Immutable All the Way Down

Using System Extensions
to ship Kubernetes

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Hello, I'm

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Cluster Plumbing

Cluster Plumbing

Shipping Kubernetes

Cluster Plumbing

Shipping Kubernetes as immutable image

Cluster Plumbing

Shipping Kubernetes as immutable image

Separating Kubernetes from the OS

Cluster Plumbing

Shipping Kubernetes as immutable image

Separating Kubernetes from the OS

Live in-place updates

Before we start

Thilo, start provisioning our ClusterAPI cluster!

Extension Images

Extension Images

UAPI group Extension Image spec
https://uapi-group.org/specifications/specs/extension_image/

Application + lean metadata wrapped in **immutable** FS image

Merge into OS FS root, usually at boot

Tie-in with sysupdate, a lightweight update mechanism

Extension Images Contents

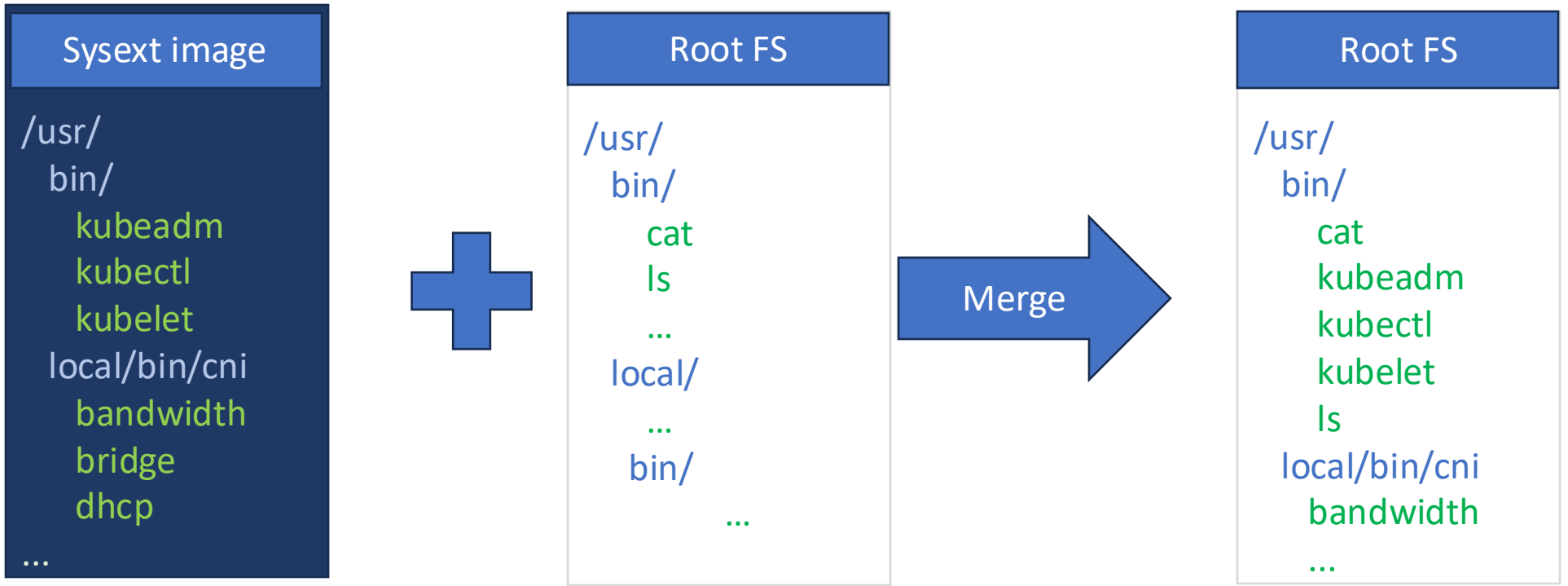
Application binaries and libraries

Static configuration files

Wrapper and helper scripts for automation

Systemd service units, timers, etc.

Merging Extension Images



Provisioning Extension Images

Download during node provisioning

Composed into base OS at boot

```
storage:
  files:
    - path: /etc/extensions/kubernetes.raw
      contents:
        source: https://github.com/flatcar/sysext-bakery/releases/download/latest/kubernetes-v1.31.3-x86-64.raw
```

Show me!

