AERO software stack, Java apps for cloud-native world with Quarkus

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Slides: https://karms.biz/dc2k23

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Overview

- Quarkus?
  - Best-of-breed Java libraries that you love and use. All wired on a standard backbone
  - Cloud-native as in: as small as possible, as mindful about resources as possible
- GraalVM?
  - Custom JDK with custom JIT, AOT capabilities, polyglot capabilities and more
- Mandrel?
  - native-image release specifically to support Quarkus, laser focused on Java, comes with vanilla Temurin JDK (Adoptium)
- Native-image?
  - A tool that compiles Java code ahead-of-time (AOT) to a binary – a native executable
- It compiles on AArch64, ship it (or not): Quality engineering
  - What we do to make the Quarkus ecosystem more and more AArch64 ready

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How do I start with Quarkus on ARM?

https://code.quarkus.io

```
export JAVA_HOME=/home/tester/dc2k23/jdk-17.0.7+7/;export PATH=$JAVA_HOME/bin:$PATH
curl -O -J https://code.quarkus.io/d?e=io.quarkus:quarkus-resteasy-reactive
unzip code-with-quarkus.zip
cd code-with-quarkus
./mvnw package -Pnative -Dquarkus.native.container-build=true
./target/code-with-quarkus-1.0.0-SNAPSHOT-runner
```

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Quarkus extensions, Quarkus platform, Quarkiverse

https://github.com/quarkusio/quarkus/tree/main/extensions

https://github.com/quarkusio/quarkus-platform

https://github.com/quarkiverse

- There are shared object (.so) libraries packaged inside many jars as various dependencies
- These libraries are either:
  - Loaded via standard Java Native Interface (JNI) at runtime in HotSpot, normal Java mode
  - Or are carefully dealt with during native-image compilation when their access to Java code is marked beforehand in a config file and their initialization is delayed to runtime, escaping the “init at build time” Quarkus native-image default
- Linux AArch64:
  - Is linux/aarch64 present?
  - How was the lib built, target ARM version etc.

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Quarkus extensions, Quarkus platform, Quarkiverse

- Examples, Quarkus extensions dependencies with native libs, including Maven dev experience:
  - com/github/luben/zstd-jni (compression)
  - com/github/jnr/jffi (foreign function interface), Extension processor -> Asciidoctor ->JRuby
  - **com/aayushatharva/brotli4j and brotli** (compression), missing Linux aarch64 lib
  - **com/swoval/file-tree-views** (filesystem browsing), missing Linux aarch64 lib
  - org/fusesource/jansi (terminal control, colours etc.)
  - io/netty/netty-transport-native-epoll (I/O)
  - io/netty/incubator/netty-incubator-transport-native-io_uring (I/O, storage)
  - io/netty/netty-tcnative-boringssl-static (crypto)
  - io/grpc/grpc-netty (remote procedure call)
  - **org/apache/activemq/activemq-artemis-native** (messaging broker), missing Linux aarch64 lib
  - org/jetbrains/kotlin/kotlin-compiler, kotlin-daemon (Kotlin integration)
  - org/lz4/lz4-java (compression)
  - org/mongodb/mongodb-crypt (client crypto)
  - org/xerial/snappy/snappy-java (compression)
  - org/rocksdb/rocksdbjni (database)
  - **org/conscrypt/conscrypt-openjdk-uber** (crypto), missing Linux aarch64 lib
  - org/elasticsearch/jna (JNA for Elastic)
  - JNA (Java Native Access)

Mandrel builds, your native-image tool

- Tarballs: https://github.com/graalvm/mandrel/releases
  - Temurin aarch64 JDK without any additional patches
  - Native-image tool from GraalVM
  - Includes AArch64
- Container images: quay.io/quarkus/ubi-quarkus-mandrel-builder-image
  - RHEL UBI (Universal Base Image 8, latest released)
  - As above, Temurin, native-image
  - Multiarch, amd64 + arm64

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How do we test aarch64 readiness?

...small reproducers, complex apps, Quarkus, stress, perf...

