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AARHUS 2023

#GOTOaar

Java in the Cloud with GraalVM

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Oracle Labs

GOTO Aarhus

Steffen Muldbjerg @ Unsplash

What GraalVM offers

More performance with the Graal compiler

- Run your Java application faster
- New JIT compiler optimizations

Fast startup with Native Image

- Create standalone binaries with low footprint
- Instant performance

Polyglot VM

- Interop: extend your Java application with libraries from JavaScript, Python, R…
- High performance for all languages
- Polyglot tooling

GraalVM

JIT

```
java MyMainClass
```

AOT

```
native-image MyMainClass
./mymainclass
```

GraalVM 🤝 Java microservice frameworks

Java in the Cloud - Goals

Start Fast

Low Resource Usage

Minimize Vulnerability

Compact Packaging

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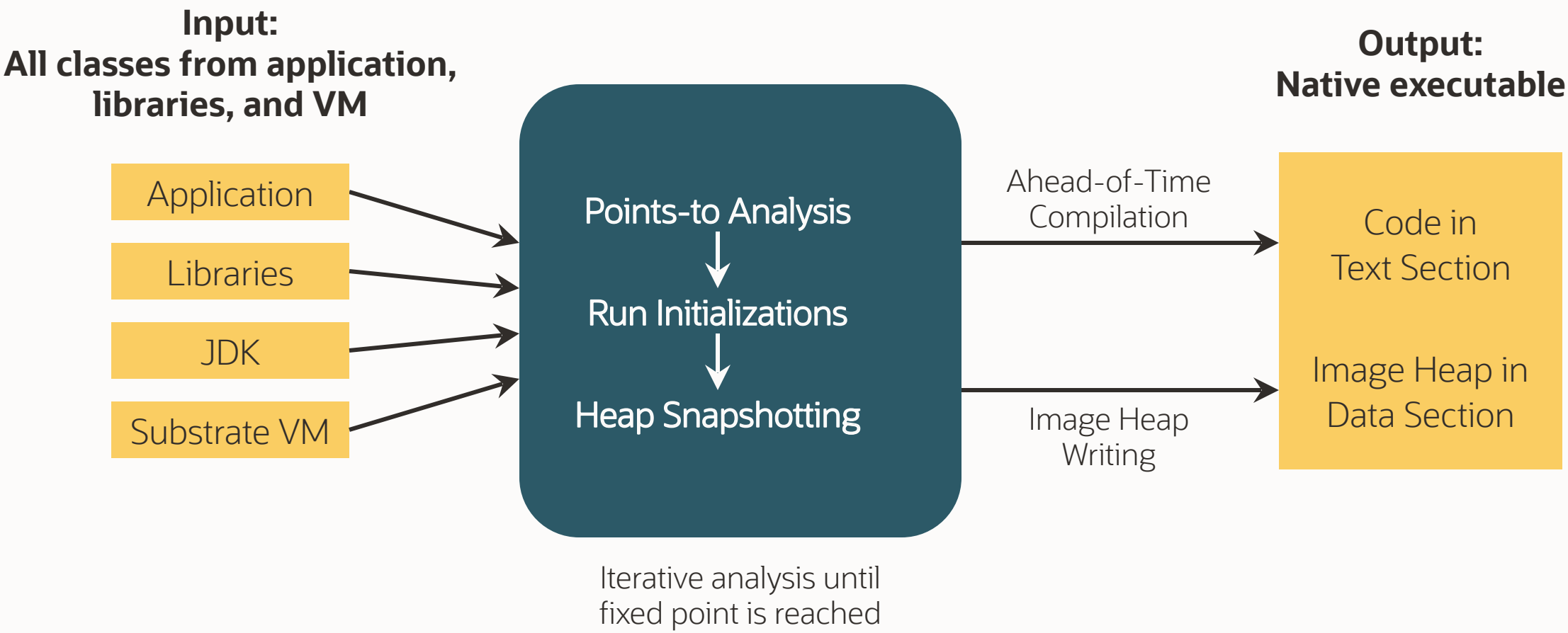
Native Image Build Process



JIT

Load JAR files from disk

⬇

Uncompress class files

⬇

Verify class definitions

⬇

Execute in interpreter (~20x slower)

