Advanced Operating Systems (CS 202)

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Today

- Course organization and mechanics

- Introduction to OS

What is this course about?

- How has the role of the operating system evolved over time?
  - How does the past inform the present?
- What are the principles that underlie Operating Systems?
- What are current and future trends in OS?
- Make it real: lab assignments to get some experience with OS development
- *Get you ready to do Systems research*

Some topics we will cover

- Operating Systems models and how they evolved
  - Monolithic kernels, micro-kernels, …
    - extensibility, protection, performance
- Concurrency:
  - Synchronization and Scheduling
  - Multicore OS
- File systems:
  - Sequential, networked, distributed, internet scale
- Virtualization:
  - Intel VT, Containers
- Other advanced topics

Class format

- For every topic:
  - Some overview
  - Discuss research papers
- Research papers:
  - Critique for some required papers (1 paper most weeks)
    - Additional papers discussed in class
    - You are responsible for required papers and material discussed in class

Questions while reading papers

- What are the primary goals (hypothesis)?
  - 2 sentence elevator pitch
- Why did the authors do what they did the way they did?
  - Understand motivation for design
- What were the driving forces for the paper at the time it was written?
- What parts still hold? What parts don’t?
- How did they experiment to support their ideas?

Reading Research Papers

- Guidelines for reading papers
  - Make sure to identify authors' goals and assumptions. Not always directly stated.
  - Look for high-level takeaways.
  - **Simulate the whole process in your head**
  - Follow a multi-pass reading strategy
    - Pass1: Get overview. Pass2: Read details and make notes. Pass3: Re-read details to evaluate.
  - Think how techniques used are applicable today. Identify extensions.

Lab Assignments

- 2 Mandatory Lab Assignments
  - Modification on xv6
  - Closely related to the topics discussed

A Course Project

- A group (no more than 3 students)
- Pick a topic and write a proposal (before midterm)
- Conduct study
- Make a final presentation
- Write a report

Expectations and little bit about me

- I do research in system security
  - I know some aspects about modern operating systems very well (Windows/Linux/Android, etc.)
- Expect to discuss and learn with you altogether
  - Read papers carefully
  - Actively participate in class discussions
  - Your participation counts 10% of your final grade!

Class Logistics

- Grader: Ali (Sina) Davanian
  - Office hours and contact information on the class website.
  - Mainly responsible for lab assignments
- Class website: http://www.cs.ucr.edu/~heng/teaching/cs202-sp18/
- Piazza: https://piazza.com/uconline/spring2018/cs_202_001_18s/home

Grading Policy

- Lab Assignments ← 25%

- Reading and critiquing papers
- Attendance
- Asking/answering questions

} 20%

- Mid-term and Final ← 35%

- Project ← 20%

Course Material

- I assume you know undergraduate material
  - If you need background, I suggest:
    - OS, 3 easy pieces: http://pages.cs.wisc.edu/~remzi/OSTEP/
      - Its free!
      - Its excellent!

- **Most material from published research papers**

Pre-requisites

- May recap basics of OS, but if so it will be quick

- **To do well, you must have had undergrad OS or equivalent preparation**
- **Architecture, networks, distributed systems courses are also a plus.**

Questions?

