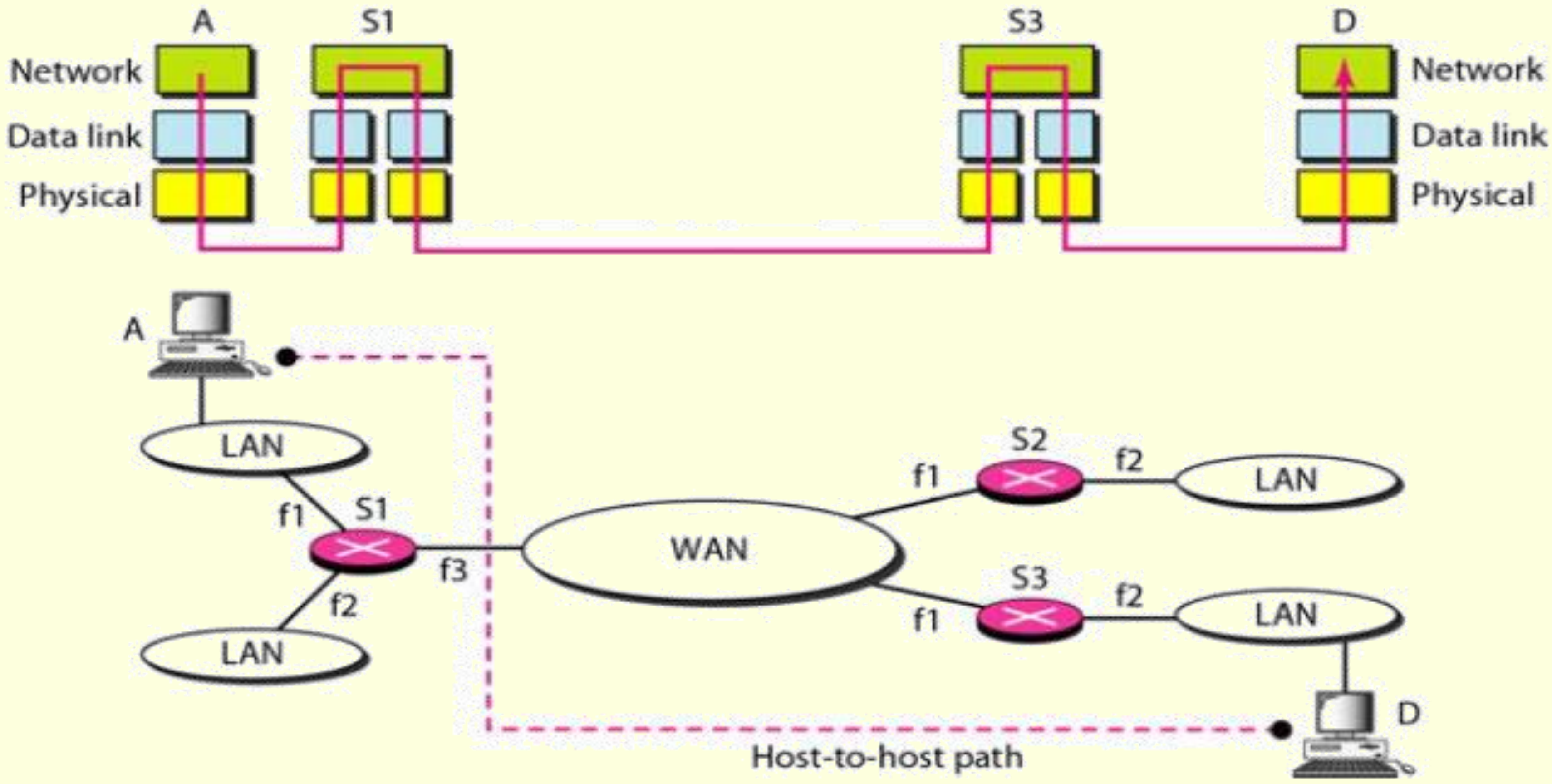
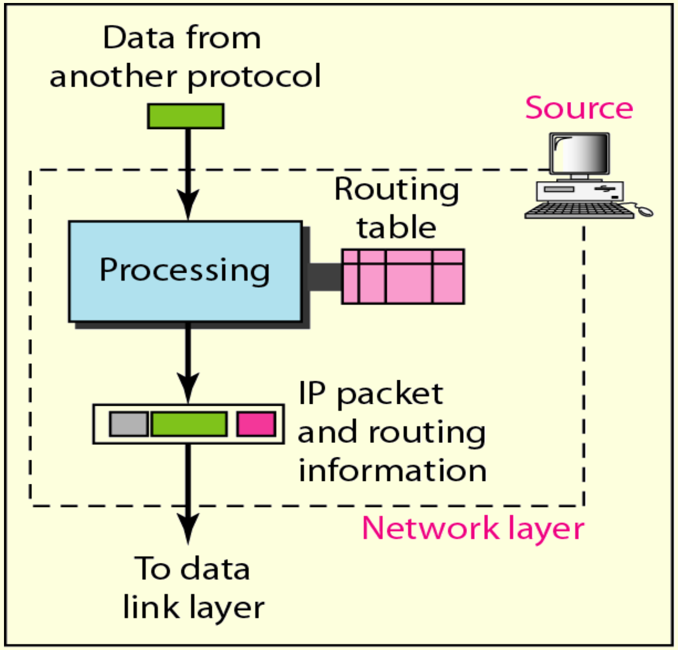
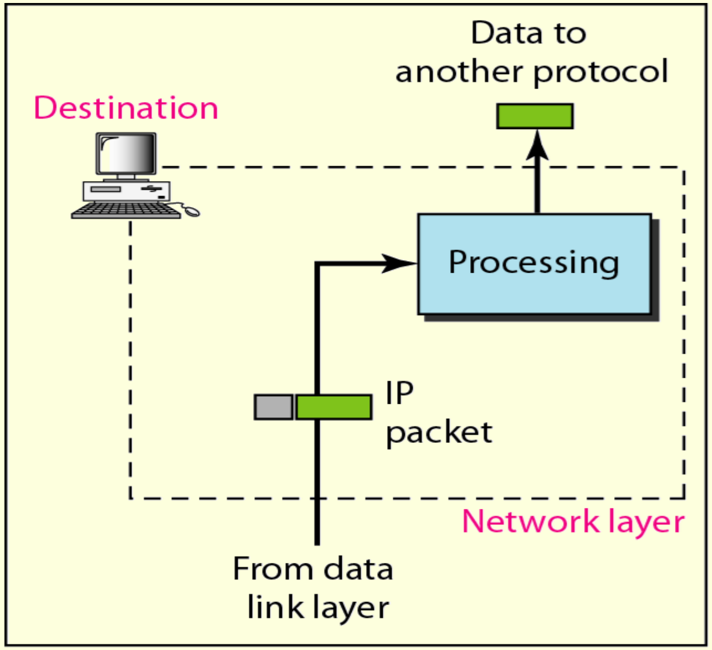
# Internet Protocol

