CSE 451: Operating Systems

Section 10

Project 3 wrap-up, final exam review

Final exam review

- Disclaimer: This is not guaranteed to be everything that you need to know for the final. This is an overview of major topics we covered in the course.
- You are responsible for all the readings and the slides only up to what we covered in class.

Exam Coverage

- Lectures: Modules 1 – 18
  - Everything from the intro to reliable storage is fair game (will not include Networking/RPC/DFS/VMMs)
  - Chapters 1 – 14 in the textbook
- Extra Readings: 2 questions from extra readings
- Projects: 2 questions based on the projects

Major Topics

- Kernels – Micro, Monolithic, etc
- Processes – fork, vfork, execve
- User and Kernel level threads
- Scheduling
- Paging, caching
- Memory Management

More Topics

- Deadlock
- Race conditions and synchronization variables
- File systems
- Projects 1 - 3

Synchronization Variables

- Locks, mutexes, semaphores, condition variables and monitors
  - Mutexes
    - Provide a waiting queue for threads that are waiting on a lock
  - Condition Variables
    - A higher level construct than mutexes. They help manage the waiting of threads by allowing them to wait until a given condition is true
    - Signal and broadcast
  - Monitors
    - Two main different types, Hoare and Mesa monitors.
    - Provides object like abstraction to synchronization. Manages condition variables and locks as well as provides methods for accessing shared memory.
    - Should be familiar with both types: http://en.wikipedia.org/wiki/Monitor_(synchroniza$on)

Thread management

- Queues
  - Why do thread libraries make use of queues?
- Synchronization
  - What are the mechanisms for protecting critical sections, how do they work, and when should one be used over another?
- Preemption
  - What is preemption and how does the process of one thread preempting another work?

Scheduling

- Different scheduling techniques:
  - First in first out, round robin, shortest processing time first, priority, multi-level feedback queue
  - What are the advantages and disadvantages of each
  - Starvation and fairness
  - Measure of response time
- What do most current systems use?

Threads

- Difference between user and kernel level threads
  - Can user level threads run across multiple processors?
- Performance differences between user / kernel level threads
- What are the benefits of using kernel over user level threads, visa-versa
  - Kernel level threads allow for scheduling across multiple processors
  - User level threads are lightweight and run in user space

Kernels

- Different types of OS kernels
  - Micro vs Monolithic
  - What are the benefits of each
  - What operations need to happen in the kernel vs user space?
    - Interactions with hardware
    - Kernel trap
    - System calls
    - Exceptions

Processes

- Should know the difference between processes and threads
- What is the difference between fork and forkv
  - Copy on write?

Memory management

- Purposes:
  - Resource partitioning / sharing
  - Isolation
  - Usability
- Paging
- Segmentation

