Giant Swarm

Cluster API: A Unified Approach to Cluster Lifecycle Management Across Diverse Environments

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Outline

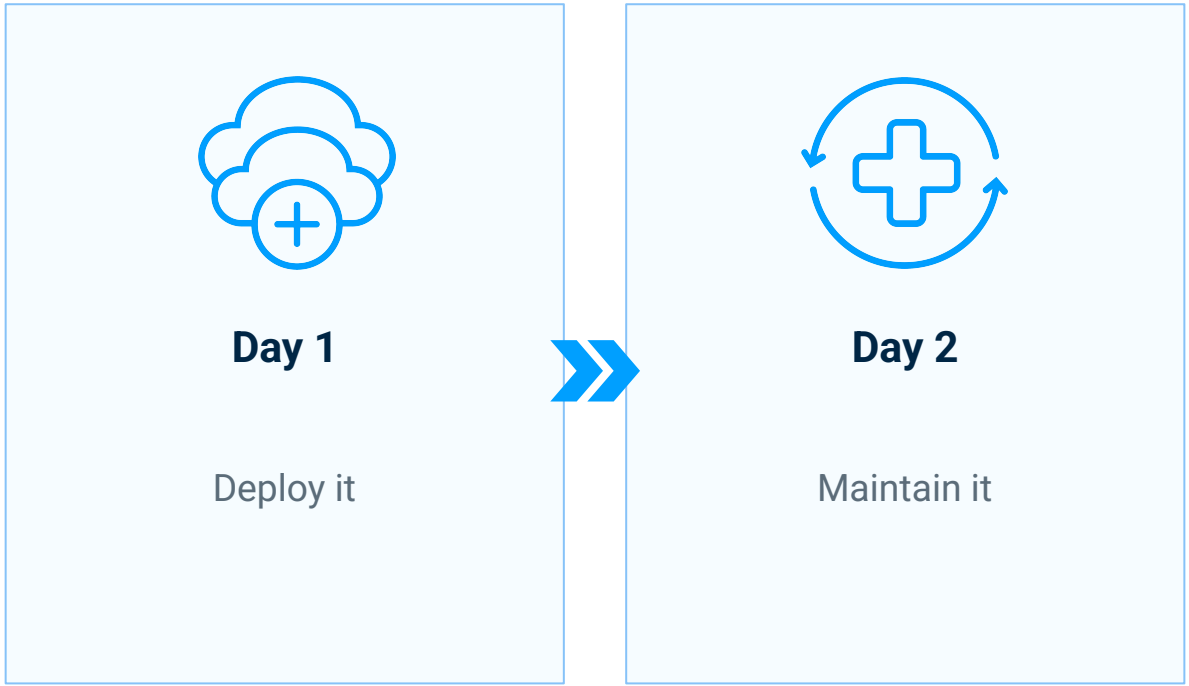
- Intro and overview of Cluster API
- Why Cluster API?
- Cluster API in practise
- Demo
- Wrap-up

Firstly; an apology

CAPI = Cluster API

Overview

The challenge: lifecycle management



Cluster creation isn’t easy

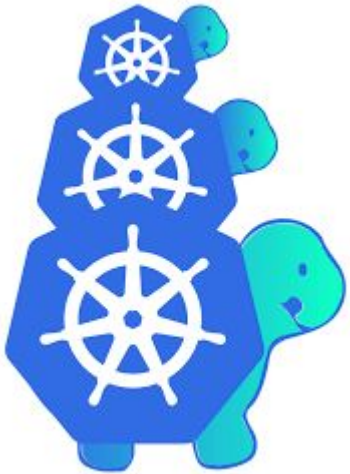
- Networking
- Identity management
- Compute
- Certificate management
- Bootstrapping of core cluster components

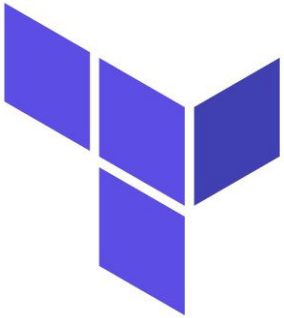
Cluster maintenance also isn’t easy

- Security and vulnerabilities
  - Releases fix vulnerabilities
- Stability and performance
  - Updates patch bugs and improve performance
- Compliance and support limitations
  - Cloud providers often only support the latest three minor versions
- Scaling
  - Clusters may need more resources
- Fault recovery
  - Incidents require remediation

