



IP Addressing

12 Nov 2020



Sections & Objectives

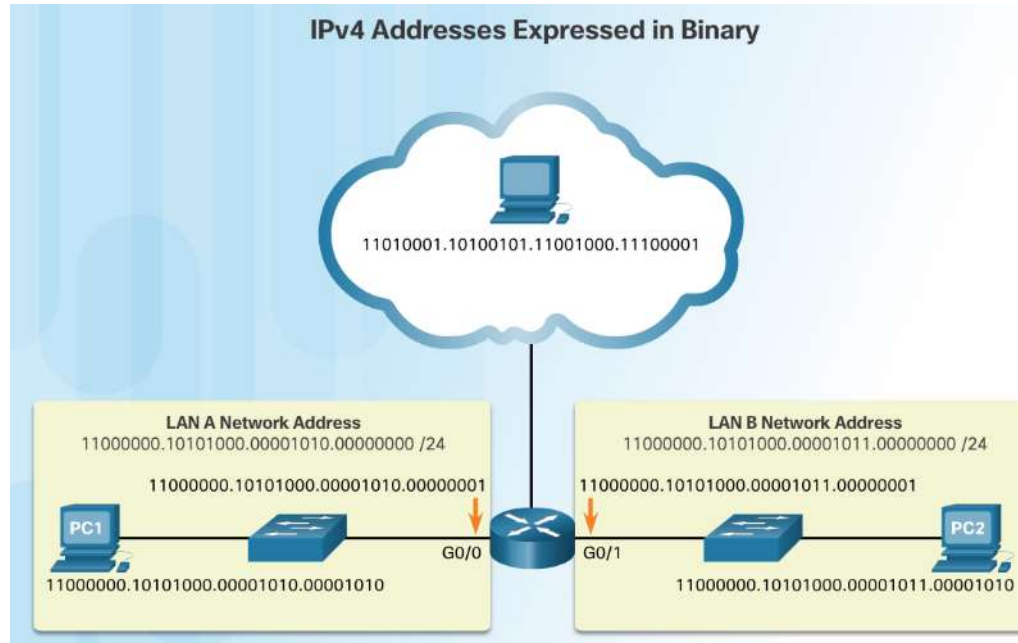
- 7.1 IPv4 Network Addresses
- Explain the use of IPv4 addresses to provide connectivity in small to medium-sized business networks
 - Convert between binary and decimal numbering systems.
 - Describe the structure of an IPv4 address including the network portion, the host portion, and the subnet mask.
 - Compare the characteristics and uses of the unicast, broadcast and multicast IPv4 addresses.
 - Explain public, private, and reserved IPv4 addresses.
- 7.2 IPv6 Network Addresses
- Configure IPv6 addresses to provide connectivity in small to medium-sized business networks.
 - Explain the need for IPv6 addressing.
 - Describe the representation of an IPv6 address.
 - Compare types of IPv6 network addresses.
 - Configure global unicast addresses.
 - Describe multicast addresses.

IPv4 Network Addresses

Binary and Decimal Conversion

IPv4 Addresses

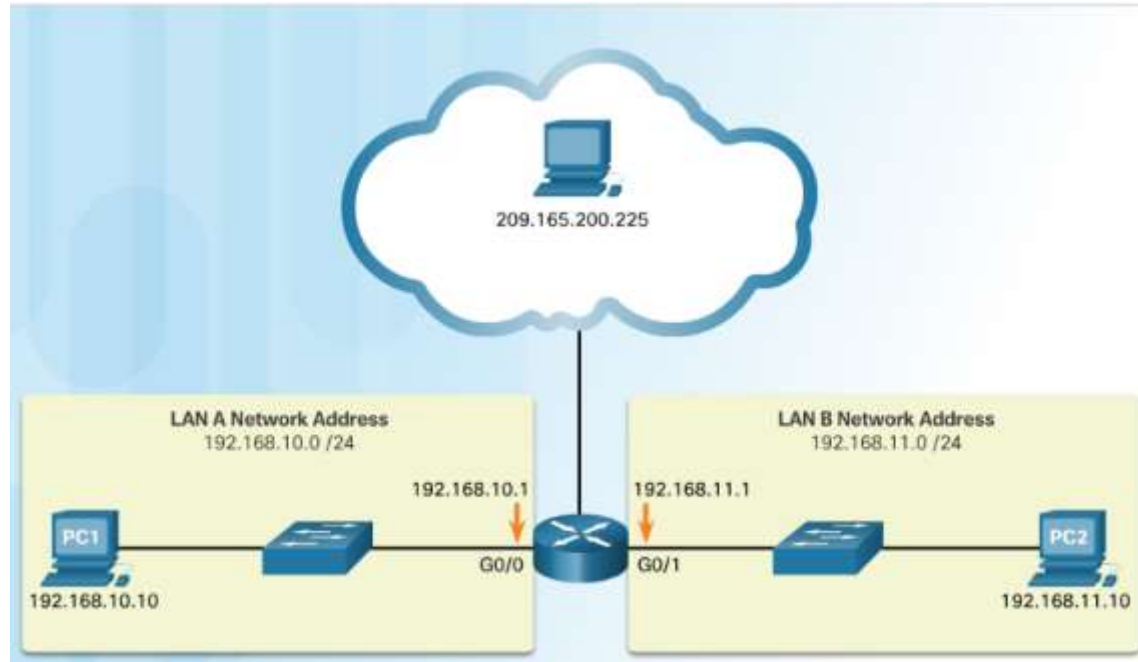
- Binary numbering system consists of the numbers 0 and 1 called bits
 - IPv4 addresses are expressed in 32 binary bits divided into 4 8-bit octets



Binary and Decimal Conversion

IPv4 Addresses (Cont.)

- IPv4 addresses are commonly expressed in dotted decimal notation



Video Demonstration – Converting Between Binary and Decimal Numbering Systems

- This video will cover the process of ANDing as it relates to discovering the network address, the host addresses, and the broadcast address in an IPv4 network.



Binary and Decimal Conversion

Positional Notation

- The first row identifies the number base or radix. Decimal is 10. Binary is based on 2, therefore radix will be 2
- The 2nd row considers the position of the number starting with 0. These numbers also represent the exponential value that will be used to calculate the positional value (4th row).
- The 3rd row calculates the positional value by taking the radix and raising it by the exponential value of its position. Note: n^0 is always = 1.
- The positional value is listed in the fourth row.

Decimal Positional Notation

Radix	10	10	10	10
Position in Number	3	2	1	0
Calculate	(10^3)	(10^2)	(10^1)	(10^0)
Positional Value	1000	100	10	1

Applying decimal positional notation

	Thousands	Hundreds	Tens	Ones
Positional Value	1000	100	10	1
Decimal Number (1234)	1	2	3	4
Calculate	1×1000	2×100	3×10	4×1
Add them up ...	1000	+ 200	+ 30	+ 4
Result	1,234			

Binary and Decimal Conversion

Positional Notation (Cont.)

Binary Positional Notation								
	Radix	2	2	2	2	2	2	2
	Position in Number	7	6	5	4	3	2	1
	Calculate	(2^7)	(2^6)	(2^5)	(2^4)	(2^3)	(2^2)	(2^1)
	Positional Value	128	64	32	16	8	4	2

- Applying binary positional notation.

Positional Value	128	64	32	16	8	4	2	1
Binary Number (11000000)	1	1	0	0	0	0	0	0
Calculate	1 x 128	1 x 64	0 x 32	0 x 16	0 x 8	0 x 4	0 x 2	0 x 1
Add Them Up ...	128	+ 64	+ 0	+ 0	+ 0	+ 0	+ 0	+ 0
Result	192							

Binary and Decimal Conversion

Binary to Decimal Conversion

- To convert a binary IPv4 address to decimal enter the 8-bit binary number of each octet under the positional value of row 1 and then calculate to produce the decimal.

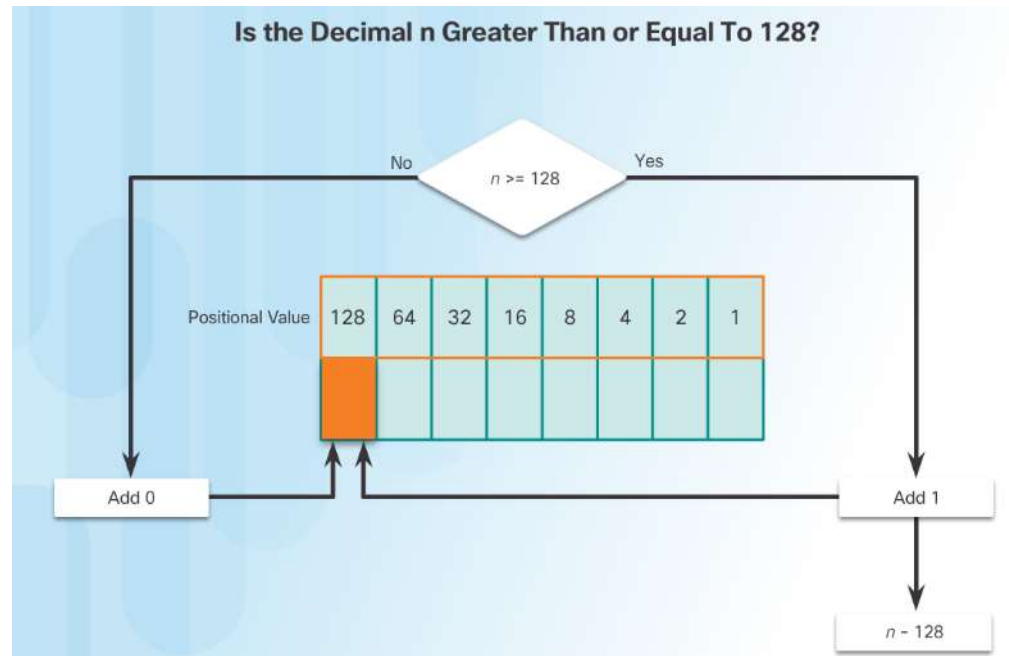
The diagram illustrates the conversion of a binary IPv4 address to dotted decimal notation. At the top, a box contains the binary address: **11000000.10101000.00001011.00001010**. An orange arrow points from the first octet, **11000000**, to a conversion table below. The table has five rows and nine columns. The first column lists the steps: Positional Value, Binary number, Calculate, Add Them Up..., and Result. The subsequent eight columns correspond to the bits of the octet, with positional values 128, 64, 32, 16, 8, 4, 2, and 1. The 'Binary number' row shows the bits 1, 1, 0, 0, 0, 0, 0, 0. The 'Calculate' row shows the products of the bits and their positional values. The 'Add Them Up...' row shows the addition of these products. The 'Result' row shows the final decimal value, 192. An orange arrow points from the 'Result' cell to a box at the bottom containing **192.____.____.____**, which is labeled 'Dotted Decimal Notation'.

Positional Value	128	64	32	16	8	4	2	1
Binary number	1	1	0	0	0	0	0	0
Calculate	128	64	32	16	8	4	2	1
Add Them Up...	128	+ 64	+ 0	+ 0	+ 0	+ 0	+ 0	+ 0
Result	192							

192.____.____.____
Dotted Decimal Notation

Decimal to Binary Conversion

- To convert a decimal IPv4 address to binary use the positional chart and check first if the number is greater than the 128 bit. If no a 0 is placed in this position. If yes then a 1 is placed in this position.
- 128 is subtracted from the original number and the remainder is then checked against the next position (64). If it is less than 64 a 0 is placed in this position. If it is greater, a 1 is placed in this position and 64 is subtracted.
- The process repeats until all positional values have been entered.



