Synchronization and Exam Review

CS439: Principles of Computer Systems
February 20, 2017
Last Time

• The Importance of Safety
  – Don’t kill people
  – Sensible defaults

• Advanced Synchronization
  – Conservative two-phase locking
  – Transactions
Today’s Agenda

• Review
  – Atomicity
  – How we get it
  – Tradeoffs and Problems
• Pemberley
• Exam Review
Synchronization Review
Concurrency Quiz

If two threads execute this program concurrently, how many different final values of the global variable X are there?

Initially, X == 0.

Thread 1

```c
void increment() {
    int tmp = X;
    tmp = tmp + 1;
    X = tmp;
}
```

Thread 2

```c
void increment() {
    int tmp = X;
    tmp = tmp + 1;
    X = tmp;
}
```

A. 0  
B. 1  
C. 2  
D. More than 2
Schedules/Interleavings

- Model of concurrent execution
- Interleave statements from each thread into a single thread
- If any interleaving yields incorrect results, some synchronization is needed

If $X == 0$ initially, $X == 1$ at the end. WRONG result!
Can both critical sections execute during a single execution of the code?

A. Yes
B. No
Atomicity

• Required to reason about multi-threaded code without considering all interleavings
• Requires mutual exclusion
• Locks provide that solution
• Looked at lock implementation
  – Requires waiting
  – Requires hardware support
• Use software abstractions
  – Semaphores
  – Monitors (lock+condition variables)
Tradeoff and Problems: Difficult to Get Right

• Ensure safety
• Ensure liveness
• No race conditions
• No starvation
• No priority inversion
• No deadlock
In Addition... the Cost of Parallelization

```c
for(k = 0; k < n; k++)
    a[k] = b[k]*c[k] + d[k]*e[k];
```

How would you parallelize this?
How many threads?
The Six Commandments

• Thou shalt always do things the same way
• Thou shalt always synchronize with locks and condition variables
• Thou shalt always acquire the lock at the beginning of a function and release it at the end
• Thou shalt always hold lock when operating on a condition variable
• Thou shalt always wait in a while loop
• (Almost) Never sleep()
Why Thread Coding Standards?

• History has tested this approach
• If you follow these commandments, you will find it easier to write correct code.
• In this class, you must use them or lose points.
• We highly recommend that you continue to do so after this class
But...

• After this class, if you can come up with something better, please use it!

• BUT...
  – Lots of really smart people have thought really hard about this already, so a day or two of thought is unlikely to change the best practice
  – The consequences of getting code wrong can be atrocious
  – People who are confident about their abilities tend to perform *worse*. If you think you are a Threading and Concurrency Ninja and truly understand, then you may wish to re-evaluate...
    • Dunning-Kruger effect
In this class...

- Six commandments
- Coarse-grained locking
- Order your locks
Pemberley!
Exam Review and Procedures
Exam Review

He who asks is a fool for five minutes; he who does not ask remains a fool forever.

- Anonymous Chinese Proverb
iClicker Question

What might be on the exam?

A. Information from lectures and reading
B. Coding questions
C. Concept questions (general understanding/thought)
D. All of the above (and more!)
Exam Procedures

• Arrive on time
  – No one may start the exam after the first person leaves
• Bring your UT ID
• Find your EID and assigned seat on the chart outside the classroom
• Do not enter the room until told to do so
• When you enter, proceed to your seat
Exam Procedures

• Leave all extra paper, electronics (including phones), hats, etc. in your bag.
• Do not begin the exam until told to do so
• No questions may be asked during the exam
  – Write any assumptions
• When finished
  – turn in exam and all scratch paper to myself or the proctor
  – present your ID
iClicker Question

What should you bring to the exam?

A. A writing utensil and your ID
B. Nothing
My Best Advice

Do NOT panic!

You have been taught how to do each question, and you can do it.
Announcements

• Class on Wednesday is shortened and optional
  – 10:15a-11:45a in GDC 6.302
  – Review sessions (driven by your questions!)
  – Any student may attend either section
• No discussion sections this week
• My Wednesday office hours are canceled
• Solutions to the sample exam will be posted later today