CSE325 Principles of Operating Systems

Operating System Structure

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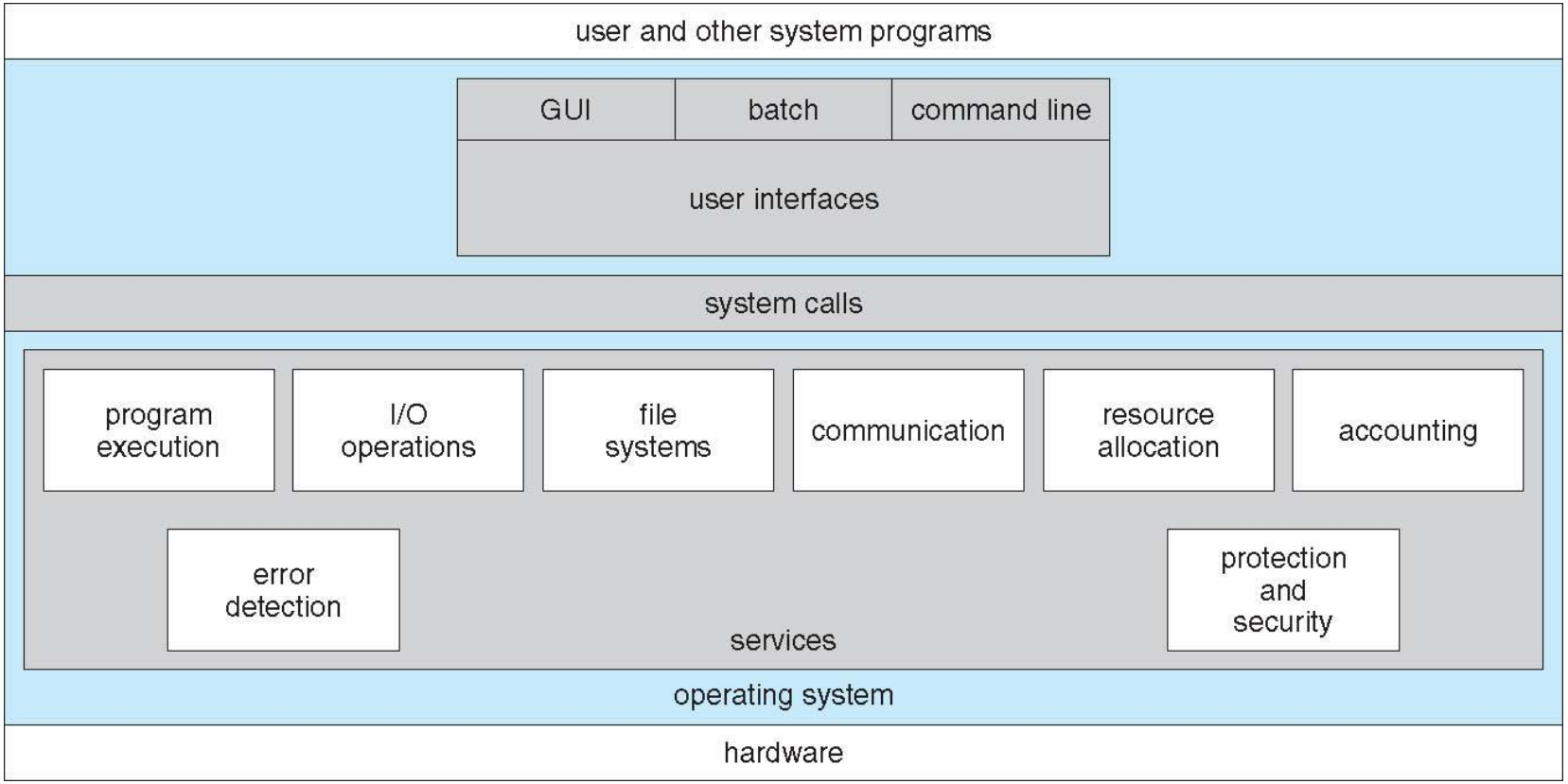
A View of Operating System Services



Operating System Design and Implementation

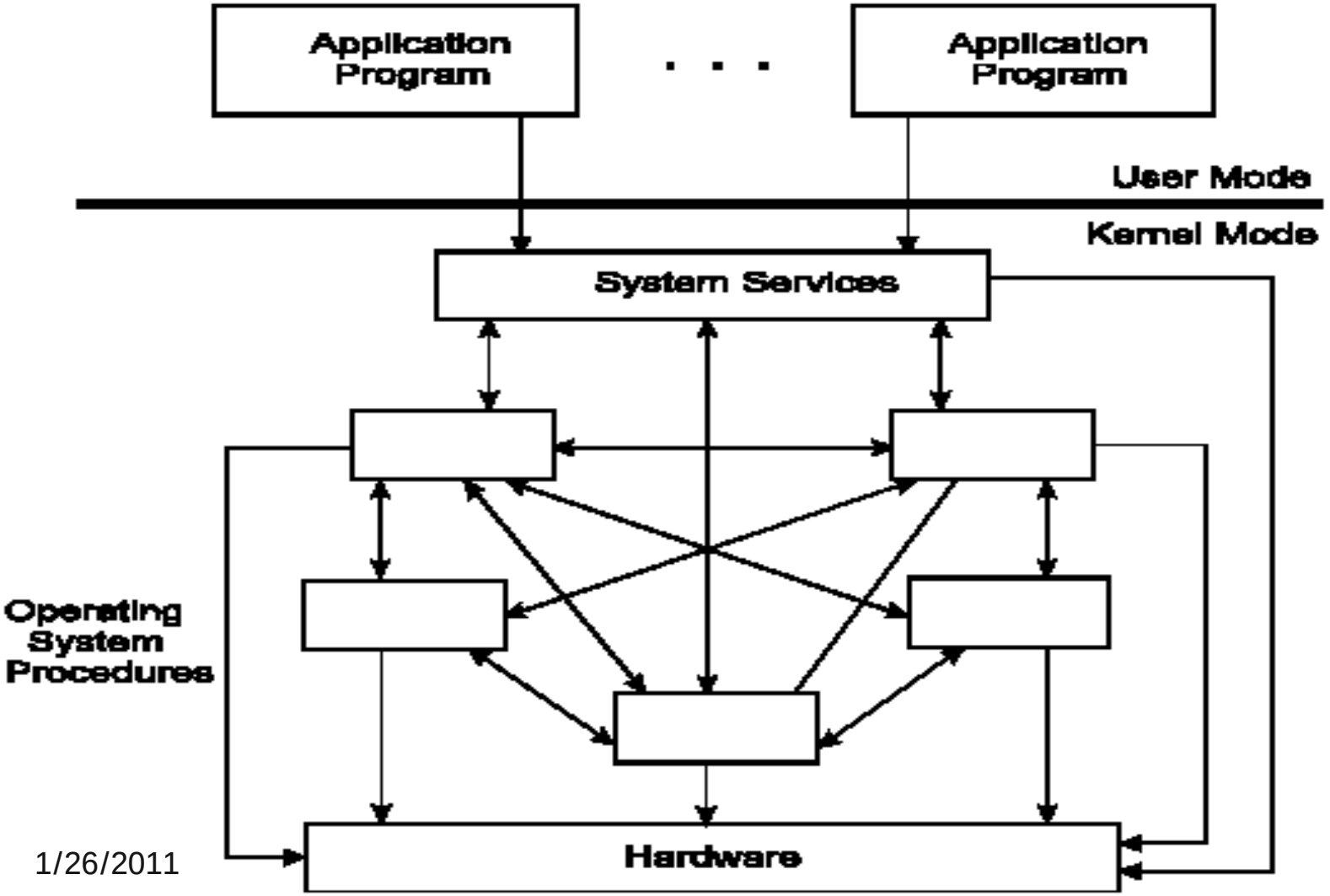
- Affected by choice of hardware, type of system
- *User* goals and *System* goals
  - User goals – operating system should be convenient to use, easy to learn, reliable, safe, secure, and fast
  - System goals – operating system should be easy to design, implement, and maintain, as well as flexible, reliable, error-free, secure, and efficient
- Important principle to separate

  Policy: What will be done?
  Mechanism: How to do it?
  - The separation of policy from mechanism is a very important principle, it allows maximum flexibility if policy decisions are to be changed later

Operating Systems Structures

- Structure/Organization/Layout of OSs:
  1. Monolithic (one unstructured program)
  2. Layered
  3. Microkernel
  4. Virtual Machines
- The role of Virtualization

