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

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Layers of Computer System

End User

Programmer

Operating-System Designer

Application Programs

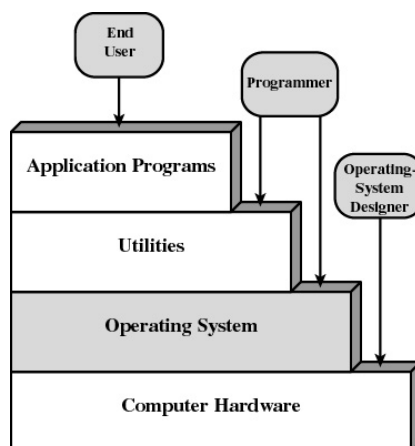Utilities

Operating System

Computer Hardware

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

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 statistics
  - monitor performance
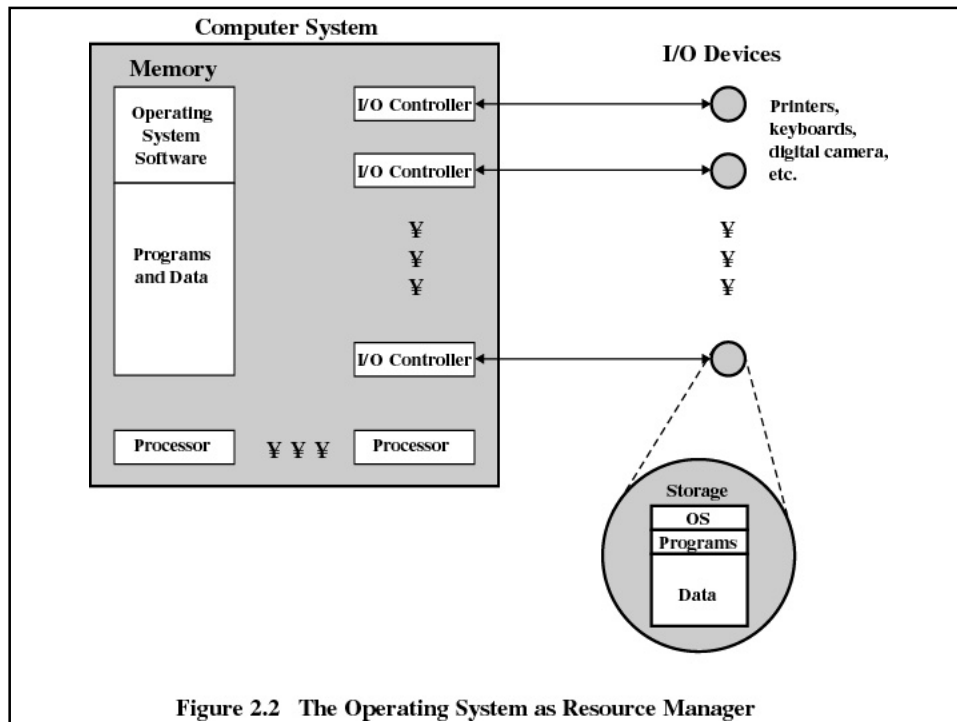 - used to anticipate future enhancements
  - used for billing users

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Operating System

- Functions same way as ordinary computer software
  - It is program that is executed
- Operating system relinquishes control of the processor to execute other programs

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Figure 2.2 The Operating System as Resource Manager

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 and new types of hardware
- New services
- Fixes

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Evolution of Operating Systems

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

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Evolution of Operating Systems

- Simple Batch Systems
  - Monitors
    - Software that controls the running programs
    - Batch jobs together
    - Program branches back to monitor when finished
    - Resident monitor is in main memory and available for execution

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Job Control Language (JCL)

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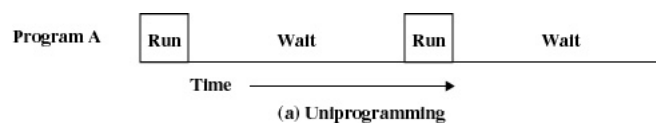 - what compiler to use
  - what data to use

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Hardware Features

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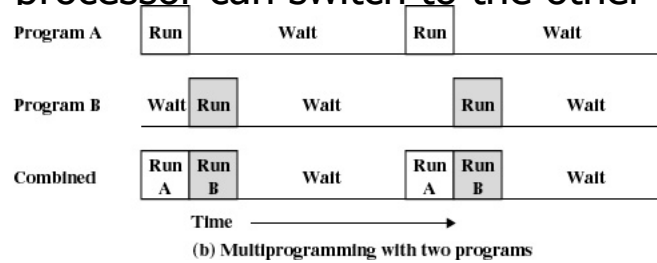 - prevents a job from monopolizing the system

