No Docker Required

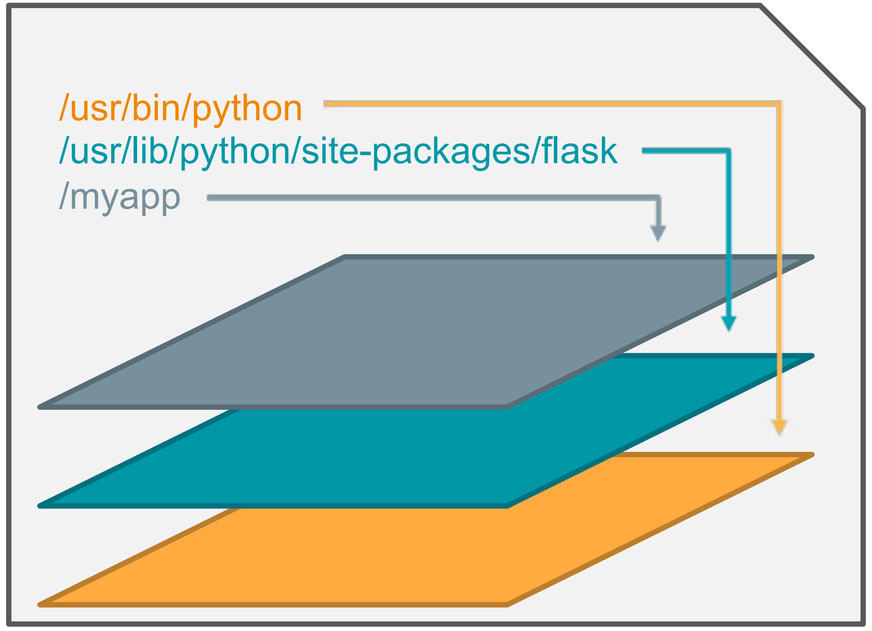
Tools to Build Container Images

Patrick Harböck and Martin Höfling
June, 7th 2019 (Big Techday)

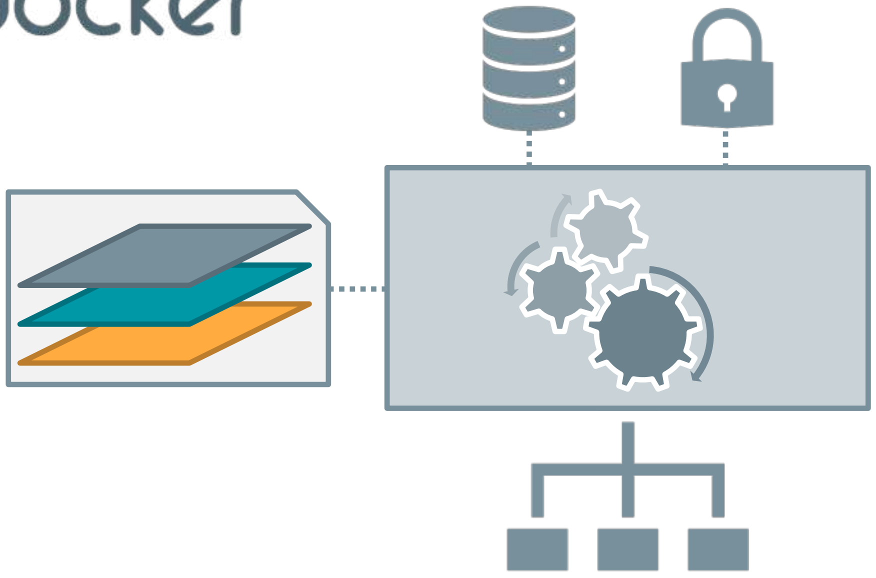
Who is using Docker?
In Development? In Production?

What is Docker?

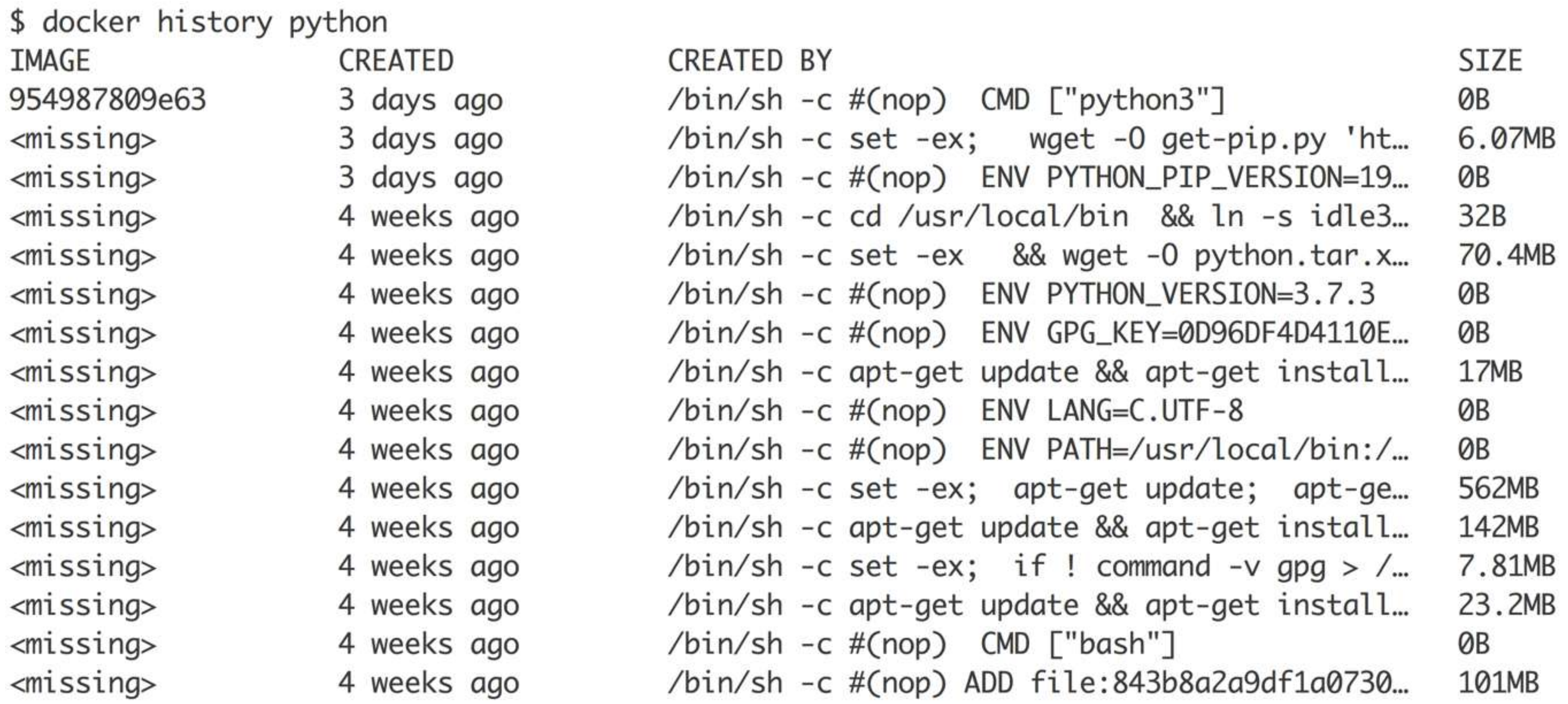
Container Image Builder



Container Runtime



Docker Images



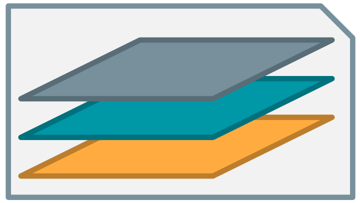
```
$ docker history python
IMAGE               CREATED             CREATED BY                                      SIZE
954987809e63        3 days ago          /bin/sh -c #(nop)  CMD ["python3"]              0B
<missing>           3 days ago          /bin/sh -c set -ex;   wget -O get-pip.py 'ht…   6.07MB
<missing>           3 days ago          /bin/sh -c #(nop)  ENV PYTHON_PIP_VERSION=19…   0B
<missing>           4 weeks ago         /bin/sh -c cd /usr/local/bin  && ln -s idle3…   32B
<missing>           4 weeks ago         /bin/sh -c set -ex   && wget -O python.tar.x…   70.4MB
<missing>           4 weeks ago         /bin/sh -c #(nop)  ENV PYTHON_VERSION=3.7.3     0B
<missing>           4 weeks ago         /bin/sh -c #(nop)  ENV GPG_KEY=0D96DF4D4110E…   0B
<missing>           4 weeks ago         /bin/sh -c apt-get update && apt-get install…   17MB
<missing>           4 weeks ago         /bin/sh -c #(nop)  ENV LANG=C.UTF-8             0B
<missing>           4 weeks ago         /bin/sh -c #(nop)  ENV PATH=/usr/local/bin:/…   0B
<missing>           4 weeks ago         /bin/sh -c set -ex;  apt-get update;  apt-ge…   562MB
<missing>           4 weeks ago         /bin/sh -c apt-get update && apt-get install…   142MB
<missing>           4 weeks ago         /bin/sh -c set -ex;  if ! command -v gpg > /…   7.81MB
<missing>           4 weeks ago         /bin/sh -c apt-get update && apt-get install…   23.2MB
<missing>           4 weeks ago         /bin/sh -c #(nop)  CMD ["bash"]                 0B
<missing>           4 weeks ago         /bin/sh -c #(nop) ADD file:843b8a2a9df1a0730…   101MB
```

