a critical control that assists with maintaining the integrity of the system and user data

- May be legal or operational requirements for the retention of data

Backup

- The process of making copies of data at regular intervals

Archive

- The process of retaining copies of data over extended periods of time in order to meet legal and operational requirements to access past data

Needs and policy relating to backup and archive should be determined during the system planning stage

- Kept online or offline
- Stored locally or transported to a remote site
  - Trade-offs include ease of implementation and cost versus greater security and robustness against different threats

Linux/Unix Security

- Patch management
  - Keeping security patches up to date is a widely recognized and critical control for maintaining security
- Application and service configuration
  - Most commonly implemented using separate text files for each application and service
  - Generally located either in the /etc directory or in the installation tree for a specific application
  - Individual user configurations that can override the system defaults are located in hidden “dot” files in each user’s home directory
  - Most important changes needed to improve system security are to disable services and applications that are not required

Linux/Unix Security

- Users, groups, and permissions
  - Access is specified as granting read, write, and execute permissions to each of owner, group, and others for each resource
  - Guides recommend changing the access permissions for critical directories and files
  - Local exploit
    - Software vulnerability that can be exploited by an attacker to gain elevated privileges
  - Remote exploit
    - Software vulnerability in a network server that could be triggered by a remote attacker

Linux/Unix Security

Remote access controls

- Several host firewall programs may be used
- Most systems provide an administrative utility to select which services will be permitted to access the system

Logging and log rotation

- Should not assume that the default setting is necessarily appropriate

Linux/Unix Security

- chroot jail
  - Restricts the server's view of the file system to just a specified portion
  - Uses chroot system call to confine a process by mapping the root of the filesystem to some other directory
  - File directories outside the chroot jail aren't visible or reachable
  - Main disadvantage is added complexity

Windows Security

Patch management

- "Windows Update" and "Windows Server Update Service" assist with regular maintenance and should be used
- Third party applications also provide automatic update support

Users administration and access controls

- Systems implement discretionary access controls resources
- Vista and later systems include mandatory integrity controls
- Objects are labeled as being of low, medium, high, or system integrity level
- System ensures the subject's integrity is equal or higher than the object's level
- Implements a form of the Biba Integrity model

Windows Security Users Administration and Access Controls

Windows systems also define privileges

- System wide and granted to user accounts

Combination of share and NTFS permissions may be used to provide additional security and granularity when accessing files on a shared resource

User Account Control (UAC)

- Provided in Vista and later systems
- Assists with ensuring users with administrative rights only use them when required, otherwise accesses the system as a normal user

Low Privilege Service Accounts

- Used for long-lived service processes such as file, print, and DNS services

Windows Security

Application and service configuration

- Much of the configuration information is centralized in the Registry
  - Forms a database of keys and values that may be queried and interpreted by applications
- Registry keys can be directly modified using the "Registry Editor"
  - More useful for making bulk changes

Windows Security

Other security controls

- Essential that anti-virus, anti-spyware, personal firewall, and other malware and attack detection and handling software packages are installed and configured
- Current generation Windows systems include basic firewall and malware countermeasure capabilities
- Important to ensure the set of products in use are compatible

Windows systems also support a range of cryptographic functions:

- Encrypting files and directories using the Encrypting File System (EFS)
- Full-disk encryption with AES using BitLocker

"Microsoft Baseline Security Analyzer"

- Free, easy to use tool that checks for compliance with Microsoft's security recommendations

Virtualization

- A technology that provides an abstraction of the resources used by some software which runs in a simulated environment called a virtual machine (VM)
- Benefits include better efficiency in the use of the physical system resources
- Provides support for multiple distinct operating systems and associated applications on one physical system
- Raises additional security concerns

