THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
EUROPE

Embedded Linux Conference

Own Your Stack

Sovereign Kubernetes from Bare Metal to Fleet

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Sunnatillo Samadov, Ericsson

THE LINUX FOUNDATION



About us



Bharath Nallapeta

- Leads the Open Source Program Office at Mirantis
- Contributor and reviewer, Cluster API Provider OpenStack (CAPO)
- Works on AI infrastructure on Kubernetes



Sunnatillo Samadov

- Open Source Developer, Ericsson
- Maintainer, Metal3
- Release lead, Cluster API v1.9
- Works on bare-metal automation for Kubernetes
- 5+ years in open source

Why sovereignty for AI infrastructure

$80B

Worldwide sovereign cloud IaaS spending in 2026, up 35.6%

15%

European providers' share of their home cloud market since 2022, down from 29% in 2017

19

EuroHPC AI Factories, with up to 7 AI Gigafactories planned

EU Data Act

Applies since 12 Sep 2025. Cloud switching charges banned from 12 Jan 2027.

EU AI Act

High-risk rules for critical infrastructure apply from 2 Dec 2027.

Sources: Gartner, 9 Feb 2026 · Synergy Research, 24 Jul 2025 · EuroHPC JU, 30 Jul 2026 · European Commission, Data Act · Regulation (EU) 2026/1744 (AI Omnibus)

Technical challenges of an AI infrastructure stack

1	**Server provisioning**	GPU servers from different vendors: BMCs, firmware, network boot, OS images
2	**Cluster lifecycle**	Create, upgrade, scale and repair clusters without a cloud API
3	**Fleet consistency**	Same versions, add-ons and policies across racks and sites
4	**Drift**	Manual changes on clusters must be detected and reverted
5	**No lock-in**	Every layer open source and replaceable

Why Kubernetes became the de facto platform

82%
of container users run Kubernetes in production (2023: 66%)

66%
of organizations hosting generative AI use Kubernetes for inference

130,000
nodes in a single Kubernetes cluster (GKE, experimental, Nov 2025)

Declarative API

Extensible with CRDs and operators

GPU allocation with DRA, GA in v1.34

31 certified Kubernetes AI platforms

"Kubernetes is the AI OS."

— Jonathan Bryce, The Linux Foundation & Daniel Krook, CNCF

Sources: CNCF Annual Survey, 20 Jan 2026 · Google Cloud blog, 22 Nov 2025 · Kubernetes blog, 1 Sep 2025 · CNCF, 24 Mar 2026

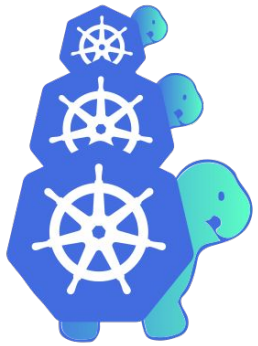
The open-source AI infrastructure stack

AI workloads	Training, inference, model serving
k0rdent	Fleet management: templates, services, drift detection
Cluster API	Declarative cluster lifecycle, 40+ infrastructure providers
Metal3	Inspect, provision and clean servers through the BMC
Bare-metal GPU servers	Hardware you operate

Every layer is open source. Metal3 is a CNCF Incubating project. Cluster API is a Kubernetes SIG Cluster Lifecycle subproject.

Sources: Cluster API book, provider list · CNCF, Metal3 project page · kubernetes-sigs/cluster-api

Cluster API



Cluster API

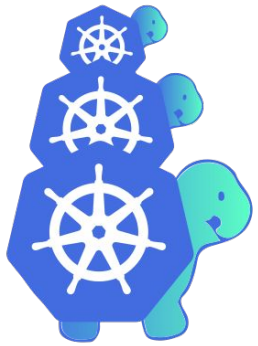
- CAPI provider AWS
- CAPI provider Azure
- CAPI provider GCP
- CAPI provider OpenStack

Public and private clouds

Virtual machines

Source: [Cluster API book, provider list (42 infrastructure providers, Oct 2026)]

Cluster API



Cluster API

- CAPI provider AWS
- CAPI provider Azure
- CAPI provider GCP
- CAPI provider OpenStack

Public and private clouds

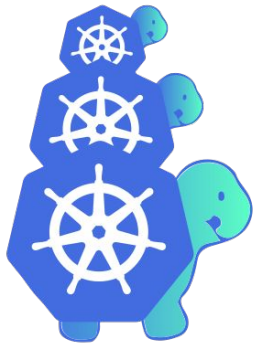
Virtual machines

Bare-metal servers

Physical machines

Source: [Cluster API book, provider list (42 infrastructure providers, Oct 2026)]

