

# Exercises on

## - Data Link Layer

### Exercise 1

110111111011111000011111011000100101011111011011111101010

- Start and end of the frame?
- Remove the stuffing bits

110111111011111000011111011000100101011111011011111101010

11111000011111011000100101011111011

11111000111111100010010101111111

### Exercise 2

- If the bit string 011110111110111110 is bit stuffed using the frame delimiter 01111110, what is the output string?

### Exercise 3

- What is the Hamming code of 0110101?

### Exercise 4

- Sixteen-bit messages are transmitted using a Hamming code. How many check bits are needed to ensure that the receiver can detect and correct single bit errors? Show the bit pattern transmitted for the message 1101001100110101. Assume that even parity is used in the Hamming code.

### Exercise 5

- A 12-bit Hamming code whose hexadecimal value is 0xE4F arrives at a receiver. What was the original value in hexadecimal? Assume that not more than 1 bit is in error.

### Exercise 6

- What is the remainder obtained by dividing  $x^7 + x^5 + 1$  by the generator polynomial  $x^3 + 1$ ?

### Exercise 7

- A bit stream 10011101 is transmitted using the standard CRC method described in the text. The generator polynomial is  $x^3 + 1$ . Show the actual bit string transmitted. Suppose the third bit from the left is inverted during transmission. Show that this error is detected at the receiver's end

### Exercise 8

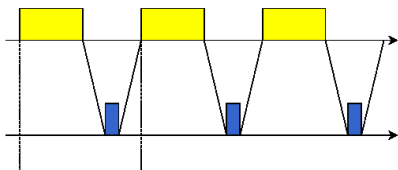
- Can you think of any circumstances under which an open-loop protocol, (e.g., a Hamming code) might be preferable to the feedback-type protocols discussed throughout this chapter?

### Exercise 9

- Assume two nodes are connected via a 64 Kbps line with  $L=100\text{km}$ . A Stop and Wait protocol is active.
- Minimum time needed to transfer 10 packets, where:
  - $L_p$  = packet length = 80 byte (header negligible)
  - $L_a$  = ACK length (RN only) = 8 byte (header negligible)

### Exercise 9 - Solution

Propagation time =  $\tau = L/c = 100000/2*10^8 = 0.5$  msec  
Packet trax time =  $T_p = L_p/v = (80*8)/64*10^3 = 10$  msec  
ACK trax time =  $T_a = L_a/v = (8*8)/64*10^3 = 1$  msec



$$T_{tot} = (\text{inizio trax } 1^{\wedge} - \text{fine trax ultimo}) \\ = 9(T_p + T_a + 2\tau) + T_p = 118 \text{ msec}$$

### Exercise 10

- In most networks, the data link layer handles transmission errors by requesting damaged frames to be re-transmitted. If the probability of a frame's being damaged is  $p$ , what is the mean number of transmissions required to send a frame if the acknowledgements are never lost?

### Exercise 11

- Assume two nodes are connected via a 64 Kbps line with  $L=100\text{km}$ . A Stop and Wait protocol is active, where:
  - $L_p$  = packet length = 80 byte (header negligible)
  - $L_a$  = ACK length (RN only) = 16 bit (header negligible)
  - propagation time  $\tau = 1$  msec
- Minimum time needed to transfer 12 packets (waiting for the last ACK)?
- Average time needed to transfer 12 packets when transmission has  $p=0.1$  packet error probability?

### Exercise 11 - Solution

Packet trax time =  $T_p = L_p/v = (80 \cdot 8) / 64 \cdot 10^3 = 10$  msec  
 ACK trax time =  $T_a = L_a/v = 16 / 64 \cdot 10^3 = 0.25$  msec

$\Rightarrow T_{tot} = N(T_p + T_a + 2\tau) = 147$  msec

As for Exe 5, the probability  $P_i$  of a frame requiring exactly  $k$  transmissions is:  $P_i = P[n=i] = p^{i-1}(1-p)$

Then the average number of transmissions is:

$$E[n] = \sum_{i=1}^{\infty} i \cdot P[n=i] = \frac{1}{1-p}$$

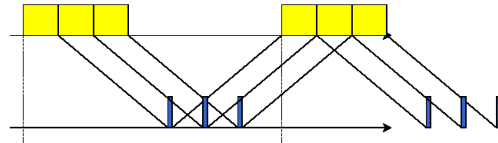
$\Rightarrow T_{tot} = N(T_p + T_a + 2\tau) E[n] = 163.3$  msec

### Exercise 12

- Assume two nodes are connected via a 6.4 Mbps line with  $L=100\text{km}$ . A GoBack- $n$  protocol is active, with  $n=3$ .
- Minimum time needed to transfer 13 packets, where:
  - $L_p$  = packet length = 80 byte (header negligible)
  - $L_a$  = ACK length (RN only) = 8 byte (header negligible)

