Operating Systems

MODERN OPERATING SYSTEMS
Third Edition
ANDREW S. TANENBAUM

Chapter 1
Introduction

Introduction

- How many operating systems have you known?

What Is An Operating System (1)

A modern computer consists of:

- One or more processors
- Main memory
- Disks
- Printers
- Various input/output devices

Managing all these components requires a layer of software – the **operating system**

What Is An Operating System (2)

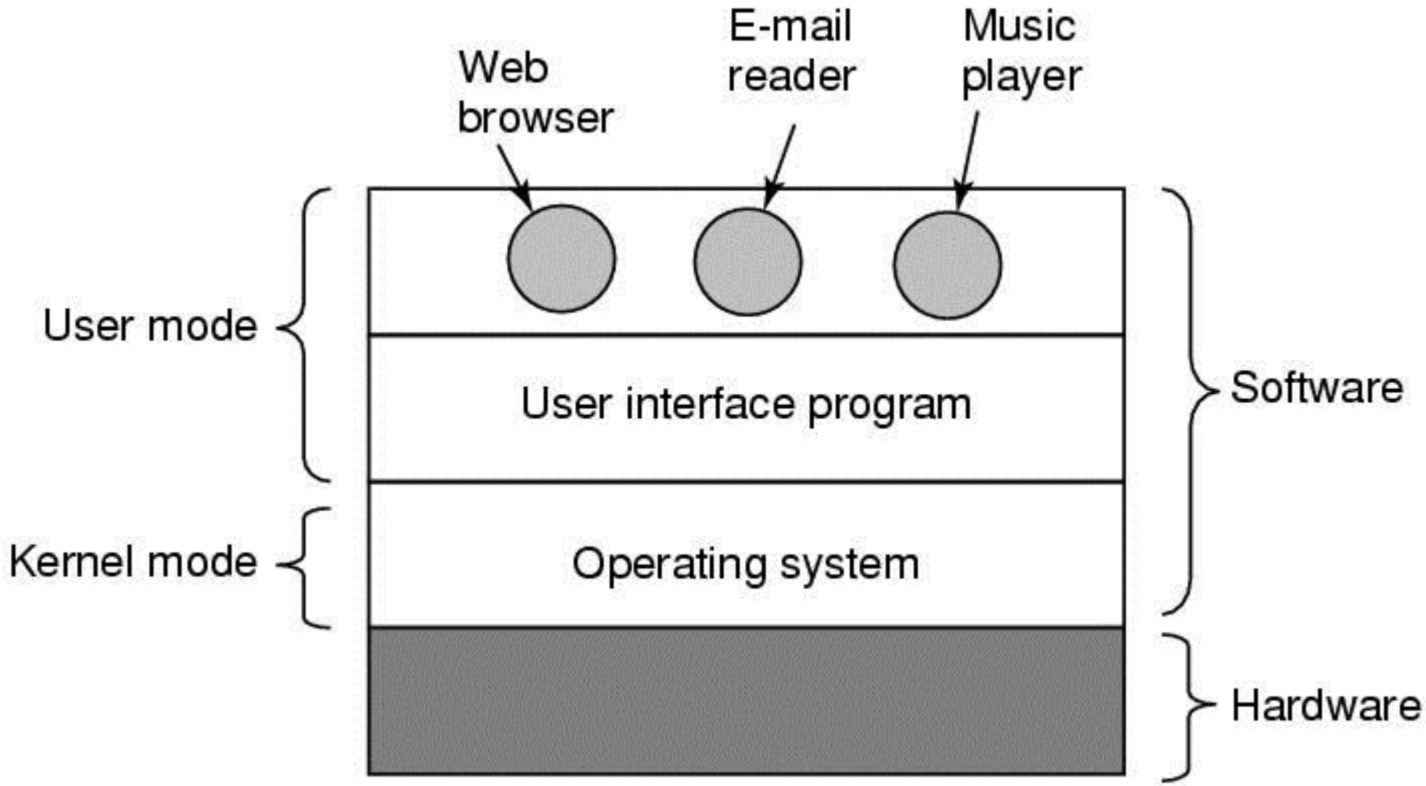


Figure 1-1. Where the operating system fits in.

The Operating System as an Extended Machine

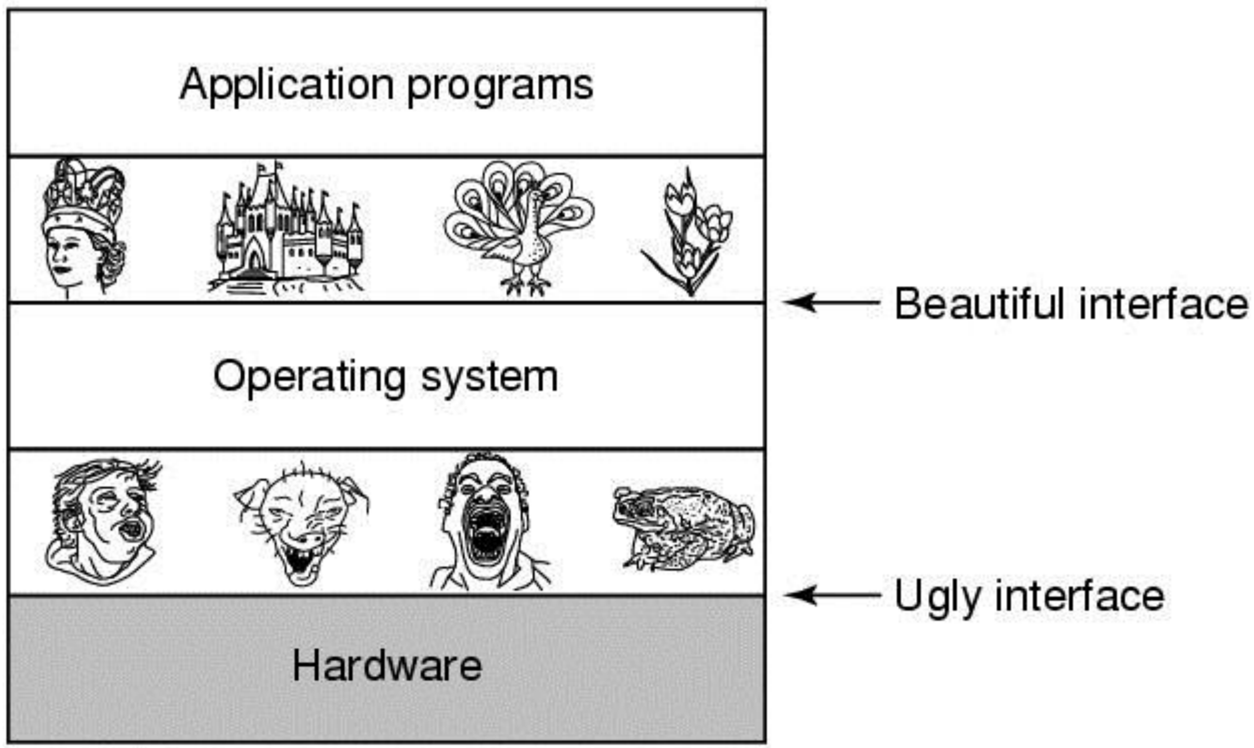


Figure 1-2. Operating systems turn ugly hardware into beautiful abstractions.

The Operating System as a Resource Manager

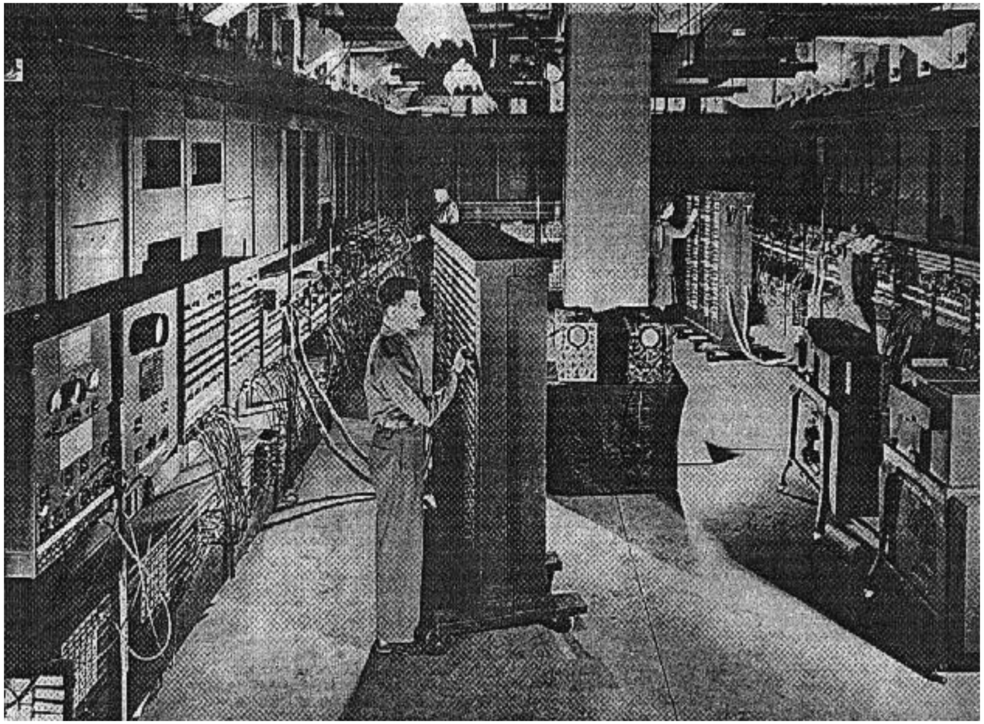
- Allow multiple programs to run at the same time
- Manage and protect memory, I/O devices, and other resources
- Includes multiplexing (sharing) resources in two different ways:
  - In time
  - In space

History of Operating Systems

Generations:

- (1945–55) Vacuum Tubes
  - 真空管和插件板
- (1955–65) Transistors and Batch Systems
  - 晶体管和批处理系统
- (1965–1980) ICs and Multiprogramming
  - 集成电路和多道程序设计
- (1980–Present) Personal Computers

1945-1955 Vacuum Tubes Plugboards



John Von Neumann

Ada Lovelace

ENIAC

Alan Turing

History of Operating Systems

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Transistors and Batch Systems (1)

