Today

IPC (Inter-process communication)
- named pipes
- shared memory
- signals

Scheduling
1) First-Come, First Serve
2) Round-Robin
3) Priority + Decay

System Calls
- calling conventions
- software interrupts
- exception/privilege levels

The first process
- bootstrapping
- more processes

Concurrency
- threads
- multiprocessor/multicore
Calling Conventions

- Machine
- Rust
- C

Which registers are ok to split (save/restore)
- How to pass parameters
- Where to store return address (link address) \( \text{lr} \) (r30), stack "Call!!!", ret

\[
\begin{array}{c}
\text{mov a, r0} \\
\text{mov b.0, r1} \\
\text{mov b.1, r2}
\end{array}
\]

\[
\begin{array}{c}
\text{pop p9} \\
\text{mov p9[5r+8]} \\
\text{mov p9[3r+8]}
\end{array}
\]

\[
\begin{array}{c}
\text{f} \\
\text{f(a; usize, b; isize) \rightarrow q}
\end{array}
\]

\[
\begin{array}{c}
\text{fn} \\
\text{f(a; usize, b; isize) \rightarrow q}
\end{array}
\]

\[
\begin{array}{c}
\text{return} \\
\text{ret}
\end{array}
\]
fn id(a: T) → T
System Calls

A request from user-level for the kernel. (typically numbered)
- typically to perform some privileged operation
  on behalf of the user

Example: read/write from disk
  : allocate memory
  : signal a process
  : create memory mapping
  : create a new process

A: Protected transfer from fewer to greater privileges.

Q: Where have we heard this before?
A: Interrupts + Exceptions!
User Mode

- Hardware exposes "privilege levels".
- OS configurations HW to run in lowest priv. level for user proc, highest for kernel.

<table>
<thead>
<tr>
<th>User Level (PL0)</th>
<th>Full Permissions</th>
<th>V VM V IDT V change PL V priv. instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>User-level</td>
<td>Permissions</td>
<td>R/W certain registers X, raw I/O X</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R/W certain memory X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PL1</th>
<th>Kernel-level</th>
<th>DSyscall or exception</th>
<th>Interrupt</th>
</tr>
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<tr>
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*Architecture dependent*
System Calls

Intel: "rings!"
ARM: "exception levels!"

Intel x86
Intel x64
Intel x64 32-bit

"syscalls!"
"int!
"brk!"
AArch64

Software Interrupt

how many?
- Drawbridge
- 300 → 17
- Linux
- 300

bootوير
jump