

## CSE505: Graduate Programming Languages

### Lecture 21 — Course Wrap-Up

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Fall 2012

### Victory Lap

- ▶ A victory lap is an extra trip around the track by the exhausted victors
  - ▶ A great way to soak in the highlights of the race
  - ▶ Very different from final-exam review (do that!)
    - ▶ Any questions about format, etc.?
- ▶ Review course goals and themes
  - ▶ Did we succeed according to lecture 1 and the syllabus?
- ▶ What didn't we have time for?
- ▶ Emphasize one last time the connection to the rest of computer science

Here are three slides verbatim from lecture 1...

### Programming-language concepts

Focus on *semantic* concepts:

What do programs mean (do/compute/produce/represent)?

How to define a language *precisely*?

English is a poor *metalanguage*

Aspects of meaning:

equivalence, termination, determinism, type, ...

This course does *not* give superficial exposure to *N* weird PLs

- ▶ But it will help you learn new languages via foundations
- ▶ And build rigorous models for any area of CS research

### Is this Really about PL?

Building a precise model is a hallmark of quality research

The value of a model is in its:

- ▶ Fidelity
- ▶ Convenience for establishing (proving) properties
- ▶ Revealing alternatives and design decisions
- ▶ Ability to communicate ideas concisely

Why we mostly do it for programming languages:

- ▶ Elegant things we all use
- ▶ Remarkably complicated (need rigor)

I believe this "theory" makes you a better computer scientist

- ▶ Focus on the model-building, not just the PL features

### Course goals

1. Learn intellectual tools for describing program behavior
2. Investigate concepts essential to most languages
  - ▶ mutation and iteration
  - ▶ scope and functions
  - ▶ types
  - ▶ objects
  - ▶ threads
3. Write programs to "connect theory with the code"
4. Sketch applicability to "real" languages
5. Provide background for current PL research (less important for most of you)

## Some common themes

- ▶ Interpretation versus compilation
- ▶ Preservation and progress
- ▶ Equivalence (what is observable, what is meaning-preserving)
- ▶ Encodings (to show expressive power)
- ▶ Functions (a great operational foundation)
- ▶ Types (a logical foundation for enforcing structured invariants)
- ▶ Composition of orthogonal features
- ▶ Abstraction

## Tons more to learn

- ▶ Type-and-effect systems
- ▶ Recursive and existential types
- ▶ Monads
- ▶ Type classes
- ▶ Multiple inheritance
- ▶ Macros
- ▶ Process calculi for concurrency
- ▶ Languages for distributed computing
- ▶ "Real" denotational semantics
- ▶ Formal verification of full correctness
- ▶ Abstract interpretation / dataflow analysis
- ▶ Module systems and foundations thereof
- ▶ and much, much more

## Unsolicited testimonials (October 2012)

I was starting my first week at Google, all fresh-faced and eager to impress. As the newest employee on the team, my co-workers gave me the task of sanity-checking the newly written Dart language spec (and it would be a good way to introduce me to the language). The specification was filled with operational and denotational semantics, and thanks to what I learned in 505 I was able to reasonably easily read through the document and get up to speed on Dart!

## Unsolicited testimonials (April 2011)

Hi Dan,

Long time, no see ;) I figured I'd drop you a line about the latest project I've been working on for a few months: [snip] Finally, a chance to apply my hard-won 505 knowledge to something out here in the so-called "real world." I even had to pull out the Pierce book at one point.

(A language for querying streams of real-time data on top of Hadoop)

## Unsolicited testimonials (March 2011)

I'm writing up the proof that my selector-intersection function is Correct and Total:

...

And lo and behold, my algorithm isn't total. Two of the cases fell through--once I rewrote the cases to be in the form needed for the induction, it became obvious that they were false. Fortunately, it's easily fixable... but I'll have to go redo the performance calculations now (there are more cases than there were before...)

(An algorithm for deciding if there exist HTML trees for which two CSS selectors apply to the same nodes)

## Unsolicited testimonials (July 2010)

I'm not sure if you remember me, but I took your programming languages course a year or two ago...

Today I had to do some work with a minimal browser shell around [snip], and found that I didn't have my usual Javascript debugging tools. So I tried to write a small "immediate window" for Javascript so I could conveniently execute commands. I started off knowing I'd probably use some eval(), but only a little while in, I realized the naive approach wasn't going to work because eval() does its evaluation in the current context...

I eventually got it to work using some eval tricks and some closure tricks. I am 100% sure that if I had not taken your mind-bending class, there's no way I could have figured this out...

## Unsolicited testimonials (May 2010)

Hi Dan,

I just came across continuations by accident while I was looking at comparisons of lua with other languages. I completely forgot we had gone over those in your class, and am beating myself up for not using them *\*ALL THE TIME\** in my code - they are awesome! Why are languages the coolest?!

## Unsolicited testimonials (July 2006)

This class has changed the way I think about programming - even if I don't get to use all of the concepts we explored in OCaml (I work in C++ most of the time), understanding more of the theory makes a tremendous difference to how I go about solving a problem.

## My interpretation

What I think these testimonials are hinting at:

- ▶ Languages follow guiding principles you have now seen
- ▶ You can use these principles to make software better
- ▶ An education gives you "muscle memory" in surprising ways
- ▶ Computer science is fun (better than being a dog)

So... thanks for a great class!

- ▶ And please do spend the time to be thoughtful and helpful on your course evaluations...

## Course Evaluations

I am going to distribute course evaluation forms so you may rate the quality of this course. Your participation is voluntary, and you may omit specific items if you wish. To ensure confidentiality, do not write your name on the forms. There is a possibility your handwriting on the yellow written comment sheet will be recognizable; however, I will not see the results of this evaluation until after the quarter is over and you have received your grades. Please be sure to use a No. 2 PENCIL ONLY on the scannable form.

I have chosen (*name*) to distribute and collect the forms. When you are finished, he/she will collect the forms, put them into an envelope and mail them to the Office of Educational Assessment. If there are no questions, I will leave the room and not return until all the questionnaires have been finished and collected. Thank you for your participation.