OPERATING SYSTEMS DESIGN AND IMPLEMENTATION

Third Edition

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Chapter 1 Introduction

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The Modern Computer System

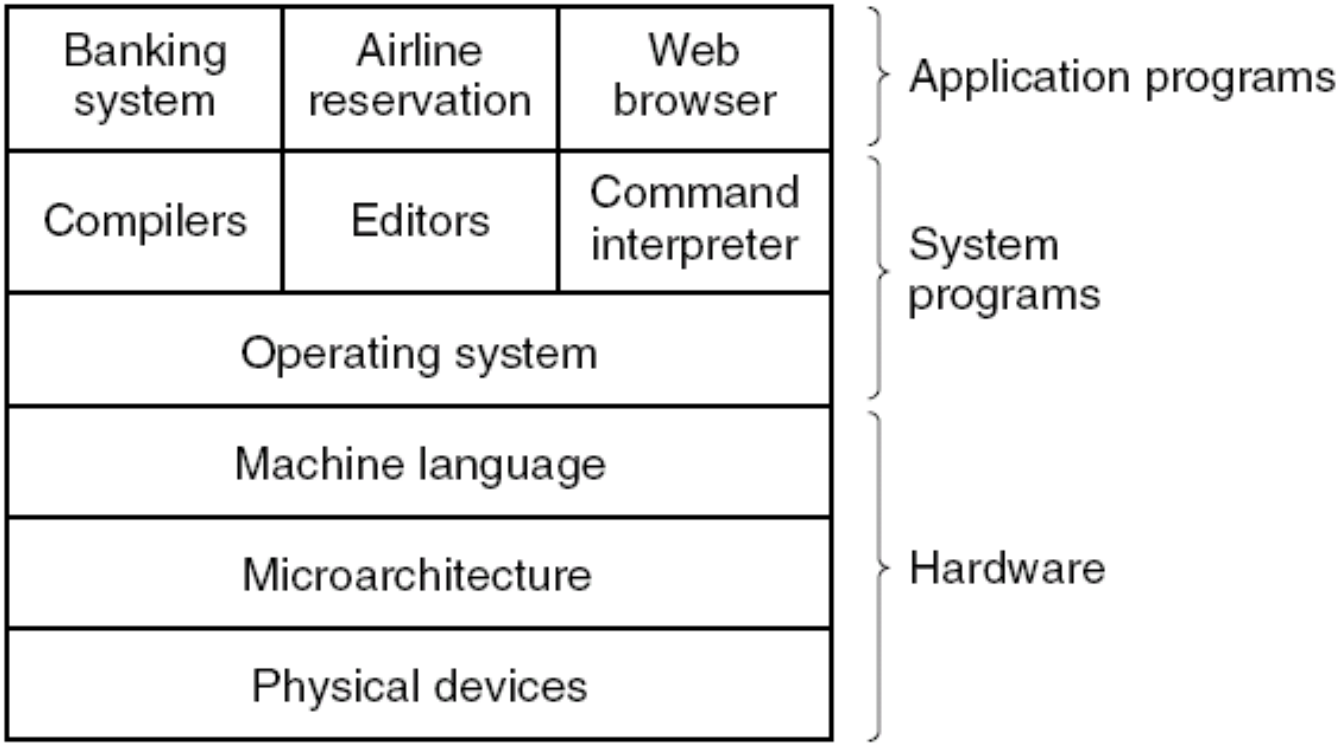

Figure 1.1 A computer system consists of hardware, system programs, and application programs.

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What Is an Operating System?

The operating system has two basic functions of the operating system

- It is an extended machine or virtual machine
  - Easier to program than the underlying hardware
- It is a resource manager
  - Shares resources in time and space

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Operating System Generations

- Generation 1 (1945 – 55)
  Vacuum tubes and plugboards
- Generation 2 (1955 – 65)
  Transistors and batch systems
- Generation 3 (1965 – 80)
  ICs and multiprogramming
- Generation 4 (1980 – Present)
  Personal computers

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Early Batch System (1)

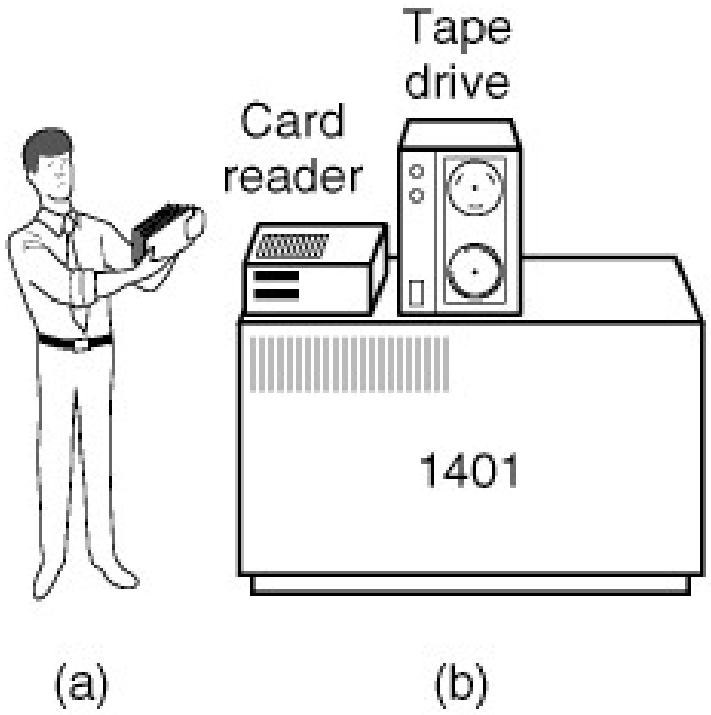

Figure 1-2. An early batch system. (a) Programmers bring cards to 1401. (b)1401 reads batch of jobs onto tape.

