1 Error Control and Flow Control

1. Why do we do error control and flow control?

2. In case the receiver is not infinitely fast, what can we do to avoid overwhelming the receiver?

3. What can happen if the channel is error-prone rather than error-free?

4. How can one handle the loss of frames?

2 Stop-and-Wait Channel Utilization

1. What is the definition of channel utilization?

2. Consider the following scenarios. What is the corresponding channel utilization (stop-and-wait)? In each case the frame length is given as 1500 byte.
   Note: $v_l = 300 \cdot 10^6\,\mathrm{m/s}$ (speed of light)

(a) 100 Mbps Ethernet cable of 500 meter length and $v_p = \frac{2}{3}v_l$

(b) 1 Gbps fibre cable of 10 km length and $v_p = \frac{2}{3}v_l$

(c) 10 Gbps link of 10,000 km length in vacuum and $v_p = v_l$

3. Consider the formula for channel utilization. In case of $N - 1$ retransmissions due to an error-prone channel, how does the formula change?

4. Given a bit error rate BER and a frame of length l, how do you determine the frame error rate FER?

5. Frames consist of two parts: the payload and an overhead which is independent of the payload length. How do you determine the effective data rate R in an error free and an error prone environment given capacity C, frame length l, overhead h, a propagation time T_P and a bit error rate BER?

6. What are the characteristics of a graph depicting the effective data rate vs. the packet length (assuming an error-prone channel)?

3 Pipelining Channel Utilization

1. What is pipelining?

2. Which condition has to be fulfilled in order to achieve full utilization?

3. For the scenarios from 2.2, what is the minimum number of frames needed to achieve full utilization?

4. Consider a serial transmission on a $s_c = 100$ meter cable used at $C = 100$ Mbit/s. How many bits are in flight at full utilization?

4 Sliding Window Protocols

1. Explain both the receive and the send window. How do they correlate with each other?

2. Assume a sliding window protocol with $k = 8$ distinct sequence numbers and a send window size $n = 5$. Describe the following situations:

   (a) V(A) = 1, V(S) = 3

   (b) V(A) = 4, V(S) = 4

   (c) V(A) = 0, V(S) = 5

3. For go-back-n, what can happen if $n \geq k$?

4. What is the difference between go-back-n and selective repeat?

5. For selective repeat, what can happen if $n > k/2$?