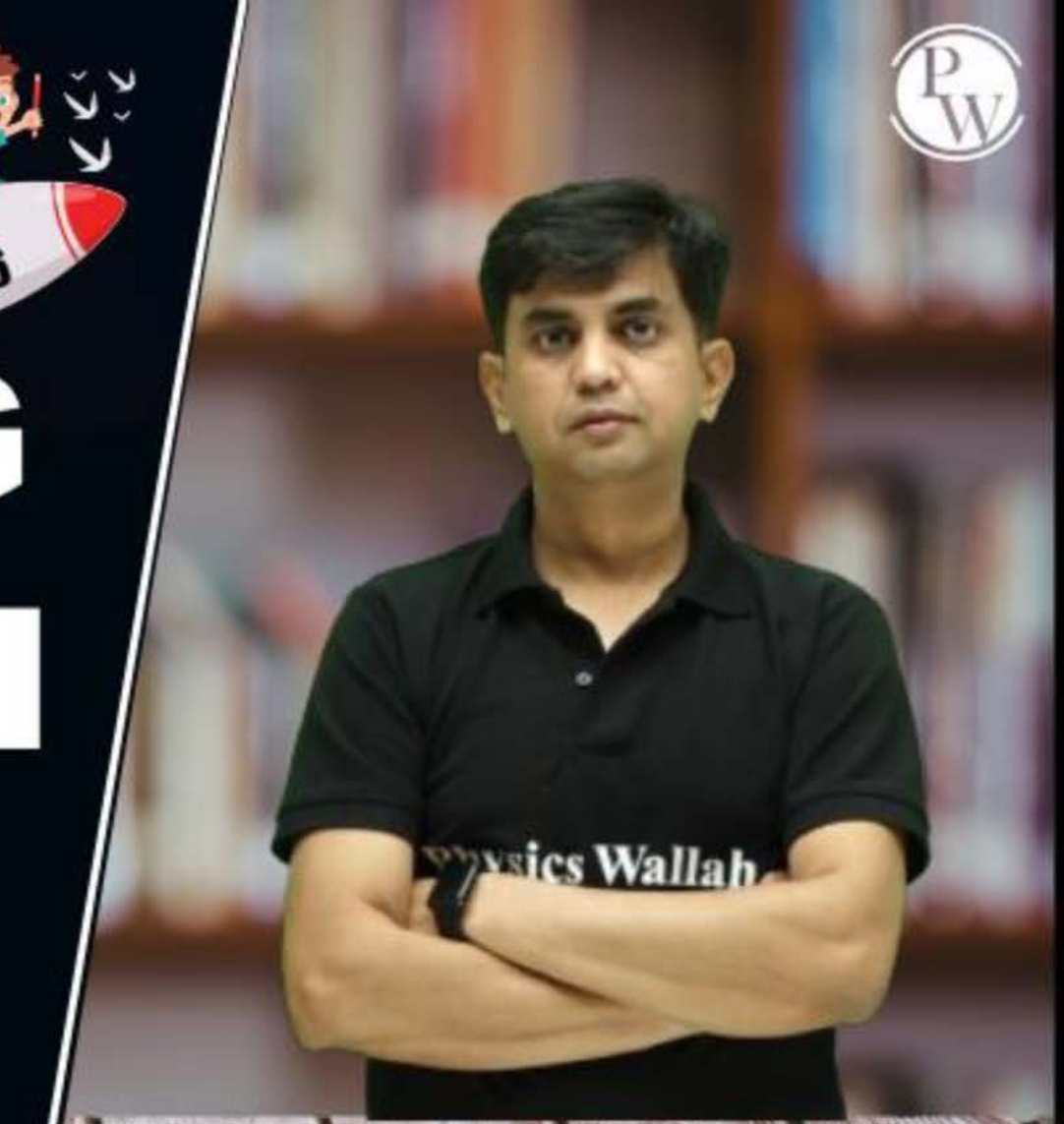
CS & IT ENGINEERING

Computer Network

IPv4 Header

Lecture No. - 01



By - Abhishek Sir

ABOUT ME

Hello, I'm Abhishek

- GATE CS AIR - 96
- M.Tech (CS) - IIT Kharagpur
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Recap of Previous Lecture

Topic Store-and-Forward Delay

Topic End-to-End Delay

Topic Bit Error Probability

→ Framing
Frame synchroni-zation
Bit stuffing

Topics to be Covered

- Topic: IPv4 Packet Header Structure
- Topic: IPv4 Packet Header Size
- Topic: IPv4 Packet Size
- Topic: MTU

#Q. Two hosts are connected via a packet switch with 10^7 bits per second links. Each link has a propagation delay of 20 microseconds. The switch begins forwarding a packet 35 microseconds after it receives the same. If 10000 bits of data are to be transmitted between the two hosts using a packet size of 5000 bits, the time elapsed between the transmission of the first bit of data and the reception of the last bit of the data in microseconds is _____.

