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# ICMPv6 Neighbor Discovery

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The slide features a title in a large, bold, red serif font. The title is centered and flanked by two horizontal teal lines. Below the title, there are two short, horizontal gold-colored dashes, one on the left and one on the right, positioned symmetrically. At the bottom of the slide, there are two more horizontal teal lines, mirroring the ones at the top.

# ICMPv6 Neighbour Discovery

- ICMPv6 informational and error messages are very similar to those in ICMPv4.
- The addition of **ICMPv6 Neighbor Discovery Protocol (ND)** makes ICMPv6 a much more robust protocol.
- Neighbor Discovery includes similar processes as in IPv4, such as address resolution, router discovery, and redirect.
- ICMPv6 ND also includes new functionality such as **Prefix Discovery**, **Duplicate Address Detection (DAD)**, and **Neighbor Unreachability Detection (NUD)**.

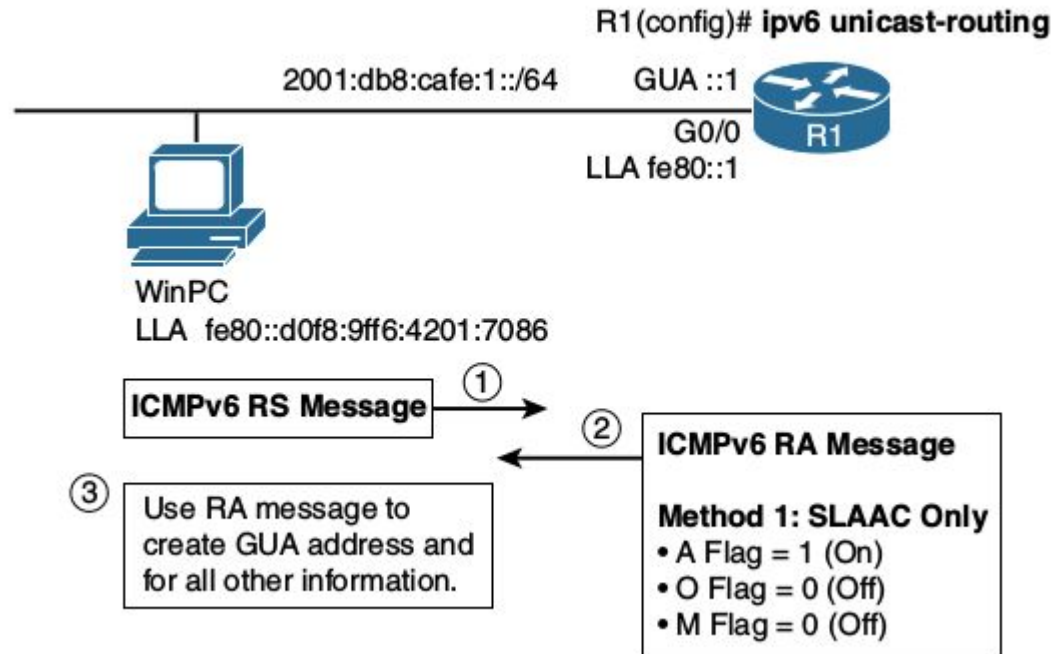
## Neighbor Discovery uses five ICMPv6 messages:

- Router–device messages used for dynamic address allocation:
  - Router Solicitation (RS) message
  - Router Advertisement (RA) message
- Device–device messages used for address resolution:
  - Neighbor Solicitation (NS) message
  - Neighbor Advertisement (NA) message
- Router–device messages used for better first-hop selection:
  - Redirect message

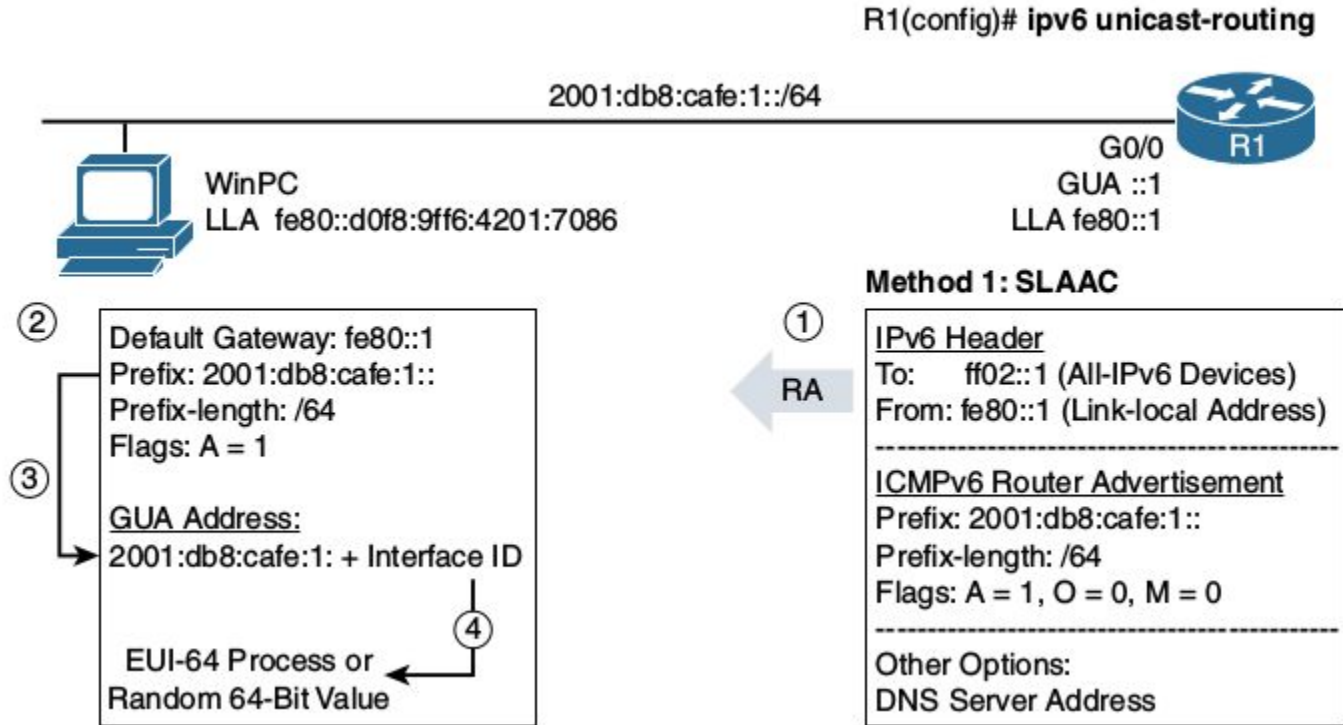
# ICMPv6 ND can be used for following:

- Router and Prefix Discovery
- Address Resolution
- Duplicate Address Detection (DAD)
- Neighbour Unreachability Detection (NUD)
- Redirection

