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.

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.

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 5x10^5 m per second.
   - The message size is 15Mega 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 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.

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 $M$th packet has already been transmitted when the second batch of packets arrives.)

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.