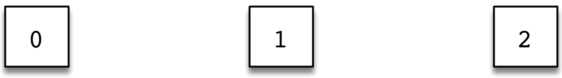
1. A datalink protocol uses a CRC that is based on the following generator polynomial: $C(x) = 1 + x + x^3$

   a. Calculate the CRC polynomial resulting when transmitting the following data: (Leftmost bit is the MSB): **101110**

1. Generator polynomial $C(x) = 1 + x + x^3$

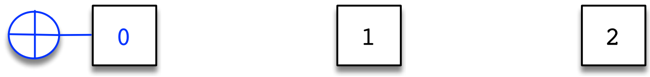
2. The circuit uses k one-bit shift registers (k=3 in this case)

Since the order of C(x) is k = 3, the circuit must have 3 registers, each one of which is assigned to powers of x^0 through (3-1), in this case <u>powers are: 0, 1 and 2</u> (It can be mathematically demonstrated that the value stored at the register for x^k (In this case, x^3) is always 1, consequently, it's not necessary to add it to the circuit!)

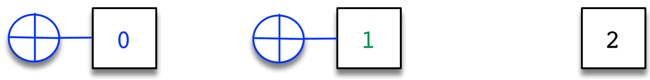


3. Add an XOR gate at the input of each register which coefficient is 1 in C(x): $1x^0$, $1x^1$ and $0x^2$

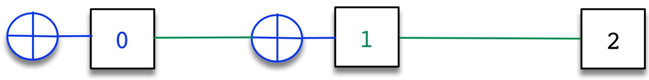
Since term $1 \cdot x^0$ does belong in C(x), we add an XOR gate at the input of register 0



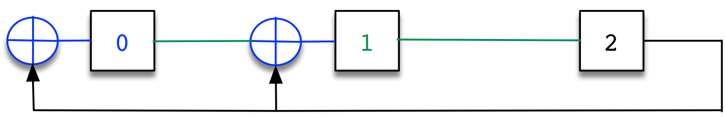
Since term $1 \cdot x^1$ does belong in C(x), we add an XOR gate at the input of register 1



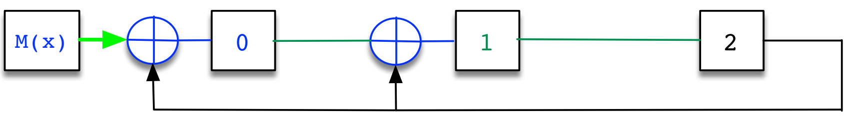
Since the term x^2 <u>does not</u> belong in C(x), we connect its input directly to the output of its former shift register (0)



4. Connect the output of the Most Significant Register (2) to all the XOR gates



5. Connect the output of the data string (Polynomial M(x)) to the input of the least significant XOR gate (At the leftmost area)



The following table develops the evolution of the circuit state from the initial state through the end of CRC computation:

- Initial state: We load 0's in all the registers. Register M(x), at this initial stage contains the Most Significant Bit of the data string (Polynomial M(x))
- Add k zeros at the least significant end of M(x), in this case, we will add three bits 0
- CRC computation proceeds as a *state machine* by computing the next row from the contents of only the present row. It finishes when the last bit 0 from M(x) is consumed (The last of the k bits 0 that we appended to M(x)); at that point in time, the next row is the CRC polynomial.

M(x)	x^0	x^1	x^2
1	0	0	0
0	1	0	0
1	0	1	0
1	1	0	1
1	0	0	0
0	1	0	0
0	0	1	0
0	0	0	1
0	1	1	0
CRC =	0	1	1

The sender transmits the data bits (M(x)) alongside with the CRC bits, when the receiver receives all these bits, it has to apply the CRC error checking.

b. What operation is executed at the receiver for checking whether some error took place? Calculate the result of that operation and tell whether or not an error took place (That is, probabilistically).

CRC error checking at the receiver basically consists of forming the same table replacing the last k bits 0 by the received CRC bits and proceeding likewise.

M(x)	x^0	x^1	x^2
1	0	0	0
0	1	0	0
1	0	1	0
1	1	0	1
1	0	0	0
0	1	0	0
1	0	1	0
1	1	0	1
0	0	0	0
CRC' =	0	0	0

c. If the execution of the operation you explained on section b. of this question reports that no error took place, what interpretation should be derived from this fact?

The CRC' resulting in this case should be k (k = 3) bits 0: 000. These 3 bits being 0 is the indication that *probably* no error took place in this transmission. We cannot state for sure that no error took place on the basis of the CRC' bits being all 0, but, we can state that with a high probability. Additionally, we must notice that the computed CRC is not comprised of all bits 0, then, we can state with a *full certainty* that at least one error took place.