Monolithic Operating System

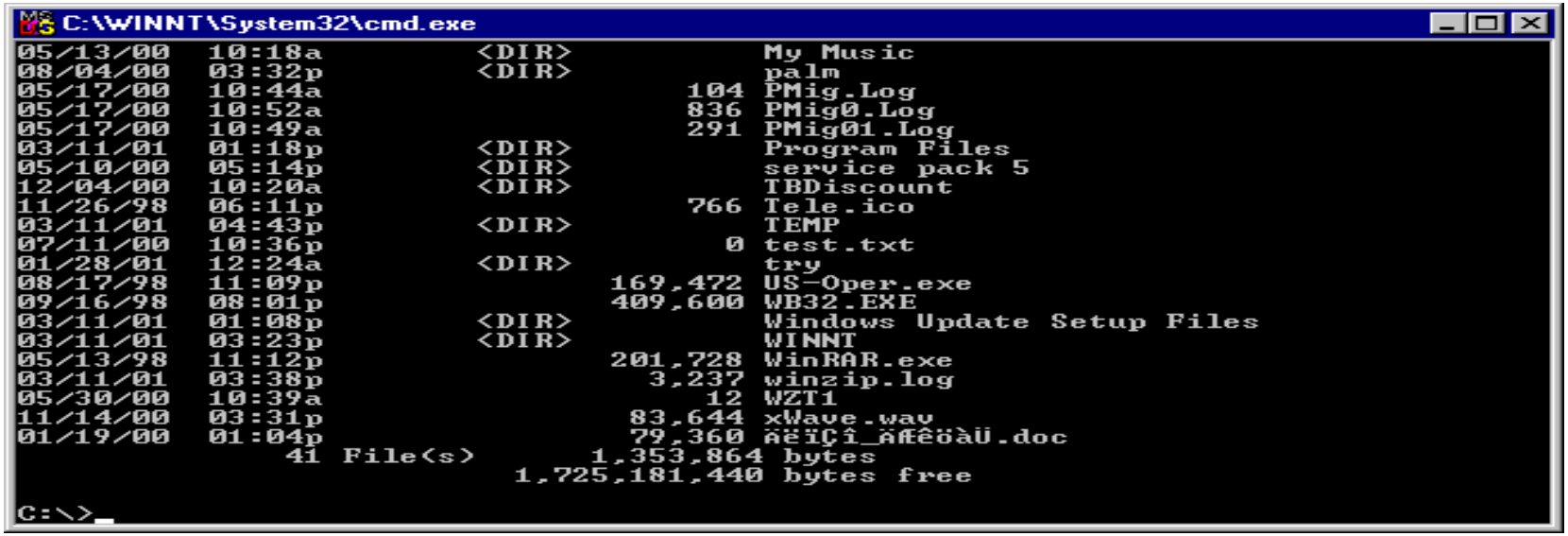


Monolithic OS – Basic Structure

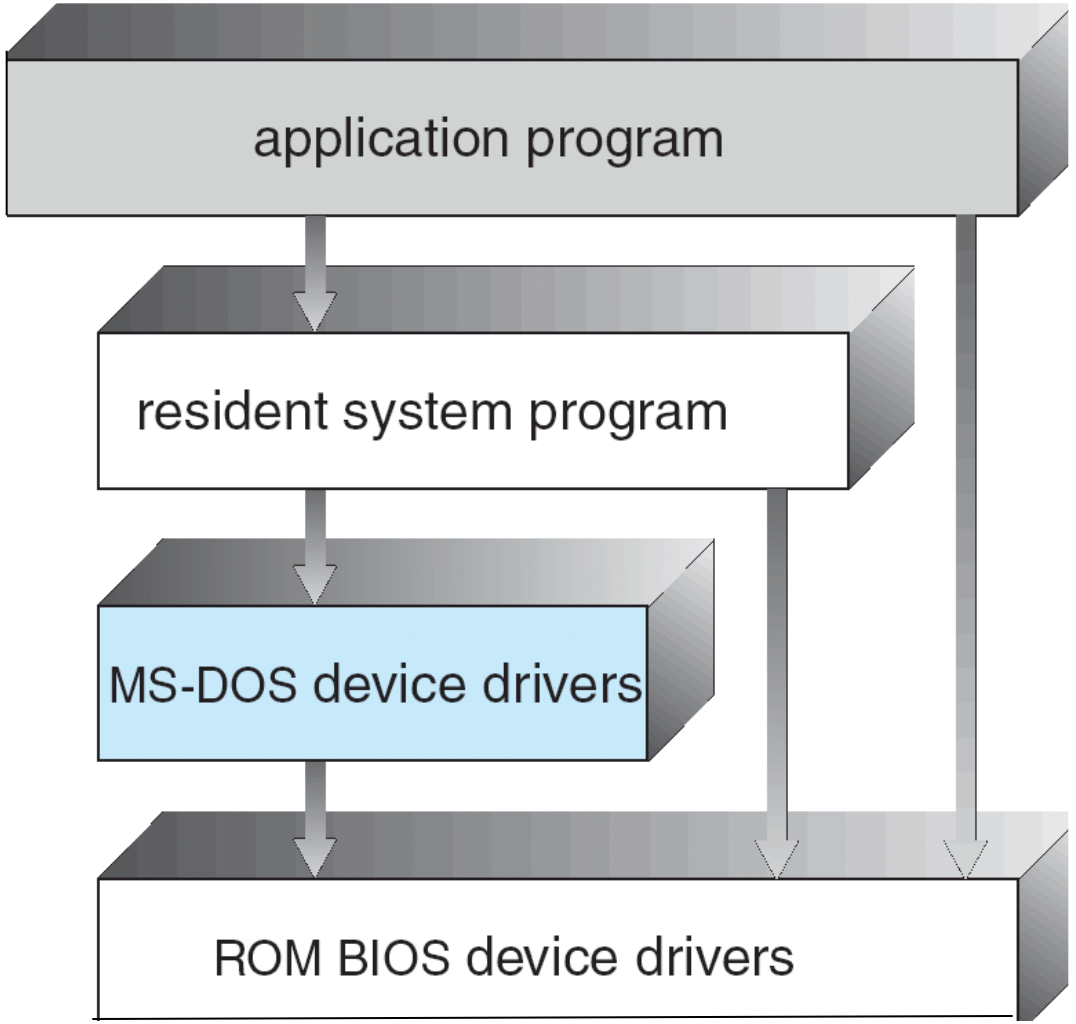
- Application programs that invoke the requested system services.
- A set of system services that carry out the operating system procedures/calls.
- A set of utility procedures that help the system services.

MS-DOS System Structure

- MS-DOS – written to provide functionality in the least space:
  - not divided into modules (monolithic).
  - Although MS-DOS has some structure, its interfaces and levels of functionality are not well separated.



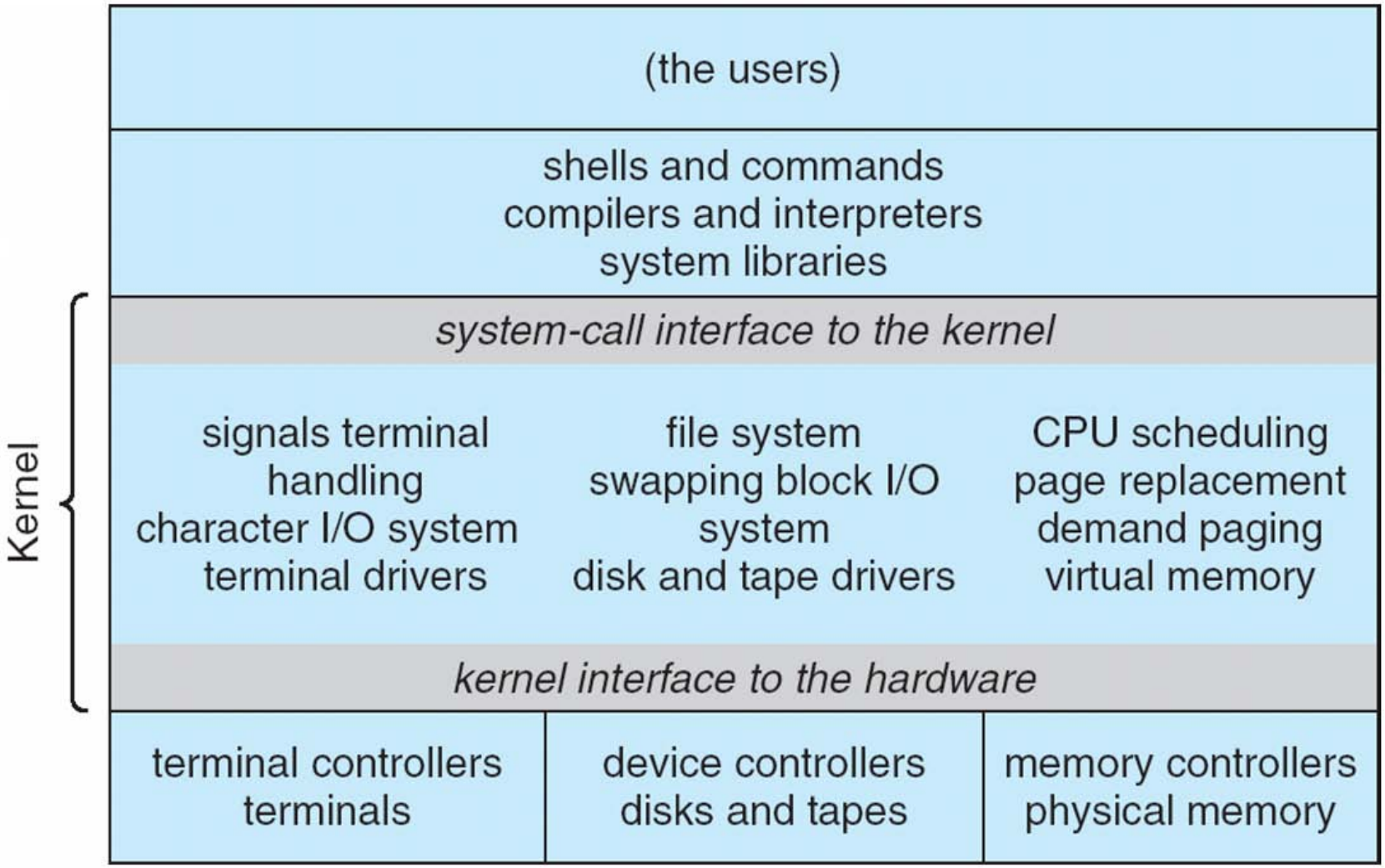
MS-DOS Layer Structure



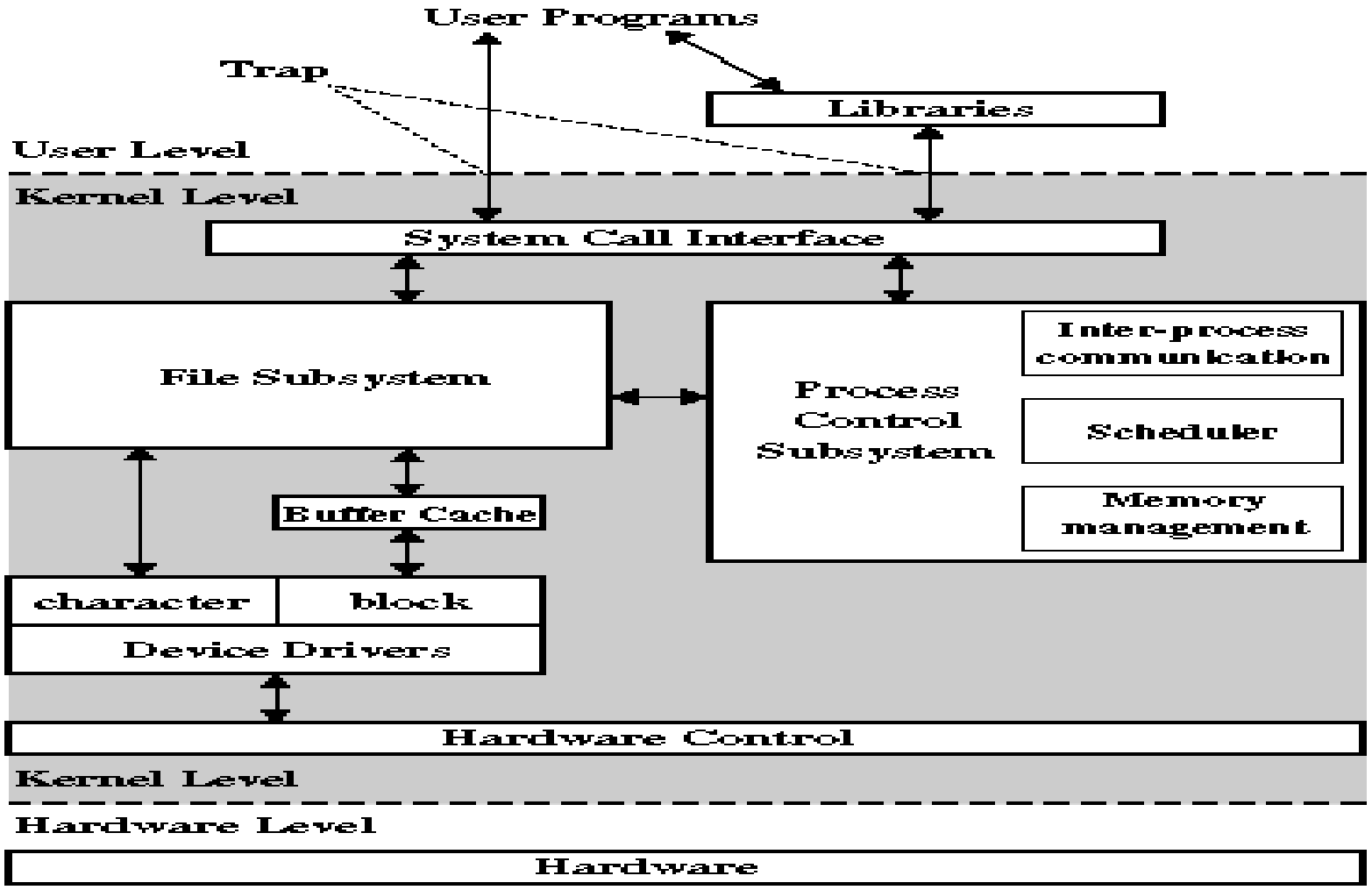
UNIX System Structure

- UNIX – limited by hardware functionality, the original UNIX operating system had limited structuring. The UNIX OS consists of two separable parts
  - The kernel
    - Consists of everything below the system-call interface and above the physical hardware
    - Provides the file system, CPU scheduling, memory management, and other operating-system functions; a large number of functions for one level
  - Systems programs

Traditional UNIX System Structure

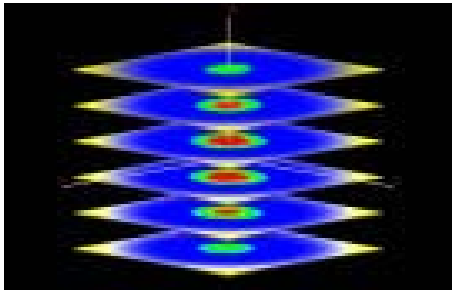


Traditional UNIX Kernel [Bach86]

