Networking Basics

1. Communication

Data Transmission

The bit

The term bit is an abbreviation of “binary digit” and represents the smallest piece of data. Humans interpret words and pictures, computers interpret only patterns of bits.

Computers use binary codes to represent and interpret letters, numbers and special characters with bits. A commonly used code is the American Standard Code for Information Interchange (ASCII). With ASCII, each character is represented by eight bits. For example:

- Capital letter: A = 01000001
- Number: 9 = 00111001
- Special character: # = 00100011

Each group of eight bits, such as the representations of letters and numbers, is known as a byte.

Common Methods of Data Transmission

Media refers to the physical medium on which the signals are transmitted. Examples of media are copper wire, fiber-optic cable, and electromagnetic waves through the air.There are three common methods of signal transmission used in networks:

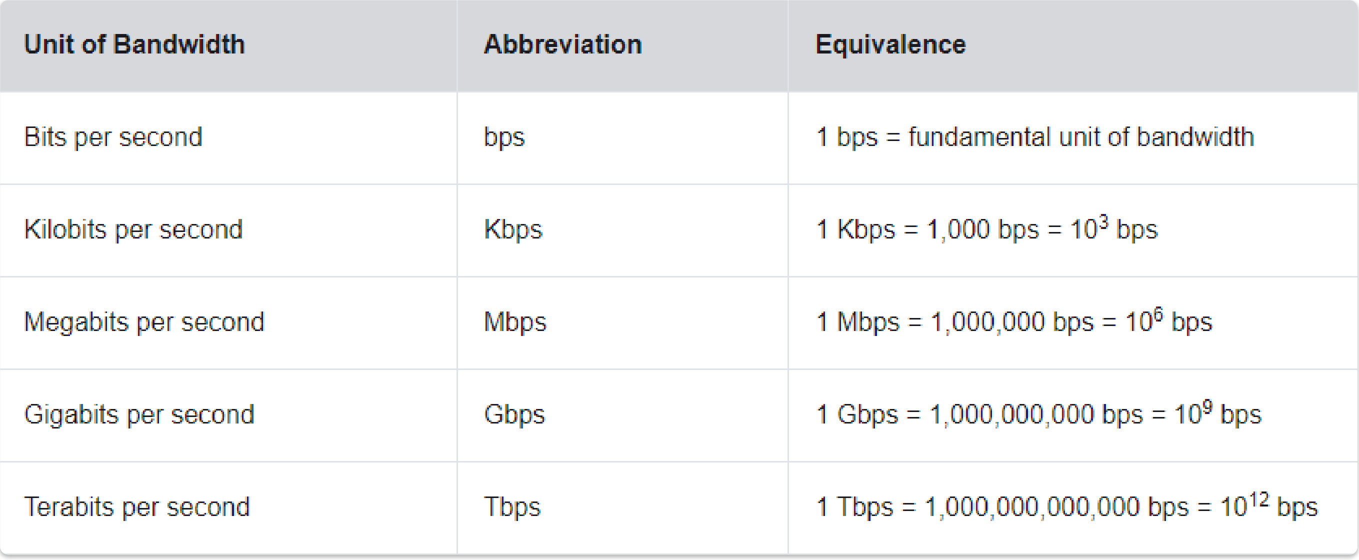
- Electrical signals - Transmission is achieved by representing data as electrical pulses on copper wire.
- Optical signals - Transmission is achieved by converting the electrical signals into light pulses.
- Wireless signals - Transmission is achieved by using infrared, microwave, or radio waves through the air.

Question

When using your credit card to make purchases at several places, the credit card company can use this information to learn about your location and your preferences. This type of personal data is known as: inferred data

Bandwidth and Throughput

Bandwidth is the capacity of a medium to carry data. Digital bandwidth measures the amount of data that can flow from one place to another in a given amount of time.



Unit of Bandwidth	Abbreviation	Equivalence
Bits per second	bps	1 bps = fundamental unit of bandwidth
Kilobits per second	Kbps	1 Kbps = 1,000 bps = 10^3 bps
Megabits per second	Mbps	1 Mbps = 1,000,000 bps = 10^6 bps
Gigabits per second	Gbps	1 Gbps = 1,000,000,000 bps = 10^9 bps
Terabits per second	Tbps	1 Tbps = 1,000,000,000,000 bps = 10^{12} bps

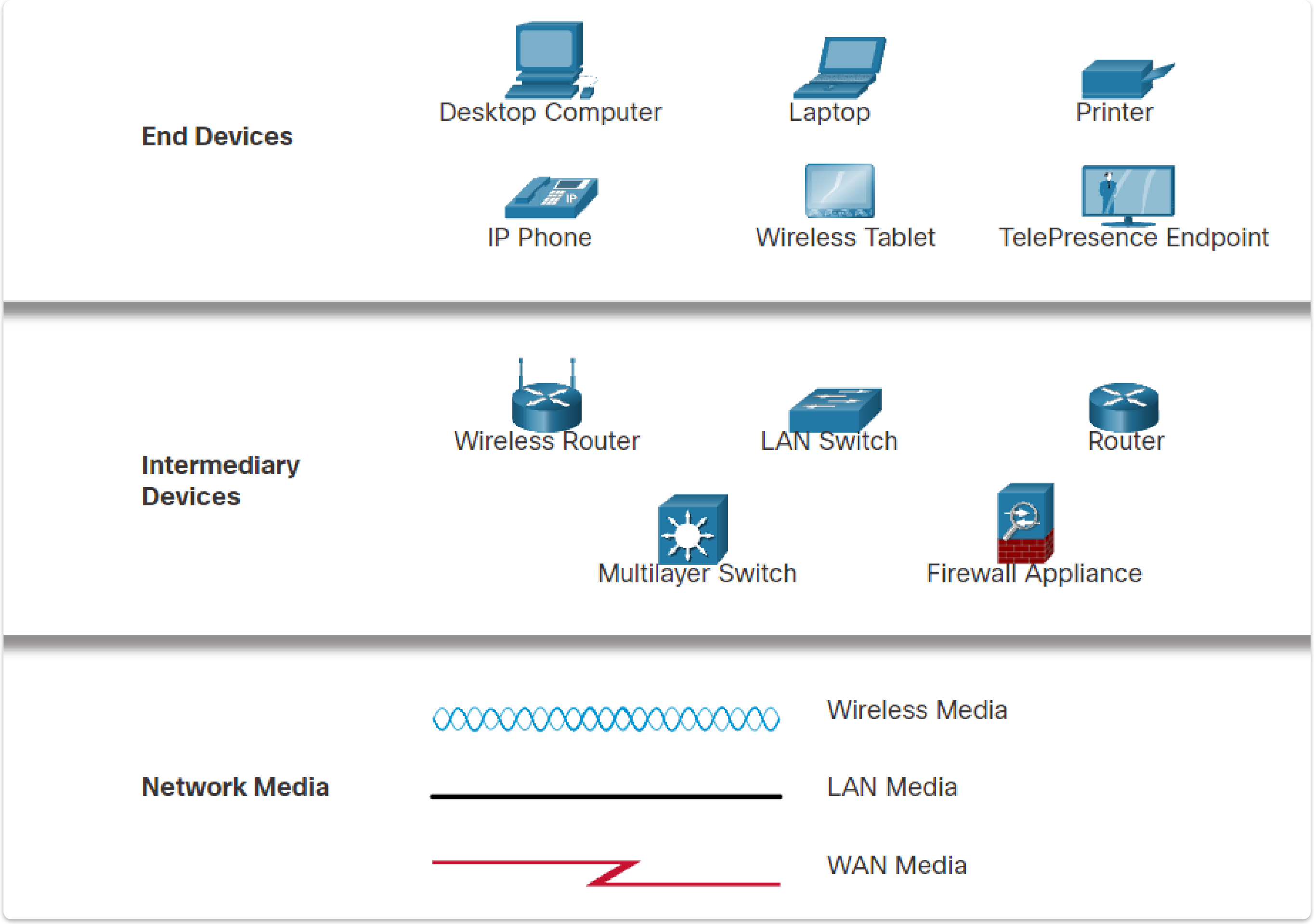
Like bandwidth, throughput is the measure of the transfer of bits across the media over a given period of time. However, due to a number of factors, throughput does not usually match the specified bandwidth. Many factors influence throughput including:

- The amount of data being sent and received over the connection
- The types of data being transmitted
- The latency created by the number of network devices encountered between source and destination

  Latency refers to the amount of time, including delays, for data to travel from one given point to another.

2. Network Components, Types, Connections

Network Components

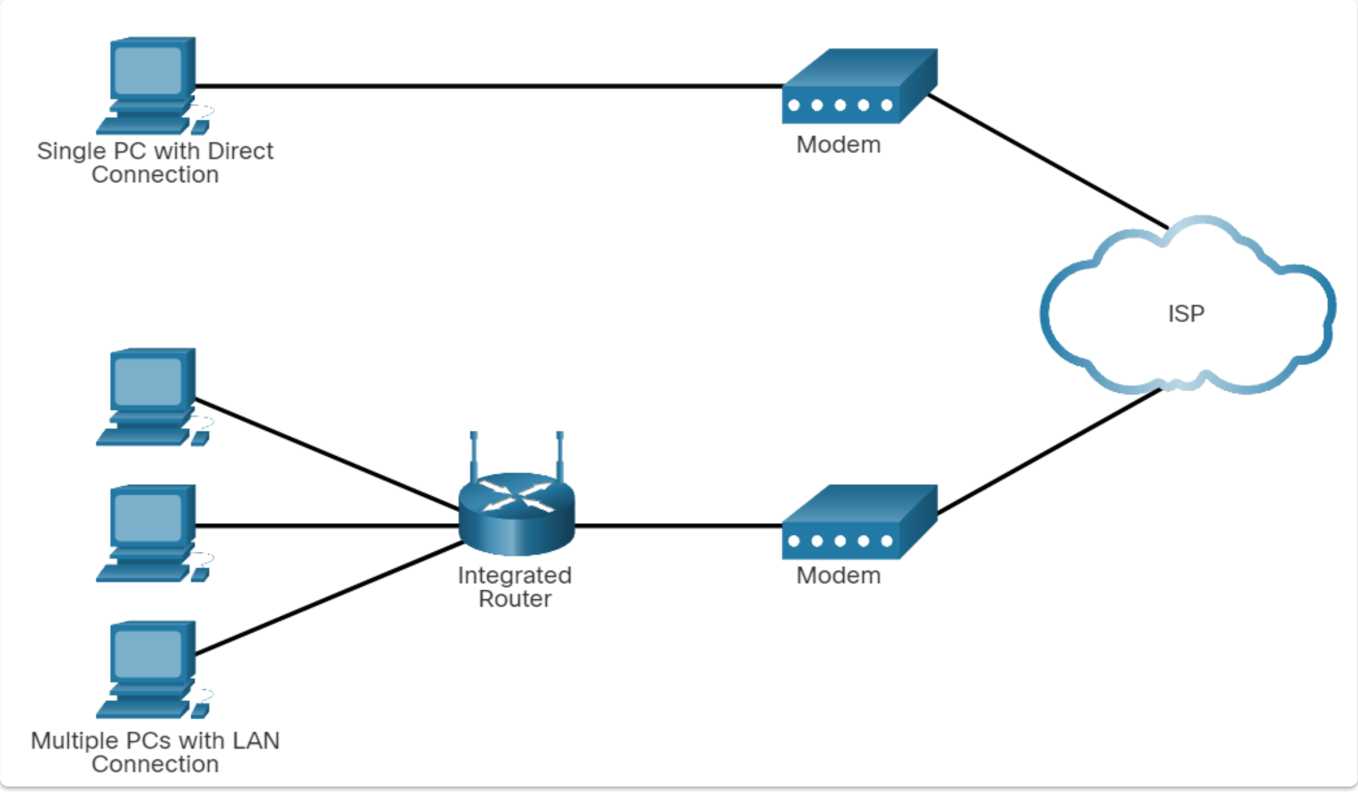


ISP Connectivity Options

An Internet Service Provider (ISP) provides the link between the home network and the internet. An ISP can be the local cable provider, a landline telephone service provider, the cellular network that provides your smartphone service, or an independent provider who leases bandwidth on the physical network infrastructure of another company.

ISP Connections

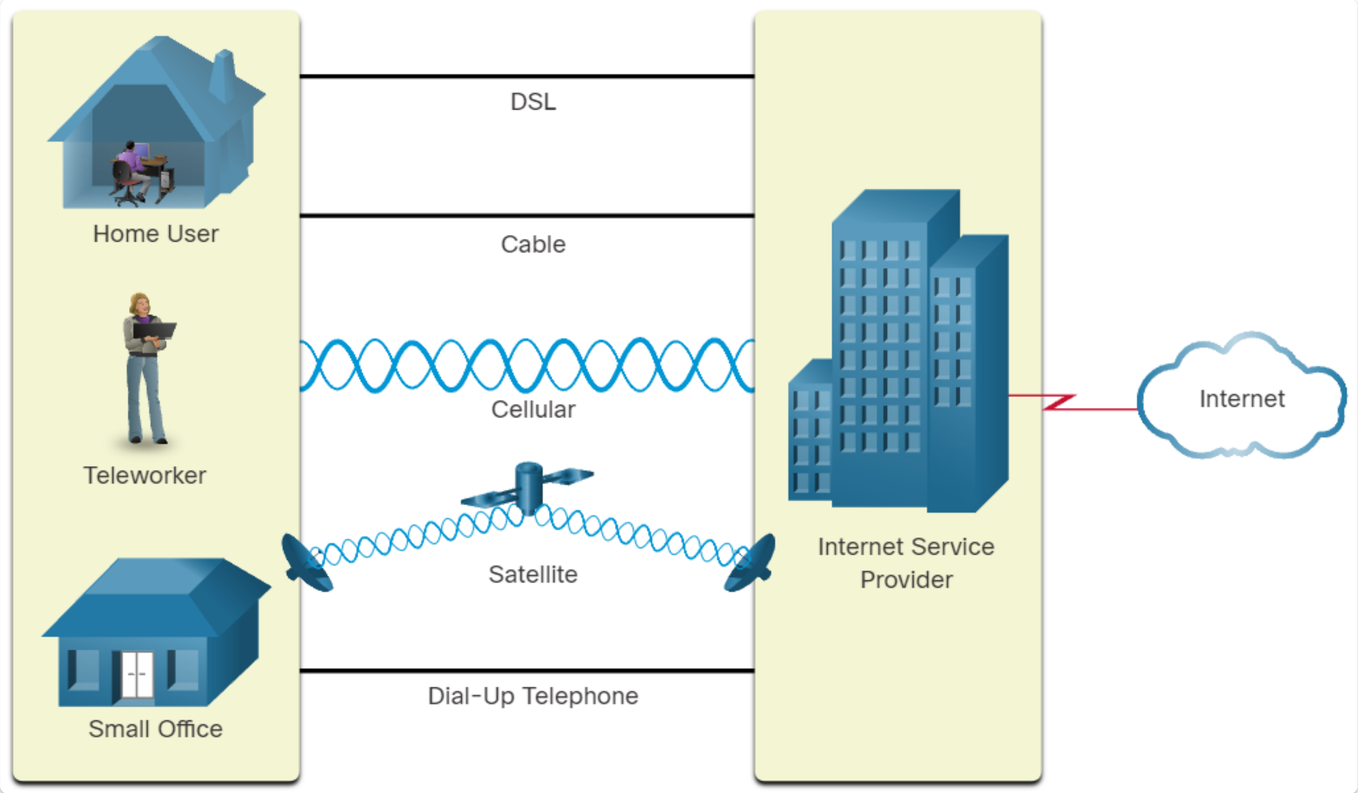
The interconnection of ISPs that forms the backbone of the internet is a complex web of fiber-optic cables with expensive networking switches and routers that direct the flow of information between source and destination hosts. Average home users are not aware of the infrastructure outside of their network. For a home user, connecting to the ISP is a fairly uncomplicated process.


Single PC with Direct Connection
Modem
ISP
Integrated Router
Modem
Multiple PCs with LAN Connection

The top portion of the figure displays the simplest ISP connection option. It consists of a modem that provides a direct connection between a computer and the ISP. This option should not be used though, because your computer is not protected on the internet.

As shown in the bottom portion of the figure, a router is required to securely connect a computer to an ISP. This is the most common connection option. It consists of using a wireless integrated router to connect to the ISP. The router includes a switch to connect wired hosts and a wireless AP to connect wireless hosts. The router also provides client IP addressing information and security for inside hosts.

