CCNA 1 v7.0 Curriculum: Module 16 – Network Security Fundamentals

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16.0 – Introduction

16.0.1. Why should I take this module?

Welcome to Network Security Fundamentals!

You may have already set up a network, or you may be getting ready to do just that. Here is something to think about. Setting up a network without securing it is like opening all the doors and windows to your home and then going on vacation. Anyone could come by, gain entry, steal or break items, or just make a mess. As you have seen on the news, it is possible to break into any network! As a network administrator, it is part of your job to make it difficult for threat actors to gain access to your network. This module gives you an overview of types of network attacks and what you can do to reduce a threat actor's chances of succeeding. It also has Packet Tracer activities to let you practice some basic techniques for network security. If you have a network, but it is not as secure as possible, then you will want to read this module right now!

16.0.2. What will I learn to do in this module?

Module Title: Network Security Fundamentals

Module Objective: Configure switches and routers with device hardening features to enhance security.

Topic Title	Topic Objective
Security Threats and Vulnerabilities	Explain why basic security measure are necessary on network devices.
Network Attacks	Identify security vulnerabilities.
Network Attack Mitigation	Identify general mitigation techniques.
Device Security	Configure network devices with device hardening features to mitigate security threats.

16.1. Security Threats and Vulnerabilities

16.1.1. Types of Threats

Wired and wireless computer networks are essential to everyday activities. Individuals and organizations depend on their computers and networks. Intrusion by an unauthorized person can result in costly network outages and loss of work. Attacks on a network can be devastating and can result in a loss of time and money due to damage, or theft of important information or assets.

Intruders can gain access to a network through software vulnerabilities, hardware attacks, or through guessing someone's username and password. Intruders who gain access by modifying software or exploiting software vulnerabilities are called threat actors.

After the threat actor gains access to the network, four types of threats may arise.

Click each button for information about each threat.

Information theft is breaking into a computer to obtain confidential information. Information can be used or sold for various purposes. Example: stealing an organization's proprietary information, such as research and development data.

Data loss and manipulation is breaking into a computer to destroy or alter data records. An example of data loss is a threat actor sending a virus that reformats a computer hard drive. An example of data manipulation is breaking into a records system to change information, such as the price of an item.

16.1.2. Types of Vulnerabilities

Vulnerability is the degree of weakness in a network or a device. Some degree of vulnerability is inherent in routers, switches, desktops, servers, and even security devices. Typically, the network devices under attack are the endpoints, such as servers and desktop computers.

There are three primary vulnerabilities or weaknesses: technological, configuration, and security policy. All three of these sources of vulnerabilities can leave a network or device open to various attacks, including malicious code attacks and network attacks.

Click each button for a table with examples and a description of each type of vulnerability.

Technological Vulnerabilities

Vulnerability	Description
TCP/IP Protocol Weakness	• Hypertext Transfer Protocol (HTTP), File Transfer Protocol (FTP), and Internet Control Message Protocol (ICMP) are inherently insecure. • Simple Network Management Protocol (SNMP) and Simple Mail Transfer Protocol (SMTP) are related to the inherently insecure structure upon which TCP was designed.
Operating System Weakness	• Each operating system has security problems what must be addressed. • UNIX, Linux, Mac OS, Mac OS X, Windows Server 2012, Windows 7, Windows 8 • They are documented in the Computer Emergency Response Team (CERT) archives at http://www.cert.org
Network Equipment Weakness	Various types of network equipment, such as routers, firewalls, and switches have security weaknesses that must be recognized and protected against. Their weaknesses include password protection, lack of authentication, routing protocols, and firewall holes.

Policy Vulnerabilities

Vulnerability	Description
Lack of written security policy	A security policy cannot be consistently applied or enforced if it is not written down.
Politics	Political battles and turf wars can make it difficult to implement a consistent security policy.
Lack of authentication continuity	Poorly chosen, easily cracked, or default passwords can allow unauthorized access to the network.
Logical access controls not applied	Inadequate monitoring and auditing allow attacks and unauthorized use to continue, wasting company resources. This could result in legal action or termination against IT technicians, IT management, or even company leadership that allows these unsafe conditions to persist.
Software and hardware installation and changes do not follow policy	Unauthorized changes to the network topology or installation of unapproved application create or enable holes in security.
Disaster recovery plan is nonexistent	The lack of a disaster recovery plan allows chaos, panic, and confusion to occur when a natural disaster occurs or a threat actor attacks the enterprise.

16.1.3. Physical Security

An equally important vulnerable area of the network to consider is the physical security of devices. If network resources can be physically compromised, a threat actor can deny the use of network resources.

The four classes of physical threats are as follows:

- **Hardware threats** – This includes physical damage to servers, routers, switches, cabling plant, and workstations.
- **Environmental threats** – This includes temperature extremes (too hot or too cold) or humidity extremes (too wet or too dry).
- **Electrical threats** – This includes voltage spikes, insufficient supply voltage (brownouts), unconditioned power (noise), and total power loss.
- **Maintenance threats** – This includes poor handling of key electrical components (electrostatic discharge), lack of critical spare parts, poor cabling, and poor labeling.

A good plan for physical security must be created and implemented to address these issues. The figure shows an example of physical security plan.

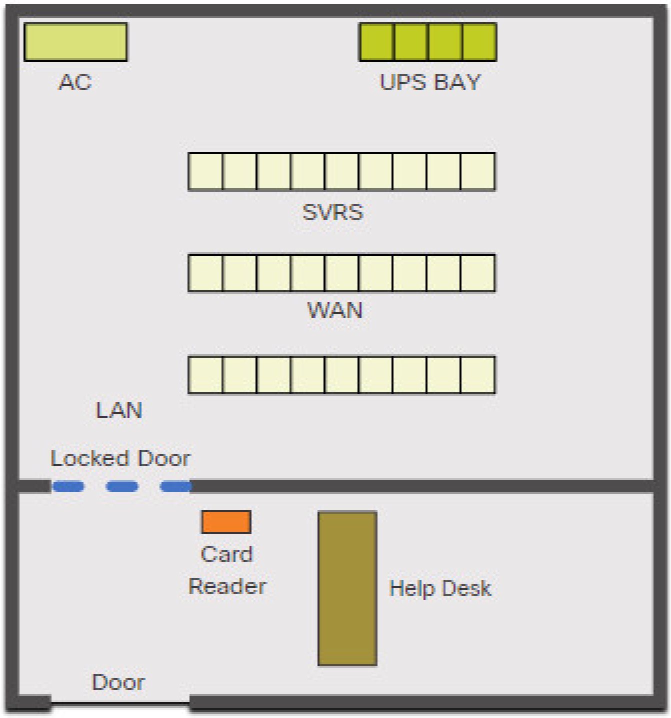
Plan Physical Security to Limit Damage to Equipment

- Secure computer room.
- Implement physical security to limit damage to the equipment.

Step 1. Lock up equipment and prevent unauthorized access from the doors, ceiling, raised floor, windows, ducts, and vents.

Step 2. Monitor and control closet entry with electronic logs.

Step 3. Use security cameras.



16.2. Network Attacks

16.2.1. Types of Malware

The previous topic explained the types of network threats and the vulnerabilities that make threats possible. This topic goes into more detail about how threat actors gain access to network or restrict authorized users from having access.

Malware is short for malicious software. It is code or software specifically designed to damage, disrupt, steal, or inflict “bad” or illegitimate action on data, hosts, or networks. Viruses, worms, and Trojan horses are types of malware.

Viruses

A computer virus is a type of malware that propagates by inserting a copy of itself into, and becoming part of, another program. It spreads from one computer to another, leaving infections as it travels. Viruses can range in severity from causing mildly annoying effects, to damaging data or software and causing denial of service (DoS) conditions. Almost all viruses are attached to an executable file, which means the virus may exist on a system but will not be active or able to spread until a user runs or opens the malicious host file or program. When the host code is executed, the viral code is executed as well. Normally, the host program keeps functioning after the virus infects it. However, some viruses overwrite other programs with copies of themselves, which destroys the host program altogether. Viruses spread when the software or document they are attached to is transferred from one computer to another using the network, a disk, file sharing, or infected email attachments.