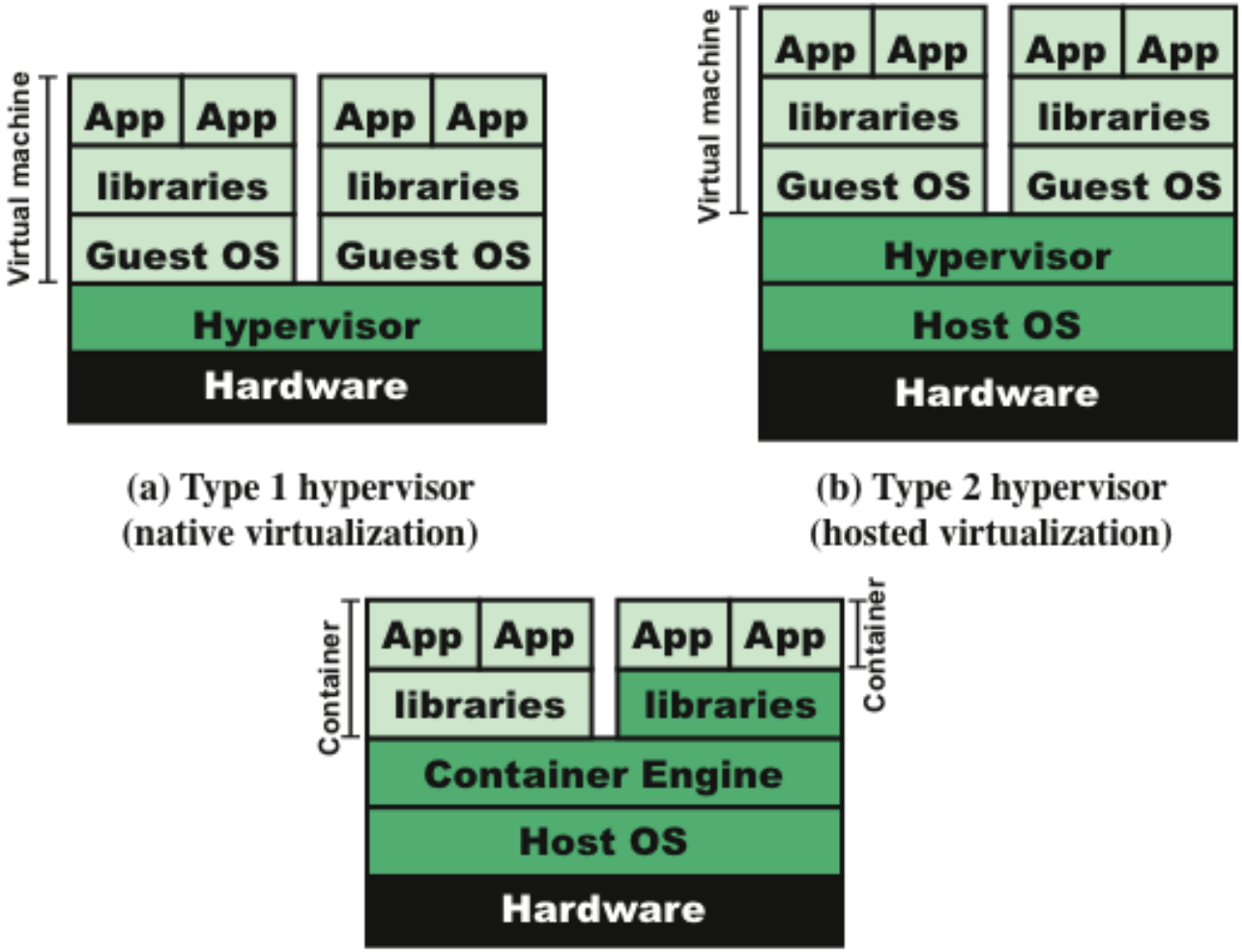
Hypervisor

- Software that sits between the hardware and the VMs
- Acts as a resource broker
- It allows multiple VMs to safely coexist on a single physical server host and share that host's resources
- Virtualizing software provides abstraction of all physical resources and thus enables multiple computing stacks, called virtual machines, to be run on a single physical host
- Each VM includes an OS, called the guest OS
    - This OS may be the same as the host OS, if present, or a different one

