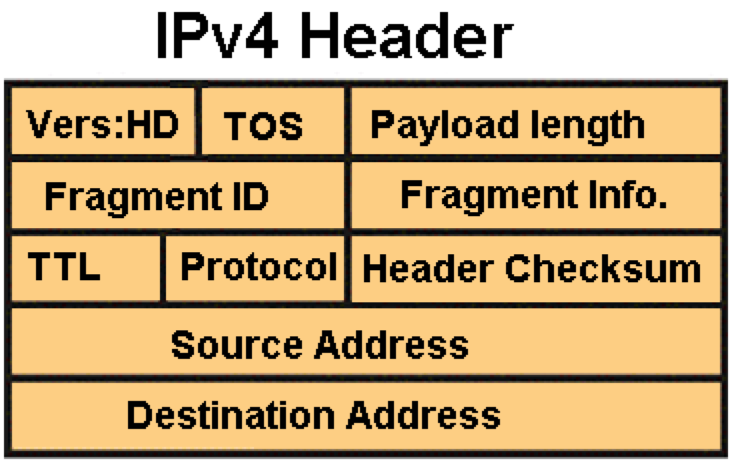
IPv6: Deep Dive
SHARE Session 12153

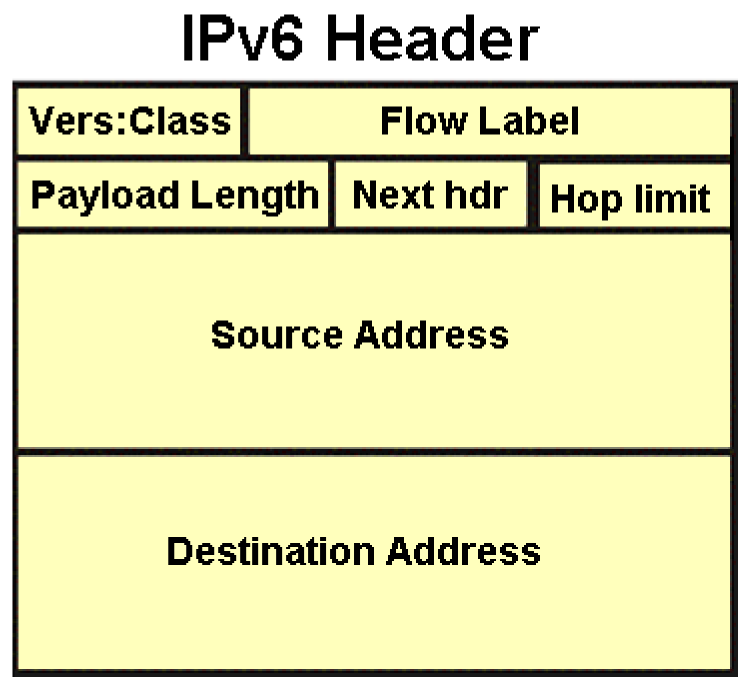
Laura Knapp
WW Business Consultant
Laurak@aesclever.com

What is IPv6?

Addressing	128-bit addresses hierarchically assigned
Routing	Strongly hierarchical (route aggregation)
Performance	Simple datagram
Extensibility	New flexible option header format
	Improved support for extensions and options
Multimedia	Better support for QoS
Multicast	Compulsory-better scope control
Security	Built in security (IPSEC)
Auto-configuration	Stateless and state-full address configuration
Mobility	Better efficiency and security

IPv6 Header



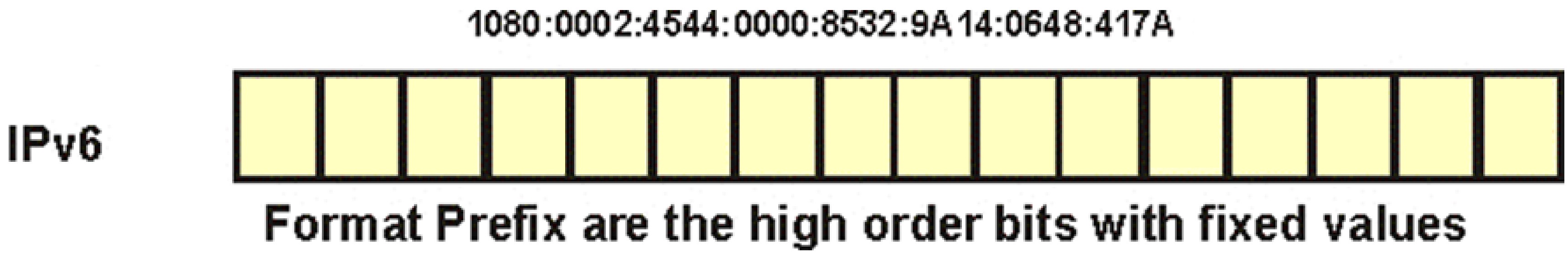


- IPv4 header is 20 bytes: IPv6 header is 40 bytes
- Address increased from 32 to 128 bits
- Fragmentation fields moved out of base header
- Header checksum
- Time to Live replaced with 'Hop Limit'
- Protocol replaced with 'Next Header'
- TOS replaced with 'Flow Label'
- Alignment changed from 32 to 64 bits

Items to Be Discussed

- IP Addressing
- ICMPv6
  - Error Messages
  - Informational Messages
  - Neighbor Discovery Protocol
  - Multicast Listener Discovery Protocol
  - Packet MTU Size
  - Fragmentation
  - Other ICMPv6 functions

Addressing Format



- **Defined in RFC 3513:**
  - **40,282,366,920,938,463,374,607,431,768,211,456 addresses**
  - **40 trillion trillion trillion addresses**
- **Addresses are assigned to interfaces**
- **Multiple address can be defined to a single interface**
- **Address structure**
  - **Ipv6 address = Prefix + Interface id**
- **Separation of ‘who you are’ from ‘where you are connected’**
- **Assignments by ARIN, APNIC, RIPE**

IPv6 Address Types

unicast:

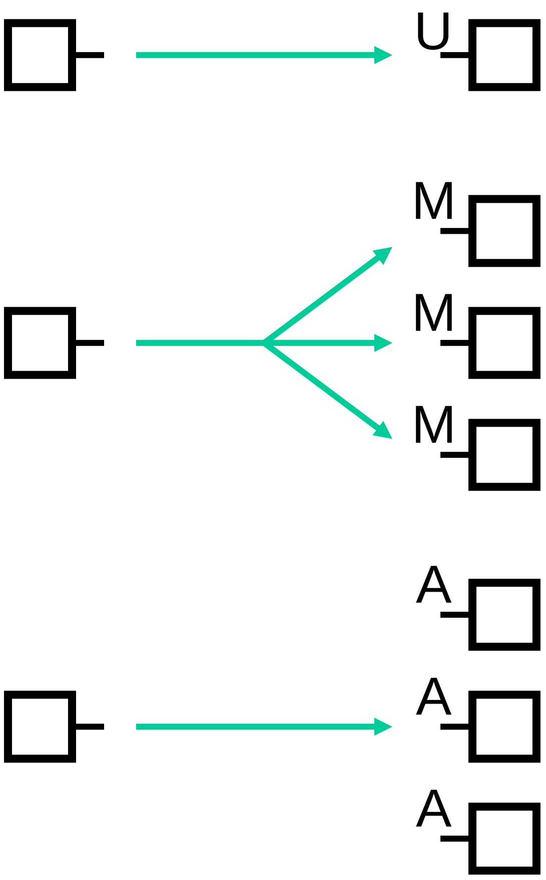
for one-to-one communication

multicast:

for one-to-many communication

anycast:

for one-to-nearest communication



Link Local Address

10 bits	54 bits	64 bits
1111 1110 10	00 00 .. 00	Interface id

- FE80 prefix
- Similar to IPv4 APIPA (169.254.0.0/16)
- Only for on-link communication, not routable
- Used for
  - Auto configured addresses
  - Neighbor discovery process

Multicast Address

8 bits	4 bits	4 bits	8 bits	8 bits	64 bits	32 bits
1111 1111	flags	scope	reserve	plen	net prefix	group prefix

Flags

0: well known address, 1: transient address

Scope

1: Node Local (FF01::1), 2: Link Local (FF02::1)

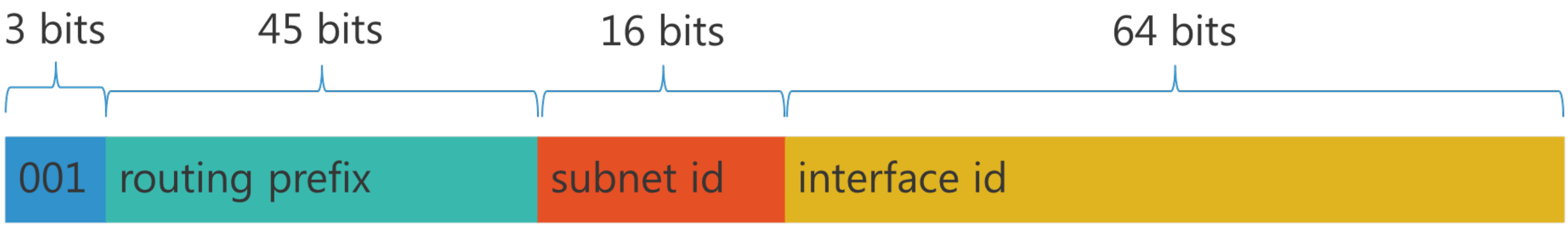
All routers group: FF02::2)

Group ID

1: All nodes, 2: All routers, 101: all NTP servers

- Multicast replaces Broadcast
- All IPv6 nodes must support multicast
- You must enable IGMP snooping

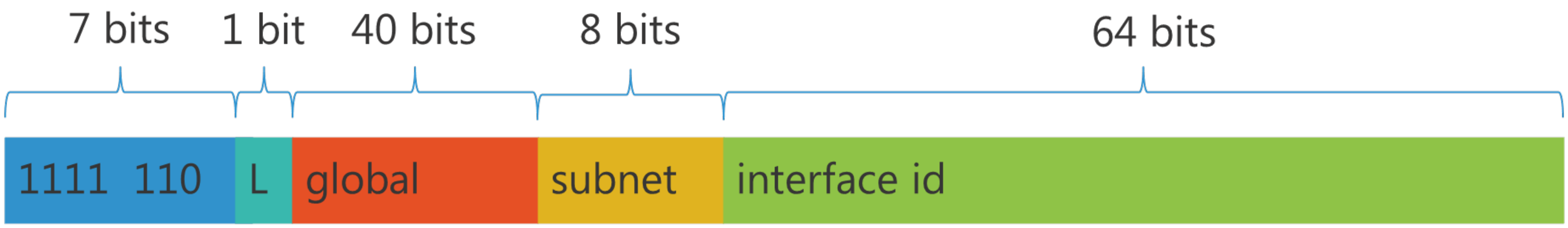
Global Unicast Address



Address Type	Binary Prefix	Prefix
Unspecified	000…0	::/128
Loopback	0000…01	::1/128
ULA	1111 110	FC00::/7
Assigned to RIRs	001	2003:/3
Global Unicast	Everything else!!	

