The University of Jordan, Comp. Eng. Dept.
Networks lab: Handout: Experiment 3
IP Addressing: Version 6: (Theory and Practice)

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Parts Involved: 1) Need for IPv6, 2) IPv6 Types of Addresses, 3) Solicited-Node Multicast Address, 4) Subnetting IPv6, and 5) Configuring IPv6 (Practical part)

Part I: The Need for IPv6:

There are many downsides of IPv4, out of which:

- IPv4 address depletion; therefore, 2^{32} addresses are not enough.
- Increasing Internet population whereas all organizations, companies, universities, schools and homes are connected now.
- Network Address Translations (NAT) breaking certain applications, no end-to-end connection between devices. **Note that the NAT is a service that enables private networks to use the Internet and cloud.**
- Internet of things (IoT) launching where things should have IP address to communicate with each other.

For the above reasons, IPv6 is ready today. Interestingly, IPv6 offers:

- 128-bit hierarchical addressing to expand addressing capabilities, as shown in Fig. 1.
- 2^{128} addresses, which is so huge.
- Header format simplification to improve packet handling.
- Flow labeling capability and quality of service mechanisms.

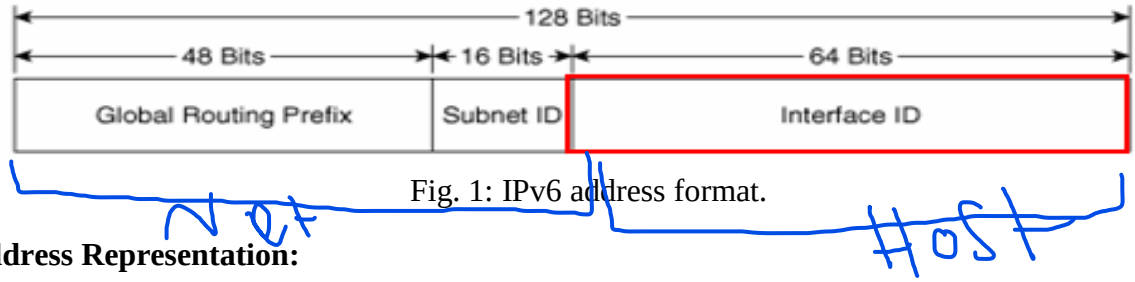


Fig. 1: IPv6 address format.

IPv6 Address Representation:

IPv6 addresses are 128-bit addresses, which are usually represented as shown in Fig. 2. They are characterized of the following:

- Eight groups of 16-bit for each one.
- Hexadecimal Format between 0000 and FFFF
- Separated by colons (:)
- Subnetting IPv6 is easier than IPv4!

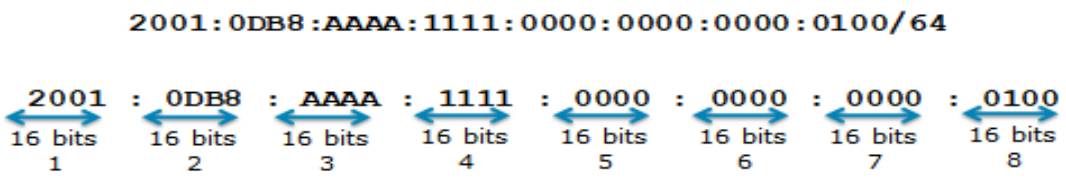


Fig. 2: IPv6 address representation.

Rules for reducing the size of written IPv6 addresses:

- **Rule 1: leading zeros**

Fig. 3 demonstrates that, leading zeroes in any 16-bit segment do not have to be written.

```
2001 : 0DB8 : 0001 : 1000 : 0000 : 0000 : 0ef0 : bc00
2001 :  DB8 :    1 : 1000 :    0 :    0 :  ef0 : bc00

2001 : 0DB8 : 010d : 000a : 00dd : c000 : e000 : 0001
2001 :  DB8 :  10d :    a :   dd : c000 : e000 :    1

2001 : 0DB8 : 0000 : 0000 : 0000 : 0000 : 0000 : 0500
2001 :  DB8 :    0 :    0 :    0 :    0 :    0 :  500
```

Fig. 3: Omitting leading zero based on rule 1.

- **Rule 2: Double-colon (::) equals 0000…0000**

Any single, contiguous string of one or more 16-bit segments consisting of all zeroes can be represented with a double colon, as represented in Fig. 4.

```
FE80 : 0000 : 0000 : 0000 : 0000 : 0000 : 0000 : 0001
FE80 :                                    : 1

FE80::1
```

Fig. 4: Double colon representation based on rule 2.

IPv6 Address Representation Example:

Representation	**IPv6 Multicast Address**
Preferred	ff00:0000:0000:0000:0000:0000:0000:0000/8
Rule #1: Leading 0s omitted	ff00:0:0:0:0:0:0:0/8
Rule #2: Compressed	ff00::/8

Part II: IPv6 Types of Addresses:

There are three types of IPv6 addresses, which are detailed as follows:

1. **Unicast** **2. Anycast** **3. Multicast**

1. **Unicast Addresses, where there are five widely known addresses, discussed as follows:**
   - **A. Unique local unicast addresses:**
     - They are similar to private IPv4.
     - These addresses are not globally reachable and routed.
     - They are not registered; everyone can use it.

(Global, link local) عند جهاز محلي

- Used once companies are not interested in Internet and planning to use NAT (if needed).
- They must begin with "FD".

B. Global unicast addresses:

- They are similar to public IPv4
- These addresses are globally reachable and routed
- They are registered; only authorized can use it.
- They start with 2000::/3
- Any address not reserved for specific purpose can be used as a global unicast address.
- There are different ways to configure global unicast address, as shown in the Fig. 5 below:

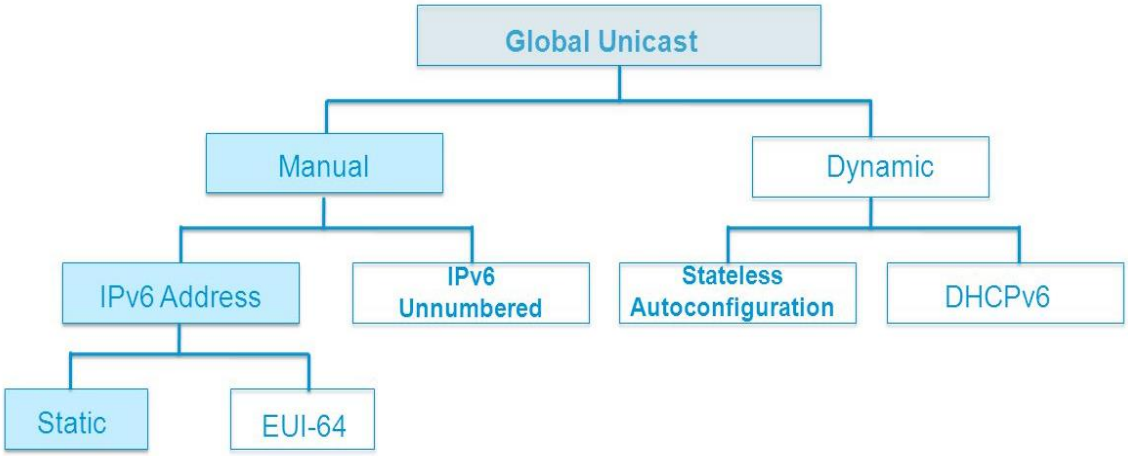


Fig. 5: Global unicast address's configuration ways.

- In configuration, we use the following commands to configure static ipv6:

```
R1(config)#interface GigabitEthernet0/0/0
R1(config-if)#ipv6 address 2001:db8:acad:1::1/64
R1(config-if)#no shutdown
R1(config-if)#exit
```

- No space between IPv6 address and Prefix-length.

C. Link-local addresses:

- They are unicast address which are only valid within a local network segment or subnet.
- Packet sent to link-local address do not carry data.
- They are used by some overhead protocols and for routing.
- Neighbor discovery protocol (NDP) uses link-local address.
- Link-local address can be used by routers as a next hop IP address.
- A host or router interface can create its link-local address automatically when (before) the global unicast address is.
- It should start with "FE80".
- They are not routable off the link (network).
- They are not included in the IPv6 routing table.
- An IPv6 device must have at least a link-local address.
- They are used by:
  - Hosts to communicate with IPv6 network before it has a global unicast address.

- Router's link-local address is used by hosts as the default gateway address.
- Adjacent routers to exchange routing updates.

- The interface ID can be created using Extended Unique Identifier (EUI-64) whereas some OS can randomly generate interface ID.
- EUI-64 format is the IPv6 format used to create IPv6 global and link-local Unicast Addresses. It is a specific format. With this format, basically, interface id of the whole IPv6 address is created with the help of the MAC address. After that, this created interface id is appended to the network ID.
- Here, the steps taken to create EUI-64 interface ID.
  - Suppose the MAC address of the PC is 00-03-6B-E9-D4-80 (in hexadecimal notation).
  - Suppose the prefix is: 2001:DB8:ACAD:1::
  - Suppose the prefix length: /64.
  - Suppose the default gateway: FE80::1
  - Global Unicast Address is:
  - Prefix +Interface ID
  - 2001:DB8:ACAD:1:+ +Interface ID
  - The interface ID is created using EUI-64 format based on the following steps:

MAC address in hexadecimal:

00	03	6B	E9	D4	80

Step1: Split the MAC address in two halves as:

00	03	6B

E9	D4	80

Step 2: Insert FFFE between the two halves as:

00	03	6B	FF	FE	E9	D4	80

Step 3: Flip the U/L 7th bit in binary of the most significant hexdecimal digit (**00**) as:

0000 0000

0000 0010

Step 4: The modified EUI-64 **interface ID in Hexadecimal notation is:**

02	03	6B	FF	FE	E9	D4	80

Step 5: The full Global Unicast Address is: **2001:DB8:ACAD:1:0203:6BFF:FEE9:D480**

Important note: both global unicast address and link local address of router interfaces can be viewed using the following command:

```
R1#show ipv6 interface brief
GigabitEthernet0/0/0     [up/up]
    FE80::FE99:47FF:FE75:C3E0
    2001:DB8:ACAD:1::1
GigabitEthernet0/0/1     [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
```

Important note: both global unicast address and link local address of PC's can be viewed using the **ipconfig** command:

```
PC1> ipconfig
Windows IP Configuration
Ethernet adapter Local Area Connection:
   Connection-specific DNS Suffix  .:
   IPv6 Address. . . . . . . . . . : 2001:db8:acad:1:3496:1c51:3f57:fe89
   Link-local IPv6 Address . .: fe80::3496:1c51:3f57:fe89
   Default Gateway . . . . . . : fe80::1
```

D. Unspecified address:

The unspecified address is 0:0:0:0:0:0:0:0. You can abbreviate the address with two colons **(::)**. The unspecified address indicates the absence of an address, and it can never be assigned to a host. It can be used by an IPv6 host that does not yet have an address assigned to it.

E. Loopback address:

The loopback address is 0:0:0:0:0:0:0:1. You can abbreviate the address as **::1**. The loopback address is used by a node to send a packet to itself.

2. Anycast addresses, which are characterized of the following:

- When routers collectively implement a service, all of these routers are configured with the same Anycast address, as shown in Fig. 6.
- One address is assigned to multiple nodes/interfaces.
- The nearest node/interface is supposed to respond.
- Every unicast address can be used for this purpose.

