

Assignment 1

EECS325 Spring 2019

Yue Shu

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1. What are the advantages and disadvantages of circuit-switched network and packet-switched network?

packet-switching:

- advantages:
 - allow resources to be shared
 - can accomodate more users to use network
 - is simpler, no need for call setup
- disadvantages:
 - could have queueing delay if the arrival rate to link exceeds the transmission rate of link for a period of time
 - if the buffer fills up, could have packets lost (dropped out)
 - need reliable data transfer and congestion control

circuit-switching:

- advantages:
 - dedicated resources reserved for the user, thus can guarantee the performance
 - disadvantages:
 - fewer users can be accomodated
 - circuit segements remain idle if not in use, kind of a waste
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2. Consider sending a packet from a source host to a destination host over a fixed route. List the delay components in the end-to-end delay. Which of these delays are constant and which are variable?

There are four major delay components in one single nodal delay, which are processing delay, queueing delay, transmission delay, and propogation delay. Therefore, the end-to-end delay also consists of the four delays above, while the total length of delay would be accumulated according to the number of routers between the source host and the destination host.

constant delays:

- processing delay
 - very small amount of time, mostly less than microseconds, to examine the packet's header and check for bit errors
 - determined by the programs or processes running in the network devices, thus won't vary according to the change in the packet
 - therefore processing delay is a constant delay
- propogation delay
 - $d_{prop} = d/s$, where d is length of physical link and s is propogation speed

- since the packet follows a fixed route, d remains constant
- s also remains constant since it is roughly $2 \times 10^8 m/sec$ in most cases
- thus propagation delay is also a constant delay

variable delays:

- queueing delay
 - depends on the congestion level of the router, which can be expressed as La/R , where L is the packet length in bits, R is the link bandwidth, and a is the average packet arrival rate
 - both L and a could be varied, thus this is a variable delay
- transmission delay
 - $d_{trans} = L/R$
 - depends on the total length of the packet in bits, which can be varied
 - thus is a variable delay

3. What is the difference between transmission delay and propagation delay? Will the length of the packet affect the propagation delay and why?

transmission delay:

- the time the router takes to push all of the packet's bits into the link
- $d_{trans} = L/R$, where L is the packet length in bits, and R is the link transmission rate
- will be affected by the length of the packet

propagation delay:

- the time it takes the packets to travel in the link from one router to the next
- $d_{prop} = d/s$, where d is length of physical link and s is propagation speed
- thus will not be affected by the length of the packet

4. Consider the following institutional network system. Suppose the average object size is 100k bits and the average rate from browsers to origin servers is 15 requests/sec. (ignore the LAN delay in the following questions)

Assume that $R_{access} = 1.5Mbps$ and the RTT on the Internet side of the access link is $2sec$.

1. Considering the queueing delay in the access router, the access delay could be calculated with the equation $D_{access} = \frac{D_{trans}}{(1-traffic\ intensity)} \cdot D_{trans}$ represents the transmission delay at the access link. Without web cache, what is the total average response time?

$$1Mb = 1,000kbits$$

The transmission delay of one request at the access link can be calculated as below:

$$D_{trans} = L/R_{access} = 100kbits/1.5Mbps = 100kbits/1500kbps \approx 0.0667sec$$

And the traffic intensity can be expressed as:

$$traffic\ intensity = La/R_{access} = \frac{100kbits/request \times 15\ request/sec}{1500kbits/sec} = 1$$

Thus the access delay for each request would be:

$$D_{access} = \frac{D_{trans}}{(1 - traffic\ intensity)} = \frac{0.0667sec}{1 - 1} \rightarrow hours$$

And the total average response time for each request would be:

$$T_{response} = D_{internet} + D_{access} = 1RTT + D_{access} = 2sec + hours \rightarrow hours$$

Which means we might need to wait for very long since the access link utilization is always 100%!

