# Leveraging Cluster API for Production-Ready Multi-Regional Infrastructures

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**Shotaro Gotanda**

*Software Engineer,*
*LY Corporation*

# Agenda

01 Overview of our Platform

02 Adoption of Cluster API

03 Multi-Region and Multi-AZ with Cluster API

04 In-place Migration to Cluster API

05 Obstacles and Insights

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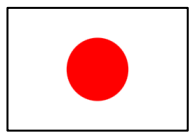
# LINE

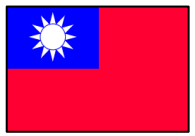
A communication app that connects people, services, and information

Launched on June 23, 2011

## MAU


95M


54M


22M


6M

As of Mar. 2023

# Private Cloud Platform: Verda

## for LINE Service Developers

VM/Baremetal

Kubernetes

Block Storage

OpenSearch

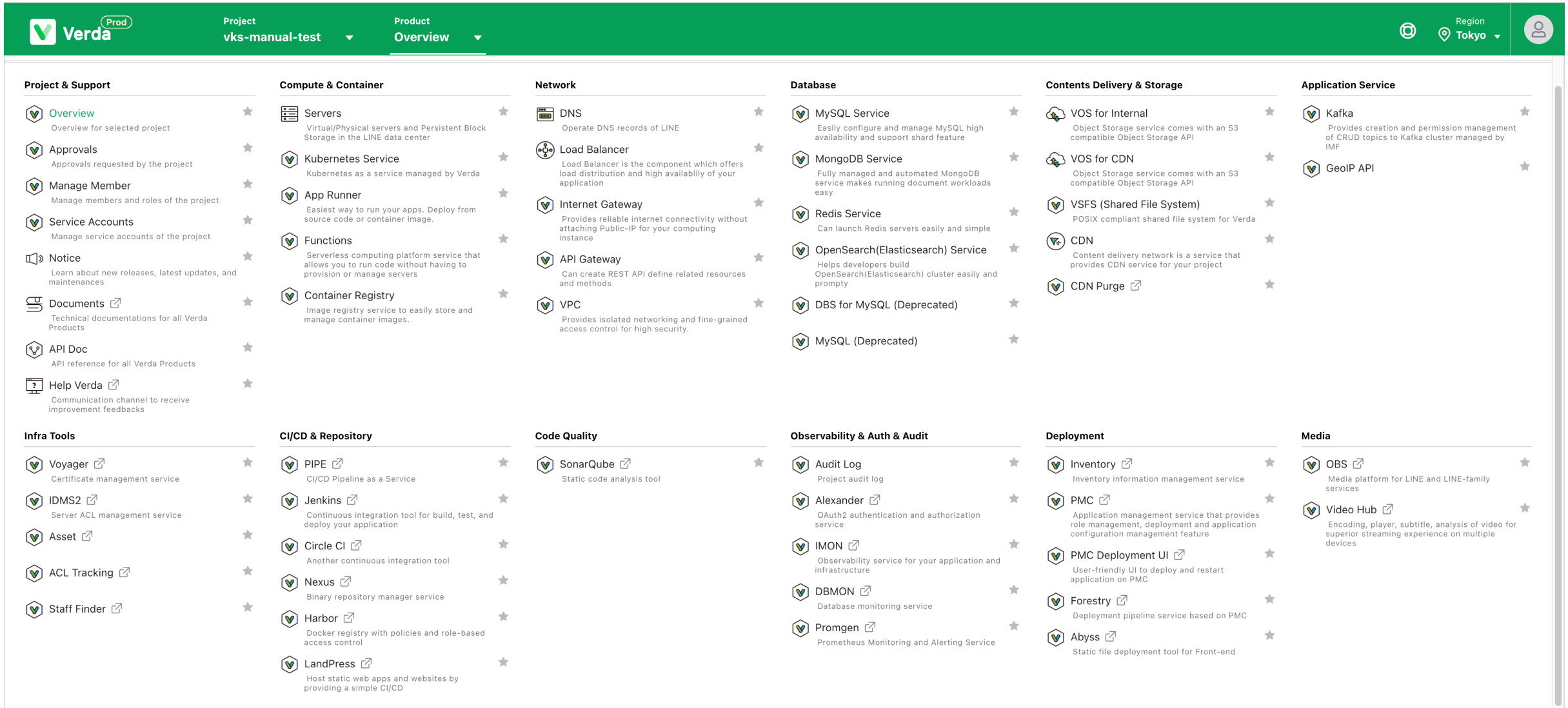
NAT

Load Balancer

openstack

And more…

# 40+ Services in Verda



# Large Scale Platform

**@ October, 2023**

**Region**

**3**

Tokyo,
Osaka,
Singapore

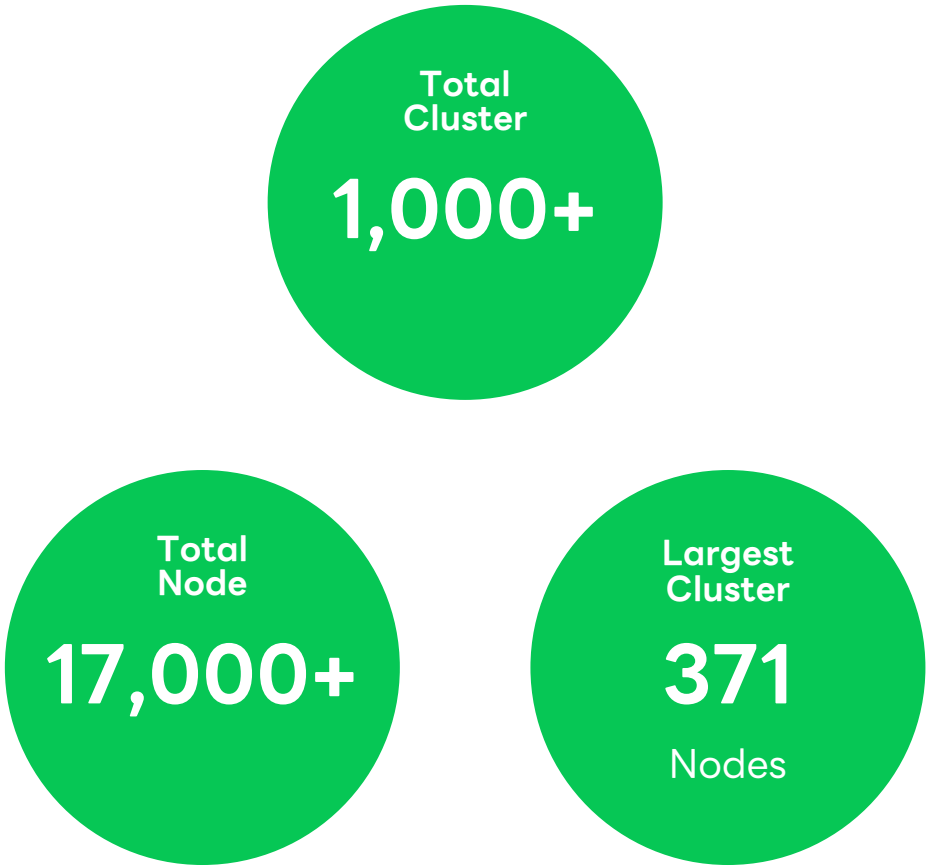
**VM**

**100,000+**

**Baremetal**

**30,000+**

# Verda Kubernetes Service (VKS)




@ October 16th, 2023

- Managed Kubernetes Platform
- Provide Native Integration of Verda and Corporate Platform
- Self-Serviced via REST API
- Launched in 2019

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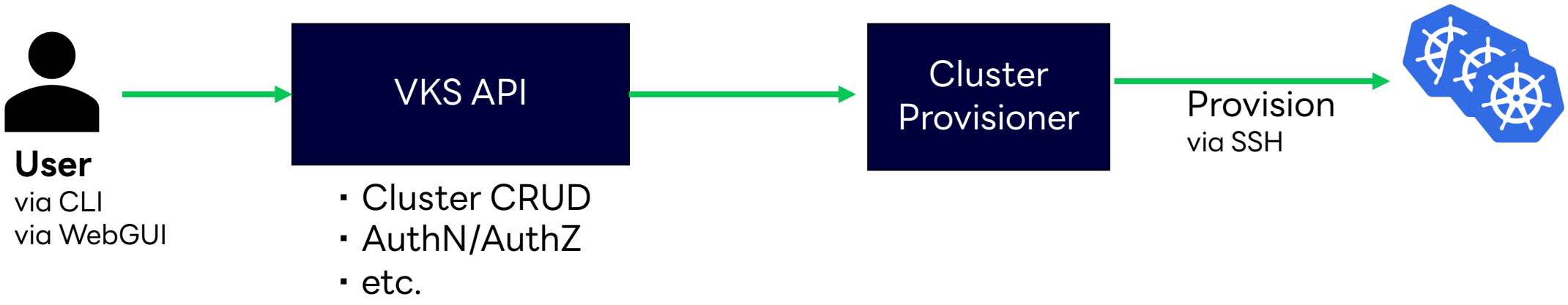
# Overview of Legacy

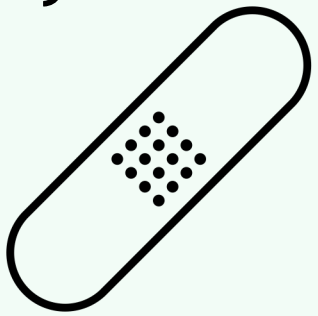
**As of 2022**



# Management of Cluster Provisioner

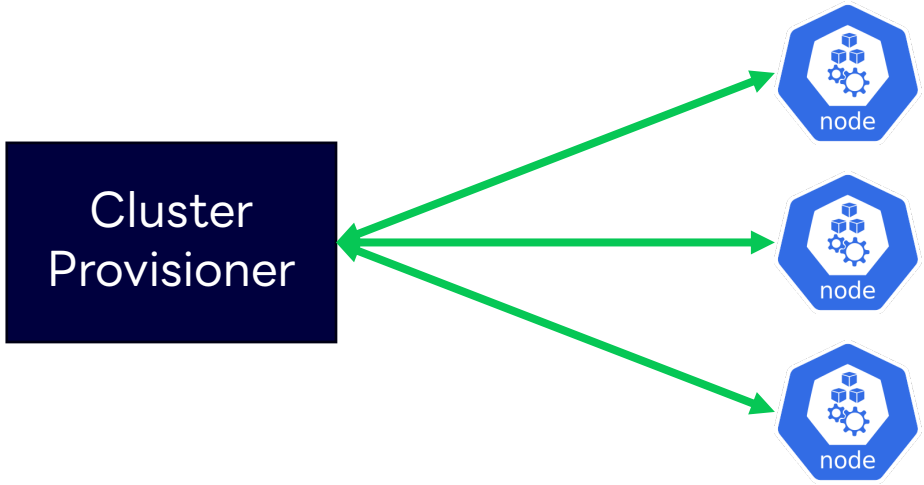
**Issue #1**

- Multiple patches into our Fork (**6** repositories in total)
  - Custom Features
  - Bug Fixes
- Outdated Version
- Hard to backport upstream changes
  - Complex codebase because of our patches