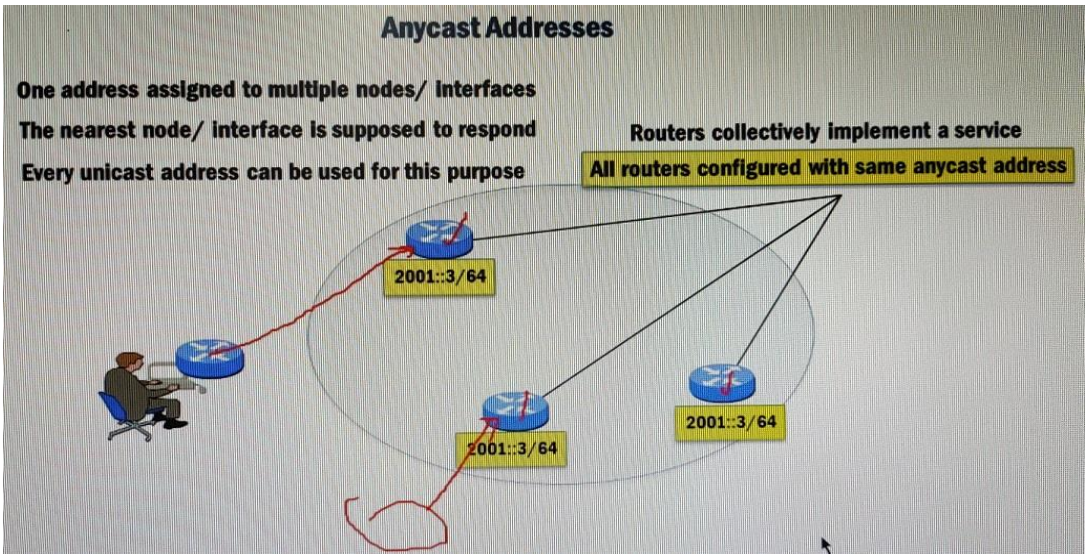


Fig. 6: Any address configuration example.

3. Multicast addresses, which are detailed as follows:

Multicast is a type of communication where multicast traffic addressed for a group of devices on the network. IPv6 multicast traffic are sent to a group and only members of that group receive the Multicast traffic, as shown in Fig. 7. Furthermore, Figs. 8-9 represent the three types of multicast traffic.

A. **Well known multicast addresses where they start with FF00::/12.**
B. **Transient multicast addresses where they start with FF10::/12.**

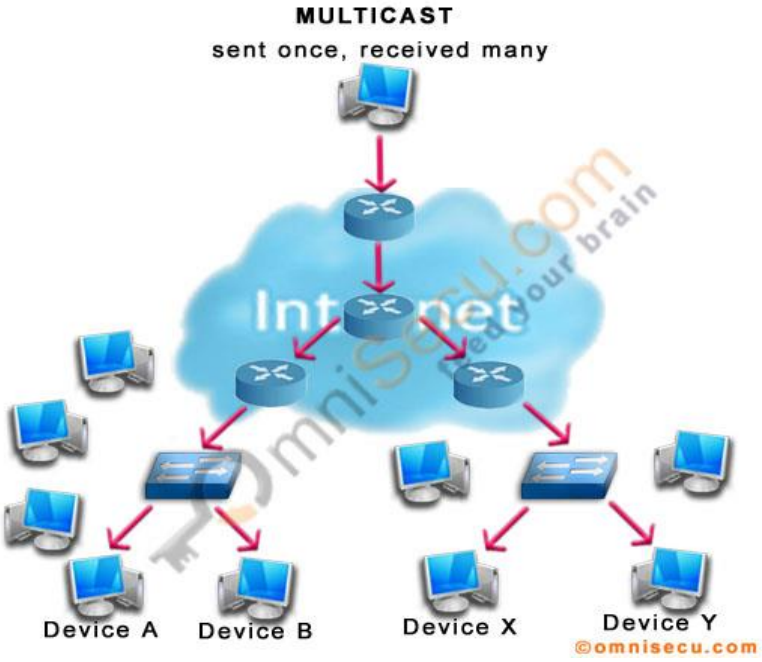


Fig. 7: Multicast traffic direction.

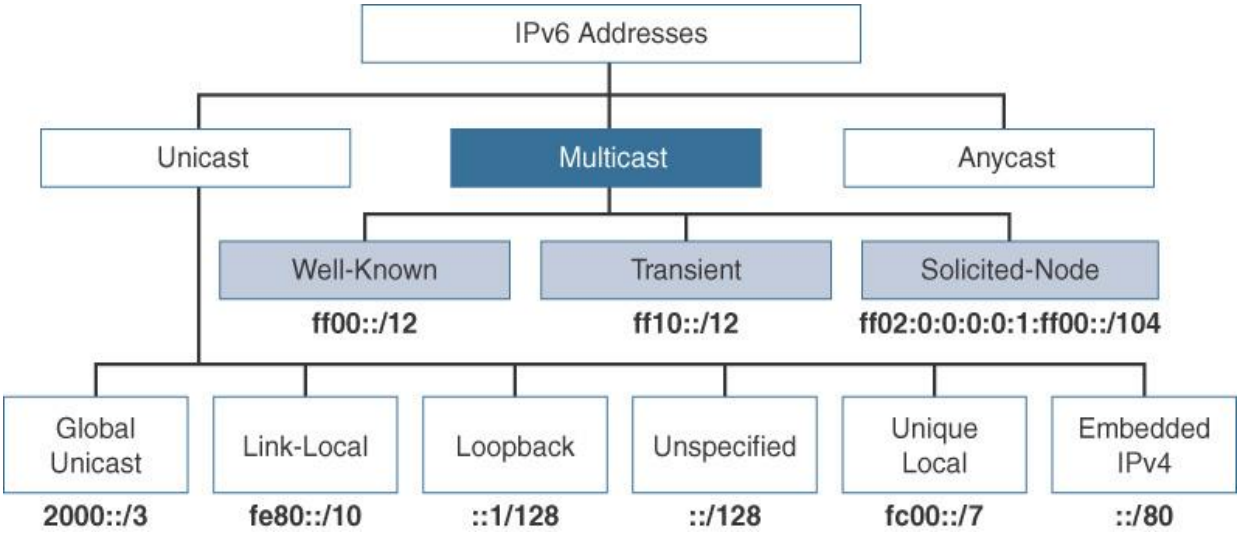


Fig. 8: Multicast traffic types.

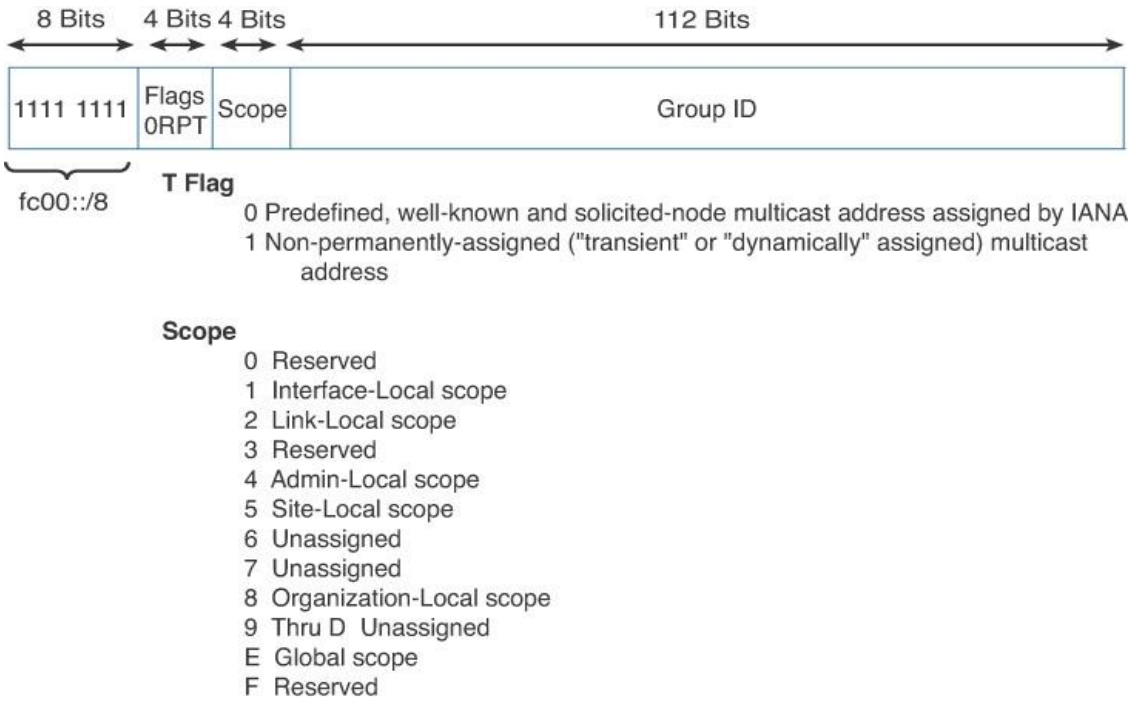


Fig. 9: Multicast traffic types.

C. Solicited-node multicast addresses, which are detailed as follows:

- TCP/IP defines ARP to map an IP address to MAC address on the same LAN
- IPv6 neighbor discovery protocol replaces IPv4 ARP and uses solicited-node multi-cast address instead.
- Router calculates solicited-node multicast address for each interface as shown in Fig. 10, bearing in mind that all solicited node multicast group addresses start with FF02::1:FF /104 (defined by RFC).

Fig. 10: Solicited-node multicast address.

Where The last 24 bits are taken from unicast address.

For example, to configure an IPv6 unicast address while using EUI-64 to generate the last 64 bits, we use the following CLI commands:

```
R1(config)#interface GigabitEthernet0/0
R1(config-if)#ipv6 address 2001:DB8:1212:1212::/64 eui-64
```

Interestingly, to look at or show the joined group addresses, we use the following CLI command:

```
R1#show ipv6 interface GigabitEthernet0/0
GigabitEthernet0/0 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::21D:A1FF:FE8B:36D0
  No Virtual link-local address(es):
  Global unicast address(es):
    2001:DB8:1212:1212:21D:A1FF:FE8B:36D0, subnet is 2001:DB8:1212:1212::/64 [EUI]
  Joined group address(es):
    FF02::1
    FF02::1:FF8B:36D0
```

Important note: the following table (i.e., Table 1) lists of some of the most common link local multicast addresses:

Table 1: The most common link local multicast addresses

Purpose	Address
All nodes on the link	FF02::1
All routers on the link	FF02::2
OSPF	FF02::5, FF02::6
RIP-2	FF02::9
EIGRP	FF02::A

Part III: More on Solicited-Node Multicast Addresses:

Interestingly, the following figures (i.e., Figures 11 through 28) detail the process of creating IPv6 solicited node multicast address, IPv6 neighbor discovery protocol, IPV6 Ethernet multicast address, as well as IPv4address resolution protocol bearing in mind that the **Ethernet broadcast address is FF:FF:FF:FF:FF:FF**.

