CS 3502
Operating Systems

Conclusion and Review

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Topics

- Memory
- Page replacement
- Page design and segmentation
- File and directory
- File system
- Storage
- I/O
- Others

Topics

- Memory
- Page replacement
- Page design and segmentation
- File and directory
- File system
- Storage
- I/O
- Others

Memory system

Storage system

I/O and others

Lec 11 Memory management

- Memory management overview
  - Memory abstraction and address spaces
  - Physical address and virtual address
  - Physical memory and virtual memory
- Memory management
  - Translation look-aside buffer
  - Page table
  - Multi-level page table

Lec 12 Page replacement

- Memory management data structure
  - Bit maps vs. Linked lists
- Page replacement algorithm
  - OPR, FIFO, LRU
  - NFU, NRU
  - Second chance, Clock
  - Aging

Lec 13 Page Design and Segmentation

- Page design
  - Internal fragmentation vs. External fragmentation
  - Local page replacement vs. Global page replacement
  - Page size small vs. Large
  - Shared page
  - Paging with Process life cycle
- Segmentation
  - Page vs. Segmentation

Lec 14 File and Directory

- File: abstraction of storage
  - Name, structure, type
  - Access, attribute, operation
- Memory-mapped files
- Directory: a file to organize files
  - Single-level, two-level, hierarchical
  - Path, operation

Lec 15 File System

- What is File System?
  - The OS component that organizes data on raw storage device
- File implementation
  - Contiguous allocation, Linked list allocation, File allocation table (FAT), Index allocation
- Directory implementation
  - Fixed entry, i-node index
- Shared Files
  - Hard link vs soft link
- Virtual file system

Lec 16 Storage

- File system reliability, consistency and performance
- Storage system structure
- Hard disk drive(HDD) vs SSD
- Case study: Distributed and Parallel File Systems

Lec 17 I/O

- I/O System
- Characteristics and Category of I/O Devices
- I/O Device Component
- How CPU works with I/O devices
- I/O Performance

Lec 18 All Other Topics

- Disk scheduling algorithm
- Time in OS and Networking
- Power management in OS
- Virtualization and cloud

Midterm Format

- 8 short answer questions
  - 5 points for each
  - Totally 40 points
- 6 calculation and analysis questions
  - Totally 60 points

Part 1: Short answer question example

- What are external and internal fragmentations?

Answer:

- External fragmentation occurs when the free memory space is enough for memory allocation but is not contiguous so it cannot be used. It is the result of frequent memory allocations and de-allocations.

- Internal fragmentation refers to the extra space left inside a block of memory.

Part 1: Short answer question example

- What are memory-mapped files and what are the advantages

Answer:

- A memory-mapped file is a part of virtual memory, which has been mapped to some portion of a file or file-like resource.

- The advantages of memory-mapped files are improved I/O performance and avoidance of kernel to user data copying.

Part 1: Short answer question example

- What is symbolic linking?

Answer:

  - A symbolic link or a soft link is a new file containing the path of the linked file.

Part 1: Short answer question coverage

- Memory
- Page replacement
- Page design and segmentation
- File and directory
- File system
- Storage
- I/O
- Others

Part 2: Calculation and Analysis Question Example

- Given a two-level page table with 4-KB pages and. Assume that each level uses 10 bits. What would be the virtual address if PT1=2, PT2=3, offset=5?

Answer:

- 4 KB = 2^{12} B, so the offset has 12 bits
- *Virtual address: $2\times2^{22}+3\times2^{12}+5=8400901$*

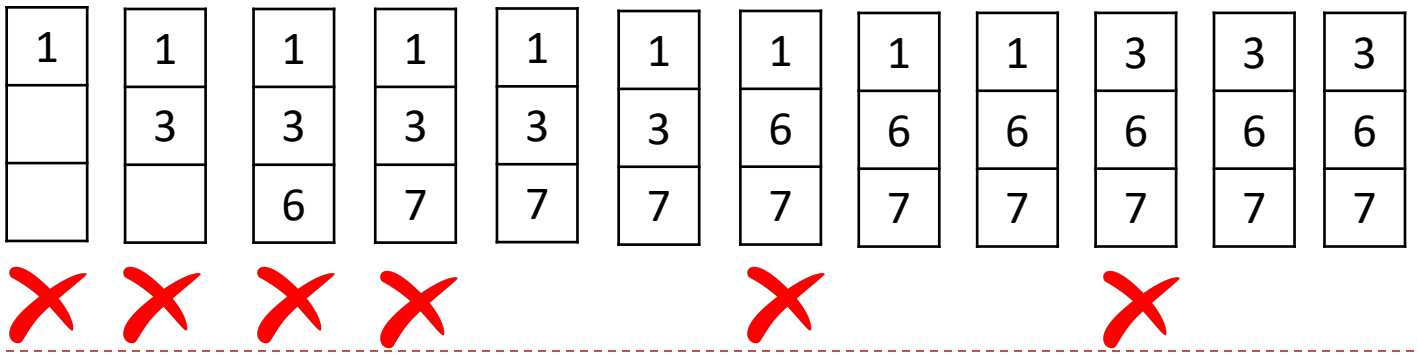
Part 2: Calculation and Analysis Question Example