2. Compare this result with the situation where $R_{access} = 100Mbps$.

The new transmission delay of one request at the access link can be calculated as below:

$$D_{trans} = L/R_{access} = 100kbits/100Mbps = 0.001sec$$

And the new traffic intensity can be expressed as:

$$traffic\ intensity = La/R_{access} = \frac{100kbits/request \times 15\ request/sec}{100Mbps} = 0.015$$

Thus the new access delay for each request would be:

$$D_{access} = \frac{D_{trans}}{(1 - traffic\ intensity)} = \frac{0.001sec}{1 - 0.015} \approx 1.02 \times 10^{-3}sec$$

And the total average response time for each request would be:

$$T_{response} = D_{internet} + D_{access} = 1RTT + D_{access} = 2sec + 1.02 \times 10^{-3}sec \approx 2.00sec$$

which is so much shorter than the time it takes in part 1.

5. Two hosts, A and B, are directly connected via a link $R = 1\ Mbps$. The distance between A and B is 10,000 kilometers and the propagation speed over the link is $2.5 \times 10^8 m/s$.

1. How long does it take to send a file of 20,000 bits from A to B?

When it comes to the calculation of end-to-end delay, we may apply the formula below, supposing that we do not take processing delay and queueing delay into consideration as the problem suggested:

$$d_{end-end} = (N + 1)(d_{trans} + d_{prop})$$

where N denotes the total number of routers between two end hosts. Since A and B are directly connected, we may conclude that $N = 0$, and thus the total length of time to send a file of 20,000 bits from A to B can be calculated as below:

$$d_{end-end} = d_{trans} + d_{prop} = L/R + d/s = \frac{20000bits}{1Mbps} + \frac{10000km}{2.5 \times 10^8 m/s}$$

$$d_{end-end} = 0.02sec + 0.04sec = 0.06sec$$

2. Suppose now the file is broken up into 5 packets with each packet containing 4,000 bits. Suppose that each packet is acknowledged by the receiver and the transmission time of an acknowledgment packet is negligible. Finally, assume that the sender cannot send a packet until the preceding one is acknowledged. How long does it take to send the file?

In general, the file will be sent in five individual packets, while each time it takes A $d_{trans} + d_{prop}$ amount of time to send a single packet of length 4,000 bits, and d_{prop} amount of time to receive the ACK packet sent by B. So the total amount of time needed to send all 5 packets from A to B would be $5 \times (2d_{prop} + d_{trans})$:

$$d_{trans} = L/R = \frac{4000bits}{1Mbps} = 0.004sec$$

$$d_{prop} = d/s = 0.04sec$$

$$T_{total} = 5 \times (2d_{prop} + d_{trans}) = 5 \times (2 \times 0.04 + 0.004) = 0.42sec$$

So now it takes 0.42 seconds to send the file.

3. Now assume there are two separate links between host A and host B, i.e. $R_1 = 500$ kbps and $R_2 = 10$ Mbps. Roughly, how long does it take to send the same file?

According to the definition of throughput, we need to take the smaller among R_1 and R_2 as our throughput in order to calculate the length of time to send the same file from A to B:

$$throughput = \min\{R_1, R_2\} = R_1 = 500kbps$$

$$d_{end-end} = d_{trans} + d_{prop} = L/R_1 + d/s = \frac{20000bits}{500kbps} + \frac{10000km}{2.5 \times 10^8 m/s} = 0.04 + 0.04 = 0.08sec$$

So it takes 0.08 seconds to send the same file.

6. Referring to problem 4, suppose the local web cache satisfy 60% of the requests, the remaining 40% requests will be satisfied by the origin web servers. What is the total response time in this case? (bandwidth of LAN is 100Mbps)

The total response time is the sum of total delay that could be processed by the local web cache and total delay that could only be satisfied by the origin server. We already know D_{trans} from problem4, and the rest can be formulated as below:

$$traffic\ intensity = La/R_{access} = \frac{100kbits/request \times 15\ request/sec \times 0.4}{1.5Mbps} = 0.4$$

$$D_{access} = \frac{D_{trans}}{(1 - traffic\ intensity)} = \frac{0.0667sec}{1 - 0.4} \approx 0.111sec$$

$$D_{LAN} = L/R_{LAN} = \frac{100kbits}{100Mbps} = 1 \times 10^{-3}sec$$

$$T_{total} = 0.4 \times (D_{internet} + D_{access} + D_{LAN}) + 0.6 \times D_{LAN} = 0.4 \times (2 + 0.111 + 0.001) + 0.6 \times 0.001 = 0.8454sec$$

So the total response time in this case is 0.8454 seconds