# Node Management via Stateful Connections

**Issue #2**




- Establish connections to all nodes
- Connections often become unstable
  - Need to restart controllers manually for mitigation

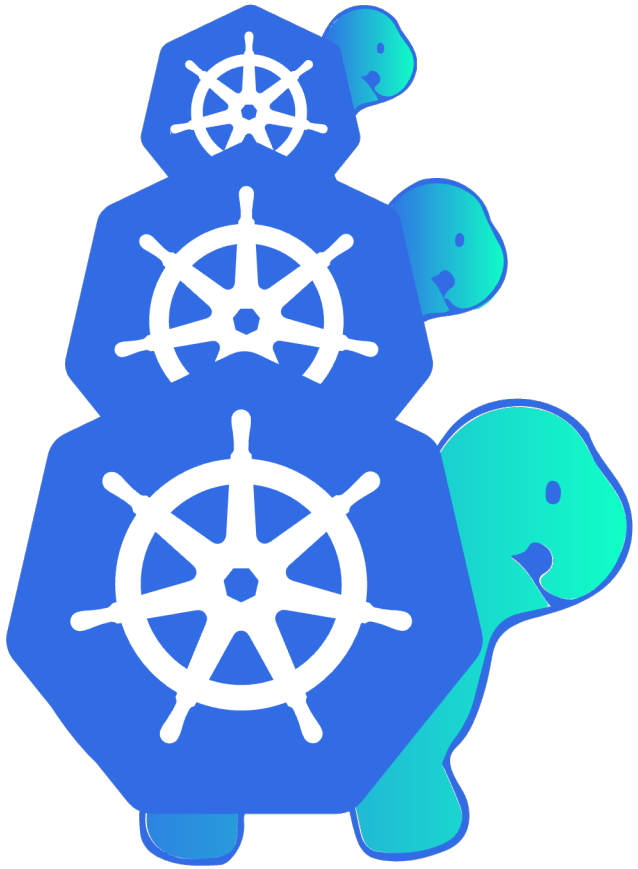
**Local cluster: ClusterOwnerDisappeared**
Runbook - Graph

- Owners of 26.18181818181818 clusters disappeared. Web socket sessions are unstable

# Requirement for new Cluster Provisioner

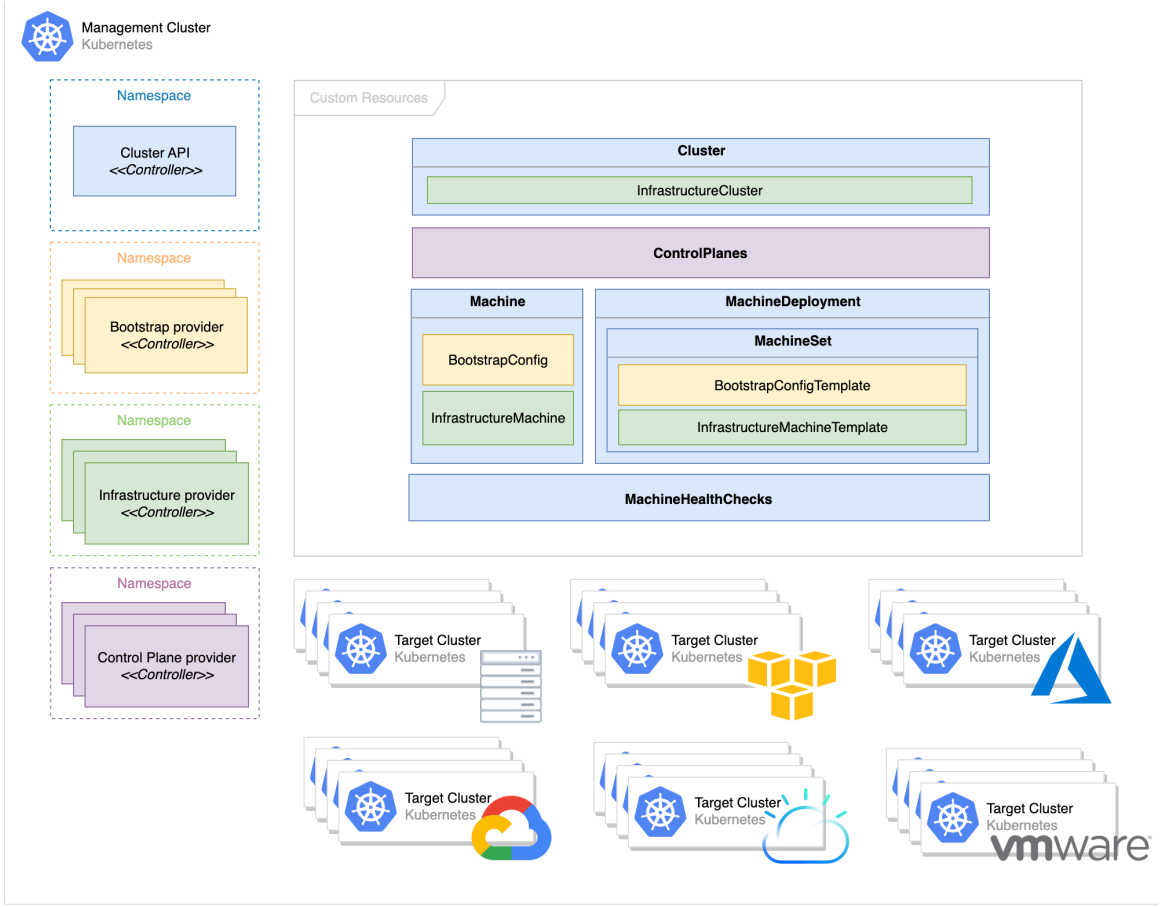
- **Open Source**
- **Lower maintenance cost**
  - Pluggable Interfaces
- **Scalable**
  - No stateful connections for node management

# Cluster API (CAPI)



- Open Source Cluster Provisioner
- SIG Cluster Lifecycle
- Declarative API
  - Help to provision/operate multiple k8s clusters
- Set of Tools
  - Useful for k8s cluster/node management

# Cluster API ❤️ Any Platforms



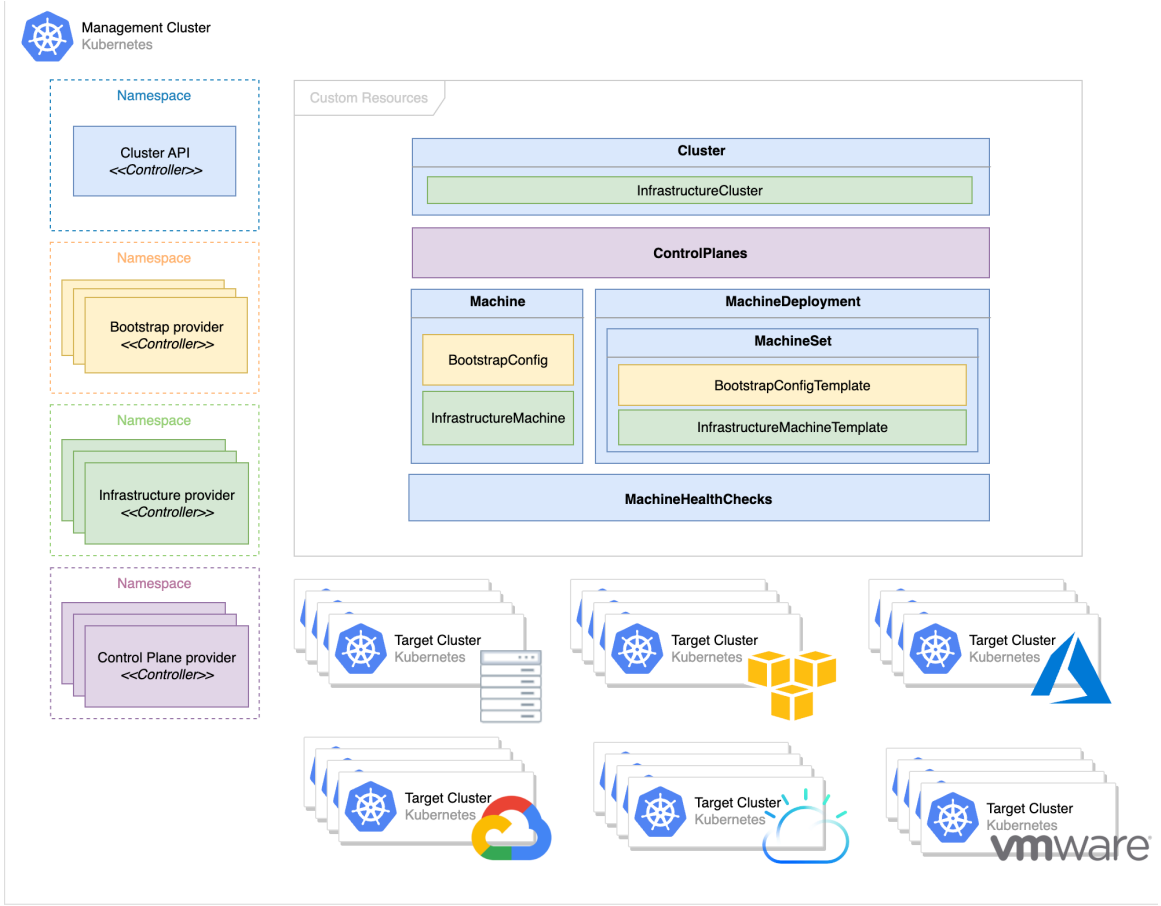

https://cluster-api.sigs.k8s.io/user/concepts

## Pluggable Interfaces

- **Infrastructure Provider**
  - Prepare underlying resources
    - LoadBalancer, VM, Baremetal
  - Example: OpenStack Provider
- **Bootstrap Provider**
  - Turn Machines into k8s Nodes
    - Cloud-Init, Ignition
  - Example: kubeadm
- **Control Plane Provider**
  - Instantiate Kubernetes Control Plane
  - Example: kubeadm

