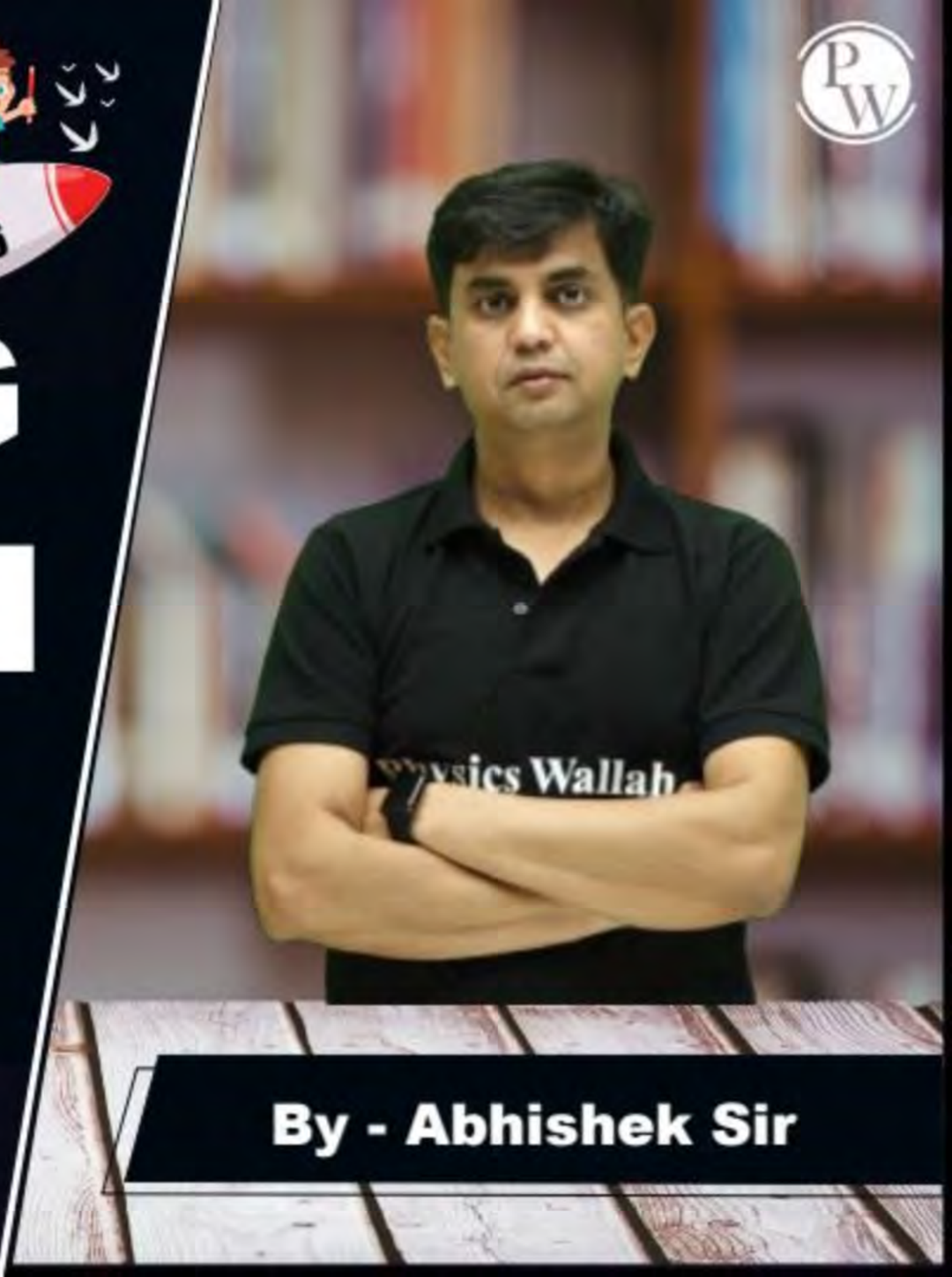
# CS & IT ENGINEERING


## Computer Network

## IPv4 Header

Lecture No. - 03



# Recap of Previous Lecture

**Topic** Fragmentation at Source Host

# Topics to be Covered

**Topic** Fragmentation at Router

[MCQ] [GATE-2013] [2 Mark]

#Q. In an IPv4 datagram, the M bit is 0, the value of HLEN is 10, the value of total length is 400 and the fragment offset value is 300. The position of the datagram, the sequence numbers of the first and the last bytes of the payload, respectively are