- Schedule will be posted incrementally on course website

http://www.cs.ucr.edu/~heng/teaching/cs202-sp18

- Watch out for course announcements on

http://ilearn.ucr.edu

And Piazza

https://piazza.com/uconline/spring2018/cs_202_001_18s/home

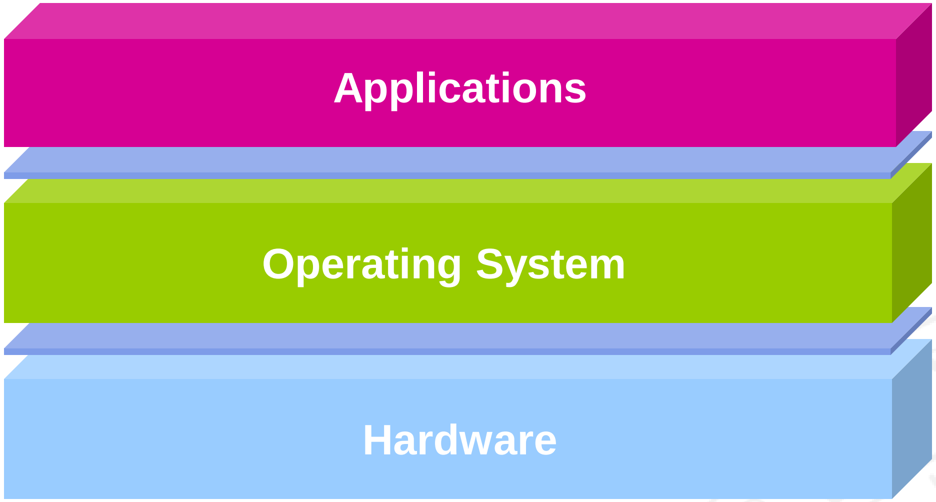
Situation

- We all have multiple applications running on our smart phone or computer
  - Written by programmers that don’t know each other
  - They all just magically work – how??
- Goal today: get you ready to discuss OS structure, our first topic

Computing Systems – a hierarchy of abstractions

- Computing systems are a series of abstractions
  - Impossible to think about a system from electrons to application in one shot
  - What are some abstraction layers we have from transistors to applications?
- This class: OS level abstractions

What is an OS?



- Directly has access to underlying hardware
- Hides hardware complexity
  - Offers nice abstractions to the applications through system calls
- Manage the hardware on behalf of one or more applications
- Ensures that applications are isolated and protected from each other

Getting more technical

- What is an OS?
  - A piece of software that *abstracts* and *arbitrates* a computing system
- A manager in a shop
  - Directs resources
    - Controls CPUs, memory, devices…
  - Enforces working policies
    - Fairness, resource limits, …
  - Simplifies complex tasks
    - Abstracts hardware; offers system calls

Abstraction and Arbitration

- OS offers abstractions and arbitration
- Example of arbitration?
  - Allocate memory or CPU time
  - Arbitrate access to a shared device
- Examples of abstractions?
  - Files, sockets, process, thread, …

Abstractions, mechanisms, policies

- Memory management example
- Abstraction: memory page
- Mechanisms: allocate, map to a process, deallocate
- Policies: page replacement, LRU, LFU, …

