Introduction to PureScript for Haskell Developers

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Why PureScript Instead of JavaScript

- Safety
  - No more `undefined is not a function`
  - No more `0 == false`
  - No more mutation

```
const people = [{name: 'John'}, {name: 'Anna'}]
const newPeople = people.map(x => {
  x.color = 'green'
  return x
})
```

- More robust
- Better maintainability and refactoring

Example

Write a function which creates a CSS RGB string:

```
function getRgbColor (red, green, blue) {
  return `rgb(${red},${green},${blue})`
}
```

Well . . . this shouldn't be possible:

```
console.log(getRgbColor(undefined, 234, null))
```

Let's fix it:

```
function getRgbColor (red, green, blue) {
  if (red && green && blue) {
    return `rgb(${red},${green},${blue})`
  }
  else throw new Error('Please provide a valid color')
}
```

But wait a minute:

```
console.log(getRgbColor(221, 175, 15))
// rgb(221,175,15)

console.log(getRgbColor(221, 0, 89))
// Error: Please provide a valid color
```

Solution:

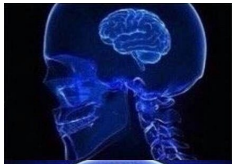
```
function getColor (red, green, blue) {
  const isValidColor =
    isFinite(red) &&
    isFinite(green) &&
    isFinite(blue)

  // TODO: Check for upper and lower bound

  if (isValidColor) return `rgb(${red},${green},${blue})`
  else throw new Error('Please provide a valid color')
}
```

NOT THE GLOBAL `isFinite`

```
isFinite(null) === true
Number.isFinite(null) === false
```

JavaScript is a Minefield!

ES3



ES2015

TypeScript

PureScript

Compilation Example 1: Curried Functions

PureScript

```
add3 :: Int -> Int -> Int -> Int
add3 valA valB valC =
  valA + valB + valC
```

JavaScript

```
var add3 = function (valA) {
    return function (valB) {
        return function (valC) {
            return (valA + valB | 0) + valC | 0;
        };
    };
};
```

Compilation Example 2: Foreign Function Interface

JavaScript

```
exports.calculateInterest = amount => {
  return amount * 0.1
}
```

PureScript

```
module Interest where

foreign import calculateInterest :: Number -> Number
```

Main Differences

- Prelude
  - Must be included explicitly
  - Smaller
  - No libraries are distributed with the compiler
- Strict, and not Lazy
- `head`, `tail`, `...` safe per default
- More explicit:
  - "X has unspecified imports, consider using the explicit form"
  - Type-classes must explicitly be imported with the `class` keyword

    ```
    import A (class B)
    ```
- Applicative Do with `ado` keyword
- | (pipe character) must appear on every line in documentation comments

Class and Type Differences

- Type variables must be declared

```
length :: forall a. Array a -> Int
```

- Instance chains (type-class programming without overlapping instances)

```
instance zeroSucc :: Succ "zero" "one"
else instance oneSucc :: Succ "one" "two"
...
```

- Class constraint arrow is flipped

```
class (Eq a) <= Ord a where ...
```

  where <= means “logical implication”

- No default member implementations for type classes (yet)

Missing Features

- Lists only via external library (`[]` and `(:)` for Arrays, `List` and `Cons` for Lists)
- No built in tuples (but external Tuple library with `Tuple a b`)
- No `qualified` keyword as `import` is qualified per default
- No Template PureScript (yet)
- Orphan instances are completely disallowed

Deriving

Basically as if `StandaloneDeriving` was enabled in GHC.

Haskell:

```
data Point = Point Int Int deriving (Eq, Ord)
```

PureScript:

```
data Point = Point Int Int

derive instance eqPoint :: Eq Foo
derive instance ordPoint :: Ord Foo
```

Instance Names

Instances must be given names:

```
instance arbitraryUnit :: Arbitrary Unit where ...`
```

- Increase readability of compiled JavaScript
- Deterministic names are good, but no good function which still produces nice names
- Renaming a class or type can break FFI code
- Name instances differently: `instance refl :: TypeEquals a a`

Defining Operators

Only available as operator alias for named functions:

Haskell:

```
f $ x = f x
```

PureScript:

```
apply f x = f x
infixr 0 apply as $
```

Operator Sections

Sections of an infix operator are only available with wildcards:

Haskell:

```
(2 /)
(/ 2)
```

PureScript:

```
(2 / _)
(_ / 2)
```

Multiline Strings

Additional support for """ multiline strings:

Haskell and PureScript:

```
sentence = "\
  \This is\n\
  \just some text\n\
  \split over several lines\n"
```

PureScript:

```
sentence = """This is
just some text
split over several lines
"""
```

Names

Haskell	PureScript
`IO`	`Effect`
`data () = ()`	`data Unit = unit`
`&`	`#`
`Bool`	`Boolean`
`..`	`range`
`++`	`<>`
`fmap`	`map`
`Text`	`String`

Haskell	PureScript
`.`	`<<<`
`>>>`	`>>>`
`[a]`	`Array a` / `List a`
`(a, b)`	`Tuple a b`
`return`	`pure`
`[x^2 | x<-[1..5]]`	`list monad + guard`
`undefined`	`unsafeCoerce`
`>>`	`*>`

But as nothing is included per default, you can change everything!