(A) Last fragment, 2400 and 2789

(B) First fragment, 2400 and 2759

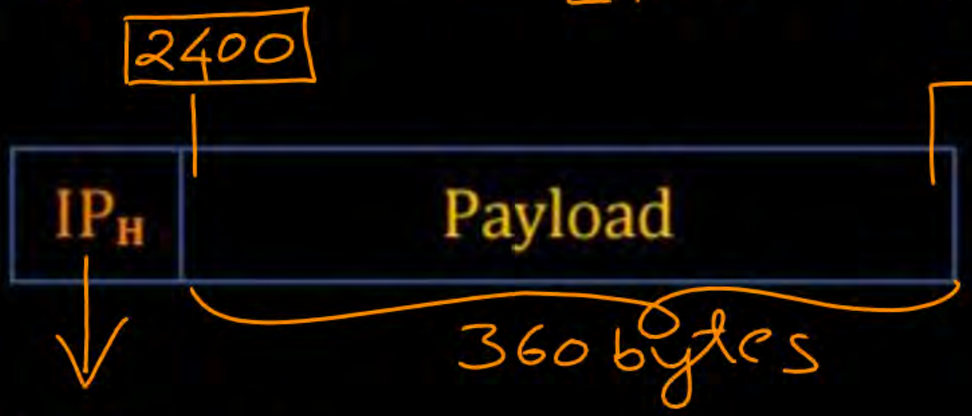
(C) Last fragment, 2400 and 2759

(D) Middle fragment, 300 and 689

Ans: C

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

~~bytes~~ = [400 − (10*4)] bytes = 360 bytes




HLEN = 10

TL = 400

Offset = 300

MF bit = 0

First byte sequence number = Offset * 8 = 300*8 = 2400

Last byte sequence number = (Offset * 8) + Payload Size − 1

= (300*8) + 360 − 1

= 2759

[MCQ] [GATE-2015] [2 Mark]

#Q. Host A sends a UDP datagram containing 8880 bytes of user data to host B over an Ethernet LAN. Ethernet frames may carry data up to 1500 bytes (i.e. MTU = 1500 bytes). Size of UDP header is 8 bytes and size of IP header is 20 bytes. There is no option field in IP header. How may total number of IP fragments will be transmitted and what will be the contents of offset field in the last fragment?

A. 6 and 925

B. 6 and 7400

C. 7 and 1110

D. 7 and 8880

Ans: C

UDP Header Size = 8 bytes
UDP Payload Size = 8880 bytes

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UDP Segment Size = 8888 bytes

MTU = 1500 bytes
IPv4 Header Size = 20 bytes

Maximum Payload Size = [ MTU - Header Size ] bytes

= [1500 - 20] bytes
= 1480 bytes

UDP Segment Size = 8888 bytes

$$\text{Total Number of IP fragments [N]} = \left\lceil \frac{\text{UDP Segment Size}}{\text{Payload Size}} \right\rceil$$

$$N = \left\lceil \frac{8888 \text{ bytes}}{1480 \text{ bytes}} \right\rceil$$

$$N = \lceil 6.005 \rceil$$

$$N = 7$$

Offset value of the last IP fragment $= \dfrac{(N-1) * \text{Payload Size}}{8}$

$= \left[\dfrac{(7-1) * 1480 \text{ Byte\_No}}{8}\right]$

$= \left[\dfrac{8880 \text{ Byte\_No}}{8}\right]$

$= 1110 \text{ word\_no}$

[MCQ] [GATE-2025] [1 Mark]

#Q. Consider a network that uses Ethernet and IPv4. Assume that IPv4 headers do not use any options field. Each Ethernet frame can carry a maximum of 1500 bytes in its data field. A UDP segment is transmitted. The payload (data) in the UDP segment is 7488 bytes. Which ONE of the following choices has the CORRECT total number of fragments transmitted and the size of the last fragment including IPv4 header?

A 5 fragments, 1488 bytes

B 6 fragments, 88 bytes

C 6 fragments, 108 bytes

D 6 fragments, 116 bytes

Ans: D

UDP Header Size = [8 bytes]
UDP Payload Size = [7488 bytes]

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UDP Segment Size = [7496 bytes]

MTU = 1500 bytes
IPv4 Header Size = 20 bytes

Maximum Payload Size = [MTU - Header Size] bytes

= (1500 - 20) bytes
= 1480 bytes

UDP Segment Size = 7496 bytes

Total Number of IP fragments [N] = $\left\lceil \frac{\text{UDP Segment Size}}{\text{Payload Size}} \right\rceil$

$= \left\lceil \frac{7496 \text{ bytes}}{1480 \text{ bytes}} \right\rceil$

$= \lceil 5.064 \rceil$

$N = 6$

Total length of the last IP fragment =

Header Size + [ UDP Segment Size − (N−1) * Payload Size ] bytes

= 20 bytes + [ 7496 byte − (6−1) * 1480 bytes ]