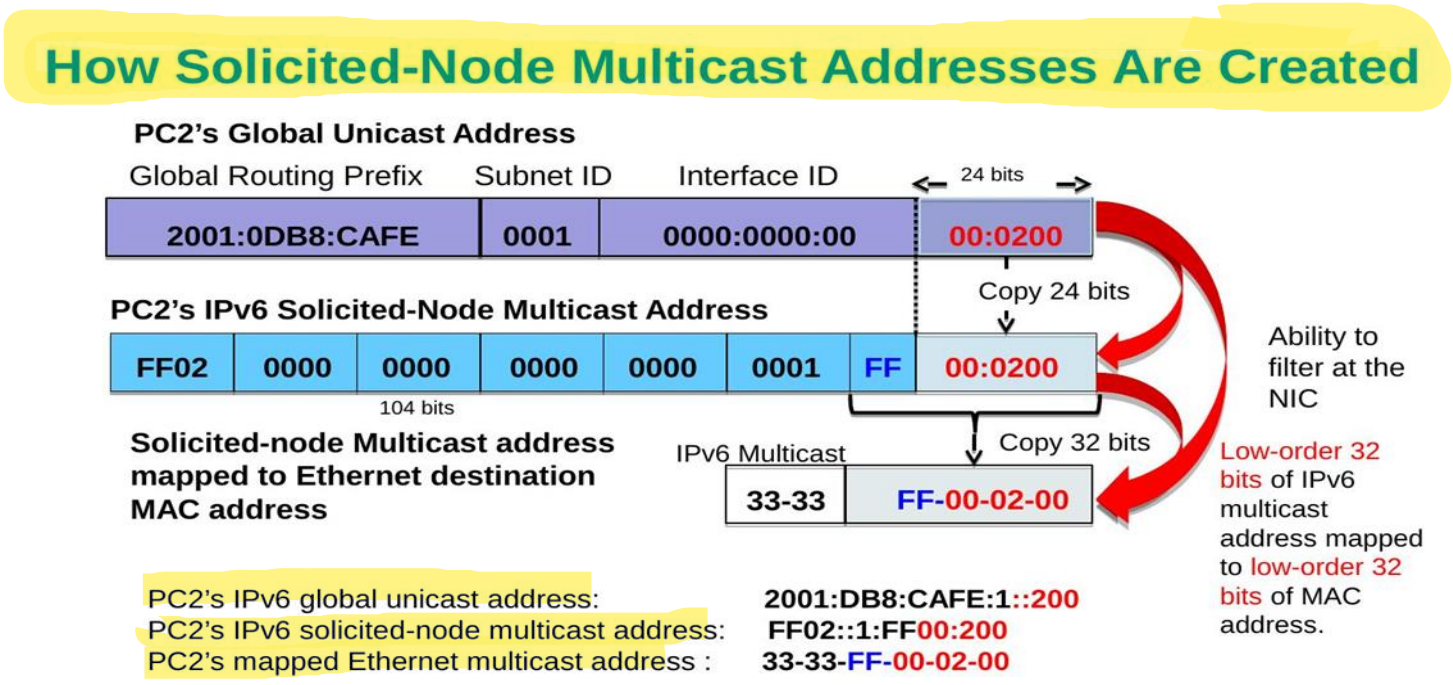


Fig. 11: Solicited-node multicast address' creation.

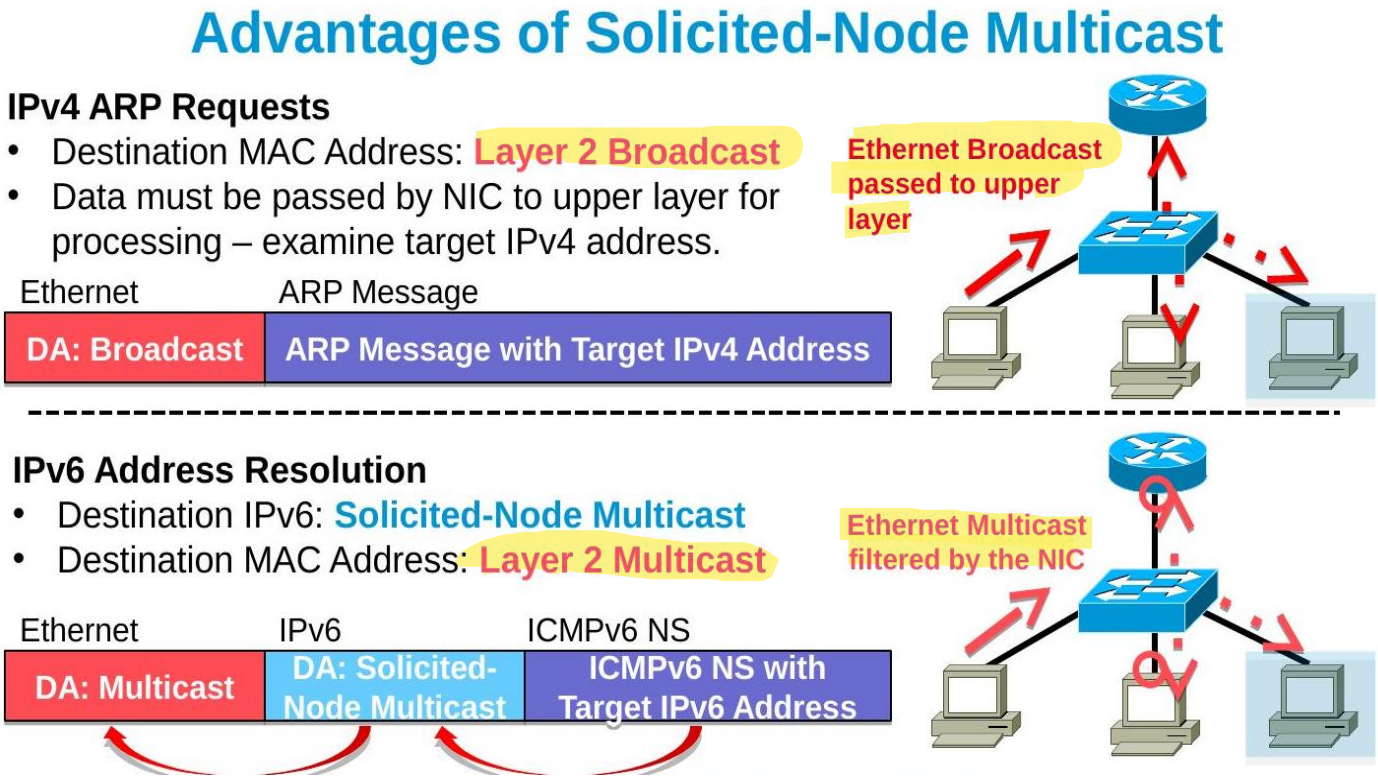


Fig. 12: Advantages of solicited-node multicast.

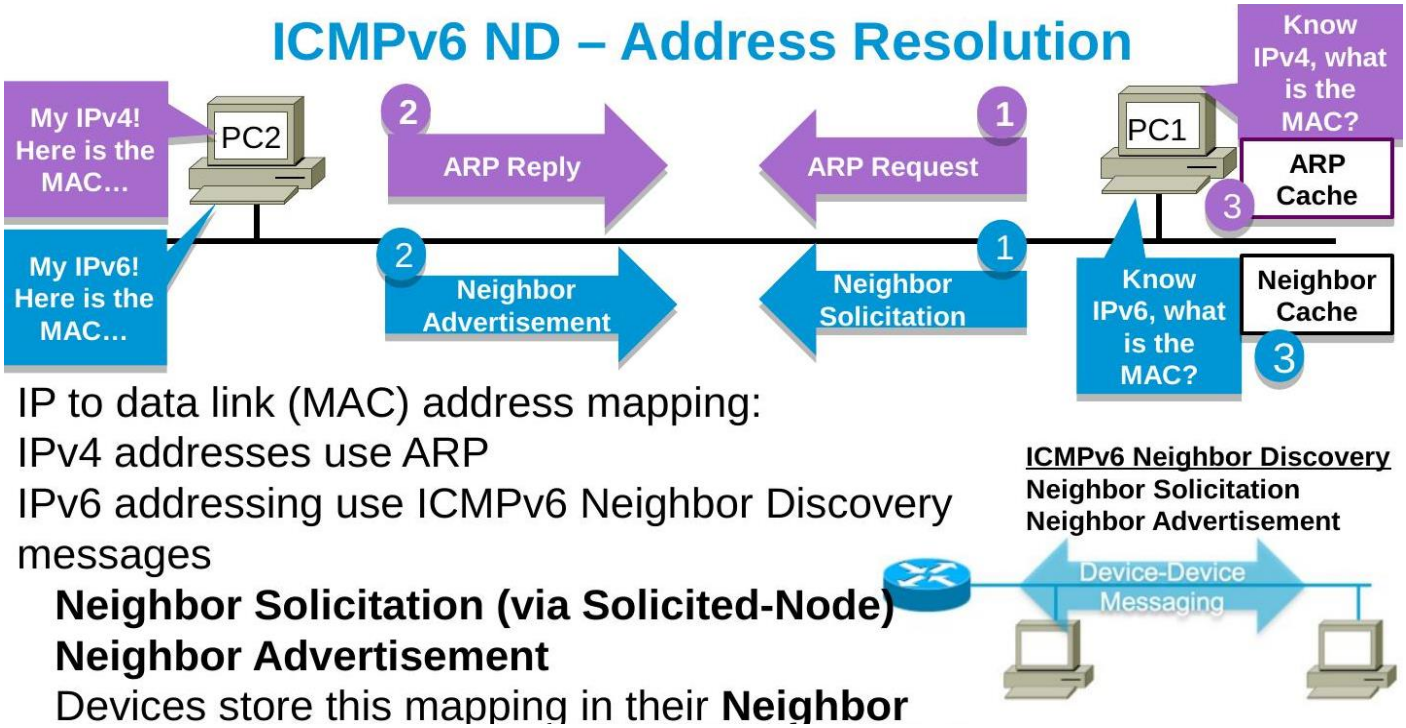


Fig. 13: ICMPv6 ND- Address resolution.

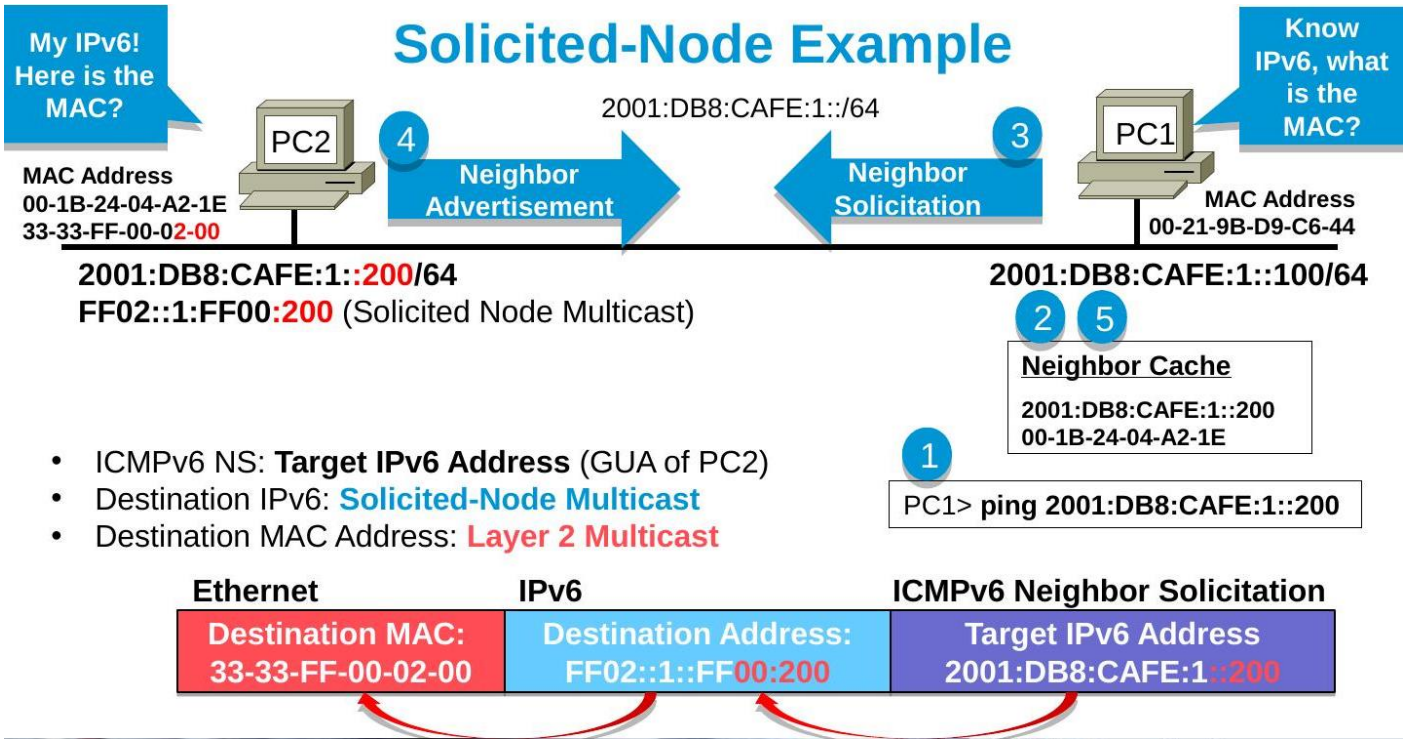


Fig. 14: Solicited-node example.

