Metal³ - Kubernetes-Native Bare Metal Host Management

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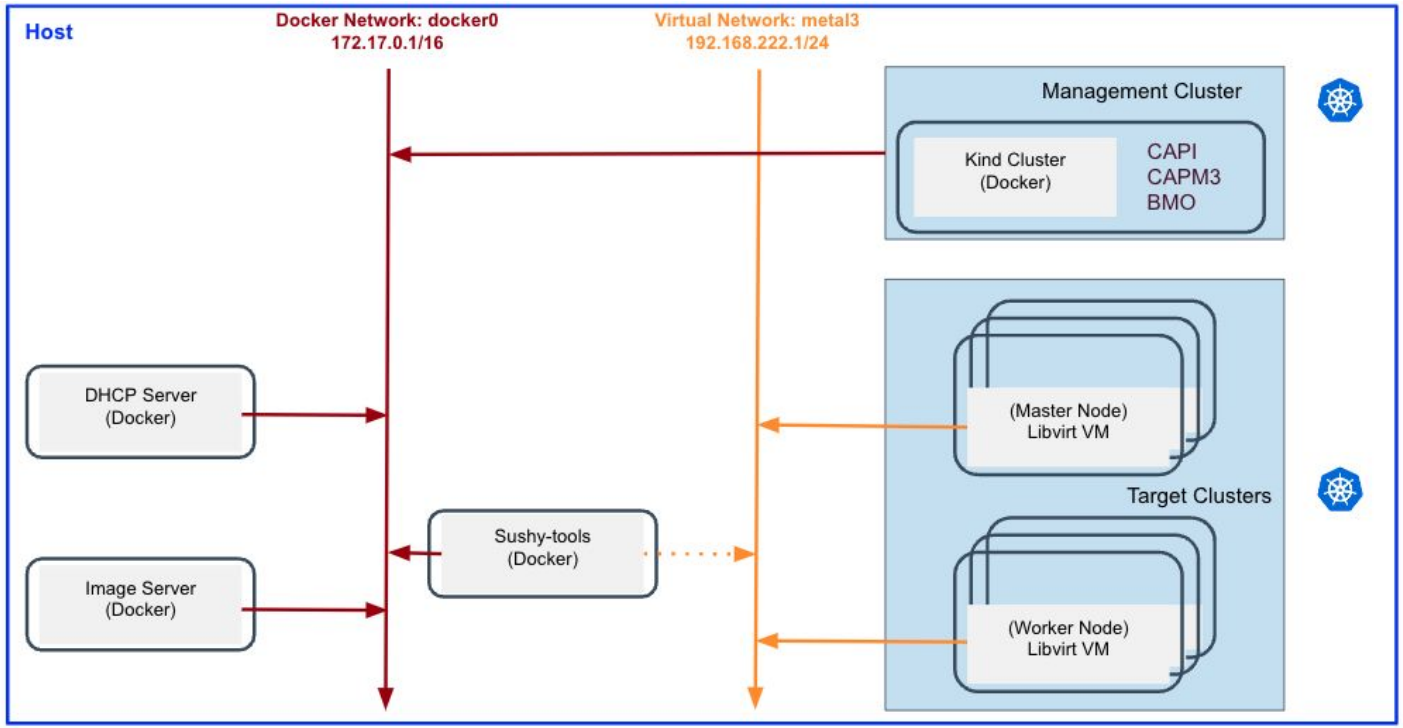
Agenda

- Metal³: Overview
- Demos and Diagrams for
  - Workflow from **Bare Metal Machine** to **k8s CRD BareMetalHost**
  - Workflow from **k8s CRD BareMetalHost** to **Workload Cluster's Node**

Metal³: Demo Env



Ironic: Ironic → vBMC → IPMI [4]

```
root@metal3-ThinkPad-T14p-Gen-1:~# virsh list --all
 Id   Name   State
----------------------
 6    vm1    running
 -    vm2    shut off

root@metal3-ThinkPad-T14p-Gen-1:~# vbmc add vm1 --port 6231 --address 192.168.122.1 --libvirt-uri qemu+ssh://root@192.168.122.1/system --username admin --password admin
root@metal3-ThinkPad-T14p-Gen-1:~# vbmc add vm2 --port 6232 --address 192.168.122.1 --libvirt-uri qemu+ssh://root@192.168.122.1/system --username admin --password admin
root@metal3-ThinkPad-T14p-Gen-1:~# vbmc list
+-------------+--------+--------------+------+
| Domain name | Status | Address      | Port |
+-------------+--------+--------------+------+
| vm1         | down   | 192.168.122.1 | 6231 |
| vm2         | down   | 192.168.122.1 | 6232 |
+-------------+--------+--------------+------+
root@metal3-ThinkPad-T14p-Gen-1:~# vbmc start vm1
root@metal3-ThinkPad-T14p-Gen-1:~# vbmc start vm2
root@metal3-ThinkPad-T14p-Gen-1:~# vbmc list
+-------------+---------+--------------+------+
| Domain name | Status  | Address      | Port |
+-------------+---------+--------------+------+
| vm1         | running | 192.168.122.1 | 6231 |
| vm2         | running | 192.168.122.1 | 6232 |
+-------------+---------+--------------+------+
root@metal3-ThinkPad-T14p-Gen-1:~# ipmitool -I lanplus -U admin -P admin -H 192.168.122.1 -p 6231 power off
Chassis Power Control: Down/Off
root@metal3-ThinkPad-T14p-Gen-1:~# ipmitool -I lanplus -U admin -P admin -H 192.168.122.1 -p 6232 power on
Chassis Power Control: Up/On
root@metal3-ThinkPad-T14p-Gen-1:~# virsh list --all
 Id   Name   State
----------------------
 7    vm2    running
 -    vm1    shut off
```

