IPv6 Courses

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December 20, 2010

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G6

Protocol

- Group of IPv6 actors in France (researchers, engineers...)
- Academic & industrial partners
  - CNRS, Institut TELECOM, INRIA, Universities...
  - AFNIC, 6Wind, Bull...
- Launched in 1995 by:
  - Alain Durand
  - Bernard Tuy
- Is today a legal association under French Law (1901)
  - Laurent Toutain, President
- For further information: http://www.g6.asso.fr/

G6Charter

Protocol

- Share experience gained from IPv6 experimentations and deployment
- Spread IPv6 information
  - Tutorials and trainings (ISPs, Engineers, netadmins...)
  - Online book (in French), "IPv6, Théorie et pratique": http://livre.g6.asso.fr/
- Initiate research activities around IPv6
- Active in RIPE & IETF working groups
- Promotion of IPv6: French Task Force

Hypertext Symbols

- Several symbols are used in this document:
  - All RFCs and Internet Drafts are hypertext links.
    - Check that there is no more recent version of the document.
  - is a link to a *Techniques de l'Ingénieur* article on the subject (in French, access may be restricted).
  - is a link to the online edition of *IPv6, Théorie et Pratique* (in French)
  - W is a link to other information on the web.
- Material concerning IPv6 is taken from the G6 tutorial and copyrighted from G6.

Protocol
IPv6 Header

IPv6 Packet : Simpler

Protocol
IPv6 Header
IPv6 Header
IPv6 Extensions
ICMPv6
Impact on Layers 4

Definition

- IPv6 header follows the same IPv4 principle:
  - fixed address size ... but 4 times larger
  - alignment on 64 bit words (instead of 32)
- Features not used in IPv4 are removed
- Minimum MTU 1280 Bytes
  - If L2 cannot carry 1280 Bytes, then add an adaptation layer such as AAL5 for ATM or 6LoWPAN (RFC 4944) for IEEE 802.15.4.

Goal :

- Forward packet as fast as possible
- Less processing in routers
- More features at both ends

IPv6 Header

Protocol
IPv6 Header
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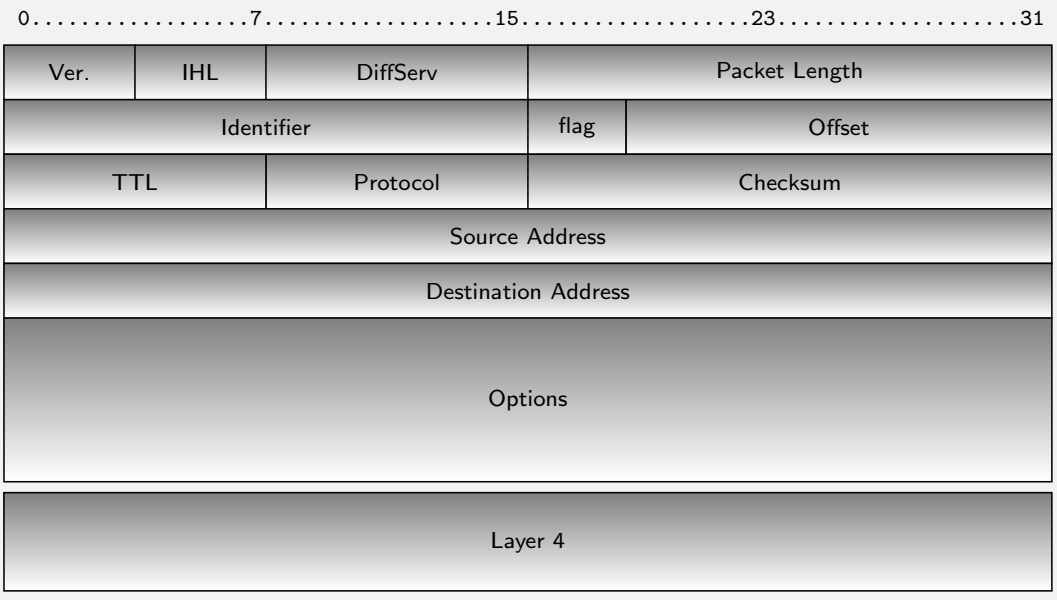
IPv6 Extensions
ICMPv6
Impact on Layers 4



IPv6 Header

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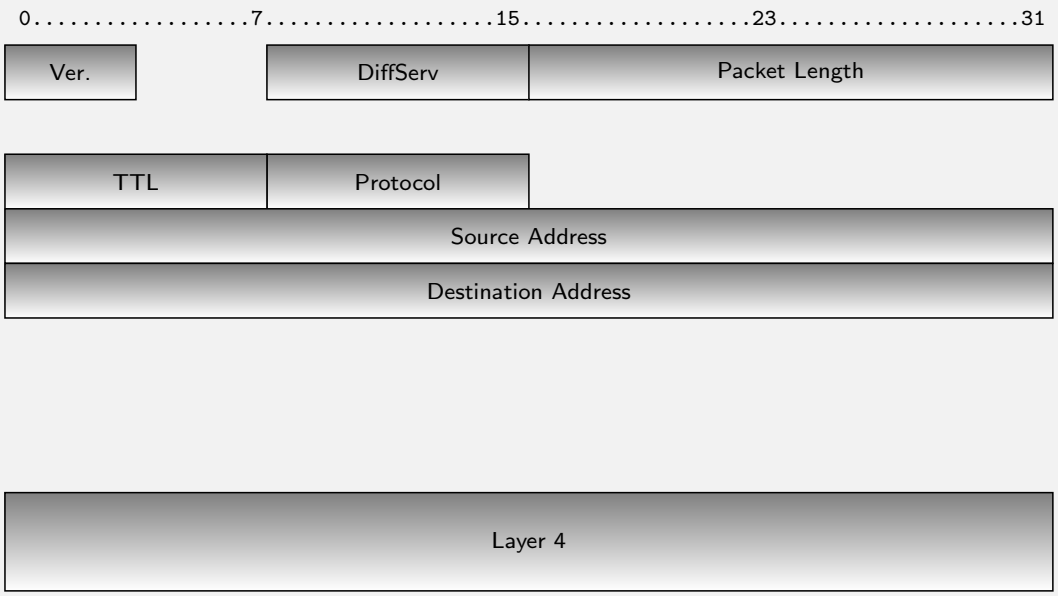

