First Day of CS202, 2021 Winter

Hung-Wei Tseng



CS202: Let's say something!

What's your name?

Why're you taking **CS202**



What's the most **exciting New Year's Eve** experience you ever had?





https://az-eandt-live-legacy.azureedge.net/news/2013/apr/images/640_edsac-web.jpg

What releases human beings from the queues?

Operating systems



The basic idea of execution







The beast: von Neuman Architecture





By loading different programs into memory, your computer can perform different functions



 130020e4
 00000000

 00003d24
 00000000

 2ca4e2b3
 000000008

Memory

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Storage

How processor executes a program

- The program counter (PC) tells where the upcoming instruction is in the memory
- Processor fetches the instruction, decode the instruction, execute the instruction, present the instruction results according to clock signals
- The processor fetches the next instruction whenever it's safe to do so



instruction memory

b27	ldah	gp,15(t12)
d23	lda	gp,-25520(gp)
d24	ldah	t1,0(gp)
d24	ldah	t4,0(gp)
2a0	ldl	t0,-23508(t1)
0e4	beq	t0,120007a94
d24	ldah	t0,0(gp)
2b3	stl	zero,-23508(t1)
f47	clr	vØ
5b3	stl	zero,-23512(t4)
1a4	ldq	t0,-23520(t0)
0e4	beq	t0,120007a98
147	mov	t0,t1
f47	clr	t2
0c3	br	120007a80

Desktop Computer



Server



als (e.g., DRA GPUs) (in figure 1000) Process Pro

Peripher

I/O Connectors (e.g., keyboard/mouse)

als (e.g., DRAM DRAM DRAM DRAM

Processor Processor

DRAM DRAM DRAM DRAM

MacBook Pro 13"



iPhone 12 Pro





SSD

0 :: 0

I/O

Connec

tors





Play Station 4



Processor + GPU



Peripherals (e.g., H.D.D.)

Peripher als (e.g., codecs)

Nintendo Switch

(e.g., HDMI)

I/O Connectors

1 15

DRAM



Processor + GPU

Network Modules/ Codecs

Peripherals (e.g., memory cards.)

Tesla Model 3





Operating system









Why is there an operating system?



Why is there an operating system?

- Make it easy to run programs
- Enable programs to interact with devices
- Allow programs to share hardware resources
- Support multithreaded programs
- Execute programs efficiently
- Low overhead
- Store data safely
- Secure



The evolution of OSs



Batch systems: earliest type of operating systems

- Executes jobs in-order, one at a time
 - Provide storage (drum, card holder)
 - Load programs into the memory
 - Setup the processor to execute the job
 - Run until the program finishes and load the next in the queue



Batch systems

- Benefits
 - You don't have to be physically in the line, just drop your cards and take the result later
 - Keep the computer running
- Drawbacks
 - Head-of-line blocking
 - Cannot terminate a process in the middle
 - Cannot communicate among different machines
 - Hard to debug





