Topic 2

Operating System Overview

Topic Objectives

- understand the objectives of operating systems, and the types of services provided by operating systems
- be aware of the evolution of operating systems
- understand the five areas of operating systems (such as processes, memory management etc.)
- Be aware of concepts such as microkernel, multithreading, etc.
- Be aware of overall system structures of Windows and UNIX systems.

Readings

- Stallings: Chapter 2

Operating System

Definition 1:

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

Definition 2:

- Exploits the hardware resources of one or more processors
- Provides a set of services to system users
- Manages secondary memory and I/O devices

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

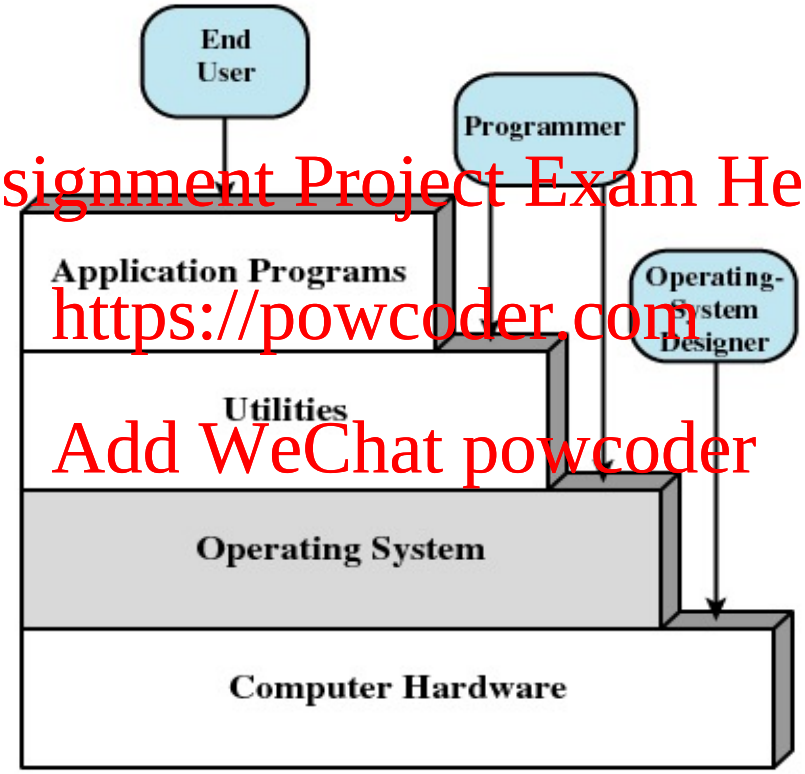


Figure 2.1 Layers and Views of a Computer System

Services Provided by the Operating System

- Program development
  - Eg, for creating 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 frequently relinquishes control of the processor and must rely on the processor to allow it to regain control of the processor

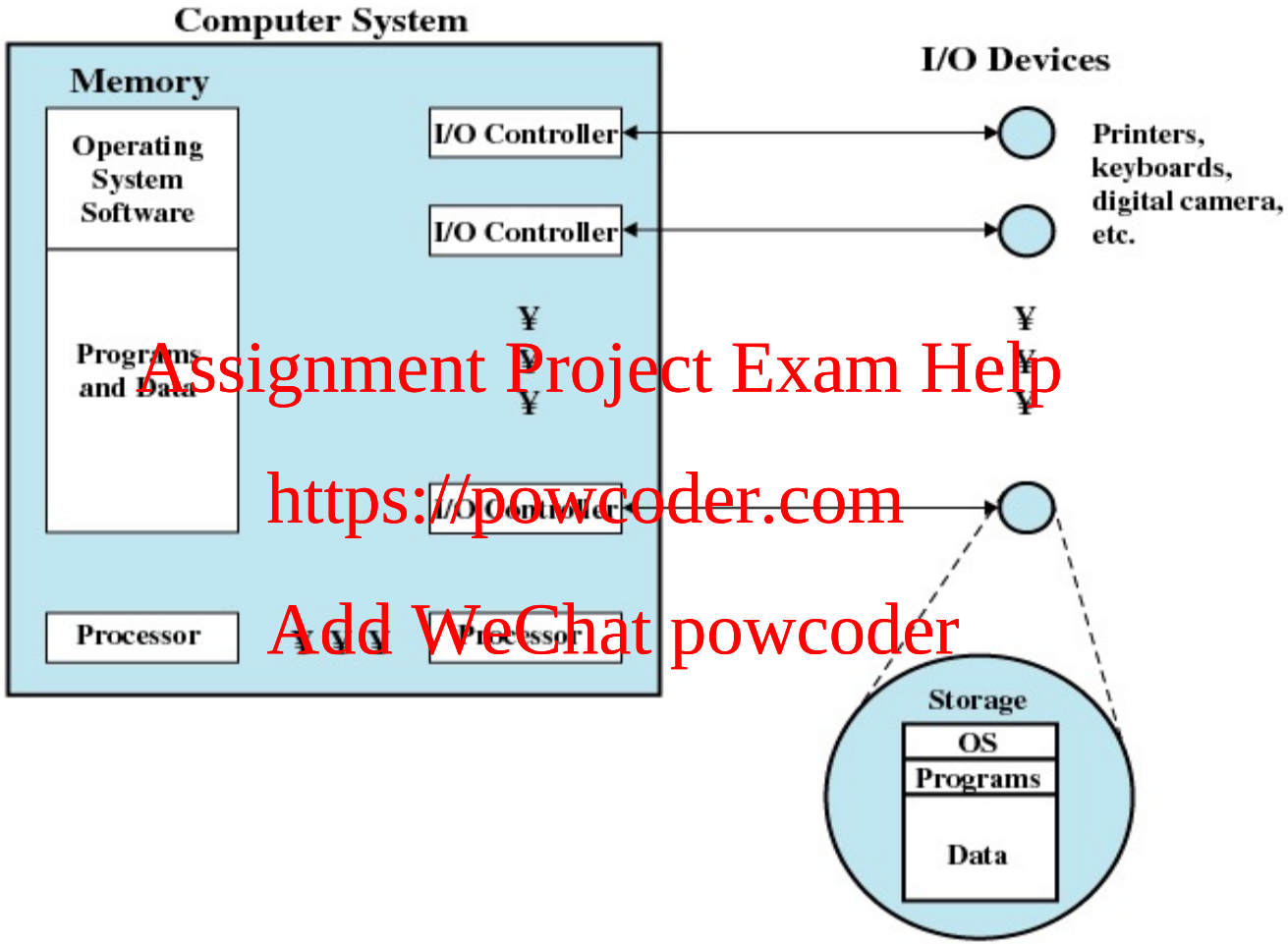


Figure 2.2 The Operating System as Resource Manager

Kernel

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

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

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
  - 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

