Datakommunikation I - HT05

Theoretical Exercise 1

Deadline Friday September 9, 2005, 12:00. You can either hand in the assignment during the class, or in mailbox 73 outside room P1457.

Realisation You can work in groups of two. Please answer in English.

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Exercise 1: OSI Reference Model

The protocol stack performs the following operations on a message:

1. Encipher the message by replacing each character with its alphabetical successor (e.g., B $\rightarrow$ C).
2. For transmission, encode all characters in ASCII (e.g., A $\rightarrow$ 65).
3. Provide each packet with a sequence number.
4. Insert a checksum for error detection into each packet.
5. Bit by bit transmission of the information over a link with signal levels of +/- 5V.
6. Determine the routing path.
7. Insert a CRC for error detection into each data frame.
8. Multiplex several connections on a channel.
9. Demultiplex received packets depending on the application.
10. Insert checkpoints for transferring large files.
11. Waits until the physical link is available and then sends the frame.
12. Retransmission of packets because of bit errors.
13. Translate a Uniform Resource Locator (URL) into a network address.

a) For each of the operations (1)-(13) indicate the corresponding layer of the OSI Reference Model.

b) Explain the advantage of layering for the definition of communication protocols.

Exercise 2: Circuit Switching versus Packet Switching

Compare circuit switching and packet switching (datagram): Give for both networking strategies one shot statement (one sentence) about the following issues:

1. connection setup
2. packet headers
3. end-to-end delay, delay jitter
4. in-order delivery
5. constant data rate

Exercise 3: Packet Segmentation and End-to-End Delay

Two computers A and B are connected to the Internet by ADSL connections. The ADSL connection of A has a datarate R_A=1Mbit/s, the connection of B a datarate R_B=2Mbit/s. Both nodes are located 3km from the same switching center, propagation velocity on the cable is $c = 3 \cdot 10^8$m/s. We assume perfect channels without errors.

a) A file of size $O = 10$MB is sent from computer A to computer B. Compute the end-to-end delay under the assumption that the file is sent as one single packet. Keep in mind that the intermediate node uses store-and-forward packet switching, that is, does not start forwarding until the last bit of the incoming packet is received.

b) Same as (a), but segment the file into many packets of size $S = 1500$Bytes (excluding packet headers of 40Bytes). Compare with (a).

c) Compute the average end-to-end delay for the packets ($\frac{1}{N} \sum delay_i$ where N is the number of packets). Same setting as (b).

d) Same as (c), but now the file is sent from computer $B$to computer A. Assume an infinite queue at the intermediate node.

Disregard processing delay.

Exercise 4: Forward Error Control

a) Assume the network is loaded at 95 procent, the protocol data unit (PDU) loss rate is 10e-1, and losses are due to congestion (i.e. they are not random).

Statement: When all connections use FEC, they can reduce their block loss rate by several orders of magnitude. Say whether or not this statement is correct and explain why.

b) Assume that FEC is used and that PDUs can get locally reordered up to 10 PDUs (for example, PDU 5 can arrive in the worst case after PDU 15, but not any later).

Statement: The reordering of the PDUs affects the capability of FEC to recover from lost PDUs. Say whether or not this statement is correct and explain why.

Exercise 5: Selective ACK versus Negative ACK

Suppose we design a reliable transport protocol that uses only NAKs as feedback from receiver to sender

a) If the data rate is low (sender sends packets infrequently), is a NAK-only protocol better than a ACK- based protocol? Why?

a) Same question if the data rate is high and the network drops only a small number of packets

Exercise 6 (Optional): Cyclic Redundancy Check

The underlying mathematical theory of polynomial codes is beyond the scope of this course but, essentially, consider it as modulo-2 arithmetic. Let:

- D be a d-bit number (the message to be transmitted)
- G be an $(r + 1)$-bit number (the divisor or generator)
- R be an r-bit number such that $k > n$ (the remainder)

The receiver will accept the transmitted packet $D \cdot 2^r \oplus R$ if it can verify that it is dividable by the generator G without remainder. The task of the transmitter is therefore to find R such that this condition is satisfied.

a) Calculate $R = \frac{D \cdot 2^r}{G} \mod 2$ for the message $D = 11100110$ and generator $G = 11001$.

b) Convince yourself that the code can detect (up to r) burst errors in the transmitted frame $D \cdot 2^r \oplus R$ by changing some consecutive bits in that frame: Compute the remainder of $\frac{D \cdot 2^r \oplus R}{G}$. A non-zero remainder indicates an error.

c) Do the same experiment by changing six ($> r$) random bits of the transmitted frame. Does the code detect the errors?