⬇

Gather profiling feedback

⬇

Compile to machine code

⬇

Execute at peak performance

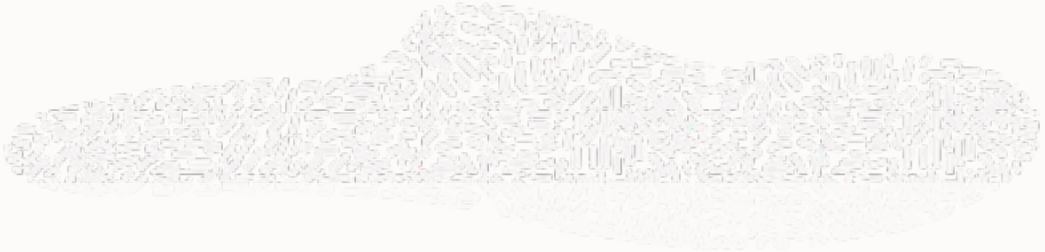
AOT

Load executable from disk

⬇

Execute at peak performance

Java in the Cloud - Goals



Start Fast

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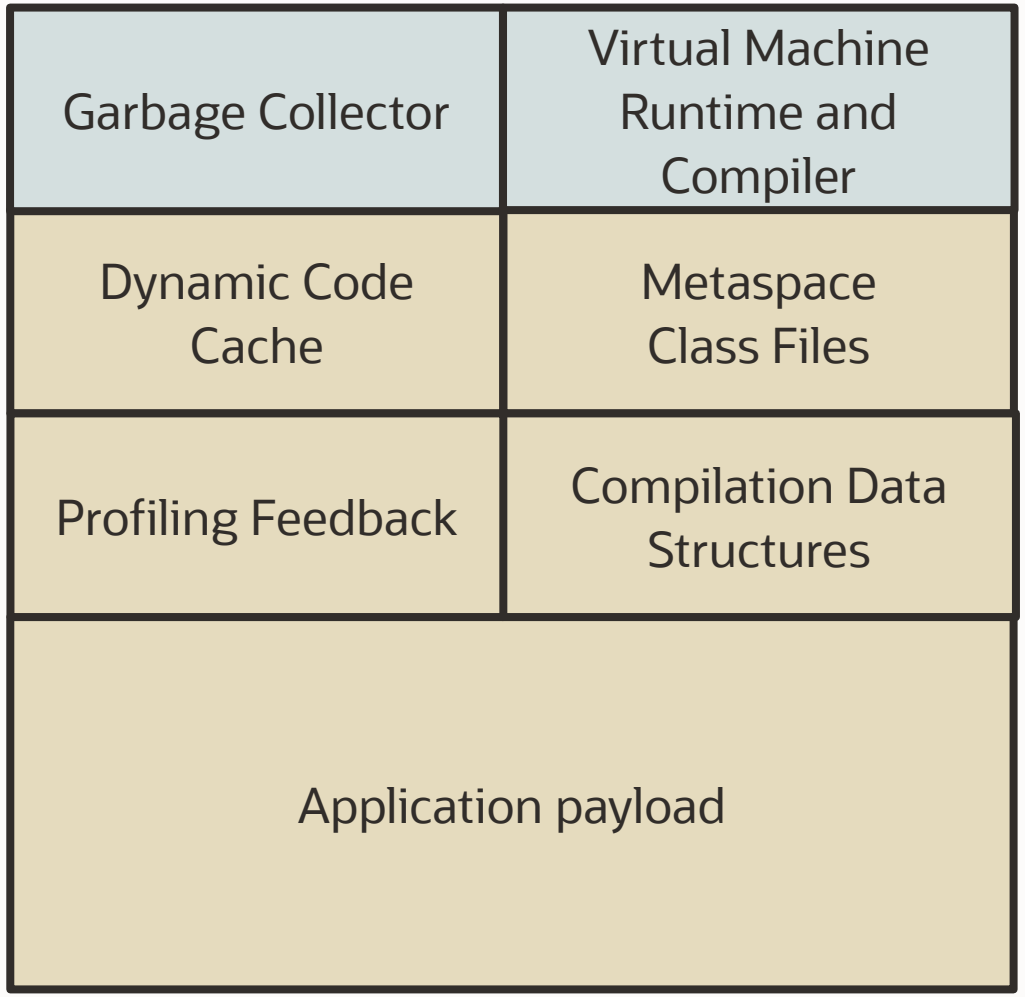
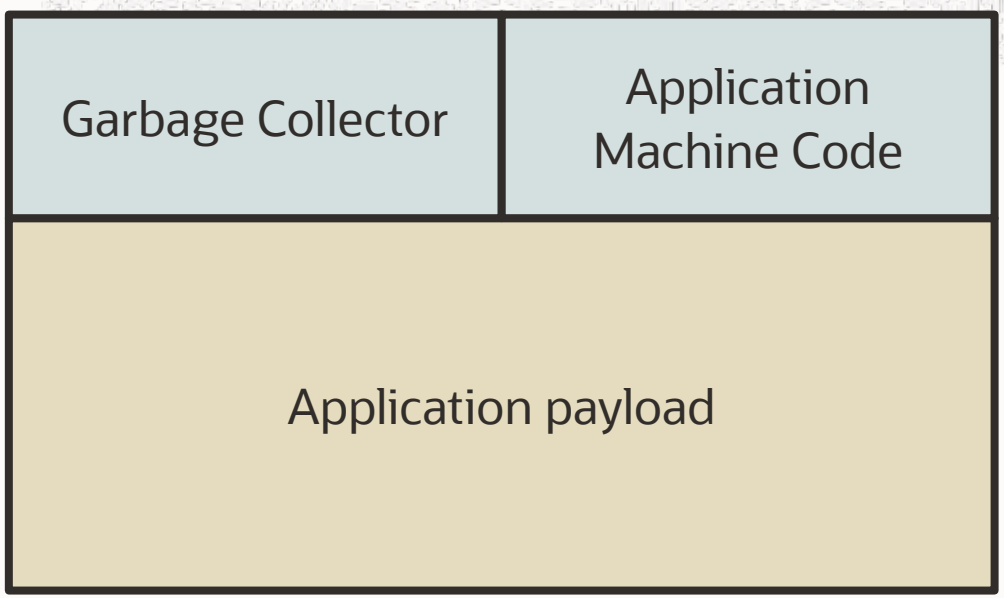
JIT



