CMP-4005 – Homework 2

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1. Let A and B be two stations attempting to transmit on an Ethernet. Each has a steady queue of frames ready to send; A's frames will be numbered A1, A2, and so on, and B's similarly. Let T=
51.2μs be the exponential backoff base unit. Suppose A and B simultaneously attempt to send frame 1, collide, and happen to choose backoff times of 0 x T and 1 x T, respectively, meaning A wins the race and transmits A1 while B waits. At the end of this transmission, B will attempt to retransmit B1 while A will attempt to transmit A2. These first attempts will collide, but now A backs off for either 0 x T or 1 x T, while B backs off for time equal to one of 0 x T, . . ., 3 x T.

a) Give the probability that A wins this second backoff race immediately after this first collision;
that is A's first choice of backoff time k x 51.2 is less that B's.

A: 0, 1
B: 0, 1, 2, 3

A wins when:
A: 0; B: 1
A: 0; B: 2
A: 0; B: 3
A: 1; B: 2
A: 1; B: 3

The probability that A wins is of 5/8

b) Suppose A wins this second backoff race. A transmits A3, and when it is finished, A and B collide again as A tries to transmit A4 and B tries once more to transmit B1. Give the probability that A wins this third backoff race immediately after the first collision.

A: 0, 1
B: 0, 1, 2, 3, 4, 5, 6, 7

If a = 0xT, wins when B = 1,2,3,4,5,6,7
If a = 1xT, wins when B = 2,3,4,5,6,7

The probability that A wins is of 13/16

c) Give a reasonable lower bound for the probability that A wins all the remaining backoff races.

P(A) = (2+2n-1)+ (2+2n-2) / 2*(2+2n)
P(A) = 1+4n / 4+4n

$$P(A) = \frac{1+4n}{4+4n}$$

P(A wins every race | A won first 3 races) ≈ $\prod_{n=4} \frac{1+4n}{4+4n} \approx 3/4$

d) What then happens to the frame B1? This scenario is known as the Ethernet capture effect.

Node A wins the backoff and transmits frame A1, while node B defers its transmission and waits for the medium to become idle again. However, when node B attempts to retransmit its frame B1 after the transmission of A1, the capture effect occurs and A's transmission continues to occupy the medium, preventing B from transmitting its frame. As a result, B1 is lost and will need to be retransmitted after another backoff period.

2. Suppose Ethernet physical addresses are chosen at random (using true random bits).
a) What is the probability that on a 1024-host network, two addresses will be the same?

Possible addresses = 2^48

P(x) = $1 - (\frac{1+2+3\ldots+1023}{2^{48}})$
P(x) ≈ $1.87x10^{-9}$

b) What is the probability that the above event will occur on some one or more of 2^20 networks?

2^20=1048576
$1.87x10^{-9}$*11048576=0.00196 ≈ $1.96x10^{-3}$

c) What is the probability that of the 2^30 hosts in all the network of (b), some pair has the same address?
Hint: Check the Birthday Problem

P(x) = $\frac{(2^{30})^\wedge 2}{2*2^{48}}$

P(x) = $2^{11} = 2048$

3. Why might a mesh topology be superior to a base station topology for communications in a natural disaster?

In a mesh topology, each node can communicate with multiple other nodes. This redundancy can help to ensure that if one node fails or is destroyed, the network can still function. In contrast, in a base station topology, if the base station is destroyed, the entire network can be compromised.

Mesh topologies are highly flexible and can be quickly adapted to changing conditions. Nodes can be added or removed as needed, and the network can reconfigure itself to find new paths for communication.

4. Suppose an IP packet is fragmented into 10 fragments, each with a 1% (independent) probability of loss. To a reasonable approximation, this means there is a 10% chance of losing the whole packet due to loss of a fragment. What is the probability of net loss of the whole packet if the packet is transmitted twice

a) Assuming all fragments received must have been part of the same transmission?

P(x) = 0.1*0.1 = 0.01

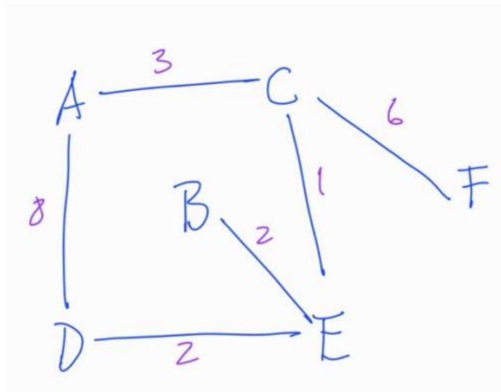
b) Assuming any given fragment may have been part of either transmission?

P(x) = 0.01*0.01*10 = 0.001

c) Explain how use of the ident field might be applicable here

One way to use the identification field is to set a unique ID value for each fragment of the original packet. This allows the receiving end to recognize which fragments belong to the same packet and reassemble them accordingly. Moreover, if any of the fragments are lost during transmission, the receiver can request retransmission of only the missing fragments by specifying their identification values.

