Computer Networks

Internet Protocol version 6 (**IPv6**) Header

Lecture Contents

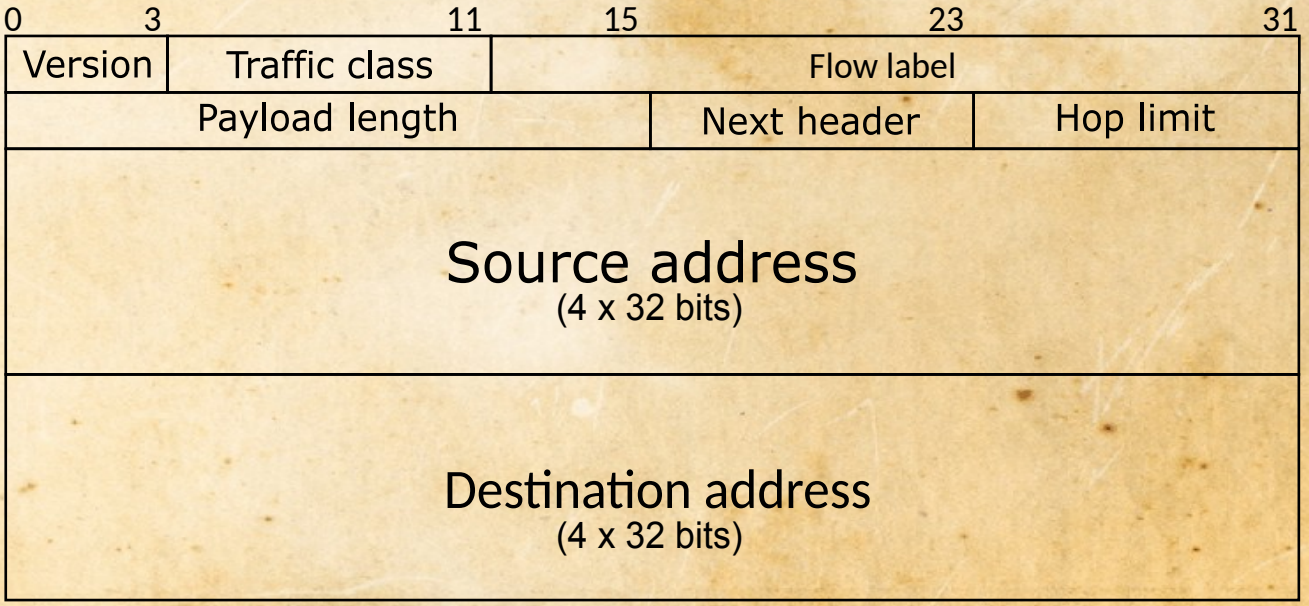
- Review of IPv4 Header
- IPv6 header
- IPv6 Addresses
- IPv6 Fragmentation

Internet Protocol version 6 (IPv6)

- Solve the problem of IPv4 address exhaustion
  - IPv4 only ~4 billion addresses, IPv6 ~3.4×10^{38} addresses
- Not designed to be interoperable with IPv4
  - Slows transition from IPv4 to IPv6
- Hierarchical address allocation facilitate route aggregation (?)
  - Reduce routing table size
- Multicast simplified and expanded (?)
- Device mobility, security, configuration considered in design (?)