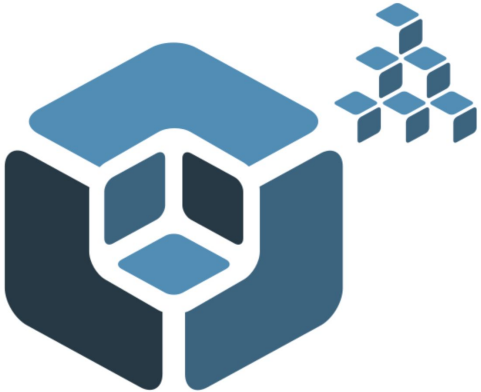
Tools

There are **lots** of options





HashiCorp
Terraform



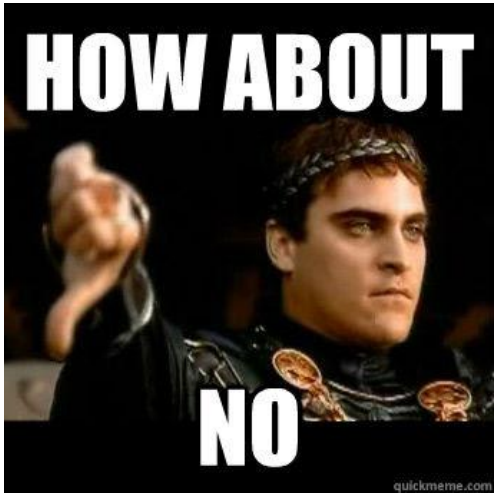
KUBESPRAY

K3S

kops

Why Cluster API?

Manual cluster creation



- Creates snowflakes
  - Clusters are unique and unreproducible
  - Differences happen between environments
- Causes config drift
  - Ad-hoc changes cause deviations
  - You cannot reconcile the desired state vs the actual state
- Requires manual operations
  - Upgrades aren’t smooth
  - Scaling is often slow with a human in the pipeline

What is Cluster API?

> The Cluster API project uses Kubernetes-style APIs and patterns to automate cluster lifecycle management
>
> *SIG Cluster Lifecycle, https://cluster-api.sigs.k8s.io/*

Automated cluster creation

- Automated by controllers
  - Provisioning, configuration and teardown
  - No manual intervention or fragile custom scripts
- Config is declarative
  - The entire cluster is defined in YAML
  - Infra is now immutable and reproducible
- GitOps workflows
  - Desired state can now be stored in Git
  - Single source of truth
  - Versioned

Basic concepts

- Management Cluster
  - A Kubernetes cluster which manages the lifecycle of Workload Clusters
- Workload Cluster
  - A Kubernetes cluster whose lifecycle is managed by a Management Cluster
- Infrastructure Controller
  - Provisions infrastructure required by the cluster
- ControlPlane Controller
  - Manages the control plane
- Bootstrap Controller
  - Turns the infrastructure into a cluster

Cluster

- Cluster is the top-level resource
- Represents the logical cluster
- Provider agnostic
- References:
  - The InfrastructureCluster (e.g. AWSCluster, ProxmoxCluster)
  - The ControlPlane resource

Control plane

- Managed by a control plane provider
- Responsible for:
  - Managing the control plane Machines
  - Managing the services running on the control plane nodes
  - Rolling upgrades and scaling
- References a MachineTemplate for the underlying infrastructure

Worker resources

- Managed by MachineDeployments and MachineSets
- MachineDeployment
  - Defines desired worker count, update strategy etc
  - References a MachineTemplate for the underlying infrastructure
- MachineSet
  - Handles replica management of worker Machines
  - Creates Machine objects (actual VMs)

MachineHealthCheck

- MachineHealthChecks heal your physical infrastructure
- When to heal is defined via health checks
- Safety is provided via remediation guardrails
- Integrates tightly with other Cluster API controllers

