IP Versions

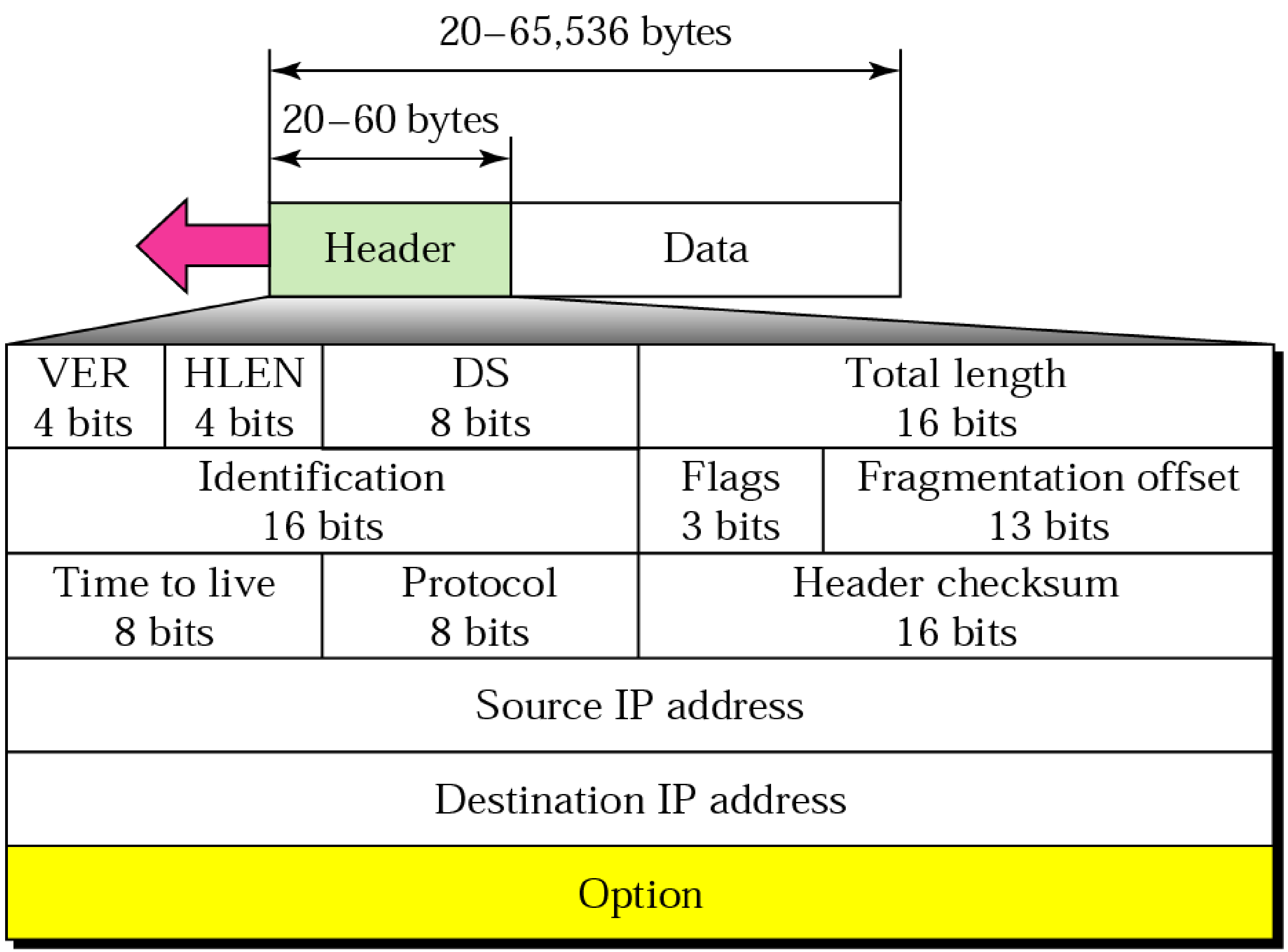
- • IPv4
  - Current Internet version
  - 32-bit addresses
  - Many incremental improvements
- • IPv6
  - Next generation Internet
  - 128-bit addresses
  - Optimization and simplifications
  - Mobility, security are integrated parts
- • *IPv5*
  - *ST (Stream protocol) connection oriented protocol for real-time application*

IP datagram

VER- protocol version(IPv4, IPv6)
Hlen (4 bits) The Internet Header Length (IHL) describes how big the header is in 32-bit words. For instance, the minimum value is 5
DS (8 bits) Type of service

TTL – each router decrement the value; TTL=1 the packet don't go outside of LAN

The total length field defines the total length of the datagram including the header.

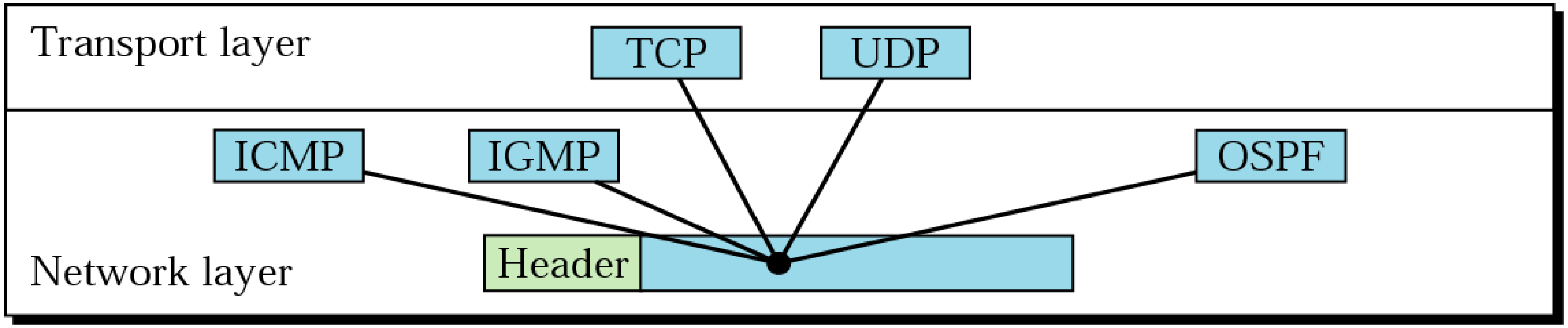


Protocol field

The values are common for IPv4 şi IPv6

- 1 – ICMP for IPv4
- 2 – IGMP for IPv4
- 4 – IP in IP
- 6 – TCP
- 17 – UDP
- 41 – IPv6
- 58 – ICMP for IPv6
- 59 – do not exist another antet