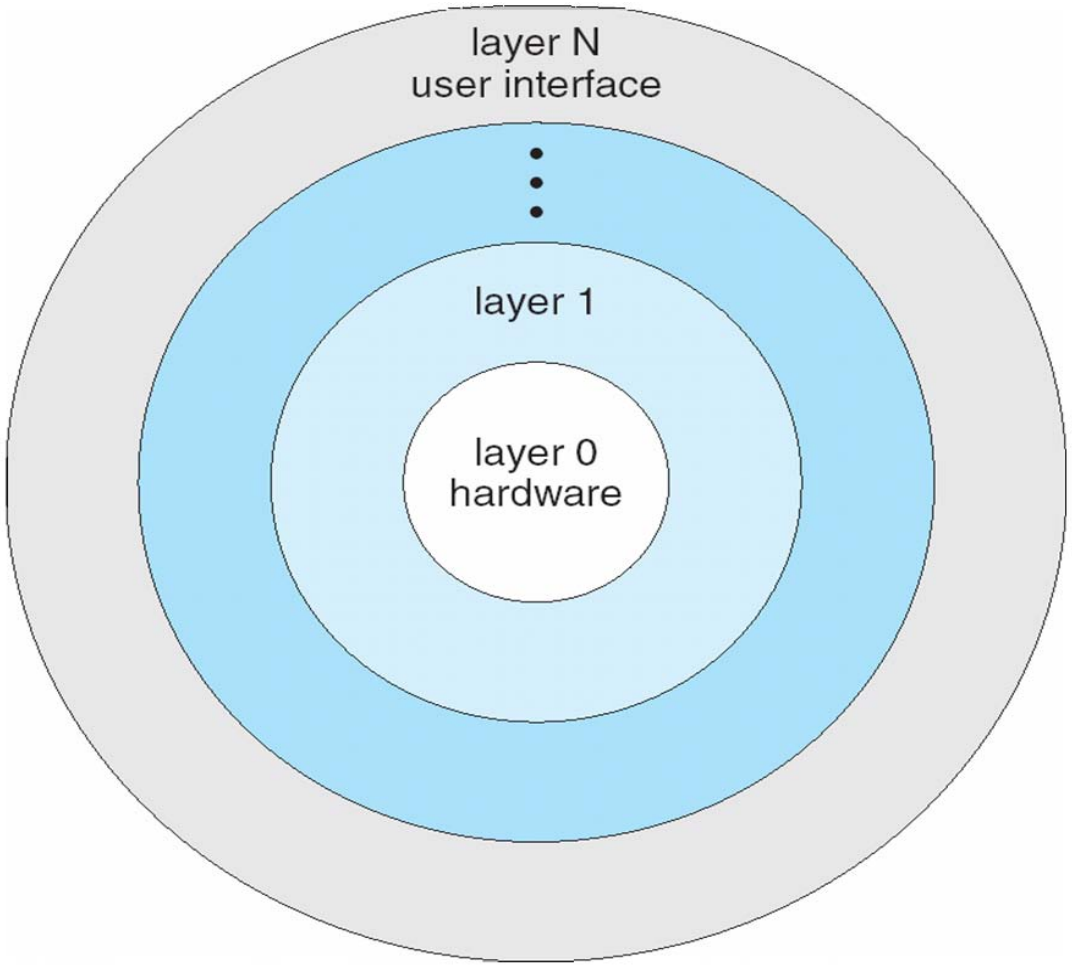


Layered Approach

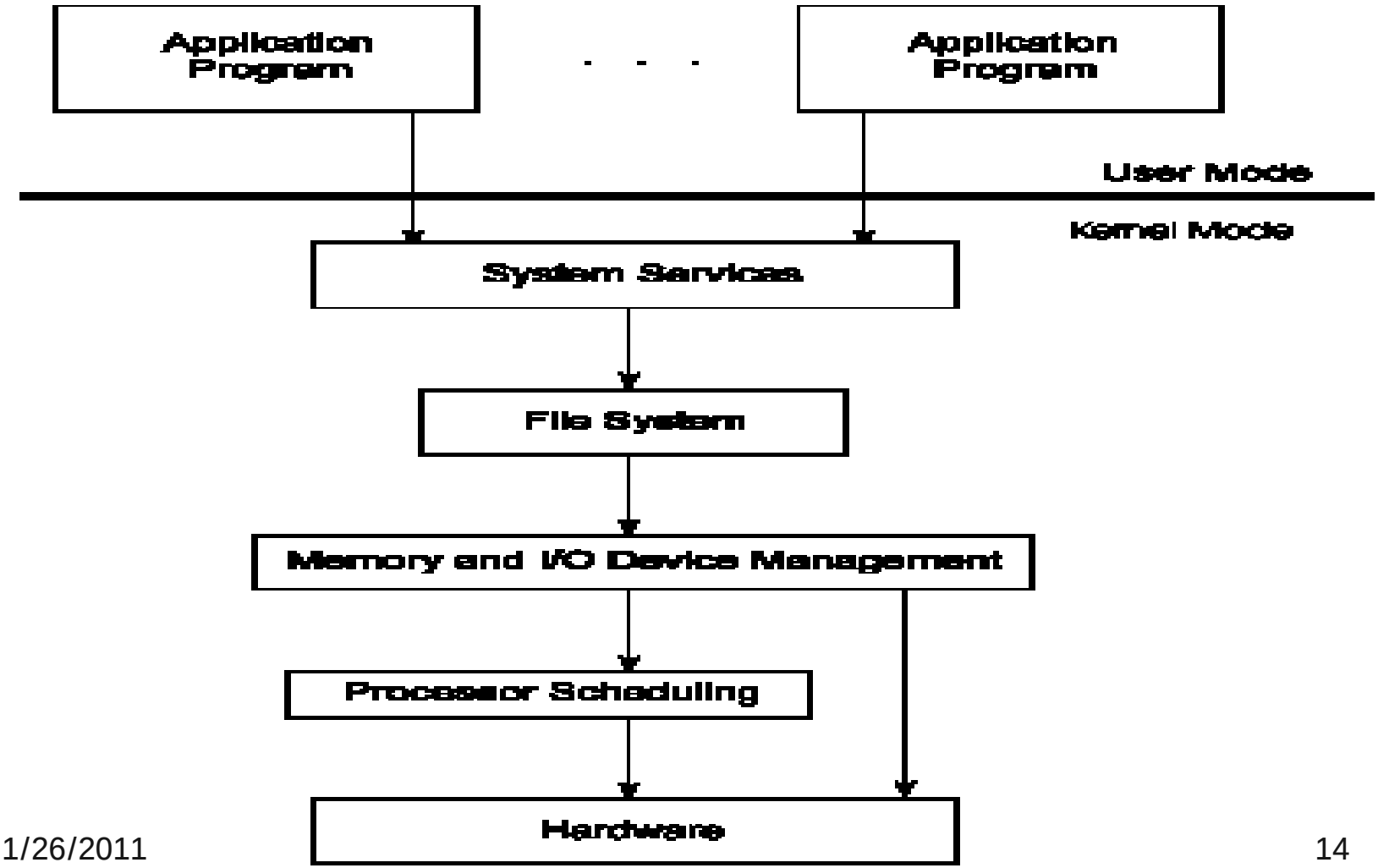
- The operating system is divided into a number of layers (levels), each built on top of lower layers.
- The bottom layer (layer 0) is the hardware; the highest (layer N) is the user interface.
- With modularity, layers are selected such that each uses functions (operations) and services of only lower-level layers.



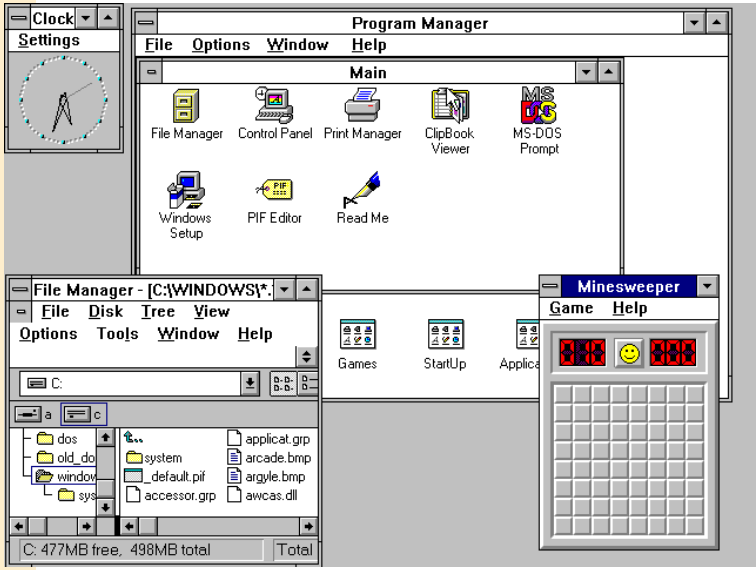
Layered Operating System



Operating System Layers



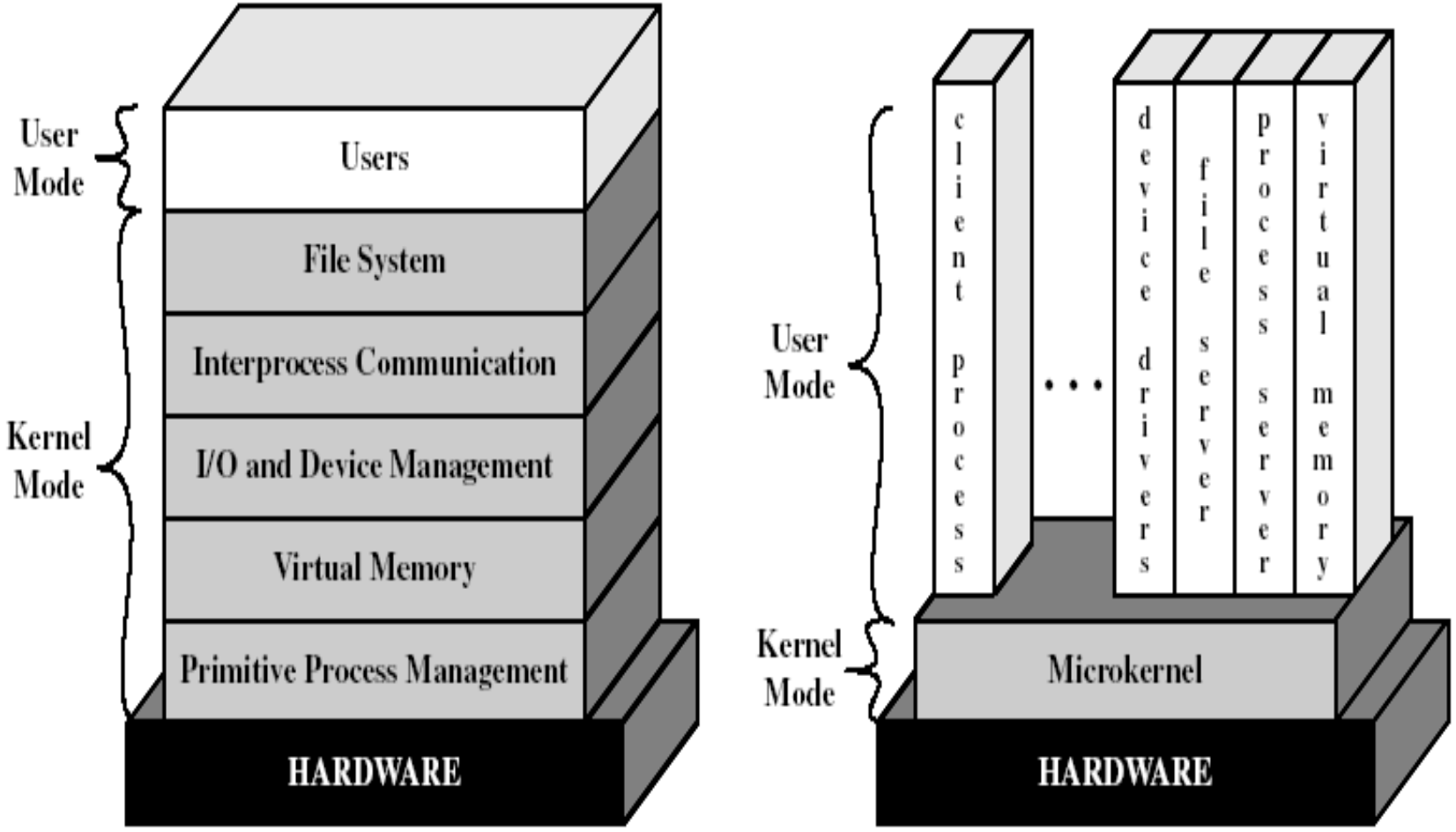
Older Windows System Layers



Microkernel System Structure

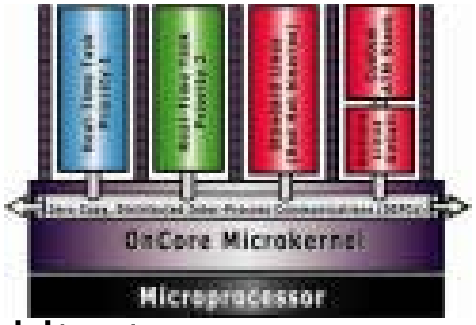
- Move as much functionality as possible from the kernel into "*user*" space.
- Only a few essential functions in the kernel:
  - primitive memory management (address space)
  - I/O and interrupt management
  - Inter-Process Communication (IPC)
  - basic scheduling
- Other OS services are provided by processes running in user mode (vertical servers):
  - device drivers, file system, virtual memory...