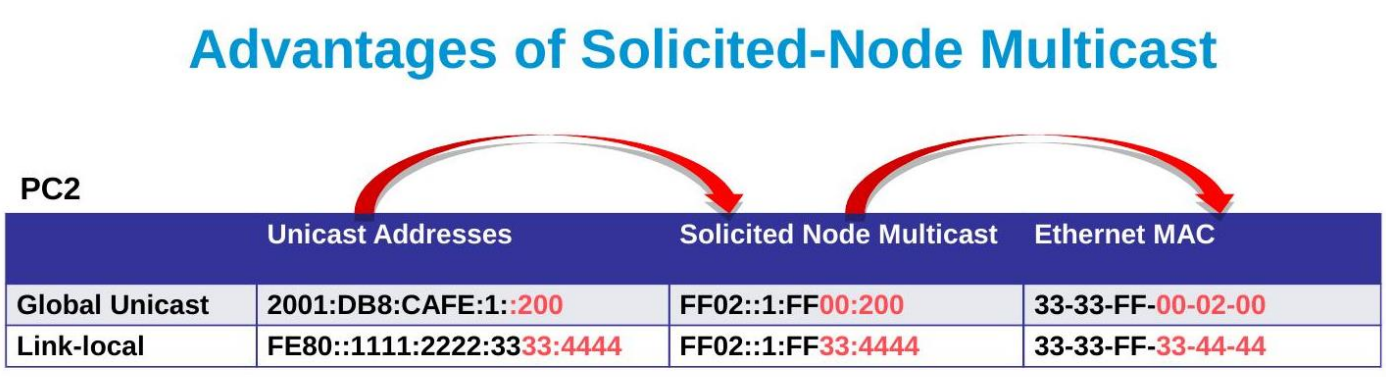


Fig. 15: Advantages of solicited-node multicast.

Mapping IPv6 Multicast to Ethernet Addresses

Assigned Multicast

Assigned Multicast	Description (IPv6 assumed)	Ethernet MAC Address
FF02::1	All-devices	33-33-00-00-00-01
FF02::2	All-routers	33-33-00-00-00-02
FF02::5	OSPF routers	33-33-00-00-00-05
FF02::A	EIGRP routers	33-33-00-00-00-0A

- 48-bit MAC addresses used for IPv6 multicast, range from: 33-33-00-00-00-00 to 33-33-FF-FF-FF-FF
- Low-order 32 bits of IPv6 multicast address mapped to low-order 32 bits of MAC address.
- Why 33-33?

Fig. 16: Mapping IPv6 multicast to Ethernet addresses.

Mapping IPv6 Multicast to Ethernet Addresses

Ethernet Multicast Destination Address	IPv6 Multicast Destination Address	
33-33-00-00-00-01	FF02::1 (All-devices)	Rest of IPv6 Packet
33-33-00-00-00-02	FF02::2 (All-routers)	Rest of IPv6 Packet
33-33-00-00-00-0A	FF02::A (EIGRP routers)	Rest of IPv6 Packet

- Another view of assigned IPv6 multicast address mappings to Ethernet MAC addresses.

Fig. 17: Mapping IPv6 multicast to Ethernet addresses.

Why 33-33?

Ethernet IPv6 Multicast

Destination MAC:
33-33-xx-xx-xx-xx

3333 Coyote Hill Road, Palo Alto, California, is the address of XEROX PARC

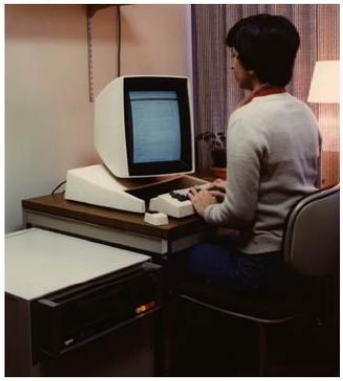


Image courtesy of Computer History Museum

Image courtesy of Xerox PARC

Fig. 18: The reason of using 33-33 address.

Ethernet NICs and Solicited-Node Multicasts

PC2 Processes the following IPv6 and Ethernet MAC Addresses

32 bits

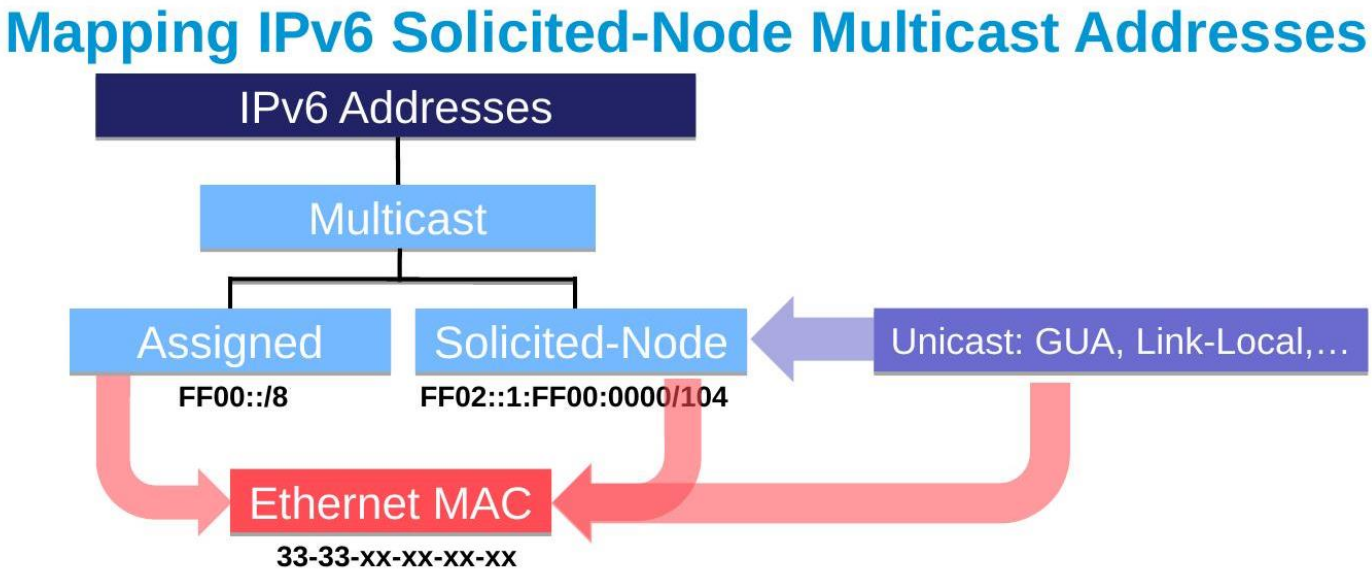
	Unicast Addresses	Solicited Node Multicast	Ethernet MAC
Ethernet NIC	N/A (24 bits)	N/A	00-1B-24-04-A2-1E
Global Unicast	2001:DB8:CAFE:1::200	FF02::1:FF00:200	33-33-FF-00-02-00
Link-local	FE80::1111:2222:3333:4444	FF02::1:FF33:4444	33-33-FF-33-44-44
Multicast (All-IPv6-Devices)	FF02::1	N/A	33-33-00-00-00-01

- Besides its own MAC address, the Ethernet NIC will accept multicast addresses created from the:
  - Solicited node multicast (global unicast address)
  - Solicited node multicast (link-local address)
  - Any assigned multicast address such as All-IPv6-Devices.
  - Mapping of IPv6 multicast to Ethernet addresses discussed soon.

00-1B-24-04-A2-1E

* Ethernet MAC addresses such as IPv4 broadcasts and those associated with other protocols are not shown.

Fig. 19: Ethernet NICs and solicited-node multicasts.



- Remember, all IPv6 unicast addresses also have an associated IPv6 solicited-node multicast address.
- Each solicited-node multicast address is mapped to an Ethernet MAC address.

Fig. 20: Mapping IPv6 solicited-node multicast addresses.

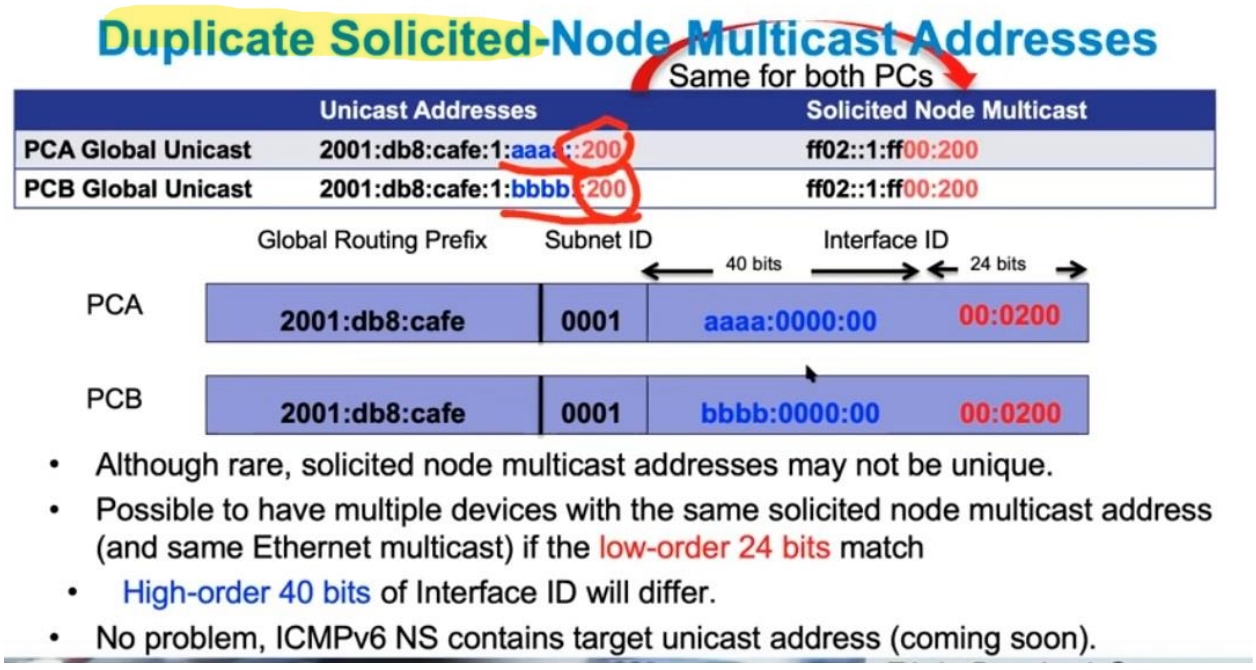


Fig. 21: Duplicate solicited-node multicast addresses.

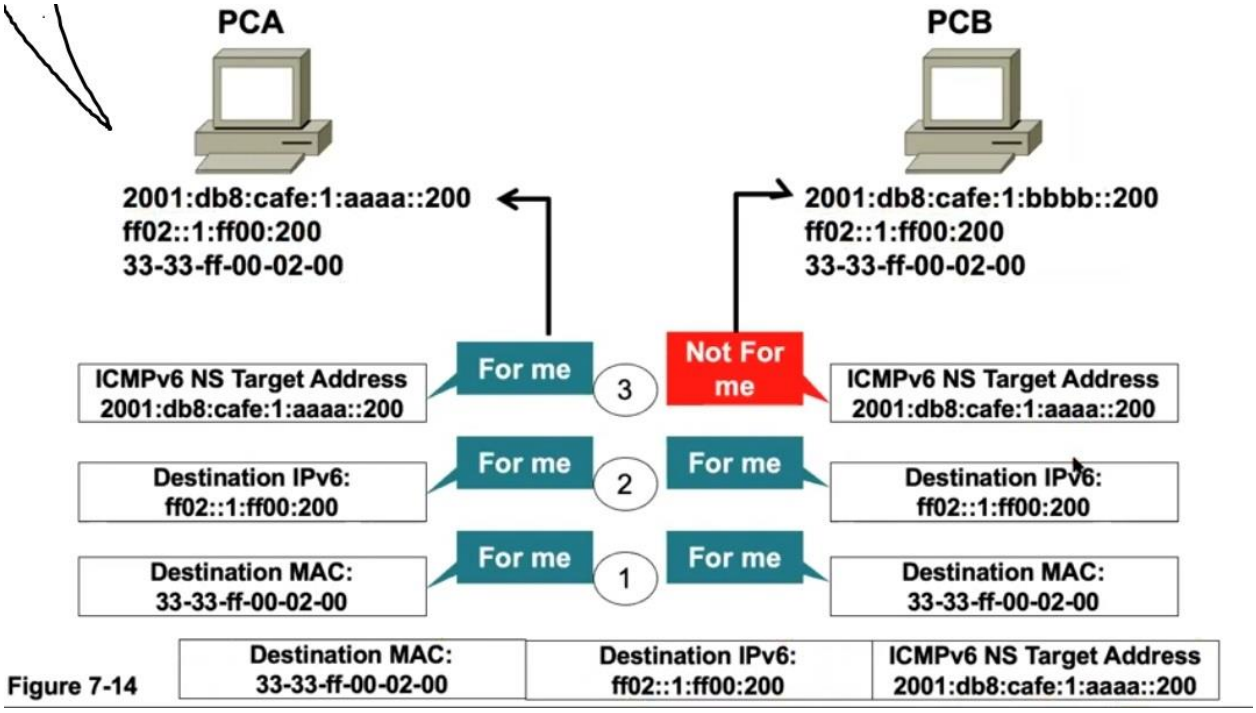


Fig. 22: Ethernet NICs and solicited-node multicasts.

