Virtual Memory (3)

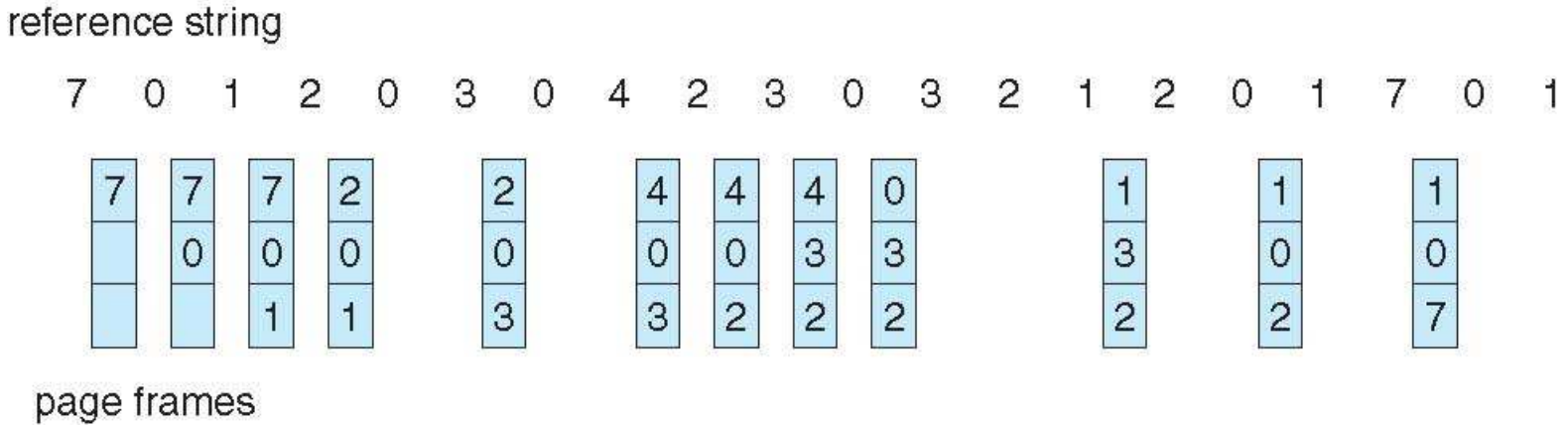
Dr. Jun Zheng

CSE325 Principles of Operating Systems

11/8/2019

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



12 faults – better than FIFO but worse than OPT

Generally good algorithm and frequently used

But how to implement?

