Name:

CSCI 3753: Operating Systems
Spring 2013
Final Exam Solutions
05/07/2013 (4:30 – 6:00 PM)

Answer all questions in the space provided

Multiple Choice Questions: Choose one option that answers the question best.
[30 Points]

1. Process deadlock can be prevented if

   - A. Processes are required to release all their resources before requesting new ones
   - B. OS imposes some arbitrary upper limit (e.g. 10) on the number of resources a process may hold at any point in time
   - C. Processes do not request more resources of any type than that are available in the system
   - D. OS limits the number of processes executing concurrently in the system below a threshold
   - E. None of the resources in the system allow concurrent access

2. Which of the following items is typically NOT stored in a file control block?

   - A. File name
   - B. File size
   - C. Time and date when the file was created
   - D. Name of the directory to which this file belongs
   - E. Access control list

3. Which of the following actions in smartphones does not require execution in the supervisor mode?

   - A. Skype to a friend
   - B. Take a picture
   - C. Shoot a pig in angry bird
   - D. Locate yourself in the map
   - E. All of the above

4. A buffer overflow attack is feasible because

Note: I have accepted both C or E as correct answers

   - A. Programmers use arrays to store data
   - B. OS uses stacks to manage function call
   - C. Programmers omit array bound checking in their code
   - D. Arrays may store data of type *char*
   - E. All of the above

5. Advantages of virtual memory are

    - A. Size of a process may exceed the size of available RAM in the system
    - B. There is no limit on the size of a process as long as there is unlimited supply of secondary storage
    - C. Processes can have large sparse address spaces, in which most of the address space is unused, without taking up lots of physical RAM
    - D. A, B and C
    - E. A and C but not B

6. Which of the following is NOT correct about TLB?

    - A. TLBs allow for fast logical → physical address translation
    - B. TLBs incorporate fast parallel search in hardware
    - C. TLBs are implemented in hardware
    - D. TLBs are inexpensive compared to RAM
    - E. TLBs are used to cache page table entries

7. Access Control List is

    - A. a list of files and directories that a process can access
    - B. a linked list of files and directories that can be accessed only in supervisor mode
    - C. a set of access control rights that different processes have to access an object
    - D. stored as part of a Process Control Block
    - E. None of the above

8. An advantage of symmetric key cryptography is

    - A. the strength of encryption and decryption algorithm lies in Mathematics
    - B. the encryption and decryption algorithms are extremely difficult for anyone to understand
    - C. key sharing is simplified
    - D. encryption and decryption algorithms can be implemented very efficiently
    - E. it can be used for secure conversation between two complete strangers

9. Which of the following is NOT correct about SSH?

    - A. It provides support for secure authentication over a public network
    - B. It is not vulnerable to replay attacks
    - C. It uses a different symmetric key every time a user logs in from remote
    - D. It uses a different asymmetric key every time a user logs in from remote
    - E. It may be vulnerable to man-in-the-middle attack

10. Two threads with in a process
    - A. share their stacks
    - B. have their own separate heaps
    - C. have their own separate program counters
    - D. have their own separate code segment
    - E. cannot have race conditions

Short Answer Questions:

1. **[5 Points]** What are the four necessary conditions for a process deadlock to occur?

No preemption of resources
Mutual exclusion
Hold and wait
Circular wait

Grading: 5 points for all correct. Partial credit: 1 point each for each correct condition

2. **[5 Points]** Provide a step-by-step description of how an *open( )* command is implemented in a file system.

1. Search the directory structure for the file. FCB entry is stored there
2. Retrieve FCB from disk. Copy into system OFT
3. Create an entry in per process OFT
4. Return a handle

Grading: Identifying OFT: 2 points

3. **[5 Points]** Suppose you are a system administrator of a large university computer center that uses Linux. One day you find out that some students have discovered the algorithm used for encrypting passwords and posted it on their Facebook page. What should you do? Explain your answer.

Do nothing (2 Points). Encryption algorithm is well known (3 Points)

4. **[5 Points]** Explain how run time binding with dynamic linking aids in (a) swapping a process between main memory and disk during execution; (b) saving memory space.

(a) Since address mapping from logical to physical address happens at runtime, a process may be loaded at different locations in memory, every time it is swapped in (2.5 Points)

(b) It allows for sharing of libraries among concurrently running processes (2.5 Points)

5. **[6 Points]** What is the difference between external fragmentation and internal fragmentation in memory allocation? What type of fragmentation can occur in memory allocation using (i) fixed partition strategy; (ii) variable partition strategy?