- Consider a system with 3 physical frames of memory that is given the following page memory reference sequence: 1, 3, 6, 7, 1, 3, 6, 7, 1, 3, 6, 7. What is the number of page faults that would occur for each of the following page replacement algorithms? An optimal page replacement algorithm

Answer:

Reference string:

1, 3, 6, 7, 1, 3, 6, 7, 1, 3, 6, 7



6 page faults

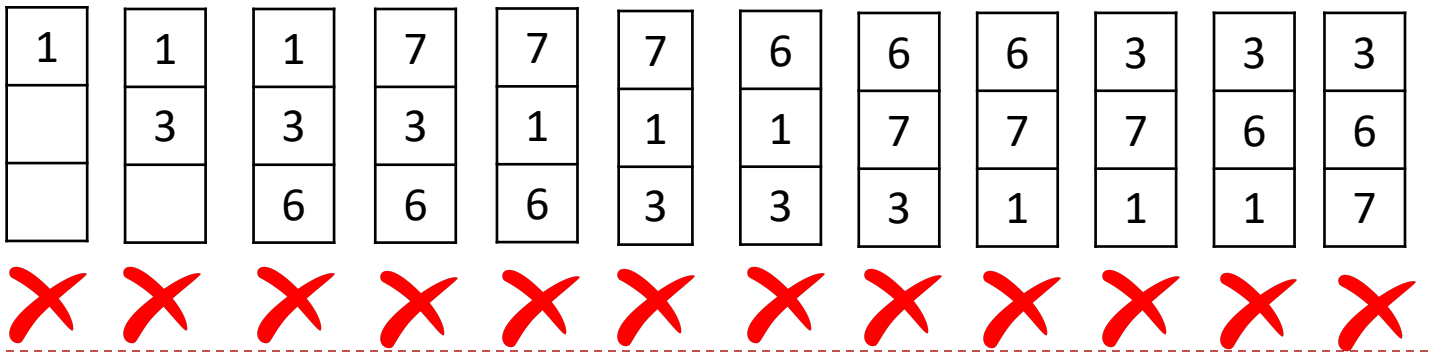
Part 2: Calculation and Analysis Question Example

- Consider a system with 3 physical frames of memory that is given the following page memory reference sequence: 1, 3, 6, 7, 1, 3, 6, 7, 1, 3, 6, 7. What is the number of page faults that would occur for each of the following page replacement algorithms? A FIFO page replacement algorithm

Answer:

Reference string:

1, 3, 6, 7, 1, 3, 6, 7, 1, 3, 6, 7



12 page faults

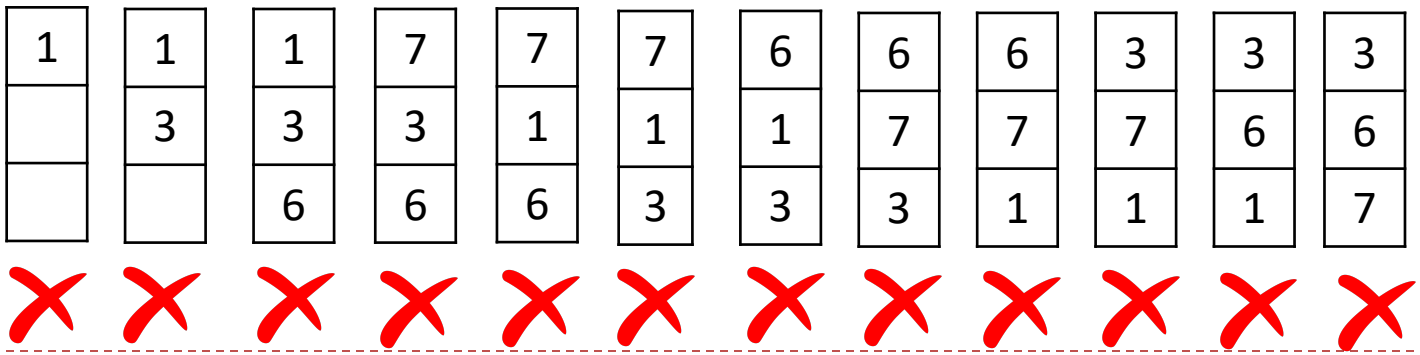
Part 2: Calculation and Analysis Question Example

