

CS450

Structure of Higher Level Languages

Lecture 23: PhD program / dynamic dispatch / generic methods

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Today we will learn about...

- What is a PhD degree
- Dynamic scoping in Racket

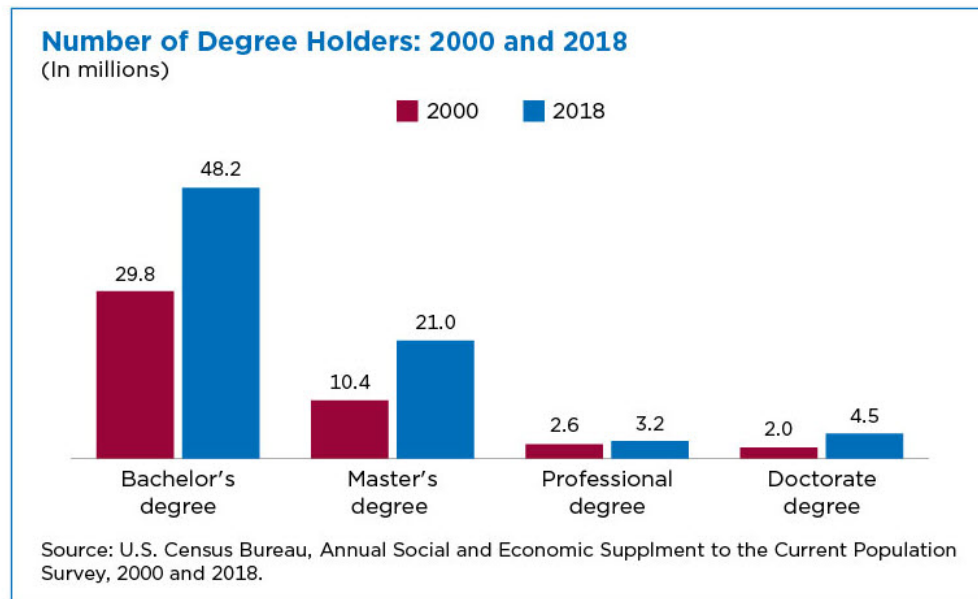
What is a Ph.D.?

An academic degree where you must:

1. Master a subject completely
2. Advance the state of the art

- **Meaning:** Doctor of Philosophy
- **Importance:** The highest academic degree
- **Rarity:** Specialized workforce (4.5% of the population)
- **Prestige:** The title of Doctor

Source: www.cs.purdue.edu/homes/dec/essay.phd.html



Overview: What is a Ph.D.?

1. Why join graduate school?
2. Why not join graduate school?
3. Why a graduate degree in CS?
4. What is the structure of a PhD?
5. How do the a PhD effectively?

Why join graduate school?

Why join graduate school?

- **Intellectual curiosity:** the challenge of learning, the culture of seeking and *sharing* knowledge
- **Specialized degree:** after graduation you will be a better professional
- **Autonomy:** you want time to develop your own project
- **Better paying work prospects:** a graduate degree is a good investment

