Experimenting for Greener Code

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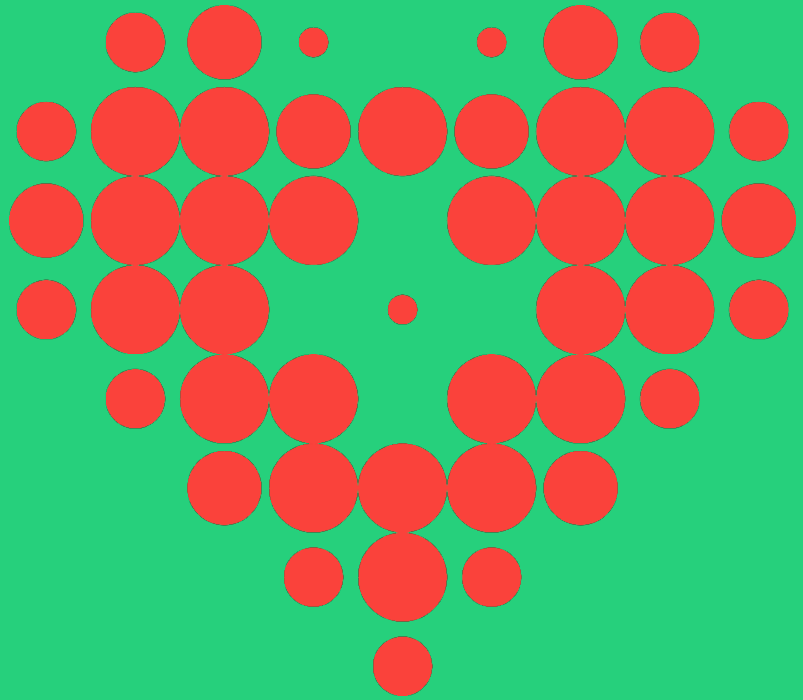
BOSkonf 2023

tietoevry

Why Green Code

- Demand will force us to code greener, so we might as well get started
- Coding greenly may become a competitive advantage
- Side-effects
  - Lower cost
  - Simpler and more maintainable code
  - Modern architectures and thechnologies
  - Faster load sand startups
  - Happier customers



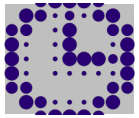
Measuring Carbon in Software - Indirect

Cost

- A major cost for datacenters is energy
- Therfore, energy consumption will be closely related to cost.

Infer from infrastructure

- Static analysis at build time https://github.com/Green-Software-Foundation/carbon-ci
- Dashboards



Time

- Runtime is highly corrolated with energy
- CPU and memory time is even more so
- This can be used to conduct experiments

Track carobon intensity

- Datacenter location matters
- Find low carbon intencity locations
- Tools for estimating intensity
  - Wattime
  - Electricity Maps

About me:
Kent Inge Fagerland Simonsen

- Guru @ friByte
- Works in Tietoevry
- PhD in Software Engineering
- About 20 years experience in Software Engineering
- 1.5 Year with thinking about green code

Why experiment

Our Intuitions fail

- Intuitions fail
- Even documentation may be misleading
- Little things done many times makes a big difference

Showing our work

- SDG reports
- Sharing knowledge

Increasing confidence

- Decrease uncertainty
- Making the right choices

Fun

- Learn new stuff
- Challenge preconceptions
  - ... or prove your skills

Experimentation – example 1

```python
import time

# Initialize variable inside the loop
start_time = time.time()
y=0
for i in range(10_000_000):
    x = 1 + 1
    y = y + x
end_time = time.time()
print(f"Time: {end_time - start_time} seconds")
print(f"Result when initializing variable inside the loop: {y}")

# Initialize variable outside the loop
start_time = time.time()
y = 0
x = 1 + 1
for i in range(10_000_000):
    y = y + x
end_time = time.time()
print(f"Time: {end_time - start_time} seconds")
print(f"Result when initializing variable outside the loop: {y}")

```

Experimentation – example 1

```
➜  variable_initialization_in_loop_py git:(main) ✗ python3 run_both_using_timer.py
Time: 1.4754528999328613 seconds
Result when initializing variable inside the loop: 20000000
Time: 1.2558479309082031 seconds
Result when initializing variable outside the loop: 20000000
➜  variable_initialization_in_loop_py git:(main) ✗
```

