CSE 341 : Programming Languages

Interlude
Course Motivation, Midterm Debrief

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Spring 2014

Midterm

Friday was . . . interesting?

Spent the weekend reflecting.

Learning experience for all of us.

Debrief:
- what we learned
- what we're going to do moving forward

Midterm: What's the point?

Sadism?

Flexing my intellectual muscle?

Break spirits so I can rebuild them?

Build reputation as a super hardcore prof?

NO

Midterm: What's the point?

Preparation, study, review.

Feedback for me and feedback for you.

Just one part of demonstrating your ability.

Practice performing under pressure.

Midterm: How did we do?

Preparation, study, review. ✓

Feedback for me and feedback for you.

Just one part of demonstrating your ability.

Practice performing under pressure. ✓

Midterm: Feedback / Analyzing Results

Feedback for me:

- despite best efforts, test a bit long / difficult
- in the end, distribution very informative
- y’all did *extremely* well considering challenge

Feedback for you:

- great job preparing, keep it up!
- pretty good job being strategic, nice work ☺
- opportunity to consider motivations / priorities

Midterm: How did we do?

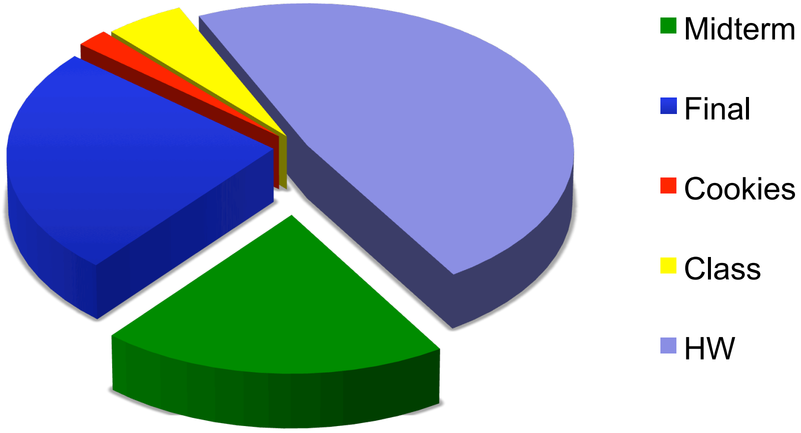
Preparation, study, review. ✓

Feedback for me and feedback for you. ✓ –

Just one part of demonstrating your ability.

Practice performing under pressure. ✓

Midterm: Just One Part of Grade



Midterm: Just One Part of Grade

That said, I was once an undergrad myself.

Despair = worst possible midterm outcome.

So:

$$\mathrm{midterm} = \max\,(\mathrm{midterm}_0, \mathrm{final})$$

or (curried):

$$\mathrm{midterm} = \max\ \mathrm{midterm}_0\ \mathrm{final}$$

Midterm: How did we do?

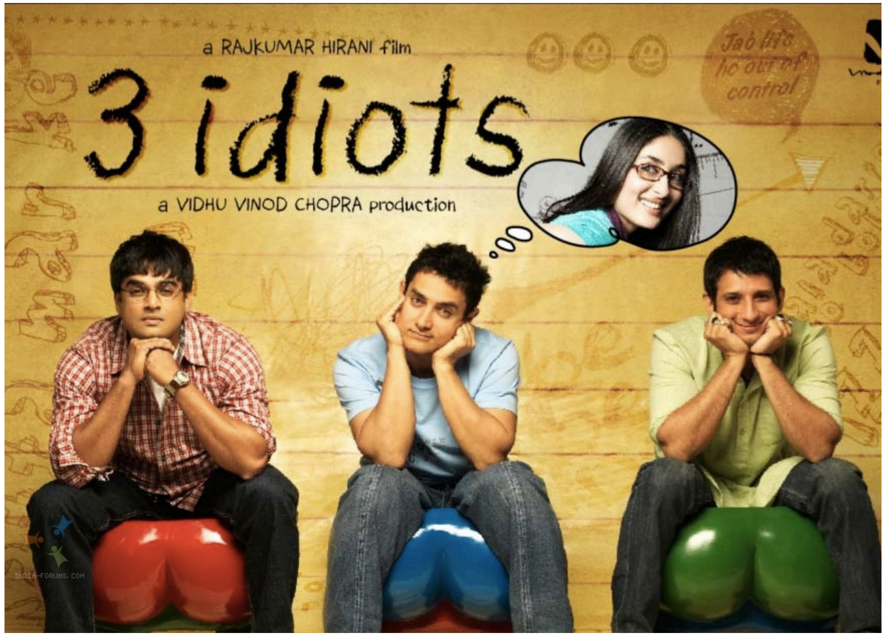
Preparation, study, review. ✓

Feedback for me and feedback for you. ✓−

Just one part of demonstrating your ability. ✓

Practice performing under pressure. ✓

We're actually in pretty good shape.



