IPv6

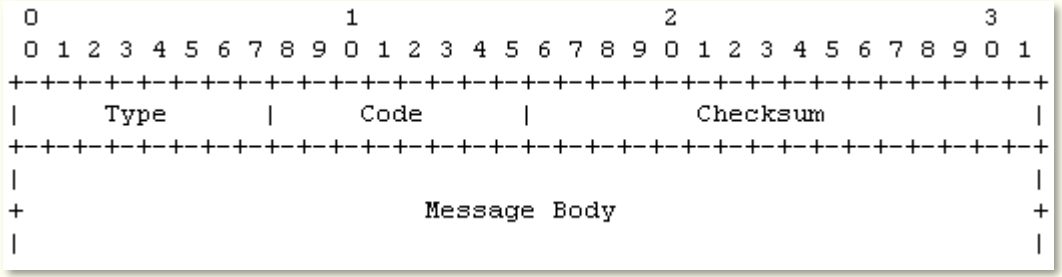
ICMPv6 and autoconfiguration

ICMPv6

- Internet Control Message Protocol v6
  - Error management and diagnostic functions
- New functionalities (!)
  - Neighbour Discovery protocol (ND)
    - determine link-layer addresses of neighbours attached to the same link (was ARP & RARP with IPv4)
    - find routers
    - keep track of which neighbours are reachable
    - detect changed link-layer addresses
  - Multicast group membership management (was IGMP with IPv4)
  - Mobility support (MIPv6)
  - …

Message format

- Type & Code
  - Identify the type of message, e.g.
    - Type=1,Code=0: Destination Unreachable, No route to destination
- Checksum
  - Used to detect data corruption
- Message body
  - Original packet (error messages) or
  - Additional data (informational messages)



ICMPv6 message classes

- Error messages
  - Destination Unreachable (type 1)
  - Packet Too Big (type 2)
  - Time Exceeded (type 3)
  - Parameter Problem (type 4)

- Informational messages

Neighbour Discovery protocol

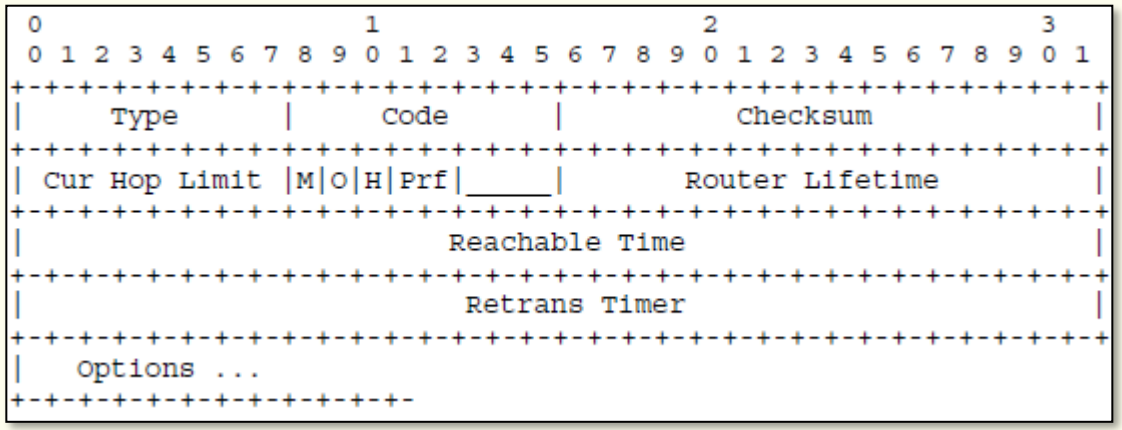
Message number	Message type	Description
128	Echo Request	RFC 4443. Used for the ping command.
129	Echo Reply	
…		
133	**Router Solicitation**	RFC 4861. Used for neighbor discovery and autoconfiguration.
134	**Router Advertisement**	
135	**Neighbor Solicitation**	
136	**Neighbor Advertisement**	
137	**Redirect Message**	
…		
155	Routing Protocol for Low-Power Network Messages	RFC 6550

