Tutorial questions for Chapter 6

The Link Layer and LANs

Expected time to complete: 1 week.

1. Briefly define/explain the following terms/concepts:
   a. Parity bit – the bit after a binary sequence that must, in conjunction with the preceding bits, have an even/odd sum.
   b. CRC (Cyclic Redundancy Check) – It is a form of error detection coding that is more powerful than checksum.
   c. FEC (Forward Error Correction) - is an error correction technique to detect and correct a limited number of errors in transmitted data without the need for retransmission.
   d. ALOHA – it is a random access MAC protocol that sends the data if there is data to send, and if there is a incoming message while the data is being sent, then a message collision is said to have occurred. Transmitting stations will need to transmit after an interval.
   e. CSMA/CD (Carrier Sense Multiple Access/Collision Detection) - it is a random-access MAC protocol where collisions are detection within a short time and uses carrier-sensing to defer transmissions until no other stations are transmitting.
   f. ARP (Address Resolution Protocol) – It is a communication protocol used for discovering the link layer address, i.e. MAC address, associated with a given internet layer address, i.e. typically IPv4 address.
   g. MAC (Media Access Control) – It is a network data transfer policy that determines how data is transmitted between two computer terminals through a network cable.
   h. Physical topology (bus, star)
      i. Bus topology – All nodes connected to a single medium/channel where it is possible for collisions to occur.
      ii. Star topology – All nodes are connected to a central switch where each spoke runs a separate ethernet protocol (nodes do not collide with each other).
   i. Ethernet switch – Link layer device that stores and forward ethernet frames.
   j. VLAN (Virtual Local Area Network) – any switch with VLAN capabilities can be configured to define multiple virtual LANS over a single physical infrastructure.
   k. MPLS (Multiprotocol Label Switching) - is a routing technique in telecommunications networks that directs data from one node to the next based on short path labels rather than long network addresses, thus avoiding complex lookups in a routing table and speeding traffic flows.

2. MAC address
   The following is an example MAC address.
   00:A0:C9:14:C8:29

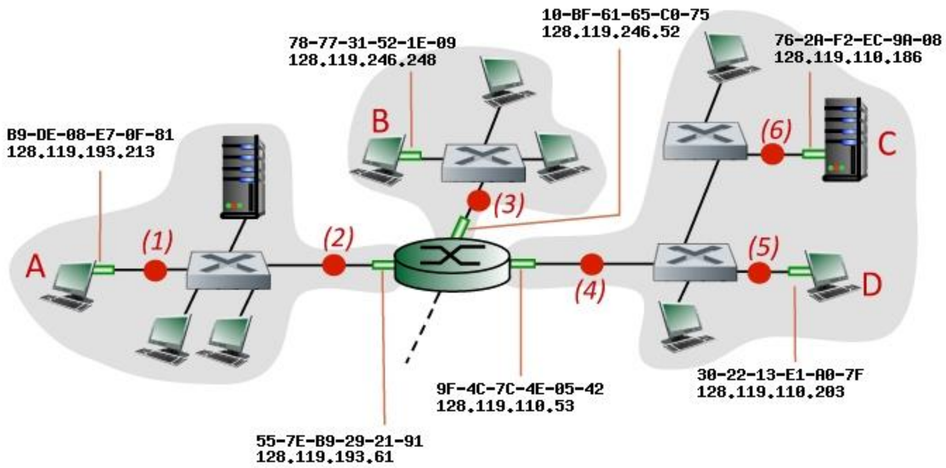
   a. Write down the part in hexadecimal indicating the adapter's manufacturer. 00:A0:C9

b. What is the identification number of the given MAC address? 14:C8:29

3. Link Layer (and network layer) addressing and forwarding:

Consider the figure below. The IP and MAC addresses are shown for nodes A, B, C and D, as well as for the router's interfaces.

https://gaia.cs.umass.edu/kurose_ross/interactive/link_layer_addressing.php



Consider an IP datagram being sent from node **B** to node **D**. Give the source and destination Ethernet addresses, as well as the source and destination addresses of the IP datagram encapsulated within the Ethernet frame at points *(1)*, *(3)*,*(4)*, and *(5)* in the figure above.

At point (3):

Ethernet source, destination address: 78-77-31-52-1E-09, 10-BF-61-65-C0-75

IP source, destination address: 128.119.246.248, 128.119.110.203

At point (4):

Ethernet source, destination address: 9F-4C-7C-4E-05-42, 30-22-13-E1-A0-7F

IP source, destination address: 128.119.246.248, 128.119.110.203

At point (5):

Same as point (4)

4. Parity bit

The two-dimensional 'odd' parity scheme is used for the following data:
01110 01010 01001 11001.
4.1. Show how one-bit error can be detected using the two-dimensional parity scheme.

The correct odd block parity is in green

0 1 1 1 0	0
0 1 0 1 0	1
0 1 0 0 1	1
1 1 0 0 1	0
0 1 0 1 1	**1**

Assuming one bit changed from 1 to 0

0 0 1 1 0	~~0~~
0 1 0 1 0	1
0 1 0 0 1	1
1 1 0 0 1	0
0 ~~1~~ 0 1 1	1

Here it can be seen that row 1 column 2 is the wrong bit, as the parity bits are incorrect. Flipping the bit at the intersection will correct the error.

4.2. Show one example of un-correctable error pattern.

0 0 1 0 0	~~0~~
0 1 0 1 0	1
0 1 0 0 1	1
1 1 0 0 1	0
0 ~~1~~ 0 ~~1~~ 1	1

In addition to part 4.1, if row 1 column 4 is also flipped, the first row fulfills the 'odd' parity scheme. But columns 2 and 4 will have bad parity, which is detectable but not correctable.

5. Cyclic Redundancy Check

Suppose we chose to send 16-bit sequence "0001 0010 0011 0100" over the Bluetooth channel. In order to enhance communication reliability, we chose to attach the CRC code using CRC-8-AUTOSAR scheme, which is commonly used in automotive integration applications. It is defined as x^8 + x^5 + x^3 + x^2 + x + 1.

5.1. How many CRC bits are added? And, what is the total number of bits to be sent?
n-k: 8 bit(s), k (data): 16 bits. Therefore, n (total) is 24 bits.

5.2. What is the CRC value? Show all your works.

1. 0001 0010 0011 0100 is multiplied by 2^8, yielding 0001 0010 0011 0100 0000 0000
2. $remainder\left(\frac{000100100011010000000000}{100101111}\right) = 10111001$

http://www.ee.unb.ca/cgi-bin/tervo/calc.pl?num=000100100011010000000000&den=100101111&f=d&e=1&m=1

3. Therefore, CRC value is 0001 00010 0011 0100 10111001

6. FEC

For k=2 and n=4, we can make the following assignment.

No	Data Block	Codeword
1	00	0000
2	01	0010
3	10	1000
4	11	1110

Suppose that a codeword block is received with the bit pattern 1001.

6.1. Can the error be detected?

Yes, the error can be detected since 1001 is not a valid codeword.

6.2. Can the error be corrected? (Calculate the Hamming distance d.)

The error can be corrected by flipping the least significant bit of 1001 to turn it to 1000.

This means that the Hamming distance is 1.