Graduate Operating Systems
(History & Architecture)

Fall 2020

Today’s Paper(s)


Operating System

• A program that controls the execution of application programs
• An interface between applications and hardware

User vs Kernel Mode

• User program executes in **user mode**
  – Certain instructions may not be executed
  – Certain memory areas are protected from user’s use and may not be accessed
• OS/kernel executes in **system (kernel) mode**
  – Privileged instructions are executed
  – Protected areas of memory may be accessed
Multiprogramming

- When one job needs to wait for I/O, the processor can switch to the other job

<table>
<thead>
<tr>
<th>Program A</th>
<th>Run</th>
<th>Wait</th>
<th>Run</th>
<th>Wait</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program B</td>
<td>Wait</td>
<td>Run</td>
<td>Wait</td>
<td>Run</td>
</tr>
<tr>
<td>Program C</td>
<td>Wait</td>
<td>Run</td>
<td>Wait</td>
<td>Run</td>
</tr>
<tr>
<td>Combined</td>
<td>Run A</td>
<td>Run B</td>
<td>Run C</td>
<td>Wait</td>
</tr>
</tbody>
</table>

(c) Multiprogramming with three programs

OS Responsibilities

- Program Development and Execution
- Process Management
- Memory Management
- I/O & File Management
- Protection and Security
- Inter-Process Communication
- Synchronization (Deadlocks)
- Accounting & Logging
- ...

Four Interfaces

• Figure 3-6. Various interfaces offered by computer systems.

Four Interfaces (1)

• An interface between the hardware and software, consisting of machine instructions – that can be invoked by any program
Four Interfaces (2)

- An interface between the hardware and software, consisting of **machine instructions**
  - that can be invoked only by privileged programs, such as an operating system

Four Interfaces (3)

- An interface consisting of **system calls** as offered by an operating system
Four Interfaces (4)

- An interface consisting of **library calls**
  - Generally forming what is known as an application programming interface (API)
  - In many cases, the aforementioned system calls are hidden by an API

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**Figure 2.1 Layers and Views of a Computer System**

- **Layers and Views**
  - End User
  - Programmer
  - Operating-System Designer

- **Application Programs**
- **Utilities**
- **Operating System**
- **Computer Hardware**
“Nucleus” of a System

• RC 4000 computer system
  – OS is group of programs communicating via a message passing kernel
  – Sparked the concept of microkernels
  – Ideas that drove further research in the 70s and 80s

“Nucleus” of a System

• What is the problem addressed in this work?
  – Batch, priority, RT, interactive
• What is the “idea” presented here?
  – System nucleus that can be extended with new OS features
• Process, synchronization, communication, process management
“Nucleus” of a System

• Process: internal (execution) & external (I/O)

• What is the difference of a program and a process?

• Nucleus: “interrupt response program”?

Process Communication (IPC)

– Binary semaphores

– Message buffering

– Blocking (synchronous communication)

– FCFS (alternatives?)

– What if buffer is full?

– How is addressing performed?

– Protection, efficiency, resource problem
“Nucleus” of a System

- External processes
  - Reservation & release
  - Backing store
  - Real-time synchronization (timer)
- Internal processes
  - Typical UNIX creation/removal process
  - Scheduling not part of nucleus
  - Process hierarchy
- Final thoughts on paper?

UNIX Time-Sharing System

- PDP-11/45

- File systems & files
  - Ordinary, directories, special
  - “mount” system call
  - Protection
  - I/O Calls
UNIX Time-Sharing System

• Processes
  – What is the difference between image and process?