# Method 1 : SLAAC

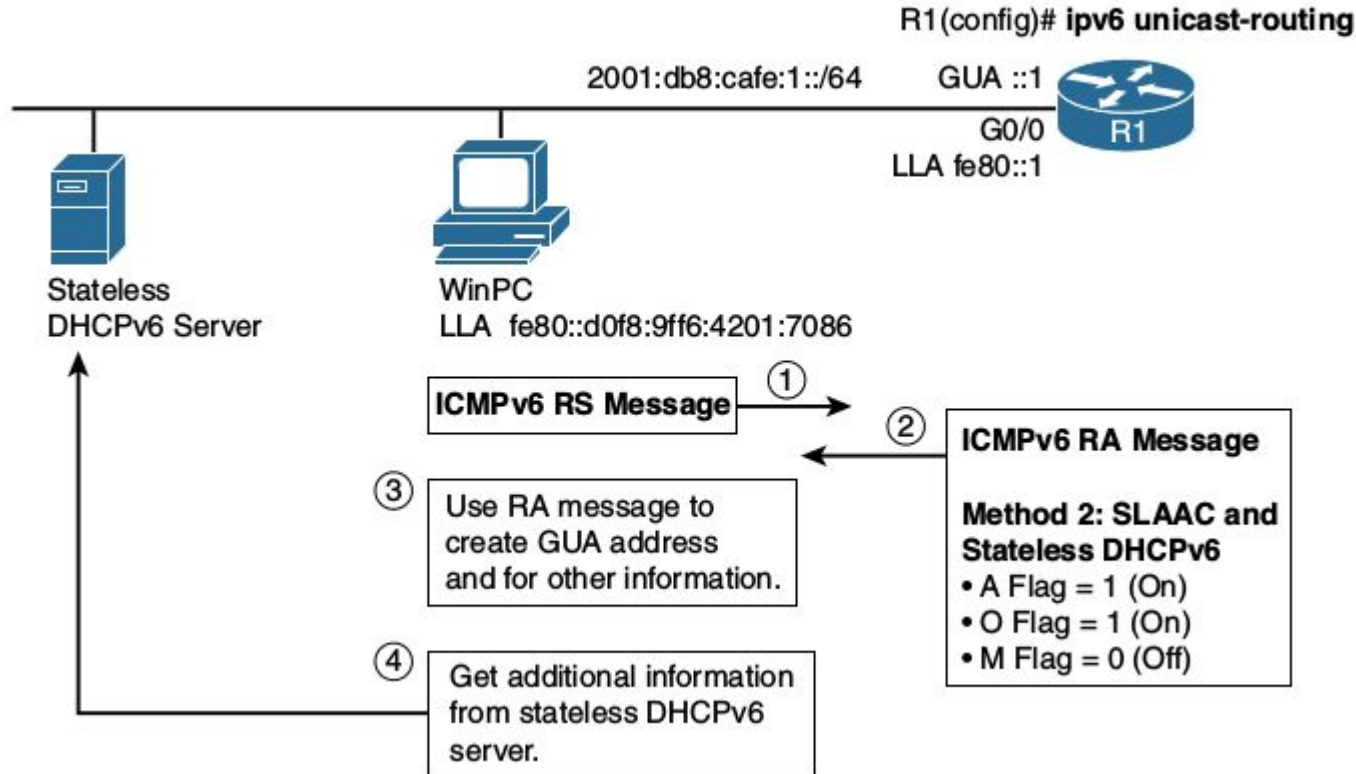


# Method 1: SLAAC

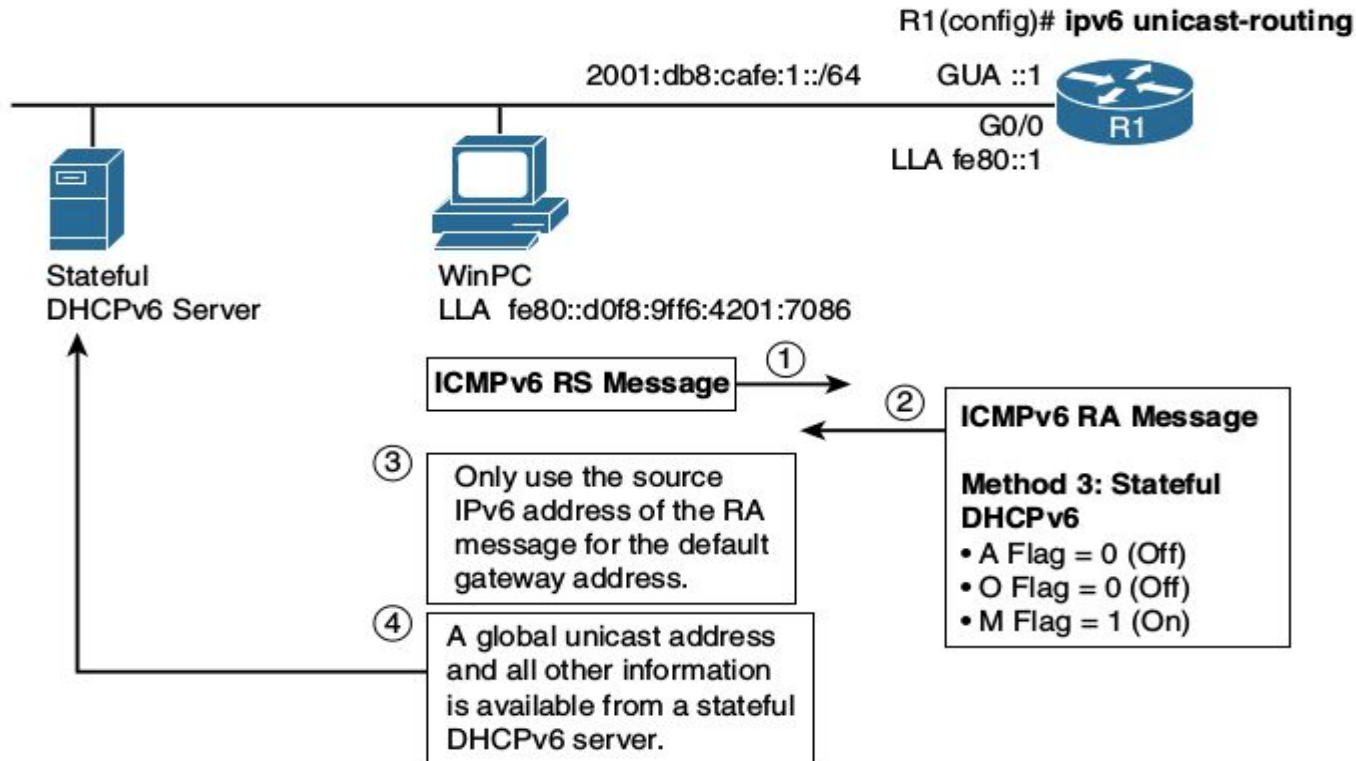


*Note: DAD will be performed after GUA has been assigned*

# Method 2 : SLAAC and Stateless DHCPv6



# Method 3 : Stateful DHCPv6





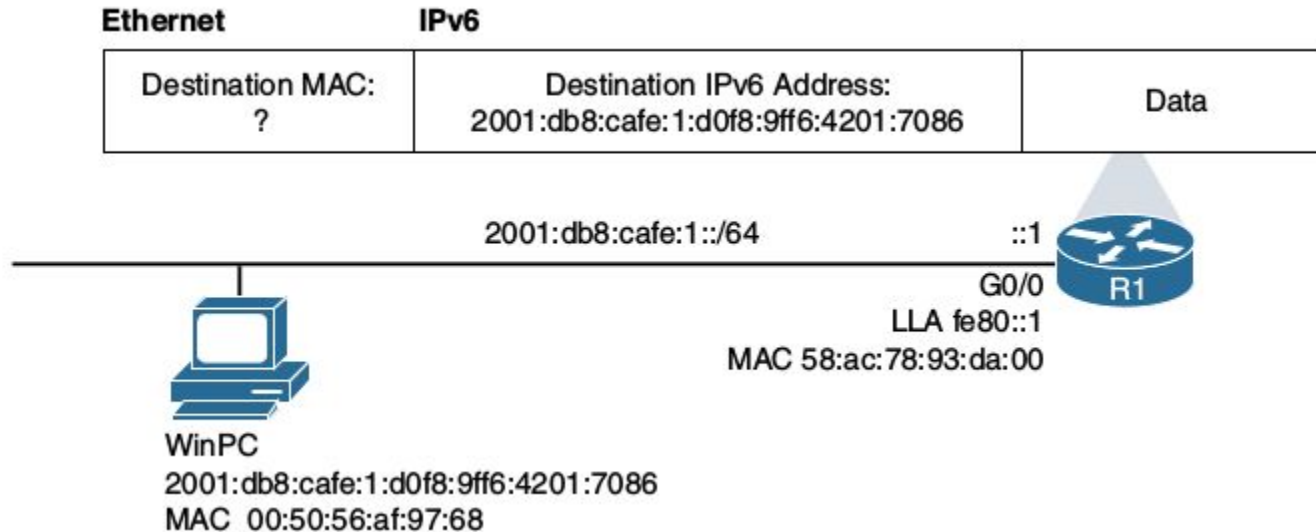
# Address Resolution

- **Address resolution:** Address resolution in IPv6 is similar to ARP in IPv4.
  - A device sends a **Neighbor Solicitation** message when it knows the destination IPv6 address but needs to request its Layer 2 address