I **really** like studying programming languages.

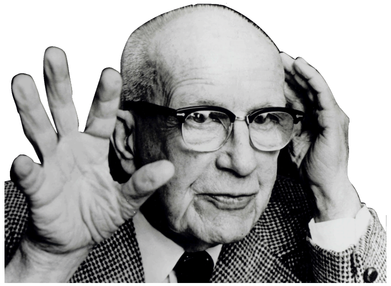
Super stoked to explore PL with all of you.

Why?

If you are in a shipwreck and all the boats are gone, a piano top buoyant enough to keep you afloat may come along and make a fortuitous life preserver.

This is not to say, though, that the best way to design a life preserver is in the form of a piano top.

I think we are clinging to a great many piano tops in accepting yesterday's fortuitous contrivings as constituting the only means for solving a given problem.



R. Buckminster Fuller

Wat

@garybernhardt

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Super stoked to explore PL with all of you.

Why?

PL helps us *break free* to think thoughts, ask questions, and solve problems that would otherwise be inaccessible.

More Detailed Course Motivation

- Why learn fundamental concepts that appear in all languages?
- Why use languages quite different from C, C++, Java, Python?
- Why focus on functional programming?
- Why use ML, Racket, and Ruby in particular?
- Not: Language X is better than Language Y

[You won’t be tested on this stuff]

Summary

- No such thing as a “best” PL
- Fundamental concepts easier to teach in some (multiple) PLs
- A good PL is a relevant, elegant interface for writing software
  - There is no substitute for precise understanding of PL semantics
- Functional languages have been on the leading edge for decades
  - Ideas have been absorbed by the mainstream, but very slowly
  - First-class functions and avoiding mutation increasingly essential
  - Meanwhile, use the ideas to be a better C/Java/PHP hacker
- Many great alternatives to ML, Racket, and Ruby, but each was chosen for a reason and for how they complement each other

What is the best kind of car?

What is the best kind of shoe?

Cars / Shoes

Cars are used for rather different things:

- Winning a Formula 1 race
- Taking kids to soccer practice
- Off-roading
- Hauling a mattress
- Getting the wind in your hair (some of us…)
- Staying dry in the rain

Shoes:

- Playing frisbee
- Going to a formal
- Going to the beach

More on cars

- A good mechanic might have a specialty, but also understands how “cars” (not a particular make/model) work
  - The upholstery color isn’t essential (syntax)
- A good mechanical engineer really knows how cars work, how to get the most out of them, and how to design better ones
  - I don’t have a favorite kind of car or a favorite PL
- To learn how car pieces interact, it may make sense to start with a classic design rather than the latest model
  - A popular car may not be best
  - May especially not be best for learning how cars work

Why semantics and idioms

This course focuses as much as it can on semantics and idioms

- Correct reasoning about programs, interfaces, and compilers *requires* a precise knowledge of semantics
  - Not “I feel that conditional expressions might work like this”
  - Not “I like curly braces more than parentheses”
  - Much of software development is designing precise interfaces; what a PL means is a *really* good example

- Idioms make you a better programmer
  - Best to see in multiple settings, including where they shine
  - See Java in a clearer light even if I never show you Java

Hamlet

The play *Hamlet*:

- Is a beautiful work of art
- Teaches deep, eternal truths
- Is the source of some well-known sayings
- Makes you a better person

Continues to be studied centuries later even though:

- The syntax is really annoying to many
- There are more popular movies with some of the same lessons
- Reading Hamlet will not get you a summer internship

All cars are the same

- To make it easier to rent cars, it is great that they all have steering wheels, brakes, windows, headlights, etc.
  - Yet it is still uncomfortable to learn a new one
  - Can you be a great driver if you only ever drive one car?

- And maybe PLs are more like cars, trucks, boats, and bikes

- So are all PLs really the same…

Are all languages the same?