I/O Devices Slow

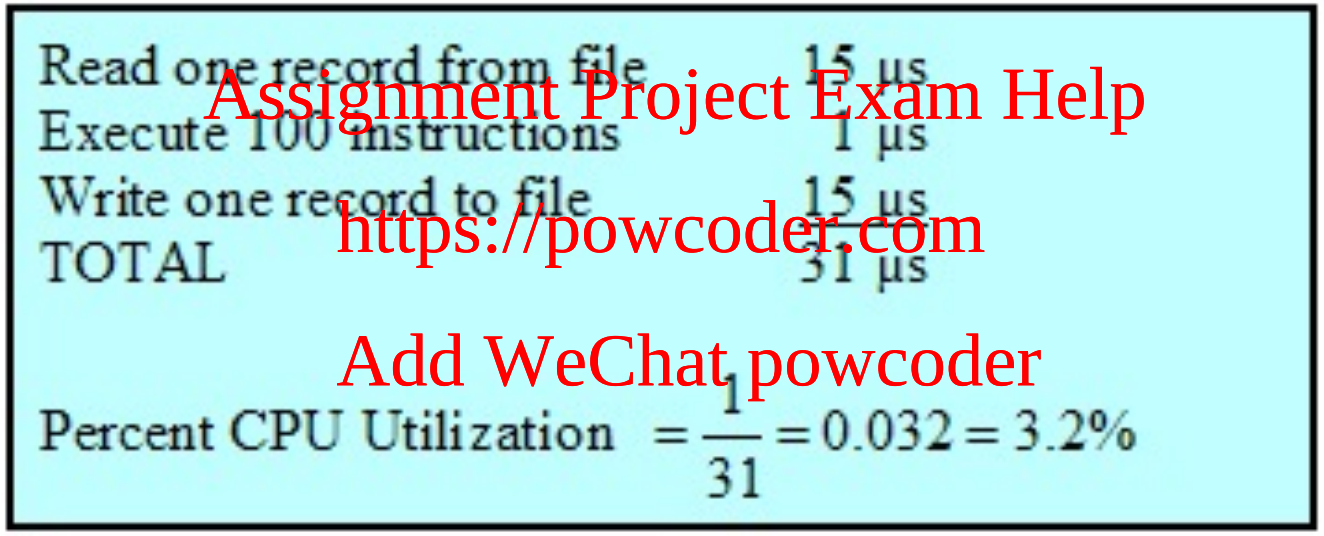


Figure 2.4 System Utilization Example

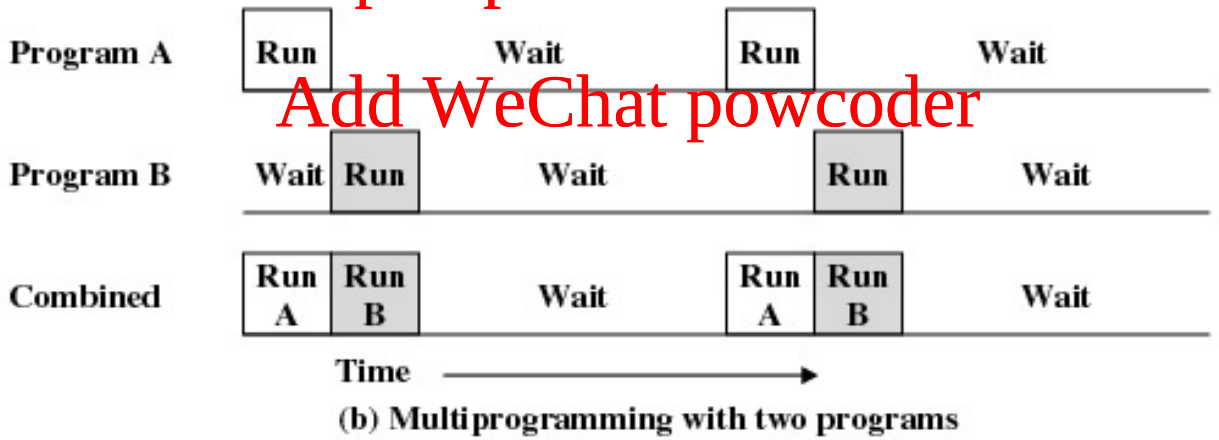
Uniprogramming

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

(a) Uniprogramming

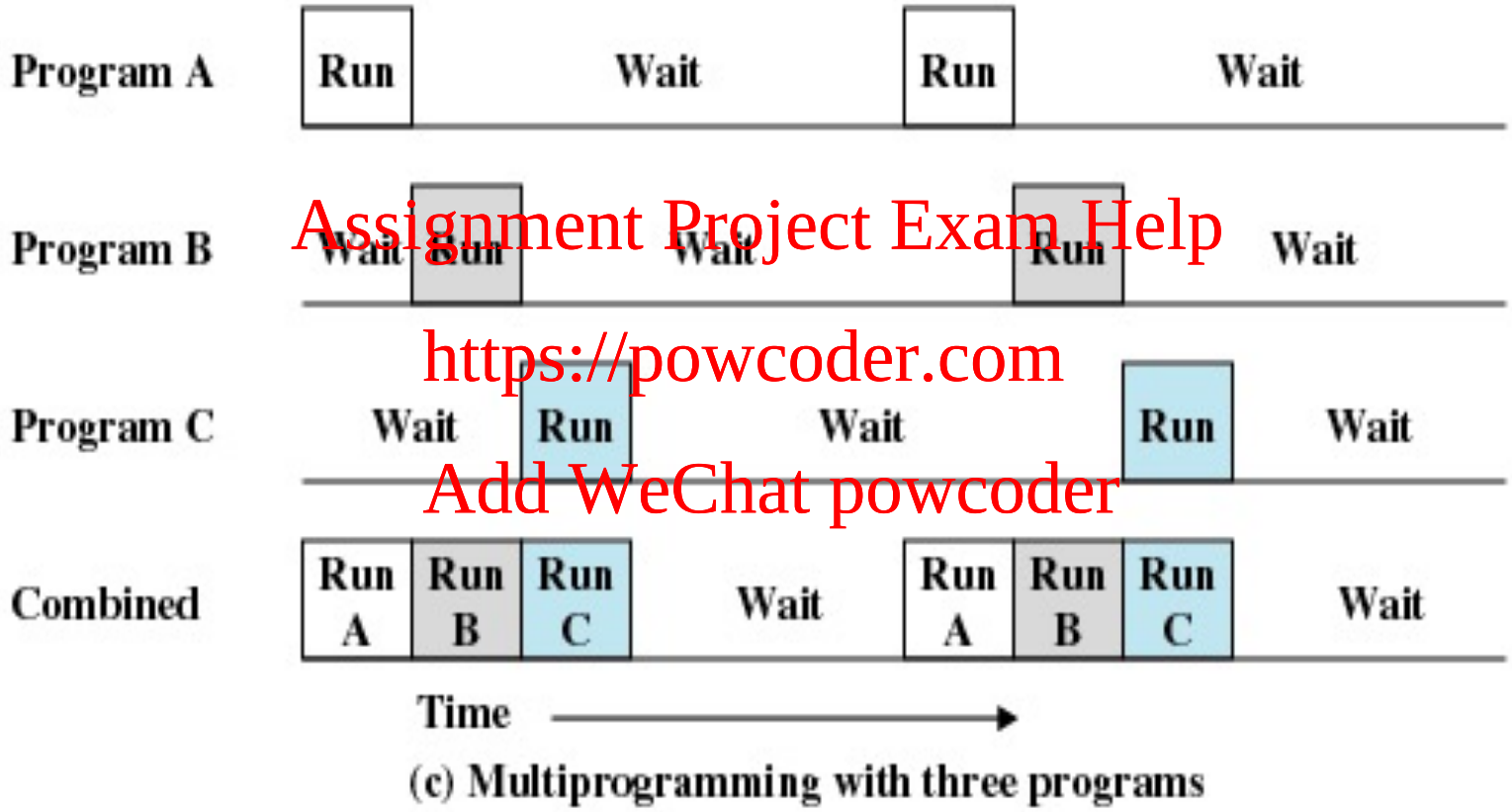
Multiprogramming