Multiplexing



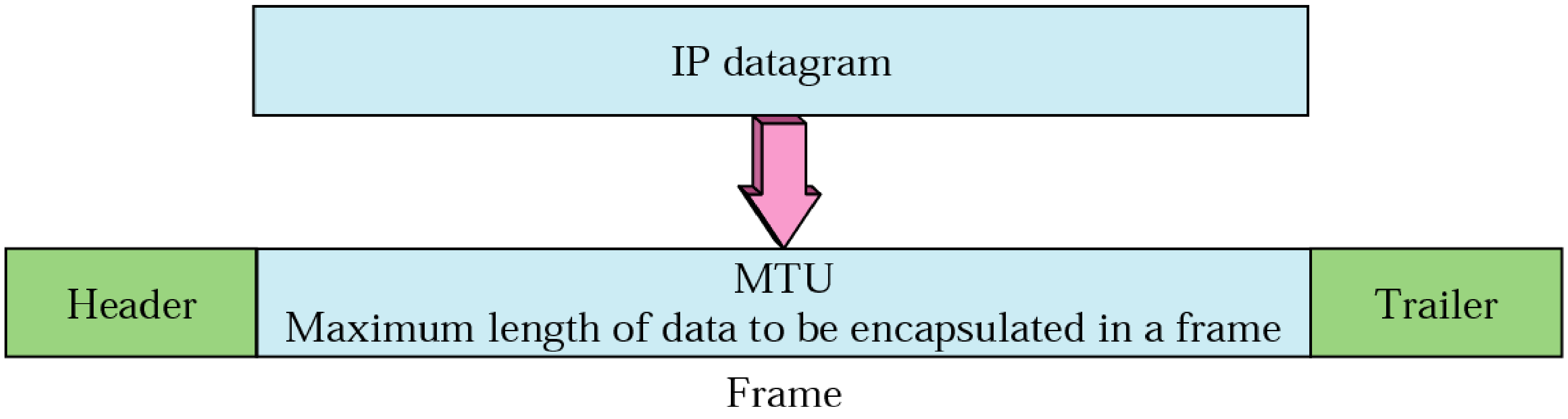
Example of checksum calculation

4	5	0	28	
1			0	0
4	17		0	
10.12.14.5				
12.6.7.9				

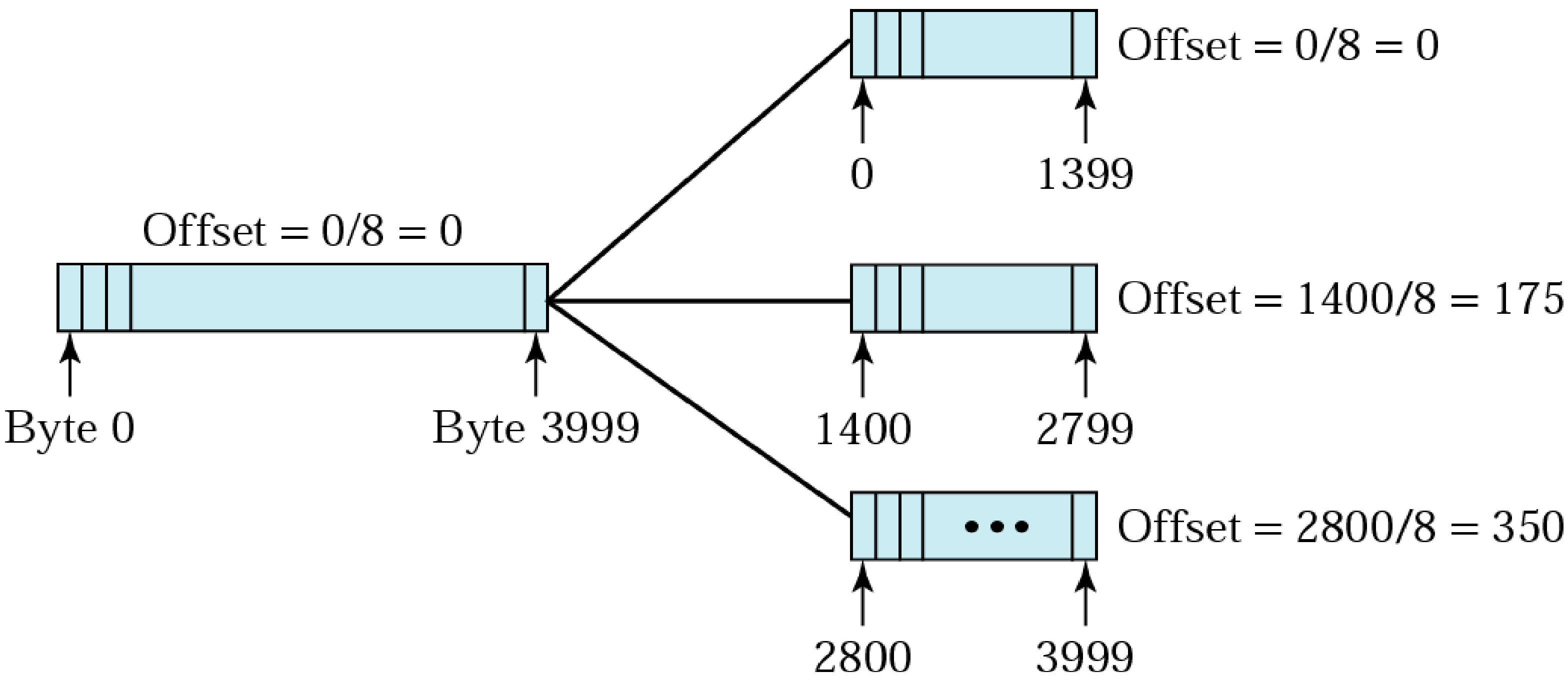
4, 5, and 0 → 0100010100000000
28 → 0000000000011100
1 → 0000000000000001
0 and 0 → 0000000000000000
4 and 17 → 0000010000010001
0 → 0000000000000000
10.12 → 0000101000001100
14.5 → 0000111000000101
12.6 → 0000110000000110
7.9 → 0000011100001001

