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Problem Set 1

Network Overview

1. Your company has a large data store that needs to backed up to a new site every week. You have two choices:
   a. Use your high-speed Internet connection and transfer all of the data over the Internet;
   b. <u>Copy your data to a number of portable hard disks, drive them over in your van, then read data from the hard disks at the new site.</u>

Your Internet connection is 200 Mbps. The one-way latency to the remote site is 10ms. The read/write speed of your portable hard disks is 700 Mbps. Each disk can hold 2 TB. You can only copy to or read data from one disk at a time. You need to drive 2 hours to the new site. You have 15 TB of data to backup every week. Compute and compare the data rate for the two choices, from the moment you start moving the first byte, to the moment the last byte is online at its new location. Which one is faster?

a. If uses high speed Internet connection:
   The transfer time of 15TB data is: $\frac{15TB}{200Mbps} = 600000s$.
   Plus 10ms one way latency, the total time is 166.7 h.

b. If my company uses portable hard disk:
   The time for one round of read/write of 15TB data needs $\frac{15TB}{700Mbps} = \frac{1200000}{7}s = \frac{1000}{21}h$.
   Plus 2 hrs of drive and another round of read/write, the total time is: $97.2h$.

<u>According to my calculation, I'll choose b because this way is much faster.</u>

2. Consider two machines, A and B, connected by a 200 Mbps Ethernet with four store-and-forward relay switches on the path between them. Suppose that no other machines are using the Ethernet, that each of the links between the machines and switches, as well as between each adjacent switch, introduces a propagation delay of 5μs, and that a switch begins transmitting a packet immediately after receiving the last bit of the packet.
   a. What is the total transfer time for a 512B packet, as measured from transmission of the first bit at A to receipt of the last bit at B?

   For each link, it takes $\frac{512B}{200Mbps} = 20.48\mu s$ to transmit the packet.
   Since there are four store-and forward relay switches on the path between A and B, the time for transmit the packet is: $20.48 \times 5 = 102.4\mu s$.
   <u>Plus 5 propagation delay, the total transfer time is $\mathbf{102.4 + 5 \times 5 = 127.4\mu s}$.</u>

   b. What is the effective bandwidth for transmission of a large file from A to B, assuming that packets of size 512B are used and that packet headers use 100B of the 512B? Assume that the nodes can send constantly, and in particular that the switches can simultaneously receive a packet from one side while transmitting a previous packet out the other side, and that A is not slowed down waiting for acknowledgements.

   The effective bandwidth = $\frac{512B}{Total\ Latency}$. According to the calculation of a, the effective bandwidth is:

$$\frac{\mathbf{512B}}{\mathbf{127.4\mu s}} = \mathbf{32.15Mbps}$$

   c. What is the effective bandwidth if, after each transmission of a 512B packet, node A must wait for an 100-byte acknowledgement from B?

The latency of the 100 B acknowledgement is:

$$\frac{100B}{200Mbps} \times 5 + 5 \times 5 = 45\mu s$$

Plus the latency of the packet the total latency is: $127.4 + 45 = 172.4\mu s$
Thus, the effective bandwidth is:

$$\boldsymbol{\frac{512B}{172.4\mu s} = 23.76Mbps}$$

3. Suppose users share a 100 Gbps link. Also suppose each user requires 700 Mbps when transmitting, but each user only transmits 8 percent of the time. Whether a user is transmitting or not is an independent random variable with uniform distribution.

a. When circuit switching is used, how many users can be supported?

If a circuit switch is used, a dedicated circuit has to be established, thus, the shared link can only support 700 Mbps.
Then the number of users that the link can support is:

$$\frac{700\ Mbps}{8\% \times 700\ Mbps} = 12.5 \approx 12$$

Thus, when circuit switching is used, 12 users can be supported.

b. For the remainder of this problem, suppose packet switching is used. Suppose there are 1500 users. First, find an equation for the probability that at any given time, n users are transmitting simultaneously. (You only need to set up the equations)

The equation of the probability that n users are transmitting simultaneously is:

$$Pr = \binom{1500}{n} \times 8\%^n \times (1 - 8\%)^{(1500-n)}$$

c. What is the probability that the link will get overloaded?
The number of users that this link can support using packet switching is $\frac{100\ Gbps}{700\ Mbps} = \frac{1000}{7} \approx 142$.
When the number of user is greater than 142, the link will get overloaded.
Since the number of users is large, I'll use normal distribution to approximate the probability:

$$p = 0.08, np = 120, np(1-p) = 110.4$$

So, approximately, $X \sim N(120, 110.4)$, we need to find $P(X > 142)$
If X = 142, then Z= 2.09
So, $P(X > 142) = P(Z > 2.09) = 1 - P(Z < 2.09) = 1 - 0.9817 = 1.83\%$
Thus, the probability that the link is overloaded is 1.83%.