- 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

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

Utilization Histograms

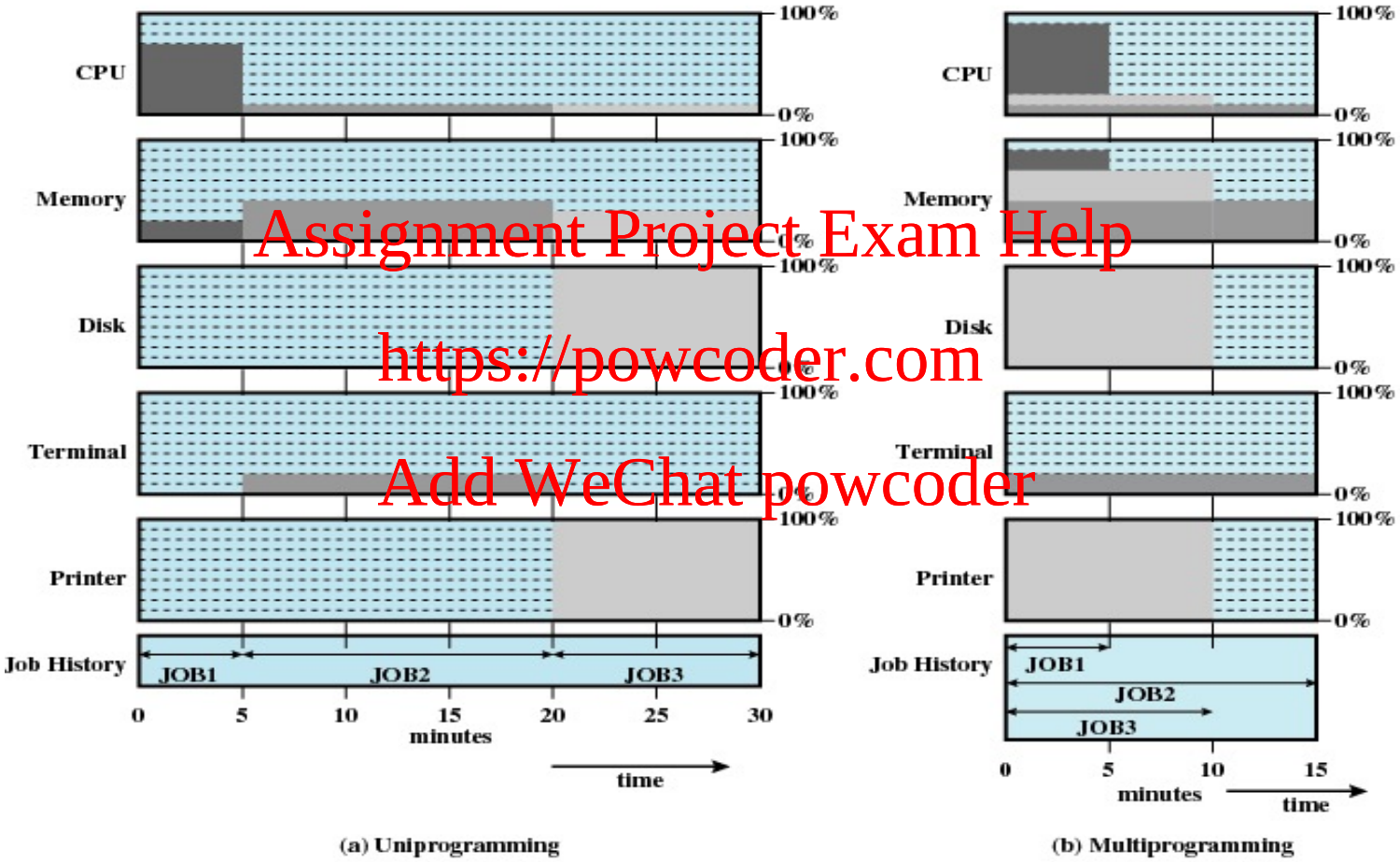


Figure 2.6 Utilization Histograms

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

Compatible Time-Sharing System (CTSS)

- First time-sharing system developed at MIT

