CS 252:
Advanced Programming Language Principles

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What are some programming languages?

Taken from http://pypl.github.io/PYPL.html
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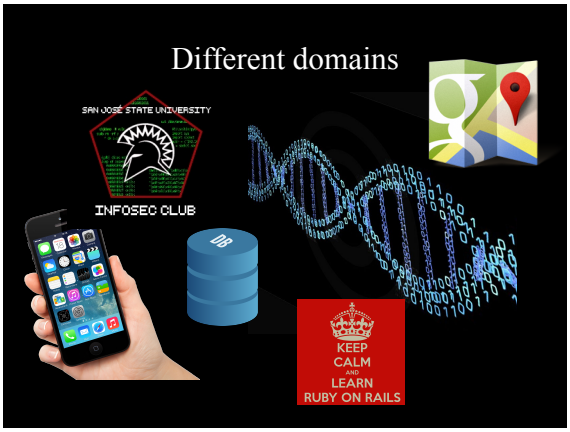
Why are there so many?

Different domains



Different design choices

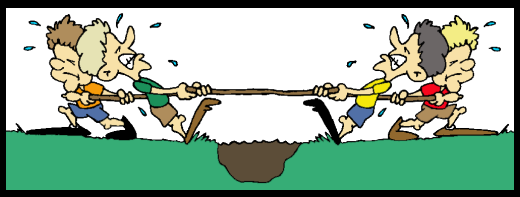
- Flexibility
- Type safety
- Performance
- Build time
- Concurrency

Which language is better?

Good language features

- Simplicity
- Readability
- Learn-ability
- Safety
- Machine independence
- Efficiency

These goals almost always conflict



Conflict: Type Systems

Stop "bad" programs

… *but* ...

restrict the programmer

Why do we study programming languages?

For undergrads:
to warp their minds

Objectives for grad students:

- Understand advanced language features
- *Evaluate* different features
- Choose the right language
- Understand formalisms

The "Blub" paradox

"As long as our hypothetical Blub programmer is looking down the power continuum, he knows he's looking down…

[Blub programmers are] satisfied with whatever language they happen to use, because it dictates the way they think about programs."

--Paul Graham

http://www.paulgraham.com/avg.html

Languages we will cover
(subject to change)

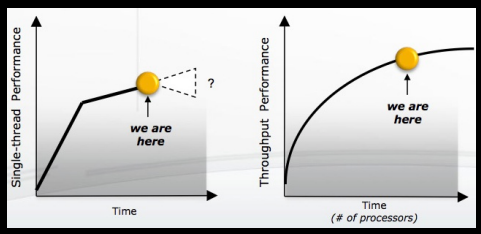
Theoretical foundations topics

- Formal semantics
- Type systems
- Concurrency approaches
- Metaprogramming
- Security features

In this course, you will learn the practical *and* the theoretical

What are the PL issues of interest to industry?

Multi-core explosion



Big Data

Mobile Devices

Rise of the Web & Scripting Languages

- Perl, Python, Ruby, PHP, JavaScript…
- Flexible
- Dynamically typed
- Easy to get started
- Minimal typing

Hello world in Java

```
public class HelloWorld {
  public static void main(String[] args) {
    System.out.println("Hello World!");
  }
}
```

Hello world in Ruby

```
puts "Hello World!"
```

What are the PL academics interested in?

- Types
- Types
- More types!

(OK, maybe a *little* more than that…)

Why are they different?

Major PL research contributions

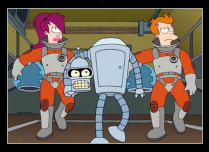
- Garbage collection
- *Sound* type systems
- Concurrency tools
- Closures

But PL researchers have missed some areas of interest

Academia and industry: Idealized relationship

Academics come up with brilliant ideas

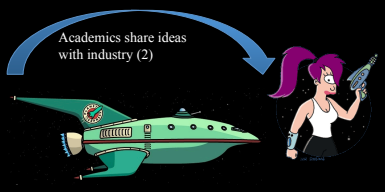
Academia shares its ideas with people in industry



Engineers use these ideas to build great things

Actual relationship

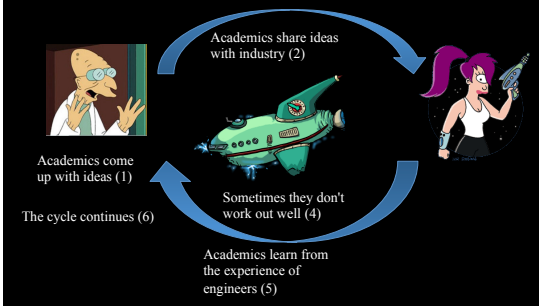
Academics come up with ideas (1)



Academics share ideas with industry (2)

Engineers use these ideas, incorporating their own ideas and experiences (3)

Actual relationship



To participate in this discussion, you must understand **formal semantics**.