- Created in AT&T Bell Labs, a project leading by Ken Thompson and Dennis Ritchie
 - Started in 1969, internally public in 1971, public in 1973
- Closely tied to the development of the C programming language
 - Large portion of UNIX version 2 was written in C (version 1 was written in assembly)
 - Unix was one of the first operating system kernels implemented in a language other than assembly
 - Easier to port to many other platforms

```
q97-2.jpg
cover_letter2.pdf
                                       q98-1.jpg
cv.tar.gz
                                       q98-2.jpg
cv2
cxbook-search.pdf
                                       q99-1.jpg
deadlines.pdf
                                       q99-2.jpg
docs
                                       referenceform.pdf
e00-1-1.jpg
                                       schools.pdf
e00-1-2.jpg
                                       umac.pdf
e01-1-1.jpg
                                       wms
e01-1-2.jpg
                                       wu94envy.pdf
e98-1-2.jpg
                                       yangc.pdf
                                       ?C?L?????.pdf
e98-2-2.jpg
e99-1-1.jpg
                                       w?x
e99-1-2.jpg
bsd1 [/home/master/92/r92022] -r92022- cd htdocs/
bsd1 [/home/master/92/r92022/htdocs] -r92022- 1s -altr
total 16
-rw-r-r-+ 1 r92022 graduate 153 Sep 17 2006 index.htm1~
-rw-r-r-+ 1 r92022 graduate 154 Sep 17 2006 index.html
drwxr-xr-x+ 2 r92022 graduate 4096 Sep 17 2006.
drwxr-xr-x+ 36 r92022 graduate 4096 Aug 7 2010 ...
bsd1 [/home/master/92/r92022/htdocs] -r92022- uname -a
FreeBSD bsd1.csie.ntu.edu.tw 10.3-RELEASE-p5 FreeBSD 10.3-RELEASE-p5 #30: Sun Jul 10 10:30:27 CST
        root@:/usr/obj/usr/src/sys/WSBSD amd64
2016
bsd1 [/home/master/92/r92022/htdocs] -r92022-
```

UNIX (cont.)

- Support multiple users
- Support interprocess communication
- First portable operating system
- Everything is a file
 - Max filename length: 255 bytes
- No GUI



[screen is terminating] bunny@ubuntu:/dev\$ 🙂 🔍 🗇 Download QEMU - QEMU - Mozilla Firefox [sudo] password for Cownload QEMU-QEMIX + [detached from 2205 $(\epsilon) \rightarrow$ C' 🛈 bunny@ubuntu:/dev\$ HOME [detached from 2343 bunny@ubuntu:/dev\$ [sudo] password for [screen is terminat: bunny@ubuntu:/dev\$ Linux [screen is terminat: bunny@ubuntu:/dev\$ [sudo] password for [screen is terminat: bunny@ubuntu:/dev\$ [sudo] password for [screen is terminat: bunny@ubuntu:/dev\$ [screen is terminating]

bunny@ubuntu:/dev bunny@ubuntu:/dev\$ screen /dev/ttyUSB0 115200 ① A https://www.gemu.org/download/ ··· 🖂 ŵ DOWNLOAD SUPPORT CONTRIBUTE Download QEMU Windows macOS QEMU is packaged by most Linux distributions: Arch: paeman -S gemu Debian/Ubuntu: apt-get install gemu Fedora: dnf install @virtualization

Gentoo: emerge --ask app-emulation/gemu

[SUDD] password for 👩 It looks like you haven't started Firefox in a while. Do you want to clean it up for a fresh, like-new experience? And by the way, welcome back!

bunny@ubuntu:/dev\$ sudo screen /dev/ttyUSB0 115200 [screen is terminating]



UNIX (cont.)

- Support **multiple users**
- Support interprocess communication
- First portable operating system
- Everything is a file
 - Max filename length: 255 bytes
- No GUI
 - X Window provides a GUI for UNIX since 1987.
 - Now X Window is replaced by X.Org still not part of the default system

UNIX (cont.)

- Descendants
 - BSD (Berkeley Software Distribution)
 - FreeBSD, OpenBSD, NetBSD
 - The base of Apple's MacOS X and iOS
 - Solaris
 - IBM AIX
- Affected
 - Linux
 - Started in 1983 by Richard Stallman
 - Linus Torvalds, principal developer of the Linux kernel

C:\Users\bunny>dir Volume in drive C has no label. Volume Serial Number is 56EB-C458

