UNIVERSITY OF BIRMINGHAM

M.Sc. CS/AI & CS
Computer Systems
Threads & Introduction to Networks

Exercise #1: Suppose that two long-running processes, P1 and P2, are running in a system. Neither program performs any system calls that might cause it to block, and there are no other processes in the system. P1 has 3 threads and P2 has 2 threads. The system may use either kernel or user threads.

a) What percentage of CPU time will P1 get if the threads are kernel threads? Briefly Explain.

b) What percentage of CPU time will P1 get if the threads are user threads? Briefly Explain.

Exercise #2: Suppose there is exactly one packet switch between a sending host and a receiving host. The transmission rates between the sending host and the switch and between the switch and the receiving host are R_1 and R_2, respectively. Assuming that the switch uses store-and-forward packet switching, what is the total end-to-end delay to send a packet of length L? (Ignore queuing, propagation delay, and processing delay).

$d = L/R_1 + L/R_2$

Exercise #3: Suppose users share a 2Mbps link. Also suppose each user transmits continuously at 1 Mbps when transmitting, but each user transmits only 20 percent of the time.

a) When circuit-switching is used, how many users can be supported?

b) When packet-switching is used, why will there be essentially no queuing delay before the link if two or fewer users transmit at the same time? Why will there be a queuing delay if three users transmit at the same time?

Exercise #4: Consider an application that transmits data at a steady rate (for example, the sender generates an N-bit unit of data every k time units, where k is small and fixed). Also, when such an application starts, it will continue running for a relatively long period of time. Answer the following questions, briefly justifying your answers:

a) Would a packet-switched network or a circuit-switched network be more appropriate for this application? Why?

b) Suppose that a packet-switched network is used and the only traffic in this network comes from such applications as described above. Furthermore, assume that the sum of the application data rates is less than the capacities of each and every link. Is some form of congestion control needed? Why?

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bits per sec

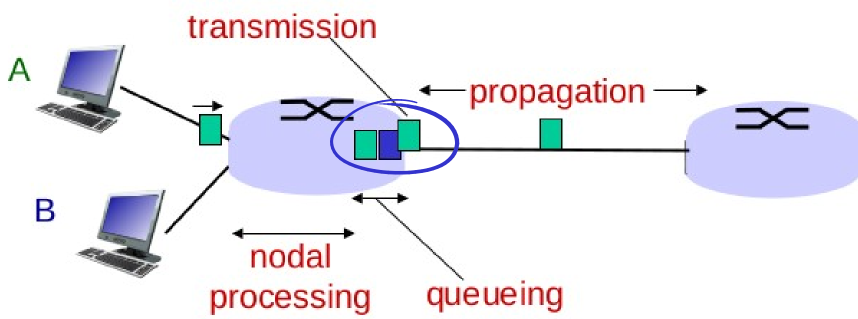
Exercise #5: Suppose Host A wants to send a large file to Host B. The path from Host A to Host B has three links, of rates R_1 = 500 kbps, R_2 = 2 Mbps, and R_3 = 1 Mbps

a) Assuming no other traffic in the network, what is the throughput for the file transfer?

b) Suppose the file is 4 million bytes. Dividing the file size by the throughput, roughly how long will it take to transfer the file to Host B?

c) Repeat (a) and (b), but now with R_2 reduced to 100 kbps.

Exercise #6: There are actually four types of delays that can occur in networks:



$$\boxed{d_{nodal} = d_{proc} + d_{queue} + d_{trans} + d_{prop}}$$

1. d_{proc}: nodal processing (check bit errors, determine output link, typically < msec)
2. d_{queue}: queueing delay (time waiting at output link for transmission, depends on congestion level of router)
3. d_{trans}: transmission delay (L: packet length (bits), R: link bandwidth (bps), $d_{trans} = L/R$)
4. d_{prop}: propagation delay (d: length of physical link, s: propagation speed in medium (~2×10^8 m/sec), $d_{prop} = d / s$)

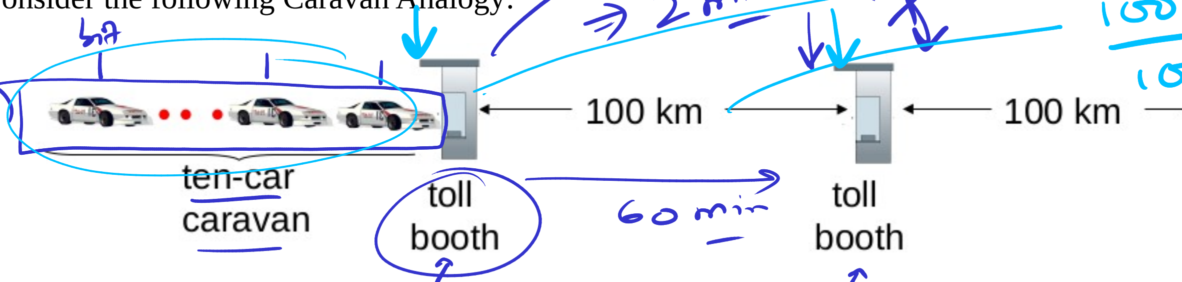
10x12 => 2 mins

10x1 = 10mins

150 / 1000 = 6 mins

Consider the following Caravan Analogy:

Packet



The cars "propagate" at 100 km/h, and each toll booth takes 12 secs to service a car (bit transmission time).

a) How long it will take until the caravan is lined up before 2^{nd} toll booth?

62 mins

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b) Suppose cars now "propagate" at 1000 km/hr and suppose toll booth now takes one min to service a car. Will cars arrive to 2nd booth before all cars serviced at first booth? Yes, 3 Cars @ Booth 1

c) Assume a propagation speed of 100 km/hour, toll booths are 75 km apart and it takes 12 secs to service a car at each toll booth. Suppose the caravan travels 150 km, beginning in front of one tollbooth, passing through a second tollbooth, and finishing just after a third tollbooth. What is the end-to-end delay?

$d = L/R$ $\quad d = d/s$

Exercise #7: How long does it take a packet of length 1,000 bytes to propagate over a link of distance 2,500 km, propagation speed 2.5 x 10^8 m/s, and transmission rate 2 Mbps? More generally, how long does it take a packet of length L to propagate over a link of distance d, propagation speed s, and transmission rate R bps? Does this delay depend on packet length? Does this delay depend on transmission rate?

$d = \frac{2500 \times 10^3}{2.5 \times 10^8} \Rightarrow 0.01$ sec $\Rightarrow 10$ms

Exercise #8: In this problem, we consider sending real-time voice from Host A to Host B over a packet-switched network (VoIP). Host A converts analog voice to a digital 64 kbps bit stream on the fly. Host A then groups the bits into 56-byte packets. There is one link between Hosts A and B; its transmission rate is 2 Mbps and its propagation delay is 10 msec. As soon as Host A gathers a packet, it sends it to Host B. As soon as Host B receives an entire packet, it converts the packet's bits to an analog signal. How much time elapses from the time a bit is created (from the original analog signal at Host A) until the bit is decoded (as part of the analog signal at Host B)?

→ $d_{proc} = (56 \times 8)/(64 \times 10^3) = 7$ms

→ $d_{trans} = (56 \times 8)/(2 \times 10^6) = 0.224$ms

→ $d_{queue} = 0$

$d_{prop} = 10$ms

$\Rightarrow 7 + 0.224 + 10$

$\Rightarrow 17.224$ms