Design principles

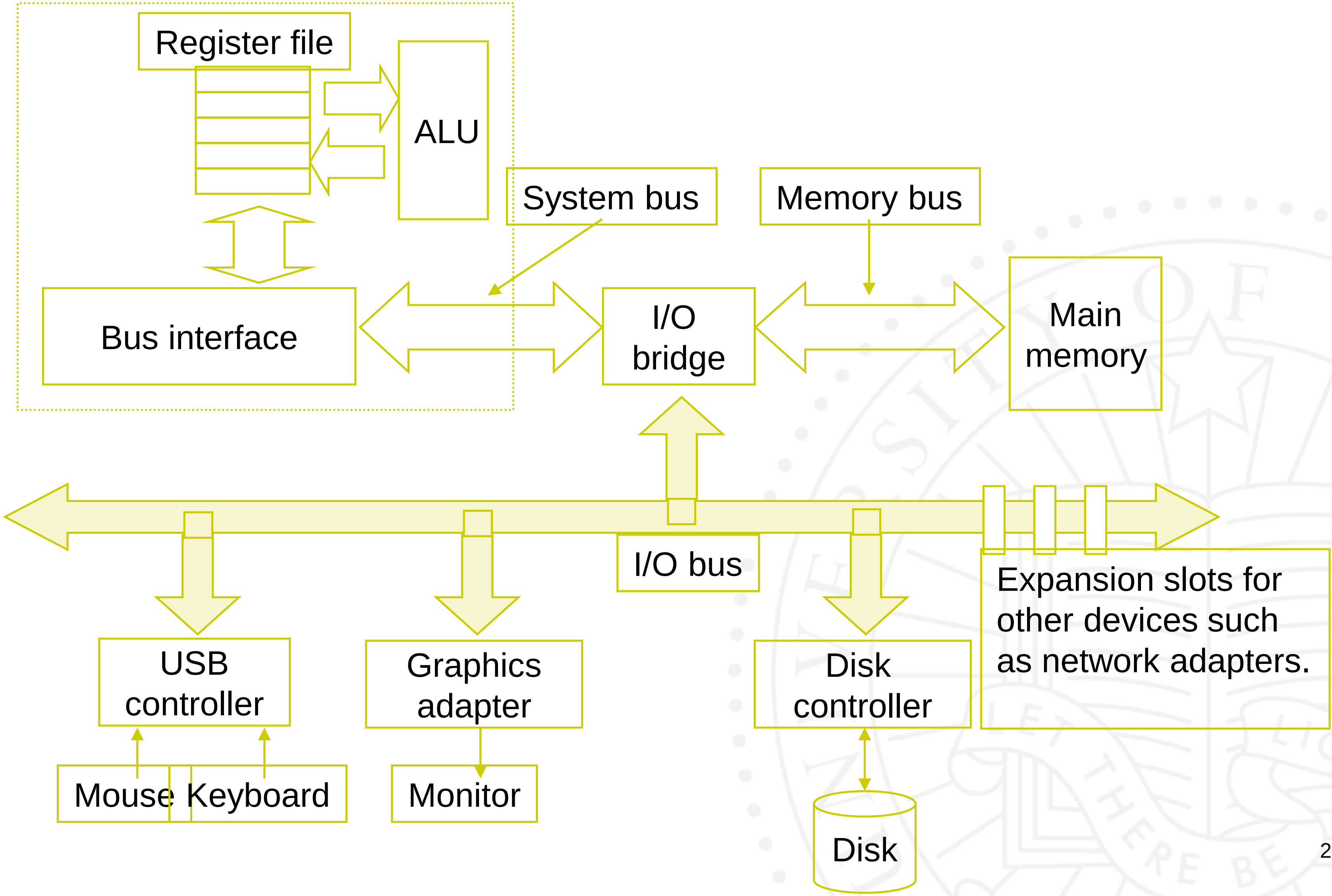
- Separation of mechanism and policy
  - Implement flexible mechanisms to support many policies

- Policies must optimize for the common case
  - Where will the OS be used?
  - What will the user want to execute?

Hardware and Resources

- Good understanding of the hardware is essential to understanding OS
- What hardware?
  - Smart phone/tablets?
  - Desktops?
  - Servers?
  - Computing clusters?
  - Cloud?
- How different are these?

They are not that different!



How does the OS interact with the hardware?

- OS
  - Has protected access to hardware resources
  - Arbitrates among competing requests
  - Receives and handles events from the hardware

What support does the hardware provide to allow that?

- Manipulating privileged machine state
  - Protected instructions
  - Manipulate device registers, TLB entries, etc.

- Generating and handling “events”
  - Interrupts, exceptions, system calls, etc.
  - Respond to external events
  - CPU requires software intervention to handle fault or trap

- Mechanisms to handle concurrency
  - Interrupts, atomic instructions

Catering to Applications

- Provide resource needs of an application
  - CPU, memory, device access
- When applications launch, the OS loads the program from file into memory
  - Allocates memory for code, data, heap and stack
  - Can the application ask for more resources?
    - Yes, it receives additional requests and provides resources as needed
- OS also reacts to events in the system
- Gets out of the way as fast as possible

CPU management

- Abstractions
  - Program: static entity
  - Process: program in execution
    - Unit of resource allocation and one thread of execution

Memory management

- Abstractions:
  - Address space for each processor

- OS implements these abstractions using the available hardware support
  - Paging, segmentation, TLBs, caches…

Storage/file system

- Abstraction: Files and directories
  - Others possible: e.g., object store
- Implemented in a variety of different ways
  - Traditional file system: mapping of files to storage
  - Network file system
  - Distributed FS
  - Internet scale FS

Conclusions

- Today was a quick overview of the role of an OS
- Goal is to get you ready to discuss OS organization and evolution, our first topic
  - First reading assignment out this evening.
- We did not discuss any implementation details
  - You should know from undergraduate OS
  - But please read on your own if you do not remember