4. For each of the following links, calculate the bandwidth x delay product in bits using one-way delay.

a. 15 Gbps Ethernet with a delay of 60 µs.

$$\boldsymbol{15\ Gbps \times 60 \times 10^{-6} s = 9 \times 10^5\ bits}$$

b. 450 Mbps wireless link, with a one-way delay of 0.15 µs.

$$\boldsymbol{450\ Mbps \times 0.15 \times 10^{-6} s = 67.5\ bits}$$

c. 500 Mbps link through a satellite in geosynchronous orbit, 35,786 km high. The only delay is speed-of-light propagation delay.
The speed of light propagation delay is:

$$\frac{35786\text{ km } \times 2}{3.0\ \times\ 10^8\ m/s} = 0.239\ s$$

$$\boldsymbol{500\ Mbps \times 0.239\ s = 119.29\ Mb}$$

5. Every year, an industrious CS student heads to Las Vegas to play in a poker tournament. There are seven rounds in the tournament, and the student must win each round to advance to the next. The student wins (50*n) chips in the nth round, if the student makes it that far, and has a 65% chance of winning each round they play. Let m be the (statistical) mean number of chips earned by the student in a tournament, and let n be the mean number of rounds played per tournament. Use cycle analysis to find:
Let F denote Failure, and W denote Win

Cycle	Probability	Chips
F	0.35	0
WF	0.65×0.35	50
W^2F	$0.65^2 \times 0.35$	100
W^3F	$0.65^3 \times 0.35$	150
W^4F	$0.65^4 \times 0.35$	200
W^5F	$0.65^5 \times 0.35$	250
W^6F	$0.65^6 \times 0.35$	300
W^7	0.65^7	350

a. What fraction of years does the student make it to the final round?
The fraction of year the student makes it to the final round is:
$$\mathbf{0.65^7 = 0.05}$$

b. m
In a tournament, the mean number of chips earned is:
$$\mathbf{50 \times 0.65 + 100 \times 0.65^2 + 150 \times 0.65^3 + 200 \times 0.65^4 + 250 \times 0.65^5 + 300 \times 0.65^6 + 350 \times 0.65^7 = 220.4357304}$$

c. n
The mean number of rounds per tournament is:
$$\mathbf{0.35 + 2 \times 0.65 \times 0.35 + 3 \times 0.65^2 \times 0.35 + 4 \times 0.65^3 \times 0.35 + 5 \times 0.65^4 \times 0.35 + 6 \times 0.65^5 \times 0.35 + 7 \times 0.65^6 \times 0.35 + 7 \times 0.65^7 = 2.717}$$

d. m/n. Note that this ratio is the student's long-term rate of chips per round.
$$\mathbf{\frac{m}{n} = \frac{220.4357304}{2.717} = 81.1296668}$$

6. The Unix utility whois can be used to find the domain name corresponding to an organization, or vice versa. The information is provided by a *domain name registration* service provider. This utility is commonly shipped with linux, but it is not available on the ews machines. If you try it on your own linux machine with high probability you will find it available. Read the online man page for whois and experiment with it. For example, try whois twitter.com.
Now, do a whois query for the following domains:

microsoft.com
microsoot.com
illinois.edu
npr.org
chelseafc.com

For each, turn in the registar and the date in which this record was created and/or activated and the expiration date, if present.

twitter.com

Registrar WHOIS Server: whois.corporatedomains.com
Registrar URL: http://www.cscglobal.com/global/web/csc/digital-brand-services.html
Registrar: CSC Corporate Domains, Inc.
Registrar IANA ID: 299
Registrar Abuse Contact Email: domainabuse@cscglobal.com
Registrar Abuse Contact Phone: 8887802723

Updated Date: 2016-11-08T05:20:23Z
Creation Date: 2000-01-21T16:28:17Z
Registry Expiry Date: 2020-01-21T16:28:17Z

microsoft.com
Registrar WHOIS Server: whois.markmonitor.com
Registrar URL: http://www.markmonitor.com
Registrar: MarkMonitor Inc.
Registrar IANA ID: 292
Registrar Abuse Contact Email: abusecomplaints@markmonitor.com
Registrar Abuse Contact Phone: +1.2083895740

Updated Date: 2014-10-09T16:28:25Z
Creation Date: 1991-05-02T04:00:00Z
Registry Expiry Date: 2021-05-03T04:00:00Z

microsoot.com
Registrar WHOIS Server: whois.markmonitor.com
Registrar URL: http://www.markmonitor.com
Registrar: MarkMonitor Inc.
Registrar IANA ID: 292
Registrar Abuse Contact Email: abusecomplaints@markmonitor.com
Registrar Abuse Contact Phone: +1.2083895740

Updated Date: 2017-04-20T09:24:49Z
Creation Date: 1999-05-22T10:29:58Z
Registry Expiry Date: 2018-05-22T10:29:26Z

illinois.edu

Domain record activated: 13-Jan-1997
Domain record last updated: 10-Apr-2017
Domain expires: 31-Jul-2018

npr.org
Registrar WHOIS Server: whois.networksolutions.com
Registrar URL: http://www.networksolutions.com
Registrar Registration Expiration Date:
Registrar: Network Solutions, LLC
Registrar IANA ID: 2
Registrar Abuse Contact Email: abuse@web.com
Registrar Abuse Contact Phone: +1.8003337680

Updated Date: 2018-01-13T20:23:41Z
Creation Date: 1993-12-13T05:00:00Z
Registry Expiry Date: 2018-12-12T05:00:00Z

chelseafc.com
Registrar WHOIS Server: whois.godaddy.com
Registrar URL: http://www.godaddy.com
Registrar: GoDaddy.com, LLC
Registrar IANA ID: 146

Registrar Abuse Contact Email: abuse@godaddy.com
Registrar Abuse Contact Phone: 480-624-2505

Updated Date: 2016-07-11T14:43:21Z
Creation Date: 1998-09-12T04:00:00Z
Registry Expiry Date: 2021-09-11T04:00:00Z