NETWORK AND TELECOMMUNICATION

ACADEMIC BACKGROUNDS:

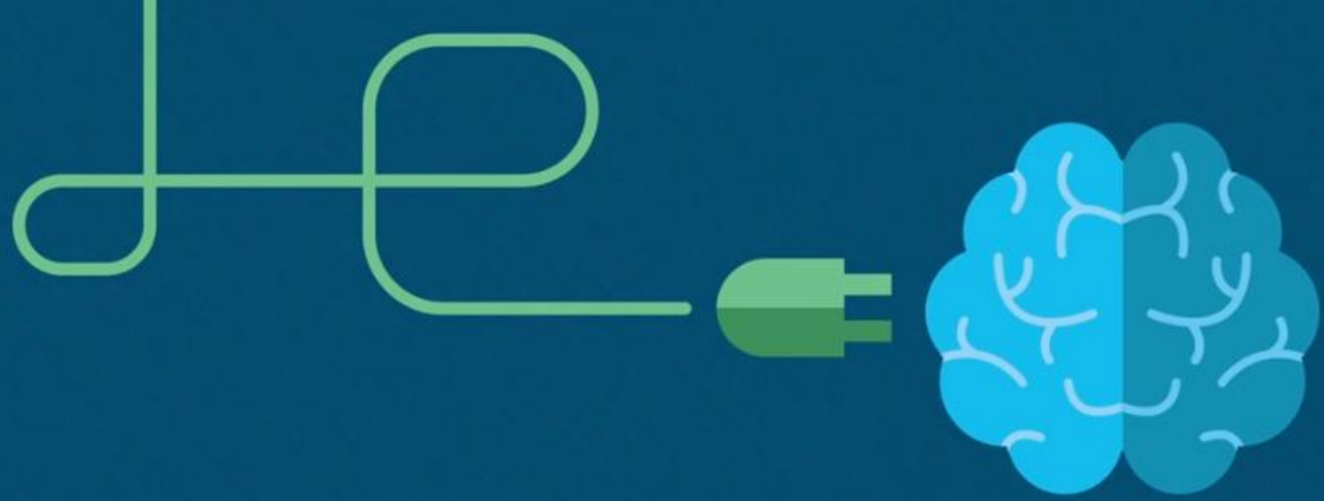
- 1987-1993 Georgia University of Technology (Former USSR) **Specialize: Radio Transmitting Device of Satellite Telecommunication Systems** (Master of Science).
- 1997-1998 Advanced course at the Saint–Petersburg State University of Technology in computer simulation of ground stations Modem for Sputnic communication (Russia).

PREVIOUS EMPLOYMENT:

- 2002-2018 The World Bank Cambodia (IT Analyst, Client Services).
- 1999 -2001 Worked as Systems Engineer at VIRTU International Limited.
- 1995 -1997 Worked as assistant manager in operation and technical department at CAMINTEL.
- 1993 – 1995 Worked as engineer in Operations and Technical Department in HUB-station (ex-UNTAC Networks) at Ministry of Post and Telecommunications of Cambodia.

Teaching Experiences:

- 2000 Royal Academy of Cambodia (MSc.IT).
- 2002 Build Bright University (MSc.IT).
- 2019 National Polytechnic Institute of Cambodia (BSc.Telecom).
- 2020 Norton University (BSc.IT)
- 2023 Cambodia Academy of Digital Technology (BSc.Telecom).
- 2024 East Asia Management University (BSc.IT)



Module 11: IPv4 Addressing

Introduction to Networks v7.0
(ITN)

Module Objectives

Module Title: IPv4 Addressing

Module Objective: Calculate an IPv4 subnetting scheme to efficiently segment your network.

Topic Title	Topic Objective
IPv4 Address Structure	Describe the structure of an IPv4 address including the network portion, the host portion, and the subnet mask.
IPv4 Unicast, Broadcast, and Multicast	Compare the characteristics and uses of the unicast, broadcast and multicast IPv4 addresses.
Types of IPv4 Addresses	Explain public, private, and reserved IPv4 addresses.
Network Segmentation	Explain how subnetting segments a network to enable better communication.
Subnet an IPv4 Network	Calculate IPv4 subnets for a /24 prefix.

11.1 IPv4 Address Structure

IPv4

- A logical numbering system
- All node addresses on a network segment must be unique
- Used to identify particular nodes (computers, printers, etc.) on a network
- MAC addresses are unique but similar to the unique ID's of cell phones, we cannot use them to “call” other computers. We need “logical” addresses.
- For cell phones, we use telephone numbers but for computers, we use IP addresses.

IPv4 Dotted-Decimal Format

- A IPv4 address is **Binary** and **32 bits**
- Shown in “dotted-decimal” format
  - Easier for humans to read
  - Each decimal value represents an **8-bit binary number**
  - **8 bits** is called an **octet** or a **byte**
    - **10 . 1 . 2 . 3**
    - 00001010 . 00000001 . 00000010 . 00000011
    - Actual Address = 00001010000000010000001000000011
- Decimal range is **0** to **255**
  - Decimal 0 = Binary 00000000
  - Decimal 255 = Binary 11111111

IPv4 Address Structure

- An IPv4 address has two parts
  - The first part is the **Network**
    - Also called the **Subnet**
  - The second part is the **Host**
    - Also called Device or Node
- The Mask
  - Also called **Subnet Mask**
  - Which bits are **Network** and which are **Host**
    - The subnet mask dictates which portion of the IP address represents the Network and Host
  - Binary: **1** = **Network**, **0** = **Host**
  - Expressed in Dotted-Decimal and Prefix
    - 255.255.255.0 = /24
    - 192.168.1.3 255.255.255.0 = 192.168.1.3 /24

IPv4 Address Structure

The Prefix Length

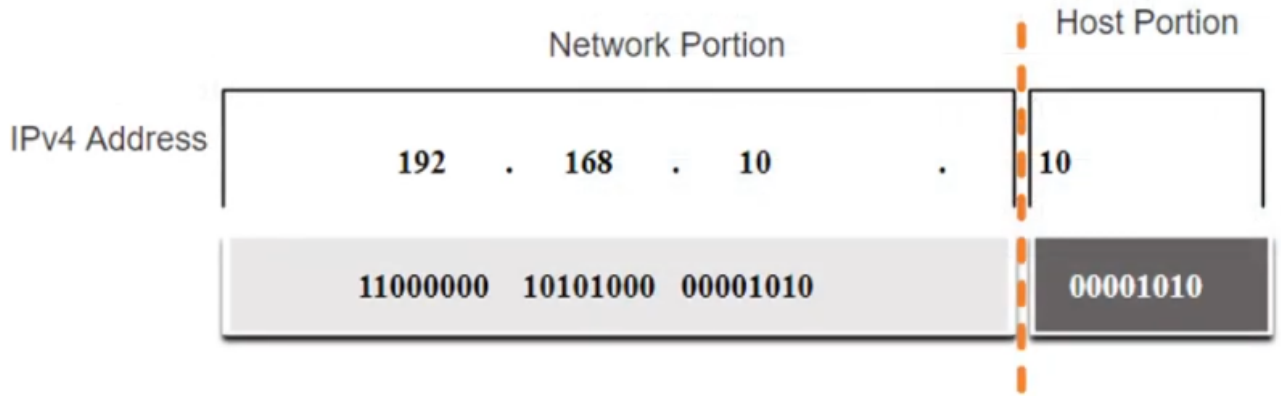
- The prefix length is the number of bits set to 1 in the subnet mask.
- It is written in “slash notation” therefore, count the number of bits in the subnet mask and prepend it with a slash.

Subnet Mask	32-bit Address	Prefix Length
255.0.0.0	11111111.00000000.00000000.00000000	/8
255.255.0.0	11111111.11111111.00000000.00000000	/16
255.255.255.0	11111111.11111111.11111111.00000000	/24
255.255.255.128	11111111.11111111.11111111.10000000	/25
255.255.255.192	11111111.11111111.11111111.11000000	/26
255.255.255.224	11111111.11111111.11111111.11100000	/27
255.255.255.240	11111111.11111111.11111111.11110000	/28
255.255.255.248	11111111.11111111.11111111.11111000	/29
255.255.255.252	11111111.11111111.11111111.11111100	/30

Network and Host Portions

- An IPv4 address is a 32-bit hierarchical address that is made up of a network portion and a host portion.

- When determining the network portion versus the host portion, you must look at the 32-bit stream.
- A subnet mask is used to determine the network and host portions.

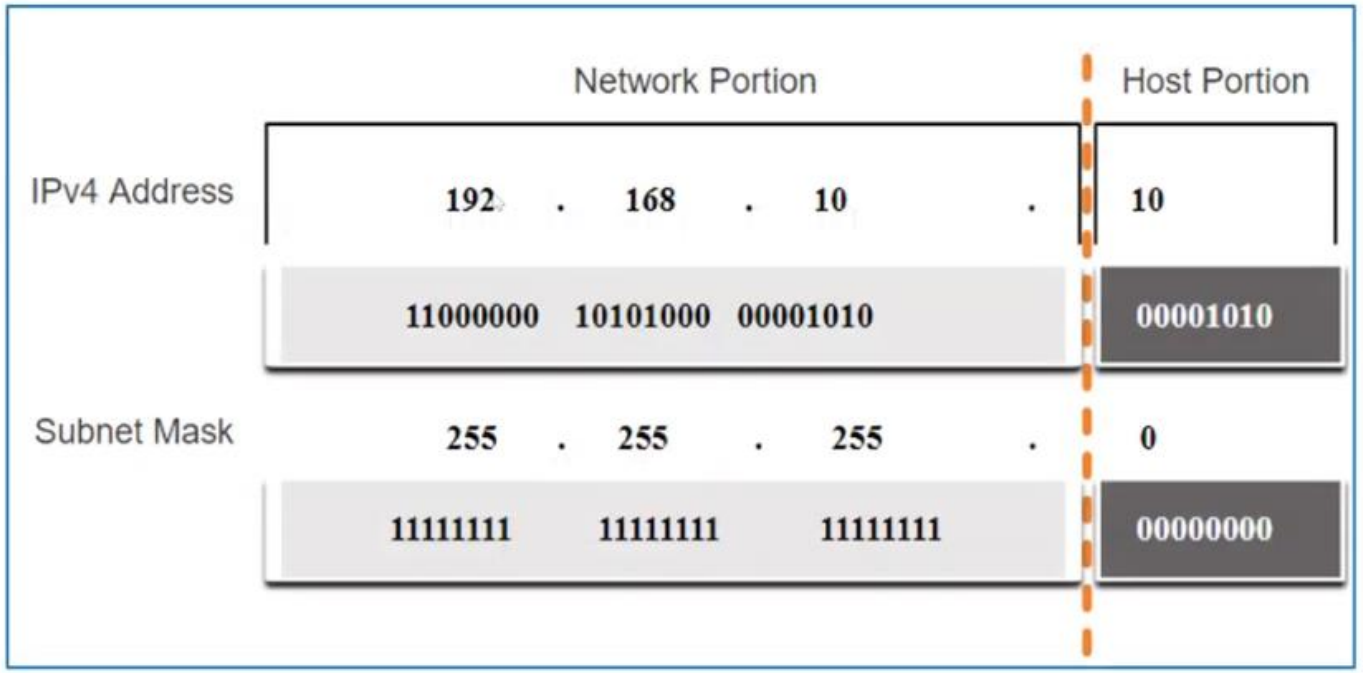


IPv4 Address Structure

The Subnet Mask

- To identify the network and host portions of an IPv4 address, the subnet mask is compared to the IPv4 address bit for bit, from left to right.