= (20 + 96) bytes

= 116 bytes

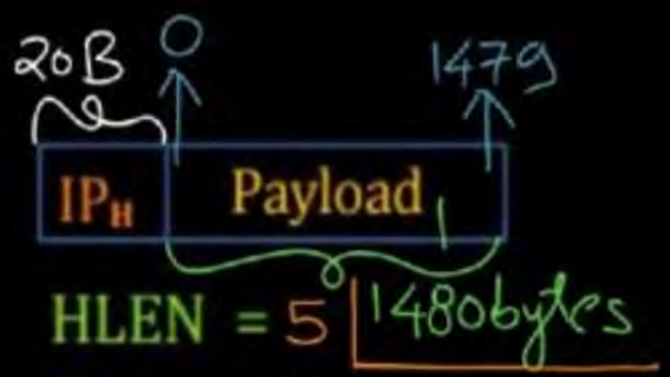
## Example 7 :-

Frag. at Router

[NAT]

#Q. Consider following IPv4 datagrams carrying one UDP segment (created in example 6) are arrived at intermediate IPv4 router. The next network (link) MTU at router is 500 bytes, calculate total number of IPv4 fragments required to carry the UDP segment after fragmentation ?

Ans = 11



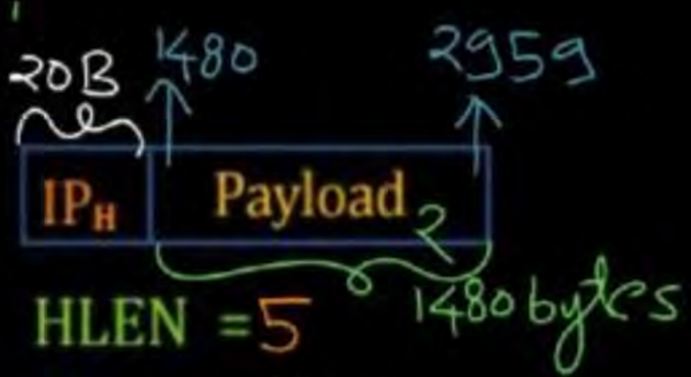

HLEN = 5 | 1480 bytes

TL = 1500

Id No. = Y

Offset = $\frac{0}{8} = 0$

MF bit = 1



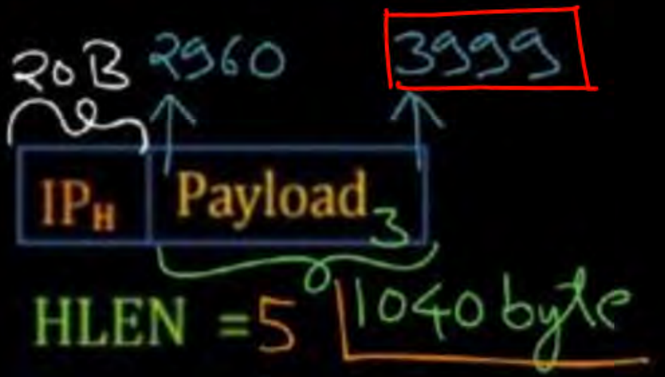

HLEN = 5 | 1480 bytes

TL = 1500

Id No. = Y

Offset = $\frac{1480}{8} = 185$

MF bit = 1




HLEN = 5 | 1040 byte

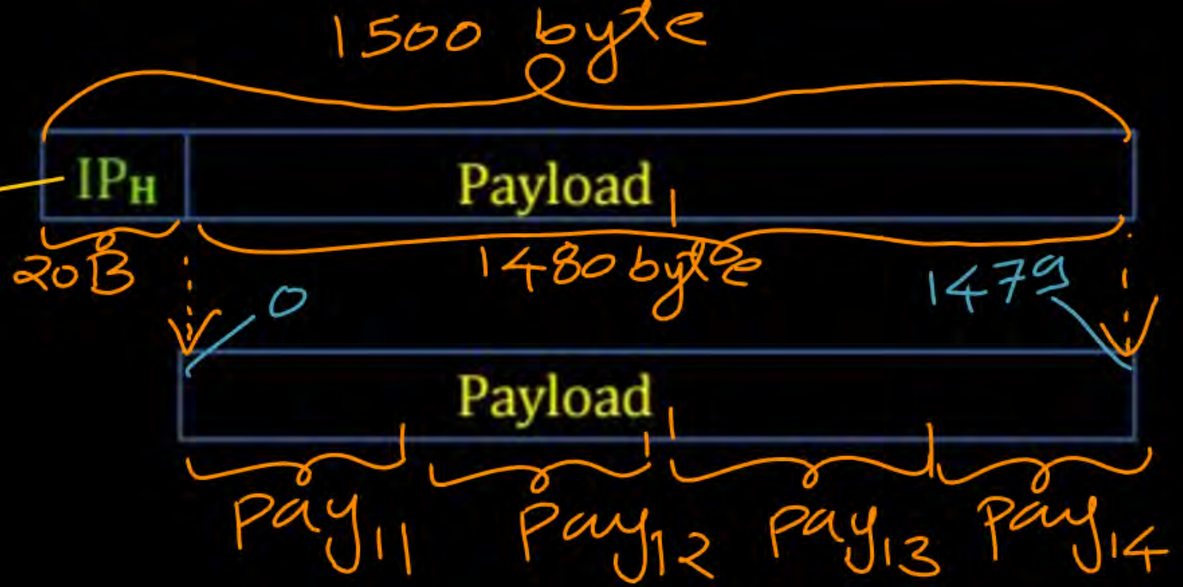
TL = 1060

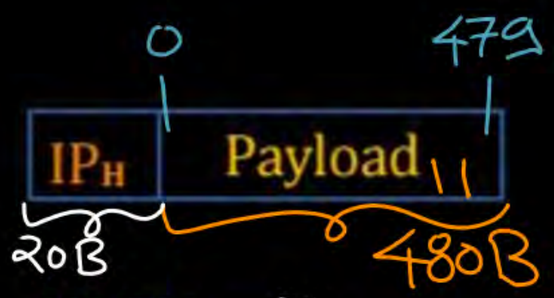
Id No. = Y

Offset = $\frac{2960}{8} = 370$

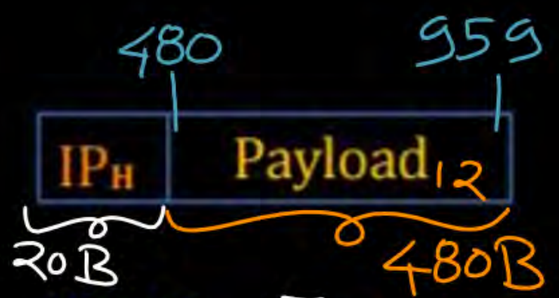
MF bit = 0

HLEN = 5
TL = 1500
Id No. = Y
Offset = 0
MF bit = 1

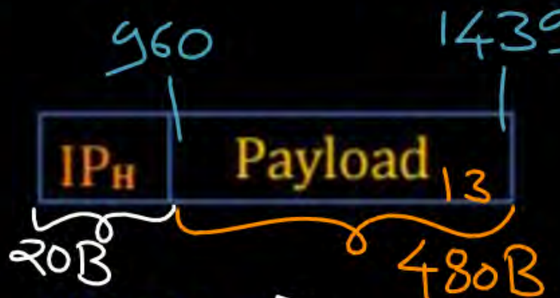


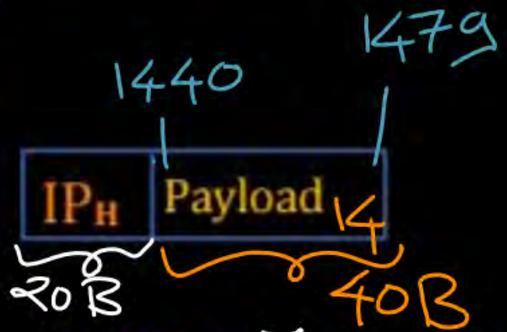

HLEN = 5
TL = 500
Id No. = Y
Offset = $\frac{0}{8} = 0$