Korea: 2001:0200 – 099F
ATT: 2001:0408/32
Verizon: 2001:0506:0000/48

Unique Local Address (ULA)



- L=1
- FC00::/7 prefix
- Local or site local communications
- Most likely will be unique and not expected to be routable
- Well known, somewhat like the RFC1918

Windows and IPv6

IPv6 is preferred

Nameserver query

Try to reach IPv6

Try to reach IPv4

Timeout

```
Wireless LAN adapter Wireless Network Connection 2:

   Media State . . . . . . . . . . . : Media disconnected
   Connection-specific DNS Suffix  . :

Wireless LAN adapter Wireless Network Connection:

   Media State . . . . . . . . . . . : Media disconnected
   Connection-specific DNS Suffix  . :

Ethernet adapter Local Area Connection:

   Connection-specific DNS Suffix  . : hawaii.rr.com
   Link-local IPv6 Address . . . . . : fe80::6947:83b1:88e2:73d4%13
   IPv4 Address. . . . . . . . . . . : 192.168.1.146
   Subnet Mask . . . . . . . . . . . : 255.255.255.0
   Default Gateway . . . . . . . . . : 192.168.1.1

Ethernet adapter Bluetooth Network Connection:

   Media State . . . . . . . . . . . : Media disconnected
   Connection-specific DNS Suffix  . :

Tunnel adapter Teredo Tunneling Pseudo-Interface:

   Connection-specific DNS Suffix  . :
   IPv6 Address. . . . . . . . . . . : 2001:0:4137:9e76:10f7:1e4b:9d69:43f8
   Link-local IPv6 Address . . . . . : fe80::10f7:1e4b:9d69:43f8%15
   Default Gateway . . . . . . . . . : ::

Tunnel adapter isatap.hawaii.rr.com:

   Media State . . . . . . . . . . . : Media disconnected
   Connection-specific DNS Suffix  . : hawaii.rr.com
```

Address Type Prefixes

- Unspecified
  - used when there is no address
- Loopback
- Link Local Unicast
- Multicast
- Unicast + Anycast
  - hierarchical
  - /13 - /32 to LIRs (ISPs)
  - /48 or /56 to end-users / sites

  - "Site Local" used to exist (fec0::/10) but this has been deprecated in favor of ULA

http://www.iana.org/assignments/ipv6-address-space

0000 .... 0000 (::/128)

0000 .... 0001 (::1/128)

1111 1110 1000 0000 .... (fe80::/16)

1111 1111 .... (ffxx::/8)

The rest, 2000::/3, which is 1/8th of total IPv6 space

2001::/16 = RIRs

2001::/32 = Teredo

2002::/16 = 6to4

3ffe::/16 = 6bone*

fd00::/8 = ULA

* = 6bone shut down on 6/6/6

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- IP Addressing
- ICMPv6
  - Error Messages
  - Informational Messages
  - Neighbor Discovery Protocol
  - Multicast Listener Discovery Protocol
  - Packet MTU Size
  - Fragmentation
  - Other ICMPv6 functions

IPv6: Autoconfiguration

Combination

ARP : ICMP router discovery : ICMP redirect

Neighbor discovery

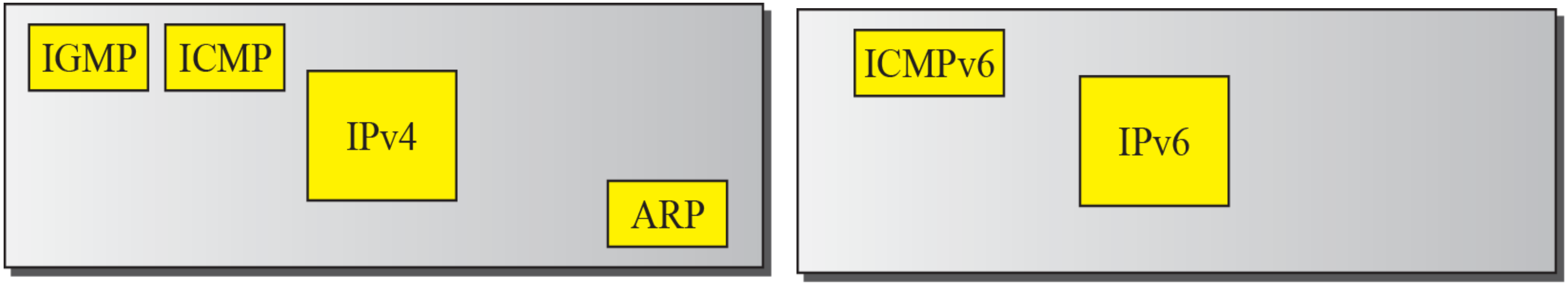
- Multicast and unicast datagrams
- Establishes MAC address on same network
- ICMPv6 router solicitation
- ICMPv6 router advertisement
- ICMPv6 neighbor solicitation
- ICMPv6 redirect
- ICMPv6 includes IGMP protocol for Multicast IP
  - Reduces impact of finding hosts

Stateless: router configures a host with IPv6 address

Stateful: DHCP for IPv6

Link Local Address: IPv6 connectivity on isolated LANs

ICMPv4 and ICMPv6 Quick View



Network layer in version 4

Network layer in version 6

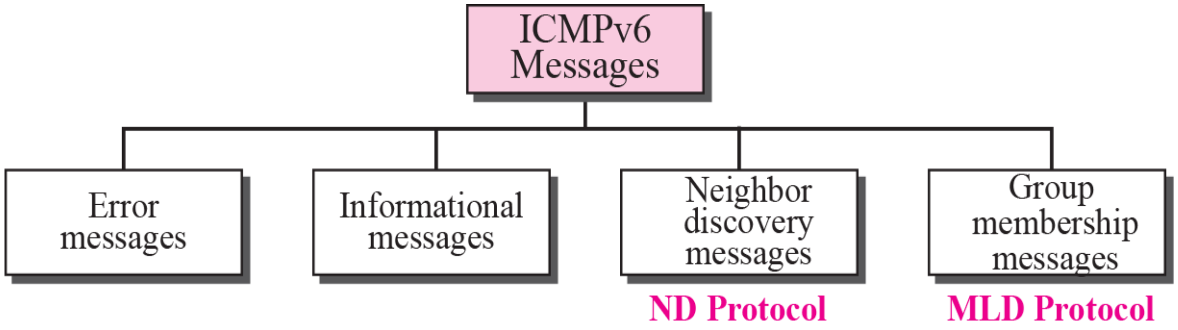
ICMPv6 is more complicated than ICMPv4.

Protocol consolidation occurred in IPv6.

Additional messages have been added.

ICMPv6

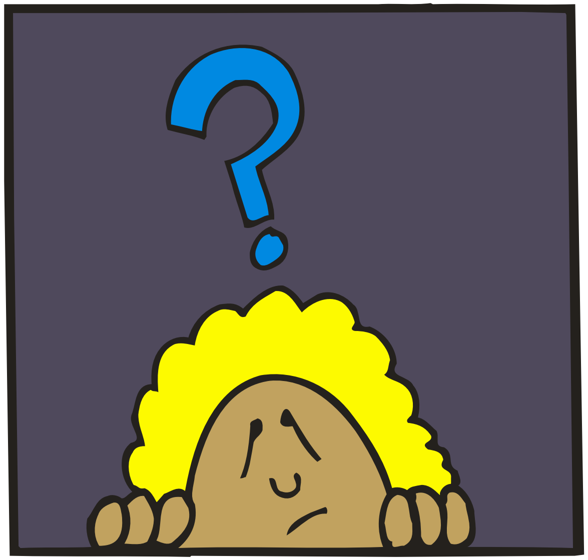
- ICMPv6 is used by IPv6 nodes to report errors encountered in processing packets, and to perform other internet-layer functions, such as diagnostics (ICMPv6 "ping")
- ICMPv6 is an integral part of IPv6 and MUST be fully implemented by every IPv6 node
- ICMPv6 messages are grouped into two classes:
  - error messages - Types 0-127
  - informational messages - Types 128-255
- IPv6 next ‘header’ value for ICMPv6 is 58



ICMPv6 Functions

Reports:

- **packet processing errors**
- **intranetwork communications path diagnosis**
- **multicast membership**



New functions:

- **Neighbor Discovery**
  - **allows nodes on the same link to discover each other**
  - **allows nodes to discover each other's addresses**
  - **finds routers for paths to other networks**
  - **determines the fully qualified name of a node**
  - **path MTU discovery determines the maximum path size along a path**

ICMPv6 Header

Three Fields

Type (8 bits)

- Indicates the type of the message.
- If the high order bit = 0 (0- 127)→ error message
- if the high-order bit = 1 (128 – 255) → information message.

Code (8 bits)

- content depends on the message type, and it is used to create an additional level of message granularity.

Checksum (16 bits)

- Used to detect errors in the ICMP message and in part of the IPv6 message.

MAC header	IPv6 header	ICMPv6 header	ICMPv6 message

<table>
<tr><td>00</td><td>01</td><td>02</td><td>03</td><td>04</td><td>05</td><td>06</td><td>07</td><td>08</td><td>09</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td><td>31</td></tr>
<tr><td colspan="8">Type</td><td colspan="8">Code</td><td colspan="16">Checksum</td></tr>
<tr><td colspan="32">ICMPv6 message
...</td></tr>
</table>

ICMPv6 Messages

ICMPv6 messages are grouped into two classes:

- **Error messages**
  - To provide feedback to a source device about an error that has occurred.
  - Generated specifically in response to some sort of action, usually the transmission of a datagram
  - Identified as such by having a zero in the high-order bit of their message
  - Type field values 0 to 127.
- **Informational messages**
  - Used to let devices exchange information, implement certain IP-related features, and perform testing.
  - Message Types from 128 to 255.

Error messages

Type	Description	References
1	Destination unreachable:	RFC 2463
2	Packet too big.	RFC 2463
3	Time exceeded.	RFC 2463
4	Parameter problem.	RFC 2463

Informational messages

Type	Description	References
128	Echo request.	RFC 2463
129	Echo reply.	RFC 2463

Many of these ICMP types have a "code" field.

ICMPv6 Error Messages

Type Value	Message Name	Summary Description of Message Type
1	Destination Unreachable	Indicates that a datagram could not be delivered to its destination. *Code* value provides more information on the nature of the error.
2	Packet Too Big	Sent when a datagram cannot be forwarded because it'is too big for the MTU of the next hop in the route. This message is only needed in IPv6 because routers cannot fragment oversized messages in IPv6, but they can in IPv4.
3	Time Exceeded	Sent when a datagram has been discarded prior to delivery because the *Hop Limit* field was reduced to zero.
4	Parameter Problem	Indicates a miscellaneous problem (specified by the *Code* value) in delivering a datagram.