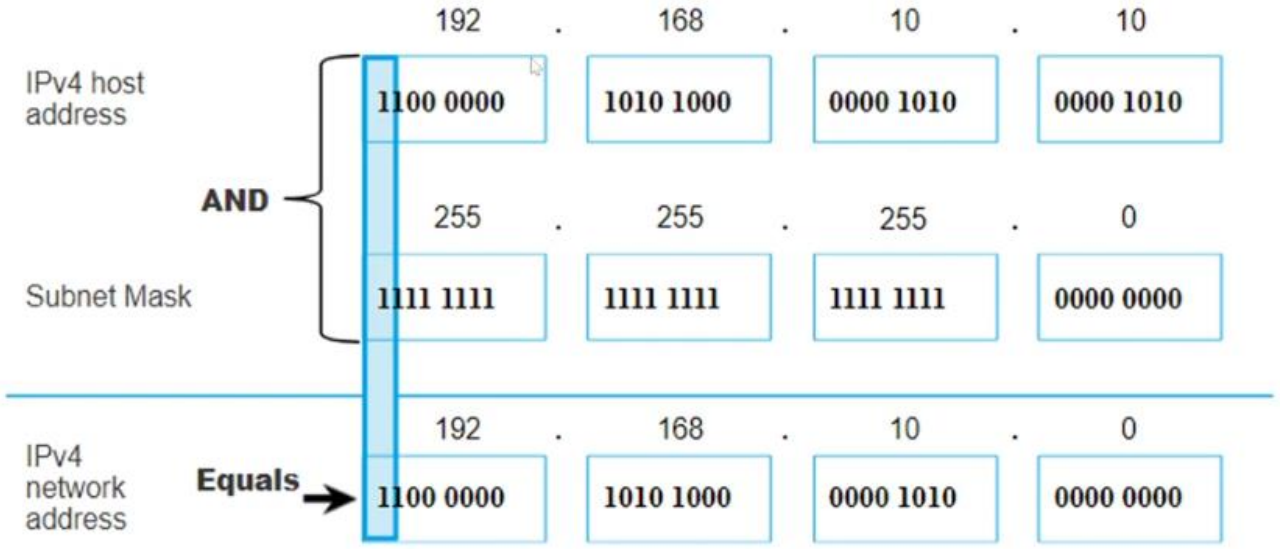
- The actual process used to identify the network and host portions is called ANDing.



Determining the Network: Logical AND

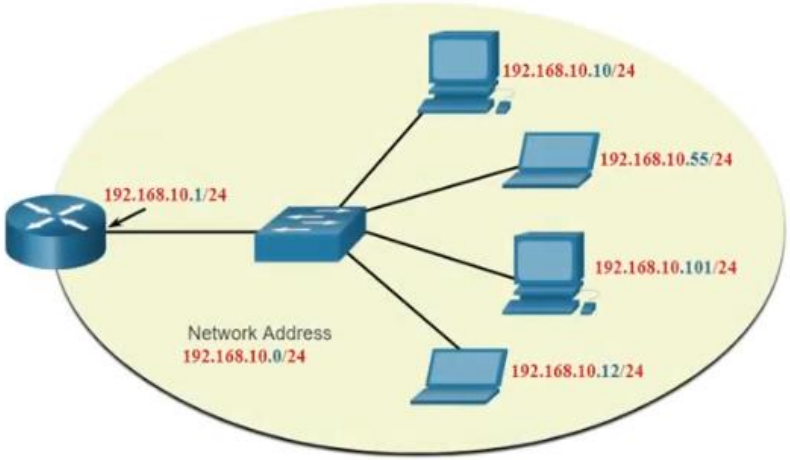
- A logical AND Boolean operation is used in determining the network address.
  - Logical AND is the comparison of two bits where only a 1 AND 1 produces a 1 and any other combination results in a 0.
  - 1 AND 1 = 1, 0 AND 1 = 0, 1 AND 0 = 0, 0 AND 0 = 0
  - 1 = True and 0 = False

- To identify the network address, the host IPv4 address is logically ANDed, bit by bit, with the subnet mask to identify the network address.



Network, Host, and Broadcast Addresses

- Within each network are three types of IP addresses:
  - Network address
  - Host addresses
  - Broadcast address



	Network Portion			Host Portion	Host Bits
Subnet mask **255.255.255.**0 or **/24**	255 11111111	255 11111111	255 11111111	0 00000000	
Network address **192.168.10.**0 or **/24**	192 11000000	168 10100000	10 00001010	0 00000000	All 0s
First address **192.168.10.**1 or **/24**	192 11000000	168 10100000	10 00001010	1 00000001	All 0s and a 1
Last address **192.168.10.**254 or **/24**	192 11000000	168 10100000	10 00001010	254 11111110	All 1s and a 0
Broadcast address **192.168.10.**255 or **/24**	192 11000000	168 10100000	10 00001010	255 11111111	All 1s

Network Addresses

Network address

- A network address is an address that represents a specific network. A device belongs to this network if it meets three criteria:
  - It has the same subnet mask as the network address.
  - It has the same network bits as the network address, as indicated by the subnet mask.
  - It is located on the same broadcast domain as other hosts with the same network address.
  - The network address has all 0 bits in the host portion, as determined by the subnet mask. In this example, the network address is 192.168.10.0/24. **A network address cannot be assigned to a device**.

Host Addresses

- **Host addresses:**
- Host addresses are addresses that can be assigned to a device such as a host computer, laptop, smart phone, web camera, printer, router, etc. The host portion of the address is the bits indicated by **0 bits in the subnet mask**. Host addresses can have any combination of bits in the host portion except for all 0 bits (this would be a network address) or all 1 bits (this would be a broadcast address).
- All devices within the same network, must have the same subnet mask and the same network bits. Only the host bits will differ and must be unique.
- With IP address, 192.168.10.0/24, there is a first and last host address:
  - **First host address** - This first host within a network has all 0 bits with the last (right-most) bit as a 1 bit. In this example it is 192.168.10.1/24.
  - **Last host address** - This last host within a network has all 1 bits with the last (right-most) bit as a 0 bit. In this example it is 192.168.10.254/24.
  - Any addresses between and including, 192.168.10.1/24 through 192.168.10.254/24 can be assigned to a device on the network.

Broadcast Addresses

- Broadcast address
- A broadcast address is an address that is used when it is required to reach all devices on the IPv4 network.
- The network broadcast address has **all 1 bits in the host portion**, as determined by the subnet mask. In this example, the network address is 192.168.10.255/24. A broadcast address cannot be assigned to a device.

	Network Portion			Host Portion	Host Bits
Subnet mask **255.255.255.0** or **/24**	255 11111111	255 11111111	255 11111111	0 00000000	
Network address **192.168.10.0** or **/24**	192 11000000	168 10100000	10 00001010	0 00000000	All 0s
First address **192.168.10.1** or **/24**	192 11000000	168 10100000	10 00001010	1 00000001	All 0s and a 1
Last address **192.168.10.254** or **/24**	192 11000000	168 10100000	10 00001010	254 11111110	All 1s and a 0
Broadcast address **192.168.10.255** or **/24**	192 11000000	168 10100000	10 00001010	255 11111111	All 1s

11.2 IPv4 Unicast, Broadcast, and Multicast

IPv4 Address Types

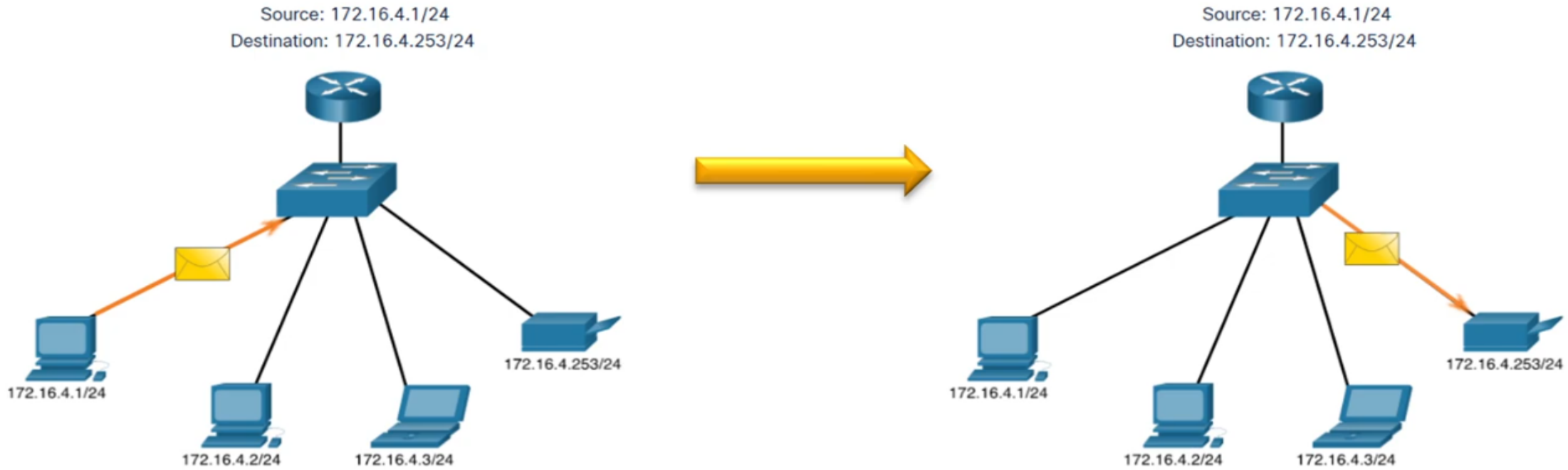
- Unicast address (one host)
  - **Host section cannot be** all 0's or all 1's
- Network (also called Subnet)
  - **Host section all 0's**
  - **Example: 92.168.10.0/24**
- Directed Broadcast
  - **Host section all 1's**
  - **Example: Network address:192.168.10.0/24, its broadcast address=192.168.10.255**
- Limited Broadcast
  - 255.255.255.255 **(all 1's)**
- Multicast
  - D Class
  - **224**.0.0.0 – **239.255.255.255**

