Functional programming, Seminar No. 1

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Basic intro

General words on Haskell and History

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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- 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).

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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 desinged by Simon Peyton Jones, Philip Wadler, and others

Functional programming and its foundations

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- 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?

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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

The Haskell Platform installation

There are several ways to install the Haskell platform on Mac (if you have M1, don't cry):

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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

- GHC is a default Haskell compiler.
- GHC is an open-source project. Don’t hesitate to contribute!
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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

- 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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- A *resolver* is a reference to a required snapshot
- A screenshot from Stackage:

News

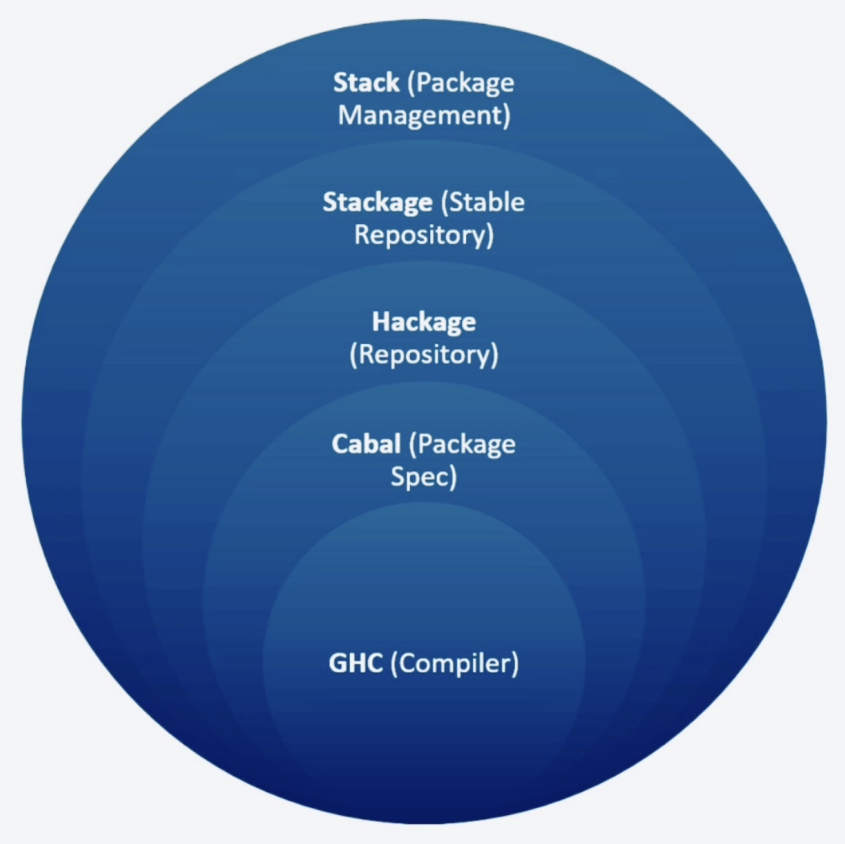
Stackage nightly snapshots to switch to GHC 9.0.1, 3 months ago

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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```
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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```yaml
resolver:
  url: https://raw.githubusercontent.com/commercialhaskell/stackage-snapshots/master/lts/18/7.yaml

# User packages to be built.
# Various formats can be used as shown in the example below.
#
# packages:
# - some-directory
# - https://example.com/foo/bar/baz-0.0.2.tar.gz
#   subdirs:
#   - auto-update
#   - wai
packages:
- .
# Dependency packages to be pulled from upstream that are not in the resolver.
# These entries can reference officially published versions as well as
# forks / in-progress versions pinned to a git hash. For example:
#
# extra-deps:
# - acme-missiles-0.3
# - git: https://github.com/commercialhaskell/stack.git
#   commit: e7b331f14bcffb8367cd58fbfc8b40ec7642100a
#
# extra-deps: []

# Override default flag values for local packages and extra-deps
# flags: {}
```

Cabal file

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

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```
cabal-version: 1.12

-- This file has been generated from package.yaml by hpack version 0.34.4.
--
-- see: https://github.com/sol/hpack

name:           my-first-project
version:        0.1.0.0
description:    Please see the README on GitHub at <https://github.com/githubuser/my-first-project#readme>
homepage:       https://github.com/githubuser/my-first-project#readme
bug-reports:    https://github.com/githubuser/my-first-project/issues
author:         Author name here
maintainer:     example@example.com
copyright:      2021 Author name here
license:        BSD3
license-file:   LICENSE
build-type:     Simple
extra-source-files:
    README.md
    ChangeLog.md

source-repository head
  type: git
  location: https://github.com/githubuser/my-first-project

library
```

