Computer Networks

Homework 2

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Exercise 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.

- 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.
- 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.
- Give a reasonable lower bound for the probability that A wins all the remaining backoff races.
- What then happens to the frame B1?

This scenario is known as the Ethernet capture effect.

Sol.

- The idea is that A has to be smaller than B, thus as $k(A) = [0, 1]$ and $k(B) = [0, 1, 2, 3]$, then the case is that A is 0 and B is any other than 0 or A is 1 and B is either 2 or 3, thus, as we expect same probability of each case then

$$P[E = A] = P[A = 0, B \neq 0] + P[A = 1, B > 1]$$
$$P[E = A] = \frac{1}{2} * \frac{3}{4} + \frac{1}{2} * \frac{2}{4}$$
$$P[E = A] = \frac{3}{8} + \frac{2}{8}$$
$$P[E = A] = \frac{5}{8}$$

- Same idea in this case $k(A) = [0, 1]$ and $k(B) = [0, 1, 2, 3, 4, 5, 6, 7]$

$$P[E = A] = P[A = 0, B \neq 0] + P[A = 1, B > 1]$$

$$P[E = A] = \frac{1}{2} * \frac{7}{8} + \frac{1}{2} * \frac{6}{8}$$
$$P[E = A] = \frac{7}{16} + \frac{6}{16}$$
$$P[E = A] = \frac{13}{16}$$

- I think we can actually calculate for an n collision what is the probability for A to win, for that we can see that for $P[E = A_n]$ that is the probability for A to win in the n step is

$$P[E = A_n] = \frac{2^n - 1 + 2^n - 2}{2^{n+1}}$$
$$\lim_{n\to\infty} P[E = A_n] = 1$$

For n ∈ 3,10,20,30 we can show a table

n	P[E=A_n]
3	0.95
10	0.99926
20	0.99999
30	0.99999

Table 1: P for n

as n grows we an see this graphic So we have to find the probability that each times it wins,

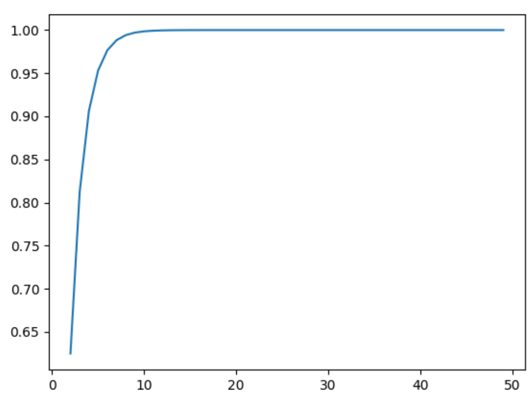


Figure 1: Limit of P

thus at first we are going to see that we need

$$P[Aremaining] = \prod_{n=4}^{\infty} \frac{2^n - 1 + 2^n - 2}{2^{n+1}}$$
$$P[Aremaining] \approx 0.8245$$

Probability drops when added the first two instances (so the important part is to not loose anyone)

$$P[Aall] = \prod_{n=2}^{\infty} \frac{2^n - 1 + 2^n - 2}{2^{n+1}}$$

$$P[Aall] \approx 0.418$$

- If we set a limit of time that the Ethernet cable has to transmit, then after it passes B will drop B1, and start transmitting B2.

Exercise 2:

> Suppose Ethernet physical addresses are chosen at random (using true random bits).
>
> - What is the probability that on a 1024-host network, two addresses will be the same?
> - What is the probability that the above event will occur on some one or more of 2^{20} networks?
> - 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

Sol.
Ethernet addresses will be a 12-long char address, for simplicity is the same as saying that the Ethernet is a 48bits char array, as a bit can only be 1 or 0, then there exits 2^{48} possible addresses, but in Ethernet there are two fixed bits, thus there is 2^{46} possible addresses

- If there is 1024-host network then the probability is going to be

$$P_{1024} = \frac{\sum_{i=1023}^{1} i}{2^{46}} = 7.4433046393096446990966796875 \times e^{-9}$$