[GATE 2015, Set-2, 2-Mark]

Solution:-

Packet Size = 5000 bits = $5 * 10^3$ bits

Bandwidth = 10^7 bits / sec

$$t_x = \frac{\text{Packet Size}}{\text{Bandwidth}} = \frac{5 * 10^3 \text{ bits}}{10^7 \text{ bits / sec}} = 500\ \mu s$$

$t_{p_1} = 20\ \mu s = t_{p_2}$

Processing Delay = 35 μs

File Size = 10,000 bits

Packet Size = 5,000 bits

$$\text{Number of packets } (N) = \frac{\text{File Size}}{\text{Packet Size}} = \frac{10000 \text{ bits}}{5000 \text{ bits}} = 2$$

$$\text{End-to-end delay} = (N * t_x + t_p) + \text{Processing Delay} + (t_x + t_p)$$

$$= (2 * 500 + 20) + 35 + (500 + 20)\ \mu s$$

$$= 1575\ \mu s$$

Ans = 1575

#Q. Consider a source computer (S) transmitting a file of size 10^6 bits to a destination computer (D) over a network of two routers (R1 and R2) and three links (L1, L2, and L3). L1 connects S to R1; L2 connects R1 to R2; and L3 connects R2 to D. Let each link be of length 100 km. Assume signals travel over each link at a speed of 10^8 meters per second. Assume that the link bandwidth on each link is 1Mbps. Let the file be broken down into 1000 packets each of size 1000 bits. Find the total sum of transmission and propagation delays in transmitting the file from S to D.

[GATE 2012, 2-Mark]

(A) 1005 ms

(B) 1010 ms

(C) 3000 ms

(D) 3003 ms

Ans: A

Solution:-

Packet Size = 1000 bits = 10^3 bits

Bandwidth = 1 Mbps = 10^6 bits / sec

$$t_x = \frac{\text{Packet Size}}{\text{Bandwidth}} = \frac{10^3 \text{ bits}}{10^6 \text{ bits / sec}} = 1 \text{ ms} = 10^{-3} \text{ sec}$$

Distance = 100 Km = 10^5 m

Signal Speed = 10^8 m/s

$$t_{p_1} = \frac{\text{Distance}}{\text{Signal Speed}} = \frac{10^5 \text{ m}}{10^8 \text{ m/s}} = 1 \text{ ms} = t_{P_2} = t_{P_3}$$

$= 10^{-3}$ sec

File Size = 10^6 bits

Packet Size = 10^3 bits

Number of packets (N) = $\frac{\text{File Size}}{\text{Packet Size}} = \frac{10^6 \text{ bits}}{10^3 \text{ bits}} = 10^3$

End-to-end delay = $(N * t_x + t_p) + (t_x + t_p) + (t_x + t_p)$

$= (10^3 * 1 + 1) + (1 + 1) + (1 + 1)$ ms

$= 1005$ ms

#Q. On a wireless link, the probability of packet error is 0.2. A stop-and-wait protocol is used to transfer data across the link. The channel condition is assumed to be independent from transmission to transmission. What is the average number of transmission attempts required to transfer 100 packets?

[GATE 2006]

A 100

B 125

C 150

D 200

Ans > 100

100 + 20 + 4 = 124 .....

Ans: B

Stop-and-Wait ARQ.