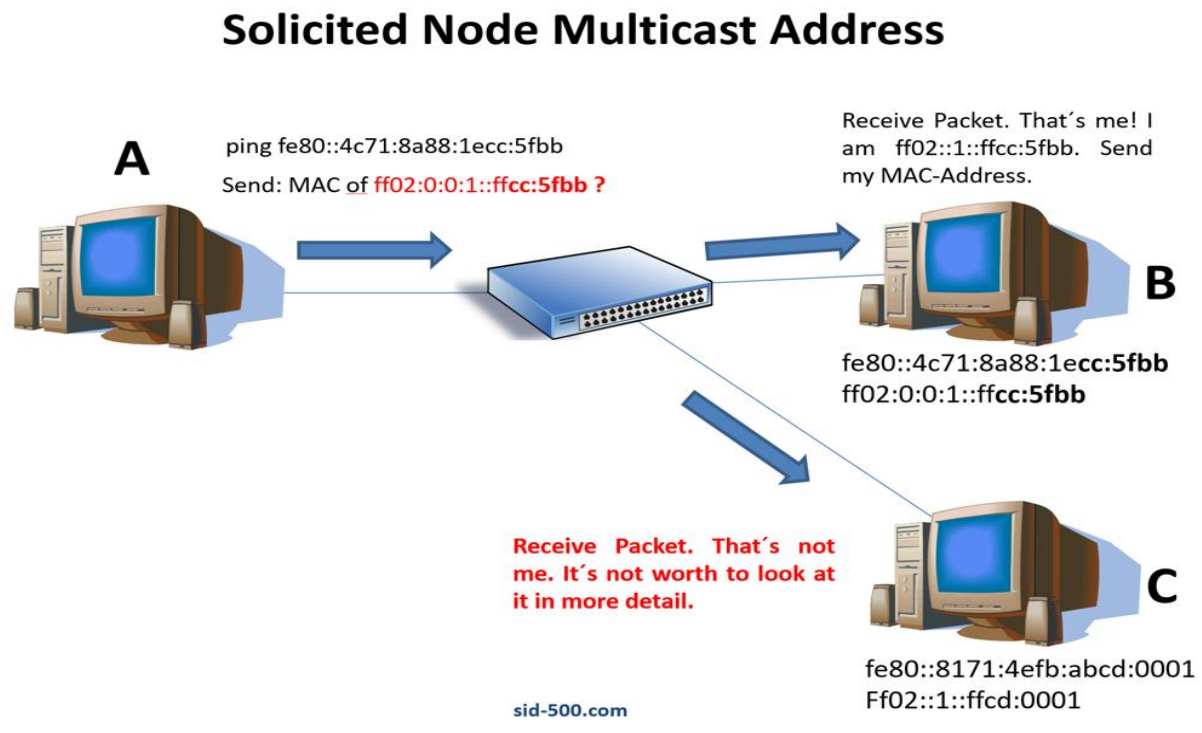


Fig. 23: Solicited-node multicast address.

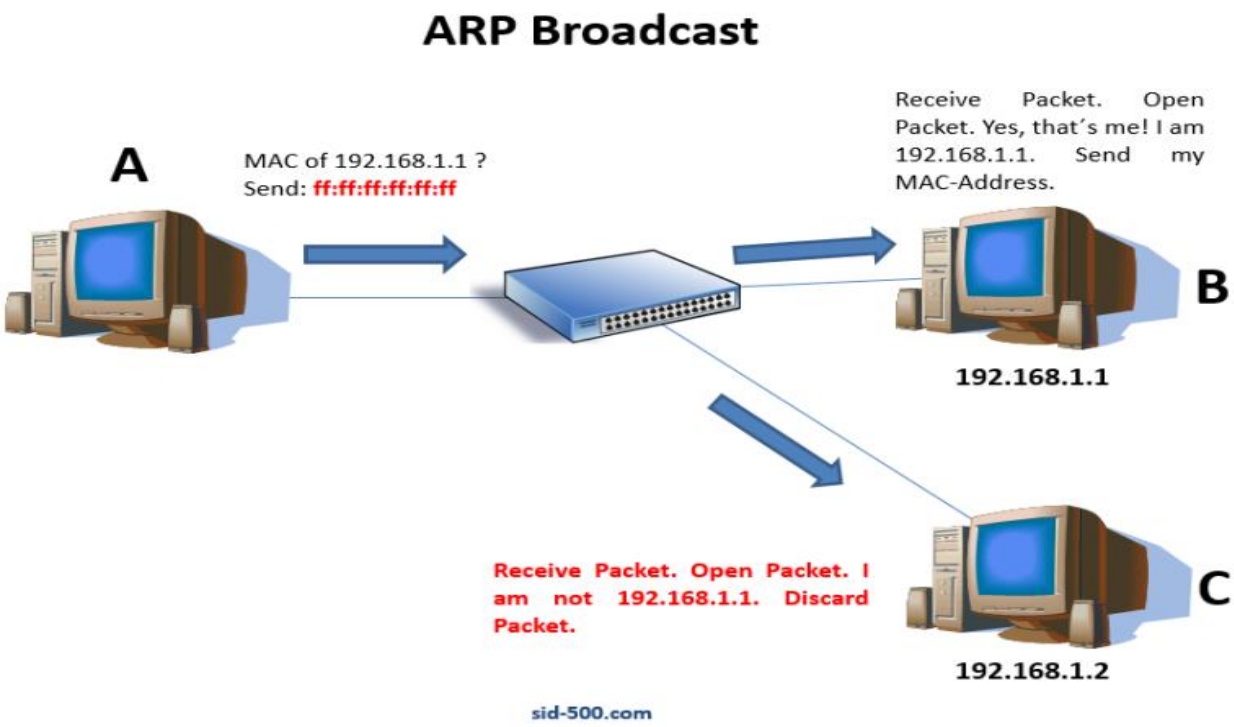


Fig. 24: ARP broadcast.

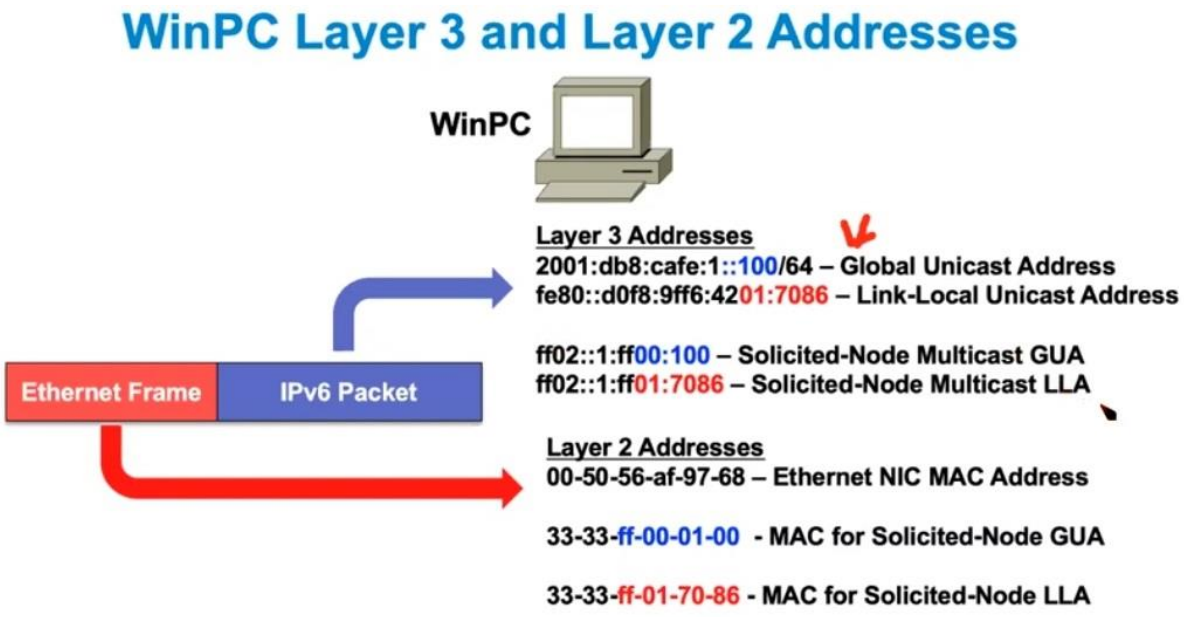


Fig. 25: WinPC layer 3 and layer 2 addresses.

Verifying Solicited-Node Multicast Addresses on the WinPC

```
WinPC> ipconfig

   Connection-specific DNS Suffix  . :
   IPv6 Address. . . . . . . . . . . : 2001:db8:cafe:1::100
   Link-local IPv6 Address . . . . . : fe80::d0f8:9ff6:4201:7086%11

WinPC> netsh interface ipv6 show joins

Interface 11: Local Area Connection

Scope  References  Last  Address
-----  ----------  ----  --------------------------------
<output omitted>
! Solicited-node GUA
0               1  Yes   ff02::1:ff00:100
! Solicited-node LLA
0               2  Yes   ff02::1:ff01:7086
<output omitted for brevity>
```

Fig. 26: Verifying solicited-node multicast addresses on the WinPC.

Verifying IPv6 Multicast Addresses on the Router

```
Router# show ipv6 interface gigabitethernet 0/0
GibabitEthernet0/0 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::1
  Global unicast address(es):
    2001:DB8:CAFE:1::1, subnet is 2001:DB8:CAFE:1::/64
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::5
    FF02::6
    FF02::1:FF00:1
<output omitted for brevity>
```

Member of these Multicast Groups

- All-IPv6 devices on this link
- All-IPv6 routers on this link: IPv6 routing enabled
- *OSPFv3 All OSPF Routers (similar to 224.0.0.5)*
- *OSPFv3 All DR Routers (similar to 224.0.0.6)*
- Solicited-node multicast addresses

Fig. 27: Verifying IPv6 multicast addresses on the router.

Verifying the Solicited-Node Multicasts

```
Router# show ipv6 interface gigabitethernet 0/0
GigabitEthernet0/0 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::FE99:47FF:FE75:C3E0
  Global unicast address(es):
    2001:DB8:CAFE:1::1, subnet is 2001:DB8:CAFE:1::/64
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:FF00:1
    FF02::1:FF75:C3E0
<output omitted for brevity>
```

Member of these Multicast Groups

- FF02::1 ← All-IPv6 devices on this link
- FF02::2 ← All-IPv6 routers on this link: IPv6 routing enabled
- FF02::1:FF00:1 ← Solicited-node multicast address Global Unicast
- FF02::1:FF75:C3E0 ← Solicited-node multicast address link-local

- FF02 – "2" means link-local scope
- Router's NIC will process destination MAC addresses for assigned and solicited node multicasts such as 33-33-FF-00-00-01 and 33-33-FF-75-C3-E0 (solicited node)

Fig. 28: Verifying the solicited-node multicast.

