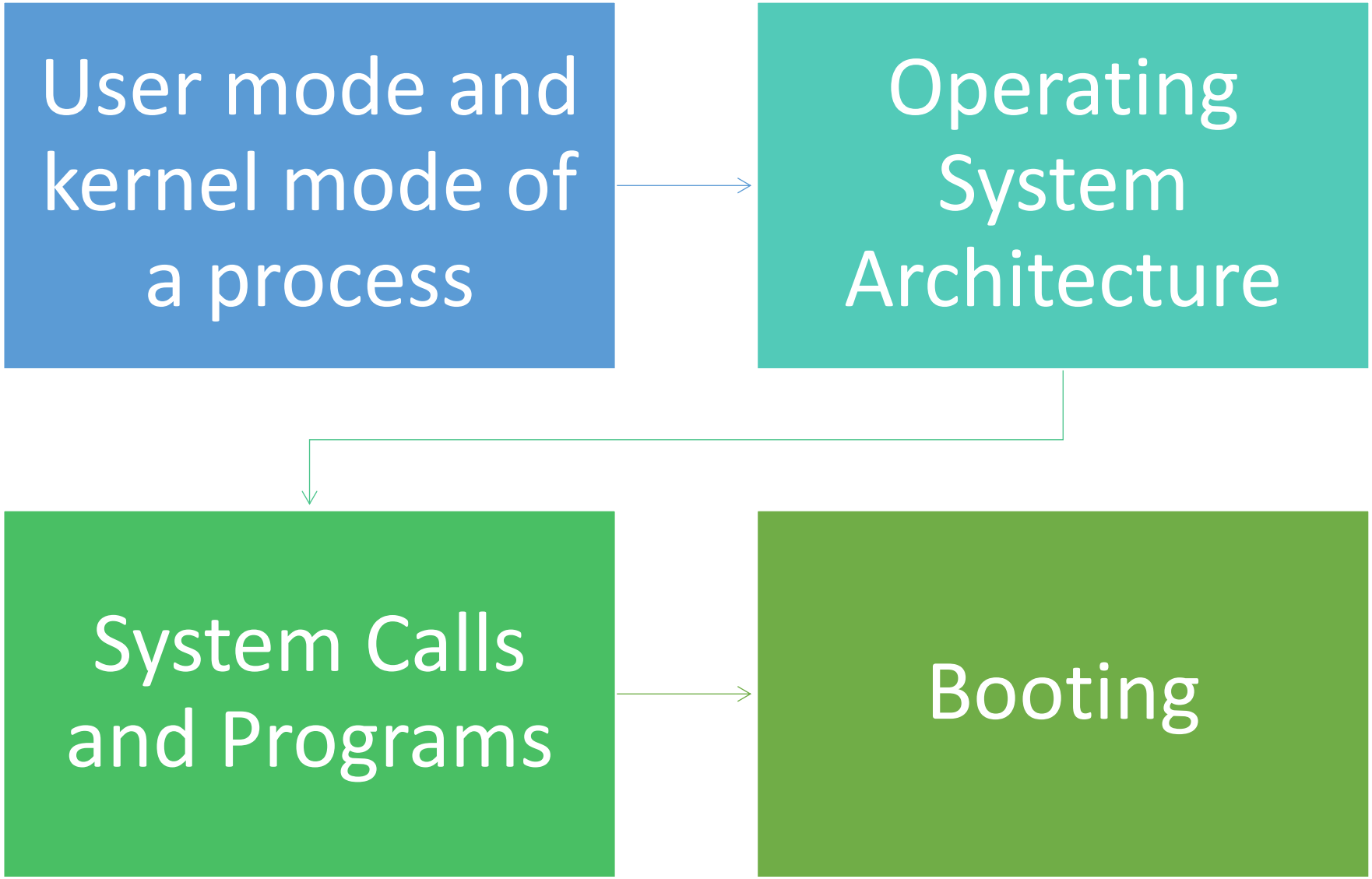
Contents


User mode and kernel mode of a process
Operating System Architecture
System Calls and Programs
Booting

Interrupt types

- **Interrupt driven** (hardware and software)
  - Hardware interrupt by one of the devices
  - Software interrupt (**exception** or **trap):**
    - Software error (e.g., division by zero)
    - Request for operating system service
    - Other process problems include infinite loop, processes modifying each other or the operating system

