Introducing Haskell

COS 441 Slides 3

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Course Agenda (Initial Lectures)

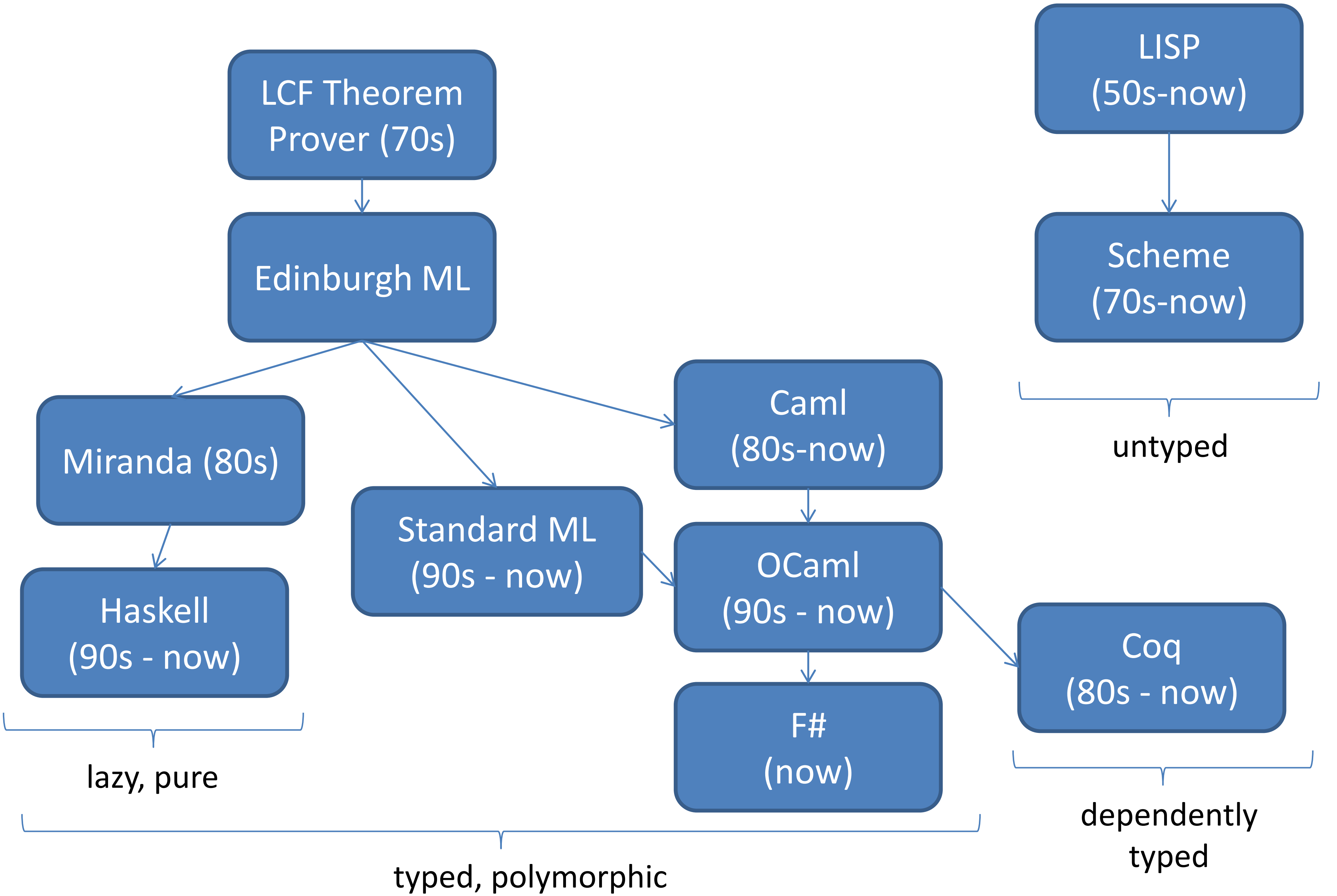
- Week 1 (Appel):
  - Syntactic definitions
  - Denotational definitions
  - Proofs by induction

- The coming weeks (Walker):
  - Introduction to Haskell
  - Syntactic definitions in Haskell
  - Denotational definitions in Haskell
  - Proofs in Haskell and about Haskell programs
  - Type classes
  - Applications of denotational semantics:
    - Domain-specific languages for graphics & animation

PL: Some Broad Categories

- Imperative
  - oriented around assignment to variables and simple control flow
  - C, Pascal, Go
- Object-oriented (Class-based)
  - oriented around classes and objects
  - Java, C#
- Logic programming
  - oriented around logical formulae, unification and search
  - Prolog, Twelf
- Functional
  - oriented around functions and immutable data structures
  - SML, O'Caml, F#, Coq, Scheme, Map-Reduce, Erlang, *Haskell*

Vastly Abbreviated FP Geneology



Functional Languages: Who's using them?