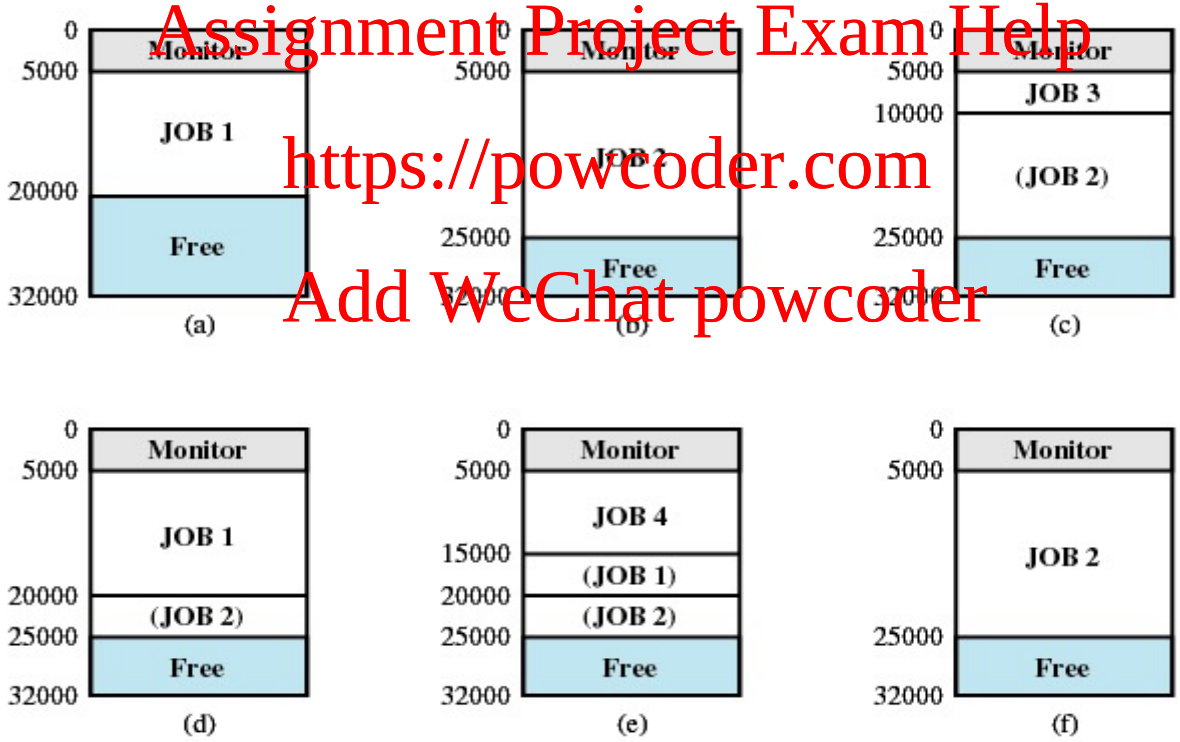


Figure 2.7 CTSS Operation

Major Achievements

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

Process Definition

- 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

Difficulties with Designing 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

