Belady's Anomaly

Introduction

Belady's anomaly demonstrates that increasing the number of page frames may also increase the number of page faults. Suppose the reference string is *w* = dcbadcedcbae. The page replacement algorithm is FIFO. Let us consider two memories, one with 3 frames and one with 4 frames.

Memory With 3 Frames

time	0	1	2	3	4	5	6	7	8	9	10	11
w	d	c	b	a	d	c	e	d	c	b	a	e
frame 1	d	d	d	a	a	a	e	e	e	e	e	e
frame 2		c	c	c	d	d	d	d	d	b	a	a
frame 3			b	b	b	c	c	c	c	c	c	c
page fault	1	2	3	4	5	6	7			8	9	
page(s) loaded	d	c	b	a	d	c	e			b	a	
page(s) removed				d	c	b	a			d	b	

Memory With 4 Frames

time	0	1	2	3	4	5	6	7	8	9	10	11
w	d	c	b	a	d	c	e	d	c	b	a	e
frame 1	d	d	d	d	d	d	e	e	e	e	a	a
frame 2		c	c	c	c	c	c	d	d	d	d	e
frame 3			b	b	b	b	b	b	c	c	c	c
frame 4				a	a	a	a	a	a	b	b	b
page fault	1	2	3	4			5	6	7	8	9	10
page(s) loaded	d	c	b	a			e	d	c	b	a	e
page(s) removed							d	c	b	a	e	a

Analysis

The memory with 3 frames produces 9 page faults. The memory with 4 page frames produces 10 page faults.

To see why, look at the pages in memory at each time unit. At time 6, the set of pages in the 3-frame memory is not a subset of the set in the 4-frame memory. This means the 4-frame memory will producing a page fault that does not occur in the 3-frame memory. You can see this again at time 7 and time 10.

If the pages in the frames of a memory are also in the frames of a larger memory, the algorithm is said to be a *stack algorithm*. Because a stack algorithm by definition prevents the discrepancy above, no stack algorithm can suffer from Belady's anomaly.