Computer Networks Mid-Semester Examination Solutions

Answer 1

(1) The various forms of noise include **thermal noise, intermodulation noise, crosstalk, and impulse noise**.

(2) **Transport, Session, Presentation and Application layers** are end-to-end.

(3) **Data rate, Bandwidth, Noise and Error rate** are the key factors which affect channel capacity.

(4) Period **T = 1/f**, where f is the fundamental frequency. Therefore, T = 1/1000 s = 1 ms.

(5) **Bipolar-AMI** and **Pseudoternary** are two multilevel binary digital-to- digital encoding techniques.

(6) The difference between QPSK and offset QPSK is that **a delay of one bit time is introduced in the Q stream** for offset QPSK.

QPSK Signal: $$s(t) = \frac{1}{\sqrt{2}} I(t) \cos 2\pi f_c t - \frac{1}{\sqrt{2}} Q(t) \sin 2\pi f_c t$$

Offset QPSK Signal: $$s(t) = \frac{1}{\sqrt{2}} I(t) \cos 2\pi f_c t - \frac{1}{\sqrt{2}} Q(t - T_b) \sin 2\pi f_c t$$

(7) **Piggybacking** is when a station has data to send and an acknowledgment to send, and it sends both together in one frame, saving communication capacity.

(8) In the **Manchester** code, there is a transition at the middle of each bit period. The midbit transition serves as a clocking mechanism and also as data: a low-to-high transition represents a 1, and a high-to-low transition represents a 0.

In **differential Manchester**, the midbit transition is used only to provide clocking. The encoding of a 0 is represented by the presence of a transition at the beginning of a bit period, and a 1 is represented by the absence of a transition at the beginning of a bit period.

(9) The **bit length of a link** is defined as follows:

$$B = R \times (d/V),$$

where,

B = length of the link in bits; this is the number of bits present on the link at an instance in time when a stream of bits fully occupies the link;

R = data rate of the link, in bps;

d = length, or distance, of the link in meters;

V = velocity of propagation, in m/s.

(10) The variations of the Automatic Repeat Request error control mechanisms include:

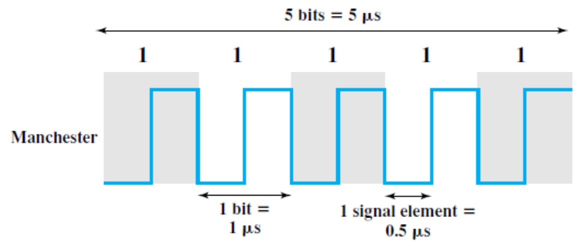
1) Stop-and-wait ARQ
2) Go-back-N ARQ
3) Selective-reject ARQ

Answer 2

(1) It is possible. One could design a code in which all codewords are at least at a distance of 3 from all other codewords, allowing all single-bit errors to be corrected. Suppose that some but not all codewords in this code are at least at a distance of 5 from all other codewords. Then for those particular codewords, but not the others, a double-bit error could be corrected.

(2) The data rate, or bit rate, is $1/T_b$, where T_b = bit duration. The baud rate, or modulation rate, is the rate at which signal elements are generated.

Consider, for example, Manchester encoding. The minimum size signal element is a pulse of one-half the duration of a bit interval, as shown in the diagram below. For a string of all binary zeroes or all binary ones, a continuous stream of such pulses is generated. Hence the maximum modulation rate for Manchester is $2/T_b$.

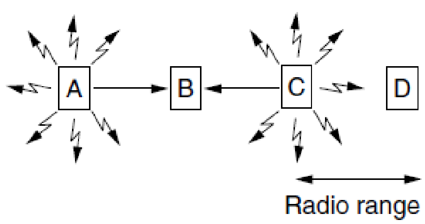


In general, $D = R/L = R / \log_2 M$, where

D = modulation rate, baud
R = data rate, bps
M = number of different signal elements = 2^L
L = number of bits per signal element

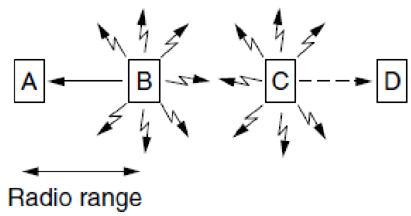
(3) The last coefficient, or the x^0 term, should be 1 (that is, G should not be divisible by x), because otherwise the last bit of the checksum would always be 0 (because if G is divisible by x, then R must be also).

(4) Hidden terminal problem:



If A sends and then C immediately senses the medium, it will not hear A because A is out of range. Thus C will falsely conclude that it can transmit to B. If C does start transmitting, it will interfere at B, wiping out the frame from A. The problem of a station not being able to detect a potential competitor for the medium because the competitor is too far away is called the **hidden terminal** problem.

Exposed terminal problem:



If C senses the medium, it will hear a transmission and falsely conclude that it may not send to D (shown as a dashed line). In fact, such a transmission would cause bad reception only in the zone between B and C, where neither of the intended receivers is located. The problem is called the **exposed terminal** problem.

(5) The minimum Hamming distance should be (2x4 + 1) = 9.

Distance between any two valid codes should be at least (2t+1). Even if t bits of a valid code get flipped, the nearest valid code can be identified and the error can be corrected accordingly. However, if (t+1) bits get flipped, then the modified code will be close to another valid code, and hence error correction will not be possible.

Answer 3

(1) According to Nyquist formula, $C = 2B \log_2 M$. So, for a given bandwidth, the data rate can be increased by increasing the number of different signal elements.

(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.