Neighbour Discovery protocol

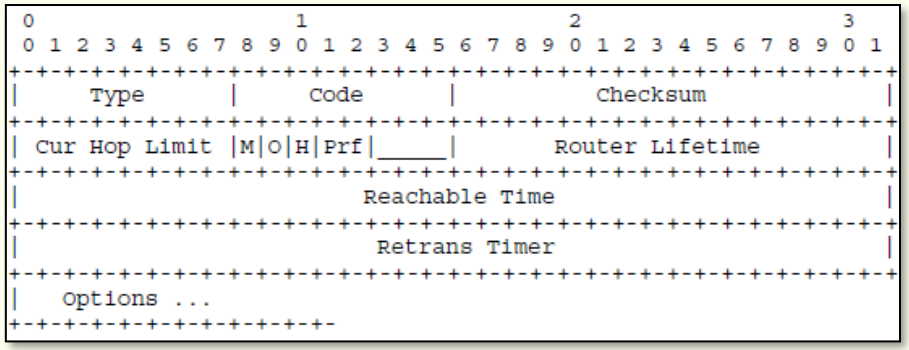
- Address Resolution
- Stateless Address Autoconfiguration (SLAAC)
- Router Discovery (RD)
- Neighbor Unreachability Detection (NUD)
- Duplicate Address Detection (DAD)
- Redirection

Router Discovery

- Routers send out Router Advertisement messages at regular intervals to the multicast *all-nodes* address (FF02::1)



Router discovery

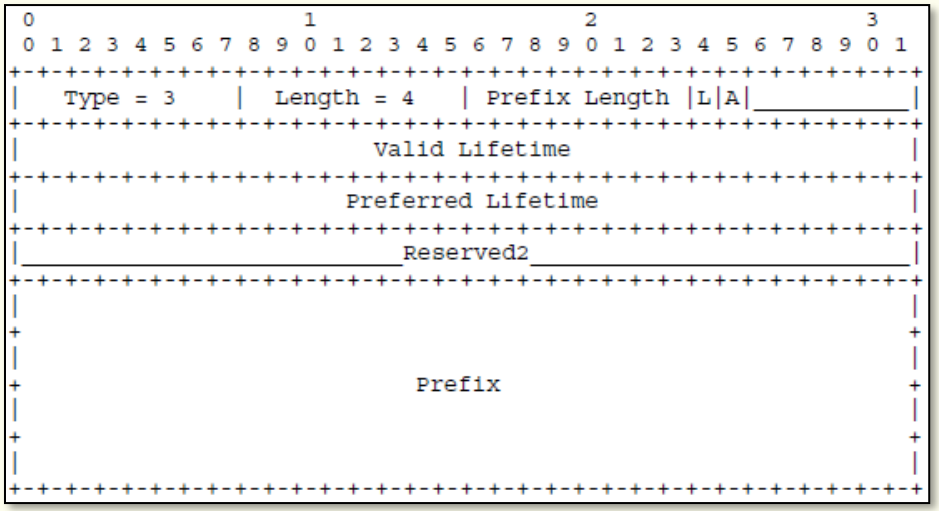


- Type=134, Code=0
- Cur Hop Limit
  - Default value for hop count field; zero if unspecified
- Time
  - Configuration params

- M flag (1bit)
  - 0: stateless autoconfiguration
  - 1: stateful (DHCPv6)
- Prf flag (2 bits)
  - Default router preference
- Options
  - Source link-layer address
  - MTU
  - Prefix information