Sum → 0111010001001110
Checksum → 1000101110110001

MTU


IP datagram
Header
MTU
Maximum length of data to be encapsulated in a frame
Trailer
Frame

Fragmentation example

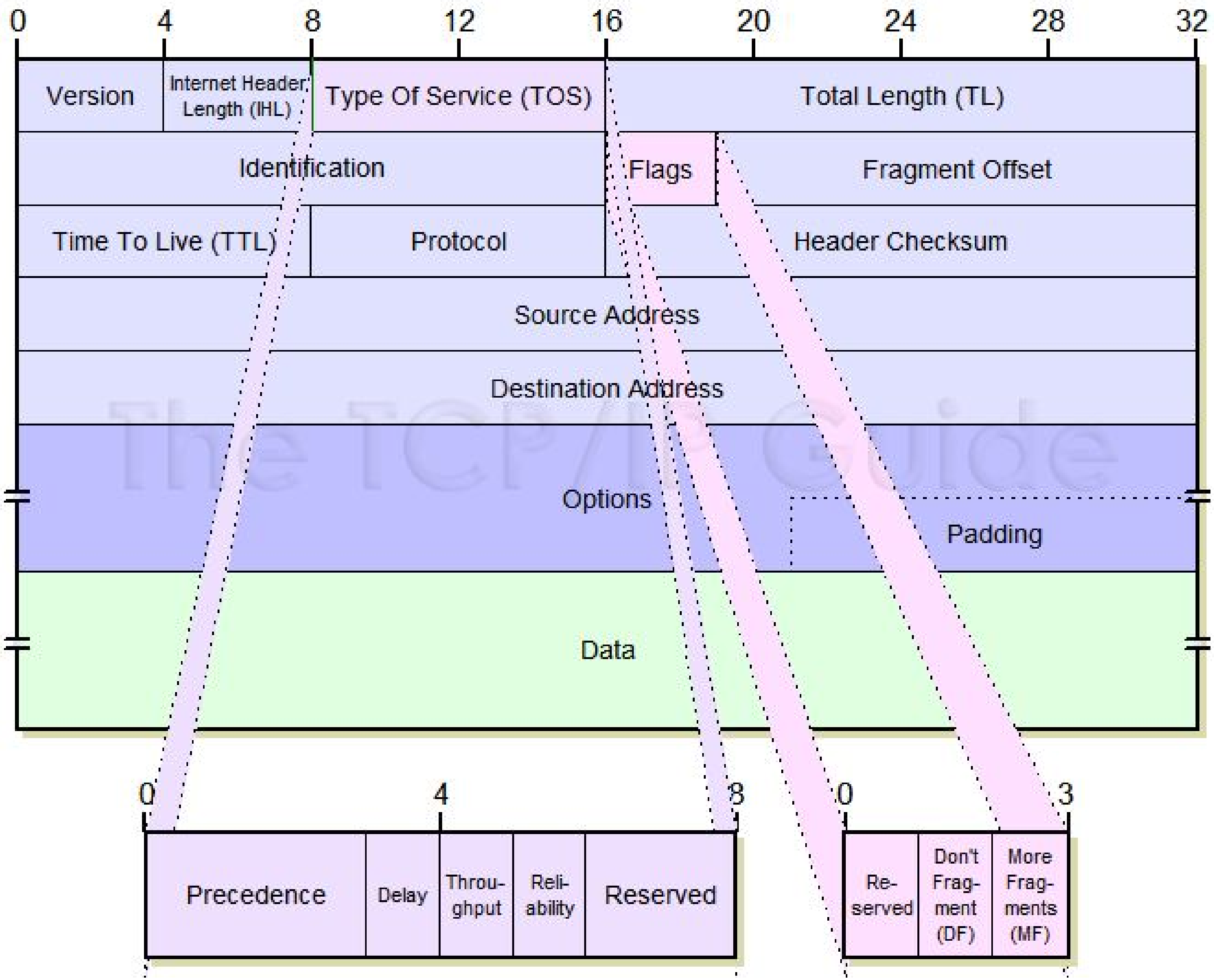


IPv4 features

IPv4

- Source and destination addresses are 32 bits (4 bytes) in length.
- IPSec support is optional.
- IPv4 header does not identify packet flow for QoS handling by routers.
- Both routers and the sending host fragment packets.
- Header includes a checksum.
- Header includes options.
- Address Resolution Protocol (ARP) uses broadcast ARP Request frames to resolve an IP address to a link-layer address.
- Internet Group Management Protocol (IGMP) manages membership in local subnet groups.
- ICMP Router Discovery is used to determine the IPv4 address of the best default gateway, and it is optional.
- Broadcast addresses are used to send traffic to all nodes on a subnet.
- Must be configured either manually or through DHCP.
- Uses host address (A) resource records in Domain Name System (DNS) to map host names to IPv4 addresses.
- Uses pointer (PTR) resource records in the IN-ADDR.ARPA DNS domain to map IPv4 addresses to host names.
- Must support a 576-byte packet size (possibly fragmented).