kubeadm

# Choose Providers for Verda




https://cluster-api.sigs.k8s.io/user/concepts

## Pluggable Interfaces

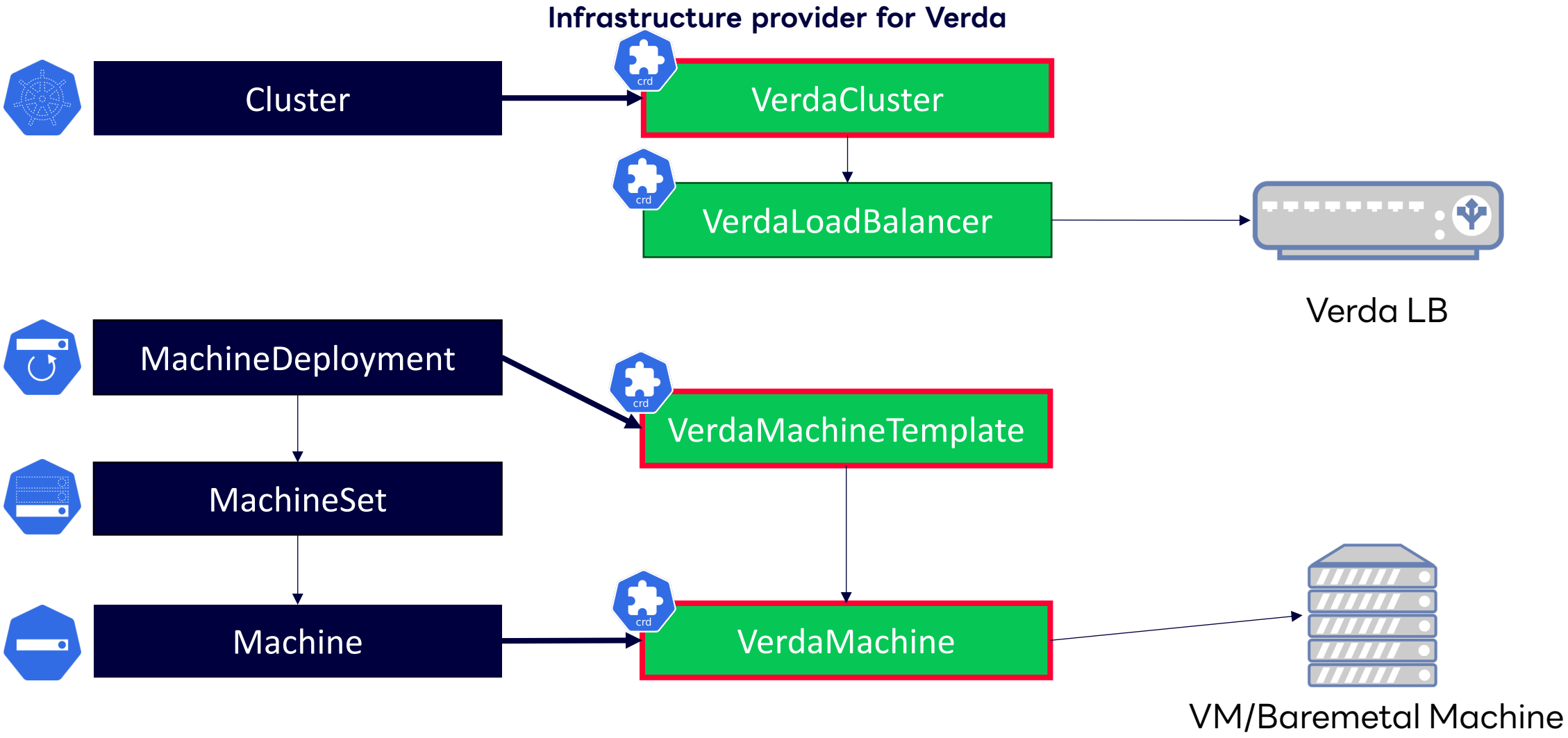
- **Infrastructure Provider**
  → Cluster API Provider OpenStack (CAPO) …?
- **Bootstrap Provider**
  → Cluster API Bootstrap Provider Kubeadm (CABPK)
- **Control Plane Provider**
  → Cluster API Control Plane Provider Kubeadm (CACPK)

kubeadm

# Potential Blocker for CAPO

- Verda doesn’t meet the requirements of CAPO
  - Customized IaaS API
  - Own LBaaS API ( != OpenStack Octavia API )
  - Cannot use `kubernetes-sigs/image-builder` directly

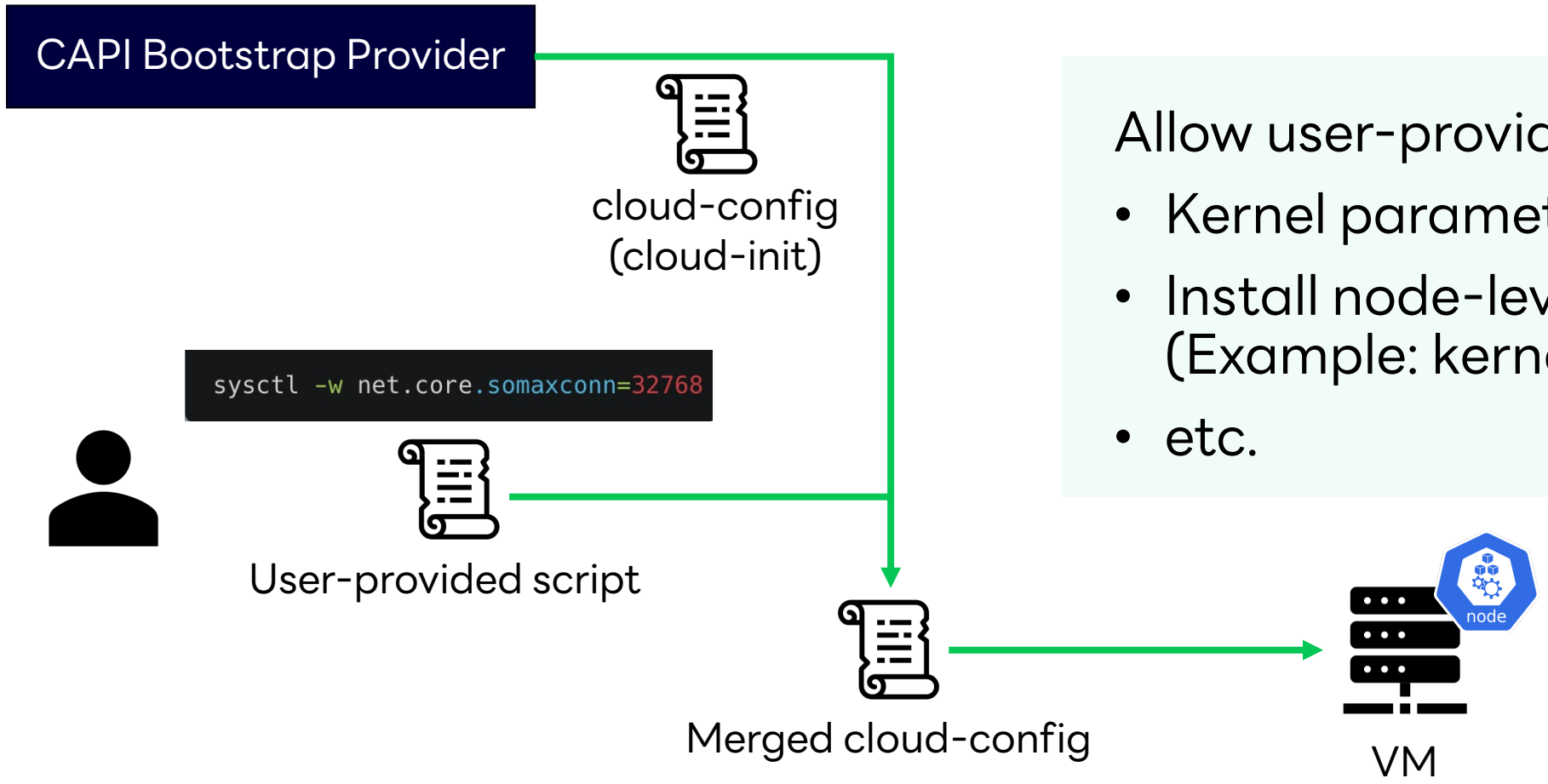
# Cluster API Provider Verda (CAPV)



# Custom Features of CAPV

- User Script
- Static IP Node Pool
- etc.

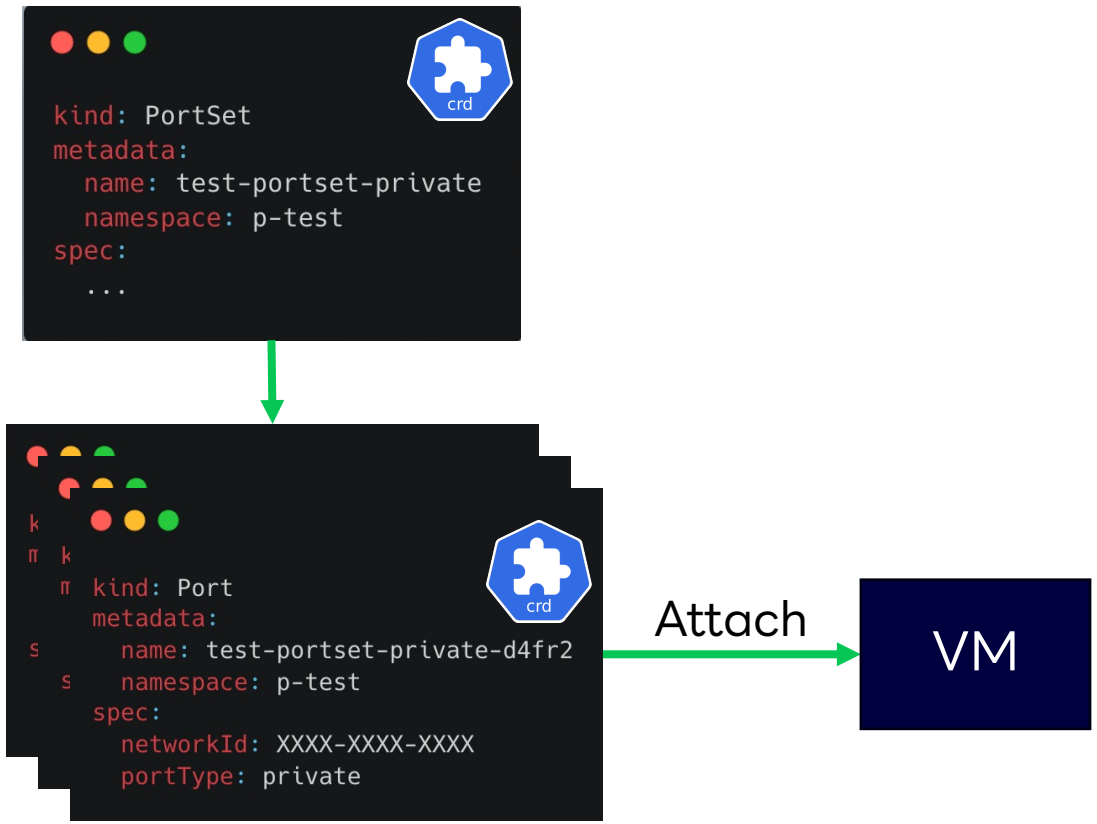
# Custom feature: User Script




Allow user-provided init script

- Kernel parameter tuning
- Install node-level software (Example: kernel modules)
- etc.

