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SOFTWARE ENGINEERING

The Fast and the Frugal: Microservices at Race

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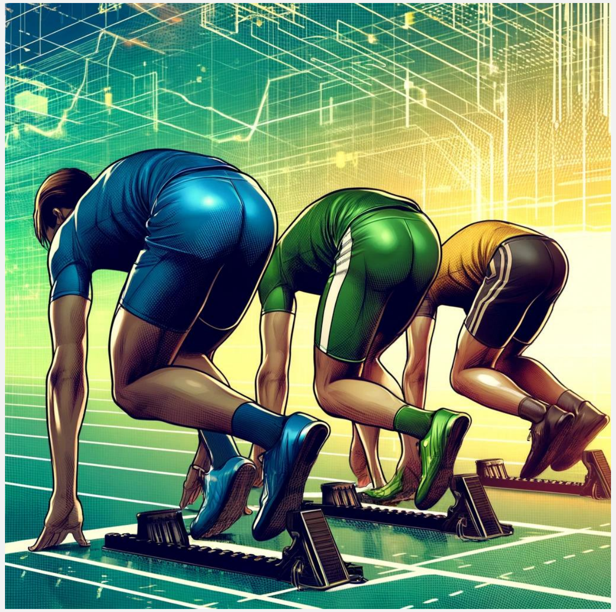
Ready

Steady



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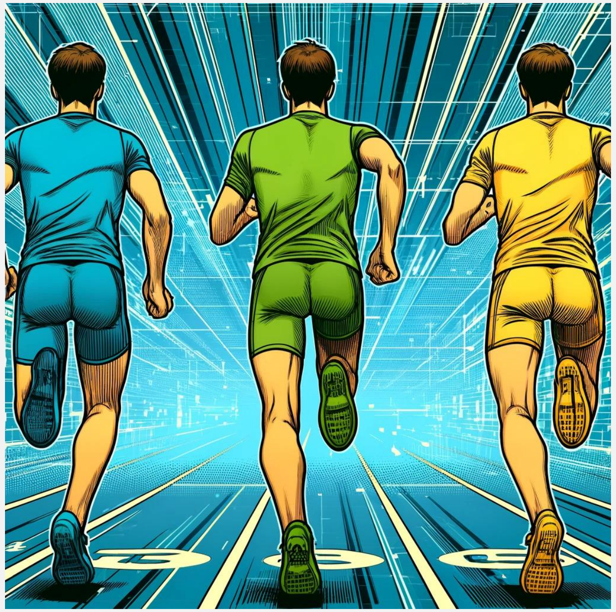

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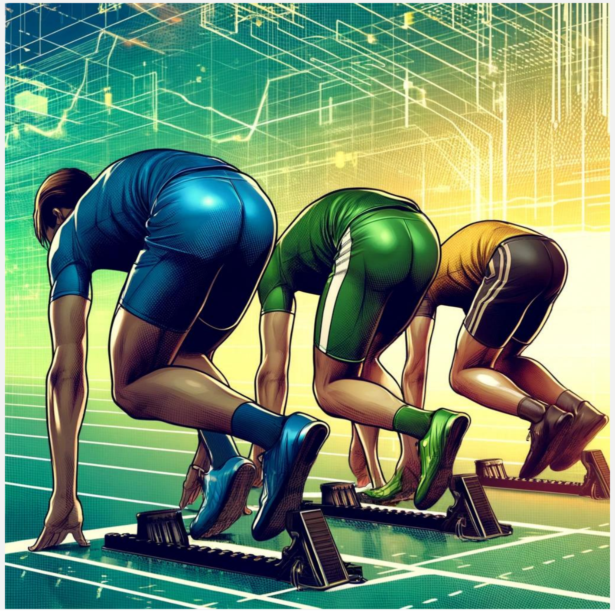
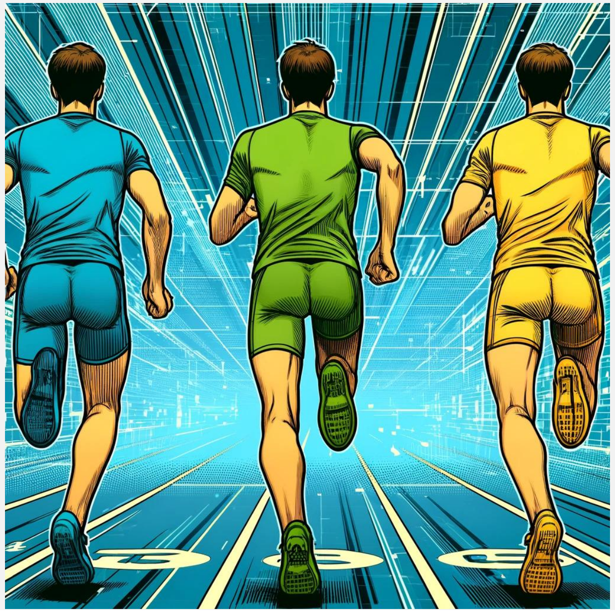
Microservices