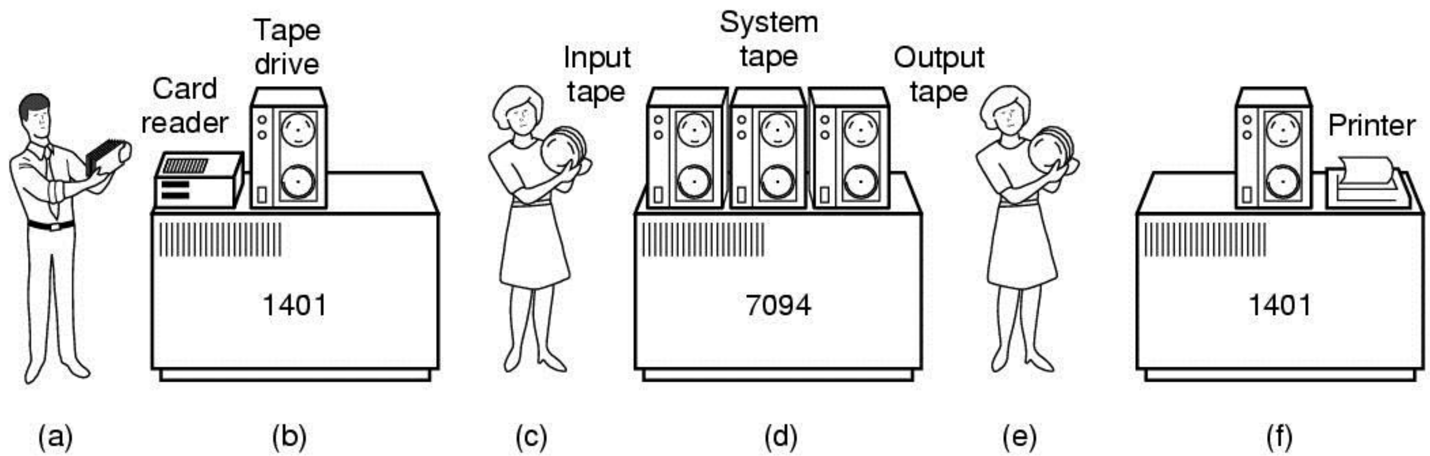
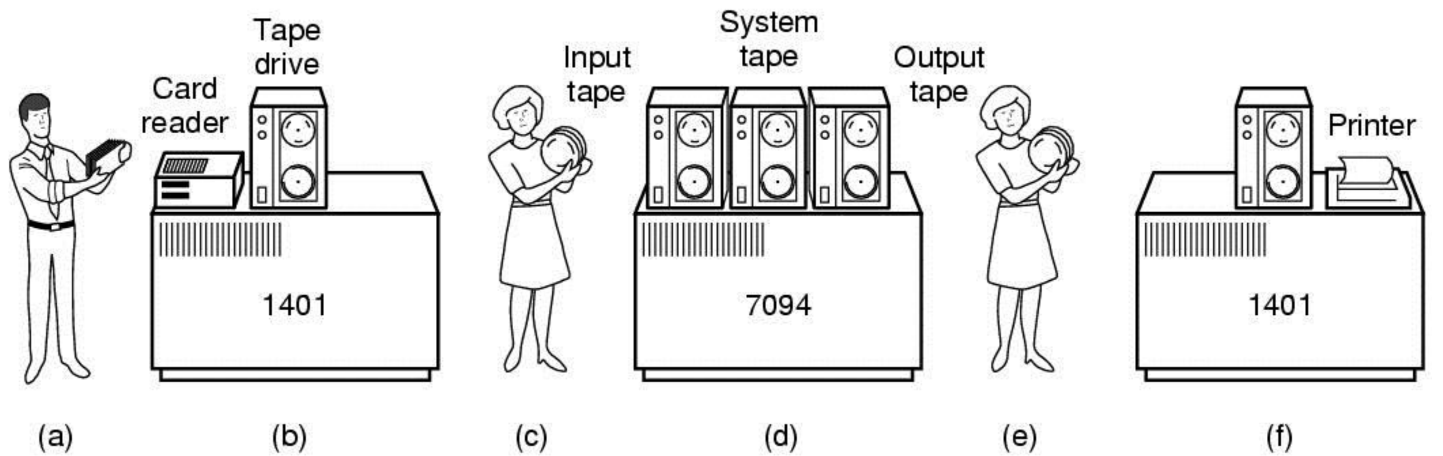


Figure 1-3. An early batch system.
(a) Programmers bring cards to IBM 1401.
(b)1401 reads batch of jobs onto tape.

Transistors and Batch Systems (2)



(c) Operator carries input tape to IBM 7094.

(d) 7094 does computing.

(e) Operator carries output tape to 1401.

(f) 1401 prints output.

Transistors and Batch Systems (4)

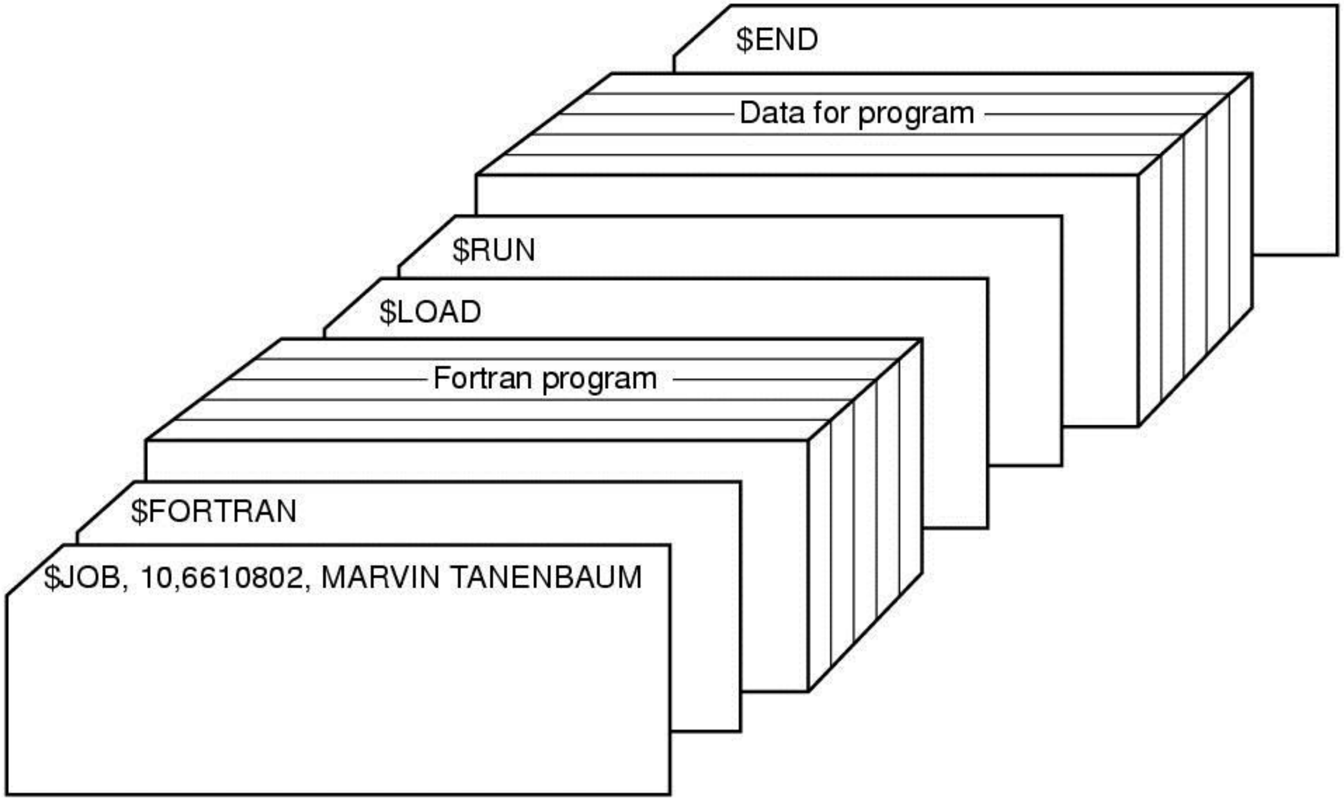


Figure 1-4. Structure of a typical FMS job.

History of Operating Systems

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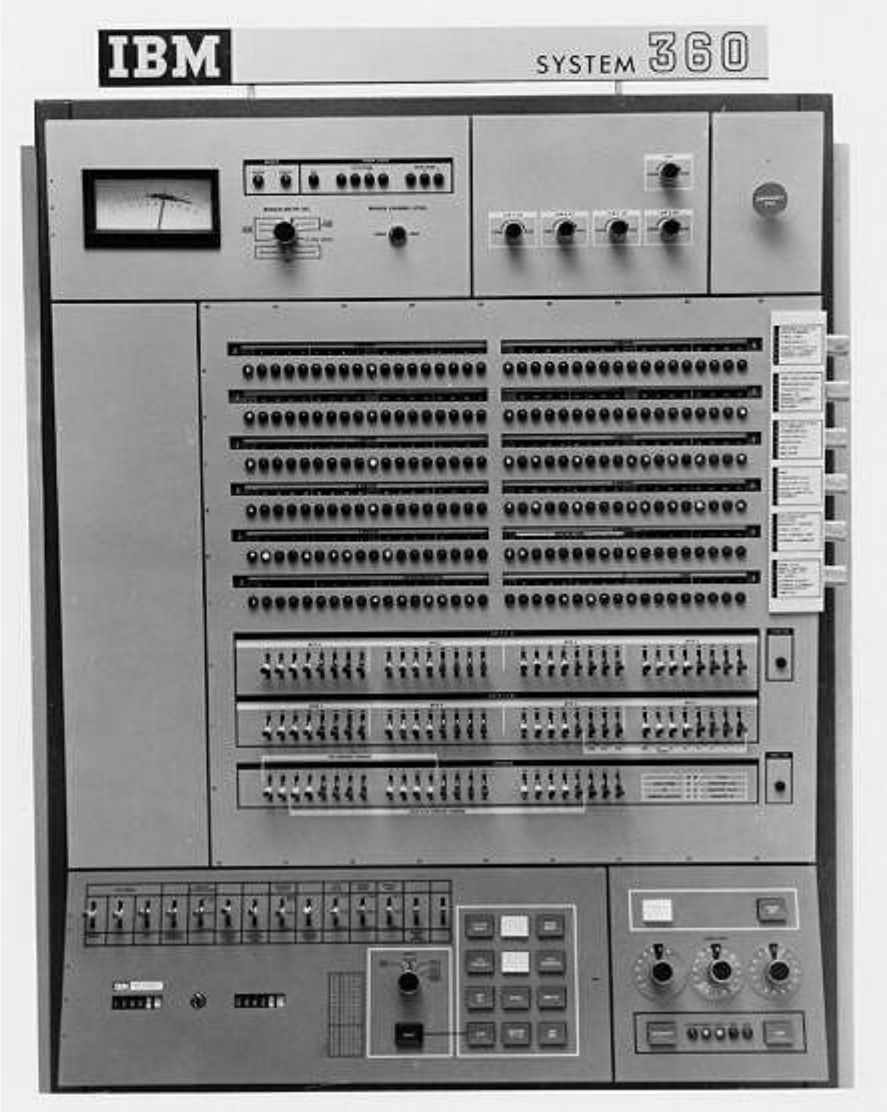
- (1980–Present) Personal Computers

IBM System/360



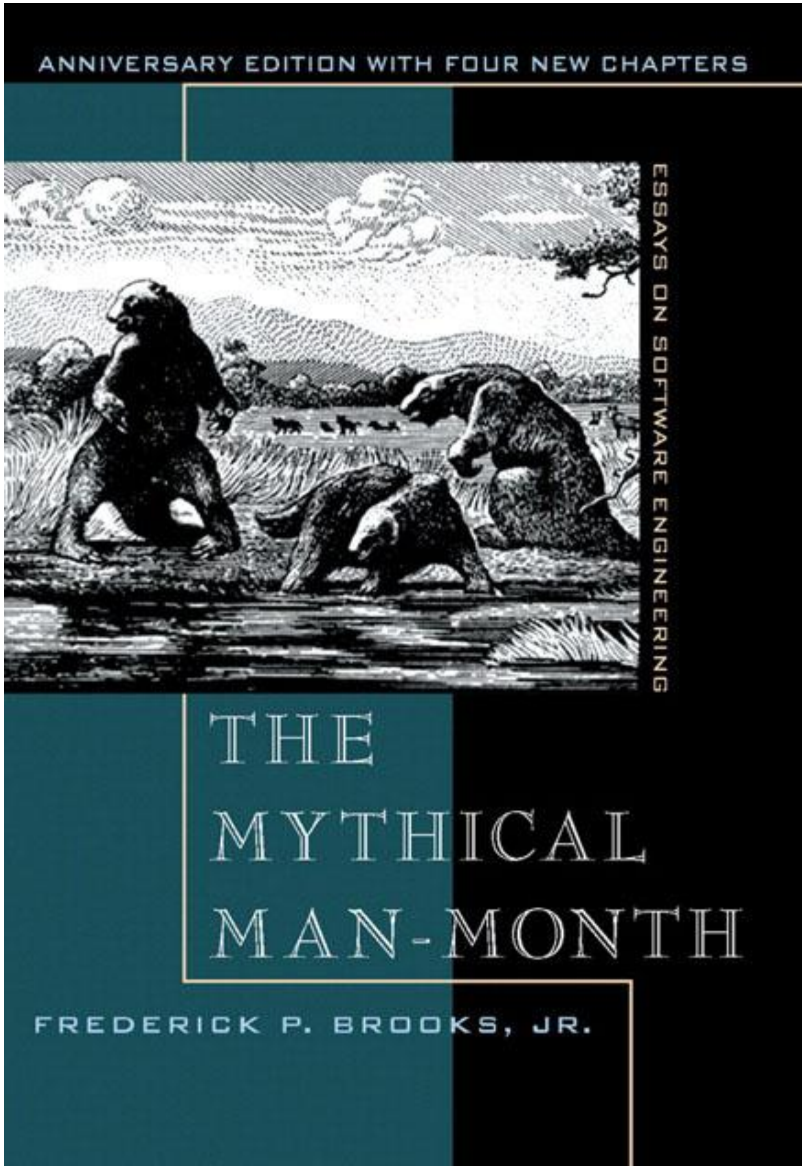
One Family

OS/360

Multiprogramming

SPOOLing
(Simultaneous Peripheral Operation On Line)

