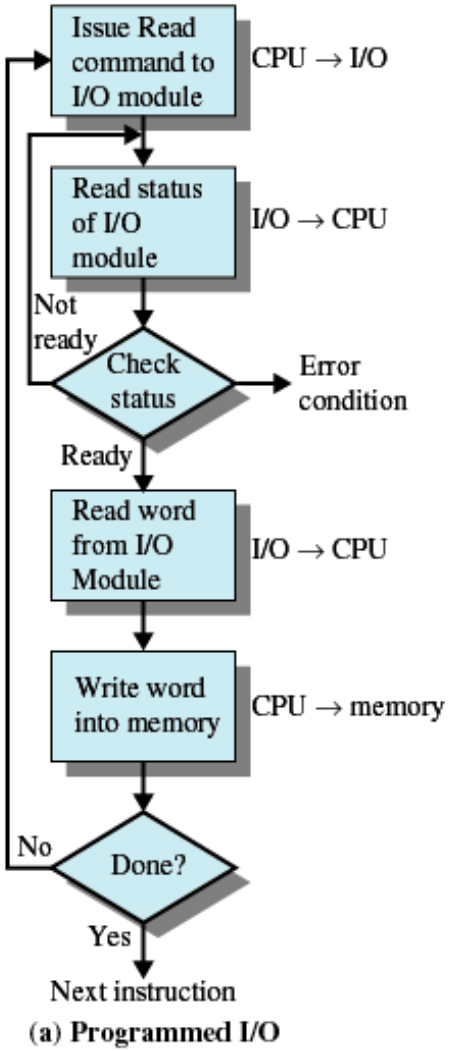
Programmed I/O

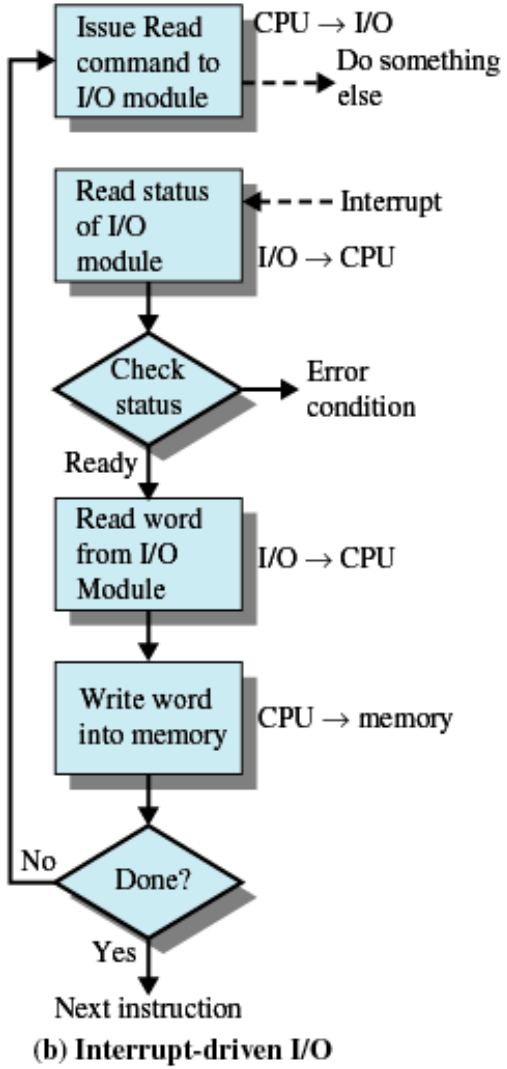
- I/O module performs the action, not the processor
- Sets appropriate bits in the I/O status register
- No interrupts occur
- Processor checks status until operation is complete