- Examples:
- Quarkus Integration Tests
  https://github.com/quarkusio/quarkus/tree/main/integration-tests
- Mandrel Integration Tests
  https://github.com/Karm/mandrel-integration-tests
- Selected apps from Quarkus quickstarts
  https://github.com/quarkusio/quarkus-quickstarts/tree/main/awt-graphics-rest-quickstart
- Workbench for some targeted small apps and reproducers
  https://github.com/Karm/dev-null
- Build scripts written in Java using JBang, anyone can build from source easily (really :))
  https://github.com/graalvm/mandrel-packaging

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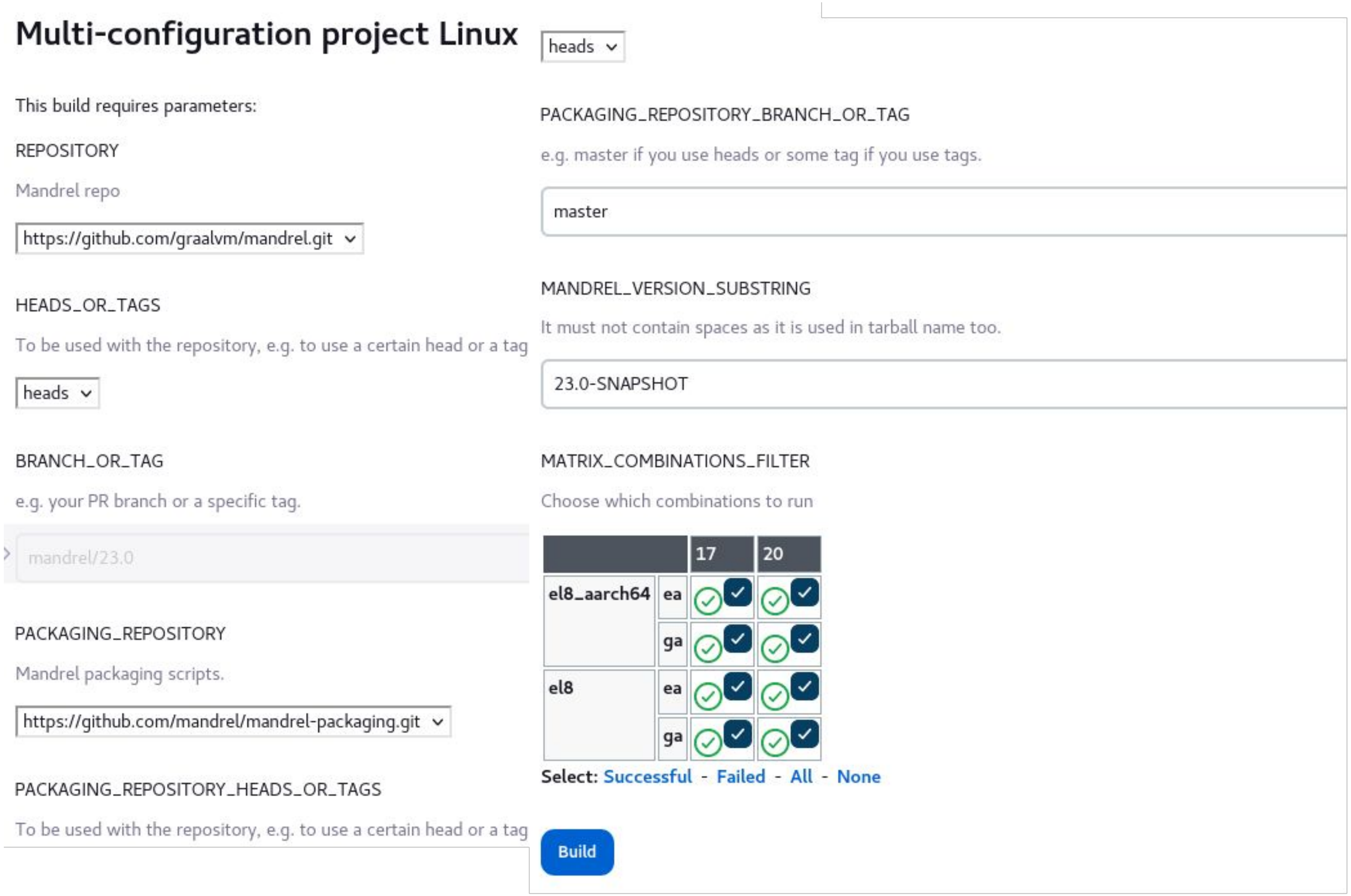
Mandrel (native-image) https://ci.modcluster.io/view/Mandrel/ (our public facing workbench, prototyping, Mandrel release testing)