Packet error probability (P) = 0.2

Number of packets (n) = 100 packets

Average number of transmission attempts (N) = ?

$$N = n + (n*p) + (n*p^2) + (n*p^3) + \dots\dots\dots$$

$$N = n * [1 + p + p^2 + p^3 + \dots\dots\dots]$$

$$N = n * \frac{1}{(1-p)}$$

$$\boxed{N = \frac{n}{(1-p)}} = \frac{100}{(1-0.2)} = 125$$

Topic : Network Layer

→ Internet Protocol (IP)

→ Two versions :

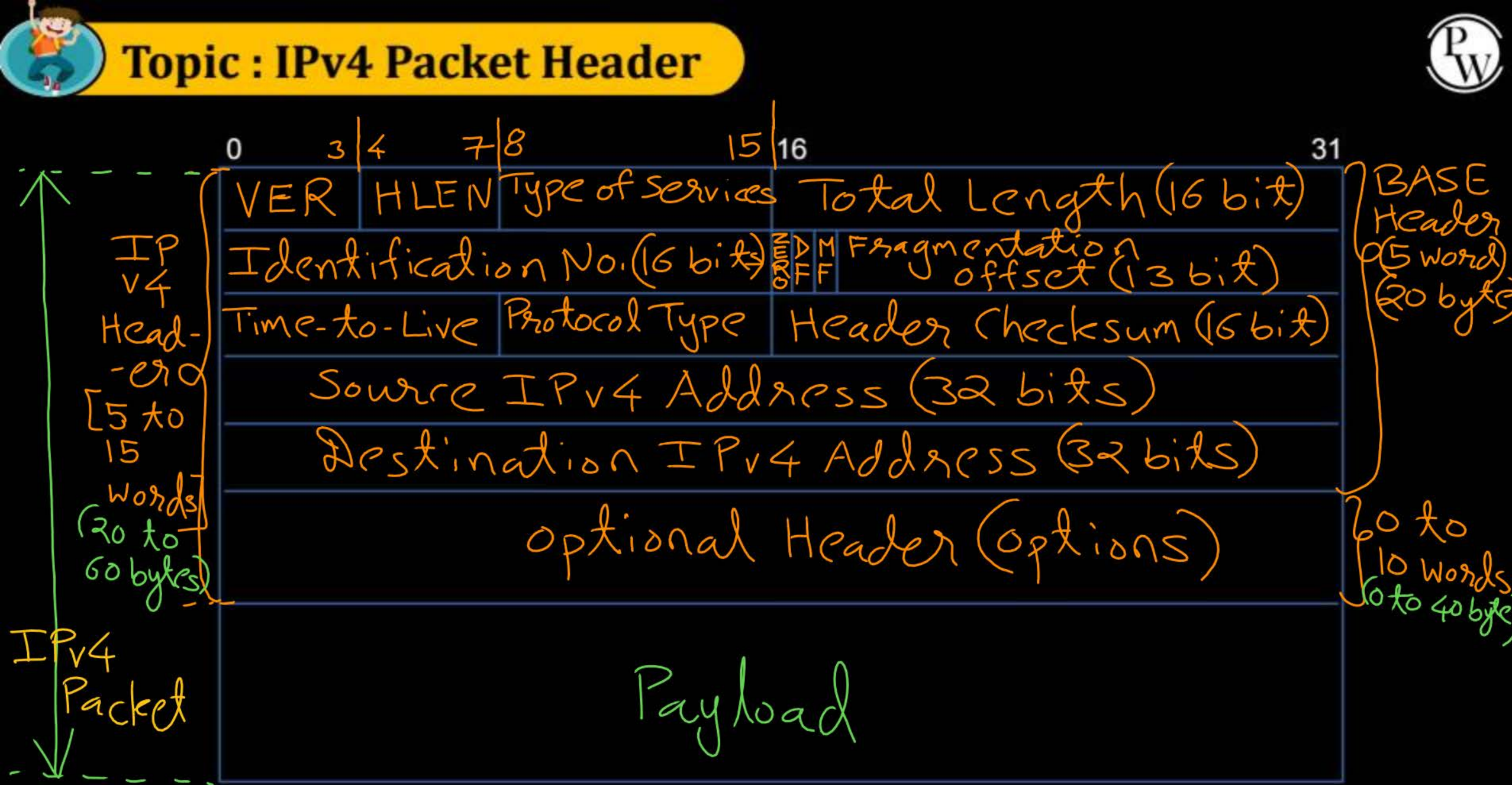
1. IPv4
2. IPv6

*Network layer PDU = Datagram
[IP Datagram]
or
IP Packet

Topic : IPv4 Packet Header

IPv4 Packet

Topic : IPv4 Packet Header



Topic : IPv4 Packet Header

→ IPv4 Header represented in words
[Word of 32 bits (4 bytes)]

