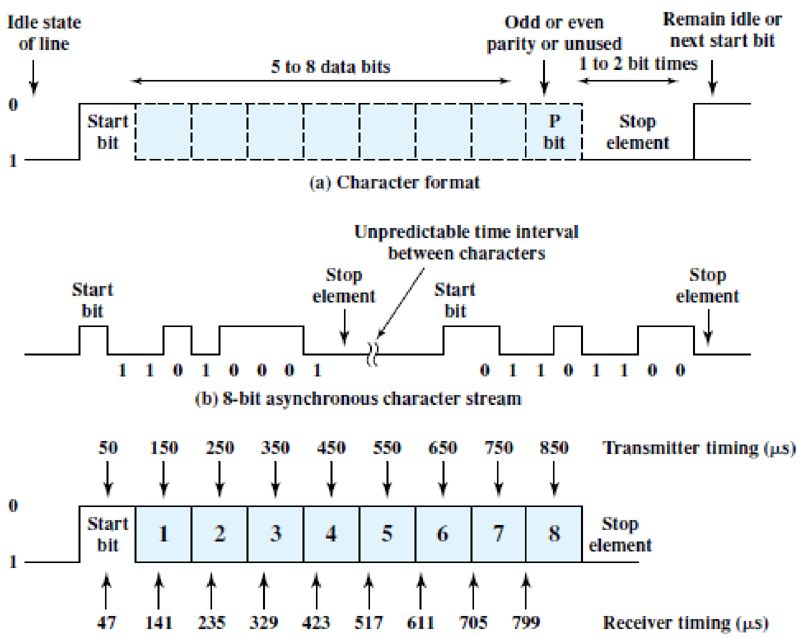
CS-31006: Computer Networks (Theory)
Class Test – I: Solutions

Answer 1

(1) Framing error in asynchronous transmission (The below is just the concept – a student answering on these lines should be awarded full marks):



(a) Character format

(b) 8-bit asynchronous character stream

(c) Effect of timing error

> **EXAMPLE 6.1** Figure 6.1c shows the effects of a timing error of sufficient magnitude to cause an error in reception. In this example we assume a data rate of 10,000 bits per second (10 kbps); therefore, each bit is of 0.1 millisecond (ms), or 100 μs, duration. Assume that the receiver is fast by 6%, or 6 μs per bit time. Thus, the receiver samples the incoming character every 94 μs (based on the transmitter's clock). As can be seen, the last sample is erroneous.

An error such as just described actually results in two errors. First, the last sampled bit is incorrectly received. Second, the bit count may now be out of alignment. If bit 7 is a 1 and bit 8 is a 0, bit 8 could be mistaken for a start bit. This condition is termed a *framing error*, as the character plus start bit and stop element are sometimes referred to as a frame. A framing error can also occur if some noise condition causes the false appearance of a start bit during the idle state.

(2) Answers are as follows:

(a) We take the message 1011 0010 0100 1011, append 8 zeros and divide by 1 0000 0111 ($x^8 + x^2 + x^1 + 1$). The remainder is 1001 0011. We transmit the original message with this remainder appended, resulting in 1011 0010 0100 0011 1001 0011.

(b) Inverting the first bit gives 0011 0010 0100 1011 1001 0011. Dividing by 1 0000 0111 ($x^8 + x^2 + x^1 + 1$) gives a remainder of 1011 0110.

(c) One-way latency of the link is 100 ms. (Bandwidth) x (roundtrip delay) is about 125 pps x 0.2 sec, or 25 packets. SWS should be this large.

(a) If RWS=1, the necessary sequence number space is 26. Therefore, 5 bits are needed.

(b) If RWS=SWS, the sequence number space must cover twice the SWS, or up to 50. Therefore, 6 bits are needed.

Answer 2

(1) Types of noise:

Thermal noise or white noise, Shot noise, Transit time noise

(Any 3 of thermal noise, intermodulation noise, crosstalk, and impulse noise are also acceptable answers).

(2) We will count the transfer as complete when the last data bit arrives at its destination.

(a) 1.5 MB = 12582912 bits. 2 initial RTTs (160 ms) + 12,582,912/10,000,000 bps (transmit) + RTT/2 (propagation) ≈ 1.458 seconds.

(b) Number of packets required = 1.5 MB/1KB = 1536. To the above, we add the time for 1535 RTTs (the number of RTTs between when packet 1 arrives and packet 1536 arrives), for a total of 1.458 + 122.8 = 124.258 seconds.

(c) Dividing the 1536 packets by 20 gives 76.8. This will take 76.5 RTTs (half an RTT for the first batch to arrive, plus 76 RTTs between the first batch and the 77th partial batch), plus the initial 2 RTTs, for 6.28 seconds.

(d) Right after the handshaking is done we send one packet. One RTT after the handshaking we send two packets. At n RTTs past the initial handshaking we have sent: $1 + 2 + 4 + \cdots + 2n = 2^{n+1} - 1$ packets. At n = 10, we have thus been able to send all 1536 packets; the last batch arrives 0.5 RTT later. Total time is 2 + 10.5 RTTs, or 1 second.

