# Zero-Touch OS Infrastructure for Container and Kubernetes Workloads

Containers Devroom, FOSDEM'24

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Hello, I'm

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# Outline

Foundational Concepts

Fresh & Stable: Staying up to Date, safely

Composability

Community

# Container Optimised Linux

# Container Optimised Linux

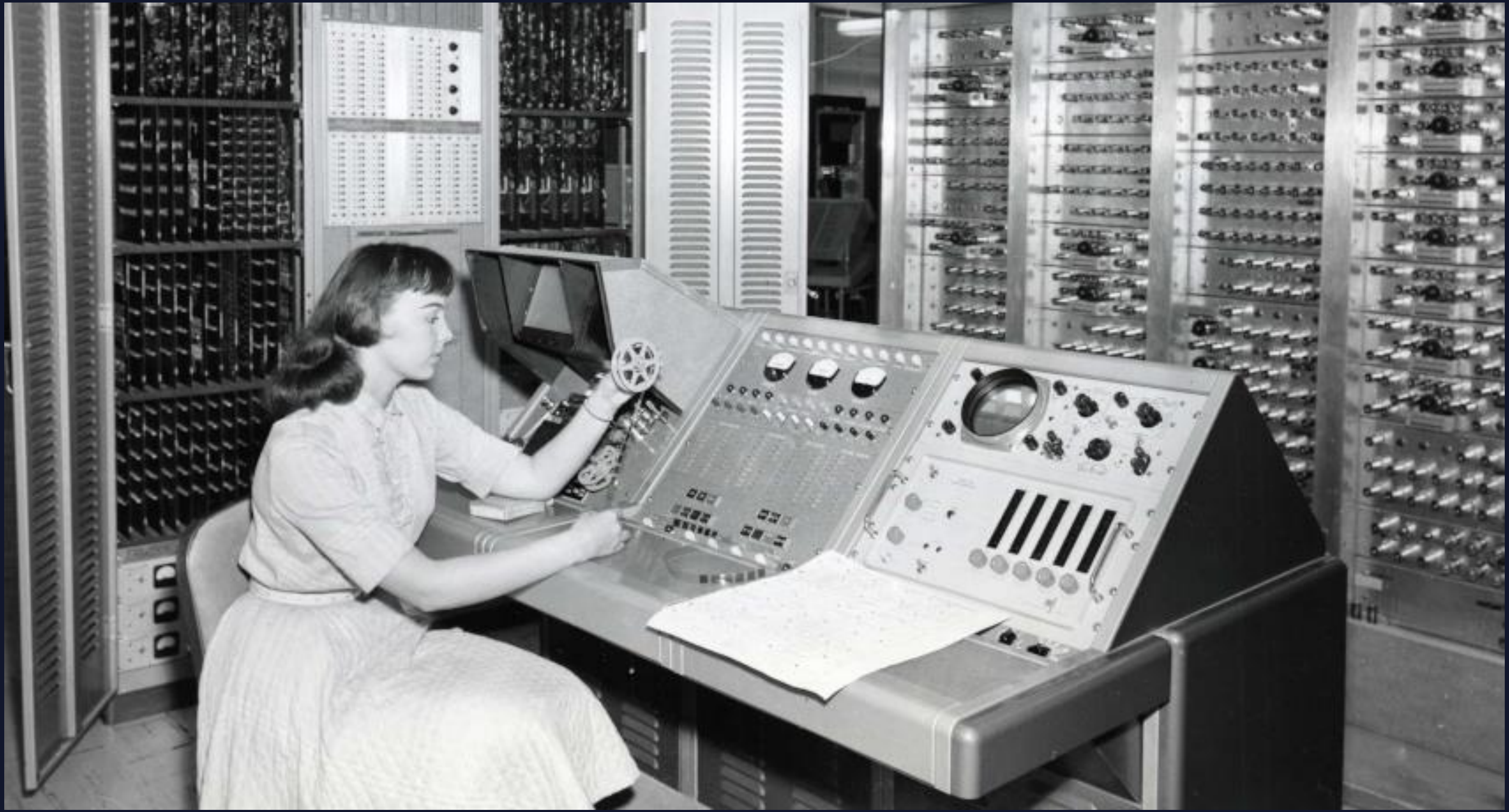
Rethink the OS as a replaceable commodity