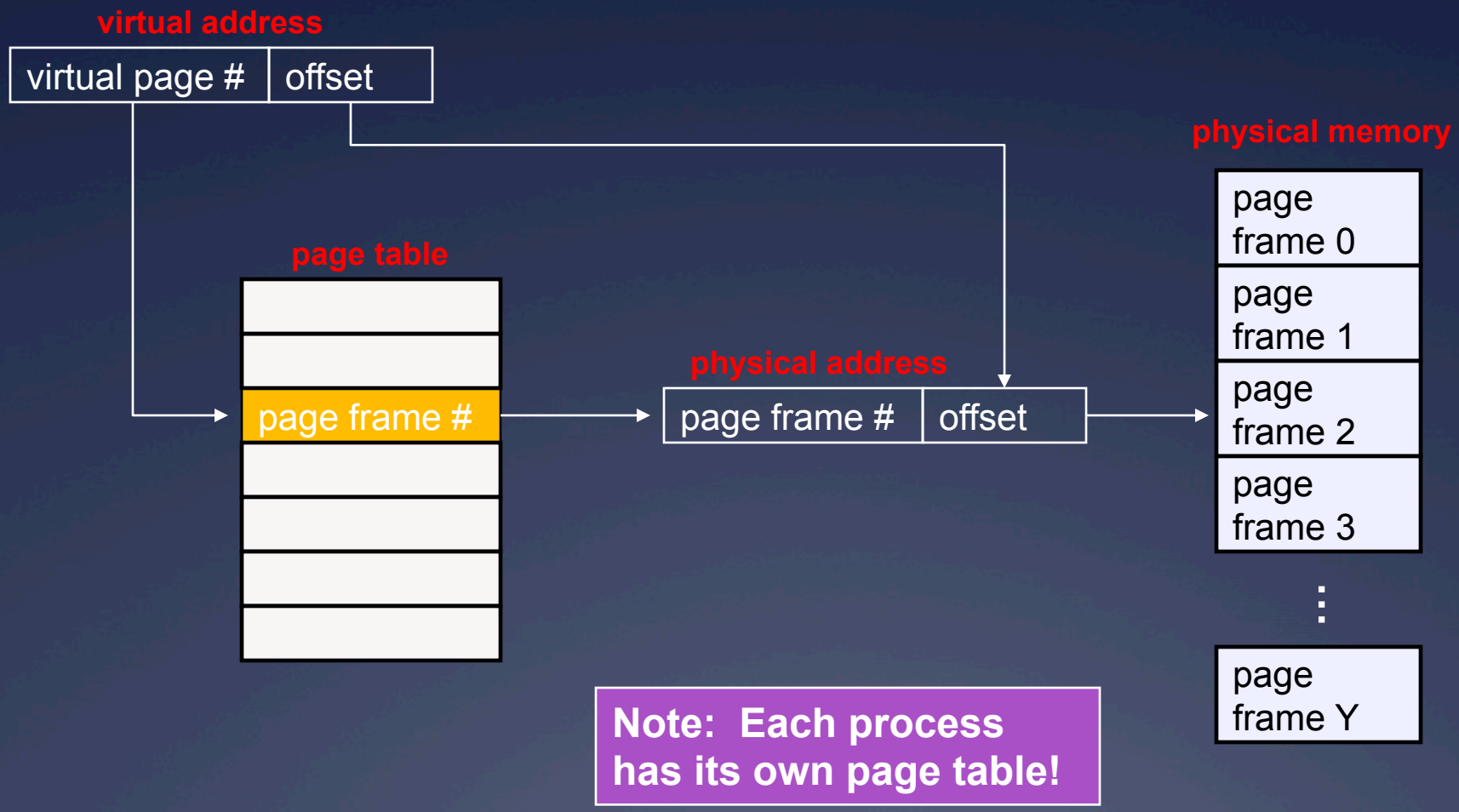
Virtual memory

- What happens on a virtual memory access?

Virtual memory

- What happens on a virtual memory access?
  - Address translation: who performs it?
    - Page table lookup
    - Translation Lookaside Buffer (TLB)
  - Page fault?
    - Page replacement
    - Process/queue management
- How does all of this overhead pay off?
  - Locality! Both temporal (in time) and spatial (nearby).

Virtual memory



Page replacement

- Algorithms:
  - Belady, FIFO, LRU, LRU clock / NRU, random, working set…
  - Local vs. global
- How/why are any of these better or worse than the others?
- What happens when paging goes wrong?
  - Thrashing, 10-year old computers running XP?

Advanced virtual memory

- What problem does a TLB address?
- What problem do two-level page tables address?
  - What's the key concept?

Advanced virtual memory

- What problem does a TLB address?
  - Increases speed of virtual address translation
- What problem do two-level page tables address?
  - What's the key concept?
    - Indirection