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

Process

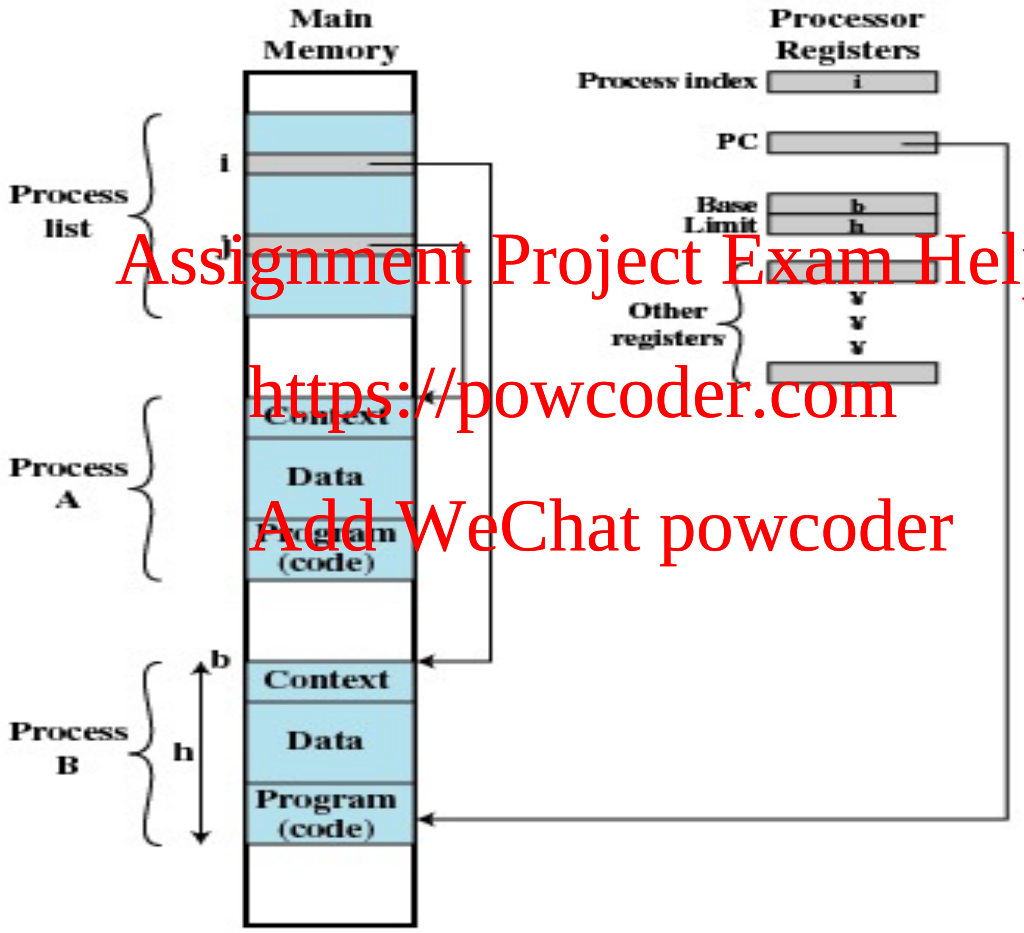


Figure 2.8 Typical Process Implementation

Memory Management

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

File System

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

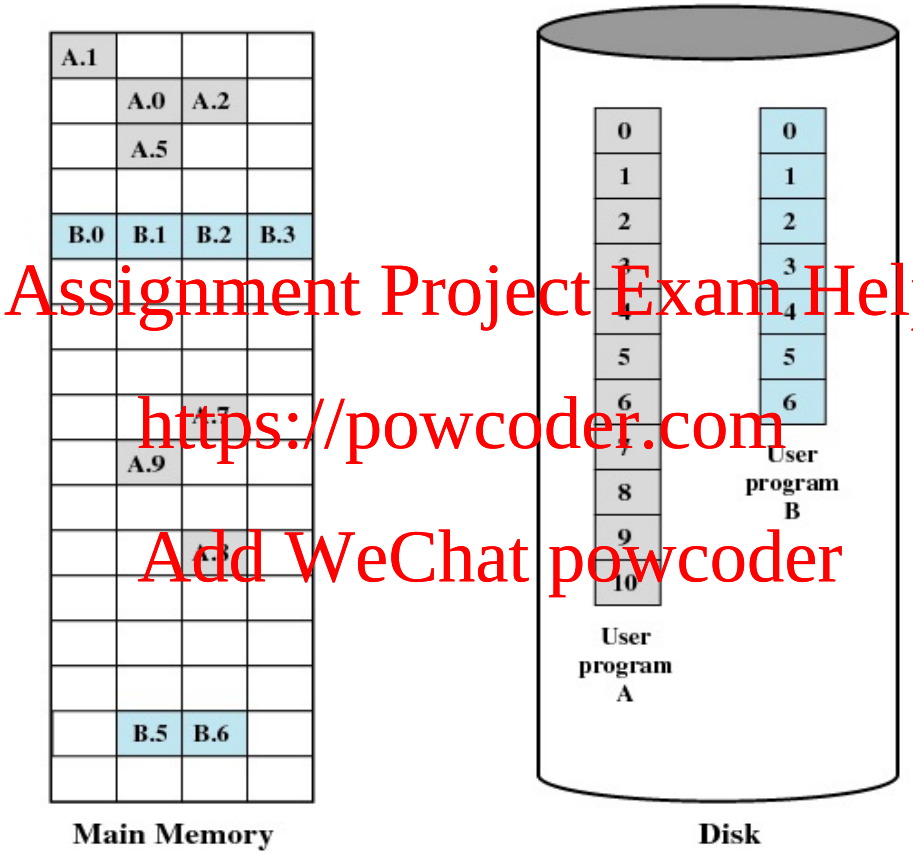
Virtual Memory

- 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 process was read in

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

Virtual Memory



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

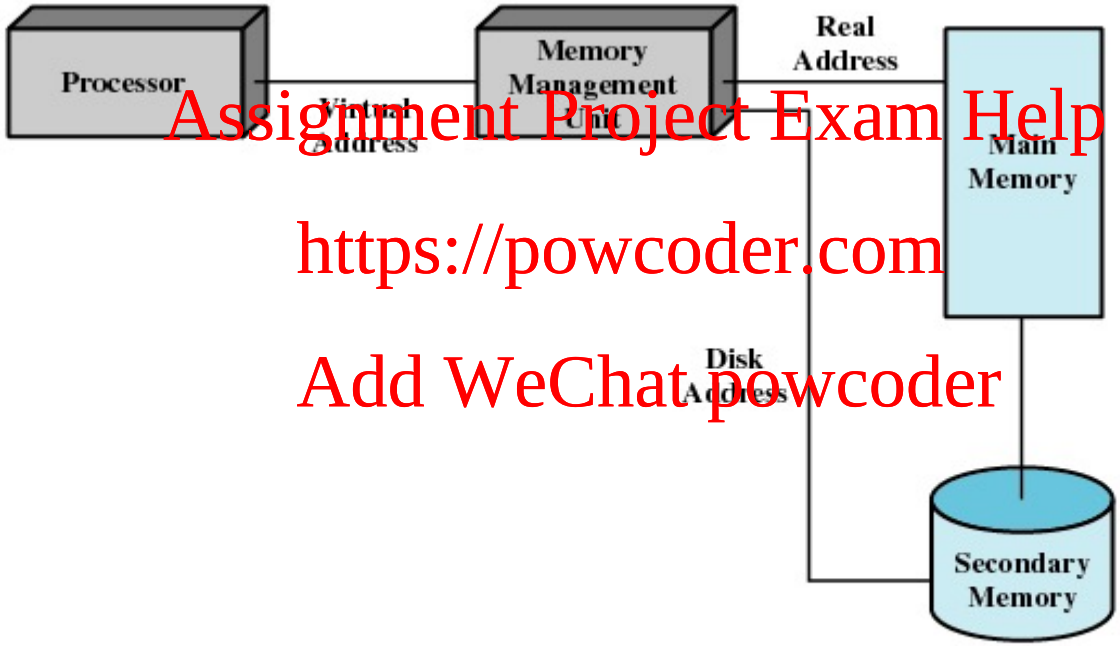


Figure 2.10 Virtual Memory Addressing

Information Protection and Security

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

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

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

Key Elements of Operating System

