

# **Functional programming, Seminar No. 1**

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# Basic intro



henlo

# **General words on Haskell and History**

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# Intro

- The language is named after Haskell Curry, an American logician
- The first implementation: 1990
- The language standard: Haskell2010
- Default compiler: Glasgow Haskell compiler
- Haskell is a strongly-typed, polymorphic, and purely functional programming language

# Lambda calculus and type theory. Incomplete and Utter History of Functional Programming

- At the end of the 1920-s, Alonzo Church proposed an alternative approach to the foundations of mathematics where the notion of a function is a primitive one. Informally, lambda-calculus is a formal system that describes abstract functions.

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- Kleene and Rosser showed that the initial version of the lambda calculus is inconsistent. Initially (due to Bertrand Russell), the idea of typing was the instrument that would allow us to avoid paradoxes.
- The first system of typed the lambda calculus is a hybrid from the lambda calculus and type theory developed by Bertrand Russell and Alfred North Whitehead in Principia Mathematica (1910-s).

## Lambda calculus and type theory. Historical notes

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- Polymorphic type inference (Roger Hindley, Robin Milner and Luis Damas (1970-1980-s))
- ML: the very first language with polymorphic inferred type system (Robin Milner, 1973)
- The language Haskell appeared at the beginning of 1990-s. Haskell designed by Simon Peyton Jones, Philip Wadler, and others

# Functional programming and its foundations

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The lambda calculus establishes the foundations for functional programming in the same manner as the von Neumann principles for imperative programming.

- We have no assignment in imperative languages. Variables are nullary constant functions rather than boxes.
- We have no states (in a usual sense)
- We use recursion instead of loops
- Pattern-matching
- ...

# What are types needed for?

## According to Benjamin Pierce

A type system is a tractable syntactic method for proving the absence of certain program behaviours by classifying phrases according to the kinds of values they compute.

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Types in programming languages are about

- A partial specification
- Type preserving
- Type checking allows one to catch simple errors
- Type inference
- Etc

# A landscape of typing from a bird's eye view

We may classify possible ways of typing as follows

- Static and dynamic typing
  - C, C++, Java, Haskell, etc
  - JavaScript, Ruby, PHP, etc
- Implicit and explicit typing
  - JavaScript, Ruby, PHP, etc
  - C++, Java, etc
- Inferred typing
  - Haskell, Standard ML, Ocaml, Idris, etc

# Ecosystem

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# The Haskell Platform installation

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- Install ghc, stack, and cabal using Homebrew

Choose any way you prefer. All these ways are equivalent to each other.

- GHC is a default Haskell compiler.
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- GHC is developed under the GHC Steering committee control.
- Very roughly, compiling pipeline has the following form:  
parsing  $\Rightarrow$  compile-time (type-checking mostly)  $\Rightarrow$  runtime  
(program execution)

- GHCI is a Haskell interpreter based on GHC.
- One may run GHCI with the command `ghci`.
- You may play with GHCI as a calculator, arithmetic operators are usual
- You may also have a look at the GHCI chapter in the GHC User's Guide to get familiar with GHCI closer.

```
cylindricalgebra@daniels-mbp ~ % ghci
GHCI, version 8.10.5: https://www.haskell.org/ghc/ :? for help
Loaded package environment from /Users/cylindricalgebra/.ghc/x86_64-dar
win-8.10.5/environments/default
Prelude> 
```

# Cabal

- Cabal is a system of library and dependency management
- A .cabal file describes the version of a package and its dependencies
- Cabal is also a packaging tool
- Cabal used to cause dependency hell, and it still does.

# Stack

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- Stack is about

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- Stack is a *mainstream* cross-platform build tool for Haskell projects
- Stack is about
  - installation of required packages and the latest GHC (and their more concrete versions),
  - building, execution, and testing
  - creating an isolated location.
  - Builds are reproducible

# Snapshots

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- Stackage is a stable repository that stores snapshots
- A *resolver* is a reference to a required snapshot
- A screenshot from Stackage:

