CS 423
Operating System Design: Midterm Review

Professor Adam Bates
Spring 2018

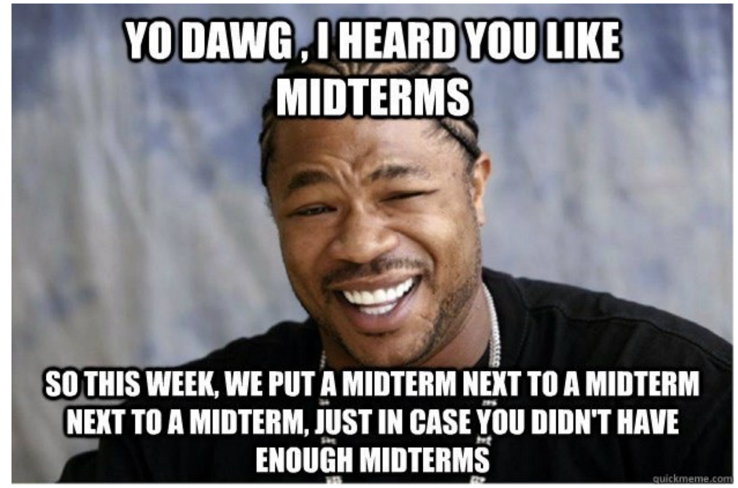
Goals for Today

- Learning Objective:
  - Review material, and also my strategies for writing midterm questions
- Announcements, etc:
  - MP1 Grades Released*
    - Average score — 87%

* Plagiarism checking still in-progress

Reminder: Please put away devices at the start of class

Midterm Details



- In-Class on March 7th.
  - i.e., <u>*50 minutes*</u>
- Scantron Multiple choice
  - bring pencils!
- 20-30 Questions
- **Openbook**: Textbooks, paper notes, printed sheets allowed. <u>*No electronic devices permitted (or necessary)!*</u>
- **Content**: All lecture and text material covered prior to March 5th (i.e., up to and including memory)

Sample Midterm Q

- Which of the following is <u>not</u> a good reason for increasing the size of a system's page frames?
    - Improves memory utilization/efficiency
    - Decreases memory footprint of
      virtual memory management
    - Improves disk utilization/efficiency

