



Welcome to COMP 530

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Welcome!

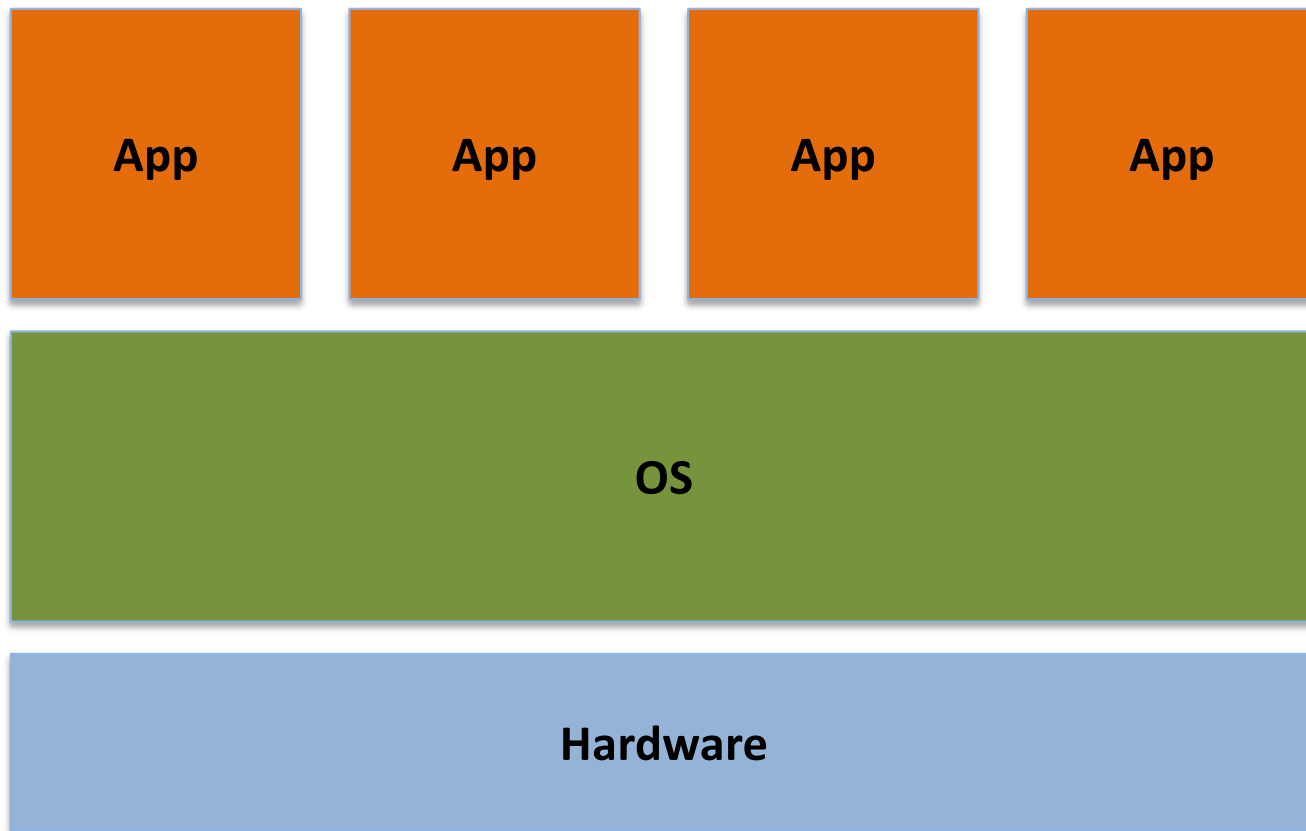
- Today's goals:
 - Give you a flavor of my teaching style with a mini-lecture
 - Cover course organization
- My high-level goals for the class:
 - Demystify how computers work (No magic)
 - Learn core principles: secure multiplexing, scheduling, concurrency, performance analysis
 - This is a class for everyone, not just gurus
 - **Challenging, but supportive, environment**



So what is an OS?