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Early Batch System (2)

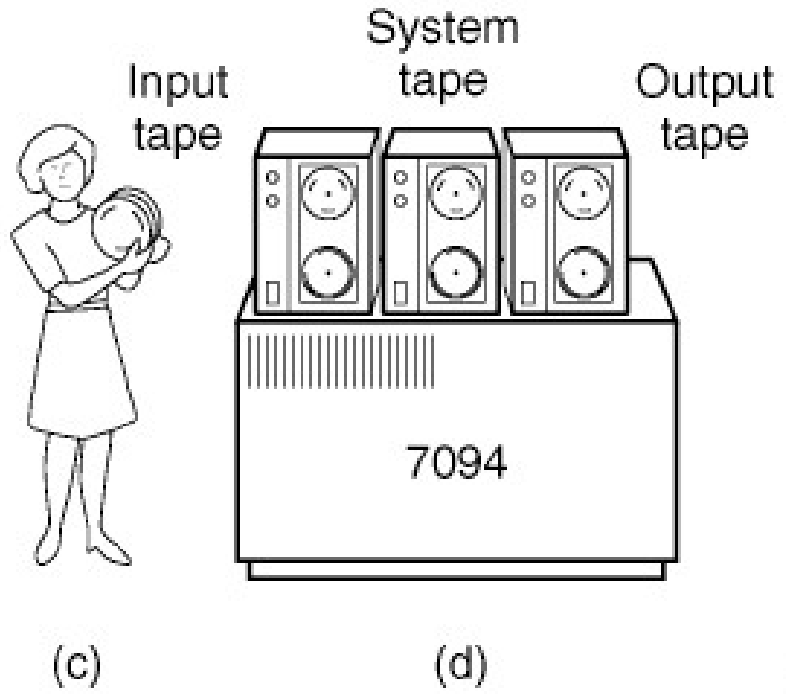

Figure 1-2. An early batch system. (c) Operator carries input tape to 7094. (d) 7094 does computing.

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Early Batch System (3)

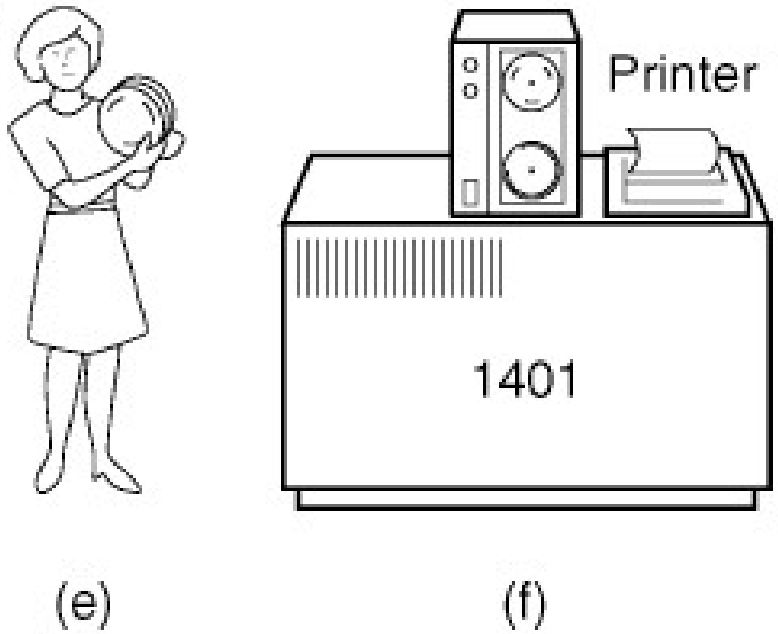

Figure 1-2. An early batch system. (e) Operator carries output tape to 1401. (f) 1401 prints output.

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Early Batch System (4)

