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CIS 415: Operating Systems

VM Issues

Spring 2012

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- Last class:
  - Virtual Memory
- Today:
  - Virtual Memory Uses

Efficient Physical Memory

- Through virtual memory…
  - *N* 2^{32}-sized address spaces
  - All isolated by default
- Uses for memory
  - Make a new process
    - Address space
  - Make an IPC
    - Or a cross-address space call
- Challenges in memory use

Shared Pages

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- Shared code
  - One copy of read-only (*reentrant*) code shared among processes (i.e., text editors, compilers, window systems).
- Private code and data
  - Each process keeps a separate copy of the code and data
  - The pages for the private code and data can appear anywhere in the logical address space

Shared Pages Example

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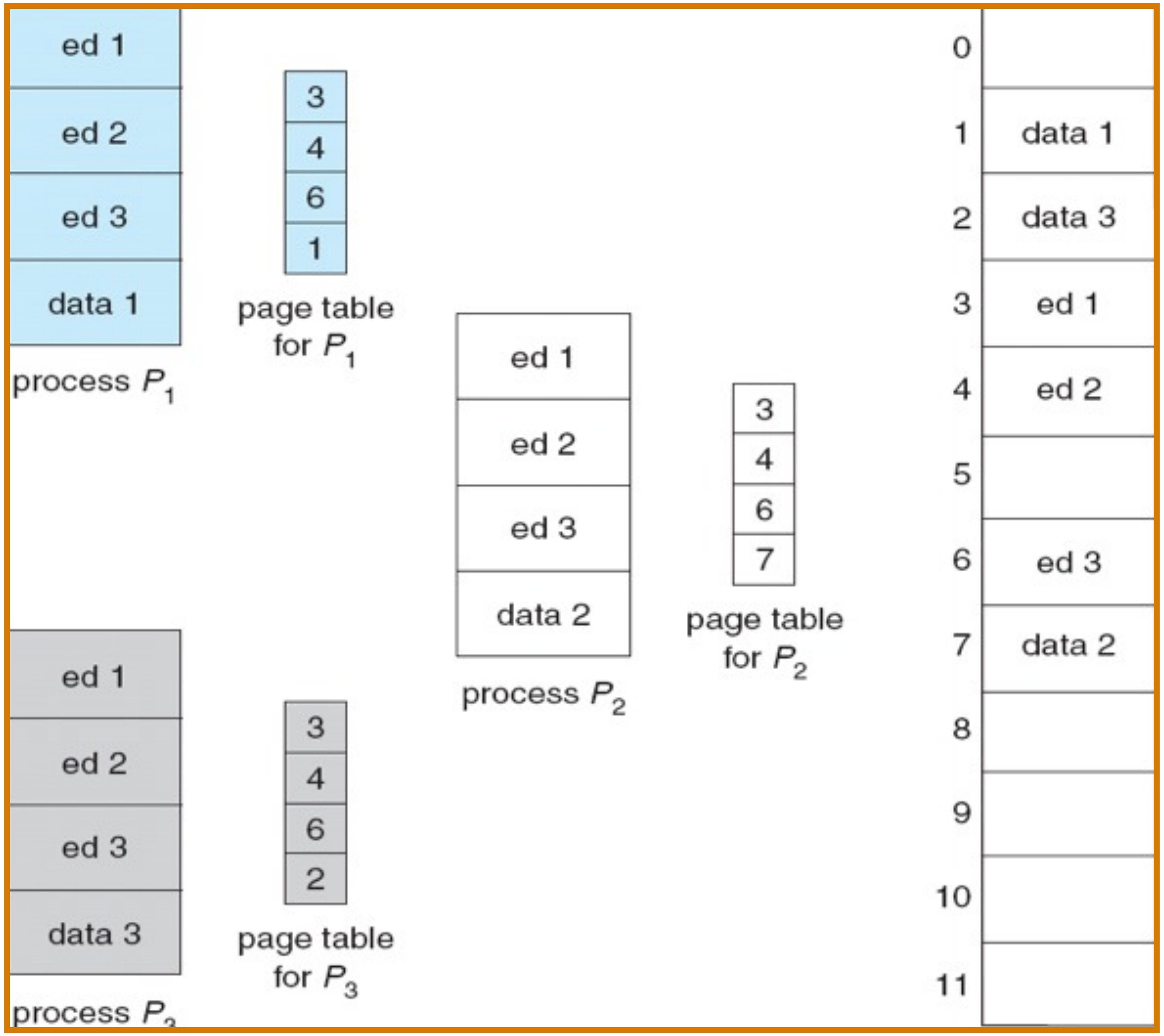

