

EIE 3333 Data and Computer Communications (2019/20)

Suggested Solutions to Tutorial 4

Unit 4: Data Link Layer: Flow Control and Error Control

Review Questions

2. *Define frame and the reason for the need.*

[Answer]

The data link layer needs to pack bits into *frames*. Framing divides a message into smaller entities to make flow and error control more manageable.

4. *Explain the reason for moving from the stop-and-wait ARQ protocol to Go-Back-N ARQ protocol.*

[Answer]

Go-Back-N ARQ is more efficient than Stop-and-Wait ARQ. The second uses *pipelining*, the first does not. In the first, we need to wait for an acknowledgment for each frame before sending the next one. In the second we can send several frames before receiving an acknowledgment.

6. *Define Piggybacking and its usefulness.*

[Answer]

Piggybacking is used to improve the efficiency of bidirectional transmission. When a frame is carrying data from A to B, it can also carry control information about frames from B; when a frame is carrying data from B to A, it can also carry control information about frames from A.

7. *In the stop-and-wait protocol, assume that the sender has only one slot in which to keep the frame to send or the copy of the sent frame. What happens if the network layer delivers a packet to the data-link layer at this moment?*

[Answer]

The packet from the network layer should be rejected.

8. *Is a negative acknowledgement (REJ) necessary in the stop-and-wait ARQ protocol?*

[Answer]

In fact, a REJ is not needed at all, since the sender will time out if it fails to receive an ACK. The REJ improves efficiency by informing the sender of a bad frame as early as possible.

Problems

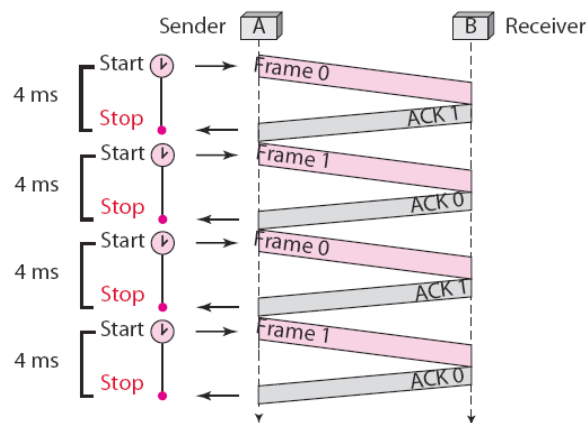
1. A sender sends a series of packets to the same destination using 5-bit sequence number. If the sequence number starts with 0, what is the sequence number after sending 100 packets?

[Solution]

A five-bit sequence number can create sequence numbers from 0 to 31. If the sequence number starts at 0, the sequence number in the Nth packet is $(N-1 \bmod 32)$. This means that the 101th packet has the sequence number $((101-1) \bmod 32)$ or **4**.

2. The timer of a system using the Stop-and-Wait ARQ protocol has a time-out of 6ms. Draw the flow diagram for four frames if the round trip delay is 4ms. Assume no data frame or control frame is lost or damaged.

[Solution]



3. A systems use the Stop-and-Wait ARQ protocol. If each data frame carries 1000 bits of data, how long does it take to send 1 million bits of data if the distance between sender and receiver is 5000 Km and the propagation speed is 2×10^8 m/s? Given the data rate of the link is 1 Mbps. Ignore waiting, and processing delays. We assume no data or control frame is lost or damaged.

[Solution]

We need to send 1000 frames. We ignore the overhead due to the header and trailer.

Data frame propagation time = $5000\text{km} / 2 \times 10^8 \text{ m/s} = 25\text{ms}$

Data frame transmission time = $1000 \text{ bits} / 1 \times 10^6 = 1\text{ms}$

The time for one transmission cycle (1 frame) = $t_{\text{frame}} + 2t_{\text{prop}} = 51\text{ms}$

Total number of frames = $1,000,000 / 1,000 = 1000$ frames

Total delay = $1000 \times 51\text{ms} = 51\text{s}$

4. Repeat Question 3 using the Go-Back-N ARQ protocol with a window size of 7. Ignore the overhead due to the header and trailer.

[Solution]

We need to send $1000/7 = 143$ windows

The time for the first ack arrives = $t_{\text{frame}} + 2t_{\text{prop}} = 51\text{ms}$

The time for sending 7 frames = $7 t_{\text{frame}} = 7\text{ms}$

So the utilization is not 1 and the server has to wait. In this case, each window transmission takes 51ms.

We ignore the overhead due to the header and trailer.

Delay for one window = 51ms

For the last windows, it will only send 6 frames and we need to wait for the acknowledgement of the last frame, so

Total delay = $142 \times 51 \text{ ms} + 6 t_{\text{frame}} + 2t_{\text{prop}} = 7.298\text{s}$

5. Repeat Question 3 using the Selective-Repeat ARQ protocol with a window size of 4. Ignore the overhead due to the header and trailer.

[Solution]

We need to send $1000/4 = 250$ windows

The time for the first ack arrives = $t_{\text{frame}} + 2t_{\text{prop}} = 51\text{ms}$

The time for sending 4 frames = $4 t_{\text{frame}} = 4\text{ms}$

So the utilization is not 1 and the server has to wait. In this case, each window transmission takes 51ms.

We ignore the overhead due to the header and trailer.

Delay for one window = 51ms

For the last windows, we need to wait for the acknowledgement of the last frame, so

Total delay = $249 \times 51 \text{ ms} + 4 t_{\text{frame}} + 2t_{\text{prop}} = 12.699 + 0.054 = 12.753\text{s}$

6. Assume we need to design a Go-Back-N sliding window protocol for a network in which the bandwidth is 100 Mbps and the average distance between the sender and receiver is 10,000km. Assume the average frame size is 100,000 bits and the propagation speed in the media is 2×10^8 m/s. Find the maximum size of the send and receive windows, the number of bits in the sequence number field (m) and an appropriate time-out value for the timer.

[Solution]

$$RTT = 2 \times (10,000 \text{ Km}) / (2 \times 10^8) = 100\text{ms}$$

$$\text{Frame transmission time } t_{\text{frame}} = 100,000 \text{ bits} / 100 \text{ Mbps} = 1\text{ms}$$

To achieve 100% utilization, we have

$$W t_{\text{frame}} = t_{\text{frame}} + RTT \Rightarrow (W-1) t_{\text{frame}} = RTT$$

$$W-1 = 100 \Rightarrow W=101$$

Hence, the send window size is 101 and the receive window size is 1. The number of bits in the sequence number field (m) is 7 and the sequence number is from 0 to 127. The time out value should be greater than RTT to avoid early retransmission of the frame.

7. Draw the sender and receiver windows for a system using Selective Repeat ARQ (3-bits for sequence number), given the following:
- Frame 0 is sent; frame 0 is acknowledged.
 - Frame 1 and 2 are sent; frames 1 and 2 are acknowledged.
 - Frame 3, 4 and 5 are sent; frame 4 is acknowledged; timer for frame 5 expires.
 - Frame 5, 6 and 7 are sent; frames 4 through 7 are acknowledged.

[Solution]