- Consider a system with 3 physical frames of memory that is given the following page memory reference sequence: 1, 3, 6, 7, 1, 3, 6, 7, 1, 3, 6, 7. What is the number of page faults that would occur for each of the following page replacement algorithms? A LRU page replacement algorithm

Answer:

Reference string:

1, 3, 6, 7, 1, 3, 6, 7, 1, 3, 6, 7



12 page faults

Part 2: Calculation and Analysis Question Example

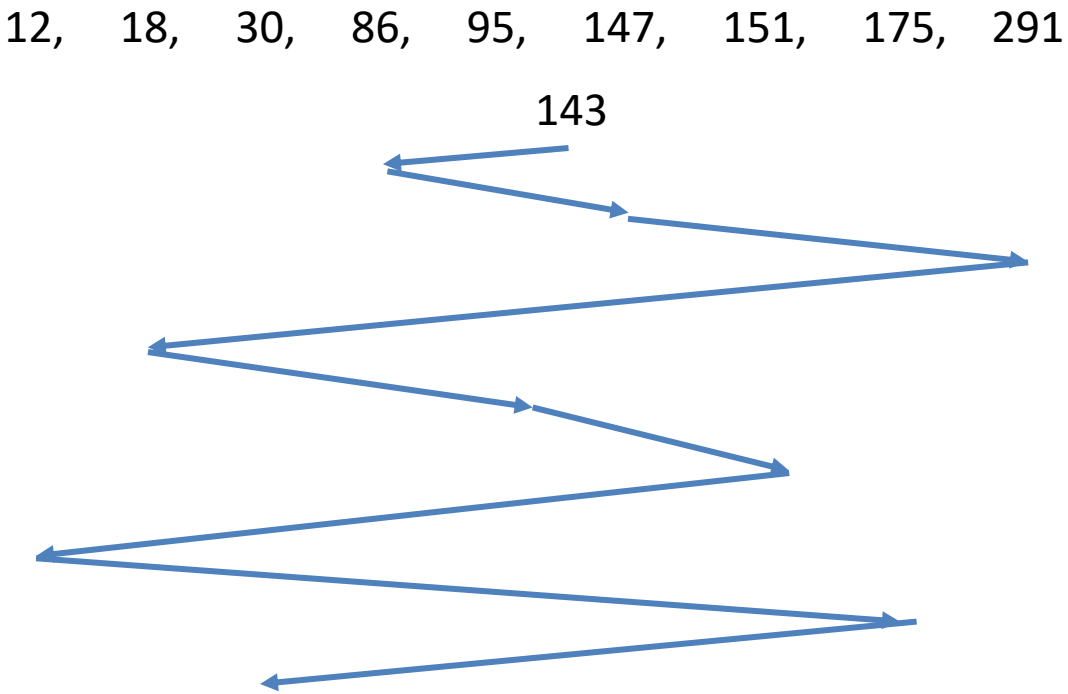
- Suppose that a disk drive has 300 cylinders, numbered 0 to 299. The drive is currently serving a request at cylinder 143, and the previous request was at cylinder 15. The queue of pending requests, in FIFO order, is 86, 147, 291, 18, 95, 151, 12, 175, 30. Starting from the current head position, what 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. SSF
- c. Elevator algorithm

Part 2: Calculation and Analysis Question Example

- Example: header start from 143, and the previous request was at cylinder 15, and the track sequence is 86, 147, 291, 18, 95, 151, 12, 175, 30. FIFO:

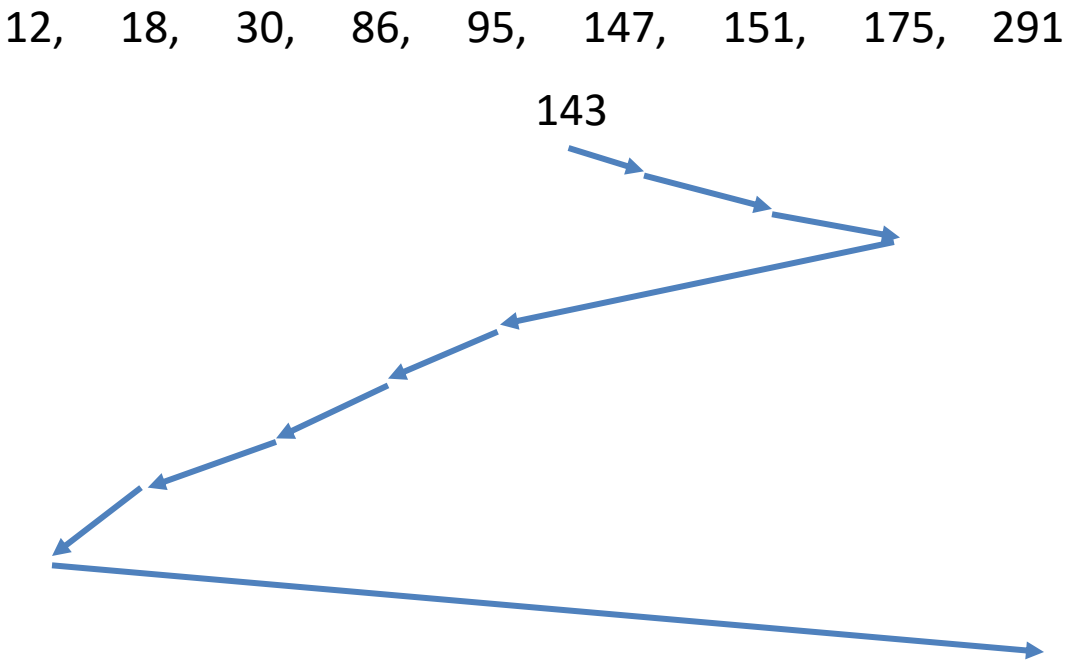
Start from 100	
The next track	Distance
86	57
147	61
291	144
18	273
95	77
151	56
12	139
175	163
30	145
Average: 132.25	



