UC RIVERSIDE
UNIVERSITY OF CALIFORNIA

Advanced Operating Systems (CS 202)

OS Evolution and Organization

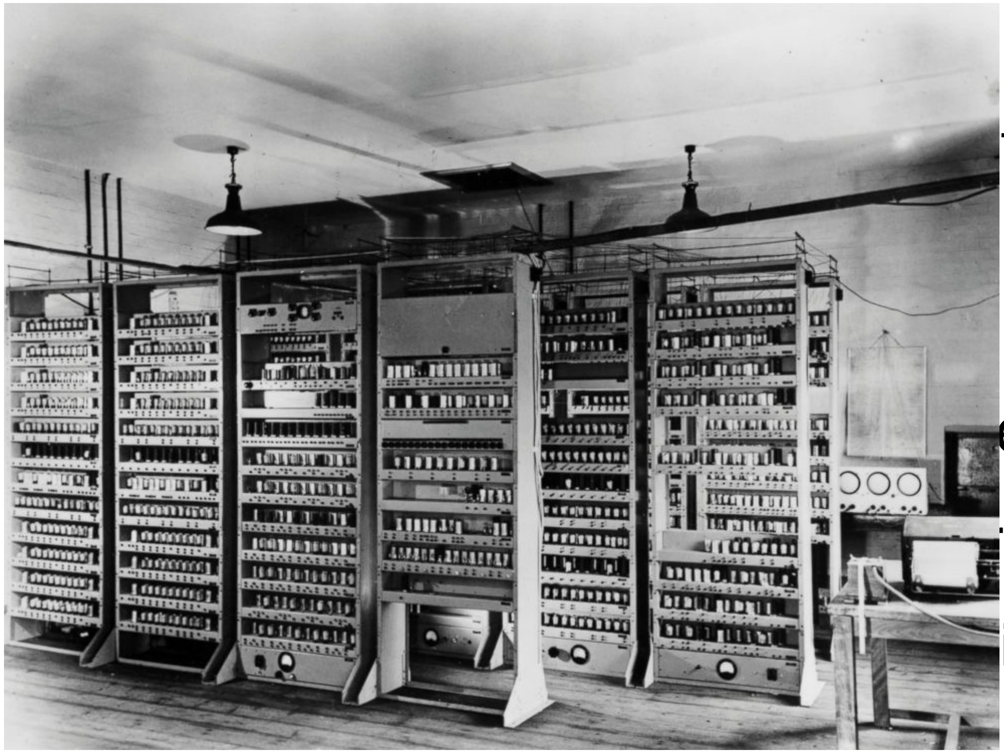
Operating Systems Models

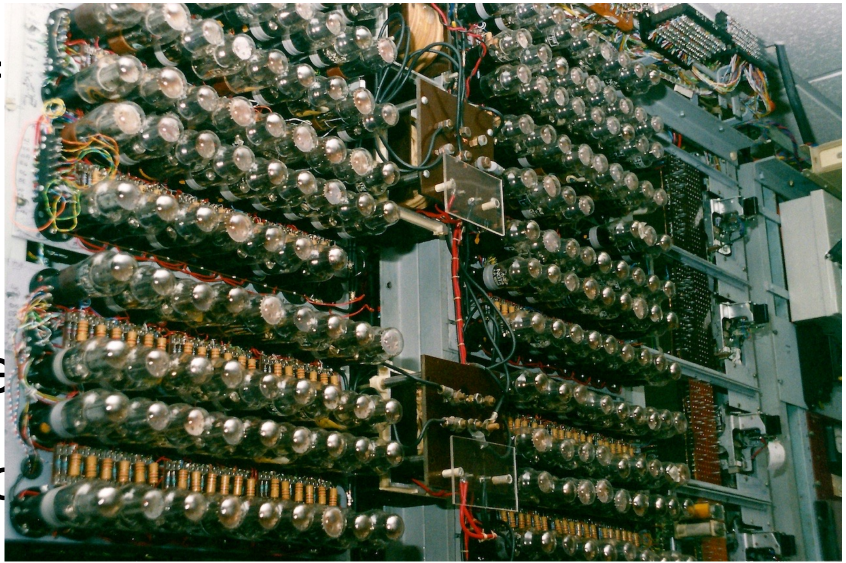
- Our first topic will explore OS models
  - Why do Operating Systems look the way they do?
  - What drives the decisions? What else is possible?

