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!

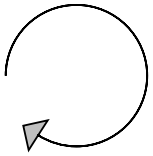
Operation-System Services

- 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

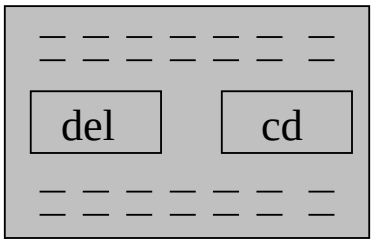
Operation-System Services

- 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!

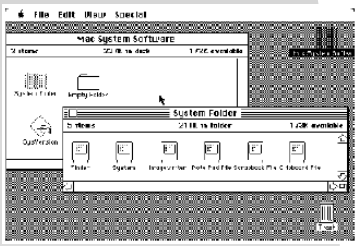


User OS Interface – Command Interpreter

- 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 ~ XP



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.

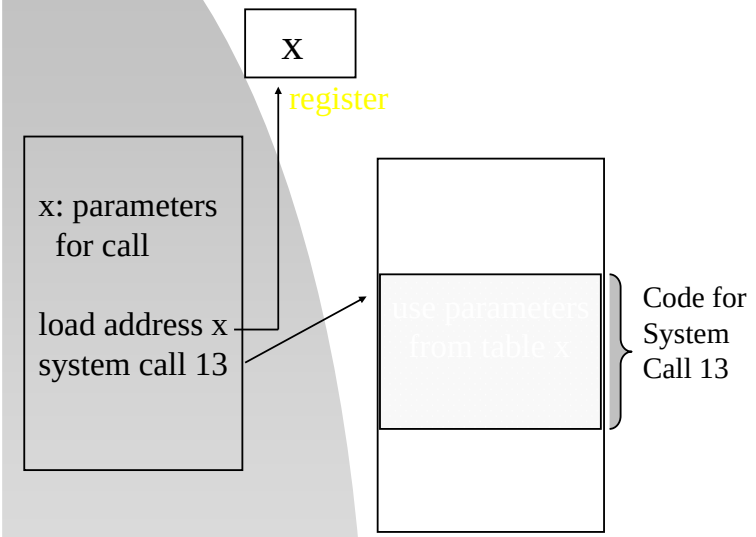
System Calls

- System calls
  - Interface between processes & OS
- How to make system calls?
  - Assemble-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

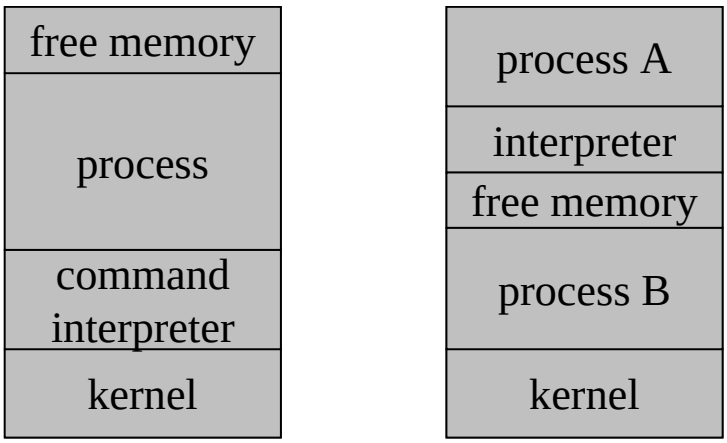
- Process & Job Control
  - End (normal exit) or abort (abnormal)
    - Error level or no
    - Interactive, batch, GUI-supported systems
  - Load and execute
    - How to return control?
      - e.g., shell load & execute commands
  - Creation and/or termination of processes
    - Multiprogramming?