Operate the OS like a container app or pod

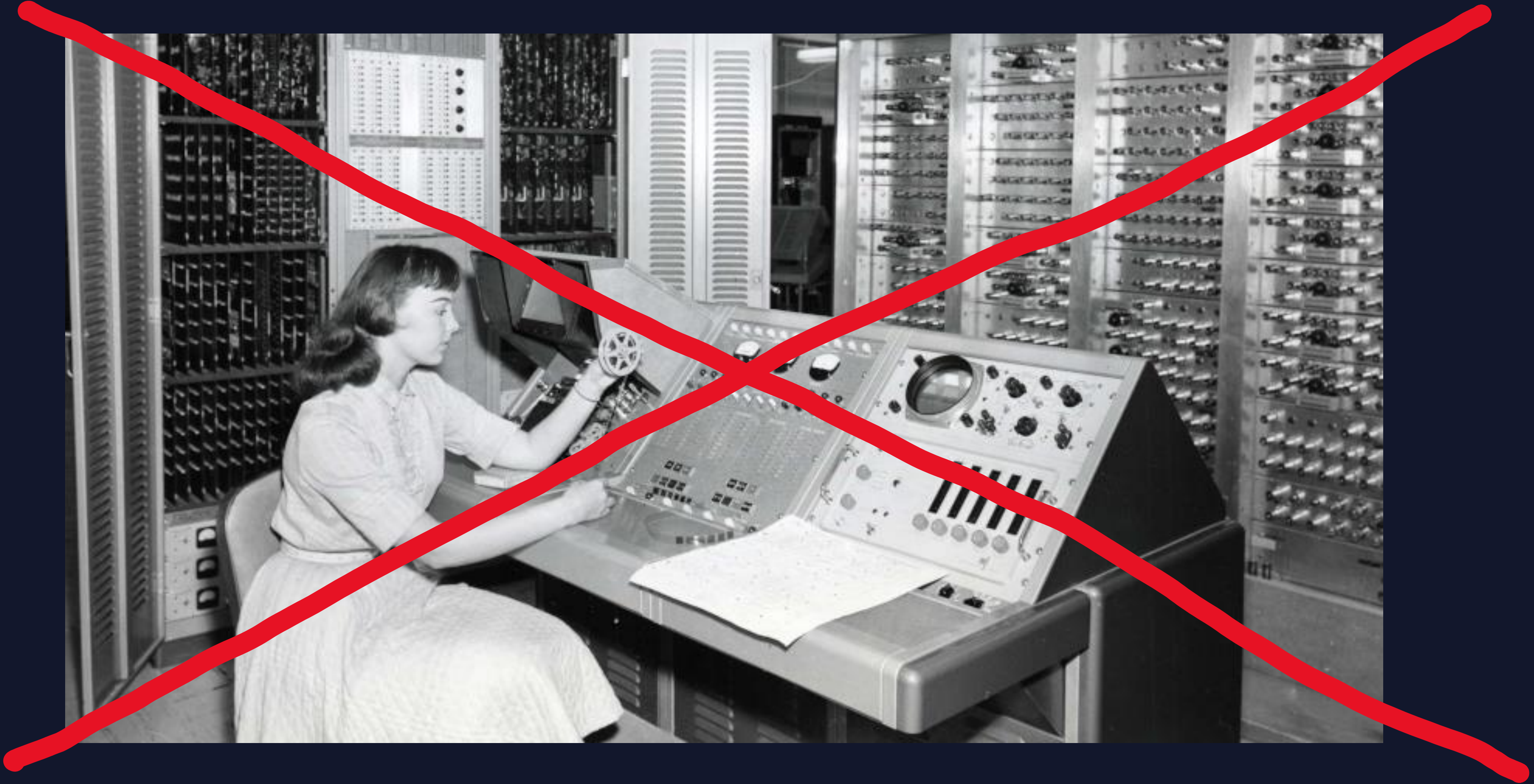
Image-Based OS: Nodes are instances

Leverage container isolation from the OS side

# UX Philosophy

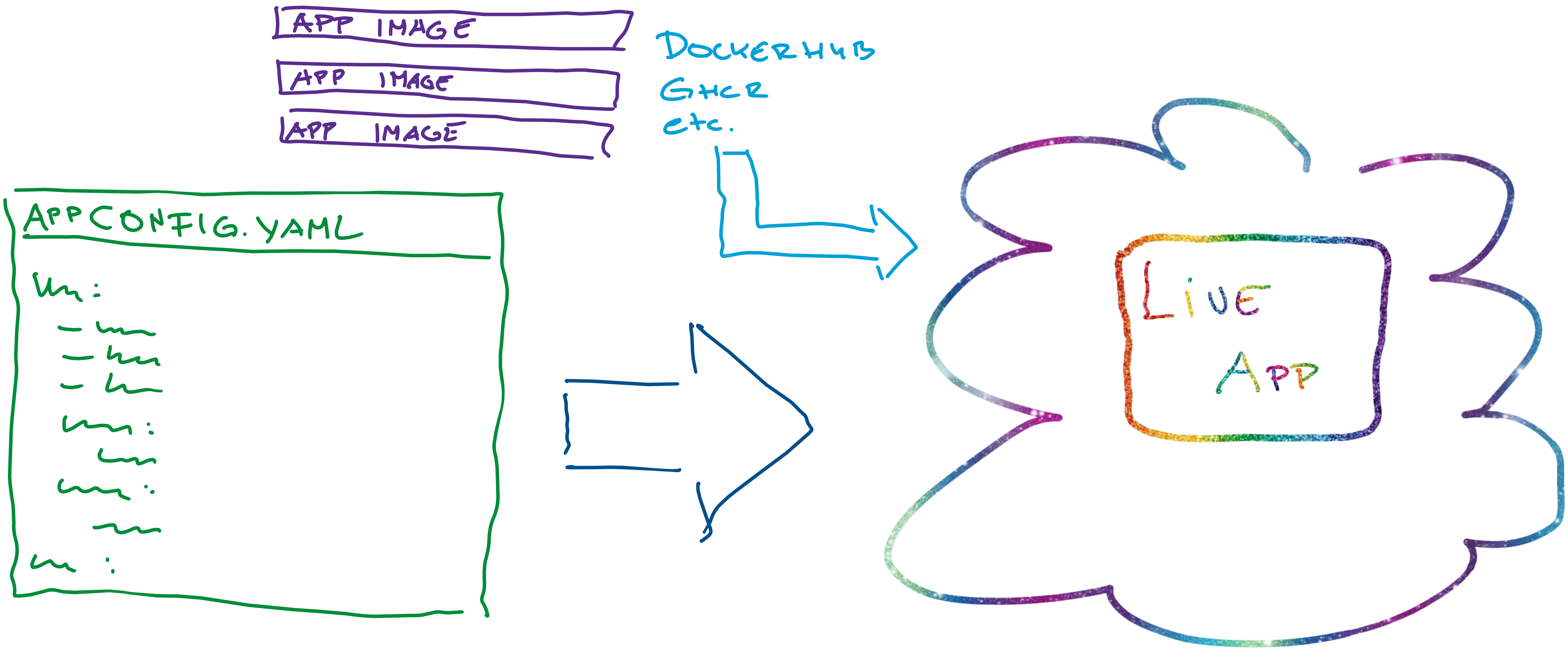


# UX Philosophy

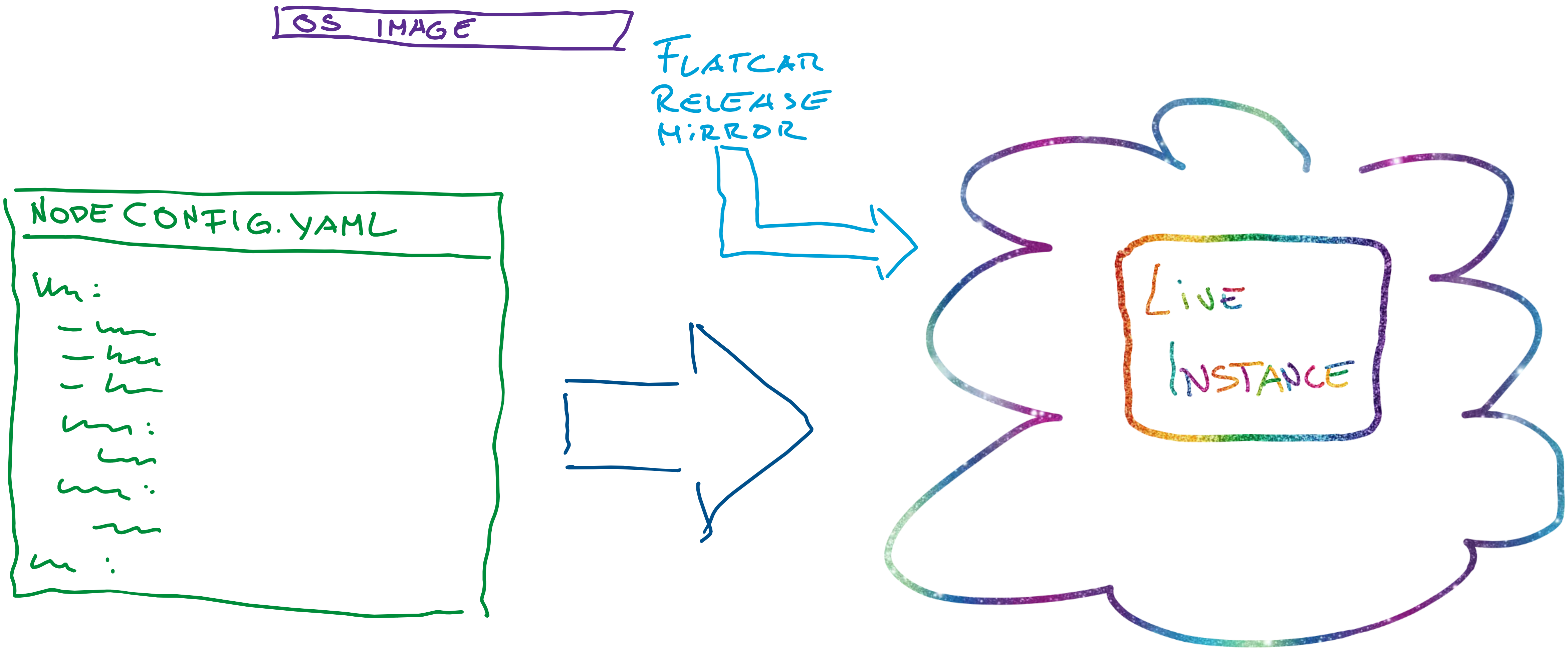


# UX Philosophy

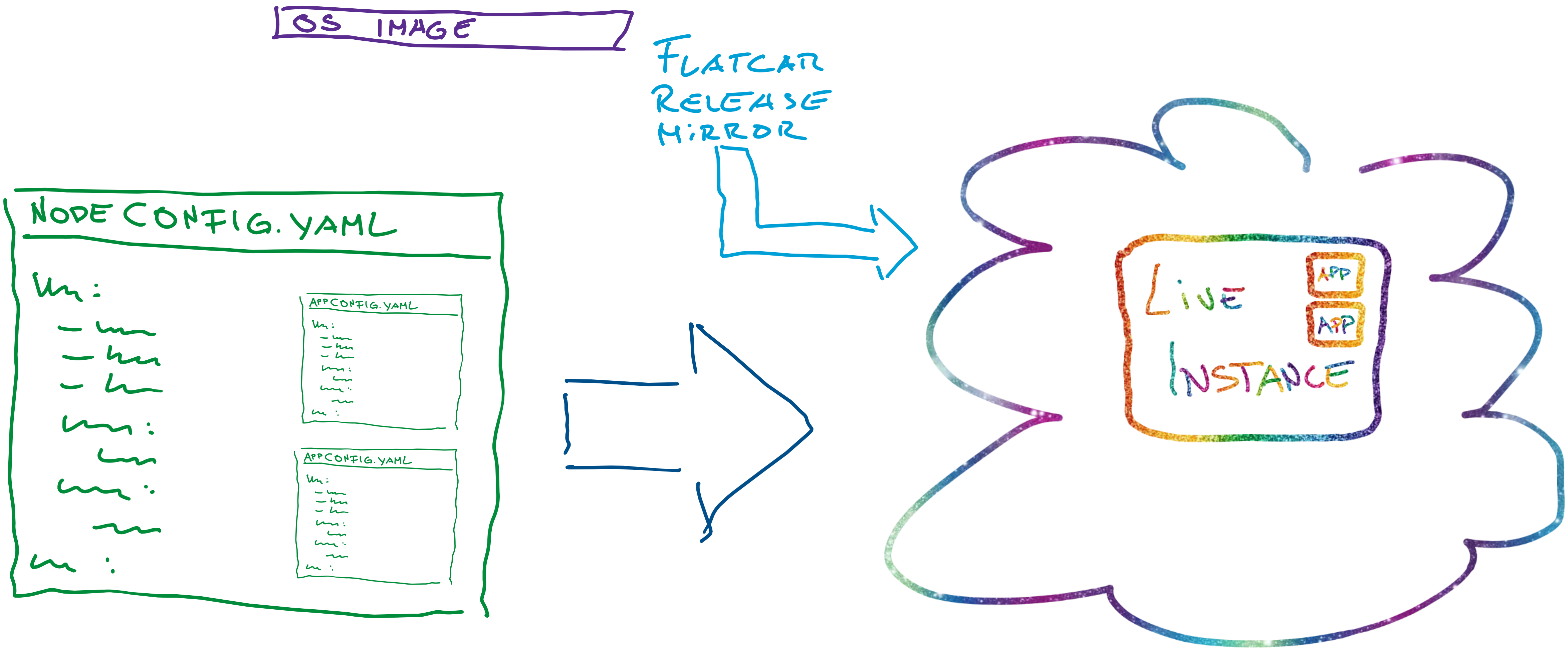
# Container / Kubernetes App Provisioning



# OS Provisions like a Container App



# Bootstrap Initial Apps when Provisioning



# Provisioning Demo

# Operate the OS like a Container App or Pod

## Sensible defaults, no boilerplate

Focus on your business logic

Storage, networking, users, ssh, systemd units – only if you need these

Inline / download custom directories and files

## No config drift

Configured at first boot / during provisioning

New and existing (updated) node configs do not differ

## Extensive Automation

OS supports many cloud providers and private clouds, support is growing

Terraform integration, Go bindings

ClusterAPI integration

# Configuration applied once, at provisioning time

YOU WOULDN'T
kubectl exec
to configure
A POD

# Large-Scale deployments? ClusterAPI!

Supported out-of-the box by Core CAPI and image-builder

Multiple large vendors are supported

- AWS
- Azure
- VSphere
- OpenStack
- Tinkerbell (via Sysexts)

GCP support is work-in-progress.