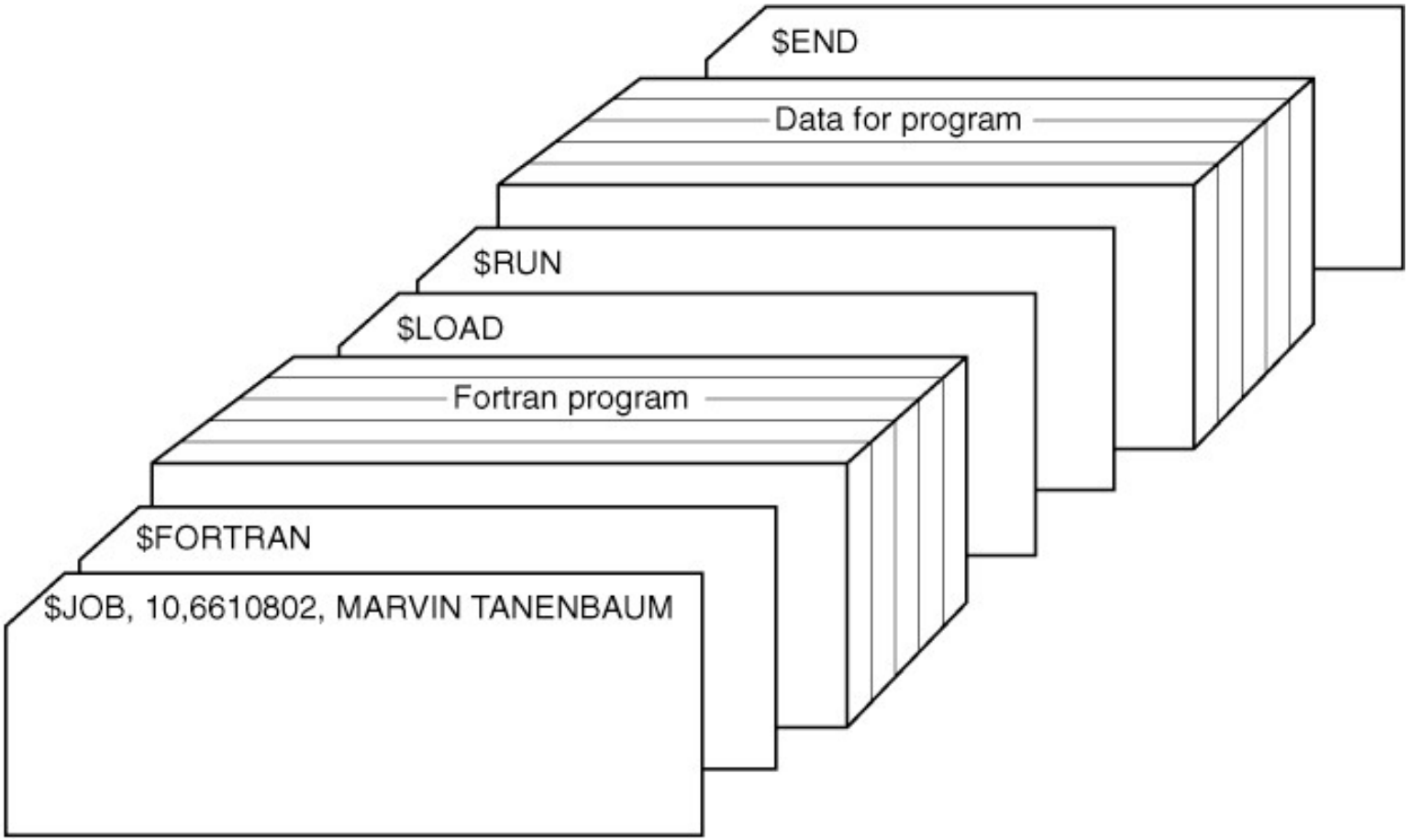

Figure 1-3. Structure of a typical FMS job.

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Multiprogramming

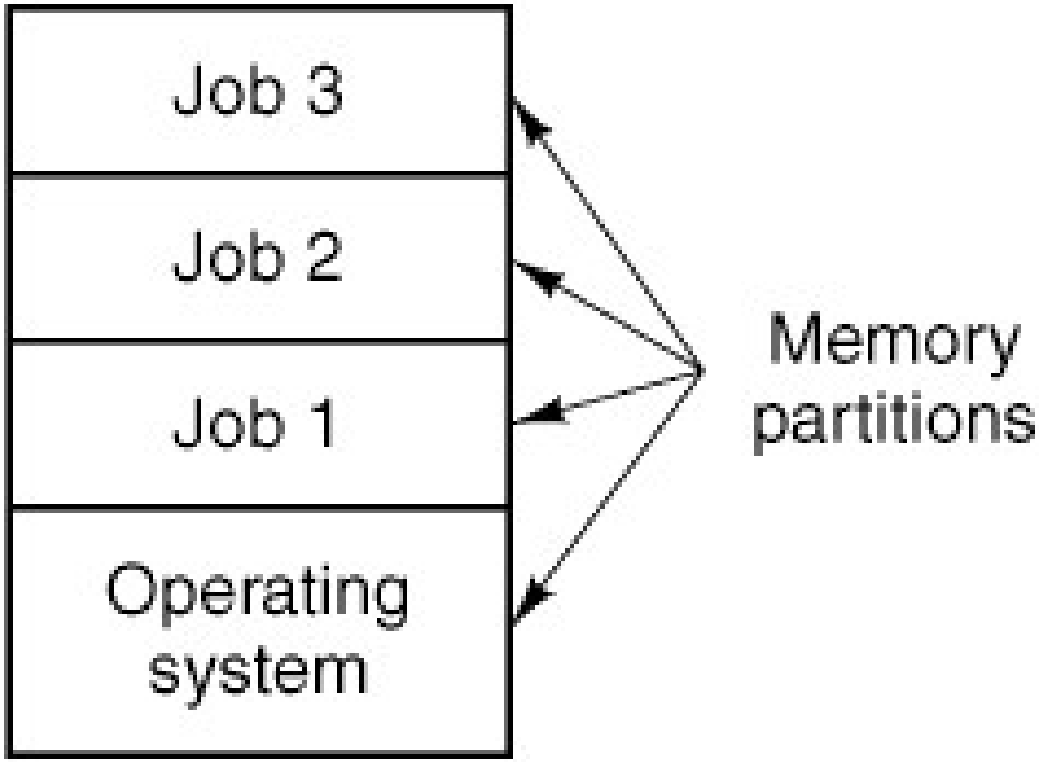

Figure 1-4. A multiprogramming system with three jobs in memory.

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Processes

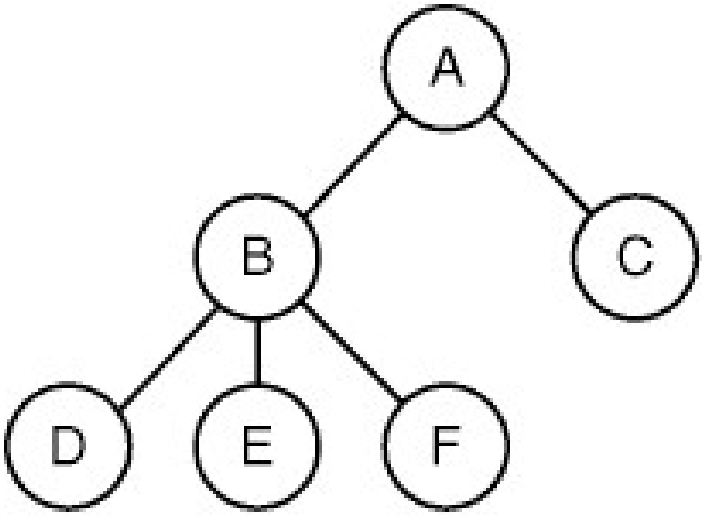

Figure 1-5. A process tree. Process A created two child processes, B and C. Process B created three child processes, D, E, and F.