Cable and DSL Connections



Cable - Typically offered by cable television service providers, the internet data signal is carried on the same coaxial cable that delivers cable television.
DSL - Digital Subscriber Line provides a high bandwidth, always on, connection to the internet. It requires a special high-speed modem that separates the DSL signal from the telephone signal and provides an Ethernet connection to a host computer or LAN.

3. Wireless and Mobile Networks

Wireless Networks

Mobile phones use radio waves to transmit voice signals to antennas mounted on towers located in specific geographic areas. When a telephone call is made, the voice signal is relayed from one tower to another tower until it is delivered to its destination. This type of network is used when you make a phone call to another mobile phone or to a wired telephone. It is also used to send text messages directly from the phone. The most common type of cellular telephone network is called a GSM network. The abbreviations 3G, 4G, 4G-LTE, and 5G are used to describe enhanced cell phone networks that are optimized for the fast transmission of data. Currently, 4G still dominates as the current mobile network used by most phones.

In addition to the GSM and 4G/5G transmitters and receivers, smartphones make connections in a variety of ways.

Wi-Fi transmitters and receivers located within the smartphone enable the phone to connect to local networks and the internet. Wi-Fi networks are usually privately owned but often provide guest or public access hotspots. A hotspot is an area where Wi-Fi signals are available.

Bluetooth is wireless technology that allows devices to communicate over short distances. Multiple devices can be connected at the same time with Bluetooth.

NFC is a wireless communication technology that enables data to be exchanged by devices that are in very close proximity to each other, usually less than a few centimeters.

Mobile Device Connectivity

Almost all mobile devices are capable of connecting to Wi-Fi networks. These precautions should be taken to protect Wi-Fi communications on mobile devices:

- Never send login or password information using unencrypted text (plaintext).
- Use a VPN connection when possible if you are sending sensitive data.
- Enable security on home networks.
- Use WPA2 or higher encryption for security.

Two of the most popular operating systems for mobile devices are Android and Apple iOS. Mobile devices are preprogrammed to use a Wi-Fi network for the internet if one is available, and the device can connect to the access point and receive an IP address. If no Wi-Fi network is available, the device uses the cellular data capability if it is configured.

Bluetooth technology provides a simple way for mobile devices to connect to each other and to wireless accessories. Bluetooth is wireless, automatic, and uses very little power, which helps conserve battery life. Some examples of devices that use Bluetooth include hands-free headsets, keyboards, a mouse, stereo controls, car speakerphones, and mobile speakers.

Bluetooth pairing occurs when two Bluetooth devices establish a connection to share resources. In order for the devices to pair, the Bluetooth radios are turned on, and one device begins searching for other devices. Other devices must be set to discoverable mode, also called visible, so that they can be detected.

When a Bluetooth device is in discoverable mode, it transmits the following information when another Bluetooth device requests it:

- Name
- Bluetooth class
- Services that the device can use
- Technical information, such as the features or the Bluetooth specification that it supports

During the pairing process, a PIN may be requested to authenticate the pairing process.

4. Build a Home Network

Home Network Basics

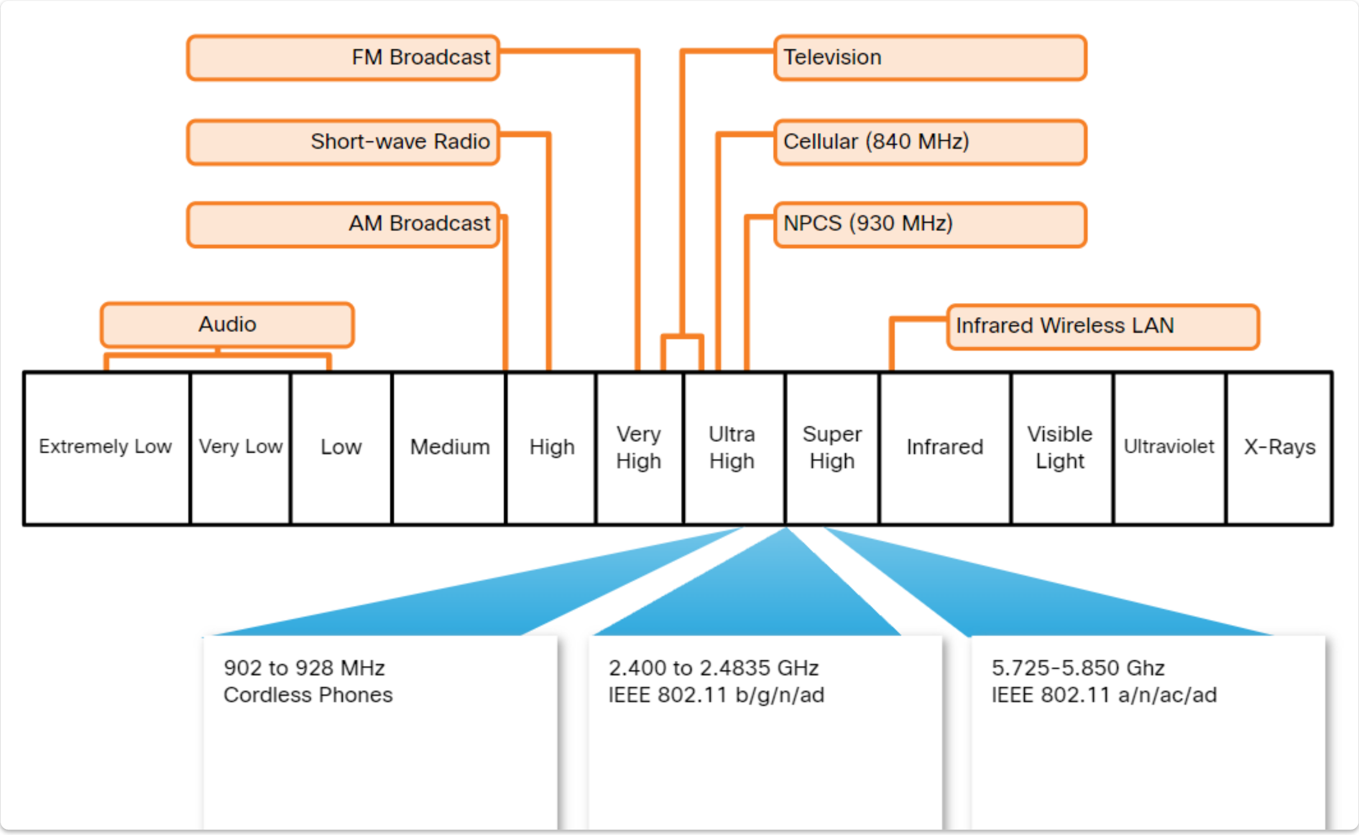
Most home networks consist of at least two separate networks. The public network coming in from the service provider. The router is connected to the internet. Most likely, the home router is equipped with both wired and wireless capabilities. A home network is a small LAN with devices that usually connect to an integrated router and to each other in order to exchange information.

Wireless technology is fairly easy and inexpensive to install. Advantages of wireless LAN technology include mobility, scalability, flexibility, cost savings, reduced installation time, and reliability in harsh environments.

In addition to an integrated router, there are many different types of devices that might be connecting to a home network, Examples include desktop computers, gaming systems, smart tv systems, printers, scanners, security cameras, and climate control devices.

Small business and home routers typically have two primary types of ports: ethernet ports and internet ports. In addition to the wired ports, many home routers include a radio antenna and a built-in wireless access point.

Network Technologies in the Home



Wireless technologies use electromagnetic waves to carry information between devices. The electromagnetic spectrum includes such things as radio and television broadcast bands, visible light, x-rays, and gamma-rays. Some types of electromagnetic waves are not suitable for carrying data. Other parts of the spectrum are regulated by governments and licensed to various organizations for specific applications.

Certain unlicensed sections of the spectrum are incorporated into consumer products, including the Wi-Fi routers found in most homes. The wireless technologies most frequently used in home networks are in the unlicensed 2.4 GHz and 5 GHz frequency ranges. Bluetooth is a technology that makes use of the 2.4 GHz band. Other technologies that use the 2.4 GHz and 5 GHz bands are the modern wireless LAN technologies that conform to the various IEEE 802.11 standards. Unlike Bluetooth technology, 802.11 devices transmit at a much higher power level giving them a great range and improved throughput.

Although many home network devices support wireless communications, there are still a few applications where devices benefit from a wired switch connection. The most commonly implemented wired protocol is the Ethernet protocol. Directly connected devices use an Ethernet patch cable, usually unshielded twisted pair. Category 5e is the most common wiring used in a LAN. The cable is made up of 4 pairs of wires that are twisted to reduce electrical interference. For those homes that do not have UTP wiring, there are other technologies, such as powerline, that can distribute wired connectivity throughout the premises.

Wireless Standarts

The IEEE 802.11 standard governs the WLAN environment. Wireless standards for LANs use the 2.4 GHz and 5 GHz frequency bands. Collectively these technologies are referred to as Wi-Fi. The Wi-Fi Alliance is responsible for testing wireless LAN devices from different manufacturers.

Wireless routers using the 802.11 standards have multiple settings that have to be configured. These settings include the following:

- Network mode - Determines the type of technology that must be supported. For example, 802.11b, 802.11g, 802.11n or Mixed Mode.
- Network Name (SSID) - Used to identify the WLAN. All devices that wish to participate in the WLAN must have the same SSID.
- Standard Channel - Specifies the channel over which communication will occur. By default, this is set to Auto to allow the access point (AP) to determine the optimum channel to use.
- SSID Broadcast - Determines if the SSID will be broadcast to all devices within range. By default, set to Enabled.

The 802.11 protocol can provide increased throughput based on the wireless network environment. If all wireless devices connect with the same 802.11 standard, maximum speeds can be obtained for that standard. If the access point is configured to accept only one 802.11 standard, devices that do not use that standard cannot connect to the access point. A mixed mode wireless network environment can include devices that use any of the existing Wi-Fi standards.

When building a wireless network, it is important that the wireless components connect to the appropriate WLAN. This is done using the SSID. The SSID is used to tell wireless devices, called STAs, which WLAN they belong to and with which other devices they can communicate. The SSID broadcast allows other devices and wireless clients to automatically discover the name of the wireless network. When the SSID broadcast is disabled, you must manually enter the SSID on wireless devices.

Set up a Home Router

Many wireless routers designed for home use have an automatic setup utility that can be used to configure the basic settings on the router. To connect to the router using a wired connection, plug an Ethernet patch cable into the network port on the computer. Plug the other end into a LAN port on the router.

After the computer is connected to the network router and the link lights on the NIC indicate a working connection, the computer needs an IP address. Most network routers are set up so that the computer receives an IP address automatically from a local DHCP server automatically configured on the wireless router.

Before entering the configuration utility, or manually configuring the router through a web browser, you should consider how your network will be used. Consider what you will call your network and what devices should connect to your network. It is not a good practice to include the device model or brand name as part of the SSID since internet searches can expose security weaknesses.

The decision regarding who can access your home network should be determined by how you plan to use the network. Many routers support MAC address filtering. This enables you to specifically identify who is allowed on the wireless network. This makes the wireless network more secure, but it also less flexible when connecting new devices. On some wireless routers, it is possible to set up guest access. This is a special SSID coverage area that allows open access but restricts that access to using the internet only.

5. Communication Principles

Communication Protocol

Protocols are required for computers to properly communicate across the network. These include message format, message size, timing, encoding, encapsulation, and message patterns.

- Message format - When a message is sent, it must use a specific format or structure.
- Message size - The rules that govern the size of the pieces communicated across the network are very strict. They can also be different, depending on the channel used.
- Timing - Timing determines the speed at which the bits are transmitted across the network. It also affects when an individual host can send data and the total amount of data that can be sent in any one transmission.
- Encoding - Messages sent across the network are first converted into bits by the sending host. Each bit is encoded into a pattern of sounds, light waves, or electrical impulses depending on the network media over which the bits are transmitted.
- Encapsulation - Each message transmitted on a network must include a header that contains addressing information that identifies the source and destination hosts. Encapsulation is the process of adding this information to the pieces of data that make up the message.

- Message pattern - Some messages require an acknowledgment before the next message can be sent. This type of request/response pattern is a common aspect of many networking protocols. However, there are other types of messages that may be simply streamed across the network, without concern as to whether they reach their destination.

Communication Standarts

Topologies allow us to see the networking using representation of end devices and intermediary devices. How does a device see a network? Think of a device in a bubble. The only thing a device sees is its own addressing information. How does the device know it is on the same network as another device? The answer is network protocols. Most network communications are broken up into smaller data units, or packets.

A standard is a set of rules that determines how something must be done. Networking and internet standards ensure that all devices connecting to the network implement the same set of rules or protocols in the same manner. Using standards, it is possible for different types of devices to send information to each other over the internet.

An internet standard is the end result of a comprehensive cycle of discussion, problem solving, and testing. These different standards are developed, published, and maintained by a variety of organizations. When a new standard is proposed, each stage of the development and approval process is recorded in a numbered RFC document so that the evolution of the standard is tracked. RFCs for internet standards are published and managed by the IETF.

Network Communication Models

Protocols are the rules that govern communications. Successful communication between hosts requires interaction between a number of protocols. Protocols include HTTP, TCP, IP, and Ethernet. These protocols are implemented in software and hardware that are installed on each host and networking device.

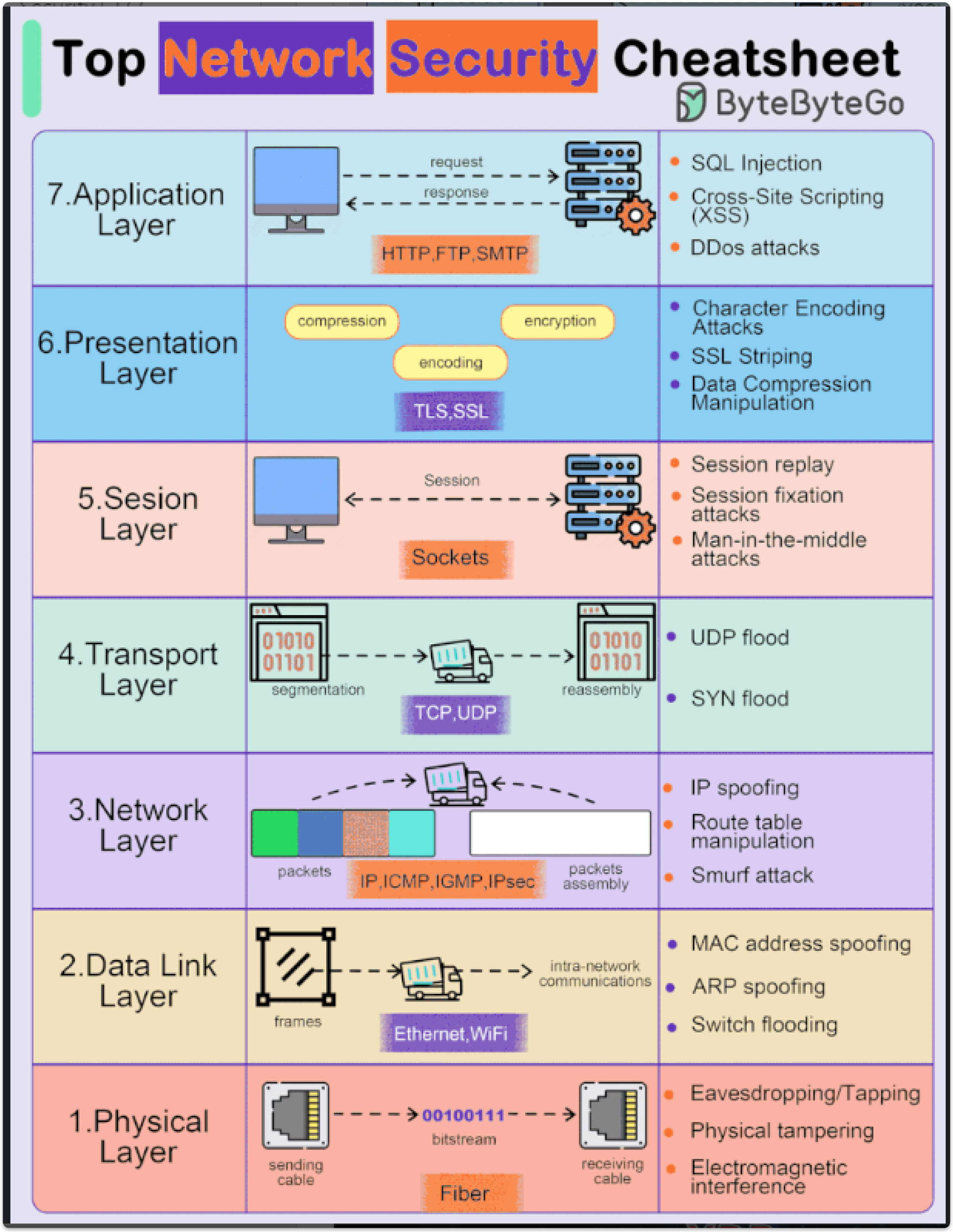
The interaction between the different protocols on a device can be illustrated as a protocol stack. A stack illustrates the protocols as a layered hierarchy, with each higher-level protocol depending on the services of the protocols shown in the lower levels. The separation of functions enables each layer in the stack to operate independently of others.