Single node sysext live demo

Updating Extension Images

Systemd-sysupdate: complementary service for updating images

Can consume from HTTP[S]

Sysupdate supports updating symlinks

```
[Source]
Type=url-file
Path=https://github.com/flatcar/sysext-bakery/releases/latest/download/
MatchPattern=kubernetes-v1.31.@v-%a.raw

[Target]
InstancesMax=3
Type=regular-file
Path=/opt/extensions/kubernetes/
CurrentSymlink=/etc/extensions/kubernetes.raw
```

Producing and hosting Extension Images

Run mksquashfs on directory w/ sysext root

Host on HTTP[S] w/ index file

==> GitOps!

```
6565cf8912076cb7c966b7019f512ca639263266924bc983bd21e82885e80f26  kubernetes-v1.28.14-
11d8f9898c2bb7ccb4ecebcb1dca142874cc7b3d82c91268c0c2be2e80af4318  kubernetes-v1.28.14-
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cdb15c905147b8985ed0ce50dfc1b4c71fc93fe02c235fc56e8ca1fe077c63d1  kubernetes-v1.28.6-x
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899146b4dbc386fbccd90e555f4f325169b8339931ab59c2f1652aff4d9df237  kubernetes-v1.28.8-x
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866f2741a619fb3371796bc04924ecb7b078fac4ae0a69eb5b0af15cef151982  kubernetes-v1.29.1-x
3ab9d5ad92476270806fbc53de2c0bc7343bab53cff894dcab2075f608cf6933  kubernetes-v1.29.10-
1d380d23d5ffa99d4b93cc9281b5e8162445308c3582c062753cf13ffba17203  kubernetes-v1.29.10-
4516c74e30a02b9486a7ab0e83c923b07186472ca9e34a7bb9fc3badfdb8cfb9  kubernetes-v1.29.11-
5f9066d7e71e2bd8d4439a5adf320a841b03903370cb066957047c07190be75c  kubernetes-v1.29.11-
67a5755f2136d9c160bc5ae36683e2558328a731ee6e279d0c57101d69567b4f  kubernetes-v1.29.12-
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b90b4da1ca309e66921698ae83870176524e9631b9b7e5a5f485d2abf4c61446  kubernetes-v1.29.2-a
46c5705d7468ca3b9d6d2c103c4598f034e1957af01c69b0cb39905a590b66e1  kubernetes-v1.29.2-x86-64.raw
95d645ced1b639d509fba3eb78d46913f03fe3afbd46d61e88371e1da737a2ed  kubernetes-v1.29.3-arm64.raw
```
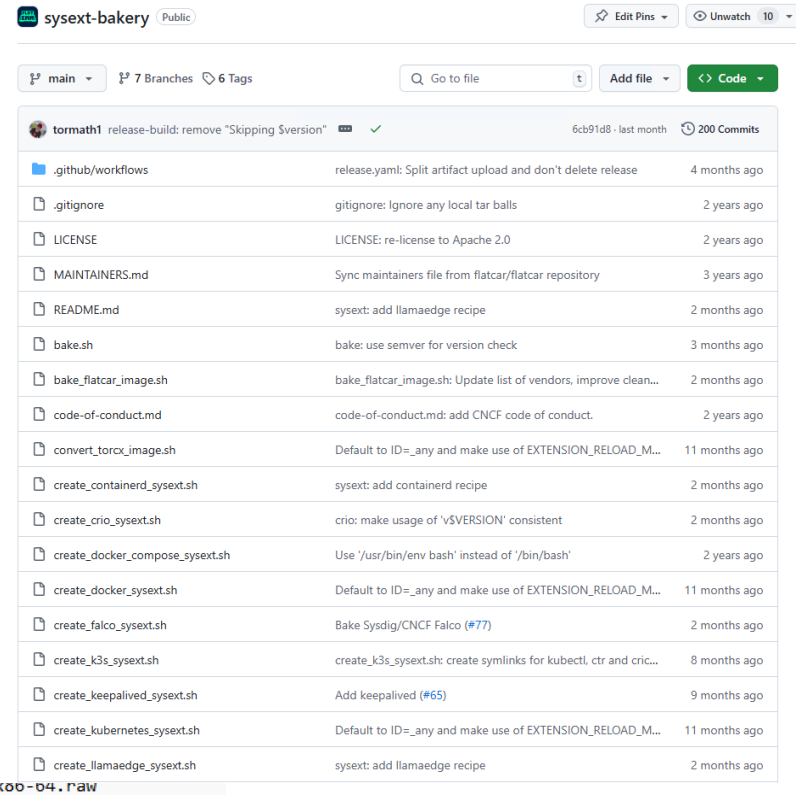



Show me!

Single node sysext sysupdate

Extension Images

Self-contained, immutable OS level application images

Easy to generate, easy to compose, easy to manage

Complementary update mechanism

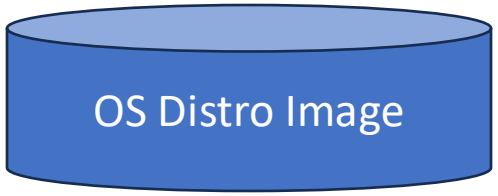
Your Linux distro likely supports it (if it ships systemd). Try it out!

