EECE.4810/EECE.5730: Operating Systems

Spring 2017

Final Exam
May 5, 2017

Name: _____

Section: **EECE.4810 (undergraduate)** **EECE.5730 (graduate)**

For this exam, you may use two 8.5" x 11" double-sided page of notes. All electronic devices (e.g., cell phones, calculators, laptops) are prohibited. If you have a cell phone, please turn it off prior to the start of the exam to avoid distracting other students.

The exam contains 6 questions for a total of 100 points. Please answer the questions in the spaces provided. If you need additional space, use the back of the page on which the question is written and clearly indicate that you have done so.

Please note that students enrolled in EECE.5730 must complete three extra problems, which are worth a total of 20 points:

- Question 2d, on page 5
- Question 3d, on page 7
- Question 6c, on page 12

You will have three hours to complete this exam.

Q1: Storage devices	/ 16
Q2: File system implementation	/ 18 + 6
Q3: Block allocation and free space management	/ 18 + 9
Q4: Reliability	/ 12
Q5: Distributed systems	/ 21
Q6: Protection and security	/ 15 + 5
TOTAL SCORE	/ 100 + 20

1. (16 points) ***Storage devices***

Assume you have a magnetic hard disk with tracks numbered from 0-127, track 0 being the outermost track. As a simplifying assumption, assume all tracks have 64 sectors numbered 0-63. Given the list of read requests to specific sectors listed below, show the order in which the sectors would be read using (a) shortest seek time first (SSTF) scheduling and (b) SCAN scheduling. Use the following assumptions:

- Given a sector, S, another sector in the same track as S will be closer (and therefore have a shorter seek time) than a sector in a different track.
- Seek time is directly proportional to the difference between track numbers. For example, moving from track 1 to track 2 would take half as long as moving from track 5 to track 7.
- Multiple sectors in the same track will be read in ascending order (lowest number first).
- The sequence should always start with the first request in the list (track 40, sector 5) Once that request has been serviced, all other requests can be serviced in any order.

The next page of the exam has been left blank (except for an extra copy of the request list) to allow you extra space to solve the problem if necessary.

Request list:

i. Track 40, sector 5
ii. Track 15, sector 60
iii. Track 100, sector 0
iv. Track 95, sector 12
v. Track 40, sector 63
vi. Track 0, sector 0
vii. Track 15, sector 59
viii. Track 127, sector 63

Additional space to solve Question 1

Request list:

i. Track 40, sector 5
ii. Track 15, sector 60
iii. Track 100, sector 0
iv. Track 95, sector 12
v. Track 40, sector 63
vi. Track 0, sector 0
vii. Track 15, sector 59
viii. Track 127, sector 63

2. (18 + ***6*** points) ***File system implementation***

a. (6 points) Operating systems often contain direct support for one specific file type but otherwise require applications to impose other types based on file structure. What one type must the operating system support, and why?

b. (6 points) The open-file table, which contains information about open files, is typically split into one centralized table and several per-process tables. Name one piece of information stored in the centralized table and explain why it is kept centrally, and name one piece of information stored in a per-process table and explain why it is kept on a per-process basis.

2 (continued)

c. (6 points) A file created on a Unix system should be readable to the public, readable and executable to its group, and readable, writeable, and executable to its owner. What 3-digit integer represents the access rights for this file? Briefly explain your answer.

d. (6 points, ***EECE.5730 only***) We discussed the different layers of a typical file system, from the logical file system down to the device drivers. Some of these layers deal with logical addresses within a file, while others deal with physical addresses. Explain how and when logical file addresses and physical file addresses are used.

3. (18 + ***9*** points) ***Block allocation and free space management***

a. (6 points) Explain the difference between extent-based file allocation and linked file allocation.

