

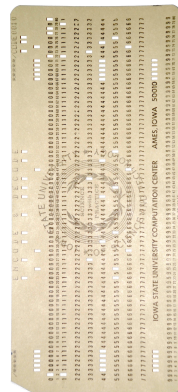
A Brief History of Operating Systems

ComS 252 — Iowa State University

Andrew Miner

Batch systems

1. A user prepares a “job”
 - ▶ Typically, a stack of punch cards
 - ▶ Program, data, and some control information
2. Jobs are given to the computer operator
3. Operators group similar jobs together
 - ▶ Less work for the operator
 - ▶ Reduces down time for computer
4. Simple “operating systems”
 - ▶ When a job completes, start the next one
5. User receives job output later (minutes, hours, or days)



A punch card

Timeshare systems: circa 1962 —

- ▶ More interactive — fast response time
- ▶ Multiple users can log in, each on a different terminal
- ▶ Operating system shares CPU among jobs
- ▶ Idle users do not burden CPU
- ▶ Requires hardware support
 - ▶ To protect memory
 - ▶ To regain CPU control
- ▶ First serious system was MIT's
“Compatible Time Sharing System” (CTSS)

MULTICS: circa 1965 — 2000

MULTICS (MULTIplexed Information and Computing Service)

- ▶ Started by MIT, Bell Labs, and General Electric
- ▶ Very ambitious; followed success of CTSS
- ▶ Goal: one huge machine provides computing power for hundreds of users in Boston area

Innovations:

- ▶ Hierarchical file system
- ▶ File access controls
- ▶ Dynamic linking
- ▶ Modern shell (with I/O redirection)

Did not enjoy commercial success

Birth of UNIX: circa 1969

- ▶ 1969: Bell Labs pulls out of the MULTICS project
- ▶ Ken Thompson wants a “personal” copy of MULTICS
 - ▶ Uses a discarded PDP-7 minicomputer
 - ▶ Ports ‘Space Travel’ game with Dennis Ritchie
 - ▶ Writes a stripped-down version of MULTICS
 - ▶ In assembly language
 - ▶ In about a month
 - ▶ Develops notion of a *process*
- ▶ Dennis Ritchie, Brian Kernighan, and others join the project
- ▶ Name “UNiplexed Information and Computing Service” (UNICS) is a pun on MULTICS
- ▶ UNIX grows, is ported to more powerful machines

Ken Thompson discusses the birth of Unix. Video courtesy of Vintage Computer Federation. Used with permission.



A PDP-7 minicomputer

C: circa 1973

- ▶ Re-writing UNIX in assembly for each new machine is no fun
- ▶ Thompson designs simple language, “B”
 - ▶ B is too weak to implement UNIX
- ▶ Ritchie designs successor(s) to B, named “C”
 - ▶ Brian Kernighan and Dennis Ritchie write the first book on C
 - ▶ ANSI standardizes C in 1989, 1990, 1999, and 2011
 - ▶ C is still the language of choice for system programming
- ▶ Thompson and Ritchie successfully rewrite UNIX in C
- ▶ Other features added to UNIX
 - ▶ Support for multiple users simultaneously
 - ▶ Pipes

Ken Thompson discusses the birth of C. Video courtesy of Vintage Computer Federation. Used with permission.

Berkeley: circa 1974 — 1995

- ▶ 1974: Thompson and Ritchie publish landmark UNIX paper
- ▶ Bell Labs could not legally sell UNIX
- ▶ UNIX is licensed to Universities for a small fee
- ▶ Thompson mails tapes of UNIX source code
- ▶ University of California at Berkeley obtains an early copy
- ▶ Researchers at Berkeley make numerous improvements
 - ▶ Virtual memory (paging)
 - ▶ Networking
 - ▶ Utilities: vi, csh, various compilers
- ▶ Berkely Software Distribution (BSD) UNIX “competes” with AT&T Bell Labs UNIX

Mid 1970s — UNIX spreads

Why?