IPv4 Broadcast Transmission

- Broadcast may be Directed or Limited.
- Directed Broadcast:
  - A directed broadcast is sent to all hosts on a specific network.
  - For example, with 192.168.1.0/24, what is directed broadcast address?
  - 192.168.1.255
  - 11000000.10101000.00000001. **11111111**
- Limited Broadcast:
  - A limited broadcast is sent to 255.255.255.255.
- By default, routers do not forward broadcasts.

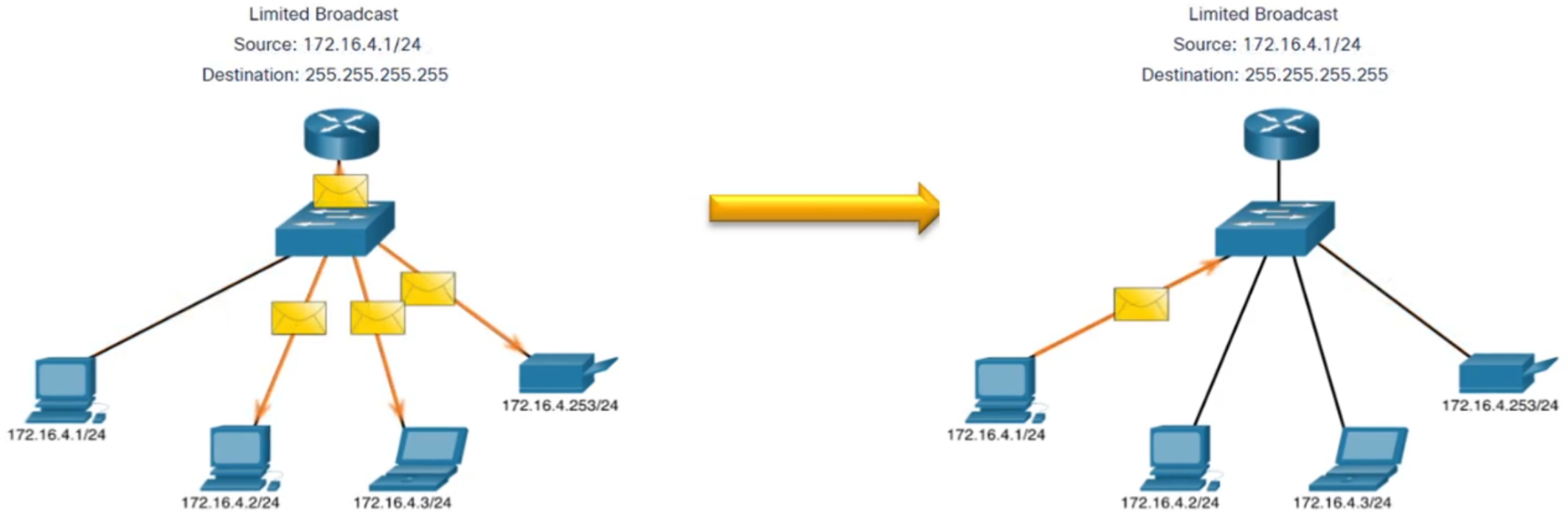
Unicast

- Unicast transmission is sending a packet to one destination IP address.
- For example, the PC at 172.16.4.1 sends a unicast packet to the printer at 172.16.4.253.



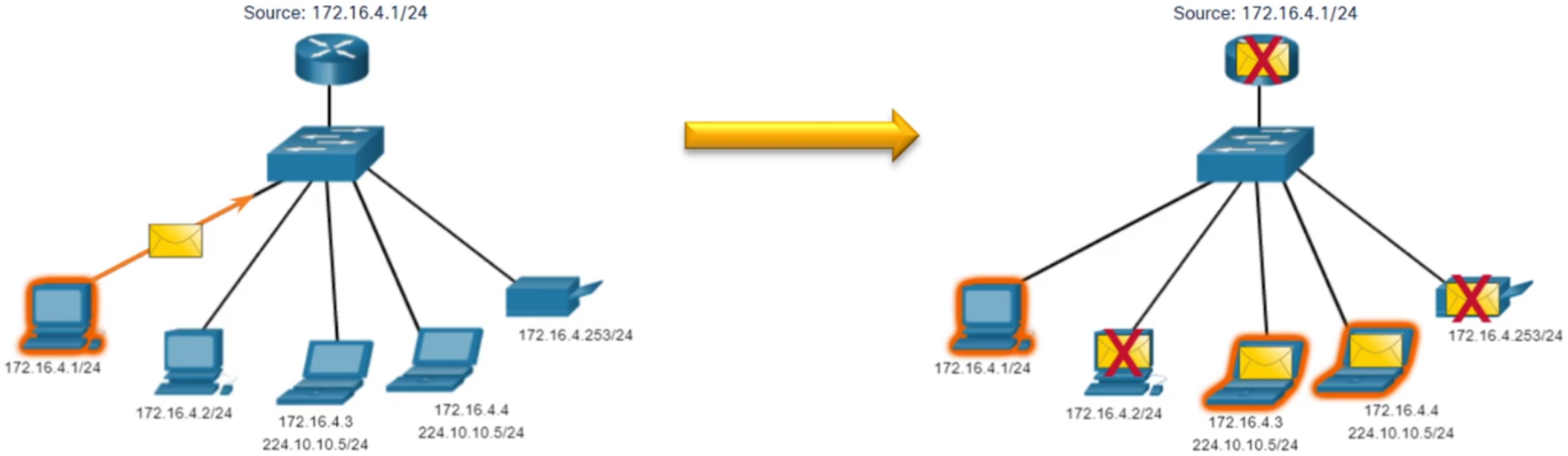
Broadcast

- Broadcast transmission is sending a packet to all other destination IP addresses.
- For example, the PC at 172.16.4.1 sends a broadcast packet to all IPv4 hosts.



Multicast

- Multicast transmission is sending a packet to a multicast address group.
- For example, the PC at 172.16.4.1 sends a multicast packet to the multicast group address 224.10.10.5.



11.3 Types of IPv4 Addresses

Legacy IPv4 Address Classes

- **1.0.0.0 - 126.0.0.0 : Class A.**
  - **First octet of IP address is 1-126 with subnet mask: 255.0.0.0**
    - **# of possible networks: 128 networks (2^8)**
    - **# of possible hosts per network :16,777,214 (2^{24} -2)**
- **128.0.0.0 - 191.255.0.0 : Class B.**
  - **First octet of IP address is 128-191 with subnet mask: 255.255.0.0**
    - **# of possible networks 16,384 networks (2^{16})**
    - **# of possible hosts per network 65,534 hosts (2^{16} -2)**
- **192.0.0.0 - 223.255.255.0 : Class C.**
  - **First octet of IP address is 192-223 with subnet mask: 255.255.255.0**
    - **# of possible networks 2,097,150 networks (2^{21})**
    - **# of possible hosts per network 254 hosts (2^8 -2)**
- Classful addressing wasted many IPv4 addresses.
- Classful address allocation was replaced with classless addressing which ignores the rules of classes (A, B, C).

IPv4 Address Classes

- Based on **first four bits** of the IP address
  - Class **A**
    - **0**xxxxxxx = **0**0000000 to **0**1111111 = **0 to 126**
    - Default mask = 255.0.0.0 = **/8**
  - Class **B**
    - **10**xxxxxx = **10**000000 to **10**111111 = **128 to 191**
    - Default mask = 255.255.0.0 = **/16**
  - Class **C**
    - **110**xxxxx = **110**00000 to **110**11111 = **192 to 223**
    - Default mask = 255.255.255.0 = **/24**
  - Class **D** (Multicast)
    - **1110**xxxx = **1110**0000 to **1110**1111 = **224 to 239**
  - Class **E** (Experimental)
    - **1111**xxxx = **1111**0000 to **1111**1111 = **240 to 255**

Special Use IPv4 Addresses

Loopback addresses

- **127.0.0.0 /8 (127.0.0.1 to 127.255.255.254)**
- Commonly identified as only 127.0.0.1
- Used on a host to **test if TCP/IP is operational**.

```
C:\Users\NetAcad> ping 127.0.0.1
Pinging 127.0.0.1 with 32 bytes of data:
Reply from 127.0.0.1: bytes=32 time<1ms TTL=128
Reply from 127.0.0.1: bytes=32 time<1ms TTL=128
```

Link-Local addresses

- 169.254.0.0 /16 (169.254.0.1 to 169.254.255.254)
- Commonly known as the Automatic Private IP Addressing (APIPA) addresses or self-assigned addresses.
- Used by Windows DHCP clients to self-configure when no DHCP servers are available.