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File Systems (1)

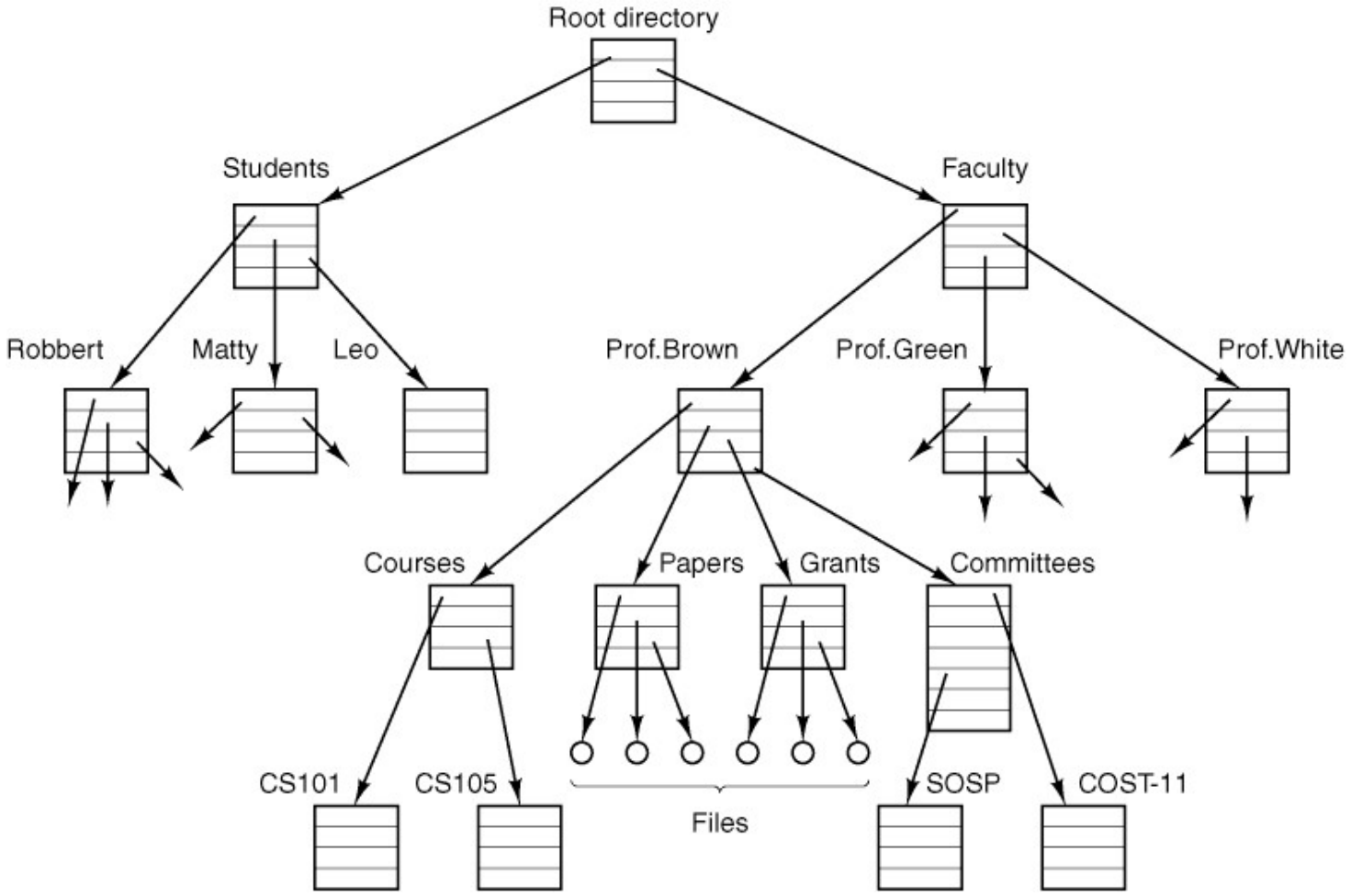

Figure 1-6. A file system for a university department.

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File Systems (2)

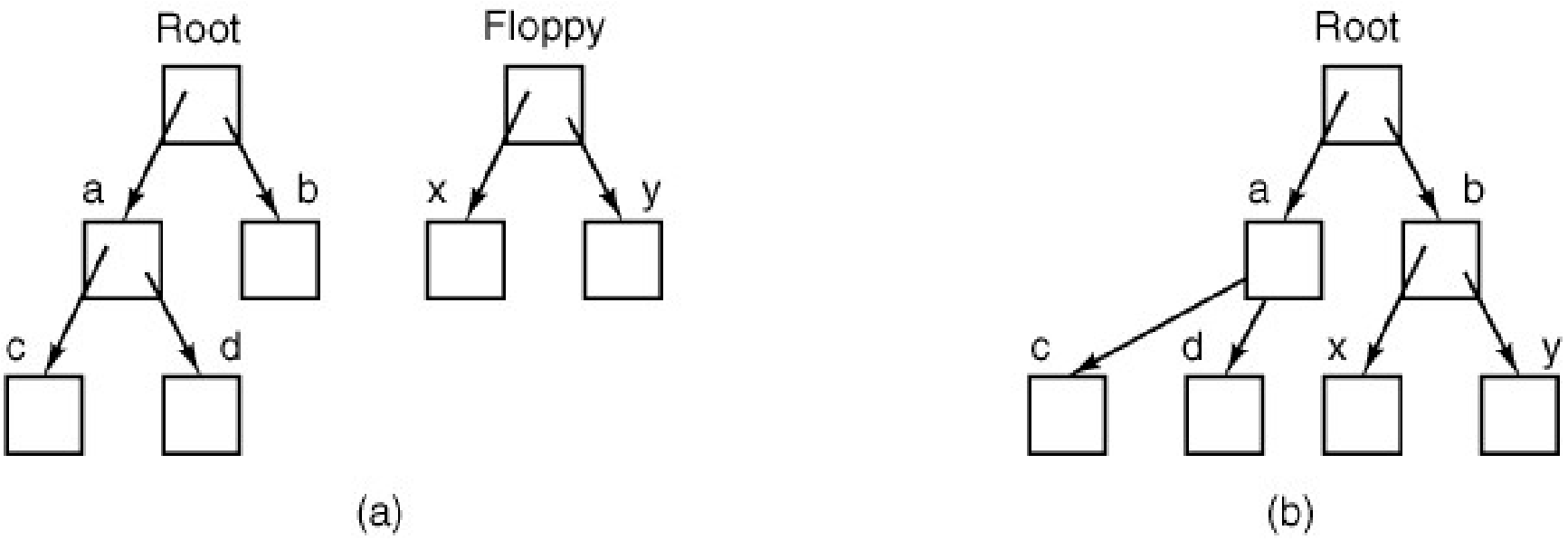

Figure 1-7. (a) Before mounting, the files on drive 0 are not accessible. (b) After mounting, they are part of the file hierarchy.