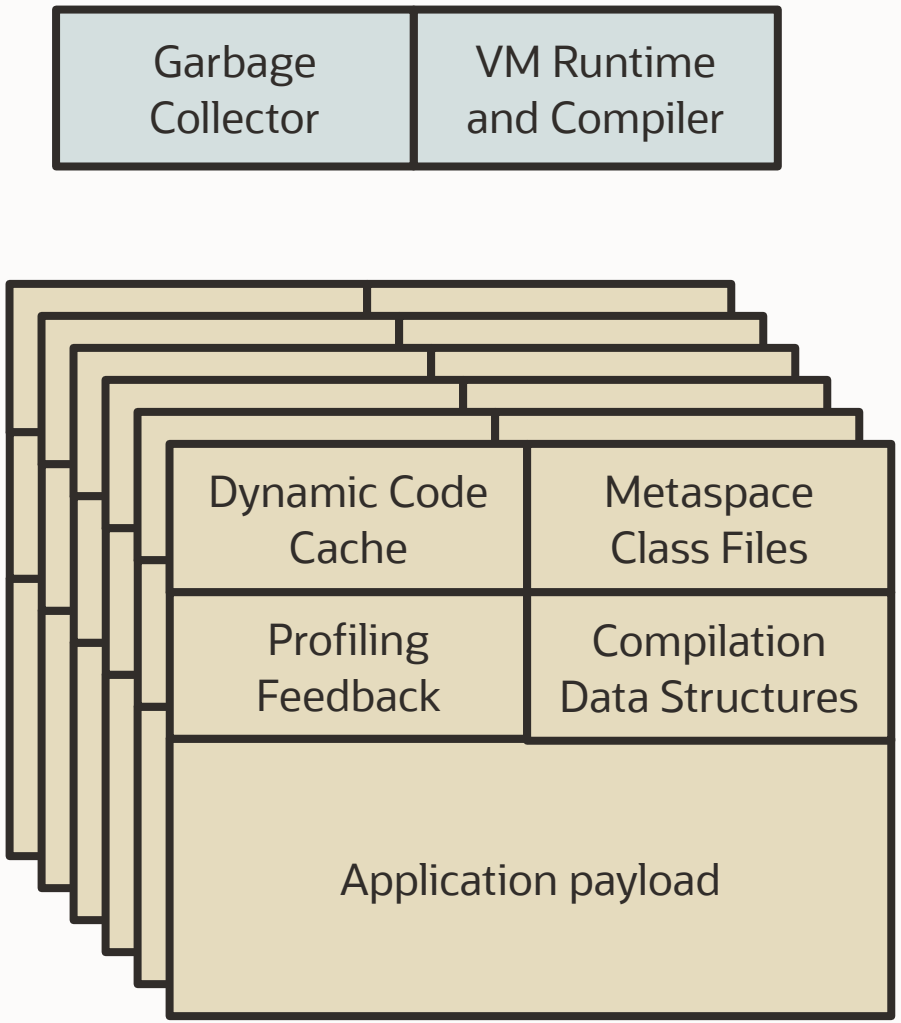
Memory

AOT



Memory Scalability

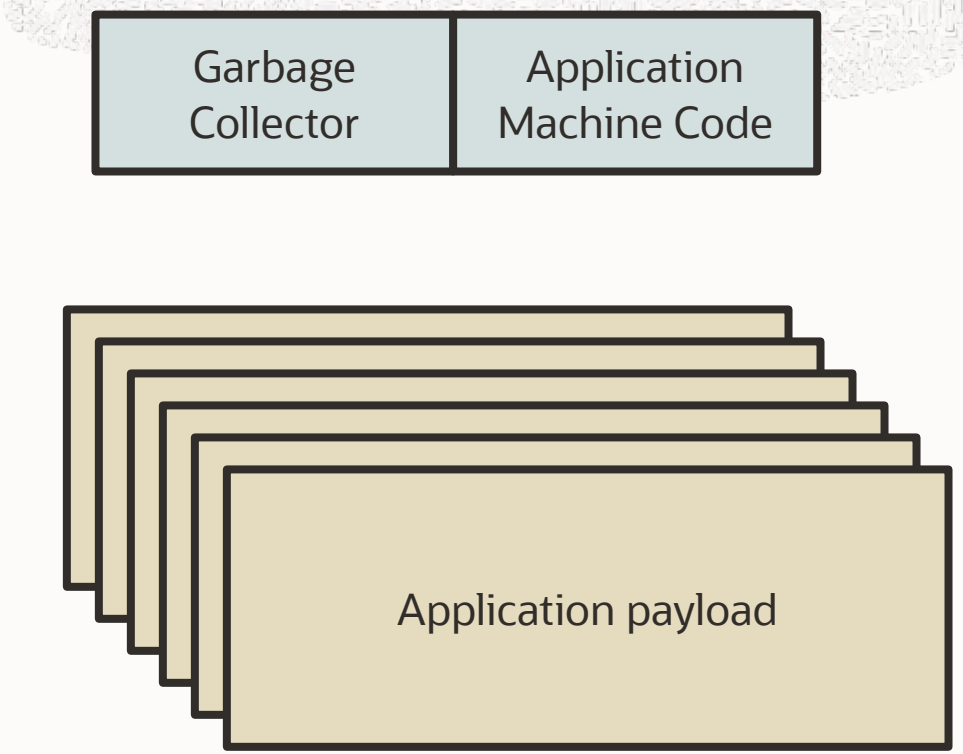
JIT



shared

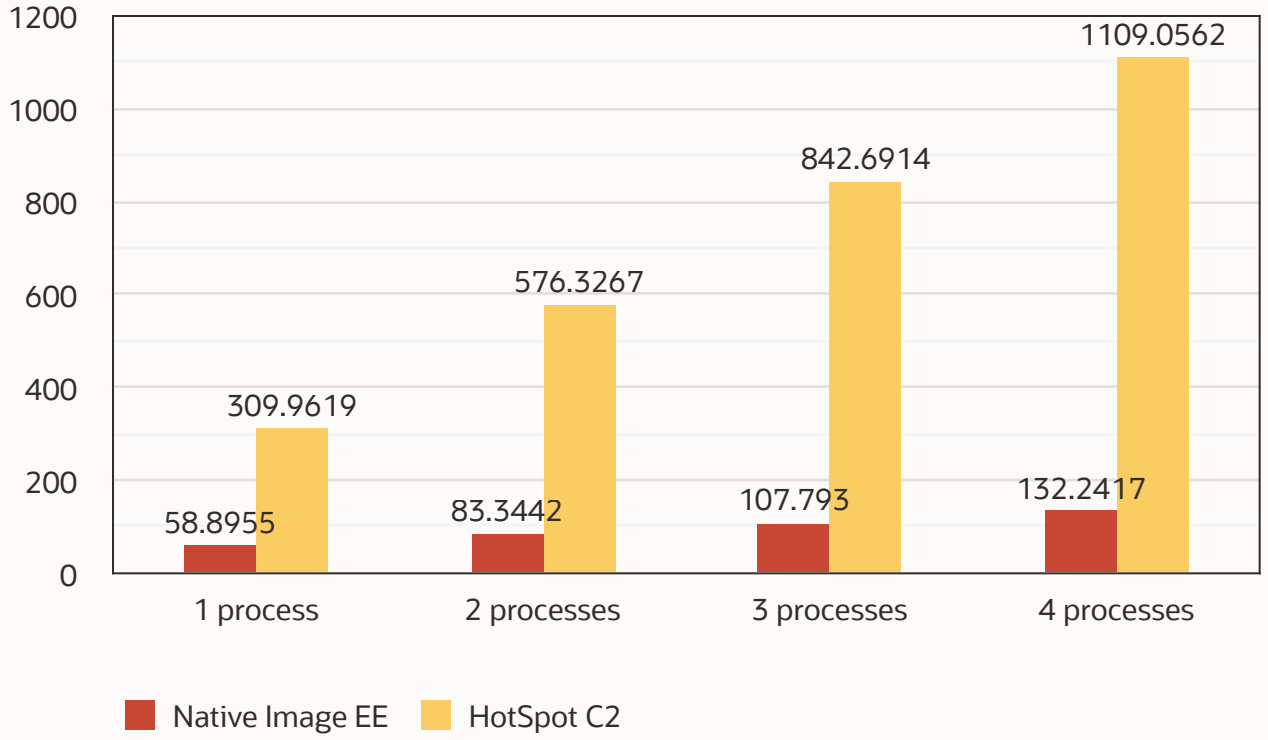
duplicated per process

AOT



Example: horizontal scaling of microservices

Memory Usage in MB
Quarkus Apache Tika ODT in a “tiny” configuration and with the serial GC
(1 CPU core per process, -Xms32m -Xmx128m) – JDK 11



Java HotSpot VM

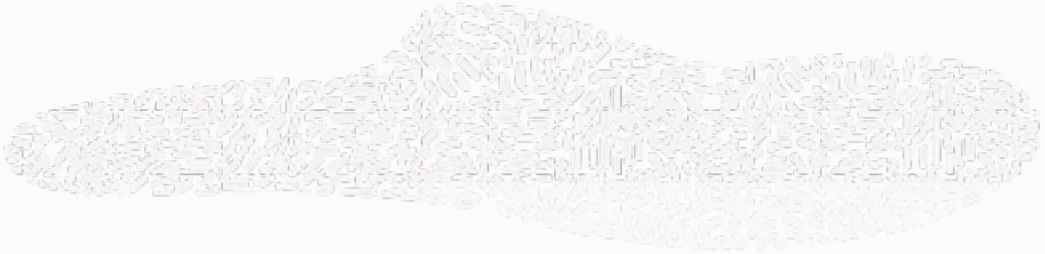
- **4 VM instances = 4 times the memory**

Native Image

- **4 VM instances = 2 times the memory**
- Image heap shared between processes
- Machine code shared between processes