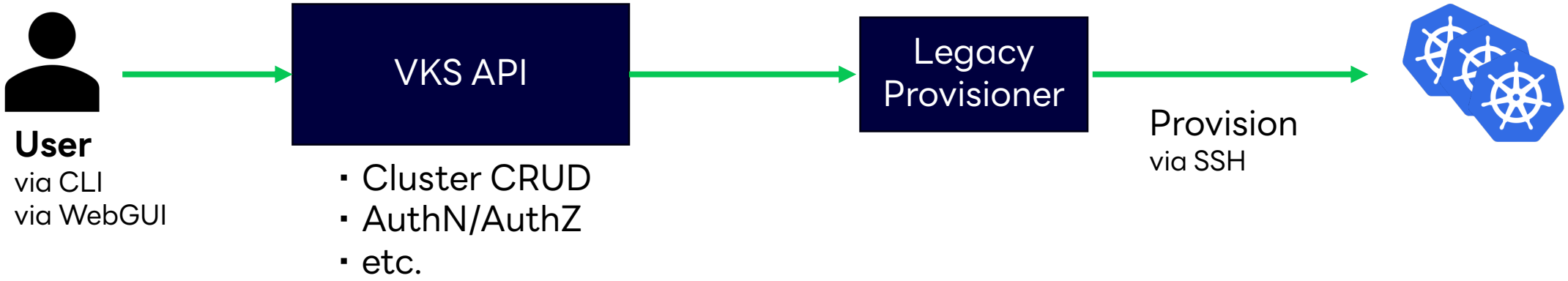
# Custom feature: Static IP Node Pool




- Reuse OpenStack Neutron Ports to assign reserved fixed IPs
  - New Custom Resource to manage Neutron Ports
- Useful for IP ACLs
  - Having the same IP even recreating nodes

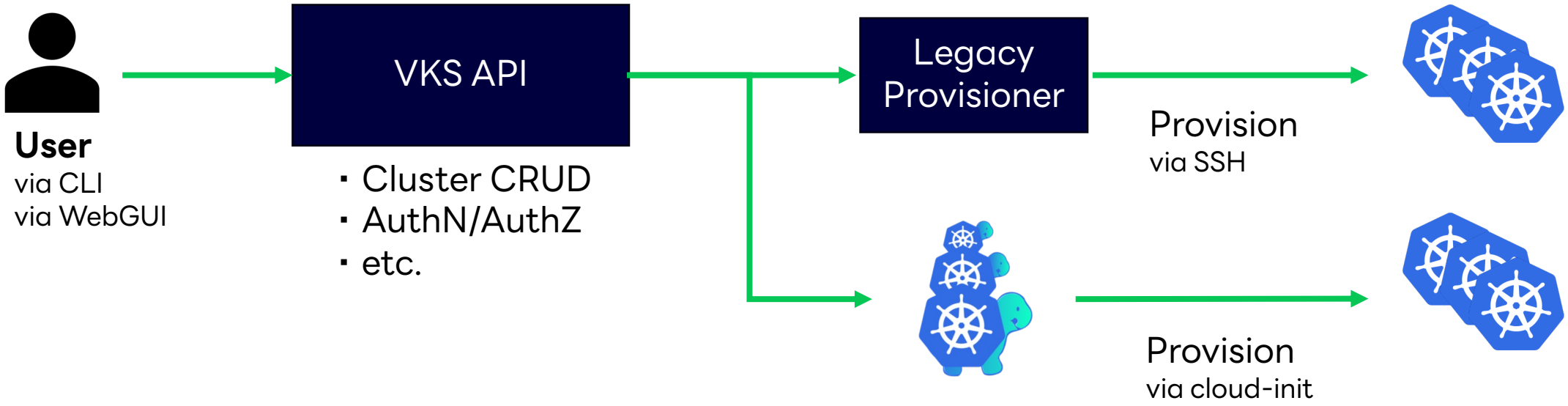
# Overview of Legacy (Recap)

**As of 2022**



# Same Interface, Same Experience

**Transparent thanks to the VKS API in front of cluster provisioners**



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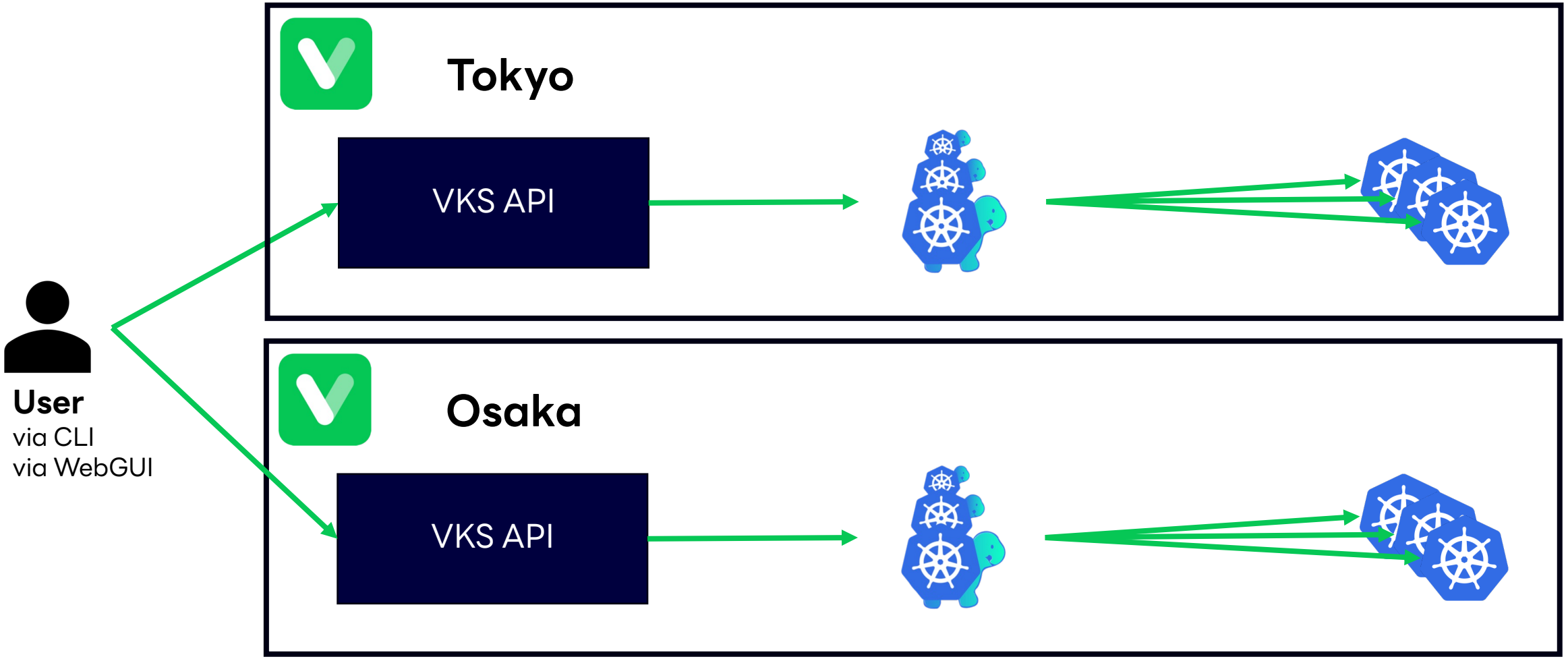
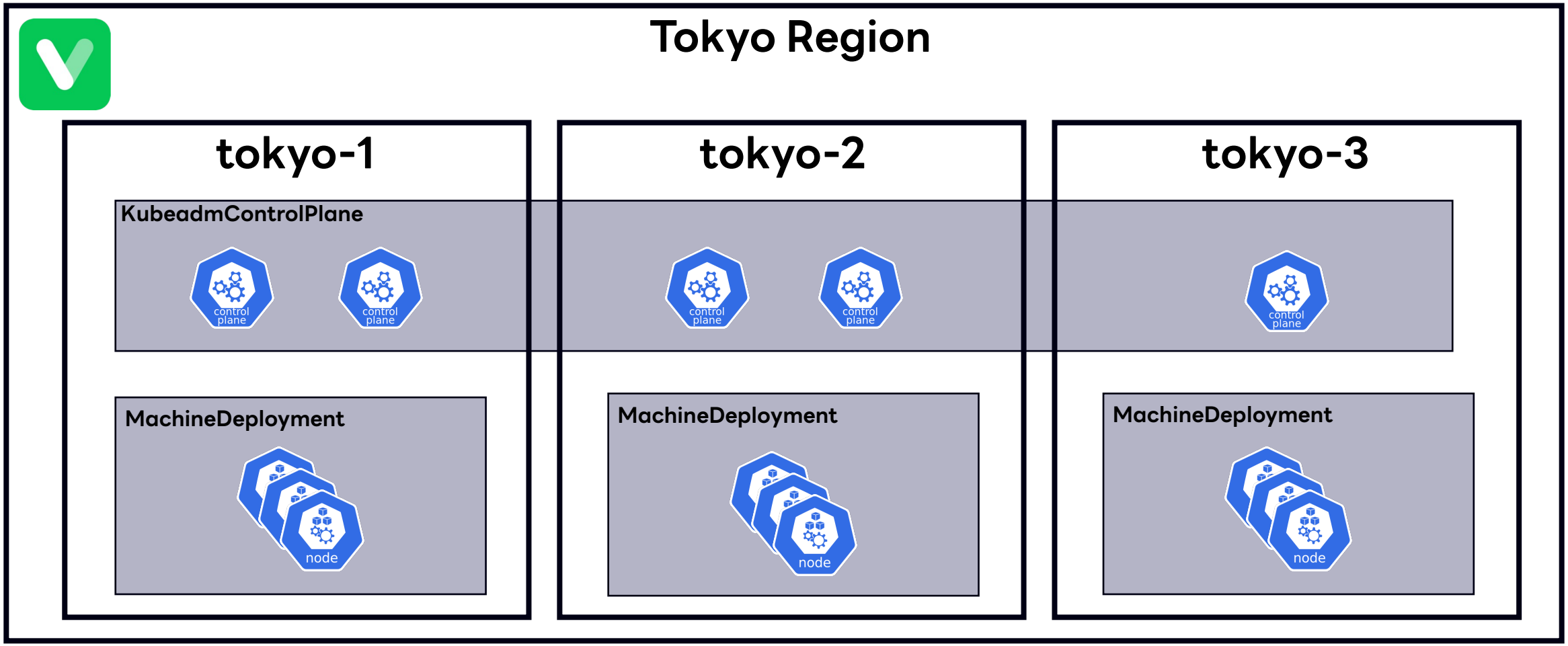
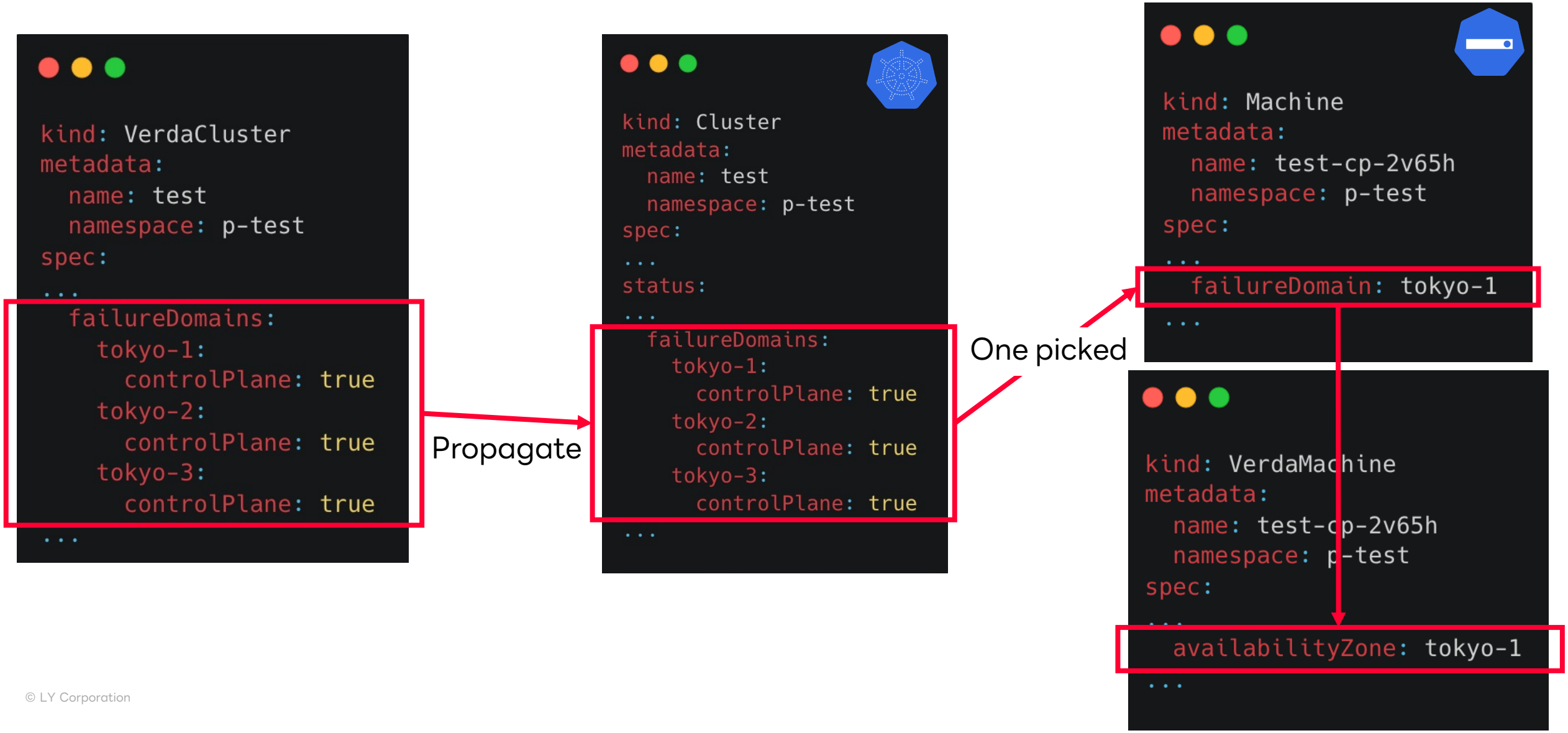
# Multi Region



