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!

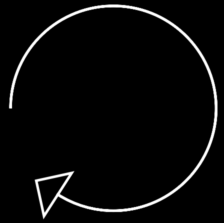
Operation-System Services

- 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 privilege, protection
- Communications
  - Intra-processor or inter-processor communication – shared memory or message passing

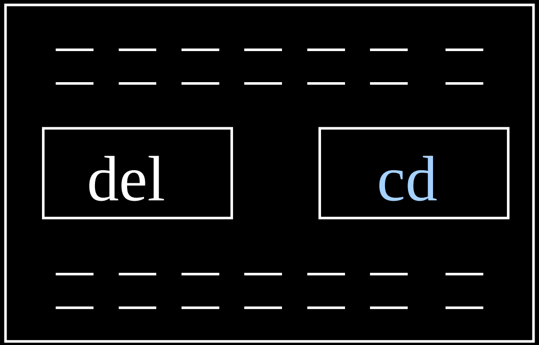
Operation-System Services

- 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!



是 Command Interpreter 自己往上爬一層，所以放在 Command Interpreter 裡面

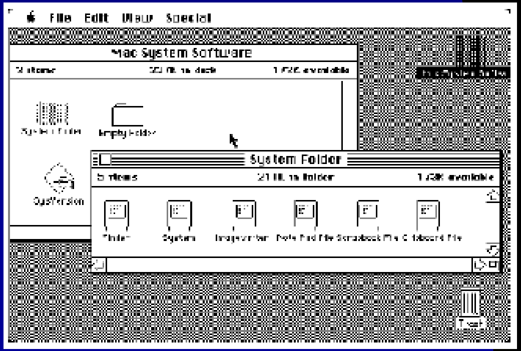
User OS Interface – Command Interpreter

- 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

DOS + GUI



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

OS 提拱給 user 最基本的服務
eg. open()

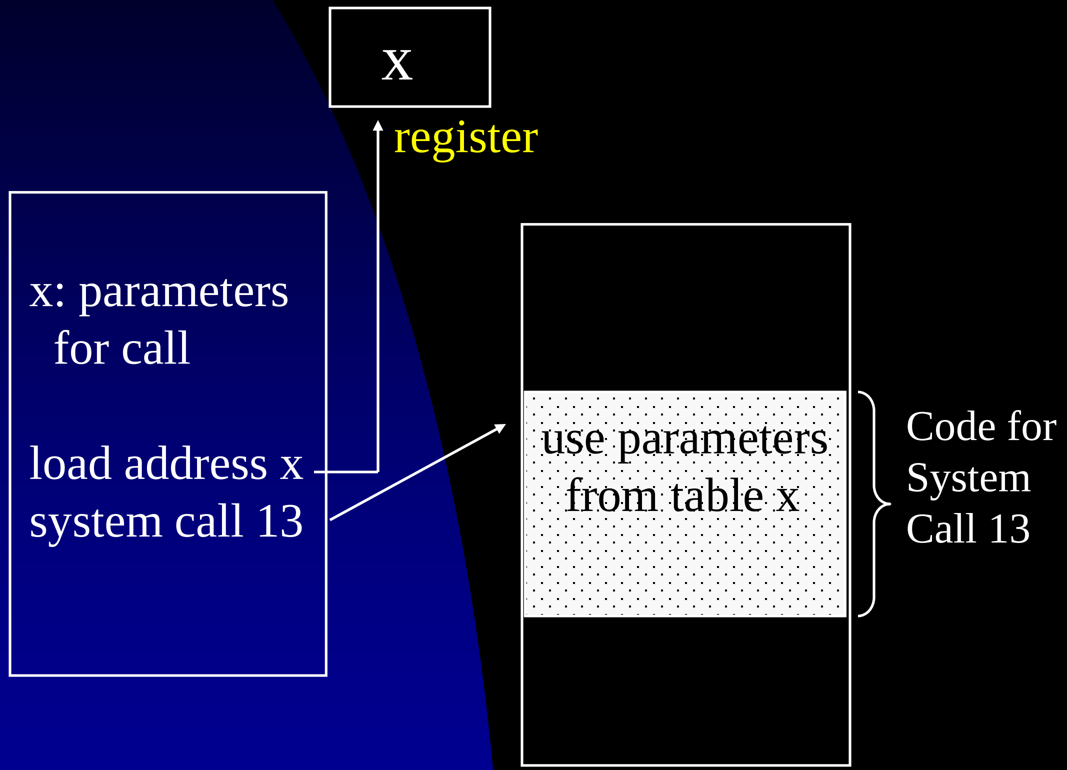
- System calls
  - Interface between processes & OS
- How to make system calls?
  - Assembly-language instructions or subroutine/functions calls in high-level language such as C or Perl?
    - Generation of in-line instructions or a call to a special run-time routine.
- Example: read and copy of a file!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

    interpret
  - Benefits (API $\xrightarrow{}$ vs System Calls)
    - Portability
    - Ease of Use & Better Functionality

System Calls



- How a system call occurs? #?
  - Types and information
- Parameter Passing
  - Registers path 太長，不優
  - Registers pointing to blocks
    - Linux 放在 memory 裡，用 register 指向它
  - Stacks return address, variables, parameters…