Part IV: Subnetting IPv6:

- An IPv6 address space is not subnetted to conserve addresses;
- It is subnetted to support hierarchical, logical design of the network.
- Recall that an IPv6 address with a /48 prefix has 16 bits for subnet ID.
- Subnetting using the 16-bit subnet ID yields a possible 65,536 /64 subnets.
- Subnets created from the subnet ID are easy to represent because there is no conversion to binary required.
- To determine the next available subnet, just count up in hexadecimal in the subnet ID portion.
- For example, to subnet the address 2001:DB8:ACAD/48 IPv6 address:

2001:0DB8:ACAD:0000::/64
2001:0DB8:ACAD:0001::/64
2001:0DB8:ACAD:0002::/64
2001:0DB8:ACAD:0003::/64
2001:0DB8:ACAD:0004::/64
2001:0DB8:ACAD:0005::/64
2001:0DB8:ACAD:0006::/64
2001:0DB8:ACAD:0007::/64
2001:0DB8:ACAD:0008::/64
2001:0DB8:ACAD:0009::/64
2001:0DB8:ACAD:000A::/64
2001:0DB8:ACAD:000B::/64
2001:0DB8:ACAD:000C::/64
. . . .

2001:0DB8:ACAD:FFFF::/64

➢ **Subnetting into the Interface ID:**

- IPv6 bits can be borrowed from the interface ID to create additional IPv6 subnets.
- This is typically done for security reasons to create fewer hosts per subnet.
- When extending the subnet ID by borrowing bits from the interface ID, the best practice is to subnet on a nibble boundary, as shown in Figs. 29 and 30.
- A nibble is 4 bits or one hexadecimal digit.
- Valid nibble boundaries include /64, /68, /72, /76, /80, etc.

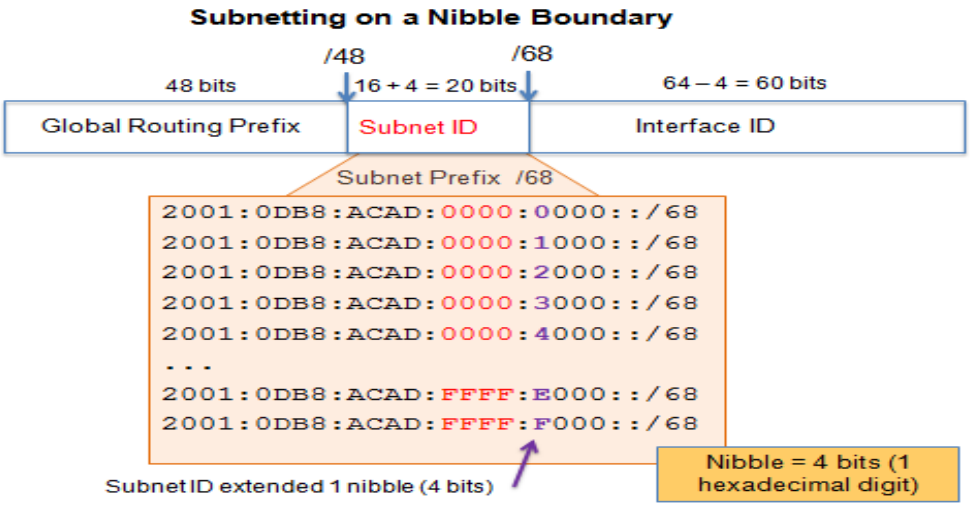


Fig. 29: Subnetting on a nibble boundary.

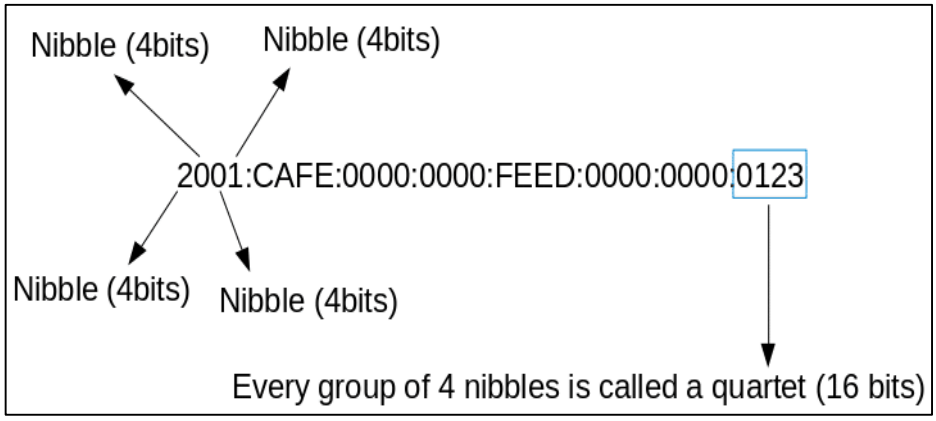


Fig. 30: Nibble boundary.

➢ **IPv6 subnetting exercises:**

- **Exercise 1: Your ISP has given you the IPv6 prefix 3FFF:6666:7777::/48.**

a) How many /64 subnets are available with this address?
   - 64-48 = 16 bits for subnetting, thus the number of subnet is 2^16 =65,536 subnets (0000-FFFF)

b) What are the first four /64 subnets?
   - 3FFF:6666:7777:0000::/64

- 3FFF:6666:7777:0001::/64
- 3FFF:6666:7777:0002::/64
- 3FFF:6666:7777:0003::/64

c) What are the last two /64 subnets in this range?

- 3FFF:6666:7777:FFFE::/64
- 3FFF:6666:7777:FFFF::/64

- **Exercise 2: Your ISP has given you the IPv6 prfix 2001:1111:2222:3000::/52.**

a) How many /64 subnets are available with this address?

- 64-52 = 12 bits for subnetting, thus the number of subnet is 2^12 =4096 subnets (000-FFF)

b) What are the first four /64 subnets?

- 2001:1111:2222:3000::/64.
- 2001:1111:2222:3001::/64.
- 2001:1111:2222:3002::/64.
- 2001:1111:2222:3003::/64.

c) What are the last two /64 subnets in this range?

- 2001:1111:2222:3FFE::/64.
- 2001:1111:2222:3FFF::/64.

- **Exercise 3: Your ISP has given you the IPv6 prefix 2001:AAAA:BBBB:9900::/56.**

a) How many /64 subnets are available with this address?

- 64-56 = 8 bits for subnetting, thus the number of subnet is 2^8 =256 subnets (00-FF)

b) What are the first four /64 subnets?

- 2001:AAAA:BBBB:9900::/64
- 2001:AAAA:BBBB:9901::/64
- 2001:AAAA:BBBB:9902::/64
- 2001:AAAA:BBBB:9903::/64

c) What are the last two /64 subnets in this range?

- 2001:AAAA:BBBB:99FE::/64
- 2001:AAAA:BBBB:99FF::/64

- **Exercise 4: Your ISP has given you the IPv6 prefix 2001:4444:5555:6660::/60.**

a) How many /64 subnets are available with this address?

- 64-60 = 4 bits for subnetting, thus the number of subnet is 2^4 =16 subnets (0-F)

b) What are the first four /64 subnets?

- 2001:4444:5555:6660::/64.
- 2001:4444:5555:6661::/64.
- 2001:4444:5555:6662::/64.
- 2001:4444:5555:6663::/64.

- **Exercise 5:** Your ISP has given you the IPv6 prefix 2001:AAAA:BBBB:8000::/52 to use it in building the network of the University of Jordan, as shown in Fig. 31. As you see in the following

chart, for instance, you have six schools to distribute this address, also, under these schools, their departments. According to the previous scenario, you are required to design the following network using IPv6 subnetting based on location to meet the previous requirements. Tip: Start the subnets with 1.

Please answer the following questions:

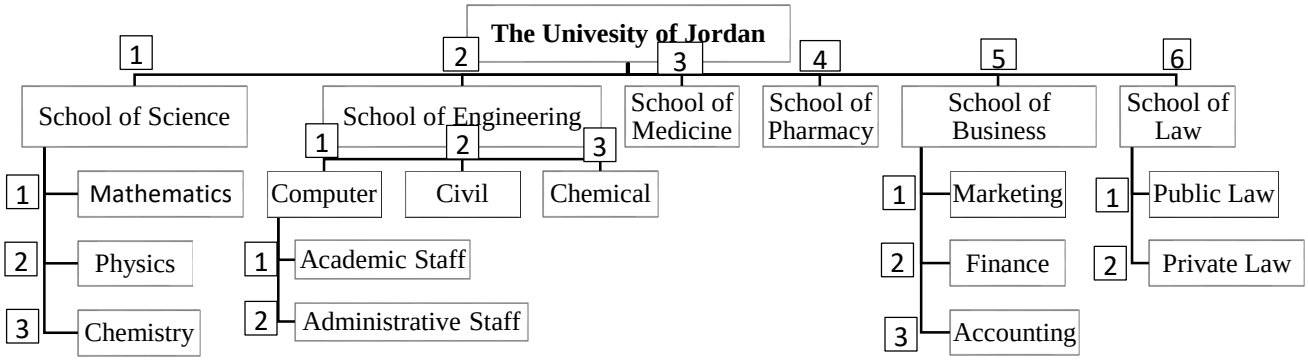


Fig. 31: The network of the University of Jordan.

1. How many bits do you need to choose for creating subnets?

   We have 3 levels, therefore, we need 3 digits where every digit consists of 4 bits, thus, we need as overall 3×4 = 12 bits.

2. What is the most optimal **prefix length** that would you use?

   52 bits + 12 bits = 64 bits (/64)

3. List down **the prefix** of the following with the selected prefix length:

   A. School of Science 2001:AAAA:BBBB:8100::/56

   B. School of engineering 2001:AAAA:BBBB:8200::/56

   C. Academic staff of Computer department 2001:AAAA:BBBB:8211::/64

   D. School of pharmacy 2001:AAAA:BBBB:8400::/56

   E. Accounting department 2001:AAAA:BBBB:8530::/60

4. What is the first usable address in public law department

   2001:AAAA:BBBB:8610::1/60

Part V: Configuring IPv6 (Practical part):

A. IPv6 Basic commands configurations:

Table 2 summarizes the basic CLI commands for this experiment.

Table 2. Basic CLI commands for IPv6 configuration

Command	Usage
Router>	- User EXEC mode.
Router>enable	- Change from EXEC mode to Privileged EXEC mode.
Router#	- Privileged EXEC mode.
Router# configure terminal	- Change from Privileged EXEC mode to configuration mode.
Router(config)#	- Configuration mode.
Router(config)# ipv6 unicast-routing	- This command globally enables IPv6 routing and must be the first command executed on the router.
Router(config)# interface name type	- Enter the interface mode using the name and type of the interface.
Router(config-if)#	- Interface level within configuration mode.
Router(config-if)#no shutdown	- Enable the interface to become administratively up.
Router(config-if)#ipv6 address [ipv6 address]/[prefix length]	- Configure the router interface with an IPv6 global unicast address with prefix length.
Router(config-if)#ipv6 address [ipv6 address] link-local	- Configure the router interface with an IPv6 link-local address.
Router #show ipv6 interface [interface name]	- Verify that the IPv6 address has been configured.
Router # show ipv6 interface brief	- To check the IPv6 address that we have manually assigned.
R1#ping ipv6 [ipv6 address]	-Test the connectivity between the devices using ping for IPv6.

B. IPv6 Example Configuration:

Consider the scenario, shown in Fig. 32, which helps you practice configuring IPv6 addresses on routers, servers, and clients, followed by Table 3, which represents the addressing table for each interface.