Layered vs. Microkernel Architecture

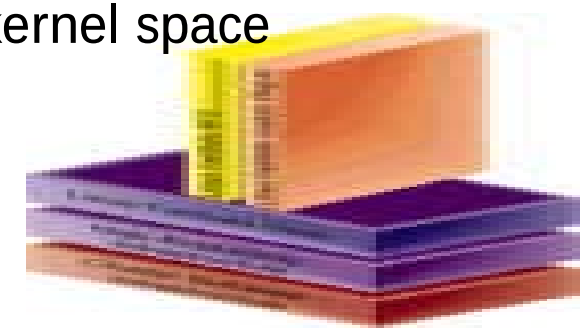


Microkernel System Structure

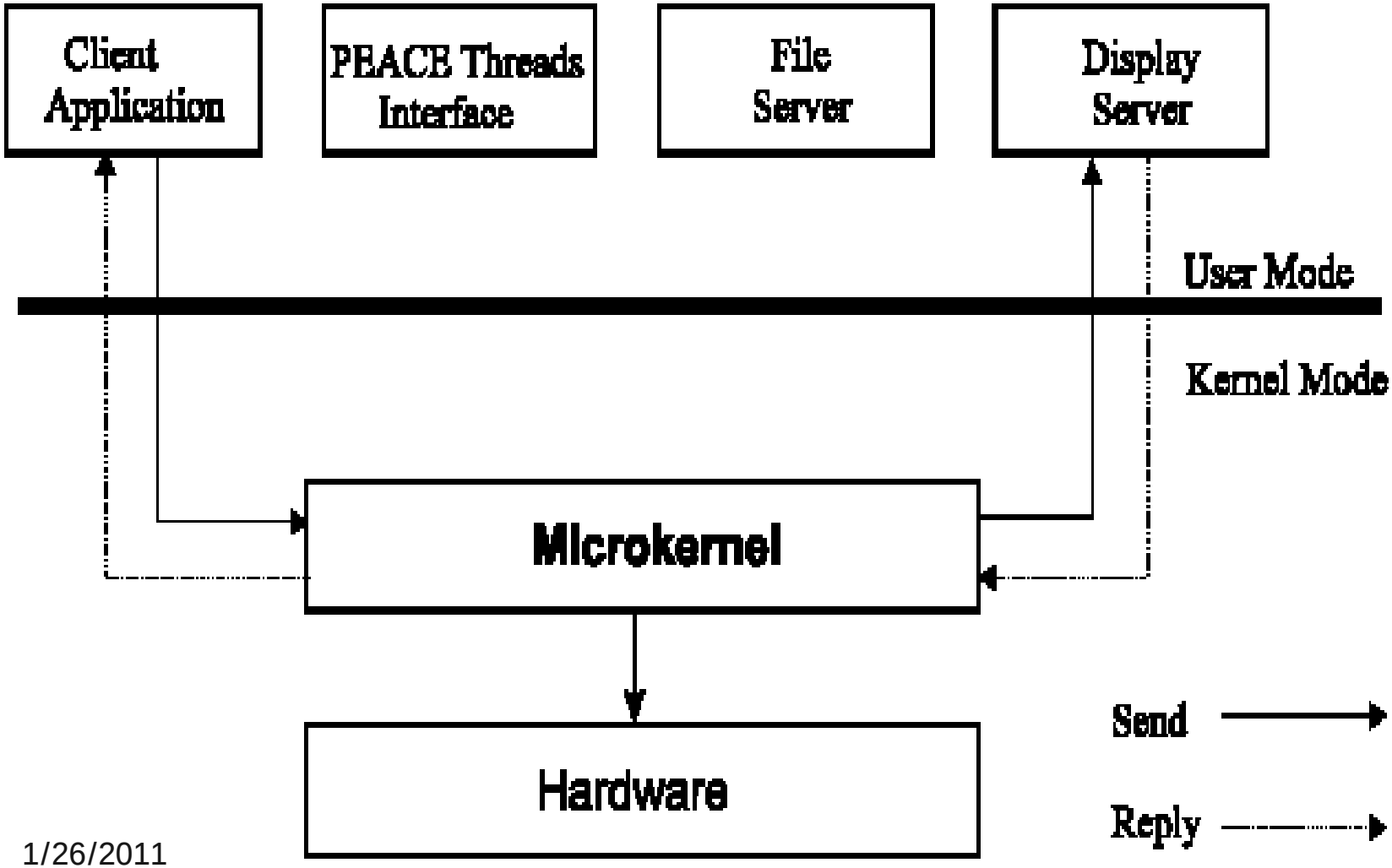
- Communication takes place between user modules using message passing



- Benefits:
  - Easier to extend a microkernel
  - Easier to port the operating system to new architectures
  - More reliable (less code is running in kernel mode)
  - More secure
- Detriments:
  - Performance overhead of user space to kernel space communication



Microkernel Operating System



Benefits of a Microkernel Organization

- Extensibility/Reliability
  - modular design
  - easier to extend a microkernel
  - more reliable (less code is running in kernel mode)
  - more secure (less code to be validated in kernel)
  - small microkernel can be rigorously tested.
- Portability
  - changes needed to port the system to a new processor is done in the microkernel, not in the other services.

Mach 3 Microkernel Structure

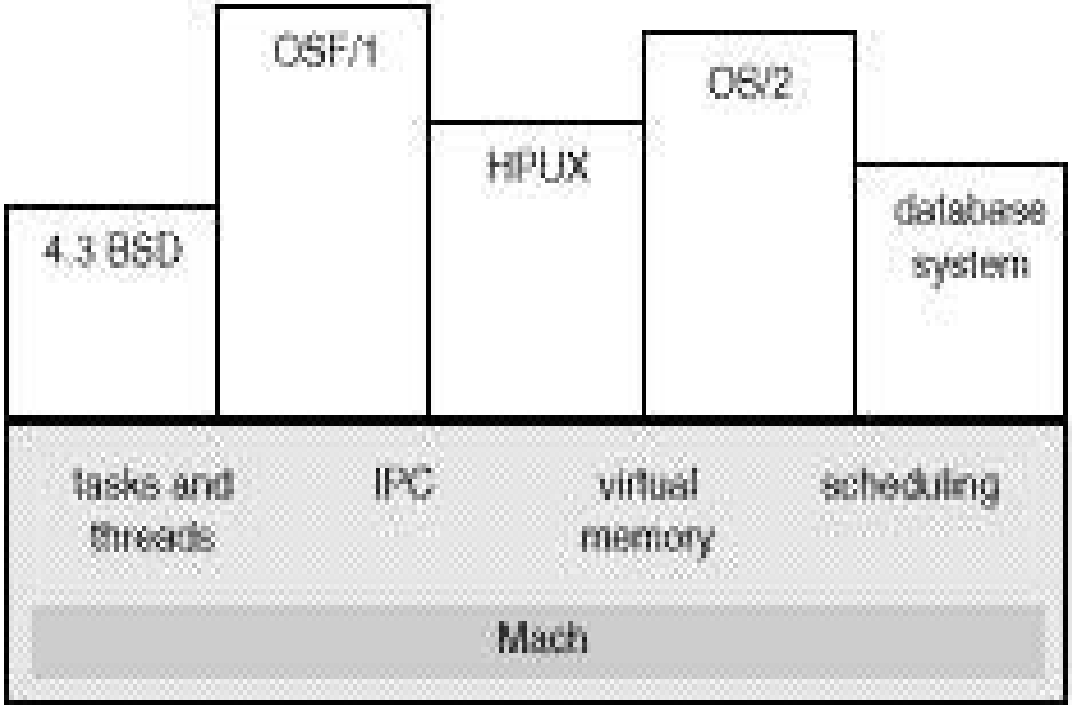
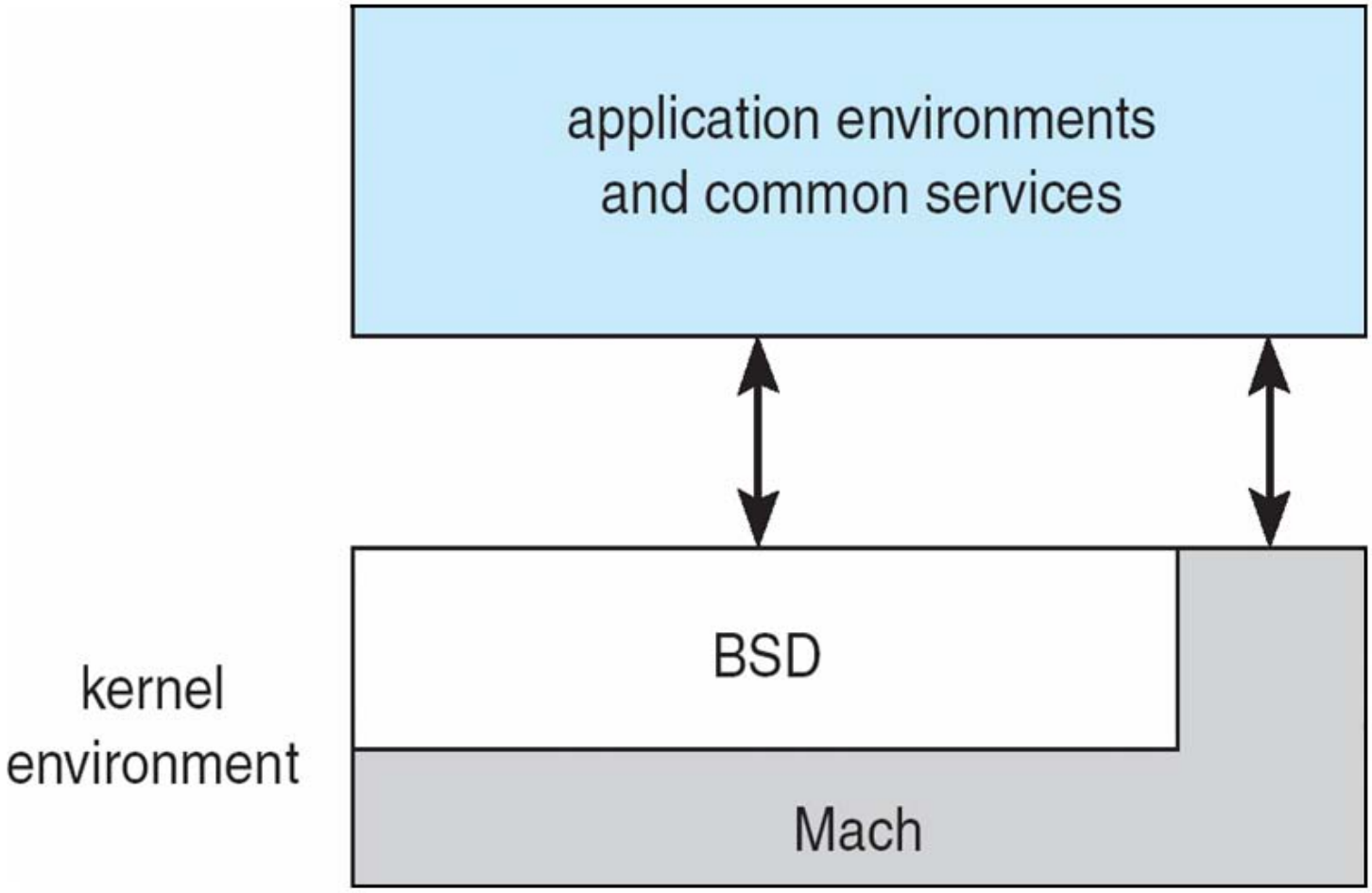
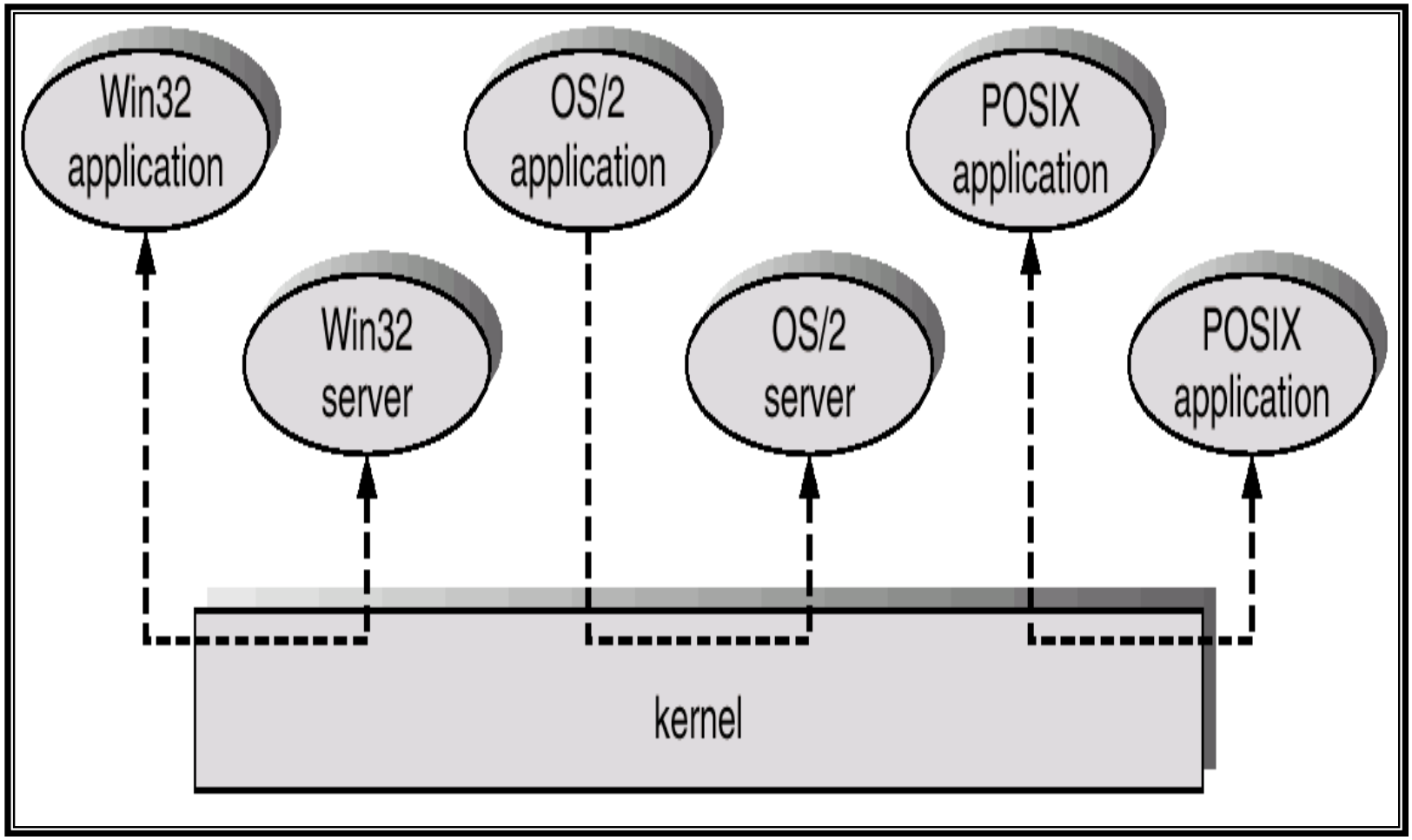