- ▶ Because it CAN — written in C, very portable
- ▶ Universities use it
 - ▶ Students graduate, expect UNIX environment at work
- ▶ UNIX Philosophy
 - ▶ Many small, compact utilities to perform simple tasks
 - ▶ AND, the ability to combine these
 - ▶ Utilities are also written in C — you can write your own
- ▶ Stability
 - ▶ Users don't need to know system details
 - ▶ Different machines can use the same environment
 - ▶ That environment has not changed much in 50 years
- ▶ What are the alternatives?

Licensing issues begin

- ▶ 1984: US Department of Justice splits up the Bell System
- ▶ AT&T can legally start selling UNIX
- ▶ AT&T moves to commercialize UNIX
 - ▶ New licenses not as favorable for academic use
 - ▶ Berkeley begins removing AT&T code
- ▶ 1992: Unix System Laboratories sues Berkeley Software Design (loses)
- ▶ 1994: AT&T sells all rights to UNIX to Novell
- ▶ 1995: Novell “partially” sells to SCO
- ▶ 2000: SCO sells to The SCO Group
- ▶ 2003 and after: The SCO Group sues everybody about Linux

POSIX: circa 1988

- ▶ POSIX: Portable Operating System Interface
- ▶ A family of standards for compatibility between OS's
 - ▶ Standards are specified by the IEEE
- ▶ Goal is to keep UNIX space coherent

100% POSIX compliant:

- ▶ BSD
- ▶ HP-UX
- ▶ Mac OS X

Mostly POSIX compliant

- ▶ FreeBSD, NetBSD, OpenBSD
- ▶ GNU/Linux



Ken Thompson and Dennis Ritchie are awarded the “National Medal of Technology” by Bill Clinton

Richard Stallman

- ▶ Annoyed by software licenses
- ▶ 1984: Quits MIT AI Lab, starts “GNU” project
 - ▶ GNU: GNU's Not UNIX
(acronym with recursive definition)
- ▶ Goal of GNU: develop a complete UNIX-like OS but *avoid licensing issues*
- ▶ Wrote first versions of
 - ▶ gcc: C compiler
 - ▶ gdb: debugger
 - ▶ Emacs: text editor
- ▶ See <http://www.gnu.org>
- ▶ 1985: founds *Free Software Foundation*

GNU Freedoms

0. Freedom to run the program for any purpose
 1. Freedom to study how the program works, and change it (source code must be available)
 2. Freedom to redistribute copies to others, with source code
 3. Freedom to distribute your *modified* copies (note: you are allowed to sell them, but you still *must* include the source code)
- ▶ GNU refers to this as “copyleft” since freedoms are guaranteed, instead of taken away
 - ▶ This is an example of “open source software”

GNU Licenses

- ▶ LGPL: GNU Lesser General Public License
 - ▶ Requires software and derivatives to have source code available
 - ▶ Basically, the four freedoms
 - ▶ Can be used by open source, or proprietary software
- ▶ GPL: GNU General Public License
 - ▶ LGPL, plus the following requirement:
Software that uses GPL software *must be open source*

There are many other open source software licenses.

Status in 1990

- ▶ GNU has working versions of most UNIX utilities
 - ▶ In many cases, utilities have been improved
- ▶ However, still needs a *kernel*

What is a kernel?

- ▶ Essentially, the “core” of the operating system
- ▶ Layer of software between hardware and applications
- ▶ Starts when the system boots
- ▶ Always “running”
- ▶ Manages memory, CPU, devices, I/O, running applications

1991: Birth of Linux

- ▶ Started by Linus Torvalds
 - ▶ Finnish undergraduate student
- ▶ August 25: posts message to MINIX OS newsgroup
 - ▶ He's working on a "hobby" UNIX-like OS (kernel)
- ▶ October 5: First version available to the public
 - ▶ Runs on AT clones (386/486)
- ▶ Kernel is self-named (Lin-UX)
- ▶ Linux kernel is released under GNU GPL (version 2)
- ▶ 1992: Linux kernel is combined with GNU utilities
 - ▶ This gives a complete system
 - ▶ Proper name is "GNU/Linux", but most simply call it "Linux"