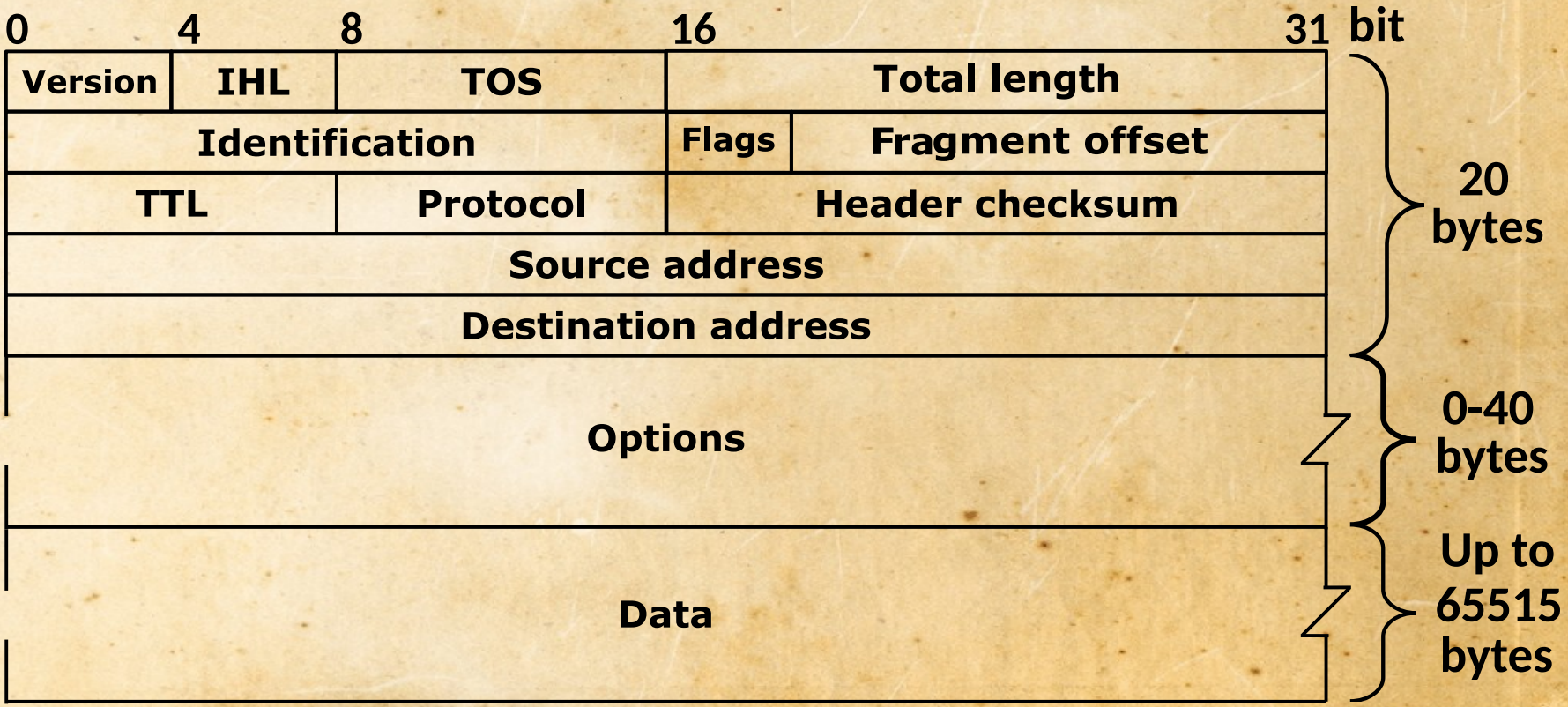
Internet Protocol version 6 (IPv6) Header

- IPv6 header
  - first defined in *RFC1883* in December 1995
  - Standardized in *RFC 8200*, July 2017

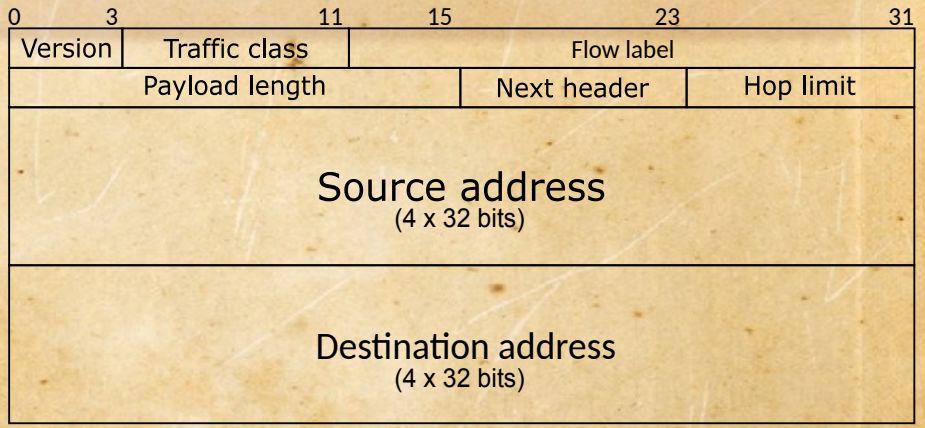


Review of IPv4 Header

- IPv4 header given in ***IEN 54*** (and *RFC 760*)