System Calls

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

System Calls

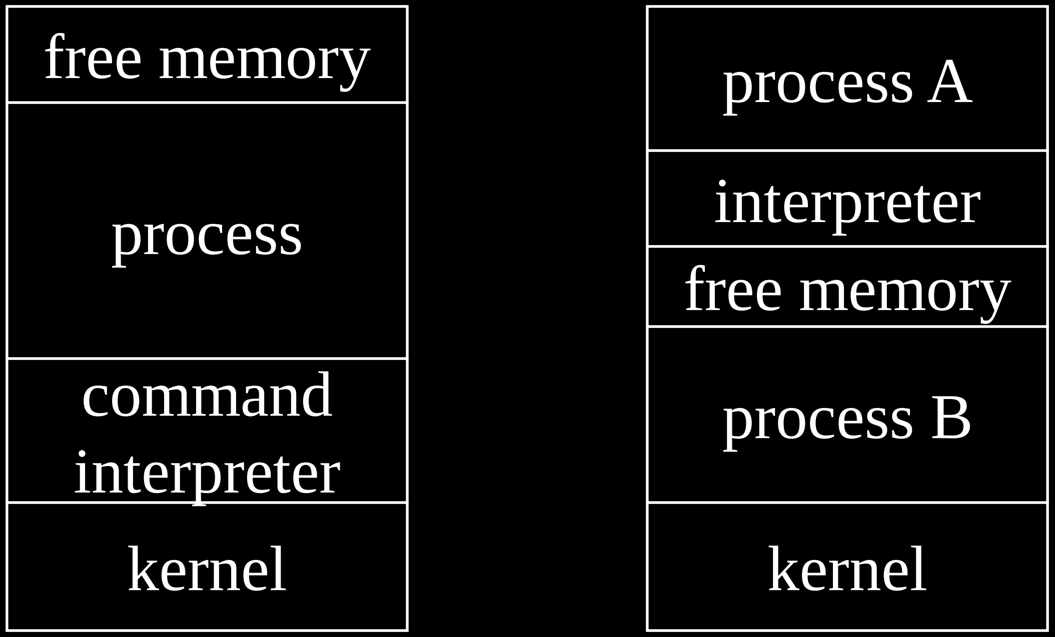
- Process & Job Control
  - End (normal exit) or abort (abnormal)
    - Error level or no
    - Interactive, batch, GUI-supported systems
  - Load and execute
    - How to return control?
      - e.g., shell load & execute commands
  - Creation and/or termination of processes
    - Multiprogramming?

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 沒有做 I/O
  - 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

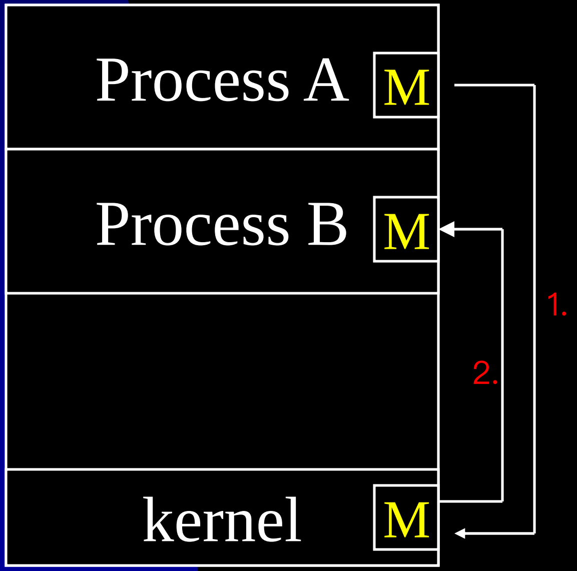
- Information maintenance
  - Get or set date or time
  - Get or set system data, such as the amount of free memory
- Communication
  - Message Passing e.g. socket (like pipe)
    - Open, close, accept connections
      - Host ID or process ID
    - Send and receive messages
    - Transfer status information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

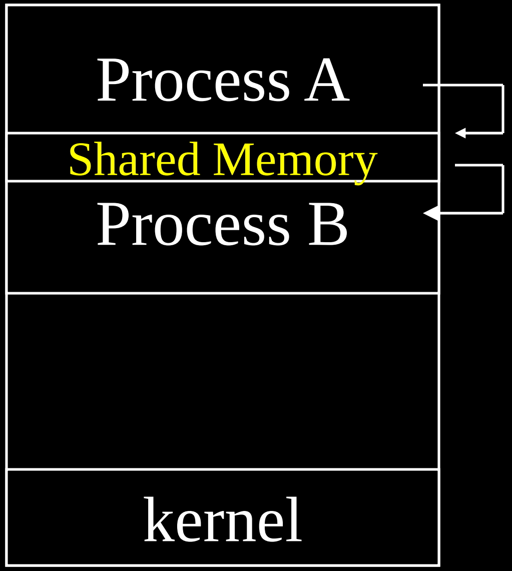
System Calls

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

pros: no synchronization problem

cons: the file may be very big!





pros: fast, easy

cons: since you may see dirty things, it needs synchronization protocol (lock)

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? 先改誰的作業？
  - Mechanism：How to do things? 怎改？
  - Example: timer construct and time slice
- Two extreme cases:

Microkernel-based OS $\longleftrightarrow$ 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 compiler 進步、儲存容量也變便宜