IPv6 Header

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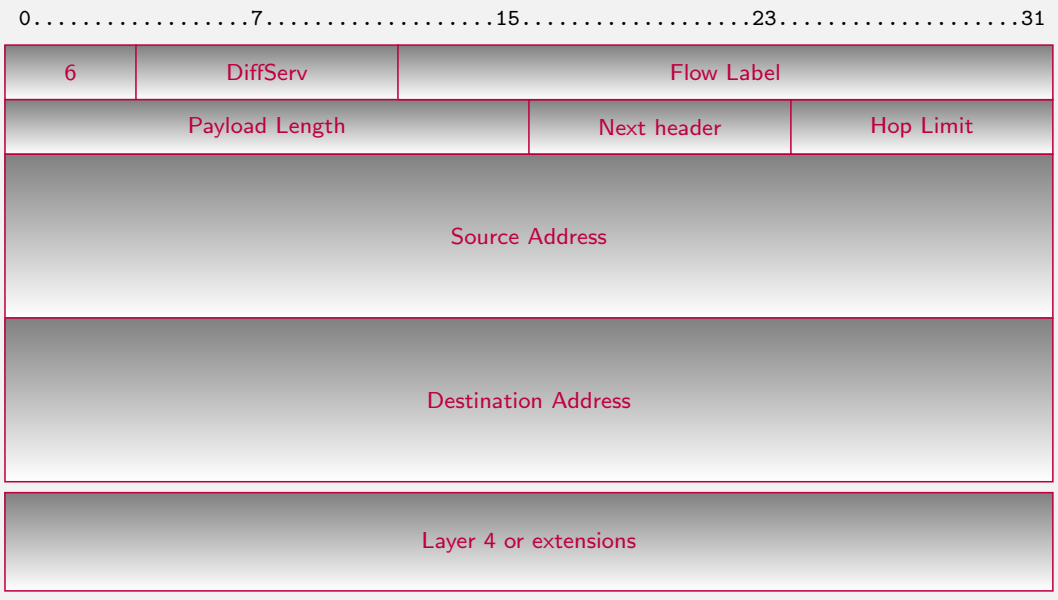
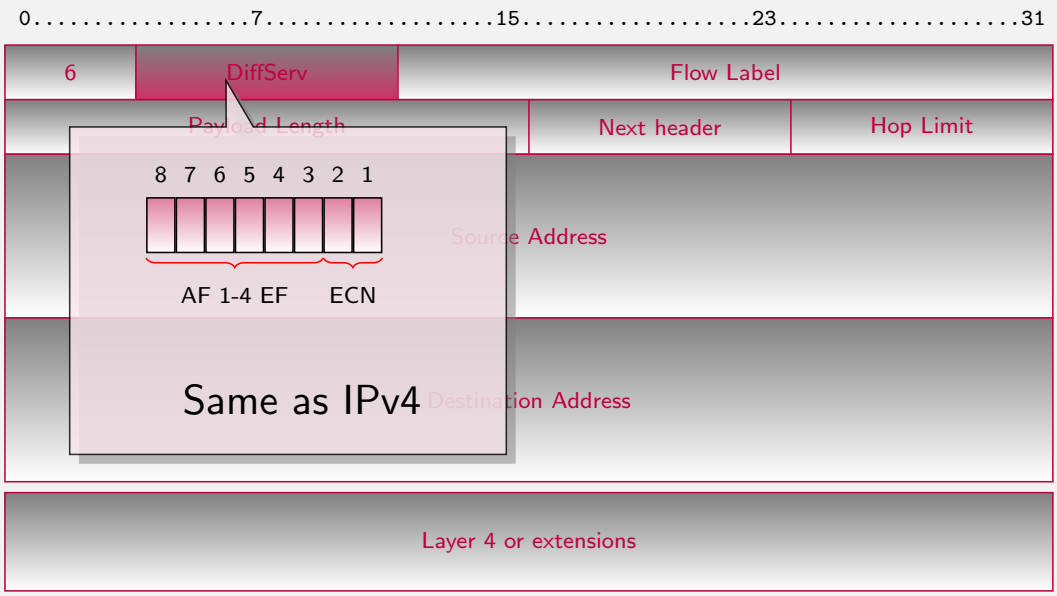


DiffServ & Flow Label

Protocol
IPv6 Header
IPv6 Header
IPv6 Extensions
ICMPv6
Impact on Layers 4



DiffServ & Flow Label

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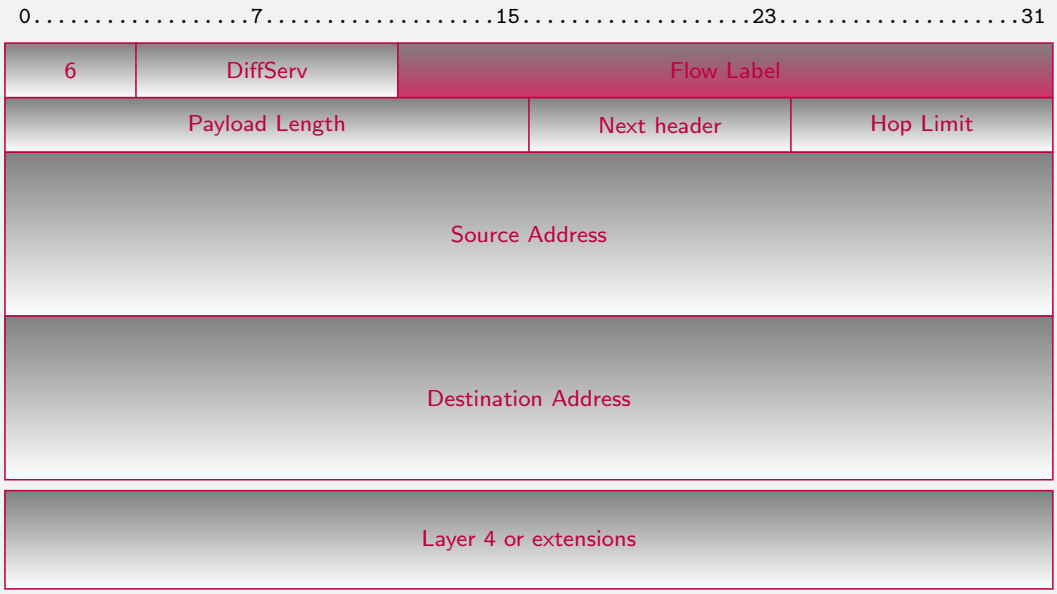

Flow Label (RFC 3697): Why?

Protocol
IPv6 Header
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Impact on Layers 4

- A flow is a sequence of packets that should receive specific non-default handling from the network
  - For instance : 5-tuple of the same source/destination address/port and transport protocol values
- The Flow Label field is designed to enable classification of packets belonging to a specific flow
  - Without the flow label the classifier must use transport next header value and port numbers
    - Less efficient (need to parse the option headers)
    - May be impossible (fragmentation or IPsec ESP)
- A flow is a unique identifier (for the source)
  - Flow label + source address is unique
  - Reduce processing time by 2-4 times in IPv4 and 3-6 times in standard IPv6
  - After a silence of 120 seconds, packets are not assumed to belong to the same flow

Flow Label: Why not?

