

# Crafting the Ultimate Docker Image for Spring Applications



**bellsoft**

whoami



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- Pasha Finkelshteyn



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- Dev  at BellSoft



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-  asm0di0
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# 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-21.0.3_10-musl
2
3 COPY . /app
4 RUN cd /app && ./gradlew build
5 ENTRYPOINT java -jar /app/build/libs/spring-petclinic*.jar
```

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# Dockerfile directives

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2. Layers are *immutable*
3. Some layers are zero-sized (for example `RUN rm -rf /app`)

```
1 FROM bash  
2  
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-21.0.3_10-musl
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```

# Result

|    | ID         | TAG  | SIZE      | COMMAND          |
|----|------------|--|-----------|------------------|
| 1  | cda5201e70 | dumb:latest  | 0B        | CMD [ "/bin/sh"  |
| 2  | 74a0788411 |  | 512.03MiB | /bin/sh -c cd /  |
| 3  | 7b82eb08ec |  | 67.41MiB  | COPY dir:ef251b  |
| 4  | e4bcf83d29 | bellsoft/liberica-runtime-container:jdk-21.0.3_10-musl | 98.32MiB  | 15 BUNDLE_TYPE   |
| 5  | <missing>  |  | 0B        | ENV JAVA_HOME="  |
| 6  | <missing>  |  | 0B        | ENV LANG=en_US.  |
| 7  | <missing>  |  | 0B        | LABEL org.openc  |
| 8  | <missing>  |  | 0B        | LABEL org.openc  |
| 9  | <missing>  |  | 0B        | LABEL maintaine  |
| 10 | <missing>  |  | 0B        | ARG BUNDLE_TYPE  |
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# 579.44 MB are changed on every build!

Why do we care? We care because:

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

Also, more disk pspace is inefficiently used



# Optimizing. Round 1.

Let's build it outside of container

```
1 FROM bellsoft/liberica-runtime-container:jdk-21.0.3_10-musl
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3 COPY . /app
4 RUN cd /app && ./gradlew build
5 ENTRYPOINT java -jar /app/build/libs/spring-petclinic*.jar
```

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Let's build it outside of container

```
1 FROM bellsoft/liberica-runtime-container:jdk-21.0.3_10-musl
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3 COPY build/libs/spring-petclinic-3.3.0.jar /app/app.jar
4 CMD java -jar /app/app.jar
```

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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

|    | ID         | TAG  | SIZE      | COMMAND                    |
|----|------------|--|-----------|----------------------------|
| 1  | cda5201e70 | dumb:latest  | 0B        | CMD [ "/bin/sh" "-c" "/app |
| 2  | 74a0788411 |  | 512.03MiB | /bin/sh -c cd /app && ./g  |
| 3  | 7b82eb08ec |  | 67.41MiB  | COPY dir:ef251bd1e17ac0af  |
| 4  | e4bcf83d29 | bellsoft/liberica-runtime-container:jdk-21.0.3_10-musl | 98.32MiB  | 15 BUNDLE_TYPE=jdk CDS=n   |
| 5  | <missing>  |  | 0B        | ENV JAVA_HOME="/usr/lib/j  |
| 6  | <missing>  |  | 0B        | ENV LANG=en_US.UTF-8 LANG  |
| 7  | <missing>  |  | 0B        | LABEL org.opencontainers.  |
| 8  | <missing>  |  | 0B        | LABEL org.opencontainers.  |
| 9  | <missing>  |  | 0B        | LABEL maintainer="\$MAINTA |
| 10 | <missing>  |  | 0B        | NER                        |
| 11 | <missing>  |  | 0B        | ARG BUNDLE_TYPE CDS DESCRI |
| 12 | <missing>  |  | 0B        | ARG BUNDLE_TYPE CDS JAVA_  |
| 13 | <missing>  |  | 0B        | ARG BUNDLE_TYPE CDS JAVA_  |
| 14 | <missing>  |  | 0B        | ARG BUNDLE_TYPE CDS JAVA_  |
| 15 | <missing>  |  | 0B        | ARG BUNDLE_TYPE JAVA_REL   |
| 16 | <missing>  |  | 0B        | ARG JAVA_RELEASE           |
| 17 | <missing>  |  | 7.49MiB   | CMD [ "/bin/sh"            |