Binary and Decimal Conversion

Decimal to Binary Conversion Examples

Example: 192.168.10.11

128	64	32	16	8	4	2	1
1	1	0	0	0	0	0	0

11000000 . _____ . _____ . _____

Example: 192.168.10.11

Positional Value	128	64	32	16	8	4	2	1
	1	0	1	0	1	0	0	0

11000000 . 10101000 . _____ . _____

Example: 192.168.10.11

Positional Value	128	64	32	16	8	4	2	1
	0	0	0	0	1	0	1	0

11000000 . 10101000 . 00001010 . _____

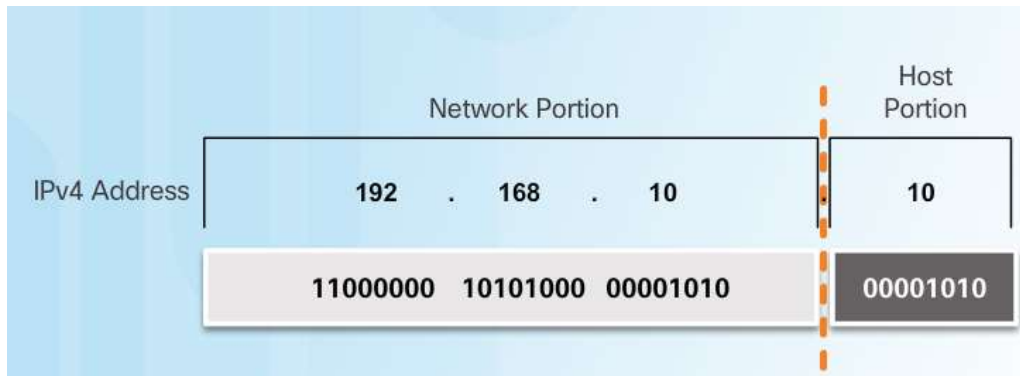
Example: 192.168.10.11

Positional Value	128	64	32	16	8	4	2	1
	0	0	0	0	1	0	1	1

11000000 . 10101000 . 00001010 . 00001011

Network and Host Portions

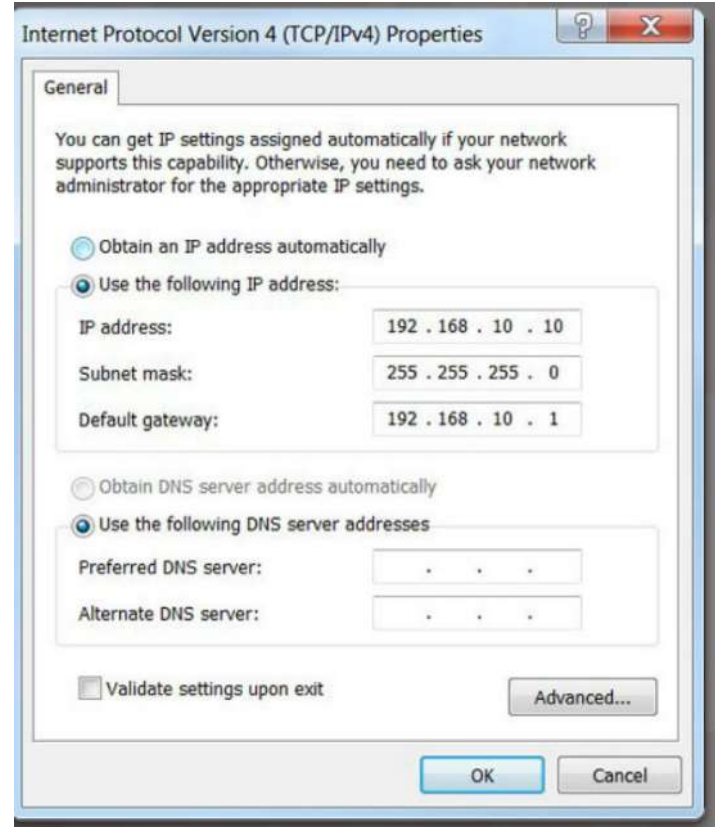
- An IPv4 address is hierarchical.
 - Composed of a Network portion and Host portion.
- All devices on the same network must have the identical network portion.
- The Subnet Mask helps devices identify the network portion and host portion.



IPv4 Address Structure

The Subnet Mask

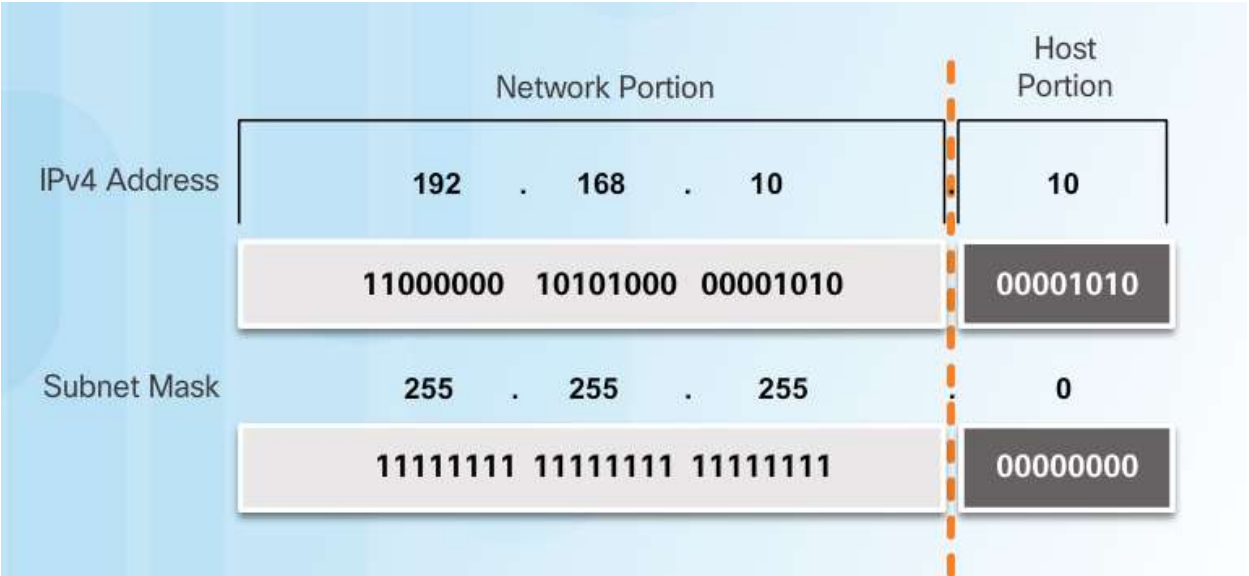
- Three IPv4 addresses must be configured on a host:
 - Unique IPv4 address of the host.
 - Subnet mask - identifies the network/host portion of the IPv4 address.
 - Default gateway -IP address of the local router interface.



IPv4 Address Structure

The Subnet Mask (Cont.)

- The IPv4 address is compared to the subnet mask bit by bit, from left to right.
- A 1 in the subnet mask indicates that the corresponding bit in the IPv4 address is a network bit.



Logical AND

- A logical AND is one of three basic binary operations used in digital logic.
- Used to determine the Network Address
- The Logical AND of two bits yields the following results:

1 AND 1 = 1

0 AND 1 = 0

0 AND 0 = 0

1 AND 0 = 0

IP Address	192	168	10	10
Binary	11000000	10101000	00001010	00001010
Subnet mask	255	255	255	0
	11111111	11111111	11111111	00000000
AND Results	11000000	10101000	00001010	00000000
Network Address	192	168	10	0

IPv4 Address Structure

The Prefix Length

Comparing the Subnet Mask and Prefix Length

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

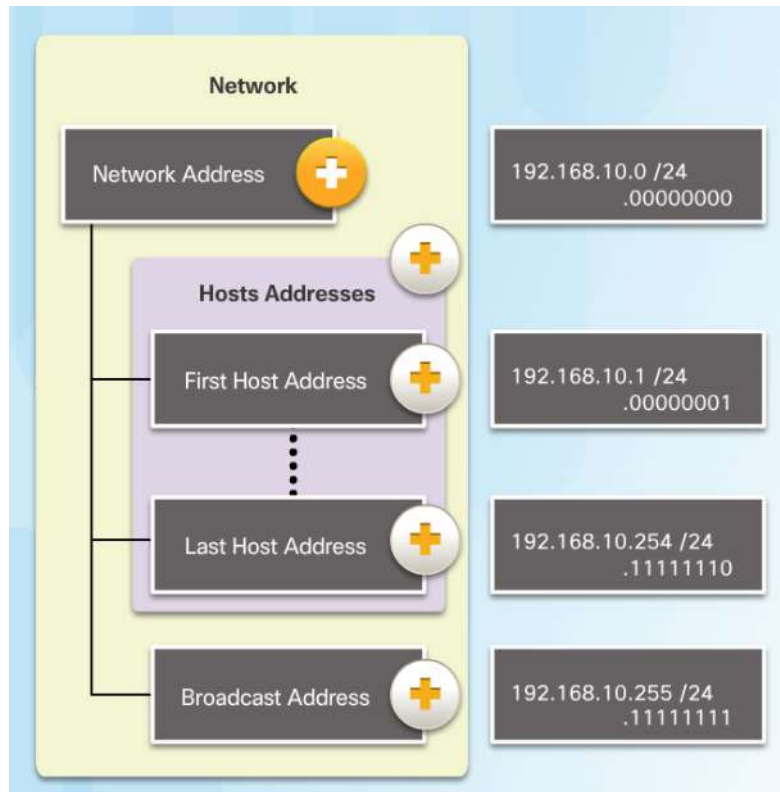
Length:

and method of
g the subnet mask.

the number of bits in
t mask set to 1.

slash notation, /
y the number of
its.

Network, Host, and Broadcast Addresses

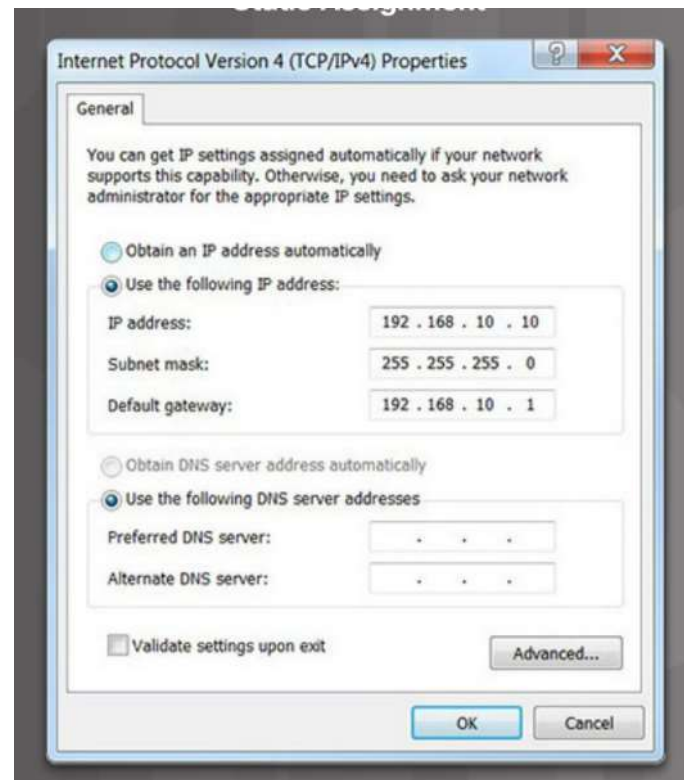


Types of Addresses in Network 192.168.10.0/24

- Network Address - host portion is all 0s (.00000000)
- First Host address - host portion is all 0s and ends with a 1 (.00000001)
- Last Host address - host portion is all 1s and ends with a 0 (.11111110)
- Broadcast Address - host portion is all 1s (.11111111)

Static IPv4 Address Assignment to a Host

- Some devices like printers, servers and network devices require a fixed IP address.
- Hosts in a small network can also be configured with static addresses.