Public and Private IPv4

- **Public IPv4**
  - To send or receive traffic on the Internet
  - Normally assigned by your ISP
- **Private IPv4**
  - According to RFC-1918.
- Private addresses are common blocks of addresses used by most organizations to assign IPv4 addresses to internal hosts.
  - Cannot be used on the Internet because private addresses are not globally routable.
  - They will be discarded by Internet devices
    - **Class A**: **10.0.0.0 – 10.255.255.255** (10.0.0.0/8)
    - **Class B**: **172.16.0.0 - 172.31.255.255** (172.16.0.0/12)
    - **Class C**: **192.168.0.0 - 192.168.255.255** (192.168.0.0/16)

Types of IPv4 Addresses

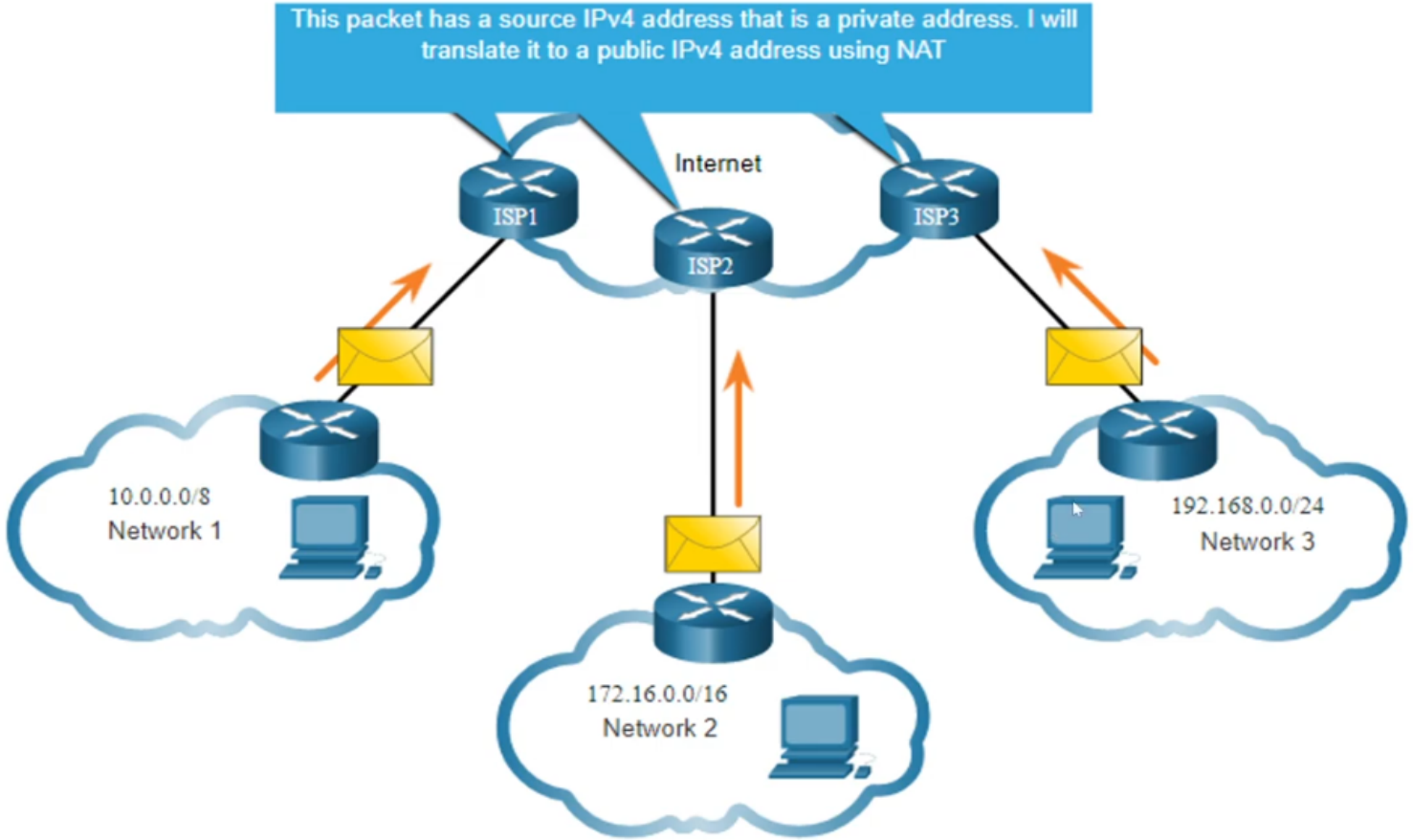
Public and Private IPv4 Addresses

- As defined in in RFC 1918, public IPv4 addresses are globally routed between internet service provider (ISP) routers.
- Private addresses are common blocks of addresses used by most organizations to assign IPv4 addresses to internal hosts.
- Private IPv4 addresses are not unique and can be used internally within any network.
- However, private addresses are not globally routable.

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

Routing to the Internet

- **Network Address Translation (NAT)** translates private IPv4 addresses to public IPv4 addresses.
- NAT is typically enabled on the edge router connecting to the internet.
- It translates the internal private address to a public global IP address.



Types of IPv4 Addresses

Assignment of IP Addresses

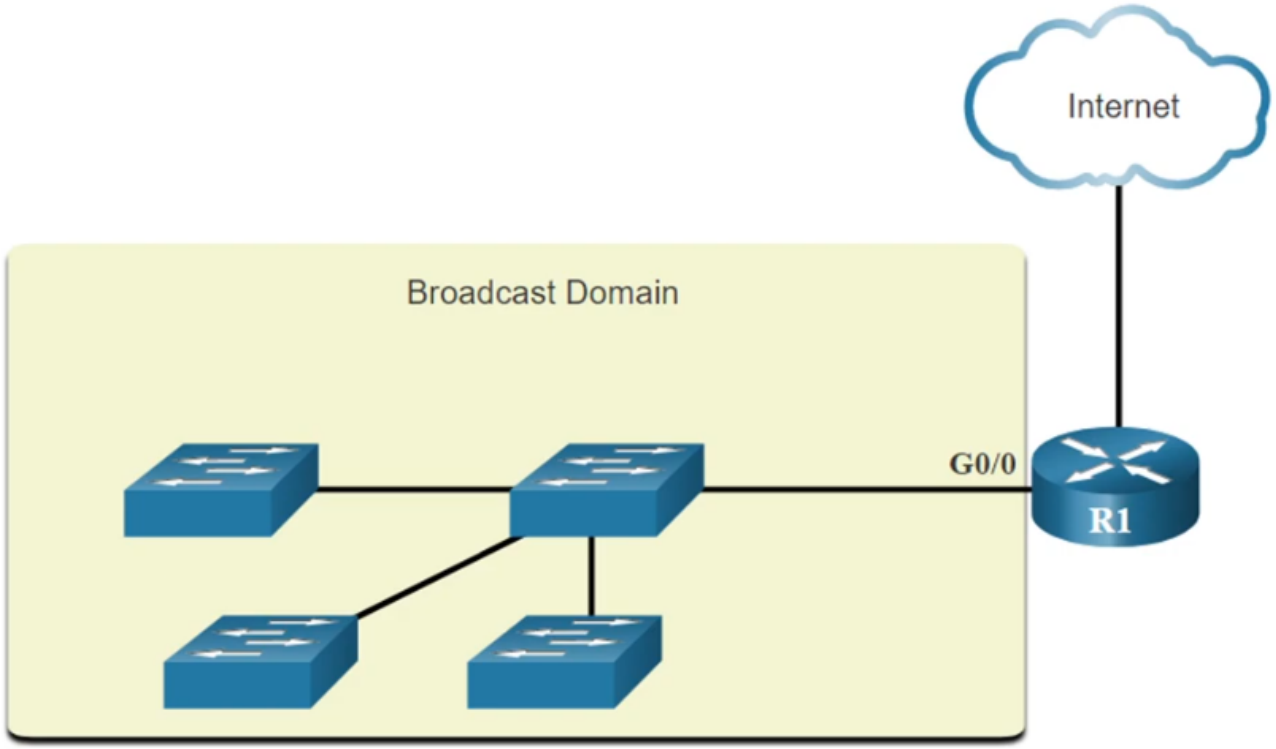
- The Internet Assigned Numbers Authority (IANA) manages and allocates blocks of IPv4 and IPv6 addresses to five Regional Internet Registries (RIRs).

- RIRs are responsible for allocating IP addresses to ISPs who provide IPv4 address blocks to smaller ISPs and organizations.

11.4 Network Segmentation

Broadcast Domains and Segmentation

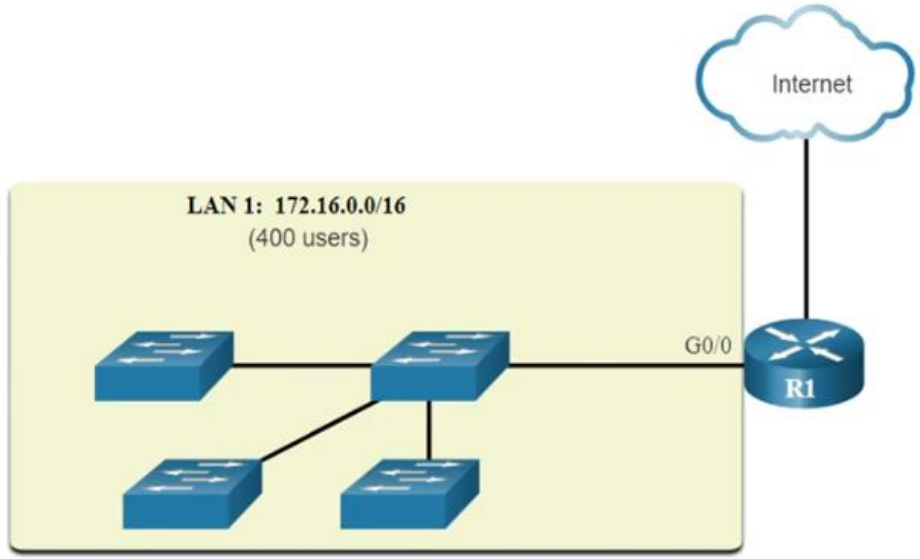
- Many protocols use broadcasts or multicasts (e.g., ARP use broadcasts to locate other devices, hosts send DHCP discover broadcasts to locate a DHCP server.)
- Switches propagate broadcasts out all interfaces except the interface on which it was received.

