# Contents

# Chapter 2
# System Structures

# Operating-System Structures

- Goals: Provide a way to understand an operating systems
  - Services
  - Interface
  - System Components
- The type of system desired is the basis for choices among various algorithms and strategies!

# Operation-System Services

- Goal:
  - Provide an environment for the execution of programs.
  - Services are provided to programs and their users.
- User Interface (UI)
  - Command Line Interface, Batch Interface, Graphical User Interface (GUI), etc.
  - Interface between the user and the operating system

# Operation-System Services

- Friendly UI's
  - Command-line-based interfaces or mused-based window-and-menu interface
- e.g., UNIX shell and command.com in MS-DOS

User-friendly?

Get the next command
Execute the command

- Program Execution
  - Loading, running, terminating, etc

# Operation-System Services

- I/O Operations
  - General/special operations for devices:
    - Efficiency & protection
- File-System Manipulation
  - Read, write, create, delete, etc.
  - Files and Directories
  - Permission Management
- Communications
  - Intra-processor or inter-processor communication – shared memory or message passing

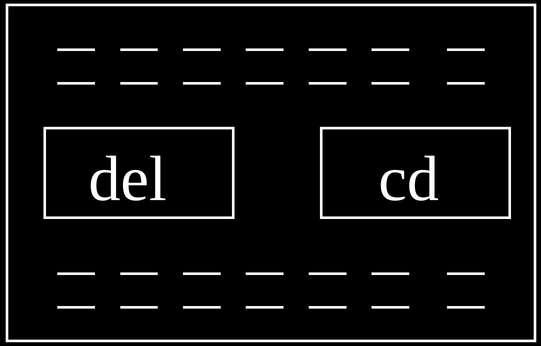
# Operation-System Services

- Error Detection
  - Possible errors from CPU, memory, devices, user programs → Ensure correct & consistent computing
- *Resource Allocation*
  - *Utilization & efficiency*
- *Accounting*
  - *Statistics or Accounting*
- *Protection & Security*

• user convenience or *system efficiency!*

# User OS Interface – Command Interpreter

- Two approaches:
  - Contain codes to execute commands
    - Fast but the interpreter tends to be big!
    - Painful in revision!

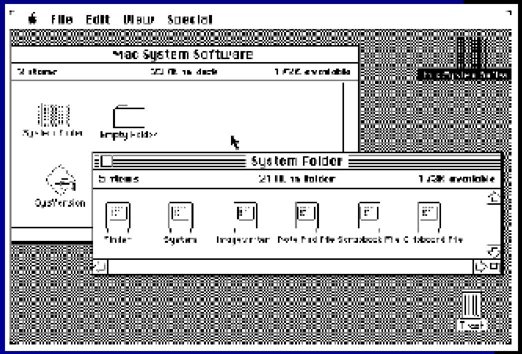


# User OS Interface – Command Interpreter

- Implement commands as system programs → Search exec files which corresponds to commands (UNIX)
  - Issues
    a. Parameter Passing
       - Potential Hazard: virtual memory
    b. Being Slow
    c. Inconsistent Interpretation of Parameters

# User OS Interface – GUI

- Components
  - Screen, Icons, Folders, Pointer, etc.
- History
  - Xerox PARC research facility (1970's)
  - Mouse – 1968
  - Mac OS – 1980's
  - Windows 1.0 ~ 8




# User OS Interface – GUI

- Unix & Linux
  - Common Desktop Environment (CDE), X-Windows, K Desktop Environment (KDE), GNOME
- Trend
  - Mixture of GUI and command-line interfaces
  - Multimedia, Intelligence, etc.