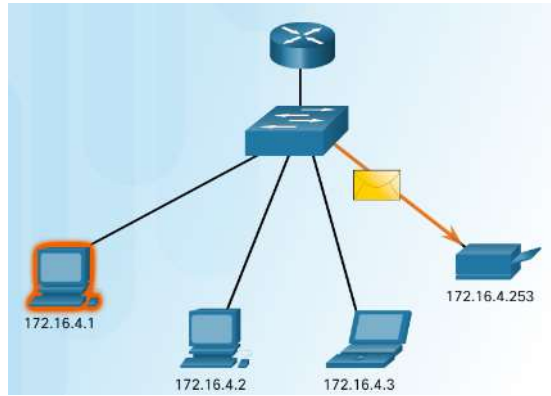
Dynamic IPv4 Address Assignment to a Host

- Most networks use Dynamic Host Configuration Protocol (DHCP) to assign IPv4 addresses dynamically.
- The DHCP server provides an IPv4 address, subnet mask, default gateway, and other configuration information.
- DHCP leases the addresses to hosts for a certain length of time.
- If the host is powered down or taken off the network, the address is returned to the pool for reuse.

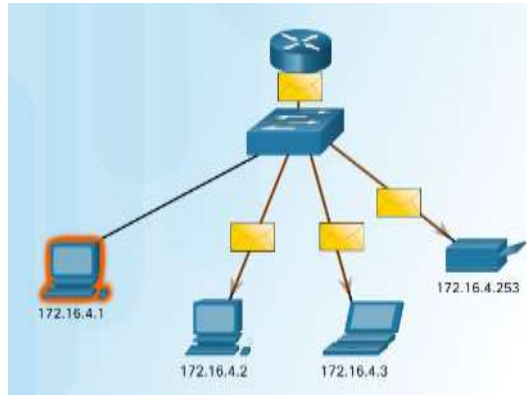


IPv4 Unicast, Broadcast, and Multicast

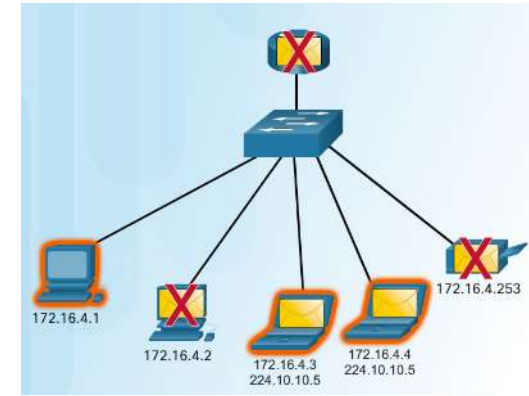
IPv4 Communication



- Unicast – one to one communication.



- Broadcast– one to all.

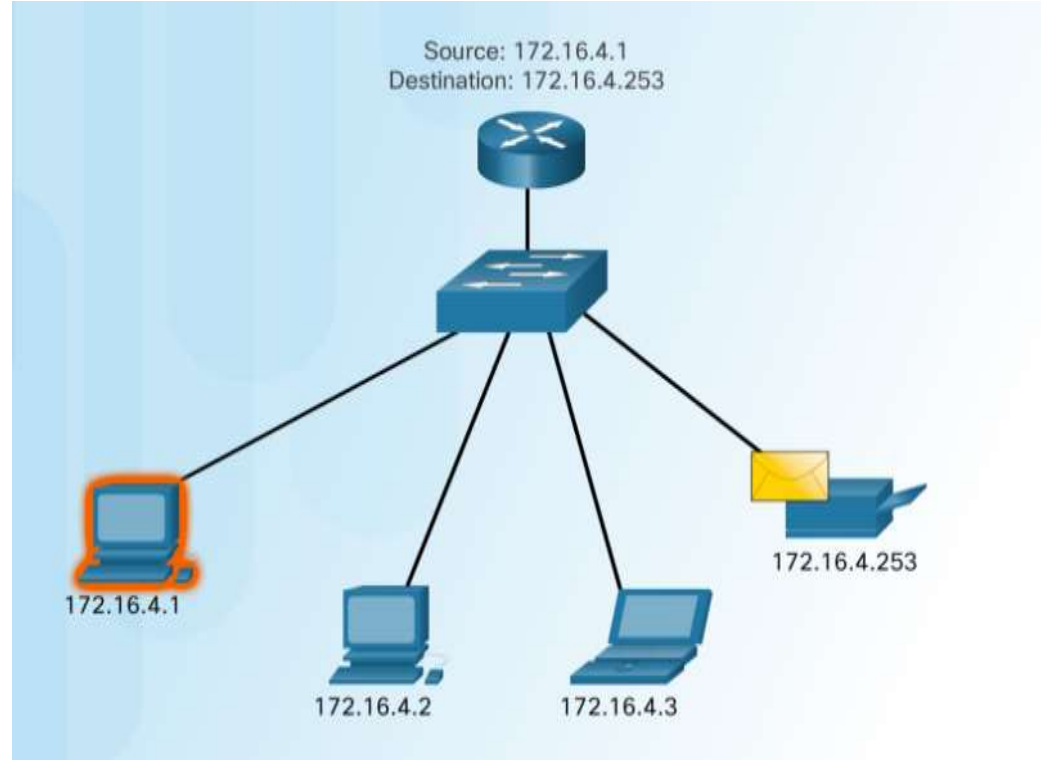


- Multicast – one to a select group.

IPv4 Unicast, Broadcast, and Multicast

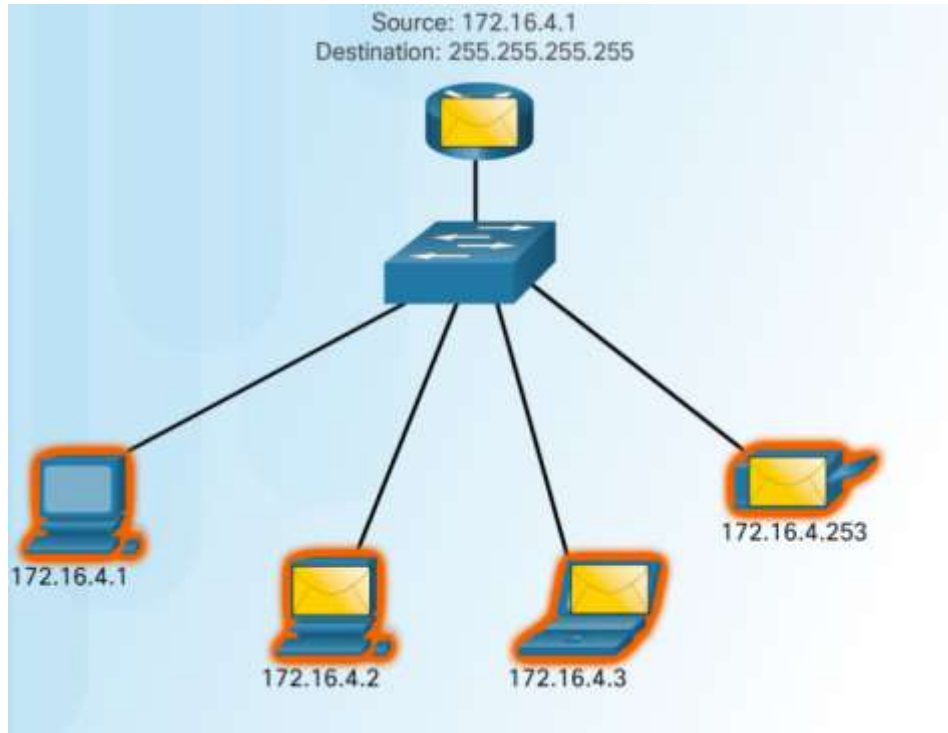
Unicast Transmission

- Unicast – one to one communication.
 - Use the address of the destination device as the destination address.



IPv4 Unicast, Broadcast, and Multicast

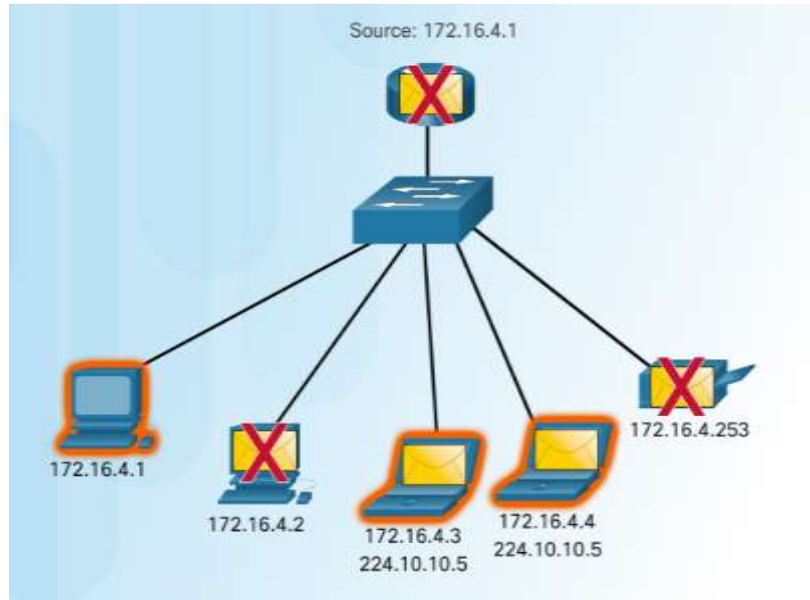
Broadcast Transmission



- Broadcast– one to all
 - Message sent to everyone in the LAN (broadcast domain.)
 - destination IPv4 address has all ones (1s) in the host portion.

IPv4 Unicast, Broadcast, and Multicast

Multicast Transmission



- Multicast– one to a select group.
 - 224.0.0.0 to 239.255.255.255 addresses reserved for multicast.
 - routing protocols use multicast transmission to exchange routing information.

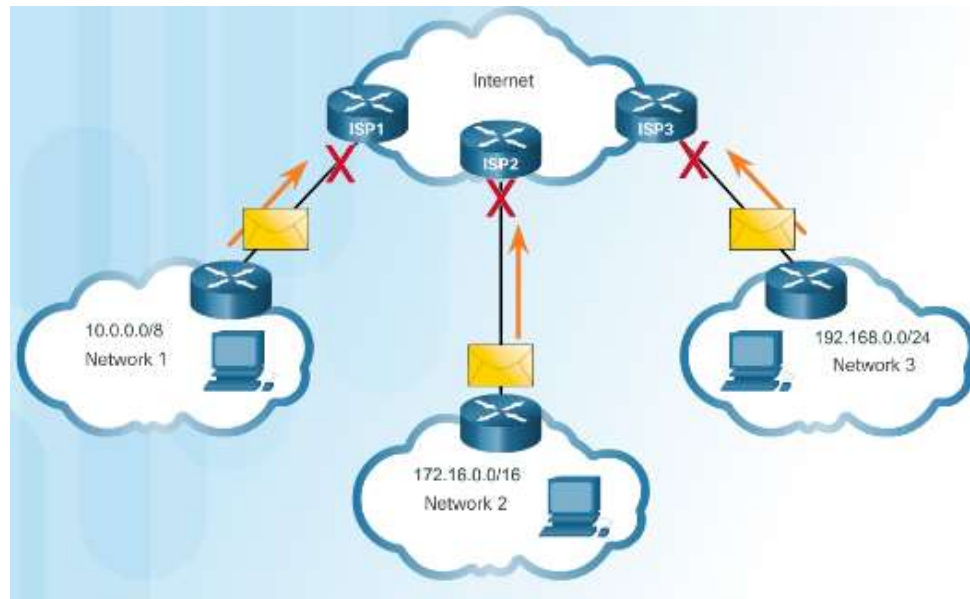
Public and Private IPv4 Addresses

■ Private Addresses

- Not routable
- Introduced in mid 1990s due to depletion of IPv4 addresses
- Used only in internal networks.
- Must be translated to a public IPv4 to be routable.
- Defined by RFC 1918

■ Private Address Blocks

- 10.0.0.0 /8 or 10.0.0.0 to 10.255.255.255
- 172.16.0.0 /12 or 172.16.0.0 to 172.31.255.255
- 192.168.0.0 /16 or 192.168.0.0 to 192.168.255.255



Special User IPv4 Addresses

Pinging the Loopback Interface

Microsoft Windows [Version 6.1.7601]
Copyright (c) 2009 Microsoft Corporation. All rights reserved.