Uniprogramming

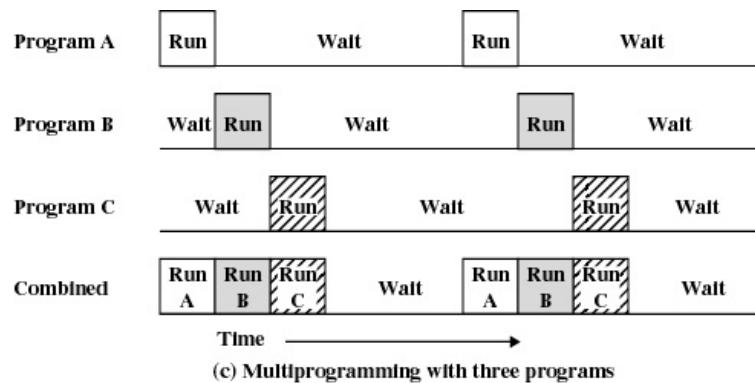- Processor must wait for I/O instruction to complete before proceeding

Program A	Run	Wait	Run	Wait

Time ⟶

(a) Uniprogramming

Multiprogramming

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

Program A	Run	Wait	Run	Wait	

Program B	Wait	Run	Wait	Run	Wait

Combined	Run A	Run B	Wait	Run A	Run B	Wait

Time ⟶

(b) Multiprogramming with two programs

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Multiprogramming

Program A	Run	Wait	Run	Wait

Program B	Wait	Run	Wait	Run	Wait

Program C	Wait	Run	Wait	Run	Wait

Combined	Run A	Run B	Run C	Wait	Run A	Run B	Run C	Wait

Time ⟶

(c) Multiprogramming with three programs

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Figure 2.6 Utilization Histograms
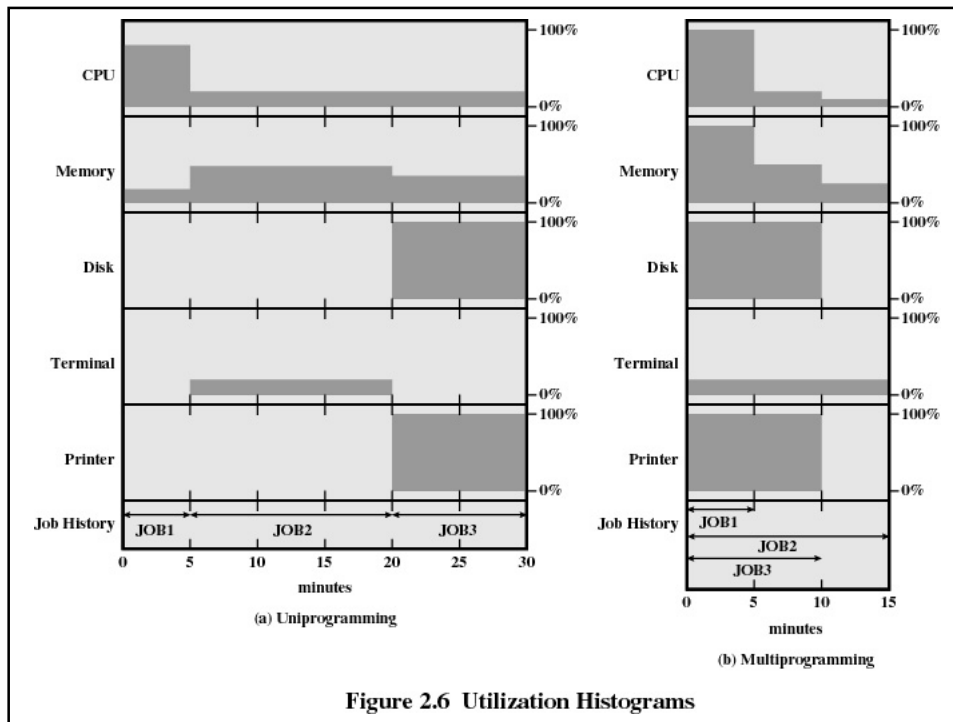
Example