August 25 post to MINIX newsgroup

From: torvalds@@klaava.Helsinki.FI (Linus Benedict Torvalds)
Newsgroups: comp.os.minix
Subject: What would you like to see most in minix?
Summary: small poll for my new operating system
Message-ID: <1991Aug25.205708.9541@@klaava.Helsinki.FI>
Date: 25 Aug 91 20:57:08 GMT
Organization: University of Helsinki

Hello everybody out there using minix -

I'm doing a (free) operating system (just a hobby, won't be big and professional like gnu) for 386(486) AT clones. This has been brewing since april, and is starting to get ready. I'd like any feedback on things people like/dislike in minix, as my OS resembles it somewhat (same physical layout of the file-system (due to practical reasons) among other things).

I've currently ported bash(1.08) and gcc(1.40), and things seem to work. This implies that I'll get something practical within a few months, and I'd like to know what features most people would want. Any suggestions are welcome, but I won't promise I'll implement them :-)

Linus (torvalds@@kruuna.helsinki.fi)

PS. Yes - it's free of any minix code, and it has a multi-threaded fs. It is NOT portable (uses 386 task switching etc), and it probably never will support anything other than AT-harddisks, as that's all I have :-).

GNU utilities and Linux

Technically, they are separate

- ▶ Linux refers to the *kernel*
- ▶ GNU utilities can run on
 - ▶ Linux kernel
 - ▶ FreeBSD kernel (www.freebsd.org)
 - ▶ GNU Hurd kernel
 - ▶ Mac OS X
 - ▶ Homebrew
 - ▶ MacPorts
 - ▶ ...or build them yourself from source code
 - ▶ Windows
 - ▶ Cygwin
 - ▶ ...others
 - ▶ Mobile devices
- ▶ Freedom 0 actually encourages this

Building a Linux system — early 1990s

1. Download Linux kernel, and GNU components
 - ▶ Internet makes this easy
2. Compile everything on your hardware
 - ▶ Not that hard, but time consuming
3. Track down missing pieces and dependencies by hand
 - ▶ Software requires libraries (other software)
 - ▶ This part can be unpleasant

Not surprisingly, we start to see

- ▶ Support groups and HOWTOs
 - ▶ www.tldp.org
 - ▶ “Here’s how I got it to work. Your mileage may vary.”
- ▶ Distributions

Distributions

- ▶ Someone else gets all the components for you
- ▶ Typically use “package management” software
 - ▶ Packages come in self-contained files
 - ▶ Is aware of software dependencies
 - ▶ Makes it easier to install, upgrade, remove software
- ▶ Why? For fun and/or profit
 - ▶ Can sell the CDs / DVDs
 - ▶ Legally under GPL
 - ▶ ... but it is also legal for people to copy them
 - ▶ Can sell *support*
- ▶ There are **hundreds** of Linux distributions
 - ▶ www.linux.org
 - ▶ Not all are in English
 - ▶ Not all are for PCs

Red Hat (www.redhat.com)

- ▶ Started around 1994
- ▶ In 2003, branched into two main directions
 - ▶ RH Enterprise Linux
 - ▶ Pay subscription for updates
 - ▶ Certified, 24-7 support, etc.
 - ▶ Fedora
 - ▶ Open source project
 - ▶ **NOT** a product of Red Hat
 - ▶ www.fedoraproject.org
- ▶ Uses RPM package files (Red Hat Package Management)
 - ▶ Files with extension `.rpm`

Some other popular distributions

- ▶ Debian (www.debian.org)
 - ▶ No cost; maintained by volunteers
 - ▶ Started 1993
 - ▶ Uses dpkg package management (files with extension .deb)
- ▶ Ubuntu (Debian based)
- ▶ Slackware (www.slackware.com)
- ▶ Gentoo (www.gentoo.org)
 - ▶ Fast — all packages are compiled for your machine
- ▶ Arch Linux
- ▶ openSUSE

Xerox Alto

- ▶ A computer developed at Xerox PARC
- ▶ Uses 3-button mouse
- ▶ “Portrait orientation” display with GUI
- ▶ Built-in ethernet for networking
- ▶ Works great with Xerox laser printer

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- ▶ *So what?*

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- ▶ Was released in 1973



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- ▶ *So what?*
- ▶ Was released in 1973
- ▶ What happened?
 - ▶ Shouldn't we all have Xerox machines on our desk?
 - ▶ Shouldn't we all be running Xerox OS's?



