Networking Architectures and Protocols
Homework #1

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General remarks:

- Return date: See course Web page
- Put printed copy of you homework in box aoutside room 015
- Show how you **derive** the answer to the questions. It is not sufficient to just present a numerical result as answer, without indicating how you obtained this result.
- Indicate for each exercise the number
- **NO collaboration on the homework among students is allowed, neither copying the solution from a student who took the course previously.**

Error Control

1 Forward Error Control

1.1

Assume the network is loaded at 95%, the 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.

1.2

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.

2 Receiver based loss detection

Explain for each of the 2 scenarios whether or not the use of receiver-based loss detection (as compared to sender-based loss detection) will reduce **the total transfer time** of the data (we assume that the network does not reorder PDUs)?

2.1

A large amount of data (multiple Mega bytes), whose size is known before transfer must be transmitted from the sender to the receiver.

2.2

Many independent data transfers of small (several bytes), different size must be executed.

3 Policies

In the case of a random loss and a big send window the efficiency of Cumulative Ack/One-at a time Retransmission is higher than the efficiency of Cumulative Ack/Go-Back-N because of

1. the buffering of out-of-order PDUs at the receiver side.
2. resetting the timers of all outstanding un-acknowledged PDUs after timeout.

3. the higher priority of retransmissions.

Explain which of the statements is/are true.

4 Performance of policies

We can define Latency and Efficiency as follows:

- **Latency:** The average time elapsed for a PDU from the moment on where a PDU is sent by the sender side *for the first time* until this PDU delivered to the application on the receiver side.
- **Efficiency:** The number of PDUs received by the application at the **receiver** side divided by **the number of PDUs transmitted by the error control protocol at the sender** side.
- **Throughput:** The number of PDUs received by the application at the receiver side divided by the time of the transfer.

4.1 Go Back N

Assume random PDU loss and Go-Back-N error recovery.
Statement: When the transmission time per PDUs increases, the efficiency decreases. Say if this is **true or false and why**.

4.2 Error control over satellite links

Satellite connections have a big propagation delay (300 milli seconds or more). Which error recovery mechanism would you use in this case? Discuss its latency and efficiency for the case a *high bandwidth* (one Mbit/sec or more) connection.

4.3 Error control over satellite links

Satellite connections have a big propagation delay (300 milli seconds or more). Which error recovery mechanism would you use in this case? Discuss its latency and efficiency for the case of a *low bandwidth* (e.g. 10 kbit/sec) connection.

5 Questions in Error Control

Definitions:

- **a_parameter:** Ratio between the propagation time and the transmission time.
- **Latency:** Transmission time of a PDU, i.e. (t2−t1), where t2 = the time at which the PDU was delivered at the receiver side to the application; t1 = the time at which the PDU was created at the senders side.

- **Efficiency:** ratio between the number of PDUs delivered at the receiver side to the application and the number of PDUs sent by the sender.
- **Gap-based loss detection:** The receiver evaluates the sequence numbers of the arriving PDUs. If it receives PDU $i + n$, with $n > 1$ after PDU i, it infers that the PDUs $i + 1$ to $i + n$ are lost.

For each of the following statements, please state if it TRUE or FALSE and explain in a few sentences why.

5.1

Assume that PDUs do not get reordered during the transmission from the sender to the receiver.
Statement: Gap-based loss detection alone at the receiver is not sufficient to reliably detect the loss of any PDU that was sent but did not arrive at the receiver.

5.2

Assume the receiver generates cumulative acknowledgments.
Statement: The only retransmission strategy the sender can use is Go-back-N.

5.3

Assume that PDUs do not get reordered during the transmission from the sender to the receiver and that the sender applies selective retransmission, uses timers to detect the loss of PDUs, and the timeout value is larger than 2 times the round-trip time. Assume that the receiver generates selective positive acknowledgments for all PDUs that are received correctly by the sender.
Statement: The efficiency of the transmission will be improved if the receiver is augmented to do gap-based loss detection and generates a single NAK whenever it observes the loss of a PDU.

5.4

Assume the a_parameter is larger than 100.
Statement: The efficiency of the Go-Back-N retransmission strategy will increase for a constant loss rate when the number of PDUs that are lost consecutively increases.

Flow Control

6 At what layer(s)

While data transmission takes place between two applications Flow Control can be used

1. in several layers of the ISO/OSI - model.
2. in at most one of the layers.
3. only in the transport layer.

Say which of the statements is/are true

7 Misc

For each of the following statements, please indicate if it is TRUE or FALSE and **explain** in a few sentences why.

7.1

Assume a session is flow controlled on an end-to-end basis.
Statement: Whenever the round trip time RTT increases, the transmission rate of the sender will decrease.

7.2

Assume there are n sessions that are all flow controlled on an end-to-end basis. All sessions share at least one common link.
Statement: If any session S out of the n sessions will double its window size, while the window sizes for the other session stay constant, the average end-to-end transmission delay seen by session S will increase.

7.3

Assume that we have 2 sessions that both use TCP with slow start. One session has a round trip time of rtt, the other session has a round trip time of 2*rtt. Both sessions have the same bottleneck link/node. There are no other sessions currently active in the network.
Statement: Both sessions will achieve the same throughput.

7.4

Assume that we have 2 sessions that both use TCP with slow start and *fast retransmit and fast recovery*. One session has a round trip time of rtt, the other session has a round trip time of 2*rtt. Both sessions have the same bottleneck link/node. There are no other sessions currently active in the network.
Statement: Both sessions will achieve the same throughput.

8 Window-Based Flow Control

Consider a satellite link with capacity 56000 bit/s connecting source and destination. The round trip propagation time is 250 ms. The window size is 101 PDUs. What is the minimum positive PDU size for which the flow control is not active?

Connection Management

8.1

In handshake-based connection management schemes the handshake, i.e. the exchange of set-up PDUs during connection establishment ensures that no old or duplicate set-up PDUs will be accepted.
Timer-based connection management schemes do not need to handshake. Explain how timerbased connection management schemes ensure that no old or duplicate set-up PDUs will be accepted.

8.2

Handshake-based connection management needs timers. Explain why and when.

8.3 For the timer-based connection management,

the sender uses a timer T_S and the receiver a timer T_R to determine when to release the connection record. The sender sets $T_S =$ "*current time*" + "'*lifetime*". Does the sender need to use the **same** value for *lifetime* for all PDUs of a connection or could the sender decide to use at some point a smaller value?

TCP Misc

9 HTTP over TCP

Question: What are major problems in the interaction of HTTP and TCP?

10 Congestion Control in TCP:

Assume we apply the Fast Retransmit and Fast Recovery algorithm proposed by V. Jacobson. The following example illustrates the case where PDU 1 is lost (window $a : b$ indicates that the PDUs with sequence numbers from a to b are inside the sliding window; ACK x acknowledges all PDUs **up to** sequence number $x - 1$). Complete the remaining

rows in the table from the point where PDU 5 was sent up to the point where PDU 13 is sent. (Assume PDUs and ACKs arrive in sequence and for each PDU successfully received an ACK is sent back).

Send	Receive	Comment	cwnd	ssthresh	window
PDU 1		send new PDU, **lost**	8		1:8
PDU 2		send new PDU	8		1:8
PDU 3		send new PDU	8		1:8
PDU 4		send new PDU	8		1:8
	ACK 1		8		1:8
PDU 5		send new PDU	8		1:8
PDU 6					
PDU 7					
PDU 1					
PDU 8					
PDU 9					
PDU 10					
PDU 11					
PDU 12					
PDU 13					