

# **CS241 System Programming Memory Management (VI)**

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Lecture 33

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# Content

- Design Issues for Paging Systems
  - Thrashing
  - Working set
  - Page size issues

# Administrative

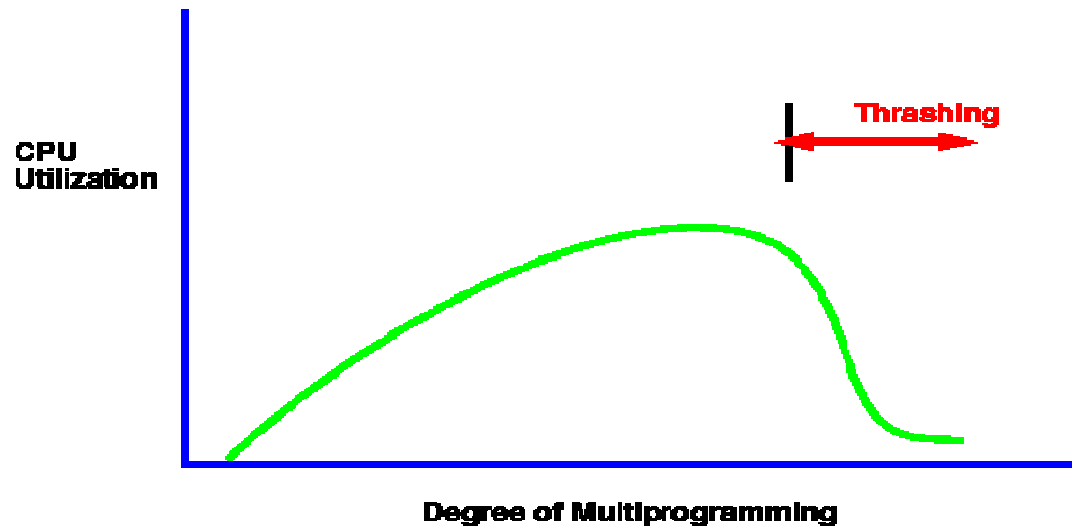
- MP4 is posted, due April 17, 2006

# Thrashing

- Computations have locality.
- As page frames decrease, the page frames available are not large enough to contain the locality of the process.
- The processes start faulting heavily.
- Pages that are read in, are used and immediately paged out.

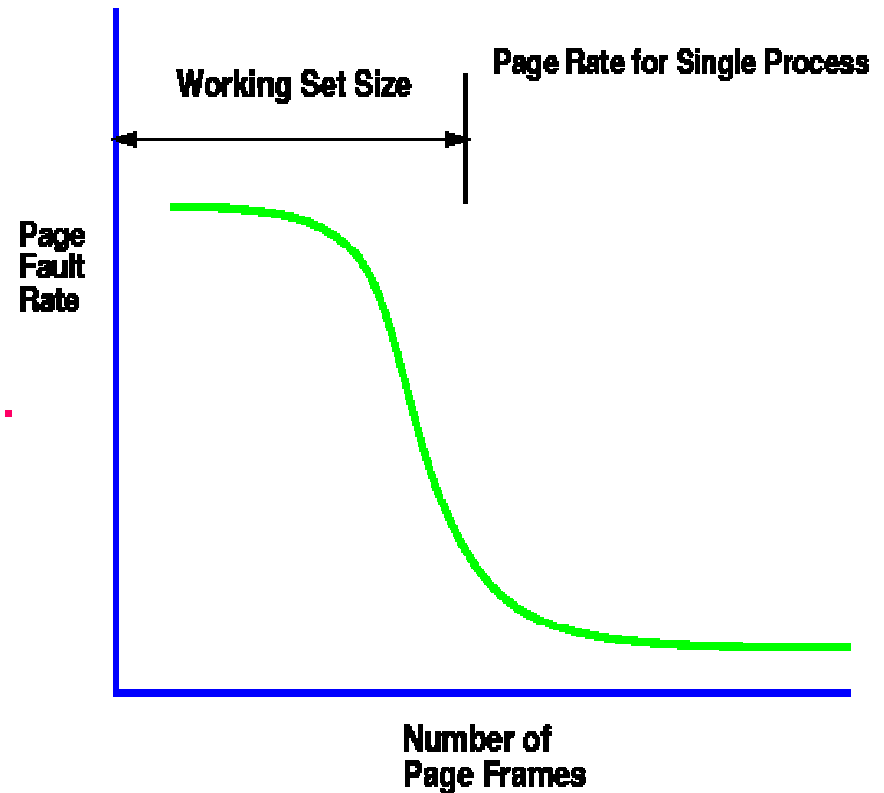
# Thrashing and CPU Utilization

- As the page rate goes up, processes get suspended on page out queues for the disk.
- the system may try to optimize performance by starting new jobs.
- starting new jobs will reduce the number of page frames available to each process, increasing the page fault requests.
- system throughput plunges.



# Working Set

- the working set model assumes locality.
- **the principle of locality states that a program clusters its access to data and text temporally.**
- *As the number of page frames increases above some threshold, the page fault rate will drop dramatically.*



# Working Set in Action

- Algorithm
  - if # free page frames  $>$  working set of some suspended process, then activate process and map in all its working set
  - if working set size of some process increases and no page frame is free, suspend process and release all its pages
- moving window over reference string used for determination.
- keeping track of working set.