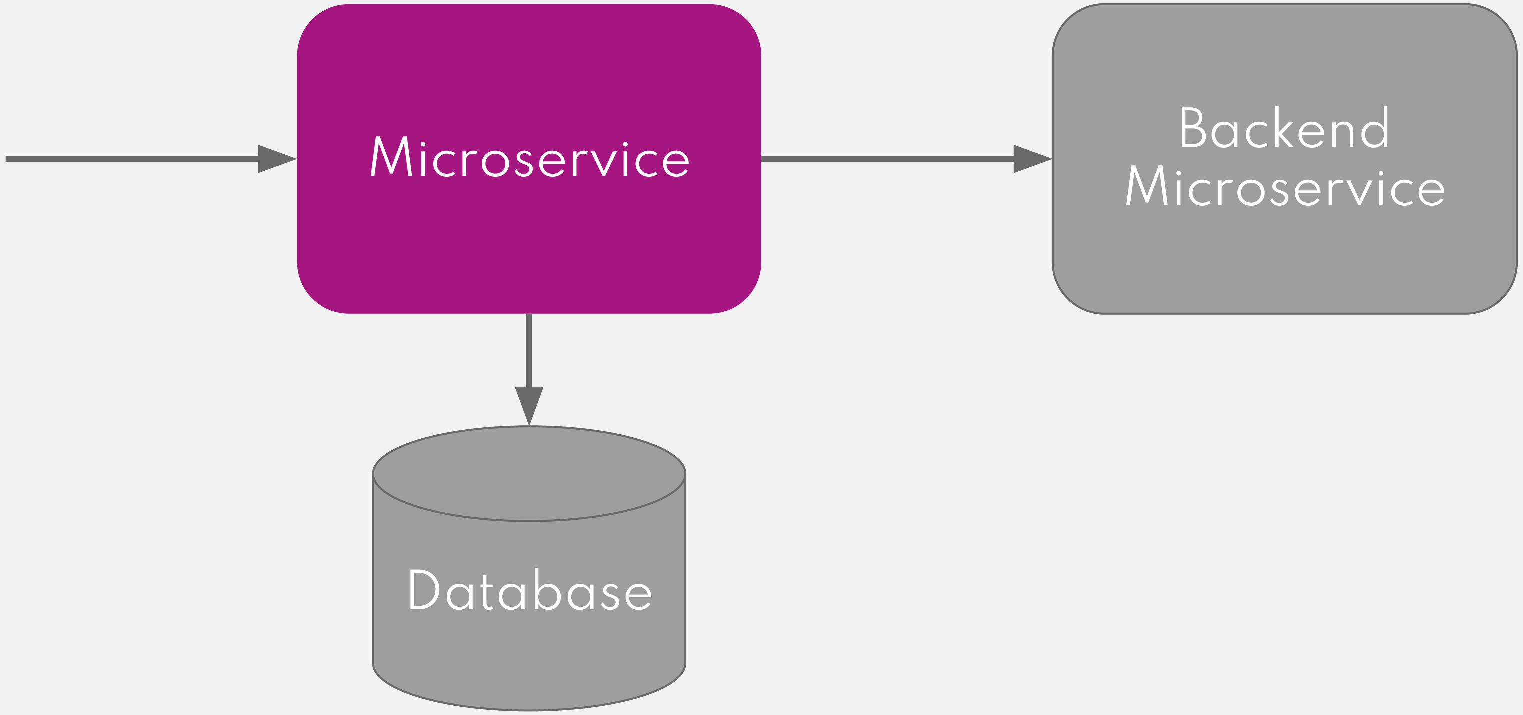
Measuring Tools

Comparison

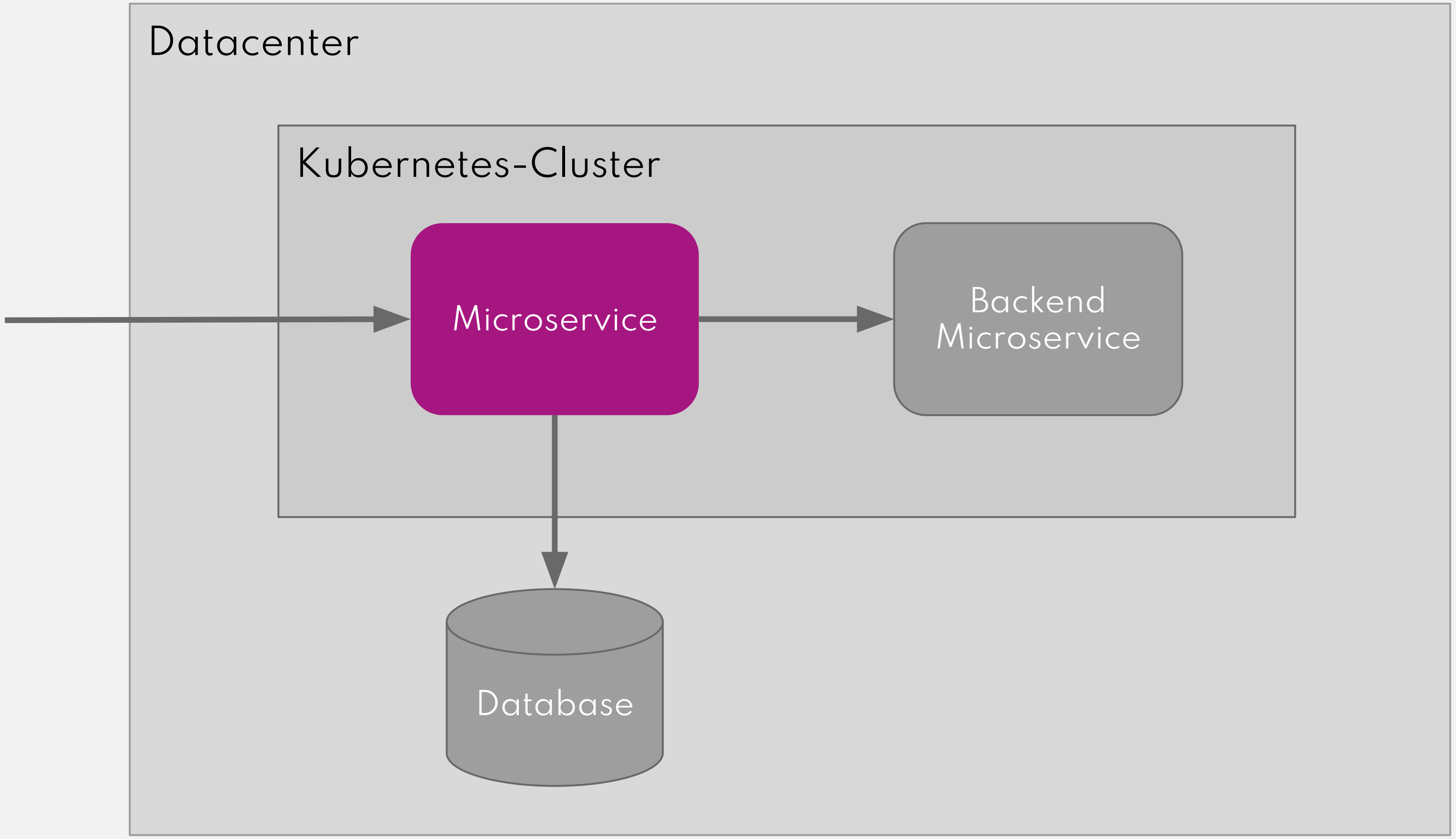




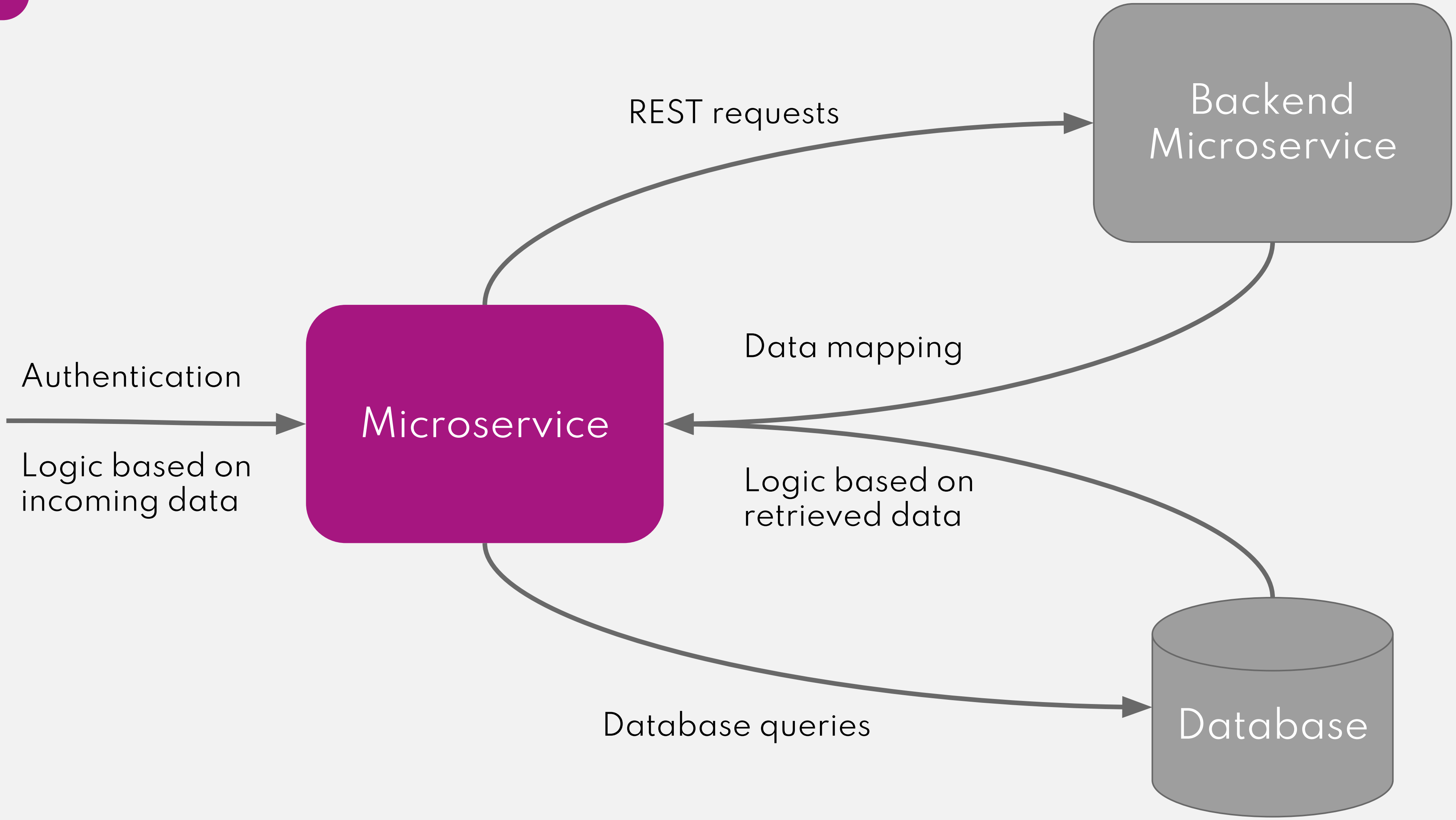
Typical Setup of Microservices



Typical Setup of Microservices



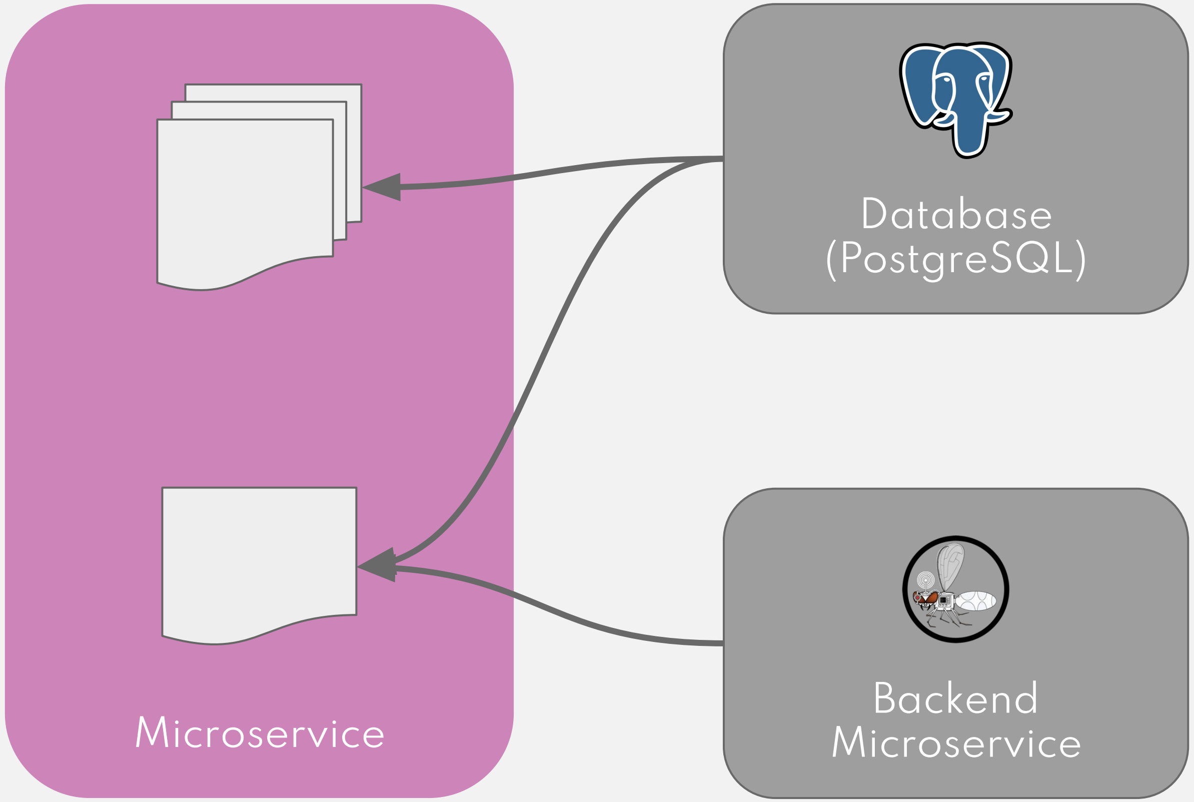
Typical Tasks of Microservices



Sample Microservice Architecture

Overview
Query a list of items with pagination

Details
Query a single items by identifier



Sample Microservice Implementations (Functionally Equivalent)

Rust
Actix-Web

Java
Quarkus
JVM, native

Go
Gin

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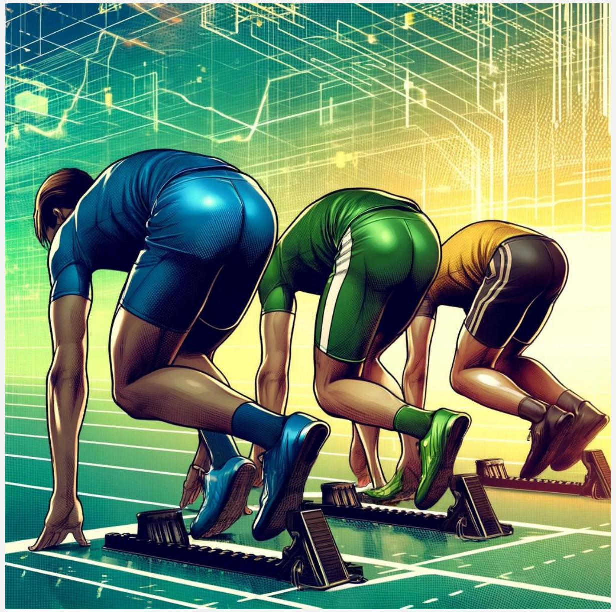

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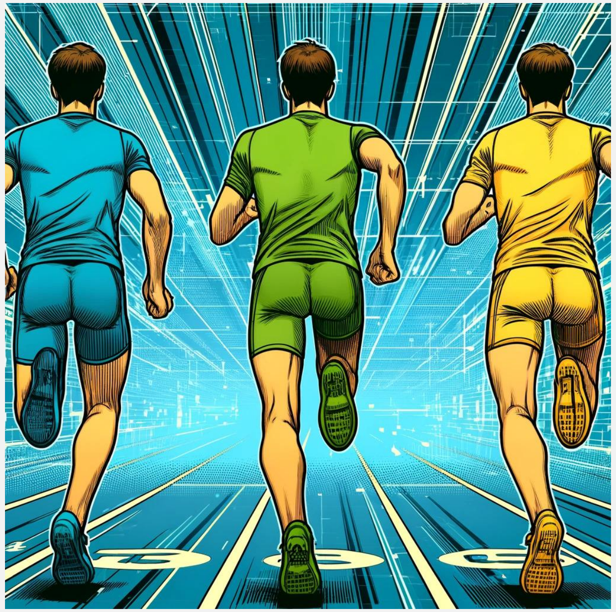

Requirements for Measuring Energy Consumption

Measurable	Comparable	Reviewable	Iterable
choose significant sensors (typically for CPU & memory)	iterate and average measurements	measure on the same hardware	repeat measurements regularly or upon changes
measure values that correlate to energy consumption	avoid noise and interferences	automate the setup	

Measurement Tools under Consideration

- LiMo
- Green Metrics Tool
- Kepler

Approach 1: Simple Linear Model

LiMo

Approach:

- measure usage of CPU usage and memory of a container
- normalize measured values into comparable ranges ("energy consumption") via constant factors

Assumptions:

- simple linear model
- constant factors are realistic (see greenframe.io)

Approach 2: Detailed Hardware Model

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Green Metrics Tool

Approach:

- run system of containers and measure changes to the idle state of the machine
- compute the energy consumption from measured sensor values and based on a knowledge of the hardware

Assumptions:

- most systems are built on containers
- hardware sensors and machine model give sufficient insights, higher level of details would be unreliable

Approach 3: Fine-Granular CPU Measurement

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Kepler

Approach:

- collect Linux performance counters and further hardware sensors with low overhead at system runtime
- compute the energy consumption from measured sensor values, optionally supported by machine learning

Assumptions:

- CPU usage dominates energy consumption
- relevant systems run on Kubernetes and Linux