  - In response to the Neighbor Solicitation message, the target device sends in a **Neighbor Advertisement** message, similar to an ARP Reply.

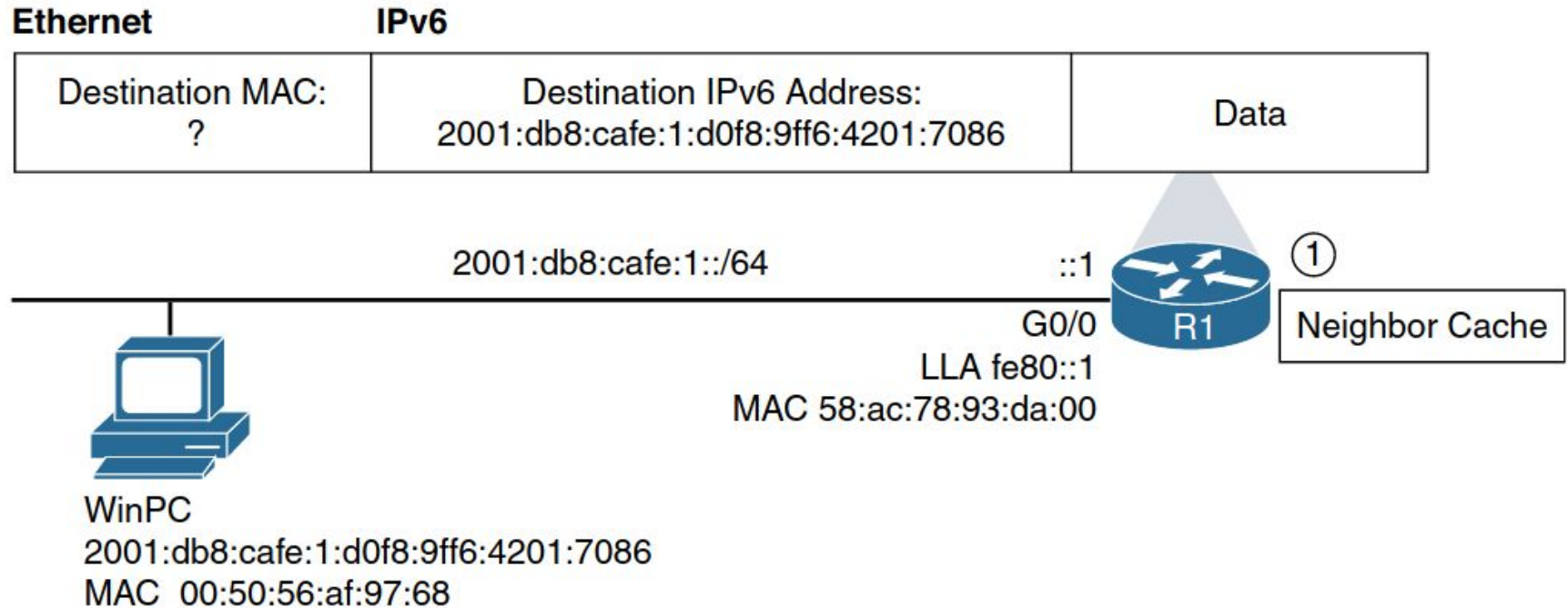
- **Neighbor Cache and Neighbor Unreachability Detection (NUD):**

- IPv6 devices use NS messages and their associated NA messages to build a Neighbor Cache.
- The Neighbor Cache contains a mapping of IPv6 to Ethernet MAC addresses, similar to an IPv4 ARP cache.
- Neighbor Unreachability Detection (NUD) uses NS and NA messages to detect whether another device is reachable on the link.