Piloting sysext CAPI deployments (composed at provisioning, updatable)

# Image-Based OS

## Provisioning and updates are immutable images

Always built from scratch, always fully tested. Self-contained, all bits included.

No version drift: releases are frozen version sets

No difference between new and existing (updated) nodes

## All OS binaries on a separate, immutable partition

Everything is in /usr, read-only and dm-verity protected

## In-place updates via A/B partitions

Retains node state - DB node operators rejoice!

Updates are atomic, roll-backs are easy

# Leverage Container Isolation

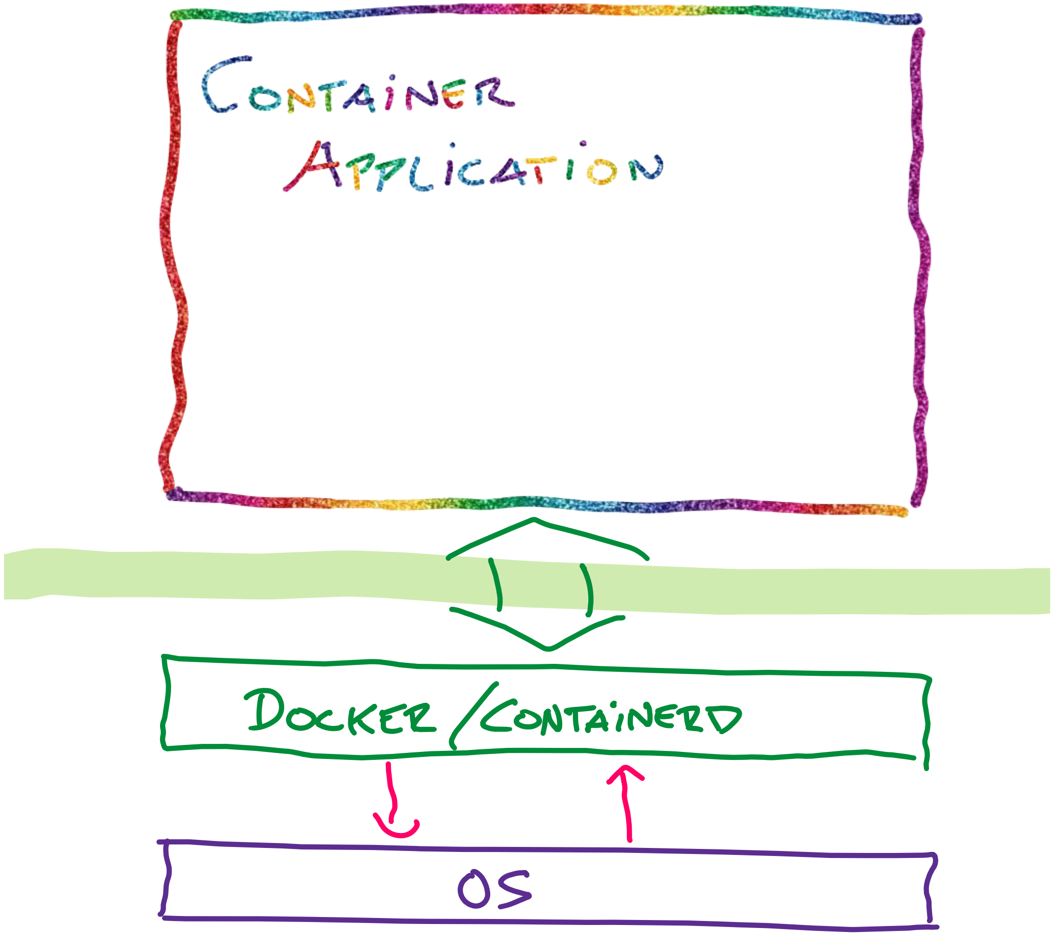
Container apps are self-contained and run isolated

- From each other, but also from the OS
- Few and well-defined dependencies on the OS

