

Cornell University

Operating Systems

CS 4410

Fall 2023

Lorenzo Alvisi

[Agarwal, Alvisi, Bracy, Crooks, Schneider, Sirer, van Renesse]

Welcome!

- You belong here!
- We strive to make CS4410/CS4411 welcoming, inclusive, respectful, and supportive environments, consistent with Cornell's commitments

About me



search, dark

databases that

🕒 Founding Director of CMMRS

An outstanding team

- Aaron Biederman
- Miles Bramwit
- Charlie Brush
- Michael Carr
- Andrew Cheng
- Stephanie Ginting
- Cameron Goddard
- Willy Jiang
- CJ Lee
- Ian Lee
- Kate Liang
- Shenni Liang
- Ahmend Moustafa
- Zach Nelson

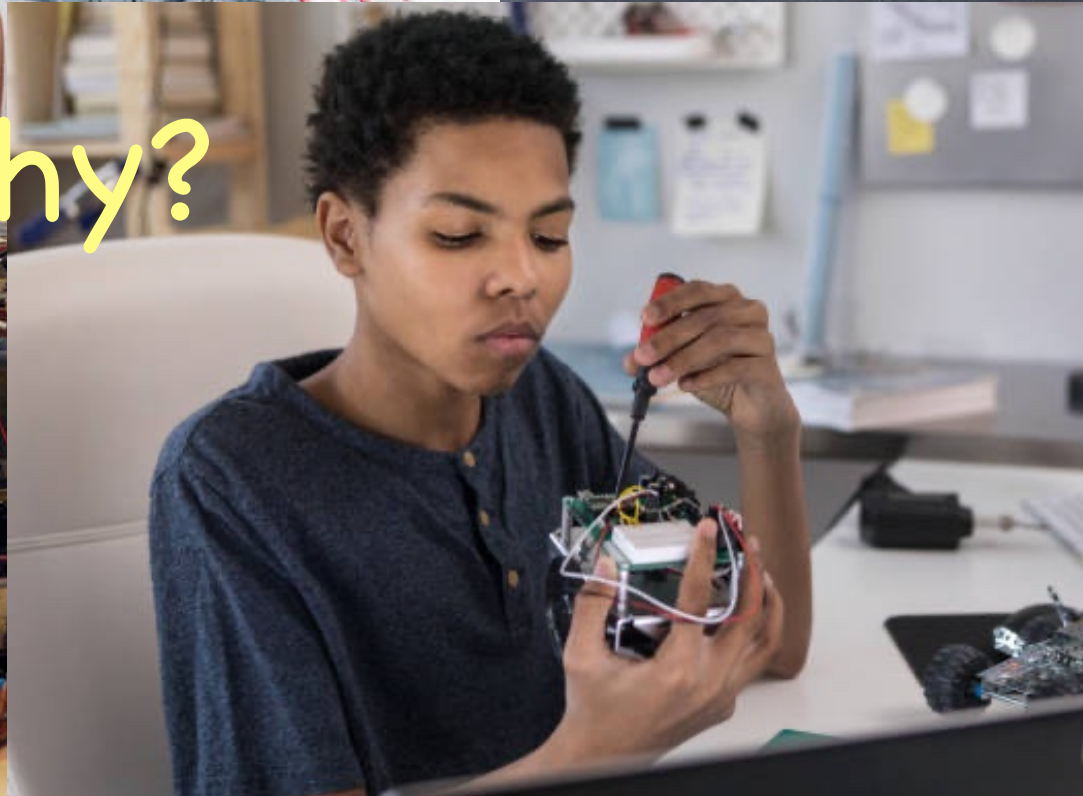
An outstanding team

- Chuhan Ouyang
- Noah Rebei
- Soorya Rethinasamy
- Benny Rubin
- Jorge Tapias Gomez
- Stephan Verderame
- Yifan Wang
- Rian Xu
- Cindy Zhang
- Emily Zhang
- Kevin Zhen

Operating Systems...



Why?



The OS is everywhere!!

