

# Cloud Native Spring

Crafting the Perfect Java Image for K8s

**bellsoft**

# whoami



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- Dev  at BellSoft



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- ≈10 years in JVM. Mostly  and 



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- <https://asm0dey.site>



# BellSoft

- Vendor of Liberica JDK
- Contributor to the OpenJDK
- Author of ARM32 support in JDK
- Own base images
- Own Linux: Alpaquita

Liberica is the JDK officially recommended  
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We know our stuff!



# So, what is ultimate?

- Smallest
- Fatsest startup
- Something inbetween

So, let's look at all of  
them!

# How do we create an image?

Let's start from trivial.

```
1 FROM bellsoft/liberica-runtime-container:jdk-25-musl
2
3 COPY . /app
4 RUN cd /app && ./gradlew build
5 ENTRYPOINT java -jar /app/build/libs/spring-petclinic*.jar
```

# How do we create an image?

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1 FROM bash  
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3 COPY . /app  
4 RUN rm -rf /app
```

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```
1 FROM bash  
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3 COPY . /app  
4 RUN rm -rf /app
```

4. We would like image to be light, but it's not :(

# Our Dockerfile

```
1 FROM bellsoft/liberica-runtime-container:jdk-25-musl
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3 COPY . /app
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5 ENTRYPOINT java -jar /app/build/libs/spring-petclinic*.jar
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3 COPY . /app
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```

# Result

```
1   Cmp    Size  Command
2       10 MB  FROM blobs
3      109 MB  cd /app && ./gradlew build -xtest
4      85 MB  (missing)
5      591 MB  (missing)
```

# Result

```
1   Cmp    Size  Command
2       10 MB  FROM blobs
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```

109 MB of Java

# Result

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4       85 MB  (missing)
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```

109 MB of Java

85 MB of the app

# Result

```
1   Cmp    Size  Command
2       10 MB  FROM blobs
3       109 MB cd /app && ./gradlew build -xtest
4       85 MB  (missing)
5       591 MB (missing)
```

109 MB of Java

85 MB of the app

591 MB of Java build caches

# 600+ MB are changed on every build!

Why do we care? We care because:

1. `push` takes a longer time to start  
(update is longer)
2. `pull` takes longer  
(update takes longer & scaling takes  
longer)

Also, more disk space is inefficiently used



# Optimizing. Round 1.

Let's build it outside of container

```
1 FROM bellsoft/liberica-runtime-container:jdk-25-musl
2
3 COPY . /app
4 RUN cd /app && ./gradlew build
5 ENTRYPOINT java -jar /app/build/libs/spring-petclinic*.jar
```

# Optimizing. Round 1.

Let's build it outside of container

```
1 FROM bellsoft/liberica-runtime-container:jdk-25-musl
2
3 COPY build/libs/spring-petclinic-3.3.0.jar /app/app.jar
4 CMD java -jar /app/app.jar
```

# Optimizing. Round 1.

Let's build it outside of container

```
1 FROM bellsoft/liberica-runtime-container:jdk-25-musl
2
3 COPY build/libs/spring-petclinic-3.3.0.jar /app/app.jar
4 CMD java -jar /app/app.jar
```

Just copying the prebuilt `jar` file

# Results

```
1 Cmp    Size  Command
2      10 MB  FROM blobs
3     109 MB  cd /app && ./gradlew build -xtest
4      85 MB  (missing)
5     591 MB  (missing)
```

No Gradle caches and build dir!

# Results

```
1 Cmp    Size  Command
2          10 MB  FROM blobs
3          109 MB (missing)
4          69 MB (missing)
```

No Gradle caches and build dir!

# Saved 600+ MB

But the build is not clean now :(

# Saved 600+ MB

But the build is not clean now :(

We have to build everything outside, what if environment affects the build?

A grand, ornate theater stage with red curtains, gold chandeliers, and a large rug.