# Results

| 1  | ID         | TAG  | SIZE     | COMMAND                      |
|----|------------|--|----------|------------------------------|
| 2  | cefb30e21d | smarter:latest   | 0B       | CMD ["/bin/sh" "-c" "java    |
| 3  | 46d7594000 |  | 58.80MiB | COPY file:8d96bee95ae5ce43   |
| 4  | e4bcf83d29 | bellsoft/liberica-runtime-container:jdk-21.0.3_10-musl | 98.32MiB | 15 BUNDLE_TYPE=jdk CDS=no    |
| 5  | <missing>  |  | 0B       | ENV JAVA_HOME="/usr/lib/jv   |
| 6  | <missing>  |  | 0B       | ENV LANG=en_US.UTF-8 LANGU   |
| 7  | <missing>  |  | 0B       | LABEL org.opencontainers.i   |
| 8  | <missing>  |  | 0B       | LABEL org.opencontainers.i   |
| 9  | <missing>  |  | 0B       | LABEL maintainer="\$MAINTAI  |
| 10 | <missing>  |  | 0B       | ARG BUNDLE_TYPE CDS DESCRI   |
| 11 | <missing>  |  | 0B       | ARG BUNDLE_TYPE CDS JAVA_R   |
| 12 | <missing>  |  | 0B       | ARG BUNDLE_TYPE CDS JAVA_R   |
| 13 | <missing>  |  | 0B       | ARG BUNDLE_TYPE CDS JAVA_R   |
| 14 | <missing>  |  | 0B       | ARG BUNDLE_TYPE JAVA_RELEASE |
| 15 | <missing>  |  | 0B       | ARG JAVA_RELEASE             |
| 16 | <missing>  |  | 7.49MiB  | CMD ["/bin/sh"]              |

# Saved 500+ MB

But the build is not clean now :(

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But the build is not clean now :(

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

The background image depicts a grand, ornate interior of a theater or opera house. The room is filled with rich, dark wood paneling and gold-colored decorations. A large, ornate chandelier hangs from the ceiling above a grand stage. The stage is framed by heavy, red velvet curtains with gold fringe. Several gold-colored armchairs are arranged on the stage, and a small, ornate sofa sits in front of them. The floor is made of polished wood, and a large, patterned rug lies on the floor in the foreground. The overall atmosphere is one of luxury and grandeur.

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-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 runner
7
8 COPY --from=builder /app/build/libs/spring-petclinic-3.3.0.jar /app/app.jar
```

# Staged example

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```

# Result

| 1  | ID         | TAG  | SIZE     | COMMAND   |
|----|------------|--|----------|---|
| 2  | 6ea7ad11af | smarter:latest   | 0B       | CMD ["/bin/sh" "-c", "exit 0"]                                      |
| 3  | d6eb71a5df |  | 58.80MiB | COPY file:8d96bedf3e3333343333333333333333                          |
| 4  | c6ede8dac2 | bellsoft/liberica-runtime-container:jdk-21.0.3_10-musl | 98.32MiB | 15 BUNDLE_TYPE=JAR  |
| 5  | <missing>  |  | 0B       | ENV JAVA_HOME="/opt/jdk-21.0.3_10-musl"                             |
| 6  | <missing>  |  | 0B       | ENV LANG=en_US.UTF-8  |
| 7  | <missing>  |  | 0B       | LABEL org.opencor   |
| 8  | <missing>  |  | 0B       | LABEL org.opencor   |
| 9  | <missing>  |  | 0B       | LABEL maintainer="Pasha Finkelshteyn <pashafinkelshteyn@gmail.com>" |
| 10 | <missing>  |  | 0B       | ARG BUNDLE_TYPE JAR   |
| 11 | <missing>  |  | 0B       | ARG BUNDLE_TYPE JAR   |
| 12 | <missing>  |  | 0B       | ARG BUNDLE_TYPE JAR   |
| 13 | <missing>  |  | 0B       | ARG BUNDLE_TYPE JAR   |
| 14 | <missing>  |  | 0B       | ARG BUNDLE_TYPE JAR   |
| 15 | <missing>  |  | 0B       | ARG JAVA_RELEASE 21   |
| 16 | <missing>  |  | 7.49MiB  | CMD ["/bin/sh"]   |

## Result

# That's all folks!

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Or is it?

# What's these 59 MiB?

We have to pull 59 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 --launcher
```

- Build image

# 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
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8  COPY --from=builder /app/build/libs/spring-petclinic-3.3.0.jar /app/app.jar
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```