Container Images

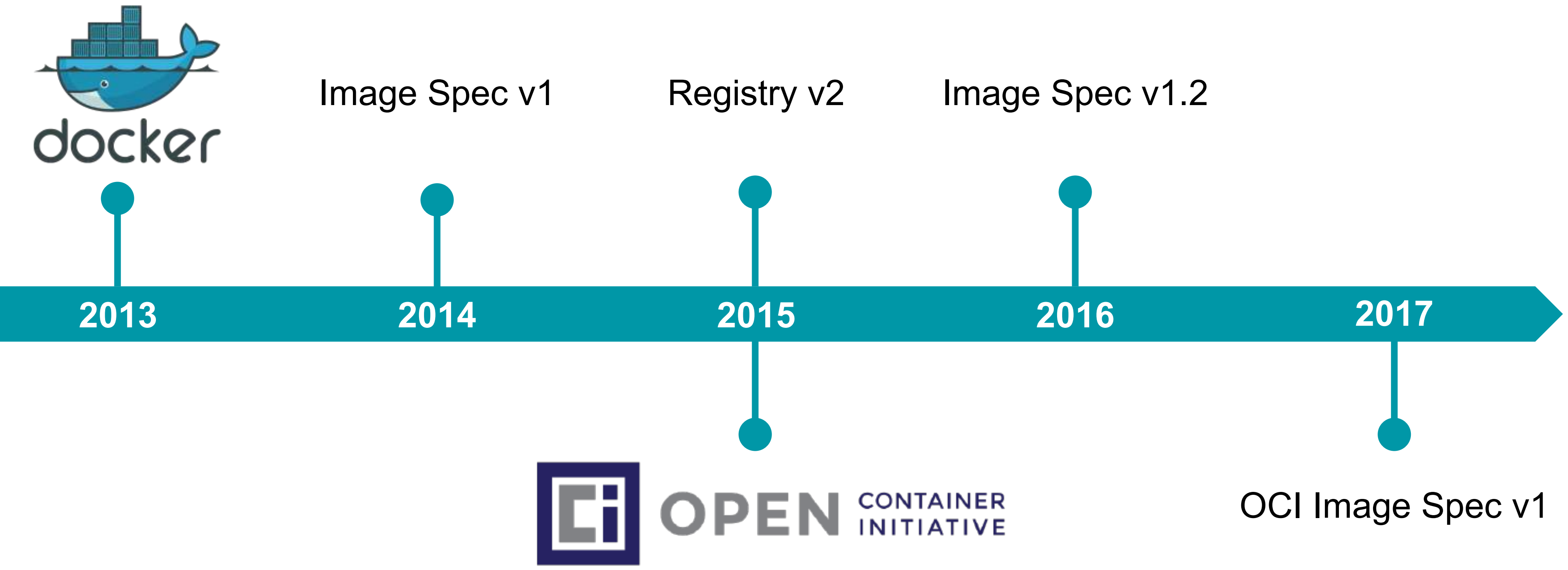
- Manifest / Metadata
  - Default configuration for creating containers
  - Content hashes of layers to ensure integrity
- Layers
  - File system packed with *tar*
  - Multiple layers → root file system for containers

```
ENV | WORKDIR | USER | CMD
```

```
Layer1: 7d97e98f8af71
Layer2: e703abc8f639e
```



Container Image Format Evolution

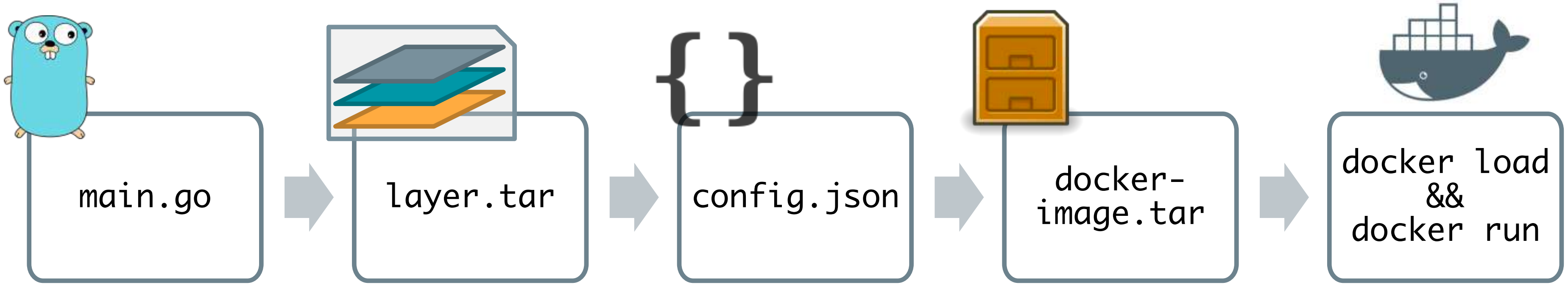


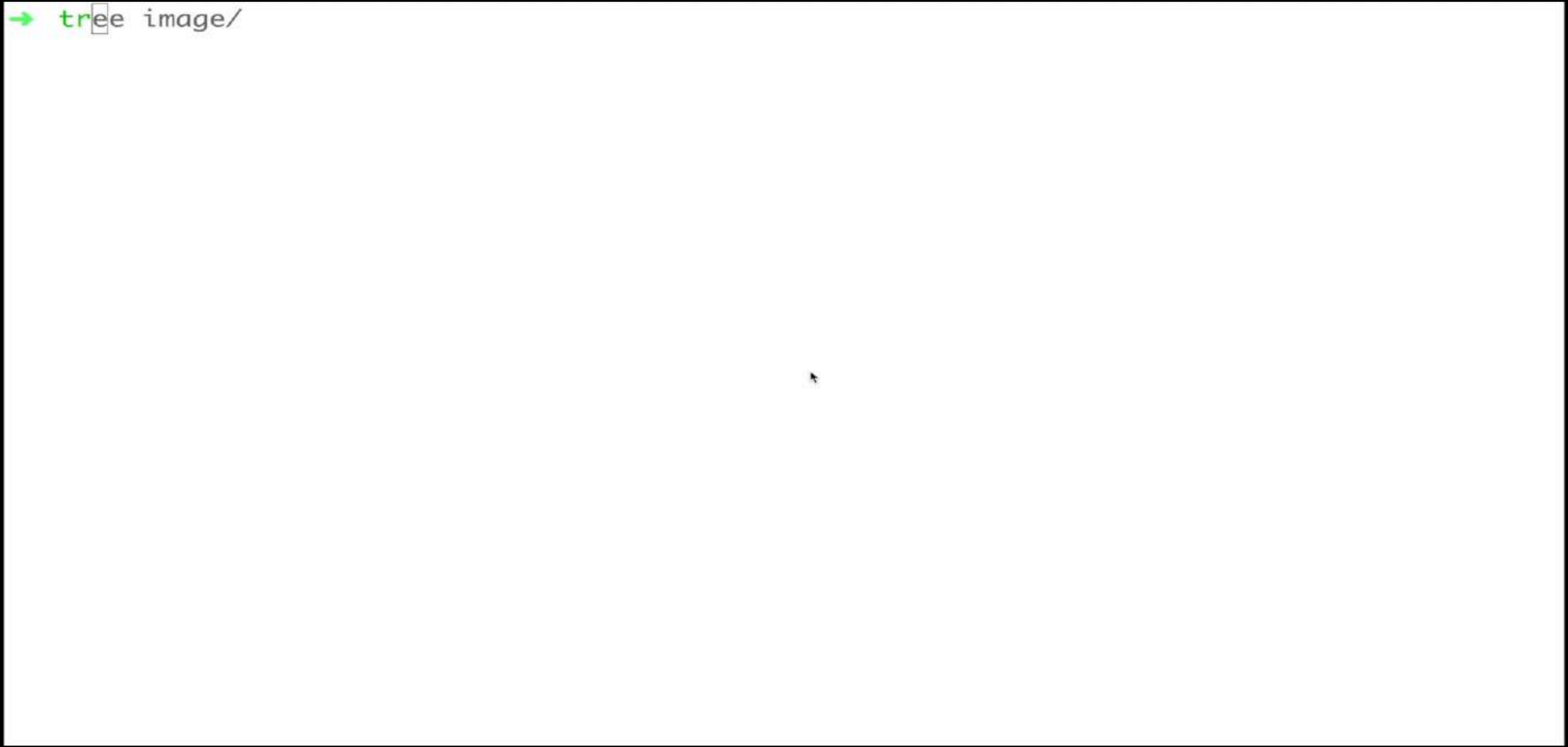
Open Container Initiative

九州云 Cloud
Alibaba Cloud
amazon web services™
at&t
CISCO
DELL EMC
docker
EasyStack
facebook
FUJITSU
Goldman Sachs
Google
HUAWEI
IBM
InfoSiftr
intel
Joyent
MESOSPHERE
Microsoft
openstack.
ORACLE®
Pivotal
portworx
redhat.
REPLICATED
SUSE.
sysdig
Twistlock
UNIVA
vmware®
weaveworks

