Haskell Communities and Activities Report

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Twenty-Eighth Edition — May 2015

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Preface

This is the 28th edition of the Haskell Communities and Activities Report. There are a number of completely new entries but a large chunk of the old entries have not been updated. However, we have two old entries which have resurfaced, so there is hope that other old entries will receive updates on the next edition.

As usual, fresh entries – either completely new or old entries which have been revived after a short temporarily disappearance – are formatted using a blue background, while updated entries have a header with a blue background.

Entries on which no new activity has been reported since 2013 have been dropped completely. Please do revive such entries next time if you do have news on them.

A call for new HCAR entries and updates to existing ones will be issued on the Haskell mailing lists in late September/early October.

Now enjoy the current report and see what other Haskellers have been up to lately. Any feedback is very welcome, as always.

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1 Community

1.1 Haskellers

Report by:	Michael Snoyman
Status:	experimental

Haskellers is a site designed to promote Haskell as a language for use in the real world by being a central meeting place for the myriad talented Haskell developers out there. It allows users to create profiles complete with skill sets and packages authored and gives employers a central place to find Haskell professionals.

Haskellers is a web site in maintenance mode. No new features are being added, though the site remains active with many new accounts and job postings continuing. If you have specific feature requests, feel free to send them in (especially with pull requests!).

Haskellers remains a site intended for all members of the Haskell community, from professionals with 15 years experience to people just getting into the language.

Further reading

http://www.haskellers.com/

2 Books, Articles, Tutorials

2.1 The Monad.Reader

Report by: Edward Z. Yang

There are many academic papers about Haskell and many informative pages on the HaskellWiki. Unfortunately, there is not much between the two extremes. That is where The Monad.Reader tries to fit in: more formal than a wiki page, but more casual than a journal article.

There are plenty of interesting ideas that might not warrant an academic publication—but that does not mean these ideas are not worth writing about! Communicating ideas to a wide audience is much more important than concealing them in some esoteric journal. Even if it has all been done before in the Journal of Impossibly Complicated Theoretical Stuff, explaining a neat idea about "warm fuzzy things" to the rest of us can still be plain fun.

The Monad.Reader is also a great place to write about a tool or application that deserves more attention. Most programmers do not enjoy writing manuals; writing a tutorial for The Monad.Reader, however, is an excellent way to put your code in the limelight and reach hundreds of potential users.

Further reading

http://themonadreader.wordpress.com/

2.2 Oleg's Mini Tutorials and Assorted Small Projects

Report by: Oleg Kiselyov

The collection of various Haskell mini tutorials and assorted small projects (http://okmij.org/ftp/Haskell/) has received two additions:

Combinators for parsing several streams at once

Parsing combinators, from the basic Text.ParserCombinators.ReadP to iteratees, obtain their input from an *implicit* stream. It is this implicitness that makes the combinators easily compose and convenient to use. It also makes the parsing of two streams at the same time seemingly impossible. A characteristic example is merging two sorted streams, where the streams are read in a complex, statically unpredictable pattern.

With iteratees at least, the problem is solvable. The solution maintains all the advantages of iteratees: incremental processing, buffering, precise resource control and the prevention of resource leaks. It surprising how trivial the solution is, requiring no changes to the iteratee implementation nor even the knowledge of it. The key is observation is that `Iteratee` is a monad transformer and hence can be iterated. Laying iteratee monad transformers upon each other gives an us access to several streams at once. The solution thus extends to other parser combinators that are transformers.

Read the tutorial online.

Leibniz equality can, after all, be made injective

The paper "Typing Dynamic Typing" (Baars and Swierstra, ICFP 2002) demonstrated the first implementation and application of so-called Leibniz equality witnesses in Haskell:

$$\textbf{newtype}\ \mathsf{EQU}\ a\ b = \mathsf{EQU}\ \{ subst :: \forall c.\, c\ a \to c\ b \}$$

Given a term $eq :: \mathsf{EQU}\ a\ b$, $subst\ eq :: \forall c.\, c\ a \to c\ b$ will convert a value $c\ a$ – that is, the value of type a in the context represented by the type constructor c – into $c\ b$. In other words, in any context c, the type a can be substituted with the type b, which is how Leibniz defined equality. The Leibniz equality term EQU is a poor-man GADT, and that's why it is useful. Unlike GADT, it is implementable in any language with the rank-2 polymorphism.

The Baars and Swierstra paper showed a good example of using Leibniz equality, to implement type checkers and type inferencers. For this task we also need to establish the equality of two arrow types: two arrow types are equal if their components are equal:

$$eq\_arr :: \mathsf{EQU}\ a1\ a2 \to \mathsf{EQU}\ b1\ b2 \to \mathsf{EQU}\ (a1 \to b1)\ (a2 \to b2)$$

Such a function *eq_arrow* is easily implementable. Yet sometimes (see for example, "Implementing Cut Elimination: A Case Study of Simulating Dependent Types in Haskell" by Chen, Zhu and Xi, PADL'04) we need the reverse direction: if two arrow types are equal, their argument types are equal as well (ditto for the result types). This reverse direction, which relies on arrow being injective, is impossible to obtain without extra features. It is here were GADTs show more power over Leibniz equality.

It turns out that with type functions, Leibniz equality is injective. The key is a realization that type-constructor polymorphism extends to the polymorphism over arbitrary type functions. Leibniz injectivity is also the example of type functions seemingly more expressive than type-class functional dependencies. Despite a long-standing challenge no one has shown how

to implement injective Leibniz equality using just functional dependencies.

Read the tutorial online.

2.3 School of Haskell

Report by:	Natalia Muska
Participants:	Michael Snoyman, Edward Kmett, Simon Peyton Jones and others
Status:	active

The School of Haskell has been available since early 2013. It's main two functions are to be an education resource for anyone looking to learn Haskell and as a sharing resources for anyone who has built a valuable tutorial. The School of Haskell contains tutorials, courses, and articles created by both the Haskell community and the developers at FP Complete. Courses are available for all levels of developers.

Two new features were added to the School of Haskell. First is the addition of Disqus for commenting on each tutorial and highlighting other potentially interesting tutorials. Second is the inclusion of autorun tags. This enables users to run a snippet as soon as they open a tutorial.

Currently 3150 tutorials have been created (a 125% increase from this time last year) and 441 have been officially published (a 53% increase from this time last year). Some of the most visited tutorials are Text Manipulation Attoparsec, Learning Haskell at the SOH, Introduction to Haskell - Haskell Basics, and A Little Lens Starter Tutorial. Over the past year the School of Haskell has averaged about 16k visitors a month.

All Haskell programmers are encouraged to visit the School of Haskell and to contribute their ideas and projects. This is another opportunity to showcase the virtues of Haskell and the sophistication and high level thinking of the Haskell community.

Further reading

Visit the School of Haskell here https://www.fpcomplete.com/school

2.4 Agda Tutorial

Report by:	Péter Diviánszky
Participants:	Ambrus Kaposi, students at ELTE IK
Status:	experimental

Agda may be the next programming language to learn after Haskell. Learning Agda gives more insight into the various type system extensions of Haskell, for example.

The main goal of the tutorial is to let people explore programming in Agda without learning theoretical background in advance. Only secondary school mathematics is required for the tutorial.

Further reading

http://people.inf.elte.hu/divip/AgdaTutorial/Index.html

3 Implementations

3.1 The Glasgow Haskell Compiler

Report by:	Austin Seipp
Participants:	many others

GHC 7.10.1 was released in March this year, shipping several major improvements, and development continues to steam forward as it always does. However, things have been relatively quiet for most of 2015 so far, as people have simply been working away. Currently our master branch does not heavily diverge much from GHC 7.10, but that could change soon!

Major changes in GHC 7.10.1

When we shipped GHC 7.10, we incorporated some major new features - but not without some major decision making, it turns out. These included:

Making Applicative a superclass of Monad Yes, finally!

Generalizing Prelude operators Known in various circles as "The Burning-Bridges Proposal" (BBP) or "The Foldable Traversable Proposal" (FTP), this proposal offered to generalize many Prelude operations to functions in Data.Traversable and Data.Foldable. However, this plan stirred up a relatively large amount of debate regarding deviations from the standard, communicating plans, and the implications will be. In the end, Simon Peyton Jones and Simon Marlow sought feedback from the community, and ended up making a final decision in February, after hundreds of input votes from the community, and decided to move forward with the plan.

Distributed programming, *static* values, and reflection Mathieu Boespflug and Facundo Dominguez at TweagIO completely reimplemented their old proposal for *static* values, primarily intended to support Cloud Haskell, and it was merged into GHC 7.10. The support as it stands should be experimental, but the new implementation is much simpler and easier to understand. This is part of a larger project involving runtime reflection and distributed programming

Binary literals Herbert Valerio Riedel implemented the −XBinaryLiterals language extension which finally closes the syntax gap relative to other languages which allow to write base-2 literals such as 0 *b11001001*.

Partial type signatures Thomas Winant and Dominique Devriese implemented partial type signatures for GHC. A partial type signature is a type signature that can contain *wildcards*, written as underscores. These wildcards can be types unknown to the programmer or types he doesn't care to annotate. The type checker will use the annotated parts of the partial type signature to type check the program, and infer the types for the wildcards. A wildcard can also occur at the end of the constraints part of a type signature, which indicates that an arbitrary number of extra constraints may be inferred. Whereas −XTypedHoles allow holes in your terms, −XPartialTypeSignatures allow holes in your types!

Preliminary backpack support Edward Yang has been working tirelessly on support for Backpack features in GHC. GHC 7.10 shipped with some preliminary code to support it, including signature file support and some Cabal support, but we have a new plan for GHC 7.12, with new syntax and a new implementation strategy. You can find out more by checking out the algorithm specification (https://github.com/ghc/ghc/blob/master/docs/backpack/algorithm.pdf). Work is currently proceeding on the ghc-backpack branch.

Reimplemented GMP-based Integer backend Herbert Valerio Riedel completely reimplemented the *integer − gmp* backend, and is now shipping it on all Tier 1 platforms. This should make interoperation with GMP (and C libraries that depend on GMP) radically simpler, while being easier to maintain.

DWARF support for debugging symbols Peter Wortmann has gotten the first piece of his long-term work in place: support for GHC to emit DWARF symbols to object files, so debuggers can utilize it. The preliminary support works for simple cases, but is very experimental! (Case in point: it was broken in 7.10.1 due to #10236 – https://ghc.haskell.org/trac/ghc/ticket/10236)

API Annotations and other GHC API changes Alan Zimmerman has added API Annotations to the AST, so that the precise layout of the original source code can be regenerated. An initial library making use of these to fully round trip Haskell source code is at https://github.com/alanz/ghc-exactprint. This will be updated shortly after 7.10.2 comes out, and then used by HaRe to handle the low level AST manipulation. Also, the landmines have been removed from the AST, so that traversals over it

no longer need to tiptoe around embedded *panic* values. Andrew Gibiansky has added more parser entry points, so that tools can now parse fragments of source code.

Typechecker plugins Iavor Diatchki, Eric Seidel and Adam Gundry implemented preliminary support for extending the typechecker using plugins, making it easier to experiment with custom constraint solvers.

Upcoming plans for the next release

The current plan is to steam forward to the end of the year, and begin to get ready for a new release, probably in February of 2016. We have some tentative plans marked below - and some of them are huge! In particular - we may ship GHC 8.0 next year, if we're going to change the entire Core language!

Libraries, source language, type system

Signature sections Lennart Augustsson is implementing $(::ty)$ to work the same as $(\lambda x \to x :: ty)$

ApplicativeDo Now that Applicative is a superclass of Monad, Simon Marlow has implemented a new extension for GHC, which will allow do notation to be used in the context of Applicative, not just Monad. The patch for review is available at https://phabricator.haskell.org/D729, and Simon Marlow believes it's ready for review and merge.

Overloaded record fields After countless more discussions and several revisions, Adam Gundry implemented the new −XOverloadedRecordFields extension for GHC – again! – but this time with a newer design – and the first piece of the implementation is up for review at https://phabricator.haskell.org/D761 – we're hoping to review it and integrate it soon.

Using an SMT Solver as a type-checker plugin Iavor Diatchki is working on implementing support for using SMT solvers in the typechecker, via the plugins mechanism. Currently, the main focus for this is improved support for reasoning with type-level natural numbers, but it opens the doors to other interesting functionality, such as supported for lifted (i.e., type-level) $(\wedge)$, and $(|)$, type-level bit-vectors (perhaps this could be used to implement type-level sets of fixed size), and others.

Kind equality, kind coercions, and dependently typed Core Richard Eisenberg (with support from Simon PJ and Stephanie Weirich, among others) is implementing a change to the Core language, as described in "System FC with explicit kind equality". When this work is complete, all types will be promotable to kinds, and all data constructors will be promotable to types. This will include promoting type synonyms and type families. As the details come together, there may be other source language effects, such as the ability to make kind variables explicit. It is not expected for this to be a breaking change – the change should allow strictly more programs to be accepted. This can also go down as one of the larger changes in recent memory – https://phabricator.haskell.org/D808 is the biggest Phabricator review we've done to date, changing over 10,000 lines of code in the compiler!

Injective type families Jan Stolarek (with support from Richard Eisenberg and Simon PJ) is working on adding injective type families to GHC. With this feature it will be possible to annotate declaration of a type family - closed, open or associated with class - with injectivity annotation and GHC will be able to use that information during type checking.

Safe Haskell & Overlapping Instances David Terei has overhauled how overlapping instances work under Safe Haskell. This greatly expands the number of regular Haskell programs that work under Safe Haskell and makes use of the new per-instance overlapping instances added in GHC 7.10. It also unifies how overlapping instances work when inferring a modules safety, vs. explicit use of −XSafe.

Safe Haskell, GND & Roles David Terei and Richard Eisenberg are currently discussing possible changes to how Roles should work to allow them to be included in the safe-language of Safe Haskell. These are early discussions with no changes yet planned, but they'd love any feedback. The wiki page contains a wealth of information. Both the background and possible paths forward.

Back end and runtime system

CPU-specific optimizations Austin Seipp is currently investigating the implementation of CPU-specific optimisations for GHC, including new `-march` and `-mcpu` flags to adjust tuning for a particular processor. Right now, there is some preliminary work towards optimizing copies on later Intel machines. There's interest in expanding this further as well.

Changes to static closures for faster garbage collection Edward Yang is working on an overhaul of how static closures represented at runtime to eliminate some expensive memory dereferences in the GC hotpath. The initial results are encouraging: these changes can result in an up to 8% in the runtime of some GC heavy benchmarks. See ticket #8199.

DWARF-based stack tracing Peter Wortmann and Arash Rouhani (with support from the Simons) are working on enabling GHC to now use the DWARF debugging information it generates. This should allow us to obtain stack traces and do profiling without

the need for instrumentation, directly from Haskell executables.

An Improved LLVM Backend that ships with every major Tier 1 platform.

Native code generator for PowerPC 64-bit Peter Trommler has been working on an extension of the PowerPC native code backend to support 64-bit Linux systems. There are two 64-bit ELF ABI versions. The implementation of ABI version 1, which is mostly used by big endian systems, is fairly stable and support for ABI version 2, which is used by systems with POWER8 processors running in little endian mode, is currently under testing. See ticket #9863.

Frontend, build-system, and miscellaneous changes

Shaking up GHC [Shake]. Andrey Mokhov (with support from Neil Mitchell, Simon Marlow and Simon PJ) is working on a new Shake-based build system for GHC. The goal is to make it much more understandable, maintainable and convenient to use than the current *make*-based one. It is also expected that the new build system will be faster, because Shake allows to express build dependencies more accurately.

Development updates, joining in and a big Thank You!

In the past several months, GHC has seen a surge of community involvement, and a great deal of new contributors.

As ever, there is a ton of stuff in the future for us to do. If you want something done — don't wait, it might take a while. You should join us instead!

Links:

- https://ghc.haskell.org/trac/ghc/wiki/Prelude710
- https://mail.haskell.org/pipermail/libraries/2015-February/024925.html
- https://mail.haskell.org/pipermail/libraries/2015-February/025009.html
- https://ghc.haskell.org/trac/ghc/wiki/StaticPointers
- https://ghc.haskell.org/trac/ghc/wiki/Typeable
- https://ghc.haskell.org/trac/ghc/wiki/DistributedHaskell
- https://ghc.haskell.org/trac/ghc/wiki/PartialTypeSignatures
- https://github.com/ezyang/ghc/tree/ghc-backpack
- https://ghc.haskell.org/trac/ghc/wiki/DWARF
- https://ghc.haskell.org/trac/ghc/wiki/GhcApi
- https://ghc.haskell.org/trac/ghc/wiki/ApiAnnotations
- https://ghc.haskell.org/trac/ghc/wiki/Plugins/TypeChecker
- https://ghc.haskell.org/trac/ghc/wiki/ApplicativeDo
- https://ghc.haskell.org/trac/ghc/wiki/Records/OverloadedRecordFields
- https://github.com/yav/type-nat-solver
- https://github.com/yav/type-nat-solver/raw/master/docs/paper.pdf
- http://www.seas.upenn.edu/~eir/papers/2013/fckinds/fckinds-extended.pdf
- https://ghc.haskell.org/trac/ghc/wiki/InjectiveTypeFamilies
- https://ghc.haskell.org/trac/ghc/wiki/SafeHaskell/NewOverlappingInstances
- https://ghc.haskell.org/trac/ghc/wiki/SafeRoles
- https://ghc.haskell.org/trac/ghc/wiki/DWARF
- https://ghc.haskell.org/trac/ghc/wiki/ImprovedLLVMBackend
- https://phabricator.haskell.org/D629
- https://ghc.haskell.org/trac/ghc/wiki/Building/Shake
- https://ghc.haskell.org/trac/ghc/wiki/Phabricator

3.2 Ajhc Haskell Compiler

Report by:	Kiwamu Okabe
Participants:	John Meacham, Hiroki Mizuno, Hidekazu Segawa, Takayuki Muranushi
Status:	experimental

What is it?

Ajhc is a Haskell compiler, and acronym for "A fork of jhc".

Jhc (http://repetae.net/computer/jhc/) converts Haskell code into pure C language code running with jhc's runtime. And the runtime is written with 3000 lines (include comments) pure C code. It's a magic!

Ajhc's mission is to keep contribution to jhc in the repository. Because the upstream author of jhc, John Meacham, can't pull the contribution speedily. (I think he is too busy to do it.) We should feedback jhc any changes. Also Ajhc aims to provide the Metasepi project with a method to rewrite NetBSD kernel using Haskell. The method is called Snatch-driven development http://www.slideshare.net/master_q/20131020-osc-tokyoajhc.

Ajhc is, so to speak, an accelerator to develop jhc.

Demonstrations

https://www.youtube.com/watch?v=XEYcR5RG5cA

NetBSD kernel's HD Audio sound driver has interrupt handler. The interrupt handler of the demo is re-written by Haskell language using Ajhc.

At the demo, run following operations. First, set breakpoint at the interrupt of finding headphone, and see Haskell function names on backtrace. Second, set breakpoint s_alloc() function, that allocate area in Haskell heap. Make sure of calling the function while anytime running kernel. Nevertheless, playing wav file does not break up.

The source code is found at https://github.com/metasepi/netbsd-arafura-s1 The interrupt handler source code at https://github.com/metasepi/netbsd-arafura-s1/blob/fabd5d64f15058c198ba722058c3fb89f84d08a5/metasepi/sys/hssrc/Dev/Pci/Hdaudio/Hdaudio.hs#L15.

Discussion on mailing list: http://www.haskell.org/pipermail/haskell-cafe/2014-February/112802.html

http://www.youtube.com/watch?v=n6cepTfnFoo

The touchable cube application is written with Haskell and compiled by Ajhc. In the demo, the application is breaked by ndk-gdb debugger when running GC. You could watch the demo source code at https://github.com/ajhc/demo-android-ndk.

http://www.youtube.com/watch?v=C9JsJXWyajQ

The demo is running code that compiled with Ajhc on Cortex-M3 board, mbed. It's a simple RSS reader for reddit.com, showing the RSS titles on Text LCD panel. You could watch the demo detail and source code at https://github.com/ajhc/demo-cortex-m3.

http://www.youtube.com/watch?v=zkSy0ZroRIs

The demo is running Haskell code without any OS. Also the clock exception handler is written with Haskell.

Usage

You can install Ajhc from Hackage.

```
$ cabal install ajhc
$ ajhc --version
ajhc 0.8.0.9 (9c264872105597700e2ba403851cf3b
236cb1646)
compiled by ghc-7.6 on a x86_64 running linux
$ echo 'main = print "hoge"' > Hoge.hs
$ ajhc Hoge.hs
$ ./hs.out
"hoge"
```

Please read "Ajhc User's Manual" to know more detail. (http://ajhc.metasepi.org/manual.html)

Future plans

Maintain Ajhc as compilable with latast GHC.

License

- Runtime: MIT License https://github.com/ajhc/ajhc/blob/master/rts/LICENSE
- Haskell libraries: MIT License https://github.com/ajhc/ajhc/blob/master/lib/LICENSE
- The others: GPLv2 or Later https://github.com/ajhc/ajhc/blob/arafura/COPYING

Contact

- Mailing list: http://groups.google.com/group/metasepi
- Bug tracker: https://github.com/ajhc/ajhc/issues
- Metasepi team: https://github.com/ajhc?tab=members

Further reading

- Ajhc – Haskell everywhere: http://ajhc.metasepi.org/
- jhc: http://repetae.net/computer/jhc/
- Metasepi: Project http://metasepi.org/
- Snatch-driven-development: http://www.slideshare.net/master_q/20131020-osc-tokyoajhc

3.3 The Helium Compiler

Report by:	Jurriaan Hage
Participants:	Bastiaan Heeren

Helium is a compiler that supports a substantial subset of Haskell 98 (but, e.g., n+k patterns are missing). Type classes are restricted to a number of built-in type classes and all instances are derived. The advantage of Helium is that it generates novice friendly error feedback, including domain specific type error diagnosis by means of specialized type rules. Helium and its associated packages are available from Hackage. Install it by running `cabal install helium`. You should also `cabal install lvmrun` on which it dynamically depends for running the compiled code.

Currently Helium is at version 1.8.1. The major change with respect to 1.8 is that Helium is again well-integrated with the Hint programming environment that Arie Middelkoop wrote in Java. The jar-file for Hint can be found on the Helium website, which is located at http://www.cs.uu.nl/wiki/Helium. This website also explains in detail what Helium is about, what it offers, and what we plan to do in the near and far future.

A student has added parsing and static checking for type class and instance definitions to the language, but type inferencing and code generating still need to be added. Completing support for type classes is the second thing on our agenda, the first thing being making updates to the documentation of the workings of Helium on the website.

3.4 UHC, Utrecht Haskell Compiler

Report by:	Atze Dijkstra
Participants:	many others
Status:	active development

UHC is the Utrecht Haskell Compiler, supporting almost all Haskell98 features and most of Haskell2010, plus experimental extensions.

Status Current active development directly on UHC:

- Making intermediate Core language available as a compilable language on its own (Atze Dijkstra) to be used for experimenting with alternate Agda backends (Philipp Hausmann, released, talk at upcoming TFP).
- The platform independent part of UHC has been made available via Hackage, as package "uhc-light" together with a small interpreter for Core files (Atze Dijkstra, interpreter still under development).
- Implementing static analyses (various students, Jurriaan Hage).

Current work indirectly on or related to UHC:

- Incrementality of analysis via the Attribute Grammar system used to construct UHC (Jeroen Bransen, PhD thesis finished (soon to be defended), see also UUAGC).
- Rewriting the type system combining ideas from the constrained-based approach in GHC and type error improvements found in Helium (Alejandro Serrano).

Background. UHC actually is a series of compilers of which the last is UHC, plus infrastructure for facilitating experimentation and extension. The distinguishing features for dealing with the complexity of the compiler and for experimentation are (1) its stepwise organisation as a series of increasingly more complex standalone compilers, the use of DSL and tools for its (2) aspectwise organisation (called Shuffle) and (3) tree-oriented programming (Attribute Grammars, by way of the Utrecht University Attribute Grammar (UUAG) system (→ 5.3.2).

Further reading

- UHC Homepage: http://www.cs.uu.nl/wiki/UHC/WebHome
- UHC Github repository: https://github.com/UU-ComputerScience/uhc
- Attribute grammar system: http://www.cs.uu.nl/wiki/HUT/AttributeGrammarSystem

3.5 Specific Platforms

3.5.1 Haskell on FreeBSD

Report by:	PÁLI Gábor János
Participants:	FreeBSD Haskell Team
Status:	ongoing

The FreeBSD Haskell Team is a small group of contributors who maintain Haskell software on all actively supported versions of FreeBSD. The primarily supported implementation is the Glasgow Haskell Compiler together with Haskell Cabal, although one may also find Hugs and NHC98 in the ports tree. FreeBSD is a Tier-1 platform for GHC (on both i386 and amd64) starting from GHC 6.12.1, hence one can always download vanilla binary distributions for each recent release.

We have a developer repository for Haskell ports that features around 560 ports of many popular Cabal packages. The updates committed to this repository are continuously integrated to the official ports tree on a regular basis. However, the FreeBSD Ports Collection already includes many popular and important Haskell software: GHC 7.8.3, Haskell Platform 2014.2.0.0, Gtk2Hs, wxHaskell, XMonad, Pandoc, Gitit, Yesod, Happstack, Snap, Agda, git-annex, and so on – all of them have been incorporated into the upcoming 10.1-RELEASE.

If you find yourself interested in helping us or simply want to use the latest versions of Haskell programs on FreeBSD, check out our development repository on GitHub (see below) where you can find the latest versions of the ports together with all the important pointers and information required for contacting or contributing.

Further reading

https://github.com/freebsd-haskell/ports

3.5.2 Debian Haskell Group

Report by:	Joachim Breitner
Status:	working

The Debian Haskell Group aims to provide an optimal Haskell experience to users of the Debian GNU/Linux distribution and derived distributions such as Ubuntu. We try to follow the Haskell Platform versions for the core package and package a wide range of other useful libraries and programs. At the time of writing, we maintain 812 source packages.

A system of virtual package names and dependencies, based on the ABI hashes, guarantees that a system upgrade will leave all installed libraries usable. Most libraries are also optionally available with profiling enabled and the documentation packages register with the system-wide index.

The just released stable Debian release ("jessie") provides the Haskell Platform 2013.2.0.0 and GHC 7.6.3, while in Debian unstable, we ship GHC 7.8.4. We plan to upload GHC 7.10.1 to Debian experimental shortly.

Debian users benefit from the Haskell ecosystem on 14 architecture/kernel combinations, including the non-Linux-ports KFreeBSD and Hurd.

Further reading

http://wiki.debian.org/Haskell

3.5.3 Fedora Haskell SIG

Report by:	Jens Petersen
Participants:	Ricky Elrod, Ben Boeckel, and others
Status:	active

The Fedora Haskell SIG works to provide good Haskell support in the Fedora Project Linux distribution.

Fedora 22 is about to be released. Updating to ghc-7.8.4 turned out to be a lot of work. Some packages now have static subpackages for portability: alex, cabal-install, pandoc, and darcs. Lots of Haskell packages were updated to their latest versions (see "Package changes" below).

Fedora 23 development is starting: we are considering if we can update to ghc-7.10 if there is a bugfix release in time, and to refresh packages to their latest versions tracking Stackage where possible. In the meantime there is a ghc-7.10.1 Fedora Copr repo available for Fedora 20+ and EPEL 7.

At the time of writing we have 314 Haskell source packages in Fedora. The cabal-rpm packaging tool has improved further with a new update command, dnf support, and various bugfixes and improvements.

If you are interested in Fedora Haskell packaging, please join our mailing-list and the Freenode #fedora-haskell channel. You can also follow @fedorahaskell for occasional updates.

Further reading

- Homepage: http://fedoraproject.org/wiki/Haskell_SIG
- Mailing-list: https://admin.fedoraproject.org/mailman/listinfo/haskell
- Package list: https://admin.fedoraproject.org/pkgdb/users/packages/haskell-sig
- Package changes: http://git.fedorahosted.org/cgit/haskell-sig.git/tree/packages/diffs/f21-f22.compare

4 Related Languages and Language Design

4.1 Agda

Report by:	Andreas Abel
Participants:	Nils Anders Danielsson, Ulf Norell, Makoto Takeyama, Stevan Andjelkovic, Jean-Philippe Bernardy, James Chapman, Dominique Devriese, Péter Diviánszky Fredrik Nordvall Forsberg, Olle Fredriksson, Daniel Gustafsson, Alan Jeffrey, Fredrik Lindblad, Guilhem Moulin, Nicolas Pouillard, Andrés Sicard-Ramírez and many more
Status:	actively developed

Agda is a dependently typed functional programming language (developed using Haskell). A central feature of Agda is inductive families, i.e., GADTs which can be indexed by *values* and not just types. The language also supports coinductive types, parameterized modules, and mixfix operators, and comes with an *interactive* interface—the type checker can assist you in the development of your code.

A lot of work remains in order for Agda to become a full-fledged programming language (good libraries, mature compilers, documentation, etc.), but already in its current state it can provide lots of fun as a platform for experiments in dependently typed programming.

Since the release of Agda 2.3.2 in November 2012 the following has happened in the Agda project and community:

- Ulf Norell gave a keynote speech at ICFP 2013 on dependently typed programming in Agda.
- Agda has attracted new users, the traffic on the mailing list (and bug tracker) is increasing.
- Agda has seen several enhancements in its type checker, termination checker, interactive editor, and LaTeX-backend.
- Copatterns are being added to Agda as a new way to define record and coinductive values.
- Agda's pattern matching can be restricted to not use Streicher's Axiom K; which makes it more compatible with Homotopy Type Theory.

Release of Agda 2.3.4 is planned to happen in the second quartal of 2014.

Further reading

The Agda Wiki: http://wiki.portal.chalmers.se/agda/

4.2 MiniAgda

Report by:	Andreas Abel
Status:	experimental

MiniAgda is a tiny dependently-typed programming language in the style of Agda (→ 4.1). It serves as a laboratory to test potential additions to the language and type system of Agda. MiniAgda's termination checker is a fusion of sized types and size-change termination and supports coinduction. Bounded size quantification and destructor patterns for a more general handling of coinduction. Equality incorporates eta-expansion at record and singleton types. Function arguments can be declared as static; such arguments are discarded during equality checking and compilation.

MiniAgda is now hosted on http://hub.darcs.net/abel/miniagda.

MiniAgda is available as Haskell source code on hackage and compiles with GHC 6.12.x – 7.8.2.

Further reading

http://www.cse.chalmers.se/~abela/miniagda/

4.3 Disciple

Report by:	Ben Lippmeier
Participants:	Ben Lippmeier, Amos Robinson, Erik de Castro Lopo, Kyle van Berendonck
Status:	experimental, active development

The Disciplined Disciple Compiler (DDC) is a research compiler used to investigate program transformation in the presence of computational effects. It compiles a family of strict functional core languages and supports region, effect and closure typing. This extra information provides a handle on the operational behaviour of code that isn't available in other languages. Programs can be written in either a pure/functional or effectful/imperative style, and one of our goals is to provide both styles coherently in the same language.

What is new?

DDC is in an experimental, pre-alpha state, though parts of it do work. In March this year we released DDC 0.4.1, with the following new features:

- Added a bi-directional type inferencer based on Joshua DunïňĄeld and Neelakantan Krishnaswami's recent ICFP paper.
- Added a region extension language construct, and coeffect system.
- Added the Disciple Tetra language which includes infix operators and desugars into Disciple Core Tetra.

- Compilation of Tetra and Core Tetra programs to C and LLVM.
- Early support for rate inference in Core Flow.
- Flow fusion now generates vector primops for maps and folds.
- Support for user-defined algebraic data types.
- Civilized error messages for unsupported or incomplete features.
- Most type error messages now give source locations.
- Building on Windows platforms.
- Better support for foreign imported types and values.
- Changed to Git for version control.

Further reading

http://disciple.ouroborus.net

4.4 Ermine

Report by:	Edward Kmett
Participants:	Dan Doel, Josh Cough, Elliot Stern, Stephen Compall, Runar Oli Bjarnason, Paul Chiusano
Status:	actively developed, experimental

Ermine is a Haskell-like programming language, extended with rank-N types, kind and row polymorphism that runs on the JVM designed at McGraw Hill Financial.

The language currently has two implementations, a legacy implementation that was written in Scala, and a newer, more extensible, implementation that is actively being developed in Haskell.

The Scala implementation is designed more or less as a straight interpreter, while the Haskell version is designed to be able to compile down to a smaller, relatively portable core. Neither backend generates Java bytecode directly to avoid leaking "Permgen" space.

In July, we were able to obtain corporate approval to open source the existing Scala-based compiler and the nascent Haskell implementation. The Scala version of the language is being actively used to generate a number of financial reports within the S&P Capital IQ web platform.

An introduction to Ermine has been given at Boston Haskell and at CUFP 2013. Stephen Compall has been putting together a documentation project.

Further reading

- Ermine Github: http://github.com/ermine-language
- Boston Haskell Presentation: http://www.youtube.com/watch?v=QCvXlOCBe5A
- A Taste of Ermine: https://launchpad.net/ermine-user-guide
- CUFP Slides: http://tinyurl.com/qem8phk

5 Haskell and ...

5.1 Haskell and Parallelism

5.1.1 Eden

Report by:	Rita Loogen
Participants:	**in Madrid:** Yolanda Ortega-Mallén, Mercedes Hidalgo, Lidia Sánchez-Gil, Fernando Rubio, Alberto de la Encina, **in Marburg:** Mischa Dieterle, Thomas Horstmeyer, Rita Loogen, **in Copenhagen:** Jost Berthold
Status:	ongoing

Eden extends Haskell with a small set of syntactic constructs for explicit process specification and creation. While providing enough control to implement parallel algorithms efficiently, it frees the programmer from the tedious task of managing low-level details by introducing automatic communication (via head-strict lazy lists), synchronization, and process handling.

Eden's primitive constructs are process abstractions and process instantiations. The Eden logo

consists of four λ turned in such a way that they form the Eden instantiation operator (#). Higher-level coordination is achieved by defining *skeletons*, ranging from a simple parallel map to sophisticated master-worker schemes. They have been used to parallelize a set of non-trivial programs.

Eden's interface supports a simple definition of arbitrary communication topologies using *Remote Data*. The remote data concept can also be used to compose skeletons in an elegant and effective way, especially in distributed settings. A *PA*-monad enables the *eager* execution of user defined sequences of *Parallel Actions* in Eden.

Survey and standard reference: Rita Loogen, Yolanda Ortega-Mallén, and Ricardo Peña: *Parallel Functional Programming in Eden*, Journal of Functional Programming 15(3), 2005, pages 431–475.

Tutorial: Rita Loogen: Eden - Parallel Functional Programming in Haskell, in: V. Zsók, Z. Horváth, and R. Plasmeijer (Eds.): CEFP 2011, Springer LNCS 7241, 2012, pp. 142-206.
(see also: http://www.mathematik.uni-marburg.de/~eden/?content=cefp)

Implementation

Eden is implemented by modifications to the Glasgow-Haskell Compiler (extending its runtime system to use multiple communicating instances). Apart from MPI or PVM in cluster environments, Eden supports a shared memory mode on multicore platforms, which uses multiple independent heaps but does not depend on any middleware. Building on this runtime support, the Haskell package *edenmodules* defines the language, and *edenskels* provides a library of parallel skeletons.

A new version based on GHC-7.8.2 (including binary packages and prepared source bundles) has been released in April 2014. The new version fixes a number of issues related to error shut-down and recovery, and features extended support for serialising Haskell data structures. The release of a version based on GHC-7.10.2 is in preparation. Previous stable releases with binary packages and bundles are still available on the Eden web pages.

The source code repository for Eden releases is http://james.mathematik.uni-marburg.de:8080/gitweb, the Eden libraries (Haskell-level) are also available via Hackage. Please contact us if you need any support.

Tools and libraries

The Eden trace viewer tool *EdenTV* provides a visualisation of Eden program runs on various levels. Activity profiles are produced for processing elements (machines), Eden processes and threads. In addition message transfer can be shown between processes and machines. EdenTV is written in Haskell and is freely available on the Eden web pages and on hackage. Eden's thread view can also be used to visualise ghc eventlogs.

