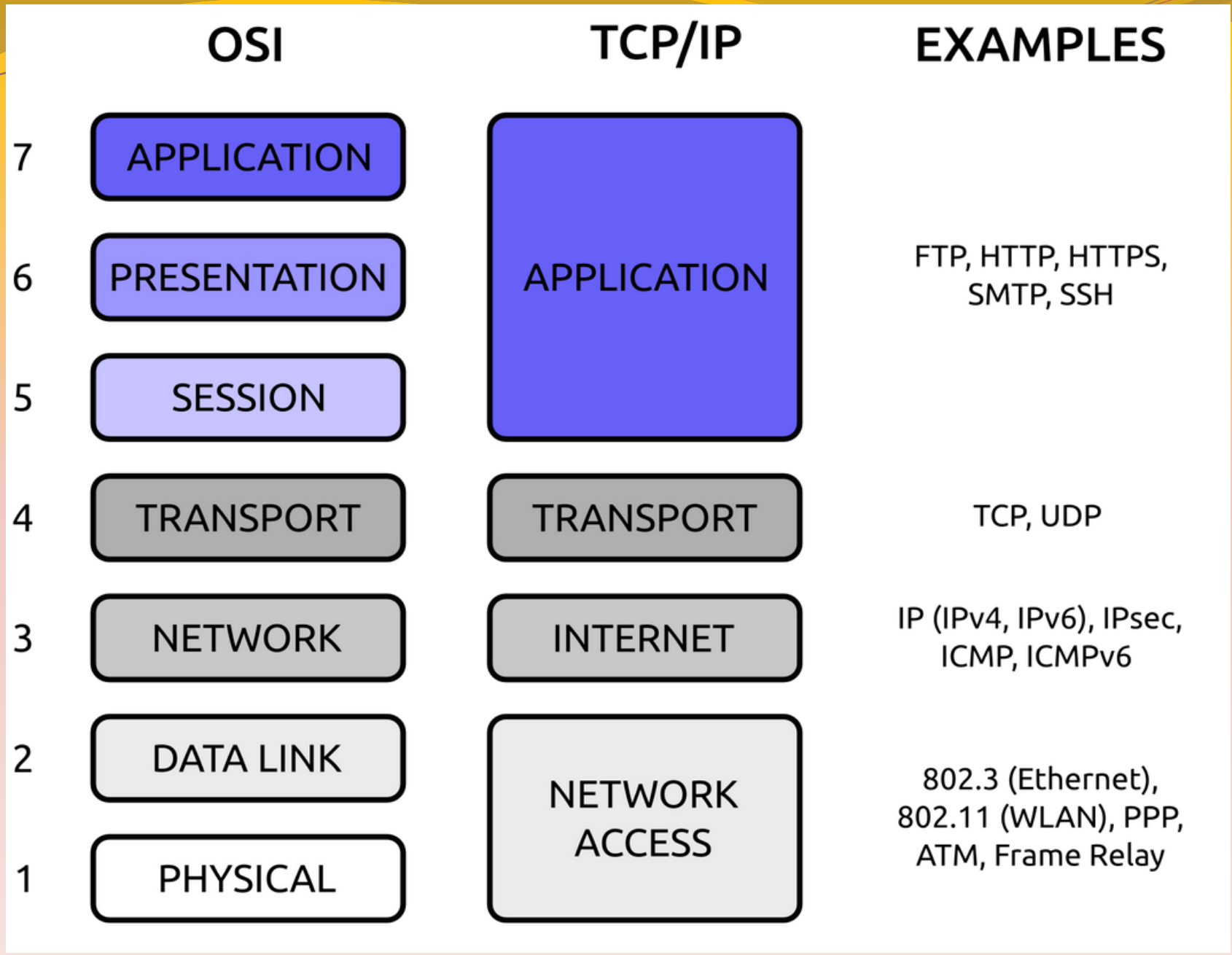
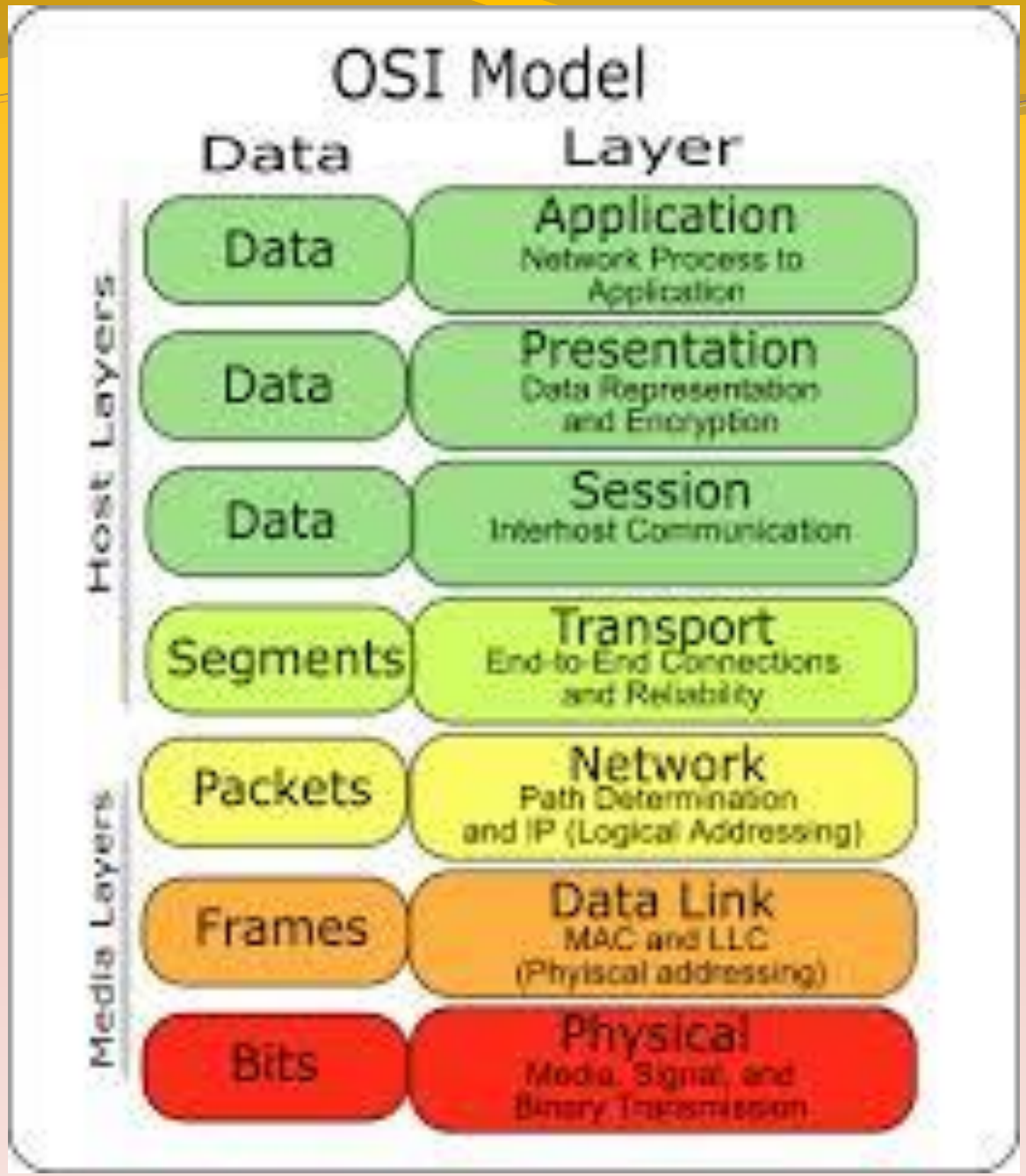