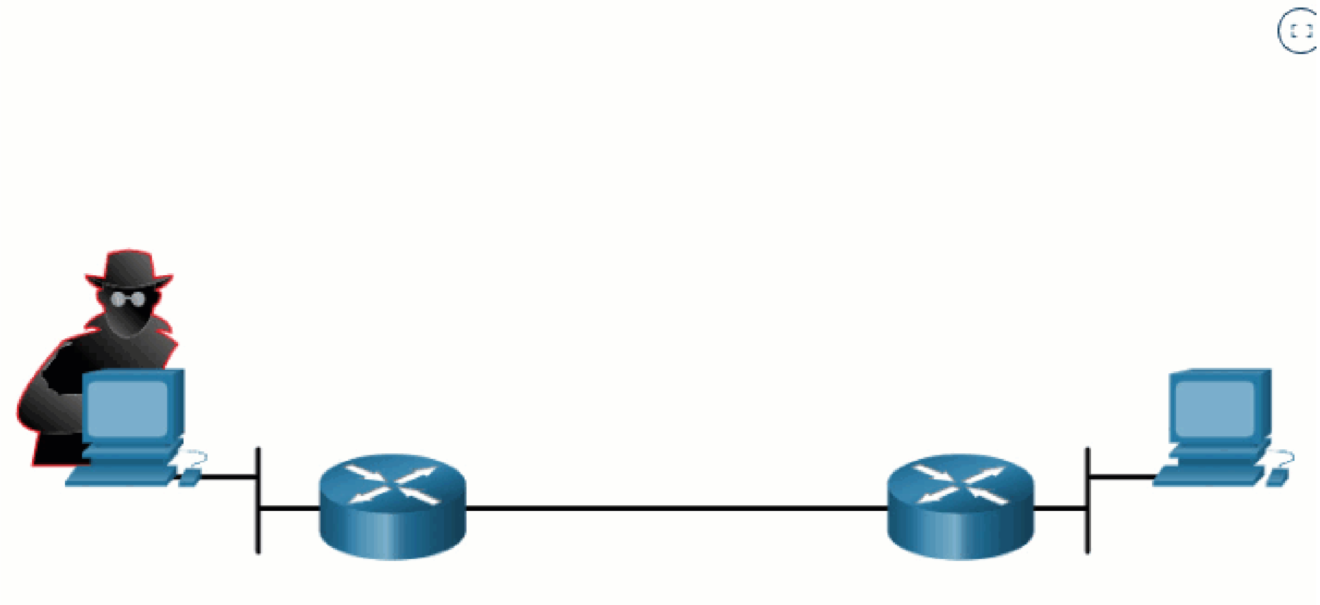
Worms

Computer worms are similar to viruses in that they replicate functional copies of themselves and can cause the same type of damage. In contrast to viruses, which require the spreading of an infected host file, worms are standalone software and do not require a host program or human help to propagate. A worm does not need to attach to a program to infect a host and enter a computer through a vulnerability in the system. Worms take advantage of system features to travel through the network unaided.

Trojan Horses

A Trojan horse is another type of malware named after the wooden horse the Greeks used to infiltrate Troy. It is a harmful piece of software that looks legitimate. Users are typically tricked into loading and executing it on their systems. After it is activated, it can achieve any number of attacks on the host, from irritating the user (with excessive pop-up windows or changing the desktop) to damaging the host (deleting files, stealing data, or activating and spreading other malware, such as viruses). Trojan horses are also known to create back doors to give malicious users access to the system.

Unlike viruses and worms, Trojan horses do not reproduce by infecting other files. They self-replicate. Trojan horses must spread through user interaction such as opening an email attachment or downloading and running a file from the internet.



Three types of malware

16.2.2. Reconnaissance Attacks

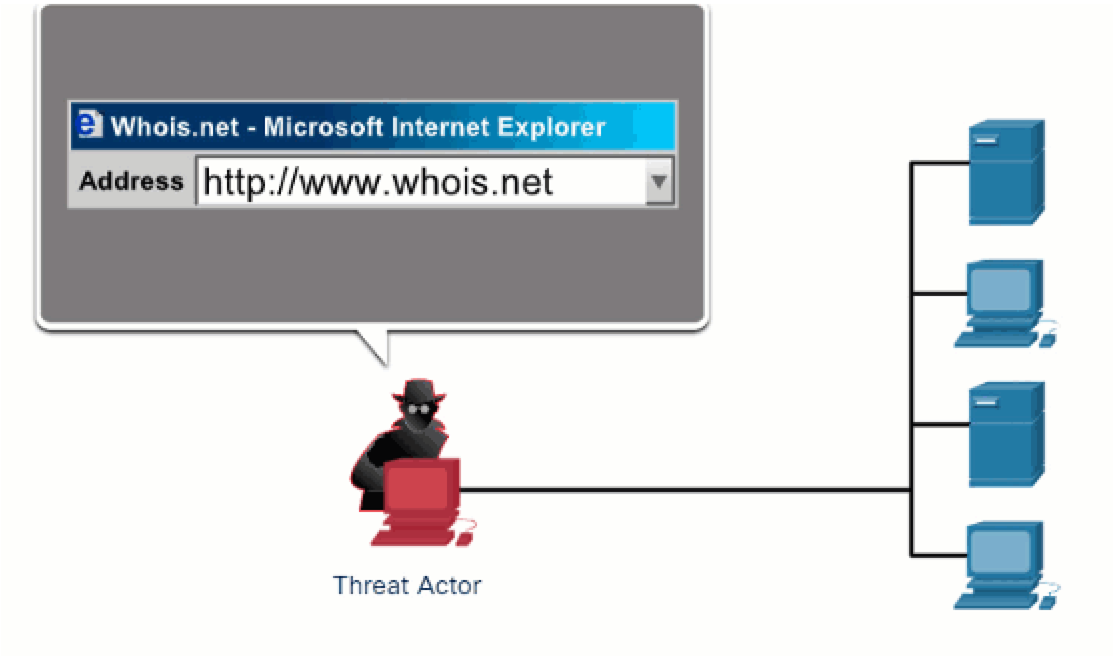
In addition to malicious code attacks, it is also possible for networks to fall prey to various network attacks. Network attacks can be classified into three major categories:

- **Reconnaissance attacks** – The discovery and mapping of systems, services, or vulnerabilities.
- **Access attacks** – The unauthorized manipulation of data, system access, or user privileges.
- **Denial of service** – The disabling or corruption of networks, systems, or services.

For reconnaissance attacks, external threat actors can use internet tools, such as the nslookup and whois utilities, to easily determine the IP address space assigned to a given corporation or entity. After the IP address space is determined, a threat actor can then ping the publicly available IP addresses to identify the addresses that are active. To help automate this step, a threat actor may use a ping sweep tool, such as fping or gping. This systematically pings all network addresses in a given range or subnet. This is similar to going through a section of a telephone book and calling each number to see who answers.

Click each type of reconnaissance attack tool to see an animation of the attack.

The threat actor is looking for initial information about a target. Various tools can be used, including Google search, the websites of organizations, whois, and more.



16.2.3. Access Attacks

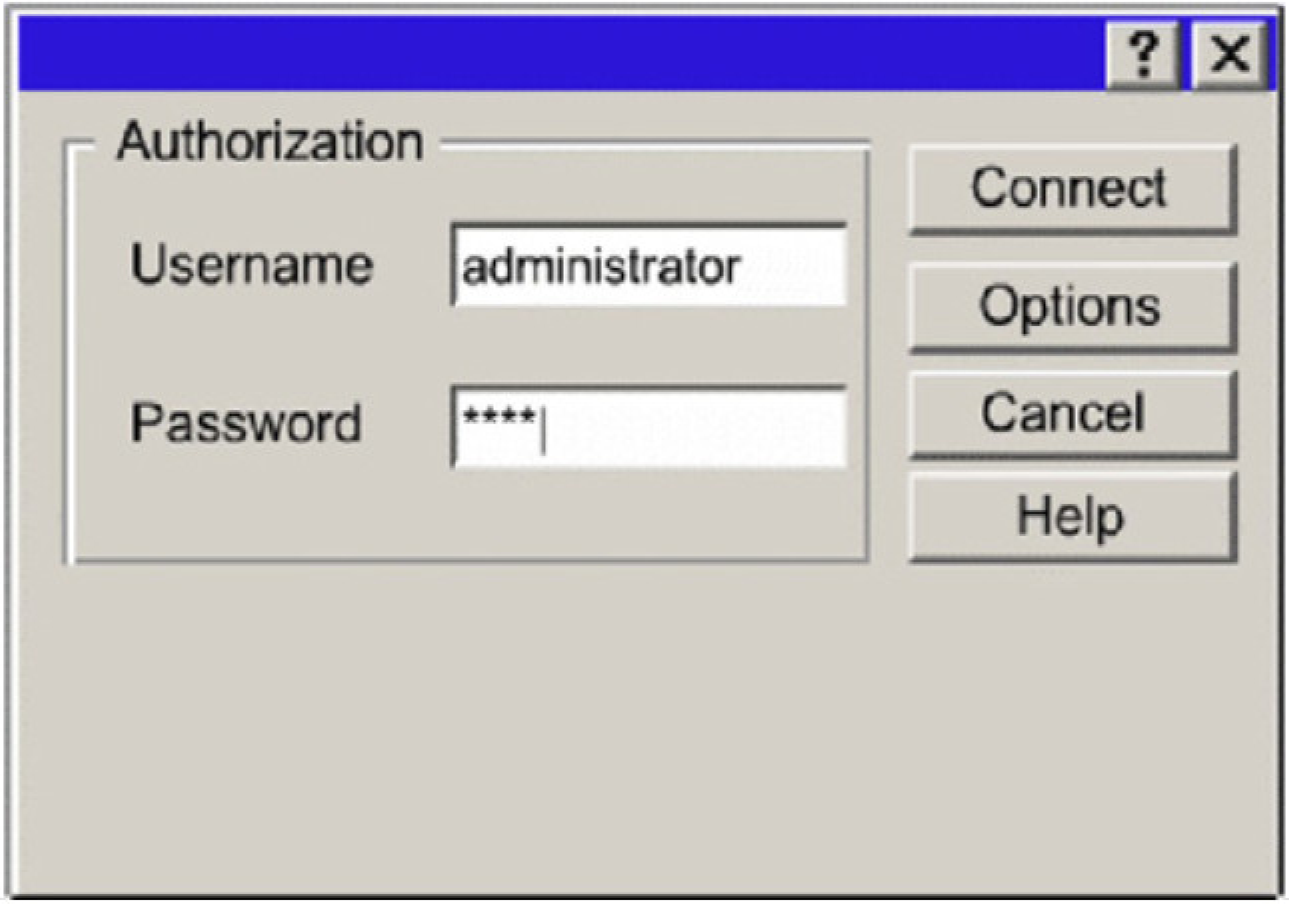
Access attacks exploit known vulnerabilities in authentication services, FTP services, and web services to gain entry to web accounts, confidential databases, and other sensitive information. An access attack allows individuals to gain unauthorized access to information that they have no right to view. Access attacks can be classified into four types: password attacks, trust exploitation, port redirection, and man-in-the middle.

