# CS 153
# Design of Operating Systems

## Winter 2023

Lecture 2: Historical perspective

# Questions we started considering last time

- 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.

# Roles an OS plays

- Beautician that hides all the ugly low level details so that anyone can use a machine (e.g., smartphone!)
- Wizard that makes it appear to each program that it owns the machine and shares resources while making them seem better than they are
- Referee that arbitrates the available resources between the running programs efficiently, safely, fairly, and securely
  - Managing a million crazy things happening at the same time is part of that – concurrency
- Elephant that remembers all your data and makes it accessible to you -- persistence

# More technically...

- **Abstraction**: defines a set of logical resources (objects) and well-defined operations on them (interfaces)

- **Virtualization**: Isolates and multiplexes physical resources via spatial and temporal sharing

- **Access Control**: who, when, how
  - Scheduling (when): efficiency and fairness
  - Permissions (how): security and privacy

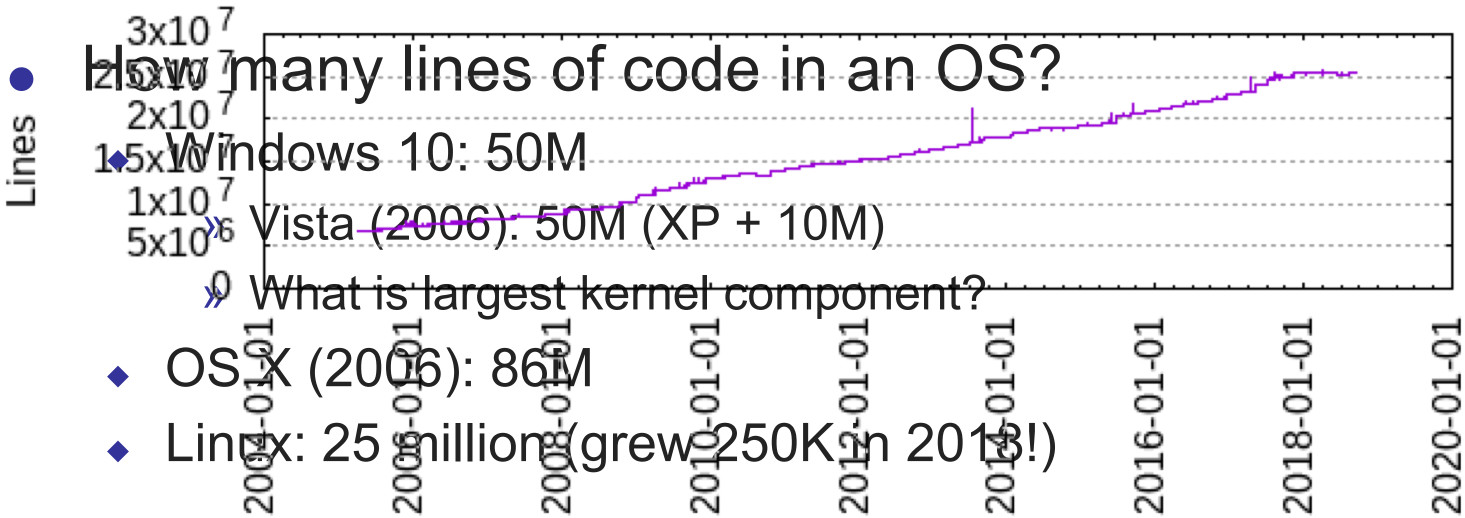
- **Persistence**: how to keep and share data