The Eden skeleton library is under constant development. Currently it contains various skeletons for parallel maps, workpools, divide-and-conquer, topologies and many more. Take a look on the Eden pages.

Recent and Forthcoming Publications

- M. KH. Aswad, P. W. Trinder, A. D. Al-Zain, G. J. Michaelson, J. Berthold: *Comparing Low-Pain and No-Pain Multicore Haskells*, revised and extended version of TFP 2009 paper, in Special Issue of Higher-Order Symbol Computation (HOSC) 2016.

- M. Dieterle, Th. Horstmeyer, R. Loogen, J. Berthold: *Skeleton Composition in Eden*, submitted for publication
- J. Berthold, H.-W. Loidl, K. Hammond: *PAEAN: Portable Runtime Support for Physically-Shared-Nothing Architectures in Parallel Haskell Dialects*, submitted for publication

Further reading

http://www.mathematik.uni-marburg.de/~eden

5.1.2 speculation

Report by:	Edward Kmett
Participants:	Jake McArthur
Status:	stable

This package provides speculative function application and speculative folds based on

- Prakash Prabhu, G. Ramalingam, and Kapil Vaswani, "Safe Programmable Speculative Parallelism", In the proceedings of Programming Language Design and Implementation (PLDI) Vol 45, Issue 6 (June 2010) pp 50-61.

Unlike the original paper, we can take advantage of immutability and the spark queue in Haskell to ensure we never worsen the asymptotics of a single-threaded algorithm. Speculative STM transactions take the place of the transactional rollback machinery from the paper.

Further reading

- http://hackage.haskell.org/package/speculation
- http://research.microsoft.com/pubs/118795/pldi026-vaswani.pdf

5.1.3 Wakarusa

Report by:	Andrew Gill
Participants:	Mark Grebe, Ryan Scott, James Stanton, David Young
Status:	active

The Wakarusa project is a domain-specific language toolkit, that makes domain-specific languages easier to deploy in high-performance scenarios. The technology is going to be initially applied to two types of high-performance platforms, GPGPUs and FPGAs. However, the toolkit will be general purpose, and we expect the result will also make it easier to deploy DSLs in situations where resource usage needs to be well-understand, such as cloud resources and embedded systems. The project is funded by the NSF.

Wakarusa is a river just south of Lawrence, KS, where the main campus of the University of Kansas is located. Wakarusa is approximately translated as "deep river", and we use deep embeddings a key technology in our DSL toolkit. Hence the project name Wakarusa.

A key technical challenge with syntactic alternatives to deep embeddings is knowing when to stop unfolding. We are using a new design pattern, called the remote monad, which allows a monad to be virtualized, and run remotely, to bound our unfolding. We have already used remote monads for graphics (Blank Canvas), hardware bus protocols (λ-bridge), and a driver for MineCraft. Using the remote monad design pattern, and HERMIT, we are developing a translation framework that translates monadic Haskell to GPGPUs (building on accelerate), and monadic Haskell to Hardware (building on Kansas Lava), and monadic imperative Haskell to Arduino C.

Further reading

- https://github.com/ku-fpg/wakarusa
- http://ku-fpg.github.io/research/wakarusa/

5.2 Haskell and the Web

5.2.1 WAI

Report by:	Michael Snoyman
Participants:	Greg Weber
Status:	stable

The Web Application Interface (WAI) is an interface between Haskell web applications and Haskell web servers. By targeting the WAI, a web framework or web application gets access to multiple deployment platforms. Platforms in use include CGI, the Warp web server, and desktop webkit.

WAI is also a platform for re-using code between web applications and web frameworks through WAI middleware and WAI applications. WAI middleware can inspect and transform a request, for example by automatically gzipping a response or logging a request. The Yesod (→ 5.2.5) web framework provides the ability to embed arbitrary WAI applications as subsites, making them a part of a larger web application.

By targeting WAI, every web framework can share WAI code instead of wasting effort re-implementing the same functionality. There are also some new web frameworks that take a completely different approach to web development that use WAI, such as webwire (FRP), MFlow (continuation-based) and dingo (GUI). The Scotty (→ 5.2.11) web framework also continues to be developed, and provides a lighter-weight alternative to Yesod. Other frameworks- whether existing or newcomers- are welcome to take advantage of the existing WAI architecture to focus on the more innovative features of web development.

WAI applications can send a response themselves. For example, wai-app-static is used by Yesod to serve static files. However, one does not need to use a web

framework, but can simply build a web application using the WAI interface alone. The Hoogle web service targets WAI directly.

Since the last HCAR, WAI has successfully released version 3.0, which removes dependency on any specific streaming data framework. A separate wai-conduit package provides conduit bindings, and such bindings can easily be provided for other streaming data frameworks.

The WAI community continues to grow, with new applications and web frameworks continuing to be added. We've recently started a new mailing list to discuss WAI related topics. Interested parties are strongly encouraged to join in!

Further reading

http://www.yesodweb.com/book/wai https://groups.google.com/d/forum/haskell-wai

5.2.2 Warp

Report by:	Michael Snoyman

Warp is a high performance, easy to deploy HTTP server backend for WAI (→ 5.2.1). Since the last HCAR, Warp has followed WAI in its move from conduit to a lower level streaming data abstraction. We've additionally continued work on more optimizations, and improved support for power efficiency by using the auto-update package.

Due to the combined use of ByteStrings, blaze-builder, conduit, and GHC's improved I/O manager, WAI+Warp has consistently proven to be Haskell's most performant web deployment option.

Warp is actively used to serve up most of the users of WAI (and Yesod).

"Warp: A Haskell Web Server" by Michael Snoyman was published in the May/June 2011 issue of IEEE Internet Computing:

- Issue page: http://www.computer.org/portal/web/csdl/abs/mags/ic/2011/03/mic201103toc.htm
- PDF: http://steve.vinoski.net/pdf/IC-Warp_a_Haskell_Web_Server.pdf

5.2.3 Happstack

Report by:	Jeremy Shaw

Happstack is a very fine collection of libraries for creating web applications in Haskell. We aim to leverage the unique characteristics of Haskell to create a highly-scalable, robust, and expressive web framework.

Over the past year, much development has been focused on the higher-level components such as a rewrite of the `happstack-authentication` library and work on unifying the various `stripe` bindings into a single authoritative binding.

Over the next year we hope to get back to the core and focus on `hyperdrive`, a new low-level, trustworthy HTTP backend, as well as focusing on developing and deploying applications using `nixops`.

Further reading

- http://www.happstack.com/
- http://www.happstack.com/docs/crashcourse/index.html

5.2.4 Mighttpd2 — Yet another Web Server

Report by:	Kazu Yamamoto
Status:	open source, actively developed

Mighttpd (called mighty) version 3 is a simple but practical Web server in Haskell. It provides features to handle static files, redirection, CGI, reverse proxy, reloading configuration files and graceful shutdown. Also TLS is experimentally supported.

Mighttpd 3 is now based on WAI 3.0. It also adopts the auto-update library to reduce CPU power consumption at no connection.

You can install Mighttpd 3 (*mighttpd2*) from HackageDB. Note that the package name is *mighttpd2*, not *mighttpd3*, for historical reasons.

Mighttpd 3 now supports GHC 7.10.

Further reading

- http://www.mew.org/~kazu/proj/mighttpd/en/
- http://www.yesodweb.com/blog/2014/01/new-fast-logger
- http://www.yesodweb.com/blog/2014/02/new-warp

5.2.5 Yesod

Report by:	Michael Snoyman
Participants:	Greg Weber, Luite Stegeman, Felipe Lessa
Status:	stable

Yesod is a traditional MVC RESTful framework. By applying Haskell's strengths to this paradigm, Yesod helps users create highly scalable web applications.

Performance scalablity comes from the amazing GHC compiler and runtime. GHC provides fast code and built-in evented asynchronous IO.

But Yesod is even more focused on scalable development. The key to achieving this is applying Haskell's type-safety to an otherwise traditional MVC REST web framework.

Of course type-safety guarantees against typos or the wrong type in a function. But Yesod cranks this up a notch to guarantee common web application errors won't occur.

- declarative routing with type-safe urls — say goodbye to broken links
- no XSS attacks — form submissions are automatically sanitized
- database safety through the Persistent library (→ 7.7.2) — no SQL injection and queries are always valid
- valid template variables with proper template insertion — variables are known at compile time and treated differently according to their type using the shakesperean templating system.

When type safety conflicts with programmer productivity, Yesod is not afraid to use Haskell's most advanced features of Template Haskell and quasi-quoting to provide easier development for its users. In particular, these are used for declarative routing, declarative schemas, and compile-time templates.

MVC stands for model-view-controller. The preferred library for models is Persistent (→ 7.7.2). Views can be handled by the Shakespeare family of compile-time template languages. This includes Hamlet, which takes the tedium out of HTML. Both of these libraries are optional, and you can use any Haskell alternative. Controllers are invoked through declarative routing and can return different representations of a resource (html, json, etc).

Yesod is broken up into many smaller projects and leverages Wai (→ 5.2.1) to communicate with the server. This means that many of the powerful features of Yesod can be used in different web development stacks that use WAI such as Scotty (→ 5.2.11).

The new 1.4 release of Yesod is almost a completely backwards-compatible change. The version bump was mostly performed to break compatibility with older versions of dependencies, which allowed us to remove approximately 500 lines of conditionally compiled code. Notable changes in 1.4 include:

- New routing system with more overlap checking control.
- yesod-auth works with your database and your JSON.
- yesod-test sends HTTP/1.1 as the version.
- Type-based caching with keys.

The Yesod team is quite happy with the current level of stability in Yesod. Since the 1.0 release, Yesod has maintained a high level of API stability, and we intend to continue this tradition. Future directions for Yesod are now largely driven by community input and patches. We've been making progress on the goal of easier client-side interaction, and have high-level interaction with languages like Fay, TypeScript, and CoffeeScript. GHCJS support is in the works.

The Yesod site (http://www.yesodweb.com/) is a great place for information. It has code examples, screencasts, the Yesod blog and — most importantly — a book on Yesod.

To see an example site with source code available, you can view Haskellers (→ 1.1) source code: (https://github.com/snoyberg/haskellers).

Further reading

http://www.yesodweb.com/

5.2.6 Snap Framework

Report by:	Doug Beardsley
Participants:	Gregory Collins, Shu-yu Guo, James Sanders, Carl Howells, Shane O'Brien, Ozgun Ataman, Chris Smith, Jurrien Stutterheim, Gabriel Gonzalez, and others
Status:	active development

The Snap Framework is a web application framework built from the ground up for speed, reliability, stability, and ease of use. The project's goal is to be a cohesive high-level platform for web development that leverages the power and expressiveness of Haskell to make building websites quick and easy.

Since the last HCAR, the Snap Team released a new major version of the Heist template system. This release allows you to require a namespace on all your splices and enable better error reporting when you have tags without a bound splice. Along with this we exposed a mechanism for generalized error reporting from splices. Now if your splices detect an error condition at application load time they can throw an error to better communicate the problem.

If you would like to contribute, get a question answered, or just keep up with the latest activity, stop by the `#snapframework` IRC channel on Freenode.

Further reading

- Heist 0.14 release announcement: http://snapframework.com/blog/2014/09/24/heist-0.14-released
- Snaplet Directory: http://snapframework.com/snaplets
- http://snapframework.com

5.2.7 MFlow

Report by:	Alberto Gómez Corona
Status:	active development

MFlow is a Web framework of the kind of other functional, stateful frameworks like WASH, Seaside, Ocsigen or Racket. MFlow does not use continuation passing properly, but a backtracking monad that permits the synchronization of browser and server and error tracing. This monad is on top of another "Workflow" monad that adds effects for logging and recovery of process/session state. In addition, MFlow is RESTful. Any GET page in the flow can be pointed to with a REST URL. The navigation as well as the page results are type safe. It also implements monadic formlets: They can have their own flow within a page. If

JavaScript is enabled, the widget refreshes itself within the page. If not, the whole page is refreshed to reflect the change of the widget.

MFlow hides the heterogeneous elements of a web application and expose a clear, modular, type safe DSL of applicative and monadic combinators to create from multipage to single page applications. These combinators, called widgets or enhanced formlets, pack together javascript, HTML, CSS and the server code. [1].

A paper describing the MFlow internals has been published in The Monad Reader issue 23 [2]

The use of backtracking to solve "the integration problem". It happens when the loose coupling produce exceptional conditions that may trigger the rollback of actions in the context of failures, shutdowns and restart of the systems (long running processes). That has been demonstrated using MFlow in [3].

A web application can be considered as an special case of integration. MFlow pack the elements of a web aplication within composable widgets. This "deep integration" is the path followed by the software industry to create from higher level framewors to operating systems [4]

perch and hplayground are two new packages that make run the page logic of MFlow in the Web Browser using Haste, the Haskell-to-JavaScript compiler. perch has the syntax of blaze-html and hplayground uses the syntax and primitives of the View Monad. Both permit the page logic of MFlow to run fully in the Web Browser. Under the same syntax, they are completely different.

Perch[5] are the composable combinators of blaze-html running in the browser. They generate trees by calling DOM primitives directly instead of creating intermediary, lineal descriptions. While string builders are unary tree constructors, perch uses a generalized builder for n-trees. It also has combinators for the modification of elements and it can assign perch event handlers to elements and it has also JQuery like operations. It can be used alone for the creation of client-side applications.

hplayground is a monadic functional reactive[6] framework with MFlow syntax that permits the creation of seamless client-side applications. hplayground sequence the perch events in his monad instance, it add monadic and applicative formlets with validations, so the code is modular and seamless. There is a site with example Haste-perch-hplayground (made with MFlow) online[6] . There is also a tutorial for the creation of Client-side applications, that describe the structure of a small accounting application for haskell beginners[7]. Since the event are keep in his scope and the DOM modifications are local but there are no event handlers, Monadic Reactive may be a better alternative to functional Reactive in the creation of seamless Web Browser applications whenever there are many dynamic DOM updates[8].

Future work: The integration of MFlow and perch-hplayground: since both share the same syntax, the aim is to allow the application to decide either to run the page logic in the server or in the client. The first step is to let the programmer decide it. To embed hplayground code inside MFlow some hacks in the Haste generated code are necessary.

Perch is being ported to purescript, hplayground will be ported too. The next target is GHCJS.

Further reading

- MFlow as a DSL for web applications https://www.fpcomplete.com/school/to-infinity-and-beyond/older-but-still-interesting/MFlowDSL1
- MFlow, a continuation-based web framework without continuations http://themonadreader.wordpress.com/2014/04/23/issue-23
- How Haskell can solve the integration problem https://www.fpcomplete.com/school/to-infinity-and-beyond/pick-of-the-week/how-haskell-can-solve-the-integration-problem
- Towards a deeper integration: A Web language: http://haskell-web.blogspot.com.es/2014/04/towards-deeper-integration-web-language.html
- Perch https://github.com/agocorona/haste-perch
- hplayground demos http://tryplayg.herokuapp.com
- haste-perch-hplaygroun tutorial http://www.airpair.com/haskell/posts/haskell-tutorial-introduction-to-web-apps
- react.js a solution for a problem that Haskell can solve in better ways http://haskell-web.blogspot.com.es/2014/11/browser-programming-reactjs-as-solution.html
- MFlow demo site: http://mflowdemo.herokuapp.com

5.2.8 Scotty

Report by:	Andrew Farmer
Participants:	Andrew Farmer
Status:	active

Scotty is a Haskell web framework inspired by Ruby's Sinatra, using WAI (→ 5.2.1) and Warp (→ 5.2.2), and is designed to be a cheap and cheerful way to write RESTful, declarative web applications.

- A page is as simple as defining the verb, url pattern, and Text content.
- It is template-language agnostic. Anything that returns a Text value will do.
- Conforms to WAI Application interface.
- Uses very fast Warp webserver by default.

The goal of Scotty is to enable the development of simple HTTP/JSON interfaces to Haskell applications. Implemented as a monad transformer stack, Scotty applications can be embedded in arbitrary MonadIOs. The Scotty API is minimal, and fully documented via haddock. The API has recently remained stable, with

a steady stream of improvements contributed by the community.

Further reading

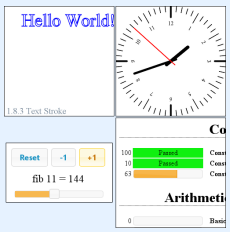
- Hackage: http://hackage.haskell.org/package/scotty
- Github: https://github.com/scotty-web/scotty

5.2.9 Sunroof

Report by:	Andrew Gill
Participants:	Jan Bracker
Status:	active

Sunroof is a Domain Specific Language (DSL) for generating JavaScript. It is built on top of the JS-monad, which, like the Haskell IO-monad, allows read and write access to external resources, but specifically JavaScript resources. As such, Sunroof is primarily a feature-rich foreign function API to the browser's JavaScript engine, and all the browser-specific functionality, like HTML-based rendering, event handling, and drawing to the HTML5 canvas.

Furthermore, Sunroof offers two threading models for building on top of JavaScript, atomic and blocking threads. This allows full access to JavaScript APIs, but using Haskell concurrency abstractions, like MVars and Channels. In combination with the push mechanism Kansas-Comet, Sunroof offers a great platform to build interactive web applications, giving the ability to interleave Haskell and JavaScript computations with each other as needed.



It has successfully been used to write smaller applications. These applications range from 2D rendering using the HTML5 canvas element, over small GUIs, up to executing the QuickCheck tests of Sunroof and displaying the results in a neat fashion. The development has been active over the past 6 months and there is a drafted paper submitted to TFP 2013.

Further reading

- Homepage: http://www.ittc.ku.edu/csdl/fpg/software/sunroof.html
- Tutorial: https://github.com/ku-fpg/sunroof-compiler/wiki/Tutorial
- Main Repository: https://github.com/ku-fpg/sunroof-compiler

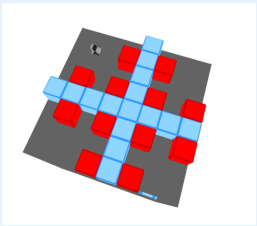
5.2.10 Blank Canvas

Report by:	Andrew Gill
Participants:	Justin Dawson, Mark Grebe, Ryan Scott, James Stanton, Jeffrey Rosenbluth, and Neil Sculthorpe
Status:	active

Blank Canvas is a Haskell binding to the complete HTML5 Canvas API. Blank Canvas allows Haskell users to write, in Haskell, interactive images onto their web browsers. Blank Canvas gives the user a single full-window canvas, and provides many well-documented functions for rendering images. Out of the box, Blank Canvas is pac-man complete – it is a platform for simple graphics, classic video games, and building more powerful abstractions that use graphics.

Blank Canvas was written in Spring 2012, as part of the preparation for a graduate-level functional programming class. In Fall 2012 and Fall 2013, we used Blank Canvas to teach Functional Reactive Programming. This was our first hint that the Blank Canvas library was faster than we expected, as we had hundreds of balls bouncing smoothly on the screen, much to the students' delight.

Blank Canvas has now been used by the students in four separate instances of our functional programming class. Students find it easy to understand, given the analog between the IO monad, and the remote Canvas monad, with student often choosing to use Blank Canvas for their end-of-semester project. To give two examples, one end-of-semester project was Omar Bari and Dain Vermaak's Isometric Tile Game, that can be rotated in 3D in real-time; another project was Blankeroids, a playable asteroids clone, written by Mark Grebe, on top of Yampa and yampa-canvas.



For more details, read the blank-canvas wiki.

Further reading

- https://hackage.haskell.org/package/blank-canvas
- https://github.com/ku-fpg/blank-canvas
- https://github.com/ku-fpg/blank-canvas/wiki

5.2.11 PureScript

Report by:	Phil Freeman
Status:	active, looking for contributors

PureScript is a small strongly typed programming language that compiles to efficient, readable JavaScript. The PureScript compiler is written in Haskell.

The PureScript language features Haskell-like syntax, type classes, rank-n types, extensible records and extensible effects.

PureScript features a comprehensive standard library, and a large number of other libraries and tools under development, covering data structures, algorithms, Javascript integration, web services, game development, testing, asynchronous programming, FRP, graphics, audio, UI implementation, and many other areas. It is easy to wrap existing Javascript functionality for use in PureScript, making PureScript a great way to get started with strongly-typed pure functional programming on the web. PureScript is currently used successfully in production in commercial code.

PureScript development is currently focussed on the following areas:

- The development of a searchable online database of PureScript code with type search and rendered documentation
- Enabling new forms of optimization by allowing developers to specify rewrite rules in PureScript code
- Enabling new backends (C++, Lua, Python, etc.) by extracting intermediate core languages which exist during the compilation process
- The development of new PureScript libraries

The PureScript compiler can be downloaded from purescript.org, or compiled from source from Hackage.

Further reading

https://github.com/purescript/purescript/

5.3 Haskell and Compiler Writing

5.3.1 MateVM

Report by:	Bernhard Urban
Participants:	Harald Steinlechner
Status:	looking for new contributors

MateVM is a method-based Java Just-In-Time Compiler. That is, it compiles a method to native code on demand (i.e. on the first invocation of a method). We use existing libraries:

hs-java for processing Java Classfiles according to *The Java Virtual Machine Specification*.

harpy enables runtime code generation for `i686` machines in Haskell, in a domain specific language style.

We believe that Haskell is suitable to implement compiler technologies. However, we have to jump between "Haskell world" and "native code world", due to the low-level nature of Just-In-Time compiler in a virtual machine. This poses some challenges when it comes to signal handling and other interesting rather low level operations. Not immediately visible, the task turns out to be well suited for Haskell although we experienced some tensions with signal handling and GHCi. We are looking forward to sharing our experience on this.

In the current state we are able to execute simple Java programs. The compiler eliminates the JavaVM stack via abstract interpretation, does a liveness analysis, linear scan register allocation and finally machine code emission. The software architecture enables easy addition of further optimization passes based on an intermediate representation.

Future plans are, to add an interpreter to gather profile information for the compiler and also do more aggressive optimizations (e.g. method inlining or stack allocation). An interpreter can also be used to enable speculation during compilation and, if such a speculation fails, compiled code can *deoptimize* to the interpreter.

Apart from that, features are still missing to comply as a JavaVM, most noteable are proper support for classloaders, floating point operations or threads. We would like to see a real base library such as GNU Classpath or the JDK running with MateVM some day. Other hot topics are Hoopl and Garbage Collection.

We are looking for new contributors! If you are interested in this project, do not hesitate to join us on IRC (`#MateVM @ OFTC`) or contact us on Github.

Further reading

- https://github.com/MateVM
- http://docs.oracle.com/javase/specs/jvms/se7/html/
- http://hackage.haskell.org/package/hs-java
- http://hackage.haskell.org/package/harpy
- http://www.gnu.org/software/classpath/
- http://hackage.haskell.org/package/hoopl-3.8.7.4
- http://en.wikipedia.org/wiki/Club-Mate

5.3.2 UUAG

Report by:	Atze Dijkstra
Participants:	ST Group of Utrecht University
Status:	stable, maintained

UUAG is the *Utrecht University Attribute Grammar* system. It is a preprocessor for Haskell that makes it easy to write *catamorphisms*, i.e., functions that do to any data type what *foldr* does to lists. Tree walks are

defined using the intuitive concepts of *inherited* and *synthesized attributes*, while keeping the full expressive power of Haskell. The generated tree walks are *efficient* in both space and time.

An AG program is a collection of rules, which are pure Haskell functions between attributes. Idiomatic tree computations are neatly expressed in terms of copy, default, and collection rules. Attributes themselves can masquerade as subtrees and be analyzed accordingly (higher-order attribute). The order in which to visit the tree is derived automatically from the attribute computations. The tree walk is a single traversal from the perspective of the programmer.

Nonterminals (data types), productions (data constructors), attributes, and rules for attributes can be specified separately, and are woven and ordered automatically. These aspect-oriented programming features make AGs convenient to use in large projects.

The system is in use by a variety of large and small projects, such as the Utrecht Haskell Compiler UHC (→ 3.4), the editor Proxima for structured documents (http://www.haskell.org/communities/05-2010/html/report.html#sect6.4.5), the Helium compiler (http://www.haskell.org/communities/05-2009/html/report.html#sect2.3), the Generic Haskell compiler, UUAG itself, and many master student projects. The current version is 0.9.52.1 (January 2015), is extensively tested, and is available on Hackage. There is also a Cabal plugin for easy use of AG files in Haskell projects.

We recently implemented the following enhancements:

Evaluation scheduling. We have done a project to improve the scheduling algorithms for AGs. The previously implemented algorithms for scheduling AG computations did not fully satisfy our needs; the code we write goes beyond the class of OAGs, but the algorithm by Kennedy and Warren (1976) results in an undesired increase of generated code due to non-linear evaluation orders. However, because we know that our code belongs to the class of linear orderable AGs, we wanted to find and algorithm that can find this linear order, and thus lies in between the two existing approaches. We have created a backtracking algorithm for this which is currently implemented in the UUAG (`-aoag` flag).

Another approach to this scheduling problem that we implemented is the use of SAT-solvers. The scheduling problem can be reduced to a SAT-formula and efficiently solved by existing solvers. The advantage is that this opens up possibilities for the user to influence the resulting schedule, for example by providing a cost-function that should be minimized. We have also implemented this approach in the UUAG which uses Minisat as external SAT-solver (`-loag` flag).

We have recently worked on the following enhancements:

Incremental evaluation. We have just finished a Ph.D. project that investigated incremental evaluation of AGs. The target of this work was to improve the UUAG compiler by adding support for incremental evaluation, for example by statically generating different evaluation orders based on changes in the input. The project has lead to several publications, but the result has not yet been implemented into the UUAG compiler.

Further reading

- http://www.cs.uu.nl/wiki/bin/view/HUT/AttributeGrammarSystem
- http://hackage.haskell.org/package/uuagc

5.3.3 LQPL — A Quantum Programming Language Compiler and Emulator

Report by:	Brett G. Giles
Participants:	Dr. J.R.B. Cockett
Status:	v 0.9.1 experimental released in November 2013

LQPL (Linear Quantum Programming Language) is a functional quantum programming language inspired by Peter Selinger's paper "Towards a Quantum Programming Language".

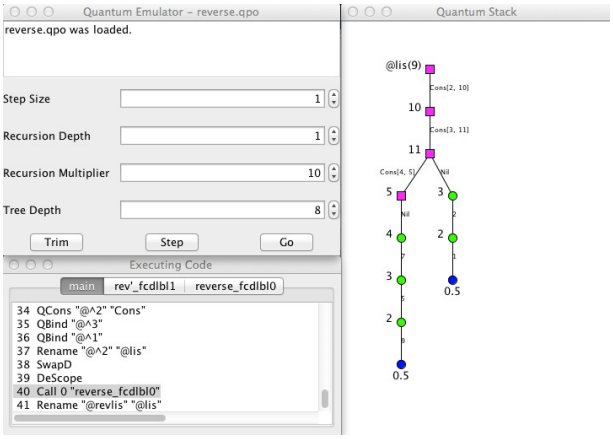
The LQPL system consists of a compiler, a GUI based front end and an emulator. LQPL incorporates a simple module / include system (more like C's include than Haskell's import), predefined unitary transforms, quantum control and classical control, algebraic data types, and operations on purely classical data.

Starting with the 0.9 series, LQPL is now split into separate components:

- The compiler (Haskell) — available at the command line and via a TCP/IP interface;
- The emulator (which emulates a virtual quantum machine) (Haskell) — available as a server via a TCP/IP interface;
- The front end (JRuby/Swing) — which connects to both the compiler and the emulator via TCP/IP.

Version 0.9.1 was a bugfix release.

A screenshot of the interface (showing a probabilistic list) is included below.



Quantum programming allows us to provide a fair coin toss:

```
qdata Coin      = {Heads | Tails}
toss ::( ; c:Coin) =
{  q = |0>;     Had q;
   measure q of      |0> => {c = Heads}
                     |1> => {c = Tails}
}
```

This allows programming of probabilistic algorithms, such as leader election.

The next major items on the road map are:

- Change the TCP/IP data format to something less verbose;
- Implementing a translation of the virtual machine code into quantum circuits.

Further reading

Documentation and executable downloads may be found at http://pll.cpsc.ucalgary.ca/lqpl/index.html. The source code, along with a wiki and bug tracker, is available at https://bitbucket.org/BrettGilesUofC/lqpl.

5.3.4 free — Free Monads

Report by:	Edward Kmett
Participants:	Gabriel Gonzalez, Aristid Breitkreuz, Nickolay Kudasov, Ben Gamari, Matvey Aksenov, Mihaly Barasz, Twan van Laarhoven
Status:	actively developed

This package provides common definitions for working with free monads and free applicatives. These are very useful when it comes to defining EDSLs.

This package also supports cofree comonads, which are useful for tracking attributes through a syntax tree.

Recently support was added for the free completely-iterative monad of a monad as well. This can be used as part of a scheme to deamortize calculations in the ST *s* monad.

Further reading

- http://hackage.haskell.org/package/free
- http://www.haskellforall.com/2012/06/you-could-have-invented-free-monads.html
- http://www.iai.uni-bonn.de/~jv/mpc08.pdf
- http://comonad.com/reader/2011/free-monads-for-less/
- http://comonad.com/reader/2011/free-monads-for-less-2/
- http://comonad.com/reader/2011/free-monads-for-less-3/
- http://paolocapriotti.com/assets/applicative.pdf
- http://skillsmatter.com/podcast/scala/monads-for-free
- http://comonad.com/reader/2009/incremental-folds/
- http://www.ioc.ee/~tarmo/tday-veskisilla/uustalu-slides.pdf
- https://www.fpcomplete.com/user/edwardk/oblivious/deamortized-st

5.3.5 bound — Making De Bruijn Succ Less

Report by:	Edward Kmett
Participants:	Nicolas Pouillard, Jean-Philippe Bernardy, Andrea Vezzosi, Gabor Greif, Matvey B. Aksenov
Status:	actively developed

This library provides convenient combinators for working with "locally-nameless" terms. These can be useful when writing a type checker, evaluator, parser, or pretty printer for terms that contain binders like forall or lambda, as they ease the task of avoiding variable capture and testing for alpha-equivalence.

Notably, it uses a representation based on type-safe generalized De Bruijn indices that lets you naturally make your expression type into a Monad that permits capture-avoiding substitution, and the use of Foldable's *toList* and Traversable's *traverse* to find free variables. This makes it much easier to manipulate your syntax tree with tools you already know how to use, while still safely avoiding issues with name capture.

The generalized De Bruijn encoding permits asymptotic improvement in the running time of many calculations, enabling simultaneous substitution of everything within a complex binder, O(1) lifting, and avoiding paying for the traversal of lifted trees, but the complexity of the encoding is hidden behind a monad transformer that provides you with variable capture.

Further reading

- http://fpcomplete.com/user/edwardk/bound
- http://hackage.haskell.org/package/bound
- http://www.slideshare.net/ekmett/bound-making-de-bruijn-succ-less

6 Development Tools

6.1 Environments

6.1.1 Haskell IDE From FP Complete

Report by:	Natalia Muska
Status:	available, stable

Since FP Complete™ announced the launch of FP Haskell Center™ (FPHC) in early September 2013, a lot of additions to the original IDE have been added and the pricing structure has changed dramatically. The new features and the pricing modifications are a direct result of community feedback. The changes were gradually rolled out over the past year.

As of October 1, 2014, all users of FPHC who are using it for non-commercial projects have free access under the new Open Publish model. This means that Open Publish accounts will automatically publish all projects on the FPHC site with each commit, similar to Github. This move is meant to make FPHC more valuable, and increase support for users sharing their work with the community. There are still paid subscriptions available for Commercial projects.

This is a current list of features included with the free version of FPHC:

- Create and Edit Haskell Projects,
- Open Projects from Git, FPHC, or Web
- Continuous Error and Type Information
- Hoogle and Haddock Integration
- Easy to use build system
- Vetted Stable Libraries
- Easy to Understand Error Messages
- No setup or install
- Free Community Support
- Push Projects to Git and GitHub
- Emacs Integration
- Shared Team Accounts
- Support for Sub Projects
- Multiple Repository Projects
- Deploy to FP Application Servers
- Large Project and Megarepos Support (new)
- Subscriptions include continuous refresh releases on new features, updates, bug fixes and free community support

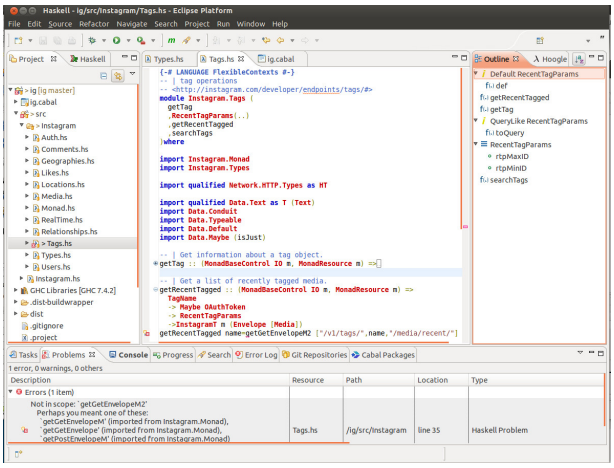
Over the past year the feedback and activity on FPHC has been very positive. To ensure FPHC is meeting the demands of the Haskell community, FP complete is constantly seeking feedback and suggestions from users and the Haskell community.

Further reading

Visit www.fpcomplete.com for more information.

6.1.2 EclipseFP

Report by:	JP Moresmau
Participants:	building on code from Alejandro Serrano Mena, Thomas ten Cate, B. Scott Michel, Thiago Arrais, Leif Frenzel, Martijn Schrage, Adam Foltzer and others
Status:	unmaintained, looking for a maintainer to take over



EclipseFP is a set of Eclipse plugins to allow working on Haskell code projects. Its goal is to offer a fully featured Haskell IDE in a platform developers coming from other languages may already be familiar with. It provides the following features, among others:

Cabal Integration

Provides a .cabal file editor, uses Cabal settings for compilation, allows the user to install Cabal packages from within the IDE. Supports cabal sandboxes (or cabal-dev) to provide install isolation and project dependencies inside an Eclipse workspace.

GHC Integration

Compilation is done via the GHC API, syntax coloring uses the GHC Lexer.

Productive Coding

Quick fixes for common errors, warnings, and HLint suggestions. Automatic organization of imports. Autocompletion. Find and rename across modules and projects. Stylish-haskell integration for consistent code formatting.

Live Programming

A Haskell worksheet allows the developer to see values of expressions, including images and HTML content, as the code changes.

Debugging
Easy to launch GHCi sessions on any module with proper parameters. Manages breakpoints, the evaluation of variables and expressions, uses the Eclipse debugging framework, and requires no knowledge of GHCi syntax. Also it integrates with Yesod (launch the web application from EclipseFP). Running a program with profiling options results in profiling graphs being displayed in the UI for easy analysis.

Browsing
The Haskell Browser perspective allows the user to navigate the list of packages and their documentation. It integrates seamlessly with Hackage. The Haskell module editor provides code folding, outline view of the module, popup of types and documentation mouse hovers, etc.

Testing
EclipseFP integrates with Haskell test frameworks, most notably HTF, to provide UI feedback on test failures.

The source code is fully open source (Eclipse License) on github and anyone can contribute. Current version is 2.6.4, released in January 2015. There are currently no plan for another release unless a new maintainer steps in.

Further reading

- http://eclipsefp.github.com/
- http://jpmoresmau.blogspot.com/

6.1.3 ghc-mod — Happy Haskell Programming

Report by:	Daniel Gröber
Status:	open source, actively developed

`ghc-mod` is both a backend program for enhancing editors and other kinds of development environments with support for Haskell, and an Emacs package providing the user facing functionality, internally called `ghc` for historical reasons. Other people have also developed numerous front ends for Vim and there also exist some for Atom and a few other proprietary editors.

After a period of declining activity, development has been picking up pace again since Daniel Gröber took over as maintainer. Most changes during versions 5.0.0–5.2.1.2 consisted only of fixes and internal cleanup work, but for the past four months, vastly improved Cabal support has been in the works and is now starting to stabilize.

This work is a major step forward in terms of how well ghc-mod's suggestions reflect what `cabal build` would report, and should also allow ghc-mod's other features to work even in more complicated Cabal setups.