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

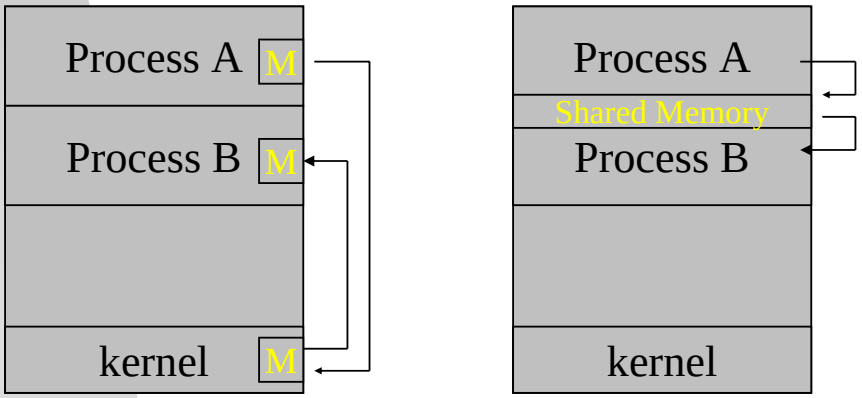
- Device management
  - Physical or virtual devices, e.g., files.
  - Request or release
    - Open and close of special files
    - Files are abstract or virtual devices.
  - Read, write, and reposition (e.g., rewinding)
  - Get or set file attributes
  - Logically attach or detach devices

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

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, 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

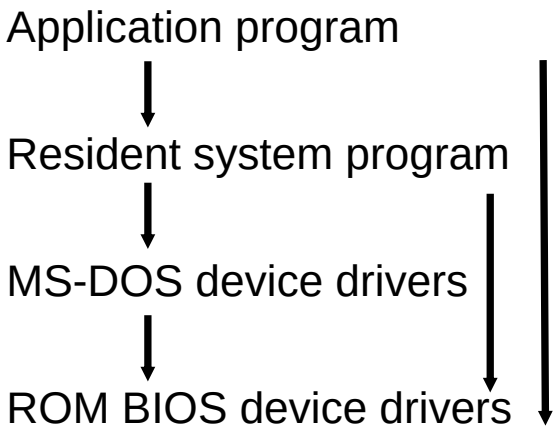
System Design & Implementation

- 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

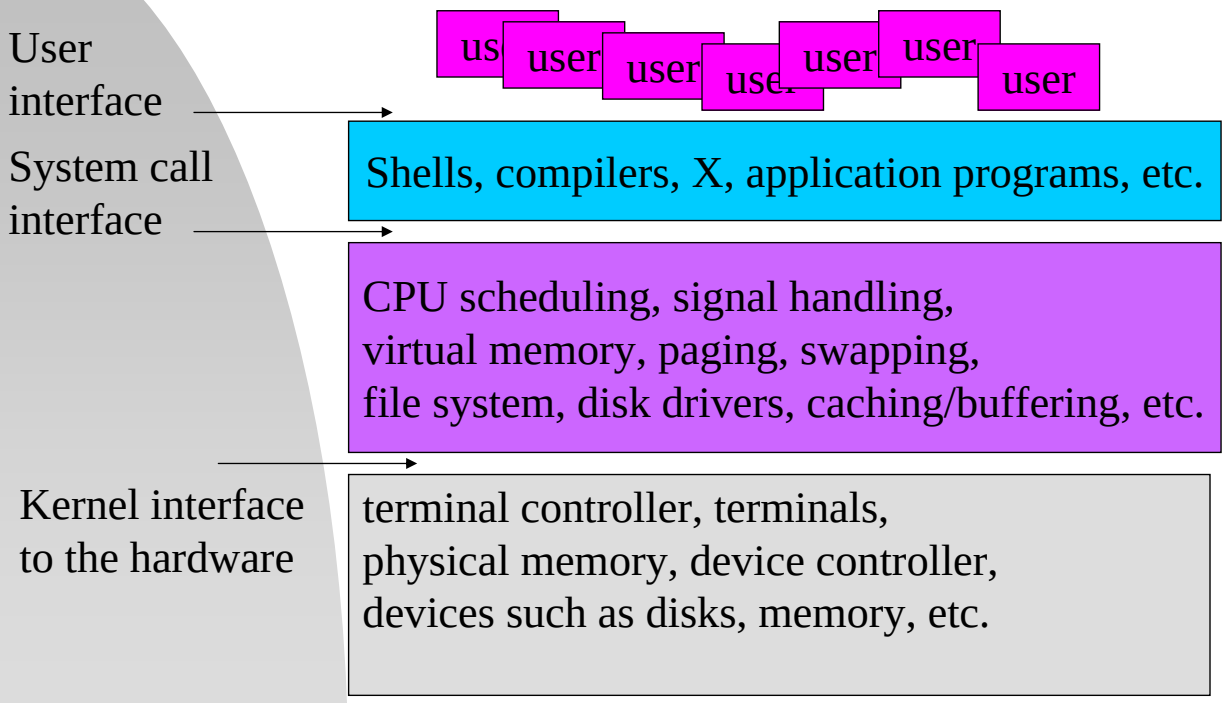
* Tracing for bottleneck identification, exploring of excellent algorithms, etc.