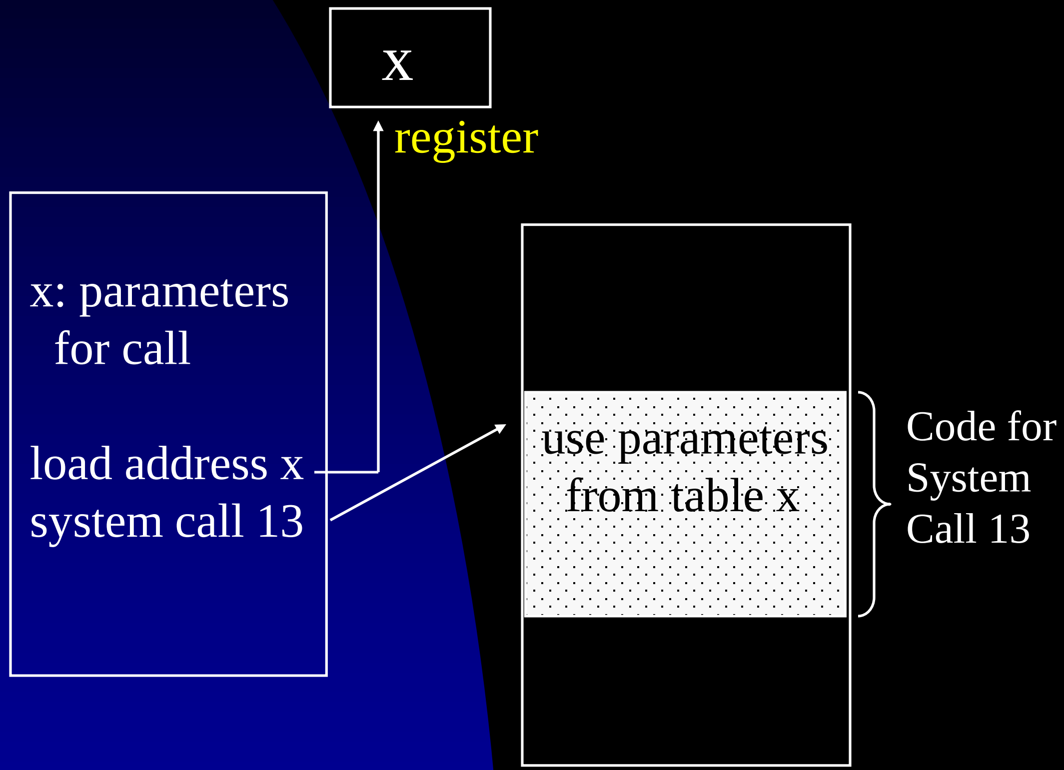
# System Calls

- System calls
  - Interface between processes & OS
- How to make system calls?
  - Assembly-language instructions or subroutine/functions calls in high-level language such as C or Perl?
    - Generation of in-line instructions or a call to a special run-time routine.
- Example: read and copy of a file!
  - Library Calls vs System Calls

# System Calls

- Application Programming Interface (API)
  - Examples: Win 32 API for Windows, POSIX API for POSIX-based Systems, Java API for Java virtual machines
  - Benefits (API vs System Calls)
    - Portability
    - Ease of Use & Better Functionality

# System Calls




- How a system call occurs?
  - Types and information
- Parameter Passing
  - Registers
  - Registers pointing to blocks
    - Linux
  - Stacks

# System Calls

- Process Control
- File Management
- Device Management
- Information Maintenance
- Communications

# System Calls

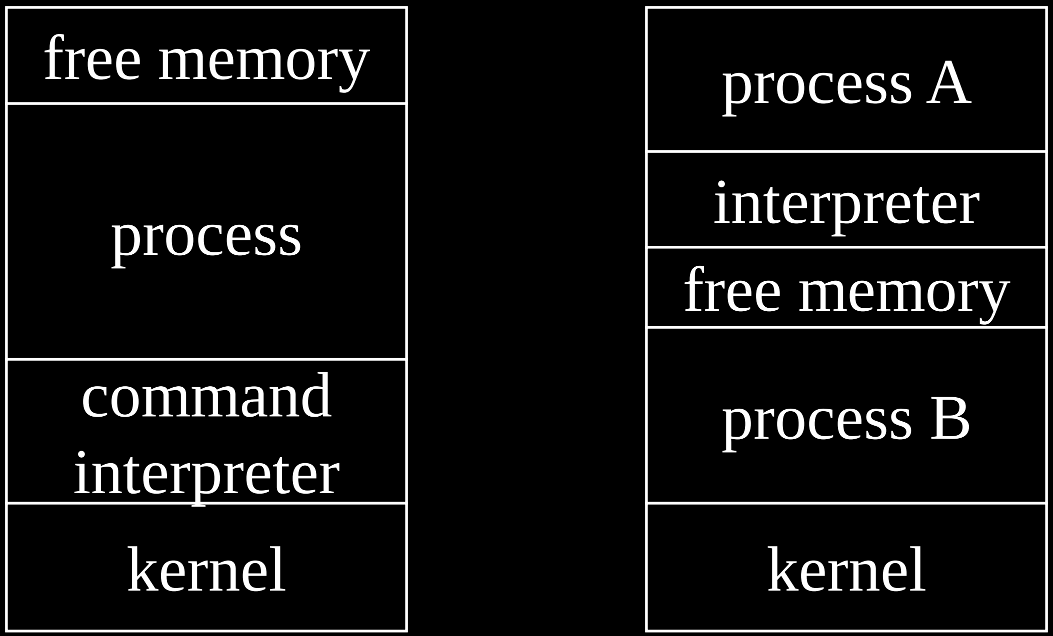
- Process & Job Control
  - End (normal exit) or abort (abnormal)
    - Error level or no
    - Interactive, batch, GUI-supported systems
  - Load and execute
    - How to return control?
      - e.g., shell load & execute commands
  - Creation and/or termination of processes
    - Multiprogramming?

# System Calls

- Process & Job Control (continued)
  - Process Control
    - Get or set attributes of processes
  - Wait for a specified amount of time or an event
    - Signal event
  - Memory dumping, profiling, tracing, memory allocation & de-allocation

# System Calls

- Examples: MS-DOS & UNIX



# System Calls

- File Management
  - Create and delete
  - Open and close
  - Read, write, and reposition (e.g., rewinding)
    - lseek
  - Get or set attributes of files
  - Operations for directories