(a) Programmed I/O

Interrupt-Driven I/O

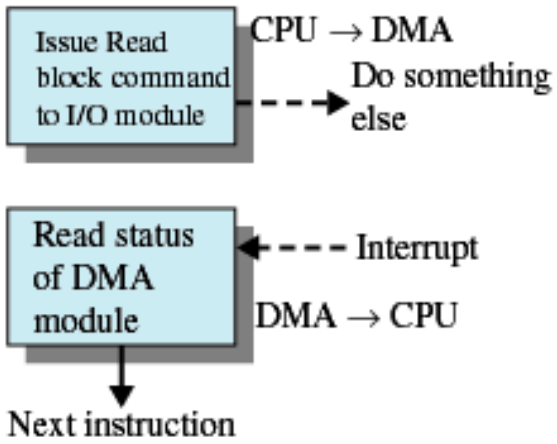
- Processor is interrupted when I/O module ready to exchange data
- Processor saves context of program executing and begins executing interrupt-handler
- No needless waiting
- Consumes a lot of processor time because every word read or written passes through the processor



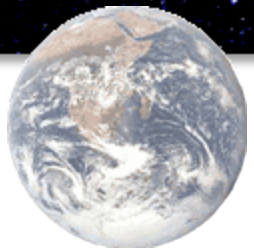
(b) Interrupt-driven I/O

Direct Memory Access

- Transfers a block of data directly to or from memory
- An interrupt is sent when the transfer is complete
- Processor continues with other work

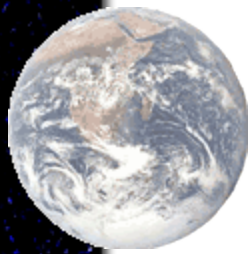


(c) Direct memory access



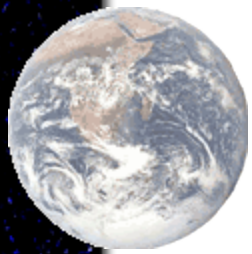
Operating System Overview

Chapter 2



Operating System

- A program that controls the execution of application programs
- An interface between applications and hardware



Operating System Objectives

- Convenience
  - Makes the computer more convenient to use
- Efficiency
  - Allows computer system resources to be used in an efficient manner
- Ability to evolve
  - Permit effective development, testing, and introduction of new system functions without interfering with service

Layers of Computer System

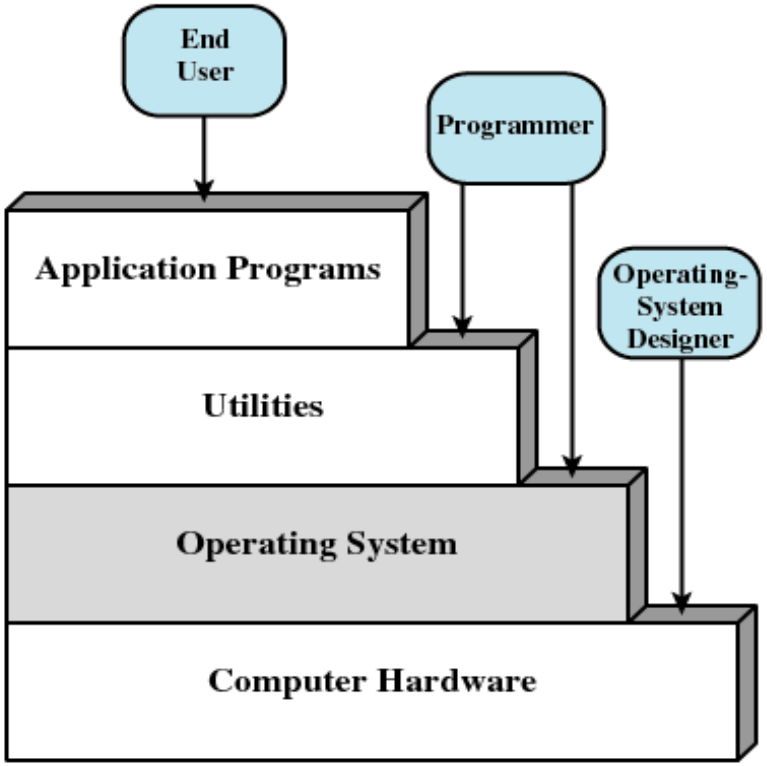
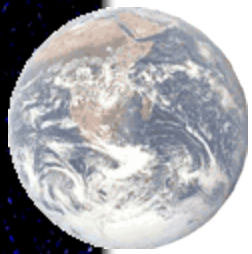
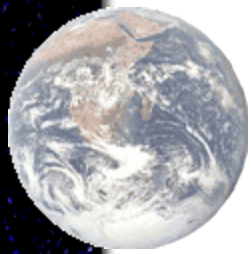


