1. **Efficiency of Stop-and-Wait**

   Assume a channel with a bit rate of 1 Mbps and a delay of 20 ms. A Stop-and-Wait protocol is used which unfortunately introduces waiting times and thus a low efficiency. The efficiency is dependent on the size of the frames.

   (a) Determine the frame size that leads to an efficiency of 50%.

2. **Flow Control and Satellites**

   Assume a geostationary satellite sends frames of 1000 bits over a channel with a bit rate of 1 Mbps. The frame take 270 ms to arrive at the station on earth. The acknowledgements are always piggybacked on data frames.

   (a) Calculate the maximum achievable efficiency using a
      i. Stop-and-Wait protocol,
      ii. Sliding Window protocol with window size 13.

   (b) Discuss the advantages and disadvantages of both algorithms from question (a).

3. **LLC vs. MAC**

   (a) Discuss the different tasks of the LLC and MAC.

4. **Ethernet - Capture Effect**

   Two hosts (A and B) are connected to an Ethernet and we assume that both have unlimited data to transmit. The frames belonging to A shall be denoted as $A_1, A_2, \ldots, A_n$ and the frames of B as $B_1, B_2, \ldots, B_n$.

   A and B try to transmit frames A_1 and B_1 at the same time. The frames collide and both hosts select a random waiting time as specified by the standard (*binary-exponential-backoff*). Station A's waiting time is $W_A = 0$ time slots and station B's is $W_B = 1$ slots. A "wins" the contention for the medium access and retransmits frame A_1 while B waits for A to finish.

   Station B sends frame B_1 again after the transmission of A_1 is finished. Unfortunately, frame B_1 collides with A_2 as A is also trying to transmit. In this situation, A either waits $W_A \in \{0, 1\}$ slots, while B has to choose a random waiting time $W_B \in \{0, 1, 2, 3\}$.

   (a) Calculate the probability that A wins this contention after the second collision.

   (b) Assume that station A wins the second contention and frame A_2 is transmitted while B_1 still has to wait. Calculate the probability for A also winning the next (third) contention.

   (c) Specify a formula to calculate the probability that A wins the i-th contention. Calculate the probability of A winning the i-th contention with $i \in [1..MAX]$.

   (d) The term **Capture Effect** denotes a situation in which A wins all contentions after the first collision. Host B cannot send data until the maximum number of retransmissions has been reached and the current frame is dropped. Give the probability of this event.

   (e) Is the capture effect still relevant in today's Ethernet based networks?

5. **Bridges**

   (a) Bridges can be classified as local and remote bridges. Discuss the differences.

   (b) What is the difference between transparent and source bridging?

   (c) A host is connected to a switch. You know the MAC address of the corresponding NIC. How can you discover the switch port to which the host is connected using SNMP?

6. **Broken Links**
   Consider a LAN with multiple switches. A link between the switches breaks.

   (a) How can you guarantee the reachability of all end hosts?

   (b) If the network is able to handle broken links, which problem arises? How can you solve this problem?

7. **Network Components**
   A network may consist of the following components: Repeater, hub, switch, bridge, router, and gateway.

   (a) Discuss the function of the these network components.

   (b) Which "data" do they handle and on which layer of the ISO/OSI reference model do they operate?

8. **Asynchronous Transfer Mode**

   (a) Why is ATM defining a fixed size for data packages?

   (b) Compare advantages and disadvantages of fixed cells with dynamic packet sizes.