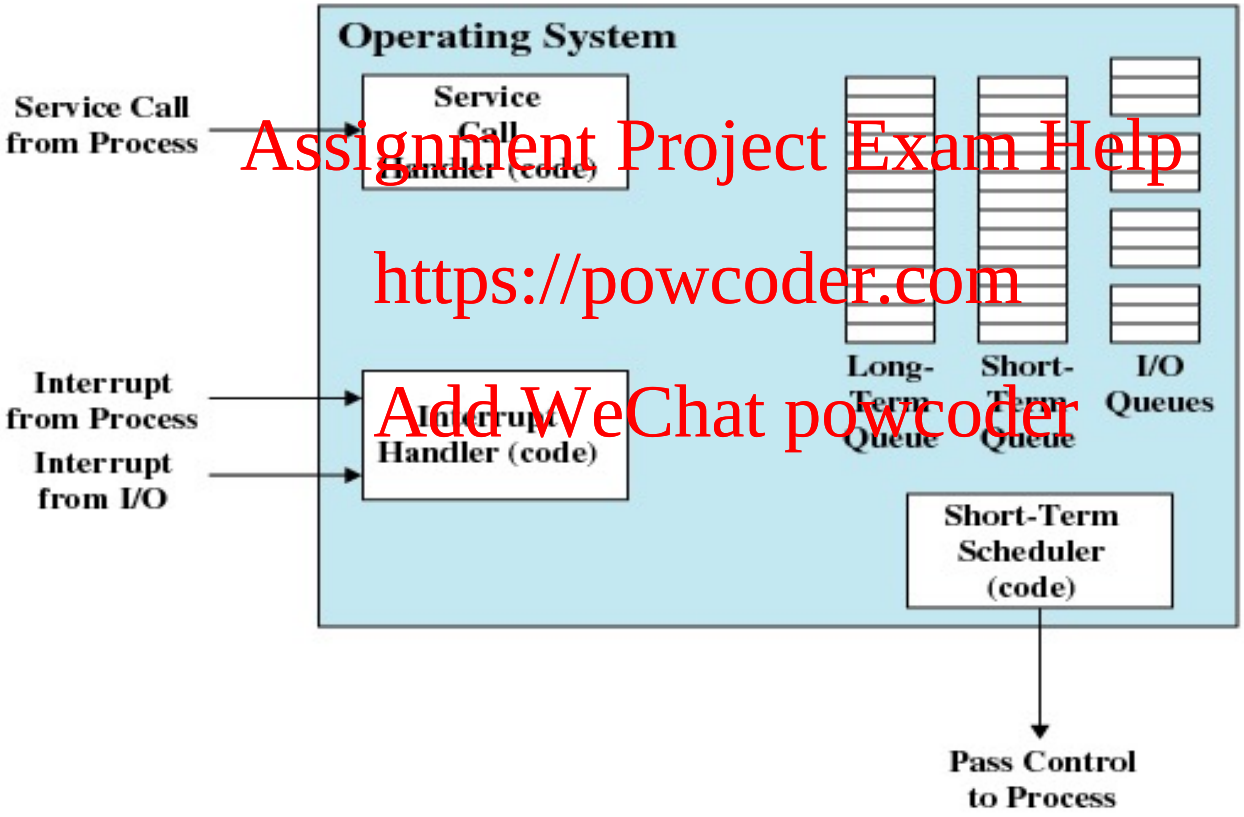


Figure 2.11 Key Elements of an Operating System for Multiprogramming

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 method decomposes a problem into a number of more manageable subproblems

Table 2.4 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 printers, 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
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 processes, semaphores, ready list	Suspend, resume, wait, signal
4	Interrupts	Interrupt-handling programs	Invoke, mask, unmask, retry
3	Procedures	Procedures, call stack, display	Mark stack, call, return
2	Instruction set	Evaluation stack, microprogram interpreter, scalar and array data	Load, store, add, subtract, branch
1	Electronic circuits	Registers, gates, buses, etc.	Clear, transfer, activate, complement

Grey shaded area represents hardware.