Xerox PARC (Palo Alto Research Center)

- ▶ Founded in 1970 for R&D
 - ▶ Worried about cheap copiers from Japan
 - ▶ Wanted new technologies, leading to future products
 - ▶ Charter was to “invent the electronic office”
- ▶ Researchers had complete intellectual freedom
 - ▶ Invented: laser printing, ethernet, GUI, OOP (Smalltalk)
 - ▶ Alto had GUI word processing (“Bravo”), email, and other applications
- ▶ Xerox management did not see value in the Alto
 - ▶ Wanted things involved with photocopiers
- ▶ 1979: Apple visits Xerox PARC
 - ▶ Xerox buys Apple stock (before IPO)
 - ▶ Xerox discloses R&D to Apple
 - ▶ Apple targets new machines for GUI

X (or, X Window System)

- ▶ Originated at MIT in 1984
- ▶ Is a successor to older window system, named “W”
 - ▶ Ran under the “V” operating system
- ▶ Current protocol: version 11 (released 1987)
- ▶ X11 currently governed by the X.Org Foundation
- ▶ Several implementations, for many platforms
 - ▶ UNIX, Linux
 - ▶ Mac OS
 - ▶ Microsoft Windows
 - ▶ Android
- ▶ Note: X is a simple GUI
 - ▶ Need a window manager, runs on top of X
 - ▶ Need a desktop environment, runs on top of window manager

Apple: 1976

- ▶ Steve Wozniak and Steve Jobs released Apple I in 1976
 - ▶ First computer consisting of a single circuit board
- ▶ Apple II released 1977
 - ▶ First personal computer with color graphics
- ▶ These were basic machines with a limited OS



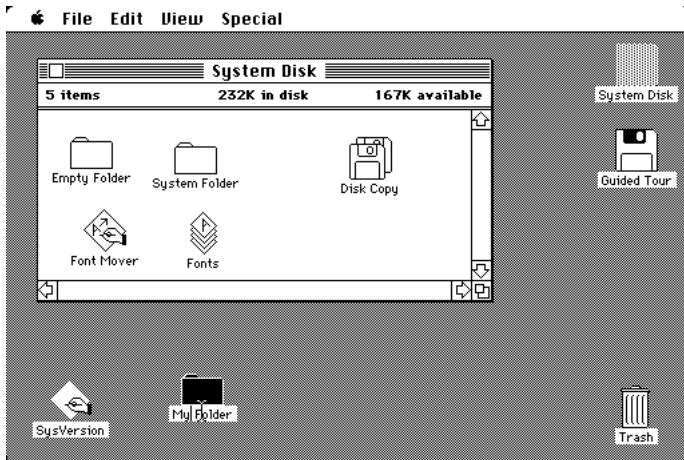
Lisa and Macintosh

- ▶ During Apple III design, Jef Raskin wanted to
 - ▶ Eliminate the character generator
 - ▶ Do character generation graphically
- ▶ Raskin started Macintosh project in 1979
- ▶ Raskin and others set up the Xerox PARC visit
- ▶ After the Xerox PARC demos, Jobs was convinced
- ▶ Many improvements were made to Xerox Alto GUI
 - ▶ Trash, overlapping windows, menu bar, drag & drop, ...
- ▶ Lisa: first personal computer with GUI, released 1983
 - ▶ Late, and expensive: \$10k
- ▶ Macintosh: released 1984 (\$2500)

Steve Jobs discusses the Xerox PARC visit. Clip from “Steve Jobs: The Lost Interview”.