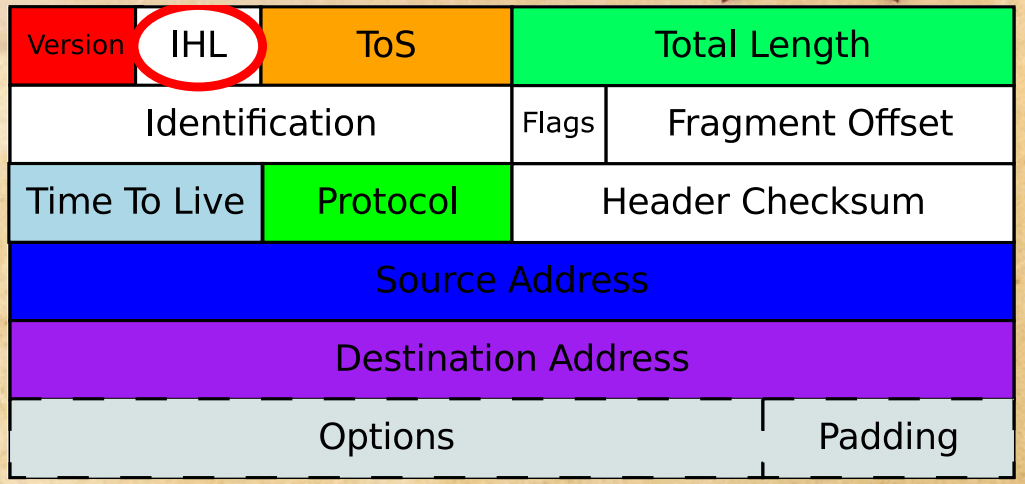


Internet Protocol version 6 (IPv6) Header

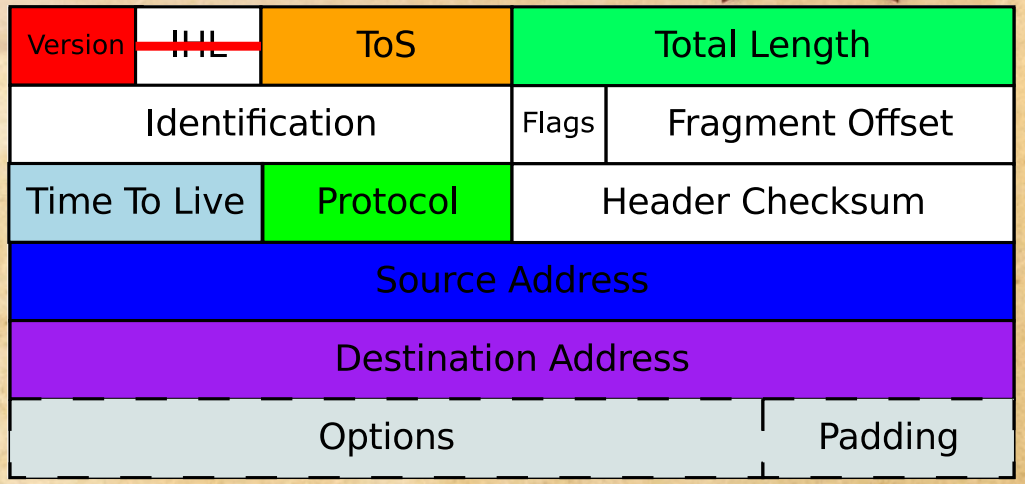


- ***Version*** set to 6: `0110`
- ***Traffic Class / Flow Label***
  - Intended for QOS (Quality of Service) uses for special handling of packets
  - Allows special handling by intermediate IPv6 routers
  - Set to zero if router/host does not support
  - Flows must be set up
    - supposed to specify lifetime of the flow.