Enter build stages

# Multi-stage builds

Holy grail of pure builds

- Allow clean builds
- Allow optimal packaging
- Allow different base images

# Staged example

```
1 FROM bellsoft/liberica-runtime-container:jdk-25-musl as builder
2
3 COPY . /app
4 RUN cd /app && ./gradlew build -xtest
5
6 FROM bellsoft/liberica-runtime-container:jre-25-musl as runner
7
8 COPY --from=builder /app/build/libs/spring-petclinic-3.3.0.jar /app/app.jar
```

# Staged example

```
1 FROM bellsoft/liberica-runtime-container:jdk-25-musl as builder
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8 COPY --from=builder /app/build/libs/spring-petclinic-3.3.0.jar /app/app.jar
```

# Result

- jar - same size
- JRE - 48.28

# That's all folks!

# That's all folks!

Or is it?

# What's these 60 MiB?

We have to pull 60 MiB of petclinic on every small commit!

Is there a way to optimize it?

# Layers!

```
1  FROM bellsoft/liberica-runtime-container:jdk-musl as builder
2
3  COPY . /app
4  RUN cd /app && ./gradlew build -xtest
5
6  FROM bellsoft/liberica-runtime-container:jre-slim-musl as optimizer
7
8  COPY --from=builder /app/build/libs/spring-petclinic-3.3.0.jar /app/app.jar
9  WORKDIR /app
10 RUN java -Djarmode=tools -jar /app/app.jar extract --layers --destination extracted
```

- Build image

# Layers!

```
1  FROM bellsoft/liberica-runtime-container:jre-slim-musl as builder
2
3  COPY . /app
4  RUN cd /app && ./gradlew build -xtest
5
6  FROM bellsoft/liberica-runtime-container:jre-slim-musl as optimizer
7
8  COPY --from=builder /app/build/libs/spring-petclinic-3.3.0.jar /app/app.jar
9  WORKDIR /app
10 RUN java -Djarmode=tools -jar /app/app.jar extract --layers --destination extracted
11
```

- Build image
- Introduce new "optimizer" stage

# Layers!

```
4 RUN cd /app/uu */gradlew build -xtest
5
6 FROM bellsoft/liberica-runtime-container:jre-slim-musl as optimizer
7
8 COPY --from=builder /app/build/libs/spring-petclinic-3.3.0.jar /app/app.jar
9 WORKDIR /app
10 RUN java -Djarmode=tools -jar /app/app.jar extract --layers --destination extracted
11
12 FROM bellsoft/liberica-runtime-container:jre-slim-musl as runner
13
14 ENTRYPOINT ["java", "-jar", "/app/spring-petclinic.jar"]
```

- Build image
- Introduce new "optimizer" stage

# Layers!

```
5
6 FROM bellsoft/liberica-runtime-container:jre-slim-musl as optimizer
7
8 COPY --from=builder /app/build/libs/spring-petclinic-3.3.0.jar /app/app.jar
9 WORKDIR /app
10 RUN java -Djarmode=tools -jar /app/app.jar extract --layers --destination extracted
11
12 FROM bellsoft/liberica-runtime-container:jre-slim-musl as runner
13
14 ENTRYPOINT ["java", "-jar", "./app/spring-petclinic.jar"]
15 COPY --from=optimizer /app/extracted/dependencies/ /
```

- Build image
- Introduce new "optimizer" stage
- Extract the jar to layered structure

# Layers!

```
7  
8     COPY --from=builder /app/build/libs/spring-petclinic-3.3.0.jar /app/app.jar  
9     WORKDIR /app  
10    RUN java -Djarmode=tools -jar /app/app.jar extract --layers --destination extracted  
11  
12    FROM bellsoft/liberica-runtime-container:jre-slim-musl as runner  
13  
14    ENTRYPOINT ["java", "-jar", "./app/spring-petclinic.jar"]  
15    COPY --from=optimizer /app/extracted/dependencies/ ./  
16    COPY --from=optimizer /app/extracted/spring-boot-loader/ ./  
17    COPY --from=optimizer /app/extracted/snapshot_dependencies/ ./
```

