Introduction to optimizing Haskell code

8th GhentFPG meeting

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Hello!

My name is Jasper
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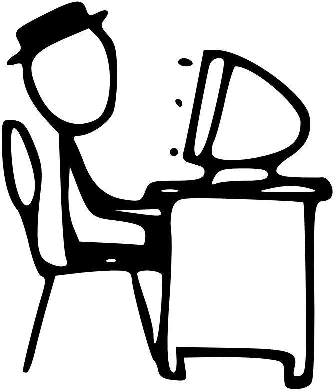

Overview

Credit where credit is due

High-Performance Haskell
(And general advice)
Johan Tibell

Overview

Introduction

Strictness analysis

Benchmarking pitfalls

GHC Core

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Strictness analysis

Haskell has lazy evaluation as default

Strictness analysis

Lazy evaluation leads to more composable code

Disadvantage: too much laziness

Strictness analysis

A function can be strict in it's arguments

```
null :: [a] -> Bool
null [] = True
null _  = False
```

Strictness analysis

```haskell
hello :: String -> String
hello name =
  "Hello, " ++ name ++ "!"
```

Strictness analysis

```
quadr :: Floating a
      => a -> a -> a -> a -> a
quadr a b c x =
  a * x ^ 2 + b * x + c
```

Strictness analysis

```
if' :: Bool -> a -> a -> a
if' True  x _ = x
if' False _ y = y
```

Strictness analysis

```
maybe ::
   b -> (a -> b) -> Maybe a -> b
maybe d _ Nothing  = d
maybe _ f (Just x) = f x
```

Strictness analysis

Functions can easily be made strict

```
seq :: a -> b -> b
```

Strictness analysis

```haskell
quadr :: Floating a
      => a -> a -> a -> a -> a
quadr a b c x =
  a `seq` b `seq` c `seq`
    a * x ^ 2 + b * x + c
```

Strictness analysis

Useful syntactic sugar

```
{-# LANGUAGE BangPatterns #-}
quadr :: Floating a
      => a -> a -> a -> a -> a
quadr !a !b !c x =
  a * x ^ 2 + b * x + c
```

Strictness analysis

Some notes about seq

Strictness analysis

Right usage

```
f x = x `seq` g x
```

Strictness analysis

Wrong usage

```
x ‘seq‘ x
```

Strictness analysis

Most important: `seq` is no magic!
Translates to a `case` statement

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Benchmarking pitfalls

Haskell is a lazy language
This makes benchmarking hard

Benchmarking pitfalls

Two types of benchmarks:
Functions and programs

(we focus on the former)

Benchmarking pitfalls

Benchmarking some function

```
f :: Int -> Int
```

Benchmarking pitfalls

In e.g. Python

```
total = 0
for i in range(100):
    start = time.time()
    f()
    end = time.time()
    total += (end - start) / 100
```

Benchmarking pitfalls

In Haskell?

```
replicateM 100 $ do
    start <- getTime
    let y = f x
    end <- y ‘seq‘ getTime
```

This is pretty hard to get right

Benchmarking pitfalls

Conclusion?

Never write your own benchmarking code

Benchmarking pitfalls

Criterion

By Bryan O'Sullivan

Benchmarking pitfalls

Criterion

```
bench "f" $ nf   f x
bench "g" $ whnf g x
```

Benchmarking pitfalls

Eq for string types

```
whnf (== T.init t
     `T.snoc` '\xfffd') t

whnf (== BL.init bl
     `BL.snoc` '\xfffd') bl
```

Benchmarking pitfalls

But `ByteString.Lazy`
is a little faster

`Text`: 2.489305 us
`ByteString.Lazy`: 39.29312 **ns**

Benchmarking pitfalls

Digging into the code...

```
eq (Chunk a as) (Chunk b bs) =
   case compare (S.length a)
                (S.length b) of
     ...
     EQ -> a == b && eq as bs
     ...
```

Benchmarking pitfalls

Digging further...

```
eq a@(PS p s l) b@(PS p' s' l')
    -- short cut on length
    | l /= l'                = False
    -- short cut for same string
    | p == p' && s == s' = True
    | ...
```

Benchmarking pitfalls

Conclusion?

Libraries can be smarter than you think they are, make sure you know what you are benchmarking!

Benchmarking pitfalls

Benchmarking IO

```
bench "HtmlCombinator" $ do
  putStr "Content-Type:␣..."
  ...
  putStr "<table>"
  putStr $ toLazyText $
    makeTable 20000
  putStr "</table>"
```

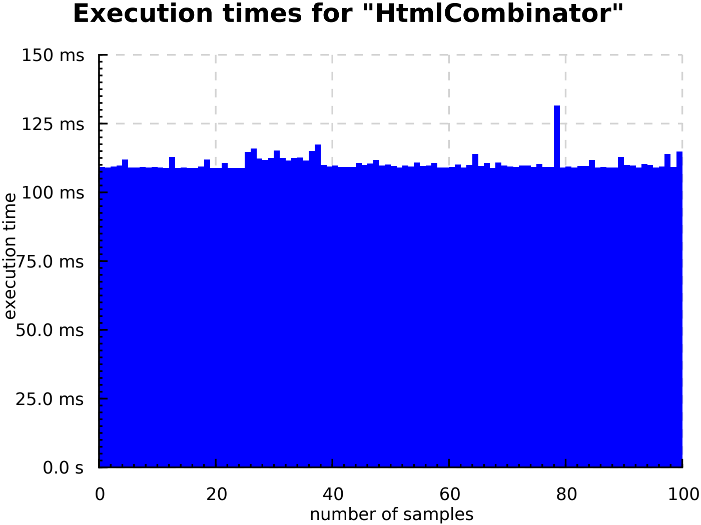
Benchmarking pitfalls

This looks suspicious

```
benchmarking HtmlCombinator
collecting 100 samples (...)
    estimated 30.80161 s
mean: 107.6378 ms (...)
```

$$100 * 100ms \neq 30s$$

Benchmarking pitfalls



Benchmarking pitfalls

Where is the issue?

```
bench "HtmlCombinator" $ do
  putStr "Content-Type:␣..."
  ...
  putStr "<table>"
  putStr $ toLazyText $
    makeTable 20000
  putStr "</table>"
```

Benchmarking pitfalls

```
putStr . toLazyText .
    makeTable =<< rows
...
where
  rows :: IO Int
  rows = return 20000
  {-# NOINLINE rows #-}
```

Benchmarking pitfalls

Conclusion?

GHC is pretty smart as well

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GHC Core

GHC Core

What is GHC Core?
Why should we care?

GHC Core

What is GHC Core?

Internal representation used by GHC

A kernel language

Optimizations are applied here

GHC Core

Why should we care?

Understanding benchmark results
Know what is going on
Impress your friends!

GHC Core

A few basic rules

GHC Core

Function pattern matching, guards, if's are translated to `case`

GHC Core

`where` is translated to `let`

GHC Core

Type annotations everywhere

GHC Core

Reading core

Clean up qualified names
Use proper variable names
Remove unnecessary type annotations

GHC Core

Demo

Questions?