OS/360



Written by
Fred Brooks,
One of the designers
of OS/360

ICs and Multiprogramming

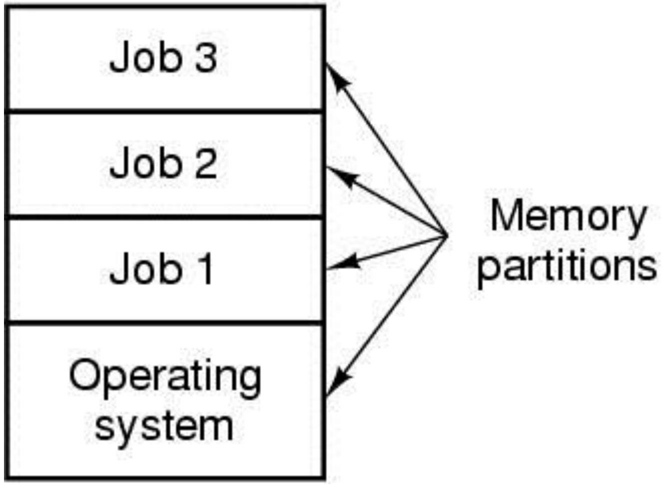
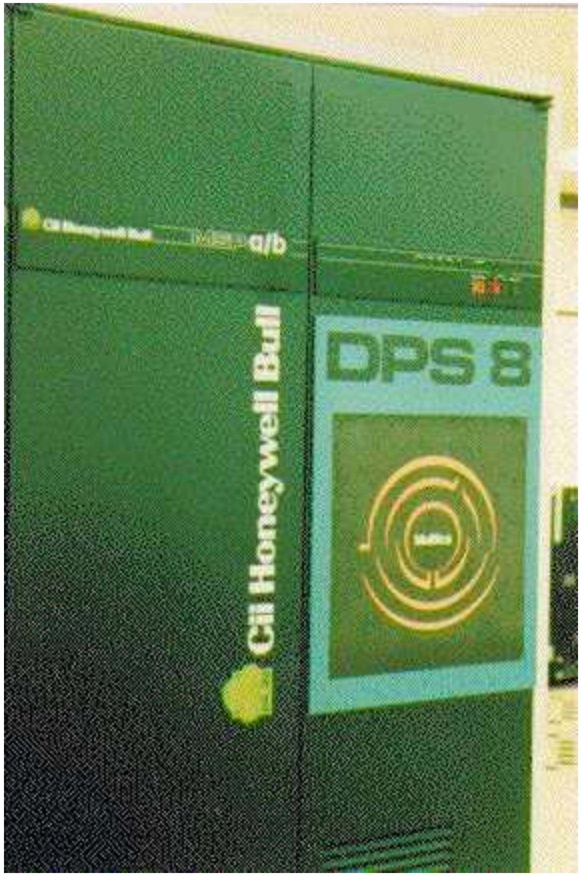


Figure 1-5. A multiprogramming system with three jobs in memory.

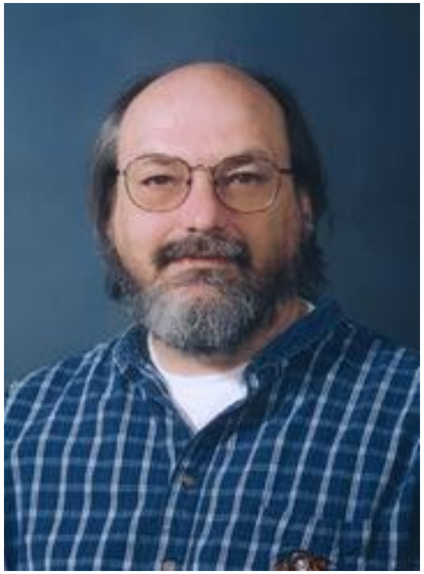
Time Sharing Systems

- CTSS
  - Compatible Time Sharing system
  - MIT, 7094 based
- MULTICS
  - MULTiplexed Information and Computing Service
  - MIT, Bell Labs, General Electric
  - Sold by Honeywell



GE-645

History of UNIX



Dennis Ritchie Ken Thompson

History of UNIX

- 1969' UNIX
  - Ken Thompson
  - Bell Lab (AT&T)
  - DEC PDP-7
  - UNICS -> UNIX
  - BCPL (Basic Combined Programming Language)
  - Richie BCPL->C

PDP - Programmed Data Processor

History of UNIX

- 1970: PDP-11/20
- 1971: Unix Programmer's Manual
- 1972: Richie B->C, *The C Programming Language*
- 1973: *The UNIX Time — Sharing System*
- 1983 Turing Award

History of UNIX

- AT&T: System V Release

- Berkeley Software Distribution: BSD

- UNIX Family
  - IBM: AIX
  - HP: HP-UX
  - SUN: Solaris
  - Linux, FreeBSD

1997 Deep Blue vs Kasparsov

History of Operating Systems

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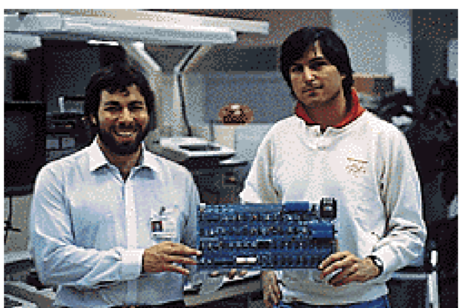
- <u>**(1980–Present) Personal Computers**</u>

First Microcomputer

1975: MIPS 8800 (Intel 8080)

Apple



Wozniak, Jobs, and the Apple I

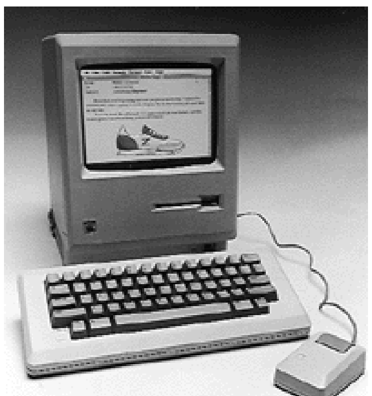
1976: Apple I

1977: Apple II

1MHz, 4KB Memory

Apple Computer

- 1984: Motorola 68000
- 1998: PowerPC
- 2006: Intel



The Original Macintosh:$2495

IBM PC

- 1981: IBM Personal Computer
  - Intel 8088(4.77MHz) 16KB
  - MS-DOS/PC-DOS
- 1985: Intel 80386
- 1986: Compaq 386
- 1987: IBM PS/2 (386, MCA)

  IBM OS/2
- RISC: PowerPC vs Intel
- 1993: Intel Pentium

Microsoft Windows

- 1985: Windows 1.0; 1987: 2.0
- 1990: Windows 3.0; 1992: 3.1
- 1993: Windows NT 3.1
- 1995: Windows 95 4.0; 1996: NT4.0
- 1998: Windows 98 4.1
- 2000: Windows ME 4.9; Win2000 (NT 5.0)
- 2001: XP(NT 5.1); 2003:Server 2003
- 2006: Vista(NT 6.0); 2008: Server 2008
- 2009: Windows 7 (NT 6.1)

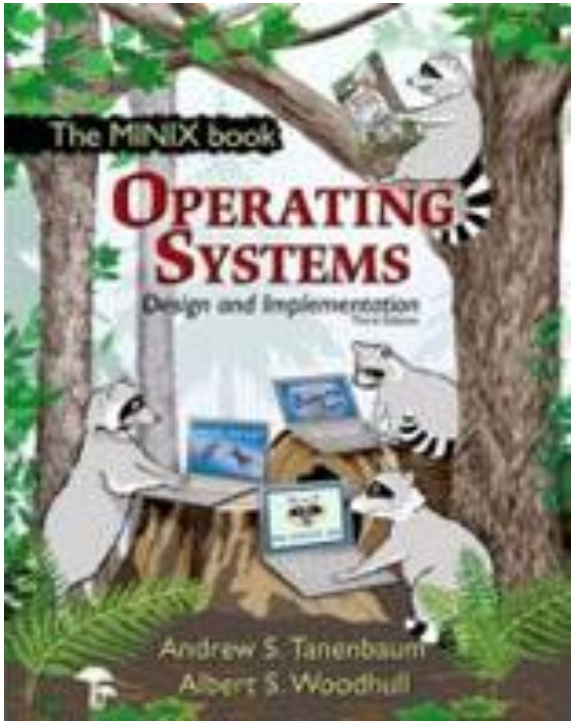
GNU Free Software – R. Stallman

- 1984: Richard Stallman starts GNU project
  - GNU's not UNIX
  - http://www.gnu.org
- Purpose: Free UNIX
  - "Free as in Free Speech, not Free Beer"
- First step: re-implementation of UNIX Utilities
  - C compiler, C library
- To fund the GNU project, the Free Software

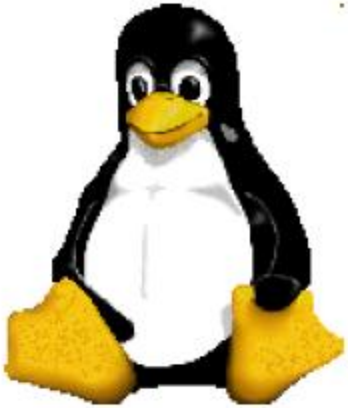
Foundation is founded
  - http://www.fsf.org

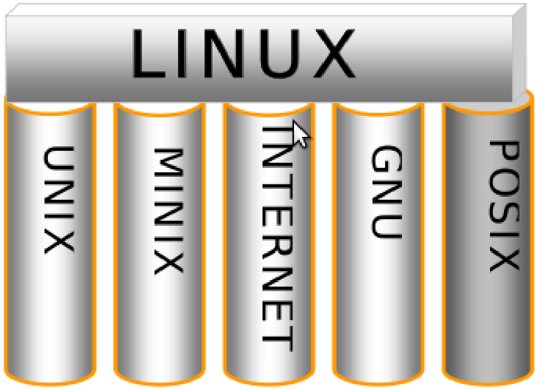
Minix – AST

- Andrew S. Tanenbaum (AST)
- http://www.cs.vu.nl/~ast/
- http://www.minix3.org/



Linux – Linus Torvalds

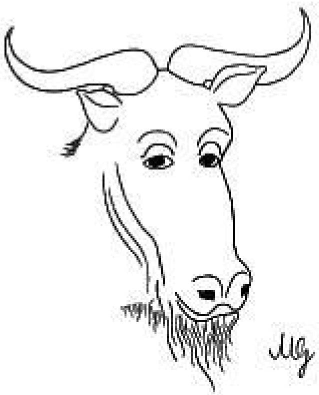




- 1991: Linus Torvalds writes 1st version of Linux kernel
- Linus' UNIX -> Linux
- Combined with the GNU and other tools forms a complete UNIX system
- Mascot: Tux

General Public License

- Most software (including the Linux kernel) is GPL'ed (GNU General Public License)
  - http://www.gnu.org/copyleft/gpl.html
- Linux is called "copyleft" (instead of "copyright").
  - You can copy the software.
  - You get the source code.
  - You can alter the source code and recompile it.
  - You can distribute the altered source and binaries.
  - You can charge money for all this.