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

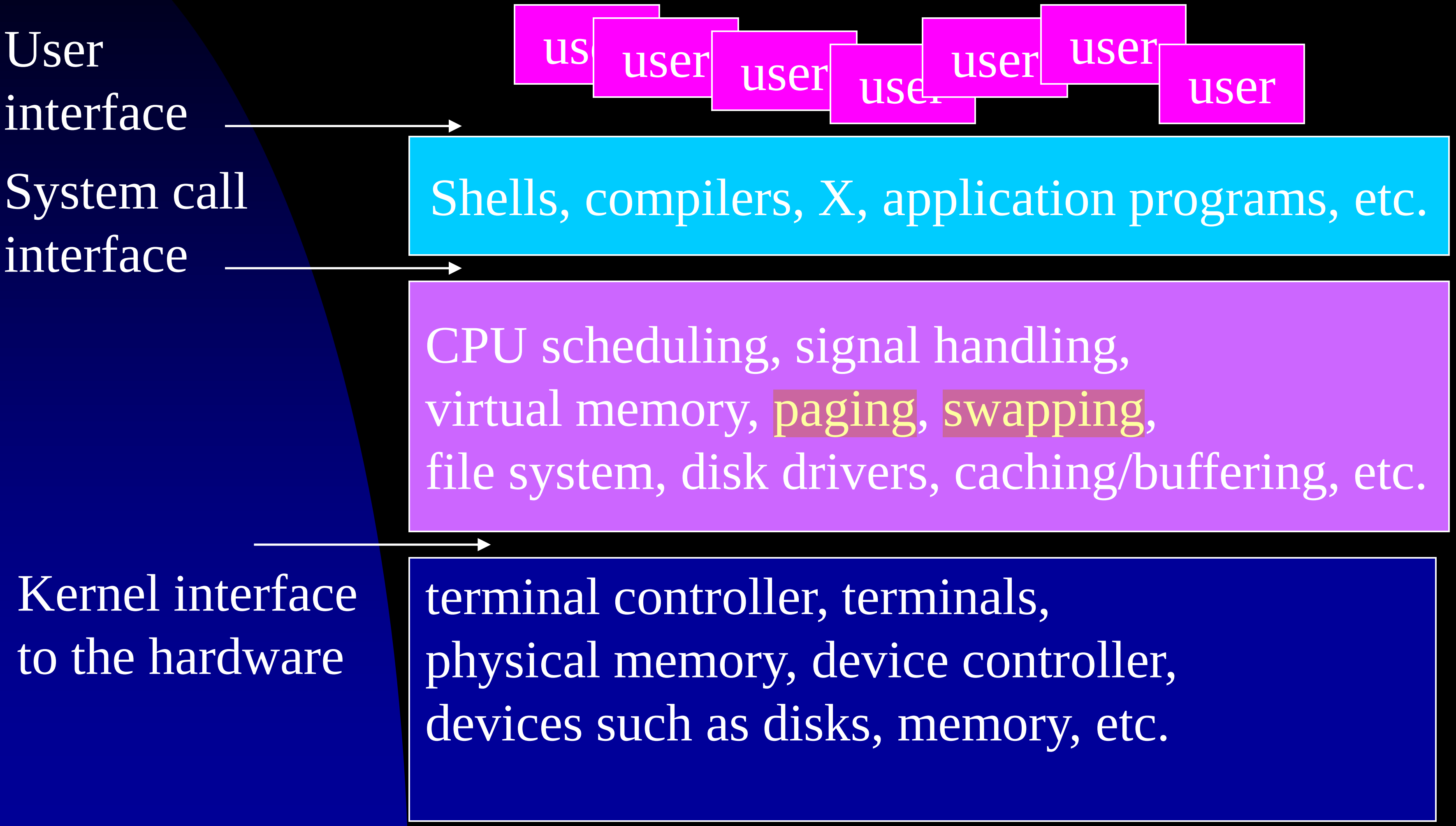
OS Structure – MS-DOS

- MS-DOS Layer Structure

$$\begin{tikzcd}
\text{Application program} \arrow[d] \arrow[ddd, bend left=60] \\
\text{Resident system program} \arrow[d] \arrow[dd, bend left=40] \\
\text{MS-DOS device drivers} \arrow[d] \\
\text{ROM BIOS device drivers}
\end{tikzcd}$$

