## Haskell in Green Land: Analyzing the Energy Behavior of a Purely Functional Language

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#### Global energy system is unsustainable





Photograph by Jasper Doest/Foto Natura/Minden Pictures/Corbis

Every year, computing giants including Hewlett-Packard (HPQ), Dell (DELL), and Cisco Systems (CSCO) sell north of \$100 billion in hardware. That's the total for the basic iron—







Haskell isn't a common choice for large production systems like Sigma, and in this post, we'll explain some of the thinking that led to that decision. We also wanted to share the experiences and lessons we learned along the way. We made several improvements to GHC (the Haskell compiler) and fed them back upstream, and we were able to achieve better performance from Haskell compared with the previous implementation.

#### The adventures of Haskell in Greenland



To what extent can we save energy by refactoring existing Haskell **programs** to use different **data structure implementations** or **concurrent programming constructs**?

#### **Experimental Setup**



#### 2x10-core Intel Xeon E5-2660 v2

**Processors** (Ivy Bridge) 256GB of DDR3 1600MHz RAM

Criterion

RAPL

## Study 1: Purely functional data structures

# RQ1. How do different implementations of

# the same abstractions compare in terms of

# run time and energy efficiency?

# **RQ2**. For concrete operations, what is the **relationship** between their **performance** and their **energy consumption**?

#### Study 1: Edison Library

Collections	Associative Collections	Sequences
EnumSet StandardSet UnbalancedSet LazyPairingHeap LeftistHeap MinHeap SkewHeap SplayHeap	AssocList PatriciaLoMap StandardMap TernaryTrie	BankersQueue SimpleQueue BinaryRandList JoinList RandList BraunSeq FingerSeq ListSeq RevSeq SizedSeq MyersStack

#### Study 1: Benchmark

iters	operation	base	aux
1	add	100000	100000
1000	addAll	100000	1000
1	clear	100000	n.a.
1000	contains	100000	1
5000	containsAll	100000	1000
1	iterator	100000	n.a.
10000	remove	100000	1
10	removeAll	100000	1000
5000	toArray	100000	n.a.
10	retainAll	100000	1000

```
iters = 0;
while iters < 10
retainAll base aux;
iters++;
```

# 320 configurations 3000+ executions

#### Study 1: Results



**RQ1**. How do **different implementations** of the same **abstractions** compare in terms of **runtime** and **energy efficiency**?

## Full details on green-haskell.github.io.

**RQ2**. For concrete operations, what is the **relationship** between their **performance** and their **energy consumption**?

## **Energy** is **proportional** to execution **time**.

# Study 2: Concurrent programming constructs

# **RQ1**. Do alternative **thread management** constructs have different impacts on **energy consumption**?

# RQ2. Do alternative data-sharing primitives have different impacts on energy consumption?

# Thread management: forkIO, forkOn, forkOS

#### Data sharing: MVar, TVar, TMVar

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**ROSETTACODE.ORG** 

The Computer Language Benchmarks Game

9 benchmarks: IO, memory,

synchronization bound

Up to **9 variants** per benchmark **9** configurations for **# of capabilities** 

Small changes can produce big savings

#### chameneos-redux



#### Faster is not always greener

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fasta

#### There is no overall winner





# Made two tools energy-aware:

# GHC profiler Criterion



#### Population: 56483 (2013)

## Haskell programmers: 0 (est.)



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Branch: master - New	pull request. New file Upload files Find fi	e SSH - git@github.com:neurocyt	e/ 🔁 De	Simon Marlow
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I patches	Merge branch 'master' of github.com.joeyh/ghc-android			One of our weapons in the fight against spam, malware, and other abuse on Facebook is a sy called Sigma. Its job is to proactively identify malicious actions on Facebook, such as spam, p
gitignore	Clean-up .glignore			attacks, posting links to malware, etc. Bad content detected by Sigma is removed automatical
README md	update			that it doesn't show up in your News Feed.
build	Build both arm and x86 by default			We recently completed a two-year-long major redesign of Sigma, which involved replacing the
build-arch	Bumped version for automake			nouse FXL language previously used to program Sigma with Haskell. The Haskell-powered in now runs in production, serving more than one million requests per second.
minor	Add build and mirror scripts			Underlight a supreme shall a factories and other supreme like from and in this meet well.
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#### Study 1: Results



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some of the thinking that led to that decision. We also wanted to share the experiences and lessons we learned along the way. We made several improvements to GHC (the Haskell compiler) and fed them back upstream, and we were able to achieve better performance from Haskell compared with the previous implementation.

#### Study 1: Results



#### Faster is not always greener



fasta

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#### Faster is not always greener



#### Study 1: Results



Small changes can produce big savings

chameneos-redux



http://green-haskell.github.io

120 7

110 -100

90

80

70 Time (sec)

60

50

40

30

20

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