Operating Systems
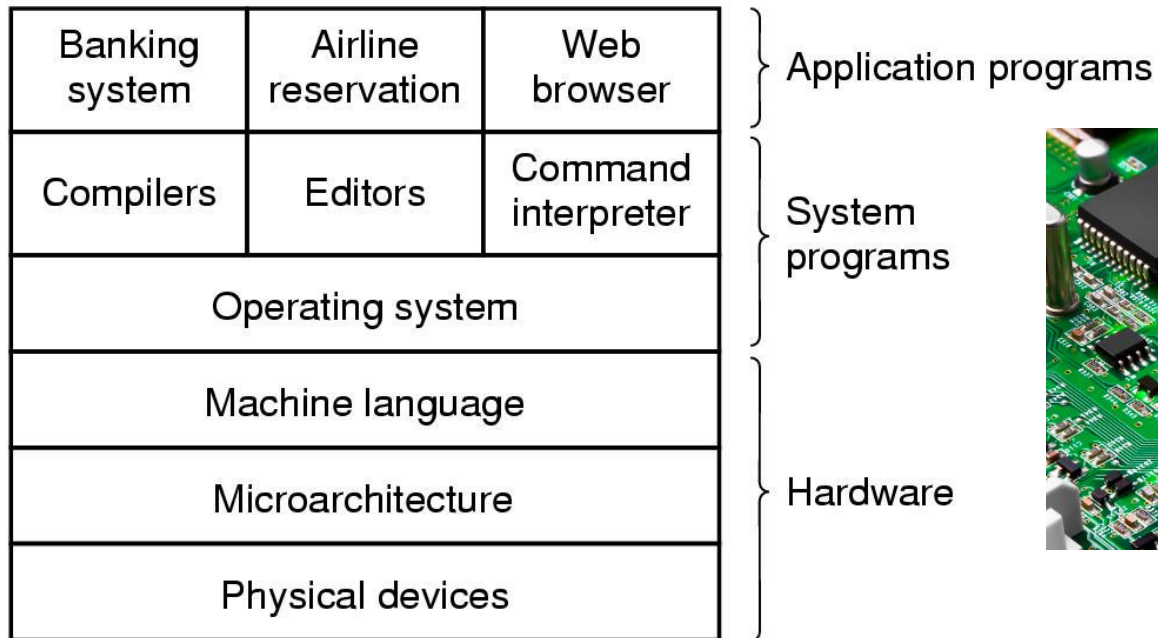
Chapter 1 Introduction

Tien Pham Van, Dr. rer. nat.

Compiled with reference to other presentations

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Banking system	Airline reservation	Web browser	} Application programs
Compilers	Editors	Command interpreter	} System programs
Operating system			
Machine language			} Hardware
Microarchitecture			
Physical devices			

- A computer system consists of
  - hardware
  - system programs
  - application programs

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Operating System

- A program that controls the execution of application programs
- An interface between applications and hardware
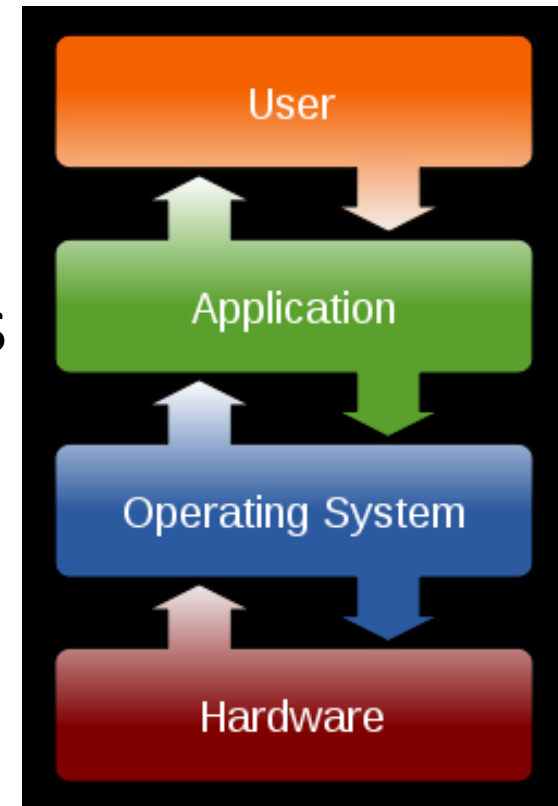
What is an Operating System

- It is an extended machine
  - Hides the messy details which must be performed
  - Presents user with a virtual machine, easier to use

- It is a resource manager
  - Each program gets time with the resource
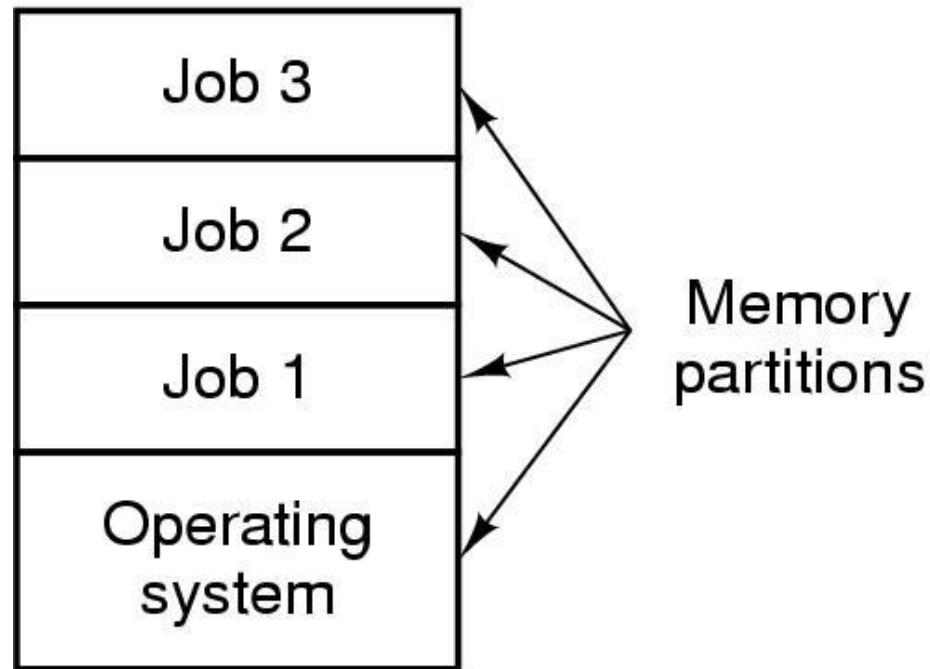 - Each program gets space on the resource