Daniel Gröber has been accepted for a summer internship at IIJ Innovation Institute's Research Laboratory working on `ghc-mod` for two months (August–September). He will be working on:

- adding GHCi-like interactive code execution, to bring `ghc-mod` up to feature parity with GHCi and beyond,
- investigating how to best cooperate with `ide-backend`,
- adding a network interface to make using ghc-mod in other projects easier, and
- if time allows, cleaning up the Emacs frontend to be more user-friendly and in line with Emacs' conventions.

The goal of this work is to make `ghc-mod` the obvious choice for anyone implementing Haskell support for a development environment and improving `ghc-mod`'s overall feature set and reliability in order to give new as well as experienced Haskell developers the best possible experience.

Right now `ghc-mod` has only one core developer and only a handful of occasional drive-by contributors. If *you* want to help make Haskell development even more fun come and join us!

Further reading

https://github.com/kazu-yamamoto/ghc-mod

6.1.4 HaRe — The Haskell Refactorer

Report by:	Alan Zimmerman
Participants:	Francisco Soares, Chris Brown, Stephen Adams, Huiqing Li,Matthew Pickering

Refactorings are source-to-source program transformations which change program structure and organization, but not program functionality. Documented in catalogs and supported by tools, refactoring provides the means to adapt and improve the design of existing code, and has thus enabled the trend towards modern agile software development processes.

Our project, *Refactoring Functional Programs*, has as its major goal to build a tool to support refactorings in Haskell. The HaRe tool is now in its seventh major release. HaRe supports full Haskell 2010, and is integrated with (X)Emacs. All the refactorings that HaRe supports, including renaming, scope change, generalization and a number of others, are *module-aware*, so that a change will be reflected in all the modules in a project, rather than just in the module where the change is initiated.

Snapshots of HaRe are available from our GitHub repository (see below) and Hackage. There are related presentations and publications from the group (including LDTA'05, TFP'05, SCAM'06, PEPM'08, PEPM'10, TFP'10, Huiqing's PhD thesis and Chris's

PhD thesis). The final report for the project appears on the University of Kent Refactoring Functional Programs page (see below).

There is also a Google+ community called HaRe, a Google Group called https://groups.google.com/forum/#!forum/hare and an IRC channel on freenode called #haskell-refactorer. IRC is the preferred contact method.

Currently HaRe only supports GHC 7.4.x and 7.6.x. The changes for GHC 7.8.3 showed up the brittleness of the token management process.

As a result, the focus over the last year has been on improving the support in the GHC API for this. This work is summarized here https://ghc.haskell.org/trac/ghc/wiki/GhcApi, but the lightning summary is

- More parser entry points, to allow parsing fragments.
- Removal of landmines from the AST, allowing traversals with freedom.
- The parser can now produce annotations, which can be used to reproduce the original source from the AST and the annotations only.

An initial version landed in GHC 7.10.1. This has formed the basis for the ghc-exactprint library aimed at providing a tool to roundtrip a GHC AST, after modification.

Development of this library has shown up some shortcomings in the 7.10.1 support, which should hopefully be resolved in 7.10.2.

The engine for reproducing the source is here https://github.com/alanz/ghc-exactprint.

Recent developments

- The last GHC version supported by HaRe is 7.6.3. The next one will be GHC 7.10.2, once ghc-exactprint is stable, and fully integrated into HaRe. This is only likely to be towards the end of 2015.
- Matthew Pickering has been deeply involved in the ghc-exactprint development, and is continuing this in his Google Summer of Code project, which will help tremendously for HaRe.
- HaRe 0.7, which is a major change from 0.6 as it makes use of the GHC library for analysis, has been released; HaRe 0.7 is available on Hackage, and also downloadable from our GitHub page
- HaRe 0.7 is alpha software, and comes with a limited number of refactorings, as the work so far has concentrated on getting the new architecture in place to make use of the GHC AST. The new architecture has stabilised and the token management while manipulating the AST is able to preserve layout, thus maintaining the original layout as well as syntactically correct alignment as new elements are added or have their size changed.
- There is plenty to do, so anyone who has an interest is welcome to fork the repo and get stuck in.
- Stephen Adams is continuing his PhD at the University of Kent and will be working on data refactoring in Haskell.

Further reading

- http://www.cs.kent.ac.uk/projects/refactor-fp/
- https://github.com/alanz/HaRe
- https://github.com/alanz/ghc-exactprint
- http://mpickering.github.io/gsoc2015.html

6.1.5 ghc-exactprint

Report by:	Matthew Pickering
Participants:	Alan Zimmerman
Status:	Active, Experimental

`ghc-exactprint` aims to be a low-level foundation for refactoring tools. Unlike most refactoring tools, it works directly with the GHC API which means that it can understand any legal Haskell source file.

The program works in two phases. The first phase takes the output from the parser and converts all absolute source positions into relative source positions. This means that it is much easier to manipulate the AST as you do not have to worry about updating irrelevant parts of your program. The second phase performs the reverse process, it converts relative source positions back into absolute positions before printing the source file. The entire library is based around a free monad which keeps track of which annotations should be where. Each process is then a different interpretation of this structure.

In theory these two processes should be entirely separate but at the moment they are not entirely decoupled due to shortcomings we hope to fix in GHC 7.12.

In order to verify our foundations, the program has been run on every source file on Hackage. This testing highlighted a number of bugs which have been fixed for GHC 7.10.2. Apart from a few outstanding issues with very rare cases, we can now confidently say that `ghc-exactprint` is capable of processing *any* Haskell source file.

The goal for the next few months is to put this tool into action. Alan Zimmerman will be working to integrate `ghc-exactprint` into HaRe(→ 6.1.4) whilst Matthew Pickering will be participating in Google Summer of Code to provide integration with HLint. In order to facilitate both these processes, we anticipate that an intermediate user-level library may be useful to abstract away from the (quite gory) implementation. We hope that this library would also be useful for other tool writers.

Further reading

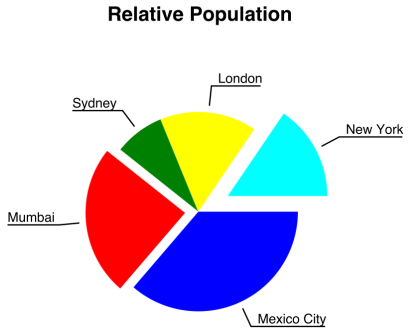
https://github.com/alanz/ghc-exactprint

6.1.6 IHaskell: Haskell for Interactive Computing

Report by:	Andrew Gibiansky
Status:	stable

IHaskell is an interactive interface for Haskell development. It provides a *notebook* interface (in the style of Mathematica or Maple). The notebook interface runs in a browser and provides the user with editable cells in which they can create and execute code. The output of this code is displayed in a rich format right below, and if it's not quite right, the user can go back, edit the cell, and re-execute. This rich format defaults to the same boring plain-text output as GHCi would give you; however, library authors will be able to define their own formats for displaying their data structures in a useful way, with the only limit being that the display output must be viewable in a browser (images, HTML, CSS, Javascript). For instance, integration with graphing libraries yields in-browser data visualizations, while integration with Aeson's JSON yields a syntax-highlighted JSON output for complex data structures.

```
toRenderable
  $ pie_title .~ "Relative Population"
  $ pie_plot . pie_data .~ map pitem values
  $ def
```

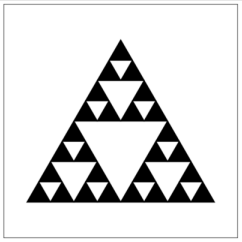


Implementation-wise, IHaskell is a language kernel backend for the Jupyter project, a *language-agnostic* protocol and set of frontends by which interactive code environments such as REPLs and notebooks can communicate with a language evaluator backend. IHaskell also provides a generic library for writing Jupyter kernels, which has been used successfully in the ICryptol project.

```
-- We can draw diagrams, right in the notebook.
:extension NoMonomorphismRestriction
import Diagrams.Prelude

-- By Brent Yorgey
-- Draw a Sierpinski triangle!
sierpinski 1 = eqTriangle 1
sierpinski n =     s
                  ===
                (s ||| s) # centerX
  where s = sierpinski (n-1)

-- The `diagram` function is used to display them
diagram $ sierpinski 4
           # centerXY
           # fc black
         `atop` square 10
                  # fc white
```



Integration with popular Haskell libraries can give us beautiful and potentially interactive visualizations of Haskell data structures. On one hand, this could range from simple things such as foldable record structures — imagine being able to explore complex nested records by folding and unfolding bits and pieces at a time, instead of trying to mentally parse them from the GHCi output. On the other end, we have interactive outputs, such as Parsec parsers which generate small input boxes that run the parser on any input they're given. And these things are just the beginning — tight integration with IPython may eventually be able to provide things such as code-folding in your REPL or an integrated debugger interface.

Further reading

https://github.com/gibiansky/IHaskell

6.2 Code Management

6.2.1 Darcs

Report by:	Eric Kow
Participants:	darcs-users list
Status:	active development

Darcs is a distributed revision control system written in Haskell. In Darcs, every copy of your source code is a full repository, which allows for full operation in a disconnected environment, and also allows anyone with read access to a Darcs repository to easily create their own branch and modify it with the full power of Darcs' revision control. Darcs is based on an underlying theory of patches, which allows for safe reordering and merging of patches even in complex scenarios. For all

its power, Darcs remains a very easy to use tool for every day use because it follows the principle of keeping simple things simple.

After three years of development, we have released Darcs 2.10 (April 2015). This new major release includes the new `darcs rebase` command (for merging and amending patches that would be hard to do with patch theory alone), numerous optimisations and performance improvements, a `darcs convert` command for switching to and from Git, as well as general improvements to the user interface.

SFC and donations Darcs is free software licensed under the GNU GPL (version 2 or greater). Darcs is a proud member of the Software Freedom Conservancy, a US tax-exempt 501(c)(3) organization. We accept donations at http://darcs.net/donations.html.

Further reading

- http://darcs.net
- http://darcs.net/Releases/2.10

6.2.2 `cab` — A Maintenance Command of Haskell Cabal Packages

Report by:	Kazu Yamamoto
Status:	open source, actively developed

`cab` is a MacPorts-like maintenance command of Haskell cabal packages. Some parts of this program are a wrapper to `ghc-pkg` and `cabal`.

If you are always confused due to inconsistency of `ghc-pkg` and `cabal`, or if you want a way to check all outdated packages, or if you want a way to remove outdated packages recursively, this command helps you.

`cab` now supports GHC 7.10.

Further reading

http://www.mew.org/~kazu/proj/cab/en/

6.3 Interfacing to other Languages

6.3.1 java-bridge

Report by:	Julian Fleischer
Status:	active development

The Java Bridge is a library for interfacing the Java Virtual Machine with Haskell code and vice versa. It comes with a rich DSL for discovering and invoking Java methods and allows to set up callbacks into the Haskell runtime. If exported via the FFI it is also possible to use Haskell libraries from within the JVM natively.

The package also offers a bindings generator which translates the API of a Java class or package into a Haskell API. Using the bindings generator it is possible to generate a Haskell module with a clean Haskell API that invokes Java behind the scenes. Typical conversions, for example byte arrays to lists or Java maps to lists of key value pairs, are taken care of. The generated bindings and predefined conversions are extensible by defining appropriate type class instances accordingly.

While the documentation for the bindings generator still needs improvement, the overall library is in a quite usable state.

The java bridge is published under the MIT license and available via hackage as `java-bridge`.

Further reading

If you want to know more about the inner workings: The Java Bridge has been created as part of a bachelor thesis which you can access at http://page.mi.fu-berlin.de/scravy/bridging-the-gap-between-haskell-and-java.pdf.

6.3.2 fficxx

Report by:	Ian-Woo Kim
Participants:	Ryan Feng
Status:	Actively Developing

fficxx ("eff fix") is an automatic haskell Foreign Function Interface (FFI) generator to C++. While haskell has a well-specified standard for C FFI, interfacing C++ library to haskell is notoriously hard. The goal of fficxx is to ease making haskell-C++ binding and to provide relatively nice mapping between two completely different programming paradigms.

To make a C++ binding, one write a haskell model of the C++ public interfaces, and then fficxx automatically generates necessary boilerplate codes in several levels: C++-C shims, C-haskell FFI, low level haskell type representation for C++ class/object and high level haskell type and typeclass representation and some casting functions. The generated codes are organized into proper haskell modules to minimize name space collision and packaged up as cabal packages.

The tool is designed to adapt different configurations and unique needs, such as splitting bindings into multiple cabal packages and renaming classes and functions to resolve some obstacles that are originated from naming collision, which is quite inevitable in making an FFI library.

The information of a C++ library can be written in terms of simple haskell expressions, aiming at good usability for ordinary haskell users. For example, if we have a C++ library which has the following interface:

```
class A {
public:
  A();
```

```
  virtual void Foo();
};
class B : public A {
public:
  B();
  virtual void Bar();
};
```

one provide the model in terms of haskell data type defined in fficxx library:

```
a = myclass "A" [] mempty Nothing
    [ Constructor [] Nothing
    , Virtual void_ "Foo" [ ] Nothing ]
b = myclass "B" [a] mempty Nothing
    [ Constructor [] Nothing
    , Virtual void_ "Bar" [] Nothing ]
```

One of the projects that successfully uses fficxx is HROOT which is a haskell binding to the ROOT library. ROOT is a big C++ histogramming and statistical analysis framework. Due to fficxx, the HROOT package faithfully reflects the ROOT C++ class hierarchy, and the user from C++ can use the package relatively easily.

fficxx is available on hackage and being developed on the author's github (http://github.com/wavewave/fficxx). In 2013, with Ryan Feng, we tried to make fficxx more modernized with more transparent support of various C/C++ data types, including consistent multiple pointer/reference operations and function pointers. fficxx is still being in progress in incorporating the new pointer operations. C++ template support is now planned.

Further reading

- http://ianwookim.org/fficxx

6.4 Deployment

6.4.1 Cabal and Hackage

Report by:	Duncan Coutts

Background

Cabal is the standard packaging system for Haskell software. It specifies a standard way in which Haskell libraries and applications can be packaged so that it is easy for consumers to use them, or re-package them, regardless of the Haskell implementation or installation platform.

Hackage is a distribution point for Cabal packages. It is an online archive of Cabal packages which can be used via the website and client-side software such as cabal-install. Hackage enables users to find, browse and download Cabal packages, plus view their API documentation.

cabal-install is the command line interface for the Cabal and Hackage system. It provides a command line program `cabal` which has sub-commands for installing and managing Haskell packages.

Looking forward

We would like to encourage people considering contributing to take a look at the bug tracker on github, take part in discussions on tickets and pull requests, or submit their own. The bug tracker is reasonably well maintained and it should be relatively clear to new contributors what is in need of attention and which tasks are considered relatively easy. For more in-depth discussion there is also the `cabal-devel` mailing list.

Further reading

- Cabal homepage: http://www.haskell.org/cabal
- Hackage package collection: http://hackage.haskell.org/
- Bug tracker: https://github.com/haskell/cabal/

6.4.2 Stackage: the Library Dependency Solution

Report by:	Natalia Muska
Status:	new

Stackage began in November 2012 with the mission of making it possible to build stable, vetted sets of packages. The overall goal was to make the Cabal experience better. Two years into the project, a lot of progress has been made and now it includes both Stackage and the Stackage Server. To date, there are over 700 packages available in Stackage. The official site is www.stackage.org.

Stackage Update: Stackage is an infrastructure to create stable builds of complete package sets referred to as "snapshots." Stackage provides users with the assurance that their packages will always build, will actually compile, all tests suites pass, and all will work across three GHC versions (7.8, 7.6, and 7.4). Users of a snapshot verified by Stackage can expect all packages to install the first time.

Each snapshot is given a unique hash which is a digest of that snapshot's package set. Snapshots don't change. Once a hash is provided, it refers only to that snapshot. So if a user writes a project using snapshot aba1b51af, and in two months switches to another machine and builds their project with aba1b51af, it will succeed.

For package authors, Stackage gives them the valuable knowledge that their package builds and tests successfully across the current, stable and old GHC versions. Library authors have guarantees that users of Stackage can easily use their library and can do so on a reasonable number of GHCs. Authors are also informed when a newly uploaded package breaks theirs, meaning it's time to update the package for it to be included in the latest snapshot.

Recently Stackage added some additional features including Haddock documentation and cabal.config files. By including Haddock documentation in Stackage all new exclusive snapshots have Haddock links allowing users to view documentation of all packages included in the snapshot. This means users can generally view everything in one place, on one high-availability service. By creating a cabal.config link on snapshot pages, Stackage users don't have to change their remote-repo field.

Stackage Server: Before Stackage Server, use of Stackage was limited to either manually downloading a project and building it all locally, or by using FP Haskell Center. With Stackage Server, users are able to go to the server web site and pick a snapshot. On the build is a simple copy/paste line to use as a Cabal repo, to replace the users existing remote-repo line.

When a new package is released and has been properly updated, users can go to the Stackage home page and get the latest snapshot and update their repo. The Stackage server also supports the uploading of custom snapshots, this allows a company, a Linux distribution, an organization, a university, or just as a general hacker who wants to keep all their projects under one package set, to maintain their own custom series of snapshots, and also make it available to other people. Then the burden will be on those users to make sure it builds, rather than the recommended and Stackage maintained snapshots.

If you've written some code that you're actively maintaining, don't hesitate to get it in Stackage. You'll be widening the potential audience of users for your code by getting your package into Stackage, and you'll get some helpful feedback from the automated builds so that users can more reliably build your code.

6.4.3 Haskell Cloud

Report by:	Gideon Sireling

Haskell Cloud is an OpenShift cartridge for deploying Haskell on Red Hat's open source PaaS cloud. It includes GHC 7.8, cabal-install, Gold linker, and a choice of pre-installed frameworks - a full list can be viewed on the Wiki.

Using a Haskell Cloud cartridge, existing Haskell projects can be uploaded, build, and run from the cloud with minimal changes. Ongoing development is focused on OpenShift's upcoming Docker release and GHC 7.10.

Further reading

- https://bitbucket.org/accursoft/haskell-cloud
- http://www.haskell.org/haskellwiki/Web/Cloud#OpenShift
- https://blog.openshift.com/functional-programming-in-the-cloud-how-to-run-haskell-on-openshift/

6.5 Others

6.5.1 ghc-heap-view

Report by:	Joachim Breitner
Participants:	Dennis Felsing
Status:	active development

The library ghc-heap-view provides means to inspect the GHC's heap and analyze the actual layout of Haskell objects in memory. This allows you to investigate memory consumption, sharing and lazy evaluation.

This means that the actual layout of Haskell objects in memory can be analyzed. You can investigate sharing as well as lazy evaluation using ghc-heap-view.

The package also provides the GHCi command `:printHeap`, which is similar to the debuggers' `:print` command but is able to show more closures and their sharing behaviour:

```
> let x = cycle [True, False]
> :printHeap x
_bco
> head x
True
> :printHeap x
let x1 = True : _thunk x1 [False]
in x1
> take 3 x
[True,False,True]
> :printHeap x
let x1 = True : False : x1
in x1
```

The graphical tool ghc-vis (→ 6.5.2) builds on ghc-heap-view.

Since version 0.5.3, ghc-heap-view also supports GHC 7.8.

Further reading

- http://www.joachim-breitner.de/blog/archives/548-ghc-heap-view-Complete-referential-opacity.html
- http://www.joachim-breitner.de/blog/archives/580-GHCi-integration-for-GHC.HeapView.html
- http://www.joachim-breitner.de/blog/archives/590-Evaluation-State-Assertions-in-Haskell.html

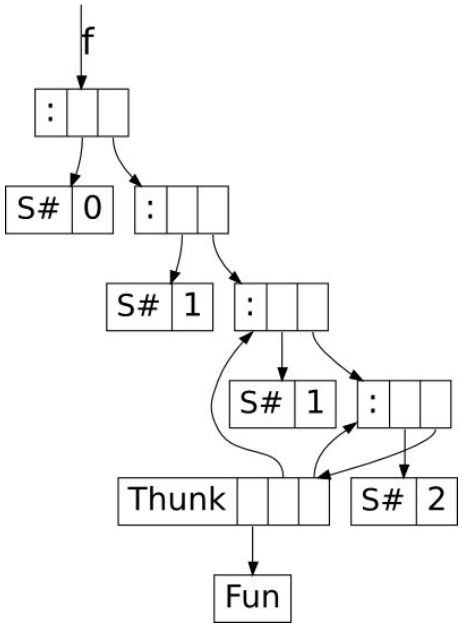
6.5.2 ghc-vis

Report by:	Dennis Felsing
Participants:	Joachim Breitner
Status:	active development

The tool ghc-vis visualizes live Haskell data structures in GHCi. Since it does not force the evaluation of the values under inspection it is possible to see Haskell's lazy evaluation and sharing in action while you interact with the data.

Ghc-vis supports two styles: A linear rendering similar to GHCi's `:print`, and a graph-based view where closures in memory are nodes and pointers between them are edges. In the following GHCi session a partially evaluated list of fibonacci numbers is visualized:

```
> let f = 0 : 1 : zipWith (+) f (tail f)
> f !! 2
> :view f
```



At this point the visualization can be used interactively: To evaluate a thunk, simply click on it and immediately see the effects. You can even evaluate thunks which are normally not reachable by regular Haskell code.

Ghc-vis can also be used as a library and in combination with GHCi's debugger.

Further reading

http://felsin9.de/nnis/ghc-vis

6.5.3 Hat — the Haskell Tracer

Report by:	Olaf Chitil

Hat is a source-level tracer for Haskell. Hat gives access to detailed, otherwise invisible information about a computation.

Hat helps locating errors in programs. Furthermore, it is useful for understanding how a (correct) program works, especially for teaching and program maintenance. Hat is not a time or space profiler. Hat can be used for programs that terminate normally, that terminate with an error message or that terminate when interrupted by the programmer.

Tracing a program with Hat consists of two phases: First the program needs to be run such that it additionally writes a trace to file. To add trace-writing, *hat-trans* translates all the source modules *Module* of a Haskell program into tracing versions *Hat.Module*. These are compiled as normal and when run the program does exactly the same as the original program except for additionally writing a trace to file. Second, after the program has terminated, you view the trace with a tool. Hat comes with several tools for selectively viewing fragments of the trace in different ways: *hat-observe* for Hood-like observations, *hat-trail* for exploring a computation backwards, *hat-explore* for freely stepping through a computation, *hat-detect* for algorithmic debugging, ...

Hat is distributed as a package on Hackage that contains all Hat tools and tracing versions of standard libraries. Currently Hat supports Haskell 98 plus some language extensions such as multi-parameter type classes and functional dependencies. For portability all viewing tools have a textual interface; however, many tools use some Unix-specific features and thus run on Unix / Linux / OS X, but not on Windows.

Hat was mostly built around 2000–2004 and then disappeared because of lack of maintenance. Now it is back and new developments have started.

The source-to-source transformation of hat-trans has been completely rewritten to use the haskell-src-exts parser. Thus small bugs of the old parser disappeared and in the future it will be easier to cover more Haskell language extensions. This work was released on Hackage as Hat 2.8.

When a traced program uses any libraries besides the standard Haskell 98 / 2010 ones, these libraries currently have to be transformed (in trusted mode). So the plan for the next release of Hat is to enable Hat to use trusted libraries without having to transform them.

Feedback on Hat is welcome.

Further reading

- Initial website: http://projects.haskell.org/hat
- Hackage package: http://hackage.haskell.org/package/hat

6.5.4 Tasty

Report by:	Roman Cheplyaka
Participants:	Michael LaCorte, Sergey Vinokurov, and many others
Status:	actively maintained

Tasty is a modern testing framework for Haskell. As of May 2015, 230 hackage packages use Tasty for their tests. We've heard from several companies that use Tasty to test their Haskell software.

What's new since the last HCAR?

- Tasty now sets the number of parallel running tests equal to the number of available capabilities (i.e. the number set by `-N`) by default. As always, that can be changed with `-j`.
- Printing test results on Windows used to be slow, but now it's fast!
- Tasty-HUnit now has a new function, `testCaseSteps`, which lets you annotate a multi-step unit test. Here's an example:

```
main =
  defaultMain $
  testCaseSteps "Multi-step test" $
  \step -> do

  step "Step 1"
  -- do something

  step "Step 2"
  -- do something else
```

  As a reminder from the last HCAR, Tasty-HUnit no longer uses the original HUnit package; instead it reimplements the relelvant subset of its API.
- The way Tasty-Golden works internally has changed. There are a few consequences (see the CHANGELOG for details); an interesting one is that you can now update golden files in parallel. Also, if a golden file doesn't exist, it will be created automatically. You'll see a message like

```
UnboxedTuples:                    OK (0.04s)
  Golden file did not exist; created
```

  This is convenient when adding new tests.

Further reading

- For more information about Tasty and how to use it, please consult the README at http://bit.ly/tasty-home
- Tasty has a mailing list http://bit.ly/tasty-ml and an IRC channel (`#tasty` on FreeNode), where you can get help with Tasty.

6.5.5 Automatic type inference from JSON

Report by:	Michal J. Gajda
Status:	stable

This rapid software development tool `json-autotype` interprets JSON data and converts them into Haskell module with data type declarations.

```
$ json-autotype input.json -o JSONTypes.hs
```

The generated declarations use automatically derived Aeson class instances to read and write data directly from/to JSON strings, and facilitate interaction with growing number of large JSON APIs.

Generated parser can be immediately tested on an input data:

```
$ runghc JSONTypes.hs input.json
```

The software can be installed directly from Hackage.

It uses sophisticated union type unification, and robustly interprets most ambiguities using clever typing.

The tool has reached maturity this year, and thanks to automated testing procedures it seems to robustly infer types for all JSON inputs considered valid by Aeson.

The author welcomes comments and suggestions at ⟨mjgajda@gmail.com⟩.

Further reading

http://hackage.haskell.org/packages/json-autotype

6.5.6 Exference

Report by:	Lennart Spitzner
Status:	experimental, active development

Exference is a tool aimed at supporting developers writing Haskell code by generating expressions from a type, e.g.
Input:

```
(Show b) => (a -> b) -> [a] -> [String]
```

Output:

```
\ b -> fmap (\ g -> show (b g))
```

Input:

```
   (Monad m, Monad n)
=> ([a] -> b -> c) -> m [n a] -> m (n b)
-> m (n c)
```

Output:

```
\ b -> liftA2 (\ i j ->
  liftA2 (\ o p -> b p o) j (sequenceA i))
```

There are two primary use-cases for Exference:

- In combination with typed holes: The programmer can insert typed holes into the source code, retrieve the expected type from ghc and forward this type to Exference. If a solution, i.e. an expression, is found and if it has the right semantics, it can be used to fill the typed hole.
- As a type-class-aware search engine. For example, Exference is able to answer queries such as Int → Float, where the common search engines like hoogle or hayoo are not of much use.

In contrast to Djinn, the well known tool with the same general purpose, Exference supports a larger subset of the Haskell type system - most prominently type classes. (Djinn's environment many contain type classes, but using them in queries will not really work.) This comes at a cost, however: Exference makes no promise regarding termination. In fact, the problem tackled by Exference is an undecidable one (a draft of a proof can be found in the pdf below).

Future work includes optimizations (reducing the memory requirements most importantly) and extending the dictionary. Contributions are welcome.

Try it out by on IRC(freenode): exferenceBot is in #exference.

Further reading

- https://github.com/lspitzner/exference
- https://github.com/lspitzner/exference/raw/master/exference.pdf

7 Libraries, Applications, Projects

7.1 Language Features

7.1.1 Conduit

Report by:	Michael Snoyman
Status:	stable

While lazy I/O has served the Haskell community well for many purposes in the past, it is not a panacea. The inherent non-determinism with regard to resource management can cause problems in such situations as file serving from a high traffic web server, where the bottleneck is the number of file descriptors available to a process.

The left fold enumerator was one of the first approaches to dealing with streaming data without using lazy I/O. While it is certainly a workable solution, it requires a certain inversion of control to be applied to code. Additionally, many people have found the concept daunting. Most importantly for our purposes, certain kinds of operations, such as interleaving data sources and sinks, are prohibitively difficult under that model.

The conduit package was designed as an alternate approach to the same problem. The root of our simplification is removing one of the constraints in the enumerator approach. In order to guarantee proper resource finalization, the data source must always maintain the flow of execution in a program. This can lead to confusing code in many cases. In conduit, we separate out guaranteed resource finalization as its own component, namely the ResourceT transformer.

Once this transformation is in place, data producers, consumers, and transformers (known as Sources, Sinks, and Conduits, respectively) can each maintain control of their own execution, and pass off control via coroutines. The user need not deal directly with any of this low-level plumbing; a simple monadic interface (inspired greatly by the pipes package) is sufficient for almost all use cases.

Since its initial release, conduit has been through many design iterations, all the while keeping to its initial core principles. Since the last HCAR, we've released version 1.2. This release introduces two changes: it adds a stream fusion implementation to allow much more optimized runs for some forms of pipelines, and uses the codensity transform to provide better behavior of monadic bind.

Additionally, much work has gone into `conduit-combinators` and `streaming-commons`, both of which are packages introduced in the last HCAR.

There is a rich ecosystem of libraries available to be used with conduit, including cryptography, network communications, serialization, XML processing, and more.

The library is available on Hackage. There is an interactive tutorial available on the FP Complete School of Haskell. You can find many conduit-based packages in the Conduit category on Hackage as well.

Further reading

- http://hackage.haskell.org/package/conduit
- https://www.fpcomplete.com/user/snoyberg/library-documentation/conduit-overview
- http://hackage.haskell.org/packages/archive/pkg-list.html#cat:conduit

7.1.2 lens

Report by:	Edward Kmett
Participants:	many others
Status:	very actively developed

The `lens` package provides families of lenses, isomorphisms, folds, traversals, getters and setters. That is to say, it provides a rich, compositional vocabulary for separating "what you want to do" from "what you want to do it to" built upon rigorous foundations.

Compared to other libraries that provide lenses, key distinguishing features for lens are that it comes "batteries included" with many useful lenses for the types commonly used from the Haskell Platform, and with tools for automatically generating lenses and isomorphisms for user-supplied data types.

Also, included in this package is a variant of Neil Mitchell's `uniplate` generic programming library, modified to provide a Traversal and with its combinators modified to work with arbitrary traversals.

Moreover, you do not need to incur a dependency on the lens package in order to supply (or consume) lenses or most of the other lens-like constructions offered by this package.

Further reading

- Simon Peyton Jones: http://skillsmatter.com/podcast/scala/lenses-compositional-data-access-and-manipulation
- Edward Kmett: http://www.youtube.com/watch?v=cefnmjtAolY
- Lens Development, Visualized: http://www.youtube.com/watch?v=ADAprOOgi-A&feature=youtu.be&hd=1
- http://hackage.haskell.org/package/lens
- http://lens.github.io/
- https://github.com/ekmett/lens/wiki

- https://github.com/ekmett/lens/issues
- http://statusfailed.com/blog/2013/01/26/haskells-strength-generalising-with-lenses.html
- http://ocharles.org.uk/blog/posts/2012-12-09-24-days-of-hackage-lens.html
- http://www.haskellforall.com/2013/05/program-imperatively-using-haskell.html
- https://www.fpcomplete.com/school/to-infinity-and-beyond/pick-of-the-week/a-little-lens-starter-tutorial
- http://stackoverflow.com/questions/5767129/lenses-fclabels-data-accessor-which-library-for-structure-access-and-mutatio/5769285#5769285
- http://comonad.com/reader/2012/mirrored-lenses/
- http://r6.ca/blog/20121209T182914Z.html
- http://r6.ca/blog/20120623T104901Z.html

7.1.3 folds

Report by:	Edward Kmett
Status:	actively developed

This package provides a playground full of resumable comonadic folds and folding homomorphisms between them.

Further reading

- http://hackage.haskell.org/package/folds
- https://www.fpcomplete.com/user/edwardk/cellular-automata/part-2
- http://squing.blogspot.com/2008/11/beautiful-folding.html
- http://conal.net/blog/posts/another-lovely-example-of-type-class-morphisms
- http://conal.net/blog/posts/more-beautiful-fold-zipping
- http://www.haskellforall.com/2013/08/composable-streaming-folds.html

7.1.4 machines

Report by:	Edward Kmett
Participants:	Anthony Cowley, Shachaf Ben-Kiki, Paul Chiusano, Nathan van Doorn
Status:	actively developed

Ceci n'est pas une pipe

This package exists to explore the design space of streaming calculations. Machines are demand-driven input sources like pipes or conduits, but can support multiple inputs.

You design a Machine by writing a Plan. You then construct the machine from the plan.

Simple machines that take one input are called a Process. More generally you can attach a Process to the output of any type of Machine, yielding a new Machine. More complicated machines provide other ways of connecting to them.

Typically the use of machines proceeds by using simple plans into machine Tees and Wyes, capping many of the inputs to those with possibly monadic sources, feeding the rest input (possibly repeatedly) and calling run or runT to get the answers out.

There is a lot of flexibility when building a machine in choosing between empowering the machine to run its own monadic effects or delegating that responsibility to a custom driver.

Further reading

- https://vimeo.com/77164337
- http://acowley.github.io/NYHUG/FunctionalRoboticist.pdf
- https://github.com/runarorama/scala-machines
- https://dl.dropbox.com/u/4588997/Machines.pdf

7.1.5 exceptions

Report by:	Edward Kmett
Participants:	Gabriel Gonzales, Michael Snoyman, John Weigley, Mark Lentczner, Alp Mestanogullari, Fedor Gogolev, Merijn Verstraaten, Matvey B. Aksenov
Status:	actively developed

This package was begun as an effort to define a standard way to deal with exception handling in monad transformer stacks that could scale to the needs of real applications in terms of handling asynchronous exceptions, could support GHC now that *block* and *unblock* have been removed from the compiler, and which we could reason about the resulting behavior, and still support *mocking* on monad transformer stacks that are not built atop IO.

Further reading

http://hackage.haskell.org/package/exceptions

7.1.6 Faking even more dependent types!

Report by:	Richard Eisenberg
Participants:	Jan Stolarek
Status:	released

The singletons package enables users to fake dependent types in Haskell via the technique of singletons. In brief, a singleton type is a type with exactly one value; by knowing the value, you also know the type, and vice versa. See "Dependently typed programming with singletons" (Haskell '12) for more background.

Jan Stolarek and Richard Eisenberg have released a major update to singletons, which will include processing of a much larger subset of Haskell, including **case** and **let** statements, **where** clauses, anonymous functions, and classes. Since the release (of version 1.0), more improvements have been made to

the HEAD version, available at http://github.com/goldfirere/singletons.

Of particular interest, the library exports a *promote* function that will take ordinary term-level function definitions and promote them to type family definitions. After the update, this will allow users to write term-level code in a familiar style and have that code work on promoted datatypes at the type level.

Further reading

- *Dependently typed programming with singletons*, by Richard A. Eisenberg and Stephanie Weirich. Haskell Symposium '12. http://www.cis.upenn.edu/~eir/papers/2012/singletons/paper.pdf
- *Promoting Functions to Type Families in Haskell*, by Richard A. Eisenberg and Jan Stolarek. Haskell Symposium '14. http://www.cis.upenn.edu/~eir/papers/2014/promotion/promotion.pdf
- GitHub repo: http://github.com/goldfirere/singletons

7.1.7 Type checking units-of-measure

Report by:	Richard Eisenberg
Participants:	Takayuki Muranushi
Status:	released

The units package, available on Hackage, allows you to type-check your Haskell code with respect to units of measure. It prevents you from adding, say, meters to seconds while allowing you to add meters to feet and dividing meters by seconds. A Double can be converted into a dimensioned quantity only by specifying its units, and a dimensioned quantity can be converted to an ordinary Double only by specifying the desired units of the output.

The set of units is fully extensible. The package, in fact, exports units only for dimensionless quantities. Instead, the companion units-defs package contains definitions for SI dimensions and units, as well as the US customary units. Because of units's extensibility, the package is suitable for use outside of physics applications, such as finance or keeping your apples apart from your bananas.