Directory of C:\Users\bunny

07/02/2019	08:06 AM	<dir></dir>		-
07/02/2019	08:06 AM	<dir></dir>		
02/02/2018	11:52 PM		8,067	A125386726.pfx
02/11/2016	01:30 AM	<dir></dir>		Contacts
06/23/2016	08:20 AM		504	cpuz.ini
04/21/2016	01:59 PM	3,3	77,880	cpuz_x64.exe
11/04/2015	02:23 AM	<dir></dir>		Desktop
11/04/2015	02:23 AM	<dir></dir>		Documents
06/25/2016	01:56 AM	<dir></dir>		Downloads
02/11/2016	01:30 AM	<dir></dir>		Favorites
05/09/2017	12:02 AM	17,2	43,245	IRX1800.EXE
02/11/2016	01:30 AM	<dir></dir>		Links
11/04/2015	02:23 AM	<dir></dir>		Music
11/04/2015	02:23 AM	<dir></dir>		Pictures
07/02/2019	08:06 AM		Ø	qms-bmh1.bmp
07/02/2019	08:06 AM		Ø	qms-bmh2.bmp
07/02/2019	08:06 AM		Ø	qms-bmh3.bmp
06/28/2016	08:30 AM		462	quartus2.ini
07/11/2019	04:39 AM		51,806	quartus2.greg
07/02/2019	08:06 AM		0	quartus_web_rule:
02/11/2016	01:30 AM	<dir></dir>		Saved Games
02/11/2016	01:30 AM	<dir></dir>		Searches
11/04/2015	02:23 AM	<dir></dir>		Videos
	10 File	(s) 20,	681,964	bytes

s_file.txt

DOS

- Disk Operating System
 - Originally Quick and Dirty Operating System
 - Introduced in 1981 for IBM PC based on 8086/8088
- Only 640KB memory available for applications
 - No virtual memory
 - Need quite a few tricks (EMS, XMS, QEMM, and etc.) to use all memory that you installed on the computer
- No multi-user, no multi-tasking, no multi-threading
- Notorious 8.3 filename restrictions
- No GUI
 - Now the command line environment of Windows
 - Windows is originally a graphic user interface running on DOS like X-Window



MacOS "Classic"

- Released in 1984 w/ the legendary Macintosh
- Adopted GUI/mouses from Xerox PARC
- The first popularized all GUI OS
- Support multitasking
- Not a multi-user system





- Released in 1987, discontinued in 2006
- First true 32-bit OS on x86
- Was developed together by IBM/MS to be the GUI OS alternative to DOS




Windows 95/98/ME

- Before Windows 95, "Windows" (e.g., Windows 3.1) was just a GUI operating "environment" on DOS
 - You cannot directly boot your machine using early versions of Windows
 - Similar to X-window, Xorg in UNIX/Linux
- First full-fledged Windows OS introduced in 1995 as Windows 95







Recycle Bin misc





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2 Google Chrome

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anime







Manual.pdf





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Windows NT/2000/XP/Vista/7/8/10

- Originally for servers, initially released in 1993
- First true 32-bit Windows OS, Windows Vista/7 started to become natively 64-bit
- Support multi-user, multi-tasking
- NTFS: more secure, modernized file system
- Different driver model than DOS/Windows 95
- Most code in C/C++, reasonably portable (IA-32, x86-64, DEC) Alpha, MIPS, PowerPC, ARM, Itanium)





MacOS X

- Initially released in 2001
- Originated from NeXTSTEP, a company Steve Jobs funded after leaving from Apple in 1985
- Darwin: based on Mach and BSD kernels
 - Inherits all the good things from UNIX
 - Better integration with GUI
- Shares the same kernel with iOS

iOS

- Share the same kernel foundation with MacOS X
- The 2nd most popular mobile OS



Android

- Based on Linux
- The most popular operating system since 2014



What modern operating systems support?

- Virtualize hardware/architectural resources
 - Easy for programs to interact with hardware resources
 - Share hardware resource among programs
 - Protect programs from each other (security)
- Execute multithreaded programs concurrently
 - Support multithreaded programming model
 - Execute multithreaded programs efficiently
- Store data persistently
 - Store data safely
 - Secure





CS202: Advanced Operating Systems



Why? What? How?