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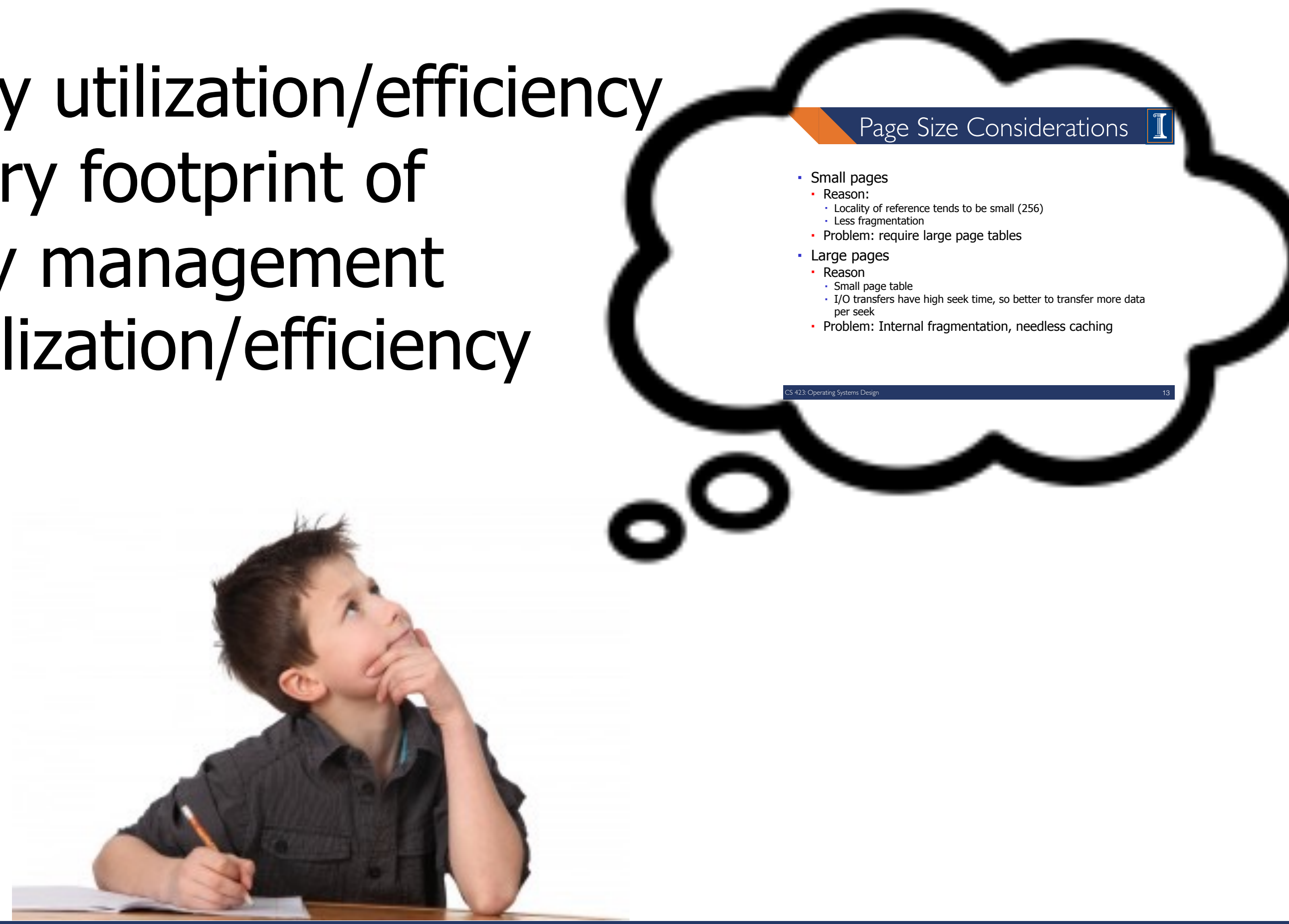
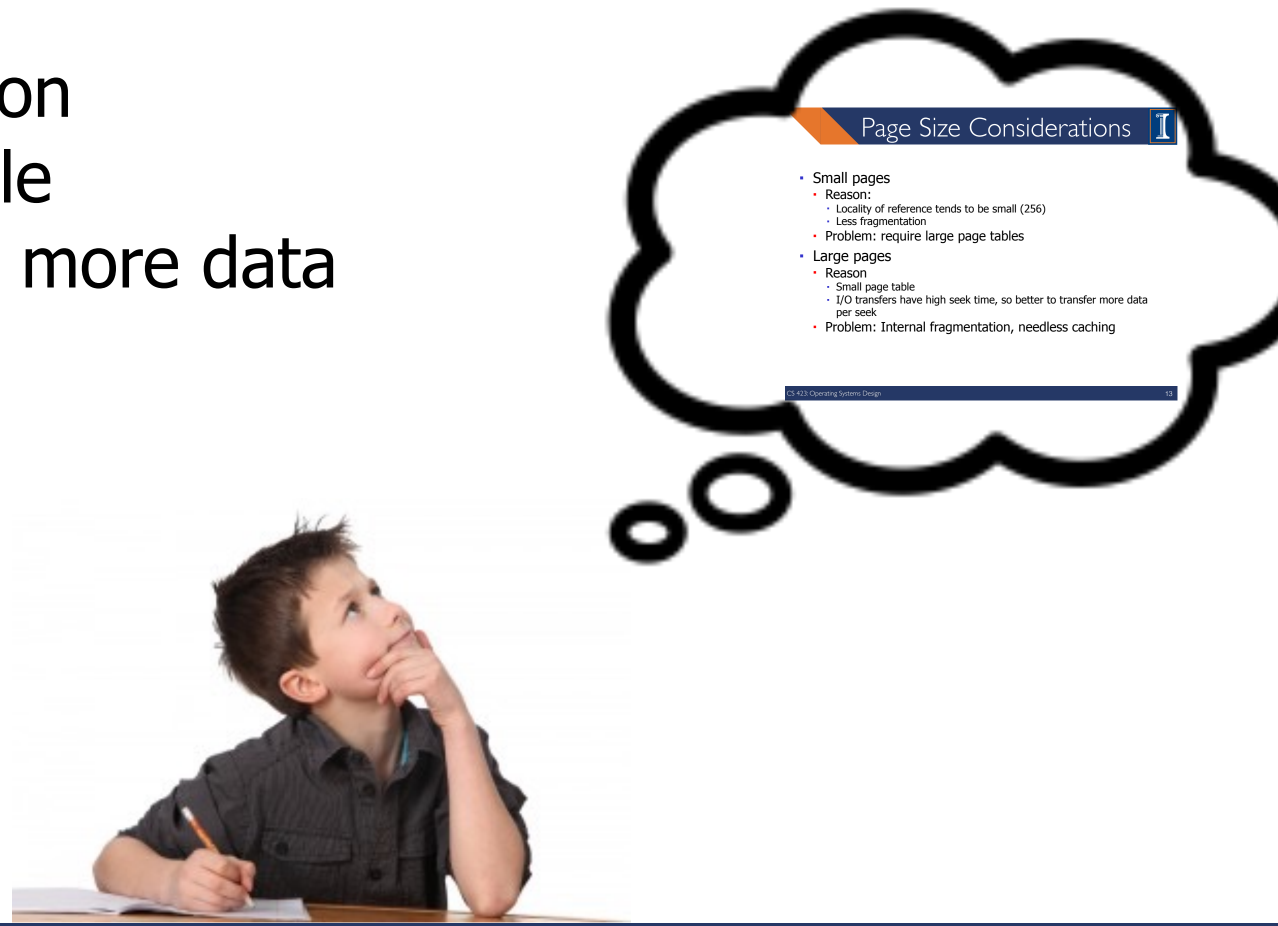