Create New Address Space

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- Via `fork` or `clone`
  - Copy of the old address space
- Change completely
  - `Exec`
- Or use the copy independently

Copy-on-Write

- *Copy-on-Write* (COW) allows both parent and child processes to initially *share* the same pages in memory
  - If either process modifies a shared page, only then is the page copied
- COW allows more efficient process creation as only modified pages are copied
- Free pages are allocated from a **pool** of zeroed-out pages

COW in Action

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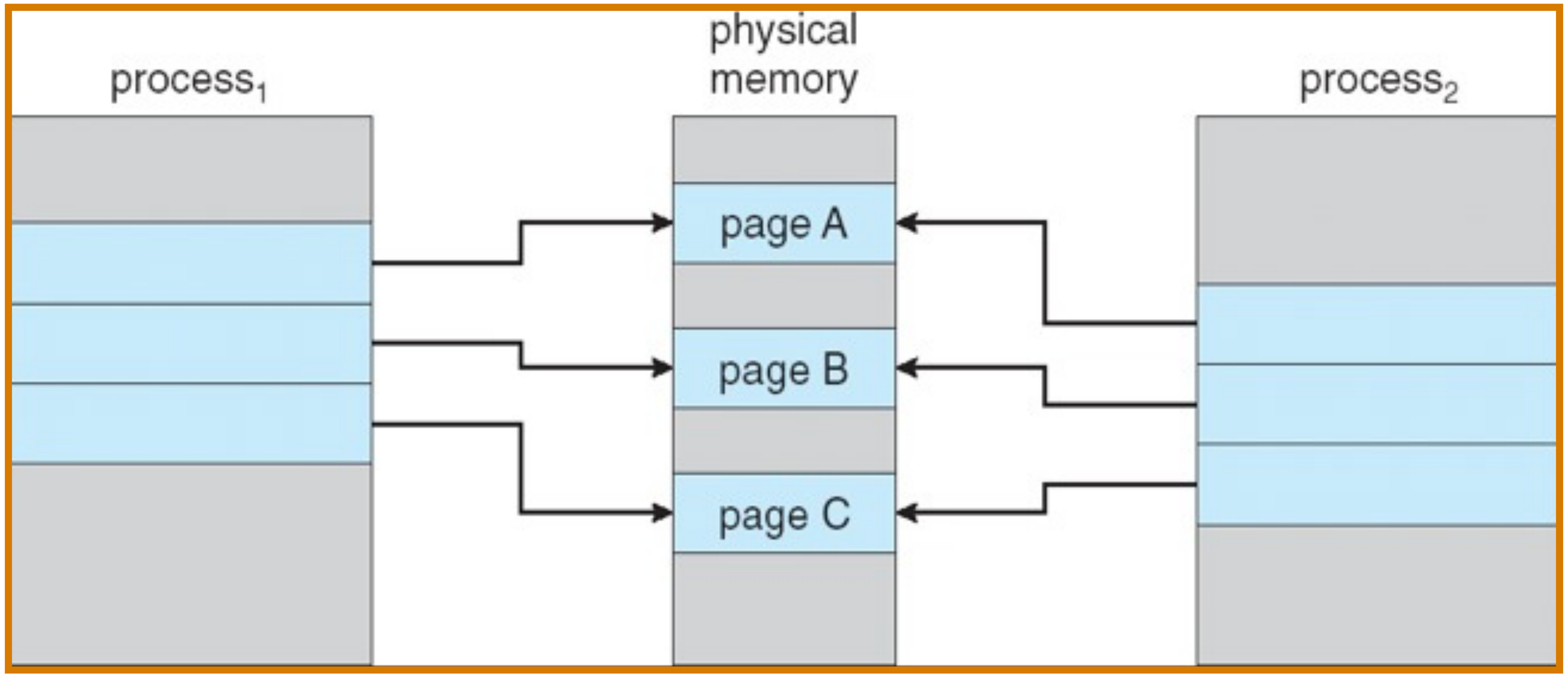
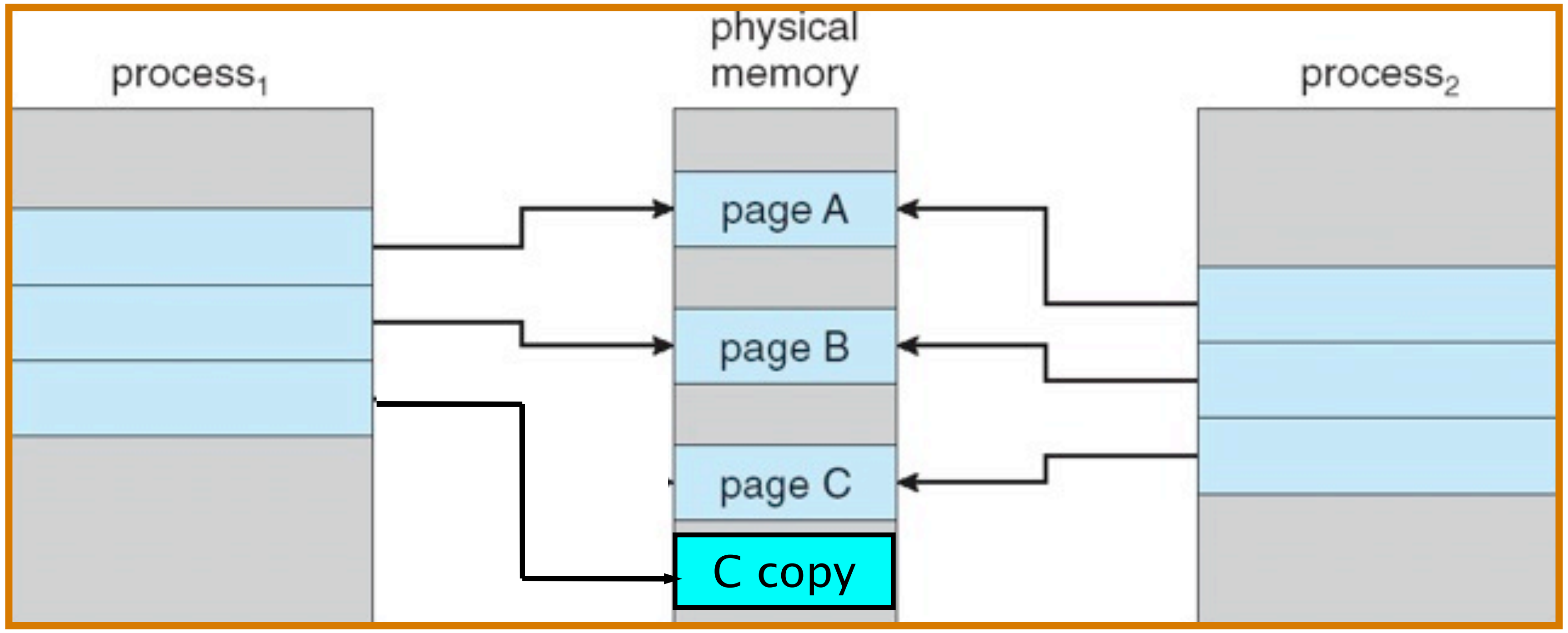
Before Process 1 modifies Page C...



