Fall 2024 COMP 3511 Homework Assignment #4

Handout Date: November 20 2024, Due Date: December 4 2024

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Please read the following instructions carefully before answering the questions:

- You must finish the homework assignment **individually**.
- When you write your answers, please try to be precise and concise.
- **Homework Submission:** Please submit your homework to **Homework #4** on **Canvas**.
- TA responsible for HW4: Peng YE, pyeac@connect.ust.hk

1. (30 points) Multiple Choices

Write your answers in the boxes below:

MC1	MC2	MC3	MC4	MC5	MC6	MC7	MC8	MC9	MC10
C	B	A	A	C	D	C	A	D	B

(1) Consider that a system uses 2-level paging scheme and has a TLB hit ratio of 90%. It requires 15 nanoseconds to access the TLB, and 100 nanoseconds to access main memory. What is the effective memory access time for this system? (A TLB hit directly results in page translation, i.e., frame number)

A) 115 nanoseconds
B) 125 nanoseconds
C) 135 nanoseconds
D) 150 nanoseconds

Answer: C

(2) Consider a paging scheme with 32-bit logical address and 4KB page size. Suppose that a single-level page table is used with a page table entry (PTE) size of 4 bytes, and each PTE contains 10 control bits. What are the sizes of logical address space and physical address space, respectively?

A) 4GB, 8GB
B) 4GB, 16GB
C) 8GB, 8GB
D) 8GB, 16GB

Answer: B

(3) Which of the following statements about Belady's Anomaly is TRUE?

A) FIFO page replacement algorithm suffers from Belady's Anomaly
B) LRU page replacement algorithm suffers from Belady's Anomaly

C) OPT page replacement algorithm suffers from Belady's Anomaly
D) All of the above
Answer: A

(4) Which of the following statements about thrashing is FALSE?
A) Thrashing leads to extremely high CPU utilization
B) Thrashing occurs due to the locality of all processes exceeds the total memory
C) Local page replacement strategy can limit the trashing within one process
D) Working set model can be leveraged to track the locality of the process to mitigate the thrashing problem
Answer: A

(5) Consider a disk with average seek time is 4ms, RPM is 6,000, transfer rate is 100MB/s, and a 1MB read occurs at a random location. The controller overhead is 1ms. The effective bandwidth or transfer rate is:
A) 150MB/s
B) 100MB/s
C) 50MB/s
D) 25MB/s
Answer: C
Average latency = 60/6000/2 = 5ms
Average seek time = 4ms
Average IO time = 5ms+4ms+ 1/100 + 1ms = 20ms

(6) Which of the following statements about RAID is FALSE?
A) RAID0 is used to achieve high performance
B) RAID1 is used to achieve high reliability
C) Parity bits are used in some RAID levels
D) We cannot simultaneously achieve high performance and high reliability with RAID
Answer: D

(7) Which of the following statements about acyclic-graph directories is FALSE?
A) Acyclic-graph directories support links pointing to an existing file
B) Acyclic-graph directories allow aliasing
C) Acyclic-graph directories do not bring extra complexity in identifying cycles
D) Deleting a file may cause dangling pointers
Answer: C

(8) Consider a file system stored on a disk with block size of 1024 bytes. Suppose the disk address (block number) uses 4 bytes. Please compute the total number of blocks required to allocate a file of size 100,350 bytes under (a) contiguous and (b) indexed allocation.
A) 98 and 99

B) 99 and 100
C) 100 and 110
D) 100 and 101
Answer: A

(9) Suppose process A has 10 files open, process B has 6 files open and process C has 8 files open. 4 files are shared among the three processes. How many entries are in the system-wide open-file tables?
A) 20
B) 18
C) 26
D) 16
Answer: D

(10) A protection domain is a collection of access rights, each of which is _____.
A. a pair <object-name, users>
B. a pair <object-name, rights-set>
C. a triplet <object-name, users, rights-set>
D. a triplet <object-name, processes, rights-set>
Answer: B

2. (30 points) Page Replacement Algorithm
Consider the following page reference string:
1, 2, 3, 2, 3, 5, 6, 7, 1, 6, 1, 6, 2, 6, 5, 2, 1
Assuming demand paging with 3 frames. Please illustrate each step that the following replacement algorithms work for this reference string and compute the number of page faults in each algorithm.
(1) (10 points) FIFO replacement
(2) (10 points) Optimal replacement
(3) (10 points) LRU replacement
Answer:
FIFO Replacement

1	2	3	2	3	5	6	7	1	6	1	6	2	6	5	2	1
1	1	1	1	1	5	5	5	1	1	1	1	1	1	5	5	5
	2	2	2	2	2	6	6	6	6	6	6	2	2	2	2	1
		3	3	3	3	3	7	7	7	7	7	7	6	6	6	6
PF	PF	PF			PF	PF	PF	PF				PF	PF	PF		PF

Page Fault = 11 (1 point)

Optimal Replacement

1	2	3	2	3	5	6	7	1	6	1	6	2	6	5	2	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	2	2	2	2	2	2	7	7	7	7	7	2	2	2	2	2
		3	3	3	5	6	6	6	6	6	6	6	6	5	5	5
PF	PF	PF			PF	PF	PF					PF		PF		

Page Fault = 8 (1 point)

LRU Replacement

1	2	3	2	3	5	6	7	1	6	1	6	2	6	5	2	1
1	1	1	1	1	5	5	5	1	1	1	1	1	1	5	5	5
	2	2	2	2	2	6	6	6	6	6	6	6	6	6	6	1
		3	3	3	3	3	7	7	7	7	7	2	2	2	2	2
PF	PF	PF			PF	PF	PF	PF				PF		PF		PF

Page Fault = 10 (1 point)

3. (20 points) Disk Scheduling

Suppose that a disk drive has 1000 cylinders, numbered 0 to 999. The drive is currently serving a request at cylinder 233. The queue of pending requests, in FIFO order, is:

87, 100, 143, 126, 241, 313, 18, 768, 756, 811

Starting from the current head position (233), 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? The disk arm is moving from left to right (0 to 999).

