MPCS 54001, Winter 2021

Homework 1 - Solutions

Due: January 21 at 5:30 pm

Submit your assignment to Gradescope. This work must be entirely your own. If you need help, post questions to Ed Discussion and/or visit the staff during office hours. As a reminder, if you make a public post on Ed Discussion, please don't give away the answer!

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1. 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. The propagation delays between the sending host and the switch and between the switch and the receiving host are P_1 and P_2, respectively. The queueing delay at the packet switch is Q (you may assume that there are no queueing delays at the end hosts). The processing delay at the packet switch is H (you may assume that there are no processing delays at the end hosts).

   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? (10 points)

   Let's consider the path of the packet from sender to receiver. It takes L/R_1 for the sender to transmit the packet. It takes P_1 for the bits of the packet to travel from the sender to the router. At the router, the packet experiences a queuing delay Q and a processing delay H. It takes L/R_2 for the router to transmit the packet. It takes P_2 for the bits of the packet to travel from the router to the receiver.
   Thus, the end-to-end delay is $L/R_1 + P_1 + Q + H + L/R_2 + P_2$

2. What is the difference between circuit switching and packet switching? Be sure to discuss the advantages and disadvantages of each approach in your answer. (10 points)

Circuit switching reserves resources in advance along a fixed path before data transfer. With circuit switching, all data travels along the same path. Packet switching breaks the data into smaller chunks that are then transmitted along possibly different paths. Circuit switching provides bandwidth guarantees since resources are reserved in advance. Such guarantees are very beneficial for certain classes of applications like real-time video chat. Packet switching does not provide bandwidth guarantees, but it makes more efficient use of network resources.

3. Describe the end-to-end argument and how it relates to the following networks. (20 points)

   The end-to-end argument is the principle that *complete and correct* functionality can only be implemented at the endpoints of a system. Smart endpoints, dumb network.

   a. Public switched telephone network (PSTN)

      Disagrees with end-to-end argument (smart network, dumb endpoints).

   b. Internet

      Agrees with end-to-end argument (dumb network, smart endpoints).

   c. Mobile ad hoc networks

      Technically agrees with the end-to-end argument, but the smart endpoints *are also* the network

   d. 4G cellular network

      Disagrees (or partially disagrees) with the end-to-end argument (smart network, smart endpoints).

4. Briefly describe the five layers of the ARPANET reference model. In particular, list the main function of each layer along with the name of its associated protocol data unit. (20 points)

Layer	*Function*	*PDU*
Application	user-facing networked applications like WWW	message
Transport	process-to-process data transfer like TCP	segment/datagram
Network	multi-hop machine-to-machine data transfer like IP	packet/datagram
Link	single hop data transfer between adjacent machines like Ethernet	frame
Physical	transfer medium (wire or over-the-air)	bit

5. Python provides an API for connection-oriented sockets that include *listening sockets* and *accept sockets*. (20 points)
    a. What is the difference between a listening socket and an accept socket?
    A listening socket is a long-lived socket with a well-known port that accepts incoming connections from may potential clients. An accept socket is a temporary socket with an ephemeral port that is used to service a request from a single client.
    b. Why are both socket types necessary for a connection-oriented server?
    Servers need to advertise a single well-known port for incoming client connections (listening socket), but they also need to be able to simultaneously handle multiple clients on different sockets (accept sockets).

6. Protocol layering. (20 points)
    a. Suppose that the algorithms used to implement the services at some protocol layer *i* are changed. How would these changes impact services at layers *i*-1 and *i*+1 in the protocol stack?
    These changes should not impact either of the adjacent protocol layers.

b. Suppose that there is a change in the service provided by protocol layer *i*. How would this change impact services at layers *i*-1 and *i*+1 in the protocol stack?

This change would not impact protocol layer *i*-1, but it could cause protocol layer *i*+1 to be re-implemented in order to account for the service change at protocol layer *i*.