Sample Midterm Q

- Which of the following is <u>not</u> a good reason for increasing the size of a system's page frames?
  - Less Fragmentation
  - Smaller Page Table
  - Better to transfer more data per disk seek



Page Size Considerations

- Small pages
  - Reason:
    - Locality of reference tends to be small (256)
    - Less fragmentation
  - Problem: require large page tables
- Large pages
  - Reason
    - Small page table
    - I/O transfers have high seek time, so better to transfer more data per seek
  - Problem: Internal fragmentation, needless caching

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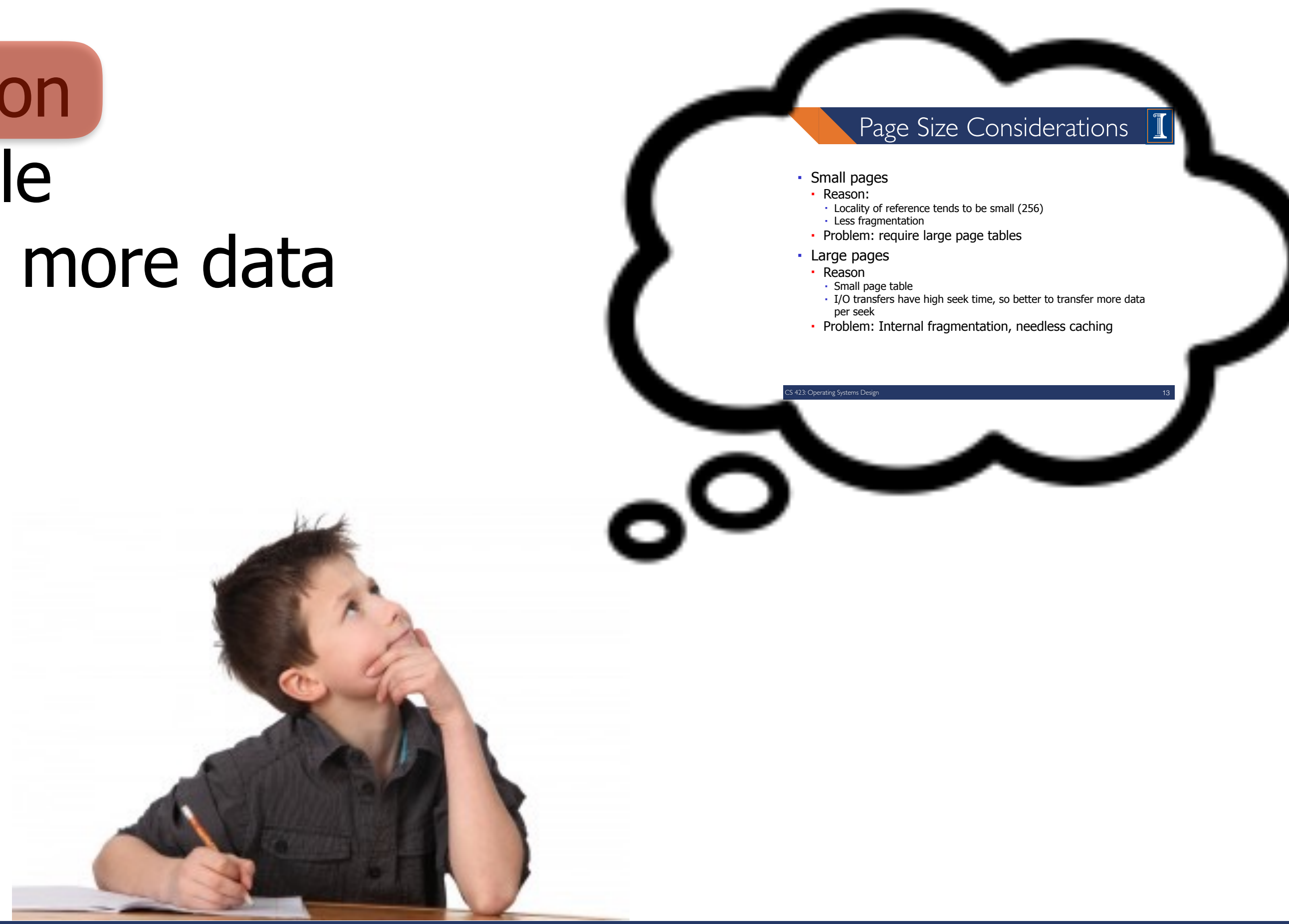