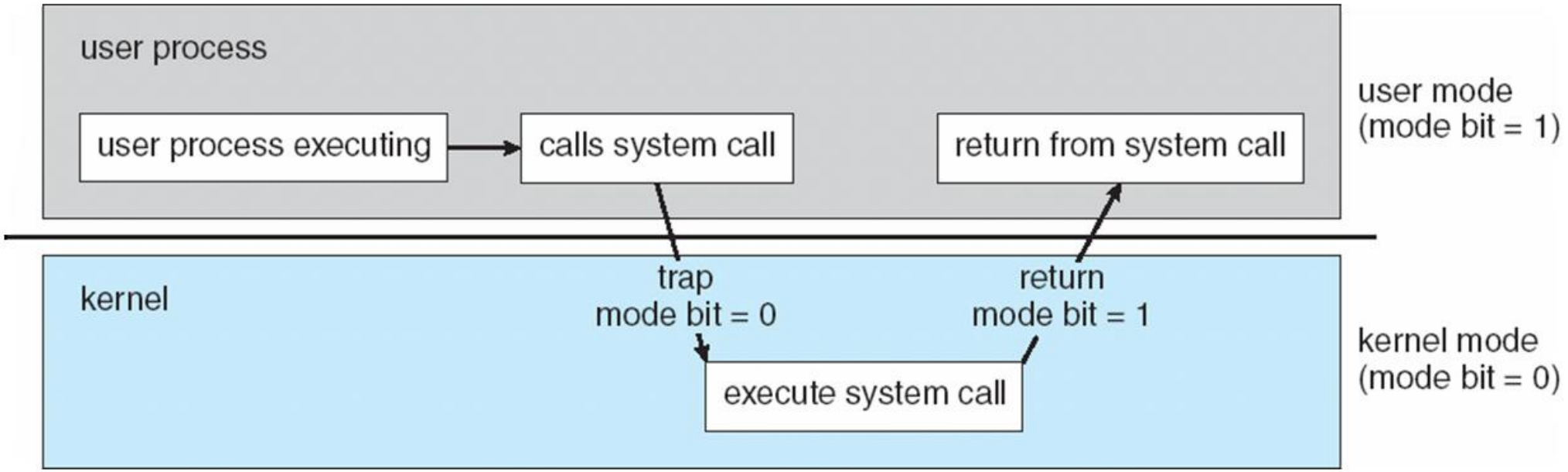
Common functions of interrupt

- Interrupt transfers control to the interrupt service routine generally, through the **interrupt vector**, which contains the addresses of all the service routines
- Interrupt architecture must save the address of the interrupted instruction
- A **trap** or **exception** is a software-generated interrupt caused either by an error or a user request
- An operating system is interrupt driven. **Kernel of OS** is a collection of **Interrupt Service Routines (ISRs).**

Interrupt Handling

- The operating system preserves the state of the CPU by storing registers and the program counter
- Determines which type of interrupt has occurred:
  - **polling**
  - **vectored** interrupt system
- Separate segments of code determine what action should be taken for each type of interrupt

Transition from User to Kernel mode



OS Structure / Architecture

Monolithic Systems

- 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.

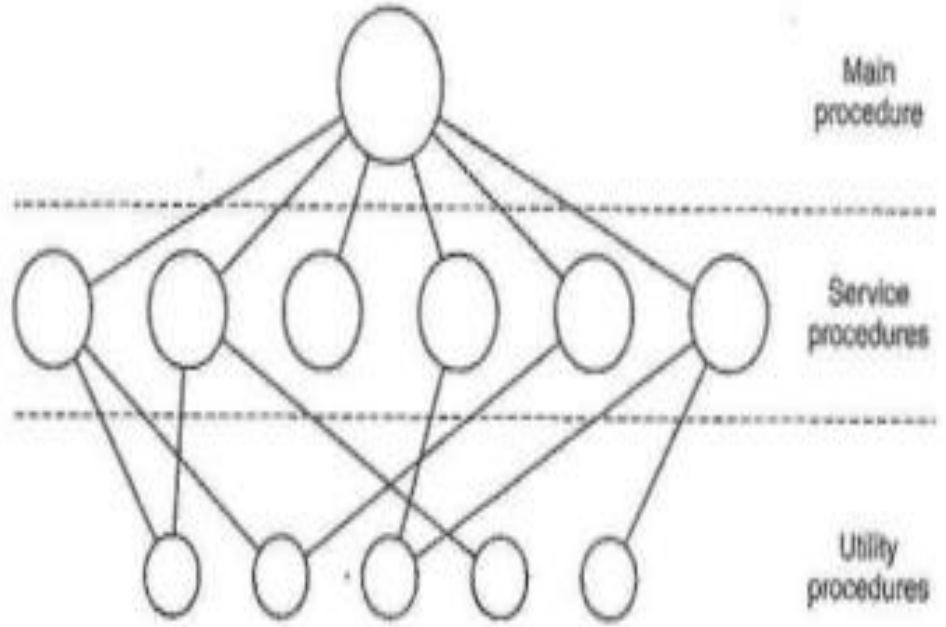


Figure 1-24. A simple structuring model for a monolithic system.

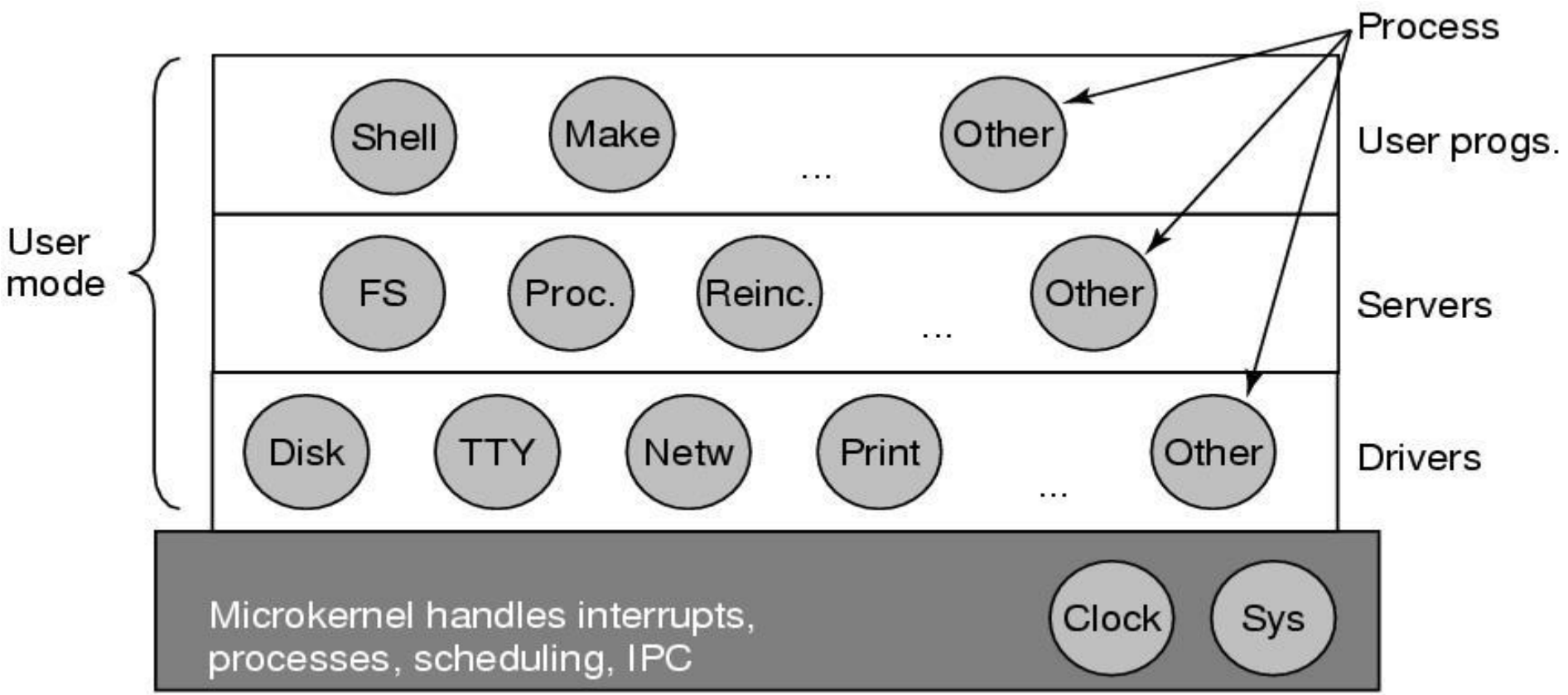
Layered Systems

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

Difference between Monolithic and Layered

Monolithic	Layered
Complete OS functions inside the kernel space itself.	OS functions are divided into multiple layers.
It consists of a total of three layers.	It consists of multiple layers which cannot be allotted a fixed number.
Components interact directly with one another.	Components do not interact directly with one another.
Lesser modularity.	More modularity.
Debugging and modification are less accessible.	Debugging and modification are more accessible.

Microkernels



Difference between Monolithic and Microkernel

S. No.	Parameters	Microkernel	Monolithic kernel
1.	**Address Space**	In microkernel, user services and kernel services are kept in separate address space.	In monolithic kernel, both user services and kernel services are kept in the same address space.
2.	**Design and Implementation**	OS is complex to design.	OS is easy to design and implement.
3.	**Size**	Microkernel are smaller in size.	Monolithic kernel is larger than microkernel.
4.	**Functionality**	Easier to add new functionalities.	Difficult to add new functionalities.
5.	**Coding**	To design a microkernel, more code is required.	Less code when compared to microkernel
6.	**Failure**	Failure of one component does not effect the working of micro kernel.	Failure of one component in a monolithic kernel leads to the failure of the entire system.
7.	**Processing Speed**	Execution speed is low.	Execution speed is high.

Difference between Monolithic and Microkernel

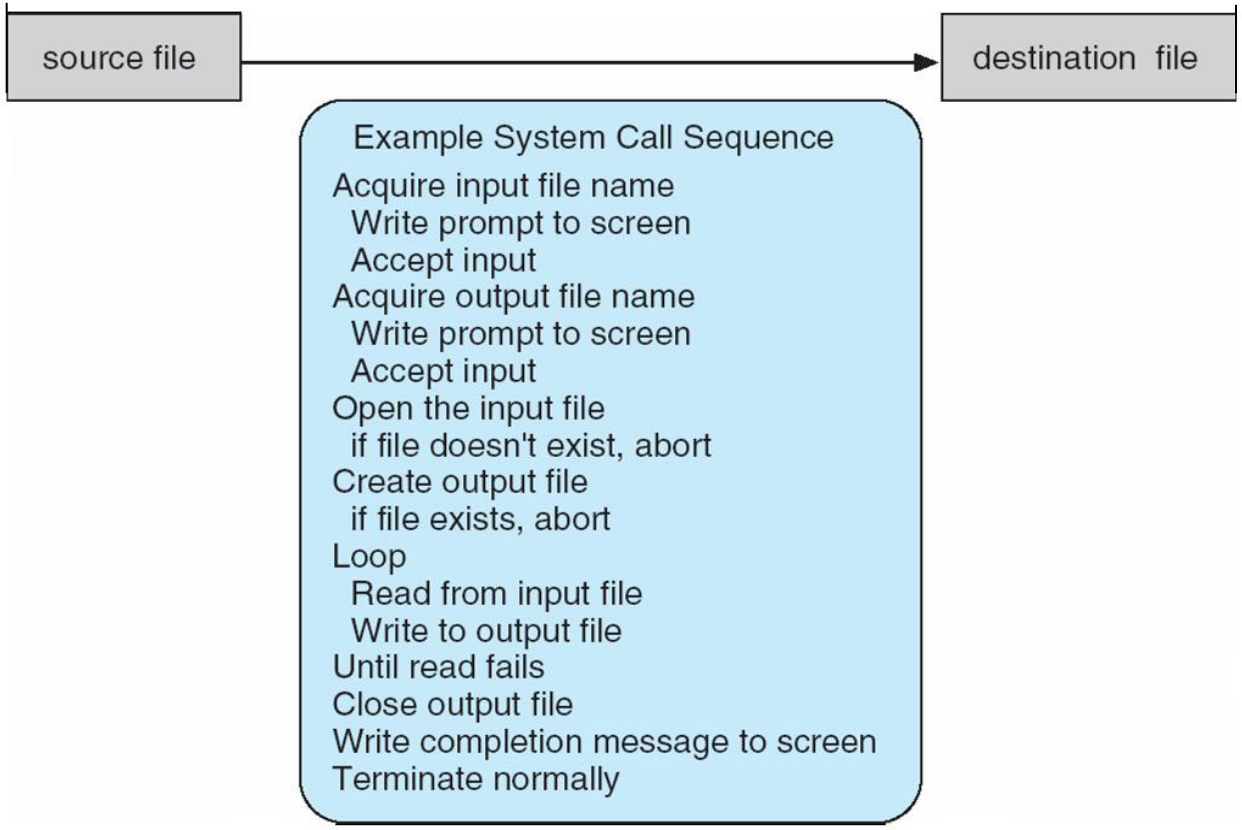
S. No.	Parameters	Microkernel	Monolithic kernel
8.	**Extend**	It is easy to extend Microkernel.	It is not easy to extend monolithic kernel.
9.	**Communication**	To implement IPC messaging queues are used by the communication microkernels.	Signals and Sockets are utilized to implement IPC in monolithic kernels.
10.	**Debugging**	Debugging is simple.	Debugging is difficult.
11.	**Maintain**	It is simple to maintain.	Extra time and resources are needed for maintenance.
12.	**Message passing and Context switching**	Message forwarding and context switching are required by the microkernel.	Message passing and context switching are not required while the kernel is working.
13.	**Services**	The kernel only offers IPC and low-level device management services.	The Kernel contains all of the operating system's services.
14.	**Example**	**Example :** Mac OS X.	**Example :** Microsoft Windows 95.

System Calls

System Calls

- Programming interface to the services provided by the OS
- Typically written in a high-level language (C or C++)
- Mostly accessed by programs via a high-level **Application Programming Interface (API)** rather than direct system call use

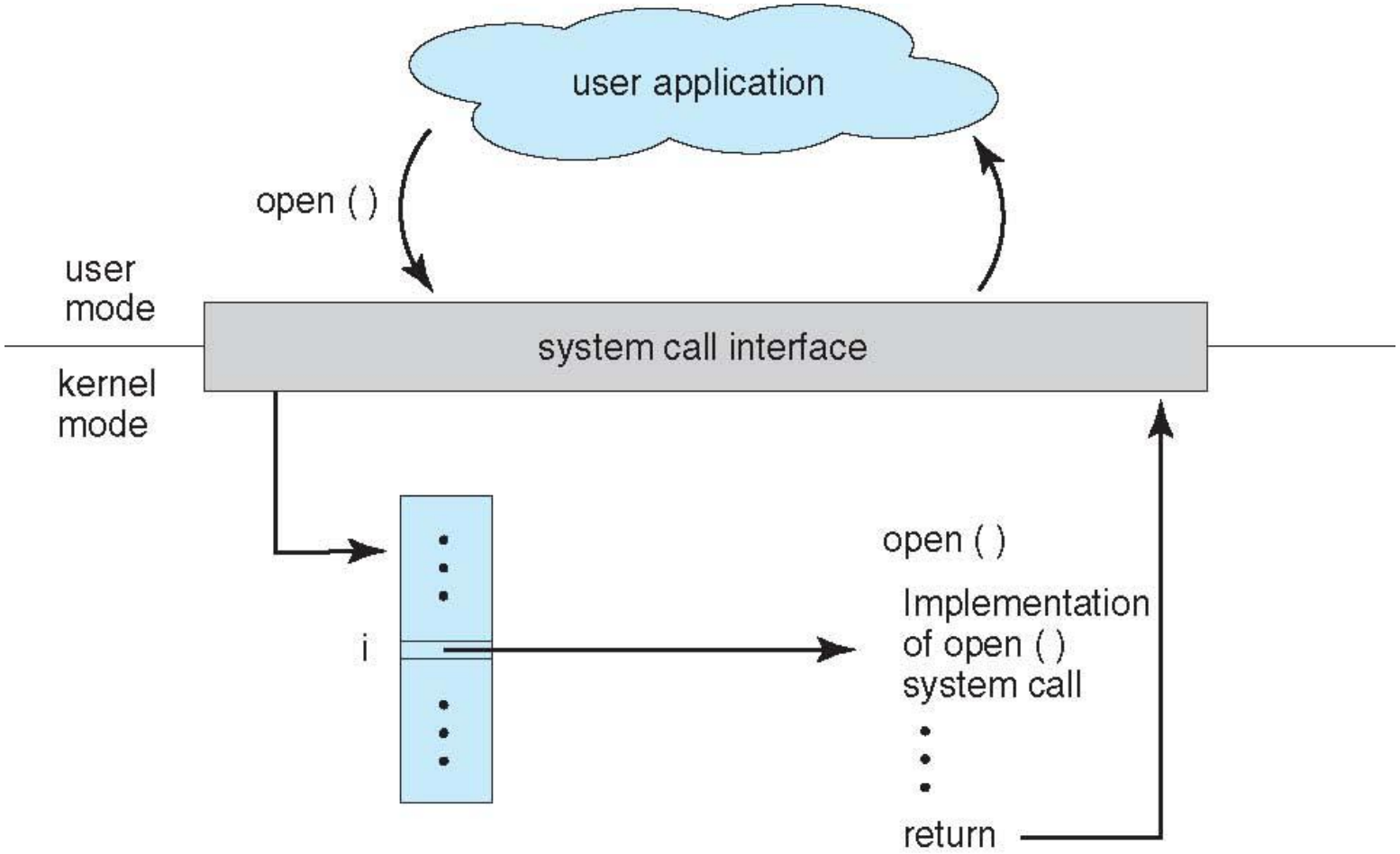
Example of System Call for copy file (cp of Linux)



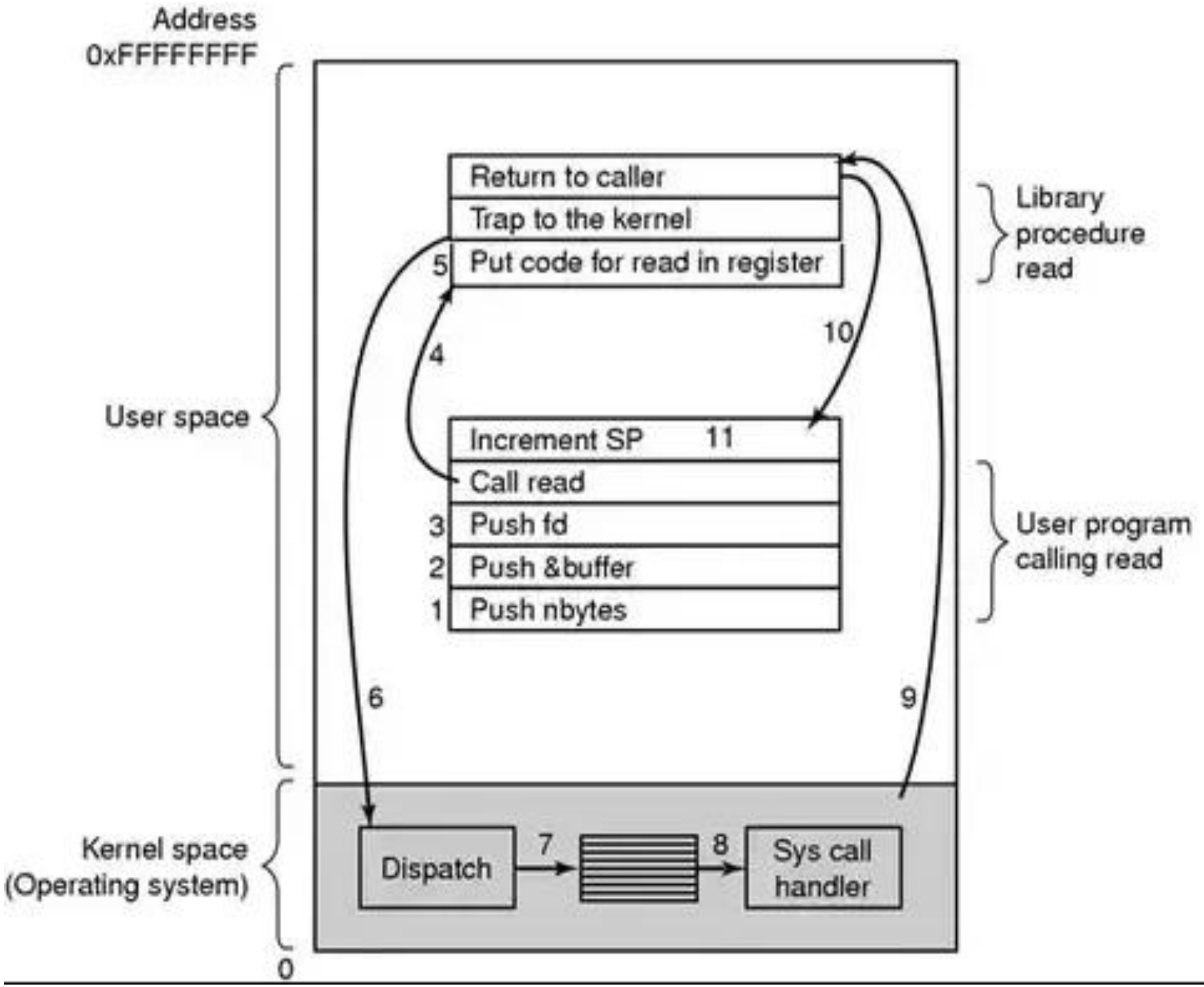
System Call Implementation / Invoking System Call