Demo: startup and performance

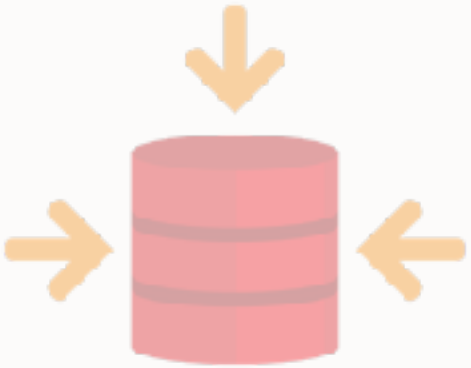
Java in the Cloud - Goals



Start Fast

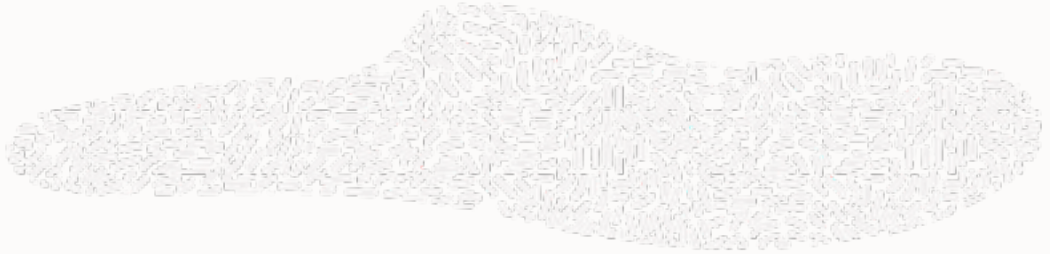
Low Resource Usage

Minimize Vulnerability



Compact Packaging

Reduced Attack Surface



- No new unknown code can be loaded at run time
- Only paths proven reachable by the application are included in the image
- Reflection is disabled by default and needs an explicit include list
- Deserialization only enabled for specified list of classes
- Just-in-time compiler crashes, wrong compilations, or “JIT spraying” to create machine code gadgets are impossible

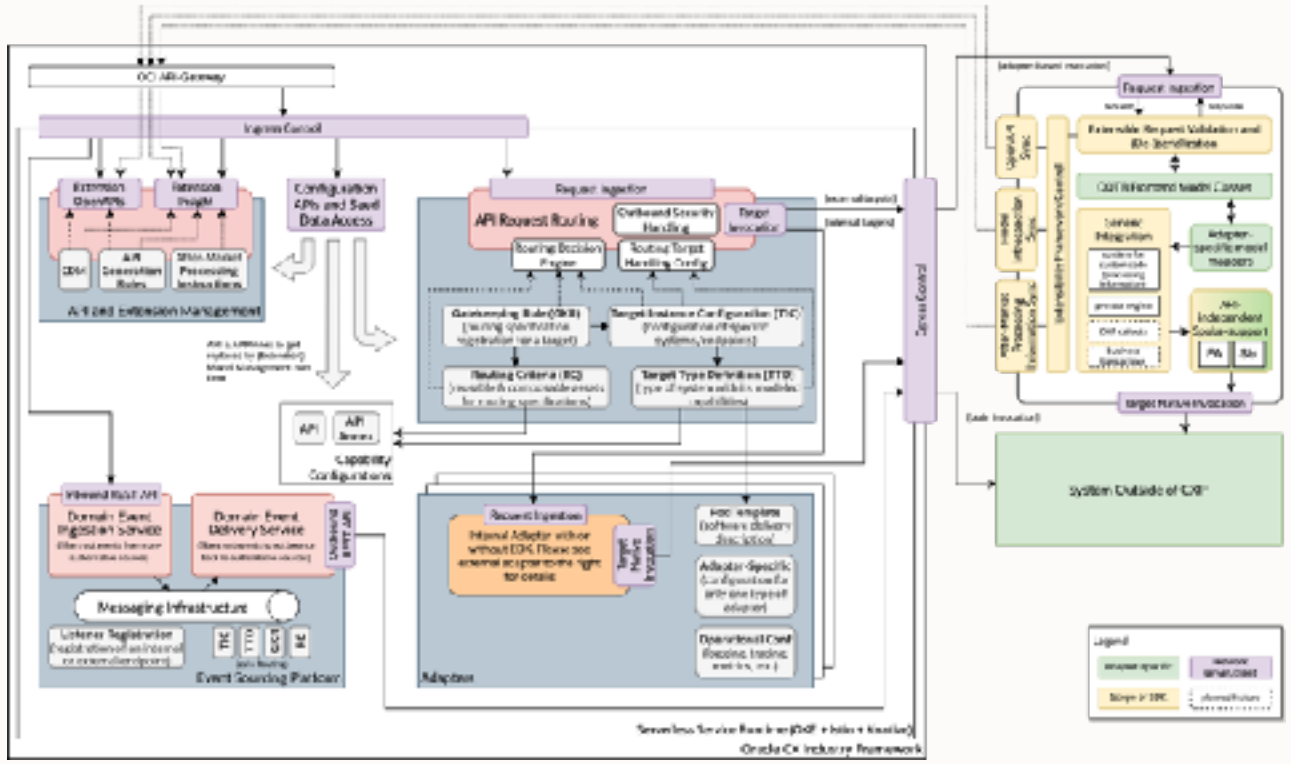
Demo: reducing attack surface

Scalable Microservices with Helidon SE and Native Image

Oracle Customer Experience Industry Framework

- Use GraalVM Native Image to create minimum-size, precompiled executable images of its microservices: container images of <50MB
- “It’s a killer feature for security”

medium.com/helidon/oracle-cx-industry-framework-a-helidon-flight-with-aerobatic-stunts-4666683d5176



