

# Page Replacing Algorithms

# Paging

- The mapping from virtual to physical address is done by the memory management unit (MMU) which is a hardware device and this mapping is known as paging technique.

# Page Replacement Algorithms

- In an operating system that uses paging for memory management, a page replacement algorithm is needed to decide which page needs to be replaced when new page comes in.

# Page Fault

- A page fault happens when a running program accesses a memory page that is mapped into the virtual address space, but not loaded in physical memory.

# First-In-First-Out (FIFO) Algorithm

- Reference string: 1, 2, 3, 4, 1, 2, 5, 1, 2, 3, 4, 5
- 3 frames (3 pages can be in memory at a time per process)

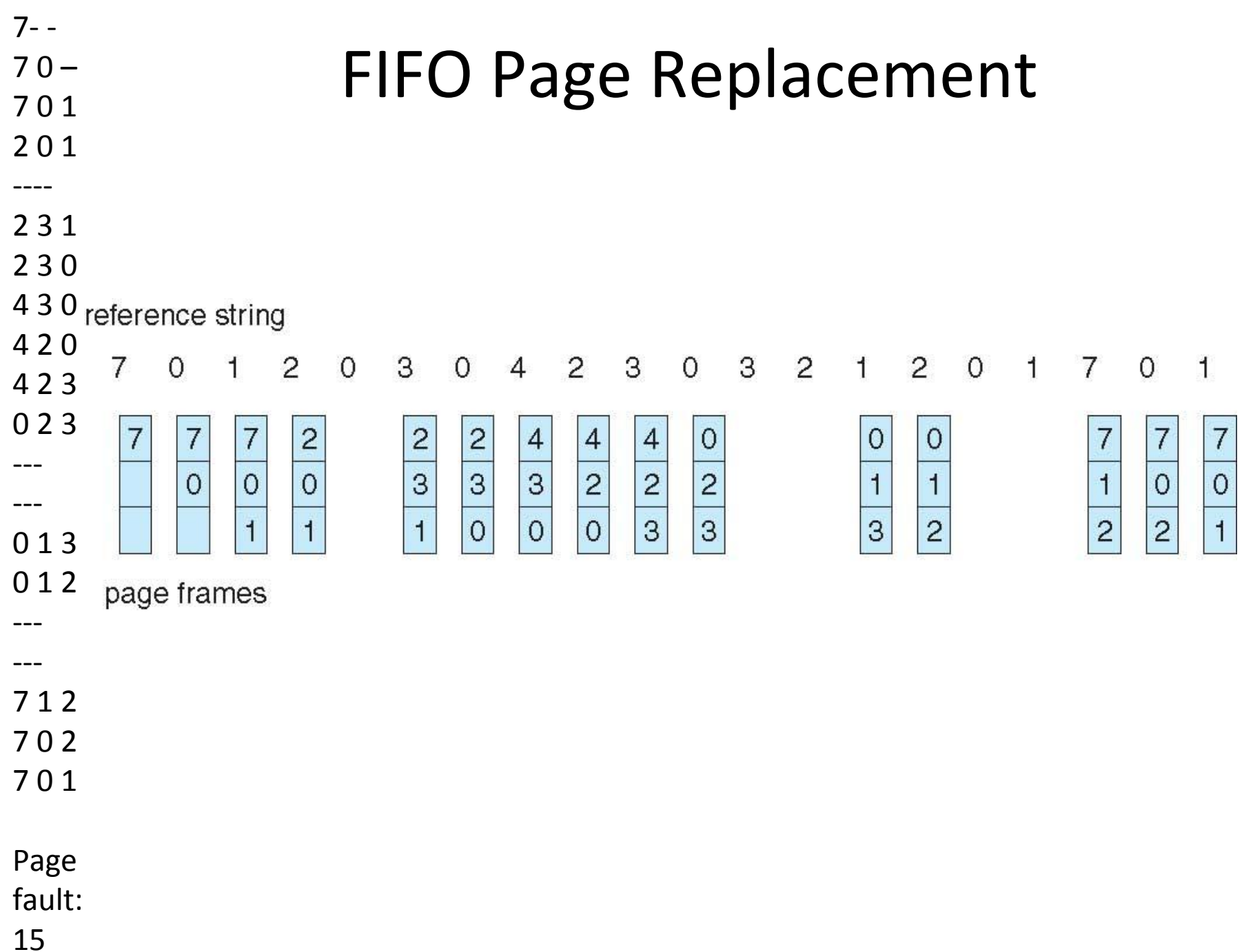
1	1	4	5	9 page faults
2	2	1	3	
3	3	2	4	

- 4 frames

1	1	5	4	10 page faults
2	2	1	5	
3	3	2		
4	4	3		

- Belady's Anomaly: more frames  $\Rightarrow$  more page faults

# FIFO Page Replacement



# Optimal Algorithm

- Replace page that will not be used for longest period of time
- 4 frames example

1, 2, 3, 4, 1, 2, 5, 1, 2, 3, 4, 5

1
2
3
4

4

6 page faults

5

- How do you know this?
- Used for measuring how well your algorithm performs

# Optimal Page Replacement

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

page frames



# Least Recently Used (LRU) Algorithm

- Reference string: 1, 2, 3, 4, 1, 2, **5**, 1, 2, **3**, **4**, **5**

1	1	1	1	<b>5</b>
2	2	2	2	2
3	<b>5</b>	5	<b>4</b>	4
4	4	<b>3</b>	3	3

- 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 determine which are to change

# LRU Page Replacement

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

**THANK YOU!**