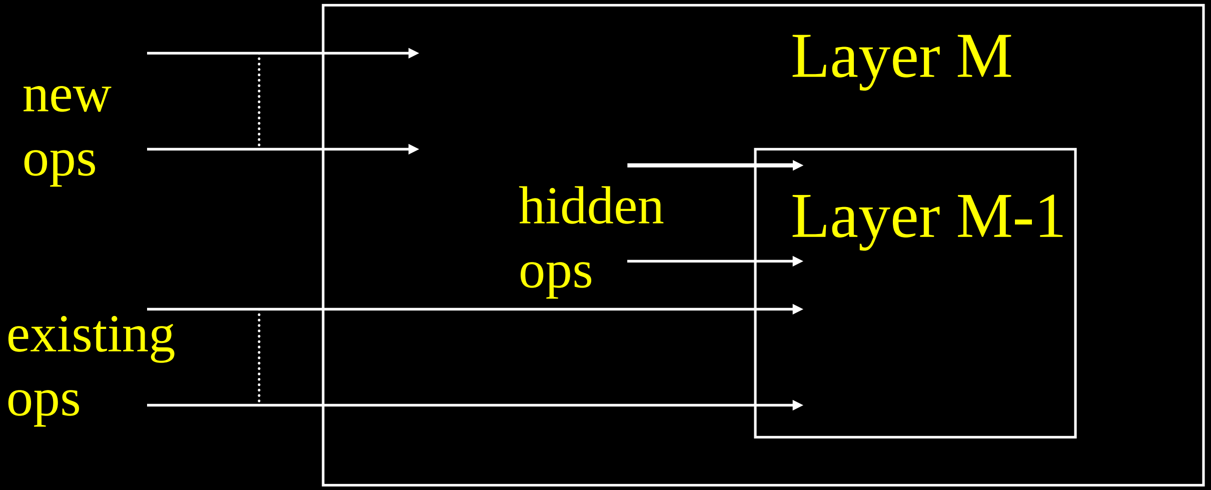
init system

OS Structure – UNIX


us
user
user
use
user
user
user
User interface
Shells, compilers, X, application programs, etc.
System call interface
CPU scheduling, signal handling, virtual memory, paging, swapping, file system, disk drivers, caching/buffering, etc.
Kernel interface to the hardware
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:

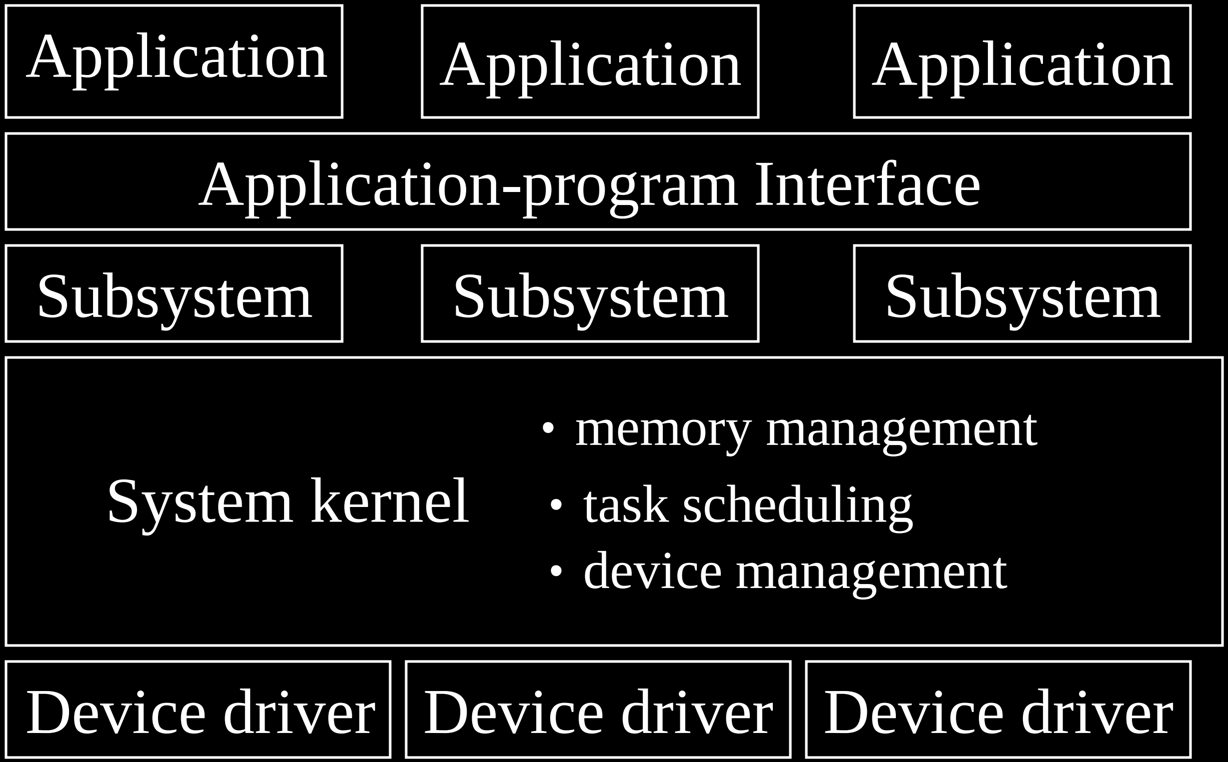
上面那層用下面的東西，需要一個好的 layer definition：誰在上面，誰在下面？

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

做 I/O 時會用到 Memory management

OS Structure – OS/2

- OS/2 Layer Structure



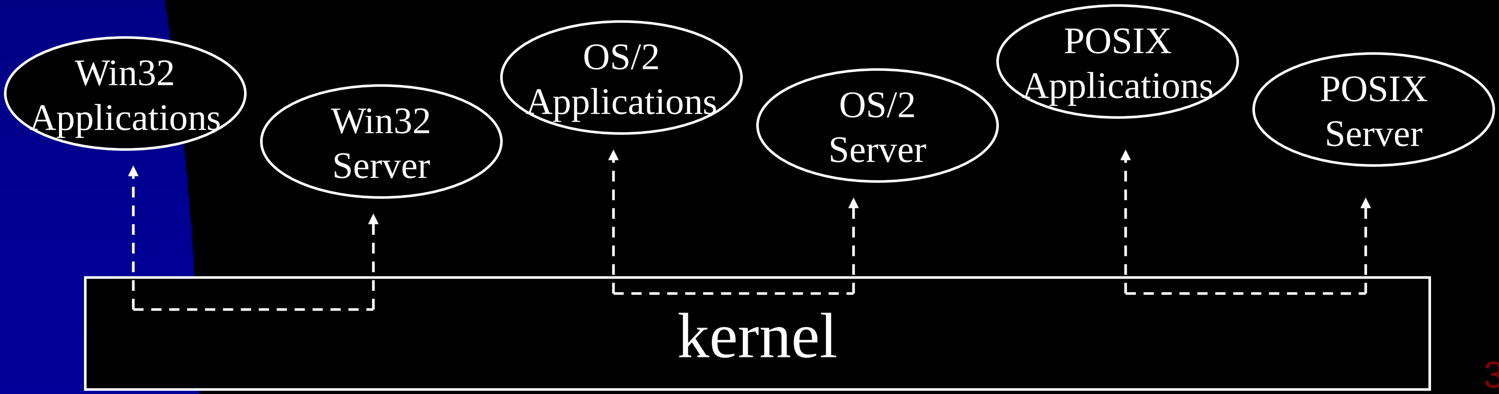
* Some layers of NT were from user space to kernel space in NT4.0