- To set the table
  - Today, we will do a walk through historical evolution of OS
  - Next (next time), we will overview traditional/modern OS organization (monolithic kernel)

Dawn of computing

- Pre 1950 : the very first electronic computers





f

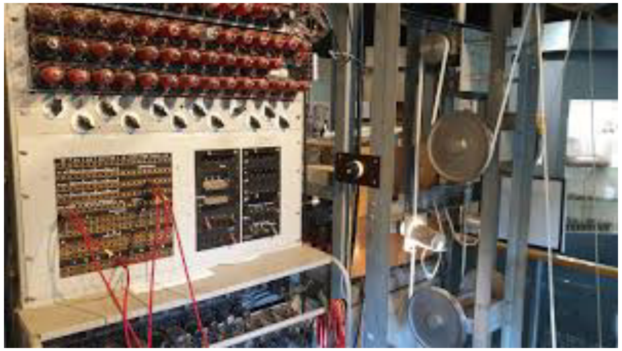
e

rc

ice Wilkes receives Turing

Phase 0 of OS Evolution (40s to 1955)

- No OS
  - Computers are exotic, expensive, large, slow experimental equipment
  - Program in machine language and using plugboards
  - User sits at console: no overlap between computation, I/O, user thinking, etc..
    - Program manually by plugging wires in
    - Goal: number crunching for missile computations
- Imagine programming that way
  - Painful and slow



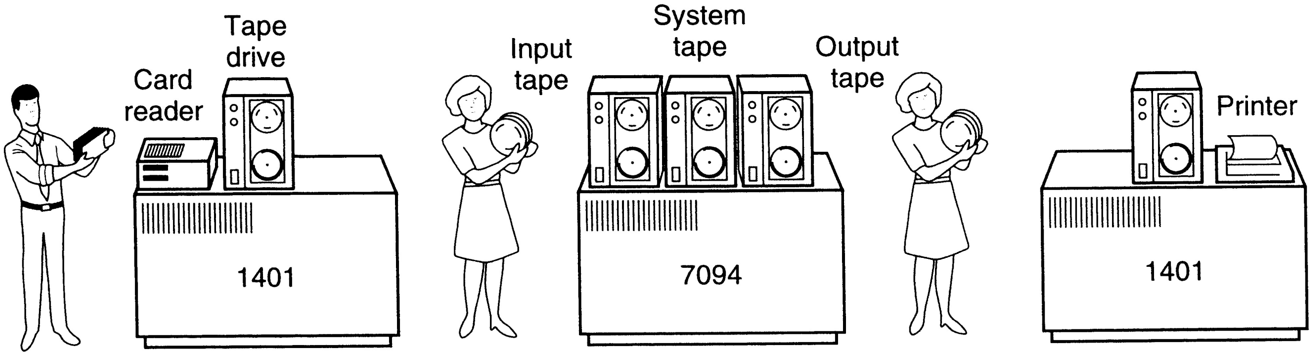
OS progress in this period

- Libraries of routines that are common
  - Including those to talk to I/O devices
  - Punch cards (enabling copying/exchange of these libraries) a big advance!
  - Pre-cursor to OS

Phase 1: 1955-1970

- Computers expensive; people cheap
  - Use computers efficiently – move people away from machine
  - OS becomes a batch monitor
    - Loads a job, runs it, then moves on to next
    - If a program fails, OS records memory contents somewhere
    - More efficient use of hardware but increasingly difficult to debug

- Batch systems on *mainframe* computers
- collections of jobs made up into a *batch*
- example: IBM 1401/7094
  - card decks spooled onto magnetic tape and from tape to printer



- example: English Electric Leo KDF9
  - 32K 48-bit words, 2μsec cycle time
  - punched paper-tape input 'walk-up' service or spooling via mag tape

IBM 7094, thought to be first computer singing (1961)
https://youtu.be/yIwhx3NQSLg

Advances in technology in this stage

- Data channels and interrupts
  - Allow overlap of I/O and computing
  - Buffering and interrupt handling done by OS
  - Spool (buffer) jobs onto “high speed” drums

Phase 1, problems

- Utilization is low (one job at a time)
- No protection between jobs
- Short jobs wait behind long jobs
  - So, we can only run one job at a time
- Coordinating concurrent activities
- Still painful and slow (but less so?)

