Chapter 7: IP Addressing

CCNA Routing and Switching

Introduction to Networks v6.0

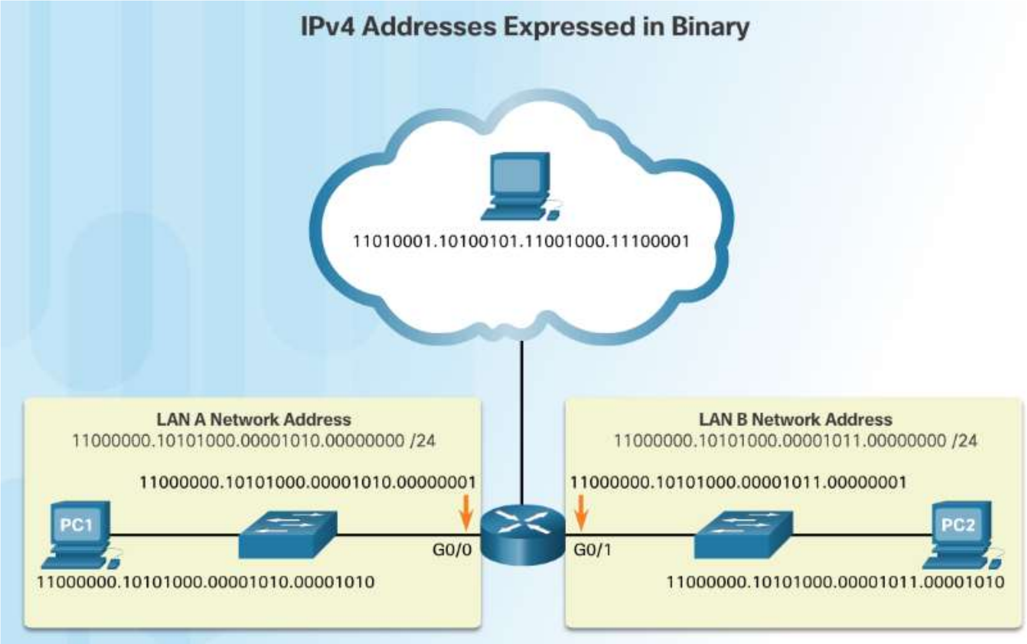
Chapter 7 - Sections & Objectives

- 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.

7.1 IPv4 Network Addresses

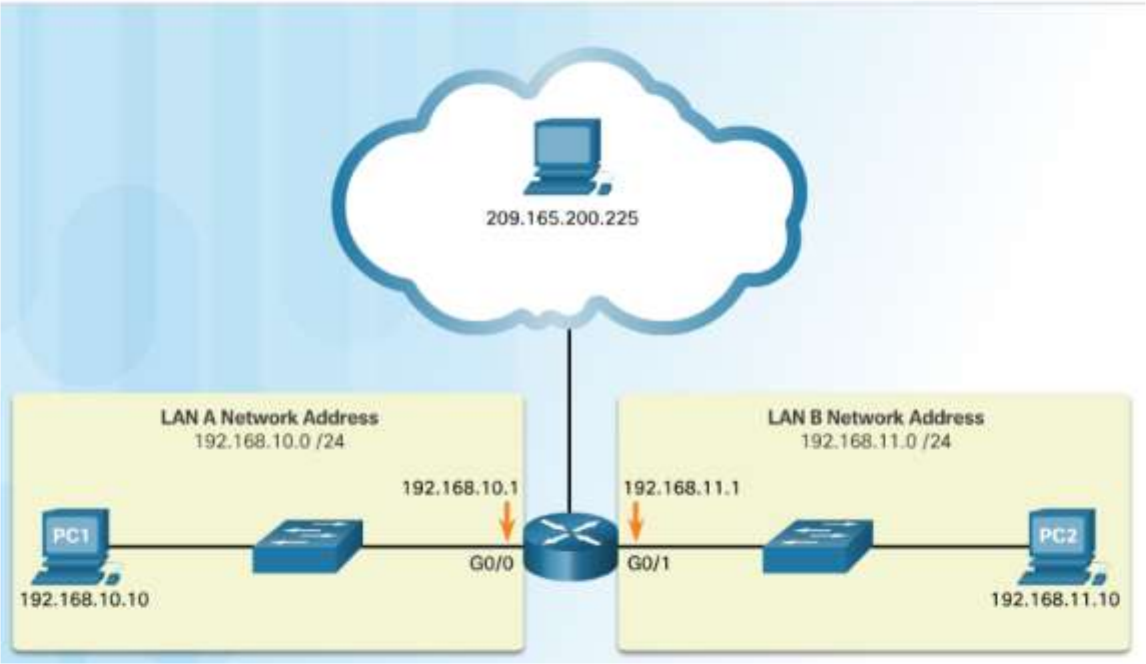
IPv4 Addresses

- 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



IPv4 Addresses (Cont.)

- IPv4 addresses are commonly expressed in dotted decimal notation



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 x 1000	2 x 100	3 x 10	4 x 1
Add them up ...	1000	+ 200	+ 30	+ 4
Result	1,234			

Positional Notation (Cont.)

Binary Positional Notation

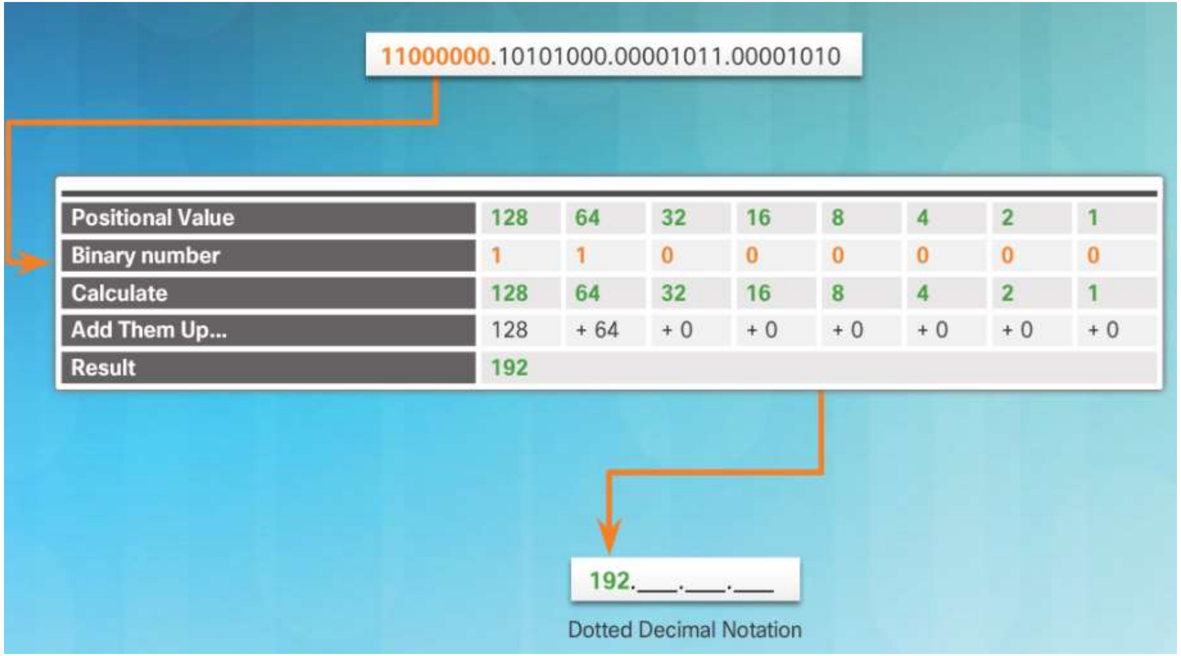
Radix	2	2	2	2	2	2	2	2
Position in Number	7	6	5	4	3	2	1	0
Calculate	(2^7)	(2^6)	(2^5)	(2^4)	(2^3)	(2^2)	(2^1)	(2^0)
Positional Value	128	64	32	16	8	4	2	1

- 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 to Decimal Conversion

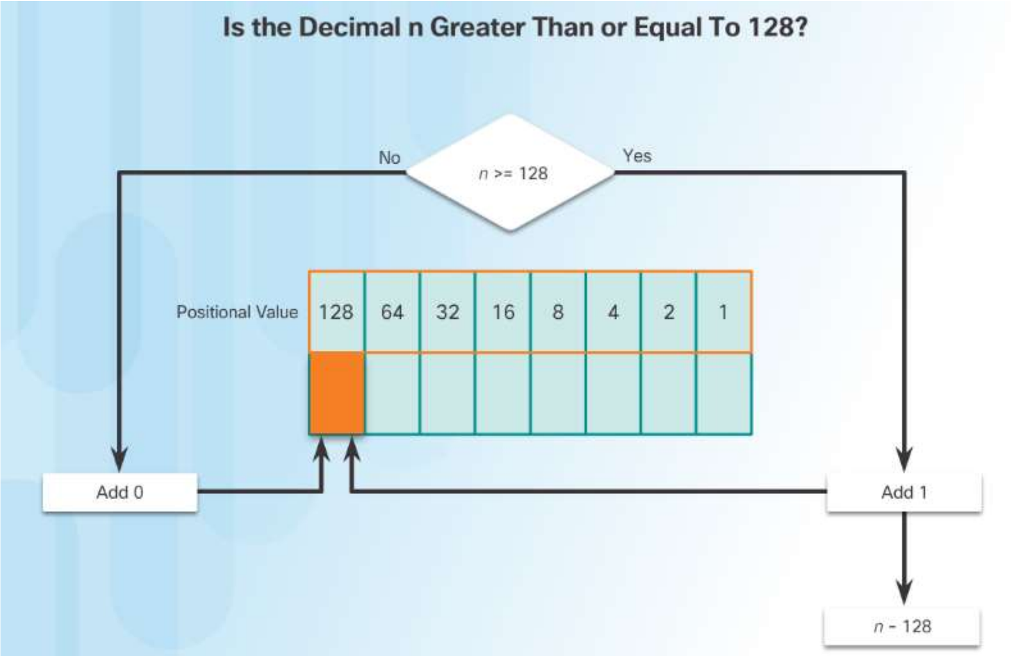
- To convert a binary IPv4 address to decimal enter the 8-bit binary number of each octet under the positional value of row 1 and then calculate to produce the decimal.