Sysexts and Kubernetes Deployments

Separation of Concerns

Leverage upstream OS maintenance

Take control of Kubernetes



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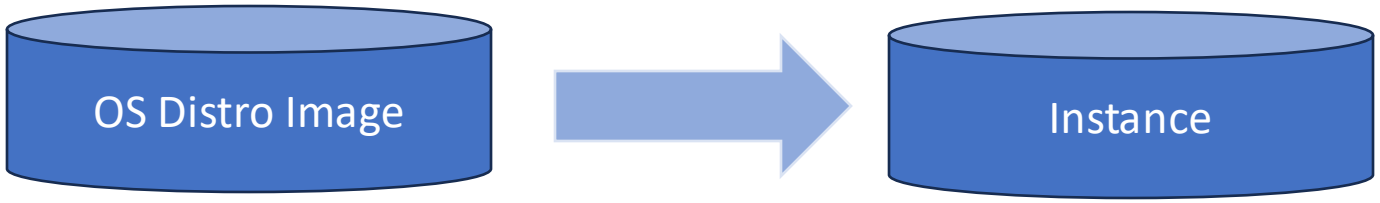

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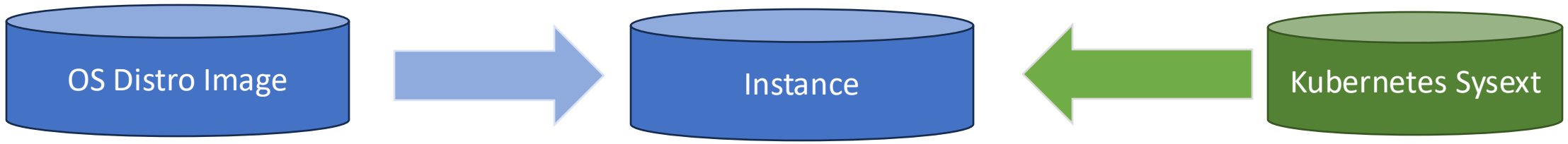

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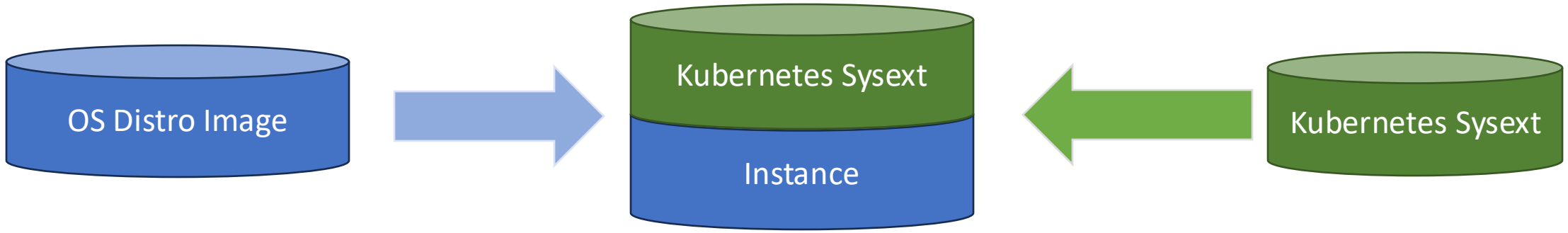

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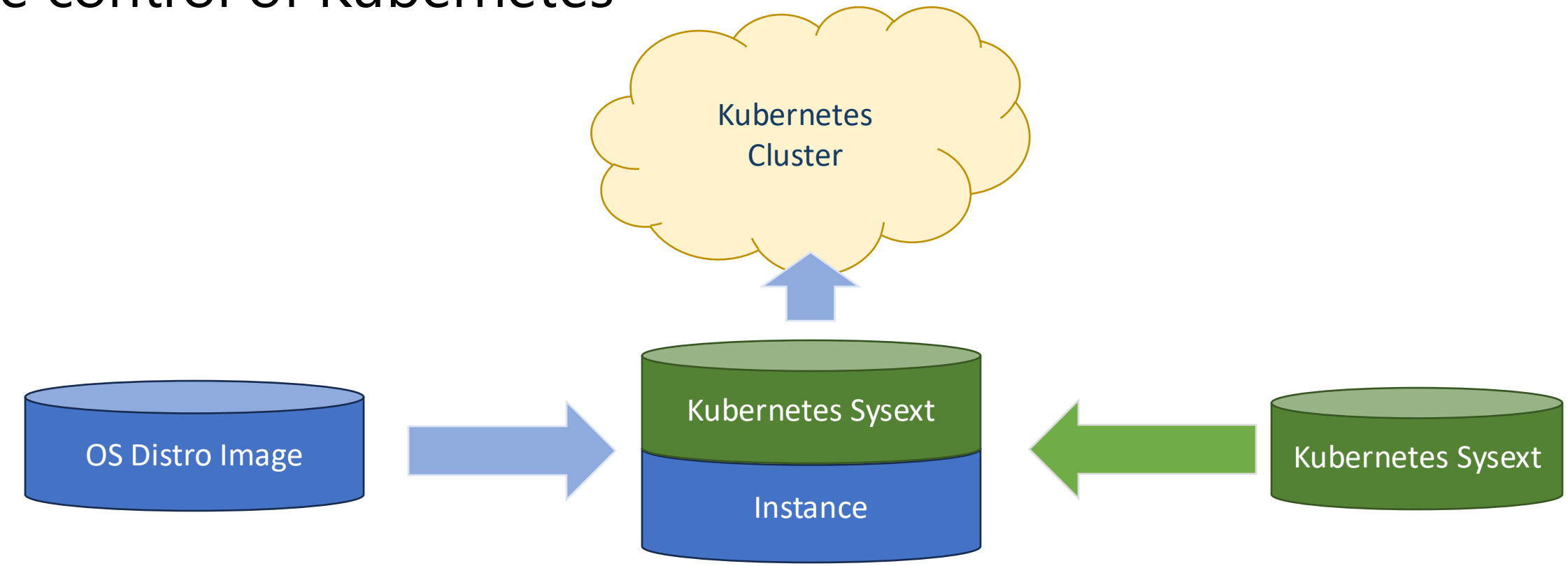