# Multi AZ



# CAPI is Multi-AZ friendly



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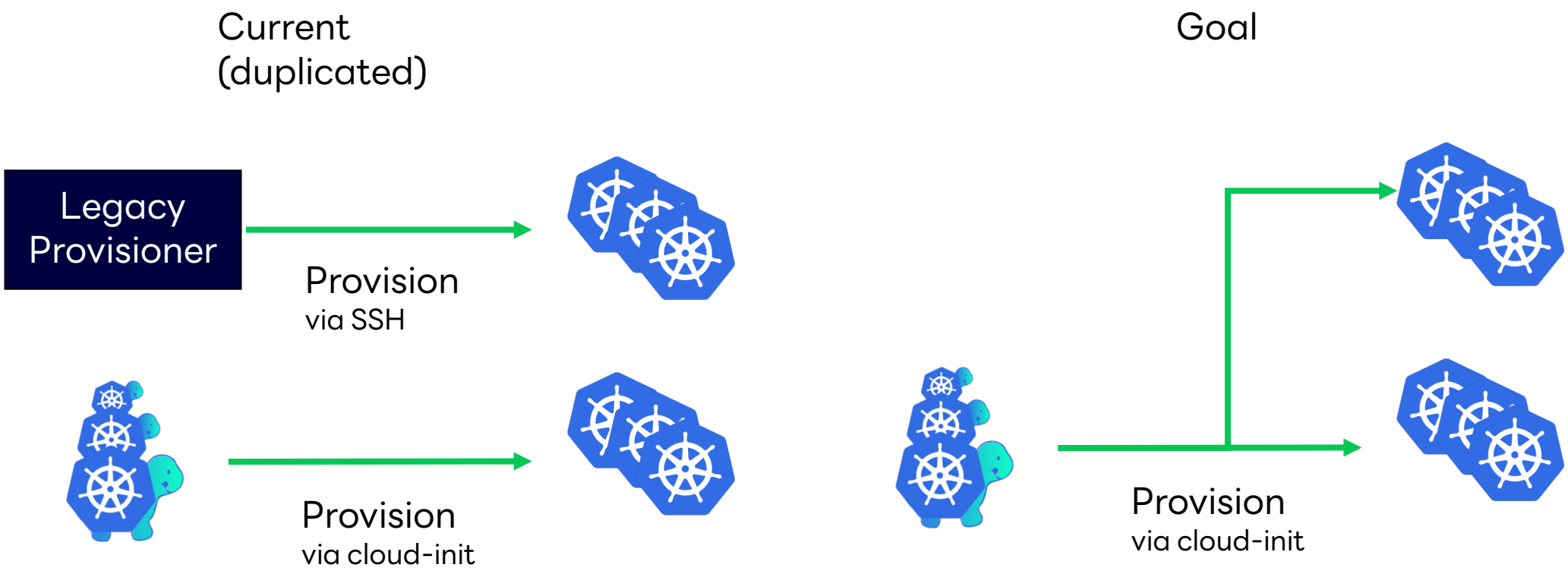
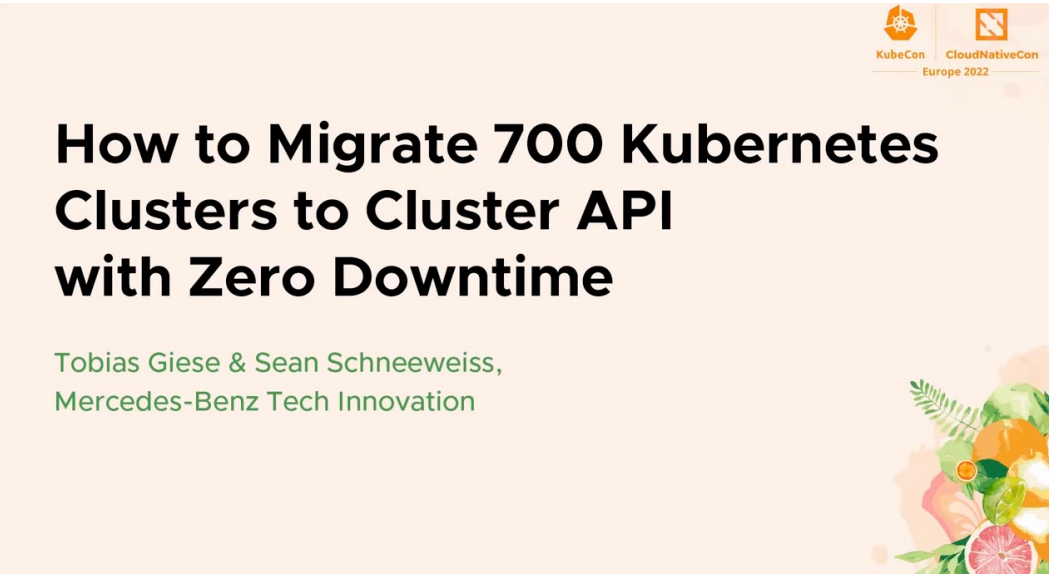
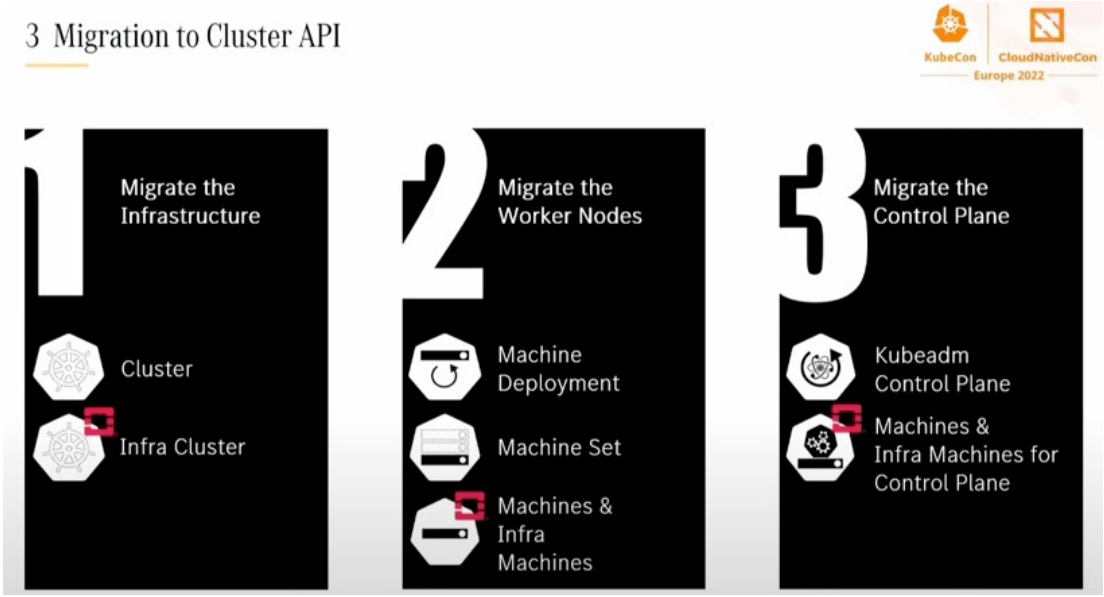
# Goal: Deprecating Legacy Provisioner