The magic under the hood uses lots of type families and no functional dependencies. One upshot of this design is that user code can generally be free of constraints on types. Here is some sample code:

$$kinetic\_energy :: \mathsf{Mass} \to \mathsf{Velocity} \to \mathsf{Energy}$$
$$kinetic\_energy\ m\ v = redim\ \$\ 0.5 *|\ m\ |*|\ v\ |*|\ v$$
$$g\_earth :: \mathsf{Acceleration}$$
$$g\_earth = redim\ \$\ 9.8\ \%\ (\mathsf{Meter} :/ (\mathsf{Second} :\hat{}\ sTwo))$$

Type annotations are not necessary – all types can be inferred.

Further reading

- GitHub repo: http://github.com/goldfirere/units
- *Experience Report: Type-checking Polymorphic Units for Astrophysics Research in Haskell*, by Takayuki Muranushi and Richard A. Eisenberg. Haskell Symposium '14. http://www.cis.upenn.edu/~eir/papers/2014/units/units.pdf

7.1.8 GHC type-checker plugin for kind Nat

Report by:	Christiaan Baaij
Status:	actively developed

As of GHC version 7.10, GHC's type checking and inference mechanisms can be enriched by plugins. This particular plugin enriches GHC's knowledge of arithmetic on the type-level. Specifically it allows the compiler to reason about *equalities* of types of kind `GHC.TypeLits.Nat`.

GHC's type-checker's knowledge of arithmetic is virtually non-existent: it doesn't know addition is associative and commutative, that multiplication distributes over addition, etc. In a dependently-typed language, or in Haskell using singleton types, one can provide proofs for these properties and use them to type-check programs that depend on these properties in order to be (type-)correct. However, most of these properties of arithmetic over natural number are elementary school level knowledge, and it is cumbersome and tiresome to keep on providing and proving them manually. This type-checker plugin adds the knowledge of these properties to GHC's type-checker.

For example, using this plugin, GHC now knows that:

```
(x + 2)^(y + 2)
```

is equal to:

```
4*x*(2 + x)^y + 4*(2 + x)^y + (2 + x)^y*x^2
```

The way that the plugin works, is that it normalises arithmetic expressions to a normal form that very much resembles *Cantor normal form for ordinals*(http://en.wikipedia.org/wiki/Ordinal_arithmetic#Cantor_normal_form). Subsequently, it perform a simple syntactic equality of the two expressions. Indeed, in the example above, the latter expression is the normal form of the former expression.

The main test suite for the plugin can be found at: https://github.com/christiaanb/ghc-typelits-natnormalise/blob/master/tests/Tests.hs. It demonstrates what kind of *correct* code can be written without type equality annotations, or the use of `unsafeCoerce`.

One important aspect of this plugin is that it only enriches the type checkers knowledge of equalities, but not *in*equalities. That is, it does not allow GHC to solve constraints such as:

```
CmpNat (x + 2) (x + 3) ~ 'LT
```

The plugin is available on hackage, for GHC version 7.10 and higher:

```
$ cabal update
$ cabal install ghc-typelits-natnormalise
```

Development focus for the plugin is on further testing and improving its testsuite.

Further reading

- http://hackage.haskell.org/package/ghc-typelits-natnormalise
- http://hackage.haskell.org/package/base/docs/GHC-TypeLits.html

7.1.9 Dependent Haskell

Report by:	Richard Eisenberg
Status:	work in progress

I am working on an ambitious update to GHC that will bring full dependent types to the language. On my branch [1] the Core language and type inferenace have already been updated according to the description in our ICFP'13 paper [2]. Accordingly, *all* type-level constructs are simultaneously kind-level constructs, as there is no distinction between types and kinds. Specifically, GADTs and type families will be promotable to kinds. At this point, I conjecture that any construct writable in those other dependently-typed languages will be expressible in Haskell through the use of singletons.

As of the time of writing, the branch works on many examples but is still a bit buggy. I hope to merge with GHC's master branch over the summer.

After this phase, I will embark on working a proper Π-binder into the language, much along the lines of Adam Gundry's thesis on the topic [3]. Having Π would give us "proper" dependent types, and there would be no more need for singletons. A sampling of what I hope is possible when this work is done is online [4], excerpted here:

$$
\begin{aligned}
&\textbf{data}\ \mathsf{Vec} :: * \to \mathsf{Integer} \to * \ \textbf{where}\\
&\quad \mathsf{Nil}\ \ :: \mathsf{Vec}\ a\ 0\\
&\quad (:::) :: a \to \mathsf{Vec}\ a\ n \to \mathsf{Vec}\ a\ (1\ '+\ n)\\
&\mathit{replicate} :: \pi\ n.\ \forall a.\ a \to \mathsf{Vec}\ a\ n\\
&\mathit{replicate}\ @0\ \_ = \mathsf{Nil}\\
&\mathit{replicate}\quad\ x = x ::: \mathit{replicate}\ x
\end{aligned}
$$

Of course, the design here (especially for the proper dependent types) is preliminary, and input is encouraged.

Further reading

- [1]: https://github.com/goldfirere/ghc, the `nokinds` branch.
- [2]: *System FC with Explicit Kind Equality*, by Stephanie Weirich, Justin Hsu, and Richard A. Eisenberg. ICFP '13. http://www.cis.upenn.edu/~eir/papers/2013/fckinds/fckinds.pdf
- [3]: *Type Inference, Haskell and Dependent Types*, by Adam Gundry. PhD Thesis, 2013. https://personal.cis.strath.ac.uk/adam.gundry/thesis/
- [4]: https://github.com/goldfirere/nyc-hug-oct2014/blob/master/Tomorrow.hs
- Haskell Implementors' Workshop 2014 presentation on Dependent Haskell. Slides: http://www.cis.upenn.edu/~eir/talks/2014/hiw-dependent-haskell.pdf; Video: https://www.youtube.com/watch?v=O805YjOsQjI
- Repo for presentation on Dependent Haskell at the NYC Haskell Users' Group: https://github.com/goldfirere/nyc-hug-oct2014
- Wiki page with elements of the design: https://ghc.haskell.org/trac/ghc/wiki/DependentHaskell

7.2 Education

7.2.1 Exercism: crowd-sourced code reviews on daily practice problems

Report by:	Bob Ippolito
Status:	available

Exercism.io is an open source (AGPL) site that provides programming exercises suitable for new programmers, or programmers new to a programming language.

The feature that differentiates exercism from self-study is that once a solution is submitted, others who have completed that exercise have an opportunity to provide code review. Anecdotally, this seems to put programmers on the right track quickly, especially with regard to the subtler points of Haskell style, non-strict evaluation, and GHC-specific features.

Exercism fully supports Haskell as of August 2013, with more than 50 exercises currently available. As of this writing, 165 people have completed at least one Haskell exercise.

I intend to continue actively participating in the code review process and ensure that the Haskell exercise path is well maintained.

Further reading

http://exercism.io/

7.2.2 Holmes, Plagiarism Detection for Haskell

Report by:	Jurriaan Hage
Participants:	Brian Vermeer, Gerben Verburg

Holmes is a tool for detecting plagiarism in Haskell programs. A prototype implementation was made by Brian Vermeer under supervision of Jurriaan Hage, in order to determine which heuristics work well. This implementation could deal only with Helium programs. We found that a token stream based comparison and Moss style fingerprinting work well enough, if you remove template code and dead code before the comparison. Since we compute the control flow graphs anyway, we decided to also keep some form of similarity checking of control-flow graphs (particularly, to be able to deal with certain refactorings).

In November 2010, Gerben Verburg started to reimplement Holmes keeping only the heuristics we figured were useful, basing that implementation on `haskell-src-exts`. A large scale empirical validation has been made, and the results are good. We have found quite a bit of plagiarism in a collection of about 2200 submissions, including a substantial number in which refactoring was used to mask the plagiarism. A paper has been written, which has been presented at CSERC'13, and should become available in the ACM Digital Library.

The tool will be made available through Hackage at some point, but before that happens it can already be obtained on request from Jurriaan Hage.

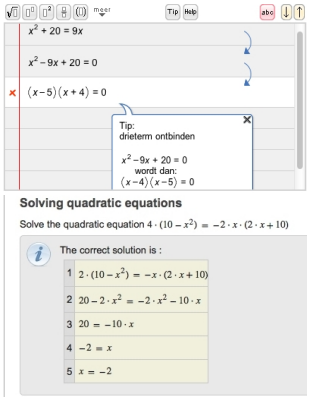
Contact

⟨J.Hage@uu.nl⟩

7.2.3 Interactive Domain Reasoners

Report by:	Bastiaan Heeren
Participants:	Johan Jeuring, Alex Gerdes, Josje Lodder, Hieke Keuning
Status:	experimental, active development

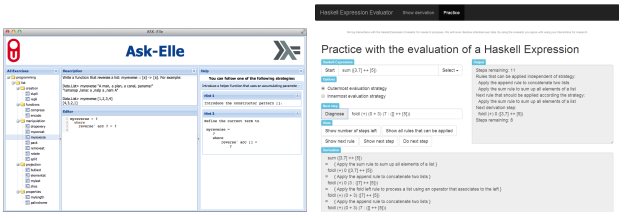
The IDEAS project at the Open Universiteit and Utrecht University aims at developing domain reasoners for stepwise exercises on various topics. These reasoners assist students in solving exercises incrementally by checking intermediate steps, providing feedback on how to continue, and detecting common mistakes. The reasoners are based on a strategy language, and feedback is derived automatically from rewriting strategies that are expressed in this language. The calculation of feedback is offered as a set of web services, enabling external (mathematical) learning environments to use our work. We currently have a binding with the Digital Mathematics Environment of the Freudenthal Institute (first/left screenshot), the ActiveMath learning system of the DFKI and Saarland University (second/right screenshot), and several exercise assistants of our own.



We have used our domain reasoners to model dialogues in Communicate!, which is a serious game for training communication skills. This game is being developed by a team of teachers and students at Utrecht University.

A group of bachelor students from the Open Universiteit has developed a new web interface for our tutor for logic, to which we have added exercises for proving equivalences.

We have continued working on the domain reasoners that are used by our programming tutors. The Ask-Elle functional programming tutor lets you practice introductory functional programming exercises in Haskell. We have extended this tutor with QuickCheck properties for testing the correctness of student programs, and for the generation of counterexamples. We have analysed the usage of the tutor to find out how many student submissions are correctly diagnosed as right or wrong. Tim Olmer has developed a tutor in which a student can practice with evaluating Haskell expressions. Finally, Hieke Keuning has developed a programming tutor for imperative programming.



The library for developing domain reasoners with feedback services is available as a Cabal source package. We have written a tutorial on how to make your own domain reasoner with this library. We have also released our domain reasoner for mathematics and logic as a separate package.

Further reading

- Bastiaan Heeren, Johan Jeuring, and Alex Gerdes. Specifying Rewrite Strategies for Interactive Exercises. Mathematics in Computer Science, 3(3):349–370, 2010.

- Bastiaan Heeren and Johan Jeuring. Feedback services for stepwise exercises. Science of Computer Programming, Special Issue on Software Development Concerns in the e-Learning Domain, volume 88, 110–129, 2014.
- Tim Olmer, Bastiaan Heeren, Johan Jeuring. Evaluating Haskell expressions in a tutoring environment. Trends in Functional Programming in Education 2014.
- Hieke Keuning, Bastiaan Heeren, Johan Jeuring. Strategy-based feedback in a programming tutor. Computer Science Education Research Conference (CSERC 2014).
- Johan Jeuring, Thomas van Binsbergen, Alex Gerdes, Bastiaan Heeren. Model solutions and properties for diagnosing student programs in Ask-Elle. Computer Science Education Research Conference (CSERC 2014).

7.3 Parsing and Transforming

7.3.1 epub-metadata

Report by:	Dino Morelli
Status:	experimental, actively developed

Library for parsing and manipulating epub OPF package data. Now with epub3 support.

- Added support for epub3 documents. This was done using a single set of datatypes, not specific to either epub2 or epub3.
- Redesigned the book file querying API to be an edsl. Actions are to be combined together based on what the developer needs from the document.
- Data structures to contain epub metadata "sections" were redesigned to no longer be nested. Part of this change includes a typeclass-based pretty-print API for displaying this data.
- Documentation rewrites and additions, including a working code example in the API docs.

epub-metadata is available from Hackage and the Darcs repository below.

See also epub-tools (→ 7.10.1).

Further reading

- Project page: http://ui3.info/d/proj/epub-metadata.html
- Source repository: `darcs get` http://ui3.info/darcs/epub-metadata

7.3.2 Utrecht Parser Combinator Library: uu-parsinglib

Report by:	Doaitse Swierstra
Status:	actively developed

With respect to the previous version the code for building interleaved parsers was split off into a separate package `uu-interleaved`, such that it can be used by other parsing libraries too. Based on this another small package `uu-options` was constructed which can be used to parse command line options and files with preferences. The internals of these are described in a technical report: http://www.cs.uu.nl/research/techreps/UU-CS-2013-005.html.

As an example of its use we show how to fill a record from the command line. We start out by defining the record which is to hold the options to be possibly set:

```
data Prefers  = Agda | Haskell deriving Show
data Address = Address { city_ :: String
                       , street_ :: String}
             deriving Show
data Name    = Name { name_ :: String
                    , prefers_ :: Prefers
                    , ints_ :: [Int]
                    , address_ :: Address}
             deriving Show
$ (deriveLenses " Name)
$ (deriveLenses " Address)
```

The next thing to do is to specify a default record containing the default values:

```
defaults = Name "Doaitse" Haskell []
                (Address "Utrecht"
                         "Princetonplein")
```

Next we define the parser for the options, by specifying each option:

```
oName =
      name    `option` ( "name",    pString,
                         "Name")
  <> ints     `options` ( "ints",    pNaturalRaw,
                         "Some numbers")
  <> prefers `choose` [("agda",     Agda,
                        "Agda preferred")
                      ,("haskell", Haskell,
                        "Haskell preferred")
                      ]
  <> address `field`
               (  city   `option` ("city", pString,
                                   "Home city")
               <> street `option` ("street", pString,
                                   "Home Street")
               )
```

Finally when running this parser by the command *run* (($*defaults*) <$> *mkP oName*) on the string (`"-int=7 -city=Tynaarlo -i 5 -agda -i3 " ++ "-street=Zandlust"`) the result is

```
Name { name_    = Doaitse
     , prefers_ = Agda
     , ints_    = [7,5,3]
     , address_ = Address
                  { city_   = Tynaarlo
                  , street_ = Zandlust}
     }
```

If you make a mistake in the list of options, automatic error reporting and correction steps in and you get the following message:

```
./OptionsDemo --street=Zandlust -nDoaitse
-i3 --city=Tynaarlo
 --name     [Char]  optional  Name
 --ints     Int     recurring Some numbers
 Choose at least one from(
 --agda         required  Agda preferred
 --haskell      required  Haskell preferred
    )
 --city     [Char]  optional  Home city
 --street   [Char]  optional  Home Street
 --
 --  Correcting steps:
 --    Inserted  "-a" at position 70
 --    expecting one of
       [  "--agda", "--agda=", "--haskell",
          "--haskell=", "--ints=", "--ints",
          "-i", "-h", "-a"]
 --    Inserted  EOT at position 70
 --    expecting EOT
```

Features

- Combinators for easily describing parsers which produce their results online, do not hang on to the input and provide excellent error messages. As such they are "surprise free" when used by people not fully aware of their internal workings.
- Parsers "correct" the input such that parsing can proceed when an erroneous input is encountered.
- The library basically provides the to be preferred applicative interface and a monadic interface where this is really needed (which is hardly ever).
- No need for *try*-like constructs which make writing `Parsec` based parsers tricky.
- Scanners can be switched dynamically, so several different languages can occur intertwined in a single input file.
- Parsers can be run in an interleaved way, thus generalizing the merging and permuting parsers into a single applicative interface. This makes it e.g. possible to deal with white space or comments in the input in a completely separate way, without having to think about this in the parser for the language at hand (provided of course that white space is not syntactically relevant).

Future plans

Future versions will contain a check for grammars being not left-recursive, thus taking away the only remaining source of surprises when using parser combinator libraries. This makes the library even greater for use in teaching environments. Future versions of the library, using even more abstract interpretation, will make use of computed look-ahead information to speed up the parsing process further.

Contact

If you are interested in using the current version of the library in order to provide feedback on the provided interface, contact ⟨doaitse@swierstra.net⟩. There is a low volume, moderated mailing list which was moved to ⟨parsing@lists.science.uu.nl⟩ (see also http://www.cs.uu.nl/wiki/bin/view/HUT/ParserCombinators).

7.3.3 HERMIT

Report by:	Andrew Gill
Participants:	Andrew Farmer, Neil Sculthorpe, Ryan Scott
Status:	active

The Haskell Equational Reasoning Model-to-Implementation Tunnel (HERMIT) is an NSF-funded project being run at KU (→ 9.7), which aims to improve the applicability of Haskell-hosted Semi-Formal Models to High Assurance Development. Specifically, HERMIT uses a Haskell-hosted DSL and a new refinement user interface to perform rewrites directly on Haskell Core, the GHC internal representation.

In the project we want to demonstrate the equivalences between efficient Haskell programs, and their clear specification-style Haskell counterparts. In doing so there are several open problems, including refinement scripting and managing scaling issues, data representation and presentation challenges, and understanding the theoretical boundaries of the worker/wrapper transformation.

We have reworked KURE, a Haskell-hosted DSL for strategic programming, as the basis of our rewrite capabilities, and constructed the rewrite kernel making use of the GHC Plugins architecture. A journal writeup of the KURE internals is available in JFP. As for interfaces to the kernel, we currently have a command-line REPL, which we are replacing this summer with a GHCi DSL, called Black Shell. We have used HERMIT to successfully mechanize many smaller examples of program transformations, drawn from the literature on techniques such as concatenate vanishes, tupling transformation, and worker/wrapper.

Further reading

https://github.com/ku-fpg/hermit

7.3.4 Generalized Algebraic Dynamic Programming

Report by:	Christian Höner zu Siederdissen
Status:	usable, active development

Generalized Algebraic Dynamic Programming provides a solution for high-level dynamic programs. We treat the formal grammars underlying each DP algorithm as an algebraic object which allows us to *calculate* with them. Below, we describe three highlights, our systems offers:

Grammars Products

We have developed a theory of algebraic operations over linear and context-free grammars. This theory allows us to combine simple "atomic" grammars to create more complex ones.

With the compiler that accompanies our theory, we make it easy to experiment with grammars and their products. Atomic grammars are user-defined and the algebraic operations on the atomic grammars are embedded in a rigerous mathematical framework.

Our immediate applications are problems in computational biology and linguistics. In these domains, algorithms that combine structural features on individual inputs (or tapes) with an alignment or structure between tapes are becoming more commonplace. Our theory will simplify building grammar-based applications by dealing with the intrinsic complexity of these algorithms.

We provide multiple types of output. LaTeX is available to those users who prefer to manually write the resulting grammars. Alternatively, Haskell modules can be created. TemplateHaskell and QuasiQuoting machinery is also available turning this framework into a fully usable embedded domain-specific language. The DSL or Haskell module use ADPfusion (→ 7.12.1) with multitape extensions, delivering "close-to-C" performance.

Set Grammars

Most dynamic programming frameworks we are aware of deal with problems over sequence data. There are, however, many dynamic programming solutions to problems that are inherently non-sequence like. Hamiltonian path problems, finding optimal paths through a graph while visiting each node, are a well-studied example.

We have extended our formal grammar library to deal with problems that can not be encoded via linear data types. This provides the user of our framework with two benifits. She can now easily encode problems based on set-like inputs and obtain dynamic programming solutions. On a more general level, the extension of ADPfusion and the formal grammars library shows how to encode new classes of problems that are now gaining traction and are being studied.

If, say, the user wants to calculate the shortest Hamiltonian path through all nodes of a graph, then the grammar for this problem is:

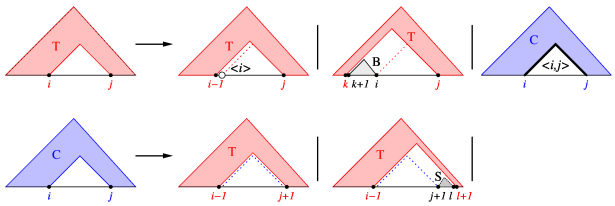
```
s (f <<< s % n ||| g <<< n ... h)
```

which states that a path s is either extended by a node n, or that a path is started by having just a first, single node n. Functions f and g evaluate the cost of moving to the new node. gADP has notions of sets with interfaces (here: for s) that provide the needed functionality for stating that all nodes in s have been visited with a final visited node from which an edge to n is to be taken.

Automatic Outside Grammars

Our third contribution to high-level and efficient dynamic programming is the ability to automatically construct Outside algorithms given an Inside algorithm. The combination of an Inside algorithm and its corresponding Outside algorithm allow the developer to answer refined questions for the ensemble of all (suboptimal) solutions.

The image below depicts one such automatically created grammar that parses a string from the Outside in. T and C are non-terminal symbols of the Outside grammar; the production rules also make use of the S and B non-terminals of the Inside version.



One can, for example, not only ask for the most efficient path through all cities on a map, but also answer which path between two cities is the most frequented one, given all possible travel routes. In networks, this allows one to determine paths that are chosen with high likelihood.

Further reading

- http://www.bioinf.uni-leipzig.de/Software/gADP/
- http://dx.doi.org/10.1109/TCBB.2014.2326155
- http://dx.doi.org/10.1007/978-3-319-12418-6_8

7.3.5 parsers

Report by:	Edward Kmett
Participants:	Nathan Filardo, Dag Odenall, Mario Blazevic, Tony Morris, Tim Dixon, Greg Fitzgerald
Status:	actively developed

This package provides a common lingua franca for working with `parsec`-like parsing combinator libraries, such that the combinators support being lifted over monad transformers. Instances are provided for use with the `parsec` `Parser` and `base`'s `ReadP`, and it is used by `trifecta` (→ 7.3.6) to provide its suite of parsing combinators.

Notably, many of the combinators have been modified to only require the use of `Alternative` rather than `MonadPlus`, enabling some base `Parser` instances to operate more efficiently.

Further reading

http://hackage.haskell.org/package/parsers

7.3.6 trifecta

Report by:	Edward Kmett
Participants:	Austin Seipp, Nathan Filardo, John Weigley
Status:	actively developed

This package is designed to explore the space of "human scale" parsers for programming languages. That is to say, it isn't optimized for parsing protocols or other huge streaming datasets, but rather to provide nice error messages for files that are usually written by hand by human beings.

Trifecta supports `clang`-style colored diagnostics with markup denoting locations, spans and fixits for user code. It builds on top of the `parsers` (→ 7.3.5) framework for most of its parsing combinators.

Much of the focus of `trifecta` is on supporting functionality beyond basic parsing, such as syntax highlighting, that arise once you have a programming language.

In the long term, we plan to support built-in CPP, auto-completion and parser transformers to support Haskell-style layout.

Further reading

http://hackage.haskell.org/package/trifecta

7.4 Mathematics

7.4.1 Rlang-QQ

Report by:	Adam Vogt
Status:	active development

Rlang-QQ is intended to make it easier to call R from Haskell programs. This allows access to a large number of R packages for graphing, statistics or other uses. Rlang-QQ provides a quasiquoter which runs the R interpreter and tries to translate values between the two languages.

Haskell expressions can be referenced from R using syntax like `$(take 10 [1.0 .. ])`. Haskell variables can also be passed in by prefixing them with `hs_`: `hs_x` refers to `x`. Values that can be taken out of a Haskell `x :: Chan t` are accessible using `ch_x`. When the R code has an assignment such as `hs_x <- f()`, the quasiquote evaluates to an HList record which contains the result from `f()`.

Future work may include supporting the serialization of more data types between the two languages, passing data between the two runtimes in-memory instead of through files, and doing inference when possible on the R-code to restrict the types of the Haskell values that are serialized or deserialized.

Further reading

- http://hackage.haskell.org/package/Rlang-QQ
- http://www.r-project.org/
- http://www.haskell.org/haskellwiki/Quasiquotation

7.4.2 order-statistics

Report by:	Edward Kmett
Status:	stable

This package extends Bryan O'Sullivan's `statistics` package with support for order statistics and L-estimators.

An order statistic is simply a position in the sorted list of samples given just the size of the sample. L-estimators are linear combinations of order-statistics.

L-estimators are used in robust statistics to collect statistics that are robust in the presence of outliers, and have the benefit that you can jackknife them without changing their asymptotics.

This package provides a compositional vocabulary for describing order statistics.

Further reading

- http://hackage.haskell.org/package/order-statistics
- http://en.wikipedia.org/wiki/Order_statistic
- http://en.wikipedia.org/wiki/L-estimator

7.4.3 linear

Report by:	Edward Kmett
Participants:	Anthony Cowley, Ben Gamari, Jake McArthur, John Weigley, Elliott Hird, Eric Mertens, Niklas Haas, Casey McCann
Status:	actively developed

This package provides 'low-dimensional' linear algebra primitives that are based explicitly on the notion that all vector spaces are free vector spaces, and so are isomorphic to functions from some basis to an underlying

field. This lets us use representable functors, which are represented by such a basis to encode all of our linear algebra operations, and provides a natural encoding for dense vector spaces.

A nice *lens*-based API is provided that permits punning of basis vector names between different vector types.

Further reading

http://hackage.haskell.org/package/linear

7.4.4 algebra

Report by:	Edward Kmett
Status:	experimental

This package provides a large cross section of constructive abstract algebra.

Notable theoretical niceties include the fact that covectors form a Monad, linear maps form an Arrow, and this package bundles a rather novel notion of geometric coalgebra alongside the more traditional algebras and coalgebras.

Further reading

http://hackage.haskell.org/package/algebra

7.4.5 semigroups and semigroupoids

Report by:	Edward Kmett
Participants:	Nathan van Doorn, Mark Wright, Adam Curtis
Status:	stable

The `semigroups` package provides a standard location to obtain the notion of Semigroup.

The `semigroupoids` package provides the notion of a Semigroupoid, which is a Category that does not necessarily provide *id*. These arise in practice for many reasons in Haskell.

Notably, we cannot express a product category with the existing implementation of Data Kinds.

But more simply, there are many types for which their Kleisli category or Cokleisli category lacks identity arrows, because they lack *return* or *extract*, but could otherwise pass muster.

With `semigroupoids 4.0`, this package has now come to subsume the previous `groupoids` and `semigroupoid-extras` packages.

Further reading

- http://hackage.haskell.org/package/semigroups
- http://hackage.haskell.org/package/semigroupoids

7.4.6 Arithmetics packages (Edward Kmett)

Report by:	Edward Kmett
Participants:	Sjoerd Visscher, Austin Seipp, Daniel Bergey, Chris Schneider, Ben Gamari
Status:	actively developed

- The `compensated` package provides compensated arithmetic for when you need greater precision than the native floating point representation can provide. A Compensated Double has over 100 bits worth of effective significand. Unlike other "double double" variants in other languages, this construction can be iterated. A Compensated (Compensated Double) gives over 200 bits worth of precision.
  However, not all RealFloat operations have yet been upgraded to work in full precision.
- The `approximate` package (with Sjoerd Visscher and Austin Seipp) provides a notion of approximate result values and intervals with log-domain lower bounds on confidence. It also provides fast piecewise-rational, but monotone increasing approximate versions of log and exp that execute many times faster than the native machine instructions that are suitable for use in machine learning.
- The `intervals` package (with Daniel Bergey and Chris Schneider) provides basic interval arithmetic. An Interval is a closed, convex set of floating point values.
  We do not control the rounding mode of the end points of the interval when using floating point arithmetic, so be aware that in order to get precise containment of the result, you will need to use an underlying type with both lower and upper bounds like CReal.
- The `log-domain` package (with Ben Gamari) provides log domain floats, doubles and complex numbers with an emphasis on supporting probabilities biased towards conservative lower bounds.

Further reading

- http://hackage.haskell.org/package/compensated
- http://hackage.haskell.org/package/approximate
- http://hackage.haskell.org/package/intervals
- http://hackage.haskell.org/package/log-domain

7.4.7 ad

Report by:	Edward Kmett
Participants:	Alex Lang, Takayuki Muranushi, Chad Scherrer, Lennart Augustsson, Ben Gamari, Christopher White
Status:	actively developed

This package provides an intuitive API for Automatic Differentiation (AD) in Haskell. Automatic differentiation provides a means to calculate the derivatives of a function while evaluating it. Unlike numerical methods based on running the program with multiple inputs

or symbolic approaches, automatic differentiation typically only decreases performance by a small multiplier.

AD employs the fact that any program $y = \mathsf{F}\ (x)$ that computes one or more values does so by composing multiple primitive operations. If the (partial) derivatives of each of those operations is known, then they can be composed to derive the answer for the derivative of the entire program at a point.

This library contains at its core a single implementation that describes how to compute the partial derivatives of a wide array of primitive operations. It then exposes an API that enables a user to safely combine them using standard higher-order functions, just as you would with any other Haskell numerical type.

There are several ways to compose these individual Jacobian matrices. We hide the choice used by the API behind an explicit "Mode" type-class and universal quantification. This prevents the end user from exploiting the properties of an individual mode, and thereby potentially violating invariants or confusing infinitesimals.

We are actively seeking ways to better support unboxed vectors, new modes, new primitives, and better-optimized forms for gradient descent.

Features:

- Provides many variants on forward- and reverse-mode AD combinators with a common API.
- Type-level "branding" is used to both prevent the end user from confusing infinitesimals and to limit unsafe access to the implementation details of each mode.
- Each mode has a separate module full of combinators, with a consistent look and feel.

Further reading

- http://hackage.haskell.org/package/ad
- http://en.wikipedia.org/wiki/Automatic_differentiation
- http://www.autodiff.org/

7.4.8 integration

Report by:	Edward Kmett
Participants:	Adrian Keet
Status:	actively developed

This package provides robust numeric integration via tanh-sinh quadrature. "Tanh-Sinh quadrature scheme is the fastest known high-precision quadrature scheme, especially when the time for computing abscissas and weights is considered. It has been successfully employed for quadrature calculations of up to 20,000-digit precision. It works well for functions with blow-up singularities or infinite derivatives at endpoints."

Further reading

- http://hackage.haskell.org/package/integration
- http://en.wikipedia.org/wiki/Tanh-sinh_quadrature
- http://crd-legacy.lbl.gov/~dhbailey/dhbpapers/dhb-tanh-sinh.pdf

7.4.9 contravariant

Report by:	Edward Kmett
Participants:	Dag Odenhall, Merijn Verstraaten
Status:	stable

This package provides the notion of a contravariant functor, along with various forms of composition for contravariant functors and Day convolution.

Further reading

- http://hackage.haskell.org/package/contravariant
- http://ncatlab.org/nlab/show/Day+convolution

7.4.10 categories

Report by:	Edward Kmett
Participants:	Gwern Branwen
Status:	stable

This package provides a number of classes for working with Category instances with more structure in Haskell. In many ways this package can be viewed as an alternative to working with Arrows, as working with a CCC can provide you with much more fuel for optimization.

Further reading

http://hackage.haskell.org/package/categories

7.4.11 bifunctors

Report by:	Edward Kmett
Status:	stable

This package provides a standard location to retrieve the notion of a Bifunctor, Bifoldable or Bitraversable data type.

Further reading

- http://hackage.haskell.org/package/bifunctors
- http://ncatlab.org/nlab/show/bifunctor

7.4.12 profunctors

Report by:	Edward Kmett
Participants:	Shachaf Ben-Kiki, Elliott Hird
Status:	stable

This package provides profunctors, which act like an Arrow you don't necessarily know how to put together.

These form the bedrock upon which *lens* (→ 7.1.2) is built.

With profunctors 4.0 we've merged together the contents of the older `profunctors`, `profunctor-extras` and `representable-profunctors` packages.

In addition to the basic notion of a profunctor, we also provide the category of collages for a profunctor, notions of representable and corepresentable profunctors, along with weaker notions of Strong and Choice that correspond to various Arrow classes, profunctor composition.

Further reading

- http://hackage.haskell.org/package/profunctors
- http://blog.sigfpe.com/2011/07/profunctors-in-haskell.html
- https://www.fpcomplete.com/school/to-infinity-and-beyond/pick-of-the-week/profunctors
- http://ncatlab.org/nlab/show/profunctor

7.4.13 comonad

Report by:	Edward Kmett
Participants:	Dave Menendez, Gabor Greif, David Luposchainsky, Sjoerd Visscher, Luke Palmer, Nathan van Doorn
Status:	stable

This package provides the comonads, the categorical dual of monads, along with comonad transformers, and the comonadic equivalent of the `mtl`.

With `comonad 4.0` we've merged together the contents of the older `comonad`, `comonad-transformers`, and `comonads-fd packages`.

You can work with this package using Dominic Orchard's `codo-notation`, or use them directly.

The `kan-extensions` (→ 7.4.15) package also provides a transformer that can turn a comonad into a monad.

Further reading

- http://hackage.haskell.org/package/comonad
- http://comonad.com/haskell/Comonads_1.pdf
- http://www.cs.ox.ac.uk/ralf.hinze/WG2.8/28/slides/Comonad.pdf
- http://www.cl.cam.ac.uk/~dao29/publ/codo-notation-orchard-ifl12.pdf
- http://www.ioc.ee/~tarmo/papers/cmcs08.pdf
- http://cs.ioc.ee/~tarmo/papers/essence.pdf

7.4.14 recursion-schemes

Report by:	Edward Kmett
Status:	stable

This package provides generalized bananas, lenses and barbed wire based on the recursion schemes that came out of the constructive algorithmics community over the years.

In addition to the standard recursion schemes, all of their distributive laws can be made compositional, enabling the creation of such interesting and impractical beasts as the zygohistomorphic prepromorphism.

Further reading

- http://hackage.haskell.org/package/recursion-schemes
- http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.174.8068&rep=rep1&type=pdf
- http://math.ut.ee/~eugene/kabanov-vene-mpc-06.pdf
- http://www.ioc.ee/~tarmo/tday-viinistu/kabanov-slides.pdf
- http://www.ioc.ee/~tarmo/papers/msfp08.pdf
- http://www.cs.uu.nl/wiki/pub/GP/Schedule/JoaoAlpuim.pdf
- http://eprints.eemcs.utwente.nl/7281/01/db-utwente-40501F46.pdf
- http://www.mii.lt/informatica/pdf/INFO141.pdf
- http://wwwhome.ewi.utwente.nl/~fokkinga/mmfphd.pdf
- http://comonad.com/reader/2008/elgot-coalgebras/
- http://comonad.com/reader/2008/time-for-chronomorphisms/
- http://comonad.com/reader/2008/dynamorphisms-as-chronomorphisms/
- http://comonad.com/reader/2008/generalized-hylomorphisms/
- http://web.engr.oregonstate.edu/~erwig/meta/
- http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.4.9706&rep=rep1&type=pdf
- http://www.cs.ox.ac.uk/people/jeremy.gibbons/publications/metamorphisms-scp.pdf

7.4.15 kan-extensions

Report by:	Edward Kmett
Status:	stable

This package provides Kan extensions, Kan lifts, various forms of the Yoneda lemma, and (co)density (co)monads.

These constructions have proven useful for many purposes:

- Codensity can be used to accelerate the performance of code written for free monads or to correct the assocativity of an "almost-monad" that fails the associativity law, as it performs a sort of fusion on $(\gg\!=)$ operations.
- CoT can be used to turn any Comonad into a Monad transformer.
- Various forms of the Yoneda lemma give rise to ways to enforce "Functor fusion".

Further reading

- http://hackage.haskell.org/package/kan-extensions
- http://blog.sigfpe.com/2006/11/yoneda-lemma.html
- http://blog.sigfpe.com/2006/12/yonedic-addendum.html
- http://comonad.com/reader/2008/kan-extensions/
- http://comonad.com/reader/2008/kan-extensions-ii/

- http://comonad.com/reader/2008/kan-extension-iii/
- http://blog.ezyang.com/2012/01/problem-set-the-codensity-transformation/
- http://www.iai.uni-bonn.de/~jv/mpc08.pdf
- http://www.cs.ox.ac.uk/ralf.hinze/Kan.pdf
- http://ncatlab.org/nlab/show/Kan+lift
- http://hackage.haskell.org/package/monad-ran

7.5 Numerical Packages and High Performance Computing

7.5.1 arb-fft

Report by:	Ian Ross
Status:	actively developed

This package started as an experiment to see how close a pure Haskell FFT implementation could get to FFTW ("the Fastest Fourier Transform in the West"). The result is a library that can do fast Fourier transforms for arbitrarily sized vectors with performance within a factor of about five of FFTW.

