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School of Engineering

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Assignment Questions:

Data Link Layer

1. Parity Check

Suppose you are using even parity for error detection. Given the data byte '11010101', determine the parity bit that would be appended to ensure even parity. Explain the process.

Answer:

Sender sent the data '11010101'

The no. of 1's here in the data is 5. But here we are using even parity, so the no. of 1 should be even. That's why we should append another 1 with the data to make it even parity. The 1 should be appended as parity bit.

2. Cyclic Redundancy Check (CRC)

A 7-bit data string '1011101' is to be transmitted using a CRC generator polynomial '1011'. Calculate the CRC code that should be appended to the data for error detection. Show all steps in the division process.

Answer:

Given the 7-bit data string is '1011101'

CRC generator polynomial is '1011'.

It is 4 bits, we append 3 zeros (one less than the length of the polynomial) to the data string 1011101 to prepare it for division.

So, the data is now 1011101000

```
1011) 1 0 1 1 1 0 1 0 0 0 (
      1 0 1 1
      0 0 0 0 1
        1 0 1 1
        1 0 1 0
        1 0 1 1
        0 0 0 1 0
          1 0 1 1
          1 0 0 1
          1 0 1 1
          0 0 1 0 1
            1 0 1 1
            1 1 1 0
            1 0 1 1
            0 1 0 1 0
              1 0 1 1
              0 0 0 1 0
                1 0 1 1
                1 0 0 1
                1 0 1 1
                0 0 1 0 0
                  1 0 1 1
                  1 1 1 1
                  1 0 1 1
                    1 0 0
```

So, the CRC code that should be appended to the data for error detection is 100.

The final data to be checked '10 1110 1100'.

3. Checksum Calculation

Given two 8-bit data values : '10111010' and '11000111', calculate the checksum value that would be appended to detect errors. Explain how the checksum works in detecting transmission errors.

<u>Answer:</u>

The data values are '10111010' and '11000111'.
We have to do binary addition between these two numbers.

$$
\begin{array}{r}
1\ \cancel{1}\ \cancel{1}\ \cancel{1}\ \cancel{1}\ \cancel{1} \\
1\ 0\ 1\ 1\ 1\ 0\ 1\ 0 \\
+\ 1\ 1\ 0\ 0\ 0\ 1\ 1\ 1 \\
\hline
\underline{1}\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 1
\end{array}
$$

So, binary addition need to be done again with the result value '10000001' and the left most 1.

$$
\begin{array}{r}
1 \\
1\ 0\ 0\ 0\ 0\ 0\ 0\ 1 \\
+\ \ 1 \\
\hline
1\ 0\ 0\ 0\ 0\ 0\ 1\ 0
\end{array}
$$

The wrapped sum is 10000010

The one's compliment of wrapped sum is checksum value. So, the one's compliment of wrapped sum is 01111101.

Therefore, the checksum value that would be appended to detect errors is 01111101.

// How the checksum detects errors –

(i) In transmission, the sender appends this checksum to the data block.

(ii) The receiver then receives the data with the appended checksum and performs the same addition of all blocks (including the checksum).

(iii) If there are no errors, the sum should yield a result of all 1's.

(iv) If any bits have changed during transmission, the sum will differ from the expected result, allowing the receiver to detect an error in the transmission.

4. Single-Bit Error Detection Using Hamming Code

Given a 4-bit data sequence '1011', use single-bit Hamming code to generate the codeword with the necessary parity bits. Describe how the parity bits are determined and show the final encoded sequence.

Answer:

Balance the inequality

$2^r > m + r + 1$

where, m = no. of bits in data

r = no. of redundant bit required

Here, $m = 4$ bit

$\Rightarrow 2^r > 5 + r$

True for $r = 4$,

Suppose, $r1$, $r2$, $r4$, $r8$

So, total = 4 + 4 = 8 bits will be transmitted.

$r = 2^n$ ($\because n = 0, 1, 2, \ldots$)

$r8$ 1 0 1 $r4$ 1 $r2$ $r1$

$r1 : 1 \oplus 1 \oplus 1$

To make it even parity $r1 = 1$

$r2 : 1 \oplus 0 \oplus 1$

To make it even parity $r2 = 0$

$r4 : 1 \oplus 0 \oplus 1$

To make it even parity $r4 = 0$

$r8$: 0 (No operation needed)

So, Final encoded sequence 01010101.