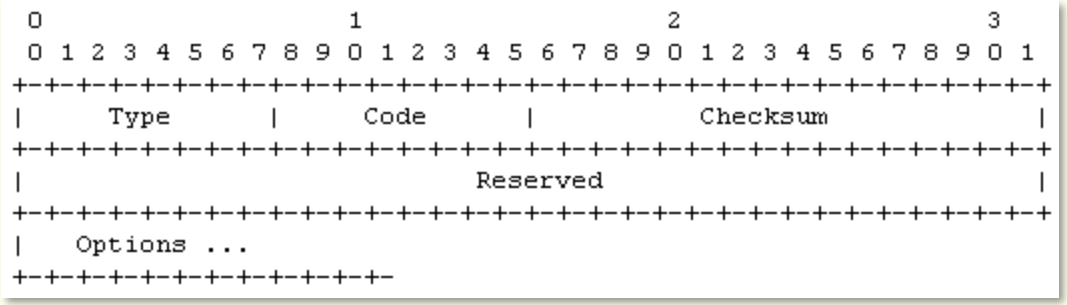
Router discovery

- Prefix Information option
- L flag
  - On-link determination
- A flag
  - Autonomous address configuration
- Address lifetime

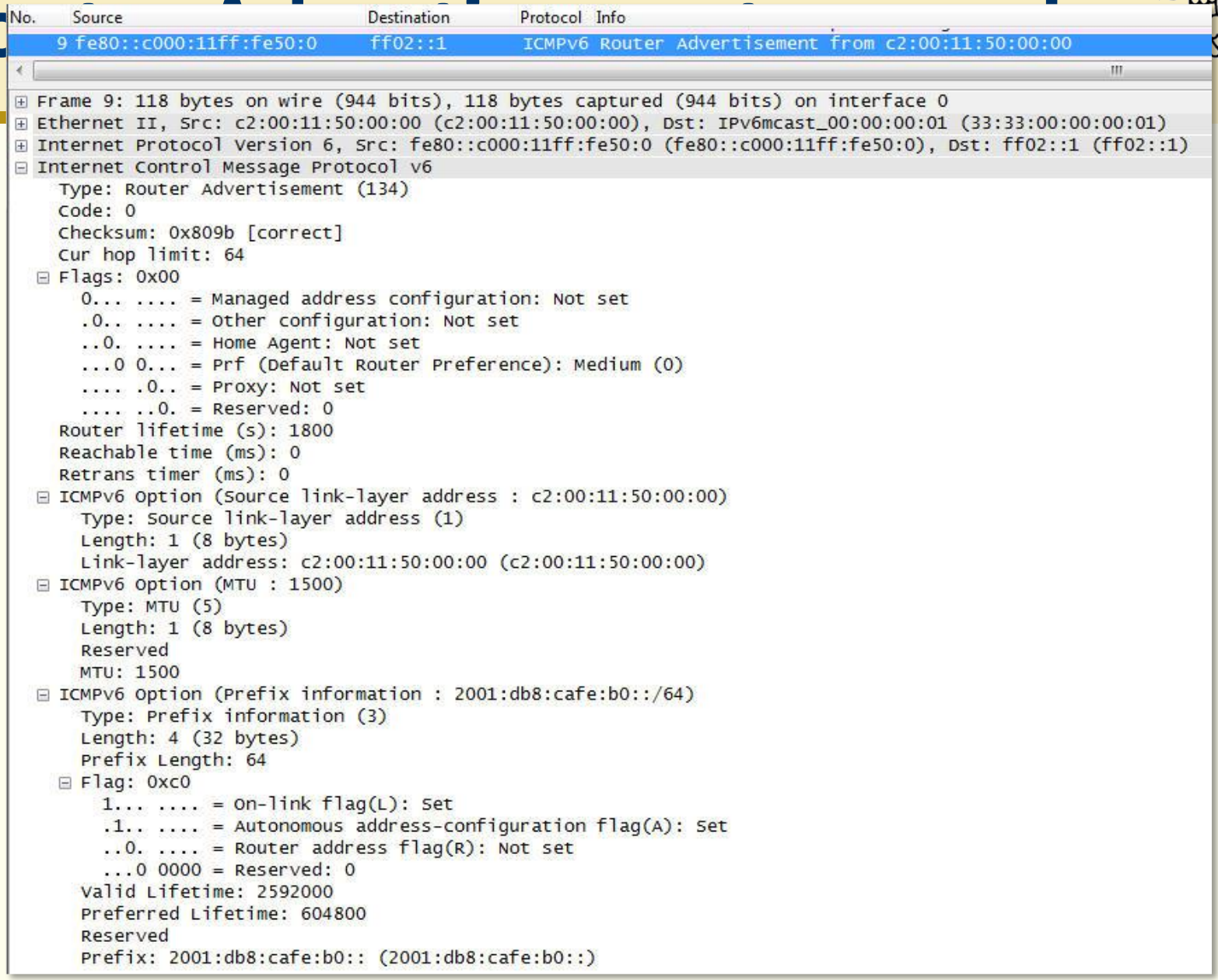


Router discovery

- Router Advertisement messages can be solicited by a node by sending a Router Solicitation message at the multicast *all-routers* address (FF02::2)
  - Type=133, Code=0



Ro



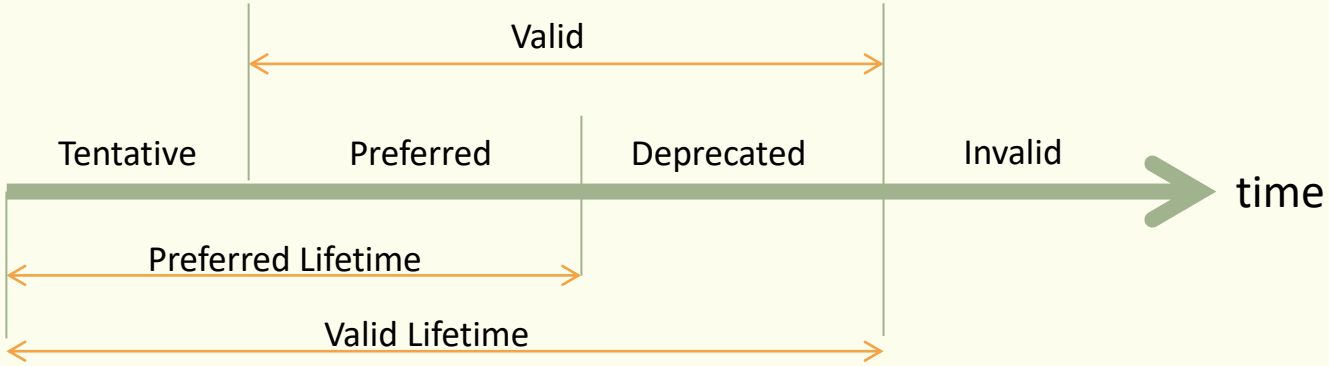
```
No.  Source                  Destination  Protocol  Info
   9 fe80::c000:11ff:fe50:0  ff02::1      ICMPv6    Router Advertisement from c2:00:11:50:00:00

Frame 9: 118 bytes on wire (944 bits), 118 bytes captured (944 bits) on interface 0
Ethernet II, Src: c2:00:11:50:00:00 (c2:00:11:50:00:00), Dst: IPv6mcast_00:00:00:01 (33:33:00:00:00:01)
Internet Protocol Version 6, Src: fe80::c000:11ff:fe50:0 (fe80::c000:11ff:fe50:0), Dst: ff02::1 (ff02::1)
Internet Control Message Protocol v6
    Type: Router Advertisement (134)
    Code: 0
    Checksum: 0x809b [correct]
    Cur hop limit: 64
  Flags: 0x00
      0... .... = Managed address configuration: Not set