ICMPv6 Error Messages

0	8	16	31
Type: 1	Code: 0 to 6	Checksum	
Unused (All 0s)			
As much of received datagram as possible without exceeding the maximum IPv6 MTU			

ICMPv6 error messages:

1 Destination unreachable

- **code=0 no route to destination**
- **code=1 communication with destination prohibited**
- **code=2 (not assigned)**
- **code=3 address unreachable**
- **code=4 port unreachable**
- **code=5 source address failed**
- **code=6 reject route to destination**

ICMPv6 Error Messages

0	8	16	31
Type: 2	Code: 0	Checksum	
MTU			
As much of received datagram as possible without exceeding the maximum IPv6 MTU			

2 Packet too big

code=0 next byte contains the maximum transmission MTU of the next hop

0	8	16	31
Type: 3	Code: 0 or 1	Checksum	
Unused (All 0s)			
As much of received datagram as possible without exceeding the maximum IPv6 MTU			

3 Time exceeded

0	8	16	31
Type: 4	Code: 0, 1, 2	Checksum	
Offset pointer			
As much of received datagram as possible without exceeding the maximum IPv6 MTU			

4 Parameter problem

code=0 erroneous header field encountered

code=1 unrecognized next header type encountered

code=2 unrecognized IPv6 option encountered

ICMPv6 Informational Messages

ICMPv6 Informational Messages	128	*Echo Request*	Sent by a device to test connectivity to another device on the internetwork.	2463
	129	*Echo Reply*	Sent in reply to an *Echo (Request)* message; used for testing connectivity.	2463
	133	*Router Solicitation*	Prompts a router to send a *Router Advertisement*.	2461
	134	*Router Advertisement*	Sent by routers to tell hosts on the local network the router exists and describe its capabilities.	2461
	135	*Neighbor Solicitation*	Sent by a device to request the layer two address of another device while providing its own as well.	2461
	136	*Neighbor Advertisement*	Provides information about a host to other devices on the network.	2461
	137	*Redirect*	Redirects transmissions from a host to either an immediate neighbor on the network or a router.	2461
	138	*Router Renumbering*	Conveys renumbering information for router renumbering.	2894

ICMPv6 Informational Messages

0	8	16	31
Type: 128	Code: 0	Checksum	
Identifier		Sequence number	
Optional data Sent by the request message; repeated by the reply message			

128 Echo request

code=0 and Identifier and sequence number carried

129 Echo reply

code=0 and identifier and sequence number carried

0	8	16	31
Type: 129	Code: 0	Checksum	
Identifier		Sequence number	
Optional data Sent by the request message; repeated by the reply message			

ICMPv6 Neighbor Discovery Protocol (NDP)

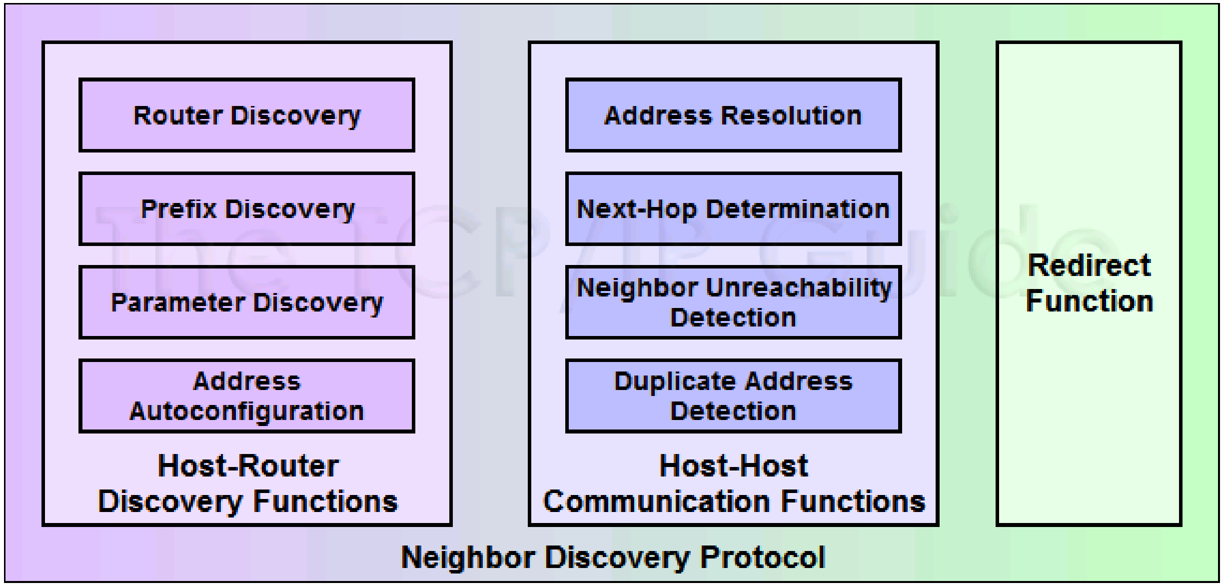
Defined in RFC 2461

- **Combines prior IPV4 functions**
  - **ARP (RFC 826)**
  - **Router Discovery (RFC 1256)**
  - **Redirect Message (RFC 792)**

Mechanisms to:

- **Discover routers**
- **Prefix discovery for on-link**
- **Parameter discovery (i.e link MTU)**
- **Address autoconfiguration**
- **Address resolution**
- **Next hop determination**
- **Neighbor unreachable**
- **Duplicate address**
- **Redirect**

NDP Groups



Main three functions:

1. Host-Router Functions
2. Host-Host Communication Functions
3. Redirect Function

NDP Functional Groups

Host-Router Discovery Functions

- **Router Discovery**
  - Core function of this group: the method by which hosts locate routers on their local network.
- **Prefix Discovery**
  - Closely related to the process of router discovery is prefix discovery.
  - Determines what network they are on, which tells them how to differentiate between local and distant destinations and whether to attempt direct or indirect delivery of datagrams.
- **Parameter Discovery**
  - A host learns important parameters about the local network and/or routers, such as the MTU of the local link.
- **Address Autoconfiguration**
  - Hosts in IPv6 are designed to be able to **automatically configure themselves**, but this requires information that is normally provided by a router.

Host-Host communications

- **Address Resolution**
  - The process by which a device determines the layer two address of another device on the local network from that device's layer three (IP) address.
  - Performed by ARP in IP version 4.
- **Next-Hop Determination**
  - Looking at an IP datagram's destination address and determining where it should next be sent.
- **Neighbor Unreachability Detection**
  - Determining whether or not a neighbor device can be directly contacted.
- **Duplicate Address Detection (DAD)**
  - Determining if an address that a device wishes to use already exists on the network.

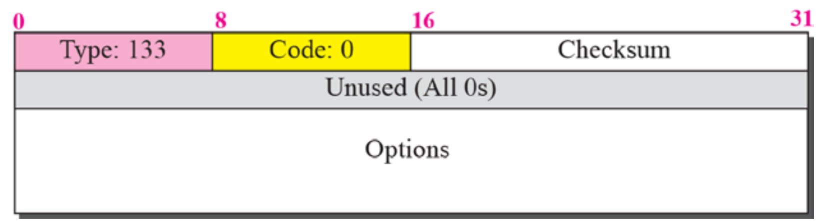
Redirect Function

  - The technique whereby a router informs a host of a better next-hop node to use for a particular destination.

ICMPv6 Router Solicitation/Advertisement

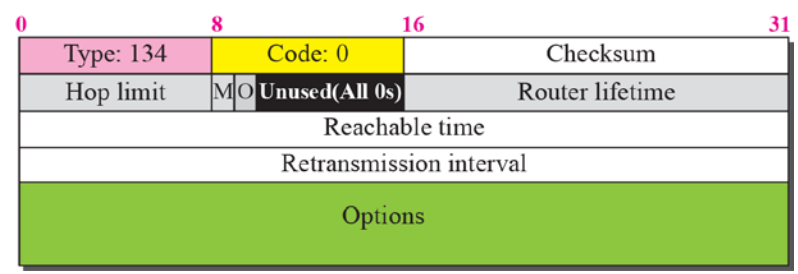
Router Solicitation (ICMPv6 Type 133)

Sent by hosts to request that any local routers send a *Router Advertisement* message so they don't have to wait for the next regular advertisement message.



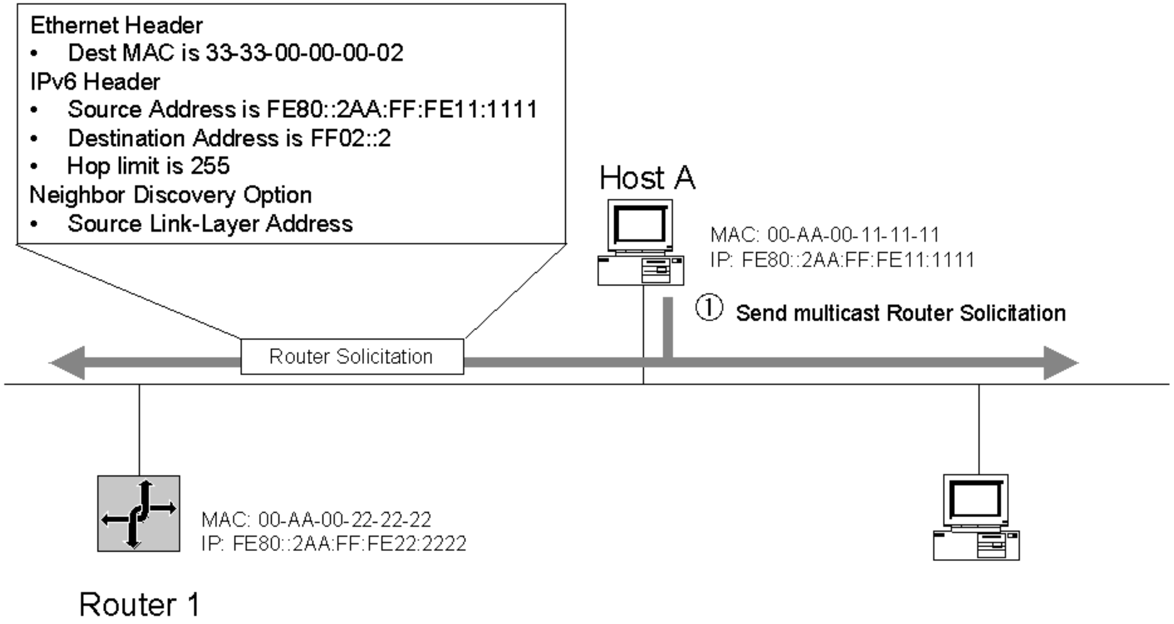
Router Advertisement (ICMPv6 Type 134)

Sent regularly by routers to tell hosts that they exist and to provide them with important prefix and parameter Information.