COW (ctd.)

After Process 1 modifies Page C…



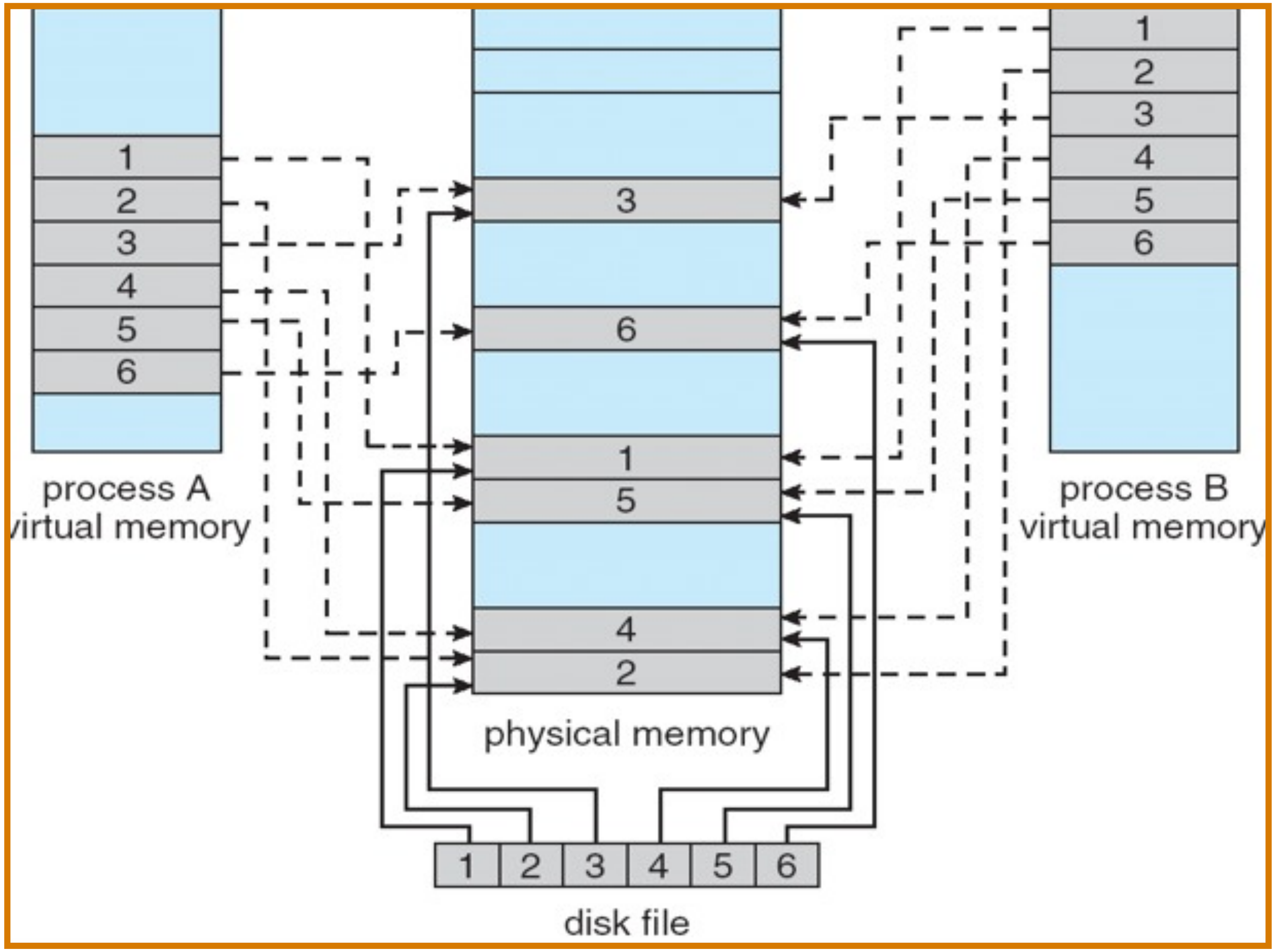
Memory-Mapped Files

- Memory-mapped file I/O allows file I/O to be treated as *routine memory access* by **mapping** a disk block to a page in memory
  - File is initially read using demand paging
  - Page-sized portion of the file is read from the file system into a physical page
  - Subsequent reads/writes to/from the file are treated as ordinary memory accesses.