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IPv6 Header
IPv6 Header
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ICMPv6
Impact on Layers 4

- When IPv6 started to be designed:
  - RSVP was forecast to allow end-to-end micro flows reservation.
  - Short path for ATM VC
- With DiffServ, aggregation inside provider network is preferred:
  - Macro flows (e.g. from an ingress to an egress router)
  - Different sources, possibility of no common bits in the header
- Providers do not have to look at flow label to identify macro-flows
  - Only hosts have to do it, and they ≪ have time ≫ to look at port numbers
  - Firewalls cannot use Flow Label to take decisions

Protocol

IPv6 Extensions

Extensions

Protocol
IPv6 Header
IPv6 Header
IPv6 Extensions
ICMPv6
Impact on Layers 4

- Seen as a L4 protocol
- Processed only by destination
  - Except Hop-by-Hop processed by every router
  - Equivalent of option field in IPv4
- No size limitation
- Several extensions can be linked to reach L4 protocol
- Processed only by destination
  - Destination (mobility)
  - Routing (loose source routing, mobility)
  - Fragmentation
  - Authentication (AH)
  - Security (ESP)

Extensions in packets

Protocol
IPv6 Header
IPv6 Header
IPv6 Extensions
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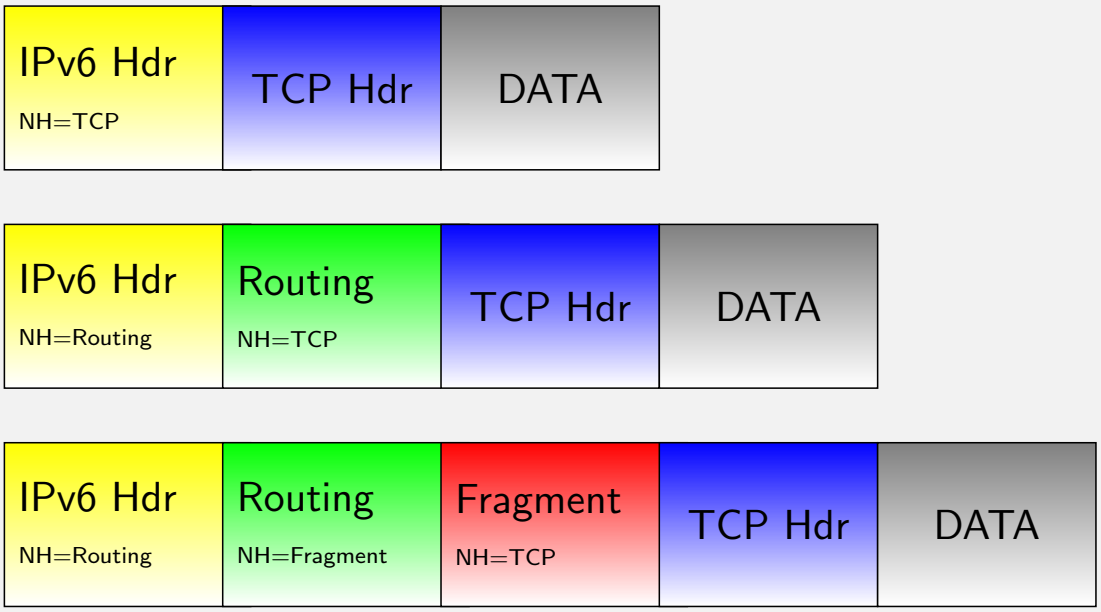
Impact on Layers 4



Extension Superiority

Protocol
IPv6 Header
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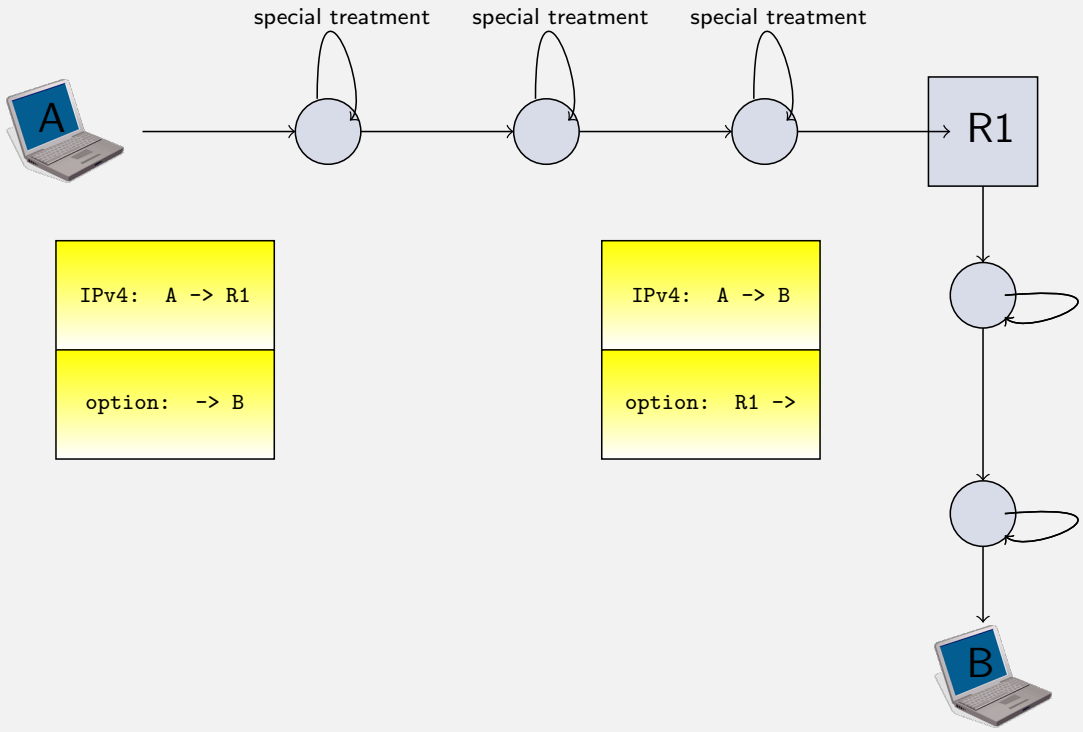
ICMPv6
Impact on Layers 4