   External fragmentation: Small chunks of memory that is available for allocation, but cannot be allocated due to small size (2 Points)

   Internal fragmentation: Small chunks of memory allocated to processes even though the processes do not need them (2 Points)

   (i) Internal fragmentation (1 Point)
   (ii) External fragmentation (1 Point)

6. **[5 Points]** Explain the working set theory. How does it avoid thrashing?

Draw or explain graph about degree of multiprogramming vs CPU utilization (2 Points)

Each process is allocated a working set of pages. The size of the working set is adjusted dynamically to maintain page fault rate between low and high thresholds (2 Points)

A process is allowed to run only if its entire working set is loaded in memory (1 Point)

7. **[4 Points]** What role does the jump table play in executing a system call?

Jump table stores pointers to the system call handling routines (2 Points)

It resides in the kernel. On a system call, trap( ) instruction changes user to supervisor mode so that it can access the jump table (1 Point)

The process then indexes into the jump table to find the address of the system call handling routine (1 Point)

Problems

1. **[8 Points]** An operating system uses Banker's algorithm to avoid any deadlocks. There are 5 types of resources, with the total number of each resource types in the system as follows: R0: 4, R1: 2, R2: 3, R3: 3, R4: 5. Consider the following current state of the system:

Maximum Claims:

	R0	R1	R2	R3	R4
P0	2	2	1	0	3
P1	1	2	1	1	0
P2	3	1	1	2	1
P3	2	1	1	2	2
P4	0	1	2	1	2

Current Allocation:

	R0	R1	R2	R3	R4
P0	0	1	1	0	1
P1	1	0	1	0	0
P2	1	0	0	0	0
P3	1	0	0	1	1
P4	0	0	0	1	2

At this time, process P3 requests one instance of resourceR1. Will the operating system grant this request? Explain your answer and show all your work.

Increment P3's current allocation of R1 (0 → 1) (2 Points)

Find a safe sequence. Several exist, all starting with P3, P0, … (5 Points)

Answer: YES (1 Point)

2. **[9 Points]** Assume that you have a primary memory consisting of 3 page frames. Initially, this memory is empty. Consider a page reference string 3, 4, 3, 1, 2, 1, 4, 6, 1, 2. For each of the following page replacement algorithm (a) show the pages loaded in memory after each page reference, and (2) calculate the number of page faults.

   Showing the page frames after every page reference (2 Points)
   Correct # of page faults (1 Point)

   (a) Optimal

   (b) Least Recently Used

   (c) Clock

3. **[8 Points]** Compute physical addresses for the following virtual addresses (represented in binary). Write the corresponding physical addresses in binary format. Assume that memory size is 64K, page size is 4K, and the page mapping table is as shown below (page numbers not shown are not loaded in the memory):

Page Number	Page Frame Number
1	0
2	8
5	10
8	3
12	2
13	4
18	1
22	15
32	13

Page size 4 K → 12 bits for offset (2 Points)

1000000000000 (page 1 → frame 0): 0 000000000000

1001010001111100 (page 9 → page fault)

1001011111010000 (page 18 → frame 1): 1 011111010000

1000001111111111111 (page 32 → 13): 1101 111111111111

4. **[5 Points]** Suppose a two-level page table is used in a virtual memory system with 32-bit addresses, 4 KB page size, and 10 bits to index into the top-level page table. How many page tables (top-level + secondary-level) are needed to implement a 12 MB process?

   4 K page size → 12 bits for offset
   So, 10 bit index for secondary level page table (1 Point)

   Number of pages: 12 MB/4 KB = 3 X 2^{10} (1 Point)

   Since each secondary level page table accommodates 210 addresses, need 3 secondary level page table to accommodate 3 X 2^{10} addresses (2 Point)

   Total # of page tables = 1 top level + 3 secondary level = 4 (1 Point)

5. **[5 Points]** A file system that uses I-nodes allocates 10 direct block addresses, one single indirect block address, one double indirect block address, and one triple indirect block address. What is the maximum file size that can be accommodated in this file system? How many blocks (data and index blocks) are needed to store a file of size 1 MB? Assume that the size of a block is 1 KB and 4 bytes are needed to represent an integer.

Max file size: 10 (direct blocks) + (2^{10}/4) single indirect blocks + (2^{10}/4 * 2^{10}/4) single indirect blocks + (2^{10}/4 * 2^{10}/4 * 2^{10}/4) single indirect blocks
= 10 + 256 + 256*256 + 256*256*256 KB (2 Points)

# of data blocks needed = 1 MB/ 1 KB = 2^{10} = 1024 (1 Point)

10 blocks indexed by direct block addresses
256 blocks indexed by 1 singly indirect index block
Remaining 758 blocks indexed by one 1st level and three 2nd level doubly indirect index blocks
So, # of index blocks = 5 (2 Points)

Total # of blocks = 1024 + 5 = 1029