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- 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
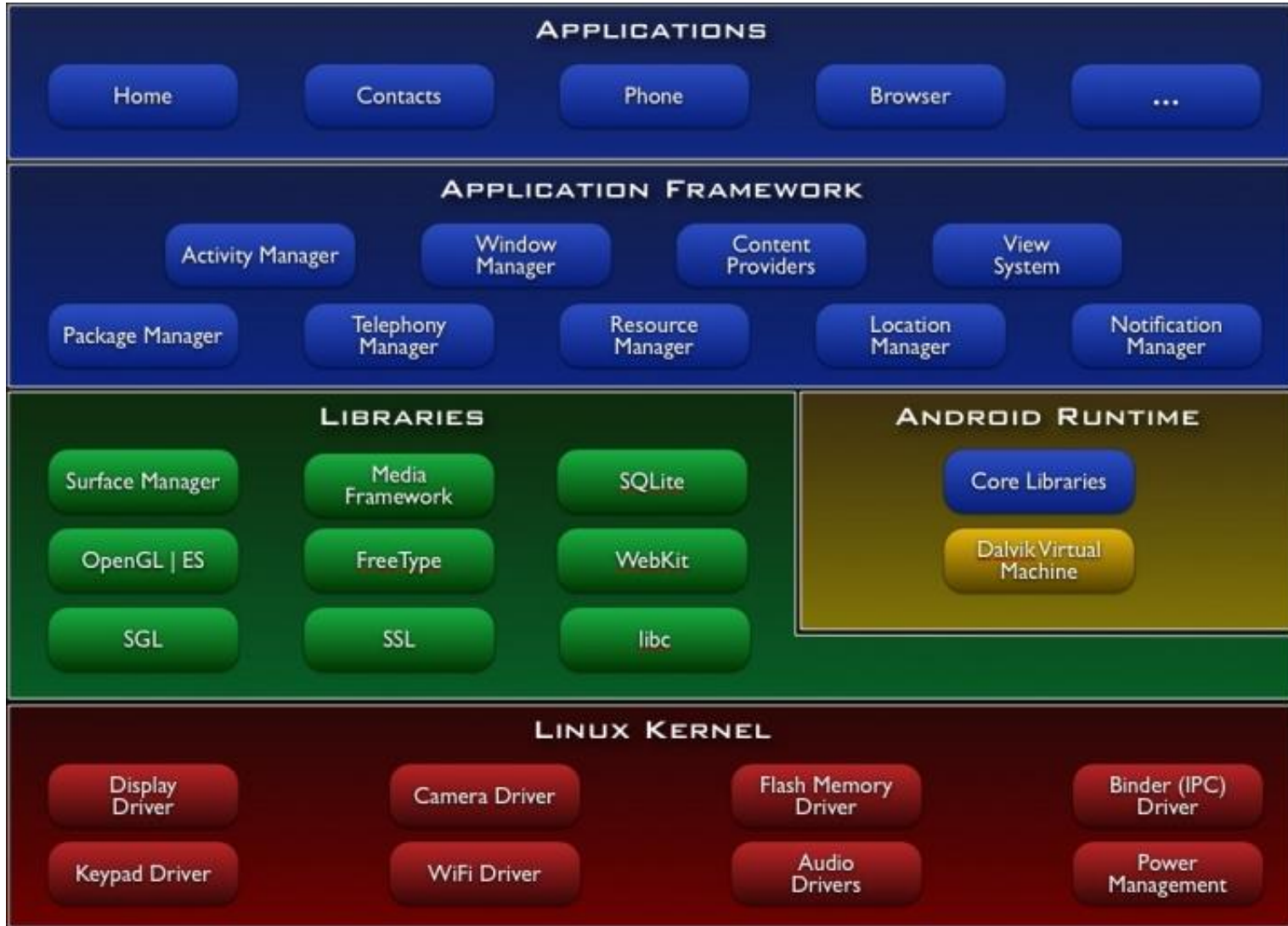
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- First generation 1945 - 1955
  - vacuum tubes, plug boards
- Second generation 1955 - 1965
  - transistors, batch systems
- Third generation 1965 – 1980
  - ICs and multiprogramming
- Fourth generation 1980 – present
  - personal computers

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Multiprogramming

- Multiprogramming system
  - three jobs in memory – 3rd generation

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Modern OS

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The Operating System family

- Mainframe operating systems

- Server operating systems

- Distributed operating systems

- Personal computer operating systems

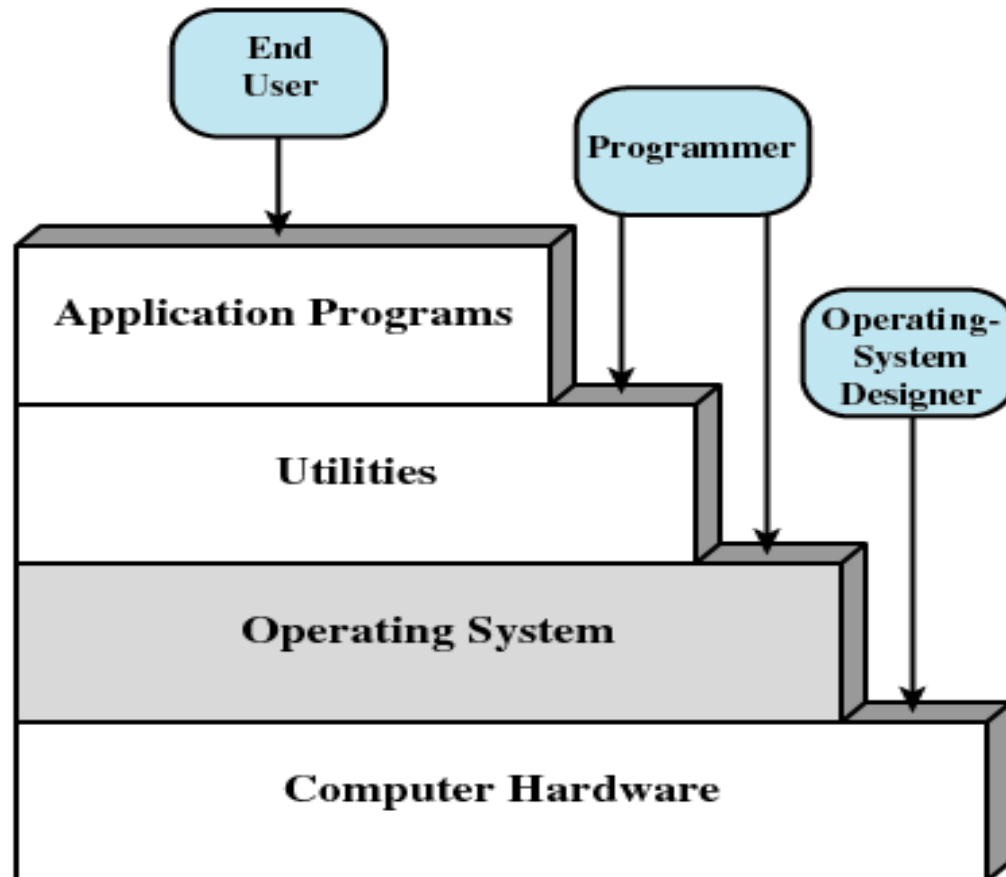- Real-time operating systems

- Embedded operating systems

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- https://youtu.be/ChQ18B1hofI

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Layers of Computer System

Figure 2.1   Layers and Views of a Computer System

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- Program development
    - Editors and debuggers

