Review Questions – Main Memory (Chapter 9)

Operating Systems SFWRENG 3SH3 Term 2, Winter 2023
Prof. Neerja Mhaskar

Questions

1. Consider a system in which memory protection is achieved using the **Base and Limit registers**. Suppose the value in base register = 1200 and value in limit register = 1000.
    a. If the logical address generated by the CPU = 32. To what physical address is this logical address mapped to?
    b. If the logical address generated by the CPU = 1500. To what physical address is this logical address mapped to?
2. Consider a system in which the logical addresses are mapped to physical addresses using relocation registers. Suppose the value of the relocatable register =14000 and the limit register = 1200. If the CPU generated a logical address = 1300. To what physical address is the logical address mapped to?
3. Explain the difference between internal and external fragmentation.
4. Given six memory partitions of 300 KB, 600 KB, 350 KB, 200 KB, 750 KB, and 125 KB (in order), how would the first-fit, best-fit, and worst-fit algorithms place processes of size 115 KB, 500 KB, 358 KB, 200 KB, and 375 KB (in order)? Rank the algorithms in terms of how efficiently they use memory.
5. Consider a physical memory of size 64MB. It is partitioned using the contiguous dynamic partitioning scheme. The operating system uses 8MB of memory space. At a given instance in time, below is the snapshot of memory:

OS = 8MB	P1=16MB	P2=20MB	P3=18MB	2MB

Process P2 terminates and releases 20MB space and P4 is brought into main memory.

OS = 8MB	P1=16MB	P_4=14MB	6MB	P3=18MB	2MB

a) Can Process P5 = 8MB be brought into memory? If not, why?
b) Can Process P6 = 10MB be brought into memory? If not, why?

6. Compare the memory organization schemes of contiguous memory allocation (fixed and dynamic partitioning), and pure paging with respect to the following issues: a) External fragmentation b) Internal fragmentation.

7. Assuming a 1-KB page size, what are the page numbers and offsets for the following address references (provided as decimal numbers):
a. 3085
b. 42095
c. 215201
d. 650000
e. 2000001

8. Consider a logical address space of 256 pages with a 4-KB page size, mapped onto a physical memory of 64 frames.
a. How many bits are required in the logical address?
b. How many bits are required in the physical address?

9. The BTV operating system has a 21-bit virtual address, yet on certain embedded devices, it has only a 16-bit physical address. It also has a 2-KB page size. How many entries are there in each of the following?
    a. A conventional, single-level page table.
    b. An inverted page table.

10. What is the maximum amount of physical memory in the BTV operating system?

11. Consider a computer system with a 32-bit logical address and 4-KB page size. The system supports up to 512 MB of physical memory. How many entries are there in each of the following?
    c. A conventional single-level page table
    d. An inverted page tables.

12. Consider a paging system with the page table stored in memory.
    e. If a memory reference takes 200 nanoseconds, how long does a paged memory reference take?
    f. If we add TLBs, and 75 percent of all page-table references are found in the TLBs, what is the effective memory reference time? (Assume that finding a page-table entry in the TLBs takes 2 nanoseconds, if the entry is present.)

13. Assume a program has just referenced an address in virtual memory. Describe a scenario how each of the following can occur: (If a scenario cannot occur, explain why.)
    g. TLB miss with no page fault
    h. TLB miss and page fault
    i. TLB hit and no page fault
    j. TLB hit and page fault

14. Consider Hierarchical paging, with logical address space of 2^{48} bytes, page size = 1024 = 2^{10} bytes and each page table entry takes 8 bytes. A multi-level page table is used because each table must be contained within a page.
a. How many levels of page table are required?

b. What is the distribution of no. of bits to represent each level of the multi-level page table, and the page offset?

15. Consider the page table shown below for a system with 12-bit virtual and physical addresses and with 256-byte pages. The list of free page frames is D, E, F (that is, D is at the head of the list, E is second, and F is last). Convert the following virtual addresses to their equivalent physical addresses in hexadecimal. All numbers are given in hexadecimal. (A dash for a page frame indicates that the page is not in memory.)