Multi-configuration project Linux

This build requires parameters:

REPOSITORY

Mandrel repo

https://github.com/graalvm/mandrel.git ⌄

HEADS_OR_TAGS

To be used with the repository, e.g. to use a certain head or a tag

heads ⌄

BRANCH_OR_TAG

e.g. your PR branch or a specific tag.

mandrel/23.0

PACKAGING_REPOSITORY

Mandrel packaging scripts.

https://github.com/mandrel/mandrel-packaging.git ⌄

PACKAGING_REPOSITORY_HEADS_OR_TAGS

To be used with the repository, e.g. to use a certain head or a tag

heads ⌄

PACKAGING_REPOSITORY_BRANCH_OR_TAG

e.g. master if you use heads or some tag if you use tags.

master

MANDREL_VERSION_SUBSTRING

It must not contain spaces as it is used in tarball name too.

23.0-SNAPSHOT

MATRIX_COMBINATIONS_FILTER

Choose which combinations to run

		17	20
el8_aarch64	ea	✓ ☑	✓ ☑
	ga	✓ ☑	✓ ☑
el8	ea	✓ ☑	✓ ☑
	ga	✓ ☑	✓ ☑

Select: Successful - Failed - All - None

Build

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HW we currently work with the most

1x CentOS 8 AArch64 – 80 cores, 256GB RAM, baremetal
1x CentOS 9 AArch64 – 80 cores, 256GB RAM, baremetal

Do NOT use this desk, please.
NO FOOD & NO DRINKS
You can have a look, but DO NOT TOUCH
KARM@REDHAT.com
OPENJDK QE

Ampere® Altra® 64-Bit Multi-Core Processor Datasheet
Processor Subsystem

- 80 Arm® v8.2+ 64-bit CPU cores up to 3.30 GHz maximum
- 64 KB L1 I-cache, 64 KB L1 D-cache per core
- 1 MB L2 cache per core
- 32 MB System Level Cache (SLC)
- 2x full-width (128b) SIMD
- Coherent Mesh Interconnect (CMI):

– Distributed snoop filtering

Source: datasheet

WORKS ON arm

The architecture is aligned with the main AArch64 core of the European Processor, i.e. Neoverse N1.

Both systems are housed in a proper datacenter now :)

