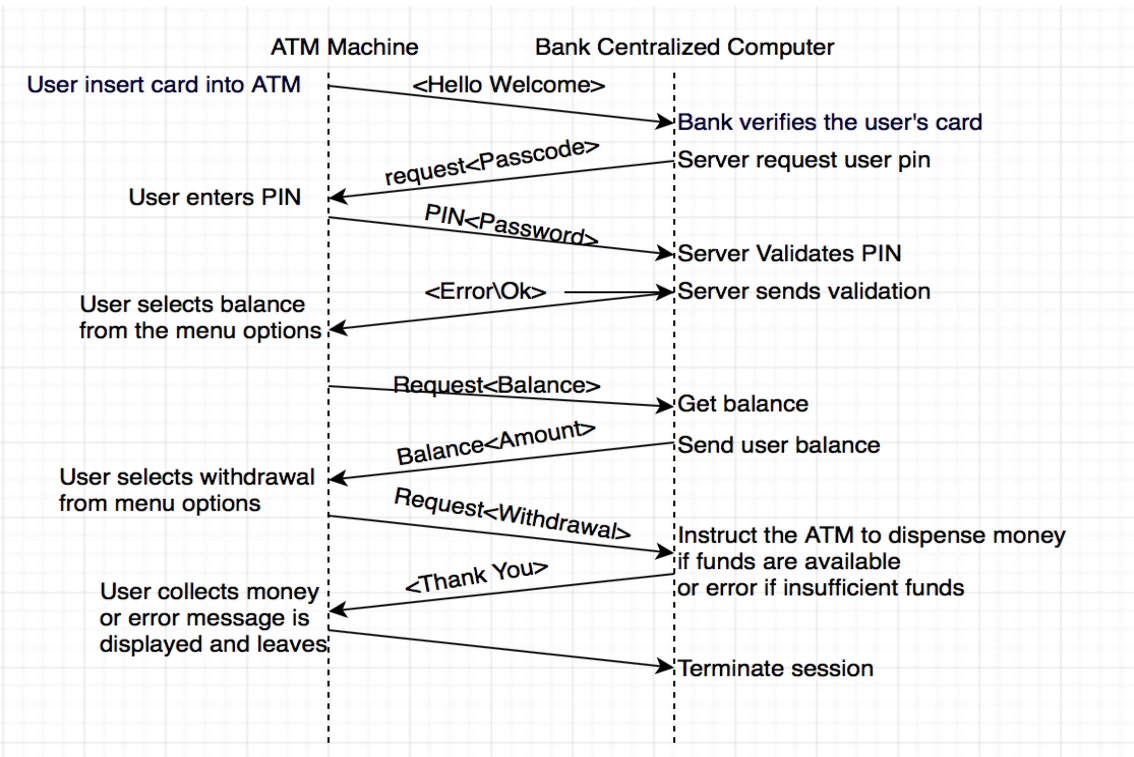
Assignment #1
Csci4211 Fall 2018
Due on Oct 3rd, 2018

October 6, 2018

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.

Answer:



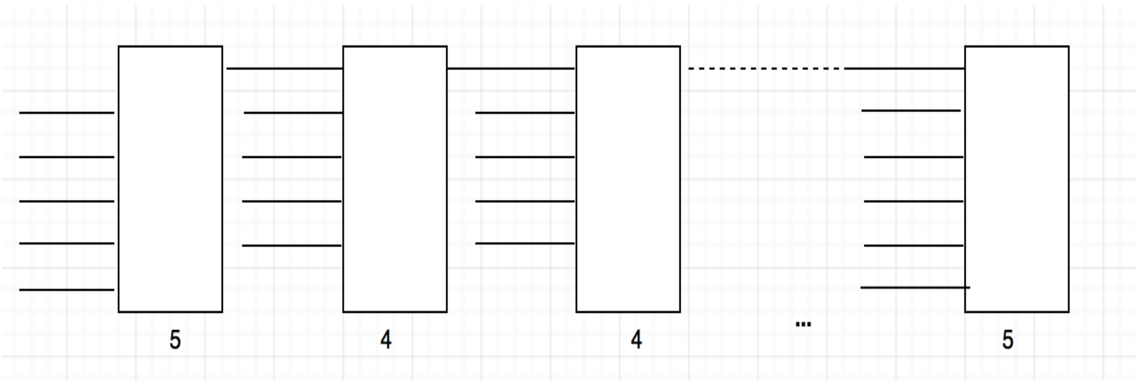
Some assumption made by the protocol about the underlying end-to-end transport services:
- We assume there is minimum bandwidth between the ATM machine and the Centralized Bank computer for fast transmission.
- We assume that there is secure connection between and ATM machine and the centralized bank computer.
- We assume the transport protocol between the ATM and the Centralized bank computer is reliable.
- We assume the system is not time sensitive.

Grading:
7 Points for a well label diagram including messages exchanged and formats, actions taken by both the ATM and centralized computer on transmission and receipt of the messages.
-2 for no diagram.
-2 if user card and password is not verified by the centralized bank computer.
-2 for not querying and showing the account balance.
-1 for not handling the all-too-common cases.
3 points for underlying assumptions. 2 assumptions suffice to get all 3 points.