DEMO: Build a Container Image from Scratch

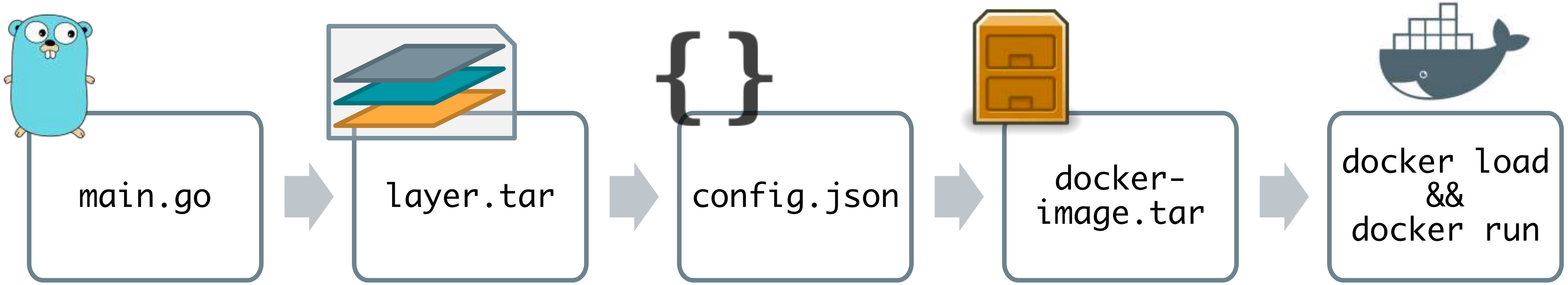
DEMO: Build a Container Image from Scratch





```
➜  tree image/
```

DEMO: Build a Container Image from Scratch



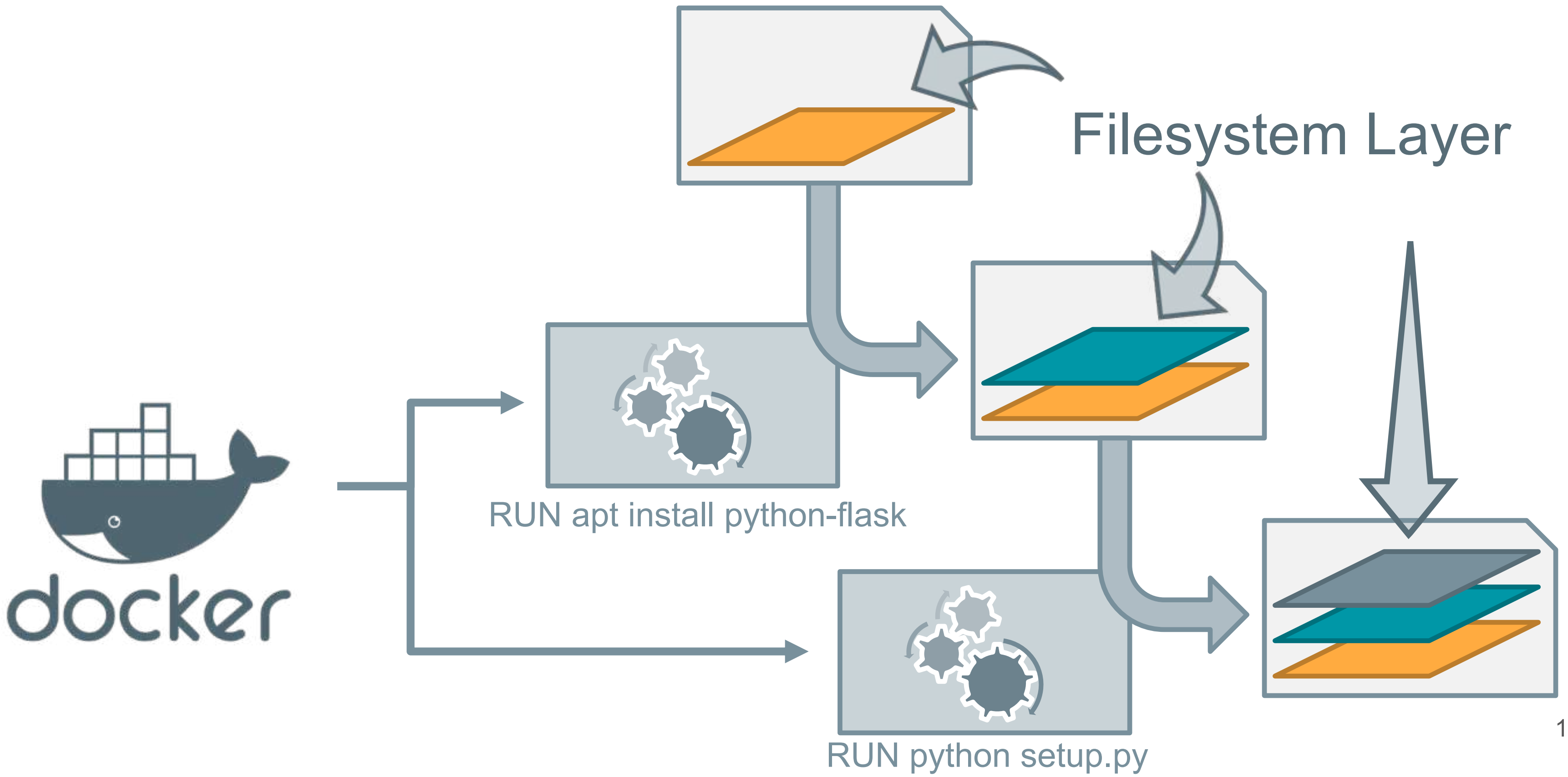
- No elevated privileges required
- No Dockerfile
- No *docker build*

What’s wrong with building images via Docker?

- ➔ **Security**
- ➔ **Scalability**
- ➔ **Flexibility**

- ➔ **Security**
- ➔ **Scalability**
- ➔ **Flexibility**

How Docker builds container images

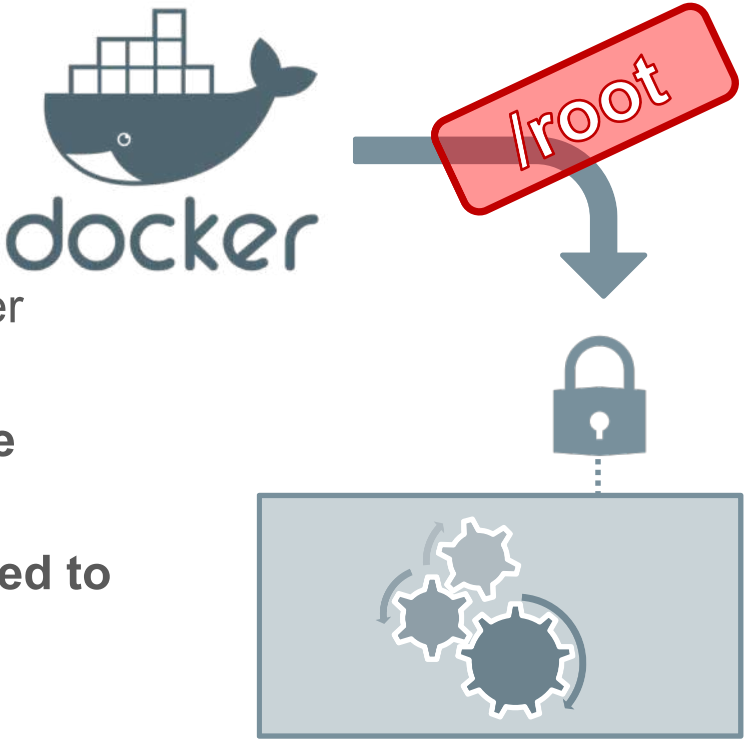


How Docker builds container images

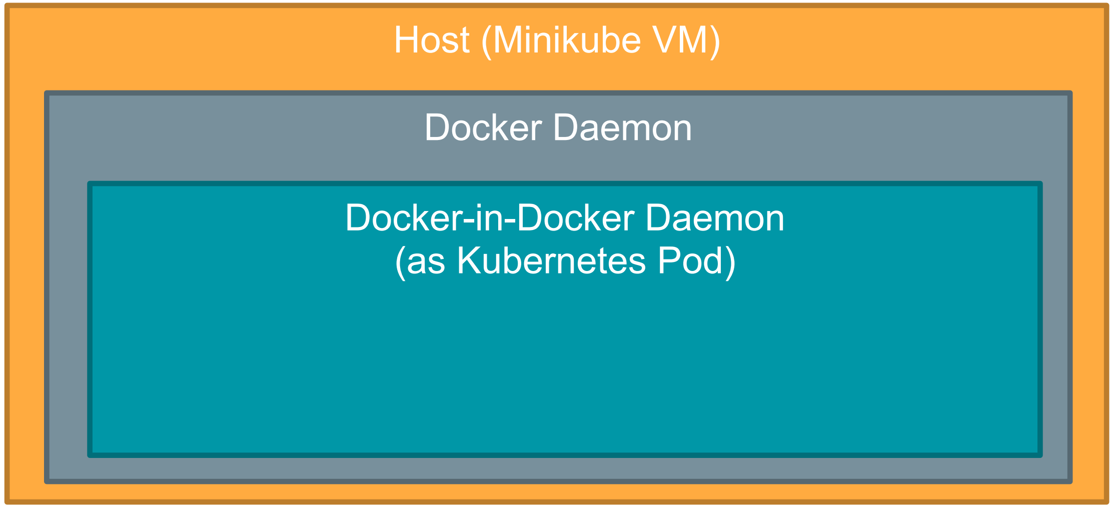
- `docker build` uses Docker containers
- Docker containers require isolation
- Docker requires elevated privileges
- Build pipelines / developers can access Docker

➔ **Security nightmare on shared infrastructure**

“First of all, **only trusted users should be allowed to control your Docker daemon.**”
https://docs.docker.com/engine/security/security/#docker-daemon-attack-surface

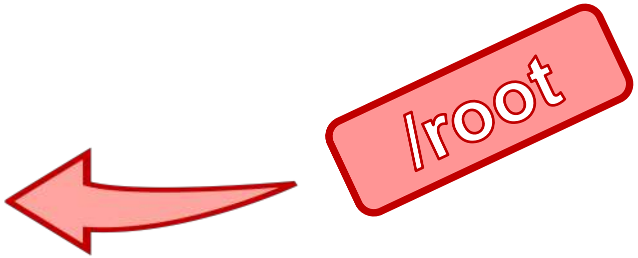


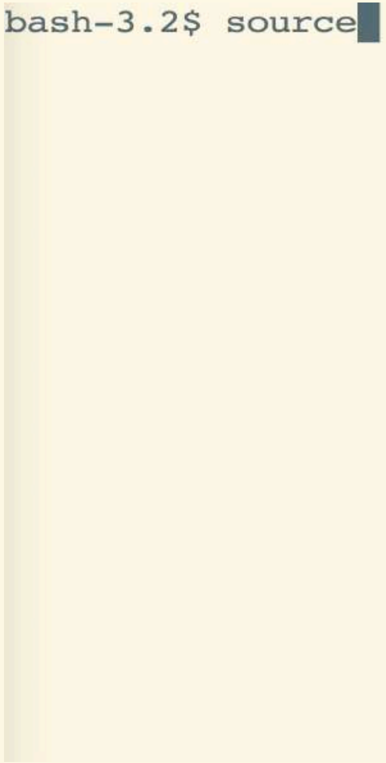
DEMO: Host Access via privileged container



Docker in Docker Kubernetes Pod Spec

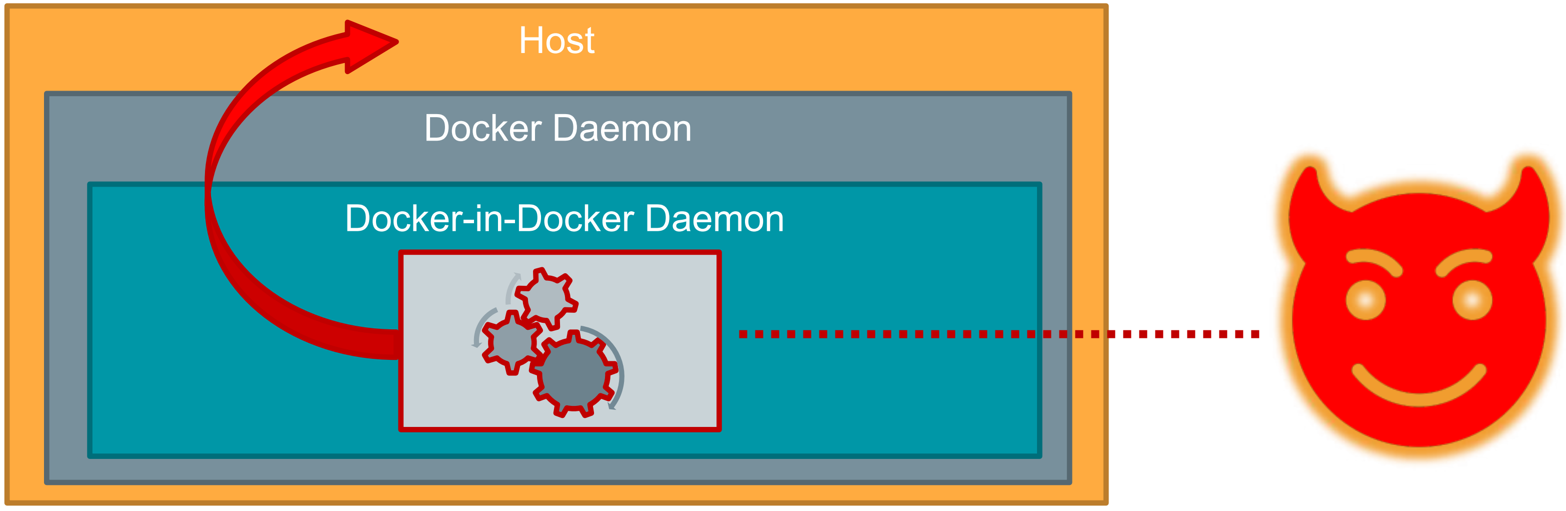
```
apiVersion: v1
kind: Pod
metadata:
  name: dind
spec:
  hostname: dind-pod
  containers:
    - name: dind
      image: docker:dind
      securityContext:
        privileged: True
      ports:
        - containerPort: 2375
```





```
bash-3.2$ source
```

DEMO: Host Access via privileged container



Security Risks?

- Privileged Docker-in-Docker → **full host access**
- Mounting or exposing Docker socket → **full host access**
- Base image runs as container *root* → larger vulnerability surface

→ Easy to break and lose container isolation

Remark: Hermetic Builds and Reproducibility

→ Hermetic: sandboxed build process

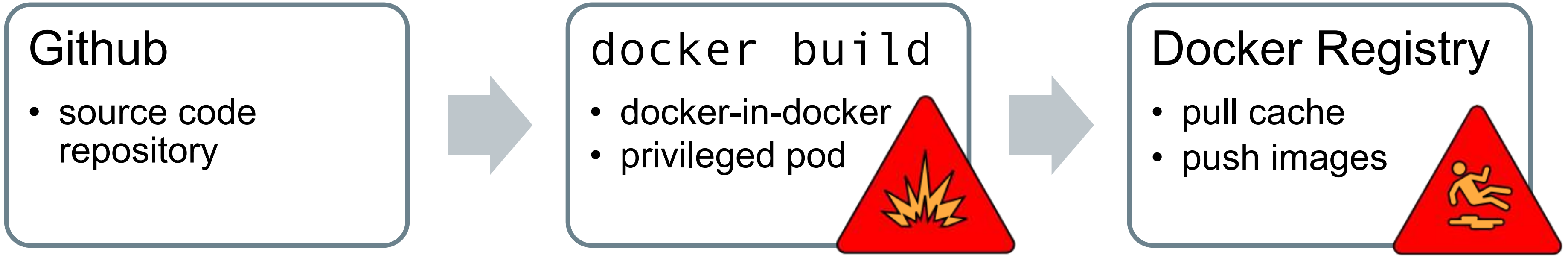
→ Reproducible builds result in verifiable artifacts

- ➔ Security
- ➔ **Scalability**
- ➔ Flexibility

Caching

- Allows scaling up CI/CD pipelines
- Reuse base layers across different branches and builds
- Reproducible builds improve caching

Build Pipeline kubernetes + Jenkins



Scalability Issues

- One Docker daemon does not scale for parallel builds
- No distributed caching support

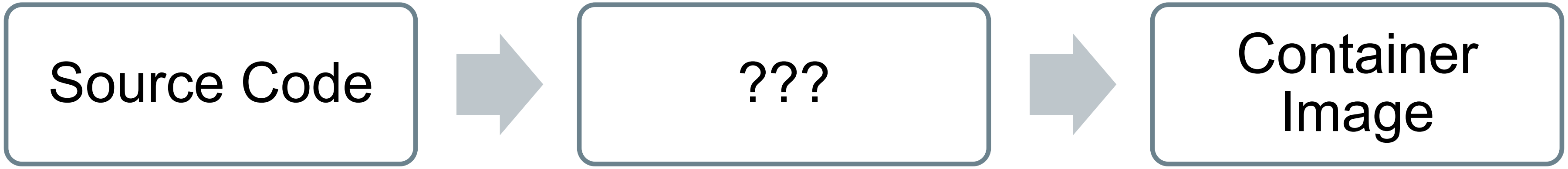
➔ Security

➔ Scalability

➔ **Flexibility**

Flexibility

- How restricted is the build process and image definition?
    - Can developers use any tools and languages they want?
    - How well does it integrate into an existing development pipeline?



Dockerfile based Tools

- Extract base layer(s)
- Run a command in sub container or directly
- Snapshot Filesystem

✓ Generic

– Problem: Supported Dockerfile Features?

