TA responsible for HW4: Peng YE, pyeac@connect.ust.hk

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**.
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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? (ATLB hit directly results in page translation, i.e., frame number)

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

(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

(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

(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

(5) Consider a disk with average seek time is 4ms, RPM is 6,000, transfer rate is 100MB/s,and a 1MBread 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

(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

(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 causedangling pointers

(8) Consider afile 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

(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

(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>

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

(1) FIFO replacement

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

Page faults = 11

(2) 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		
	2	2			2	2	7					2		2		
		3			5	6	6					6		5		

Page faults = 8

(3) LRU replacement

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

Page faults = 10

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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

(1) FCFS

233, 87, 100, 143, 126, 241, 313, 18, 768, 756, 811

The total seek distance is 1518

(2) SSTF

233, 241, 313, 143, 126, 100, 87, 18, 756, 768, 811

The total seek distance is 1168

(3) SCAN

233, 241, 313, 756, 768, 811, 143, 126, 100, 87, 18

The total seek distance is 1747

(4) LOOK

233, 241, 313, 756, 768, 811, 143, 126, 100, 87, 18

The total seek distance is 1371

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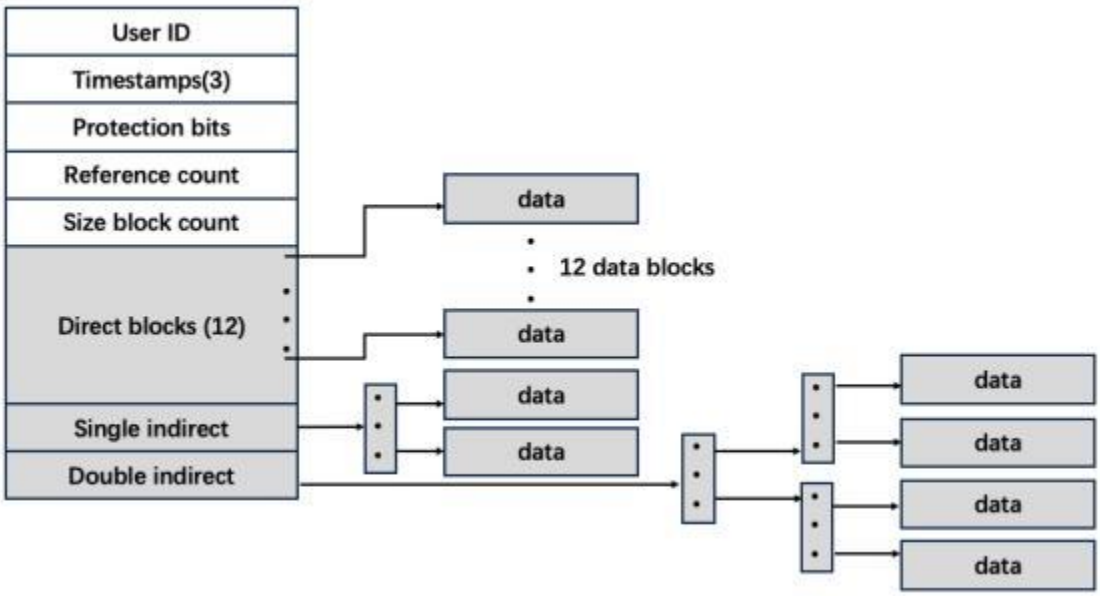
4. (20 points) File System

Consider a filesystem 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 userid (2 bytes), 3 timestamps (4 bytes each), 1 protection bits (2 bytes), areference 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.

- Block size = 2048 Bytes
- Direct pointers = 12×2048=24,576 Bytes
- Single indirect = 512×2048=1,048,576 Bytes
- Double indirect = 512×512×2048=536,870,912 Bytes

Maximum file size = 24,576+1,048,576+536,870,912 = 537,944,064 Bytes ≈ 513MB

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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?

- File A (10KB): Direct pointer → Fast
- File B (1MB): Single indirect → Slower
- File C (250MB): Double indirect → Slowest

No, the time differs due to the level of indirection.