## News

Stackage nightly snapshots to switch to GHC 9.0.1, 3 months ago

## Latest releases per GHC version

- Stackage Nightly 2021-08-24 (ghc-9.0.1), today
- LTS 18.7 for ghc-8.10.6, published 4 days ago
- LTS 18.6 for ghc-8.10.4, published 4 days ago
- LTS 17.2 for ghc-8.10.3, published 7 months ago
- LTS 16.31 for ghc-8.8.4, published 7 months ago
- LTS 16.11 for ghc-8.8.3, published a year ago
- LTS 15.3 for ghc-8.8.2, published a year ago
- LTS 14.27 for ghc-8.6.5, published a year ago
- LTS 13.19 for ghc-8.6.4, published 2 years ago
- LTS 13.11 for ghc-8.6.3, published 2 years ago
- LTS 12.26 for ghc-8.4.4, published 3 years ago
- LTS 12.14 for ghc-8.4.3, published 3 years ago
- LTS 11.22 for ghc-8.2.2, published 3 years ago
- LTS 9.21 for ghc-8.0.2, published 4 years ago
- LTS 7.24 for ghc-8.0.1, published 4 years ago
- LTS 6.35 for ghc-7.10.3, published 4 years ago
- LTS 3.22 for ghc-7.10.2, published 6 years ago
- LTS 2.22 for ghc-7.8.4, published 6 years ago
- LTS 0.7 for ghc-7.8.3, published 7 years ago

# Ecosystem encapsulation

The Haskell ecosystem encapsulation can be described as the sequence of the following inclusions:



## Creating a Haskell project using Stack

- Name your project somehow and run the script `stack new <projectname>`
- You will see the following story after the command `tree .` in the project directory:

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- Name your project somehow and run the script `stack new <projectname>`
- You will see the following story after the command `tree .` in the project directory:

```
cylindricalgebra@daniels-mbp my-first-project % tree .
.
├── ChangeLog.md
├── LICENSE
├── README.md
├── Setup.hs
└── app
    └── Main.hs
├── my-first-project.cabal
└── package.yaml
└── src
    └── Lib.hs
└── stack.yaml
└── test
    └── Spec.hs
```

3 directories, 10 files

`stack.yaml`

Let us discuss on how dependency files look like. First of all, we have a look the `stack.yaml` file:

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```
20  resolver:
21    url: https://raw.githubusercontent.com/commercialhaskell/stackage-snapshots/master/lts/18/7.yaml
22
23 # User packages to be built.
24 # Various formats can be used as shown in the example below.
25 #
26 # packages:
27 # - some-directory
28 # - https://example.com/foo/bar/baz-0.0.2.tar.gz
29 #   subdirs:
30 #     - auto-update
31 #     - wai
32 packages:
33 - .
34 # Dependency packages to be pulled from upstream that are not in the resolver.
35 # These entries can reference officially published versions as well as
36 # forks / in-progress versions pinned to a git hash. For example:
37 #
38 # extra-deps:
39 # - acme-missiles-0.3
40 # - git: https://github.com/commercialhaskell/stack.git
41 #   commit: e7b331f14bcffb8367cd58fbfc8b40ec7642100a
42 #
43 # extra-deps: []
44
45 # Override default flag values for local packages and extra-deps
46 # flags: {}
```

## Cabal file

The .cabal file describes the relevant version of a project and its dependencies:

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```
1 cabal-version: 1.12
2
3 -- This file has been generated from package.yaml by hpack version 0.34.4.
4 --
5 -- see: https://github.com/sol/hpack
6
7 name: my-first-project
8 version: 0.1.0.0
9 description: Please see the README on GitHub at <https://github.com/githubuser/my-first-project#readme>
10 homepage: https://github.com/githubuser/my-first-project#readme
11 bug-reports: https://github.com/githubuser/my-first-project/issues
12 author: Author name here
13 maintainer: example@example.com
14 copyright: 2021 Author name here
15 license: BSD3
16 license-file: LICENSE
17 build-type: Simple
18 extra-source-files:
19   README.md
20   ChangeLog.md
21
22 source-repository head
23   type: git
24   location: https://github.com/githubuser/my-first-project
25
26 library
```

## package.yaml

The package.yaml is used to generate the .cabal file automatically:

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```
1 name:          my-first-project
2 version:       0.1.0.0
3 github:        "githubuser/my-first-project"
4 license:       BSD3
5 author:        "Author name here"
6 maintainer:    "example@example.com"
7 copyright:     "2021 Author name here"
8
9 extra-source-files:
10 - README.md
11 - ChangeLog.md
12
13 # Metadata used when publishing your package
14 # synopsis:      Short description of your package
15 # category:      Web
16
17 # To avoid duplicated efforts in documentation and dealing with the
18 # complications of embedding Haddock markup inside cabal files, it is
19 # common to point users to the README.md file.
20 description:   Please see the README on GitHub at <https://github.com/githubuser/my-first-project#readme>
21
22 dependencies:
23 - base >= 4.7 && < 5
24
25 library:
26   source-dirs: src
```

# Building and running a project

The basic commands:

- stack build
- stack run
- stack exec
- stack ghci
- stack clean
- stack test

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The roles of all these commands follow from their quite self-explanatory names.

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## singletons: Basic singleton types and definitions

[ bsd3, dependent-types, library ] | Propose Tags

singletons contains the basic types and definitions needed to support dependently typed programming techniques in Haskell. This library was originally presented in *Dependently Typed Programming with Singletons*, published at the Haskell Symposium, 2012.

(<https://cs.brynmawr.edu/~rae/papers/2012/singletons/paper.pdf>)

singletons is intended to be a small, foundational library on which other projects can build. As such, singletons has a minimal dependency footprint and supports GHCs dating back to GHC 8.0. For more information, consult the [singletons README](#).

You may also be interested in the following related libraries:

- The `singletons-th` library defines Template Haskell functionality that allows *promotion* of term-level functions to type-level equivalents and *singling* functions to dependently typed equivalents.
- The `singletons-base` library uses `singletons-th` to define promoted and singled functions from the `base` library, including the `Prelude`.

[Skip to Readme]

[Build](#) [Symbolic](#) [Documentation](#) [Available](#)

### Modules

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Data

Data.Singletons  
Data.Singletons.Decide  
Data.Singletons.ShowSing  
Data.Singletons.Sigma

Versions [RSS] [TSV]

0.8, 0.8.1, 0.8.2, 0.8.3, 0.8.4, 0.8.5, 0.8.6, 0.9.0, 0.9.1, 0.9.2, 0.9.3, 0.10.0, 1.0, 1.1, 1.1.1, 1.1.2, 1.1.2.1, 2.0, 2.0.0.1, 2.0.0.2, 2.0.1, 2.1, 2.2, 2.3, 2.3.1, 2.4, 2.4.1, 2.5, 2.5.1, 2.6, 2.7, 3.0

Changes log

[CHANGES.md](#)

Dependencies

base (>=4.9 & & <4.16) [details]

License

BSD-3-Clause

Author

Richard Eisenberg <rae@cs.brynmawr.edu>, Jan Stolarek <jan.stolarek@p.lodz.pl>

Maintainer

Ryan Scott <ryan.gScott@gmail.com>

Category

Dependent Types

Home page

<http://www.github.com/goldfirere/singletons>

Bug tracker

<https://github.com/goldfirere/singletons/issues>

Source repo

this: git clone <https://github.com/goldfirere/singletons.git> (tag v3.0)  
(singletons)  
head: git clone <https://github.com/goldfirere/singletons.git> -b master(singletons)

Uploaded

by [ryan.gScott](#) at 2021-03-12T17:18:52Z

## Hoogle

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**Hoogλe**  set:stackage

**Packages**

- ⊖ is:exact
- ⊖ is:module
- ⊖ base
- ⊖ Cabal
- ⊖ hedgehog
- ⊖ semigroupoids
- ⊖ comonad
- ⊖ rio