	JOB1	JOB2	JOB3
Type of job	Heavy compute	Heavy I/O	Heavy I/O
Duration	5 min.	15 min.	10 min.
Memory required	50K	100 K	80 K
Need disk?	No	No	Yes
Need terminal	No	Yes	No
Need printer?	No	No	Yes

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Effects of Multiprogramming

|	Uniprogramming	Multiprogramming
Processor use	22%	43%
Memory use	30%	67%
Disk use	33%	67%
Printer use	33%	67%
Elapsed time	30 min.	15 min.
Throughput rate	6 jobs/hr	12 jobs/hr
Mean response time	18 min.	10 min.

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Time Sharing

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

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Batch Multiprogramming versus Time Sharing

	Batch Multiprogramming	Time Sharing
Principal objective	Maximize processor use	Minimize response time
Source of directives to operating system	Job control language commands provided with the job	Commands entered at the terminal

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Figure 2.7 CTSS Operation
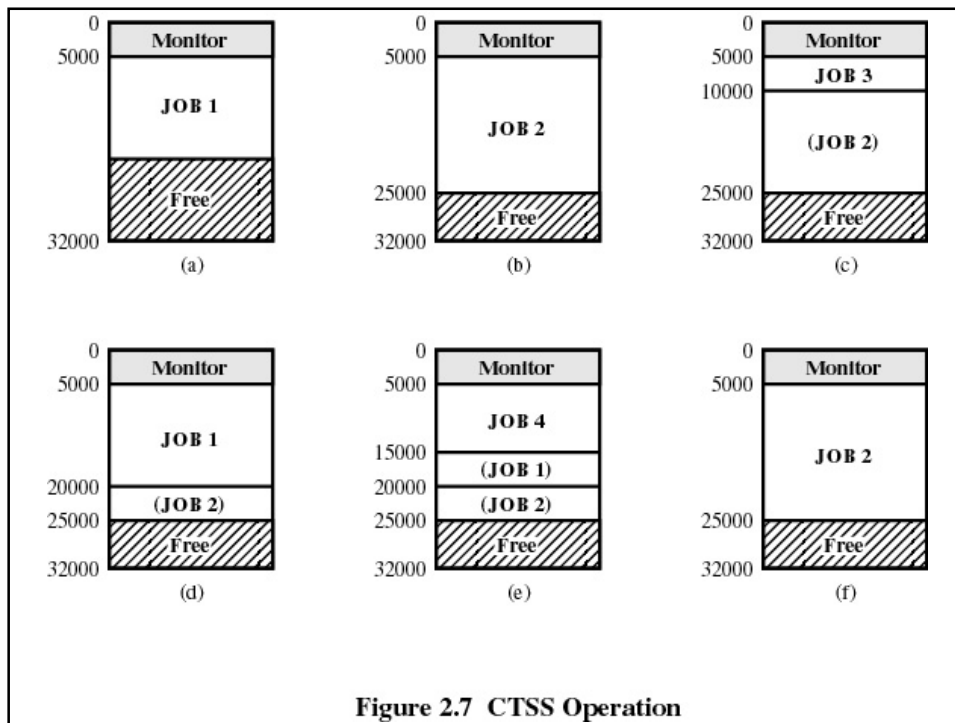
Major Achievements

- 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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Difficulties with Designing System Software