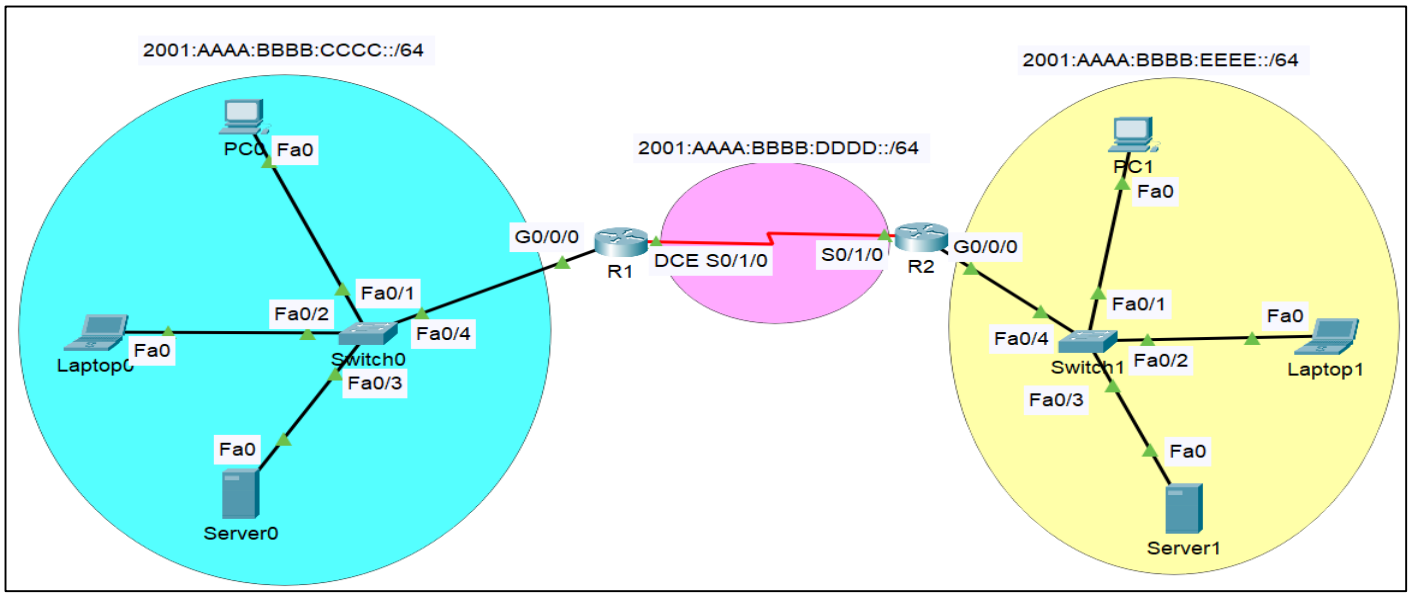


Fig. 32: IPv6 network topology

Table 3: Addressing table for the above scenario

Device	Interface	IPv6 Address/Prefix	Default Gateway
R1	G0/0/0	2001:AAAA:BBBB:CCCC::1/64	-
	S0/1/0	2001:AAAA:BBBB:DDDD::1/64	-
	Link-local	FE80::1	-
R2	G0/0/0	2001:AAAA:BBBB:EEEE::1/64	-
	S0/1/0	2001:AAAA:BBBB:DDDD::2/64	-
	Link-local	FE80::2	-
PC0	Fa0	2001:AAAA:BBBB:CCCC::2/64	FE80::1
Laptop0	Fa0	2001:AAAA:BBBB:CCCC::3/64	FE80::1
Server0	Fa0	2001:AAAA:BBBB:CCCC::4/64	FE80::1
PC1	Fa0	2001:AAAA:BBBB:EEEE::2/64	FE80::2
Laptop1	Fa0	2001:AAAA:BBBB:EEEE::3/64	FE80::2
Server1	Fa0	2001:AAAA:BBBB:EEEE::4/64	FE80::2

B.1 Configuring IPv6 Addressing on the PCs, laptops, and servers.

The following steps are taken to configure IPv6 on PC0, laptop0, server 0, PC1, laptop1, and server 1:

1. Click on PC/Laptop/Server icon on the work space in the packet tracer.
2. Go to the Desktop tab and then choose IP Configuration as shown below in Fig. 33.

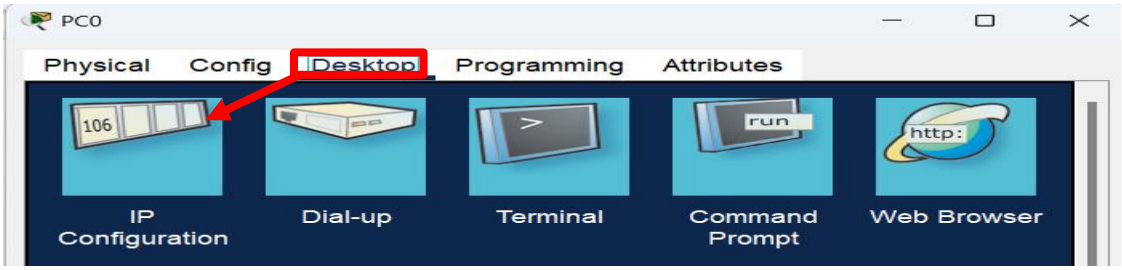


Fig. 33: IP address configuration

Here, the IPv6 can be configured statically or dynamically. **For static configuration:**

3. Set the static IPv6 address as shown in the addressing table with prefix /64.
4. Set the default gateway, as mentioned in the table above, as shown in Fig. 34.

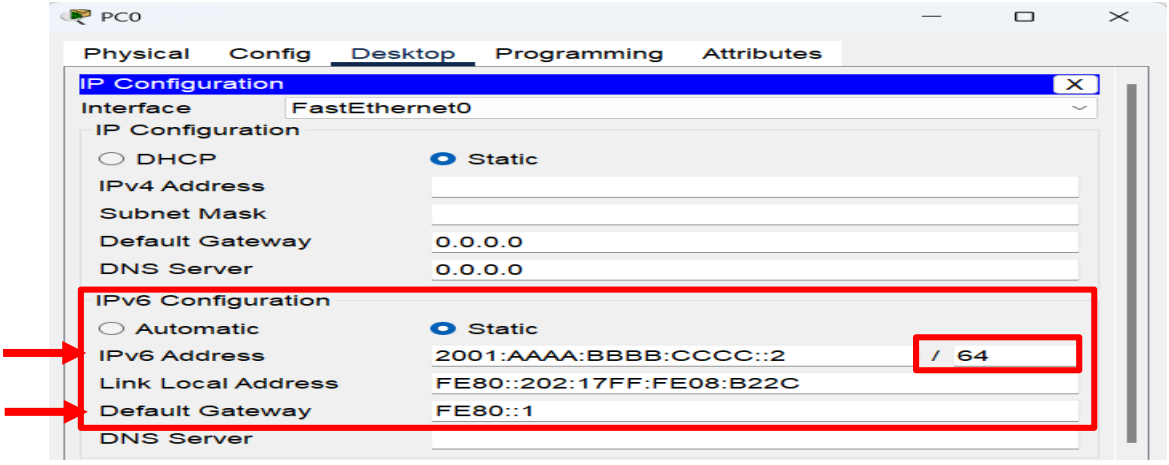


Fig. 34: Static IPv6 address configuration.

5. Below, Fig. 35 shows how the IPv6 is configured dynamically.

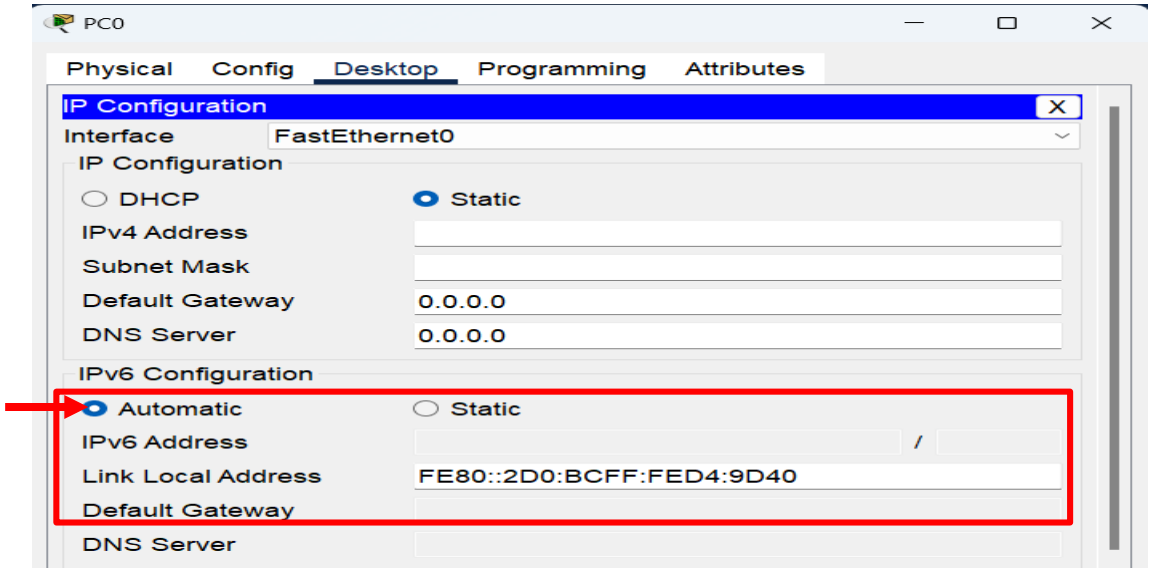


Fig. 35: Dynamic IPv6 address configuration.

6. Repeat the prior steps for all PCs, laptops, and severs.

B.2 Configuring IPv6 Addressing on the Router interfaces:

The following steps are taken to configure IPv6 over router interfaces:

1. Enable IPv6 Globally

After going to the configuration mode with "configure terminal" command, you must enable IPv6 on a Cisco router, by typing the following command "**ipv6 unicast-routing**". With this Cisco command, IPv6 is enabled globally on the router. This must be done before interfaces' configurations and IPv6 routing protocol configurations. Below is the command that is used on both routers:

```
R1# configure terminal
R1(config)# ipv6 unicast-routing

R2# configure terminal
R2(config)# ipv6 unicast-routing
```

2. Configure IPv6 on the Router's interfaces (As used in the lab experiment):

If we do not use EUI-64 format address, we have to write the whole IPv6 Address to the configuration line with the prefix length. Let's configure Gigabit Ethernet 0/0 interface of Router 2 manually. **For each interface in both routers, we must do the following four steps, as shown in Fig. 36:**

Step 1: Enter the commands necessary to transition to interface configuration mode for GigabitEthernet0/0.

```
R1(config)# interface GigabitEthernet0/0/0
```

Step 2: Configure the IPv6 address with the following command:

```
R1(config-if)# ipv6 address 2001:AAAA:BBBB:CCCC::1/64
```

Step 3: Configure the link-local IPv6 address with the following command:

```
R1(config-if)# ipv6 address FE80::1 link-local
```

Step 4: Activate the interface.

```
R1(config-if)# no shutdown
```

- **Repeat the previous steps for all interfaces of both routers.**

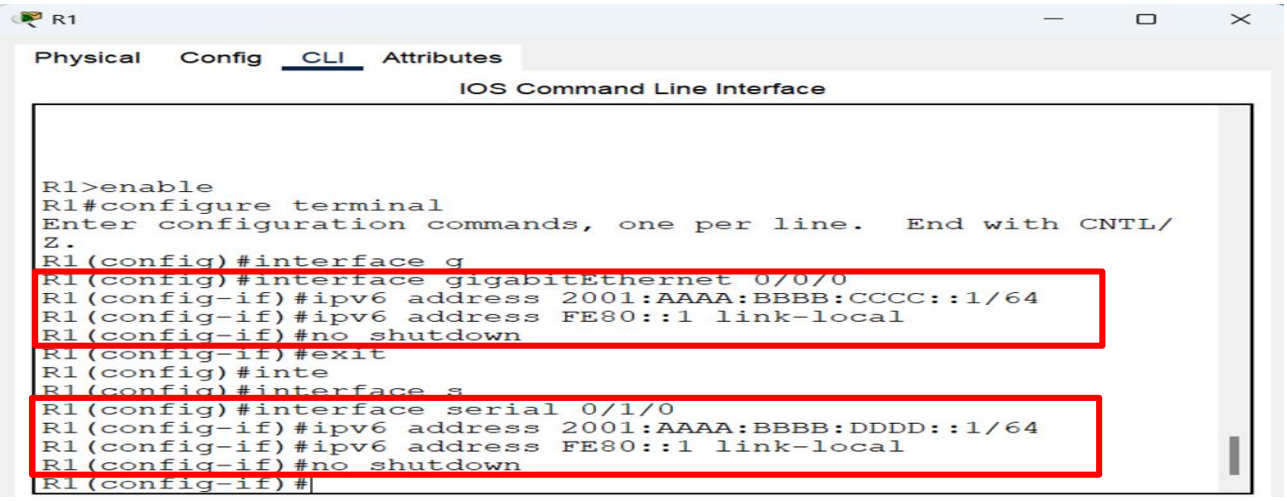


Fig. 36: Steps to configure IPv6 on the R1 interfaces.

