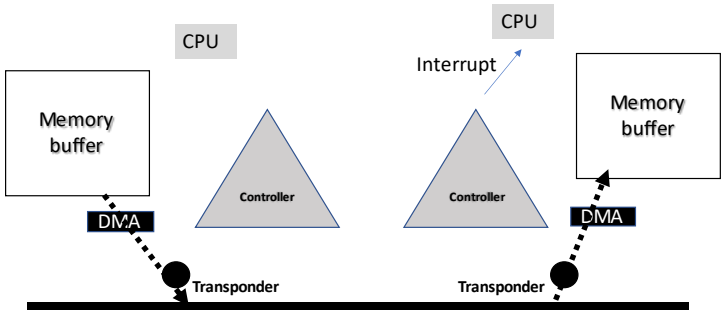
CS 520: Introduction to Operating Systems

Homework Assignment #6

Read Chapters 11-15, and make sure you understand **everything** covered there as well as in Lectures 8 and 9.

Solve the following problems:

1. A local area network is used as follows. The user issues a system call to write a data packet to the network. The operating system then copies these data to a kernel buffer. Then it copies these data to the network controller board. When all the bytes are safely inside the controller, they are sent over the network at a rate of 10 megabits/sec. The receiving network controller stores each bit a microsecond after it is sent. When the last bit arrives, the destination CPU is interrupted, and the kernel copies the newly arrived packet to a kernel buffer to inspect it. Once it has figured out which user the packet is for, the kernel copies the data to the user space. (This is illustrated by the figure below.)



   If we assume that each interrupt and its associated processing takes 1 millisecond (msec), that packets are 1024 bytes long (including the headers), and that copying a byte takes 1 microsecond (μsec), what is the maximum rate at which one process can pump data to another? Assume that the sender is blocked until the work is finished at the receiving side and an acknowledgement comes back. For simplicity, assume that the time to get the acknowledgement back is so small that it can be ignored. [**Suggestions**: Observe 1) how many times a packet is copied

and how long it takes, 2) how many interrupts are there to be processed and how long that takes, and 3) how long the transmission of a packet takes. Then calculate the overall data transmission rate.] (**25 points)**

2. A computer can read or write a memory word in 10 nsec. The computer has 34 CPU registers (including the program counter and status word), each one word long. When an interrupt occurs, all these registers are pushed onto the stack. What is the maximum number of interrupts this machine can handle in a second? (**10 points**)

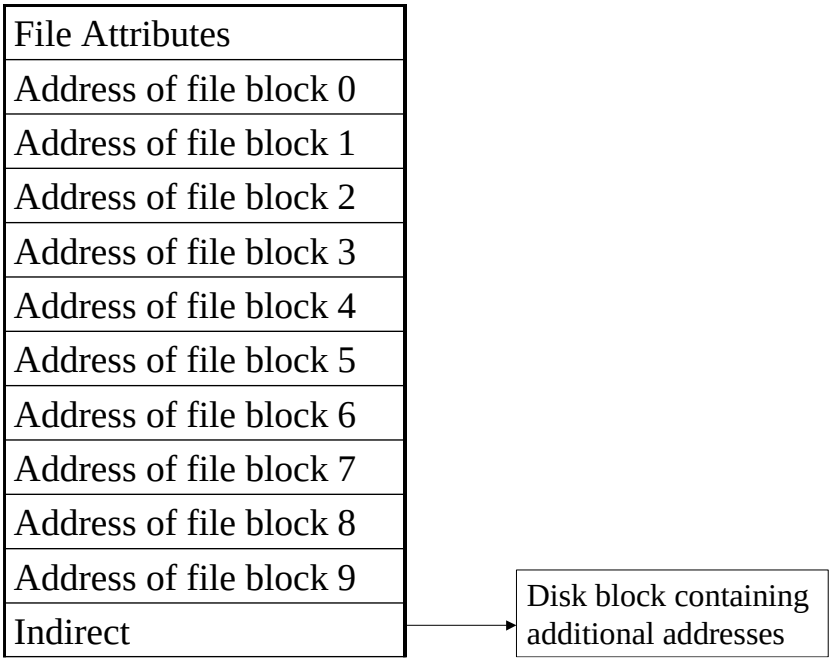
3. A floppy disc is doubly-interleaved. It has eight sectors of 512 bytes per track, and a rotation rate of 300 *rpm*. How long does it take to read all the sectors of a track in order, assuming the arm is already correctly positioned, and *half rotation* is needed to get sector 0 under the head? What is the data rate? Now, solve the same problem for the case without interleaving. How much does the data rate degrade because of interleaving? (**10 points**)

4. Disk requests come in to the disk driver for cylinders 10, 22, 20, 2, 40, 6, and 38, in that order. A *seek* takes *6 msec* per cylinder moved. The arm is initially at cylinder 20. How much seek time is needed if a) FCFS, b) SSTF, or c) SCAN (elevator) algorithm is employed? **(5 points)**

5. The *Stupido v1.0* operating system only supports a single directory but allows that directory to have arbitrarily many files with arbitrarily long name. Furthermore, every printable character is allowed as part of a file name. Can you suggest a naming convention that allows to simulate a hierarchical (i.e., nested-directory) file system? (**5 points**)

6. The *i-node* of Figure 1 contains 10 direct addresses of 4 bytes each and a pointer to a block of addresses. All addresses are four-bytes long; each block is 1024 bytes. What is the size of the largest file possible? (**10 points**)

Figure 1: The I-Node



7. After the disk partition is first formatted, the beginning of a free space bitmap looks like this: *1000 0000 0000 0000* (the first block is used by the root directory). As we discussed during the lecture, the system always searches for free blocks starting at the lowest numbered block, so after writing file *A*, which uses six blocks, the bitmap would change to *1111 1110 0000 0000...* . Show the bitmap after each of the following actions: a) File *B* is written, using five blocks; b) File *A* is deleted; c) File *C* is written, using eight blocks; d) File *B* is deleted. (**5 points)**

8. What is more efficient way of caching file data—caching through physical disc blocks or caching using virtual memory? Explain your answer (**5 points)**

9. Explain why using a unified buffer cache results in better performance of a file system? **(15 points)**

10. Explain how the data structures of the Linux file system serve to map file names to blocks of a storage device. (Use the *man* page descriptions to obtain the information you need for this and the next problems.) (**10 points)**