Original 1984 Mac



Original 1984 Mac OS

NeXT: circa 1985 — 1996

- ▶ 1983: Jobs hires Pepsi-Cola CEO, John Sculley
- ▶ 1985: Steve Wozniac leaves Apple
- ▶ 1985: Jobs demoted from head of Macintosh division
- ▶ 1985: Jobs quits Apple, founds “NeXT”
- ▶ 1988: NeXT workstation computer introduced
 - ▶ Target is University use
 - ▶ Competes with Sun
- ▶ NeXT machines run NeXTSTEP OS
 - ▶ “Unix-like”
 - ▶ Based on Mach kernel plus BSD
- ▶ Fun fact: WWW was invented on a NeXT Computer

Mac OS X

- ▶ 1993: John Sculley leaves Apple
- ▶ 1996: Apple buys NeXT
 - ▶ Mac OS 9 needs to be updated
 - ▶ Want to base replacement on NeXTSTEP OS
- ▶ 1997: Jobs returns to Apple
- ▶ 2001: Mac OS X released
 - ▶ Still “Unix-like”
 - ▶ Uses Quartz for GUI
 - ▶ An implementation of X is available for compatibility

DOS: about 1980 — 2000

In 1980, IBM decides to get into personal computer business

- ▶ Met with Bill Gates
- ▶ Microsoft made deal to write *Basic* for IBM PC
- ▶ Gates suggested CP/M for an OS
- ▶ CP/M deal fell through for IBM
- ▶ Tim Paterson wrote “86-DOS” based on CP/M
 - ▶ Microsoft hired Tim Paterson
 - ▶ Bought 86-DOS
 - ▶ Renamed MS-DOS
- ▶ IBM let Microsoft keep rights to MS-DOS
 - ▶ Allowed Microsoft to market MS-DOS separately
- ▶ All this was secret until IBM PC appeared in 1981



Original IBM PC

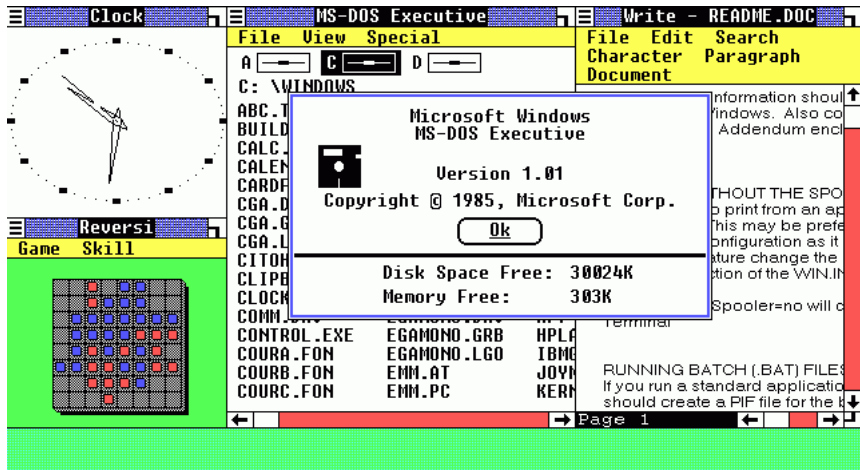
DOS limitations

DOS was designed to run on Intel 8088/8086 computers

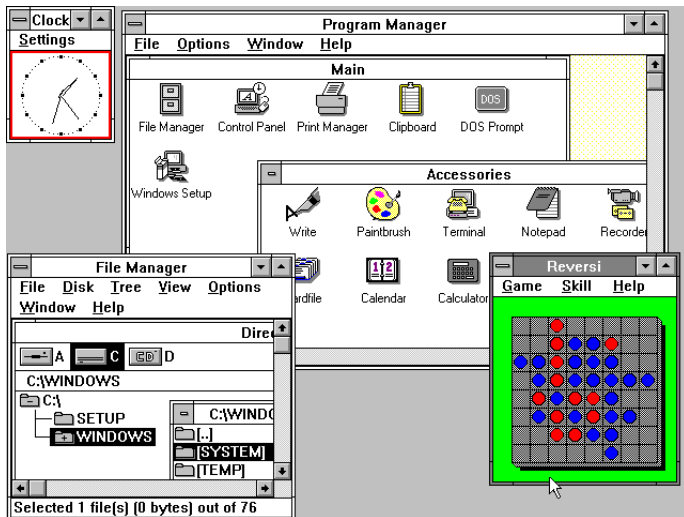
- ▶ Text only, no GUI
- ▶ No hardware protection
- ▶ Applications can access hardware directly
 - ▶ Would do so, for speed
- ▶ OS accesses hardware directly
 - ▶ Can lead to conflicts
 - ▶ Spectacular crashes were common
- ▶ Many faults of DOS are due to the hardware
- ▶ Good hardware protection not available until Intel 80386