Records

```
module Main where
import Effect.Console (log)

book =
  { title: "Eine Woche voller Samstage"
  , author: "Paul Maar"
  , year: 1973
  }

main = log book.title
```

compiles to ...

```
// Generated by purs version 0.12.0
"use strict";
var Effect_Console = require("../Effect.Console/index.js");
var book = {
    title: "Eine Woche voller Samstage",
    author: "Paul Maar",
    year: 1973
};
var main = Effect_Console.log(book.title);
module.exports = {
    book: book,
    main: main
};
```

Side note: The syntax for fields is the reason why `.` isn't used for function composition

Field Access Function

```
main = do
  log $ _.title {title: "Just a title"}
  log $ _.title book
```

Updating a Record

```
nextBook = book {title = "Am Samstag kam das Sams zurück"}
```

Side note: This would be ambiguous if Records used = instead of : for assignments.

Does it mean "apply function `book` to object `{ title: "..." }`" or "update the `title` of `book`"?

Pattern Matching on Records

```
paulsTitle {author: "Paul Maar", title: t} = Just t
paulsTitle _ = Nothing
```

Record Types

Haskell:

```
data Book = Book
  { title :: Text
  , author :: Text
  , year :: Int
  }
```

PureScript:

```
type Book =
  { title :: String
  , author :: String
  , year :: Int
  }
```

Row Polymorphism

```
showPrint :: forall a.
  { title :: String, author :: String | a }
  -> String
showPrint b =
  b.title <> " by " <> b.author

main :: Effect Unit
main = do
  log $ showPrint book
```

The kind of a is # Type (A row of types)

```
> :kind { title :: String }
Type
> :kind ( title :: String )
# Type
> :kind Record
# Type -> Type
> :kind Record ( title :: String )
Type
```

- A row of types is a type level description of pairs of labels and types
- `{ title :: String }` is just syntax sugar for `Record ( title :: String )`

```
type EitherTitleOrYear = Variant ( title :: String, year :: Int )
```

Type Class Hierarchy

Finer subdivision into more classes:

- `Category` has a superclass `Semigroupoid` (provides <<<, does not require an identity)
- `Monoid` has a superclass `Semigroup` (provides <>, does not require an identity)
- `Applicative` has a superclass `Apply` (provides <*>, does not require an implementation for `pure`)

Active Extensions

Equivalent to enabling following extension in GHC

- `DataKinds`
- `EmptyDataDecls`
- `ExplicitForAll`
- `FlexibleContexts`
- `FlexibleInstances`
- `FunctionalDependencies`
- `KindSignatures`
- `MultiParamTypeClasses`
- `PartialTypeSignatures`
- `RankNTypes`
- `RebindableSyntax`
- `ScopedTypeVariables`
- `UndecidableInstances` (cuts off after to much looping)

Low Level Adaptions for JavaScript

Several design decisions were made to improve the generated JavaScript:

- Direct mapping to JavaScript:

  ```
  Boolean = true | false
  ```

- Arrays instead of lists
- Named instances
- Records $\rightarrow$ JavaScript Objects
- `String` is a JavaScript String (and not `[Char]`)

Tooling

Haskell	PureScript
`ghc`	`purs`
`ghci`	`purs repl`
`ghcid`	`pscid`
`stack`	`pulp`
`stack init`	`pulp init`
`stack exec`	`pulp run`
haskell.org	purescript.org
hackage.haskell.org	bower.io (or psc-package via git)
hoogle.haskell.org	pursuit.purescript.org
try.haskell.org	try.purescript.org (not up to date yet)

Use Cases and Notable Projects 1

- Frontend
  - Halogen - UI library
  - Pux - Web apps like Elm
- Reactive Tools / Websites
  - Flare - Reactive UI
  - PureScript Pop - FRP demo
- JavaScript Plugins
- Cloud functions

Use Cases and Notable Projects 2

- CLI tools (can also be executed in the browser!)
  - Insect - CLI calculator
  - Transity - Plaintext accounting tool
  - Neodoc - CLI args parser
- Game Development
  - PureScript is Magic
- Interfaces, bindings, and wrappers for JavaScript libraries
  - D3
  - React
- Language experiments
  - Neon - Alternative Prelude without type class hierarchy

The Not so Good

- Trying to remember the differences to Haskell
- Smaller Ecosystem than Haskell
- New compiler versions break a lot
- Performance
- Memory footprint of Node.js

Future Development

PureScript

- More backends:
  - pure-c - C backend for PureScript
  - pureswift - Swift backend for PureScript
- Stable compiler

Haskell

- Backport features (most PureScript developers are also Haskell developers)
- Maybe it catches up
  - Compile to Webassembly
  - Fix Records

PureScript is currently the best way to write JavaScript!