Assignment #1  
Csci4211 Spring 2016  
Due on Feb. 10th, 2016

Notes: There are five questions in this assignment. Each question has 10 points.

1. (10 pt.) Design and describe an application-level protocol to be used between an Automatic Teller Machine, and a bank's centralized computer. Your protocol should allow a user's card and password to be verified, the account balance (which is maintained at the centralized computer) to be queried, and an account withdrawal (i.e., when money is given to the user) to be made. Your protocol entities should be able to handle the all-too-common case in which there is not enough money in the account to cover the withdrawal. Specify your protocol by listing the messages exchanged and their formats, and the action taken by the Automatic Teller Machine or the bank's centralized computer on transmission and receipt of messages. Sketch the operation of your protocol for the case of a simple withdrawal with no errors, using a diagram to illustrate the messages exchanged. Explicitly state the assumptions made by your protocol about the underlying end-to-end transport service.

Assumption:
No message lost and error in the middle of transmission.  
Stateless

Messages:
(1). ATM takes card and gets password input: sends user verify message which includes user id and password to Central Computer (CC)
(2). Receiving the user verify message, CC checks if the combination is correct, if yes, sends verify success message to ATM. Otherwise, sends verify failed message to ATM. 
(3). Receiving the verify success message, ATM shows further options of withdrawal and balance checking.
(4). Receiving the verify failed message, ATM shows wrong password alert and returns the card.
(5). ATM gets balance checking requirement: sends balance checking message to CC including user id.
(6). Receiving the balance checking message, CC checks this user’s balance and send balance message to ATM.
(7). ATM gets account withdrawal requirement: sends withdrawal message to CC which includes the user id and the requested amount of money.
(8). Receiving the withdrawal message, CC checks this user’s balance and compare it with the requested amount. If the balance can cover the withdrawal, CC updates this user’s balance information and sends allow withdrawal message to ATM. Otherwise, CC sends forbid withdrawal message to ATM.
(9). Receiving the allow withdrawal message, ATM outputs money.
(10). Receiving the forbid withdrawal message, ATM shows not enough balance alert and show options of withdrawal and balance checking.
2. (10 pt.) There are 80 computers to be connected to each other. How many connections required if they are connected to each other with a direct link? Given a set of 4X4 switches (4 inputs and 4 outputs), what is the minimum number of switches needed to provide connectivity between any two computers? Please show how these switches are connected.

   (1) \[1+2+\ldots+79 = 3160\]
   (2) \[2 \times 7 + 11 \times 6 = 80\]
   \[2 + 11 = 13\] (multiple possible topologies)

3. (10 pt.) Compute the time required for circuit switching and packet switching with the following conditions:
   - The destination is 3 hops away from the source (2 intermediate routers between the source and the destination, with 3 links).
   - The distance between any two adjacent nodes is 10 Km.
   - The signal propagation speed is 5x10^5 m per second.
   - The message size is 10 Mega bits (1 Mega = 10^6)
   - The maximum packet size is 100k bits (1k = 10^3. You can ignore the size of the header).
   - The transmission speed of each link is 100Mbps.
   - The circuit setup time is 10-1 second for the case of circuit switching.
   - The processing time for routing decision at each node is negligible.

In this case, which switching method has a shorter completion time? If the message size can be enlarged, is there a chance the other switching method can be better?

Note: Please show your computation steps.

**Circuit Switching:**
- Setup time = 0.1s
- Propagation Time per hop = \(10 \times 10^3 / 5 \times 10^5 = 0.02s\)
- Transmission Time = \(10\text{Mb} / 100\text{Mbps} = 0.1s\)
- Totally Time = \(0.1 + 3 \times 0.02 + 0.1 = 0.26s\)
Packet Switching:
Number of packets = 10Mb / 100kb = 100
Packet Transmission Time = 100kb / 100Mbps = 0.001s
Propogation Time = 10 x 10^3 / 5 x 10^5 = 0.02s
Total Time = (N-1) * T_{transmit} + N_{hop} * T_{transmit} + N_{hop} * T_{propagation} = (100 - 1) * 0.001 + 3 * 0.001 + 3 * 0.02 = 0.162s

When message size increases, packet switching is still better than circuit switching.

Let packet size be x
For packet switching: 10M/x * x/100M + 2 * x/100M + 0.06 > 0.26
x > 5M bits
So packet switching will be worse when pkt size > 5Mbits

4. (10 pt.) Consider the queuing delay in a router buffer (preceding an outbound link). Suppose all packets are L bits, the transmission rate is R bps, and the N packets simultaneously arrive at the buffer every LN/R seconds. Find the average queueling delay of a packet. (Hint: The queuing delay for the first packet is zero; for the second packet L/R; for the third packet 2L/R. The Nth packet has already been transmitted when the second batch of packets arrives.)

\[0 + \frac{L}{R} + 2\frac{L}{R} + \ldots + (N-1) \frac{L}{R}/N \]
\[= \frac{(N-1)/2)(L/R)}{N}\]

5. (10 pt.) What is today’s Internet? Describe the essential components as well as the design principles in details. However, your answer should be no more than a page.
Components:
Hosts, Routers, Links, Applications, Protocols, Hardware, Software.
Design Principles:
1. Heterogeneity. For example, multiple types of hardware must be allowed, multiple protocols must be allowed. 2. Scalability. Scale to very many nodes per site and many millions of sites. 3. Should be robust and adaptive to changes. 4. Modularization. Keep things separate. 5. Performance and cost must be considered as well as functionality. 6. End-to-End principle. Functions should reside in the end hosts of network rather than in intermediary nodes. 7. Simplicity. Keep it simple.