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=0ms TTL=128

Reply from 127.0.0.1: bytes=32 time=0ms TTL=128

Reply from 127.0.0.1: bytes=32 time=0ms TTL=128

Reply from 127.0.0.1: bytes=32 time=0ms TTL=128

Ping statistics for 127.0.0.1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\NetAcad> ping 127.1.1.1

Pinging 127.1.1.1 with 32 bytes of data:

Reply from 127.1.1.1: bytes=32 time=0ms TTL=128

Reply from 127.1.1.1: bytes=32 time=0ms TTL=128

Reply from 127.1.1.1: bytes=32 time=0ms TTL=128

Reply from 127.1.1.1: bytes=32 time=0ms TTL=128

Ping statistics for 127.1.1.1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\NetAcad>

- Loopback addresses (127.0.0.0 /8 or 127.0.0.1)
 - Used on a host to test if the TCP/IP configuration is operational.
- Link-Local addresses (169.254.0.0 /16 or 169.254.0.1)
 - Commonly known as Automatic Private IP Addressing (APIPA) addresses.
 - Used by Windows client to self configure if no DHCP server available.
- TEST-NET addresses (192.0.2.0/24 or 192.0.2.0 to 192.0.2.255)
 - Used for teaching and learning.

Legacy Classful Addressing

Class A Specifics	
Address Block	0.0.0.0 – 127.0.0.0
Default Subnet Mask	/8 (255.0.0.0)
Maximum Number of Networks	128
Number of Host per Network	16,777,214
High order bit	0xxxxxx._____._____

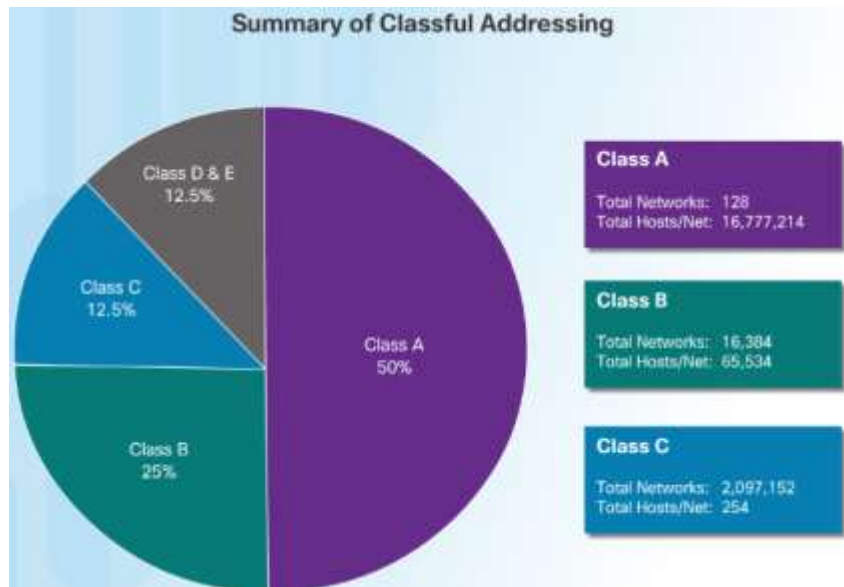
* 0.0.0.0 and 127.0.0.0 are reserved and cannot be assigned

Class B Specifics	
Address Block	128.0.0.0 – 191.255.0.0
Default Subnet Mask	/16 (255.255.0.0)
Maximum Number of Networks	16,384
Number of Host per Network	65,534
High order bit	10xxxxx._____._____

Class C Specifics	
Address Block	192.0.0.0 – 223.255.255.0
Default Subnet Mask	/24 (255.255.255.0)
Maximum Number of Networks	2,097,152
Number of Host per Network	254
High order bit	110xxxx._____._____

- In 1981, Internet IPv4 addresses were assigned using classful addressing (RFC 790)
- Network addresses were based on 3 classes:
 - **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 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.

Classless Addressing



- Classful Addressing wasted addresses and exhausted the availability of IPv4 addresses.
- Classless Addressing Introduced in the 1990s
 - Classless Inter-Domain Routing (CIDR, pronounced “cider”)
 - Allowed service providers to allocate IPv4 addresses on any address bit boundary (prefix length) instead of only by a class A, B, or C.

Assignment of IP Addresses



- The following organizations manage and maintain IPv4 and IPv6 addresses for the various regions.
 - American Registry for Internet Numbers (ARIN)- North America.
 - Réseaux IP Européens (RIPE) - Europe, the Middle East, and Central Asia
 - Asia Pacific Network Information Centre (APNIC) - Asia and Pacific regions
 - African Network Information Centre (AfriNIC) – Africa
 - Regional Latin-American and Caribbean IP Address Registry (LACNIC) - Latin America and some Caribbean islands

7.2 IPv6 Network Addresses

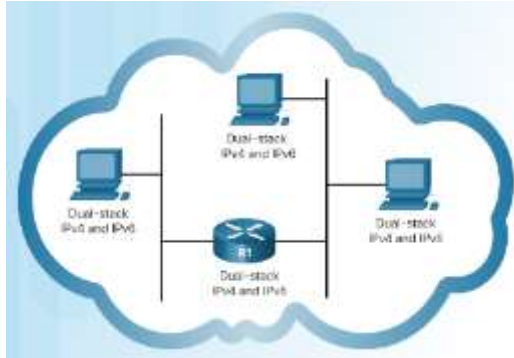
The Need for IPv6



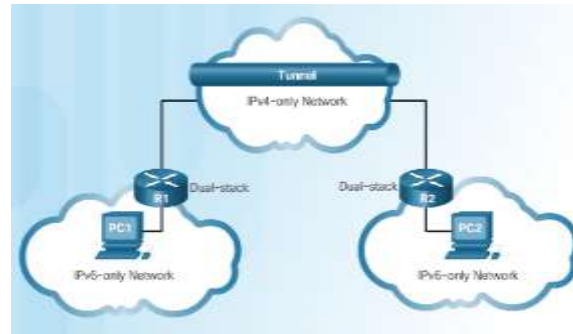
- IPv6 versus IPv4:
 - Has a larger 128-bit address space
 - 340 undecillion addresses
 - Solves limitations with IPv4
 - Adds enhancement like address auto-configuration.
- Why IPv6 is needed:
 - Rapidly increasing Internet population
 - Depletion of IPv4
 - Issues with NAT
 - Internet of Things

IPv4 and IPv6 Coexistence

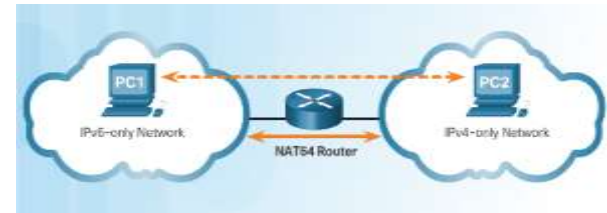
■ Migration from IPv4 to IPv6 Techniques



Dual stack - Devices run both IPv4 and IPv6 protocol stacks simultaneously.



Tunneling - The IPv6 packet is encapsulated inside an IPv4 packet.

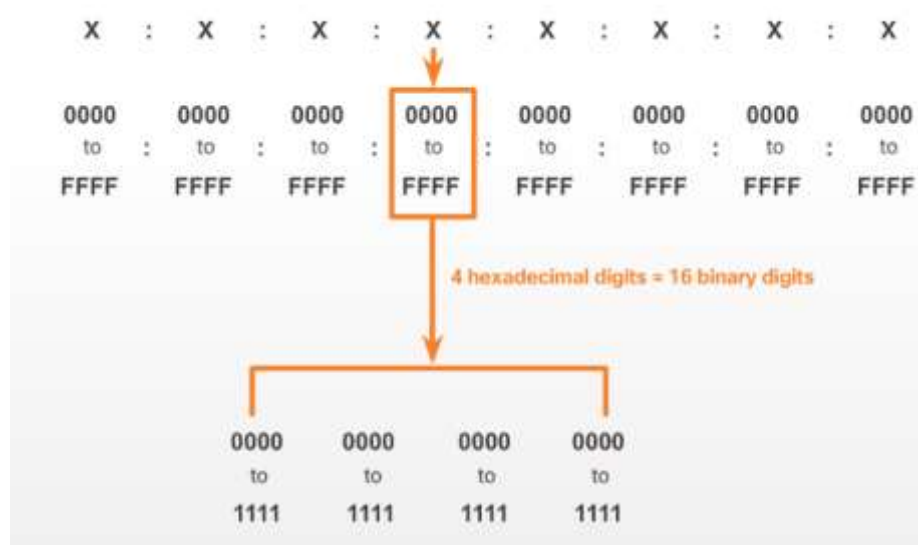


Translation - Network Address Translation 64 (NAT64) allows IPv6-enabled devices to communicate with IPv4 devices.

IPv6 Address Representation

■ IPv6 Addresses:

- 128 bits in length
- Every 4 bits is represented by a single hexadecimal digit
- Hextet - unofficial term referring to a segment of 16 bits or four hexadecimal values.



IPv6 Address Representation (Cont.)

- Preferred format for IPv6 representation

2001	:	0DB8	:	0000	:	1111	:	0000	:	0000	:	0000	:	0200
2001	:	0DB8	:	0000	:	00A3	:	ABCD	:	0000	:	0000	:	1234
2001	:	0DB8	:	000A	:	0001	:	0000	:	0000	:	0000	:	0100
2001	:	0DB8	:	AAAA	:	0001	:	0000	:	0000	:	0000	:	0200
FE80	:	0000	:	0000	:	0000	:	0123	:	4567	:	89AB	:	CDEF
FE80	:	0000	:	0000	:	0000	:	0000	:	0000	:	0000	:	0001
FF02	:	0000	:	0000	:	0000	:	0000	:	0000	:	0000	:	0001
FF02	:	0000	:	0000	:	0000	:	0000	:	0001	:	FF00	:	0200
0000	:	0000	:	0000	:	0000	:	0000	:	0000	:	0000	:	0001
0000	:	0000	:	0000	:	0000	:	0000	:	0000	:	0000	:	0000

Rule 1 – Omit Leading 0s

- In order to reduce or compress IPv6
 - First rule is to omit leading zeros in any hextet.

Preferred	2001:0DB8:0000:1111:0000:0000:0000:0200
No leading 0s	2001: DB8: 0:1111: 0: 0: 0: 200

Preferred	2001:0DB8:000A:1000:0000:0000:0000:0100
No leading 0s	2001: DB8: A:1000: 0: 0: 0: 100

Preferred	0000:0000:0000:0000:0000:0000:0000:0000
No leading 0s	0: 0: 0: 0: 0: 0: 0: 0

Rule 2 – Omit All 0 Segments

- Rule 2 – Omit All 0 Segments
 - A double colon (::) can replace any single, contiguous string of one or more 16-bit segments (hexets) consisting of all 0s.

Preferred	2001:0DB8:0000:0000:ABCD:0000:0000:0100
No leading 0s	2001: DB8: 0: 0:ABCD: 0: 0: 100
Compressed	2001:DB8::ABCD:0:0:100
or	
Compressed	2001:DB8:0:0:ABCD::100

Only one :: may be used.

Rule 2 – Omit All 0 Segments (Cont.)