- Program execution

- Access to I/O devices

- Controlled access to files

- System access

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

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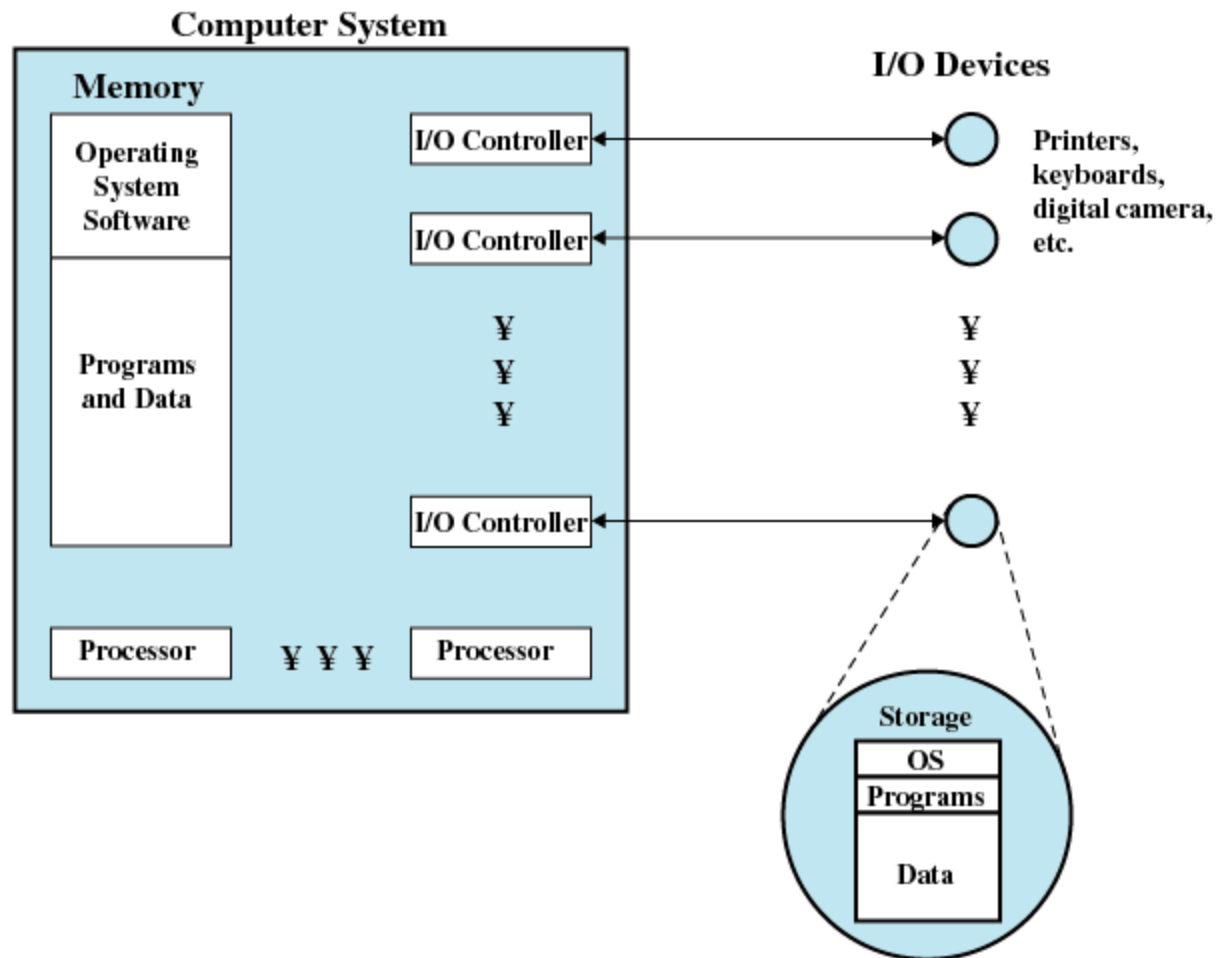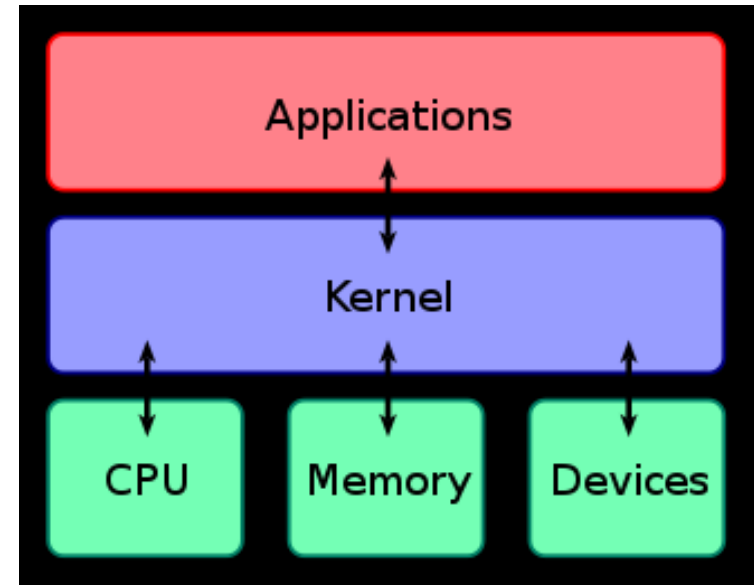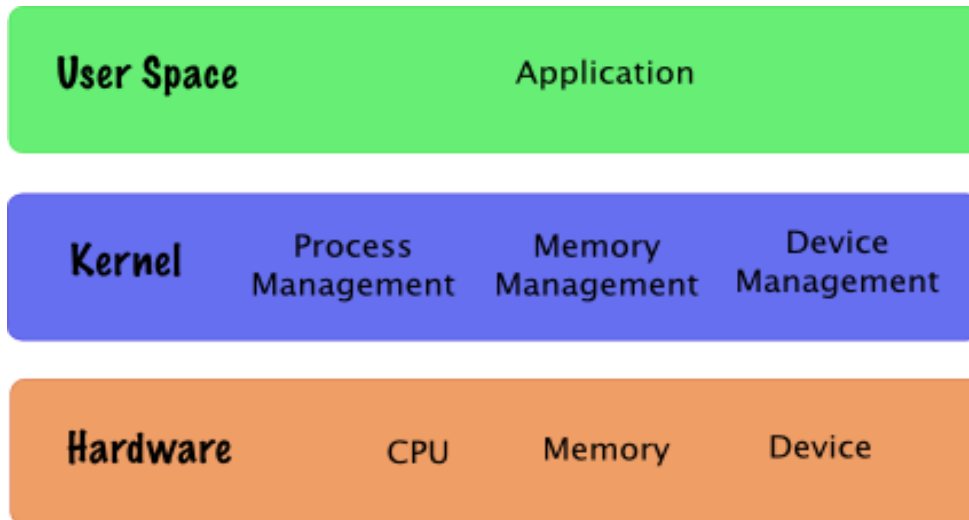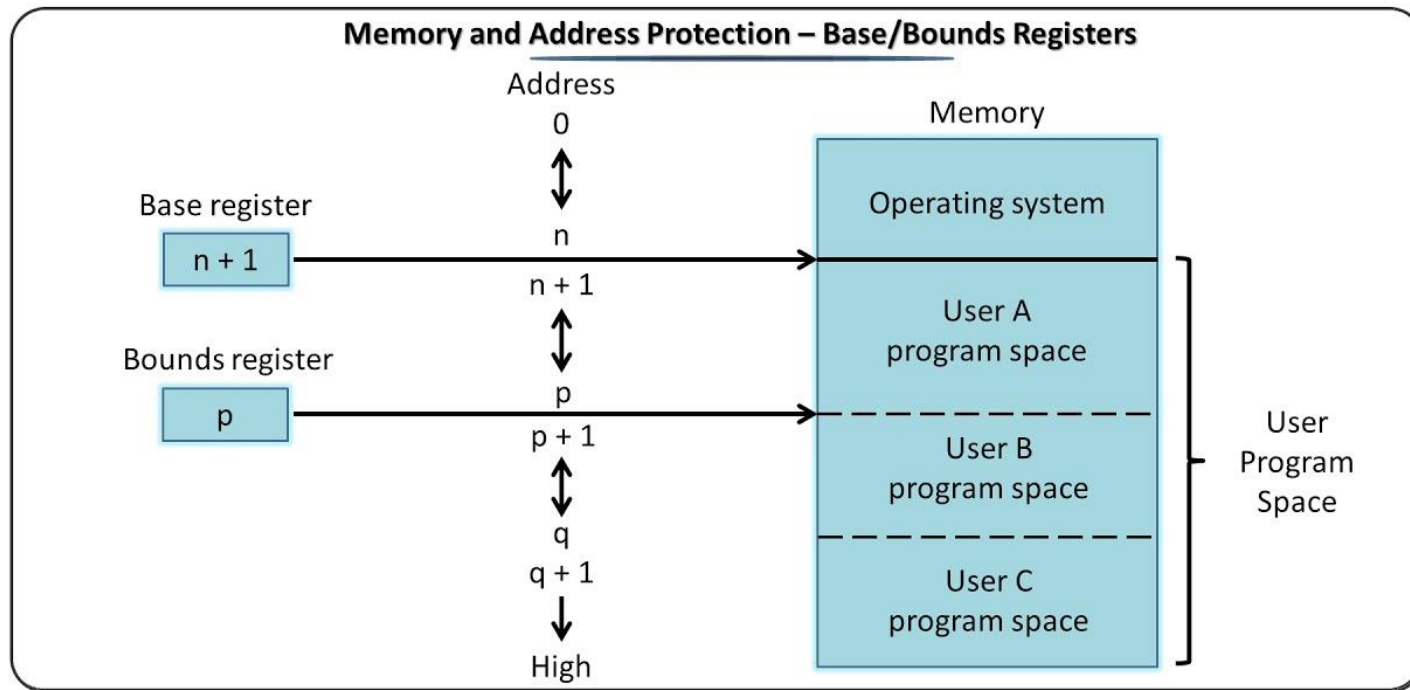C9-411, Dai Co Viet str. 1, HBT, Hanoi   Tel: +84-243-8693596