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! 多工系統，kernel 要有最基本的 memory management and communication
  - 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

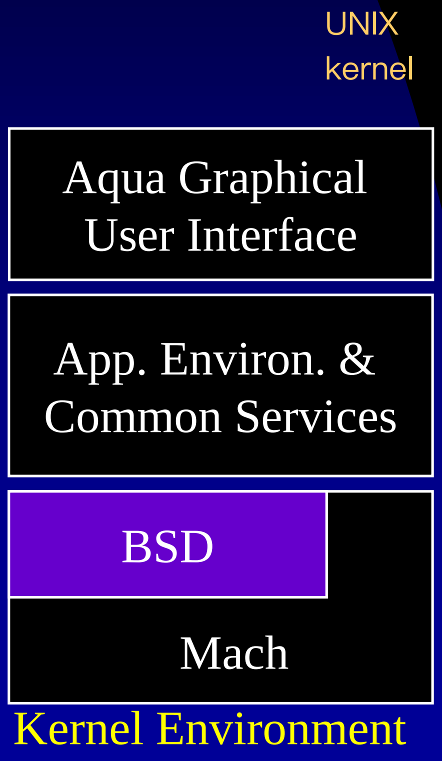


OS Structure – Modules

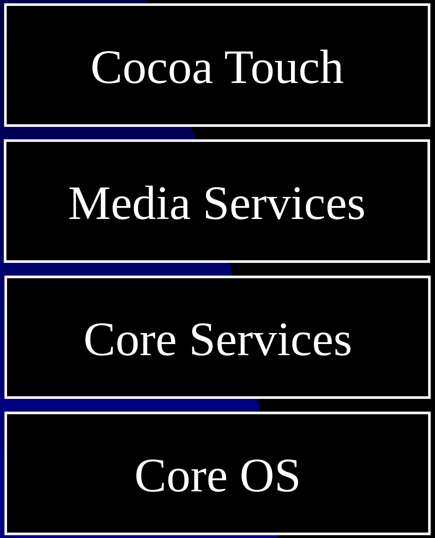
- A Modular Kernel
  - A Set of Core Components
  - Dynamic Loadable Modules
    - E.g., Solaris: Scheduling Classes, File Systems, Loadable System Calls, Executable Formats, STREAMS Modules, Miscellaneous, Device and Bus Drivers
  - Characteristics:
    - Layer-Like – Modules
    - Microkernel-Like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


UNIX kernel
Aqua Graphical User Interface
App. Environ. & Common Services
BSD
Mach
Kernel Environment

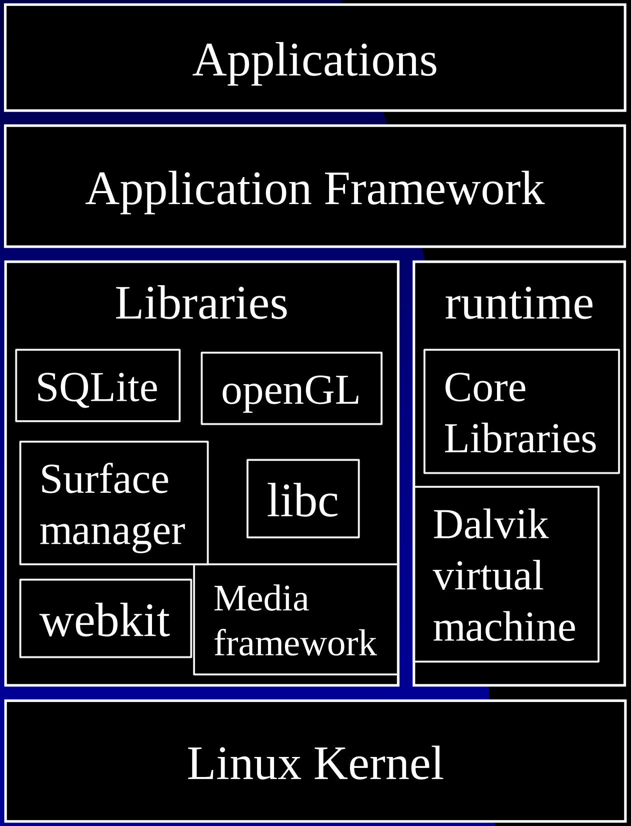
OS Structure – Hybrid Systems



- 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.