- Build image
- Introduce new "optimizer" stage
- Extract the jar to layered structure

# Layers!

```
WORKDIR /app
10  RUN java -Djarmode=tools -jar /app/app.jar extract --layers --destination extracted
11
12  FROM bellsoft/liberica-runtime-container:jre-slim-musl as runner
13
14  ENTRYPOINT ["java", "-jar", "./app/spring-petclinic.jar"]
15  COPY --from=optimizer /app/extracted/dependencies/ ./
16  COPY --from=optimizer /app/extracted/spring-boot-loader/ ./
17  COPY --from=optimizer /app/extracted/snapshot-dependencies/ ./
18  COPY --from=optimizer /app/extracted/application/ ./
```

- Build image
- Introduce new "optimizer" stage
- Extract the jar to layered structure
- Copy layers

# Layers!

```
7   WORKDIR /app
10  RUN java -Djarmode=tools -jar /app/app.jar extract --layers --destination extracted
11
12  FROM bellsoft/liberica-runtime-container:jre-slim-musl as runner
13
14  ENTRYPOINT ["java", "-jar", "./app/spring-petclinic.jar"]
15  COPY --from=optimizer /app/extracted/dependencies/ ./
16  COPY --from=optimizer /app/extracted/spring-boot-loader/ ./
17  COPY --from=optimizer /app/extracted/snapshot-dependencies/ ./
18  COPY --from=optimizer /app/extracted/application/ ./
```

- Build image
- Introduce new "optimizer" stage
- Extract the jar to layered structure
- Copy layers

# Layers

Because Spring Boot jar is complex!

```
1 Usage:  
2     java -Djarmode=tools -jar my-app.jar  
3  
4 Available commands:  
5     extract      Extract the contents from the jar  
6     list-layers  List layers from the jar that can be extracted
```

# Layers

```
1 extracted
2   └── application
3     └── spring-petclinic-4.0.0-SNAPSHOT.jar
4   └── dependencies
5     └── lib
6       ├── angus-activation-2.0.2.jar
7       ├── antlr4-runtime-4.13.2.jar
8       ├── aspectjweaver-1.9.24.jar
9       ├── attoparser-2.0.7.RELEASE.jar
10      ├── bootstrap-5.3.8.jar
11      ├── byte-buddy-1.17.7.jar
12      ├── cache-api-1.1.1.jar
13      ├── caffeine-3.2.2.jar
14      ├── checker-qual-3.49.3.jar
15      ├── classmate-1.7.0.jar
16      └── commons-logging-1.3.5.jar
```

# Layers

```
91      └── spring-orm-7.0.0-M9.jar  
92      └── spring-tx-7.0.0-M9.jar  
93      └── spring-web-7.0.0-M9.jar  
94      └── spring-webmvc-7.0.0-M9.jar  
95      └── thymeleaf-3.1.3.RELEASE.jar  
96      └── thymeleaf-spring6-3.1.3.RELEASE.jar  
97      └── tomcat-embed-core-11.0.11.jar  
98      └── tomcat-embed-el-11.0.11.jar  
99      └── tomcat-embed-websocket-11.0.11.jar  
100     └── txw2-4.0.5.jar  
101     └── unescape-1.1.6.RELEASE.jar  
102     └── webjars-locator-lite-1.1.1.jar  
103     └── snapshot-dependencies  
104     └── spring-boot-loader  
105  
106  6 directories, 98 files
```

# Layers

```
91 └── spring-orm-7.0.0-M9.jar  
92 └── spring-tx-7.0.0-M9.jar  
93 └── spring-web-7.0.0-M9.jar  
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106 6 directories, 98 files
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# Layers