MF bit = 1




HLEN = 5
TL = 500
Id No. = Y
Offset = $\frac{480}{8} = 60$
MF bit = 1




HLEN = 5
TL = 500
Id No. = Y
Offset = $\frac{960}{8} = 120$
MF bit = 1




HLEN = 5
TL = 60
Id No. = Y
Offset = $\frac{1440}{8} = 180$
MF bit = 1

HLEN = 5

Total Length = 1500

Old Payload Size = [ Total Length − (HLEN * 4) ] bytes

= [1500 − (5*4)] byte = 1480 bytes

MTU = 500 bytes

New Payload Size = [ MTU − (HLEN * 4) ] bytes

= [500 − (5*4)] bytes

= 480 bytes

$$\text{Total Number of IP fragments [N]} = \left\lceil \frac{\text{Old Payload Size}}{\text{New Payload Size}} \right\rceil$$

$$N = \left\lceil \frac{1480 \text{ bytes}}{480 \text{ bytes}} \right\rceil$$

$$N = \lceil 3.08 \rceil$$

$$N = 4$$

Total length of the last IP fragment =

[ HLEN * 4 ] + [ Old Payload Size - (N-1) * New Payload Size ] bytes

$= (5*4)\text{Byte} + [1480\text{byte} - (4-1)*480\text{byte}]$

$= (20 + 40)\text{ bytes}$

$= 60\text{ bytes}$

$$\text{Offset value of the last IP fragment} = \text{Old offset value} + \left[\frac{(N-1) * \text{New Payload Size}}{8}\right]$$