Comparing Measurement Tools

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LiMo

Green Metrics Tool

Kepler

High-Level Comparison

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LiMo	Green Metrics Tool	Kepler
focus on benchmarks, possibly artificial setup	focus on benchmarks, possibly artificial setup	continuous measurement, even in production environment
very few fixed sensors	configurable set of sensors, support for custom sensors	rich fixed set of sensors
linear model with factors based on greenframe.io	hardware-specific, non-linear model with machine learning	linear model, support for machine-learning model

Technical Comparison

LiMo	Green Metrics Tool	Kepler
application runs in Docker	application runs in Docker	application runs in Kubernetes
focus on a single container	holistic view of an entire machine	statistics for all pods and nodes in a cluster
no history of runs, no graphical views	history of runs, graphical comparison	continuous history, graphical dashboards

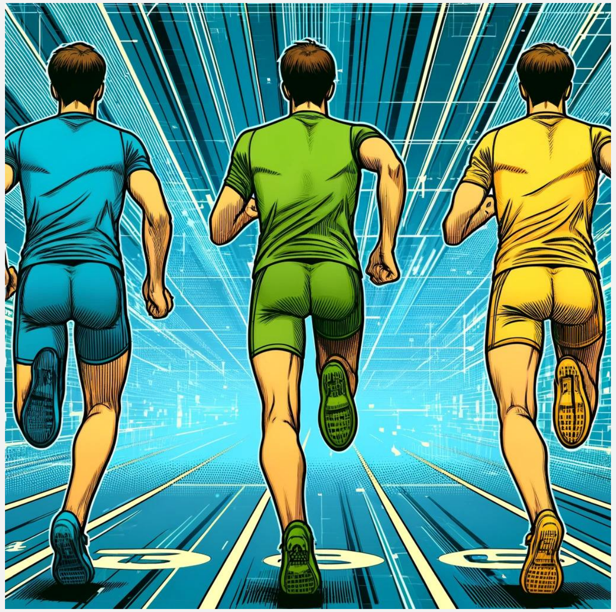
Experience Report

LiMo	Green Metrics Tool	Kepler
simple setup, easy usage	complex setup, smooth usage	standard setup, slightly complex usage
doubtful factors for scaling measurements	not very well suited for long running processes, issues in configuration	regular outages and issues at runtime
applicable to simple, initial analyses	well-suited for full-stack benchmarks, elaborate model	well-suited for trends, usable for comparisons, insights into running clusters

Ready

Steady

Go



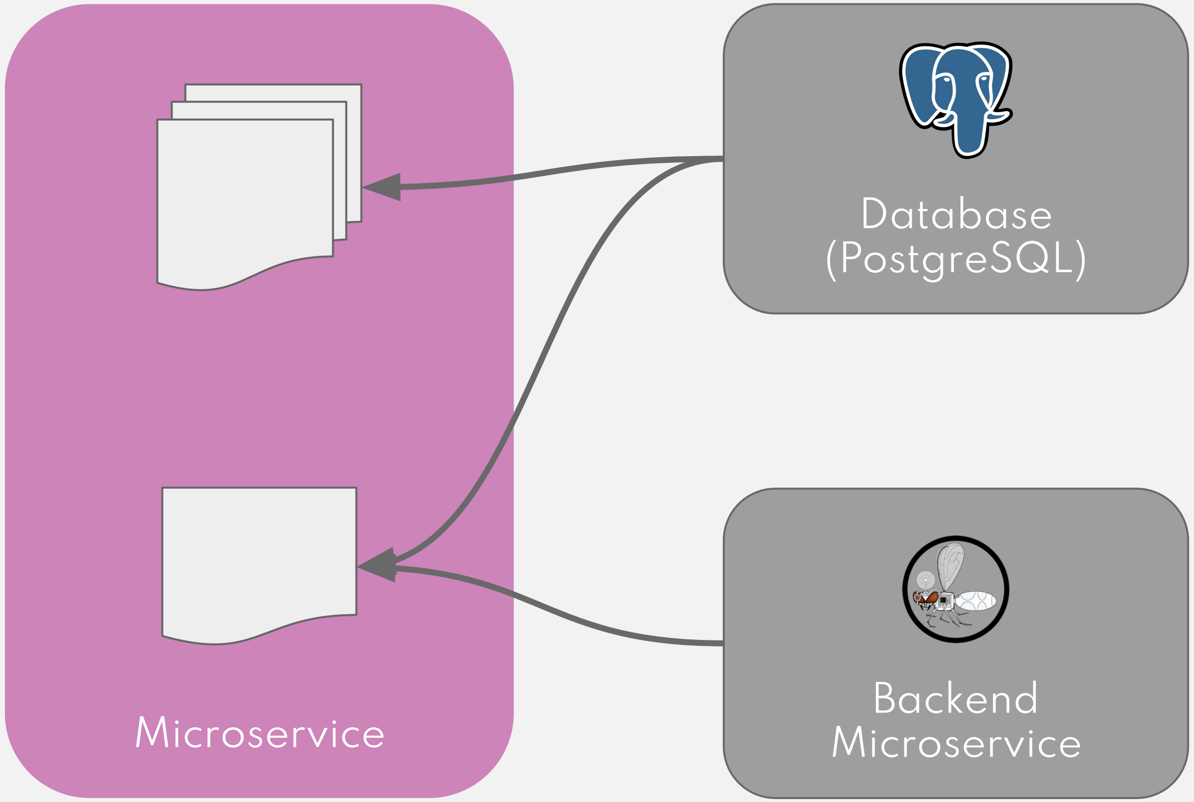
Comparison Setup

Overview

- pick a random page of 10 items

Details

- pick a random item
- enrich with 3 data points
- fetch data for every data point