Click each button for an explanation of each type of attack.

Password Attacks

Threat actors can implement password attacks using several different methods:

- Brute-force attacks
- Trojan horse attacks
- Packet sniffers



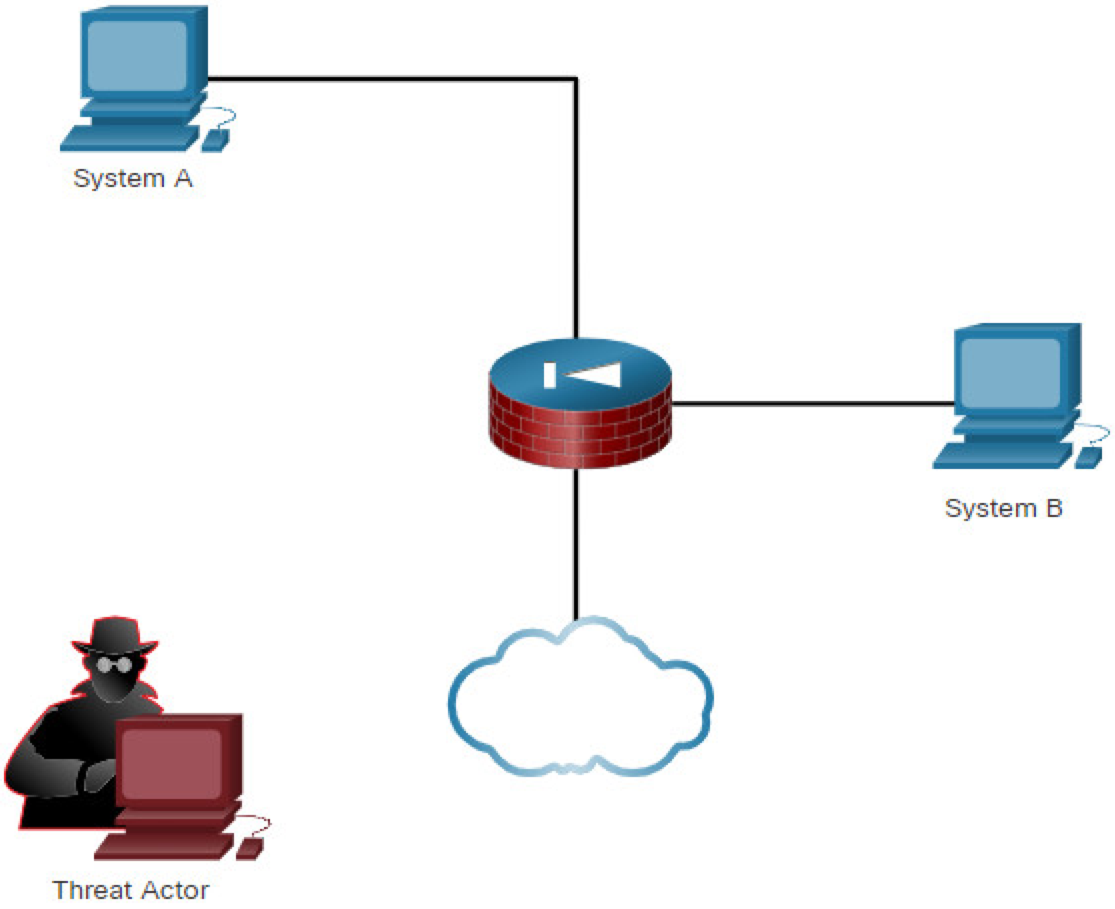
Authorization

Username: administrator

Password: ****

Trust Exploitation

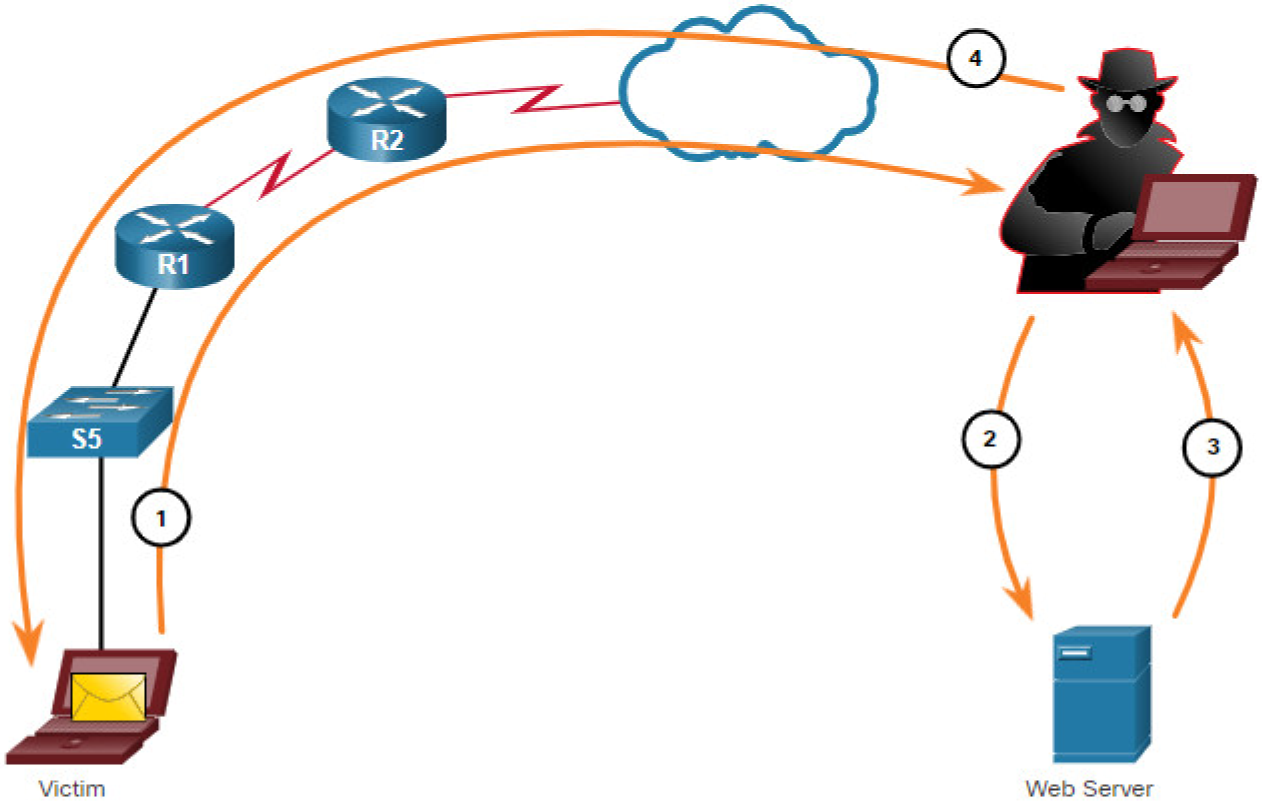
In a trust exploitation attack, a threat actor uses unauthorized privileges to gain access to a system, possibly compromising the target. Click Play in the figure to view an example of trust exploitation.