Middle Layer = Libraries + runtime

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

當有新的東西，OS 會去 table 搜尋

- 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 他不希望你修改
    - Boot/system disk with a boot block

兩段式的 booting 有很多好處：security, more complex procedure…

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

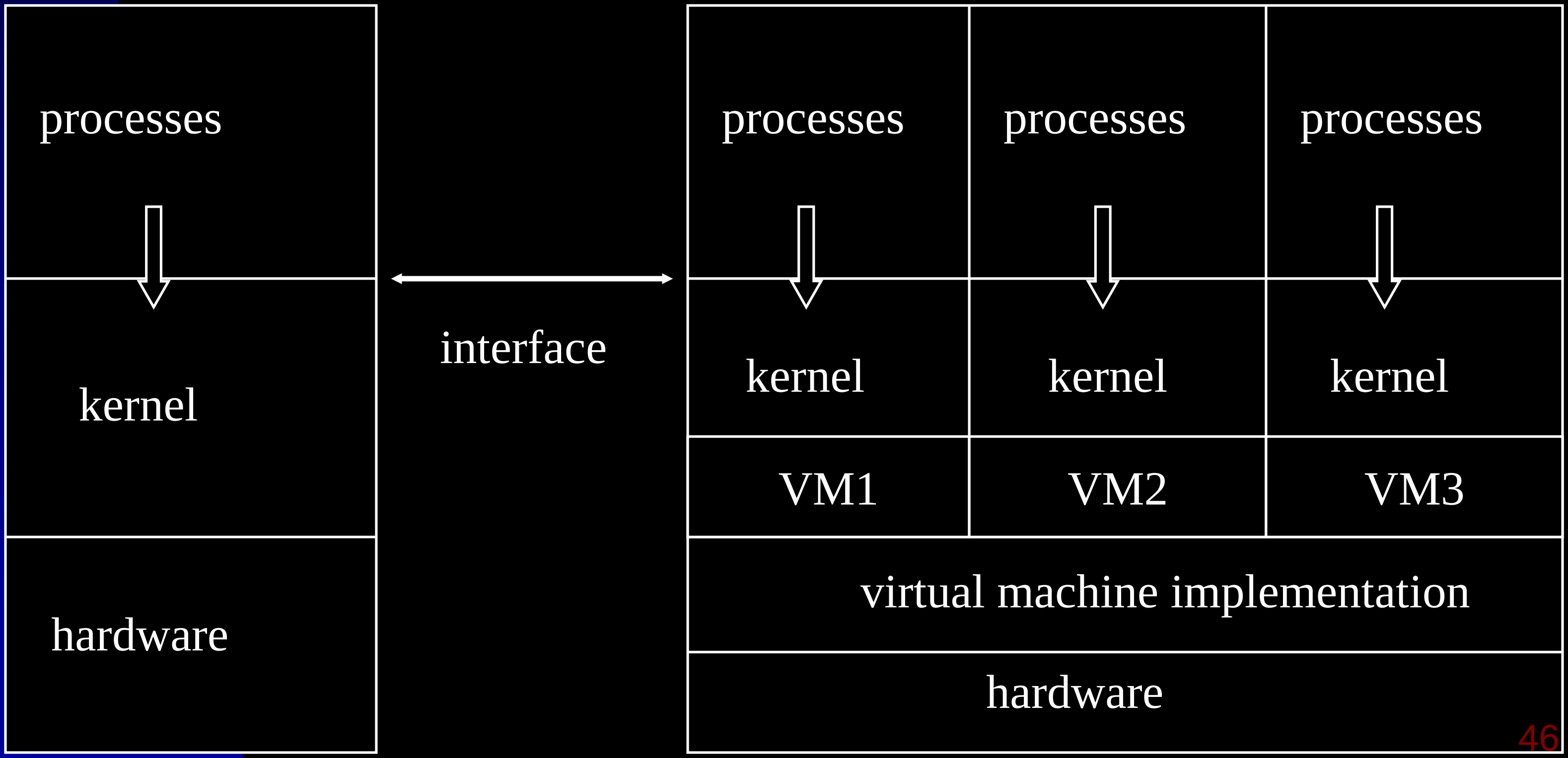
- Multimedia Data
  - Audio and video files and conventional files
  - Multimedia data must be delivered according to certain time restrictions (e.g., 30 frames per second)
- Variety on Platforms
  - Desktop personal computers, Personal Digital Assistant (PDA), cellular telephones, etc.