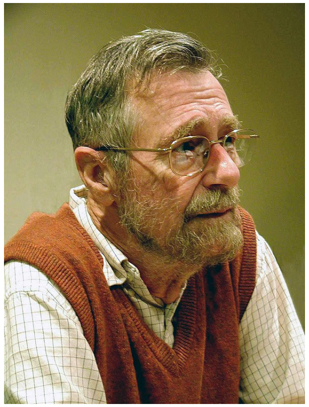
Advances in OS in this period

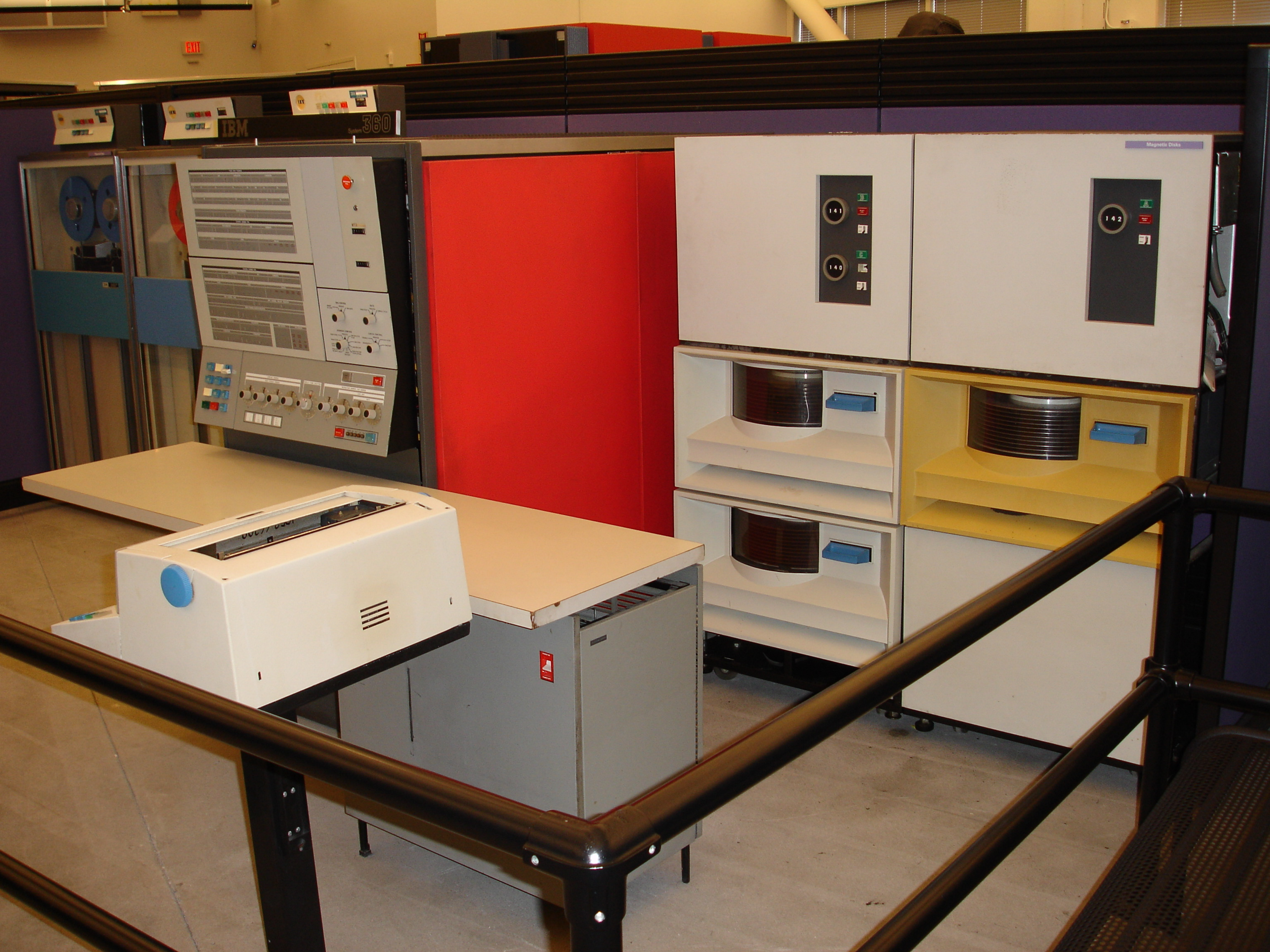
- Hardware provided memory support (protection and relocation)
- Multiprogramming (not to be confused with time sharing)
- Scheduling: let short jobs run first
- OS must manage interactions between concurrent things
  - Starts emerging as a field/science
- OS/360 from IBM first OS designed to run on a family of machines from small to large