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Figure 2.2   The Operating System as Resource Manager

- Portion of operating system that is in main memory

- Contains most frequently used functions

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- https://www.youtube.com/watch?v=o_JCGR_9HRs

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- Memory protection
  - Do not allow the memory area containing the monitor to be altered

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Realization of 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

- ## Timer
  - – Prevents a job from monopolizing the system

Process	Arrival time	Burst time
P1	0 ms	10 ms
P2	0 ms	5 ms
P3	0 ms	8 ms

Gantt Chart

P1	P2	P3	P1	P2	P3
1 2	2 4	4 6	6 8	8 10	10 12

P1	P2	P3	P1	P3	P1
12 14	14 15	15 17	17 19	19 21	21 23

AfterAcademy

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

$$\text{Percent CPU Utilization} = \frac{1}{31} = 0.032 = 3.2\%$$
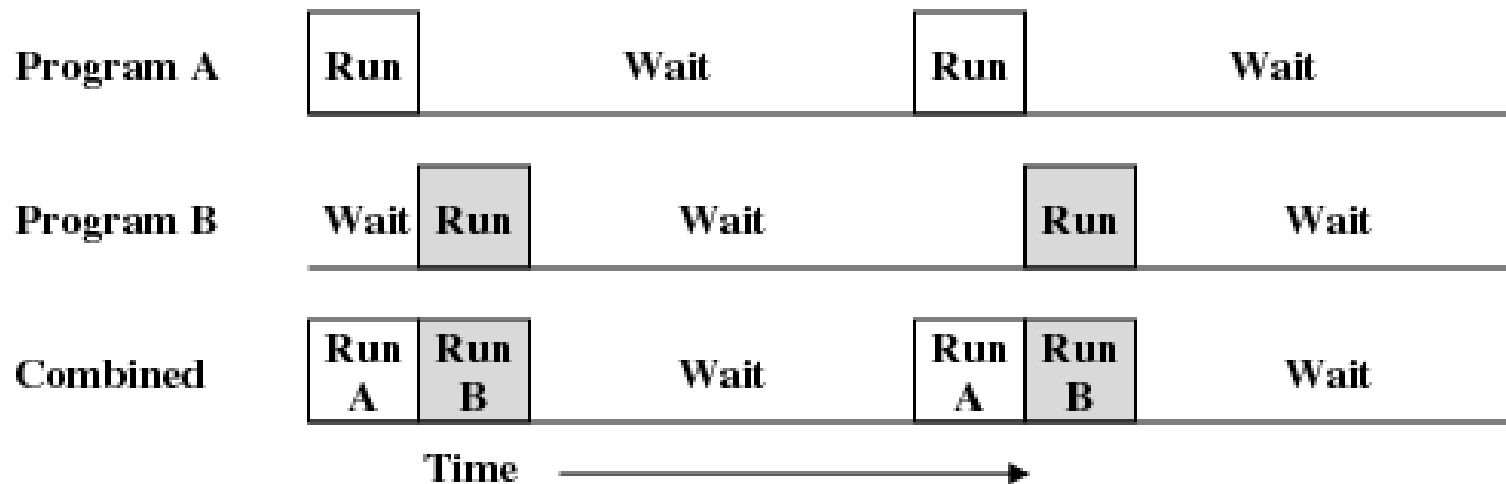
Figure 2.4 System Utilization Example