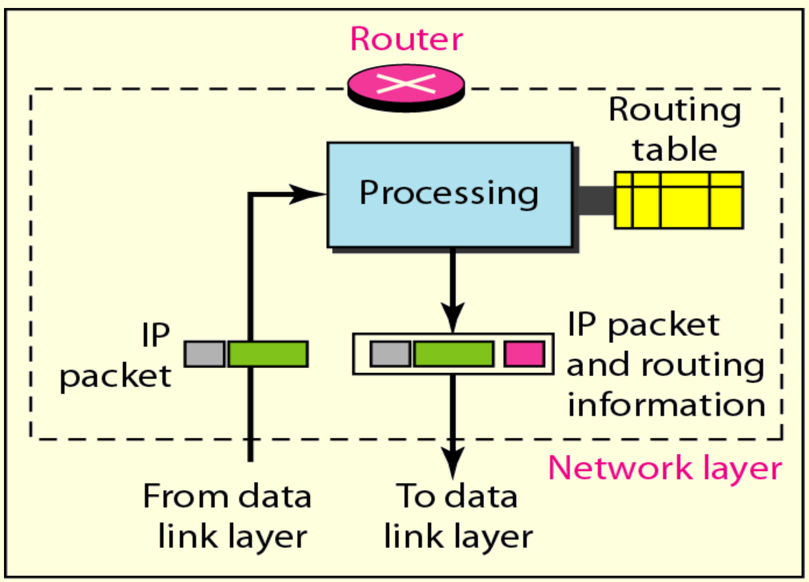




a. Network layer at source



b. Network layer at destination



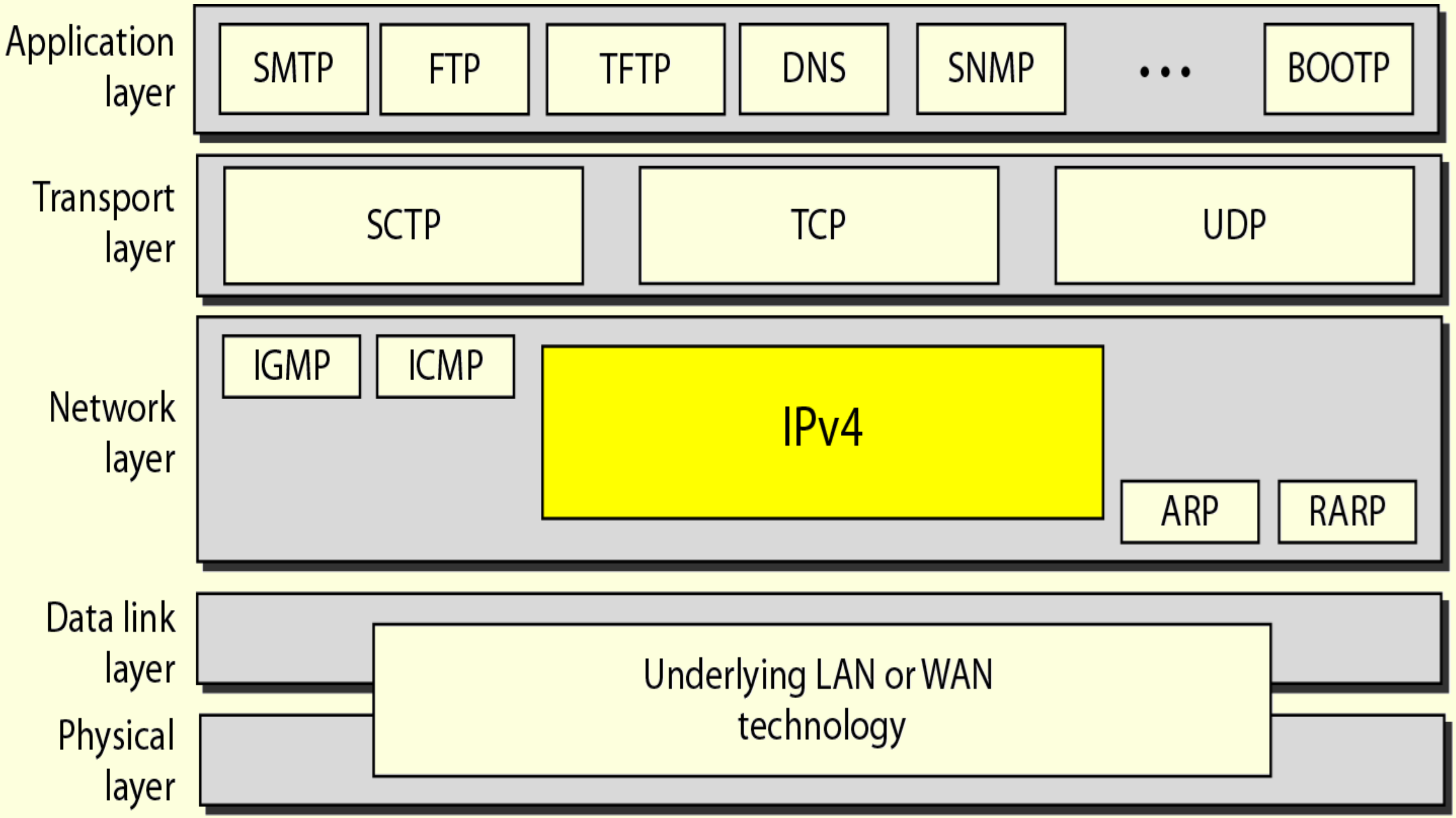
c. Network layer at a router

# Internet as a Datagram Network

# Internet as a Connectionless Network

# IPv4

## Delivery mechanism



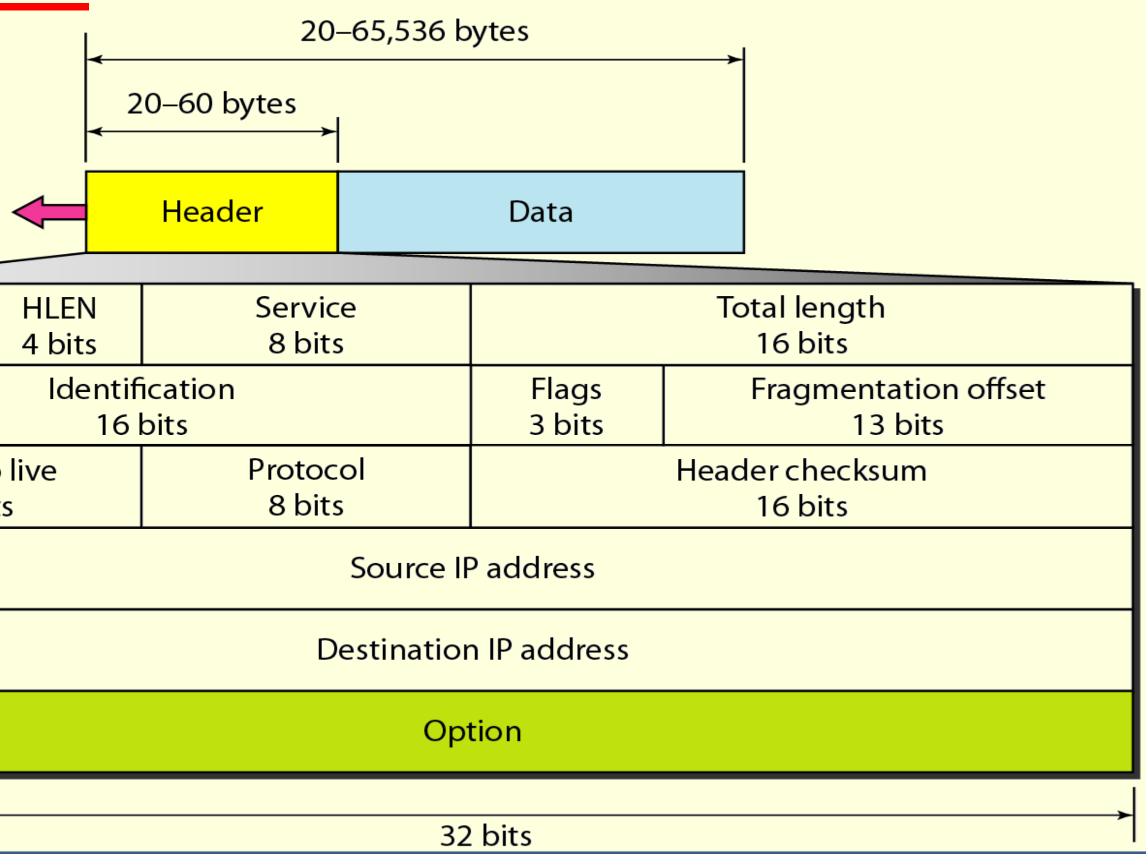

Position of IPv4 in TCP/IP protocol suite

# IPv4

- An unreliable
  - ✓ no guarantees
- Connectionless
- Datagram protocol
- Best-effort delivery
  - ✓ No error control or flow control
    - Except for error detection on the header

# Datagram

- **Packets** in the IPv4 layer are called **datagrams** .