2. (10 pt.) There are 100 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 6X6 switches (6 inputs and 6 outputs), what is the minimum number of switches needed to provide connectivity between any two computers? Please show how these switches are connected. Please note that we typically put one input port together with one output port such that we can send and receive on the same port. A 6X6 switch is a switch with 6 ports.

Answer:

1) $\binom{100}{2} = \frac{100x99}{2x1} = 4,950$
2) For a 6x6 switch, we mean that the switch has 6 ports that can both be inputs and outputs. Thus we can connect them in series.



Assume there are x intermediate switches, thus we have; $5 \times 2 + 4x \geq 100$
Then we have $x \geq 22.5$
Hence we need at least $2 + 23 = 25$ switches
(This is not the only structure; some other structure can also be build but the least switches needed is still 25)

Grading:
5 points for each sub question.
-5 if you forget the first part of the question
-2 or -3 if you think there are more than 6 ports on each switch; -1 if you forget 2 end switches
-1 if you have other misunderstanding of “switch”
-1 if you have computation errors

3. . (10 pt.) Compute the time required for circuit switching and packet switching with the following conditions:
• The destination is 4 hops away from the source (3 intermediate routers between the source and the

destination, with 4 links).

- The distance between any two adjacent nodes is 10 Km.
- The signal propagation speed is 5×10^5 m per second.
- The message size is 15Mega bits (1 Mega = 106)
- The maximum packet size is 100k bits (1k = 103. You can ignore the size of the header.).
- The transmission speed of each link is 1Gbps.
- 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.

Answer: Book 1.4.1, 1.4.3

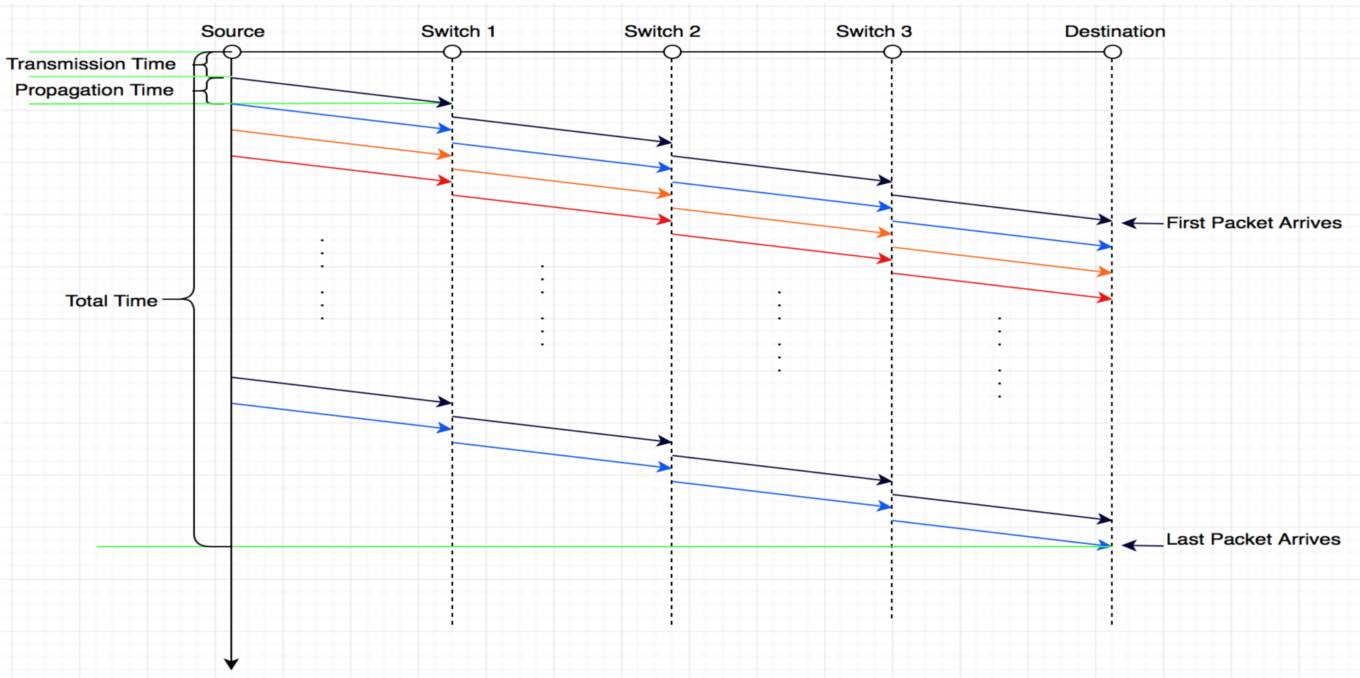
$$d_{setup} = 0.1s$$

$$d_{trans} = \frac{L}{R} = \frac{15Mb}{1 \times 10^3 Mbps} = 0.015s$$

$$d_{prop} = \frac{4 * 10 * 10^3 m}{5 \times 10^5 m/s} = 0.08s$$

$$d_{end-end} = 0.195s$$

Circuit Switching:



$$N_{Packet} = \frac{15 \times 10^6}{100 \times 10^3} = 150$$

$$d_{trans}^{source} = \frac{L}{R_1} = \frac{100k}{1Gbps} = 0.0001s$$

$$d_{trans}^{switch1} = \frac{L}{R_2} = \frac{100k}{1Gbps} = 0.0001s$$

$$d_{trans}^{switch2} = \frac{L}{R_3} = \frac{100k}{1Gbps} = 0.0001s$$

$$d_{trans}^{switch3} = \frac{L}{R_4} = \frac{100k}{1Gbps} = 0.0001s$$

$$d_{wait} = (N_{Packet} - 1) \times d_{trans}^{source} = (150 - 1) \times 0.0001 = 0.0149s$$

$$d_{trans} = d_{trans}^{source} + d_{trans}^{switch1} + d_{trans}^{switch2} + d_{trans}^{switch3} = 0.0004s$$

$$d_{prop} = \frac{4 * 10 * 10^3 m}{5 \times 10^5 m/s} = 0.08s$$

$$d_{end-end} = d_{wait} + d_{trans} + d_{prop} = 0.0953$$

Packet switching has shorter completion time.
Let message be X mb, here we compare the time of circuit switching and packet switching as follows:

$$d_{CircuitSwitching} = 0.1 + \frac{X}{1 \times 10^3} + 0.08 = 0.18 + 0.001X$$

$$d_{PacketSwitching} = (\frac{X}{0.001} - 1) \times 0.0001 + 0.0004 + 0.08 = 0.0803 + 0.1X$$

Grading: 4 points for each time result, 2 points for final conclusion.
At least 1 points will be given for each if you realize there are several types of delay;
-1 if you forget set up time in circuit switching
-1 if you talk "packet" when computing circuit switching time
-1 if you think circuit switching has transmission time at each hop
-2 if you think the transmission time of packet switching corresponding to the message size, or, if you compute transmission time for each packet -1 if you forget waiting time (or similar mistakes)
-1 or -2 if the answer lacks computation steps
-1 if there are computation errors;
For the analysis:
-1 if you mistake "Message size" as "Packet size")
-1 or -2 if your explanation is not reasonable (or you don't have an explanation)
-1 if you give a wrong conclusion

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

Answer:

$$\bar{d}_{queue} = \frac{1}{M}\left(0 + \frac{K}{R} + \frac{2K}{R} + ... + \frac{(M-1)K}{R}\right) = \frac{(M-1)K}{2R}$$

Grading:
A large portion of points will be deducted if you answer is wrong and there is no derivation
-2 if you count from 1 to M instead of from 0 to M-1
-2 if there are computation errors
-1 or -2 if a final formula is not given

5. (10 pt.) What is today's Internet? Describe the essential components as well as the design principles in details using your own language. However, your answer should be more than one page, but less than two pages. Please print your answer on papers.

Answer:
Basically, the Internet can be divided into two main components: the Internet core and the end system. The services provided by these two parts are different. The end system can have a variety of applications to server for different purposes, like web browsing, video streaming, file sharing. Thus there are a lot of protocols for people to choose, like HTTP, FTP, and SMTP. It's more flexible and can

be update quickly and easily. While the core part of the Internet focuses exclusively on the routing and switching of the packet. This makes the core part more efficient in doing their own job. Thus there are only a few protocols in the Network layer. IP plays like a narrow waist in the protocol stack of the Internet. The division of the functions of core part and end system also reflects the most important design principles of the Internet: push the complexity of Internet to the end system and keep the core part simple and efficient. The two famous features of TCP protocol, flow control and congestion control, both try to recognize and fix the problem at the end instead of adding extra functions to the routers. This design principle can also be observed in the evolution from IPv4 to IPv6. Some functions originally performed in the router at Network layer, like checksum, are moved to the end system to improve the efficiency of the routers. Layering is another important design principle in the Internet. This brings benefits as well as drawbacks. By dividing the design into different layers, the complexity of the lower layer would be transparent to the upper layer. Moreover, no matter what implementation is used in the lower layer, the upper layer can treat them as the same as long as they provide uniformed interfaces to the upper layer. This makes the mobile network possible in some ways. The APPs on our phone can perform perfectly regardless of connecting LTE of Wi-Fi. Although some disadvantages emerge, such as function duplication in different layers (integrity checking is performed both in the transport layer and network layer) and difficulties in upgrading the key layer: Network layer, the strength of layer brings the prosperity of current Internet. The Internet is said to be the network of network. This can be interpreted in many ways. First, Internet is becoming increasingly complex since the initial ARPANET. We have LAN, WLAN, Ethernet and mobile network. Each itself is a network and can be a part of the whole Internet. Second, the Internet is also a commercial place. BGP4 acts as a backbone of the whole Internet and different level of AS all have their own profit and customers in the market of the Internet. At the end of this semester, hopefully we will have a better understanding of the Internet.

Grading:
No points will be deducted unless your answer is too short to convey the basic ideas.