Unraveling the Magic Behind Buildpacks

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Overview

- What are container images?
- How container builds typically work?
- How Buildpacks and lifecycle work?

What are container images?

What are container images?

What are container images?

```
--- app.py ---
from flask import Flask
app = Flask(__name__)


@app.route("/")
def hello_world():
    return "Hello, Kubecon EU!"
--- requirements.txt ---
click==8.0.3
Flask==2.0.2
itsdangerous==2.0.1
Jinja2==3.0.2
MarkupSafe==2.0.1
Werkzeug==2.0.2
--- Dockerfile ---
FROM python:3.8-slim-buster

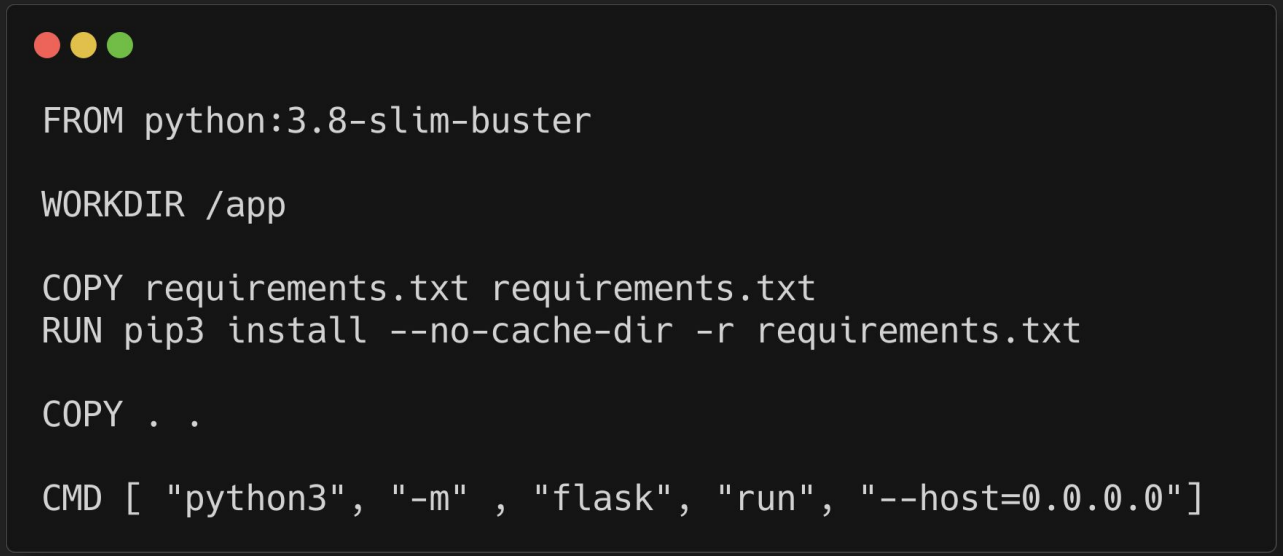
WORKDIR /app

COPY requirements.txt requirements.txt
RUN pip3 install --no-cache-dir -r requirements.txt

COPY . .

CMD [ "python3", "-m" , "flask", "run", "--host=0.0.0.0"]
```

What are container images?



```
FROM python:3.8-slim-buster

WORKDIR /app

COPY requirements.txt requirements.txt
RUN pip3 install --no-cache-dir -r requirements.txt

COPY . .

CMD [ "python3", "-m" , "flask", "run", "--host=0.0.0.0"]
```

What are container images?


```
{
    "Id": "sha256:bc43796e3c8a0c247f3af164756b304cba278f2c1abdb336da8b8b387fd296f2",
    "Config": {
        "User": "",
        "Env": [
            "PATH=/usr/local/bin:/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin",
            "LANG=C.UTF-8",
            "PYTHON_VERSION=3.8.12"
        ],
        "Cmd": ["python3", "-m", "flask", "run", "--host=0.0.0.0"],
        "Image": "sha256:489a14c15b1736f39c9ae90d2f1705ce1a185adfca70388d079365507934bb72",
        "WorkingDir": "/app"
    },
    "Architecture": "amd64",
    "Os": "linux",
    "Size": 124011190,
    "RootFS": {
        "Type": "layers",
        "Layers": [
            "sha256:e81bff2725dbc0bf2003db10272fef362e882eb96353055778a66cda430cf81b",
            "sha256:9d1100648d6db485e16fa8d60c4535830bf128c9ef274a4eb884367127829a3f",
            "sha256:da27cd6210afeafcafad4cf8cedbfc187d296c7059b4ac97ad38e5db98fb2280",
            "sha256:c511542be34c785e7ae85d7e5184fb67cd55ddb23aad6825e4120ec0362de3f9",
            "sha256:1d486fa85b2686240b30037987470187f177c2d54c5f6fd0cc331da04bbbfe0e",
            "sha256:f32958cc0f4563e5b3198be5179977c280e8d1786884bb2c686cd8f6a851ddde",
            "sha256:16682f259c74c6436c5e1545dcf1ea80c908074800b44ba39313af6803a11307",
            "sha256:4c8c9b21ed6a352c64e25a6b50094cc0d48478f0c6ad120c456c03524549c95b",
            "sha256:18238e863646fe305fa14400c1a70bcae8d3f76abc7da69456f470785c73f775"
        ]
    }
}
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What are container images?


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What are container images?

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FROM python:3.8-slim-buster

WORKDIR /app

COPY requirements.txt requirements.txt
RUN pip3 install --no-cache-dir -r requirements.txt

COPY . .

CMD [ "python3", "-m" , "flask", "run", "--host=0.0.0.0"]
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```
"Config": {
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RUN pip3 install --no-cache-dir -r requirements.txt

COPY . .

CMD [ "python3", "-m" , "flask", "run", "--host=0.0.0.0"]
```


```
"Layers": [
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FROM python:3.8-slim-buster

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COPY . .

CMD [ "python3", "-m" , "flask", "run", "--host=0.0.0.0"]
```

```
Layers
   Size  Command
  69 MB  FROM 970b29bb2c78938
 7.0 MB  set -eux;     apt-get update;     apt-get install -y --no-install-recommends         ca-cer
  28 MB  set -ex         && savedAptMark="$(apt-mark showmanual)"     && apt-get update && apt-get i
   0 B   cd /usr/local/bin     && ln -s idle3 idle     && ln -s pydoc3 pydoc     && ln -s python3 py
 9.5 MB  set -ex;         savedAptMark="$(apt-mark showmanual)";     apt-get update;     apt-get ins
   0 B   #(nop) WORKDIR /app
  94 B   #(nop) COPY file:b10a0855c3dfb57177be69422acdb25833f35312143fe73fa6fd9e31f4ab0b8a in requir
 9.8 MB  pip3 install --no-cache-dir -r requirements.txt
 6.5 kB  #(nop) COPY dir:a6249b228993dcdb127f6c96790fb8ceb5952f55aa12db5c7796c9f1a3e96c79 in .
```