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

(a) Uniprogramming

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Multiprogramming

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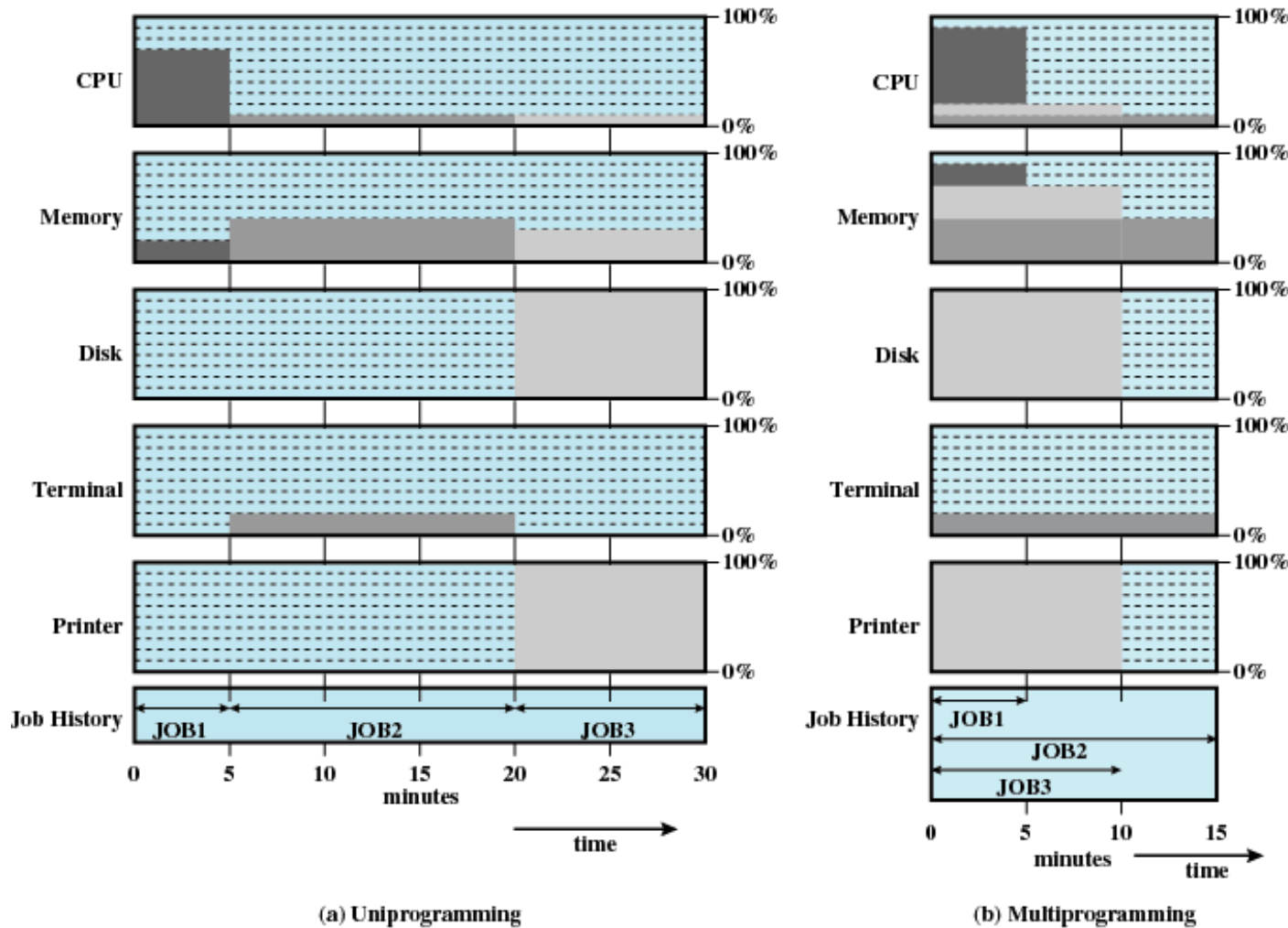

(b) Multiprogramming with two programs

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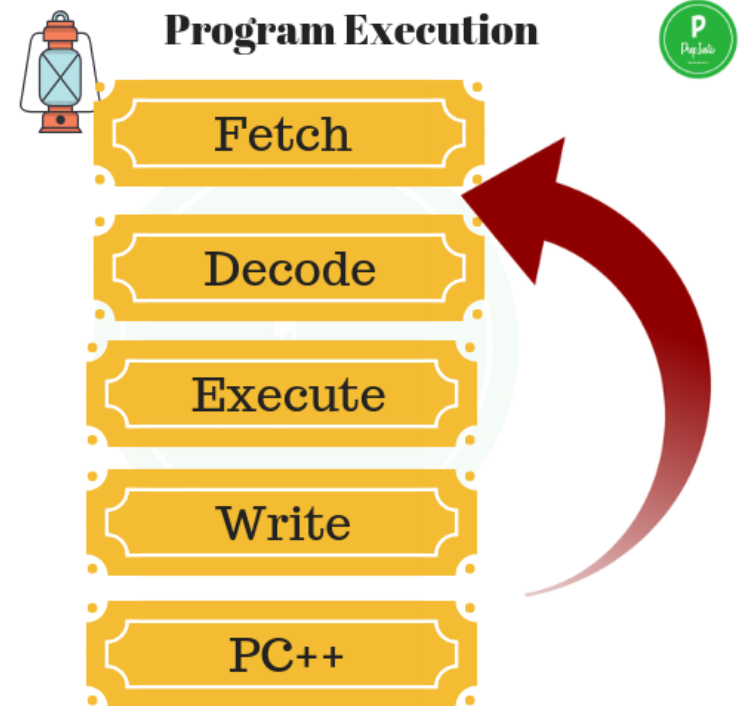Email: tien.phamvan1@hust.edu.vn

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Utilization Histograms

Figure 2.6 Utilization Histograms

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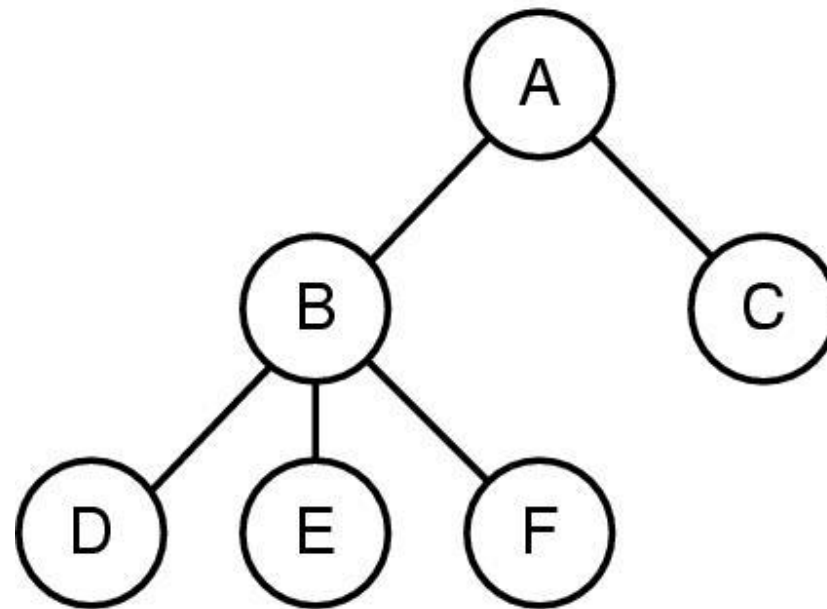
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Scheduling and Resource Management

- 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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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

Program Execution

Fetch

Decode

Execute

Write

PC++

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Process

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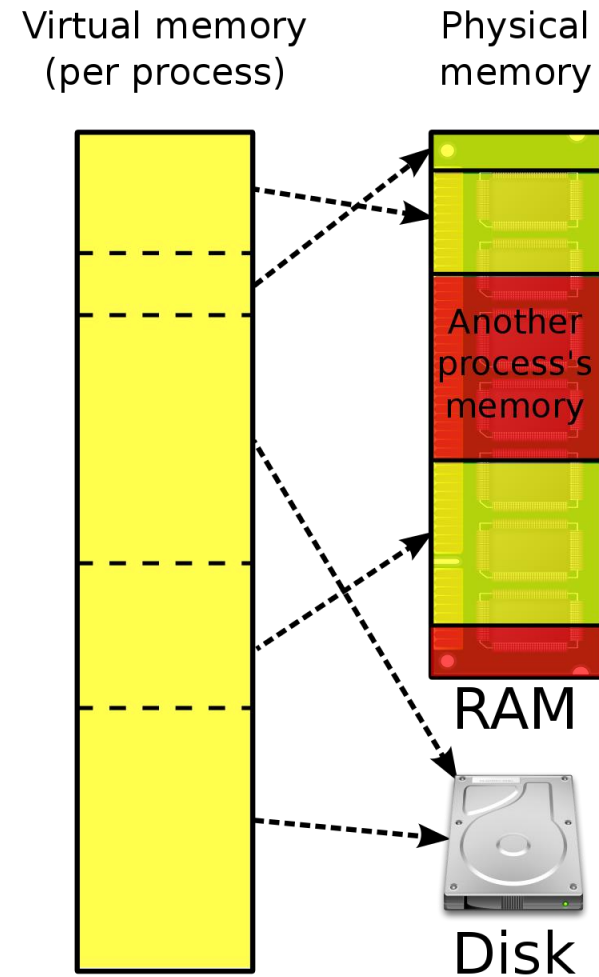   - All information the operating system needs to manage the process