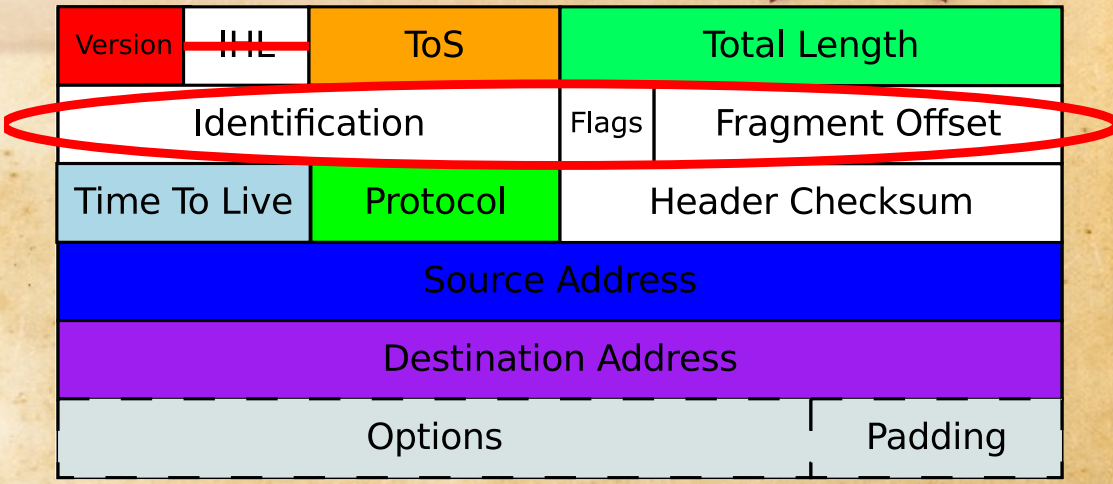
- No header length
  - Why?



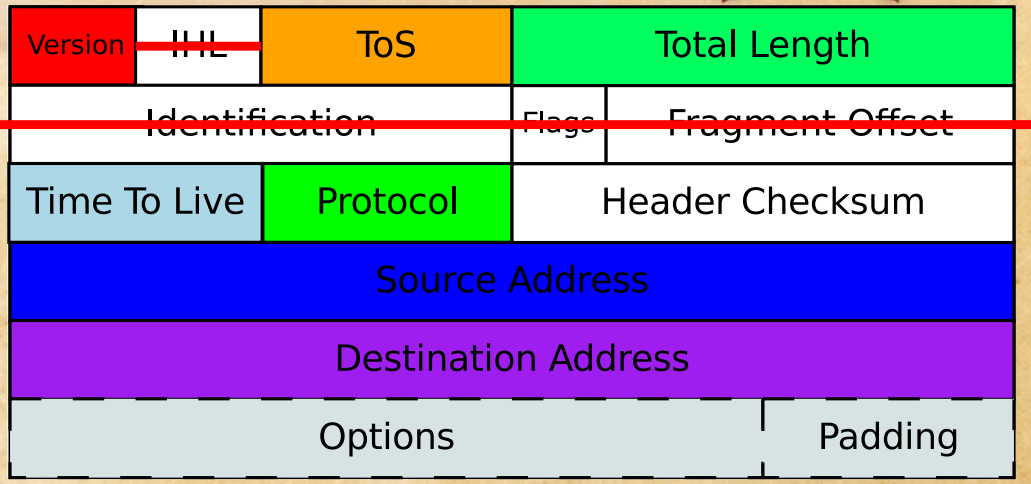
- No header length
  - IPv6 header is fixed 40 octets



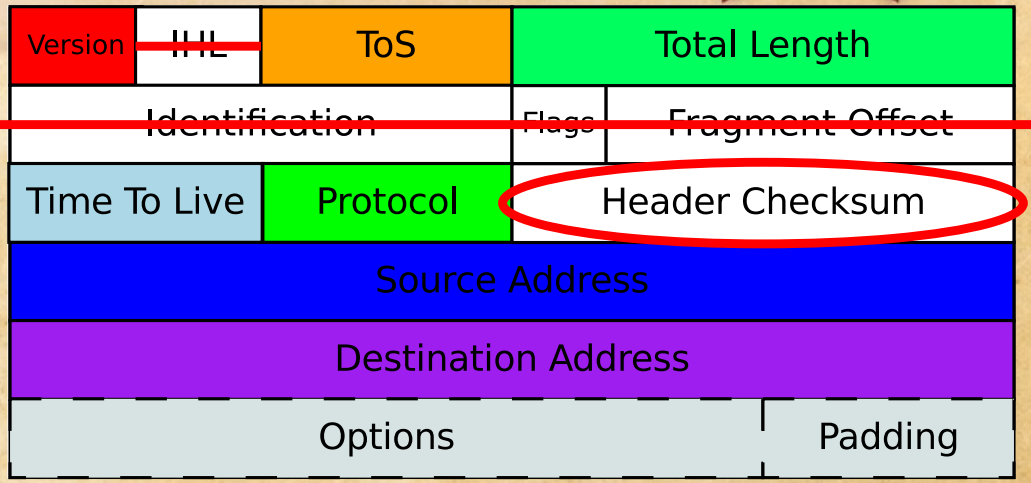
- No header length
  - IPv6 header is fixed 40 octets
- No fragmentation fields
  - Then how to solve?