OS Structure – MS-DOS

- MS-DOS Layer Structure

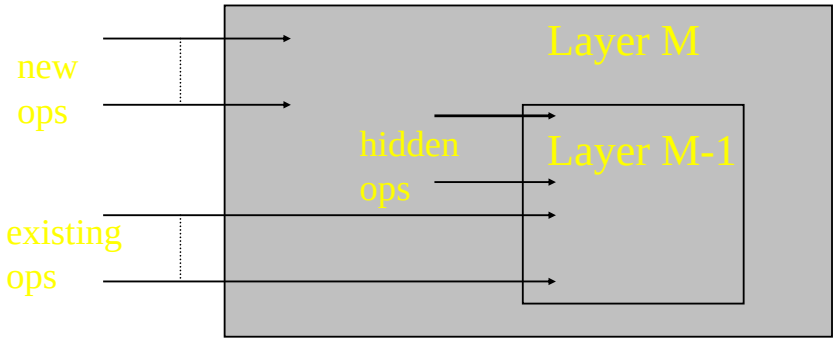


OS Structure – UNIX



OS Structure

- A Layered Approach – A Myth



Advantage: Modularity ~ Debugging & Verification

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

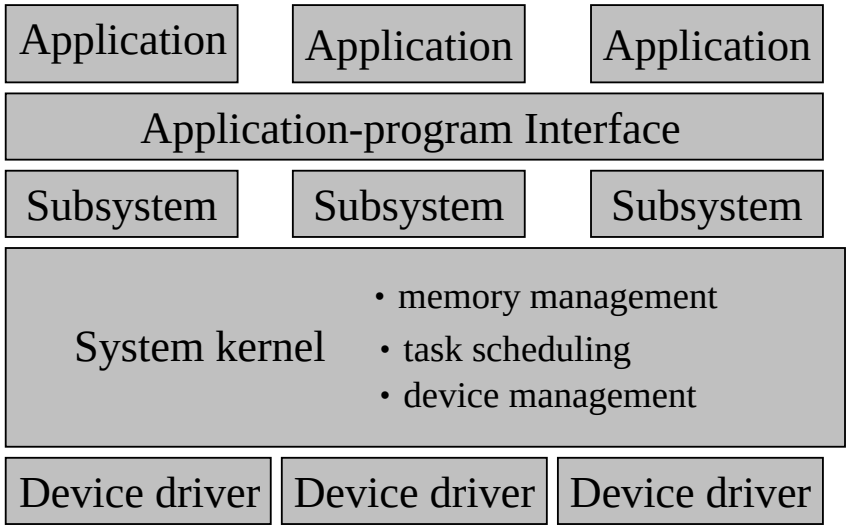
OS Structure

- 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



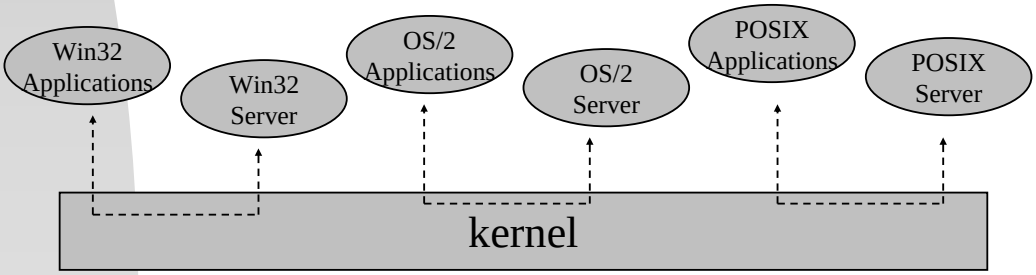
* Some layers of NT were from user space to kernel space in NT4.0