Modern Operating Systems

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

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

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

Multiprogramming and Multiprocessing

Figure 2.12 Multiprogramming and Multiprocessing

Modern Operating Systems

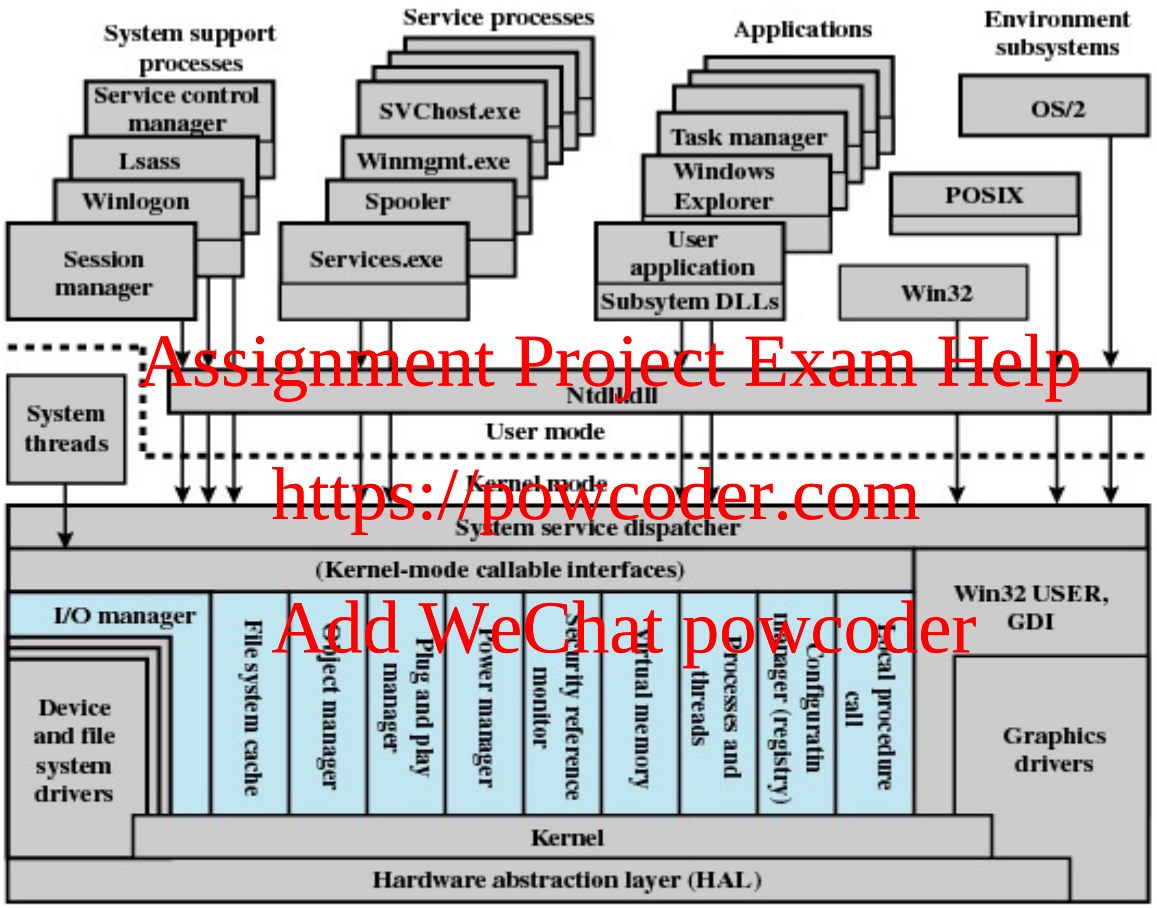
- Distributed operating systems
  - Provides the illusion of a single main memory space and single secondary memory space

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

Windows Architecture

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



Lsass = local security authentication server
POSIX = portable operating system interface
GDI = graphics device interface
DLL = dynamic link libraries

Colored area indicates Executive

Figure 2.13 Windows 2000 Architecture [SOLO00]

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

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

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)