### Exercise 12 - Solution

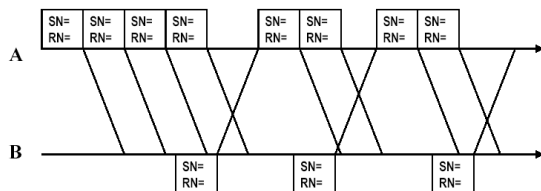
Propagation time =  $\tau = L/c = 100000/2 \cdot 10^8 = 0.5$  msec  
 Packet trax time =  $T_p = L_p/v = (80 \cdot 8) / 6.4 \cdot 10^6 = 0.1$  msec  
 ACK trax time =  $T_a = L_a/v = (8 \cdot 8) / 6.4 \cdot 10^6 = 0.01$  msec



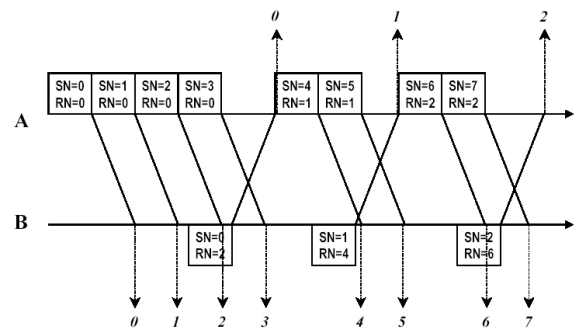
$\Rightarrow$  4 groups of 3 packets + 1 single packet  
 $T_{tot} = (\text{inizio trax } 1^{\wedge} - \text{fine trax ultimo})$   
 $= 4(T_p + T_a + 2\tau) + T_p = 4.54$  msec

### Exercise 13

- Assume a GoBack- $n$  protocol is active, with  $n=4$  and time-out equal to 5 times the frame transmission time.
- SN = Sending Number, RN = Request Number (it indicates the **expected** frame number, and NOT the acknowledged SN from the other side)
- Conclude the following picture:

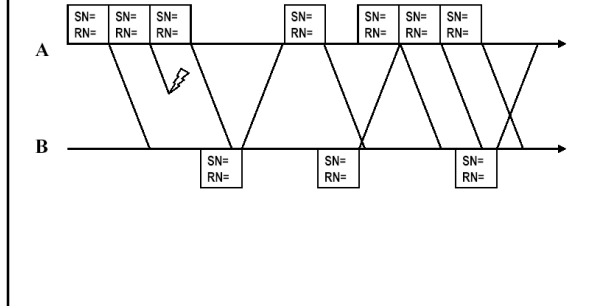


### Exercise 13 - Solution

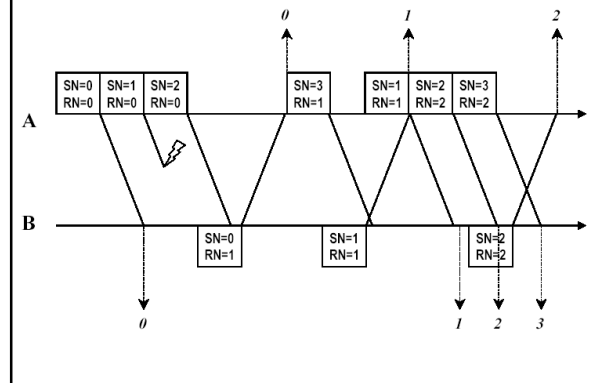


### Exercise 14

- Assume a GoBack-n protocol is active, with  $n=3$  and time-out equal to 5 times the frame transmission time.
- Conclude the following picture:



### Exercise 14 - Solution

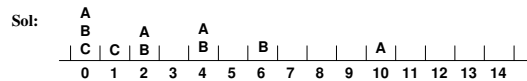


### Exercise 15

- Consider a network based on pure ALOHA with poissonian traffic
- If the success probability is equal to 0.1, calculate:
  - the traffic  $G$
  - throughput  $S$

### Exercise 16

- Consider a network based on slotted-ALOHA, made of three stations with these MAC address: **A (21); B (17); C (8)**
- Retransmission rule after a collision:
  - the station retransmit after a number of slots equal to the remainder of the division between its MAC address and  $2^k$ , where  $k$  is the number of successive collisions experienced by the station itself
- If the three stations collide in the first slot, when do they manage to transmit correctly their packet?



### Exercise 17

- As in the previous exercise, but with 4 stations: **A (18); B (17); C (20); D (4)**
- If A, B e C transmit a packet during slot 0, while D transmits a packet during slot 2, when do the stations manage to transmit correctly their packet?



### Exercise 18

- Assume a maximum data field for an Ethernet frame of 1500 bytes. What is the overhead (in %) for a 4096-byte application message?
- (Hint: consider 56 bytes of upper layers headers)

### Exercise 19

- Ethernet frames must be at least 64 bytes long to ensure that the transmitter can detect collisions. Fast-Ethernet has the same minimum frame size but can transmit 10 times faster. How is it possible to still detect collisions?

### Exercise 20

- Consider building a CSMA/CD network at 1Gbps over a 1km cable with no repeaters. What is the minimum frame size? (Assume the signal speed in the cable is 200,000 Km/sec).