CSC358 Tutorial 1

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January 17, 2020

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Question 1: Concept Review

(a) What's the difference between circuit switching and packet switching?

(b) What are the types of delays when a packet travels from a source host to a destination host?

(c) What are in the edge and core of the Internet?

(d) Why do we say the Internet is a network of networks? What are the roles of access networks, ISP, IXP, and CDN?

(e) What's the point of the layered protocol stack?

For the answers, review the lectures, books, go to office hours, and use the discussion board!

Question 2: Circuit Switching vs Packet Switching

Suppose a number of users share a 3 Mbps link. Also suppose each user requires 150 kbps when transmitting, but each user transmits only 10 percent of the time. Answer the following questions.

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

(b) For the remainder of this question, suppose packet switching is used. Find the probability that a given user is transmitting at any given point in time.

(c) Suppose there are 120 users. Find the probability that at any given time, exactly n users are transmitting simultaneously.

(d) Find the probability that there are 21 of more users transmitting simultaneously.

(e) How do you interpret the meaning of this probability?

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Recall: Bandwidth has to be reserved in circuit switching.

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

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$\frac{3Mbps}{150kbps} = \frac{3000kbps}{150kbps} = 20$

Hence, 20 users can be supported

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$p = 0.1$

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Recall: Binomial distribution

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$Pr(n) = \binom{120}{n} \times p^n \times (1-p)^{120-n}$

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$\binom{120}{n}$: Different ways of choosing n users from 120 users

p^n: Probability of choosing these n users

$(1-p)^{120-n}$: Probability of $n-k$ users not being chosen

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AKA. The probability that there are 21 users or 22 users or ...

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$Pr(21 \leq n \leq 120)$

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$Pr(21 \leq n \leq 120) = \sum_{n=21}^{120} Pr(n) = 0.003$

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Suppose a number of users share a 3 Mbps link. Also suppose each user requires 150 kbps when transmitting, but each user transmits only 10 percent of the time.

(e) How do you interpret the meaning of this probability?

As in, what does $Pr(21 \leq n \leq 120)$ represent in our case? What's special about having over 20 users transmitting simultaneously?

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As in, what does $Pr(21 \leq n \leq 120)$ represent in our case? What's special about having over 20 users transmitting simultaneously?

When there are more than 20 users transmitting simultaneously, packets will start queueing up. Packet drop may occur during this time.
However, note that even with 120 users, the probability of this happening is very small.

Question 3: Propagation Delay and Transmission Delay

Consider two hosts, A and B, connected by a single link of rate R bps. Suppose that the two hosts are separated by m meters, and suppose the propagation speed along the link is s meters/sec. Host A is to send a packet of size L bits to Host B.

(a) What is the propagation delay, d_{prop}?
(b) What is the transmission delay of a packet, d_{trans}?
(c) Ignoring processing and queueing delays, obtain an expression for the end-to-end delay
(d) Suppose Host A begins to transmit the packet at time $t = 0$. At time $t = d_{trans}$, where is the last bit of the packet?
(e) Suppose d_{prop} is greater than d_{trans}. At time $t = d_{trans}$, where is the first bit of the packet?
(f) Suppose d_{prop} is less than d_{trans}. At time $t = d_{trans}$, where is the first bit of the packet?
(g) Suppose $s = 2.5 \times 10^8$, $L = 120$ bits, and $R = 56$ kbps. Find the distance m so that d_{prop} equals d_{trans}.

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(b) d_{trans}

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(c) $d_{endtoend} = d_{prop} + d_{trans} + d_{queue} + d_{proc} = \frac{m}{s} + \frac{L}{R} + 0 + 0$

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The bit is just leaving Host A

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The first bit is in the link and has not reached Host B

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$\frac{m}{s} = \frac{L}{R} \implies m = s \cdot \frac{L}{R} = 2.5 \times 10^8 \cdot \frac{120}{56 \cdot 1000} = 536\text{kilometer}$

Question 4: Optimal Packet Size

Consider sending a large file of F bits from Host A to Host B using packet switching. There are three hops of links (therefore two switches) between A and B, and the links are uncongested, i.e., no queueing delays. Host A segments the file into segments of S bits each and adds 80 bits of header to each segment, forming packets of size $L = 80 + S$ bits. Each link has a transmission rate of R bps.

(a) Suppose you are the network administrator to decide on the value of S. Discuss, qualitatively, the pros and cons of choices of S values that are very large or very small.

(b) Now do the math: find the value of S that minimizes the delay of moving the file from Host A to Host B. Disregard propagation delay.

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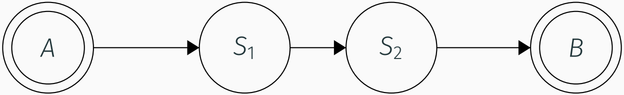

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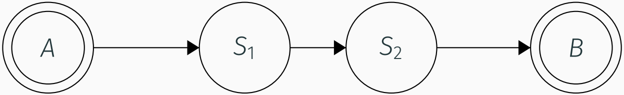

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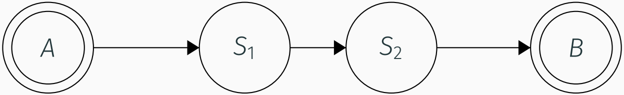

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With smaller S, we will have more, smaller packets. This means much better pipelining, but more overhead

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(b) Now do the math: find the value of S that minimizes the delay of moving the file from Host A to Host B. Disregard propagation delay.

Total packets:
Packet size:

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Total packets: $\frac{F}{S}$
Packet size: $S + 80$

How long does it take for first switch to receive the last packet?

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$\frac{S+80}{R} \cdot \frac{F}{S}$ sec

At this time, how many packets have reached the destination? How many are in second router?

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$\frac{F}{S} - 2$ packets in destination.
A single, $\frac{F}{S} - 1_{th}$ packet will be in second router.

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Hence, the delay in sending the whole file is

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$\frac{d}{ds} \cdot Delay = \frac{2}{R} - \frac{80F}{R} \cdot S^{-2} = 0$

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$\frac{d}{ds} \cdot Delay = \frac{2}{R} - \frac{80F}{R} \cdot S^{-2} = 0$
$\implies S = \sqrt{40F}$