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Comp 5320 - Homework 1

Due: Tuesday, 10/4

1. Transfer file size = 1000 KB

   RTT = 50 ms = 0.05 sec

   Packet size = 1 KB = 1(1024)(8 bits) = 8912 bits

   Initial RTT = 2(RTT)

   a) Bandwidth is 1.5 Mbps, data packets sent continuously

      1.5(1000)(1000) = 1500000 bits/second

      Transmission time per packet:

      packet size / bandwidth $\longrightarrow \frac{8912 \text{ bits}}{1500000 \text{ bits/sec}} = 0.00546 \text{ sec} = 5.46 \text{ ms}$

      # of packets to send: 1000 KB / 1 KB = 1000

      Transmission time of all packets: 5.46 ms (1000) = 5.46 sec

      Total Time $\longrightarrow$ 2(0.05 sec) + 5.46 sec + 0.05 sec/2

      = 0.1 sec + 5.46 sec + 0.025 sec

      = **5.585 sec**

   b) Total time $\longrightarrow$ waiting for one RTT before sending the next

      5.585 sec + 999(RTT)

      = 5.585 + 999(0.05) = 5.585 + 49.95 = **55.535 sec**

   c) bandwidth is infinite, up to 20 packets can be sent

      1000/20 = 50 RTTs to transmit data

      for remaing 20 packets, only need (RTT/2)

      total RTTs required $\longrightarrow$ 49.5

      total time = 2(RTT) + 49.5(RTT)

      = 51.5(0.05) = **2.575 sec**

   d) Total time = inital 2 RTT + 9(RTT) + 0.5(RTT)

      = 2(RTT) + 9.5(RTT)

      = 11.5(RTT)

      = 11.5(0.05)

      = **0.575 sec**

2. propagation delay between A and B = 5 μs / km

transmission time per data frame = $1000/10^3$ = 10 msec

transmission time between B and C per frame
= data frame size / data rate (set data rate = X)
= $1000/X$

- Node A can transmit 3 data frames to B, must wait for B to accept first data frame before sending more
- Final bit of the first data frame arrives at Node B 20 msec post transmission and 30 msec after start of transmission
- It will take an additional 20 msec for Node B's ACK to return to Node A
- So adding 30 msec + 20 msec → it takes 50 msec for Node A to transmit 3 data frames

Node B can transfer one data frame to Node C at a time.

- takes 5+ (transmission time) per second for the data frame to be accepted at Node C
- takes an additional 5 msec for C to accept and return to A

30 + (3(transmission time / sec)) = 50

transmission time / sec = 6.7

X = 1000 / 6.7 = **150 Kbps**

3. a) {111, 100, 001, 010}

# of codewords = 4

# of bits in each codeword → n = 3

# of bits transmitted per codeword → K = 2

minimum Hamming distance → d = 2

coding rate → (K/n) = (2/3)

error detection capability → K = 1

error correction capability → (d-1)/2 = 1/2

b) {00000, 01111, 10100, 11011}

# of codewords = 4

# of bits in each codeword → n = 5

# of bits transmitted per codeword → K = 2

minimum Hamming distance → d = 2

coding rate → (K/n) = (2/5)

error detection capability → K = 1

error correction capability → (d-1)/2 = 1/2

4. n = length of any codeword  K = 20

- the following condition should be satisfied for any codeword

$$(n+1) \leq 2^{n-K}$$

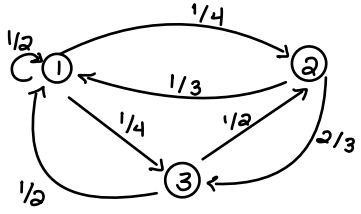
- assume $n = 16 \longrightarrow 16+1 \leq 2^{16-20}$
- assume $n = 24 \longrightarrow 24+1 \leq 2^{24-20}$
- assume $n = 25 \longrightarrow 25+1 \leq 2^{25-20}$, success

} Trial and Error

**minimum value of n = 25**

5. Markov Chain with 3 states

a) State transition diagram




b) Find $P(X_1 = 3, X_2 = 2, X_3 = 1)$

$$P(X_1 = 3) = 1 - P(X_1 = 1) - P(X_1 = 2)$$
$$= 1 - 1/4 - 1/4$$
$$= \boxed{1/2}$$

6.
$$a_3 = 1/2\, a_{R1} + 1/2\, a_4$$
$$= 1/2 + 1/2\, a_4$$
$$a_4 = 1/4\, a_{R1} + 1/4\, a_3 + 1/2\, a_{R2}$$
$$= 1/4 + 1/4\, a_3$$

$$\boxed{a_3 = 5/7}$$