Lecture 9: Software systems

- operating systems
  - runs programs, controls the computer, stores information, communicates
- applications ("apps")
  - programs that do things
- cloud computing, virtual machines, ...
  - where boundaries become even less clear

- intellectual property
  - copyrights, patents, licenses
- interfaces, standards, antitrust, ...
  - agreements on how to communicate and inter-operate
- open source software
  - freely available, non-proprietary
- jurisdiction
  - where are the computers? where is the data? who has access to it?

Software systems come in lots of sizes

- programs come in different sizes
  - 10 - 20 lines (COS 109 psets and labs: tiny, like a response paragraph)
- programs in intro courses like COS 126
  - 100 - 300 lines? (like a short paper?)
- projects in courses like COS 333
  - 2000 - 5000 lines (like a term paper)
- significant applications
  - 100,000 - 10,000,000 lines (like a book, maybe a very big book)
- operating systems, major applications
  - 10,000,000 and up (like a multi-volume book?)

- a typical programmer produces at most a few thousand lines of production code per year

Operating system

- a program that controls the resources of a computer
  - interface between hardware and all other software
  - examples: MS-DOS, Windows 3.0/95/98/NT/ME/2000/XP/Vista/7/8/10/11
    macOS, iOS, Android, ...
    Unix/Linux

- runs other programs ("applications", your programs, ...)
- manages information on disk (file system)
- controls peripheral devices, communicates with outside world
- keeps things from interfering with each other

- provides a level of abstraction above the raw hardware
  - makes the hardware appear to provide high-level services
  - makes programming much easier

What an operating system does

- manages CPUs, schedules and coordinates running programs
  - switches CPU among programs that are actually computing
  - suspends programs that are waiting for something (e.g., disk, network)
  - keeps individual programs from hogging resources
- manages primary memory (RAM)
  - loads programs in memory so they can run
  - swaps them to disk and back if there isn't enough RAM (virtual memory)
  - keeps separate programs from interfering with each other
  - and with the operating system itself (protection)
- manages and coordinates input/output to devices
  - disks, display, keyboard, mouse, network, ...
  - keeps separate uses of shared devices from interfering with each other
  - provides uniform interface to disparate devices
- manages files on secondary storage (file system)
  - provides hierarchy of folders/directories and files for storing information

History of general-purpose operating systems

- 1950's: signup sheets
- 1960's: batch operating systems
  - operators running batches of jobs
  - OS/360 (IBM)
- 1970's: time-sharing
  - simultaneous access for multiple users
  - Unix (Bell Labs; Ken Thompson & Dennis Ritchie)
- 1980's: personal computers, single user systems
  - DOS, Windows, MacOS, Unix
- 1990's: personal computers, PDA's, …
  - PalmOS, Windows CE, Unix / Linux
- 2000's: Windows, Unix/Linux, MacOSX (a Unix variant)
- 2010 and beyond: Apple vs. Google vs. Microsoft
  - macOS, iOS, Android, ChromeOS, … (all Unix/Linux-based)
  - cloud computing
- not all computers have general-purpose operating systems
  - "embedded systems": small, specialized, but increasingly general (often Linux)

Unix operating system

- developed ~1971 at Bell Labs
  - by Ken Thompson and Dennis Ritchie
- clean, elegant design
  - at least in the early days
- efficient, robust, easy to adapt, fun
  - widely adopted in universities, spread from there
- written in C, so easily ported to new machines
  - runs on everything (not just PC's)

- influence
  - languages, tools, de facto standard environment
  - enabled workstation hardware business (e.g., Sun Microsystems)
  - supports a lot of Internet services and infrastructure
    - often Linux

Linux

- a version of Unix written from scratch
  - by Linus Torvalds, Finnish student (started 1991)

- source code freely available (kernel.org)
  - large group of volunteers making contributions
  - anyone can modify it, fix bugs, add features
  - Torvalds approves, sets standard
  - commercial versions make money by packaging and support,
    not by selling the code itself

- used by many major sites, including
  - Google, Amazon, Facebook, Twitter, YouTube, ABC, CBS, CNN, ...