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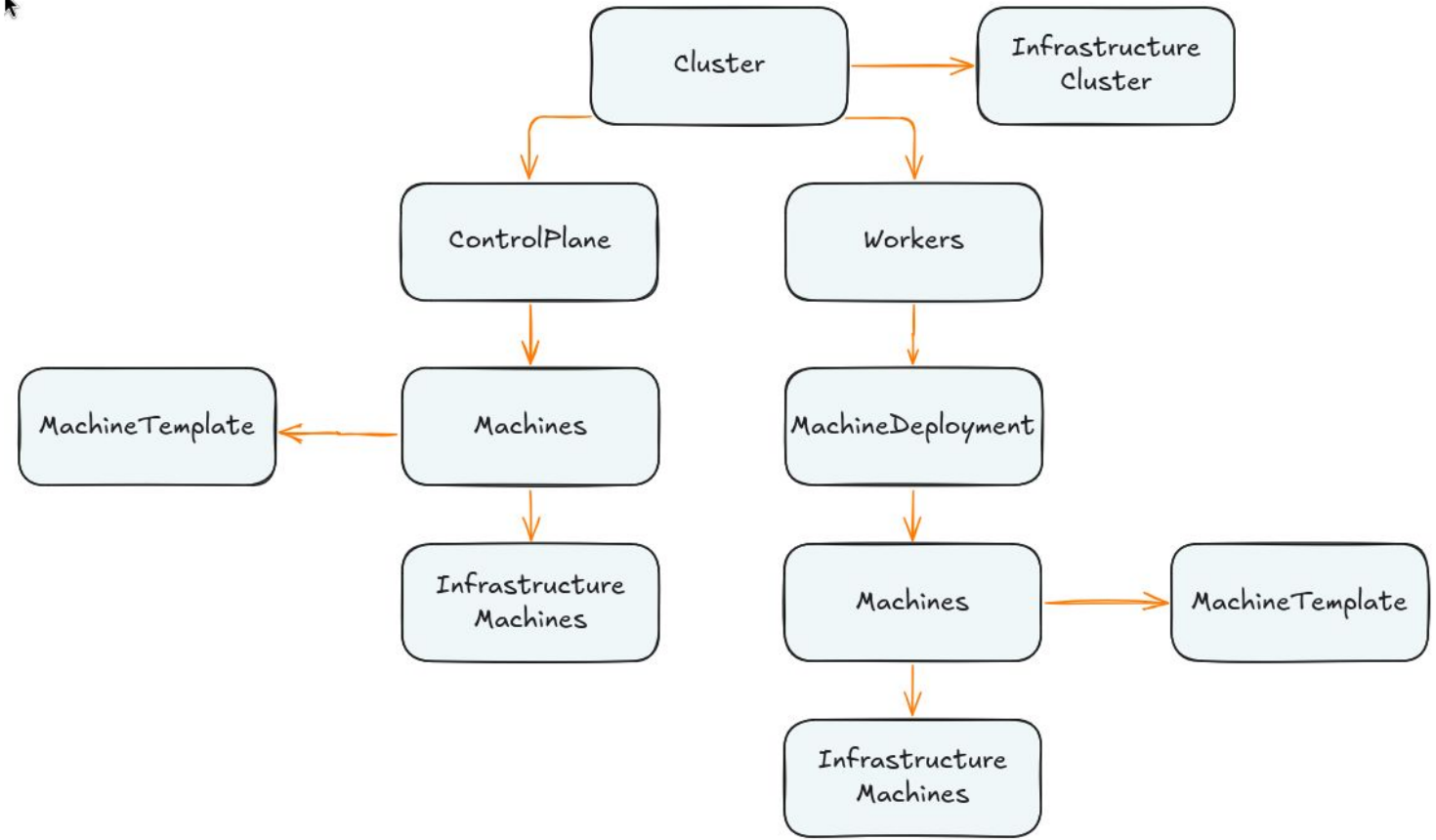
```yaml
apiVersion: cluster.x-k8s.io/v1beta2
kind: MachineHealthCheck
metadata:
  name: worker-health-check
spec:
  clusterName: my-workload-cluster
  selector:
    matchLabels:
      nodepool: worker-pool
  checks:
    nodeStartupTimeoutSeconds: 600
    unhealthyNodeConditions:
      - type: Ready
        status: Unknown
        timeoutSeconds: 300
      - type: Ready
        status: "False"
        timeoutSeconds: 300
  remediation:
    triggerIf:
      unhealthyLessThanOrEqualTo: 20%
```