Some important projects

- Atlas computer/OS from Manchester U. (late 50s/early 60s)
  - First recognizable OS
  - Separate address space for kernel
  - Early virtual memory

- THE Multiprogramming system (early 60s)
  - Introduced semaphores
  - Attempt at proving systems correct; interesting software engineering insights
  - Project lead by Dijkstra (Turing award winner)




EXIT
IBM
System 360
Magnetic Disks
141
140
142

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
  - Keep data online on fancy file systems
  - Attempt to provide reasonable response times (Avoid thrashing)

Important advances and systems

- Compatible Time-Sharing System (CTSS)
  - MIT project (demonstrated in 1961)
  - One of the first time sharing systems
  - Corbato won Turing award in 1990
  - Pioneered much of the work in scheduling
  - Motivated MULTICS

MULTICS

- Jointly developed by MIT, Bell Labs and GE
- Envisioned one main computer to support everyone
  - People use computing like a utility like electricity – sound familiar? Ideas get recycled
- Many many fundamental ideas: protection rings, hierarchical file systems, devices as files, …
- Building it was more difficult than expected
- Technology caught up

Unix appears

- Ken Thompson, who worked on MULTICS, wanted to use an old PDP-7 laying around in Bell labs
- He and Dennis Ritchie built a system designed by programmers for programmers
- Originally in assembly. Rewritten in C
  - If you notice for the paper, they are defending this decision
  - However, this is a new and important advance: portable operating systems!
- Shared code with everyone (particularly universities)

Ken Thompson

Dennis M. Ritchie

1983 Turing Award for unix

Unix (cont’d)

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

Some important ideas in Unix

- OS written in a high level language
- OS portable across hardware platforms
  - Computing is no longer a pipe stove/vertical system
- Pipes
  - E.g., grep foo file.txt | wc -l
- Mountable file systems
- Many more (we'll talk about unix later)

Phase 3: 1980s

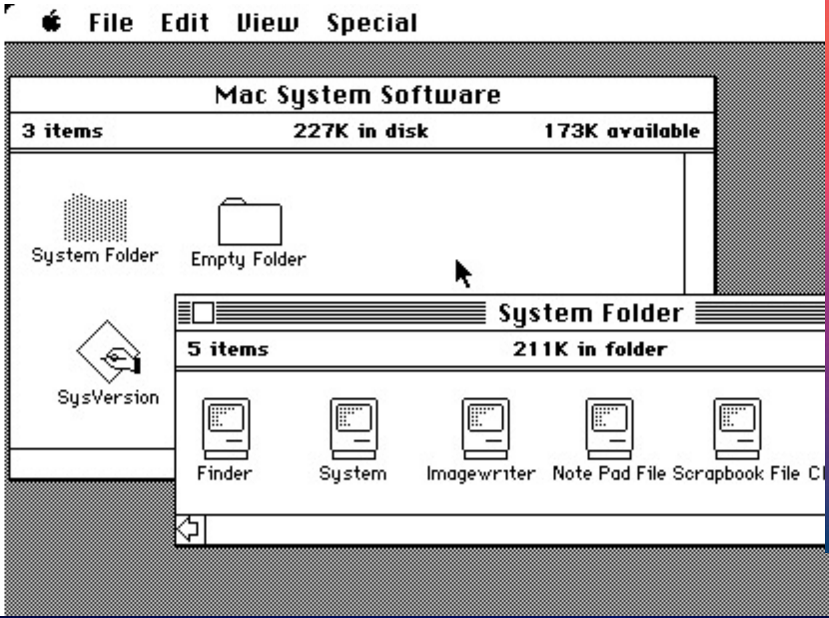
- Computers are cheap, people expensive
  - Put a computer in each terminal
  - CP/M from DEC first personal computer OS (for 8080/85) processors
  - IBM needed software for their PCs, but CP/M was behind schedule
  - Approached Bill Gates to see if he can build one
  - Gates approached Seattle computer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

Disk Operating System (DOS)

- 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

New advances in OS

- PC OS was a regression for OS
  - Stepped back to primitive phase 1 style OS leaving the cool developments that occurred in phase 2
- Academia was still active, and some developments still occurred in mainframe and workstation space
- Eventually, Windows, Linux, MacOS, took over
  - Phase 2 OS' making it to PCs
  - GUIs!