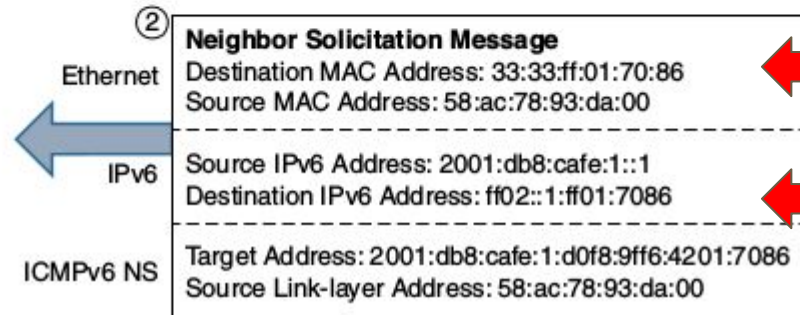
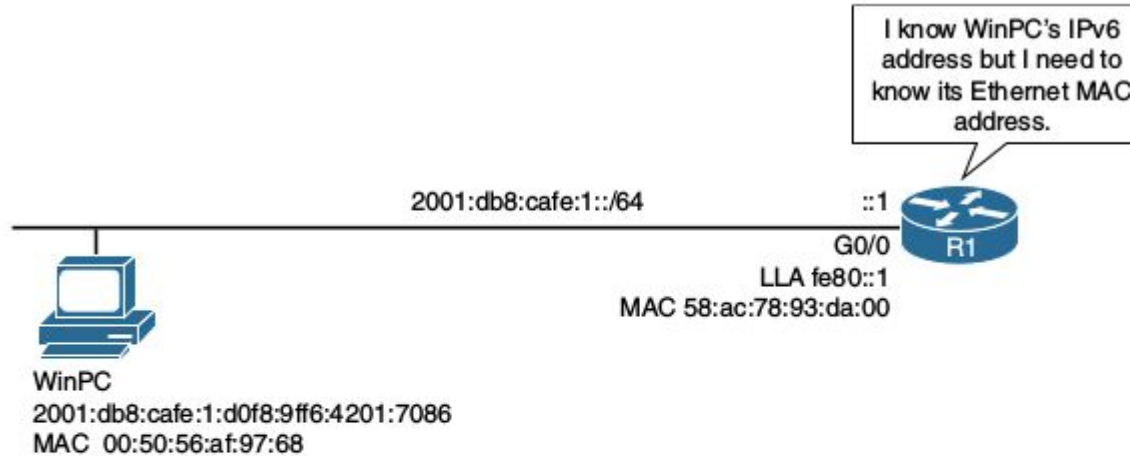
# Finding Destination MAC



# Step1:



# Step-2: Finding Destination MAC



# Deriving Multicast L2 Address

## Global Unicast Address

Global Routing Prefix	Subnet ID	Interface ID	←24 bits→
2001:db8:cafe	0001	0000:0000:00	00:0001

## Solicited-Node Multicast Address

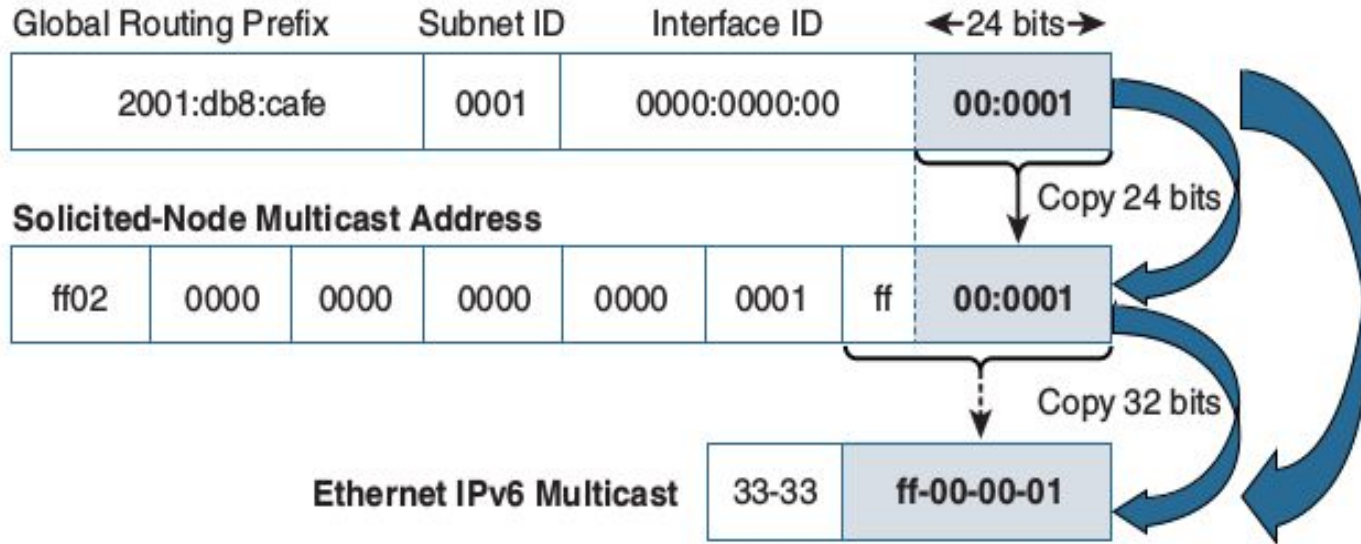
ff02	0000	0000	0000	0000	0001	ff	00:0001
------	------	------	------	------	------	----	---------

## Ethernet IPv6 Multicast

33-33	ff-00-00-01
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Copy 24 bits

Copy 32 bits



## Link-Local Unicast Address

Link-Local Prefix

Link-Local Prefix				Interface ID	←24 bits→
fe80	0000	0000	0000	5aac:78ff:fe	93:da00

