CS 502
Introduction to Operating Systems

Spring 99

WPI MetroWest/Southboro Campus

Operating Systems Introduction Outline

- Course Introduction
  - Administration
  - Major components
    - Homework
    - Research Paper Presentation
    - Exams
    - Project
  - Syllabus
- Operating Systems Background
  - Context of Operating Systems
  - Definitions of an Operating System
  - Historical Perspective
- Computer Organization and Operating Systems

Administration

- Professor Thomas Bressoud
  - Stratus Computer (Ascend)
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  - Tom_Bressoud@stratus.com
- Office Hours
  - Before class
  - By appointment
  - 24 hour email response
- Class Email List -- cs502w@cs.wpi.edu
- Web ReCourse
  - http://penguin.wpi.edu:4545
- Textbook

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Course Components

- Homework
  - Two in the first half of the semester. 10% of grade.
- Research Paper Presentation
  - Select a current research paper in the operating systems field and read and understand it and present a short presentation summarizing the work and detailing some aspect of the work.
- Exams
  - A midterm on Oct. 27 and a final on Dec. 15. They count 20% and 30% of your grade respectively. Closed book. One handwritten note sheet permitted.
- The Project
  - Totals 25% of your grade. See next transparency.
- Class Participation
  - 5% of your grade

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The CS 502 Project

- By the end of the semester you will write an operating system for the Z502 computer architecture. The Z502 is a hypothetical processor that is defined for you.
- You will be given a simulator for the Z502 and a suite of user programs to test your Operating System implementation.
- This is a *large* project, involving upwards of a couple thousand lines of code. You must start early to succeed.
- To encourage students to begin early, I will divide Phase 1 into a set of milestones that get turned in for "checkmark" credit. The first two of these milestones are due *next week*.

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CS 502 Project (cont.)

- What did you like about this course/lab?
  - "The project was interesting and challenging. It is a good way to learn the inner workings of an operating system"
  - "The project was extremely well thought-out"
  - "Everything was pretty good, but the project was a lot of fun to work on"
- What did you dislike about this course/lab?
  - "Sometimes too much work to do"
  - "It took a lot of time to do the lab"
  - "Project very time consuming"
- What strategy would you advise a friend?
  - "Start working on project phases as early as possible"
  - "Start the project early!"
  - "Hire a full time maid to keep the house going …"

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Overall Cautions

- Substantial time commitment
  - This is a major project class; students that try to take another class simply run out of time.
  - This burden is lessened if you start early.
- Substantial programming required in C (C++ possible)
  - This is not the time to learn C.
  - Students who have not built modular structures in C (I.e. have mostly built < 100 line programs) can get lost in the effort to program in the large.
- This is an *introduction* to operating systems
  - Considerable overlap with undergraduate OS courses
  - If you are had a CS undergraduate major and/or have taken a course on OS, then the implementation project may be the primary value-add for taking this course. See me.

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For Next Week (January 26):

- Milestone 1: Build the Z502 simulator
  - Download the C source for the Z502 into your development environment and build it. For instructions, see the Student Manual
    - http://www.cs.wpi.edu/~cs502/s99/project/student.html
  - Deliverables:
    - Makefile or equivalent
    - Log of execution run with and without “sample” argument

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For February 2:

- Milestone 2: Build a queue abstract data type (ADT).
  - The assignment is as described for "Phase 0" in the project documentation. This is a very straightforward programming task. Focus on unit testing and clean modular design.
  - URLS:
    - http://www.cs.wpi.edu/~cs502/s99/project/phase0.html
    - http://www.cs.wpi.edu/~cs502/s99/project/implementC.html
    - http://www.cs.wpi.edu/~cs502/s99/project/grading.html

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*What **is** an Operating System?*

- Class provided definitions …

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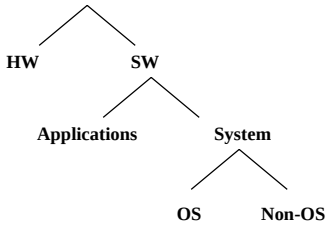
Where does the OS fit in?