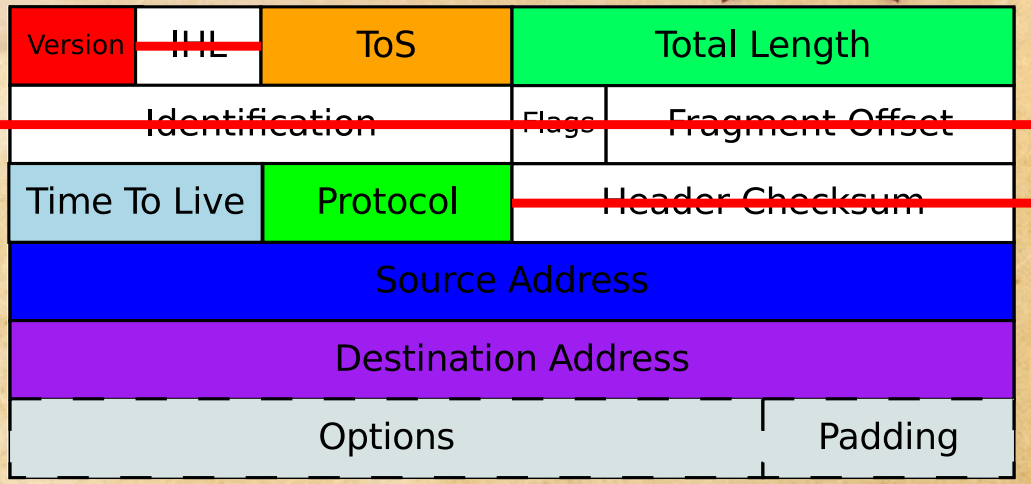
- No header length
  - IPv6 header is fixed 40 octets
- No fragmentation fields
  - Fragmentation at endpoints



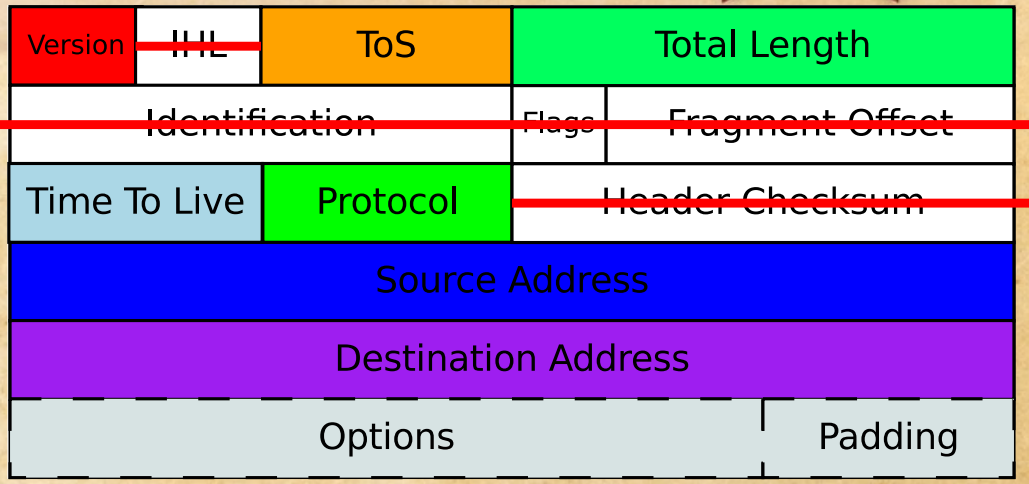
- No header length
  - IPv6 header is fixed 40 octets
- No fragmentation fields
  - Fragmentation at endpoints
- No header checksum
  - Why?

