CS 537: INTRO TO OPERATING SYSTEMS

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WHO AM I?

Professor Andrea Arpaci-Dusseau
PhD from U.C. Berkeley – Implicit Coscheduling of Parallel Jobs
Postdoc at Stanford – Taught OS course there

Teach CS 537, CS 736 (Adv OS), CS 739 (Dist Systems) and CS 402

Co-Advised about 25 PhD students, mostly research in file and storage systems

Co-Chair for 2018 OSDI Program Committee

2018 (w/ Remzi) - SIGOPS Mark Weiser award for "outstanding leadership, innovation, and impact in storage and computer systems research"

CALL ME

Prof. Andrea, Prof. Dusseau, or Andrea

TODAYS AGENDA

What will you do in this course?

What is an operating system and why do we need one?

Why study operating systems?

COURSE SYLLABUS

LEARNING OUTCOMES

- High-level understanding of an Operating System and role it plays
- Understand how OS virtualizes physical resources, abstractions the OS provides, and how abstractions efficiently implemented w/ current hardware
- Create correct multi-threaded applications using synchronization primitives
- Understand how OS ensures information persists despite power outages, crashes, and failures
- Implement open-ended programming projects (alone and w/ partner)
- Use existing system calls and add functionality to a simplified OS

ASSESSMENTS

Lecture Material (50%)

- Two midterms and a final exam
- Closed book, multiple choice
- Assess OS concepts discussed in class
- May have homeworks as part of this
- Form study groups of 5 or so; meet weekly to discuss lecture content

Projects (50%)

- Eight programming projects done on CS Linux labs
- Gain hands-on experience, Build your own OS system calls!

FORMAT

Lecture

Tue and Thu, 11:00-12:15

Location: 1125 BioChem

Conceptual content,
Shows Slides,

Reading matches textbook chapters

Discussion

5 “smaller” sections on Wednesday …

Hands-on code walk through (BYOL)

Explain programming projects

Led by TAs (and Peer Mentors)

PERSONNEL

Instructor: Andrea Arpaci-Dusseau

Teaching assistants:
Yifan Dai,
Abigail Matthews,
Vanshika Baoni,
Adarsh Mittal,
Apurbaa Bhattacharjee,
Akhil Guliani,
Akshaya Kalyanaraman

Peer mentors:
Anthony Barthell,
Siddhant Bhagat,
Taijing Chen,
Alan Gao,
Emma He,
Kieran Mulligan,
Shashwat Srivastava,
Sean Sun,
June Werner,
Jerry Yu,
Shawn Zhong,
Jerry Zou

20 course staff!

IMPORTANT LINKS

Course website
https://canvas.wisc.edu/courses/154998

Piazza
https://piazza.com/wisc/fall2019/fa19compsci537001/home

MATERIALS

Operating Systems: Three Easy Pieces

Remzi H. Arpaci-Dusseau and Andrea C. Arpaci-Dusseau

Blog: Why Textbooks Should Be Free

Quick: Free Book Chapters - Hardcover - Softcover (Lulu) - Softcover (Amazon) - Buy PDF - EU (Lulu) - Buy in India - Buy T-shirt - Donate - For Teachers - Homework - Projects - News - Acknowledgements - Other Books

COMING SOON: Computer Systems: Three Easy Steps --- ALSO COMING SOON: Distributed Systems: Three Easy Steps

Welcome to **Operating Systems: Three Easy Pieces** (now **version 1.00** -- see book news for details), a free online operating systems book! The book is centered around three conceptual pieces that are fundamental to operating systems: **virtualization, concurrency,** and **persistence.** In understanding the conceptual, you will also learn the practical, including how an operating system does things like schedule the CPU, manage memory, and store files persistently. Lots of fun stuff!

This book **is and will always be free** in PDF form, as seen below. For those of you wishing to **BUY** a copy, please consider the following:

- Lulu Hardcover (v1.00): this may be the best printed form of the book (it really looks pretty good), but it is also the most expensive way to obtain *the black book* of operating systems (a.k.a. *the comet book* or *the asteroid book* according to students). Now just: **$38.00**
- Lulu Softcover (v1.00): this way is pretty great too, if you like to read printed material but want to save a few bucks. Now just: **$22.00**
- Amazon Softcover (v1.00): Same book as softcover above, but printed through Amazon CreateSpace. Now just: **$27.50** (but works with Prime shipping)
- Downloadable PDF (v1.00): this is a nice convenience and adds things like a hyperlinked table of contents, index of terms, lists of hints, tips, systems advice, and a few other things not seen in the free version, all in one massive DRM-free PDF. Once purchased, you will always be able to get the latest version. Just: **$10.00**
- Kindle: Really, just the PDF and does not include all the bells and whistles common in e-pub books.

