CS/ECE 438: Communication Networks for Computers Spring 2017
Problem Set 1 Solutions

Network Overview, Physical Layer, Basic Probability and Network Utilities

Network Overview

1. USB memory contains 1 TB = 8 Tb. Carrying only one device and given a travel time 280km/40kmph = 420 min = 25200 sec, we have a data rate of 8 Tb / 25200 sec = 317.460 Mbps. Therefore, we need 32 pigeons (or one pigeon carrying 32 SD cards) to achieve a higher rate than a direct 10 Gbps Ethernet connection.

2.

a. The transmission time necessary for station A to put the first packet onto the Ethernet, is (1024 x 8) / 10^9 = 0.000008192, or 8.19μs. The time needed for the last bit of the packet to propagate to the first switch is 4μs. The time needed for the first switch to transmit the packet to the second switch on the second Ethernet is again 8.19μs, and the time needed for the last bit to propagate over the second Ethernet is 4μs. The time needed for the second switch to transmit the packet to the third switch on the third Ethernet is again 8.19μs, and the time needed for the last bit to propagate over the third Ethernet is 4μs. Finally, the time needed for the third switch to transmit the packet to B on the fourth Ethernet is again 8.19μs, and the time needed for the last bit to propagate over the third Ethernet is 4μs. Thus, the total latency is (8.19μs + 4μs) x 4 = 48.76μs, with the propagation time accounting for about 32% of the total latency.

b. The intermediate switches do not decrease the long term effective data rate, since they transmit and receive simultaneously after receipt of the first packet. The data rate (end-to-end bandwidth) is therefore the link speed times a factor (1024 – 150) / 1024 = 0.854 due to packet headers, yielding an effective bandwidth of 854 Mbps.

c. As found in part (a), the latency for a single 1024B packet is 48.76μs. Similarly, the latency for a 80byte acknowledgment is 4 x (($80 \times 8/10^9$)s + 4μs) = 4 x (4.64 μs) = 18.56 μs. Thus, the total time to send a packet and receive an acknowledgment is 67.32μs. Therefore, 1024B – 150B = 874B = 6992 bits of data can be sent every 67.32μs, and the effective bandwidth is 6992 / 0.00006732 = 103.862 Mbps.

3.

a. Up to 50 circuits can be established, independently from their actual usage. So **at most 50 users** are supported in this case.

b. The probability that a specific group of n users are transmitting is:

$p_n \times (1 - p)^{(800-n)}$

And in a group of 800 users, there are (800 choose n) different groups of n users. So the probability that n users are transmitting simultaneously is:

(800 choose n) x 0.04^n x $(1-0.04)^{(800-n)}$

c. The link is overloaded if more than users are transmitting at the same time. This can be computed as one minus the probability that 0,1,2…50 users are transmitting. Following from part (b), the probability is:

$P_{overload} = 1 - \sum_{i=0}^{50} P_i$

4.

a. Bandwidth x delay = (1 Gbps)(80 x 10^{-6} sec) = 80,000 bits

b. Bandwidth x delay = (54 x 10^{6})(2 x 10^{-7} sec) = 10.8 bits

c. This link went through a satellite so we have to account for both the delays involved in going both up to the satellite and back down (these delays are, of course, the same). Given that the speed of light = c = $3*10^{8}$, the propagation delay is then 2 x 35,786,000/c = .24 sec. The bandwidth x delay product is thus (100 x 10^{6} bits/sec)(.24 sec) = 24,000,000 bits.

5. Cycles:

11	.30	1	6
121	.70 x .30	2	6 + 5
1231	.70 x .70 x .30	3	6 + 5 + 4
12341	.70 x .70 x .70 x .30	4	6 + 5 + 4 + 3
123451	.70 x .70 x .70 x .70 x .30	5	6 + 5 + 4 + 3 + 2
1234561 (w)	.70 x .70 x .70 x .70 x .70 x .70	6	6 + 5 + 4 + 3 + 2 + 1
1234561 (l)	.70 x .70 x .70 x .70 x .70 x .30	6	6 + 5 + 4 + 3 + 2 + 1

a. Fraction of time spent in cycle (1234561 (w)) and cycle (1234561 (w)) = $(.70)^{5}$

b. m = 6 * P[cycle 11]
+ (6 + 5) * P[cycle (121)]
+ (6 + 5 + 4) * P[cycle (1231)]
+ (6 + 5 + 4 + 3) * P[cycle (12341)]
+ (6 + 5 + 4 + 3 + 2) * P[cycle (123451)]
+ (6 + 5 + 4 + 3 + 2 + 1) * P[cycle (1234561 (w))]
+ (6 + 5 + 4 + 3 + 2 + 1) * P[cycle (1234561 (l))]

m = 6 * .30
+ (11) * 0.21
+ (15) * 0.147
+ (18) * 0.1029
+ (20) * 0.07203
+ (21) * 0.117649
+ (21) * 0.050421

m = 13.137 points

c. n = 1*P[1 game] + 2*P[2 games] + 3*P[3 games] + 4*P[4 games] + 5*P[5 games] + 6*P[6 games] n = 1 * P[cycle 11]
+ 2 * P[cycle (121)]
+ 3 * P[cycle (1231)]
+ 4 * P[cycle (12341)]
+ 5 * P[cycle (123451)]
+ 5 * P[cycle (123451)] n = 1 * .30 + 2 * 0.21+ 3 * 0.147 + 4 * 0.1029 + 5 * 0.07203+ 6 * 0.117649+ 6 * 0.050421 n = 2.94117 games

d. m/n = 13.137 points /2.94117 games = 4.4665 points/game

Networking Utilities

6.

Domain Name: UIUC.EDU
Registrar: EDUCAUSE
Domain record activated: 18-Jul-1985
Domain record last updated: 01-Feb-2016
Domain expires: 31-Jul-2017

Domain Name: GOOGLE.COM
Registrar: MARKMONITOR INC.
Updated Date: 20-jul-2011
Creation Date: 15-sep-1997
Expiration Date: 14-sep-2020

Domain Name: GOOOOOGLE.COM
Registrar: ENOM, INC.
Updated Date: 2016-07-04T00:34:42.00Z
Creation Date: 2001-08-02T09:56:29.00Z

Domain Name: KRAVETS.ORG
Sponsoring Registrar: New Dream Network, LLC dba DreamHost Web Hosting
Updated Date: 2016-11-01T06:48:34Z
Creation Date: 1999-09-01T19:52:53Z

Domain: acmilan.it
Registrar Organization: BT Italia s.p.a.
Created: 2001-05-02 00:00:00
Last Update: 2011-03-01 11:45:14

Note: These are all domains that belong to an organization, which takes care of managing the various subdomains such as **www**.*company.com* or **mail**.*company.com.* But someone must have registered simply **com, edu, net, gov,** and all the other root domains, first! Do some more digging if this topic finds you interested, and have fun!