# Some Questions to Ponder

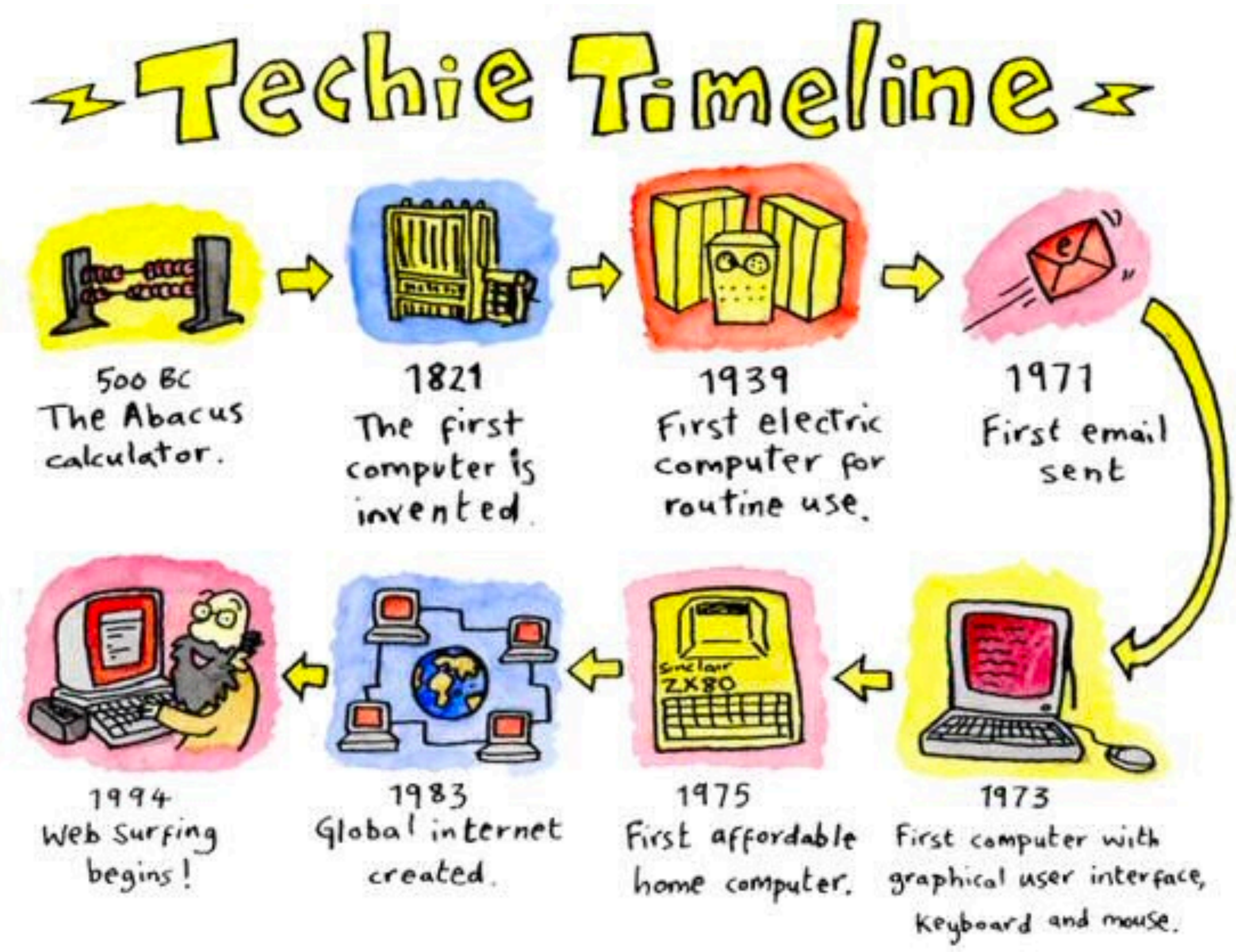
- What is part of an OS?  What is not?
  - Is the windowing system part of an OS? Java? Apache server? Compiler?  Firmware?
- Popular OS's today include Windows, Linux, and OS X
  - How different/similar do you think these OSes are?
- Somewhat surprisingly, OSes change all of the time
  - Consider the series of releases of Windows, Linux, OS X…
  - What are the drivers of OS change?
  - What are the most compelling issues facing OSes today?

# Pondering Cont'd

- How many lines of code in an OS?
  - Windows 10: 50M
    - » Vista (2006): 50M (XP + 10M)
    - » What is largest kernel component?
  - OS X (2006): 86M
  - Linux: 25 million (grew 250K in 2018!)




- What does this mean (for you)?
  - OSes are useful for learning about software complexity
    - » The mythical man month
    - » KDE (X11): 4M
    - » Browser : 2M+, …
  - If you become a developer, you will face complexity
    - » Including lots of legacy code




https://copleycomputing.weebly.com/a-history-of-computing.html

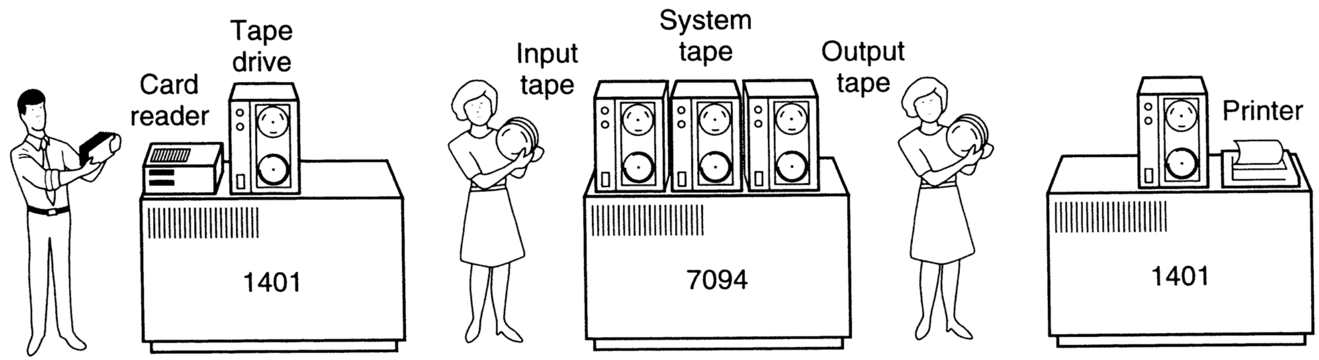
# A brief history—Phase 0

- 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 cards and tape
  - 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, 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 Operation 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: let short jobs run first
  - OS must manage interactions between concurrent things
- OS/360 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?
- Short jobs wait behind long jobs
- Coordinating concurrent activities
- People time is still being wasted
- Operating Systems didn't really work
  - Birth of software engineering