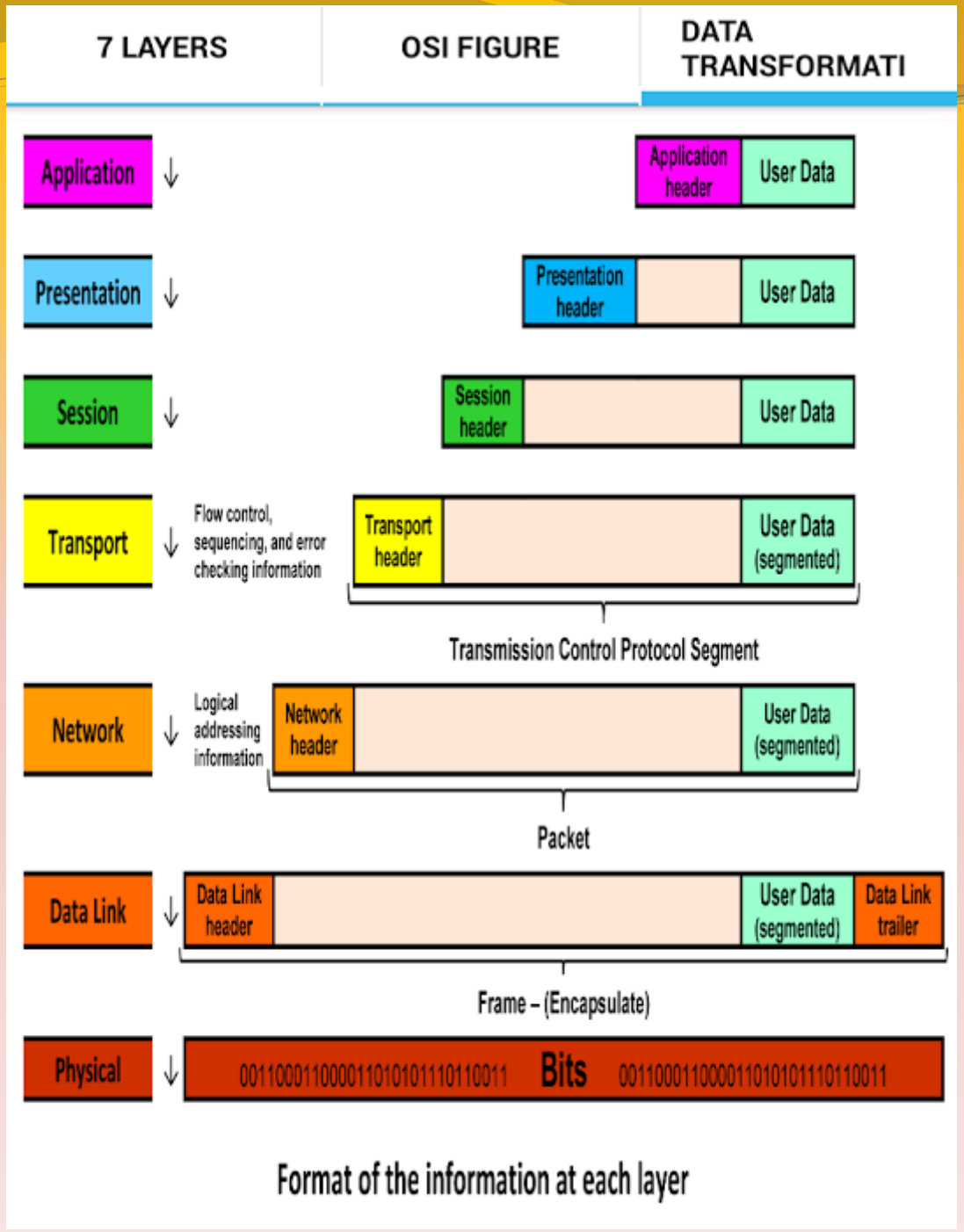
Computer Networks

