

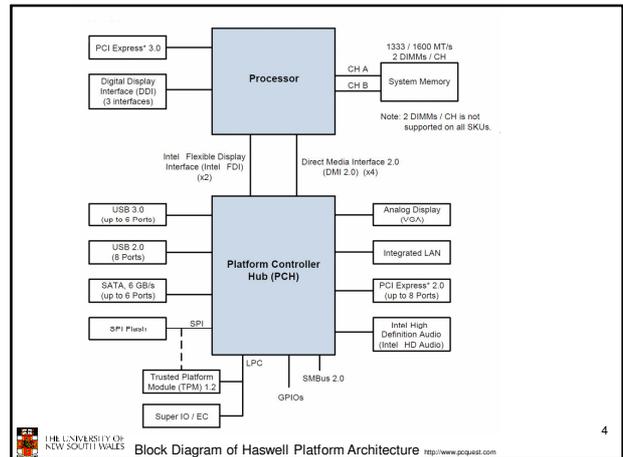
Introduction to Operating Systems

Chapter 1 – 1.3
Chapter 1.5 – 1.9

Learning Outcomes

- High-level understand what is an operating system and the role it plays
- A high-level understanding of the structure of operating systems, applications, and the relationship between them.
- Some knowledge of the services provided by operating systems.
- Exposure to some details of major OS concepts.

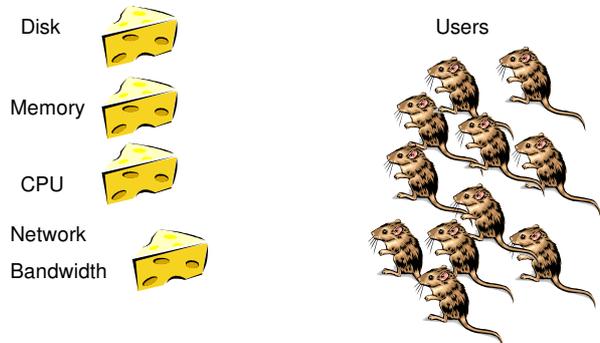
What is an Operating System?



Block Diagram of Haswell Platform Architecture <http://www.pcquest.com>

Role 1: The Operating System is an Abstract Machine

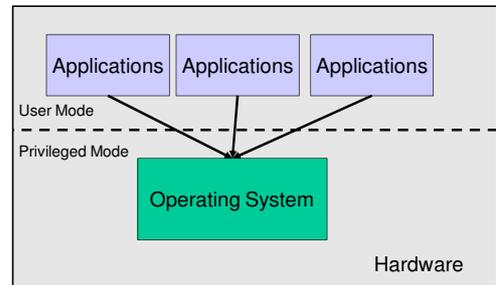
- Extends the basic hardware with added functionality
- Provides high-level abstractions
 - More programmer friendly
 - Common core for all applications
 - E.g. Filesystem instead of just registers on a disk controller
- It hides the details of the hardware
 - Makes application code portable



Role 2: The Operating System is a Resource Manager

- Responsible for allocating resources to users and processes
- Must ensure
 - No Starvation
 - Progress
 - Allocation is according to some desired policy
 - First-come, first-served; Fair share; Weighted fair share; limits (quotas), etc...
 - Overall, that the system is efficiently used

Structural (Implementation) View: the Operating System is the Privileged Component

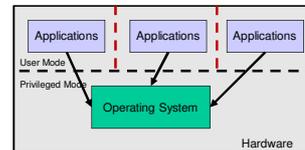


Operating System Kernel

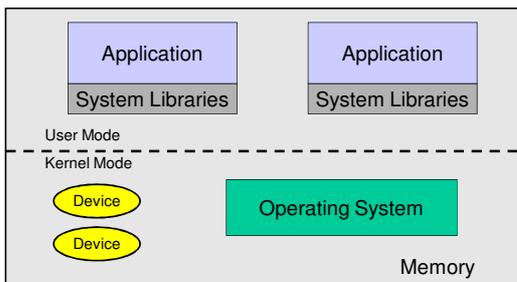
- Portion of the operating system that is running in *privileged mode*
- Usually resident (stays) in main memory
- Contains fundamental functionality
 - Whatever is required to implement other services
 - Whatever is required to provide security
- Contains most-frequently used functions
- Also called the nucleus or supervisor

The Operating System is Privileged

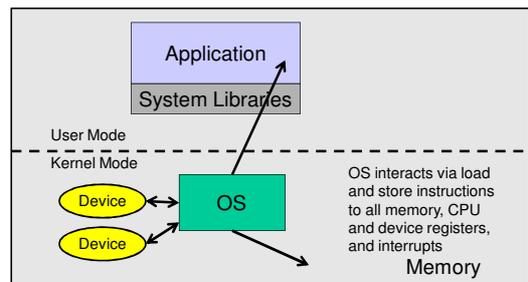
- Applications should not be able to interfere or bypass the operating system
 - OS can enforce the “extended machine”
 - OS can enforce its resource allocation policies
 - Prevent applications from interfering with each other