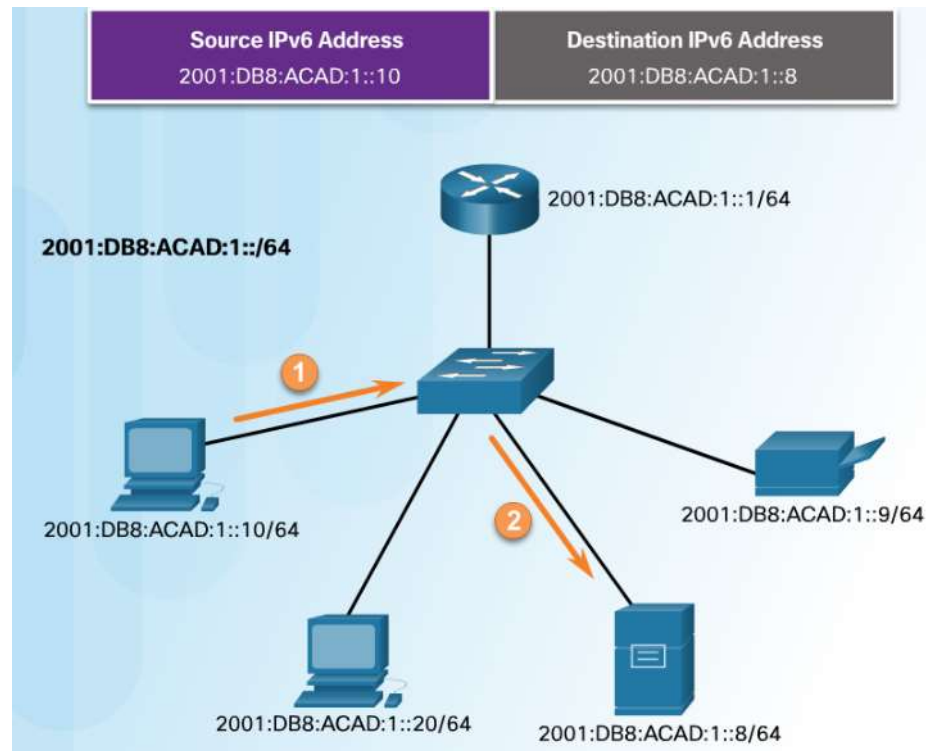
- Rule 2 – Omit All 0 Segments
 - A double colon (::) can replace any single, contiguous string of one or more 16-bit segments (hextets) consisting of all 0s.

Preferred	FF02:0000:0000:0000:0000:0000:0000:0001
No leading 0s	FF02: 0: 0: 0: 0: 0: 0: 1
Compressed	FF02::1

Preferred	0000:0000:0000:0000:0000:0000:0000:0000
No leading 0s	0: 0: 0: 0: 0: 0: 0: 0
Compressed	::

IPv6 Address Types

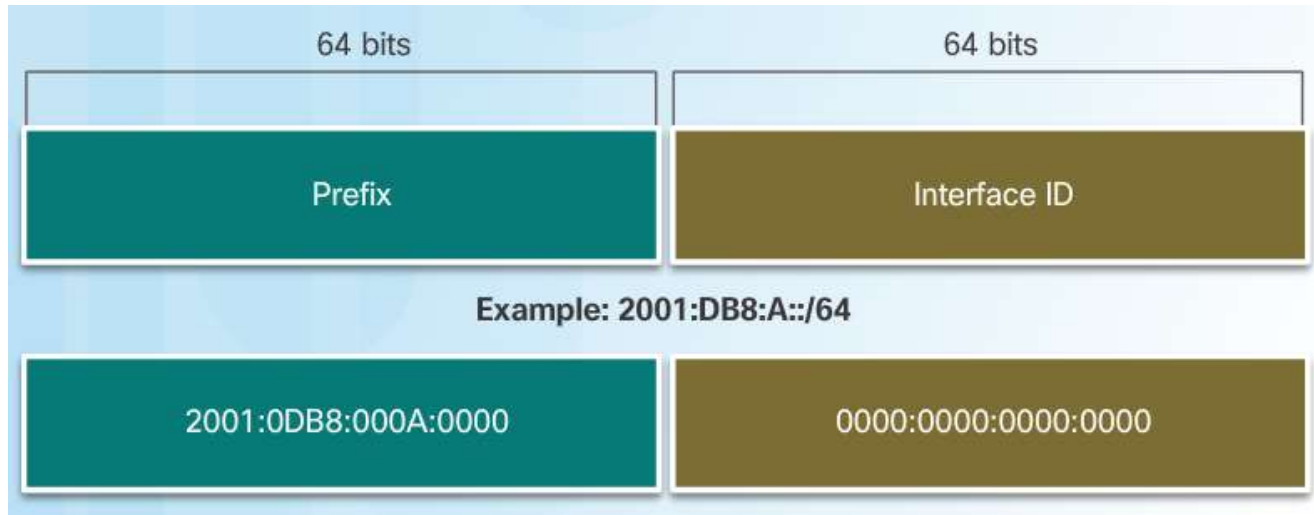
- Three types of IPv6 addresses:
 - Unicast**- Single source IPv6 address.
 - Multicast** - An IPv6 multicast address is used to send a single IPv6 packet to multiple destinations.
 - Anycast** - An IPv6 anycast address is any IPv6 unicast address that can be assigned to multiple devices.



Types of IPv6 Addresses

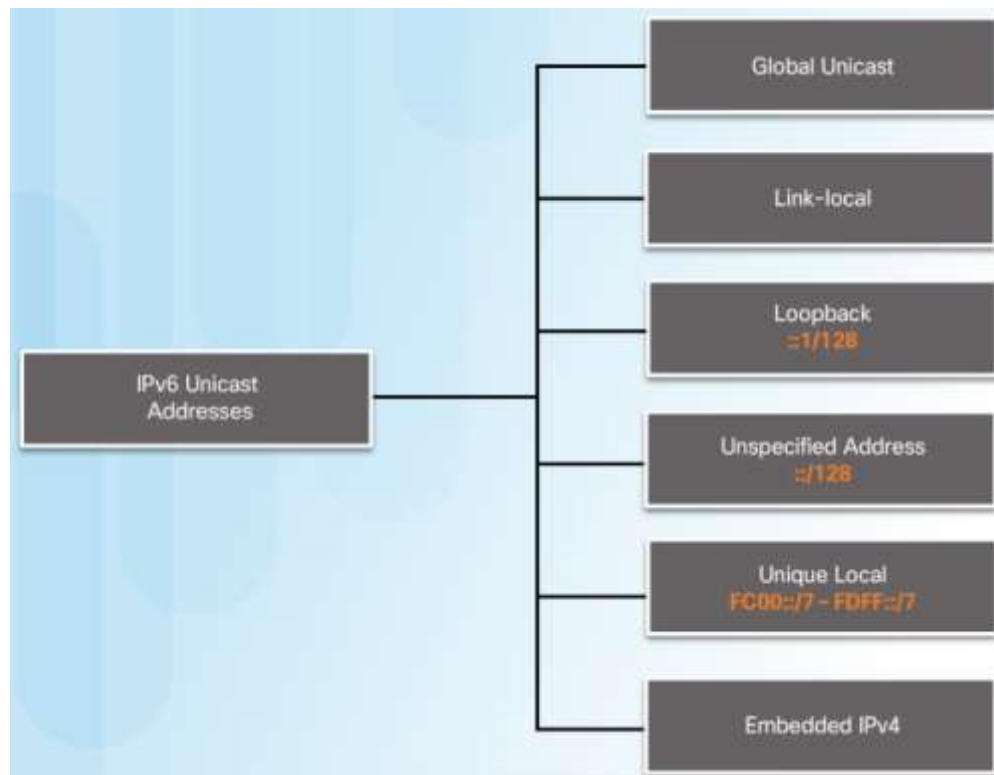
IPv6 Prefix Length

- The IPv6 prefix length is used to indicate the network portion of an IPv6 address:
 - The prefix length can range from 0 to 128.
 - Typical IPv6 prefix length for most LANs is /64



IPv6 Unicast Addresses

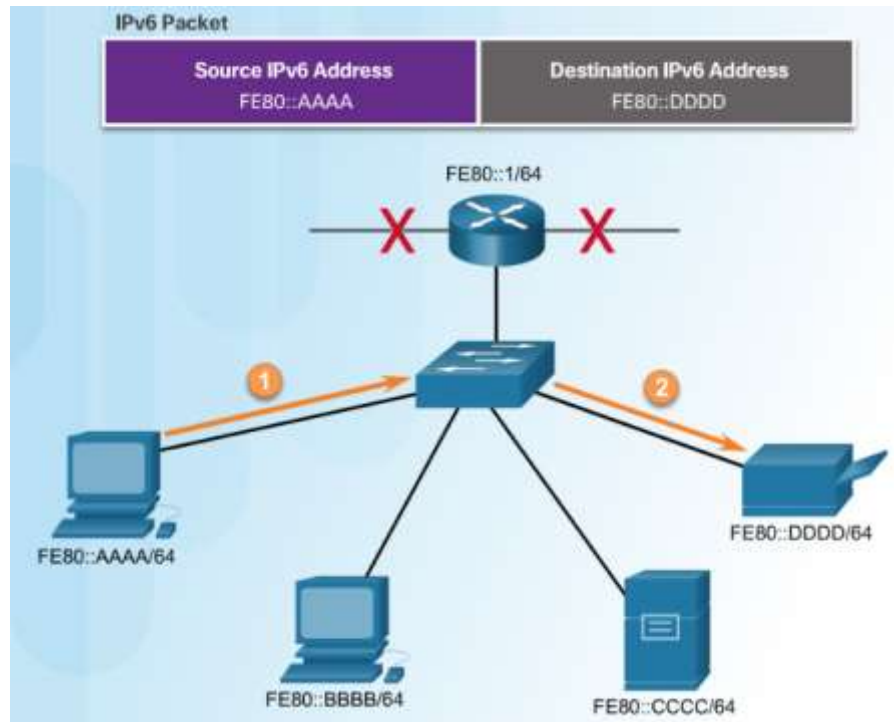
- **Global Unicast** - These are globally unique, Internet routable addresses.
- **Link-local** - used to communicate with other devices on the same local link. Confined to a single link.
- **Unique Local** - used for local addressing within a site or between a limited number of sites.



IPv6 Link-Local Unicast Addresses

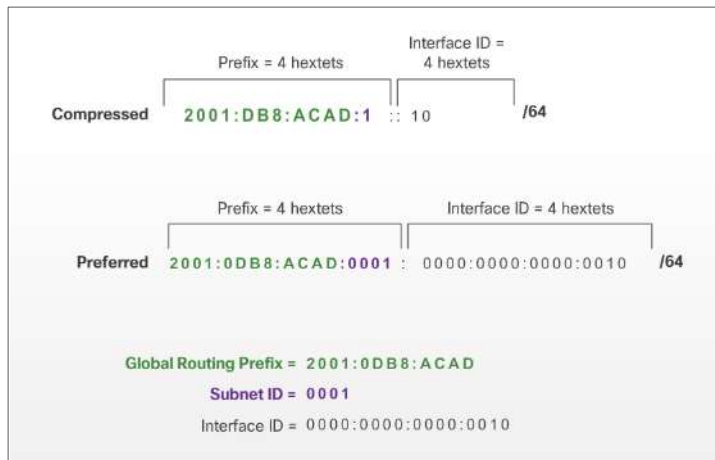
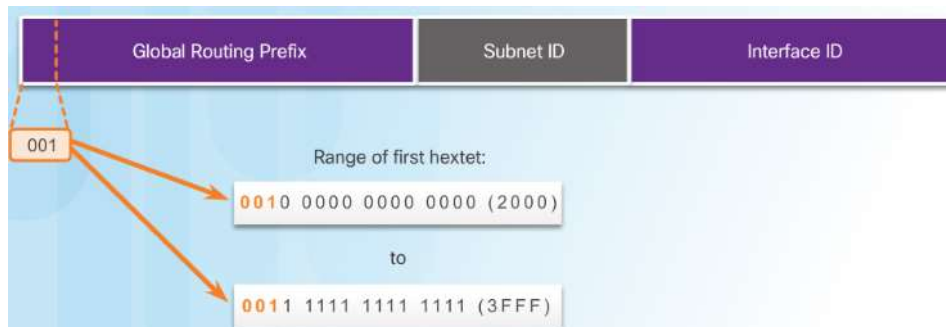
- IPv6 link-local addresses:
 - Enable a device to communicate with other IPv6-enabled devices on the same link only.
 - Are created even if the device has not been assigned a global unicast IPv6 address.
 - Are in the FE80::/10 range.