→ Minimum (Base) Header Size = 5 Words (20 Bytes)
[Word size = 4 bytes]

→ Variable Size IPv4 Header
[due to options (optional header)]

Topic : Version

→ First four bits of IPv4 datagram

→ "0100" : for IPv4

→ "0110" : for IPv6

Topic : Header Length

→ Header Length [HLEN]

→ HLEN field is 4 bits long

→ Size of header in words
[Word of 4 bytes]

→ Header Length = HLEN Words
= [HLEN * 4] Bytes

4-bit
unsigned Int

Range → 0 to 15

HLEN ⩾ 5

⇒ Pointer : it points first word of payload

Topic : Header Length

→ Minimum Header Size = 5 Words (20 Bytes)

5 <= HLEN <= 15

→ Maximum Header Size = 15 Words (60 Bytes)

→ Word of 4 bytes

Example 1 :-

[MSQ]

#Q. Which of the following is/are can be a valid IPv4 packet header size in bytes ?

A) 15

B) 20

C) 50

D) 60

Words → 5 to 15 words

Bytes → 20 to 60 bytes

Ans : B & D

Topic : Header Length

Header Size = 5 Words (20 Bytes)

Header Size = 6 Words (24 Bytes)

Header Size = 7 Words (28 Bytes)

Header Size = 8 Words (32 Bytes)

Header Size = 9 Words (36 Bytes)

Header Size = 10 Words (40 Bytes)

Header Size = 11 Words (44 Bytes)

Header Size = 12 Words (48 Bytes)

Header Size = 13 Words (52 Bytes)

Header Size = 14 Words (56 Bytes)

Header Size = 15 Words (60 Bytes)

Example 2 :-

[MSQ]

#Q. Which of the following is/are can be a valid IPv4 packet starting bits ?

VERHLEN

A. 0100 0100

B. 0100 0101

C. 0100 0110

D. 0110 0110

Ans: B & C

Example 3 :-

[NAT]

#Q. Consider starting eight bits of an IPv4 packet is "0100 1010", calculate IPv4 packet header size in bytes ?

VER HLEN

HLEN = 10 words

Header Size = (HLEN * 4) bytes

= (10 * 4) bytes

= 40 bytes

Ans = 40

Topic : Header Length

Size of options (in IPv4 packet header)

= [HLEN – Base Heder Size] words

= [HLEN – 5] words

= [HLEN – 5] * 4 bytes

Topic : Header Length

Maximum Size of options (in IPv4 packet header)

= [Maximum Header Size – Base Heder Size] words

= [15 – 5] words

= 10 words

= 10 * 4 bytes

= 40 bytes

Example 4 :-

[NAT]

#Q. Consider starting eight bits of an IPv4 packet is "0100 1100", calculate IPv4 packet options size in bytes ?

VER HLEN

HLEN = 12 words

Size of options = (HLEN − 5) * 4 bytes

= (12 − 5) * 4 bytes

= 28 bytes

Ans = 28

Topic : Type of Services

→ Type of Services [ToS]

→ ToS field is 8 bits long
[Second byte of IPv4 packet header]

→ For QoS
[Quality of Services]

{ Delay
Throughput
Reliability

Topic : Total Length

→ Total Length field is 16 bits long

→ Define size of IPv4 packet (datagram) in bytes [including header]

→ Maximum IPv4 datagram size = $[2^{16} - 1]$ bytes

16 bit Unsigned Int

Range →
0 to $(2^{16} - 1)$

TL ≥ 20

Topic : Total Length

Size of Payload = [Total Length – (HLEN * 4)] bytes`

Example 5 :-

[NAT]

#Q. Consider an IPv4 packet, the values in total length field and header length (HLEN) fields are 250 and 10 respectively, calculate size of data (payload size) in bytes carrying by this packet ?

