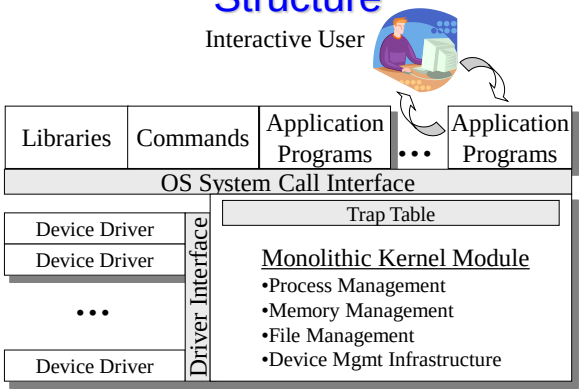
OS Architecture: Monolithic Structure



Most modern OSes fall into this category!

Microkernel System Architecture

- Microkernel architecture:
  - Moves as much from the kernel into "*user*" space (still protected from normal users)
  - Communication takes place between user modules using message passing
- What must be in the kernel and what can be in user space?
  - Mechanisms determine how to do something
  - Policies decide what will be done
- Benefits:
  - More reliable (less code is running in kernel mode)
  - More secure (less code is running in kernel mode)
- Disadvantage?

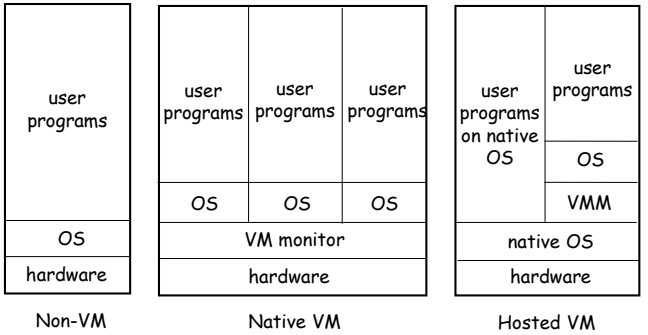
Layered Structure

- Layered structure
  - 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
  - Decreased privileges for higher layers
- Benefits:
  - more reliable
  - more secure
  - more flexibility, easier to extend
- Disadvantage?
  - Weak integration results in performance penalty (similar to the microkernel structure)

Virtual Machines

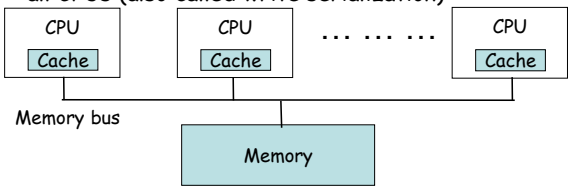
- Virtual machine architecture
  - Virtualization: A piece of software that provides an interface *identical* to the underlying bare hardware.
    - the upper-layer software has the illusion of running directly on hardware
    - the virtualization software is called virtual machine monitor
  - Multiplexing: It may provide several virtualized machines on top of a single piece of hardware.
    - resources of physical computer are shared among the virtual machines
    - each VM has the illusion of owning a complete machine
- Trust and privilege
  - the VM monitor does not trust VMs
  - only the VM monitor runs in full privilege
- Compared to an operating system
  - VM monitor is a resource manager, but not an extended machine

Virtual Machine Architecture



Multiprocessor Hardware

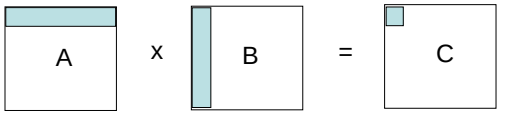
- A computer system in which two or more CPUs share full access to the main memory
- Each CPU might have its own cache and the coherence among multiple caches is maintained
  - write operation by a CPU is visible to all other CPUs
  - writes to the same location is seen in the same order by all CPUs (also called write serialization)



  - bus snooping and cache invalidation

Multiprocessor Applications

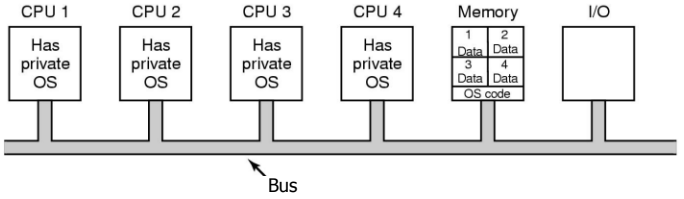
- Multiprogramming
  - Multiple regular applications running concurrently
- Concurrent servers
  - Web servers, … …
- Parallel programs
  - Utilizing multiple processors to complete one task (parallel matrix multiplication, Gaussian elimination)



Single-processor OS vs. Multiprocessor OS

- Single-processor OS
  - easier to support kernel synchronization
    - coarse-grained locking vs. fine-grain locking
    - disabling interrupts to prevent concurrent executions
  - easier to perform scheduling
    - which to run, not where to run
- Multiprocessor OS
  - evolution of OS structure
  - synchronization
  - scheduling

Multiprocessor OS



- Each CPU has its own operating system
  - quick to port from a single-processor OS
- Disadvantages
  - difficult to share things (processing cycles, memory, buffer cache)

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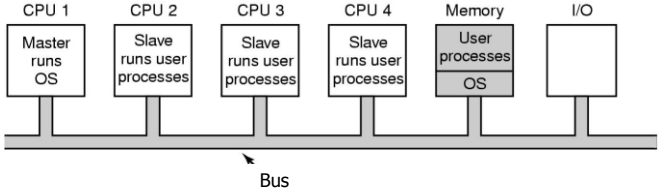
Multiprocessor OS – Master/Slave



- All operating system functionality goes to one CPU
  - no multiprocessor concurrency in the kernel
- Disadvantage
  - OS CPU consumption may be large so the OS CPU becomes the bottleneck (especially in a machine with many CPUs)

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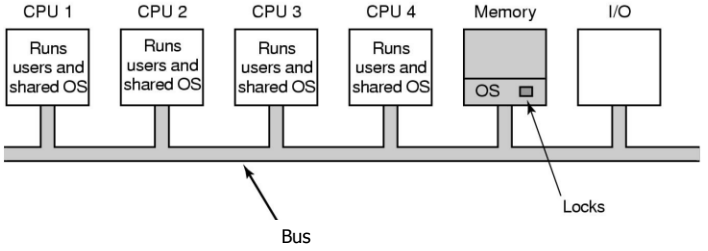
Multiprocessor OS – Shared OS



- A single OS instance may run on all CPUs
- The OS itself must handle multiprocessor synchronization
  - multiple OS instances from multiple CPUs may access shared data structure

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