LBSC 690 Information Technology (Fall 2007)

Homework #1 Solutions

First, let's look at a detailed specification for a computer system that you might consider buying:

Processor type:	Intel Core
Processor speed:	3 GHz
Hard drive:	80 GB, 10 ms access time
RAM:	512 MB
Additional peripherals:	CD-RW

1. If you buy some 640 MB CD-R disks, how many would you need to back up a full hard drive once (assume no compression)? At 7 cents per disk, how much would a full backup cost? At 10 minutes per disk, how long would a full backup take?

Hard drive capacity: 80GB = 80×2^{30} = 85,899,345,920 bytes
1 CD capacity: 640MB = 640×2^{20} = 671,088,640 bytes
85,899,345,920 bytes on full hard drive / 671,088,640 bytes per CD = 128 CDs

$0.07 for 1 CD
For 128 CDs: 128 × 0.07 = $8.96
10 minutes for 1 CD
For 128 CDs: 128 × 10 = 1280 minutes = 21.3 hours

Now let's see how much stuff that hard drive can hold. Assume you have access to the following information stored for all 295 million people in the United States

Name: 40 characters
Phone Number: 10 characters
Library Card Number: 9 characters
Unpaid Fines: one 4-byte number

Assume that each character is stored in one byte.

2. Would all of this data fit on the hard drive of the computer described above? If not, how big a hard drive would you need? If so, what fraction of the disk would this fill?

Bytes needed to store all the data:
Number of people × (name bytes + phone bytes + card bytes + fine bytes)
= 295,000,000 × (40 + 10 + 9 + 4) = 18,585,000,000 bytes

1GB = 2^{30} bytes = 1,073,741,824 bytes

18,711,000,000 bytes / 1,073,741,824 bytes per GB = 17.3 GB
Hard drive capacity = 80 GB.
So, the data will fit in the drive.

Fraction of disk = 17.3/80 = 0.21625 (or 21.6% of 80GB)

Now let's see how long it would take to read that much data off the disk. Assume you have a hard drive large enough to store all the data.

3. Assume that you access the data in a random order, and that you start a new disk access for each person. How long would it take to add up the library fines for all 295 million people? Could this be done in a second? In a minute? In an hour? In a day? In a month? In a year?

Given that the hard drive has an access time of 10ms = 0.01 seconds. We assume that the amount of time needed to actually perform the addition is negligible compared to the disk access time.

0.01 seconds per record × 295,000,000 people = 2,950,000 seconds
2,950,000 seconds / 86,400 seconds per day = 34.14 days
Just over one month

Assume for the sake of comparison that all of this data could fit in RAM (it won't; you should convince yourself of that).

4. How long would it take the processor to perform 295 million additions if it can perform one addition instruction for every two clock cycles? Could this be done in a second? In a minute? In an hour? In a day? In a month? In a year?

3 GHz processor = 3,000,000 cycles per second = 1,500,000 additions per second
297,000,000 additions / 1,500,000,000 addition instructions per second= 0.1967 sec.

From these answers, you should be able to conclude that the processor is much faster than the hard drive. Review your notes and read the section in the book about "virtual memory". Think about how virtual memory helps to accommodate this mismatch.

Now let's see how long it would take to move the bits around.

5. How long would it take to move the contents of your entire hard drive to your friend's computer in California over a modem? Over DSL? Over a dedicated T1 line? Overnight mail?

Note: transfer speeds are usually measured in units of **bits**, not **bytes**. One byte = 8 bits.

80GB = 80 × 2^{30} × 8 = 85,899,345,920 bytes = 687,194,767,360 bits = 687,194,767 Kb

Modem: 56 Kbps
687,194,767 kb / 56 Kb per second = 12,271,335 seconds = 3408.7 hours = 142 days

DSL: 128 Kbps
687,194,767 kb / 128 Kb per second = 5,368,709 seconds = 1491.3 hours = 62.1 days

T1: 1.544 Mbps = 1,544 Kbps
687,194,767 kb / 56 kb per second = 445,074 seconds = 123.6 hours = 5.15 days

Overnight mail: takes overnight!