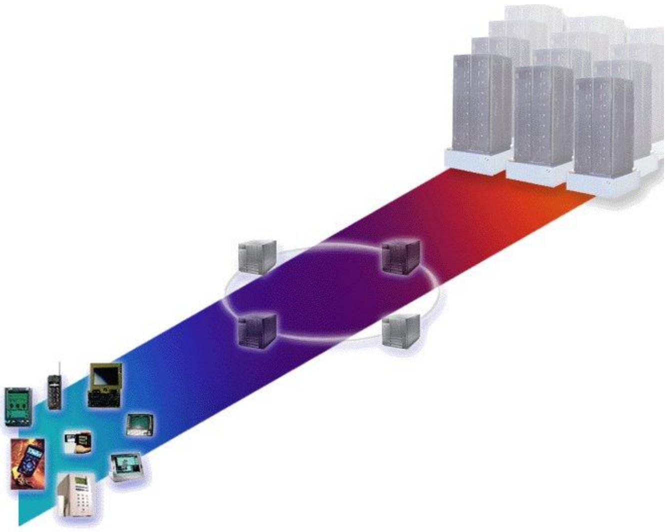
- You cannot change the license.
  - So all your customers have the same rights as you.
  - So you really cannot make money from selling the software alone.
- Other Open Source licenses (for example, BSD) are also used

Linux Kernel vs Distributions

- Kernel version like: 2.6.32-24
- Distributions:
  - RedHat: Fedora
  - Ubuntu: from Debian
  - SuSE: OpenSuSE
  - RedFlag
  - …

Linux Today

- Linux covers the whole spectrum of computing
  - Embedded devices
  - Laptops
  - Desktop systems
  - Development systems
  - Small and large servers
  - Megaclusters/supercomputers



- Linux is used throughout the world
  - ... and in space
- Linux is used by home users
  - ... and by some of the largest companies in the world
  - IBM
  - NASA

Embedded/Mobile Operating Systems

- Symbian OS
- RIM BlackBerry OS
- iOS for Apple
- Windows Phone
- Android from Google
- Linux
- Palm OS
- …

Computer Hardware Review

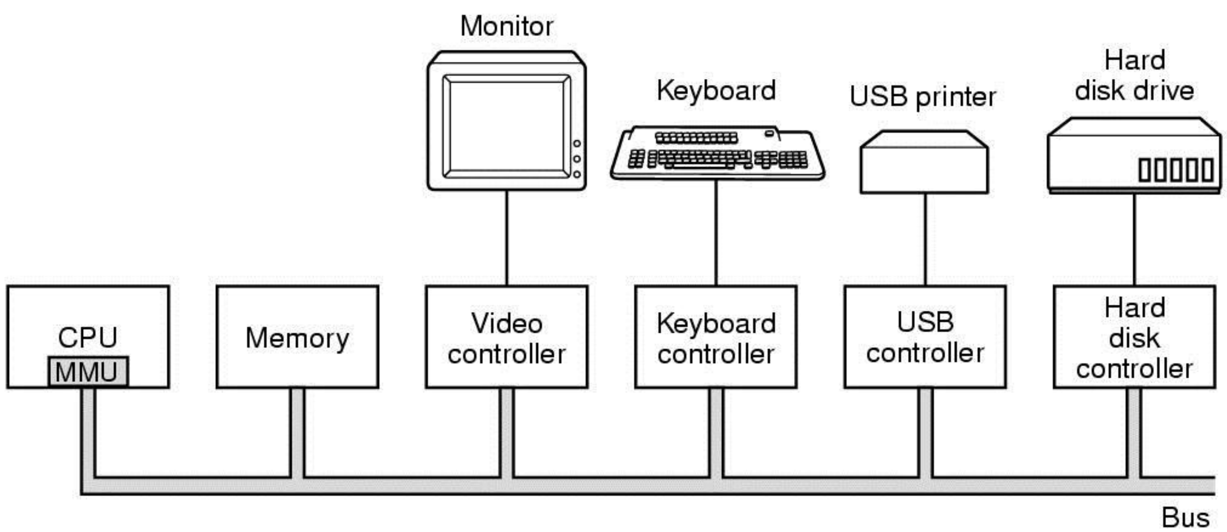


Figure 1-6. Some of the components of a simple personal computer.

CPU Pipelining

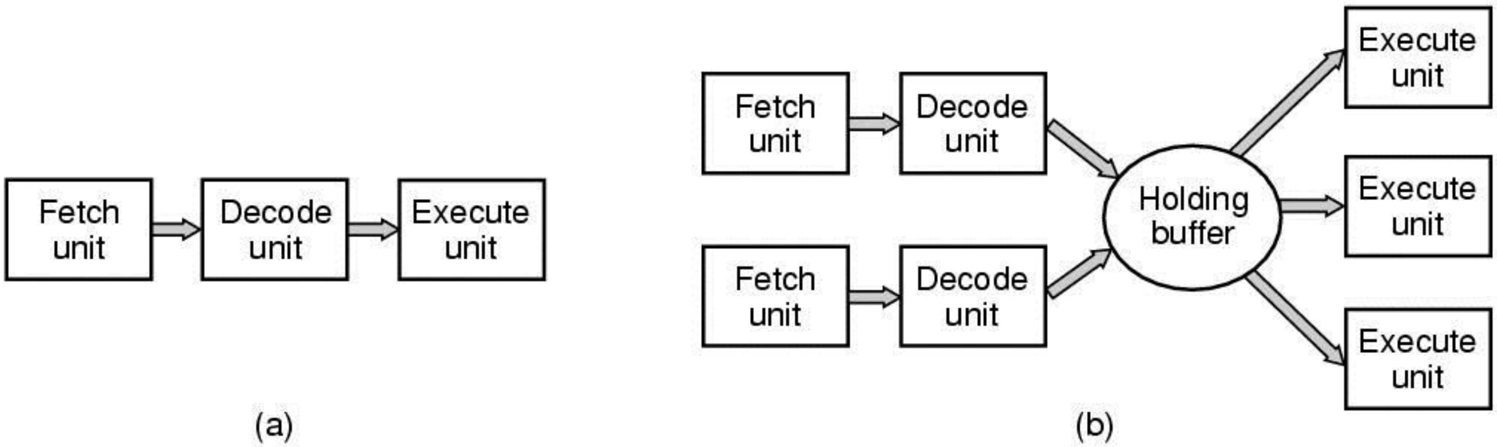


Figure 1-7. (a) A three-stage pipeline. (b) A superscalar CPU.

Multithreaded and Multicore Chips

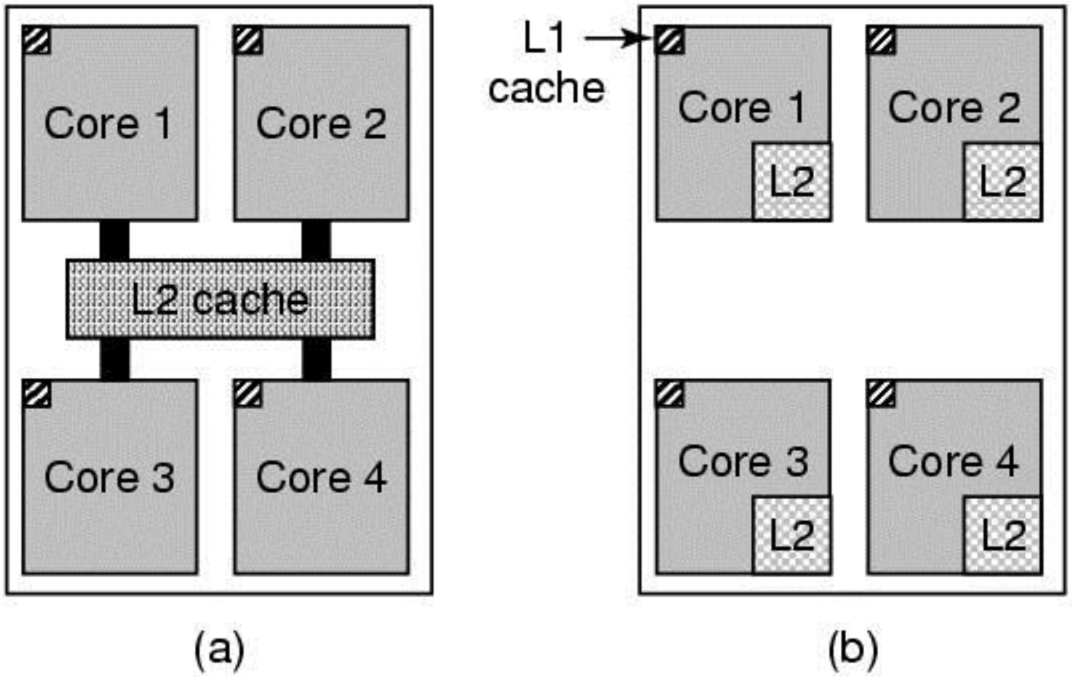


Figure 1-8. (a) A quad-core chip with a shared L2 cache.
(b) A quad-core chip with separate L2 caches.

Memory (1)

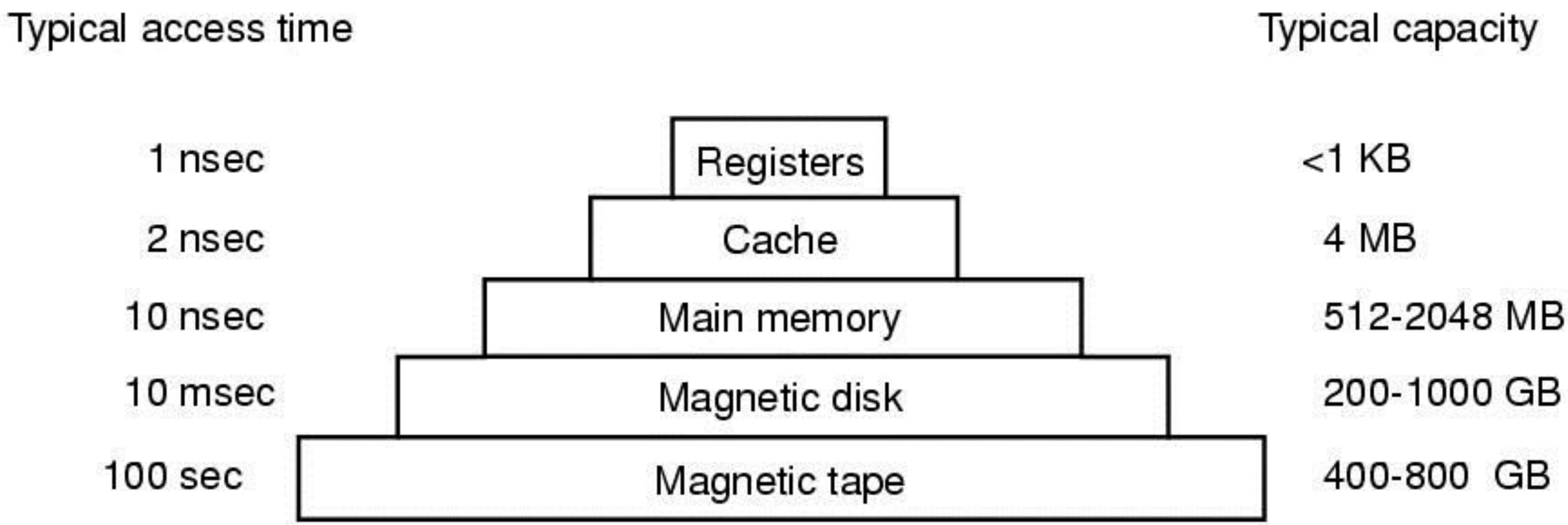


Figure 1-9. A typical memory hierarchy.
The numbers are very rough approximations.