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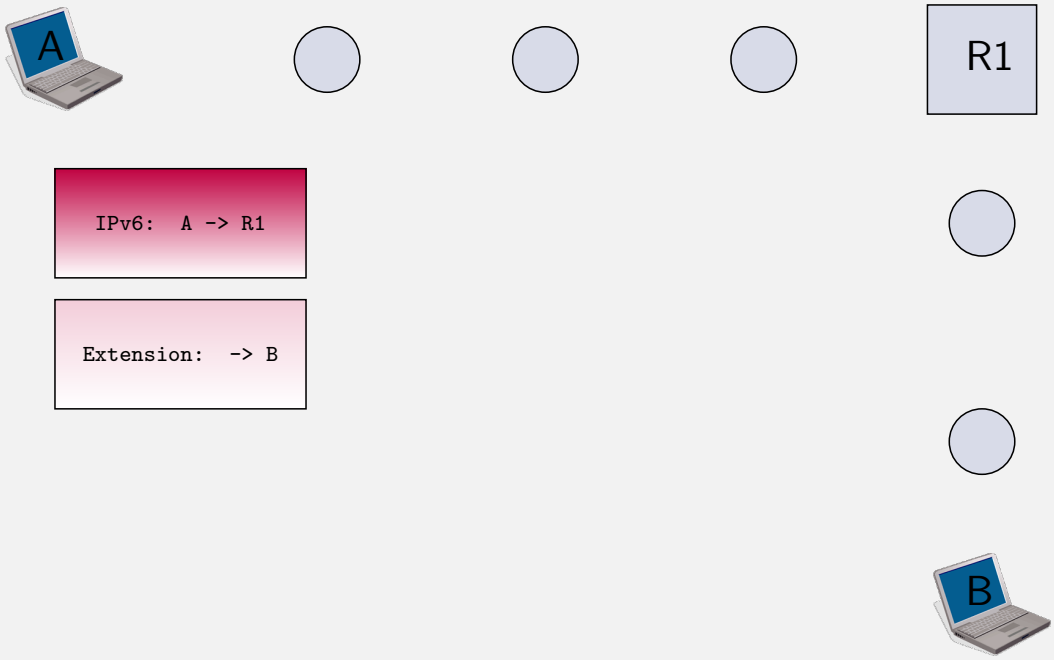

Extension Superiority

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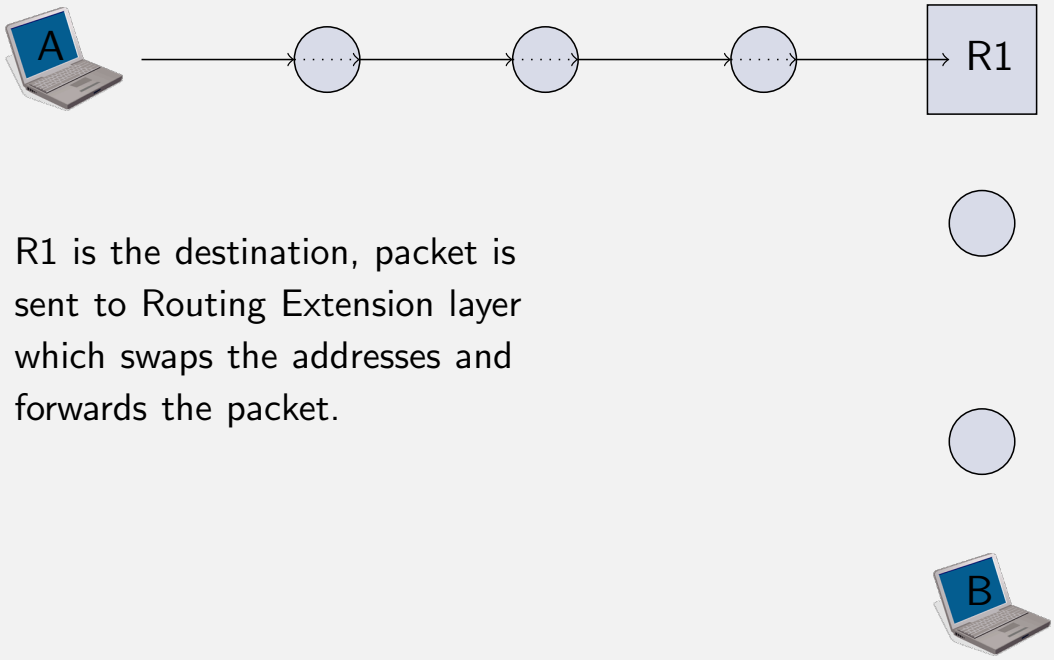

R1 is the destination, packet is sent to Routing Extension layer which swaps the addresses and forwards the packet.

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Extension Superiority

Protocol
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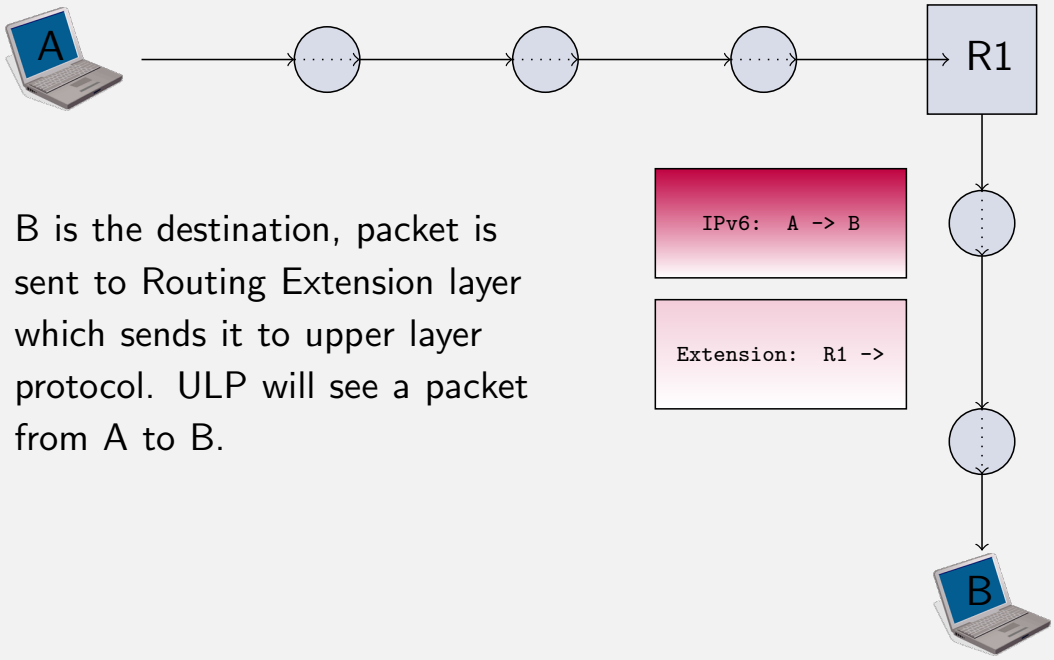

B is the destination, packet is sent to Routing Extension layer which sends it to upper layer protocol. ULP will see a packet from A to B.

