Virtual Memory

1. Under what circumstances do page faults occur? Describe the actions taken by the operating system when a page fault occurs.

Answer: A page fault occurs when an access to a page that has not been brought into main memory takes place. The operating system verifies the memory access, aborting the program if it is invalid. If it is valid, a free frame is located and I/O is requested to read the needed page into the free frame. Upon completion of I/O, the process table and page table are updated, and the instruction is restarted.

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 following replacement algorithms?

- LRU replacement
- FIFO replacement
- Optimal replacement

Answer: • 18 • 17 • 13

3. A page-replacement algorithm should minimize the number of page faults. We can achieve this minimization by distributing heavily used pages evenly over all of memory, rather than having them compete for a small number of page frames. We can associate with each page frame a counter of the number of pages associated with that frame. Then, to replace a page, we can search for the page frame with the smallest counter.

a. Define a page-replacement algorithm using this basic idea. Specifically address these problems:

i. What the initial value of the counters is
ii. When counters are increased
iii. When counters are decreased
iv. How the page to be replaced is selected

b. How many page faults occur for your algorithm for the following reference string, for four page frames?

1, 2, 3, 4, 5, 3, 4, 1, 6, 7, 8, 7, 8, 9, 7, 8, 9, 5, 4, 5, 4, 2.

c. What is the minimum number of page faults for an optimal page replacement strategy for the reference string in part b with four page frames?

Answer:

a. Define a page-replacement algorithm addressing the problems of:

i. Initial value of the counters—0.
ii. Counters are increased—whenever a new page is associated with that frame.

iii. Counters are decreased—whenever one of the pages associated with that frame is no longer required.

iv. How the page to be replaced is selected—find a frame with the smallest counter. Use FIFO for breaking ties.

b. 14 page faults

c. 11 page faults

4. Consider the following page reference string:

2、3、2、1、5、2、4、5、3， 2， 5、2.

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

- LRU replacement

- FIFO replacement

- Optimal replacement

Answer:

FIFO：

2 3 2 1 5 2 4 5 3 2 5 2
2 3 3 1 5 2 4 4 3 3 5 2
2 2 3 1 5 2 2 4 4 3 5
2 3 1 5 5 2 2 4 3
x x √ x x x x√x√x x 9 page faults

LRU 算法：

2 3 2 1 5 2 4 5 3 2 5 2
2 3 2 1 5 2 4 5 3 2 5 2
2 3 2 1 5 2 4 5 3 2 5
3 2 1 5 2 4 5 3 3
x x√x x√ x√ x x√√ 7 page faults

File System

5. Transfers between memory and disk are performed a _____.
   A) byte at a time
   B) file at a time
   C) block at a time
   D) sector at a time

Ans: C

6. Order the following file system layers in order of lowest level to highest level.

[1] I/O control
[2] logical file system
[3] basic file system
[4] file-organization module
[5] devices
A) 1, 3, 5, 4, 2
B) 5, 1, 3, 2, 4
C) 1, 5, 3, 4, 2
D) 5, 1, 3, 4, 2

Ans: D

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?

Answer:

(12 * 8 /KB/) + (2048 * 8 /KB) + (2048 * 2048 * 8 /KB/) + (2048 * 2048 * 2048 * 8 /KB) = 64 terabytes

Mass-Storage Structure

8. 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?
   a. FCFS
   b. SSTF
   c. SCAN
   d. LOOK
   e. C-SCAN
   f. C-LOOK

Answer:

a. The FCFS schedule is 2150, 2069, 1212, 2296, 2800, 544, 1618, 356, 1523, 4965, 3681. The total seek distance is 13,011.

b. The SSTF schedule is 2150, 2069, 2296, 2800, 3681, 4965, 1618, 1523, 1212, 544, 356. The total seek distance is 7586.

c. The SCAN schedule is 2150, 2296, 2800, 3681, 4965, 2069, 1618, 1523, 1212, 544, 356. The total seek distance is 7492.

d. The LOOK schedule is 2150, 2296, 2800, 3681, 4965, 2069, 1618, 1523, 1212, 544, 356. The total seek distance is 7424.

e. The C-SCAN schedule is 2150, 2296, 2800, 3681, 4965, 356, 544, 1212, 1523, 1618, 2069. The total seek distance is 9917.

f. The C-LOOK schedule is 2150, 2296, 2800, 3681, 4965, 356, 544, 1212, 1523, 1618, 2069. The total seek distance is 9137.

9. Consider a disk queue holding requests to the following cylinders in the listed order: 116, 22, 3, 11, 75, 185, 100, 87. Using the SCAN scheduling algorithm, what is the order that the requests are serviced, assuming the disk head is at cylinder 88 and moving upward through the cylinders?
   A) 116 - 22 - 3 - 11 - 75 - 185 - 100 - 87
   B) 100 - 116 - 185 - 87 - 75 - 22 - 11 - 3
   C) 87 - 75 - 100 - 116 - 185 - 22 - 11 - 3
   D) 100 - 116 - 185 - 3 - 11 - 22 - 75 - 87

Ans: B

10. Consider a disk queue holding requests to the following cylinders in the listed order: 116, 22, 3, 11, 75, 185, 100, 87. Using the SSTF scheduling algorithm, what is the order that the requests are serviced, assuming the disk head is at cylinder 88 and moving upward through the cylinders?
   A) 116 - 22 - 3 - 11 - 75 - 185 - 100 - 87
   B) 100 - 116 - 185 - 87 - 75 - 22 - 11 - 3
   C) 87 - 75 - 100 - 116 - 185 - 22 - 11 - 3
   D) 100 - 116 - 185 - 3 - 11 - 22 - 75 - 87

Ans: C

IO System

11. A character-stream device ____.
   A) transfers data in blocks of bytes
   B) transfers data a byte at a time
   C) is a device such as a disk drive
   D) is similar to a random access device

Ans: B

12. Which of the following is a principle that can improve the efficiency of I/O?
   A) Increase the number of context switches.
   B) Use small data transfers
   C) Move processing primitives into hardware
   D) Decrease concurrency using DMA controllers

Ans: C

13. Polling for an I/O completion can waste a large number of CPU cycles if the processor iterates a busy-waiting loop many times before the I/O completes. But if the I/O device is ready for service, polling can be much more efficient than catching and dispatching an interrupt. Describe a hybrid strategy that combines polling, sleeping, and interrupts for I/O device service. For each of these three strategies (pure polling, pure interrupts, hybrid), describe a computing environment in which that strategy is more efficient than either of the others.

Answer:

A hybrid approach could switch between polling and interrupts depending on the length of the I/O operation wait. For example, we could poll and loop N times, and if the device is still busy at N+1, we could set an interrupt and sleep. This approach would avoid long busy-waiting cycles and would be best for very long or very short busy times. It would be inefficient if the I/O completes at N+T (where T is a small number of cycles) due to the overhead of polling plus setting up and catching interrupts. Pure polling is best with very short wait times. Interrupts are best with known long wait times.

14. How does DMA increase system concurrency? How does it complicate hardware design?

Answer:

DMA increases system concurrency by allowing the CPU to perform tasks while the DMA system transfers data via the system and memory buses. Hardware design is complicated because the DMA controller must be integrated into the system, and the system must allow the DMA controller to be a bus master. Cycle stealing may also be necessary to allow the CPU and the DMA controller to share use of the memory bus.