Sent on periodic basis from router to the 'all nodes address'
Hop limit should be 255
Could include security header
M=1 use DHCP for address configuration
O=1 use stateful protocol for address configuration

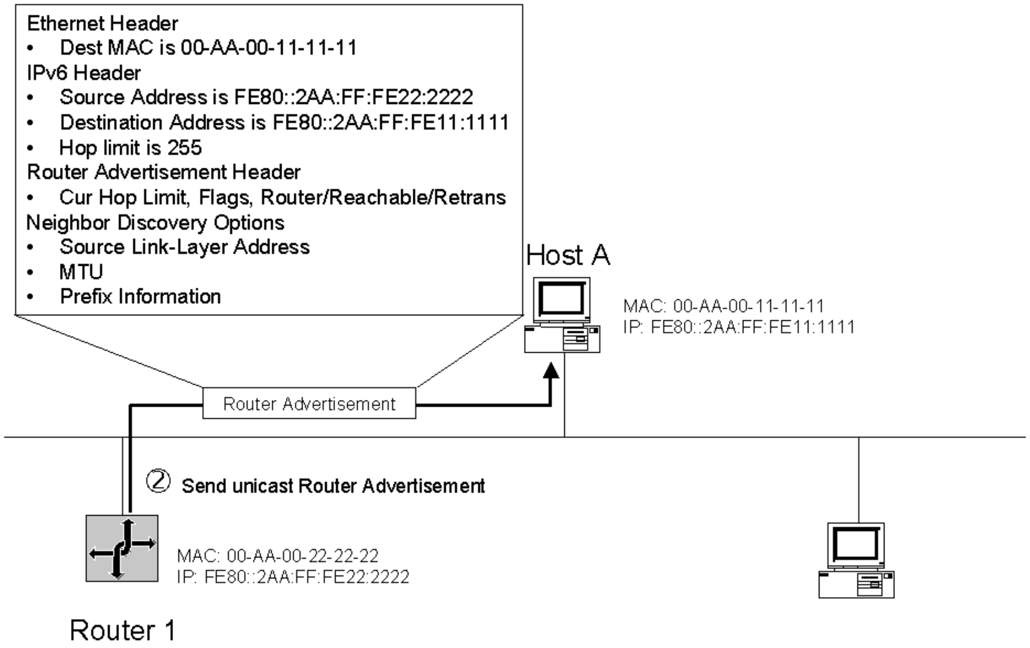
IPv6 Router Discovery



To forward packets to off-link destinations,
Host A must discover the presence of Router 1.

Host A sends a multicast Router Solicitation to the address FF02::2

Router Discovery Response



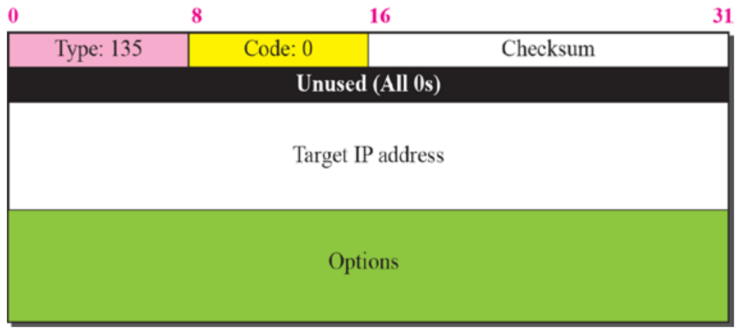
Router 1, having registered the multicast address of 33-33-00-00-00-02 with its Ethernet adapter, receives and processes the Router Solicitation.

Router 1 responds with a unicast Router Advertisement message containing configuration parameters and local link prefixes

ICMPv6 Neighbor Messages

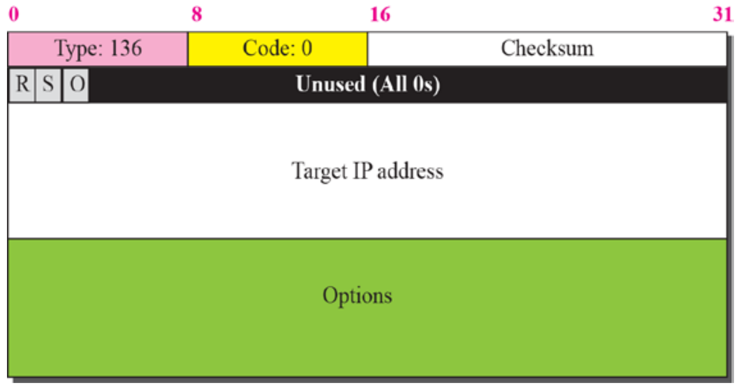
Neighbor Solicitation (ICMPv6 Type 135)

- Nodes ask for link layer address of a target while providing their own link layer address to the target.
- Multicast to resolve an address in the range FF02:::::001:FF00:000 to FF02:::::001:FFF:FFF
- Take low order 32 bits of address and append to the following prefix: FF02:::::001.
- Unicast to verify the reachability of a neighbor.

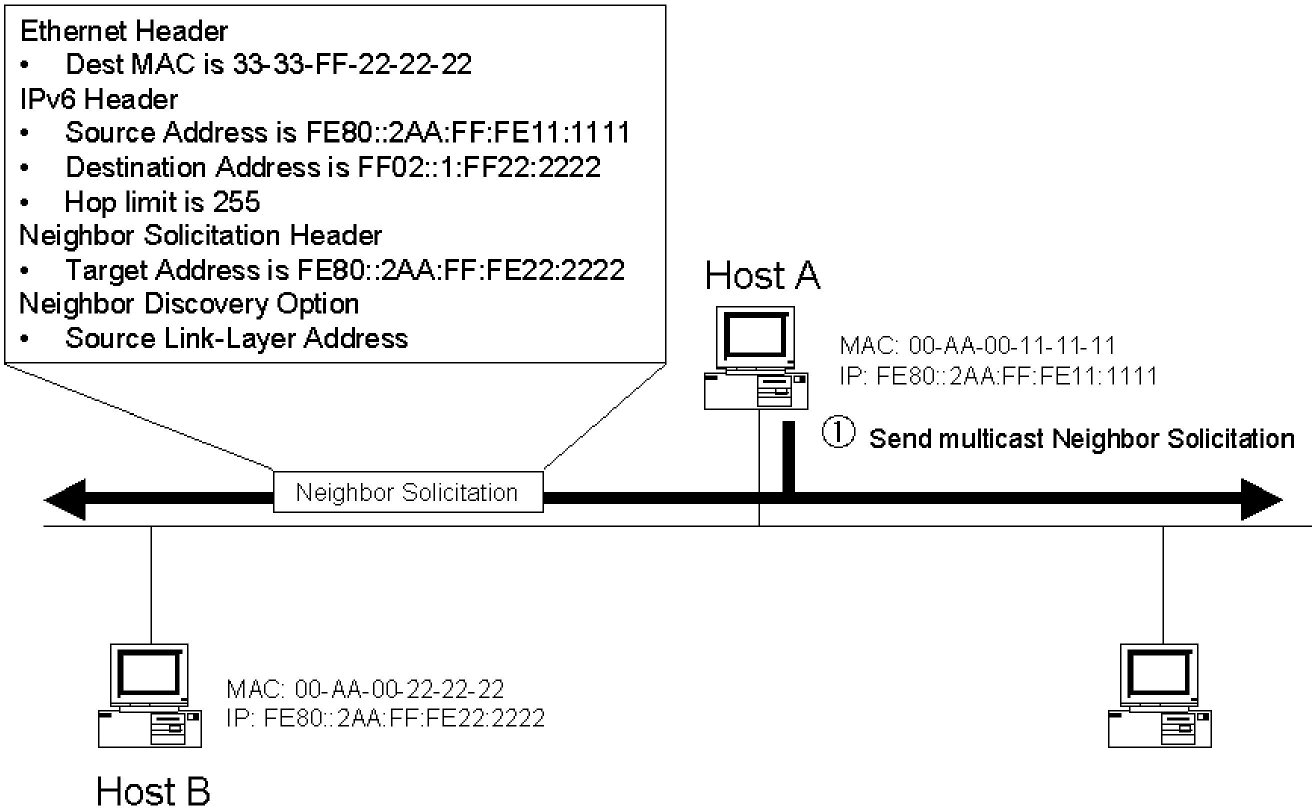


Neighbor Advertisement (ICMPv6 Type 136)

- Sent by nodes in response to Neighbor solicitation message.
- Can be sent unsolicited to quickly ask for information
- Identify sender as router, destination address, or over-ride existing cache

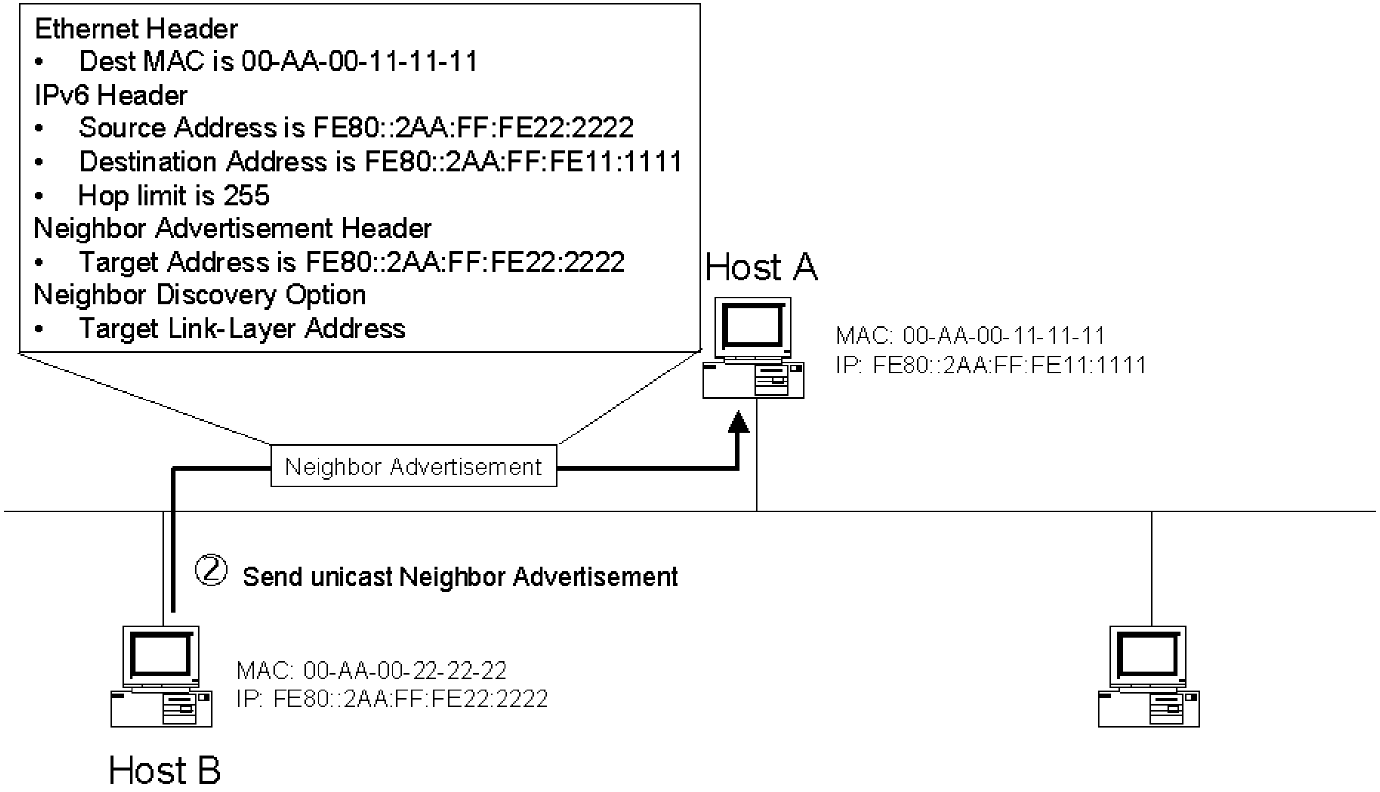


Address Resolution: Multicast Neighbor Solicitation



To send a packet to Host B, Host A must use address resolution to resolve Host B's link-layer address.