```
3   SPRING-POLYGRAPHIC-THREE-DEEP-SHOT.jar
4   └── dependencies
5       └── lib
6           ├── angus-activation-2.0.2.jar
7           ├── antlr4-runtime-4.13.2.jar
8           ├── aspectjweaver-1.9.24.jar
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14          ├── checker-qual-3.49.3.jar
15          ├── classmate-1.7.0.jar
16          ├── commons-logging-1.3.5.jar
17          ├── context-propagation-1.2.0-M1.jar
18          ├── error_prone_annotations-2.40.0.jar
19          └── font-awesome-4.7.0.jar
```

# Layers

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16     └── commons-logging-1.3.5.jar
```

# Layered image structure

```
1 > du -h --max-depth=1 extracted
2 66M   extracted/dependencies
3 0     extracted/spring-boot-loader
4 0     extracted/snapshot-dependencies
5 892K  extracted/application
6 66M   extracted
```

# Layered image structure

```
1 > du -h --max-depth=1 extracted
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6 66M   extracted
```

- Dependencies: ~66MiB

# Layered image structure

```
1 > du -h --max-depth=1 extracted
2 66M   extracted/dependencies
3 0     extracted/spring-boot-loader
4 0     extracted/snapshot-dependencies
5 892K  extracted/application
6 66M   extracted
```

- Dependencies: ~66MiB
- Application: ~892K

# 66.0MiB > 60Mib!



# What are we optimizing?

Pull size!

Pull size here is usually only around 1MiB!

# We just reinvented how the BellSoft's buildpack works!

And it is amazing

# Diversion: buildpacks

<https://paketo.io/>

Trivial usage:

```
1 /usr/sbin/pack build petclinic \
2   --builder bellsoft/buildpacks.builder:musl \
3   --path . \
4   -e BP_JVM_VERSION=21
```

# Diversion: buildpacks

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```
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2   --builder bellsoft/buildpacks.builder:musl \
3   --path . \
4   -e BP_JVM_VERSION=21
```

# Result

	ID	TAG	SIZE	COMMAND
1	2774e3f214	petclinic:latest	0B	Buildpacks Process Types
2	<missing>		1.44kiB	Buildpacks Launcher Config
3	<missing>		2.44MiB	Buildpacks Application Launcher
4	<missing>		59.17MiB	Application Layer
5	<missing>		729.21kiB	Software Bill-of-Materials
6	<missing>		97.87MiB	Layer: 'jre', Created by buildpack: bellsoft/buildpack
7	<missing>		200.00B	Layer: 'java-security-properties', Created by buildpac
8	<missing>		4.27MiB	Layer: 'helper', Created by buildpack: bellsoft/buildp
9	<missing>		2.97kiB	
10	<missing>		7.48MiB	
11	<missing>			

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8	<missing>		200.00B	Layer: 'java-security-properties', Created by buildpac
9	<missing>		4.27MiB	Layer: 'helper', Created by buildpack: bellsoft/buildp
10	<missing>		2.97kiB	
11	<missing>		7.48MiB	

# Buildpacks

Why do we need them?

- Buildpacks transform your application source code into container images
- The Paketo open source project provides production-ready buildpacks for the most popular languages and frameworks
- Use Paketo Buildpacks to easily build your apps and keep them updated
- Reminds of s2i images
- Build better than default
- Spring-aware

# Is this all?

We've optimized pull/push size, right?

# Optimization is multidimensional

When startup time is more important...

There are several solutions for the Spring application startup time

1. Class Data Sharing (CDS)
2. Project Leyden
3. Coordinated Restore at Checkpoint
4. Native Image

# Class Data Sharing (CDS)

- When: Java 5 (!)
- Why: reduce the startup and memory footprint of multiple JVM instances running on the same host
- How: stores data in an archive

How does it help us?

# Class Data Sharing (CDS)

- When: Java 5 (!)
- Why: reduce the startup and memory footprint of multiple JVM instances running on the same host
- How: stores data in an archive

How does it help us?

It does not! 

# Class Data Sharing (CDS)

- When: Java 5 (!)
- Why: reduce the startup and memory footprint of multiple JVM instances running on the same host
- How: stores data in an archive

How does it help us?

It does not! 🤪 But

# Application Class Data Sharing

- When: Java 10
- Why: add application classes to the archive

And then:

- When: Java 13, JEP 350
- Why: allow addition of classes into the archive upon app exit!

And this helps! How?

# How to use AppCDS with Spring?

- `-XX:ArchiveClassesAtExit=application.jsa` to create an archive
- `-Dspring.context.exit=onRefresh` to start and immediately exit the application

NB:

1. Use the same JDK
2. Use the same arguments

# And even better!

Spring AOT

Add `-Dspring.aot.enabled=true`

Even more classes!!!

# Practice