Windows: 1985 — 1995

- ▶ Apple hired Microsoft to develop applications for Macintosh
- ▶ Microsoft licensed part of Macintosh user interface from Apple
- ▶ Windows 1.0 contained only the licensed parts
- ▶ 1987: Windows 2.0, added some Macintosh features
- ▶ 1988: Apple sued Microsoft for copyright infringement, lost
- ▶ 1990: Windows 3.0 (started to catch on)
- ▶ Early 1990's: Windows 3.0, 3.1, 3.11, etc.
- ▶ All these ran on top of DOS



Windows 1.0 (Used with permission from Microsoft)



Windows 3.0 (Used with permission from Microsoft)

Windows 95 and derivatives: about 1995 — 2000

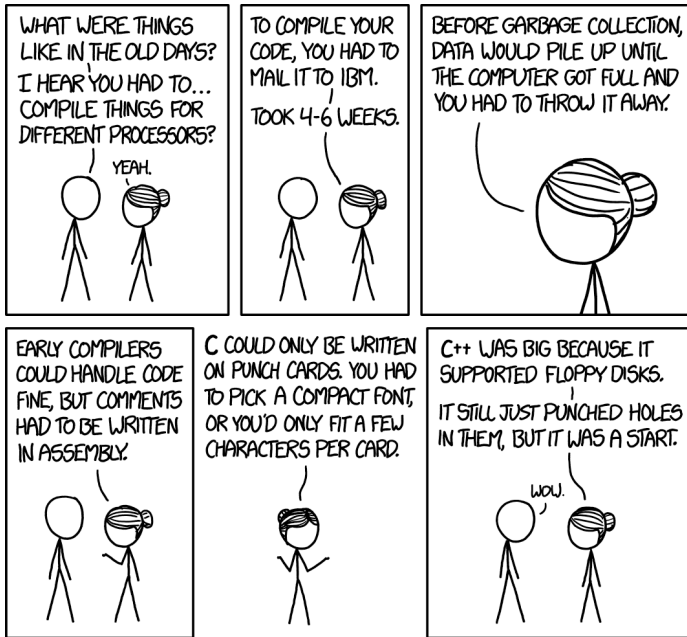
- ▶ Windows 95 released in 1995
- ▶ PC now boots directly into Windows 95
 - ▶ Ok, not always, you can still boot into DOS mode
- ▶ All applications run in 386 enhanced mode
 - ▶ Flat 32-bit address space
 - ▶ Virtual memory
 - ▶ Hardware protections
 - ▶ PCs are much more stable now
- ▶ Windows 98
- ▶ Windows ME (2000)

Windows NT and derivatives: about 1993 — 2000

- ▶ Late 1980's: Microsoft and IBM are cooperating on OS/2
- ▶ Early 1990's: Microsoft / IBM relationship is terminated
- ▶ Microsoft continues working on its version of OS/2
 - ▶ This becomes Windows NT (released 1993)
 - ▶ Designed for network use
- ▶ 1996: Windows NT 4.0
- ▶ 2000: Windows NT 5.0 (Windows 2000)

Merging of NT and 95 lines: 2001 —

- ▶ 2001: Windows NT 5.1 (Windows XP)
 - ▶ Finally merged NT and 95/98/ME lines
- ▶ 2007: Windows NT 6.0 (Vista)
- ▶ 2009: Windows 7
- ▶ 2012: Windows 8
- ▶ 2015: Windows 10
 - ▶ Windows Subsystem for Linux



End of lecture