Lecture 5

Internet Protocol (IP)


OSI
TCP/IP
EXAMPLES
7
APPLICATION
6
PRESENTATION
5
SESSION
APPLICATION
FTP, HTTP, HTTPS, SMTP, SSH
4
TRANSPORT
TRANSPORT
TCP, UDP
3
NETWORK
INTERNET
IP (IPv4, IPv6), IPsec, ICMP, ICMPv6
2
DATA LINK
1
PHYSICAL
NETWORK ACCESS
802.3 (Ethernet), 802.11 (WLAN), PPP, ATM, Frame Relay


OSI Model
Data
Layer
Host Layers
Media Layers
Data
Application
Network Process to Application
Data
Presentation
Data Representation and Encryption
Data
Session
Interhost Communication
Segments
Transport
End-to-End Connections and Reliability
Packets
Network
Path Determination and IP (Logical Addressing)
Frames
Data Link
MAC and LLC (Physical addressing)
Bits
Physical
Media, Signal, and Binary Transmission


7 LAYERS
OSI FIGURE
DATA TRANSFORMATI
Application
Application header
User Data
Presentation
Presentation header
User Data
Session
Session header
User Data
Transport
Flow control, sequencing, and error checking information
Transport header
User Data (segmented)
Transmission Control Protocol Segment
Network
Logical addressing information
Network header
User Data (segmented)
Packet
Data Link
Data Link header
User Data (segmented)
Data Link trailer
Frame – (Encapsulate)
Physical
00110001100001101010111011001 1
Bits
00110001100001101010111011001 1
Format of the information at each layer

Overview of IP

- IP is the network layer protocol of TCP/IP
- No Error control, flow control and congestion control

  Hence IP is an unreliable protocol
- Combination TCP/IP is reliable

  But UDP/IP is an unreliable combination

- IP packets operate as datagram
- IP packets originated from same source can travel through different routes and reach the destination at different times
- Therefore IP packets may reach the destination out of order

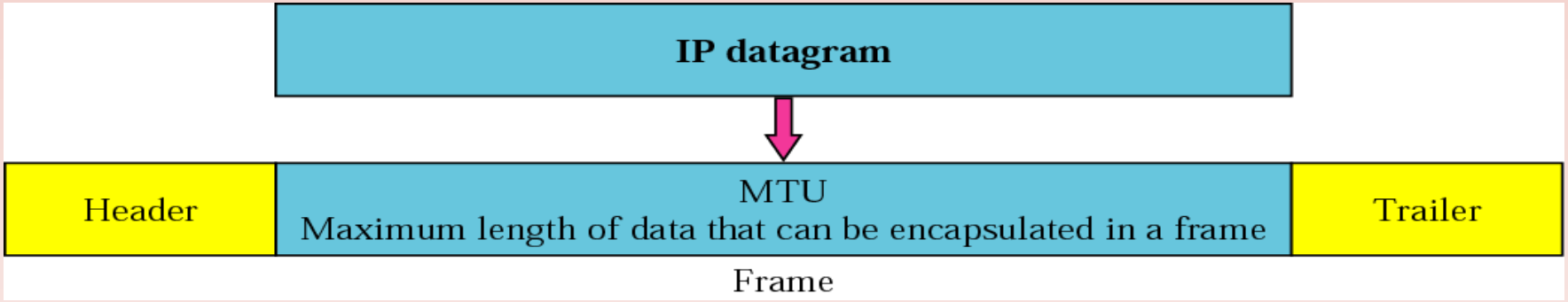
Identification

- Each IP packet is identified by a serial number called “Identification”
- This sequence will be helpful to the receiver to reassemble the packets in the correct order, although they may receive in out of order

Maximum Transmission Unit (MTU)