In the animation, System A trusts System B. System B trusts everyone. The threat actor wants to gain access to System A. Therefore, the threat actor compromises System B first and then can use System B to attack System A.

Man-in-the-Middle

In a man-in-the-middle attack, the threat actor is positioned in between two legitimate entities in order to read or modify the data that passes between the two parties. The figure displays an example of a man-in-the-middle attack.



Step 1. When a victim requests a web page, the request is directed to the threat actor's computer.

Step 2. The threat actor’s computer receives the request and retrieves the real page from the legitimate website.

Step 3. The threat actor can alter the legitimate web page and make changes to the data.

Step 4. The threat actor forwards the requested page to the victim.

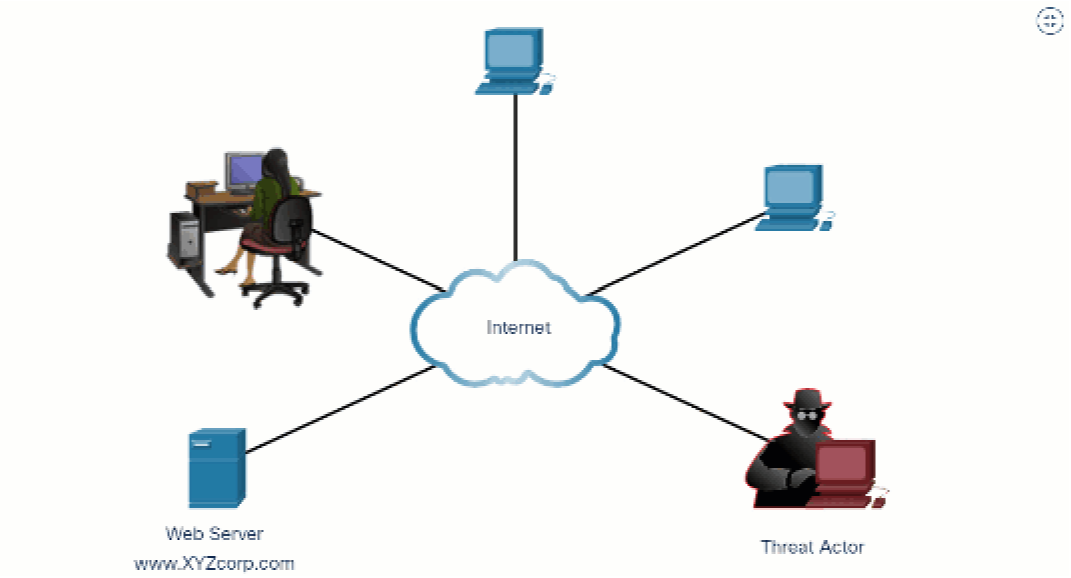
16.2.4. Denial of Service Attacks

Denial of service (DoS) attacks are the most publicized form of attack and among the most difficult to eliminate. However, because of their ease of implementation and potentially significant damage, DoS attacks deserve special attention from security administrators.

DoS attacks take many forms. Ultimately, they prevent authorized people from using a service by consuming system resources. To help prevent DoS attacks it is important to stay up to date with the latest security updates for operating systems and applications.

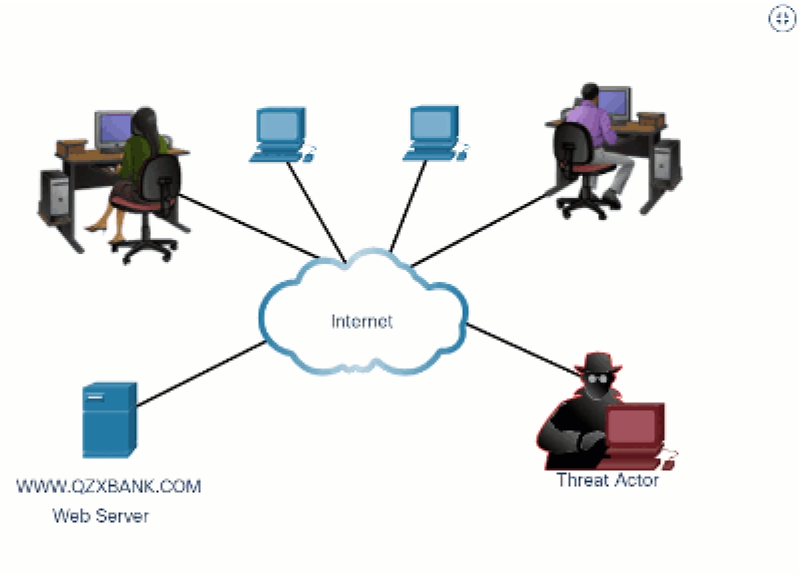
DoS Attack

DoS attacks are a major risk because they interrupt communication and cause significant loss of time and money. These attacks are relatively simple to conduct, even by an unskilled threat actor.



DDoS Attack

A DDoS is similar to a DoS attack, but it originates from multiple, coordinated sources. For example, a threat actor builds a network of infected hosts, known as zombies. A network of zombies is called a botnet. The threat actor uses a command and control (CnC) program to instruct the botnet of zombies to carry out a DDoS attack.



16.2.6. Lab – Research Network Security Threats

In this lab, you will complete the following objectives:

- Part 1: Explore the SANS Website
- Part 2: Identify Recent Network Security Threats
- Part 3: Detail a Specific Network Security Threat

16.2.6 Lab – Research Network Security Threats

16.3. Network Attack Mitigations

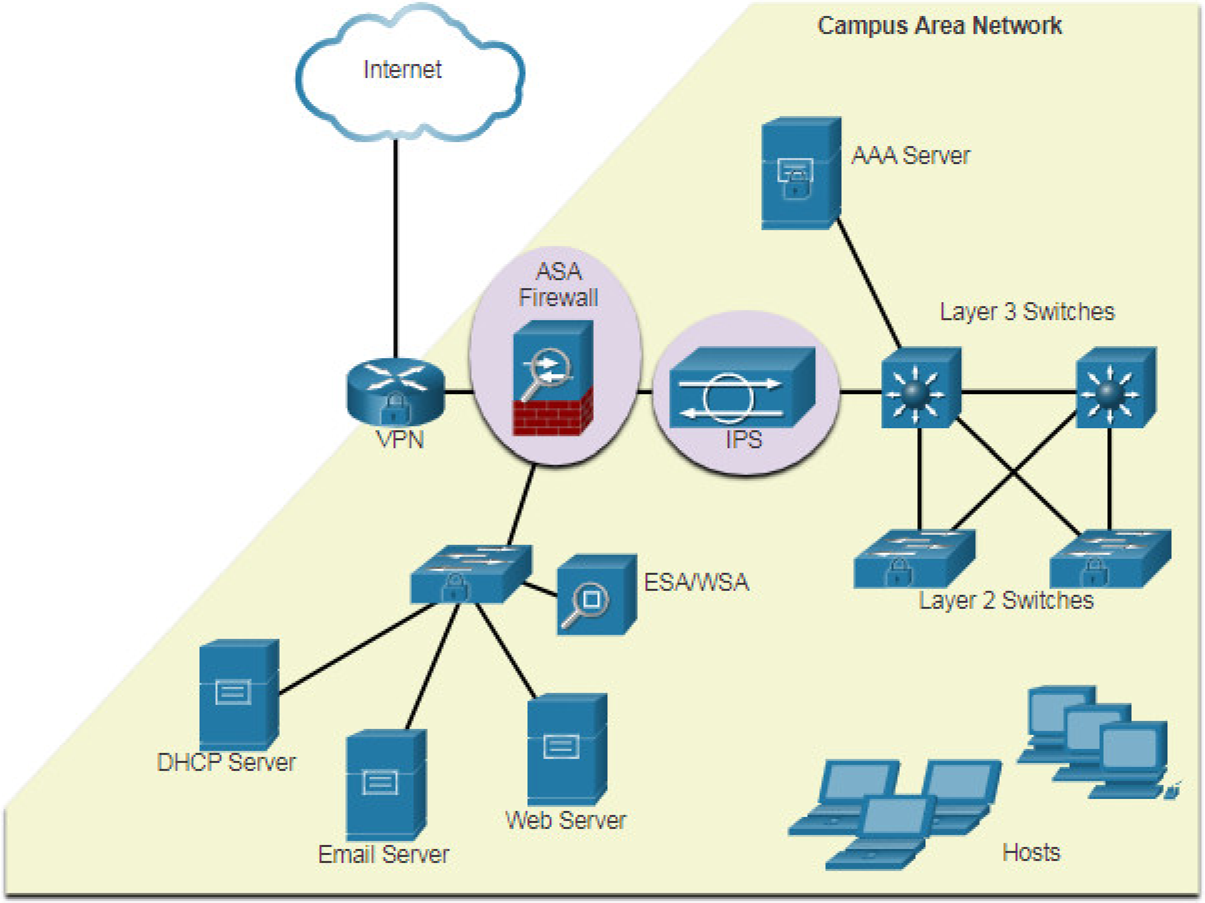
16.3.1. The Defense-in-Depth Approach

Now that you know more about how threat actors can break into networks, you need to understand what to do to prevent this unauthorized access. This topic details several actions you can take to make your network more secure.