Metal3



Cluster API

- CAPI provider AWS
- CAPI provider Azure
- CAPI provider GCP
- CAPI provider OpenStack
- **CAPI provider Metal3**

Public and private clouds

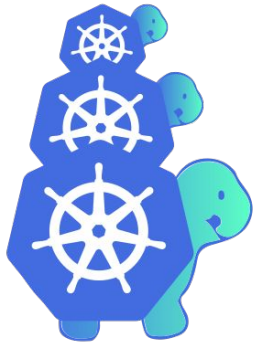
Virtual machines

Bare-metal servers

Physical machines

Source: [Cluster API book, provider list (42 infrastructure providers, Oct 2026)]

Metal3



Cluster API

CAPI provider GCP

CAPI provider Metal3

Google Cloud

API

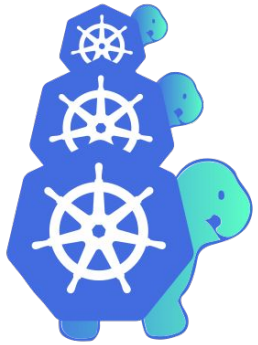
?

Bare-metal servers

Physical machines

Source: Cluster API book, provider list (42 infrastructure providers, Oct 2026)

Metal3



Cluster API

CAPI provider GCP

CAPI provider Metal3

Google Cloud

API

IRONIC

Bare-metal servers

Physical machines

Source: [Cluster API book, provider list (42 infrastructure providers, Oct 2026)]

Ironic



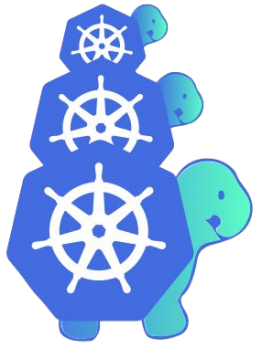
Manages the full server lifecycle through one REST API: enroll, inspect, provision, clean.

Drivers handle vendor differences:

- **Redfish**
- **IPMI**
- **Dell iDRAC**
- **HP ILO**

Written in Python. Part of OpenStack.

Metal3



Cluster API

CAPI provider GCP

CAPI provider Metal3

Google Cloud

API

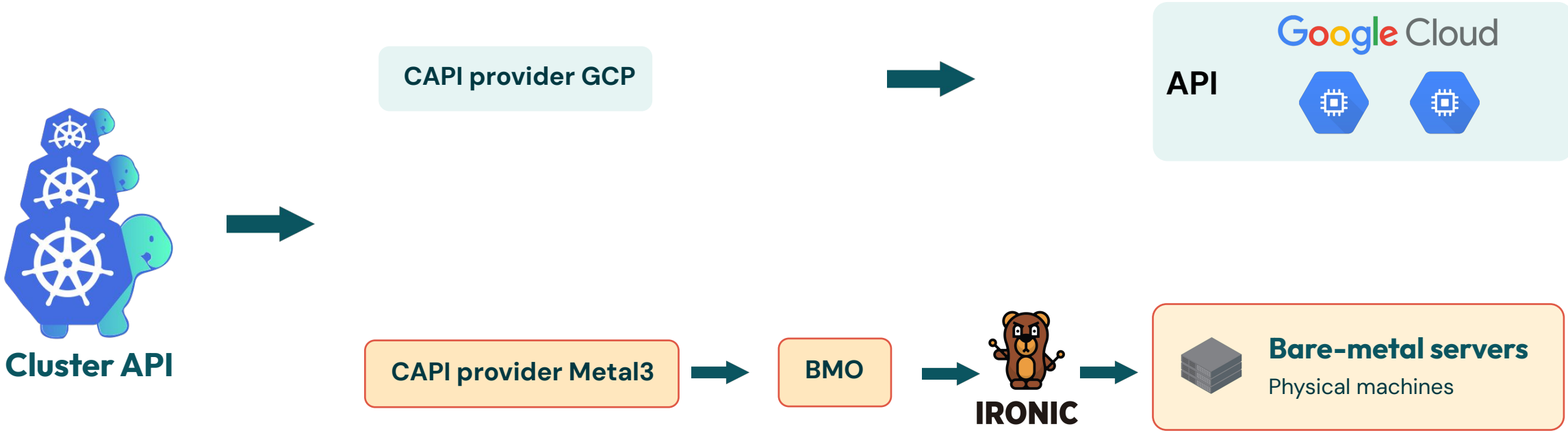
IRONIC

Bare-metal servers

Physical machines

Source: [Cluster API book, provider list (42 infrastructure providers, Oct 2026)]