NEW MEXICO TECH
SCIENCE · ENGINEERING · RESEARCH · UNIVERSITY

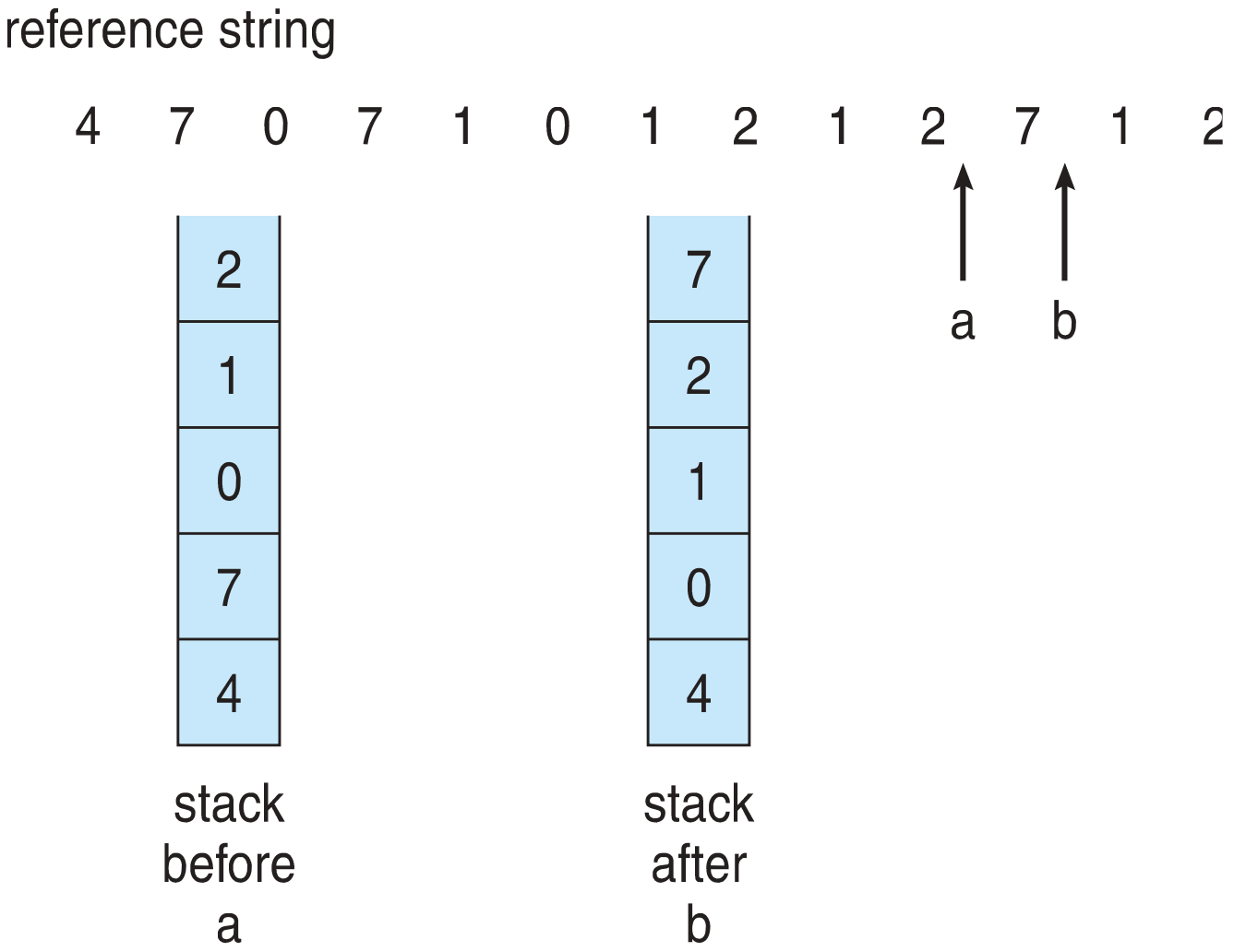
LRU Algorithm (Cont.)

- Counter implementation
  - Every page-table entry has a time-of-use field and the CPU has a logic clock or counter;
  - The clock is incremented for every time a page is referenced and the content of the clock register is copied to the time-of-use field in the page-table entry
  - When a page needs to be replaced, look at the counters to find smallest value
    - Search through table needed
  - Overflow of the clock must be considered

LRU Algorithm (Cont.)

- Stack implementation
  - Keep a stack of page numbers (use a doubly linked list)
  - Page referenced, move it to the top
    - The LRU page is always at the bottom of the stack
  - Update is more expensive (at worst changing six pointers) but no search for replacement
- LRU and OPT are cases of **stack algorithms** that don't have Belady's anomaly
  - A stack algorithm is an algorithm for which it can be shown that the set of pages in memory for *n* frames is always a *subset* of the set of pages that would be in memory with *n* + 1 frames.

Use Of A Stack to Record Most Recent Page References



NEW MEXICO TECH
SCIENCE · ENGINEERING · RESEARCH · UNIVERSITY

In-Class Work 6

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 three frames?

Remember that all frames are initially empty, so your first unique pages will cost one fault each.

- LRU replacement
- FIFO replacement
- Optimal replacement

NEW MEXICO TECH
SCIENCE · ENGINEERING · RESEARCH · UNIVERSITY