IPv4 Datagram format



Protocol field in IPv4

Protocol: Identifies the higher-layer protocol (generally either a transport layer protocol or encapsulated network layer protocol) carried in the datagram. The values of this field were originally defined by the IETF "Assigned Numbers" standard, RFC 1700, and are now maintained by the Internet Assigned Numbers Authority (IANA):

Value (Hexadecimal)	Value (Decimal)	Protocol
00	0	Reserved
01	1	ICMP
02	2	IGMP
03	3	GGP
04	4	IP-in-IP Encapsulation
06	6	TCP
08	8	EGP
11	17	UDP
32	50	Encapsulating Security Payload (ESP) Extension Header
33	51	Authentication Header (AH) Extension Header

Note that the last two entries are used when IPSec inserts additional headers into the datagram: the AH or ESP headers.

Technical Problems with IPv4

- • Limited number and types of addresses
  - Bad planning of address assignment gives an inefficient utilization ofthe address space
- • “Things that think” – auto configuration
  - Does not mange the growth. Address space full ~ 2015?
- • Address structure gives large routing tables
  - Bad address hierarchy
  - Supernetworking
- • Missing support for new services
  - No QoS guarantee
  - Mobility, multicast
- • Missing security mechanisms

IPv6 features

IPv6

- Source and destination addresses are 128 bits (16 bytes) in length.
- IPSec support is required.
- IPv6 header contains Flow Label field, which identifies packet flow for QoS handling by router.
- Only the sending host fragments packets; routers do not.
- Header does not include a checksum.
- All optional data is moved to IPv6 extension headers.
- Multicast Neighbor Solicitation messages resolve IP addresses to link-layer addresses.
- Multicast Listener Discovery (MLD) messages manage membership in local subnet groups.
- ICMPv6 Router Solicitation and Router Advertisement messages are used to determine the IP address of the best default gateway, and they are required.
- IPv6 uses a link-local scope all-nodes multicast address.
- Does not require manual configuration or DHCP.
- Uses host address (AAAA) resource records in DNS to map host names to IPv6 addresses.
- Uses pointer (PTR) resource records in the IP6.ARPA DNS domain to map IPv6 addresses to host names.
- Must support a 1280-byte packet size (without fragmentation).

IPV6

<table>
<tr><td>Version
(4 bit)</td><td>Traffic Class
(4 bit)</td><td colspan="3">Flow Label
(24 bit)</td></tr>
<tr><td colspan="3">Payload Length
(16 bit)</td><td>Next Header
(8 bit)</td><td>Hop Limit
(8 bit)</td></tr>
<tr><td colspan="5">Source Address
(128 bit)</td></tr>
<tr><td colspan="5">Destination Address
(128 bit)</td></tr>
</table>

IPv6 header contains the following things:

- **Version** - This field contains the version of the IP used in the packet. It is of 4-bit in IP version 6.
- **Traffic class** - This is an 8-bits field determining the packet priority. Priority values subdivide into ranges: traffic where the source provides congestion control and non-congestion control traffic.
- **Flow label** - This 20 bits specifies the QoS management. Originally created for giving real-time applications special service, but currently unused.
- **Payload length** - This 16 bits determines the payload length in bytes. When cleared to zero, the option is a "Jumbo payload" (hop-by-hop).
- **Next header** - This 8-bits field specifies the next encapsulated protocol. The values are compatible with those specified for the IPv4 protocol field.
- **Hop limit** - This is an 8-bits field newly introduced in IPv6. It replaces the time to live field of IPv4.
- **Source Address** - This 128 bits field determines the logical address of the host that is sending the packet.
- **Destination Address** - This 128 bits field determines the logical address of the host that is receiving the packet.

IPv6 vs IPv4

- Changes in IPv6 compared to IPv4
- 128 bit addresses
- extended address hierarchy
- simplified header
- simpler and better support for options
- possible to extend the protocol
- support for autoconfiguration (plug-and-play)
- support for QoS treatment
- security
- no fragmentation

IPv6 Simplifications

- Fixed format headers
  - use extension headers instead of options
- Remove header checksum
  - rely on link layer and higher layers to check
  - integrity of data
- Remove hop-by-hop segmentation
  - no fragmentation due to path MTU discovery

IPv4 vs IPv6 Header

- 1. Header length removed
- 2. ToS Class + Flow label
- 3. Total length Payload Length
- 4. Identification, flags and offset are removed
  - Fragmentation extension
- 5. TTL Hop limit
- 6. Protocol Next Header
- 7. Header checksum removed
- 8. Options Extension headers

IPv6 Addresses

- IPv6 has three address categories:
- unicast - identifies exactly one interface
- multicast - identifies a group; packets get delivered to all members of the group
- anycast - identifies a group; packets normally get delivered to nearest member of the group

IPv6 Addresses

- An IPv6 unicast address identifies an interface connected to an IP subnet (as is the case in IPv4)
- One big difference between IPv6 and IPv4 is that IPv6 routinely allows each interface to be identified by several addresses

IPv6 Addresses

- 128 bits results in 2128 addresses
- Distributed over the Earth:
- 665,570,793,348,866,943,898,599/m2
- Pessimistic estimate with hierarchies: ~1,564 addresses/m2

How real is IPv6 in the future?