      .0.. .... = Other configuration: Not set
      ..0. .... = Home Agent: Not set
      ...0 0... = Prf (Default Router Preference): Medium (0)
      .... .0.. = Proxy: Not set
      .... ..0. = Reserved: 0
    Router lifetime (s): 1800
    Reachable time (ms): 0
    Retrans timer (ms): 0
  ICMPv6 Option (Source link-layer address : c2:00:11:50:00:00)
      Type: Source link-layer address (1)
      Length: 1 (8 bytes)
      Link-layer address: c2:00:11:50:00:00 (c2:00:11:50:00:00)
  ICMPv6 Option (MTU : 1500)
      Type: MTU (5)
      Length: 1 (8 bytes)
      Reserved
      MTU: 1500
  ICMPv6 Option (Prefix information : 2001:db8:cafe:b0::/64)
      Type: Prefix information (3)
      Length: 4 (32 bytes)
      Prefix Length: 64
    Flag: 0xc0
        1... .... = On-link flag(L): Set
        .1.. .... = Autonomous address-configuration flag(A): Set
        ..0. .... = Router address flag(R): Not set
        ...0 0000 = Reserved: 0
      Valid Lifetime: 2592000
      Preferred Lifetime: 604800
      Reserved
      Prefix: 2001:db8:cafe:b0:: (2001:db8:cafe:b0::)
```