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- A process tree

  – A created two child processes, B and C

  – B created three child processes, D, E, and F

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Memory Management

- Process isolation

- Automatic allocation and management

- Support of modular programming

- Protection and access control

- Long-term storage

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

Virtual memory (per process)

Physical memory

Another process's memory

RAM

Disk

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Virtual Memory

Main 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.
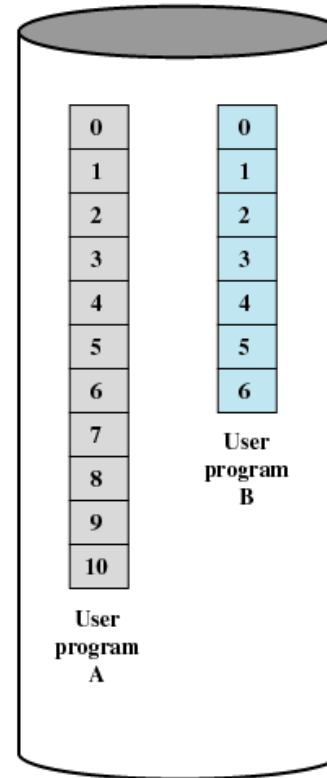
Disk

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.
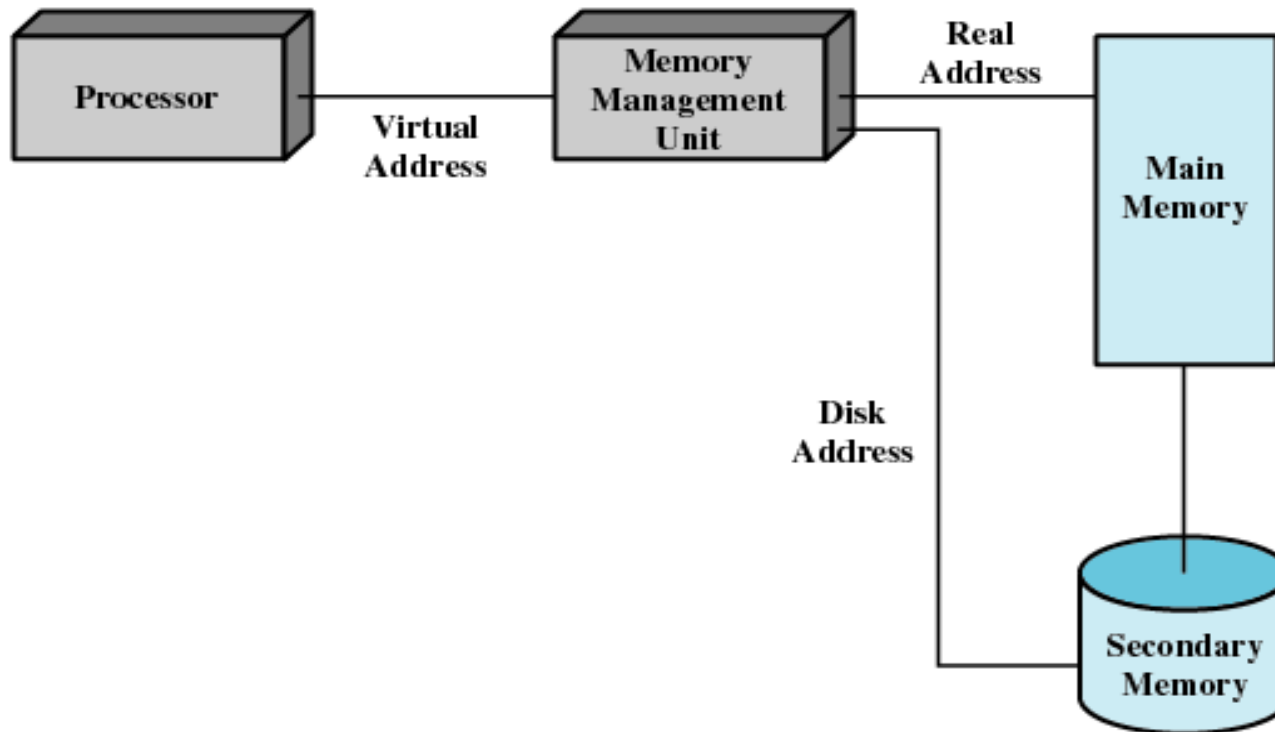
Figure 2.9   Virtual Memory Concepts

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Virtual Memory Addressing

Figure 2.10   Virtual Memory Addressing

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- ## Availability
  - Concerned with protecting the system against interruption

- ## Confidentiality
  - Assuring that users cannot read data for which access is unauthorized