2. **Each of two hosts A and B, connected to an Ethernet network has one frame pending of transmission, F_a and F_b, respectively.** So far, host A has undergone a total of 29 collisions, 3 of which were as a result of attempting the transmission of F_a. Likewise, host A has undergone a total of 48 collisions, 2 of which were as a result of attempting the transmission of F_b. Respond to the following questions based on this context:

   a. Calculate the probability that the two hosts do not collide again

   - In transmitting a frame, host A has undergone 3 collisions, therefore the cardinal of sample space it will use for selecting a random number is $2^3 = 8$; we assign an integer to each of the 8 possible results:
     $\Omega_A = \{0, 1, 2, 3, 4, 5, 6, 7\}$
   - In transmitting a frame, host B has undergone 2 collisions, therefore the cardinal of sample space it will use for selecting a random number is $2^2 = 4$; we assign an integer to each of the 4 possible results:
     $\Omega_B = \{0, 1, 2, 3\}$
   - The cartesian product of represents all the results possible after A and B choose their respective random number:
     Ω_A x Ω_B = {

```
 (0,0), (0,1), (0,2), (0,3),
 (1,0), (1,1), (1,2), (1,3),
 (2,0), (2,1), (2,2), (3,3),
 (3,0), (3,1), (3,2), (3,3),

 . . .

 (7,0), (7,1), (7,2), (7,3)
}
```

     The total number of possibilities is card(Ω_A) x card(Ω_B) = 8 x 4 = 32. This is the number of *possible cases.*
   - Responding to the present question entails determining how many of the possible cases are favorable to the hypothesis "not a collision takes place". This hypothesis is represented by all the pairs (x,y) $\in \Omega_A$ x Ω_B such that $x \neq y$; on the first four rows, there exist 16 – 4 such cases; on the remaining 4 rows (The last ones), all the pairs comply with the predicate $x \neq y$. In summary, we have a total of (16-4)+16 = 28. Now, we can calculate the a-priori probability using as number of possible cases the cardinal sample space Ω_A x Ω_B:

$$P_{no-collision} = \frac{28}{32} = 0{,}875$$

   b. Calculate the probability that host A takes less than 150 μs in attempting a new transmission

   - The backoff exponential algorithm sets the time to the next transmission attempt equal to the random number generated by the host (r) times the constant 51,2μs: r x 51,2μs. The problem is asking us the probability that the time to the next transmission attempt be less than 150 μs, then, we resolve r in the following inequation: $r \in \mathbb{N}$,   r x 51,2μs < 150 μs; r <2,93. The only integers that satisfy the previous expression are r = {0, 1, 2}, therefore, there exist 3 favorable cases and; using Ω_A as the sample space:

$$P_{less\ 150\mu s} = \frac{3}{card(\Omega_A)} = \frac{3}{8} = 0{,}375$$

(Consult the teaching materials at paloalto.unileon.es/cn for working out the following questions on the present page)

3. **Briefly explain the essential components of the CSMA/CD access protocol**

4. **Briefly explain the Ethernet Switching algorithm**

5. **Briefly explain the collision detection mechanism included in CSMA/CD**

6. **Which of the following statements about the transparency mechanism included in the HDLC protocol are true:**

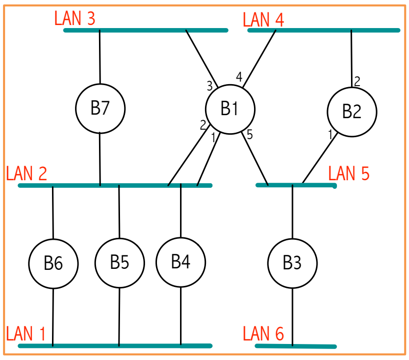
    a. It's based on the use of sentinels
    b. Sentinels are the EBCDIC characters SOH and EOH
    c. It consists of bit stuffing
    d. It consists of bit stuffing only when the data to transmit contain the special sequence SOH/EOH
    e. It consists of transmitting a DLE character before sending any special character

7. **Assume you want to transmit a block of data using the BiSync protocol and the last two Bytes in that block are the** characters DLE (one byte) and another ensuing DLE (one byte). What sequence of bytes are going to be sent by the transmitter right before the CRC? (The format of the BiSync frame specifies that tha payload is to be transmitted right before the CRC).

    a. [DLE] [ETX]
    b. [DLE] [ETX] [DLE] [ETX]
    c. [DLE] [DLE] [ETX] [ETX]
    d. [DLE] [DLE] [ETX] [DLE] [ETX]
    e. [DLE] [DLE] [DLE] [DLE] [ETX]
    f. [DLE] [DLE] [DLE] [ETX]
    g. None of the options included above

7. Spanning Tree

a. Apply the Spanning Tree Algorithm to the Extended Lan depicted in the diagram to obtain its Spanning Tree.