Yes:

- Any input-output behavior implementable in language X is implementable in language Y [Church-Turing thesis]
- Java, ML, and a language with one loop and three infinitely-large integers are “the same”

Yes:

- Same fundamentals reappear: variables, abstraction, one-of types, recursive definitions, …

No:

- The human condition vs. different cultures
  (travel to learn more about home)
- The primitive/default in one language is awkward in another
- Beware “the Turing tarpit”

Functional Programming

Why spend 60-80% of course using *functional languages*:

- Mutation is discouraged
- Higher-order functions are very convenient
- One-of types via constructs like datatypes

Because:

1. These features are invaluable for correct, elegant, efficient software (great way to think about computation)
2. Functional languages have always been ahead of their time
3. Functional languages well-suited to where computing is going

Most of course is on (1), so a few minutes on (2) and (3) …

Ahead of their time

All these were dismissed as “beautiful, worthless, slow things PL professors make you learn”

- Garbage collection (Java didn’t exist in 1995, PL courses did)
- Generics (**`List<T>`** in Java, C#), much more like SML than C++
- XML for universal data representation (like Racket/Scheme/LISP/…)
- Higher-order functions (Ruby, Javascript, C#, …)
- Type inference (C#, Scala, …)
- Recursion (a big fight in 1960 about this – I’m told ☺)
- …

The future may resemble the past

Somehow nobody notices we are right… 20 years later

- “To conquer” versus “to assimilate”
- Societal progress takes time and muddles “taking credit”
- Maybe pattern-matching, currying, hygienic macros, etc. will be next

Recent-ish Surge, Part 1

Other popular functional PLs (alphabetized, pardon omissions)

- Clojure http://clojure.org
- Erlang http://www.erlang.org
- F# http://tryfsharp.org
- Haskell http://www.haskell.org
- OCaml http://ocaml.org
- Scala http://www.scala-lang.org

Some “industry users” lists (surely more exist):

- http://www.haskell.org/haskellwiki/Haskell_in_industry
- http://ocaml.org/companies.html
- In general, see http://cufp.org

Recent-ish Surge, Part 2

Popular adoption of concepts:

- C#, LINQ (closures, type inference, …)
- Java 8 (closures)
- MapReduce / Hadoop
  - Avoiding side-effects essential for fault-tolerance here
- …

Why a surge?

Dan’s best *guesses*:

- Concise, elegant, productive programming
- JavaScript, Python, Ruby helped break the Java/C/C++ hegemony
- Avoiding mutation is *the* easiest way to make concurrent and parallel programming easier
  - In general, to handle sharing in complex systems
- Sure, functional programming is still a small niche, but there is so much software in the world today even niches have room

The languages together

SML, Racket, and Ruby are a useful *combination* for us

	dynamically typed	statically typed
functional	Racket	SML
object-oriented	Ruby	Java

ML: polymorphic types, pattern-matching, abstract types & modules
Racket: dynamic typing, “good” macros, minimalist syntax, eval
Ruby: classes but not types, very OOP, mixins
[and much more]

If we had more time:
Haskell: laziness, purity, type classes, monads
Prolog: unification and backtracking
[and much more]

But why not…

Instead of SML, could use similar languages easy to learn after:

- OCaml: yes indeed but would have to port all my materials 😐
  - And a few small things (e.g., second-class constructors)
- F#: yes and very cool, but needs a .Net platform
  - And a few more small things (e.g., second-class constructors, less elegant signature-matching)
- Haskell: more popular, cooler types, but lazy semantics and type classes from day 1

Admittedly, SML and its implementations are showing their age (e.g., **`andalso`** and less tool support), but it still makes for a fine foundation in statically typed, eager functional programming

But why not…

Instead of Racket, could use similar languages easy to learn after:

- Scheme, Lisp, Clojure, …

Racket has a combination of:

- A modern feel and active evolution
- "Better" macros, modules, structs, contracts, …
- A large user base and community (*not* just for education)
- An IDE tailored to education

Could easily define our own language in the Racket system

- Would rather use a good and vetted design

But why not…

Instead of Ruby, could use another language:

- Python, Perl, JavaScript are also dynamically typed, but are not as "fully" OOP, which is what I want to focus on
  - Python also does not have (full) closures
  - JavaScript also does not have classes but is OOP

- Smalltalk serves our OOP needs
  - But implementations merge language/environment
  - Less modern syntax, user base, etc.

Is this real programming?

- The way we use ML/Racket/Ruby can make them seem almost "silly" precisely because lecture and homework focus on interesting language constructs

- "Real" programming needs file I/O, string operations, floating-point, graphics, project managers, testing frameworks, threads, build systems, …
  - Many elegant languages have all that and more
    - Including Racket and Ruby
  - If we used Java the same way, Java would seem "silly" too

A note on reality

Reasonable questions when deciding to use/learn a language:

- What libraries are available for reuse?
- What tools are available?
- What can get me a job?
- What does my boss tell me to do?
- What is the de facto industry standard?
- What do I already know?

Our course by design does not deal with these questions

- You have the rest of your life for that
- And technology *leaders* affect the answers