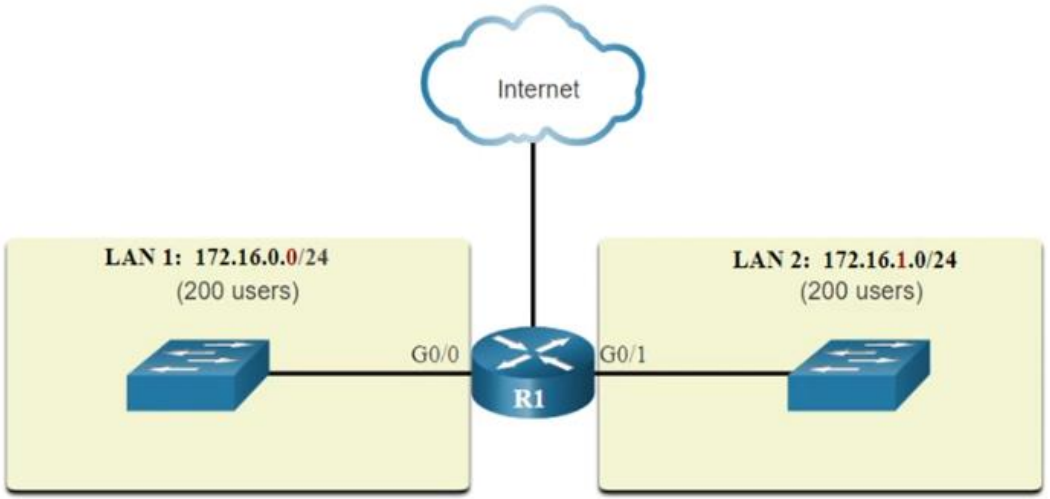


- The only device that stops broadcasts is a router.
- Routers do not propagate broadcasts.
- Each router interface connects to a broadcast domain and broadcasts are only propagated within that specific broadcast domain.

Problems with Large Broadcast Domains

- 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.
- Dividing the network address 172.16.0.0 /16 into two subnets of 200 users each: 172.16.0.0 /24 and 172.16.1.0 /24.
- Broadcasts are only propagated within the smaller broadcast domains.



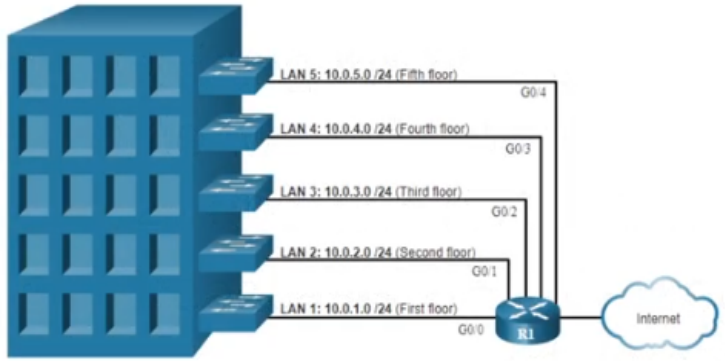


Reasons for Segmenting Networks

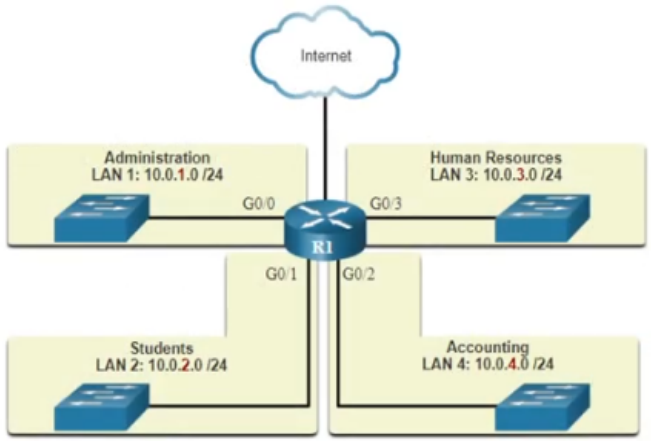
- Subnetting reduces overall network traffic and improves network performance.
- It can be used to implement security policies between subnets.
- Subnetting reduces the number of devices affected by abnormal broadcast traffic.

- Subnets are used for a variety of reasons including by:

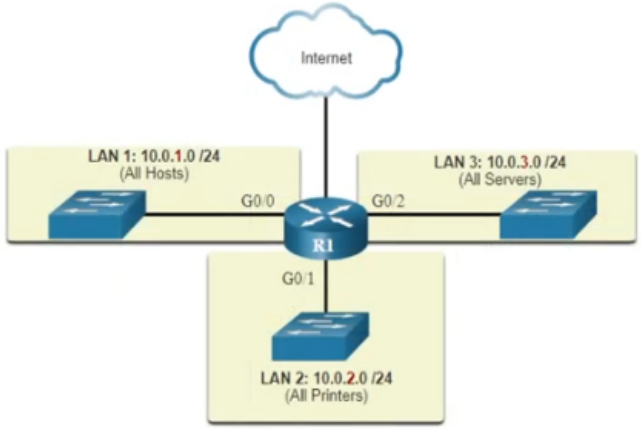
Location



Group or Function



Device Type



11.5 Subnet an IPv4 Network

Subnet an IPv4 Network

Subnet on an Octet Boundary

- Networks are most easily subnetted at the octet boundary of /8, /16, and /24.
- Notice that using longer prefix lengths decreases the number of hosts per subnet.

Prefix Length	Subnet Mask	Subnet Mask in Binary (n = network, h = host)	# of hosts
/8	**255**.0.0.0	**nnnnnnnn**.hhhhhhhh.hhhhhhhh.hhhhhhhh **11111111**.00000000.00000000.00000000	16,777,214
/16	**255.255**.0.0	**nnnnnnnn.nnnnnnnn**.hhhhhhhh.hhhhhhhh **11111111.11111111**.00000000.00000000	65,534
/24	**255.255.255**.0	**nnnnnnnn.nnnnnnnn.nnnnnnnn**.hhhhhhhh **11111111.11111111.11111111**.00000000	254

Subnet on an Octet Boundary (Cont.)

- In the first table 10.0.0.0/8 is subnetted using /16 and in the second table, a /24 mask.

Subnet Address (256 Possible Subnets)	**Host Range** (65,534 possible hosts per subnet)	**Broadcast**
10.0.0.0/**16**	**10.0**.0.1 - **10.0**.255.254	**10.0**.255.255
10.1.0.0/**16**	**10.1**.0.1 - **10.1**.255.254	**10.1**.255.255
10.2.0.0/**16**	**10.2**.0.1 - **10.2**.255.254	**10.2**.255.255
10.3.0.0/**16**	**10.3**.0.1 - **10.3**.255.254	**10.3**.255.255
10.4.0.0/**16**	**10.4**.0.1 - **10.4**.255.254	**10.4**.255.255
10.5.0.0/**16**	**10.5**.0.1 - **10.5**.255.254	**10.5**.255.255
10.6.0.0/**16**	**10.6**.0.1 - **10.6**.255.254	**10.6**.255.255
10.7.0.0/**16**	**10.7**.0.1 - **10.7**.255.254	**10.7**.255.255
…	…	…
10.255.0.0/**16**	**10.255**.0.1 - **10.255**.255.254	**10.255**.255.255

Subnet Address (65,536 Possible Subnets)	**Host Range** (254 possible hosts per subnet)	**Broadcast**
10.0.0.0/**24**	**10.0.0**.1 - **10.0.0**.254	**10.0.0**.255
10.0.1.0/**24**	**10.0.1**.1 - **10.0.1**.254	**10.0.1**.255
10.0.2.0/**24**	**10.0.2**.1 - **10.0.2**.254	**10.0.2**.255
…	…	…
10.0.255.0/**24**	**10.0.255**.1 - **10.0.255**.254	**10.0.255**.255
10.1.0.0/**24**	**10.1.0**.1 - **10.1.0**.254	**10.1.0**.255
10.1.1.0/**24**	**10.1.1**.1 - **10.1.1**.254	**10.1.1**.255
10.1.2.0/**24**	**10.1.2**.1 - **10.1.2**.254	**10.1.2**.255
…	…	…
10.100.0.0/**24**	**10.100.0**.1 - **10.100.0**.254	**10.100.0**.255
…	…	…
10.255.255.0/**24**	**10.255.255**.1 - **10.2255.255**.254	**10.255.255**.255

Subnet an IPv4 Network

Subnet within an Octet Boundary

- Refer to the table to see six ways to subnet a /24 network.

Prefix Length	Subnet Mask	Subnet Mask in Binary (n = network, h = host)	# of subnets	# of hosts
/25	255.255.255.128	nnnnnnnn.nnnnnnnn.nnnnnnnn.**n**hhhhhhh 11111111.11111111.11111111.**1**0000000	**2**	126
/26	255.255.255.192	nnnnnnnn.nnnnnnnn.nnnnnnnn.**nn**hhhhhh 11111111.11111111.11111111.**11**000000	**4**	62
/27	255.255.255.224	nnnnnnnn.nnnnnnnn.nnnnnnnn.**nnn**hhhhh 11111111.11111111.11111111.**111**00000	**8**	30
/28	255.255.255.240	nnnnnnnn.nnnnnnnn.nnnnnnnn.**nnnn**hhhh 11111111.11111111.11111111.**1111**0000	**16**	14
/29	255.255.255.248	nnnnnnnn.nnnnnnnn.nnnnnnnn.**nnnnn**hhh 11111111.11111111.11111111.**11111**000	**32**	6
/30	255.255.255.252	nnnnnnnn.nnnnnnnn.nnnnnnnn.**nnnnnn**hh 11111111.11111111.11111111.**111111**00	**64**	2

11.6 Subnet a Slash 16 and a Slash 8 Prefix

Subnet a Slash 16 and a Slash 8 Prefix

Create Subnets with a Slash 16 prefix

- The table highlights all the possible scenarios for subnetting a /16 prefix.