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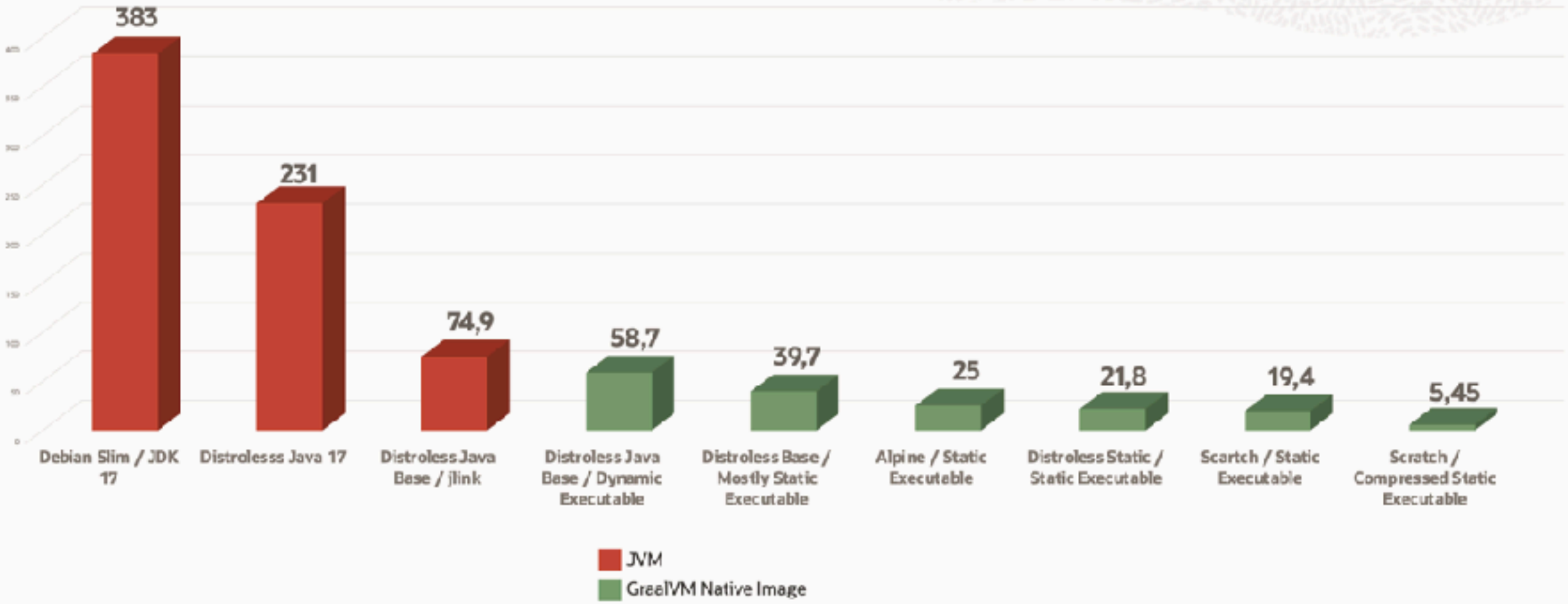
Compact Packaging

Single Native Executable

- All relevant JVM runtime and JDK library code is included
- Unreachable paths (i.e., dead code) in the application and its dependencies eliminated
- Disadvantage that Java runtime installation cannot be shared, but also advantage that applications can be patched/updated individually

Lightweight containerized applications

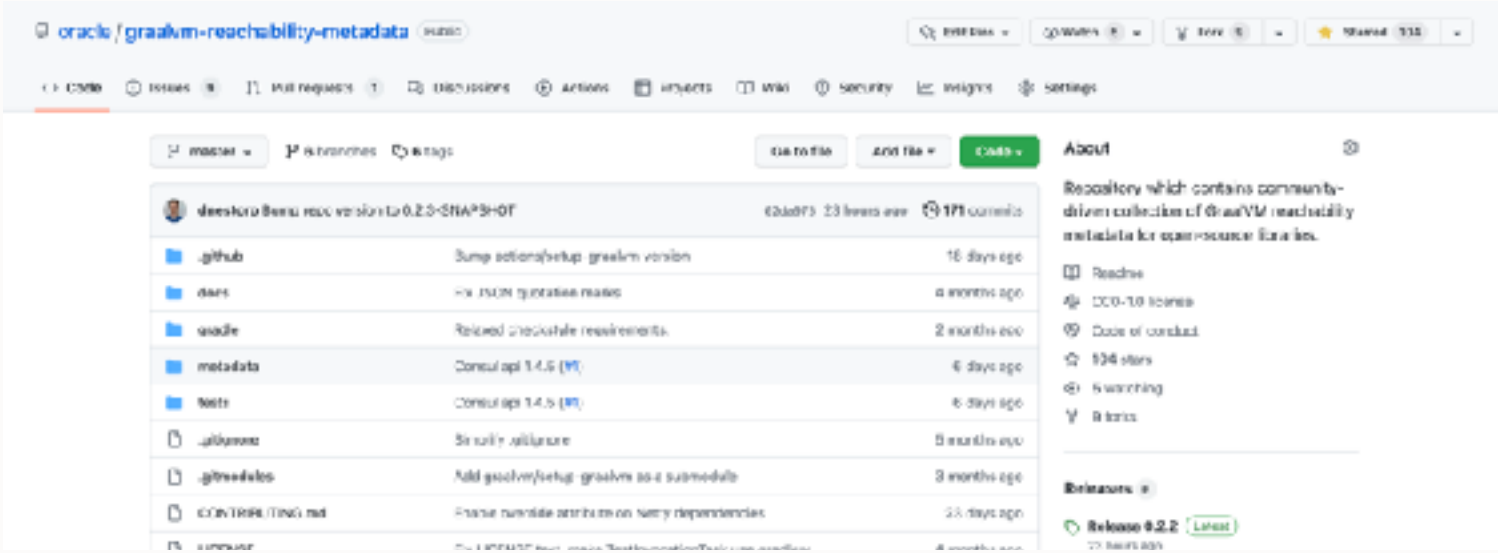


YouTube: A 1.5MB Java Container App? Yes you can! by Shaun Smith

What’s the catch?