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FROM python:3.8-slim-buster

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COPY requirements.txt requirements.txt
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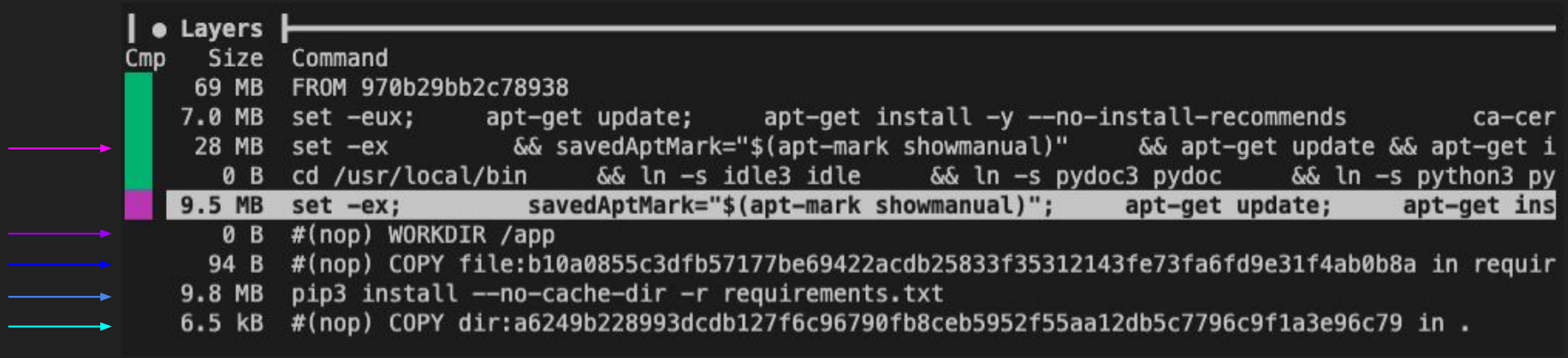
CMD [ "python3", "-m" , "flask", "run", "--host=0.0.0.0"]
```



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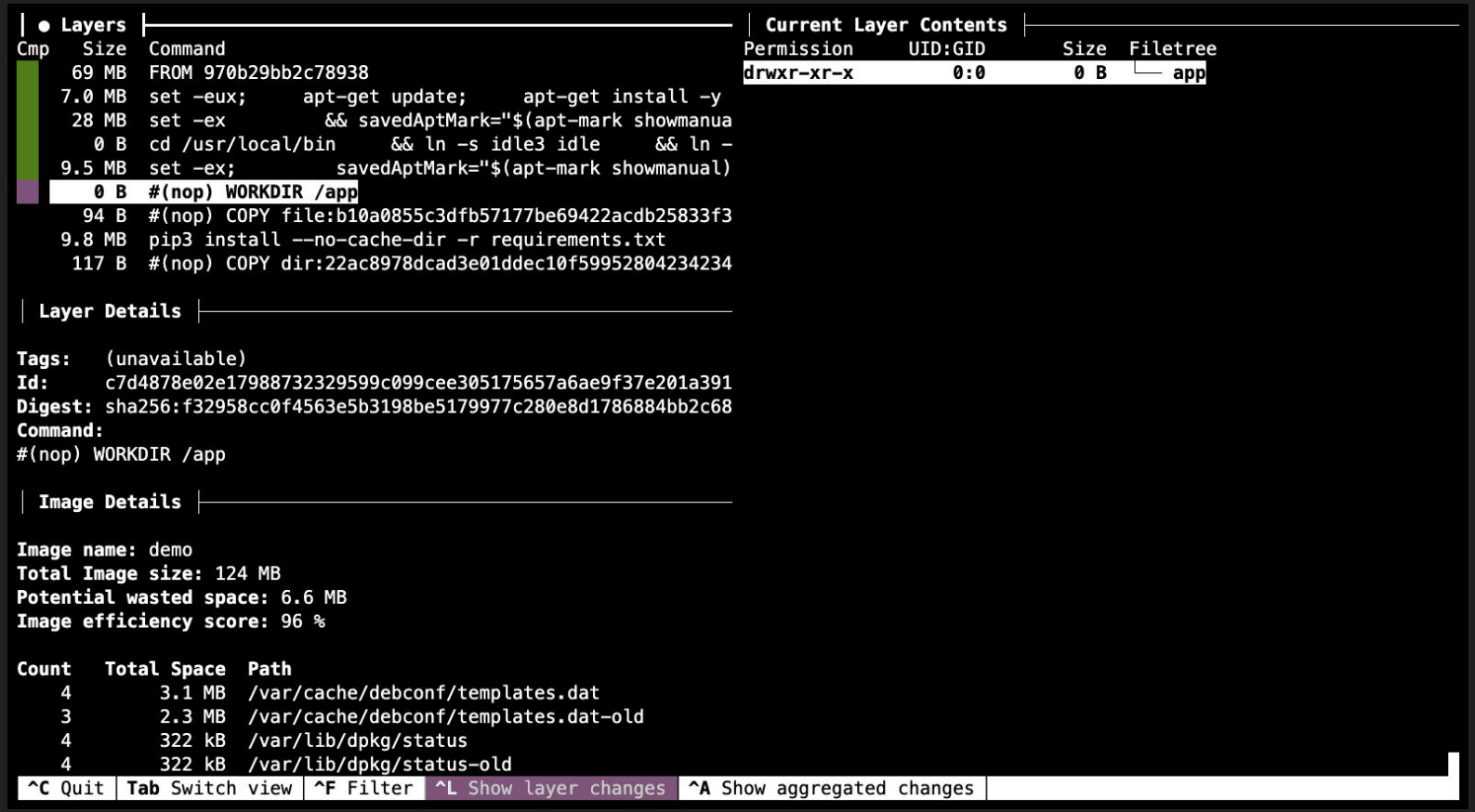

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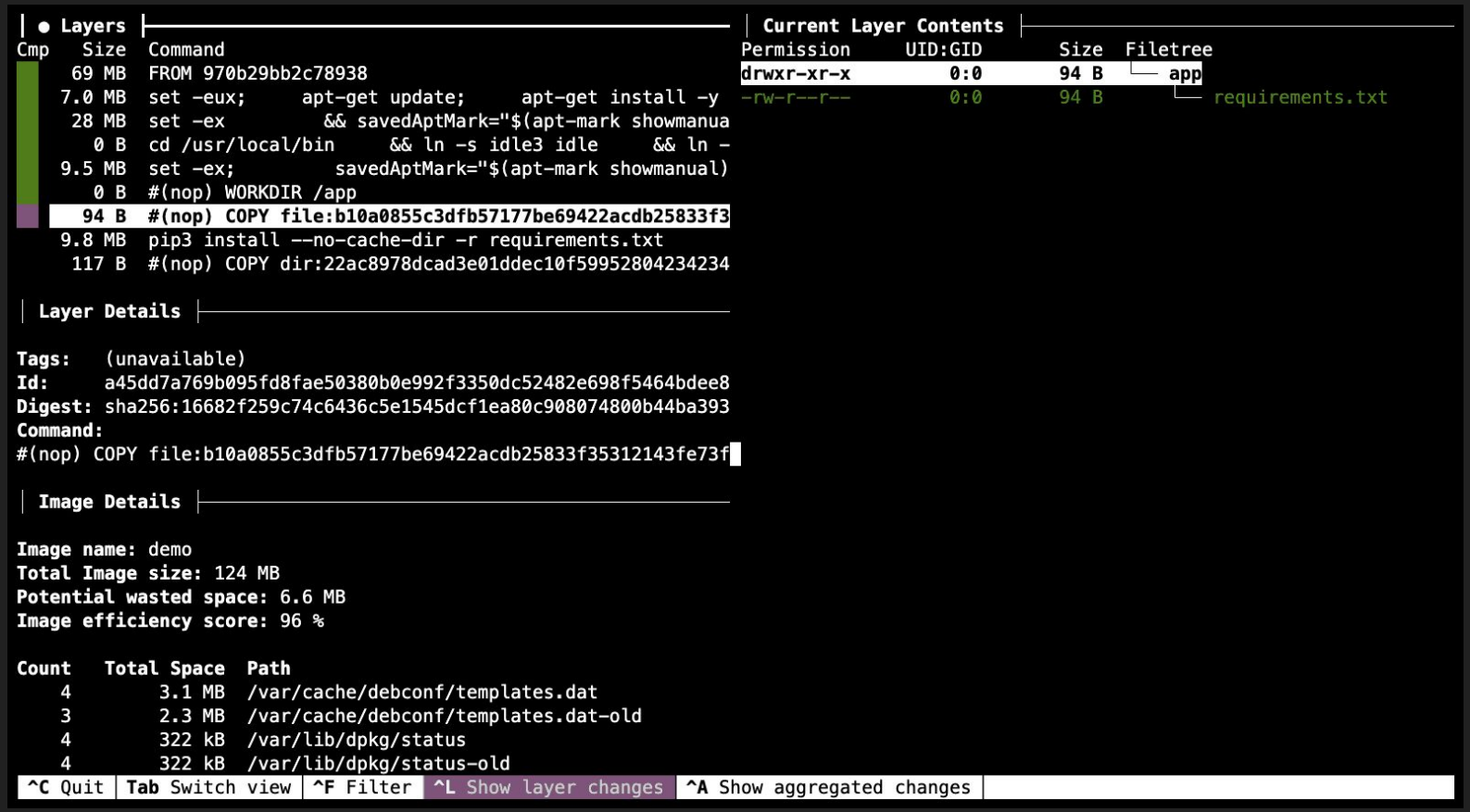

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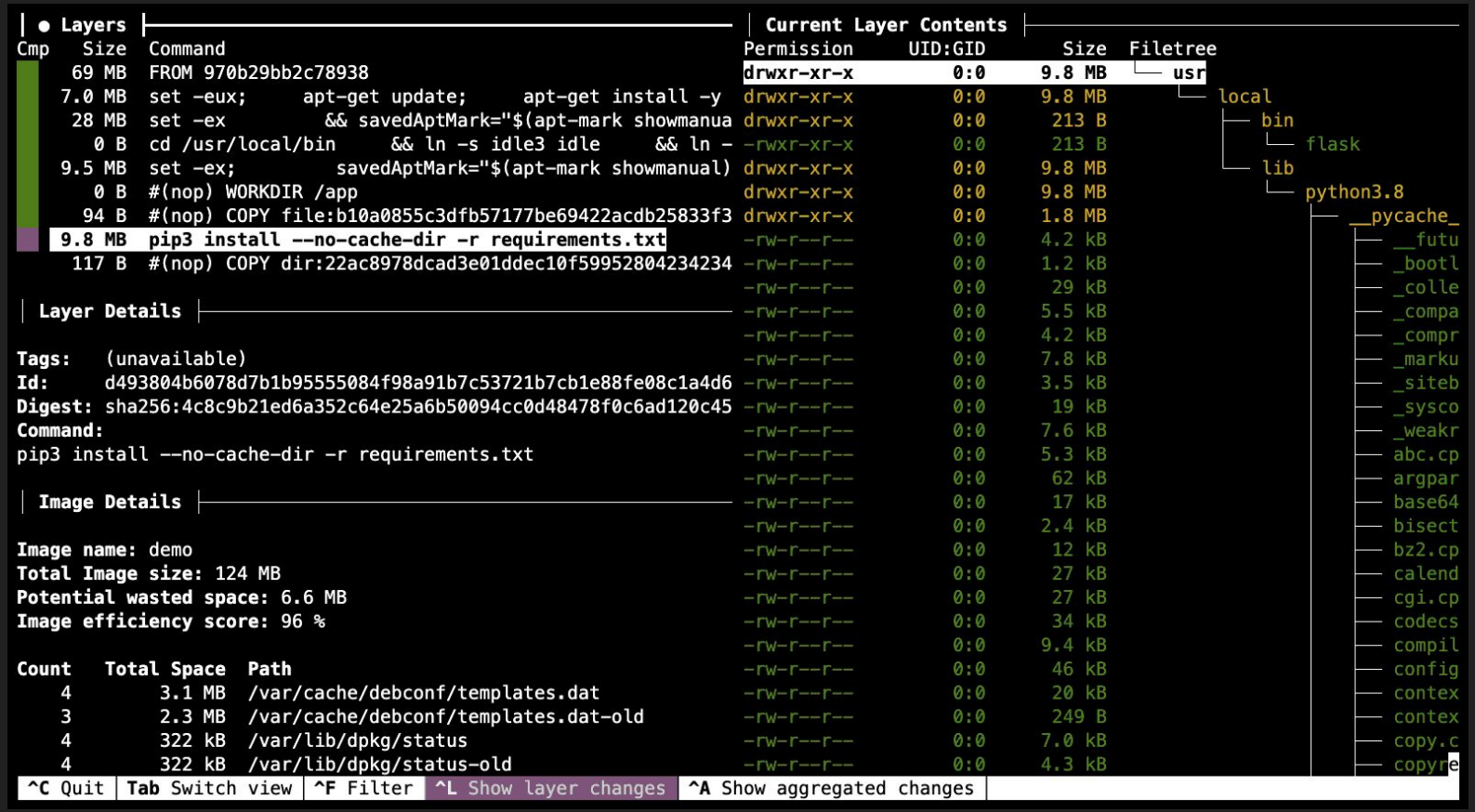

How do container builds typically work?

How does Docker do it?

- Start a container
- Run the command to make changes
- Commit the changes in a layer
- Repeat if necessary
- Image is ready!

Start a container

Run the command

```
[1] → packaging-con-demo docker run -d --name demo-container busybox sleep infinity
3b0f0b032623306f2d39b3b2f3520d7a2967c3bee8cd2b698449f6325347992b
[2] → packaging-con-demo docker exec demo-container /bin/sh -c "echo \"Hello World\" > /demo"
[3] → packaging-con-demo docker exec demo-container /bin/sh -c "cat /demo"
Hello World
```

Commit the changes

```
[1] → packaging-con-demo docker run -d --name demo-container busybox sleep infinity
3b0f0b032623306f2d39b3b2f3520d7a2967c3bee8cd2b698449f6325347992b
[2] → packaging-con-demo docker exec demo-container /bin/sh -c "echo \"Hello World\" > /demo"
[3] → packaging-con-demo docker exec demo-container /bin/sh -c "cat /demo"
Hello World
[4] → packaging-con-demo docker commit -m "Add demo file" demo-container demo-image
sha256:c2a4ec1914f9897a52ce5914375bc92803b328a544d06fb01032608482c33373
```

Image is ready!