ACADEMIC INTEGRITY

It is OK to:

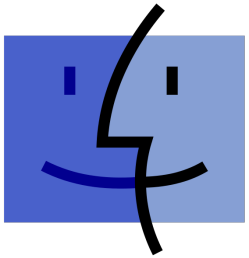
- discuss project or specification in general terms (when to return an error?)
- discuss how different library routines/system calls work
- ask peer mentors, TAs, and professor for help

It is NOT OK to:

- use code samples for similar problems you may find on-line
- bug someone else for a lot of help
- share your code directly with other people/project groups
- post your code in a public place

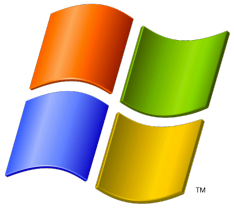
We will run tools to check for similar code across individuals

WHAT IS AN OPERATING SYSTEM ?



Mac OS

OS X Yosemite



Microsoft® Windows® xp

Users

Applications

Operating System

Hardware

Software that converts hardware into a useful form for applications

WHAT DOES OS PROVIDE: ROLE #1

Abstraction: Provide standard library for resources

What is a resource?

- Anything valuable (e.g., CPU, memory, disk)
- What abstraction does modern OS typically provide?
  - CPU: process and/or thread
  - Memory: address space
  - Disk: files

WHY SHOULD OS DO THIS ?

Advantages of OS providing abstraction?

- Allow applications to reuse common facilities
- Make different devices look the same
- Provide higher-level or more useful functionality

Challenges

- What are the correct abstractions?
- How much of hardware should be exposed?

WHAT DOES OS PROVIDE: ROLE #2

Resource management – Share resources well

What is sharing?

- Multiple users of the system
- Multiple applications run by same user
- Multiple devices for same functionality

WHY SHOULD OS DO THIS ?

Advantages of OS providing resource management?

- Protect applications at a common layer
- Provide efficient access to resources (cost, time, energy)
- Provide fair access to resources

Challenges

- What are the correct mechanisms?
- What are the correct policies?

OPERATING SYSTEM ROLES SUMMARY

Two main roles

- Abstraction
- Resource management

Common layer to implement roles

Number of design, implementation challenges

BREAK TIME?

- You form a unique community
- Get to know your classmates
- Introduce yourself to the **two** people around you
  - Your name
  - What year are you in school?
  - What other classes are you taking?
  - Have you already taken any that they are – if so, advice?

COURSE APPROACH

OPERATING SYSTEMS: THREE EASY PIECES

Three conceptual pieces

1. Virtualization

2. Concurrency

3. Persistence

VIRTUALIZATION

Make each application believe it has each resource to itself

Demo: Virtualize CPU and memory

CONCURRENCY

Events occur simultaneously and may interact with one another

Need to

- Hide concurrency from independent processes
- Manage concurrency with interacting processes

Provide abstractions (locks, semaphores, condition variables etc.)

Demo with threads

PERSISTENCE

Lifetime of data is longer than lifetime of any one process

Machine may lose power or crash unexpectedly

Issues:

- High-level abstractions: Files, directories (folders), links
- Correctness with unexpected failures
- Performance: disks are very slow!

ADVANCED TOPICS

Virtualization

Concurrency

Persistence

Advanced Topics

- SSDs
- Network and Distributed File Systems

WHY STUDY OS ?

Build, modify, or administer an operating system

Understand system performance

- Behavior of OS impacts entire machine
- Tune workload performance
- Apply knowledge across many layers

Fun and challenging to understand large, complex systems

WAITLIST

If you are on the waitlist, sign sheet showing you attended lecture today

NEXT STEPS

Check out Canvas pages and Register on Piazza

First programming assignment available now

- More details in discussion next Wednesday
- Due Monday 9/16
- Lab hours in CS instructional lab for help from TAs and Peer Mentors

Welcome to CS 537!