Course Overview

Lecture 1

Course Books:
- Operating Systems
  Deitel, Deitel and Chodnes
  Wiley
- Understanding the Linux Kernel
  (SECOND EDITION ONLY!!!)
  Bovet & Cassati

Jonathan had to be away

- For 2 weeks…
- My name is Andreas Terzis.
- Prof. Yair Amir and myself will cover for Jonathan.

Course Information

- Professor Jonathan Shapiro,
  shap@cs.jhu.edu
- Jonathan’s Office Hours: Tuesday & Wednesday at 9:30am.
- TA: John Lane, johnlane@jhu.edu

Course Information

- Course web site: http://srl.cs.jhu.edu and follow the links from there
- Students MUST join the mailing list: http://eros.cs.jhu.edu/mailman/listinfo
- No excuses regarding mailing list messages.
- Mailing list archives: http://eros.cs.jhu.edu/pipermail/cs318
Course Information

- Grading:
  - Default: 50% projects, 30% final exam, 20% homework and quizzes.
  - One of the projects could become a final project and cancel the final exam.
  - Late homework gets a zero. Late project gets a zero (unless arrangements are made in extreme personal circumstances).

Prerequisites

- A strong reading and writing knowledge of the C language.
- If you do not have that, this is not the course for you.
- If you know other languages including at least one systems programming language, you may be able to pick up C as you go. If the only programming language background you have is Java, experience suggests that you are not likely to do well in this course.
- The first assignment (given today) will tell you whether you should drop the course.

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

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

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
Relative Efficiency

<table>
<thead>
<tr>
<th>Operation</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read one record from file</td>
<td>0.0015 sec</td>
</tr>
<tr>
<td>Execute 100 instructions</td>
<td>0.0001 sec</td>
</tr>
<tr>
<td>Write one record to file</td>
<td>0.0015 sec</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>0.0031 sec</strong></td>
</tr>
</tbody>
</table>

% CPU Utilization = \( \frac{0.0001}{0.0031} = 3.2\% \)

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

<table>
<thead>
<tr>
<th>Batch Multiprogramming</th>
<th>Time Sharing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Objective</td>
<td></td>
</tr>
<tr>
<td>Maximize Processor Utilization</td>
<td>Minimize response time to user commands</td>
</tr>
<tr>
<td>Outcome</td>
<td>Throughput</td>
</tr>
</tbody>
</table>

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

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!
- Questions:
  - Are PC’s more cost effective than minicomputers?
  - What about maintenance cost?

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 emperor 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.

Course Content

- Introduction (Jan 26-27)
- Process Control and Scheduling (Feb 2-3)
- Process Synchronization (Feb 9-10)
- Deadlocks (Feb 16-17)
- Memory Management (Feb 23-24)
- Virtual Memory (Mar 1-2)
- File Systems (Mar 8-9)
- File System and Disk Management (Mar 22-23)

Course Content (cont.)

- Access Control and Security (March 29-30)
- Microkernels, Distributed Systems (Apr 5-6)
- Discussion (Apr 12-13)
- Final Exam (Apr 19-20)
- Advanced Topics (Apr 26-27)

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