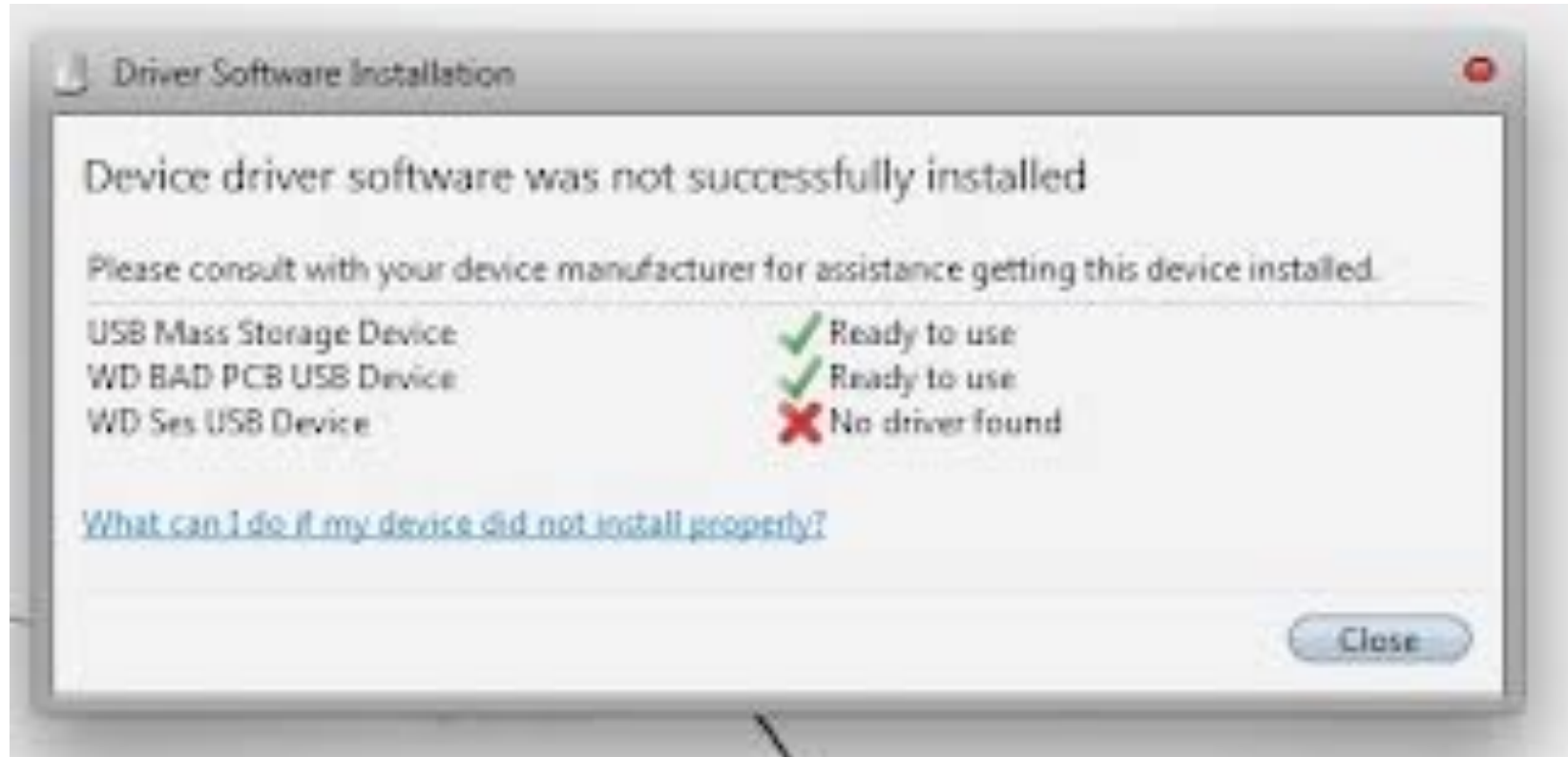


Another simple view of an OS





A less happy view of an OS





So which one is right?

- They all are



An OS serves three constituencies

1. Human users: a desktop environment
2. Application Developers: More usable abstractions of the hardware
3. Hardware manufacturers: An abstraction of the applications to the device



Why Study Operating Systems?

- Primary Goal: Demystify how computers work
 - Lots of abstractions and heuristics between your application and the hardware
 - A good computer scientist should understand what happens inside the system when one types a command
- Secondary: Learn how to write robust programs
 - OSes like Linux have many users and work on a wide range of hardware
 - Deal with subtle issues: concurrency, consistency, etc.

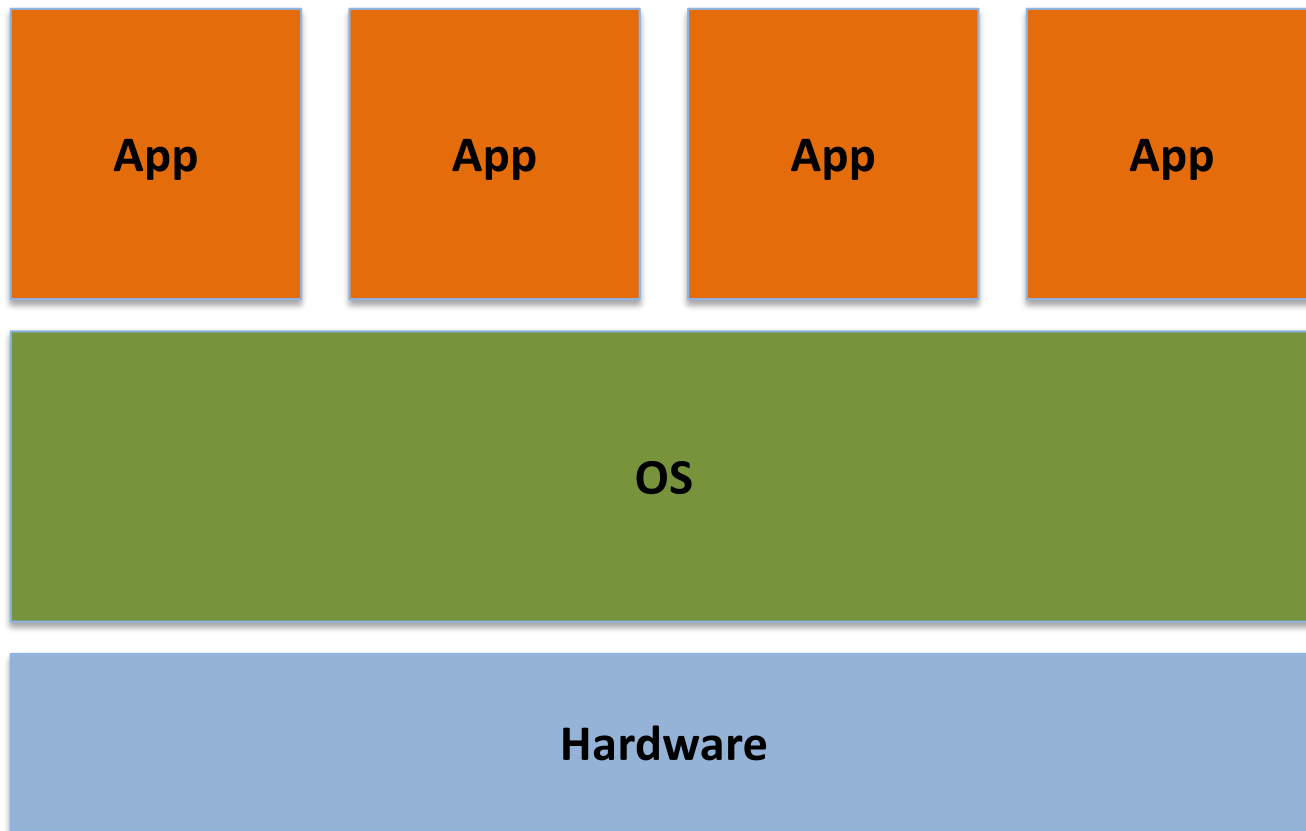


Background (1)