Metal3



Source: [Cluster API book, provider list (42 infrastructure providers, Oct 2026)]

The Metal3 stack, layer by layer

Component	Kubernetes object it manages
Cluster API	Machine
CAPM3 · Cluster API provider Metal3	Metal3Machine
Bare Metal Operator	BareMetalHost



BareMetal server

Cluster API creates a Machine. CAPM3 binds it to a free BareMetalHost. BMO tells Ironic to inspect the server, write the OS image and boot it through the BMC. Each layer keeps its own object and status.

Metal3 features

Remediation

An unhealthy node gets power-cycled through its BMC

Upgrade

Chained upgrades and in-place upgrades

Self-management (pivoting)

Move the controllers into the managed cluster

Automated cleaning

Disks are wiped before a host is reused

Scale testing

1,000 clusters

Node reuse

Get the same host back after an upgrade or change

CNCF Incubating since Aug 2025. Adopters: Ericsson, Fujitsu, IKEA, Red Hat and SUSE.

Sources: CNCF, 27 Aug 2025 · Metal3 blog, Scaling part 3, 30 May 2024

k0rdent architecture

k0RDENT

MANAGEMENT CLUSTER

KCM

k0rdent Cluster Manager

Cluster lifecycle: ClusterTemplate, ClusterDeployment, Credential

Built on Cluster API, k0smotron, Flux

KSM

k0rdent State Manager

Service lifecycle: ServiceTemplate, MultiClusterService

Built on Project Sveltos

KOF

k0rdent Observability and FinOps

Metrics, logs, traces and cost across clusters

Built on VictoriaMetrics, OpenTelemetry, OpenCost



Child clusters Created by KCM through any Cluster API provider. Services installed by KSM. Telemetry collected by KOF.

k0rdent capabilities

k0RDENT

Open-source multi-cluster management built on Cluster API. Runs on the management cluster.

Templates

ClusterTemplate: versioned, reusable cluster definitions.

Services and policy

ServiceTemplate and MultiClusterService: deploy add-ons and policies to clusters selected by label.

Drift detection

Sveltos detects and reverts manual changes on managed clusters.

Other Cluster API providers can be added to the same management cluster.

Adding Metal3 to kOrdent

kOrdent takes any Cluster API provider through templates.

Metal3 plugs in with one provider template and one cluster template, using kOrdent's standard extension points.

PROVIDERTEMPLATE

`cluster-api-provider-metal3`

Installs CAPM3, Metal3 IPAM, the kubeadm providers and a ProviderInterface

CLUSTERTEMPLATE

`metal3-cluster`

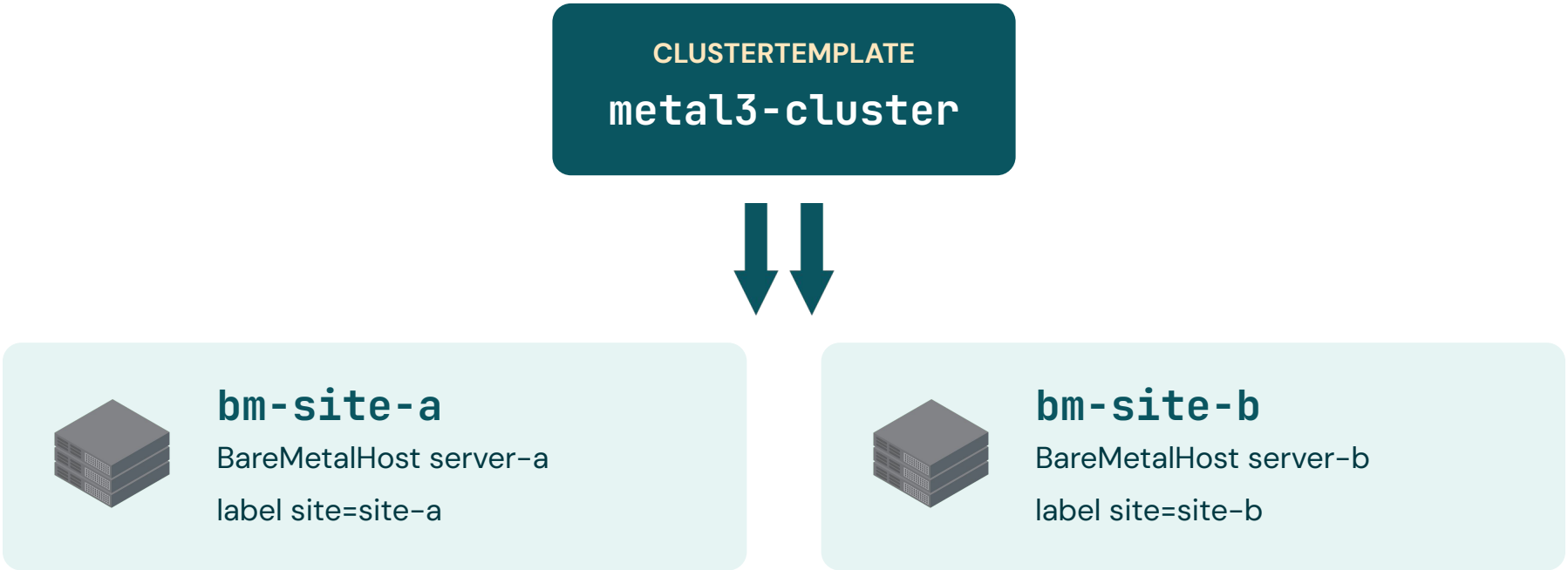
Renders a kubeadm cluster onto BareMetalHosts