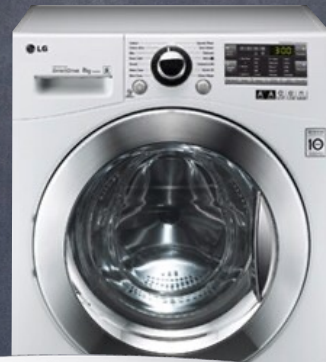
- Every **device**, from your smartwatch, your smart light bulb, to your mobile phone and laptop runs an operating system
- Every **program** you will ever write will run on an operating system
 - Its **performance** and **execution behavior** will depend on the operating system

You'll be a better software engineer!

Pollà ta deinà...

The OS is an
awesome
piece of software

Across a huge
variety of devices...

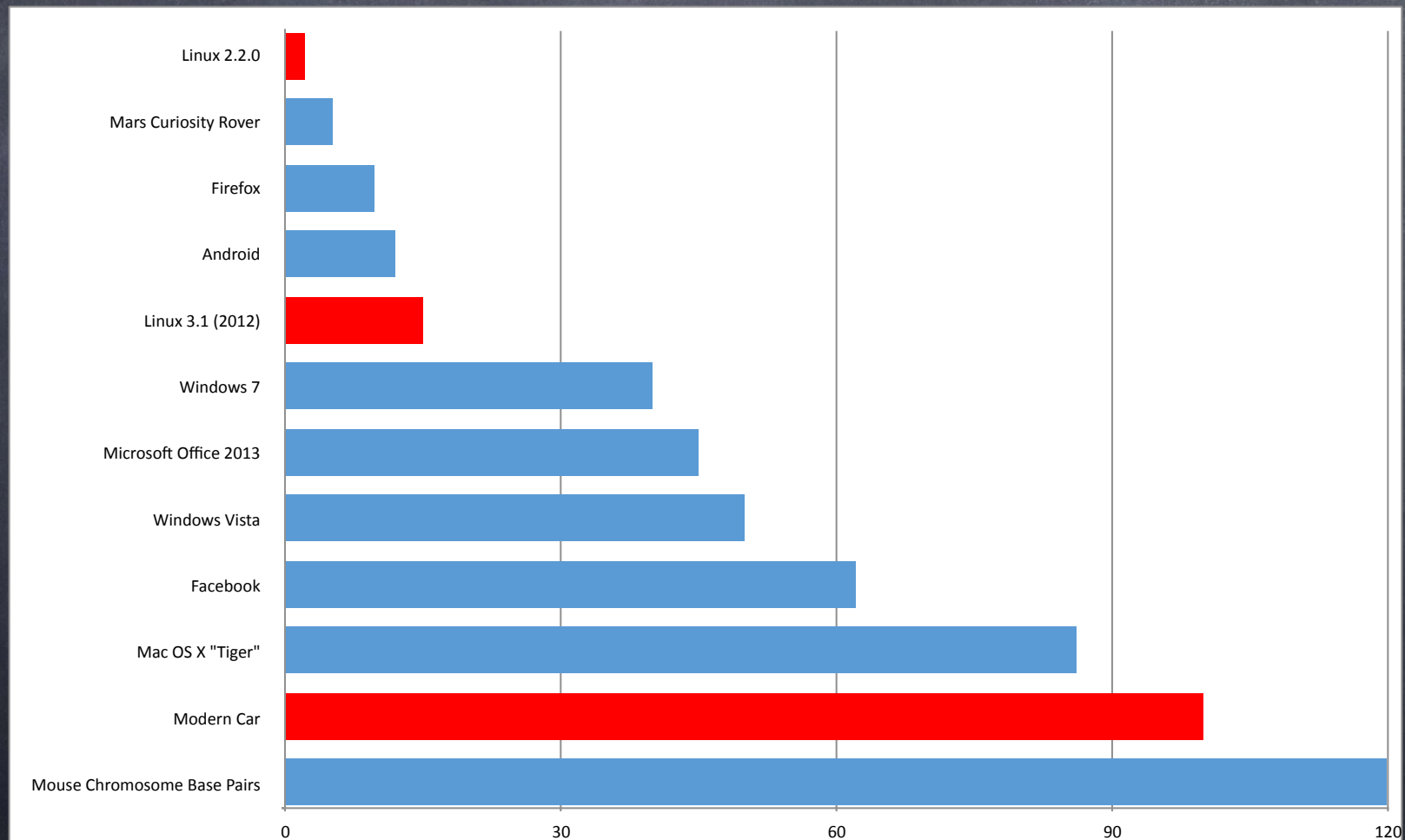


Across widely different timescales...