Extension Order is Important

Protocol
IPv6 Header
IPv6 Header
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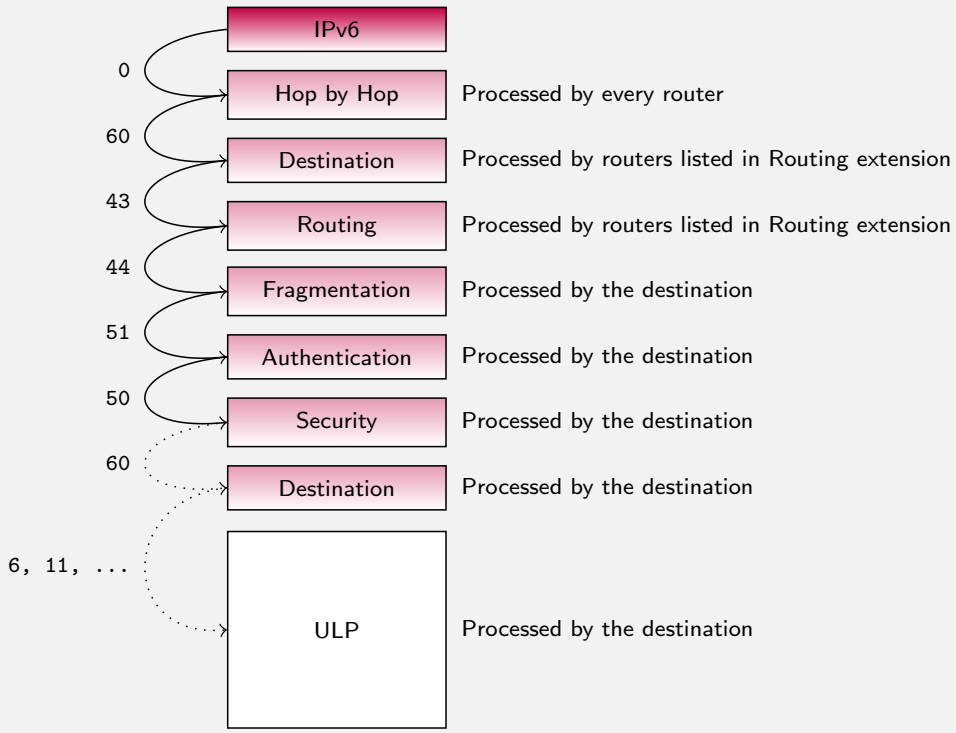
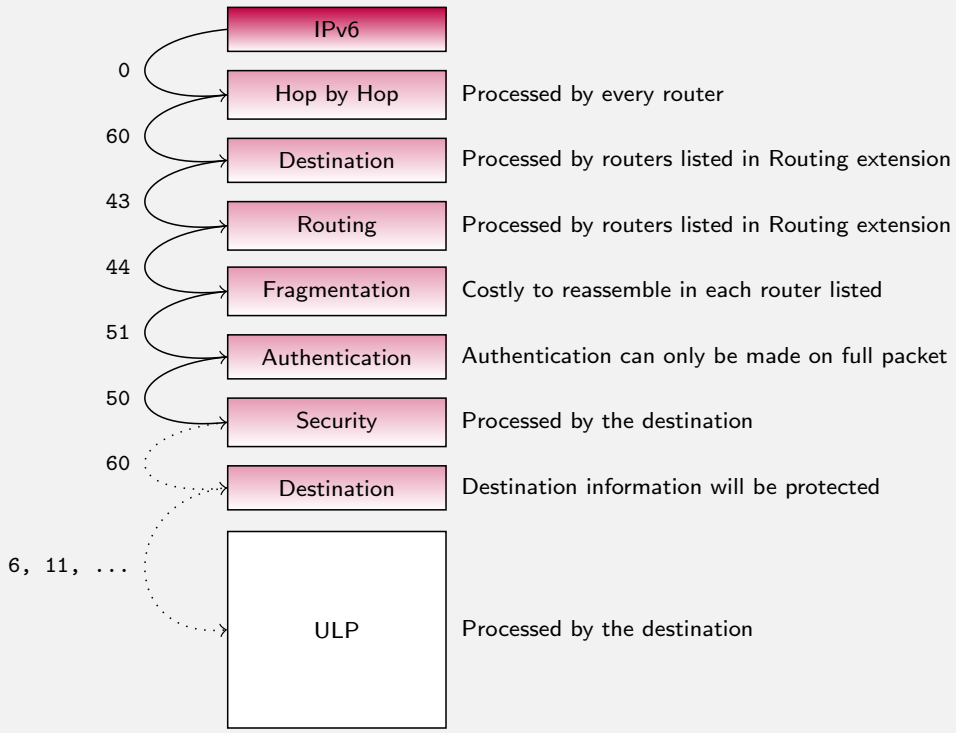
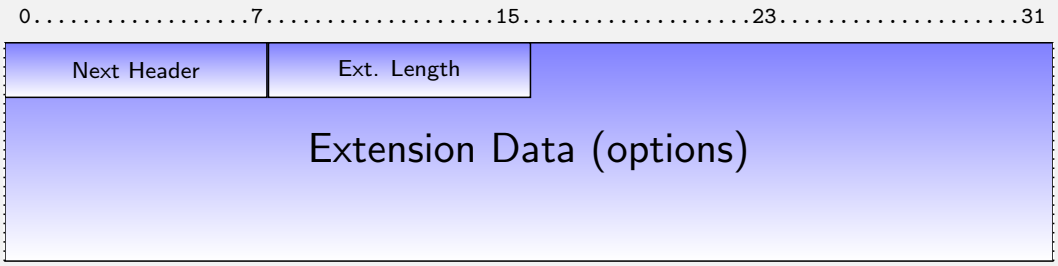
ICMPv6
Impact on Layers 4



Extension Order is Important



Extensions Generic Format

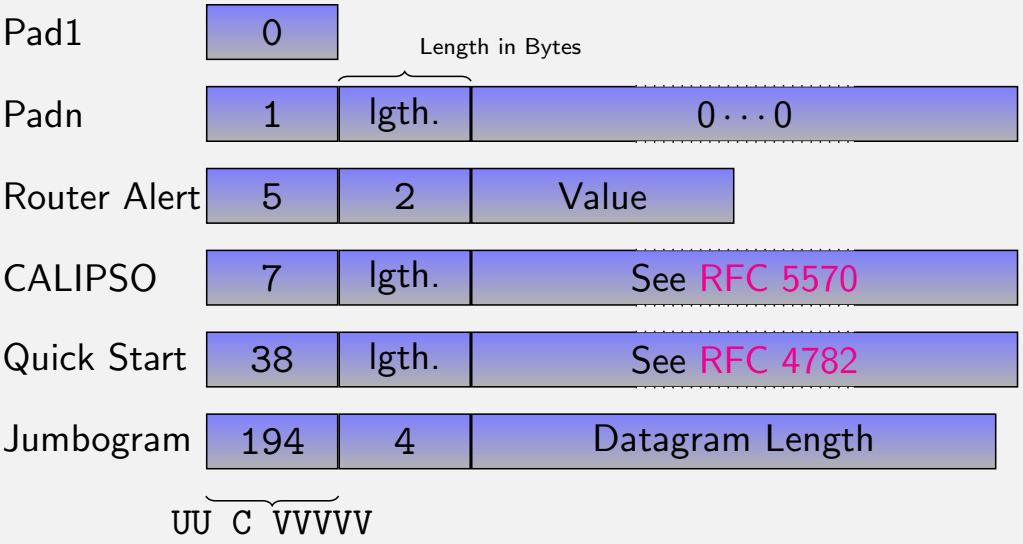


- Next Header: Save values as in IPv6 packets
- Length: numbers 64-bit long words for variable length extensions (0 for fixed length fragmentation extension)
- Data: options (Hop by hop, Destination) or specific format