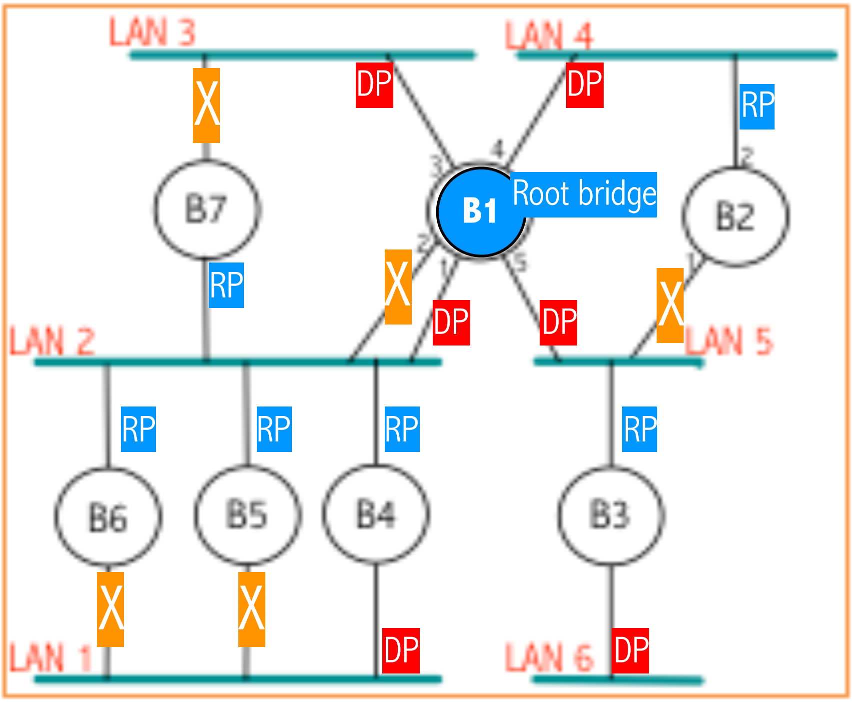


b. What SOURCE MAC and what DESTINATION MAC are contained in Ethernet frames that carry Spanning Tree Protocol messages (Protocol IEEE 802.1D)? (That is, explain their semantics or function).

- Source MAC is the MAC of the transmitting switch port
- Destination MAC is a special MAC address known as the all bridges multicast MAC address, which value is IEEE reserved address `0x0180C2000000`. It serves for the bridges to exchange BPDU's without resorting to the IEEE MAC broadcast address and limiting the receivers to the bridges.

c. What is the purpose of the Root Ports? And, what is the purpose of the Designated Ports?

- In summary, the **root port** of a bridge has the property of connecting it to the root bridge via one of the many possible least-cost paths to the root bridge, and the **designated port** of a LAN provides that LAN connectivity to the root bridge via one specific least-cost path to the root bridge[1].



[1] From textbook "Conceptual Computer Networks"

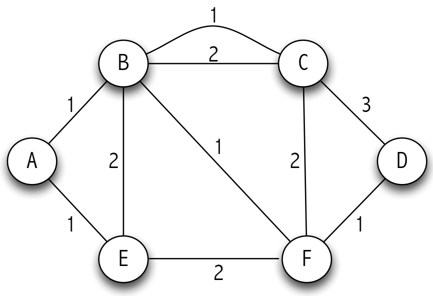
(Consult the teaching materials at paloalto.unileon.es/cn for working out the following questions)

8. The internetwork diagram included in this question represents a routing domain based on the OSPF protocol

a. Apply the Dijkstra's algorithm at node B to obtain its Shortest Path Tree

b. Obtain node B's FIB (Routing Table).

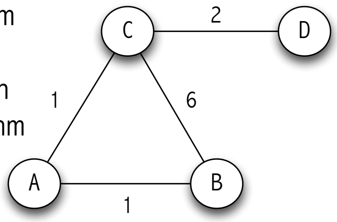
c. Depict the resulting Shortest Path Tree of node B



9. Distance Vector Algorithm/Bellman-Ford formula

a. Briefly explain the Distance Vector routing algorithm

b. The adjoining diagram represents a routing domain based on the RIP protocol (DV). Apply that algorithm to obtain the final routing table of node D.



10. The adjoining table represents the routing table of an IP router. An IP packet is received by the router which destination address 193.146.97.254. Determine the next-hop selected by the IP router in this case for forwarding the IP packet. Explain the process you followed in computing it.

Prefix	Next hop
193.146.96.0/22	192.168.1.2
193.146.97.0/24	Eth1
192.168.1.0/24	Eth0
0.0.0.0 (default)	192.168.2.2
192.168.2.0/24	Eth2

11. An organization O has four departments containing the following numbers of internet hosts: A = 20, B = 40, C = 60 and D = 12. Obtain a correct IP numbering scheme that uses a single CIDR block that encompasses the IP addresses for the four CIDR blocks. One of the IP addresses contained in the global CIDR block is 190.44.55.66.

12. Consider the internetwork included in the following diagram:

a. Develop the path of a packet sent from comp0 to comp1

b. Do the switch port MAC addresses have any importance in this context?

c. In which networking context do those switch port MAC addresses have an essential role?