The suite of TCP/IP protocols that are used for internet communications follows the structure of this model:

- Application - Represents data to the user, plus encoding and dialog control
- Transport -Supports communication between various devices across diverse networks
- Internet - Determines the best path through the network
- Network Access - The hardware devices and media that make up the network.

A reference model describes the functions that must be completed at a particular layer but does not specify exactly how a function should be accomplished. The primary purpose of a reference model is to aid in clearer understanding of the functions and processes necessary for network communications.

The most widely known internetwork reference model was created by the OSI project at the International ISO. It is used for data network design, operation specifications, and troubleshooting. This model is commonly referred to as the OSI model.



Top Network Security Cheatsheet

ByteByteGo

7.Application Layer	request response HTTP,FTP,SMTP	• SQL Injection • Cross-Site Scripting (XSS) • DDos attacks
6.Presentation Layer	compression encryption encoding TLS,SSL	• Character Encoding Attacks • SSL Striping • Data Compression Manipulation
5.Sesion Layer	Session Sockets	• Session replay • Session fixation attacks • Man-in-the-middle attacks
4.Transport Layer	01010 01101 segmentation 01010 01101 reassembly TCP,UDP	• UDP flood • SYN flood
3.Network Layer	packets IP,ICMP,IGMP,IPsec packets assembly	• IP spoofing • Route table manipulation • Smurf attack
2.Data Link Layer	frames intra-network communications Ethernet,WiFi	• MAC address spoofing • ARP spoofing • Switch flooding
1.Physical Layer	00100111 bitstream sending cable receiving cable Fiber	• Eavesdropping/Tapping • Physical tampering • Electromagnetic interference

Osi Model Layer Description

- 7 – Application - The application layer contains protocols used for process-to-process communications.
- 6 – Presentation - The presentation layer provides for common representation of the data transferred between application layer services.
- 5 – Session - The session layer provides services to the presentation layer to organize its dialogue and to manage data exchange.
- 4 – Transport - The transport layer defines services to segment, transfer, and reassemble the data for individual communications between the end devices.
- 3 – Network - The network layer provides services to exchange the individual pieces of data over the network between identified end devices.
- 2 - Data Link - The data link layer protocols describe methods for exchanging data frames between devices over a common media
- 1 – Physical - The physical layer protocols describe the mechanical, electrical, functional, and procedural means to activate, maintain, and de-activate physical connections for a bit transmission to and from a network device.

6. Network Media

Network Media Types

Communication transmits across a network on media. The media provides the channel over which the message travels from source to destination.

Modern networks primarily use three types of media to interconnect devices are:

- Metal wires within cables - Data is encoded into electrical impulses.
- Glass or plastic fibers within cables (fiber-optic cable) - Data is encoded into pulses of light.
- Wireless transmission - Data is encoded via modulation of specific frequencies of electromagnetic waves.

The four main criteria for choosing media are the following:

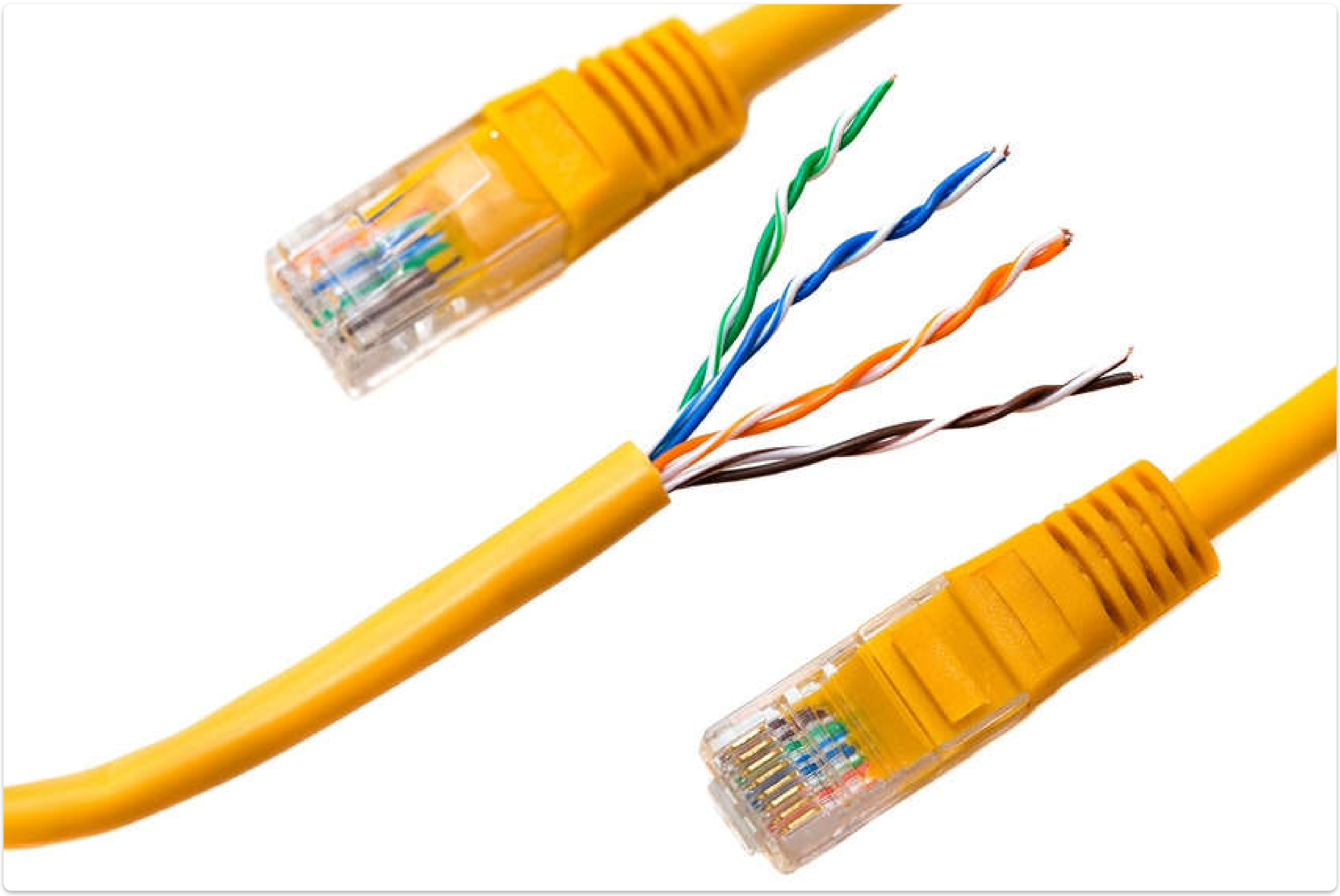
- What is the maximum distance that the media can successfully carry a signal?
- What is the environment in which the media will be installed?
- What is the amount if data and at what speed must is be transmitted?
- What is the cost of the media installation?

Common Network Cables

Twisted-Pair Cable

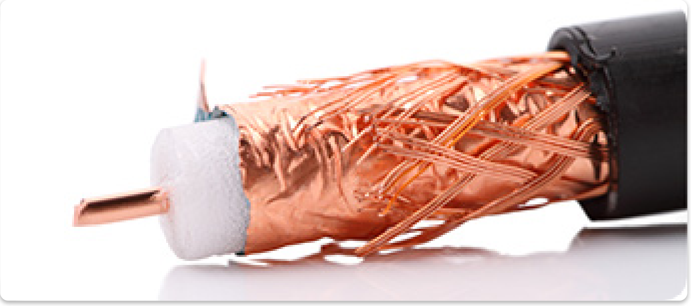
Ethernet technology generally uses twisted-pair cables to interconnect devices. Because Ethernet is the foundation for most local networks, twisted-pair is the most commonly encountered type of network cabling.

In twisted-pair, wires are grouped in pairs and twisted together to reduce interference. The pairs of wires are colored so that you can identify the same wire at each end. Typically, in each pair, one of the wires is a solid color and its partner is the same color striped onto a white background.



Coaxial Cable

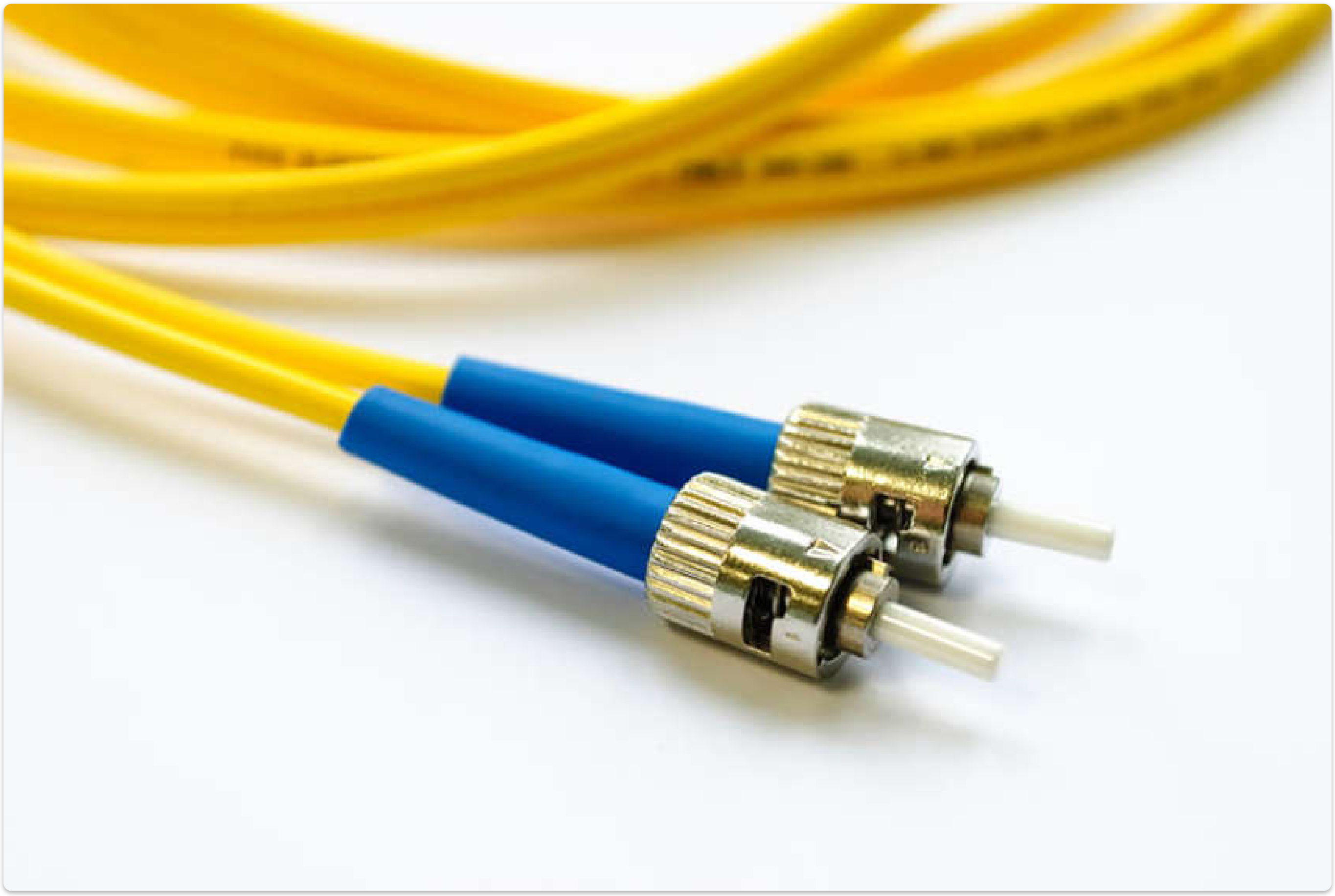
Coaxial was one of the earliest types of network cabling developed. Coaxial cable is the kind of copper cable used by cable TV companies. It is also used for connecting the various components which make up satellite communication systems. Coaxial cable has a single rigid copper core that conducts the signal. This core is typically surrounded by a layer of insulation, braided metal shielding, and a protective jacket. It is used as a high-frequency transmission line to carry high-frequency or broadband signals.



Fiber-Optic Cable

Fiber-optic cable can be either glass or plastic with a diameter about the same as a human hair and it can carry digital information at very high speeds over long distances. Because light is used instead of electricity, electrical interference does not affect the signal. Fiber-optic cables have many uses as well

as communications. They are also used in medical imaging, medical treatment, and mechanical engineering inspection.
They have a very high bandwidth, which enables them to carry very large amounts of data. Fiber is used in backbone networks, large enterprise environments, and large data centers. It is also used extensively by telephone companies.



7. The Access Layer

Encapsulation and the Ethernet Frame

The process of placing one message format inside another message format is called encapsulation. De-encapsulation occurs when the process is reversed by the recipient and the letter is removed from the envelope. Just as a letter is encapsulated in an envelope for delivery, so computer messages are encapsulated. A message that is sent over a computer network follows specific format rules for it to be delivered and processed.

The Ethernet protocol standards define many aspects of network communication including frame format, frame size, timing, and encoding. The format for Ethernet frames specifies the location of the destination and source MAC addresses, and additional information including preamble for sequencing and timing, start of frame delimiter, length and type of frame, and frame check sequence to detect transmission errors.

The Access Layer

The access layer is the part of the network in which people gain access to other hosts and to shared files and printers. The access layer provides the first line of networking devices that connect hosts to the wired Ethernet network. Within an Ethernet network, each host can connect directly to an access layer networking device using an Ethernet cable. Ethernet hubs contain multiple ports that are used to connect hosts to the network. Only one message can be sent through an Ethernet hub at a time. Two or more messages sent at the same time will cause a collision. Because excessive retransmissions can clog up the network and slow down network traffic, hubs are now considered obsolete and have been replaced by Ethernet switches.

An Ethernet switch is a device that is used at Layer 2. When a host sends a message to another host connected to the same switched network, the switch accepts and decodes the frames to read the MAC address portion of the message. A table on the switch, called a MAC address table, contains a list of all the active ports and the host MAC addresses that are attached to them. When a message is sent between hosts, the switch checks to see if the destination MAC address is in the table. If it is, the switch builds a temporary connection, called a circuit, between the source and destination ports. Ethernet switches also allow for sending and receiving frames over the same Ethernet cable simultaneously. This improves the performance of the network by eliminating collisions.

A switch builds the MAC address table by examining the source MAC address of each frame that is sent between hosts. When a new host sends a message or responds to a flooded message, the switch immediately learns its MAC address and the port to which it is connected. The table is dynamically updated each time a new source MAC address is read by the switch.

8. The Internet Protocol

Purpose of the IPV4 Address

The IPv4 address is a logical network address that identifies a particular host. It must be properly configured and unique within the LAN, for local communication. It must also be properly configured and unique in the world, for remote communication.

An IPv4 address is assigned to the network interface connection for a host. This connection is usually a NIC installed in the device.