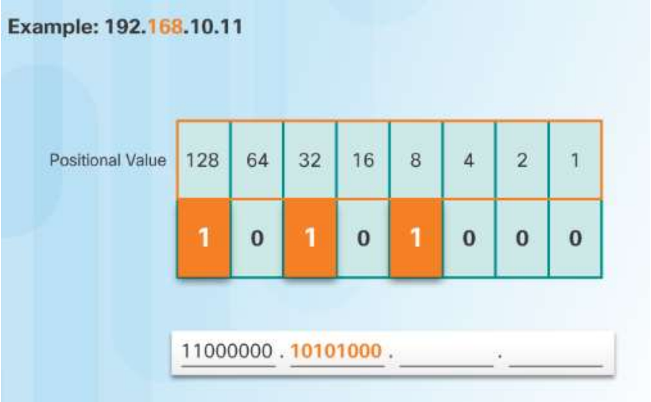
Positional Value	128	64	32	16	8	4	2	1
Binary number	1	1	0	0	0	0	0	0
Calculate	128	64	32	16	8	4	2	1
Add Them Up...	128	+ 64	+ 0	+ 0	+ 0	+ 0	+ 0	+ 0
Result	192							

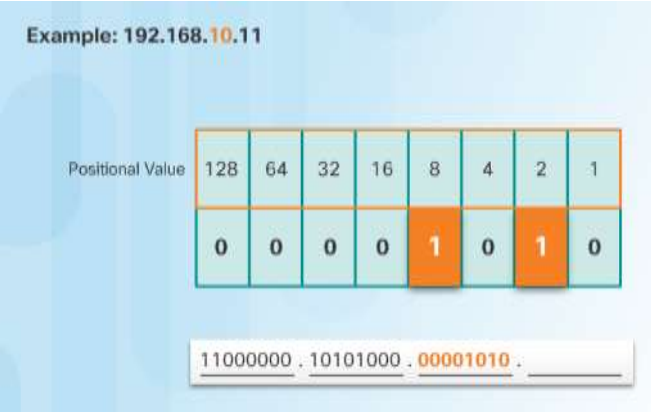
Decimal to Binary Conversion

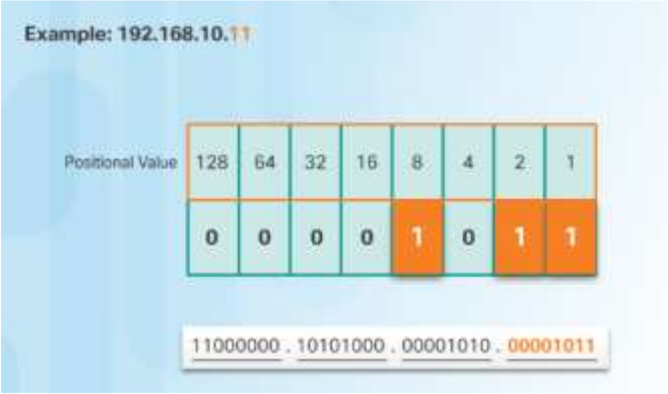
- To convert a decimal IPv4address to binary use the positional chart and check first if the number is greater than the 128 bit. If no a 0 is placed in this position. If yes then a 1 is placed in this position.
- 128 is subtracted from the original number and the remainder is then checked against the 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.



Decimal to Binary Conversion Examples

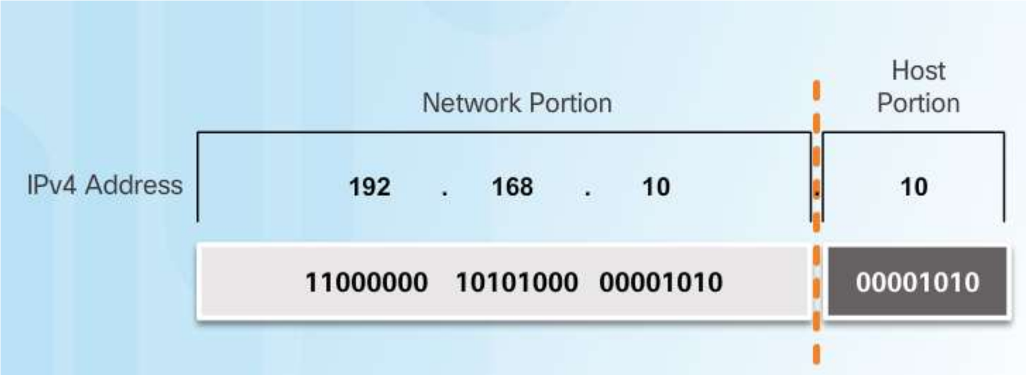






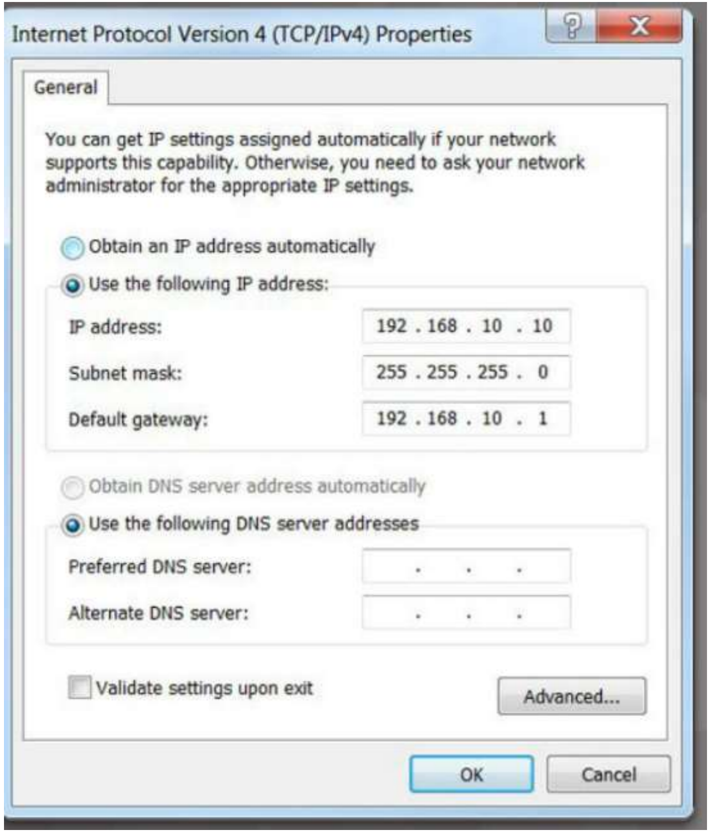
Network and Host Portions

- 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.



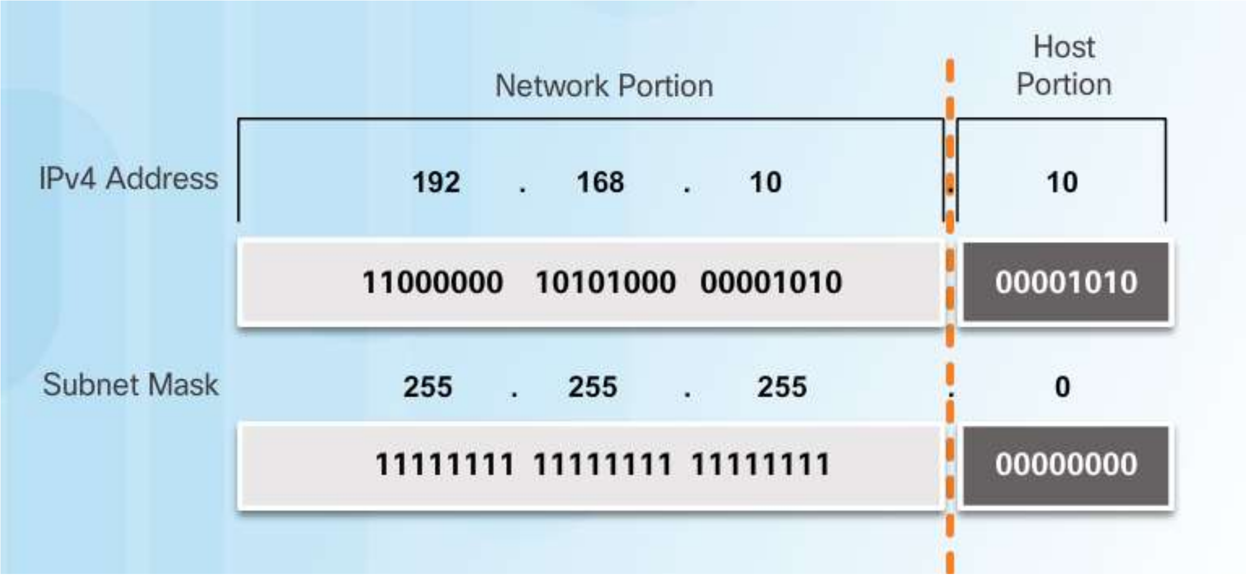
The Subnet Mask

- 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.