  – USER – run commands as specific user

  – Multistage builds

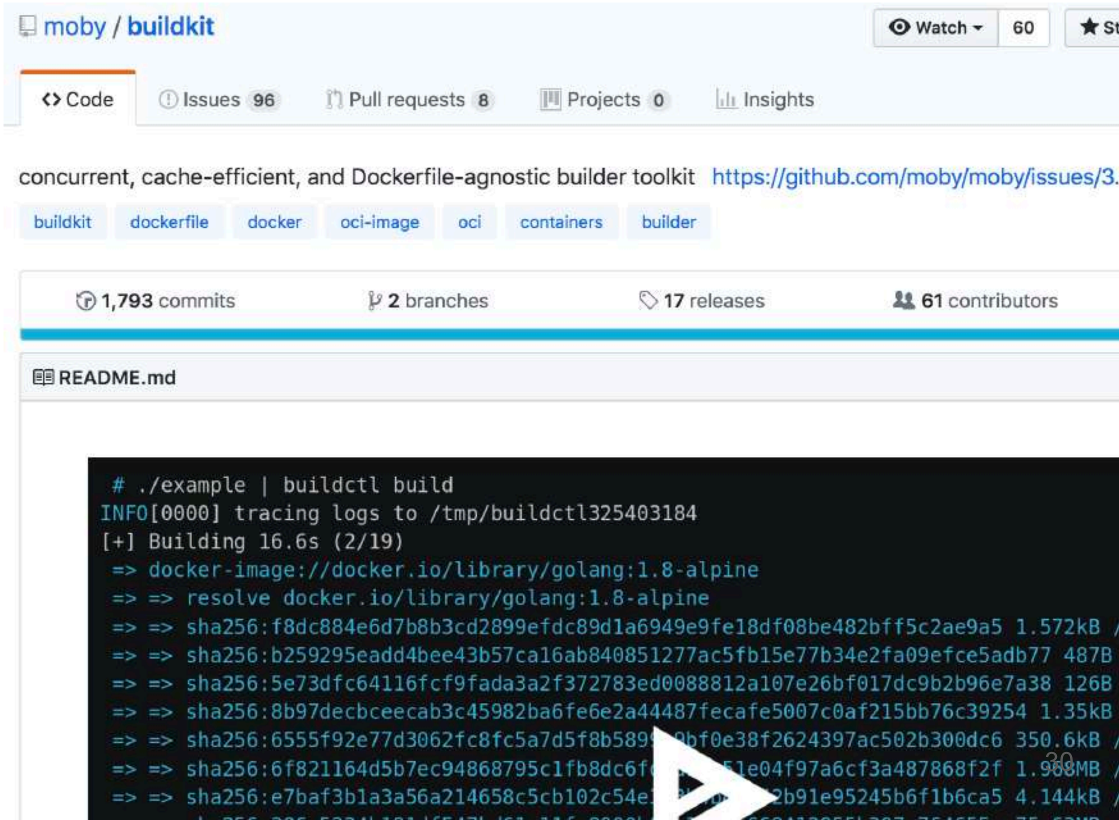
  – Root vs. non-root

```
FROM ubuntu:18.04

RUN apt-get update
RUN apt-get install -y nginx

COPY nginx.conf /etc/nginx/

EXPOSE 8080

ENTRYPOINT ['/usr/bin/nginx']
```

Tool	Primary Maintainer	Security	Scalability	Flexibility
docker build	Docker	🙁	🙁	🙂

Tool	Primary Maintainer	Security	Scalability	Flexibility
BuildKit	Docker	😐	🙂	Dockerfile

- Focus on scalability, performance, extensibility
- Experimental support in newer Docker versions
- Optional rootless mode



moby / **buildkit**

concurrent, cache-efficient, and Dockerfile-agnostic builder toolkit https://github.com/moby/moby/issues/3

1,793 commits · 2 branches · 17 releases · 61 contributors

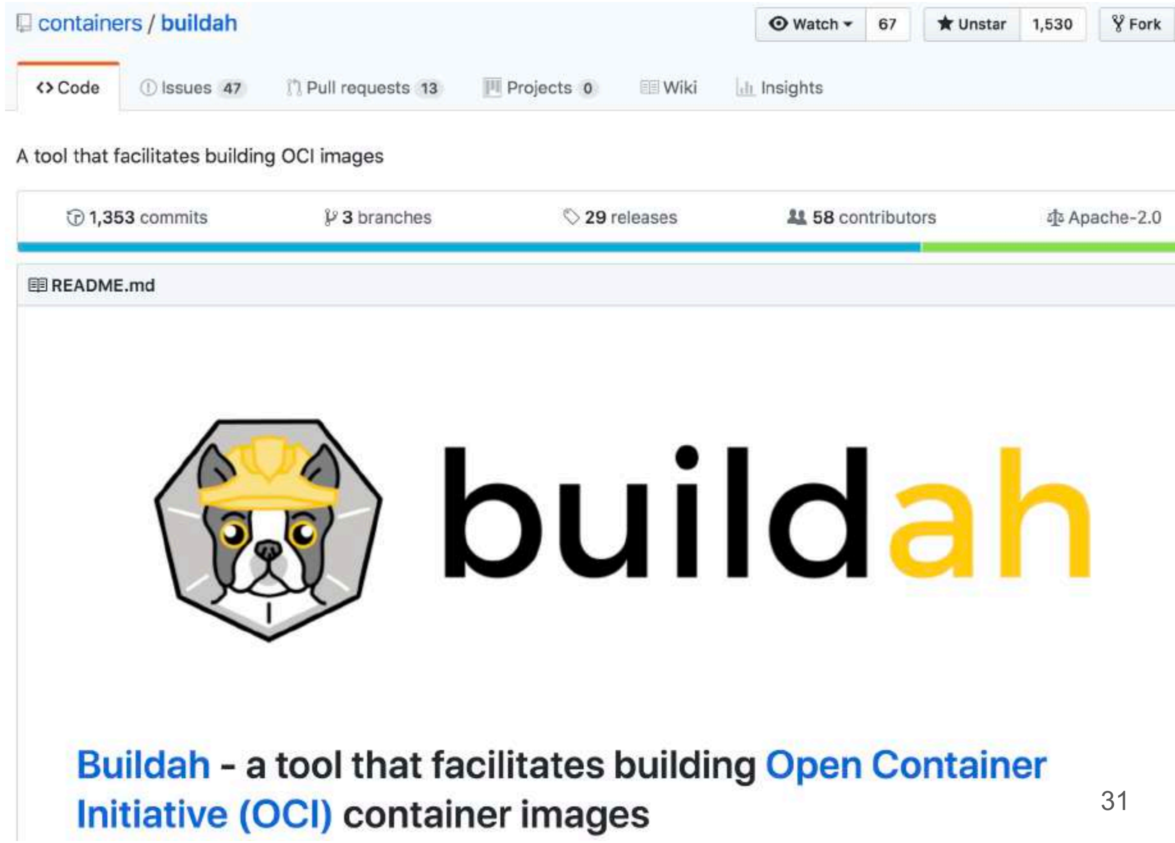
README.md

```
 # ./example | buildctl build
INFO[0000] tracing logs to /tmp/buildctl325403184
[+] Building 16.6s (2/19)
 => docker-image://docker.io/library/golang:1.8-alpine
 => => resolve docker.io/library/golang:1.8-alpine
 => => sha256:f8dc884e6d7b8b3cd2899efdc89d1a6949e9fe18df08be482bff5c2ae9a5 1.572kB
 => => sha256:b259295eadd4bee43b57ca16ab840851277ac5fb15e77b34e2fa09efce5adb77 487B
 => => sha256:5e73dfc64116fcf9fada3a2f372783ed0088812a107e26bf017dc9b2b96e7a38 126B
 => => sha256:8b97decbceecab3c45982ba6fe6e2a44487fecafe5007c0af215bb76c39254 1.35kB
 => => sha256:6555f92e77d3062fc8fc5a7d5f8b589[illegible]bf0e38f2624397ac502b300dc6 350.6kB
 => => sha256:6f821164d5b7ec94868795c1fb8dc6f[illegible]1e04f97a6cf3a487868f2f 1.9[illegible]MB
 => => sha256:e7baf3b1a3a56a214658c5cb102c54e[illegible]2b91e95245b6f1b6ca5 4.144kB
```

Tool	Primary Maintainer	Security	Scalability	Flexibility
Buildah	Red Hat	🙂	🙂	Dockerfile

- Secure and flexible builds of OCI images

- Intended as a Docker replacement together with Podman



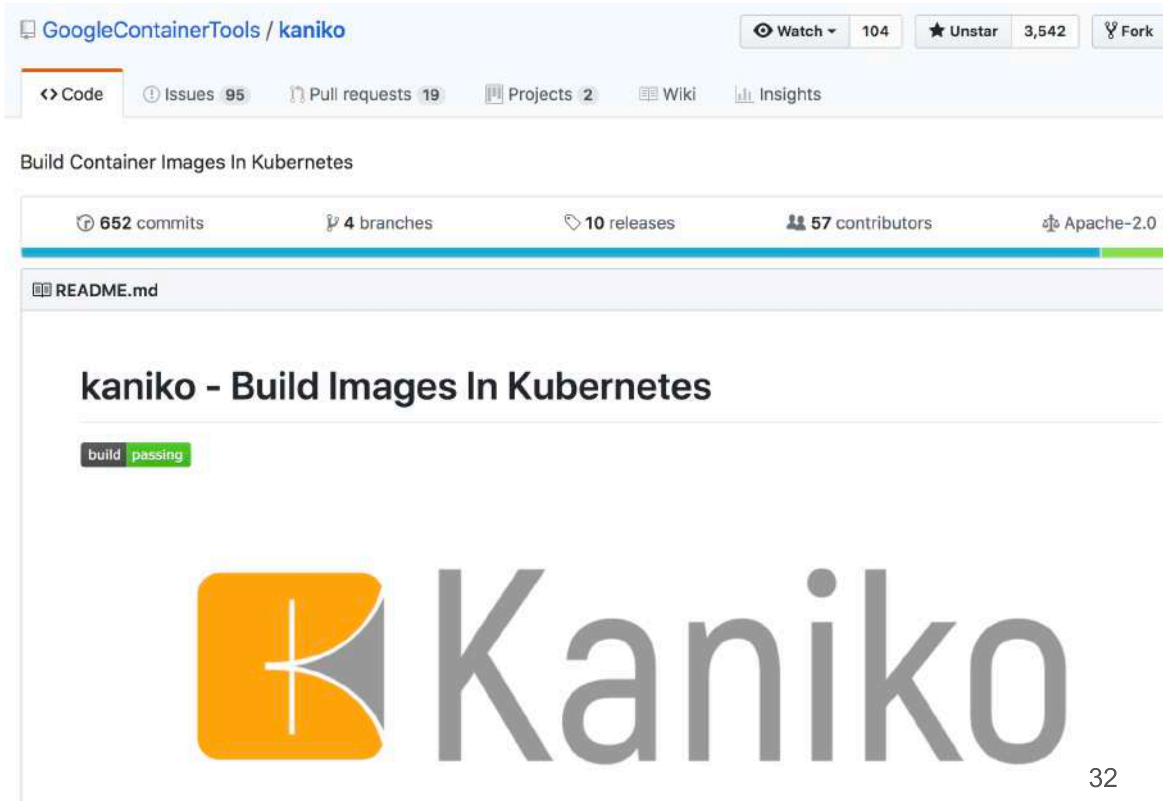
A tool that facilitates building OCI images