No inter-dependencies OS <-> App

- No shared libraries / binaries
- No shared configuration

➔ Portable Applications



# Leverage Container Isolation from the OS side

## Well-defined interfaces OS <-> App

Very few components, easy to test thoroughly

No other inter-dependencies

Container apps isolate from the OS

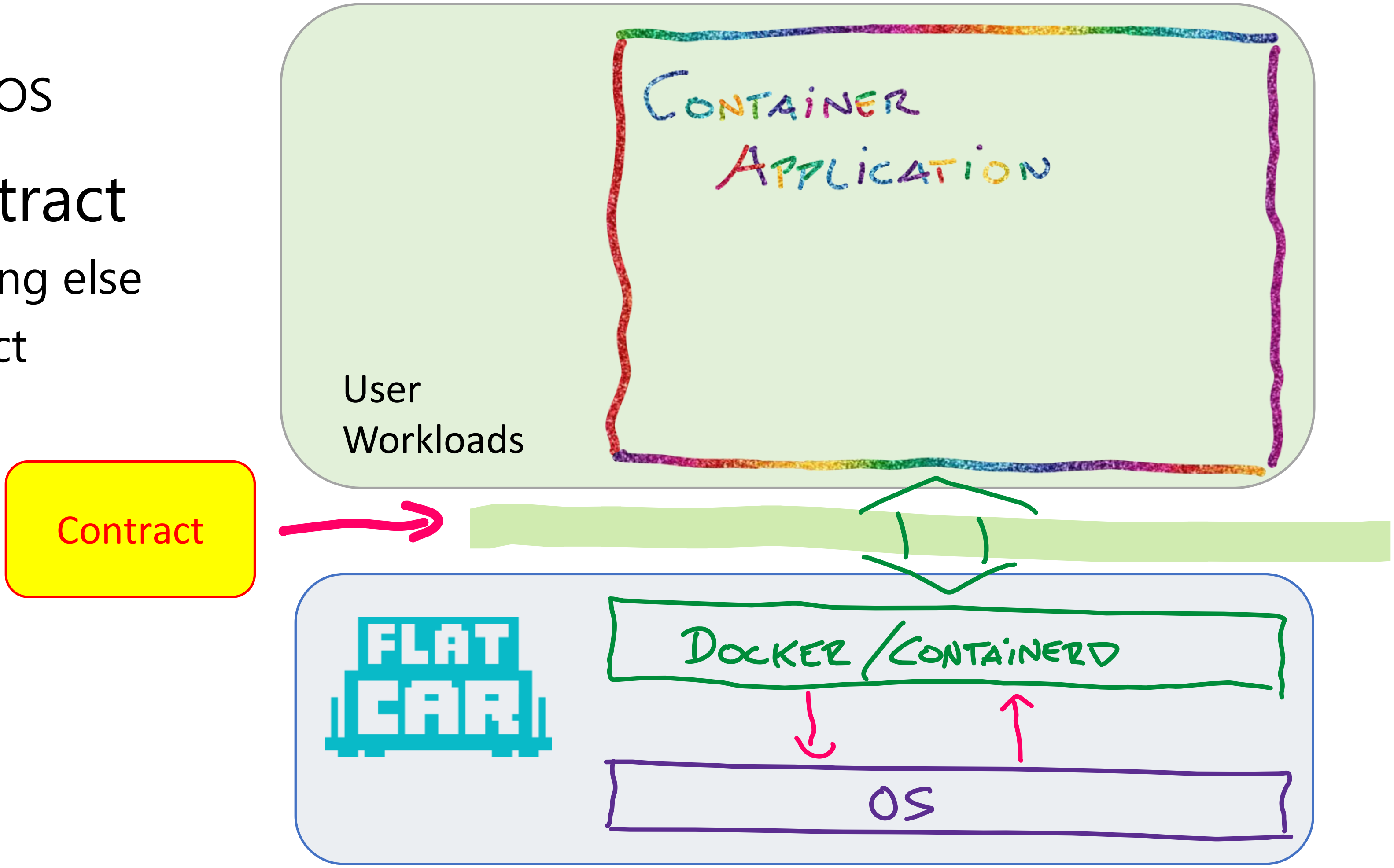
## Runtime + Kernel is a Contract

App relies on contract and nothing else

OS guarantees and fulfils contract

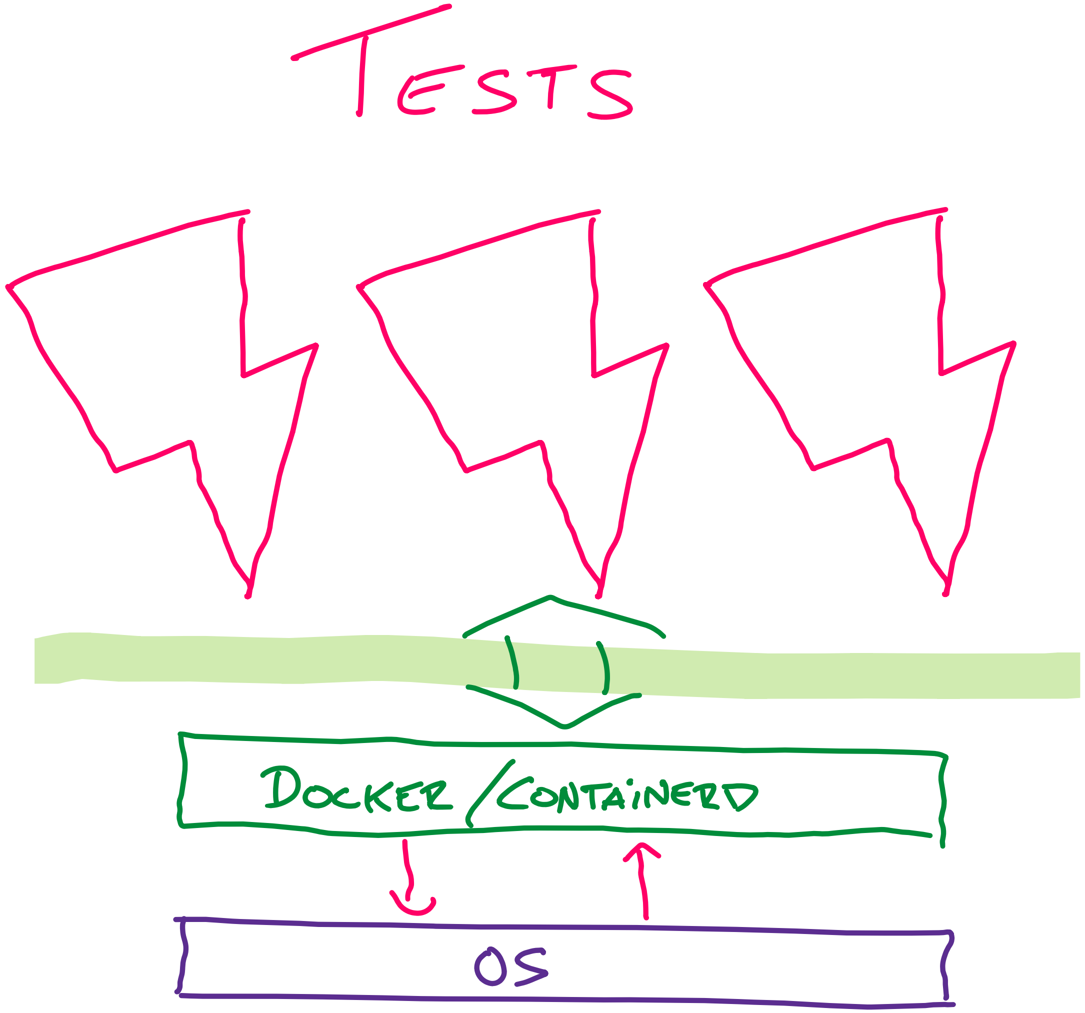
## ➔ Interchangeable OS

Main Focus on upholding runtime contract



# Interchangeable OS

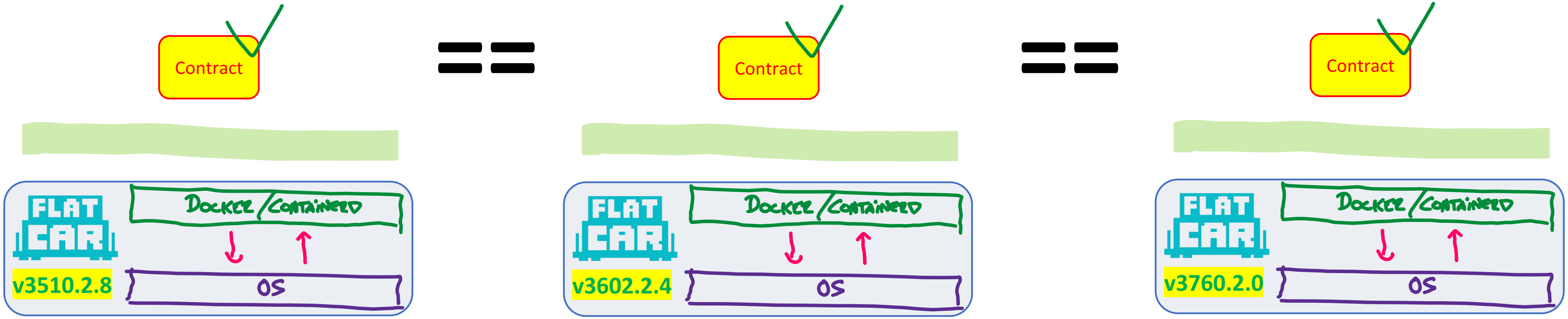
Contract is well-testable (and rigorously tested)