# System Calls

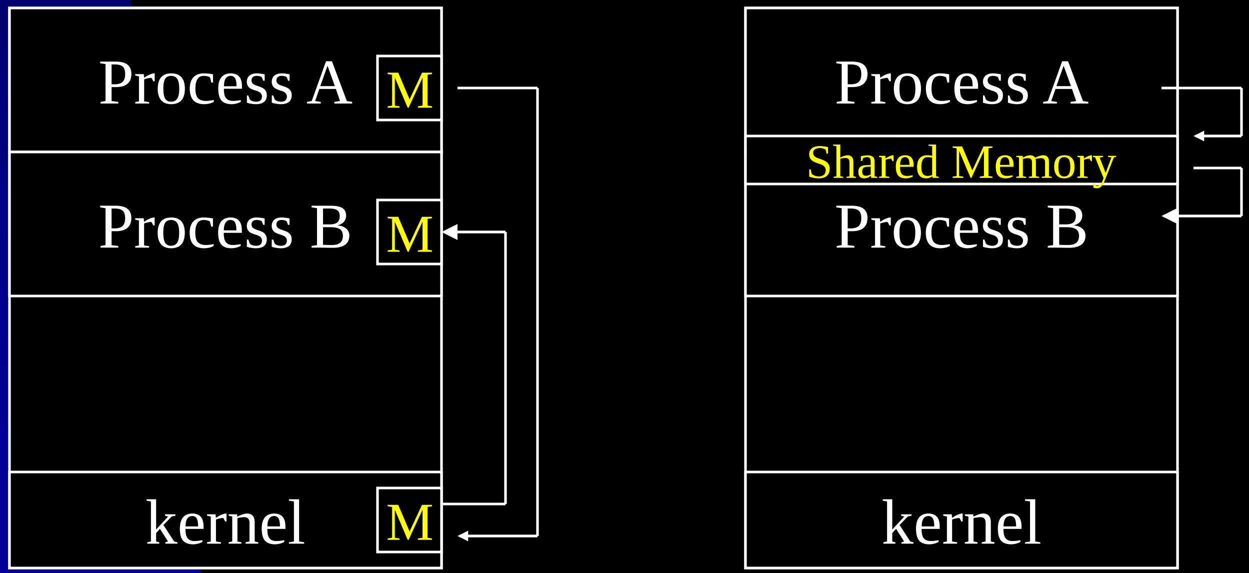
- Device management
  - Physical or virtual devices, e.g., files.
  - Request or release
    - Open and close of special files
    - Files are abstract or virtual devices.
  - Read, write, and reposition (e.g., rewinding)
  - Get or set file attributes
  - Logically attach or detach devices

# System Calls

- Information maintenance
  - Get or set date or time
  - Get or set system data, such as the amount of free memory
- Communication
  - Message Passing
    - Open, close, accept connections
      - Host ID or process ID
    - Send and receive messages
    - Transfer status information
  - Shared Memory
    - Memory mapping & process synchronization
- Protection

# System Calls

- Shared Memory
  - Max Speed & Comm Convenience
- Message Passing
  - No Access Conflict & Easy Implementation



# System Programs

- Goal:
  - Provide a convenient environment for program development and execution
- Types
  - File Management, e.g., rm.
  - Status information, e.g., date.
  - File Modifications, e.g., editors.
  - Program Loading and Executions, e.g., loader.
  - Programming Language Supports and background services, e.g., compilers.
  - Communications, e.g., telnet.

# System Design & Implementation

- Design Goals & Specifications:
  - User Goals, e.g., ease of use
  - System Goals, e.g., reliable
- Rule 1: Separation of Policy & Mechanism
  - Policy：What will be done?
  - Mechanism：How to do things?
  - Example: timer construct and time slice
- Two extreme cases:

Microkernel-based OS ←·········→ Macintosh OS

# System Design & Implementation

- OS Implementation in High-Level Languages
  - E.g., UNIX, OS/2, MS NT, etc.
  - Advantages:
    - Being easy to understand & debug
    - Being written fast, more compact, and portable
  - Disadvantages:
    - Less efficient but more storage for code

* Tracing for bottleneck identification, exploring of excellent algorithms, etc.

# OS Structure – MS-DOS

- MS-DOS Layer Structure

Application program

Resident system program

MS-DOS device drivers

ROM BIOS device drivers

# OS Structure – UNIX

User interface

System call interface

Kernel interface to the hardware

user user user user user user user

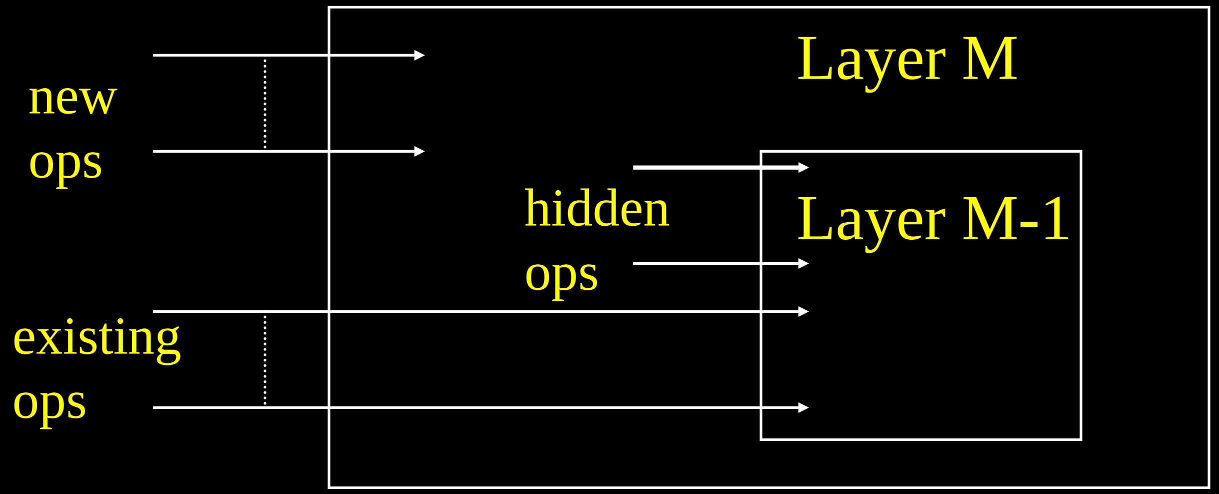
Shells, compilers, X, application programs, etc.

CPU scheduling, signal handling,
virtual memory, paging, swapping,
file system, disk drivers, caching/buffering, etc.

terminal controller, terminals,
physical memory, device controller,
devices such as disks, memory, etc.

# OS Structure

- A Layered Approach – A Myth




Advantage: Modularity ~ Debugging & Verification

Difficulty: Appropriate layer definitions, less efficiency due to overheads !

