1. Introduction

1.1 The Role of Operating Systems

- Bridge the "Semantic Gap" between Hardware and Application
- Three Views of Operating System
  1. Abstraction (addresses complexity)
  2. Virtualization (addresses sharing)
  3. Resource management (addresses performance)

1.2 Organization of Operating Systems

- Structural Organization
- The Hardware Interface
- The Programming Interface
- The User Interface
- Runtime Organization

1.3 Operating System Evolution & Concepts

Single CPU System

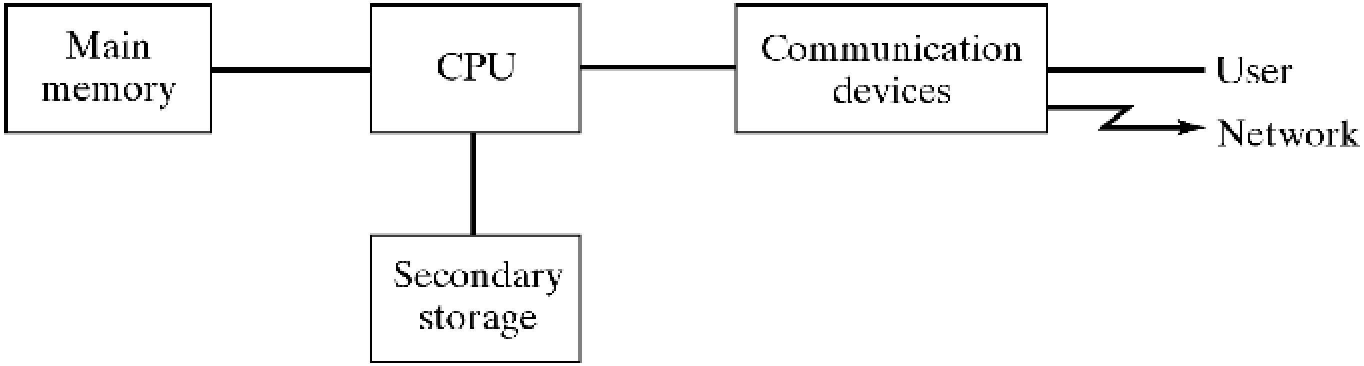


Figure 1-1

Multiprocessor Systems

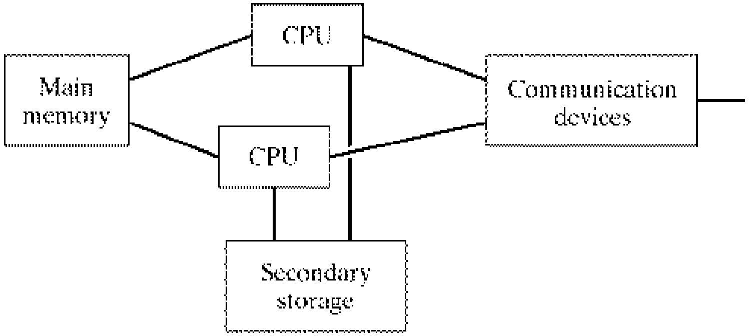


Figure 1-2a

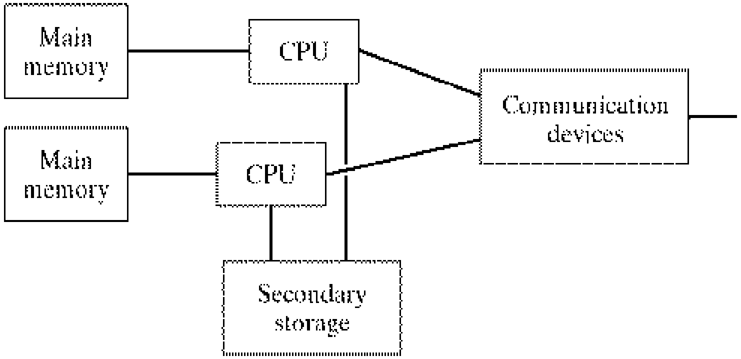


Figure 1-2b

Multicomputer System

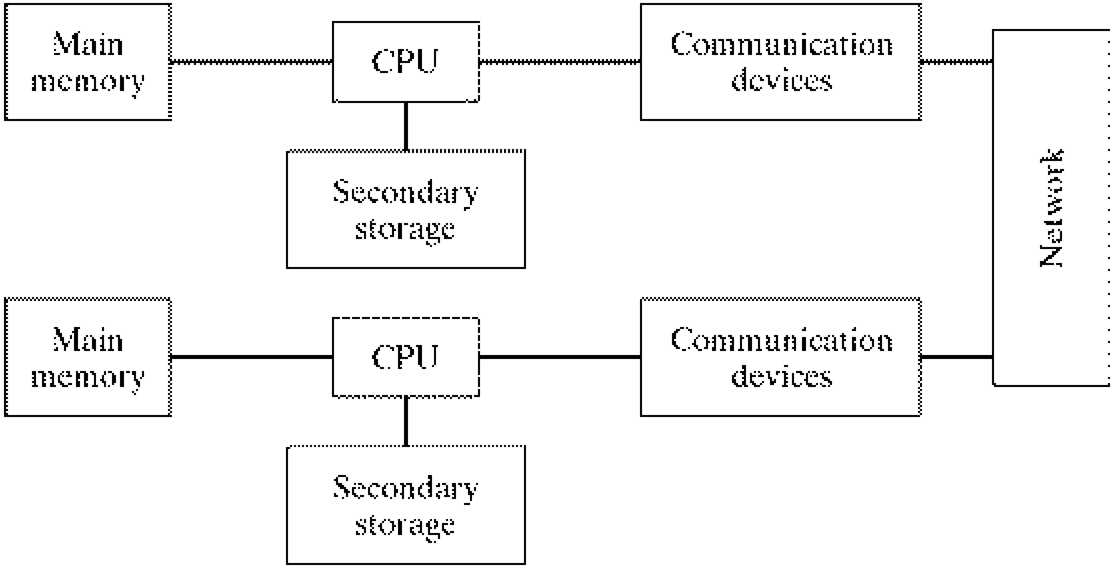


Figure 1-2c

PC Hardware Organization

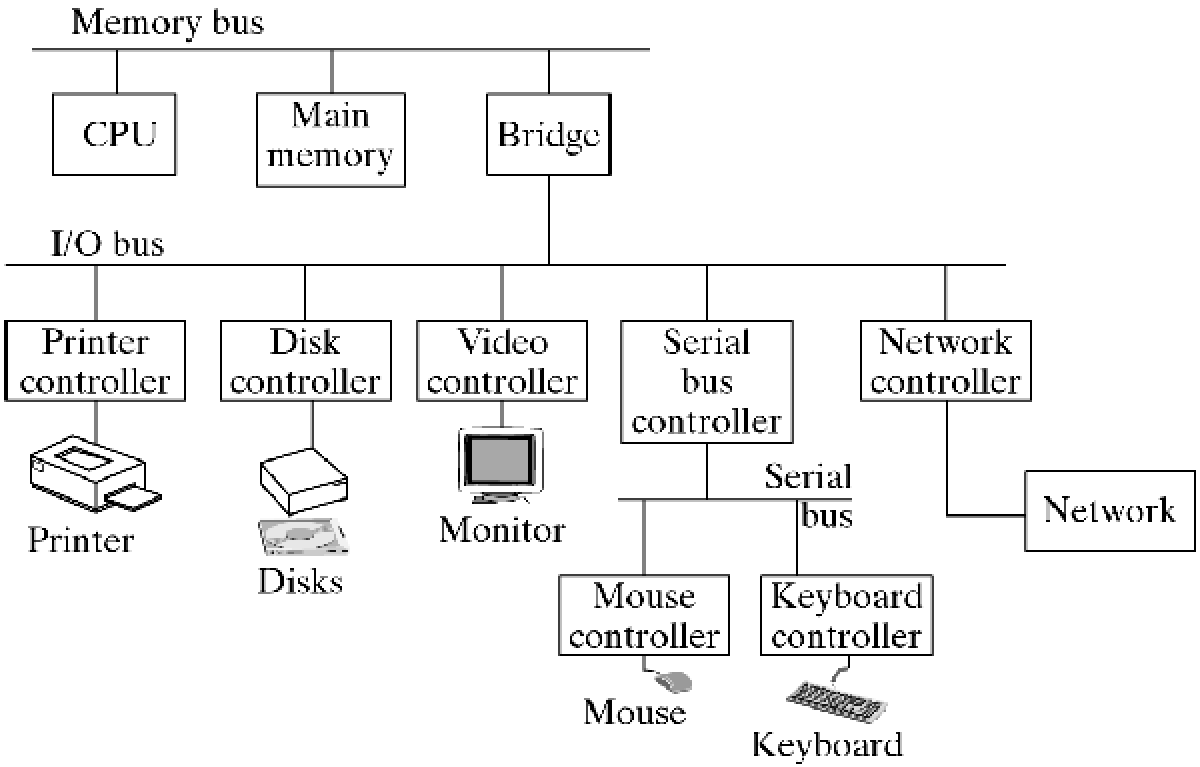


Figure 1-7

Bridging the Semantic Gap

