COMPUTER COMMUNICATION NETWORK

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Numerical Problems - 1

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Problem 1

- With the CSMA/CD protocol, the adapter waits $K \times 512$ bit times after a collision, where K is drawn randomly.
- For K = 100, what is the waiting time for the adapter before retransmission on 10 Mbps broadcast channel?
- For a 100 Mbps broadcast channel, after 2 collisions, what is the average waiting time for the adapter before retransmission?

Problem 1 - Solution

- Waiting time with K=100 and R=10 Mbps is given by 100 × 512 bit times = 100 × 512 × $(1/10x10^6)$ =5.12 ms
- Random number k can take values in the range $[0,2^3-1]$={0,1,...,7}. The average value of k is 3.5. Therefore, the average waiting time in the 3rd round will be 3.5 × 512 bit times = 3.5 × 512 × $(1/100x10^6)$ =17.92 µs

Problem 2

- Let the propagation delay (tprop) between nodes A and B be 225 bit times. On a 10 Mbps broadcast channel, suppose A starts transmitting and before it can complete B starts transmitting. For analysis, let us assume A transmits a frame of 512 bit times.
- Will A detect collision and if so what is the worst case scenario for A to detect collision?
- Suppose tprop is changed to 325 bit times, when will A not detect collision from B?

Problem 2 - Solution

- Worst case scenario for A to detect collision
- Suppose A starts transmission at t=0, it takes 512 bit times to complete its transmission of the frame (i.e., at t=512 bit times A's transmission ends).
- The first bit of the frame transmitted by A reaches B at t=225 bit times due to the propagation delay
- If B starts transmission before the first bit of A reaches it (i.e., B presumes the channel to be idle). Then the transmission of B also takes 225 bit times (same propagation delay) to reach A.

Problem 2 - Solution

- Given this, suppose B starts transmission any time before t= 225 bit times (i.e., B observes the channel idle). Then it results in collision detection at A. The earlier B schedules its transmission before t=225, the earlier A detects the collision. In the worst case, suppose B starts transmission at t=224 bit times, this results in A detecting collision at t=224+225=449 bit times (note that A's transmission can complete only at t=512 bit times)
- However, if B performed channel sensing after t=225 bit times, then the channel would have been detected busy hence, it would have deferred transmission till t=225+512 = 737 bit times. This makes A transmission successful.
- Similar analysis can be done for part 2 of the question.

Problem 3

- Assume we have a MAC protocol in which the hosts access the slots like in slotted ALOHA. However, the frame size is much larger than the slot size S. Let the transmission rate be R Mbps and size of frame be L bits.
- Each host accesses the slot with a probability of p.
- So if a host acquires the channel it transmits for k slots and others refrain from transmission.
- Calculate the efficiency of the protocol (i.e., $k/(k+x)$ where x is the expected number of consecutive unproductive slots).
- What is the maximum efficiency?

Problem 3 - Solution

Let p denote the transmit probability of every user in a set of N users

The probability of success in slotted ALOHA is given by $P = Np(1-p)^{N-1}$

Suppose it takes y number of slots to successfully contend for the channel then the probability of successful transmission after $y-1$ attempts is given by $(1-P)^{y-1}P$

It can be seen that the above is a geometric distribution in y hence the average number of unproductive slots $E[y]$ is given by $1/P$

Let x denote the mean number of wasted slots

$$x = E[y] - 1 = \frac{1-P}{P}$$

Problem 3 - Solution

The efficiency of the given protocol is given by

$$\eta = \frac{\text{Number of useful slots}}{\text{Number of useful slots} + \text{Mean number of wasted slots}} = \frac{k}{k+x}$$

$$= \frac{k}{k + \frac{1 - Np(1-p)^{N-1}}{Np(1-p)^{N-1}}}$$

The maximum efficiency is given by setting $p = 1/N$ and setting $N \to \infty$

$$\eta^{max} = \lim_{N\to\infty} \frac{k}{k + \frac{1 - \left(1 - \frac{1}{N}\right)^{N-1}}{\left(1 - \frac{1}{N}\right)^{N-1}}}$$

Note $\lim_{N\to\infty} \left(1 - \frac{1}{N}\right)^{N-1} = 1/e \longrightarrow \eta^{max} = \frac{k}{k + \frac{1 - 1/e}{1/e}} = \frac{k}{k + e - 1}$

Problem 4

- A) Consider the 5-bit generator, G=10011, and suppose that D has the value 1010101010. What is the value of R ?
- B) Consider the 5-bit generator, G=10011, find if the received data with CRC is error free or not
  1. i) 10010101010100
  2. ii) 01011010101111
  3. iii) 10101010100100

Problem 4 - Solution

A) 10011 | 1010101010000

```
10011 | 1010101010000
        10011
        ------
          110010100000
          10011
          ------
           10100100000
           10011
           ------
             111100000
             10011
             ------
              11010000
              10011
              ------
               1001000
               10011
               ------
                  0100
```

Problem 4 - Solution

B) i) 10011 | 10010101010100

10011

1101010100

10011

100110100

10011

0100 CRC Error

Problem 4 - Solution

B) ii) 10011 | 01011010101111

```
10011 | 01011010101111
         10011
         ----- 
           10110101111
           10011
           -----
             101101111
             10011
             -----
               1011111
               10011
               -----
                 10011
                 10011
                 -----
                  0000
```

No CRC Error

Problem 4 - Solution

B) iii) 10011 | 10101010100100

```
10011
-----
  110010100100
  10011
  -----
   10100100100
   10011
   -----
     111100100
     10011
     -----
      11010100
```

```
11010100
10011
-----
 1001100
 10011
 -----
    0000
```

No CRC Error

This data is actually what was calculated in A)

THANK YOU

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