CS 472 – Provably Correct Programming

William Mansky

Questions

Nobody has responded yet.

Hang tight! Responses are coming in.

Welcome to the Course!

- This is CS 472, Provably Correct Programming
- I'm glad you're here!
- Meets MW 2:00-3:15 PM in TBH 180F
- My office hours: Tuesday 12-1 and Wednesday 10-11, and by appointment, in SEO 1331 and on Zoom via Blackboard
- TA office hours: Monday 1-2 and Thursday 2-3
  - Office hours are great for homework help, or just to say hi!

Course Information

- Professor: William Mansky (he/him) (mansky1@uic.edu)
- TA: Chao Ding (he/him) (cding22@uic.edu)
- Prerequisites: CS 301 (logic and proofs)
- Website: https://www.cs.uic.edu/~mansky/teaching/cs472/sp24/
- Anonymous in-class questions: https://pollev.com/wmansky771
- In-person lectures, recordings (probably incomplete) on Blackboard
- Discussion board on Piazza, assignments via Gradescope (entry code VBPRNW)

Asking questions

- In class: raise your hand (or type in BBCollab chat) anytime
- You can ask questions anonymously with PollEverywhere (https://pollev.com/wmansky771)
- On Piazza
  - Can ask/answer anonymously
  - Can post privately to instructors
  - Can answer other students' questions
- In office hours

- If you have a question, someone else probably has the same question!

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Software works badly

United Airlines says the outage that held up departing flights was not a cybersecurity issue

NASA engineers finally came to the conclusion that there were too many files on the fl
https://en.wikipedia.org/wiki/Spirit_(rover)

to grow large enough to overwrite data that could cause unintended acceleration
ikipedia.org/wiki/2009%E2%80%932011_Toyota_vehicle_recalls

Knight Capital Says Trading Glitch Cost It $440 Million

BY NATHANIEL POPPER AUGUST 2, 2012 9:07 AM 356

Runaway Trades Spread Turmoil Across Wall St.

Explainer: What happened to shut down Toyota's production in Japan?

Reuters

August 30, 2023 6:27 AM CDT · Updated 4 months ago

htt 140-million/

Can we change the way we program?

STOP DOING JAVASCRIPT

- DOCUMENTS WERE NOT SUPPOSED TO BE TURING-COMPLETE
- YEARS OF WEB TECHNOLOGY yet NO REAL-WORLD USE FOUND for doing more than HTML FORMS
- Wanted to do more anyway for a laugh? We had a tool for that: It was called “ADOBE FLASH”
- “Yes please connect the Redux thunk to a Suspense. Please instantiate WebAssembly streaming.” - Statements dreamed up by the utterly Deranged

LOOK at what Web Developers have been demanding your Respect for all this time with all the computers & compilers we built for them

(This is REAL Javascript, done by REAL Web Developers)

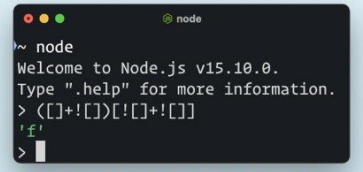
slack

?????

node_modules

807 items

???????



??????????????????

“Hello I would like `undefined` apples please”

They have played us for absolute fools

Can we change the way we program?

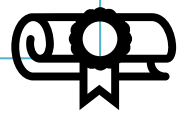
- Programs in safer languages (Rust, OCaml, …) still have bugs

- Most programmers don’t get to choose what language they write in!
  - Need to maintain/interoperate with existing code
  - We mostly write in the languages we know

Can we change the way we program?

- Prove programs correct!

```
i = 1;
while(i <= n){
   r = r * i;
   i++;
}
```



This course:

How can we write these proofs?

How can we write programs so they're easier to prove?

- This program will:
  - never overflow its stack
  - never dereference a null pointer
  - never call a function without meeting its preconditions
  - always return the right result!

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Grading

- In-class exercises: 25%
- Assignments: 50%
- Project: 25%

Exercises

- In each class, we'll work through some example problems/proofs
- Submit via Gradescope
- Due at the start of the next class
- You get credit as long as you make some progress on the problem

- Feel free to discuss with your neighbors, ask questions, suggest other approaches, etc.!

Assignments

- Programming/proving assignments
- Submit via Gradescope
- Due at 11:59 PM on the due date
- You can discuss strategy with other students, but don't look at each other's code!
- Cite your sources (websites, other students, StackOverflow, ChatGPT, etc.)
- You'll get most of the credit for attempting a problem, even if you don't finish it – do what you can, and we'll work through tricky ones in class after the deadline

Online Sources and ChatGPT

- You *can* find solutions online, but:

1. Always cite your sources!
2. Please don't make your solutions public (e.g. on GitHub)
3. There's less theorem-prover code out there than other kinds of code, so what you find will often be outdated or unreliable
4. You can always run your proofs and see if they work! (and if they don't, don't submit them!)