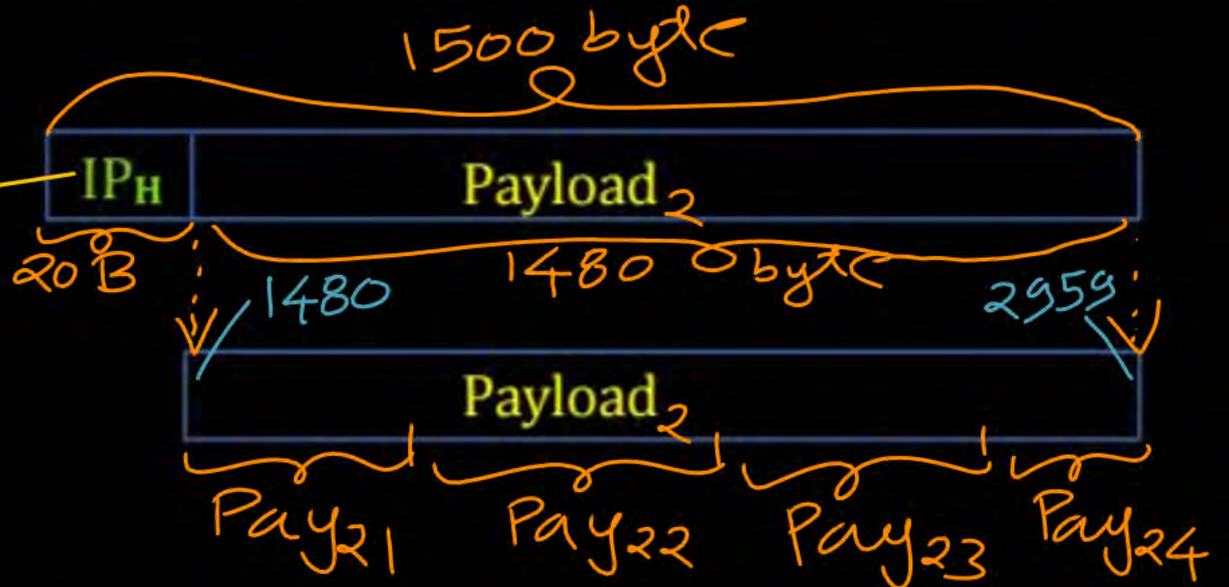
$$= 0 + \left[\frac{(4-1) * 480 \text{ bytes}}{8}\right]$$

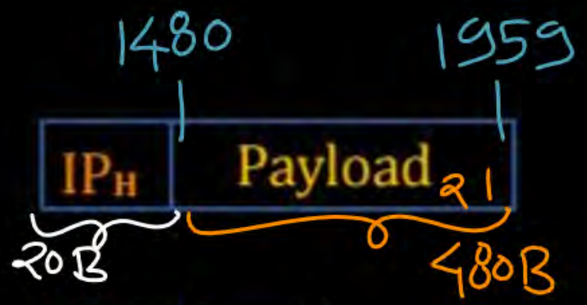
$$= 0 + \left[\frac{1440 \text{ byte\_no}}{8}\right]$$