- IPv6 as a catalyst to expand the functionality in IPv4
- IPv4 can extend towards IPv6 functionality with/by
  - – Network Address Translation
  - – Dynamical configuration of addresses
  - – RSVP combined with IP-«switching»
  - – CIDR - Classless InterDomain Routing
  - – IPSEC as an addition for IPv4, default for IPv6
- IPv6 is still needed to
  - – **Manage the future lack of addresses**
  - – Better utilization in the network

Writing IPv6 Addresses

- Colon hexadecimal notation (eight 16 bit hexadecimal integers)
  - 68E8:1480:0022:0000:ABC1:0000:0000:01FE
- Leading zeros may be oppressed
  - 68E8:1480:22:0:ABC1:0:0:1FE
- Zero compression: one of a series of zeros may be replaced by ::
  - 68E8:1480:22:0:ABC1:0:0:1FE replaced by
  - 68E8:1480:22:0:ABC1::1FE

Figure 20.15 IPv6 address

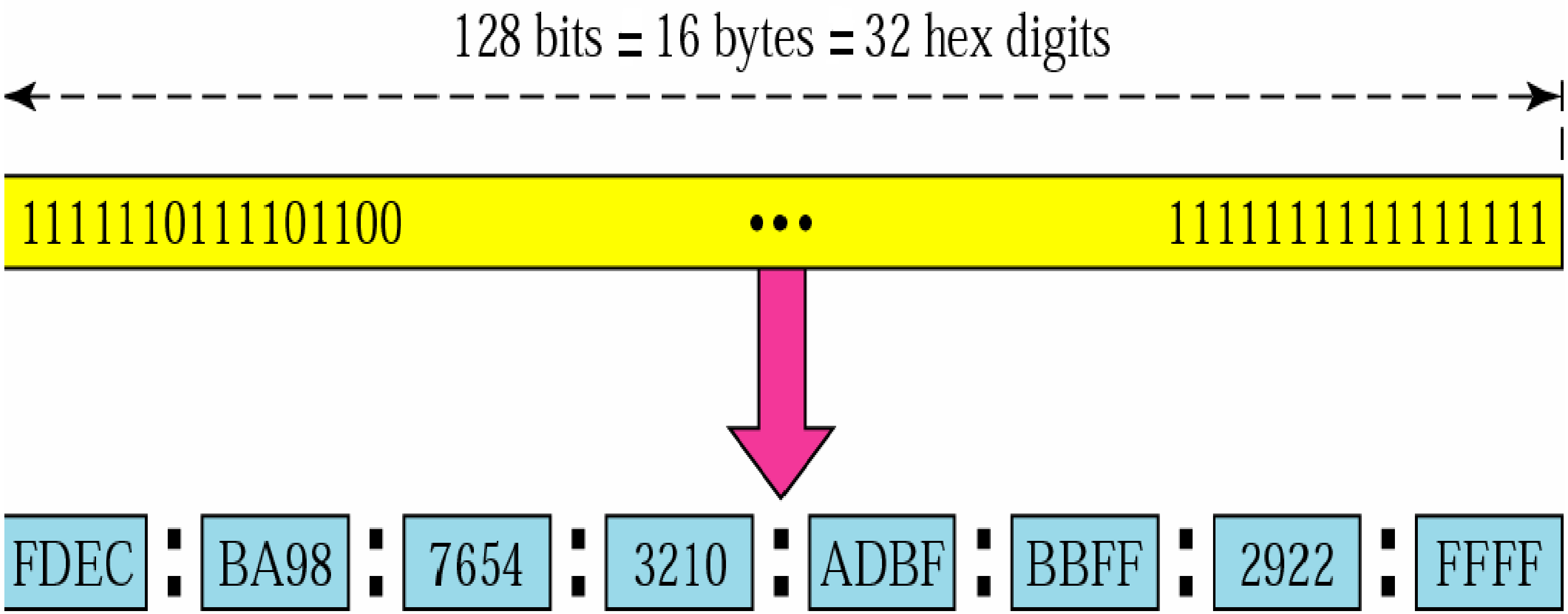
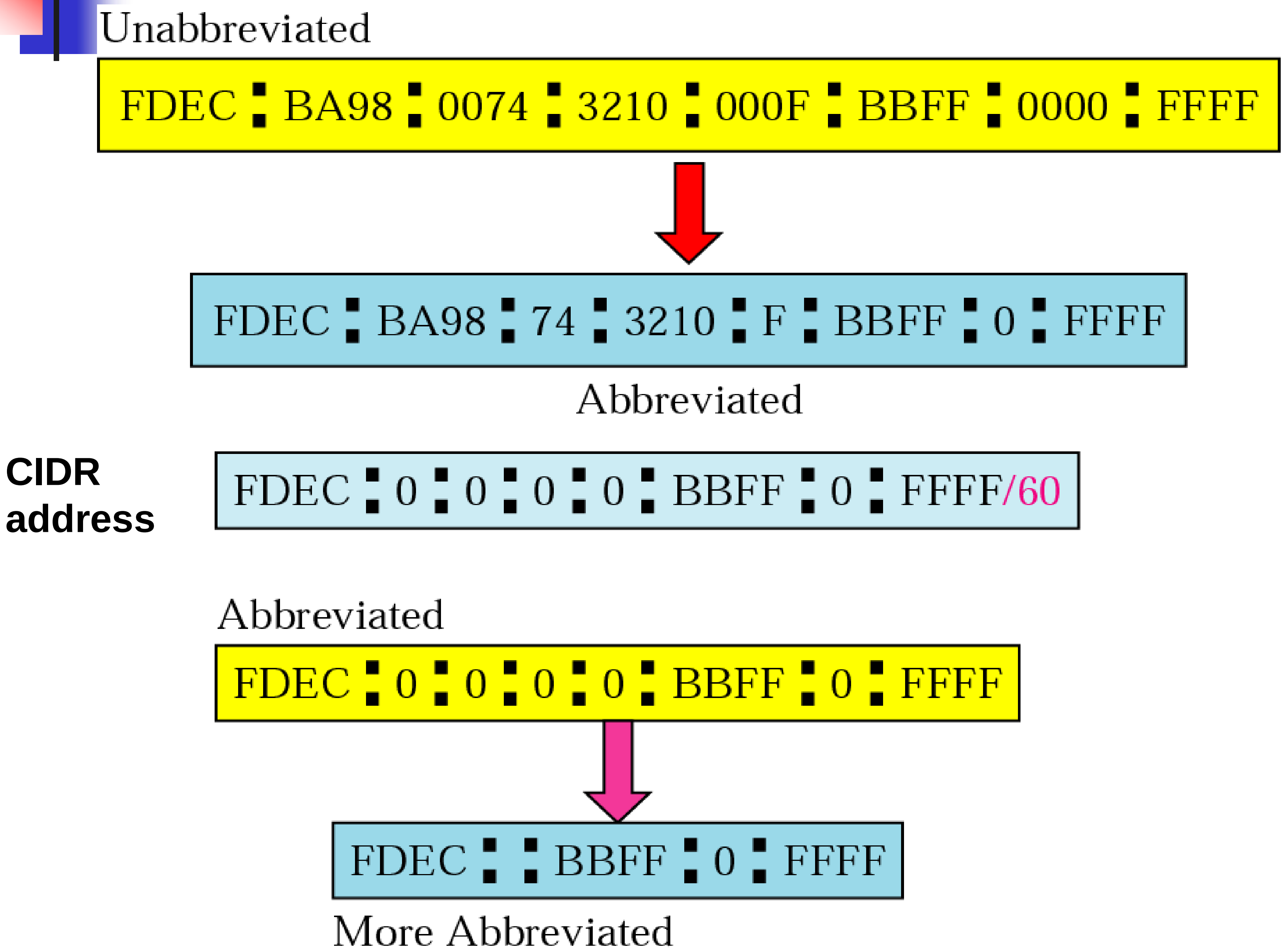