- CPUs have 2 modes: user and supervisor
 - Sometimes more, but whatevs
- Supervisor mode:
 - Issue commands to hardware devices
 - Power off, Reboot, Suspend
 - Launch missiles, Do awesome stuff
- User mode:
 - Run other code, hardware tattles if you try anything reserved for the supervisor

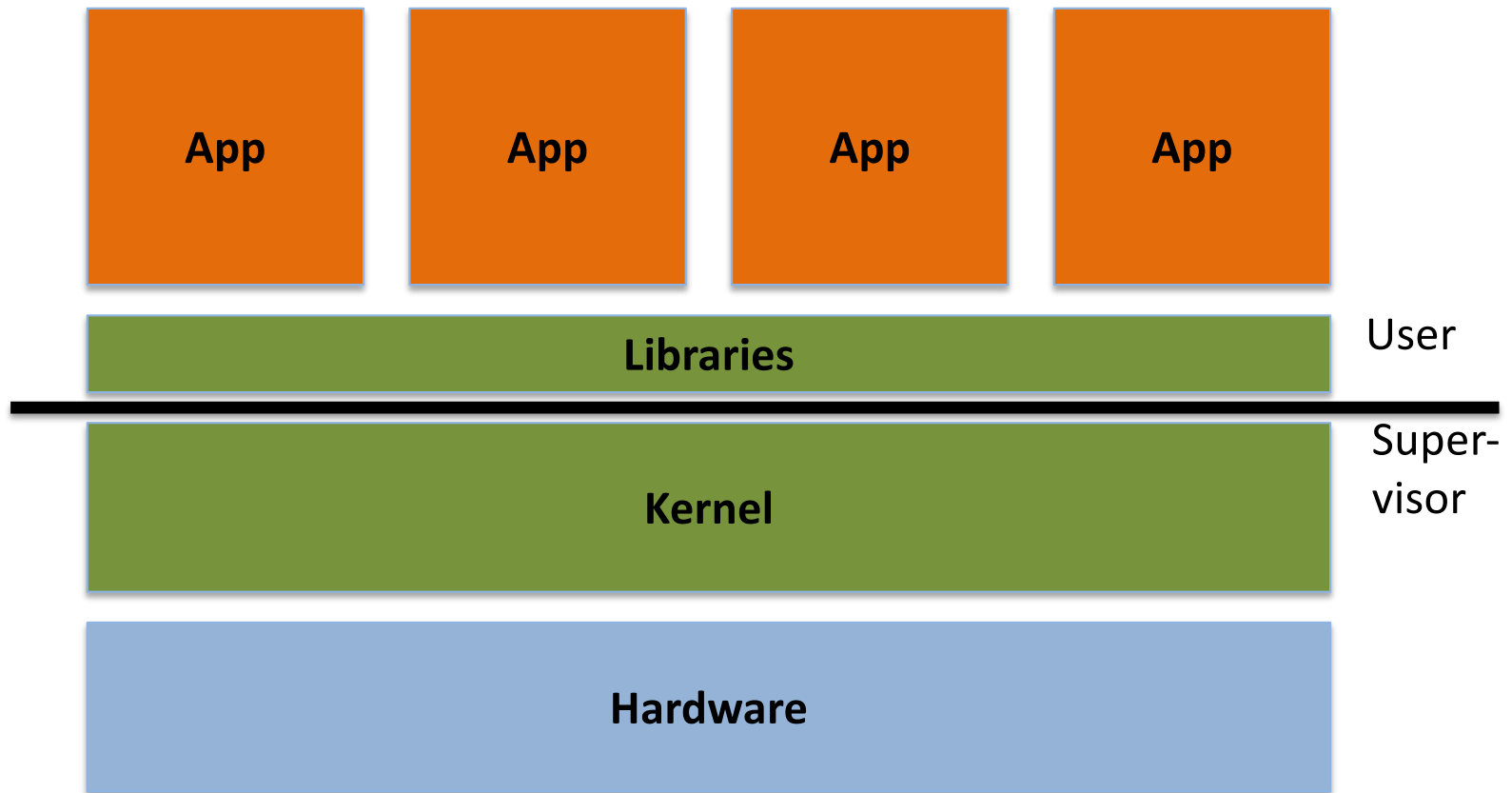


OS architecture





OS architecture