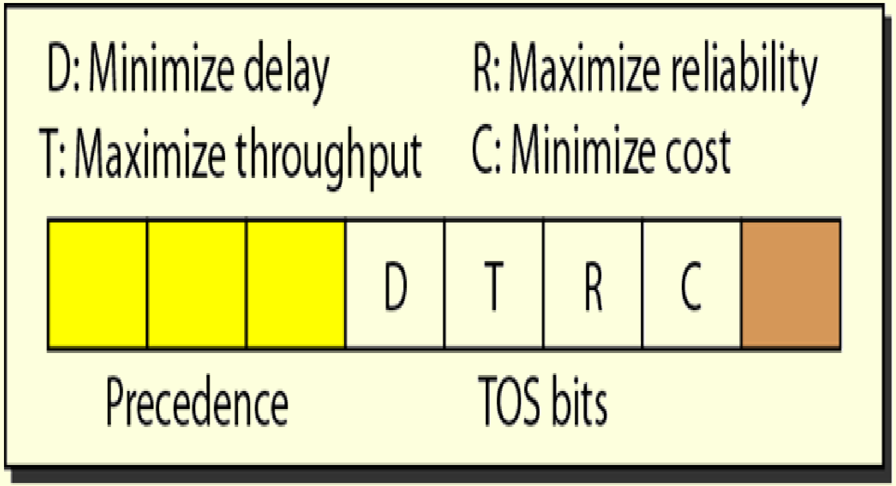


## ❑ The header of TCP/IP in 4-byte sections

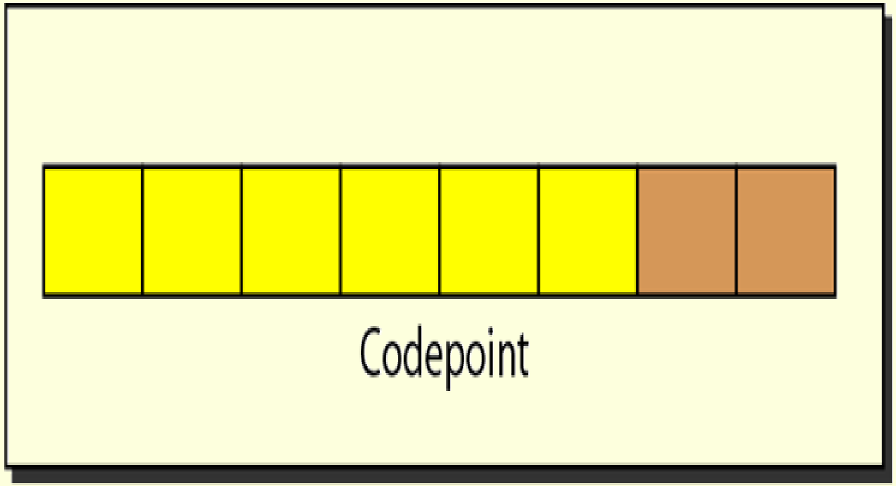
- Version (VER) :
  - ✓ 4-bits
  - ✓ Defines the version of the IPv4 protocol
  - ✓ All fields must be interpreted as IPv4
  - ✓ If the machine is using some other version of IPv4 ?

- Header length (HLEN)
  - ✓ 4-bits
  - ✓ Defines the total length of the datagram header in 4-byte words
  - ✓ Why needed ?
  - ✓ 20 byte = 5 * 4
  - ✓ 60 byte ?

- Services :8-bit field
  - ✓ Called service type
  - ✓ Differentiated services




Service type




Differentiated services

- ✓ Service Type
  - ➢ Precedence : 3 –bits (000 to 111 in binary ) , defines the priority
  - ➢ TOS : 4 –bits
  - ➢ Last bit : not used

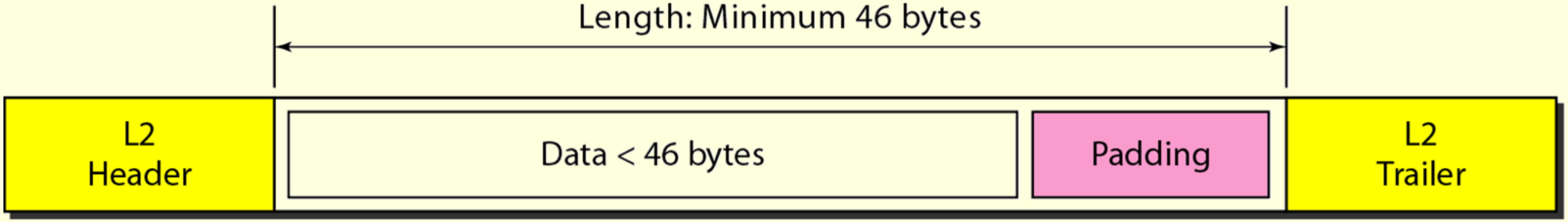
| *TOS Bits* | *Description* |
| --- | --- |
| 0000 | Normal (default) |
| 0001 | Minimize cost |
| 0010 | Maximize reliability |
| 0100 | Maximize throughput |
| 1000 | Minimize delay |

- ✓ Differentiated Services
  - 6 bits make up the code point subfieldlast 2 bits are not used
- ➢ 3 rightmost bits are Os , compatible

with the old interpretation

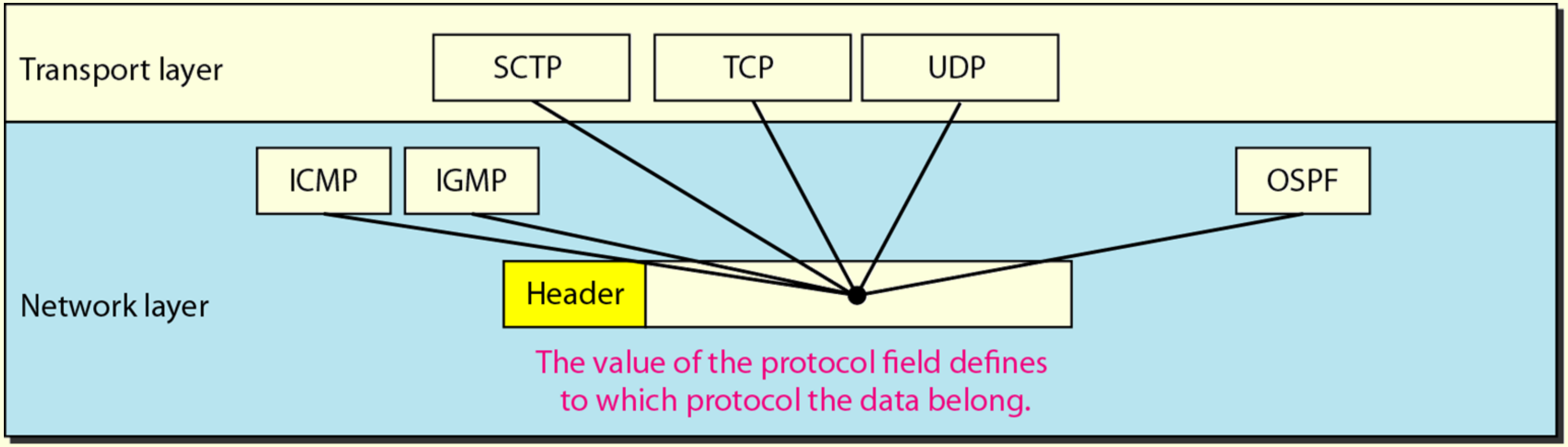
- ➢ When the 3 rightmost bits are not all Os