TL = 250 bytes

HLEN = 10 words

Size of payload = [TL − (HLEN * 4)] bytes

= [250 − (10 * 4)] bytes

= 210 bytes

Ans = 210

Topic : MTU

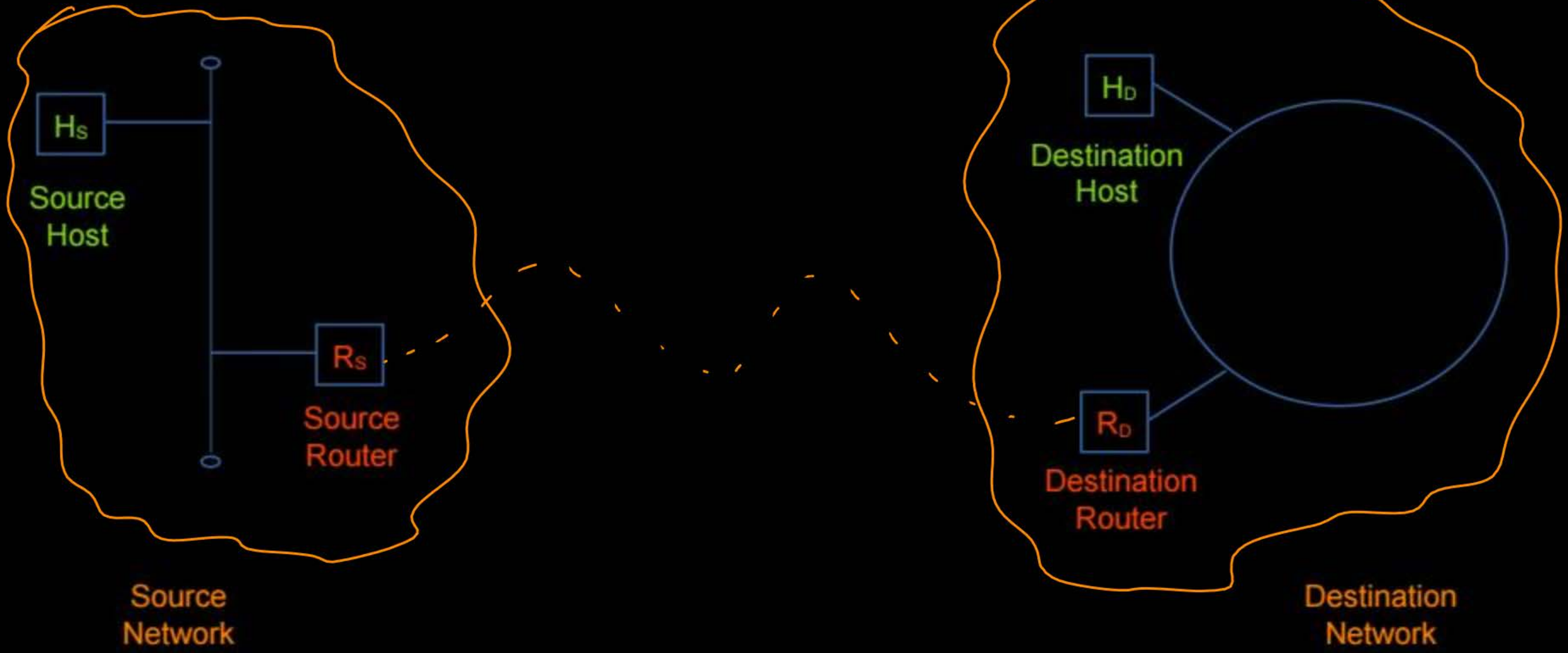
→ Maximum Transmission Unit [MTU]

→ Measurement in bytes

→ Size of largest PDU (IP datagram) that can be communicated over a network

$TL \leq MTU$

Topic : MTU


H_S
Source Host
R_S
Source Router
Source Network
H_D
Destination Host
R_D
Destination Router
Destination Network

Topic : MTU

→ Different networking technologies may have different MTU → max^m payload size for frame

→ MTUs for common media

1. Ethernet v2 (IEEE 802.3) : 1500 bytes
2. Wi-Fi (WLAN, IEEE 802.11) : 2304 bytes
3. Token Ring (IEEE 802.5) : 4464 bytes
4. FDDI : 4352 bytes

*Dynamic MTU

Topic : MTU ⇒[Fragmentation at source]