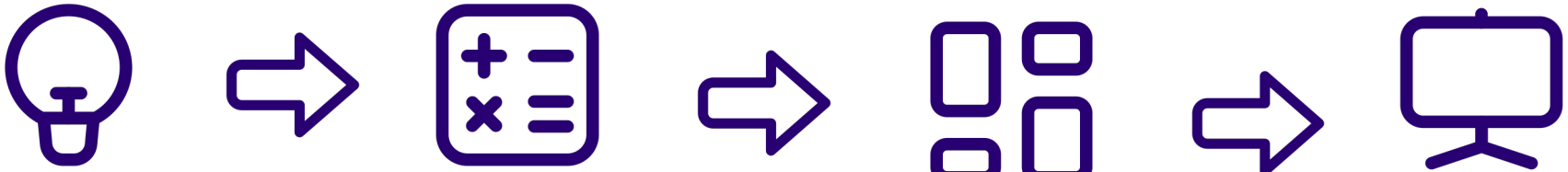
Experimentation – example 1 Java editon

```
9     public static void main(String[] args) {
10        long startTime, endTime = 0;
11
12        final int x = 1 + 1;
13        int y = 0;
14        // Example 1: Inititate outside loop
15        startTime = System.nanoTime();
16        for (int i = 0; i < 1_000_000_000; i++) {
17            y = y + x;
18        }
19        endTime = System.nanoTime();
20        String time = formatTimeDiff(startTime, endTime);
21        System.out.println("Initialize outside loop time: " + time);
22
23
24
25        // Example 2: Initiate inside loop
26        y = 0;
27        startTime = System.nanoTime();
28        for (int i = 0; i < 1_000_000_000; i++) {
29            int z = 1 + 1;
30            y = y + z;
31        }
32        endTime = System.nanoTime();
33        time = formatTimeDiff(startTime, endTime);
34        System.out.println("Initialize inside loop time:  " + time);
35    }
```

Experimentation – example 1 Java-edition

```
➜  get_value_from_function_in_loop_java git:(main) ✗ java TimeInitializationInAndOutsideLoop
Initialize outside loop time: 00:00:00.003565189
Initialize inside loop time:  00:00:00.003066401
```

Experimentation – Making your own experiment



Have a question

Design an experiment

Run experiment

Publish results

Experimentation – example 1

Question

Is there a significant difference when initiating a variable inside vs outside a loop?

Design

- Create an application that runs a loop that does some trivial task while using a varaiable initiated inside or outside a loop.
- Expect a 10% difference

Run

Run the program

Vary which loop is run first/last

Publish results

Wait and see ☺

Experimentation – example 2

Question

What is the least energy expensive way to parse a bunch of dates?

Design

Create a program that parses dates in different ways

Run

Run multiple times while varying the order of the different ways to parse the dates

Publish results

Wait and see ☺

Experimentation – example 2

```java
public static void main(String[] args) throws Exception {
    List<String> dateStrings = new ArrayList<>();
    for (int i = 0; i < 10000; i++) {
        dateStrings.add(String.format(format:"%04d-%02d-%02d", 2000 + i % 50, 1 + i % 12, 1 + i % 28));
    }

    long startTime, elapsedTime;

    // Benchmark parseWithLocalDate
    startTime = System.nanoTime();
    for (String dateString : dateStrings) {
        parseWithLocalDate(dateString);
    }
    elapsedTime = System.nanoTime() - startTime;
    System.out.println("Time taken by parseWithLocalDate: " + elapsedTime / 1_000_000.0 + " ms");

    // Benchmark parseWithLocalDateTime
    startTime = System.nanoTime();
    for (String dateString : dateStrings) {
        parseWithLocalDateTime(dateString);
    }
    elapsedTime = System.nanoTime() - startTime;
    System.out.println("Time taken by parseWithLocalDateTime: " + elapsedTime / 1_000_000.0 + " ms");

    // Benchmark parseWithSimpleDateFormat
    startTime = System.nanoTime();
    for (String dateString : dateStrings) {
        parseWithSimpleDateFormat(dateString);
    }
    elapsedTime = System.nanoTime() - startTime;
    System.out.println("Time taken by parseWithSimpleDateFormat: " + elapsedTime / 1_000_000.0 + " ms");
}
```

Experimentation –example 2

```
➜  Experiment2ParseDates java DateParsingBenchmark
Time taken by parseWithLocalDate: 64.015987 ms
Time taken by parseWithLocalDateTime: 72.663786 ms
Time taken by parseWithSimpleDateFormat: 103.76866 ms
➜  Experiment2ParseDates
```

K

how to determine the fastest way to parse dates in java?