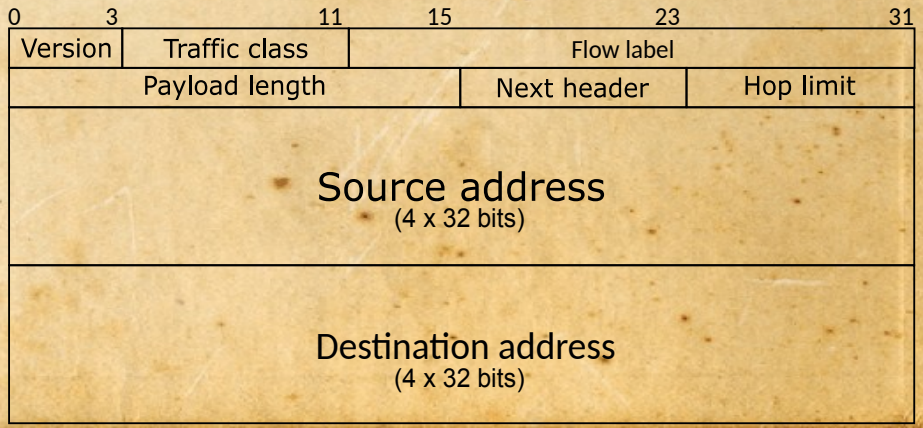


- No header length
  - IPv6 header is fixed 40 octets
- No fragmentation fields
  - Fragmentation at endpoints
- No header checksum
  - Link layers are reliable enough
  - Less computation required of nodes (why?)
  - Payload has own error checking and correcting, as necessary



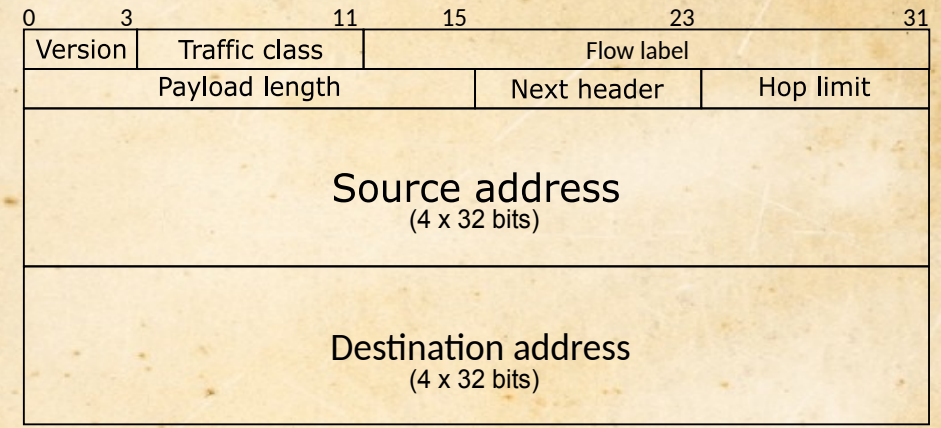
- Fixed header length
- Fragmentation at endpoints
- No header checksum
- Approximate equivalents:
  - ***Type of Service → Traffic Class / Flow label*** (QOS – Quality of Service)
  - ***Total Length → Payload Length***
  - ***Time to Live → Hop Count***
  - ***Protocol → Next Header***



