ITI0212 Functional programming

Lecture 1 - Introduction

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Introduction and admin matters

Rough schedule

- Pawel Sobocinski - weeks 1 through 5
- week 6 (2-6 March) no lectures, no labs
- Chad Nester - weeks 7 through 10
- Ed Morehouse - weeks 11 through 14
- Niccolò Veltri - weeks 15 & 16

What this course is about?

- functional programming
  - functions are first-class objects
  - pattern-matching, recursion
  - pure vs non-pure code
- the importance of types
- cross-fertilisation

What is Idris?

Overview

Idris is a general purpose pure functional programming language with dependent types. Dependent types allow *types* to be predicated on *values*, meaning that some aspects of a program's behaviour can be specified precisely in the type. It is compiled, with eager evaluation. Its features are influenced by Haskell and ML, and include:

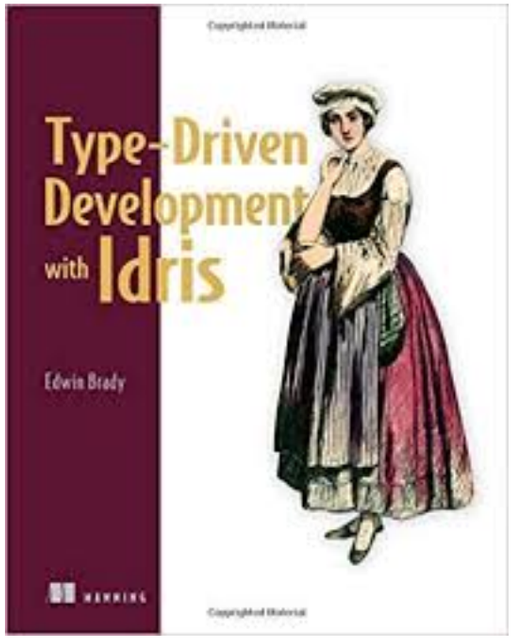
- Full dependent types with dependent pattern matching
- Simple foreign function interface (to C)
- Compiler-supported interactive editing: the compiler helps you write code using the types
- `where` clauses, `with` rule, simple `case` expressions, pattern matching `let` and lambda bindings
- Dependent records with projection and update
- Interfaces (similar to type classes in Haskell)
- Type-driven overloading resolution
- `do` notation and idiom brackets
- Indentation significant syntax
- Extensible syntax
- Cumulative universes
- Totality checking
- Hugs style interactive environment

Why Idris?

- Haskell-like syntax but strict evaluation 😍
- exciting features from recent research on programming languages that may be influential in future programming language designs
  - type-driven development
  - types as first-class objects
  - dependent types
  - total vs partial functions

Resources

- Primary textbook
  - Edwin Brady - Type-driven development with Idris
  - available online via library



- Other textbooks
  - Miran Lipovača - Learn you a Haskell for Great Good! - http://learnyouahaskell.com/chapters
  - Simon Thompson - The craft of functional programming

Assessment structure

- 4 small assignments worth 5% each and marked in labs = 20%
- 1 big assignment worth 30%.
  - spec released 24 February
  - due 27 April
- final written 2 hour exam worth 50%

Timetable

- Lectures: Tuesdays 10am, ICT-A2
- Labs: Wednesdays 10am, ICT-404
- You are expected to come to all lectures and labs
  - Tomorrow’s lab is **optional**

The REPL and basic types

Installing Idris

idris-lang.org

Home | News | Example | Documentation | Contributions | Download

Recent Posts

Idris 1.3.2 Released
Idris 1.3.1 released
Idris 1.3.0 released
Idris 1.2.0 released
Idris 1.1.1 released

Meta

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Download

Source

You can download the source from the following places:

- Hackage has the most recent released version. At the prompt, type:
  - `cabal update`
  - `cabal install idris`
- The development version is available from github:

```
git clone git://github.com/idris-lang/Idris-dev.git
```

There are various options available (pass `-f [option]` to `cabal install`) to customise the installation, which you can use depending on which libraries you have available. They are:

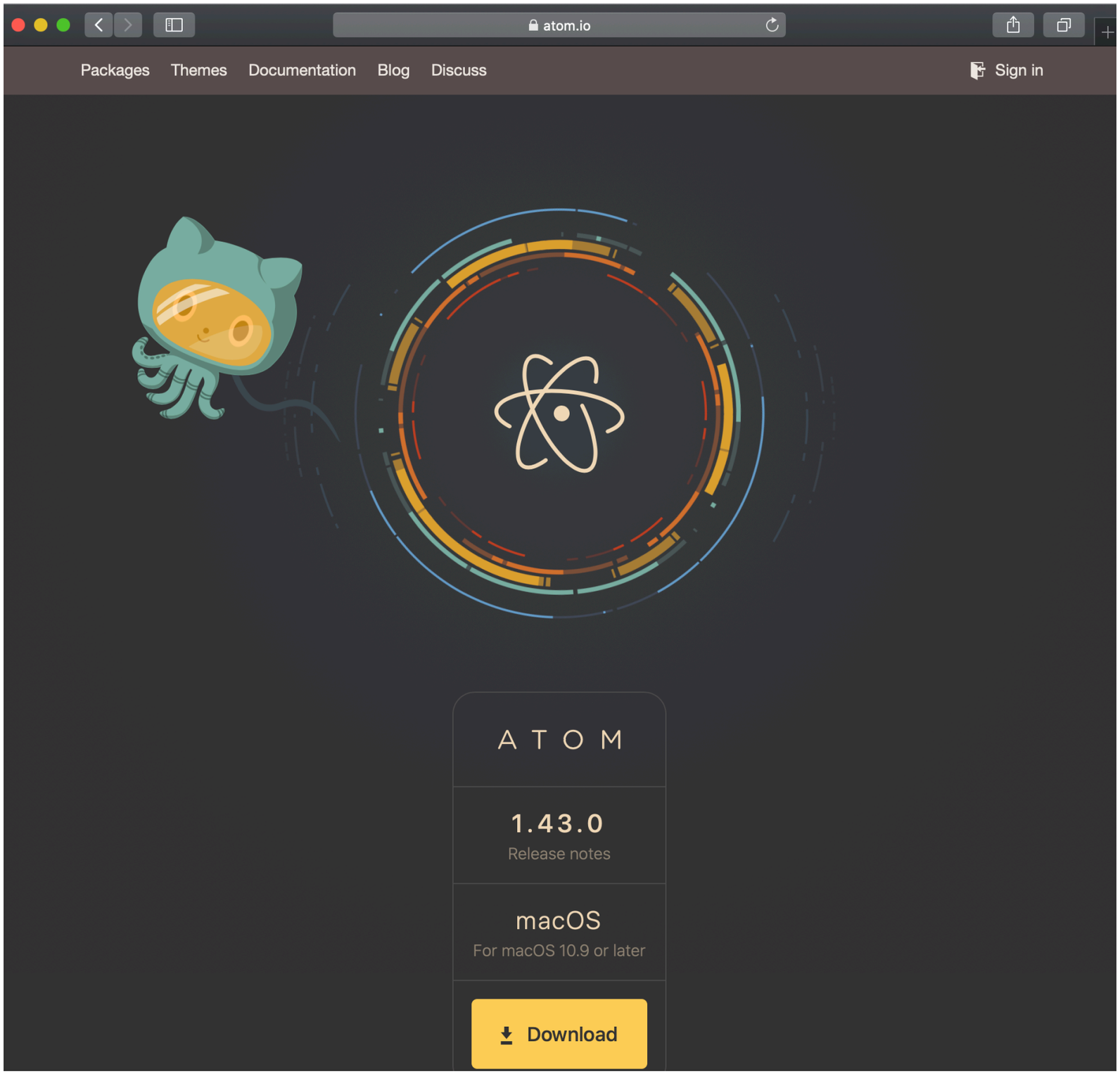
- `llvm` to build the LLVM code generation
- `ffi` to use `libffi`, which is required for the type providers feature.
- `gmp` to use `libgmp` for big integer support (instead of the less efficient `mini-gmp`).
- `curses` to use `libncurses` to get the screen width for pretty-printing.

More detailed **installation instructions** that are maintained by the Idris community are available on the wiki for the following platforms:

- Mac OS
- Windows
- Ubuntu
- Debian

Binary

Recommended editor



REPL

- Read - Eval - Print Loop
- REPL interactive environment
  - After installation, type `idris` at the command prompt
  - `:q` quits

```
⌥⌘3                                                    zsh
% idris
     ____    __     _
    /  _/___/ /____(_)____
    / // __  / ___/ / ___/     Version 1.3.2
  _/ // /_/ / /  / (__  )      http://www.idris-lang.org/
 /___/\__,_/_/  /_/____/       Type :? for help

Idris is free software with ABSOLUTELY NO WARRANTY.
For details type :warranty.
Idris> :q
Bye bye
%
```

Hello world

Hello.idr — ~/Dropbox/mystuff/teaching/functionalProgramming/code

Hello.idr

```
1  module Main
2
3  main: IO ()
4  main = putStrLn "Hello, world!"
5
```

~/Dropbox/mystuff/teaching/functionalProgramming/code/Hello.idr 5:1 LF UTF-8 Idris GitHub Git (0)

Running `Hello.idr`

```
⌥⌘3                                                    idris
% idris Hello.idr
     ____    __     _
    /  _/___/ /____(_)____
    / // __  / ___/ / ___/     Version 1.3.2
  _/ // /_/ / /  / (__  )      http://www.idris-lang.org/
 /___/\__,_/_/  /_/____/       Type :? for help

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*Hello> :exec
Hello, world!
*Hello>
```

Compiling `Hello.idr`

```
% idris Hello.idr -o Hello
% ./Hello
Hello, world!
%
```

Basic numeric types and arithmetic

- `Int` - fixed width signed integer type, at least 31 bits
- `Integer` - unbounded signed integer type
- `Nat` - unbounded unsigned integer type
- `Double` - double-precision floating point

