

From Frankenstein to Kamaji:

Lessons in Building a Single CAPI Cluster Across Multiple Providers

————— OSS Korea | August 11th 2026 —————



Antonia von den Driesch

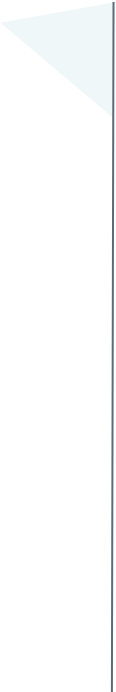
Platform Engineer
Giant Swarm



Xavier Avrillier

Solutions Architect
Giant Swarm





Cluster and Node Lifecycle with CAPI

Hybrid setups and use case

We built Frankenstein's CAPI Cluster

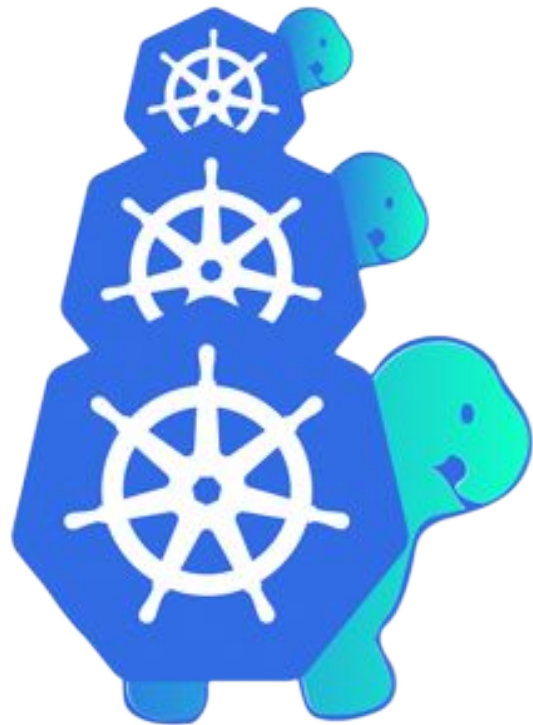
Hosted control planes

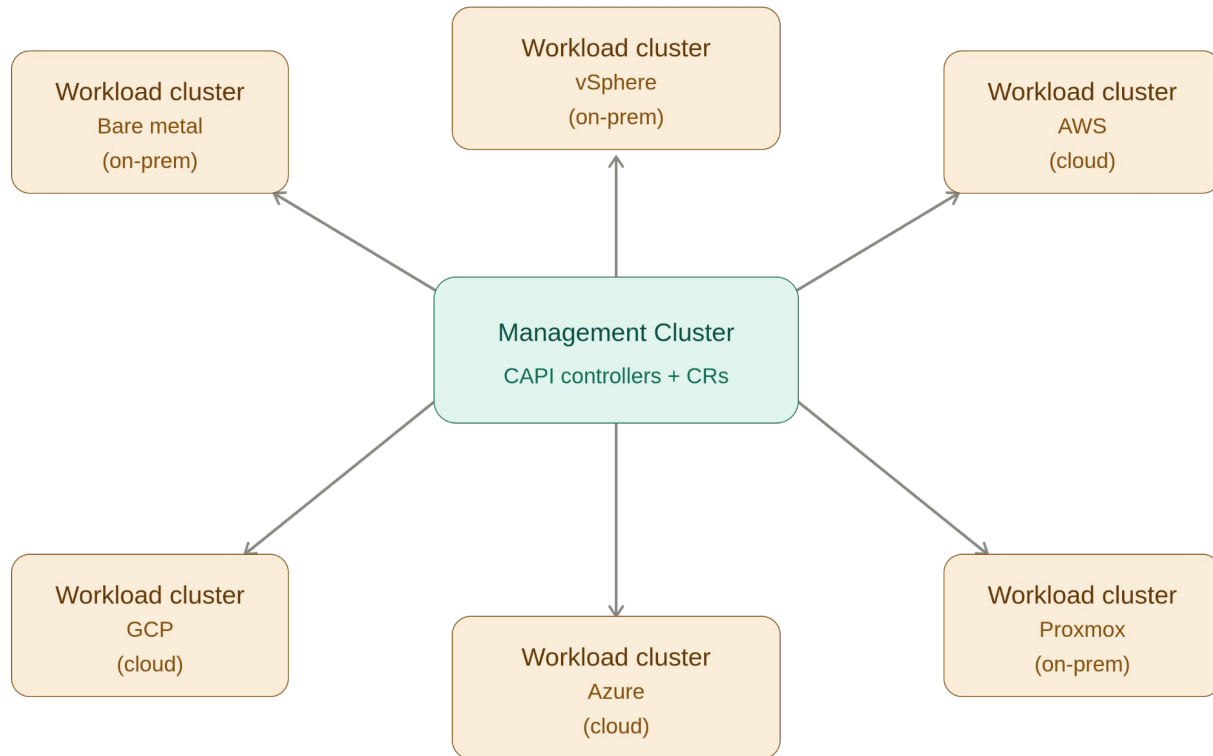
Q&A

CLUSTER API

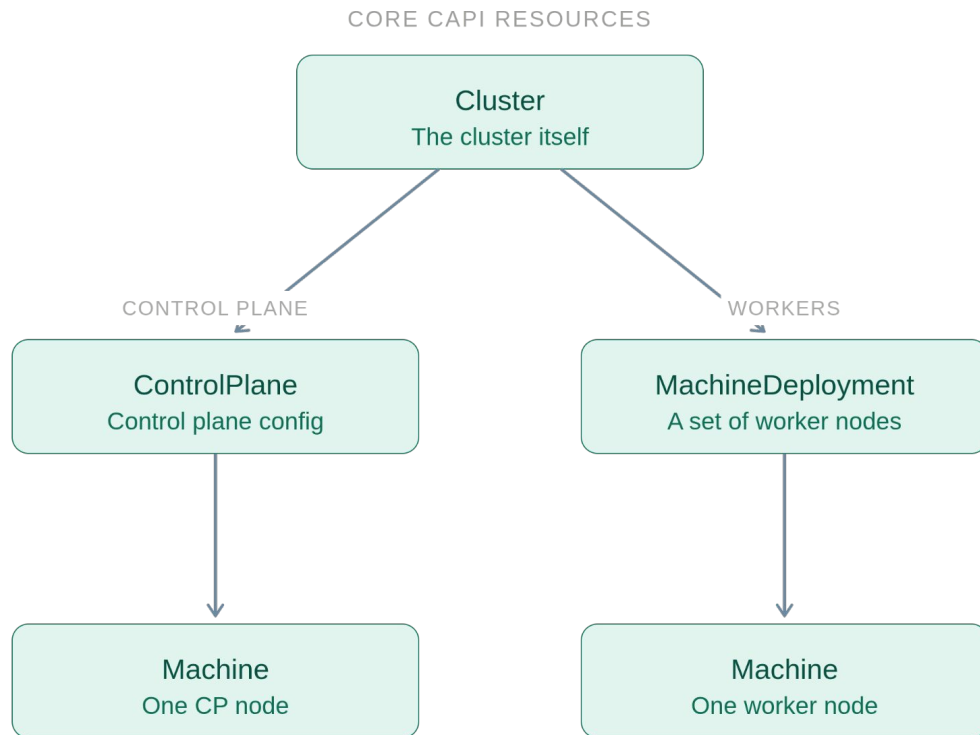
What is Cluster API

- Kubernetes sub-project - SIG Lifecycle
- Kubernetes-native cluster lifecycle management
- Cluster components as custom resources
(declarative)
- Provider model (AWS, vSphere, Azure, Metal3...)