CS202 Lecture What? CS202 Project





Logistics

Course resource

- Lectures: TuTh 6:30p-7:50p on Zoom
- Office Hours: M 1p-3p on Zoom
- Schedule, slides on course webpage: <u>https://www.escalab.org/classes/cs202-2021wi/</u>
- Discussion on piazza: https://piazza.com/class/kizaqe6jw251qj
- Reading quizzes, homework submissions on iLearn: https://ilearn.ucr.edu/
- Youtube Channel <u>https://www.youtube.com/profusagi</u>

Instructor — Hung-Wei Tseng

- Website: <u>https://intra.engr.ucr.edu/~htseng/</u>
- Office hour: M 1:00p-3:00p on Zoom
- E-mail: htseng@ucr.edu
- BS/MS in Computer Science, National Taiwan University
- PhD in Computer Science, University of California, San Diego
- Research Interests
 - Intelligent storage devices
 - Non-volatile memory based systems
 - Near-data processing
 - Anything could accelerate applications



Your tasks

- Login/discussion in iLearn and piazza.
- Read the text before class! •
 - Operating Systems: Three Easy Pieces Remzi H. Arpaci-Dusseau and Andrea C. Arpaci-Dusseau (free online http://pages.cs.wisc.edu/~remzi/OSTEP/)
 - I'm not going to cover everything in class, but you are responsible for all the assigned text. •
 - Papers
- Reading quizzes in iLearn (15%)
 - Come to class answering at least 50% of Zoom Polls during 4 grading periods, counted as 4 reading quizzes
 - We will drop at least 5 of your lowest reading quizzes, so it's OK if you don't attend
- Project (25%) intensive C programming in the system/kernel level
- Midterm (20%) take home/online, format TBA
- Final (40%) take home/online, format TBA



• You can see your grades on iLearn.

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1		TritonEd Community
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🚔 💩	Tools	
kome hage Information Cuisses	Create and view Course Annuncements	Groups Create and manage formal groups of students to callaborate on work.
Discussions Tools	Open Blockboard Help for Students	Jeumals Create and menopojournals that can be assigned to each user in a group jor the perposes of private
help Library Help Academic Integrity	Blogs Create and manage Mags for Caurses and Course Groups	Displaye detailed information about your anotes.
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- Errors in grading
 - If you feel there has been an error in how an assignment or test was graded, you have one week from when the assignment is return to bring it to our attention. You must submit (via email to the instructor and the appropriate TAs) a written description of the problem. Neither I nor the TAs will discuss regrades without receiving an email from you about it first.
- For arithmetic errors (adding up points etc.)
 - you do not need to submit anything in writing, but the one week limit still applies.

Academic Honesty

- Don't cheat.
 - Cheating on a test will get you an F in the class and no option to drop, and a visit with your college dean.
 - Cheating on homework means you don't have to turn them in any more, but you don't get points either. You will also take at least 25% penalty on the exam grades.
- Copying solutions of the internet or a solutions manual is cheating
 - They are incorrect sometimes
- Review the UCR student handbook
- When in doubt, ask.

Learning eXperience

Most lectures today ...







Me





Peer instruction

- An Active Learning teaching method proposed by Prof. Eric Mazur from Harvard University in the early 1990s
- Before the lecture You will first try your best to go through and understand the required reading
- During the lecture I'll bring in activities to ENGAGE you in exploring your understanding of the material
 - Popup questions
 - Individual thinking use polls in Zoom to express your opinion
 - Group discussion
 - Discuss in breakout rooms
 - Use polls in Zoom to express your group's opinion
 - Whole-classroom **discussion** we would like to hear from you
 - I will explain and lecture on those related concepts •



Before lectures: reading quizzes

- This is a peer instruction class
 - The lecture will require you to read and try your best to understand the material first
 - We need to make sure that you read the material first to achieve the best learning outcome
- Reading assignments from
 - Textbook: Operating Systems: Three Easy Pieces Remzi H. Arpaci-Dusseau and Andrea C. Arpaci-Dusseau (free online http://pages.cs.wisc.edu/~remzi/OSTEP/)
 - Papers at least get through those "focuses" listed in the schedule
- Reading quizzes:
 - On iLearn
 - Due before the lecture, usually once a week. Check the schedule on our webpage
 - You will have two chances. We take the average
 - No time limitation until the deadline
 - No make up reading quizzes we will drop probably one or two lowest at least



Why attend live sessions and discuss?