5;000 items

15;000 data points

provides random data with a random delay for a GET request

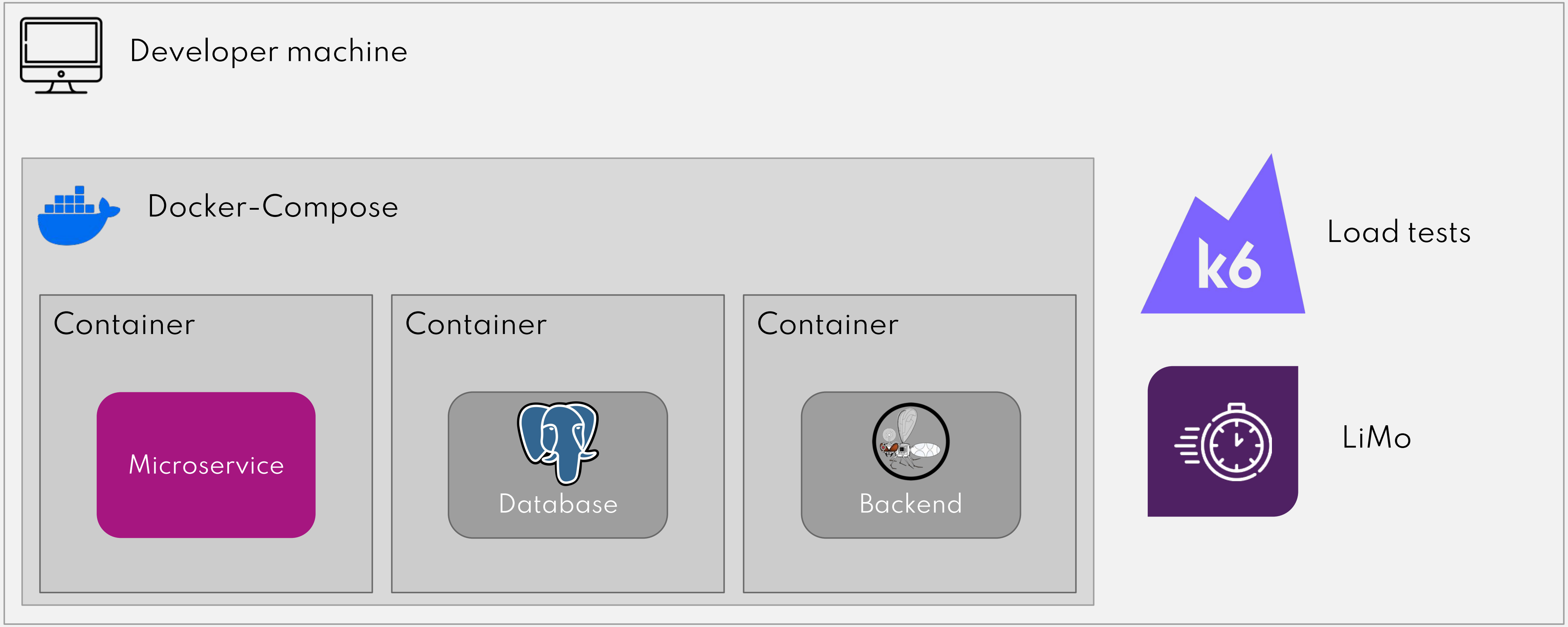
Competitors

Rust

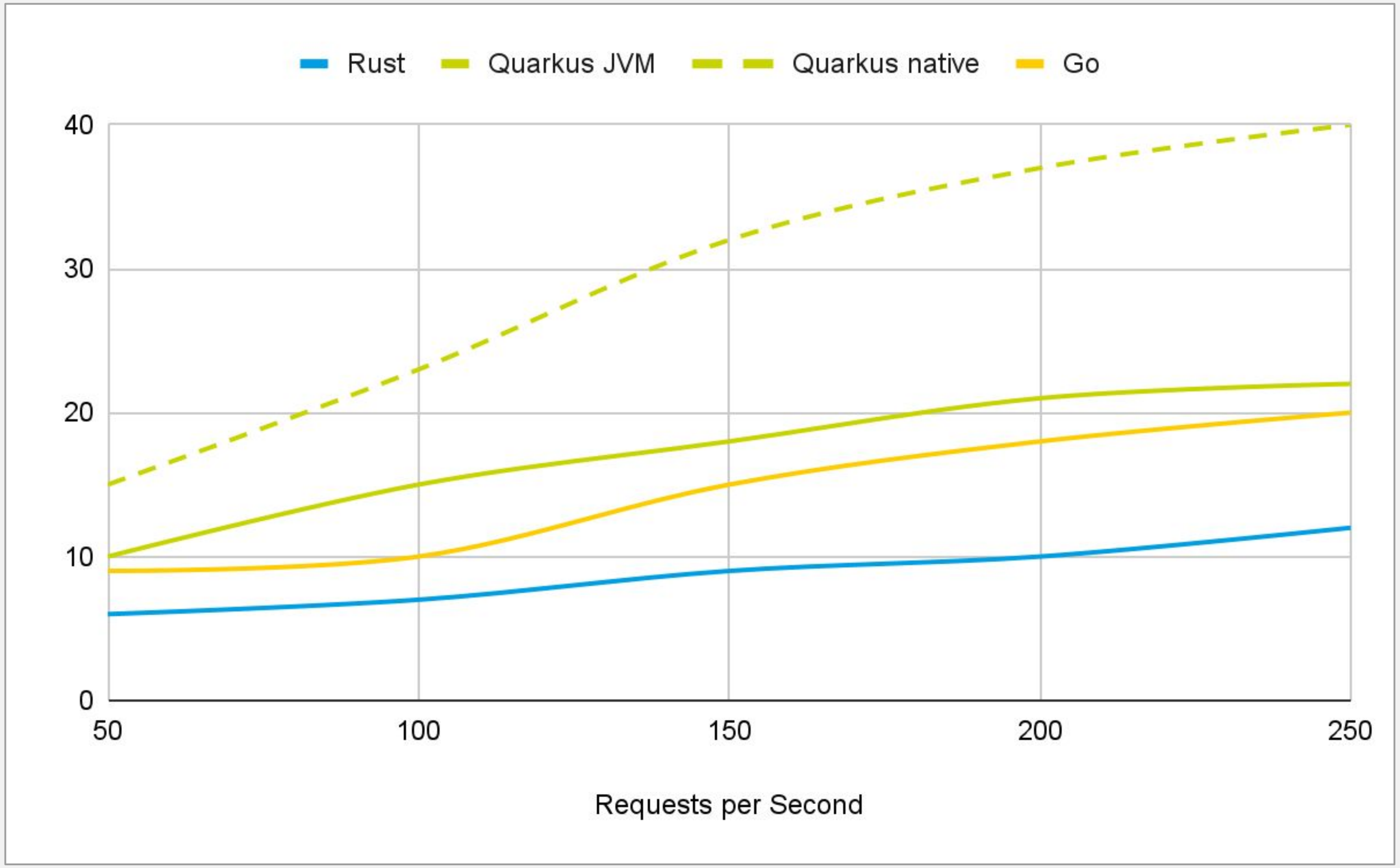
Quarkus
(Java)