→ Source host creates IPv4 datagram as per source network MTU

⇒ Fragmentation at Router

→ At intermediate IPv4 router, for an received IPv4 datagram

if IPv4 datagram size is greater then next network (link) MTU size

then need to do fragmentation according to MTU

Topic : Identification Number

→ 16 bits long

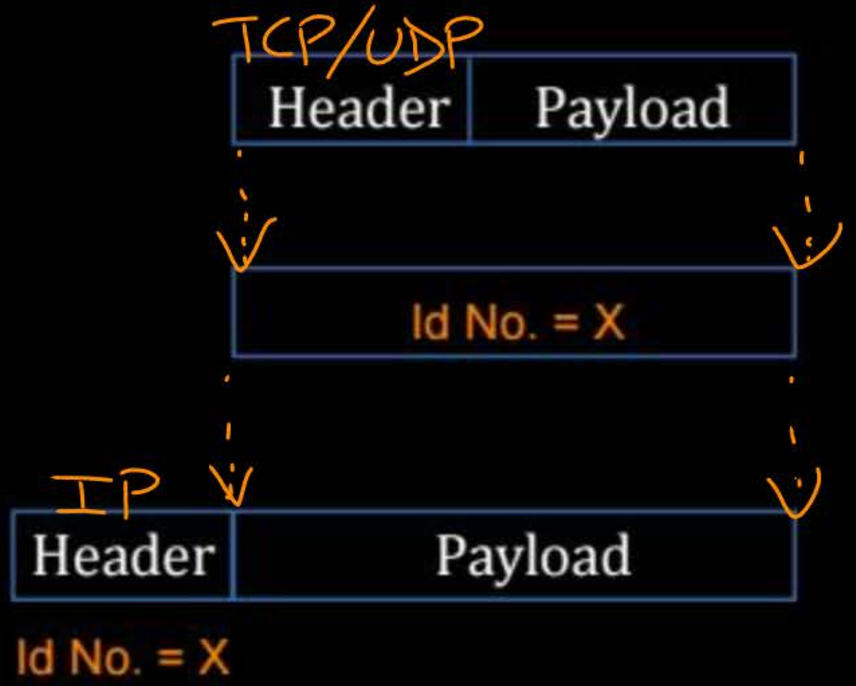
→ Assigned by source host only
[Assigned unique identification number to each transport layer Segment]

→ IP fragments of same segment, must have same identification number
[does not change during routing]

Topic : Identification Number

Transport Layer PDU (Segment)

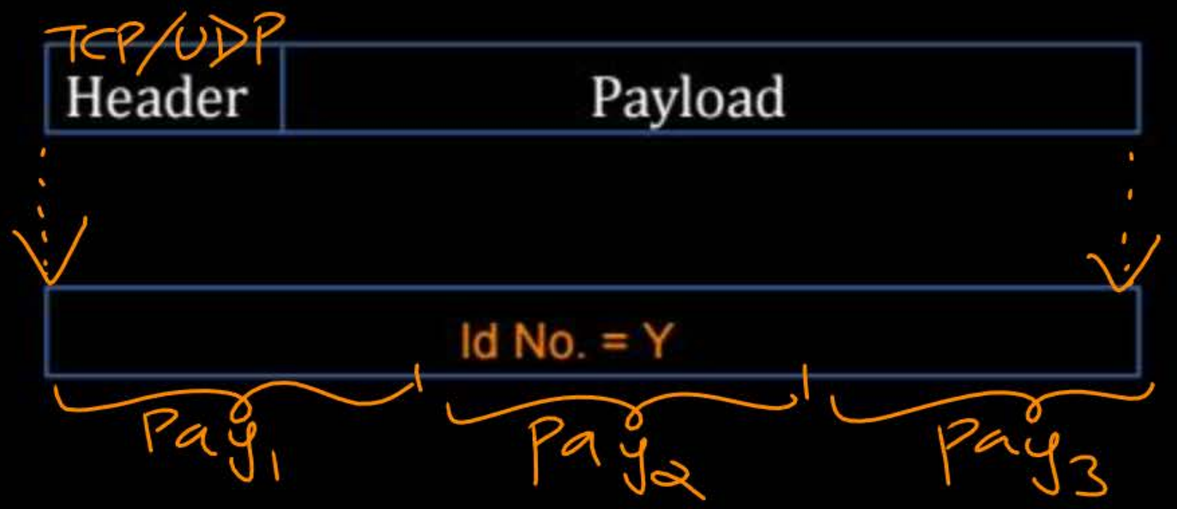
SDU for Network Layer



Topic : Identification Number

Transport Layer PDU (Segment)

SDU for Network Layer
= Segment



2 mins Summary

Topic IPv4 Packet Header Structure

Topic IPv4 Packet Header Size (HLEN)

Topic IPv4 Packet Size (TL)

Topic MTU

⇒ Identification No.

THANK - YOU