- Now for 2^{20} then we have

$$P_{2^{20}} = \left(1 - \frac{1}{2^{46}}\right) \times \cdots \times \left(1 - \frac{2^{20} - 1}{2^{46}}\right)$$

  we are going to have to find a optimization, then we can use the fact that $2^{20} << 2^{46}$ and then using stirling approximation

$$n! \approx \frac{n^n}{e^n}\sqrt{2\pi n}$$

  Making that

$$xPy \approx y^x$$

  Then

$$P_{2^{20}} \approx \frac{(2^{20})^2}{2 * 2^{46}}$$

$$P_{2^{20}} \approx \frac{(2^{40})^2}{2^{47}}$$

$$P_{2^{20}} \approx \frac{1}{2^7} = 0.007812$$

- We could not do that for 2^{30} so for this we are going to do something sketchy, we are going to map the probability to the original birthday problem to our problem, as we have essentially the same distribution, we know that the original birthday problem and use the approximation such that

$$P_n \approx 1 - \prod_{i=1}^{n} e^{\frac{i}{2^{46}}}$$

$$P_n \approx 1 - e^{-\frac{n(n-1)}{2^{46}}}$$

Then

$$P_{2^{30}} \approx 1 - e^{-\frac{2^{30}(2^{30}-1)}{2^{46}}}$$

Then

$$P_{2^{30}} \approx 1 - e^{-\frac{2^{60}}{2^{46}}}$$

$$P_{2^{30}} \approx 1 - e^{2^{14}}$$

$$P_{2^{30}} \approx 1$$

Exercise 3:

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

Sol.
First answering the question directly to a natural disaster. In this event there is a high likelihood that one of the servers, routers, devices will be damage, so in a mesh topology as there is a lot of redundancy of connections then the whole network won't stop working as it has a lot of ways to distribute it self and not be disrupted by a damaged node. So specifically, if one of the nodes is damaged in natural disaster then the network can find ways to reroute the data and manage the problematic node.
Another possible advantage is that as it is more flexible then we can add more nodes in order to manage the resolution of the problem

Exercise 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
>
> - Assuming all fragments received must have been part of the same transmission?
> - Assuming any given fragment may have been part of either transmission?
> - Explain how use of the ident field might be applicable here

- We can see that there is a 99% probability that a package will get to it's intended destination, so let's see that there are 10 packages thus the probability of a net loss then is

$$1 - 0.99^{10} = 0.95617\%$$

  This is for a single fragmented fragment, as we want send two times in the same transmission, we have to find the probability for it to happen twice

$$(0.95617\%)^2 = 0.00914\%$$

- Now as we don't have way to separated between transmission, then the probability for a package loss is $0.01^2 = 0.0001$ so the probability that for a single fragment to not fail is going to be $1 - 0.0001$, thus for fragments the probability to be a loss is going to be

$$1 - (1 - 0.001)^{10} = 0.00992\%$$

- in this case we can see that if we do not identify between the two packages then is going to be a higher probability of a net loss, thus with the identification field will help us reduce the probability of a net loss if we use this technique

Exercise 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 lowestcost path to its destination

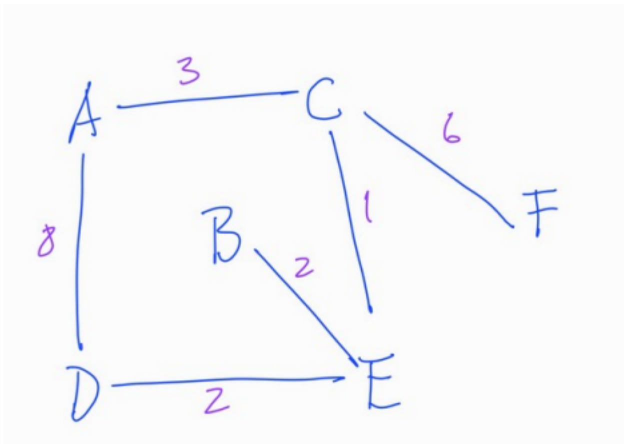


Figure 2: Problem

Sol. Respectively for each of the node that is missing for the table

Destination	Next Hop	Destination	Next Hop	Destination	Next Hop
B	C	A	E	A	A
C	C	C	E	B	E
D	C	D	E	D	E
E	C	E	E	E	E
F	C	F	E	F	F

Destination	Next Hop	Destination	Next Hop	Destination	Next Hop
A	E	A	C	A	C
B	E	B	B	B	C
C	E	C	C	C	C
E	E	D	D	D	C
F	E	F	C	E	C

Table 2: Datagram

Exercise 6:

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

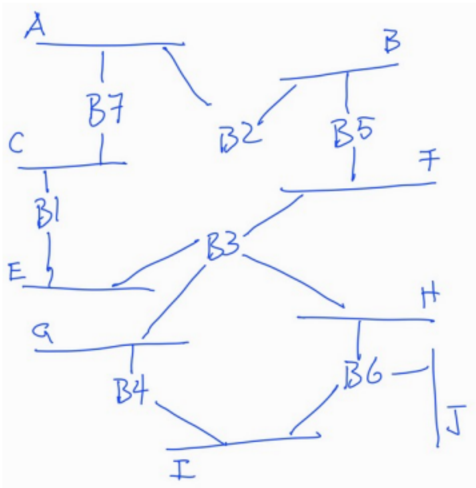


Figure 3: Problem

Solved using algorithm made in `https://github.com/Robdres/spanningTree`
If we take that the root is going to be B1 then, we have that the post that are not selected are

- B
- D
- F
- I

But we can also make it for B3 that gives better results

- A
- I

Exercise 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.

