Midterm Sample Questions

Short Questions

1. The THE system is organized in a strict hierarchy, virtualizing aspects of the machine one at a time, with higher-level abstractions built on top of the earlier layers. The lowest level of virtualization ("level 0") is of:
   (a) the processor
   (b) core memory
   (c) the drum
   (d) the keyboard console

2. In the Unix file system, file names are stored in which of the following locations
   (a) Directory i-node
   (b) Directory data block
   (c) File i-node
   (d) File data block

3. For **each** of the following sentences concerning the VAX/VMS virtual memory system, circle the word in bold that makes the sentence true.
   (a) If there are two user processes in the system, there will be a total of **1/2/3/4/5/6** pagetable(s).
   (b) Each page table is defined by **1 / 2 / 3 / 4** hardware register(s).
   (c) The *user page table base register* contains a **virtual / physical** address.
   (d) The *system page table base register* contains a **virtual / physical** address.
   (e) **One / Two / Three** memory lookups are required to translate a user's virtual address to a physical address (assuming there is no TLB).

4. Unix FFS introduced *cylinder groups* to improve locality and thus reduce seek time. Which of the following are placed together in the same cylinder group (assuming there is sufficient space)? Circle **all** that apply.
   (a) I-nodes for all files and directories
   (b) I-nodes for all files in the same directory
   (c) I-nodes for all sub-directories of the same directory
   (d) The i-node and all data blocks of a small file
   (e) The i-node and all data blocks of a small directory
   (f) The i-node and all data blocks of a very large file

5. In Hydra, if a process has a reference to an object, it can for certain
   (a) modify the object's entire representation
   (b) modify only the object's data part
   (c) destroy the object
   (d) perform operations in accordance with the access rights of the reference

6. A TLB miss occurs in an application running on Irix running on top of Disco. Which of the following represents a legal control flow? **(Circle all that apply)**
   (a) Irix TLB miss handler → resume application
   (b) Disco → resume application
   (c) Disco → Irix TLB miss handler → Disco → resume application
   (d) Disco → Irix TLB miss handler → Irix page fault handler → Disco → resume application

7. When calling `read()` from an application to read a single data block from an open file in LFS, how many disk reads **could** occur?

8. The LFS cleaner uses information in the *segment summary block* to determine whether each data block in that segment is live. Which of the following information is kept for each data block in the segment summary block? Circle **all** that apply.
   (a) Superblock
   (b) Free block bitmap
   (c) File pathname
   (d) File number (*i.e.*, i-node number)
   (e) Indirect block
   (f) I-node map
   (g) Block number (*i.e.*, offset within file)
   (h) Version number of file

Longer Questions

1. Dijkstra believed that the THE system is guaranteed to be **flawless**. Enumerate the reasons why he felt this to be so.

2. Semaphores, as invented by Dijkstra, were used in two entirely different ways in the construction of the THE system. Describe both ways.

3. In Nucleus, **message passing** was used to coordinate cooperating processes instead of semaphores. What are the reasons why message passing is more appropriate in Nucleus?

4. Unix is a very popular OS that contains support for **hard links**. First, briefly enumerate the important steps that take place in Unix when a user specifies the command `ln /a/old /b/new` (assume that the file `/a/old` and the directory `/b/` already exist). Second, briefly enumerate the steps that occur when the user runs the command `rm /a/old`. Can the user now access `/b/new`? why or why not?

5. In Vax/VMS, the per-process resident set lists were managed with a simple FIFO policy. When removed from that list, pages were placed onto either a free list or a modified page list. What could happen to a page on one of those lists?

6. The VAX architecture used **very small pages** of only 512 bytes. First, enumerate the ways in which a small page size produces challenges for the virtual memory system. Second, briefly describe how the VMS operating system deals with each of these complexities.

7. Berkeley FFS improved performance by using a **larger block size** on disk (e.g., 4KB instead of 512 bytes). First, list the advantages and disadvantages of a using a larger block size. Second, describe how FFS ensures that they obtain the advantages of both small and large blocks.

8. Consider the steps that occur in Mach when a **Unix-style** `fork()` is performed and the child process writes to a single page. First, specify the inheritance value for the address space and a "reasonable" number of memory objects. Second, draw the address maps of the parent and child process, including the memory objects; what will the address map look like after the single write?

9. The steps involved in invoking a **procedure** in Hydra help form the core of the Hydra protection-checking mechanism. Enumerate the full set of steps that may occur when a new procedure in called in Hydra; briefly describe the purpose of those steps that directly deal with capabilities

10. One of the primary roles of an Exokernel is to securely expose the underlying hardware, for example with a **secure binding**. The idea behind a secure binding is to separate the authorization for a resource from its actual use. Two of the techniques that are useful in implementing secure bindings efficiently are **hardware support** and **software caching**. Describe how these two techniques are used (and why they are needed) when securely multiplexing memory across processes.

11. The drawback of a virtual machine monitor is that it introduces overhead in both **time** and **space**. Explain the cause (or source) of both time and space overheads and describe how Disco reduces each overhead.

12. In Disco, the "illusion" provided by the virtual machine monitor to the operating system had to be "broken" sometimes, to improve performance of the system. This usually required changing some code within the operating system. Describe one such situation where this occurs, and how it improves performance.

13. Assume that you are allowed to create a single file, using sequential or random writes, and then read that file back, using sequential or random reads. Which combination of writes and then reads would lead to LFS performance that is much *worse* than FFS performance? Why?