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- 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
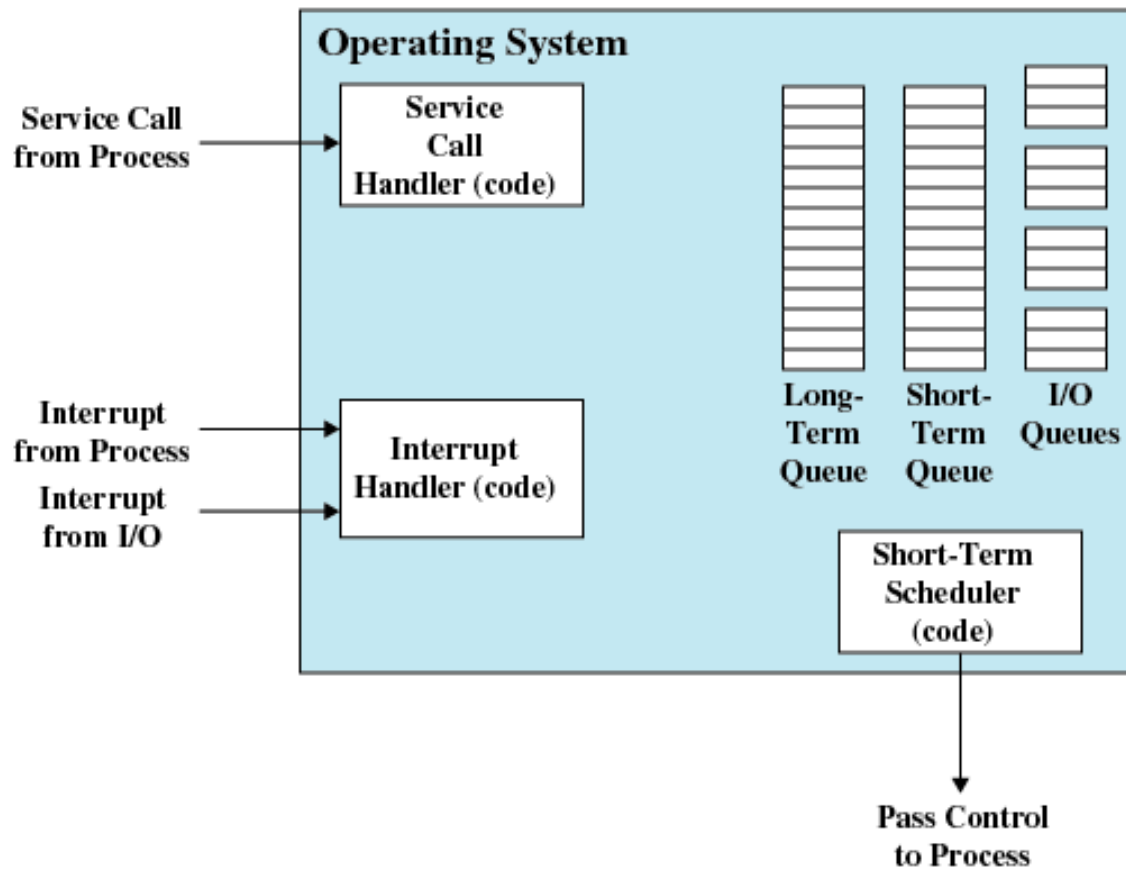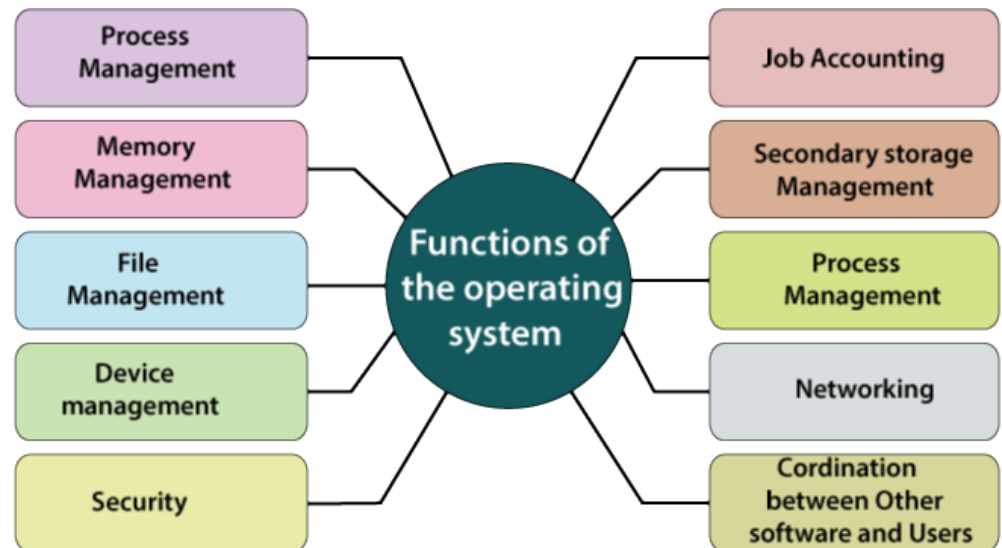
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Figure 2.11 Key Elements of an Operating System for Multiprogramming

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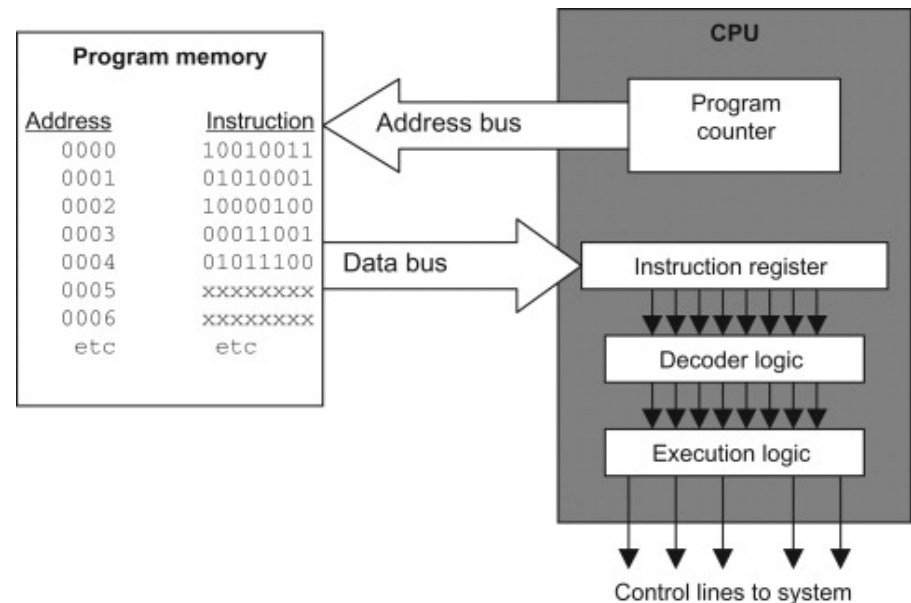
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System Structure

- 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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- Level 1
  - Electronic circuits
  - Objects are registers, memory cells, and logic gates
  - Operations are clearing a register or reading a memory location

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- Level 2
  - Processor's instruction set
  - Operations such as add, subtract, load, and store
- 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

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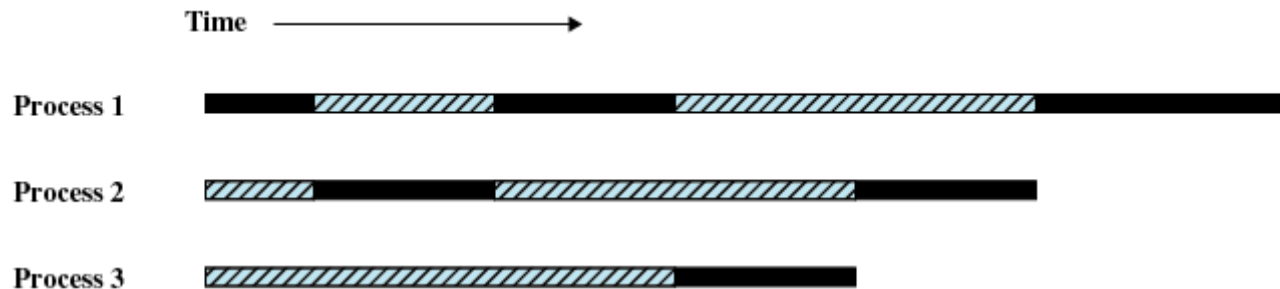
- Multithreading
  - Process is divided into threads that can run concurrently
    - Thread
      - Dispatchable unit of work
      - executes sequentially and is interruptable
    - Process is a collection of one or more threads

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- 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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Figure 2.12 Multiprogramming and Multiprocessing

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

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- 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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Kernel-Mode Components

- Executives
  - 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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User-Mode Processes