First let's test for google.com that is 12 nodes

```
(main U:7 ?:3 ✗) figures traceroute google.com
traceroute to google.com (142.250.78.46), 30 hops max, 60 byte packets
 1  _gateway (192.168.68.1)  8.561 ms  8.533 ms  9.646 ms
 2  192.168.100.1 (192.168.100.1)  9.634 ms  9.621 ms  9.610 ms
 3  100.99.214.1 (100.99.214.1)  15.399 ms  15.388 ms  15.376 ms
 4  10.224.51.134 (10.224.51.134)  14.259 ms  14.248 ms  14.236 ms
 5  192.168.0.34 (192.168.0.34)  16.700 ms  16.689 ms  16.677 ms
 6  192.168.0.42 (192.168.0.42)  16.672 ms host-181-39-98-13.telconet.net (181.39.98.13)  25.725 ms 192.168.0.42 (192.168.0.42)  18.217 ms
 7  host-181-39-98-21.telconet.net (181.39.98.21)  8.915 ms 10.201.222.28 (10.201.222.28)  9.626 ms  9.613 ms
 8  186.3.125.47 (186.3.125.47)  29.094 ms  29.067 ms 186.3.125.46 (186.3.125.46)  9.566 ms
 9  * * *
10  * * 74.125.252.60 (74.125.252.60)  28.784 ms
11  142.250.210.140 (142.250.210.140)  28.777 ms 142.250.210.117 (142.250.210.117)  28.995 ms  28.989 ms
12  bog02s15-in-f14.1e100.net (142.250.78.46)  21.870 ms  21.833 ms  20.616 ms
```

Figure 4: Google.com traceroute

For usfq.edu.ec that is 30 nodes

```
(main U:7 ?:4 ✗) figures traceroute usfq.edu.ec
traceroute to usfq.edu.ec (192.188.53.110), 30 hops max, 60 byte packets
 1  _gateway (192.168.68.1)  8.310 ms  8.286 ms  8.278 ms
 2  192.168.100.1 (192.168.100.1)  14.941 ms  14.934 ms  14.927 ms
 3  100.99.214.1 (100.99.214.1)  18.029 ms  18.010 ms  19.362 ms
 4  10.224.51.134 (10.224.51.134)  14.888 ms  14.876 ms  14.869 ms
 5  100.71.0.2 (100.71.0.2)  14.854 ms  17.954 ms  17.945 ms
 6  100.71.0.7 (100.71.0.7)  14.531 ms  9.917 ms  9.902 ms
 7  186.101.24.50 (186.101.24.50)  9.609 ms  7.935 ms  8.661 ms
 8  186.3.125.42 (186.3.125.42)  15.007 ms  14.994 ms  16.079 ms
 9  143.255.248.252 (143.255.248.252)  15.340 ms  19.905 ms  19.896 ms
10  * * *
11  * * *
12  * * *
13  * * *
14  192.188.53.214 (192.188.53.214)  19.887 ms  17.351 ms  17.326 ms
15  * * *
16  * * *
17  * * *
18  * * *
19  * * *
20  * * *
21  * * *
22  * * *
23  * * *
24  * * *
25  * * *
26  * * *
27  * * *
28  * * *
29  * * *
30  * * *
```