# Working Set Example

Window size  
is  $\Delta$

12 references,  
8 faults

Page Refs	$\Delta = 4$ References				
	Fault?	Page Contents			
A	yes	A			
B	yes	A	B		
C	yes	A	B	C	
D	yes	A	B	C	D
A	no	A	B	C	D
B	no	A	B	C	D
E	yes	A	B	D	E
A	no	A	B	E	
B	no	A	B	E	
C	yes	A	B	C	E
D	yes	A	B	C	D
E	yes	B	C	D	E

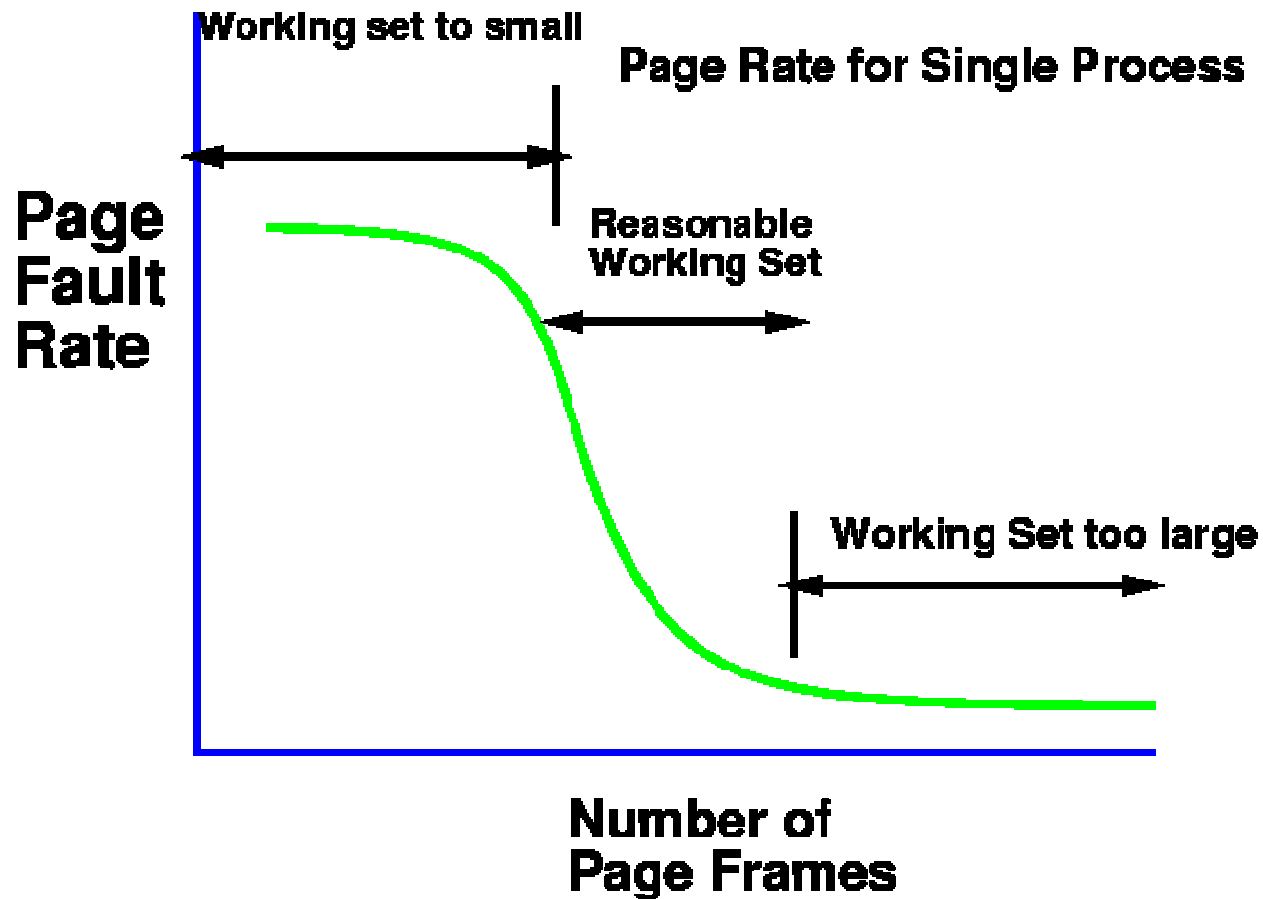
# Working Set Solution

- Approximate working set model using timer and reference bit.
- Set timer to interrupt after approximately  $x$  references,  $\tau$ .
- Remove pages that have not been referenced and reset reference bit.
- How large should be the timer (working set)?

# Page Fault Frequency Version of Working Set

- Assume that if the working set is correct there will not be many page faults.
- If page fault rate increases beyond assumed knee of curve, then increase number of page frames available to process.
- If page fault rate decreases below foot of knee of curve, then decrease number of page frames available to process.

# Page Fault Frequency Version of Working Set



# Page Size Considerations

- Small pages
  - Reason:
    - Locality of reference tends to be small (256)
    - Less fragmentation
  - What is the problem with small pages?
- Large pages
  - Reason
    - Small page table
    - I/O transfers have high seek time, so better to transfer more data per seek
  - What is the problem with large pages?

# Summary

- Design issues are of great importance to make the paging scheme effective
- Read Chapter T: 4.4.1, 4.4.2, 4.4.3, 4.4.4, 4.4.5, 4.4.6, and 4.5.1-4.5.3