- Improper synchronization
  - ensure a process waiting for an I/O device receives the signal
- Failed mutual exclusion
- Nondeterministic program operation
  - program should only depend on input to it, not relying on common memory areas
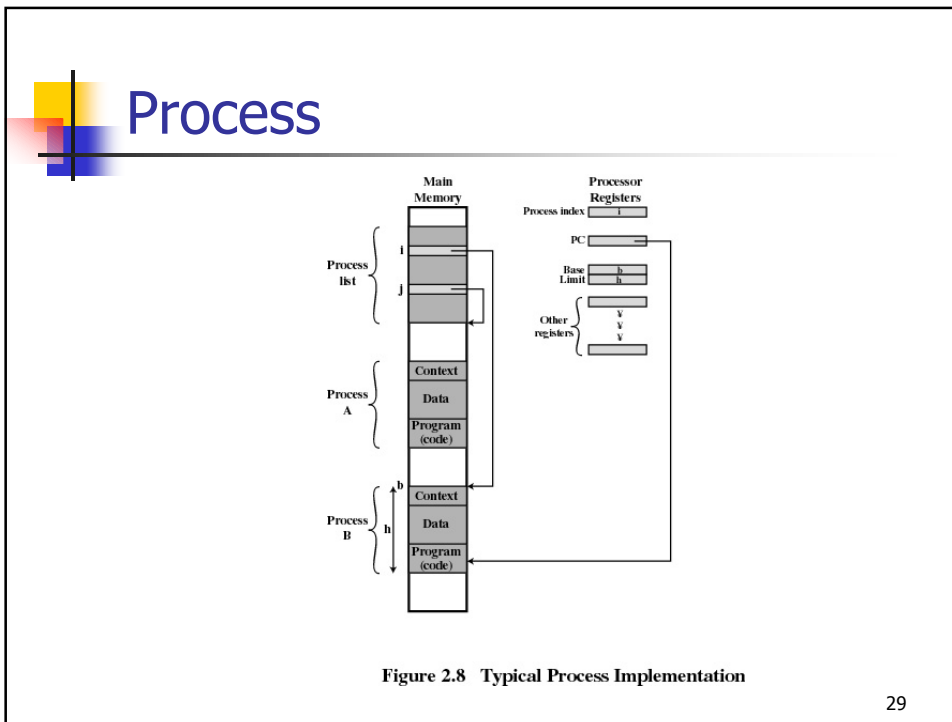- Deadlocks

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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

Memory Management

- Process isolation
- Automatic allocation and management
- Support for modular programming
- Protection and access control
- Long-term storage

Virtual Memory

- Allows programmers to address memory from a logical point of view
- While one process is written out to secondary store and the successor process read in there in no hiatus
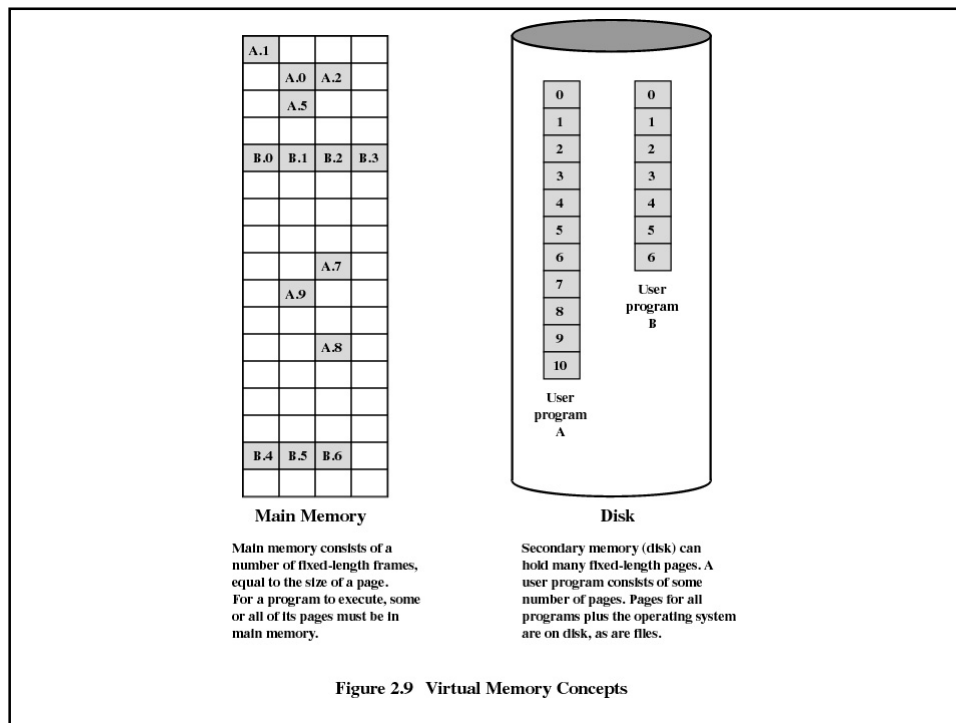
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File System

- Implements long-term store
- Information stored in named objects called files

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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 anywhere in main memory
- Real address or physical address in main memory

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A.1			
	A.0	A.2	
	A.5		
B.0	B.1	B.2	B.3
		A.7	
	A.9		
		A.8	
B.4	B.5	B.6	

Main Memory

Disk

Main memory consists of a number of fixed-length frames, equal to the size of a page. For a program to execute, some or all of its pages must be in main memory.