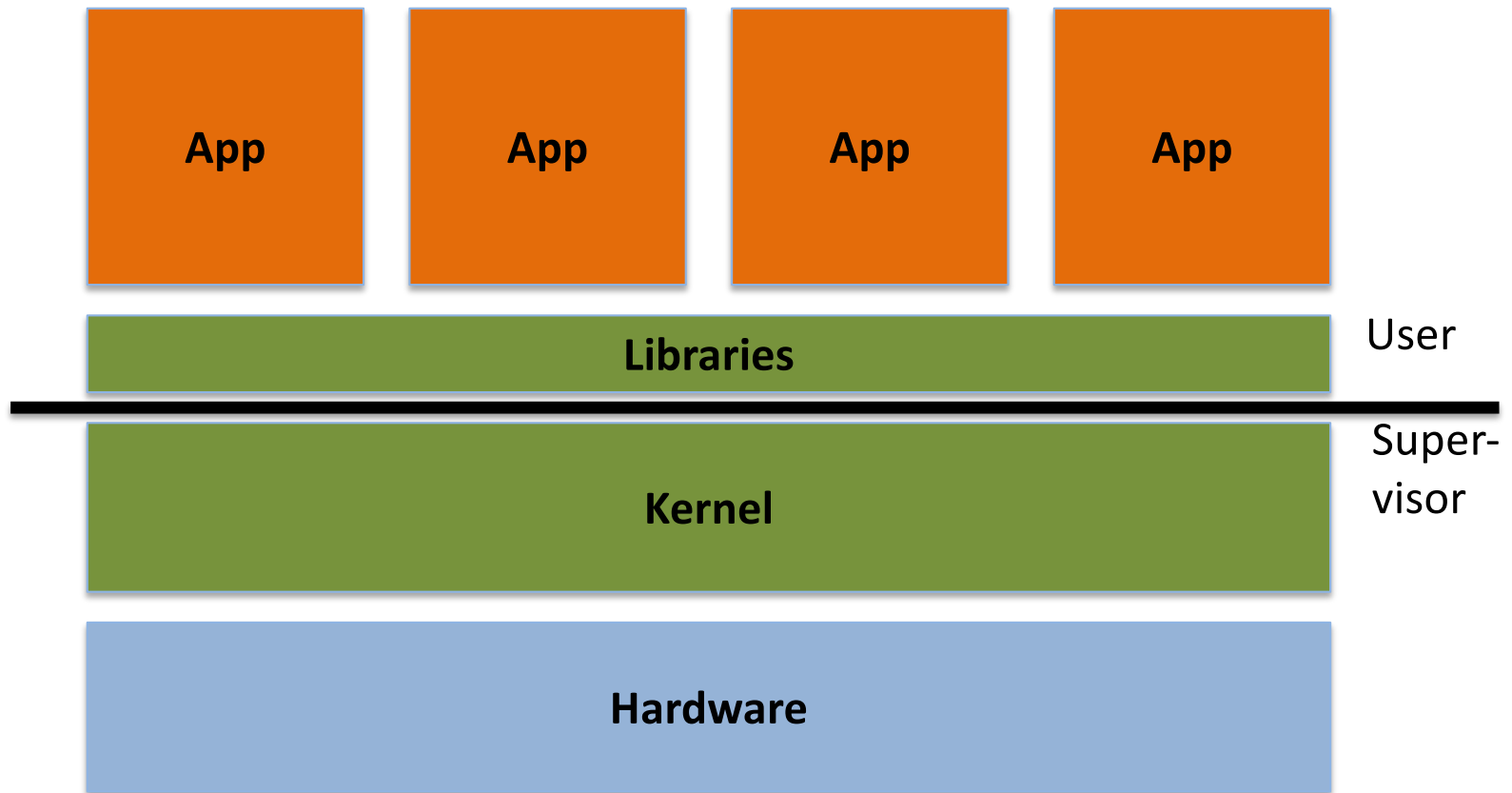


User #2: Applications

- Application Programming Interface (API)
 - Win32 (Windows)
 - POSIX (Unix/Linux)
 - Cocoa/Cocoa Touch (Mac OS/iOS)
- Application-facing functions provided by libraries
 - Injected by the OS into each application

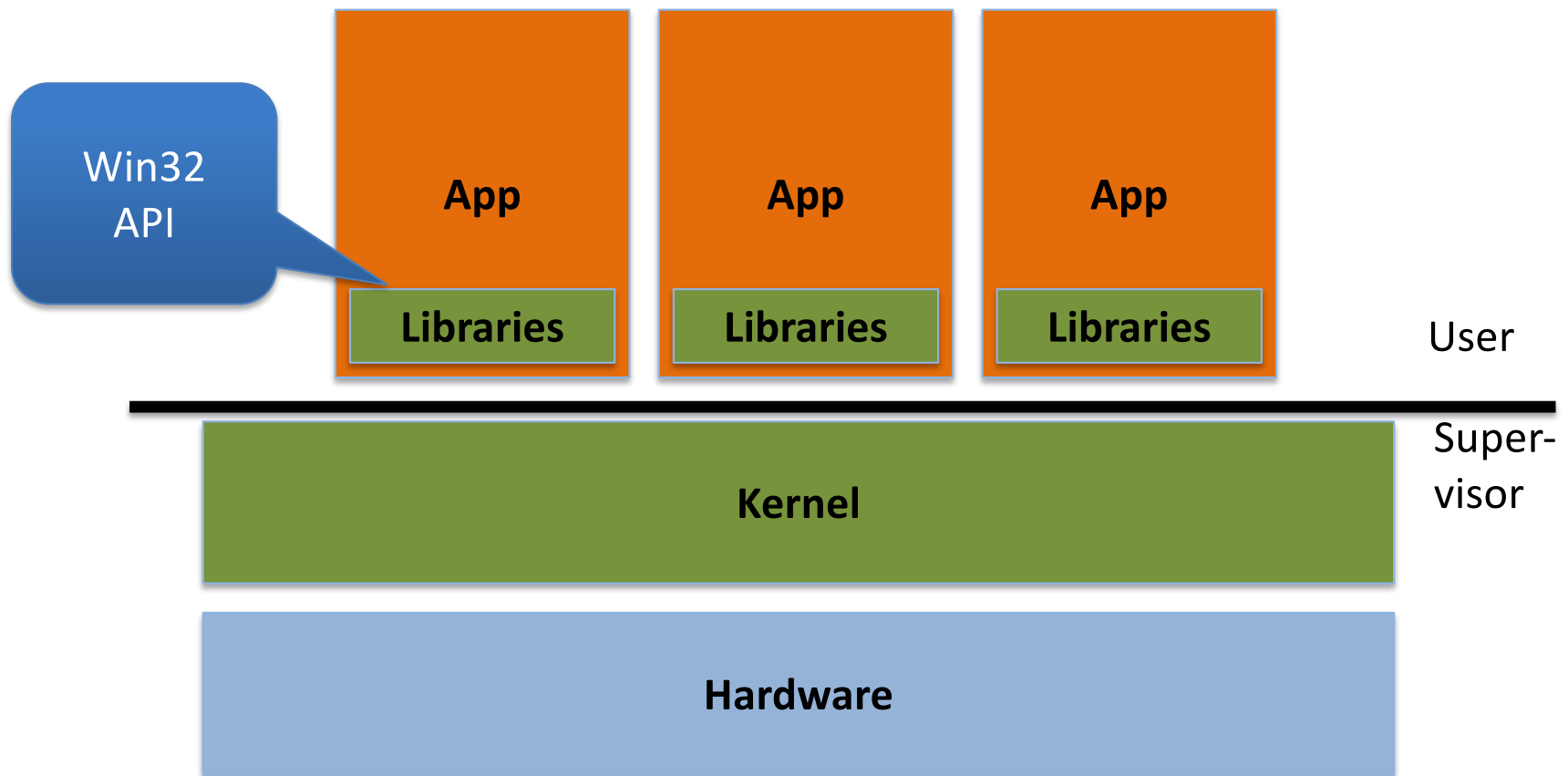


OS architecture





OS architecture





Famous libraries, anyone?