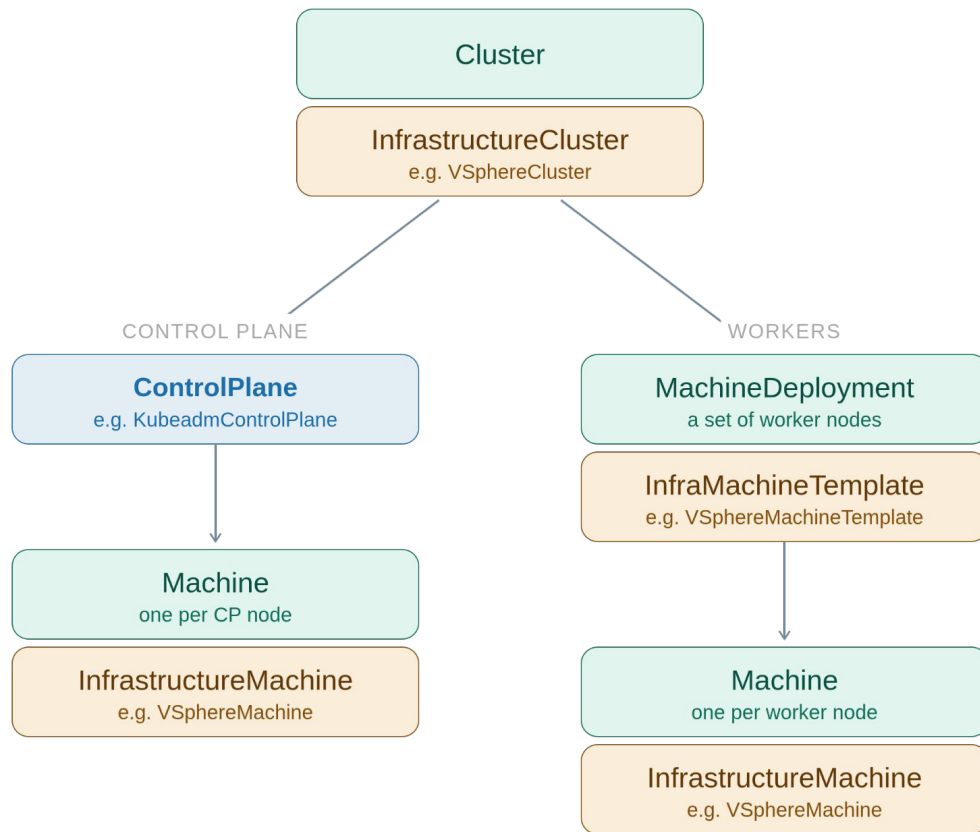


One management cluster reconciles many workload clusters across any provider



Each resource owns the ones below it via owner references in metadata

CORE + INFRASTRUCTURE RESOURCES

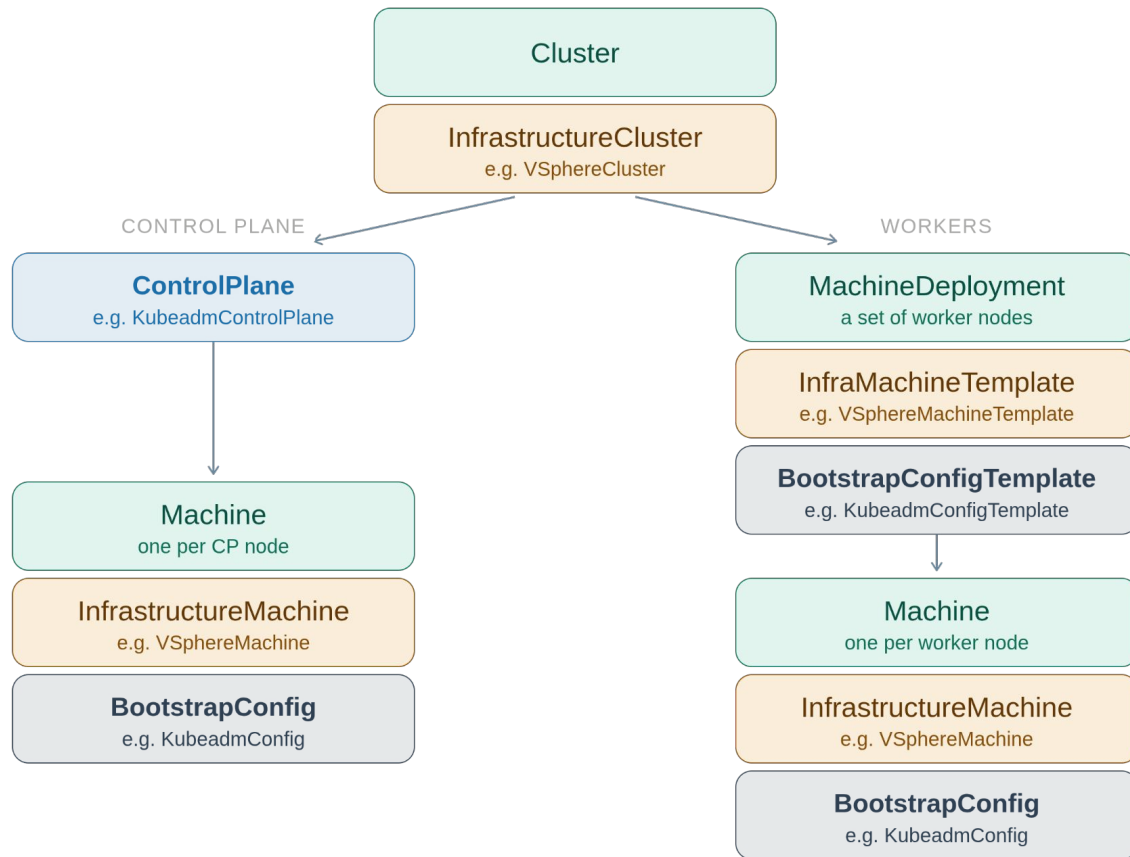


Core CR

Infrastructure CR

Control Plane CR

CORE + INFRASTRUCTURE + BOOTSTRAP RESOURCES

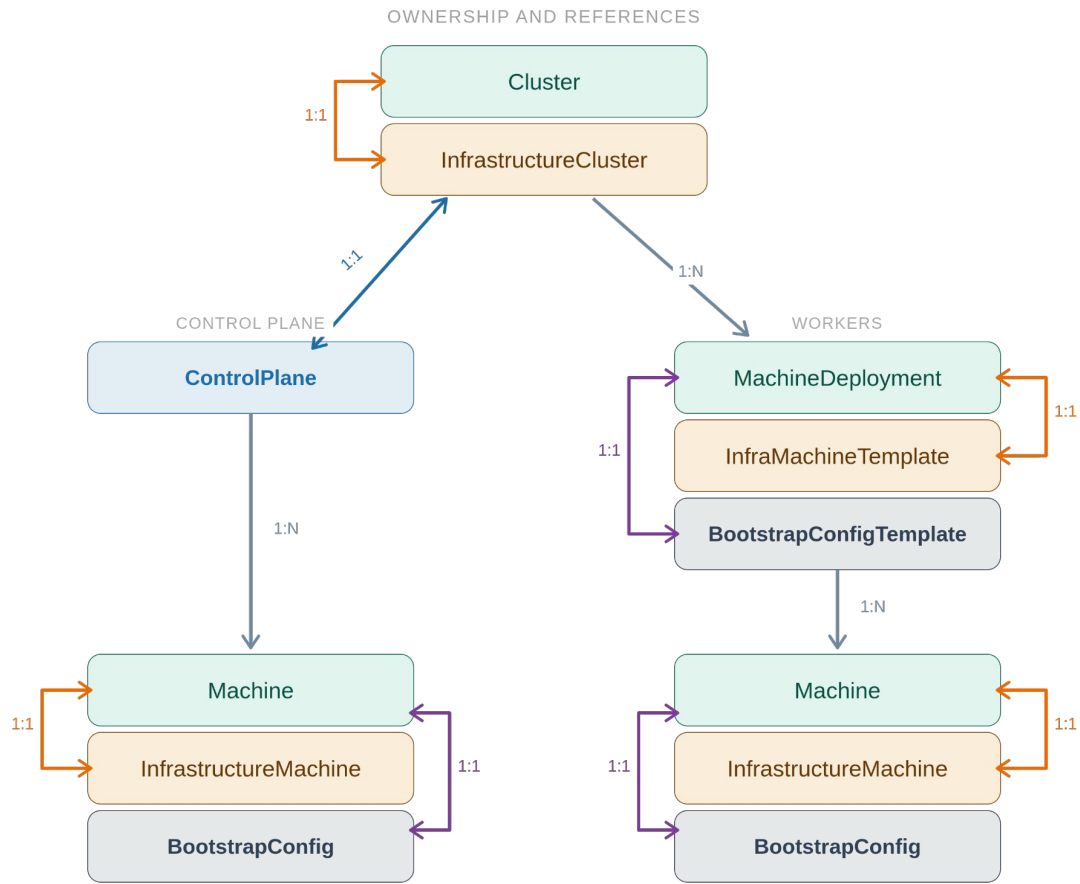


Core CR

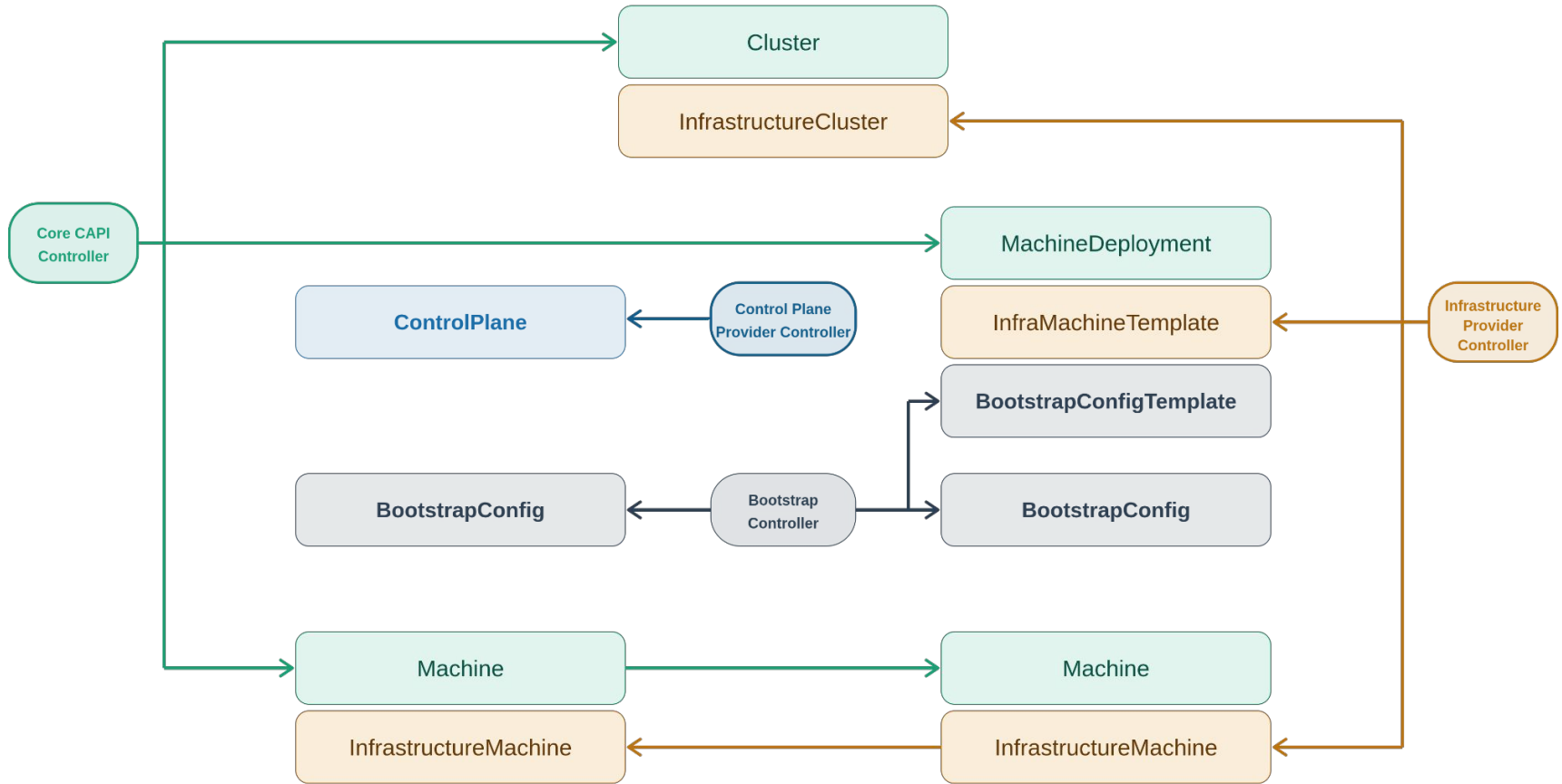
Infrastructure CR

Control Plane CR

Bootstrap CR



CAPI CONTROLLERS



What is a Cloud Controller Manager (CCM)

- **Node controller:** Manages node lifecycle (labels, metadata, registering/removing VMs...)
- **Route controller:** Sets up cloud network routes (sometimes IPs)
- **Service controller:** Sets up resources for services (cloud load balancers, IPs, health checks...)