- **Maximum amount of data that can be accommodated in a frame**

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

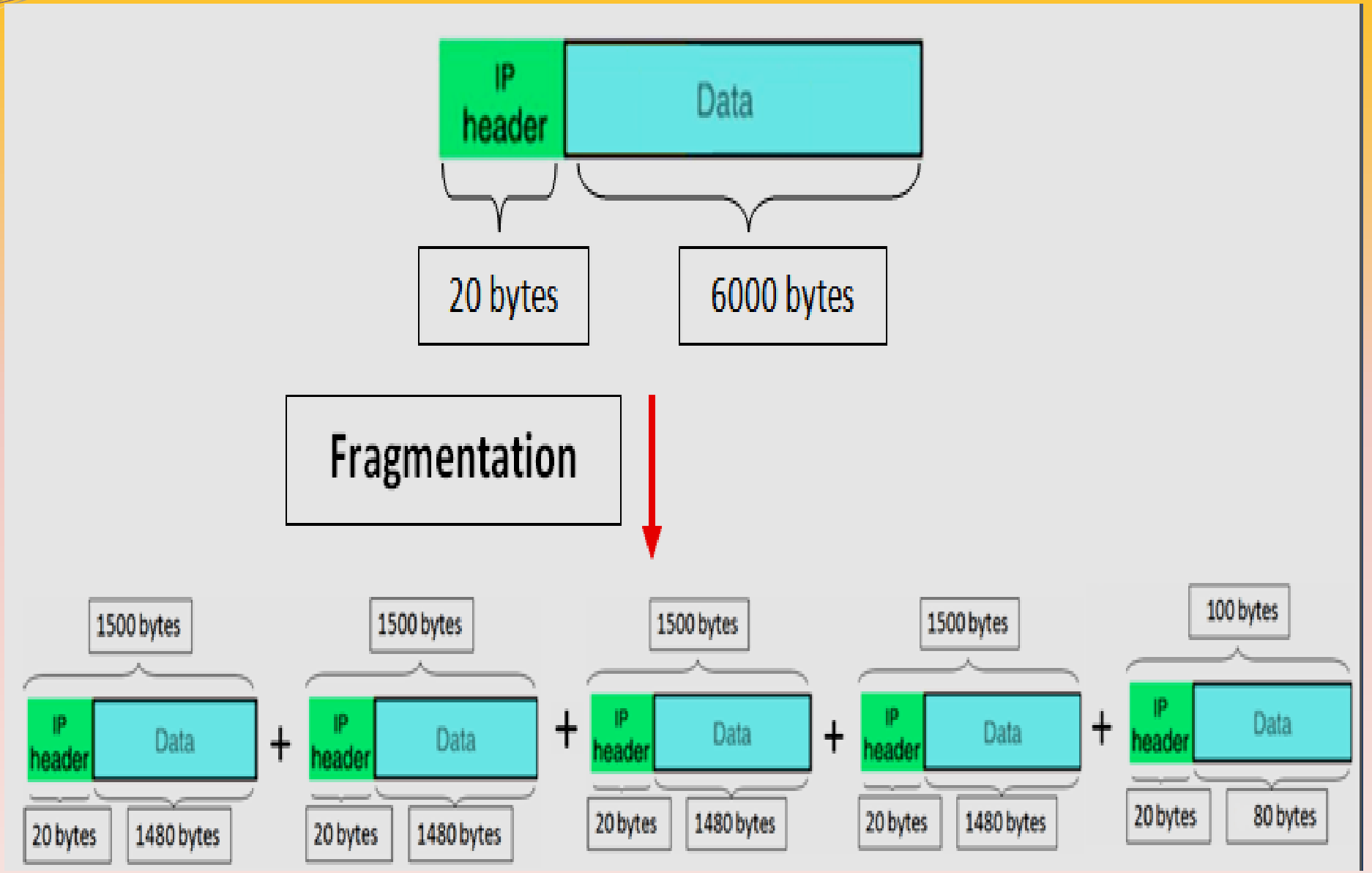


Fragmentation

- If the IP packet size is bigger than MTU, it should be fragmented

Ex : If the original packet has 6000 bytes of data

1. Separate data and Header of IP Packet
2. Break data part into MTUs (Fragments)
3. Add 20 byte header to each fragment


IP header
Data
20 bytes
6000 bytes
Fragmentation
1500 bytes
IP header
Data
20 bytes
1480 bytes
1500 bytes
IP header
Data
20 bytes
1480 bytes
1500 bytes
IP header
Data
20 bytes
1480 bytes
1500 bytes
IP header
Data
20 bytes
1480 bytes
100 bytes
IP header
Data
20 bytes
80 bytes

Fragmentation offset

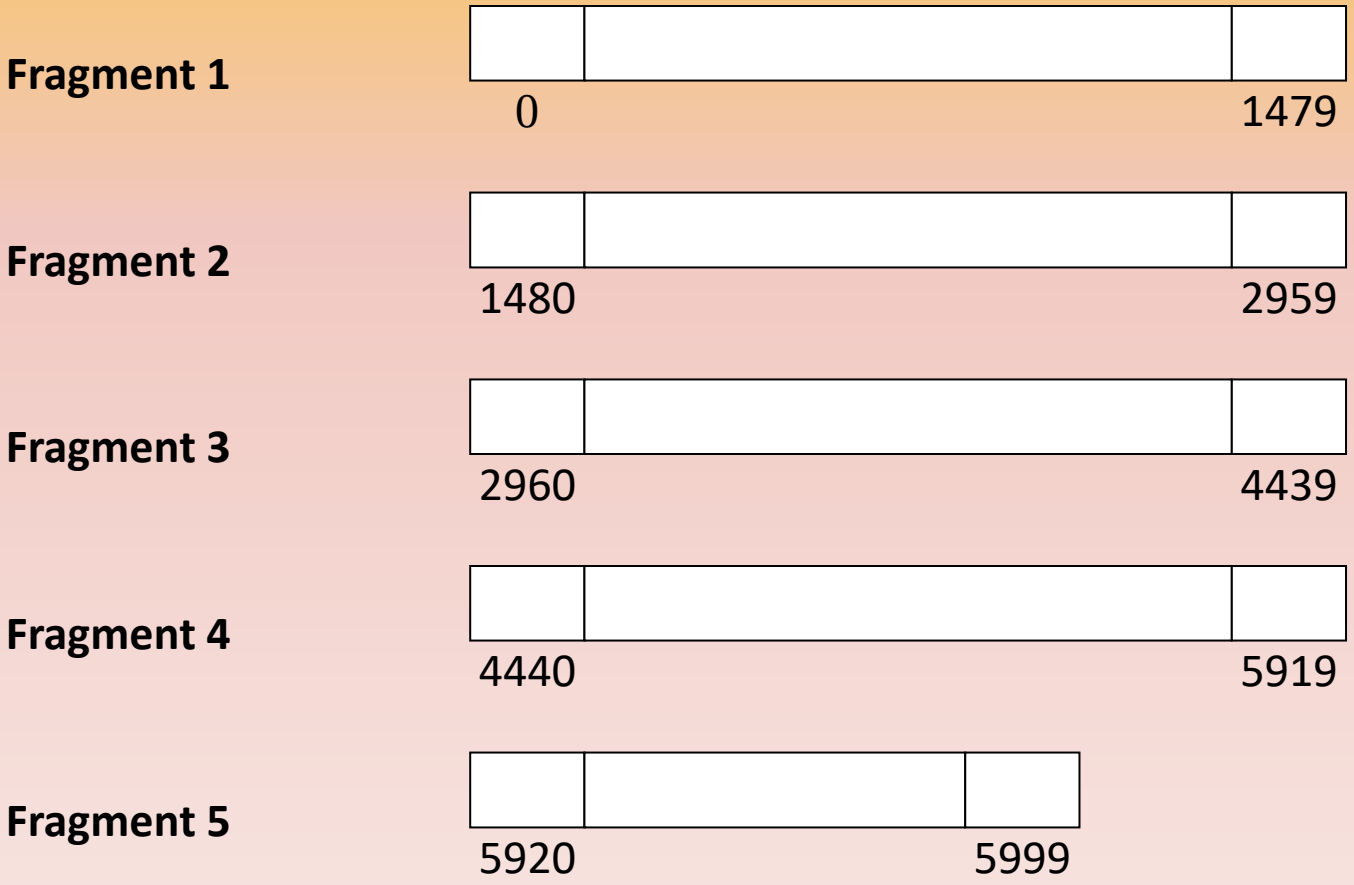
- The identification of each fragmented IP packet is equal to identification of original IP packet

  Ex : If the identification of original IP packet is 2000, identification of all five fragments is 2000

- " **Fragmentation offset** " is an another parameter used to identity the order of fragments

Fragmentation offset cont.