- Hardware capabilities are very low level
  - Arithmetic and logical operators
  - Comparison of two bit-strings
  - Branching, reading, and writing bytes
- User needs to think in terms of problem to be solved
  - High-level data structures and corresponding operations
  - Simple, uniform interfaces to subsystems,
  - Treat programs and data files as single entities
- Use software to bridge this gap
  - Language processors (e.g., assemblers, compilers, interpreters).
  - Editors and text processors, linkers and loaders.
  - Application programs, utility and service programs.
  - **Operating Systems**

The role of OSs

- Bridge Hardware/Application Gap
  - Machine instruction vs. high level operation
    - compiler bridges gap
  - Linear memory vs. data structures
    - compiler bridges gap
  - Limited CPU & memory vs. more needed
    - OS bridges gap
  - Secondary memory devices vs. files
    - OS bridges gap
  - I/O devices vs. high level I/O commands
    - OS bridges gap

Three views of OSs

- OS is an extended machine
  - Principle of abstraction hides complexity
  - OS provides high level operations using lower level operations
- OS is a virtual machine
  - Principle of virtualization supports sharing
  - OS provides virtual CPU, memory, devices
- OS is a resource manager
  - Balance overall performance with individual needs (response time, deadlines)

Structural Organization of OSs

- Monolithic vs. Layered

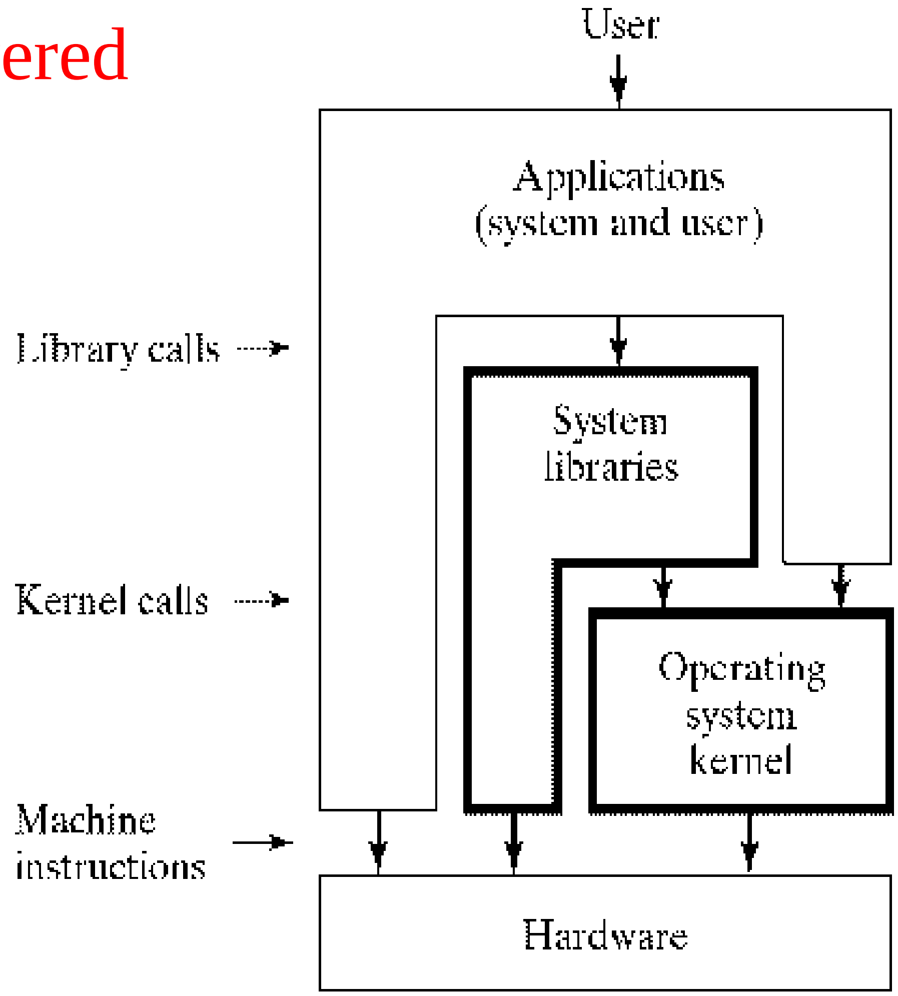


Figure 1-8

Organization of OSs

- Hardware Interface
  - Applications and OS compiled into machine instructions
  - Interrupts and Traps allow OS to seize control
    - process management (time-sharing)
    - device management (I/O completion)