Hop by Hop (NH=0)

Protocol
IPv6 Header
IPv6 Header
IPv6 Extensions
ICMPv6
Impact on Layers 4

- Always first position
- Composed of options:



Hop by Hop (NH=0)

Protocol
IPv6 Header
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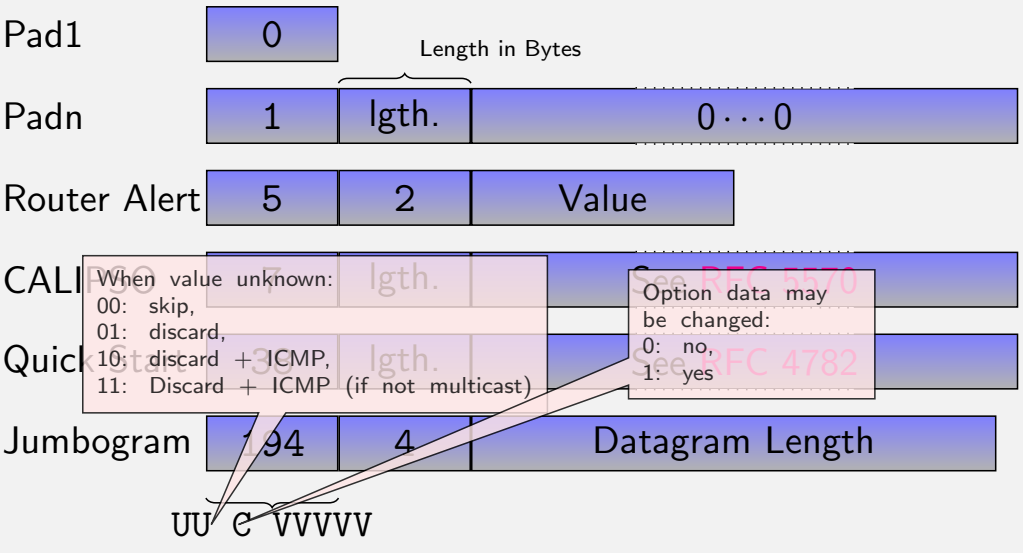
IPv6 Extensions
ICMPv6
Impact on Layers 4

- Always first position
- Composed of options:



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Hop by Hop (NH=0)

Protocol
IPv6 Header
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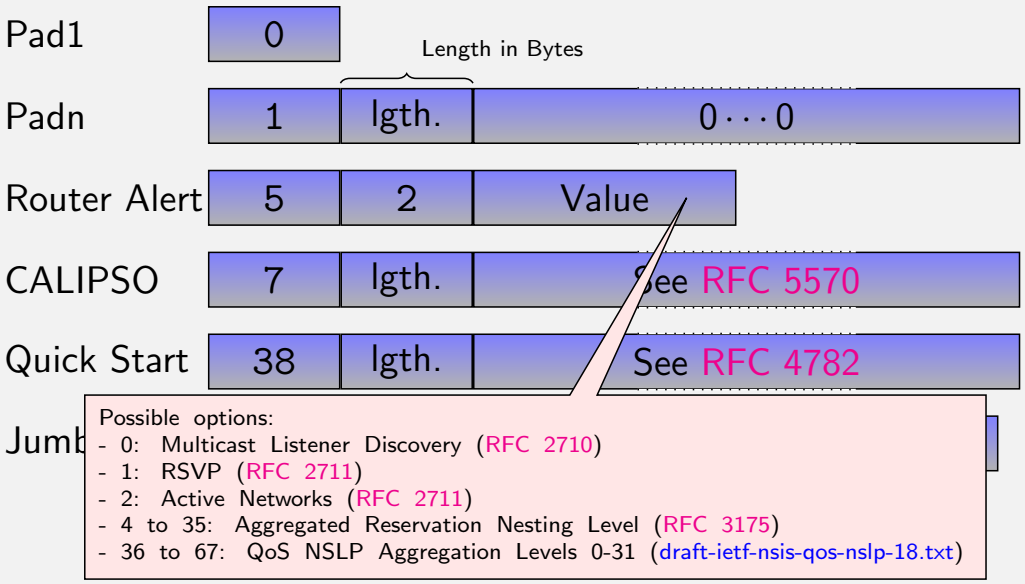
- Always first position
- Composed of options:



Destination (NH=60)

Protocol
IPv6 Header
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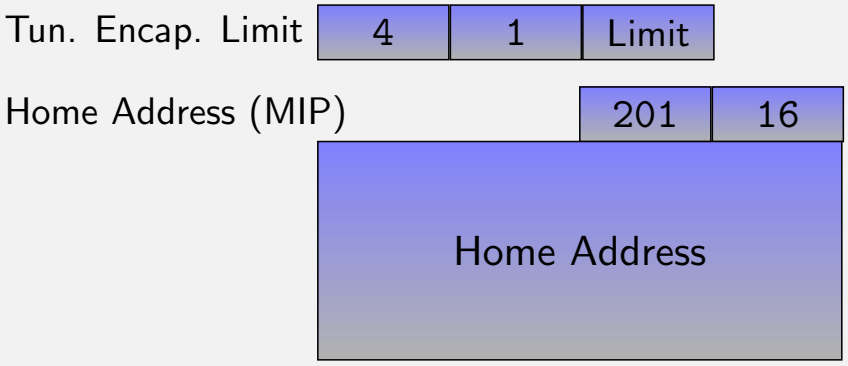
IPv6 Extensions
ICMPv6
Impact on Layers 4



- Tunnel Encapsultation Limit (RFC 2473): the maximum number of nested encapsulations of a packet. When it reaches 0, the packet is discard and an ICMPv6 message is sent.
- Home Address (RFC 3775): Contains the Home Address of the sender (IPv6 header contains the Care-of Address).