L1 cache reference	0.5 ns
Branch mispredict	5 ns
L2 cache reference	7 ns
Mutex lock/unlock	25 ns
Main memory reference	100 ns
Compress 1K bytes with Zippy	3,000 ns
Send 2K bytes over 1 Gbps network	20,000 ns
Read 1 MB sequentially from memory	250,000 ns
Round trip within same datacenter	500,000 ns
Disk seek	10,000,000 ns
Read 1 MB sequentially from disk	20,000,000 ns
Send packet CA -> Italy -> CA	150,000,000 ns

8 Orders of Magnitude!!!

...facing increasing complexity



Millions of lines of code

...but even if none of this were true...

...studying an OS teaches about developing

abstractions

expressive

performant

simple to use and implement

an art that is **at the core of** what defines
a computer scientist



**RESERVED
FOR
ADMINISTRATION**

- Who is who
- Before you take this class..
- Communication
 - Lectures, OHs, FAQ, etc.
 - Getting help
- Homework, Exams
- Grades and Policies

Prerequisites

- CS 3410, CS 3420 or equivalent
- Otherwise (or if in doubt):
 - Come and talk to me, explain your situation and request permission

Course Content

- Four Components

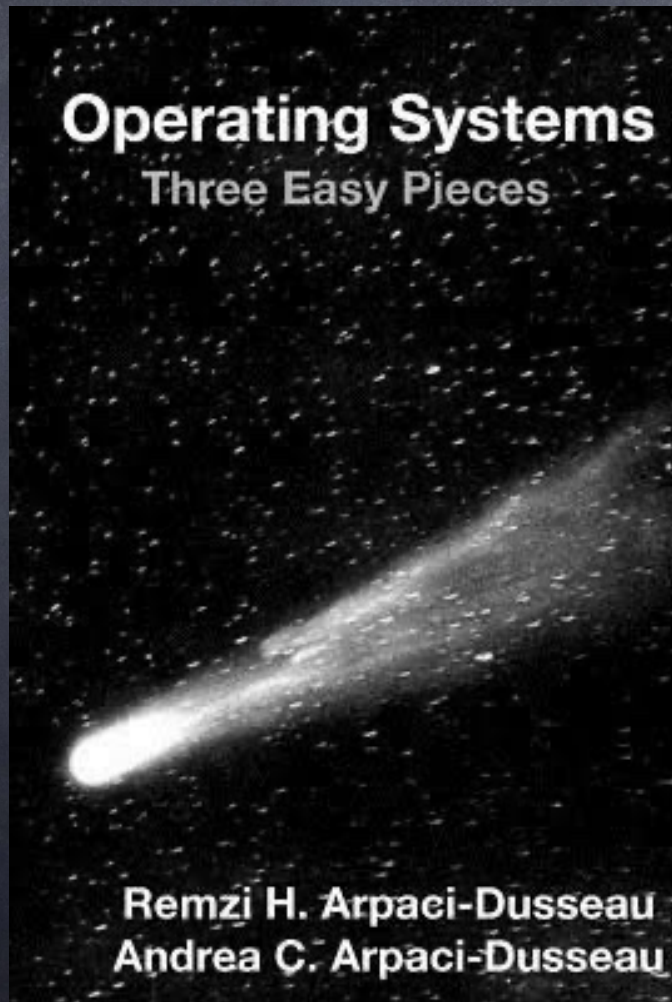
- Lectures
- Readings
- Assignments
- Exams