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

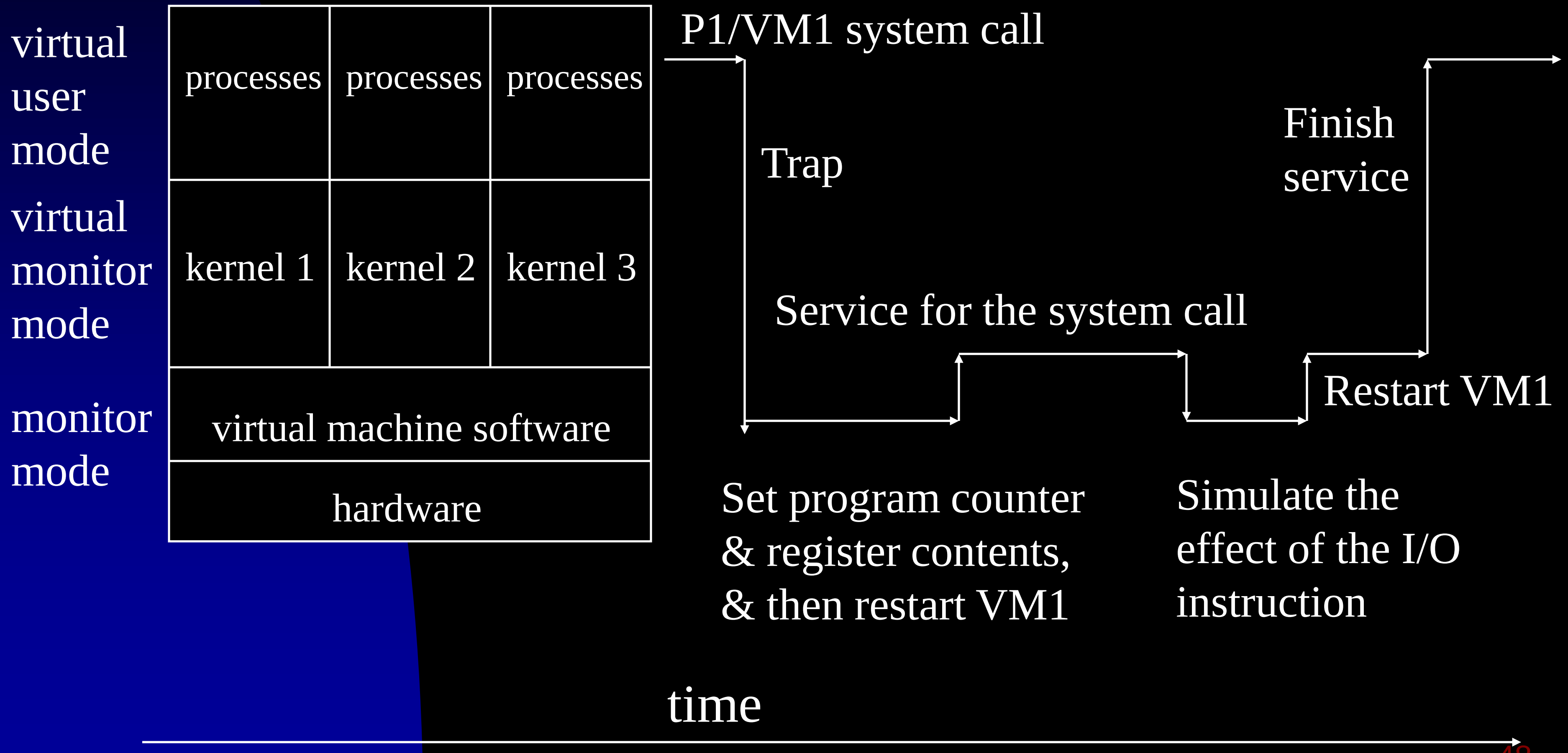
- Virtual Machines: provide an interface that is identical to the underlying bare hardware



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)

