Chapter 1 Exercises

THE SIMPLEST CASE IS A SINGLE LINK

1. Consider two hosts, A and B connected by a single link of rate **R** bits/sec (bps). Say that the hosts are separated by **D** meters and that the propagation speed along the link is **S** meters per second. A host sends a packet of size **L** bits to B
   a) What is the propagation delay d_{prog}?
   b) How much time is the transmission time d_{tras}
   c) What is the end to end delay if there is no queueing delay and processing delay?
   d) At time d_{trans} where is the last bit of the package?
   e) If $d_{prop} > d_{trans}$. At time d_{trans} where is the first bit of the packet?
   f) Say that $d_{prop} < d_{trans}$. Where would the first bit at time d_{trans}?
   g) Say $s = 2.5 \cdot 10^8$, L = 100 bits, R = 100 kbps. Find the distance m so that $d_{prop} = d_{trans}$.

   Solution: g) D = 250Km

2. Consider two hosts, A and B connected by a single link of rate **100**Mbps. Say that the hosts are separated by 50 meters and that the propagation speed along the link is 2.5×10^8 m/s.
   a) How many bits can fit in the link?
   b) How long/"wide" is a bit in meters?
   c) If we increase the transmission rate, will the bit length increase or decrease?

   Solution: a) 20 bits
   b) 2,5 m per bit

EXERCISES WITH PACKET SWITCHING NETWORKS

ONLY 1 STORE AND FORWARD ROUTER

3. In previous figure packets are generated at host A and sent to host B through router R1.
    a) Calculate the total time required to transfer a 1KB file from host A to host B based on the following data:
        - Router queues are not flooded.
        - Packet size is **1Kbits** (header size is negligible).
        - Hosts A is separated from R1 by $\mathbf{D_1}$ meters, and R1 is separated from host B by $\mathbf{D_2}$ meters, being $\mathbf{D_1 > D_2}$.
        - Both links (from A to R1, and from R1 to B) have the same propagation ($S_{prop)}$ and transmission (S_{trans}) speed.
    b) What will be the time required if the transmission speed (S_{trans}) of the link between host A and R1 is higher than S_{trans} between R1 and B? ($S_{trans\_A\text{-}R1} > S_{trans\_R1\text{-}B}$)

    Solution:
    a) $T_{total} = 8 * d_{trans\_A\text{-}R} + d_{prop\_A\text{-}R} + d_{proc} + d_{trans\_R\text{-}B} + d_{prop\_R\text{-}B}$
    b) $T_{total} = d_{trans\_A\text{-}R} + d_{prop\_A\text{-}R} + d_{proc} + 8 * d_{trans\_R\text{-}B} + d_{prop\_R\text{-}B}$

4. Repeat section b) of the previous exercise, assuming that the data travel from B to A.

    Solution: $T_{total} = 8 * d_{trans\_B\text{-}R} + d_{prop\_B\text{-}R} + d_{proc} + d_{trans\_R\text{-}A} + d_{prop\_R\text{-}A}$

MULTIPLE STORE AND FORWARD ROUTERS

5. Repeat section b) of exercise 3, assuming that the data travel from A to B, and there is a new router between R1 and B, as shown in the following figure. The new link is similar to the link between A and R1,(i.e., $S_{trans\_A\text{-}R1} = S_{trans\_R2\text{-}B} > S_{trans\_R1\text{-}R2}$).

Solution: $T_{total} = d_{trans\_A\text{-}R1} + d_{prop\_A\text{-}R1} + d_{proc\_R1} + 8 * d_{trans\_R1\text{-}R2} + d_{prop\_R1\text{-}R2} + d_{proc\_R2} + d_{trans\_R2\text{-}B} + d_{prop\_R2\text{-}B}$

6. In the following figure,

host A sends a packet to host B through routers R1, R2, and R3.