(1) (5 points) FCFS

(2) (5 points) SSTF

(3) (5 points) SCAN

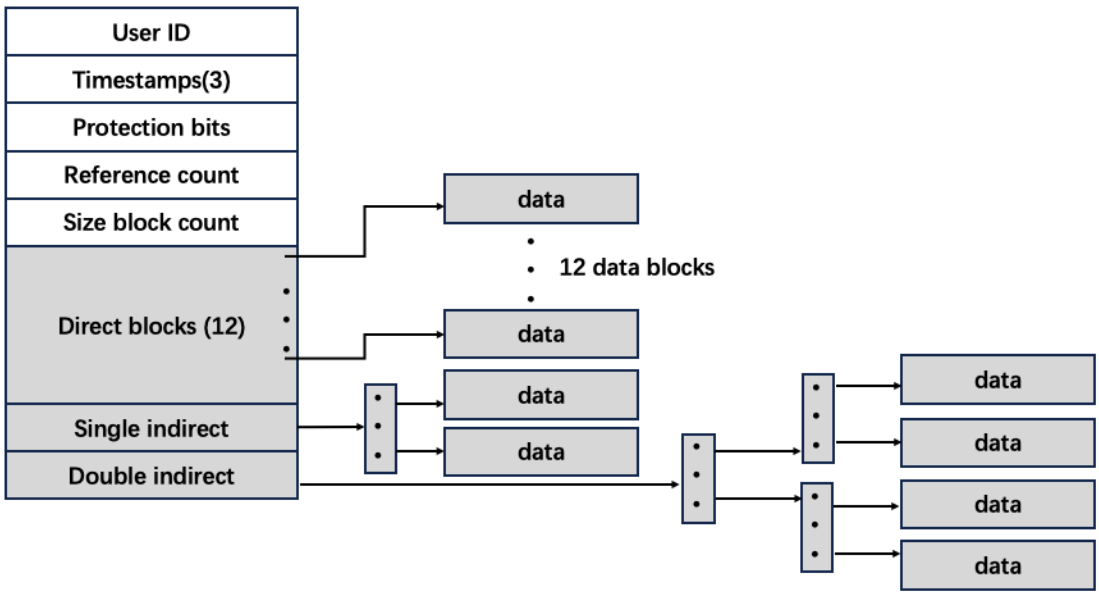
(4) (5 points) LOOK

Schedule	FCFS	SSTF	SCAN	LOOK
Starting position	233	233	233	233
	87	241	241	241
	100	313	313	313
	143	143	756	756
	126	126	768	768
	241	100	811	811
	313	87	999	143
	18	18	143	126
	768	756	126	100
	756	768	100	87

	811	811	87	18
			18	
Total Seek Time	1518	1168	1747	1371

4. (20 points) File System

Consider a file system that has the following description:



- The hard disk is divided into **2048-byte** blocks.
- As shown in the figure, a file is stored in hard disk using indexed allocation. A File Control Block (FCB) contains:
  - 12 data block pointers, each of which is 4 bytes and each of which points to a disk block.
  - ONE single indirect pointer, which points to a disk block that contains data block pointers.
  - ONE double indirect pointer, which points to a block of pointers that point to other blocks of pointers that then point to data.
- The FCB also contains a user id (2 bytes), 3 timestamps (4 bytes each), 1 protection bits (2 bytes), a reference count (3 bytes), and a size block count (4 bytes).

a) (10 points) What is the maximum file size supported by this file system? Briefly explain.

Answer:
12 direct data block pointers point 12 blocks.
1 single indirect block contains 2048/4 pointers, therefore point 512 blocks. (4 points)
1 double indirect block contains 512 pointers, each pointing to blocks with 512 pointers,

therefore point 256K blocks. (4 points)
Maximum file size possible is (12+512+256K) x 2K = 525336 Kbytes. (2 points)

b) (10 points) Consider file A with size 10KB, file B with size 1MB, and file C with size 250MB. Does the file system take the same amount of time to obtain the index of the last block of A,B,C and why?

Answer:
The time is different. (explanation: 8 point, "different": 2 points)
The size of A is 10KB < 2KB * 12, so we just only need one access to the direct disk blocks to get the last block index of file A.
However, for file B, the size is 1MB, which is greater than 2KB* 12 and less than (12+512) x 2KB. So, obtaining the index of the last block of file B requires accessing one single indirect disk blocks.
For file C, the size is 250MB, which is greater than (12+512) x 2KB and less than 525336 KB. So, obtaining the index of the last block of file C requires accessing the double indirect disk blocks.
So, their access time differs.