Memory (2)

Questions when dealing with cache:

- When to put a new item into the cache.
- Which cache line to put the new item in.
- Which item to remove from the cache when a slot is needed.
- Where to put a newly evicted item in the larger memory.

Disks

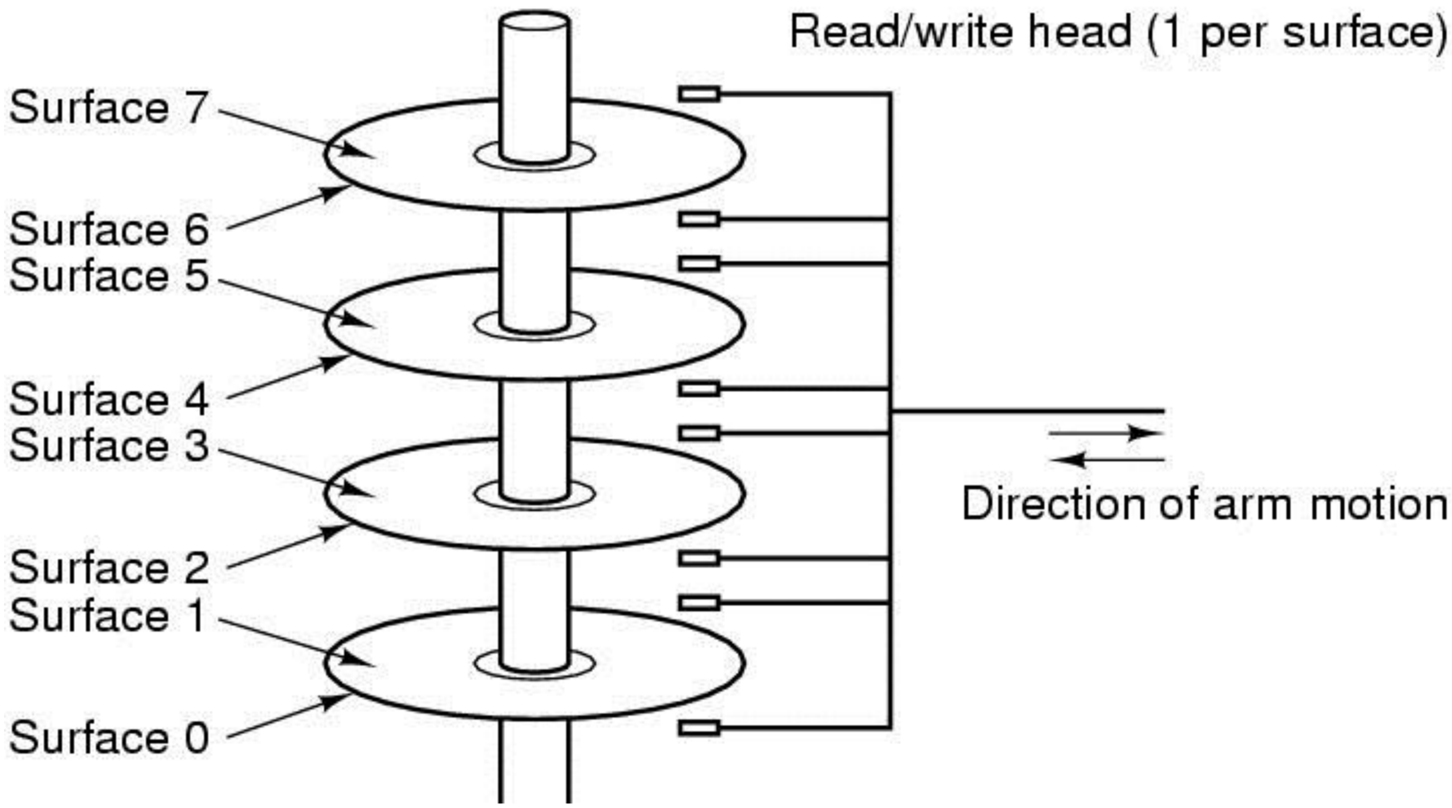


Figure 1-10. Structure of a disk drive.

I/O Devices

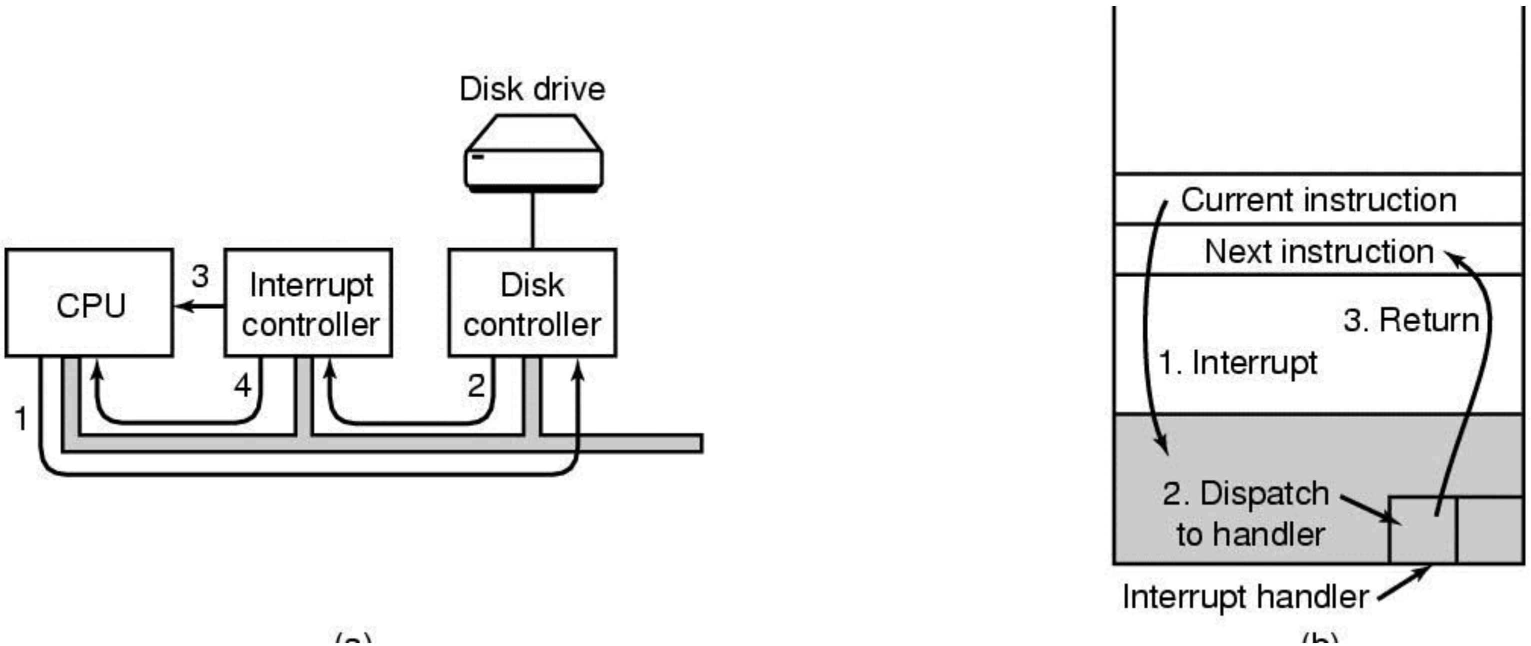
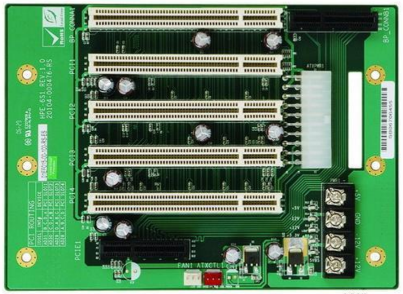
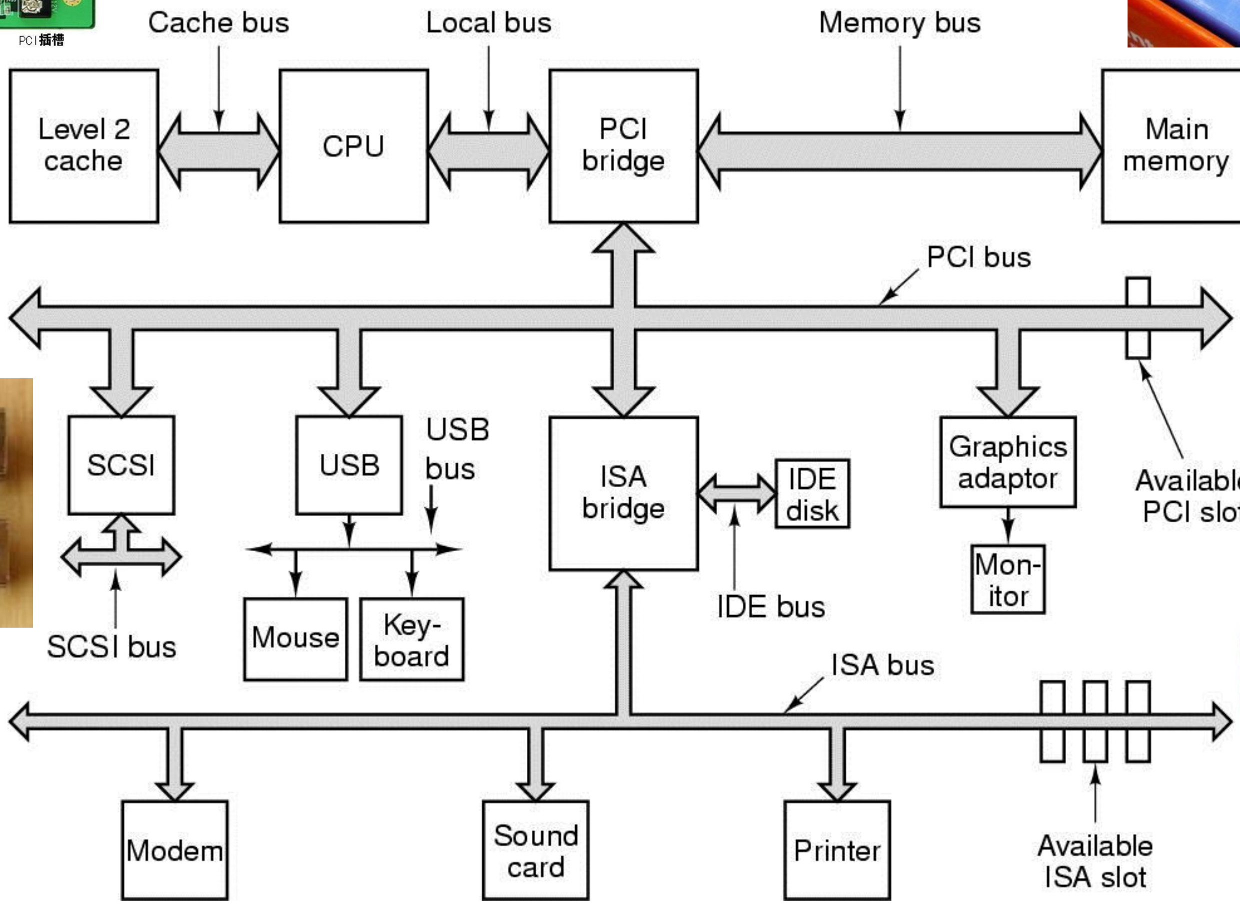


Figure 1-11. (a) The steps in starting an I/O device and getting an interrupt.