Figure 5: Usfq.edu.ec traceroute

For facebook.com that is 11 nodes!

```
(main U:7 ?:4 ✗) figures traceroute facebook.com
traceroute to facebook.com (157.240.6.35), 30 hops max, 60 byte packets
 1  _gateway (192.168.68.1)  9.855 ms  9.817 ms  9.801 ms
 2  192.168.100.1 (192.168.100.1)  9.785 ms  12.173 ms  12.157 ms
 3  100.99.214.1 (100.99.214.1)  19.070 ms  19.054 ms  19.040 ms
 4  10.224.51.134 (10.224.51.134)  14.693 ms  13.366 ms  14.667 ms
 5  100.71.0.2 (100.71.0.2)  14.651 ms 10.201.222.31 (10.201.222.31)  16.258 ms  16.245 ms
 6  100.71.0.7 (100.71.0.7)  15.113 ms  7.986 ms  7.966 ms
 7  186.101.24.50 (186.101.24.50)  10.733 ms  10.726 ms  10.392 ms
 8  ae5.pr03.bog1.tfbnw.net (157.240.80.132)  24.801 ms ae59.pr02.bog1.tfbnw.net (157.240.85.24)  23.215 ms  19.871 ms
 9  po103.psw04.bog1.tfbnw.net (129.134.55.231)  24.780 ms po103.psw03.bog1.tfbnw.net (129.134.55.229)  24.778 ms  28.032 ms
10  157.240.38.197 (157.240.38.197)  28.023 ms 157.240.38.77 (157.240.38.77)  38.685 ms 173.252.67.191 (173.252.67.191)  24.748 ms
11  edge-star-mini-shv-01-bog1.facebook.com (157.240.6.35)  23.164 ms  24.732 ms  29.672 ms
```

Figure 6: facebook.com traceroute

For amazon.com that is 30 routers

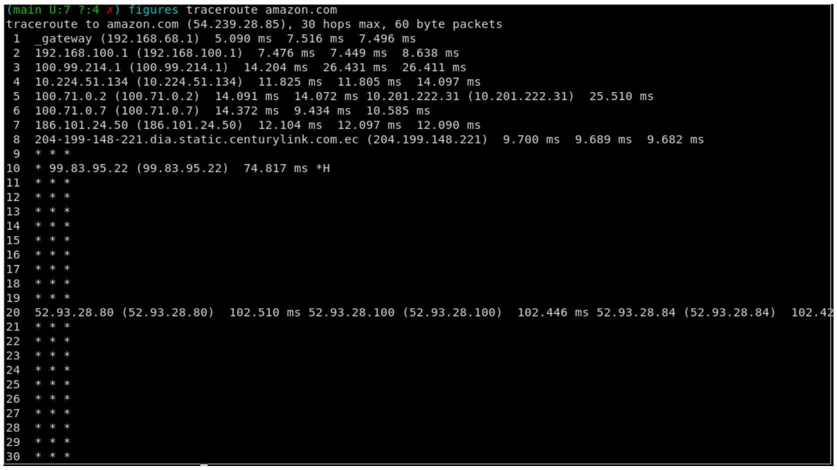


Figure 7: amazon.com traceroute

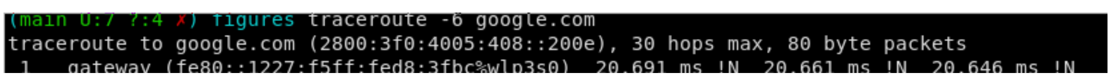
The command *man traceroute* specifies how this program works

```
traceroute  tracks  the  route packets taken from an IP network on their way
to a given host. It utilizes the IP protocols time to live
(TTL) field and attempts to elicit an ICMP TIME_EXCEEDED response from
each gateway along the path to the host.
```

This programs permits to make a tracerouting using IPv6 protocol

```
-4, -6 Explicitly force IPv4 or IPv6 tracerouting. By default, the program will try to
   resolve the name given, and choose the  appropriate protocol automatically. If
   resolving a host name returns both IPv4 and IPv6 addresses, traceroute will use IPv4.
```

For example we can make a traceroute using IPv6 protocol with pages that handles it, for example, google.com that only have 1 router that uses IPv6



Finally we can setup our own starting route with $-s$

```
-s source\_addr, --source=source\_addr
      Chooses  an  alternative source address. Note that you must select the address of
          one of the interfaces.  By default, the address
      of the outgoing interface is used.
```

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

- For the first question we get have to get the number of ip addresses needed for the first 7 years

$$IP\_Addresses = Engineering + Marketing + Sales$$

$$Engineering = 5 + 1 * 7 * 52 = 369$$

$$Marketing = 16$$

For sales we are going to use the expected values

$$Sales = (6 + 0.6 * 6 * 52 - 0.2 * 6 * 52)/2 = 130/2 = 65$$

Thus

$$IP\_Addresses = 440$$

So we need a subnet for the immediately superior power of 2, meaning $2^9 = 512$ thus the subnet mask that we will need, based on IPv4 is going to be $32 - 9 = 23$ for IPv6 is going to be $128 - 9 = 119$

- It will last for 7 years as it was stated in a), and each of the departments will have

Department	**addresses**
Engineering	369
Marketing	16
Sales	65

Table 3: Ip addresses distribution

- There are different options
  - First it can use private addressing inside its company and using Network
    Address Translation, that could help the company to share a single multiple IP address
  - The other thing can be to apply to multiple class C IP addresses, one is not enough