Graduate Operating Systems
(History & Architecture)

Fall 2020

Today's Paper(s)

- **[1]** P. Brinch Hansen, "The Nucleus of a Multiprogramming System", Communications of the ACM, 238-242, April 1970.
- **[2]** Dennis M. Ritchie and Ken Thompson, "The UNIX Time-Sharing System", Communications of the ACM, volume 17, number 7, July 1974.

Operating System

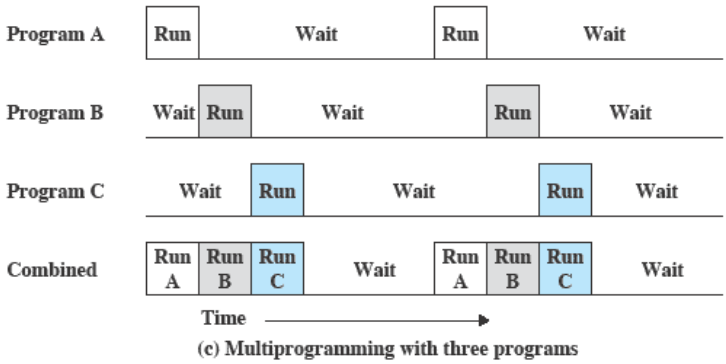
- A program that controls the execution of application programs
- An interface between applications and hardware

User vs Kernel Mode

- User program executes in **user mode**
  - Certain instructions may not be executed
  - Certain memory areas are protected from user's use and may not be accessed
- OS/kernel executes in **system (kernel) mode**
  - Privileged instructions are executed
  - Protected areas of memory may be accessed

Multiprogramming

- When one job needs to wait for I/O, the processor can switch to the other job

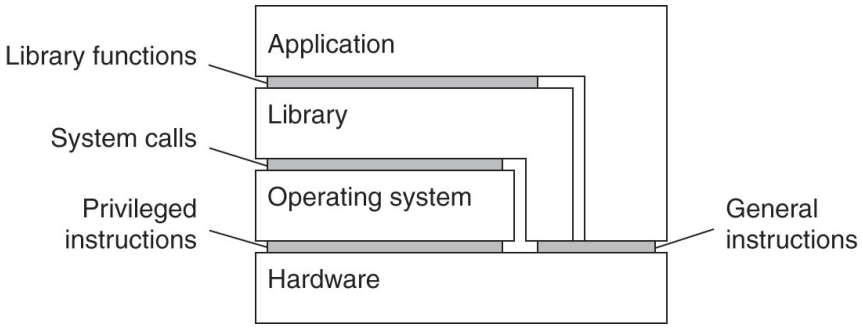


(c) Multiprogramming with three programs

OS Responsibilities

- Program Development and Execution
- Process Management
- Memory Management
- I/O & File Management
- Protection and Security
- Inter-Process Communication
- Synchronization (Deadlocks)
- Accounting & Logging
- …

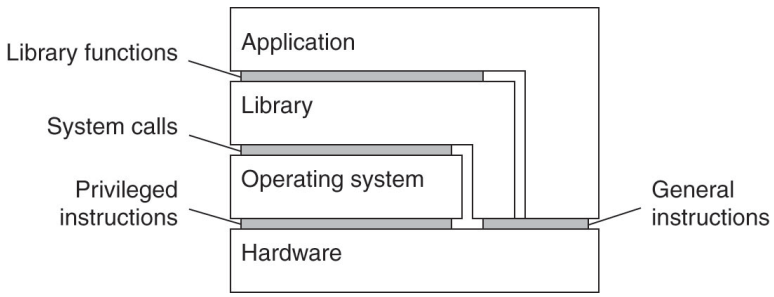
Four Interfaces



- Figure 3-6. Various interfaces offered by computer systems.

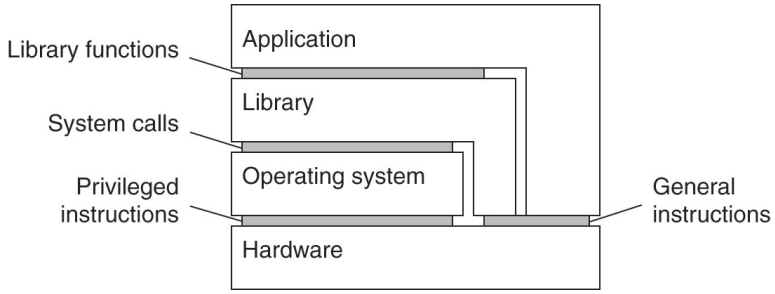
Four Interfaces (1)

- An interface between the hardware and software, consisting of machine instructions
  - that can be invoked by any program