- If the original packet has 6000 bytes of data , the numbering of data bytes are as follows

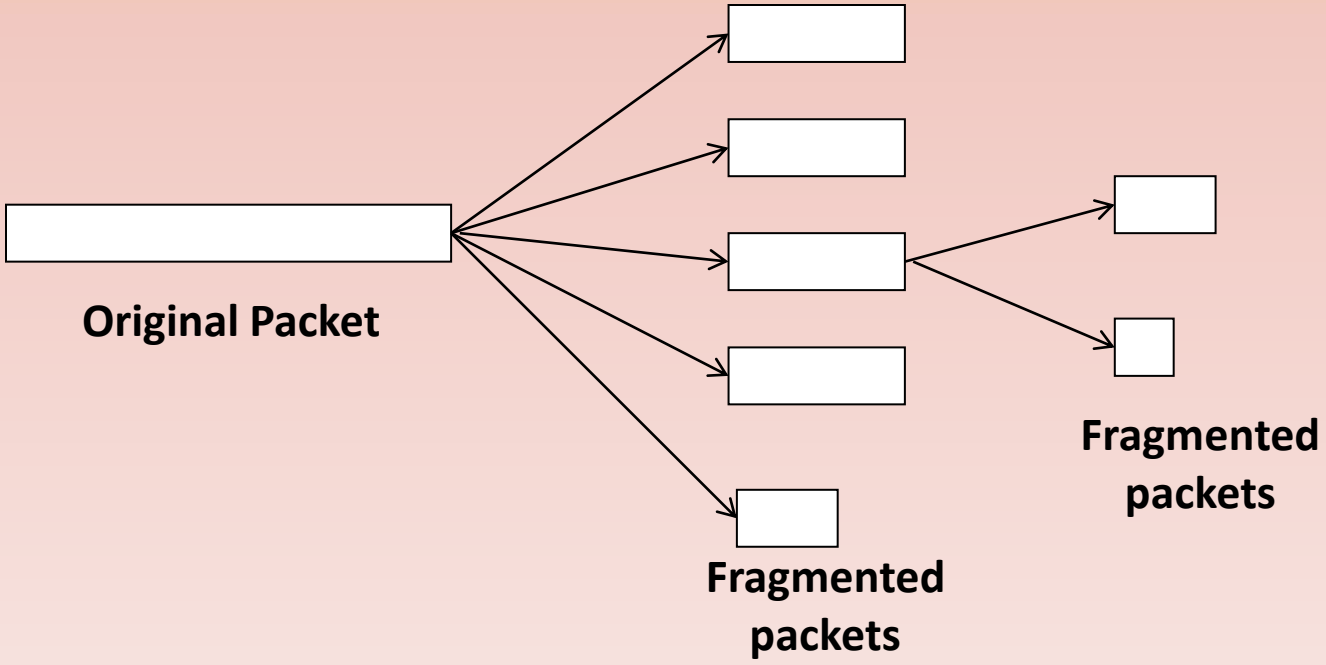


Fragmentation offset cont.

- Offset value of fragment 1 = $\frac{0}{8}$ = 0
- Offset value of fragment 2 = $\frac{1480}{8}$ = 185
- Offset value of fragments 3 = $\frac{2960}{8}$ = 370
- Offset value of fragment 4 = $\frac{4440}{8}$ = 555
- Offset value of fragment 5 = $\frac{5920}{8}$ = 740

Fragmentation offset cont.

- Fragmented packets travel independently
- They may travel through different routes to the destination
- While it is traveling it can be further fragmented at another intermediate network



Fragmentation offset cont.

- Fragmented packets reach to the destination out of order.
- The fragmented packets are combined (defragmented) at the final destination by using the *OFFSET* values.

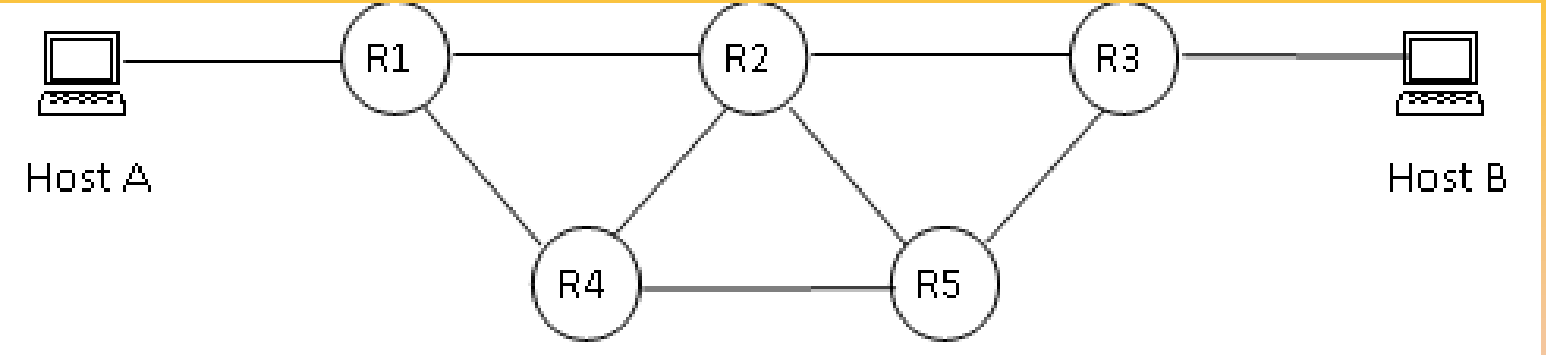
Time To Live (TTL)

- IP packets travel through many routers in the network
- Each router routes the packet according to information in the routing table
- If there is a problem in a routing table the packet may be sent in a wrong direction and it can be randomly flow in the network. This kind of IP packets can even overload the network and finally crash the network
- In order to avoid such a situation, a parameter called “Time To Live” (TTL) is defined for each IP packet

Time To Live (TTL) cont.