Hypervisor Functions

The principal functions performed by a hypervisor are:

- Execution management of VMs
- Devices emulation and access control
- Execution of privileged operations by hypervisor for guest VMs
- Management of VMs (also called VM lifecycle management)
- Administration of hypervisor platform and hypervisor software



(a) Type 1 hypervisor (native virtualization)

(b) Type 2 hypervisor (hosted virtualization)

(c) Container (application virtualization)

Figure 12.2 Comparison of Virtual Machines and Containers

Virtualized Systems

- In virtualized systems, the available hardware resources must be appropriately shared among the various guest OS's
- These include CPU, memory, disk, network, and other attached devices
- CPU and memory are generally partitioned between these, and scheduled as required
- Disk storage may be partitioned, with each guest having exclusive use of some disk resources
- Alternatively, a "virtual disk" may be created for each guest, which appears to it as a physical disk with a full file-system, but is viewed externally as a single "disk image" file on the underlying file-system
- Attached devices such as optical disks, or USB devices are generally allocated to a single guest OS at a time

Software Defined Networks (SDNs)

SDNs enable network segments to logically span multiple servers within and between data centers, while using the same underlying physical network

There are several possible approaches to providing SDNs, including the use of overlay networks

- These abstract all layer 2 and 3 addresses from the underlying physical network into whatever logical network structure is required
- This structure can be easily changed and extended as needed
- The IETF standard DOVE (Distributed Overlay Virtual Network) which uses VXLAN (Virtual Extended Local Area Network) can be used to implement such an overlay network
- With this flexible structure, it is possible to locate virtual servers, virtual IDS, and virtual firewalls anywhere within the network as required

Containers

- A recent approach to virtualization is known as *container virtualization* or *application virtualization*
- In this approach, software known as a *virtualization container,* runs on top of the host OS kernel and provides an isolated execution environment for applications
- Unlike hypervisor-based VMs, containers do not aim to emulate physical servers
- All containerized applications on a host share a common OS kernel
- For containers, only a small container engine is required as support for the containers
- Containerization sits in between the OS and applications and incurs lower overhead, but potentially introduces greater security vulnerabilities

Virtualization Security Issues

- Security concerns include:
  - Guest OS isolation
    - Ensuring that programs executing within a guest OS may only access and use the resources allocated to it
  - Guest OS monitoring by the hypervisor
    - Which has privileged access to the programs and data in each guest OS
  - Virtualized environment security
    - Particularly image and snapshot management which attackers may attempt to view or modify