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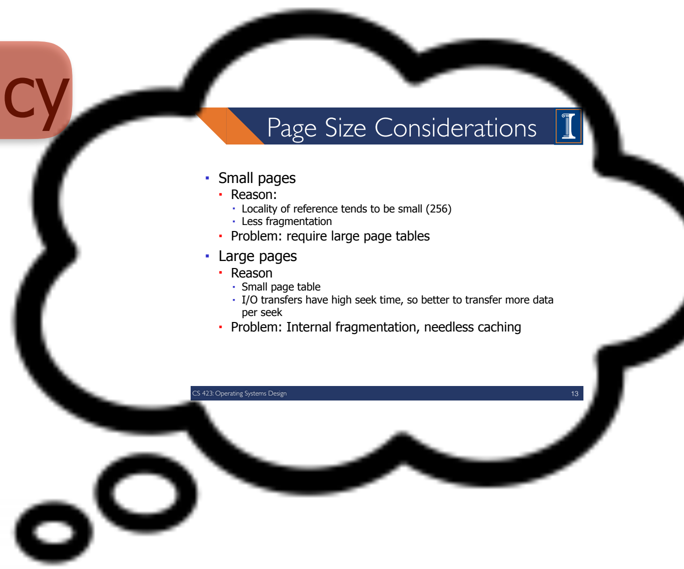
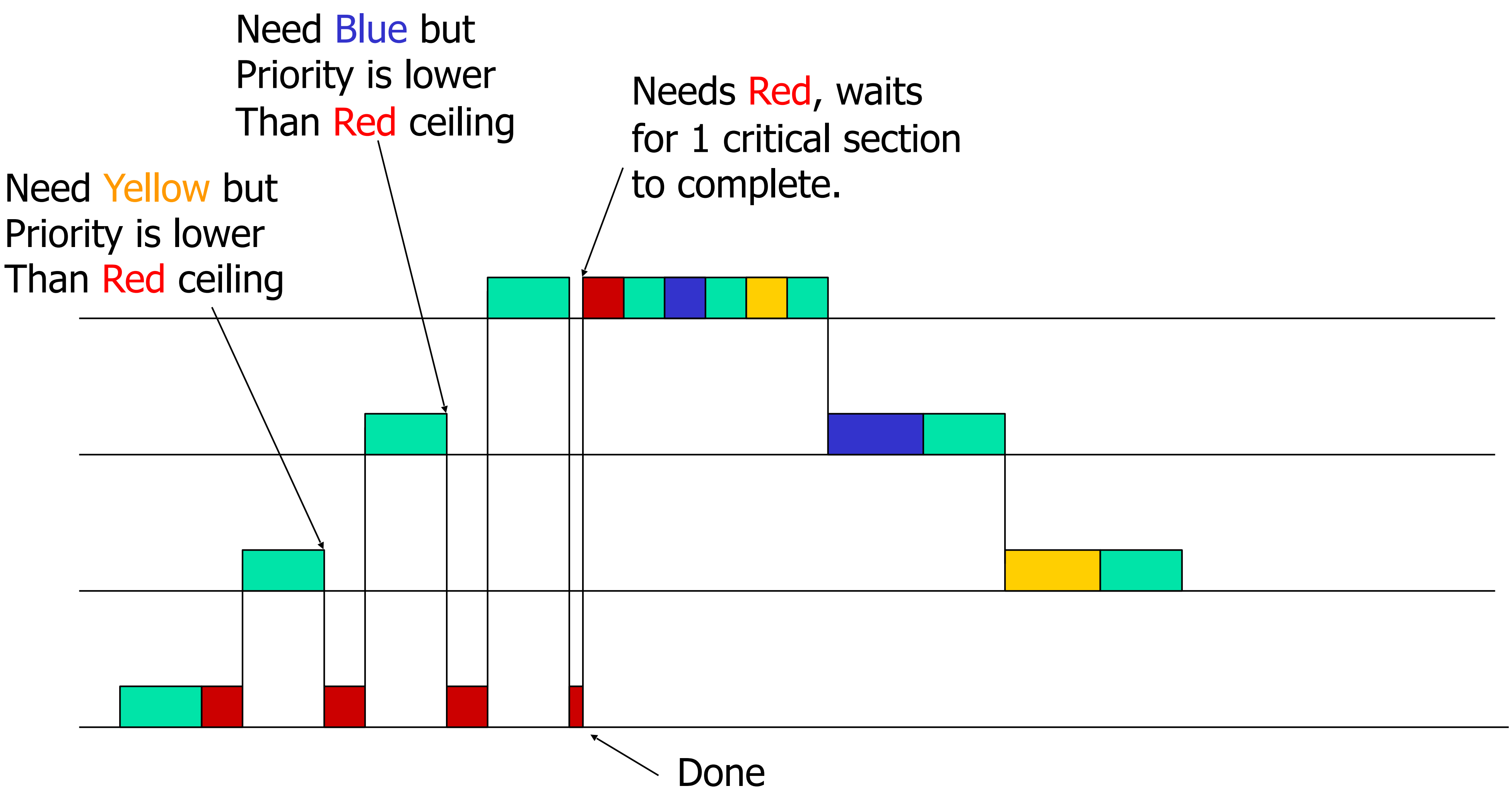