- ⊖ numeric-prelude
- ⊖relude
- ⊖ universum
- ⊖ foundation
- ⊖ basement
- ⊖ clash-prelude
- ⊖ dimensional
- ⊖ ghc
- ⊖ ghc-lib-parser

**fmap :: Functor f => (a -> b) -> f a -> f b**

base Prelude Control.Monad Instances Data.Functor GHC.Base, Cabal Distribution.Compat.Prelude.Internal, hedgehog Hedgehog.Internal.Prelude, semigroupoids Data.Functor.Apply Data.Functor.Bind, comonad Control.Comonad, rio RIO.Prelude, numeric-prelude NumericPrelude NumericPrelude.Base,relude Relude.Functor.Reexport, universum Universum.Functor.Reexport, foundation Foundation, basement Basement Compat.Base Basement.Imports, clash-prelude Clash HaskellPrelude, dimensional Numeric.Units.Dimensional.Prelude, ghc GhcPrelude, ghc-lib-parser GHC.Prelude, rebase Rebase.Prelude, nri-prelude NriPrelude, massiv-test Test.Massiv.Utils, numhash NumHash.Prelude, stack Stack.Prelude, mixed-types-num Numeric.MixedTypes.PreludeHiding, loc Data.Loc.Internal.Prelude, faktory Prelude, hledger-web Hledger.Web.Import, tonalude Tonalude, zio ZIO.Trans

⊕ Using Applicative do: "fmap f xs" can be understood as the do expression

**fmap :: Functor f => (a -> b) -> f a -> f b**

base-compat Control.Monad.Compat Data.Functor.Compat Prelude.Compat, protolude Protolude.Functor, base-prelude BasePrelude, basic-prelude CorePrelude, base-compat-batteries Control.Monad.Compat Data.Functor.Compat, prelude-compat Prelude2010, lvm-hs-pure LLVM.Prelude LLVM.Prelude, xmonad-contrib XMonad.Config.Prime, LambdaHack Game.LambdaHack.Core.Prelude Game.LambdaHack.Core.Prelude, can-i-haz Control.Monad.Except.Cohas Control.Monad.Reader.Has, yesod-paginator Yesod.Paginator.Prelude

**fmap :: Functor f => a -> b -> f a -> f b**

classy-prelude ClassyPrelude, control-monad-free Control.Monad.Free, distribution-openuse OpenSuse.Prelude OpenSuse.Prelude

**fmap :: Functor f => (a ->< b) -> f a -> f b**

invertible Control.Invertible.Functor Data.Invertible.Prelude

## Hackage Search

Hackage Search is a searching tool for Hackage based on regular expressions. This tool is by Vladislav Zavialov, my GHC teammate from Serokell.

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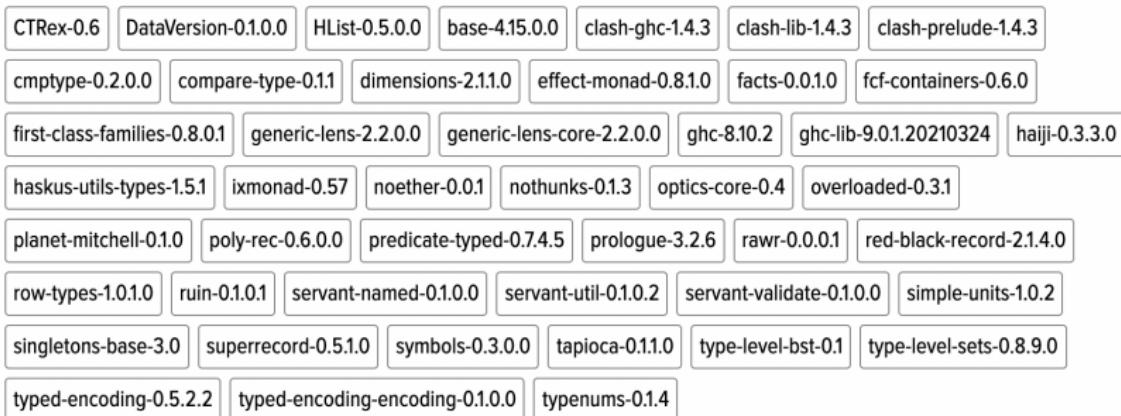
The screenshot shows the Hackage Search interface. At the top, there's a navigation bar with 'Expand All' and 'Collapse All' buttons, and links to 'Query Examples' and 'Regex Syntax Reference'. Below the navigation is a search bar containing the query 'CmpSymbol'. The main content area displays a search result for the package 'AspectAG-0.6.0.0'. The result page has a dark header bar with the package name. Below it, the file 'src/Language/Grammars/AspectAG/RecordInstances.hs' is shown. The code contains several instances of the type 'CmpSymbol'. Lines 45 and 48 are highlighted in red, while others are in black. The code listing is as follows:

```
43
44 type instance Cmp ('Att a _) ('Att b _) =
45   CmpSymbol a b
46
47 type instance Cmp ('Prd a _) ('Prd b _) =
48   CmpSymbol a b
49
50 type instance Cmp ('Chi a _ _) ('Chi b _ _) =
51   CmpSymbol a b
52
53
```

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Search completed (161 matches across 47 packages)

# Summary

We had a look at such topics as

1. General aspects of GHC and GHCI
2. The Haskell Platform installation
3. Dependency management using Stack and Cabal
4. In other words, the Haskell ecosystem in a nutshell

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On the next seminar, we will discuss:

1. The basic Haskell syntax
2. The underlying aspects of the Haskell type system
3. Functions and lambdas
4. Immutability and laziness