Figure A.1 Mach 3 structure.

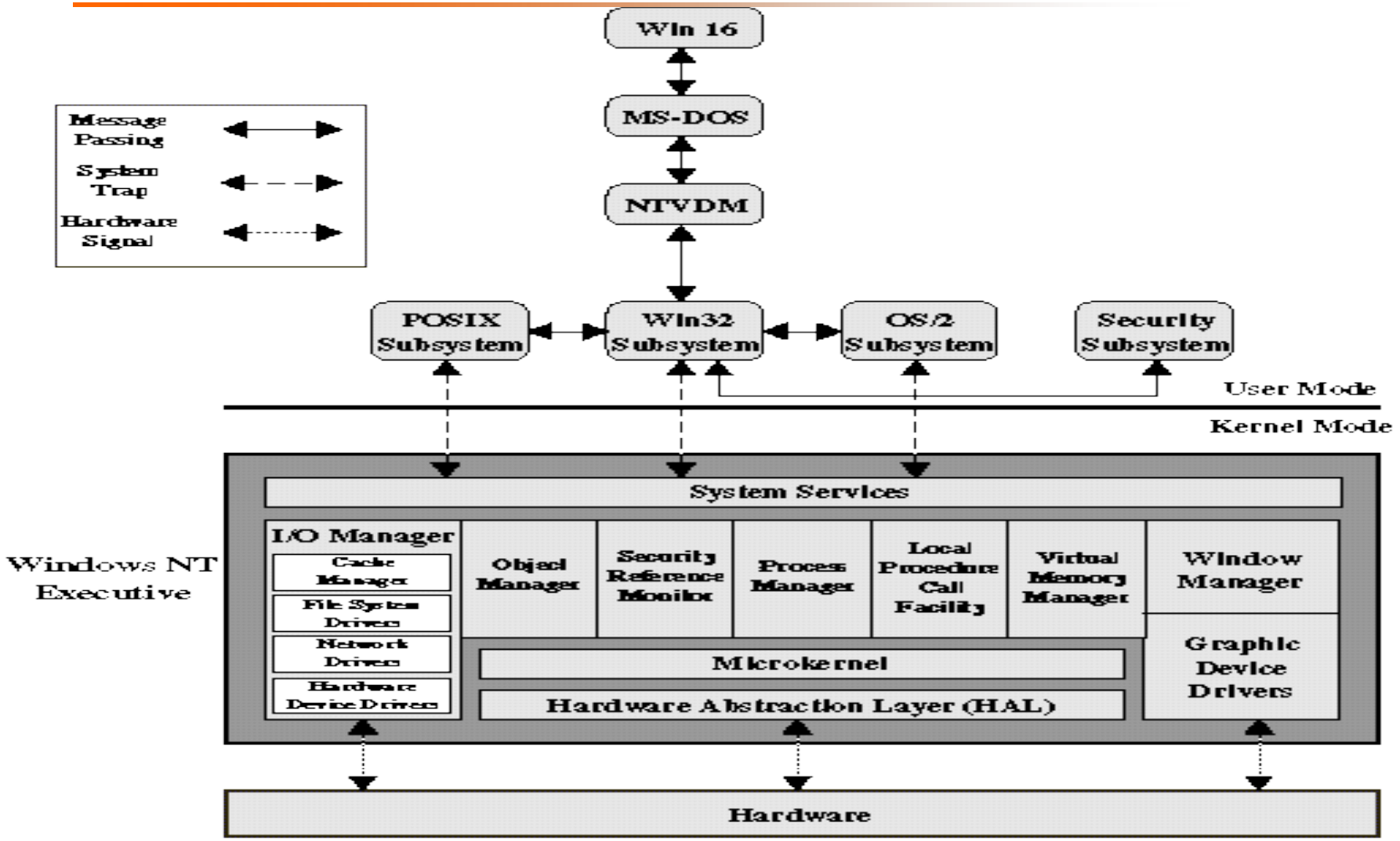
Mac OS X Structure



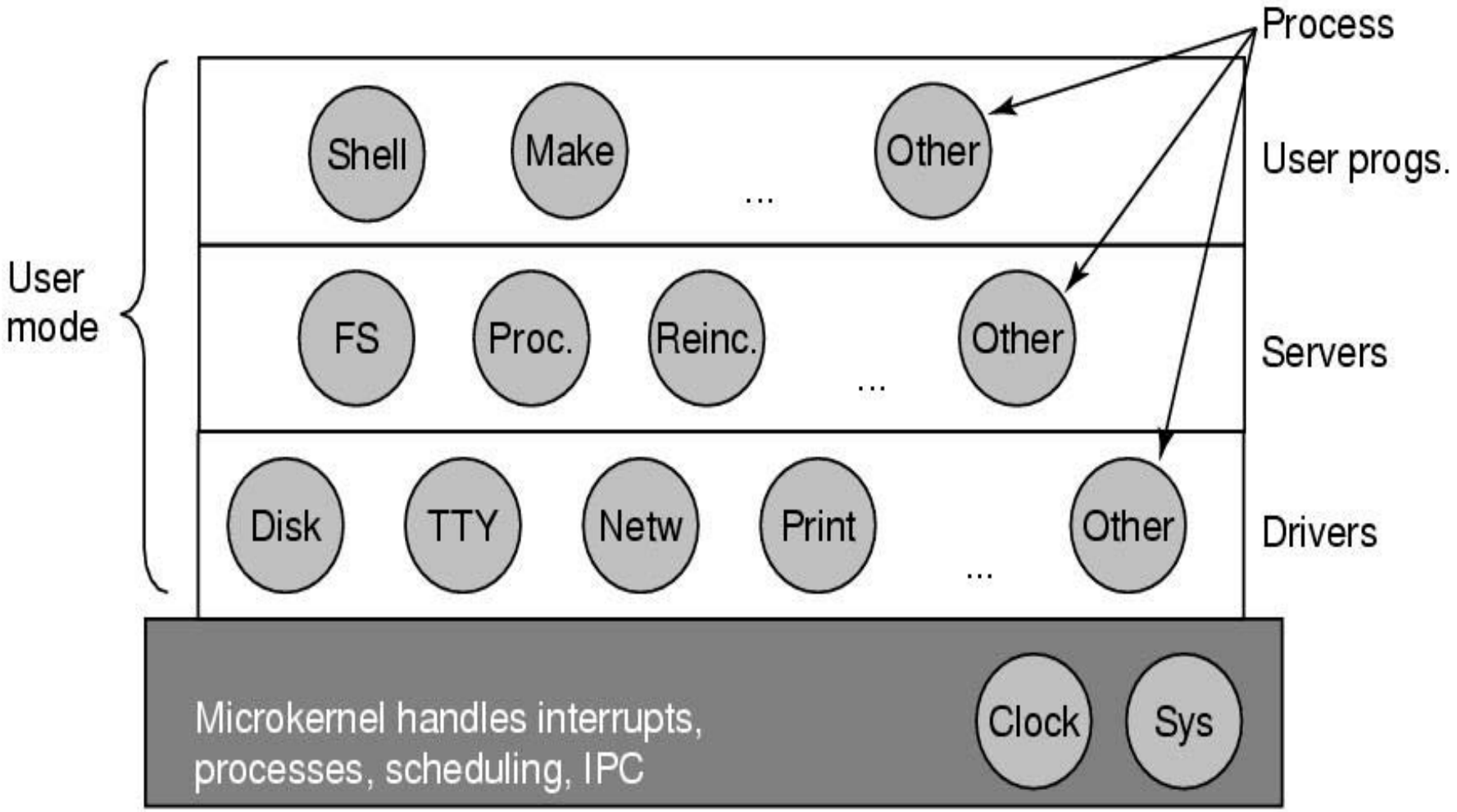
Windows NT Client-Server Structure



Windows NT 4.0 Architecture



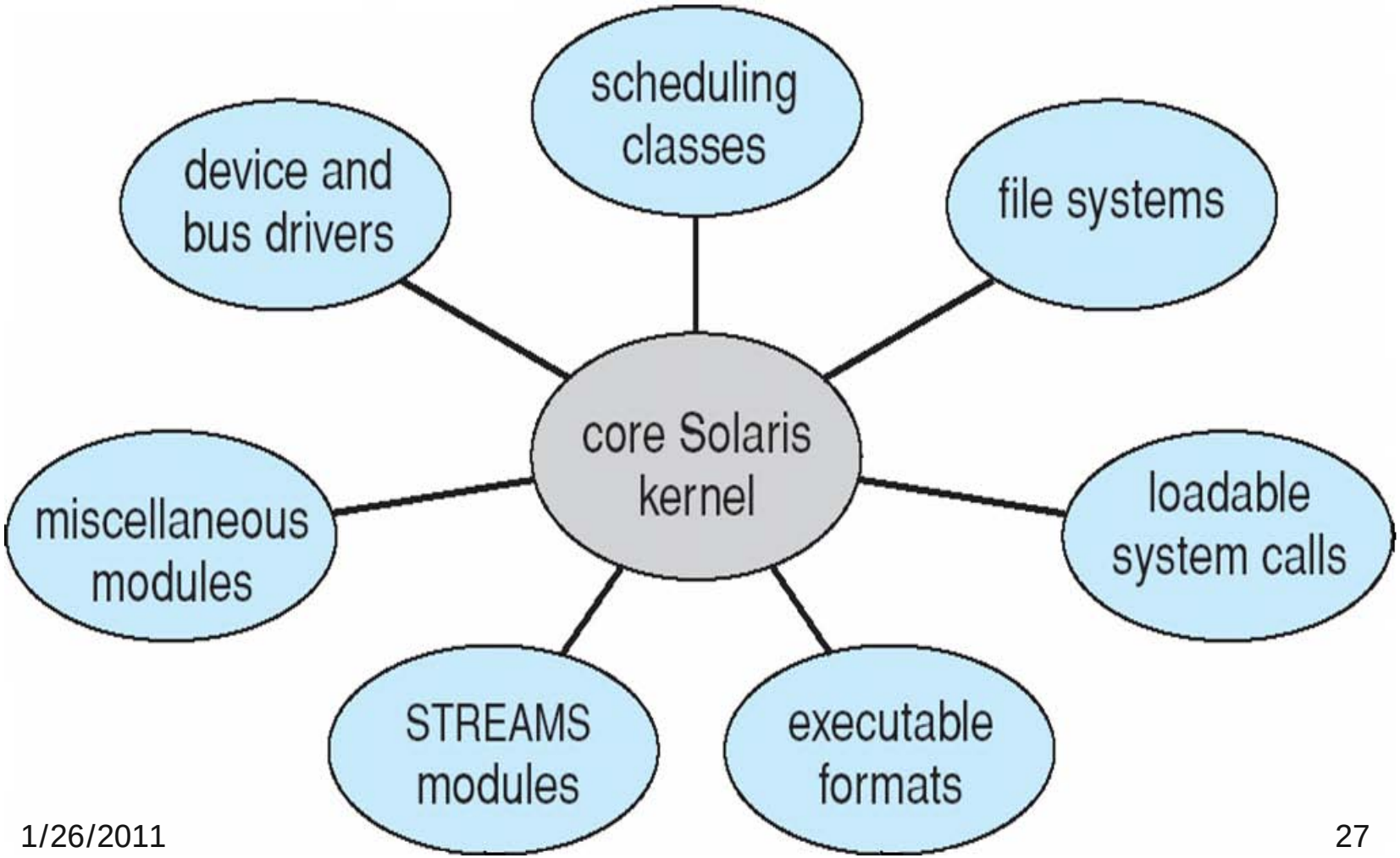
Structure of the MINIX 3 System



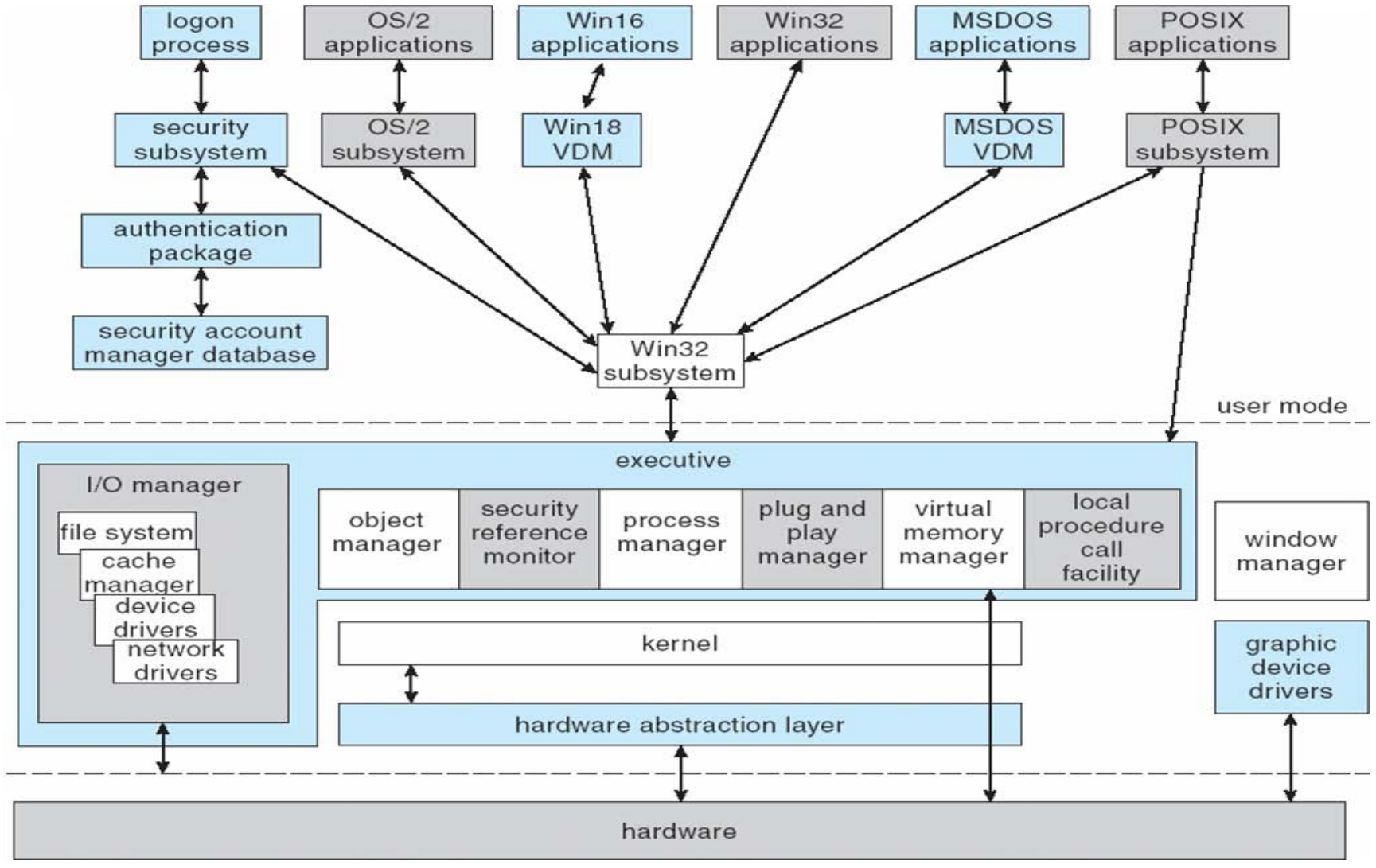
Kernel Modules

- Most modern operating systems implement kernel modules
  - Uses object-oriented approach
  - Each core component is separate
  - Each talks to the others over known interfaces
  - Each is loadable as needed within the kernel
- Overall, similar to layers but more flexible