Note: Typically, it is the link-local address of the router that is used as the default gateway for other devices on the link.



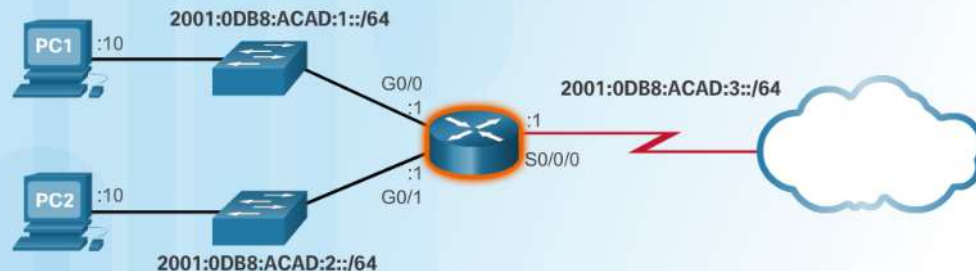
Structure of an IPv6 Global Unicast Address

- Currently, only global unicast addresses with the first three bits of 001 or 2000::/3 are being assigned
- A global unicast address has three parts:
 - **Global routing prefix** - network, portion of the address that is assigned by the provider. Typically /48.
 - **Subnet ID** – Used to subnet within an organization.
 - **Interface ID** - equivalent to the host portion of an IPv4 address.



Static Configuration of a Global Unicast Address

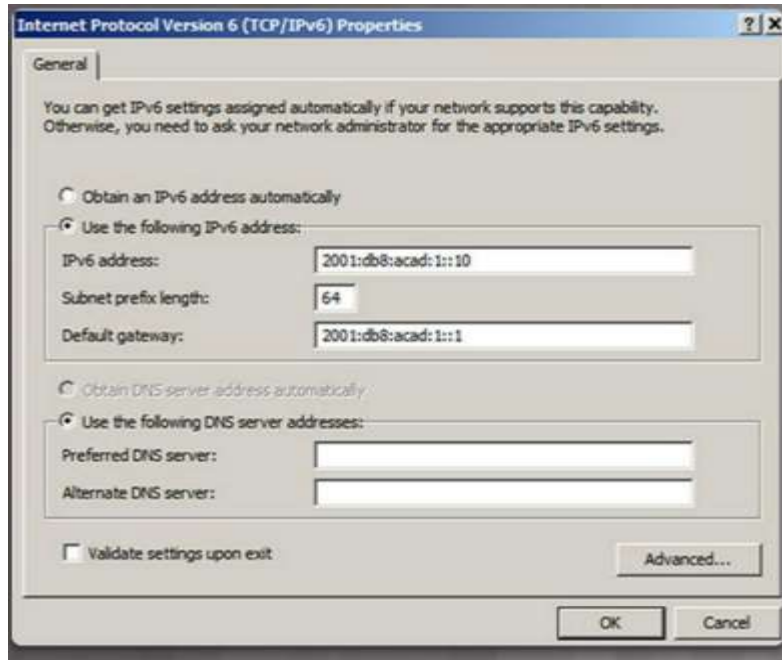
Configuring IPv6 on a Router



```
R1(config)# interface gigabitethernet 0/0
R1(config-if)# ipv6 address 2001:db8:acad:1::1/64
R1(config-if)# no shutdown
R1(config-if)# exit
R1(config)# interface gigabitethernet 0/1
R1(config-if)# ipv6 address 2001:db8:acad:2::1/64
R1(config-if)# no shutdown
R1(config-if)# exit
R1(config)# interface serial 0/0/0
R1(config-if)# ipv6 address 2001:db8:acad:3::1/64
R1(config-if)# clock rate 56000
R1(config-if)# no shutdown
```

- Router Configuration:
 - Similar commands to IPv4, replace IPv4 with IPv6
 - Command to configure and IPv6 global unicast on an interface is **ipv6 address ipv6-address/prefix-length**

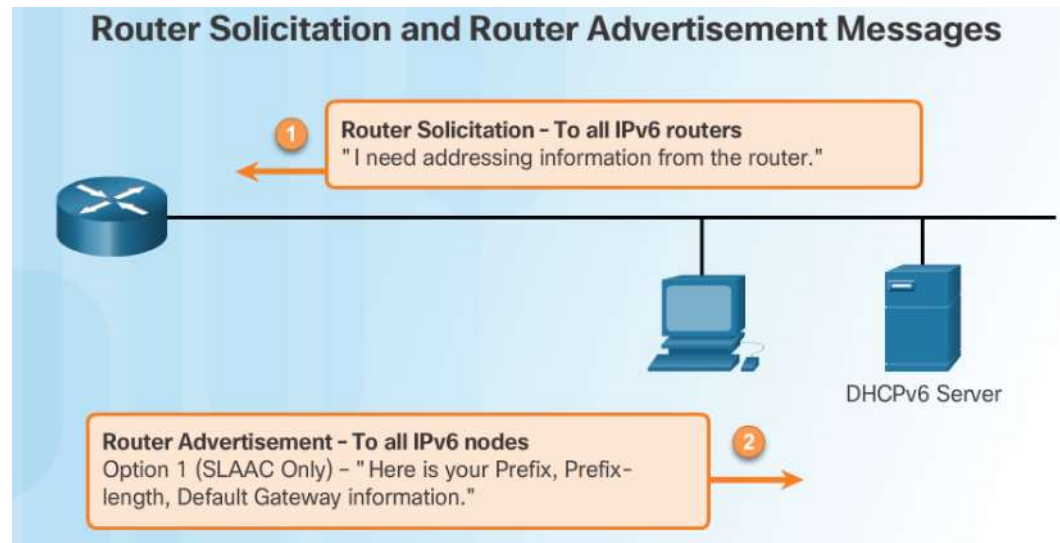
Static Configuration of a Global Unicast Address (Cont.)



- Host Configuration:
 - Manually configuring the IPv6 address on a host is similar to configuring an IPv4 address
 - Default gateway address can be configured to match the link-local or global unicast address of the Gigabit Ethernet interface.
- Dynamic assignment of IPv6 addresses:
 - Stateless Address Autoconfiguration (SLAAC)
 - Stateful DHCPv6

Dynamic Configuration - SLAAC

- **Stateless Address Autoconfiguration (SLAAC):**
 - A device can obtain its prefix, prefix length, default gateway address, and other information from an IPv6 router.
 - Uses the local router's ICMPv6 Router Advertisement (RA) messages
- ICMPv6 RA messages sent every 200 seconds to all IPv6-enabled devices on the network.



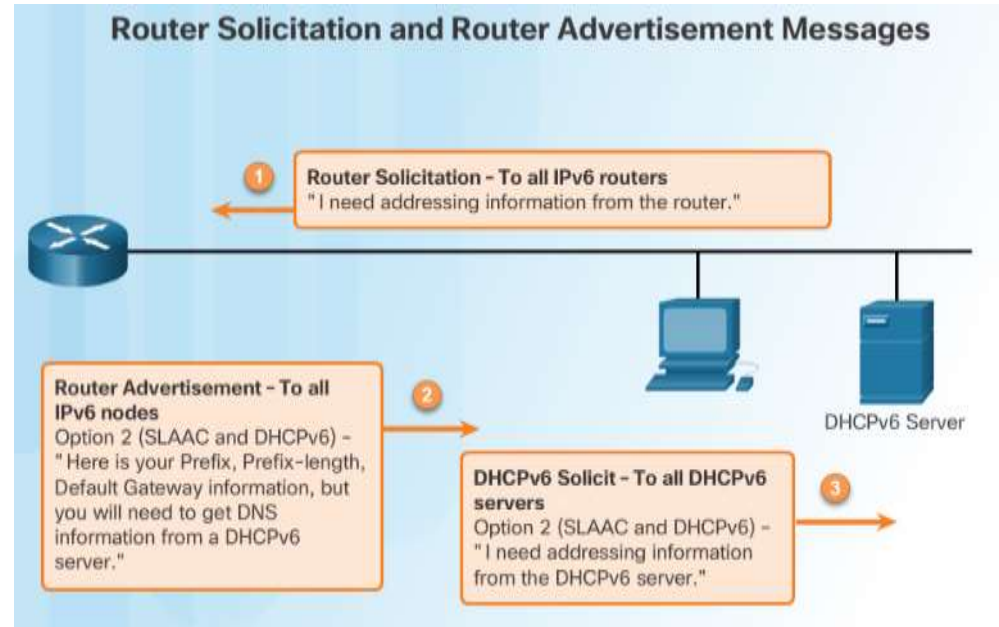
Option 1 (SLAAC Only) – "I'm everything you need (Prefix, Prefix-length, Default Gateway)"

Option 2 (SLAAC and DHCPv6) – "Here is my information but you need to get other information such as DNS addresses from a DHCPv6 server."

Option 3 (DHCPv6 Only) – "I can't help you. Ask a DHCPv6 server for all your information."

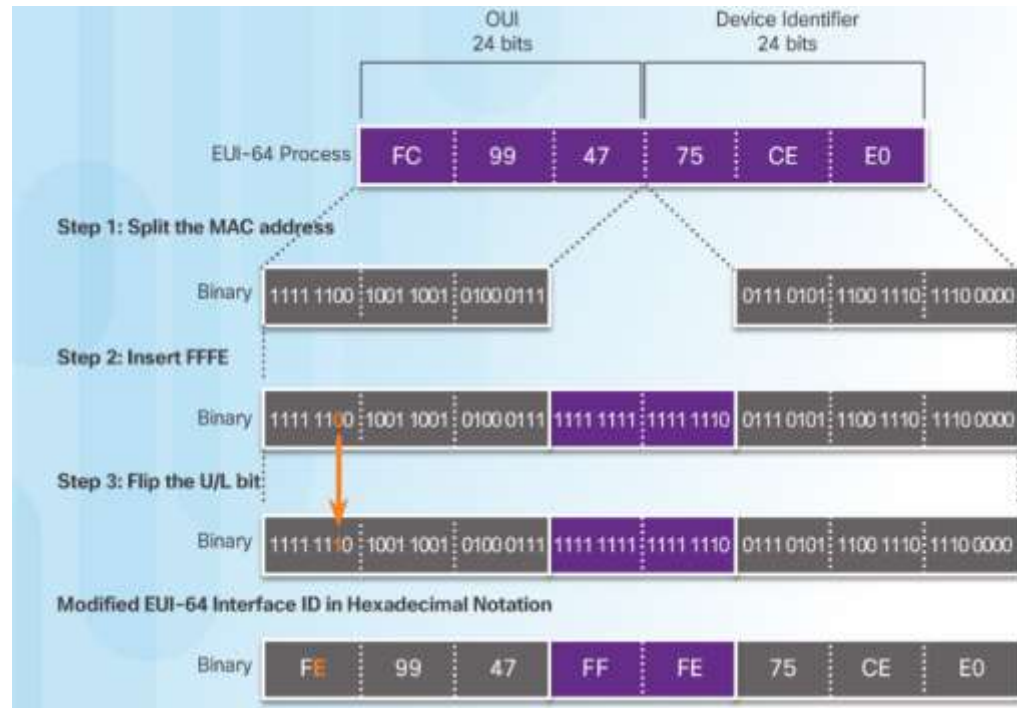
Dynamic Configuration – DHCPv6

- The RA Option 1: SLAAC only (this is the default)
- RA Option 2: SLAAC and Stateless DHCPv6:
 - Uses SLAAC for IPv6 global unicast address and default gateway.
 - Uses a stateless DHCPv6 server for other information.
- RA Option 3: Stateful DHCPv6
 - Uses the Routers link-local address for the default gateway.
 - Uses DHCPv6 for all other information.