Address configuration

- Stateful (DHCPv6)
- Stateless
  - Autoconfiguration, without any manual configuration of the host
    - The interface ID is generated from the MAC address (or randomly chosen)
    - The prefix is learned from the Router Advertisement message
  - The address goes through different states
    - Tentative, Preferred, Deprecated

Address lifetime

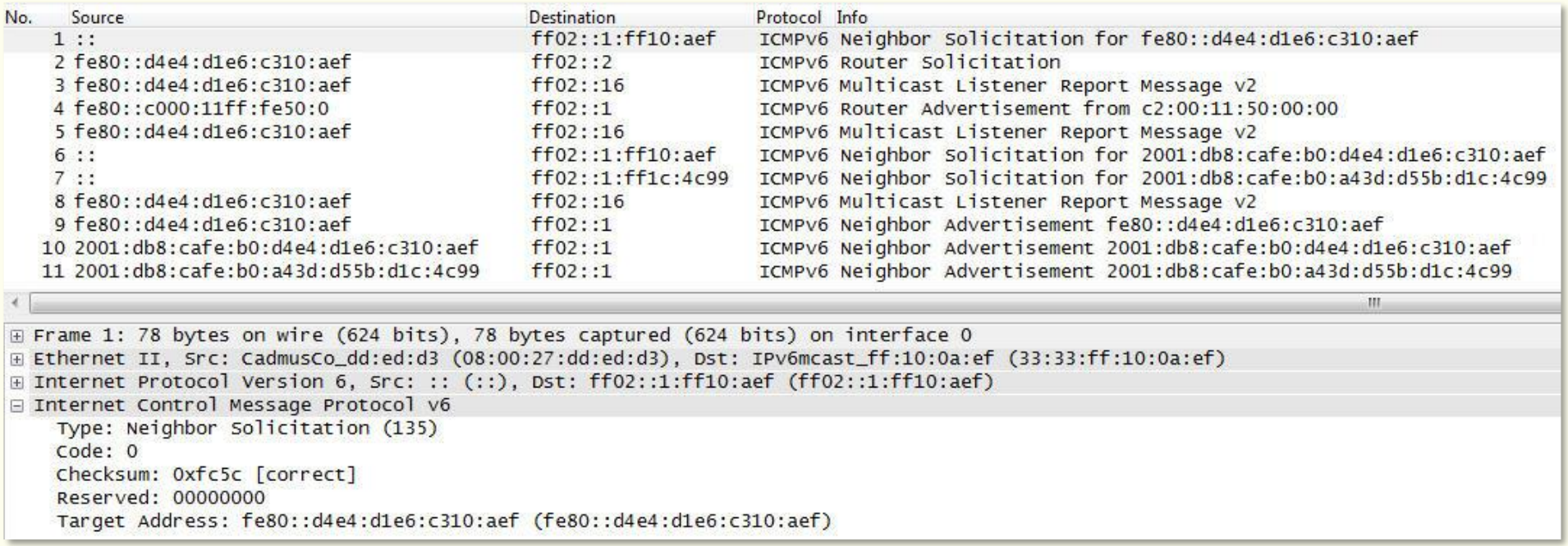
- Tentative address
  - Uniqueness on a link is being verified
    - An interface discards received packets addressed to a tentative address, but accepts Neighbor Discovery packets
- Preferred address
  - Use by upper-layer protocols is unrestricted
- Deprecated address
  - Use is discouraged, but not forbidden
- Valid address
  - A preferred or deprecated address