# Cluster Migration to Cluster API

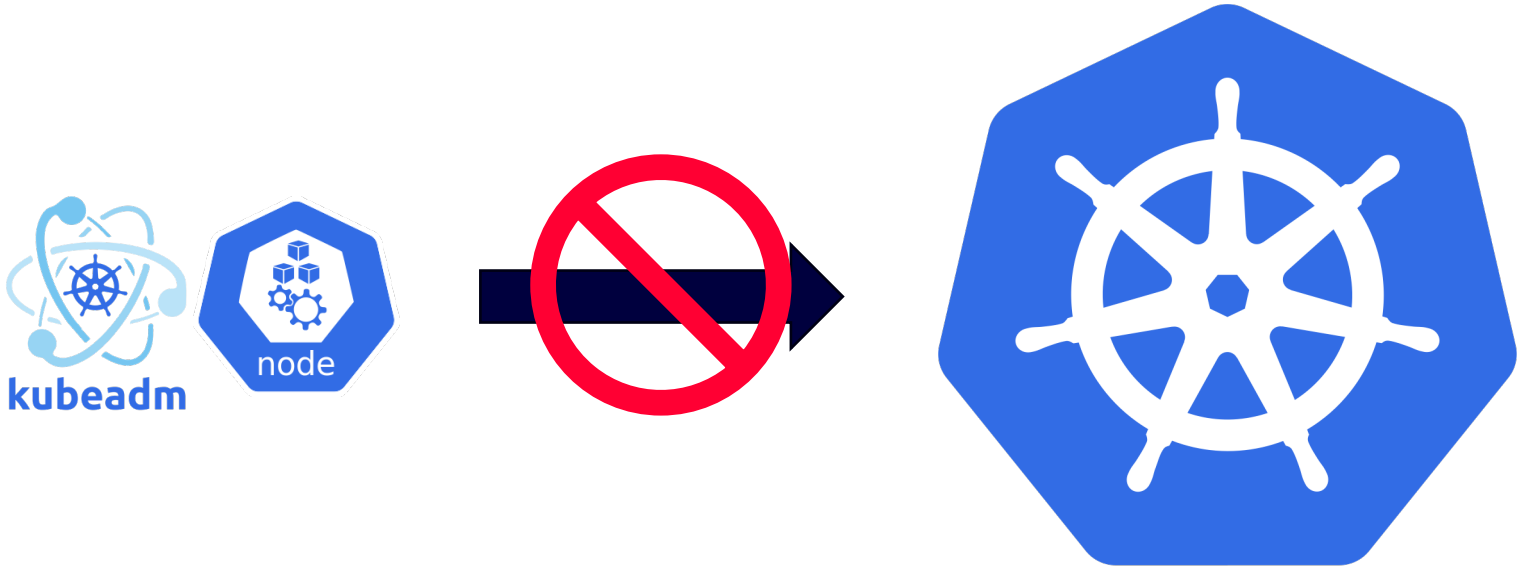



Kubecon EU 2022: How to Migrate 700 Kubernetes Clusters to Cluster API with Zero Downtime
https://www.youtube.com/watch?v=KzYV-fJ_wH0

# Problem: Node installer inconsistency

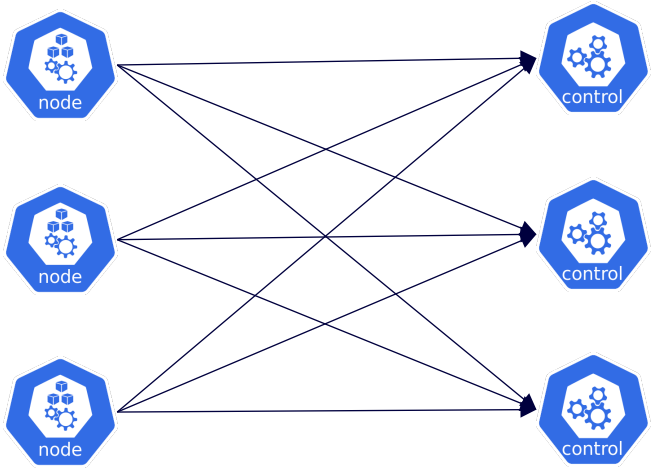
Legacy Cluster doesn't accept Kubeadm Nodes.



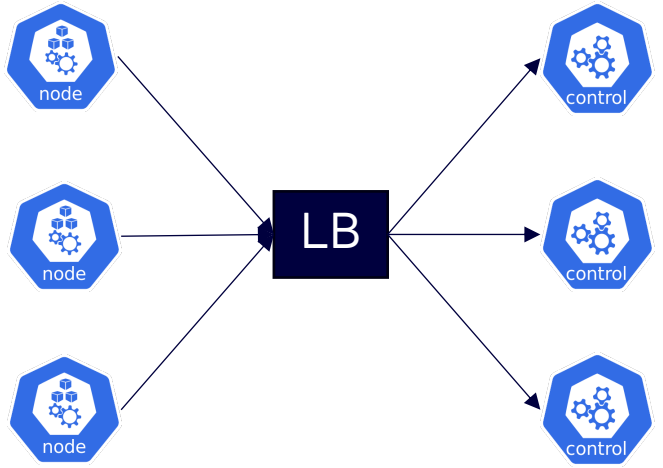

Legacy Cluster
provisioned without kubeadm

# GAP 1: API Request Load Balancing

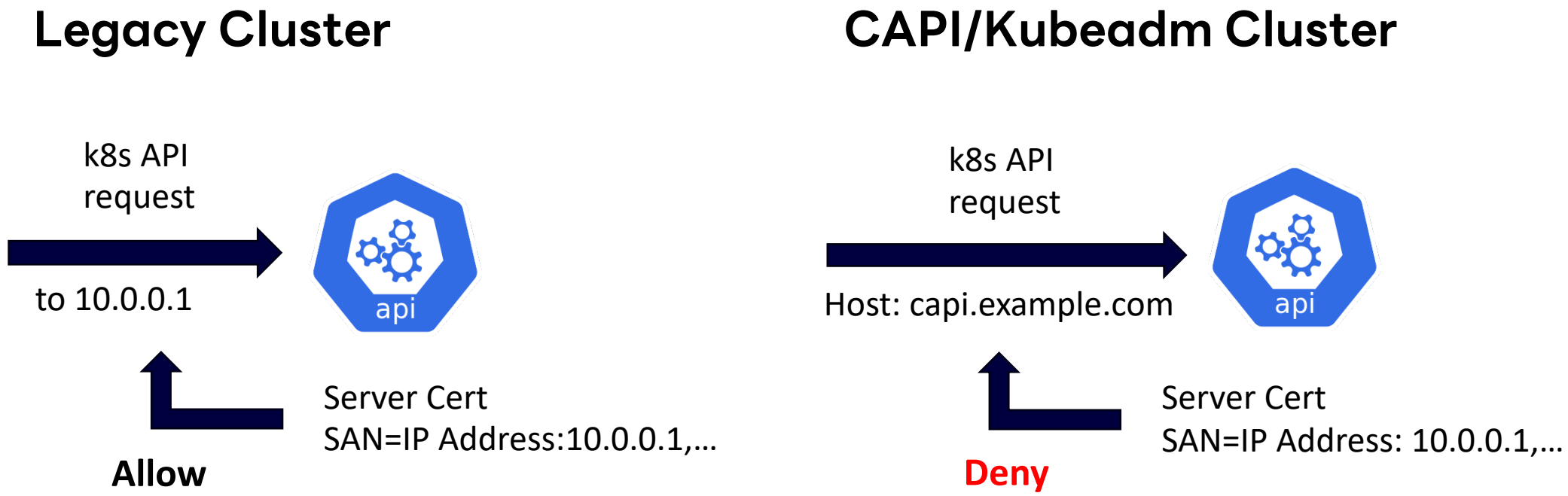
## Legacy Cluster




## CAPI/Kubeadm Cluster



# Gap 2: SAN in Server Cert



# Gap 3: Config Management

```yaml
kind: ConfigMap
metadata:
  namespace: kube-system
  name: kubeadm-config
data:
  ClusterConfiguration: |
    apiVersion: kubeadm.k8s.io/v1beta3
    kind: ClusterConfiguration
    clusterName: mycluster
    controlPlaneEndpoint: mycluster.example.com:443
    etcd:
      local:
        dataDir: /var/lib/etcd
    kubernetesVersion: v1.26.1
```

- Kubeadm manage configs with ConfigMaps.
  - kubeadm-config
  - kubelet-config
  - kube-proxy
  - …

# Gap 4: Etcd member discovery

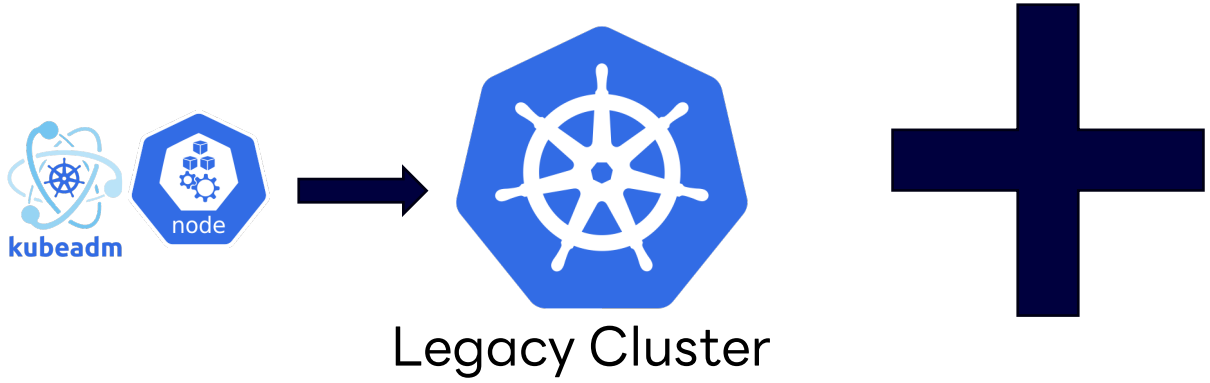
```yaml
kind: Pod
metadata:
  namespace: kube-system
  name: etcd-mycluster-cp-2x58s
  labels:
    component: etcd
    tier: control-plane
```

- Kubeadm get etcd member IPs by listing pod
  - component=etcd, tier=control-plane