Secondary memory (disk) can hold many fixed-length pages. A user program consists of some number of pages. Pages for all programs plus the operating system are on disk, as are files.

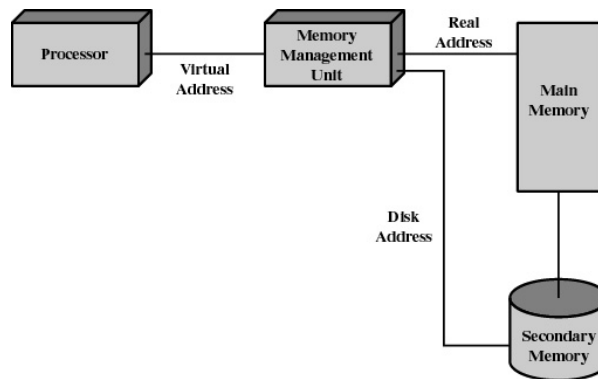**Figure 2.9 Virtual Memory Concepts**

Virtual Memory Addressing

Figure 2.10 Virtual Memory Addressing

Information Protection and Security

- Access control
  - regulate user access to the system
- Information flow control
  - regulate flow of data within the system and its delivery to users
- Certification
  - proving that access and flow control perform according to specifications

Scheduling and Resource Management

- **Fairness**
  - give equal and fair access to all processes
- **Differential responsiveness**
  - discriminate between different classes of jobs
- **Efficiency**
  - maximize throughput, minimize response time, and accommodate as many uses as possible

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Major Elements of Operating System

Operating System

Service Call from Process → Service Call Handler (code)

Interrupt from Process → Interrupt Handler (code)
Interrupt from I/O →

Long-Term Queue   Short-Term Queue   I/O Queues

Short-Term Scheduler (code)
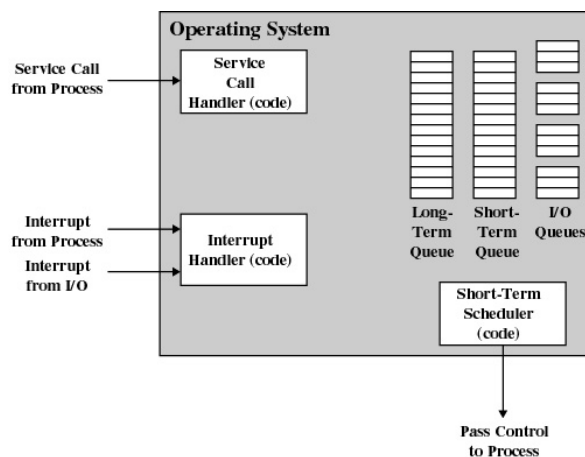
Pass Control to Process

Figure 2.11 Key Elements of an Operating System for Multiprogramming

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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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Operating System Design Hierarchy

Level	Name	Objects	Example Operations
13	Shell	User programming environment	Statements in shell language
12	User processes	User processes	Quit, kill, suspend, resume
11	Directories	Directories	Create, destroy, attach, detach, search, list
10	Devices	External devices, such as printer, displays and keyboards	Open, close, read, write
9	File system	Files	Create, destroy, open, close read, write
8	Communications	Pipes	Create, destroy, open. close, read, write

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Operating System Design Hierarchy

Level	Name	Objects	Example Operations
7	Virtual Memory	Segments, pages	Read, write, fetch
6	Local secondary store	Blocks of data, device channels	Read, write, allocate, free
5	Primitive processes	Primitive process, semaphores, ready list	Suspend, resume, wait, signal

Operating System Design Hierarchy

Level	Name	Objects	Example Operations
4	Interrupts retry programs	Interrupt-handling	Invoke, mask, unmask,
3	Procedures	Procedures, call stack, display	Mark stack, call, return
2	Instruction Set	Evaluation stack, micro-program interpreter, scalar and array data	Load, store, add, subtract branch
1	Electronic circuits	Registers, gates, buses, etc.	Clear, transfer, activate, complement

Characteristics of Modern Operating Systems

- Microkernel architecture
  - assigns only a few essential functions to the kernel
    - address space
    - interprocess communication (IPC)
    - basic scheduling

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Characteristics of Modern Operating Systems

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

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Characteristics of Modern Operating Systems