Address autoconfiguration

- A link-local address is generated appending the interface identifier to the link-local prefix FE80::/10
  - The link-local address is tentative
- A NS message is sent out to check Duplicate Address Detection
  - The link-local address becomes preferred
- A RS message is sent out to the *all-routers* address
- For each prefix in RAs with the A flag set, an address is generated
  - The address is tentative, DAD should be performed
- The address becomes preferred until its lifetime expires

Address autoconfiguration



No.	Source	Destination	Protocol	Info
1	::	ff02::1:ff10:aef	ICMPv6	Neighbor Solicitation for fe80::d4e4:d1e6:c310:aef
2	fe80::d4e4:d1e6:c310:aef	ff02::2	ICMPv6	Router Solicitation
3	fe80::d4e4:d1e6:c310:aef	ff02::16	ICMPv6	Multicast Listener Report Message v2
4	fe80::c000:11ff:fe50:0	ff02::1	ICMPv6	Router Advertisement from c2:00:11:50:00:00
5	fe80::d4e4:d1e6:c310:aef	ff02::16	ICMPv6	Multicast Listener Report Message v2
6	::	ff02::1:ff10:aef	ICMPv6	Neighbor Solicitation for 2001:db8:cafe:b0:d4e4:d1e6:c310:aef
7	::	ff02::1:ff1c:4c99	ICMPv6	Neighbor Solicitation for 2001:db8:cafe:b0:a43d:d55b:d1c:4c99
8	fe80::d4e4:d1e6:c310:aef	ff02::16	ICMPv6	Multicast Listener Report Message v2
9	fe80::d4e4:d1e6:c310:aef	ff02::1	ICMPv6	Neighbor Advertisement fe80::d4e4:d1e6:c310:aef
10	2001:db8:cafe:b0:d4e4:d1e6:c310:aef	ff02::1	ICMPv6	Neighbor Advertisement 2001:db8:cafe:b0:d4e4:d1e6:c310:aef
11	2001:db8:cafe:b0:a43d:d55b:d1c:4c99	ff02::1	ICMPv6	Neighbor Advertisement 2001:db8:cafe:b0:a43d:d55b:d1c:4c99

```
⊞ Frame 1: 78 bytes on wire (624 bits), 78 bytes captured (624 bits) on interface 0
⊞ Ethernet II, Src: CadmusCo_dd:ed:d3 (08:00:27:dd:ed:d3), Dst: IPv6mcast_ff:10:0a:ef (33:33:ff:10:0a:ef)
⊞ Internet Protocol Version 6, Src: :: (::), Dst: ff02::1:ff10:aef (ff02::1:ff10:aef)
⊟ Internet Control Message Protocol v6
    Type: Neighbor Solicitation (135)
    Code: 0
    Checksum: 0xfc5c [correct]
    Reserved: 00000000
    Target Address: fe80::d4e4:d1e6:c310:aef (fe80::d4e4:d1e6:c310:aef)
```

Details of packet 4 (RA) are in the previous slide

References

- RFC 4443, “Internet Control Message Protocol (ICMPv6) for the Internet Protocol Version 6 (IPv6) Specification,” 2006
- RFC 4861, “Neighbor Discovery for IP version 6 (IPv6)”, 2007
- RFC 4862, “IPv6 Stateless Address Autoconfiguration,” 2007