ON THE MANAGEMENT CLUSTER

`BMO + Ironic`

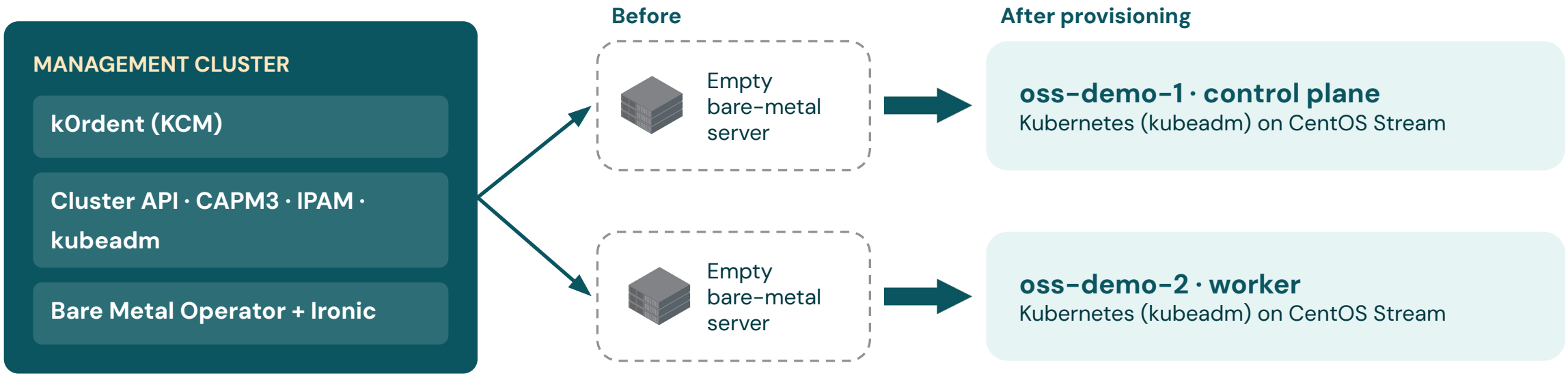
Run next to the Cluster API providers and manage the BareMetalHosts

One template, multiple clusters



Each ClusterDeployment selects its servers by label.

Demo setup



One management cluster turns two empty servers into one Kubernetes cluster: a control plane and a worker.

Demo



Trade-offs

Slower scale-out

A physical server takes minutes to boot and image. A cloud VM takes seconds.

Planned capacity

No on-demand burst. Servers, spare hosts and GPU purchases are planned ahead.

No managed services

Load balancers, block storage and DNS are yours to run, for example with MetalLB and Ceph.

Hardware operations

Firmware updates, BMC security and replacing failed parts are your responsibility.



Get involved

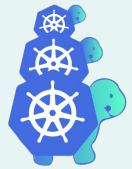
All three projects are open source and accept contributions.



Metal3

metal3.io

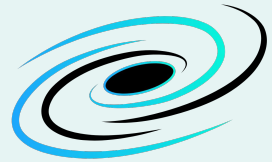
github.com/metal3-io



Cluster API

cluster-api.sigs.k8s.io

SIG Cluster Lifecycle



k0rdent

k0rdent.io

github.com/k0rdent

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Questions?

Thank you!



Bharath



Sunnatillo

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