# Interchangeable OS

Contract is well-tested

Always upheld across releases

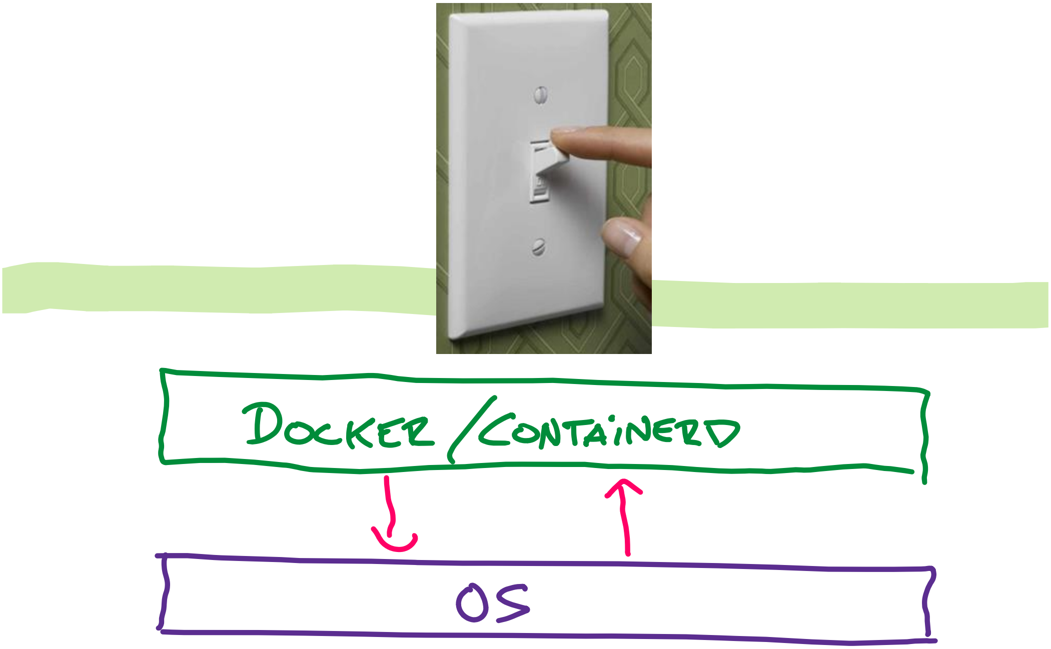


# Interchangeable OS

Contract is well-tested

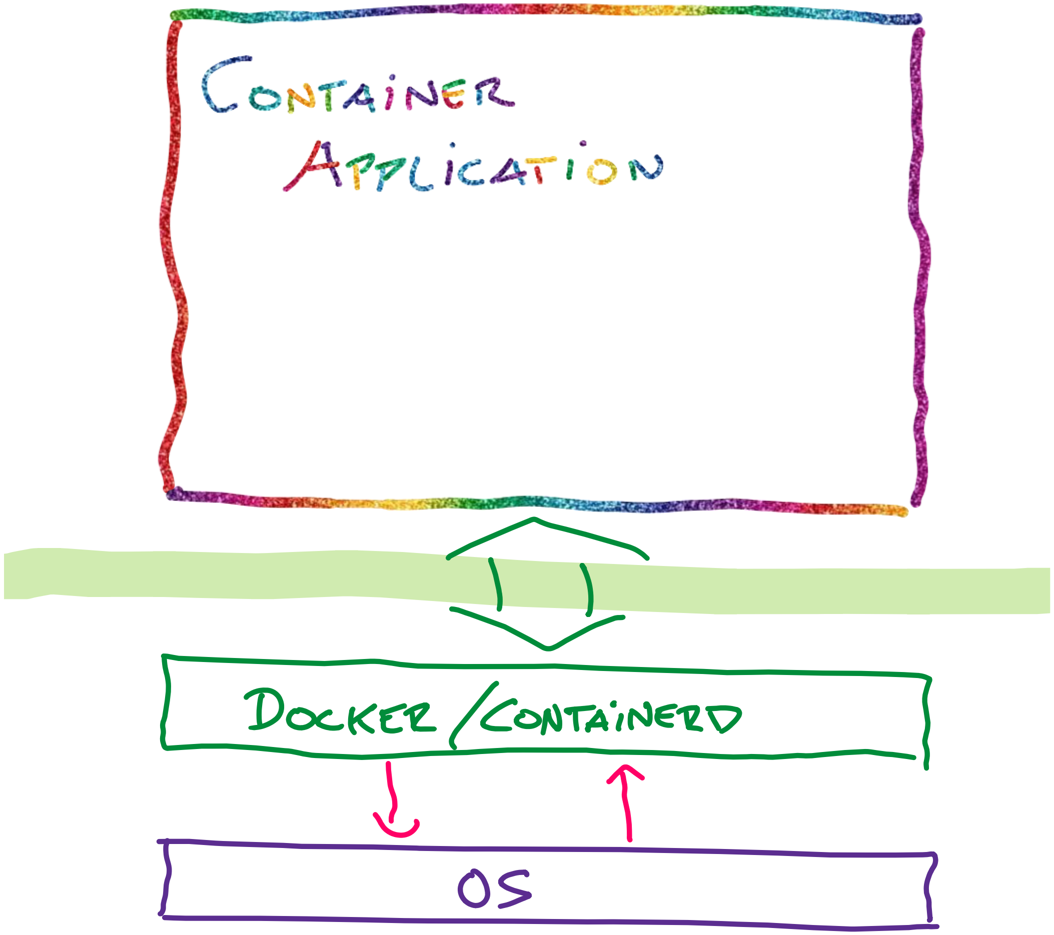
Always upheld across releases

Contract is our “light switch”