Page	Page Frame
0	–
1	2
2	C
3	A
4	–
5	4
6	3
7	–
8	B
9	0

a. 9EF
b. 111
c. 700
d. 0FF

Review Questions – Virtual Memory (Chapter 10)

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Questions

1. Consider the page table shown below for a system with 12-bit virtual and physical addresses and with 256-byte pages. The list of free page frames is D, E, F (that is, D is at the head of the list, E is second, and F is last). Convert the following virtual addresses to their equivalent physical addresses in hexadecimal. All numbers are given in hexadecimal. (A dash for a page frame indicates that the page is not in memory.)

Page	Page Frame
0	–
1	2
2	C
3	A
4	–
5	4
6	3
7	–
8	B
9	0

a. 9EF
b. 111
c. 700
d. 0FF

What is demand paging and pure demand paging?

2. Consider the following page reference string:
7, 2, 3, 1, 2, 5, 3, 4, 6, 7, 7, 1, 0, 5, 4, 6, 2, 3, 0, 1.

Assuming demand paging with three frames, how many page faults would occur for the FIFO replacement algorithm?

3. Consider the following page reference string:
7, 2, 3, 1, 2, 5, 3, 4, 6, 7, 7, 1, 0, 5, 4, 6, 2, 3, 0, 1.
Assuming demand paging with three frames, how many page faults.

would occur for the following replacement algorithms?

a. LRU replacement
b. FIFO replacement
c. Optimal replacement

4. Consider the following page reference string:
   7, 2, 3, 1, 2, 5, 3, 4, 6, 7, 7, 1, 0, 5, 4, 6, 2, 3, 0, 1.

   Assuming demand paging with three frames, how many page faults would occur for the following replacement algorithms?

   a. LRU replacement
   c. Optimal replacement

5. The VAX/VMS system uses a FIFO replacement algorithm for resident pages and a free-frame pool of recently used pages. Assume that the free-frame pool is managed using the least recently used replacement policy. Answer the following questions:

a) If a page fault occurs and if the page does not exist in the free-frame pool, how is free space generated for the newly requested page?
b) If a page fault occurs and if the page exists in the free-frame pool how is the resident page set and the free-frame pool managed to make space for the requested page?
c) What does the system degenerate to if the number of resident pages is set to one?
d) What does the system degenerate to if the number of pages in the free-frame pool is zero?

6. What is the cause of thrashing? How does the system detect thrashing? Once it detects thrashing, what can the system do to eliminate this problem?

7. Assume there is an initial 16 KB segment where memory is allocated using the Buddy system. As shown in lecture notes on the Buddy system, draw the tree illustrating how the following memory requests are allocated:
   a. request 3.6 KB
   b. request 1.5 KB
   c. request 1.2 KB
   d. request 1.9 KB
   e. request 2.7 KB

   Next, modify the tree for the following releases of memory. Perform coalescing whenever possible and list the available segment sizes:

   1. release 1.2 KB
   2. release 1.9 KB
   3. release 1.5 KB

Review Questions – Mass Storage Structure (Chapter 11)
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1. Explain why SSTF scheduling tends to favor middle cylinders over the innermost and outermost cylinders.

2. Explain why SSDs often use a FCFS disk-scheduling algorithm?

3. Suppose that a disk drive has 5,000 cylinders, numbered 0 to 4999. The drive is currently serving a request at cylinder 2150, and the previous request was at cylinder 1805. The queue of pending requests, in FIFO order, is:

   2069, 1212, 2296, 2800, 544, 1618, 356, 1523, 4965, 3681

   Starting from the current head position, what is the total distance (in cylinders) that the disk arm moves to satisfy all the pending requests for each of the following disk-scheduling algorithms?

   1. FCFS =
   2. SSTF =
   3. SCAN =
   4. LOOK =
   5. C-SCAN =
   6. C-LOOK =

4. Consider a RAID Level **5 4** organization comprising five disks, with the parity for sets of four blocks on four disks stored on the fifth disk. How many blocks are accessed in order to perform the following?
a. A write of one block of data.
b. A write of seven continuous blocks of data.