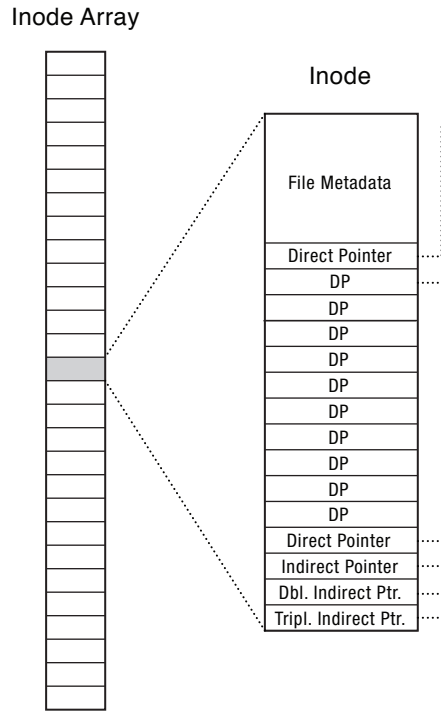
b. (6 points) Explain the difference between basic linked allocation of file blocks and the file allocation table (FAT) block allocation scheme.

c. (6 points) The two most common methods for managing free space in a file system are bitmaps and linked free space lists. Give one benefit of a bitmap over a linked free space list, and one benefit of a linked free space list over a bitmap.

3 (continued)

d. (9 points, ***EECE.5730 only***) Recall our discussion of the Berkeley Fast File System (FFS), which organizes its inodes as shown below. Each inode contains 12 direct pointers to disk blocks, as well as three other pointers—an indirect pointer, a doubly indirect pointer, and a triply indirect pointer. (Only the inode array and a single inode are shown—not all pointers.)

Assume each pointer is 32 bits and each disk block is 8 KB. If a file in this file system is 16 GB, how much space is allocated to store all of the pointers (whether direct or indirect) required to access all blocks in that file? **Show all of your work for full credit.**



4. (12 points) ***Reliability***

a. (6 points) Explain why methods for ensuring reliability in file systems center on operations that write a single sector.

b. (6 points) A Linux variant called TxOS, developed at the University of Texas, supports transactions with shadowing by decomposing inodes into two parts: a header that contains infrequently modified data about each file, and a data component holding fields that are commonly modified by system calls. The header contains a pointer to the related data component, and the data component contains a pointer to the header.

   Explain how this inode organization makes it relatively easy to implement shadowing for changes to a file's metadata.

5. (21 points) ***Distributed systems***

a. (6 points) In a distributed system, a process running on one node sends a byte stream to another node; the byte stream is split into several messages. How will the system recognize and handle (i) messages received out of order and (ii) dropped messages? In your answer, specify which process (sender or receiver) is responsible for detecting each of these issues.

b. (6 points) Distributed file systems often allow nodes to cache local copies of shared data, using either write-through or write-back policies to handle changes to those data. List one benefit of using write-through file caching, and one benefit of using write-back file caching.

5 (continued)

c. (9 points) A client process uses a binary search tree to store a set of 32-bit integers, one integer per node. The 32-bit address of the tree's root node is passed as the only argument to a remote procedure call to be executed in a server process.

   If the binary search tree contains 15 values, what is the minimum amount of space required to marshal the parameter or parameters of this function such that the remote procedure can access the entire binary search tree stored by the client? Show your work for full credit.

6. (15 + ***5*** points) ***Protection and security***

a. (9 points) Given the access matrix below, answer questions (i)-(iii).

Domains	**Objects**						
	F_1	F_2	F_3	D_1	D_2	D_3	D_4
D_1	read* write*		write		control		
D_2		owner					
D_3	read owner		read*				
D_4		write	write			control	

i. Can a process in domain D_1 grant read privileges for object F_3 to a process in domain D_2? Why or why not?

ii. Can a process in domain D_3 revoke the write privileges of a process in domain D_1 for object F_3? Why or why not?

iii. Can a process in domain D_2 give read, write, and execute privileges for object F_2 to a process in domain D_3? Why or why not?

6 (continued)

b. (6 points) Two professors are discussing the security of a distributed system in which the key used to encrypt messages is known. Professor A claims that knowing the encryption key will allow him to decrypt any message sent between nodes in the system once he determines the type of cryptography used, thus making the system insecure. Professor B claims it is possible for the system to be secure, depending on what method is used to encrypt messages. Which professor is right, and why?

c. (5 points, ***EECE.5730 only***) Briefly explain how default access rights are implemented in an access list.