`Integer` is default

The **context** means that `Double` is the only possibility

```
% idris
     ____    __     _
    /  _/___/ /____(_)____
    / // __  / ___/ / ___/     Version 1.3.2
  _/ // /_/ / /  / (__  )      http://www.idris-lang.org/
 /___/\__,_/_/  /_/____/       Type :? for help

Idris is free software with ABSOLUTELY NO WARRANTY.
For details type :warranty.
Idris> 3+4*12
51 : Integer
Idris> it - 6
45 : Integer
Idris> 2.0 * 5
10.0 : Double
Idris>
```

Type conversion with `cast` and `the`

```
Idris is free software with ABSOLUTELY NO WARRANTY.
For details type :warranty.
Idris> :let integerval = 2*2
Idris> :let doubleval = 0.5
Idris> integerval
4 : Integer
Idris> doubleval
0.5 : Double
Idris> integerval + doubleval
(input):1:12:When checking an application of function Prelude.Interfaces.+:
        Type mismatch between
                Double (Type of doubleval)
        and
                Integer (Expected type)
Idris> cast integerval + doubleval
4.5 : Double
Idris> the Integer (cast it)
4 : Integer
Idris> the Int 6
6 : Int
Idris>
```

- Prelude is a list of simple, useful functions written in Idris and loaded by default
- `the` is actually a simple but interesting function defined in the Prelude

```
module Prelude.Basics

import Builtins

%access public export

Not : Type -> Type
Not a = a -> Void

||| Identity function.
id : a -> a
id x = x

||| Manually assign a type to an expression.
||| @ a the type to assign
||| @ value the element to get the type
the : (a : Type) -> (value : a) -> a
the _ = id
```

:doc

```
% idris
     ____    __     _
    /  _/___/ /____(_)____
    / // __  / ___/ / ___/     Version 1.3.2
  _/ // /_/ / /  / (__  )      http://www.idris-lang.org/
 /___/\__,_/_/  /_/____/       Type :? for help

Idris is free software with ABSOLUTELY NO WARRANTY.
For details type :warranty.
Idris> :doc the
Prelude.Basics.the : (a : Type) -> (value : a) -> a
    Manually assign a type to an expression.
    Arguments:
        a : Type  -- the type to assign

        value : a  -- the element to get the type

    The function is: Total & public export
Idris>
```

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the _ = id
```

Characters and strings

```
⌥⌘3                                    idris
 _/ // /_/ / /  / (__  )      http://www.idris-lang.org/
/___/\__,_/_/  /_/____/       Type :? for help

Idris is free software with ABSOLUTELY NO WARRANTY.
For details type :warranty.
Idris> :t 'a'
'a' : Char
Idris> :t "Hello world"
"Hello world" : String
Idris> :let greeting = "Hello!"
Idris> :t greeting
greeting : String
Idris> length greeting
6 : Nat
Idris> reverse greeting
"!olleH" : String
Idris> greeting ++ " " ++ greeting
"Hello! Hello!" : String
Idris> length (greeting ++ " " ++ greeting)
13 : Nat
Idris>
```

- `Char` - character type
- `String` - string type
  - `++` - string concatenation

Booleans

```
⌥⌘3                                    idris
    / // __  / ___/ / ___/     Version 1.3.2
  _/ // /_/ / /  / (__  )      http://www.idris-lang.org/
 /___/\__,_/_/  /_/____/       Type :? for help

Idris is free software with ABSOLUTELY NO WARRANTY.
For details type :warranty.
Idris> :doc Bool
Data type Prelude.Bool.Bool : Type
    Boolean Data Type

    The function is: public export
Constructors:
    False : Bool


        The function is: public export
    True : Bool


        The function is: public export
Idris>
```

- && - logical and
- || - logical or

```
Idris> 3>2
True : Bool
Idris> 3==2
False : Bool
Idris> 3>2 && 3==2
False : Bool
Idris> 3>2 || 3==2
True : Bool
Idris>
```

Functions - the building blocks of FP

Function types and definitions

type declaration

type of function

```
increment: Int -> Int
increment x = x + 1
```

function definition

```
% idris Increment.idr
     ____    __     _
    /  _/___/ /____(_)____
    / // __  / ___/ / ___/     Version 1.3.2
  _/ // /_/ / /  / (__  )      http://www.idris-lang.org/
 /___/\__,_/_/  /_/____/       Type :? for help

Idris is free software with ABSOLUTELY NO WARRANTY.
For details type :warranty.
Type checking ./Increment.idr
*Increment> increment 3
4 : Int
*Increment>
```

Partially applying functions

```
add : Int -> Int -> Int
add x y = x + y
```

```
% idris Add.idr
     ____    __     _
    /  _/___/ /____(_)____
    / // __  / ___/ / ___/     Version 1.3.2
  _/ // /_/ / /  / (__  )      http://www.idris-lang.org/
 /___/\__,_/_/  /_/____/       Type :? for help

Idris is free software with ABSOLUTELY NO WARRANTY.
For details type :warranty.
Type checking ./Add.idr
*Add> add 2 3
5 : Int
*Add> add 2
add 2 : Int -> Int
*Add> :let add2 = add 2
*Add> :t add2
add2 : Int -> Int
*Add> add2 75
77 : Int
```