```
[1] → packaging-con-demo docker run -d --name demo-container busybox sleep infinity
3b0f0b032623306f2d39b3b2f3520d7a2967c3bee8cd2b698449f6325347992b
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Hello World
[4] → packaging-con-demo docker commit -m "Add demo file" demo-container demo-image
sha256:c2a4ec1914f9897a52ce5914375bc92803b328a544d06fb01032608482c33373
[5] → packaging-con-demo docker run demo-image cat /demo
Hello World
```

How docker build works?

Docker build

```
FROM python:3.8-slim-buster

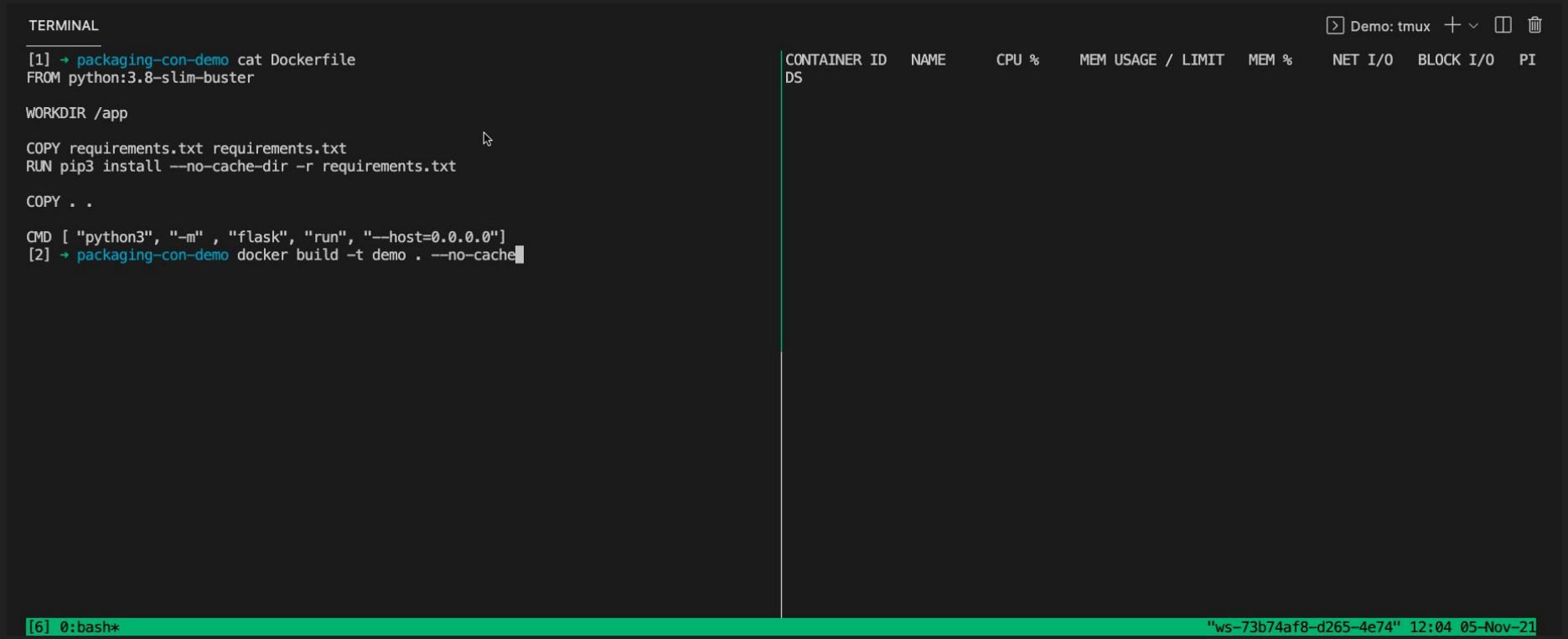
WORKDIR /app

COPY requirements.txt requirements.txt
RUN pip3 install --no-cache-dir -r requirements.txt

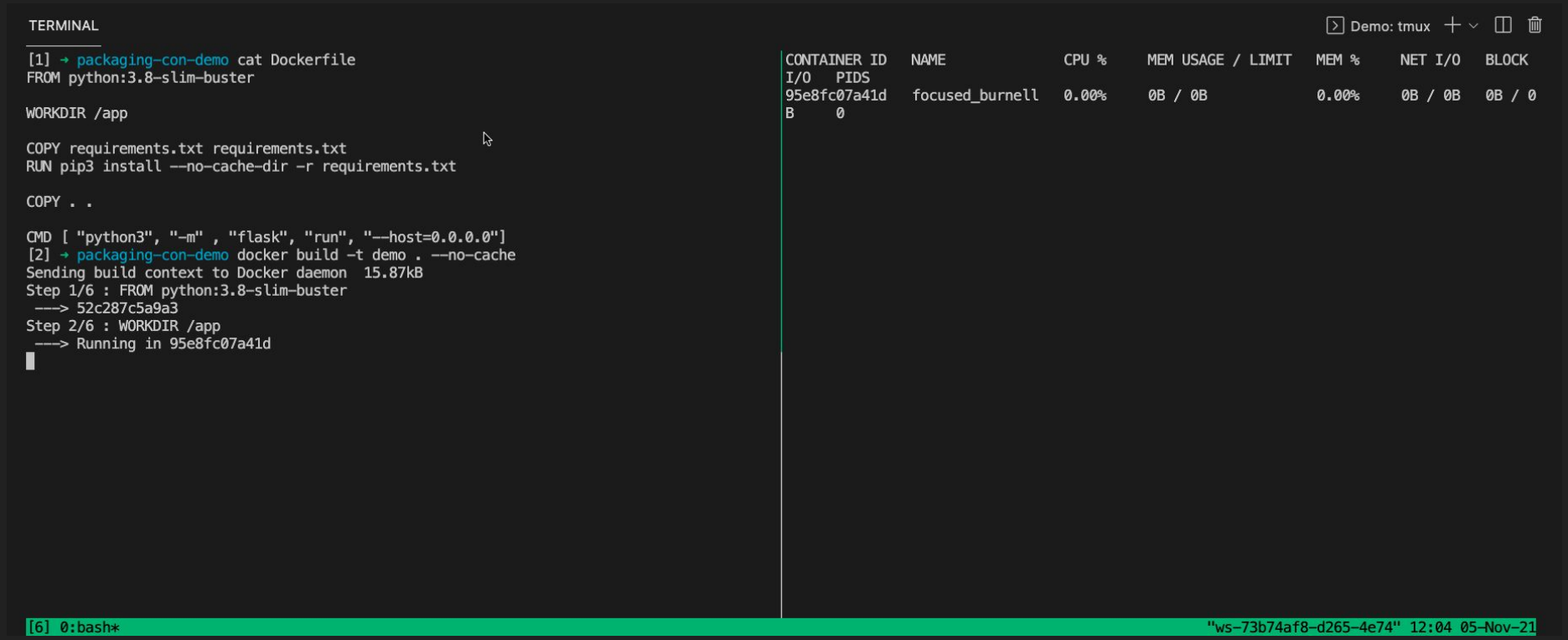
COPY . .

CMD [ "python3", "-m" , "flask", "run", "--host=0.0.0.0"]
```

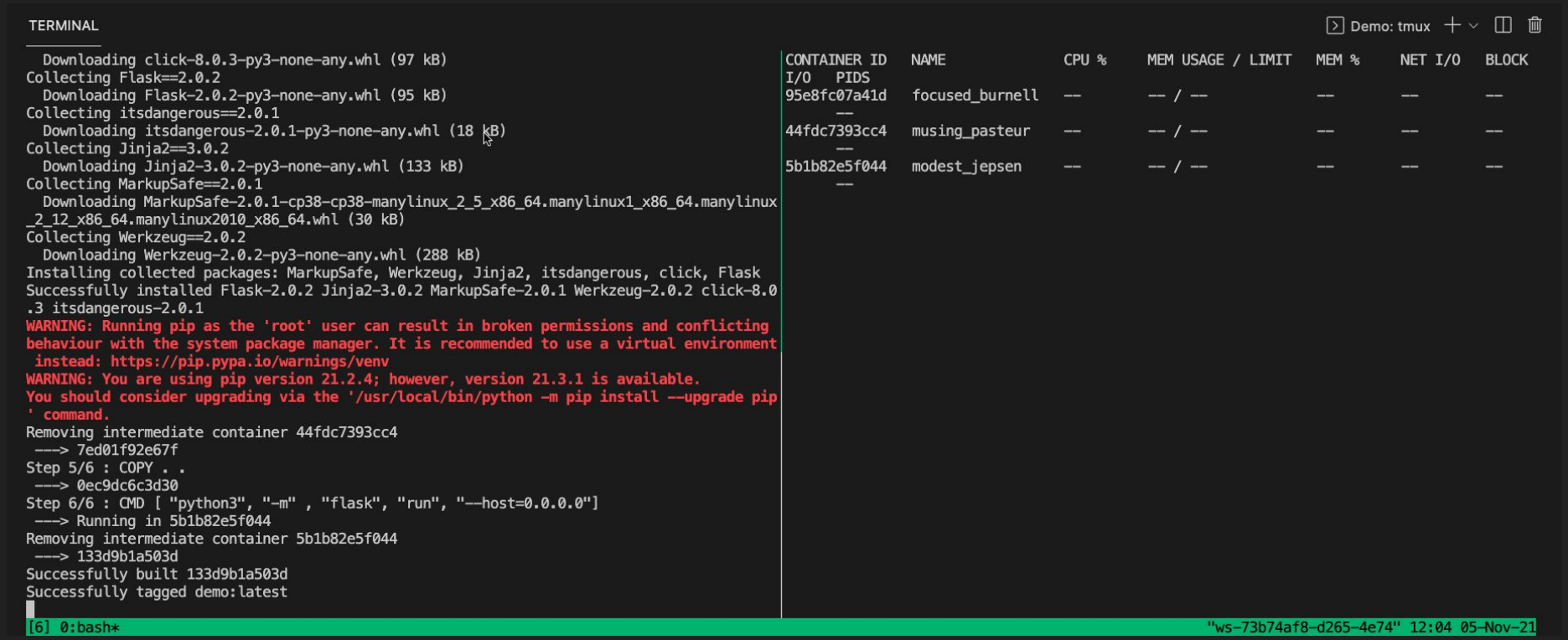
Docker build



Docker build



Docker build



Recap

Container images are just layers + config files

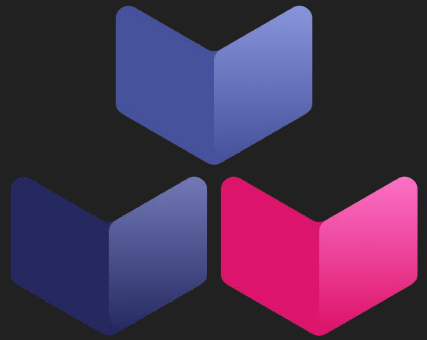
Demo

OCI Images from first principles!

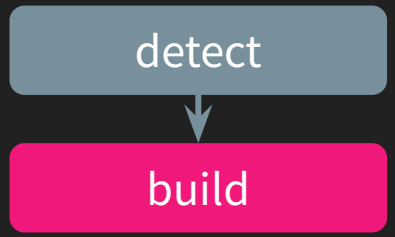
Same principle - vastly different tools

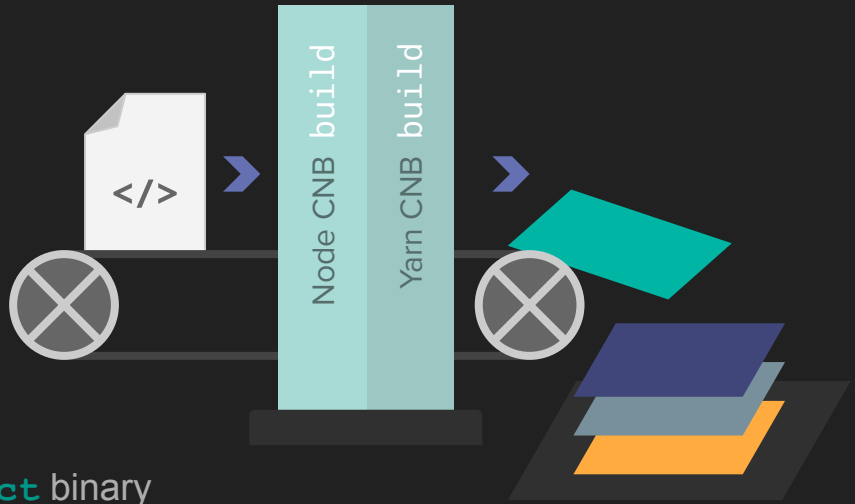
- Buildah
- Kaniko
- 🌟 **Cloud Native Buildpacks**

Cloud Native Buildpacks Build



What is a buildpack?





- The lifecycle runs each buildpack's `detect` binary against the source code
- For the first buildpack group that passes detection, it executes each buildpack's `build` binary, in order
- `build` gathers dependencies, compiles app (if needed), and sets launch command

What does a buildpack actually do?

- Install dependencies
- Run compilation if needed
- Define runtime processes
- Configure the environment
- Generate a Software Bill of Materials (SBOM) for installed dependencies

CNB Specification - Buildpack API

A buildpack’s view of the world