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

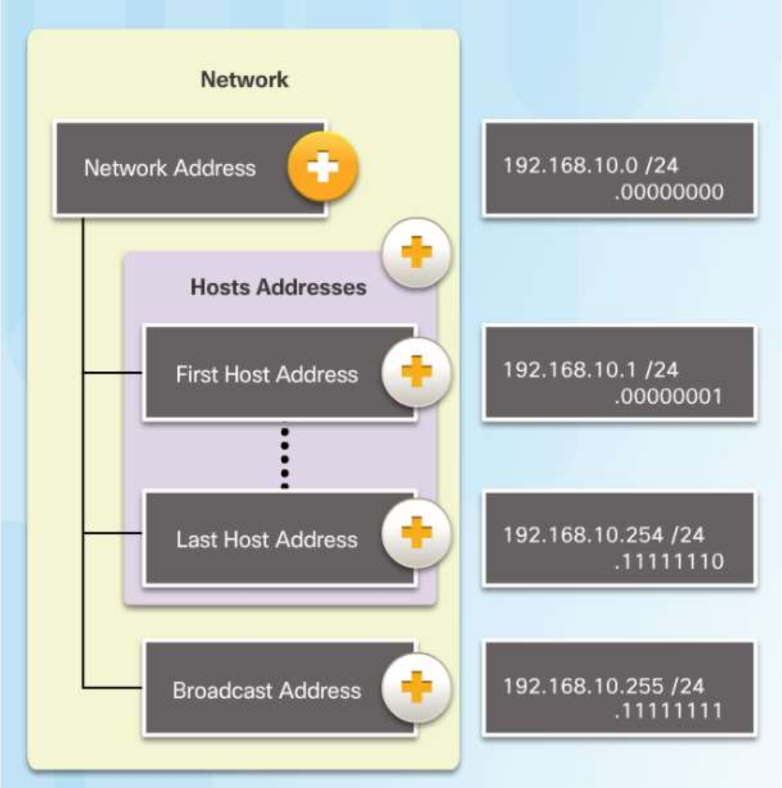
The Prefix Length

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

- The Prefix Length:
  - Shorthand method of expressing the subnet mask.
  - Equals the number of bits in the subnet mask set to 1.
  - Written in slash notation, / followed by the number of network bits.

Network, Host, and Broadcast Addresses

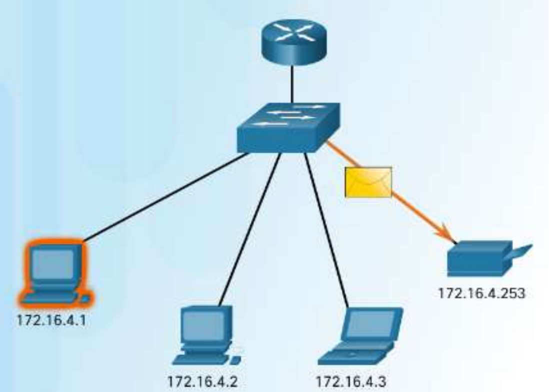


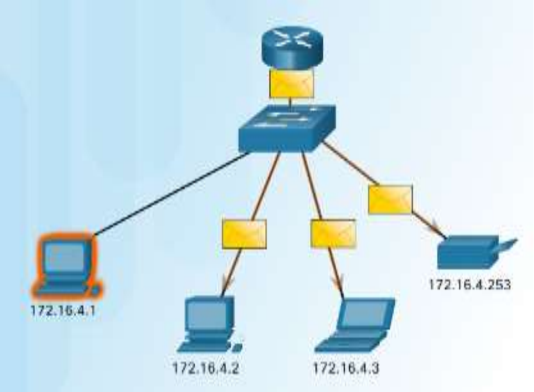
- Types of Addresses in Network 192.168.10.0/24
  - Network Address - host portion is all 0s (.00000000)
  - First Host address - host portion is all 0s and ends with a 1 (.00000001)
  - Last Host address - host portion is all 1s and ends with a 0 (.11111110)
  - Broadcast Address - host portion is all 1s (.11111111)

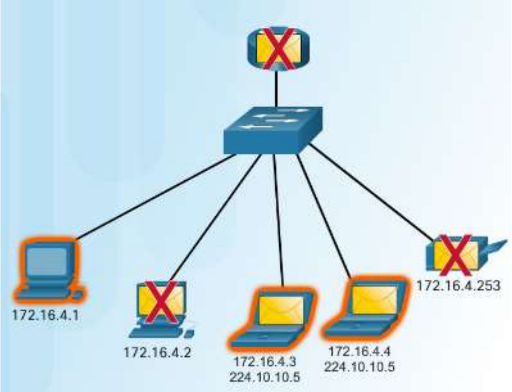
Dynamic IPv4 Address Assignment to a Host

- 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 Communication



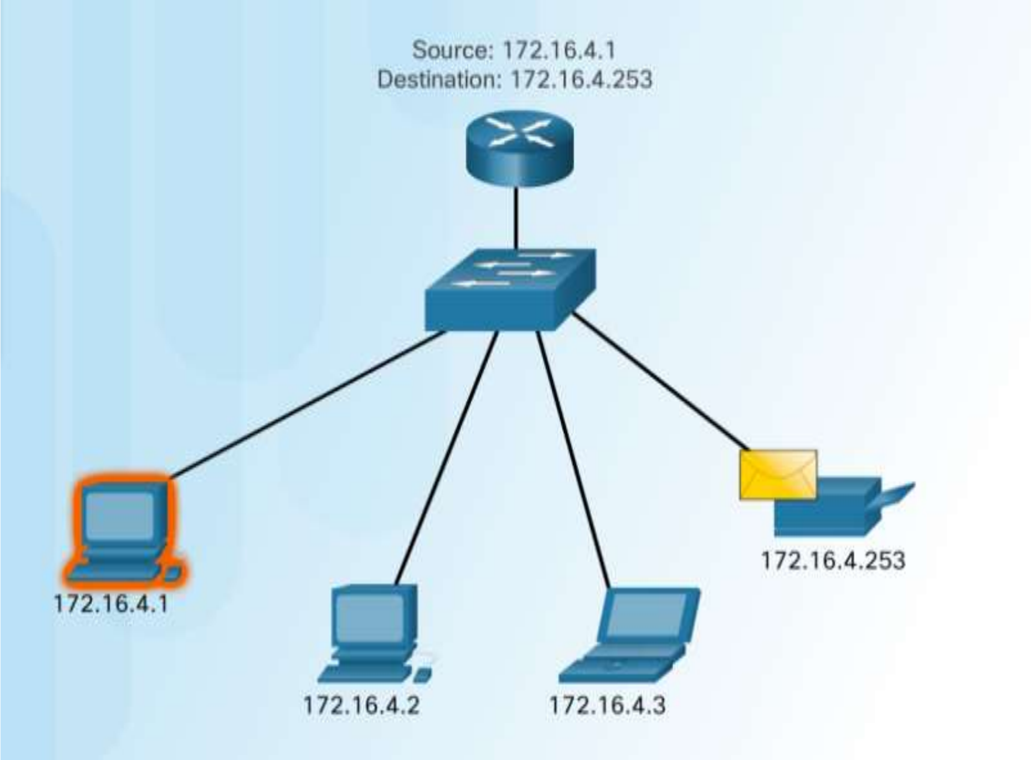




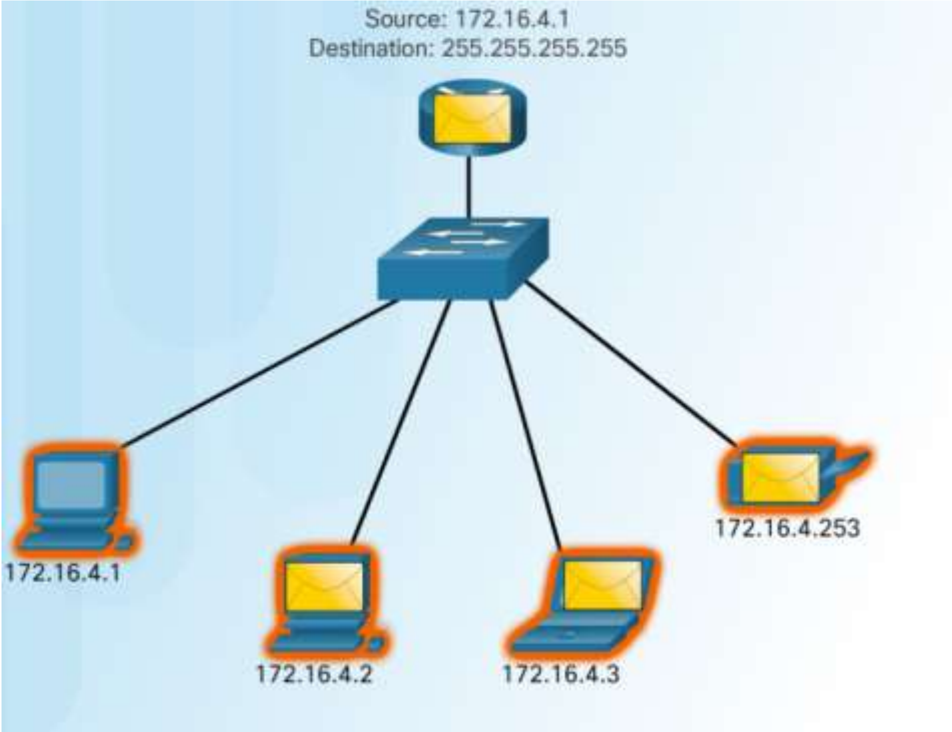
- Unicast – one to one communication.
- Broadcast– one to all.
- Multicast – one to a select group.