# OS Structure

- A Layer Definition Example:

| | |
|---|---|
| L5 | User programs |
| L4 | I/O buffering |
| L3 | Operator-console device driver |
| L2 | Memory management |
| L1 | CPU scheduling |
| L0 | Hardware |

# OS Structure – OS/2

- OS/2 Layer Structure

Application | Application | Application

Application-program Interface

Subsystem | Subsystem | Subsystem

System kernel
- memory management
- task scheduling
- device management

Device driver | Device driver | Device driver

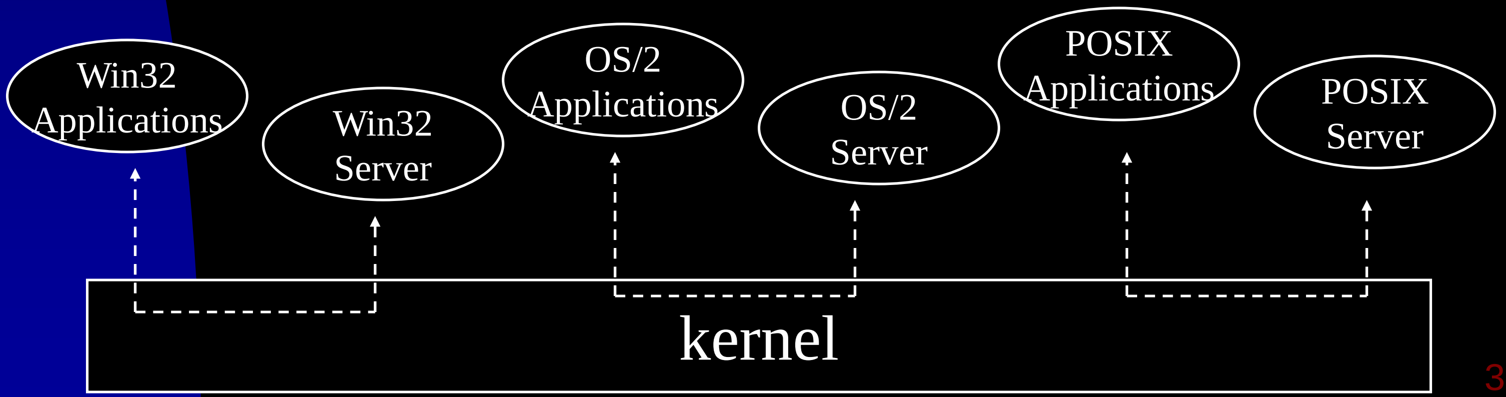
* Some layers of NT were from user space to kernel space in NT4.0

# OS Structure – Microkernels

- The concept of microkernels was proposed in CMU in mid 1980s (Mach).
  - Moving all nonessential components from the kernel to the user or system programs!
  - No consensus on services in kernel
    - Mostly on process and memory management and communication
- Benefits:
  - Ease of OS service extensions → portability, reliability, security

# OS Structure – Microkernels

- Examples
  - Microkernels: True64UNIX (Mach kernel), MacOS X (Mach kernel), QNX (msg passing, proc scheduling, HW interrupts, low-level networking)
  - Hybrid structures: Windows NT

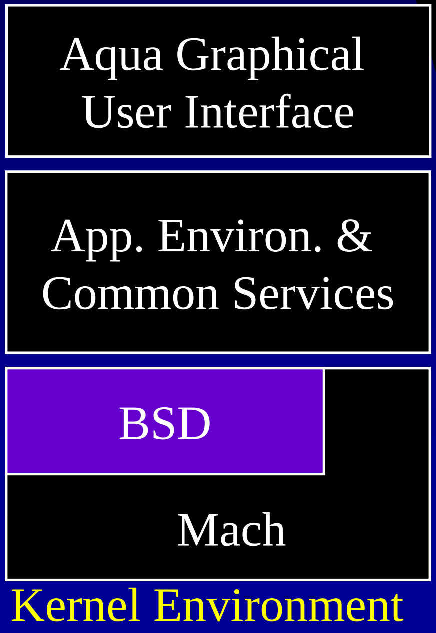


# OS Structure – Modules

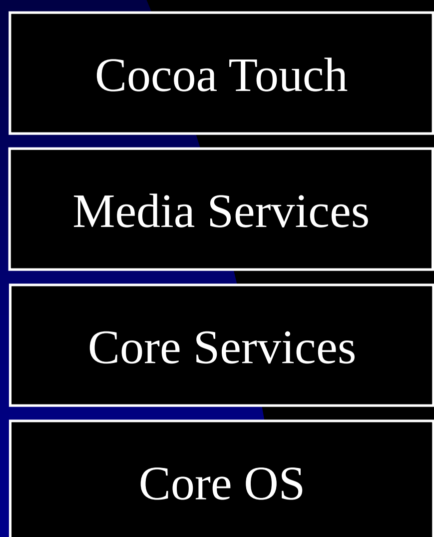
- A Modular Kernel
  - A Set of Core Components
  - Dynamic Loadable Modules
    - E.g., Solaris: Scheduling Classes, File Systems, Loadable System Calls, Executable Formats, STREAMS Modules, Miscellaneous, Device and Bus Drivers
  - Characteristics:
    - Layer-Like – Modules
    - Microkernel-Like – the Primary Module

# OS Structure – Hybrid Systems

- Definition: A combination of different structures
- Example 1: Mac OS X
  - Application Environments and Common Services
  - BSD: Command Line Interface, Support for Networking and File Systems, an Implementation of POSIX APIs.
  - Mach: Memory Management, Support for Remote Procedure Calls, Interprocess Communication Facilities
  - The Kernel Environment: I/O Kit for the Development of Device Drivers and Dynamically Loadable Modules.