```
/layers
|-- some_buildpack_id
```

```
/workspace
|-- ...source code...
```

```
/platform
|-- ...platform-specific configuration...
```

A buildpack's view of the world

```
/layers
|-- some_buildpack_id

|   |-- some_layer

|   |-- some_layer.toml
```

```
/workspace
|-- ...source code...
```

```
/platform
|-- ...platform-specific configuration...
```

A buildpack’s view of the world

```
/layers
|-- some_buildpack_id

|   |-- some_layer
|   |   |-- bin

|   |   |-- include
|   |   |-- lib
|   |   `-- ...
|   |-- some_layer.toml
```

```
/workspace
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```

```
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```

A buildpack’s view of the world

```
/layers
|-- some_buildpack_id
|   |-- some_layer
|   |   |-- bin
|   |   |-- env
|   |   |   `-- SOME_VAR
|   |   |-- include
|   |   |-- lib
|   |   `-- ...
|   |-- some_layer.toml
```

```
/workspace
|-- ...source code...
```

```
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A buildpack’s view of the world

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|-- some_buildpack_id
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|   |   |-- include
|   |   |-- lib
|   |   `-- ...
|   |-- some_layer.toml
|   |-- some_other_layer
|   `-- some_other_layer.toml
```

```
/workspace
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A buildpack’s view of the world

```
/layers
|-- some_buildpack_id
|   |-- build.toml
|
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|   |   |-- bin
|   |   |-- env
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|   |   |-- include
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```

A buildpack’s view of the world

```
/layers
|-- some_buildpack_id
|   |-- build.toml
|   |-- launch.toml
|   |-- some_layer
|   |   |-- bin
|   |   |-- env
|   |   |   `-- SOME_VAR
|   |   |-- include
|   |   |-- lib
|   |   `-- ...
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|   |   |-- include
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|   |   `-- ...
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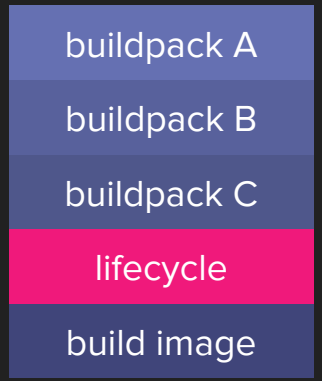
|   |-- some_other_layer
|   `-- some_other_layer.toml
|-- some_other_buildpack_id
|   |-- ...
```

```
/workspace
|-- ...source code...
```

```
/platform
|-- ...platform-specific configuration...
```

How do they work?



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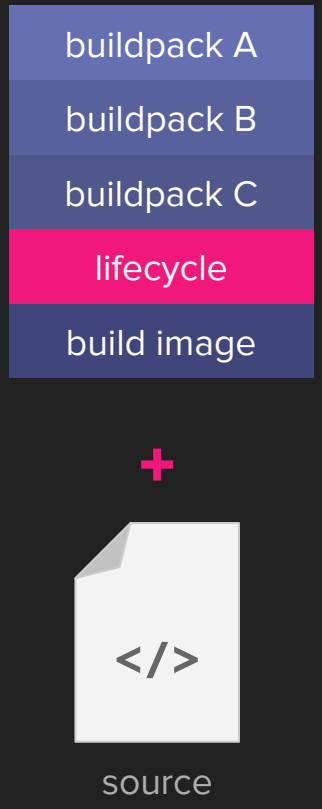

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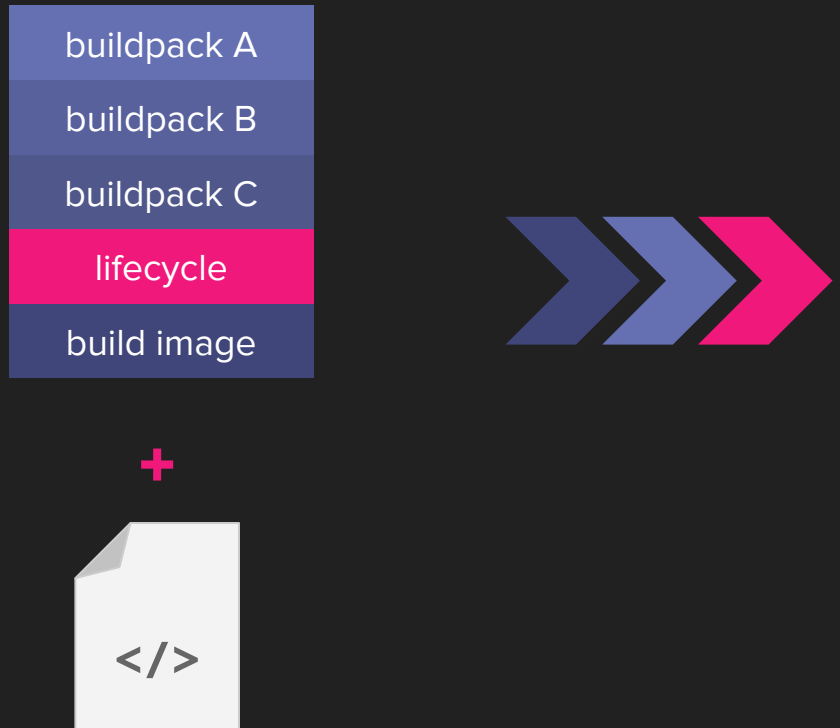
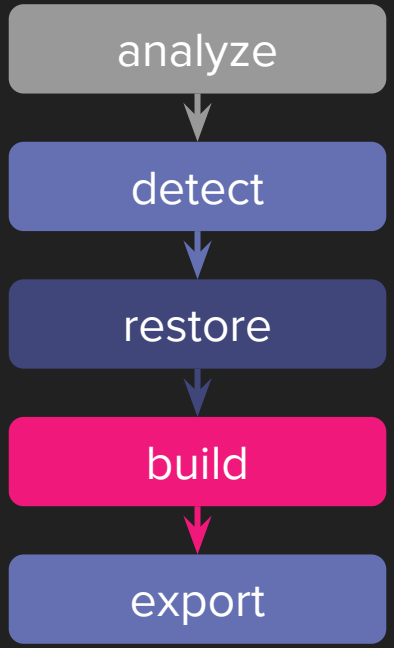


How do they work?

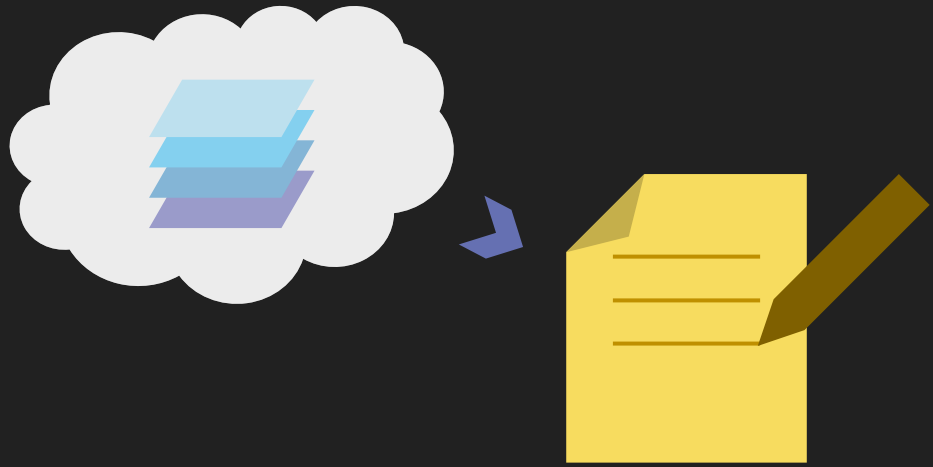
Lifecycle phases



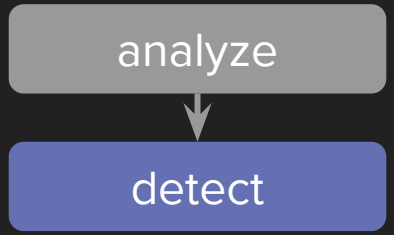
Analyze

analyze

- Gathers metadata from previously-build image
- Used during `export`, to avoid re-uploading unchanged layers

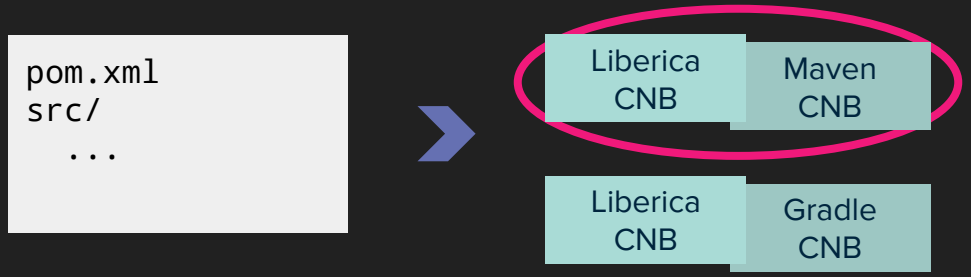


Detect



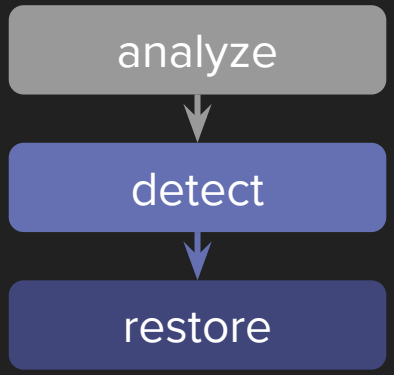
- Determines which buildpacks are needed
- Tests buildpacks against source, in order (via each buildpack's `detect` binary)

