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⑦



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 $28 = \max(12, 3)$

⑧

1	2	3	4	3	2	1	4	1	3
1	1	1	4	4	4	1	4	1	1
	2	2	2	2	2	2	2	2	2
		3	3	3	3	3	3	3	3

PPPP P P P \Rightarrow P

⑨

2	1	3	4	1	4	1
2	2	3	3	3	3	3
	2	1	4	1	4	1
		2	2	2	2	2

PPPPPP P \Rightarrow P

LRU

2	1	3	4	1	4	1
2	1	3	4	4	4	4
	2	1	3	3	3	3
		2	1	1	1	1

PPPP = 4P

⑩

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2	1	3	4	2	1	3
2	1	3	3	3	3	3
	2	1	4	4	1	1
		2	2	2	2	2

PPPP P = 5P

LRU

2	1	3	4	2	1	3
2	1	3	4	2	1	3
	2	1	3	4	2	1
		2	1	3	4	2

PPPPPP P = 7P

3

1

0	1	2	3	0	1	4	0	1	2	3	4
0	1	2	3	0	1	4	4	4	2	3	3
	0	1	2	3	0	1	1	1	4	2	2
		0	1	2	3	0	0	0	1	4	4

9P = P P P P P P P V V P P V

2

0	1	2	3	0	1	4	0	1	2	3	4
0	1	2	3	3	3	4	0	1	2	3	4
	0	1	2	2	2	3	4	0	1	2	3
		0	1	1	1	2	3	4	0	1	2
			0	0	0	1	2	3	4	0	1

P P P P V V P P P P P P = top

3

Stack algorithm לזכרון / זיכרון, FIFO - זיכרון

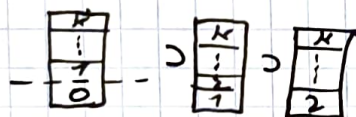
3 + 4 זיכרון / זיכרון, Stack algorithm לזכרון / זיכרון, זיכרון / זיכרון
 3 - 4 זיכרון / זיכרון, זיכרון / זיכרון, זיכרון / זיכרון

$$\begin{pmatrix} 3 & 0 & 1 \\ 2 & 3 & 0 \\ 1 & 2 & 3 \end{pmatrix} \& \begin{pmatrix} 3 & 3 & 3 \\ 2 & 2 & 2 \\ -1 & -1 & -1 \\ 0 & 0 & 0 \end{pmatrix} 3 \times 3$$

3 + 4 זיכרון / זיכרון, זיכרון / זיכרון, זיכרון / זיכרון

Belady's Anomaly זיכרון / זיכרון, זיכרון / זיכרון, זיכרון / זיכרון

4 (זיכרון / זיכרון)



Stack algorithm לזכרון / זיכרון, זיכרון / זיכרון, זיכרון / זיכרון
 זיכרון / זיכרון, זיכרון / זיכרון, זיכרון / זיכרון

5

Belady's Anomaly זיכרון / זיכרון, זיכרון / זיכרון, זיכרון / זיכרון
 זיכרון / זיכרון, זיכרון / זיכרון, זיכרון / זיכרון

שאלה 3: (זוהי שאלה 4 מדרג עבודה מס 3)

- A. Consider the following series of accesses to memory pages: 0,1,2,3,0,1,4,0,1,2,3,4.
How many page faults would happen, when using FIFO replacement policy and a memory which contains only 3 frames?

☐ - oldest

input	0	1	2	3	0	1	4	0	1	2	3	4
memory		<u>0</u>	<u>0</u>	<u>0</u>	3	3	<u>3</u>	4	4	4	4	4
		1	1	1	0	0	0	0	0	0	2	2
			2	2	2	1	1	1	1	1	1	3
fault	f	f	f	f	f	f	f			f	f	

Total of 9 page faults.

- B. Repeat A, when given that the memory contains 4 frames.

☐ - oldest

input	0	1	2	3	0	1	4	0	1	2	3	4
memory		<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	4	4	4	<u>4</u>	3
		1	1	1	1	1	1	1	0	0	0	<u>0</u>
			2	2	2	2	2	2	2	1	1	1
			3	3	3	3	3	3	3	3	2	2
fault	f	f	f	f			f	f	f	f	f	f

Total of 10 page faults.

- C. Prove or disprove: When using FIFO algorithm, the set of pages which reside in the memory of n pages is always a subset of the set of pages which reside in the memory of $n+1$ pages.

Disprove - Counter example is A)+B). For the same input the set of pages which reside in the memory of 3 pages aren't the subset of 4 pages.

input	0	1	2	3	0	1	4	0	1	2	3	4
memory		<u>0</u>	<u>0</u>	<u>0</u>	3	3	<u>3</u>	4	4	4	4	4
		1	1	1	1	0	0	0	0	0	2	2
			2	2	2	2	1	1	1	1	1	3
fault	f	f	f	f	f	f	f			f	f	

input	0	1	2	3	0	1	4	0	1	2	3	4
memory		<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	4	4	4	<u>4</u>	3
		1	1	1	1	1	1	1	0	0	0	<u>0</u>
			2	2	2	2	2	2	2	1	1	1
			3	3	3	3	3	3	3	3	2	2
fault	f	f	f	f			f	f	f	f	f	f

- D. Prove or disprove: When using FIFO algorithm, enlarging the memory may increase the number of page faults.

Prove - (A) gave us 9 page faults while (B) (enlarged memory) gave us 10.

- E. Prove or disprove: When using LRU algorithm, the set of pages which reside in the memory of n pages is always a subset of the set of pages which reside in the memory of $n+1$ pages.

Prove - as we learnt in class, LRU is a stack algorithm which applies this property (proved in the class).

- F. Prove or disprove: When using LRU algorithm, enlarging the memory may increase the number of page faults.

Disprove - as proved in class for stack algorithms (eg LRU), enlarging the memory does not increase the number of page faults (stems from property (E)).