```
1 FROM bellsoft/liberica-runtime-container:jdk-musl as builder
2
3 COPY . /app
4 RUN cd /app && ./gradlew build -xtest
5
6 FROM bellsoft/liberica-runtime-container:jre-slim-musl as optimizer
7
8 COPY --from=builder /app/build/libs/spring-petclinic-3.3.0.jar /app/app.jar
9 WORKDIR /app
10 RUN java -Djarmode=tools -jar /app/app.jar extract --layers --launcher
11
12 FROM bellsoft/liberica-runtime-container:jre-slim-musl as runner
13
14 ENTRYPOINT ["java", "-jar", "./app/app.jar"]
15 COPY --from=optimizer /app/extracted/dependencies/ ./
16 COPY --from=optimizer /app/extracted/spring-boot-loader/ ./
17 COPY --from=optimizer /app/extracted/snapshot-dependencies/ ./
18 COPY --from=optimizer /app/extracted/application/ ./
```

# Practice

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9 WORKDIR /app
10 RUN java -Djarmode=tools -jar /app/app.jar extract --layers --destination extracted
11 FROM bellsoft/liberica-runtime-container:jre-cds-slim-musl as runner
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13 ENTRYPOINT ["java", "-jar", "./app/app.jar"]
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# Practice

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# Practice

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2 FROM bellsoft/liberica-runtime-container:jre-cds-slim-musl as runner
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5 COPY --from=optimizer /app/extracted/dependencies/ ./
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8 COPY --from=optimizer /app/extracted/application/ ./
9 RUN java -Dspring.aot.enabled=true \
10   -XX:ArchiveClassesAtExit=./application.jsa \
11   -Dspring.context.exit=onRefresh \
12   -jar app.jar
```

# Practice

```
1 #omitted
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6 COPY --from=optimizer /app/extracted/spring-boot-loader/ ./
7 COPY --from=optimizer /app/extracted/snapshot-dependencies/ ./
8 COPY --from=optimizer /app/extracted/application/ ./
9 RUN java -Dspring.aot.enabled=true \
10   -XX:ArchiveClassesAtExit=./application.jsa \
11   -Dspring.context.exit=onRefresh \
12   -jar app.jar
```

# Practice

```
1 #omitted
2 FROM bellsoft/liberica-runtime-container:jre-cds-slim-musl as runner
3
4 ENTRYPOINT ["java", \
5             "-Dspring.aot.enabled=true", \
6             "-XX:SharedArchiveFile=application.jsa", \
7             "-jar", "app.jar"]
8 COPY --from=optimizer /app/extracted/dependencies / ./
9 COPY --from=optimizer /app/extracted/spring-boot-loader/ ./
10 COPY --from=optimizer /app/extracted/snapshot-dependencies/ ./
11 COPY --from=optimizer /app/extracted/application/ ./
12 RUN java -Dspring.aot.enabled=true \
13     -XX:ArchiveClassesAtExit=../application.jsa \
14     -Dspring.context.exit=onRefresh \
15     -jar app.jar
```

# Practice

```
1 #omitted
2 FROM bellsoft/liberica-runtime-container:jre-cds-slim-musl as runner
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```

# What does it cost ?

```
1 111M Nov 4 23:47 app.aot
```

Which is not small at all!

# What does it cost ?