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File Systems (3)

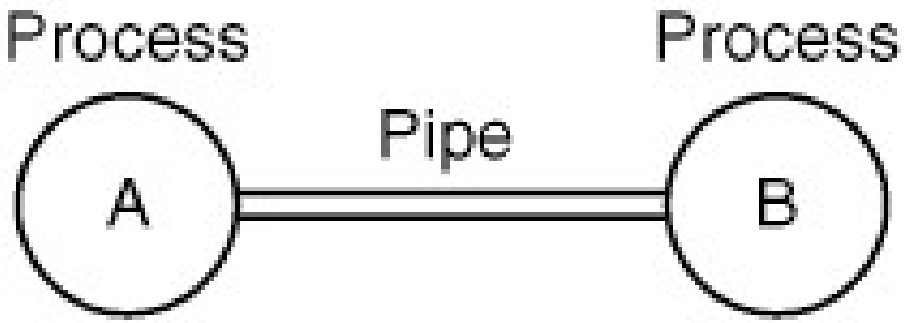

Figure 1-8. Two processes connected by a pipe.

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System Calls (1)

Process Management

pid = fork()	Create a child process identical to the parent
pid = waitpid(pid, &statloc, opts)	Wait for a child to terminate
s = wait(&status)	Old version of waitpid
s = execve(name, argv, envp)	Replace a process core image
exit(status)	Terminate process execution and return status
size = brk(addr)	Set the size of the data segment
pid = getpid()	Return the caller's process id
pid = getpgrp()	Return the id of the caller's process group
pid = setsid()	Create a new session and return its process group id
l = ptrace(req, pid, addr, data)	Used for debugging

Figure 1-9. The MINIX system calls. fd is a file descriptor; and n is a byte count.

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System Calls (2)

Signals

s = sigaction(sig, &act, &oldact)	Define action to take on signals
s = sigreturn(&context)	Return from a signal
s = sigprocmask(how, &set, &old)	Examine or change the signal mask
s = sigpending(set)	Get the set of blocked signals
s = sigsuspend(sigmask)	Replace the signal mask and suspend the process
s = kill(pid, sig)	Send a signal to a process
residual = alarm(seconds)	Set the alarm clock
s = pause()	Suspend the caller until the next signal

Figure 1-9. The MINIX system calls. fd is a file descriptor; and n is a byte count.

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System Calls (3)

File Management

fd = creat(name, mode)	Obsolete way to create a new file
fd = mknod(name, mode, addr)	Create a regular, special, or directory i-node
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
pos = lseek(fd, offset, whence)	Move the file pointer
s = stat(name, &buf)	Get a file's status information
s = fstat(fd, &buf)	Get a file's status information
fd = dup(fd)	Allocate a new file descriptor for an open file
s = pipe(&fd[0])	Create a pipe
s = ioctl(fd, request, argp)	Perform special operations on a file
s = access(name, amode)	Check a file's accessibility
s = rename(old, new)	Give a file a new name
s = fcntl(fd, cmd, ...)	File locking and other operations

Figure 1-9. The MINIX system calls. fd is a file descriptor; and n is a byte count.

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System Calls (4)

Dir. & File System Mgmt.

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
s = sync()	Flush all cached blocks to the disk
s = chdir(dirname)	Change the working directory
s = chroot(dirname)	Change the root directory

Figure 1-9. The MINIX system calls. fd is a file descriptor; and n is a byte count.

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System Calls (5)

Protection

s = chmod(name, mode)	Change a file's protection bits
uid = getuid()	Get the caller's uid
gid = getgid()	Get the caller's gid
s = setuid(uid)	Set the caller's uid
s = setgid(gid)	Set the caller's gid
s = chown(name, owner, group)	Change a file's owner and group
oldmask = umask(complmode)	Change the mode mask

Figure 1-9. The MINIX system calls. fd is a file descriptor; and n is a byte count.

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System Calls (6)

Time Management

seconds = time(&seconds)	Get the elapsed time since Jan. 1, 1970
s = stime(tp)	Set the elapsed time since Jan. 1, 1970
s = utime(file, timep)	Set a file's "last access" time
s = times(buffer)	Get the user and system times used so far

Figure 1-9. The MINIX system calls. fd is a file descriptor; and n is a byte count.

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The fork Call in the 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 1-10. A stripped-down shell. Throughout this book, TRUE is assumed to be defined as 1.

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Processes

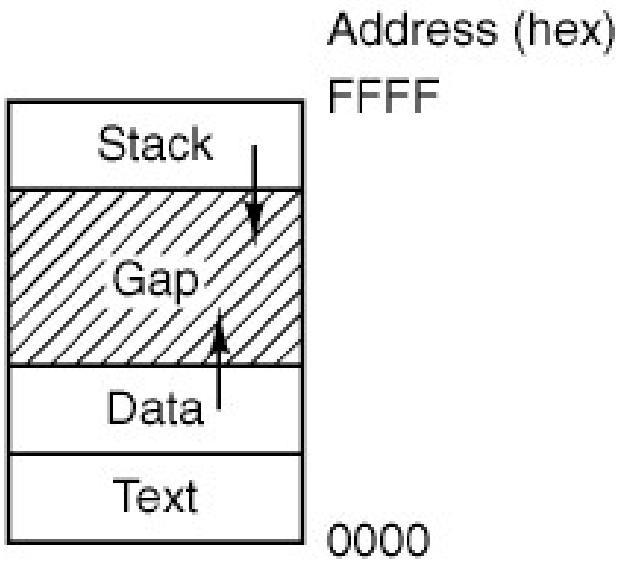

Figure 1-11. Processes have three segments: text, data, and stack. In this example, all three are in one address space, but separate instruction and data space is also supported.

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System Calls for File Management (1)

```
struct stat {
    short st_dev;                /* device where i-node belongs */
    unsigned short st_ino;       /* i-node number */
    unsigned short st_mode;      /* mode word */
    short st_nlink;              /* number of links */
    short st_uid;                /* user id */
    short st_gid;                /* group id */
    short st_rdev;               /* major/minor device for special files */
    long st_size;                /* file size */
    long st_atime;               /* time of last access */
    long st_mtime;               /* time of last modification */
    long st_ctime;               /* time of last change to i-node */
};
```

Figure 1-12. The structure used to return information for the stat and fstat system calls. In the actual code, symbolic names are used for some of the types.