- I'll bring in activities to ENGAGE you in exploring your understanding of the material
 - Let you practice
 - Bring out misconceptions
 - Let us LEARN from each other about difficult parts
 - It's going to be fun!
- You will be GET CREDIT for your efforts to learn in class
 - By answering questions with polls within Zoom
 - Answer **50%** of the clicker questions in class, get full credits for 4 reading quizzes
- Group Discussion
 - We will divide the class into two groups
 - The best group the group with the most correct answers after group discussions, will receive a USD 5 amazon gift card for each of its members





- We will work on "real Linux systems" and implement a linux kernel module
- Details will come soon
- Real human beings work on real systems!

Schedule

	Торіс	Reading	Slides (Previe
1/5/2021	Intro		
1/7/2021	The Structure of Operating Systems and the Abstraction of Processes	Arpaci-Dusseau Chapter 2, 4, 6	
1/9/2021	The Structure of Operating Systems	The Structure of the 'THE'-Multiprogramming System	
4/44/0004	Due a constante de		
1/14/2021	Processes & Threads	Ine UNIX Time-Sharing System Mash: A New Karnel Foundation For UNIX Development	
		Arpaci-Dusseau Chapter 5, 26, 27	
1/16/2021	Processes & Threads	Arpaci-Dusseau Chapter 28, 29, 30, 31	_
1/21/2021	Processes/Threads Scheduling	Arpaci-Dusseau Chapter 7	
		An experimental time-sharing system	
1/23/2021	Processes/Threads Scheduling	Lottery Scheduling: Flexible Proportional-Share Resource Management.	-
		Scheduler Activations: Effective Kernel Support for the User-level Management of Parallelism	
1/28/2021	Virtual memory	Arpaci-Dusseau Chapter 13, 15, 16, 18	_
2/2/2021	Virtual memory	Arpaci-Dusseau Chapter 20, 21, 22	
2/4/2021	Virtual memory	Machine-Independent Virtual Memory Management for Paged Uniprocessor and Multiprocessor	
		Architectures	
2/9/2021	Virtual memory	Converting a Swap-Based System to do Paging in an Architecture Lacking Page-Reference Bits	
		WSCLOCK-A Simple and Effective Algorithm for Virtual Memory Management	
2/11/2021	File systems	Arpaci-Dusseau Chapter 39, 40, 41	
2/16/2021	File systems	A Fast File System for Unix	
		The Design and Implementation of a Log-Structured File System	
2/18/2021	Fast, non-volatile memory-based storage devices	Arpaci-Dusseau Appendix-Flash-based SSDs	
		eNVy: a non-volatile, main memory storage system	
		Don't stack your log on my log	
2/23/2021	Networked & cloud storage	Arpaci-Dusseau Chapter 49	
		The Google File System	
2/25/2021	Networked & cloud storage	Windows Azure Storage: A Highly Available Cloud Storage Service with Strong Consistency	
		f4: Facebook's Warm BLOB Storage System	
3/2/2021	Distributed systems	The Sprite Network Operating System	
		The Distributed V Kernel and its Performance for Diskless Workstations	
3/4/2021	Distributed systems	Web Search for a Planet: The Google Cluster Architecture	
		Implementing Global Memory Management in a Workstation Cluster	
3/9/2021	Virtual machine	Arpaci-Dusseau Appendix-Virtual machines A You need to complete the reading of the	
3/11/2021	Virtual machine	Hints textbook and papers before lectures	
2/12/2021_2/17/2021	Subject to change		

9W()	Slides (Release)	Due
		Proiect
		Спеск
	Download	due
	slides	dates
	after	here

Lots of paper reading — up to 4 per week, a total of 23 this quarter!