Address Resolution: Unicast Neighbor Notification



Host B, having registered the solicited-node multicast address of 33-33-FF-22-22-22 with its Ethernet adapter, receives and processes the Neighbor Solicitation. Host B responds with a unicast Neighbor Advertisement message

Neighbor Solicitation and Advertisement

Traces | Query Builder | Packet Summary | Session Summary

Packet Summary

ID	Timestamp	Datagram Size	Local IP	Rmt. IP	Protocol	Messages
320	06:14:34:0405	72	2001:428:3804:0	FF02::1:FF00:1	ICMPv6	
321	06:14:34:0460	161	10.2.0.236	239.255.255.250	UDP	
322	06:14:34:0596	72	FE80::1	2001:428:3804:0	ICMPv6	

Traces | Query Builder | Packet Summary | Session Summary | Packet Details

Packet Details

Packet Details Hex

Packet Details

```
Packet ID : 320
Time : 4/10/2012 06:14:34:0405 HAT

IP Version 6
Source      : 2001:428:3804:0:D78:D8B8:F88D:8A5A
Destination : FF02::1:FF00:1
Traffic Class : 0x000
Flow Label : 0x000
Payload Length : 32
Next Header(Protocol) : ICMPv6
Hop Limit : 255

ICMPv6 Informational Message:
Type: Neighbor Solicitation (135)
Code:  0
Checksum: 0xEE6B
Target Address: FE80::1

ICMPv6 Option
    Type: Source Link_layer Address(1)
    Length: 8 bytes
    Link-layer address: EC:55:F9:C1:E1:51
```

Packet Details

Packet Details Hex

Packet Details

```
Packet ID : 322
Time : 4/10/2012 06:14:34:0596 HAT

IP Version 6
Source      : FE80::1
Destination : 2001:428:3804:0:D78:D8B8:F88D:8A5A
Traffic Class : 0x000
Flow Label : 0x000
Payload Length : 32
Next Header(Protocol) : ICMPv6
Hop Limit : 255

ICMPv6 Informational Message:
Type: Neighbor Advertisement (136)
Code:  0
Checksum: 0xD8D5
Flags:
  1... = Router: Set
  .1.. = Solicited: Set
  ..1. = Override: Set
Target Address: FE80::1

ICMPv6 Option
    Type: Target Link_layer Address(2)
    Length: 8 bytes
    Link-layer address: 00:08:E2:60:18:1A
```

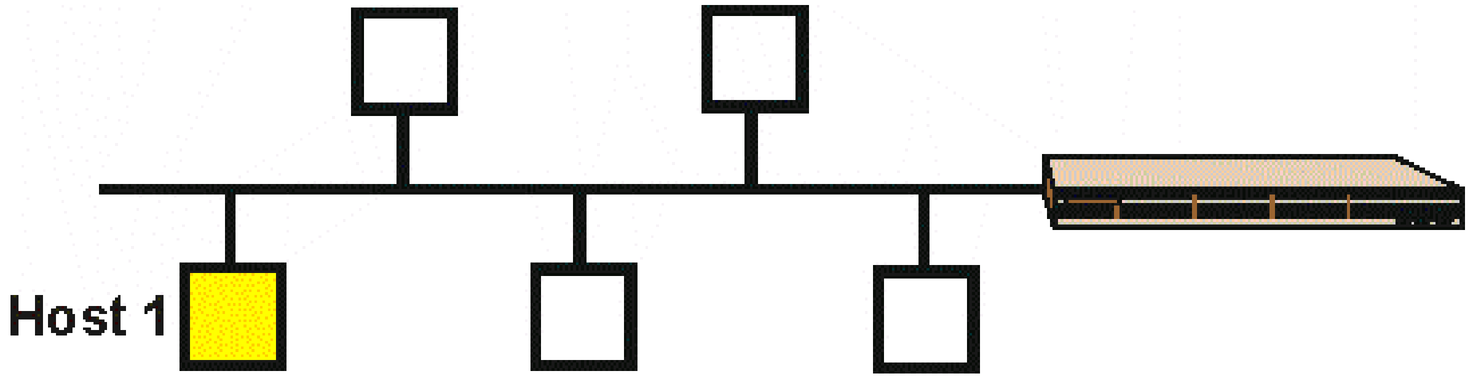
Neighbor Discovery Table

```
RouterA#show ipv6 neighbors
IPv6 Address                     Age Link-layer Addr State Interface
FEC0::1:200:86FF:FE4B:F9CE         0 0000.864b.f9ce  REACH FastEthernet0/0
<waiting of 10 minutes>
RouterA#show ipv6 neighbors
IPv6 Address                     Age Link-layer Addr State Interface
FEC0::1:200:86FF:FE4B:F9CE         2 0000.864b.f9ce  STALE FastEthernet0/0
FE80::200:86FF:FE4B:F9CE          10 0000.864b.f9ce  STALE FastEthernet0/0
```

Adding a Static Entry in the Neighbor Discovery Table (Cisco Feature)

```
RouterA(config)#ipv6 unicast-routing
RouterA(config)#ipv6 neighbor fec0::1:0:0:1:b fastEthernet 0/0 0080.12ff.6633
RouterA(config)#exit
RouterA#show ipv6 neighbors
IPv6 Address                    Age Link-layer Addr State Interface
FEC0::1:200:86FF:FE4B:F9CE       15 0000.864b.f9ce  STALE FastEthernet0/0
FEC0::1:0:0:1:B                   - 0080.12ff.6633  REACH FastEthernet0/0
FE80::200:86FF:FE4B:F9CE         15 0000.864b.f9ce  STALE FastEthernet0/0
```

IPv6 Auto-configuration



- Host 1 comes on line and generates a link local address.
- Host 1 sends out a query called neighbor discovery to the same address to verify uniqueness. If there is a positive response, a random number generator is used to generate a new address.
- Host 1 multicasts a router solicitation message to all routers.
- Routers respond with a router advertisement that contains the IPv6 Address prefix and other information.
- Host 1 automatically configures its global address by appending its interface ID to the AGA
- Host 1 can now communicate

Prefix Advertisement

Packet Summary

ID	Timestamp	Datagram Size	Local IP	Rmt. IP	Protocol	Messages	Local Port	Rmt. Port	Seq. Number	Ack. Number	Window Size
132	06:13:39:2874	104	FE80::1	FF02::1	ICMPv6						

Packet Details

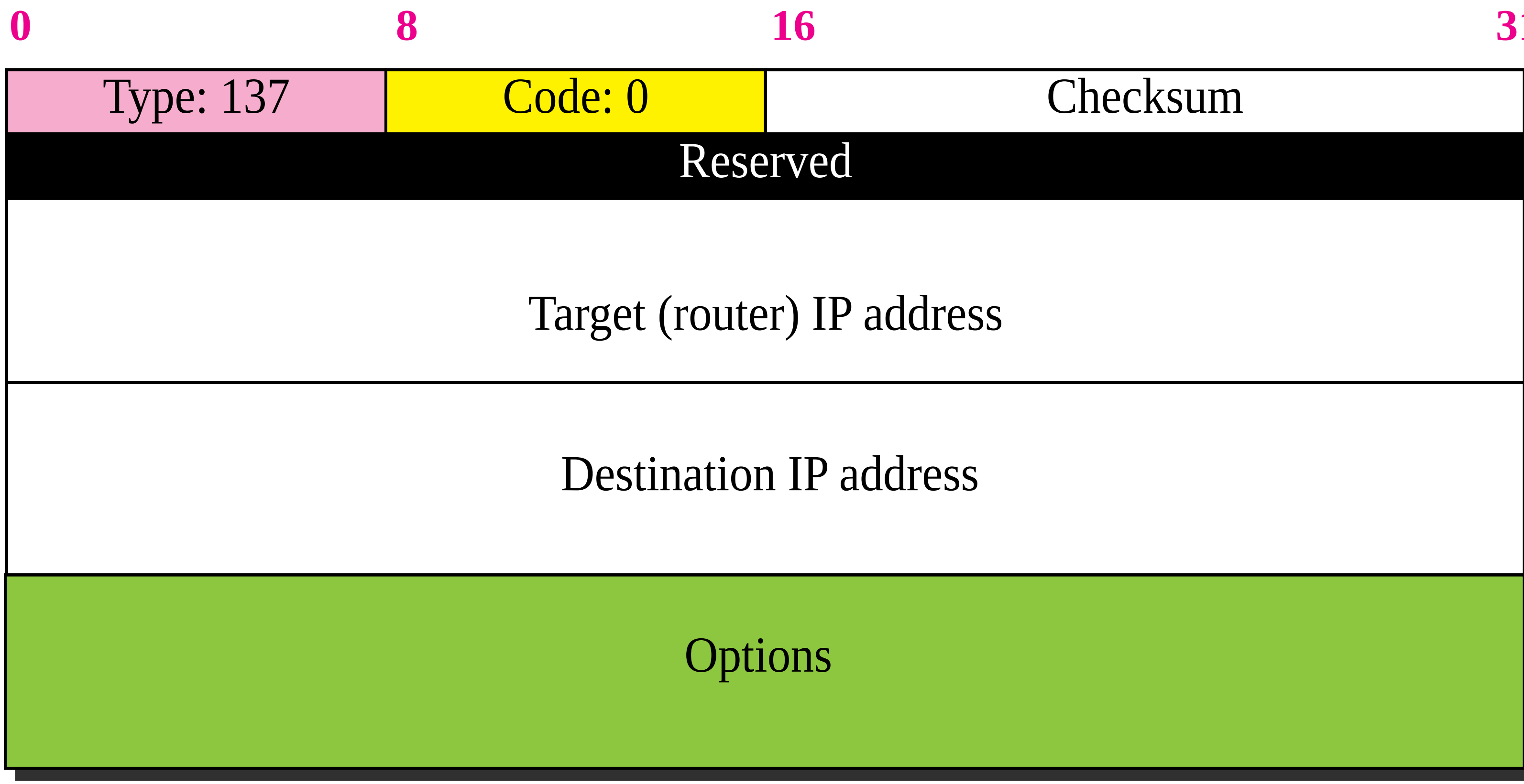
Packet Details Hex

Packet Details

```
Packet ID : 132
Time : 4/10/2012 06:13:39:2874 HAT

IP Version 6
Source      : FE80::1
Destination : FF02::1
Traffic Class : 0x000
Flow Label : 0x000
Payload Length : 64
Next Header(Protocol) : ICMPv6
Hop Limit : 255

ICMPv6 Informational Message:
Type: Router Advertisement (134)
Code:  0
Checksum: 0xC673
Cur hop limit: 64
Flags:
  1... .... = Managed address configuration: Set
  .0.. .... = Other configuration: Not Set
  ..0. .... = Home Agent: Not Set
  ...0 0... = Default Router Preference: Medium
  .... .0.. = Proxy: Not Set
Router lifetime (s): 1800
Reachable time (ms): 0
Retrans timer (ms): 0
```

