CAS CS 210 - Computer Systems
Fall 2009

PROBLEM SET #4 (I/O)
DUE: THU, DECEMBER 10, 1:00 PM
NO LATE SUBMISSIONS WILL BE ACCEPTED

1. (a) Suppose a magnetic disk has 1000 tracks on each of 4 surfaces. Each track is divided into 100 sectors each containing 512 bytes. What is the capacity of this disk in bytes?

   (b) Suppose the above disk rotates at 10800 RPM and the advertised average seek time is 9 ms. What is the average access time for a sector based on average seek time, average rotational delay, and the transfer time for a sector?

2. Consider a 500 MHz processor, and a hard disk that can transfer at 4 MB/sec. Take 1K = 1000 and 1M = 10^6. Compute the fraction of CPU time consumed by disk interrupts if (a) data is transferred in two-word chunks using interrupt-driven I/O. Assume the overhead of each interrupt is 500 clock cycles, and a word is 4 bytes; (b) data is DMA transferred in 4 KB blocks. Assume a DMA setup and completion consumes 1000 cycles.

3. Consider an I/O system that has a processor-memory bus, and one or more DMA-controlled I/O adapters that interface I/O buses to the processor-memory bus.

   - **The processor-memory bus:** The processor-memory bus has a bandwidth of 25MB per second.
   - **DMA interfaces:** The DMA controller can accommodate up to 8 disks. The DMA controller overhead (to initiate a new I/O operation) is about 2 ms.
   - **The I/O bus:** The I/O bus has a bandwidth of 4MB per second.
   - **The disks:** The disks have a measured average seek plus rotational latency of 20 ms. The disks have a read/write bandwidth of 2MB/sec.

   Assume that all accesses in the I/O system are 4KB block reads. Take 1K = 1000 and 1M = 10^6.

   (i) What is the effective bandwidth of one of the disk drives?

   (ii) How many disk drives are required to saturate the I/O bus?

   (iii) How many I/O buses (and DMA controllers) are required to saturate the processor-memory bus?

4. A client sends a 128-byte request to a server located 100 km away over a 1G bits-per-second optical fiber, and then waits for a reply to get back. Compute the minimum possible response time. Take the speed of light in fiber optics to be 200 km/msec.

   Then, consider the response time over a 1M bits-per-second link, instead of 1 Gbps. What conclusion can you draw? Take 1G = 10^9 and 1M = 10^6.