NODE LIFECYCLE



CAPI Core

Creates Machine
sets ownerRefs

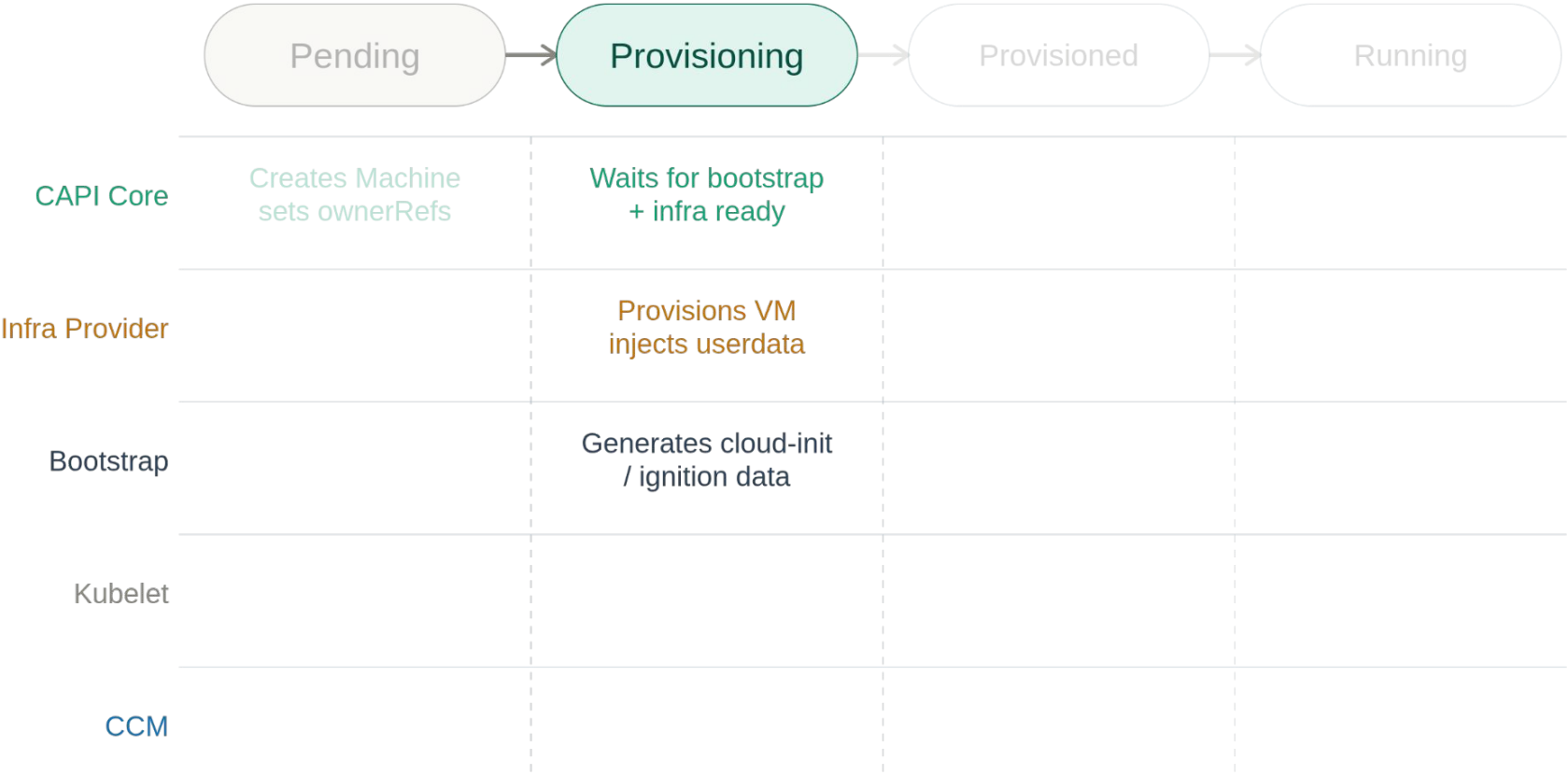
Infra Provider

Bootstrap

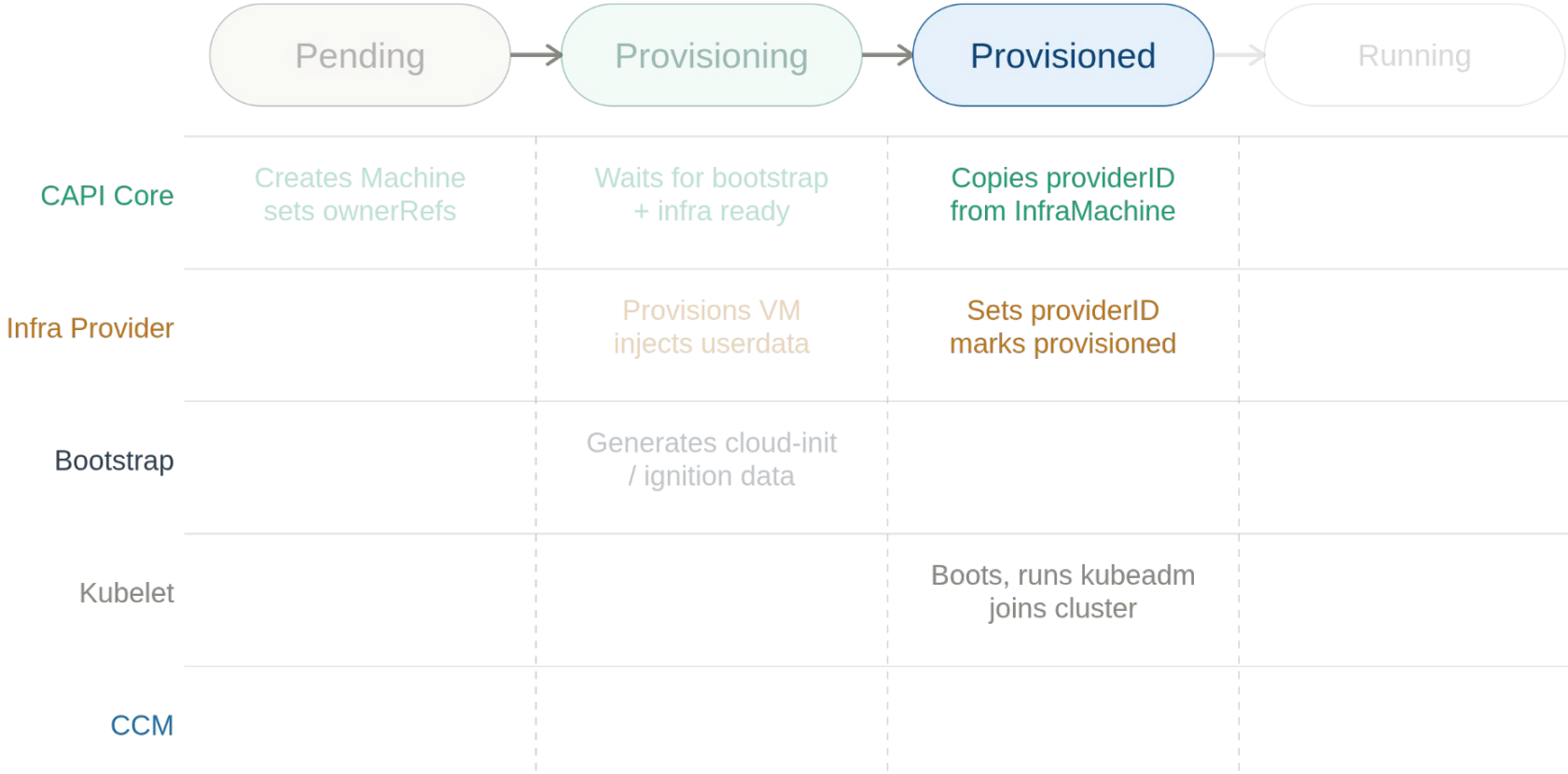
Kubelet

CCM

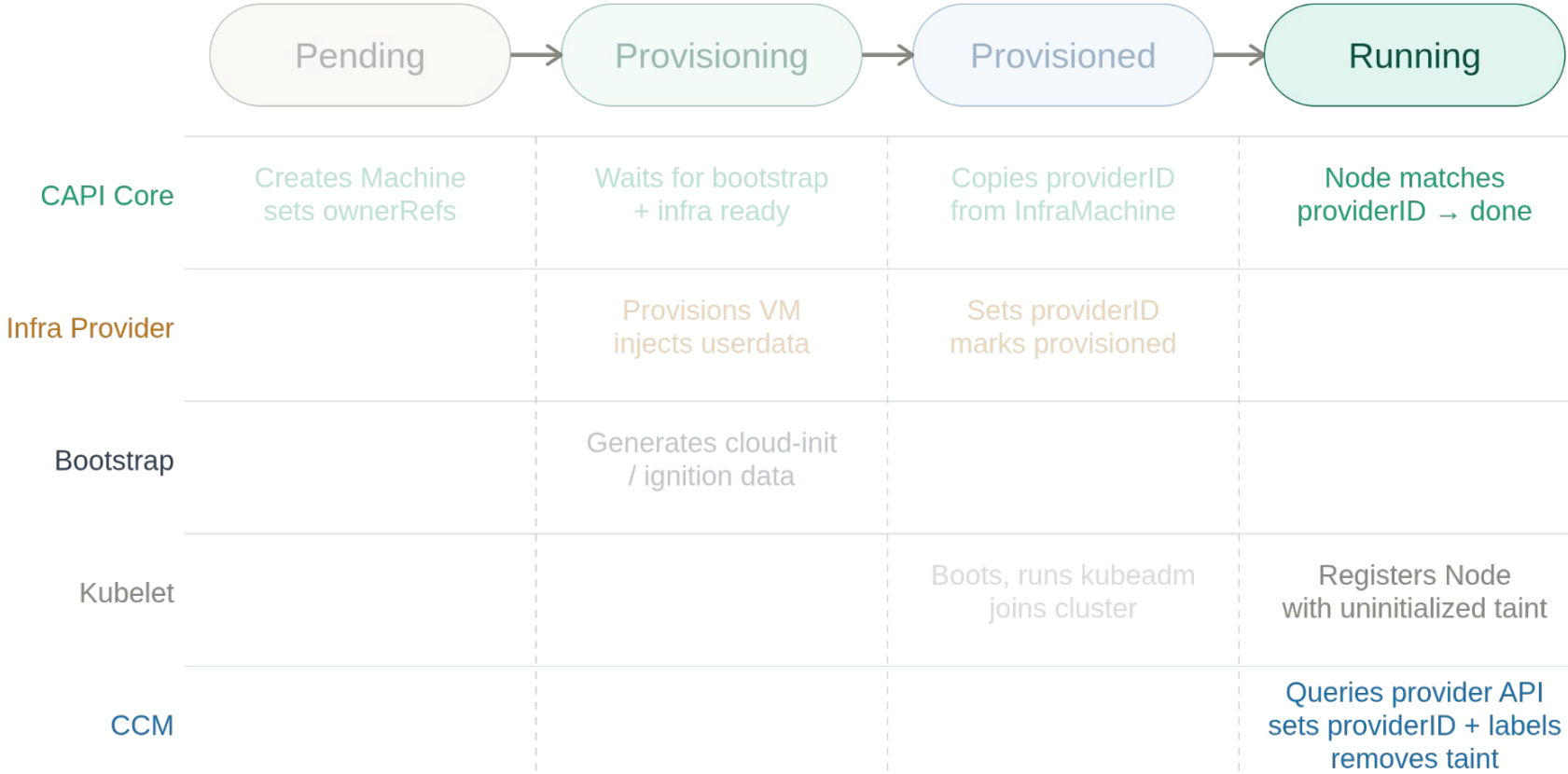
NODE LIFECYCLE



NODE LIFECYCLE



NODE LIFECYCLE



Hybrid setups and use case

I need bare metal K8s nodes

My servers are expensive so I don't want to waste
some of them on control planes

- customer



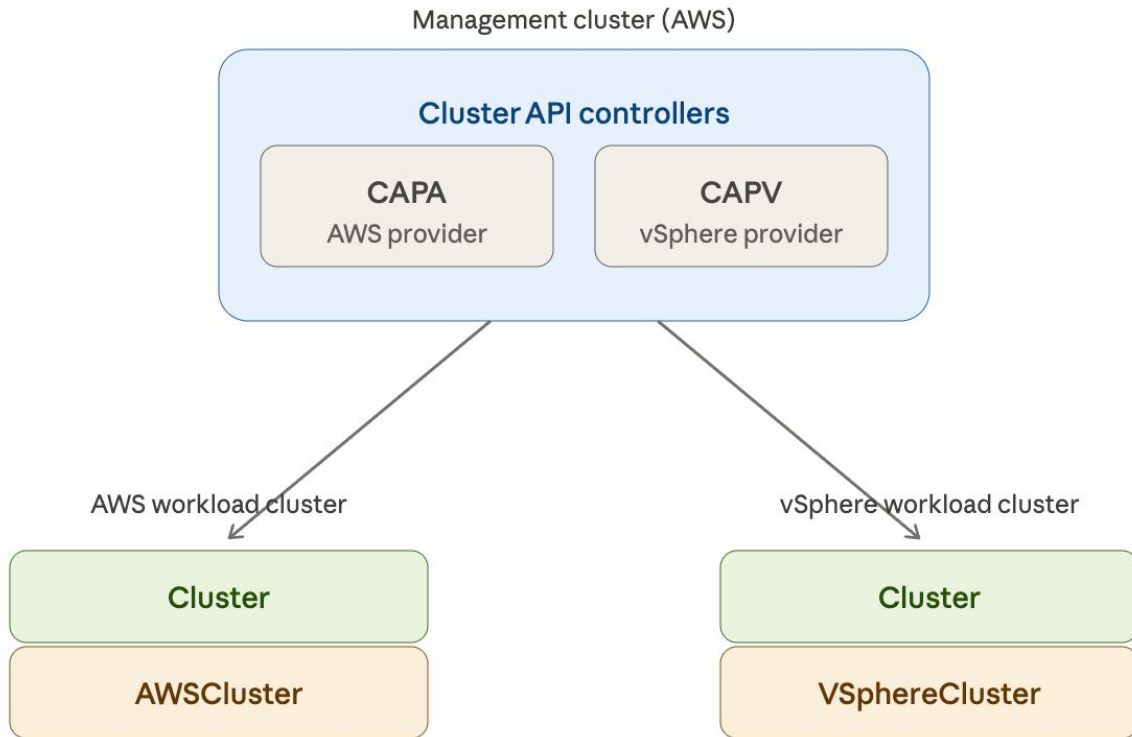
The plan:

Install vSphere and Metal3 CAPI controllers

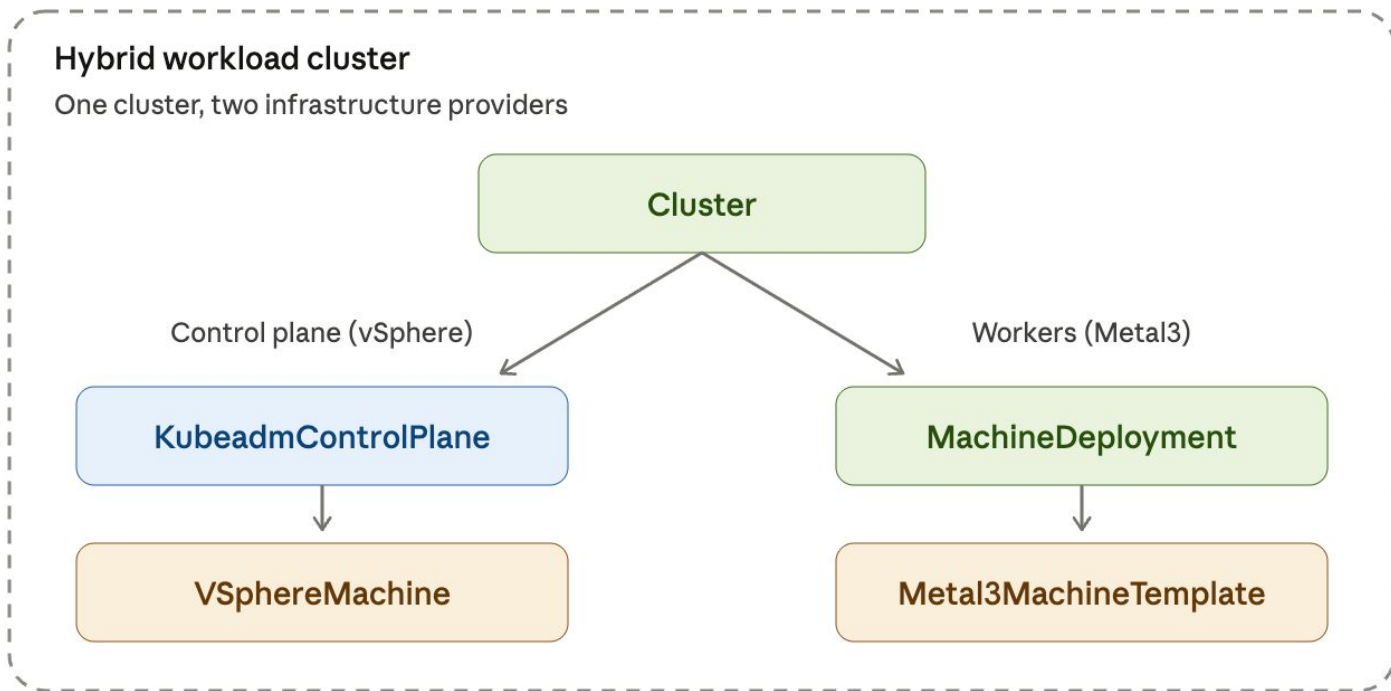
Create a vSphere cluster and add a Metal3 nodepool

EZ

Hybrid Management cluster



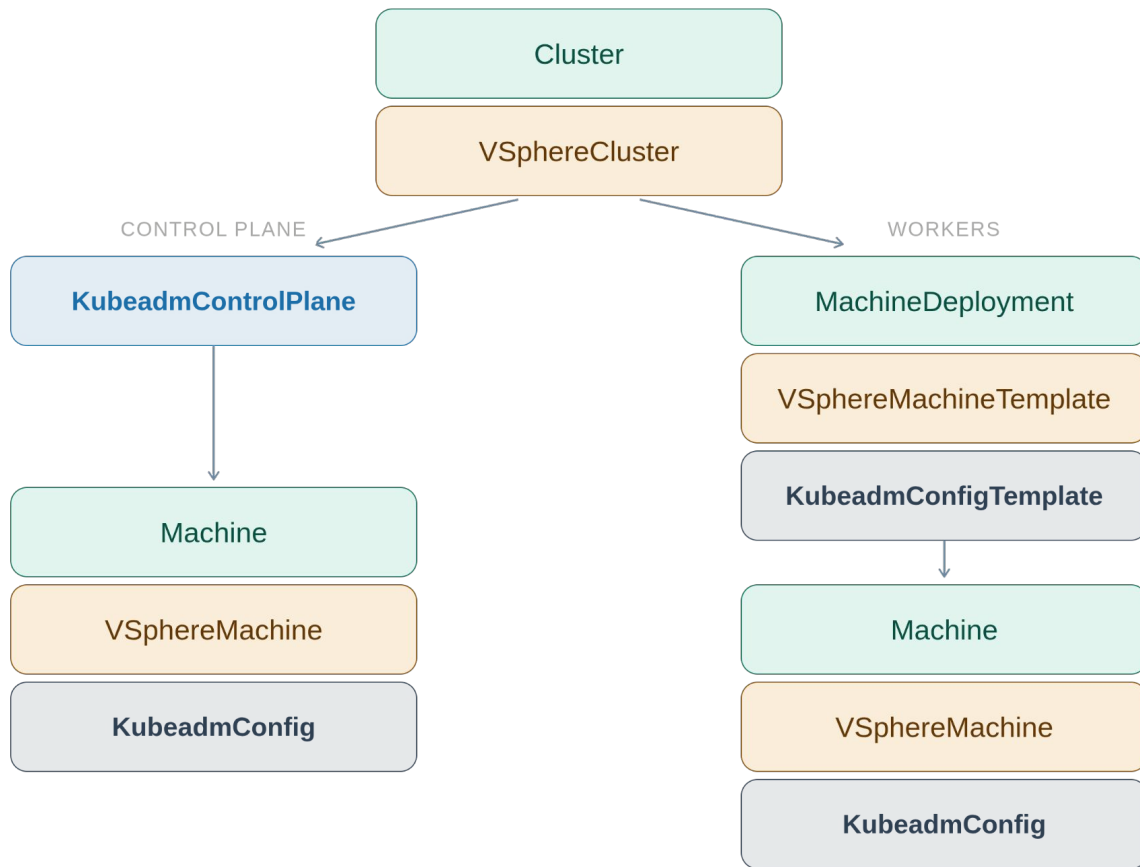
Hybrid Workload cluster



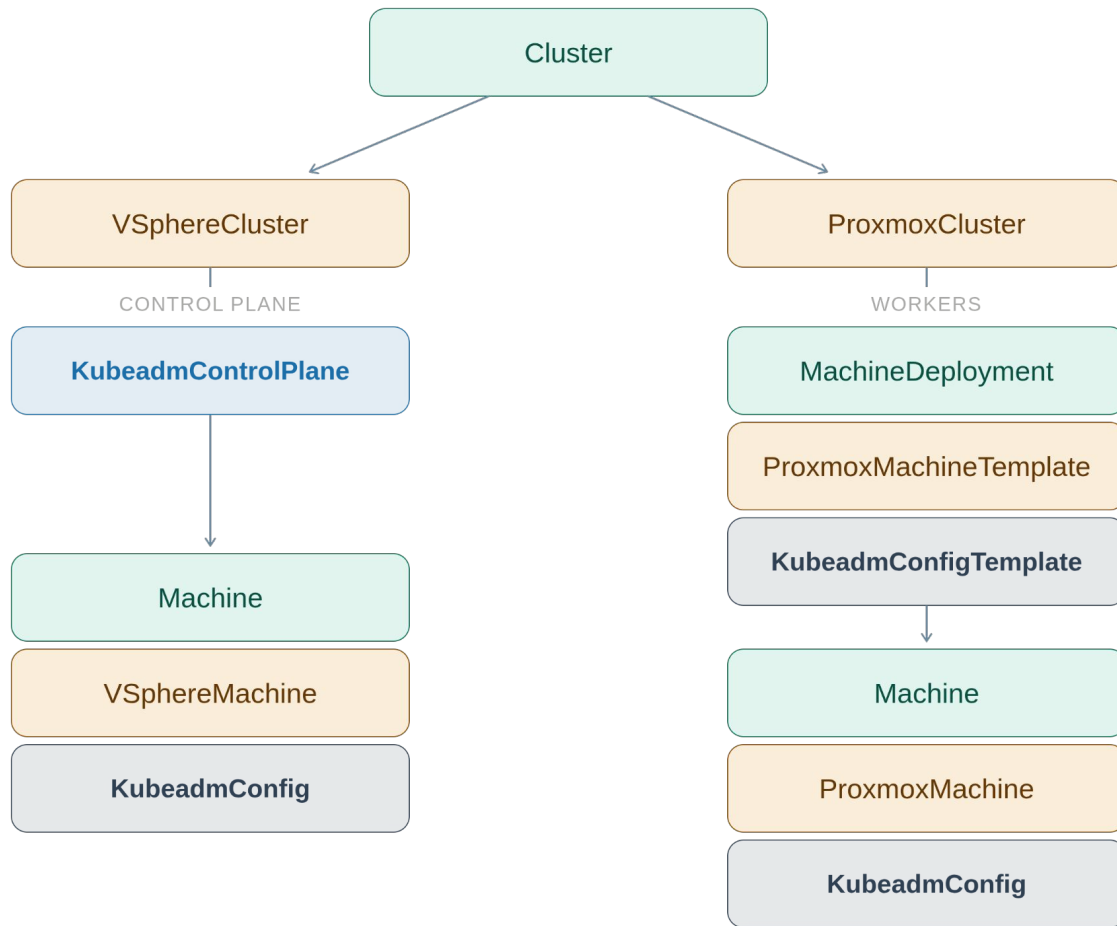
how hard could it be? ...