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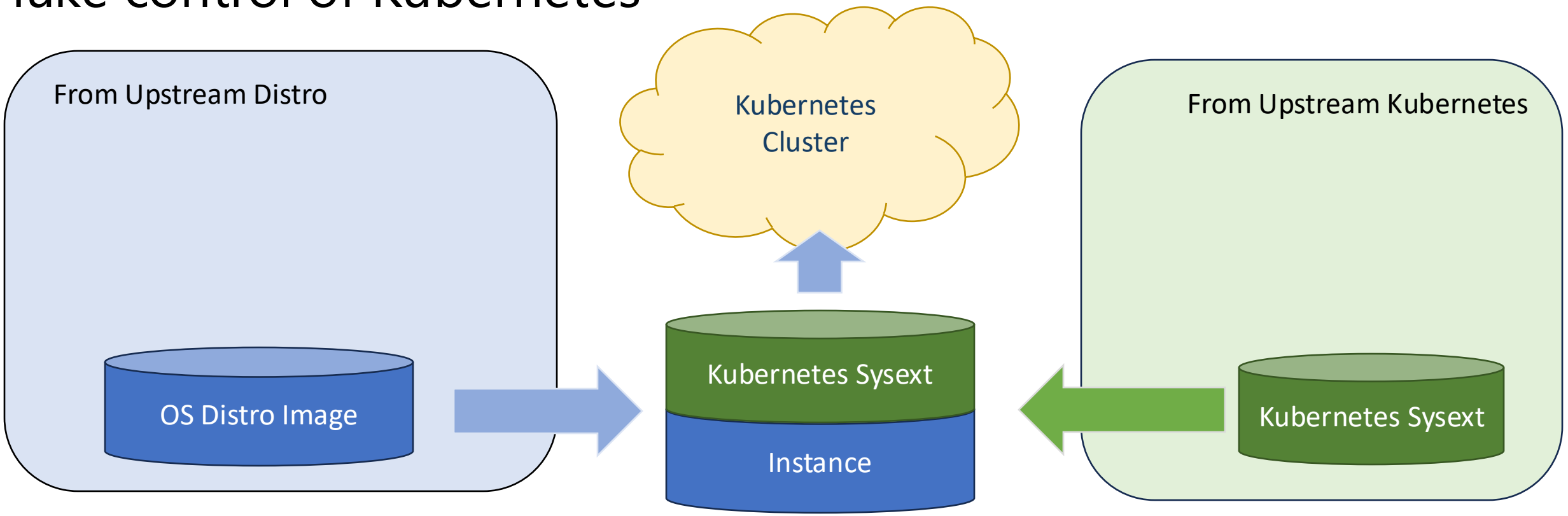

Separation of Concerns

Loose coupling

OS and Kubernetes maintained independently

Separate In-Place Updates

Cut down version / support matrix

Version Matrix? Big issue with pre-built images.

Ubuntu-22 + Kubernetes 1.29 + AWS

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Version Matrix? Big issue with self-hosted images.

Ubuntu-24 + Kubernetes 1.29 + AWS

Ubuntu-24 + Kubernetes 1.29 + Azure

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Ubuntu-24 + Kubernetes 1.30 + AWS

Ubuntu-24 + Kubernetes 1.30 + Azure

Ubuntu-24 + Kubernetes 1.30 + GCP

Ubuntu-24 + Kubernetes 1.31 + AWS

Ubuntu-24 + Kubernetes 1.31 + Azure

Ubuntu-24 + Kubernetes 1.31 + GCP

Version Matrix? Big issue with self-hosted images.

RHEL9+ Kubernetes 1.29 + AWS

RHEL9 + Kubernetes 1.29 + Azure

RHEL9 + Kubernetes 1.29 + GCP

RHEL9 + Kubernetes 1.30 + AWS

RHEL9 + Kubernetes 1.30 + Azure

RHEL9 + Kubernetes 1.30 + GCP

RHEL9 + Kubernetes 1.31 + AWS

RHEL9 + Kubernetes 1.31 + Azure

RHEL9 + Kubernetes 1.31 + GCP

Version Matrix? Big issue with self-hosted images.

