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802-15-2172

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Exam 2 Answers

(I). The following data fragment occurs in the middle of a data stream, for which the character-stuffing algorithm described in the textbook is used: A B FLAG ESC C ESC D ESC FLAG E What is the output after stuffing?
A B ESC FLAG ESC ESC C ESC ESC D ESC ESC ESC FLAG E

(II). Suppose a complete code consists of four codes:

Code 1: 00000000
Code 2: 00001111
Code 3: 11110000
Code 4: 11111111

Using the following table, determine the Hamming distance of each pair of codes:

----	Code 1	Code 2	Code 3	Code4
Code 1	----	4	4	8
Code 2	4	----	8	4
Code 3	4	8	----	4
Code 4	8	4	4	----

What is the Hamming distance of this complete code?

d = 4

How many bit errors can be detected?

d-1 = 3

How many bit errors can be corrected?

floor((d-1)/2) = 1

(III). Using Hamming coding to encode bit stream: 10101011110.

Index					Hamming
1	0	0	0	1	P1
2	0	0	1	0	P2
3	0	0	1	1	1
4	0	1	0	0	P4
5	0	1	0	1	0
6	0	1	1	0	1
7	0	1	1	1	0
8	1	0	0	0	P8
9	1	0	0	1	1
10	1	0	1	0	0
11	1	0	1	1	1
12	1	1	0	0	1
13	1	1	0	1	1
14	1	1	1	0	1
15	1	1	1	1	0

P1 = Odd = 0
P2 = Odd = 0
P3 = Odd = 0
P4 = Even = 1

Output = 00100101101110

(IV). Using CRC with general polynomial x^3 + x + 1 to encode 11001010.

CRC-4
x^3 + x +1 = 1011
Append 4 zeroes to 11001010 ---> 110010100000
Apply division

```
        11101100
       -------------
1011 ) 11001010000
        1011
        ----
         1111010000
         1011
         ----
          100010000
          1011
          ----
           01110000
            1011
            ----
             101000
             1011
             ----
              00100
```

Output Bit Stream: 110010100011

(V). Medium Access Control (MAC) Sublayer.

1) What is the main purpose of the medium access control (MAC) sublayer?

When sending data to another device on the network, the MAC sublayer encapsulates higher-level frames into frames appropriate for the transmission medium adds a frame check sequence to identify transmission errors, and then forwards the data to the physical layer as soon as the appropriate channel access method permits it. Additionally, the MAC is also responsible for compensating for collisions by initiating retransmission if a jam signal is detected. When receiving data from the physical layer, the MAC block ensures data integrity by verifying the sender's frame check sequences, and strips off the sender's preamble and padding before passing the data up to the higher layers

2) In Dr. Kejie Lu's videos, find three IEEE standards that include the MAC sublayer. For each standard, write the code of the standard and the title of video below

Wi-Fi 2 (IEEE 802.11a) Chapter 4: Wi-Fi (1)
Wi-Fi 1 (IEEE 802.11b) Chapter 4: Wi-Fi (1)
Wi-Fi 4 (IEEE 802.11n) Chapter 4: Wi-Fi(1)

(VI) A large number of stations in a slotted ALOHA network generate 50 requests per second on average, where the requests include originals and retransmissions. Suppose the duration of a time slot is 20 ms.

1) What is the arrival rate G when the unit is the number of arrivals per time slot?

   G is defined as the number of frames per frame time

   $$G = \frac{50\ requests}{1000\ ms} \times \frac{20\ ms}{1\ time\ slot} = \frac{1\ request}{time\ slot}$$

2) What is the probability that a message is successfully transmitted on an attempt?

   $$P(frame\ without\ collision) = e^{-G} = e^{-1} = 0.36787944117$$

3) What is the expected number of transmission attempts needed for a successful delivery?

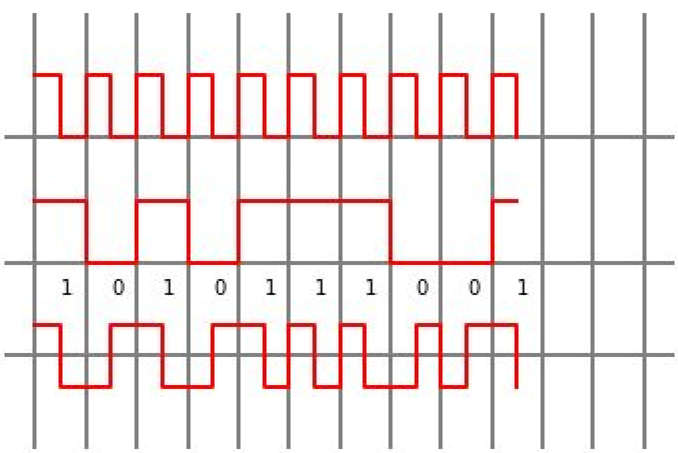
   $$S = G \cdot e^{-G} = 1 * 0.36787944117 = 0.36787944117$$

(VII) Answering the following questions about Ethernet.

