

Slide 1

### Administrivia

- Reminder: Reading quizzes 3 and 4 due this week, Homeworks 3a and 3b Monday.
- For the midterm I'm planning a take-home exam, open book/notes like all my exams. (I haven't decided about timed versus untimed.) I'd like to make that available middle of next week and give you about a week to work on it. (More in the minute essay.)

Slide 2

### O/S Versus Application Programs — Recap/Review

- Should seem reasonable to make distinction between what O/S can do and what application programs can do.
  - But how to enforce that? i.e., how to make it as difficult as possible for buggy or malicious application programs to do what they shouldn't?
- Can this problem be solved completely by clever programming? Consider that most current systems can be asked to load and execute machine-level application code . . .

### O/S Versus Application Programs, Continued

- If you don't allow that — how do you decide what's okay?
- If you do allow loading and executing arbitrary code, then some sort of hardware mechanism for limiting what it can do seems like the only way. This is the problem “dual-mode operation” is intended to solve.

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### O/S Versus Application Programs, Continued

- At hardware level, then, need to keep track of which mode we're in and use that information to allow/disallow certain operations (and maybe memory accesses — though that could be a separate problem/solution).
- To do this efficiently — single bit in a register somewhere, probably a special-purpose one, checked by “privileged” instructions.
- What happens if unprivileged program tries . . . ? Hardware version of exception — interrupt.
- How to set this bit? privileged operation, or no?

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### O/S Versus Application Programs, Continued

- But if setting the “privileged okay” bit is itself privileged, how do you ever get from unprivileged to privileged?
- A solution: Include instruction to generate interrupt, and have hardware, on interrupt, transfer control to a fixed location *and* set the “privileged” bit. If what’s at the fixed location is O/S code, then it can do more checking (e.g., passwords). (This is what’s behind “system calls”.)
- Now, if what’s at that fixed location is not O/S code . . . (So you probably don’t want that!)

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### O/S Versus Application Programs, Continued

- So maybe we need memory protection too? but we probably needed that anyway.
- How to make memory protection work? more about that later, but for now — again, seems like the only way to do this reliably and efficiently is with help from hardware.
- Most (many?) schemes for memory protection involve some special-purposes registers. Access to these registers — privileged mode or not?

### O/S Versus Application Programs, Continued

- How about general-purpose registers? and the PC? should accessing them be privileged, or not?
- (Consider what the processor is actually doing — executing instructions.)

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### Homework 1 Programming Problem, Revisited

- What most people turned in was not bad — most (but not all!) of you figured out what information to pass to the two system-call functions. (Review briefly.)
- What almost no one got, though, was what happens if `execve` fails!

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### Homework 1 Programming Problem, Revisited

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- The simple shell you wrote in this assignment created a new process for each command, using `fork()`, which creates *a full copy of the calling process*, including its program counter, with the intent of using this process to run the desired command. So now you have two processes, a “parent” and a “child” ...
- The parent process should then wait for the child to complete (successfully or not) and then continue with the next command.
- Meanwhile, the child process should use `execve` to — what? If it succeeds, it discards the running program (a copy of the parent process) and executes the program from the specified file, terminating when it's done. What if it doesn't succeed? *The existing program keeps running*. “Oops”? Does this explain behavior that — were you puzzled?

### Minute Essay

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- Anything you'd like me to review before the midterm?
- Will the proposed schedule for the midterm work for you?