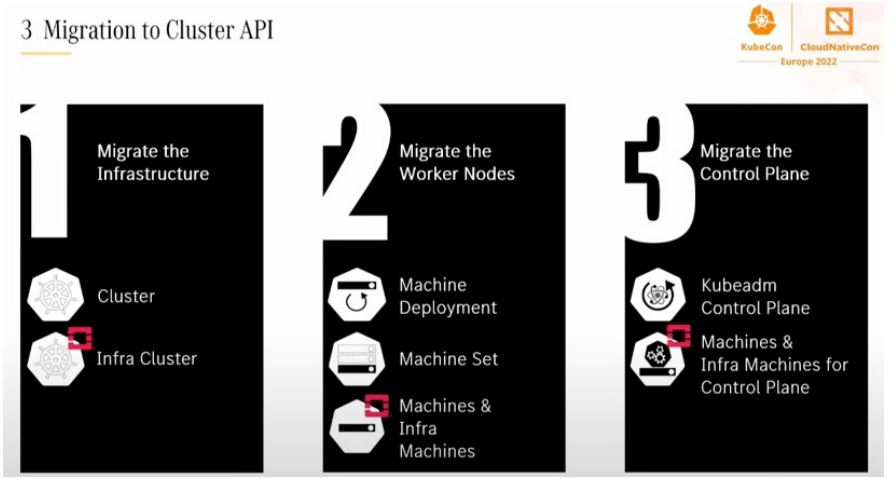
→ This issue was handled with **Dummy Pod.**

# How to support migration to CAPI

## Modify Legacy Cluster for kubeadm




## Handle Cluster API Custom Resources




How to Migrate 700 Kubernetes Clusters to Cluster API with Zero Downtime
https://www.youtube.com/watch?v=KzYV-fJ_wH0

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# Obstacles and Insights

- Controller Scalability
- Etcd Snapshot/Restore

...and more

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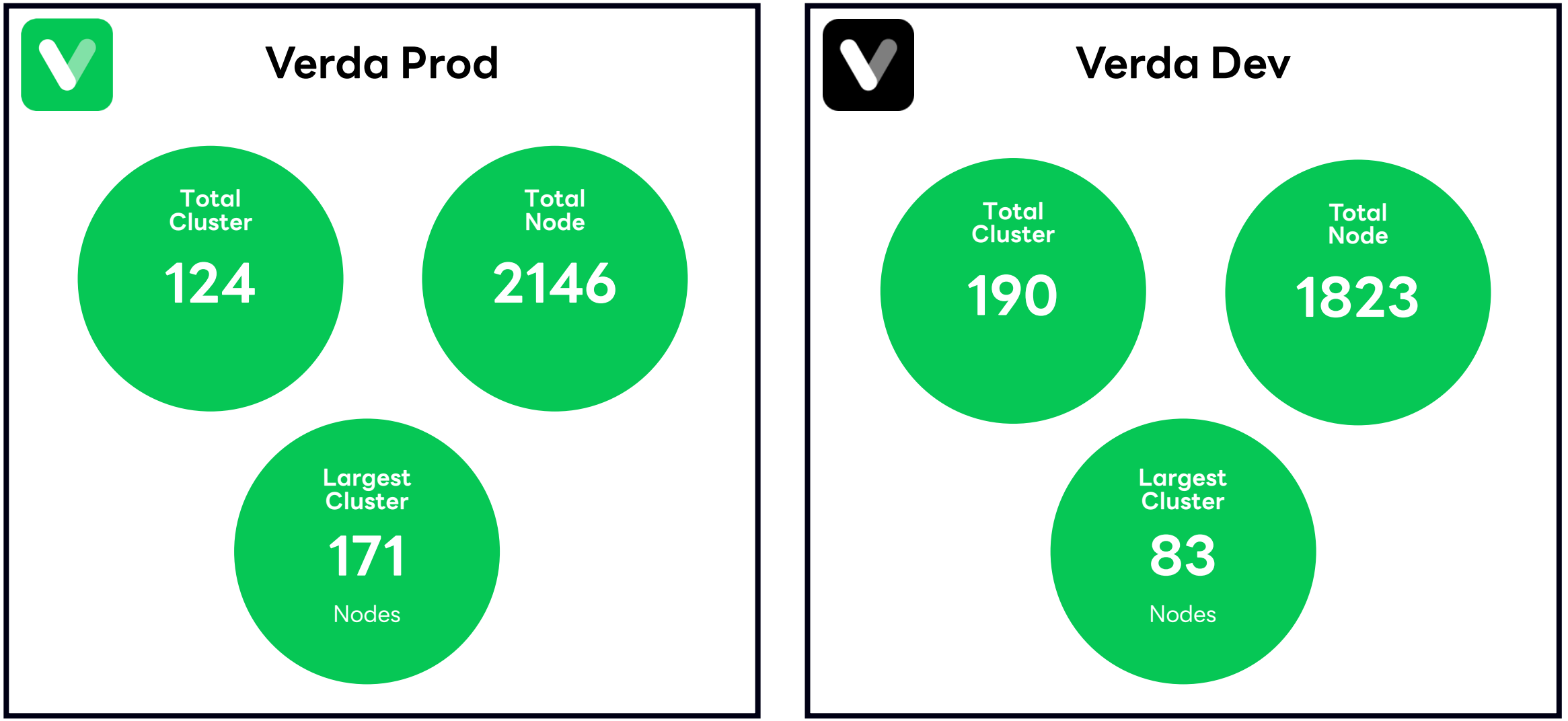
...and more

# CAPI Controller Scalability




@ Oct 2023

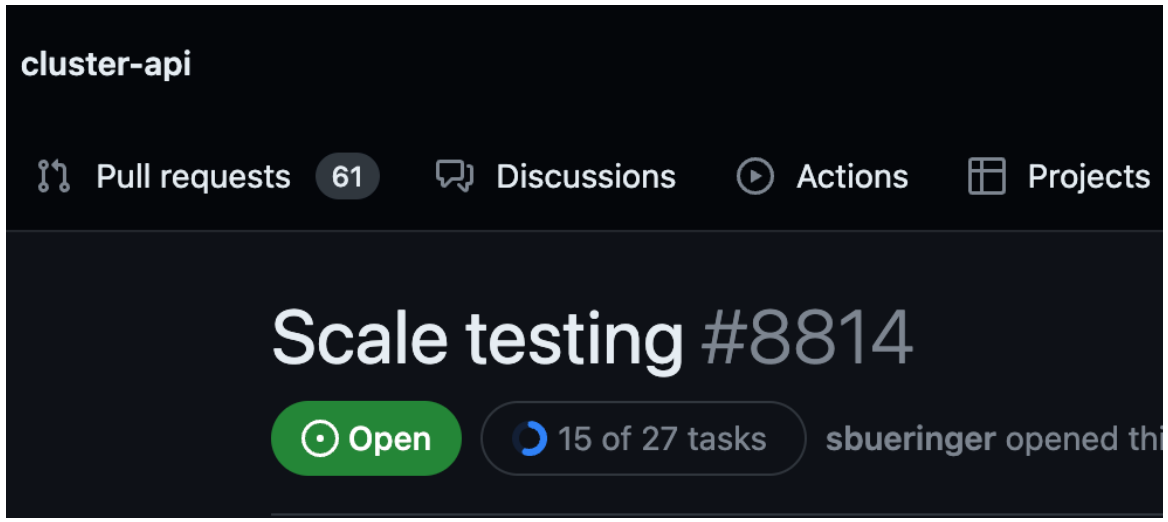
# CAPI Controller Scalability


- Constantly Long Workqueue
- Any operation takes time
  - Cluster creation
  - Node provision

↓

- Scale-Up controllers
  + Increase Concurrency
- Scale-Out(Sharding) controllers
  → leader-follower architecture
  makes it hard

# CAPI Controller Scalability




e2e test and test framework:

- Implement scale test automation:
  - Cluster topologies:
    - ☑ Small workload cluster: x * (1 control-plane + 1 worker node)
    - ☑ Small medium workload cluster: x * (3 control-plane + 10 worker node)
    - ☑ Medium Workload Cluster: x * (3 control-plane + 50 worker nodes)
    - ☑ Large Workload Cluster: x * (3 control-plane + 500 worker nodes)
      - Dimensions: # of MachineDeployments

- Scalability of CAPI is one of our interests.
- E2E for ensuring scalability seems to be now ongoing on the upstream.

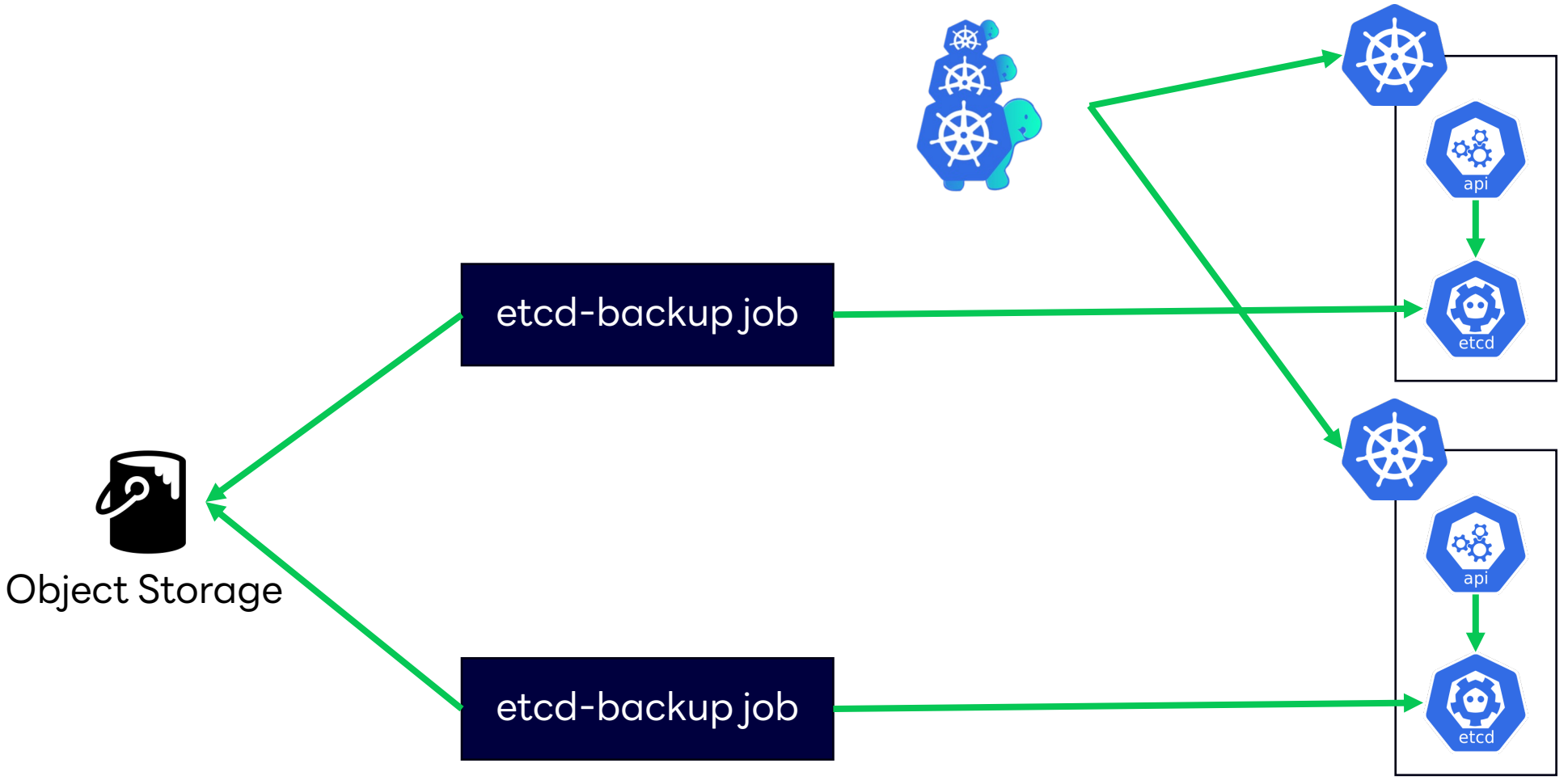
**Our Target:**
**Max 1000 nodes / cluster**

