2. Given,

bandwidth of link-1 = 400 Mbps

— u — link-2 = 100 Mbps

— u — link-3 = 200 Mbps.

Hence, the bottleneck is 100 Mbps, because pa will be queued there.

Let, no. of packets = N.

Total size of data = 100 KB = 10^5 Bytes.

Meta-data = 100 Bytes.

Size of each packet = $\frac{10^5 \text{ bytes}}{N}$ + 100 bytes.

$$\text{delivery\_time} = \frac{N \times (\text{size of packet})}{100 \text{ Mbps}}$$

$$= \frac{N \times \left(\frac{10^5}{N} + 100\right)}{\text{bottleneck-bandwidth}}$$

$$= \frac{1000 \times (1000 + N)}{100 \times \text{Mbps}}$$

$$\propto N$$

Hence, least delivery time in case of

1 packet

Assumption: No packet loss due to queuing.

3. Given,

distance = 10kms = 10^4 m

speed = $2/3 \times c = \frac{2}{3} \times 3 \times 10^8$ m/s = 2×10^8 m/s.

bandwidth = 100Mbps = $10 \cdot \times 10^{10}$ bps.

a) Propogation delay:

T_p = distance / speed

= $\frac{10^4}{2 \times 10^8}$ = 50×10^{-6} s = 50 microseconds.

b) T_p = 50 microsecands i.e. it takes a bit 50μs to reach R2 from R1.

So, (50×10^{-6}) x bandwidth bits can be send by R1.

= $50 \times 10^{-6} \times 10 \times 10^{10}$ = 5×10^6 = 5Mb

c) bit width = $\frac{\text{length of link}}{\text{bits-carrying}}$

= $\frac{10 \times 10^3}{5 \times 10^6}$ = 2×10^{-3} m = 2 mm

4. Given,

RTT b/w client & server = 10ms
Size of web page : 1kB
no. of objects = 10
Size of each object = 100kB.

a) Page load time with HTTP 1.0 (Non-Persistant)

Time : 2 RTT + transmit_time
↙
one RTT for connection & one for web page

Time : 2RTT + 10 x 2RTT (one for TCP connection & one for request)
= 22 RTT
= 220 ms.

b) Page load time with HTTP(1.1) (Persistant conn")

Time : RTT + RTT + 10 x RTT
↓ ↓ ↓
TCP connection web page (one for each object)

= 12 RTT = 120ms.

c) HTTP2.0 (Persistant + Pipelined & data frame of 1kB each)

Time : 2RTT + RTT
(connection + webpage) (for all object)
= 30 ms.