Routing (NH=43)

Protocol
IPv6 Header
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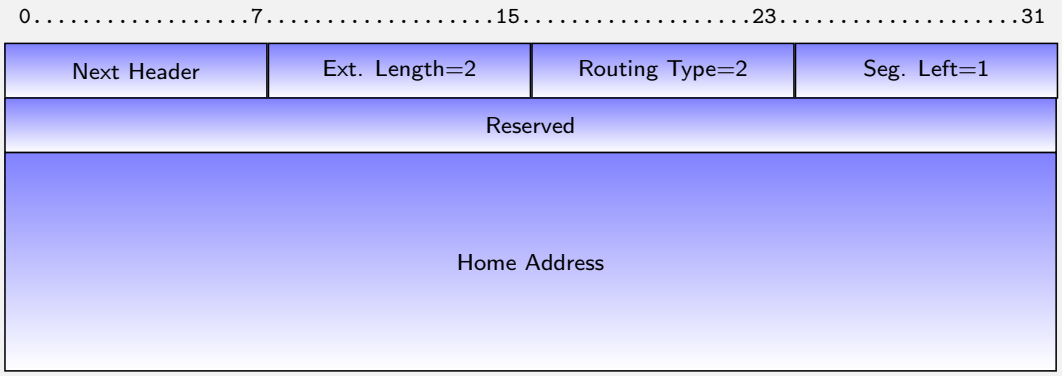
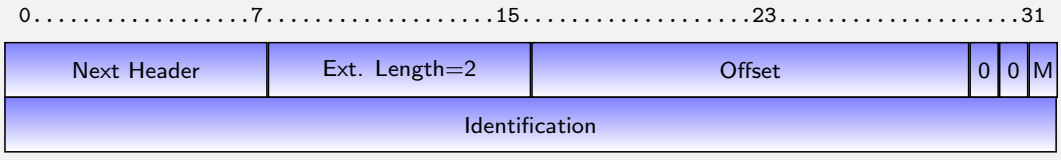
ICMPv6
Impact on Layers 4



Fragmentation (NH=44)

Protocol
IPv6 Header
IPv6 Header
IPv6 Extensions
ICMPv6
Impact on Layers 4



- Compared to IPv4, it is equivalent to DF=1
- A Router never fragments packets but sends an ICMPv6 message ("Packet Too Big") with the expected size
- The Sender either uses the fragmentation extension or adapts TCP segments

Protocol

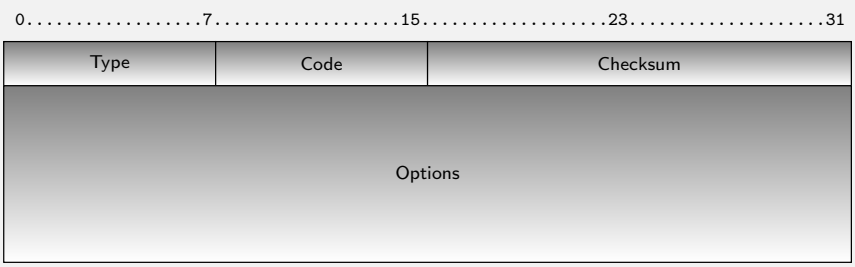
ICMPv6

ICMPv6

Protocol
IPv6 Header
IPv6 Header
IPv6 Extensions
ICMPv6
Impact on Layers 4

- ICMPv6 is different from ICMP for IPv4 (RFC 4443)
  - IPv6 (or extension): 58
- Features are extended and better organized
- Never filter ICMPv6 messages blindly, be careful to what you do (see RFC 4890)

Format :



Precision

type code nature of the message ICMPv6
code specifies the cause of the message ICMPv6
mandatory *checksum* used to verify the integrity of ICMP packet

ICMPv6 : Two Functions

Protocol
IPv6 Header
IPv6 Header
IPv6 Extensions
ICMPv6
Impact on Layers 4

- Error occurs during forwarding (*value* < 128)

1	Destination Unreachable
2	Packet Too Big
3	Time Exceeded
4	Parameter Problem

- Management Applications (*value* > 128)

128	Echo Request
129	Echo Reply
130	Group Membership Query
131	Group Membership Report
132	Group Membership Reduction
133	Router Solicitation
134	Router Advertissement
135	Neighbor Solicitation
136	Neighbor Advertissement
137	Redirect

Destination unreachable

Protocol
IPv6 Header
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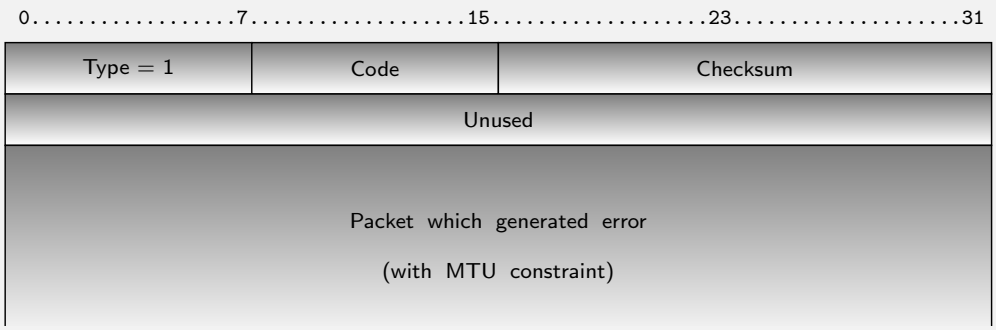

- 0 - No route to destination
- 1 - Communication with destination administratively prohibited
- 2 - Beyond scope of source address
- 3 - Address unreachable
- 4 - Port unreachable
- 5 - Source address failed ingress/egress policy
- 6 - Reject route to destination

Packet Too Big

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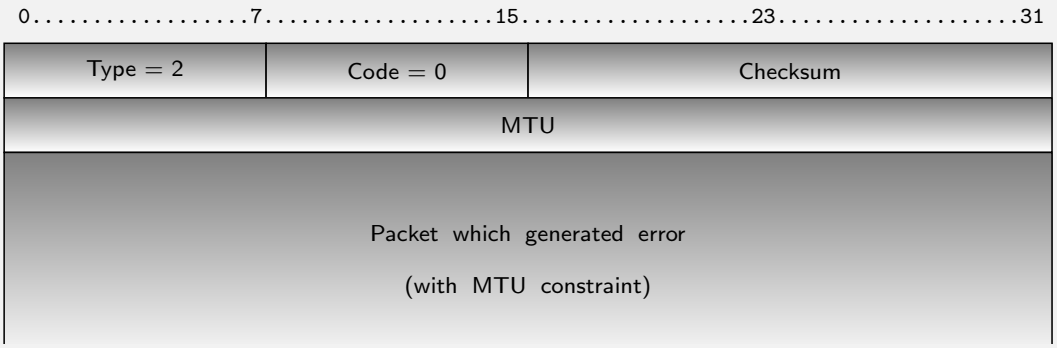
Impact on Layers 4