Securing Virtualization Systems

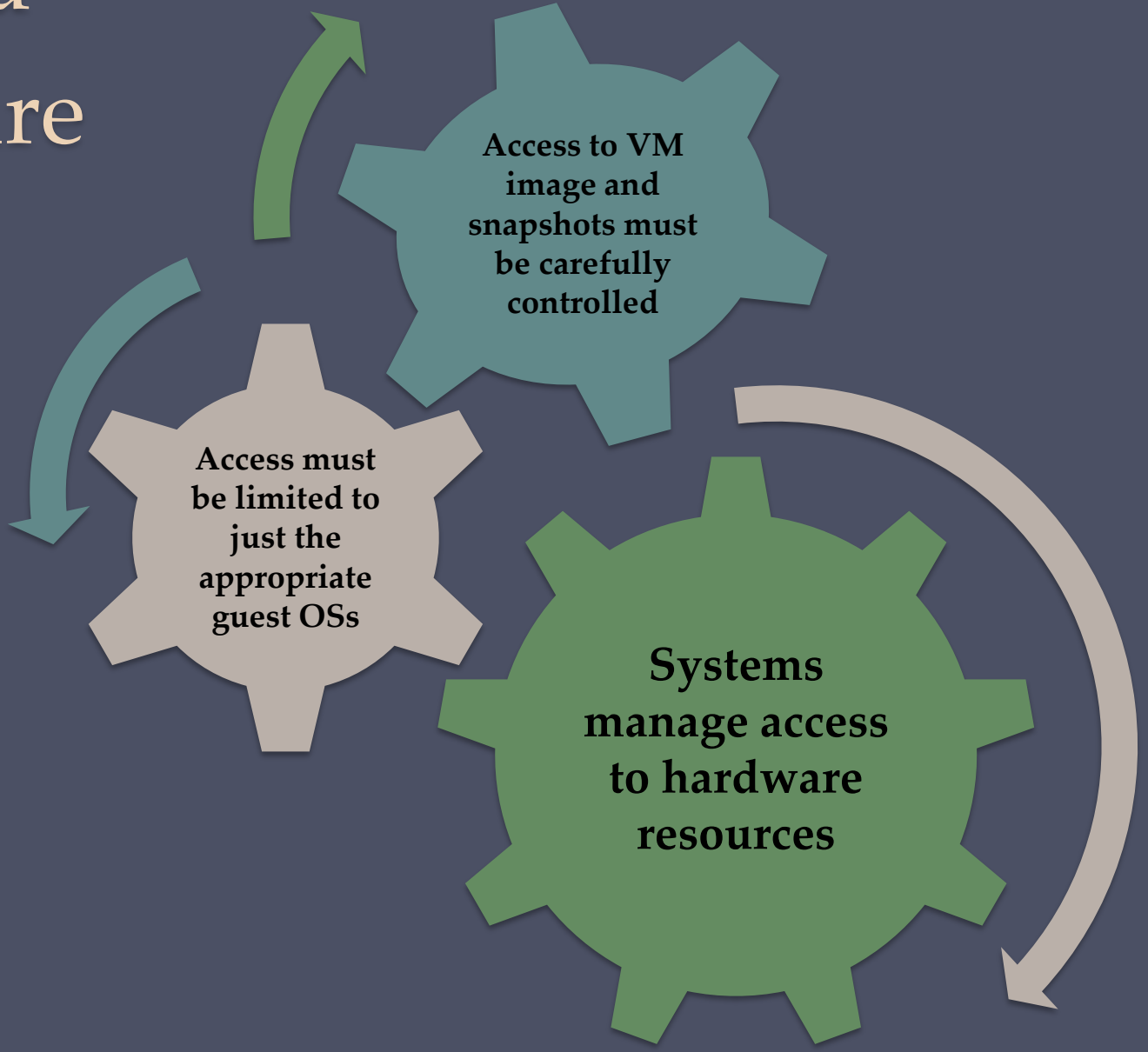
Organizations using virtualization should:

- **Carefully plan the security of the virtualized system**
- **Secure all elements of a full virtualization solution and maintain their security**
- **Ensure that the hypervisor is properly secured**
- **Restrict and protect administrator access to the virtualization solution**

Hypervisor Security

- Should be
  - Secured using a process similar to securing an operating system
  - Installed in an isolated environment
  - Configured so that it is updated automatically
  - Monitored for any signs of compromise
  - Accessed only by authorized administration
- May support both local and remote administration so must be configured appropriately
- Remote administration access should be considered and secured in the design of any network firewall and IDS capability in use
- Ideally administration traffic should use a separate network with very limited access provided from outside the organization

Virtualized Infrastructure Security



Virtual Firewall

Provides firewall capabilities for the network traffic flowing between systems hosted in a virtualized or cloud environment that does not require this traffic to be routed out to a physically separate network supporting traditional firewall services

VM Bastion Host

Where a separate VM is used as a bastion host supporting the same firewall systems and services that could be configured to run on a physically separate bastion, including possibly IDS and IPS services

VM Host-Based Firewall

Where host-based firewall capabilities provided by the Guest OS running on the VM are configured to secure that host in the same manner as used in physically separate systems

Hypervisor Firewall

Where firewall capabilities are provided directly by the hypervisor