Course Overview
Lecture 1

Course Book:
Operating System Concepts
Silberschatz & Galvin
Wiley
Additional Reading:
Operating Systems, Internals and Design Principles
Stallings (4th Edition), Prentice Hall

Understanding the Linux Kernel
Bovet & Cesati, O'Reilly

Operating System – Definitions

- A set of programs that provide convenience for the user – *no*.
- A program that acts as an intermediary between a user of a computer and the computer hardware – *yes*.
- A source of overhead that runs when you are trying to get useful work done – *yes*.
- The fundamental enforcer of protection and resource arbitration in a multi-use computer system – *yes*.

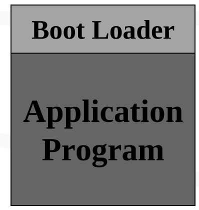
History: How Did We Get Here

- Early: no operating system at all *(real* programmers use toggle switches).
  - "Computers may someday weigh less than 150 tons." – *Popular Electronics*
- Batch systems
  - Single programming
  - Multiprogramming
- Time sharing systems (*modern* programmers eat quiche).
  - Networked and Distributed Operating Systems
- Multimedia and real-time systems
- Future: secure, reliable operating systems

The "Core" of an Early Processor

- Three types of instructions:
  - Arithmetic (add, subtract, and, or, etc.)
  - Load/Store (transfer between memory, registers)
  - Control transfer (Jump, Call)
- No protection mechanism
- One level memory hierarchy
  - Memory used to be faster than CPU!

The “Bare Iron” Era



- One program, one machine!
- Billing was by machine hours
- Key innovations:
  - – Bigger, Faster memories
    - Ferrite core => transistors (HCF: Halt and Catch Fire)
    - As much as 8 Kwords!
  - – Devices to speed loading of programs and data
    - Paper tapes, punch cards

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Simple Batch Systems

- Sequence jobs and transfer control automatically from job to job
  - – Saves setup time for jobs
- Hardware Innovations:
  - – Interrupts
- Monitor the current job
  - – Resource consumption, *billing*
- Device drivers

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Batch Multiprogramming

- Several jobs in memory
- While one program waits for I/O, another is executed
- Key Hardware Innovations:
  - Supervisor Mode
  - Drums (early disk drives)
- OS Innovations:
  - Protection
  - **Swapping**
  - Some Scheduling
  - **Accounting**

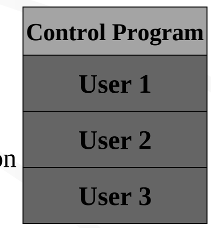
Control Program
Application 1
Application 2
Application 3

Relative Efficiency

Read one record from file	0.0015 sec
Execute 100 instructions	0.0001 sec
Write one record to file	0.0015 sec
TOTAL	0.0031 sec
% CPU Utilization	0.0001/0.0031 = 3.2%

The Mainframe (IBM, UNIVAC)

- Targets: companies
- Dawn of timesharing: ADP, Tymshare
- Key Innovations:
  - Large memories (64 Kbytes!)
  - Large disk drives (megabytes)
  - SSI circuits
  - Memory hierarchies
- OS Evolution:
  - Interactive command processing
  - Beginnings of online environments
  - Key Issues:
    - Protection
    - **Scheduling**
    - File Systems
    - Synchronization
    - **Accounting**



The “Core” of a Modern Processor

- Four or five types of instructions:
  - Arithmetic
  - Load/Store
  - Control transfer
  - Floating Point
  - Vector (e.g. MPX extensions)
- Protection
  - Address translation (virtual memory)
  - Privilege violation exceptions
  - Supervisor mode
- Five level memory hierarchy
  - Registers
  - L1 cache
  - L2 cache
  - Main memory
  - Disk

Time Sharing Systems

- Interactive use of a computer
- Several users can share the computer simultaneously
- Issues:
  - Scheduling
  - Synchronization
  - File systems
  - Security

- Questions:
  - Which is more efficient, time sharing systems or multiprogramming batch systems?
  - Which is more cost effective?

Comparison

	Batch Multiprogramming	Time Sharing
Main Objective	Maximize Processor Utilization	Minimize response time to user commands
Outcome	Throughput	Interactive Work

The Minicomputer (DEC, DG)

- Target: departments
- Drive the price down, usability up
- Timesharing turns service bureau
- Key Innovations:
  - “**Paging**” (B5500)
  - LSI circuits
  - 15”, 8” fixed disk

- OS Innovations:
  - UNIX (Bell Labs)
  - VMS (DEC)
  - Pick (Pick Computers)
  - VM (IBM)
- Other:
  - Ethernet (Xerox PARC)
  - Accounting issue fades

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Personal Computers

- Target: individuals
  - Computing for the masses
- Conceived as mainframe enhancer!
- Key Innovations:
  - Winchester Disk
  - VLSI circuits

- OS Innovations:
  - CP/M
  - DOS ☹
  - SmallTalk and window systems
  - Windows
- Other
  - No accounting at all!
  - No protection!

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Personal Systems

- *Exclusive* interactive use of a computer
- Several programs, one user
- Issues:
  - Cost
  - Cost
  - More Cost
- Questions:
  - Are PC's more cost effective than minicomputers?
  - What about maintenance cost?

Trends

- Each generation:
  - Reduced cost by 10x or more
  - Improved performance by 10x or more
  - Improved capacity by 10x or more
  - Introduced dramatic improvement in subjective functionality (timesharing, window systems)
  - Increased number of customers by 100x
  - Increased the degree of multiprocessing (and consequently the need for protection, resource management)

OS: The Next Generation

- Multimedia:
  - scheduling
  - resource reservation
- Security:
  - The emporer has no clothes
  - It's the dead of winter
  - Tailoring hasn't been invented
- There is a *huge* investment in existing (insecure) systems
- Follow the money (incentives)!
  - Good news (sort of): big companies are now getting ripped off.
- Security will take >$1B of investment to get *started.*

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Course Content

- Introduction (Jan 29-31)
- Process Control and Scheduling (Feb 5-7)
- Process Synchronization (Feb 12-14)
- Deadlocks (Feb 19-21)
- Memory Management (Feb 26-28)
- Virtual Memory (Mar 5-7)
- File Systems (Mar 12-14)
- File System and Disk Management (Mar 26-28)

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Course Content (cont.)

- Access Control and Security (Apr 2-4)
- Microkernels, Distributed Systems (Apr 9-11)
- Discussion (Apr 16-18)
- Final Exam (Apr 23-25)
- Advanced Topics (Apr 30-May 2)

More or less…

Tutorial Content

- Presenting and discussing projects
- VMWare – our basic working environment
- Linux – our basic operating system
- Case studies of component implementations in different popular operating systems
- Questions and Answers