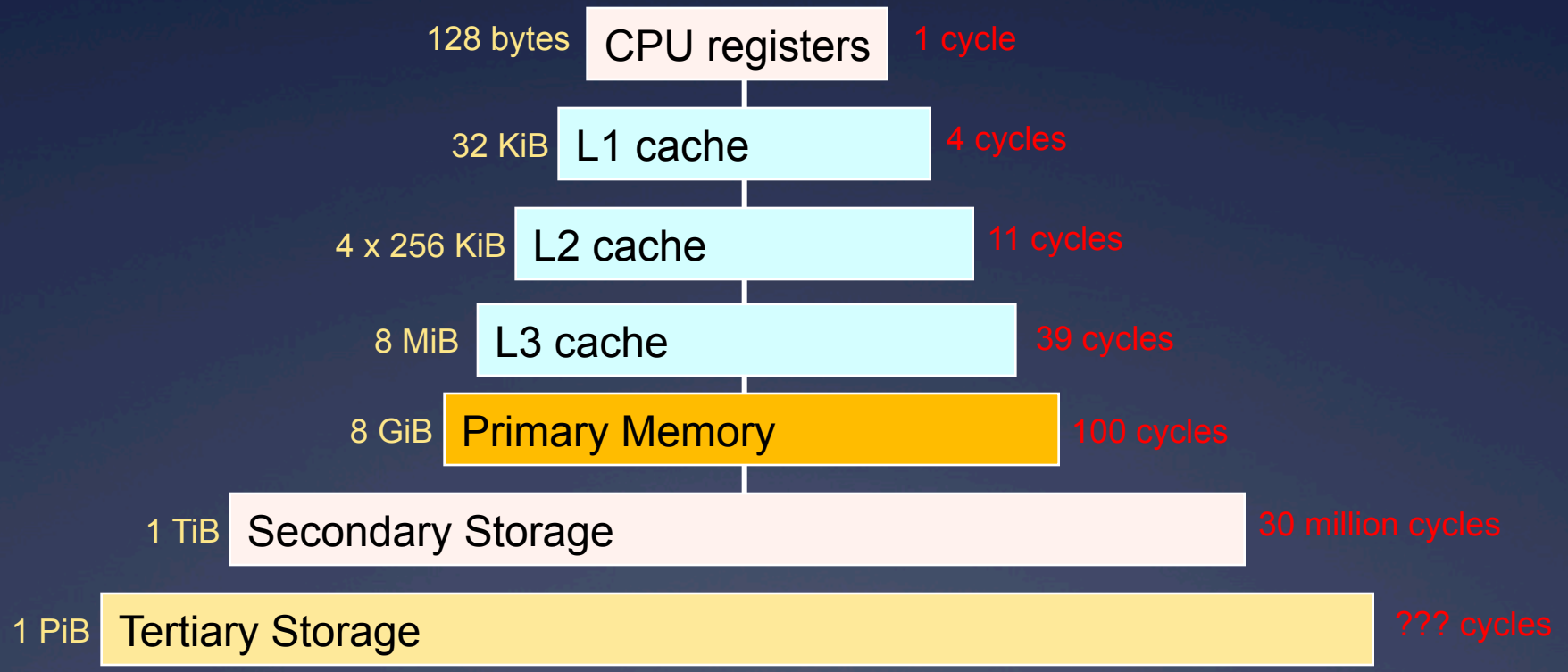
Secondary storage

- Memory forms a hierarchy
- Different levels of disk abstraction:
  - Sectors
  - Blocks
  - Files
- What factor most influences the ways that we interact with disks?

Secondary storage

- Memory forms a hierarchy
- Different levels of disk abstraction:
  - Sectors
  - Blocks
  - Files
- What factor most influences the ways that we interact with disks?
  - Latency

Memory hierarchy



* Each level acts as a cache of lower levels
  * (Stats more or less for Core i7 3770)

File systems

- What does a file system give you?
  - Useful abstraction for secondary storage
  - Organization of data
    - Hierarchy of directories and files
  - Sharing of data

File system internals

- Directories
- Directory entries
- Inodes

- Files:
  - One inode per file
  - Multiple directory entries (links) per file

Inode-based file system

- Sequence of steps when I run *echo "some text" > /home/jay/file.txt* ?
  - Open file:
  - Write to file:
  - Close file:

Inode-based file system

- Sequence of steps when I run *echo "some text" > /home/jay/file.txt* ?
  - Open file:
    - Get inode for / -> get data block for /
    - Read directory entry for / -> get inode for /homes
    - Repeat… -> get data block for file.txt, check permissions
  - Write to file:
    - Modify data block(s) for file.txt in buffer cache
  - Close file:
    - Mark buffer as dirty, release to buffer cache
    - Kernel flushes dirty blocks back to disk at a later time