$$= [0 + 180] \text{ word\_no}$$

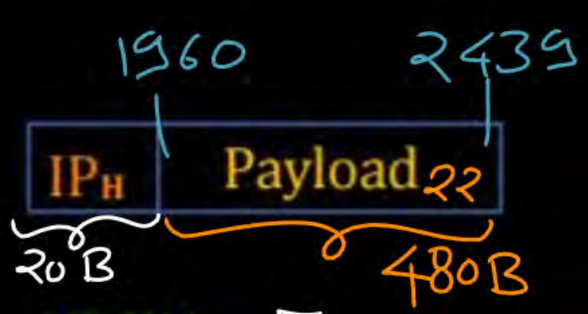
$$= 180 \text{ word\_no}$$

HLEN = 5
TL = 1500
Id No. = Y
Offset = 185
MF bit = 1

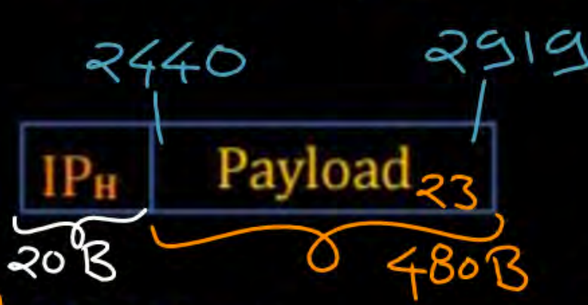


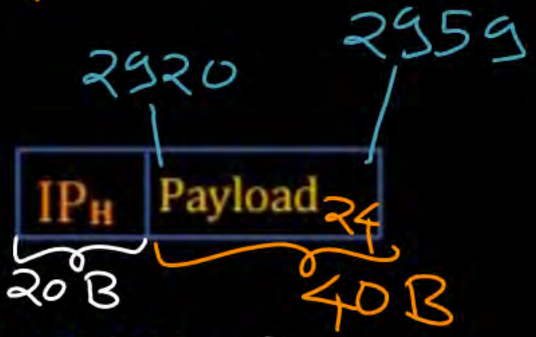

HLEN = 5
TL = 500
Id No. = Y
Offset = 185
MF bit = 1




HLEN = 5
TL = 500
Id No. = Y
Offset = 185+60=245
MF bit = 1




HLEN = 5
TL = 500
Id No. = Y
Offset = 245+60=305
MF bit = 1




HLEN = 5
TL = 60
Id No. = Y
Offset = 305+60=365
MF bit = 1

HLEN = 5

Total Length = 1500

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

= 1480 byte

MTU = 500 bytes

New Payload Size = [ MTU – (HLEN * 4) ] bytes

= 480 byte

$$\text{Total Number of IP fragments [N]} = \left\lceil \frac{\text{Old Payload Size}}{\text{New Payload Size}} \right\rceil$$

$$= 4$$

Total length of the last IP fragment =

[ HLEN * 4 ] + [ Old Payload Size - (N-1) * New Payload Size ] bytes

= 60 Byte

$$\text{Offset value of the last IP fragment} = \text{Old offset value} + \left[\frac{(N-1) * \text{New Payload Size}}{8}\right]$$

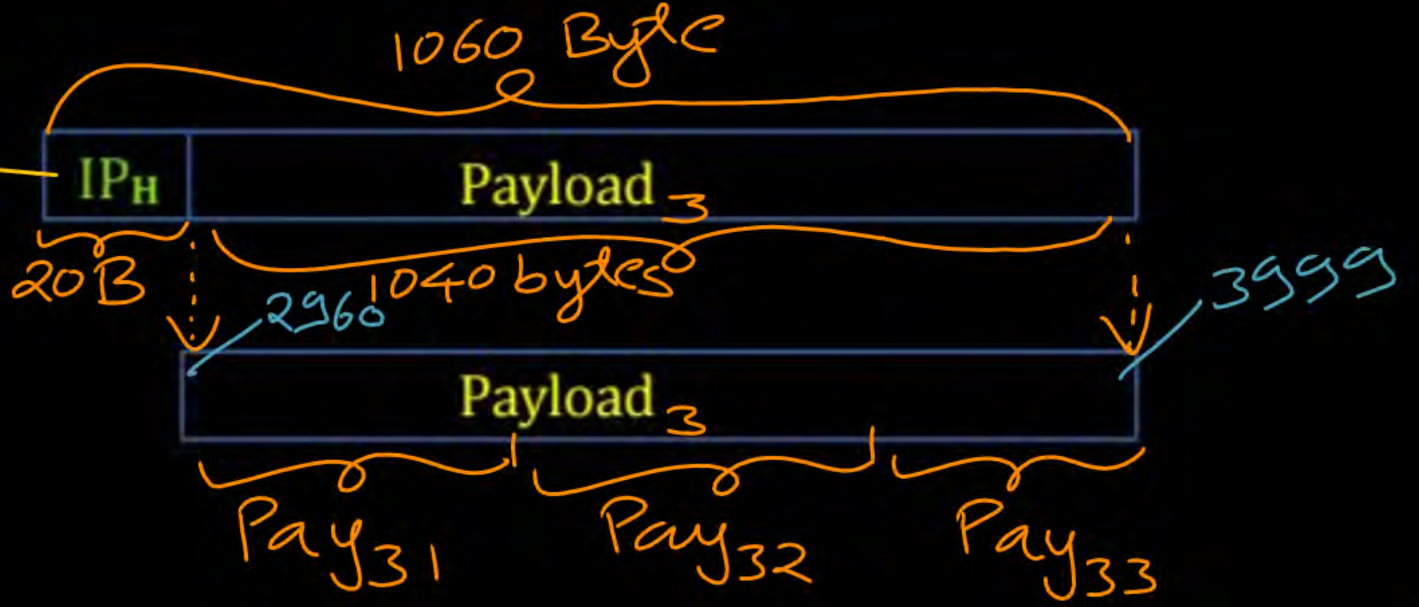
$$= 185 + \left[\frac{(4-1) * 480 \text{ byte}}{8}\right]$$