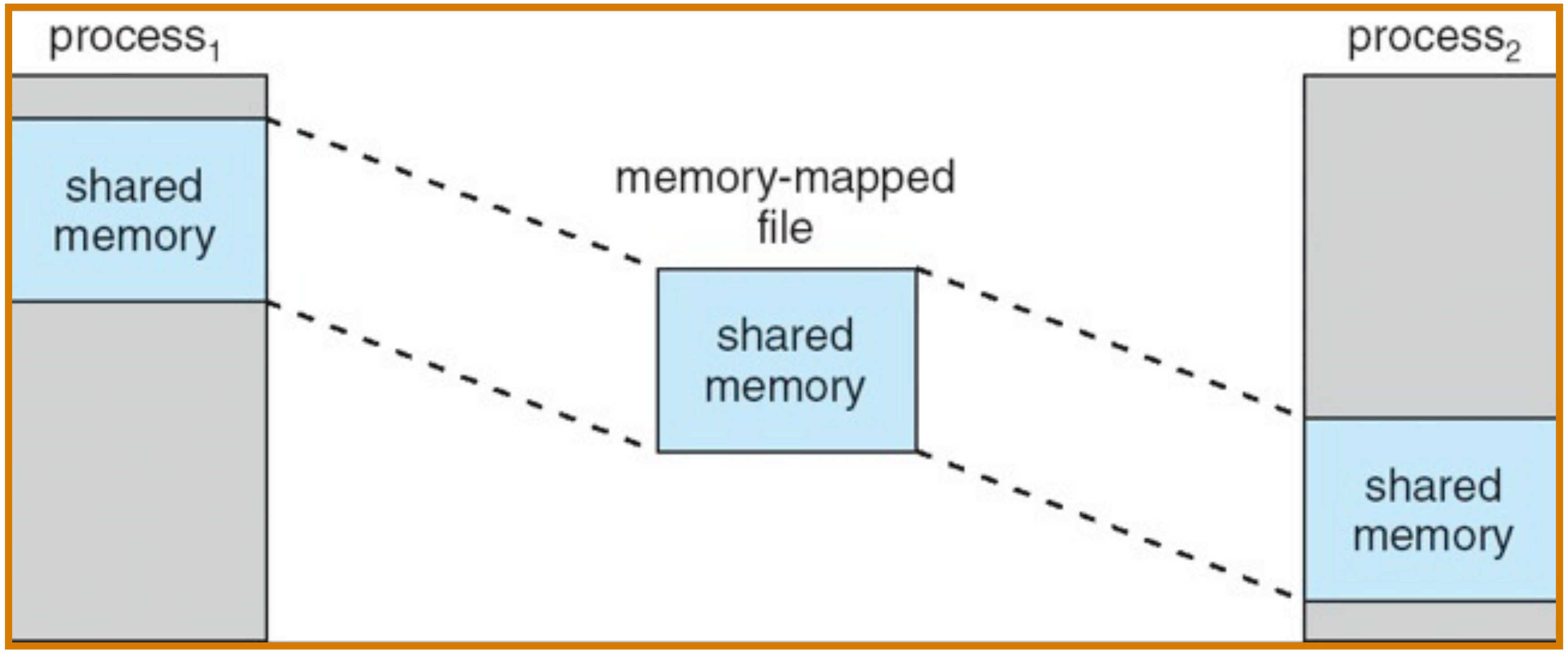
Memory Mapping Benefits

- Simplifies file access by treating file I/O through memory rather than `read()` or `write()` system calls
  - What is the benefit of doing this?
- Also allows several processes to map the same file allowing the pages in memory to be shared

Memory Mapped Files



Memory-Mapped Shared Mem



Thrashing