Unicast Transmission

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

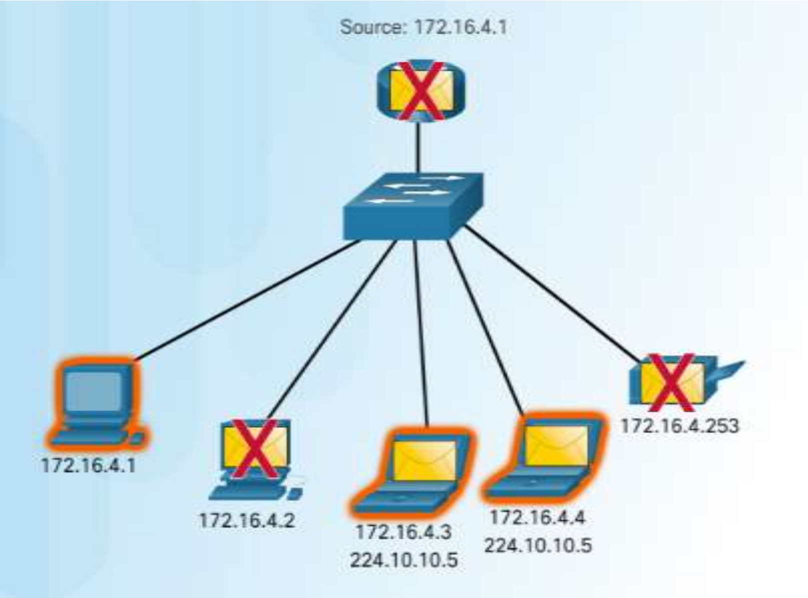


Broadcast Transmission



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

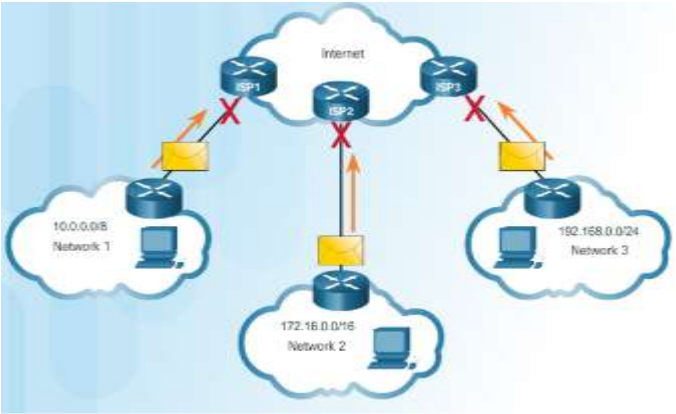
Multicast Transmission



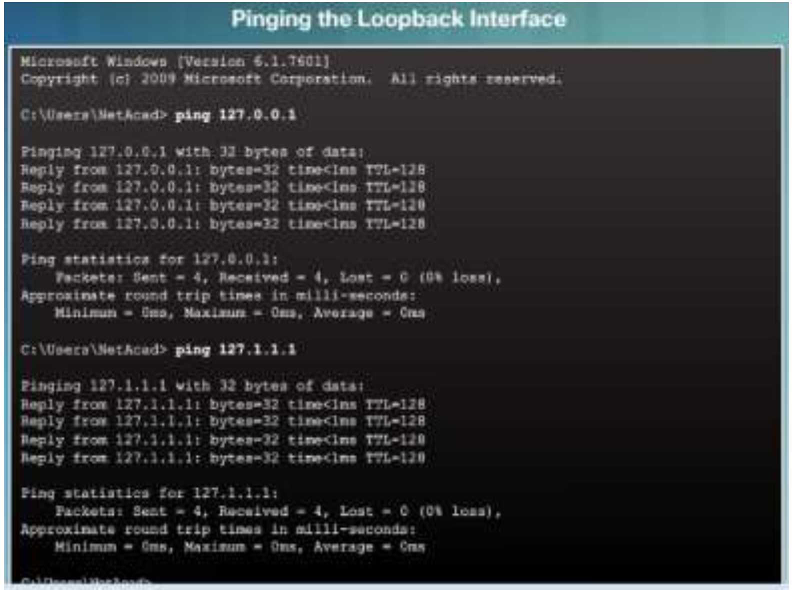
- Multicast– one to a select group.
  - 224.0.0.0 to 239.255.255.255 addresses reserved for multicast.
  - routing protocols use multicast transmission to exchange routing information.

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 172.31.255.255192.168.0.0 /16
  - 192.168.0.0 to 192.168.255.255



Special User IPv4 Addresses



- 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	0xxxxxxx.___.___.___

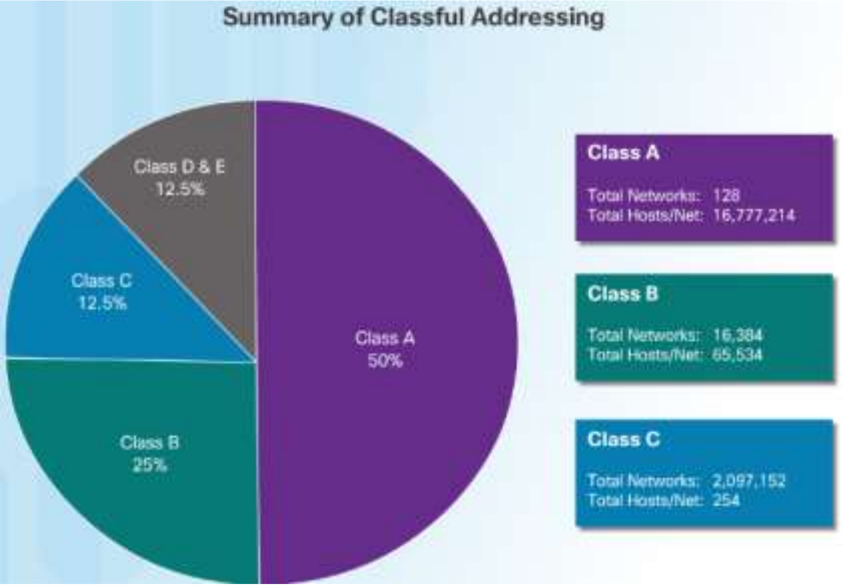
* 0.0.0.0 and 127.0.0.0 are reserved and cannot be assigned

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	10xxxxxx.___.___.___

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	110xxxxx.___.___.___

- 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



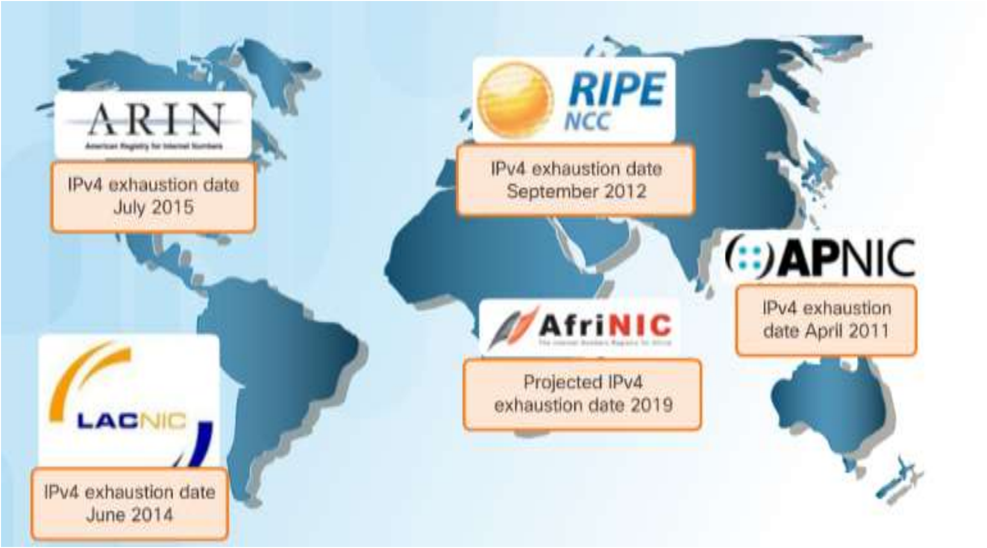
- Classful Addressing wasted addresses and exhausted the availability of IPv4 addresses.
- Classless Addressing Introduced in the 1990s
  - Classless Inter-Domain Routing (CIDR, pronounced “cider”)
  - Allowed service providers to allocate IPv4 addresses on any address bit boundary (prefix length) instead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

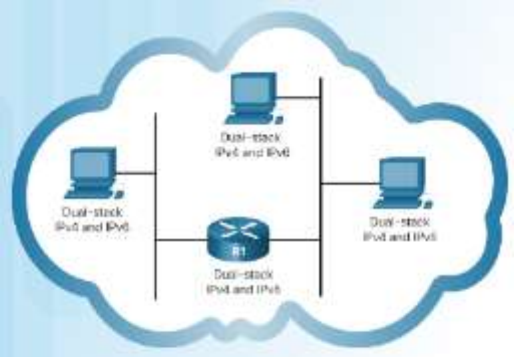
The Need for IPv6

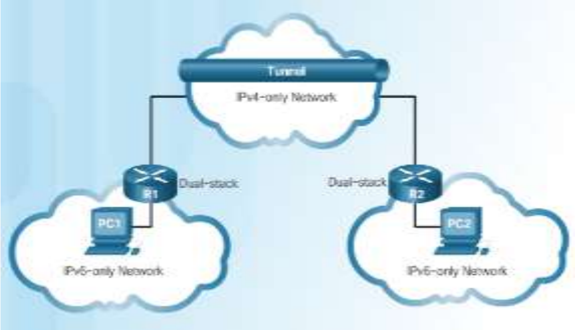


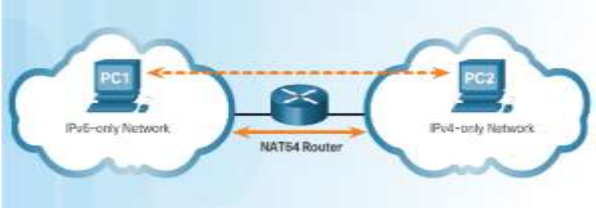
- IPv6 versus IPv4:
  - Has a larger 128-bit address space
  - 340 undecillion addresses
  - Solves limitations with IPv4
  - Adds enhancement like address auto-configuration.
- Why IPv6 is needed:
  - Rapidly increasing Internet population
  - Depletion of IPv4
  - Issues with NAT
  - Internet of Things

IPv4 and IPv6 Coexistence

- Migration from IPv4 to IPv6 Techniques







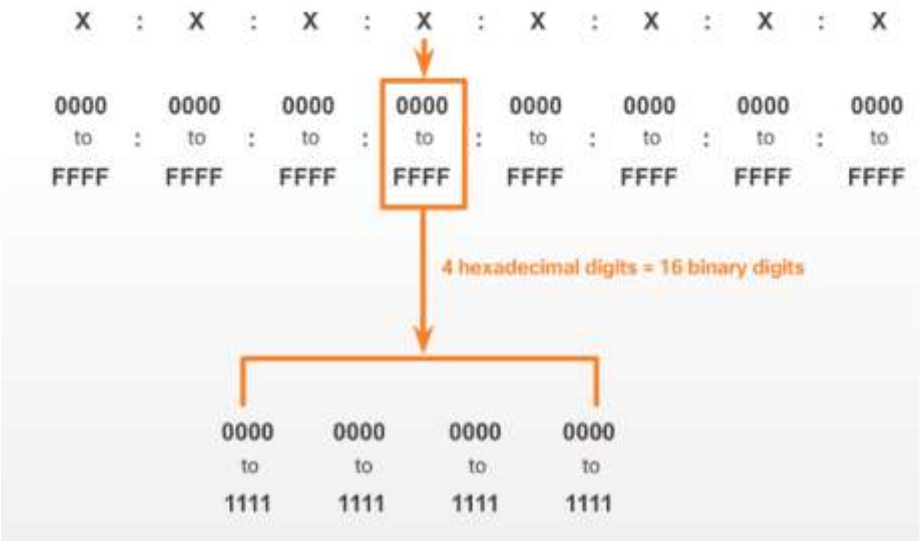
Dual stack - Devices run both IPv4 and IPv6 protocol stacks simultaneously.