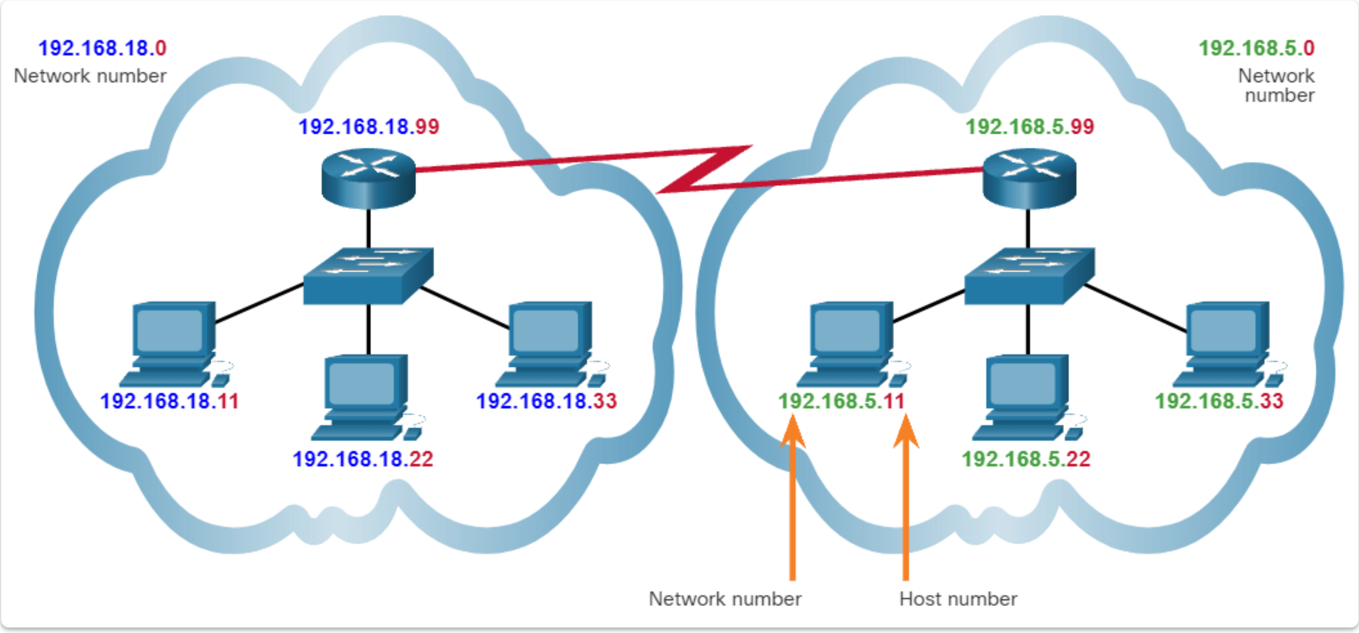
Every packet sent across the internet has a source and destination IPv4 address. This information is required by networking devices to ensure the information gets to the destination and any replies are returned to the source.

Octets and Dotted-Decimal Notation

IPv4 addresses are 32 bits in length. Here is an IPv4 address in binary:
11010001101001011100100000000001
Notice how difficult this address is to read. Imagine having to configure devices with a series of 32 bits! For this reason, the 32 bits are grouped into four 8-bit bytes called octets like this:
11010001.10100101.11001000.00000001

That's better, but still difficult to read. That's why we convert each octet into its decimal value, separated by a decimal point or period. The above binary IPv4 becomes this dotted-decimal representation:
209.165.200.1

The IPV4 Address Structure



The logical 32-bit IPv4 address is hierarchical and is made up of two parts, the network and the host. In the figure, the network portion is blue, and the host portion is red. Both parts are required in an IPv4 address. Both networks have the subnet mask 255.255.255.0. The subnet mask is used to identify the network on which the host is connected.

As an example, there is a host with an IPv4 address 192.168.5.11 with a subnet mask of 255.255.255.0. The first three octets, (192.168.5), identify the network portion of the address, and the last octet, (11) identifies the host. This is known as hierarchical addressing because the network portion indicates the network on which each unique host address is located. Routers only need to know how to reach each network, rather than needing to know the location of each individual host.

With IPv4 addressing, multiple logical networks can exist on one physical network if the network portion of the logical network host addresses is different. For example: three hosts on a single, physical local network have the same network portion of their IPv4 address (192.168.18) and three other hosts have different network portions of their IPv4 addresses (192.168.5). The hosts with the same network number in their IPv4 addresses will be able to communicate with each other, but will not be able to communicate with the other hosts without the use of routing. In this example, there is one physical network and two logical IPv4 networks.

9. IPv4 and Network Segmentation

IPv4 Unicast, Broadcast and Multicast

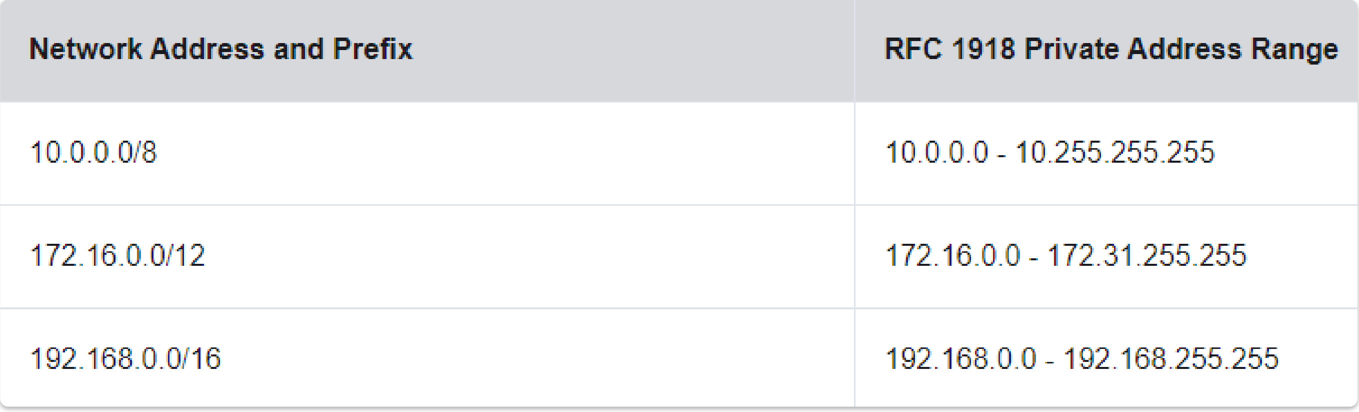
Unicast transmission refers to one device sending a message to one other device in one-to-one communications. A unicast packet has a destination IP address that is a unicast address which goes to a single recipient. A source IP address can only be a unicast address because the packet can only originate from a single source. This is regardless of whether the destination IP address is a unicast, broadcast or multicast. IPv4 unicast host addresses are in the address range of 1.1.1.1 to 223.255.255.255.

Broadcast transmission refers to a device sending a message to all the devices on a network in one-to-all communications. A broadcast packet has a destination IP address with all ones (1s) in the host portion, or 32 one (1) bits. A broadcast packet must be processed by all devices in the same broadcast domain. A broadcast may be directed or limited. A directed broadcast is sent to all hosts on a specific network. A limited broadcast is sent to 255.255.255.255. By default, routers do not forward broadcasts.

Multicast transmission reduces traffic by allowing a host to send a single packet to a selected set of hosts that subscribe to a multicast group. A multicast packet is a packet with a destination IP address that is a multicast address. IPv4 has reserved the 224.0.0.0 to 239.255.255.255 addresses as a multicast range. Each multicast group is represented by a single IPv4 multicast destination address. When an IPv4 host subscribes to a multicast group, the host processes packets addressed to this multicast address, and packets addressed to its uniquely allocated unicast address.

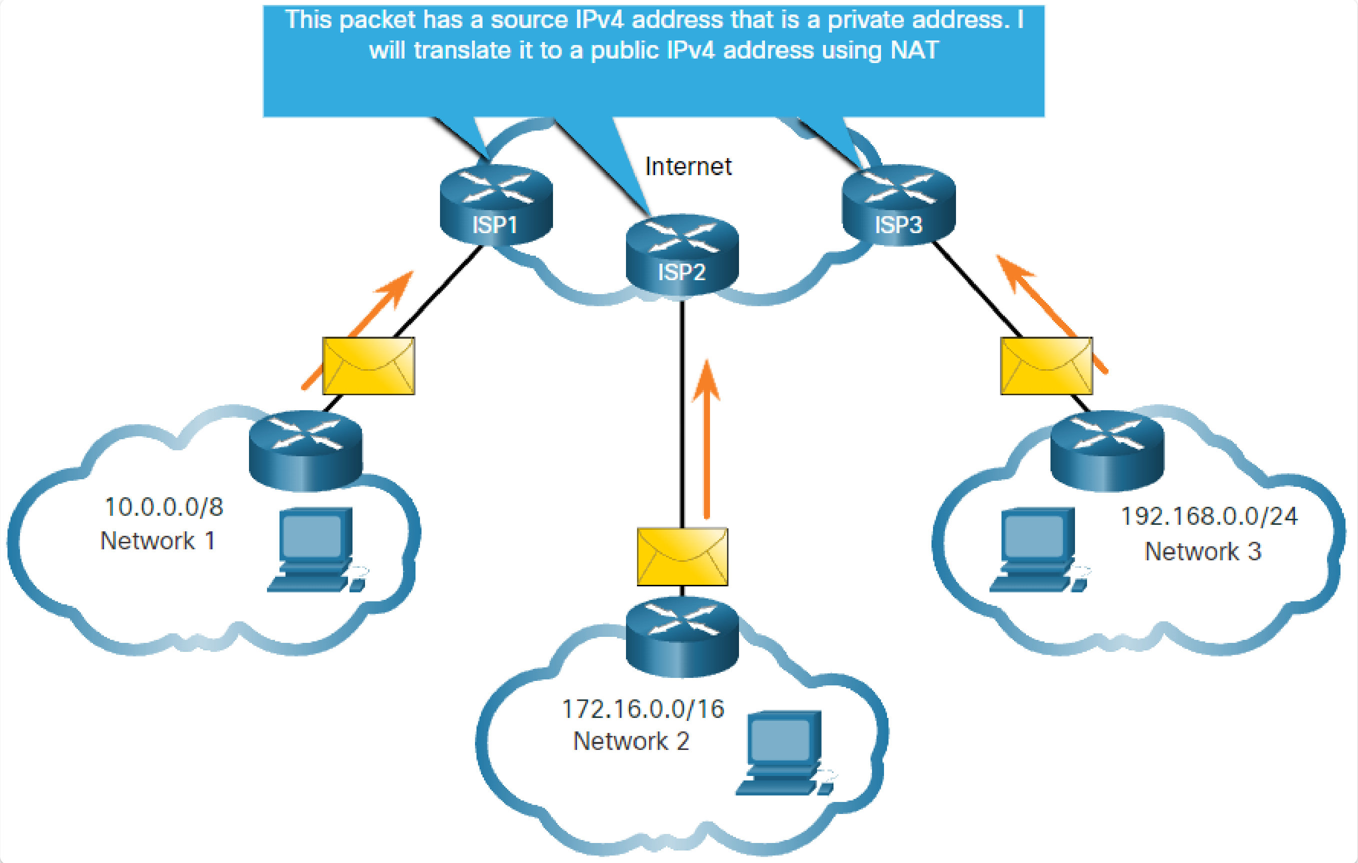
Types of IPv4 Addresses

Public IPv4 addresses are addresses which are globally routed between ISP routers. However, not all available IPv4 addresses can be used on the internet. There are blocks of addresses called private addresses that are used by most organizations to assign IPv4 addresses to internal hosts. Most internal networks, from large enterprises to home networks, use private IPv4 addresses for addressing all internal devices (intranet) including hosts and routers.



Network Address and Prefix	RFC 1918 Private Address Range
10.0.0.0/8	10.0.0.0 - 10.255.255.255
172.16.0.0/12	172.16.0.0 - 172.31.255.255
192.168.0.0/16	192.168.0.0 - 192.168.255.255

However, private addresses are not globally routable. Before the ISP can forward this packet, it must translate the source IPv4 address, which is a private address, to a public IPv4 address using NAT.


This packet has a source IPv4 address that is a private address. I will translate it to a public IPv4 address using NAT
Internet
ISP1
ISP2
ISP3
10.0.0.0/8
Network 1
172.16.0.0/16
Network 2
192.168.0.0/24
Network 3

Loopback addresses (127.0.0.0 /8 or 127.0.0.1 to 127.255.255.254) are more commonly identified as only 127.0.0.1, these are special addresses used by a host to direct traffic to itself. Link-local addresses (169.254.0.0 /16 or 169.254.0.1 to 169.254.255.254) are more commonly known as the Automatic Private IP Addressing (APIPA) addresses or self-assigned addresses. They are used by a Windows DHCP client to self-configure in the event that there are no DHCP servers available.

In 1981, IPv4 addresses were assigned using classful addressing as defined in RFC 790 (https://tools.ietf.org/html/rfc790), Assigned Numbers. Customers were allocated a network address based on one of three classes, A, B, or C. The RFC divided the unicast ranges into specific classes as follows:

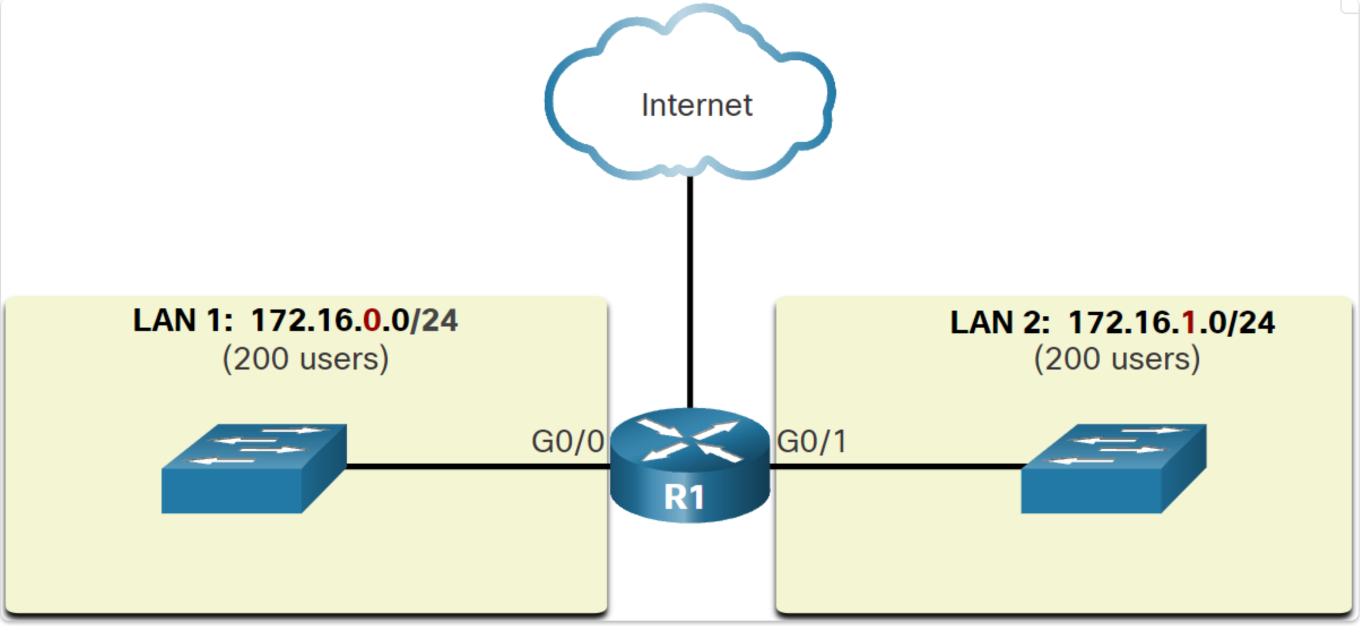
- Class A (0.0.0.0/8 to 127.0.0.0/8) - Designed to support extremely large networks with more than 16 million host addresses.
- Class B (128.0.0.0 /16 - 191.255.0.0 /16) - Designed to support the needs of moderate to large size networks with up to approximately 65,000 host addresses.
- Class C (192.0.0.0 /24 - 223.255.255.0 /24) - Designed to support small networks with a maximum of 254 hosts.

There is also a Class D multicast block consisting of 224.0.0.0 to 239.0.0.0 and a Class E experimental address block consisting of 240.0.0.0 - 255.0.0.0.

Public IPv4 addresses are addresses which are globally routed over the internet. Public IPv4 addresses must be unique. Both IPv4 and IPv6 addresses are managed by the IANA. The IANA manages and allocates blocks of IP addresses to the RIRs. RIRs are responsible for allocating IP addresses to ISPs who provide IPv4 address blocks to organizations and smaller ISPs. Organizations can also get their addresses directly from an RIR.