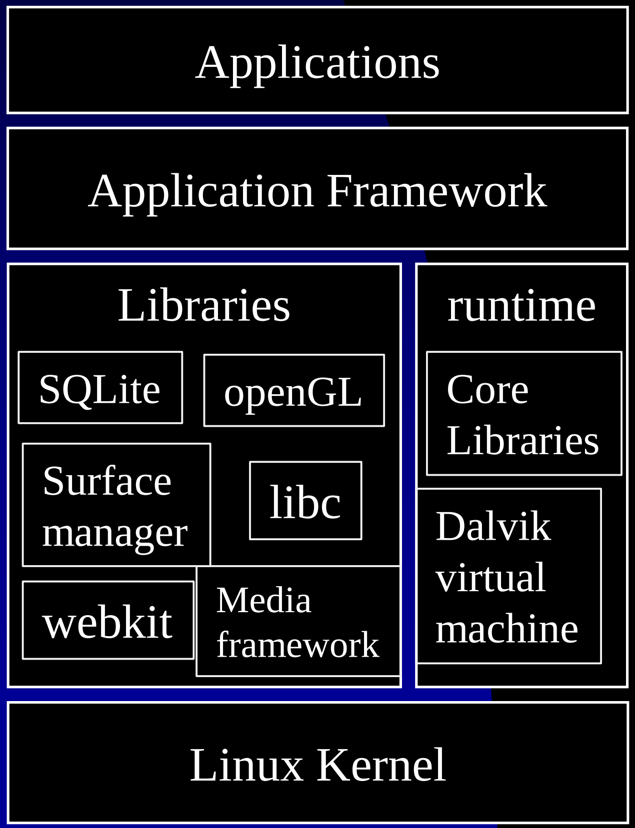
# OS Structure – Hybrid Systems




- Example 2: iOS
  - It is structured on Mac OSX, where Cocoa Touch, Media Services, and Core Services provide an API to provide frameworks for application development, services for graphics and A/V, and many features, such as databases and cloud computing.

# OS Structure – Hybrid Systems

- Example 3: Android
  - Designed by the Open Handset Alliance and primarily led by Google.
  - Android API is developed for Java program development to run on Dalvik.



# Operating System Debugging

- Debugging
  - An activity in finding and fixing errors or bugs, including performance problem, that exist in hardware or software.
- Terminologies
  - Performance Tuning – A Procedure that Seeks to Improve Performance by Removing Bottlenecks.
  - Core Dump – A Capture of the Memory of a Process or OS
  - Crash – A Kernel Failure

# System Generation

- SYSGEN (System Generation)
  - Ask and probe for information concerning the specific configuration of a hardware system
    - CPU, memory, device, OS options, etc.

| No recompilation & completely table-driven | ←·······→ Linking of modules for selected OS | Recompilation of a modified source code |
| --- | --- | --- |

- Issues
  - Size, Generality, Ease of Modification

# System Boot

- Booting
  - The procedure of starting a computer by loading the kernel.
  - The bootstrap program or the bootstrap loader
    - Firmware being ROM or EEPROM resident
    - Boot/system disk with a boot block

# Contents

# Chapter 3
# Process Concept

# Q & A

# Projects – Nachos 4.0

- Not Another Completely Heuristic Operating System
- Written by Tom Anderson and his students at UC Berkeley

  http://www.cs.washington.edu/homes/tom/nachos/
- It simulates an MIPS architecture on host systems

  (Unix/Linux/Windows/MacOS X)
- User programs need a cross-compiler (target MIPS)
- Nachos appears as a single threaded process to the host operating system.