EUI-64 Process and Randomly Generated

- When the RA message is SLAAC or SLAAC with stateless DHCPv6, the client must generate its own Interface ID
 - The Interface ID can be created using the EUI-64 process or a randomly generated 64-bit number
- An EUI-64 Interface ID is represented in binary and is made up of three parts:
 - 24-bit OUI from the client MAC address, but the 7th bit (the Universally/Locally (U/L) bit) is reversed.
 - The inserted 16-bit value FFFE (in hexadecimal).
 - 24-bit Device Identifier from the client MAC address.



EUI-64 Process and Randomly Generated (Cont.)

- Randomly Generated Interface IDs
 - Windows uses a randomly generated Interface ID

```
PCB> ipconfig
Windows IP Configuration
Ethernet adapter Local Area Connection:
    Connection-specific DNS Suffix  : 
    IPv6 Address. . . . . : 2001:db8:acad:1:50a5:8a35:a5bb:66e1
    Link-local IPv6 Address . . . . : fe80::50a5:8a35:a5bb:66e1
    Default Gateway . . . . . : fe80::1
```

Dynamic Link-Local Addresses

- Link-local address can be established dynamically or configured manually.
- Cisco IOS routers use EUI-64 to generate the Interface ID for all link-local address on IPv6 interfaces.
- Drawback to using the dynamically assigned link-local address is the long interface ID, therefore they are often configured statically.

```
R1# show interface gigabitethernet 0/0
GigabitEthernet0/0 is up, line protocol is up
  Hardware is CN Gigabit Ethernet, address is fc99.4775.c3e0
(bia fc99.4775.c3e0)
<Output Omitted>

R1# show ipv6 interface brief
GigabitEthernet0/0    [up/up]
  FE80::FE99:477F:FE75:C3E0
  2001:DB8:ACAD:1::1
GigabitEthernet0/1    [up/up]
  FE80::FE99:477F:FE75:C3E1
  2001:DB8:ACAD:2::1
Serial0/0/0           [up/up]
  FE80::FE99:477F:FE75:C3E0
  2001:DB8:ACAD:3::1
Serial0/0/1           [administratively down/down]
  unassigned
R1#
```



Link-local Addresses Using EUI-64

Static Link-Local Addresses

- Manual Configuration of the link-local address allows the creation of a simple, easy to remember address.

```
Router(config-if) #  
  
ipv6 address link-local-address link-local  
  
R1(config) # interface gigabitethernet 0/0  
R1(config-if) # ipv6 address fe80::1 ?  
link-local Use link-local address  
  
R1(config-if) # ipv6 address fe80::1 link-local  
R1(config-if) # exit  
R1(config) # interface gigabitethernet 0/1  
R1(config-if) # ipv6 address fe80::1 link-local  
R1(config-if) # exit  
R1(config) # interface serial 0/0/0  
R1(config-if) # ipv6 address fe80::1 link-local  
R1(config-if) #
```

Verifying IPv6 Address Configuration

- The commands to verify IPv6 configuration are similar to IPv4
 - show ipv6 interface brief
 - show ipv6 route
- The ping command for IPv6 is identical to the command used with IPv4, except that an IPv6 address is used.

```
R1# show ipv6 interface brief
GigabitEthernet0/0    [up/up]
 FE80::FE99:47FF:FE75:C3E0
 2001:DB8:ACAD:1::1
GigabitEthernet0/1    [up/up]
 FE80::FE99:47FF:FE75:C3E1
 2001:DB8:ACAD:2::1
Serial0/0/0           [up/up]
 FE80::FE99:47FF:FE75:C3E0
 2001:DB8:ACAD:3::1
Serial0/0/1           [administratively down/down]
 unassigned
R1#
```

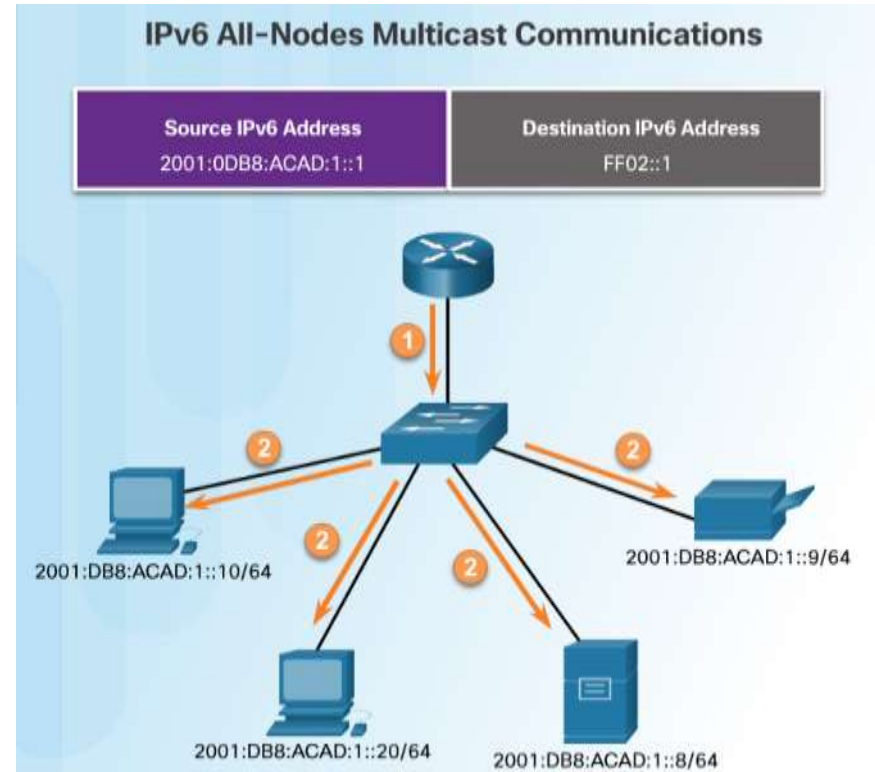
```
R1# show ipv6 route
IPv6 Routing Table - default - 7 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static

C 2001:DB8:ACAD:1::/64 [0/0]
   via GigabitEthernet0/0, directly connected
L 2001:DB8:ACAD:1::1/128 [0/0]
   via GigabitEthernet0/0, receive
C 2001:DB8:ACAD:2::/64 [0/0]
   via GigabitEthernet0/1, directly connected
L 2001:DB8:ACAD:2::1/128 [0/0]
   via GigabitEthernet0/1, receive
C 2001:DB8:ACAD:3::/64 [0/0]
   via Serial0/0/0, directly connected
L 2001:DB8:ACAD:3::1/128 [0/0]
   via Serial0/0/0, receive
L FF00::/8 [0/0]
   via Null0, receive
R1#
```

```
R1# ping 2001:db8:acad:1::10
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:1::10, timeout
is 2 seconds:
!!!!
Success rate is 100 percent (5/5)
R1#
```

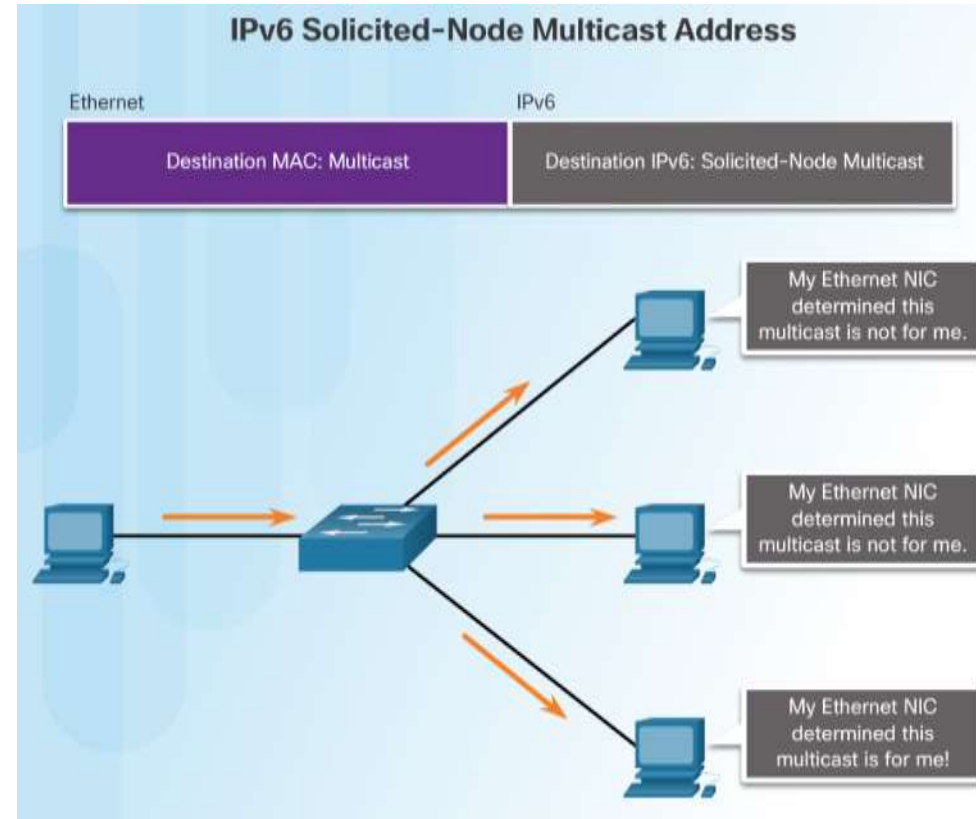
Assigned IPv6 Multicast Addresses

- There are two types of IPv6 multicast addresses:
 - Assigned multicast - reserved multicast addresses for predefined groups of devices
 - Solicited node multicast
- Two common IPv6 assigned multicast groups:
 - FF02::1 All-nodes multicast group – This is a multicast group that all IPv6-enabled devices join. Similar to a broadcast in IPv4
 - FF02::2 All-routers multicast group – This is a multicast group that all IPv6 routers join.



Solicited-Node IPv6 Multicast Addresses

- Solicited-node multicast address:
 - Mapped to .a special Ethernet multicast address
 - Allows Ethernet NIC to filter frame on destination MAC.