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 (hextets) 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.)

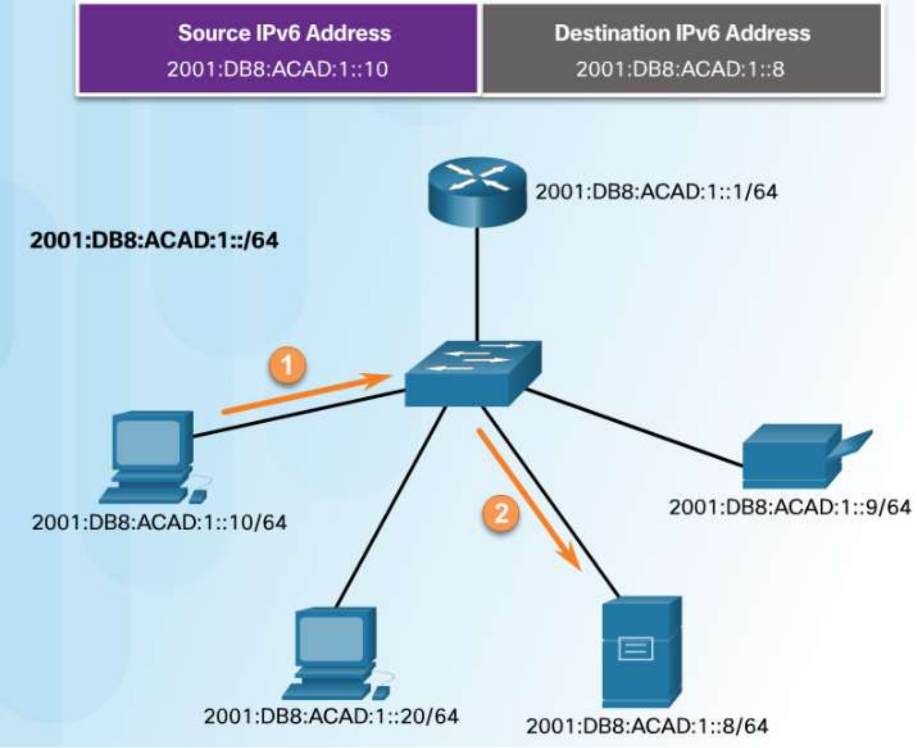
- Rule 2 – Omit All 0 Segments
  - A double colon (::) can replace any single, contiguous string of one or more 16-bit segments (hextets) consisting of all 0s.

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	::

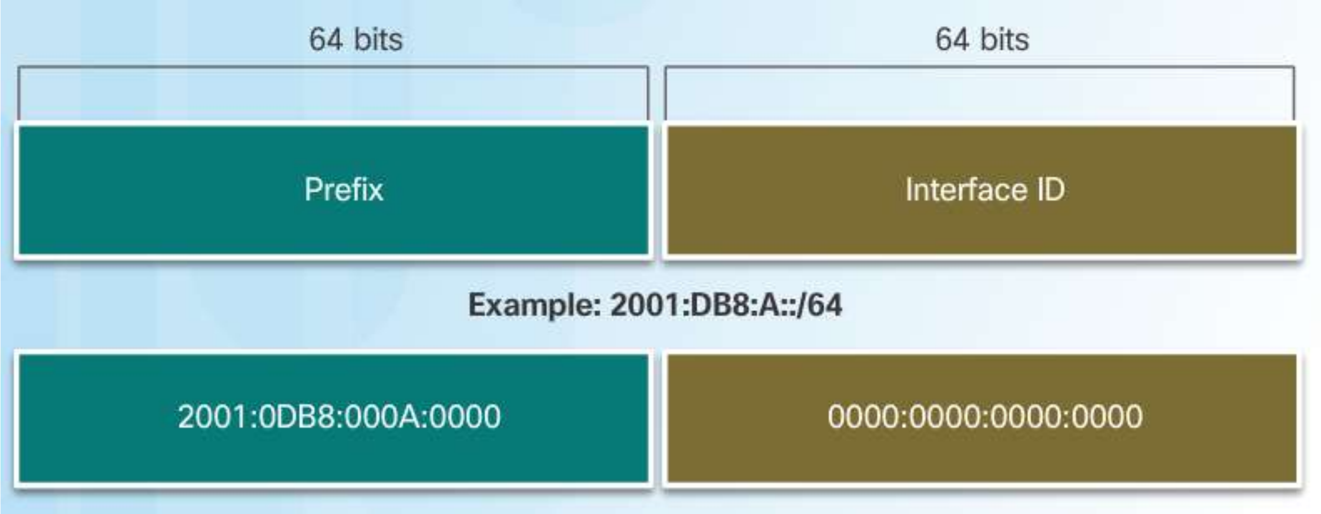
IPv6 Address Types

- 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.



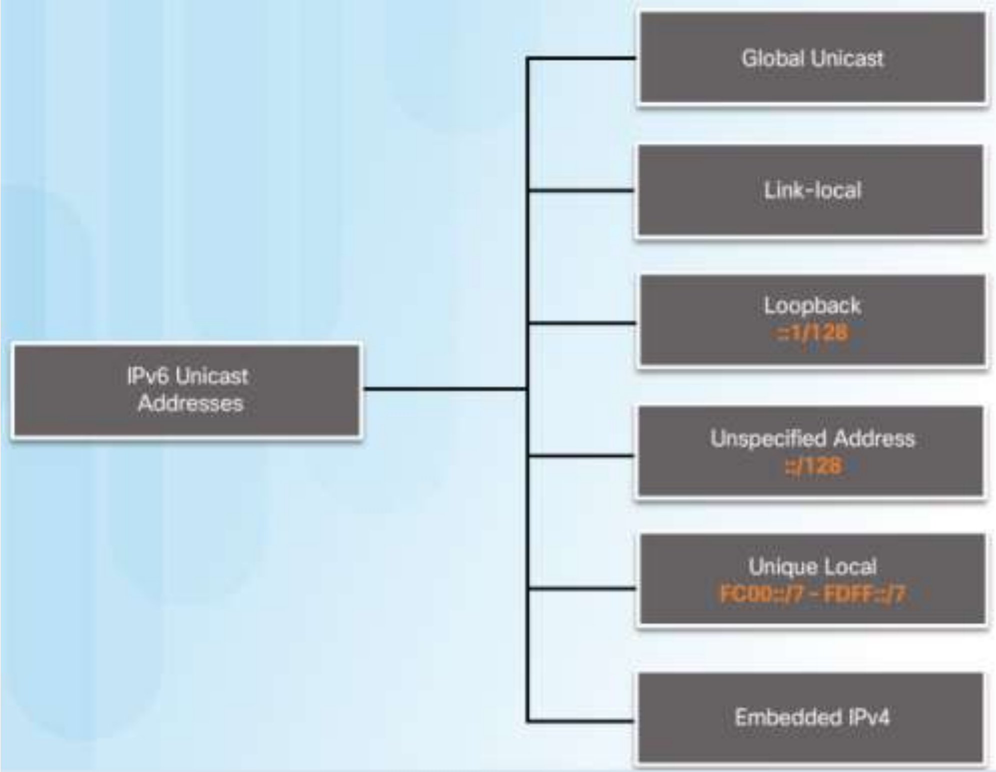
IPv6 Prefix Length

- 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

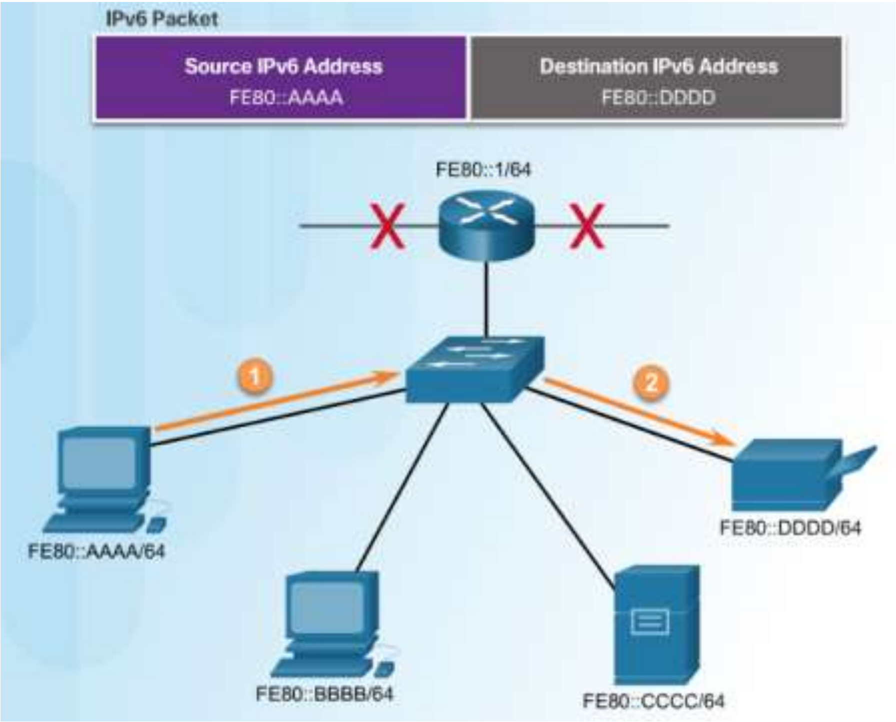
- **Global Unicast** - These are globally unique, Internet routable addresses.
- **Link-local** - used to communicate with other devices on the same local link. Confined to a single link.
- **Unique Local** - used for local addressing within a site or between a limited number of sites.