To mitigate network attacks, you must first secure devices including routers, switches, servers, and hosts. Most organizations employ a defense-in-depth approach (also known as a layered approach) to security. This requires a combination of networking devices and services working in tandem.

Consider the network in the figure. There are several security devices and services that have been implemented to protect its users and assets against TCP/IP threats.

All network devices including the router and switches are also hardened as indicated by the combination locks on their respective icons. This indicates that they have been secured to prevent threat actors from gaining access and tampering with the devices.



Several security devices and services are implemented to protect an organization's users and assets against TCP/IP threats.

- **VPN** – A router is used to provide secure VPN services with corporate sites and remote access support for remote users using secure encrypted tunnels.
- **ASA Firewall** – This dedicated device provides stateful firewall services. It ensures that internal traffic can go out and come back, but external traffic cannot initiate connections to inside hosts.
- **IPS** – An intrusion prevention system (IPS) monitors incoming and outgoing traffic looking for malware, network attack signatures, and more. If it recognizes a threat, it can immediately stop it.
- **ESA/WSA** – The email security appliance (ESA) filters spam and suspicious emails. The web security appliance (WSA) filters known and suspicious internet malware sites.
- **AAA Server** – This server contains a secure database of who is authorized to access and manage network devices. Network devices authenticate administrative users using this database.

16.3.2. Keep Backups

Backing up device configurations and data is one of the most effective ways of protecting against data loss. A data backup stores a copy of the information on a computer to removable backup media that can be kept in a safe place. Infrastructure devices should have backups of configuration files and IOS images on an FTP or similar file server. If the computer or a router hardware fails, the data or configuration can be restored using the backup copy.

Backups should be performed on a regular basis as identified in the security policy. Data backups are usually stored offsite to protect the backup media if anything happens to the main facility. Windows hosts have a backup and restore utility. It is important for users to back up their data to another drive, or to a cloud-based storage provider.

The table shows backup considerations and their descriptions.

Consideration	Description
Frequency	• Perform backups on a regular basis as identified in the security policy. • Full backups can be time-consuming, therefore perform monthly or weekly backups with frequent partial backups of changed files.
Storage	Always validate backups to ensure the integrity of the data and validate the file restoration procedures.
Security	Backups should be transported to an approved offsite storage location on a daily, weekly, or monthly rotation, as required by the security policy.

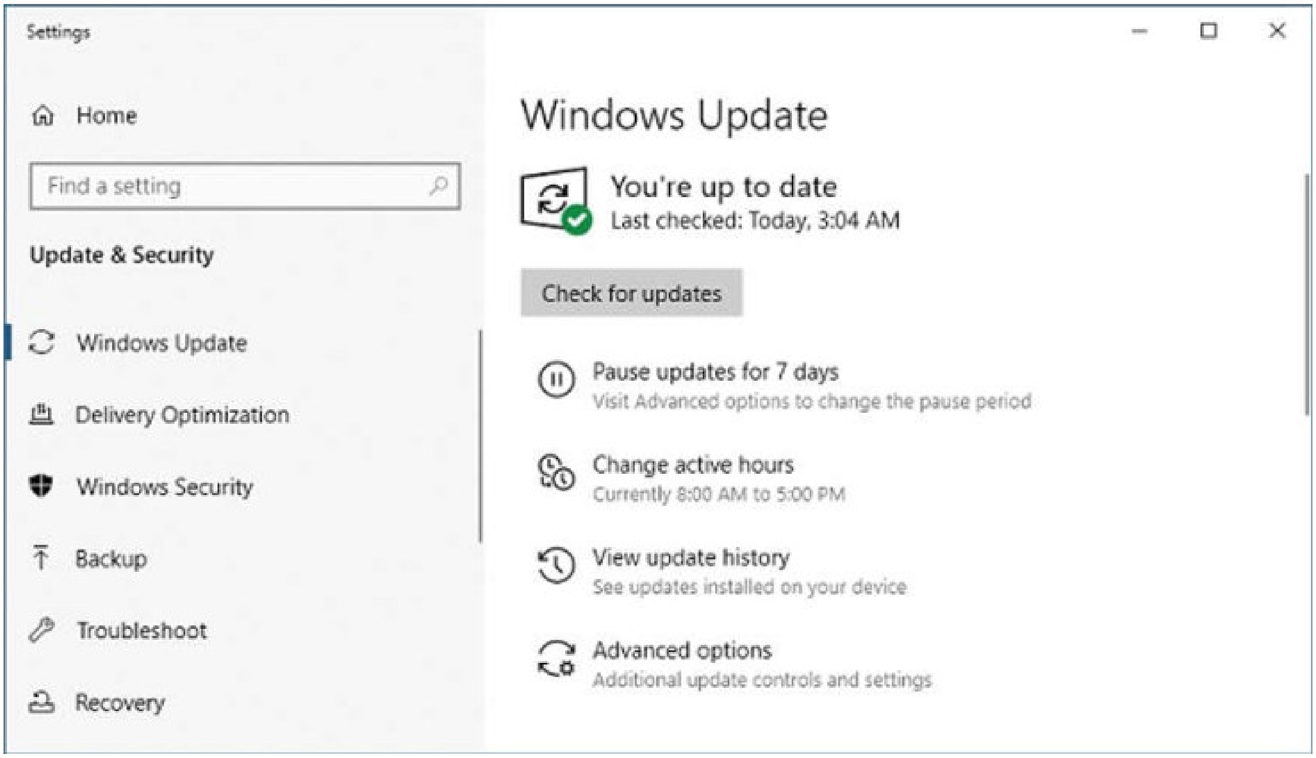
Consideration	Description
Validation	Backups should be protected using strong passwords. The password is required to restore the data.

16.3.3. Upgrade, Update, and Patch

Keeping up to date with the latest developments can lead to a more effective defense against network attacks. As new malware is released, enterprises need to keep current with the latest versions of antivirus software.

The most effective way to mitigate a worm attack is to download security updates from the operating system vendor and patch all vulnerable systems. Administering numerous systems involves the creation of a standard software image (operating system and accredited applications that are authorized for use on client systems) that is deployed on new or upgraded systems. However, security requirements change, and already deployed systems may need to have updated security patches installed.

One solution to the management of critical security patches is to make sure all end systems automatically download updates, as shown for Windows 10 in the figure. Security patches are automatically downloaded and installed without user intervention.