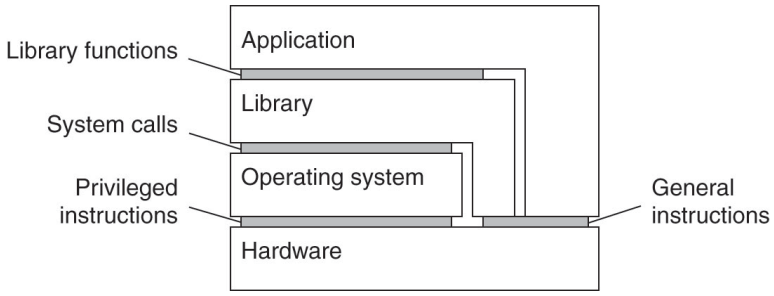
Four Interfaces (2)

- An interface between the hardware and software, consisting of machine instructions
  - that can be invoked only by privileged programs, such as an operating system



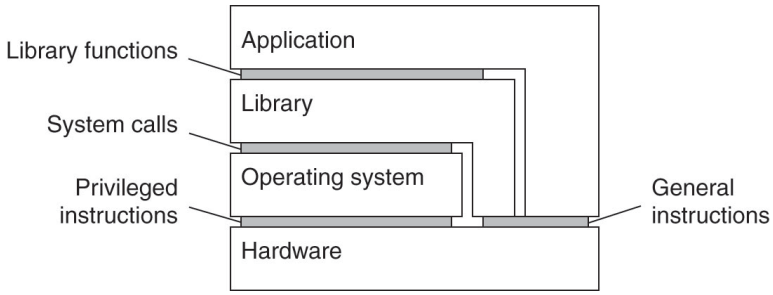
Four Interfaces (3)

- An interface consisting of system calls as offered by an operating system



Four Interfaces (4)

- An interface consisting of library calls
  - Generally forming what is known as an application programming interface (API)
  - In many cases, the aforementioned system calls are hidden by an API



Layers and Views

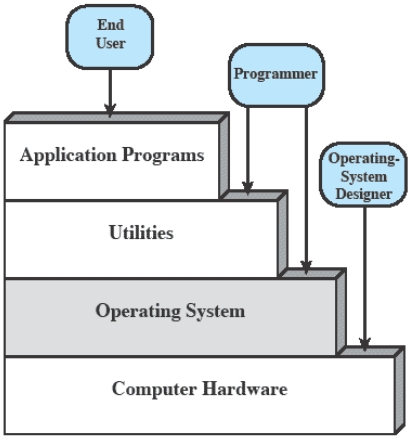


Figure 2.1 Layers and Views of a Computer System

“Nucleus” of a System

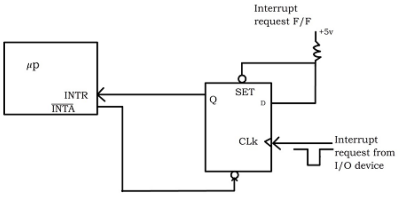
- RC 4000 computer system
  - OS is group of programs communicating via a message passing kernel
  - Sparked the concept of microkernels
  - Ideas that drove further research in the 70s and 80s

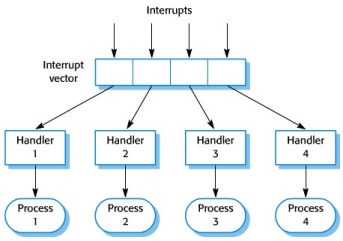
“Nucleus” of a System

- What is the problem addressed in this work?
  - Batch, priority, RT, interactive
- What is the “idea” presented here?
  - System nucleus that can be extended with new OS features
- Process, synchronization, communication, process management

"Nucleus" of a System

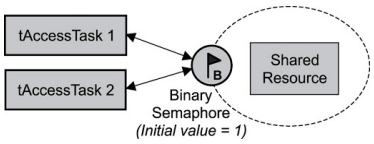
- Process: internal (execution) & external (I/O)
- What is the difference of a program and a process?
- Nucleus: "interrupt response program"?





"Nucleus" of a System

- Process Communication (IPC)
  - Binary semaphores
  - Message buffering
  - Blocking (synchronous communication)
  - FCFS (alternatives?)
  - What if buffer is full?
  - How is addressing performed?
  - Protection, efficiency, resource problem



"Nucleus" of a System

- External processes
  - Reservation & release
  - Backing store
  - Real-time synchronization (timer)
- Internal processes
  - Typical UNIX creation/removal process
  - Scheduling not part of nucleus
  - Process hierarchy
- Final thoughts on paper?

UNIX Time-Sharing System

- PDP-11/45

- File systems & files
  - Ordinary, directories, special
  - "mount" system call
  - Protection
  - I/O Calls

UNIX Time-Sharing System

- Processes
  - What is the difference between image and process?