Interrupts vs. Traps

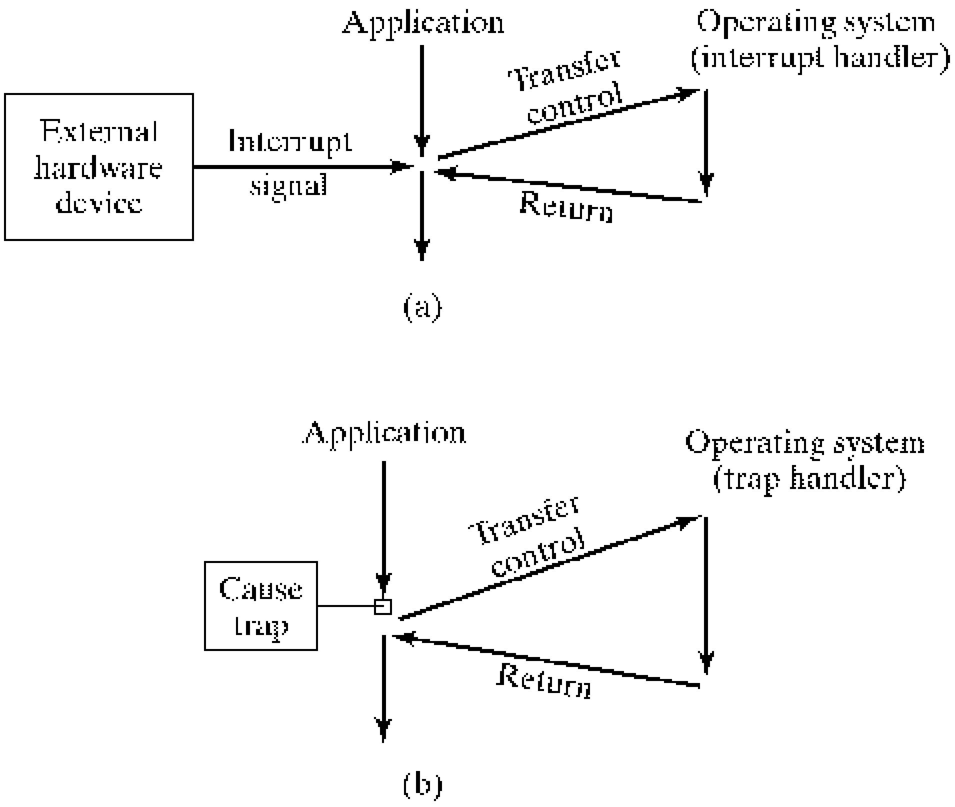


Figure 1-9

Organization of OSs

- Hardware interface (continued)
  - Modes of CPU execution
    - Privileged/Nonprivileged
    - SVC (supervisor call) causes trap
    - Control transferred to OS in privileged mode
    - OS exits privileged mode when returning to user

