

CISC 3320

# Thrashing & Working-Set Model

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# Acknowledgement

- These slides are a revision of the slides provided by the authors of the textbook via the publisher of the textbook

# Outline

- Thrashing
- Working-set Model
- Page Fault Frequency
  
- Memory-Mapped Files
- Allocating Kernel Memory
- Other Considerations
- Operating-System Examples

# Thrashing

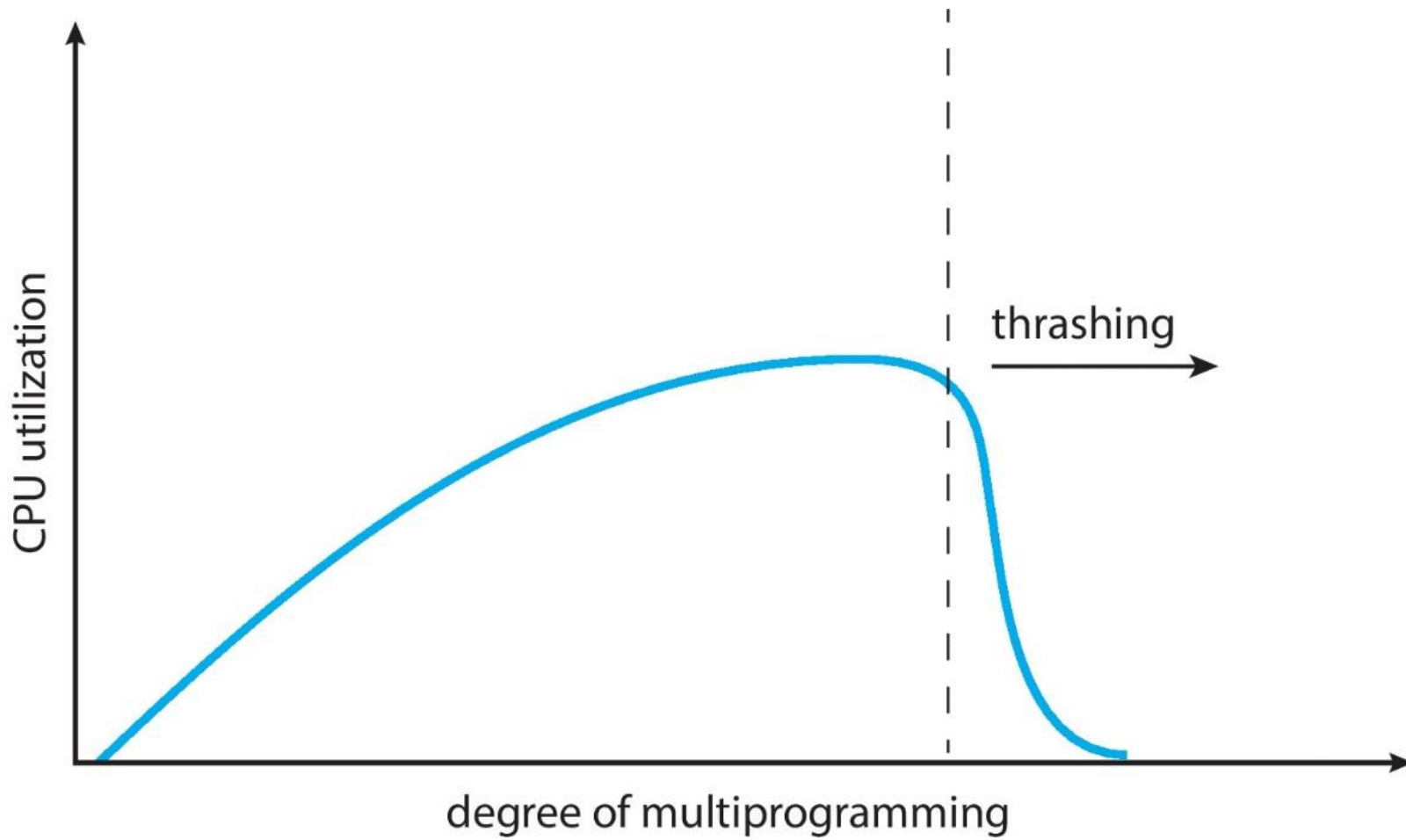
- A process is busy swapping pages in and out
- When does it happen?

# Thrashing: When Does it Happen?

- Example:
  - If a process does not have “enough” pages, the page-fault rate is very high
- Page fault to get page
- Replace existing frame
- But quickly need replaced frame back

# Thrashing: Problem

- This leads to:
  - Low CPU utilization
  - Operating system thinking that it needs to increase the degree of multiprogramming
  - Another process added to the system ...



# Demand Paging and Thrashing

- Why does demand paging work?
  - **Locality model**
    - Process migrates from one locality to another
    - Localities may overlap
- Why does thrashing occur when demand paging is in use?

