Prof. Athina Markopoulou Intro to Computer Networks
Fall 2017 EECS148/CompSci132

# Homework 1

## Topics: Packet vs. Circuit Switching, Delay and Throughput.

Posted on Friday, Oct.6, 2017
Due on Friday, Oct. 13, 2017 by 5pm in Canvas

(One canvas submission per group of two: Write BOTH names and uci ids on the front page.)

**Problem 1: Statistical Multiplexing. (Chapter 1, Problem P8)**.

Suppose users share a 3 Mbps link. Also suppose that each user transmits only for 10% of the time at 150kbps, and is idle the remaining time.

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

(b) For the remaining of the problem, assume packet-switching. (i) Find the probability that a given user is transmitting. (ii) Suppose there are $N = 120$ users. What is the probability that at any given time exactly $n$ users transmit simultaneously? (iii) What is the probability that there are 21 or more users transmitting simultaneously?

**Problem 2: End-to-end Delay and Throughput.**

Consider a path with $k+1$ nodes: a source host, a destination host and $k-1$ intermediate routers, linked by $k$ transmission links of bandwidth $W$ bits/second each. The propagation delay over each link is $\tau$ seconds. Processing and queueing delays at intermediate nodes are all negligible, no errors happen and no packets are ever lost. The source has an infinite queue of messages to be transmitted to the destination. Each message consists of $L$ bits of user data.

We are interested in two performance metrics:

- *End-to-end throughput* is defined as the number of useful bits per sec sent by the source. (From the point of view of the user, useful are considered only the bits in the message, but not the headers or signaling messages.)
- *End-to-end delay* is defined as the time elapsed from when the sender is ready to transmit the message until the message is entirely received by the destination.

We wish to compare these two metrics in each of the following switching methods:

- *Message Switching:* The message is sent from node to node in a store-and-forward manner: each node receives the whole message and then sends it on the next link to the following node, using the full transmission speed. Each message requires to add a header of length $H$ bits. As soon as the entire first message is fully received at the destination, the destination sends back an acknowledgment packet of size $H$ bits, also in a store-and-forward manner. Upon reception of the acknowledgement, the sender can start the transmission of the next message.

- *Packet Switching:* A message is broken up into packets of size $P$ (assume that $L/P$ is an integer) and a header of $H$ bits is added in front of every packet. Packets are forwarded from node to node in a store-and-forward manner, using the full transmission speed. As soon as the last packet of the message is fully received at the destination, the destination node sends an acknowledgement for the whole message, of size $H$ bits, and forwarded in a store-and-forward manner back to the sender. Upon reception of the acknowledgement, the sender can start the transmission of the second message.

*Questions:*

1. Give a formula for the throughput and delay in Message Switching, as a function of the parameters $(L, H, k, W, \tau)$.
2. Give a formula for the throughput and delay in Packet Switching, as a function of the parameters $(L, P, H, k, W, \tau)$.
3. Which one achieves lower end-to-end delay: Message Switching to Packet Switching? You can assume the following values of the parameters: $\tau = 0$, $H < P$ and $k$ is very large.
4. Consider Packet Switching again. You are free to choose the size of the packets ($P$), while all other parameters $(L, H, k, W, \tau)$ are fixed, known and out of your control. How would you choose the packet size $P$ to so as to minimize the end-to-end delay?

*Hints:*

- Start from the space-time diagrams we discussed in Lectures for circuit-, message-, packet-switching. The methods here are pretty similar, except for the last part for disconnecting the circuit or sending and acknowledgement.
- If you have difficulty working with general parameters (e.g., $k$ hops, packet size $P$ bits and header of $H$ bits, etc), choose some reasonable (e.g. based on numbers given in Chapter 1) numerical values (e.g. $k = 3$, $P = 120$Kbits, $H = 320$bits, $W = 1$Mbps, $\tau = 5$ms, $n = 10$ etc) and work with those to provide a numerical answer. This will give you partial (half of the) credit, because you answer the question for a special, not for the general case.