B.3 Test and Verify Network Connectivity

1. To check the IPv6 address, which we have manually assigned, use **"show ipv6 interface brief"** command. Fig. 37 demonstrates the results of applying the command on R1 and R2.

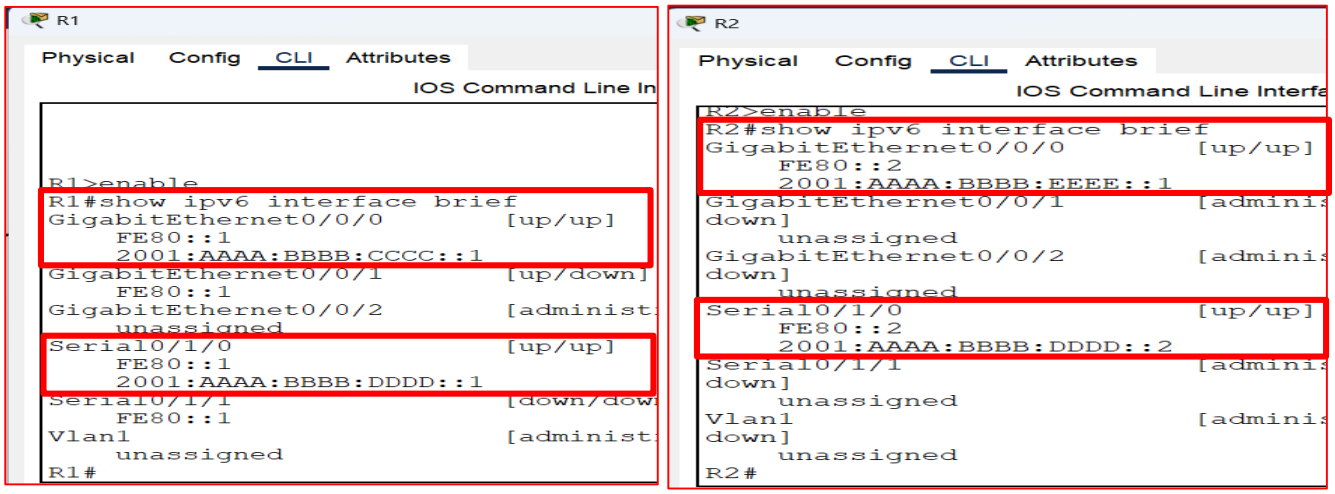


Fig. 37 : The results of show IPv6 interface brief command on R1.

2. To check the connectivity between two devices, we use the **ping** command followed by the ipv6 address without the prefix. Fig. 38 indicates the results of ping command. Double click on PC icon, go to the Desktop tab, then click on the command prompt icon.

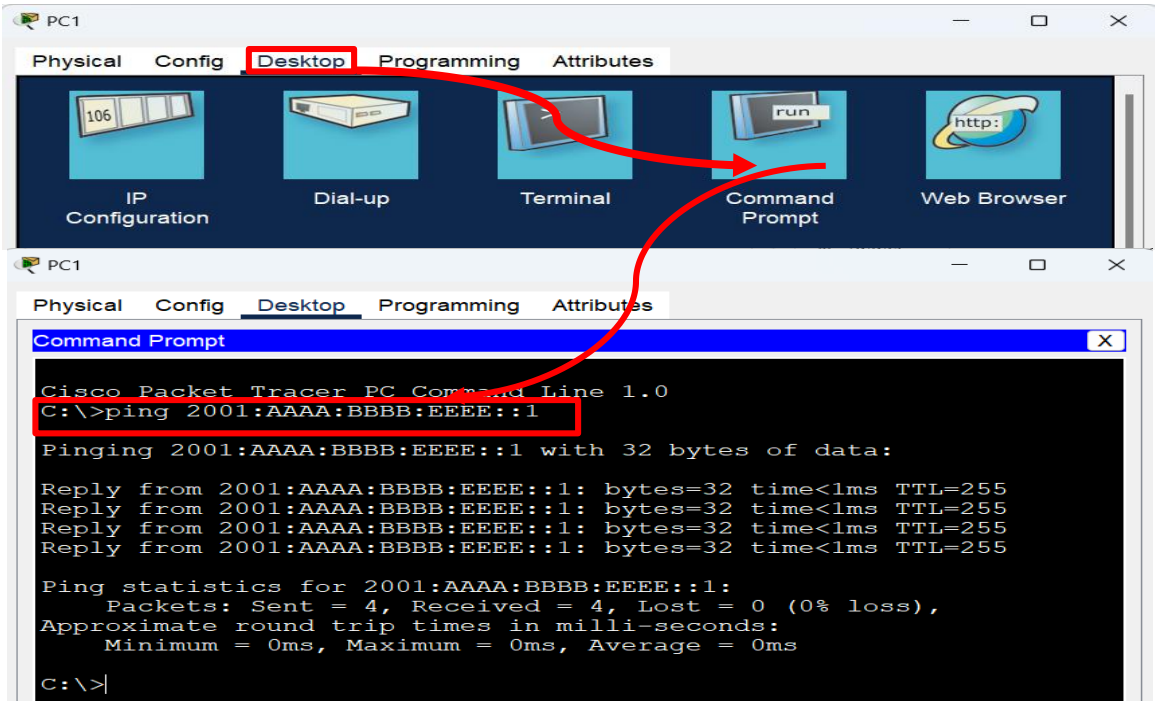


Fig. 38: The results of using ping command between PC1 and its default gateway.

3. To check the configured IPv6 Address on specific interface, we can use "**show ipv6 interface interface-name**" command, which is also shown in Fig. 39.

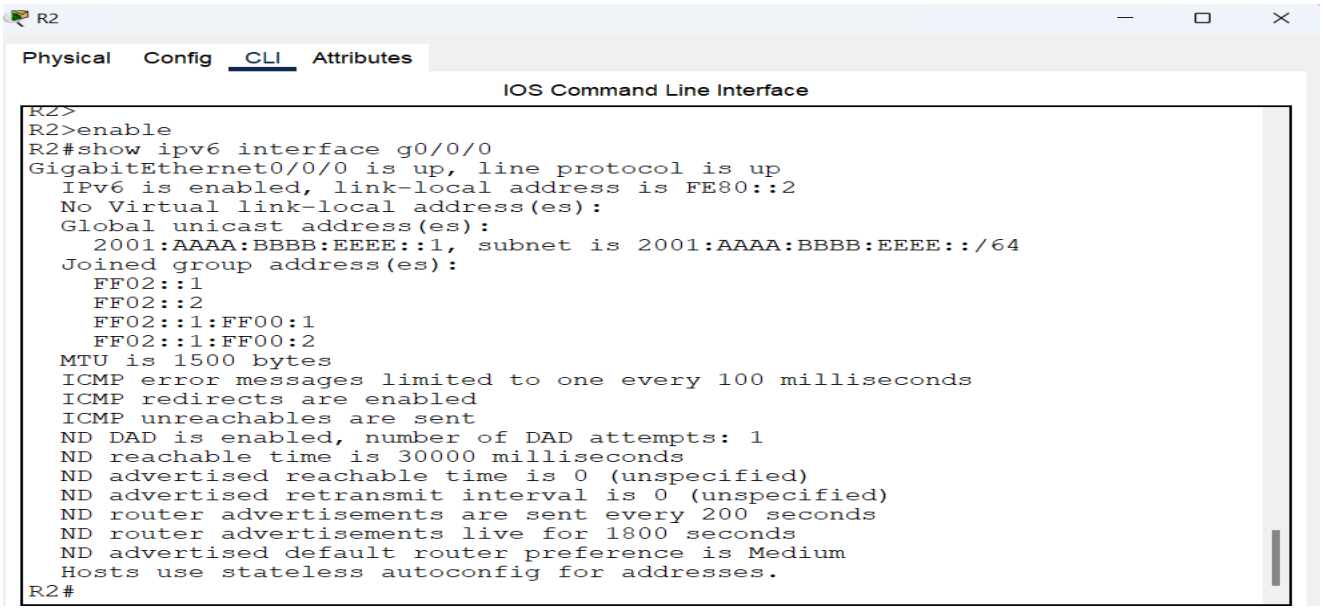


Fig. 39: The results of show IPv6 interface command.

4. To check the remote connectivity of servers from PCs (i.e., Open the server web pages from the PCs), we should use the following:

   Step 1: Click PC0 and click the Desktop tab. Close the IP Configuration window, if necessary.

   Step 2: Click Web Browser. Enter 2001:AAAA:BBBB:CCCC::4 in the URL box and click Go. The Server website should appear as shown in Fig. 40.

   Step 3: Repeat steps (1+2) for the rest of the PCs.

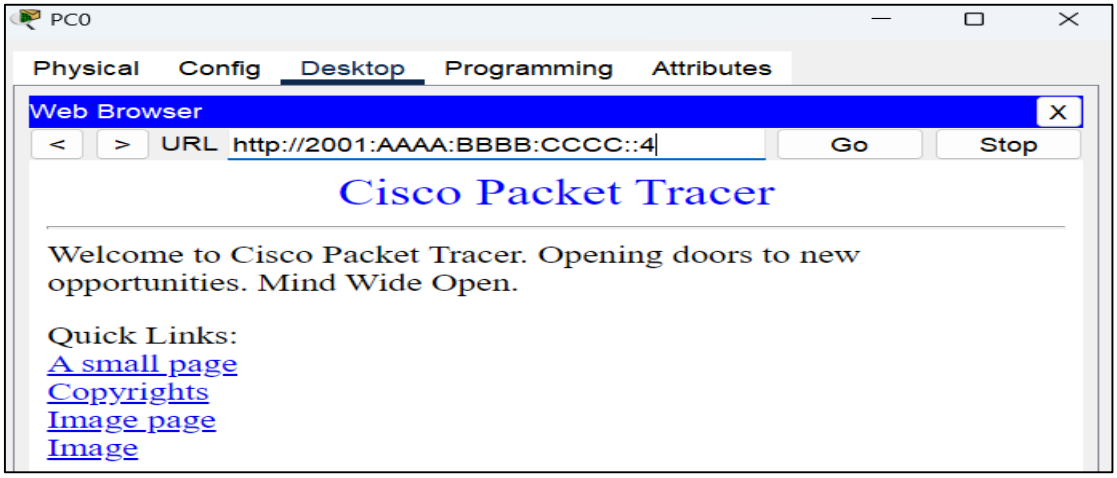


Fig. 40: The successful connection results for server web page from PC0.

Important Note: Some parts of this handout have been collected from several trustable sites, books, and published videos/slides and the other parts have been prepared and written by the instructors. As a matter of fact, this handout is made to be so straight forward, understandable, and so attractive whereas the students can do the required activities and solve the problems in a systematic and easy way, but still the instructors are expected to discuss some important material during the labs' sessions.