```
1 111M Nov 4 23:47 app.aot
```

Which is not small at all!

But you're trading pull speed for startup speed

Average startup time per variant

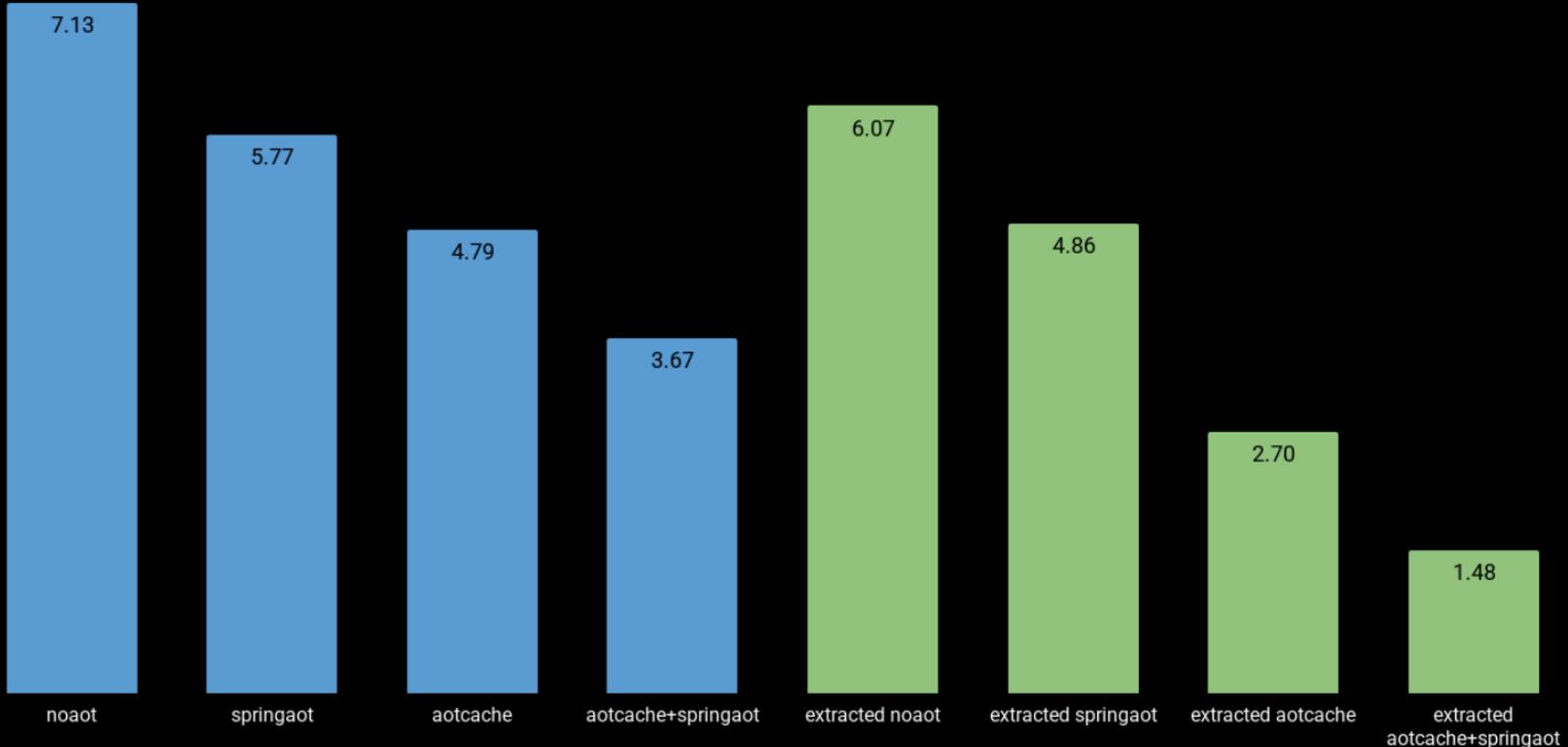
8

6

4

2

0



# Pushing further with CRaC

CRaC: Coordinated Restore at Checkpoint

The CRaC (Coordinated Restore at Checkpoint) Project researches coordination of Java programs with mechanisms to checkpoint (make an image of, snapshot) a Java instance while it is executing. Restoring from the image could be a solution to some of the problems with the start-up and warm-up times. The primary aim of the Project is to develop a new standard mechanism-agnostic API to notify Java programs about the checkpoint and restore events. Other research activities will include, but will not be limited to, integration with existing checkpoint/restore mechanisms and development of new ones, changes to JVM and JDK to make images smaller and ensure they are correct.

<https://openjdk.org/projects/crac/>

# In a perfect world it should be:

```
1 FROM bellsoft/liberica-runtime-container:jdk-musl as builder
2
3 COPY . /app
4 RUN cd /app && ./gradlew build
5
6 FROM bellsoft/liberica-runtime-container:jre-crac-slim as optimizer
7
8 COPY --from=builder /app/build/libs/spring-petclinic-3.3.0.jar /app/app.jar
9 WORKDIR /app
10 RUN java -Dspring.context.checkpoint=onRefresh -XX:CRaCCheckpointTo=/checkpoint -jar /app/app.jar
11
12 FROM bellsoft/liberica-runtime-container:jre-crac-slim as runner
13
14 ENTRYPOINT java -XX:CRaCRestoreFrom=/checkpoint
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16 COPY --from=optimizer /checkpoint /checkpoint
```

# But in reality

```
1 #12 6.051      Suppressed: java.lang.RuntimeException: Native checkpoint failed.  
2 #12 6.051          at java.base/jdk/cr.ac.Core.translateJVMEExceptions(Core.java:114) ~[r  
3 #12 6.051          at java.base/jdk/cr.ac.Core.checkpointRestore1(Core.java:192) ~[na:na:  
4 #12 6.051          at java.base/jdk/cr.ac.Core.checkpointRestore(Core.java:299) ~[na:na:  
5 #12 6.051          at java.base/jdk/cr.ac.Core.checkpointRestore(Core.java:278) ~[na:na:  
6 #12 6.051          at java.base/javax/cr.ac.Core.checkpointRestore(Core.java:73) ~[na:na:  
7 #12 6.051          at java.base/jdk/internal/reflect.DirectMethodHandleAccessor.invoke(  
8 #12 6.051          at java.base/java/lang/reflect.Method.invoke(Method.java:580) ~[na:r  
9 #12 6.051          at org.cr.ac.Core$Compat.checkpointRestore(Core.java:141) ~[crac-1.4.  
10 #12 6.051         ... 17 common frames omitted
```

# CRaC is hard!

Let's try to fix it with arcane magic

```
1 FROM bellsoft/liberica-runtime-container:jdk-musl as builder
2
3 COPY . /app
4 RUN cd /app && ./gradlew build -xtest
5
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8 COPY --from=builder /app/build/libs/spring-petclinic-3.3.0.jar /app/app.jar
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14
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17 COPY --from=optimizer /checkpoint /checkpoint
```

# CRaC is hard!

Let's try to fix it with arcane magic

```
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2 FROM bellsoft/liberica-runtime-container:jdk-musl as builder
3
4 COPY . /app
5 RUN cd /app && ./gradlew build -xtest
6
7 FROM bellsoft/liberica-runtime-container:jre-crac-slim as optimizer
8
9 COPY --from=builder /app/build/libs/spring-petclinic-3.3.0.jar /app/app.jar
10 WORKDIR /app
11 RUN --security=insecure java -Dspring.context.checkpoint=onRefresh \
12     -XX:CRaCCheckpointTo=/checkpoint -jar /app/app.jar
13
14 FROM bellsoft/liberica-runtime-container:jre-crac-slim as runner
15
16 ENTRYPOINT java -XX:CRaCRestoreFrom=/checkpoint
```

# CRaC is hard!

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8
9 COPY --from=builder /app/build/libs/spring-petclinic-3.3.0.jar /app/app.jar
10 WORKDIR /app
11 RUN --security=insecure java -Dspring.context.checkpoint=onRefresh \
12     -XX:CRaCCheckpointTo=/checkpoint -jar /app/app.jar || true
13
14 FROM bellsoft/liberica-runtime-container:jre-crac-slim as runner
15
16 ENTRYPOINT java -XX:CRaCRestoreFrom=/checkpoint
```