Network Segmentation

In an Ethernet LAN, devices use broadcasts and ARP to locate other devices. ARP sends Layer 2 broadcasts to a known IPv4 address on the local network to discover the associated MAC address. Devices on Ethernet LANs also locate other devices using services. A host typically acquires its IPv4 address configuration using DHCP which sends broadcasts on the local network to locate a DHCP server. Switches propagate broadcasts out all interfaces except the interface on which it was received.



A large broadcast domain is a network that connects many hosts. A problem with a large broadcast domain is that these hosts can generate excessive broadcasts and negatively affect the network. The solution is to reduce the size of the network to create smaller broadcast domains in a process called subnetting. These smaller network spaces are called subnets. The basis of subnetting is to use host bits to create additional subnets. Subnetting reduces overall network traffic and improves network performance. It helps administrators to implement security policies such as which subnets are allowed or not allowed to communicate together. It reduces the number of devices affected by abnormal broadcast traffic due to misconfigurations, hardware/software problems, or malicious intent.

10. IPv6 Addressing Formats and Rules

IPv4 Issues

The depletion of IPv4 address space has been the motivating factor for moving to IPv6. IPv6 has a larger 128-bit address space, providing 340 undecillion possible addresses. When the IETF began its development of a successor to IPv4, it used this opportunity to fix the limitations of IPv4 and include enhancements. One example is ICMPv6, which includes address resolution and address autoconfiguration not found in ICMPv4.

Both IPv4 and IPv6 coexist and the transition to only IPv6 will take several years. The IETF has created various protocols and tools to help network administrators migrate their networks to IPv6. The migration techniques can be divided into three categories: Dual Stack, Tunneling, and Translation. Dual stack devices run both IPv4 and IPv6 protocol stacks simultaneously. Tunneling is a method of transporting an IPv6 packet over an IPv4 network. The IPv6 packet is encapsulated inside an IPv4 packet, similar to other types of data. NAT64 allows IPv6-enabled devices to communicate with IPv4-enabled devices using a translation technique similar to NAT for IPv4. An IPv6 packet is translated to an IPv4 packet and an IPv4 packet is translated to an IPv6 packet.

IPv6 Addressing

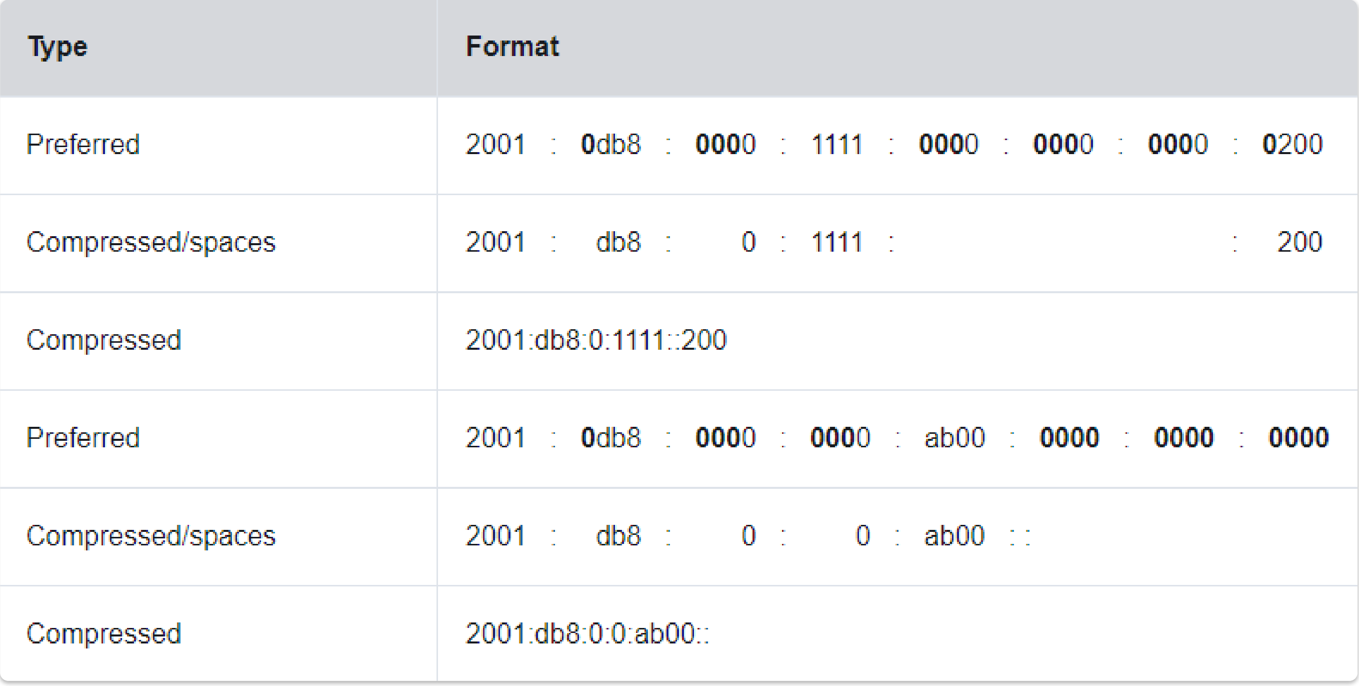
IPv6 addresses are 128 bits in length and written as a string of hexadecimal values. Every four bits is represented by a single hexadecimal digit; for a total of 32 hexadecimal values. IPv6 addresses are not case-sensitive and can be written in either lowercase or uppercase. In IPv6, a hextet that refers to a segment of 16 bits, or four hexadecimal values. Each "x" is a single hextet, which is 16 bits or four hexadecimal digits. Preferred format means that you write IPv6 address using all 32 hexadecimal digits. Here is one example - fe80:0000:0000:0000:0123:4567:89ab:cdef.

There are two rules that help to reduce the number of digits needed to represent an IPv6 address.

Rule 1 – Omit Leading Zeros. You can only omit leading zeros, not trailing zeros.

- 01ab can be represented as 1ab
- 09f0 can be represented as 9f0
- 0a00 can be represented as a00
- 00ab can be represented as ab

Rule 2 – Double Colon. A double colon (::) can replace any single, contiguous string of one or more 16-bit hextets consisting of all zeros. For example, 2001:db8:cafe:1:0:0:0:1 (leading 0s omitted) could be represented as 2001:db8:cafe:1::1. The double colon (::) is used in place of the three all-0 hextets (0:0:0). The double colon (::) can only be used once within an address, otherwise there would be more than one possible resulting address. If an address has more than one contiguous string of all-0 hextets, best practice is to use the double colon (::) on the longest string. If the strings are equal, the first string should use the double colon (::).



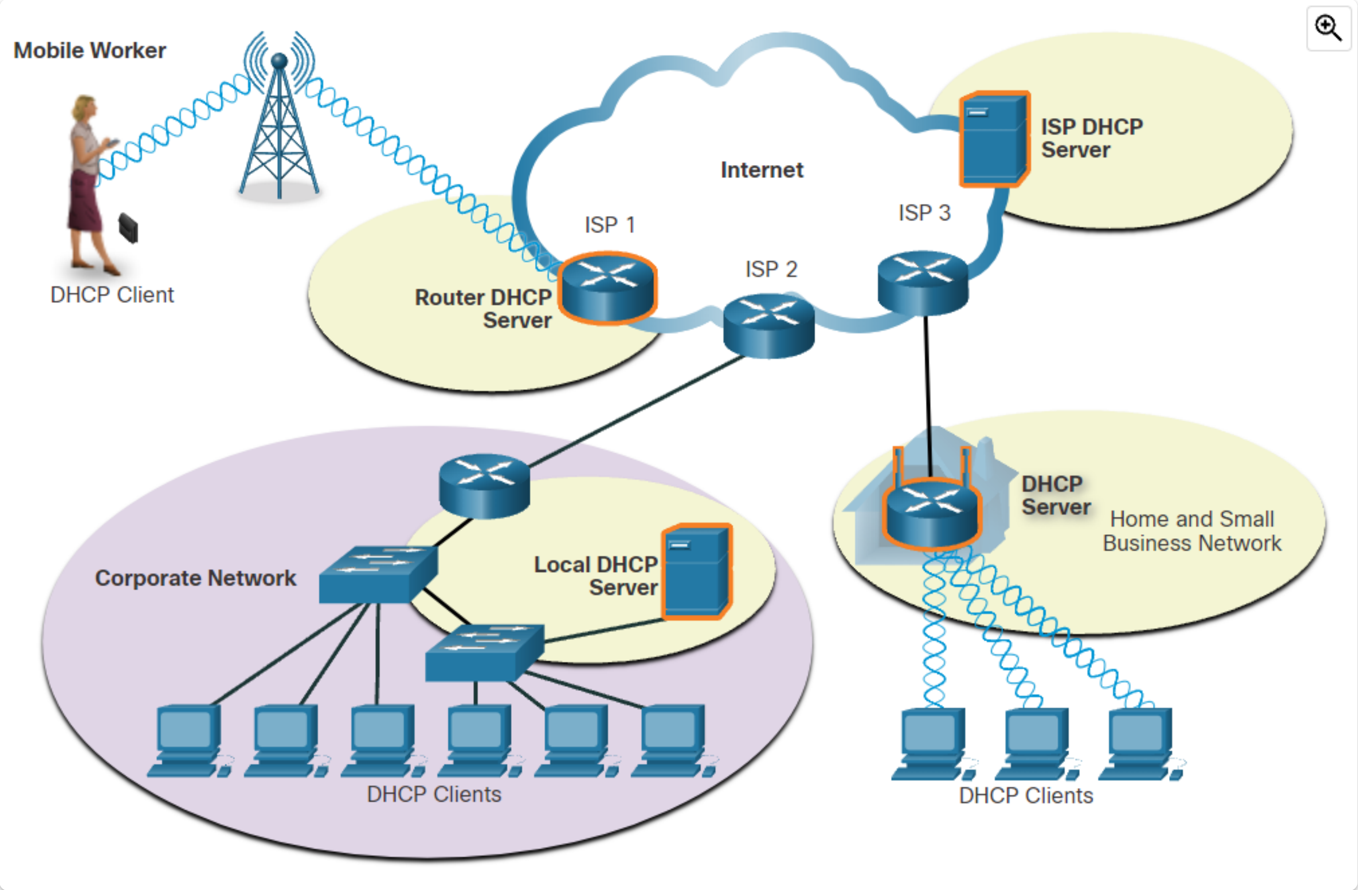
Type	Format
Preferred	2001 : 0db8 : 0000 : 1111 : 0000 : 0000 : 0000 : 0200
Compressed/spaces	2001 : db8 : 0 : 1111 : : 200
Compressed	2001:db8:0:1111::200
Preferred	2001 : 0db8 : 0000 : 0000 : ab00 : 0000 : 0000 : 0000
Compressed/spaces	2001 : db8 : 0 : 0 : ab00 : :
Compressed	2001:db8:0:0:ab00::

11. Dynamic Addressing with DHCP

Static and Dynamic Addressing

With a static assignment, the network administrator must manually configure the network information for a host. At a minimum, this includes the host IPv4 address, subnet mask, and default gateway. Static assignment of addressing information can provide increased control of network resources, but it can be time consuming to enter the information on each host. When using static IPv4 addressing, it is important to maintain an accurate list of which IPv4 addresses are assigned to which devices.

IPv4 addresses can be assigned automatically using a protocol known as DHCP. DHCP is generally the preferred method of assigning IPv4 addresses to hosts on large networks because it reduces the burden on network support staff and virtually eliminates entry errors. Another benefit of DHCP is that an address is not permanently assigned to a host but is only leased for a period of time. If the host is powered down or taken off the network, the address is returned to the pool for reuse.

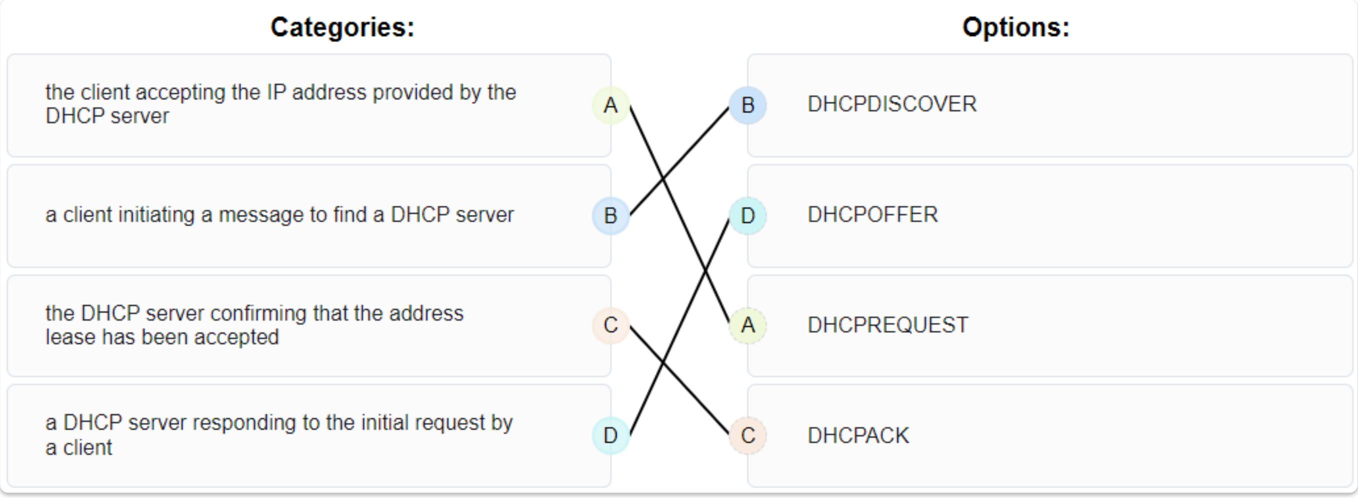


As you enter area with a wireless hotspot, your laptop DHCP client contacts the local DHCP server via a wireless connection. The DHCP server assigns an IPv4 address to your laptop. With home networks, the DHCP server may be located at the ISP and a host on the home network receives its IPv4 configuration directly from the ISP. Many home networks and small businesses use a wireless router and modem. In this case, the wireless router is both a DHCP client and a server.

DHCPv4 Configuration

The DHCP server is configured with a range, or pool, of IPv4 addresses that can be assigned to DHCP clients. A client that needs an IPv4 address will send a DHCP Discover message which is a broadcast with a destination IPv4 address of 255.255.255.255 (32 ones) and a destination MAC address of FF-FF-FF-FF-FF-FF (48 ones). All hosts on the network will receive this broadcast DHCP frame, but only a DHCP server will reply. The server will respond with a DHCP Offer, suggesting an IPv4 address for the client. The host then sends a DHCP Request asking to use the suggested IPv4 address. The server responds with a DHCP Acknowledgment.

For most home and small business networks, a wireless router provides DHCP services to the local network clients. To configure a home wireless router, access its graphical web interface by opening the browser and entering the router default IPv4 address. The IPv4 address of 192.168.0.1 and subnet mask of 255.255.255.0 are the defaults for the internal router interface. This is the default gateway for all hosts on the local network and also the internal DHCP server IPv4 address. Most home wireless routers have DHCP Server enabled by default.

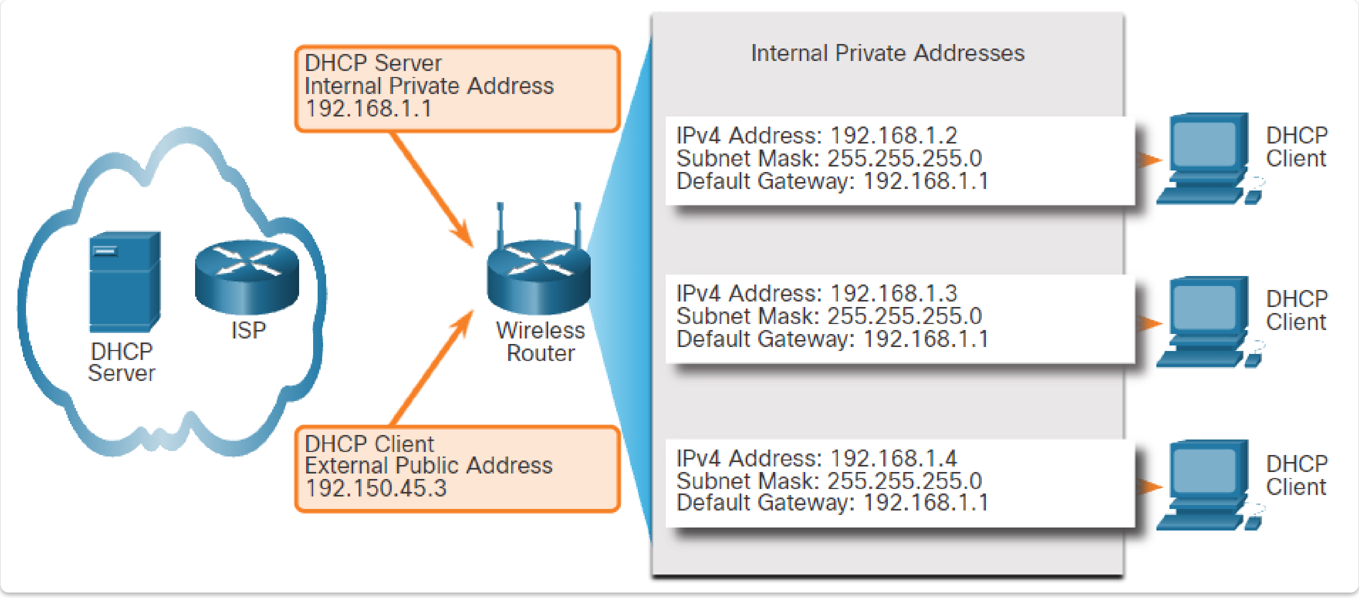


Categories:			Options:
the client accepting the IP address provided by the DHCP server	A	B	DHCPDISCOVER
a client initiating a message to find a DHCP server	B	D	DHCPOFFER
the DHCP server confirming that the address lease has been accepted	C	A	DHCPREQUEST
a DHCP server responding to the initial request by a client	D	C	DHCPACK

12. Gateways to Other Networks

Network Boundaries

Every host on a network must use the router as a gateway to other networks. Therefore, each host must know the IPv4 address of the router interface connected to the network where the host is attached. This address is known as the default gateway address. It can be either statically configured on the host or received dynamically by DHCP.


DHCP Server
Internal Private Address
192.168.1.1
DHCP Server
ISP
Wireless Router
DHCP Client
External Public Address
192.150.45.3
Internal Private Addresses
IPv4 Address: 192.168.1.2
Subnet Mask: 255.255.255.0
Default Gateway: 192.168.1.1
DHCP Client
IPv4 Address: 192.168.1.3
Subnet Mask: 255.255.255.0
Default Gateway: 192.168.1.1
DHCP Client
IPv4 Address: 192.168.1.4
Subnet Mask: 255.255.255.0
Default Gateway: 192.168.1.1
DHCP Client

The wireless router acts as a DHCP server for all local hosts attached to it, either by Ethernet cable or wirelessly. These local hosts are referred to as being located on an internal, or inside, network. When a wireless router is connected to the ISP, it acts like a DHCP client to receive the correct external network IPv4 address for the internet interface. ISPs usually provide an internet-routable address, which enables hosts connected to the wireless router to have access to the internet. The wireless router serves as the boundary between the local internal network and the external internet.

NAT Operation

The wireless router receives a public address from the ISP, which allows it to send and receive packets on the internet. It, in turn, provides private addresses to local network clients.

The process used to convert private addresses to internet-routable addresses is called NAT. With NAT, a private (local) source IPv4 address is translated to a public (global) address. The process is reversed for incoming packets. The wireless router is able to translate many internal IPv4 addresses to the same public address, by using NAT.

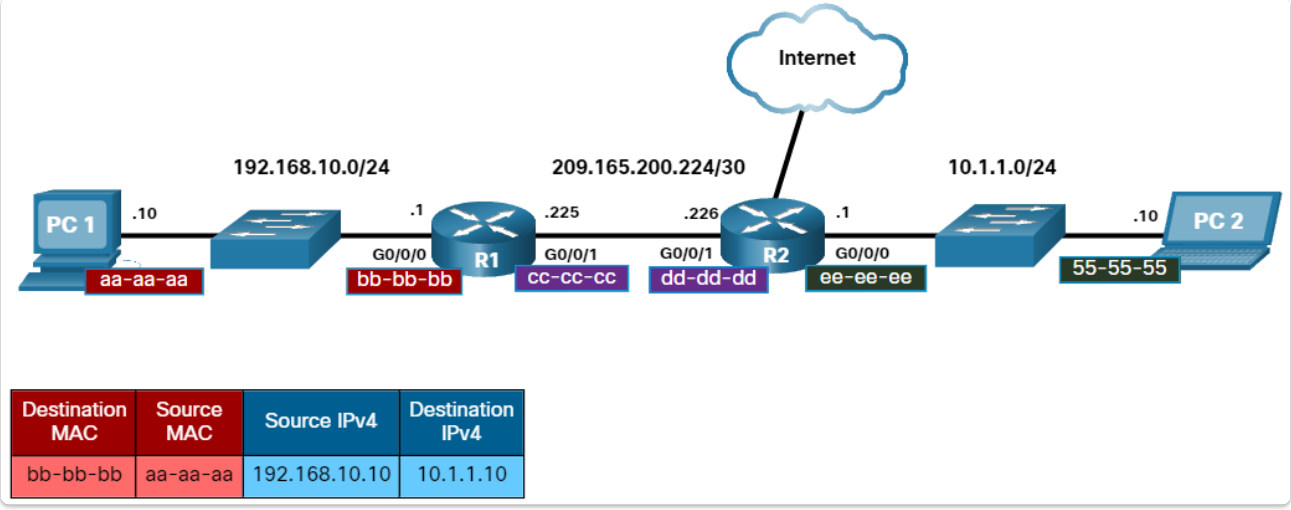
Only packets destined for other networks need to be translated. These packets must pass through the gateway, where the wireless router replaces the private IPv4 address of the source host with its own public IPv4 address.

13. The APR Process

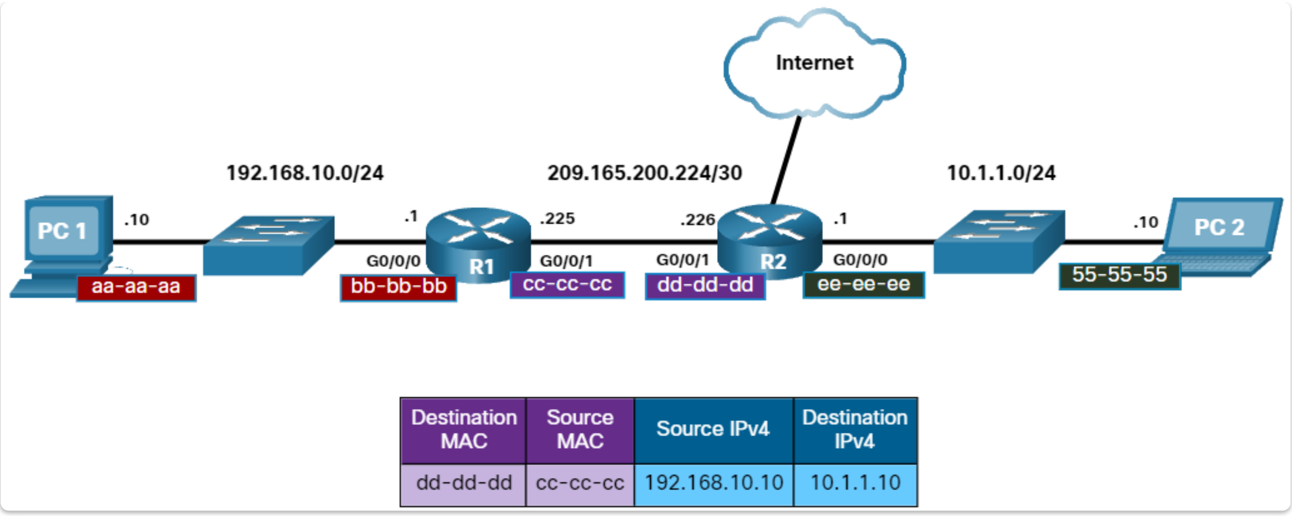
MAC and IP

Sometimes a host must send a message, but it only knows the IP address of the destination device. The host needs to know the MAC address of that device. The MAC address can be discovered using address resolution. There are two primary addresses assigned to a device on an Ethernet LAN:

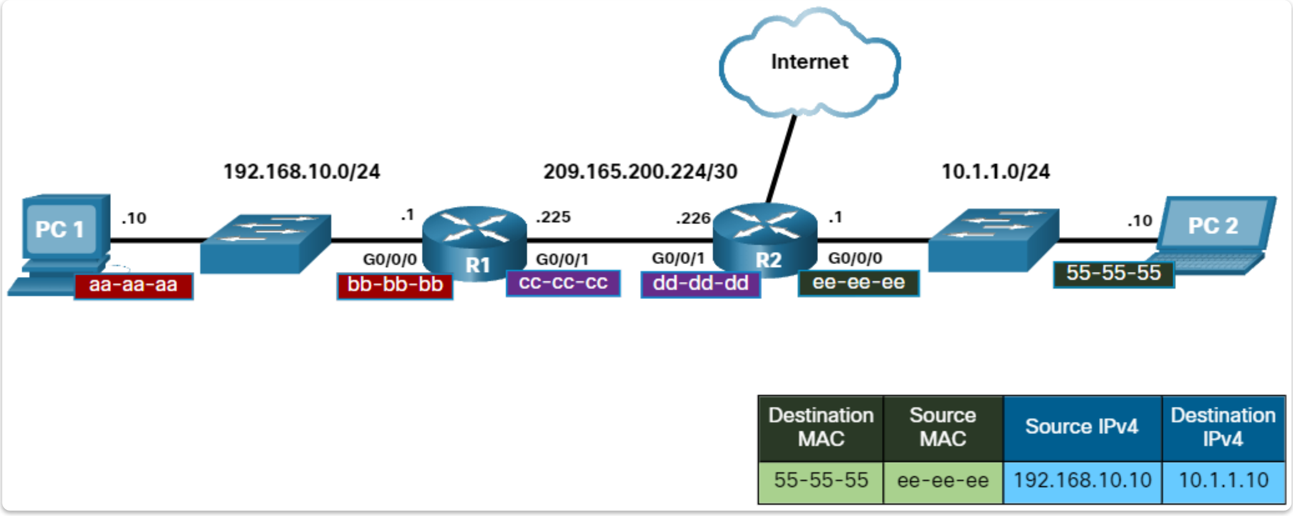
- Physical address (the MAC address) – Used for NIC-to-NIC communications on the same Ethernet network.
- Logical address (the IP address) – Used to send the packet from the source device to the destination device. The destination IP address may be on the same IP network as the source, or it may be on a remote network.



Destination MAC	Source MAC	Source IPv4	Destination IPv4
bb-bb-bb	aa-aa-aa	192.168.10.10	10.1.1.10



Destination MAC	Source MAC	Source IPv4	Destination IPv4
dd-dd-dd	cc-cc-cc	192.168.10.10	10.1.1.10



Destination MAC	Source MAC	Source IPv4	Destination IPv4
55-55-55	ee-ee-ee	192.168.10.10	10.1.1.10

When the destination IP address (IPv4 or IPv6) is on a remote network, the destination MAC address will be the address of the host default gateway (i.e., the router interface). Routers examine the destination IPv4 address to determine the best path to forward the IPv4 packet. When the router receives the Ethernet frame, it de-encapsulates the Layer 2 information. Using the destination IPv4 address, it determines the next-hop device, and then encapsulates the IPv4 packet in a new data link frame for the outgoing interface. Along each link in a path, an IP packet is encapsulated in a frame. The frame is specific to the data link technology that is associated with that link, such as Ethernet. If the next-hop device is the final destination, the destination MAC address will be that of the device Ethernet NIC.

Broadcast Containment

A message can only contain one destination MAC address. Address resolution lets a host send a broadcast message to a unique MAC address that is recognized by all hosts. The broadcast MAC address is a 48-bit address made up of all ones. MAC addresses are usually represented in hexadecimal notation. The broadcast MAC address in hexadecimal notation is FFFF.FFFF.FFFF. Each F in the hexadecimal notation represents four ones in the binary address.

When a host sends a broadcast message, switches forward the message to every connected host within the same local network. For this reason, a local area network, a network with one or more Ethernet switches, is also referred to as a broadcast domain.

If too many hosts are connected to the same broadcast domain, broadcast traffic can become excessive. The number of hosts and the amount of network traffic that can be supported on the local network is limited by the capabilities of the switches used to connect them. To improve performance, you may need to divide one local network into multiple networks, or broadcast domains. Routers are used to divide the network into multiple broadcast domains.

On a local Ethernet network, a NIC only accepts a frame if the destination address is either the broadcast MAC address, or else corresponds to the MAC address of the NIC. Most network applications rely on the logical destination IP address to identify the location of the servers and clients. How does the sending host determine what destination MAC address to place within the frame? The sending host can ARP to discover the MAC address of any host on the same local network.

ARP uses a three-step process to discover and store the MAC address of a host on the local network when only the IPv4 address of the host is known:

1. **The sending host creates and sends a frame addressed to a broadcast MAC address. Contained in the frame is a message with the IPv4 address of the intended destination host.**
2. **Each host on the network receives the broadcast frame and compares the IPv4 address inside the message with its configured IPv4 address. The host with the matching IPv4 address sends its MAC address back to the original sending host.**
3. **The sending host receives the message and stores the MAC address and IPv4 address information in a table called an ARP table.**

IPv6 uses a similar method known as Neighbor Discovery.

14. Routing Between Networks

The Need for Routing

As networks grow, it is often necessary to divide one access layer network into multiple access layer networks. There are many ways to divide networks based on different criteria:

- Broadcast containment - Routers in the distribution layer can limit broadcasts to the local network where they need to be heard.
- Security requirements - Routers in the distribution layer can separate and protect certain groups of computers where confidential information resides.
- Physical locations - Routers in the distribution layer can be used to interconnect local networks at various locations of an organization that are geographically separated.
- Logical grouping - Routers in the distribution layer can be used to logically group users, such as departments within a company, who have common needs or for access to resources.

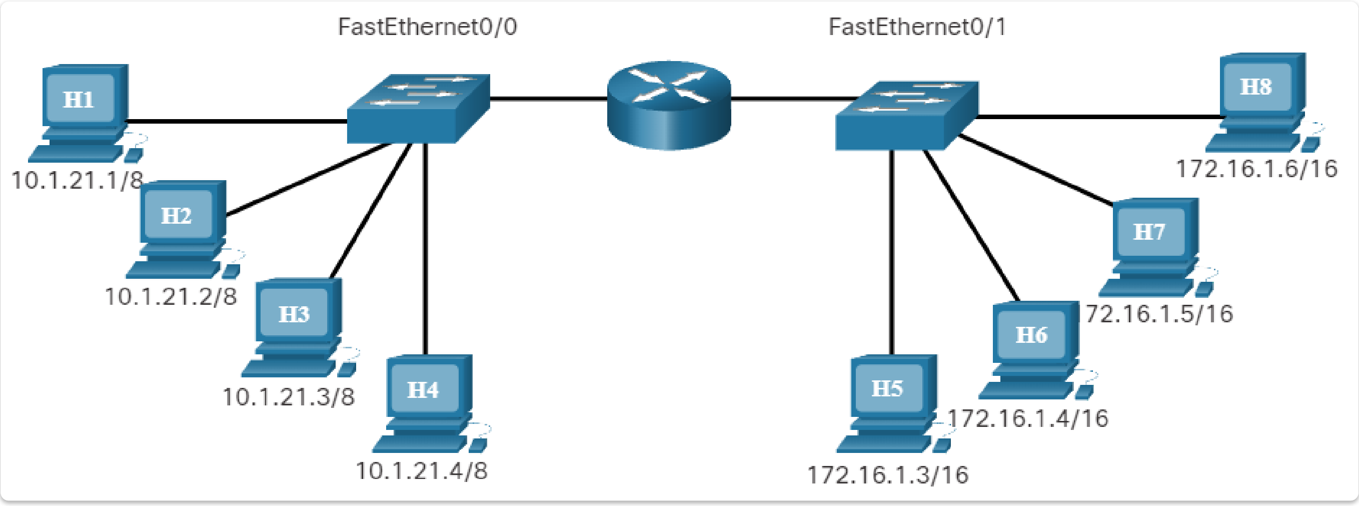
The distribution layer connects these independent local networks and controls the traffic flowing between them. It is responsible for ensuring that traffic between hosts on the local network stays local.