Programs that manipulate other programs

- compilers & interpreters
- JavaScript rewriting
- instrumentation
- program analyzers
- IDEs

Sharing ideas *unambiguosly*

- ECMAScript committee
- Highlight issues early in the design
- Prove that a language supports a given property

Three approaches to semantics

- Operational
  - big-step
  - small-step
- Axiomatic
- Denotational

$$\frac{\Gamma \vdash e \Downarrow \texttt{true} \qquad \Gamma \vdash e_1 \Downarrow v}{\Gamma \vdash \texttt{if } e \texttt{ then } e_1 \texttt{ else } e_2 \Downarrow v}$$

$$\frac{\Gamma \vdash e \Downarrow \texttt{false} \qquad \Gamma \vdash e_2 \Downarrow v}{\Gamma \vdash \texttt{if } e \texttt{ then } e_1 \texttt{ else } e_2 \Downarrow v}$$

Now we can determine in some *objective* sense whether a language feature is "good".

Administrative Details

- Green sheet available at http://cs.sjsu.edu/~austin/cs252-spring16/Greensheet.html.
- Assignments will be submitted through Canvas (https://sjsu.instructure.com/)
- Academic integrity policy: http://info.sjsu.edu/static/catalog/integrity.html

Schedule

- Greensheet: *tentative* schedule
- Official schedule on Canvas
- Late homeworks will not be accepted
- Check the schedule before every class
- Check the schedule before every class
- And finally, CHECK THE SCHEDULE BEFORE EVERY CLASS.

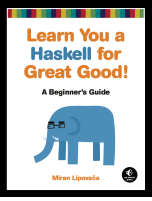
Prerequisites

You should be comfortable with:

- Functional programming
- Mathematical notation

If you are not sure, please see me

Resources



http://learnyouahaskell.com/

http://eloquentjavascript.net

All available online!!!

Grading

- 30% -- Homework
- 20% -- Midterm
- 20% -- Final
- 20% -- Project
- 10% -- Labs

Open-ended.

Labs

- Graded complete/incomplete
- I will look at them
- I *might* give feedback
- May show up on exams

Office hours

- MacQuarrie Hall room 216.
- Mondays/Thursdays noon-1pm.
- **No office hours February 4.**
- Also available by appointment

Haskell

Haskell is *purely functional*

- We define "what stuff is"
- No side effects
- *Referential transparency*

You can replace an expression with its value and you won't change anything.

Wait, no side effects?!
How is that possible?

Haskell & side effects

- Haskell functions *can* have side effects
  - e.g. file I/O
- BUT, *pure* functions can't call functions with side effects

Haskell supports *type inference*

Some languages have *explicit* types

```
// Java code
String foo(int i) {
    String s = "hello " + i;
    return s;
}
```

"Scripting languages" use dynamic typing

```
// Ruby code
def foo(i)
  s = "hello #{i}"
  return s;
end
```

Duck typing

"Duck typing" is flexible but not safe

In Haskell, you do not need to declare types; the compiler deduces them

Haskell supports *lazy evaluation*

- Results are not calculated until they are needed.
- Can represent infinite data structures.

Lazy Example

Haskell interactive mode:

```
*Main> let oddNumbers = [1,3..]
*Main> take 5 oddNumbers
[1,3,5,7,9]
```

Before next class

- Install Haskell from http://www.haskell.org/platform/contents.html
- Read chapters 1-3 of "Learn You a Haskell".

First homework due February 15th

- Available in Canvas.
  - Alternately, see http://cs.sjsu.edu/~austin/cs252-spring16/hw/hw1/
- Get started now!

HW1 Overview

Won't compile!

```
public class Test {
 public void main(String[] args){
  System.out.println(
     99999999999999999999 * 2);
 } }
```

With Haskell, there is no issue:

```
$ ghci
...
Prelude> 99999999999999999999*2
199999999999999999998
```

In this assigment, you will build your own BigNum module.