Time Exceeded

Protocol
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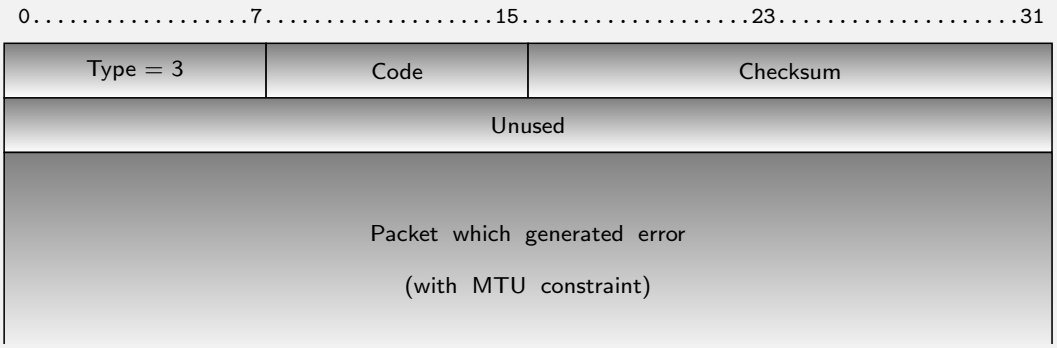
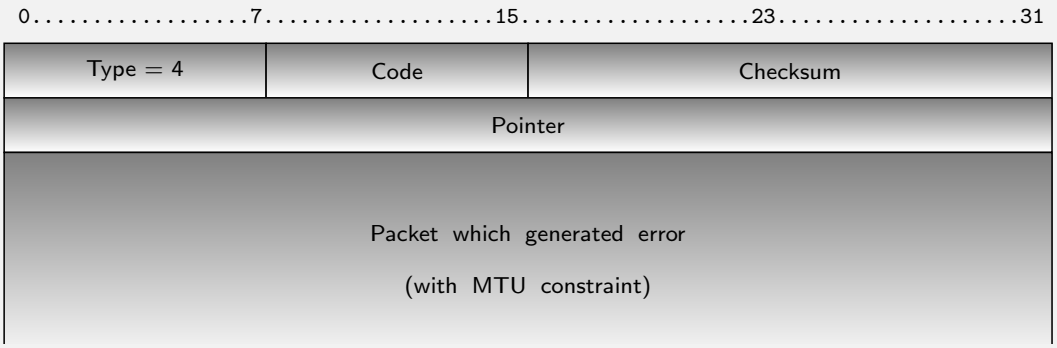


Code:

- 0 - Hop limit exceeded in transit
- 1 - Fragment reassembly time exceeded

Used by traceroute6 to find the path

Error

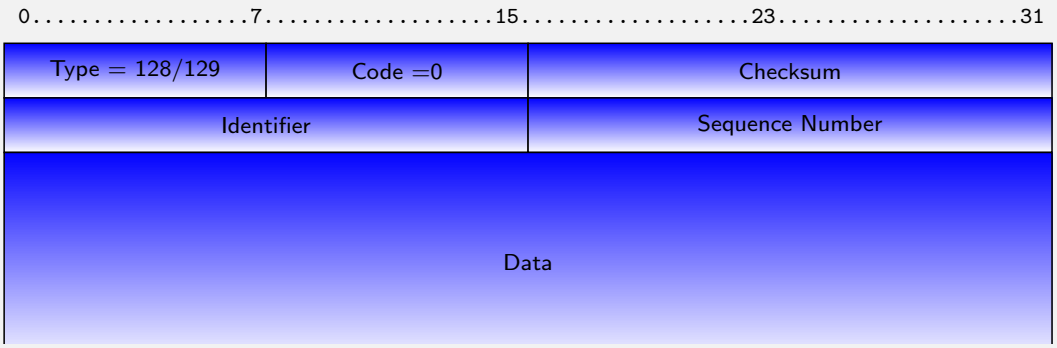


Code:

- 0 - Erroneous header field encountered
- 1 - Unrecognized Next Header type encountered
- 2 - Unrecognized IPv6 option encountered

Pointer: Byte where error occured

Ping



Type:

- 128: request
- 129 : reply

Protocol

Impact on Layers 4

Pseudo Header

Protocol
IPv6 Header
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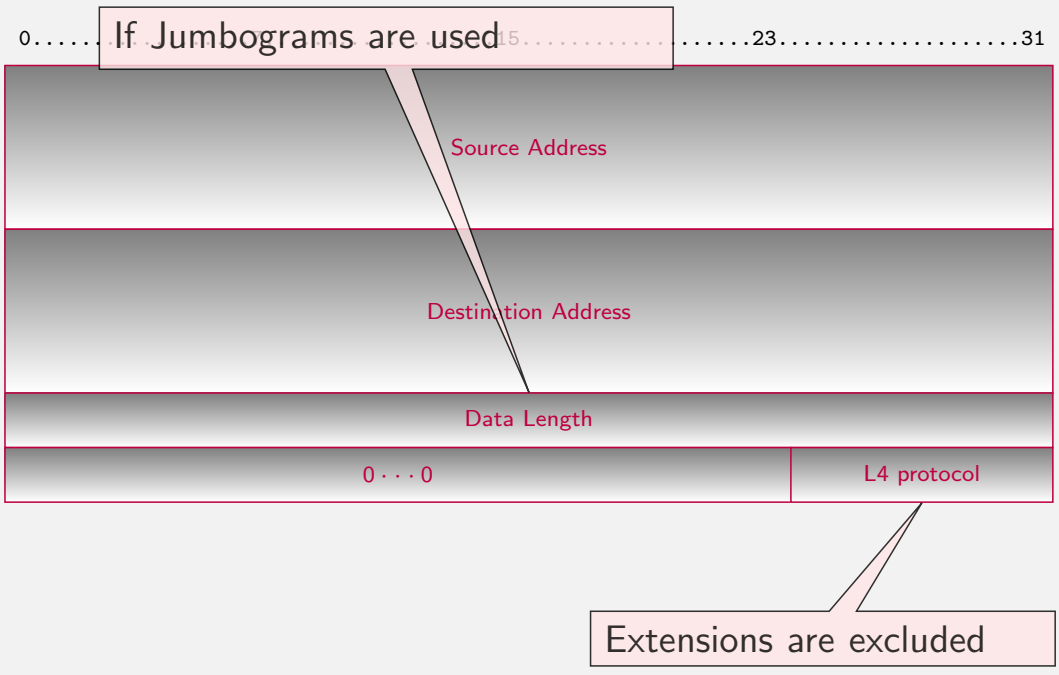
ICMPv6
Impact on Layers 4



Layer 4 protocols

Protocol
IPv6 Header
IPv6 Header
IPv6 Extensions
ICMPv6
Impact on Layers 4

IPv6 is almost transparent for Layer 4 protocol, except:

- Jumbogram impact:
  - UDP: if Jumbogram are used and $length > 65535 \Rightarrow$ UDP.length $= 0$ and use Jumbogram length
  - TCP: Use PMTU if $Length > 65535$
- UDP-Light: For multimedia flow a bit error is less important than a packet loss. UDP-light is used to not include UDP payload in L4 Checksum.
- SCTP: during session initialisation, IPv4 and IPv6 addresses are exchanged.