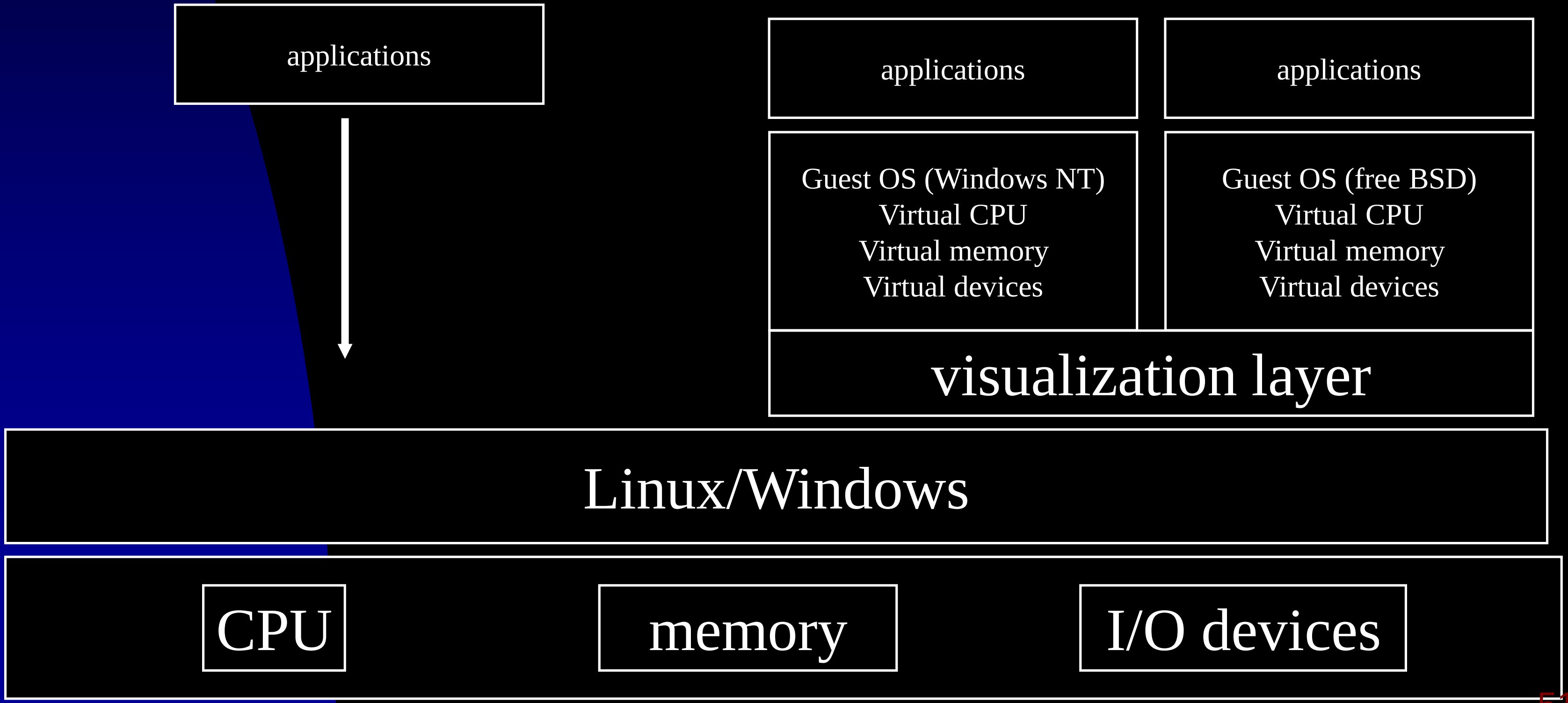
Virtual Machine

- 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

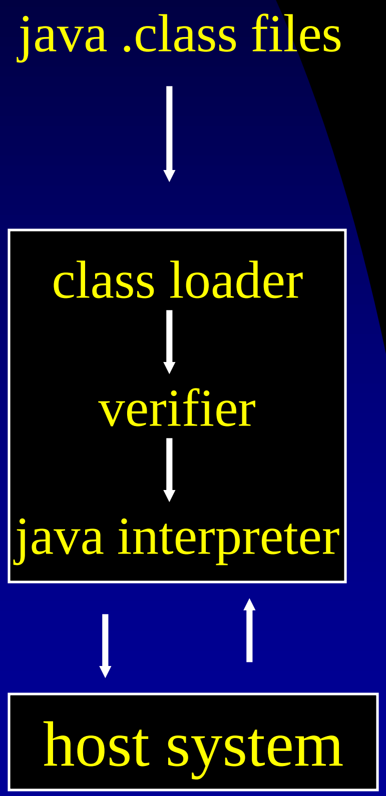
- VMware – The visualization layer abstracts the physical hardware into isolated virtual machines running as guest operating systems.



Virtual Machine – Para-Virtualization

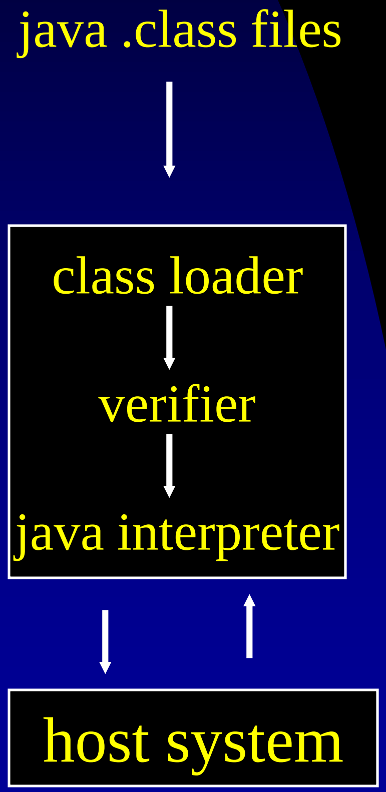
- Definition: A variation on virtualization that presents a guest/operating system that is similar but not identical to the underlying hardware.
  - Efficiency in Resource Utilization
  - Simplified Implementation
- Example: Container or Zone of Solaris 10
  - A Virtual Layer Between a Host OS and Applications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

Virtual Machine – Java



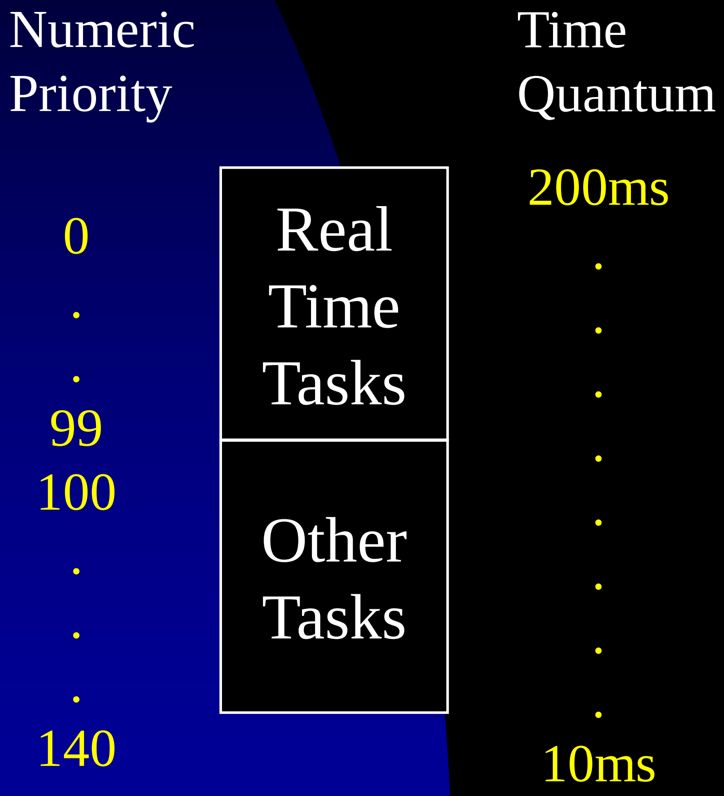
- Sun Microsystems in late 1995
  - Java Language and API Library
  - Java Virtual Machine (JVM)
    - Class loader (for bytecode .class files)
    - Class verifier
    - Java interpreter
      - An interpreter, a just-in-time (JIT) compiler, hardware

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.