IPv6 Link-Local Unicast Addresses

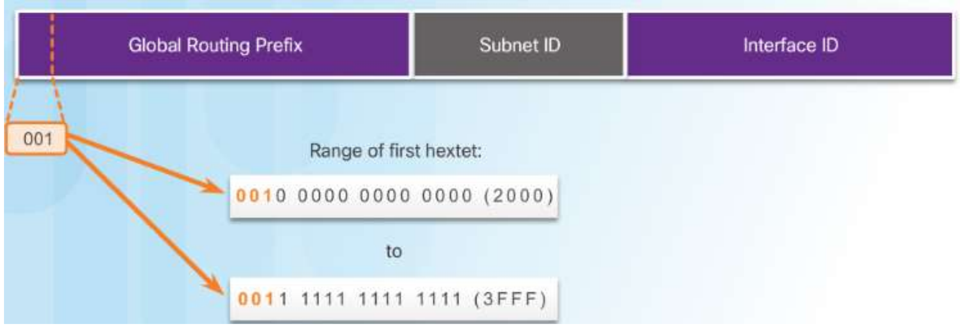
- IPv6 link-local addresses:
  - Enable a device to communicate with other IPv6-enabled devices on the same link only.
  - Are created even if the device has not been assigned a global unicast IPv6 address.
  - Are in the FE80::/10 range.

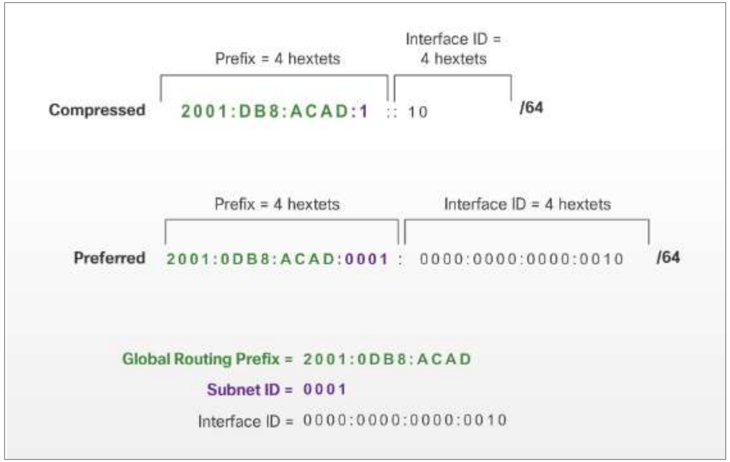
Note: Typically, it is the link-local address of the router that is used as the default gateway for other devices on the link.



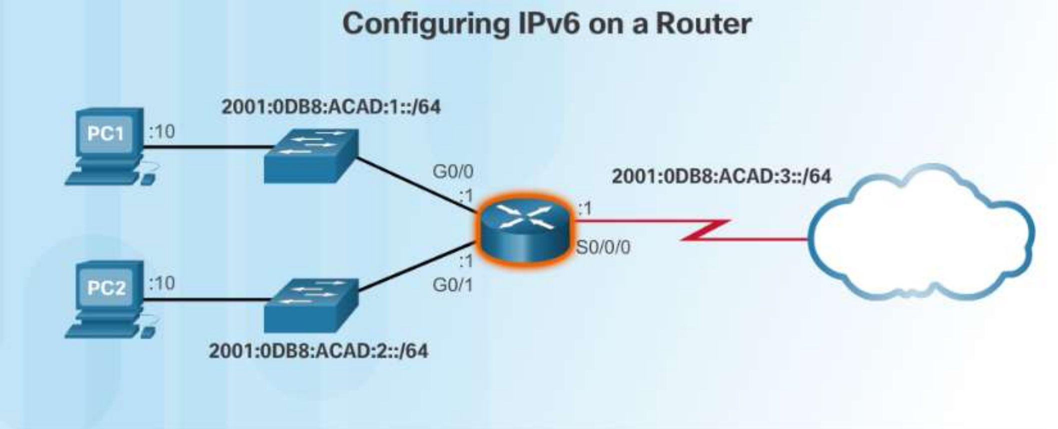
Structure of an IPv6 Global Unicast Address

- 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.





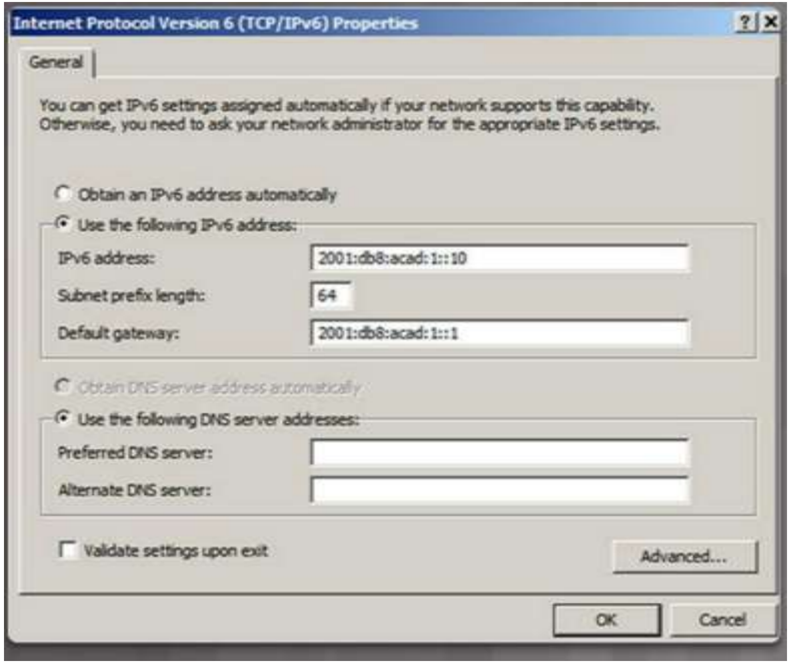
Static Configuration of a Global Unicast Address




```
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 andIPv6 global unicast on an interface is **ipv6 address** *ipv6-address/prefix-length*

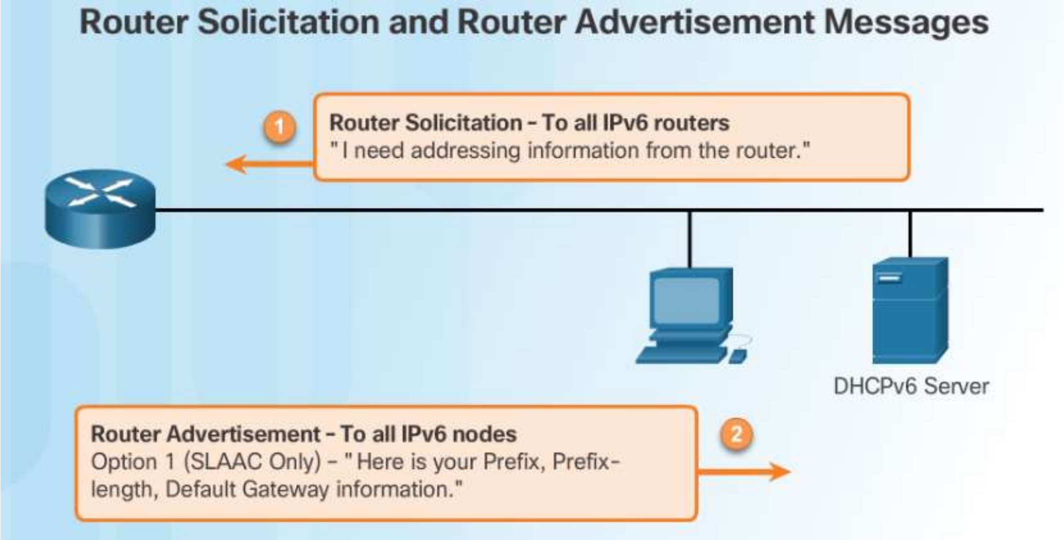
Static Configuration of a Global Unicast Address (Cont.)



- 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

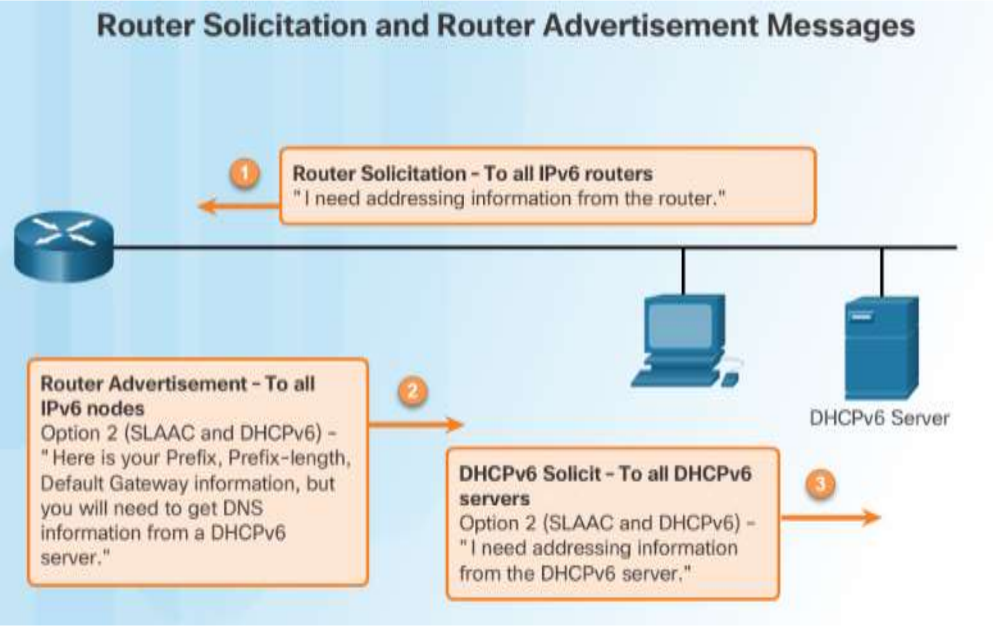
- Stateless Address Autoconfiguration (SLAAC):
  - A device can obtain its prefix, prefix length, default gateway address, and other information from an IPv6 router.
  - Uses the local router's ICMPv6 Router Advertisement (RA) messages
- ICMPv6 RA messages sent every 200 seconds to all IPv6-enabled devices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

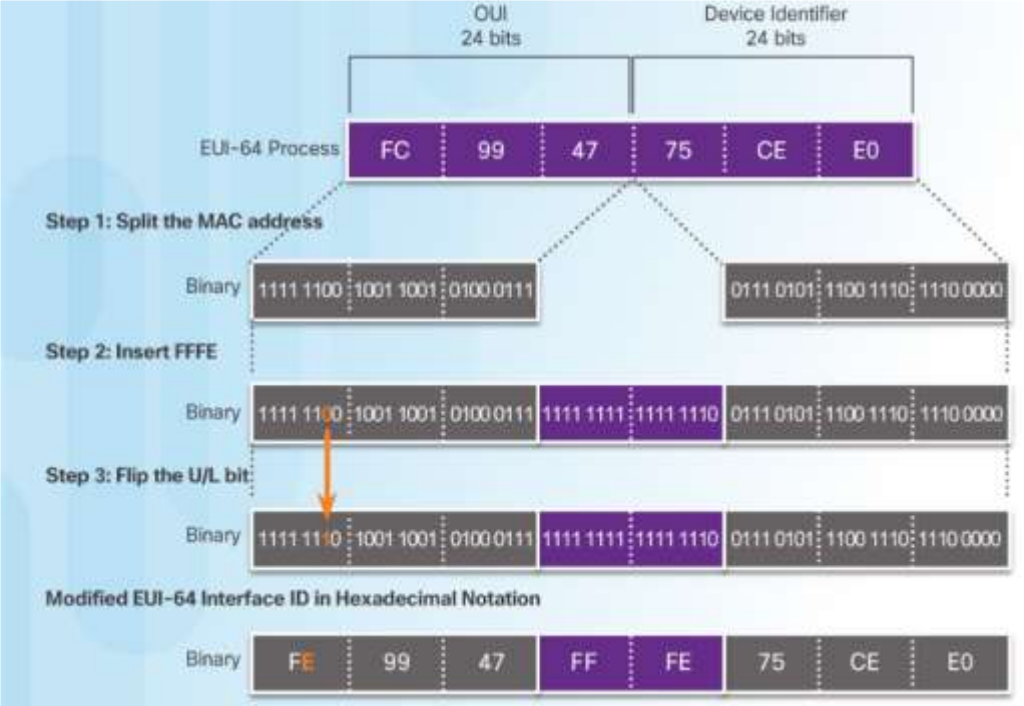
Dynamic Configuration – DHCPv6

- 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.

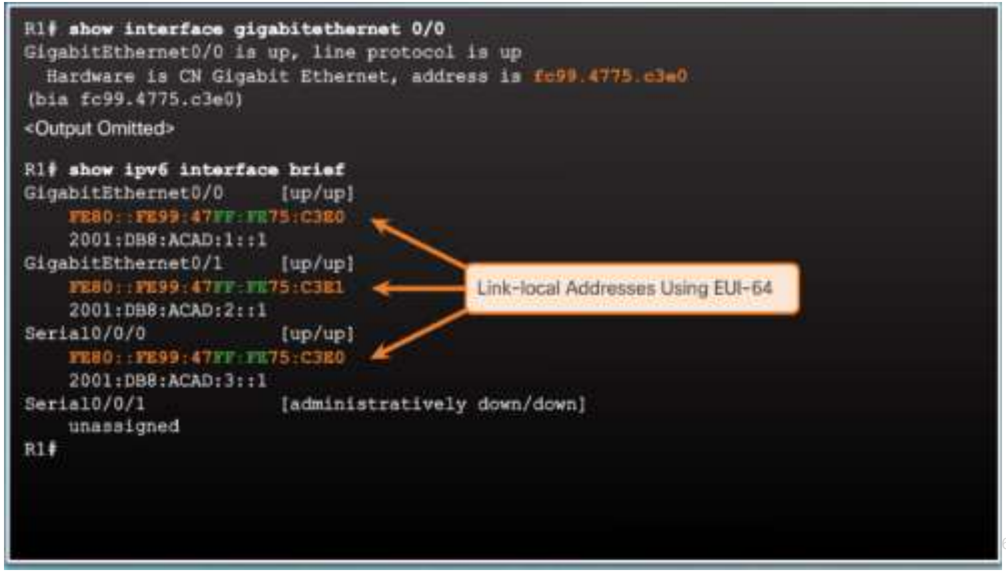


EUI-64 Process and Randomly Generated (Cont.)

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

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.



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#
```