# Multimedia Systems

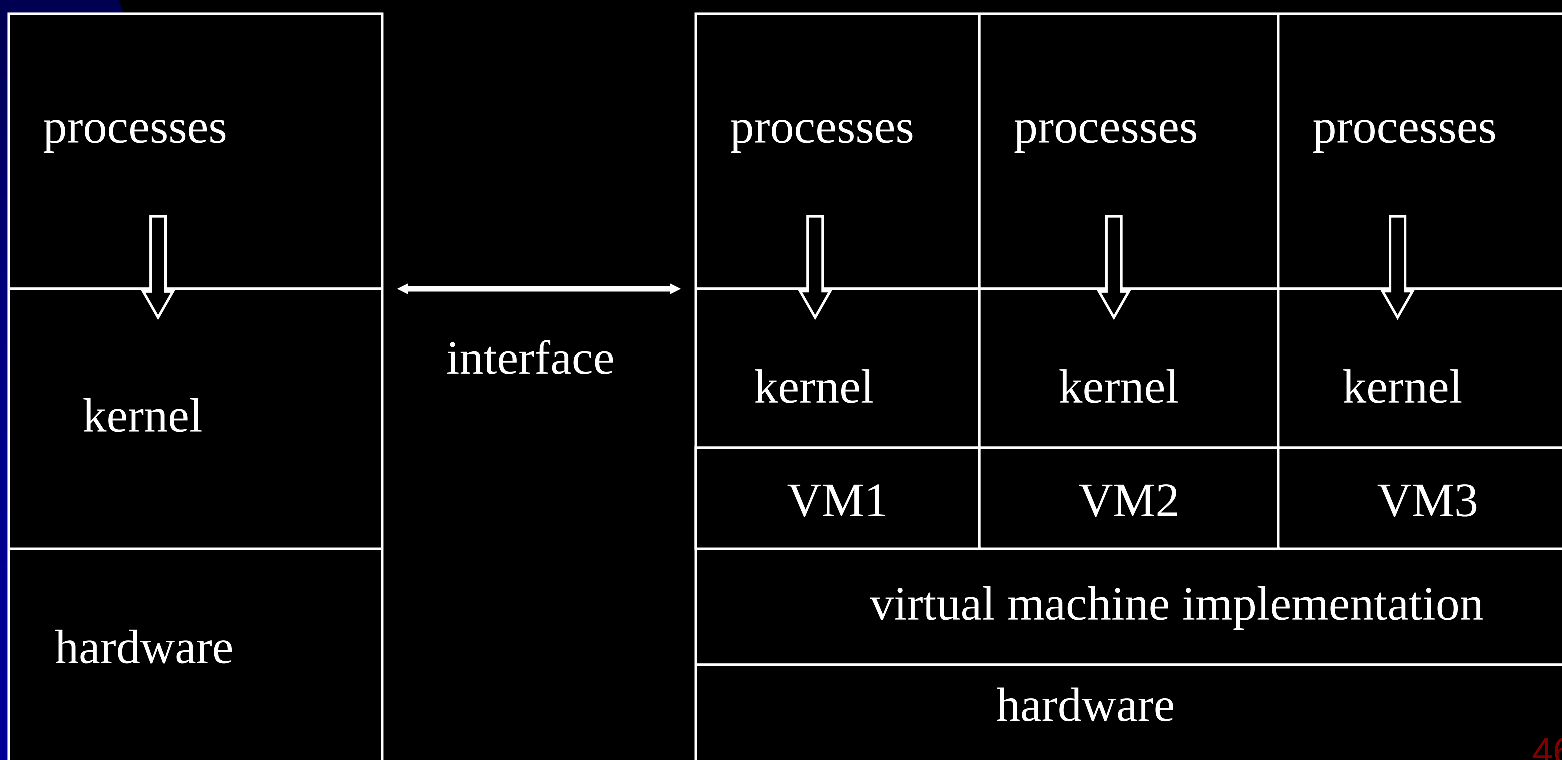
- Multimedia Data
  - Audio and video files and conventional files
  - Multimedia data must be delivered according to certain time restrictions (e.g., 30 frames per second)
- Variety on Platforms
  - Desktop personal computers, Personal Digital Assistant (PDA), cellular telephones, etc.

# Handheld Systems

- Handheld Systems
  - E.g., Personal Digital Assistant (PDA) and cellular phones.
- New Challenges – convenience vs portability
  - Limited Size and Weight
  - Small Memory Size (e.g., 512KB ~ 128MB)
    - No Virtual Memory
  - Slow Processor
    - Battery Power
  - Small Display Screen
    - Web-clipping

# Virtual Machine

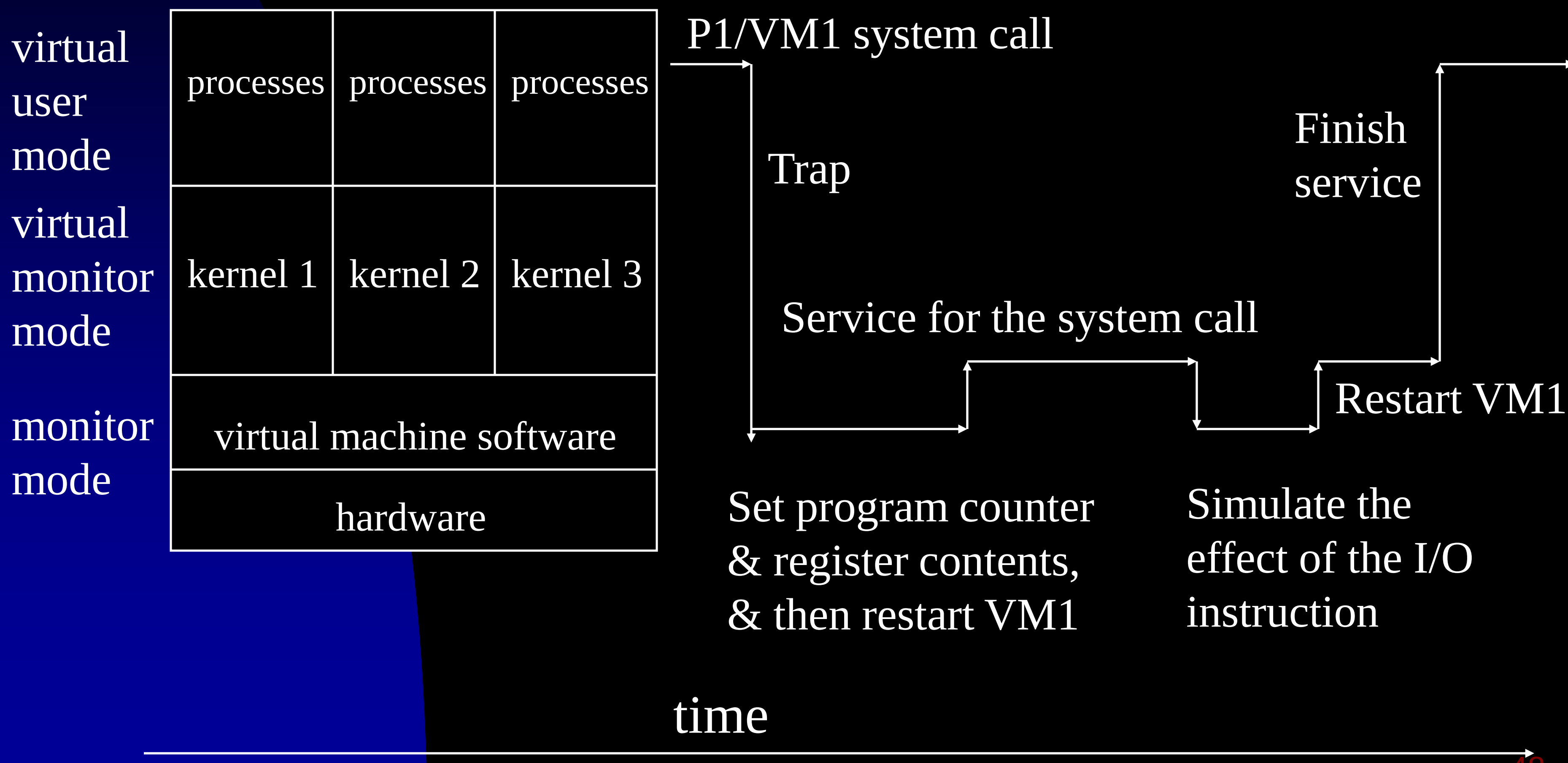
- Virtual Machines: provide an interface that is identical to the underlying bare hardware