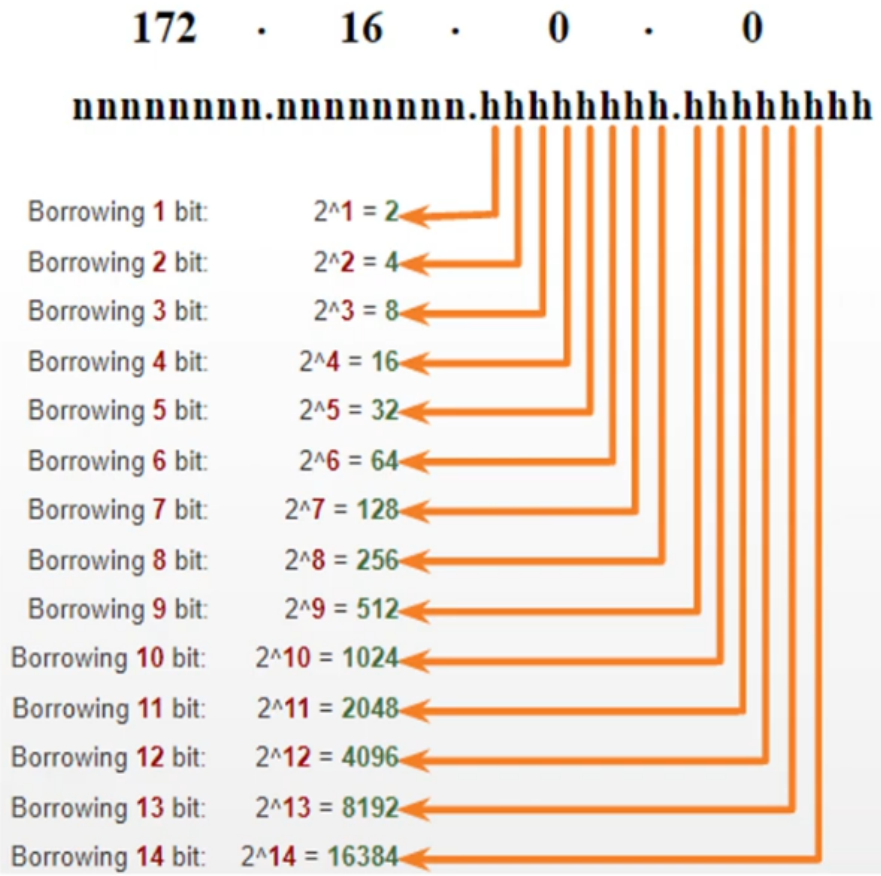
Prefix Length	Subnet Mask	Network Address (n = network, h = host)	# of subnets	# of hosts
/17	255.255.**128**.0	nnnnnnnn.nnnnnnnn.**n**hhhhhhh.hhhhhhhh 11111111.11111111.**1**0000000.00000000	**2**	32766
/18	255.255.**192**.0	nnnnnnnn.nnnnnnnn.**nn**hhhhhh.hhhhhhhh 11111111.11111111.**11**000000.00000000	**4**	16382
/19	255.255.**224**.0	nnnnnnnn.nnnnnnnn.**nnn**hhhhh.hhhhhhhh 11111111.11111111.**111**00000.00000000	**8**	8190
/20	255.255.**240**.0	nnnnnnnn.nnnnnnnn.**nnnn**hhhh.hhhhhhhh 11111111.11111111.**1111**0000.00000000	**16**	4094
/21	255.255.**248**.0	nnnnnnnn.nnnnnnnn.**nnnnn**hhh.hhhhhhhh 11111111.11111111.**11111**000.00000000	**32**	2046
/22	255.255.**252**.0	nnnnnnnn.nnnnnnnn.**nnnnnn**hh.hhhhhhhh 11111111.11111111.**111111**00.00000000	**64**	1022
/23	255.255.**254**.0	nnnnnnnn.nnnnnnnn.**nnnnnnn**h.hhhhhhhh 11111111.11111111.**1111111**0.00000000	**128**	510
/24	255.255.**255.0**	nnnnnnnn.nnnnnnnn.**nnnnnnnn**.hhhhhhhh 11111111.11111111.**11111111**.00000000	**256**	254
/25	255.255.**255.128**	nnnnnnnn.nnnnnnnn.**nnnnnnnn.n**hhhhhhh 11111111.11111111.**11111111.1**0000000	**512**	126
/26	255.255.**255.192**	nnnnnnnn.nnnnnnnn.**nnnnnnnn.nn**hhhhhh 11111111.11111111.**11111111.11**000000	**1024**	62
/27	255.255.**255.224**	nnnnnnnn.nnnnnnnn.**nnnnnnnn.nnn**hhhhh 11111111.11111111.**11111111.111**00000	**2048**	30
/28	255.255.**255.240**	nnnnnnnn.nnnnnnnn.**nnnnnnnn.nnnn**hhhh 11111111.11111111.**11111111.1111**0000	**4096**	14
/29	255.255.**255.248**	nnnnnnnn.nnnnnnnn.**nnnnnnnn.nnnnn**hhh 11111111.11111111.**11111111.11111**000	**8192**	6
/30	255.255.**255.252**	nnnnnnnn.nnnnnnnn.**nnnnnnnn.nnnnnn**hh 11111111.11111111.**11111111.111111**00	**16384**	2

Create 100 Subnets with a Slash 16 prefix

Consider a large enterprise that requires at least 100 subnets and has chosen the private address 172.16.0.0/16 as its internal network address.

- The figure displays the number of subnets that can be created when borrowing bits from the third octet and the fourth octet.
- Notice there are now up to 14 host bits that can be borrowed (i.e., last two bits cannot be borrowed).

To satisfy the requirement of 100 subnets for the enterprise, 7 bits (i.e., $2^7 = 128$ subnets) would need to be borrowed (for a total of 128 subnets).



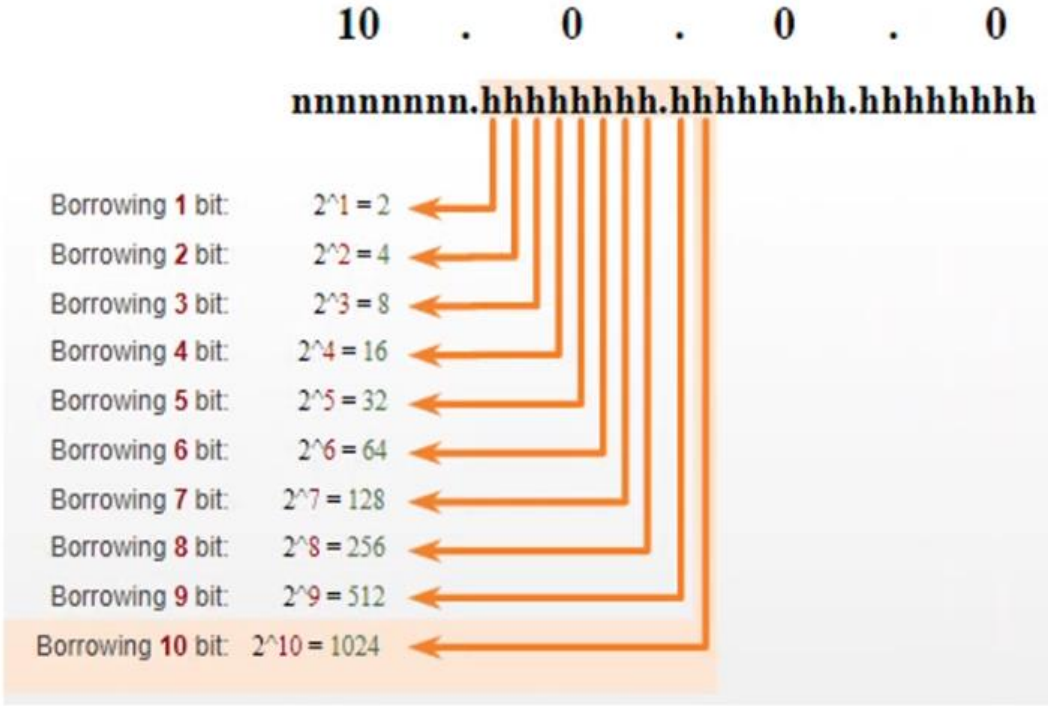
Subnet a Slash 16 and a Slash 8 Prefix

Create 1000 Subnets with a Slash 8 prefix

Consider a small ISP that requires 1000 subnets for its clients using network address 10.0.0.0/8 which means there are 8 bits in the network portion and 24 host bits available to borrow toward subnetting.

- The figure displays the number of subnets that can be created when borrowing bits from the second and third.
- Notice there are now up to 22 host bits that can be borrowed (i.e., last two bits cannot be borrowed).

To satisfy the requirement of 1000 subnets for the enterprise, 10 bits (i.e., 2^{10}=1024 subnets) would need to be borrowed (for a total of 128 subnets)



11.7 Subnet to Meet Requirements

Subnet to Meet Requirements

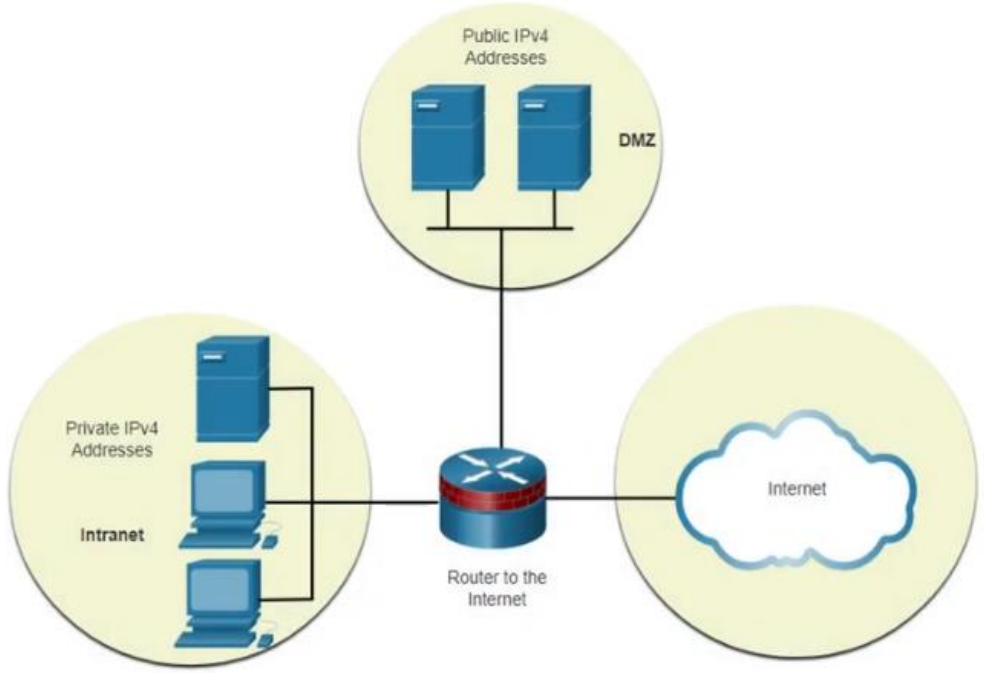
Subnet Private versus Public IPv4 Address Space

Enterprise networks will have an:

- Intranet - A company's internal network typically using private IPv4 addresses.
- DMZ – A companies internet facing servers. Devices in the DMZ use public IPv4 addresses.

