Precept 2: Non-preemptive Scheduler

COS 318: Fall 2021

Done with Bootloader!

- Now we want to add functionality to the kernel to run (many) programs!
- Have some hard-coded kernel-space programs to run
- We want each program to be able to yield periodically

Project 2 Schedule

- **Precept:** Monday 9/27, Tuesday 9/28, 7:30pm
- **Design Review:** Tuesday 9/28 8:30-10:30pm, Wednesday 9/29 3-7pm

  https://www.cs.princeton.edu/courses/archive/fall21/cos318/projects/signup/2.cgi
- **Due:** Sunday 10/10, 11:55pm

Project 2 Overview

- Goal: Build a non-preemptive kernel that can switch between different tasks (task = process or kernel thread)
- Read the project spec for more details
- *Start early*

What is a Non-Preemptive Kernel?

Current running task loses CPU or running state in the following scenarios:

1. **Yield**
2. **Block:** I/O operation, Lock (thread)
3. **Exit**

What is a Non-Preemptive Kernel?

COS 318:

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go_to_class();
go_to_precept();
yield();
thinking ();
design_review()
yield();
coding();
exit();
```

Life:

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have_fun();
yield();
play();
yield();
do_random_stuff()
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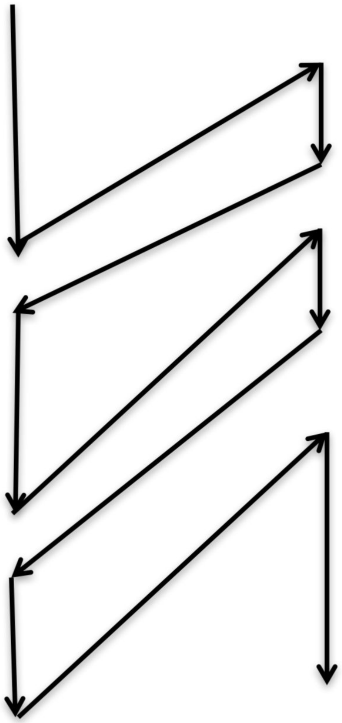

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What You Need to Deal With

1. Process Control Blocks (PCBs)
2. User and Kernel Stack
3. Basic System Call Mechanism
4. Context Switching
5. Mutual Exclusion

Assumptions

- **Protected Mode:** No more segment registers: 32 bit memory, no more BIOS
- **Non-Preemptive Tasks:** Run code until yield, block, or exit
- **Fixed Number of Tasks:** Allocate per-task state (PCB) statically in your program at compile time
- **Fixed Task Stack Size**

1. Process Control Block (PCB)

- Defined in `kernel.h` and initialized in `kernel.c:_start`
- What is its purpose?
- What should be in the PCB?

  - Process ID (PID)

  - Stack Info

  - Registers

  - CPU Time

  - Etc.

2. Allocating Stacks

- Allocate separate user-space stacks for each task in **kernel.c:_start()**
- In theory, processes have two stacks:
  1. User Stack: For the process to use
  2. Kernel Stack: For the kernel to use when executing system calls on behalf of the process

  Option: In this assignment, you can opt to use only one stack
- Kernel threads need only one stack
- 4kB per stack is enough

3. System Calls - Typically...

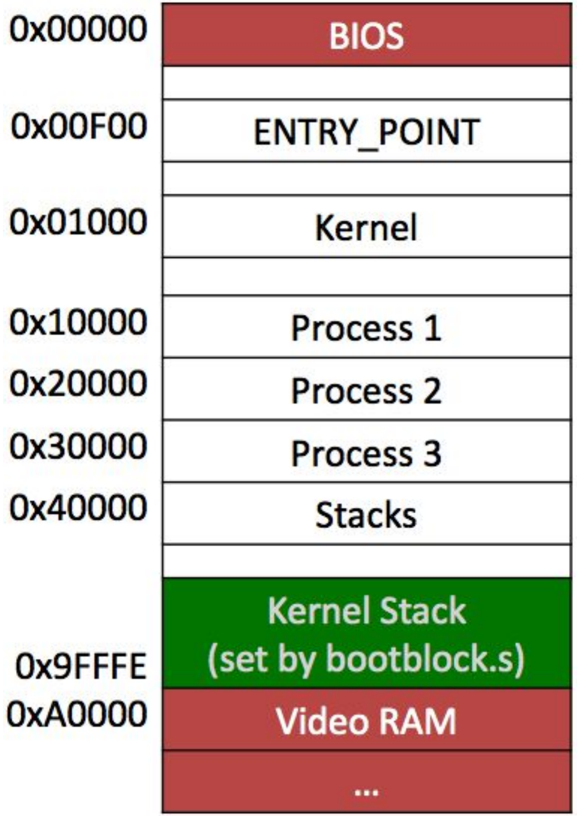
- let user processes ask for kernel services
- Standard Procedure:
  - Push system call ID + arguments onto stack
  - Interrupt / trap: elevate privileges + jumps into kernel
- NOT the case for this assignment...

3. System Calls - In this project

- User processes use library **`syslib.h`**
- This library allows for:
  - Loading kernel entry point address from known location in memory (**`ENTRY_POINT`**)
  - Push system call ID onto stack + call **`kernel_entry`** function

3. System Calls - `kernel_entry`

- **`kernel_entry`** address stored at **`ENTRY_POINT`** (0xf00)
- Saves registers + switches to kernel stack
- Does the reverse when exiting the kernel



4. Context Switch - Overview

- Goal: safely switch currently running task
- When does this happen?
  - Preemptive OS: typically when OS dictates: i.e. timer interrupt
  - Non-preemptive OS: when task yields or exits

4. Context Switch - Responsibilities

1. Save task state into PCB
2. Push current PCB into ready or block queue
3. Choose new task from ready queue + pop its PCB
4. Restore new task state + run it

4. Context Switch - Saving State

- Tasks should not care what happens while its not running - save current state in its PCB:
  - General purpose registers (including %esp)
  - Flags
- What about the instruction pointer?

4. Context Switch - Scheduling

- Kernel must maintain:
  - Ready Queue: tasks ready to be run
  - Blocked Queue: tasks blocked on some resource
- Which task runs next?
  - Regular: round-robin EC: lowest run-time

5. Mutual Exclusion (via locks)

- Spinlock implementation is provided, you must implement a blocking lock
    - See spec for precise requirements
- No preemption => no race conditions *
- Exactly one correct trace

Timing context switches

- `util.c:get_timer` returns # cycles since boot
- Implement parts of `th3` and `process3`
    - `process3` included twice in task list - be able to distinguish between the two executions

Tips + Things to think about...

- What should you do when a kernel thread is run for the first time?
- What state should be saved to PCB? In what order?
- Code and test incrementally

Design Review

(Tue & Wed, Sep 28th & 29th) Answer the questions:

- **Process Control Block:** What will be in your PCB and what will it be initialized to?
- **Context Switching:** How will you save and restore a task's context? Should anything special be done for the first task?
- **Processes:** What, if any, are the differences between threads and processes and how they are handled?
- **Mutual Exclusion:** What's your plan for implementing mutual exclusion?
- **Scheduling:** Look at the project web page for questions about an execution example.

Uses of Non-Preemptive Schedulers

- Generators in python, coroutines in C#, async operator in Javascript, must maintain state between function calls
- Inside the runtime of programming languages, i.e. Go’s goroutines will yield when locking if lock is held
- Real-time Operating Systems, such as pacemakers, or other medical devices

Questions?