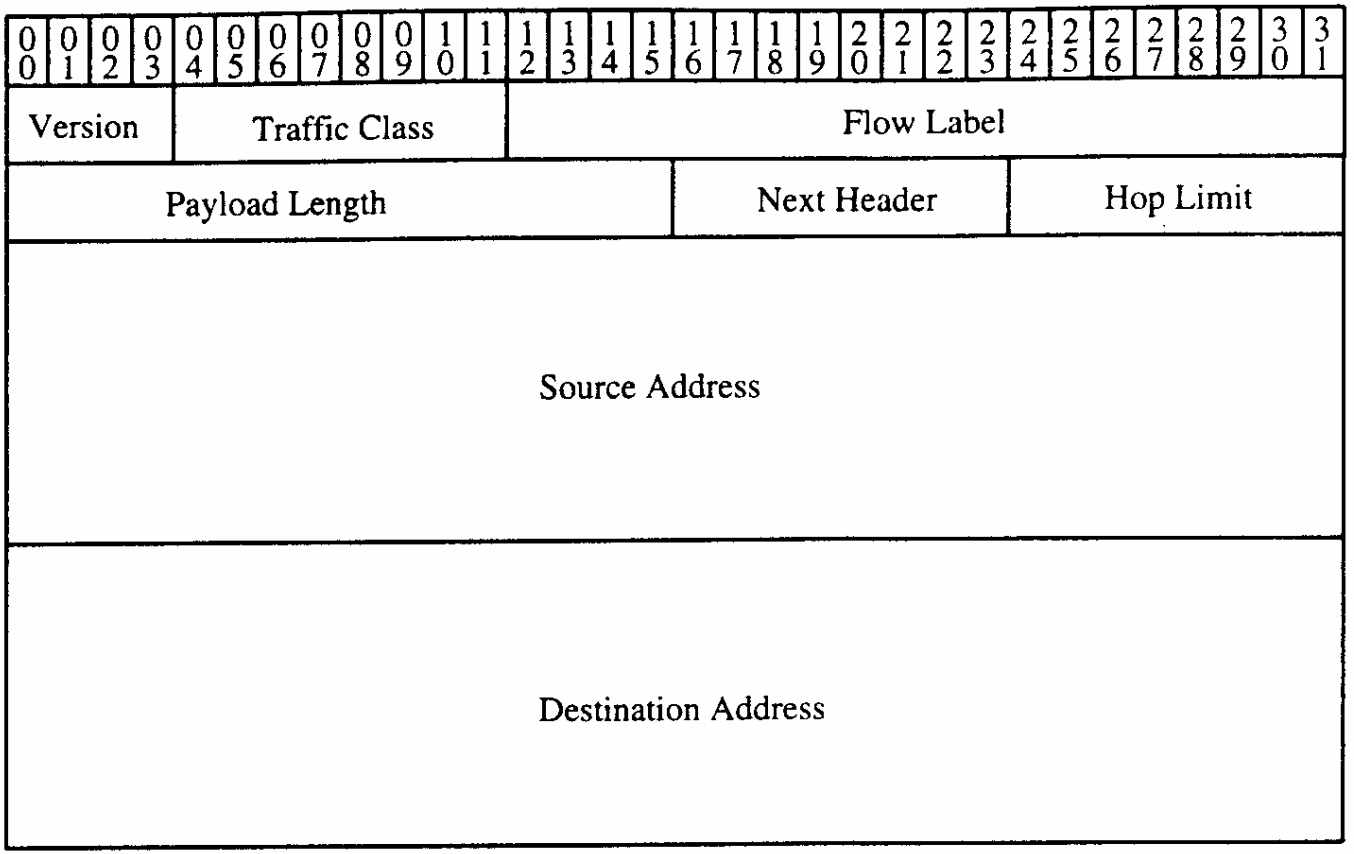
IP Version 6

- The explosive growth of the Internet
  - IPv4 address space, 32-bit
  - Real-time and interactive applications
- Expanded address space, 128 bits
- Simplified header format
  - Enabling easier processing of IP datagrams
- Improved support for headers and extensions
  - Enabling greater flexibility for the introduction of new options
- Flow-labeling capability
  - Better support at the IP level for real-time app.
- Authentication and privacy

IPv6 Header [1/3]



IPv6 Header [2/3]

- Version
  - 6
- Traffic Class, 8-bit
  - For the quality of service
- Flow Label, 20-bit
  - Label sequences of packets that belong to a single flow
  - A flow := source address, destination address, flow label

IPv6 Header [3/3]