$\Sigma$  size of locality  $>$  total memory size

- Limit effects by using local or priority page replacement

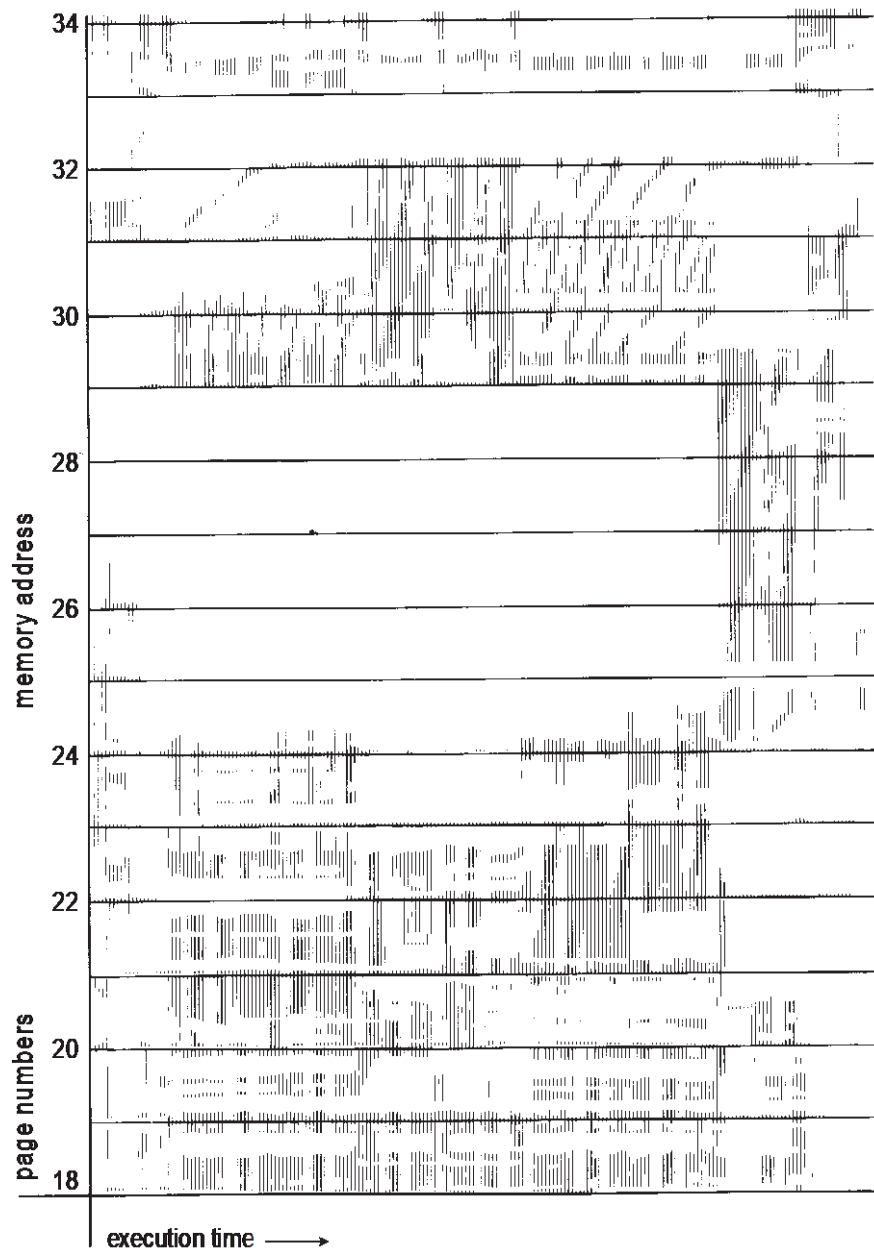


# Tackling Trashing

- Working-set model
- Page-fault frequency

# Locality In A Memory-Reference Pattern

- Example



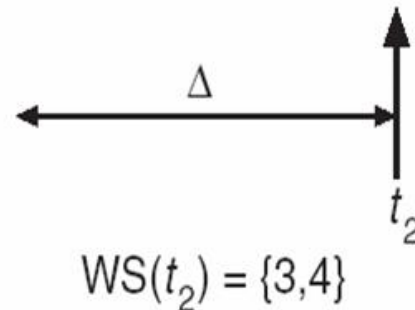
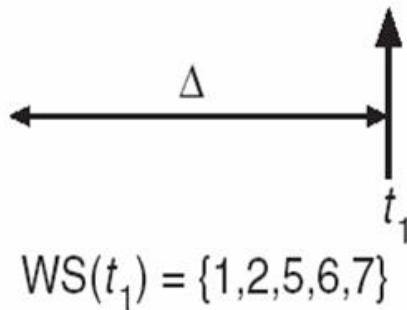
# Working-Set Model