- TTL value can be initialized to any value at the transmitting router (A) (maximum is 255)
- The TTL value is decremented at each router by 1
- If the TTL value becomes zero at a router (B) , the packet will be discarded and an ICMP message is sent to the transmitted router(A) from the discarding router (B)

Time To Live (TTL) cont.

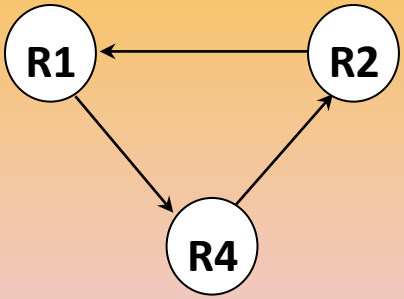


- Suppose host A sends an IP packet to Host B
- The TTL value is set to 6
- If the packet goes through Host A → R1 →R2 → R3 → Host B,

Router	TTL Value
R1	= 5
R2	= 4
R3	= 3

Time To Live (TTL) cont.

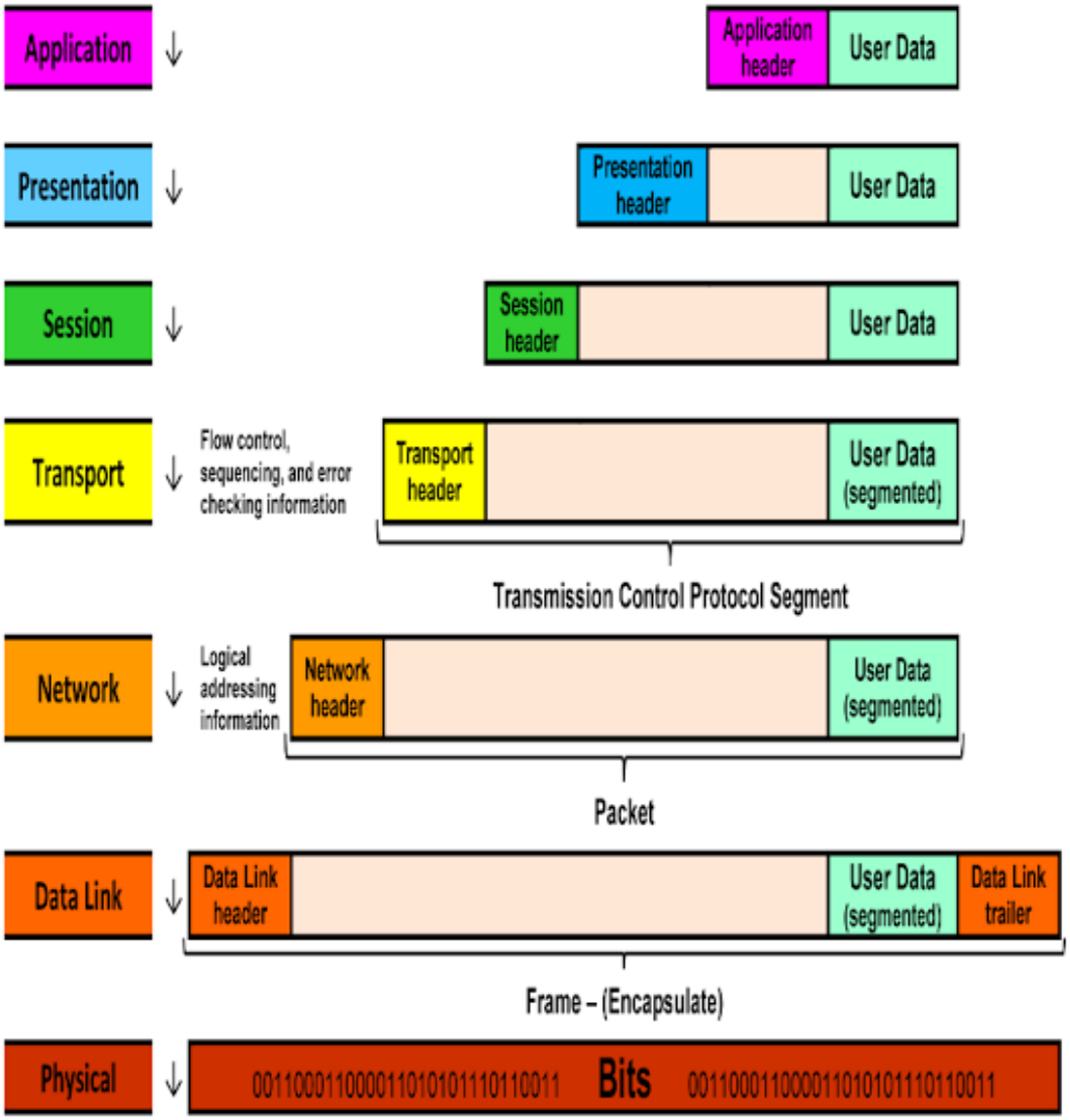
- Suppose there is a routing problem and the packet loops through the routes R1 → R4 → R2 → R1→ R4 → R2 → R1 → R4 → R2



Router	TTL Value	Action
R1	6 -1 = 5	
R4	5 – 1 = 4	
R2	4 – 1 = 3	
R1	3 – 1 = 2	
R4	2 – 1 = 1	
R2	1 – 1 = 0	Discards the Packet Send ICMP message to Host A