- Payload Length, 16-bit unsigned integer
  - The length of payload in octets
  - Header extensions are part of the payload
- Next Header, 8-bit
  - The next higher-layer protocol
    - Same as the IPv4
  - The existence of IPv6 header extensions
- Hop Limit, 8-bit unsigned integer
  - The TTL field of the IPv4 header
- Source and Destination Addresses, 128-bit

IPv6 addresses

- XXXX:XXXX:XXXX:XXXX:XXXX:XXXX:XXXX:XXXX
  - X is a hexadecimal character
- E.g., 1511:1:0:0:0:FA22:45:11
  - The symbol "::" can be used to represent a number of contiguous fields with zero values.
  - = 1511:1::FA22:45:11
- 0:0:0:0:AA11:50:22:F77 = ::AA11:50:22:F77
  - "::" can appears only once

IPv6 special addresses

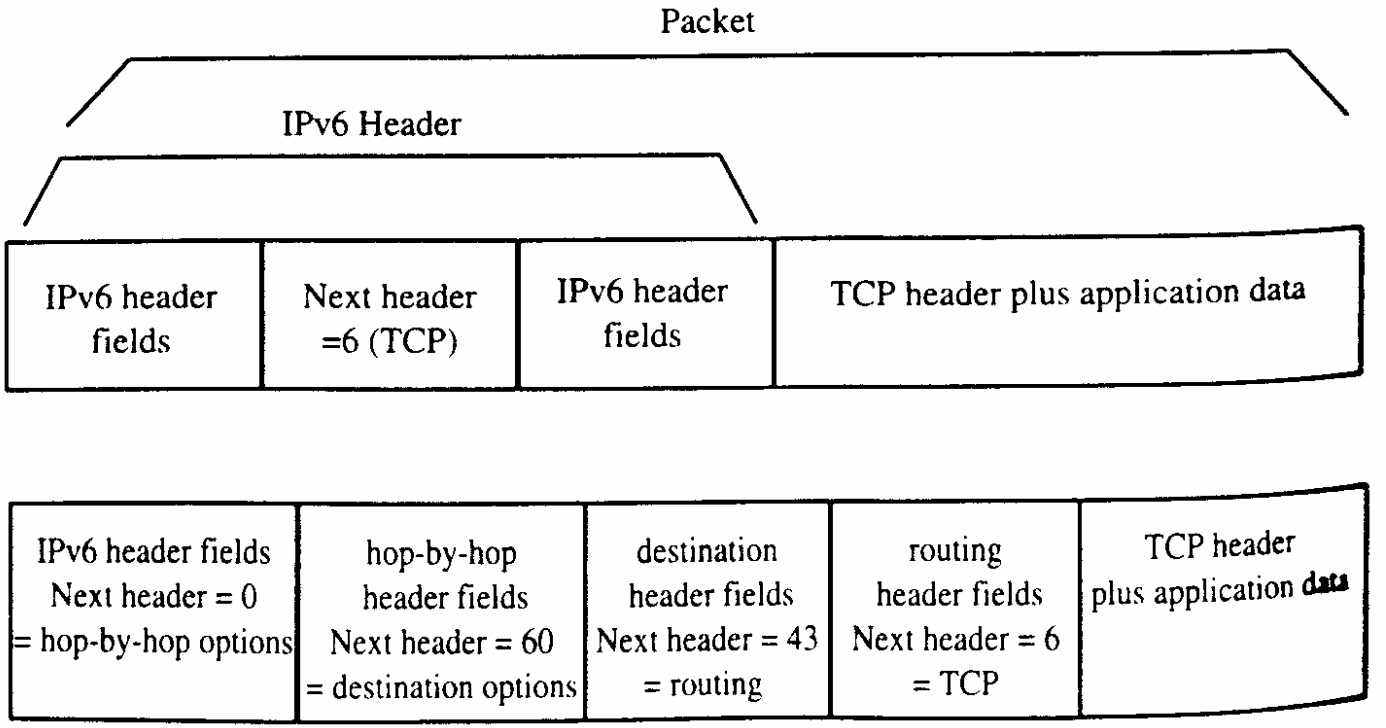
- The all-zeros address, ::
  - An unspecified address; a node does not yet know its address
- The loopback address, ::1
  - On a virtual internal interface
- IPv6 address with embedded IPv4 address (type 1)
  - 96-bit zeros + 32-bit IPv4 address
  - ::140.113.17.5
  - Used by IPv6 hosts and routers that tunnel IPv6 packets through an IPv4 infrastructure
- IPv6 address with embedded IPv4 address (type 2)
  - 80-bit zeros + FFFF + 32-bit IPv4 address
  - 0:0:0:0:0:FFFF:140.113.17.5
  - ::FFFF:140.113.17.5
  - Applied to nodes that do not support IPv6

IPv6 Header Extensions

- To be placed between the fixed header and the actual data payload
- Next Header
  - The type of payload carried in the IP datagram
  - The type of header extension
  - Each extension has its own next header field.