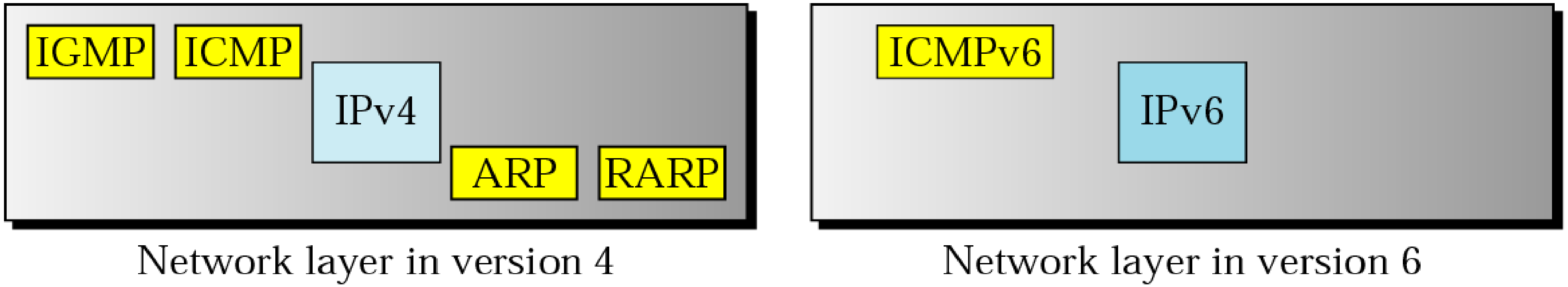
Figure 20.16 Abbreviated address



Special Address Formats

- The following special addresses are allocated from prefix 0000 0000:
- Unspecified Address (0:0:0:0:0:0:0:0)
  - only used as source address during bootstrap by a computer that has not yet learned its address
- Loopback Address (0:0:0:0:0:0:0:1)
  - used for testing software (compare with IPv4 loopback address 127.0.0.1)
- IPv6 Addresses with Embedded IPv4 Addr.
  - Needed during transition from IPv4 to IPv6 (checksum calculation unaffected)

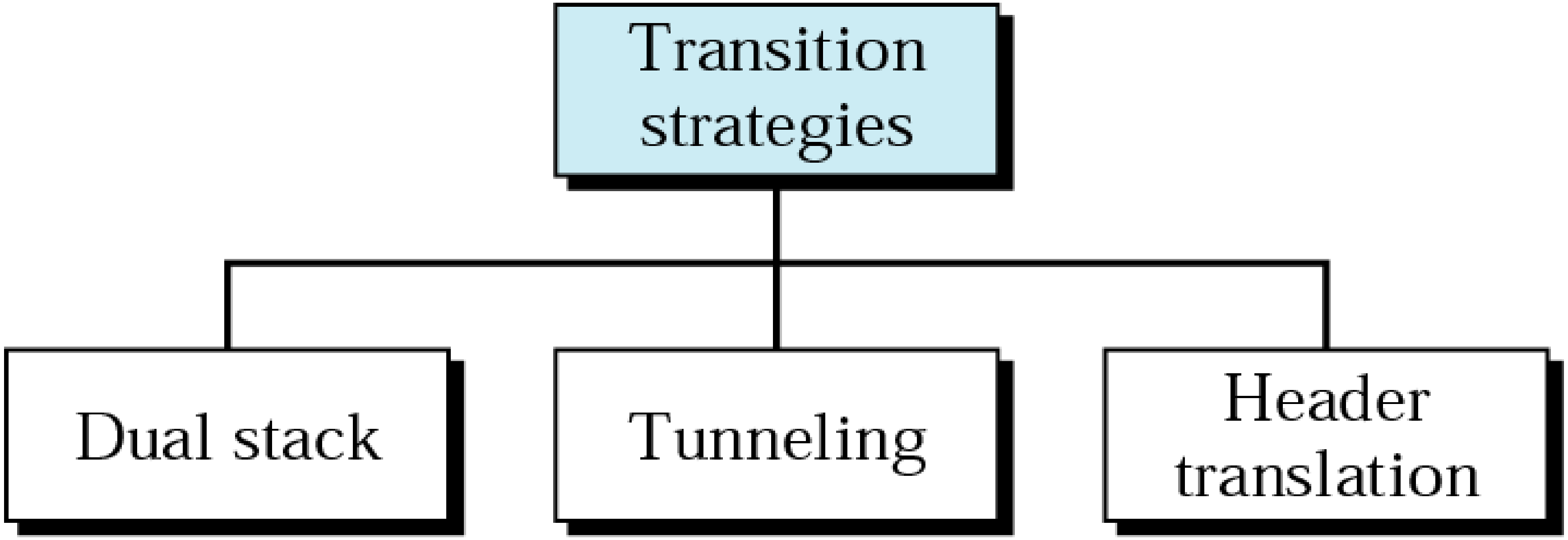
Comparison of network layers in version 4 and version 6