- Total length : 16-bits
  - Header + data
  - **Length of data =total length - header length**
    - **Header length = HLEN**
    - **Total length = $(2^{16} - 1)$ bytes**
  - **Fragmentation & padding**



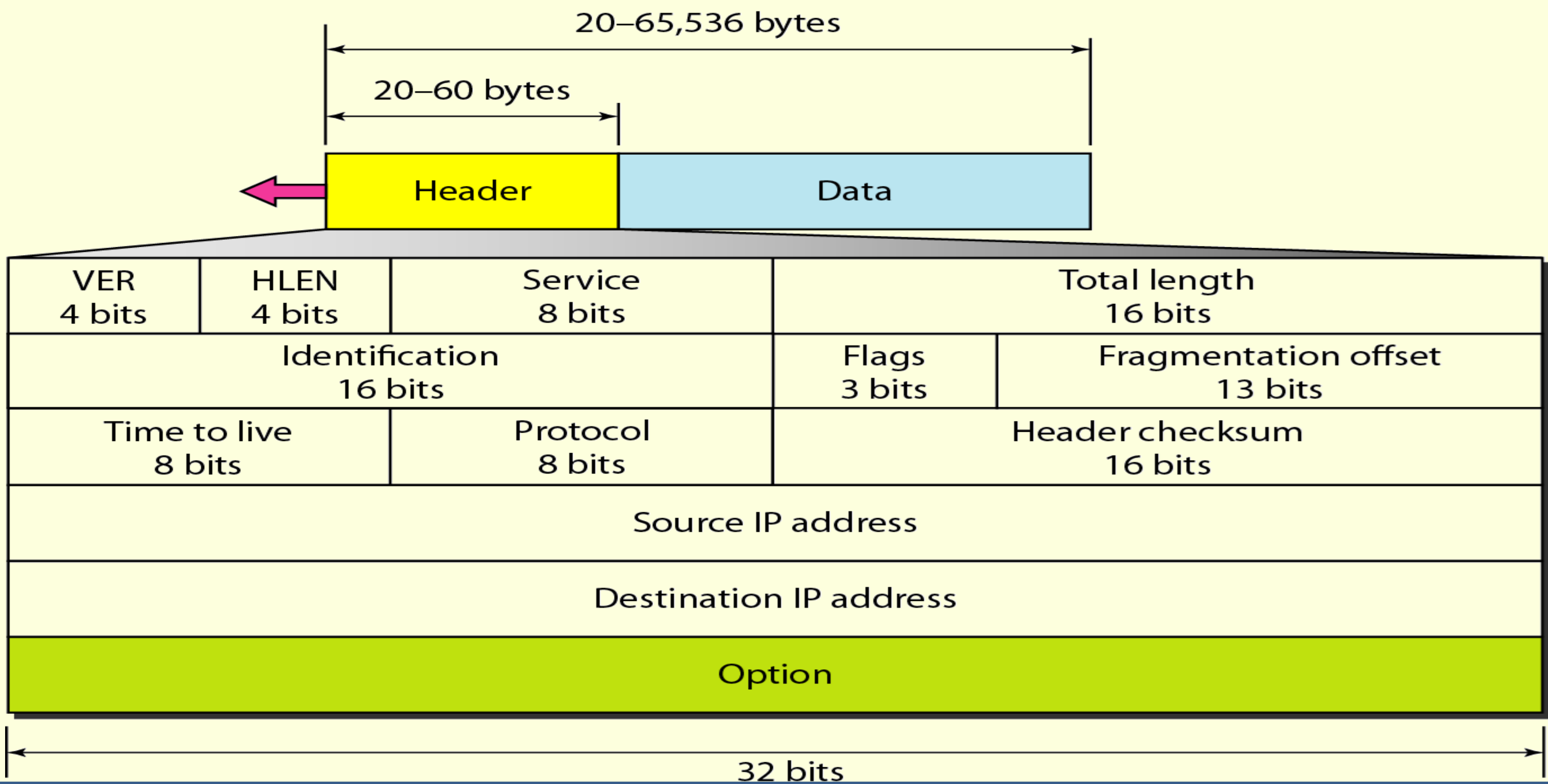
- ❑
- Identification : 16 –bits
- Flags :3-bits
- Fragmentation offset :13-bits
- ❑
- Time to live : 8-bits
  - ✓ Designed to hold a timestamp.
  - ✓ Today ?

- Protocol : 8-bits




| *Value* | *Protocol* |
|---|---|
| 1 | ICMP |
| 2 | IGMP |
| 6 | TCP |
| 17 | UDP |
| 89 | OSPF |

- Checksum : 16 –bit
- ❑ Source address : 32 –bit
- ❑ Destination address



# *Example*

*An IPv4 packet has arrived with the first 8 bits as shown:*

*01000010*

*The receiver discards the packet. Why?*

*Solution*

*There is an error in this packet. The 4 leftmost bits (0100) show the version, which is correct. The next 4 bits (0010) show an invalid header length ($2 \times 4 = 8$). The minimum number of bytes in the header must be 20. The packet has been corrupted in transmission.*

## Example

*In an IPv4 packet, the value of HLEN is 1000 in binary. How many bytes of options are being carried by this packet?*

## Solution

*The HLEN value is 8, which means the total number of bytes in the header is 8 × 4, or 32 bytes. The first 20 bytes are the base header, the next 12 bytes are the options.*