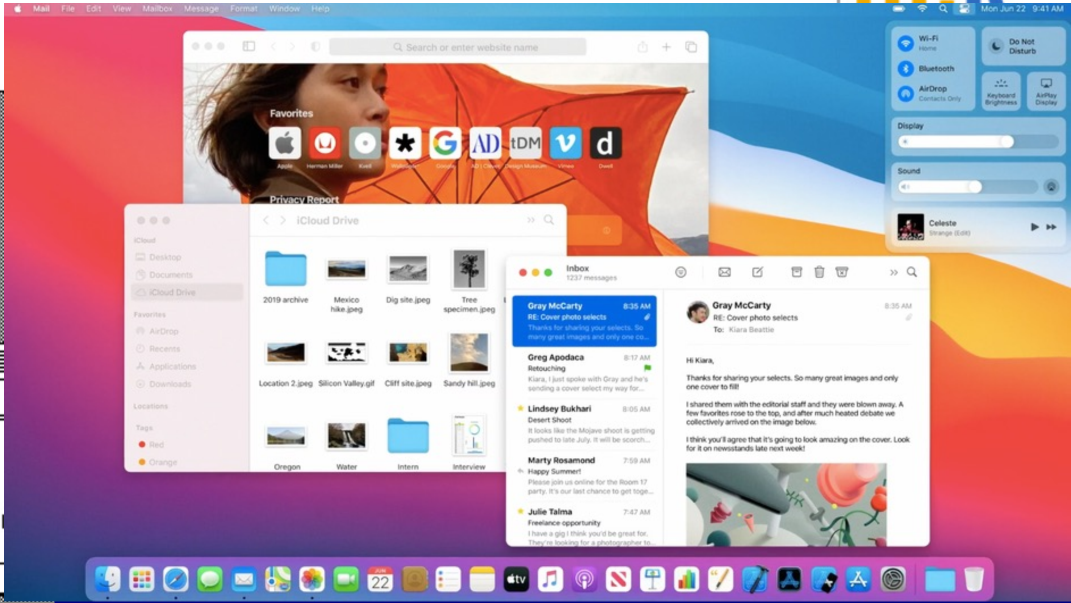


Mac System Software

3 items 227K in disk 173K available

System Folder

5 items 211K in folder



Inbox
1237 messages

Gray McCarty 8:35 AM
RE: Cover photo selects
Thanks for sharing your selects. So many great images and only one co...

Greg Apodaca 8:17 AM
Retouching
Kiara, I just spoke with Gray and he's sending a cover select my way for...

Lindsey Bukhari 8:05 AM
Desert Shoot
It looks like the Mojave shoot is getting pushed to late July. It will be scorch...

Marty Rosamond 7:59 AM
Happy Summer!
Please join us online for the Room 17 party. It's our last chance to get toge...

Julie Talma 7:47 AM
Freelance opportunity
I have a gig I think you'd be great for. They're looking for a photographer to...

