KEY TO EXAM ON FILE SYSTEMS AND I/O – SPRING 2007
CSC 262 – OPERATING SYSTEMS
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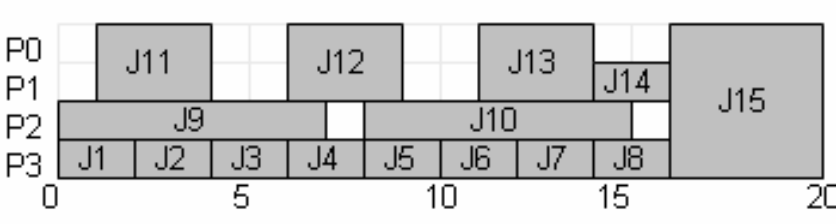
1. **Efficiency Measures**. (12 points) Consider the diagram below, representing the jobs run over a 20-minute span on a hypothetical computer with four CPUs.



a.) Compute the overall throughput of the 4-processor ensemble.

15 jobs/20 minutes = 0.75 jobs/minute

b.) Compute the mean utilization of each processor (rows P0-P3) during this period, and the overall utilization of the 4-processor ensemble.

P0: 13/20 = 65%; P1: 15/20 = 75%; P2: 18/20 = 90%; P3: 20/20 = 100%; Overall: 66/80 = 82.5%

c.) If J15 was assigned at t = 13, what is its latency?

Finished at t = 20, so latency is 7 minutes.

2. **Disk Head Scheduling**. (12 points) Consider the following group of disk scheduling algorithms: FCFS/FIFO, LIFO, Priority, SSTF, SCAN, LOOK, C-SCAN.

a.) Which ones can allow a request to wait indefinitely during times of heavy disk utilization?

FCFS/LIFO, Priority, SSTF.

b. Which ones attempt to optimize overall disk performance by handling nearby track requests together?

SSTF, SCAN, LOOK, C-SCAN

c. Which one might be expected to have the lowest mean response time, averaged over all requests?

Depending on the load profile, different algorithms may have the lowest mean response time. Any of the following responses was accepted: SSTF, LOOK, C-SCAN

3. **OS History**. (12 points) What two important OS developments occurred as computers began to be used by multiple users at once? Explain briefly why their development was vital to successful sharing of a single computer.

Time sharing and memory protection together enabled multiple users to work on the same computer at the same time, and ushered in the era of the mainframe. Time sharing was an important advance because it allowed the computer to handle interaction with each user in a timely manner. Prior to this the only way to share a computer was by submitting a batch job to be run at some point in the future, and come back for the results later. Note that the notion of timesharing goes slightly beyond simple multiprogramming, in that it implies a commitment to appear responsive to each user by regularly devoting some processing time to them.

Memory protection became necessary as soon as multiple people had programs running on a computer at the same time. Without it, an error in one program can compromise the integrity of every other program running, including the operating system itself. Thus the advent of effective memory protection mechanisms was a second enabling development.

4. **Disk Hardware**. (12 points) Over time, design of so-called "Winchester" hard disk drives has tended towards ever-smaller platter radius and faster rotation speeds. Explain why this trend makes sense from a performance standpoint. Next, explain the contrary factors that prevent platters from shrinking too far or spin rates from becoming too fast.

Disk latency is dominated by physical factors, chiefly the seek time (time required to move the comb into place above the desired cylinder) and the rotational latency (time required for the desired sector to rotate under the head). Smaller platter radii address the first issue, while faster spin rates address the second. Platter radius cannot shrink too small without limiting the storage available, while mechanical issues (heat buildup and vibrations) limit the spindle speed. Also, since the rotational latency is the reciprocal of the spin rate, incremental increases in spin have successively decreasing impact on the latency.

5. **Units**. (8 points) Give the exact number of **bits** represented by each of the following abbreviated quantities. (You may give an exact decimal representation, or express your answer in terms of its factors, e.g., 2^8*10^3.)

a.) 1 B *8 bits*
b.) 8 KiB *8192 bytes = 65536 bits*
c.) 10 Gb *10,000,000,000 bits*
d.) 16384 Mib 2^{34} *bits = 17179869184 bits*

6. **Directories**. (16 points) Shown below is a representation of the contents of a directory file on an ext2 file system. Answer the questions that follow by carefully interpreting the file's contents.

37				12		1	2	.				18							12		2	2	.	.		
44				16		5	2	a	u	s	e	r							115				36		5	1
s	t	u	f	f				99				20		12	1	a	n	d	m			o	r	e	s	
t	u	f	f	42				24		12	2	a	n	o	t	h	e	r	t			h	i	n	g	

a.) What entries would be listed as the result of an `ls` command on this directory?

auser stuff anotherthing

b.) Indicate the type (file, directory, etc.) of each of the entries you listed above.

directories: auser, anotherthing; file: stuff

c.) What is the inode number of this directory file? *37*

d.) Which former entry has been deleted? *andmorestuff*

7. **Device Drivers**. (16 points) Using the Minix driver we studied in class as your example, match the following list of driver calls to the operations that they perform.

I. Initialization	A. Query device for physical characteristics (#sectors, etc.)
II. Mounting	B. Seek specific track
III. Data Transfer	C. Unlock/eject media
IV. Unmounting	D. Register data structure with API function mapping
	E. Install interrupt handler
	F. Read device data from BIOS
	G. Assign minor device number/partition
	H. Wake up sleeping user process

I: D, F; II: A, E, G; III: B, H; IV: C

8. **Security and Protection**. (12 points) Consider the following capabilities associated with three protection domains:

Domain W can write to files of class I and II.
Domain R can read files of classes I and II, and can also execute files of class I.
Domain Z can read, write, and execute files of class III.

Now consider three users. User A has access to domains R and Z. User B has access to domains W and R. User C has access to domain R only. Write an access control list for files of each of the three types specifying permissible actions for the three users.

File I: User A (RX), User B (RWX), User C (RX)
File II: User A (R), User B (RW), User C (R)
File III: User A (RWX)