# Staying up to date

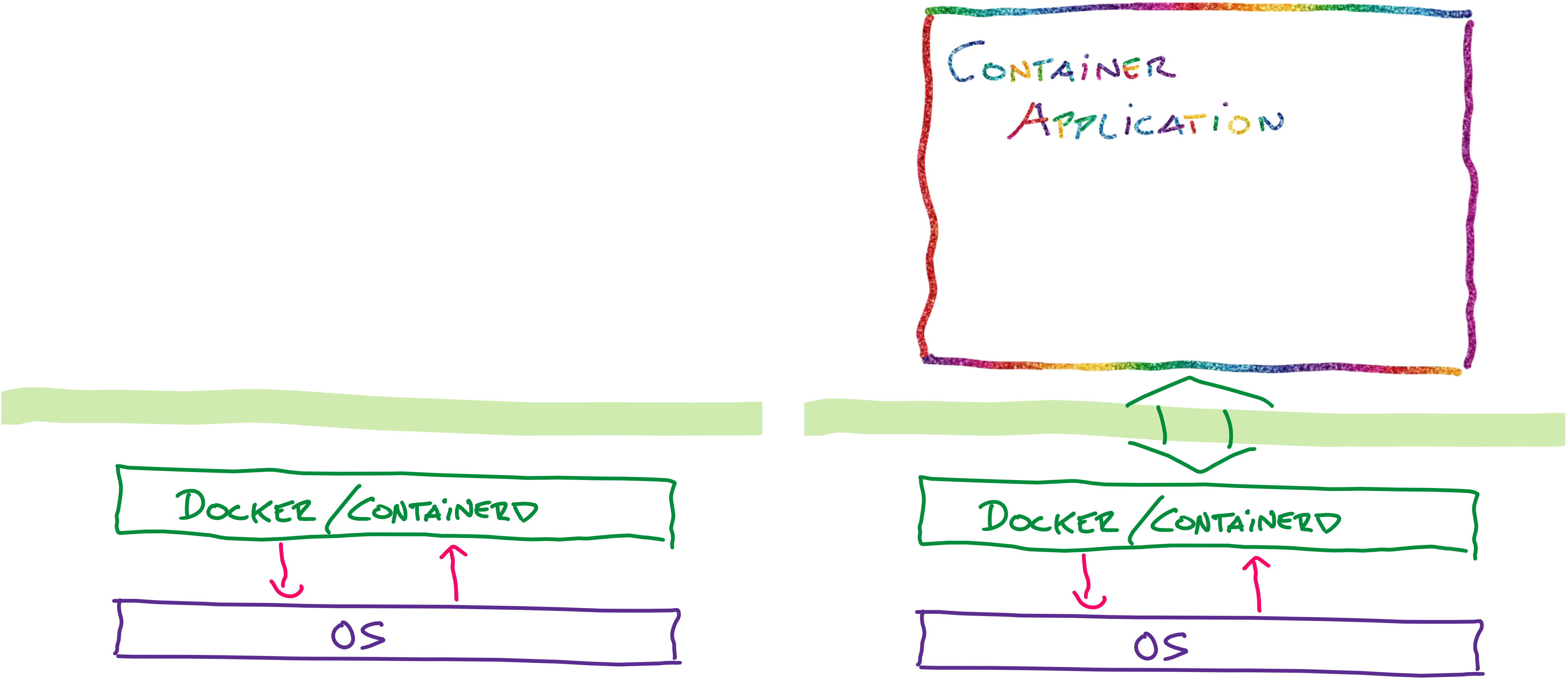
## Atomic In-Place Updates



# Staying up to date

## Atomic In-Place Updates

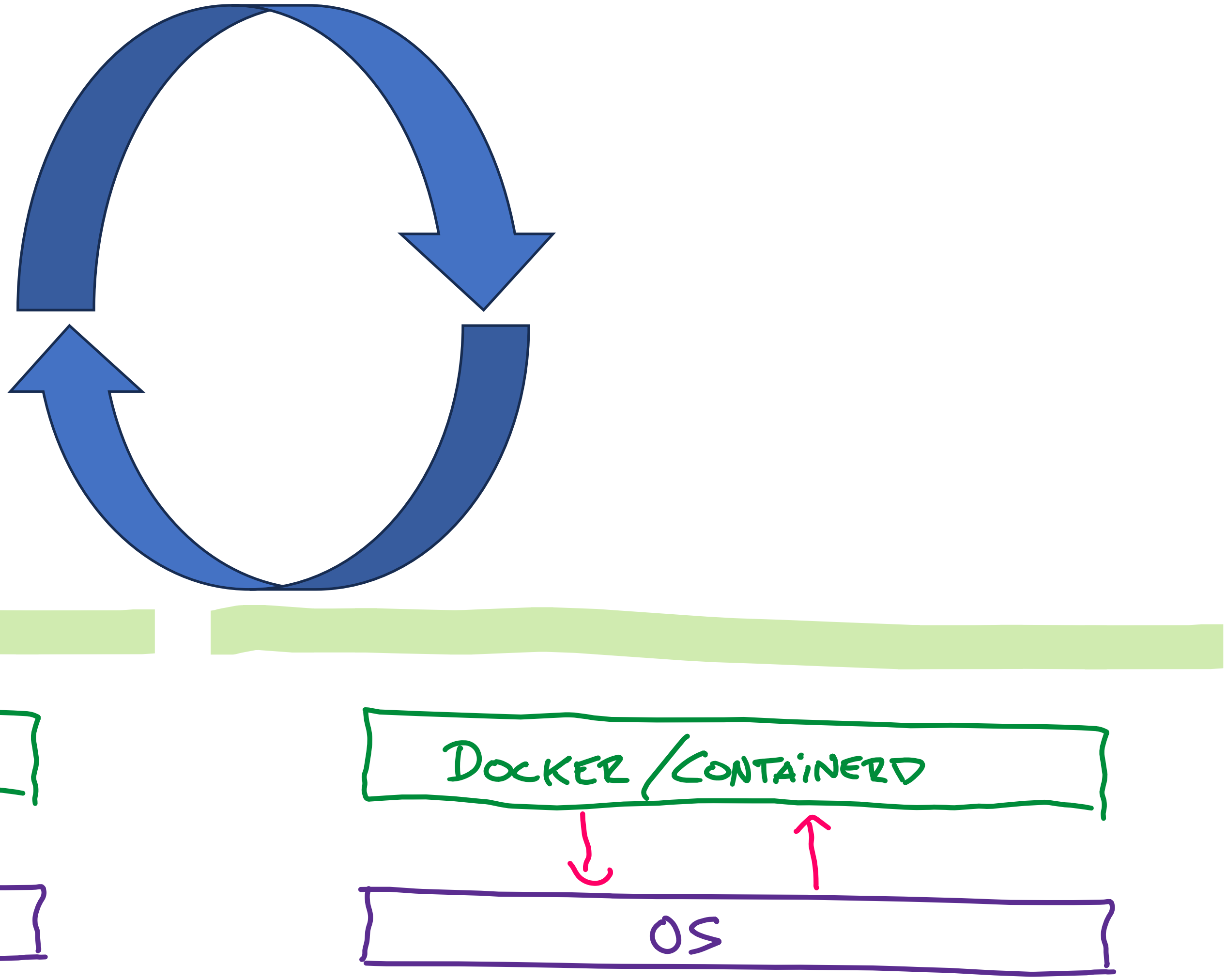
1. Stage



# Staying up to date

Atomic In-Place Updates

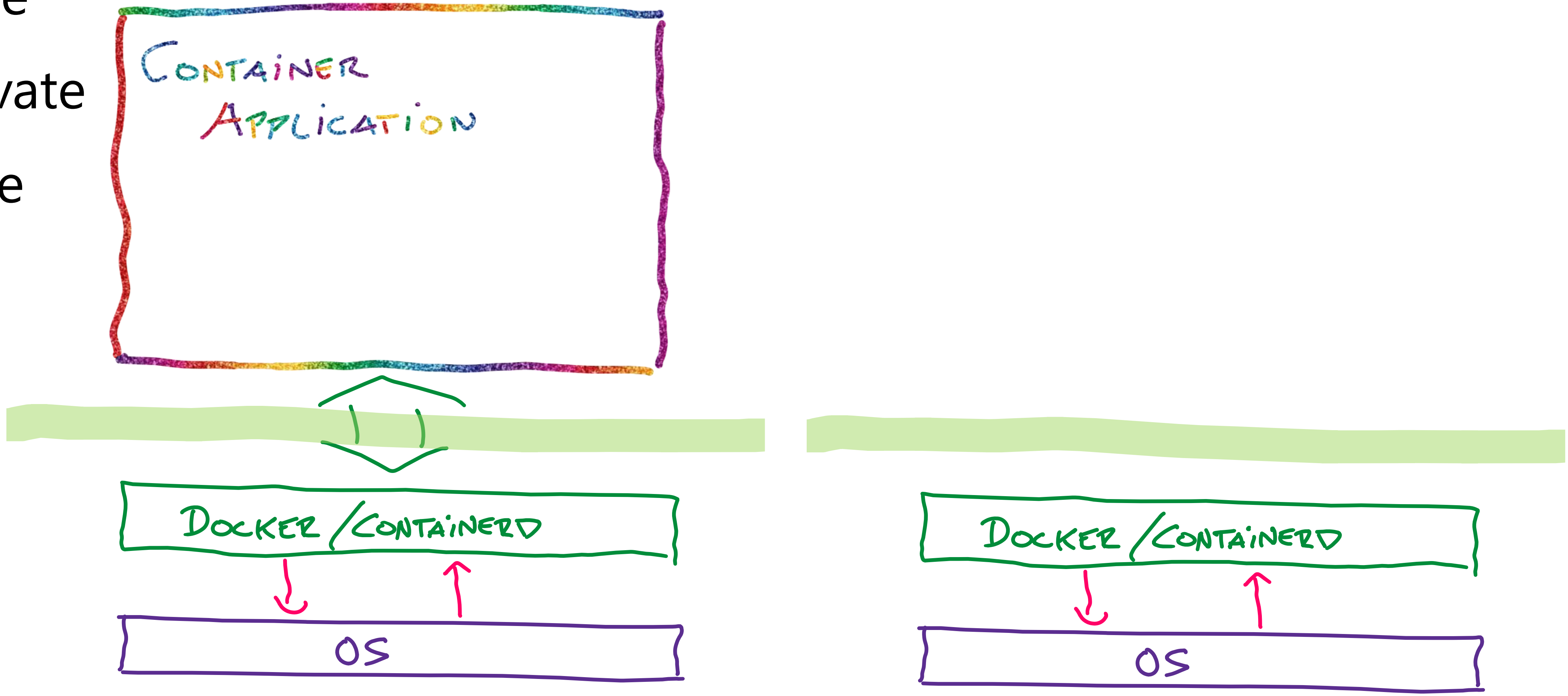
1. Stage
2. Activate (Reboot)



# Staying up to date

Atomic In-Place Updates

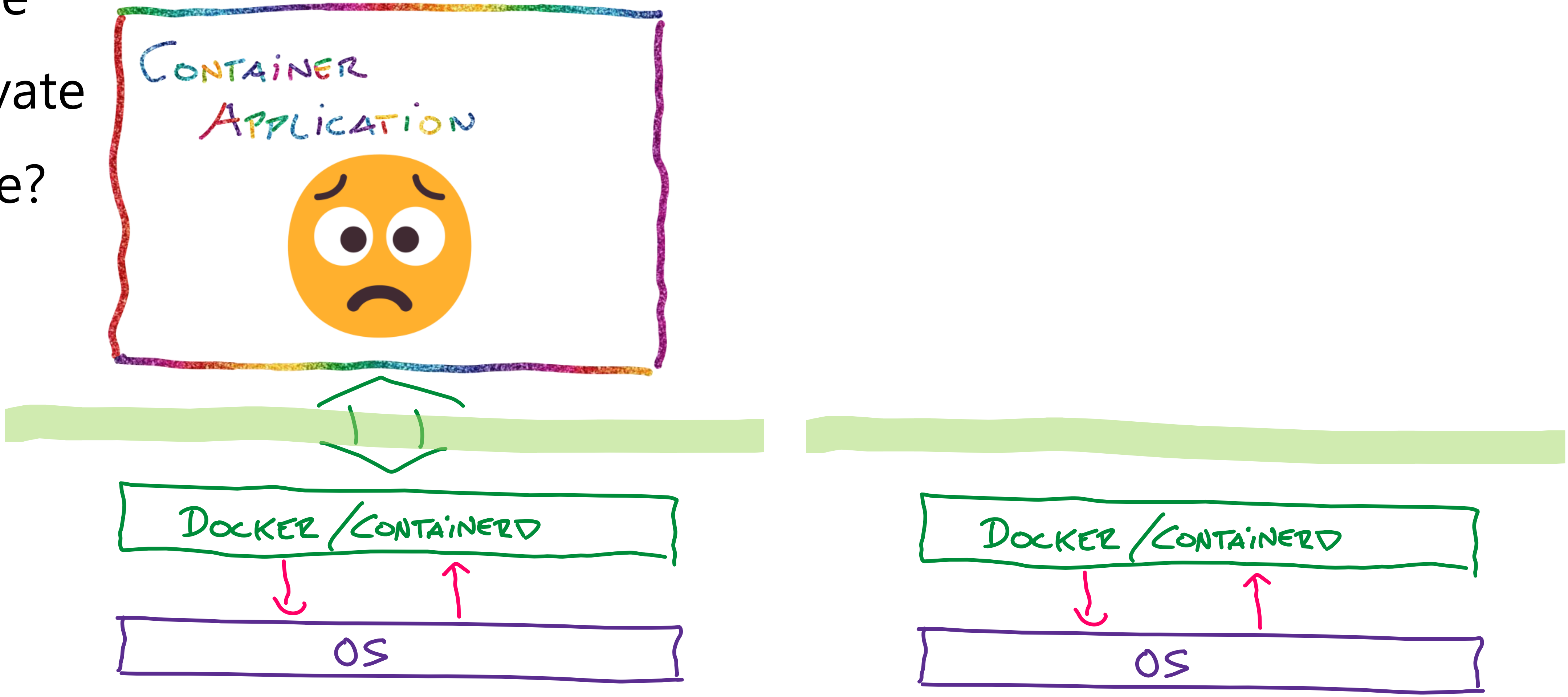
1. Stage
2. Activate
3. Done



# Staying up to date

Atomic In-Place Updates

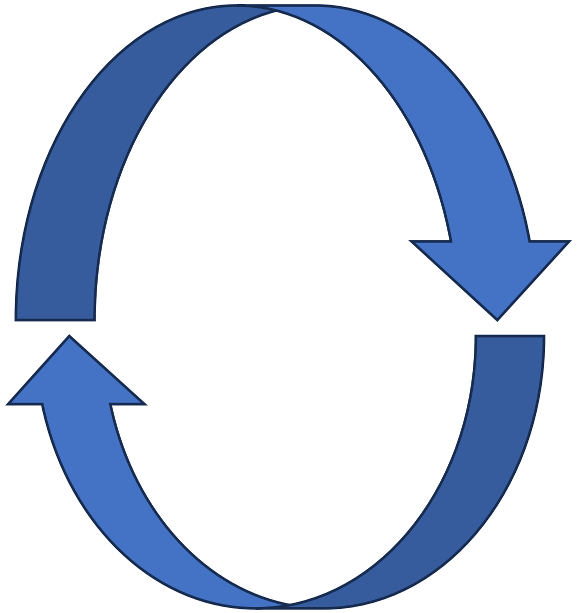
1. Stage
2. Activate
3. Done?