```
pom.xml
src/
  ...
```

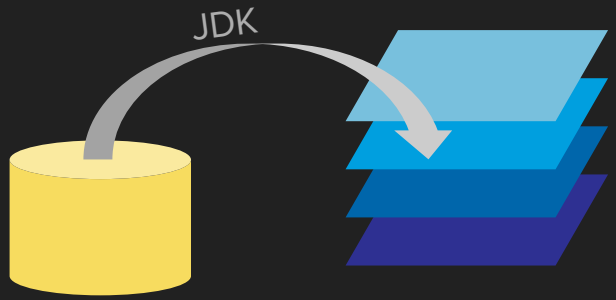



```
build.gradle
src/
  ...
```

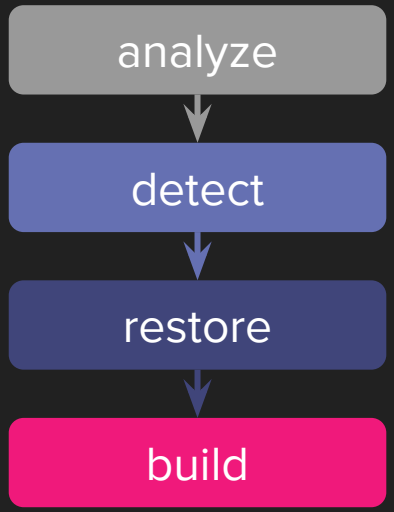
Restore



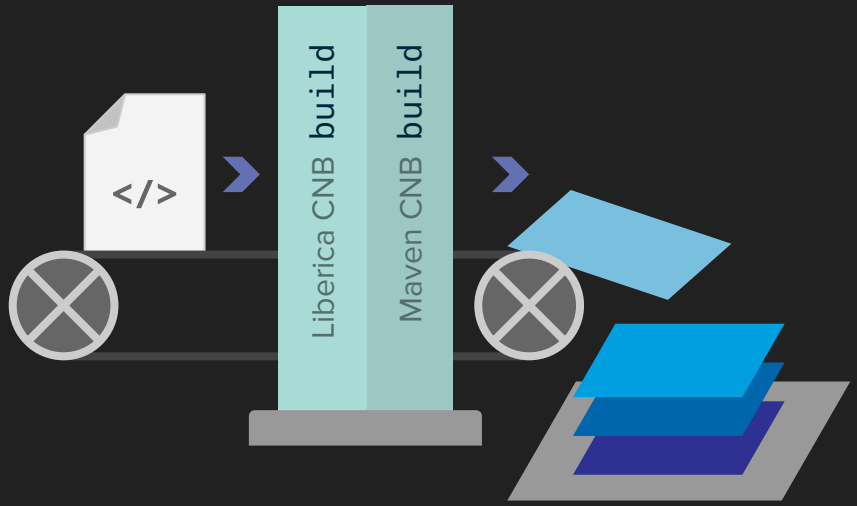
- Copies any previously-cached build-time dependencies into the build container



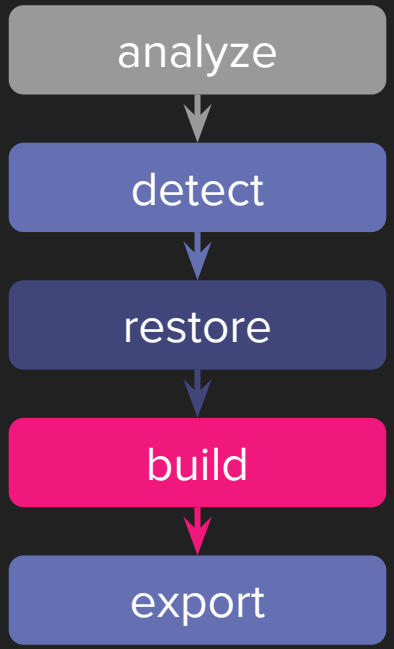
Build



- Executes each buildpack's `build` binary, in order
- `build` downloads dependencies, compiles app (if needed), sets start command, etc.



Export



- Assembles layers, creates final image
- Uses information from `analyze` phase to re-use unchanged layers
- Caches build-time dependencies

```
pack build my-app-image \
  --path ./my-source-dir \
  --builder my-builder-image
```

```
pack build my-app-image
```

Demo

Returning to our Python application…

Installs cpython

Installs pip

Populates pip cache

Installs packages

Returning to our Python application…

Installs cpython

Installs pip

Populates pip cache

Installs packages

Exported

Exported

Returning to our Python application…

Installs cpython

Installs pip

Populates pip cache

Installs packages

Exported

Exported

Exposed

Exposed

Returning to our Python application…

Installs cpython	Installs pip	Populates pip cache	Installs packages
Exported			Exported
Exposed	Exposed		
Cached	Cached	Cached	Cached

Directory structure - in the build container

```
/layers
```

```
/workspace
|-- app.py
`-- requirements.txt
```

ENV

```
PATH=

/usr/local/sbin:
/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin
```

Directory structure - in the build container

```
/layers
|-- paketo-buildpacks_cpython
|   |-- cpython
|   |   |-- bin
|   |   |-- env
|   |   |   `-- PYTHONPATH.override
|   |   |-- include
|   |   |-- lib
|   |   `-- ...
|   `-- cpython.toml
```

```
/workspace
|-- app.py
`-- requirements.txt
```

```
LD_LIBRARY_PATH=
/layers/paketo-buildpacks_cpython/cpython/lib

LIBRARY_PATH=
/layers/paketo-buildpacks_cpython/cpython/lib

CPATH=
/layers/paketo-buildpacks_cpython/cpython/include

PYTHONPATH=
/layers/paketo-buildpacks_cpython/cpython

PATH=
/layers/paketo-buildpacks_cpython/cpython/bin:
/usr/local/sbin:
/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin
```

Directory structure - in the build container

```
/layers
|-- paketo-buildpacks_cpython
|   |-- cpython
|   |   |-- bin
|   |   |-- env
|   |   |   `-- PYTHONPATH.override
|   |   |-- include
|   |   |-- lib
|   |   `-- ...
|   `-- cpython.toml
```

```
/workspace
|-- app.py
`-- requirements.txt
```

```
LD_LIBRARY_PATH=
/layers/paketo-buildpacks_cpython/cpython/lib

LIBRARY_PATH=
/layers/paketo-buildpacks_cpython/cpython/lib

CPATH=
/layers/paketo-buildpacks_cpython/cpython/include

PYTHONPATH=
/layers/paketo-buildpacks_cpython/cpython

PATH=
/layers/paketo-buildpacks_cpython/cpython/bin:
/usr/local/sbin:
/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin
```

Directory structure - in the build container

```
/layers
|-- paketo-buildpacks_cpython
|   |-- cpython
|   |   |-- bin
|   |   |-- env
|   |   |   `-- PYTHONPATH.override
|   |   |-- include
|   |   |-- lib
|   |   `-- ...
|   `-- cpython.toml
```

```
/workspace
|-- app.py
`-- requirements.txt
```

```
LD_LIBRARY_PATH=
/layers/paketo-buildpacks_cpython/cpython/lib

LIBRARY_PATH=
/layers/paketo-buildpacks_cpython/cpython/lib

CPATH=
/layers/paketo-buildpacks_cpython/cpython/include

PYTHONPATH=
/layers/paketo-buildpacks_cpython/cpython

PATH=
/layers/paketo-buildpacks_cpython/cpython/bin:
/usr/local/sbin:
/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin
```

Directory structure - in the build container

```
/layers
|-- paketo-buildpacks_cpython
|   |-- cpython
|   |   |-- bin
|   |   |-- env
|   |   |   `-- PYTHONPATH.override
|   |   |-- include
|   |   |-- lib
|   |   `-- ...
|   `-- cpython.toml
```

```
/workspace
|-- app.py
`-- requirements.txt
```

```
LD_LIBRARY_PATH=
/layers/paketo-buildpacks_cpython/cpython/lib

LIBRARY_PATH=
/layers/paketo-buildpacks_cpython/cpython/lib

CPATH=
/layers/paketo-buildpacks_cpython/cpython/include

PYTHONPATH=
/layers/paketo-buildpacks_cpython/cpython

PATH=
/layers/paketo-buildpacks_cpython/cpython/bin:
/usr/local/sbin:
/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin
```

Directory structure - in the build container

```
/layers
|-- paketo-buildpacks_cpython
|   |-- cpython
|   |   |-- bin
|   |   |-- env
|   |   |   `-- PYTHONPATH.override
|   |   |-- include
|   |   |-- lib
|   |   `-- ...
|   `-- cpython.toml
```

```
/workspace
|-- app.py
`-- requirements.txt
```

```
LD_LIBRARY_PATH=
/layers/paketo-buildpacks_cpython/cpython/lib

LIBRARY_PATH=
/layers/paketo-buildpacks_cpython/cpython/lib

CPATH=
/layers/paketo-buildpacks_cpython/cpython/include

PYTHONPATH=
/layers/paketo-buildpacks_cpython/cpython

PATH=
/layers/paketo-buildpacks_cpython/cpython/bin:
/usr/local/sbin:
/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin
```

Directory structure - in the build container

```
/layers
|-- paketo-buildpacks_cpython
|   |-- cpython
|   |   |-- bin
|   |   |-- env
|   |   |   `-- PYTHONPATH.override
|   |   |-- include
|   |   |-- lib
|   |   `-- ...
|   `-- cpython.toml
```

```
/workspace
|-- app.py
`-- requirements.txt
```

```
LD_LIBRARY_PATH=
/layers/paketo-buildpacks_cpython/cpython/lib

LIBRARY_PATH=
/layers/paketo-buildpacks_cpython/cpython/lib

CPATH=
/layers/paketo-buildpacks_cpython/cpython/include

PYTHONPATH=
/layers/paketo-buildpacks_cpython/cpython

PATH=
/layers/paketo-buildpacks_cpython/cpython/bin:
/usr/local/sbin:
/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin
```

Directory structure - in the build container

```
/layers
|-- paketo-buildpacks_cpython
|   |-- cpython
|   |   |-- bin
|   |   |-- env
|   |   |   `-- PYTHONPATH.override
|   |   |-- include
|   |   |-- lib
|   |   `-- ...
|   `-- cpython.toml
|-- paketo-buildpacks_pip
|   |-- pip
|   |   |-- bin
|   |   |-- env
|   |   |   |-- PYTHONPATH.delim
|   |   |   `-- PYTHONPATH.prepend
|   |   `-- lib
|   `-- pip.toml
```

```
/workspace
|-- app.py
`-- requirements.txt
```

```
LD_LIBRARY_PATH=
/layers/paketo-buildpacks_pip/pip/lib:
/layers/paketo-buildpacks_cpython/cpython/lib

LIBRARY_PATH=
/layers/paketo-buildpacks_pip/pip/lib:
/layers/paketo-buildpacks_cpython/cpython/lib

CPATH=
/layers/paketo-buildpacks_cpython/cpython/include

PYTHONPATH=
/layers/paketo-buildpacks_pip/pip/lib/python3.8/site-
packages:
/layers/paketo-buildpacks_cpython/cpython

PATH=
/layers/paketo-buildpacks_pip/pip/bin:
/layers/paketo-buildpacks_cpython/cpython/bin:
/usr/local/sbin:
/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin
```

Directory structure - in the build container