Go

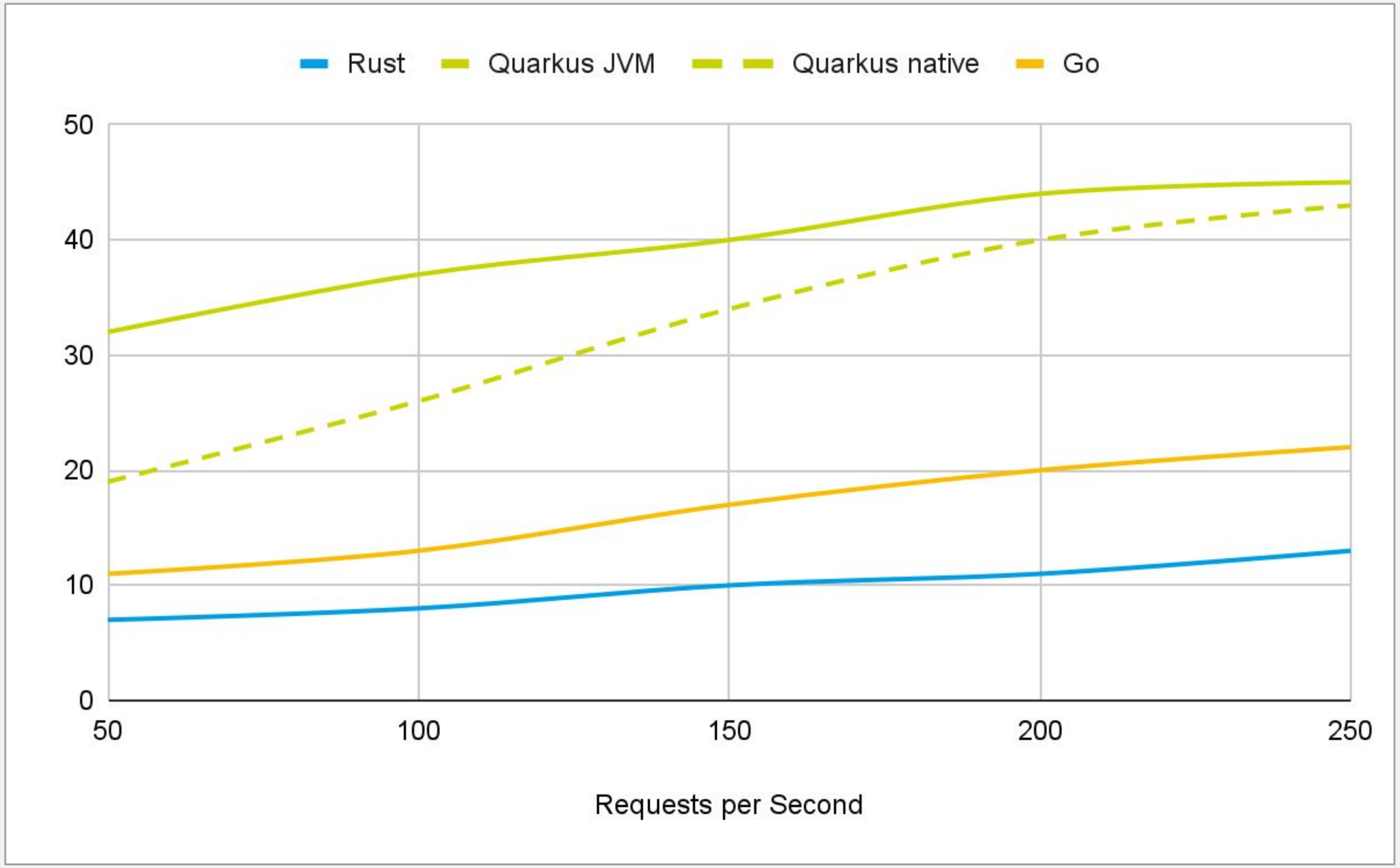
LiMo Test Infrastructure Setup



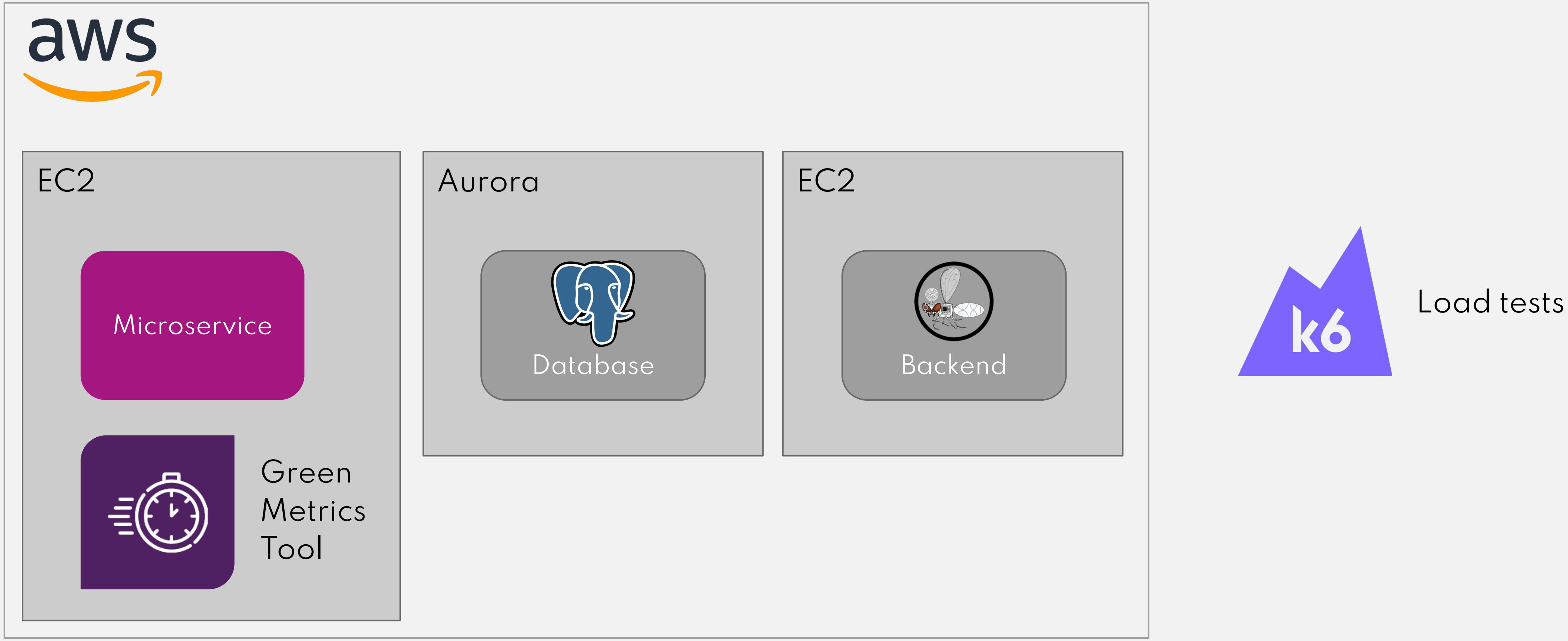
LiMo-Based Comparison: CPU only



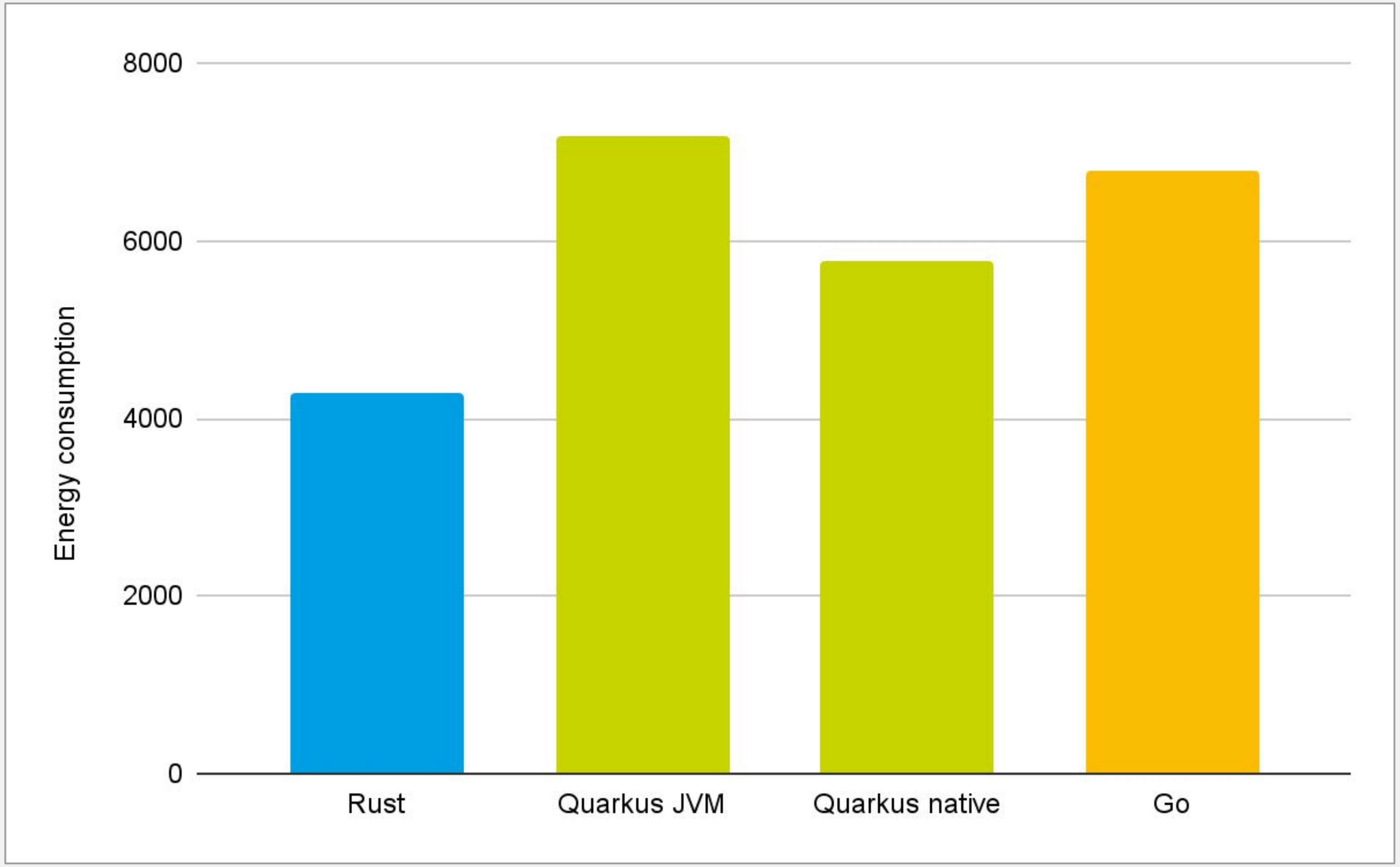
LiMo-Based Comparison: CPU and Memory



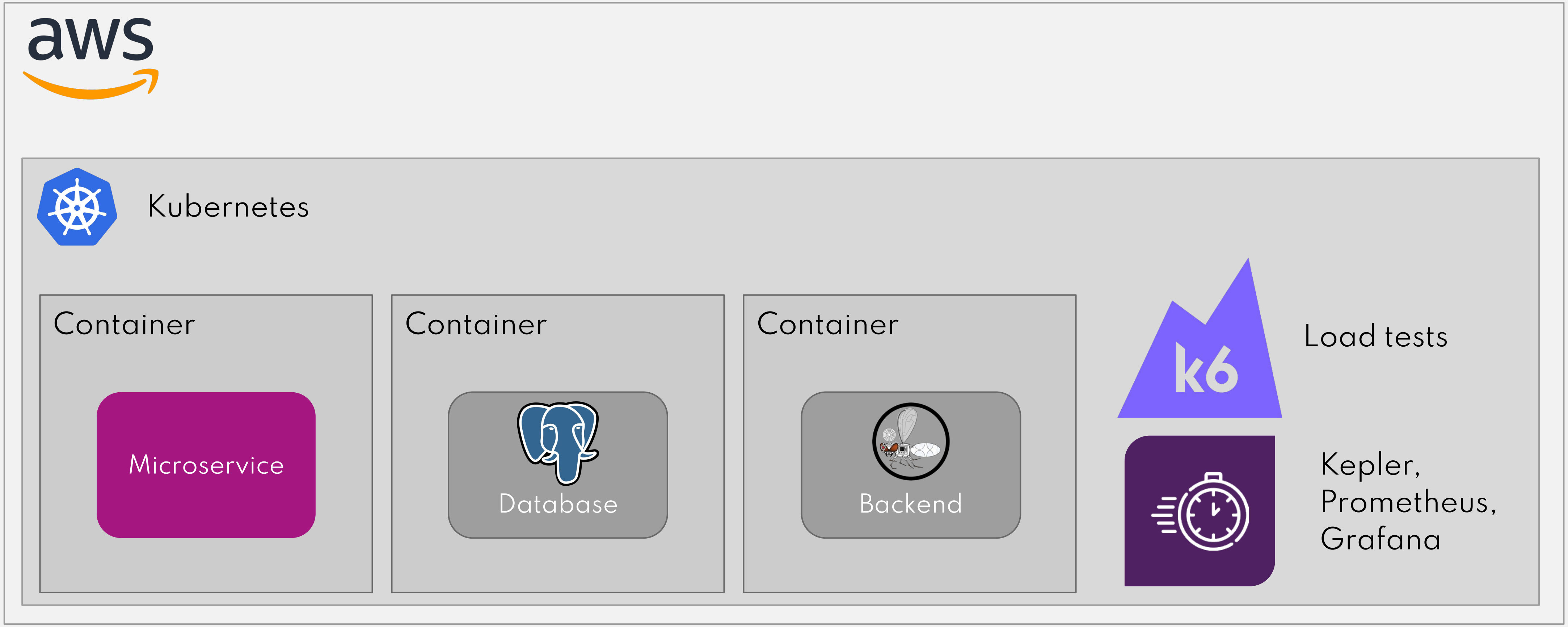
GMT Test Infrastructure Setup



GMT-Based Comparison