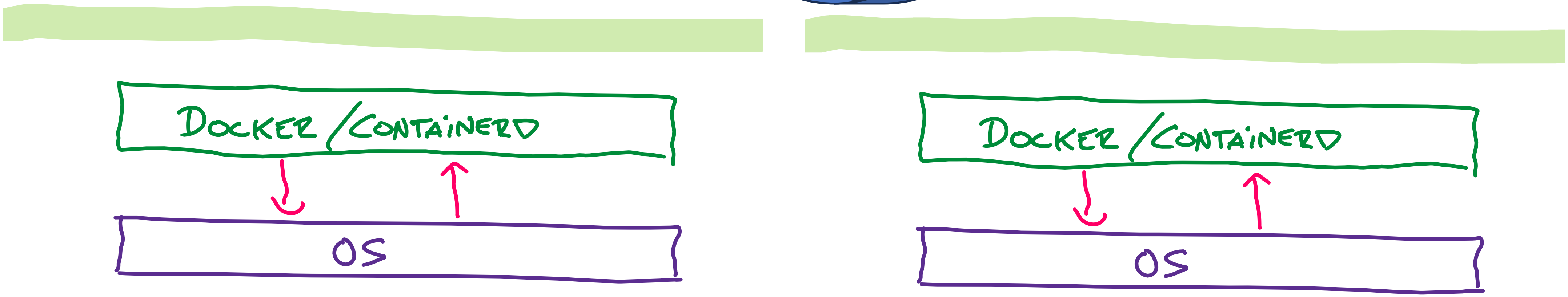


# Staying up to date

Atomic Roll-Backs

1. Stage
2. Activate
3. Done?
4. Roll Back

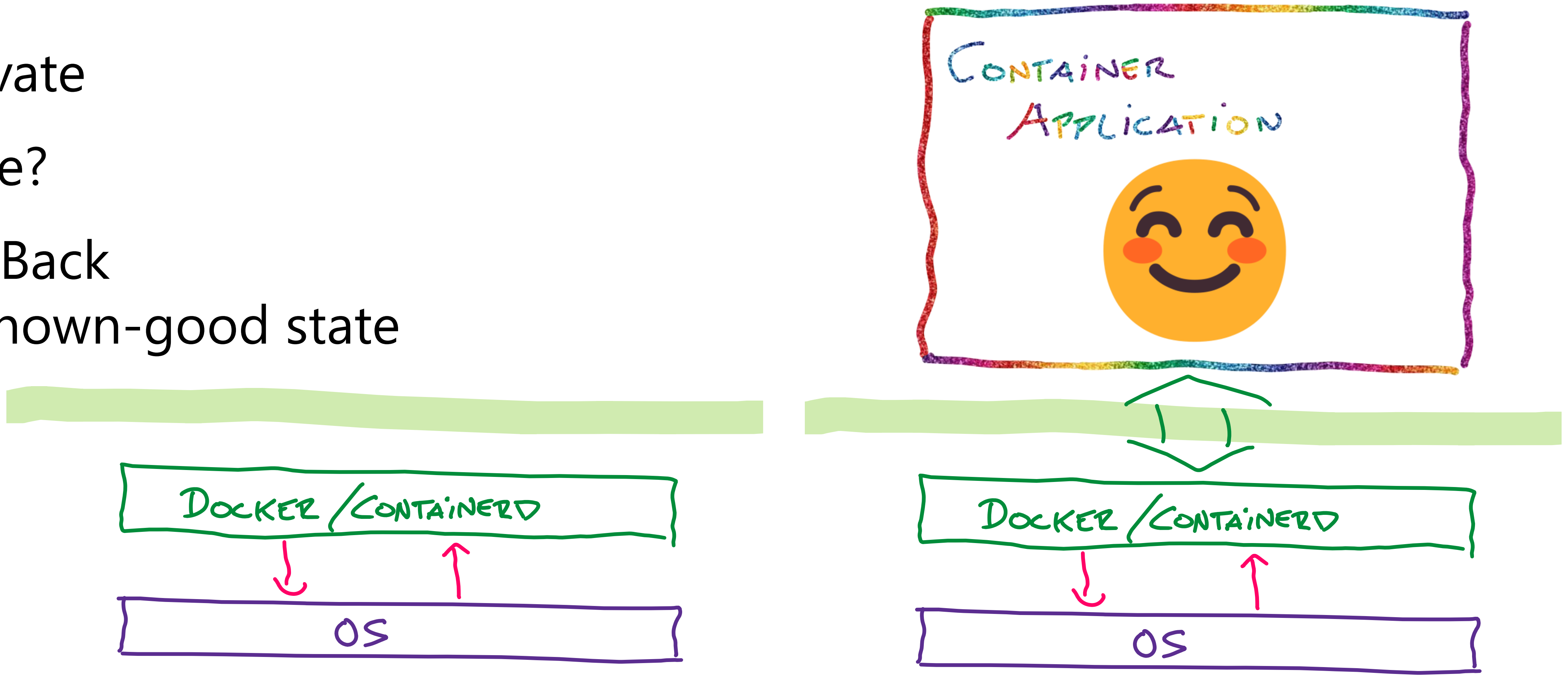




# Staying up to date

Atomic Roll-Backs

1. Stage
2. Activate
3. Done?
4. Roll Back
   to known-good state



# Update Demo

(Usually automated.
Manual ONLY
for demo purposes)

# Rolling out Updates

## Updates need Reboots

Maintenance windows (date / time)

Sync via custom etcd lock (max number of nodes to reboot)

Kubernetes: update operator (FLUO, KureD) w/ node draining, reboot, un-cordoning

## Stateful, FOSS update server

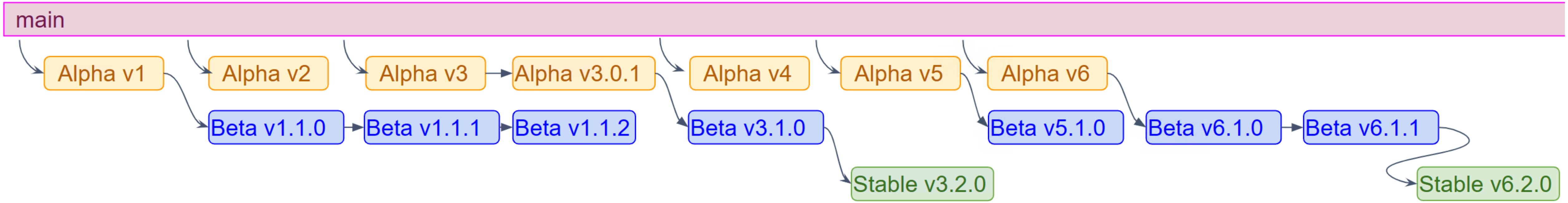
Nebraska project - “Omaha” protocol used by chromium

Easy to self-host. For large fleets – custom grouping, staggered roll-out, version overview, etc.

## Users part of the stabilization process

Run canaries and keep your workloads safe

# Stabilisation Process



## Major OS release stabilisation milestones:

"Alpha" Fully tested but may contain incomplete features. For developers.

"Beta" Fully tested for production use. Recommended for canaries

"Stable" For widespread production use.
Additional stabilisation through user feedback from Beta canaries.

Deployments defaults to "stable" but can be customised to any channel.

# Participate in the Stabilisation Process

Use stable for most workloads, and run a few Beta canaries

- Each Beta is fully tested
- Canaries smoke-test incoming changes and detect issues with your workload
  - (And roll-back is easy!)

Report Issues detected by canaries

- The issue will be fixed in the next Beta, before changes go stable

==> Your clusters will receive stable versions that are proven to work

# Composability

# OS-level extensibility via Systemd Sysext

## OS is immutable

Nice set of tools, but I need podman/Kubernetes/WASM/…

## Extensible via systemd-Sysexts

Immutable filesystem images that ship custom libraries / binaries as full root FS tree (only /usr and /opt subtrees supported)

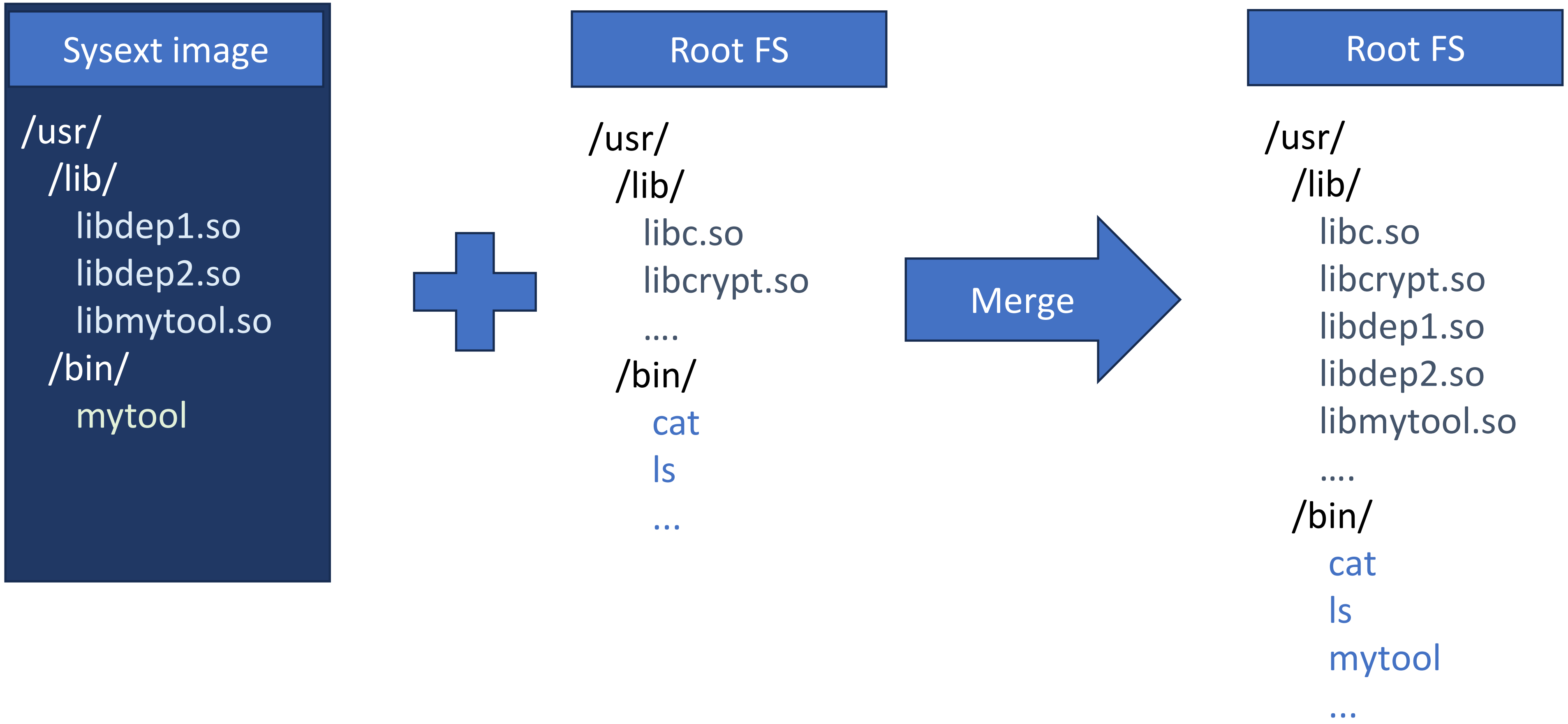
A/B updates independent from OS via systemd-sysupdate (via HTTPS server, e.g. Github Release)