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System Calls for File Management (2)

```
#define STD_INPUT 0                     /* file descriptor for standard input */
#define STD_OUTPUT 1                    /* file descriptor for standard output */

pipeline(process1, process2)
char *process1, *process2;              /* pointers to program names */
{
  int fd[2];

  pipe(&fd[0]);                         /* create a pipe */
  if (fork() != 0) {
        /* The parent process executes these statements. */
        close(fd[0]);                   /* process 1 does not need to read from pipe */
        close(STD_OUTPUT);              /* prepare for new standard output */
        dup(fd[1]);                     /* set standard output to fd[1] */
        close(fd[1]);                   /* this file descriptor not needed any more */
        execl(process1, process1, 0);
  } else {    ...
```

Figure 1-13. A skeleton for setting up a two-process pipeline.

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System Calls for File Management (3)

```
    ...
    /* The child process executes these statements. */
    close(fd[1]);                       /* process 2 does not need to write to pipe */
    close(STD_INPUT);                   /* prepare for new standard input */
    dup(fd[0]);                         /* set standard input to fd[0] */
    close(fd[0]);                       /* this file descriptor not needed any more */
    execl(process2, process2, 0);
  }
}
```

Figure 1-13. A skeleton for setting up a two-process pipeline.

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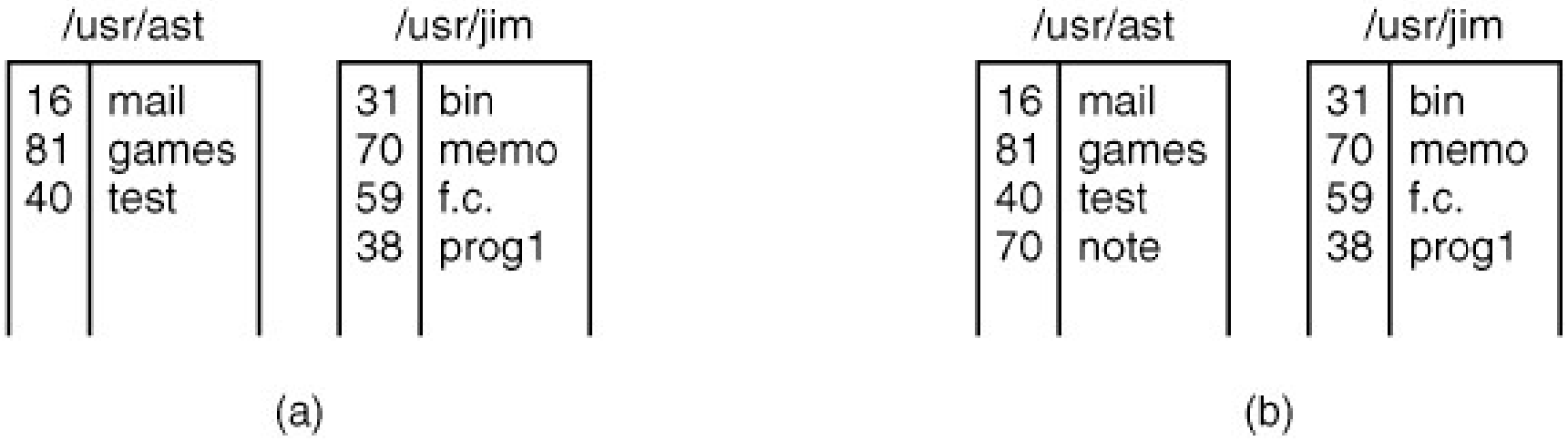
System Calls for Directory Management (1)



link("/usr/jim/memo","/usr/ast/note");

Figure 1-14. (a) Two directories before linking */usr/jim/memo* to ast's directory. (b) The same directories after linking.

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System Calls for Directory Management (2)

mount("/dev/cdrom0","/mnt",0);

Figure 1-15. (a) File system before the mount. (b) File system after the mount.