Solaris Modular Approach



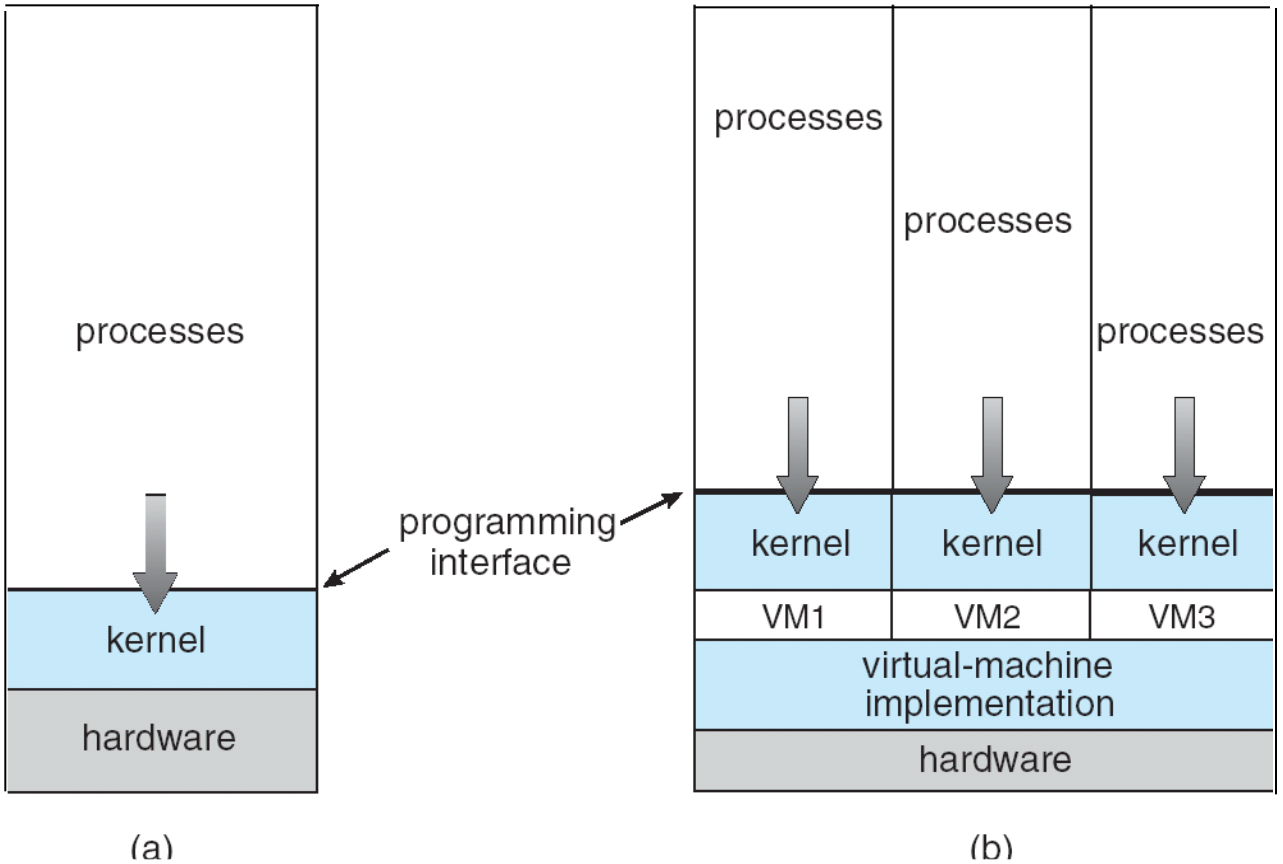
XP Architecture



Virtual Machines

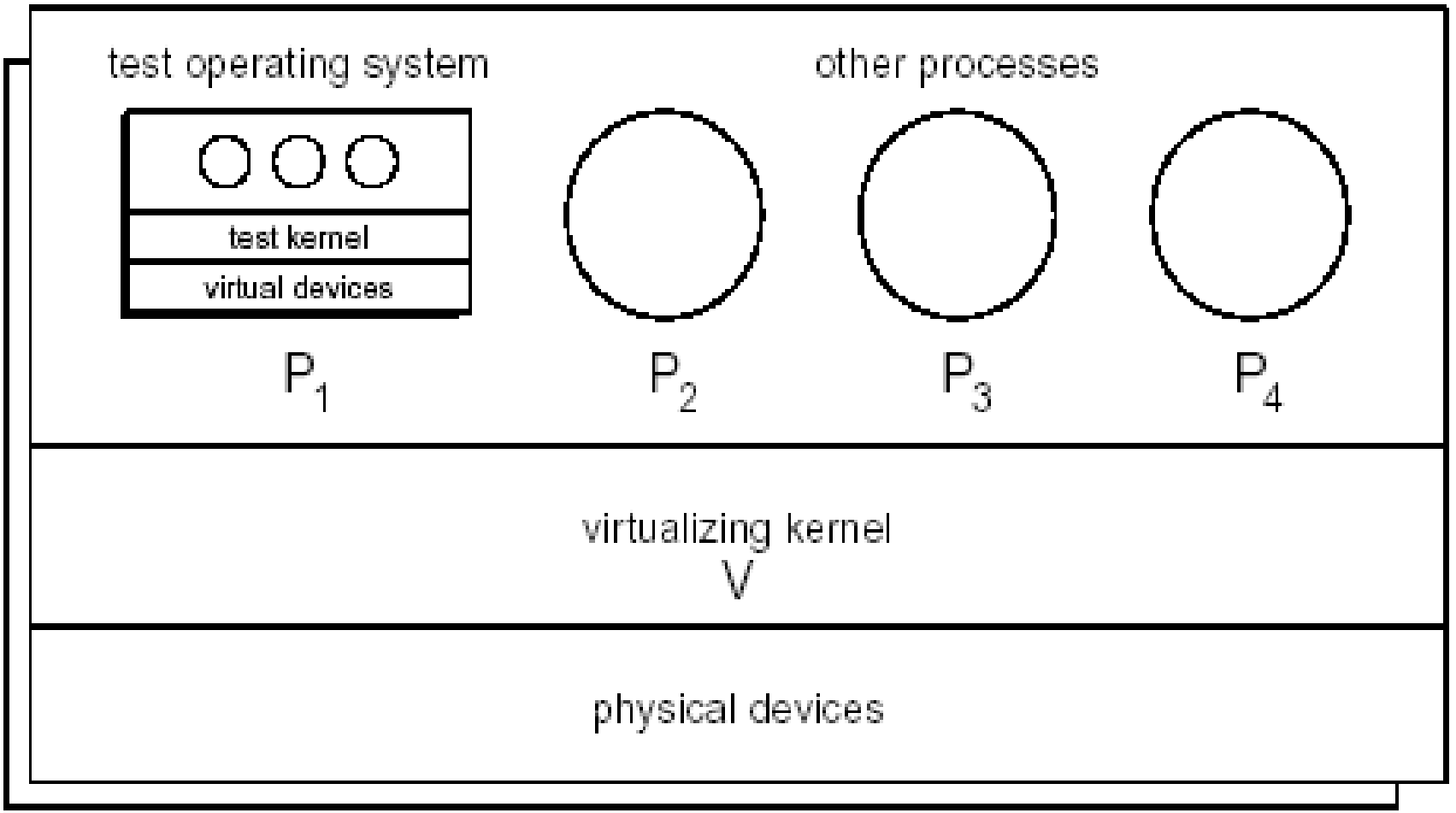
- A virtual machine takes the layered approach to its logical next step. It treats hardware and the operating system kernel as though they were all hardware
- A virtual machine provides an interface *identical* to the underlying bare hardware
- The operating system host creates the illusion that a process has its own processor (and virtual memory)
- Each guest provided with a (virtual) copy of underlying computer

Virtual Machines (Cont.)

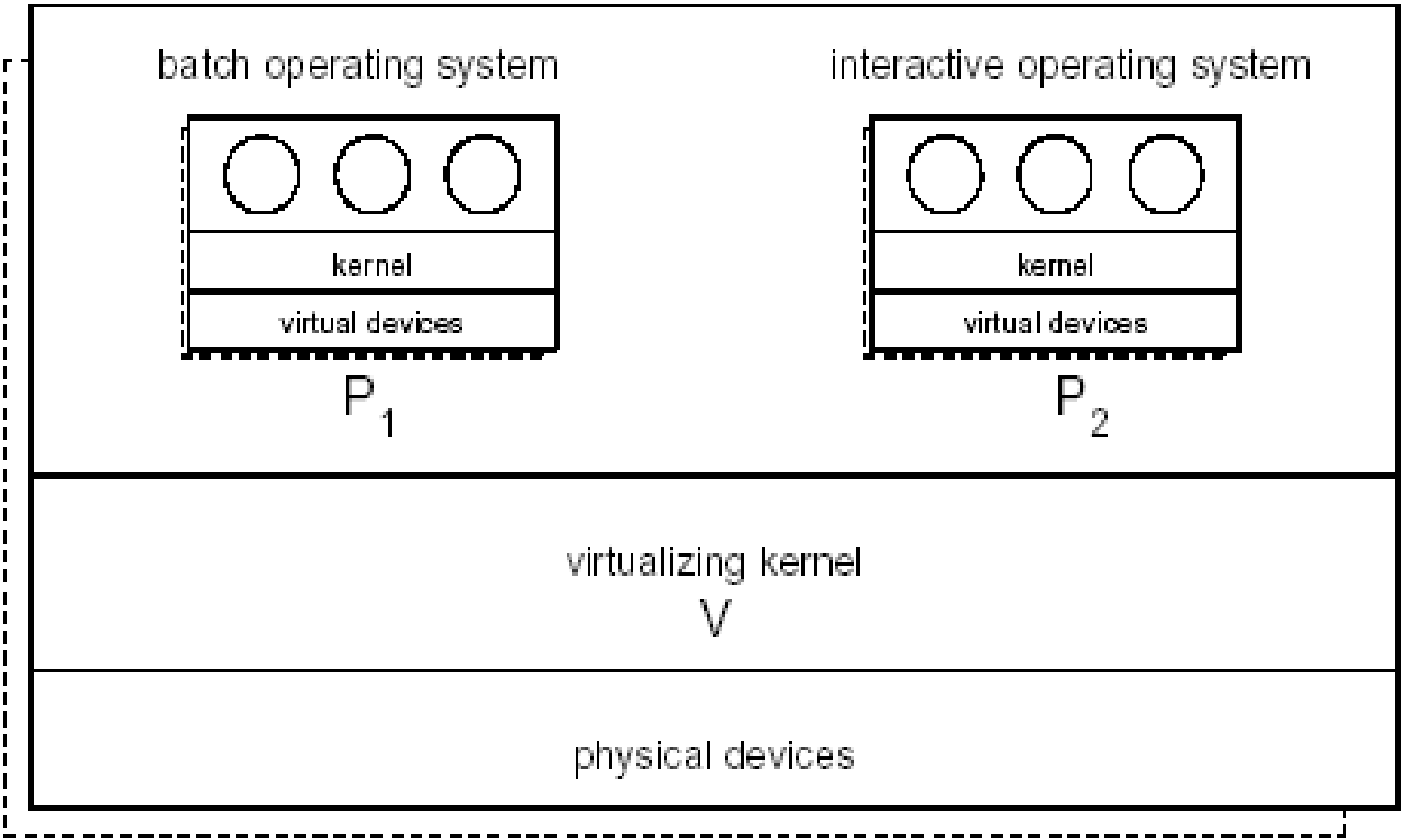


(a) Non-virtual machine (b) virtual machine

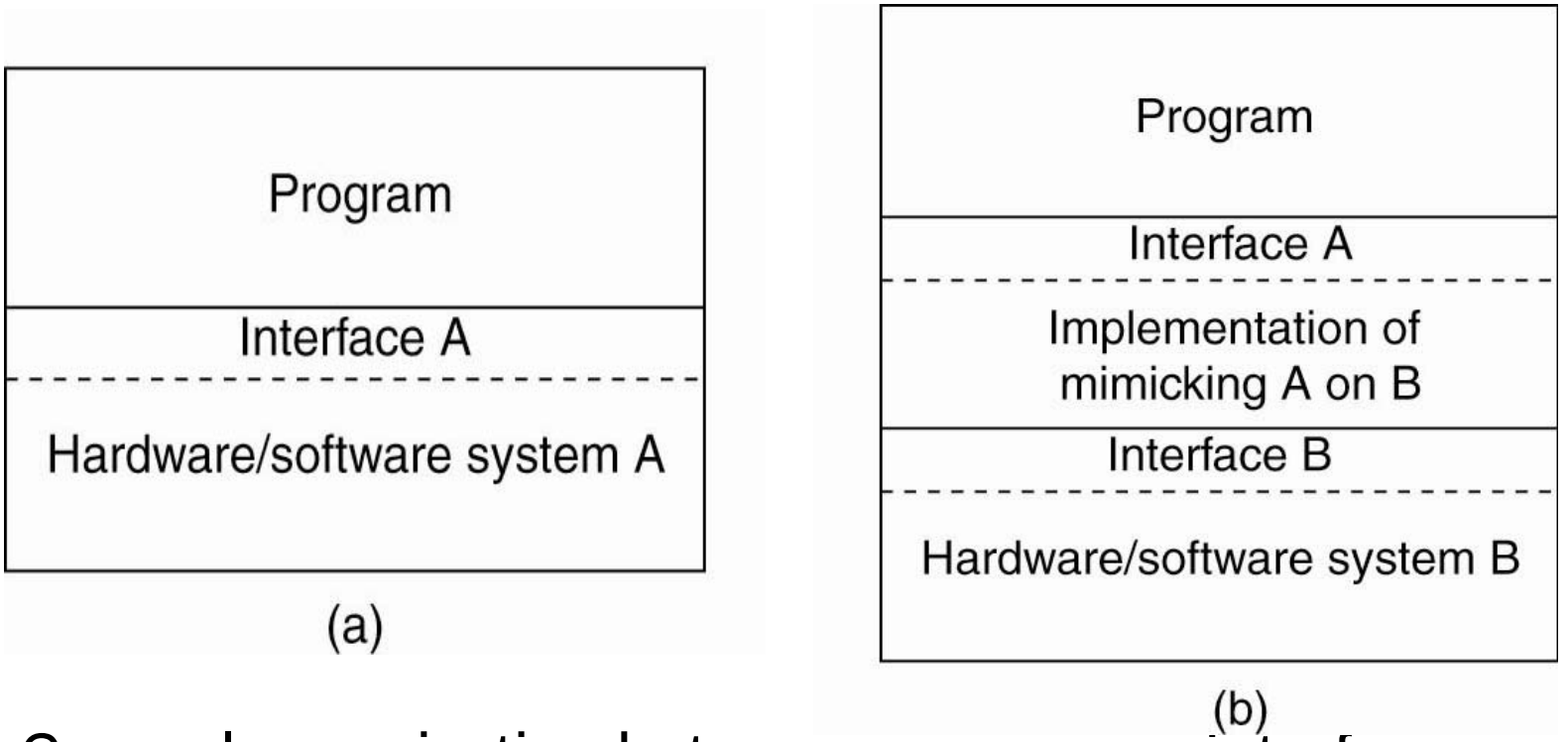
Testing a new Operating System



Integrating two Operating Systems



The Role of Virtualization



(a) General organization between a program, interface, and system.