- Build image
- Introduce new "optimizer" stage

# Layers!

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```

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

# Layers!

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

# Layers!

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```

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

# Layers!

```
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", "org.springframework.boot.loader.launch.JarLauncher"]
15 COPY --from=optimizer /app/app/dependencies/ ./
16 COPY --from=optimizer /app/app/spring-boot-loader/ ./
17 COPY --from=optimizer /app/app/snapshot-dependencies/ ./
18 COPY --from=optimizer /app/app/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 app
2   └── application
3     |   └── BOOT-INF
4     |     └── classes
5     |       ├── application-mysql.properties
6     |       ├── application-postgres.properties
7     |       ├── application.properties
8     |       ├── banner.txt
9     |       └── db
10    |         └── ...
11    |           └── org
```

# Layers

```
1 app
2   └── application
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# Layers

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```

# Layers

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# Layers

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9     |       └── db
10    |         └── ...
11    |           └── org
```

# Layered image structure

| ID         | TAG   | SIZE      | COMMAND               |
|------------|---|-----------|-----------------------|
| 618743f6a2 | layers:latest                                     | 2.96MiB   | COPY dir:e0faa63b9654 |
| 9cca3273f0 |   | 0B        | COPY dir:acd0d0ac1f7e |
| fe123ee16e |   | 382.56kiB | COPY dir:01225d3c4ef6 |
| dede9bac3d |   | 57.69MiB  | COPY dir:755815d928fc |
| 65e3fb4cbf |   | 0B        | ENTRYPOINT ["java" "o |
| 7130fa5864 | bellsoft/liberica-runtime-container:jre-slim-musl | 126.80MiB | 18 CDS=no DESCRIPTIO  |
| <missing>  |   | 0B        | ENV JAVA_HOME="/usr/l |
| <missing>  |   | 0B        | ENV LANG=en_US.UTF-8  |
| <missing>  |   | 0B        | LABEL org.opencontai  |

# Layered image structure

| ID         | TAG   | SIZE      | COMMAND               |
|------------|---|-----------|-----------------------|
| 618743f6a2 | layers:latest                                     | 2.96MiB   | COPY dir:e0faa63b9654 |
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| dede9bac3d |   | 57.69MiB  | COPY dir:755815d928fc |
| 65e3fb4cbf |   | 0B        | ENTRYPOINT ["java" "j |
| 7130fa5864 | bellsoft/liberica-runtime-container:jre-slim-musl | 126.80MiB | 18 CDS=no DESCRIPTION |
| <missing>  |   | 0B        | ENV JAVA_HOME="/usr/l |
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- Dependencies: ~57.7 MiB

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| 4  | <b>fe123ee16e</b>  | 382.56kiB | COPY dir:01225d3c4ef6 |
| 5  | dede9bac3d   | 57.69MiB  | COPY dir:755815d928fc |
| 6  | 65e3fb4cbf   | 0B        | ENTRYPOINT ["java" "j |
| 7  | 7130fa5864 bellsoft/liberica-runtime-container:jre-slim-musl | 126.80MiB | 18 CDS=no DESCRIPTION |
| 8  | <missing>  | 0B        | ENV JAVA_HOME="/usr/l |
| 9  | <missing>  | 0B        | ENV LANG=en_US.UTF-8  |
| 10 | <missing>  | 0B        | LABEL org.opencontai  |

- Dependencies: ~57.7 MiB
- Launcher: 382.56kiB

# Layered image structure

| ID         | TAG   | SIZE      | COMMAND               |
|------------|---|-----------|-----------------------|
| 618743f6a2 | layers:latest                                     | 2.96MiB   | COPY dir:e0faa63b9654 |
| 9cca3273f0 |   | 0B        | COPY dir:acd0d0ac1f70 |
| fe123ee16e |   | 382.56kiB | COPY dir:01225d3c4ef6 |
| dede9bac3d |   | 57.69MiB  | COPY dir:755815d928fc |
| 65e3fb4cbf |   | 0B        | ENTRYPOINT ["java" "j |
| 7130fa5864 | bellsoft/liberica-runtime-container:jre-slim-musl | 126.80MiB | 18 CDS=no DESCRIPTION |
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# Layered image structure

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| 9  | <missing>  | 0B        | LABEL org.opencontai  |
| 10 | <missing>  | 0B        |                       |