- Windows: ntdll.dll, kernel32.dll, user32.dll, gdi32.dll
- Linux/Unix: libc.so, ld.so, libpthread.so, libm.so



Caveat 1

- Libraries include a lot of code for common functions
 - Why bother reimplementing `sqrt`?
- They also give high-level abstractions of hardware
 - Files, printer, dancing Homer Simpson USB doll
- How does this work?

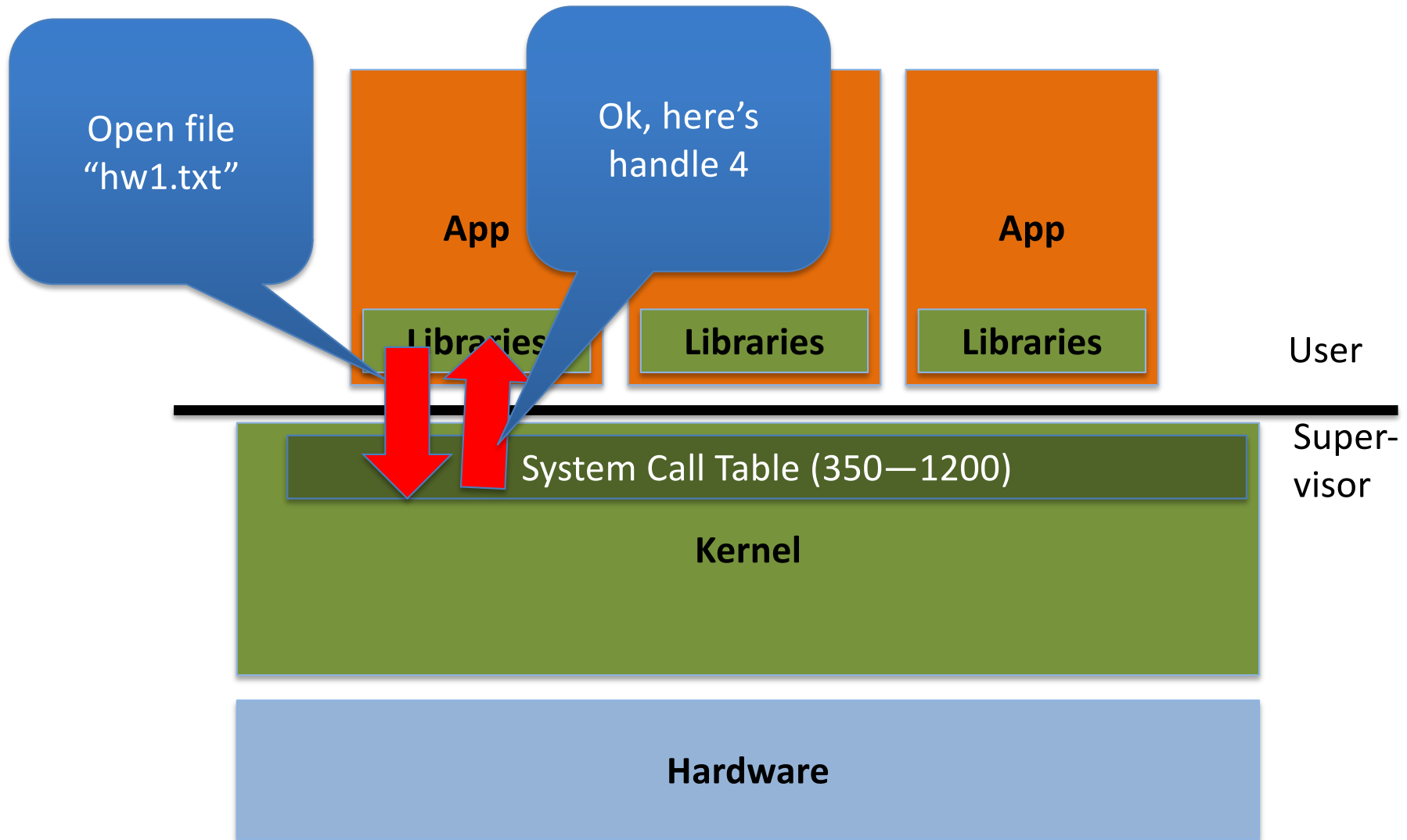


System Call

- Special instruction to switch from user to supervisor mode
- Transfers CPU control to the kernel
 - One of a small-ish number of well-defined functions
- How many system calls does Windows or Linux have?
 - Windows ~1200
 - Linux ~350