- You are expected to keep up with all four

Draft Syllabus

- ① Introduction
- ① Architectural Support for OSs
- ① Processes and Threads
- ① Synchronization
- ① Scheduling
- ① Memory Management
- ① Storage systems
- ① File systems
- ① Security (if time allows)

Textbooks



- Free online
- Can buy PDF or printed copy

Textbooks

Concurrent
Programming
with Harmony

Robbert van Renesse
Cornell University

- Free online
- Free pdf download, or read online

A white rectangular sign with rounded corners and a thick green border. The sign has two small grey dots at the top and bottom center, suggesting it's a hanging sign. The text on the sign is in a bold, green, sans-serif font, arranged in three lines: 'RESERVED' at the top, 'FOR' in the middle, and 'ADMINISTRATION' at the bottom.

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Communications

- ◉ Web page
- ◉ Lectures
- ◉ Recitation
- ◉ Ed Discussion
- ◉ Office Hours
- ◉ Gradescope
- ◉ CMSX

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Course Web Page

<https://www.cs.cornell.edu/courses/cs4410/>

- Schedule, exam & due dates
- Homework release and due dates
- Slides posted before each lecture

CMSX & Gradescope

- CMSX: <https://cmsx.cs.cornell.edu>
- Gradescope: accessible through Canvas
 - Assignments
 - Grades & Regrades

Office Hours

- In flux... but we should have great coverage

Ed Discussion

- Ask anything you want, but do not share code unless posted privately for the course staff
- May be anonymous to other students, not to the staff
- Help one another
 - Each student should feel safe, welcome, respected
 - Respect diverse talents and ways of learning

Email

- cs4410-staff@cornell.edu: time sensitive matters
 - Goes to Lorenzo and TAs
- cs4410-prof@cornell.edu: sensitive matters
 - Goes to Lorenzo only

Non technical help

Engineering Advising	www.engineering.cornell.edu/resources/advising	Academic advising for engineering students
Arts College Student	as.cornell.edu/advising	Listing of general support services for a variety of concerns
Cornell Health	www.health.cornell.edu	Cornell University Health Service
CAPS	health.cornell.edu/services/mental-health-care	If you experience emotional stress, contact Counseling and Psychological services
Student Disability Services	sds.cornell.edu	Ensures that all aspects of student life are accessible, equitable, and inclusive of those with disabilities. Send accommodation letters to Ms. Coralia Torres (ct635), by Feb. 23.

Get help. Get documentation. The earlier, the better

And look out for each other!



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Exams

- 2 prelims, 1 final
 - best 2 out of 3
- Dates:
 - September 28
 - **November 21** (Yikes!)
- Questions will cover lectures, books, homework
- Regrade requests due within a week

Homework

- ◉ Available on Gradescope
 - Fully auto-graded (no TAs involved)
- ◉ Problems designed to help you prepare for the exam
 - worth a lot in terms of prep
 - not worth much in terms of credit
 - ▶ 6%, all homework combined
 - do them for the practice, not the credit
 - do them on your own
 - regrade requests due within a week

Programming Assignments

- Three different concurrent programming assignments
- Work in groups of 2 or 3 students, or do it by yourself if you prefer

Group Code of Conduct

- Each student should feel safe, welcome, respected
- Participate, but don't dominate
- Be patient
- Respect diverse talents and ways of learning
- Fight your implicit biases

Academic Integrity and Honor Code

All submitted work must be your own

- ❑ OK to discuss concepts with any other student
- ❑ Students in the same group can submit the same code
- ❑ Different groups are not allowed to share code

Violations will be prosecuted

Academic Integrity

- Why not cheat?

It is a
betrayal of trust

and you are better than that!

If you need help, get it early!