To determine the fastest way to parse dates in Java, you can conduct a benchmarking experiment. You can compare different parsing methods or libraries to find the most efficient one for your specific use case. Here's an example of how to benchmark the performance of two date parsing methods using the `java.time` package:

1. Prepare the test data and methods:

java

Copy code

```
import java.time.LocalDate;
import java.time.LocalDateTime;
import java.time.format.DateTimeFormatter;
import java.util.ArrayList;
import java.util.List;

public class DateParsingBenchmark {
    private static final String DATE_PATTERN = "yyyy-MM-dd";
    private static final DateTimeFormatter FORMATTER = DateTimeFormatter.ofP

    private static LocalDate parseWithLocalDate(String dateString) {
        return LocalDate.parse(dateString, FORMATTER);
    }

    private static LocalDateTime parseWithLocalDateTime(String dateString) {
        return LocalDateTime.parse(dateString + "T00:00:00", DateTimeFormatt
    }

    public static void main(String[] args) {
        List<String> dateStrings = new ArrayList<>();
        for (int i = 0; i < 10000; i++) {
            dateStrings.add(String.format("%04d-%02d-%02d", 2000 + i % 50, 1
```

Regenerate

Send a message

ChatGPT can make mistakes. Verify important information.

Question Types

Is A better than B

- Makes for very simple experiments
- Easy to interpret results

What is best way to do X

- Often indeterminate
- Can be refined to more decidable research questions

What is the impact of X

- Hard to define «impact»
- Can be very interwsting questions
- Can be complex experimentation

Experimentation – example 3

Question

What is impact of using Rust and Wasm in Azure Functions

Design

Create several Azure functions using code from Language Ranking paper in several languages including Rust compiled to WASM.

Run

Run several times both locally and in the Cloud

Publish results

Wait and see ☺

Experimental Design

In order to answer the above reearch questions, we have desined two experiments. The first experiment is to time implmentations of some of the probblems used in [1] to crate a similar ranking in the Azure Functions develoopment environment on a single laptop. The secoond experiment will e a repeat of the first one but in an actual Azure Functions with the consumption plan. To reduce noice we will only run one instance og onoe function at a time. Since we ccan not know wich hardware will run the software in Azure Functinos, we will use time as our measuring tool and not use any energy measuring tools such as RAPL. We will also make only minimal adjustments to te problem too make tem runnable as Azure Functions.

In each experiment we will use implementations in te following languages

- Java
- C-Sharp
- Javascript (node.js)
- Rust comopiled to Wasm run trough Javasccript

We are using te following problems for each language:

I nessecary we will run eac experiment with 1X, 10X and 100X the input size in otder too study the effects f startup times.

Each problem in each languages will be run 10 times and we will look at both the avaerage and minimal execcution times.

Runbook

Experiment 1: Using Func

Instal the latest version the the Azure Functions Core Tools

```
npm i -g azure-functions-core-tools@4 --unsafe-perm true
```