A router is a networking device that connects multiple Layer 3, IP networks. At the distribution layer of the network, routers direct traffic and perform other functions critical to efficient network operation. Routers, like switches, are able to decode and read the messages that are sent to them. Unlike switches, which make their forwarding decision based on the Layer 2 MAC address, routers make their forwarding decision based on the Layer 3 IP address.

Anytime the network portion of the IP addresses of the source and destination hosts do not match, a router must be used to forward the message.

The Routing Table

Each port, or interface, on a router connects to a different local network. Every router contains a table of all locally connected networks and the interfaces that connect to them.

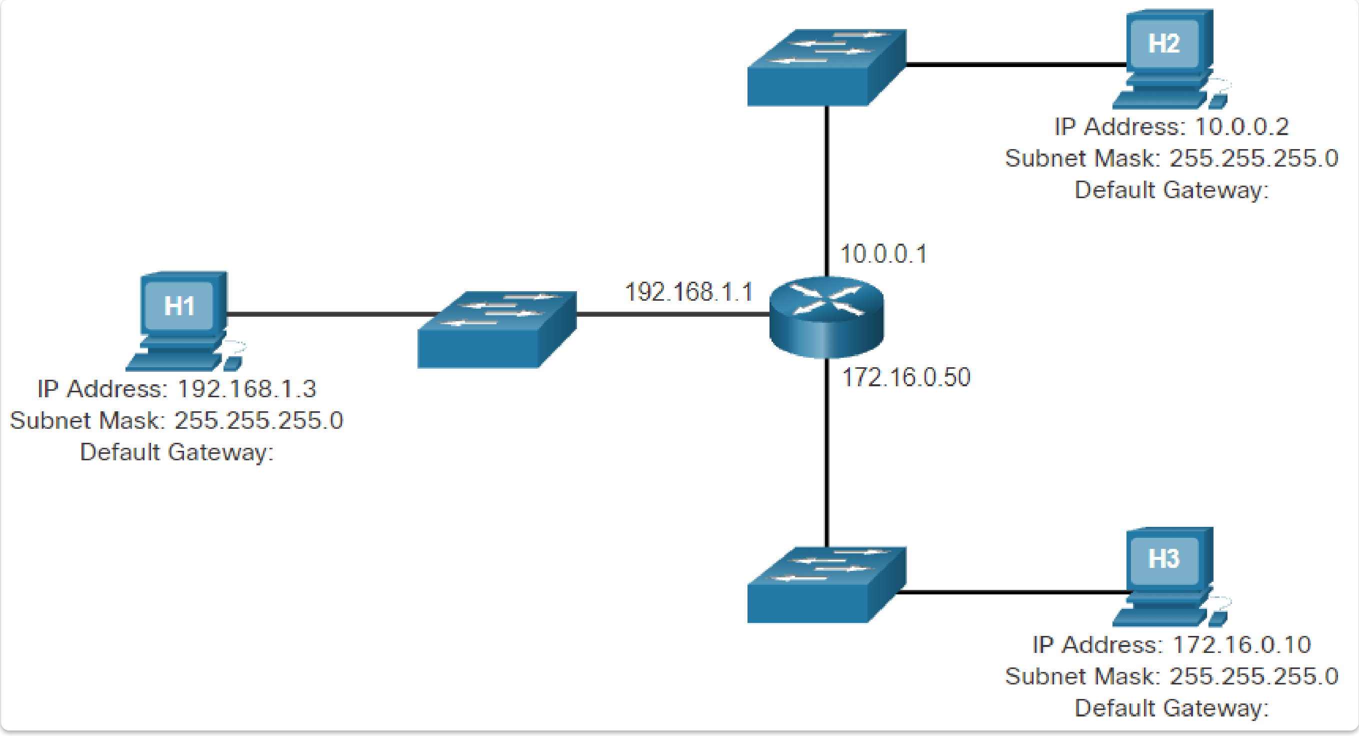


- Type - The connection type. C stands for directly connected.
- Network - The network address.
- Port - The interface used to forward packets to the network.

When a router receives a frame, it decodes the frame to get to the packet containing the destination IP address. It matches the network portion of the destination IP address to the networks that are listed in the routing table. If the destination network address is in the table, the router encapsulates the packet in a new frame in order to send it out. It forwards the new frame out of the interface associated with the path, to the destination network. The process of forwarding the packets toward their destination network is called routing.

A router forwards a packet to one of two places: a directly connected network containing the actual destination host, or to another router on the path to reach the destination host. When a router encapsulates the frame to forward it out a routed interface, it must include a destination MAC address. If the router must forward the packet to another router through a routed interface, it will use the MAC address of the connected router. Routers obtain these MAC addresses from ARP tables.

A host is given the IPv4 address of the router through the default gateway address configured in its TCP/IP settings. The default gateway address is the address of the router interface connected to the same local network as the source host. All hosts on the local network use the default gateway address to send messages to the router.

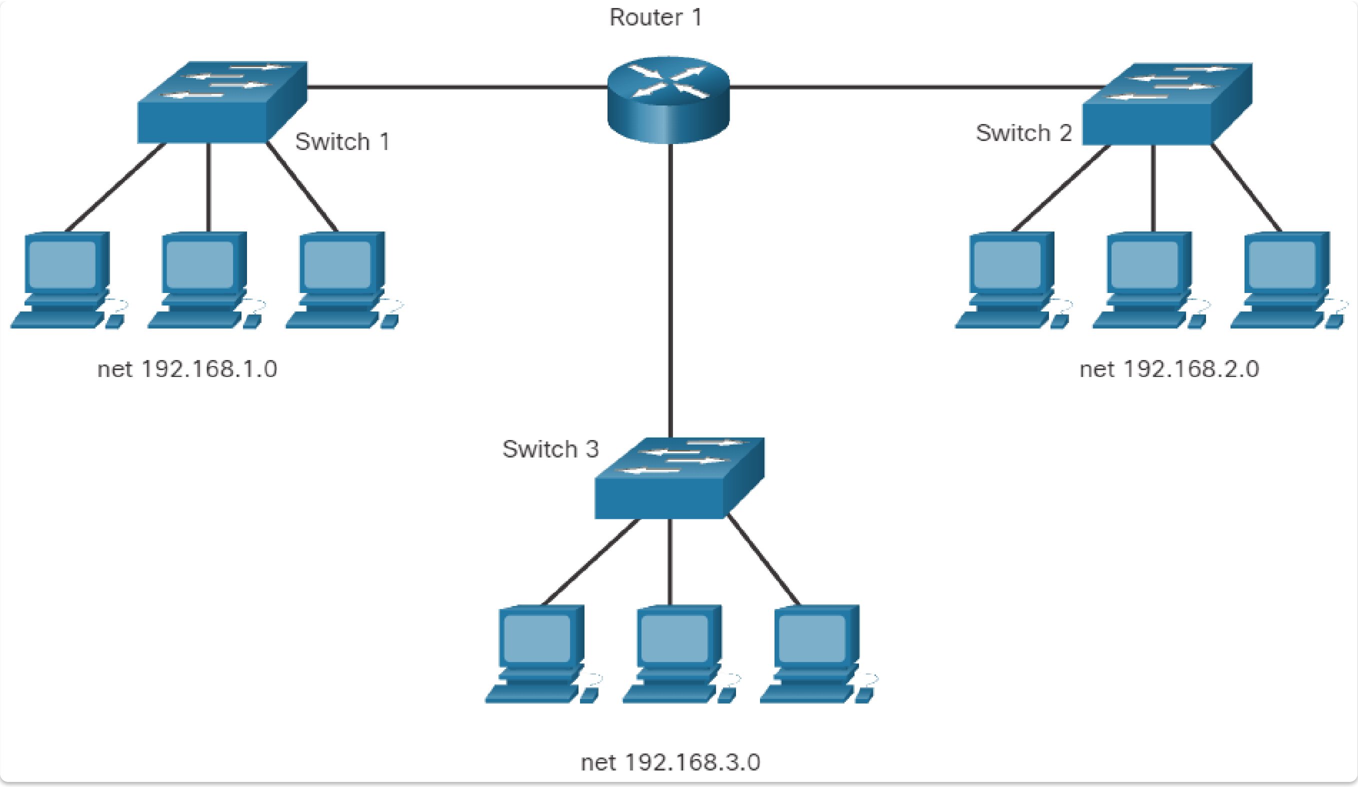


Routing tables contain the addresses of networks, and the best path to reach those networks. Entries can be made to the routing table in two ways: dynamically updated by information received from other routers in the network, or manually entered by a network administrator.

Create a LAN

LAN refers to a local network, or a group of interconnected local networks that are under the same administrative control. All the local networks within a LAN are under one administrative control. Other common characteristics of LANs are that they typically use Ethernet or wireless protocols, and they support high data rates.

Within a LAN, it is possible to place all hosts on a single local network or divide them up between multiple networks connected by a distribution layer device.



Placing all hosts on a single local network allows them to be seen by all other hosts. This is because there is one broadcast domain and hosts use ARP to find each other.

Placing additional hosts on a remote network will decrease the impact of traffic demands. However, hosts on one network will not be able to communicate with hosts on the other network without the use of routing. Routers increase the complexity of the network configuration and can introduce latency, or time delay, on packets sent from one local network to the other.

15. TCP and UDP

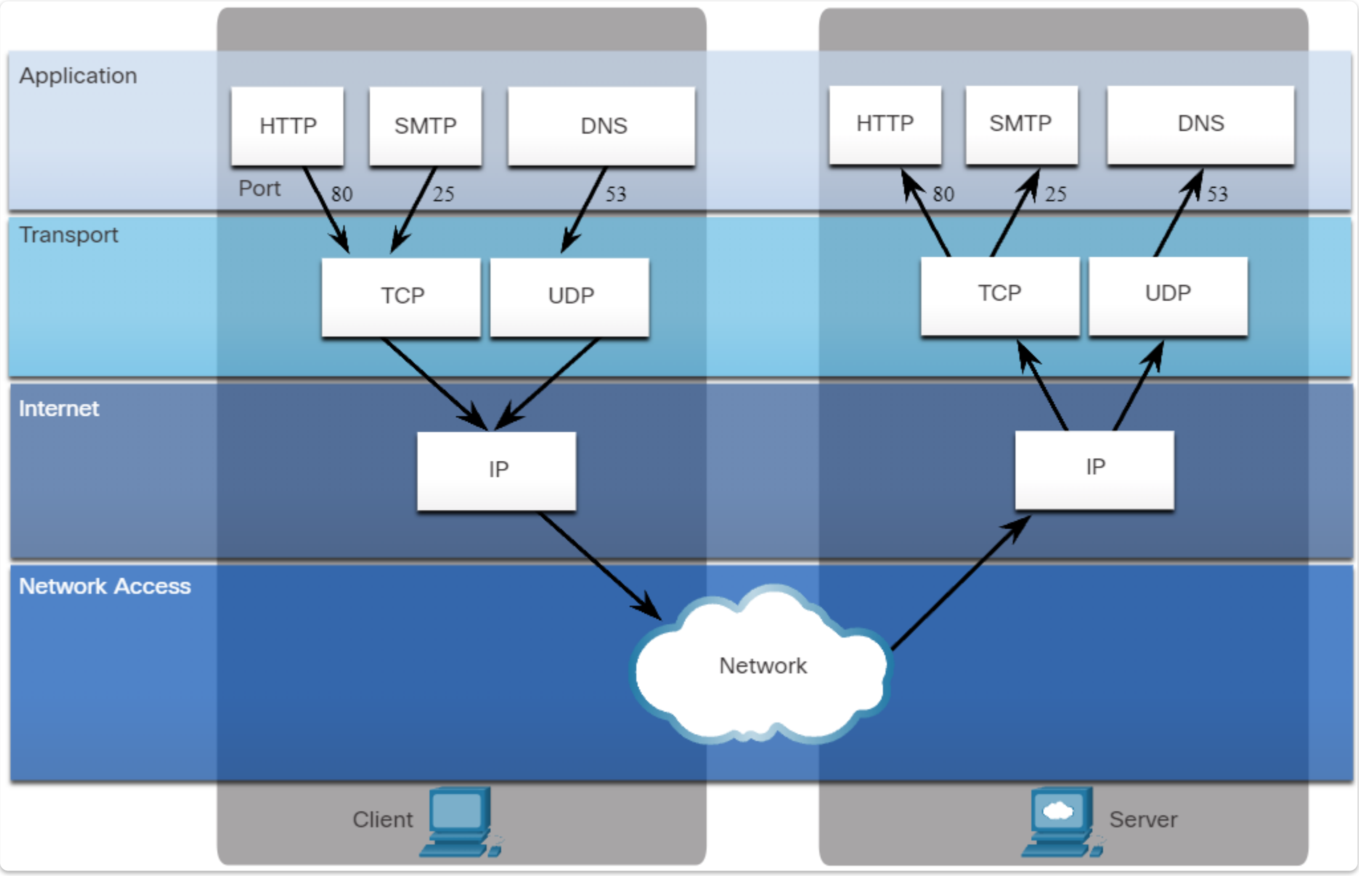
UDP is a 'best effort' delivery system that does not require acknowledgment of receipt. UDP is preferable with applications such as streaming audio and VoIP. Acknowledgments would slow down delivery and retransmissions are undesirable. Packets take a path from the source to a destination. A few packets may be lost but it is usually not noticeable.

TCP packets take a path from the source to the destination. However, each of the packets has a sequence number. TCP breaks up a message into small pieces known as segments. The segments are numbered in sequence and passed to the IP process for assembly into packets. TCP keeps track of the number of segments that have been sent to a specific host from a specific application. If the sender does not receive an acknowledgment within a certain period of time, it assumes that the segments were lost and retransmits them. Only the portion of the message that is lost is resent, not the entire message.

Port Numbers

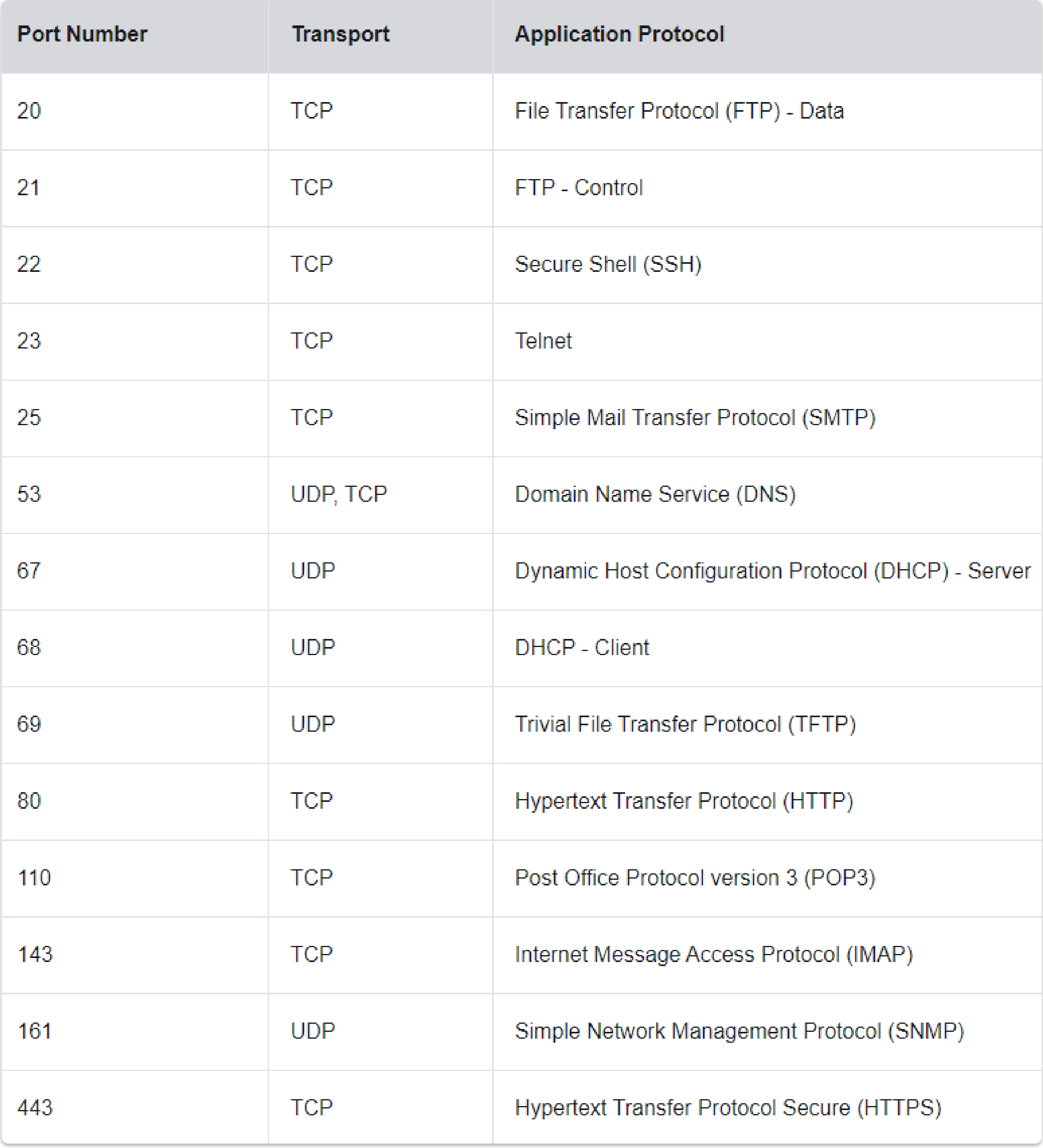
When a message is delivered using either TCP or UDP, the protocols and services requested are identified by a port number. A port is a numeric identifier within each segment that is used to keep track of specific conversations between a client and server. Every message that a host sends contains both a source and destination port.