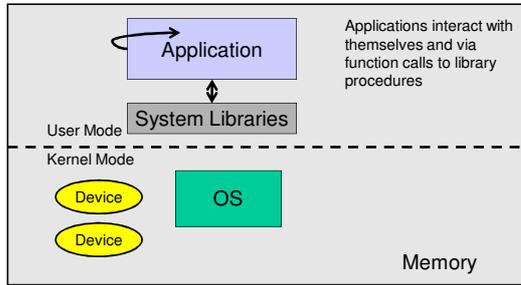
Delving Deeper: The Structure of a Computer System



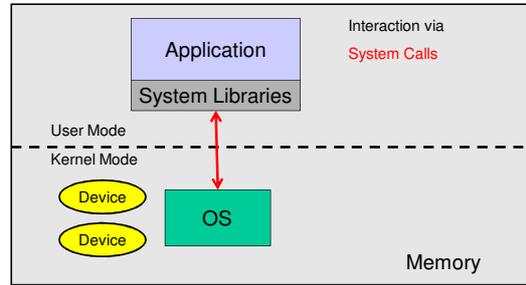
The Structure of a Computer System



The Structure of a Computer System

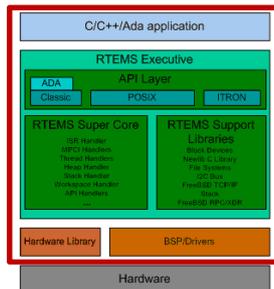


The Structure of a Computer System



Privilege-less OS

- Some Embedded OSs have no privileged component
 - e.g. PalmOS, Mac OS 9, RTEMS
 - Can implement OS functionality, but cannot enforce it.
 - All software runs together
 - No isolation
 - One fault potentially brings down entire system



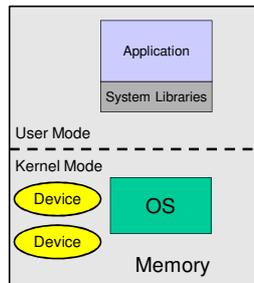
A Note on System Libraries

System libraries are just that, libraries of support functions (procedures, subroutines)

- Only a subset of library functions are actually systems calls
 - strcpy(), memcpy(), are pure library functions
 - manipulate memory within the application, or perform computation
 - open(), close(), read(), write() are system calls
 - they cross the user-kernel boundary, e.g. to read from disk device
 - Implementation mainly focused on passing request to OS and returning result to application
- System call functions are in the library for convenience
 - try `man syscalls` on Linux

Operating System Software

- Fundamentally, OS functions the same way as ordinary computer software
 - It is a program that is executed (just like applications)
 - It has more privileges
- Operating system relinquishes control of the processor to execute other programs
 - Reestablishes control after
 - System calls
 - Interrupts (especially timer interrupts)



Major OS Concepts (Overview)

- Processes
- Concurrency and deadlocks
- Memory management
- Files
- Scheduling and resource management
- Information Security and Protection

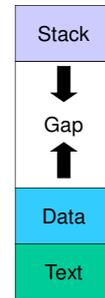
Processes

- A program in execution
- An instance of a program running on a computer
- The entity that can be assigned to and executed on a processor
- A unit of resource ownership

Process

Memory

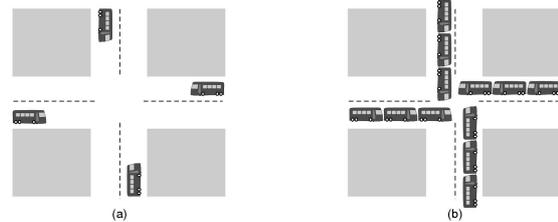
- Minimally consist of three segments
 - Text
 - contains the code (instructions)
 - Data
 - Global variables
 - Stack
 - Activation records of procedure/function/method
 - Local variables
- Note:
 - data can dynamically grow up
 - E.g., malloc()-ing
 - The stack can dynamically grow down
 - E.g., increasing function call depth or recursion



Process state

- Consists of three components
 - An executable program code
 - text
 - Associated data needed by the program
 - Data and stack
 - Execution context of the program
 - Registers, program counter, stack pointer
 - Information the operating system needs to manage the process
 - OS-internal bookkeeping, files open, etc...

Multiple processes creates concurrency issues



(a) A potential deadlock. (b) an actual deadlock.