GraalVM & Reflection?

- GraalVM 🤝 Reflection!
- Native Image tries to resolve the target elements through a static analysis that detects calls to the Reflection API
  - If the analysis can not automatically detect your use of reflection, you might need additional configuration
- Trace reflection, JNI, resource usage on the JVM with the tracing agent
  - Manual adjustment / addition might still be necessary



Required Build Time Step

- Computational effort necessary at build time
- Need a powerful machine with the same target architecture & OS
  - Use GraalVM with GitHub Actions: github.com/marketplace/actions/github-action-for-graalvm
  - Many larger apps can build with 2 GB of memory
- Develop in JIT mode for fast development, only use AOT for final deployment
- For best throughput, use profile-guided optimizations

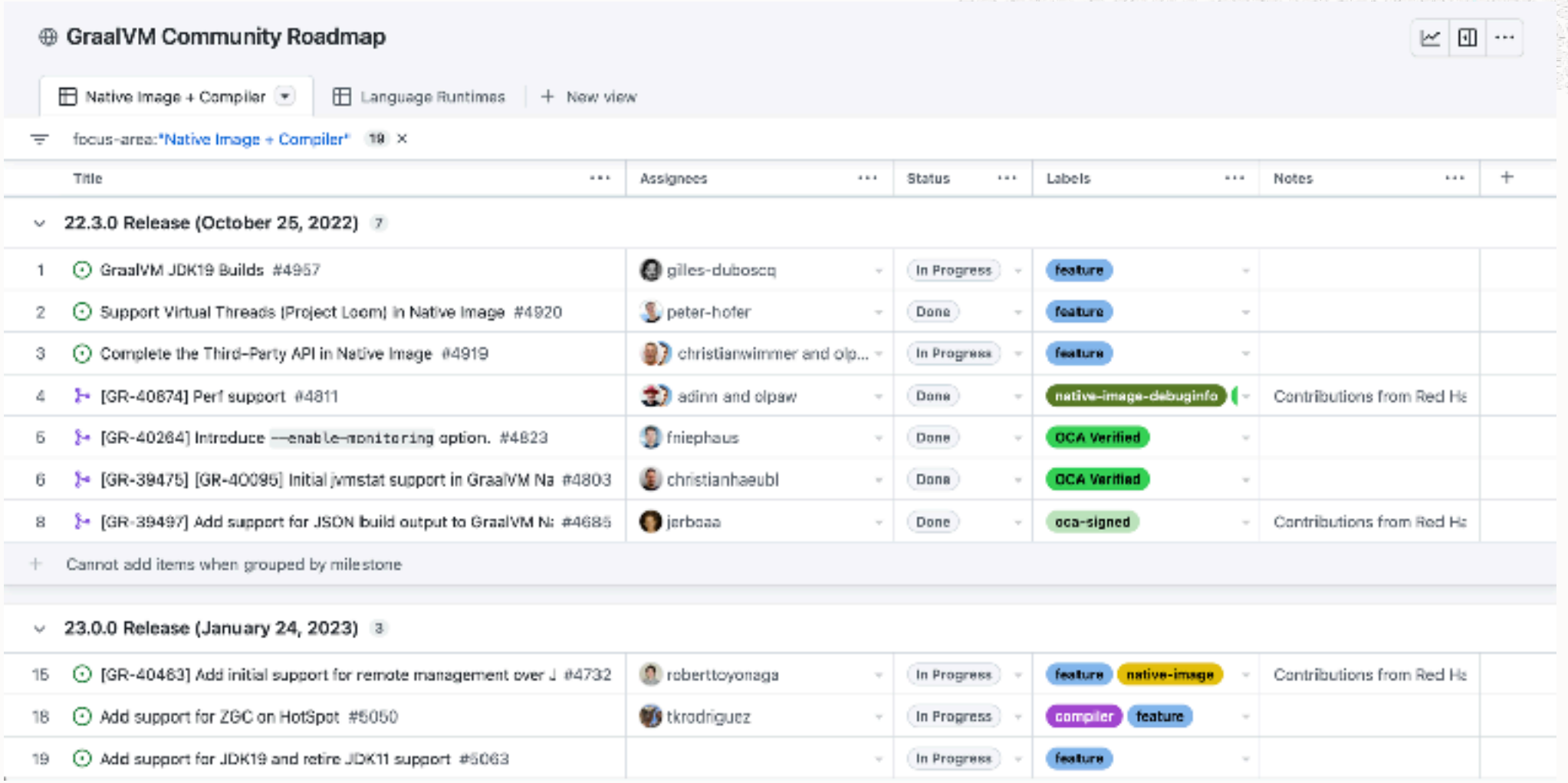
What’s new in GraalVM


GraalVM™
JDK 20
dev builds
now available!

New monitoring features in GraalVM Native Image 📈

- `-H:+AllowVMInspection -> --enable-monitoring`
  - `--enable-monitoring=<all,heapdump,jfr,jvmstat>`
- added support for jvmstat in Native Image
- keep building out the JFR support in Native Image (thanks to Red Hat for their contributions!)

