

OPERATING SYSTEMS

Memory Management

Chandravva Hebi

Department of Computer Science

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Virtual Memory

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Department of Computer Science

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Slides Credits for all PPTs of this course



- The slides/diagrams in this course are an **adaptation**, **combination**, and **enhancement** of material from the following resources and persons:
 1. Slides of Operating System Concepts, Abraham Silberschatz, Peter Baer Galvin, Greg Gagne - 9th edition 2013 and some slides from 10th edition 2018
 2. Some conceptual text and diagram from Operating Systems - Internals and Design Principles, William Stallings, 9th edition 2018
 3. Some presentation transcripts from A. Frank – P. Weisberg
 4. Some conceptual text from Operating Systems: Three Easy Pieces, Remzi Arpaci-Dusseau, Andrea Arpaci Dusseau

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Least Recently Used (LRU) Algorithm

- Use past knowledge rather than future
- Replace page that has not been used in the most amount of time
- Associate time of last use with each page

reference string

7 0 1 2 0 3 0 4 2 3 0 3 2 1 2 0 1 7 0 1

7	7	7	2		2		4	4	4	0			1		1		1		
	0	0	0		0		0	0	3	3			3		0		0		
		1	1		3		3	2	2	2			2		2		7		

page frames

- 12 faults – better than FIFO but worse than OPT
- Generally good algorithm and frequently used
- But how to implement?

- Counter implementation
 - Every page entry has a counter; every time page is referenced through this entry, copy the clock into the counter
 - When a page needs to be changed, look at the counters to find smallest value
 - 4 Search through table needed
- Stack implementation
 - Keep a stack of page numbers in a double link form:
 - Page referenced:
 - 4 move it to the top
 - 4 requires 6 pointers to be changed
 - But each update more expensive
 - No search for replacement
- LRU and OPT are cases of **stack algorithms** that don't have Belady's Anomaly

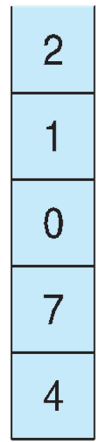
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Use Of A Stack to Record Most Recent Page References

- LRU and OPT are cases of **stack algorithms** that don't have Belady's Anomaly
- Use Of A Stack to Record Most Recent Page References

reference string

4 7 0 7 1 0 1 2 1 2 7 1 2



stack
before
a



stack
after
b





THANK YOU

Chandravva Hebi

Department of Computer Science Engineering

chandravvahebbi@pes.edu