# And this is not all!

Did you hear about `buildx` ?

```
1 docker buildx create --buildkitd-flags \  
2     '--allow-insecure-entitlement security.insecure' \  
3     --name insecure-builder
```

# And this is not all!

Did you hear about `buildx` ?

```
1 docker buildx create --buildkitd-flags \  
2     '--allow-insecure-entitlement security.insecure' \  
3     --name insecure-builder
```

# And this is not all!

Did you hear about `buildx` ?

```
1 docker buildx use insecure-builder
```

# And this is not all!

Did you hear about `buildx` ?

```
1 docker buildx build \
2     --allow security.insecure \
3     -f Dockerfile.crac \
4     -t pet-crack --output type=docker .
```

# And this is not all!

Did you hear about `buildx` ?

```
1 docker buildx build \
2     --allow security.insecure \
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# And this is not all!

Did you hear about `buildx` ?

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1 docker buildx build \
2     --allow security.insecure \
3     -f Dockerfile.crac \
4     -t pet-crack --output type=docker .
```

# And this is not all!

Did you hear about `buildx` ?

```
1 docker run --rm -it --privileged pet-crac
```

# And this is not all!

Did you hear about `buildx` ?

- 1 Restarting Spring-managed lifecycle beans after JVM restore
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- 3 Tomcat started on port 8080 (http) with context path ''
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5. Commit the container like

```
docker commit container-id new-tag
```

# Pros and Cons

## Pros:

1. Does not require arcane magic
2. Works more predictably
3. Does not depend on unstable features
4. Does not require privileged containers in

## Cons:

1. Organization-specific
2. Requires more steps

# Native image

# Native image

1. No JRE dependency
2. Size roughly JRE+app (but can upx)
3. Can run on barebones Alpaquita
4. Long time to build

And now we have all  
flavours of ultimate  
docker images!

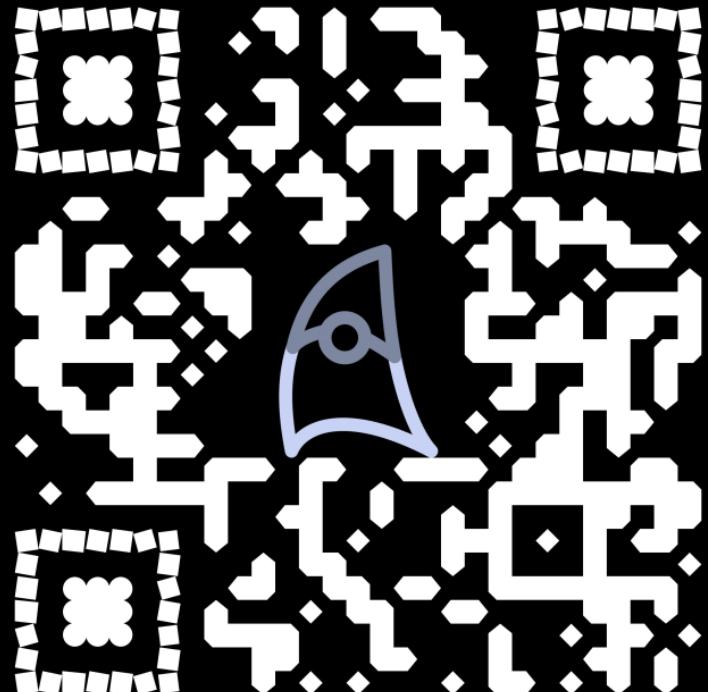
# Quick summary?

1. Use layers for faster deployment
2. Use CDS for faster startup without many compromises
3. Use CRaC for a *lightning-fast* startup (with compromises)
4. Use native image if you're prepared to sacrifice some build time

# Thank you!

Find me @

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END