Communication Networks – HW2

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Question 1 – Parity Code:

The Hamming Distance (HD) is 4.
Let's show that any number of errors lower than 4 is detectable.

1: If a single bit is changed then the row parity bit will detect this (as well as the column/cell parity bit).

2: In order to fix the affected row parity bit, the 2nd changed bit must be in the same row, but the column parity bit remained unchanged and will detect the error.

3: In order to fix the column parity bit the 3rd changed bit will need to be in the same column.
If all 3 bits are in the same cell, the 1st bit's cell parity bit will detect the error.
If only 2 bits are in the same cell, then the 3rd is in another cell and thus it's cell parity bit will detect the error.
If no bits are the same cell then all of their cell parity bits will detect an error.
If we assume the bits are not in the matrix, but parity bits themselves:
The 2nd and 3rd bits must be the 1st's row and column parity bits (otherwise they affect additional rows and columns, which will be detected). The cell's parity bit will detect the error because only a single bit was changed).

4 is a strict bond example: change the bits in positions (1,1), (1,2), (2,1), (2,2).
(1,1) and (1,2) will not affect the 1st row parity bit.
(2,1) and (2,2) will not affect the 2nd row parity bit.
(1,1) and (2,1) will not affect the 1st column parity bit.
(1,2) and (2,2) will not affect the 2nd column parity bit.
We changed 4 bits, all in the same cell, thus the cell parity bit will not be affected.

Question 2:

1) Given that $G(x)=x^5+x^2+1$ then G=100101, r=5.
   The word D padded with r zeroes: 101101011010100000.
   Long divison:

```
___________________
101101011010100000   | 100101:
100101
---------------------------------
001000 | 011010100000
   1001   01
---------------------------------
   0001   00|1010100000
        1   00 101
---------------------------------
        0   00 000 | 0100000
                      100101
---------------------------------
                      000101
```

   So we append 00101 to D: 1011010110101 00101.

2) Error in 4^{th} bit from left: 10110101101010 0101 → 10100101101010 0101.

```
 ____________________
101001011010100101 | 100101
100101
-------------------------
001100 | 011010100101
   1001   01
-------------------------
   0101   00 | 1010100101
     100   10   1
-------------------------
     001   10   0 | 010100101
         1   00   1   01
-------------------------
          0  10    1   00 | 0100101
              10    0   10   1
-------------------------
              00    1   10   1 | 100101
                     1   00   1   01
-------------------------
                     0  10    0   11 | 0101
                         10    0   10  1
-------------------------
                         00    0   01  1 | 101
```

The remainder is 11101, which is not 0, so the error will be detected.

<u>Question 3:</u>

1) There are 3 cases to consider:
   1. Only 1 red station transmitted in the time slot: 0 green, time slot with red, 0 blue.
      $$\left(1-\frac{1}{4}\right)^6\cdot\frac{1}{3}\cdot\frac{1}{5}=0.0118$$
   2. Only 1 green station transmitted in the time slot: 1 green, time slot without red, 0 blue.
      $$\binom{6}{1}\frac{1}{4}\cdot\left(1-\frac{1}{4}\right)^5\cdot\frac{2}{3}\cdot\frac{1}{5}=0.0475$$
   3. Only 1 blue station transmitted in the time slot: 0 green, time slot without red, 1 blue.
      $$\left(1-\frac{1}{4}\right)^6\cdot\frac{2}{3}\cdot\frac{4}{5^2}=\frac{243}{12800}=0.019$$

   So we get $0.0118+0.0475+0.019=0.0783$.

2) Now each blue time slots overlaps 2 red/green time slots (or the other way around: each red/green time slot overlaps with 2 blue slots). So we want blue to not transmit in those 2 time slots: $\binom{6}{1}\frac{1}{4}\cdot\left(1-\frac{1}{4}\right)^5\cdot\frac{2}{3}\cdot\left(\frac{1}{5}\right)^2=0.0095$.

Question 4:

1) The transmission time is: $t_{transmit}=\frac{\text{frame size}}{\text{bit rate}}=\frac{800\,bits}{100}\,Mbps=8\cdot 10^{-6}\,s=8\,\mu s$.

In CSMA/CD we want to satisfy: $d\leq\frac{v\cdot t_{transmit}}{2}=\frac{10^5\cdot 8\cdot 10^{-6}}{2}=400\,m$.

2) We need to calculate the time for a single bit to pass 300 meters, and add the transmission time (which we calculated in the previous section to be $8\,\mu s$). Then we multiply by 3 (3 segments).

$t_{300\,m}=\frac{300\,m}{100{,}000\,km/s}=3\cdot 10^{-6}\,s=3\,\mu s$.

$t_{segment}=3\,\mu s+8\,\mu s=11\,\mu s\Rightarrow t_{total}=3\cdot t_{segment}=33\,\mu s$.

3) Initially, both nodes will try to transmit, so we are guaranteed a collision. The probability for the 2nd collision – $\frac{1}{2}$, for the 3rd – $\frac{1}{4}$.

$P(3\,fails)=1\cdot\frac{1}{2}\cdot\frac{1}{4}=\frac{1}{8}$

Question 5:

1) A message is sent from Node A to Node E, then from Node B to Node A (**without return messages**).

Switch 1		**Switch 2**		**Switch 3**		**Switch 4**	
Port	MAC	Port	MAC	Port	MAC	Port	MAC
1	B	1	A	1		1	
2	A	2		2	A,B	2	A,B
3		3	B	3		3	

2)

Switch 1		**Switch 2**		**Switch 3**		**Switch 4**	
Port	MAC	Port	MAC	Port	MAC	Port	MAC
1	B	1	A	1		1	
2		2		2	A,B	2	A,B
3		3	B	3		3	
4	A						

After the message from A to B, because the 2 computers are directly connected to Switch1, the switch will pass the message directly to B (it knows it's location) and not spread A's location to the other switches. In addition, Switch2 still "knows" that A is in it's port1, so it will deliver the message directed to A through that port.

Therefore, any computer that is not directly connected to Switch1, will fail to send a message to A – it will be delivered to Switch2's port1, not it's destination.

Computers D,E,F will fail to send a message to A. (B and C will succeed)

Question 6:

We will show the BPDU messages and the root port:

B15 – (15, 0, 15)

B24 – (15, 1, 24), Root port: P4

B51 – (15, 1, 51), Root port: P1

B16 – (15, 1, 16), Root port: P1

B23 – (15, 2, 23), Root port: P1

B54 – (15, 2, 54), Root port: P2