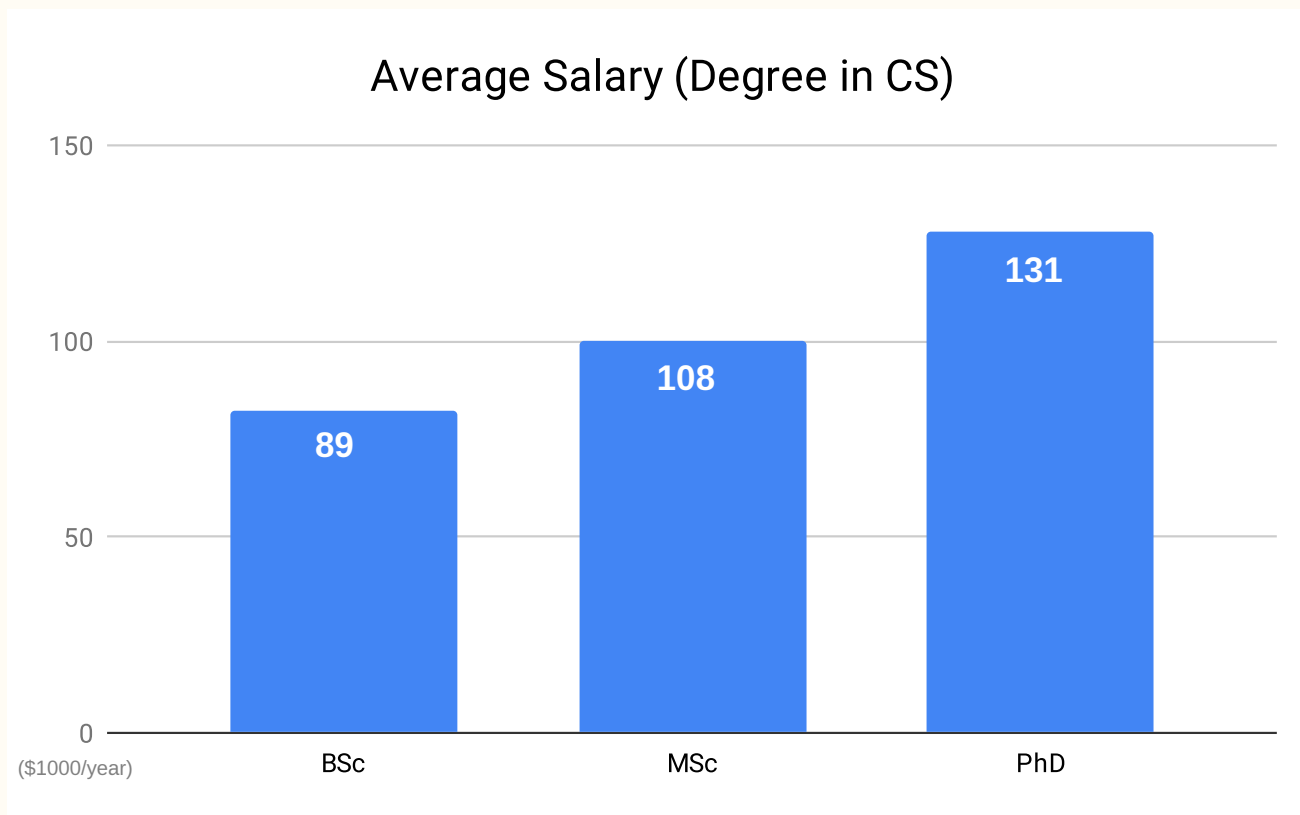
PhD degrees are generally fully-funded!

Why not join graduate school?

- **5-year investment:** You will not be paying tuition, grants and serving as a teaching assistant (TA) will pay you a stipend.
However, **this stipend is significantly lower than working in the industry!**
- **Higher workload:** Graduate course are more rigorous than undergraduate courses. You will need to juggle TA with courses and research.
- **5-year commitment:** You will be working on the **same** subject for 5 years.
- **Autonomy required:** A PhD degree is not structured like a BSc. There is no exact formula for an effective PhD degree. More freedom, more responsibility.
- **Traveling required:** You will need to travel internationally.
- **Public speaking:** A crucial part of the PhD is public speaking.