GraalVM Community roadmap on GitHub



https://github.com/orgs/oracle/projects/6

What's next for GraalVM

What's next for Native Image

- Simplifying configuration and compatibility for Java libraries
- Continuing with peak performance improvements
- Keep working with Java framework teams to leverage all Native Image features, develop new ones, improve performance, and ensure a great developer experience
- Further reduce build time and footprint of the Native Image builder
- IDE support for Native Image configuration and agent-based configuration
- Further improving GC performance and adding new GC implementations

Get started with GraalVM

Get started with GraalVM

```
bash <(curl -sL https://get.graalvm.org/jdk)\
        graalvm-ce-java19-22.3.0

sdk install java 22.3.r19-grl
```

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Tuesday May 23 10:50 – 11:40

Lille Sal

Next-Generation Cloud Native Apps with Spring Boot 3

The recent release of Spring Boot 3 laid the foundation for the next generation of modern Java applications. This session will highlight what's new, and demonstrate hands-on patterns and techniques for cloud native development.

Support for generating native executables with GraalVM is now part of the core framework, making it straightforward to build efficient applications with instant startup time and reduced memory consumption. The new Java 17 baseline and support for Jakarta EE 10 unlock many new features and integrations.

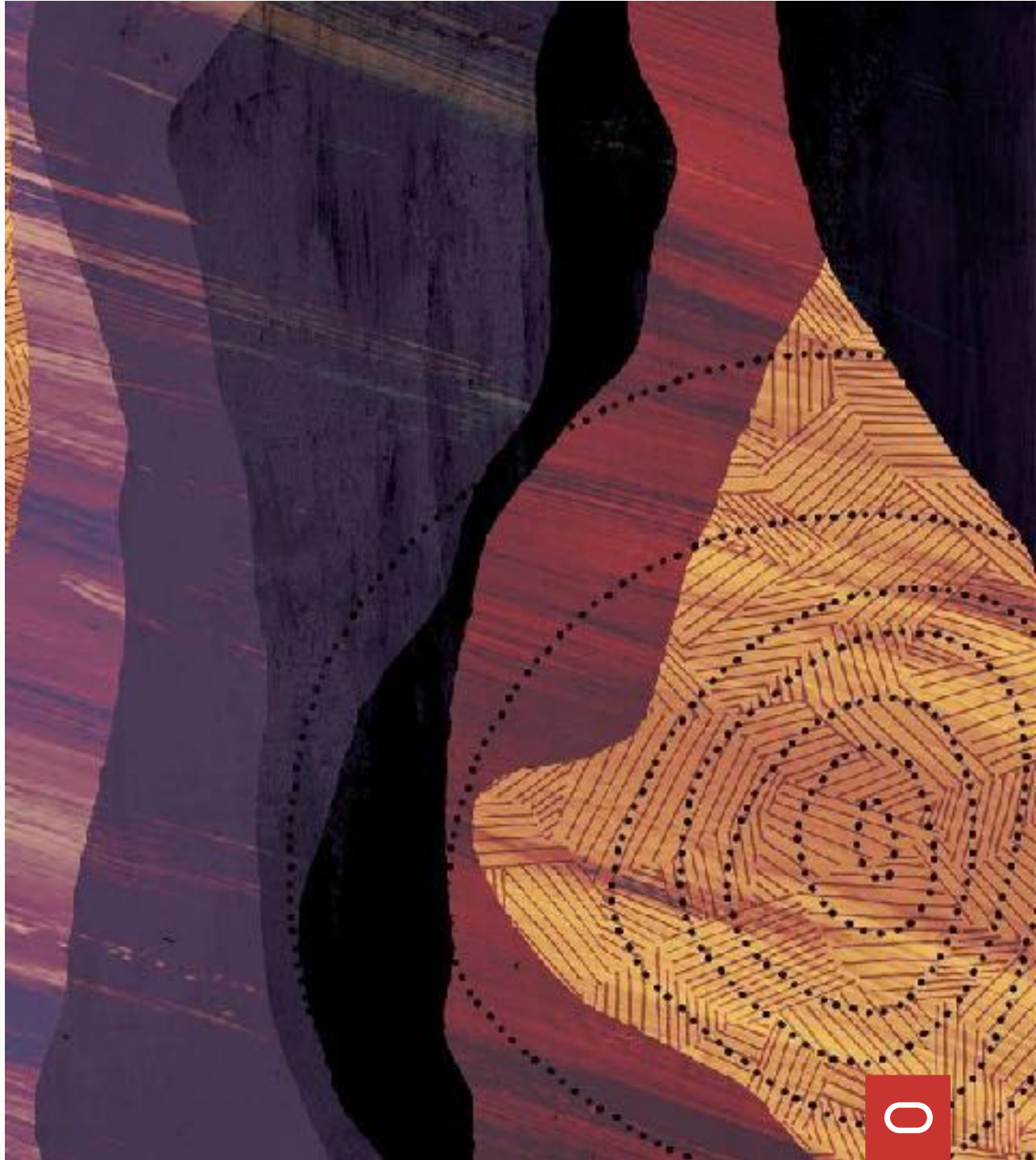
Thomas Vitale

Software Architect , author of "Cloud Native Spring in Action" and certified Red Hat enterprise application developer

Thank you!

Alina Yurenko

@alina_yurenko



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