# *Example*

*An IPv4 packet has arrived with the first few digits as shown.*

*00000101 . . .*

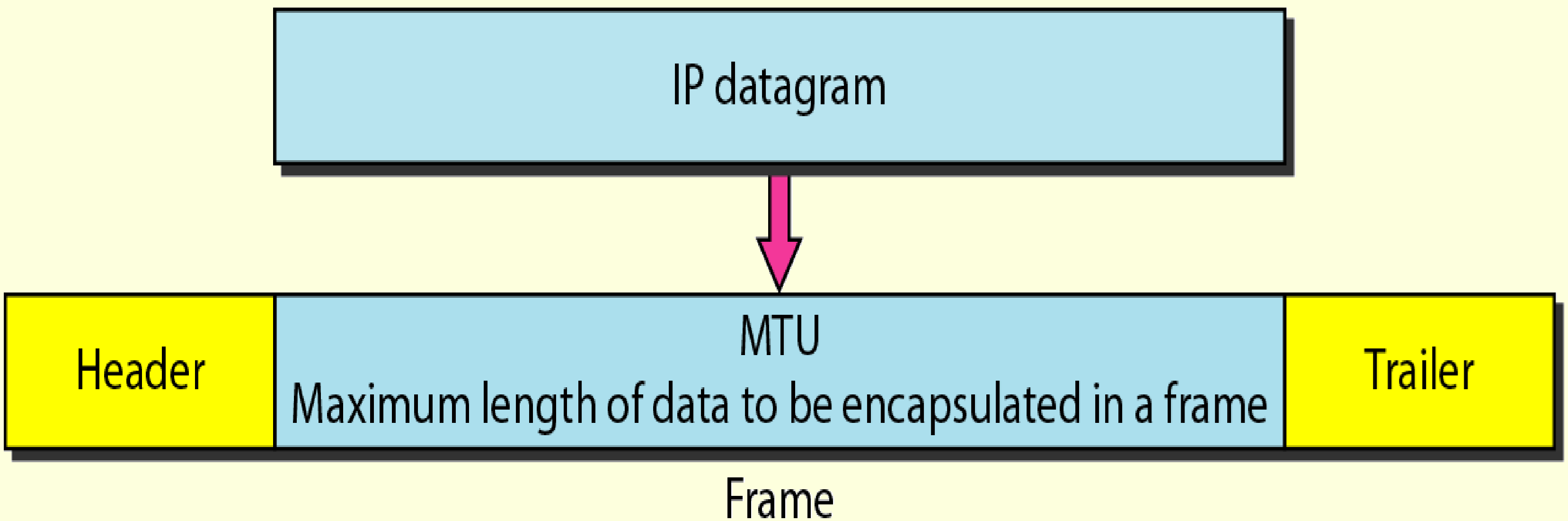
*How many hops can this packet travel before being dropped? The data belong to what upper-layer protocol?*

# Fragmentation

- A datagram can travel through different networks
- In each router
  - ✓ Decapsulates the IPv4
  - ✓ Processes it
  - ✓ Then encapsulates it in another frame
- Format and size of received frame?
  - ✓ router connects a LAN to a WAN ?

# Maximum Transfer Unit (MTU)

- Maximum size?
- If datagram is encapsulated in a frame?
- MTU depends on the physical network protocol



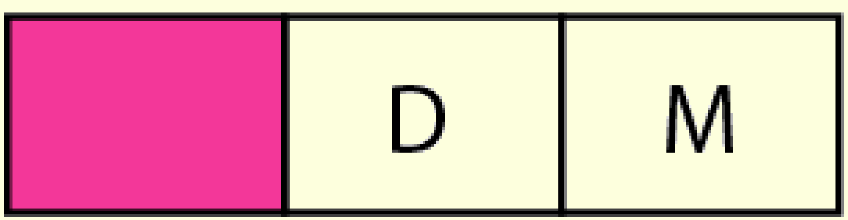
- Maximum length : 65535 bytes
- Fragmentation ?
- Reassemble & header ?

| *Protocol* | *MTU* |
|---|---|
| Hyperchannel | 65,535 |
| Token Ring (16 Mbps) | 17,914 |
| Token Ring (4 Mbps) | 4,464 |
| FDDI | 4,352 |
| Ethernet | 1,500 |
| X.25 | 576 |
| PPP | 296 |

# Fields Related to Fragmentation

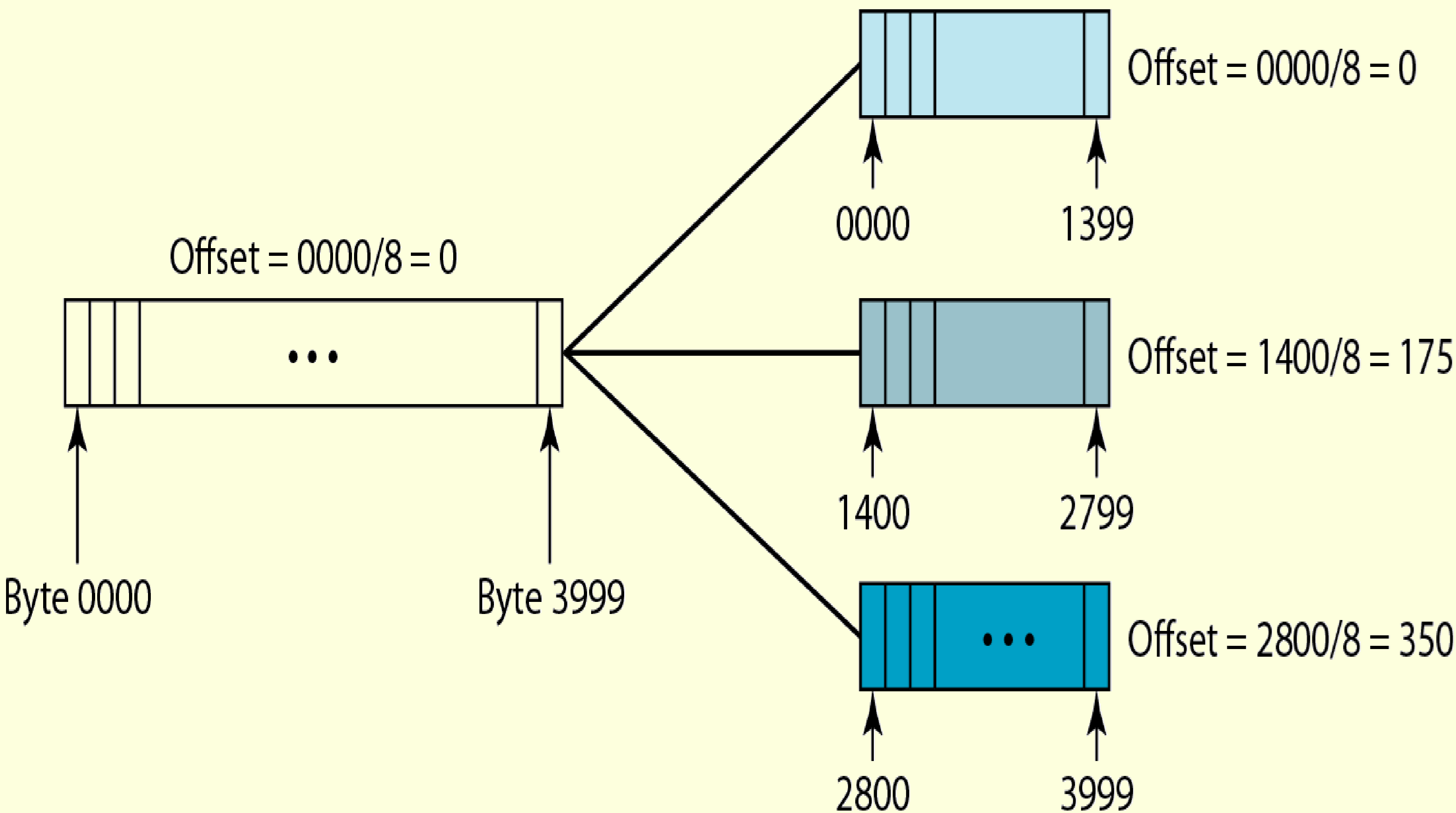
- Identification :
  - ✓ 16 bits
  - ✓ Identifies a datagram originating
  - ✓ Must uniquely & counter?
    - Main memory ?
  - ✓ Copied to all fragments

- Flag :
  - 3 – bits
  - D = Do not fragment
    - D =1 (not fragment)
      - ICMP error
    - D=0 (fragment )
  - M = more fragment
    - M = 1 (more fragment)
    - M =  0 ( last fragment)

