Spring term 2008
TELCOM 2321 - CS 2520
Wide Area Networks

# Homework 3

**Due date: Tuesday Jan 29, 2008**

One-day late submissions will be accepted without penalties.

## Problem 1

Work out textbook problem 11.3, page 300.

## Problem 2

Work out textbook problem 11.4, page 300.

## Problem 3

Consider a data link layer protocol operating over a full duplex channel with the same characteristics in both directions. The protocol is using a sliding window flow control scheme with $W > 1$ and $n = 3$ bits for frame sequence number. Assume that source has always data waiting to be transmitted. The receiver is configured to send an acknowledgment every two frames correctly received during regular operations. Assume that the frame transmission time is equal to the propagation time from sender to receiver $t_d$. Consider header and acknowledgment transmission times as well as processing delays negligible.

1. Find the minimum value of the window size such that the link utilization is maximized in case no errors occur. Use this value to solve all the following points.

2. Plot a chart showing the lower and upper bound frame numbers within the transmission window as a function of the time, covering a period at least equal to $10\,t_d$. Assume error-free transmissions.

Assume that the sender sets a timeout for each transmitted frame, starting immediately after frame transmission is completed. If the timeout expires before an acknowledgment has been received, the sender retransmits the frame.

3. Discuss the major inefficiency of this approach in case the timeout interval duration is equal to a round-trip delay, i.e. $T_{\text{out}} = 2\,t_d$.

Consider now a different use of the timeout. Instead of retransmitting the frame, when timeout expires and no ACKs have been received, the sender transmits a POLL control frame, to which the receiver must explicitly reply with an ACK carrying the expected frame number. Assume that the POLL transmission time is negligible and that $T_{\text{out}} = 3\,t_d$.

4. Draw a time diagram of the protocol behavior similar to the one shown in slide 25, starting from frame no. 0 and assuming that two error events occur, one on frame no. 5 and the other on the first ACK(0) that follows. Consider a go-back-N ARQ protocol, where the receiver is required to send a NACK for each frame received out of sequence and an ACK as soon as a retransmitted frame is correctly received.

5. Draw a similar time diagram for a selective repeat ARQ protocol, assuming the error on frame no. 5 only. In this case the receiver is required to send a selective reject (SREJ) control frame for the first out-of-sequence frame only, or when the sender transmits a POLL after a timeout expires and the receiver is still waiting for a retransmitted frame.

# Problem 4

Consider an end-to-end, window-based flow control scheme applied to a given virtual circuit over a packet-switched network. Assume that the endpoints of this virtual circuit are directly connected through a satellite link. Assume also that all packets have a transmission time of 5 msec and that the propagation delay between each endpoint and the satellite is 125 msec in each directions. Ignore processing delays and acknowledgment transmission times and assume that the satellite acts as a simple signal repeater, so packets are not stored in the satellite. In addition, assume that no errors occur.

1. Find a lower bound on the window size for the virtual circuit to be able to achieve maximum speed transmission when there is no other traffic on the link.

Suppose now that the virtual circuit goes through a short but slow terrestrial link first, then it is stored in a router and finally it is forwarded through the satellite link. The packet transmission time on the terrestrial link is 20 msec, while the processing and propagation delays are negligible. The time diagram corresponding to a single packet transmission is shown in the figure below.

2. Find the maximum transmission rate in packet/sec that can be attained now for this virtual circuit assuming no end-to-end flow control.

3. In case of end-to-end flow control, find a lower bound on the window size that will allow maximum transmission rate assuming no other traffic on the links.

4. Does it make a difference whether the terrestrial link is before or after the satellite link?