Why papers?

No alternative facts

- Papers are written by authors who create/invent these artifacts
 - First-hand information
 - Not being cooked by media/press...
- Papers are reviewed based on originality
- Papers are reviewed by experts without conflict of interests



FERNATIVE FACTS' ARE LIES



Papers give you insights!

- Papers contain design principles that are missing in your textbook or online documents
- You can apply these design principles and the skills of analyzing these principles to anywhere (e.g. you will surprisingly find how the paper you read next week affects software engineering)
- You can learn those whys for those proposed work



Industry cares

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G n	Given we are also working on in-memory and near-memory computing at my Boston team, I would like to see nodels/workloads in both datacenters and edge devices and instigate new research directions.	how do we	e work more closely to chu	im out even more useful results a
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cs.ucsd.edu

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		Q: What are the concepts in HYDRA that correspond to Lampson's definitions of "Domain" "Object" and "Access Matrix'? What about Multice?	t, <u>Concurrent Reading</u>	9/6	 Linux's History v

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/. Corwin, A. Jones, R. Levin, C. Pierson, and F. Pollack, of a Multiprocessor Operating System , Communications of the June 1974, pp. 337-345.	
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G. Bell, C.mmp: a multi-mini-processor, In Proceedings of at Computing Conference, December 1972.	ime l
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Dorward, B. Flandrena, K. Thompson, H. Trickey, and P. From Bell Labs, USENIX Computing Systems, Vol. 8, No. 3, -254.	

written by Linus Torvalds

Make yourself more valuable

- Every top 20 CS MS/PhD program has their students reading papers in OS classes and every instructor at UCR teaches similar sets of materials
- You have to compete with them when you're on the market
- You need some context to prove that you're also geeky enough to be one of their colleagues

https://www.whitehouse.gov/the-press-office/2017/04/18/presidential-executive-order-buy-american-and-hire-american supersede or revise previous rules and guidance if appropriate, to protect the interests of United States workers in the administration of our immigration system, including through the prevention of fraud or abuse.

> (b) In order to promote the proper functioning of the H-1B visa program, the Secretary of State, the Attorney General, the Secretary of Labor, and the Secretary of Homeland Security shall, as soon as practicable, suggest reforms to help ensure that H-1B visas are awarded to the most-skilled or highest-paid petition beneficiaries.

impair or otherwise affect:

Sec. 6. General Provisions. (a) Nothing in this order shall be construed to

Academic honesty

- Don't cheat.
 - Cheating on a test will get you an F in the class and no option to drop, and a visit with your college dean.
 - Cheating on project means you don't have to turn them in any more, but you don't get points either. You will also take at least 25% penalty on the exam grades.
- Copying solutions/code of the internet or a solutions manual is cheating — we do random sampling, we do check/compare all coding projects
- When in doubt, ask.
- Final grading is based your relative ranking in class if you help people cheat, you hurt yourself



Term of Service

- CS202 is an operating system related class for graduate students. It's not our responsibility to recap everything that should be covered by an undergraduate operating system class from a regular computer science undergraduate program.
- This class requires intensive readings in research papers and the assigned textbook.
- This class requires you to speak and discuss your opinion with your classmates as well as the instructor.
- This class requires programming projects that uses the C programming language. It is your responsibility to learn how to program in C. It is also your responsibility to design the architecture, implementation details and tests for your coding projects.
- The instructor and course staffs reserve the right to refuse to answer inappropriate questions (e.g. directly telling if an answer is right or not).
- It is your responsibility to track the latest schedule, information, grades and materials from our course website, e-mails from the course staffs and the piazza forum.



• Any cheating will be treated seriously. You will get an F and we will report to the Dean's office By clicking this box, you are agreeing to the Terms and Conditions of CS202, Winter 2021.

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79

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Announcement

- The first reading quiz due this Thursday before class!
 - Please find the reading quiz in iLearn!
 - Please visit the course webpage for the most accurate reading list