OPERATING SYSTEMS

Memory Management

Chandravva Hebbi
Department of Computer Science

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Virtual Memory

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Department of Computer Science

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Slides Credits for all PPTs of this course

- The slides/diagrams in this course are an **adaptation**, **combination**, and **enhancement** of material from the following resources and persons:

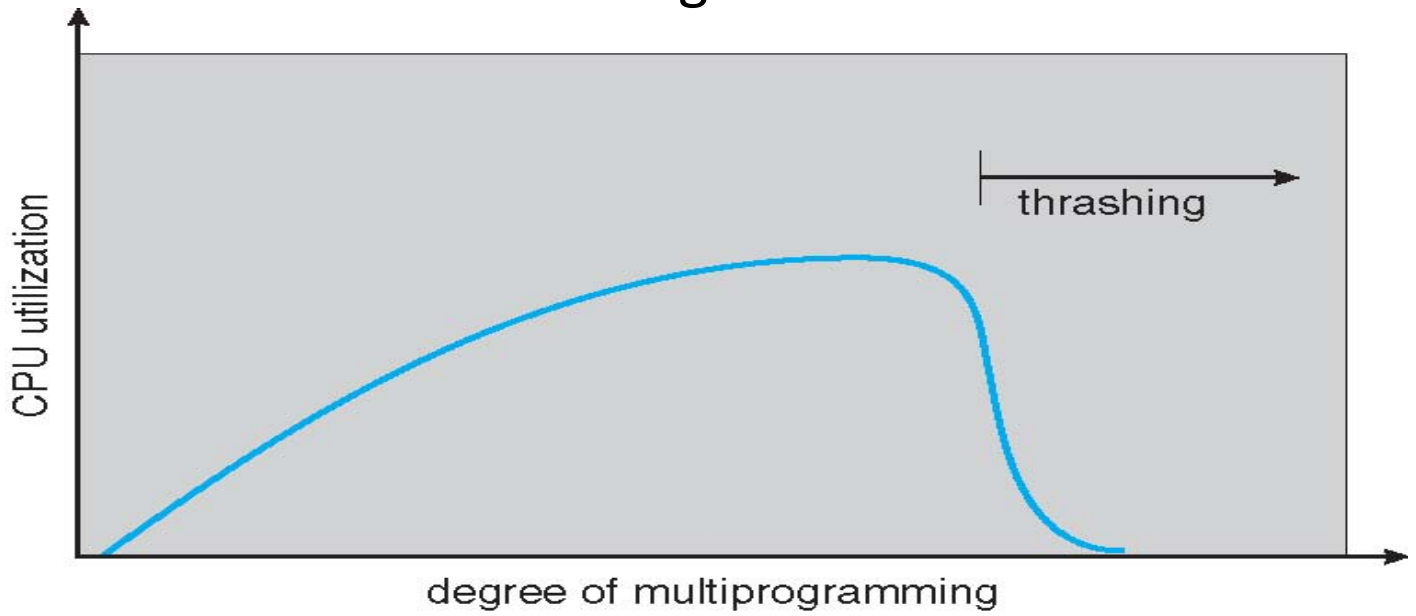
1. Slides of Operating System Concepts, Abraham Silberschatz, Peter Baer Galvin, Greg Gagne - 9th edition 2013 and some slides from 10th edition 2018
2. Some conceptual text and diagram from Operating Systems - Internals and Design Principles, William Stallings, 9th edition 2018
3. Some presentation transcripts from A. Frank – P. Weisberg
4. Some conceptual text from Operating Systems: Three Easy Pieces, Remzi Arpaci-Dusseau, Andrea Arpaci Dusseau

Thrashing

- 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
  - This leads to:
    - Low CPU utilization
    - Operating system thinking that it needs to increase the degree of multiprogramming
    - Another process added to the system
- **Thrashing** ≡ a process is busy swapping pages in and out

Cause of Thrashing

- Thrashing results in severe performance problems.
- Consider the scenario of the paging systems performance.
- As the degree of multiprogramming increases, CPU utilization also increases.
- Why there is a decrease in the CPU Utilization when the degree of multiprogramming is increased?.
- How this will be handled?