PCI插槽

Buses



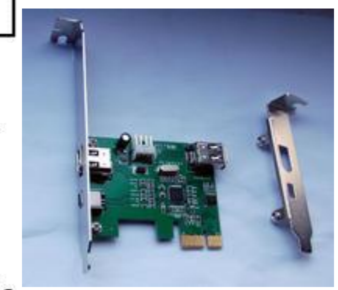


Figure 1-12. The structure of a large Pentium system

The Operating System Zoo

- Mainframe operating systems
- Server operating systems
- Multiprocessor operating systems
- Personal computer operating systems
- Handheld operating systems
- Embedded operating systems
- Sensor node operating systems
- Real-time operating systems
- Smart card operating systems

Operating System Concepts

- Processes
- Address spaces
- Files
- Input/Output
- Protection
- The shell
- Ontogeny recapitulates phylogeny
  - Large memories
  - Protection hardware
  - Disks
  - Virtual memory

Processes

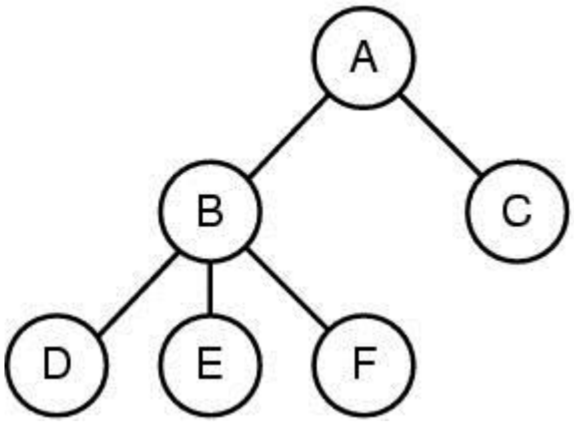


Figure 1-13. A process tree. Process A created two child processes, B and C. Process B created three child processes, D, E, and F.

Files (1)

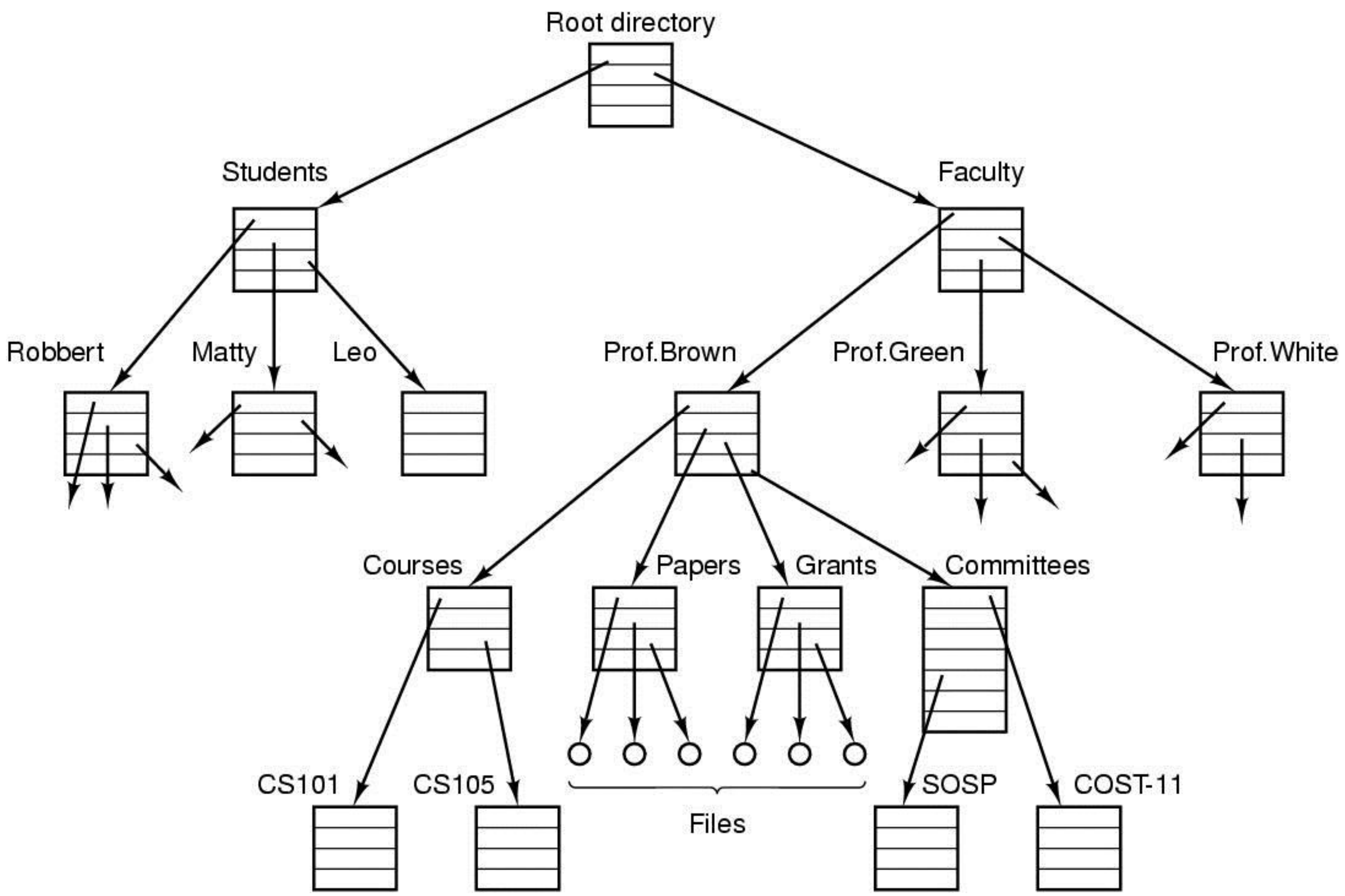


Figure 1-14. A file system for a university department.

Files (2)

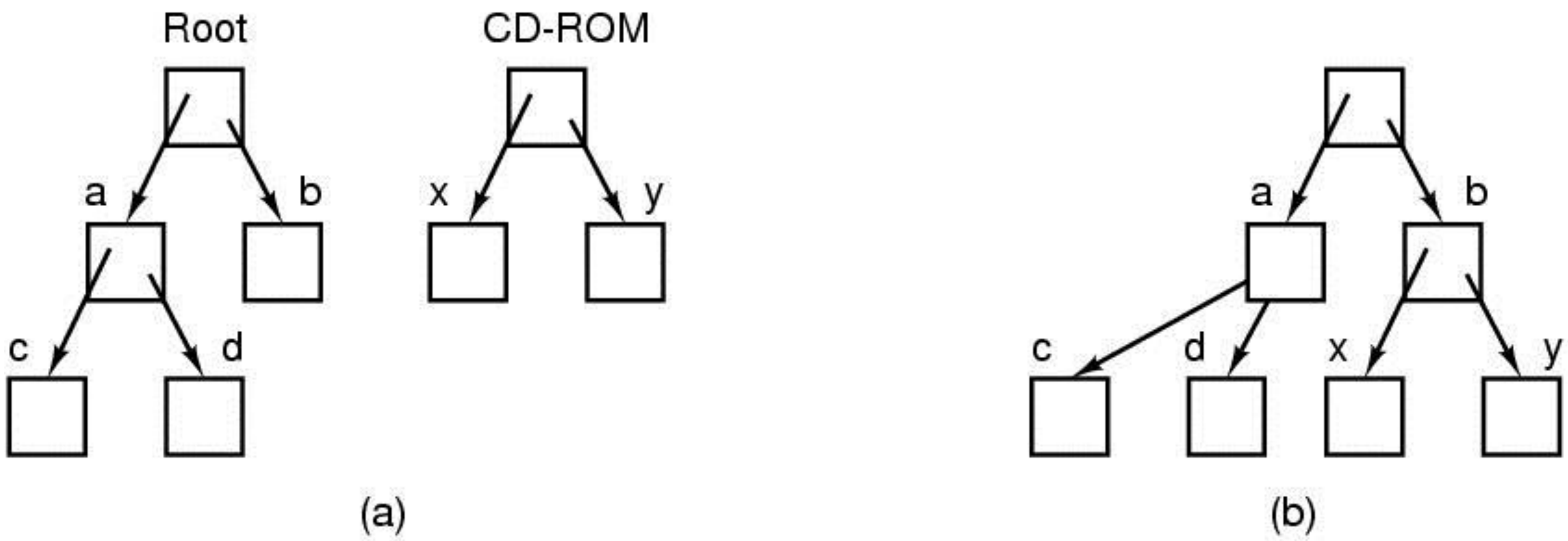


Figure 1-15. (a) Before mounting, the files on the CD-ROM are not accessible. (b) After mounting, they are part of the file hierarchy.

Files (3)

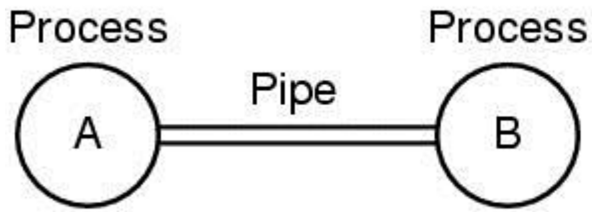


Figure 1-16. Two processes connected by a pipe.

