Computer Networks
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Problem Sheet #1

Problem 1.1: *optical fibre transmission* (1+1+1 = 3 points)

You are deploying an optical fiber across Germany with a length of $l = 790\,\mathrm{km}$. The optical fiber has a data rate of $r = 10\,\mathrm{Gbps} = 10^{10}\,\mathrm{bps}$. The signal propagation speed in the optical fiber is $v = 2 \cdot 10^8\,\frac{\mathrm{m}}{\mathrm{s}}$.

a) How many bits can be simultaneously in transit on the wire?

b) What is the round-trip-time imposed by the propagation delay of the wire?

c) Two former Jacobs students are now located in Berlin (B) and in Seattle (S). They both measure the round-trip-time to Google's DNS server (IPv4 address 8.8.8.8). The person located in Berlin measures a minimum round-trip-time of $rtt_B = 6\,\mathrm{ms}$ while the person located in Seattle measures a minimum round-trip-time of $rtt_S = 12\,\mathrm{ms}$. Are the former students sending packets to the same server?

Problem 1.2: *crc checksums* (2 points)

A transmission link uses a cyclic redundancy check (CRC) code to detect transmission errors. The generator polynomial is $G(x) = x^4 + x^2 + 1$. The bit sequence `1101 0110 0101 1010` has been received by a network interface card. Does the message pass the CRC check? Show why or why not.

Problem 1.3: *ARQ protocols* (1+1+1 = 3 points)

Automatic Repeat reQuest (ARQ) is an error-control method for data transmission that uses acknowledgements and timeouts to achieve reliable data transmission over an unreliable service. If the sender does not receive an acknowledgment before the timeout, it usually re-transmits the frame until the sender receives an acknowledgment or exceeds a predefined number of re-transmissions. Well-known types of ARQ protocols are

- Stop-and-wait ARQ,
- Go-Back-N ARQ, and
- Selective Repeat ARQ.

Read about these three well-known ARQ protocols and briefly summarize how they work.

Problem 1.4: *stop-and-wait ARQ efficiency* (2 points)

Given a fixed frame size of n_f bits with an overhead (header, checksums) of n_o bits, an acknowledgment size of n_a bits, the propagation delay t_p, the frame transmission delay t_f, the acknowledgment transmission delay t_a and the processing delay t_c (for both frames and acknowledgments), and the data rate r, what is the time t that passes from the start of the frame transmission until the acknowledgment has been processed? Assume that no transmission errors occur.

The effective data rate r_e is the amount of information bits transmitted per time unit, i.e., the useful information transmitted without any overhead bits or acknowledgment bits. Derive an expression for the effective data rate r_e and the efficiency e, which is obtained by normalizing the effective data rate r_e by the data rate r, i.e., $e = \frac{r_e}{r}$.