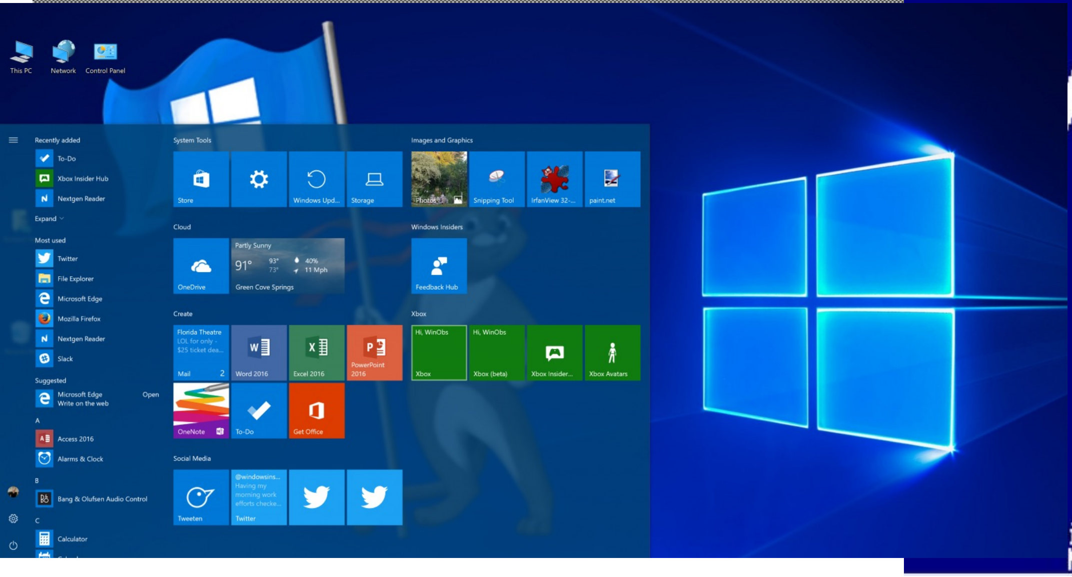
Gray McCarty 8:35 AM
RE: Cover photo selects
To: Kiara Beattie

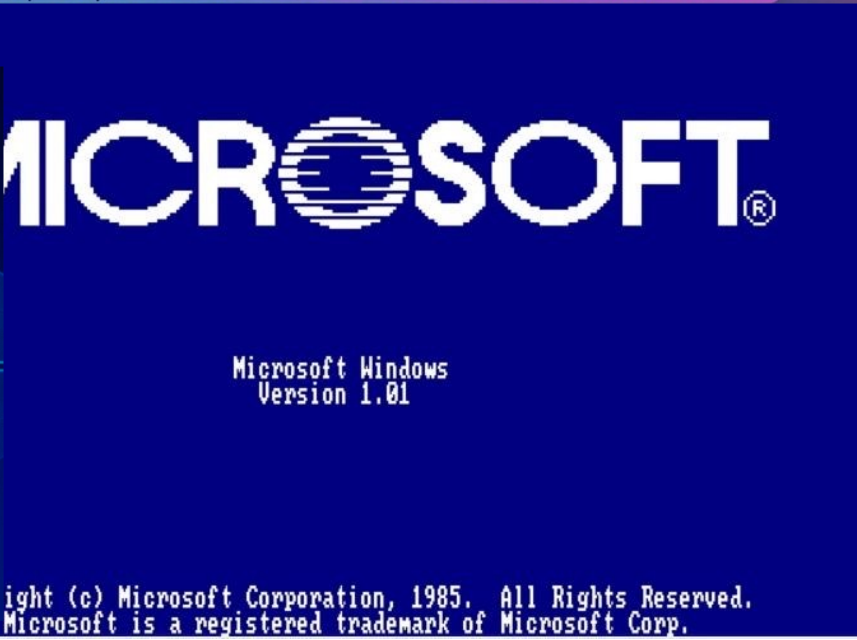
Hi Kiara,

Thanks for sharing your selects. So many great images and only one cover to fill!

I shared them with the editorial staff and they were blown away. A few favorites rose to the top, and after much heated debate we collectively arrived on the image below.

I think you'll agree that it's going to look amazing on the cover. Look for it on newsstands late next week!





Microsoft Windows
Version 1.01

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Phase 4: Networked systems 1990s to 2010s

- Machines can talk to each other
  - its all about connectivity
- We want to share data not hardware
- Networked applications drive everything
  - Web, email, messaging, social networks, …
- Protection and multiprogramming less important for personal machines
  - But more important for servers

Phase 4, continued

- Market place continued horizontal stratification
  - ISPs (service between OS and applications)
  - Information is a commodity
  - Advertising a new marketplace

- New network based architectures
  - Client server
  - Clusters
  - Grids
  - Distributed operating systems
  - Cloud computing (or is that phase 5?)

New problems

- Large scale
  - Google file system, mapreduce, …
- Concurrency at large scale
  - ACID (Atomicity, Consistency, Isolation and Durability) in Internet Scale systems
    - Very large delays
    - Partitioning
- Security and Privacy

Phase 5: 2010s -- ??

- New generation?
- Mobile devices that are powerful
- Sensing: location, motion, …
- Cyberphysical systems
- Machine learning everywhere
- Computing evolving beyond networked systems
  - But OS for them looks largely the same
  - Is that a good idea?