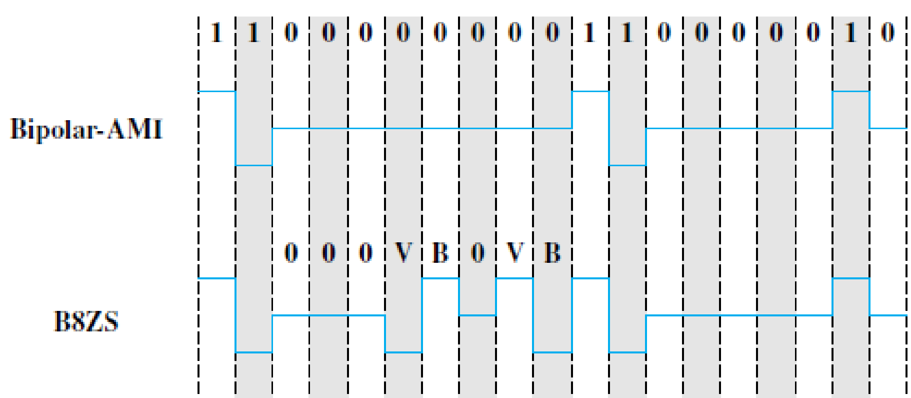
(d) Right after the handshaking is done we send one packet. One RTT after the handshaking we send two packets. At n RTTs past the initial handshaking we have sent: 1 + 2 + 4 + ⋯ + 2n = 2n+1 − 1 packets. At n = 10, we have thus been able to send all 1536 packets; the last batch arrives 0.5 RTT later.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

Answer 4

(1) B8ZS or bipolar with 8-zeros substitution, is a coding scheme based on a bipolar-AMI. Bipolar-AMI is modified with the following rules to create B8ZS:

- If an octet of all zeros occurs and the last voltage pulse preceding this octet was positive, then the eight zeros of the octet are encoded as 000+ -0- +.
- If an octet of all zeros occurs and the last voltage pulse preceding this octet was negative, then the eight zeros of the octet are encoded as 000- +0+ -.

Example:



(2) **Hub**: Any data packet coming from one port is sent to all other ports. It is then up to the receiving computer to decide if the packet is for it. Hubs are typically used on small networks where the amount of data going across the network is never very high.

Bridge: A bridge reviews the destination of the packet before sending it. A bridge only has one incoming and one outgoing port. Bridges are typically used to separate parts of a network that do not need to communicate regularly, but still need to be connected.

Switch: A switch has multiple ports. When a packet comes through a switch, it is read to determine which computer to send the data to. This leads to increased efficiency in that packets are not going to computers that do not require them.

(3) In CSMA/CD with binary exponential back-off, a station having detected a free channel, starts transmitting its frame. After it has finished, any other station having a frame to send may now attempt to do so. If two or more stations decide to transmit simultaneously, there will be a collision. If a station detects a collision, it aborts its transmission.

After a collision, time is divided into discrete slots whose length is equal to the worst-case roundtrip propagation time on the ether (2τ). After the first collision, each station waits either 0 or 1 slot times at random before trying again. If two stations collide and each one picks the same random number, they will collide again. After the second collision, each one picks either 0, 1, 2, or 3 at random and waits that number of slot times. If a third collision occurs, the next time the number of slots to wait is chosen at random from the interval 0 to $2^3 - 1$.

In general, after i collisions, a random number between 0 and $2^i - 1$ is chosen, and that number of slots is skipped. However, after 10 collisions have been reached, the randomization interval is frozen at a maximum of 1023 slots. After 16 collisions, failure is reported.

(4) Efficiency will be 50% when the time to transmit the frame equals the roundtrip propagation delay. At a transmission rate of 4 bits/ms,

160 bits takes 40 ms. For frame sizes above 160 bits, stop-and-wait is reasonably efficient.

Answer 5

(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 6

(1) Describe an error pattern as a matrix of n rows by k columns. Each of the correct bits is a 0, and each of the incorrect bits is a 1. With four errors per block, each block will have exactly four 1s. How many such blocks are there? There are nk ways to choose where to put the first 1 bit, nk − 1 ways to choose the second, and so on, so the number of blocks is $nk(nk-1)(nk-2)(nk-3)$.

Undetected errors only occur when the four 1 bits are at the vertices of a rectangle. Using Cartesian coordinates, every 1 bit is at a coordinate (x, y), where $0 \le x < k$ and $0 \le y < n$. Suppose that the bit closest to the origin (the lower-left vertex) is at (p, q). The number of legal rectangles is (k − p − 1)(n − q − 1). Then the total number of rectangles can be found by summing this formula for all possible p and q.

The probability of an undetected error is then the number of such rectangles divided by the number of ways to distribute the four bits:

$$\frac{\sum_{p=0}^{k-2}\sum_{q=0}^{n-2}(k-p-1)(n-q-1)}{nk(nk-1)(nk-2)(nk-3)}$$

(2) Interlaced scan refers one method for "painting" a video image on an electronic display screen by scanning or displaying each line or row of pixels. This technique uses two fields to create a frame. One field contains all odd lines in the image, the other contains all even lines.

A PAL-based television set display, for example, scans 60 fields every second (30 odd and 30 even). The two sets of 30 fields work together to create a full frame every 1/30 of a second (or 30 frames per second), but with interlacing create a new half frame every 1/60 of a second (or 60 fields per second). To display interlaced video on progressive scan displays, playback applies de-interlacing to the video signal (which adds input lag).

There are 483 rows and 483 x 3/4 columns. So the required bandwidth is:

483 x 483 x 3/4 x 60 bits/second = 10498005 bits/second.

(3) The patterns are as follows: