Computer System Structure

Reading:

Silberschatz

chapter 3

Additional Reading:

Stallings

chapter 2

Outline

- OS Services
- User Interfaces
- System Call
- OS Design
- OS Implementation
- System Structure
  - MSDOS
  - UNIX
  - OS/2
  - Win NT
- Virtual Machines
- System Installation

Aspects of OS

- OS from several vantage points
  - *Services that system provides*
  - *Available interfaces to users & programmers*
  - *Components and interconnections*

OS Services

- Program execution – System capability to load a program into memory and to run it
- I/O operations – User programs cannot execute I/O operations directly, the OS must provide some means to perform I/O
- File-system manipulation – Program capability to read, write, create, and delete files
- Communications – Exchange of information between processes running on same or different computers, *shared memory* or *message passing*
- Error detection – Ensure correct computing by detecting errors in the CPU and memory hardware, in I/O devices, or in user programs

Additional OS Services

Additional functions to ensure efficient system operations

- Resource allocation – allocating resources to multiple users/jobs running at the same time
- Accounting – keep track of and record which users use how much and what kinds of resources
- Protection – ensuring that all access to system resources is controlled

User OS Interface

- Two approaches
  - Command-line interface (command interpreter)
  - Graphical user interface (GUI)
- Command Interpreter
  - Main function – Get and execute the next command
    - MSDOS and UNIX shell
  - Multiple command interpreter in UNIX and Linux
    - *Bourne shell*, *C shell*, *Bourne-Again shell*, *Korn shell*, etc.
  - Two approaches to implement the commend execution
    - CI itself contains the code to interpret the command
    - Implement most commands through system program – UNIX *e.g.* `rm file.txt`, new commands by adding new files

User OS Interface

GUI

- Mouse-based window and menu system
- User friendly

- UNIX systems – dominated by CLI traditionally
- Various GUI interfaces in commercial version of UNIX
  - *Common Desktop Environment* (*CDE*), *X-Windows*, *etc*.
- Significant GUI developments from open source projects
  - *K Desktop environment* (*KDE*), *GNOME desktop*
  - Many are available under open-source license
  - Linux and various UNIX systems

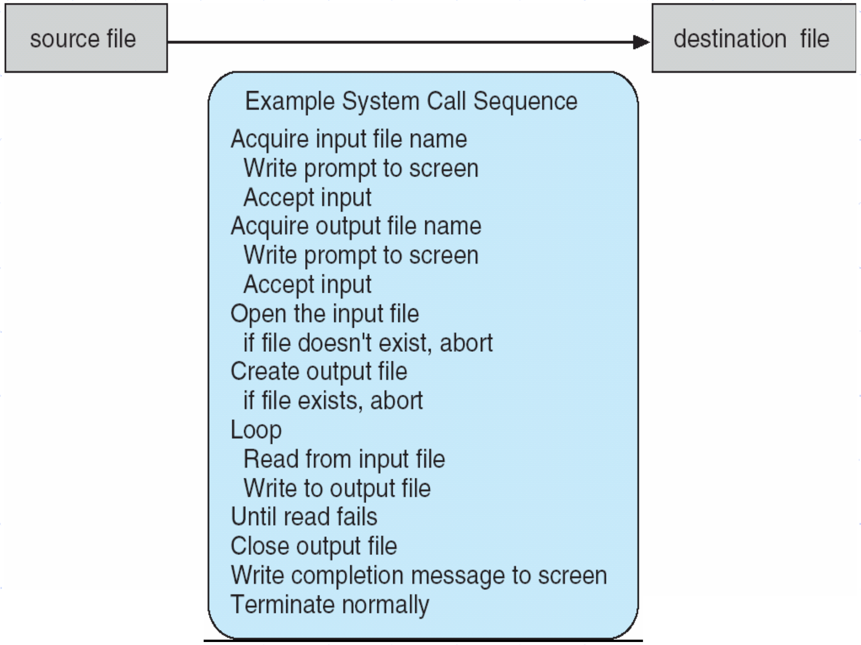
- Command-line or GUI ?
  - Powerful shell interface (many UNIX users)
  - Windows user friendly GUI (many window users)

System Calls

- Enter OS and perform a privileged operation

  Interface to the services made available by OS

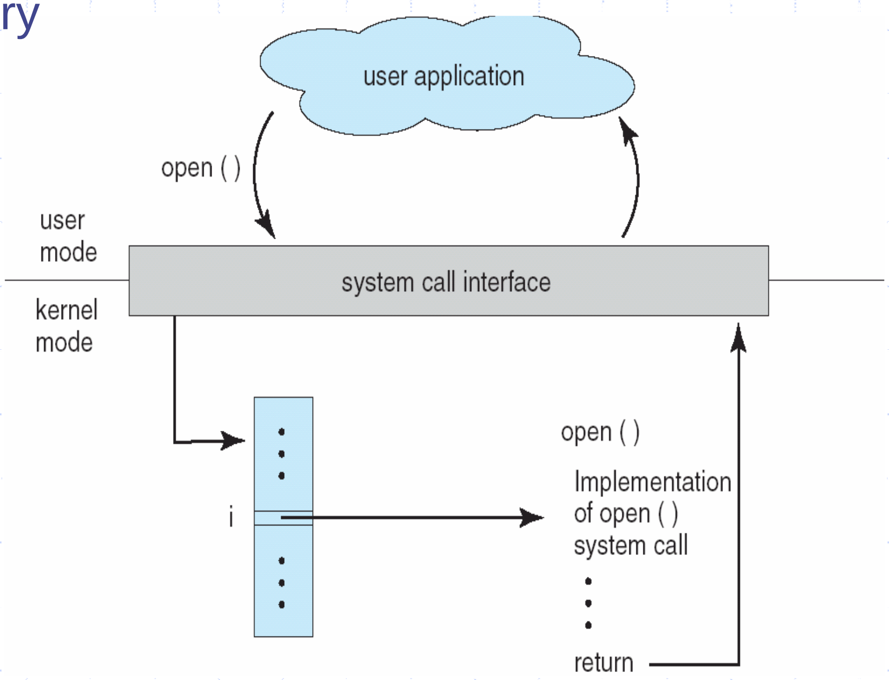
- Key Points
  - Difference between *procedure call* and *system call*
  - Generally available as routines written in C and C++
  - Some low-level tasks may need to be written using assembly language
  - How system calls are used?
    - Example → read data from file and write to another



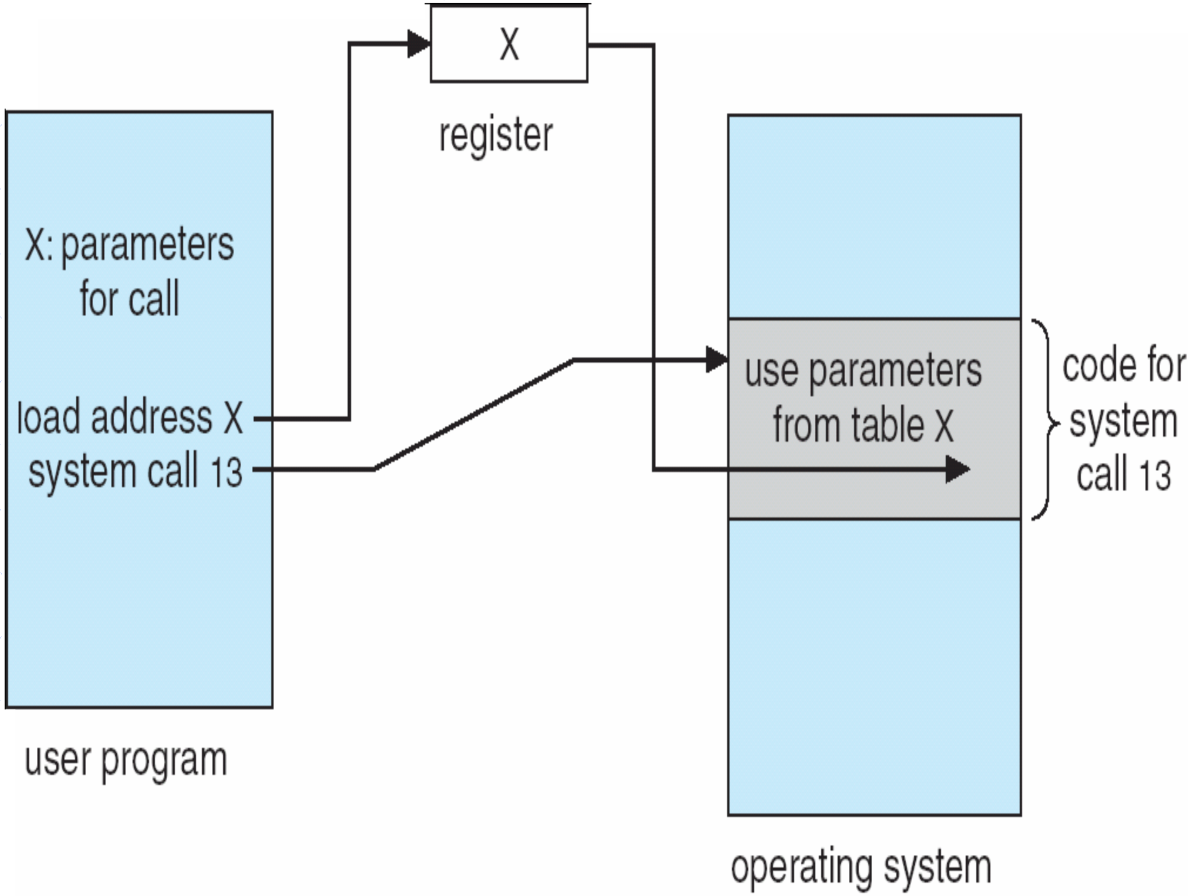
```
Example System Call Sequence
Acquire input file name
  Write prompt to screen
  Accept input
Acquire output file name
  Write prompt to screen
  Accept input
Open the input file
  if file doesn't exist, abort
Create output file
  if file exists, abort
Loop
  Read from input file
  Write to output file
Until read fails
Close output file
Write completion message to screen
Terminate normally
```

System Call Implementation

- Application Programming Interface (API)
  - API → Set of functions available to an application programmer
  - Most common APIs
    - Win32 API for Windows system
    - POSIX API for most versions of UNIX, Linux and Mac OS X
    - Java API for designing programs for JVM
  - Behind the scene? Actual system calls are invoked – portability
  - Most details of OS interface are hidden by API, managed by run-time support library

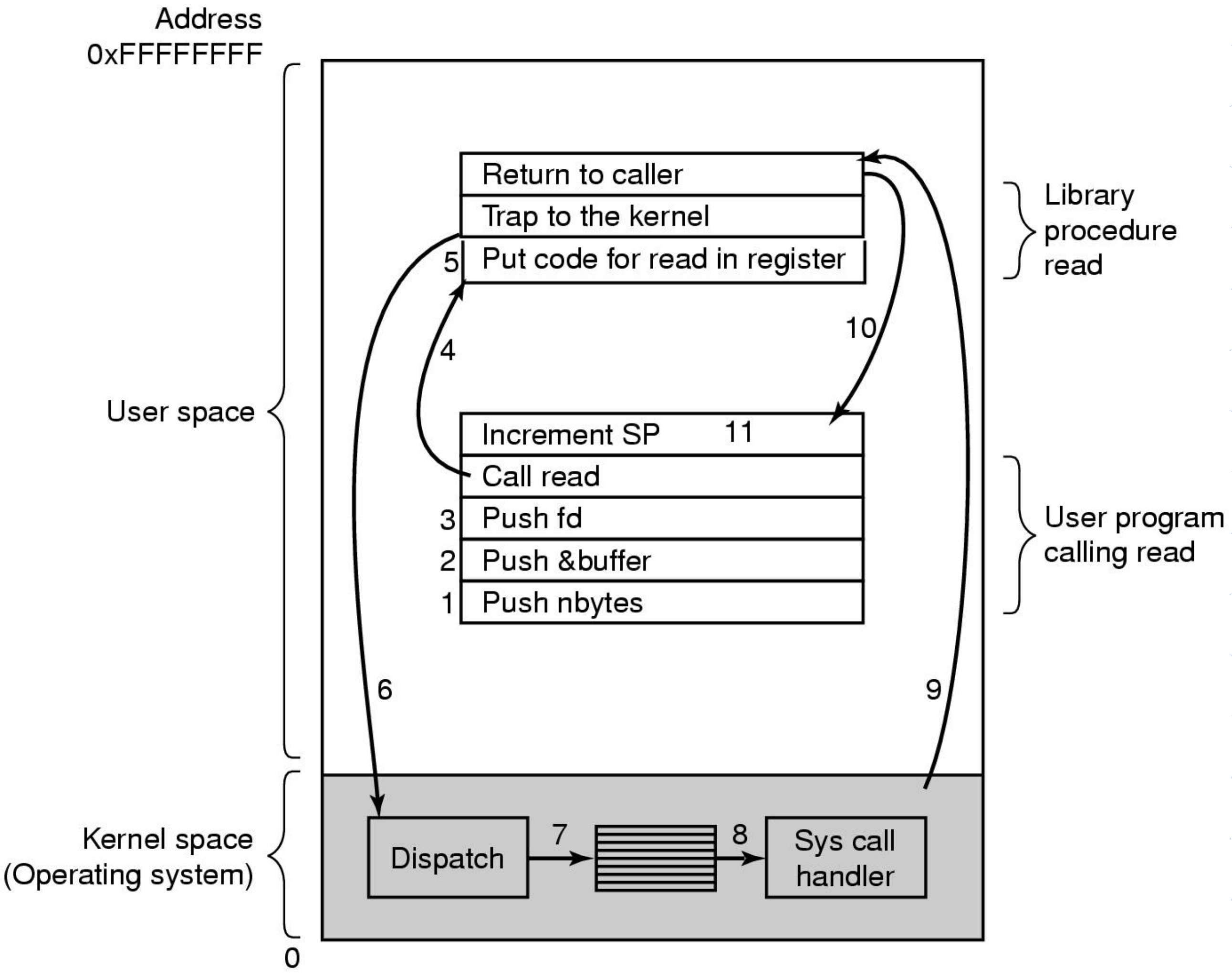


Parameter Passing



System Call Steps

There are 11 steps in making the system call → read (*fd, buffer, nbytes*)



System Call groups

System calls can be grouped into five major categories

- Process Control
  - fork(), exec(), wait(), abort()
- File manipulation
  - chmod(), link(), stst(), creat()
- Device manipulation
  - open(), close(), ioctl(), select()
- Information maintenance
  - time(), act(), gettimeofday()
- Communications
  - socket(), accept(), send(), recv()

OS design and Implementation

- Design Goals
  - Type of hardware and type of system
  - User Goals
    - *Convenient, easy to learn/use, reliable, safe and fast*
  - System Goals
    - *Easy to design, implement/maintain, flexible, reliable, error-free and efficient*

      (vague requirements! has several interpretations)
- Implementation
  - Traditionally written in assembly language
    - Now mostly written in high-level languages such as C or C++
    - Linux and Windows XP - mostly in C, small section of assembly code device drivers
  - Advantages of implementing in HLL
    - *Compact, fast and easier to understand/debug*
    - Easier to port to some other hardware
  - Disadvantages of implementing in HLL
    - Reduced speed and increased storage requirements

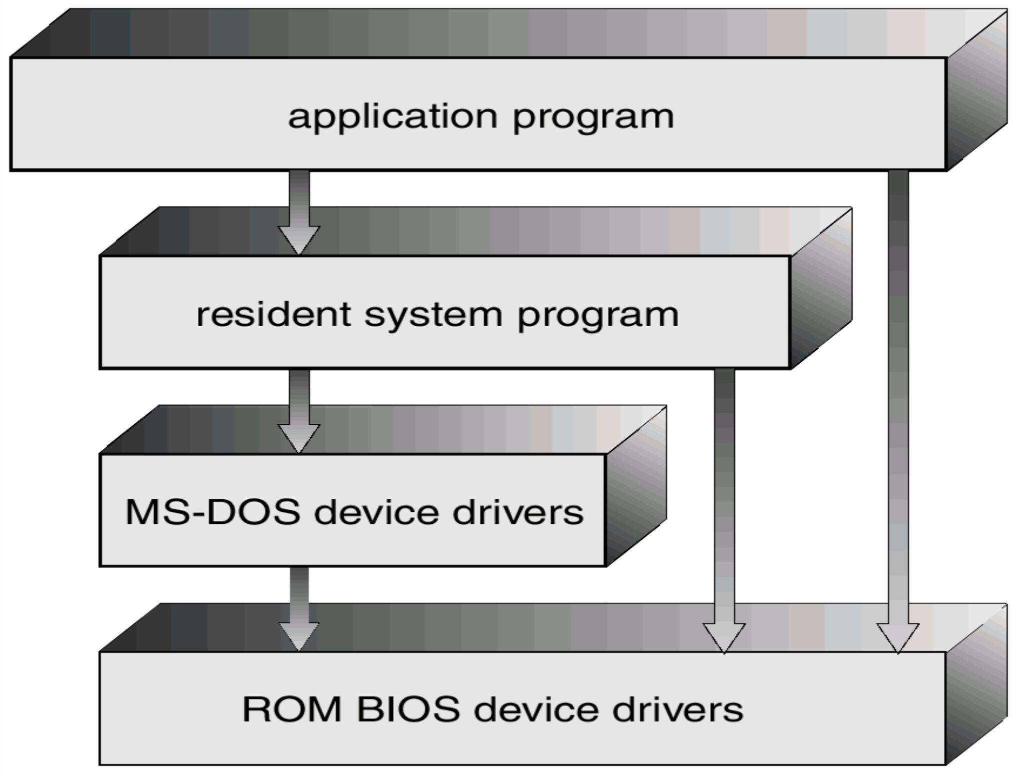
System Structure

- Possible ways to structure an operating system
  - Simple, single-user
    - *MSDOS, MacOS, Windows*
  - Monolithic, multi-user
    - *UNIX, Multics, OS/360*
  - Hybrid
    - *Win NT*
  - Virtual Machine
    - *IBM VM/370*
  - Client/Server (microkernel)
    - *Chorus/Mix*

Structure of MSDOS

- MSDOS – written to provide the most functionality in the least space
  - Not divided into modules
  - Interfaces and levels of functionality are not well separated (*e.g*. application programs access I/O)
  - Written for Intel 8088, No dual mode and no hardware protection

Structure of MSDOS

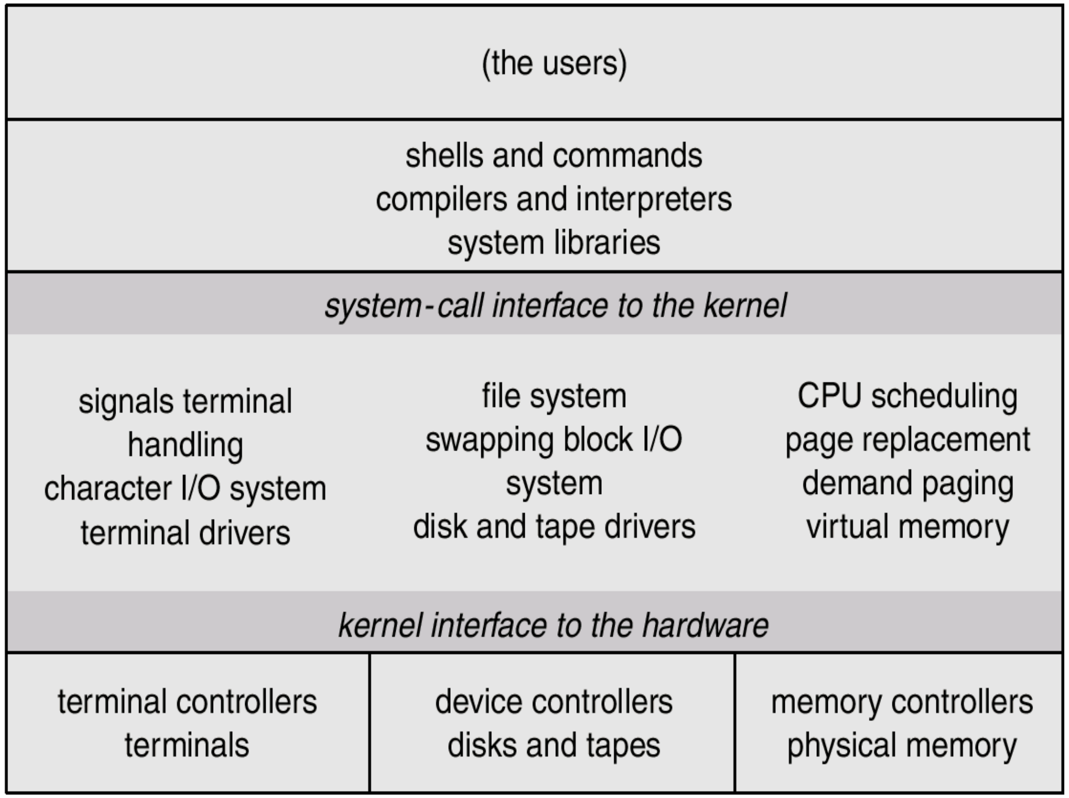


MSDOS Layer Structure

UNIX system Structure

- Original UNIX OS → Limited structuring
- Two separable parts
  - Systems programs
  - The kernel
    - Everything below system-call interface and above physical hardware
    - Provides file system, CPU scheduling, memory management, and other OS functions through system calls
    - Enormous amount of functionality into one level

UNIX System Structure



(the users)

shells and commands
compilers and interpreters
system libraries

system-call interface to the kernel

signals terminal handling
character I/O system
terminal drivers

file system
swapping block I/O system
disk and tape drivers

CPU scheduling
page replacement
demand paging
virtual memory

kernel interface to the hardware

terminal controllers
terminals

device controllers
disks and tapes

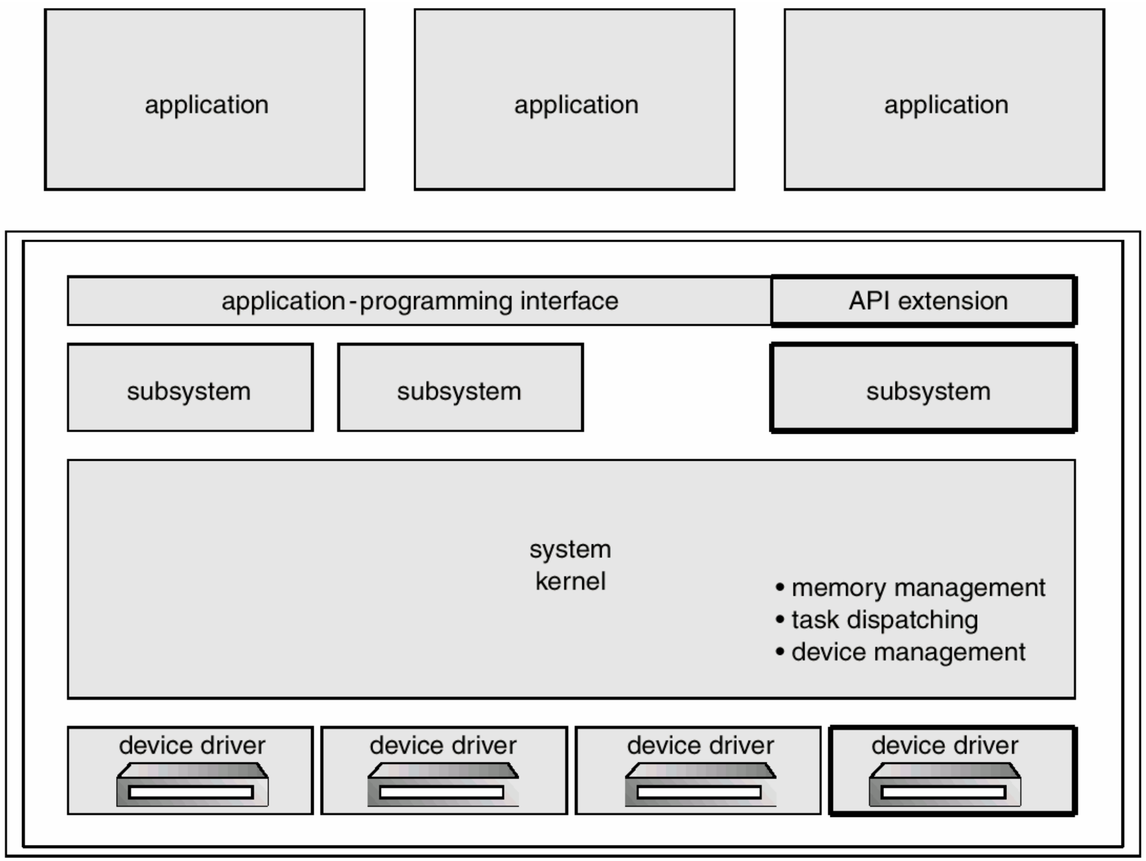
memory controllers
physical memory

UNIX System Structure

Layered Approach

- The modularization of System → Layered Approach
- The OS is divided into a number of layers (levels).
  - Bottom layer (layer 0) → Hardware
  - Highest (layer N) → User interface
- Layers are selected such that each uses functions and services of only lower-level layers
- Problem – more overhead, less efficient
- OS/2 descendent of MSDOS – Multitasking and dual mode operations
  - Advantage – direct user access to low-level facilities is prohibited
- Example – Windows NT
  - First release highly layered – low performance Vs Windows 95
  - Windows NT 4.0 – Moved layers from user space to kernel space

Layered Approach

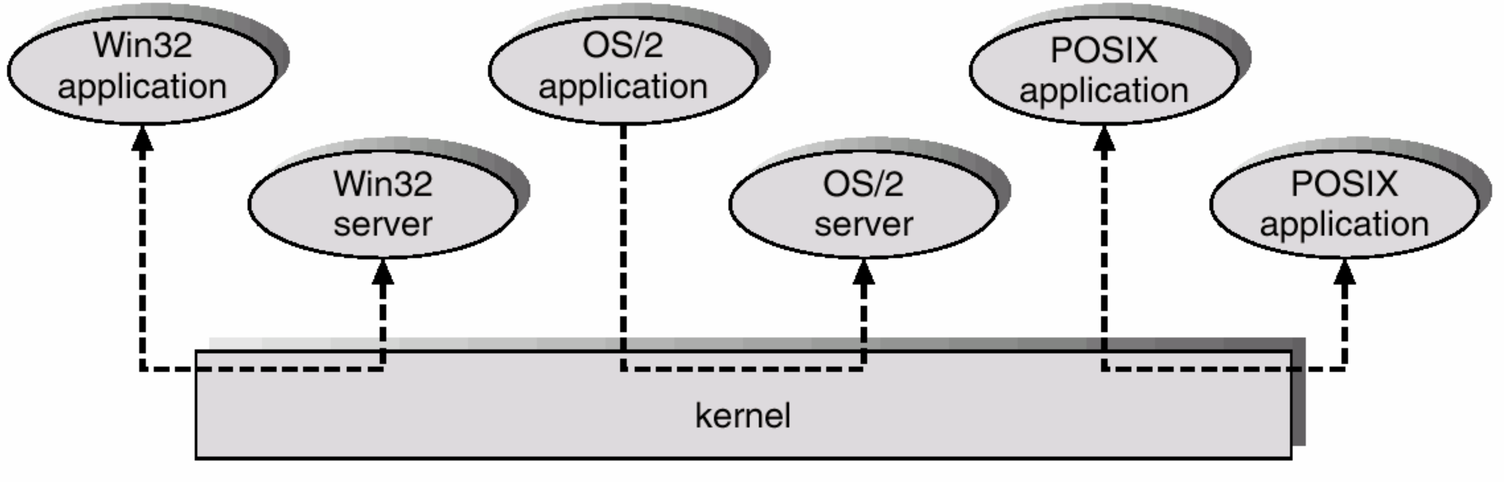


OS/2 Layer Structure

Microkernel System Structure

- Removing all nonessential components from kernel, implementing as user-level programs
- Moves as much from the *kernel* into *user* space
  - Resulting smaller kernel - *Microkernel*
  - Minimal process and memory management +
  - Communication facility using message passing
- Benefits
  - Easier to extend a microkernel
  - Easier to port OS to new architectures
  - More reliable and secure

Windows NT Client-Server Structure

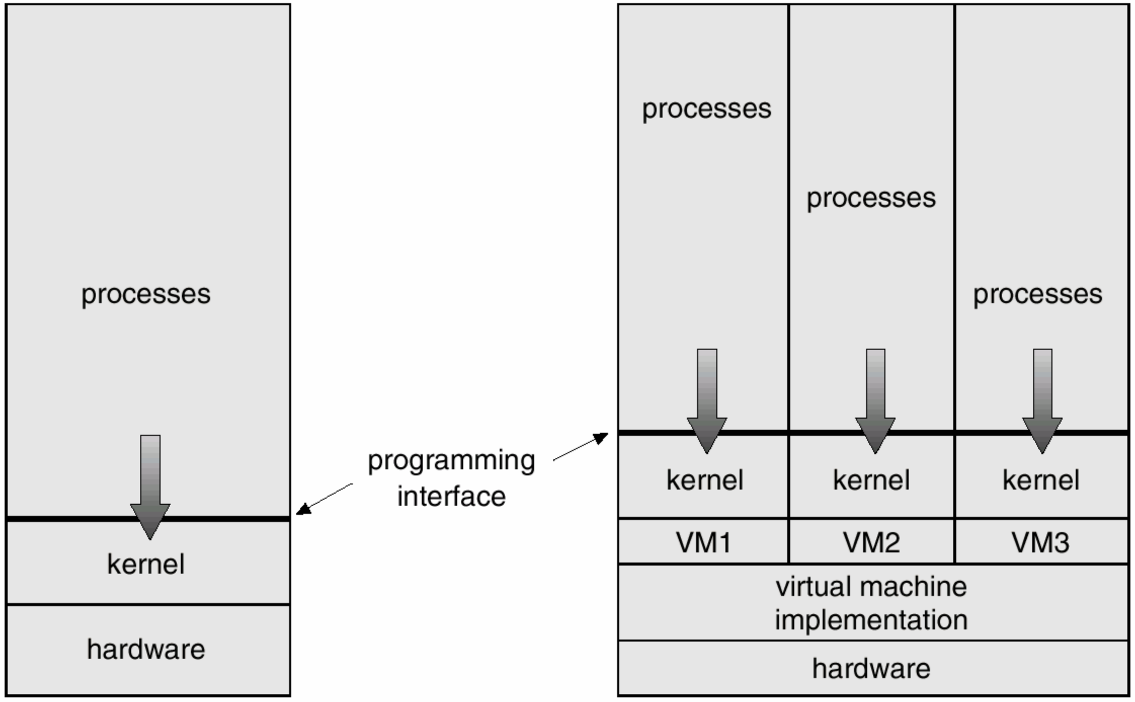


Hybrid Structure of Windows NT

Virtual Machines

- A *virtual machine* is logical conclusion of the layered approach
  - Hardware and OS kernel are treated as hardware
  - The OS creates illusion of multiple process, each executing on its own processor with its own memory
- The resources of physical computer are shared to create the virtual machines
  - CPU scheduling can create the appearance that users have their own processor
  - Virtual Memory techniques create illusion of processors own memory
  - Spooling and a file system can provide virtual card readers and virtual line printers
  - A normal user time-sharing terminal serves as the virtual machine operator’s console

Virtual Machines



Non-virtual Machine

Virtual Machine

Virtual Machines

- Complete protection of system resources - Each virtual machine is isolated another (but isolation prevents direct sharing of resources)
- System development on virtual machine, instead of on a physical machine, does not disrupt normal system operation
- The virtual machine concept is difficult to implement - Efforts required to provide an *exact* duplicate to the underlying machine

Java Virtual Machine

- Compiled Java programs are platform-neutral bytecodes executed by Java Virtual Machine (JVM)
- JVM consists of

  - class loader

  - class verifier

  - runtime interpreter
- Just-In-Time (JIT) compilers increase performance

Just-In-Time Java VM (JIT) and a Hotspot Java VM?

System Generation (installation)

- OS are designed to run on any of a class of machines. Information required for configuring for each specific computer
  - What CPU type is used? Options?
  - Number of CPUs?
  - How much memory is available?
  - What devices are available?
  - OS parameters (max # users, buffer size, max # devices, *etc*.)
  - OS features
    - Networking
    - Other file systems
    - Servers

System Generation (installation)

- How does the hardware know where the kernel is? or how to load the kernel?
  - Booting –Starting a computer by loading the kernel
  - *Bootstrap program* - Code stored in ROM that is able to locate the kernel, load it into memory, and start its execution