OS architecture



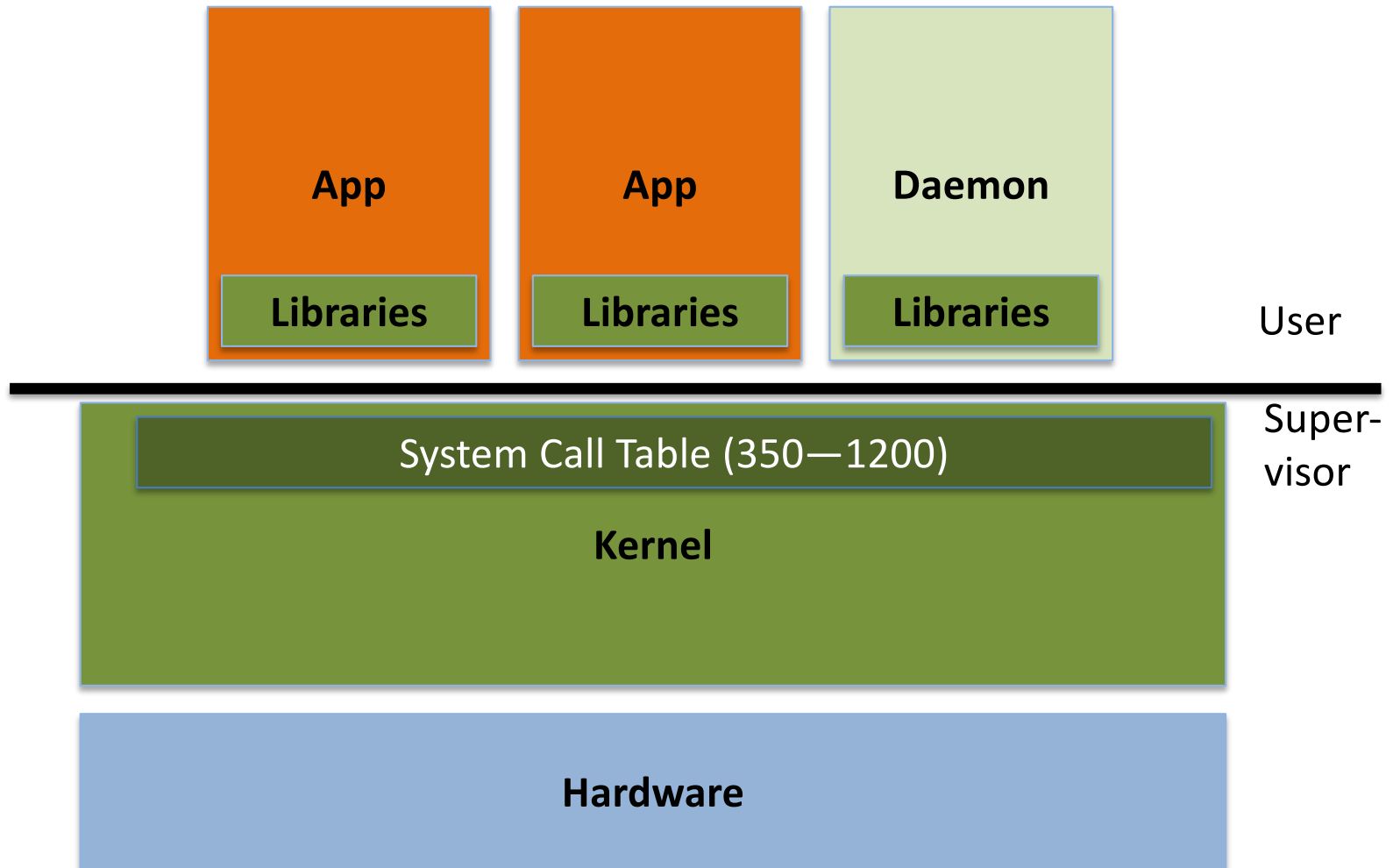


Caveat 2

- Some libraries also call special apps provided by the OS, called a ***daemon (or service)***
 - Communicate through kernel-provided API
- Example: Print spooler
 - App sends pdf to spooler
 - Spooler checks quotas, etc.
 - Turns pdf into printer-specific format
 - Sends reformatted document to device via OS kernel