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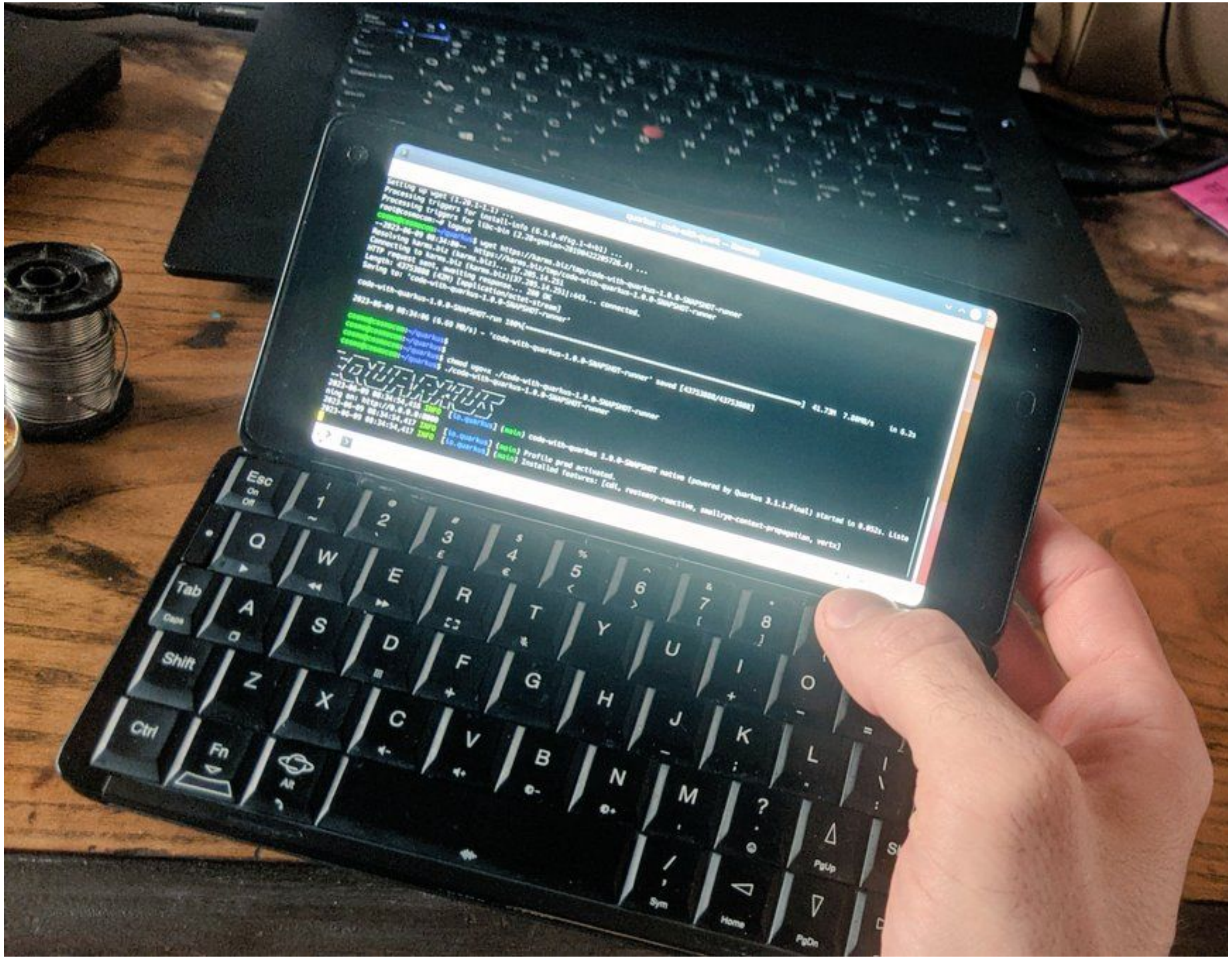
AERO

Mandrel (native-image)



```
Setting up wget (1.20.1-1.1) ...
Processing triggers for install-info (6.5.0.dfsg.1-4+b1) ...
Processing triggers for libc-bin (2.28-gemian-20190422205726.4) ...
root@cosmocom:~# logout
cosmo@cosmocom:~/quarkus$ wget https://karms.biz/tmp/code-with-quarkus-1.0.0-SNAPSHOT-runner
--2023-06-09 08:34:00--  https://karms.biz/tmp/code-with-quarkus-1.0.0-SNAPSHOT-runner
Resolving karms.biz (karms.biz)... 37.205.14.251
Connecting to karms.biz (karms.biz)|37.205.14.251|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 43753088 (42M) [application/octet-stream]
Saving to: 'code-with-quarkus-1.0.0-SNAPSHOT-runner'

code-with-quarkus-1.0.0-SNAPSHOT-run 100%[===================>]  41.73M  7.08MB/s    in 6.2s

2023-06-09 08:34:06 (6.69 MB/s) - 'code-with-quarkus-1.0.0-SNAPSHOT-runner' saved [43753088/43753088]

cosmo@cosmocom:~/quarkus$
cosmo@cosmocom:~/quarkus$
cosmo@cosmocom:~/quarkus$ chmod ugo+x ./code-with-quarkus-1.0.0-SNAPSHOT-runner
cosmo@cosmocom:~/quarkus$ ./code-with-quarkus-1.0.0-SNAPSHOT-runner
2023-06-09 08:34:54,416 INFO  [io.quarkus] (main) code-with-quarkus 1.0.0-SNAPSHOT native (powered by Quarkus 3.1.1.Final) started in 0.052s. Listening on: http://0.0.0.0:8080
2023-06-09 08:34:54,417 INFO  [io.quarkus] (main) Profile prod activated.
2023-06-09 08:34:54,417 INFO  [io.quarkus] (main) Installed features: [cdi, resteasy-reactive, smallrye-context-propagation, vertx]
```

Runs on 2018 MediaTed Helio P70 ARMv8-A chipset just fine too.