You're up to date
Last checked: Today, 3:04 AM

Visit Advanced options to change the pause period

Currently 8:00 AM to 5:00 PM

See updates installed on your device

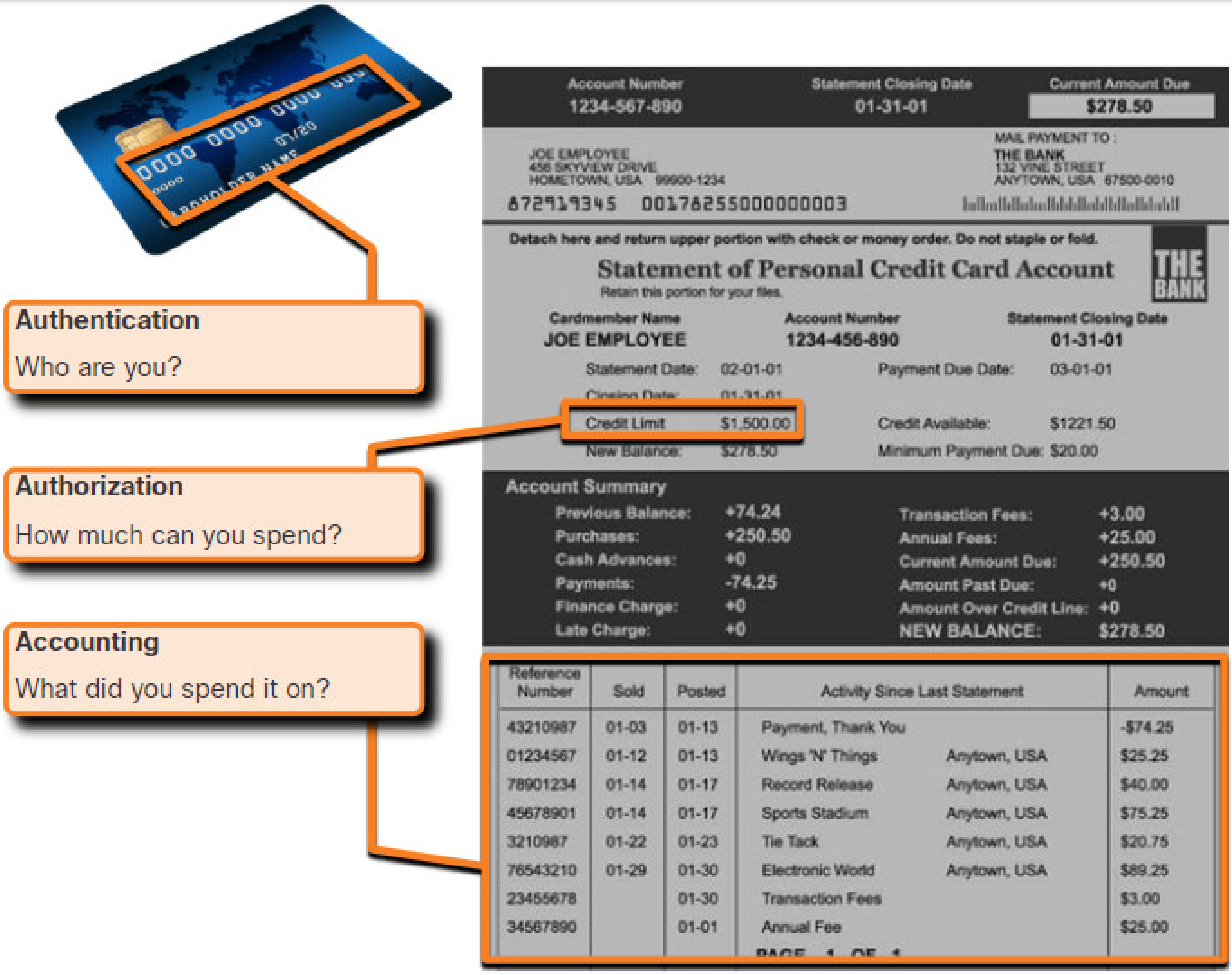
Additional update controls and settings

16.3.4. Authentication, Authorization, and Accounting

All network devices should be securely configured to provide only authorized individuals with access. Authentication, authorization, and accounting (AAA, or “triple A”) network security services provide the primary framework to set up access control on network devices.

AAA is a way to control who is permitted to access a network (authenticate), what actions they perform while accessing the network (authorize), and making a record of what was done while they are there (accounting).

The concept of AAA is similar to the use of a credit card. The credit card identifies who can use it, how much that user can spend, and keeps account of what items the user spent money on, as shown in the figure.



Account Number	Statement Closing Date	Current Amount Due
1234-567-890	01-31-01	$278.50

JOE EMPLOYEE
456 SKYVIEW DRIVE
HOMETOWN, USA 99900-1234

MAIL PAYMENT TO :
THE BANK
132 VINE STREET
ANYTOWN, USA 67500-0010

872919345 0017825500000003

Detach here and return upper portion with check or money order. Do not staple or fold.

Statement of Personal Credit Card Account

Retain this portion for your files.

THE BANK

Cardmember Name	Account Number	Statement Closing Date
JOE EMPLOYEE	1234-456-890	01-31-01

Statement Date:	02-01-01	Payment Due Date:	03-01-01
Closing Date:	01-31-01		
Credit Limit	$1,500.00	Credit Available:	$1221.50
New Balance:	$278.50	Minimum Payment Due:	$20.00

Account Summary

Previous Balance:	+74.24	Transaction Fees:	+3.00
Purchases:	+250.50	Annual Fees:	+25.00
Cash Advances:	+0	Current Amount Due:	+250.50
Payments:	-74.25	Amount Past Due:	+0
Finance Charge:	+0	Amount Over Credit Line:	+0
Late Charge:	+0	NEW BALANCE:	$278.50

Reference Number	Sold	Posted	Activity Since Last Statement		Amount
43210987	01-03	01-13	Payment, Thank You		-$74.25
01234567	01-12	01-13	Wings 'N' Things	Anytown, USA	$25.25
78901234	01-14	01-17	Record Release	Anytown, USA	$40.00
45678901	01-14	01-17	Sports Stadium	Anytown, USA	$75.25
3210987	01-22	01-23	Tie Tack	Anytown, USA	$20.75
76543210	01-29	01-30	Electronic World	Anytown, USA	$89.25
23455678		01-30	Transaction Fees		$3.00
34567890		01-01	Annual Fee		$25.00

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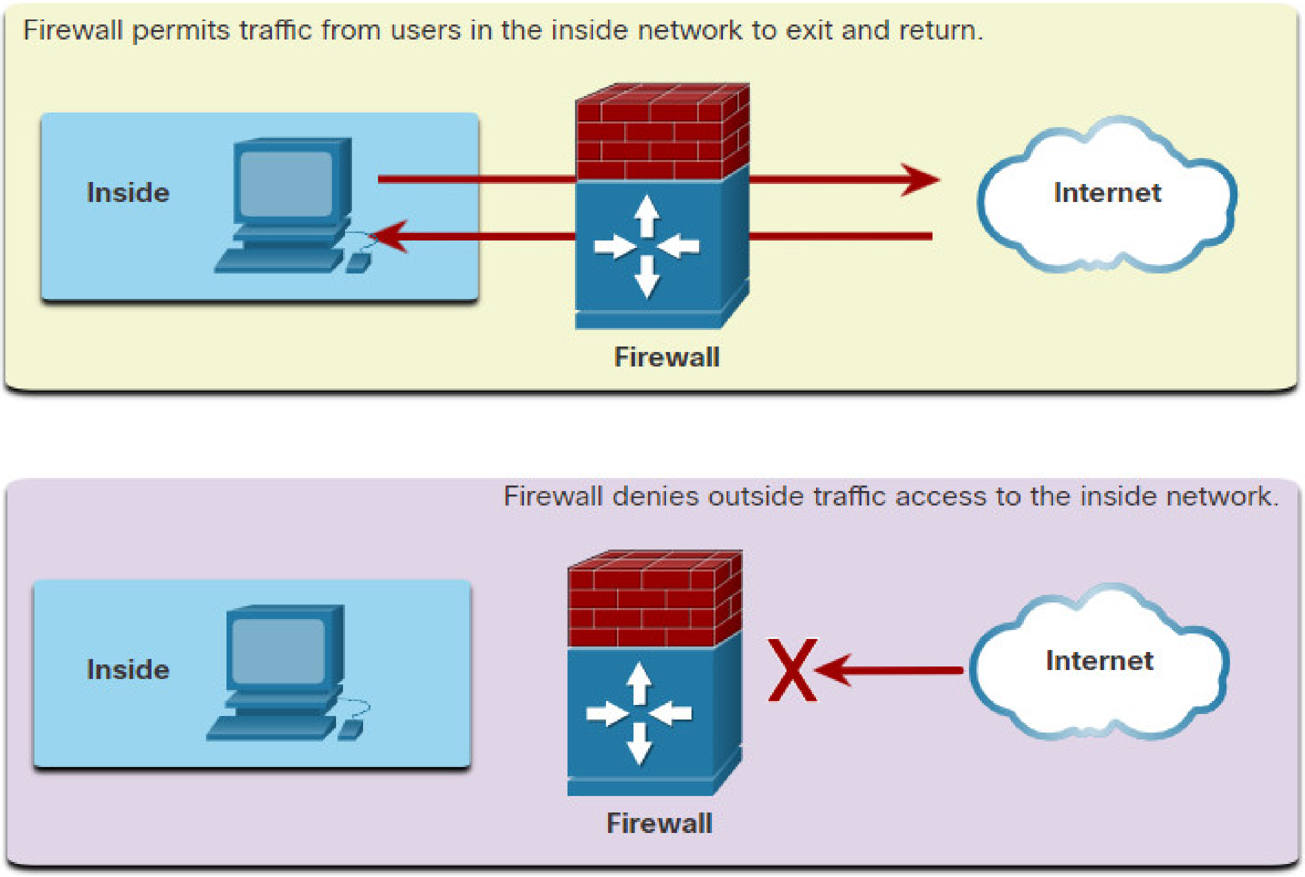
16.3.5. Firewalls

A firewall is one of the most effective security tools available for protecting users from external threats. A firewall protects computers and networks by preventing undesirable traffic from entering internal networks.