Future plans mostly revolve around making things go faster! In particular, the next thing to do is to write an equivalent of FFTW's `genfft`, a metaprogramming tool to generate fast straight-line code for transforms of specialised sizes. Other planned work includes implementing real-to-complex and real-to-real transforms, multi-dimensional transforms, and some low-level optimisation.

Further reading

- http://hackage.haskell.org/package/arb-fft
- http://www.skybluetrades.net/haskell-fft-index.html

7.5.2 hblas

Report by:	Carter Tazio Schonwald
Participants:	Stephen Diehl and Csernik Flaviu Andrei
Status:	Actively Developed

`hblas` is high level, easy to extend BLAS/LAPACK FFI Binding for Haskell.

`hblas` has several attributes that *in aggregate* distinguish it from alternative BLAS/LAPACK bindings for Haskell.

1. Zero configuration install

2. FFI wrappers are written in Haskell

3. Provides the fully generality of each supported BLAS/LAPACK routine, in a type safe wrapper that still follows the naming conventions of BLAS and LAPACK.

4. Designed to be easy to extend with further bindings to BLAS/LAPACK routines (because there are many many specialized routines!)

5. Adaptively choses between unsafe vs safe foreign calls based upon estimated runtime of a computation, to ensure that long running `hblas` ffi calls interact safely with the GHC runtime and the rest of an application.

6. `hblas` is not an end user library, but is designed to easily interop with any array library that supports storable vectors.

Further reading

- http://www.wellposed.com
- http://www.github.com/wellposed/hblas
- http://hackage.haskell.org/package/hblas

7.5.3 HROOT

Report by:	Ian-Woo Kim
Status:	Actively Developing

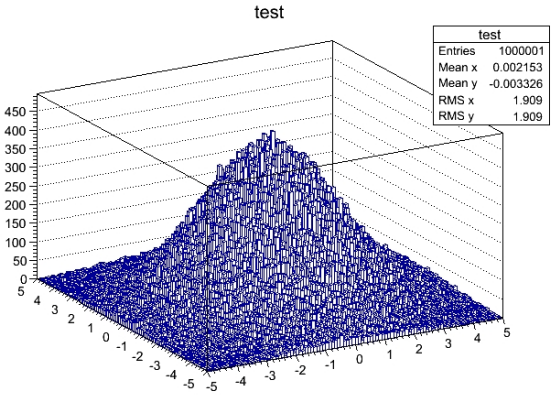
HROOT is a haskell binding to ROOT framework by fficxx, a haskell-C++ binding generator tool. ROOT (http://root.cern.ch) is an OOP framework for data analysis and statistics, which is developed at CERN. The ROOT system provides a set of OO frameworks with all the functionality needed to handle and analyze large amounts of data in a very efficient way. ROOT is a de facto standard physics analysis tool in high energy physics experiments.

This haskell binding to ROOT provides an industrial-strength statistical analysis libraries to the haskell community. The haskell code for using HROOT is very straightforward to both haskell and C++ programmers thanks to the fficxx binding generator tool. The following is a sample code and a resultant histogram for histogramming a 2D gaussian distribution:

```
import Data.Random.Distribution.Normal
import HROOT

main :: IO ()
main = do
  tcanvas <- newTCanvas "Test" "Test" 640 480
  h2 <- newTH2F "test" "test"
                100 (-5.0) 5.0 100 (-5.0) 5.0
  let dist1 = Normal (0 :: Double)
                     (2 :: Double)
  let go n | n < 0 = return ()
           | otherwise = do
               histfill dist1 dist2 h2
               go (n-1)
  go 1000000
  draw h2 "lego"
  saveAs tcanvas "random2d.pdf" ""
```

```
histfill :: Normal Double -> TH2F -> IO ()
histfill dist1 hist = do
  x <- sample dist1
  y <- sample dist1
  fill2 hist x y
  return ()
```



Until ghc 7.6, HROOT cannot be used in interpreter mode of ghc, due to the linker problem. Now with ghc 7.8, ghci now uses the standard system linker for dynamically loaded library. Thus, our current focus is to have full ghc interpreter support for making HROOT a really useful analysis framework. In addition, we keep importing features from ROOT to available haskell functions.

Further reading

http://ianwookim.org/HROOT

7.5.4 Numerical

Report by:	Carter Tazio Schonwald
Status:	actively developed

The Numerical project, starting with the `numerical` package, has the goal of providing a general purpose numerical computing substrate for Haskell.

To start with, the `numerical` provides an extensible set of type classes suitable for both dense and sparse multi dimensional arrays, high level combinators for writing good locality code, and some basic matrix computation routines that work on both dense and sparse matrix formats.

The core Numerical packages, including `numerical`, are now in public pre-alpha as of mid May 2014, with on going active work as of November 2014.

Development of the numerical packages is public on github, and as they stabilize, alpha releases are being made available on hackage.

Further reading

- http://www.wellposed.com
- http://www.github.com/wellposed/numerical
- http://hackage.haskell.org/package/numerical

7.6 Data Types and Data Structures

7.6.1 constraints

Report by:	Edward Kmett
Participants:	Sjoerd Visscher, Austin Seipp
Status:	actively developed

This package provides data types and classes for manipulating values of kind Constraint as exposed by GHC since 7.4.

Further reading

- http://hackage.haskell.org/package/constraints
- http://comonad.com/reader/2011/what-constraints-entail-part-1/
- http://comonad.com/reader/2011/what-constraints-entail-part-2/

7.6.2 HList — A Library for Typed Heterogeneous Collections

Report by:	Adam Vogt
Participants:	Oleg Kiselyov, Ralf Lämmel, Keean Schupke

HList is a comprehensive, general purpose Haskell library for typed heterogeneous collections including extensible polymorphic records and variants. HList is analogous to the standard list library, providing a host of various construction, look-up, filtering, and iteration primitives. In contrast to the regular lists, elements of heterogeneous lists do not have to have the same type. HList lets the user formulate statically checkable constraints: for example, no two elements of a collection may have the same type (so the elements can be unambiguously indexed by their type).

An immediate application of HLists is the implementation of open, extensible records with first-class, reusable, and compile-time only labels. The dual application is extensible polymorphic variants (open unions). HList contains several implementations of open records, including records as sequences of field values, where the type of each field is annotated with its phantom label. We and others have also used HList for type-safe database access in Haskell. HList-based Records form the basis of OOHaskell. The HList library relies on common extensions of Haskell 2010. HList is being used in AspectAG (http://www.haskell.org/communities/11-2011/html/report.html#sect5.4.2), typed EDSL of attribute grammars, and in Rlang-QQ.

The October 2012 version of HList library marks the significant re-write to take advantage of the fancier types offered by GHC 7.4 and 7.6. HList now relies on promoted data types and on kind polymorphism.

Since the last update, there have been several minor releases. These include features such as support for ghc-7.8 as well as additional syntax for the pun quasiquote.

Further reading

- HList repository: http://code.haskell.org/HList/
- HList: http://okmij.org/ftp/Haskell/types.html#HList
- OOHaskell: https://web.archive.org/web/20130129031410/http://homepages.cwi.nl/~ralf/OOHaskell

7.6.3 reflection

Report by:	Edward Kmett
Participants:	Elliott Hird, Oliver Charles, Carter Schonwald
Status:	stable

This package provides a mechanism to dynamically construct a type from a term that you can reflect back down to a term based on the ideas from "Functional Pearl: Implicit Configurations" by Oleg Kiselyov and Chung-Chieh Shan. However, the API has been implemented in a much more efficient manner.

This is useful when you need to make a typeclass instance that depends on a particular value in scope, such as a modulus or a graph.

Further reading

- http://hackage.haskell.org/package/reflection
- http://www.cs.rutgers.edu/~ccshan/prepose/prepose.pdf
- http://comonad.com/reader/2009/incremental-folds/
- http://comonad.com/reader/2009/clearer-reflection/
- https://www.fpcomplete.com/user/thoughtpolice/using-reflection

7.6.4 tag-bits

Report by:	Edward Kmett
Status:	stable

This package provides access to the dynamic pointer tagging bits used by GHC, and can peek into infotables to determine (unsafely) whether or not a thunk has already been evaluated.

Further reading

- http://hackage.haskell.org/package/tag-bits
- http://research.microsoft.com/en-us/um/people/simonpj/papers/ptr-tag/
- http://ghc.haskell.org/trac/ghc/wiki/Commentary/Rts/HaskellExecution/PointerTagging
- http://ghc.haskell.org/trac/ghc/wiki/Commentary/Rts/Storage/HeapObjects

7.6.5 hyperloglog

Report by:	Edward Kmett
Participants:	Ozgun Ataman
Status:	actively developed

This package provides an approximate streaming (constant space) unique object counter.

Notably it can be used to approximate a set of several billion elements with 1-2% inaccuracy in around 1.5k of memory.

Further reading

- http://hackage.haskell.org/package/hyperloglog
- http://algo.inria.fr/flajolet/Publications/FlFuGaMe07.pdf

7.6.6 hybrid-vectors

Report by:	Edward Kmett
Status:	actively developed

This package provides various ways in which you can mix the different types of Vector from Roman Leschinskiy's vector package to work with partially unboxed structures.

Further reading

- http://hackage.haskell.org/package/hybrid-vectors
- https://www.fpcomplete.com/user/edwardk/revisiting-matrix-multiplication/part-3

7.6.7 lca

Report by:	Edward Kmett
Participants:	Daniel Peebles, Andy Sonnenburg
Status:	actively developed

This package improves the previous known complexity bound of online lowest common ancestor search from $O(h)$ to $O(\log h)$ persistently, and without preprocessing by using skew-binary random-access lists to store the paths.

Further reading

- http://hackage.haskell.org/package/lca
- https://www.fpcomplete.com/user/edwardk/online-lca
- http://www.slideshare.net/ekmett/skewbinary-online-lowest-common-ancestor-search

7.6.8 concurrent-supply

Report by:	Edward Kmett
Participants:	Andrew Cowie, Christiaan Baaij
Status:	stable

This package provides a fast supply of concurrent unique identifiers suitable for use within a single process. This benefits from greatly reduced locking overhead compared to Data.Unique as it only contents for the common pool every thousand or so identifiers.

One often has a desire to generate a bunch of integer identifiers within a single process that are unique within that process. You could use UUIDs, but they can be expensive to generate; you don't want to have your threads contending for a single external counter if the identifier is not going to be used outside the process.

`concurrent-supply` builds a rose-tree-like structure which can be split; you can make smaller unique supplies and then you allocate from your supplies locally. Internally it pulls from a unique supply one block at a time as you walk into parts of the tree that haven't been explored. This ensures that computations are always replayable within a process, and that the result appears purely functional to an outside observer.

Further reading

http://hackage.haskell.org/package/concurrent-supply

7.6.9 heaps

Report by:	Edward Kmett
Status:	actively developed

This package provides asymptotically optimal purely functional Brodal-Okasaki heaps with a "Haskelly" API.

Further reading

- http://hackage.haskell.org/package/heaps
- http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.48.973

7.6.10 sparse

Report by:	Edward Kmett
Participants:	Carter Schonwald
Status:	actively developed

This package provides sparse implicitly Morton-ordered matrices based on the series 'revisiting matrix multiplication' on the School of Haskell. It is efficient for sufficiently sparse matrices.

Further reading

- http://hackage.haskell.org/package/sparse
- https://www.fpcomplete.com/user/edwardk/revisiting-matrix-multiplication

7.6.11 compressed

Report by:	Edward Kmett
Status:	stable

This package provides an LZ78-compressed stream as a data type in Haskell. Compression isn't used directly for data compression, but rather to allow for the reuse of intermediate monoidal results when folding over the data set. LZ78 is rather distinctive among LZ-variants in that it doesn't require exhaustively enumerating the token set or searching a window. By using conservative approximations of what possible values the stream may take, it is also possible to work with this LZ78 stream as an Applicative or Monad without sacrificing too much compression on the resulting unfolding.

A similar structure is provided for decompressing run-length encoded data efficiently by peasant exponentiation.

Further reading

- http://hackage.haskell.org/package/compressed
- http://oldwww.rasip.fer.hr/research/compress/algorithms/fund/lz/lz78.html
- http://www.binaryessence.com/dct/en000140.htm

7.6.12 charset

Report by:	Edward Kmett
Status:	stable

This package provides fast unicode character sets based on complemented PATRICIA tries along with common charsets for variations on the posix standard and standard unicode blocks. This encoding has the benefit that a CharSet and its complement take the same amount of space. This package is used as a building block by `parsers` (→ 7.3.5) and `trifecta` (→ 7.3.6).

Further reading

http://hackage.haskell.org/package/charset

7.6.13 Convenience types (Edward Kmett)

Report by:	Edward Kmett
Participants:	several others
Status:	stable

- The `either` package provides an EitherT monad transformer, that unlike ErrorT does not carry the unnecessary class constraint. Removing this limitation is necessary for many operations.
  EitherT is also used extensively by Gabriel Gonzales' *errors* package.
  With `either 4.0`, we consolidated many of the existing combinators from Chris Done's `eithers` package and Gregory Crosswhite's `either-unwrap` package, both of which are now deprecated.

- The `tagged` package provides a simple Tagged newtype that carries an extra phantom type parameter, and a Proxy data type that has since been merged into `base` with GHC 7.8.
  These are useful as safer ways to plumb type arguments than by passing `undefined` values around.
- Th `void` package provides a single "uninhabited" data type in a canonical location along with all of the appropriate instances.
  The need for such a data type arises in shockingly many situations as it serves as an initial object for the category of Haskell data types.

Further reading

- http://hackage.haskell.org/package/either
- http://hackage.haskell.org/package/errors
- http://hackage.haskell.org/package/tagged
- http://hackage.haskell.org/package/void

7.7 Databases and Related Tools

7.7.1 tables

Report by:	Edward Kmett
Participants:	Nathan van Doorn, Tim Dixon, Niklas Haas, Dag Odenhall, Petr Pilar, Austin Seipp
Status:	actively developed

The `tables` package provides a multiply-indexed in-memory data store in the spirit of `ixset` or `data-store`, but with a `lens`-based API.

Further reading

- http://hackage.haskell.org/package/tables
- https://github.com/ekmett/tables#examples

7.7.2 Persistent

Report by:	Greg Weber
Participants:	Michael Snoyman, Felipe Lessa
Status:	stable

The last HCAR announcement was for the release of Persistent 2.0, featuring a flexible primary key type.

Since then, persistent has mostly experienced bug fixes, including recent fixes and increased backend support for the new flexible primary key type.

Haskell has many different database bindings available, but most provide few usefeul static guarantees. Persistent uses knowledge of the data schema to provide a type-safe interface to the database. Persistent is designed to work across different databases, currently working on Sqlite, PostgreSQL, MongoDB, MySQL, Redis, and ZooKeeper.

Persistent provides a high-level query interface that works against all backends.

```
selectList [PersonFirstName == . "Simon",
  PersonLastName == . "Jones"] []
```

The result of this will be a list of Haskell records.

Persistent can also be used to write type-safe query libraries that are specific. esqueleto is a library for writing arbitrary SQL queries that is built on Persistent.

Future plans

Persistent is in a stable, feature complete state. Future plans are only to increase its ease the places where it can be easitly used:

- Declaring a schema separately from a record, possibly leveraging GHC's new annotations feature or another pattern

Persistent users may also be interested in Groundhog (→ 7.7.3), a similar project.

Persistent is recommended to Yesod (→ 5.2.5) users. However, there is nothing particular to Yesod or even web development about it. You can have a type-safe, productive way to store data for any kind of Haskell project.

Further reading

- http://www.yesodweb.com/book/persistent
- http://hackage.haskell.org/package/esqueleto
- http://www.yesodweb.com/blog/2014/09/persistent-2
- http://www.yesodweb.com/blog/2014/08/announcing-persistent-2

7.7.3 Groundhog

Report by:	Boris Lykah
Status:	stable

Groundhog is a library for mapping user defined datatypes to the database and manipulating them in a high-level typesafe manner. It is easy to plug Groundhog into an existing project since it does not need modifying a datatype or providing detailed settings. The schema can be configured flexibly which facilitates integration with existing databases. It supports composite keys, indexes, references across several schemas. Just one line is enough to analyze the type and map it to the table. The migration mechanism can automatically check, initialize, and migrate database schema. Groundhog has backends for Sqlite, PostgreSQL, and MySQL.

Unlike Persistent (→ 7.7.2) it maps the datatypes instead of creating new ones. The types can be polymorphic and contain multiple constructors. It allows creating sophisticated queries which might include arithmetic expressions, functions, and operators. The database-specific operators, for example, array-related

in PostgreSQL are statically guaranteed to run only for PostgreSQL connection. Its support for the natural and composite keys is implemented using generic embedded datatype mechanism.

Groundhog has got several commercial users which have positive feedback. Most of the recent changes were done to meet their needs. The new features include PostgreSQL geometric operators, Fractional, Floating, and Integral instances for lifted expressions, logging queries, references to tables not mapped to Haskell datatype, default column values, and several utility functions.

Further reading

- Tutorial, http://www.fpcomplete.com/user/lykahb/groundhog
- Homepage, http://github.com/lykahb/groundhog
- Hackage package, http://hackage.haskell.org/package/groundhog

7.7.4 Opaleye

Report by:	Tom Ellis
Status:	stable, active

Opaleye is an open-source library which provides an SQL-generating embedded domain specific language. It allows SQL queries to be written within Haskell in a typesafe and composable fashion, with clear semantics.

The project was publically released in December 2014. It is stable and actively maintained, and used in production in a number of commercial environments. Professional support is provided by Purely Agile.

Just like Haskell, Opaleye takes the principles of type safety, composability and semantics very seriously, and one aim for Opaleye is to be "the Haskell" of relational query languages.

In order to provide the best user experience and to avoid compatibility issues, Opaleye specifically targets PostgreSQL. It would be straightforward produce an adaptation of Opaleye targeting other popular SQL databases such as MySQL, SQL Server, Oracle and SQLite. Offers of collaboration on such projects would be most welcome.

Opaleye is inspired by theoretical work by David Spivak, and by practical work by the HaskellDB team. Indeed in many ways Opaleye can be seen as a spiritual successor to HaskellDB. Opaleye takes many ideas from the latter but is more flexible and has clearer semantics.

Further reading

http://hackage.haskell.org/package/opaleye

7.7.5 HLINQ - LINQ for Haskell

Report by:	Mantas Markevicius
Participants:	Mike Dodds, Jason Reich
Status:	Experimental

HLINQ is a Haskell implementation of the LINQ database query framework [1] modelled on Cheney *et al*'s T-LINQ system for F# [2]. Database queries in HLINQ are written in a syntax close to standard Haskell do notation:

```
getAge people = do
p <- people
guard ((name p) == "Edna")
return (age p)
```

```
getAge = [||do
p <- people db
guard ((name p) == "Edna")
return (age p)||]
```

Queries can be composed using Template Haskell splicing operators, while type-safety rules provide additional correctness guarantees. Additionally, HLINQ is built on the HDBC library and uses prepared SQL statements protecting it against most SQL injection type attacks. Furthermore queries are avalanche-safe, meaning that for any query only a single SQL statement will be generated. Our system is in prototype stage, but microbenchmarks show performance competitive with HaskellDB.

The project is hosted on GitHub [3], with a technical report planned soon.

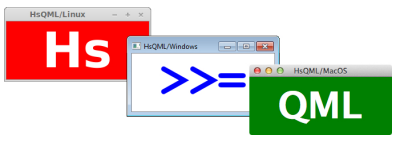
Further reading

1. Microsoft LINQ: https://msdn.microsoft.com/en-us/library/bb397926.aspx
2. Cheney, James, Sam Lindley, and Philip Wadler. "A practical theory of language-integrated query." ACM SIGPLAN Notices. Vol. 48. No. 9. ACM, 2013.
3. https://github.com/juventietis/HLINQ

7.8 User Interfaces

7.8.1 HsQML

Report by:	Robin KAY
Status:	active development



HsQML provides access to a modern graphical user interface toolkit by way of a binding to the cross-platform Qt Quick framework.

The library focuses on mechanisms for marshalling data between Haskell and Qt's domain-specific QML language. The intention is that QML, which incorporates both a declarative syntax and JavaScript code, can be used to design and animate the front-end of an application while being able to easily interface with Haskell code for functionality.

Status The latest version at time of press is `0.3.3.0`. Changes released since the previous edition of this report include support for rendering custom OpenGL graphics onto QML elements, facilities for managing object life-cycles with weak references and finalisers, and a number of bug fixes. It has been tested on the major desktop platforms: Linux, Windows, and MacOS.

Further reading

http://www.gekkou.co.uk/software/hsqml/

7.8.2 Gtk2Hs

Report by:	Daniel Wagner
Participants:	Hamish Mackenzie, Axel Simon, Duncan Coutts, Andy Stewart, and many others
Status:	beta, actively developed

Gtk2Hs is a set of Haskell bindings to many of the libraries included in the Gtk+/Gnome platform. Gtk+ is an extensive and mature multi-platform toolkit for creating graphical user interfaces.

GUIs written using Gtk2Hs use themes to resemble the native look on Windows. Gtk is the toolkit used by Gnome, one of the two major GUI toolkits on Linux. On Mac OS programs written using Gtk2Hs are run by Apple's X11 server but may also be linked against a native Aqua implementation of Gtk.

Gtk2Hs features:

- Automatic memory management (unlike some other C/C++ GUI libraries, Gtk+ provides proper support for garbage-collected languages)
- Unicode support
- High quality vector graphics using Cairo
- Extensive reference documentation
- An implementation of the "Haskell School of Expression" graphics API
- Bindings to many other libraries that build on Gtk: gio, GConf, GtkSourceView 2.0, glade, gstreamer, vte, webkit

Recent efforts include increasing the coverage of the gtk3 bindings, as well as myriad miscellaneous bugfixes. Thanks to all who contributed!

Further reading

- News and downloads: http://haskell.org/gtk2hs/
- Development version: `darcs get` http://code.haskell.org/gtk2hs/

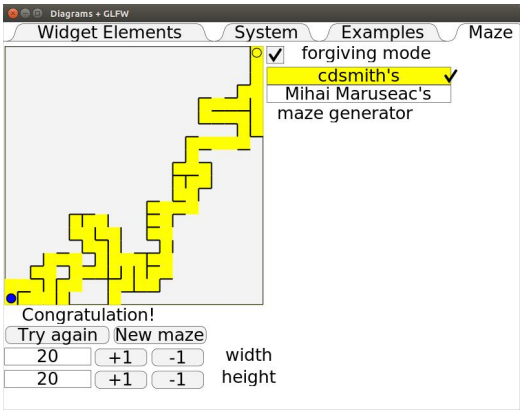
7.8.3 LGtk: Lens GUI Toolkit

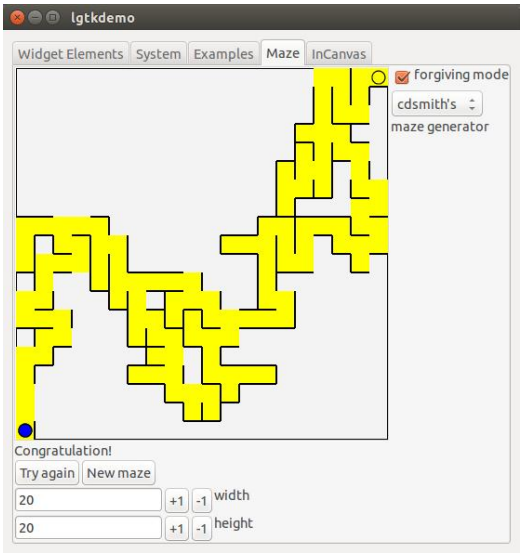
Report by:	Péter Diviánszky
Participants:	Csaba Hruska
Status:	experimental, actively developed

LGtk is a GUI Toolkit with the following goals:

- Provide a Haskell EDSL for declarative description of interactive graphical applications
- Provide an API for custom widget design
- Provide a playground for high-level declarative features like derived state-save and undo-redo operations and type-driven GUI generation

There is a demo application which presents the current features of LGtk.





Changes in lgtk-0.8 since the last official announcement:

- New features
  - New GLFW backend. One consequence is that the dependency on Gtk is not strict any more.
  - Canvas widgets rendering diagrams composed with the diagrams library. Mouse and keyboard events are also supported.
  - Widget toolkit generated with the diagrams library.
  - Slider widgets
- Architectural changes

  - Updated demo application
  - Switch from data-lens to Edward Kmett's lens library
  - Upgrade to work with GHC 8.2
  - Repository moved to GitHub
- Inner changes
  - Generalized and cleaned up interface of references
  - Cleaned up widget interface
  - More efficient reference implementation

Further reading

- haskell.org wiki page: http://www.haskell.org/haskellwiki/LGtk
- Haddock documentation on HackageDB: http://hackage.haskell.org/package/lgtk
- Wordpress blog: http://lgtk.wordpress.com/
- GitHub repository: https://github.com/divipp/lgtk

7.8.4 wxHaskell

Report by:	Henk-Jan van Tuyl
Status:	active development

The wxHaskell development is progressing, wxHaskell is adapted to the new GHC release, preperations are made to support wxWidgets 3.1. New functionality has been added and development is going on for a simpler installation procedure. For the new developments, check our GitHub repository; there will be a release in the near future. New project participants are welcome.

wxHaskell is a portable and native GUI library for Haskell. The goal of the project is to provide an industrial strength GUI library for Haskell, but without the burden of developing (and maintaining) one ourselves.

wxHaskell is therefore built on top of wxWidgets: a comprehensive C++ library that is portable across all major GUI platforms; including GTK, Windows, X11, and MacOS X. Furthermore, it is a mature library (in development since 1992) that supports a wide range of widgets with the native look-and-feel.

Further reading

http://haskell.org/haskellwiki/WxHaskell

7.8.5 threepenny-gui

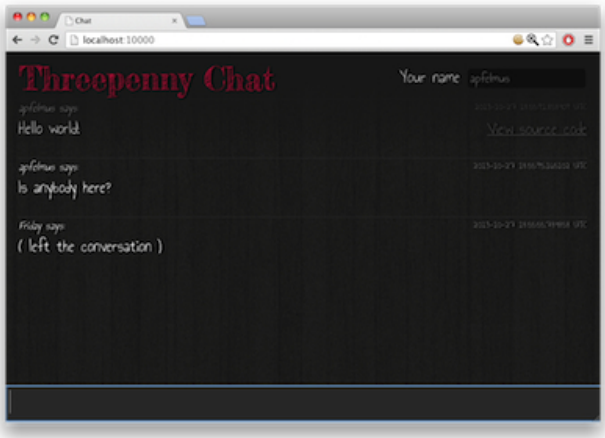
Report by:	Heinrich Apfelmus
Status:	active development

Threepenny-gui is a framework for writing graphical user interfaces (GUI) that uses the web browser as a display. Features include:

- *Easy installation.* Everyone has a reasonably modern web browser installed. Just install the library from Hackage and you are ready to go. The library is cross-platform.
- *HTML + JavaScript.* You have all capabilities of HTML at your disposal when creating user interfaces. This is a blessing, but it can also be a curse, so the library includes a few layout combinators to quickly create user interfaces without the need to deal with the mess that is CSS. A foreign function interface (FFI) allows you to execute JavaScript code in the browser.
- *Functional Reactive Programming (FRP)* promises to eliminate the spaghetti code that you usually get when using the traditional imperative style for programming user interactions. Threepenny has an FRP library built-in, but its use is completely optional. Employ FRP when it is convenient and fall back to the traditional style when you hit an impasse.

Status

The project is alive and kicking, the latest release is version `0.6.0.1`. You can download the library from Hackage and use it right away to write that cheap GUI you need for your project. Here a screenshot from the example code:



For a collection of real world applications that use the library, have a look at the gallery on the homepage.

Compared to the previous report, the communication with the web browser has been overhauled completely. Internally, Threepenny implements a HTTP server that sends JavaScript code to the web browser and receives JSON data back. However, to the library user, this is presented as a *JavaScript foreign function interface*. The module `Foreign.JavaScript` gives you the essential tools needed to manipulate JavaScript objects, call functions, and even export Haskell functions to be called from JavaScript. Moreover, the FFI also handles garbage collection. The GUI parts of the li-

brary are built on top of this FFI, but you can also use it independently if you like.

Current development

The library is still very much in flux, significant API changes are likely in future versions. The goal is to make GUI programming as simple as possible, and that just needs some experimentation.

In future versions of Threepenny, I hope to focus on making the process of designing of a GUI simpler and faster. Unfortunately, creating a GUI with HTML and CSS usually takes a significant amount of design work. My hope is that this work can be reduced by offering a default style, incorporating an existing HTML UI kit, and packaging everything in a nice set of combinators.

Further reading

- Project homepage: http://wiki.haskell.org/Threepenny-gui
- Example code: https://github.com/HeinrichApfelmus/threepenny-gui#examples
- Application gallery: http://wiki.haskell.org/Threepenny-gui#Gallery

7.8.6 reactive-banana

Report by:	Heinrich Apfelmus
Status:	active development

Reactive-banana is a library for functional reactive programming (FRP).

FRP offers an elegant and concise way to express interactive programs such as graphical user interfaces, animations, computer music or robot controllers. It promises to avoid the spaghetti code that is all too common in traditional approaches to GUI programming.

The goal of the library is to provide a solid foundation.

- Programmers interested in implementing FRP will have a *reference* for a *simple semantics* with a working implementation. The library stays close to the semantics pioneered by Conal Elliott.
- The library features an *efficient implementation*. No more spooky time leaks, predicting space & time usage should be straightforward.

The library is meant to be used in conjunction with existing libraries that are specific to your problem domain. For instance, you can hook it into any event-based GUI framework, like wxHaskell or Gtk2Hs. Several helper packages like reactive-banana-wx provide a small amount of glue code that can make life easier.

Status. The latest version of the reactive-banana library is `0.8.1.2`. The library is still in active development, but compared to the previous report, releases have mostly been aimed at ensuring compatibility with the current Haskell ecosystem.

Current development. The next version reactive-banana will finally implement garbage collection for dynamically created events and behaviors, and it will also feature some dramatic performance improvements. Judging from various user reports, it also seems that the API for dynamic event switching is too complex, in particular concerning the phantom type parameter `t`. Chances are that reactive-banana will drastically change its API in the future.

Further reading

- Project homepage: http://wiki.haskell.org/Reactive-banana
- Example code: http://wiki.haskell.org/Reactive-banana/Examples

7.8.7 fltkhs - GUI bindings to the FLTK library

Report by:	Aditya Siram
Status:	active

The `fltks` project is a set of bindings to the FLTK C++ toolkit (www.fltk.org). Coverage is fairly complete (85%) and it is easy to install and use. The main goal of this effort is to provide a low-cost, hassle-free way of creating self-contained, native GUI applications in pure Haskell that are portable to Windows, Linux and OSX.

FLTK was chosen because it is a mature toolkit and designed to be lightweight, portable and self-contained. In turn, `fltks` inherits these qualities with the additional benefit of having almost no dependencies outside of *base* and FLTK itself. This makes it very easy to get up and running with `fltks`.

`fltks` is also designed to be easy to use and learn. It tries to accomplish this by providing an API that matches the FLTK API as closely as possible so that a user can look up the pre-existing FLTK documentation for some function and in most cases be able to "guess" the corresponding Haskell function that delegates to it. Additionally `fltks` currently ships with 15 demos which are exact ports of demos shipped with the FLTK distribution so the user can study the code side-by-side. In most cases there is direct correspondence.

`fltks` is also extensible in a couple of ways. Firstly, the user can create custom GUI widgets in pure Haskell

by simply overriding some key C++ functions with Haskell functions. Secondly, it is easy to add third-party widgets without touching the core bindings. Meaning if there is a useful FLTK widget that is not part of the FLTK distribution, the user can easily wrap it and publish it as a separate package without ever touching these bindings. Hopefully this fosters contribution allowing `fltks` to keep up with the FLTK ecosystem and even outpace it since users are now able to create new widgets in pure Haskell.

Ongoing work includes not only covering 100% of the API and porting all the demos but also adding support for FLUID (http://en.wikipedia.org/wiki/FLUID), the FLTK GUI builder. Haskellers will then be able to take any existing FLTK app which uses FLUID to build the user interface and migrate it to Haskell.

Contributions are welcome!

Further reading

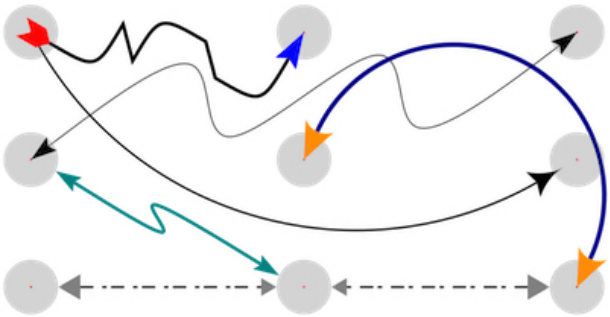
https://hackage.haskell.org/package/fltkhs

7.9 Graphics and Audio

7.9.1 diagrams

Report by:	Brent Yorgey
Participants:	Daniel Bergey, Jan Bracker, Christopher Chalmers, Daniil Frumin, Allan Gardner, Andrew Gill, Niklas Haas, John Lato, Chris Mears, Jeff Rosenbluth, Michael Sloan, Ryan Yates, Brent Yorgey
Status:	active development

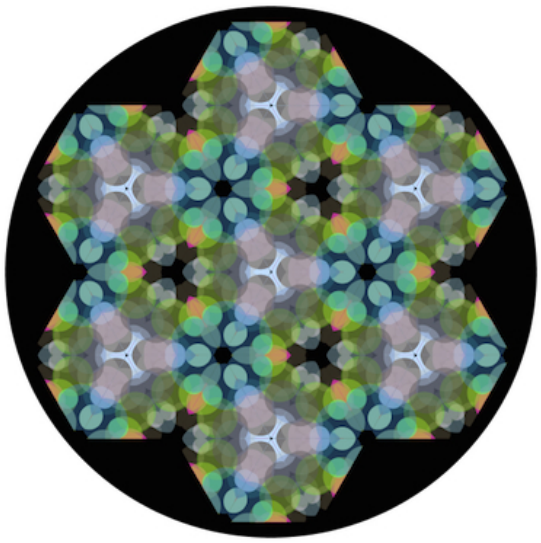
The diagrams framework provides an embedded domain-specific language for declarative drawing. The overall vision is for diagrams to become a viable alternative to DSLs like MetaPost or Asymptote, but with the advantages of being *declarative*—describing what to draw, not how to draw it—and *embedded*—putting the entire power of Haskell (and Hackage) at the service of diagram creation. There is still much more to be done, but diagrams is already quite fully-featured, with a comprehensive user manual, a large collection of primitive shapes and attributes, many different modes of composition, paths, cubic splines, images, text, arbitrary monoidal annotations, named subdiagrams, and more.



What's new

Since the last HCAR edition, diagrams 1.3 was released in April. New features include:

- Computing intersection points between paths
- Support for generalized affine maps between different vector spaces, including projections
- New backends: `diagrams-html5` generates Javascript to draw on an HTML canvas; `diagrams-pgf` generates PGF code suitable for inclusion in a TEXdocument
- Better interface for recompilation looping via the command line
- Generalized numerics: diagrams are now parameterized by a suitable numeric type, rather than having `Double` baked in
- A refactoring to use the `linear` package instead of `vector-space`

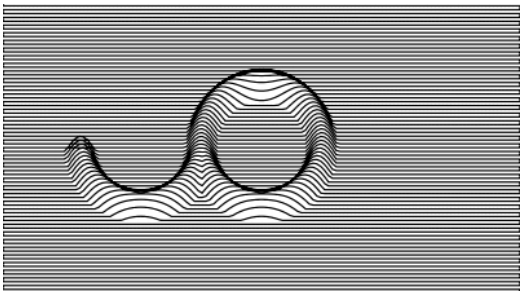


GSoC

This coming summer, Ajay Ramanathan will work under the guidance of Chris Chalmers to develop a library/API for working with a layered "Grammar of Graphics", using `diagrams` as a foundation.

Contributing

There is plenty of exciting work to be done; new contributors are welcome! Diagrams has developed an encouraging, responsive, and fun developer community, and makes for a great opportunity to learn and hack on some "real-world" Haskell code. Because of its size, generality, and enthusiastic embrace of advanced type system features, diagrams can be intimidating to would-be users and contributors; however, we are actively working on new documentation and resources to help combat this. For more information on ways to contribute and how to get started, see the Contributing page on the diagrams wiki: http://haskell.org/haskellwiki/Diagrams/Contributing, or come hang out in the `#diagrams` IRC channel on freenode.

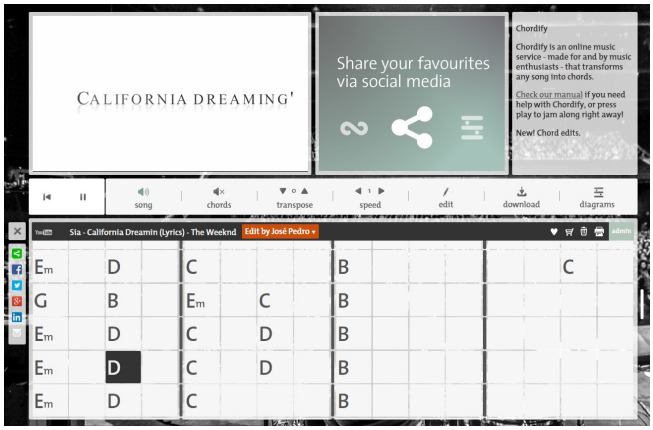


Further reading

- http://projects.haskell.org/diagrams
- http://projects.haskell.org/diagrams/gallery.html
- http://haskell.org/haskellwiki/Diagrams
- http://github.com/diagrams
- http://www.cis.upenn.edu/~byorgey/pub/monoid-pearl.pdf
- http://www.youtube.com/watch?v=X-8NCkD2vOw

7.9.2 Chordify

Report by:	José Pedro Magalhães
Participants:	W. Bas de Haas, Dion ten Heggeler, Gijs Bekenkamp, Tijmen Ruizendaal
Status:	actively developed



Chordify is a music player that extracts chords from musical sources like Youtube, Deezer, Soundcloud, or your own files, and shows you which chord to play when. The aim of Chordify is to make state-of-the-art music technology accessible to a broader audience. Our interface is designed to be simple: everyone who can hold a musical instrument should be able to use it.

Behind the scenes, we use the sonic annotator for extraction of audio features. These features consist of the downbeat positions and the tonal content of a piece of music. Next, the Haskell program HarmTrace takes these features and computes the chords. HarmTrace uses a model of Western tonal harmony to aid in the chord selection. At beat positions where the audio matches a particular chord well, this chord is used in final transcription. However, in case there is uncertainty about the sounding chords at a specific position in the song, the HarmTrace harmony model will select the correct chords based on the rules of tonal harmony.

We've recently added the ability to manually edit the chord sequences to allow our users to improve Chordify directly. We plan to use these edits to improve the algorithm itself, and to implement a system that merges edits from various users into one single corrected version.

The code for HarmTrace is available on Hackage, and we have ICFP'11 and ISMIR'12 publications describing some of the technology behind Chordify.

Further reading

http://chordify.net

7.9.3 csound-expression

Report by:	Anton Kholomiov
Status:	active, experimental

The csound-expression is a library for electronic music production. It's based on very efficient and feature rich synth Csound.

It strives to be as simple and responsive as it can be. A couple of lines of code should be enough to make something interesting. There are sensible defaults that allow the user to express the musical ideas with very short sentences.

The list of main features:

- It's easy to use. Made for artists not for algebraists.
  - Easy to use band limited oscillators.
  - There is a GUI. It's not limited to text. We can create sliders, knobs, buttons and control our synth in real-time.
  - The Csound can work with frequencies. The world of microtonal music opens up.
  - We can use the library as a sampler to create soundscapes in real-time. Check out the csound-sampler library on the Hackage.
  - Lot's of ready to use effects (resonators, filters, delays, distortions, flangers).
  - Many modern synthesis techniques are available (granular synthesis, hyper vectorial synthesis, etc).
  - There are lots of predefined instruments. Check out the csound-catalog on Hackage.
  - Good support for composition with scores.
- The Csound is very efficient
  - Unlimited polyphony
  - Almost all Csound audio units are available. It's more than 1000 audio units.
  - Csound is very portable. The output Csound file can run on android, i-devices, raspberry pi and even in the browser.
- The Csound is open
  - There is support for MIDI and OSC. Just plug and play.
  - There is support for JACK. We can use it in our DAW of choice.
  - We can run it within many other languages. There is support for reading control and audio signals from the outside world.
  - We can play sound fonts in sf2 format. With this feature we get access to thousands of free sampled instruments. Just google for free soundfonts.
- The library is very composable
  - A musical concept is just a part of the language. It's a value or a function. We can treat the musical concepts as ordinary Haskell values.
  - An audio unit is a function. It can process signals. An instrument is just a function from notes to signals.
  - There is no barrier between notes and instruments. If we apply instrument to the notes we get the signal as the output. It can become a part of another instrument.
  - Event streams and GUIs are based on FRP. User gets the stream of mouse clicks and can process it with fmap, filter it or merge with another signal.
- The library is made for real time usage
  - We can try our ideas right in the interpreter. we can load the synth into ghci, define an audio signal right in the REPL, hit enter and listen to the sound.
  - There GUIs. We can create knobs, sliders, 2D-planes, virtual midi-keyboards, buttons, etc. There a lot of predefined widgets for live performances (mixers, grids of launch buttons, racks of effects, we can create a virtual pedal boards). Check out the modules Csound.Air.Live and Csound.Air.Fx.
  - It has support for MIDI and OSC protocols. We can control it with any device we like.
  - There are many functions that made a playback of samples very easy. We have support for independent time and tempo stretching, creation of involved musical patterns, triggering of samples from the keyboard or midi devices, etc.
  - It's very efficient so it can run even on Atom processors in real-time.

Since the last report, There are many handy updates.

- There are functions for independent stretching of signal by pitch and tempo. It's a vital tool for a sampler. And it works in real-time! We can create custom samplers (module Csound.Air.Wave).
- There are functions for triggering the samples with keyboard, midi-device or an event stream (module Csound.Air.Sampler).
- There are functions for creation of step sequencers. Step sequencers are very useful in dance and techno music (module Csound.Air.Envelope).
- There are easy to use opcodes for granular synthesis. The granular synthesis is a modern technique for creation of soundscapes by reading the given audio file (or a live input signal stored in the buffer) in small portions called grains (module Csound.Air.Granular).
- The type for scores was redesigned. Many event stream functions now can trigger not a single event but a score of notes. The score type is supplied with functions that simplify the creation of musical patterns. The main type fro scores comes with the library temporal-media.
- There is a novel approach to event scheduling. We can delay or limit an audio signal with an event. We can create a sequence of audio signals that are played when something happens (like button click, or some

another signal crosses the threshold). The signal is supplied with information on how long it lasts. It's called signal segment. The duration is expressed not in in fixed amount of seconds, but in event streams. When the first event happens the signal stops. We can create many handy functions for scheduling the audio signals with event streams based on this approach (module Csound.Air.Seg).

- Easy to use functions for hyper vectorial synthesis. It makes possible to control many parameters with a couple of sliders or control signals. It interpolates between many vectors reducing the dimension of control space (module Csound.Air.Hvs).
- and many more

I've created some music with the library. You can listen to it on the soundcloud https://soundcloud.com/anton-kho. You can even run it from sources https://github.com/anton-k/csound-bits/tree/master/pieces.

The future plans for the library is to improve documentation and guide make some tutorials and papers, to make it more available to the audience of musicians and hackers.

Further reading

https://github.com/anton-k/csound-expression

7.9.4 Glome

Report by:	Jim Snow
Status:	New Version of Glome Raytracer

Glome is a ray tracer I wrote quite some time ago. The project had been dormant for about five years until a few months ago when I decided to fix some long-standing bugs and get it back into a state that compiles with recent versions of GHC. I got a little carried away, and ended up adding some major new features.

First, some background. Glome is a ray tracer, which renders 3d images by tracing rays from the camera into the scene and testing them for intersection with scene objects. Glome supports a handful of basic primitive types including planes, spheres, boxes, triangles, cones, and cylinders. It also has a number of composite primitives that modify the behavior of other primitives, such as CSG difference and intersection.

One of the more interesting composite primitives is a BIH-based accelleration structure, which sorts primitives into a hierarchy of bounding volumes. This allows for scenes with a very large number of primitives to be rendered efficiently.

Major new changes to Glome are a re-factoring of the shader code so that it is now possible to define textures in terms of user-defined types and write your own shader (though the default should be fine for most uses), a new tagging system, some changes to the front-end viewer application (which uses SDL now instead of OpenGL), and a new triangle mesh primitive type.

Tagging requires a bit of explanation. When a ray intersects with something in the scene, Glome returns a lot of information about the properties of the location where the ray hit, but until recently it didn't give much of a clue as to what exactly the ray hit. For 3D rendering applications, you don't usually care, but for many computational geometry tasks you do very much care.

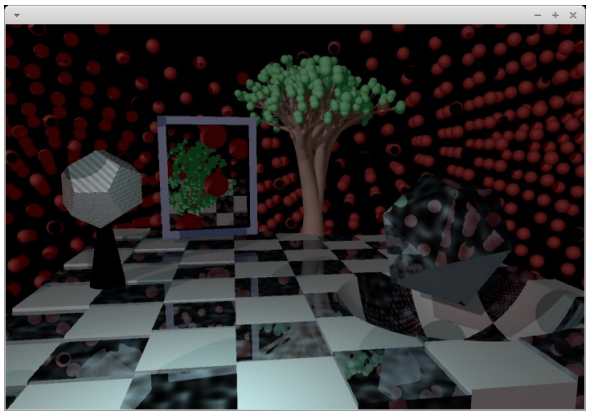
The new tagging system makes it possible to associate any 3D primitive with a tag, such that the tag is returned along with any ray intersection that hit the wrapped primitive. Tags are returned in a list, so that it's possible to have a heirarchy of tagged objects.

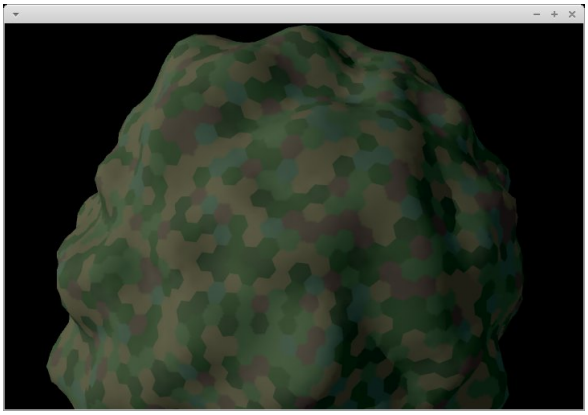
As an example of tags in action, I tagged some of the objects in Glome's default test scene, and instrumented the viewer so that clicking on the image causes a ray to be traced into the scene from the cursor's location, and then we print any tags returned by the ray intersection test. (Tags can be any type, but for illustrative purposes, the test scene uses strings.)

An interesting feature of the tagging system is that you don't necessarily have to click directly on the object to get back the tag; you could also click on the image of the object reflected off of some other shiny object in the scene.

Even though Glome is still a bit too slow for practical interactive 3D applications (I've been able to get around 2-3 FPS at 720x480 for reasonably complex scenes on a fairly fast machine), tags should at least make it easier to write interactive applications when Moore's law catches up.

Glome is split into three packages: GloveVec, a vector library, GlomeTrace, the ray-tracing engine, and GlomeView, a simple front-end viewer application. All are available on hackage or via github under a GPLv2 license.





Further reading

- https://github.com/jimsnow/glome
- http://www.haskell.org/haskellwiki/Glome

7.10 Text and Markup Languages

7.10.1 epub-tools (Command-line epub Utilities)

Report by:	Dino Morelli
Status:	stable, actively developed

A suite of command-line utilities for creating and manipulating epub book files. Included are: epubmeta, epubname, epubzip.

epubmeta is a command-line utility for examining and editing epub book metadata. With it you can export, import and edit the raw OPF Package XML document for a given book. Or simply dump the metadata to stdout for viewing in a friendly format.

epubname is a command-line utility for renaming epub ebook files based on the metadata. It tries to use author names and title info to construct a sensible name.

epubzip is a handy utility for zipping up the files that comprise an epub into an .epub zip file. Using the same technology as epubname, it can try to make a meaningful filename for the book.

This project is built on the latest epub-metadata library and so supports epub3 for the first time.

See also epub-metadata (→ 7.3.1).

epub-tools is available from Hackage and the Darcs repository below.

Further reading

- Project page: http://ui3.info/d/proj/epub-tools.html
- Source repository: `darcs get` http://ui3.info/darcs/epub-tools

7.10.2 lens-aeson

Report by:	Edward Kmett
Participants:	Paul Wilson, Benno FÃijnfstÃijck, Michael Sloan, Adrian Keet
Status:	actively developed

This package provides a suite of combinators that wrap around Bryan O'Sullivan's `aeson` library using the lens library (→ 7.1.2) to make many data access and manipulation problems much more succinctly expressable. We provide lenses, traversals, isomorphisms and prisms that conspire to make it easy to manipulate complex JSON objects.

Further reading

- http://hackage.haskell.org/package/lens-aeson
- https://www.fpcomplete.com/user/tel/lens-aeson-traversals-prisms

7.10.3 lhs2TEX

Report by:	Andres Löh
Status:	stable, maintained

This tool by Ralf Hinze and Andres Löh is a preprocessor that transforms literate Haskell or Agda code into LaTeX documents. The output is highly customizable by means of formatting directives that are interpreted by lhs2TEX. Other directives allow the selective inclusion of program fragments, so that multiple versions of a program and/or document can be produced from a common source. The input is parsed using a liberal parser that can interpret many languages with a Haskell-like syntax.

The program is stable and can take on large documents.

The current version is 1.18 and has been released in September 2012. Development repository and bug tracker are on GitHub. There are still plans for a rewrite of lhs2TEX with the goal of cleaning up the internals and making the functionality of lhs2TEX available as a library.

Further reading

- http://www.andres-loeh.de/lhs2tex
- https://github.com/kosmikus/lhs2tex

7.10.4 pulp

Report by:	Daniel Wagner
Participants:	Daniel Wagner, Michael Greenberg
Status:	Not yet released

Anybody who has used LaTeX knows that it is a fantastic tool for typesetting; but its error reporting leaves much to be desired. Even simple documents that use a handful of packages can produce hundreds of lines of

uninteresting output on a successful run. Picking out the parts that require action is a serious chore, and locating the right part of the document source to change can be tiresome when there are many files.

Pulp is a parser for LaTeX log files with a small but expressive configuration language for identifying which messages are of interest. A typical run of pulp after successfully building a document produces no output; this makes it very easy to spot when something has gone wrong. Next time you want to produce a great paper, process your log with pulp!

Features

- LaTeX log parser with special-case support for many popular packages and classes
- Expressive configuration language
  - Filter out document-specific unimportance
  - Increase verbosity as the document nears completion
- Uniform error reporting format with file and line information
- Instructions for use with latexmk
- Rudimentary Windows support

Further reading

http://github.com/dmwit/pulp

7.10.5 hyphenation

Report by:	Edward Kmett
Status:	stable

This package provides configurable Knuth-Liang hyphenation using the UTF-8 encoded hyphenation patterns for 69 languages, based on the patterns provided by the `hyph-utf8` project for LaTeX. It can be mixed with a pretty-printer to provide proper break-points within words.

Further reading

- http://hackage.haskell.org/package/hyphenation
- http://www.ctan.org/tex-archive/language/hyph-utf8

7.11 Natural Language Processing

7.11.1 NLP

Report by:	Eric Kow

The Haskell Natural Language Processing community aims to make Haskell a more useful and more popular language for NLP. The community provides a mailing list, Wiki and hosting for source code repositories via the Haskell community server.

The Haskell NLP community was founded in March 2009. The list is still growing slowly as people grow increasingly interested in both natural language processing, and in Haskell.

At the present, the mailing list is mainly used to make announcements to the Haskell NLP community. We hope that we will continue to expand the list and expand our ways of making it useful to people potentially using Haskell in the NLP world.

New packages

- *Earley-0.8.0* (Olle Fredriksson)
  This (Text.Earley) is a library consisting of two parts:

  1. **Text.Earley.Grammar**: An embedded context-free grammar (CFG) domain-specific language (DSL) with semantic action specification in applicative style.

     An example of a typical expression grammar working on an input tokenized into strings is the following:

```
expr :: Grammar r String (Prod r String String Expr)
expr = mdo
  x1 ← rule $ Add <$> x1 <* namedSymbol "+" <*> x2
     <|> x2
     <?> "sum"
  x2 ← rule $ Mul <$> x2 <* namedSymbol "*" <*> x3
     <|> x3
     <?> "product"
  x3 ← rule $ Var <$> (satisfy ident <?> "identifier")
     <|> namedSymbol "(" *> x1 <* namedSymbol ")"
  return x1
  where
    ident (x: _) = isAlpha x
    ident _ = False
```

  2. **Text.Earley.Parser**: An implementation of (a modification of) the Earley parsing algorithm.

     To invoke the parser on the above grammar, run e.g. (here using words as a stupid tokeniser):

```
fullParses $ parser expr $ words "a + b * ( c + d )"
 = ([Add (Var "a") (Mul (Var "b")
(Add (Var "c") (Var "d")))]
  , Report {...}
  )
```

     Note that we get a list of all the possible parses (though in this case there is only one).

  https://github.com/ollef/Earley

Further reading

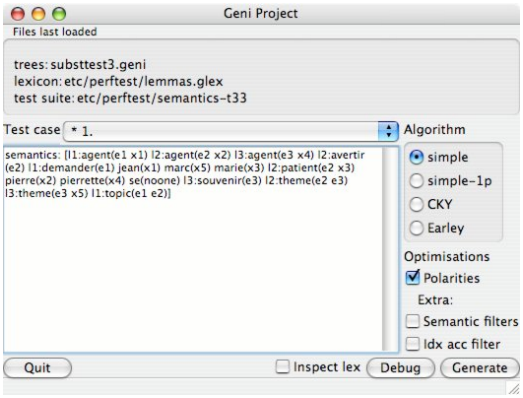
- The Haskell NLP page http://projects.haskell.org/nlp

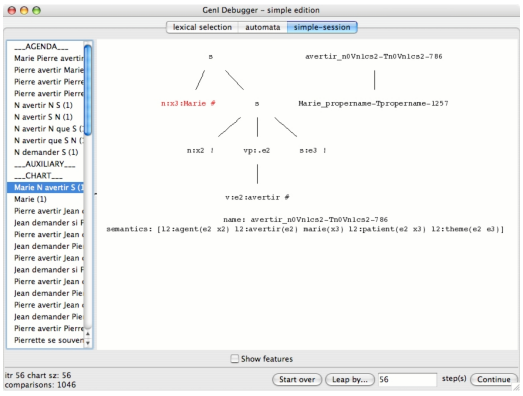
7.11.2 GenI

Report by: Eric Kow

GenI is a surface realizer for Tree Adjoining Grammars. Surface realization can be seen a subtask of natural language generation (producing natural language utterances, e.g., English texts, out of abstract inputs). GenI in particular takes a Feature Based Lexicalized Tree Adjoining Grammar and an input semantics (a conjunction of first order terms), and produces the set of sentences associated with the input semantics by the grammar. It features a surface realization library, several optimizations, batch generation mode, and a graphical debugger written in wxHaskell. It was developed within the TALARIS project and is free software licensed under the GNU GPL, with dual-licensing available for commercial purposes.

GenI is now mirrored on GitHub, with its issue tracker and wiki and homepage also hosted there. The most recent release, GenI 0.24 (2013-09-18), allows for custom semantic inputs, making it simpler to use GenI in a wider variety for applications. This has recently been joined by a companion geni-util package which offers a rudimentary geniserver client and a reporting tool for grammar debugging.





GenI is available on Hackage, and can be installed via cabal-install, along with its GUI and HTTP server user interfaces. For more information, please contact us on the geni-users mailing list.

Further reading

- http://github.com/kowey/GenI
- http://projects.haskell.org/GenI
- Paper from Haskell Workshop 2006: http://hal.inria.fr/inria-00088787/en
- http://websympa.loria.fr/wwsympa/info/geni-users

7.12 Bioinformatics

7.12.1 ADPfusion

Report by: Christian Höner zu Siederdissen
Status: usable, active development

ADPfusion provides a low-level domain-specific language (DSL) for the formulation of dynamic programs with emphasis on computational biology and linguistics. Following ideas established in Algebraic dynamic programming (ADP) a problem is separated into a grammar defining the search space and one or more algebras that score and select elements of the search space. The DSL has been designed with performance and a high level of abstraction in mind.

ADPfusion grammars are abstract over the type of terminal and syntactic symbols. Thus it is possible to use the same notation for problems over different input types. We support strings, and sets in linear and context-free languages. We will support more input types in the future. ADPfusion is extendable by the user without having to modify the core library.

As an example, consider a grammar that recognizes palindromes. Given the non-terminal p, as well as parsers for single characters c and the empty input ϵ, the production rule for palindromes can be formulated as $p \rightarrow c\ p\ c \mid \epsilon$.

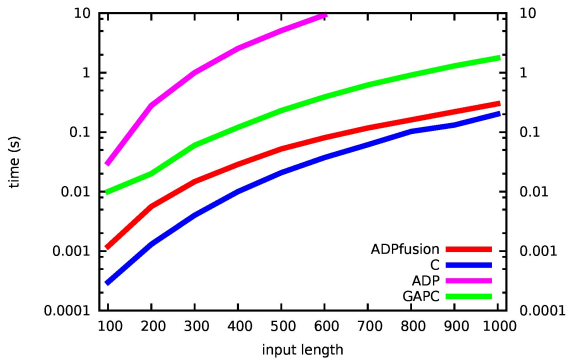
The corresponding ADPfusion code is similar:

```
p (f <<< c % p % c ||| g <<< e ... h)
```

We need a number of combinators as "glue" and additional evaluation functions f, g, and h. With $f\ c_1\ p\ c_2 = p\ \&\&\ (c_1 \equiv c_2)$ scoring a candidate, $g\ e$ = `True`, and $h\ xs$ = `or` xs determining if the current substring is palindromic.

This effectively turns the grammar into a memo-function that then yields the optimal solution via a call to `axiom p`. Backtracking for co- and sub-optimal solutions is provided as well. The backtracking machinary is derived automatically and requires the user to only provide a set of pretty-printing evaluation functions.

As of now, code written in ADPfusion achieves performance close to hand-optimized `C`, and outperforms similar approaches (Haskell-based ADP, GAPC producing `C++`) thanks to stream fusion. The figure shows running times for the *Nussinov algorithm*.



The entry on generalized Algebraic Dynamic Programming provides information on the associated high-level environment for the development of dynamic programs.

Further reading

- http://www.bioinf.uni-leipzig.de/Software/gADP
- http://hackage.haskell.org/package/ADPfusion
- http://dx.doi.org/10.1145/2364527.2364559

7.12.2 *Ab-initio* electronic structure in Haskell

Report by:	Alessio Valentini
Participants:	Felipe Zapata, Angel Alvarez
Status:	Active

We are three friends from Alcalá de Henares (Spain), two PhD students in computational chemistry from ResMol group and one sysadmin working at Alcalá University computer center. We all share the same passion in programming and after some adventures in Fortran, Bash, Python and Erlang we are now fully committed to Haskell. As PhD students working in this area, every day we face codes that are both difficult to read and improve, with no guidelines and poor documentation.

The set of problems inherent in computational chemistry are mainly due to the theoretical models complexity and the need of reducing as much as possible the computational time, leading to a demand of extremely solid and efficient software. What is happening in the actual context is the result of a poor interface between the two adjoining worlds of chemist and computer science and the necessity of publishing papers and scientific material to raise funds. This usually leads to software hastily developed by a few chemists with only a side-interest in programming and therefore a limited skill set.

The very few software that can be deemed remarkable are usually the result of massive funding, and even those packages are now facing huge problems in terms of parallelization, concurrency and stability of the code. Most of the efforts are spent trying to fix these issues instead of being addressed at developing better code (improve modularity and intelligibility) or new features and new algorithms.

We witness the proliferation of projects that serve no other purpose than to provide a bridge between different software, while the main core of molecular modeling codes, in most cases written in Fortran 77, remains untouched since the eighties.

Our first purpose in this project is to become better at Haskell programming and having fun managing a package that is every day becoming bigger. But we kind of dream of a molecular modeling software that can fully express the great upsides of functional programming. Fewer lines of code, better readability, great parallelization, embedded domain specific languages (EDSL) ... and maybe more efficiency, too !

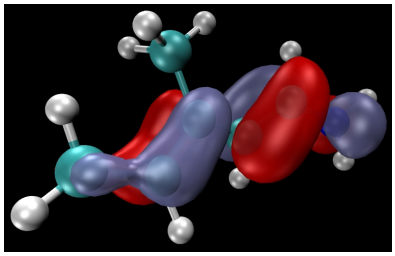
Ab-initio molecular modeling is a branch of computational chemistry that, for a set of given atoms, solves the Schrödinger equation (the analogous of Newton's equation in quantum mechanics), with no inclusion of parameters derived from experimental data. In such systems it is quite easy to calculate forces between nuclei but things get tricky when we calculate the potential energy contribution of forces related to electrons. In this case we can adopt a first approximation, the so called Hartree-Fock, that considers the electron-electron repulsion as an *average* between each electron and the mean field of all the others. This theory is right now the cornerstone of more sophisticated methods, such Multiconfigurational Methods, Møller-Plesset Perturbation Theory or Coupled Cluster, and the mathematical models behind its implementation are vastly used throughout the world of computational chemistry.

This package can calculate the Hartree Fock energy of a given molecule geometry and a basis set solving the Roothaan Hall equations through a self consistent field procedure. It uses the Harris Functional as an initial density guess and the DIIS method to greatly improve the convergence.

The entire code is written using the Repa library and focusing our efforts on efficiency, parallelism (speedups vs cores: 2,3 on 4 and 3.5 on 8) and code readability. Using Haskell's higher order abstraction we are trying to develop an EDSL appropriate for quantum mechanics problems, creating code operators able to fairly mimic the physical ones.

The code is available for download in Felipe's gitHub page.

A Hartree Fock π orbital in PSB3:



We are currently developing this code in our spare time, working on analytical gradients, on the Prisma al-

gorithm and on a solid eigenvalue problem solver. The aims of this projects are a full Haskell implementation of Multiconfigurational Methods and possibly an integration with our molecular dynamics project.

Further reading

- https://github.com/felipeZ/Haskell-abinitio.git
- http://themonadreader.files.wordpress.com/2013/03/issue214.pdf

7.12.3 Semi-Classical Molecular Dynamics in Haskell

Report by:	Alessio Valentini
Participants:	Felipe Zapata, Angel Alvarez
Status:	Active

As a first approximation, we can split the world of Molecular Dynamics into three branches: Force Fields, Classical (Semi-Classical) and Quantum Molecular Dynamics. The first approach completely ignores the description of the electrons, and the system is described by a "Balls and Springs" model leading to very cheap calculations that can be performed in big systems.

From a chemical point of view, anyway, this approach often suffers severe drawbacks, since every time an accurate description of electrons is needed (i.e. when studying the formation or breaking of bonds, reations involving excited states, or heavily polarized systems) we cannot rely on pure Classical Mechanics.

On the other side, even if the Quantum Dynamics approach is capable of describing the real quantum behavior of every single electron and nucleus, it comes with a huge increase in computational cost. It is basically unaffordable for systems with more than 5-6 atoms. That's why we need to take in consideration the Classical and Semi Classical Dynamics, where the system's forces are calculated using a Quantum method, while the geometry is updated with Classical Mechanics and some *ad-hoc formulae* to take into account quantum effects.

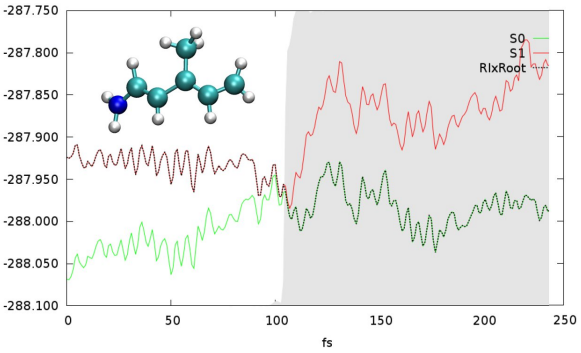
As PhD students in computational chemistry we often found ourselves in this situation: we have a chemical problem that might appear simple at first, but then it is usually quite difficult to find all the features necessary to tackle it in the same package. It is often the case where software "X" is lacking feature "Z" while software "Y" is missing feature "W".

The possible solutions to this impasse are:

1. to encode the missing features in the software of choice, a task that can reveal itself as very difficult and time consuming, since most of the time we are dealing with monolithic software written in Fortran, usually quite old and poorly maintained.

2. to write an external software (i.e. parser/launcher) capable of interact concurrently with several software, which is currently the approach employed in most cases. So much that the vast majority of computational chemists keeps a personal folder that contains just collections of parsers and scripts.

Energies vs time for a two electronic states system:



Our project takes advantage of the exceptional modularity that Haskell offers, and represents our effort to unify in a comprehensive tool all those routines that are needed in our research group to perform Classical and Semi Classical Molecular Dynamics. Our current goal is to keep a robust code and to minimize the need to use external software, limiting their application to the computation of the gradient.

Given some initial conditions and an external program (currently Molcas and Gaussian are supported) capable of calculating the energy gradient, our code is able to parse its log file and perform the whole "Semi-Classical part" of the Molecular Dynamics.

The code employs the Velocity Verlet algorithm to propagate the geometries, the Nosé Hoover thermostate for a constant temperature bath and the Tully Hammes Schiffer hopping algorithm (along with correction of Persico-Granucci) to take in consideration hops between different electronic states. It also features the possibility to add external forces to the molecule, to simulate constrained conditions that can be found, for example, in a protein binding pocket.

This is still a small project, but we are using it constantly in our research group as a flexible tool for molecular dynamics, waiting for our other project to calculate the ab-initio gradient for us.

Further reading

https://github.com/AngelitoJ/HsDynamics

7.12.4 Biohaskell

Report by:	Ketil Malde
Participants:	Christian Höner zu Siederdissen, Michal J. Gajda, Nick Ignolia, Felipe Almeida Lessa, Dan Fornika, Maik Riechert, Ashish Agarwal, Grant Rotskoff, Florian Eggenhofer, Sarah Berkemer, Niklas Hambüchen

Bioinformatics in Haskell is a steadily growing field, and the *Bio* section on Hackage now contains 69 libraries and applications. The biohaskell web site coordinates this effort, and provides documentation and related information. Anybody interested in the combination of Haskell and bioinformatics is encouraged to sign up to the mailing list (currently by emailing ⟨ketil@malde.org⟩Ketil), and to register and document their contributions on the http://biohaskell.org wiki.

In the summer of 2014, Sarah Berkemer was financed by Google's Summer of Code program to work on optimizing transalign. After a summer's work, Sarah was able to improve both space and time usage. Other new additions are parsers by Floran Eggenhofer for the NCBI Genbank format and for Clustal mulitiple sequence alignments. There is also a new library for working with EEG devices, written by Niklas Hambüchen and Patrick Chilton.

Further reading

- http://biohaskell.org
- http://blog.malde.org
- http://www.bioinf.uni-leipzig.de/~choener/haskell/
- https://bioinf.eva.mpg.de/biohazard/

7.12.5 arte-ephys: Real-time electrophysiology

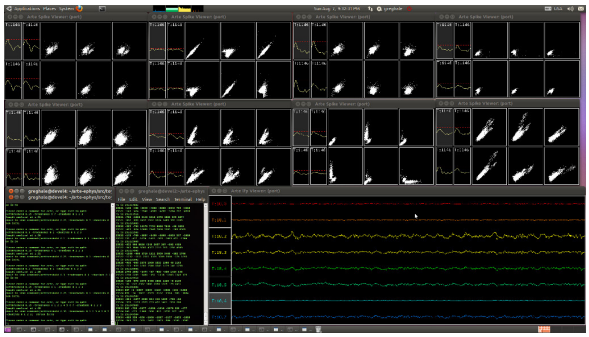
Report by:	Greg Hale
Participants:	Alex Chen
Status:	work in progress

Arte-ephys is a soft real-time neural recording system for experimental systems neuroscientists.

Our lab uses electrode arrays for brain recording in freely moving animals, to determine how these neurons build, remember, and use spatial maps.

We previously recorded and analyzed our data in two separate stages. We are now building a recording system focused on streaming instead of offline analysis, for real-time feedback experiments. For example, we found that activity in the brain of resting rats often wanders back to representations of specific parts of a recently-learned maze, and we would now like to automatically detect these events and reward the rat immediately for expressing them, to see if this influences either the speed of learning of a specific part of the maze or the nature of later spatial information coding.

We now have a proof-of-concept that streams recorded data from disk, performs the necessary preprocessing, and accurately decodes neural signals in realtime, while drawing the results with gloss. Our next goal is to integrate this into a sytem that streams raw neural data during the experiment.



Further reading

- http://github.com/ImAlsoGreg/arte-ephys
- http://github.com/ImAlsoGreg/haskell-tetrode-ephys
- http://web.mit.edu/wilsonlab/html/research.html

7.13 Embedding DSLs for Low-Level Processing

7.13.1 CλaSH

Report by:	Christiaan Baaij
Participants:	Jan Kuper, Arjan Boeijink, Rinse Wester
Status:	actively developed

The first line of the package description on hackage is:

> CλaSH (pronounced 'clash') is a functional hardware description language that borrows its syntax and semantics from the functional programming language Haskell.

In essence, however, it is a combination of:

- A Haskell library containing data types and functions for circuit design: http://hackage.haskell.org/package/clash-prelude.
- A compiler that transforms the Haskell code to low-level synthesisable VHDL or SystemVerilog: http://hackage.haskell.org/package/clash-ghc.

Of course, the compiler cannot transform arbitrary Haskell code to hardware, but only the *structural* subset of Haskell. This subset is vaguely described as the *semantic* subset of Haskell from which a *finite* structure can be inferred, and hence excludes unbounded recursion. The CλaSH compiler is thus a proper compiler (based on static analysis), and *not* an embedded Domain Specific Language (DSL) such as Kansas Lava (→ 7.13.3).

CλaSH has been in active development since 2010, and its last entry in HCAR was in 2011 http://www.haskell.org/communities/05-2011/html/report.html#sect7.5.1. Since then we have significantly improved stability, enlarged the subset of transformable Haskell, improved performance of the compiler, and added SystemVerilog generation. And, perhaps most importantly, vastly improved documentation.

CλaSH is available on hackage, for GHC version 7.10 and higher:

```
$ cabal update
$ cabal install clash-ghc
```

Development plans for CλaSH are:

- Behavioural synthesis of unbounded recursion (by Ingmar te Raa).
- Use a dependently typed internal core language, so that we can use both Haskell/GHC and Idris http://http://www.idris-lang.org/ as *front-end* language for circuit design (by Christiaan Baaij).

Further reading

http://www.clash-lang.org

7.13.2 Feldspar

Report by:	Emil Axelsson
Status:	active development

Feldspar is a domain-specific language for digital signal processing (DSP). The language is embedded in Haskell and is currently being developed by projects at Chalmers University of Technology (→ 9.6), SICS Swedish ICT AB and Ericsson AB.

The motivating application of Feldspar is telecoms processing, but the language is intended to be useful for DSP in general. The aim is to allow DSP functions to be written in pure functional style in order to raise the abstraction level of the code and to enable more high-level optimizations. The current version consists of an extensive library of numeric and array processing operations as well as a code generator producing C code for running on embedded targets.

At present, Feldspar can express the pure data-intensive numeric algorithms which are at the core of any DSP application. There is also support for the expression and compilation of parallel algorithms.

