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 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 8 port switches (each port has an input and an output connection), what is the minimum number of switches needed to provide connectivity between any two computers? Please show how these switches are connected.

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 5 Km.
   - The signal propagation speed is $5 \times 10^5$ m per second.
   - The message size is $20$ 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 $100$Mbps.
   - 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.

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 $L$ bits, the transmission rate is $R$ bps, and the $N$ packets simultaneously arrive at the buffer every $LN/R$ seconds. Find the average queuing delay of a packet. (Hint: The queuing delay for the first packet is zero; for the second packet
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.