Operating System Overview

Chapter 2

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Operating System

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

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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

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Layers of Computer System

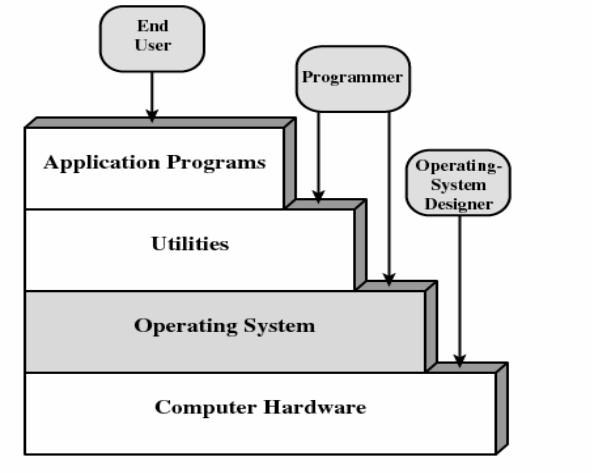

Figure 2.1 Layers and Views of a Computer System

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Services Provided by the Operating System

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

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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

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Services Provided by the Operating System

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

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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

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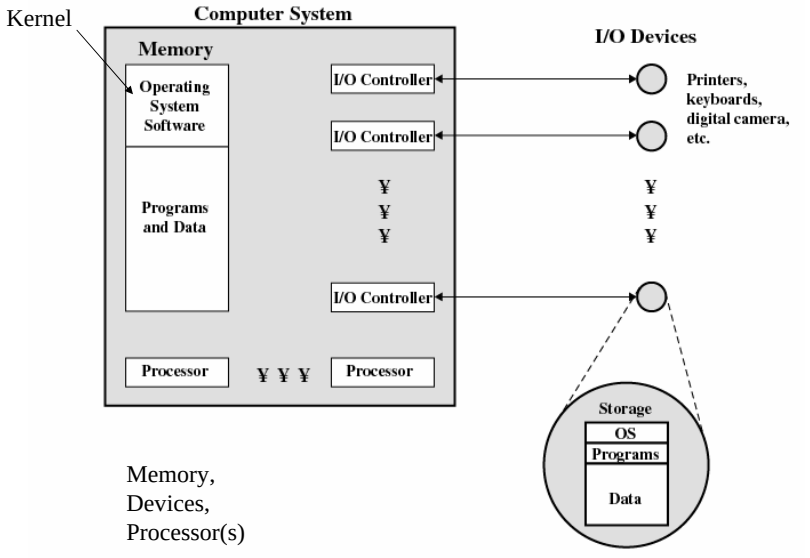

Figure 2.2 The Operating System as Resource Manager

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Kernel

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

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Evolution of an Operating System

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

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Evolution of Operating Systems

- Serial Processing
  - No operating system
- Simple Batch Systems
  - Monitor
- Multiprogrammed Batch Systems
  - Mulitprograming
- Time Sharing Systems
  - Multi-User

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Serial Processing Systems

- 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

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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

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Hardware Features (Batch Systems)

- Memory protection
  - Do not allow the memory area containing the monitor to be altered
- Timer
  - Prevents a job from monopolizing the system
- Interrupts
  - Early computer models did not have this capability

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Hardware Features (Batch Systems)

- Privileged instructions
  - Certain machine level instructions can only be executed by the monitor
  - 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

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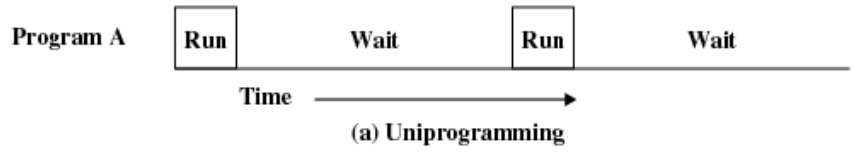
Uniprogramming

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



(a) Uniprogramming

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I/O Devices Slow

Read one record from file	15 µs
Execute 100 instructions	1 µs
Write one record to file	15 µs
TOTAL	31 µs

Percent CPU Utilization $= \frac{1}{31} = 0.032 = 3.2\%$

Figure 2.4 System Utilization Example

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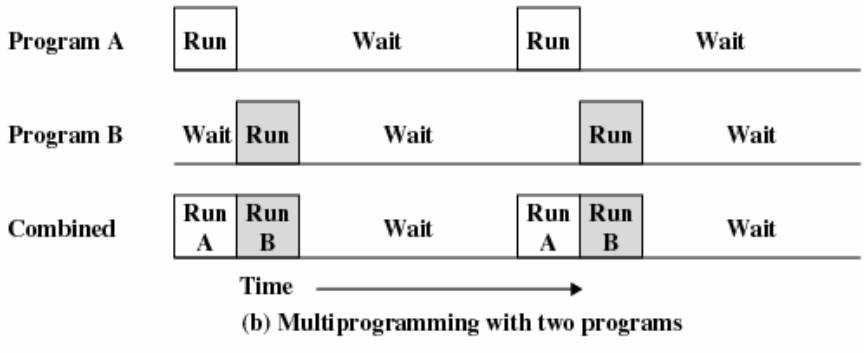
Multiprogrammed Batch Systems

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



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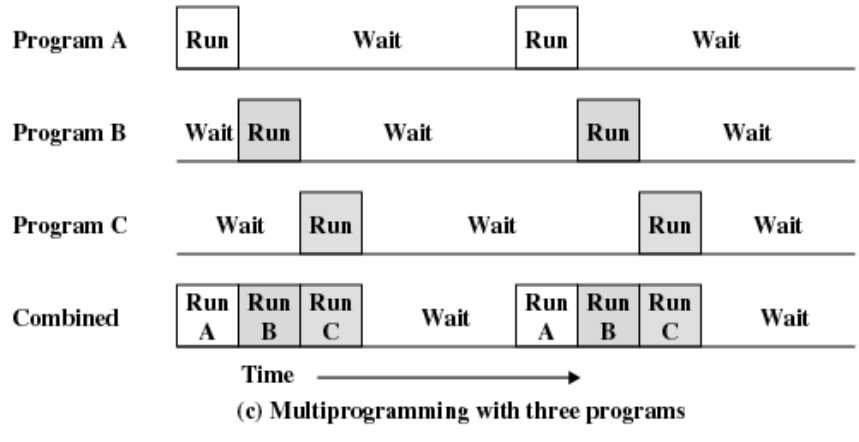
Multiprogrammed Batch System



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Example

Table 2.1 Sample Program Execution Attributes

	JOB1	JOB2	JOB3
Type of job	Heavy compute	Heavy I/O	Heavy I/O
Duration	5 min	15 min	10 min
Memory required	50 M	100 M	75 M
Need disk?	No	No	Yes
Need terminal?	No	Yes	No
Need printer?	No	No	Yes

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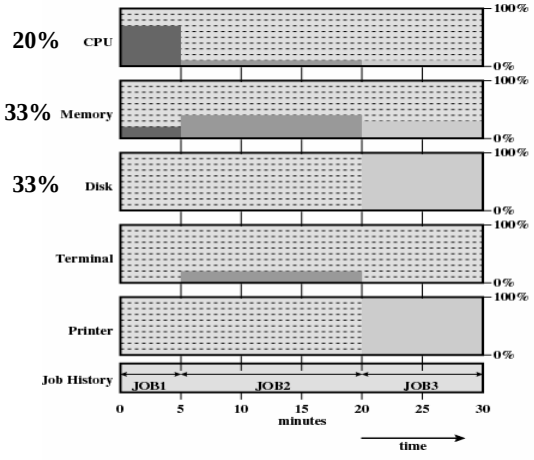
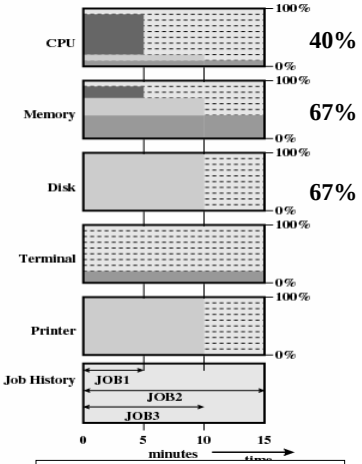
Utilization Histograms

Uniprogramming



Elapsed Time: 30 minutes
Throughput: 6 jobs/hr
Mean Response Time: 18 min

Mulitprogramming



Elapsed Time: 15 minutes
Throughput: 12 jobs/hr
Mean Response Time: 10 min

Time Sharing

- Using multiprogramming to handle multiple *interactive* jobs
- Multiple users simultaneously access the system through terminals
- Processor's time is shared among multiple users

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Compatible Time-Sharing System (CTSS)

- First time-sharing system developed at MIT

Job Execution Sequence:

Job 1
Job 2
Job 3
Job 1
Job 4
Job 2

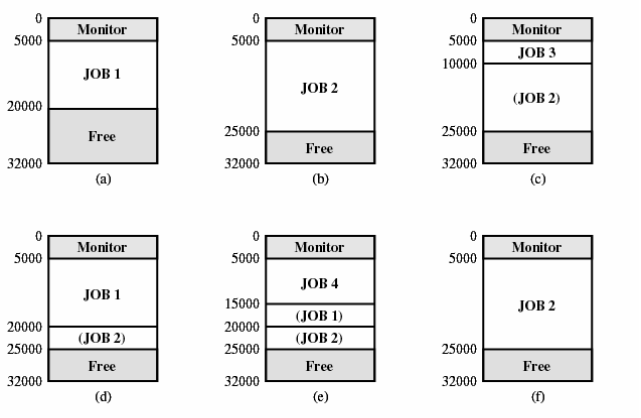

Figure 2.7 CTSS Operation

Major Achievements in Operating Systems

- Processes
- Memory Management
- Information protection and security
- Scheduling and resource management
- System structure

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Processes

- A program in execution
- An instance of a program running on a computer
- The entity that can be assigned to and executed on a processor
- A unit of activity characterized by a single sequential thread of execution, a current state, and an associated set of system resources

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Process

- Consists of three components
  - An executable program
  - Associated data needed by the program
  - Execution context of the program
    - All information the operating system needs to manage the process

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Process

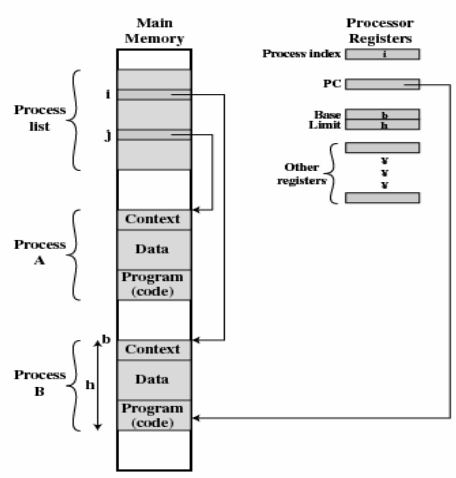

Figure 2.8 Typical Process Implementation

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Difficulties with Designing "Process-Based" System Software

- Improper synchronization
  - Ensure a process waiting for an I/O device receives the signal
- Failed mutual exclusion
- Nondeterminate program operation
  - Program should only depend on input to it, not on the activities of other programs
- Deadlocks

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Memory Management

- Process isolation
  - Memory, data, instructions
- Automatic memory allocation and management
  - Transparent to users
- Support of modular programming
  - Define program modules: dynamic creation and destruction
- Protection and access control
  - Isolated and shared memory
- Long-term storage
  - Non-volatile, persistent storage

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Virtual Memory

- Allows programmers to address memory from a logical point of view
- No hiatus between the execution of successive processes while one process was written out to secondary store and the successor procees was read in

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Paging

- Allows process to be comprised of a number of fixed-size blocks, called pages
- Virtual address is a page number and an offset within the page
- Each page may be located any where in main memory
- Real address or physical address in main memory

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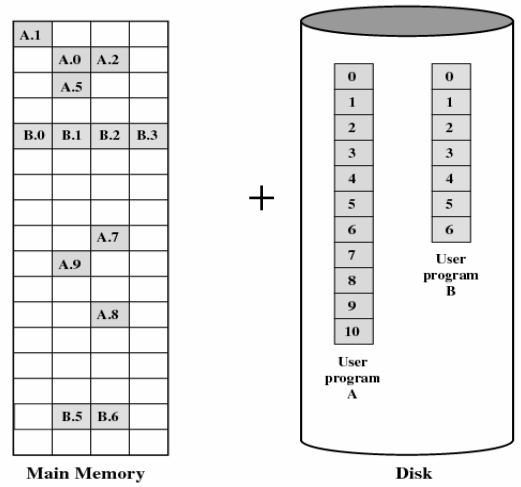
Virtual Memory



Main memory consists of a number of fixed-length frames,

Secondary memory (disk) can hold many fixed-length pages. A

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Virtual Memory Addressing

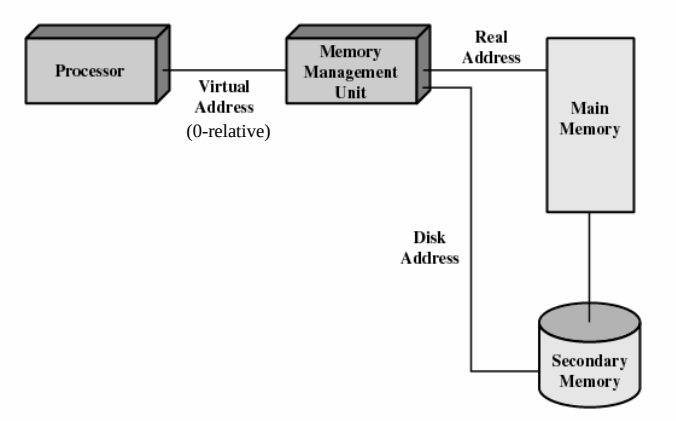

Figure 2.10 Virtual Memory Addressing

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Information Protection and Security

- Availability
  - Concerned with protecting the system against interruption
- Confidentiality
  - Assuring that users cannot read data for which access is unauthorized

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Information Protection and Security

- Data integrity
  - Protection of data from unauthorized modification
- Authenticity
  - Concerned with the proper verification of the identity of users and the validity of messages or data

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Scheduling and Resource Management

- Fairness
  - Give equal and fair access to resources
- Differential responsiveness
  - Discriminate among different classes of jobs
- Efficiency
  - Maximize throughput, minimize response time, and accommodate as many uses as possible

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Key Elements of Operating System

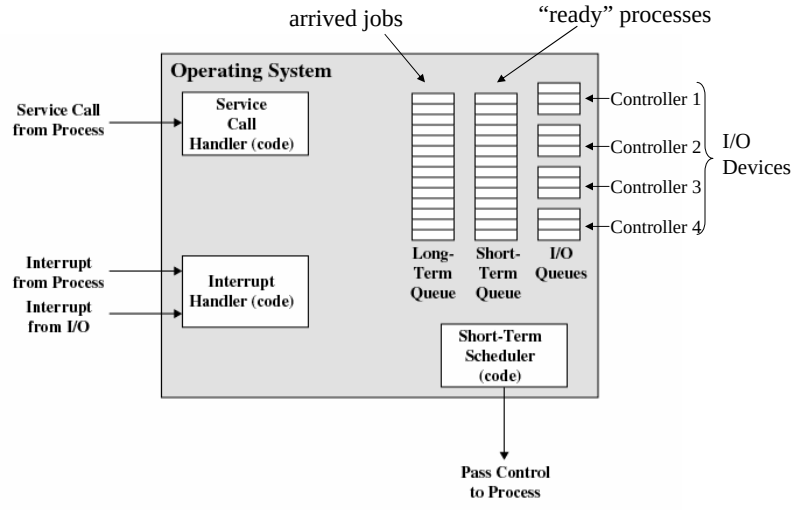

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Figure 2.11 Key Elements of an Operating System for Multiprogramming

System Structure

- View the system as a series of levels
- Each level performs a related subset of functions
- Each level relies on the next lower level to perform more primitive functions
- This decomposes a problem into a number of more manageable subproblems

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Process Hardware Levels

- Level 1
  - Electronic circuits
  - Objects are registers, memory cells, and logic gates
  - Operations are clearing a register or reading a memory location
- Level 2
  - Processor's instruction set
  - Operations such as add, subtract, load, and store

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Process Hardware Levels

- Level 3
  - Adds the concept of a procedure or subroutine, plus call/return operations
- Level 4
  - Interrupts

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Concepts with Multiprogramming

- Level 5
  - Process as a program in execution
  - Suspend and resume processes
- Level 6
  - Secondary storage devices
  - Transfer of blocks of data
- Level 7
  - Creates logical address space for processes
  - Organizes virtual address space into blocks

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Deal with External Objects

- Level 8
  - Communication of information and messages between processes
- Level 9
  - Supports long-term storage of named files
- Level 10
  - Provides access to external devices using standardized interfaces

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Deal with External Objects

- Level 11
  - Responsible for maintaining the association between the external and internal identifiers
- Level 12
  - Provides full-featured facility for the support of processes
- Level 13
  - Provides an interface to the operating system for the user

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Modern Operating Systems

- Microkernel architecture
  - Assigns only a few essential functions to the kernel
    - Address spaces
    - Interprocess communication (IPC)
    - Basic scheduling

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Modern Operating Systems

- Multithreading
  - Process is divided into threads that can run concurrently
    - Thread
      - Dispatchable unit of work
      - executes sequentially and is interruptable
    - Process is a collection of one or more threads

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Modern Operating Systems

- Symmetric multiprocessing (SMP)
  - There are multiple processors
  - These processors share same main memory and I/O facilities
  - All processors can perform the same functions

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Multiprogramming and Multiprocessing

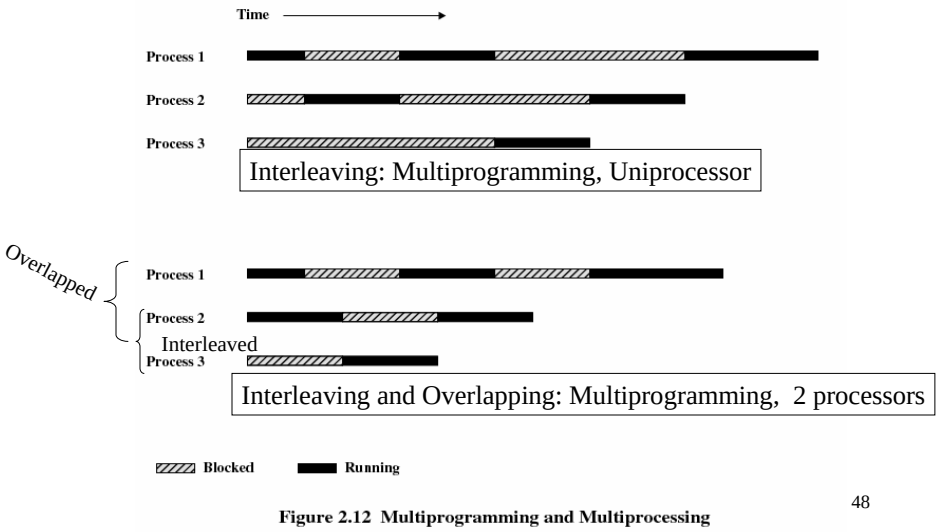

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Figure 2.12 Multiprogramming and Multiprocessing

Modern Operating Systems

- Distributed operating systems
  - Provides the illusion of a single main memory space and single secondary memory space

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Modern Operating Systems

- Object-oriented design
  - Used for adding modular extensions to a small kernel
  - Enables programmers to customize an operating system without disrupting system integrity

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Windows Architecture

- Modular structure for flexibility
- Executes on a variety of hardware platforms
- Supports application written for other operating system

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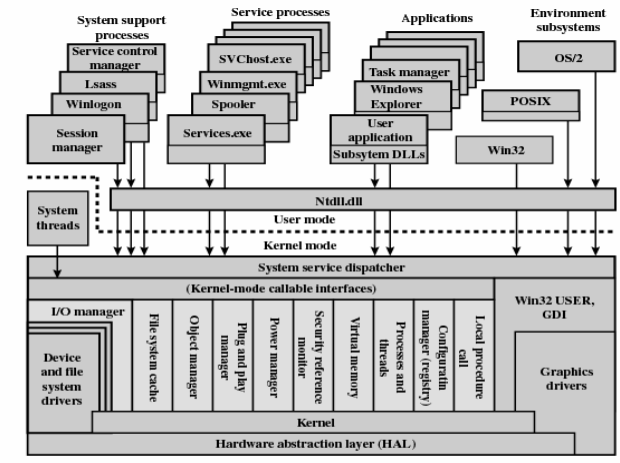

Figure 2.13 Windows 2000 Architecture [SOLO00]

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Operating System Organization

- Modified microkernel architecture
  - Not a pure microkernel
  - Many system functions outside of the microkernel run in kernel mode
- Any module can be removed, upgraded, or replaced without rewriting the entire system

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Kernel-Mode Components

- Executive
  - Contains base operating system services
    - Memory management
    - Process and thread management
    - Security
    - I/O
    - Interprocess communication
- Kernel
  - Consists of the most used components

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Kernel-Mode Components

- Hardware abstraction layer (HAL)
  - Isolates the operating system from platform-specific hardware differences
- Device drivers
  - Translate user I/O function calls into specific hardware device I/O requests
- Windowing and graphics systems
  - Implements the graphical user interface (GUI)

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Windows Executive

- I/O manager
- Cache manager
- Object manager
- Plug and play manager
- Power manager
- Security reference monitor
- Virtual memory manager
- Process/thread manager
- Configuration manager
- Local procedure call (LPC) facility

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User-Mode Processes

- Special system support processes
  - Ex: logon process and the session manager
- Service processes
- Environment subsystems
- User applications

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Client/Server Model

- Simplifies the Executive
  - Possible to construct a variety of APIs
- Improves reliability
  - Each service runs on a separate process with its own partition of memory
  - Clients cannot not directly access hardware
- Provides a uniform means for applications to communicate via LPC
- Provides base for distributed computing

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Threads and SMP

- Operating system routines can run on any available processor
- Different routines can execute simultaneously on different processors
- Multiple threads of execution within a single process may execute on different processors simultaneously
- Server processes may use multiple threads
- Share data and resources between process

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Windows Objects

- Encapsulation
  - Object consists of one or more data items and one or more procedures
- Object class or instance
  - Create specified instances of an object
- Inheritance
  - Support to some extent in the Executive
- Polymorphism

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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

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UNIX

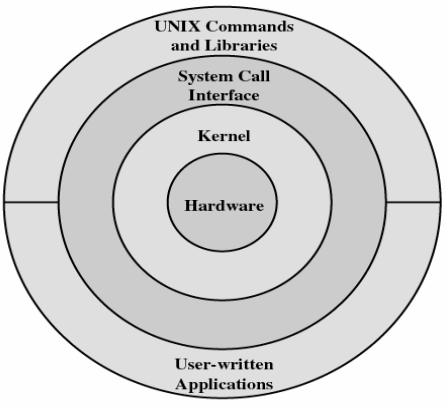

Figure 2.14 General UNIX Architecture

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UNIX Kernel

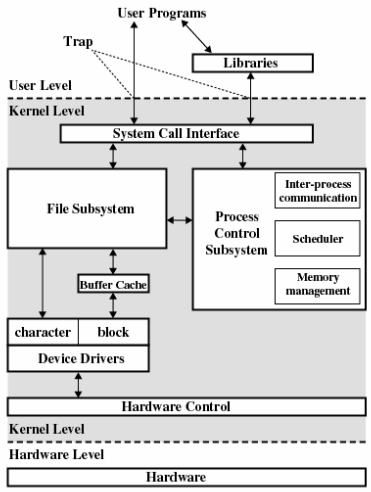

Figure 2.15 Traditional UNIX Kernel [BACH86]

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Modern UNIX Kernel

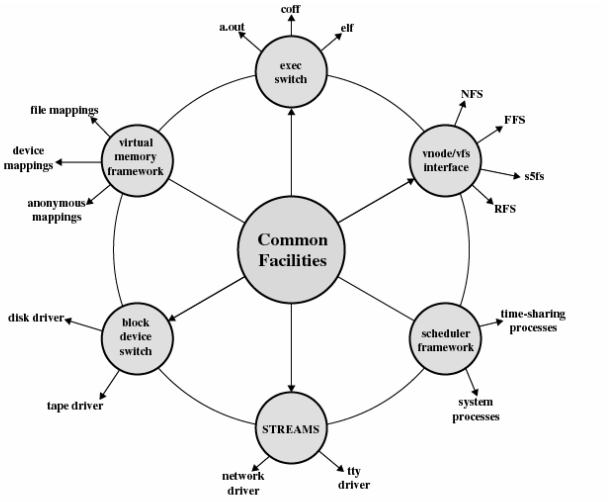

Figure 2.16 Modern UNIX Kernel [VAHA96]

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Modern UNIX Systems

- System V Release 4 (SVR4)
- Solaris 9
- 4.4BSD
- Linux

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