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

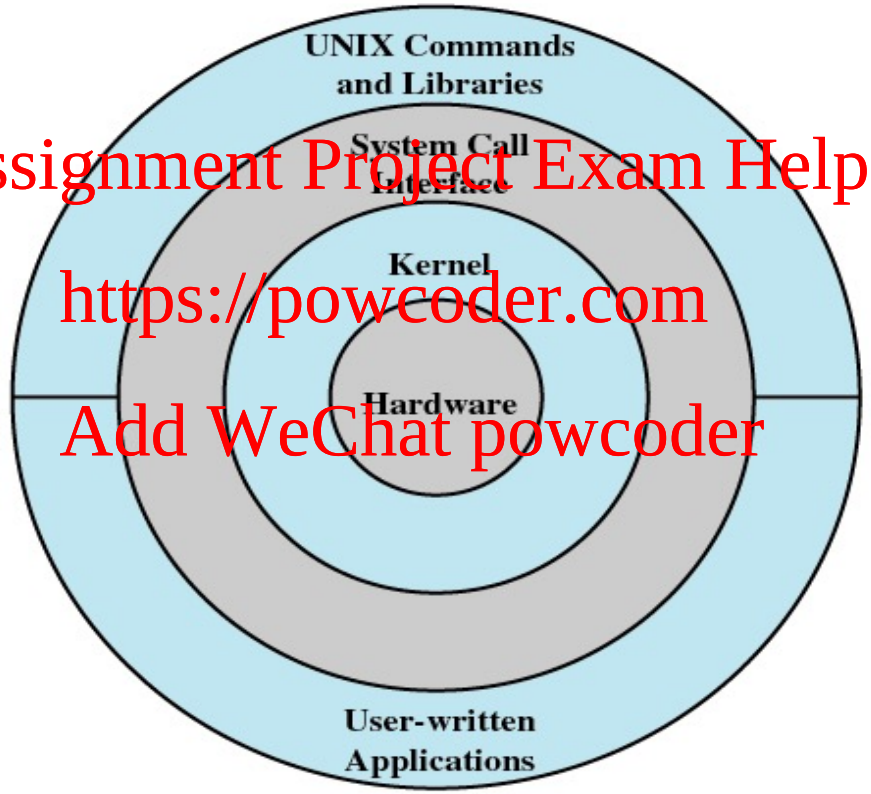


Figure 2.14 General UNIX Architecture

UNIX Kernel

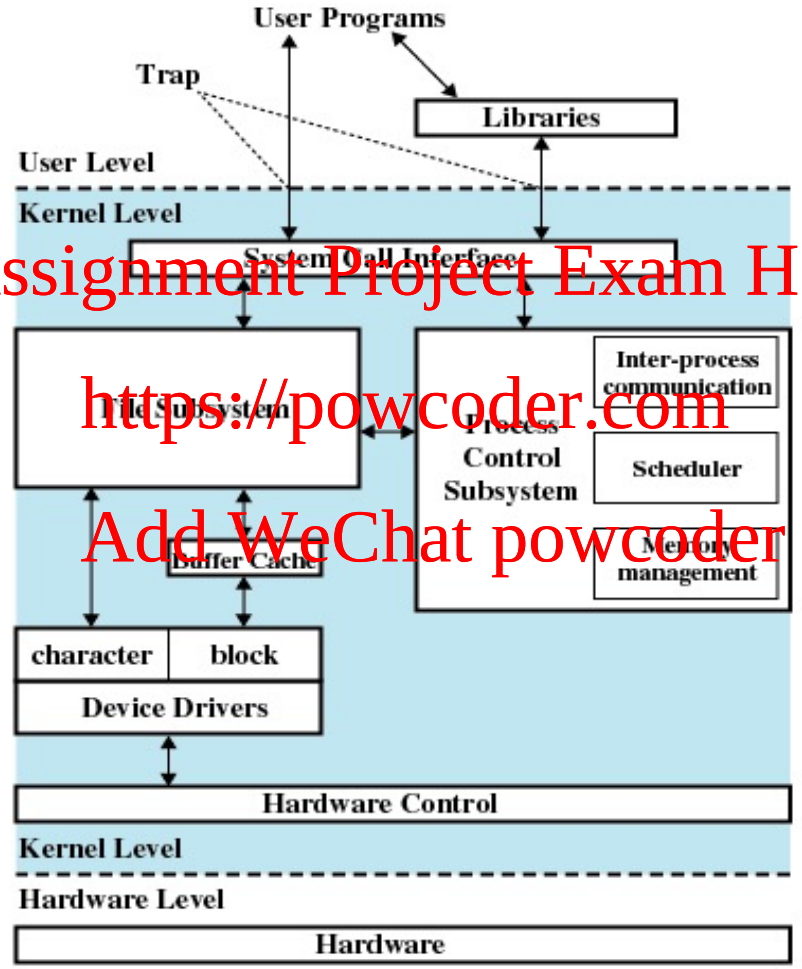


Figure 2.15 Traditional UNIX Kernel [BACH86]

Modern UNIX Kernel

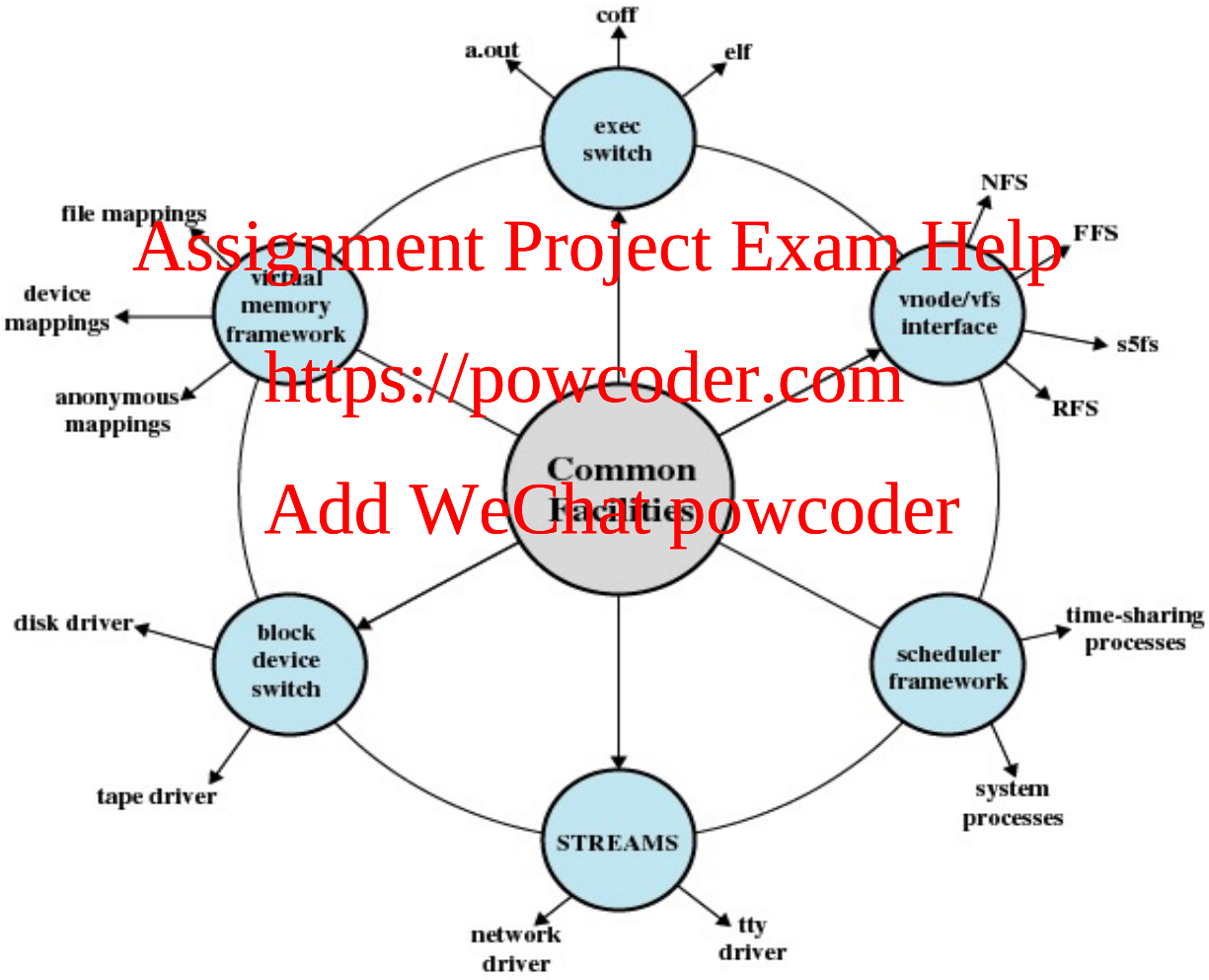


Figure 2.16 Modern UNIX Kernel [VAHA96]

Modern UNIX Systems

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