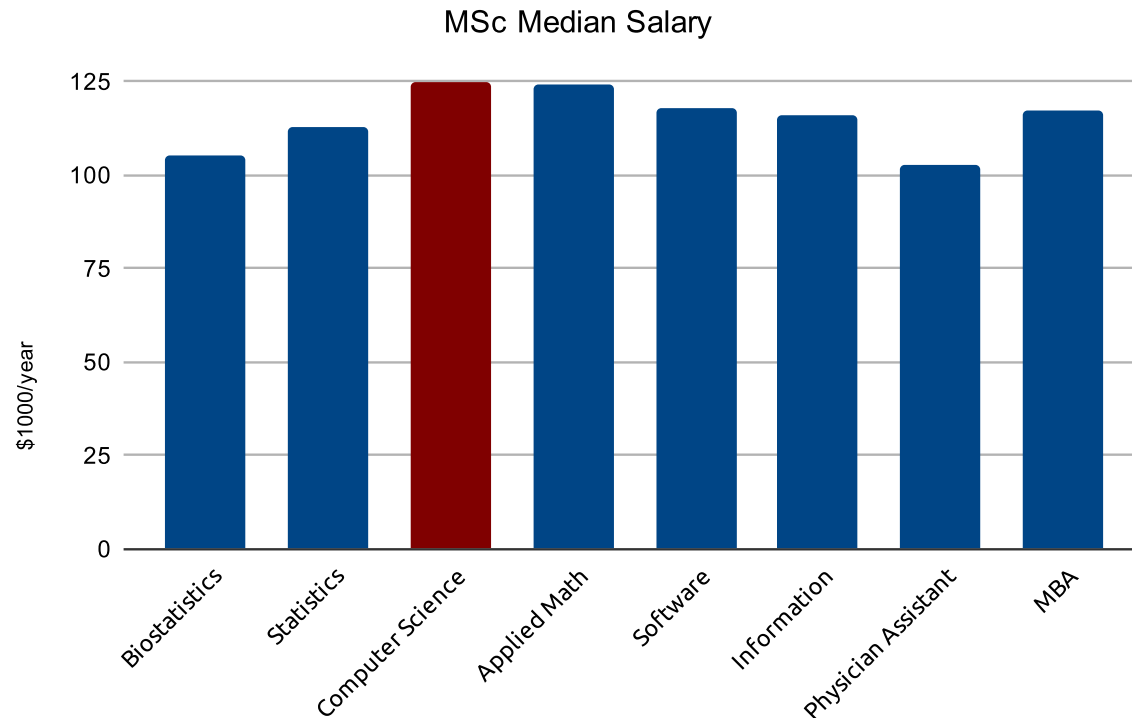
I am using 5 years as an approximate duration to conclude a PhD degree.

Why join graduate school?



Sources: Payscale.com 2022 [1] [2] [3]

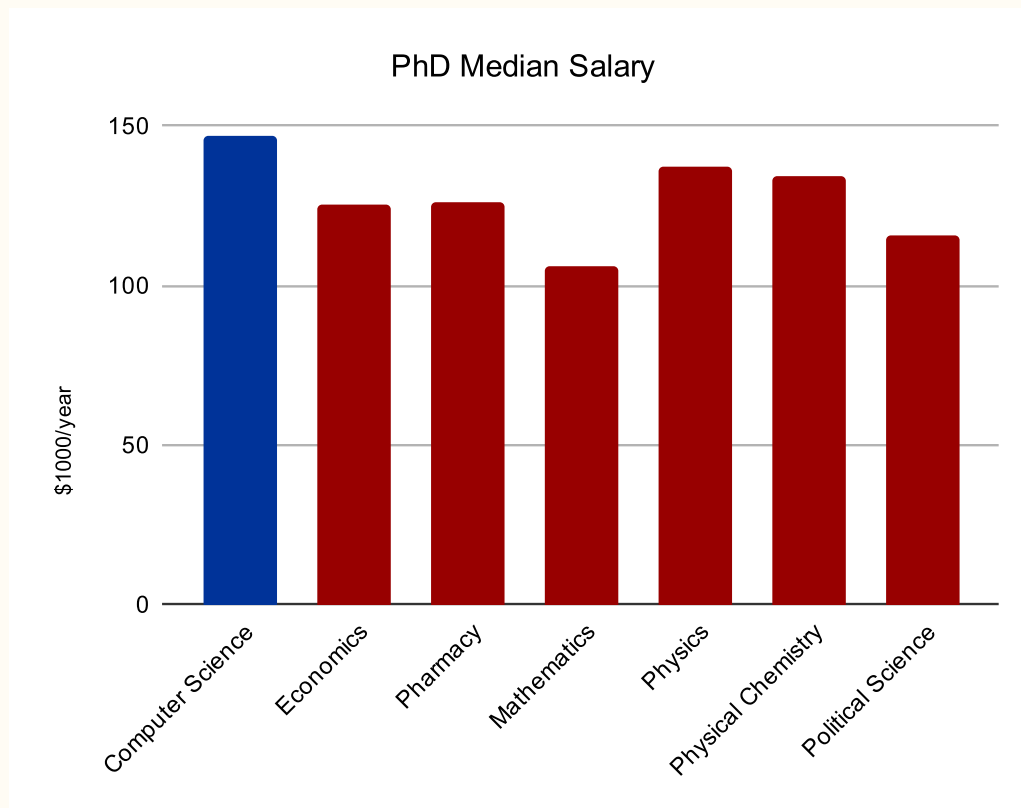
Why a graduate degree in CS?