System Calls

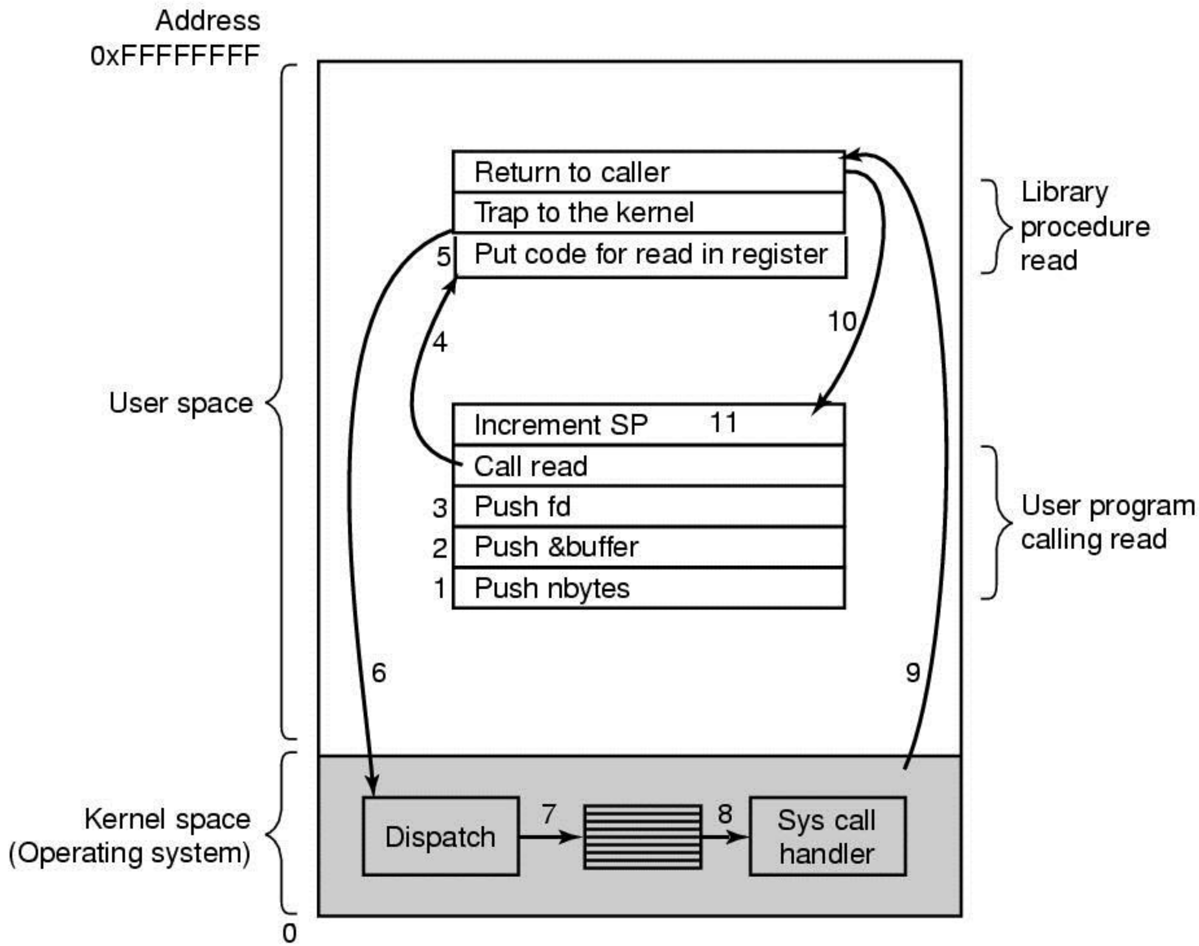


Figure 1-17. The 11 steps in making the system call read(fd, buffer, nbytes).

System Calls for Process Management

Process management

Call	Description
pid = fork( )	Create a child process identical to the parent
pid = waitpid(pid, &statloc, options)	Wait for a child to terminate
s = execve(name, argv, environp)	Replace a process' core image
exit(status)	Terminate process execution and return status

Figure 1-18. Some of the major POSIX system calls.

System Calls for File Management (1)

File management

Call	Description
fd = open(file, how, ...)	Open a file for reading, writing, or both
s = close(fd)	Close an open file
n = read(fd, buffer, nbytes)	Read data from a file into a buffer
n = write(fd, buffer, nbytes)	Write data from a buffer into a file
position = lseek(fd, offset, whence)	Move the file pointer
s = stat(name, &buf)	Get a file's status information

Figure 1-18. Some of the major POSIX system calls.

System Calls for File Management (2)

Call	Description
s = mkdir(name, mode)	Create a new directory
s = rmdir(name)	Remove an empty directory
s = link(name1, name2)	Create a new entry, name2, pointing to name1
s = unlink(name)	Remove a directory entry
s = mount(special, name, flag)	Mount a file system
s = umount(special)	Unmount a file system

Figure 1-18. Some of the major POSIX system calls.

Miscellaneous System Calls

Call	Description
s = chdir(dirname)	Change the working directory
s = chmod(name, mode)	Change a file's protection bits
s = kill(pid, signal)	Send a signal to a process
seconds = time(&seconds)	Get the elapsed time since Jan. 1, 1970

Figure 1-18. Some of the major POSIX system calls.

A Simple Shell

```
#define TRUE 1

while (TRUE) {                                    /* repeat forever */
    type_prompt( );                               /* display prompt on the screen */
    read_command(command, parameters);            /* read input from terminal */

    if (fork( ) != 0) {                           /* fork off child process */
        /* Parent code. */
        waitpid(−1, &status, 0);                  /* wait for child to exit */
    } else {
        /* Child code. */
        execve(command, parameters, 0);           /* execute command */
    }
}
```

Figure 1-19. A stripped-down shell.

Memory Layout

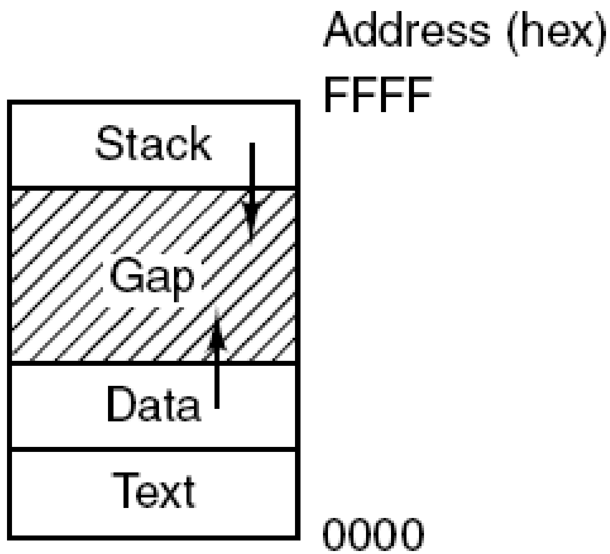


Figure 1-20. Processes have three segments: text, data, and stack.

Linking

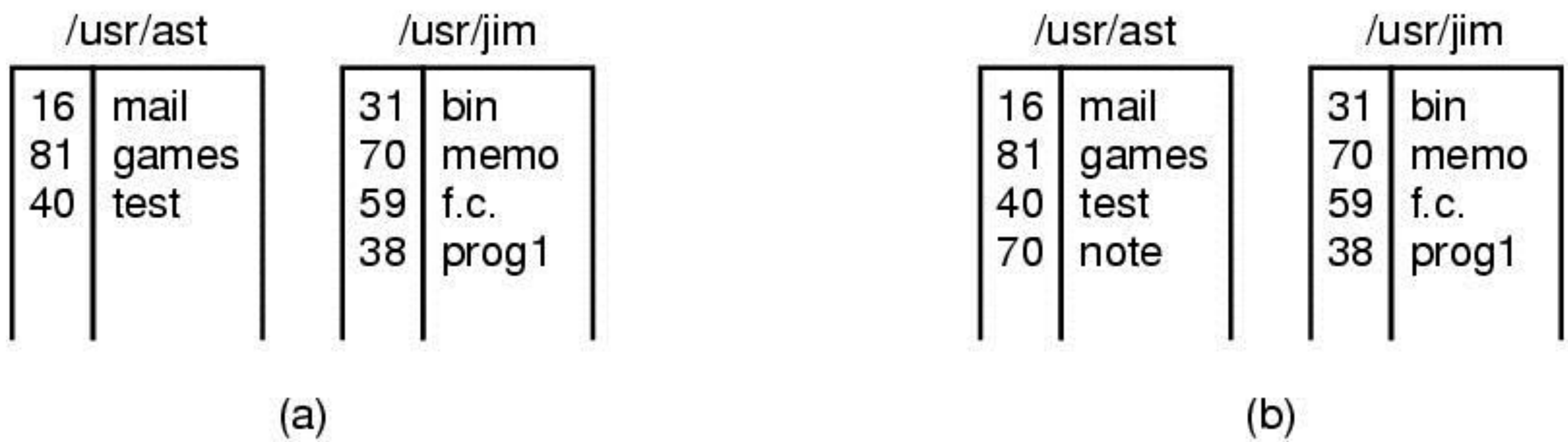


Figure 1-21. (a) Two directories before linking */usr/jim/memo* to ast's directory. (b) The same directories after linking.

Mounting

Figure 1-22. (a) File system before the mount.
(b) File system after the mount.

Windows Win32 API

UNIX	Win32	Description
fork	CreateProcess	Create a new process
waitpid	WaitForSingleObject	Can wait for a process to exit
execve	(none)	CreateProcess = fork + execve
exit	ExitProcess	Terminate execution
open	CreateFile	Create a file or open an existing file
close	CloseHandle	Close a file
read	ReadFile	Read data from a file
write	WriteFile	Write data to a file
lseek	SetFilePointer	Move the file pointer
stat	GetFileAttributesEx	Get various file attributes
mkdir	CreateDirectory	Create a new directory
rmdir	RemoveDirectory	Remove an empty directory
link	(none)	Win32 does not support links
unlink	DeleteFile	Destroy an existing file
mount	(none)	Win32 does not support mount
umount	(none)	Win32 does not support mount
chdir	SetCurrentDirectory	Change the current working directory
chmod	(none)	Win32 does not support security (although NT does)
kill	(none)	Win32 does not support signals
time	GetLocalTime	Get the current time

Figure 1-23. The Win32 API calls that roughly correspond to the UNIX calls of Fig. 1-18.

Operating Systems Structure

Monolithic systems – basic structure:

- A main program that invokes the requested service procedure.
- A set of service procedures that carry out the system calls.
- A set of utility procedures that help the service procedures.

Monolithic Systems

```
#define FALSE  0
#define TRUE   1
#define N      2                       /* number of processes */

int turn;                              /* whose turn is it? */
int interested[N];                     /* all values initially 0 (FALSE) */

void enter_region(int process);        /* process is 0 or 1 */
{
     int other;                        /* number of the other process */

     other = 1 − process;              /* the opposite of process */
     interested[process] = TRUE;       /* show that you are interested */
     turn = process;                   /* set flag */
     while (turn == process && interested[other] == TRUE) /* null statement */ ;
}

void leave_region(int process)         /* process: who is leaving */
{
     interested[process] = FALSE;      /* indicate departure from critical region */
}
```

Figure 1-24. A simple structuring model for a monolithic system.

Layered Systems

Layer	Function
5	The operator
4	User programs
3	Input/output management
2	Operator-process communication
1	Memory and drum management
0	Processor allocation and multiprogramming

Figure 1-25. Structure of the THE operating system.