- Typically, a number associated with each system call
  - **System-call interface** maintains a table indexed according to these numbers
- The system call interface invokes the intended system call in OS kernel and returns status of the system call and any return values
- The caller need not know anything about how the system call is implemented
  - Just needs to obey API and understand what OS will do as a result call
  - Most details of OS interface hidden from programmer by API
    - Managed by run-time support library (set of functions built into libraries included with compiler)

System Call Implementation



System Call Implementation



System Call Implementation

- A call from a C program:
  - count = read(fd, buffer, nbytes)
  - The system call (and the library procedure) return the number of bytes actually read in count. This value is normally the same as nbytes, but may be smaller, if, for example, end-of-file is encountered while reading.
  - If the system call cannot be carried out, either due to an invalid parameter or a disk error, count is set to —1, and the error number is put in a global variable, errno.
  - Programs should always check the results of a system call to see if an error occurred. System calls are performed in a series of steps.

System Call Implementation

- In preparation for calling the read library procedure, which actually makes the read system call, the calling program first pushes the parameters onto the stack, as shown in steps 1-3.
  - The first and third parameters are called by value, but the second parameter is passed by reference, meaning that the address of the buffer (indicated by &) is passed, not the contents of the buffer.
- Then comes the actual call to the library procedure (step 4). This instruction is the normal procedure call instruction used to call all procedures.
- The library procedure, possibly written in assembly language, typically puts the system call number in a place where the operating system expects it, such as a register (step 5).
- Then it executes a TRAP instruction to switch from user mode to kernel mode and start execution at a fixed address within the kernel (step 6).
- The kernel code that starts following the TRAP examines the system call number and then dispatches to the correct system call handler, usually via a table of pointers to system call handlers indexed on system call number (step 7).
- At that point the system call handler runs (step 8).
- Once the system call handler has completed its work, control may be returned to the user-space library procedure at the instruction following the TRAP instruction (step 9).
- This procedure then returns to the user program in the usual way procedure calls return (step 10).
- To finish the job, the user program has to clean up the stack, as it does after any procedure call (step 11).

Types of System Calls

- Process control
  - create process, terminate process
  - end, abort
  - load, execute
  - get process attributes, set process attributes
  - wait for time
  - wait event, signal event
  - allocate and free memory
  - Dump memory if error
  - **Debugger** for determining **bugs, single step** execution
  - **Locks** for managing access to shared data between processes

Types of System Calls (Cont.)

- File management
  - create file, delete file
  - open, close file
  - read, write, reposition
  - get and set file attributes
- Device management
  - request device, release device
  - read, write, reposition
  - get device attributes, set device attributes
  - logically attach or detach devices
- Information maintenance
  - get time or date, set time or date
  - get system data, set system data
  - get and set process, file, or device attributes

Types of System Calls (Cont.)