The Quarkus application was built on the Ampere Altra machine and the executable runs on my cellphone, Cosmo Communicator.

Quarkus is ready to serve requests on its REST endpoints in 52ms.

Metrics collection

There are two main areas where we measure performance:

- **Buildtime** - how long does it take to build the application all the way from a dependency tree of all the jar files to a native executable
- **Runtime** - how well the application performs at its task, how it utilizes the resources
  - An additional runtime topic is debugging (gdb) experience

- **Metrics collector,** written with Quarkus, deployed as a native-image executable. My server does not have any Java installed :) https://github.com/Karm/collector (Java, Quarkus, native-image, DB)
- **Dashboard**, work in progress https://github.com/Karm/collector-web (C, WASM, ImPlot, Imgui)
- **Grafana** - private account, prototyping, ideas sketchbook

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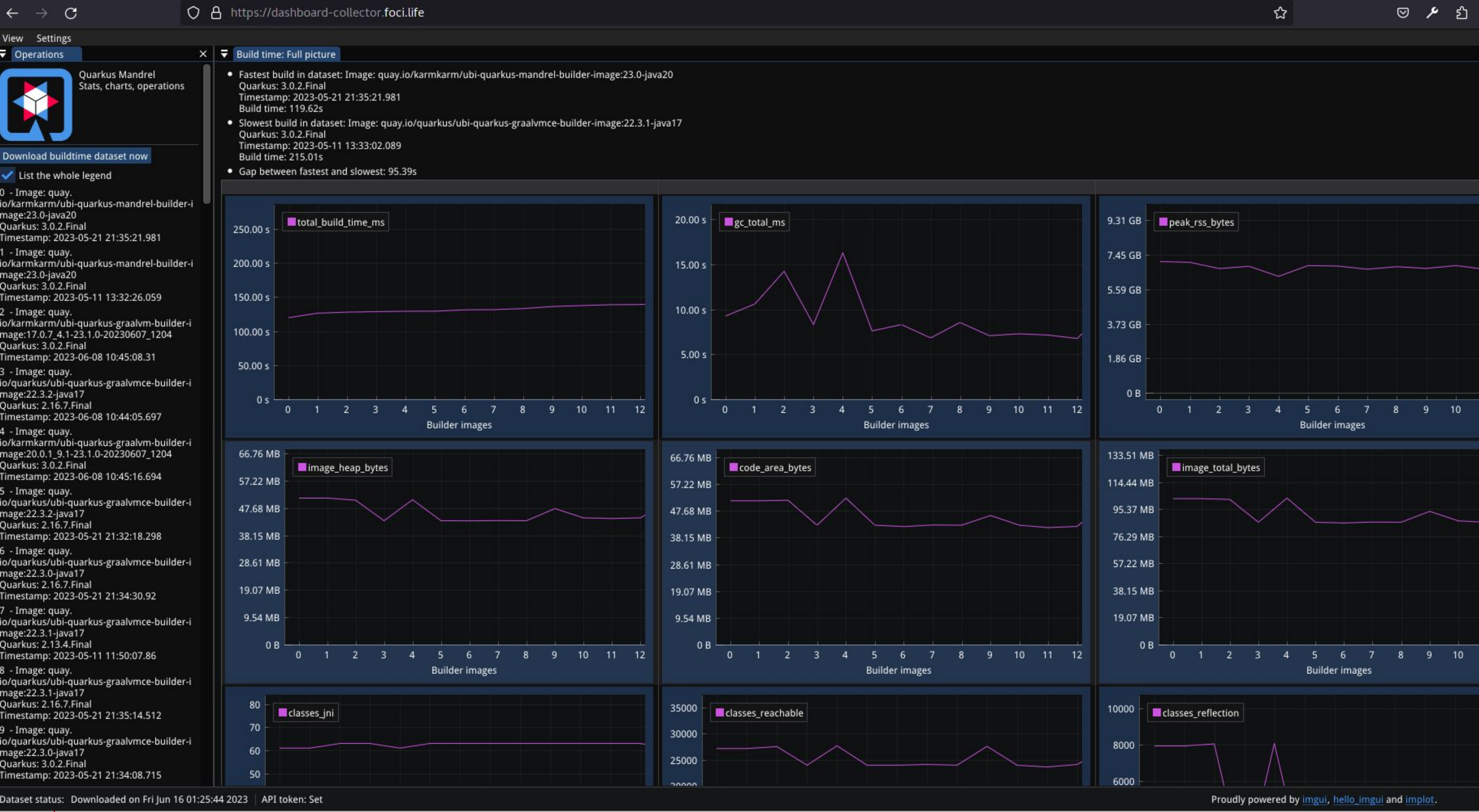