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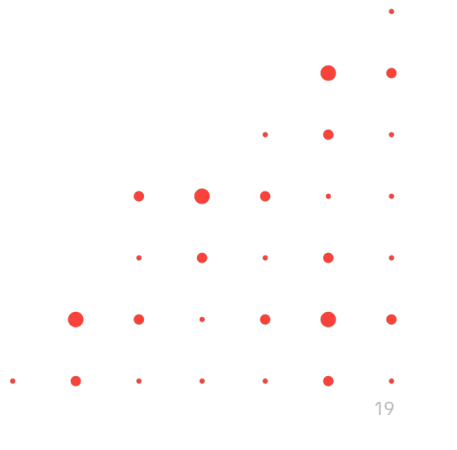
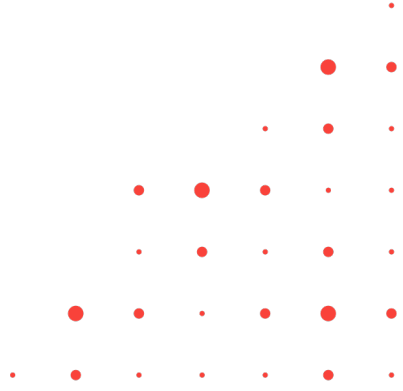


Azure (windows)	Java	Node	Rust	C#
BT no cold mean	16,44444444	6,222222222	10,11111111	2,333333333
BT no cold Sum	148	56	91	21
BT No cold min	12	5	7	1
BT Cold	255	189	95	2
FR no cold mean	11,55555556	7,888888889	4,555555556	0,6666666667
FR no cold Sum	104	71	41	6
FR No cold min	8	4	4	0
FR Cold	11	17	6	1
S no cold mean	6	5,555555556	4,777777778	0
S no cold Sum	54	50	43	0
S No cold min	5	3	4	0
S Cold	6	6	7	0



Dangers of relying on rankings/google/llm's

- Llitterature and onilne resoources are incredably useful.
- They rarly cover any possible context

	Energy
(c) C	1.00
(c) Rust	1.03
(c) C++	1.34
(c) Ada	1.70
(v) Java	1.98
(c) Pascal	2.14
(c) Chapel	2.18
(v) Lisp	2.27
(c) Ocaml	2.40
(c) Fortran	2.52
(c) Swift	2.79
(c) Haskell	3.10
(v) C#	3.14
(c) Go	3.23
(i) Dart	3.83
(v) F#	4.13
(i) JavaScript	4.45
(v) Racket	7.91
(i) TypeScript	21.50
(i) Hack	24.02
(i) PHP	29.30
(v) Erlang	42.23
(i) Lua	45.98
(i) Jruby	46.54
(i) Ruby	69.91
(i) Python	75.88
(i) Perl	79.58

Experimentation – example 4

Question

What is the fastest programming language: Java orr Perl when running regular expressions.

Design

Create a program in each language that pproocesses the same rergexp several times

Run

Run both and vary order

Publish results

Wait and see ☺

```java
public class RegexSpeedTest {
    Run | Debug
    public static void main(String[] args) {
        Instant start = Instant.now();

        String content = "";
        try {
            content = new String(Files.readAllBytes(Paths.get(first:"emails.txt")));
        } catch (IOException e) {
            e.printStackTrace();
        }

        String pattern = "[a-zA-Z0-9._%+-]+@[a-zA-Z0-9.-]+\\.[a-zA-Z]{2,}";
        Pattern compiledPattern = Pattern.compile(pattern);
        Matcher matcher = compiledPattern.matcher(content);

        int matches = 0;
        while (matcher.find()) {
            matches++;
        }

        Instant end = Instant.now();
        Duration elapsed = Duration.between(start, end);

        System.out.println("Found " + matches + " email addresses");
        System.out.println("Elapsed time: " + elapsed.toMillis() / 1000.0 + " seconds");
    }
}
```

```perl
use strict;
use warnings;
use Time::HiRes qw(time);

my $start_time = time;

open(my $file, "<", "emails.txt") or die "Could not open file: $!";
my $content = do { local $/; <$file> };
close($file);

my $pattern = qr/[a-zA-Z0-9._%+-]+@[a-zA-Z0-9.-]+\.[a-zA-Z]{2,}/;
my @matches = $content =~ /$pattern/g;

my $end_time = time;
my $elapsed_time = $end_time - $start_time;

print "Found " . scalar(@matches) . " email addresses\n";
print "Elapsed time: $elapsed_time seconds\n";

```

```
➜  tmp git:(main) ✗ java RegexJava
Java:
Time elapsed: 11 ms
```

```
➜  tmp git:(main) ✗ perl regex_perl.pl
Perl:
Time elapsed: 1.01089477539062 ms
```

Thanks!

tietoevry