Priority Ceiling Protocol

- Definition: The priority ceiling of a semaphore is the highest priority of any task that can lock it
- A task that requests a lock R_k is denied if its priority is not higher than the highest priority ceiling of all semaphores currently locked by other tasks (say it belongs to semaphore R_h)
  - The task is said to be blocked by the task holding lock R_h
- A task inherits the priority of the top higher-priority task it is blocking

Maximum Blocking Time

Priority Ceiling Protocol:



Reasoning about Page Tables

- On a 32 bit system we have 2^32 B virtual address space
  - i.e., a 32 bit register can store 2^32 values
- Page size (range) is 2^n (e.g., 512 B, 1 KB, 2 KB, 4 KB…)
- Given a page size, how many pages are needed?
  - e.g., If 4 KB pages (2^12 B), then 2^32/2^12=…
    - 2^20 pages required to represent the address space
- **But**! each page entry takes more than 1 Byte of space to represent.
  - suppose page size is 4 bytes (Why?)
  - (2*2) * 2^ 20 = 4 MB of space required to represent our page table in physical memory.

Completely Fair Scheduler

- Merged into the 2.6.23 release of the Linux kernel and is the default scheduler.
- Scheduler maintains a red-black tree where nodes are ordered according to received virtual execution time
- Node with smallest virtual received execution time is picked next
- Priorities determine accumulation rate of virtual execution time
  - Higher priority → slower accumulation rate

Completely Fair Scheduler

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- Sc … are or … ne
- N … is pi …
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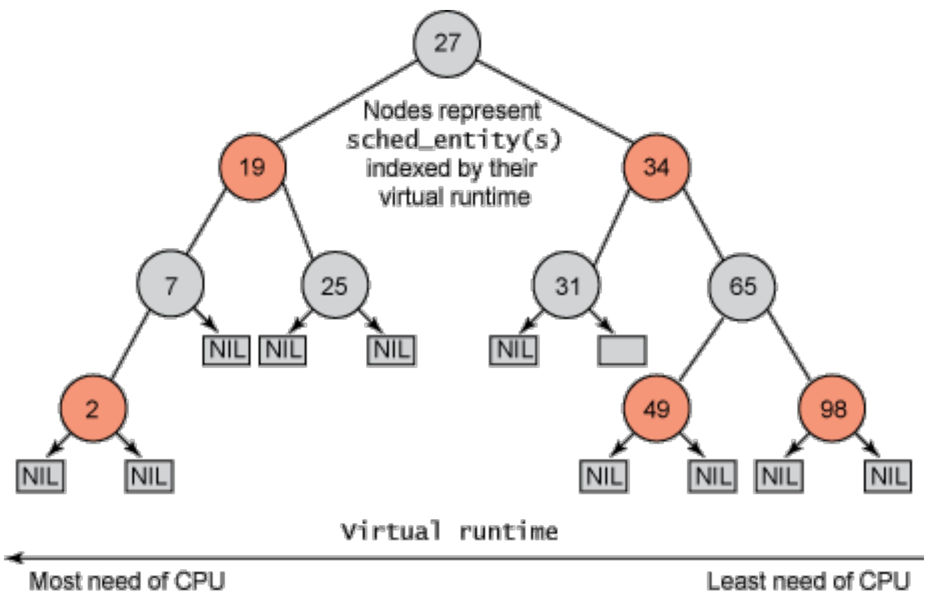
Property of CFS: If all task's virtual clocks run at exactly the same speed, they will all get the same amount of time on the CPU.