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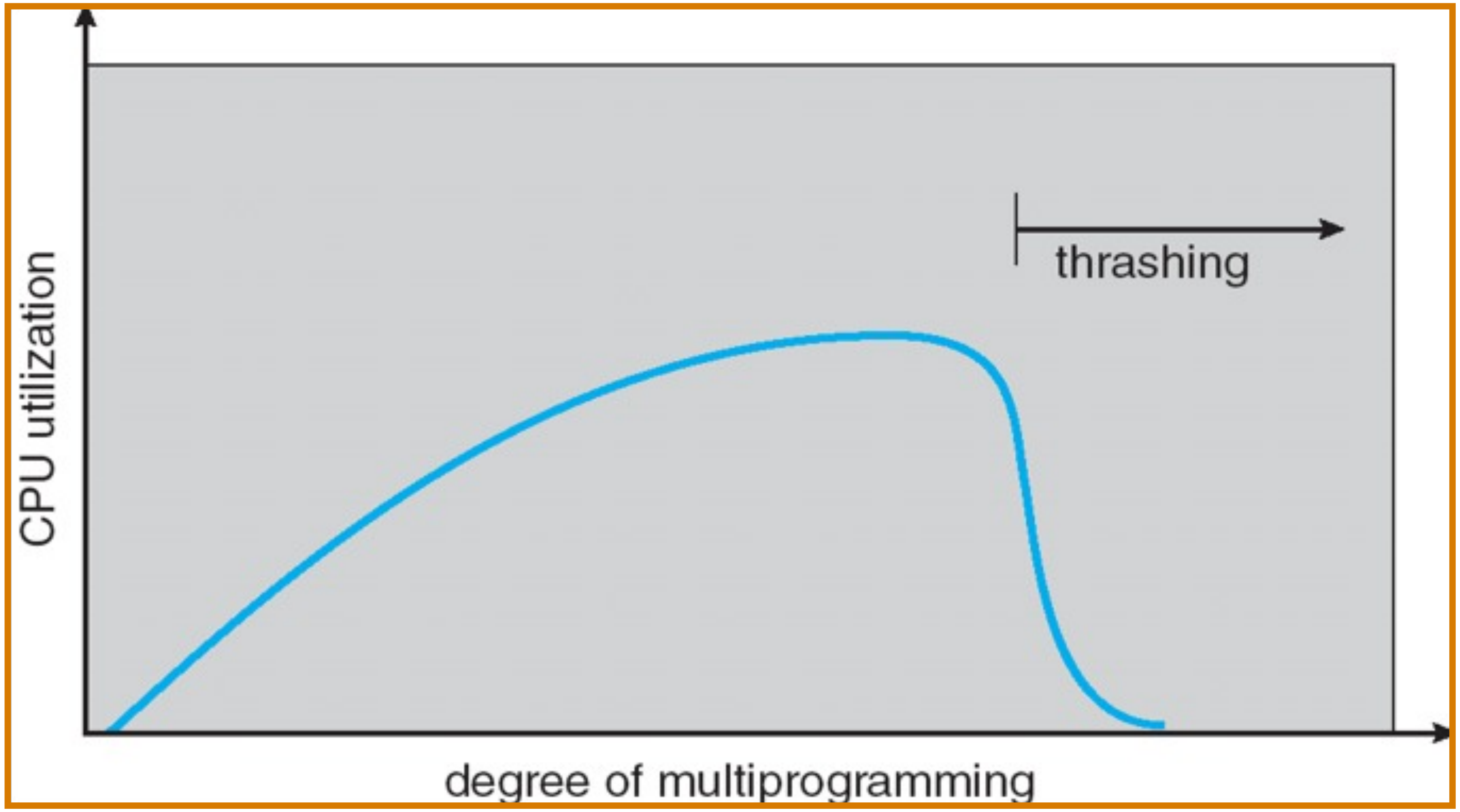
- If a process does not have "enough" pages, the page-fault rate is very high. This leads to:
  - low CPU utilization
  - operating system thinks that it needs to increase the degree of multiprogramming
  - another process added to the system
- *Thrashing* ≡ a process is busy swapping pages in and out

