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# Operating System Overview

Chapter 1.5 – 1.9

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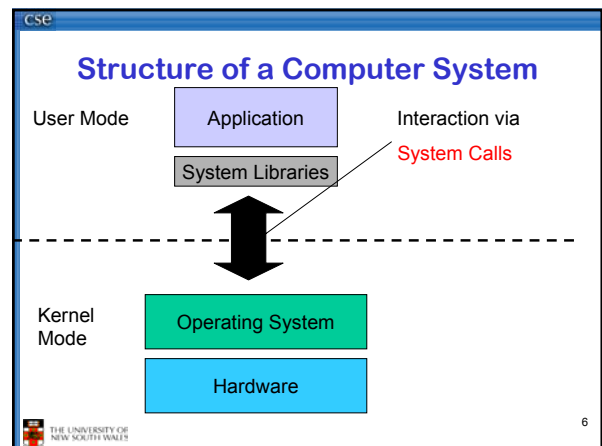
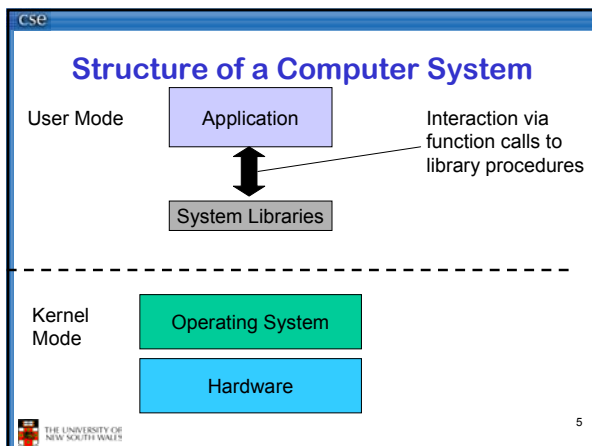
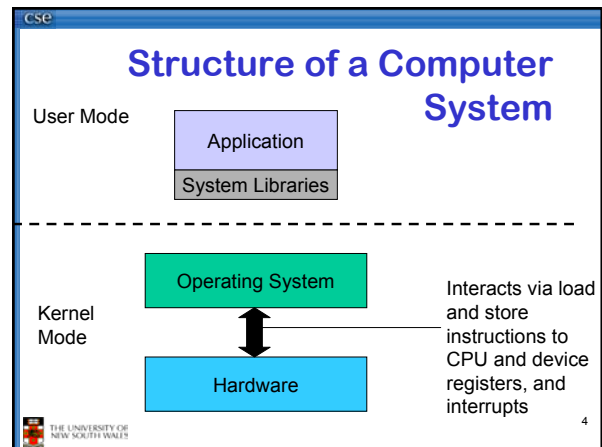
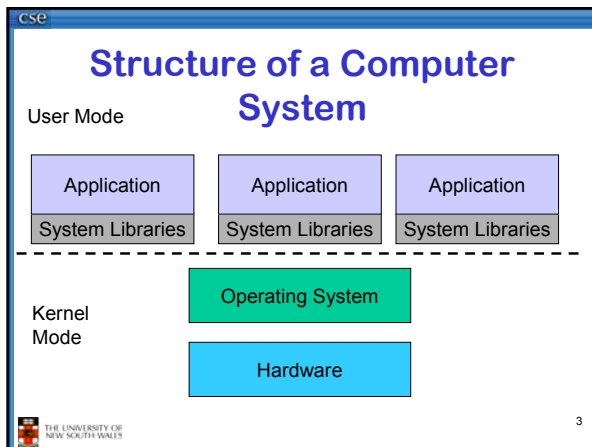
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# Operating System

- A program that controls execution of applications
  - The resource manager
- An interface between applications and hardware
  - The extended machine

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## 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
    - strcmp(), memcpy(), are pure library functions
    - open(), close(), read(), write() are system calls
  - System call functions are in the library for convenience

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## Operating System Objectives

- Convenience
  - Make the computer more convenient to use
- Abstraction
  - Hardware-independent programming model
- Efficiency
  - Allows the computer system to be used in an efficient manner
- Ability to evolve
  - Permit effective development, testing, and introduction of new system functions without interfering with existing services
- Protection