Header extension

- Use the next header field

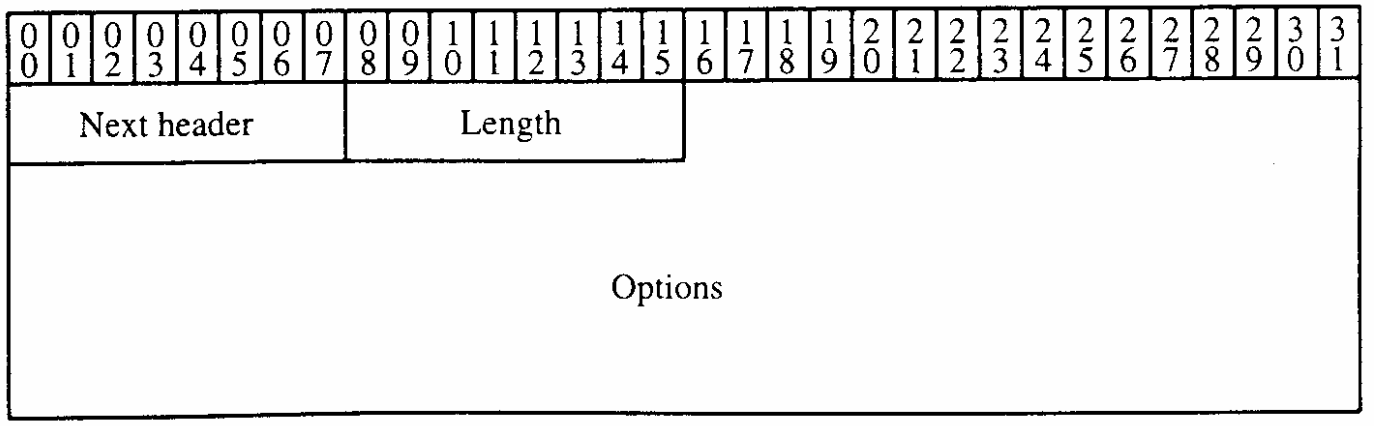


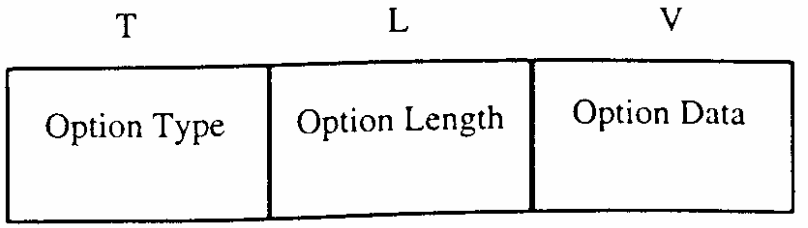
Hop-by-hop Extension [1/3]

- It is only one exception.
  - Examined and processed by every intermediate node
  - If present, the hop-by-hop extension must immediately follow the IP header
  - Of variable length
- Next header
- Length
  - in units of eight octets
- Options
  - TLV (Type-Length-Value) format
    - Type: 8-bit
    - Length: 8-bit (in units of octets)
    - Value: variable length
  - Type [0:2] are of special significance

Hop-by-hop Extension [2/3]