## Solicited-Node Multicast Address

Solicited-Node Multicast Address							
ff02	0000	0000	0000	0000	0001	ff	93:da00

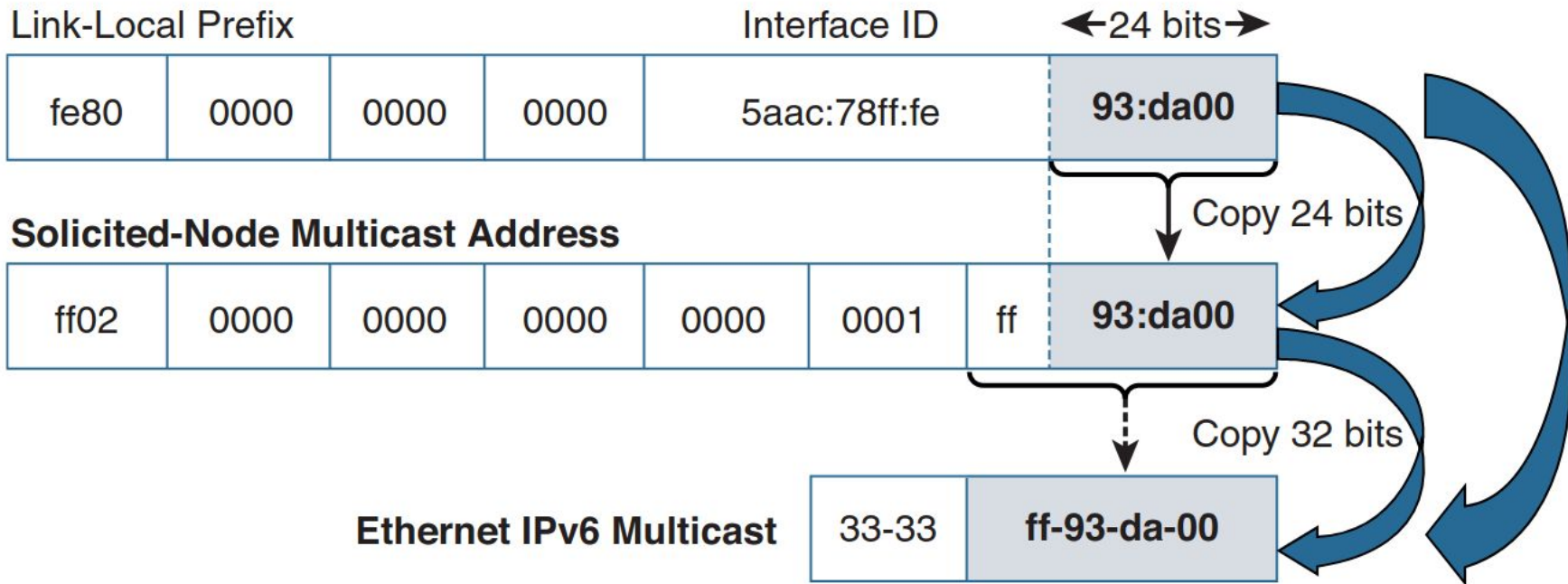
Ethernet IPv6 Multicast

Ethernet IPv6 Multicast	
33-33	ff-93-da-00

←24 bits→

Copy 24 bits

Copy 32 bits



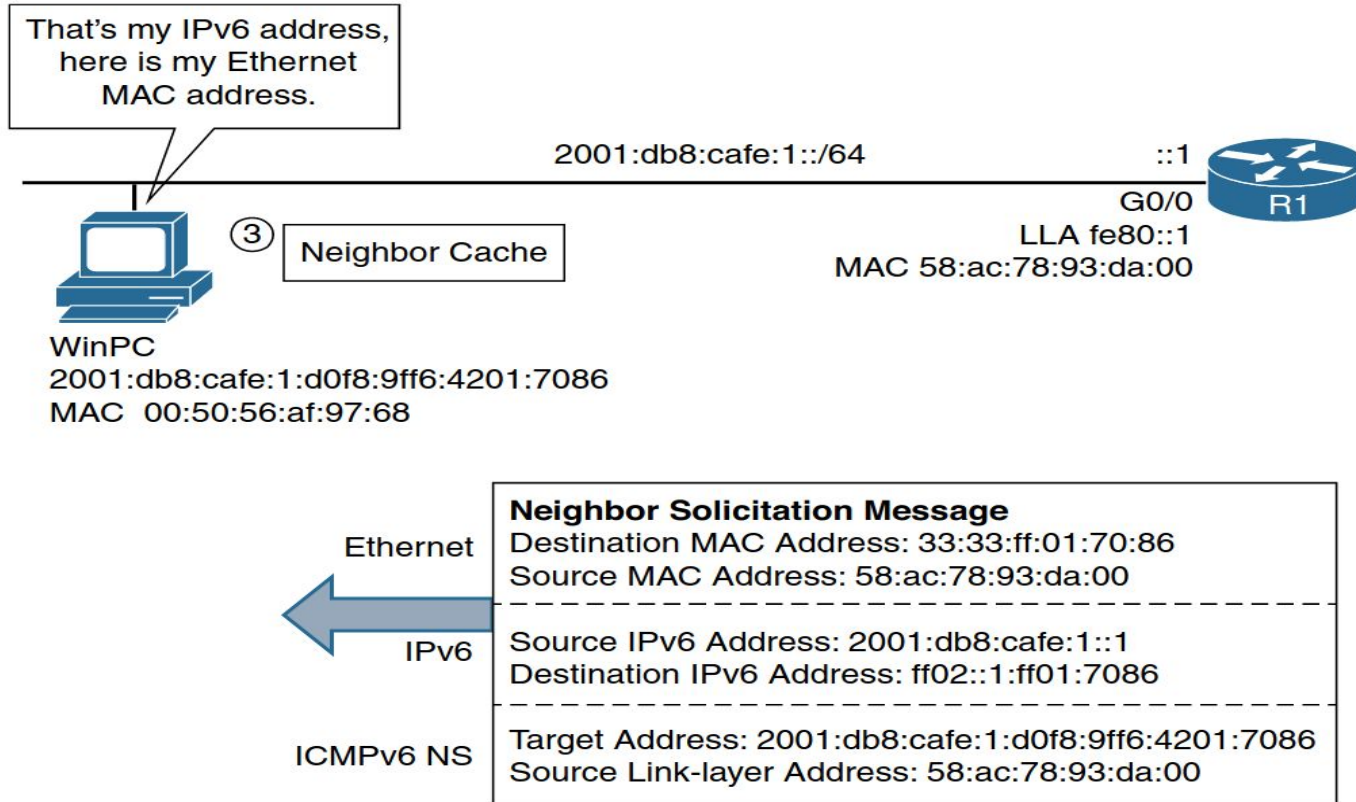
IPv6 multicast addresses, including solicited-node and well-known multicast addresses, are mapped to Ethernet MAC addresses.

**Table 7-5** *Well-Known Multicast to Ethernet MAC Address Mappings*

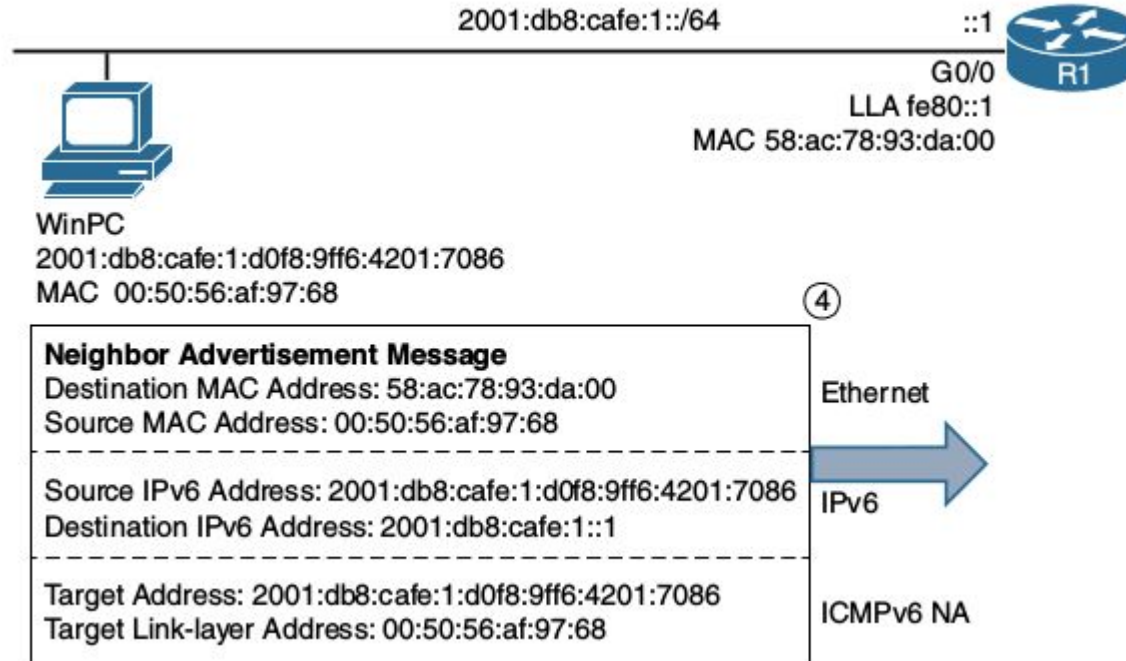
<b>Description</b>	<b>Well-Known Multicast</b>	<b>Mapped Ethernet MAC Address</b>
All-Devices	ff02::1	33-33-ff-00-00-01
All-Routers	ff02::2	33-33-ff-00-00-02
All-OSPF Routers	ff02::5	33-33-ff-00-00-05
All-EIGRP Routers	ff02::a	33-33-ff-00-00-0a