- $\Delta \equiv$  working-set window  $\equiv$  a fixed number of page references  
Example: 10,000 instructions
- $WSS_i$  (working set of Process  $P_i$ ) = total number of pages referenced in the most recent  $\Delta$  (varies in time)
  - if  $\Delta$  too small will not encompass entire locality
  - if  $\Delta$  too large will encompass several localities
  - if  $\Delta = \infty \Rightarrow$  will encompass entire program
- $D = \sum WSS_i \equiv$  total demand frames
  - Approximation of locality

# Example

page reference table

... 2 6 1 5 7 7 7 7 5 1 6 2 3 4 1 2 3 4 4 4 4 3 4 3 4 4 4 4 1 3 2 3 4 4 4 4 3 4 4 4 ...



# Working-Set Model and Thrashing

- if  $D > m \Rightarrow$  Thrashing

# Reducing Thrashing

- Policy if  $D > m$ , then suspend or swap out one of the processes

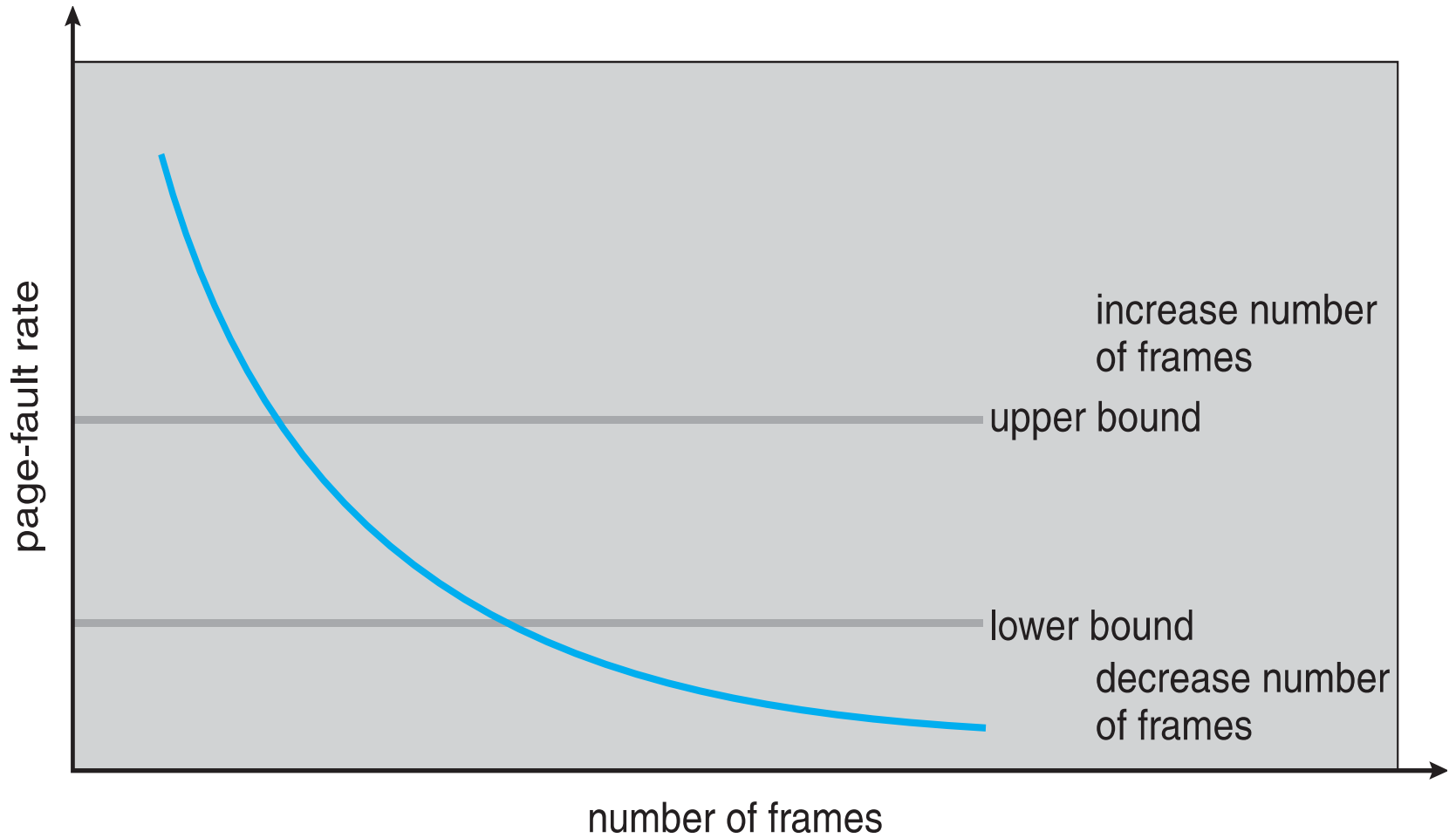
# Keeping Track of the Working Set

- Approximate with interval timer + a reference bit
- Example:  $\Delta = 10,000$ 
  - Timer interrupts after every 5000 time units
  - Keep in memory 2 bits for each page
  - Whenever a timer interrupts copy and sets the values of all reference bits to 0
  - If one of the bits in memory = 1  $\Rightarrow$  page in working set
- Why is this not completely accurate?
- Improvement = 10 bits and interrupt every 1000 time units



