CIS 5639 HW #1

1. A digital signaling system is required to operate at 9600 bps.

(a). If a signal element encodes a 4-bit word, what is the minimum required bandwidth for the channel?

(b). Repeat (a) for the case of 8-bit words.

Ans: By Nyquist's equation: $C = 2B \log_2 M$

$C = 9600$ bps

(a). Since a signal element encodes a 4-bit word, $\log_2 M = 4$

$$2B \times 4 = C = 9600$$

$$8B = 9600$$

$$B = 1200 \text{ Hz}$$

(b). $9600 = 2B \times 8$, $16B = 9600$, $B = 600$ Hz

2. Given a channel with an intended capacity of 20 Mbps, the bandwidth of the channel is 3 MHz. Assuming white thermal noise, what signal to noise ratio is required to achieve this capacity?

Ans: $C = B \log_2 (1+SNR)$

$$20 \times 10^6 = 3 \times 10^6 \times \log_2 (1+SNR)$$

$$\log_2 (1+SNR) = 6.67$$

$$SNR = 102 - 1 = 101$$

3. For $P = 110011$ and $M = 11100011$, find the CRC.

⇓ See Figure.

```
               1011011 0
       ___________________
110011 | 1110001100000
         110011
         ------
          101111
          110011
          ------
            111000
            110011
            ------
              101100
              110011
              ------
               111110
               110011
               ------
                11010 0
```

CRC is <u>11010</u>.

4. Calculate the pairwise Hamming distances among the following code words: (a). 00000, 10101, 01010 ; (b). 000000, 010101, 101010, 110110.

(a). d(00000, 10101) = 3,
d(00000, 01010) = 2,
d(10101, 01010) = 5.

(b) d(000000, 010101) = 3,
d(000000, 101010) = 3,
d(000000, 110110) = 4,
d(010101, 101010) = 6,
d(010101, 110110) = 3,
d(101010, 110110) = 3.

5. An FHSS System employs a total bandwidth of $W_s = 400MHz$ and an individual channel bandwidth of 100 Hz. What is the minimum number of PN bits required for each frequency hop?

Ans: $400\ MHz = 400 \times 10^6\ Hz$

$$\text{Hops} = \frac{\cancel{4}400 \times 10^6}{100} = 4 \times 10^6$$

Minimum number of PN bits $= \log_2 4\times10^6 = 22$, $\underline{22 \text{ bits}}$.

6. In the following figure, frames are generated at node A and sent to node C through node B. Determine the minimum data rate required between nodes B and C (for link 2) so that the buffers of node B are not flooded (do not overflow), based on the following:

(a). The data rate of between A and B (Link 1) is 100 kbps.

(b). The length of link 1 is 4000 miles; the length of link 2 is 1000 miles.

(c). The propagation speed is 2×10^5 mile/second for both lines.

(d). All data frames are 1000 bits long; Ack packets are separate control packets of negligible length.

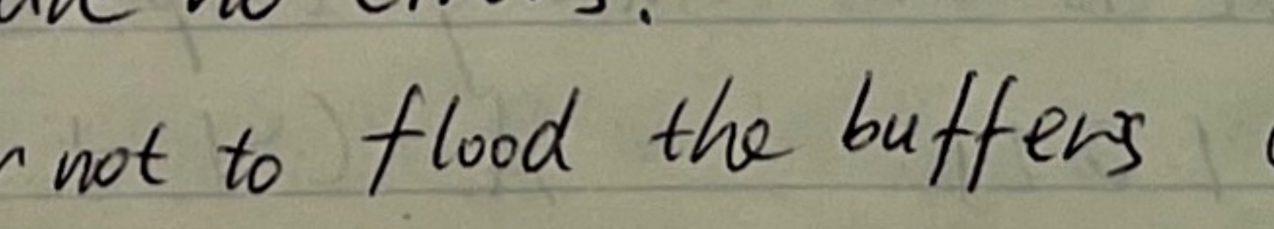
(e). processing time is negligible.

(f). Between A and B, a sliding-window protocol (pipeline protocol) with a window size of 3 is used.