`package.yaml`

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

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```yaml
name:                my-first-project
version:             0.1.0.0
github:              "githubuser/my-first-project"
license:             BSD3
author:              "Author name here"
maintainer:          "example@example.com"
copyright:           "2021 Author name here"

extra-source-files:
- README.md
- ChangeLog.md

# Metadata used when publishing your package
# synopsis:            Short description of your package
# category:            Web

# To avoid duplicated efforts in documentation and dealing with the
# complications of embedding Haddock markup inside cabal files, it is
# common to point users to the README.md file.
description:         Please see the README on GitHub at <https://github.com/githubuser/my-first-project#readm

dependencies:
- base >= 4.7 && < 5

library:
  source-dirs: src
```

Building and running a project

The basic commands:

- `stack build`
- `stack run`
- `stack exec`
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- `stack test`

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

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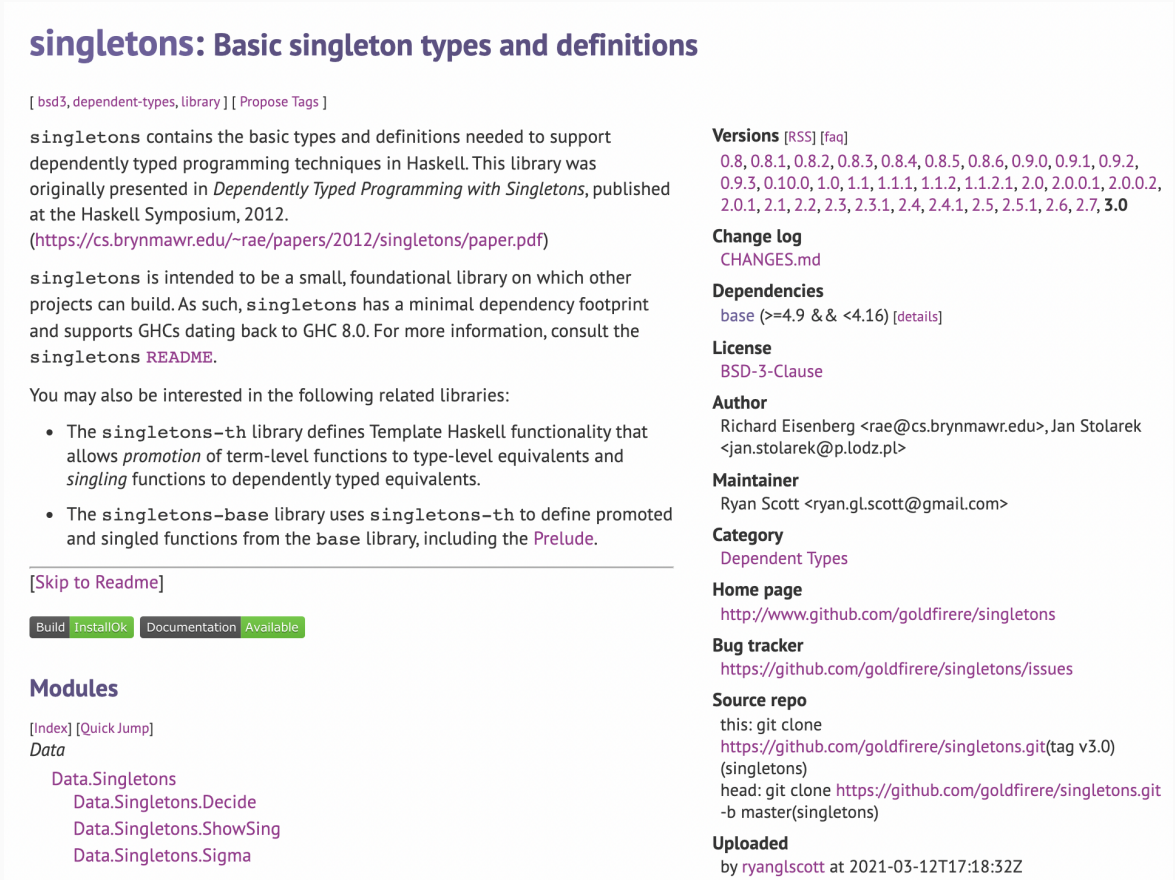

singletons: Basic singleton types and definitions

[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 InstallOk Documentation Available

Modules

[Index] [Quick Jump]
Data
Data.Singletons
Data.Singletons.Decide
Data.Singletons.ShowSing
Data.Singletons.Sigma

Versions [RSS] [faq]