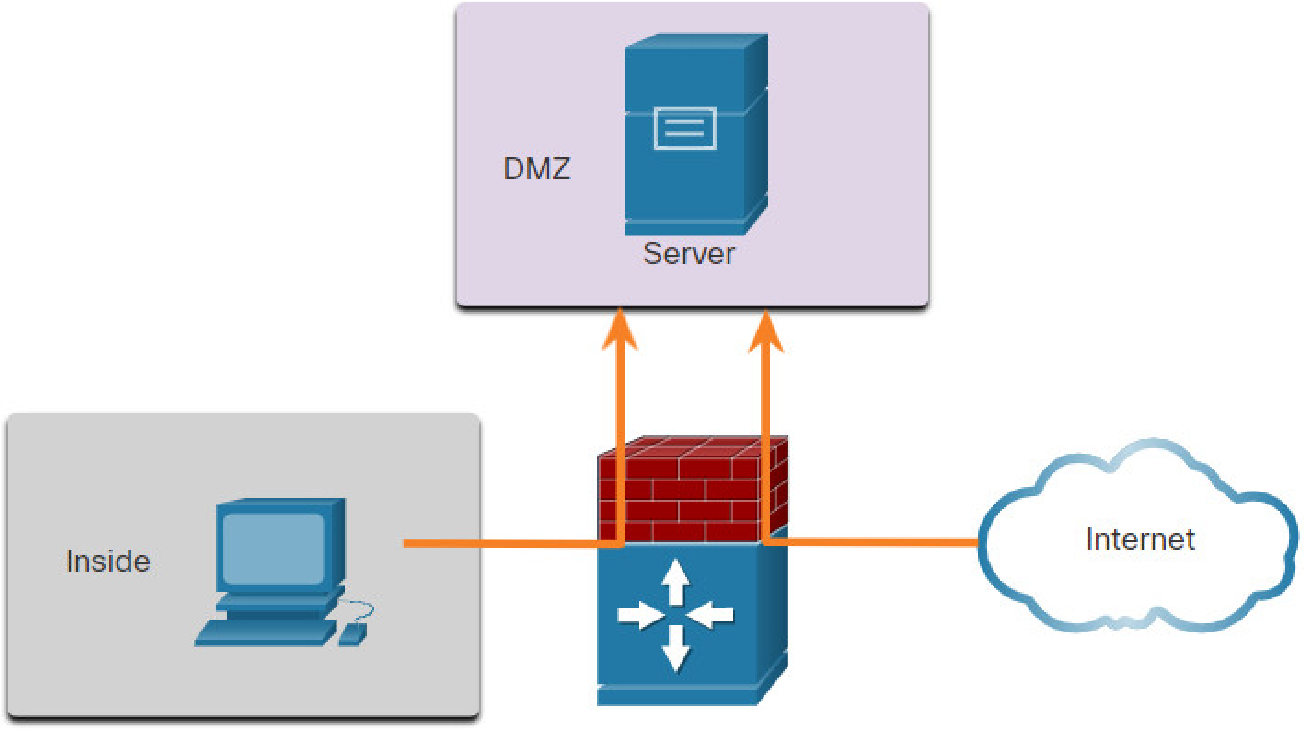
Network firewalls reside between two or more networks, control the traffic between them, and help prevent unauthorized access. For example, the top topology in the figure illustrates how the firewall enables traffic from an internal network host to exit the network and return to the inside network. The bottom topology illustrates how traffic initiated by the outside network (i.e., the internet) is denied access to the internal network.

Firewall Operation



Firewall permits traffic from users in the inside network to exit and return.

Firewall denies outside traffic access to the inside network.



A firewall could allow outside users controlled access to specific services. For example, servers accessible to outside users are usually located on a special network referred to as the demilitarized zone (DMZ), as shown in the figure. The DMZ enables a network administrator to apply specific policies for hosts connected to that network.

Firewall Topology with DMZ

16.3.6. Types of Firewalls

Firewall products come packaged in various forms. These products use different techniques for determining what will be permitted or denied access to a network. They include the following:

- **Packet filtering** – Prevents or allows access based on IP or MAC addresses
- **Application filtering** – Prevents or allows access by specific application types based on port numbers
- **URL filtering** – Prevents or allows access to websites based on specific URLs or keywords
- **Stateful packet inspection (SPI)** – Incoming packets must be legitimate responses to requests from internal hosts. Unsolicited packets are blocked unless permitted specifically. SPI can also include the capability to recognize and filter out specific types of attacks, such as denial of service (DoS)

16.3.7. Endpoint Security

An endpoint, or host, is an individual computer system or device that acts as a network client. Common endpoints are laptops, desktops, servers, smartphones, and tablets. Securing endpoint devices is one of the most challenging jobs of a network administrator because it involves human nature. A company must have well-documented policies in place and employees must be aware of these rules. Employees need to be trained on proper use of the network. Policies often include the use of antivirus software and host intrusion prevention. More comprehensive endpoint security solutions rely on network access control.

16.4. Device Security

16.4.1. Cisco AutoSecure

One area of networks that requires special attention to maintain security is the devices. You probably already have a password for your computer, smart phone, or tablet. Is it as strong as it could be? Are you using other tools to enhance the security of your devices? This topic tells you how.

The security settings are set to the default values when a new operating system is installed on a device. In most cases, this level of security is inadequate. For Cisco routers, the Cisco AutoSecure feature can be used to assist securing the system, as shown in the example.

```
Router# auto secure
--- AutoSecure Configuration ---
*** AutoSecure configuration enhances the security of
the router but it will not make router absolutely secure
from all security attacks ***
```

In addition, there are some simple steps that should be taken that apply to most operating systems:

- Default usernames and passwords should be changed immediately.
- Access to system resources should be restricted to only the individuals that are authorized to use those resources.
- Any unnecessary services and applications should be turned off and uninstalled when possible.

Often, devices shipped from the manufacturer have been sitting in a warehouse for a period of time and do not have the most up-to-date patches installed. It is important to update any software and install any security patches prior to implementation.

16.4.2. Passwords

To protect network devices, it is important to use strong passwords. Here are standard guidelines to follow:

- Use a password length of at least eight characters, preferably 10 or more characters. A longer password is a more secure password.
- Make passwords complex. Include a mix of uppercase and lowercase letters, numbers, symbols, and spaces, if allowed.
- Avoid passwords based on repetition, common dictionary words, letter or number sequences, usernames, relative or pet names, biographical information, such as birthdates, ID numbers, ancestor names, or other easily identifiable pieces of information.
- Deliberately misspell a password. For example, Smith = Smyth = 5mYth or Security = 5ecur1ty.
- Change passwords often. If a password is unknowingly compromised, the window of opportunity for the threat actor to use the password is limited.
- Do not write passwords down and leave them in obvious places such as on the desk or monitor.

The tables show examples of strong and weak passwords.

Weak Passwords

Weak Password	Why it is Weak
secret	Simple dictionary password
smith	Maiden name of mother
toyota	Make of a car
bob1967	Name and birthday of the user
Blueleaf23	Simple words and numbers

Strong Passwords

Strong Password	Why it is Strong
b67n42d39c	Combines alphanumeric characters
12^h u4@1p7	Combines alphanumeric characters, symbols, and includes a space

On Cisco routers, leading spaces are ignored for passwords, but spaces after the first character are not. Therefore, one method to create a strong password is to use the space bar and create a phrase made of many words. This is called a passphrase. A passphrase is often easier to remember than a simple password. It is also longer and harder to guess.

16.4.3. Additional Password Security

Strong passwords are only useful if they are secret. There are several steps that can be taken to help ensure that passwords remain secret on a Cisco router and switch including these:

- Encrypting all plaintext passwords
- Setting a minimum acceptable password length
- Deterring brute-force password guessing attacks
- Disabling an inactive privileged EXEC mode access after a specified amount of time.

As shown in the sample configuration in the figure, the **service password-encryption** global configuration command prevents unauthorized individuals from viewing plaintext passwords in the configuration file. This command encrypts all plaintext passwords. Notice in the example, that the password "cisco" has been encrypted as "03095A0F034F".

To ensure that all configured passwords are a minimum of a specified length, use the **security passwords min-length** *length* command in global configuration mode. In the figure, any new password configured would have to have a minimum length of eight characters.

Threat actors may use password cracking software to conduct a brute-force attack on a network device. This attack continuously attempts to guess the valid passwords until one works. Use the **login block-for # attempts # within #** global configuration command to deter this type of attack. In the figure for example, the **login block-for 120 attempts 3 within 60** command will block vty login attempts for 120 seconds if there are three failed login attempts within 60 seconds.

Network administrators can become distracted and accidently leave a privileged EXEC mode session open on a terminal. This could enable an internal threat actor access to change or erase the device configuration.