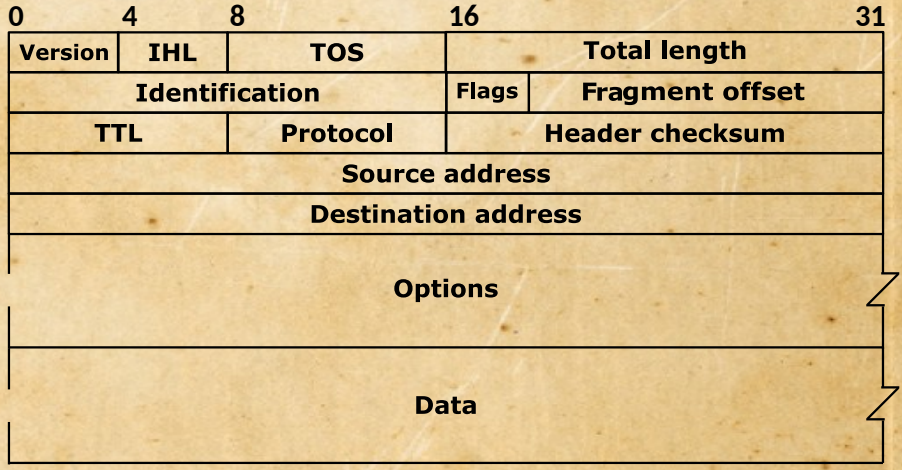


Internet Protocol version 6 (IPv6) Header

- IPv6 header defined in



Total length: **Ten** 32-bit words
(= 40 octets = 320 bits)



Minimum length: **Five** 32-bit words
(= 20 octets = 160 bits)
Maximum: **Fifteen** 32-bit words
(= 60 octets = 480 bits)
Note: four bit field, and 0xF is 15

Internet Protocol version 6 (IPv6) Addresses

- 128 bits → 32 hexadecimal digits
  - Written as `x:x:x:x:x:x:x:x`, where each `x` is 1-4 hexadecimal digits
  - Two colons "`::`" can replace one or more groups of 16 bits of zeros, but can only appear once
  - Examples:
    - `2001:DB8:0:0:8:800:200C:417A` → `2001:DB8::8:800:200C:417A`
    - `FF01:0:0:0:0:0:0:101` → `FF01::101`
    - `0:0:0:0:0:0:0:1` → `::1` ← the *loopback address*; IPv4 is `127.0.0.1`
    - `0:0:0:0:0:0:0:0` → `::` ← the *unspecified address*; host with no address
  - Can also use IPv4 format for last 2 bytes: `0:0:0:0:0:0:13.1.68.3`

Internet Protocol version 6 (IPv6) Addresses

- IPv6 Prefixes follow *Classless Inter-Domain Routing* (CIDR) notation
  - *Address / prefix-length*
  - Examples for 60-bit prefix: `20010DB80000CD3` :
    - `2001:0DB8:0000:CD30:0000:0000:0000:0000/60`
    - `2001:DB8::CD30:0:0:0:0/60`
    - `2001:DB8:0:CD30::/60`
  - Illegal:
    - `2001:0DB8:0:CD3/60` ← expands to `2001:0DB8:0:0CD3:0:0:0:0`
    - `2001:0DB8::CD30/60` ← expands to `2001:0DB8:0:0:0:0:0:CD30`
    - `2001:0DB8::CD3/60` ← expands to `2001:0DB8:0:0:0:0:0:0CD3`

Internet Protocol version 6 (IPv6) Addresses

- IPv6 node address and subnet number can be combined:
  - Example
    - node address: `2001:0DB8:0:CD30:123:4567:89AB:CDEF`
    - Subnet prefix: `2001:0DB8:0:CD30::/60`
    - Combined: `2001:0DB8:0:CD30:123:4567:89AB:CDEF/60`

Internet Protocol version 6 (IPv6) Addresses

- IPv6 address type:

Unspecified:	::/128	00...0 (upper 128 bits all zero)
Loopback:	::1/128	00...1 (upper 127 bits zero then a 1)
Multicast:	FF00::/8	11111111 (upper 8 bits all 1)
Link-local unicast:	FE80::/10	1111111010 (upper bits 7 ones then 010)
Global Unicast:	*everything else*	

Internet Protocol version 6 (IPv6) Fragmentation

- All nodes on IPv6 network required to at least handle packets up to 1280 octets in size
  - IPv4 is 576 bytes (64+512); minimum 68 bytes without fragmentation
- Routers do *not* fragment IPv6 packets
  - Too large → drop and send back ***ICMPv6 Packet Too Big*** message
- ***Path MTU Discovery***
  - Endpoints are “strongly recommended” to use to take advantage of greater packet lengths
  - **MTU** = Maximum Transmission Unit
    - Maximum packet length that can be transmitted without need for fragmentation

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