- Fastest build in dataset: Image: quay.io/karmkarm/ubi-quarkus-mandrel-builder-image:23.0-java20
  Quarkus: 3.0.2.Final
  Timestamp: 2023-05-21 21:35:21.981
  Build time: 119.62s
- Slowest build in dataset: Image: quay.io/quarkus/ubi-quarkus-graalvmce-builder-image:22.3.1-java17
  Quarkus: 3.0.2.Final
  Timestamp: 2023-05-11 13:33:02.089
  Build time: 215.01s
- Gap between fastest and slowest: 95.39s

0 - Image: quay.io/karmkarm/ubi-quarkus-mandrel-builder-image:23.0-java20
Quarkus: 3.0.2.Final
Timestamp: 2023-05-21 21:35:21.981

1 - Image: quay.io/karmkarm/ubi-quarkus-mandrel-builder-image:23.0-java20
Quarkus: 3.0.2.Final
Timestamp: 2023-05-11 13:32:26.059

2 - Image: quay.io/karmkarm/ubi-quarkus-graalvm-builder-image:17.0.7_4.1-23.1.0-20230607_1204
Quarkus: 3.0.2.Final
Timestamp: 2023-06-08 10:45:08.31

3 - Image: quay.io/quarkus/ubi-quarkus-graalvmce-builder-image:22.3.2-java17
Quarkus: 2.16.7.Final
Timestamp: 2023-06-08 10:44:05.697

4 - Image: quay.io/karmkarm/ubi-quarkus-graalvm-builder-image:20.0.1_9.1-23.1.0-20230607_1204
Quarkus: 3.0.2.Final
Timestamp: 2023-06-08 10:45:16.694

5 - Image: quay.io/quarkus/ubi-quarkus-graalvmce-builder-image:22.3.2-java17
Quarkus: 2.16.7.Final
Timestamp: 2023-05-21 21:32:18.298

6 - Image: quay.io/quarkus/ubi-quarkus-graalvmce-builder-image:22.3.0-java17
Quarkus: 2.16.7.Final
Timestamp: 2023-05-21 21:34:30.92

7 - Image: quay.io/quarkus/ubi-quarkus-graalvmce-builder-image:22.3.1-java17
Quarkus: 2.13.4.Final
Timestamp: 2023-05-11 11:50:07.86

8 - Image: quay.io/quarkus/ubi-quarkus-graalvmce-builder-image:22.3.1-java17
Quarkus: 2.16.7.Final
Timestamp: 2023-05-21 21:35:14.512

9 - Image: quay.io/quarkus/ubi-quarkus-graalvmce-builder-image:22.3.0-java17
Quarkus: 3.0.2.Final
Timestamp: 2023-05-21 21:34:08.715

Dataset status: Downloaded on Fri Jun 16 01:25:44 2023 | API token: Set

Proudly powered by imgui, hello_imgui and implot.