Source: [Best And Worst Graduate Degrees For Jobs in 2016](#). Lydia Dishman. Fortune, 2016.



Why a graduate degree in CS?



Source: [Best And Worst Graduate Degrees For Jobs in 2016](#). Lydia Dishman. Fortune, 2016.



The PhD degree

1. How to master a subject?

- Take **graduate courses**
- **Read** the literature: peer-reviewed scientific papers, books
- Attend **conferences**: meet top experts
- Attend **summer schools**: learn from world-class scholars
- Visit universities
- Do internships

What are peer-reviewed papers? Scientific articles are submitted to other scientists experts in the field, who attest the scientific accuracy of the article. Articles may also be presented in a conference.

The PhD degree

2. How to advance the state of the art?

Complete a PhD thesis manuscript

- **Novel:** the contribution must be completely new
- **Impact:** the contribution must have a useful impact to society

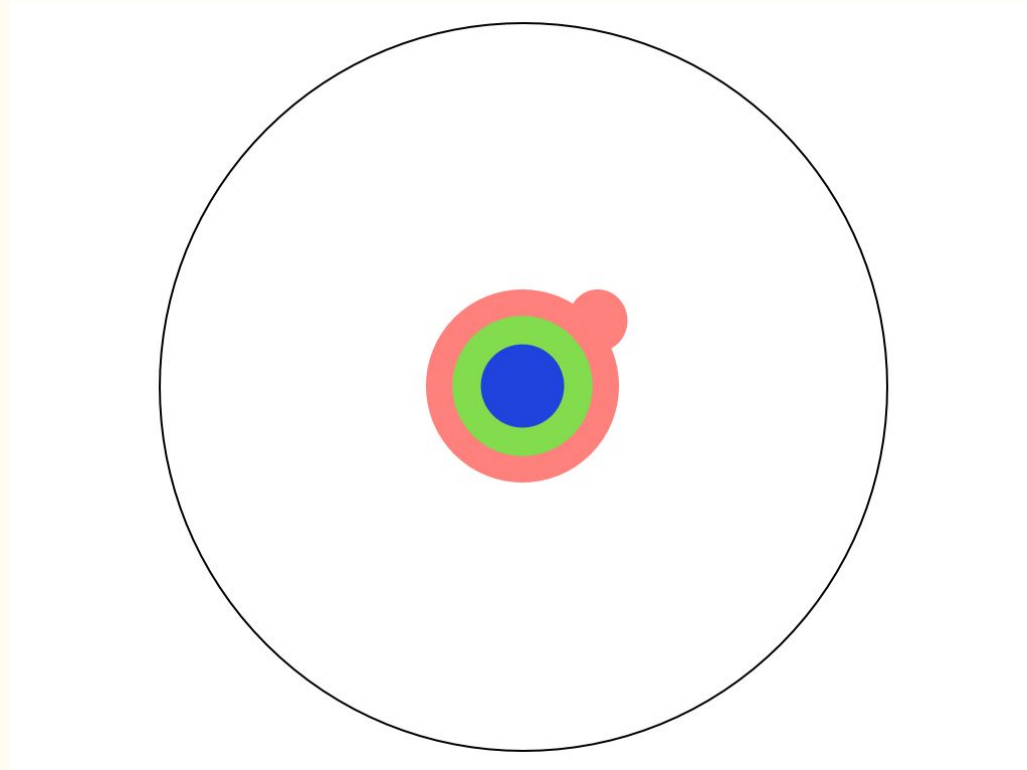
Skills

- explore, investigate, contemplate
- conceptualize, find issues, solve problems

You will be the **world expert** on a subject!