- Communications
  - create, delete communication connection
  - send, receive messages if **message passing model** to **host name** or **process name**
    - From **client** to **server**
  - **Shared-memory model** create and gain access to memory regions
  - transfer status information
  - attach and detach remote devices
- Protection
  - Control access to resources
  - Get and set permissions
  - Allow and deny user access

Examples of Windows and Unix System Calls

	Windows	Unix
Process Control	CreateProcess() ExitProcess() WaitForSingleObject()	fork() exit() wait()
File Manipulation	CreateFile() ReadFile() WriteFile() CloseHandle()	open() read() write() close()
Device Manipulation	SetConsoleMode() ReadConsole() WriteConsole()	ioctl() read() write()
Information Maintenance	GetCurrentProcessID() SetTimer() Sleep()	getpid() alarm() sleep()
Communication	CreatePipe() CreateFileMapping() MapViewOfFile()	pipe() shmget() mmap()
Protection	SetFileSecurity() InitlializeSecurityDescriptor() SetSecurityDescriptorGroup()	chmod() umask() chown()

System Programs

System Programs

- System programs provide a convenient environment for program development and execution. They can be divided into:
  - File manipulation
  - Status information sometimes stored in a File modification
  - Programming language support
  - Program loading and execution
  - Communications
  - Background services
  - Application programs
- Most users' view of the operating system is defined by system programs, not the actual system calls

System Programs

- Provide a convenient environment for program development and execution
  - Some of them are simply user interfaces to system calls; others are considerably more complex
- **File management** - Create, delete, copy, rename, print, dump, list, and generally manipulate files and directories
- **Status information**
  - Some ask the system for info - date, time, amount of available memory, disk space, number of users
  - Others provide detailed performance, logging, and debugging information
  - Typically, these programs format and print the output to the terminal or other output devices
  - Some systems implement a **registry** - used to store and retrieve configuration information

System Programs (Cont.)

- **File modification**
  - Text editors to create and modify files
  - Special commands to search contents of files or perform transformations of the text
- **Programming-language support** - Compilers, assemblers, debuggers and interpreters sometimes provided
- **Program loading and execution**- Absolute loaders, relocatable loaders, linkage editors, and overlay-loaders, debugging systems for higher-level and machine language
- **Communications** - Provide the mechanism for creating virtual connections among processes, users, and computer systems
  - Allow users to send messages to one another's screens, browse web pages, send electronic-mail messages, log in remotely, transfer files from one machine to another

System Programs (Cont.)

- **Background Services**
  - Launch at boot time
    - Some for system startup, then terminate
    - Some from system boot to shutdown
  - Provide facilities like disk checking, process scheduling, error logging, printing
  - Run in user context not kernel context
  - Known as **services**, **subsystems**, **daemons**
- **Application programs**
  - Don’t pertain to system
  - Run by users
  - Not typically considered part of OS
  - Launched by command line, mouse click, finger poke

System Boot

System Boot

- When power initialized on system, execution starts at a fixed memory location
  - Firmware ROM used to hold initial boot code
- Operating system must be made available to hardware so hardware can start it
  - Small piece of code – **bootstrap loader**, stored in **ROM** or **EEPROM** locates the kernel, loads it into memory, and starts it
  - Sometimes two-step process where **boot block** at fixed location loaded by ROM code, which loads bootstrap loader from disk
- Common bootstrap loader, **GRUB**, allows selection of kernel from multiple disks, versions, kernel options
- Kernel loads and system is then **running**

Summary of Module 1

- OS acts as an intermediate layer between hardware and other programs thereby providing a layer of abstraction. It acts as a resource allocator and control program.
- Evolution from Serial Processing to Time-Shared Operating Systems
- OS is interrupt driven. A system call service (service from kernel) is invoked through interrupts.
  - Interrupts can be software interrupts such as, running program requires a file to be opened.
  - Interrupts can be hardware interrupts such as, I/O device ready for data communication.
  - Special Interrupts occur due errors/ exceptions such as a program running in infinite loop.
- Architecture: Monolithic, Layered and Microkernel
- System Calls and their Implementation