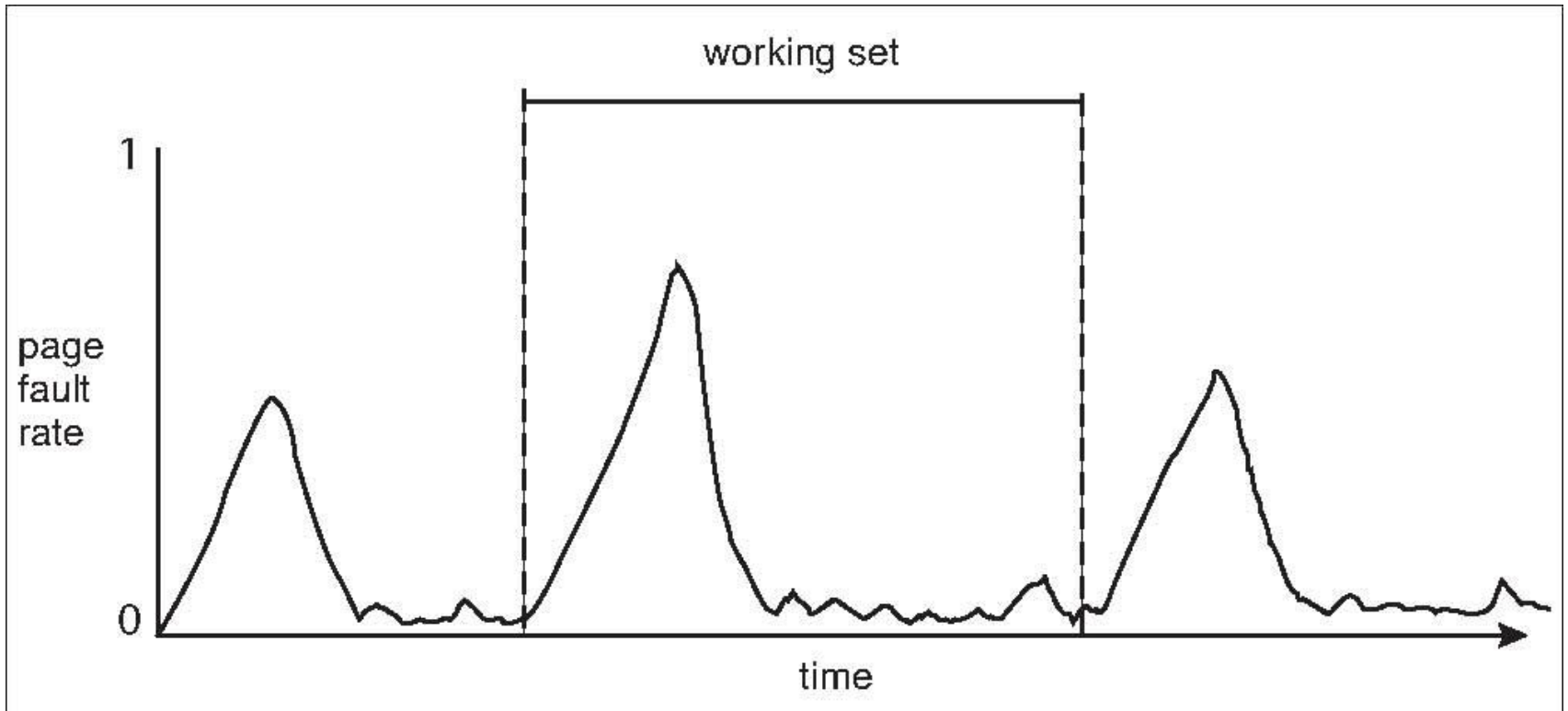
# Page-Fault Frequency

- More direct approach than WSS
- Establish “acceptable” **page-fault frequency (PFF)** rate and use local replacement policy
  - If actual rate too low, process loses frame
  - If actual rate too high, process gains frame



# Working-Set and Page Fault Rate

- Direct relationship between working set of a process and its page-fault rate
- Working set changes over time
- Peaks and valleys over time



# Questions?

- Trashing
- Working-set model
- Page fault frequency