5. For the network given in the figure below, give the datagram forwarding table for each node. The links are labeled with relative costs; your tables should forward each packet via the lowest cost path to its destination



For A:

To	**Next hop**
B	C
C	C
D	C
E	C
F	C

For B:

To	**Next hop**
A	E
C	E
D	E
E	E
F	E

For C:

To	**Next hop**
A	A
B	E
D	E
E	E
F	F

For D:

To	**Next hop**
A	E
B	E
C	E
E	E
F	E

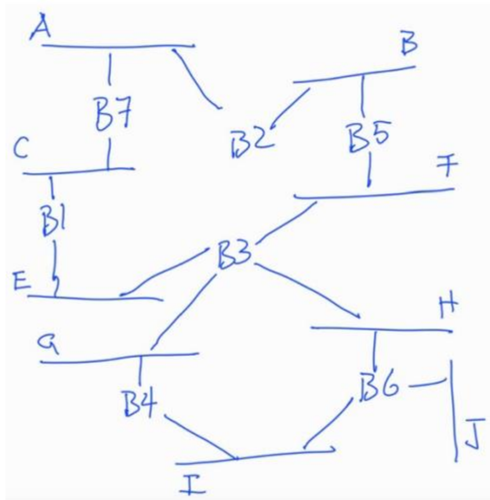
For E:

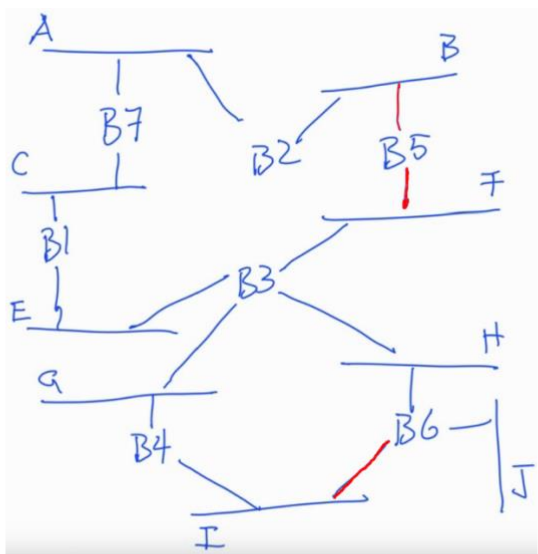
To	**Next hop**
A	C
B	B
C	C
D	D
F	C

For F:

To	**Next hop**
A	C
B	C
C	C
D	C
E	C

6. Given the extended LAN shown in the figure below, indicate which posts are not selected by the spanning tree algorithm





7. Use the Unix tool traceroute (Windows tracert) to determine how many hops it is from your host to other hosts in the internet (usfq.edu.ec, google.com, amazon.com, etc). How many routers do you traverse to get out of your local site? Read the documentation of this tool, and explain how it is implemented.