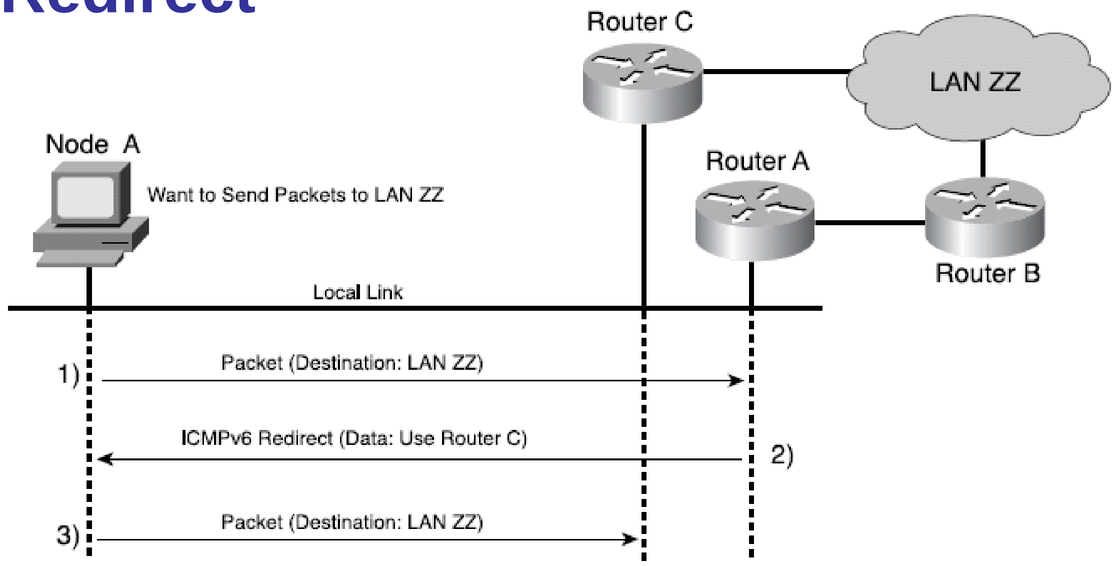
```
ICMPv6 Option
    Type: Source Link_layer Address(1)
    Length: 8 bytes
    Link-layer address: 00:08:E2:60:18:1A

ICMPv6 Option
    Type: MTU(5)
    Length: 8 bytes
    MTU: 1500

ICMPv6 Option
    Type: Prefix Information(3)
    Length: 32 bytes
    Prefix Length: 64
    Flags:
      1... = On-link flag(L): Set
      .1.. = Autonomous address-configuration flag(A): Set
    Valid Lifetime: 2592000
    Preferred Lifetime: 604800
    Prefix(IPv6 address): 2001:428:3804::
```

ICMPv6 Redirect



An option is added to let the host know the target router’s physical address.

Router Redirect



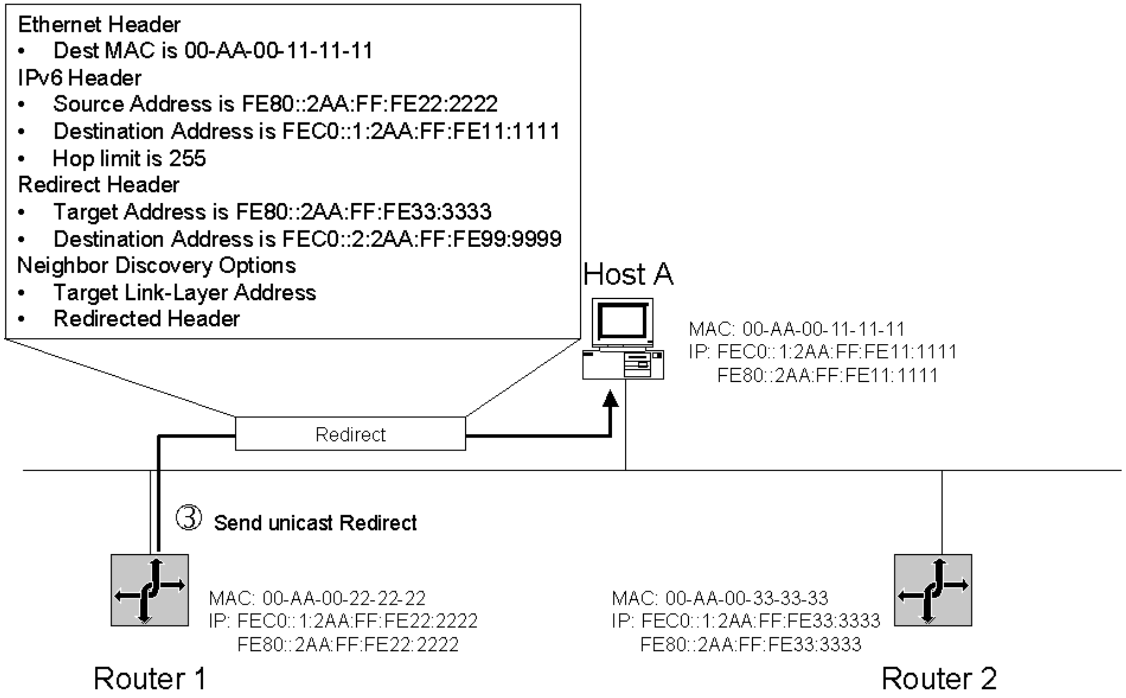
1. **A router informs an originating host of the IP address of a router available on the local link that is "closer" to the destination.**

   "Closer" is routing metric function used to reach the destination network segment. This condition can occur when there are multiple routers on a network segment and the originating host chooses a default router and it is not the best one to use to reach the destination.

2. **A router informs an originating host that the destination is a neighbor (it is on the same link as the originating host).**

   This condition can occur when the prefix list of a host does not include the prefix of the destination. Because the destination does not match a prefix in the list, the originating host forwards the packet to its default router

Router Redirect Process



To inform Host A that subsequent packets to the destination of FEC0::2:2AA:EE:FE99:9999 should be sent to Router 2, Router 1 sends a Redirect message to Host A.

ICMPv6 Multicast Listener (MLD)

Took pieces from IGMP (Internet Group Management Protocol) (RFC 1112 and RFC 2236) and merged into new protocol.

Defined in RFC 2710.

MLD is a sub-protocol of ICMPv6.

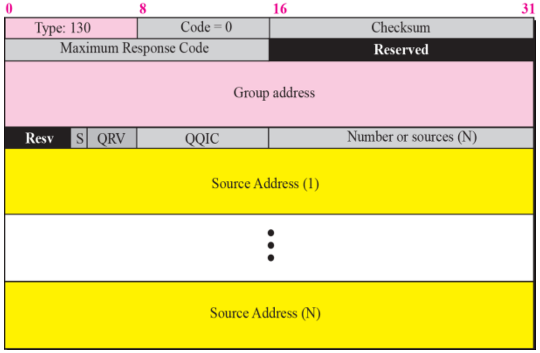
Allows routers to discover nodes that wish to receive multicast packets on all the routers links.

Query can be general or specific:

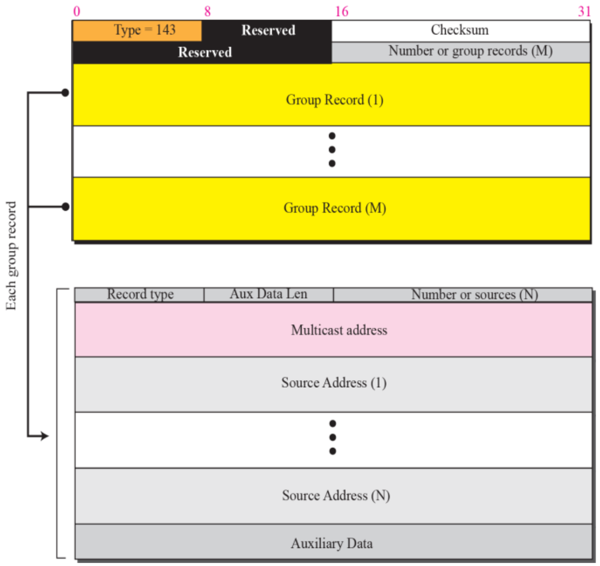
- Tell me all nodes with multicast address x
- Tell me all nodes and their multicast addresses

Maximum response delay only is used with the Query message.

