EE3204/EE3204E CCN-I (Part 1) : Semester 1, 2012-13

Tutorial 2 - Problems & Solutions

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1. Suppose that a certain communication protocol involves a per-packet overhead of 100 bytes for headers and framing. It is required to send 1 million bytes of DATA using this protocol. It is given that one data byte is corrupted and the entire packet containing it is thus lost necessitating retransmission of the lost packet. Give the total number of overhead+retransmitted bytes for packet data sizes of 5000 and 20000 bytes. Determine the optimal packet data size.

Solution:

Let X be the packet data size, O be the overhead+retransmitted bytes, and N be the number of packets.

Since there are 1 million data bytes, N is given by $10^6/X$. It is given that the overhead is 100 bytes per packet. The size of retransmitted packet (which was lost) is X+100. Therefore, $O = N \times 100 + X + 100$

$X=5000 \Rightarrow N = 200$; and $O = 25100$ bytes
$X=20000 \Rightarrow N = 50$; and $O = 25100$ bytes

The optimum value is obtained when $dO/dX = 0$.
$O = 10^6/X \times 100 + X + 100 = 10^8/X + X + 100$
$dO/dX = -10^8/X^2 + 1 = 0 \Rightarrow X = 10000$
When $X = 10000$ the number of overhead+retransmitted bytes is minimum as $d^2O/dX^2 > 0$

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2. What signal-to-noise ratio is needed to put a T1 carrier on a 50 KHz line?

Solution:

Data rate of T1 carrier is 1.544 Mbps, i.e. C = 1.544 Mbps
Bandwidth B = 50 KHz.

Using $C = B \log_2(1+S/N)$, we get $C/B = 30.88$.
$S/N = 2^{30.88}-1$ = about 93 dB

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3. Assuming a framing protocol that uses bit stuffing, show the bit sequence transmitted over the link when the frame contains the following bit sequence:

    11111111110011111011111101

    Solution

    The transmitted bit sequence is given below. The stuffed bits are in bold and underlined.

    11111**<u>0</u>**11111**<u>0</u>**0011111**<u>0</u>**1011111**<u>0</u>**101

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4. Consider a framing protocol that uses bit stuffing (e.g.HDLC). The following bit stream (the flags are not shown) is received by the receiver. Determine the original bit stream extracted by the receiver.

    0111110001111101011111010

    Solution

    01111100111111011111110

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5. A receiver receives a bit stream 11101010 including the CRC bits. Suppose that the divisor polynomial used is x^2+1, explain if the receiver detects any error.

    Solution

    Dividing 11101010 by 101 using modulo-2 arithmetic gives a non-zero remainder (01). Therefore, the receiver detects the error. Carry out the the division to obtain the remainder.

6. Node A transmits 1000 byte frames to node B using selective-repeat ARQ protocol with window size 3 over a 10 Mbps link. The link is 200 km long. The frame error probability is 0.1. The propagation delay on the link is 5μs/km. Calculate the link utilization.

Solution

Frame transmission time T_f = 8000bits/10Mbps = 0.8 ms
Link propagation time T_p = 200$\times$5 = 1 ms
Frame success probability p = 1-0.1 = 0.9
a = T_p/T_f = 1/0.8 = 1.25; 1+2a = 3.5 > W
Utilization = W$\times$p / (1+2a) = 3$\times$0.9/3.5 = 0.77

7. Suppose that Host A transfers frames to host B using stop and wait protocol through a 100 km-long 10 Mbps link with a propagation delay of 5 μs per km. Assume that each frame carries 500 bytes of data and the communication is error-free. Approximately how many frames are transferred per second?

Solution

Frame transmission time Tf = 4000/10= 400μs. Link propagation time Tp =500 μs. Since 1 frame is transferred for every Tf+2TP time, the number of frames transferred per second = 1/(Tf+2Tp) = 1000/1.4 = 714 (approx).