- Route delay is ignored (d_{router} = processing and queueing delays = 0).
- Packet size is **h + L bits** (header + data)
- All the links have the same length, D meters.
- All the links (from A to R1, R1 to R2, R2 to R3, and R3 to B) have the same propagation speed, S_{prop} m/s, and transmission speed, S_{trans} bps.

a) How long does it take to move the packet from host A to host B?
b) How long does it take to move 4 packets from host A to host B?
c) How long does it take to move 4 packets from host A to host B, if propagation delay is 0?
d) How long does it take to move 4 packets from host A to host B, if router delay > 0?
e) How long does it take to move N packets from host A to host B, if there are Q links (Q-1 routers) between host A and host B?
f) How long does it take to move 4 packets from host A to host B, if link between R2 and R3 is 4 * S_{trans}, (i.e., $S_{trans\_R2\_R3} = 4 * S_{trans}$)?
g) How long does it take to move 4 packets from host A to host B, if link between R2 and R3 is one quarter of S_{trans}, (i.e., $S_{trans\_R2\_R3} = S_{trans} / 4$)?

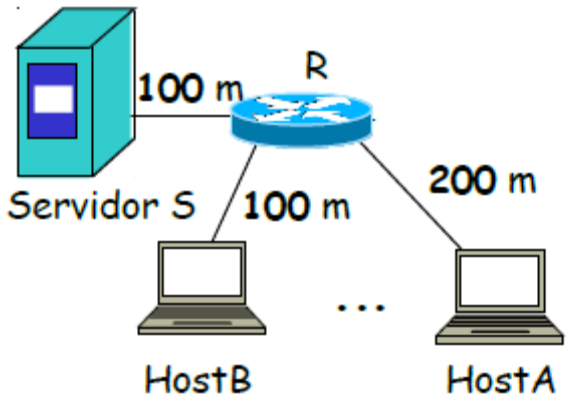
7. We define the round-trip time (RTT), as the time it takes for a packet to travel from client to server and then back to the client. The RTT includes packet-propagation delays, packet queuing delays in intermediate routers and switches, and packet-processing delays.
    a) Calculate the RTT between host A, and host B if:
        - they are connected using the network of exercise 1.

- host A sends only a request packet of 1000 bit-length, and host B sends a response back packet of 200 bit-length.
- S_{trans} = 100 Mbps; S_{prop} = $2 \cdot 10^8$ m/s; link A-R distance = 200m; link R-B distance = 100m.
- Route delay is ignored (d_{router} = processing and queueing delays = 0).

8. Based on the data of exercise 7. Calculate the RTT between host A and host B, if host A sends 5 request packets of 1000 Byte-length. Host B sends the response packet when it receives the last packet from host A.

9. Consider sending a 5000 byte-length message from host A to server S over a packet-switching network. There are two links (and one router) between host A and server S. A-R link has a transmission rate of 100 Mbps, and R-S link a transmission rate of 1 Gbps. Host A and the router are separated by 20 Km, and the router and server S are separated 10 Km. The propagation speed along both links is $2 \cdot 10^8$ m/s. Host A segments the message into packets of 2000 byte-length as maximum, including the header, that is considered negligible. Also, the router and host processing delays are considered negligible (not the queueing delays!). There are not transmission errors.
    a) Draw a space-time graph of the packets sent from host A to server S. Indicate the transmission and the propagation delay for each link.
    b) Based on the graph in part a), calculate the total time required to transfer since host A sends the first packet until the last packet is received in sever S.

10. Host A sends two consecutive packets of 1000 byte-length each to server S. Simultaneously, host B also starts a transmission of two packets of 1000 byte-length. Calculate the total time required since host A sends the first packet until the second packet of A is received in sever S. Packets are saved in input order in the router output queues. The propagation speed is $2 \cdot 10^8$ m/s, and all links works at 10Mbps.



11. Calculate the general formula of transmitting N packets through a packet switching network with R routers of d_{proc}. Both links have different transmission delay and different propagation delay.