FRANKENSTEIN`S cluster

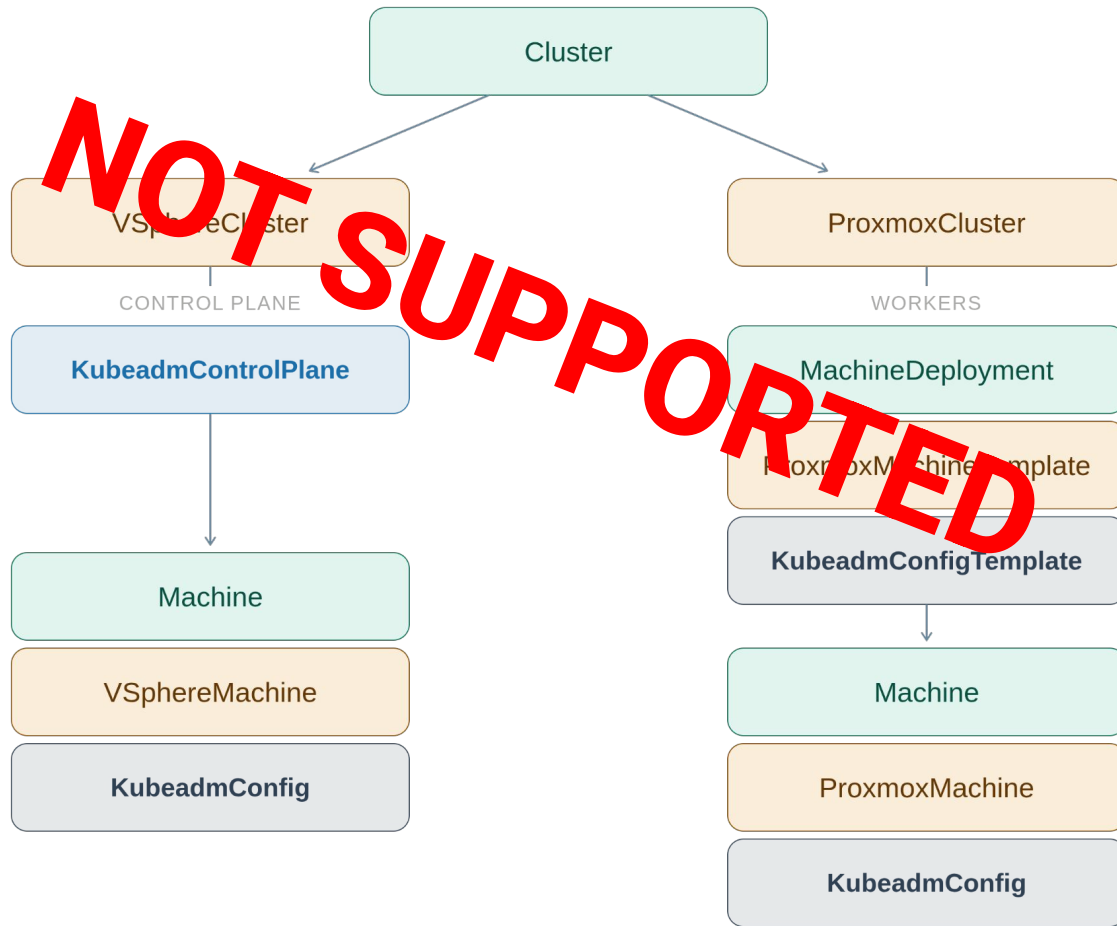
A VSPHERE CLUSTER



A CLUSTER WITH VSPHERE CONTROLPLANE AND PROXMOX WORKERS



A CLUSTER WITH VSPHERE CONTROLPLANE AND PROXMOX WORKERS

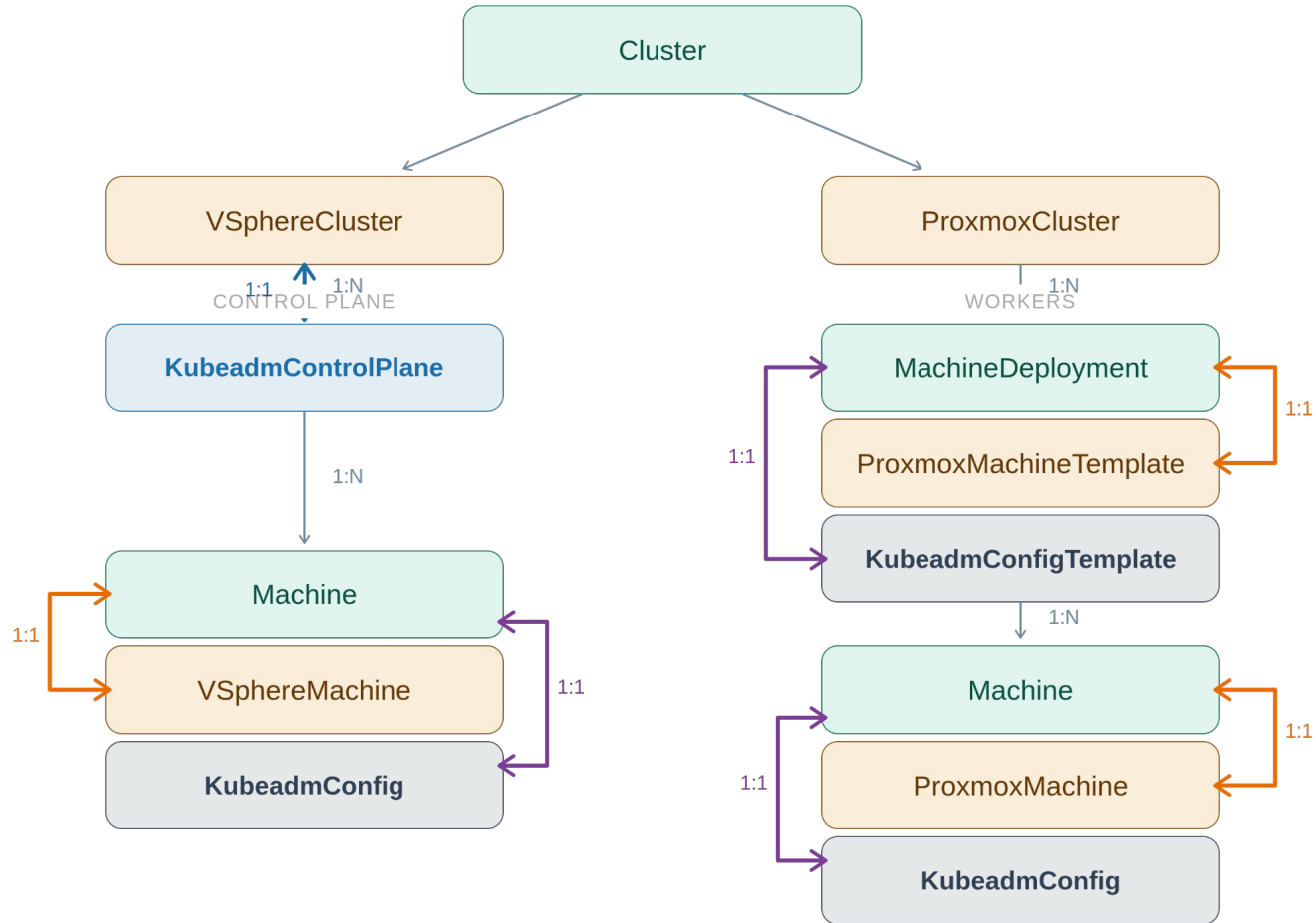


How hard could it be, really?

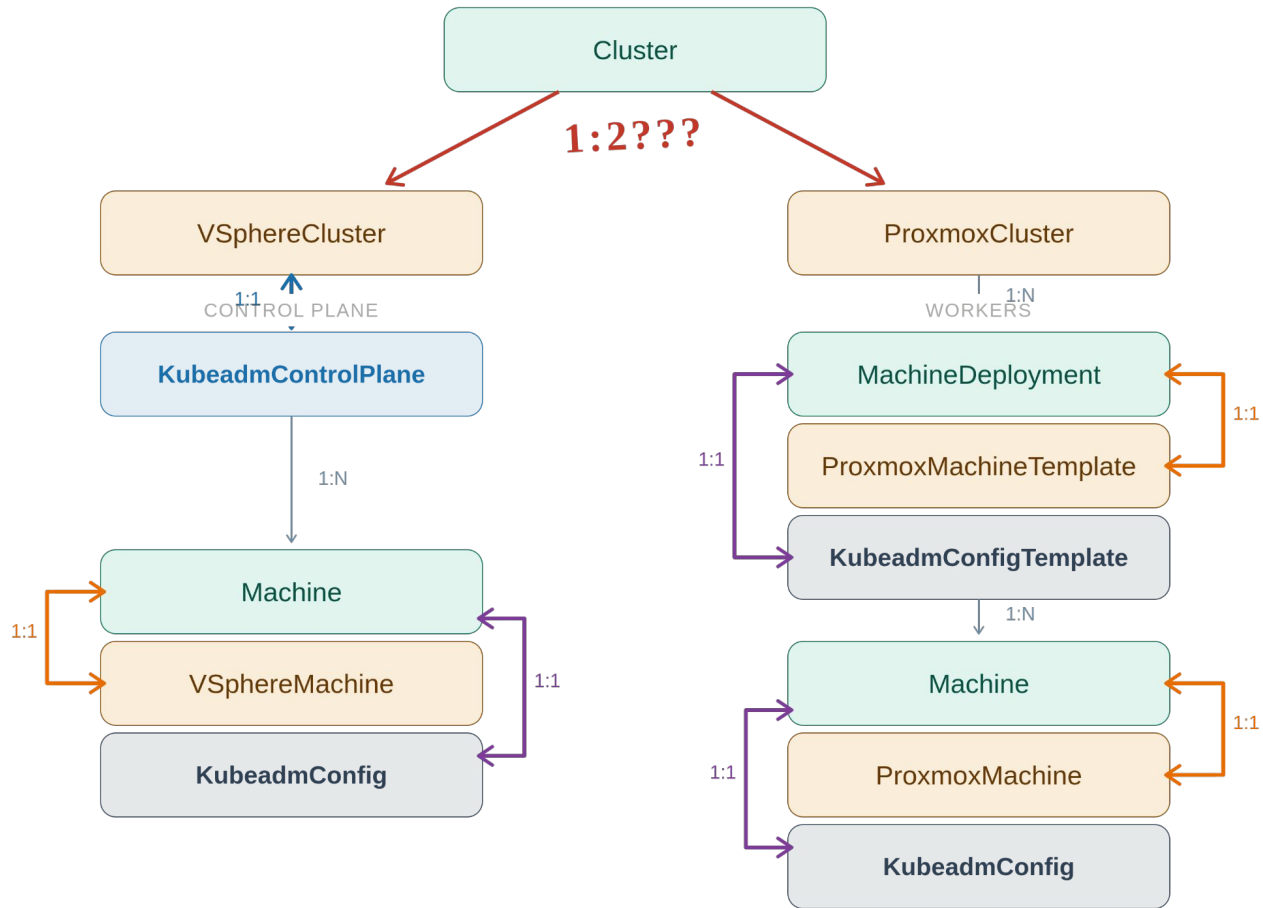
- We tried it anyway
- We created a monster
- Dependencies were a challenge



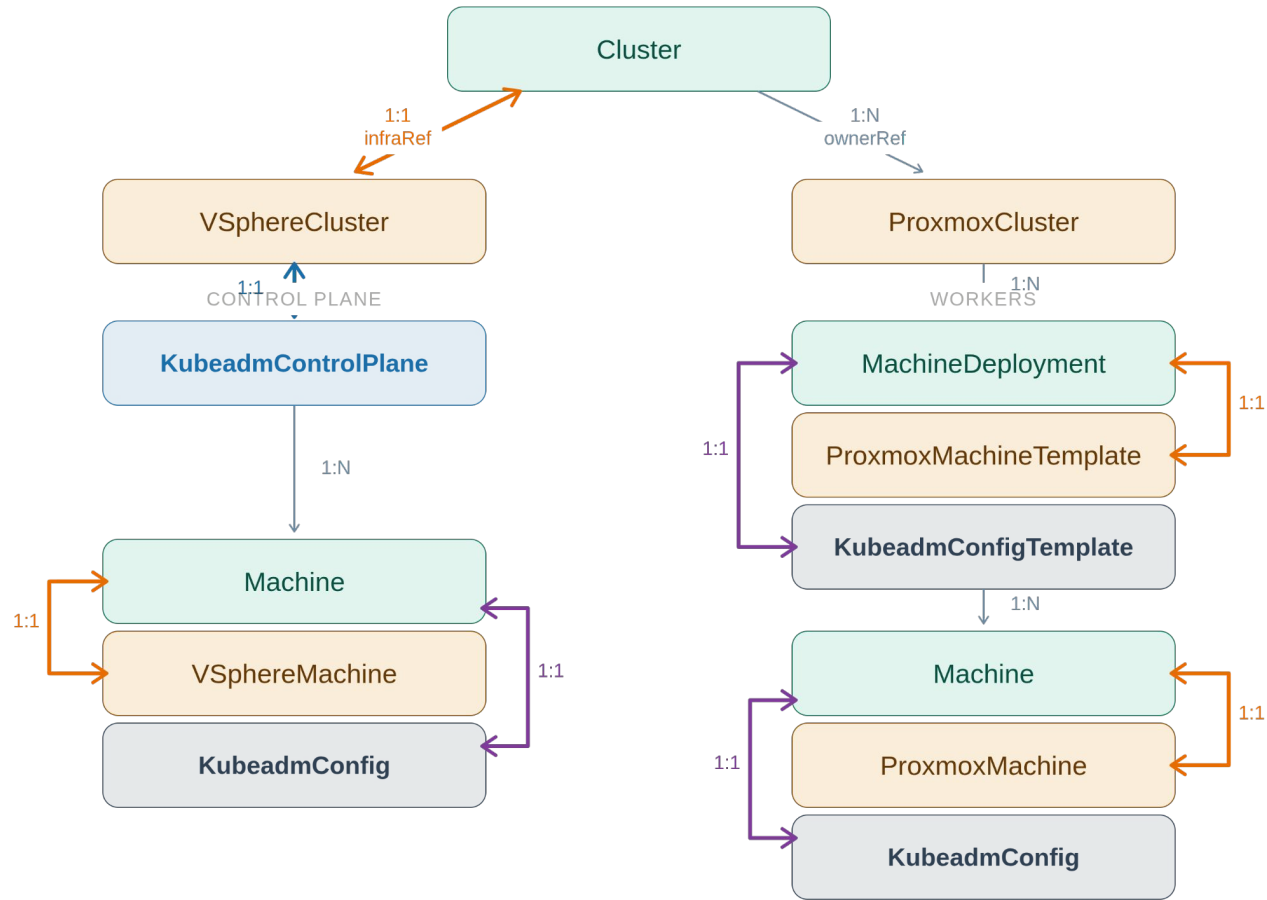
A CLUSTER WITH VSPHERE CONTROLPLANE AND PROXMOX WORKERS



FRANKENSTEIN'S CLUSTER



FRANKENSTEIN'S CLUSTER



Demo Time

- In proxmoxCluster:

Spec:
externalManagedControlPlane **true**




```
error discovering node proxmoxnodepool-workers-zx8sh-9jx7d: No VM found  
WhichVCandDCByNodeID nodeID: proxmox://<VM ID>
```

```
Unable to find VM by UUID. VM UUID: proxmox://<VM ID>
```