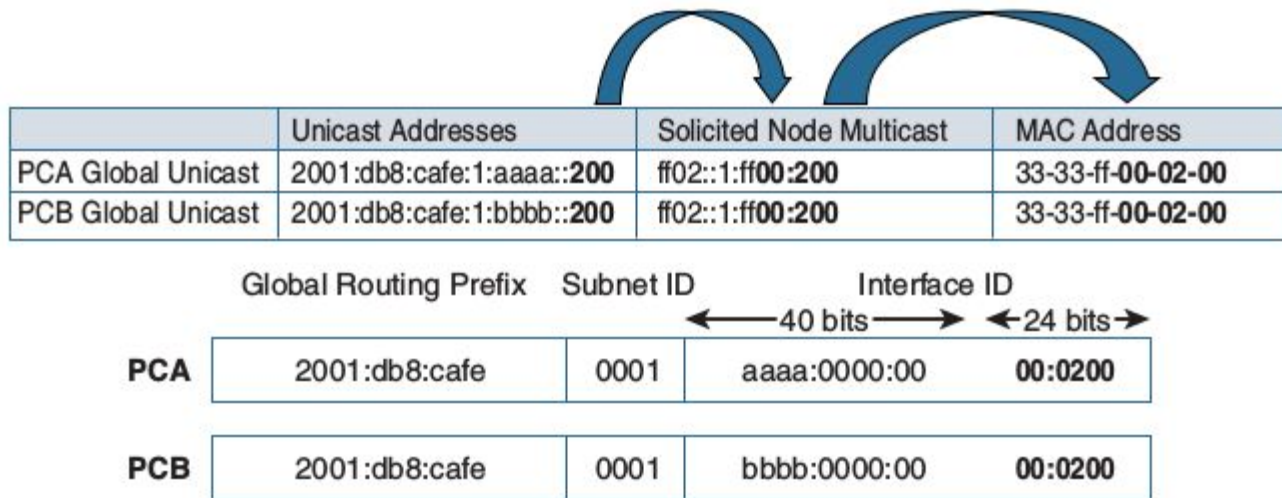


# Step 3: WinPC Is the Target of the NS Message



# Step 4: Neighbor Advertisement





**Figure 7-13** *PCA and PCB with Different GUA Addresses but the Same Solicited-Node Multicast Address*



PCA

2001:db8:cafe:1:aaaa::200  
ff02::1:ff00:200  
33-33-ff-00-02-00



PCB

2001:db8:cafe:1:bbbb::200  
ff02::1:ff00:200  
33-33-ff-00-02-00

ICMPv6 NS Target Address  
2001:db8:cafe:1:aaaa::200

For me

③

Not  
For me

ICMPv6 NS Target Address  
2001:db8:cafe:1:aaaa::200

Destination IPv6:  
ff02::1:ff00:200

For me

②

For me

Destination IPv6:  
ff02::1:ff00:200

Destination MAC:  
33-33-ff-00-02-00

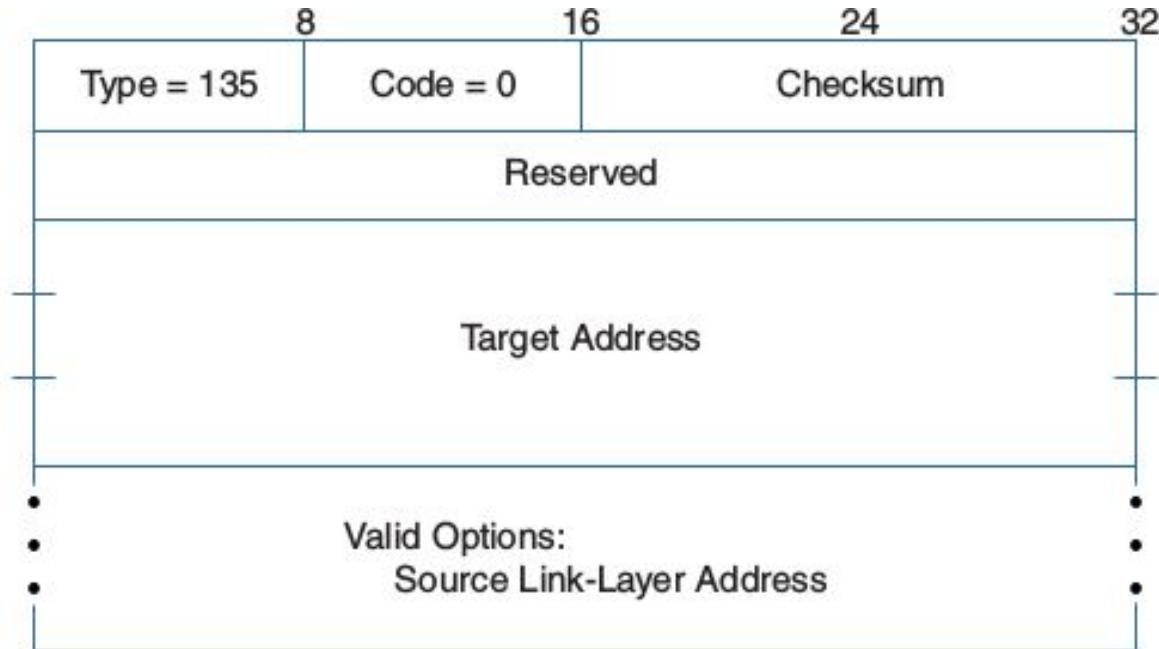
For me

①

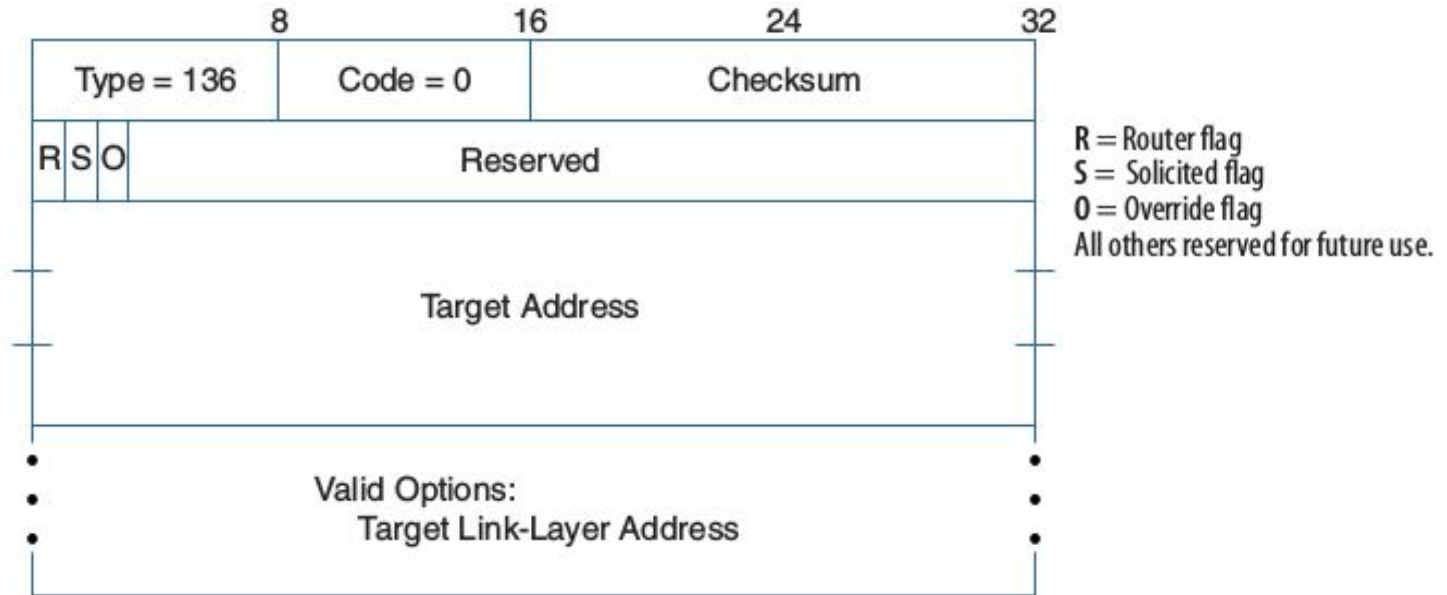
For me