Kepler Test Infrastructure Setup



aws

Kubernetes

Container

Microservice

Container

Database

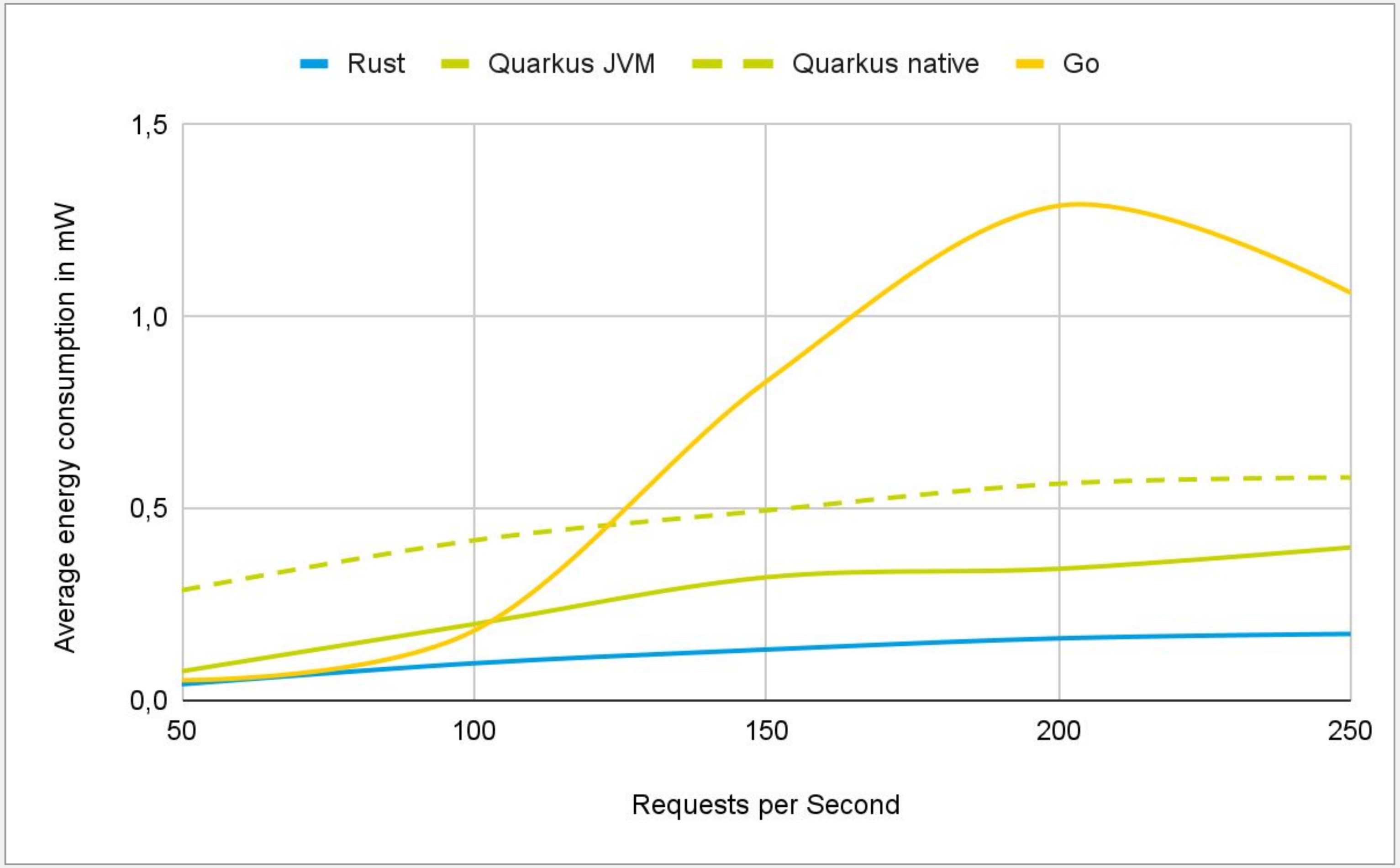
Container

Backend

Load tests

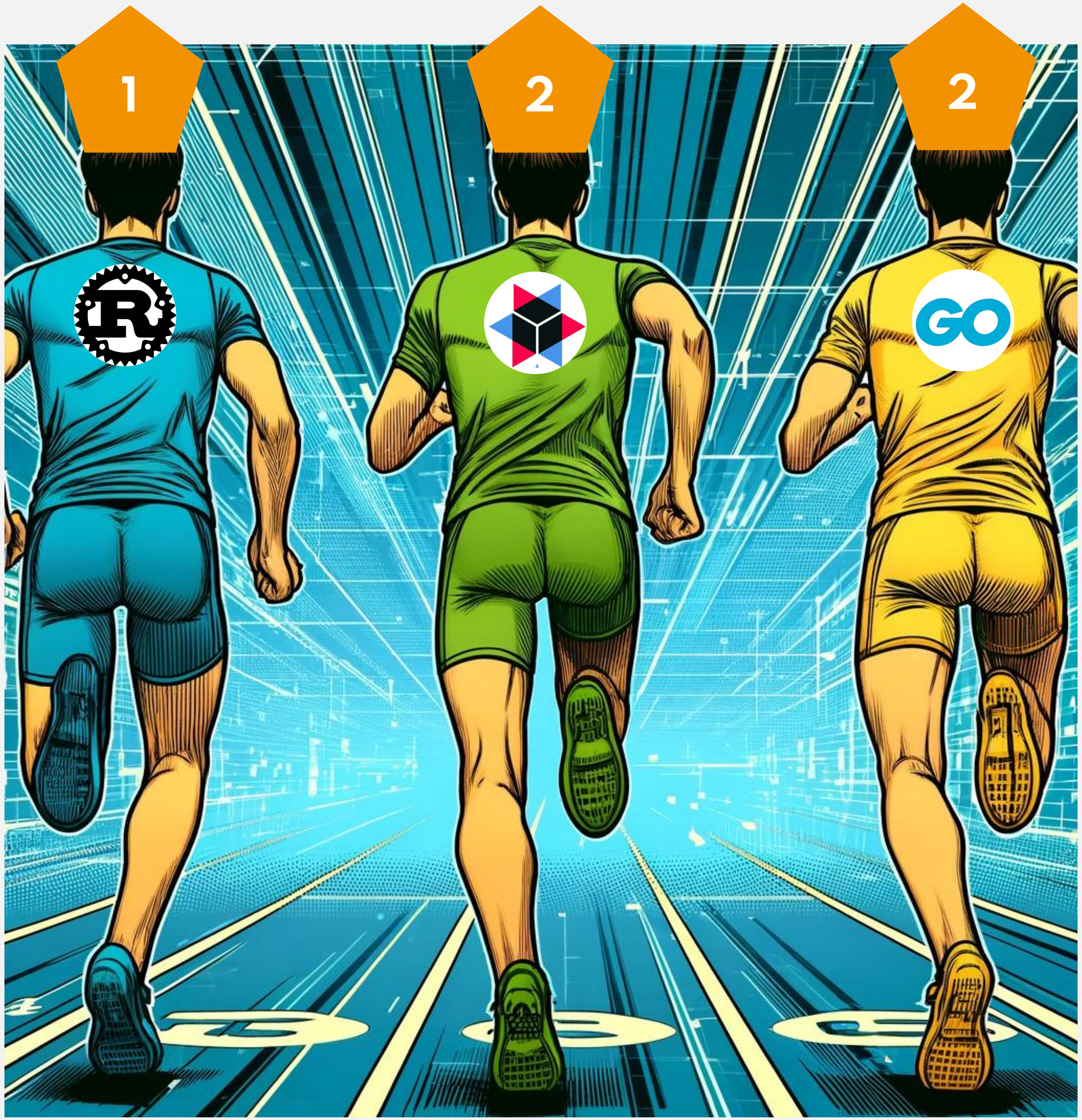
Kepler,
Prometheus,
Grafana

Kepler-Based Comparison



Awards

- Rust: consistent, low energy consumption