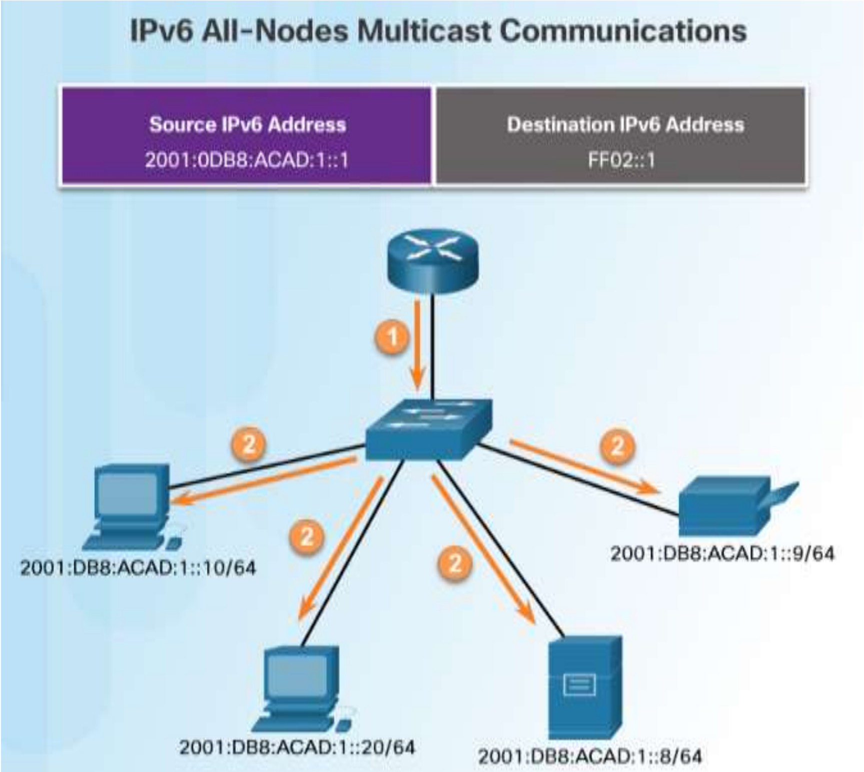
```
R1# show ipv6 route
IPv6 Routing Table - default - 7 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static


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#
```

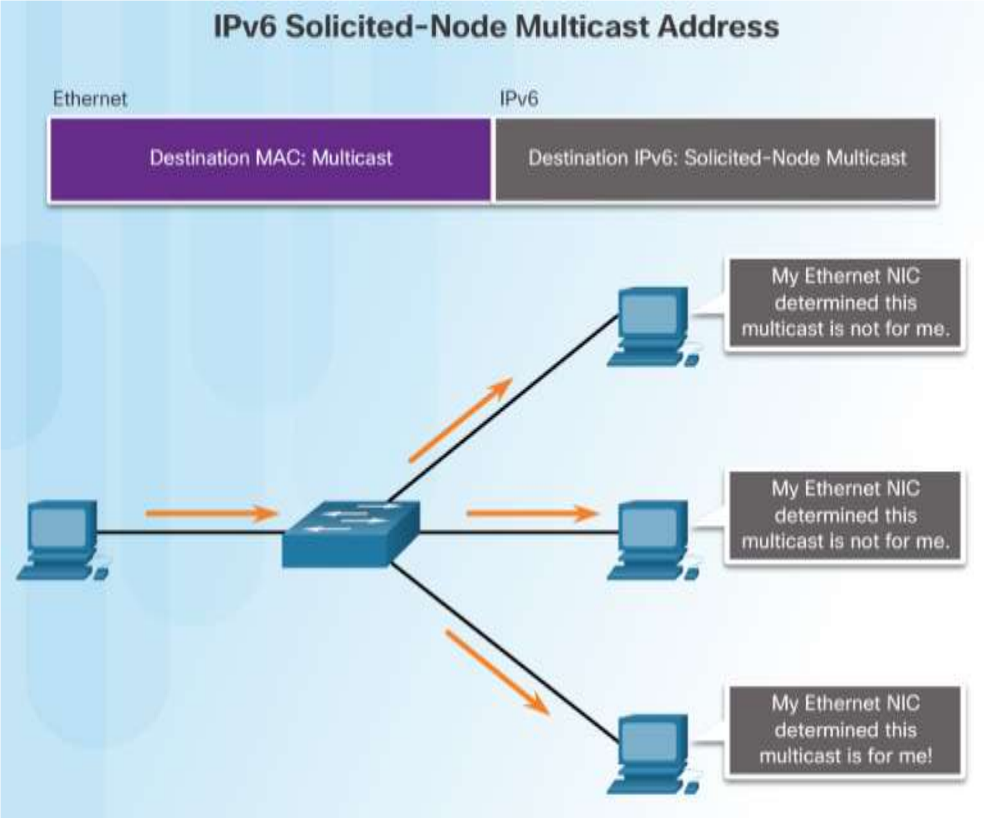
Assigned IPv6 Multicast Addresses

- 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.