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

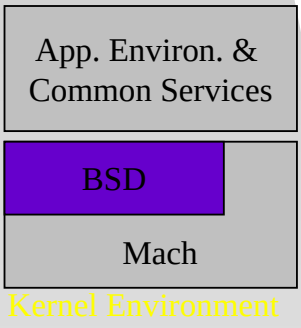


OS Structure – Modules

- 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

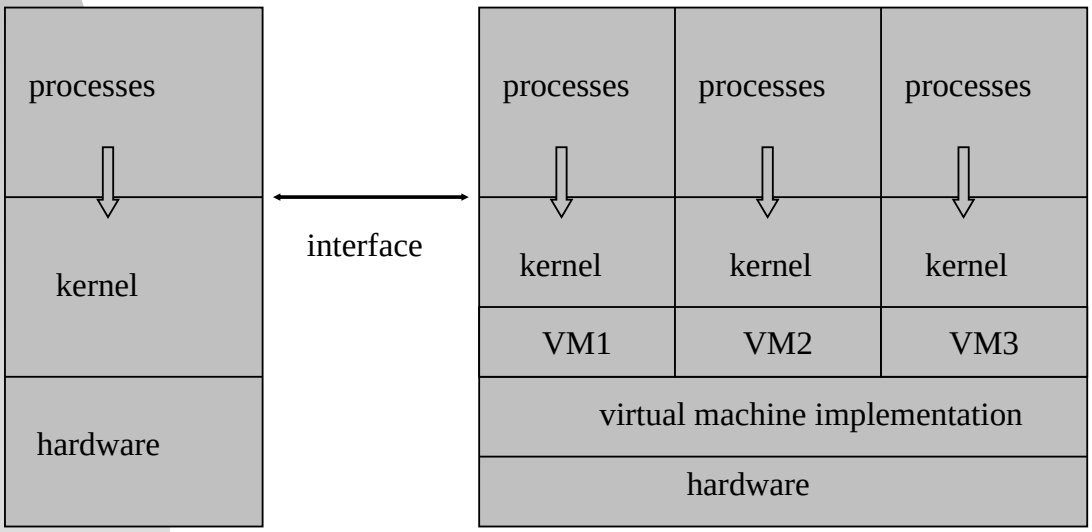
OS Structure – Modules

- Example 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.



Virtual Machine

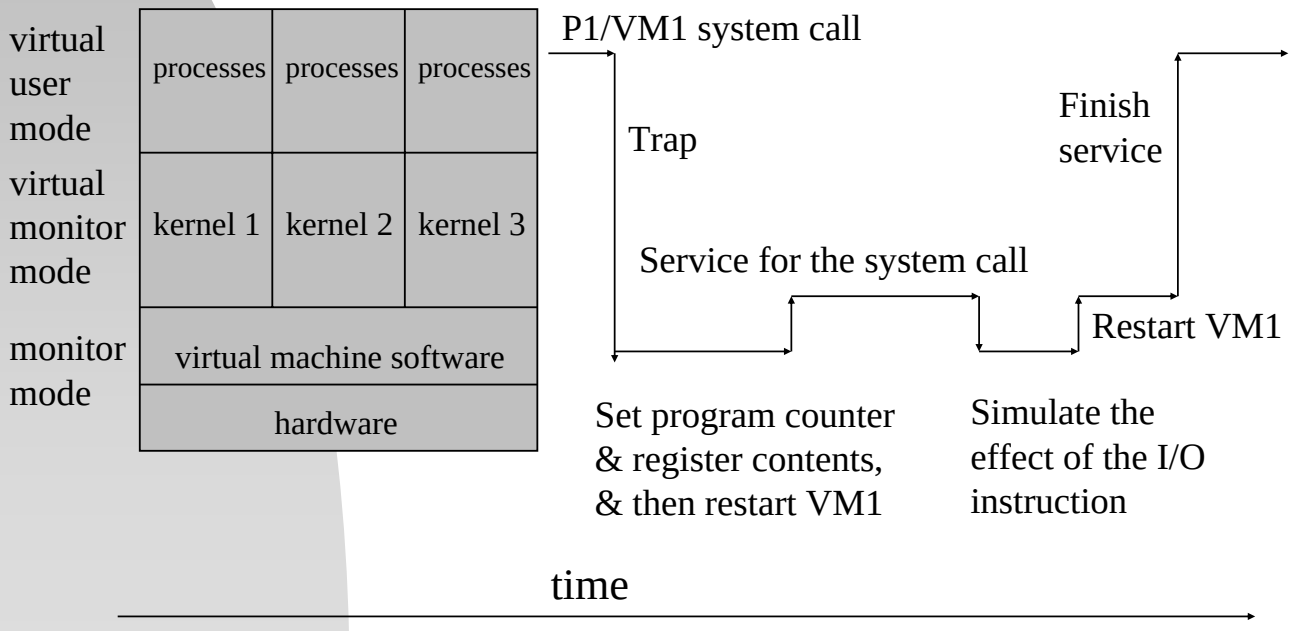
- Virtual Machines: provide an interface that is identical to the underlying bare hardware