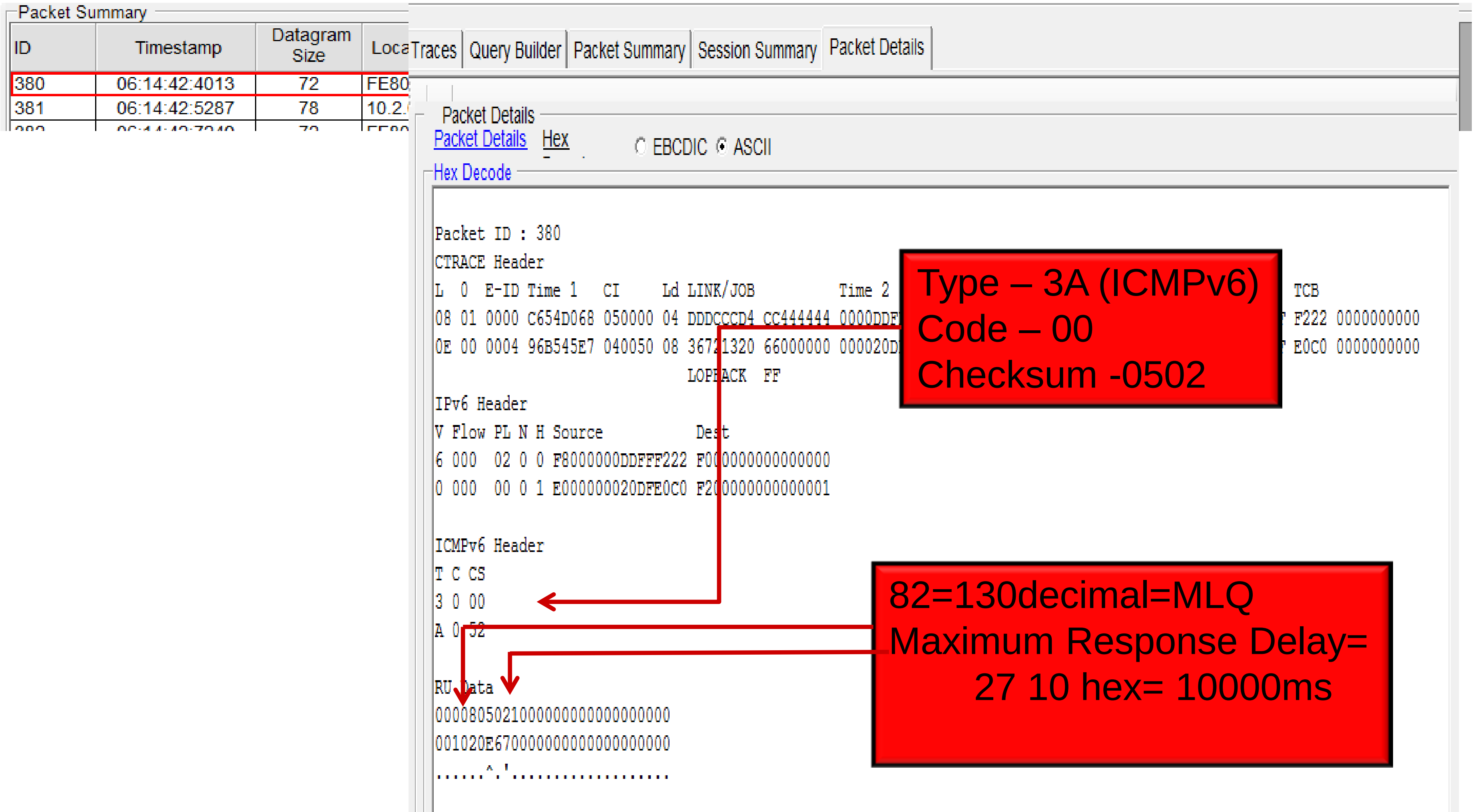
Membership Query



Membership Report



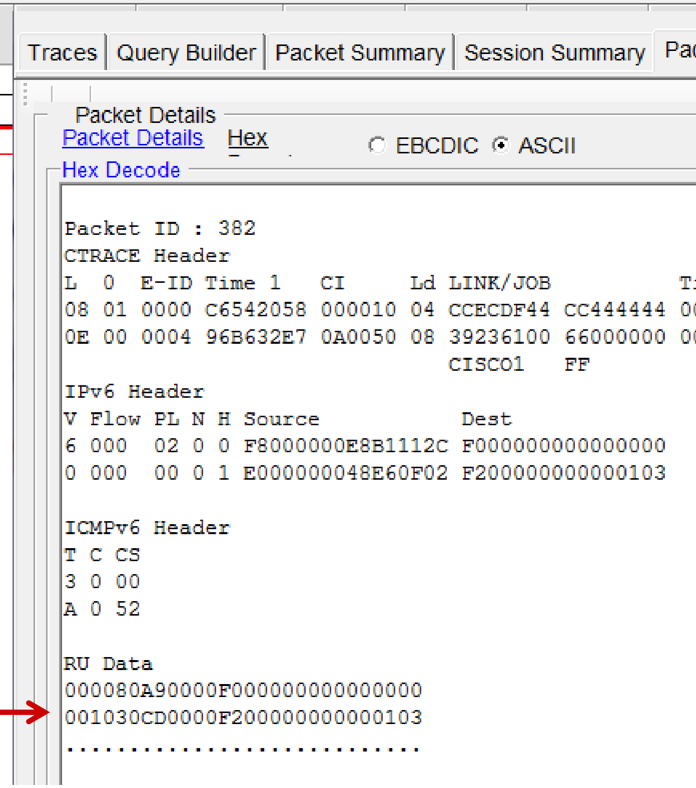
Trace Multicast Listener Query



Multicast Listener Report

Packet Summary

ID	Timestamp	Datagram Size	Local IP	Rmt. IP	Window Size
380	06:14:42:4013	72	FE80::D2D0:FDF	FF02::1	
381	06:14:42:5287	78	10.2.0.123	10.2.255.255	
382	06:14:42:7249	72	FE80::E488:BE1	FF02::1:3	



83=131decimal=MLR
Maximum Response Delay= 00 00hex= 0ms
Multicast Address FF02::1:3

ICMPv6 Path MTU Discovery

RFC 1981

To enable hosts to discover the min. MTU on a path to a particular destination.

Fragmentation in IPv6 is not performed by intermediary routers.

The source node may fragment packets by itself only when the path MTU is smaller than the packets to deliver.

PMTUD for IPv6 uses ICMPv6 error message

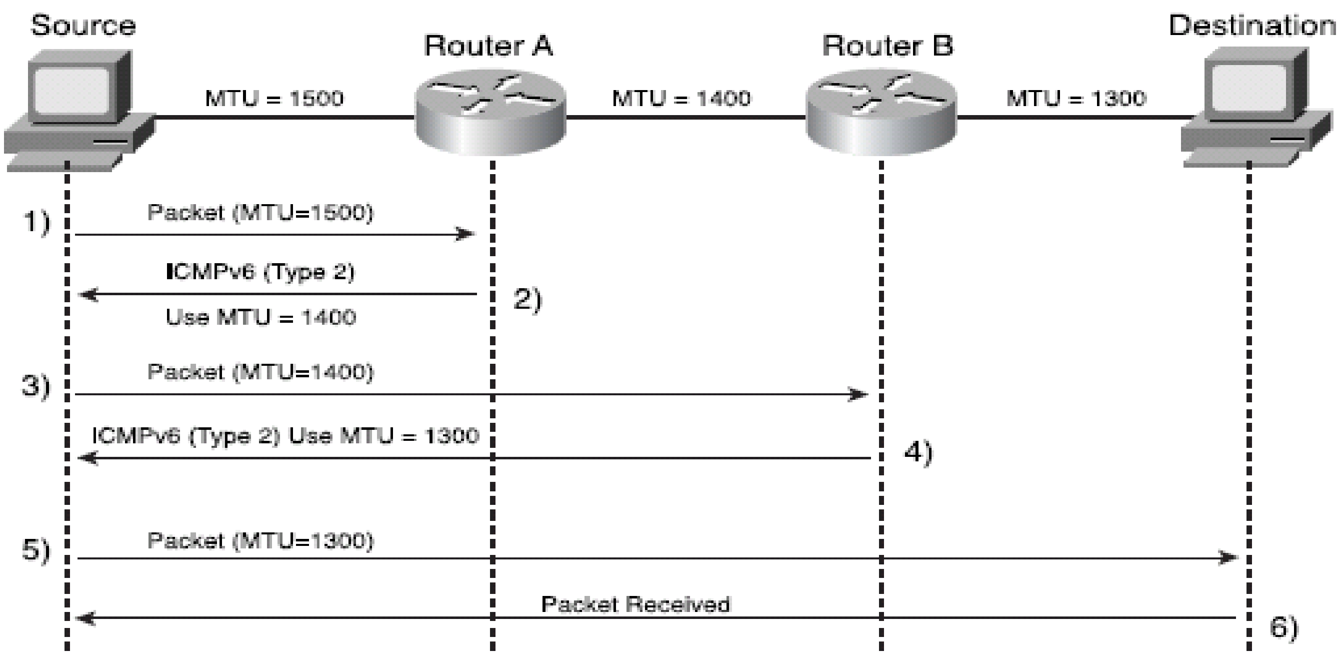
- Type 2 Packet Too Big

MTU Size Error Feedback

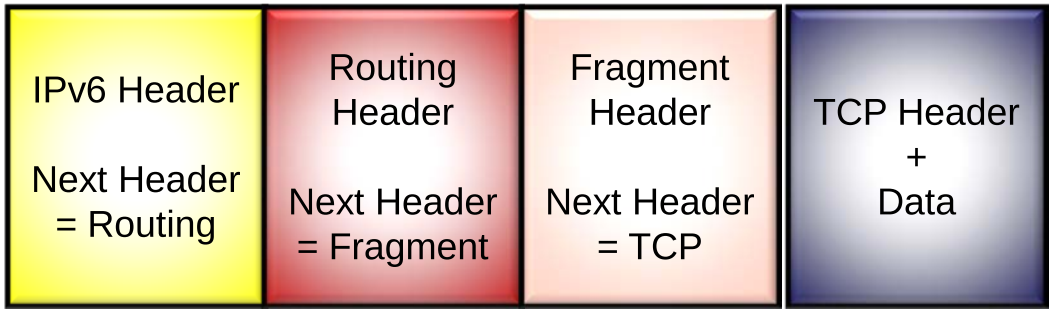
- If a router is forced to try sending a datagram that is too large over a physical link, it must drop the datagrams, since it cannot fragment them.
- A feedback process has been defined using ICMPv6 that lets routers tell source devices when the datagrams they are using are too large for the route.

How Does a Node know what MTU size to Use?

1. **Use Default MTU**
   Use the default MTU of **1280**, which all physical networks must be able to handle.
2. **Use Path MTU Discovery feature**
   A node sends messages over a route to determine the overall minimum MTU.