To run programs, the operating system must

- fetch program to be run (usually from disk)
- load it into RAM
  - maybe only part, with more loaded as it runs (dynamic libraries)
- transfer control to it
- provide services to it while it runs
  - reading and writing info on disk
  - communications with other devices, network, ...
- regain control and recover resources when program is finished
- protect itself from errant program behavior
- share memory and other resources among multiple programs running "at the same time"
  - manage memory, disks, network, ...
  - protect programs from each other
  - manage allocation of CPUs among multiple activities

Memory management

- what's in memory? over-simplified pictures:

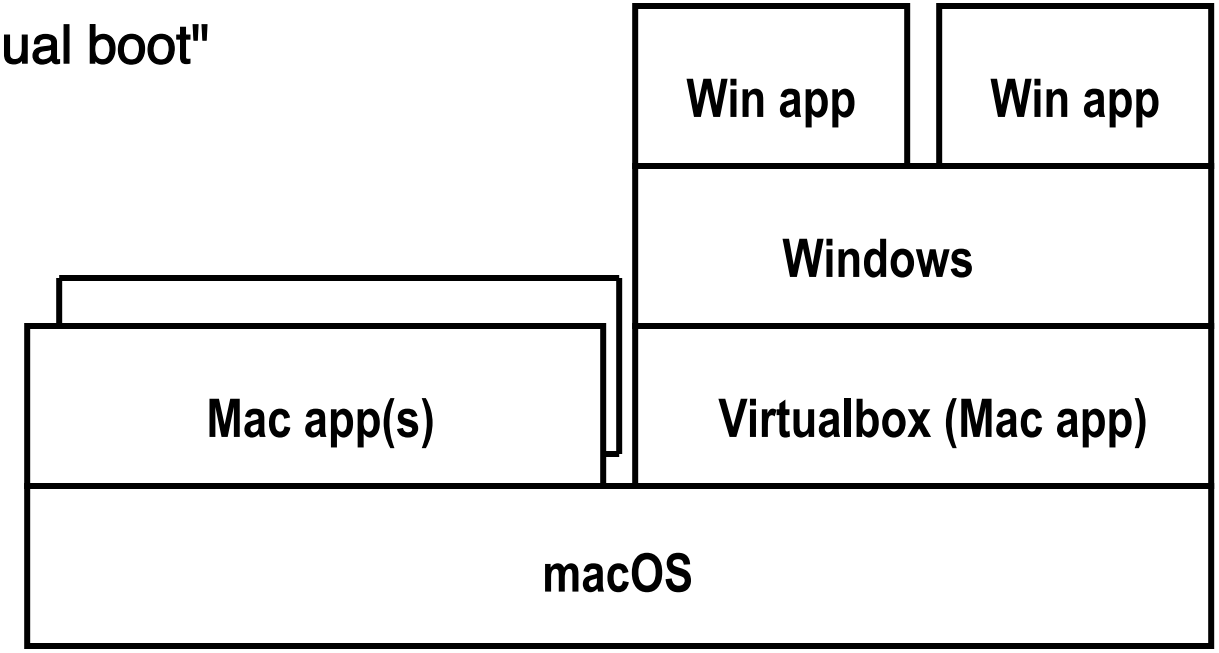
Unix:

Windows:

- reality is more complicated
  - pieces of programs are partly in RAM, partly on disk
    can only execute instructions that are in RAM
- memory protection:
  - making sure that one program can't damage another or the OS
- virtual memory:
  - making it look like there is more RAM than there really is

Virtual machines

- running other operating systems on top of an OS
  - e.g., VMWare, VirtualBox, Xen, HyperV, Parallels, ...
- system calls from applications to "guest" OS are intercepted by "host" OS
  - e.g., guest == Windows 11 or Linux, host == macOS
- passed to guest OS, which handles them by converting them into system calls to host OS
- not the same as "dual boot"



Cloud computing: computer services via the Internet

- large computer centers with many physical computers: "servers"
  - lots of memory, disk capacity, network capacity
  - centralized "data centers" (but there are often multiple data centers)
  - examples: Amazon Web Services, Microsoft Azure, Google Cloud, ...
- servers run virtual machines to share resources of physical machines
  - most cloud services run Linux
- client computers make requests of servers
  - do computation, store or retrieve information, administer resources
- advantages for clients:
  - easy to scale up or down as usage changes
  - no need to buy or manage equipment
  - can rent software as well as hardware
  - centralized administration can be more efficient
  - security should be better (but there's a single point of failure)

Browser as operating system

- a browser provides many of the services that an operating system does
  - can use "the cloud" for storage and computation
  - programs mostly run in cloud; browser is an interface
  - email, social networks, games, Google docs (and similar), ...
- how about a *computer* that only runs a browser?
  - Chromebook: runs Chrome OS (Linux-based operating system)
  - applications and data are in the cloud, not on computer itself
  - very little local storage and local apps

Samsung XE303C12 11.6" Chromebook, Samsung Exynos 5250 Dual Core, 16GB Solid State Drive, 2GB DDR3L, 2x2 802.11n, USB 3.0, HDMI, ChromeOS - (Scratch & Dent)

$99.99

This product has not been reviewed yet.

Condition Refurbished - Scratch & Dent

Screen Size 11.6"

Quantity 1 Limit 10 per customer

Shipping **Standard** - Estimated delivery Oct 17 - Oct 23
Free Standard shipping for Prime members