FIT2100 Tutorial #7
Virtual Memory
(Suggested Solutions)
Week 11 Semester 2 2019

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Acknowledgement

The majority of the content presented in this tutorial was adapted from William Stallings (2017). *Operating Systems: Internals and Design Principles*, Pearson.

Contents

1 Background

This tutorial provides students with the opportunity to explore further on the various concepts of memory and I/O managements as discussed in the lectures.

You should complete the suggested reading in Section 2 before attending the tutorial. You should also prepare the solutions for the two sets of practice tasks given in Section 3 and Section ?? respectively.

2 Pre-tutorial Reading

You should complete the following two sets of reading:

- Lecture Notes: Weeks 9, and 10
- Stalling's textbook (8th/9th Edition): Chapters 7, 8, and 11

3 Memory Management

3.1 Review Questions

Question 1

- **Internal fragmentation:** refers to the wasted space internal to a partition due to the fact that the block of data loaded is smaller than the partition.
- **External fragmentation:** is associated with dynamic partitioning, and refers to the fact that a large number of small areas of main memory external to any partitions accumulate.

Question 2

In a paging system, programs and data stored on disk are divided into equal, fixed-sized blocks called **pages**; and the main memory is divided into blocks of the same size called **frames**. One page can fit exactly in one frame.

Question 3

Instead of dividing into fixed-size pages, the program and its associated data are divided into a number of **segments**. It is not required that all segments of all programs be of the same length, although there is a maximum segment length.

Question 4

With virtual memory paging, not all pages of a process need be in main memory frames for the process to run; pages may be read in as needed.

3.2 Problem-Solving Tasks

3.2.1 Task 1

Refer to page 6.

3.2.2 Task 2

Refer to page 6.

Free Partitions	First-fit	Best-fit	Worst-fit
100K			
500K	(1) Allocate 212K from 500K; Leave a hole of size 288K (3) Allocate 112K from 288K; Leaves a hole of size 176K	(2) Allocate 417K; Leave a hole of 83K	(2) Allocate 417K (83K over allocated)
200K		(3) Allocate 112K; Leave a hole of 88K	
300K		(1) Allocate 212K; Leave a hole of 88K	
600K	(2) Allocate 417K; Leave a hole of size 183K	(4) Allocate 426K; Leave a hole of size 174K	(1) Allocate 212K; Leave a hole of 388K (3) Allocate 112K; Leave a hole of 276K
	(4) Cannot allocate for the demand of 426K		(4) Cannot allocate for the demand of 426K

Figure 1: Section 3.2 Task 1

FIFO	**1**	**2**	**3**	**4**	**5**	**3**	**4**	**1**	**6**	**7**	**8**	**7**	**8**	**9**	**7**	**8**	**9**	**5**	**4**	**5**	**2**
Frame 1	1	1	1	1	5	5	5	5	5	5	8	8	8	8	8	8	8	8	8	8	2
Frame 2		2	2	2	2	2	2	1	1	1	1	1	1	9	9	9	9	9	9	9	9
Frame 3			3	3	3	3	3	3	6	6	6	6	6	6	6	6	6	5	5	5	5
Frame 4				4	4	4	4	4	4	7	7	7	7	7	7	7	7	7	4	4	4

LRU	**1**	**2**	**3**	**4**	**5**	**3**	**4**	**1**	**6**	**7**	**8**	**7**	**8**	**9**	**7**	**8**	**9**	**5**	**4**	**5**	**2**
Frame 1	1	1	1	1	5	5	5	5	6	6	6	6	6	6	6	6	6	5	5	5	5
Frame 2		2	2	2	2	2	2	1	1	1	1	1	1	9	9	9	9	9	9	9	9
Frame 3			3	3	3	3	3	3	3	7	7	7	7	7	7	7	7	7	4	4	4
Frame 4				4	4	4	4	4	4	4	8	8	8	8	8	8	8	8	8	8	2

OPT	**1**	**2**	**3**	**4**	**5**	**3**	**4**	**1**	**6**	**7**	**8**	**7**	**8**	**9**	**7**	**8**	**9**	**5**	**4**	**5**	**2**
Frame 1	1	1	1	1	1	1	1	1	6	6	8	8	8	8	8	8	8	8	4	4	4
Frame 2		2	2	2	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Frame 3			3	3	3	3	3	3	3	7	7	7	7	7	7	7	7	7	7	7	2
Frame 4				4	4	4	4	4	4	4	4	4	4	9	9	9	9	9	9	9	9

Figure 2: Section 3.2 Task 2

3.2.3 Task 3

(a) Segment 0 starts at the location 660. With the offset of 198, the physical address is $660 + 198 = 858$

(b) Segment 1 has a length of 422, as such this logical address triggers a segment fault $(515 > 422)$

(c) Segment 3 starts at the location 996. With the offset of 445, the physical address is $996 + 445 = 1441$