- ICMPv4 has been modified to be more suitable for IPv6, and thus updated to ICMPv6
- ARP and IGMP in version 4 are now part of ICMPv6
- RARP has been dropped due to limited use (BOOTP does the job of RARP)
- As in ICMPv4, ICMPv6 messages are divided into 2 categories:
  - Error-reporting (somewhat different messages)
  - Query (rather different messages in v6 vs v4)

Three transition strategies IPv4 to IPv6

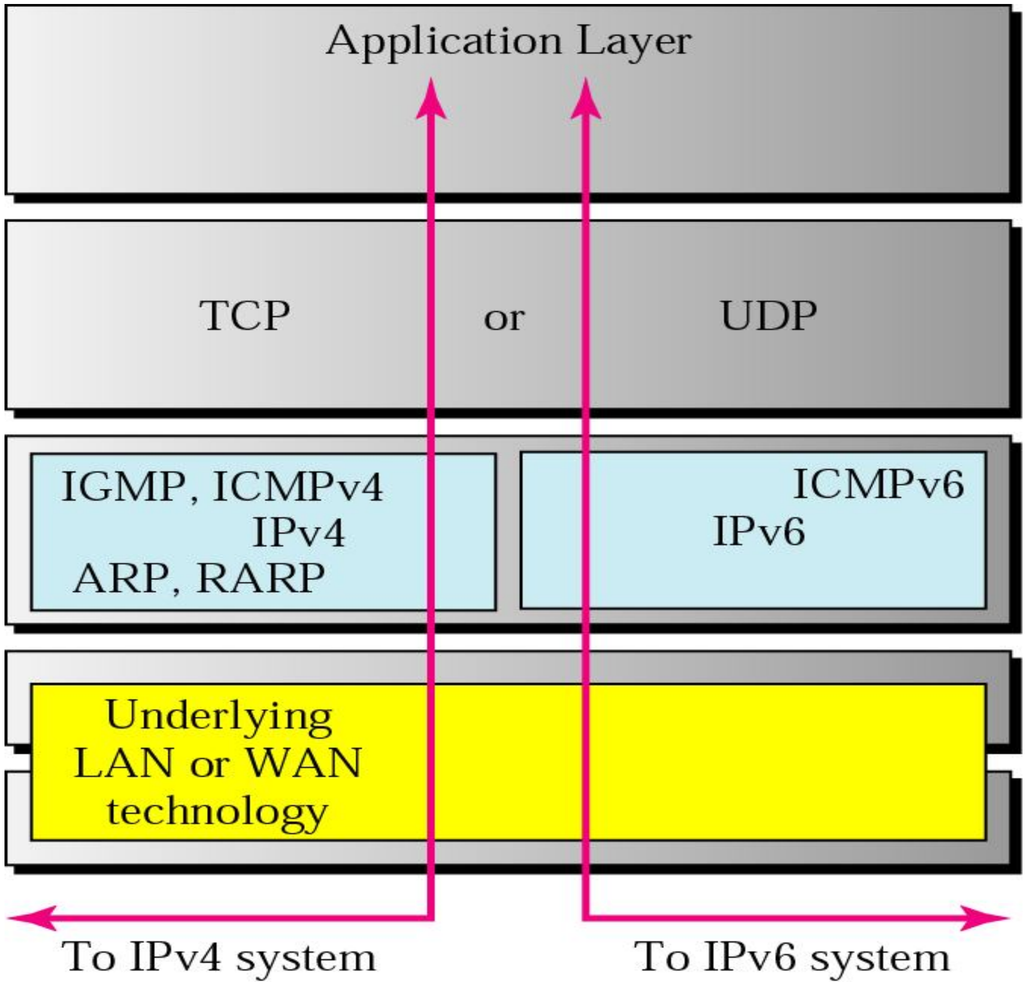
- Because of the large number of systems on the Internet, the transition from IPv4 to IPv6 cannot happen suddenly
- Transition should be smooth to prevent problems