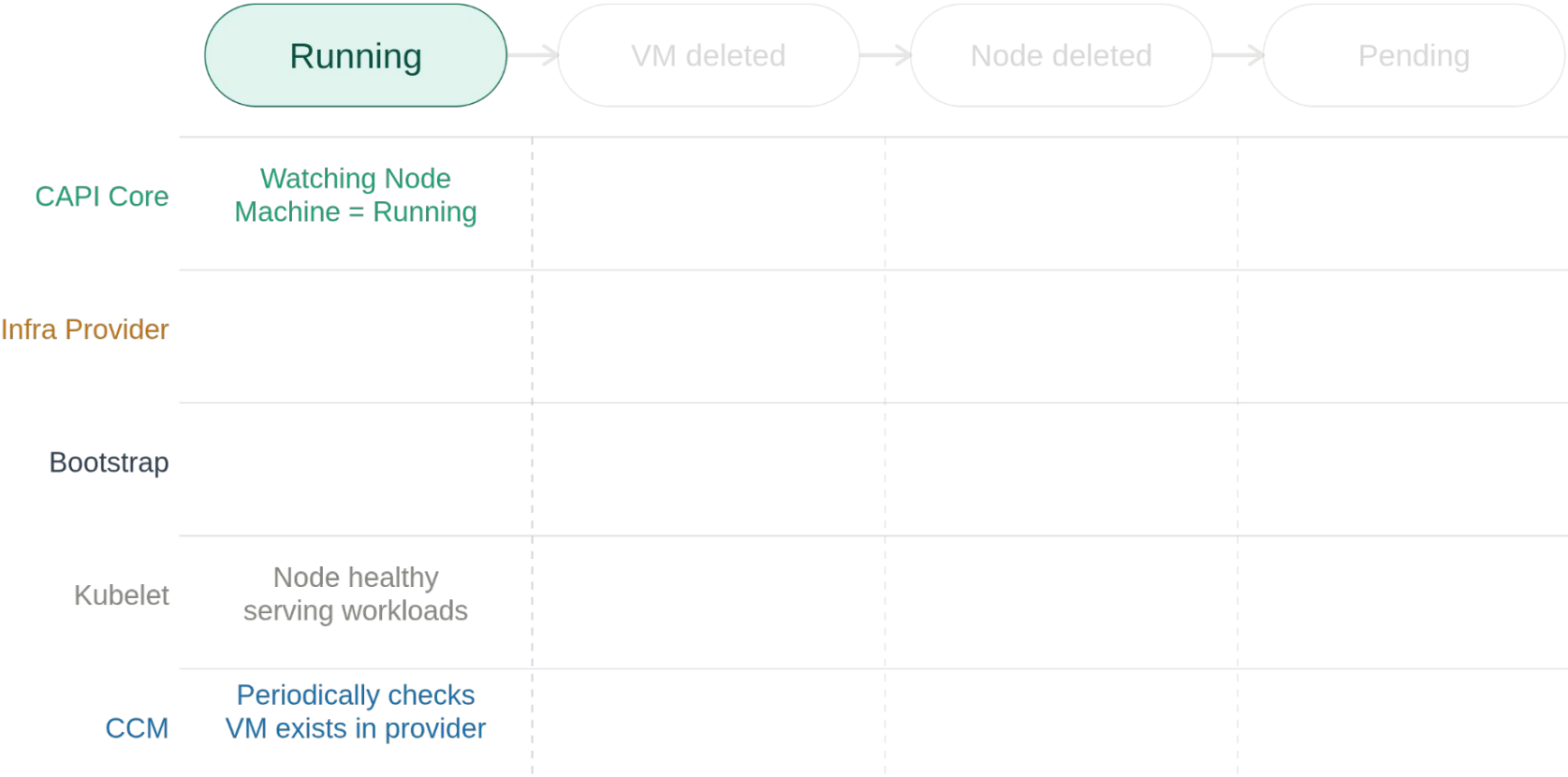
```
Error while looking for vm=proxmox://<VM ID>(byUUID) in vc=10.201.23.1 and  
datacenter=giant-swarm: No VM found
```

```
Did not find node proxmox://<VM ID> in vc=10.201.23.1 and datacenter=giant-swarm
```

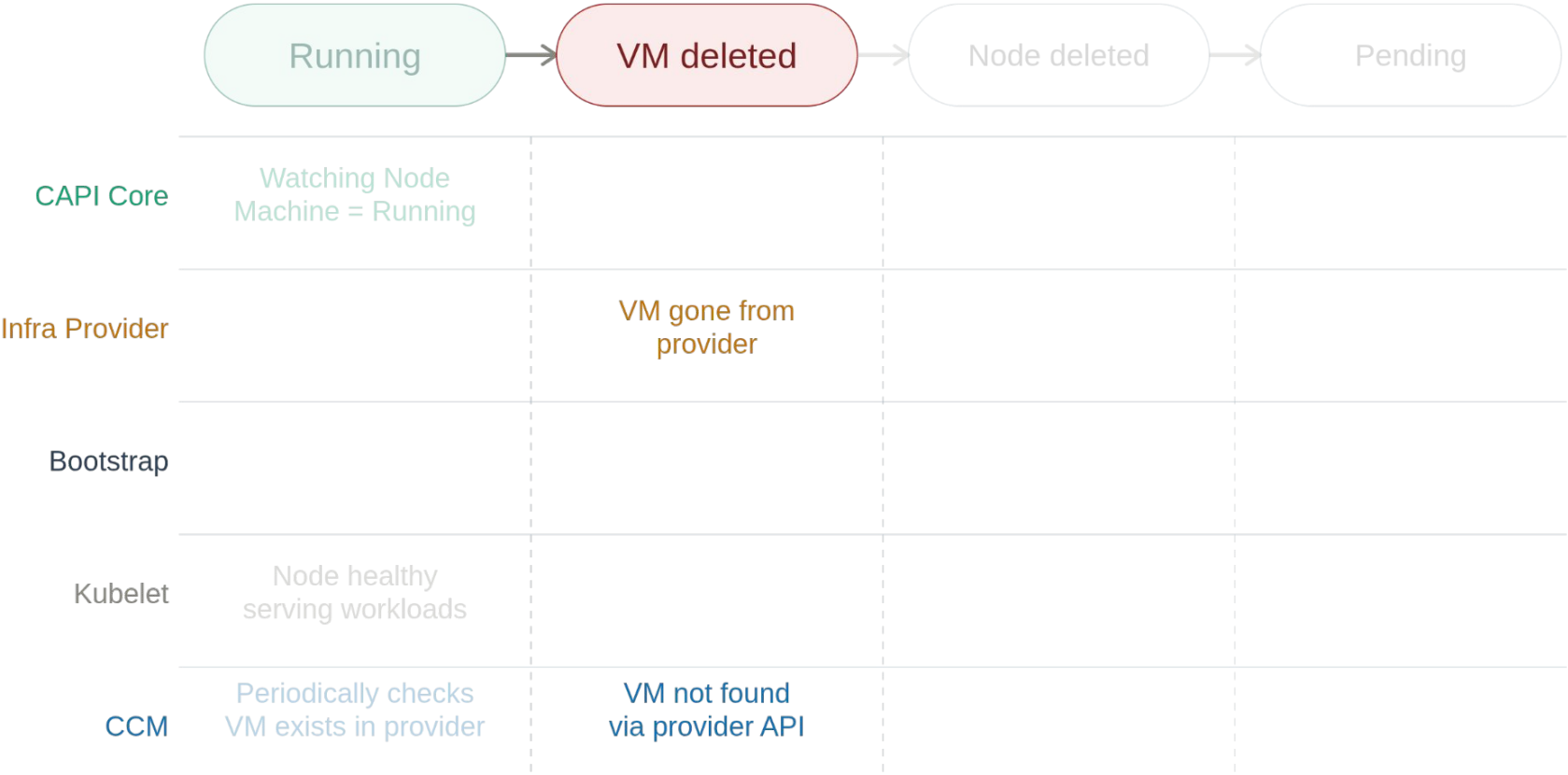
```
deleting node since it is no longer present in cloud provider:  
proxmoxnodepool-workers-zx8sh-9jx7d
```