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## Services Provided by the Operating System

- Program development
  - Editors, compilers, debuggers
    - Not so much these days
- Program execution
  - Load a program and its data
- Access to I/O devices
- Controlled access to files
  - Access protection
- System access
  - User authentication

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## Services Provided by the Operating System

- Error detection and response
  - internal and external hardware errors
    - memory error
    - device failure
  - software errors
    - arithmetic overflow
    - access forbidden memory locations
  - operating system cannot grant request of application

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## Services Provided by the Operating System

- Accounting
  - collect statistics
  - monitor performance
  - used to anticipate future enhancements
  - used for billing users

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## Operating System Software

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

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## Kernel

- Portion of the operating system that is running in *privileged mode*
- Usually resident 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

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## Major OS Concepts

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

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## 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
- A unit of activity characterized by a single sequential thread of execution, a current state, and an associated set of system resources
  - Nowadays the execution abstraction is separated out: *Thread*
  - Single process can contain many threads

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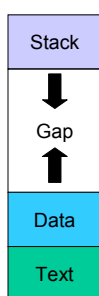
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## Process

Memory

- Consist of three segments
  - Text
    - contains the code (instructions)
  - Data
    - Global variables
  - Stack
    - Activation records of procedure
    - Local variables
- Note:
  - data can dynamically grow up
  - The stack can dynamically grow down



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## Process


- Consists of three components
  - An executable program
    - text
  - Associated data needed by the program
    - Data and stack
  - Execution context of the program
    - All information the operating system needs to manage the process
      - Registers, program counter, stack pointer, etc...
    - A multithread program has a stack and execution context for each thread

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## Multiple processes creates concurrency issues



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

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## Memory Management

- The view from thirty thousand feet
  - Process isolation
    - Prevent processes from accessing each others data
  - Automatic allocation and management
    - Don't want users to deal with physical memory directly
  - Support for modular programming
  - Protection and access control
    - Still want controlled sharing
  - Long-term storage
  - OS services
    - Virtual memory
    - File system

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## 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.

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## Virtual Memory Addressing

The diagram shows a Processor on the left sending Virtual Addresses to a Memory Management Unit (MMU) in the center. The MMU then sends Real Addresses to Main Memory on the right. Additionally, the MMU is connected to Secondary Memory (represented as a disk) via Disk Addresses.

Figure 2.10 Virtual Memory Addressing

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## Paging

- Allows process to be comprised of a number of fixed-size blocks, called pages
- Virtual address is a page number and an offset within the page
- Each page may be located any where in main memory
- A page may actually exist only on disk

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The diagram illustrates the mapping between Main Memory and Disk. Main Memory is shown as a grid of frames, with some containing data (A.1, A.2, A.5, B.0, B.1, B.2, B.3, A.7, A.9, A.8, B.4, B.5, B.6). The Disk is shown as a cylinder with pages numbered 0 to 10. Pages 0-6 are labeled 'User program A' and pages 7-10 are labeled 'User program B'.

Main Memory

Secondary memory (disk) can hold many fixed-length pages. A user program consists of some number of pages. Pages for all programs plus the operating system are on disk, as are files.

Figure 2.9 Virtual Memory Concepts

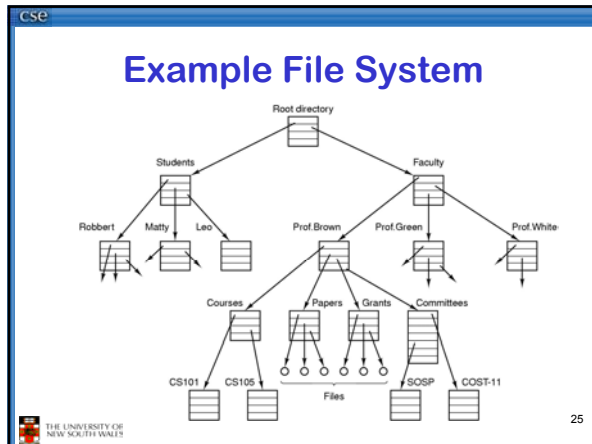
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## File System