# Phase 2: 1970s – Time sharing, Unix, Persistence

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

- Interactive time sharing: let many people use the same machine at the same time
  - CTSS/Multics projects at MIT
  - Corbato got Turing award for this idea

- 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

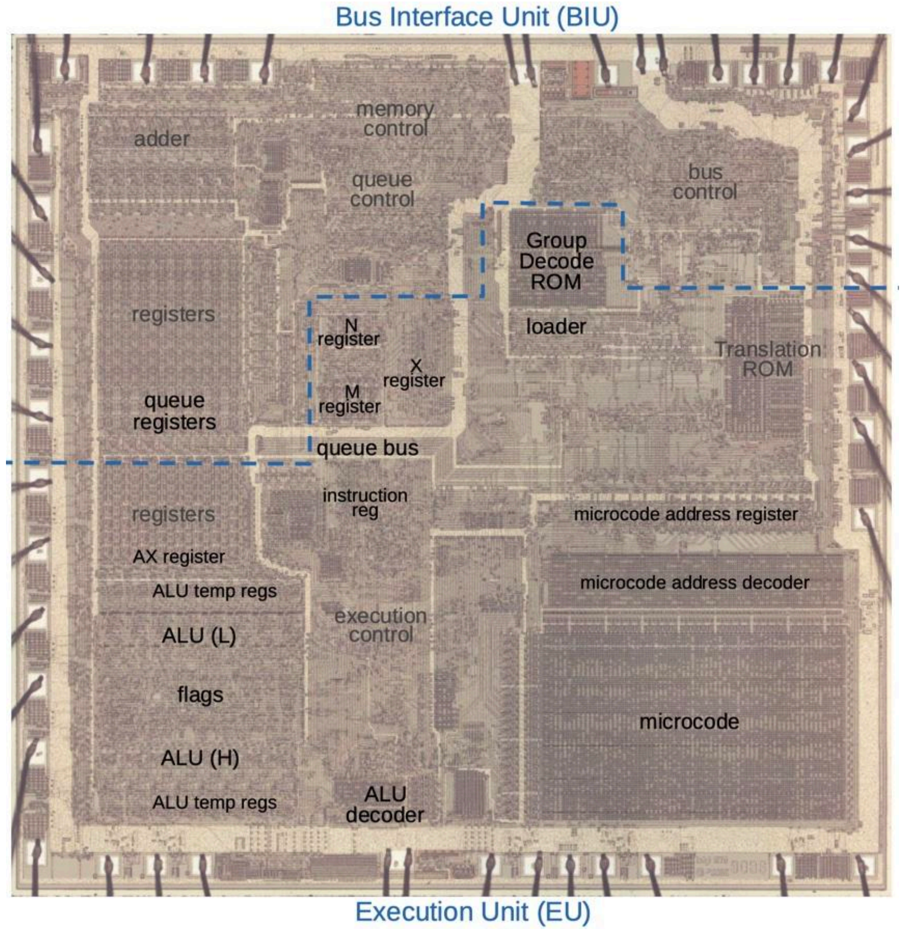
- Originally in assembly.  Rewritten in C
  - In their paper describing unix, they defend this decision!
  - However, this is a new and important advance: portable operating systems!

- Shared code with everyone (particularly universities)
  - Start of open source?

# 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

# Age of the Microprocesor




Intel 8086, 1978

# Phase 3: 1980s -- PCs

- 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?

- Its all about connectivity
- Enables parallelism but performance is not goal
- Goal is communication/sharing
  - Requires high speed communication
  - We want to share data not hardware
- Networked applications drive everything
  - Web, email, messaging, social networks, …

# New problems

- Large scale
  - Google file system, mapreduce, …
- Parallelism on the desktop (multicores)
- Heterogeneous systems, IoT
  - Real-time; energy efficiency
- Security and Privacy

# Phase 5

- Computing evolving beyond networked systems
  - Cloud computing, IoT, Drones, Cyber-physical systems, computing everywhere
- Hardware accelerators, heterogeneous systems, end of Moore’s Law, Hardware democratization/Open source HW
- New workloads: AI, Blockchain, …
- New generation?
  - 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?