- A company could use the 10.0.0.0/8 and subnet on the /16 or /24 network boundary.

- The DMZ devices would have to be configured with public IP addresses.



Subnet to Meet Requirements
Minimize Unused Host IPv4 Addresses and Maximize Subnets

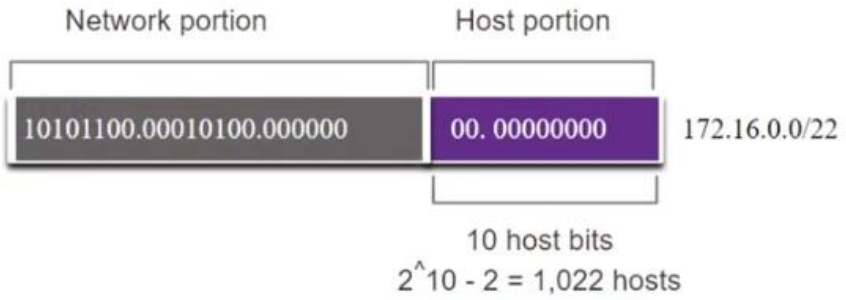
There are two considerations when planning subnets:

- The number of host addresses required for each network
- The number of individual subnets needed

Prefix Length	Subnet Mask	Subnet Mask in Binary (n = network, h = host)	# of subnets	# of hosts
/25	255.255.255.128	nnnnnnnn.nnnnnnnn.nnnnnnnn.**n**hhhhhhh 11111111.11111111.11111111.**1**0000000	**2**	126
/26	255.255.255.192	nnnnnnnn.nnnnnnnn.nnnnnnnn.**nn**hhhhhh 11111111.11111111.11111111.**11**000000	**4**	62
/27	255.255.255.224	nnnnnnnn.nnnnnnnn.nnnnnnnn.**nnn**hhhhh 11111111.11111111.11111111.**111**00000	**8**	30
/28	255.255.255.240	nnnnnnnn.nnnnnnnn.nnnnnnnn.**nnnn**hhhh 11111111.11111111.11111111.**1111**0000	**16**	14
/29	255.255.255.248	nnnnnnnn.nnnnnnnn.nnnnnnnn.**nnnnn**hhh 11111111.11111111.11111111.**11111**000	**32**	6
/30	255.255.255.252	nnnnnnnn.nnnnnnnn.nnnnnnnn.**nnnnnn**hh 11111111.11111111.11111111.**111111**00	**64**	2

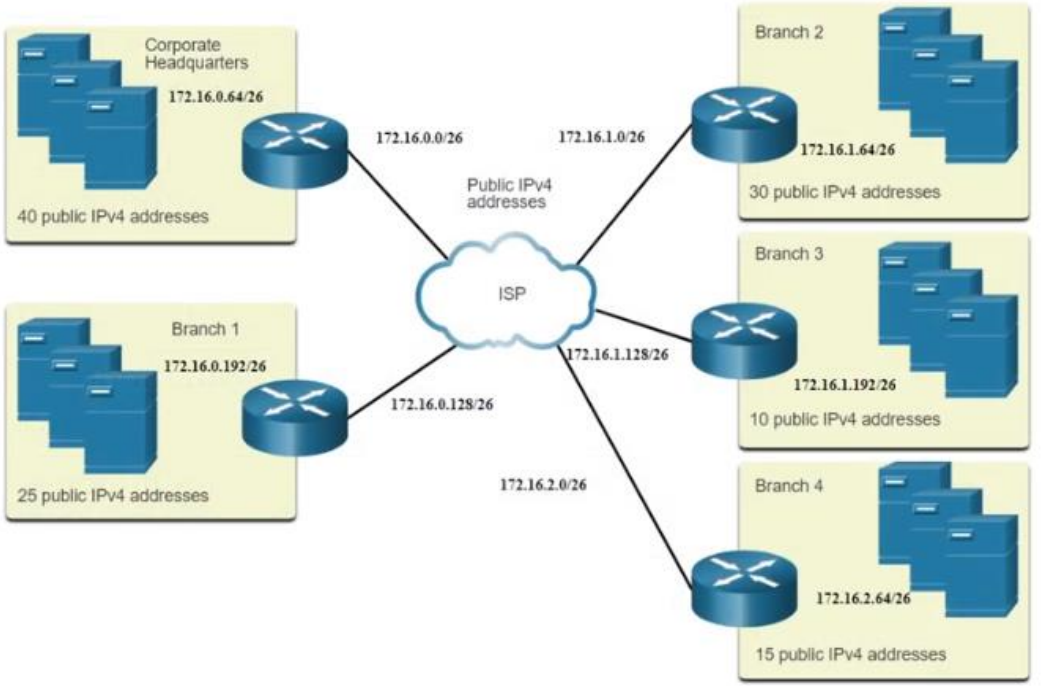
Example: Efficient IPv4 Subnetting

- In this example, corporate headquarters has been allocated a public network address of 172.16.0.0/22 (10 host bits) by its ISP providing 1,022 host addresses.



- There are five sites and therefore five internet connections which means the organization requires 10 subnets with the largest subnet requires 40 addresses.

- It allocated 10 subnets with a /26 (i.e., 255.255.255.192) subnet mask.



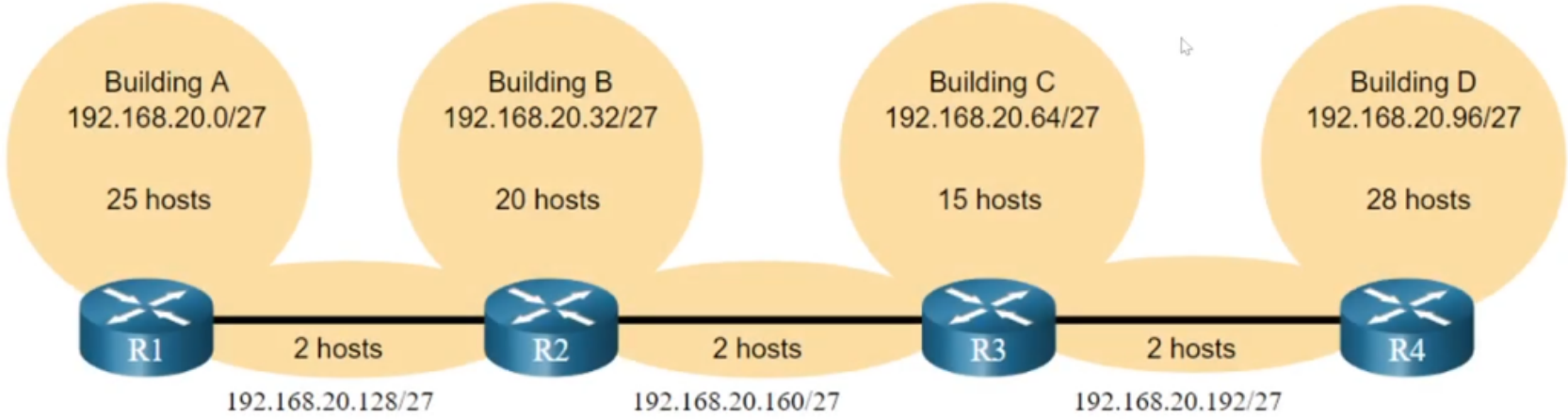
11.8 VLSM

VLSM

IPv4 Address Conservation

Given the topology, 7 subnets are required (i.e, four LANs and three WAN links) and the largest number of host is in Building D with 28 hosts.

- A /27 mask would provide 8 subnets of 30 host IP addresses and therefore support this topology.



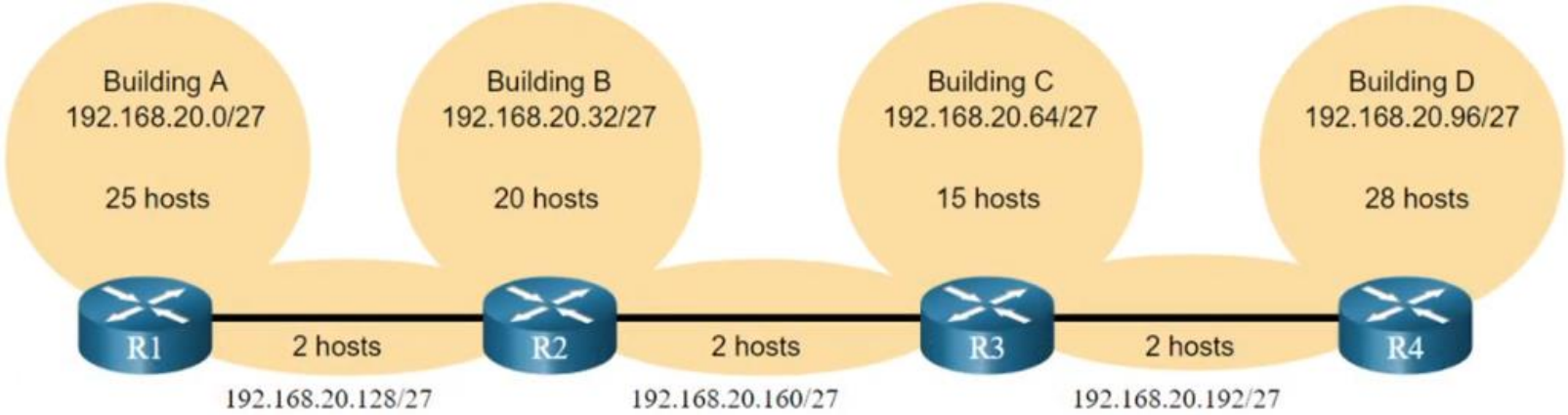
IPv4 Address Conservation (Cont.)