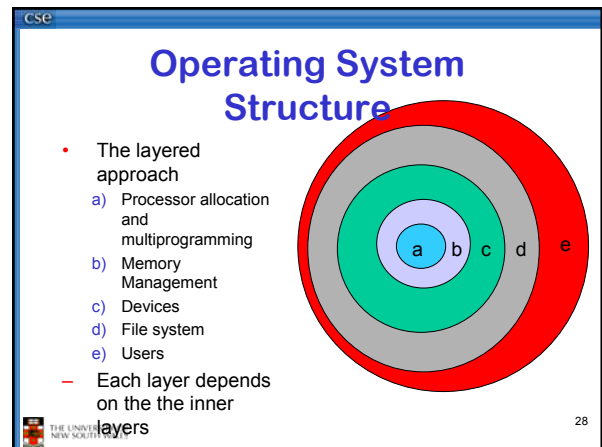
- Implements long-term store
- Information stored in named objects called files

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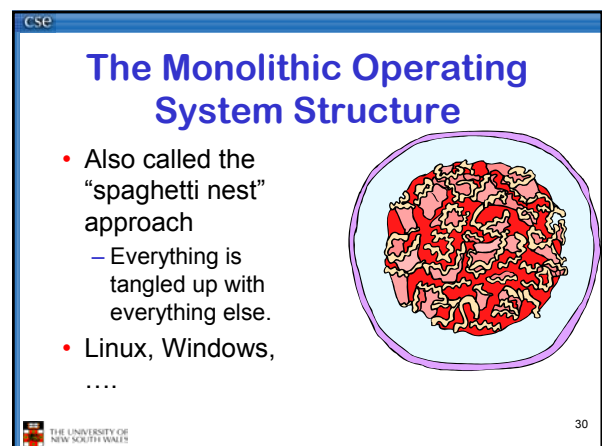


- ### Information Protection and Security
- Access control
    - regulate user access to the system
    - Involves authentication
  - Information flow control
    - regulate flow of data within the system and its delivery to users
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- ### Scheduling 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
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- ### Operating System Structure
- In practice, layering is only a guide
    - Operating Systems have many interdependencies
      - Scheduling on virtual memory
      - Virtual memory on I/O to disk
      - VM on files (page to file)
      - Files on VM (memory mapped files)
      - And many more...
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## The Monolithic Operating System Structure

- However, some reasonable structure usually prevails

Main procedure  
Service procedures  
Utility procedures

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## OS Complexity is a major issue

- Approaches to tackling the problem
  - Safe kernel extensions
    - SPIN - safe programming language
    - VINO – sandboxing (hardware protection)
  - Microkernels
  - Exokernels

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## Microkernel-based Systems

- Assigns only a few essential functions to the kernel
  - Address space
  - Interprocess Communication (IPC)
  - Basic scheduling
  - Minimal hardware abstraction
- Other services implemented by user-level servers
- Traditional “system calls” become IPC requests to servers
- Extreme view of a microkernel
  - A feature is only allowed in the kernel if required for security

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documents windows symbols stacks & heaps arrays & structures variables threads coroutines modules procedures statements

**Application**

File Address Space Semaphore Priority IPC Pipe Socket Process Monitor Event Segment ACL Task Mutex Thread Page Schedule

**Monolithic Kernel**

Bit Byte Word Register Instructions HW

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Server File

documents windows symbols stacks & heaps arrays & structures variables threads coroutines modules procedures statements

**Application**

Address Space Thread

**μ-kernel**

Bit Byte Word Register Instructions HW

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**classic +**

classic OS Security RT MM L4 HW

**thin**

native Java em-bedded app L4 HW

**specialized**

highly-specialized component L4 HW

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## Client/Server Model

- Simplifies the Executive
  - Possible to construct a variety of APIs
- Improves reliability
  - Each service runs as a separate process with its own memory partition
- Provides a uniform means for applications to communicate via IPC
- Provides a base for distributed computing

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## The client/server model

The client-server model of microkernel make it easier to extend to a distributed system

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## UNIX

- Provides a good hardware abstraction
  - Everything is a file (mostly)
- Runs on most hardware
- Comes with a number of user services and interfaces
  - shell
  - C compiler

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## Traditional UNIX Structure

Figure 2.15 General UNIX Architecture

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## Traditional UNIX Kernel

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