How does CFS account for I/O-intensive tasks?

Red-Black Trees

- CFS dispenses with a run queue and instead maintains a time-ordered **red-black tree**. Why?



Benefits over run queue:

- O(1) access to leftmost node (lowest virtual time).
- O(log n) insert
- O(log n) delete
- self-balancing

Sample Midterm Q

- With CFS active, tasks X, Y, and Z accumulate virtual execution time at a rate of 1, 2, and 3, respectively. What is the expected share of the CPU that each gets?
    - X=17%, Y=33%, Z=50%
    - X=55%, Y=27%, Z=18%
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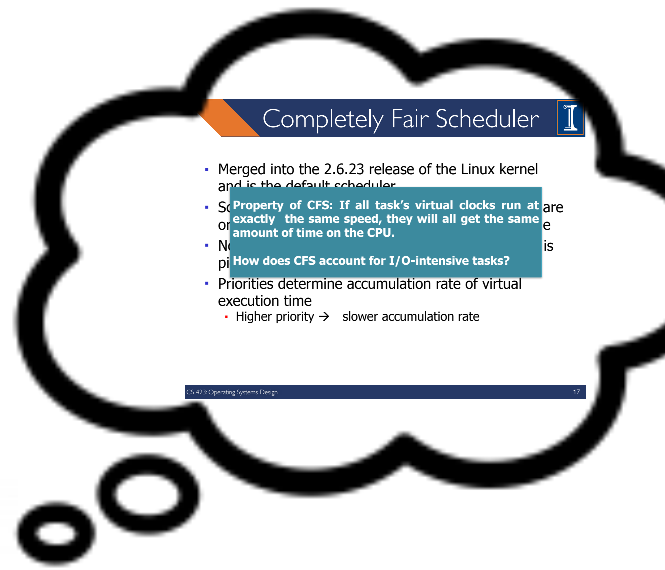
"X should have twice as much CPU as Y, three times as much CPU as Z"



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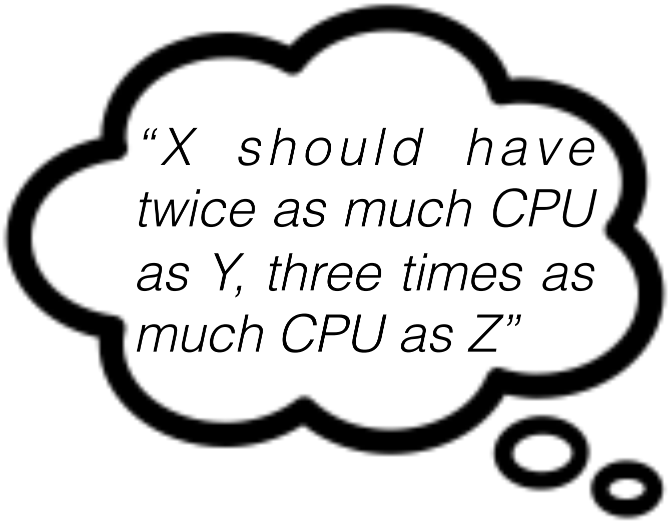

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"X should have twice as much CPU as Y, three times as much CPU as Z"

Sample Midterm Q

- Below are chronologically-ordered series of tasks with their completion time shown. Which sequence offers a pessimal (i.e., worst-case) average response time for FIFO scheduling?
  - 1, 2, 3, 4
  - 2, 2, 2, 2
  - 3, 1, 3, 1
  - 4, 3, 2, 1

More Q&A