OS architecture



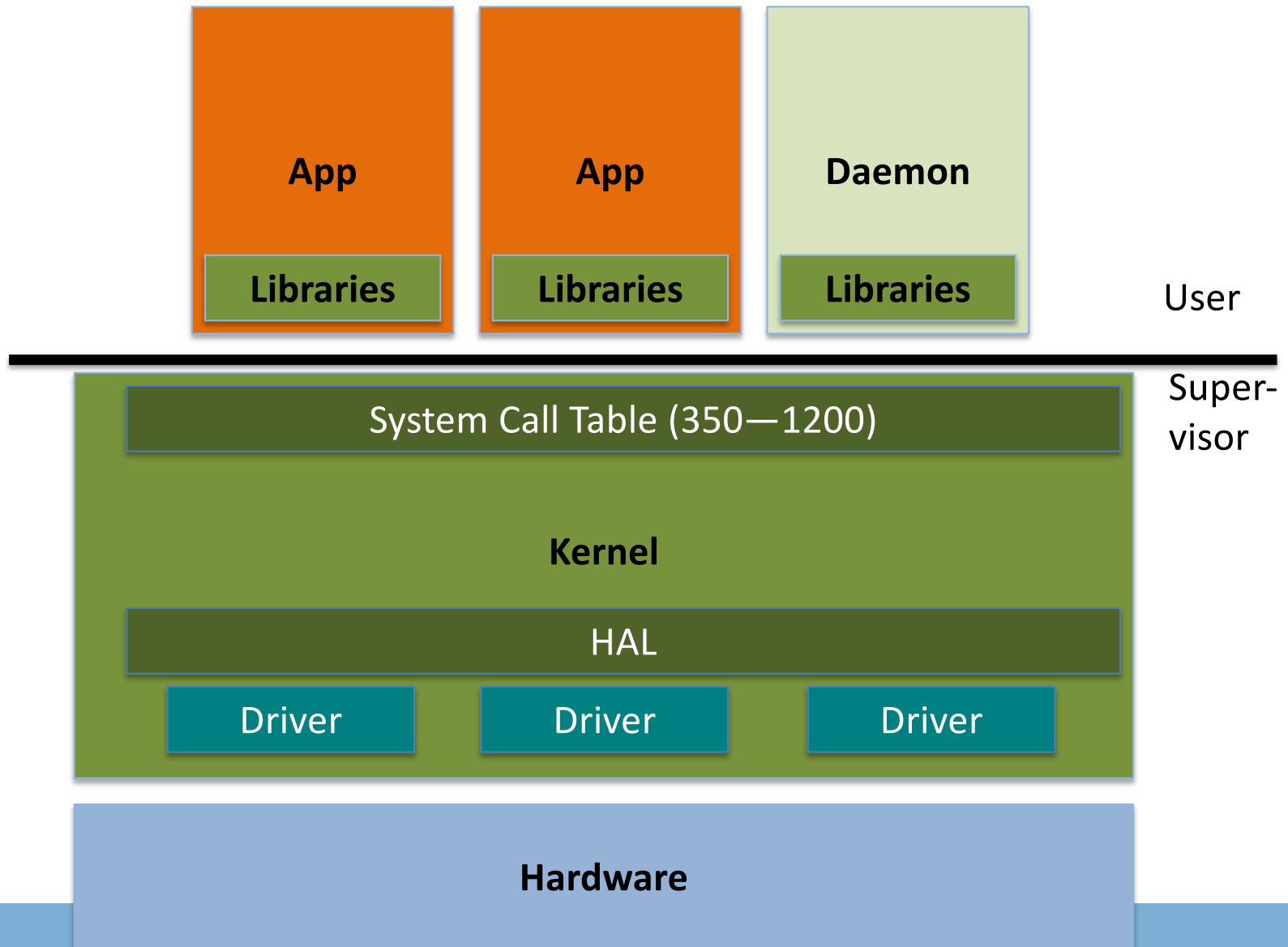


User 3: Hardware

- OS kernels are programmed at a higher low level of abstraction
 - Disk blocks vs. specific types of disks
- For most types of hardware, the kernel has a “lowest common denominator” interface
 - E.g., Disks, video cards, network cards, keyboard
 - Think Java abstract class
 - Sometimes called a hardware abstraction layer (HAL)
- Each specific device (Nvidia GeForce 600) needs to implement the abstract class
 - Each implementation is called a **device driver**



OS architecture





What about User 1

- What is the desktop?
- Really just a special daemon that interacts closely with keyboard, mouse, and display drivers
 - Launches programs when you double click, etc.
 - Some program libraries call desktop daemon to render content, etc.



An OS serves three types of users

1. Give users a desktop environment
 - Desktop, or window manager, or GUI
2. Give applications a more usable abstraction of the hardware
 - Libraries (+ system calls and daemons)
3. Give hardware manufacturers an abstraction of the applications
 - Device Driver API (or HAL)



Multiplexing Resources

- Many applications may need to share the hardware
- Different strategies based on the device:
 - Time sharing: CPUs, disk arm
 - Each app gets the resource for a while and passes it on
 - Space sharing: RAM, disk space
 - Each app gets part of the resource all the time
 - Exclusive use: mouse, keyboard, video card
 - One app has exclusive use for an indefinite period



So what is Linux?

- Really just an OS kernel
 - Including lots of device drivers
- Conflated with environment consisting of:
 - Linux kernel
 - Gnu libc
 - X window manager daemon
 - CUPS printer manager
 - Etc.



So what is Ubuntu? Centos?

- A **distribution**: bundles all of that stuff together
 - Pick versions that are tested to work together
 - Usually also includes a software update system



OSX vs iOS?

- Same basic kernel (a few different compile options)
- Different window manager and libraries



What is Unix?

- A very old OS (1970s), innovative, still in use
- Innovations:
 - Kernel written in C (first one not in assembly)
 - Co-designed C language with Unix
 - Several nice API abstractions
 - Fork, pipes, everything a file
- Several implementations: *BSDs, Solaris, etc.
 - Linux is a Unix-like kernel



What is POSIX?

- A standard for Unix compatibility
- Even Windows is POSIX compliant!



Administrative

- Syllabus, schedule, homework, etc. posted on course website
- www.cs.unc.edu/~porter/courses/comp530/f23



Prerequisites

- COMP 210 – Data Structures
 - Or 410 in the old numbering
- COMP 311 – Computer Organization
 - Or 411 in the old numbering
- **The background courses are necessary**
- In some cases, industry experience is ok
- C programming
- Basic Unix command-line proficiency



C Programming

- You should have learned C in the prerequisite courses
 - Ok if you are not a C guru (you will be)
- A very good resource is “The C Programming Language” by Kernighan and Ritchie
 - **Digital version on canvas, under course reserves**
 - Relatively short, and lots of useful exercises
- If you find yourself struggling with C, consider adding some work from this book to be able to complete this course on schedule



Labs: Learn by doing

- This course is **coding intensive**
 - You should know C, or be prepared to remediate quickly
 - You must learn on your own/with lab partners
- You will write several user-level utilities that exercise OS functionality
 - Challenging work, but a very marketable skill



Group Policy

- You may do assignments alone, or in teams of up to 3
- **You must list all teammates in code**
- **Caveat: All teammates must understand code**
 - I reserve right to ask you about the code; if you can't explain it to my satisfaction, you will lose points
 - Also, there may be exam questions on programming assignments
- You may change groups on each assignment
 - Except Labs 1 and 2, where Lab 2 builds on Lab 1
 - Changes still possible with instructor permission



Productive Frustration

- One of the “meta skills” that distinguishes an excellent programmer is the ability to get un-stuck
 - Fixing a “heisenbug” has this property
- How do you learn this skill?
 - Get stuck on a hard, but solvable problem
 - Learn which strategies will get you moving again
- If you take a quick cheat, you won’t learn the skills to solve truly hard problems



Academic Integrity

- I take cheating very seriously. It can end your career.
 - I check, and report to Honor Court
- In a gray area, it is your job to stay on right side of line
- Never show your code to anyone except your team and course staff
- Never look at anyone else's code (incl. other universities or past sections)
- Do not discuss code; do not debug each other's code
- Acknowledge students that give you good ideas
 - Note liberal group and lateness policies



Why do we care?