- Basic Taxonomy



  - Hardware and Software combined to provide a tool to solve specific problems
  - Software is differentiated according to its purpose
  - System software provides a general environment where programmers/developers can create applications and users can run applications
  - To an end user, the operating system is overhead. What matters is the application.

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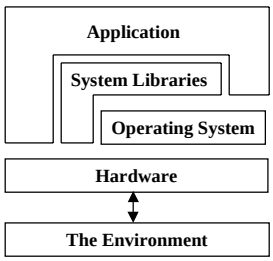
Operating System Context



- The Operating System is the layer between the hardware and the application.
- It implements some desired functionality by building on the functionality in lower levels.
- Software in general transforms one interface into another interface.
- What are the interfaces in this picture?

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Non-OS System Software

What does an Operating System Do?

- Objectives of an OS
  - Convenience
    - An operating system makes a computer more convenient to use.
  - Efficiency
    - An operating system allows the computer system resources to be used in an efficient manner.
  - Ability to Evolve
    - Should permit effective development, testing, and introduction of new system features and functions without interfering with service.
- Perspective-based OS Definition:
  - The OS is a manager of the computer system resources
  - The OS implements/manages virtual computers

Hardware Resources

- Processor
  - Component capable of executing instructions
- Memory
  - Contains all instructions and data used by a processor
  - Sometimes referred to as physical or primary memory
- Disk Devices
  - Long term storage of data
- I/O Controllers
  - Processors that are able to transfer data between memory and devices
  - Video, Terminal, Network, Mouse, Tape Drives, etc.

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The Functions of Resource Management

- Transformation
  - Hardware resources have complex interfaces
  - Operating system transforms physical resources into virtual resources that provide similar functionality to their physical counterpart, but have a simper interface.
- Multiplexing
  - Provide the sharing of physical resources among multiple users
  - Time division multiplexing
    - Exclusive use at different points in time
    - Appropriate when the resource cannot be divided into smaller versions of itself.
  - Space division multiplexing
    - A resource is divided into smaller versions of itself and each app/user is given its own part of the resource.

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Resource Management (Cont.)

- Scheduling
  - Deciding which users should be allocated what resources and when they should get it.
  - Includes allocation and security/protection.

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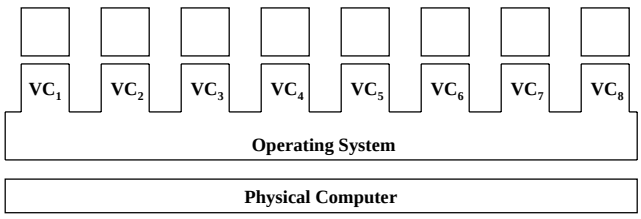
The OS as implementer of Virtual Computers



- The operating system creates software copies of the processor (the capability to execute instructions) and the memory (the capability to store information. Each constitutes a Virtual Computer (VC).
- Also transforms the devices into more abstract and easily used devices. In this way, it is building an extended machine.

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The Virtual Computer

- The Virtual Processor
  - Nearly the same interface to the user as the physical processor (I.e. nearly the same instructions) for efficiency.
  - Removes some of the physical processor instructions and adds some other “instructions” (operations).
    - Instructions are *removed* by making them privileged
    - Added operations are *system calls.* These allow the virtual processor to request virtual resources from the operating system:
      - Create new virtual computers
      - Communicate with other virtual computers
      - Allocate storage as needed
      - Perform I/O
      - Access persistent storage through file system model
  - Shares the physical processor through time multiplexing

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The Virtual Computer (Cont.)

- Virtual Primary Memory
  - Create the illusion of memory similar to hardware memory.
  - Start at 0 and addressable in bytes, load and store in words.
  - Shared via a combination of time multiplex and space multiplex of physical memory and space multiplex of secondary storage.
- Virtual Persistent Storage
  - File System
  - Shared via space multiplex
- Virtual I/O controllers and communications devices
  - Generally time multiplex most other devices.

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