5. Compare the performance of write operations achieved by a RAID Level 5 organization with that achieved by a RAID Level 1 organization.

6. Assume that you have a mixed configuration comprising disks organized as RAID Level 1 and as RAID Level 5 disks. Assume that the system has flexibility in deciding which disk organization to use for storing a particular file. Which files should be stored in the RAID Level 1 disks and which in the RAID Level 5 disks in order to optimize performance?

7. Discuss the reasons why the operating system might require accurate information on how blocks are stored on a disk. How could the operating system improve file system performance with this knowledge?

Review Questions - File System Interface, Implementation, and Internals (Chapters 13, 14, and 15)
Operating Systems SFWRENG 3SH3 Term 2, Winter 2023
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1. Describe the steps taken by a file system to create a file. Your solution should state all the data structures updated in the process.

2. Describe the steps taken by a file system to open a file. Your solution should state all the data structures updated in the process.

3. What problems could occur if a system allowed a file system to be mounted simultaneously at more than one location?

4. Fragmentation on a storage device can be eliminated by recompaction of the information. However, recompacting and relocation of files are often avoided. Why?

5. Consider a file currently consisting of 100 (0-99) blocks. Assume that the file control block (and the index block, in the case of indexed allocation) is already in memory. **Calculate how many disk I/O operations are required for contiguous, linked, and indexed** (single-level) allocation strategies, if, for one block, the following conditions hold. In the contiguous-allocation case, assume that there is no room to grow at the beginning but there is room to grow at the end. Also assume that the block information to be added is stored in memory.

    a. The block is added at the beginning.
    b. The block is added in the middle.
    c. The block is added at the end.
    d. The block is removed from the beginning.
    e. The block is removed from the middle (the middle block considered here is the 50th block).
    f. The block is removed from the end.

6. Consider a file system on a disk that has both logical and physical block sizes of 512 bytes. Assume that the information about each file is already in memory. For each of the three allocation strategies (contiguous, linked, and indexed), answer the following questions: If we are currently at logical block 10 (the last block accessed was block 10) and want to access logical block 4, how many physical blocks must be read from the disk?

7. Consider a file system that uses Inodes to represent files. Disk blocks are 8-KB in size and a pointer to a disk block requires 4 bytes. This file system has 12 direct disk blocks, plus single, double, and triple indirect disk blocks. What is the maximum size of a file that can be stored in this file system?

8. Consider a system where free space is kept in a free-space list.

    a. Suppose that the pointer to the free-space list is lost. Can the system reconstruct the free-space list? Explain your answer.

    b. Suggest a scheme to ensure that the pointer is never lost as a result of memory failure.

9. Some file systems allow disk storage to be allocated at different levels of granularity. For instance, a file system could allocate 4 KB of disk space as a single 4-KB block or as eight 512-byte blocks. How could we take advantage of this flexibility to improve performance? What modifications would have to be made to the free-space management scheme in order to support this feature?

10. What access rights does the command: `chmod 531 test.txt`, specify on the file test.txt?

Review Questions – I/O Structure, Protection and Security
(Chapters 12, 16, and 17)
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1. Consider the following I/O scenarios on a single-user PC:

   a. A mouse used with a graphical user interface.
   b. A tape drive on a multitasking operating system (with no device pre allocation available)
   c. A disk drive containing user files
   d. A graphics card with direct bus connection, accessible through memory mapped I/O.

   For each of these scenarios, would you design the operating system to use buffering, spooling, caching, or a combination? Would you use polled I/O or interrupt driven I/O? Give reasons for your choices.

2. What is the difference between symmetric and asymmetric encryption algorithms?

3. What is the difference between protection and security?

4. Consider the RSA encryption algorithm. Given $p = 5$, $q = 11$, $k_e = 3$, $k_d = 27$, compute the following:

   a. What are the public and private keys used?
   b. Given message $m = 9$. Compute the ciphertext 'C' using the encryption algorithm.
   c. Compute the message from the ciphertext 'C' using the decryption algorithm.