1) packet — 1,000,000 bytes

propagation speed = $2.5 * 10^8$ m/s distance = 2500 km

transmission rate = 200 Mbps

$$\frac{1{,}000{,}000 \text{ bytes}}{1} * \frac{8 \text{ bits}}{1 \text{ byte}} = 8{,}000{,}000 \text{ bits} \leftarrow \text{size of packet in bits}$$

$$\frac{8{,}000{,}000 \text{ bits}}{1} * \frac{1 \text{ second}}{200{,}000{,}000 \text{ bits}} = 0.04 \text{ second transmission delay}$$

$$\frac{2500 \text{ km}}{1 \text{ km}} * \frac{1 \text{ second}}{2.5 * 10^8 \text{ meter}} = 0.01 \text{ second propagation delay}$$

Total delay = 0.04 + 0.01 = 0.05 second

Propagation Time = $\frac{\text{distance}(d)}{\text{speed}(s)}$ → does not depend on packet size or rate!

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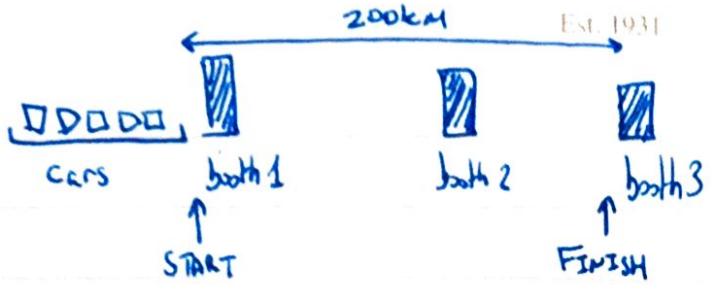
2) Link rates: $R_1 = 500$ kbps
$R_2 = 20$ Mbps
$R_3 = 1$ Mbps

a) If no traffic, throughput will be 500 kbps b/c R_1 is lowest rate.

b) Transfer time = $\frac{4 * 10^6 * 8 \text{ bits}}{500 * 10^3 \text{ bits/sec}}$ = 64 seconds

c) New throughput = 100 kbps → Transfer time = $\frac{4 * 10^6 * 8 \text{ bits}}{100 * 10^3 \text{ bits/sec}}$ = 320 seconds

3)



*Assume car speed = 100km/hr
*Assume booth has 12sec transmission time

a) assuming 10 cars: $\frac{200\text{km}}{100\text{km}} \mid \frac{1\text{hr}}{} = 2\text{hrs}$ "driving time"

12sec * 10car * 2 booth = 240second "booth time"

Total time = 2hrs & 240second = 2hrs & 4min

b) assuming 7 cars: $\frac{200\text{km}}{100\text{km}} \mid \frac{1\text{hr}}{} = 2\text{hrs}$ "driving time"

12sec * 7car * 2 booth = 168 second "booth time"

Total time = 2hrs & 168 second = 2hrs & 2min & 48sec

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4)

Transmission Rate = 1Mbps
Propagation Delay = 2ms

Generating bits = $\frac{48*8 \text{ bits packet}}{64*10^3 \text{ bits/second}} = 0.006$ seconds

Transmitting bits = $\frac{48*8 \text{ bits}}{1*10^6 \text{ bits/second}} = 0.000384$ seconds

Propagation Delay = 2ms

Total time = 0.006seconds + 0.000384seconds + $2*10^{-3}$ ms

= 0.008384 seconds

5) Applications that use HTTP, FTP, SMTP, & POP3 have zero tolerance for data loss! They need a RELIABLE delivery. TCP can provide this! UDP is only best effort... no guarantee that all data will get to the end destination!

6) Message will go from Alice's end system to her Mail server over HTTP.
Mail server belonging to Alice sends Message to Mail server belonging to Bob over SMTP.
Mail server belonging to Bob sends Message to Bob's end system over POP3.

7) Yes, it is possible for a Web server & Mail server to have the exact same alias for a host name. The resource record type that contains the hostname for the Mail server would be an MX type.

8) For client-server application over TCP, server program is executed first bc TCP is reliable delivery. So connection has to be established before any communication occurs. UDP is unreliable delivery, so it does not matter (as much) whether the connection is established first or not. With UDP, you can also send packets of data independently, so losing one packet will not be the end of the world.

9) Application Layer Protocol: HTTP and DNS
Transport Layer Protocol: HTTP and TCP

10) a) The length of the response is 3874 bytes.

b) The file was last modified on Saturday, December 10, 2005 at 18:27:46

c) The first five characters are: <!doc