SLES+ Kubernetes 1.29 + AWS

SLES + Kubernetes 1.29 + Azure

SLES + Kubernetes 1.29 + GCP

SLES + Kubernetes 1.30 + AWS

SLES + Kubernetes 1.30 + Azure

SLES + Kubernetes 1.30 + GCP

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Separation of Concerns

Leverage upstream OS maintenance

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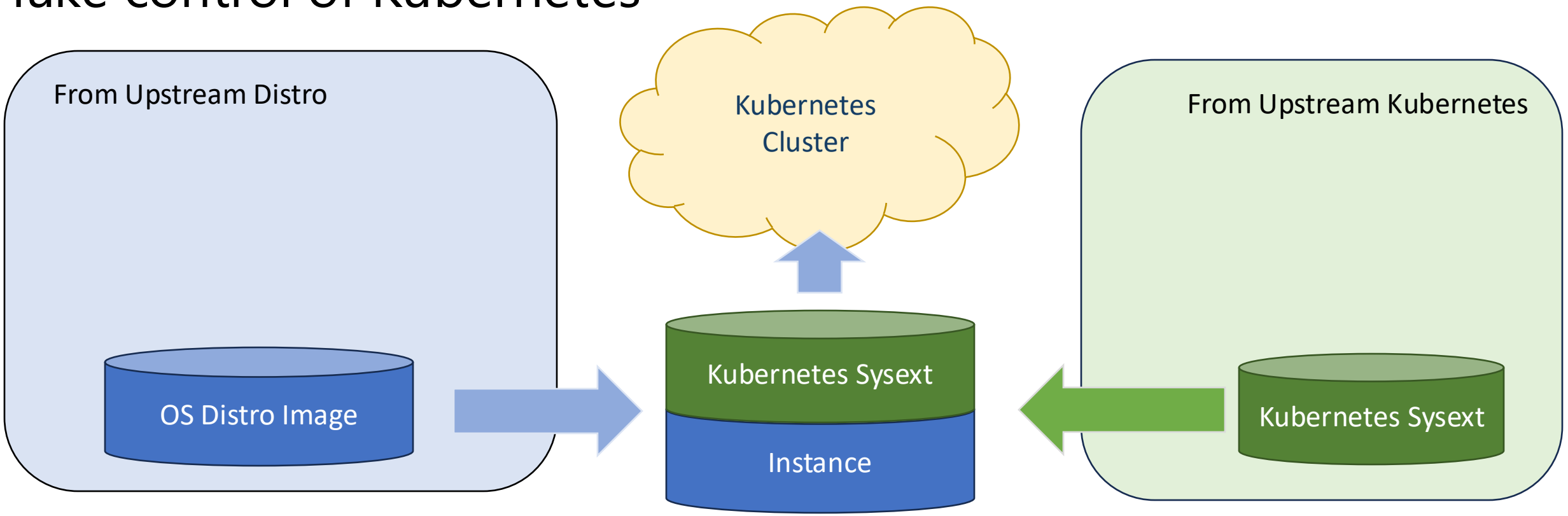
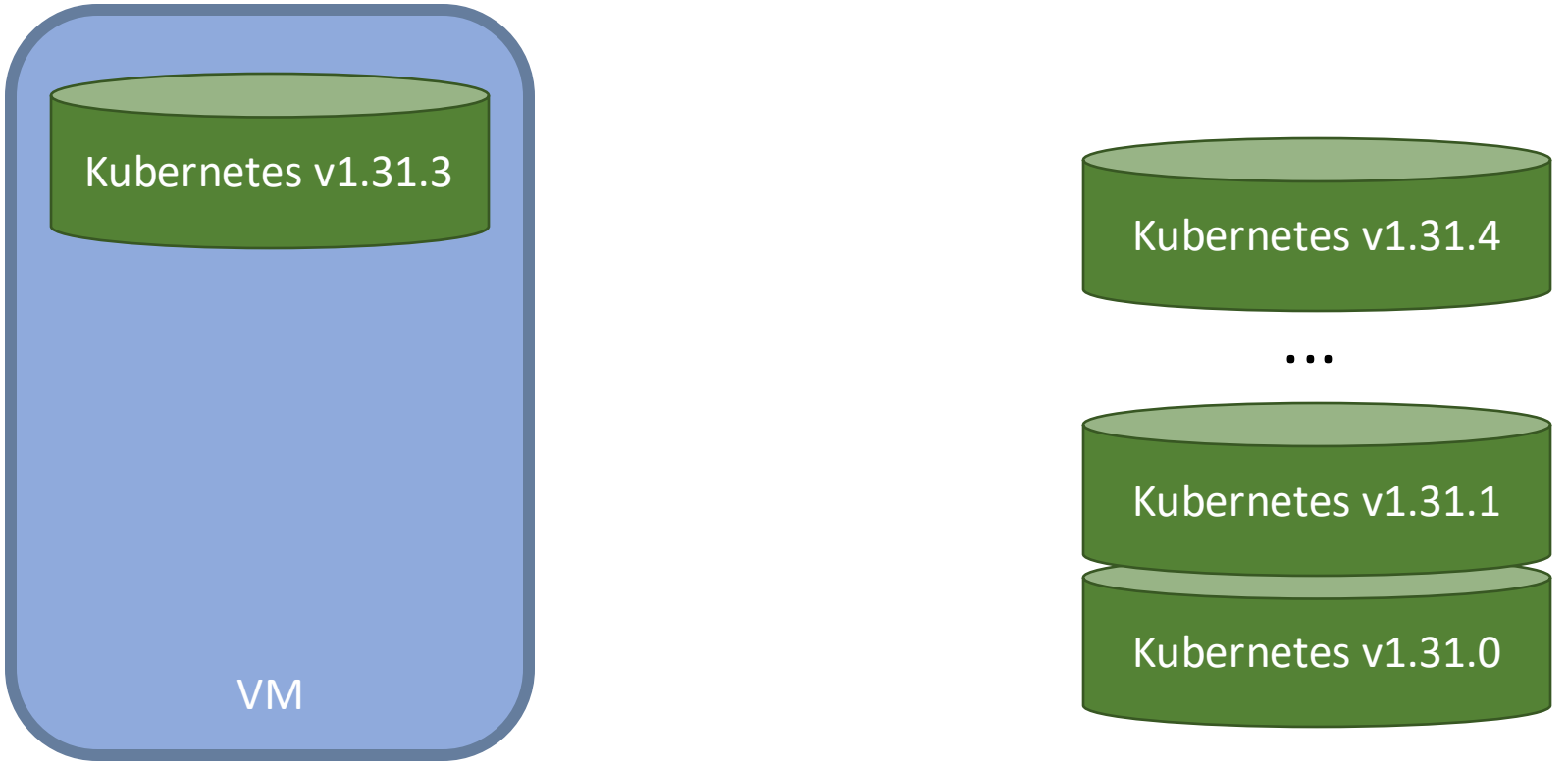