# Obstacles and Insights

- Controller Scalability
- Etcd Snapshot/Restore
- ...and more

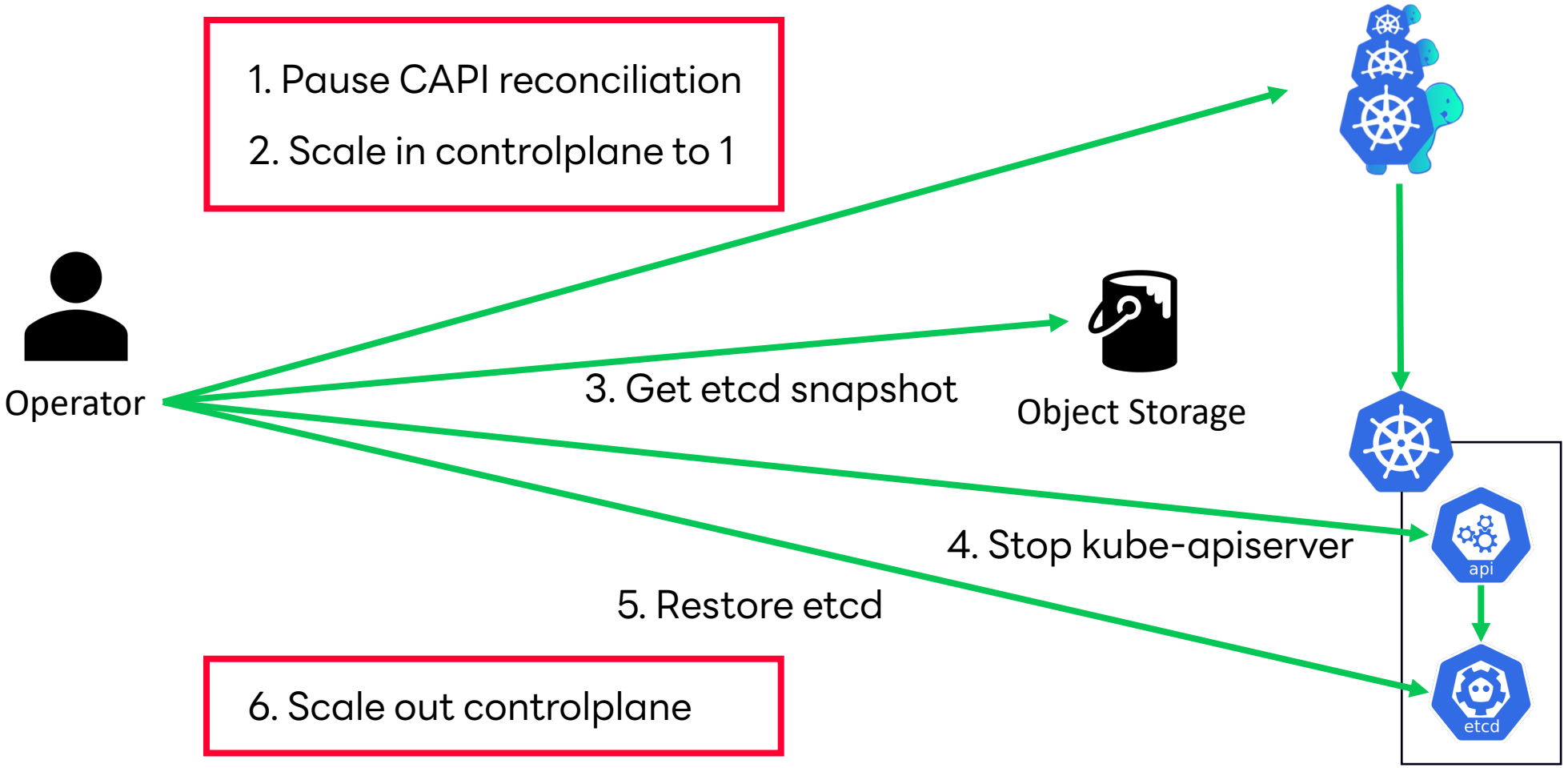
# Etcd Backup/Restore

**Automation of Backup is easy, but…**

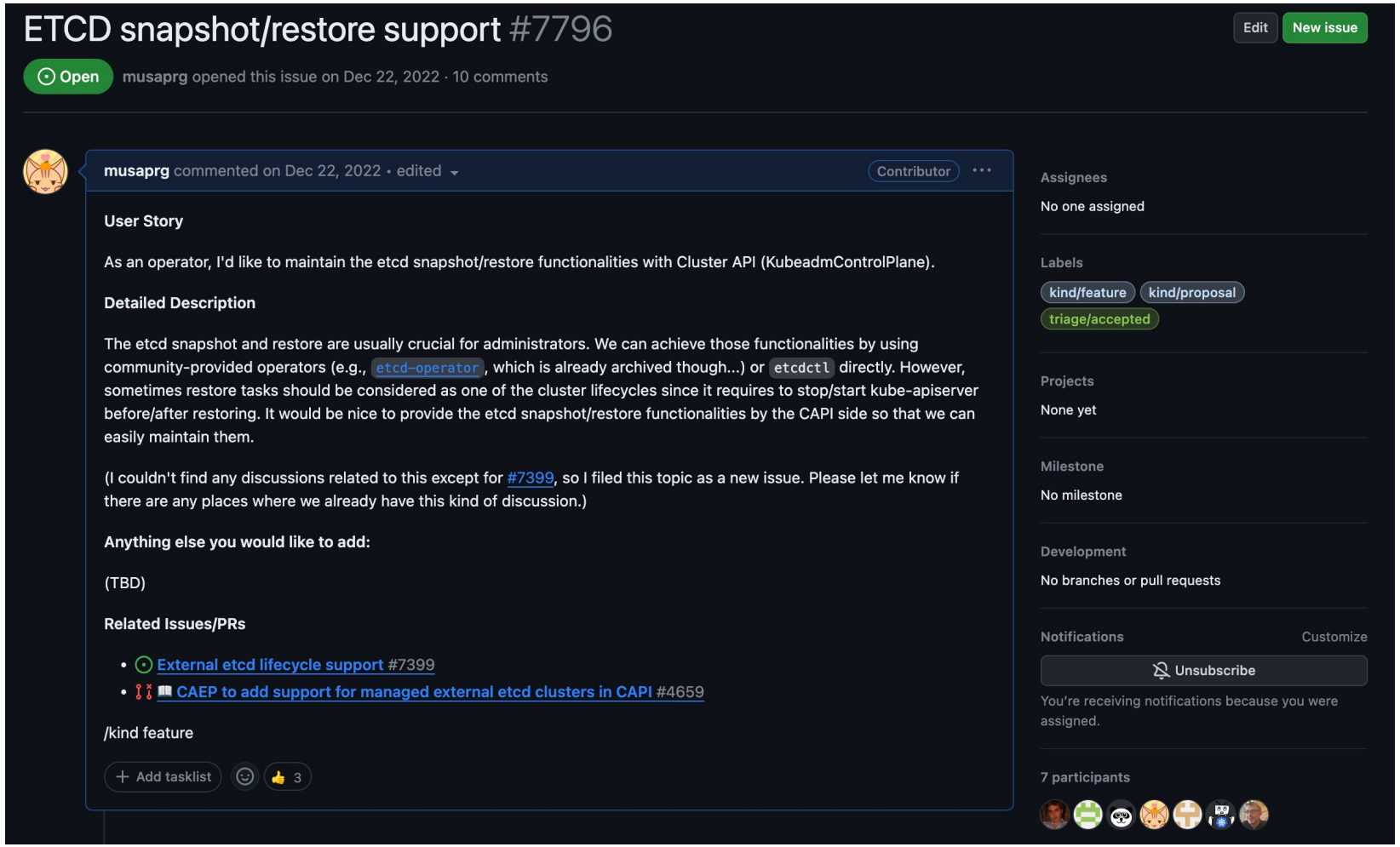


# Etcd Backup/Restore

**Done by Manual Operation for now**



# Etcd Backup/Restore



ETCD snapshot/restore support #7796

Edit | New issue

Open | musaprg opened this issue on Dec 22, 2022 · 10 comments

musaprg commented on Dec 22, 2022 • edited | Contributor

**User Story**

As an operator, I'd like to maintain the etcd snapshot/restore functionalities with Cluster API (KubeadmControlPlane).

**Detailed Description**

The etcd snapshot and restore are usually crucial for administrators. We can achieve those functionalities by using community-provided operators (e.g., `etcd-operator`, which is already archived though...) or `etcdctl` directly. However, sometimes restore tasks should be considered as one of the cluster lifecycles since it requires to stop/start kube-apiserver before/after restoring. It would be nice to provide the etcd snapshot/restore functionalities by the CAPI side so that we can easily maintain them.

(I couldn't find any discussions related to this except for #7399, so I filed this topic as a new issue. Please let me know if there are any places where we already have this kind of discussion.)

**Anything else you would like to add:**

(TBD)

**Related Issues/PRs**

- External etcd lifecycle support #7399
- CAEP to add support for managed external etcd clusters in CAPI #4659

/kind feature

Add tasklist | 3

Assignees: No one assigned

Labels: kind/feature, kind/proposal, triage/accepted

Projects: None yet

Milestone: No milestone

Development: No branches or pull requests

Notifications: Customize

Unsubscribe

You're receiving notifications because you were assigned.

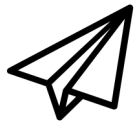
7 participants

# Summary

- **Cluster API is great for Private Cloud Platform**
  - Minimum code management cost
  - Extensibility for custom features
  - Multi-regional support with FailureDomain
- **Minimize various costs for cluster operators**
  - Consistent UI/UX leveraging API abstraction
  - In-place migration working with Cluster API & kubeadm

# Thank you!

Kubernetes: @musaprg OR @sgotnd



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shotaro.gotanda@lycorp.co.jp

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