Destination MAC:  
33-33-ff-00-02-00

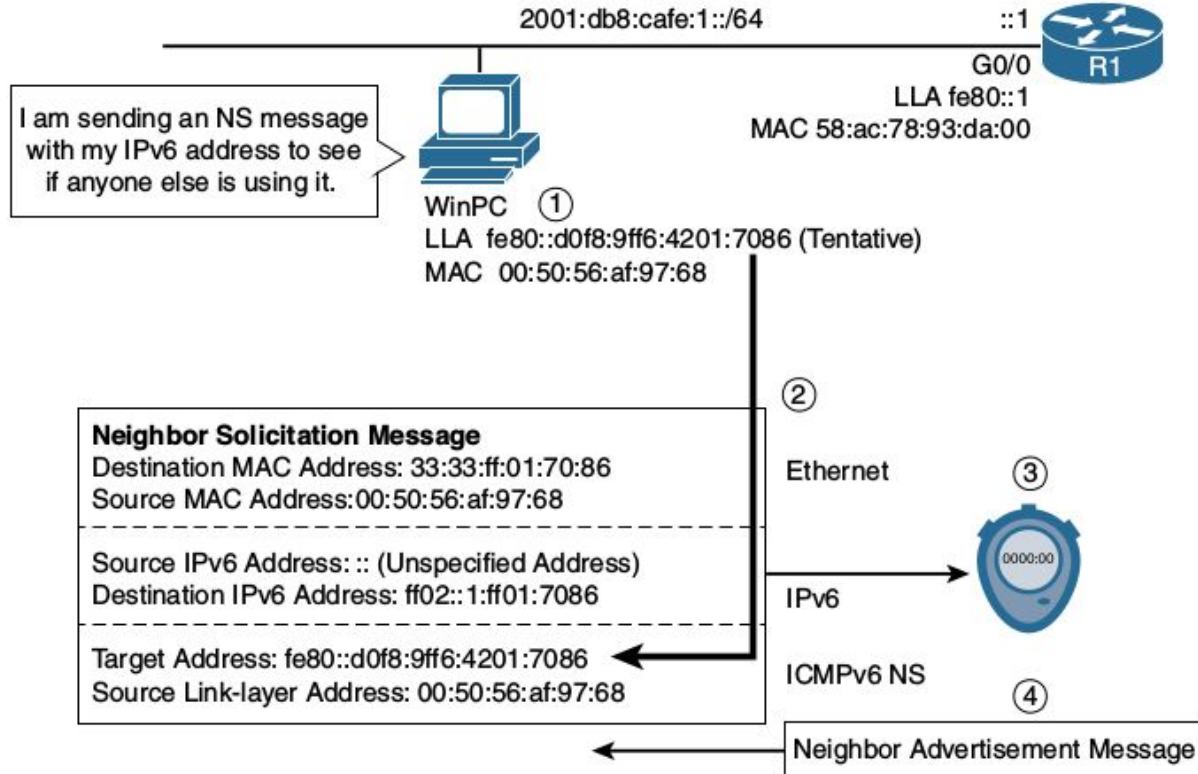
# Neighbor Solicitation Message Format



# Neighbor Advertisement Message Format



# Duplicate Address Detection



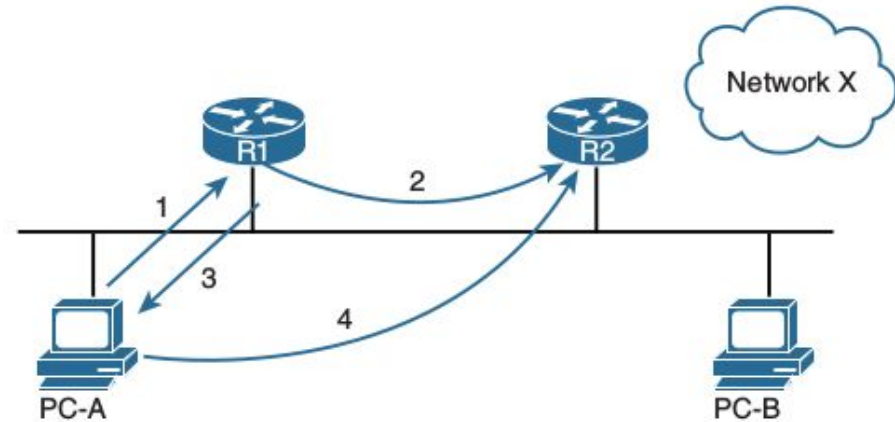
# Nighbor Unreachability Detection (NUD)

- Devices actively track the reachability state for the neighbors to which they are sending packets.
- Conditions like the host losing power or a faulty cable will result in communication failure.
- The confirmation of reachability can be achieved in one of two ways:
  - A Neighbor Advertisement message sent in response to a Neighbor Solicitation message.
  - An upper-layer process indicating a successful connection, such as acknowledgments in an active TCP connection.