- vSphere CCM

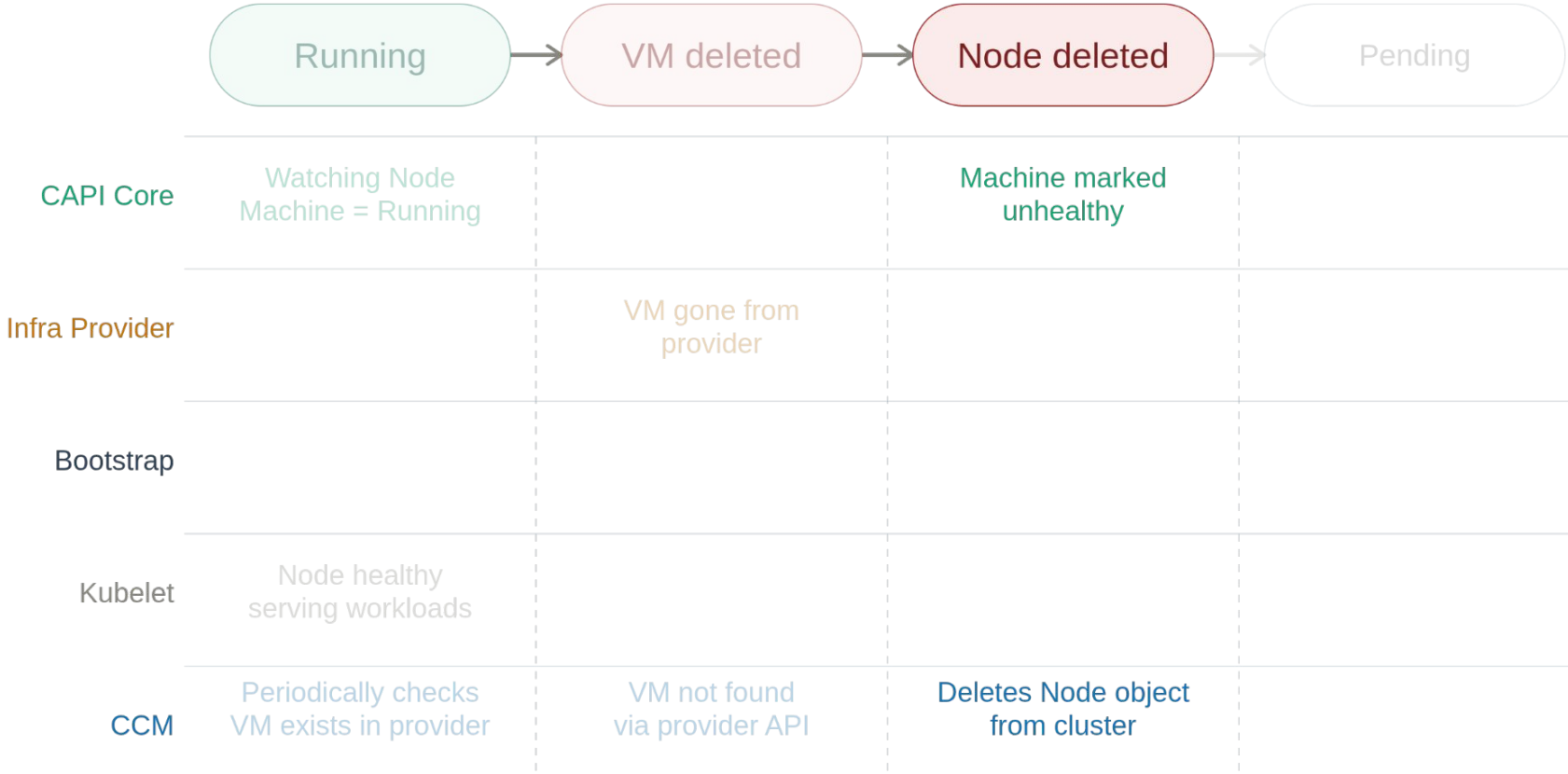
NODE DEATH



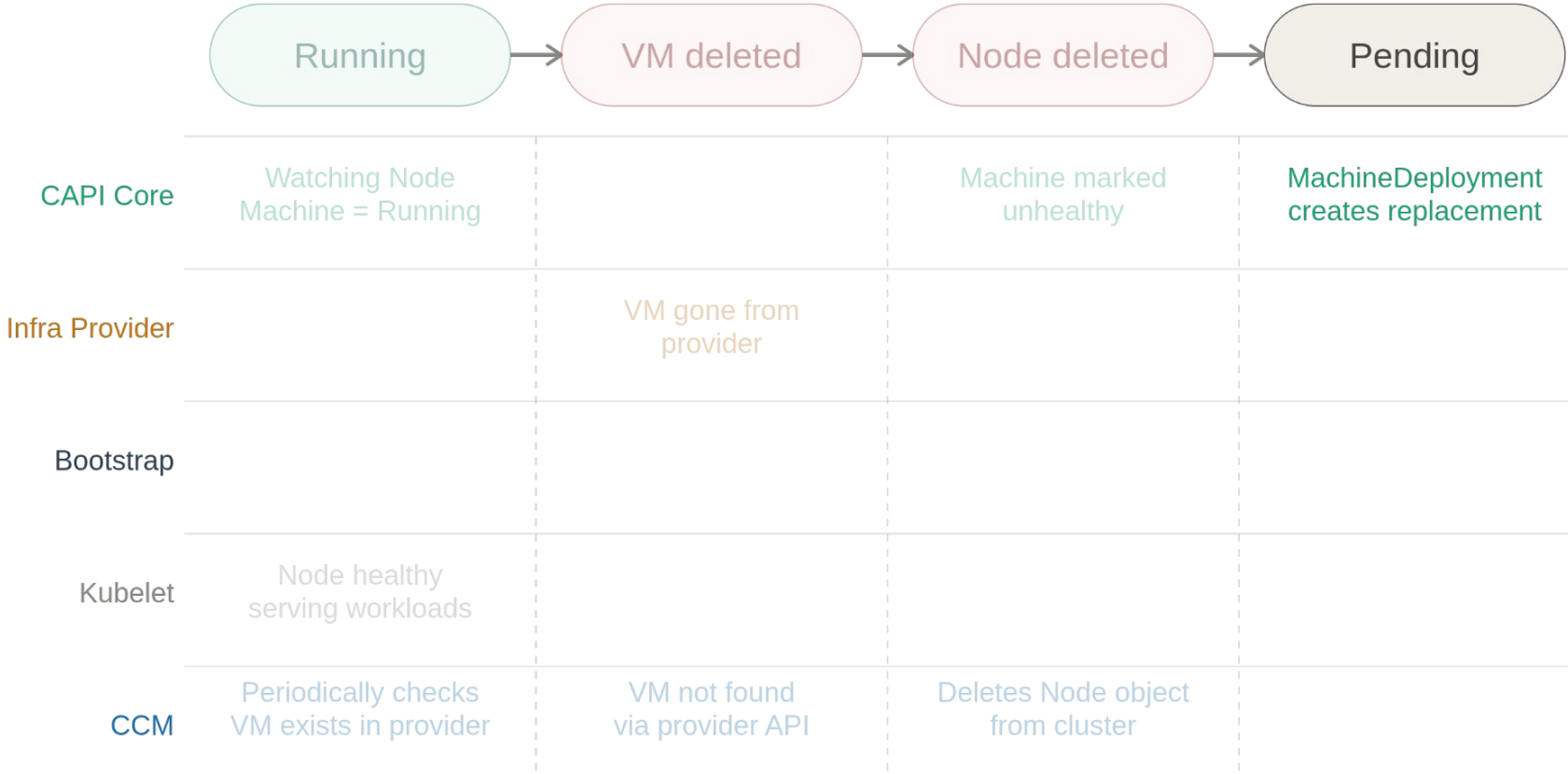
NODE DEATH



NODE DEATH

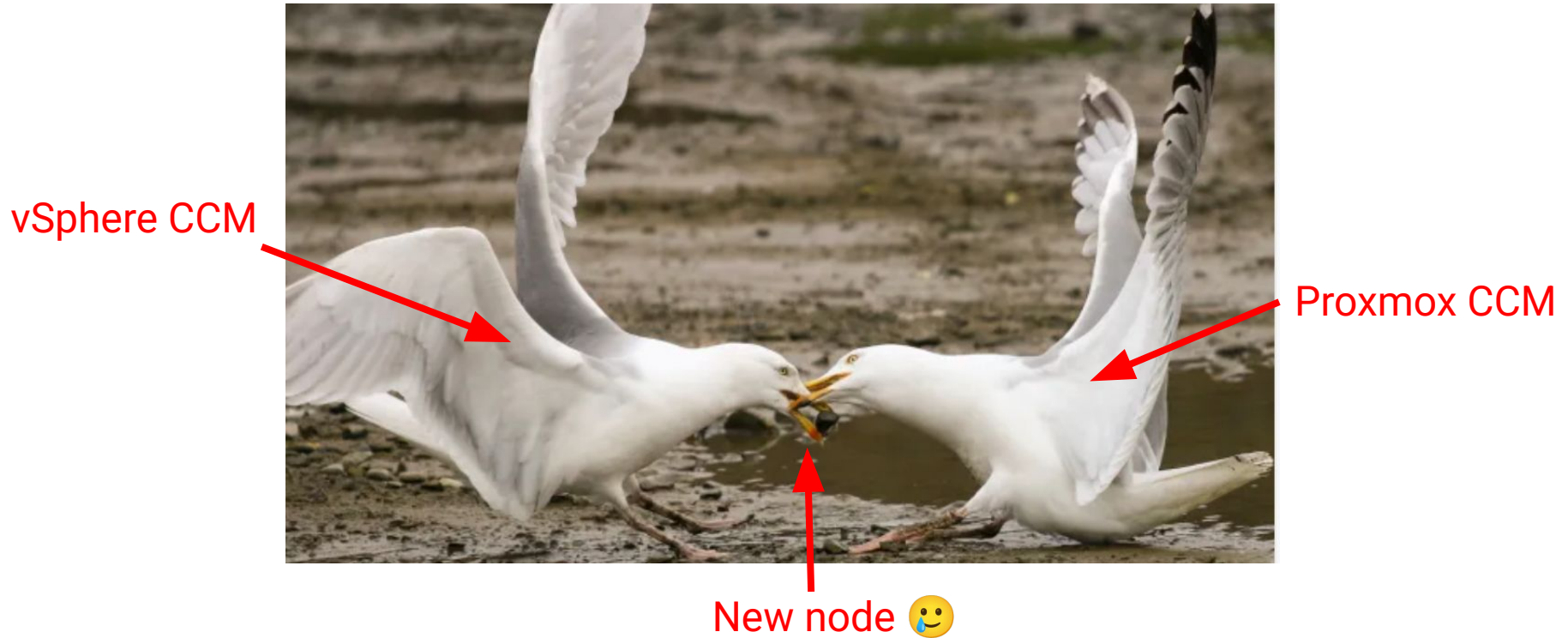


NODE DEATH





Kubernetes isn't designed to run multiple CCMs in one cluster



Anyone: "Don't do that"

But.... what if



vSphere CCM fork

vSphere providerID:

`vsphere://420bd2d2-4548-e86c-8f5c-31785f863444`

Proxmox providerID:

`proxmox://24d67b61-1c34-484b-8754-aca095b5d27b`

vSphere CCM fork

```
93 + func ShouldProcessNode(providerID string) bool {
94 +     // If ProviderID is empty, we should process this node
95 +     if providerID == "" {
96 +         return true
97 +     }
98 +
99 +     // If ProviderID starts with vsphere://, definitely process it
100 +     if strings.HasPrefix(providerID, ProviderPrefix) {
101 +         return true
102 +     }
103 +
104 +     // If ProviderID contains "://", it's for a different cloud provider
105 +     if strings.Contains(providerID, "://") {
106 +         return false
107 +     }
108 +
109 +     // If no "://", treat as raw UUID for backward compatibility
110 +     return true
111 + }
```

vSphere CCM fork

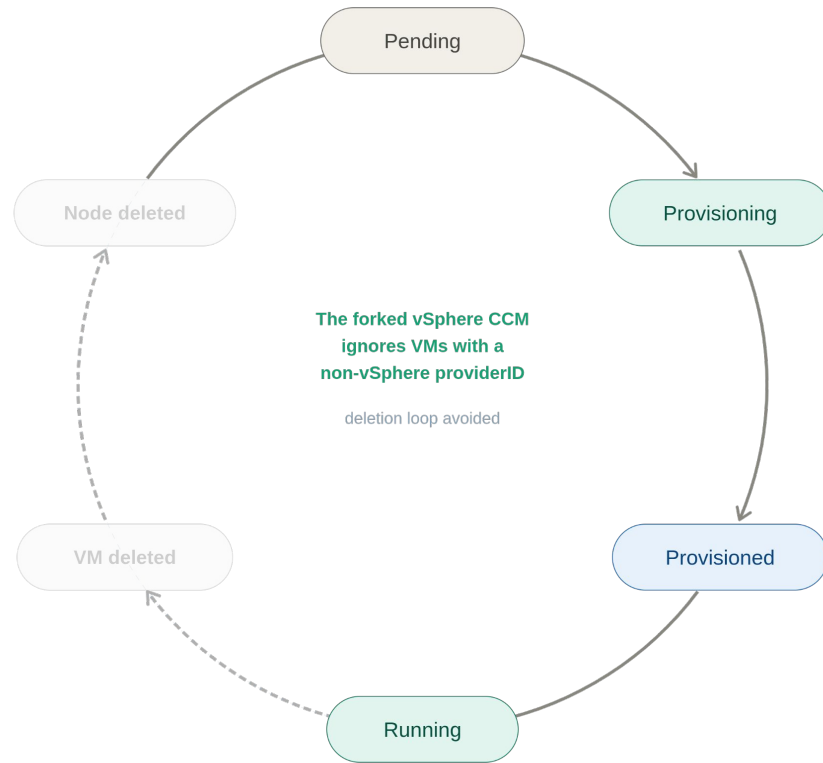
```
// Skip nodes that don't belong to vSphere cloud provider
// Return an error to prevent this cloud provider from making deletion decisions
// about nodes it doesn't manage
if !ShouldProcessNode(providerID) {
    klog.V(4).Infof("InstanceExistsByProviderID: skipping ProviderID %s (not managed by vSphere)", providerID)
    return false, fmt.Errorf("node with ProviderID %s is not managed by vSphere cloud provider", providerID)
}
```



```
instances.NodeAddresses() NOT FOUND with proxmoxnodepool-workers-86bsh-fw74s
```

```
nodeAdded: skipping node proxmoxnodepool-workers-86bsh-fw74s with ProviderID  
proxmox://fd5d2dce-ca7a-4dec-8c10-09b1868895a2 (not managed by vSphere)
```

- Forked vSphere CCM



vSphere CCM fork



This Monster Lives

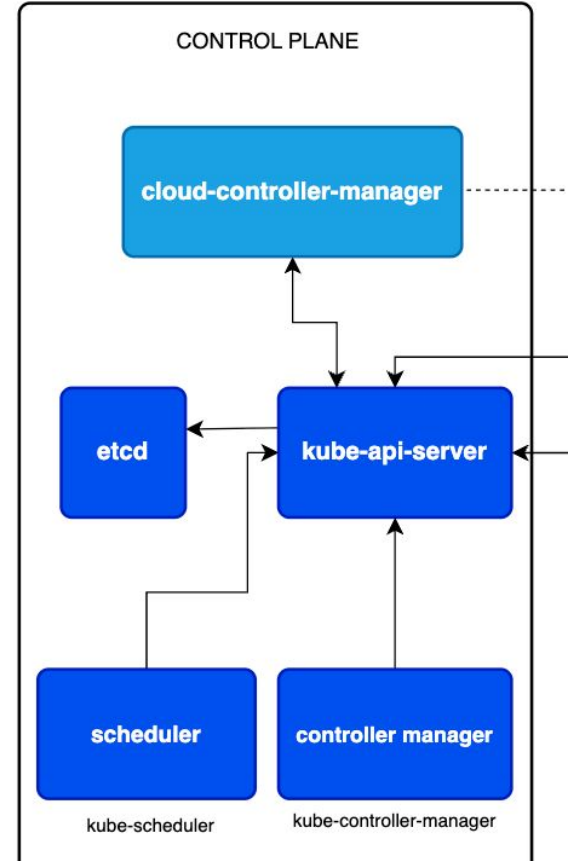
- But at what cost?
- May break silently at every update
- On-call sees half a cluster
- Endless fork maintenance
- Pod scheduling nightmare
- No upstream support (`clusterctl`)



Hosted control planes

Isn't a control plane just a set of containers after all?