Organization of OSs

- Programming Interface

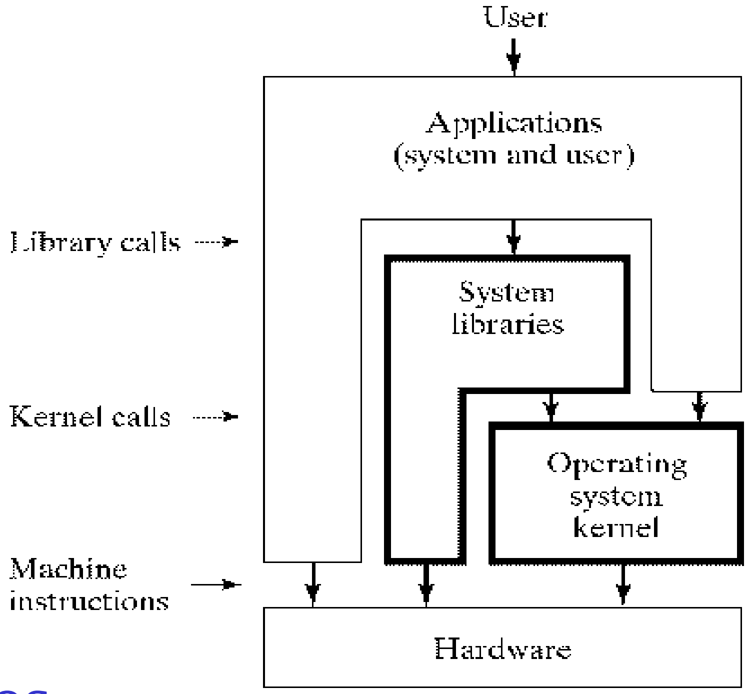
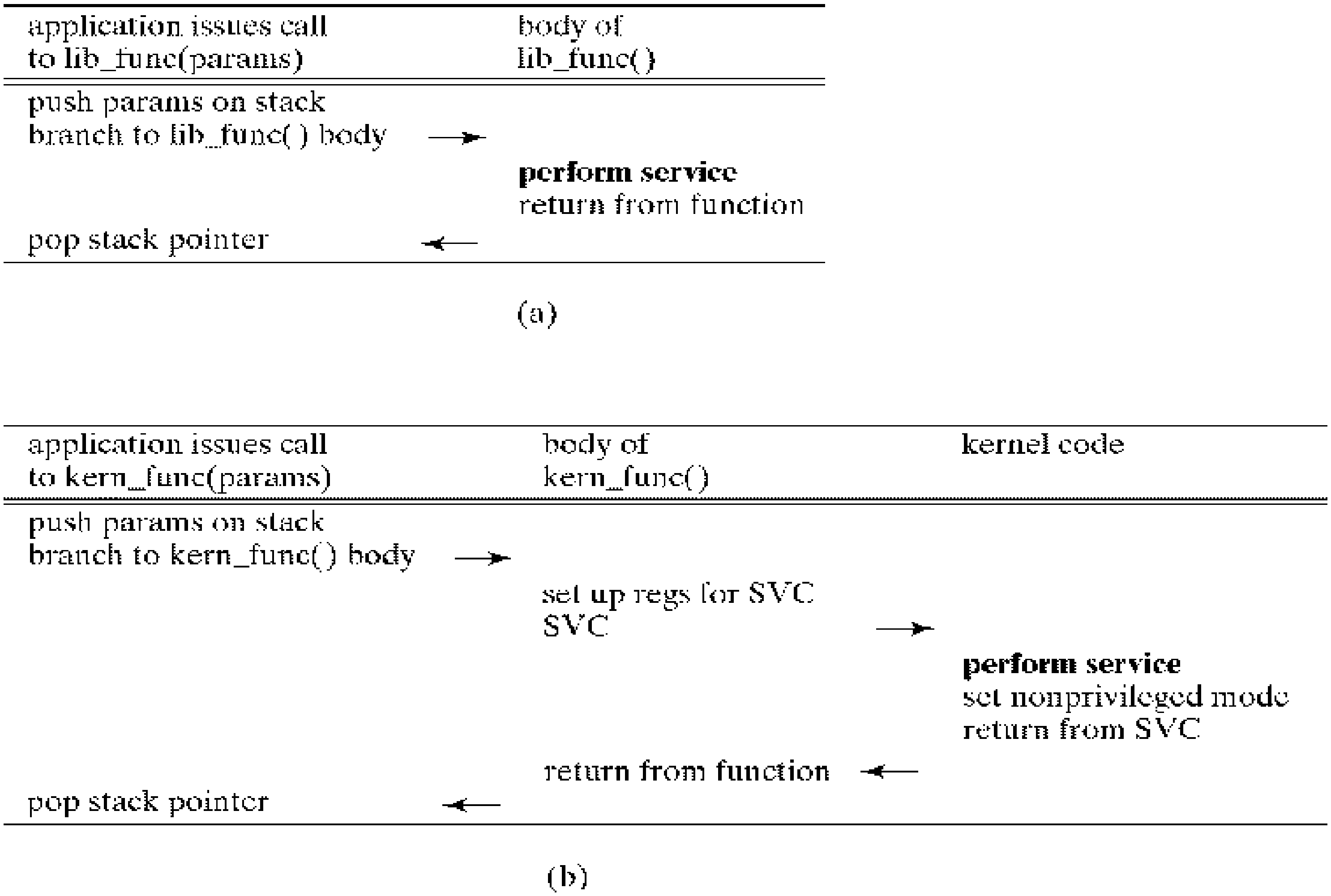