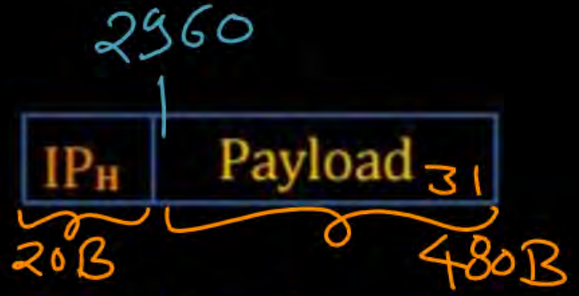
$$= 185 + \left[\frac{1440}{8}\right]$$

$$= [185 + 180] \text{ Word\_no}$$

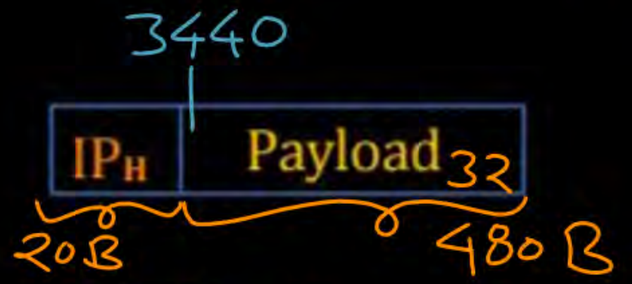
$$= 365 \text{ Word\_no}$$

HLEN = 5
TL = 1060
Id No. = Y
Offset = 370
MF bit = 0

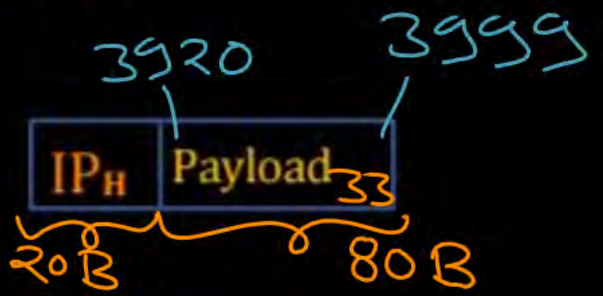



HLEN = 5
TL = 500
Id No. = Y
Offset = 370
MF bit = 1




HLEN = 5
TL = 500
Id No. = Y
Offset = 370+60 = 430
MF bit = 1




HLEN = 5
TL =
Id No. = Y
Offset = 430+60 = 490
MF bit = 0

HLEN = 5

Total Length = 1060

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

= [1060 – (5*4)] byte = 1040 bytes

MTU = 500 bytes

New Payload Size = [ MTU – (HLEN * 4) ] bytes

= 480 bytes

Total Number of IP fragments [N] = $\left\lceil \frac{\text{Old Payload Size}}{\text{New Payload Size}} \right\rceil$