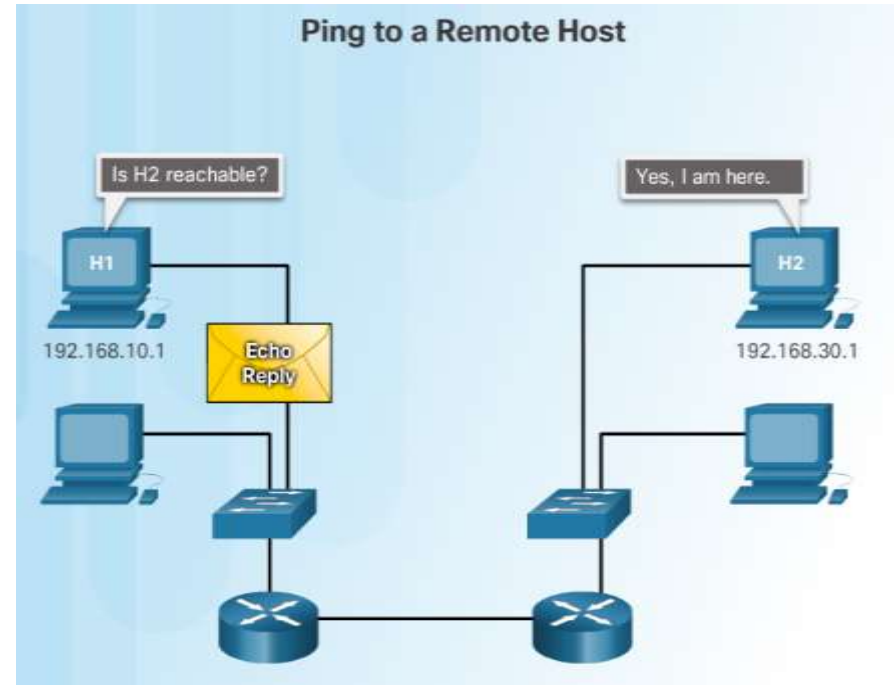


7.3 Connectivity Verification

ICMP

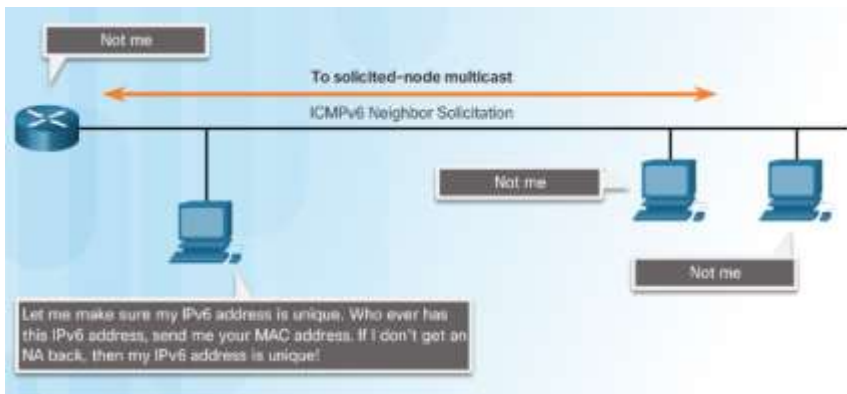
ICMPv4 and ICMPv6

- ICMPv4 is the messaging protocol for IPv4. ICMPv6 provides the same services for IPv6
- ICMP messages common to both include:
 - Host confirmation
 - Destination or Service Unreachable
 - Time exceeded
 - Route redirection



ICMPv6 Router Solicitation and Router Advertisement Messages

- ICMPv6 includes four new protocols as part of the Neighbor Discovery Protocol (ND or NDP)
 - Router Solicitation (RS) message
 - Router Advertisement (RA) message
- RA messages used to provide addressing information to hosts
 - Neighbor Solicitation (NS) message
 - Neighbor Advertisement (NA) message
- Neighbor Solicitation and Neighbor Advertisement messages are used for Address resolution and Duplicate Address Detection (DAD).



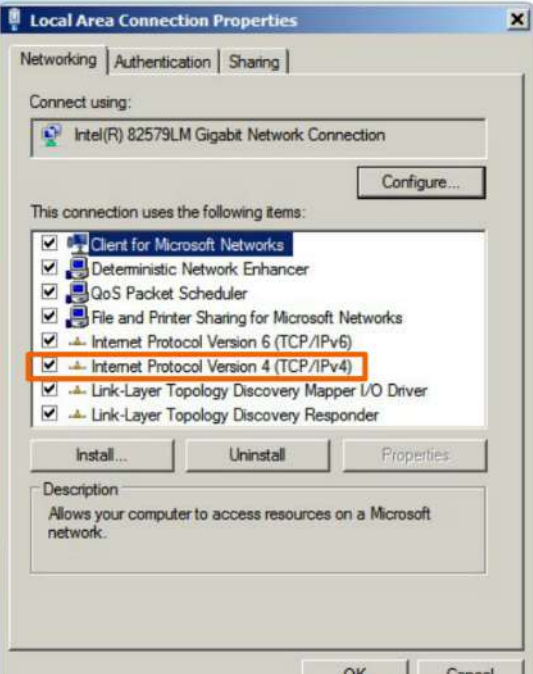
Ping - Testing the Local Stack

Testing Local TCP/IP Stack

Pinging the local host confirms that TCP/IP is installed and working on the local host.

```
C:\>ping 127.0.0.1
```

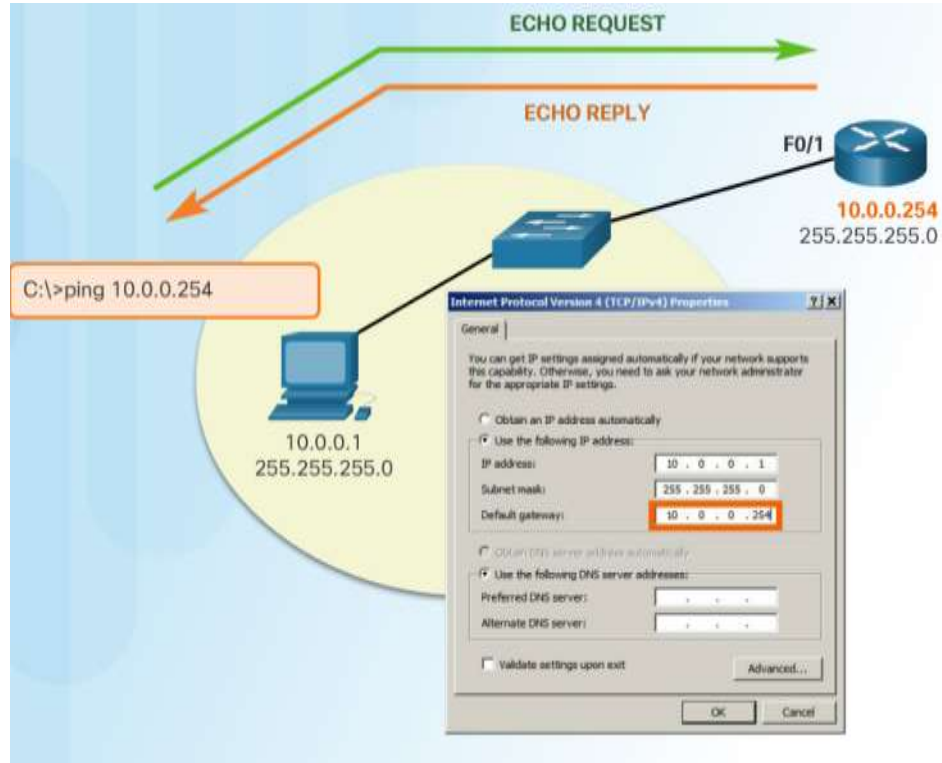
Pinging **127.0.0.1** causes a device to ping itself.



The screenshot shows the 'Local Area Connection Properties' window. The 'Networking' tab is selected. Under 'Connect using:', 'Intel(R) 82579LM Gigabit Network Connection' is listed. Below, 'This connection uses the following items:' lists several components with checkboxes. 'Internet Protocol Version 4 (TCP/IPv4)' is checked and highlighted with an orange box. Other checked items include 'Client for Microsoft Networks', 'Deterministic Network Enhancer', 'QoS Packet Scheduler', 'File and Printer Sharing for Microsoft Networks', 'Internet Protocol Version 6 (TCP/IPv6)', and 'Link-Layer Topology Discovery Mapper I/O Driver' and 'Link-Layer Topology Discovery Responder'. Buttons for 'Install...', 'Uninstall', and 'Properties' are at the bottom.

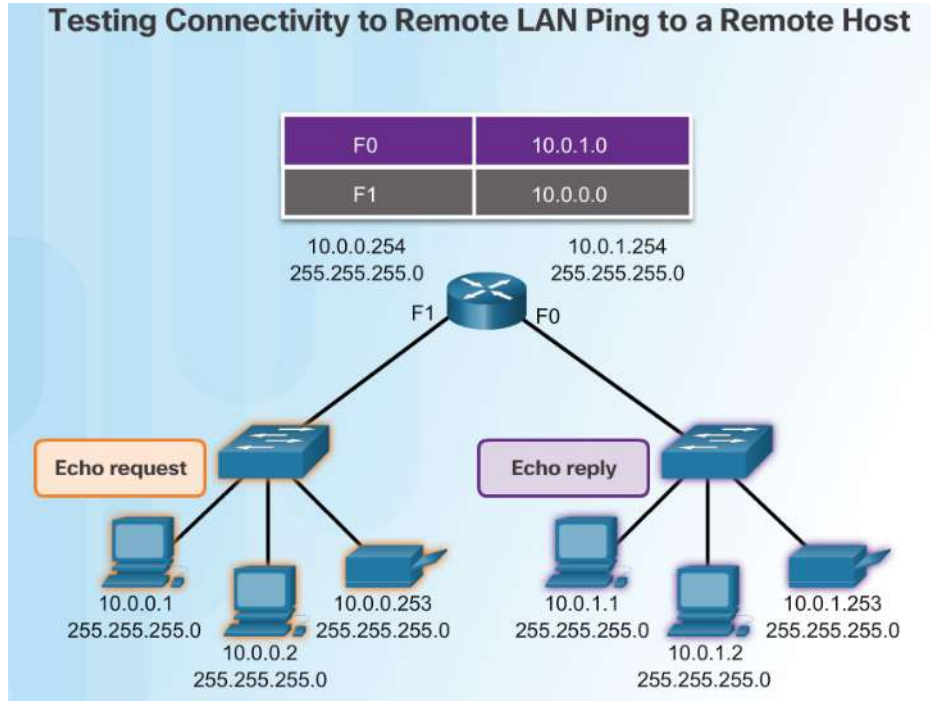
- Ping the local loopback address of 127.0.0.1 for IPv4 or ::1 for IPv6 to verify that IP is properly installed on the host.

Ping – Testing Connectivity to the Local LAN



- Use ping to test the ability of a host to communicate on the local network.

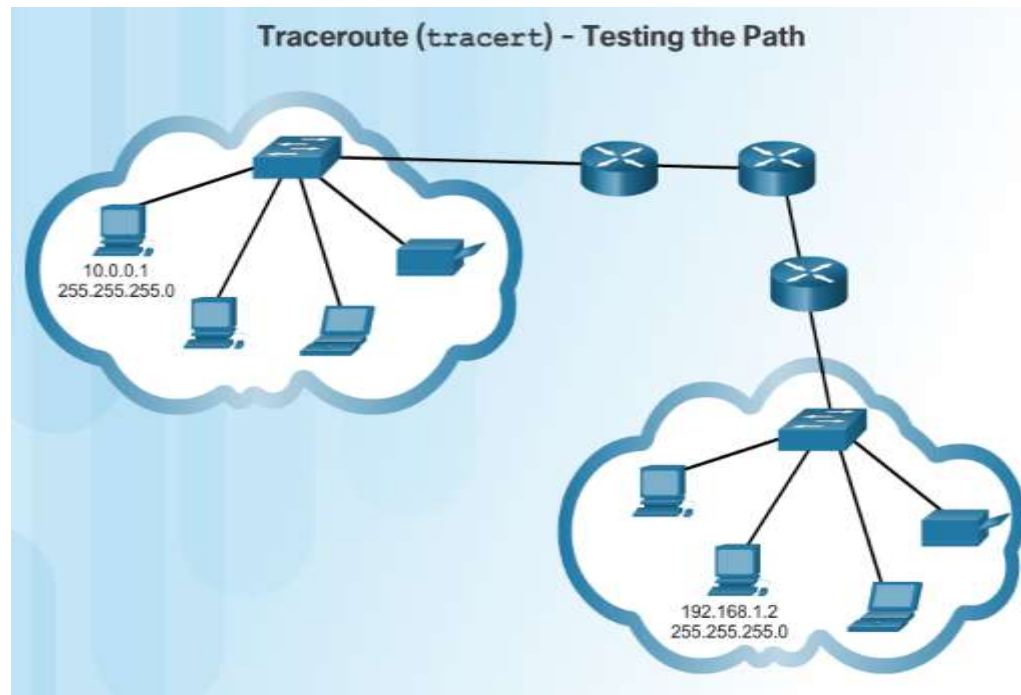
Ping – Testing Connectivity to a Remote Host



- Use ping to test the ability of a host to communicate across an internetwork.

Traceroute – Testing the Path

- Traceroute (tracert) is a utility that generates a list of hops that were successfully reached along the path.
- Round Trip Time (RTT) – Time it takes the packet to reach the remote host and for the response from the host to return.
- Asterisk (*) is used to indicate a lost packet.



Summary