Thrashing



Demand Paging & Thrashing

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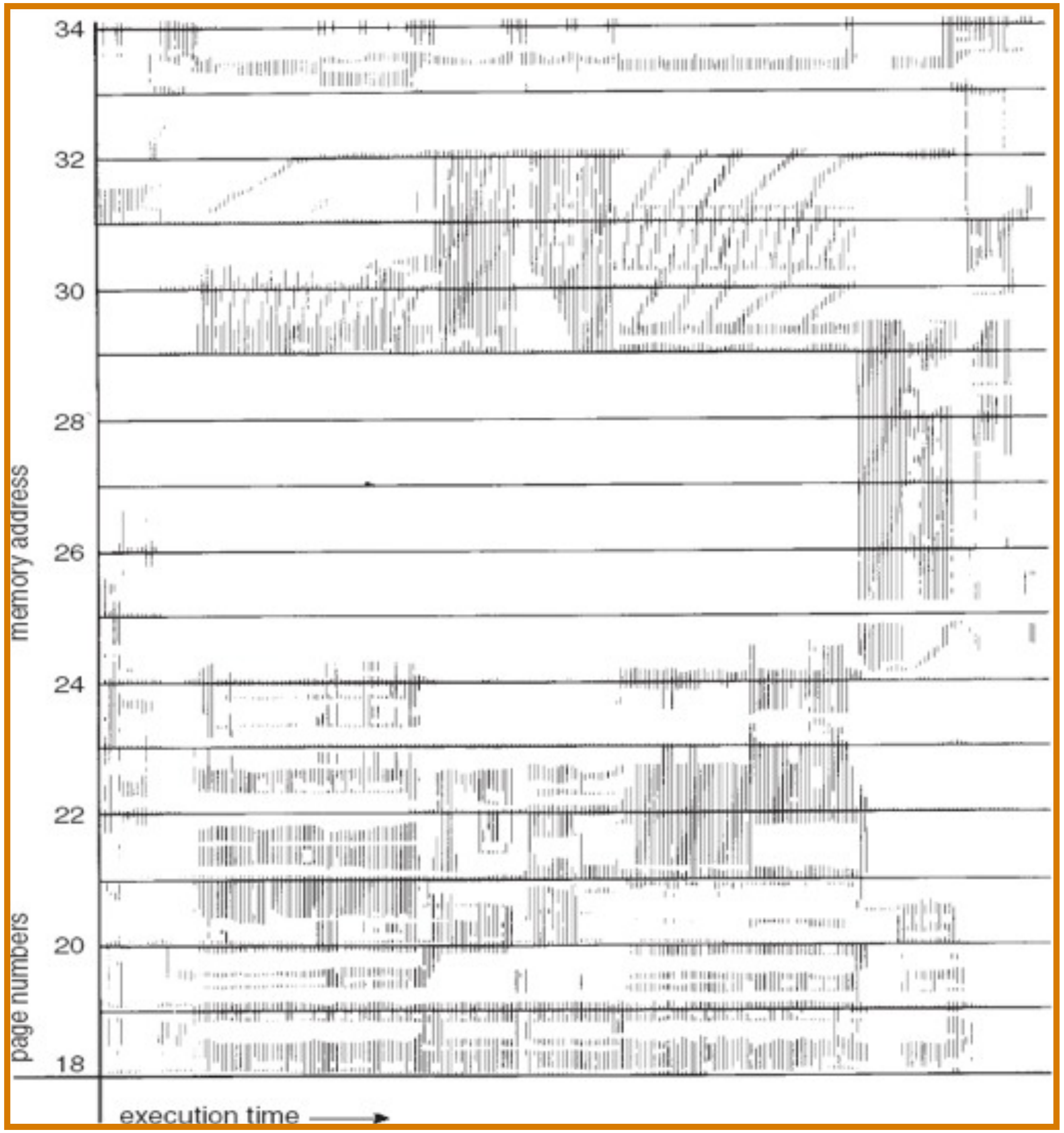
- Why does demand paging work?
  Locality model
  - Process migrates from one locality to another
  - Localities may overlap
- Why does thrashing occur?
  Σ size of locality > total memory size