Answer 3

(1) Answers are as follows:

(a) Propagation delay on the link is $(55 \times 10^9) / (3 \times 10^8) = 184$ seconds. Thus, the RTT is 368 seconds.

(b) The delay x bandwidth product for the link is $184 \times 128 \times 10^3 =$ 2.81 MB.

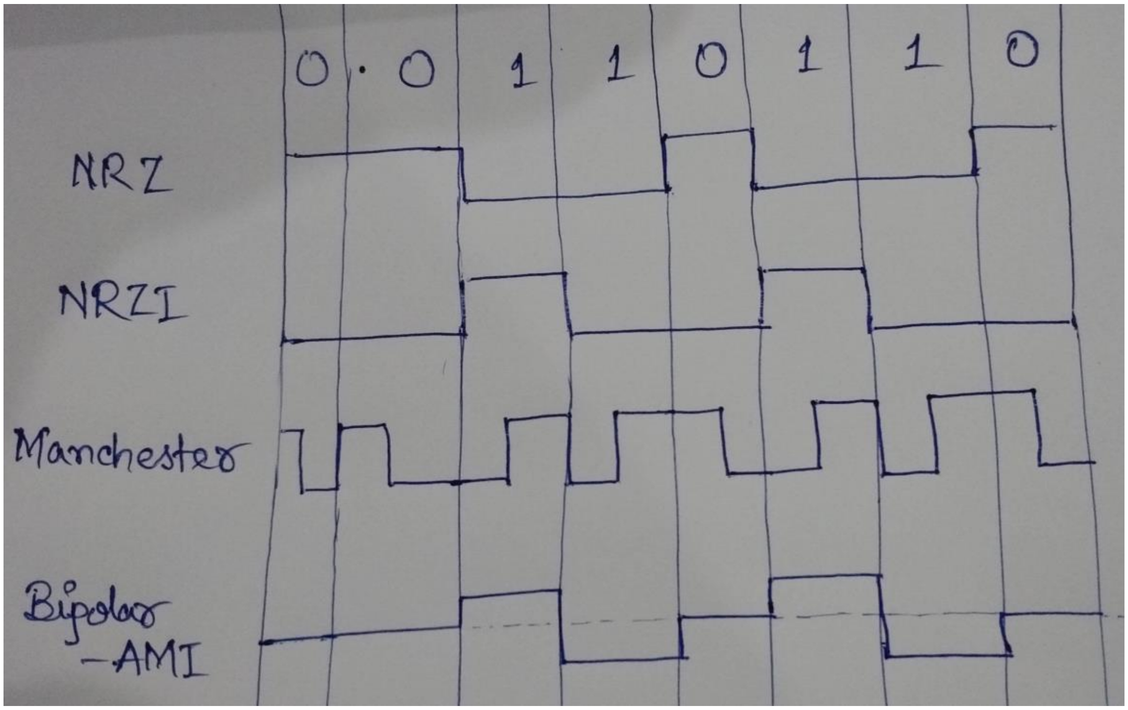
(c) After a picture is taken, it must be transmitted on the link and be completely propagated before Mission Control can interpret it. Transmit delay for 5 MB of data is $41{,}943{,}040 \text{ bits}/128 \times 10^3 = 328$ seconds. Thus, the total time required is transmit delay + propagation delay = 328+184 = 512 seconds.

(2) $C = 2B \log_2 M = 2 \times 4000 \times \log_2 8 = 24000$ bps

$C = B \log_2 (1 + SNR) \Rightarrow 24000 = 4000 \times \log_2 (1 + SNR) \Rightarrow 1 + SNR = 2^6 \Rightarrow SNR = 63$

Answer 4

(1) Waveforms below:



(2) [**NOTE**: The derivation below is fairly detailed; a student, who answers correctly, even if with one or two step jumps, should be awarded full marks.]

Under all loads, the throughput, S, is the offered load, G, times the probability, P_0, of a transmission succeeding—that is, $S = GP_0$, where P_0 is the probability that a frame does not suffer a collision.
The probability that k frames are generated during a given frame time, in which G frames are expected, is given by the Poisson distribution:

$$P[k] = (G^k e^{-G})/k!$$

In an interval one frame time long (for slotted ALOHA, vulnerable duration is one time frame), the mean number of frames generated is G. The probability of no frames being initiated during the entire vulnerable period is thus given by $P_0 = e^{-G}$

Using $S = GP_0$, we get $S = Ge^{-G}$

$S_{max} = S_{G=1}$, or, $S_{max} = 1/e = 0.368$

(3) $d_{min} = min_{i,j} \{d(w_i, w_j)\}, i \neq j$

Suppose that codeword w_i is received as w_t due to t bit errors. Then, in order to successfully correct the errors, for i, $d(w_t, w_i)$ should be lesser than $d(w_t, w_j)$ for all j where $j \neq i$. Now $d(w_t, w_i) = t$ (since there are t bit errors). Therefore, all other codewords should have a min. distance of (t+1) from w_t. Or, in the codeword generation, $d_{min} \leq (2t+1)$.

(4) BER: The bit error rate (BER) is the number of bit errors per unit time. The bit error ratio (also BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unit less performance measure, often expressed as a percentage.