8. Consider a sliding window based flow control protocol that uses a 3-bit sequence number and a window of size 7. At a given instant of time, at the sender, the current window size is 2 and the window contains frame sequence numbers 3 and 4. Now the sender receives RR1 and updates the window. What does the new window contain?

Solution

The set of frames for which acknowledgements are yet to be received at the sender (before RR1 is received) is {6,7,0,1,2}. RR1 implies acknowledgement of frames {6,7,0}. Therefore, the window now expands by 3 to become {3,4,5,6,7}.

9. Node A transmits 1000-bit frames to node C through node B. The link A-B is 4000km long and link B-C is 1000 km long. The frame error probability is 0.1 for link A-B and 0.2 for link B-C. The propagation delay is 5μs/km for each of the links. Between A and B, selective-repeat ARQ with a window size of 3 is used. Between B and C, stop-and-wait ARQ is used. The transmission time of ACK frames is negligible. Node A transmits at the rate of 100 kbps.

   (a) How many (original) frames are transferred by node A on link A-B in one second?
   (b) Calculate the utilization on link A-B.
   (c) Determine the minimum transmission rate required by B so that the buffers of node B are not flooded. [***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.]

<u>Solution</u>

Let Tf1 and Tf2 be the frame transmission time at nodes A and B, respectively. Let Tp1 and Tp2 be the propagation delay over links A-B and B-C, respectively. Let p1 and p2 be the frame error probability on links A-B and B-C, respectively.

Tf1 = 1000bits/100kbps = 10 ms
Tp1 = 20 ms; Tp2 = 5 ms
P1 = 0.1 ; p2=0.2; Window size W =3.

(a) For link A-B, a = Tp1/Tf1 = 2 $\Rightarrow$ 1+2a = 5 $\Rightarrow$ W < (1+2a).

Therefore, W (1-P1) frames are transmitted per Tf1+2Tp1 (=50 ms)time.

The number of frames transmitted per second = $(3\times0.9/50)\times1000 = 54$

(b) Utilization = W(1-P1) / (1+2a) = 2.7/5 = 0.54

(c) Node A transmits W(1-P1) frames per Tf1+2Tp1 time.
Node B transmits (1-P2) frames per Tf2+2Tp2 time.

To avoid flooding of buffers, W(1-P1) / (Tf1+2Tp1) must be smaller than or equal to (1-P2) / (Tf2+2Tp2)

Substituting the values, we have Tf2 $\leq$ 40/2.7 - 10; ie. Tf2 $\leq$ 4.815 ms.
The required transmission rate at node B $\geq$ 1000bits/4.815ms = 207.7 kbps

10. Give an example to illustrate the difference between flow control and congestion control.

<u>Solution</u>

Flow control relates to the point to point traffic between a given sender node and a receiver node. It has to make sure that a fast sender cannot continuously transmit data faster than the receiver is able to absorb it. On the other hand congestion control has to make sure the network is able to carry the offered traffic. It is a global issue, involving the behaviour of all the nodes, i.e., hosts, switches, routers, store-and forwarding processing and other factors such as buffer and link capacity etc. The following scenarios will explain the differences between the flow control and congestion control.

Consider a fiber optic network with a carrying capacity of 1000 Gbps on which a super computer is trying to transfer a file to a personal computer at 1 Gbps. Although there is no congestion in the network, flow control is needed to give the personal computer a chance to breathe.

At the other extreme, consider a store-and-forward network with 1-Mbps links and 1000 large computers, half of which are trying to transfer files at 100 kbps to the other half. Here the problem is not that of fast senders overpowering slow receivers, but that the total offered traffic exceeds what the network can handle. If we assume 50 links and each traffic traverses 4 links and all the links are evenly loaded, then the offered load to a link is at least $(500 \times 4 \times 100\text{kbps})/50 = 4$ Mbps which is larger than the link rate of 1Mbps. This could possibly lead to congestion.

Ref: S. Tanenbaum, "Computer Networks", ***Prentice Hall*****, PTR.**