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

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- 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 local procedure call (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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- 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
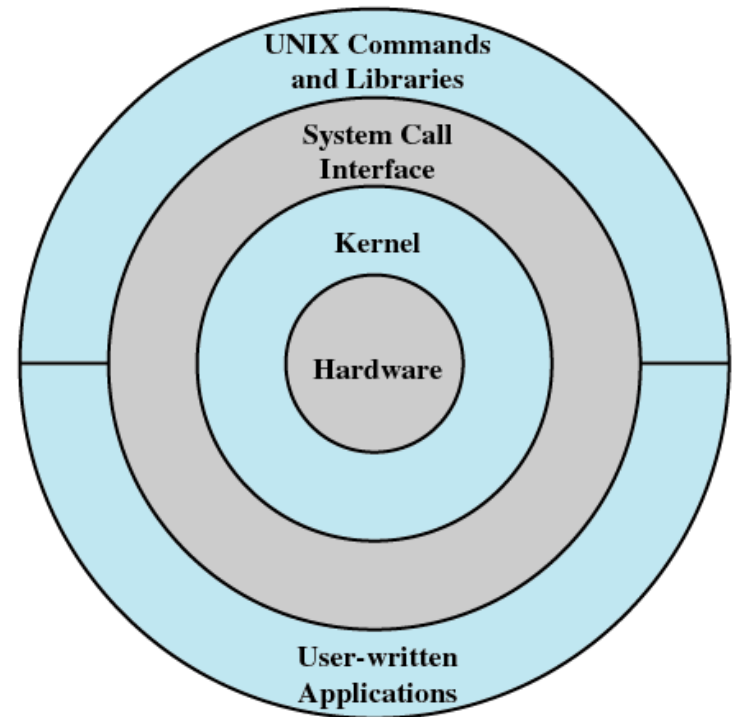
  – Components of the C compiler
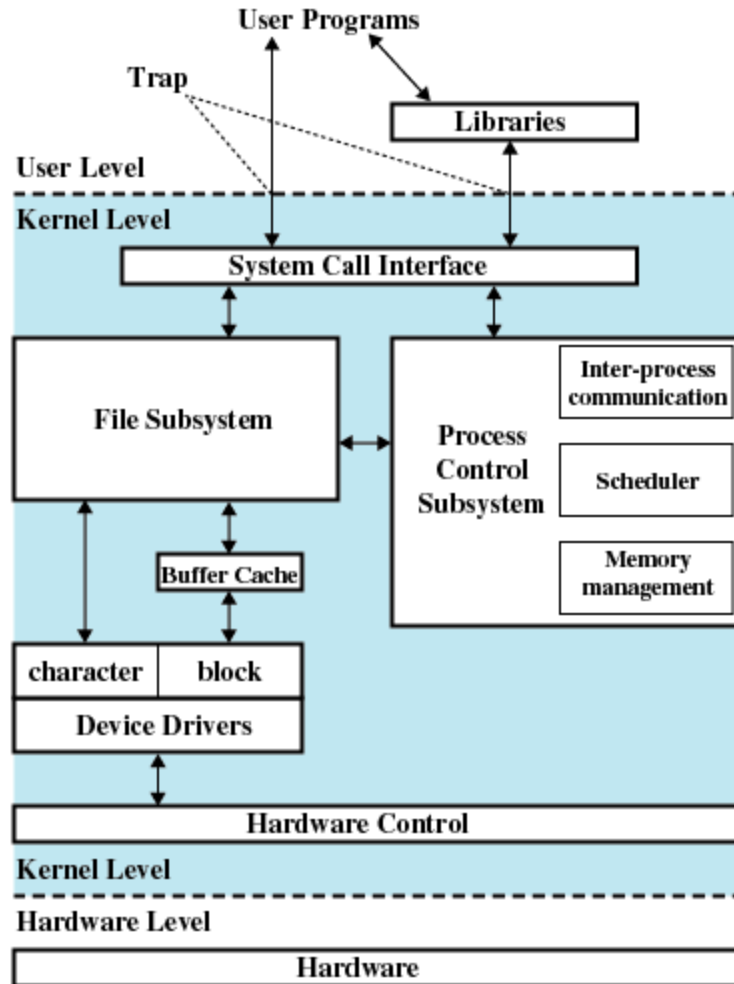

Figure 2.14 General UNIX Architecture

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UNIX Kernel

Figure 2.15 Traditional UNIX Kernel [BACH86]

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POSIX (Portable Operating System Interface)

Fully certified	Mostly complied	MS Windows supplements
HP UX	Linux	Cywin
Solaris	Android	MinGW
AIX	BSD	Windows Subsystem for Linux
QNX	Nucleus RTOS	Microsoft POSIX subsystem
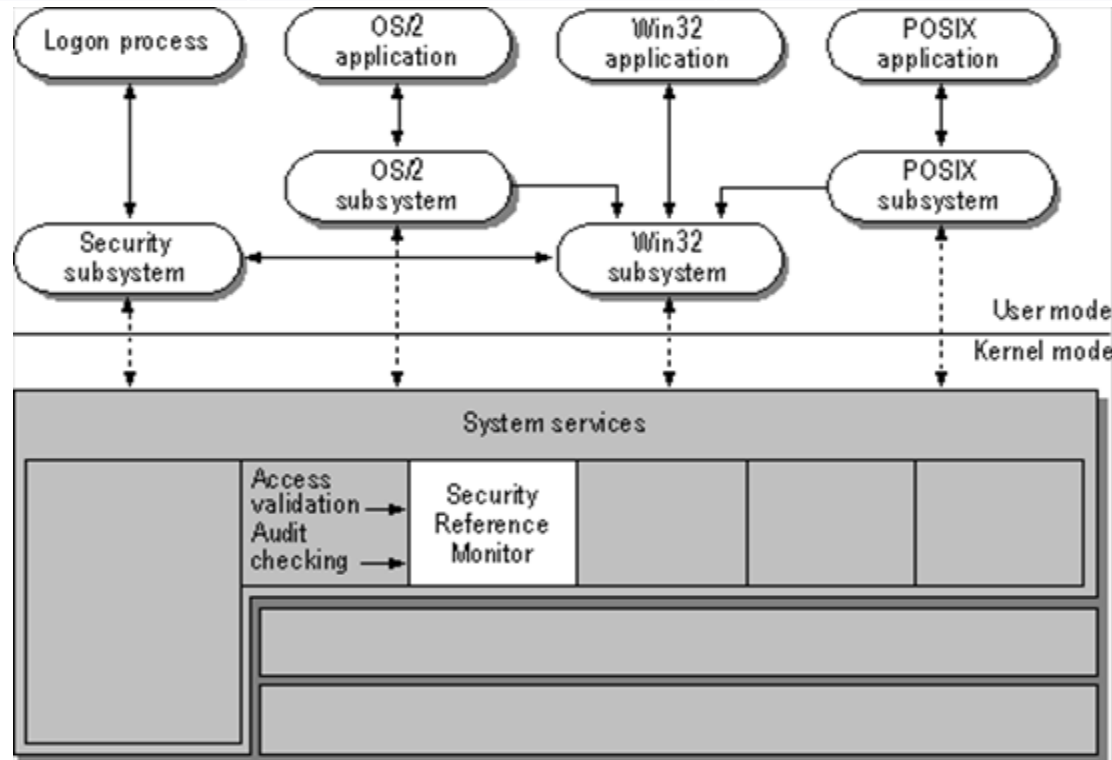
POSIX subsystem implementation.

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