Dual stack

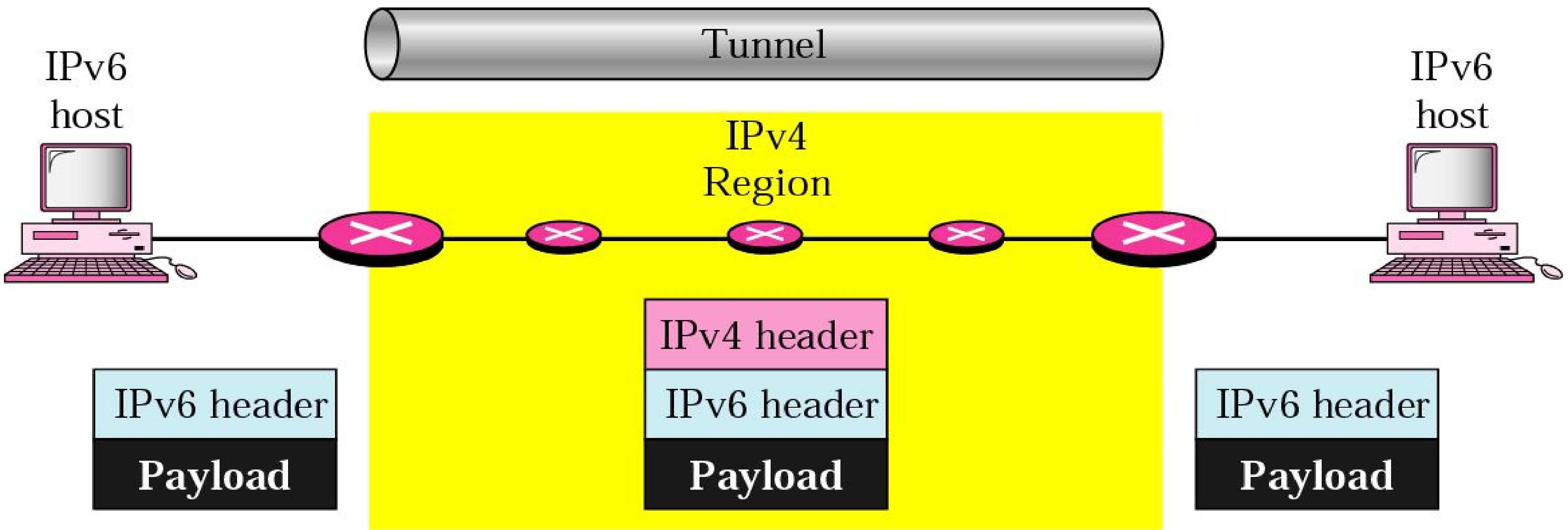
Recommended that all hosts have dual stack of protocols until all of the Internet runs IPv6

To determine which version to use, the source host queries the DNS



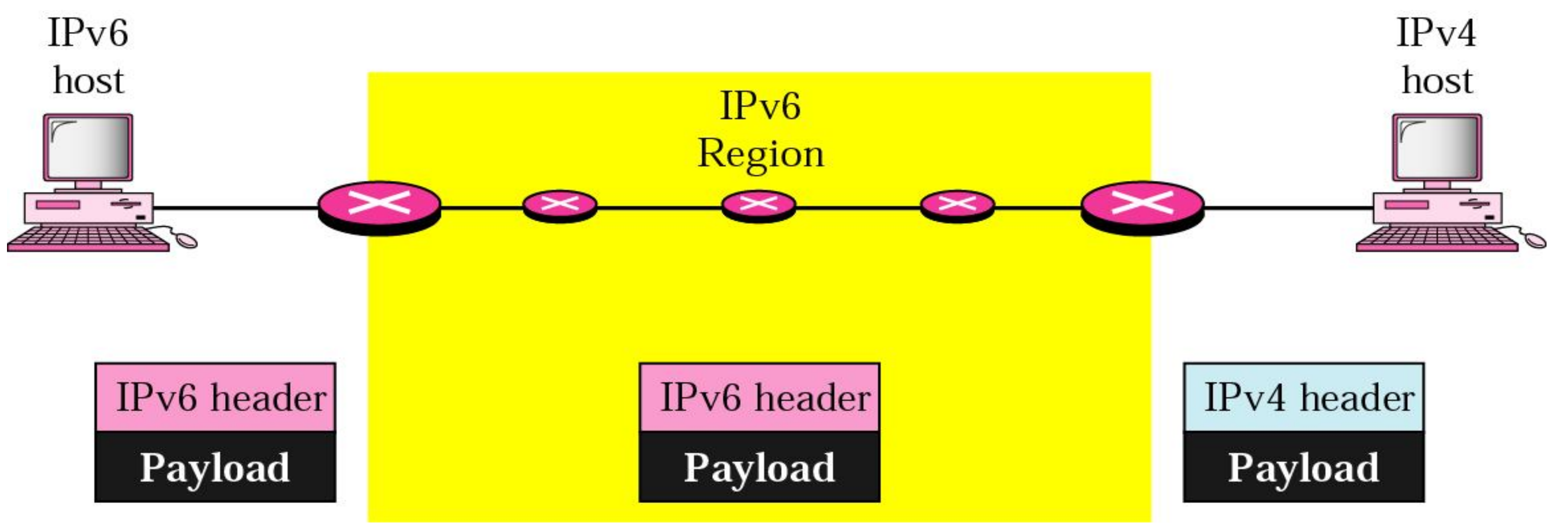
Tunneling

- The IP packets are encapsulate again
- The purpose of tunneling is to transport the information from the original IP as data
- The initial heading is keeping original
- Will be attached a new heading with the addresses the addresses of beginning respectively the end of tunnel



Header translation

- Used when majority of the Internet has moved to IPv6, but some systems still use IPv4
- Sender wants to use IPv6, but receiver does not understand IPv6
- Tunneling does not work, and the header must be changed
- Header translation uses the IPv4-mapped IPv6 address to translate an IPv6 address to an IPv4 address



IPv6 Summary

- 128-bit address space
- revised header format
- new options
- allowance for extension
- support for special handling of packet flows
- increased security measurest
- IPv6 uses hexadecimal colon notation with abbreviation methods
- IPv6 has 3 types of addresses: unicast, anycast, and multicast
- IPv4, ICMPv4, ARP, RARP, and IGMP replaced with IPv6 and ICMPv6
- IPv4 to IPv6 transition strategies are dualstack, tunneling, and header translation