Memory-Reference Locality



Working-Set Model

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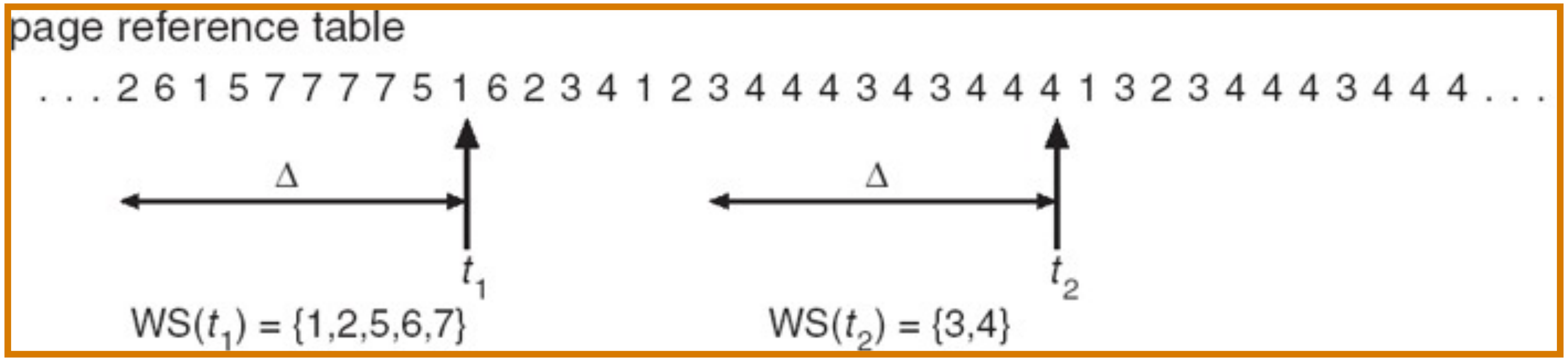
- Δ ≡ *working-set window* ≡ a fixed number of page references (e.g., 10,000 instructions)
- WSS_i (working set of Process P_i) = total number of pages referenced in the most recent Δ (varies in time)
  - if Δ too small, will not encompass entire locality
  - if Δ too large, will encompass several localities
  - if $\Delta = \infty \Rightarrow$ will encompass entire program
- $D = \Sigma\, WSS_i \equiv$ total demand frames
- if $D > m \Rightarrow$ Thrashing
- Policy: if $D > m$, suspend one of the processes