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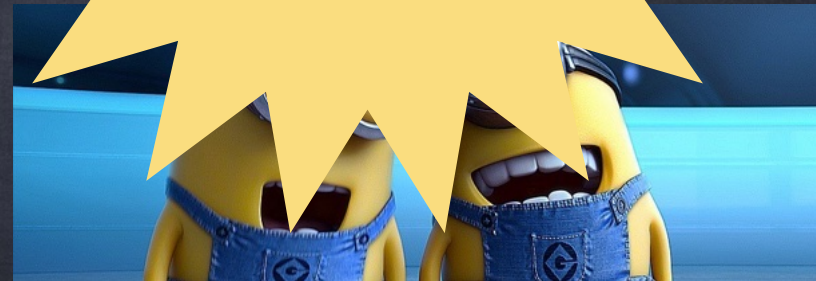
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Practicum: CS4411

- CS4410 assignments are “small”
- In CS4411, you’re going to have hands-on C development experience with an almost-real operating system: EGOS
 - Write a queue
 - Write a threading package
 - Write a scheduler
 - Write a file system cache
 - Write a file system
- Teams of 2/3 programmers

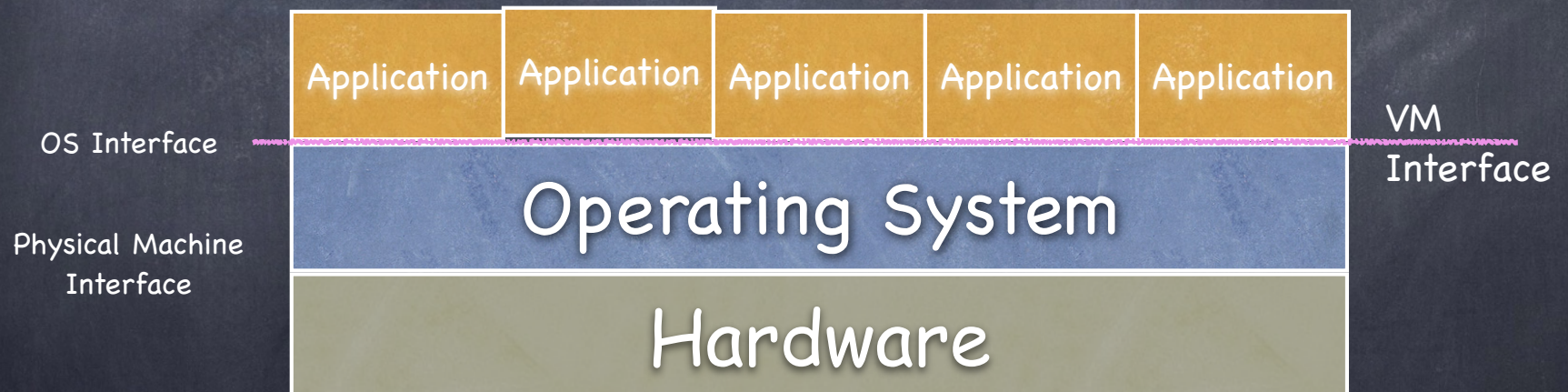


Lots
of fun!



What is an OS?

- An Operating System implements a virtual machine whose interface is **more convenient*** that the raw hardware interface



* easier to use, simpler to code, more reliable, more secure...

We study a system

What is a system?

"A complex unit formed of many often diverse parts subject to a common plan or serving a common purpose"

Webster Third New International Dictionary

What is a system?

interconnections

components

"A complex unit formed of ~~many often~~ ~~diverse parts~~ subject to a common plan or serving a common purpose"

a certain behavior
at the interface
with an environment

Webster Third New International Dictionary

"A set of interconnected components
with an expected behavior observed at
the interface with its environment"

Common systems challenges

- Emergent properties
- Propagation of effects
- Incommensurate scaling
- Trade-offs

Emergent Properties

Evident only when components are combined

Emergent Properties

Millenium Bridge London




Emergent Properties

Millenium Bridge London



Emergent Properties

Millenium Bridge London



The bridge's movements were caused by a **positive feedback** phenomenon, known as ***synchronous lateral excitation***. The natural sway motion of people walking caused small sideways **oscillations** in the bridge, which in turn caused people on the bridge to sway in step, increasing the **amplitude** of the bridge oscillations and continually reinforcing the effect;^{[7][8]} the maximum sway was around 70mm.^[9]