5. Error Detection Using Hamming Code (Single-Bit Correction)

A transmitted Hamming code '1101001' is received, but errors may have occurred in transmission. Using single-bit error correction, determine if an error occurred and, if so, correct it. Show each step clearly.

Answer:

Received data is 1101001

We have to calculate each of the parity. If there has even no. of 1's then there has no errors (0) and if there has odd no. of 1's then there has odd no. of 1's.

$2^r \geq m + r + 1$

Here, $m = 4$ and $r = 3$

Let, the parity bits are $r1$, $r2$ and $r3$

$1\,1\,0\,r_3\,0\,r_2\,r_1$

$r_1 \Rightarrow$ no. of 1's by skipping the single position = 0

$r_2 \Rightarrow$ no. of 1's by skipping two positions = 0

$r_3 \Rightarrow$ no. of 1's by skipping four positions = 1

So, the bit = 001 = 1

The problem is at ~~1th~~ 4th position.

Now, we just need to change the 4th bit from 1 to 0.

The final correct data is 1100001.

Network Layer - IP Addressing

6. Class Identification

Identify the IP class of the following IP address: '193.168.4.5'. Briefly explain why it belongs to the class.

Answer:

'193.168.4.5' - This IP Address is belongs from Class C.

The prefix of Class C is 110

So, the first octate bit of class C is 11000000 → 192

the last octate bit of class C is 11011111 → 223

The range of class C is 192 to 223 and the 1st octate bit of IP address is 193 which is in between of 192 to 223.

That's why the IP Address is belong from class C.

7. Subnetting Calculation

Given an IP address '192.168.10.0/24', divide this network into four equal subnets. Provide the subnet addresses, subnet masks, and range of IP addresses in each subnet.

Answer:

Given IP address is '192.168.10.0/24'.

Network ID = 24 bits

Host ID = 32 - 24 = 8 bits

To create four equal subnets, we need to borrow 2 bits from the host portion, because $2^2 = 4$ subnets.

Original subnet mask:

11111111.11111111.11111111.00000000/24

255.255.255.0/24

New subnet mask after borrowing 2 bits

11111111.11111111.11111111.11000000/26

255.255.255.192/26

Subnet 1

192.168.10. 00000000

00000000

⋮

00111111

Range of IP address of subnet 1:

192.168.10.1/26 to 192.168.10.62/26

Subnet mask of subnet 1:

255.255.255.192/26

Subnet address : 192.168.10.0/26

Broadcast address : 192.168.10.63/26

Subnet 2

192.168.10.01000000

01000001

⋮

01111111

Subnet address of subnet 2 : 192.168.10.64/26

Subnet mask : 255.255.255.192/26

Range of IP addresses : 192.168.10.65/26 to 192.168.10.126/26

Broadcast address : 192.168.10.127/26

Subnet 3

192.168.10.10000000

10000000

⋮

10111111

Subnet address of subnet 3 : 192.168.10.128/26

Subnet mask : 255.255.255.192/26

Range of IP addresses :

192.168.10.129/26 to 192.168.10.190/26

Broadcast address : 192.168.10.191/26

Subnet 4

192.168.10.11000000

11000001

⋮

11111111

Subnet address of subnet 4: 192.168.10.192/26

Subnet mask: 255.255.255.192/26

Range of IP addresses:

192.168.10.193/26 to 192.168.10.254/26

Broadcast address: 192.168.10.255

8. IP Address Analysis

Given the IP address '172.16.3.255' with subnet mask '255.255.255.0', identify if this is a network address, broadcast address or a host IP. Explain your reasoning.

Answer:

Given IP address is '172.16.3.255' and subnet mask is '255.255.255.0'.

To find out the network address we keep the network bits unchanged and set the host bits to 0.

But for the network 172.16.3.255, the network address will be:

$$\begin{array}{r} 172 \,.\, 16 \,.\, 3 \,.\, 255 \\ \text{XOR} \quad 255 \,.\, 255 \,.\, 255 \,.\, 0 \\ \hline 172 \,.\, 16 \,.\, 3 \,.\, 0 \end{array}$$

Network address: 172.16.3.0

Again, to calculate broadcast address we set all the host bits to 1.

For the network '172.16.3.0', the broadcast address will be 172.16.3.255

Thus '172.16.3.255' is the broadcast address for this network to send data to all host of the network.