- Symmetric multiprocessing
  - 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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Characteristics of Modern Operating Systems

- Distributed operating systems
  - provides the illusion of a single main memory and single secondary memory space
  - used for distributed file system

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Characteristics of 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 2000

- Exploits the power of today's 32-bit microprocessors
- Provides full multitasking in a single-user environment
- Client/Server computing

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Windows 2000 Architecture

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

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OS 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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Layered Structure

- Hardware abstraction layer (HAL)
  - Isolates the operating system from platform-specific hardware differences
- Microkernel
  - Most-used and most fundamental components of the operating system
- Device drivers
  - Translate user I/O function calls into specific hardware device I/O requests

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W2K Executive

- I/O manager
- Object manager
- Security reference monitor
- Process/thread manager
- Local procedure call (LPC) Facility
- Virtual memory manager
- Cache manager
- Windows/graphics modules

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User Processes

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

Client/Server Model

- Simplifies the Executive
    - possible to construct a variety of APIs
- Improves reliability
    - each service runs as 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

Threads and SMP

- 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
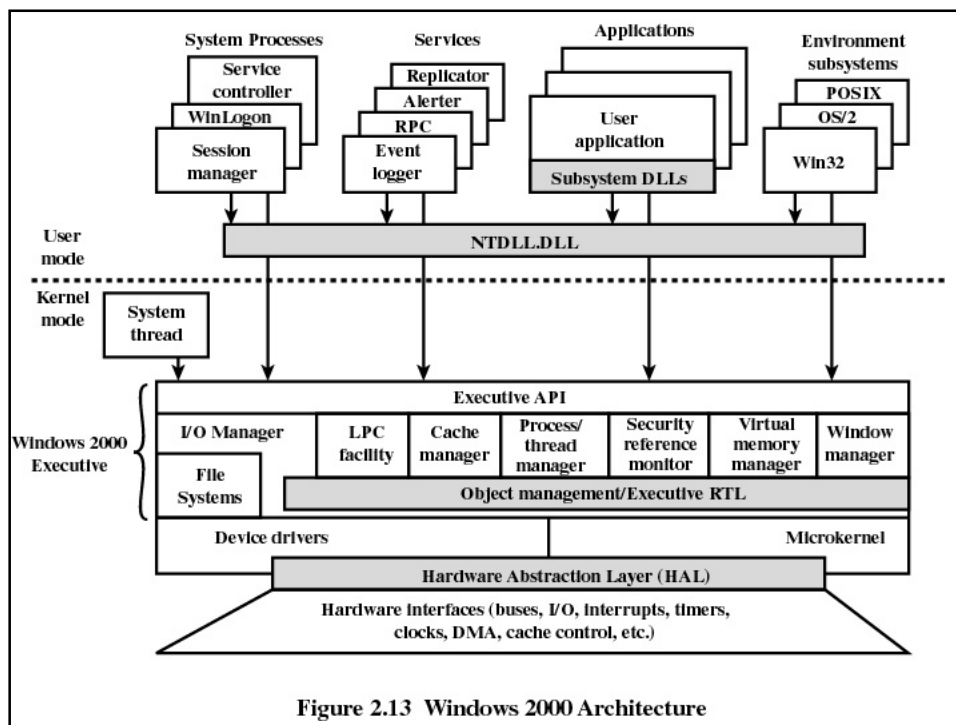- Share data and resources between processes

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Figure 2.13 Windows 2000 Architecture

UNIX

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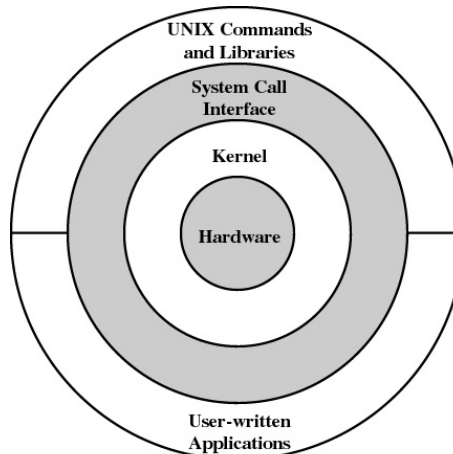 - shell
  - C compiler

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UNIX

Figure 2.15 General UNIX Architecture

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Modern UNIX Systems

- System V Release 4 (SVR4)
- Solaris 2.x
- 4.4BSD
- Linux

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