Cause of Thrashing contd…

- We can Limit the effects of thrashing by using a **local replacement algorithm** (or priority replacement algorithm)
  - If process starts thrashing, it cannot steal frames from another processes
- how does demand paging work?
  Locality model
  - Process migrates from one locality to another
  - Localities may overlap
- Why does thrashing occur?
  Σ size of locality > total memory size
  - Limit effects by using local or priority page replacement

Keeping Track of the Working Set

- The working-set model is based on the assumption of locality.
- The parameter, Δ , defines the working-set window.
- It is examine the most recent Δ page references.
- The set of pages in the most recent Δ page references is the working set.
- If a page is in active use, it will be in the working set.
- If it is no longer being used, it will drop from the working set time units after its last reference.
- Thus, the working set is an approximation of the program's locality
- Approximate the **W-S** model with interval timer + a reference bit

Keeping Track of the Working Set

- Example: Δ = 10,000 references
  - 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?
  - We cannot tell where, within an interval of 5000, a reference occurred.
- Improvement = 10 bits and interrupt every 1000 time units but overhead to service more frequent interrupts

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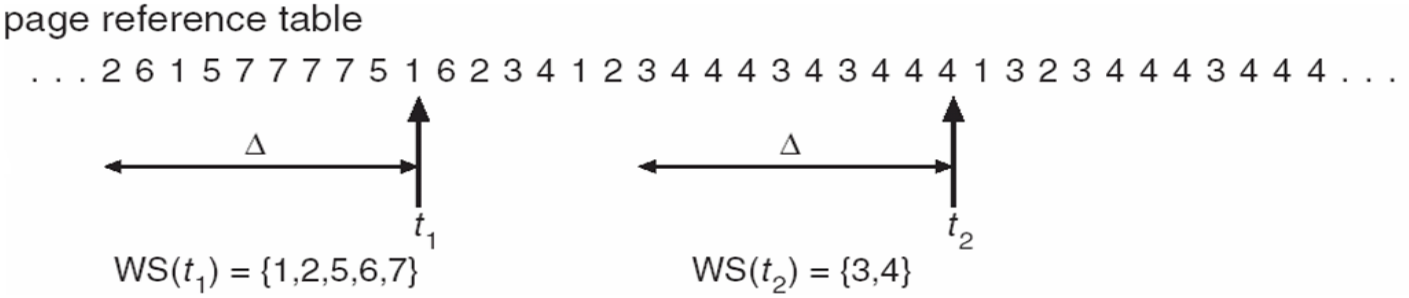
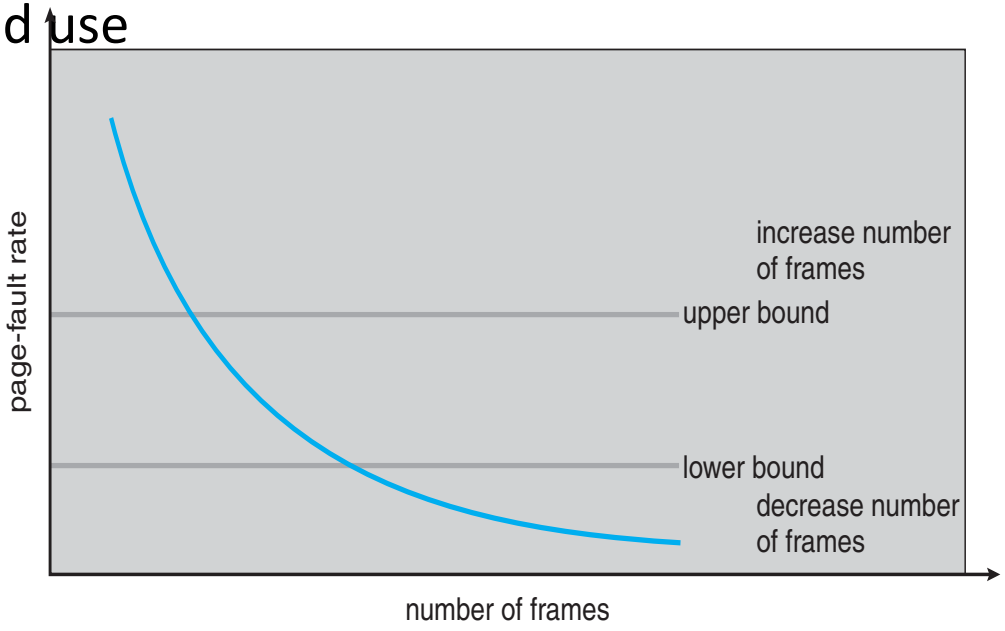
Working-Set Model

- Parameter $\Delta \equiv$ 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 Δ (parameter that varies in time)
  - if Δ too small will not encompass entire locality
  - if Δ too large will encompass several localities
  - if $\Delta = \infty \Rightarrow$ will encompass entire program
- $D = \Sigma\ WSS_i \equiv$ total demand frames
  - Approximation of locality
- if $D > m$ *(available frames)* $\Rightarrow$ Thrashing will occur
- Policy if $D >$ m, then suspend or swap out one of the processes



Page-Fault Frequency

- More direct approach than W-S model
  - Control the page-fault rate
  - Looks clumsy to control thrashing
- 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.
  - processes can be suspended if the free frames is zero
- With the working-set strategy, we may have to swap out a process.
  - If page fault Increases and no free frames available



THANK YOU

Chandravva Hebbi
Department of Computer Science Engineering

chandravvahebbi@pes.edu