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1. **Multiple Access Control**

   (a) List and explain the different media access approaches.

   (b) Discuss how these approaches may interact with or even disturb the services of upper layer protocols.

2. **Cyclic Redundancy Checksum**

   Determine whether the following bit sequences have been transmitted error-free. Use the generator polynomial

   $$x^4 + x + 1$$

   If you encounter an error, assume the checksum is wrong and (re-)calculate the value.

	Data + CRC
1.	0111 0110 0010
2.	0101 0010 1001
3.	1111 0110 1100

3. **Transmission with PPP**

   The *Point to Point Protocol* (PPP) is a protocol of the Data Link Layer (DLL). One of its purposes is to protect the data communication of two adjacent hosts (A and B). Transmission errors are detected by checksums.

   (a) Consider the bit sequence 110111110101. This sequence is to be transmitted including its CRC checksum. Compute the checksum by using the following generator polynomial instead of CCITT CRC-16:

   $$G(x) = x^4 + x + 1$$

   (b) Create/sketch the PPP frame that is used to transfer the data from host A to B. The payload of the transmitted PPP packet is IP data (cf., IANA assignment). Instead of the normal 16 bit PPP checksum, the 4 bit checksum computed in part 3a shall be used.

   (c) The frame created in part 3b is now passed to the physical layer. Draw/sketch the data part of the PPP frame using the Differential NRZ Code.

4. **Hamming Code**

   Two communication partners have agreed to the following coding scheme for transmitting characters:

Character	Code Word
A	10000
B	01000
C	11000
D	00100
...	...
Z	01011

(a) To protect the transmission a Hamming Code with 4 check bits shall be used. Give the bit sequence which represents the word HAMMING.

(b) One communication partner has received the following bit sequence:
010101000 111001000 010101001 001011000 111111100 001001100
Decode this sequence and mark the blocks detected to be damaged. Which blocks are corrected incorrectly and which blocks are detected to be correct mistakenly? How many bit errors have happened in those cases?

5. **Transmission Capacity**

Consider a host-to-network technology with a sliding window mechanism and a window size of $W = 7$. The frames are up to 1,500 bytes long and the round trip time is given with 50 ms.

(a) Calculate the maximum data rate that can be achieved with these parameters when sending frames from host A to B.

6. **Sliding Window Mechanism**

Each frame contains a sequence number $N(S)$ as well as an acknowledgement number $N(R)$. The acknowledgement number acknowledges all frames up to $R - 1$. Thus, frame R is expected to be received as next. To avoid an overflow of the counter, the value is calulated modulo M.

(a) How many frames is a sender allowed to send without getting an acknowledgement?

(b) Consider an example with $M = 8$ and window size $W = 7$. The frames with $N(S) = 5, 6, 7, 0, 1$ have been sent. No acknowledgement has been received yet. List the remaining sequence numbers that may be used by the sender?

(c) How does the situation in part 6b change if a frame with the following acknowledgement number is received:

i. $N(R) = 2$

ii. $N(R) = 6$

iii. $N(R) = 5$

List the acknowledged sequence numbers and the window of remaining sequence numbers.

(d) Why do we need preferably a full-duplex connection for sliding window protocols?