Part 2: Calculation and Analysis Question Example

- Example: header start from 143, and the previous request was at cylinder 15, and the track sequence is 86, 147, 291, 18, 95, 151, 12, 175, 30. SSF:

Start from 100	
The next track	Distance
147	4
151	4
175	24
95	80
86	9
30	56
18	12
12	6
291	279
Average: 58.75	



Part 2: Calculation and Analysis Question Example

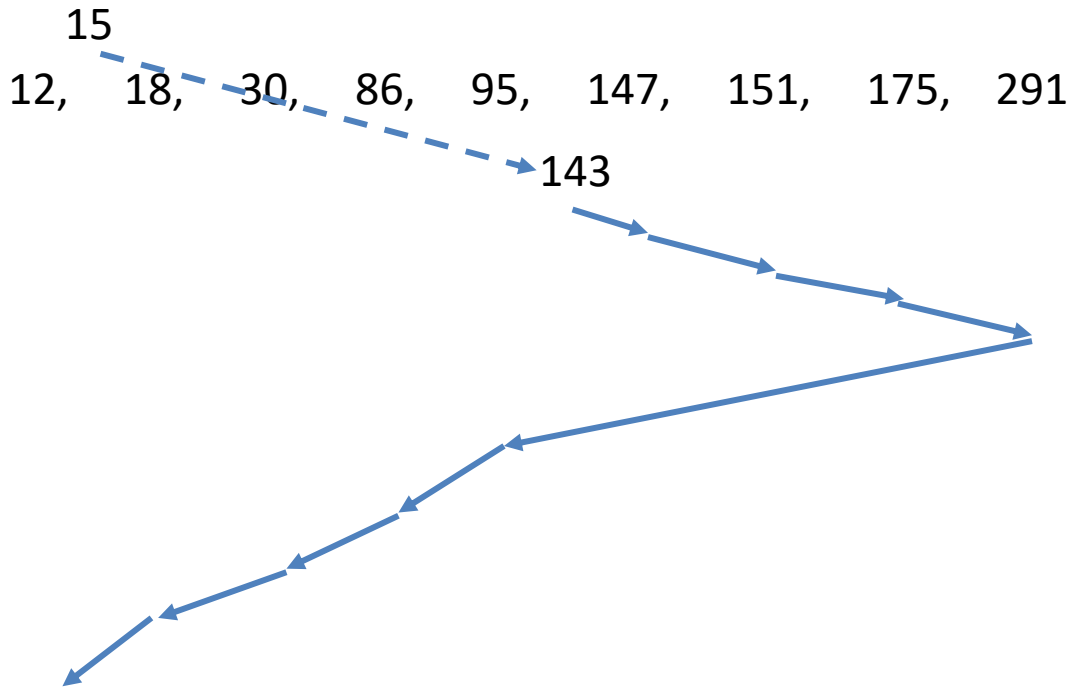
- Example: header start from 143, and the previous request was at cylinder 15, and the track sequence is 86, 147, 291, 18, 95, 151, 12, 175, 30. Elevator :

- Scheduling: keep moving in the same direction until there are no more outstanding requests in that direction

Part 2: Calculation and Analysis Question Example

- Example: header start from 143, and the previous request was at cylinder 15, and the track sequence is 86, 147, 291, 18, 95, 151, 12, 175, 30. Elevator :

Start from 100	
The next track	Distance
147	4
151	4
175	24
291	116
95	196
86	9
30	56
18	12
12	6
Average: 52.875	



Midterm Format

- 8 short answer questions
  - 5 points for each
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- 6 calculation and analysis questions
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Midterm exam

- Time: Dec 9, 3:00pm to 5:00pm
- Open book, open note exam
- Not allowed using laptop/smartphone