Computer Networks (CS30006)
Question Bank 2
Solutions

1. Suppose Host A wants to send a large file to Host B. The path from Host A to Host B has three links, of rates $R1$ = 500 kbps, $R2$ = 2 Mbps, and $R3$ = 1 Mbps.
   a. Assuming no other traffic in the network, what is the throughput for the file transfer?
   b. Suppose the file is 4 million bytes. Dividing the file size by the throughput, roughly how long will it take to transfer the file to Host B?

   Solution:
   a) 500 kbps
   b) 64 seconds

2. We need to use synchronous TDM and combine 20 digital sources, each of 100 Kbps. Each output slot carries 1 bit from each digital source, but one extra bit is added to each frame for synchronization. Answer the following questions:
   a. What is the size of an output frame in bits?
   b. What is the output frame rate?

   Solution:
   Each output frame carries 1 bit from each source plus one extra bit for synchronization. Frame size = $20 \times 1 + 1 = 21$ bits.
   Each frame carries 1 bit from each source. Frame rate = 100,000 frames/s.

3. Assume that a voice channel occupies a bandwidth of 4 kHz. We need to multiplex 10 voice channels with guard bands of 500 Hz using FDM. Calculate the required bandwidth.

   Solution:

To multiplex 10 voice channels, we need nine guard bands. The required bandwidth is then B = (4 KHz) × 10 + (500 Hz) × 9 = 44.5 KHz

4. We have 14 sources, each creating 500 8-bit characters per second. Since only some of these sources are active at any moment, we use statistical TDM to combine these sources using character interleaving. Each frame carries 6 slots at a time, but we need to add four-bit addresses to each slot. Answer the following questions:
   a. What is the size of an output frame in bits?
   b. What is the output frame rate?
   c. What is the duration of an output frame?
   d. What is the output data rate?

Solution:

a. Frame size = 6 × (8 + 4) = 72 bits.
b. We can assume that we have only 6 input lines. Each frame needs to carry one character from each of these lines. This means that the frame rate is 500 frames/s.
c. Frame duration = 1 /(frame rate) = 1 /500 = 2 ms.
d. Data rate = (500 frames/s) × (72 bits/frame) = 36 kbps.

5. Four channels, two with a bit rate of 200 kbps and two with a bit rate of 150 kbps, are to be multiplexed using multiple slot TDM with no synchronization bits. Answer the following questions:
   a. What is the size of a frame in bits?
   b. What is the frame rate?
   c. What is the duration of a frame?
   d. What is the data rate?

Solution:

a. The frame carries 4 bits from each of the first two sources and 3 bits from each of the second two sources. Frame size = 4 × 2 + 3 × 2 = 14 bits.
b. Each frame carries 4 bit from each 200-kbps source or 3 bits from each 150 kbps. Frame rate = 200,000 / 4 = 150,000 /3 = 50,000 frames/s.
c. Frame duration = 1 /(frame rate) = 1 /50,000 = 20 ms.
d. Output data rate = (50,000 frames/s) × (14 bits/frame) = 700 kbps. We can also calculate the output data rate as the sum of input data rates because there are no synchronization bits. Output data rate = 2 × 200 + 2 × 150 = 700 kbps.