```
/layers
|-- paketo-buildpacks_cpython
|   |-- cpython
|   |   |-- bin
|   |   |-- env
|   |   |   `-- PYTHONPATH.override
|   |   |-- include
|   |   |-- lib
|   |   `-- ...
|   `-- cpython.toml
|-- paketo-buildpacks_pip
|   |-- pip
|   |   |-- bin
|   |   |-- env
|   |   |   |-- PYTHONPATH.delim
|   |   |   `-- PYTHONPATH.prepend
|   |   `-- lib
|   `-- pip.toml
```

```
/workspace
|-- app.py
`-- requirements.txt
```

```
LD_LIBRARY_PATH=
/layers/paketo-buildpacks_pip/pip/lib:
/layers/paketo-buildpacks_cpython/cpython/lib

LIBRARY_PATH=
/layers/paketo-buildpacks_pip/pip/lib:
/layers/paketo-buildpacks_cpython/cpython/lib

CPATH=
/layers/paketo-buildpacks_cpython/cpython/include

PYTHONPATH=
/layers/paketo-buildpacks_pip/pip/lib/python3.8/site-
packages:
/layers/paketo-buildpacks_cpython/cpython

PATH=
/layers/paketo-buildpacks_pip/pip/bin:
/layers/paketo-buildpacks_cpython/cpython/bin:
/usr/local/sbin:
/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin
```

Directory structure - in the build container

```
/layers
|-- paketo-buildpacks_cpython
|   |-- cpython
|   |   |-- bin
|   |   |-- env
|   |   |   `-- PYTHONPATH.override
|   |   |-- include
|   |   |-- lib
|   |   `-- ...
|   `-- cpython.toml
|-- paketo-buildpacks_pip
|   |-- pip
|   |   |-- bin
|   |   |-- env
|   |   |   |-- PYTHONPATH.delim
|   |   |   `-- PYTHONPATH.prepend
|   |   `-- lib
|   `-- pip.toml
```

```
/workspace
|-- app.py
`-- requirements.txt
```

```
LD_LIBRARY_PATH=
/layers/paketo-buildpacks_pip/pip/lib:
/layers/paketo-buildpacks_cpython/cpython/lib

LIBRARY_PATH=
/layers/paketo-buildpacks_pip/pip/lib:
/layers/paketo-buildpacks_cpython/cpython/lib

CPATH=
/layers/paketo-buildpacks_cpython/cpython/include

PYTHONPATH=
/layers/paketo-buildpacks_pip/pip/lib/python3.8/site-
packages:
/layers/paketo-buildpacks_cpython/cpython

PATH=
/layers/paketo-buildpacks_pip/pip/bin:
/layers/paketo-buildpacks_cpython/cpython/bin:
/usr/local/sbin:
/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin
```

Directory structure - in the build container

```
/layers
|-- paketo-buildpacks_cpython
|   |-- cpython
|   |   |-- bin
|   |   |-- env
|   |   |   `-- PYTHONPATH.override
|   |   |-- include
|   |   |-- lib
|   |   `-- ...
|   `-- cpython.toml
|-- paketo-buildpacks_pip
|   |-- pip
|   |   |-- bin
|   |   |-- env
|   |   |   |-- PYTHONPATH.delim
|   |   |   `-- PYTHONPATH.prepend
|   |   `-- lib
|   `-- pip.toml
```

```
/workspace
|-- app.py
`-- requirements.txt
```

```
LD_LIBRARY_PATH=
/layers/paketo-buildpacks_pip/pip/lib:
/layers/paketo-buildpacks_cpython/cpython/lib

LIBRARY_PATH=
/layers/paketo-buildpacks_pip/pip/lib:
/layers/paketo-buildpacks_cpython/cpython/lib

CPATH=
/layers/paketo-buildpacks_cpython/cpython/include

PYTHONPATH=
/layers/paketo-buildpacks_pip/pip/lib/python3.8/site-
packages:
/layers/paketo-buildpacks_cpython/cpython

PATH=
/layers/paketo-buildpacks_pip/pip/bin:
/layers/paketo-buildpacks_cpython/cpython/bin:
/usr/local/sbin:
/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin
```

Directory structure - in the build container

```
/layers
|-- paketo-buildpacks_cpython
|   |-- cpython
|   |   |-- bin
|   |   |-- env
|   |   `-- ...
|   `-- cpython.toml
|-- paketo-buildpacks_pip
|   |-- pip
|   |   |-- bin
|   |   |-- env
|   |   `-- lib
|   `-- pip.toml
|-- paketo-buildpacks_pip-install
|   |-- cache
|   |   `-- http
|   |-- cache.toml
|   |-- packages
|   |   |-- bin
|   |   |-- env
|   |   `-- lib
|   `-- packages.toml
```

```
/workspace
|-- app.py
`-- requirements.txt
```

```
LD_LIBRARY_PATH=
/layers/paketo-buildpacks_pip/pip/lib:
/layers/paketo-buildpacks_cpython/cpython/lib

LIBRARY_PATH=
/layers/paketo-buildpacks_pip/pip/lib:
/layers/paketo-buildpacks_cpython/cpython/lib

CPATH=
/layers/paketo-buildpacks_cpython/cpython/include

PYTHONPATH=
/layers/paketo-buildpacks_pip/pip/lib/python3.8/site-
packages:
/layers/paketo-buildpacks_cpython/cpython

PATH=
/layers/paketo-buildpacks_pip/pip/bin:
/layers/paketo-buildpacks_cpython/cpython/bin:
/usr/local/sbin:
/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin
```

Directory structure - in the build container

```
/layers
|-- paketo-buildpacks_cpython
|   |-- cpython
|   |   |-- bin
|   |   |-- env
|   |   `-- ...
|   `-- cpython.toml
|-- paketo-buildpacks_pip
|   |-- pip
|   |   |-- bin
|   |   |-- env
|   |   `-- lib
|   `-- pip.toml
|-- paketo-buildpacks_pip-install
|   |-- cache
|   |   `-- http
|   |-- cache.toml
|   |-- packages
|   |   |-- bin
|   |   |-- env
|   |   `-- lib
|   `-- packages.toml
```

```
/workspace
|-- app.py
`-- requirements.txt
```

```
LD_LIBRARY_PATH=
/layers/paketo-buildpacks_pip/pip/lib:
/layers/paketo-buildpacks_cpython/cpython/lib

LIBRARY_PATH=
/layers/paketo-buildpacks_pip/pip/lib:
/layers/paketo-buildpacks_cpython/cpython/lib

CPATH=
/layers/paketo-buildpacks_cpython/cpython/include

PYTHONPATH=
/layers/paketo-buildpacks_pip/pip/lib/python3.8/site-
packages:
/layers/paketo-buildpacks_cpython/cpython

PATH=
/layers/paketo-buildpacks_pip/pip/bin:
/layers/paketo-buildpacks_cpython/cpython/bin:
/usr/local/sbin:
/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin
```

Directory structure - in the build container

```
/layers
|-- paketo-buildpacks_cpython
|   |-- cpython
|   |   |-- bin
|   |   |-- env
|   |   `-- ...
|   `-- cpython.toml
|-- paketo-buildpacks_pip
|   |-- pip
|   |   |-- bin
|   |   |-- env
|   |   `-- lib
|   `-- pip.toml
|-- paketo-buildpacks_pip-install
|   |-- cache
|   |   `-- http
|   |-- cache.toml
|   |-- packages
|   |   |-- bin
|   |   |-- env
|   |   `-- lib
|   `-- packages.toml
```

```
/workspace
|-- app.py
`-- requirements.txt
```

```
LD_LIBRARY_PATH=
/layers/paketo-buildpacks_pip/pip/lib:
/layers/paketo-buildpacks_cpython/cpython/lib

LIBRARY_PATH=
/layers/paketo-buildpacks_pip/pip/lib:
/layers/paketo-buildpacks_cpython/cpython/lib

CPATH=
/layers/paketo-buildpacks_cpython/cpython/include

PYTHONPATH=
/layers/paketo-buildpacks_pip/pip/lib/python3.8/site-
packages:
/layers/paketo-buildpacks_cpython/cpython

PATH=
/layers/paketo-buildpacks_pip/pip/bin:
/layers/paketo-buildpacks_cpython/cpython/bin:
/usr/local/sbin:
/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin
```

Directory structure - in the build container

```
/layers
|-- paketo-buildpacks_cpython
|   |-- cpython
|   |   |-- bin
|   |   |-- env
|   |   `-- ...
|   `-- cpython.toml
|-- paketo-buildpacks_pip
|   |-- pip
|   |   |-- bin
|   |   |-- env
|   |   `-- lib
|   `-- pip.toml
|-- paketo-buildpacks_pip-install
|   |-- cache
|   |   `-- http
|   |-- cache.toml
|   |-- packages
|   |   |-- bin
|   |   |-- env
|   |   `-- lib
|   `-- packages.toml
```

```
/workspace
|-- app.py
`-- requirements.txt
```

Directory structure - in the build container

```
/layers
|-- paketo-buildpacks_cpython
|   |-- cpython
|   |   |-- bin
|   |   |-- env
|   |   `-- ...
|   `-- cpython.toml
|-- paketo-buildpacks_pip
|   |-- pip
|   |   |-- bin
|   |   |-- env
|   |   `-- lib
|   `-- pip.toml
|-- paketo-buildpacks_pip-install
|   |-- cache
|   |   `-- http
|   |-- cache.toml
|   |-- packages
|   |   |-- bin
|   |   |-- env
|   |   `-- lib
|   `-- packages.toml
```

```
/workspace
|-- app.py
`-- requirements.txt
```

Directory structure - in the build container

```
/layers
|-- paketo-buildpacks_cpython
|   |-- cpython
|   |   |-- bin
|   |   |-- env
|   |   `-- ...
|   `-- cpython.toml
|-- paketo-buildpacks_pip
|   |-- pip
|   |   |-- bin
|   |   |-- env
|   |   `-- lib
|   `-- pip.toml
|-- paketo-buildpacks_pip-install
|   |-- cache
|   |   `-- http
|   |-- cache.toml
|   |-- packages
|   |   |-- bin
|   |   |-- env
|   |   `-- lib
|   `-- packages.toml
```

```
/workspace
|-- app.py
`-- requirements.txt
```

Directory structure - in the build container