# Virtual Machine

- Implementation Issues:
  - Emulation of Physical Devices
    - E.g., Disk Systems
      - An IBM minidisk approach
  - User/Monitor Modes
    - (Physical) Monitor Mode
      - Virtual machine software
    - (Physical) User Mode
      - Virtual monitor mode & Virtual user mode

# Virtual Machine



# Virtual Machine

- Disadvantages:
  - Slow!
    - Execute most instructions directly on the hardware
  - No direct sharing of resources
    - Physical devices and communications

* I/O could be slow (interpreted) or fast (spooling)

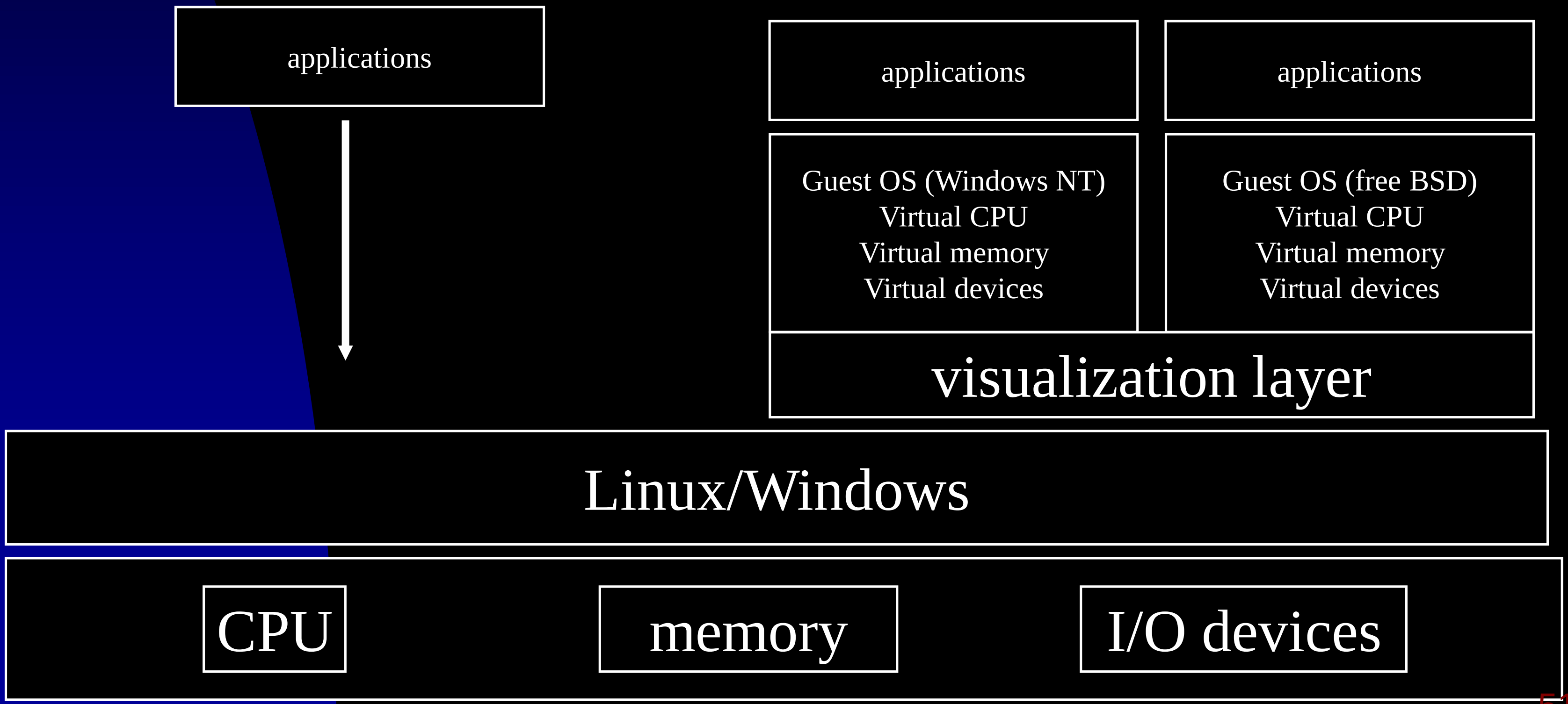
# Virtual Machine

- Advantages:
  - Complete Protection – Complete Isolation !
  - OS Research & Development
    - System Development Time
  - Extensions to Multiple Personalities, such as Mach (software emulation)
    - Emulations of Machines and OS's, e.g., Windows over Linux
  - System Consolidation

* Simulation: Programs of a guest system are run on an emulator that translate each of the guest system instructions into the native instruction set of the host system.