Buildtime metrics

The compiler:
https://github.com/graalvm/mandrel/tree/mandrel/23.0/compiler

The compiler itself uses JVMCI toolchain to get processed bytecode and it itself runs on HotSpot, i.e. "normal" Java mode.
Could be compiled to a native executable too though.

```
...
 "resource_usage": {
        "memory": {
        "system_total": 268 651 671 552,
        "peak_rss_bytes": 7 539 224 576
        },
        "garbage_collection": {
        "count": 25,
        "total_secs": 0.948
        },
        "cpu": {
        "load": 15.374661613427183,
        "total_cores": 80
        },
        "total_secs": 36.113208942
 },
 "image_details": {
        "code_area": {
        "bytes": 24 791 072,
        "compilation_units": 39437
        },
        "total_bytes": 50300432,
        "image_heap": {
        "bytes": 25165824,
        "objects": {
        "count": 302849
        ...
```

```
...
 "general_info": {
        "c_compiler": "gcc (redhat, aarch64, 11.4.1)",
        "name": "quarkus-json_-ParseOnce-runner",
        "java_version": "17.0.7+7",
        "garbage_collector": "Serial GC",
        "graal_compiler": {
        "march": "armv8-a",
        "optimization_level": "2"
        },
        "vendor_version": "Mandrel-23.0.0.0-Final",
        "graalvm_version": "Mandrel-23.0.0.0-Final"
 }
...
```

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Runtime metrics

- Many cores, e.g. anything that allocates resources based on available cores could affect startup -Dquarkus.vertx.event-loops-pool-size=$(EVENT_LOOPS)
- CentOS 8 vs. 9, page size 4k or 64k
- Aspiration is to gradually make the most of the architecture of the European Processor, well beyond “it runs”

HotSpot

```
{
 "arch": "aarch64",
 "branchMisses": 388975946,
 "contextSwitches": 49037,
 "coresAvailable": 80,
 "cpuMigrations": 312,
 "cycles": 34151291755,
 "file": "java -Xlog:gc -XX:+UseSerialGC
-Xmx2560m -jar
target/quarkus-app/quarkus-run.jar",
 "instructions": 37462561471,
 "jdkVersion": "17.0.7",
 "mandrelVersion": "23.0.0",
 "maxHeapSizeMB": 2560,
 "os": "Linux",
 "pageFaults": 4192,
 "quarkusVersion": "3.1.1.Final",
 "ramAvailableMB": 245714,
 "requestsExecuted": 100,
 "rssKb": 731 072,
 "secondsTimeElapsed": "127.989580246",
 "taskClock": "12191.1",
 "timeSpentInGCs": "0.0",
 "timeToFirstOKRequestMs": 1385
}
```

Native-image

```
{
 "arch": "aarch64",
 "branchMisses": 20716103,
 "contextSwitches": 8106,
 "coresAvailable": 80,
 "cpuMigrations": 128,
 "cycles": 4755987724,
 "executableSizeKb": 69801,
 "file": "./target/quarkus-runner -XX:+PrintGC",
 "instructions": 7022538641,
 "jdkVersion": "17.0.7",
 "mandrelVersion": "23.0.0",
 "maxHeapSizeMB": 2560,
 "os": "Linux",
 "pageFaults": 2816,
 "quarkusVersion": "3.1.1.Final",
 "ramAvailableMB": 245700,
 "requestsExecuted": 100,
 "rssKb": 143 040,
 "secondsTimeElapsed": "126.720974422",
 "taskClock": "1964.77",
 "timeSpentInGCs": "0.076697",
 "timeToFirstOKRequestMs": 296
}
```

The test app is giant on purpose to stress the startup and runtime.

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Thank you

Quarkus was created to enable Java developers to create applications for a modern, cloud-native world. Quarkus is a Kubernetes-native Java framework tailored for GraalVM and HotSpot, crafted from best-of-breed Java libraries and standards.

https://quarkus.io

https://twitter.com/AERO_Project_EU

https://twitter.com/QuarkusIO

https://github.com/graalvm/mandrel

https://github.com/quarkusio/quarkus

Karm
https://github.com/Karm
https://twitter.com/_karm
https://www.linkedin.com/in/karmmichal

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Join us for this cool session:

Quarkus Super-Heroes Workshop

Saturday, June 17 at 10:15am - 11:35am
Speaker: Martin Štefanko

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