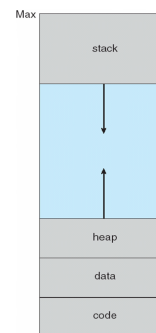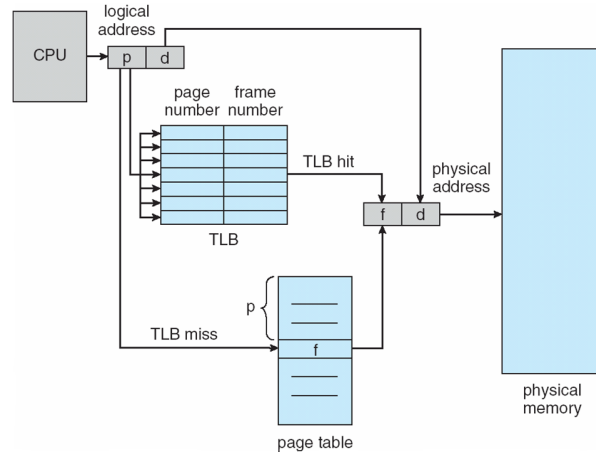# Graduate Operating Systems
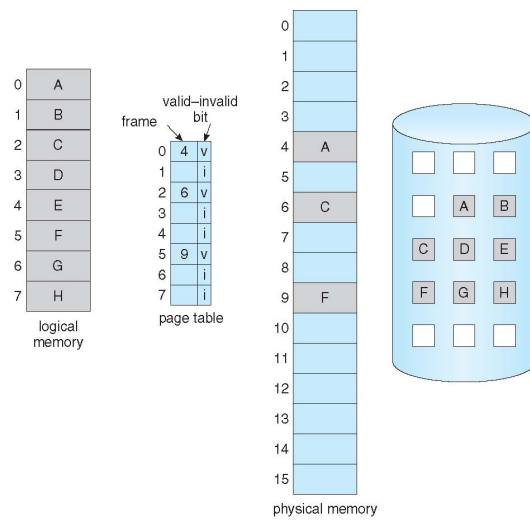## (Memory Management)

Fall 2020

Working Set Model

- How much memory does a process need?
- Virtual memory & memory management
- Paging-in, paging-out
- Page replacement strategies
  - Metric: page traffic
  - Optimal
  - Random
  - FIFO
  - LRU
  - ATLAS Loop Detection
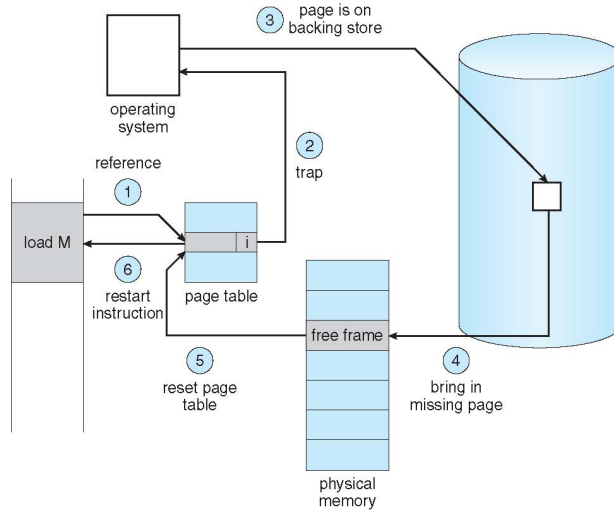 - Belady: simple + "some" historical data

Max
stack
heap
data
code
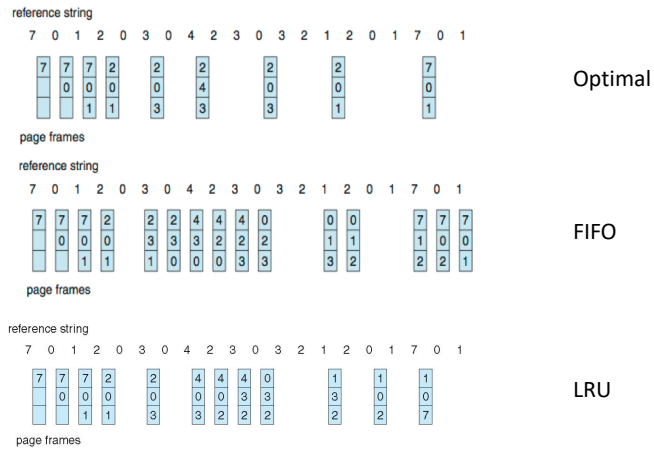0

Working Set Model

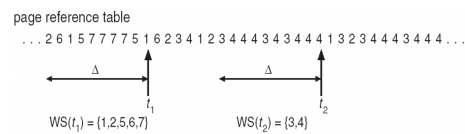# Working Set Model

Working Set Model

Working Set Model

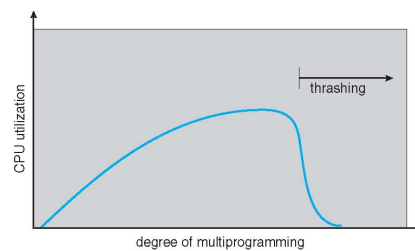- Reference string: **7,0,1,2,0,3,0,4,2,3,0,3,0,3,2,1,2,0,1,7,0,1**

Working Set Model

- Working set of information W(t,τ)
- Working set size ω(t, τ)
- Properties of working set:
  - Size (Figure 3)
  - Prediction
  - Reentry rate
  - τ-sensitivity
- τ too small/large

page reference table
. . . 2 6 1 5 7 7 7 7 5 1 6 2 3 4 1 2 3 4 4 4 3 4 3 4 4 4 1 3 2 3 4 4 4 3 4 4 4 . . .

Δ Δ

t_1 t_2

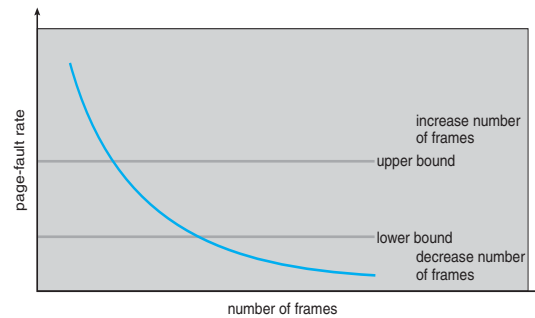WS(t_1) = {1,2,5,6,7}   WS(t_2) = {3,4}

Working Set Model

- In-core & use bits (Figure 5)
- if $D > m \Rightarrow$ Thrashing
- Policy if $D > m$, then suspend or swap out one of the processes
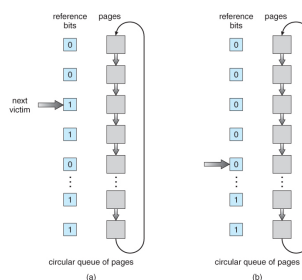
CPU utilization

thrashing

degree of multiprogramming

Working Set Model

Paper "WSCLOCK"

- Local vs. global replacement policies
- Dirty bit
- CLOCK algorithm
- Task isolation: WS vs. CLOCK

Paper "WSCLOCK"