When a message is received by a server, it is necessary for the server to be able to determine which service is being requested by the client. Clients are preconfigured to use a destination port that is registered on the internet for each service.



Ports are assigned and managed by an organization known as the ICANN. Ports are broken into three categories and range in number from 1 to 65,535:

- Well-Known Ports - Destination ports that are associated with common network applications are identified as well-known ports. These ports are in the range of 1 to 1023.
- Registered Ports - Ports 1024 through 49151 can be used as either source or destination ports. These can be used by organizations to register specific applications such as IM applications.
- Private Ports - Ports 49152 through 65535 are often used as source ports. These ports can be used by any application.



Port Number	Transport	Application Protocol
20	TCP	File Transfer Protocol (FTP) - Data
21	TCP	FTP - Control
22	TCP	Secure Shell (SSH)
23	TCP	Telnet
25	TCP	Simple Mail Transfer Protocol (SMTP)
53	UDP, TCP	Domain Name Service (DNS)
67	UDP	Dynamic Host Configuration Protocol (DHCP) - Server
68	UDP	DHCP - Client
69	UDP	Trivial File Transfer Protocol (TFTP)
80	TCP	Hypertext Transfer Protocol (HTTP)
110	TCP	Post Office Protocol version 3 (POP3)
143	TCP	Internet Message Access Protocol (IMAP)
161	UDP	Simple Network Management Protocol (SNMP)
443	TCP	Hypertext Transfer Protocol Secure (HTTPS)

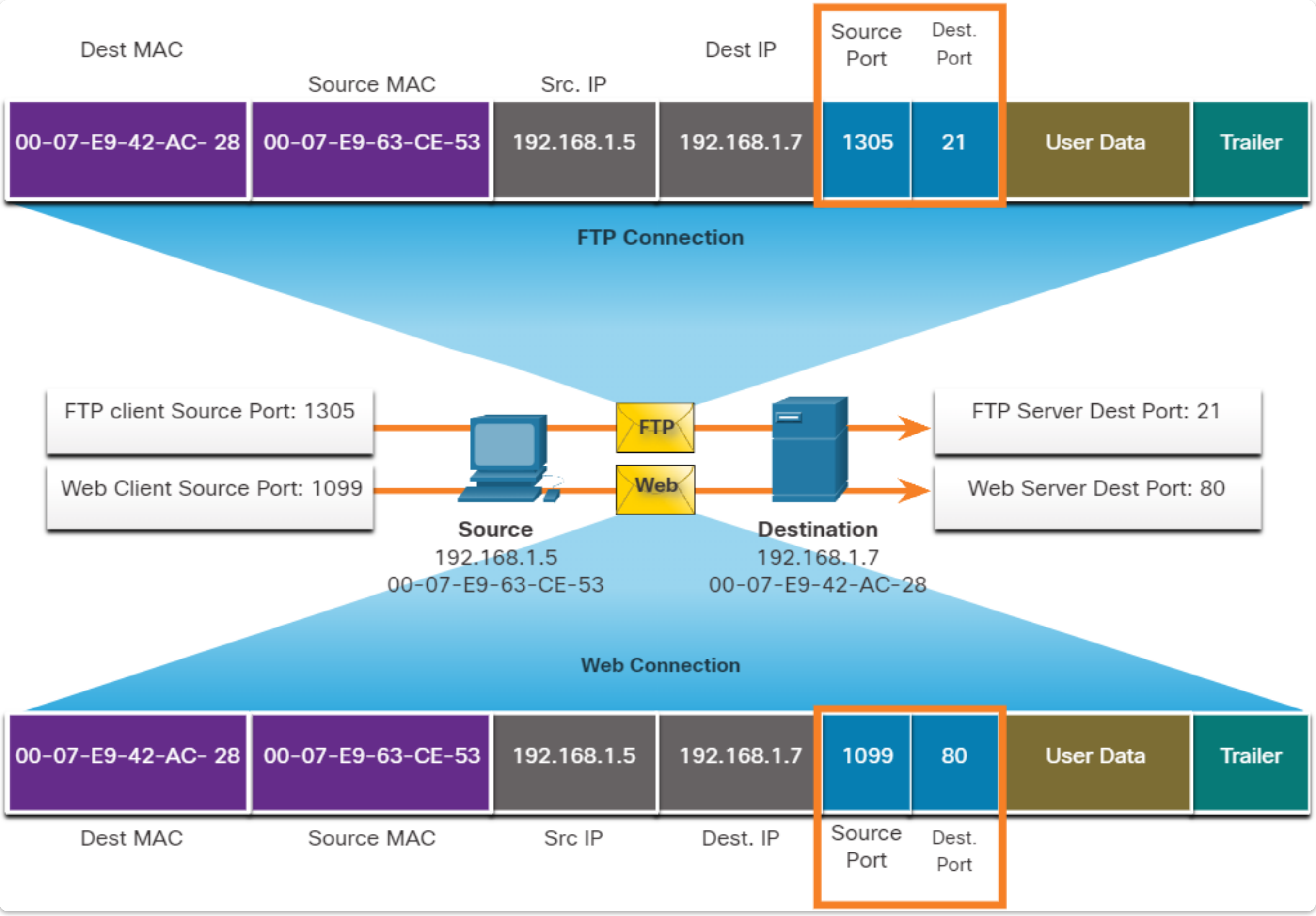
The source port number is dynamically generated by the sending device to identify a conversation between two devices. This process allows multiple conversations to occur simultaneously. It is common for a device to send multiple HTTP service requests to a web server at the same time. Each separate HTTP conversation is tracked based on the source ports.

The client places a destination port number in the segment to tell the destination server what service is being requested. A server can offer more than one service simultaneously, such as web services on port 80 at the same time that it offers FTP connection establishment on port 21.

Unexplained TCP connections can pose a major security threat. They can indicate that something or someone is connected to the local host. Sometimes it is necessary to know which active TCP connections are open and running on a networked host. Netstat is an important network utility that can be used to verify those connections. The command netstat is used to list the protocols in use, the local address and port numbers, the foreign address and port numbers, and the connection state.

Socket Pairs

The source and destination ports are placed within the segment. The segments are then encapsulated within an IP packet. The IP packet contains the IP address of the source and destination. The combination of the source IP address and source port number, or the destination IP address and destination port number is known as a socket.



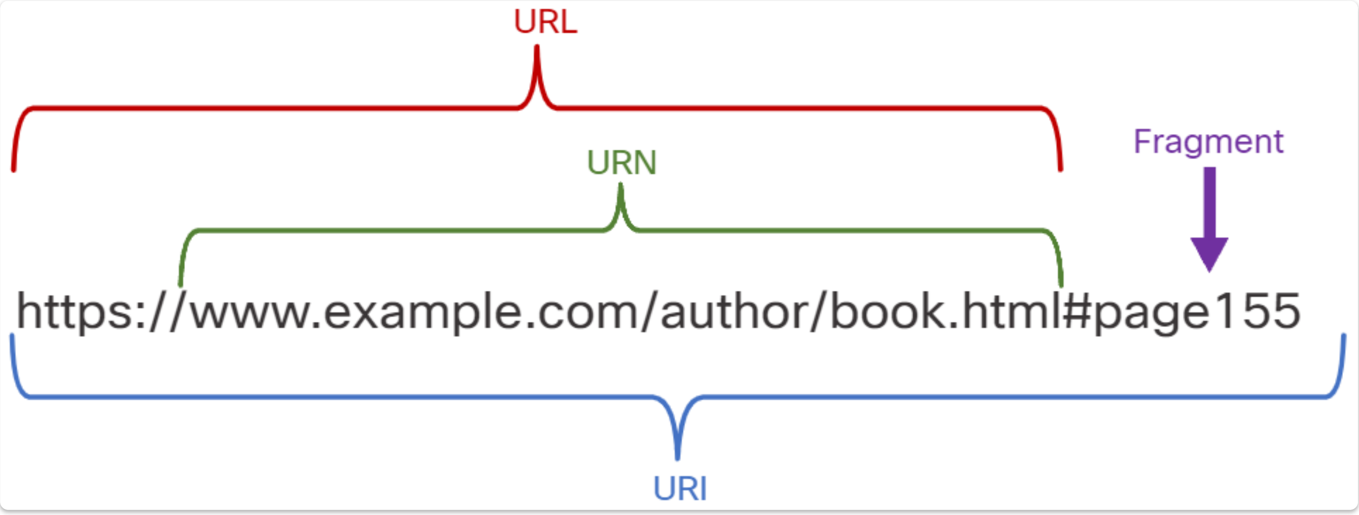
16. Application Layer Services

The Client Server Relationship

The term server refers to a host running a software application that provides information or services to other hosts that are connected to the network, such as a web server. An example of client software is a web browser, like Chrome or Firefox. A single computer can also run multiple types of client software. A crucial factor to enable these complex interactions to function is that they all use agreed upon standards and protocols.

The key characteristic of client/server systems is that the client sends a request to a server, and the server responds by carrying out a function, such as sending the requested document back to the client. The combination of a web browser and a web server is perhaps the most commonly used instance of a client/server system.

A URI is a string of characters that identifies a specific network resource. The parts of a URI are protocol/scheme, hostname, path and file name, and fragment. A URI has two specializations:



- URN - This identifies only the namespace of the resource without reference to the protocol.
- URL - This defines the network location of a specific resource on the network. HTTP or HTTPS URLs are typically used with web browsers. Other protocols such as FTP, SFTP, SSH, and others can be used as a URL.

Domain Name System

The DNS provides a way for hosts to request the IP address of a specific server. DNS names are registered and organized on the internet within specific high-level groups, or domains. Some of the most common high-level domains on the internet are .com, .edu, and .net.

When the DNS server receives the request from a host, it checks its table to determine the IP address associated with that web server. If the local DNS server does not have an entry for the requested name, it queries another DNS server within the domain. When the DNS server learns the IP address, that information is sent back to the host.
You can use the command nslookup to discover the IP addresses for any domain name.

Web Clients and Servers

When a web client receives the IP address of a web server, the client browser uses that IP address and port 80 to request web services. This request is sent to the server using HTTP. The HTTP protocol is not a secure protocol; information could easily be intercepted by other users as data is sent over the network. To provide security for the data, HTTP can be used with secure transport protocols. Requests for secure HTTP are sent to port 443. These requests use https in the site address in the browser, rather than http.

When the server receives a port 80 request, the server responds to the client request and sends the web page to the client. The information content of a web page is encoded using HTML. HTML coding tells the browser how to format the web page and what graphics and fonts to use.

There are many different web servers and web clients. The HTTP protocol and HTML standards make it possible for these servers and clients from many different manufacturers to work together seamlessly.

FTP Clients and Servers

FTP provides an easy method to transfer files from one computer to another. A host running FTP client software can access an FTP server to perform various file management functions including file uploads and downloads. The FTP server enables a client to exchange files between devices. It also enables clients to manage files remotely by sending file management commands such as delete or rename. To accomplish this, the FTP service uses two different ports to communicate between client and server. **To begin an FTP session, control connection requests are sent to the server using destination TCP port 21. When the session is opened, the server uses TCP port 20 to transfer the data files.**

Most client operating systems such as Windows, Mac OS, and Linux include a command-line interface for FTP. There is also GUI-based FTP client software that provides a simple drag-and-drop interface for FTP.

Virtual Terminals

Telnet provides a standard method of emulating text-based terminal devices over the data network. Both the protocol itself and the client software that implements the protocol are commonly referred to as Telnet. Telnet servers listen for client requests on TCP port 23. A connection using Telnet is called a vty session, or connection. Rather than using a physical device to connect to the server, Telnet uses software to create a virtual device that provides the same features of a terminal session with access to the server’s CLI.

Telnet is not considered to be a secure protocol. Although the Telnet protocol can require a user to login, it does not support transporting encrypted data. All data exchanged during Telnet sessions is transported as plaintext across the network. This means that the data can be easily intercepted and understood.

SSH(Port 22) provides the structure for secure remote login and other secure network services. It also provides stronger authentication than Telnet and supports transporting session data using encryption. Network professionals should always use SSH in place of Telnet, whenever possible.

Email and Messaging

Each mail server receives and stores mail for users who have mailboxes configured on the mail server. Each user with a mailbox must then use an email client to access the mail server and read these messages. Many internet messaging systems use a web-based client to access email including Microsoft 365, Yahoo, and Gmail. Application protocols used in processing email include SMTP, POP3, and IMAP4.

SMTP is used by an email client to send messages to its local email server. The local server then decides if the message is destined for a local mailbox or if the message is addressed to a mailbox on another server. If the server must send the message to a different server, SMTP is used between those two servers. SMTP requests are sent to port 25. A server that supports POP clients receives and stores messages addressed to its users. When the client connects to the email server, the messages are downloaded to the client. By default, messages are not kept on the server after they have been accessed by the client. Clients contact POP3 servers on port 110.

A server that supports IMAP clients also receives and stores messages addressed to its users. However, unlike POP, IMAP keeps the messages in the mailboxes on the server, unless they are deleted by the user. The most current version of IMAP is IMAP4 which listens for client requests on port 143.

Text messages may be called instant messages, direct messages, private messages, and chat messages. Text messaging enables users to chat over the internet in real-time. Text messaging services on a computer are usually accessed through a web-based client that is integrated into a social media or information sharing site. These clients usually only connect to other users of the same site.

An internet telephony client uses peer-to-peer technology similar to that used by instant messaging. IP telephony uses VoIP, which converts analog voice signals into digital data. The voice data is encapsulated into IP packets which carry the phone call through the network.

17. Network Testing Utilities

Troubleshooting Commands

A number of software utility programs are available that can help identify network problems. Most of these utilities are provided by the operating system as CLI commands.

Some of the available utilities include:

- ipconfig - Displays IP configuration information.
- ping - Tests connections to other IP hosts.
- netstat - Displays network connections.
- tracert - Displays the route taken to the destination.
- nslookup - Directly queries the name server for information on a destination domain.

The ipconfig command is used to display the current IP configuration information for a host. Issuing this command from the command prompt will display the basic configuration information including IP address, subnet mask, and default gateway.

The command ipconfig /all displays additional information including the MAC address, IP addresses of the default gateway, and the DNS servers. It also indicates if DHCP is enabled, the DHCP server address, and lease information.

If IP addressing information is assigned dynamically, the command ipconfig /release will release the current DHCP bindings. ipconfig /renew will request fresh configuration information from the DHCP server. A host may contain faulty or outdated IP configuration information and a simple renewal of this information is all that is required to regain connectivity.

Probably the most commonly used network utility is ping. Most IP enabled devices support some form of the **ping** command in order to test whether or not network devices are reachable through the IP network. When a ping is sent to an IP address, a packet known as an echo request is sent across the network to the IP address specified. If the destination host receives the echo request, it responds with a packet known as an echo reply. If the source receives the echo reply, connectivity is verified by the reply from the specific IP address.