Does it really need dedicated nodes in the cluster?

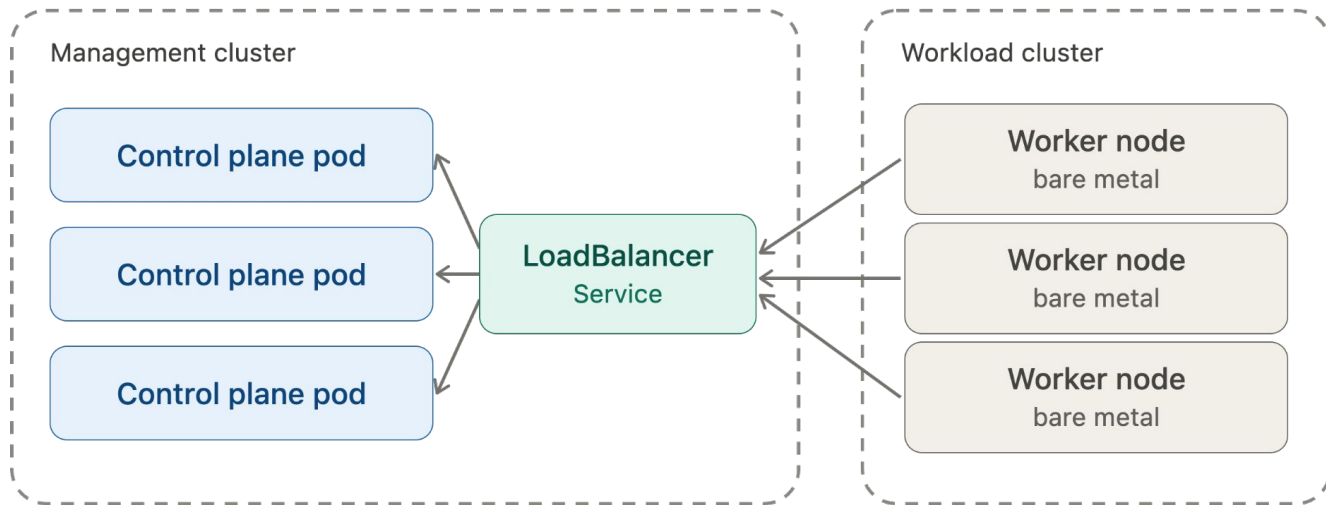


kubernetes.io/docs

Hosted control plane

Control plane as MC pods

- Massive Resource Savings
- New control planes start in seconds
- Multi-tenancy



Hosted control plane



Gardener



HyperShift



vCluster

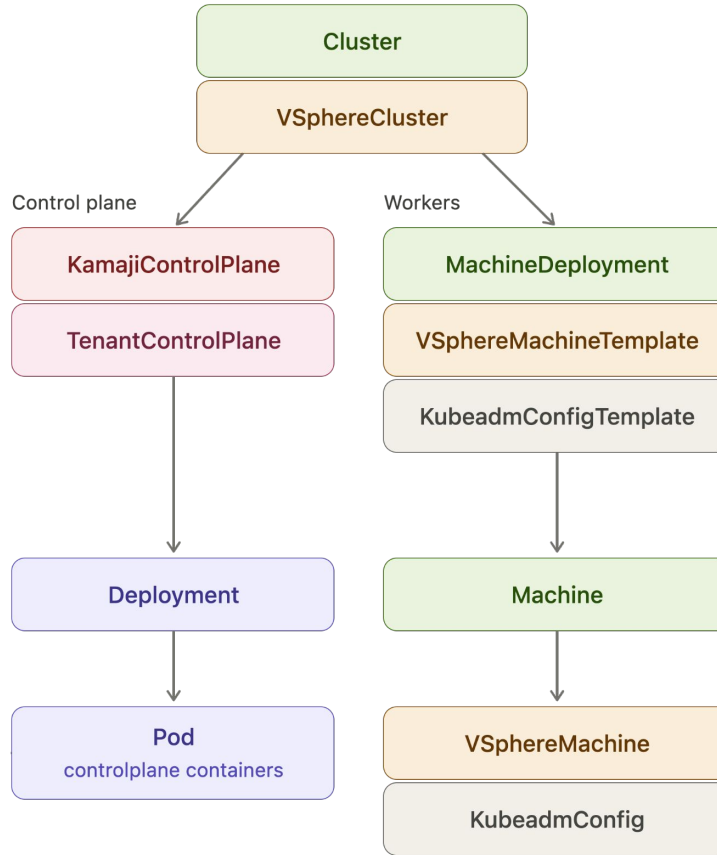


Kamaji

- Open Source
- Maintained by Clastix
- Cluster API Control Plane provider
- Multi-tenancy (database and compute)
- Access to stable releases with enterprise subscription



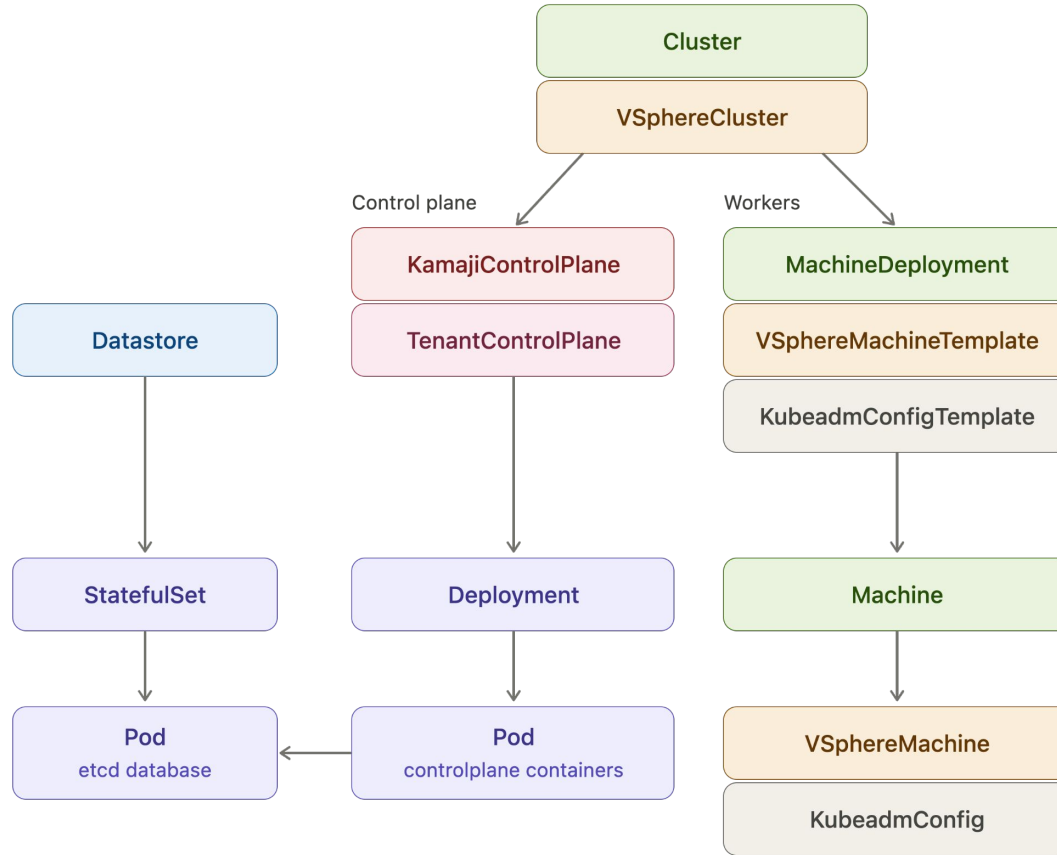
A Kamaji cluster



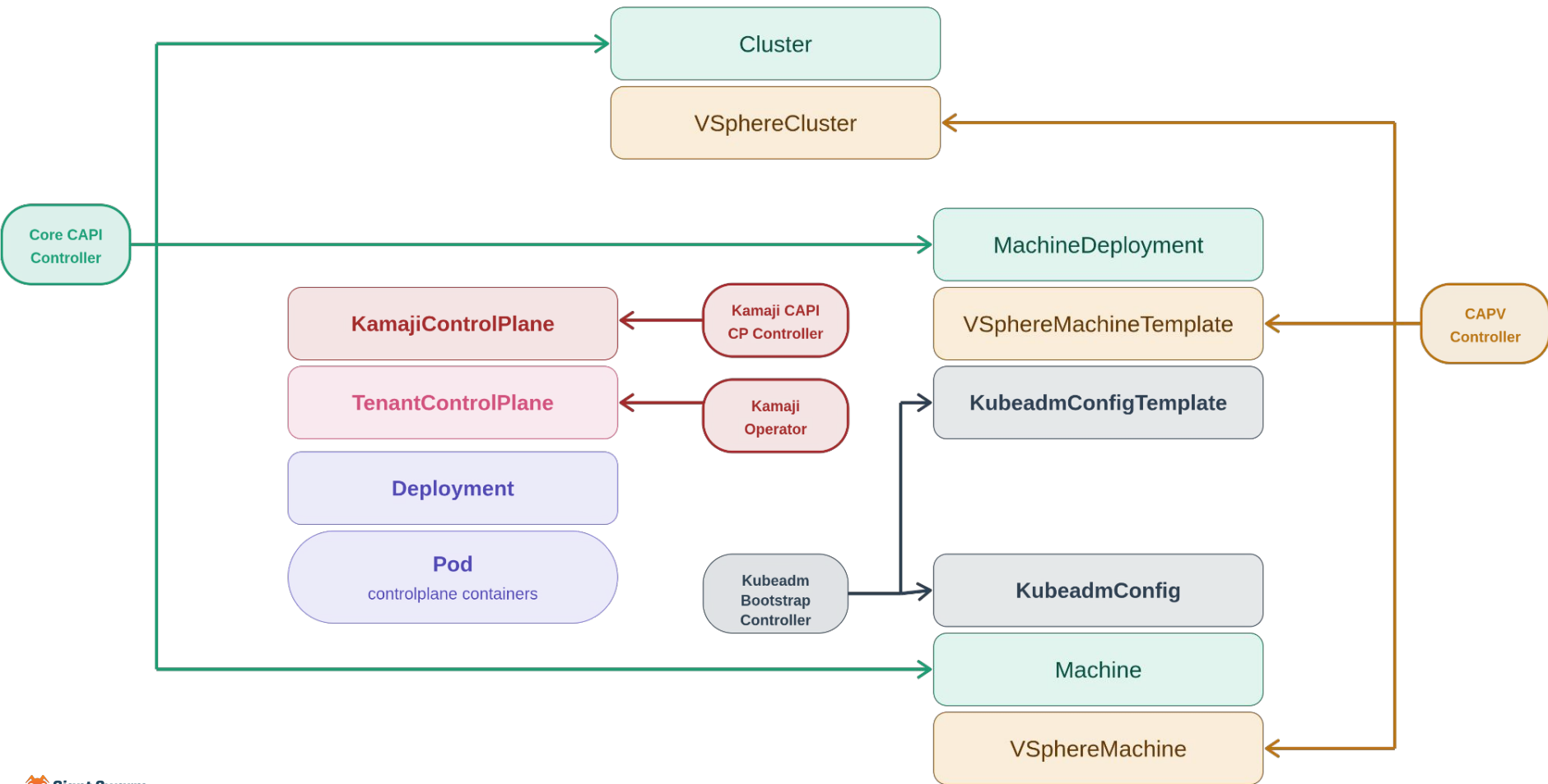
Pods in MC

VMs

A Kamaji cluster



KAMAJI CONTROLLERS



A few knobs to tweak

- Disable components with control plane affinity
- Rework etcd backup/defrag automation
- Netpol for webhooks, connectivity..
- Datastore CRs are non-namespaced



A few trade offs

- Management cluster is a SPOF (blast radius)
- Noisy Neighbor Risk on MC
- Strict Security Multi-Tenancy Required
- Database multi-tenancy is cool but.. Should you?

Hosted control plane is a good supported architecture to mix providers in a single cluster



Should CAPI support mixing providers?

Q&A