Liquid Haskell as a GHC Plugin

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Liquid Haskell in brief

- Liquid Haskell[1] is a **Refinement Type Checker** for Haskell.
- **Refinement Types** are types with a logical predicate attached to them.

[1] http://ucsd-progsys.github.io/liquidhaskell

Example

```haskell
{-@ safeDiv :: Int -> {y : Int | y /= 0} -> Int @-}
safeDiv :: Int -> Int -> Int
safeDiv = div
```

If we try to call `safeDiv 3 0` , Liquid Haskell rejects the program as **UNSAFE**.

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- Available as an executable
- “Hardcoded” prelude
- No *ghcid* or *ghcide* support

The new way

Starting from version 0.8.10.1, Liquid Haskell is **available as a GHC Plugin**.

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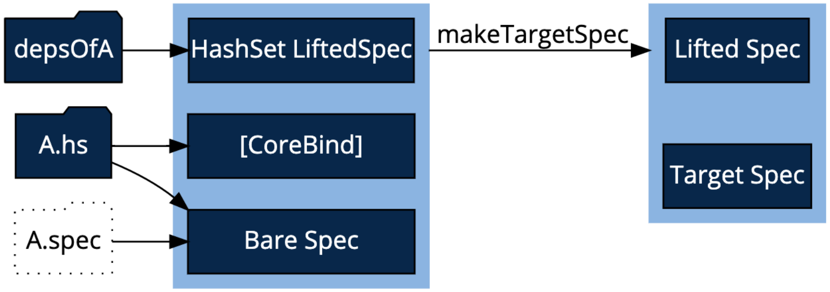
- Allow users to ship their own specifications as well as re-use existing ones
- Support IDE tools
- **Make Liquid Haskell easier for people to try and use**

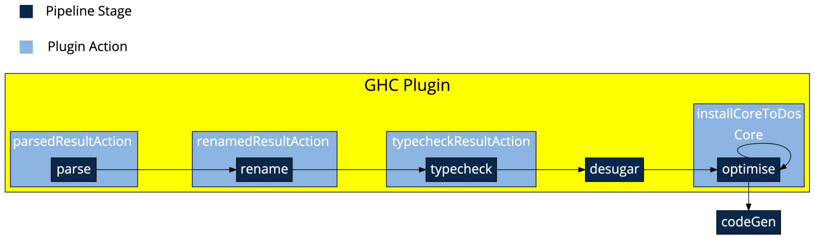
Demo

The Liquid Haskell architecture in brief

Bird's eye view over Liquid Haskell's architecture:



Brief GHC Plugin architecture recap



Attempt 1: Proper pipeline split

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Idea: Follow the natural lifecycle of the GHC pipeline.

While probably more elegant, this didn't work for most programs.

Challenge 1

Liquid Haskell requires access to the unoptimised `[CoreBind]` , and we cannot assume anything about the program's `-O` level.

Attempt 2: Duplicate (some) work

New idea

Use the input `DynFlags` to generate another version with **optimisations switched off**.

Use the latter to parse, typecheck and desugar the module again (!), to extract a suitable `[CoreBind]` .

This worked, until we tried to use the plugin with *ghcide*.

Challenge 2

When checking an input module, *ghcide* calls only the `typeCheckResultAction` hook of any registered GHC plugin.

Attempt 3: Reduce the plugin surface

Attempt 3

The final design of the plugin does **everything** in the `typeCheckResultAction`, so that we can integrate the plugin with *ghcide*.

The double parsing, typechecking, desugaring is still necessary.

More on *ghcide*

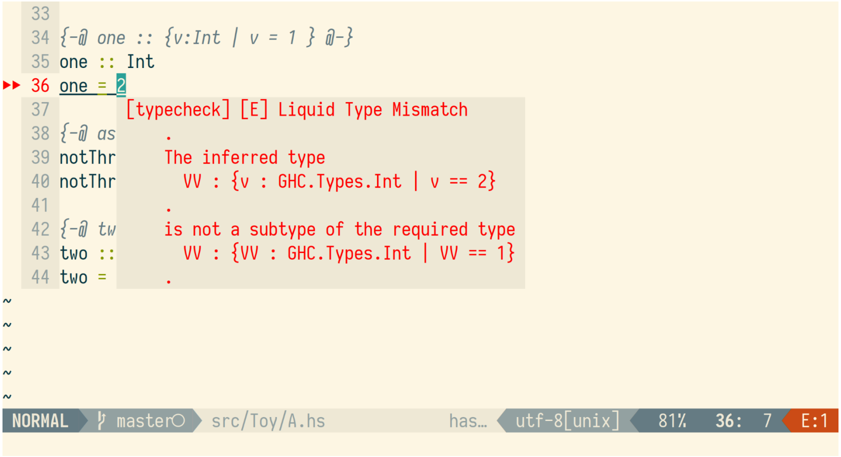
Even with “Attempt 3” implemented, we couldn’t get *ghcide* to work properly. The issue was twofold:

- GHC issue `#18070` [2] prevented plugins to be properly used on 8.10.1. This is **now fixed** and is part of the **8.10.2** release;
- We had to patch *ghcide*[3] to fully support GHC plugins.

Once we fixed the above, we got *ghcide* **working**!

[2]https://gitlab.haskell.org/ghc/ghc/-/issues/18070
[3]https://github.com/digital-asset/ghcide/pull/698

Success, at last



```
{-@ one :: {v:Int | v = 1 } @-}
one :: Int
one = 2
            [typecheck] [E] Liquid Type Mismatch
{-@ as          .
notThr          The inferred type
notThr            VV : {v : GHC.Types.Int | v == 2}
                .
{-@ tw          is not a subtype of the required type
two ::            VV : {VV : GHC.Types.Int | VV == 1}
two =           .
~
~
~
~
~
NORMAL  master  src/Toy/A.hs        has…  utf-8[unix]  81%  36:  7  E:1
```

Ecosystem

We offer drop-in replacements for some popular Haskell libraries:

- `liquid-base`
- `liquid-containers`
- `liquid-bytestring`
- `...`

We also propose a simple PVP scheme to track the dependency on the upstream package, for users willing to contribute to the ecosystem by adding new packages:

```
liquid-<package-name>-A.B.C.D.X.Y
```

- `A.B.C.D` track the upstream package,
- `X.Y` allow for LH-related bug fixes and breaking changes.

Have we achieved our goals?

- Harness GHC for recompilation avoidance and dependency resolution ✔
- Allow users to ship their own specifications ✔
- Support IDE tools ✔

We hope the plugin will help with Liquid Haskell’s adoption.

Conclusions and lessons learned

The low-level nature of the GHC API makes tricky to write plugins which modify the compilation pipeline but need to be compatible with tools that extend the frontend (like *ghcide*).

- Each plugin action is fairly stateless, no first-class support to pass user's state around.
- Not having access to the "unoptimised" `[CoreBind]` complicated the design.
- Calling the GHC API **inside** some actions might lead to surprising results (like *ghci* looping).
- The fact that our plugin worked with *ghcid* and *ghcide* with minor adjustments was very satisfactory.

Start refining your types today, use `-fplugin=LiquidHaskell` in your next project!