- Hop-by-hop header extension

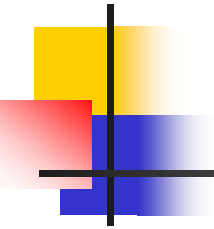




T = Type
L = Length
V = Value

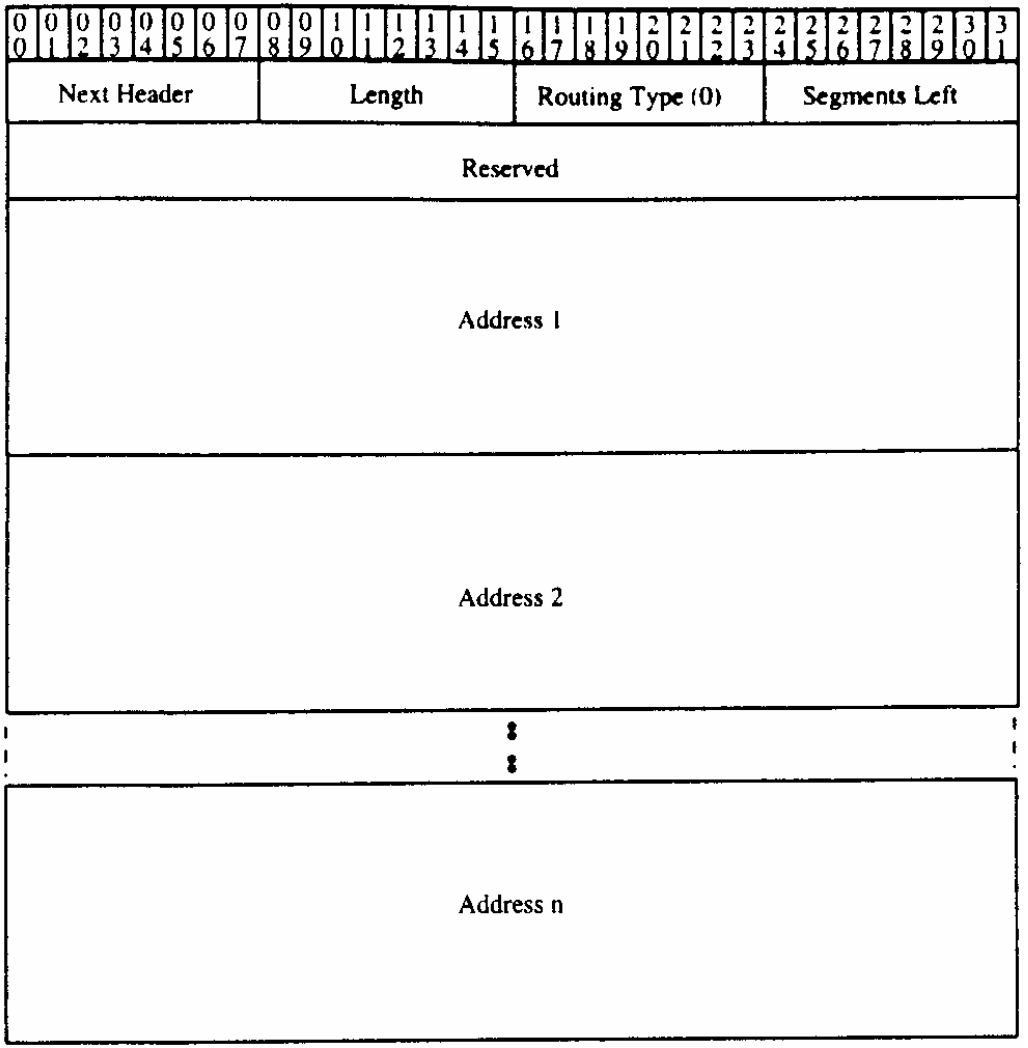
Hop-by-hop Extension [3/3]

- Option Type: the first two bits (how the node react if it does not understand the option)
  - 00: skip this option and continue processing the header
  - 01: discard the packet
  - 10: discard the packet and send an ICMP Parameter Problem, Code 2 message to the originator of the packet
  - 11: do above only if the destination address in the IP header is not a multicast address
- Option Type: the third bit
  - 1, the option data can be changed
  - 0, cannot



- Destination options extension
  - Has the same format as the hop-by-hop extension
  - Only the destination node examine the extension.
  - Header type = 60
- Routing Extension
  - A routing type field to enable various routing options
  - Only routing type 0 is defined for now
    - Specify the nodes that should be visited

Routing Extension [1/2]



Routing Extension [2/2]

- Routing type
- Segments Left
  - The number of nodes that still need to be visited
- A list of IP addresses needs to be visited
- Is this type of header analyzed by intermediate node?
  - Yes or no
  - A->Z, 3, (B,C,D)
  - A->B, 3, (C,D,Z)
  - A->C, 2, (B,D,Z) by B
  - A->D, 1, (B,C,Z) by C
  - A->Z, 0, (B,C,D) by D

Interoperation IPv4 and IPv6

- IPv4 and IPv6 will coexist for a long time
  - IPv4 nodes ⇔ IPv6 nodes
  - IPv6 nodes ⇔ IPv6 nodes via IPv4 networks
  - IPv4 nodes ⇔ IPv4 nodes via IPv6 networks
- IPv4-compatible nodes with IPv4-compatible addresses at the boundaries of IPv6 networks
  - IPv6 in IPv4 packets