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**

Change 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.gl.scott@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 ryanglscott at 2021-03-12T17:18:32Z

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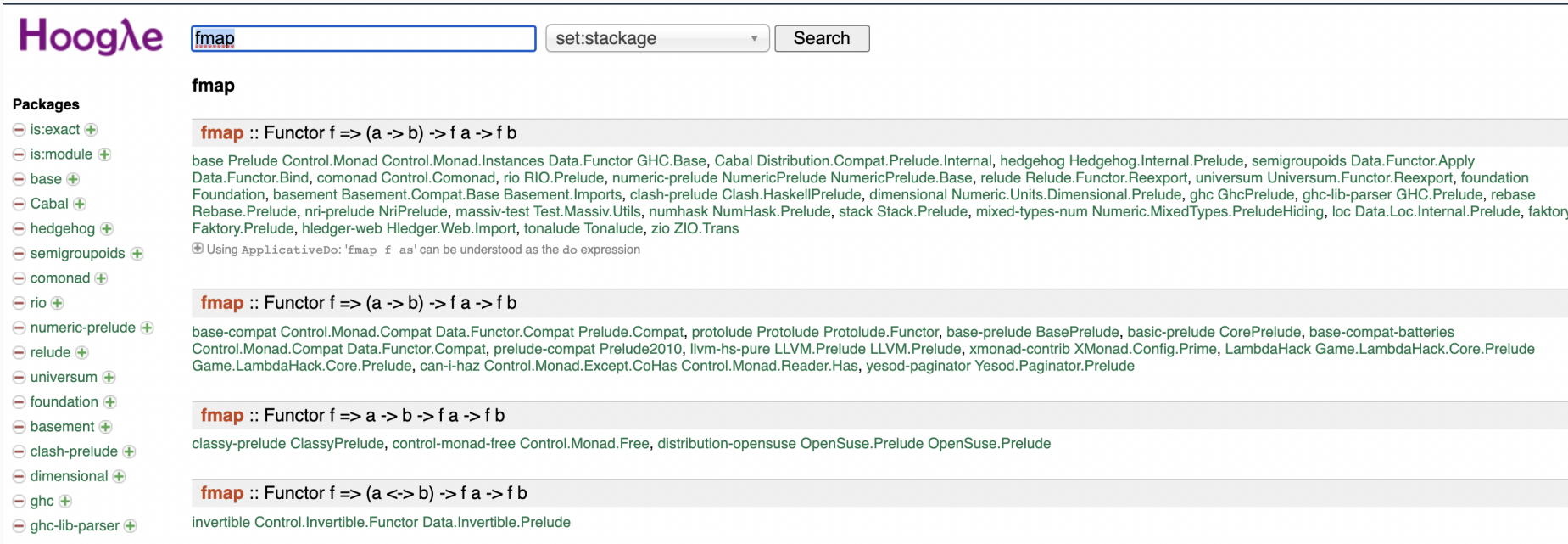

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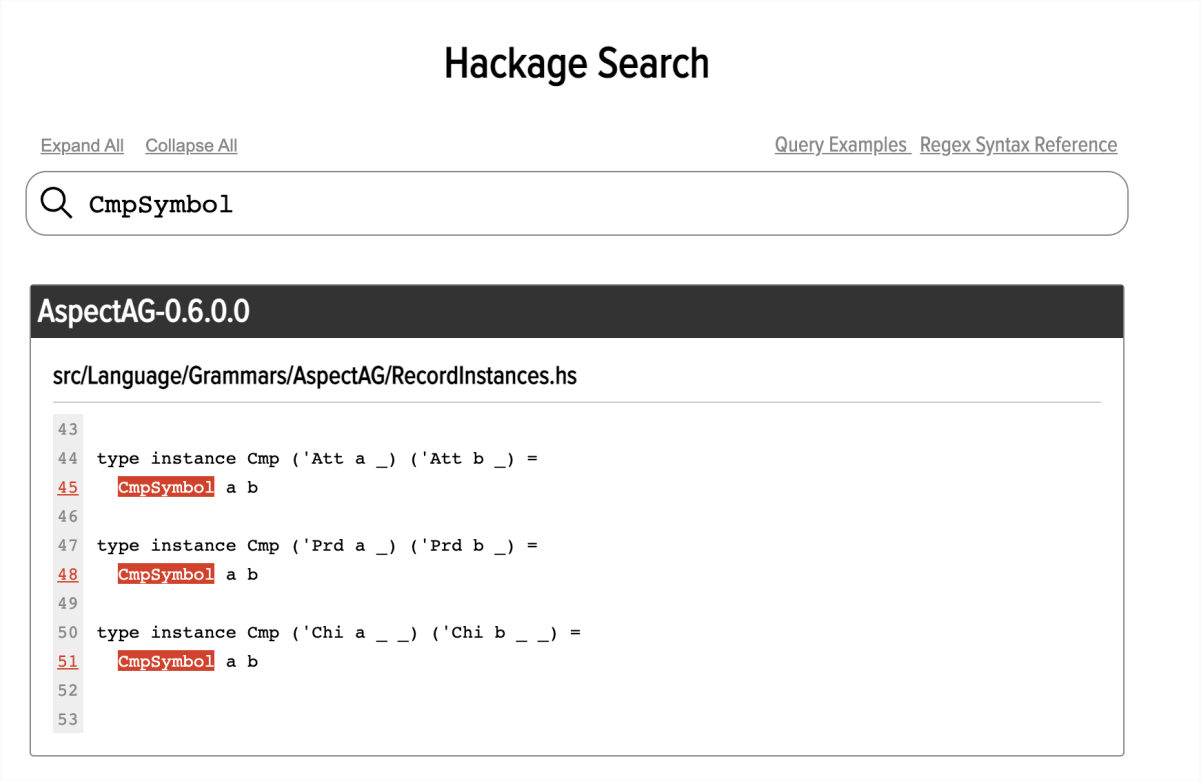

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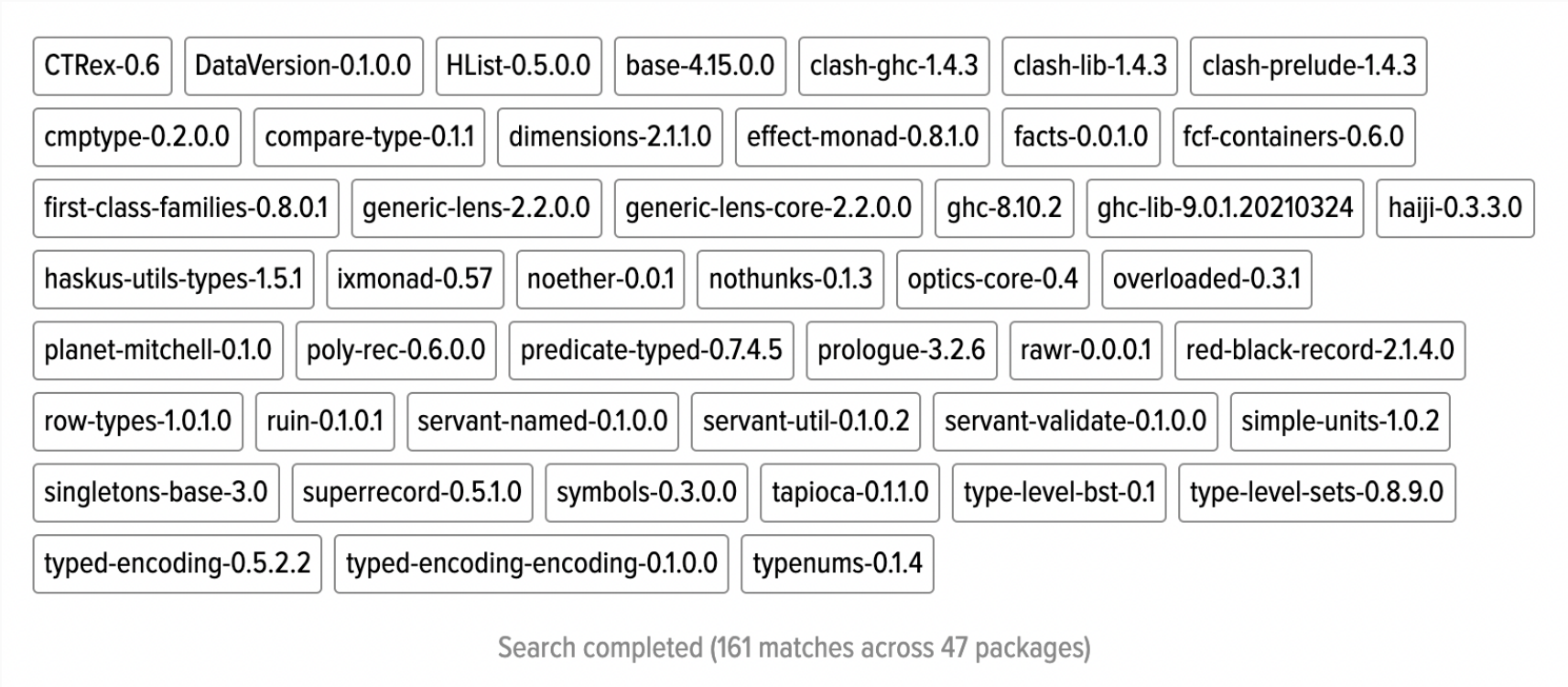

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2. The Haskell Platform installation
3. Dependency management using Stack and Cabal
4. In other words, the Haskell ecosystem in a nutshell

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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