- Go: medium energy consumption, high variance
- Quarkus: medium energy consumption, unclear benefit of native mode

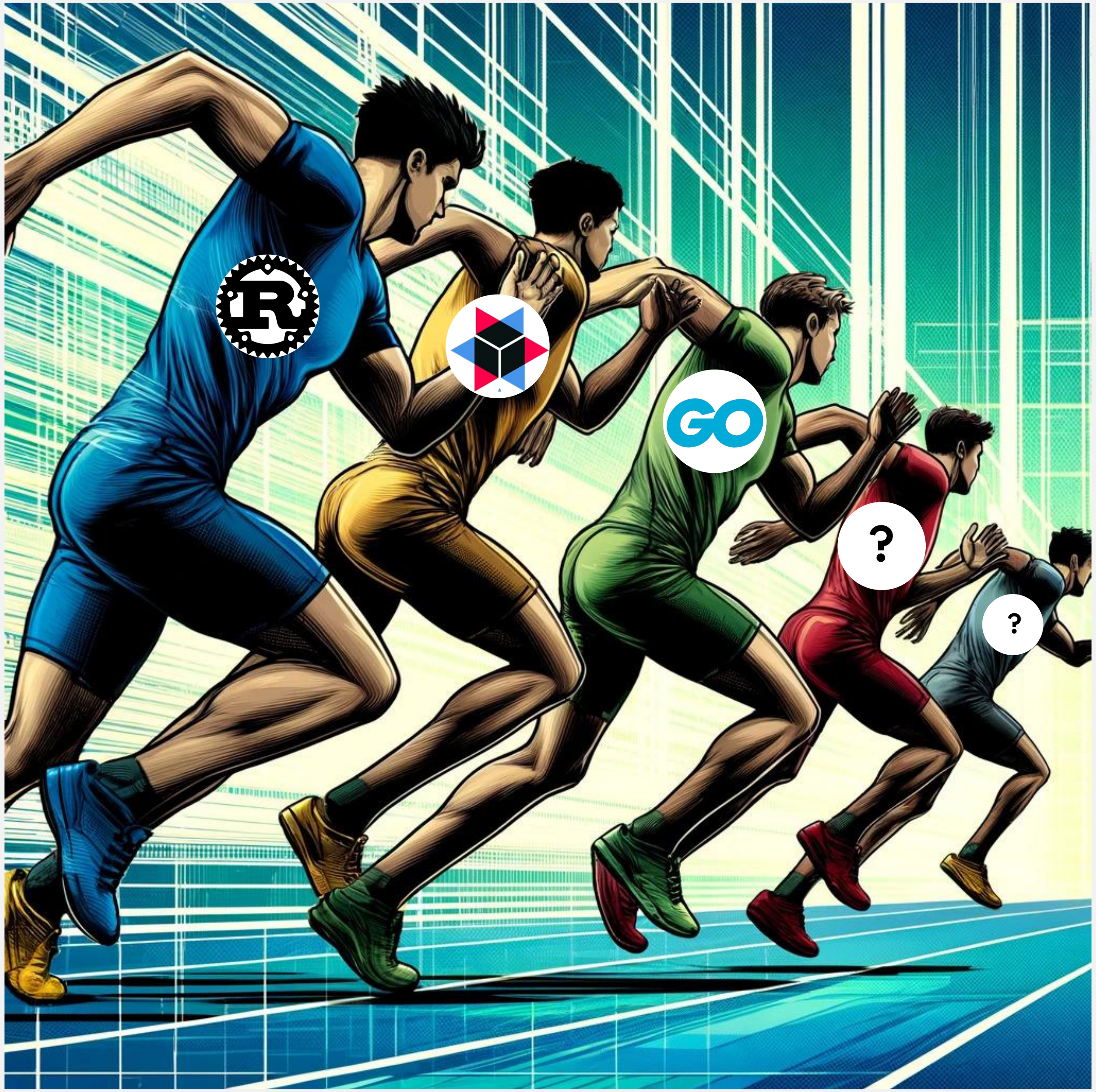


The Next Comparison

Further implementations:

- Javascript?
- Java with Spring?
- ? something else?

With improved measuring tools?



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