Microkernels

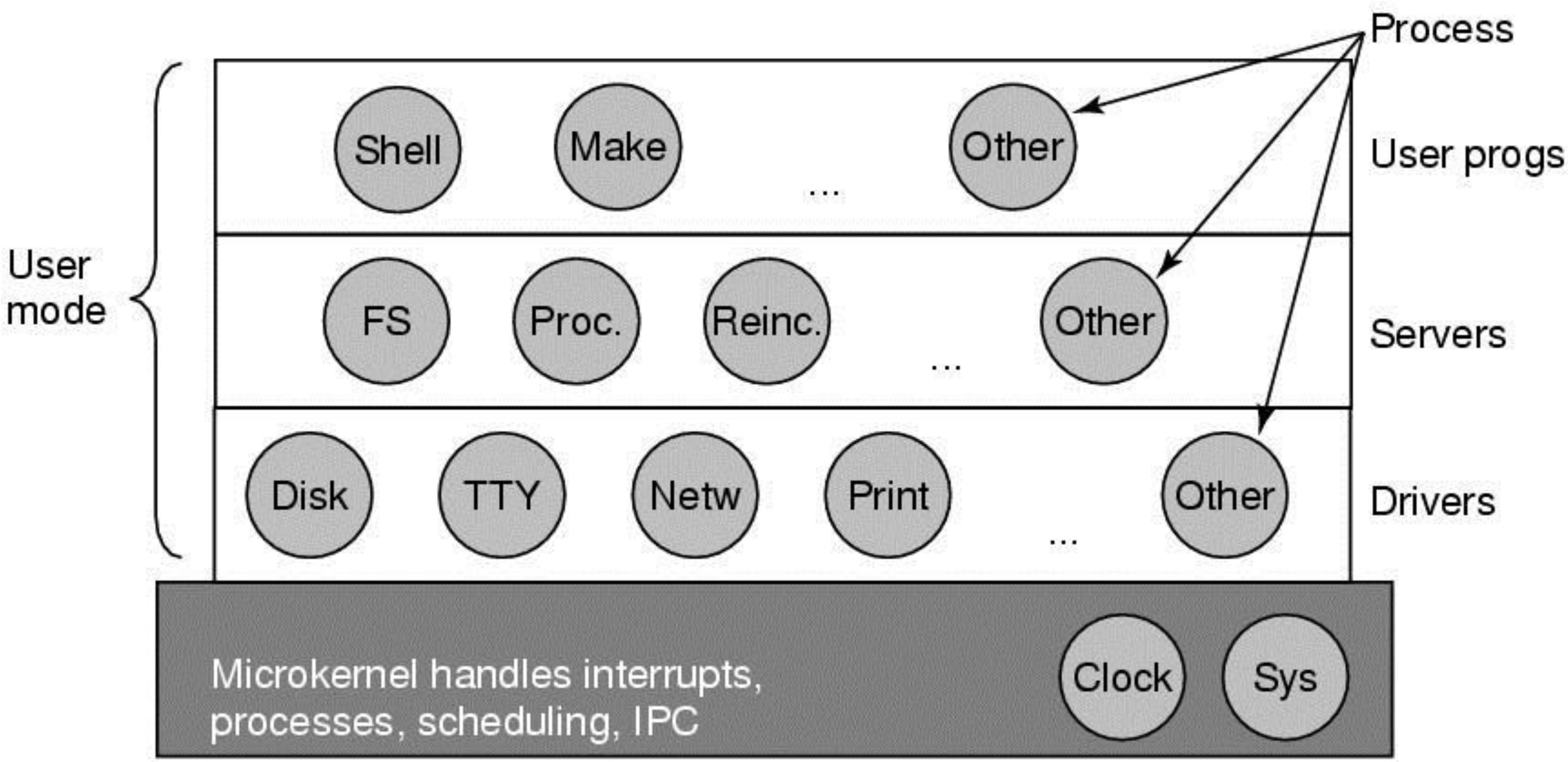


Figure 1-26. Structure of the MINIX 3 system.

Client-Server Model

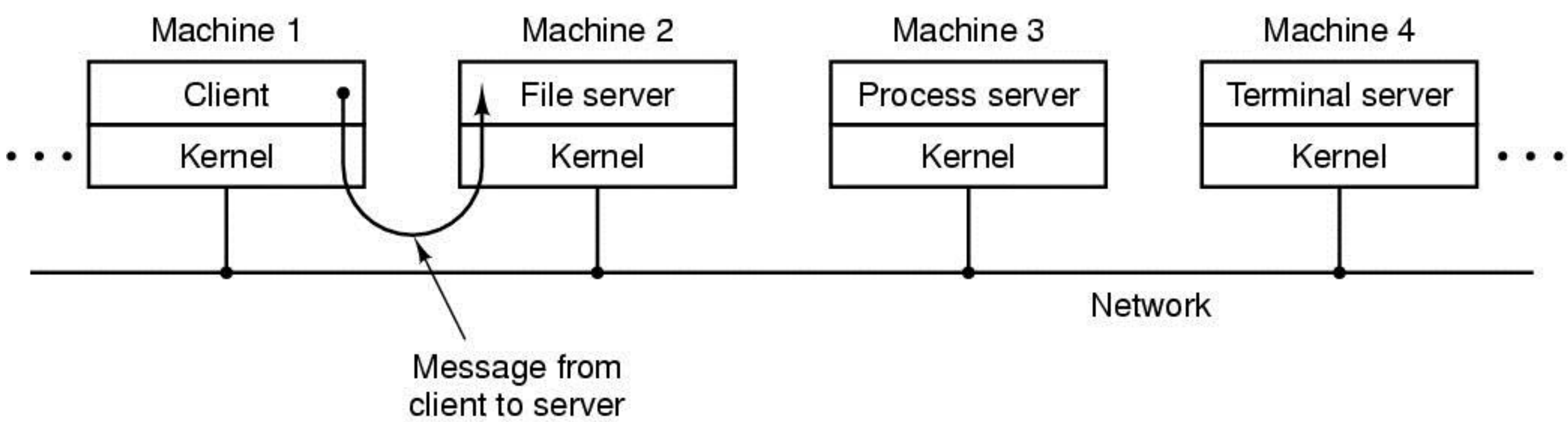


Figure 1-27. The client-server model over a network.

Virtual Machines (1)

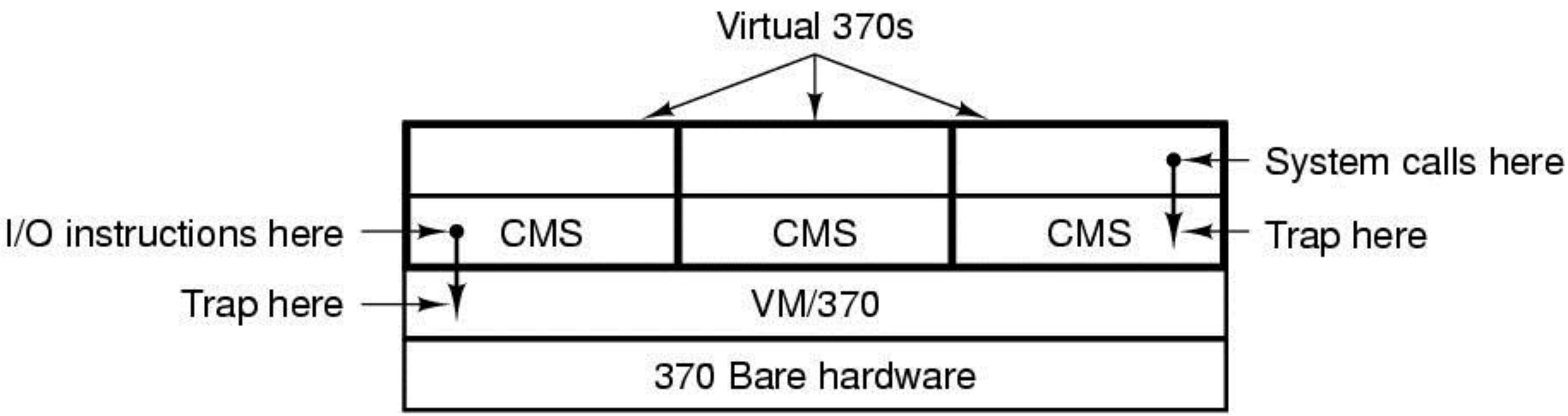


Figure 1-28. The structure of VM/370 with CMS.

Virtual Machines (2)

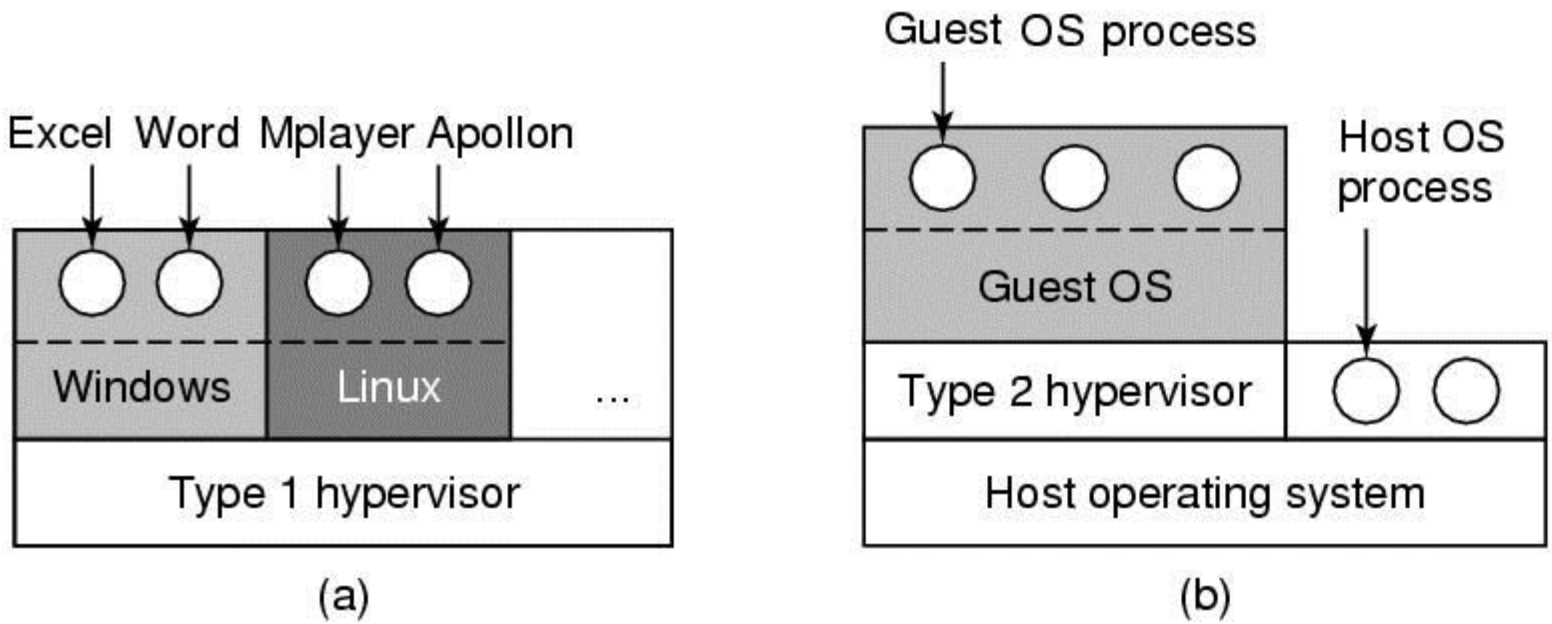


Figure 1-29. (a) A type 1 hypervisor. (b) A type 2 hypervisor.

The World According to C

- The C language
- Header files
- Large programming projects
- The model of run time

The Model of Run Time

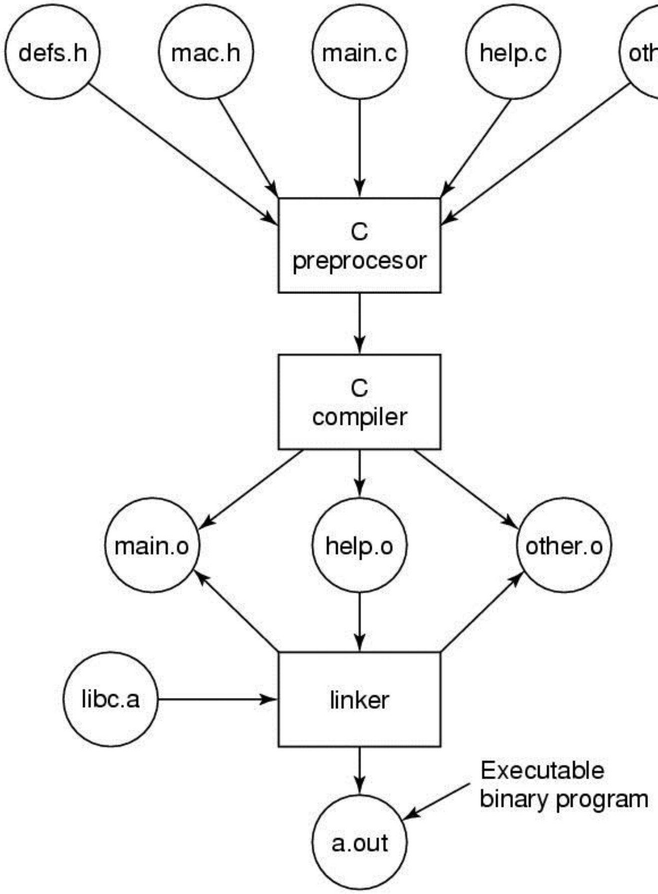


Figure 1-30. The process of compiling C and header files to make an executable.