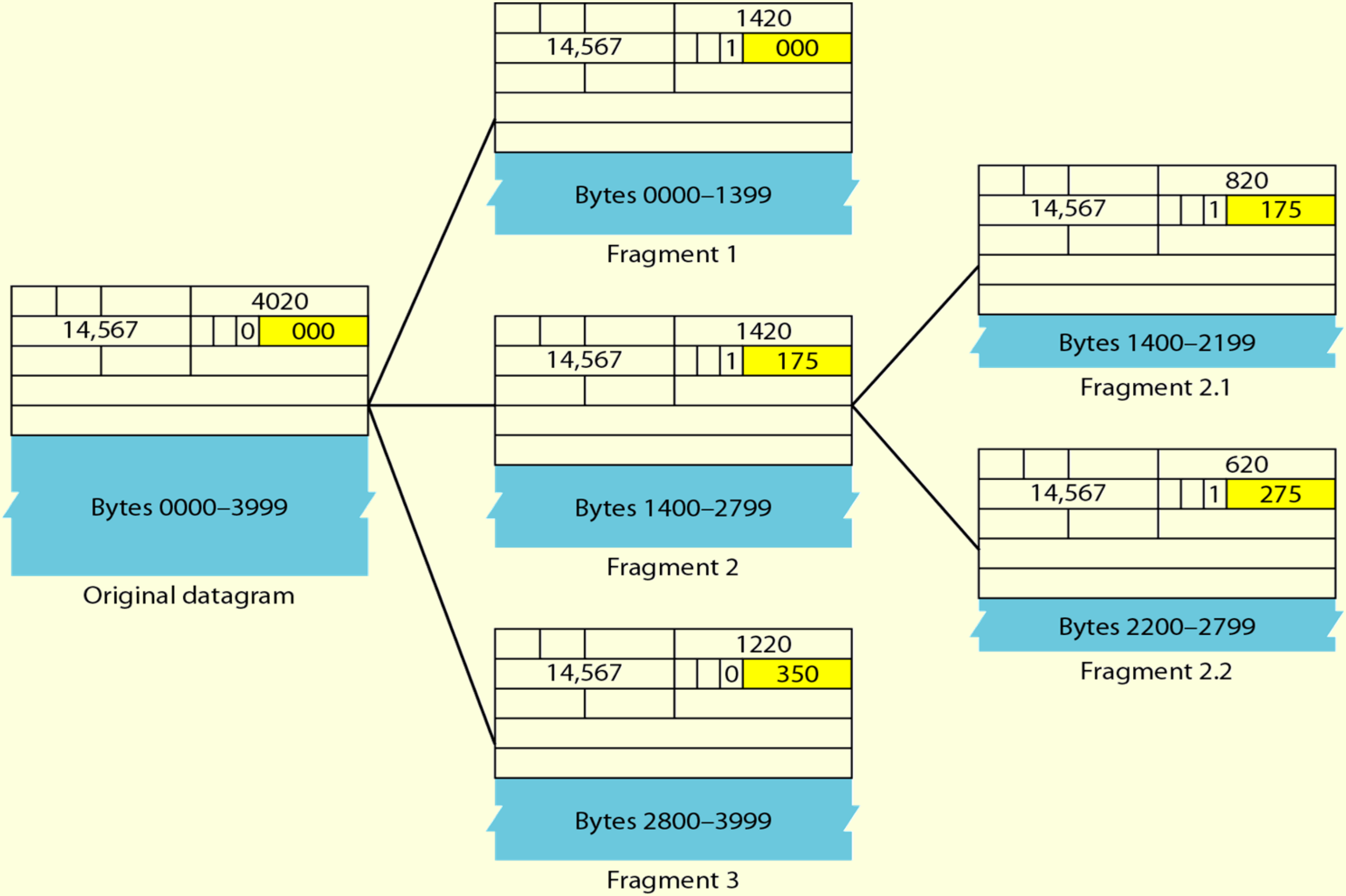



D: Do not fragment
M: More fragments

- Fragmentation offset : 13-bits
  - 8191 & 65536 ?



# Example :



1420
14,567
1
000
Bytes 0000–1399
Fragment 1
4020
14,567
0
000
Bytes 0000–3999
Original datagram
1420
14,567
1
175
Bytes 1400–2799
Fragment 2
1220
14,567
0
350
Bytes 2800–3999
Fragment 3
820
14,567
1
175
Bytes 1400–2199
Fragment 2.1
620
14,567
1
275
Bytes 2200–2799
Fragment 2.2

*Example :A packet has arrived with an M bit value of 0. Is this the first fragment, the last fragment, or a middle fragment? Do we know if the packet was fragmented?*

## Solution

*If the M bit is 0, it means that there are no more fragments; the fragment is the last one. However, we cannot say if the original packet was fragmented or not. A non-fragmented packet is considered the last fragment.*

*Example :A packet has arrived with an M bit value of 1. Is this the first fragment, the last fragment, or a middle fragment? Do we know if the packet was fragmented?*

## Solution

*If the M bit is 1, it means that there is at least one more fragment. This fragment can be the first one or a middle one, but not the last one. We don't know if it is the first one or a middle one; we need more information (the value of the fragmentation offset).*

*A packet has arrived with an M bit value of 1 and a fragmentation offset value of 0. Is this the first fragment, the last fragment, or a middle fragment?*

## *Solution*

*Because the M bit is 1, it is either the first fragment or a middle one. Because the offset value is 0, it is the first fragment.*

*A packet has arrived in which the offset value is 100. What is the number of the first byte? Do we know the number of the last byte?*

*Solution*

*To find the number of the first byte, we multiply the offset value by 8. This means that the first byte number is 800. We cannot determine the number of the last byte unless we know the length.*

*A packet has arrived in which the offset value is 100, the value of HLEN is 5, and the value of the total length field is 100. What are the numbers of the first byte and the last byte?*

Solution

*The first byte number is 100 × 8 = 800. The total length is 100 bytes, and the header length is 20 bytes (5 × 4), which means that there are 80 bytes in this datagram. If the first byte number is 800, the last byte number must be 879.*

# Checksum : 16 - bits

- Checksum field is set to O
- Divide header into 16-sections & added together
- Complemented the sum

➢ Algorithm ?

➢ Advantages ?