The traceroute tool is a network diagnostic tool used to determine the path that a packet takes from a source to a destination. It works by sending packets with varying time-to-live (TTL) values to the destination host, and each router along the path decrements the TTL value by 1. When the TTL reaches 0, the router discards the packet and sends an ICMP Time Exceeded message back to the source, indicating that the packet has expired. By repeatedly sending packets with increasing TTL values, traceroute can determine the path taken by the packet and the number of hops it takes to reach the destination.

```
traceroute to google.com (142.250.78.142), 64 hops max, 52 byte packets
 1  192.168.1.1 (192.168.1.1)  5.339 ms  3.025 ms  5.515 ms
 2  192.168.100.1 (192.168.100.1)  3.760 ms  6.432 ms  13.233 ms
 3  181.39.211.129 (181.39.211.129)  9.228 ms  5.908 ms  17.346 ms
 4  10.224.51.134 (10.224.51.134)  37.863 ms  4.927 ms  4.479 ms
 5  186.3.125.46 (186.3.125.46)  5.950 ms
    142.250.163.94 (142.250.163.94)  11.772 ms
    186.3.125.46 (186.3.125.46)  8.691 ms
 6  142.250.163.95 (142.250.163.95)  25.214 ms
    186.3.125.47 (186.3.125.47)  21.237 ms
    142.250.163.95 (142.250.163.95)  19.425 ms
 7  * * *
 8  bog02s18-in-f14.1e100.net (142.250.78.142)  17.512 ms  26.287 ms
    142.250.210.116 (142.250.210.116)  49.168 ms
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```
traceroute to facebook.com (157.240.6.35), 64 hops max, 52 byte packets
 1  192.168.1.1 (192.168.1.1)  5.432 ms  2.645 ms  2.147 ms
 2  192.168.100.1 (192.168.100.1)  10.582 ms  14.766 ms  4.785 ms
 3  181.39.211.129 (181.39.211.129)  10.528 ms  10.023 ms  8.348 ms
 4  10.224.51.134 (10.224.51.134)  53.150 ms  18.085 ms  6.634 ms
 5  157.240.81.119 (157.240.81.119)  5.927 ms
    157.240.71.55 (157.240.71.55)  6.645 ms
    157.240.81.119 (157.240.81.119)  10.205 ms
 6  ae8.pr01.bog1.tfbnw.net (157.240.71.54)  28.888 ms
    ae0.pr04.bog1.tfbnw.net (157.240.81.118)  28.201 ms
    ae8.pr01.bog1.tfbnw.net (157.240.71.54)  85.732 ms
 7  po101.psw04.bog1.tfbnw.net (129.134.46.113)  20.458 ms
    po104.psw02.bog1.tfbnw.net (129.134.55.235)  21.094 ms
    po101.psw03.bog1.tfbnw.net (129.134.32.43)  21.875 ms
 8  157.240.38.175 (157.240.38.175)  29.839 ms
    173.252.67.73 (173.252.67.73)  20.809 ms
    157.240.38.137 (157.240.38.137)  20.639 ms
 9  edge-star-mini-shv-01-bog1.facebook.com (157.240.6.35)  26.713 ms  21.901 ms  54.055 ms
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```
traceroute to youtube.com (172.217.173.46), 64 hops max, 52 byte packets
 1  192.168.1.1 (192.168.1.1)  2.039 ms  1.790 ms  1.757 ms
 2  192.168.100.1 (192.168.100.1)  2.829 ms  2.485 ms  3.619 ms
 3  181.39.211.129 (181.39.211.129)  46.549 ms  15.605 ms  7.693 ms
 4  10.224.51.134 (10.224.51.134)  5.203 ms  35.531 ms  4.709 ms
 5  142.250.163.94 (142.250.163.94)  5.025 ms
    186.3.125.46 (186.3.125.46)  11.321 ms
    74.125.146.39 (74.125.146.39)  10.688 ms
 6  186.3.125.47 (186.3.125.47)  24.209 ms
    74.125.146.38 (74.125.146.38)  116.952 ms
    142.250.163.95 (142.250.163.95)  36.408 ms
 7  * * *
 8  bog02s12-in-f14.1e100.net (172.217.173.46)  18.994 ms
    142.250.231.162 (142.250.231.162)  22.029 ms
    142.250.210.144 (142.250.210.144)  24.150 ms
```

It takes about 8 hops to reach other hosts, and the 4 first hops are traversed to get out of my local site.

8. An ISP with a class B address is working with a new company to allocate it a portion of address space based on CIDR. The new company needs IP addresses for machines in three divisions of its corporate network: Engineering, Marketing, and Sales. These divisions plan to grow as follows: Engineering has 5 machines as of the start of year 1 and intends to add 1 machine every week; Marketing will never need more than 16 machines; and Sales needs 1 machine for every two clients. As of the start of year 1, the company has no clients, but the sales model indicates that by the start of year 2, the company will have six clients and each week thereafter gets one new client with probability 60%, loses one client with probability 20%, or maintains the same number with probability 20%.

a) What address range would be required to support the company's growth plans for at least seven years if marketing uses all 16 of its addresses and the sales and engineering plans behave as expected?

Engineering:

At the start of year 1, Engineering has 5 machines. Every week, they add 1 machine. So at the end of year 1, they will have 5 + 52 = 57 machines. Over the course of seven years, they will have 5 + 52 x 7 = 369 machines.

Marketing:

Marketing will never need more than 16 machines.

Sales:

Sales needs 1 machine for every two clients. As of the start of year 1, the company has no clients. By the start of year 2, they will have six clients. From year 2 onwards, they will gain or lose clients according to the given probabilities. Assuming that the number of clients grows at an average rate, we can estimate the number of clients at the end of each year as follows:

-0.2+0.6 = 0.4 clients per week
0.4*52 = 20.8 clients per year -> 10.4 machines per year

Now we can calculate the total number of IP addresses needed for the company's growth plans:

Engineering: 369
Marketing: 16
Sales: 6+10.4*6 = 68

Total: 369 + 16 + 68 = 453 machines

A subnet of /23 is needed, to fit at most 512 machines.

b) How long would this address assignment last? At the time when the company runs out of address space, how would the addresses be assigned to the three groups?

512 = 5+52n + 6 +10.4n + 16
n ≈ 7.77 years

It would last 7.77 years
Engineering = 409
Marketing = 16
Sales = 86

c) If CIDR addressing were not available for the 7-year plan, what options would the new company have in terms of getting address space?

If CIDR addressing were not available, the company would have to obtain additional class B or class C address blocks from the ISP to accommodate its growth plans. One class B, or 2 class C address blocks would be needed.