1,353 commits | 3 branches | 29 releases | 58 contributors | Apache-2.0

Buildah - a tool that facilitates building Open Container Initiative (OCI) container images

Tool	Primary Maintainer	Security	Scalability	Flexibility
Kaniko	Google	☺	☺	Dockerfile

- Designed for Kubernetes
- Compatible with
    - AppArmor / SELinux
    - gVisor
- Focus on security and performance
- Reproducible builds


GoogleContainerTools / kaniko

Watch 104 | Unstar 3,542 | Fork

Build Container Images In Kubernetes

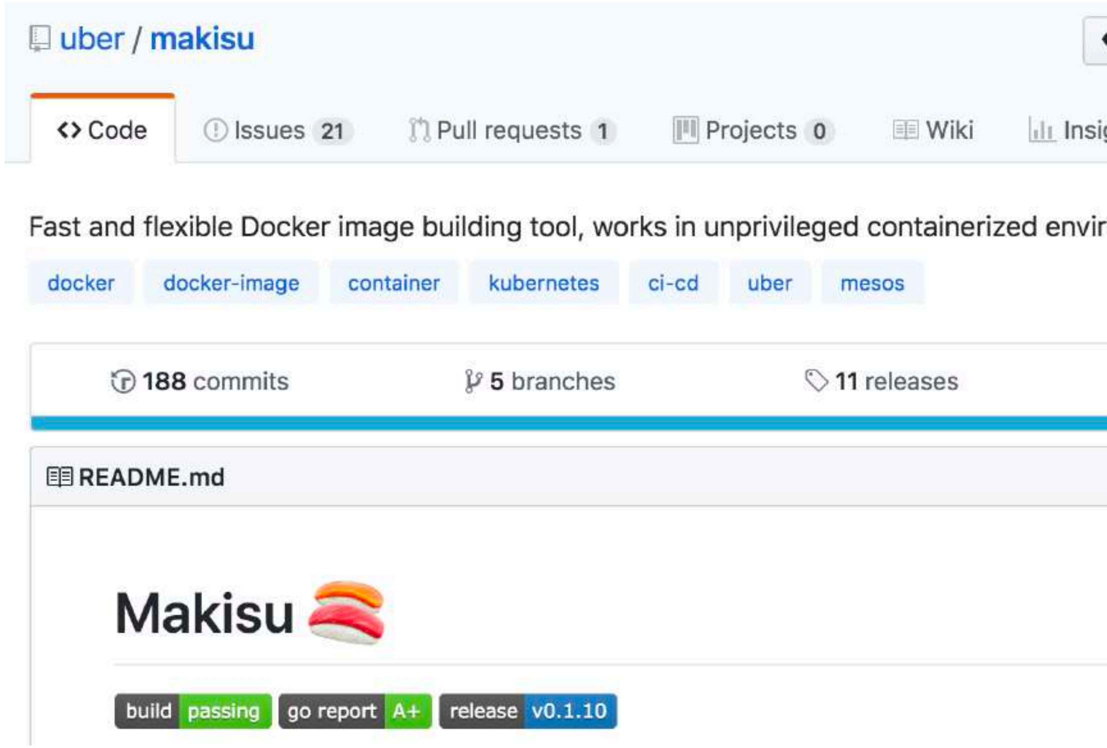
652 commits | 4 branches | 10 releases | 57 contributors | Apache-2.0

README.md

kaniko - Build Images In Kubernetes

Tool	Primary Maintainer	Security	Scalability	Flexibility
Makisu	Uber	🙂	🙂	Dockerfile

- Focus on security and performance
- Dockerfile support with opinionated modifications
- Distributed caching of layers


uber / makisu

Code | Issues 21 | Pull requests 1 | Projects 0 | Wiki | Insi

Fast and flexible Docker image building tool, works in unprivileged containerized envir

docker docker-image container kubernetes ci-cd uber mesos

188 commits | 5 branches | 11 releases

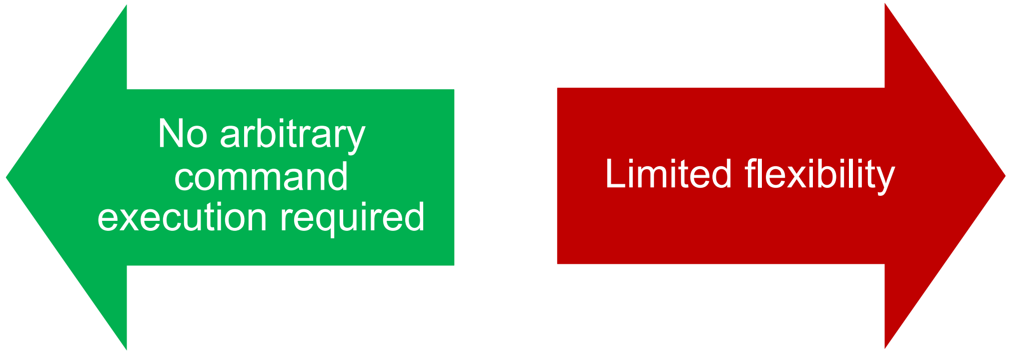
README.md

Makisu

build passing | go report A+ | release v0.1.10

Tailored image construction

- Tailored for a distinct language and build-system
- The actual **build is not performed in a (child) container**
- The build result is often combined with a base image
    - e.g. Python interpreter + virtualenv + application

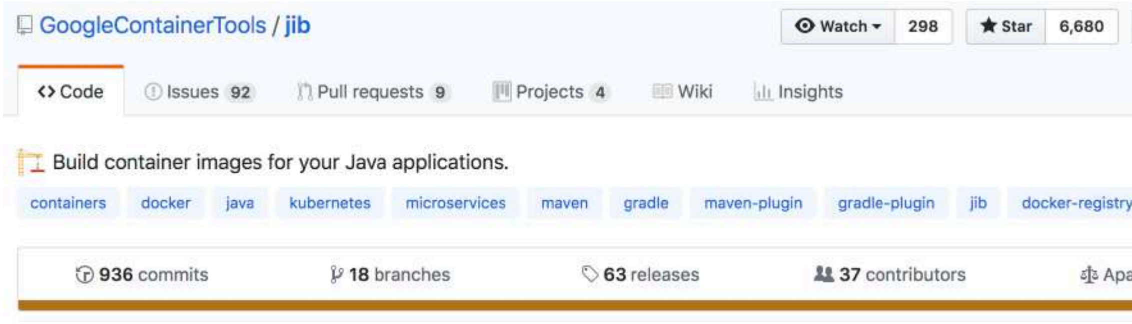


Tool	Primary Maintainer	Security	Scalability	Flexibility
Jib	Google	🙂	🙂	Java only

- Maven / Gradle plugin
- Distroless Java base image

Builds are

- ✓ Minimal
- ✓ Reproducible
- ✓ Fast (caching)


GoogleContainerTools / jib

Watch 298 | Star 6,680

Code | Issues 92 | Pull requests 9 | Projects 4 | Wiki | Insights

Build container images for your Java applications.

containers docker java kubernetes microservices maven gradle maven-plugin gradle-plugin jib docker-registry