```
/layers
|-- paketo-buildpacks_cpython
|   |-- cpython
|   |   |-- bin
|   |   |-- env
|   |   `-- ...
|   `-- cpython.toml
|-- paketo-buildpacks_pip
|   |-- pip
|   |   |-- bin
|   |   |-- env
|   |   `-- lib
|   `-- pip.toml
|-- paketo-buildpacks_pip-install
|   |-- cache
|   |   `-- http
|   |-- cache.toml
|   |-- packages
|   |   |-- bin
|   |   |-- env
|   |   `-- lib
|   `-- packages.toml
```

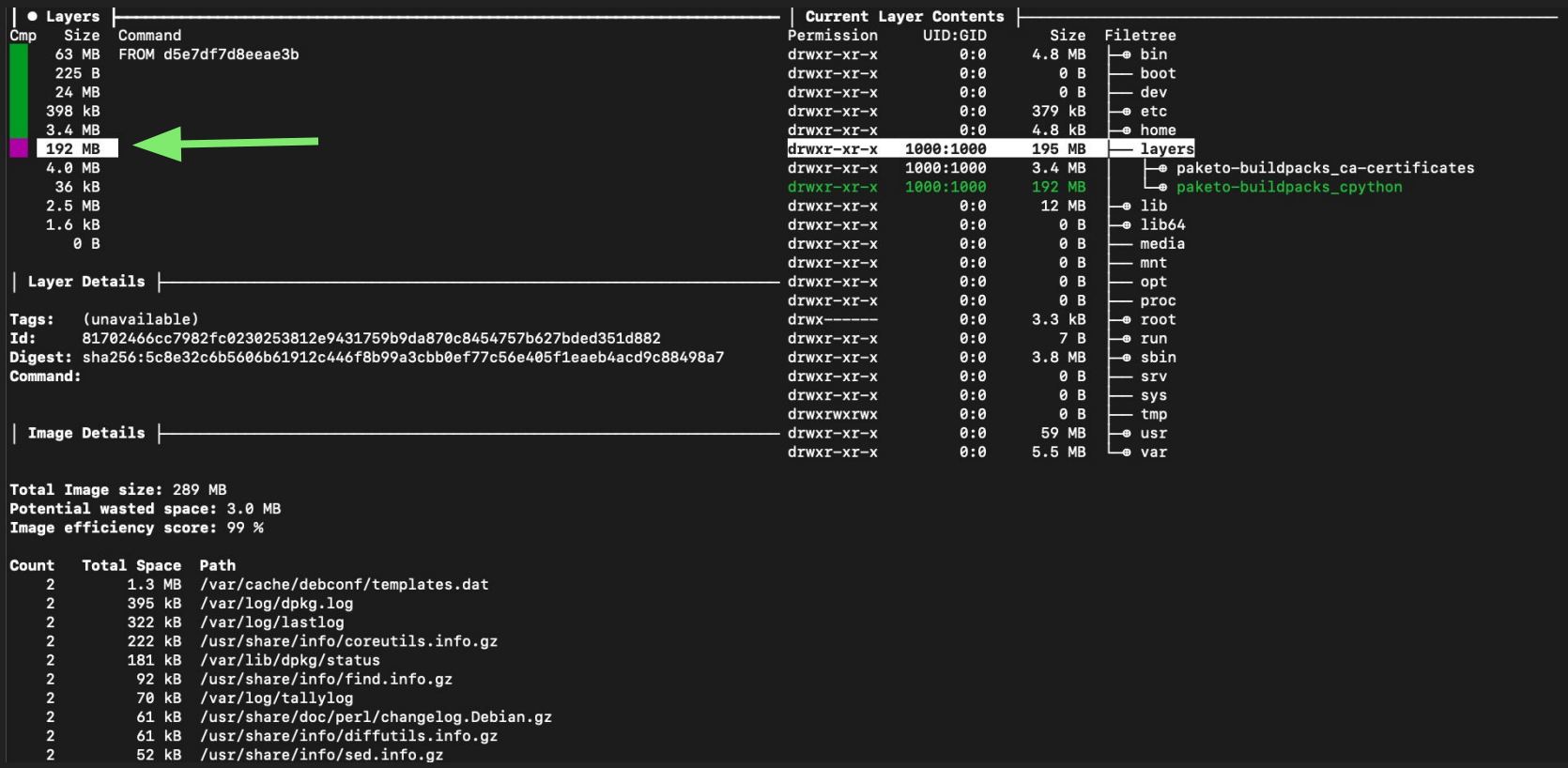
```
/workspace
|-- app.py
`-- requirements.txt
```

Directory structure - in the build container

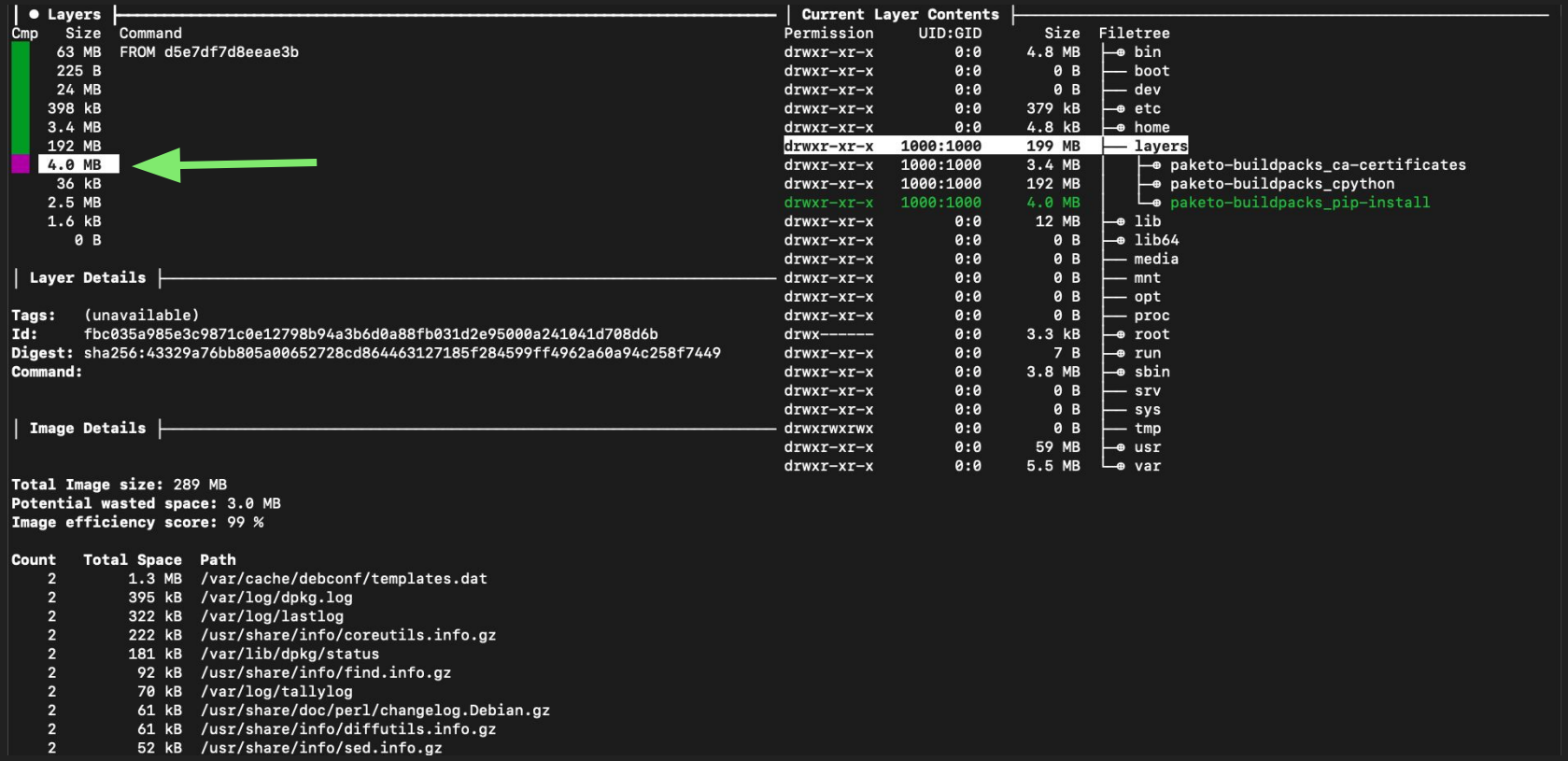
```
/layers
|-- paketo-buildpacks_cpython
|   |-- cpython
|   |-- cpython.cdx.json
|   |-- cpython.spdx.json
|   |-- cpython.syft.json
|   |-- ...
|   `-- cpython.toml
|-- paketo-buildpacks_pip
|   |-- pip
|   |-- pip.cdx.json
|   |-- pip.spdx.json
|   |-- pip.syft.json
|   |-- ...
|   `-- pip.toml
|-- paketo-buildpacks_pip-install
|   |-- packages
|   |-- packages.cdx.json
|   |-- packages.spdx.json
|   |-- packages.syft.json
|   |-- ...
|   `-- packages.toml
```