(g). Between B and C, stop-and-wait is used.

(h). There are no errors.

Hint: In order not to flood the buffers of B, the average number of frames entering and leaving B must be the same over a long interval.



Ans: The Size of an ACK is negligible, we assume that $t_{ACK} = t_{prop}$

t_{ab} = Time to send one frame and recieve its ACK between nodes A and B

$$= 2\, t_{prop\,(A,B)} + \frac{L_{frame}}{R_{AB}}$$

$$= 2 \times \left(\frac{\cancel{4}^{2} \times 10^{\cancel{3}^{1}}}{1.2 \times 10^{\cancel{8}^{2}}}\right) + \frac{\cancel{1000} \text{ bits}}{\cancel{10^3} \times 100 \text{ bits/s}}$$

$$= 2 \times 0.02 + 0.01$$

$$= 0.04 + 0.01 = 0.05 \text{ s}$$

$$E_{rate(AB)} = \frac{W_s}{t_{ab}} = \frac{3}{0.05} = 60 \text{ frames/s}$$

To not flood B's buffer, we should have $E_{rate(AB)} \le E_{rate(BC)}$

$$\Rightarrow 60 \le \frac{W_s}{t_{BC}}$$

$$\frac{W_s}{t_{BC}} = \frac{W_s}{t_{prop(B,C)} + \frac{L_{frame}}{R_{BC}}} = \frac{1}{2 \times \left(\frac{5 \times 10^{-6}}{1}\right) \times 1000 + \frac{1000}{R_{BC}}}$$

$\therefore$ $R_{BC} \ge 14999.99$ bps (149.99 kilobits/s)

7. Suppose that A, C, and D are simultaneously transmitting 1 bits, using a CDMA system with the chip sequences of following figure. What is the resulting chip sequence?

A: 00011011	A: (−1 −1 −1 +1 +1 −1 +1 +1)
B: 00101110	B: (−1 −1 +1 −1 +1 +1 +1 −1)
C: 01011100	C: (−1 +1 −1 +1 +1 +1 −1 −1)
D: 01000010	D: (−1 +1 −1 −1 −1 −1 +1 −1)
(a)	(b)

(a) Binary chip sequences for four stations. (b) Bipolar chip sequences.

A: +1 +1 +1 -1 -1 +1 -1 -1

B: -1 -1 +1 -1 +1 +1 +1 -1

C: -1 +1 -1 +1 +1 +1 -1 -1

D: +1 -1 +1 +1 +1 +1 -1 +1

[3 1 1 -1 -3 -1 -1 1]

8. A CDMA receiver gets the following chips: (-1 +1 -3 +1 -1 -3 +1 +1). Assuming the chip sequences defined in above figure, which stations transmitted, and which bits did each one send?

A and D sent 1 bits, B sent 0 bit, C was silent.

[1, -1 0 1]

9. How can MACA still fail in case of hidden/exposed terminals. Think of mobile stations and changing transmission characteristics

Ans: When station move, new channels can arise all the time and old ones can break down. Furthermore due to increase or weakening of signals based on propagation characteristics, the same connection between two stations in both directions can have completely different signal strength. It's possible that one station does not receive the CTS of another one, but still can distrirb the other station with its sendings. The mechanism is only suitable for more or less ~~dh~~ deterministic propagation characteristics and static devices. Ad-hoc networks can't make use of it.

10. Assume all stations can hear all other stations and use CSMA. One station wants to transmit and sense the carrier idle. Why can a collision still occur after the start of transmission?

Ans. All centralistic systems, i.e., systems with a base station or access point controlling data transfer can give gurantees whereas all non-deterministic schemes. Such as CSMA/CA cannot give guarantees. The variation of CSMA ~~achieves a~~ is referred to as carrier sense multiple access with collision detection (CSMA-CD). It can happen that a sender senses the medium idle, starts the transmission and just in a moment before the waves reach another sender this second sender senses the medium idle and starts another transmission. This would be a reason for CD in classical CSMA/CD Ethernets.