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

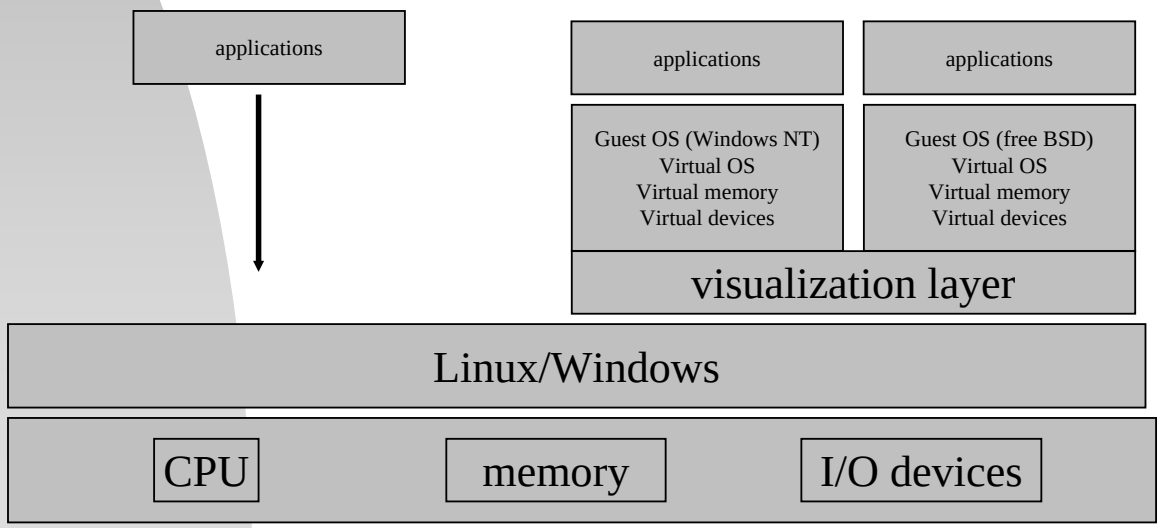
* I/O could be slow (interpreted) or fast (spooling)

Virtual Machine

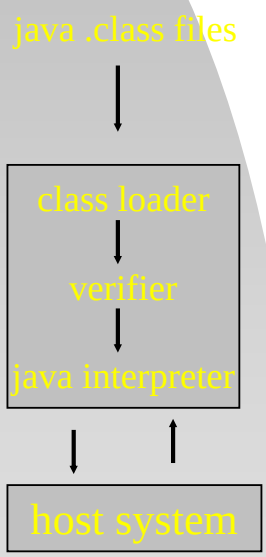
- Advantages:
  - Complete Protection – Complete Isolation !
  - OS Research & Development
    - System Development Time
  - Extensions to Multiple Personalities, such as Mach (software emulation)
    - Emulations of Machines and OS's, e.g., Windows over Linux

Virtual Machine – VMware

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

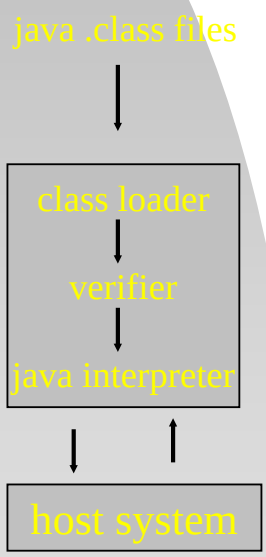


Virtual Machine – Java



- 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

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