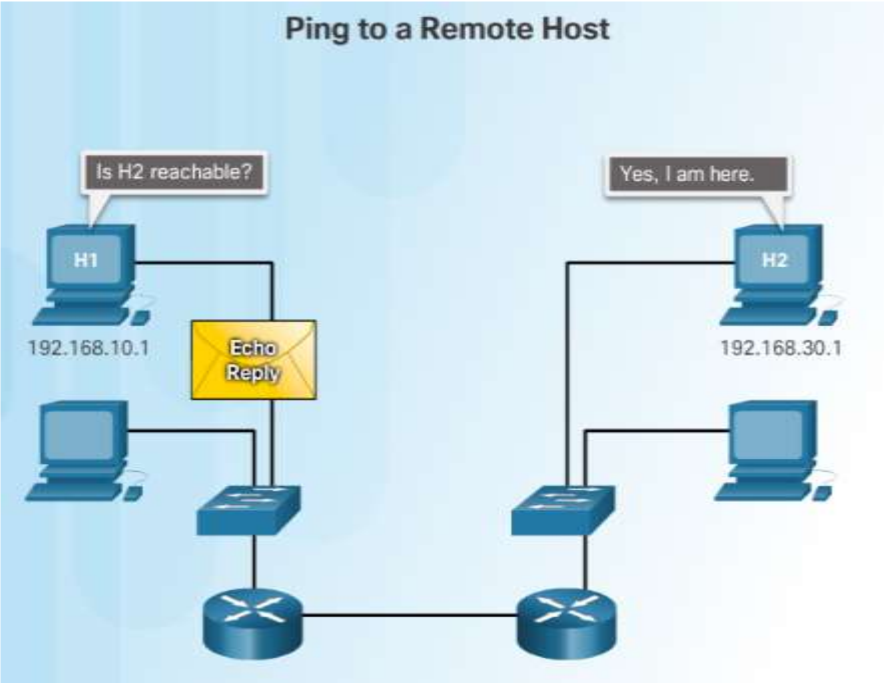
Solicited-Node IPv6 Multicast Addresses

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



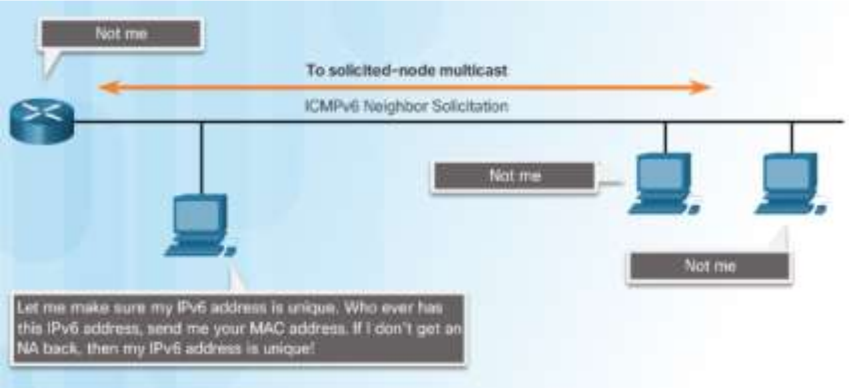
ICMPv4 and ICMPv6

- 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

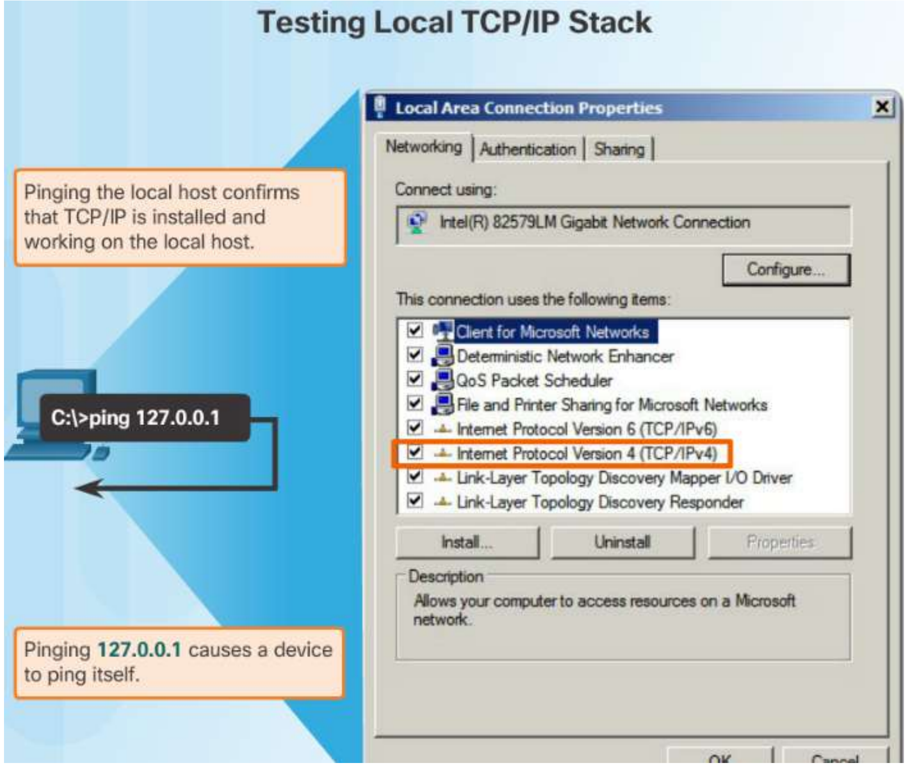


ICMPv6 Router Solicitation and Router Advertisement Messages

- 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).

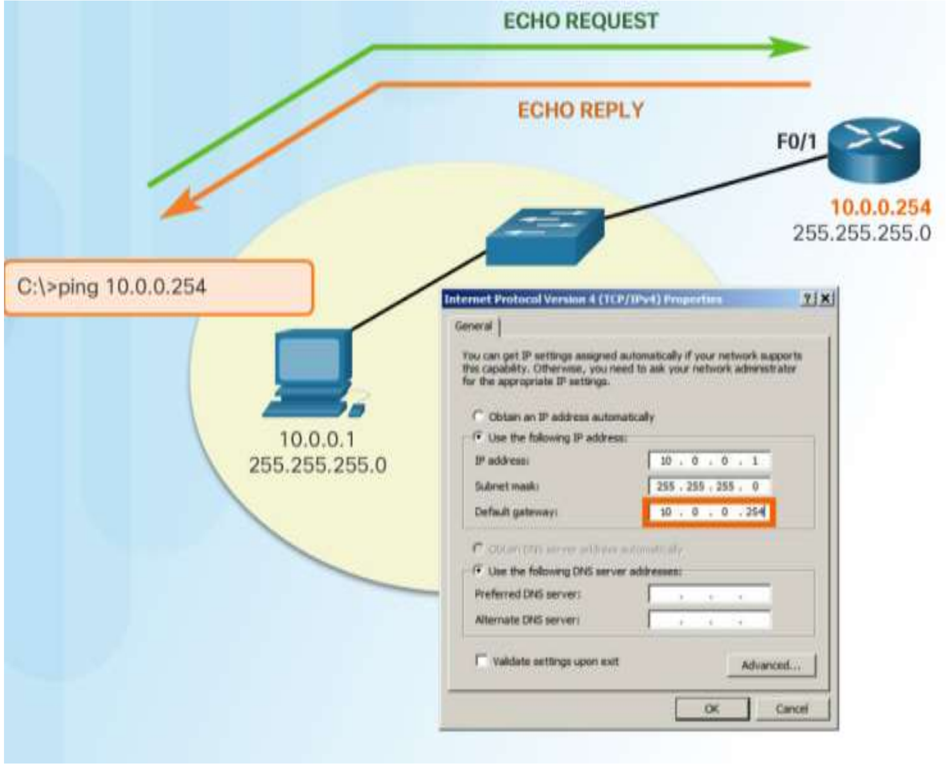


Ping - Testing the Local Stack



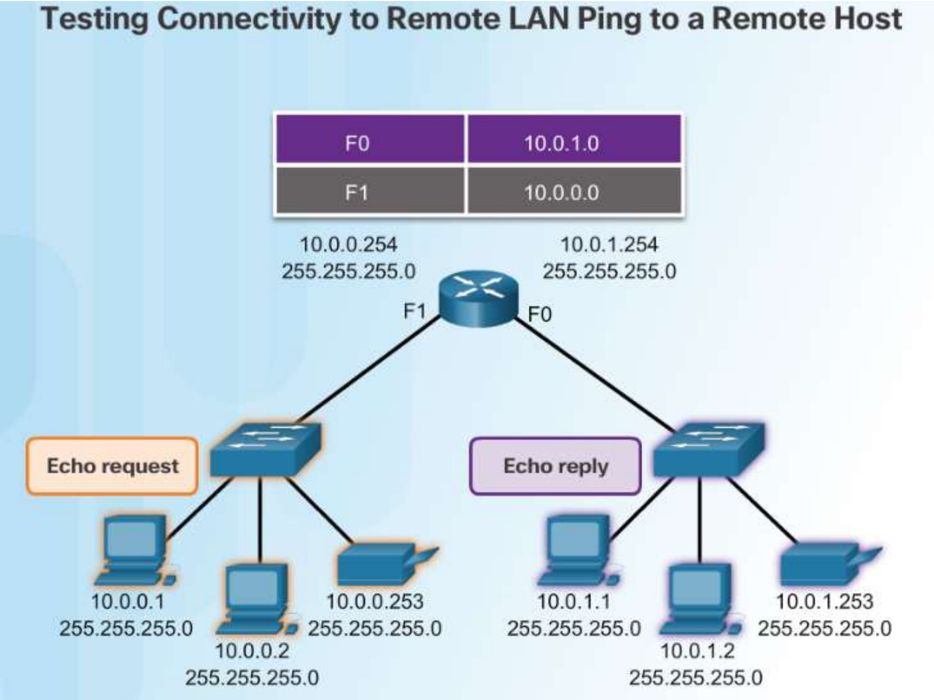
- Ping the local loopback address of 127.0.0.1 for IPv4 or ::1 for IPv6 to verify that IP is properly installed on the host.

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.