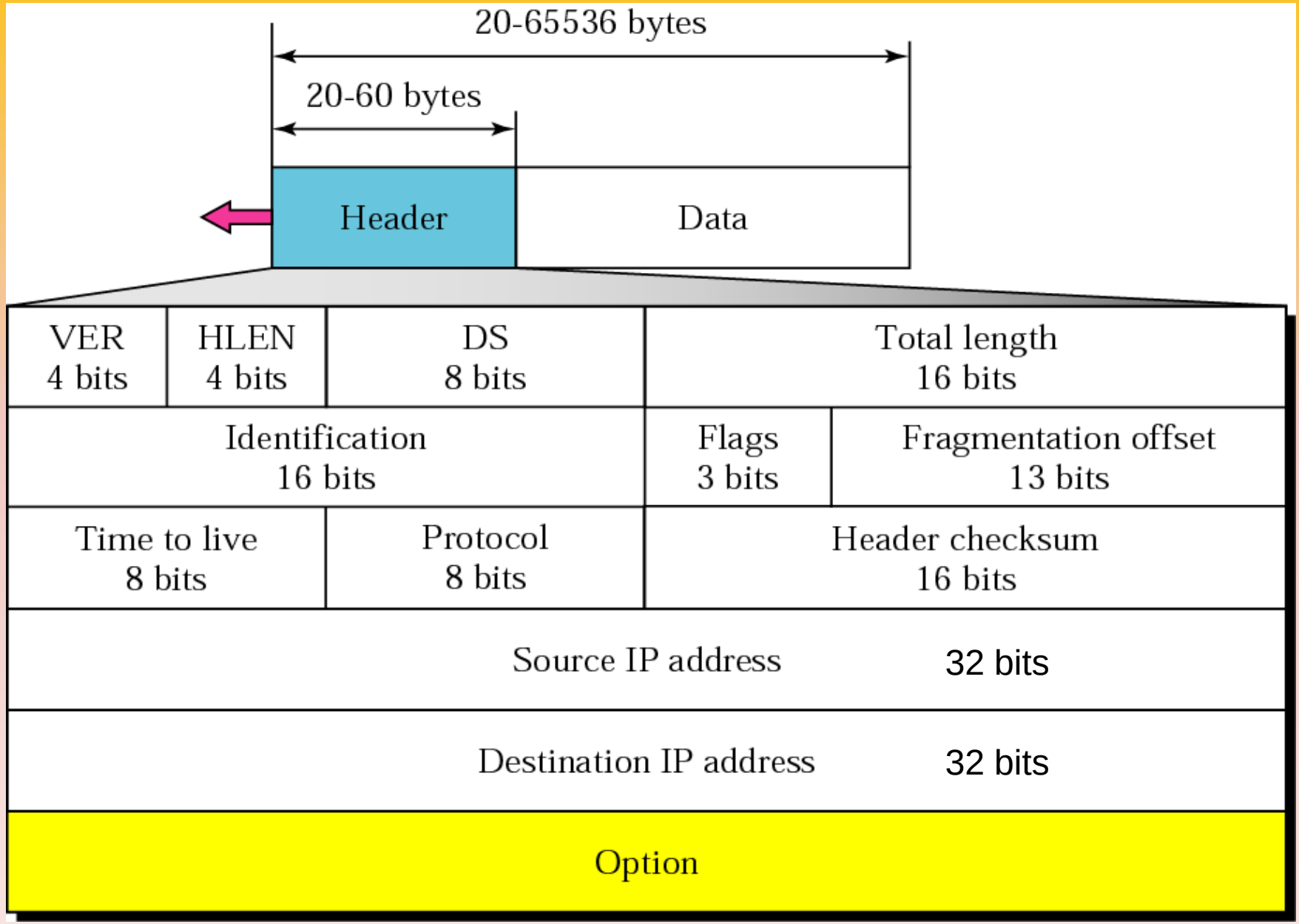
- The TTL value becomes zero at router R2
- Therefore IP packet is discarded

7 LAYERS	OSI FIGURE	DATA TRANSFORMATI



Format of the information at each layer

IP header


20-65536 bytes
20-60 bytes
Header
Data
VER
4 bits
HLEN
4 bits
DS
8 bits
Total length
16 bits
Identification
16 bits
Flags
3 bits
Fragmentation offset
13 bits
Time to live
8 bits
Protocol
8 bits
Header checksum
16 bits
Source IP address
32 bits
Destination IP address
32 bits
Option

Version (VER)

- A field of 4 bits
- Indicates the version of the using IP addresses in the IP packet

IPv4 : 0100

IPv6 : 0110

Header Length (HLEN)

- A 4 bit field indicates the number of 4 bytes in the header
- Header size in bytes = HLEN x 4

- The standard header size = 20 bytes

  20 = 5 x 4

  HLEN = 5 $(0101)_2$

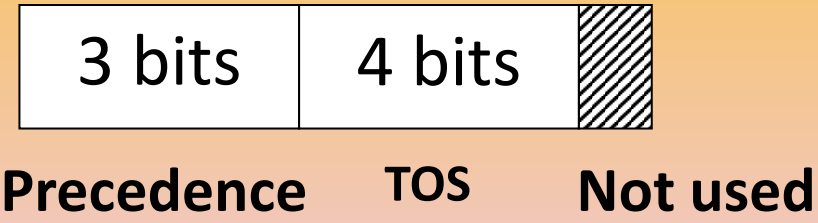
- The standard header size = 60 bytes

  60 = 15 x 4

  HLEN = 15 $(1111)_2$

Service Type

- A 8 bit field
- IETF has changed the name of this field as **Differentiated Services**



- **Precedence** defines the priority of the packet
- **Precedence** is not used in IPv4

Service Type cont.

- A 4-bit field
- Each bit has a special meaning
- There are five types of services

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

Service Type cont.