## Flatcar makes extensive use of sysexts

Bundled with the base OS and updated in lock-step, e.g. OEM / guest tools

Independent of the base OS with custom update cycle, e.g. Kubernetes sysext for CAPI, WASM, …

# Using Sysexts



Sysext image

```
/usr/
  /lib/
    libdep1.so
    libdep2.so
    libmytool.so
  /bin/
    mytool
```

Root FS

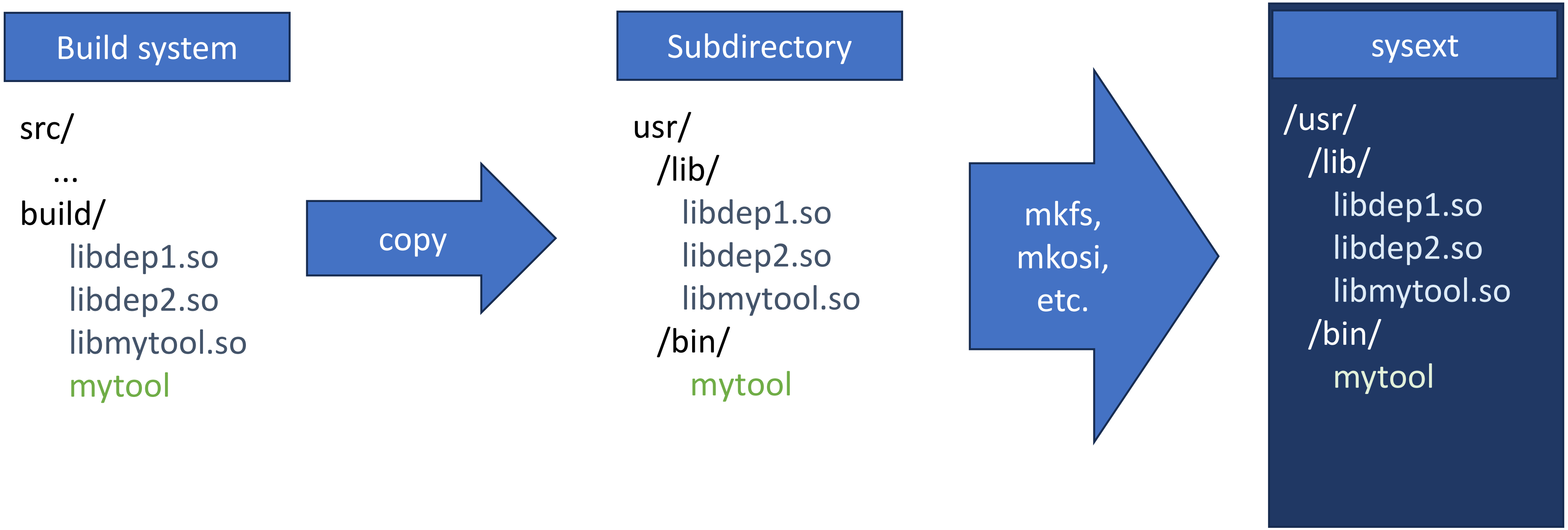
```
/usr/
  /lib/
    libc.so
    libcrypt.so
    ….
  /bin/
    cat
    ls
    …
```

Merge

Root FS

```
/usr/
  /lib/
    libc.so
    libcrypt.so
    libdep1.so
    libdep2.so
    libmytool.so
    ….
  /bin/
    cat
    ls
    mytool
    …
```

# Building Sysexts



Build system

```
src/
  ...
build/
    libdep1.so
    libdep2.so
    libmytool.so
    mytool
```

copy

Subdirectory

```
usr/
  /lib/
    libdep1.so
    libdep2.so
    libmytool.so
  /bin/
    mytool
```

mkfs,
mkosi,
etc.

sysext

```
/usr/
  /lib/
    libdep1.so
    libdep2.so
    libmytool.so
  /bin/
    mytool
```

# Image composability

## Pre-bake images

- Add custom sysexts + configuration to stock Flatcar release image
- Update via self-hosted sys

## Compose at provisioning time

- Use declarative configuration to download & configure, sysupdate to update

## CAPI pilot

- Proof-of-concept Kubernetes sysext composed into stock image during provisioning
- CAPO, Tinkerbell are supported, CAPA, CAPZ, and CAPV work in progress.

# Sysext Demo

# Community

# Flatcar Community

Community-driven FOSS project

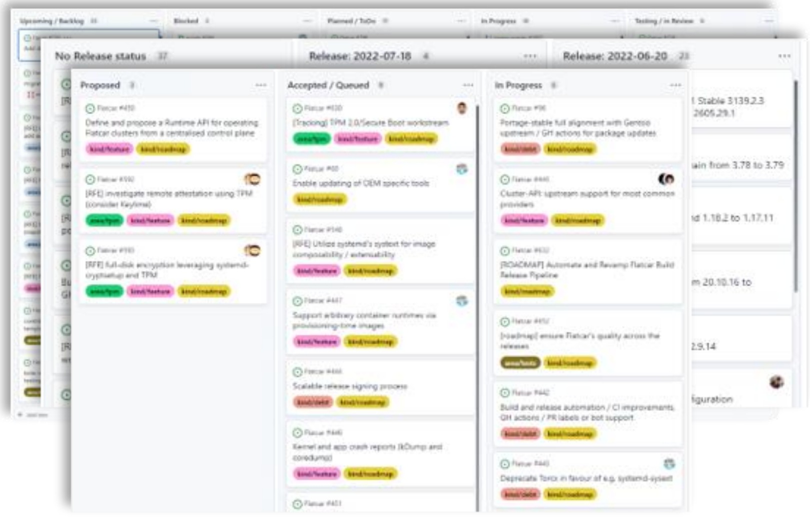
- No single vendor, full community stewardship
- Submitted to the CNCF as incubation project (ongoing)

Matrix, Slack - Our day-to-day comms

Office hours - Every 2nd Tuesday, 3:30pm UTC

Dev Sync - Every 4th Tuesday, 3:30pm UTC

Roadmap, Implementation, Releases



Define and propose a Runtime API for operating Flatcar clusters from a centralised control plane

[RFE] investigate remote attestation using TPM (consider Keylime)

[RFE] full-disk encryption leveraging systemd-cryptsetup and TPM

[Tracking] TPM 2.0/Secure Boot workstream

Enable updating of OEM specific tools

[RFE] Utilize systemd's sysext for image composability / extensibility

Support arbitrary container runtimes via provisioning-time images

Scalable release signing process

Kernel and app crash reports (kDump and coredump)

Portage-stable full alignment with Gentoo upstream / GH actions for package updates

Cluster-API: upstream support for most common providers

[ROADMAP] Automate and Revamp Flatcar Build Release Pipeline

[roadmap] ensure Flatcar's quality across the releases

Build and release automation / CI improvements, GH actions / PR labels or bot support

Deprecate Torcx in favour of e.g. systemd-sysext

Stable 3139.2.3
2605.29.1

ain from 3.78 to 3.79

d 1.18.2 to 1.17.11

m 20.10.16 to

2.9.14

figuration

# Portable, Easy to use SDK

Focus on low entry bar to OS Development

(Some Gentoo knowledge is useful though)

Used by Maintainers and in our automation

Includes easy-to-run, full test suite

```
git clone https://github.com/flatcar/scripts.git
cd scripts
git checkout alpha-3794.0.0

./run_sdk_container –t ./build_packages
./run_sdk_container –t ./build_image
./image_to_vm.sh --from=../build/images/amd64-usr/latest/ \
                 --format=qemu_uefi --image_compression_formats none

./run_local_tests.sh
```

# Wrap Up

Leverage Isolation of OS and Apps

Declarative Configuration at Provisioning

Atomic, Automated Updates

Composable images with Sysext

Community driven, submitted to CNCF

FLAT
CAR

Thank you

The Community's
Container Linux