Working-set model



Sliding window that approximates program locality

Tracking the Working Set

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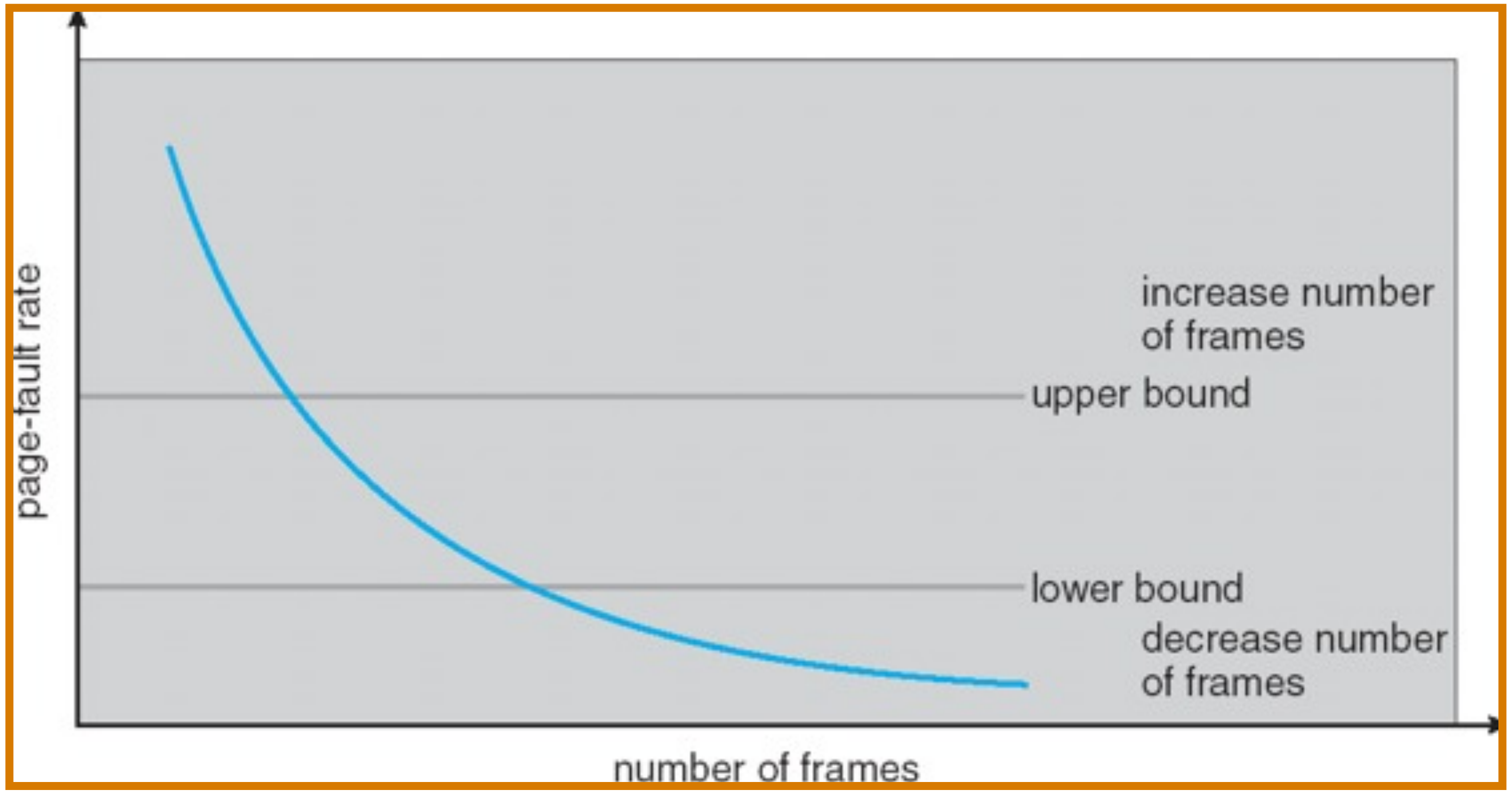
- Approximate with interval timer + reference bits
- Example: $\Delta = 10{,}000$
  - Timer interrupts after every 5000 time units
  - Keep in memory 2 bits for each page
  - Whenever a timer interrupts copy and set the values of all reference bits to 0
  - If one of the bits in memory = 1 $\Rightarrow$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

Page-Fault Frequency

- Establish “acceptable” page-fault rate
  - If actual rate too low, process loses frame
  - If actual rate too high, process gains frame



Summary

- Uses
  - Shared Pages
  - Copy-on-write
  - Memory-mapped files
- Thrashing and the Working Set model

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- Next time: Files