Fragmentation



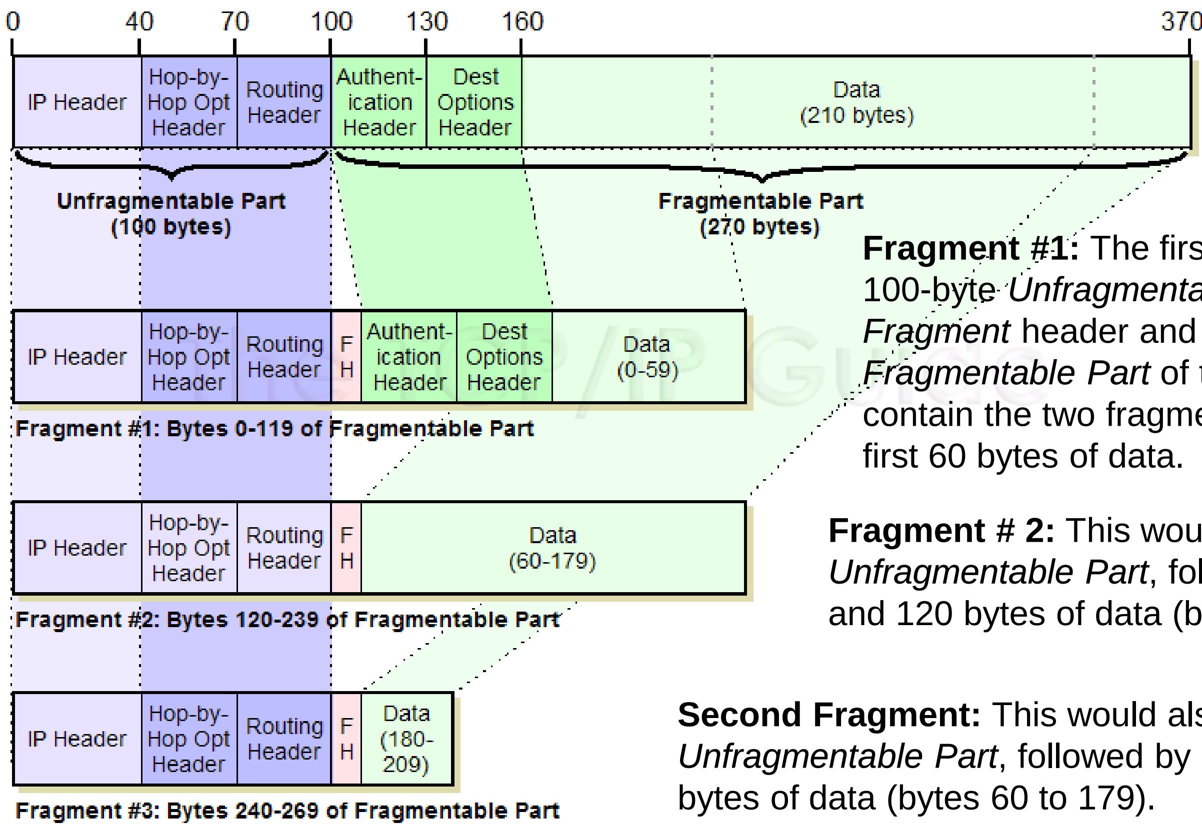
For purposes of fragmentation, IPv6 datagrams are broken into two pieces:

- **Unfragmentable Part**
  Includes the main header of the original datagram + any extension headers that need to be present in each fragment - ***Hop-By-Hop Options***, ***Destination Options*** (for those options to be processed by devices along a route) and ***Routing***.
- **Fragmentable Part**
  Data portion of the datagram + other extension headers if present - *authentication Header*, *Encapsulating Security Payload* and/or *Destination Options* (for options to be processed only by the final destination).

The ***Unfragmentable Part*** must be present in each fragment, while the **Fragmentable Part** is split up amongst the fragments.

Fragmentation Example

Suppose we need to send this over a link with an MTU of only 230 bytes. Three fragments are created. This is due to the need to put the two 30-byte unfragmentable extension headers in each fragment and the requirement that each fragment be a length that is a multiple of 8.

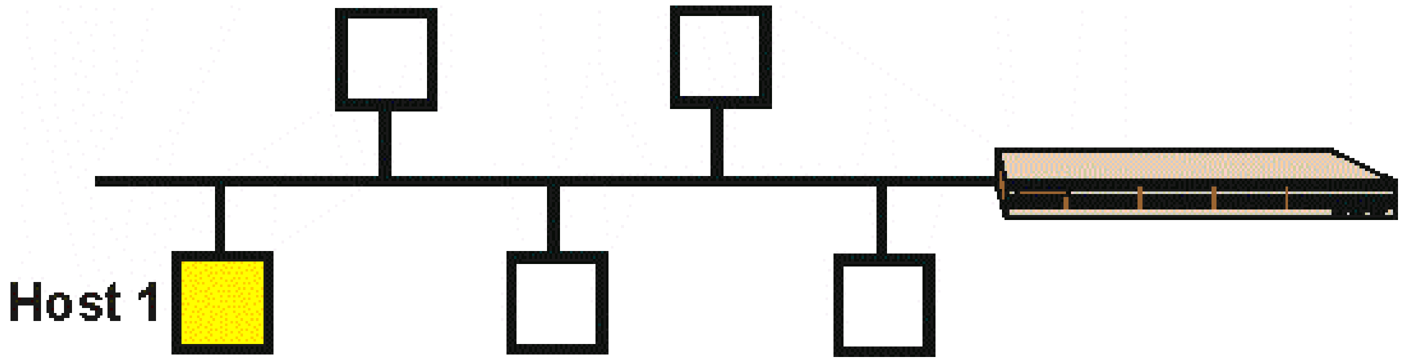


Fragment #1: The first fragment would consist of the 100-byte *Unfragmentable Part*, followed by an 8-byte *Fragment* header and the first 120 bytes of the *Fragmentable Part* of the original datagram. This would contain the two fragmentable extension headers and the first 60 bytes of data.

Fragment # 2: This would also contain the 100-byte *Unfragmentable Part*, followed by a *Fragment* header and 120 bytes of data (bytes 60 to 179).2

Second Fragment: This would also contain the 100-byte *Unfragmentable Part*, followed by a *Fragment* header and 120 bytes of data (bytes 60 to 179).

ICMPv6 Model Host



Each host is to maintain the following:

- **Neighbor Cache**
- **Destination Cache**
- **Prefix List**
- **Default Router List**
- **LinkMTU**
- **CurHopLimit**
- **BaseReachable Time**
- **Reachable Time**
- **Retransmit Timer**

Changes Needed to Implement IPv6

Hosts

- ✓ Implement IPv6 code in operating system
- ✓ TCP/UDP aware of IPv6
- ✓ Sockets/Winsock library updates for IPv6
- ✓ Domain Name Server updates for IPv6

Domain Name Server (DNS)

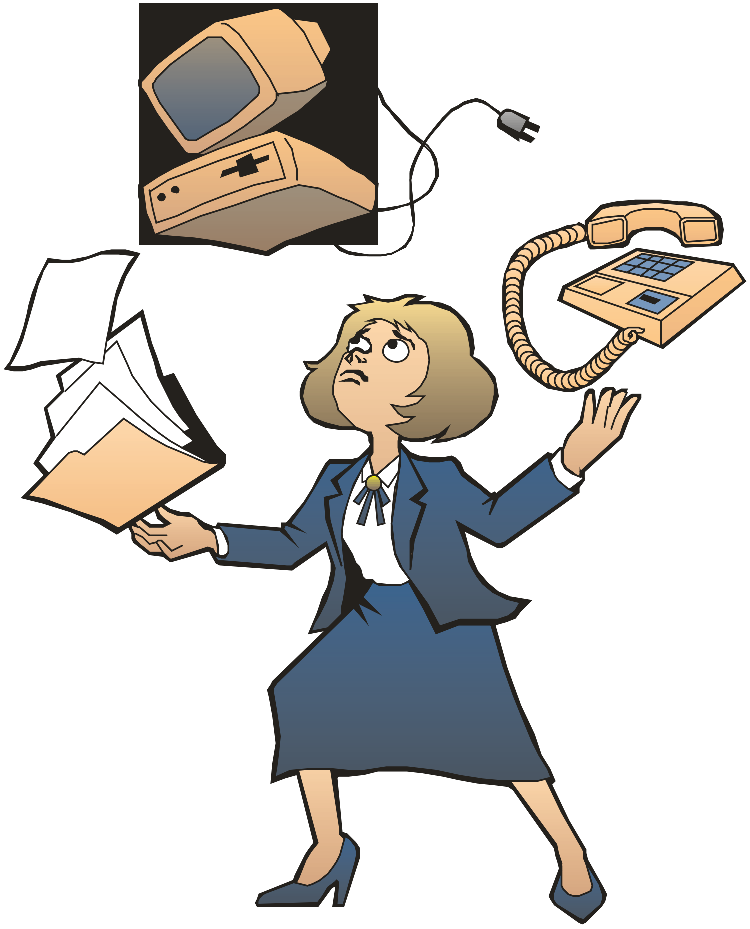
- ✓ Many products already support 128 bit addresses
- ✓ Uses ‘AAAA’ records for IPv6
- ✓ IP6.INT (in_addr_arpa in IPv4)

Routers

- ✓ IPv6 forwarding protocols
- ✓ Routing protocols updated to support IPv6
- ✓ Management needs to support ICMPv6
- ✓ Implement transition mechanisms

IPv6 Protocol Status

- ✓ RIPv6 - Same as RIPv2
- ✓ OSPFv6 - Updated for IPv6
- ✓ EIGRP - Extensions implemented
- ✓ IDRP - Recommended for exterior protocol over BGP4
- ✓ BGP4+ - Preferred implementation in IPv6 today



AES Sessions

Session	Title	Day	Time	Room
12152	IPv6 Basics	Tuesday February 5	1:30 PM	Golden Gate 4
12777	Network Problem Diagnosis with Packet Traces	Wednesday February 6	9:30 AM	Golden Gate 3
12778	Performance Factors in Cloud Computing	Wednesday February 6	11:00 AM	Golden Gate 4
12150	I'm Running IPv6 How Do I Access?	Wednesday February 6	3:00 PM	Golden Gate 4
12158	Managing an IPv6 Network	Thursday February 7	11:00 AM	Golden Gate 4
12149	Kick Start your IPv6 Skills using your home network	Friday February 8	8:00 AM	Golden Gate 4
12153	IPv6 Deep Dive	Friday February 8	9:30 AM	Golden Gate 4

Vielen Dank

ありがとうございました

Köszönettel

Спасибо

ขอบคุณ

شكراً

Bedankt

Gracias

Ευχαριστώ

شكرا

धन्यवाद

Grazie

THANK YOU

Danke

Merci

Díky

Hvala

תודה

Merci

ขอบคุณ

Teşekkürler

धन्यवाद
Hindi
Gracias

laurak@aesclever.com

www.aesclever.com

650-617-2400

감사합니다

நன்றி
Tamil

Obrigado

IPv6 References

IPv6 Home Page

http://www.ietf.org/

http://playground.sun.com/pub/ipng/html/ipng-main.html

http://www.getipv6.info/index.php/IPv6_Presentations_and_Documentshttp://www.6ren.net

http://www.ipv6forum.com

http://arin.net

http://www.internet2.edu

http://www.ipv6.org

http://ipv6.or.kr/english/natpt.overview

http://www.research.microsoft.com/msripv6

http://www.ipv6.org.uk

Books

New Internet Protocol - Prentice Hall - ISBN 0-13-241936-x
IPNG and the TCP/IP Protocols - John Wiley and Sons - ISBN-0-471-13088-5
IPv6 The New Internet Protocol - ISBN-0-13-24-241936
IPNG Internet Protocol Next Generation - ISBN-0-201-63395-7
Internetworking IPv6 with Cisco Routers - ISBN 0-07-022831-1

IPv6 RFCs

View any IPv6 RFC

http://datatracker.ietf.org/doc/search/