Figure 1-8

- Invoking system services
  - Library call (nonprivileged)
  - Kernel call (privileged)

Invoking System Services



application issues call to lib_func(params)		body of lib_func( )
push params on stack branch to lib_func( ) body	→	
		perform service return from function
pop stack pointer	←	

(a)

application issues call to kern_func(params)		body of kern_func( )		kernel code
push params on stack branch to kern_func( ) body	→			
		set up regs for SVC SVC	→	
				perform service set nonprivileged mode return from SVC
		return from function	←	
pop stack pointer	←			

(b)

Figure 1-10

Organization of OSs

- User interface (cf. Fig. 1-8)
  - Text-based shell (e.g. Unix)
    - command interpreter
    - shell scripts
  - Graphics-based GUI (e.g. Mac, MS Windows)
    - **W**indows
    - **I**cons
    - **M**enus
    - **P**ointer

Organization of OSs

- Runtime organization
  - Service is a Subroutine
  - Service is an Autonomous Process ("client-server")

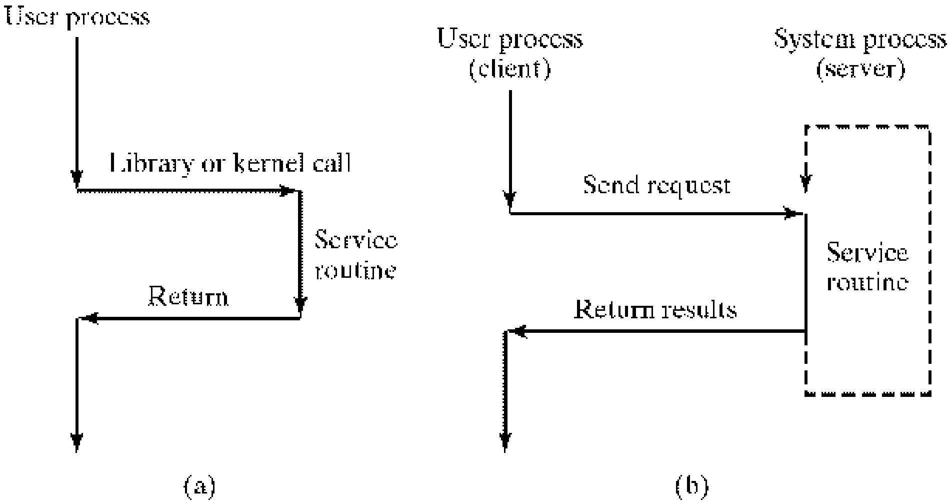


Figure 1-12

OS Evolution and Concepts

- Early systems
  - Bootstrapping
- Batch OSs
  - I/O processors
  - Interrupts
  - Relocatable code (Allows separately compile programs to be combined without recompilation)
- Multiprogramming

Multiprogramming

- Basic problem:
  - Some programs are compute-bound, some I/O-bound
  - Even “balanced” programs are balance only over time
  - No one program can make full use of the system
- Solution: ***Multiprogramming***
  - Have more than one active (running) program in memory at any one time
- Multiprogramming requires
  - Bridging the semantic gap
  - Sharing resources among different programs
  - Hiding from each program the fact of this sharing

OS Evolution and Concepts

- Multiprogramming Systems
  - Overlap CPU and I/O
  - Protection
  - Synchronization and Communication
  - Dynamic Memory Management (swapping and paging)
- Interactive OSs
  - Guaranteed response time
  - Time-sharing (quantum)

OS Evolution and Concepts

- PC and workstation OSs
  - GUI
- Real-time OSs
  - Deadlines (scheduling)
- Distributed OSs
  - Loosely coupled/tightly coupled
  - Consistent timeline (logical clocks, time stamps)

Abstraction

- E.W.Dijkstra, “The Humble Programmer” (1972):
  “The purpose of abstraction is *not* to be vague,
  but to create a new semantic level
  in which one can be absolutely precise.”
- “abstraction” is created by distinguishing
  - Essential characteristics from Unimportant details
- Build levels (layers) of abstractions:
  - What is unimportant detail at one level is an essential characteristic at a lower one.

History

- Originally developed by Steve Franklin
- Modified by Michael Dillencourt, Spring, 2009
- Modified by Michael Dillencourt, Summer 2012