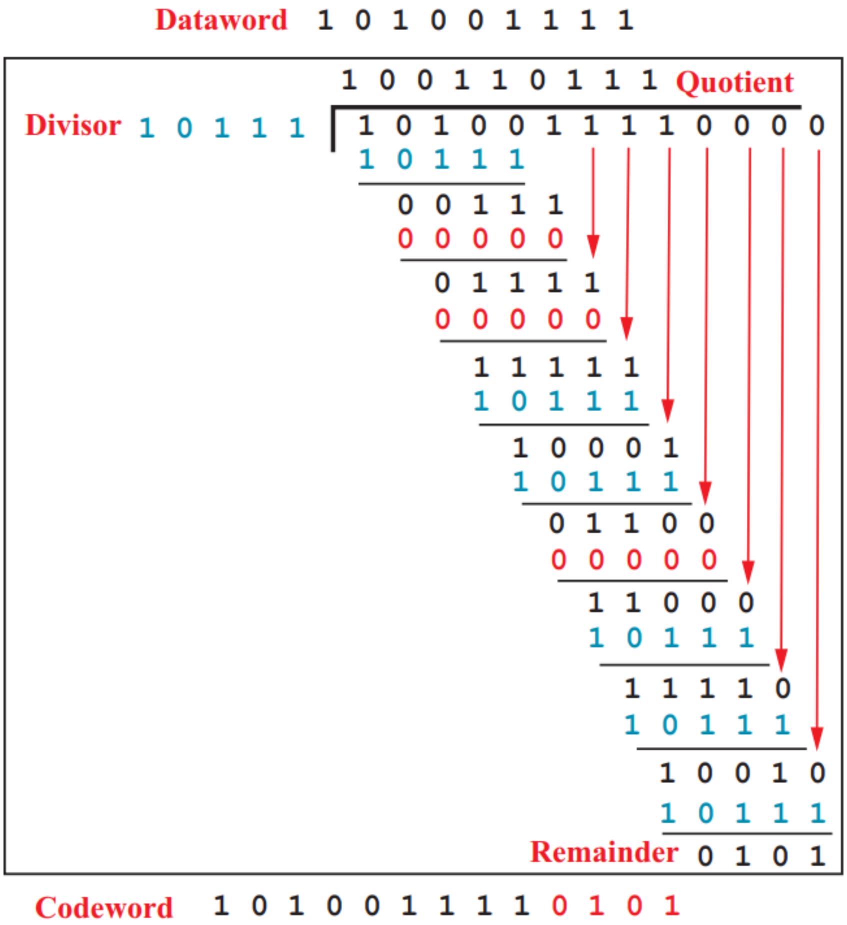
6. Assuming even parity, find the parity bit for each of the following data units.
   a. 1001011
   b. 0001100
   c. 1000000
   d. 1110111

Solution:

	Dataword		Number of 1s		Parity	Codeword
a.	1001011	→	4 (even)	→	0	10010110
b.	0001100	→	2 (even)	→	0	00011000
c.	1000000	→	1 (odd)	→	1	10000001
d.	1110111	→	6 (even)	→	0	11101110

7. Given the dataword 1010011110 and the divisor 10111,
   a. Show the generation of the codeword at the sender site (using binary division).

Solution:



8. Using 5-bit sequence numbers, what is the maximum size of the send and receive windows for each of the following protocols?
   a. Stop-and-Wait ARQ
   b. Go-Back-N ARQ
   c. Selective-Repeat ARQ

   Solution:
   a) 1,1
   b) 31, 1
   c) 16,16

9. A system uses the Stop-and-Wait ARQ Protocol. If each packet carries 1000 bits of data, how long does it take to send 1 million bits of data if the distance between the sender and receiver is 5000 Km and the propagation speed is 2 x 10^8 m? Ignore transmission, waiting, and processing delays.

   Solution:

We assume no data or control frame is lost or damaged. Packet size = 10^3 bits
Total data to be transmitted = 10^6 bits
Therefore, number of packets to be transmitted = $10^6 / 10^3$ = 1000
Propagation delay for one packet = Distance / Propagation speed = $(5 * 10^6) / (2*10^8)$ = 0.025 s
Propagation delay for one ACK = Distance / Propagation speed = $(5 * 10^6) / (2*10^8)$ = 0.025 s
Here, transmission delay is 0.
So, Total time to transmit one packet and receive its ACK = 2 * 0.025 = 0.05s
Therefore, total time to transmit 1000 packets = 1000 * 0.05 = **50 s**

10. Assume the propagation delay in a broadcast network is 5 ms and the frame transmission time is 10 ms.
    a. How long does it take for the first bit to reach the destination?
    b. How long does it take for the last bit to reach the destination after the first bit has arrived?
    c. How long is the network involved with this frame (vulnerable to collision)?The last bit is 10 ms behind the first bit.

    Solution:
    a. It takes 5 ms for the first bit to reach the destination.
    b. The last bit arrives at the destination 10 ms after the first bit.
    c. The network is involved with this frame for 5 + 10 = 15 ms.

11. Assume the propagation delay in a broadcast network is 3 μs and the frame transmission time is 5 ms. Can the collision be detected no matter where it occurs?

    Solution:
    The sender needs to detect the collision before the last bit of the frame is sent out. If the collision occurs near the destination, it takes 2 × 3 = 6 μs for the collision news to reach the sender. The sender has already sent out the whole frame; it is not listening for a collision anymore.

12. Assume the propagation delay in a broadcast network is 12 ms and the frame transmission time is 8 ms.
    a. How long does it take for the first bit to reach the destination?

b. How long does it take for the last bit to reach the destination after the first bit has arrived?
c. How long is the network involved with this frame (vulnerable to collision)?