  ✓ Does not have to check the encapsulated data

  ✓ Check only  the part that has changed

# Options

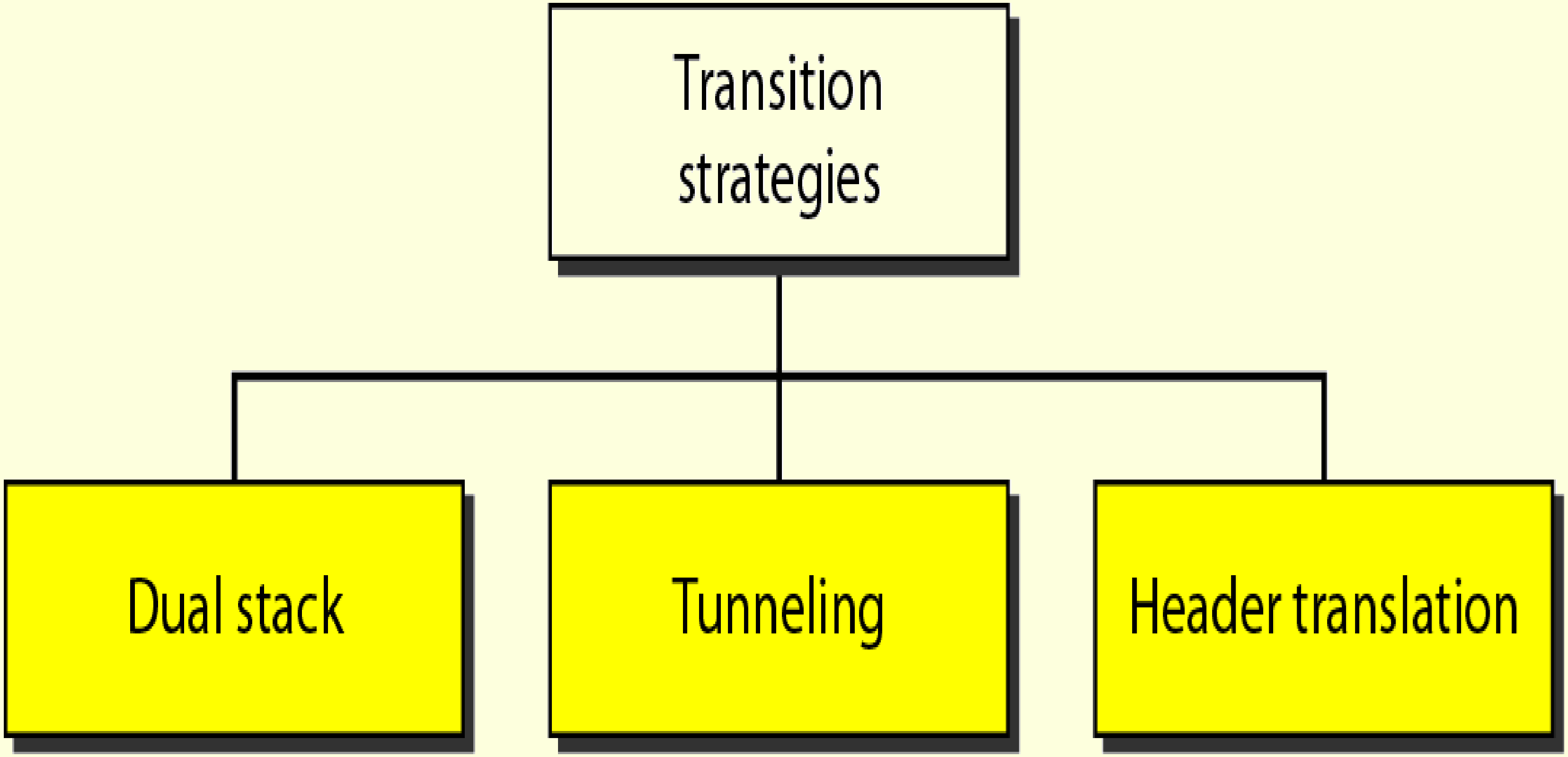
- Header is made of two parts :
  - ✓ Fixed part (20 Bytes)
  - ✓ Variable part (40 Bytes )
- Implies, are not required for a datagram
- Testing and debugging

# IPv6

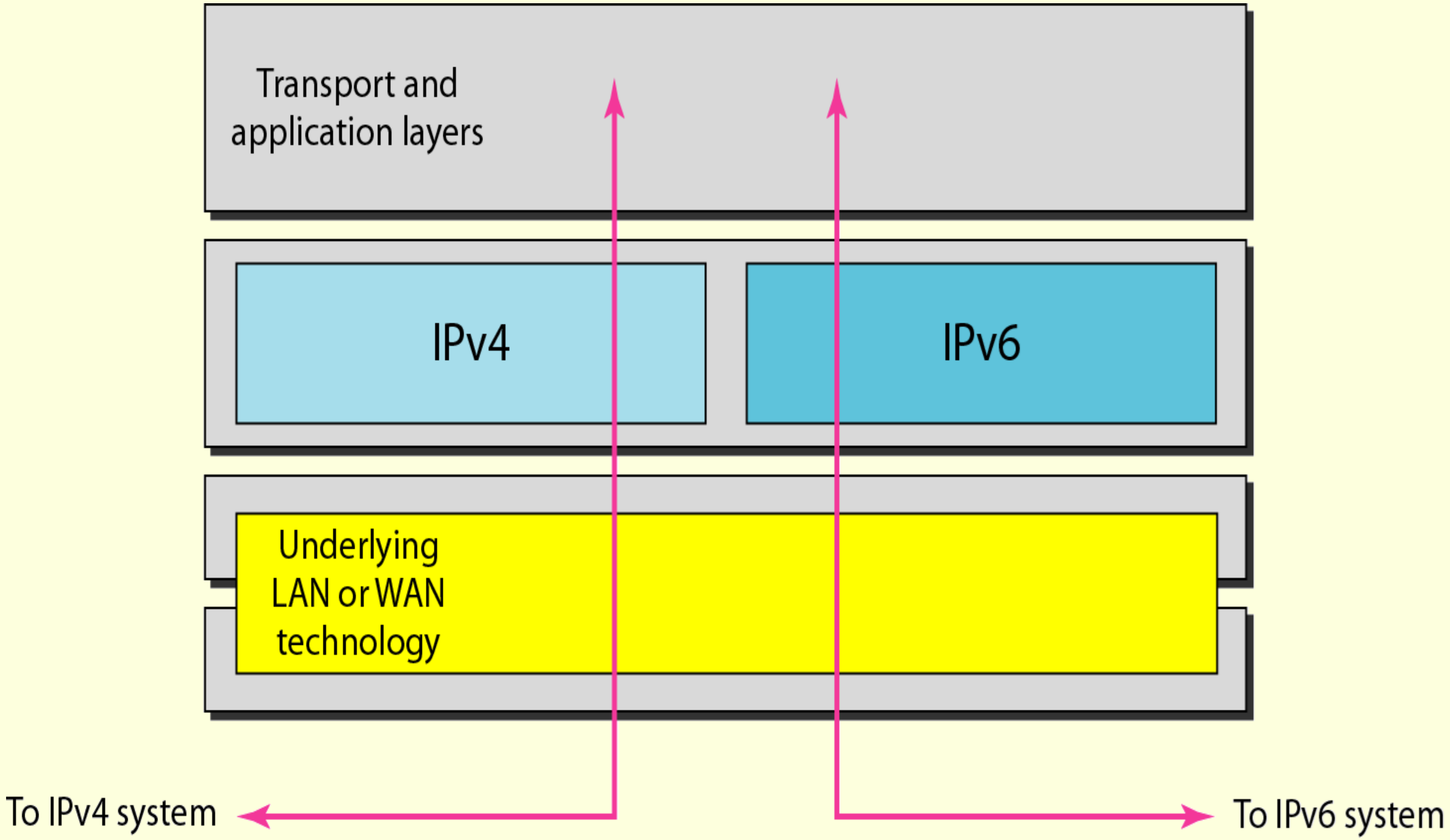
- Why IPv6 ?
  - IPv4 address depletion
  - Real-time audio and video
  - Encryption and authentication
- IPv6 or Ipng ?