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Operating System Structure

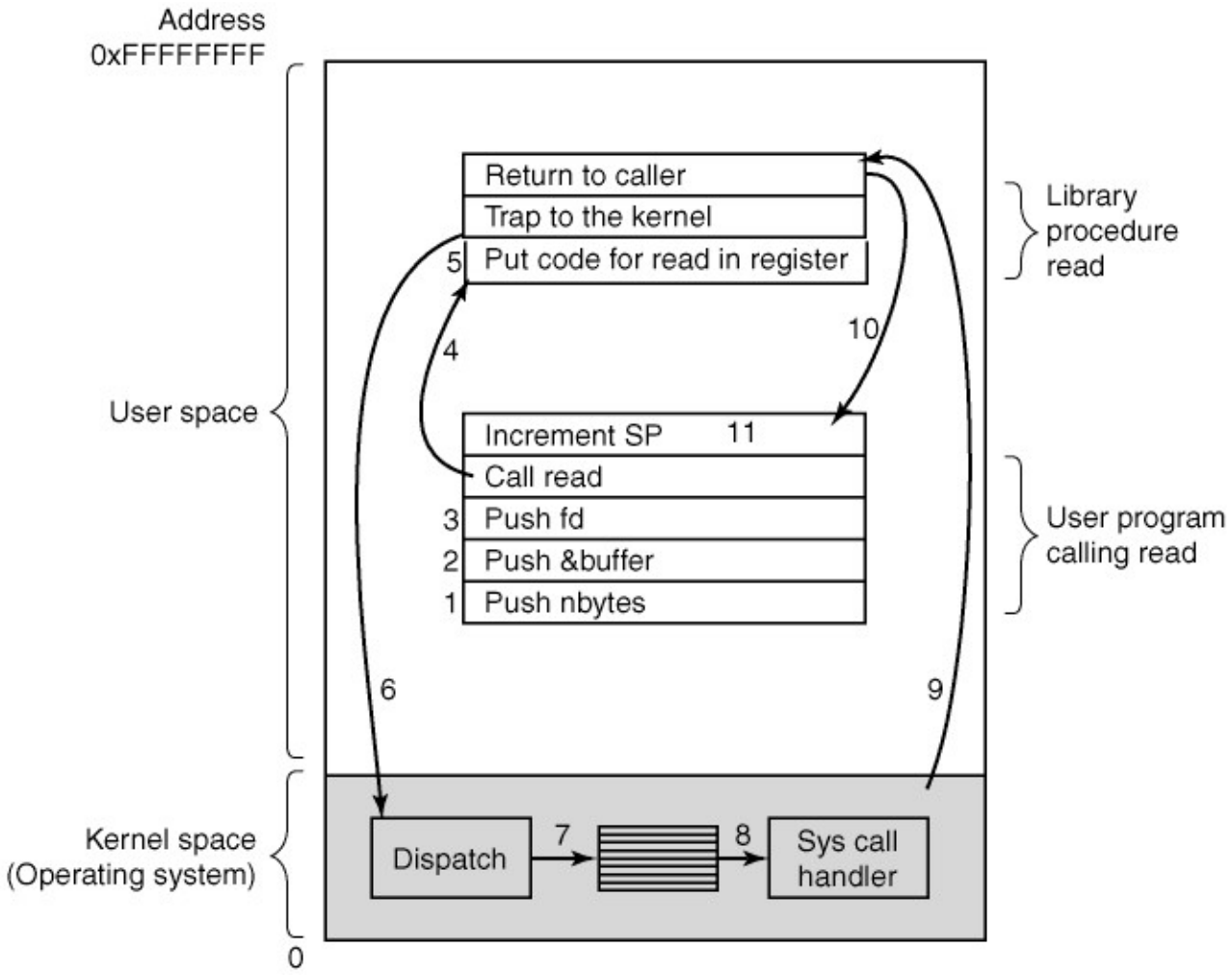

Figure 1-16. The 11 steps in making the system call read(fd, buffer, nbytes).

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Basic Structure for Operating System

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

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Layered Systems (1)

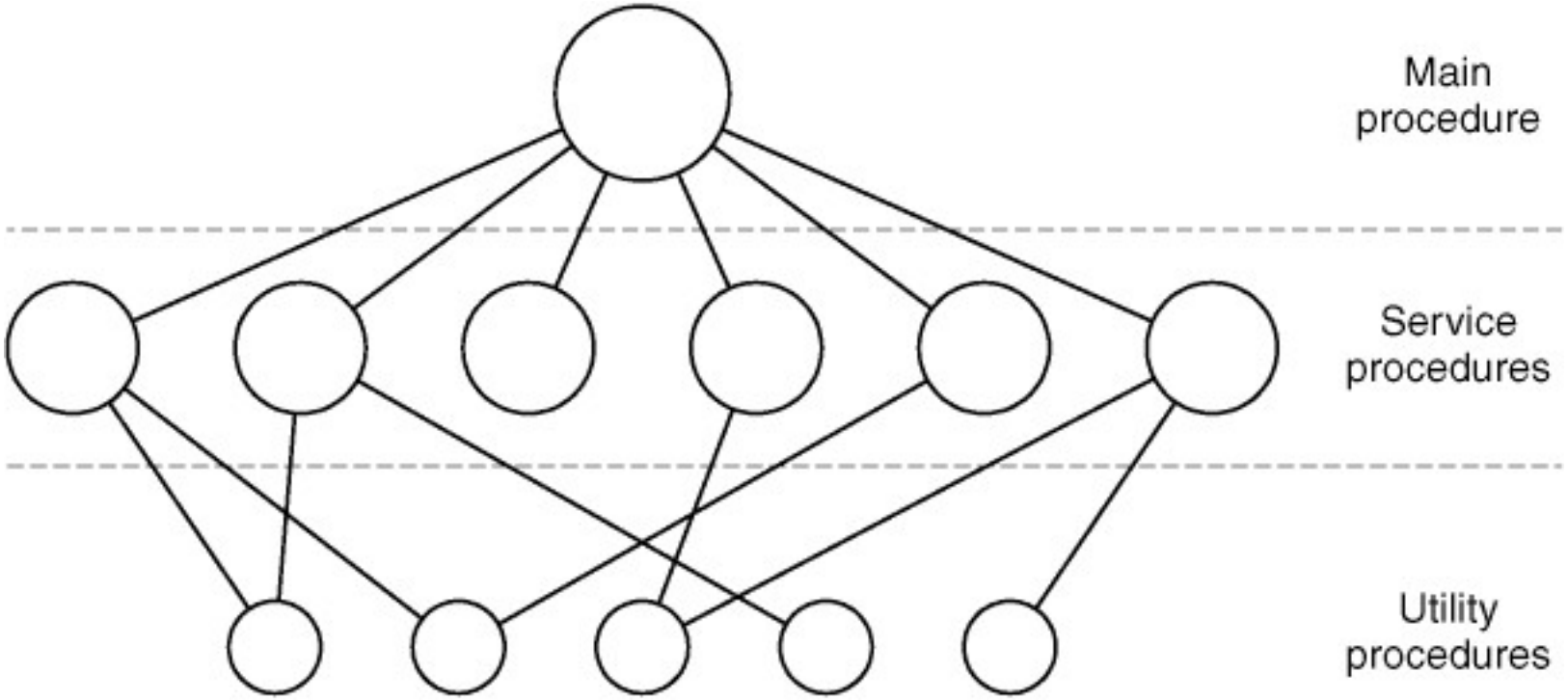

Figure 1-17. A simple structuring model for a monolithic system.

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Layered Systems (2)

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 1-18. Structure of the THE operating system.