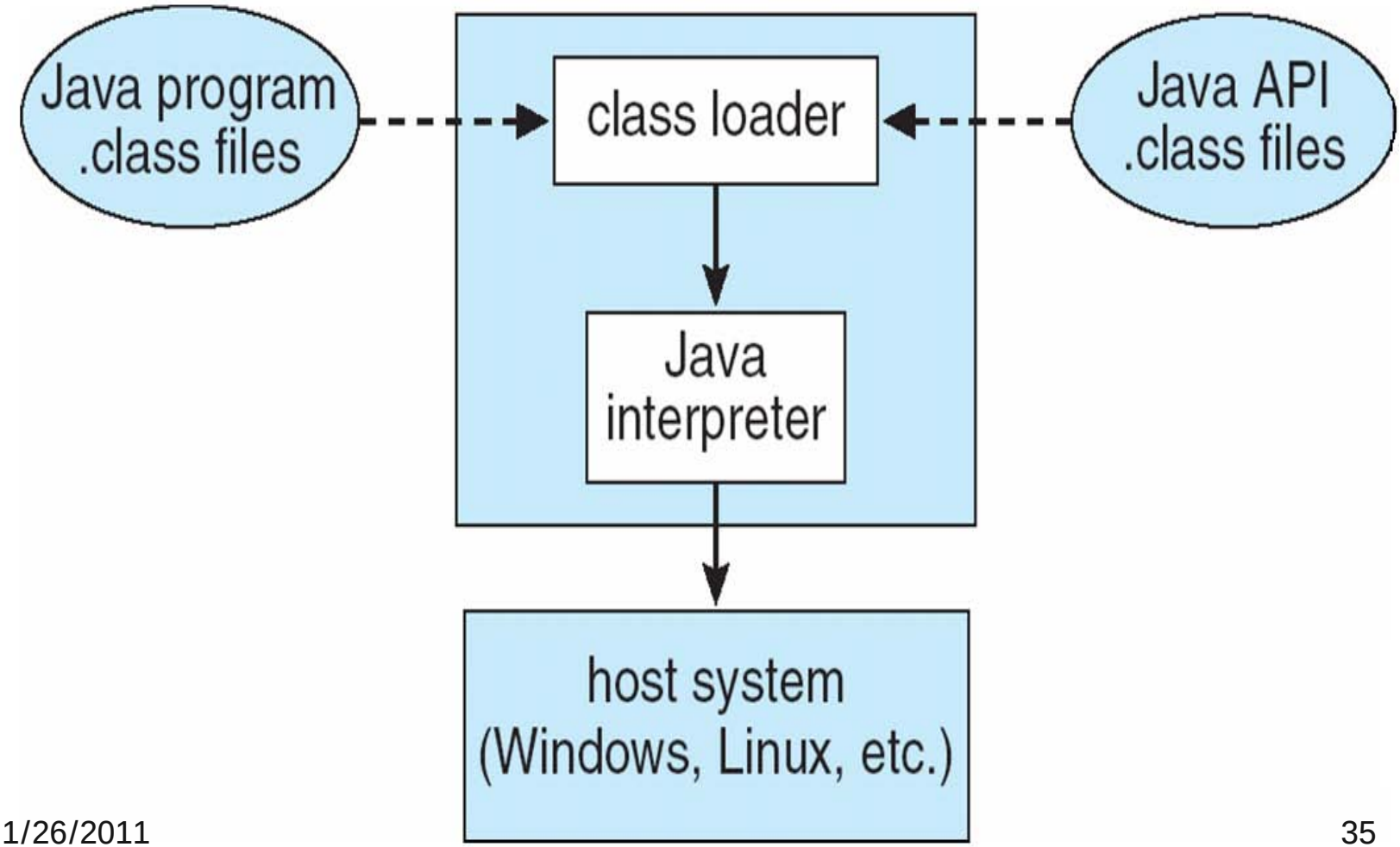
(b) General organization of virtualizing system A on top of system B.

Java Virtual Machine

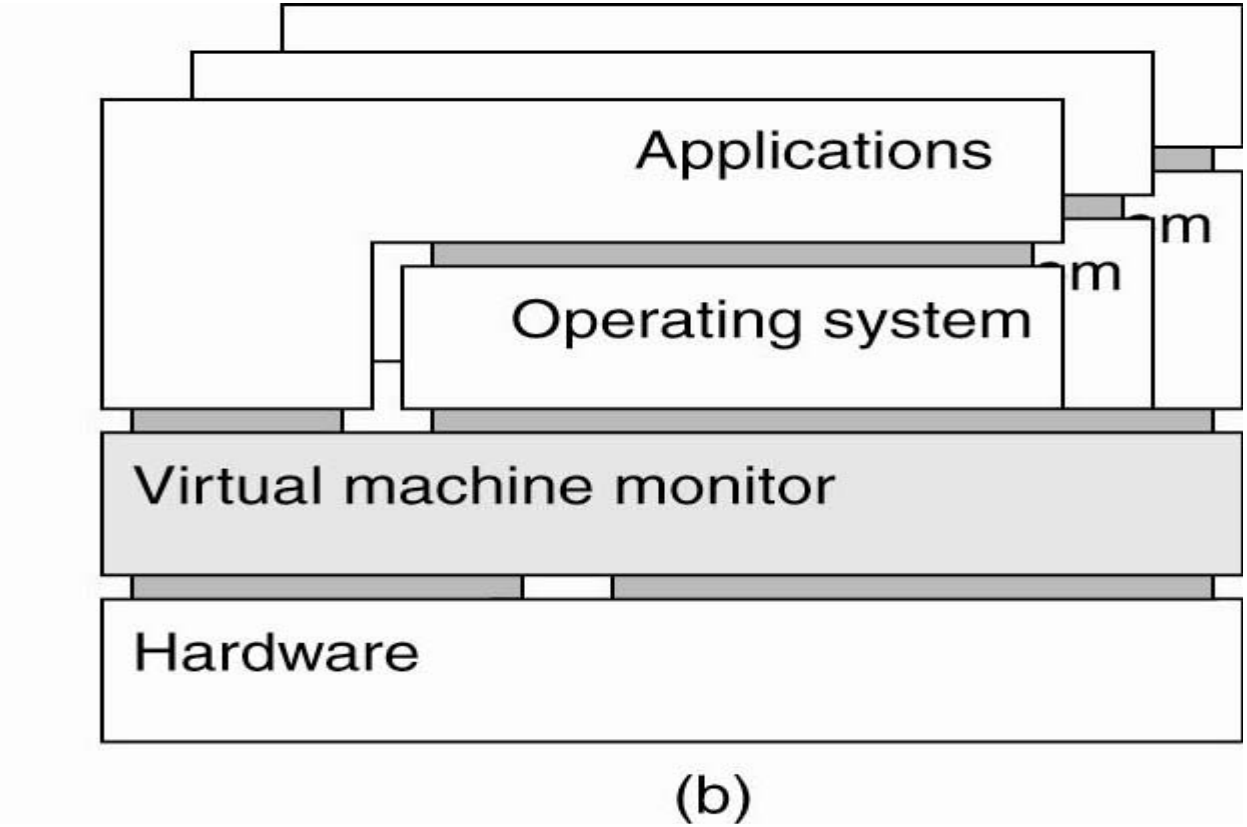
- Compiled Java programs are platform-neutral bytecodes executed by a Java Virtual Machine (JVM).
- JVM consists of:
  - class loader
  - class verifier
  - runtime interpreter

- Just-In-Time (JIT) compilers increase performance.

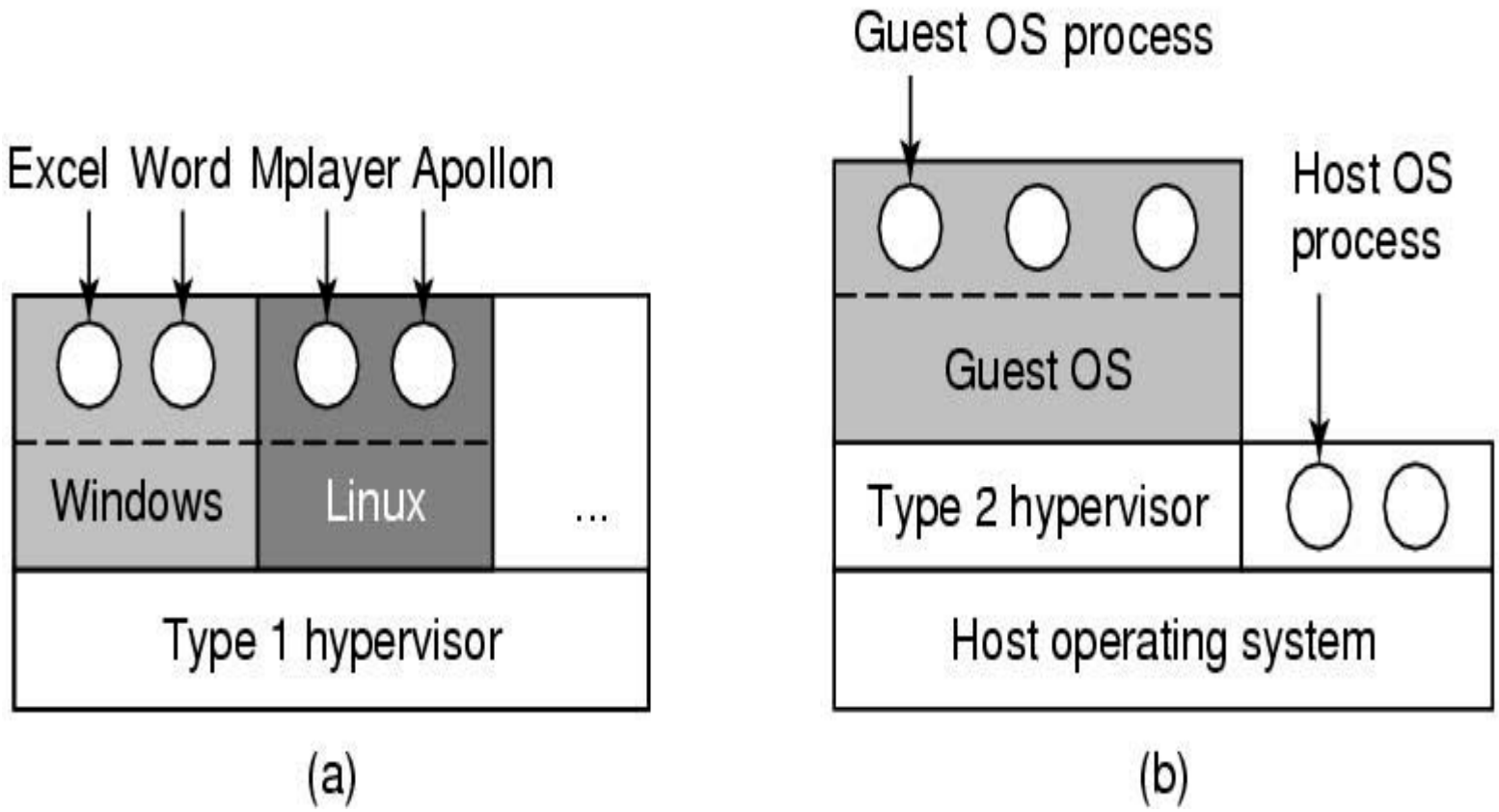
The Java Virtual Machine



Hypervisor / VMM



Types of Hypervisors



(a) A type 1 hypervisor. (b) A type 2 hypervisor

Para- vs. Full-virtualization

- Presents guest with system similar but not identical to hardware
- Guest must be modified to run on paravirtualized hardware
- Guest can be an OS, or in the case of Solaris 10 applications running in containers
- Full-virtualization: unmodified guest OSes