```
/workspace
|-- app.py
`-- requirements.txt
```

Dive


● Layers
Cmp Size Command
63 MB FROM d5e7df7d8eeae3b
225 B
24 MB
398 kB
3.4 MB
192 MB
4.0 MB
36 kB
2.5 MB
1.6 kB
0 B
Layer Details
Tags: (unavailable)
Id: 81702466cc7982fc0230253812e9431759b9da870c8454757b627bded351d882
Digest: sha256:5c8e32c6b5606b61912c446f8b99a3cbb0ef77c56e405f1eaeb4acd9c88498a7
Command:
Image Details
Total Image size: 289 MB
Potential wasted space: 3.0 MB
Image efficiency score: 99 %
Count Total Space Path
2 1.3 MB /var/cache/debconf/templates.dat
2 395 kB /var/log/dpkg.log
2 322 kB /var/log/lastlog
2 222 kB /usr/share/info/coreutils.info.gz
2 181 kB /var/lib/dpkg/status
2 92 kB /usr/share/info/find.info.gz
2 70 kB /var/log/tallylog
2 61 kB /usr/share/doc/perl/changelog.Debian.gz
2 61 kB /usr/share/info/diffutils.info.gz
2 52 kB /usr/share/info/sed.info.gz
Current Layer Contents
Permission UID:GID Size Filetree
drwxr-xr-x 0:0 4.8 MB ├⊕ bin
drwxr-xr-x 0:0 0 B ├── boot
drwxr-xr-x 0:0 0 B ├── dev
drwxr-xr-x 0:0 379 kB ├⊕ etc
drwxr-xr-x 0:0 4.8 kB ├⊕ home
drwxr-xr-x 1000:1000 195 MB ├── layers
drwxr-xr-x 1000:1000 3.4 MB │ ├⊕ paketo-buildpacks_ca-certificates
drwxr-xr-x 1000:1000 192 MB │ └⊕ paketo-buildpacks_cpython
drwxr-xr-x 0:0 12 MB ├⊕ lib
drwxr-xr-x 0:0 0 B ├⊕ lib64
drwxr-xr-x 0:0 0 B ├── media
drwxr-xr-x 0:0 0 B ├── mnt
drwxr-xr-x 0:0 0 B ├── opt
drwxr-xr-x 0:0 0 B ├── proc
drwx------ 0:0 3.3 kB ├⊕ root
drwxr-xr-x 0:0 7 B ├⊕ run
drwxr-xr-x 0:0 3.8 MB ├⊕ sbin
drwxr-xr-x 0:0 0 B ├── srv
drwxr-xr-x 0:0 0 B ├── sys
drwxrwxrwx 0:0 0 B ├── tmp
drwxr-xr-x 0:0 59 MB ├⊕ usr
drwxr-xr-x 0:0 5.5 MB └⊕ var

Dive


● Layers
Cmp Size Command
63 MB FROM d5e7df7d8eeae3b
225 B
24 MB
398 kB
3.4 MB
192 MB
4.0 MB
36 kB
2.5 MB
1.6 kB
0 B
Layer Details
Tags: (unavailable)
Id: fbc035a985e3c9871c0e12798b94a3b6d0a88fb031d2e95000a241041d708d6b
Digest: sha256:43329a76bb805a00652728cd864463127185f284599ff4962a60a94c258f7449
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drwxr-xr-x 1000:1000 4.0 MB │ └⊕ paketo-buildpacks_pip-install
drwxr-xr-x 0:0 12 MB ├⊕ lib
drwxr-xr-x 0:0 0 B ├⊕ lib64
drwxr-xr-x 0:0 0 B ├── media
drwxr-xr-x 0:0 0 B ├── mnt
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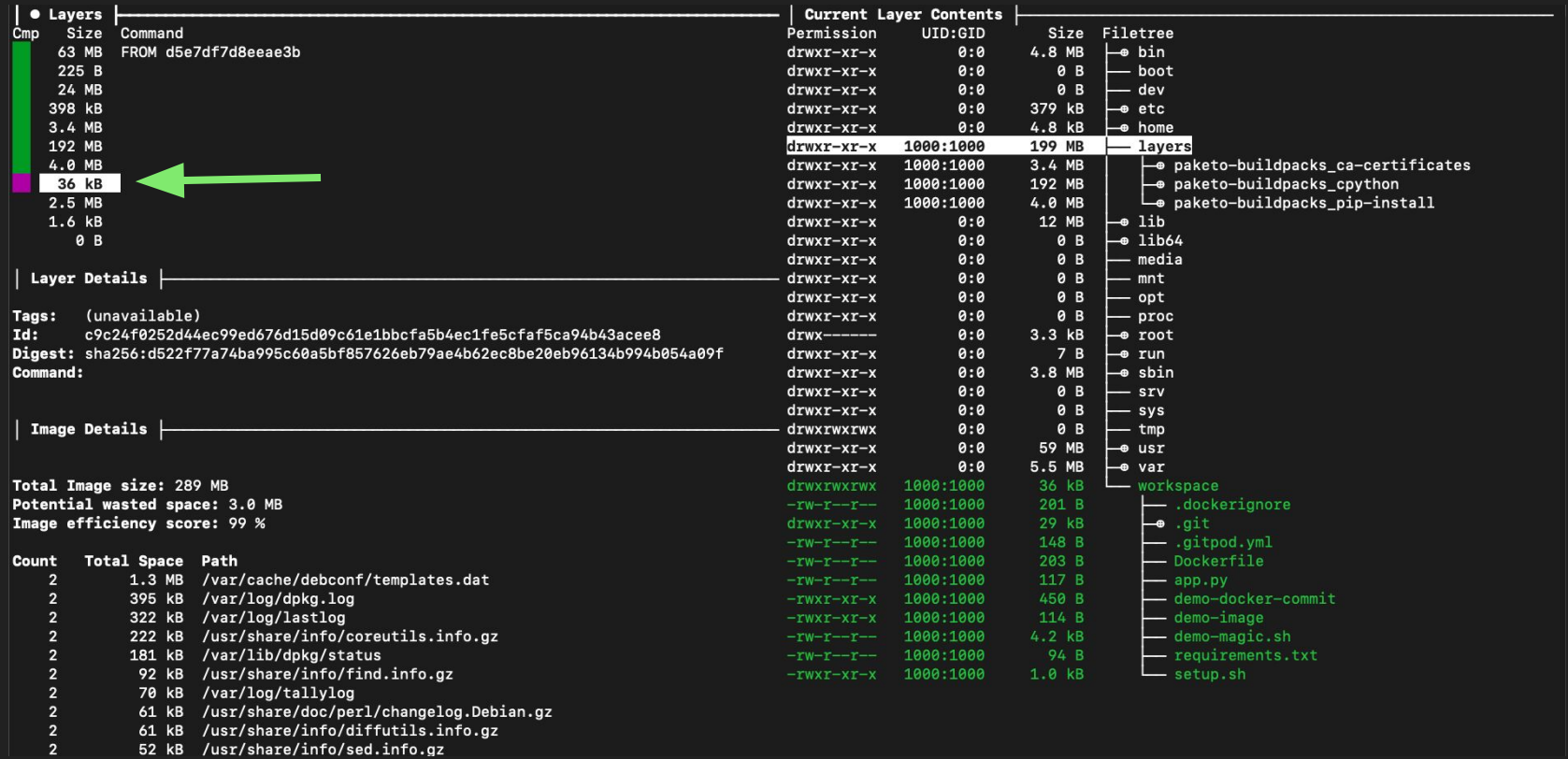
drwxr-xr-x 0:0 59 MB ├⊕ usr
drwxr-xr-x 0:0 5.5 MB └⊕ var

Dive


● Layers
Cmp Size Command
63 MB FROM d5e7df7d8eeae3b
225 B
24 MB
398 kB
3.4 MB
192 MB
4.0 MB
36 kB
2.5 MB
1.6 kB
0 B
Layer Details
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Id: c9c24f0252d44ec99ed676d15d09c61e1bbcfa5b4ec1fe5cfaf5ca94b43acee8
Digest: sha256:d522f77a74ba995c60a5bf857626eb79ae4b62ec8be20eb96134b994b054a09f
Command:
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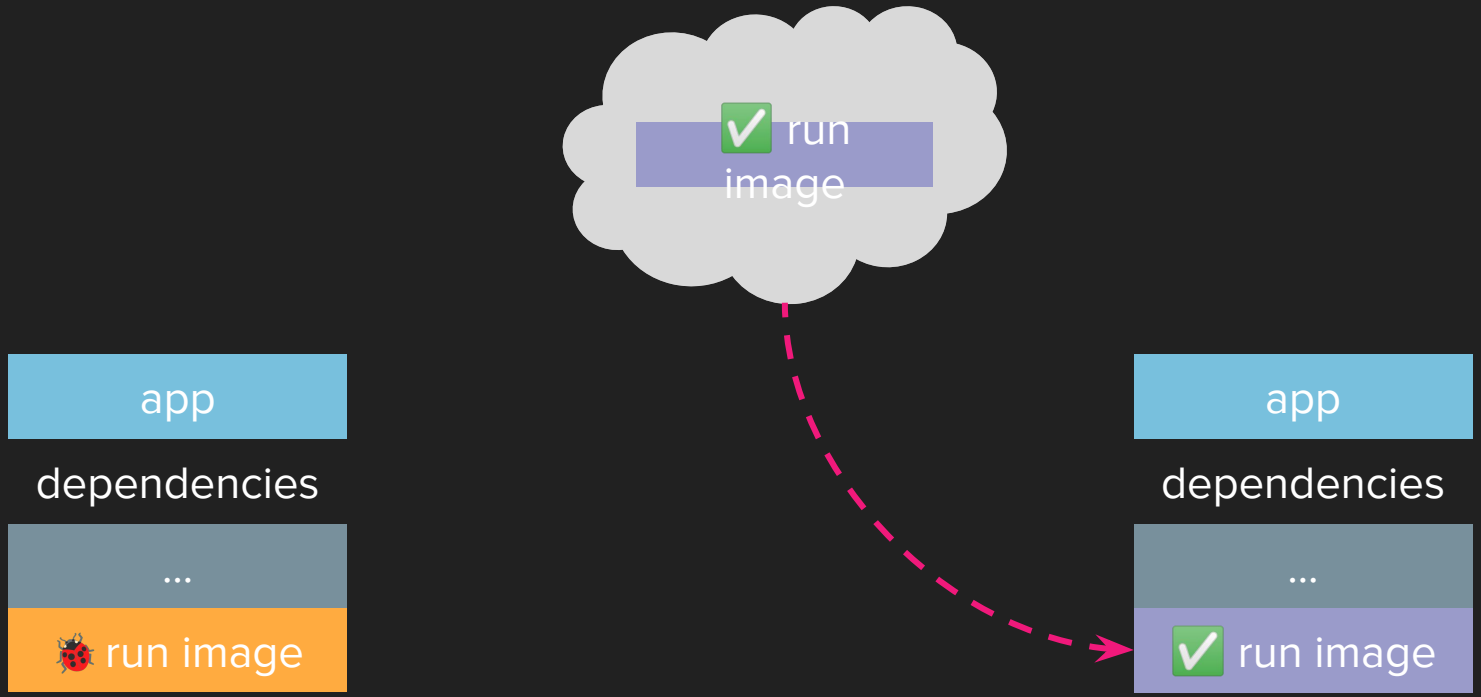
drwxr-xr-x 0:0 0 B ├── sys
drwxrwxrwx 0:0 0 B ├── tmp
drwxr-xr-x 0:0 59 MB ├⊕ usr
drwxr-xr-x 0:0 5.5 MB ├⊕ var
drwxrwxrwx 1000:1000 36 kB ├── workspace
-rw-r--r-- 1000:1000 201 B │ ├── .dockerignore
drwxr-xr-x 1000:1000 29 kB │ ├⊕ .git
-rw-r--r-- 1000:1000 148 B │ ├── .gitpod.yml
-rw-r--r-- 1000:1000 203 B │ ├── Dockerfile
-rw-r--r-- 1000:1000 117 B │ ├── app.py
-rwxr-xr-x 1000:1000 450 B │ ├── demo-docker-commit
-rwxr-xr-x 1000:1000 114 B │ ├── demo-image
-rw-r--r-- 1000:1000 4.2 kB │ ├── demo-magic.sh
-rw-r--r-- 1000:1000 94 B │ ├── requirements.txt
-rwxr-xr-x 1000:1000 1.0 kB │ └── setup.sh

Image Config

```
docker inspect demo-app | jq .[0].Config
```


```
{
  "Hostname": "",
  "Domainname": "",
  "User": "1000:1000",
  "AttachStdin": false,
  "AttachStdout": false,
  "AttachStderr": false,
  "Tty": false,
  "OpenStdin": false,
  "StdinOnce": false,
  "Env": [
    "PATH=/cnb/process:/cnb/lifecycle:/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin",
    "CNB_LAYERS_DIR=/layers",
    "CNB_APP_DIR=/workspace",
    "CNB_PLATFORM_API=0.8",
    "CNB_DEPRECATION_MODE=quiet"
  ],
  "Cmd": null,
  "Image": "sha256:6c9f16a1fcc23ed7b7aff2bb9d8247c3d7e08183d9c24bf6b36ecf578df94973",
  "Volumes": null,
  "WorkingDir": "/workspace",
  "Entrypoint": [
    "/cnb/process/web"
  ],
```

Rebase


✅ run image
app
dependencies
...
🐞 run image
app
dependencies
...
✅ run image

What did we see?

- Buildpacks analyze source code and determine the best way to build it
- Buildpacks follow a specification
- Logical mapping of buildpack-installed dependencies to layers
- The lifecycle orchestrates the build
- Ability to rebase

Pros

- Concentrates understanding of container build best practices to buildpack authors - not app developers!
- Dependency updates / patches are easy and straightforward
- Layers within an image are logically mapped to the dependencies that they provide
- More accurate SBOMs
- Rebase allows fast patching at scale

Limitations

- Does not allow arbitrary file system changes
- Must be run unprivileged

Community

Buildpacks.io

Slack

#buildpacks@cncf.slack.io

Twitter

@buildpacks_io

GitHub

github.com/buildpacks

Thanks!