Figure 2.1 Layers and Views of a Computer System



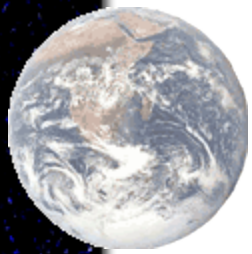
Services Provided by the Operating System

- Program development
  - Editors and debuggers
- Program execution
- Access to I/O devices
- Controlled access to files
- System access



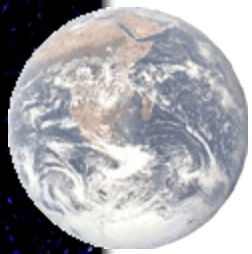
Services Provided by the Operating System

- Error detection and response
  - Internal and external hardware errors
    - Memory error
    - Device failure
  - Software errors
    - Arithmetic overflow
    - Access forbidden memory locations
  - Operating system cannot grant request of application



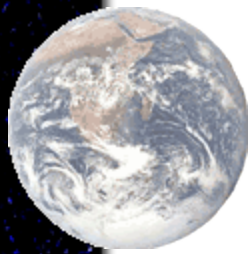
Services Provided by the Operating System

- Accounting
  - Collect usage statistics
  - Monitor performance
  - Used to anticipate future enhancements
  - Used for billing purposes



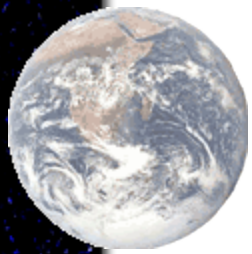
Operating System

- Responsible for managing resources
- Functions same way as ordinary computer software
  - It is program that is executed
- Operating system relinquishes control of the processor



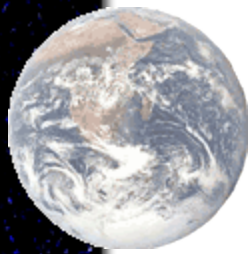
Kernel

- Portion of operating system that is in main memory
- Contains most frequently used functions
- Also called the nucleus



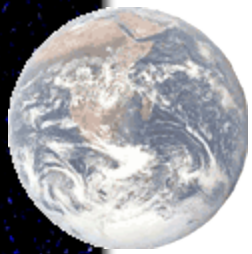
Evolution of an Operating System

- Hardware upgrades plus new types of hardware
- New services
- Fixes



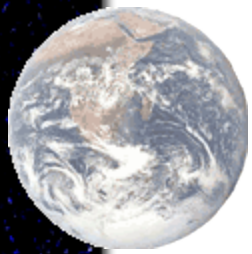
Evolution of Operating Systems

- Serial Processing
  - No operating system
  - Machines run from a console with display lights, toggle switches, input device, and printer
  - Schedule time
  - Setup included loading the compiler, source program, saving compiled program, and loading and linking



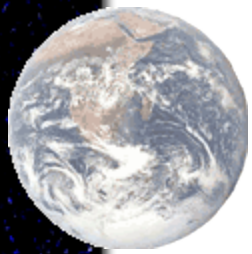
Evolution of Operating Systems

- Simple Batch Systems
  - Monitors
    - Software that controls the sequence of events
    - Batch jobs together
    - Program branches back to monitor when finished



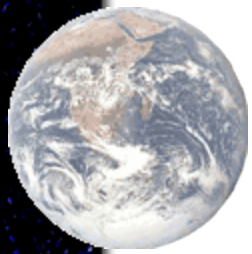
Job Control Language (JCL)

- Special type of programming language
- Provides instruction to the monitor
  - What compiler to use
  - What data to use