Ongoing work, presented at IFL 2014, extends Feldspar with basic input/output capabilities and adds a library to express streaming systems using a synchronous programming model. Future work involves extending and improving the system programming part of the language, and adding support for compilation to heterogeneous multi-core targets.

Further reading

- http://feldspar.github.io
- http://hackage.haskell.org/package/feldspar-language
- http://hackage.haskell.org/package/feldspar-compiler

7.13.3 Kansas Lava

Report by:	Andrew Gill
Participants:	Bowe Neuenschwander
Status:	ongoing

Kansas Lava is a Domain Specific Language (DSL) for expressing hardware descriptions of computations, and is hosted inside the language Haskell. Kansas Lava programs are descriptions of specific hardware entities, the connections between them, and other computational abstractions that can compile down to these entities. Large circuits have been successfully expressed using Kansas Lava, and Haskell's powerful abstraction mechanisms, as well as generic generative techniques, can be applied to good effect to provide descriptions of highly efficient circuits.

- The Fabric monad is now a Monad transformer. The Fabric monad historically provided access to named input/output ports, and now also provides named variables, implemented by ports that loop back on themselves. This additional primitive capability allows for a *typed* state machine monad. This design gives an elegant stratospheric pattern: purely functional circuits using streams; a monad for layout over *space*; and a monad for state generation, that acts over *time*.
- On top of the Fabric monad, we are implementing an atomic transaction layer, which provides a BSV-like interface, but in Haskell. An initial implementation has been completed, and this is being reworked to include BSV's Ephemeral History Registers.

Further reading

http://www.ittc.ku.edu/csdl/fpg/Tools/KansasLava

7.14 Games

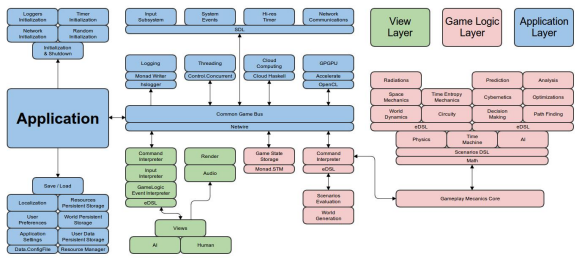
7.14.1 The *Amoeba-World* game project

Report by:	Alexander Granin
Status:	work in progress

In functional programming, there is a serious problem: there are no materials for the development of large applications. As we know, this field is well studied for imperative and object-oriented languages. There are books on design, architecture, design patterns and modeling practices. But we have no idea how this big knowledge can be adapted to functional languages.

I'm working on a game called "The Amoeba World". The goal of this project is to explore approaches to the development of large applications on Haskell. The results of my research are some articles which will be used to compose a book about functional design and architecture. Currently two articles are written out of the planned four (in Russian, but the articles will be translated to English soon). The first highlights the issue of whether the mainstream knowledge of architecture is applicable to the functional paradigm and what tools can be used for designing of architecture. It shows that the UML is ill-suited for the functional paradigm and the architecture is constructed using mind maps and concept cards. The second article talks about a low-level design of the application using the language Haskell. It has a theoretical part named *what makes a good design*, but there is also practical part describing of the some anti-patterns in Haskell. The third article is under development now. In it, the application design based on properties and scenarios is researched. The fourth article will be discussing the use of FRP.

Code of the game "The Amoeba World" should be written well to be a good example of the design concepts. These concepts are: using DSL, parsing, layering, using lenses, Inversion of Control, testing, FRP, SDL, usefulness of monads. The overall architecture of the game looks as follows:



At the moment, the game logic has been rewritten twice. The draft of game logic is ready. A special file format 'ARF' (Amoeba Raw File) for the game objects is done. Parsec is used for parsing, and a custom safe translator is written, which works on rules. Now I'm are working on a Application Layer. Settings loading is done. A primitive renderer for the game world is created. A draft game cycle and IO event handler from SDL subsystem is done by using Netwire FRP library. The next objectives are to add an interaction within the game world and then move to the execution of scenarios on game objects.

Further reading

- https://github.com/graninas/The-Amoeba-World
- http://bit.ly/ArchitectureAndDesingInFP (in Russian)

7.14.2 EtaMOO

Report by:	Rob Leslie
Status:	experimental, active development

EtaMOO is a new, experimental MOO server implementation written in Haskell. MOOs are network accessible, multi-user, programmable, interactive systems well suited to the construction of text-based adventure games, conferencing systems, and other collaborative software. The design of EtaMOO is modeled closely after LambdaMOO, perhaps the most widely used implementation of MOO to date.

Unlike LambdaMOO which is a single-threaded server, EtaMOO seeks to offer a fully multi-threaded environment, including concurrent execution of MOO tasks. To retain backward compatibility with the general MOO code expectation of single-threaded semantics, EtaMOO makes extensive use of software transactional memory (STM) to resolve possible conflicts among simultaneously running MOO tasks.

EtaMOO fully implements the MOO programming language as specified for the latest version of the LambdaMOO server, with the aim of offering drop-in compatibility. Several enhancements are also planned to be introduced over time, such as support for 64-bit MOO integers, Unicode MOO strings, and others.

While still under development, the current implementation supports loading a LambdaMOO-format database from a file, receiving client (telnet) connections from the network, and executing MOO code as a result of processing the commands received from each connection. Soon to be implemented will be the ability to save the changes made to the MOO object database back to a file, at which point the server should be largely usable.

Latest development of EtaMOO can be seen on GitHub, with periodic releases also being made available through Hackage.

Further reading

- https://github.com/verement/etamoo
- https://hackage.haskell.org/package/EtaMOO
- https://en.wikipedia.org/wiki/MOO

7.14.3 scroll

Report by:	Joey Hess
Status:	stable, complete

Scroll is a roguelike game, developed in one week as an entry in the 2015 Seven Day Roguelike Challenge.

In scroll, you're a bookworm that's stuck on a scroll. You have to dodge between words and use spells to make your way down the page as the scroll is read. Go too slow and you'll get wound up in the scroll and crushed.

This was my first experience with using Haskell for game development, and I found it quite an interesting experience, and a great crutch in such an intense coding sprint. Strong typing and purely functional code saved me from many late night mistakes, until I eventually became so exhausted that String → String seemed like a good idea. Even infinite lists found a use; one of scroll's levels features a reversed infinite stream of consciousness based on Joyce's Ulysses...

Scroll was written in continuation passing style, and this turned out to be especially useful in developing its magic system, with spells that did things ranging from creating other spells, to using a quick continuation based threading system to handle background tasks, to letting the player enter the altered reality of a dream, from which they could wake up later.

I had a great time creating a game in such a short time with Haskell, and documenting my progress in 7 blog posts, and it's been well received by players.

Further reading

http://joeyh.name/code/scroll/

7.14.4 Nomyx

Report by:	Corentin Dupont
Status:	pre-release version

Nomyx is a unique game where you can change the rules of the game itself, while playing it! In fact, changing the rules is the goal of the game. Changing a rule is considered as a move. Of course even that can be changed! The players can submit new rules or modify existing ones, thus completely changing the behaviour of the game through time. The rules are managed and interpreted by the computer. They must be written in the Nomyx language, based on Haskell. This is the first complete implementation of a Nomic game on a computer.

At the beginning, the initial rules are describing:

- How to add new rules and change existing ones. For example a unanimity vote is necessary to have a new rule accepted.
- How to win the game. For example you win the game if you have 5 rules accepted.

But of course even that can be changed!

A Beta version has been released. A match is currently on-going, join us! A lot of learning material is available, including a video, a tutorial, a FAQ, a forum and API documentation.

If you like Nomyx, you can help! There is a development mailing list (check the website). The plans now are to fix the remaining bugs and release a V1.0 in some month.

Further reading

http://www.nomyx.net

7.15 Others

7.15.1 General framework for multi-agent systems

Report by:	Nickolay Kudasov
Status:	experimental

The goal is to create a general framework for developing and testing of multi-agent systems. That includes general representation for multi-agent systems as well as library implementations for well-known agent models, distributed algorithms and communication and coordination patterns.

Notions of agent and environment are separated with the help of free monads. Agent-environment interface is defined by an underlying functor.

The basic representation of agent and environment has been chosen and tested for an agent-based distributed graph coloring problem.

The concrete implementation is being revised frequiently and thus is not very stable.

Implementations for some general distributed algorithms (ABT, DBA, etc.) will be available shortly.

Further reading

https://github.com/fizruk/free-agent

7.15.2 ersatz

Report by:	Edward Kmett
Participants:	Johan Kiviniemi, Iain Lane
Status:	stable

Ersatz is a library for generating QSAT (CNF/QBF) problems using a monad. It takes care of generating the normal form, encoding your problem, marshaling the data to an external solver, and parsing and interpreting the result into Haskell types.

What differentiates Ersatz from other SAT bindings is the use of observable sharing in the API.

This enables you to use the a much richer subset of Haskell than the purely monadic meta-language, and it becomes much easier to see that the resulting encoding is correct.

Support is offered for decoding various Haskell datatypes from the solution provided by the SAT solver.

A couple of examples are included with the distribution. Neither are as fast as a dedicated solver for their respective domains, but they showcase how you can solve real world problems involving 10s or 100s of thousands of variables and constraints.

Further reading

http://hackage.haskell.org/package/ersatz

7.15.3 leapseconds-announced

Report by:	Björn Buckwalter
Status:	stable, maintained

The leapseconds-announced library provides an easy to use static LeapSecondTable with the leap seconds announced at library release time. It is intended as a quick-and-dirty leap second solution for one-off analyses concerned only with the past and present (i.e. up until the next as of yet unannounced leap second), or for applications which can afford to be recompiled against an updated library as often as every six months.

Version 2015 of leapseconds-announced contains all leap seconds up to 2015-07-01. A new version will be uploaded if/when the IERS announces a new leap second.

Further reading

https://hackage.haskell.org/package/leapseconds-announced

7.15.4 arbtt

Report by:	Joachim Breitner
Status:	working

The program arbtt, the automatic rule-based time tracker, allows you to investigate how you spend your time, without having to manually specify what you are doing. arbtt records what windows are open and active, and provides you with a powerful rule-based language to afterwards categorize your work. And it comes with documentation!

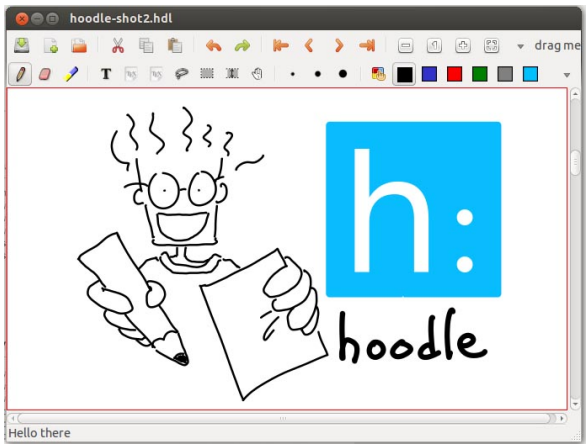
Further reading

- http://arbtt.nomeata.de/
- http://www.joachim-breitner.de/blog/archives/336-The-Automatic-Rule-Based-Time-Tracker.html
- http://arbtt.nomeata.de/doc/users_guide/

7.15.5 Hoodle

Report by:	Ian-Woo Kim
Status:	Actively Developing

Hoodle is a pen-notetaking programing written in haskell using Gtk2hs. The name Hoodle is from Haskell + doodle.



This project first started as making a haskell clone of Xournal, a notetaking program developed in C. But now Hoodle has more unique features, as well as basic pen notetaking function. Pen input is directly fed into from X11 events, which has sub-pixel level accuracy for the case of wacom tablets. Therefore, the resultant pen strokes are much smoother than other similar open-source programs such as Jarnal and Gournal.

Hoodle can be used for annotation on PDF files, and also supports importing images of PNG, JPG and SVG types, and exporting Hoodle documents to PDF. One of the most interesting features is "linking": each Hoodle document can be linked with each other by simple drag-and-drop operations. Then, the user can navigate linked Hoodle documents as we do in web browser. Another interesting feature is that one can edit a document in split views, so that a long Hoodle document can be easily edited. Hoodle can embed LaTeXtexts and the embedded text can be edited via network.

GUI programming is in general tightly tied into a GUI framework. Since most frameworks rely on callbacks for event processing, program logic is likely to be scattered in many callback functions. We cure this situation by using coroutines. In haskell, coroutine can be implemented in a straightforward way without relying on specific language feature. This abstraction enable us to reason through the program logic itself, not through an inverted logic in a GUI framework.

Hoodle is being very actively developed as an open-source project hosted on Github. The released versions are located on Hackage, and it can be installed by simple cabal install. On Linux, OS X, and Windows systems with Gtk2hs and Poppler, Hoodle can be installed without problems. Recently, it is packaged for NixOS. Making a Hoodle binary package for other linux distributions, OS X and window is planned.

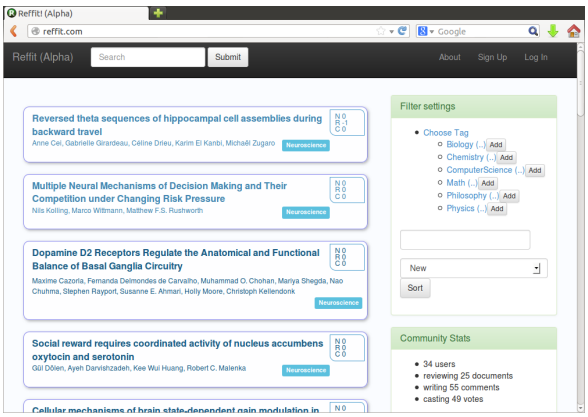
The development focus as of now is to have more flexible link features (link to arbitrary position of a document) and an internal database for document management. Hoodle manages documents with a unique UUID, but it does not have a good internal database yet. This feature can also be extended to saving Hoodle documents in cloud storage in a consistent way. Refining rendering with appropriate GPU acceleration is also planned. In the long run, we plan to support mobile platforms.

Further reading

http://ianwookim.org/hoodle

7.15.6 Reffit

Report by:	Greg Hale
Status:	work in progress



Reffit is a Snap website for collecting and organizing short comments on peer reviewed papers, blog posts, and videotaped talks. We hope to attract a community and foster a culture of open discussion of papers, with a lighthearted attitude, informality, and gamification.

Further reading

- http://reffit.com
- http://github.com/ImAlsoGreg/reffit

7.15.7 Laborantin

Report by:	Lucas DiCioccio
Status:	Working, development for new features

Conducting scientific experiments is hard. Laborantin is a DSL to run and analyze scientific experiments. Laborantin is well-suited for experiments that you can run offline such as benchmarks with many parameters.

Laborantin encourages users to express experiments parameters, experiment results, as well as execution, startup, and teardown procedures in a methodical manner. For instance, the following snippet defines a network 'ping' experiment with a destination and packet-size parameters.

```
ping = scenario "ping" $ do
  describe "ping to a remote server"
  parameter "destination" $ do
    describe "a destination server (host or ip)"
    values [str "example.com", str "dicioccio.fr"]
  parameter "packet-size" $ do
    describe "packet size in bytes"
    values [num 50, num 1500]
  run $ do
    (StringParam srv) <- param "destination"
    (NumberParam ps) <- param "packet-size"
    liftIO (execPing srv ps) >>= writeResult "ping.out"

execPing :: Text -> Rational -> IO (Text)
execPing host pktSz =
  let args = [ "-c", "10"
             , "-s" , show (round pktSz) , T.unpack host]
  in fmap T.pack (readProcess "ping" args "")
```

Laborantin also lets users express dependencies between experiments. Laborantin is designed to allow multiple backend (where to run and store experiments) and multiple frontends (how a user interacts with Laborantin). The current backend stores experiment results on the filesystem and provides a command line frontend.

Contributions are welcome. In the future, we plan to enrich Laborantin with helper modules for common tasks such as starting and collecting outputs of remote processes, reformatting results, and generating plots (e.g., with Diagrams). Laborantin would also benefit from new backends (e.g., to store results in an SQL database or HDFS) and new frontends (e.g., an integration in IHaskell).

Further reading

- Hackage page: http://hackage.haskell.org/package/laborantin-hs
- Example of web-benchmarks: https://github.com/lucasdicioccio/laborantin-bench-web

7.15.8 tempuhs

Report by:	Alexander Berntsen
Status:	pre-release

tempuhs is an ambitious effort by plaimi (→ 8.7) to chronicle time. This means recording events, and arranging them with regards to time.

The grand vision is a system capable of storing a timespan that includes The Big Bang on the scale of Planck-time, the history of the universe on the scale of milliards-of-years, your Mother's birthday on the scale of days in the Gregorian new style calendar, and your meeting scheduler on the scale of minutes. These are represented as timespans inside of a big parent timespan as of today, allowing a frontend to present this and navigate between levels of zoom that preserve precision and resolution.

In addition to having a grand vision for functionality, careful thought is placed on the design of tempuhs and how to use it. tempuhs should be completely fron-

tend agnostic and extendible. Generality is taken to its logical extreme in functionality and architecture both.

tempuhs consists of two pieces. tempuhs may refer to both of these pieces, or one in particular: the library which specifies how we represent our data. tempuhs-server is the Web server that makes tempuhs frontend agnostic by being a common API for communicating with the database. The tempuhs backbone will in the future need to deal with conversion between time units.

All of this is AGPLv3, and contributions would be very welcome. We would be happy to help you find your way around in the source code, or setting up your own frontend for tempuhs.

The technology currently used for tempuhs includes HSpec and HUnit for tests, the Scotty Web server, Persistent for dealing with databases (PostgreSQL for the production server and SQLite for the tests), wai for various things, The Glorious Glasgow Haskell Compiler (of course), and some other libraries.

Further reading

- https://secure.plaimi.net/works/tempuhs.html
- https://github.com/plaimi/tempuhs
- https://github.com/plaimi/tempuhs-server

7.15.9 tttool

Report by:	Joachim Breitner
Status:	active development

The Ravensburger Tiptoi® pen is an interactive toy for kids aged 4 to 10 that uses OiD technology to react when pointed at the objects on Ravensburger's Tiptoi books, games, puzzles and other toys. The are programmed via binary files in a proprietary, undocumented data format.

We have reverse engineered the format, and created a tool to analze these files and generate your own. This program, called tttool, is implemented in Haskell, which turned out to be a good choice: Thanks to Haskell's platform independence, we can easily serve users on Linux, Windows and OS X.

The implementation makes use of some nice Haskell idoms such as a monad that, while parsing a binary, creates a hierarchical description of it and a writer monad that uses lazyness and MonadFix to reference positions in the file "before" these are determined.

Further reading

- https://github.com/entropia/tip-toi-reveng
- http://tttool.entropia.de/ (in German)
- http://funktionale-programmierung.de/2015/04/15/monaden-reverse-engineering.html (in German)

7.15.10 Transient

Report by:	Alberto Gómez Corona
Status:	active development

Transient is a new way to manage continuations for the creation of high level effects like event handling, backtracking, indetermism, thread control. With this mechanism it is possible to create combinators that permit newcomers to Haskell to program at a higher level that was not previously possible. Transient programs look like specifications.

The impedance mismatch between specifications and programming comes from the fact that requirement descriptions manage similar concepts, but at a higher level: For example: this specification description: "the query processor will send request for each data source and filter the results according with the provided function"

A specification like this is described as a sequence of steps, as if the functionality were a single process, but really it implies many threads, synchronization, event handling, possibly undoing actions under some conditions, stopping on some condition etc.

Transient permits to write a monadic sequence that express this requirement with a one-to-one correspondence, since the effects of parallelization, event handling, thread management, and indeterminism are included and are managed automatically. a monadic or applicative expression in Transient may receive events in the middle of the sequence and may dispatch threads for these events and yet externally it is a single expression.

Transient uses a different way to produce effects: A transient statement can access the continuations that are scheduled in the sequence after himself. Therefore it can add, execute them when an event arrives or store then in state, so that other statements can make use of them later, so combinations of statements can change the execution flow.

Future work:

Transient will be the base EDSL for both MFlow and HPlayground.

Further reading

- Transient GIT repository
  https://github.com/agocorona/transient
- An EDSL for Hard-working IT programmers
  https://www.fpcomplete.com/user/agocorona/EDSL-for-hard-working-IT-programmers
- The hardworking programmer II: practical backtracking to undo actions
  https://www.fpcomplete.com/user/agocorona/the-hardworking-programmer-ii-practical-backtracking-to-undo-acti

7.15.11 gipeda

Report by:	Joachim Breitner
Status:	active development

Gipeda is a a tool that presents data from your program's benchmark suite (or any other source), with nice tables and shiny graphs. Its name is an abbreviation for "Git performance dashboard" and highlights that it is aware of git, with its DAG of commit.

The implementation builds on shake and creates static files, so that hosting a gipeda site is easily possible.

Gipeda is meant to be used for GHC development, and is just waiting for the designated site at http://perf.haskell.org to go live, but can be used independently of GHC as well.

Further reading

- https://github.com/nomeata/gipeda

7.15.12 Octohat (Stack Builders)

Report by:	Stack Builders
Participants:	Juan Carlos Paucar, Sebastian Estrella, Juan Pablo Santos
Status:	Working, well-tested minimal wrapper around GitHub's API

Octohat is a comprehensively test-covered Haskell library that wraps GitHub's API. While we have used it successfully in an open-source project to automate granting access control to servers, it is in very early development, and it only covers a small portion of GitHub's API.

Octohat is available on Hackage, and the source code can be found on GitHub.

We have already received some contributions from the community for Octohat, and we are looking forward to more contributions in the future.

Further reading

- https://github.com/stackbuilders/octohat
- Octohat announcement
- Octohat update

7.15.13 git-annex

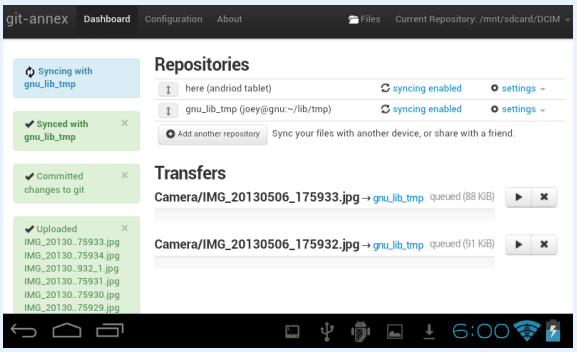
Report by:	Joey Hess
Status:	stable, actively developed

git-annex allows managing files with git, without checking the file contents into git. While that may seem paradoxical, it is useful when dealing with files larger than git can currently easily handle, whether due to limitations in memory, time, or disk space.

As well as integrating with the git command-line tools, git-annex includes a graphical app which can be used to keep a folder synchronized between computers. This is implemented as a local webapp using yesod and warp.

git-annex runs on Linux, OSX and other Unixes, and has been ported to Windows. There is also an incomplete but somewhat usable port to Android.

Five years into its development, git-annex has a wide user community. It is being used by organizations for purposes as varied as keeping remote Brazilian communities in touch and managing Neurological imaging data. It is available in a number of Linux distributions, in OSX Homebrew, and is one of the most downloaded utilities on Hackage. It was my first Haskell program.



At this point, my goals for git-annex are to continue to improve its foundations, while at the same time keeping up with the constant flood of suggestions from its user community, which range from adding support for storing files on more cloud storage platforms (around 20 are already supported), to improving its usability for new and non technically inclined users, to scaling better to support Big Data, to improving its support for creating metadata driven views of files in a git repository.

At some point I'd also like to split off any one of a half-dozen general-purpose Haskell libraries that have grown up inside the git-annex source tree.

Further reading

http://git-annex.branchable.com/

7.15.14 openssh-github-keys (Stack Builders)

Report by:	Stack Builders
Participants:	Justin Leitgeb
Status:	A library to automatically manage SSH access to servers using GitHub teams

It is common to control access to a Linux server by changing public keys listed in the `authorized_keys` file. Instead of modifying this file to grant and revoke access, a relatively new feature of OpenSSH allows the accepted public keys to be pulled from standard output of a command.

This package acts as a bridge between the OpenSSH daemon and GitHub so that you can manage access to servers by simply changing a GitHub Team, instead of manually modifying the `authorized_keys` file. This package uses the Octohat wrapper library for the GitHub API which we recently released.

openssh-github-keys is still experimental, but we are using it on a couple of internal servers for testing purposes. It is available on Hackage and contributions and bug reports are welcome in the GitHub repository.

While we don't have immediate plans to put openssh-github-keys into heavier production use, we are interested in seeing if community members and system administrators find it useful for managing server access.

Further reading

https://github.com/stackbuilders/openssh-github-keys

7.15.15 propellor

Report by:	Joey Hess
Status:	actively developed

Propellor is a configuration management system for Linux that is configured using Haskell. It fills a similar role as Puppet, Chef, or Ansible, but using Haskell instead of the ad-hoc configuration language typical of such software. Propellor is somewhat inspired by the functional configuration management of NixOS.

A simple configuration of a web server in Propellor looks like this:

```
webServer :: Host
webServer = host "webserver.example.com"
  & ipv4 "93.184.216.34"
  & staticSiteDeployedTo "/var/www"
    `requires` Apt.serviceInstalledRunning "apache2"
    `onChange` Apache.reloaded

staticSiteDeployedTo :: FilePath → Property NoInfo
```

There have been many benefits to using Haskell for configuring and building Propellor, but the most striking are the many ways that the type system can be used to help ensure that Propellor deploys correct and consistent systems. Beyond typical static type benefits, GADTs and type families have proven useful. For details, see http://propellor.branchable.com/posts/

An eventual goal is for Propellor to use type level programming to detect at compile time when a host has eg, multiple servers configured that would fight over the same port. Moving system administration toward using types to prove correctness properties of the system.

Another exciting possibility is using Propellor to not only configure existing Linux systems, but to manage their entire installation process. This has already been prototyped in a surprisingly small amount of added code (under 200 lines), which can replace arbitrary Linux systems with clean re-installs described entirely by Propellor's config.hs.

Further reading

http://propellor.branchable.com/

7.15.16 dimensional: Statically Checked Physical Dimensions

Report by:	Björn Buckwalter
Participants:	Douglas McClean
Status:	active

Dimensional is a library providing data types for performing arithmetics with physical quantities and units. Information about the physical dimensions of the quantities/units is embedded in their types, and the validity of operations is verified by the type checker at compile time. The boxing and unboxing of numerical values as quantities is done by multiplication and division with units. The library is designed to, as far as is practical, enforce/encourage best practices of unit usage within the frame of the SI. Example:

```
d :: Fractional a ⇒ Time a → Length a
d t = a / _2 ∗ t ^ pos2
  where a = 9.82 ∗~ (meter / second ^ pos2)
```

The dimensional library currently has three incarnations:

- dimensional – The "classic" dimensional library released in 2006 is based on multi-parameter type classes and functional dependencies. It is stable with units being added on an as-needed basis. The primary documentation is the literate Haskell source code.
- dimensional-tf – In January 2012 a port of dimensional using type families was released.
- dimensional-dk – Recent activities have been focused around a port of dimensional using the data kinds and closed type families introduced in GHC 7.8. dimensional-dk improves upon classic dimensional and dimensional-tf in virtually every way (including

proper Haddock documentation!) with only minimal impact to the API.

Further reading

- http://dimensional.googlecode.com
- https://github.com/bjornbm/dimensional-dk

8 Commercial Users

8.1 Well-Typed LLP

Report by:	Andres Löh
Participants:	Duncan Coutts

Well-Typed is a Haskell services company. We provide commercial support for Haskell as a development platform, including consulting services, training, and bespoke software development. For more information, please take a look at our website or drop us an e-mail at ⟨info@well-typed.com⟩.

We are working for a variety of commercial clients, but naturally, only some of our projects are publicly visible.

Austin has been working hard to help get GHC-7.8 released.

On behalf of the Industrial Haskell Group (IHG) (→ 8.4), we are currently working on tasks related to Hackage 2 and Cabal.

We continue to be involved in the community, maintaining several packages on Hackage and giving talks at a number of conferences. Some of our recent projects are available online, such as for example Edsko's `ghc-events-analyze` tool, or Adam's talk about overloaded record fields in Haskell (links below).

We are continuing to offer training services. We offer regular courses in London (the next course dates are in July and in October), and on-demand on-site training courses elsewhere as well.

We are of course always looking for new clients and projects, so if you have something we could help you with, just drop us an e-mail.

Further reading

- Company page: http://www.well-typed.com
- Blog: http://blog.well-typed.com/
- Training page: http://www.well-typed.com/services_training
- Skills Matter Haskell course overview: https://skillsmatter.com/explore?content=courses&location=&q=Haskell
- `ghc-events-analyze`: http://www.well-typed.com/blog/86/
- Adam's records talk: http://www.well-typed.com/blog/93/

8.2 Bluespec Tools for Design of Complex Chips and Hardware Accelerators

Report by:	Rishiyur Nikhil
Status:	Commercial product; free for academia

Bluespec, Inc. provides an industrial-strength language (BSV) and tools for high-level hardware design. Components designed with these are shipping in some commercial smartphones and tablets today.

BSV is used for all aspects of ASIC and FPGA design — specification, synthesis, modeling, and verification. Digital circuits are *described* using a notation with Haskell semantics, including algebraic types, polymorphism, type classes, higher-order functions and monadic elaboration. Strong static checking is also used to support discipline for multiple clock-domains and gated clocks. The dynamic semantics of a such circuits are described using Term Rewriting Systems (which are essentially atomic state transitions). BSV is applicable to all kinds of hardware systems, from algorithmic "datapath" blocks to complex control blocks such as processors, DMAs, interconnects, and caches, and to complete SoCs (Systems on a Chip).

Perhaps uniquely among hardware-design languages, BSV's rewrite rules enable design-by-refinement, where an initial executable approximate design is systematically transformed into a quality implementation by successively adding functionality and architectural detail.

Before synthesizing to hardare, a circuit description can be executed and debugged in *Bluesim*, a fast simulation tool. Then, the *bsc* tool compiles BSV into high-quality Verilog, which is then further synthesized into netlists for ASICs and FPGAs using standard synthesis tools. There are extensive libraries and infrastructure components to make it easy to build FPGA-based accelerators for compute-intensive software.

Bluespec also provides implementations and development environments for CPUs based on the U.C. Berkeley RISC-V instruction set (www.riscv.org).

Status and availability

BSV tools have been available since 2004, both commercially and free for academic teaching and research. It is used in a several leading universities (incl. MIT, U.Cambridge, and IIT Chennai) for computer architecture research.

Further reading

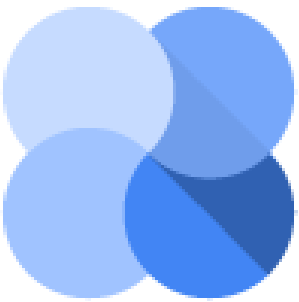
- *Types, Functional Programming and Atomic Transactions in Hardware Design*, R.S. Nikhil, in *In Search of Elegance in the Theory and Practice of Computation, Essays dedicated to Peter Buneman (Festschrift), Springer-Verlag Lecture Notes in Computer Science, LNCS 8000*, pp.418-431, 2013.
- *Abstraction in Hardware System Design*, R.S. Nikhil, in *Communications of the ACM*, 54:10, October 2011, pp. 36-44.
- *BSV by Example*, R.S. Nikhil and K. Czeck, 2010, book available on Amazon.com (or free PDF from Bluespec, Inc.)
- http://bluespec.com/SmallExamples/index.html: from *BSV by Example*.
- http://www.cl.cam.ac.uk/~swm11/examples/bluespec/: Simon Moore's BSV examples (U. Cambridge).
- http://csg.csail.mit.edu/6.375: *Complex Digital Systems*, MIT courseware.

8.3 Haskell in the industry in Munich

Report by: Haskell Consultancy Munich

Haskell is used by several companies specializing in the development of reliable software and hardware, for example for the automotive industry in Munich. It is also in use by the developers of medical software which needs assure the integrity of data processing algorithms. It is also used by new media and internet companies. You may contact the author of this report (⟨haskell.consultancy@gmail.com⟩) for details.

Haskell at Google Munich



Google is using Haskell in Ganeti (http://code.google.com/p/ganeti/), a tool for managing clusters of virtual servers built on top of Xen and KVM. There is a mailing list (http://groups.google.com/group/ganeti) which is the official contact to the team.

There are lots of presentations about Ganeti online (http://downloads.ganeti.org/presentations/), and some of them are accompanied by videos to be found with a quick search on the internet.

Energy Flow Analysis – Ingenieurbüro Guttenberg & Hördegen

The Engineering Office provides services and tools to companies designing and operating smart systems with energy management: Smart Grids, Smart Houses, Smart Production, and so on. Smart systems are complex: efficiency is only one aspect in a challenging system design. We want to make measurement and optimisation of overall system efficiency as comfortable and easy as possible. The objective is to provide support in choosing between system functionality, performance, safety, and reliability as well as energy efficiency. We provide a support service for the whole development chain, starting with specification, through system design and simulation to system implementation and validation. The advantage of our approach is that we can directly model, investigate and optimise energy flow. This opens new possibilities, such as better optimisation of efficiency, operation, and design for local grids containing electrochemical storage, thermal storage, heat pumps, block heat and power units and so on.

Since it combines good performance and parallelization features while providing a very high level of assurance, we have chosen to execute our technology with Haskell.

For more information, please visit http://www.energiefluss.info. There is an introductory document to the services provided (http://energiefluss.info/img/profile_gh.pdf).

Informatik Consulting Systems AG

ICS AG (http://ics-ag.de), with 11 offices in Germany, use Haskell for their software, as it is a good fit for their domain, which is simulation, safety, and business-critical systems. It affords ICS a competitive edge over the market. Industries ICS work with include advanced technologies, automotive, industrial solutions, and transportation and they have an impressive list of customers (http://ics-ag.de/kunden.html).

Haskell Consultancy Munich

The author of this report runs a Haskell consultancy. Established in 2008, the business provides full-stack

support for industries ranging from finance and media to medical and electronics design and automation, with a permanent focus on functional programming. We have a strong background in statistics and operations research. The current trend in the industry is the migration of monolithic legacy software in C, C#, Python, Java, or PHP towards a functional, service-oriented architecture, with on-site training of personnel in the new programming paradigm. Another trend is design of hard realtime applications for industrial use. Further information can be requested via email (⟨haskell.consultancy@gmail.com⟩).

Funktionale Programmierung – Dr. Heinrich Hördegen

Funktionale Programmierung - Dr. Heinrich Hördegen (http://funktional.info) is a Haskell and functional programming software consultancy located in Munich.

Dr. Hördegen has a lot of experience in software engineering and has been an advocate of functional programming since 2005. It follows that during his doctoral thesis at the LORIA (http://www.loria.fr) he was able to design and implement compiler modules for the AVISPA project (http://www.avispa-project.org/) using OCaml.

Dr. Hördegen has been using Haskell as his main technology to implement robust and reliable software since 2009. In his role co-founder and CTO of Ingenieurbüro Guttenberg & Hördegen (http://www.energiefluss.info) he leads the development of proprietary software for energy flow analysis. This complex system is comprised of 50000 lines of code, distributed into 130 modules.

Some of Dr. Hördegen's favourite things about Haskell are algebraic data types, which simplify symbolic computation, the amazing speed Haskell can provide during number crunching, the powerful parallelization capabilities Haskell provides, and finally Cloud Haskell, which lets you easily distribute computations onto whole clusters.

Dr. Hördegen's consultancy sponsors and organizes the Haskell Meetup (http://www.haskell-munich.de/) and supports the Haskell community as a whole.

codecentric AG

Here at codecentric (https://www.codecentric.de/), we believe that more than ever it's important to keep our tools sharp in order to provide real value to our customers. The best way to do this is to provide software expertise and an environment in which people can freely express their ideas and develop their skills. One of the results is codecentric Data Lab, where mathematicians, data scientists and software developers join forces to live up to the big data hype. Another is the Functional Institute (http://clojureworkshop.com/), which helps to spread the word about functional programming with Clojure and Haskell.

We provide services in functional programming in Clojure and Haskell as well as services for Big Data projects, ranging from project support and knowledge sharing to bespoke software development and project management. We are over 200 employees strong in 10 offices around Germany and Europe. You may contact Alex Petrov (⟨alex.petrov@codecentric.de⟩) with any enquiries.

8.4 Industrial Haskell Group

Report by: Andres Löh

The Industrial Haskell Group (IHG) is an organization to support the needs of commercial users of Haskell.

The main activity of the IHG is to fund work on the Haskell development platform. It currently operates two schemes:

- The collaborative development scheme pools resources from full members in order to fund specific development projects to their mutual benefit.
- Associate and academic members contribute to a separate fund which is used for maintenance and development work that benefits the members and community in general.

Projects the IHG has funded in the past years include work on Hackage 2, Cabal and cabal-install, and GHC itself.

Details of the tasks undertaken by the IHG are appearing on the Well-Typed (→ 8.1) blog, on the IHG status page and on standard communication channels such as the Haskell mailing list.

In the past six months, three new associate members have joined the IHG: Jon Kristensen, alephcloud and OTAS Technologies.

The collaborative development scheme is running continuously, so if you are interested in joining as a member, please get in touch. Details of the different membership options (full, associate, or academic) can be found on the website.

We are very interested in new members.

If you are interested in joining the IHG, or if you just have any questions or comments, please drop us an e-mail at ⟨info@industry.haskell.org⟩.

Further reading

- http://industry.haskell.org/
- http://industry.haskell.org/status/

8.5 Better

Report by: Carl Baatz

Better provides a platform for delivering adaptive online training to students and employees.

Companies and universities work with us to develop courses which are capable of adapting to individual learners. This adaptivity is based on evidence we collect about the learner's understanding of the course material (primarily by means of frequent light-weight assessments). These courses run on our platform, which exposes a (mobile-compatible) web interface to learners. The platform also generates course statistics so that managers/teachers can monitor the progress of the class taking the course and evaluate its effectiveness.

The backend is entirely written in Haskell. We use the `snap` web framework and we have a storage layer written on top of `postgres-simple` which abstracts data retrieval, modification, and versioning. The choice of language has worked out well for us: as well as the joy of writing Haskell for a living, we get straightforward deployment and extensive server monitoring courtesy of `ekg`. Using GHC's profiling capabilities, we have also managed to squeeze some impressive performance out of our deployment.

The application-specific logic is all written in Haskell, as is *most* of the view layer. As much rendering as possible is performed on the backend using `blaze-html`, and the results are sent to a fairly thin single-page web application written in Typescript (which, while not perfect, brings some invaluable static analysis to our front-end codebase).

The company is based in Zurich, and the majority of the engineering team are Haskellers. We enjoy a high level of involvement with the Zurich Haskell community and are delighted to be able to host the monthly HaskellerZ user group meetups and the yearly ZuriHac hackathon.

8.6 Keera Studios LTD

Report by: Ivan Perez

Keera Studios Ltd. is a game development studio currently working on Android games using Haskell. We have published the first commercial game for Android written in Haskell, now available on Google Play™ (https://goo.gl/cM1tD8).

We have also shown a breakout-like game running on a Android tablet (http://goo.gl/53pK2x), using *hardware acceleration* and *parallelism*. The desktop version of this game additionally supports Nintendo Wiimotes and Kinect. This proves that Haskell truly is viable option for *professional game development*, both for mobile and for desktop.

We have developed GALE, a DSL for graphic adventures, together with an engine and a basic IDE that allows non-programmers to create their own 2D graphic adventure games without any knowledge of programming. Supported features include multiple character states and animations, multiple scenes and layers, movement bitmasks (used for shortest-path calculation), luggage, conversations, sound effects, background music, and a customizable UI. The IDE takes care of asset management, generating a fully portable game with all the necessary files. The engine is multiplatform, working *seamlessly* on Linux, Windows and Android. We are currently beta-testing GALE games on Google Play.

We have released Keera Hails, the *reactive* library we use for desktop GUI applications, as Open Source (http://git.io/vTvXg). Keera Hails is being *actively developed* and provides integration with Gtk+, network sockets, files, FRP Yampa signal functions and other external resources. Keera Hails also addresses common problems in Model-View-Controller, providing an application skeleton with a scalable architecture and thread-safe access to the application's internal model. Accompanying libraries provide standarised solutions for common features such as configuation files and internationalisation. We have used this framework in commercial applications (including but not limited to GALE IDE), and in the Open-Source posture monitor Keera Posture (http://git.io/vTvXy).

We are committed to using Haskell for all our operations. For games we often opt for the Arrowized Functional Reactive Programming Domain-Specific Language Yampa (http://git.io/vTvxQ) or for Keera GALE. For desktop GUI applications we use our own Keera Hails (http://git.io/vTvXg). To create web applications and internal support tools we use Yesod, and have recently put in production a project management, issue tracking and invoicing web application to facilitate communication with our clients.

For more information, please contact us at . Screenshots, videos and other details are published regularly on our Facebook page (https://www.facebook.com/keerastudios). and on our website (http://www.keera.co.uk).

8.7 plaimi

Report by: Alexander Berntsen

plaimi are an omnium-gatherum of free software researchers and hackers from Norway.

Haskell is the primary language used at plaimi. We use it for all our currently active development projects. Our development computers and servers all use Gentoo Linux, and consequently Gentoo-Haskell. We contribute back to the Haskell and Gentoo ecosystems, and have upstream patches for many of the libraries and tools that we use. One of the researchers at plaimi is on the Gentoo development team, and has contributed to both Gentoo-Haskell and the package manager it uses, Portage.

Our website is https://secure.plaimi.net/. Contact information may be obtained there. We are currently looking for work. Do you have any? Get in touch! WeâĂŹd also love to hear from anyone that has questions, ideas or patches for our projects.

8.8 Stack Builders

Report by: Stack Builders
Status: software consultancy

Stack Builders is an international Haskell and Ruby agile software consultancy with offices in New York, United States, and Quito, Ecuador.

In addition to our Haskell software consultancy services, we are actively involved with the Haskell community:

- We organize Quito Lambda, a monthly meetup about functional programming in Quito, Ecuador.
- We maintain several packages in Hackage including hapistrano, inflections, octohat, openssh-github-keys, and twitter-feed.
- We talk about Haskell at universities and events such as Lambda Days and BarCamp Rochester.
- We write blog posts and tutorials about Haskell.

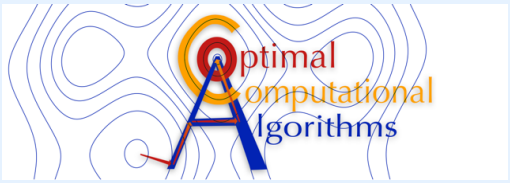
For more information, take a look at our website or get in touch with us at info@stackbuilders.com.

Further reading

http://www.stackbuilders.com/

8.9 Optimal Computational Algorithms, Inc.

Report by: Christopher Anand



OCA develops high-performance, high-assurance mathematical software using Coconut (COde CONstructing User Tool), a hierarchy of DSLs embedded in Haskell, which were originally developed at McMaster University. The DSLs encode declarative assembly language, symbolic linear algebra, and algebraic transformations. Accompanying tools include interpreters, simulators, instruction schedulers, code transformers (both rule-based and ad-hoc) and graph and schedule visualizers.

To date, Coconut math function libraries have been developed for five commercial architectures. Taking advantage of Cocont's symbolic code generation, software for reconstructing multi-coil Magnetic Resonance Images was generated from a high-level mathematical specification. The implementation makes full use of dual-CPUs, multiple cores and SIMD parallelism, and is licensed to a multi-national company. The specification is transformed using rules for symbolic differentiation, algebraic simplification and parallelization. The soundness of the generated parallelization can be verified in linear time (measured with respect to program size).

Further reading

- http://www.cas.mcmaster.ca/~kahl/Publications/TR/Anand-Kahl-2007a_DSL/
- http://www.cas.mcmaster.ca/~anand/papers/AnandKahlThaller2006.pdf
- http://www.cas.mcmaster.ca/sqrl/papers/SQRLreport50.pdf
- https://macsphere.mcmaster.ca/handle/11375/10755
- http://www.cas.mcmaster.ca/~anand/papers/CAS-14-05-CA.pdf

9 Research and User Groups

9.1 Haskell at Eötvös Loránd University (ELTE), Budapest

Report by:	PÁLI Gábor János
Status:	ongoing

Education

We are again glad to report that there are many different courses on Haskell at Eötvös Loránd University, Faculty of Informatics. Currently, we are offering the following courses in that regard:

- Functional programming for first-year Hungarian undergraduates in Software Technology and second-year Hungarian teacher of informatics students, both as part of their official curriculum.
- An additional semester on functional programming with Haskell, where many of the advanced concepts are featured. This is an optional course for Hungarian undergraduate and master's students, supported by the Eötvös József Collegium.
- Advanced functional programming for Hungarian and foreign-language master's students in Software Technology, supported by the fund TÁMOP-4.1.2.A/1-11/1-2011-0052. The curriculum features discussion of parallel and concurrent programming, property-based testing, purely functional data structures, efficient I/O implementations, embedded domain-specific languages, and reactive programming.

In addition to these, there is also a Haskell-related course, Type Systems of Programming Languages, taught for Hungarian master's students in Software Technology. This course gives a more formal introduction to the basics and mechanics of type systems applied in many statically-typed functional languages.

For teaching some of the courses mentioned above, we have been using an interactive online evaluation and testing system, called ActiveHs. It contains several dozens of systematized exercises, and through that, some of our course materials are available there in English as well.

Besides teaching Haskell, some effort has been made to restart our introductory course on Agda with an English-language tutorial. It is based on the works of PÃľter DiviÃąnszky and Ambrus Kaposi from the previous years, and the chapters for the first semester has been reviewed and improved by GÃąbor. Matthias Troffaes has moved PÃľter's original darcs repository to GitHub for more visibility. Note that the changes made to the lectures notes used at the course has not yet been merged into the git repository, but it will done soon as time permits. We are hoping that our tutorial may be of use for other universities.

Our homebrew online assignment management system, "BE-AD" keeps working on for the third semester starting from this February. The BE-AD system is implemented almost entirely in Haskell, based on the Snap web framework and Bootstrap. Its goal to help the lecturers with scheduling course assignments and tests, and it can automatically check the submitted solutions as an option. It currently has over 1,100 users and it provides support for 14 courses at the department, including all the Haskell and Agda ones. This is still in an alpha status yet so it is not available on Hackage as of yet, only on GitHub, but so far it has been performing well, especially in combination with ActiveHs.

GÃąbor also regularly advises bachelor's and master's theses in Haskell, sometimes in cooperation with Csaba Hruska and PÃľter DiviÃąnszky, the developers of LambdaCube 3D, on related topics.

Further reading

- Haskell course materials (in English): http://pnyf.inf.elte.hu/fp/Index_en.xml
- Agda tutorial (in English): http://people.inf.elte.hu/pgj/agda/tutorial/
- ActiveHs: http://hackage.haskell.org/package/activehs
- BE-AD: http://github.com/andorp/bead

9.2 Artificial Intelligence and Software Technology at Goethe-University Frankfurt

Report by:	David Sabel
Participants:	Manfred Schmidt-Schauß

Semantics of Functional Programming Languages. Extended call-by-need lambda calculi model the semantics of Haskell. In our research we analyze the semantics of those calculi with a special focus on the correctness of program analyses and program transformations. Our results include the correctness of strictness analysis by abstract reduction, results on the equivalence of the call-by-name and call-by-need semantics, correctness of program transformations w.r.t. contextual equivalence, and investigations on the conservativity of language extensions. Recently, we analyzed a polymorphically typed core language

of Haskell which uses System F-polymorphism, and we analyzed the question whether program transformations are optimizations, i.e. whether they improve the time resource behavior. We showed that common subexpression elimination is indeed an improvement (which seems to be obvious, but its proof was an open problem for several years). We also showed that our notion of improvement is (asymptotically) resource equivalent to the improvement theory developed by Moran & Sands in an untyped setting.

We also established theoretical results like completeness of applicative bisimilarity w.r.t. contextual equivalence, and unsoundness of applicative bisimilarity in nondeterministic languages with `letrec`.

We also use Haskell to develop automated tools to show correctness of program transformations, where the method is syntax-oriented and computes so-called forking and commuting diagrams by a combination of several unification algorithms. Also automated termination provers for term rewrite systems are used in a part of the automation. Future research goals are to automate correctness proofs of program translations as they appear in compilers.

Concurrency. We analyzed a higher-order functional language with concurrent threads, monadic IO, MVars and concurrent futures which models Concurrent Haskell. We proved correctness of program transformations, correctness of an abstract machine, and we proved that this language conservatively extends the purely functional core of Haskell. In a similar program calculus we proved correctness of a highly concurrent implementation of Software Transactional Memory (STM) and developed an alternative implementation of STM Haskell which performs quite early conflict detection.

Grammar based compression. This research topic focuses on algorithms on grammar compressed data like strings, matrices, and terms. Our goal is to reconstruct known algorithms on uncompressed data for their use on grammars without prior decompression. We implemented several of those algorithms as a Haskell library including efficient algorithms for fully compressed pattern matching.

Further reading

http://www.ki.informatik.uni-frankfurt.de/research/HCAR.html

9.3 Functional Programming at the University of Kent

Report by: Olaf Chitil

The Functional Programming group at Kent is a subgroup of the Programming Languages and Systems Group of the School of Computing. We are a group of staff and students with shared interests in functional programming. While our work is not limited to Haskell, we use for example also Erlang and ML, Haskell provides a major focus and common language for teaching and research.

Our members pursue a variety of Haskell-related projects, several of which are reported in other sections of this report. Three new PhD students joined the group last September. Stephen Adams is working on advanced refactoring of Haskell programs. Andreas Reuleaux is working on refactoring dependently typed functional programs. Maarten Faddegon is working on making tracing for Haskell practical and easy to use. In June he will talk at PLDI 2015 about "Algorithmic Debugging of Real-World Haskell Programs: Deriving Dependencies from the Cost Centre Stack". Olaf Chitil is working on tracing, including the further development of the Haskell tracer Hat, and on type error debugging. Scott Owens is working on verified compilers for the (strict) functional language CakeML. Currently Colin Runciman from the University of York is visiting the PLAS group during his study leave.

We are always looking for more PhD students. We are particularly keen to recruit students interested in programming tools for verification, tracing, refactoring, type checking and any useful feedback for a programmer. The school and university have support for strong candidates: more details at http://www.cs.kent.ac.uk/pg or contact any of us individually by email.

We are also keen to attract researchers to Kent to work with us. There are many opportunities for research funding that could be taken up at Kent, as shown in the website http://www.kent.ac.uk/researchservices/sciences/fellowships/index.html. Please let us know if you're interested in applying for one of these, and we'll be happy to work with you on this.

Finally, if you would like to visit Kent, either to give a seminar if you're passing through London or the UK, or to stay for a longer period, please let us know.

Further reading

- PLAS group: http://www.cs.kent.ac.uk/research/groups/plas/
- Haskell: the craft of functional programming: http://www.haskellcraft.com
- Refactoring Functional Programs: http://www.cs.kent.ac.uk/research/groups/plas/hare.html
- Hat, the Haskell Tracer: http://projects.haskell.org/hat/
- CakeML, a verification friendly dialect of SML: https://cakeml.org
- Heat, an IDE for learning Haskell: http://www.cs.kent.ac.uk/projects/heat/

9.4 Haskell at KU Leuven, Belgium

Report by: Tom Schrijvers

Functional Programming, and Haskell in particular, is an active topic of research and teaching in the Declarative Languages & Systems group of KU Leuven, Belgium.

Teaching Haskell is an integral part of the curriculum for both informatics bachelors and masters of engineering in computer science. In addition, we offer and supervise a range of Haskell-related master thesis topics.

Research We actively pursue various Haskell-related lines of research. Some recent and ongoing work:

- Steven Keuchel works on InBound, a Haskell-like DSL for specifying abstract syntax trees with binders.
- George Karachlias works on extending GHC's pattern match checker to deal with GADTs, in collaboration with Dimitrios Vytiniotis and Simon Peyton Jones.
- Alexander Vandenbroucke extends the nondeterminism monad with tabulation, a form of memoization "on steroids" from logic programming.
- With Nicolas Wu we have recently worked on fusion for free monads to obtain efficient algebraic effect handlers. See our forthcoming MPC 2015 paper.
- With Mauro Jaskelioff and Exequiel Rivas we launch a new slogan:

  > Nondeterminism monads are just near-semirings in the category of endofunctors, what's the problem?

  See our forthcoming paper at PPDP 2015.

Leuven Haskell User Group We host the Leuven Haskell User Group, which has held its first meeting on March 3, 2015. The group meets roughly every other week and combines formal presentations with informal discussion. For more information: http://groups.google.com/forum/#!forum/leuven-haskell

Further reading

http://people.cs.kuleuven.be/~tom.schrijvers/Research/

9.5 fp-syd: Functional Programming in Sydney, Australia

Report by: Erik de Castro Lopo
Participants: Ben Lippmeier, Shane Stephens, and others

We are a seminar and social group for people in Sydney, Australia, interested in Functional Programming and related fields. Members of the group include users of Haskell, Ocaml, LISP, Scala, F#, Scheme and others. We have 10 meetings per year (Feb–Nov) and meet on the third (usually, sometimes fourth) Wednesday of each month. We regularly get 30–40 attendees, with a 70/30 industry/research split. Talks this year have included material on compilers, theorem proving, type systems, Haskell web programming, Haskell database libraries, Scala and more. We usually have about 90 mins of talks, starting at 6:30pm, then go for drinks afterwards. All welcome.

Further reading

- http://groups.google.com/group/fp-syd
- http://fp-syd.ouroborus.net/
- http://fp-syd.ouroborus.net/wiki/Past/2013

9.6 Functional Programming at Chalmers

Report by: Jean-Philippe Bernardy

Functional Programming is an important component of the CSE department at Chalmers and University of Gothenburg. In particular, Haskell has a very important place, as it is used as the vehicle for teaching and numerous research projects. Besides functional programming, language technology, and in particular domain specific languages is a common aspect in our projects. We have hosted ICFP 2014 in Gothenburg this September.

Property-based testing. QuickCheck, developed at Chalmers, is one of the standard tools for testing Haskell programs. It has been ported to Erlang and used by Ericsson, Quviq, and others. QuickCheck continues to be improved. Quickcheck-based tools and related techniques are currently being developed:

- We have shown how to successfully apply QuickCheck to test polymorphic properties.
- A new exhaustive testing tool (testing-feat on Hackage) has been developed. It is especially suited to generate test cases from large groups of mutually recursive syntax tree types. A paper describing it was presented at the Haskell Symposium 2012.
- Testing Type Class Laws: the specification of a class in Haskell often starts with stating, in comments, the

laws that should be satisfied by methods defined in instances of the class, followed by the type of the methods of the class. We have developed a library (ClassLaws) that supports testing such class laws using QuickCheck.

Parsing: BNFC. The BNF Converter (BNFC) is a frontend for various parser generators in various languages. BNFC is written in Haskell and is commonly used as a frontend for the Haskell tools Alex and Happy. BNFC has recently been extended in two directions:

- A Haskell backend, which offers incremental and parallel parsing capabilities, as well as the ability to parse context-free grammars in full generality, has been added to BNFC. The underlying concepts are described in a paper published at ICFP 2013.
- BNFC has been embedded in a library (called BNFC-meta on Hackage) using Template-Haskell. An important aspect of BNFC-meta is that it automatically provides quasi-quotes for the specified language. This includes a powerful and flexible facility for anti-quotation.

Parsing: Combinators. A new package for combinator-based parsing has been released on Hackage. The combinators are based on the paper Parallel Parsing Processes. The technique is based on parsing in parallel all the possibly valid alternatives. This means that the parser never "hold onto" old input. A `try` combinator is also superfluous.

Parsing: Natural languages. Grammatical Framework is a declarative language for describing natural language grammars. It is useful in various applications ranging from natural language generation, parsing and translation to software localization. The framework provides a library of large coverage grammars for currently fifteen languages from which the developers could derive smaller grammars specific for the semantics of a particular application.

Generic Programming. Starting with Polytypic Programming in 1995 there is a long history of generic programming research at Chalmers. Recent developments include fundamental work on parametricity. This work has led to the development of a new kind of abstraction, to generalize notions of erasure. This means that a new kind of generic programming is available to the programmer. A paper describing the idea was presented in ICFP 2013.

Our research on generic-programming is lively, as witnessed by a constant stream of publications: Testing Type Class Laws, Functional Enumeration of Algebraic Types (FEAT), Testing versus proving in climate impact research and Dependently-typed programming in scientific computing — examples from economic modelling. The last two are part of our effort to contribute to the emerging research programme in Global Systems Science.

Program Inversion/bidirectionalization. Program transformation systems that generate pairs of programs that are some sort of inverses of each other. The pairs are guaranteed to be consistent by construction with respect to certain laws. Applications include pretty-printing/parsing, XML transformation etc. The work is done in collaboration with University of Tokyo and University of Bonn.

Language-based security. SecLib is a light-weight library to provide security policies for Haskell programs. The library provides means to preserve confidentiality of data (i.e., secret information is not leaked) as well as the ability to express intended releases of information known as declassification. Besides confidentiality policies, the library also supports another important aspect of security: integrity of data. SecLib provides an attractive, intuitive, and simple setting to explore the security policies needed by real programs.

Type theory. Type theory is strongly connected to functional programming research. Many dependently-typed programming languages and type-based proof assistants have been developed at Chalmers. The Agda system (→ 4.1) is the latest in this line, and is of particular interest to Haskell programmers. While today's GHC incorporates much of the dependently-typed feature set, supporting plain old Haskell means a certain amount of clunkiness. Agda provides a cleaner language, while remaining close to Haskell syntax.

Embedded domain-specific languages. The functional programming group has developed several different domain-specific languages embedded in Haskell. The active ones are:

- **Feldspar** (→ 7.13.2) is a domain-specific language for digital signal processing (DSP).
- **Obsidian** is a language for data-parallel programming targeting GPUs.
  Most recently we used Obsidian to implement an interesting variation of counting sort that also removes duplicate elements. This work was presented at FHPC 2013.

We are also working on general methods for EDSL development:

- **Syntactic** is a library that aims to support the definition of EDSLs. The core of the library was presented at ICFP 2012. The paper presents a generic model of typed abstract syntax trees in Haskell, which can serve as a basis for a library supporting the implementation of deeply embedded DSLs.
- **Names For Free.** A new technique for representing names and bindings of object languages represented as Haskell data types has been developed.

The essence of the technique is to represent names using *typed* de Bruijn indices. The type captures exactly the context where the index is valid, and hence is as safe to use as a name. The technique was presented at Haskell Symposium 2013. We are currently extending the technique to work for proofs as well as programs.

- **Circular Higher-Order Syntax** We have also developed a light-weight method for generating names while building an expression with binders. The method lends itself to be used in the front end of EDSLs based on higher-order syntax. The technique was presented at ICFP 2013.
- **Simple and Compositional Monad Reification** A method for reification of monads (compilation of monadic embedded languages) that is both simple and composable. The method was presented at ICFP 2013.

Automated reasoning. We are responsible for a suite of automated-reasoning tools:

- **Equinox** is an automated theorem prover for pure first-order logic with equality. Equinox actually implements a hierarchy of logics, realized as a stack of theorem provers that use abstraction refinement to talk with each other. In the bottom sits an efficient SAT solver. Paradox is a finite-domain model finder for pure first-order logic with equality. Paradox is a MACE-style model finder, which means that it translates a first-order problem into a sequence of SAT problems, which are solved by a SAT solver.
- **Infinox** is an automated tool for analysing first-order logic problems, aimed at showing finite unsatisfiability, i.e., the absence of models with finite domains. All three tools are developed in Haskell.
- **QuickSpec** generates algebraic specifications for an API automatically, in the form of equations verified by random testing. http://www.cse.chalmers.se/~nicsma/quickspec.pdf
- **Hip** (the Haskell Inductive Prover) is a new tool to automatically prove properties about Haskell programs by using induction or co-induction. The approach taken is to compile Haskell programs to first order theories. Induction is applied on the meta level, and proof search is carried out by automated theorem provers for first order logic with equality.
- On top of Hip we built **HipSpec**, which automatically tries to find appropriate background lemmas for properties where only doing induction is too weak. It uses the translation and structural induction from Hip. The background lemmas are from the equational theories built by QuickSpec. Both the user-stated properties and those from QuickSpec are now tried to be proven with induction. Conjectures proved to be theorems are added to the theory as lemmas, to aid proving later properties which may require them. For more information, see http://web.student.chalmers.se/~danr/hipspec-atx.pdfthe draft paper.

Teaching. Haskell is present in the curriculum as early as the first year of the BSc programme. We have four courses solely dedicated to functional programming (of which three are MSc-level courses), but we also provide courses which use Haskell for teaching other aspects of computer science, such the syntax and semantics of programming languages, compiler construction, data structures and parallel programming.

9.7 Functional Programming at KU

Report by:	Andrew Gill
Status:	ongoing

Functional Programming continues at KU and the Computer Systems Design Laboratory in ITTC! The System Level Design Group (lead by Perry Alexander) and the Functional Programming Group (lead by Andrew Gill) together form the core functional programming initiative at KU. There are three major Haskell projects at KU (as well as numerous smaller ones): the GHC rewrite plugin HERMIT (→ 7.3.3), the Wakarusa Project (→ 5.1.3), and the Blank Canvas HTML5 Graphics Library (→ 5.2.10).

Further reading

- The Functional Programming Group: http://www.ittc.ku.edu/csdl/fpg

9.8 Regensburg Haskell Meetup

Report by:	Andres Löh

Since autumn 2014 Haskellers in Regensburg, Bavaria, Germany have been meeting roughly once per month to socialize and discuss Haskell-related topics.

Haskell beginners and experts are equally welcome. Meetings are announced on our meetup page: http://www.meetup.com/Regensburg-Haskell-Meetup/.

9.9 Haskell in the Munich Area

Report by:	Haskell Consultancy Munich

Haskell in education

Haskell is widely used as an educational tool for both teaching students in computer science as well as for teaching industry programmers transitioning to functional programming. It is very well suited for that and there is a huge educational body present in Munich.

Haskell at the Ludwig-Maximilians-Universität, Munich

Following a limited test run last year which included 12 people, the Institut für Informatik (Institute for Computer Science) has switched their *Programming and Modelling* (http://www.tcs.ifi.lmu.de/lehre/ss-2014/promo) course from ML to Haskell. It runs during the summer semester and is frequented by 688 students. It is a mandatory course for Computer Science and Media Information Technology students as well as many students going for degrees related to computer science, e.g. Computer Linguistics (where lambda calculus is very important) or Mathematics. The course consists of a lecture and tutorial and is led by Prof. Dr. Martin Hofmann and Dr. Steffen Jost. It started on the 7th April, 2014. It is expected that 450 students will complete the course. Notably, the course is televised and is accessible at the LMU portal for Programming and Modelling (https://videoonline.edu.lmu.de/de/sommersemester-2014/5032).

Haskell is also used in *Advanced Functional Programming* (https://www.tcs.ifi.lmu.de/lehre/ss-2012/fun) which runs during the winter semester and is attended by 20-30 students. It is mandatory for Computer Science as well as Media Information Technology students.

Neither of these courses has any entry requirements, and you may enter the university during the summer semester, which makes them very accessible.

Any questions may be directed to Dr. Steffen Jost (⟨jost@tcs.ifi.lmu.de⟩).

Haskell at the Hochschule für angewandte Wissenschaften München (Academy for applied sciences Munich)

Haskell is taught in two courses at the College: Functional Programming and Compiler Design. Both courses consist of lectures and labs. Prof. Dr. Oliver Braun has brought Haskell to the school and has been using it during the last year for both courses; before that he taught Haskell at FH Schmalkalden Thüringen (http://www.fh-schmalkalden.de/) for 3.5 years.

Compiler Design (http://ob.cs.hm.edu/lectures/compiler) is a compulsory course taught, depending on the group, using Haskell, Scheme, or Java. The Haskell version is frequented by over 40 students. Part of the note depends on a compiler authored in Haskell.

Functional Programming (http://ob.cs.hm.edu/lectures/fun) is a new, non-compulsory course attended by 20 students, taught with Haskell. The grade depends among others on an exam in Haskell knowledge and a project authored in Haskell with the Yesod web framework. It is taught with Learn You a Haskell and teaches practical skills such as Cabal, Haddock, QuickCheck, HUnit, Git, and Yesod. The school department's website itself is in Snap.

Dr. Oliver Braun has started using Haskell in 1997, when it became the first programming language he's used during his studies. He has later used Haskell during his thesis and afterwards his dissertation. He finds Haskell great for teaching. Oliver Braun can be reached via email (⟨ob@cs.hm.edu⟩).

Haskell as a teaching tool in the industry

Haskell is used in Munich to teach functional programming to industrial programmers. Since it uses the same basic programming model, it can also be used as a simple learning tool to introduce people to Scala. That is because both are based on System F and Haskell has a very clean, minimal implementation of it. It has been successfully used to teach a team of 10 PHP programmers the basics of functional programming and Scala and, together with other educational tools, get them up and running within a couple months, during which time the team remained productive. This approach makes it easy for companies to switch from the likes of PHP, Java, .NET, or C# to functional programming (Haskell, Scala, Clojure). At the same time the project switched to SOA (service oriented architecture) using

the Twitter scala libraries. Having understood the basics of FP in Haskell, the team could easily move onto the more complicated task of understanding the more unique and intricate parts of Scala that correspond to extensions to System F while being able to understand Scala's syntax. You may contact the author of this report (⟨haskell.consultancy@gmail.com⟩) for details.

Haskell community

There are several meetups dedicated to Haskell in Munich. The organizers have initiated cooperation in order to build and support the local community, as well as the community in Germany. There is something related to Haskell happening every week.

The organizers would like to establish contact with other Haskell communities in Germany as well as the whole world. You may write to the Haskell Hackathon organizer (⟨haskell.hackathon@gmail.com⟩). As of 2014, it is known that there is Haskell activity in Berlin, Cologne (Köln), Düsseldorf, Frankfurt am Main, Halle, Hamburg, and Stuttgart, as well as in Austria, Switzerland and the Czech Republic. If you're from one of those communities, please write us! The Munich community welcomes any new connections from other locations.

The community receives notable guests, such as:

- Reinhard Zumkeller, one of the regular contributors to the OEIS. Reinhard likes to use Haskell for work with integer sequences.
- Lars R. Hupel, the maintainer of scalaz. Lars teaches with Haskell at the local university and enjoys advanced topics in type systems and category theory.
- Andres Löh, co-founder of Well-Typed LLP. Andres always brings up very practical discussions on the use of Haskell. For example, he has recently held a presentation on the Par monad.
- Heiko Seeberger from . Heiko is interested in all sorts of functional programming and loves Haskell for its simplicity and consistency.
- many others which the author of this report could not reach for comment before the publication due to time constraints.

The community is very lively and there are many initiatives being worked on. For example, actively popularizing Haskell in the local industry, creating a network of companies, programmers, and informational events. The author of this report may be reached for more information (⟨haskell.consultancy@gmail.com⟩).

Haskell Hackathon

The Haskell Hackathon is a small meeting for people who would like to build their Haskell skillset. People bring their laptops and work on one of the proposed topics together, sharing experience and teaching each other. Topics range from very easy (if you don't know Haskell, you may come and the organizer will teach you the basics one on one) through intermediate (how to best set up the dev env, how to read the papers, how to use important libraries) to very advanced (free applicatives, comonads). Defocus is discouraged (subjects not related to Haskell are limited). The operating language is German but if you speak any other language you are welcome to join us.

The Hackathon is organized by the author of this report (⟨haskell.consultancy@gmail.com⟩) and is currently in its second year. It is frequented by the staff and students of the local universities, industry programmers, as well as Haskell enthusiasts. You may contact the Hackathon with any questions via email (⟨haskell.hackathon@gmail.com⟩).

We keep track of ideas we would like to explore during the Haskell Hackathon (http://haskell-hackathon.no-ip.org/ideen.html). Any and all new questions are welcome!

Haskell Meetup

The Haskell Meetup, also called Haskell Stammtisch (which directly translates to: Haskell regulars table) is a social event for the Haskell community. It is the original Haskell event in Munich. Everyone is welcome (even non-Haskell programmers!). It happens once a month, usually at Cafe Puck which is a pub in one of the cooler parts of Munich, where the members can eat schnitzel and drink beer while chatting about topics ranging from Haskell itself to abstract mathematics, industrial programming, and so on. The group is very welcoming and they make you feel right at home. The Meetup attracts between 15 and 20 guests and there's a large proportion of regulars. Attendance ranges from students, through mathematicians (notably the OEIS has a presence), industry programmers, physicists, and engineers. The Meetup receives international guests and sometimes we hold lectures.

The Haskell Meetup, established 29th September 2011 by Heinrich Hördegen. It is sponsored by Funktionale Programmierung Dr. Heinrich Hördegen (http://funktional.info) and Energy Flow Analysis – Ingenieurbüro Guttenberg & Hördegen (http://www.energiefluss.info).

Munich Lambda

Munich Lambda (http://www.meetup.com/Munich-Lambda/) was founded on Jun 28, 2013 by Alex Petrov. There have been 12 events so far, on topics including Haskell, Clojure, and generally functional programming, as well as Emacs. Meetups on the topic of Haskell occur every month to two months.

Typically, the meetup begins with a short introductory round where the visitors can talk about their work or hobbies and grab some food (provided by sponsors), followed by couple of presentations, and topped off by

an informal discussion of relevant topics and getting to know each other. It is a great opportunity to meet other likeminded people who like Haskell or would like to start out with it.

Munich Lambda is sponsored by codecentric (http://www.codecentric.de/) and StyleFruits (http://www.stylefruits.de).

Mailing lists in Munich

There are two mailing lists in use: https://lists.fs.lmu.de/mailman/listinfo/high-order-munich and http://mailman.common-lisp.net/cgi-bin/mailman/listinfo/munich-lisp.

The lists are used for event announcements as well as to continue discussions stemming from recent events. It is usually expected that anyone subscribed to one is also on the other, but conversations normally happen only on one or the other. There are 59 subscribers to high-order-munich.

There is a mail distributor for the Haskell Hackathon (http://haskell-hackathon.no-ip.org). In order to receive emails, send mail to the Haskell Hackathon organizer (⟨haskell.hackathon@gmail.com⟩).

ZuriHac 2014, Budapest Hackathon 2014, and the Munich Hackathon

There is a group of people going to ZuriHac 2014 (http://www.haskell.org/haskellwiki/ZuriHac2014). We are currently planning the logistics. If you would like to join us, you may write to the high-order-munich mailing list (https://lists.fs.lmu.de/mailman/listinfo/high-order-munich). Some people going to ZuriHac want to visit Munich first and will be received by the Munich community. There will be events during the week before ZuriHac. Boarding in Munich is inexpensive; the bus to Zurich is only 15 Euro and you may travel with a group of Haskell enthusiasts. There is a lot to see and visit in Munich. It is an easy travel destination as the Munich Airport has direct connections with most large airports in the world. Zurich is 312 kilometers (194 miles) away and no passport is necessary to travel from Munich to Zurich.

In addition, there is a group going to the Budapest Hackathon (http://www.haskell.org/haskellwiki/BudapestHackathon2014), which is a week before ZuriHac. To connect those two together, both geographically and in time, a Munich Lambda event is planned for the 4th of June in Munich. The travel is very cheap (the bus tickets from Budapest to Munich and from Munich to Zurich are on the order of 30 Euro). This way people can attend all three, completing what has been nicknamed the Haskell World Tour 2014. For more information you may contact the organizer of the Haskell Hackathon in Munich (⟨haskell.hackathon@gmail.com⟩). You may have fun, meet people from three huge Haskell communities, travel together, and see the world, all in one week!

Halle

There is a group of Haskell members going to HaL-9 in Halle (http://www.haskell.org/pipermail/haskell/2014-March/024115.html), which is 439 kilometers (273 miles) away. Henning Thielemann (⟨schlepptop@henning-thielemann.de⟩), the event organizer, is in charge of car pooling for visitors coming from all locations.

9.10 HaskellMN

Report by:	Kyle Marek-Spartz
Participants:	Tyler Holien
Status:	ongoing

HaskellMN is a user group from Minnesota. We have monthly meetings on the third Wednesday in downtown Saint Paul.

Further reading

http://www.haskell.mn