- Advantages
  - ✓ Larger address space
  - ✓ Better header format
  - ✓ New options
  - ✓ Allowance for extension
  - ✓ Support for resource allocation
    - ○ Label :real time & video
  - ✓ Support for more security

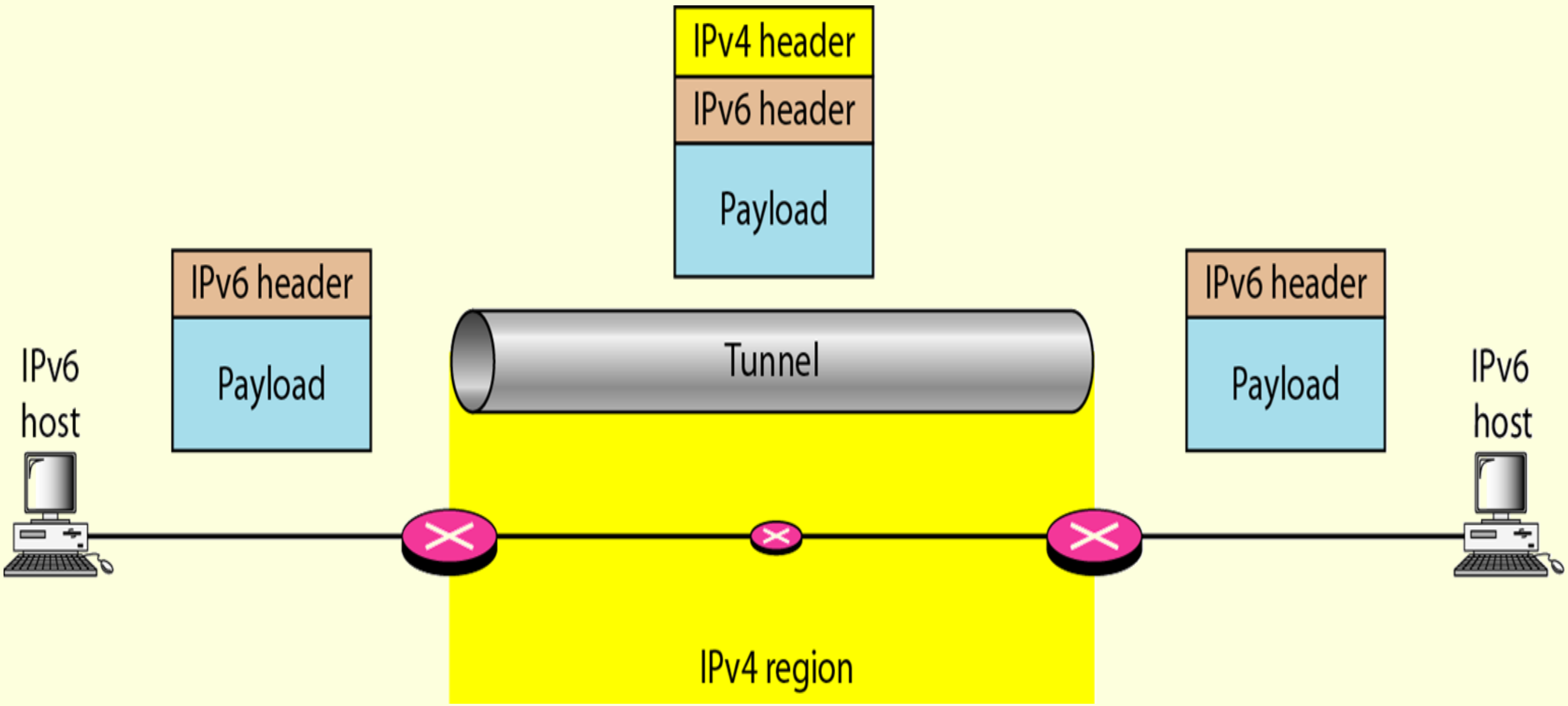
# TRANSITION FROM IPv4 TO IPv6



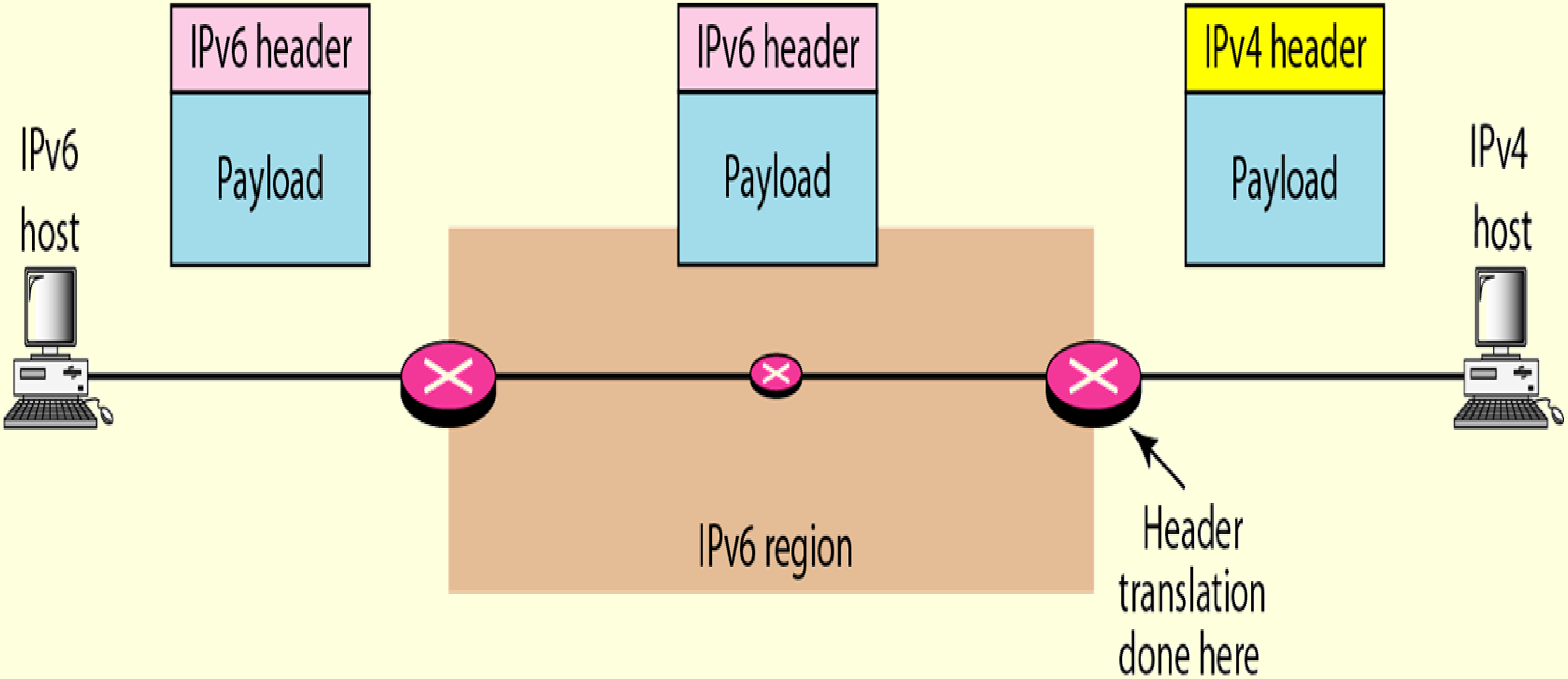
# Dual stack


Transport and application layers
IPv4
IPv6
Underlying LAN or WAN technology
To IPv4 system
To IPv6 system

# Tunneling strategy



# Header translation strategy



# Header translation

| *Header Translation Procedure* |
| --- |
| 1. The IPv6 mapped address is changed to an IPv4 address by extracting the rightmost 32 bits. |
| 2. The value of the IPv6 priority field is discarded. |
| 3. The type of service field in IPv4 is set to zero. |
| 4. The checksum for IPv4 is calculated and inserted in the corresponding field. |
| 5. The IPv6 flow label is ignored. |
| 6. Compatible extension headers are converted to options and inserted in the IPv4 header. Some may have to be dropped. |
| 7. The length of IPv4 header is calculated and inserted into the corresponding field. |
| 8. The total length of the IPv4 packet is calculated and inserted in the corresponding field. |