936 commits | 18 branches | 63 releases | 37 contributors | Apa

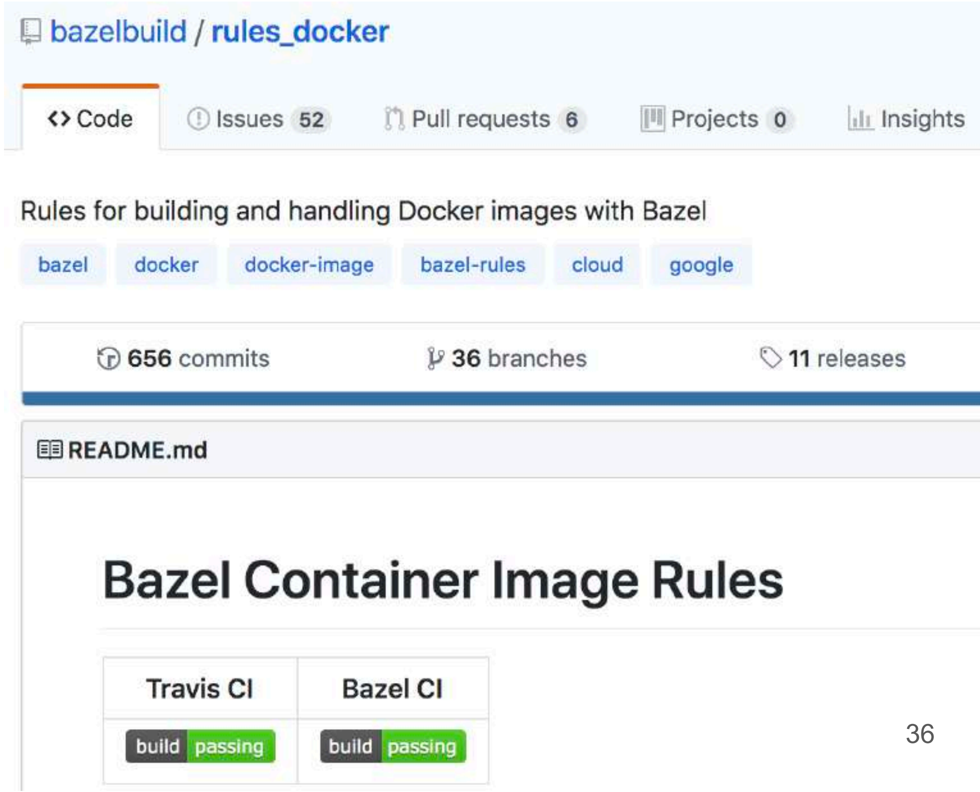
Tool	Primary Maintainer	Security	Scalability	Flexibility
Bazel	Google	🙂	🙂	Starlark rules

- Supports Python, Node.js, Java, C/C++, Go, Rust, …

Builds are

- ✓ Minimal
- ✓ Reproducible
- ✓ Fast (caching)

– Complex rules written in Starlark



bazelbuild / rules_docker

<> Code | Issues 52 | Pull requests 6 | Projects 0 | Insights

Rules for building and handling Docker images with Bazel

bazel | docker | docker-image | bazel-rules | cloud | google

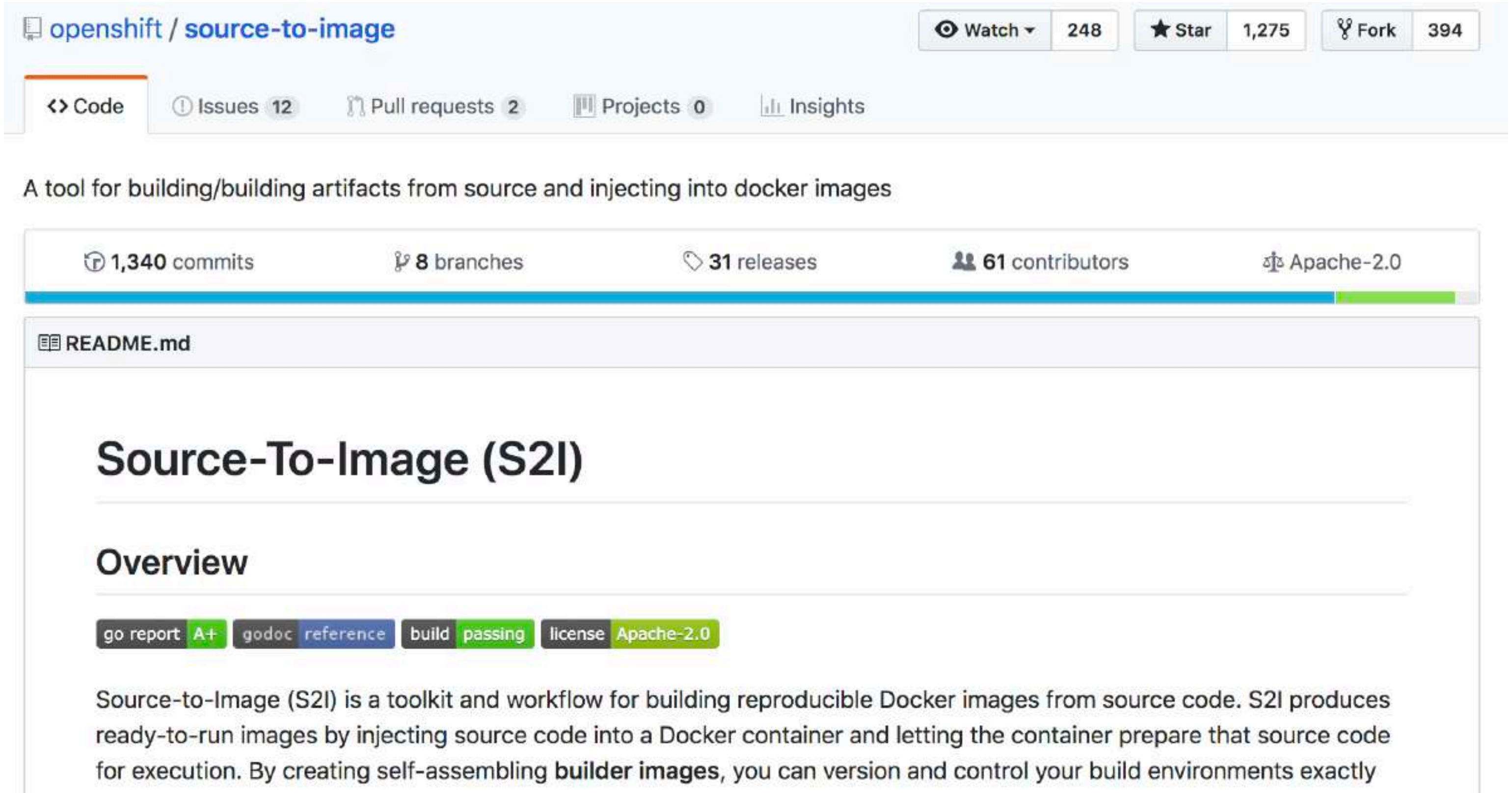
656 commits | 36 branches | 11 releases

README.md

Bazel Container Image Rules

Travis CI	Bazel CI
build passing	build passing

Tool	Primary Maintainer	Security	Scalability	Flexibility
OpenShift Source-to-Image	Red Hat	🙂	🙂	Common stacks



A tool for building/building artifacts from source and injecting into docker images

1,340 commits | 8 branches | 31 releases | 61 contributors | Apache-2.0

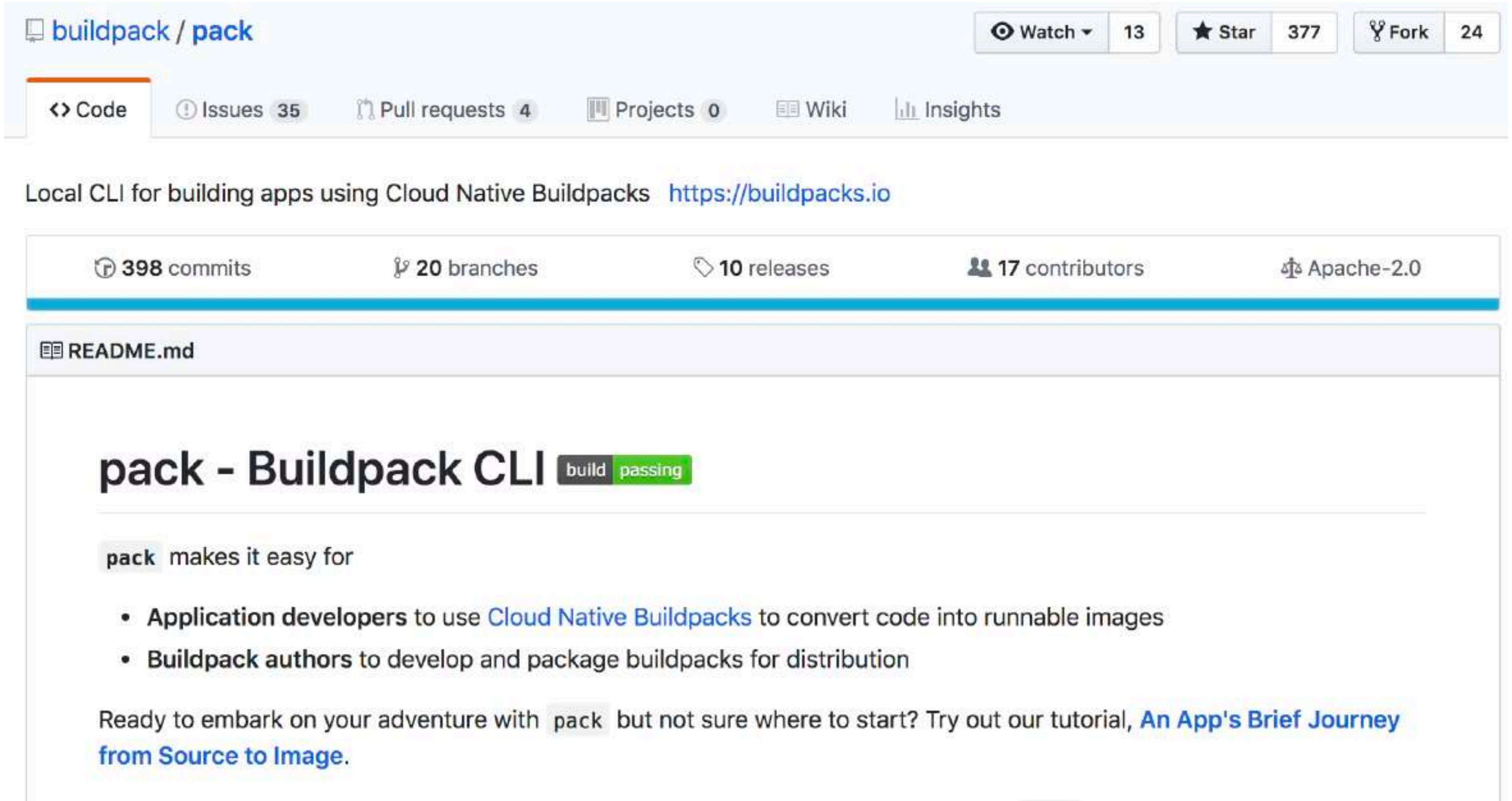
README.md

Source-To-Image (S2I)