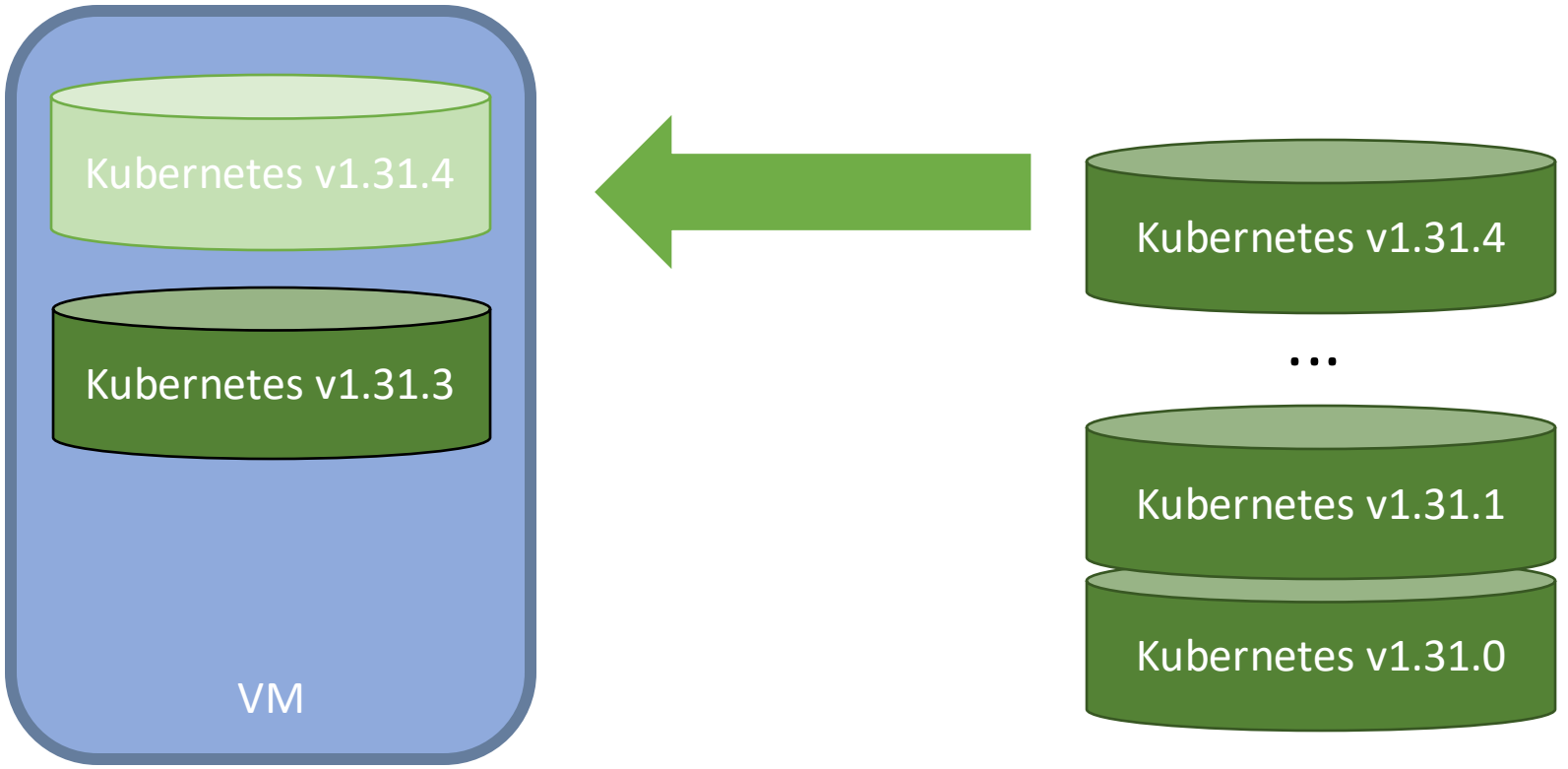
In-Place Updates



Instance

Update Server

In-Place Updates



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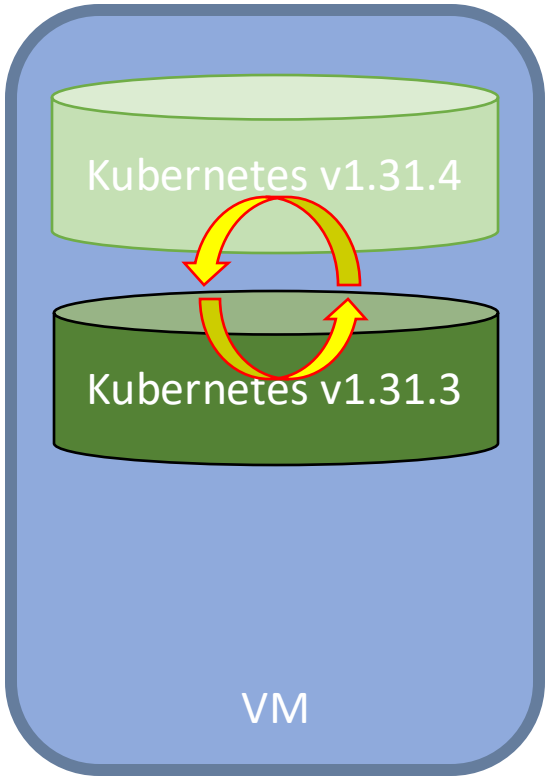
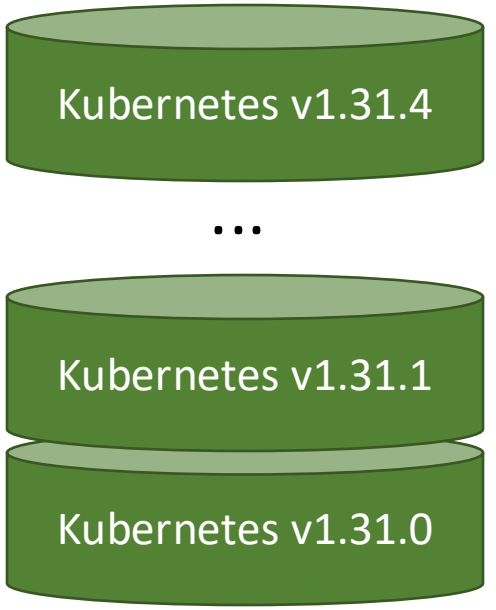
In-Place Updates

