Lecture 2: Historical Perspective
Instructor: Chengyu Song
Slide contributions from
Nael Abu-Ghazaleh, Harsha Madhyvasta and Zhiyun Qian
Last time

- What is an OS?
- What roles does it play?
- Today: Historic evolution of Operating Systems (and computing!)
Some Questions to Ponder

● What is part of an OS? What is not?

● What are the drivers of OS change?
  ◆ Consider the series of releases of Windows, Linux, OS X…
  ◆ Performance, functionality, usability, security, etc.

● What are the most compelling issues facing OS today?
Questions for today

- Why do we need operating systems course?
- Why do we need operating systems?
- What does an operating system need to do?
- Looking back, looking forward.
A brief history—Phase 0

- In the beginning, OS is just runtime libraries
  - A piece of code used/sharable by many programs
  - Abstraction: reuse magic to talk to physical devices
  - Avoid bugs

- User scheduled an exclusive time where they would use the machine

- User interface was switches and lights, eventually punched tape and cards
  - An interesting side effect: less bugs
Phase 1: Batch systems (1955-1970)

- Computers expensive; people cheap
  - Use computers efficiently – move people away from machine
- OS in this period became a program loader
  - Loads a job, runs it, outputs result, then moves on to next
  - More efficient use of hardware but increasingly difficult to debug
    » Still less bugs 😊
Advances in OS in this period

- **SPOOLING/Multiprogramming**
  - Simultaneous Peripheral Operations On-Line (SPOOL)
    - Non-blocking tasks
    - Copy document to printer buffer so printer can work while CPU moves on to something else
  - Hardware provided memory support (protection and relocation)
  - Scheduling
  - OS must manage interactions between concurrent things

- **OS/360 from IBM** from IBM first OS designed to run on a family of machines from small to large
Phase 1, problems

- Utilization is low (one job at a time)
- No protection between jobs
  - But one job at a time, so what can go wrong?
- Scheduling
- Coordinating concurrent activities
- People time is still being wasted
- Operating Systems didn’t really work
  - The mythical man month
  - Birth of software engineering
Fun statistics

- How many lines of code in a modern OS?
  - Vista (2006): 50M (XP + 10M)
  - OS X (2006): 86M
  - Linux kernel (4.16): 20M
  - Debian Sid (2018): 1,684M

- What does this mean (for you)?
  - OSes are useful for learning about software complexity
  - If you become a developer, you will face complexity
    - Including lots of legacy code
Phase 2: 1970s

- Computers and people are expensive
  - Help people be more productive

- Interactive time sharing: let many people use the same machine at the same time

- Emergence of minicomputers
  - Terminals are cheap

- Persistence: keep data online on fancy file systems
Unix appears

- Ken Thompson, who worked on MULTICS, wanted to use an old PDP-7 laying around in Bell labs
- He and Dennis Richie built a system designed by programmers for programmers
- Originally in assembly. Rewritten in C
  - In their paper describing unix, they defend this decision!
  - However, this is a new and important advance: portable operating systems!
- Shared code with everyone (particularly universities)
Unix (cont’d)

- Berkeley added support for virtual memory for the VAX
  - Unix BSD
- DARPA selected Unix as its networking platform in arpanet
- Unix became commercial
  - …which eventually lead Linus Torvald to develop Linux
Phase 3: 1980s

- Computers are cheap, people expensive
  - Put a computer in each terminal
  - CP/M from DEC first personal computer OS (for 8080/85) processors
  - IBM needed software for their PCs, but CP/M was behind schedule
  - Approached Bill Gates to see if he can build one
  - Gates approached Seattle computer products, bought 86-DOS and created MS-DOS
  - Goal: finish quickly and run existing CP/M software
  - OS becomes subroutine library and command executive
Phase 4: Networked/distributed systems--1990s to now?

- It's all about connectivity

- Enables parallelism but performance is not goal

- Goal is communication/sharing/power consumption/…
  - Requires high speed communication
  - We want to share data not hardware

- Networked applications drive everything
  - Web, email, messaging, social networks, …
  - Chromebook
New problems

- Large scale
  - Google file system, mapreduce, ...

- Parallelism on the desktop (multicores)

- Heterogeneous systems, IoT
  - GPU, FPGA, ...
  - Real-time; energy efficiency

- Security and Privacy
Phase 5

- New generation?

- Computing evolving beyond networked systems
  - Cloud computing, edge computing, IoT, Drones, Cyber-physical systems, autonomous cars, computing everywhere
  - But what is it?
  - ... and what problems will it bring?
Where are we headed next?

- How is the OS structured? Is it a special program? Or something else?
  - How do other programs interact with it?

- How does it protect the system?
  - What does the architecture/hardware need to do to support it?
Why Start With Architecture?

- Recall: Key roles of an OS are
  1) Wizard: isolation and resource virtualization
  2) Referee: efficiency, fairness, and security

- Architectural support can greatly simplify – or complicate – OS tasks
  - Easier for OS to implement a feature if supported by hardware
  - OS needs to implement everything hardware doesn’t

- OS evolution accompanies architecture evolution
  - New software requirements motivate new hardware
  - New hardware features enable new software
Some questions to get you thinking

- What is the OS? Software?

- Is the OS always executing?
  - If not, how do we make sure it gets to run?

- How do we prevent user programs from directly manipulating hardware?
For next class...

- Continue to get familiar with xv6
  - Chapter 0
  - Appendix A and B