Solution:
The last bit is 8 ms behind the first bit.
a. It takes 12 ms for the first bit to reach the destination.
b. The last bit arrives at the destination 8 ms after the first bit.
c. The network is involved with this frame for 8 + 12 = 20 ms.

13. We have a pure ALOHA network with a data rate of 10 Mbps. What is the maximum number of 1000-bit frames that can be successfully sent by this network?

    Solution:
    The maximum efficiency in a pure Aloha network is 0.184.
    Smax = 0.184 *10 Mbps = 1,840,000 bps
    Maximum number of frames per second = 1,840,000 / 1000 = 1840

14. To understand why we need to have a minimum frame size $T_{fr} = 2 \times T_p$ in a CDMA/CD network, assume we have a bus network with only two stations, A and B, in which $T_{fr} = 40$ ms and $T_p = 25$ ms. Station A starts sending a frame at time $t = 0.0$ ms and station B starts sending a frame at $t = 23.0$ ms. Answer the following questions:
    a. Do frames collide?
    b. If the answer to part *a* is yes, does station A detect collision?
    c. If the answer to part *a* is yes, does station B detect collision?

    Solution:
    The first bit of each frame needs at least 25 ms to reach its destination.
    a. The frames collide because 2 ms before the first bit of A's frame reaches the destination, station B starts sending its frame. The collision of the first bit occurs at t = 24 ms.
    b. The collision news reaches station A at time t = 24 ms + 24 ms = 48 ms. Station A has finished transmission at t = 0 + 40 = 40 ms, which means that the collision news reaches station A 8 μs after the whole frame is sent and station A has stopped listening to the channel for collision. Station A cannot detect the collision because Tfr < 2 × Tp.
    c. The collision news reaches station B at time t = 24 + 1 = 25 ms, just two ms after it has started sending its frame. Station B can detect the collision.

15. In a slotted Aloha network with $G = 1/2$, how is the throughput affected in each of the following cases?
a. G is increased to 1. **b.** G is decreased to 1/4.

Solution:
In a slotted Aloha, the throughput at G = 1/2 is 30.2%.
a. When G = 1, the throughput is increased to the maximum value of 36.8%.
b. When G = 1/4, the throughput is increased to 32.1%

16. Answer the following questions:
a. What is the polynomial representation of 101110?
b. What is the result of shifting 101110 three bits to the left?
c. Repeat part b using polynomials.
d. What is the result of shifting 101110 four bits to the right?
e. Repeat part d using polynomials.

Solution:

a. 101110 $\rightarrow$ $x^5 + x^3 + x^2 + x$

b. 101110 $\rightarrow$ 101110**000** (Three 0s are added to the right)

c. $x^3 \times (x^5 + x^3 + x^2 + x) = x^8 + x^6 + x^5 + x^4$

d. 101110 $\rightarrow$ 10 (The four rightmost bits are deleted)

e. $x^{-4} \times (x^5 + x^3 + x^2 + x) = x$ (Note that negative powers are deleted)

17. Traditional checksum calculation needs to be done in one's complement arithmetic. Computers and calculators today are designed to do calculations in two's complement arithmetic. One way to calculate the traditional checksum is to add the numbers in two's complement arithmetic, find the quotient and remainder of dividing the result by 216, and add the quotient and the remainder to get the sum in one's complement. The checksum can be found by subtracting the sum from 216 - 1. Use the above method to find the checksum of the following four numbers: 43689, 64463, 45112, and 59683.

Solution:
The following shows the steps:
a. We first add the numbers in two's complement to get 212,947.
b. We divide the above result by 65,536 (or 216). The quotient is 3 and the remainder is 16,339. The sum of the quotient and the remainder is 16,342.
c. Finally, we subtract the sum from 65,535 (or 216 - 1), simulating the

complement operation, to get 49,193 as the checksum.

18. This problem shows a special case in checksum handling. A sender has two data items to send: (4567)16 and (BA98)16. What is the value of the checksum?

Solution:
The sum in this case is (FFFF)16 and the checksum is (0000)16. The problem shows that the checksum can be all 0s in hexadecimal. It can be all Fs in the hexadecimal only if all data items are all 0s, which makes no sense.

19. Bit-stuff the following frame payload:

0001111111001111101000111111111110000111

Solution:
The following shows the result. We inserted extra 0 after each group of five consecutive 1's.

0001111101100111110010001111101111110000111

20. Unstuff the following frame payload:

000111110000011111011101001110111111000001111

Solution:

We remove the zero that comes after five 1's.

00011111000011111111010011101111100001111