



UTM
UNIVERSITI TEKNOLOGI MALAYSIA

SECR2043-07 OPERATING SYSTEMS

EXERCISE 9

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Odd number Matric Card – 9.5, 9.8, 9.11, 9.17, 9.20

9.5 Discuss the hardware support required to support demand paging.

- **Translation Lookaside Buffer (TLB)**
- **Page table entries with disk addresses**
- **Secondary Memory**

9.8 Consider the following page reference string:

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

How many page faults would occur for the following replacement algorithms, assuming one, two, three, four, five, six, and seven frames? Remember that all frames are initially empty, so your first unique pages will cost one fault each.

- LRU replacement
- FIFO replacement
- Optimal replacement

LRU replacement

1 frame:

	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
frame-1	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6

Page faults: 20

2 frames:

	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
frame-1	1	1	3	3	2	2	5	5	2	2		2	7	7	3	3	1		3	3
frame-2		2	2	4	4	1	1	6	6	1		3	3	6	6	2	2		2	6

Page faults: 18

3 frames:

	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
frame-1	1	1	1	4		4	5	5	5	1		1	7	7		2	2			2
frame-2		2	2	2		2	2	6	6	6		3	3	3		3	3			3
frame-3			3	3		1	1	1	2	2		2	2	6		6	1			6

Page faults: 15

4 frames:

	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
frame-1	1	1	1	1			1	1				1	1	6			6			
frame-2		2	2	2			2	2				2	2	2			2			
frame-3			3	3			5	5				3	3	3			3			
frame-4				4			4	6				6	7	7			1			

Page faults: 10

5 frames:

	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
frame-1	1	1	1	1			1	1				1	1							
frame-2		2	2	2			2	2				2	2							
frame-3			3	3			3	6				6	6							
frame-4				4			4	4				3	3							
frame-5							5	5				5	7							

Page faults: 8

6 frames:

	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
frame-1	1	1	1	1			1	1					1							
frame-2		2	2	2			2	2					2							
frame-3			3	3			3	3					3							
frame-4				4			4	4					4							

frame-5							5	5					7							
frame-6								6					6							

Page faults: 7

7 frames:

	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
frame-1	1	1	1	1			1	1					1							
frame-2		2	2	2			2	2					2							
frame-3			3	3			3	3					3							
frame-4				4			4	4					4							
frame-5							5	5					5							
frame-6								6					6							
frame-7													7							

Page faults: 7

FIFO replacement

1 frame:

	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
frame-1	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6

Page faults: 20

2 frames:

	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
frame-1	1	1	3	3	2	2	5	5	2	2		2	7	7	3	3	1		3	3
frame-2		2	2	4	4	1	1	6	6	1		3	3	6	6	2	2		2	6

Page faults: 18

3 frames:

	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
frame-1	1	1	1	4		4	4	6	6	6		3	3	3		2	2		2	6
frame-2		2	2	2		1	1	1	2	2		2	7	7		7	1		1	1
frame-3			3	3		3	5	5	5	1		1	1	6		6	6		3	3

Page faults: 16

4 frames:

	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
frame-1	1	1	1	1			5	5	5	5		3	3	3		3	1		1	
frame-2		2	2	2			2	6	6	6		6	7	7		7	7		3	
frame-3			3	3			3	3	2	2		2	2	6		6	6		6	
frame-4				4			4	4	4	1		1	1	1		2	2		2	

Page faults: 14

5 frames:

	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
frame-1	1	1	1	1			1	6		6	6	6	6							
frame-2		2	2	2			2	2		1	1	1	1							
frame-3			3	3			3	3		3	2	2	2							
frame-4				4			4	4		4	4	3	3							
frame-5							5	5		5	5	5	7							

Page faults: 10

6 frames:

	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
frame-1	1	1	1	1			1	1					7				7	7	7	
frame-2		2	2	2			2	2					2				1	1	1	
frame-3			3	3			3	3					3				3	2	2	
frame-4				4			4	4					4				4	4	3	

frame-5							5	5					5				5	5	5	
frame-6								6					6				6	6	6	

Page faults: 10

7 frames:

	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
frame-1	1	1	1	1			1	1					1							
frame-2		2	2	2			2	2					2							
frame-3			3	3			3	3					3							
frame-4				4			4	4					4							
frame-5							5	5					5							
frame-6								6					6							
frame-7													7							

Page faults: 7

Optimal replacement

1 frame:

	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
frame-1	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6

Page faults: 20

2 frames:

	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
frame-1	1	1	3	4		1	5	6		1		3	7	6	3		1		3	6
frame-2		2	2	2		2	2	2		2		2	2	2	2		2		2	2

Page faults: 15

3 frames:

	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
frame-1	1	1	1	1			1	1				3	3			3	3			3
frame-2		2	2	2			2	2				2	7			2	2			2
frame-3			3	4			5	6				6	6			6	1			6

Page faults: 11

4 frames:

	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
frame-1	1	1	1	1			1	1					7				1			
frame-2		2	2	2			2	2					2				2			
frame-3			3	3			3	3					3				3			
frame-4				4			5	6					6				6			

Page faults: 8

5 frames:

	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
frame-1	1	1	1	1			1	1					1							
frame-2		2	2	2			2	2					2							
frame-3			3	3			3	3					3							
frame-4				4			4	4					7							
frame-5							5	6					6							

Page faults: 7

6 frames:

	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
frame-1	1	1	1	1			1	1					1							
frame-2		2	2	2			2	2					2							
frame-3			3	3			3	3					3							
frame-4				4			4	4					4							

frame-5							5	5					7							
frame-6								6					6							

Page faults: 7

7 frames:

	1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
frame-1	1	1	1	1			1	1					1							
frame-2		2	2	2			2	2					2							
frame-3			3	3			3	3					3							
frame-4				4			4	4					4							
frame-5							5	5					5							
frame-6								6					6							
frame-7													7							

Page faults: 7

9.11 Segmentation is similar to paging but uses variable-sized “pages.” Define two segment-replacement algorithms, one based on the FIFO pagereplacement scheme and the other on the LRU page-replacement scheme. Remember that since segments are not the same size, the segment that is chosen for replacement may be too small to leave enough consecutive locations for the needed segment. Consider strategies for systems where segments cannot be relocated and strategies for systems where they can.

FIFO page-replacement scheme

- **Find the first segment that coming and is large enough.**
- **If not applicable, find the closest to first on the list.**
- **If applicable, rearrange the memory so that the first segment is large enough for the next segment.**

LRU page-replacement scheme

- **Choose the segment that is last recently used and is large enough.**
- **If not applicable, choose the combination of the oldest segment on the list.**
- **If applicable, rearrange the oldest segment in memory and replace it with new segment.**

9.17 What is the copy-on-write feature, and under what circumstances is its use beneficial? What hardware support is required to implement this feature?

- **It allows processes to share pages rather than having separate copy of the pages.**
- **It is beneficial when the operating system allows parent and child to share the parent's pages in fork() operation.**
- **The hardware support required is the page table needs to be consulted to check whether the page is protected.**

9.20 When a page fault occurs, the process requesting the page must block while waiting for the page to be brought from disk into physical memory. Assume that there exists a process with five user-level threads and that the mapping of user threads to kernel threads is one to one. If one user thread incurs a page fault while accessing its stack, would the other user threads belonging to the same process also be affected by the page fault—that is, would they also have to wait for the faulting page to be brought into memory? Explain.

Yes, because there is only one kernel thread for all users. The kernel thread blocks while waiting for the page fault to be resolved. Because that is the only one kernel thread available, other users are affected by the page fault.