COM S 352: Introduction to Operating Systems
Final Practice Exam (KEY)
Spring 2023

Cover Sheet

Student Name: _____

Format:

- Time: 90 mins
- Points: 100
- Question Types: matching, true/false and short answer

Instructions:

- You may use 2 (two) letter sized sheets of paper (front and back), that you have prepared yourself with notes before the exam, as "cheat sheets" during the exam.
- You may use calculator (not part of smart phone). You may not consult classmates, other electronic devices or resources other than the cheat sheet during the exam.
- Questions of clarification should be asked directly to an instructor or TA.

Question	Points
1	/16
2	/28
3	/7
4	/7
5	/7
6	/7
7	/14
8	/7
9	/7
Total	/100

1. (16 pts, 2 pts each) For each description on the left, select the best matching term on the right, each term is used only once but some will not be used.

K ____ data structure for tracking free blocks

A ____ a cryptographic key system in which some keys are intentionally shared publicly

H ____ a physical circular path around a disk where the data is stored

F ____ an example of the transport layer in networking

E ____ contains a list of file names and the inodes they are associated with

G ____ principle that makes it safe to retry sending commands any number of times

D ____ the software structure to which a server binds

I ____ synchronization mechanism that provides only locking, not signaling

A. asymmetric
B. swap
C. AFS
D. socket
E. directory
F. TCP
G. idempotent
H. track
I. mutex
J. locality
K. bitmap
L. fork()

2. (28 pts, 2 pts each) Which of the following statements are true? Write T or F for true or false.

T ____ I/O completion triggers an interrupt.

T ____ The bounded-buffer problem can be solved with just semaphores to control concurrency.

T ____ A thread requesting a resource never causes a deadlock as long as that thread does not currently have any other resources assigned to it.

T ____ An application reading two files located in the same directory is a demonstration of path locality.

F ____ In an access control matrix a file would be an example of a subject.

F ____ When a router detects a packet loss it requests the host to resend the packet.

F ____ One cause of latency in SSD is seek time.

F ____ It is possible for a soft link to point to a file that does not exist.

T ____ A software bug that can be used to gain access to a system is an example of a threat.

T ____ NFS does not solve all cache consistency corner cases and pushes some problems on the application to resolve.

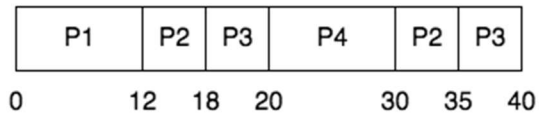
F ____ In symmetric encryption algorithms, one key is used to encrypt and a different one is used to decrypt.

T ____ In file system journaling, the checkpoint must always come after the journal commit.

T ____ Denial of service is an example of an attack on the security concept of availability.

T ____ NFS clients simply retry sending commands after a timeout because it would be too difficult to figure out why no response was received by the client.

3. (7 pts) Consider the following Gantt chart. Assume all the processes arrive at time 0.



What are the values for the following metrics? You must show your calculations.

a) Average response time

[(0-0) + (12-0) + (18-0) + (20-0)]/4 = 12.5

b) Average turnaround time

[(12-0) + (35-0) + (40-0) + (30-0)]/4 = 29.25

4. (7 pts) Suppose a process is running on an operating system that is a guest of a virtual machine. Consider the memory mappings below. Assume the page size is 1KB (1,024 bytes) for both operating systems.

If the process reads from virtual address 2,050, what address will be read from the machine's memory? Show calculations.

Guest OS Page Table

VPN	PFN	Valid
0	5	1
1	6	1
2	1	1
3	2	1
4	0	0
5	0	0
6	7	1

VMM Page Table

PFN	MFN	Valid
0	2	1
1	0	1
2	7	1
3	5	1
4	6	1
5	1	1
6	3	1

Some useful values

1KB = 1,024
2KB = 2,048
3KB = 3,072
4KB = 4,096
5KB = 5,120
6KB = 6,144
7KB = 7,168

VPN = 2050/1024 = 2 and offset = 2050 % 1024 = 2; PFN for VPN=2 is 1; MFN for PFN=1 is 0.

Machine's memory address: MFN*1024 + 2 = 2.

5. (7 pts) Threads 1 and 2 (shown below) share a semaphore S that is initialized to 0. List all possible outputs or if there will be no output write "none". Even if either thread can become stuck, list the output that will be produced.

Thread 1	Thread 2
`sem_wait(S);`	`sem_post(S);`
`printf("A");`	`printf("B");`
`sem_post(S);`	`sem_wait(S);`
	`printf("C");`

As an example, you might list the output "ABC".

ABC, BAC, BC

6. (14 pts) The figure below shows a timeline (top to bottom) of the reads and writes a Unix-style file system performs in response to the system call `write(fd, char_buffer, num_bytes)` where `fd` is a file descriptor for an empty file called "os.txt".

data bitmap	os.txt inode	data block 0
	1. read	
2. read 3. write		
		4. write
	5. write	

For each numbered read and write provide a short explanation (maximum two sentences) of the purpose of the read or write. It is not sufficient to simply say it "reads the os.txt inode", you must be specific. For example, what type of information is being read from the inode and for what purpose?

1. Read the inode of os.txt to get the length of the file

2. Because a new data block needs to be allocated for the file, read the data bitmap to find the location of a free data block

3. After finding a free data block, update the data bitmap by setting a bit to indicate the block has been taken

4. Write the data from char_buffer to the new data block

5. Update the inode to point to the new data block. Also, update other meta data such as the length of the file and time of last modification.

7. (7 pts) Consider a file system that uses Unix-style inodes. The system uses 8-KB blocks and 4-byte pointers. Multi-level indexing is used with an inode containing 8 direct pointers, 1 single

indirect pointer, 1 double indirect pointer and 1 triple indirect pointer. What is the first file address that will be mapped to the double indirect pointers. You must show work, the answer can be left as an unsimplified arithmetic expression.

The 8 direct pointers point to addresses from 0 to 8*8K-1
The single indirect pointers point to addresses from 8*8K to 8*8K+(8K*8K/4)-1
The double indirect pointers to addresses starting at 8*8K+(8K*8K/4) = 64K + 8K*2048 = 16,842,752.

8. (7 pts) In a man-in-the-middle attack the attacker secretly relays and possibly alters communications between two parties who believe that they are in direct communication with each other. Describe confidentiality, integrity and availability with respect to a man-in-the-middle attack. Which of these if any may be compromised and in what way?

Confidentiality – the attacker is impersonating both sides of the communication to see and possible decrypt all communication

Integrity – the attacker can modify the messages being passed between each side

Availability – the attacker can selectively drop messages being passed between the two sides making a service not available.

9. (7 pts) Explain how the distributed file system AFS uses callbacks. What would be an alternative approach? What are the advantages and disadvantages of callback over the alternative approach?

When a client fetches a file, the whole file is cached on the client. This means all future reads and write of the file are performed only from the cached version. Because the cached version can become out of date the client depends on the server notifying it of changes to the file by sending a notification callback message.

Callback has the advantage of fewer message from the client to the server because the client doesn't need to poll the server for file updates like in NFS.

Callback has the disadvantage that the server needs to be stateful, specifically it needs to remember all of the client that have files in their cache. This can be a problem if the server crashes and forgets its state.