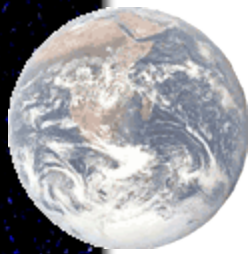
Hardware Features

- Memory protection
  - Do not allow the memory area containing the monitor to be altered
- Timer
  - Prevents a job from monopolizing the system



Hardware Features

- Privileged instructions (e.g. I/O)
  - Certain machine level instructions can only be executed by the monitor
- Interrupts
  - Early computer models did not have this capability

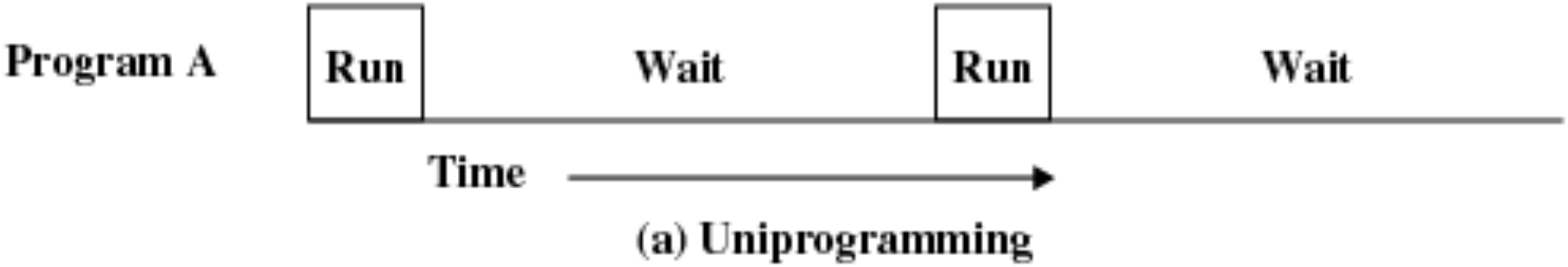


Memory Protection

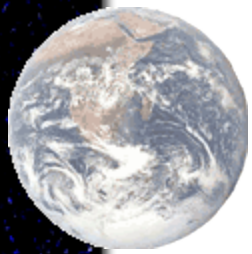
- User program executes in user mode
  - Certain instructions may not be executed
- Monitor executes in system mode
  - Kernel mode
  - Privileged instructions are executed
  - Protected areas of memory may be accessed

Uniprogramming

- Processor must wait for I/O instruction to complete before preceding

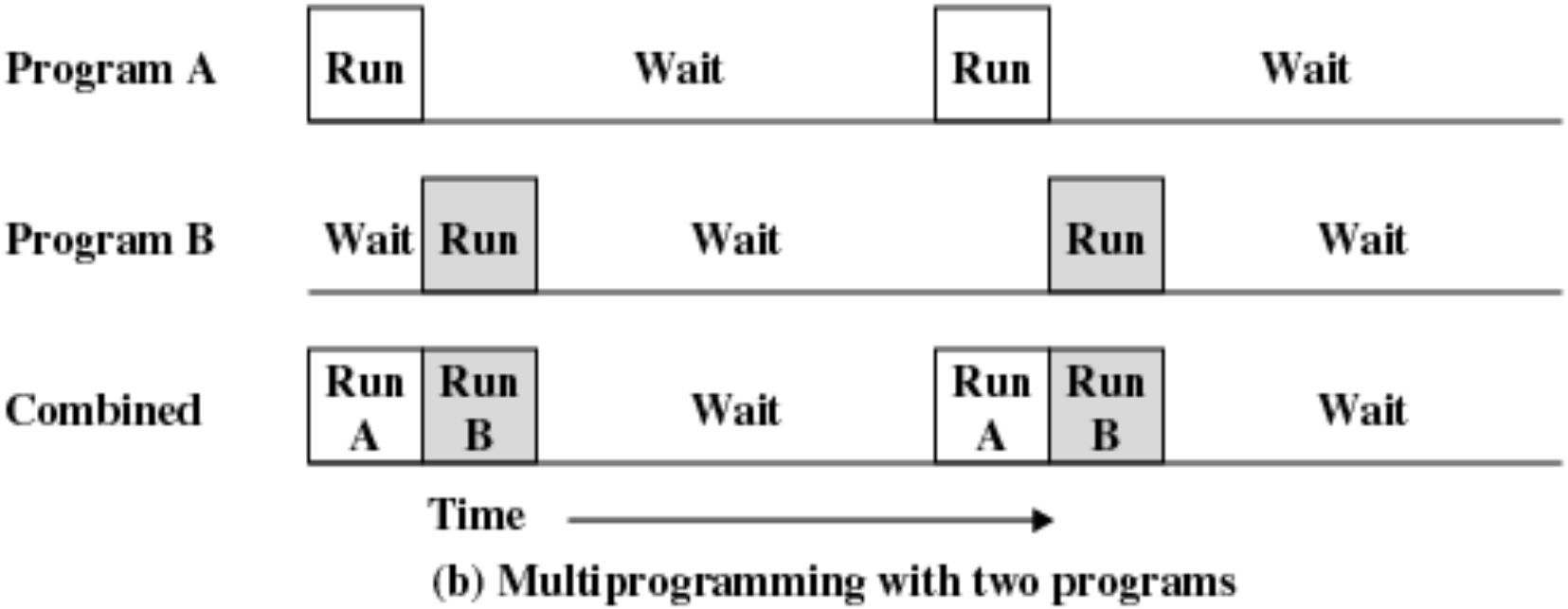


(a) Uniprogramming



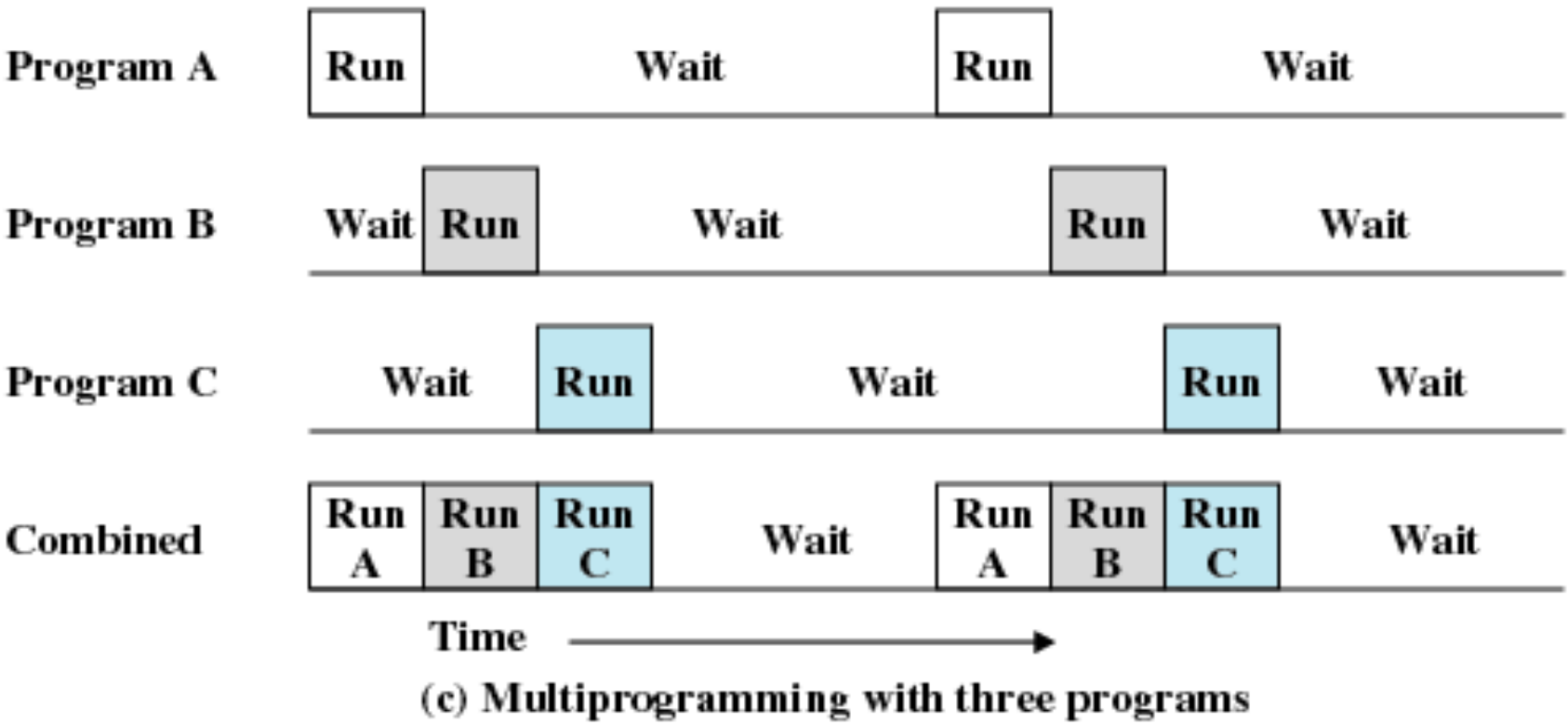
Multiprogramming

- When one job needs to wait for I/O, the processor can switch to the other job

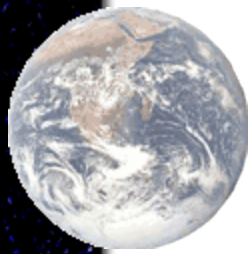


(b) Multiprogramming with two programs

Multiprogramming



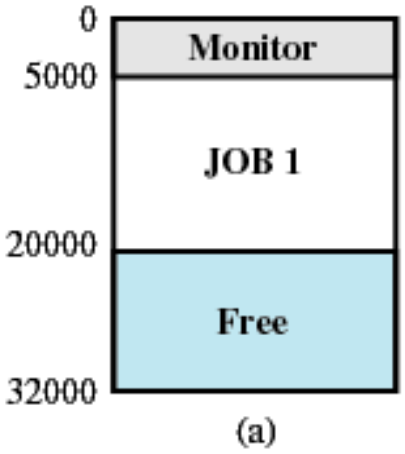
(c) Multiprogramming with three programs



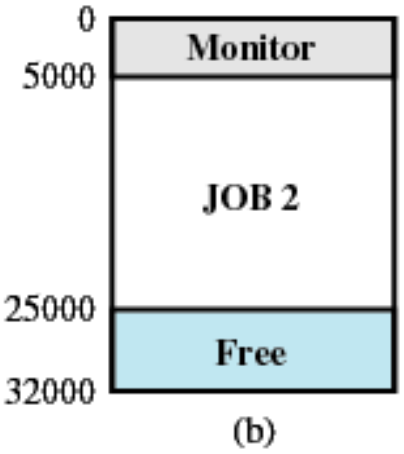
Time Sharing

- Using multiprogramming to handle multiple interactive jobs
- Time-slicing: Processor's time is shared among multiple users (clock every 0.2 sec.)
- Multiple users simultaneously access the system through terminals

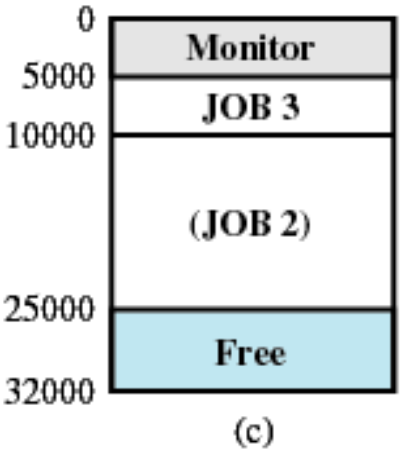
Compatible Time-Sharing System (CTSS) (32 users)



(a)



(b)

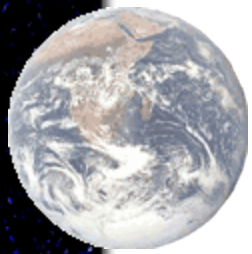


(c)

(d)

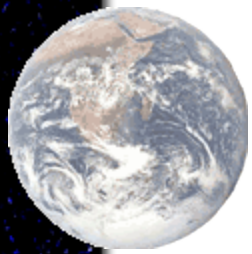
(e)

(f)

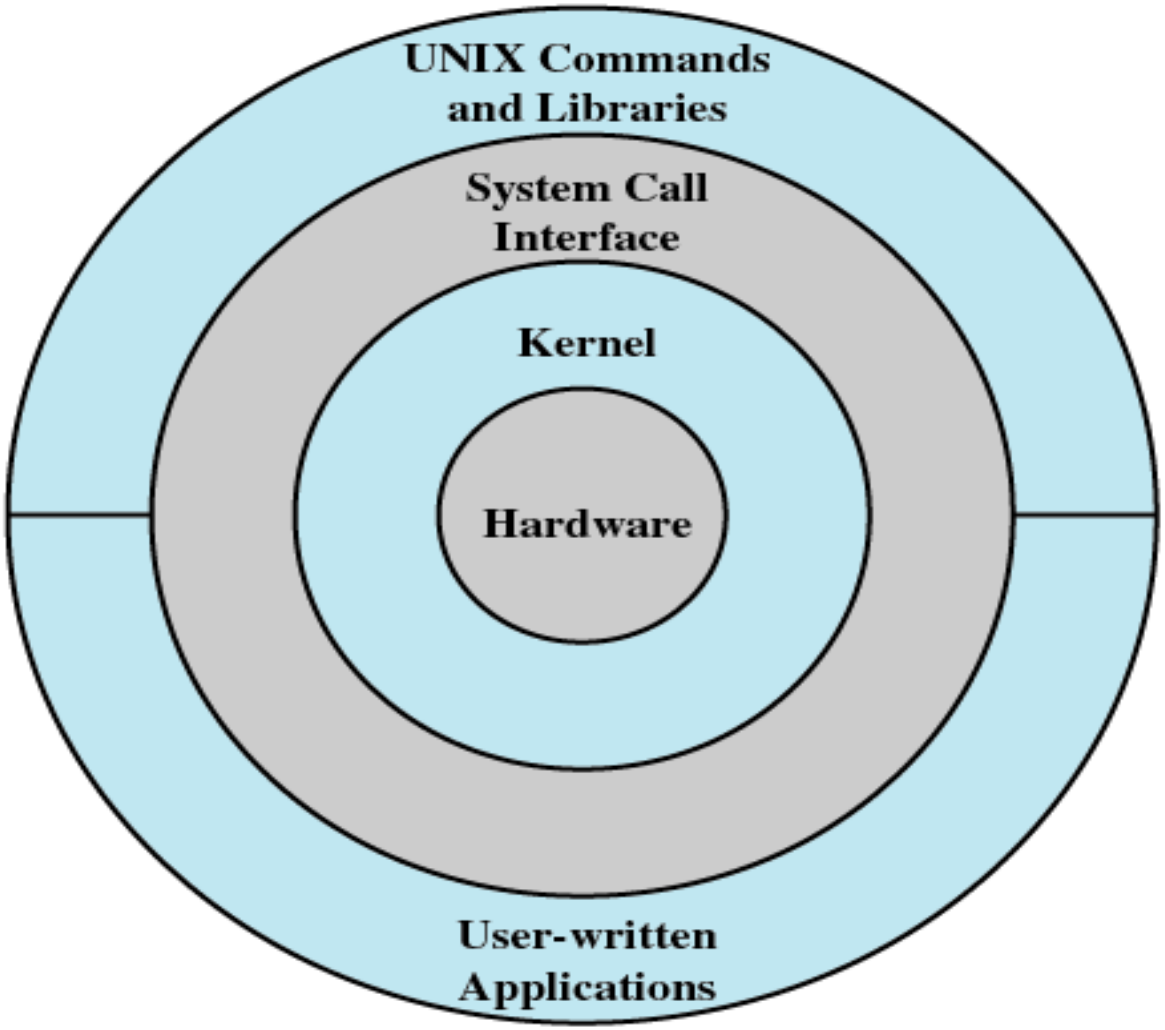


UNIX

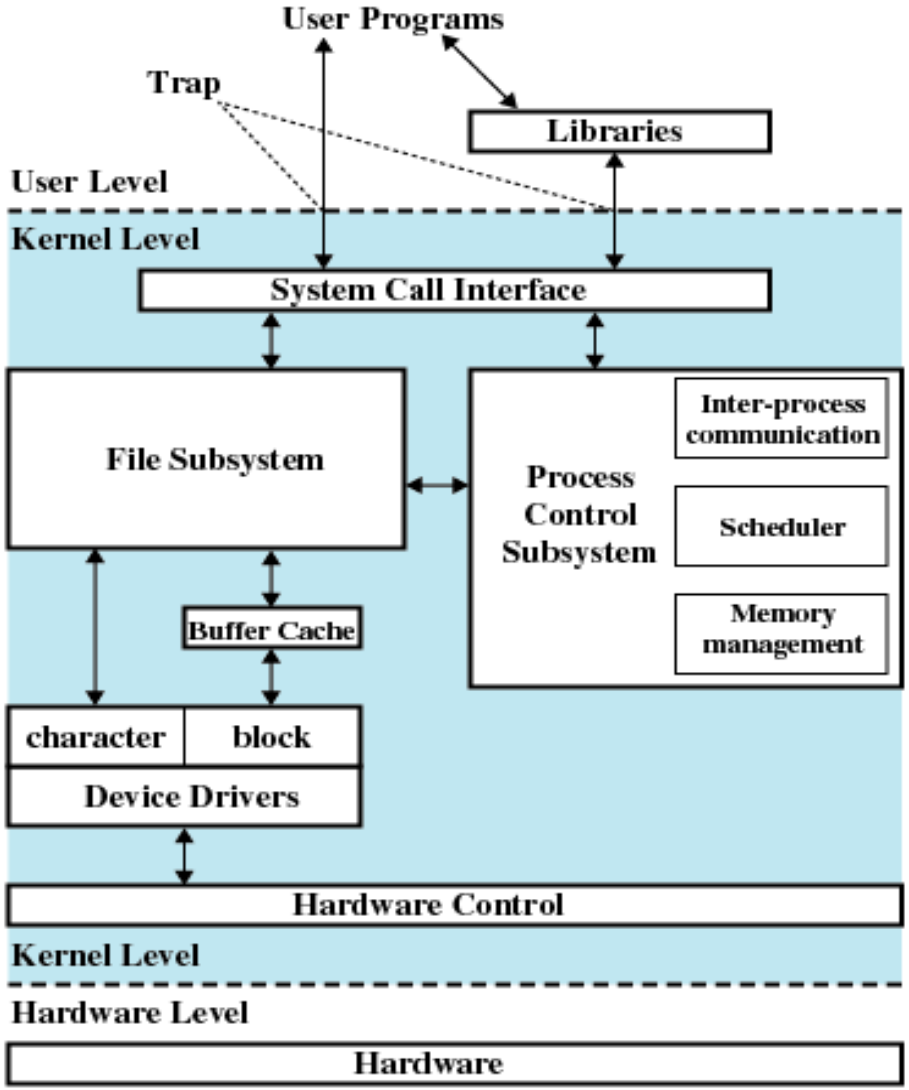
- Hardware is surrounded by the operating system software
- Operating system is called the system kernel
- Comes with a number of user services and interfaces
  - Shell
  - Components of the C compiler



UNIX


UNIX Commands and Libraries
System Call Interface
Kernel
Hardware
User-written Applications

UNIX Kernel


User Programs
Trap
Libraries
User Level
Kernel Level
System Call Interface
File Subsystem
Process Control Subsystem
Inter-process communication
Scheduler
Memory management
Buffer Cache
character
block
Device Drivers
Hardware Control
Kernel Level
Hardware Level
Hardware