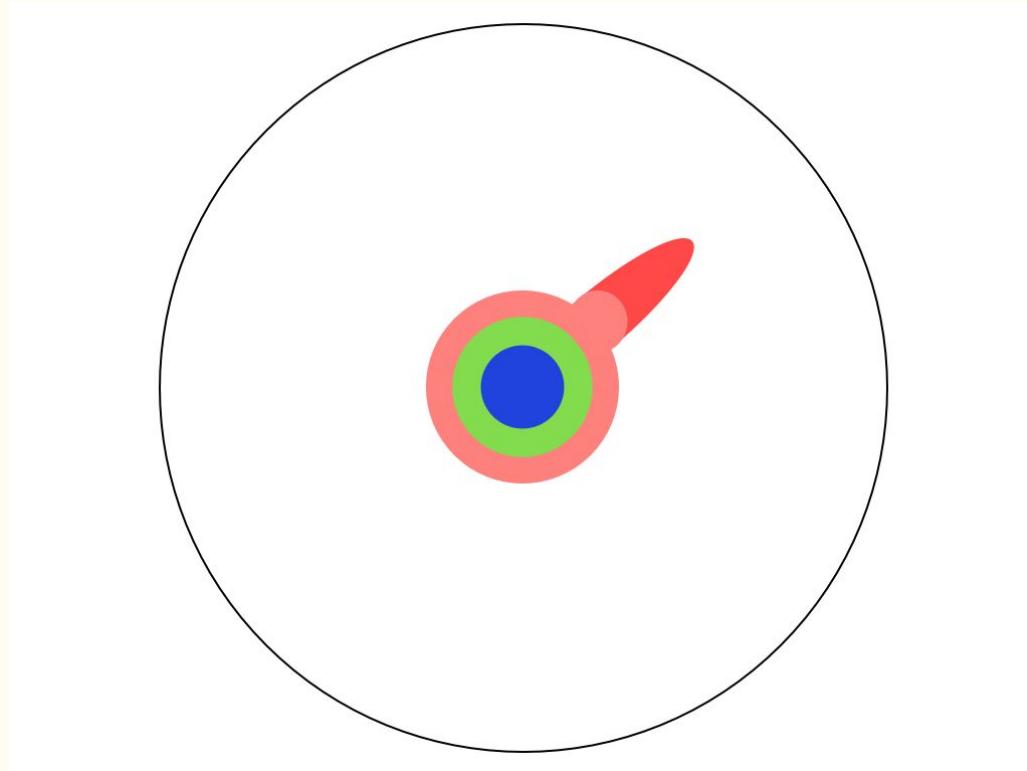


Let us say you are here



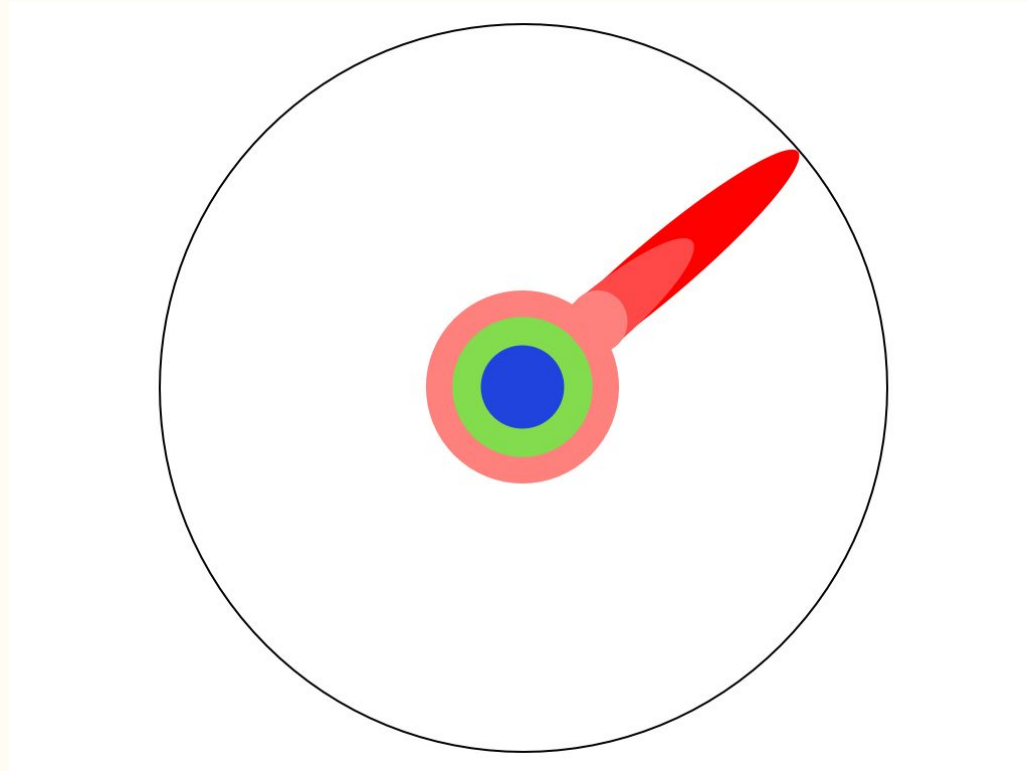
Source: matt.might.net/articles/phd-school-in-pictures/