Schedule Disruptions

- Next week: I'll be at POPL
  - 1/15 is MLK Day; for 1/17, I'll ask you to watch some videos about proved-correct programming

- Sometime mid-April: I'm expecting my second child
  - We'll probably have a few online classes – more details when we get closer

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Getting Started with Proofs

- You already know how to write programs: languages, compilers, IDEs, etc.
- How do we write proofs? The same way: with software tools!

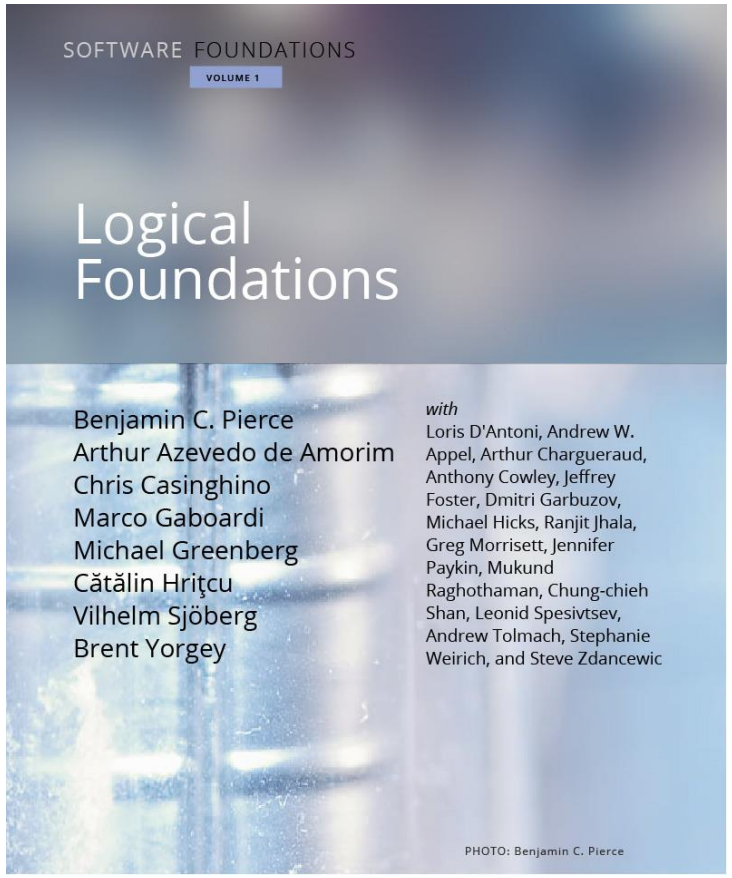
- Tool #1: The Coq proof assistant (https://coq.inria.fr/)
- For the first ~4 weeks, we'll learn how to use it to write guaranteed-correct mathematical proofs
- After that, we'll apply those techniques to programs!
- And look at some complicated use cases, esp. *concurrent* programs (see also CS 454)

Interactive Theorem Provers

- In the theorem prover, we can:

1. Write **definitions**, in a math-like programming language
2. Write **proofs** about those definitions, using logic “tactics”
3. See the **proof state** at each point in a proof (what do we know? what do we still need to show?)
4. Automatically **check** that each step of our proofs is valid

Logical Foundations



- Online textbook, each chapter is a file that can be run in Coq
- Contents:
  - Introduction to Coq
  - Basic logic and functional programming
  - More advanced logic, mostly induction
  - How to describe the behavior of programs

https://softwarefoundations.cis.upenn.edu/lf-current/index.html

Getting Started with Coq

- Available online at https://coq.inria.fr/
- You can download installers for Windows and Mac from the website
- Coq file extension is .v
- If it matters, we'll use version 8.17.1

- Two main IDEs: CoqIDE (ships with Coq) and Visual Studio Code (VSCoq extension)

Today's Exercise

1. Download and install Coq (https://github.com/coq/platform/releases/tag/2023.03.0, or from the download links at https://coq.inria.fr/)
2. Download and unpack the textbook (https://softwarefoundations.cis.upenn.edu/lf-current/index.html)
   — It's a .tgz file, so you may need to install 7-zip (https://www.7-zip.org/) to unpack it
3. Run `make` in the textbook's folder to compile the textbook. If you don't have a command line with `make`, you'll need to set one up: I use Cygwin (https://cygwin.com/install.html)
4. If you finish, run demo.v, then submit it for Exercise 1/8 on Gradescope. If you haven't finished, submit a description of where you're stuck instead.

If you get stuck, raise your hand, post on Piazza, or come by office hours

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