However, the point-to-point WAN links only require two addresses and therefore waste 28 addresses each for a total of 84 unused addresses.

Host portion
2^5 – 2 = 30 host IP addresses per subnet

30 – 2 = 28
Each WAN subnet wastes 28 addresses

28 x 3 = 84
84 addresses are unused

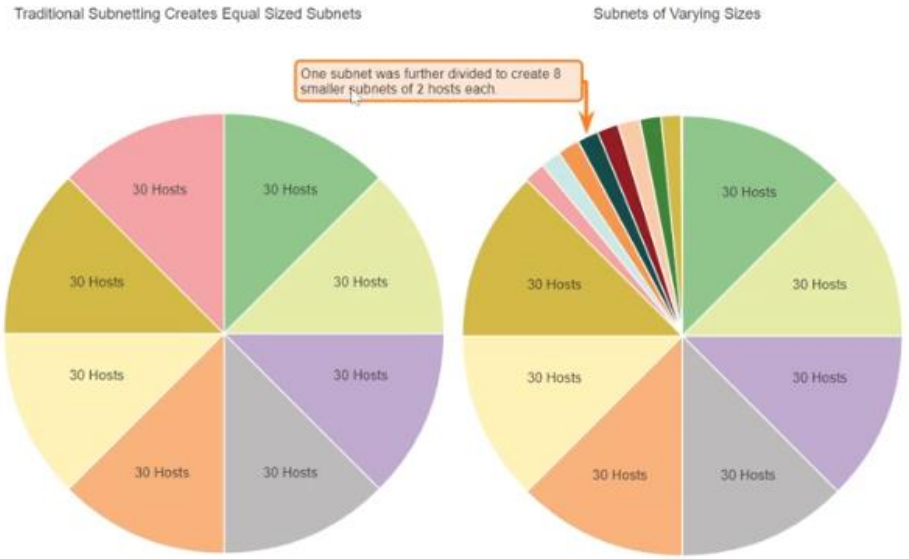


- Applying a traditional subnetting scheme to this scenario is not very efficient and is wasteful.

- VLSM was developed to avoid wasting addresses by enabling us to subnet a subnet.

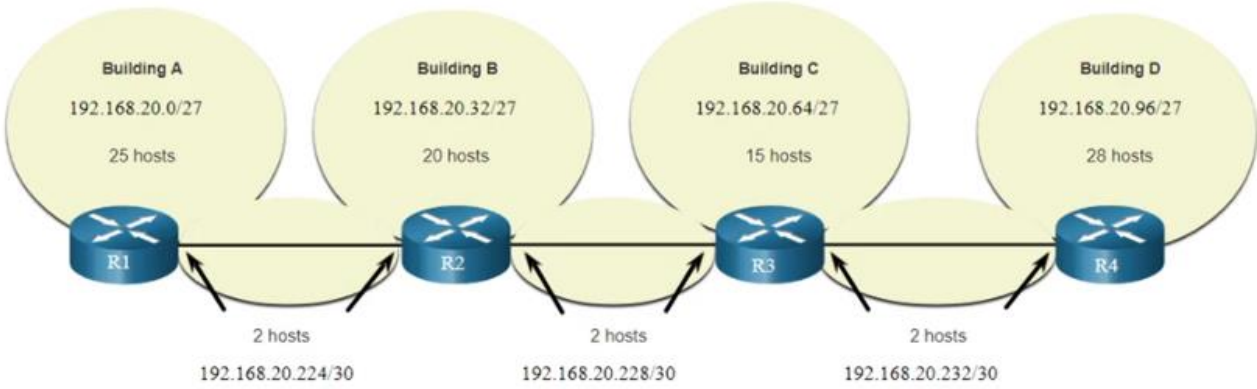
VLSM

- The left side displays the traditional subnetting scheme (i.e., the same subnet mask) while the right side illustrates how VLSM can be used to subnet a subnet and divided the last subnet into eight /30 subnets.



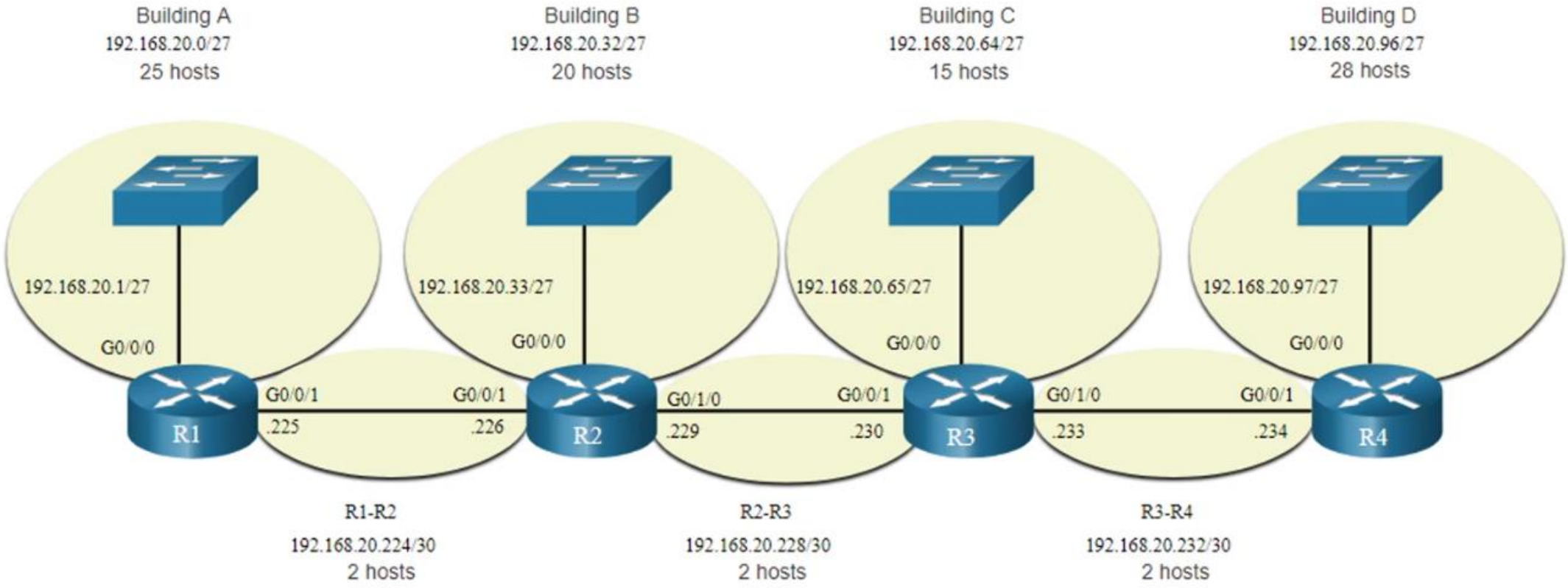
- When using VLSM, always begin by satisfying the host requirements of the largest subnet and continue subnetting until the host requirements of the smallest subnet are satisfied.

- The resulting topology with VLSM applied.



VLSM Topology Address Assignment

- Using VLSM subnets, the LAN and inter-router networks can be addressed without unnecessary waste as shown in the logical topology diagram.



11.9 Structured Design

Structured Design

IPv4 Network Address Planning

IP network planning is crucial to develop a scalable solution to an enterprise network.

- To develop an IPv4 network wide addressing scheme, you need to know how many subnets are needed, how many hosts a particular subnet requires, what devices are part of the subnet, which parts of your network use private addresses, and which use public, and many other determining factors.

Examine the needs of an organization's network usage and how the subnets will be structured.

- Perform a network requirement study by looking at the entire network to determining how each area will be segmented.
- Determine how many subnets are needed and how many hosts per subnet.
- Determine DHCP address pools and Layer 2 VLAN pools.

Structured Design

Device Address Assignment

Within a network, there are different types of devices that require addresses:

- **End user clients** – Most use DHCP to reduce errors and burden on network support staff. IPv6 clients can obtain address information using DHCPv6 or SLAAC.
- **Servers and peripherals** – These should have a predictable static IP address.
- **Servers that are accessible from the internet** – Servers must have a public IPv4 address, most often accessed using NAT.
- **Intermediary devices** – Devices are assigned addresses for network management, monitoring, and security.
- **Gateway** – Routers and firewall devices are gateway for the hosts in that network.

When developing an IP addressing scheme, it is generally recommended that you have a set pattern of how addresses are allocated to each type of device.

11.10 What did we learn?

What did I learn in this module?

- The IP addressing structure consists of a 32-bit hierarchical network address that identifies a network and a host portion. Network devices use a process called ANDing using the IP address and associated subnet mask to identify the network and host portions.
- Destination IPv4 packets can be unicast, broadcast, and multicast.
- There are globally routable IP addresses as assigned by the IANA and there are three ranges of private IP network addresses that cannot be routed globally but can be used on all internal private networks.
- Reduce large broadcast domains using subnets to create smaller broadcast domains, reduce overall network traffic, and improve network performance.
- Create IPv4 subnets using one or more of the host bits as network bits. However, networks are most easily subnetted at the octet boundary of /8, /16, and /24.
- Larger networks can be subnetted at the /8 or /16 boundaries.
- Use VLSM to reduce the number of unused host addresses per subnet.

Module Practice and Quiz

What did I learn in this module? (Cont.)

- VLSM allows a network space to be divided into unequal parts. Always begin by satisfying the host requirements of the largest subnet. Continue subnetting until the host requirements of the smallest subnet are satisfied.
- When designing a network addressing scheme, consider internal, DMZ, and external requirements. Use a consistent internal IP addressing scheme with a set pattern of how addresses are allocated to each type of device.


CISCO

THANK YOU