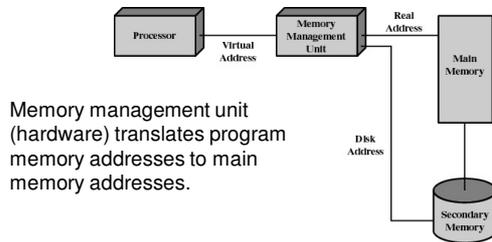
Memory Management

- The view from thirty thousand feet
 - Process isolation
 - Prevent processes from accessing each others data
 - Automatic allocation and management
 - Users want to deal with data structures
 - Users don't want to deal with physical memory directly
 - Protection and access control
 - Still want controlled sharing
 - OS services
 - Virtual memory
 - File system

Virtual Memory

- Allows programmers to address memory from a logical point of view
 - Gives apps the illusion of having RAM to themselves
 - Logical addresses are independent of other processes
 - Provides isolation of processes from each other
- Can overlap execution of one process while swapping in/out others to disk.

Virtual Memory Addressing



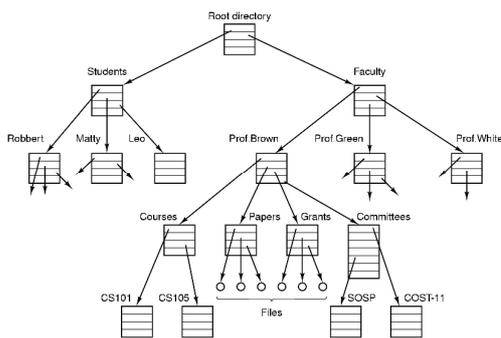
Memory management unit (hardware) translates program memory addresses to main memory addresses.

Figure 2.10 Virtual Memory Addressing

File System

- Implements long-term store
- Information stored in named objects called files

Example File System



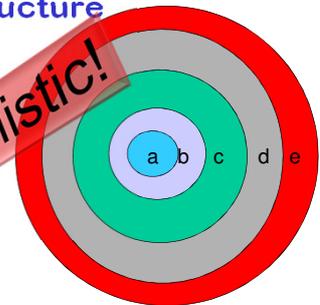
Scheduling and Resource Management

- Fairness
 - give equal and fair access to all processes
- Differential responsiveness
 - discriminate between different classes of jobs
- Efficiency
 - maximize throughput, minimize response time, and accommodate as many uses as possible

Operating System Internal Structure?

Classic Operating System Structure

- The layered approach
 - a) Processor allocation and multiprogramming
 - b) Memory Management
 - c) Devices
 - d) File system
 - e) Users
- Each layer depends on the inner layers

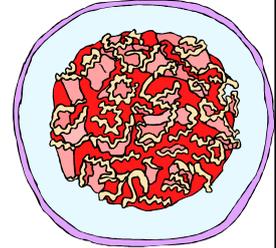


Operating System Structure

- In practice, layering is only a guide
 - Operating Systems have many interdependencies
 - Scheduling on virtual memory
 - Virtual memory (VM) on I/O to disk
 - VM on files (page to file)
 - Files on VM (memory mapped files)
 - And many more...

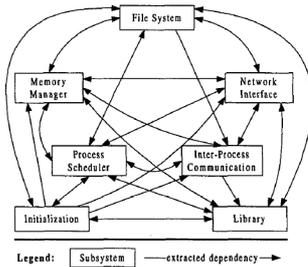
The Monolithic Operating System Structure

- Also called the “spaghetti nest” approach
 - Everything is tangled up with everything else.
- Linux, Windows, ...

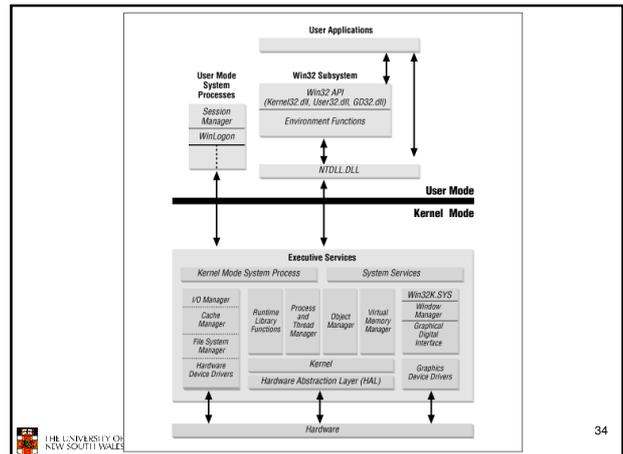


The Monolithic Operating System Structure

- However, some reasonable structure usually prevails



Bowman, J. T., Holt, R. C., and Bhowmick, N. V. 1999. Linux as a case study: its extracted software architecture. In Proceedings of the 21st International Conference on Software Engineering (Los Angeles, California, United States, May 18 - 22, 1999). ICSE '99. ACM, New York, NY, 555-563. DOI: <http://doi.acm.org/10.1145/320465.320591>



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