# Redirect

- Step 1. PC-A has several packets to send to a device on a remote network, network X. PC-A sends the first packet to router R1, its default gateway.
- Step 2. After checking its routing table, router R1 forwards this packet to router R2.
- Step 3. Router R1 sees that it has forwarded the packet to R2 out the same interface on which it received it from PC-A. R1 sends an ICMPv6 Redirect message to PC-A, suggesting that PC-A use the better first-hop router R2.
- Step 4. PC-A receives the Redirect message and sends subsequent messages directly to router R2.



# Multicast Listener Discovery

- IPv6 routers use Multicast Listener Discovery (MLD) to discover multicast clients on the particular subnet.
- The IPv6 router uses MLDv2.
- Similar to IGMP in IPv4
- MLD uses ICMPv6, which is used to transport the MLD messages.

# MLD messages

- **Multicast Listener Query (Type = decimal 130):** The router periodically transmits host membership query messages.
  - **General Query:** This is used to learn which multicast addresses have listeners on an attached link.
    - The General Query is sent to the link-scope all-nodes multicast address ff02::1, to all-IPv6 devices on the link.
  - **Multicast-Address-Specific Query:** This is used to learn whether a particular multicast address (multicast group) has any listeners on an attached link.
    - An Address-Specific Query is sent to the multicast address being queried.

# MLD Messages

- **Multicast Listener Report (Type = decimal 131):** This message is sent by the listener to register for a multicast group.
  - Can be unsolicited or solicited.
- **Multicast Listener Done (Type = decimal 132):** When a listener no longer wants to receive traffic for a particular multicast group, it sends a Multicast Listener Done.
  - Listener Done messages are sent to the link-scope all-routers multicast address (ff02::2)



### Source for Groups

ff3e:40:2001:db8:cafe:1:aaaa:aaaa  
ff3e:40:2001:db8:cafe:1:bbbb:bbbb



MLD Querier

①

General Query to ff02::1  
(All-IPv6 Devices with Link-scope)



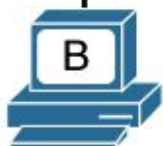
②



Listener Report for Group  
ff3e:40:2001:db8:cafe:1:aaaa:aaaa  
To ff02::16 (All MLDv2 Routers)



③



Listener Report for Group  
ff3e:40:2001:db8:cafe:1:bbbb:bbbb  
To ff02::16 (All MLDv2 Routers)



④



*Suppressed* Listener Report for Group  
ff3e:40:2001:db8:cafe:1:aaaa:aaaa  
To ff02::16 (All MLDv2 Routers)



### Source for Groups

ff3e:40:2001:db8:cafe:1:aaaa:aaaa  
ff3e:40:2001:db8:cafe:1:bbbb:bbbb



④

### Traffic Continues for

ff3e:40:2001:db8:cafe:1:aaaa:aaaa



MLD Querier

②

Anyone else still an active member of this group?

### Address Specific Query for

ff3e:40:2001:db8:cafe:1:aaaa:aaaa  
to ff3e:40:2001:db8:cafe:1:aaaa:aaaa

①



I'm leaving  
this group.

### Listener Done for Group

ff3e:40:2001:db8:cafe:1:aaaa:aaaa  
To ff02::16 (All MLDv2 Routers)



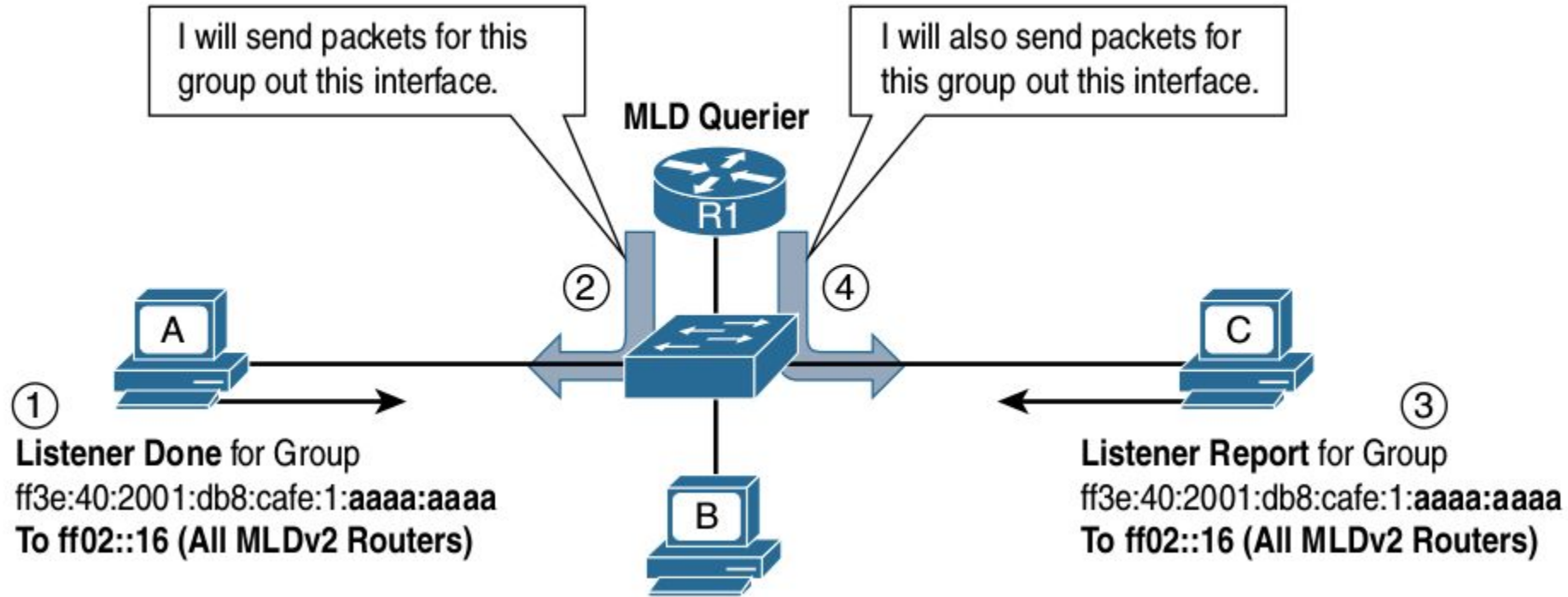
I still want  
these  
packets.

### Listener Report for Group

ff3e:40:2001:db8:cafe:1:aaaa:aaaa  
To ff02::16 (All MLDv2 Routers)

③

# MLD Snooping



# REFERENCES

- Cisco IPv6 Fundamental - 2nd Edition, Rick Graziani