By default, Cisco routers will logout an EXEC session after 10 minutes of inactivity. However, you can reduce this setting using the **exec-timeout** *minutes seconds* line configuration command. This command can be applied online console, auxiliary, and vty lines. In the figure, we are telling the Cisco device to automatically disconnect an inactive user on a vty line after the user has been idle for 5 minutes and 30 seconds.

```
Router(config)# service password-encryption
Router(config)# security password min-length 8
Router(config)# login block-for 120 attempts 3 within 60
Router(config)# line vty 0 4
Router(config-line)# password cisco
Router(config-line)# exec-timeout 5 30
Router(config-line)# transport input ssh
Router(config-line)# end
Router#
Router# show running-config | section line vty
line vty 0 4
 password 7 03095A0F034F
 exec-timeout 5 30
 login
Router#
```

16.4.4. Enable SSH

Telnet simplifies remote device access, but it is not secure. Data contained within a Telnet packet is transmitted unencrypted. For this reason, it is highly recommended to enable Secure Shell (SSH) on devices for secure remote access.

It is possible to configure a Cisco device to support SSH using the following six steps:

Step 1. Configure a unique device hostname. A device must have a unique hostname other than the default.

Step 2. Configure the IP domain name. Configure the IP domain name of the network by using the global configuration mode command **ip-domain name.**

Step 3. Generate a key to encrypt SSH traffic. SSH encrypts traffic between source and destination. However, to do so, a unique authentication key must be generated by using the global configuration command **crypto key generate rsa general-keys modulus** *bits*. The modulus *bits* determines the size of the key and can be configured from 360 bits to 2048 bits. The larger the bit value, the more secure the key. However, larger bit values also take longer to encrypt and decrypt information. The minimum recommended modulus length is 1024 bits.

Step 4. Verify or create a local database entry. Create a local database **username** entry using the username global configuration command. In the example, the parameter **secret** is used so that the password will be encrypted using MD5.

Step 5. Authenticate against the local database. Use the **login local** line configuration command to authenticate the vty line against the local database.

Step 6. Enable vty inbound SSH sessions. By default, no input session is allowed on vty lines. You can specify multiple input protocols including Telnet and SSH using the **transport input [ssh | telnet]** command.

As shown in the example, router R1 is configured in the span.com domain. This information is used along with the bit value specified in the **crypto key generate rsa general-keys modulus** command to create an encryption key.

Next, a local database entry for a user named Bob is created. Finally, the vty lines are configured to authenticate against the local database and to only accept incoming SSH sessions.

```
Router# configure terminal
Router(config)# hostname R1
R1(config)# ip domain-name span.com
R1(config)# crypto key generate rsa general-keys modulus 1024
The name for the keys will be: Rl.span.com % The key modulus size is 1024 bits
% Generating 1024 bit RSA keys, keys will be non-exportable...[OK]
•Dec 13 16:19:12.079: %SSH-5-ENABLED: SSH 1.99 has been enabled
R1(config)#
R1(config)# username Bob secret cisco
R1(config)# line vty 0 4
R1(config-line)# login local
R1(config-line)# transport input ssh
R1(config-line)# exit
R1(config)#
```

16.4.5. Disable Unused Services

Cisco routers and switches start with a list of active services that may or may not be required in your network. Disable any unused services to preserve system resources, such as CPU cycles and RAM, and prevent threat actors from exploiting these services. The type of services that are on by default will vary depending on the IOS version. For example, IOS-XE typically will have only HTTPS and DHCP ports open. You can verify this with the show ip ports all command, as shown in the example.

```
Router# show ip ports all
Proto Local Address                  Foreign Address             State       PID/Program
Name
TCB       Local Address                  Foreign Address             (state)
tcp   :::443                     :::*                        LISTEN
309/[IOS]HTTP CORE
tcp   *:443                      *:*                         LISTEN
309/[IOS]HTTP CORE
udp   *:67                        0.0.0.0:0
387/[IOS]DHCPD Receive
Router#
```

IOS versions prior to IOS-XE use the **show control-plane host open-ports** command. We mention this command because you may see it on older devices. The output is similar. However, notice that this older router has an insecure HTTP server and Telnet running. Both of these services should be disabled. As shown in the example, disable HTTP with the **no ip http server** global configuration command. Disable Telnet by specifying only SSH in the line configuration command, **transport input ssh.**

```
Router# show control-plane host open-ports
Active internet connections (servers and established)
Prot        Local Address      Foreign Address                  Service    State
 tcp                 *:23                 *:0                    Telnet   LISTEN
 tcp                 *:80                 *:0                 HTTP CORE   LISTEN
 udp                 *:67                 *:0             DHCPD Receive   LISTEN
Router# configure terminal
Router(config)# no ip http server
Router(config)# line vty 0 15
Router(config-line)# transport input ssh
```

16.4.6. Packet Tracer – Configure Secure Passwords and SSH

The network administrator has asked you to prepare RTA and SW1 for deployment. Before they can be connected to the network, security measures must be enabled.

16.4.6 Packet Tracer – Configure Secure Passwords and SSH

16.4.7. Lab – Configure Network Devices with SSH

In this lab, you will complete the following objectives:

- Part 1: Configure Basic Device Settings
- Part 2: Configure the Router for SSH Access
- Part 3: Configure the Switch for SSH Access
- Part 4: SSH from the CLI on the Switch

16.4.7 Lab – Configure Network Devices with SSH

16.5. Module Practice and Quiz

16.5.1. Packet Tracer – Secure Network Devices

In this activity you will configure a router and a switch based on a list of requirements.

16.5.1 Packet Tracer – Secure Network Devices

16.5.2. Lab – Secure Network Devices

In this lab, you will complete the following objectives:

- Part 1: Configure Basic Device Settings
- Part 2: Configure Basic Security Measures on the Router
- Part 3: Configure Basic Security Measures on the Switch

16.5.2 Lab – Secure Network Devices

16.5.3. What did I learn in this module?

Security Threats and Vulnerabilities

Attacks on a network can be devastating and can result in a loss of time and money due to damage or theft of important information or assets. Intruders who gain access by modifying software or exploiting software vulnerabilities are threat actors. After the threat actor gains access to the network, four types of threats may arise: information theft, data loss and manipulation, identity theft, and disruption of service. There are three primary vulnerabilities or weaknesses: technological, configuration, and security policy. The four classes of physical threats are: hardware, environmental, electrical, and maintenance.

Network Attacks

Malware is short for malicious software. It is code or software specifically designed to damage, disrupt, steal, or inflict “bad” or illegitimate action on data, hosts, or networks. Viruses, worms, and Trojan horses are types of malware. Network attacks can be classified into three major categories: reconnaissance, access, and denial of service. The four classes of physical threats are: hardware, environmental, electrical, and maintenance. The three types of reconnaissance attacks are: internet queries, ping sweeps, and port scans. The four types of access attacks are: password (brute-force, Trojan horse, packet sniffers), trust exploitation, port redirection, and man-in-the-middle. The two types of disruption of service attacks are: DoS and DDoS.

Network Attack Mitigation

To mitigate network attacks, you must first secure devices including routers, switches, servers, and hosts. Most organizations employ a defense-in-depth approach to security. This requires a combination of networking devices and services working together. Several security devices and services are implemented to protect an organization’s users and assets against TCP/IP threats: VPN, ASA firewall, IPS, ESA/WSA, and AAA server. Infrastructure devices should have backups of configuration files and IOS images on an FTP or similar file server. If the computer or a router hardware fails, the data or configuration can be restored using the backup copy. The most effective way to mitigate a worm attack is to download security updates from the operating system vendor and patch all vulnerable systems. To manage critical security patches, to make sure all end systems automatically download updates. AAA is a way to control who is permitted to access a network (authenticate), what they can do while they are there (authorize), and what actions they perform while accessing the network (accounting). Network firewalls reside between two or more networks, control the traffic between them, and help prevent unauthorized access. Servers accessible to outside users are usually located on a special network referred to as the DMZ. Firewalls use various techniques for determining what is permitted or denied access to a network including: packet filtering, application filtering, URL filtering and SPI. Securing endpoint devices is critical to network security. A company must have well-documented policies in place, which may include the use of antivirus software and host intrusion prevention. More comprehensive endpoint security solutions rely on network access control.

Device Security

The security settings are set to the default values when a new OS is installed on a device. This level of security is inadequate. For Cisco routers, the Cisco AutoSecure feature can be used to assist securing the system. For most OSs default usernames and passwords should be changed immediately, access to system resources should be restricted to only the individuals that are authorized to use those resources, and any unnecessary services and applications should be turned off and uninstalled when possible. To protect network devices, it is important to use strong passwords. A pass phrase is often easier to remember than a simple password. It is also longer and harder to guess. For routers and switches, encrypt all plaintext passwords, setting a minimum acceptable password length, deter brute-force password guessing attacks, and disable an inactive privileged EXEC mode access after a specified amount of time. Configure appropriate devices to support SSH, and disable unused services.

16.5.4 Module Quiz – Network Security Fundamentals

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