Operating systems

Virtual-Memory Management

Ch 9
Virtual memory

• Why?

• How?
Basic Demand paging

- Logical memory:
  - A
  - B
  - C
  - D
  - E
  - F
  - G
  - H

- Page table:
  - Page 0: Valid
  - Page 1: Invalid
  - Page 2: Valid
  - Page 3: Invalid
  - Page 4: Valid
  - Page 5: Invalid
  - Page 6: Valid
  - Page 7: Invalid

- Physical memory:
  - Frame 0
  - Frame 1
  - Frame 2
  - Frame 3
  - Frame 4
  - Frame 5
  - Frame 6
  - Frame 7
  - Frame 8
  - Frame 9
  - Frame 10
  - Frame 11
  - Frame 12
  - Frame 13
  - Frame 14
  - Frame 15

- Frame bit:
  - Valid (v)
  - Invalid (i)
Page fault trap

1. Trap
2. Page is on backing store
3. Operating system
4. Bring in missing page
5. Reset page table
6. Restart instruction

load M

physical memory

free frame

page table

restart instruction

reference

operating system
Efficient process creation (Copy-on-Write)
Page replacement

1. swap out victim page
2. change to invalid
3. swap desired page in
4. reset page table for new page

page table

frame valid–invalid bit

physical memory
Different strategies

reference string

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

page frames

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

page frames

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

page frames

7 7 7 2 2 4 4 4 0 1 1 1
0 0 0 0 3 3 3 3 3 3 0 0
1 1 3 2 2 2 2 2 2 7 0 0
Problem 9.9

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 one, two, three, four, five, six and seven frames? Remember that all frames are initially empty, so your first unique pages will cost one fault each.

- LRU replacement
- FIFO replacement
- Optimal replacement
Frame allocation

• Allocation
Thrashing

![Thrashing Graph](image)

degree of multiprogramming

CPU utilization

thrashing
Problem 9.4

Consider a demand-paging system with the following time-measured utilizations:

   CPU utilization: 20 %
   Paging disk: 97.7%
   Other I/O devices: 5%

For each of the following, say whether it will (or is likely to) improve CPU utilization. Explain your answers.
Problem 9.4 contd.

CPU utilization: 20%
Paging disk: 97.7%
Other I/O devices: 5%

a) Install a faster CPU
b) Install a bigger paging disk
c) Increase the degree of multiprogramming
d) Decrease the degree of multiprogramming
e) Install more main memory
f) Install a faster HDD or multiple controllers with multiple HDDs
g) Add prepaging to the page-fetch algorithms
h) Increase the page size