Step 1: complete PhD courses (MSc)



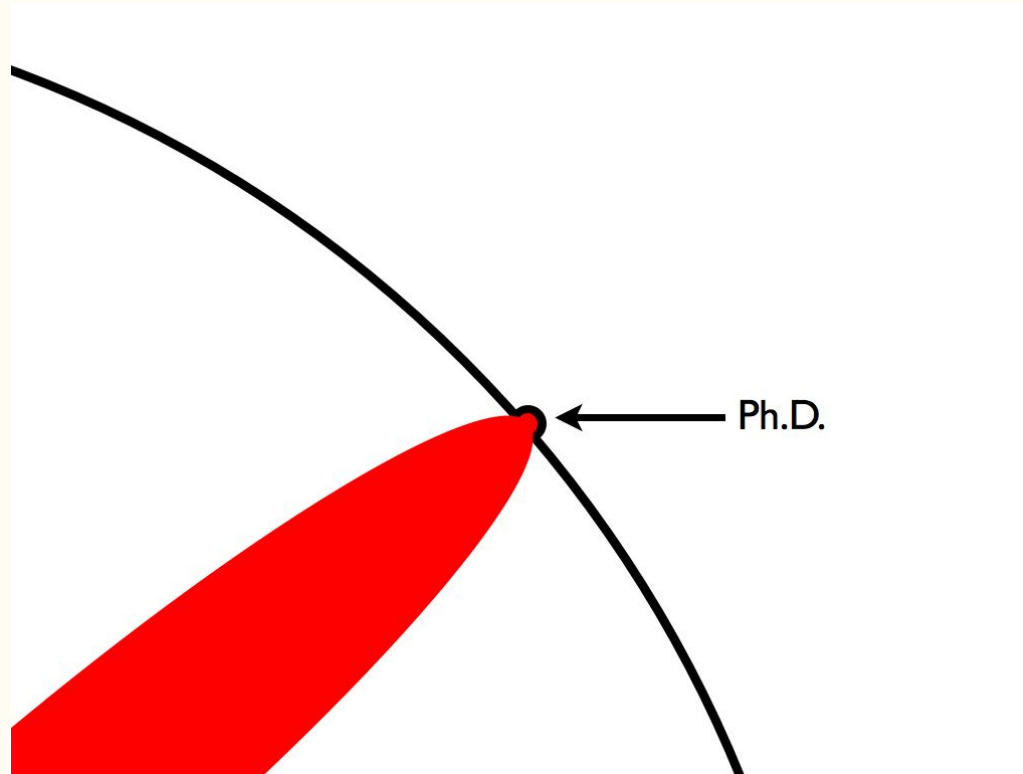
Source: matt.might.net/articles/phd-school-in-pictures/

Step 2: master a subject completely



Source: matt.might.net/articles/phd-school-in-pictures/

Step 3: advance the state of the art



Source: matt.might.net/articles/phd-school-in-pictures/

Pursuing a Ph.D. effectively

A PhD adviser shall...