The application can select a specific type of service

Protocol	*TOS Bits*	*Description*
ICMP	0000	Normal
BOOTP	0000	Normal
NNTP	0001	Minimize cost
IGP	0010	Maximize reliability
SNMP	0010	Maximize reliability
TELNET	1000	Minimize delay
FTP (data)	0100	Maximize throughput
FTP (control)	1000	Minimize delay
TFTP	1000	Minimize delay
SMTP (command)	1000	Minimize delay
SMTP (data)	0100	Maximize throughput
DNS (UDP query)	1000	Minimize delay
DNS (TCP query)	0000	Normal
DNS (zone)	0100	Maximize throughput

Total length

- A 16-bit field
- Gives the total length of the IP packet.

Total length = data length + header length

- If total length value is 300 and if this is a normal IP packet

  Header length = 20 bytes

  Data length = 300 – 20

  = 280 bytes

Identification

- Each IP packet is identified by a serial number called "**Identification**"
- A 16 bit field
- The identification of each fragmented IP packet is equal to identification of original IP packet

Flags

- ***D = 1,*** means is not allowed to be fragmented
- ***D = 0,*** means is allowed to be fragmented

- ***M = 0,*** means that there are no more fragments;

  The fragment is the last one.

  Non fragmented packet is considered the last fragment
- ***M = 1,*** The fragment is not the last one.

Fragmentation offset

- A 13-bit field
- This gives the offset value of the fragment

Time To Live (TTL)

- A 8 bit field
- Defines the maximum number of hops the packet can travel

Protocol

- The IP packet data can be UDP, TCP, ICMP, IGMP, EGP
- Used to identify the type of data a special field called “protocol”
- A a 8-bit field which defines the protocol number

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

Header Checksum

- A 16-bit field
- Checks the errors of the header only.
- If errors are found in the header, the whole IP packet is discarded.

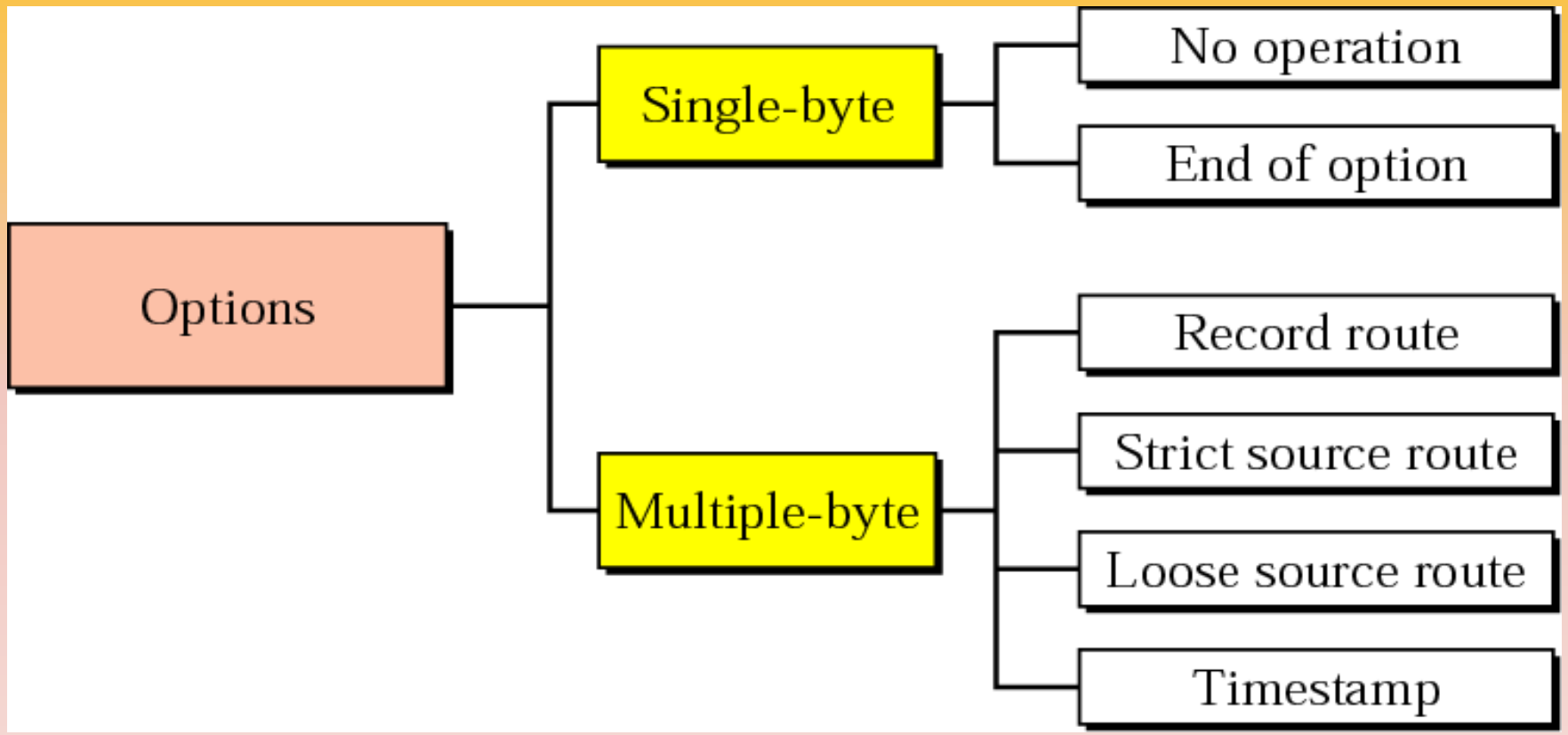
Source IP Address

- A 32-bit field
- This gives the IP address of the source

Destination IP Address

- A 32-bit field
- This gives the IP address of the destination

IP option


Options
Single-byte
No operation
End of option
Multiple-byte
Record route
Strict source route
Loose source route
Timestamp