- Dependencies: ~57.7 MiB
- Launcher: 382.56kiB
- Application: ~3MiB

# Layered image structure

| ID | TAG  | SIZE      | COMMAND               |
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| 1  | 618743f6a2 layers:latest                                     | 2.96MiB   | COPY dir:e0faa63b9654 |
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| 3  | fe123ee16e   | 382.56kiB | COPY dir:01225d3c4ef6 |
| 4  | dede9bac3d   | 57.69MiB  | COPY dir:755815d928fc |
| 5  | 65e3fb4cbf   | 0B        | ENTRYPOINT ["java" "j |
| 6  | 7130fa5864 bellsoft/liberica-runtime-container:jre-slim-musl | 126.80MiB | 18 CDS=no DESCRIPTIO  |
| 7  | <missing>  | 0B        | ENV JAVA_HOME="/usr/t |
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| 9  | <missing>  | 0B        | LABEL org.opencontai  |
| 10 | <missing>  | 0B        |                       |

- Dependencies: ~57.7 MiB
- Launcher: 382.56kiB
- Application: ~3MiB

Together: ~61MiB

61.0MiB > 58.8Mib!



# What are we optimizing?

Pull size!

Pull size here is usually only around 3MiB!

# 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 \
3   --path . \
4   -e BP_JVM_VERSION=21
```

# Diversion: buildpacks

<https://paketo.io/>

Trivial usage:

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# Diversion: buildpacks

<https://paketo.io/>

Trivial usage:

```
1 /usr/sbin/pack build petclinic \
2   --builder bellsoft/buildpacks.builder \
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>  |                  |           |  |

# Result

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

# Result

|    | ID         | TAG              | SIZE      | COMMAND  |
|----|------------|------------------|-----------|--|
| 1  | 2774e3f214 | petclinic:latest | 0B        | Buildpacks Process Types                               |
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# Result

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# 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. Coordinated Restore at Checkpoint
3. 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", "org.springframework.boot.loader.launch.JarLauncher"]
15 COPY --from=optimizer /app/app/dependencies/ ./
16 COPY --from=optimizer /app/app/spring-boot-loader/ ./
17 COPY --from=optimizer /app/app/snapshot-dependencies/ ./
18 COPY --from=optimizer /app/app/application/ ./
```

# 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
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18 COPY --from=optimizer /app/app/application/ ../
```

# 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-cds-slim-musl as runner
13
14 ENTRYPOINT ["java", "org.springframework.boot.loader.launch.JarLauncher"]
15 COPY --from=optimizer /app/app/dependencies/ ../
16 COPY --from=optimizer /app/app/spring-boot-loader/ ../
17 COPY --from=optimizer /app/app/snapshot-dependencies/ ../
18 COPY --from=optimizer /app/app/application/ ../
```

# Practice

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

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

# 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             "org.springframework.boot.loader.launch.JarLauncher"]
8 COPY --from=optimizer /app/app/dependencies / ./
9 COPY --from=optimizer /app/app/spring-boot-loader/ ./
10 COPY --from=optimizer /app/app/snapshot-dependencies/ ./
11 COPY --from=optimizer /app/app/application/ ./
12 RUN java -Dspring.aot.enabled=true \
13     -XX:ArchiveClassesAtExit=../application.jsa \
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# Practice

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# What does it cost ?

```
1 -r-- r-- r-- 0:0 81 MB — application.jsa
```

Which is not small at all!

# What does it cost ?

```
1 -r-- r-- r-- 0:0 81 MB — application.jsa
```

Which is not small at all!

But you're trading pull speed for startup speed

# How much faster?

Up to 50-60%

# 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
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14 ENTRYPOINT java -XX:CRaCRestoreFrom=/checkpoint
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```

# 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.translateJVMExceptions(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
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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
13
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# CRaC is hard!

Let's try to fix it with arcane magic

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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
```

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Did you hear about `buildx` ?

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1 docker buildx create --buildkitd-flags \  
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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!

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```

# 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
- 2 HikariPool-1 - Thread starvation or clock leap detected (housekeeper delta=1d19h37m42s102ms798μs806ns)
- 3 Tomcat started on port 8080 (http) with context path ''
- 4 Restored PetClinicApplication in 0.186 seconds (process running for 0.19)

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# Is it a good solution?

It depends

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- If "It Works" is enough for you

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- If "It Works" is enough for you -> YES
- If you need more predictable and maintainable thing

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3. Run the container with capabilities:
  1. CAP\_SYS\_PTRACE
  2. CAP\_CHECKPOINT\_RESTORE
4. Container will run and stop
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

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)

# Thank you!

Find me @

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-  me@asm0dey.site
-  asm0dey
-  asm0dey
-  asm0dey
-  asm0dey
-  asm0dey



END