# Virtual Machine – VMware

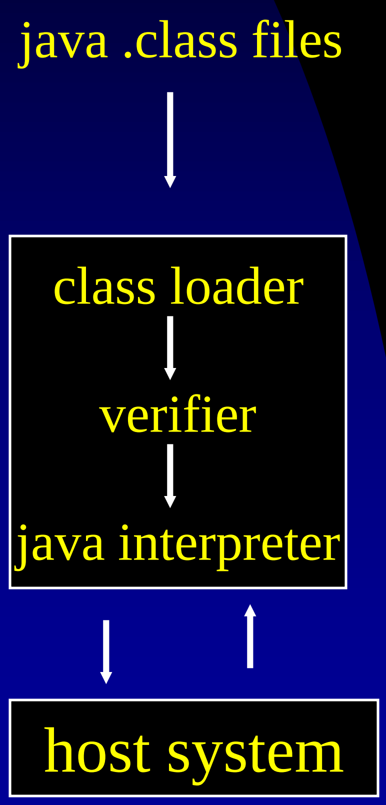
- VMware – The visualization layer abstracts the physical hardware into isolated virtual machines running as guest operating systems.



# Virtual Machine – Para-Virtualization

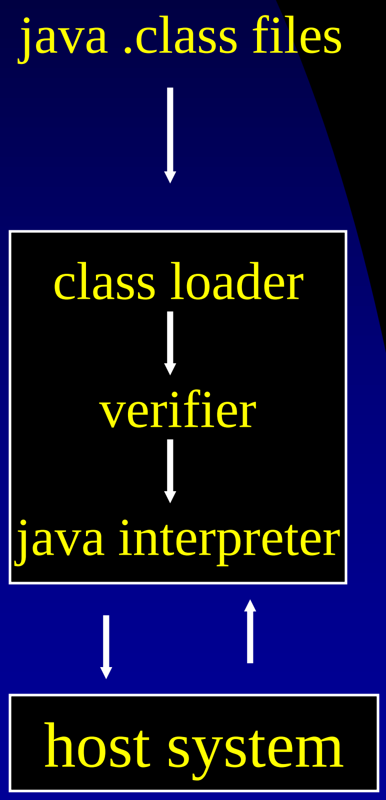
- Definition: A variation on virtualization that presents a guest/operating system that is similar but not identical to the underlying hardware.
  - Efficiency in Resource Utilization
  - Simplified Implementation
- Example: Container or Zone of Solaris 10
  - A Virtual Layer Between a Host OS and Applications
    - The OS and devices are virtualized.

# Virtual Machine – Java



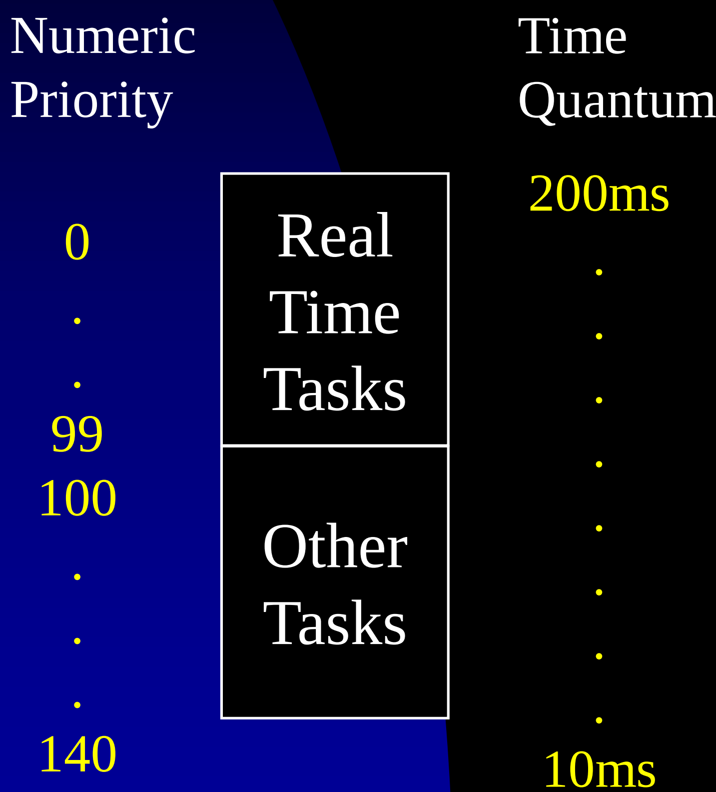

- Sun Microsystems in late 1995
  - Java Language and API Library
  - Java Virtual Machine (JVM)
    - Class loader (for bytecode .class files)
    - Class verifier
    - Java interpreter
      - An interpreter, a just-in-time (JIT) compiler, hardware

# Virtual Machine – Java




- JVM
  - Garbage collection
    - Reclaim unused objects
  - Implementation being specific for different systems
    - Programs are architecture neutral and portable

# Operating System Examples – Linux Ver. 2.5+




- Scheduling Algorithm
  - O(1)
  - SMP, load balancing, and processor affinity
  - Fairness and support for interactive tasks
  - Priorities
    - Real-time: 0..99
    - Nice: 100..140

# Operating System Examples – Linux Ver. 2.5+

- Each processor has a runqueue
  - An active array and an expired array
  - Switching of the two arrays when all processes in the active array have their quantum expired.
  - Priority-Driven Scheduling
    - Fixed Priority – Real-Time
    - Dynamic Priority – nice $\pm$ x, for x <= 5
      - Interactive tasks are favored.
      - The dynamic priority of a task is recalculated when its quantum is expired.