1) Why is the Manchester encoding used in Ethernet?
   You do not need to synchronize with the systems clock

2) Sketch the Manchester encoding for the bit stream 1010111001.

```python
import matplotlib.pyplot as plt
import numpy as np

def my_lines(ax, pos, *args, **kwargs):
    if ax == 'x':
        for p in pos:
            plt.axvline(p, *args, **kwargs)
    else:
        for p in pos:
            plt.axhline(p, *args, **kwargs)


#1010111001
bits = [1,0,1,0,1,1,1,0,0,1]
data = np.repeat(bits, 2)
clock = 1 - np.arange(len(data)) % 2
manchester = 1 - np.logical_xor(clock, data)
t = 0.5 * np.arange(len(data))


my_lines('x', range(13), color='.5', linewidth=2)
my_lines('y', [0.5, 2, 4], color='.5', linewidth=2)
plt.step(t, clock + 4, 'r', linewidth = 2, where='post')
plt.step(t, data + 2, 'r', linewidth = 2, where='post')
plt.step(t, manchester, 'r', linewidth = 2, where='post')
plt.ylim([-1,6])

for tbit, bit in enumerate(bits):
    plt.text(tbit + 0.5, 1.5, str(bit))

plt.gca().axis('off')
plt.show()
```



3) Suppose a CSMA/CD network is operating at 100Mbps, and suppose there are no repeaters and the length of the cable is 1.0km. Determine the minimum frame size. (Hint: The signal propagation speed is 200km/ms in cable).

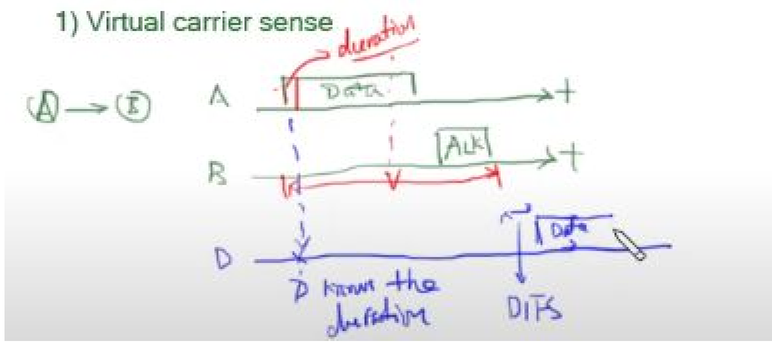
T_r = Transmission Time
T_p = Propagation Time
$T_r = 2\,T_p$

$$T_p = 1\ km\ \left(\frac{1\ ms}{200\ km}\right) = 0.005\ ms\ \implies 5.0 \times 10^{-6}\ s$$

$$F_{size} = 5.0 \times 10^{-6} s\ (100 \times 10^{6} bps) = 5.0 \times 100\ bits = 500\ bits$$

(VIII). List four main collision avoidance schemes used in IEEE 802.11 DCF (CSMA/CA). Then briefly explain how each scheme can help to avoid collision.

1) Virtual Carrier Sense
    a) Say we have 3 stations A, B, C
    b) A sends data
    c) B sends ack frame
    d) C knows the duration of both data frame and ack frame. It will defer to transmit data



2) Binary Exponential Backoff
   a) Say we detect a collision, then the station will wait using the following rule:
   b)

First collision	Wait between [0,1]
Second collision	Wait between [0,3]
Third collision	Wait between [0, 7]
Fourth collision	Wait between [0, 15]

   c) And so on so forth with more collision, its called exponential backoff because the amount of time it has to wait is exponential to the number of collisions
3) Inter-Frame Spacing
   a) In order to avoid collisions between incoming and outgoing frames we specify at time duration which the station will wait in order to send another frame. This may vary according to the type of frame to be sent and the policy on how they are sent.
   b) There are different schemes for each spacing.
      SIFS, PIFS, DIFS and EIFS

   c) Where EIFS> DIFS > PIFS > SIFS and
      EIFS = SIFS + T_{ack} + DIFS

4) RTS/CTS

a) Say we have three stations A, B,C
b) A sends an RTS
c) B sends further along sends a CTS frame
d) C will act as a hidden terminal of A and with the information of the RTS and CTS frames it will defer from sending a frame. It will know the duration each of these take and thus avoiding collisions.