Slide 1

Administrivia

- Reminder: Homework 2 due today.
- About the midterm . . .

  I wanted us it include all of Chapters 1 and 2, but that's not realistic if it's going to happen a week from today. I'm inclined to move it to Friday after break and have it cover only material through today's lecture. Then we can have one more homework, over what we've done since the preceding homework.

  Please send me mail today if this is *not* okay; otherwise we'll reschedule.

Slide 2

Classical IPC Problems

- Literature (and textbooks) on operating systems talk about "classical problems" of interprocess communication.
- Idea — each is an abstract/simplified version of problems o/s designers actually need to solve. Also a good way to compare ease-of-use of various synchronization mechanisms.
- Examples so far — mutual exclusion, bounded buffer.
- Other examples sometimes described in silly anthropomorphic terms, but underlying problem is a simplified version of something "real".

Slide 3

Dining Philosophers Problem

- Scenario (originally proposed by Dijkstra, 1972):
  - Five philosophers sitting around a table, each alternating between thinking and eating.
  - Between every pair of philosophers, a fork; philosopher must have two forks to eat.
  - So, neighbors can't eat at the same time, but non-neighbors can.
- Why is this interesting or important? It's a simple example of something more complex than mutual exclusion — multiple shared resources (forks), processes (philosophers) must obtain two resources together. (Why five? smallest number that's "interesting".)

Slide 4

Dining Philosophers — Naive Solution

- Naive approach — we have five mutual-exclusion problems to solve (one per fork), so just solve them.
- Does this work? No — deadlock possible.

Dining Philosophers — Simple Solution

- Another approach — just use a solution to the mutual exclusion problem to let only one philosopher at a time eat.
- Does this work? Well, it "works" w.r.t. meeting safety condition and no deadlock, but it's too restrictive.

Slide 5

Dining Philosophers — Dijkstra Solution

- Another approach — use shared variables to track state of philosophers and semaphores to synchronize.
- I.e., variables are
  - Array of five `state` variables (`states[5]`), possible values `thinking`, `hungry`, `eating`. Initially all `thinking`.
  - Semaphore `mutex`, initial value 1, to enforce one-at-a-time access to `states`.
  - Array of five semaphores `self[5]`, initial values 0, to allow us to make philosophers wait.
- And then the code is somewhat complex . . .

Slide 6

Slide 7

Dining Philosophers — Code

- Shared variables as on previous slide.

Pseudocode for philosopher i:

```
while (true) {
    think();
    down(mutex);
    state[i] = hungry;
    test(i);
    up(mutex);
    down(self[i]);
    eat();
    down(mutex);
    state[i] = thinking;
    test(right(i));
    test(left(i));
    up(mutex);
}
```

Pseudocode for function:

```
void test(i)
{
    if ((state[left(i)] != eating) &&
            (state[right(i)] != eating) &&
            (state[i] == hungry))
    {
        state[i] = eating;
        up(self[i]);
    }
}
```

Slide 8

Dining Philosophers — Dijkstra Solution Works?

- Could there be problems with access to shared `state` variables?
- Do we guarantee that neighbors don't eat at the same time?
- Do we allow non-neighbors to eat at the same time?
- Could we deadlock?
- Does a hungry philosopher always get to eat eventually?
- (To be continued . . .)

Slide 9

Minute Essay

- None — quiz.