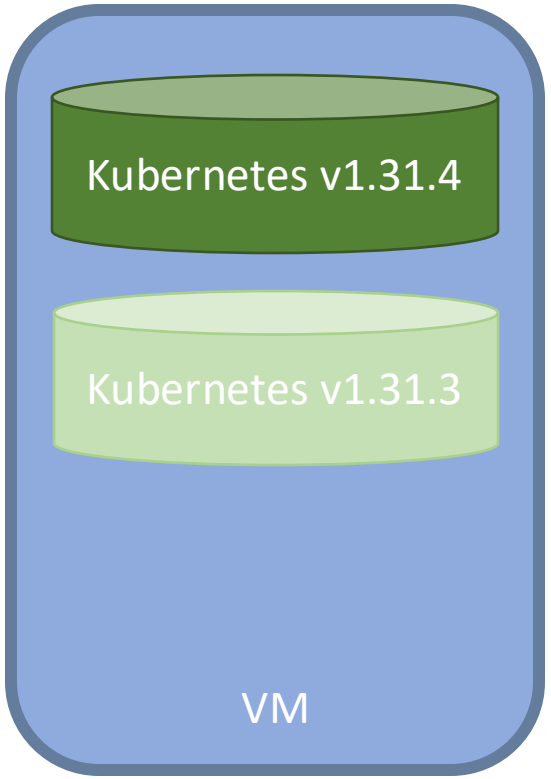


Instance

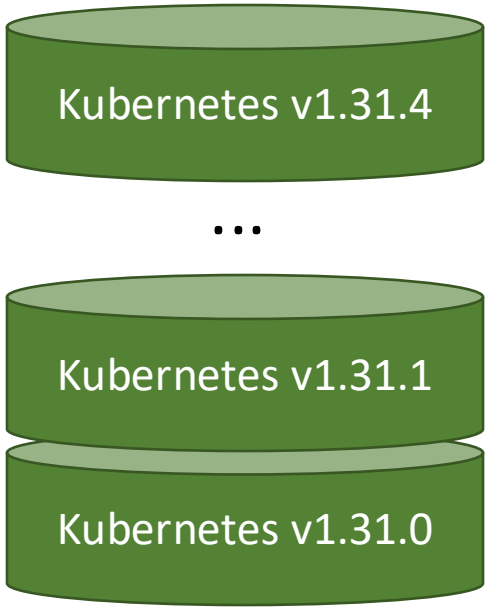


Update Server

In-Place Updates



Instance



Update Server

Show me!

Local Cluster from Scratch

Operating on Scale

Operate on Scale

AUTOMATE

ALL

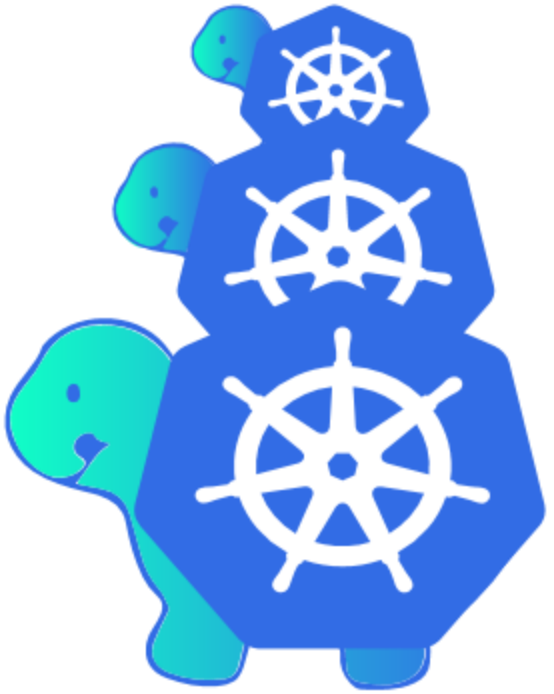
THE UPDATES!

Scenario: large ClusterAPI deployment

Cluster Management System (not an API)

Provision / operate workload clusters from management cluster

Think hosted Kubernetes offers



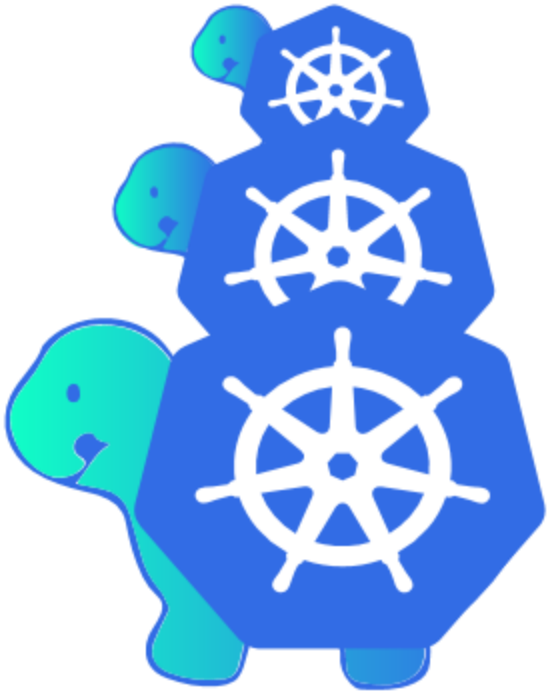
Flatcar + Sysext enable ClusterAPI in-place updates

Prepared, but deactivated by default

CAPI workload cluster provisioning:

1. Install provider to management cluster
2. Generate workload cluster configuration
3. Apply config to management cluster

==> Patch workload cluster config after 2., before 3.



Enter Kured

Kubernetes Reboot Daemon, CNCF project

https://github.com/kubereboot/kured

Drain, Reboot, Un-cordon, Done

Flexible configuration to cover special needs / corner cases

Show me!

Introspect CAPZ cluster, use Kured to in-place update

Thank you