Putting it all together



Lifecycle management is now easy

Cluster API in practise

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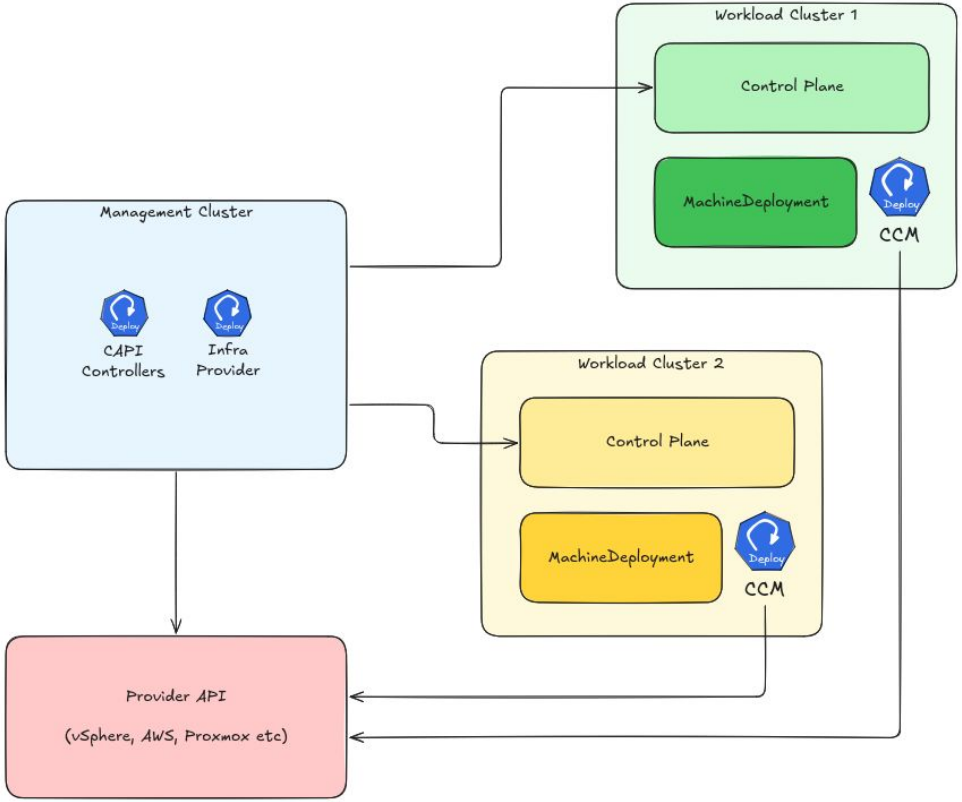
Potential pitfalls

- Version skew can be a problem
- All providers are not equal
- Multiple controllers can make debugging difficult
  - No single pane of glass to identify issues
- MachineTemplates are immutable
- Management Clusters are a single point of failure
- Management Clusters must be able to communicate with the Kubernetes API of the Workload Clusters

Management Architecture



Demo


StarTech.com

Wrap-up

Wrap-up

- Cluster lifecycle management is complex
  - Creation, upgrades, scaling, and recovery all have traps
- Manual approaches lead to drift, unreproducibility, and operational toil.
- Cluster API abstracts complexity with declarative, provider-agnostic automation.
- It standardises lifecycle operations through controllers, YAML, and GitOps workflows.
- There are still pitfalls
  - Version skew, provider maturity, controller sprawl, and management cluster fragility
- Cluster API doesn’t remove complexity - it organises it.

Resources

Slides and resources:

https://github.com/a7d-corp/talks

Cluster API book:

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

Thoughts and feedback:

https://simonweald.com

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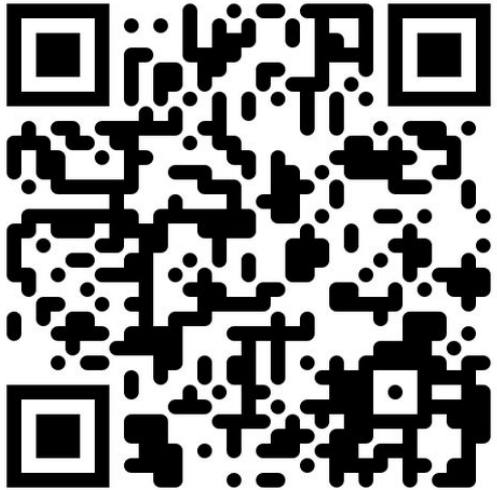


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