- **Advise the student.** Help find a thesis topic, teach how to do research, write papers, give talks, etc.
- **Protect the student.** Provide protection from and information about funding concerns.
- **Inform the student.** Proactively provide realistic, honest advice about post-Ph.D. career prospects.
- **Frame student's work.** Provide early and clear guidance about the time frames and conditions for graduation.

A PhD student shall...

- **Get educated about career prospects post-PhD.**
- **Determine if these career prospects match your expectations.**
- **A PhD is not just research.** There is coursework, quals, and writing a thesis.
- **Work hard and maintain a rhythm.**
- **Follow the PhD program.** You are responsible for meeting the program's deadlines and requirements.

Source: [5+5 Commandments of a Ph.D.](#) Matt Might, John Regehr, Suresh Venkatasubramanian. 2011.



Research in the Software Verification Lab

Software Verification Lab

We make your programs run right

- We study how systems work
- We describe what we learned mathematically
- We understand why systems fail
- **We build tools and prove theorems** to help programmers

11 Active Members (alphabetically)

- **Faculty:** Tiago Cogumbreiro, Julien Lange (RHUL)
- **PhD students:** Greg Blike, Paul Maynard, Dennis Liew, Hannah Zicarelli
- **MS students:** Ramsey Harrison
- **BS students:** Soroush Aghajani, Austin Guiney, Emma Kelminson, Udaya Sathiyamoorthy



Software Verification Lab

The big picture

- We care about High Performance Computing (the backbone of scientific advancement)
- We focus on large-scale scientific workloads
- Our research improves the quality assurance of scientific codes

Looking for collaborators

- Summer/winter research projects

Check out the more than 40 software open source projects, written in Python, C++, Java, OCaml, Coq, Racket, ...



What you will learn...

Intersection between

- Software Engineering
- Logic

Things you may learn

- Functional programming
- Multithreading/parallel programming
- Developing Continuous Integration pipelines
- Using super computers (clusters in national labs with 1000s of cores)
- Implementing compilers/interpreters/debuggers
- Programming proofs & proof engineering
- Using SAT/SMT solvers & model checkers



Dynamic scoping in Racket

`parameterize`

Static versus dynamic scoping

Static Scoping

Static binding: variables are captured at creation time

```
(define x 1)

(define (f y) (+ y x))

(define (g)
  (define x 20)
  (define y 3)
  (f (+ x y)))

(check-equal? (g) (+ 23 1))
```

Dynamic Scoping

Dynamic binding: variables depends on the calling context

```
(define x 1)

(define (f y) (+ y x))

(define (g)
  (define x 20)
  (define y 3)
  (f (+ x y)))
; NOT VALID RACKET CODE
(check-equal? (g) (+ 23 20))
```

Why dynamic scoping?

1. A controlled way to represent global variables
2. A technique to make code testable

Dynamic scoping example

Dynamic scoping In Racket

```
(define x (make-parameter 1))  
(define (f y) (+ y (x)))  
  
(define (g)  
  (parameterize ([x 20])  
    (define y 3)  
    (f (+ (x) y))))  
  
(check-equal? (g) (+ 23 20))
```

Pseudo-Racket dynamic scoping

```
(define x 1)  
(define (f y) (+ y x))  
  
(define (g)  
  (define x 20)  
  (define y 3)  
  (f (+ x y))  
  ; NOT VALID RACKET CODE  
(check-equal? (g) (+ 23 20))
```

- Function `make-parameter` returns a reference to a dynamically scoped memory-cell
- Calling a parameter without parameter returns the contents of the memory-cell
- Use `parameterize` to overwrite the memory-cell

Dynamic binding

Globals

Dynamic binding: controlled globals

■ We can define different globals in different contexts.

```
(define buff (open-output-string))
(parameterize ([current-output-port buff])
  ; In this context, the standard output is a string buffer.
  (display "hello world!"))
(check-equal? (get-output-string buff) "hello world!")
```

Racket uses parameters to allow extending the behavior of many features:

- command line parameters
- standard output stream (known as a port)
- formatting options (eg, default implementation to print structures)