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Virtual Machines

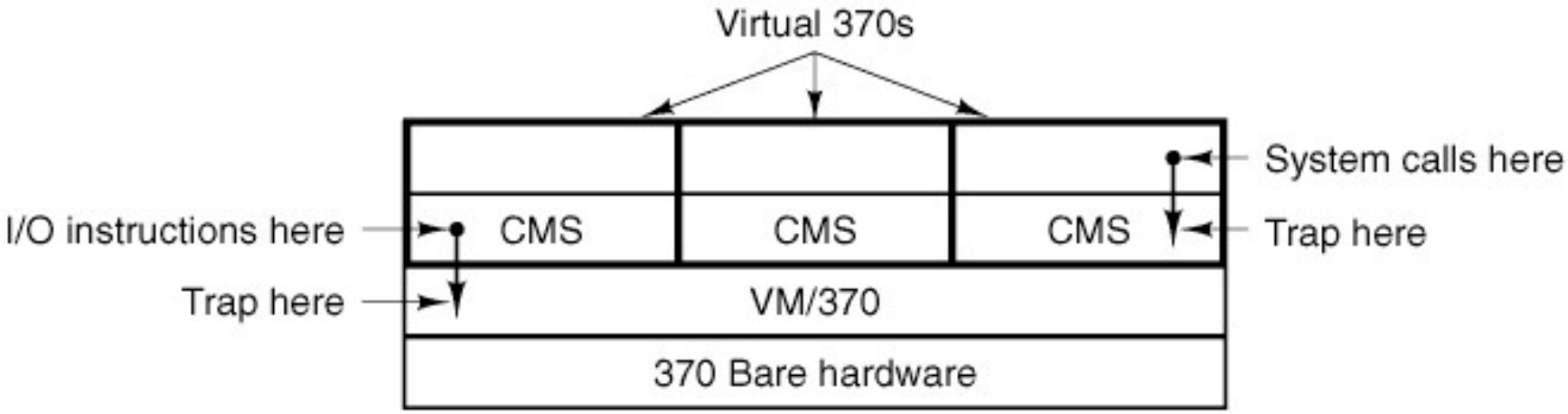

Figure 1-19. The structure of VM/370 with CMS.

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Client-Server Model (1)

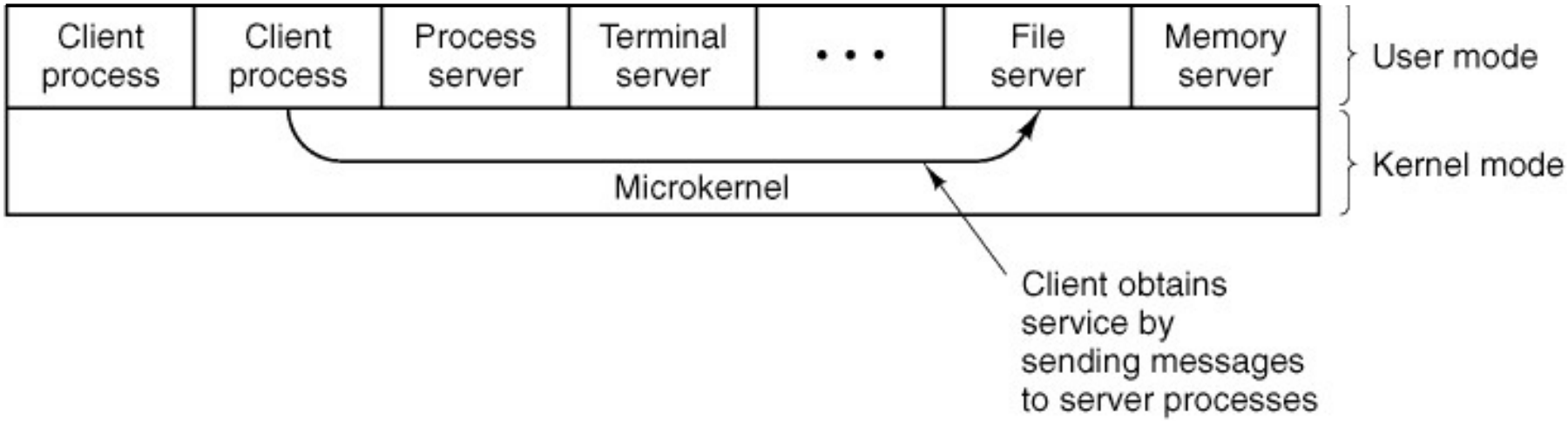

Figure 1-20. The client-server model.

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Client-Server Model (2)

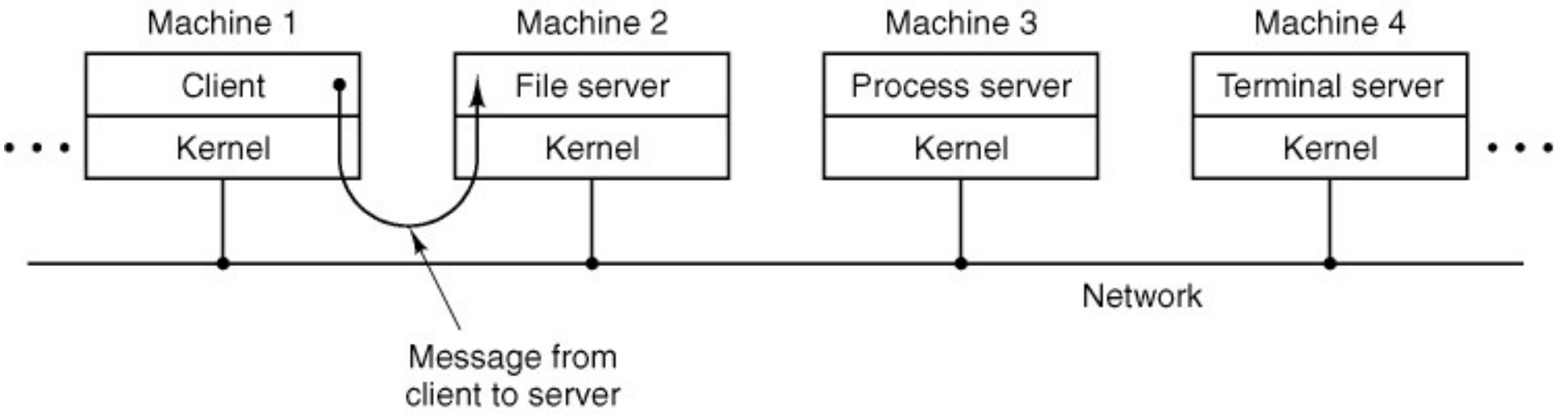

Figure 1-21. The client-server model in a distributed system.

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