F# in Visual Studio

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Microsoft Be what's next.

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facebook

Erlang for concurrency, Haskell for managing PHP

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JANE STREET

O'Caml for reliability

BARCLAYS

Haskell for specifying equity derivatives

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http://www.janestcapital.com/technology/ocaml.php
http://msdn.microsoft.com/en-us/fsharp/cc742182
http://labs.google.com/papers/mapreduce.html
http://www.haskell.org/haskellwiki/Haskell_in_industry

Haskell vs. ML

- My research, many of my courses have used ML
  - SML or O'Caml
- What do ML and Haskell have in common?
  - functions as first-class data
  - rich, sound type systems & type inference
  - rich data types and algebraic pattern matching
  - immutable data is the default
- ML has:
  - A powerful module system
  - SML has a complete, formal definition
- Haskell has:
  - Type classes, Pure functions, Monads
  - Lazy evaluation

    not my favourite as a default
- I *vastly* prefer programming in ML or Haskell vs. C or Java

INTRODUCING HASKELL

Computation by Calculation

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- All computation occurs via substitution of one expression for another equal expression, like in ordinary mathematics:

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int x = 0;

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int x = 0;		int x = 0;		int x = 0;
…	?	…		x = 1;
y = x + x;		y = 0 + 0;		y = x + x;

Computation with Abstraction

- Good programmers use abstraction:
  - we recognize repeated patterns and capture them succinctly in one place instead of many
  - for example:

3 * (4 + 5)   9 * (1 + 7)   200 * (1 – 8)

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- This is functional abstraction: the process of capturing repeated idioms and representing them as functions

Computation by Calculation with Abstraction

- Computation by calculation with function abstraction is done by unfolding function definitions (just like we unfolded mathematical definitions):

easy 3 4 5	
= 3 * (4 + 5)	(by unfold/by definition)
= 3 * 9	(by add)
= 27	(by multiply)

definition:
easy x y z = x * (y + z)

Computation by Calculation with Abstraction

- We can also reason with symbolic values:

```
easy a b c
=  a * (b + c)       (by unfold)
=  a * (c + b)       (by commutativity of add)
=  easy a c b        (by fold)
```

definition:
easy x y z = x * (y + z)

- With these concepts:
  - computation by calculation
  - abstraction
  - symbolic values
- … we are well on our way to reasoning about Haskell definitions just like we reasoned about mathematical definitions, though Haskell gives us an implementation!

HASKELL BASICS:
EXPRESSIONS, VALUES, TYPES

Expressions, Values, Types

- The phrases on which we calculate are called expressions.
- When no more unfolding of user-defined functions or application of primitives like + is possible, the resulting expression is called a value.
- A type is a collection of expressions with common attributes. Every expression (and thus every value) belongs to a type.
- We write exp :: T to say that expression exp has type T.

Basic Types

- Integers

  3 + 4 * 5 :: Integer

- Floats

  3 + 4.5 * 5.5 :: Float

- Characters

  ‘a’ :: Char

Functions

- The type of a function taking arguments A and B and returning a result of type C is written A -> B -> C

```
(+)     :: Integer -> Integer -> Integer
easy  :: Integer -> Integer -> integer
```

- Note that (+) is syntax for treating an infix operator as a regular one. Conversely, we can take a non-infix operator and make it infix:

```
plus x y = x + y

easier x y z = x * (y ‘plus’ z)
```

A SHORT DEMO

Summary

- Haskell is
  - a functional language emphasizing immutable data
  - where every expression has a type:
    - Char, Int, Int -> Char
- Reasoning about Haskell programs involves
  - substitution of "equals for equals," unlike in Java or C
  - proofs about Haskell programs often:
    - unfold function abstractions
    - push symbolic names around like we do in mathematical proofs
    - reason locally using properties of operations (eg: + commutes)
    - fold function abstractions back up
- Homework: Install Haskell. Read LYAHFGG Intro, Chapter 1