$$N = \left\lceil \frac{1040 \text{ bytes}}{480 \text{ bytes}} \right\rceil$$

$$N = \lceil 2.16 \rceil$$

$$N = 3$$

Total length of the last IP fragment =

[ HLEN * 4 ] + [ Old Payload Size - (N-1) * New Payload Size ] bytes

$= (5 * 4)\ \text{Byte} + [1040\ \text{byte} - (3-1) * 480\ \text{bytes}]$

$= (20 + 80)\ \text{bytes}$

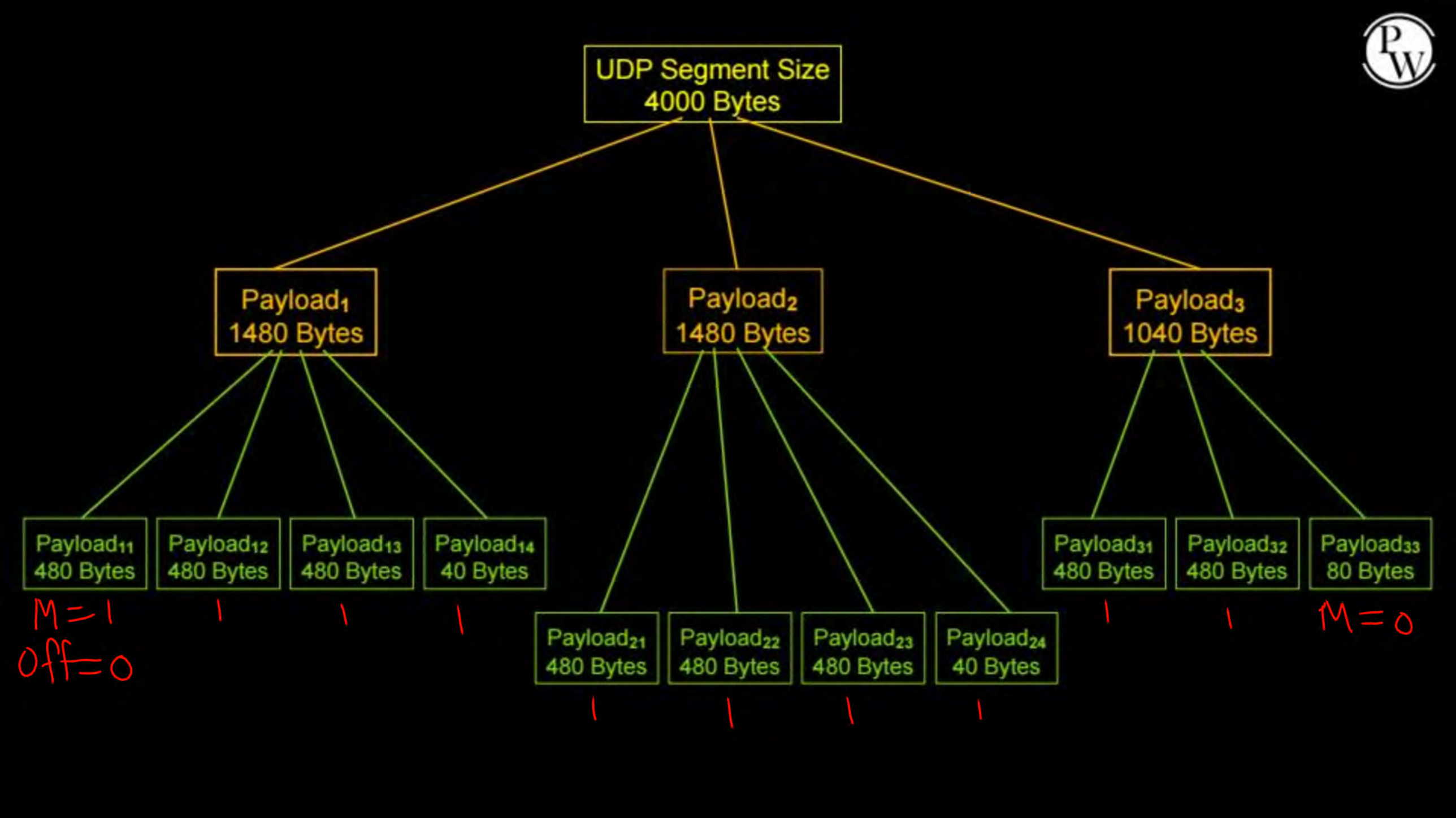
$= 100\ \text{bytes}$

$$\text{Offset value of the last IP fragment} = \text{Old offset value} + \left[\frac{(N-1) * \text{New Payload Size}}{8}\right]$$

$$= 370 + \left[\frac{(3-1) * 480 \text{ byte}}{8}\right]$$

$$= (370 + 120) \text{ word\_no}$$

$$= 490 \text{ word\_no}$$


UDP Segment Size
4000 Bytes
Payload1
1480 Bytes
Payload2
1480 Bytes
Payload3
1040 Bytes
Payload11
480 Bytes
Payload12
480 Bytes
Payload13
480 Bytes
Payload14
40 Bytes
Payload21
480 Bytes
Payload22
480 Bytes
Payload23
480 Bytes
Payload24
40 Bytes
Payload31
480 Bytes
Payload32
480 Bytes
Payload33
80 Bytes
M=1
off=0
1
1
1
1
1
1
1
1
1
M=0

# Topic : Fragmentation at Router

IPv4 Datagram Size ≤ Intermediate Network MTU

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

New Payload Size = [ MTU – (HLEN * 4) ] bytes

Total Number of IP fragments [N] = [ Old Payload Size / New Payload Size ]

Total length of the last IP fragment =
[ HLEN * 4 ] + [ Old Payload Size – (N–1) * New Payload Size ] bytes

Offset value of the last IP fragment =
Old offset value + [ (N–1) * New Payload Size / 8 ]

[NAT] IISC, H.W. [GATE-2016] [2 Mark]

#Q. An IP datagram of size 1000 bytes arrives at a router. The router has to forward this packet on a link whose MTU (maximum transmission unit is 100 bytes. Assume that the size of the IP header is 20 bytes. The number of fragments that the IP datagram will be divided into for transmission is _____ .

[MCQ] IIT-D, H.W. [GATE-IT-2004] [2 Mark]

#Q. A TCP message consisting of 2100 bytes is passed to IP for delivery across two networks. The first network can carry a maximum payload of 1200 bytes per datagram and the second network can carry a maximum payload of 400 bytes per datagram, excluding network overhead. Assume that IP overhead per packet is 20 bytes. What is the total IP overhead in the second network for this transmission?

A 40 bytes

B 80 bytes

C 120 bytes

D 160 bytes

# 2 mins Summary

**Topic** Fragmentation at Router

# THANK - YOU