- Analogy: This is the programming dojo
 - If you don't do your exercises, you will be unprepared for battle
 - You've wasted your money and both of our time
 - It brings dishonor on the dojo when you lose every battle
- Similarly, a lot of what I teach (and what will make you a valuable employee when you graduate) has no short cut
 - How do you learn to punch through a board?
 - You punch a board over and over until your fist goes through it



Integrity Homework

- Exercises applying course policies and ethics to several situations
- Due by midnight on Weds 8/30, in gradescope
- Note: no other assignments will be graded for you until this is completed



Lateness

- Each student gets 72 late hours for programming hw
 - List how many you use in slack.txt
 - Each day after these are gone costs a full letter grade on the assignment
 - If you work in a team, each member loses 1 hour for each hour late
- It is your responsibility to use these to manage:
 - Holidays, weddings, research deadlines, conference travel, new season drops, release of the next Zelda game, etc.
- 3 Exceptions: illness (need doctor's note), death in immediate family, accommodation for disability



Lateness, continued

- Maximum lateness penalty is a 'D' on the assignment
- Anything may be turned in up until LDOC for up to 60% credit
 - Challenge problems may be turned in up until LDOC
- After midnight on LDOC, remaining late hours may be used, but no other late submissions will be accepted
- Resubmissions are allowed, including late ones
 - We will just grade (and penalize if late) the most recent submission



Challenge Problems

- Each lab may include challenge problems, which you may complete for bonus points (generally 5—10 points out of 100)
 - Unwise to turn in a lab late to do challenge problems
 - Can complete challenge problems at any point in the semester---even on old labs
- Indicate any challenge problems completed in challenge.txt file



Lectures

- Discuss and supplement reading material
- An important chance to clarify issues
 - Questions are encouraged!
- I expect you to arrive prepared to answer and ask questions about the reading material
- Everything in lectures may appear on the exams, even if not in the book
- I need you here: Digressions are common to fill in “gaps” and to integrate material from other classes



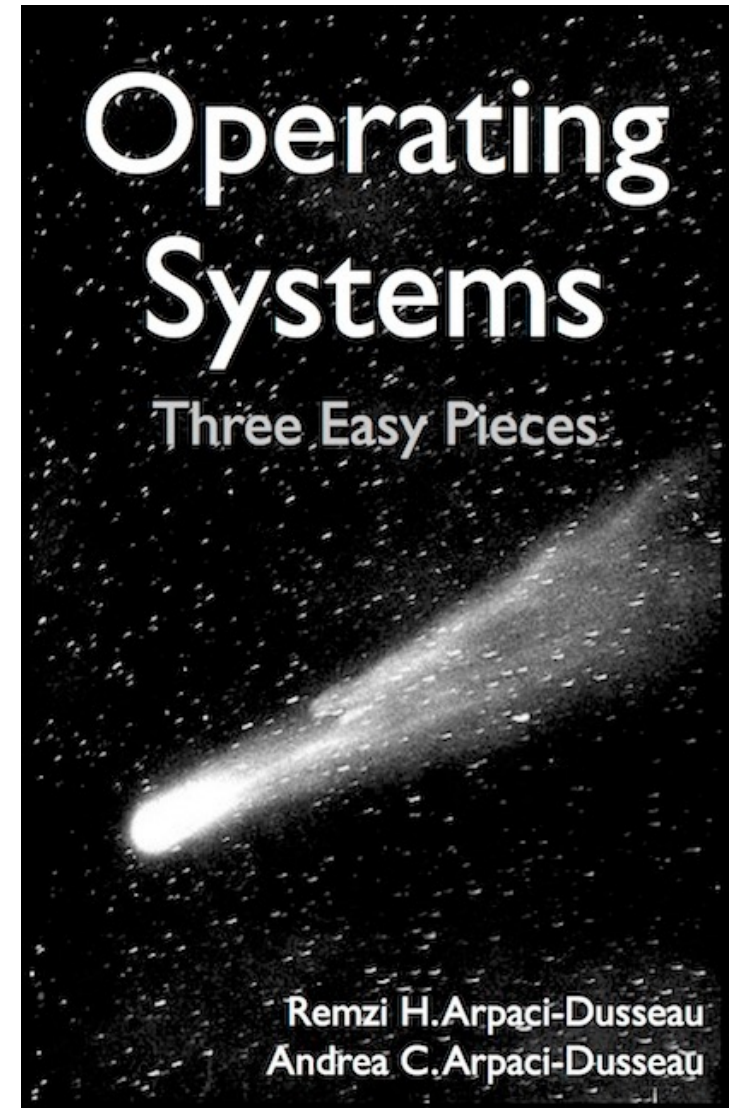
Recordings

- I usually record lectures for students to review later
 - I will share on Panopto/sakai
 - I hope automatically, each new classroom is a mini-adventure
 - All students in the course should be given access via your ONYEN
- Recordings are **best effort**
 - Recordings may fail, be unwatchable, or get deleted by accident
 - Or be discontinued if too many students stop attending
 - I need your facial expressions and questions to know if lectures make sense
- Do not use this as a substitute for class attendance



Textbook

- Free online at:
<http://pages.cs.wisc.edu/~remzi/OSTEP/>
- You can buy a hard-copy or ebook format online if you want
- Other optional references, definitely not required





Readings

- My lectures aren't perfect; some concepts are subtle
 - Reading other words can be helpful for reinforcement and clarification
- You will learn more in class if you read before class
 - Can't ask the textbook questions
- A few papers will be posted and discussed; these you should read before class



Course email list

- We will use campuswire this semester. Link and enrollment code on course sakai site
- Will help scale up to a large class
- This is the primary announcement medium
- And for discussions about course work
 - Do not post code here or other solutions
 - Goal: Everyone can learn from general questions
- Material discussed on the mailing list can be an exam question



Worksheets

- You will get worksheets throughout the semester
 - And randomly assigned teams
- These will not be graded, except for participation
- But are valuable practice for the exams

- Do not save these until right before the exam
 - A lot of work
 - The material is cumulative



Other administrative notes

- Read syllabus completely
- Subscribe to the class campuswire forum
- 3 exams cover: lectures, labs, mailing list
- All staff email goes to comp530ta@cs.unc.edu
 - Except private issues for instructor only



Special Offer!

- You can write your own exam questions
 - Send them to me in advance of the test, if I like them, I will use them
 - Do NOT share with anyone else



Getting help

- TA's will keep office hours
 - See course calendar for times and zoom links
- Instructor keeps office hours
 - Note that “by appointment” means more time available on demand



Github Classroom

- Git/github are powerful and common industry tools
 - And useful for group work
- We will use github to distribute and submit assignments (in tandem with gradescope)
 - Bear with us as we work out any issues, esp with autograders



Questions?

- Remember:
 - Do academic honesty homework
 - Lab 0 up/coming soon