Overview

Source-to-Image (S2I) is a toolkit and workflow for building reproducible Docker images from source code. S2I produces ready-to-run images by injecting source code into a Docker container and letting the container prepare that source code for execution. By creating self-assembling **builder images**, you can version and control your build environments exactly

Tool	Primary Maintainer	Security	Scalability	Flexibility
Cloud Native Buildpacks	Heroku / Pivotal / CNCF	☺	☺	Common stacks



Local CLI for building apps using Cloud Native Buildpacks https://buildpacks.io

398 commits | 20 branches | 10 releases | 17 contributors | Apache-2.0

README.md

pack - Buildpack CLI build passing

`pack` makes it easy for

- **Application developers** to use Cloud Native Buildpacks to convert code into runnable images
- **Buildpack authors** to develop and package buildpacks for distribution

Ready to embark on your adventure with `pack` but not sure where to start? Try out our tutorial, An App's Brief Journey from Source to Image.

Tool	Primary Maintainer	Security	Scalability	Flexibility
docker build	Docker	🙁	🙁	Dockerfile
BuildKit	Docker	😐	🙂	Dockerfile
Buildah	Red Hat	🙂	🙂	Dockerfile
Kaniko	Google	🙂	🙂	Dockerfile
Makisu	Uber	🙂	🙂	Dockerfile
Jib	Google	🙂	🙂	Java only
Bazel	Google	🙂	🙂	Starlark rules
OpenShift Source-to-Image	Red Hat	🙂	🙂	Common stacks
Cloud Native Buildpacks	Heroku / Pivotal / CNCF	🙂	🙂	Common stacks

What should I use now?

Use case: Small Team

- No strict security requirements for team isolation
- Teams have full access to CI infrastructure

➔ **Docker**
Still a valid choice

➔ **Buildah**
Flexible, only parts Dockerfile syntax supported securely

➔ **BuildKit**
Are you feeling adventurous? Potential transition path for Docker

Use case: Multiple teams, Provided K8s infrastructure

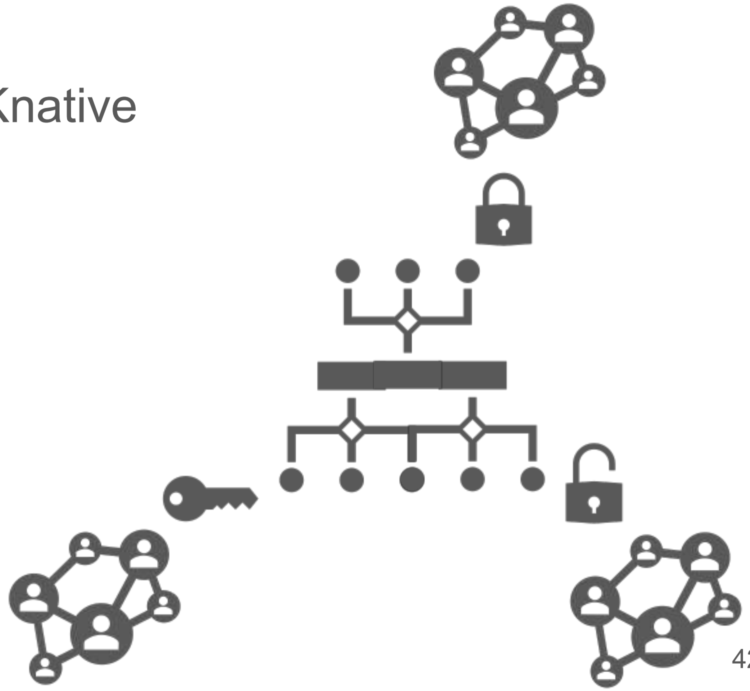
- Cannot modify K8s infrastructure, no privileged containers, no container nesting
- Teams are isolated, e.g. on namespace level

➔ **Kaniko**, e.g. combined with Skaffold or Knative

- Shared volume caching
  (e.g. on Google Cloud Platform)

➔ **Makisu**: with Knative

- Fine grained cache control



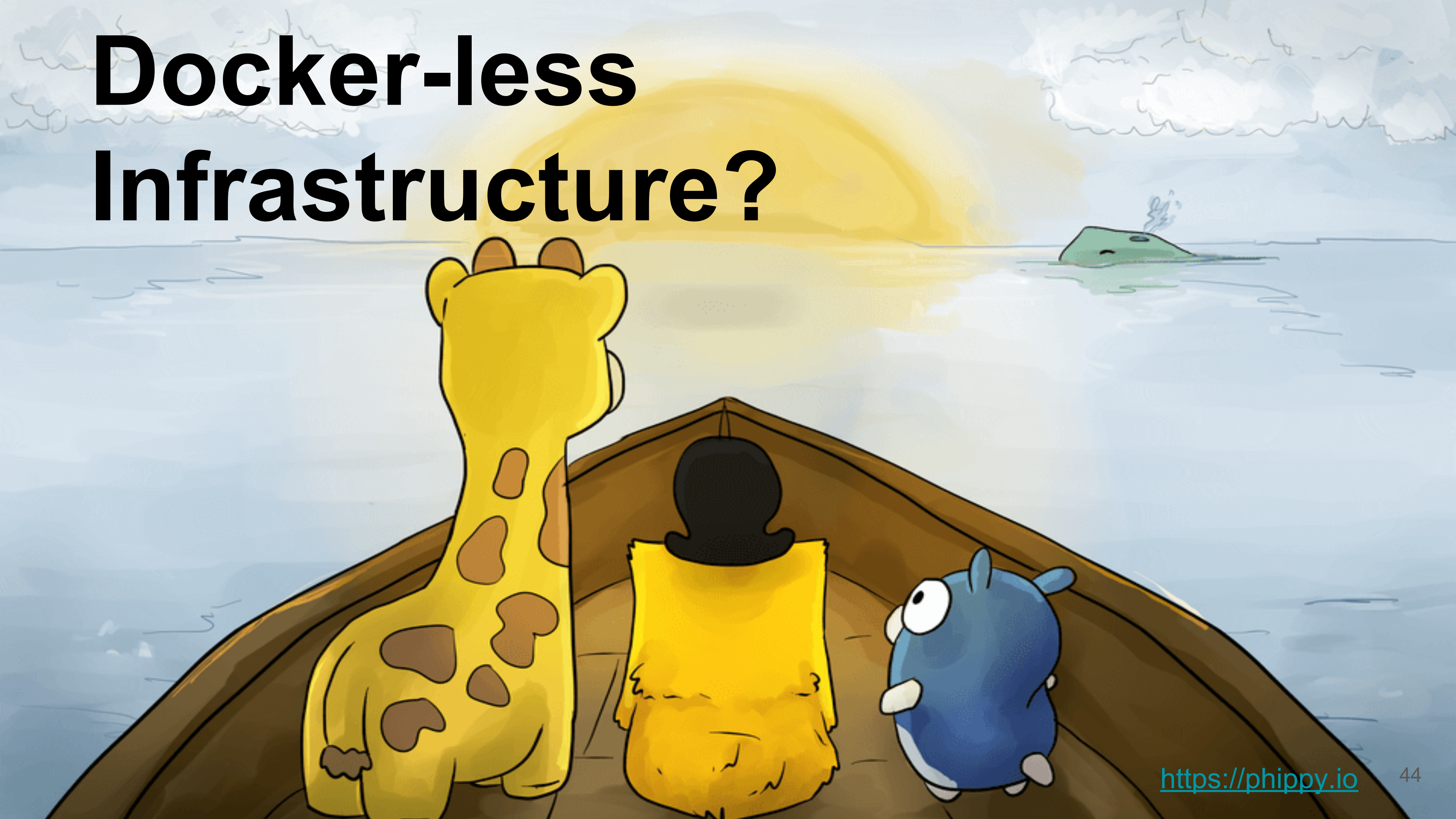
Use case: No Dockerfile required

e.g. Java only, Container Native Team

- ➔ **Bazel**
- ➔ **Jib**
- ➔ **Cloud Native Buildpacks**

~~`apt-get install python-dev`~~

No classical ops pattern!



Docker-less Infrastructure?

https://phippy.io

Re-evaluate your container build process!

Martin Höfling / Patrick Harböck, TNG