Ironic: Ironic → sushy-tools (redfish RestAPI) → Libvirt driver

```
root@metal3-ThinkPad-T14p-Gen-1:~# cat sushy-tools.conf
# Listen on 192.168.222.1:8000
SUSHY_EMULATOR_LISTEN_IP = u'192.168.222.1'
SUSHY_EMULATOR_LISTEN_PORT = 8000
# The libvirt URI to use. This option enables libvirt driver.
SUSHY_EMULATOR_LIBVIRT_URI = u'qemu:///system'

root@metal3-ThinkPad-T14p-Gen-1:~# docker run --name sushy-tools --rm --network host -d \
  -v /var/run/libvirt:/var/run/libvirt \
  -v "/root/sushy-tools.conf:/etc/sushy/sushy-emulator.conf" \
  -e SUSHY_EMULATOR_CONFIG=/etc/sushy/sushy-emulator.conf \
  quay.io/metal3-io/sushy-tools:latest sushy-emulator
03ec7aba7075dfd7227fcaa1ebb07b16533f524578ded8891f20f69784fa1a04
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~# docker container ps -a | grep sushy-tools
03ec7aba7075   quay.io/metal3-io/sushy-tools:latest   "sushy-emulator"
```

```
root@metal3-ThinkPad-T14p-Gen-1:~# virsh list --all
 Id   Name        State
---------------------------
 9    bmh-vm-01   running
 10   bmh-vm-02   running

root@metal3-ThinkPad-T14p-Gen-1:~# virsh domuuid bmh-vm-01
3dae22f3-a707-4c11-a982-5cb24cadbd0b

root@metal3-ThinkPad-T14p-Gen-1:~# virsh domuuid bmh-vm-02
793a6fbf-355b-4a47-a85f-5d6668e70afd

root@metal3-ThinkPad-T14p-Gen-1:~# curl -s http://192.168.222.1:8000/redfish/v1/Systems | jq '.Members'
[
  {
    "@odata.id": "/redfish/v1/Systems/3dae22f3-a707-4c11-a982-5cb24cadbd0b"
  },
  {
    "@odata.id": "/redfish/v1/Systems/793a6fbf-355b-4a47-a85f-5d6668e70afd"
  }
]
```

Deployment: DHCP and Image services

```
root@metal3-ThinkPad-T14p-Gen-1:~# cat dnsmasq.env
DHCP_HOSTS=00:60:2f:31:81:01;00:60:2f:31:81:02
DHCP_IGNORE=tag:!known
# IP of the host from VM perspective
PROVISIONING_IP=192.168.222.1
GATEWAY_IP=192.168.222.1
DHCP_RANGE=192.168.222.100,192.168.222.149

root@metal3-ThinkPad-T14p-Gen-1:~# docker run --name dnsmasq --rm -d --net=host --privileged --user 997:994 \
  --env-file dnsmasq.env --entrypoint /bin/rundnsmasq \
  quay.io/metal3-io/ironic
0ea994e899ba3da0c16e8e74ea225872d372191df1e249f1fd6ee4c1dccee7f9
root@metal3-ThinkPad-T14p-Gen-1:~# docker container ps -a | grep dnsmasq
0ea994e899ba   quay.io/metal3-io/ironic              "/bin/rundnsmasq"        About a minute ago   Up About a minute
```

DHCP server

OpenStack: Neutron DHCP agent (dnsmasq)

OpenStack: Glance

```
root@metal3-ThinkPad-T14p-Gen-1:~# ls -l disk-images/
total 3485892
-rw-r--r-- 1 root root 2270668288  8月  9 10:40 CENTOS_9_NODE_IMAGE_K8S_v1.29.0.qcow2
-rw-r--r-- 1 root root 1210159616  8月  9 10:35 CentOS-Stream-GenericCloud-9-latest.x86_64.qcow2
-rw-r--r-- 1 root root        194  8月  9 10:35 CentOS-Stream-GenericCloud-9-latest.x86_64.qcow2.SHA256SUM
-rw-r--r-- 1 root root   88702976  8月  9 10:58 jammy-server-cloudimg-amd64.img
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~# docker run --name image-server --rm -d -p 80:8080 \
  -v "/root/disk-images:/usr/share/nginx/html" nginxinc/nginx-unprivileged
f795498d060a5f49445c6d3b65a19a5ff848ebf76b8af570eb42c429a1fe9fad
root@metal3-ThinkPad-T14p-Gen-1:~# curl --head http://127.0.0.1:80/CENTOS_9_NODE_IMAGE_K8S_v1.29.0.qcow2
HTTP/1.1 200 OK
Server: nginx/1.27.0
Date: Fri, 09 Aug 2024 03:04:00 GMT
Content-Type: application/octet-stream
Content-Length: 2270668288
Last-Modified: Fri, 09 Aug 2024 02:40:28 GMT
Connection: keep-alive
ETag: "66b5819c-8757a600"
Accept-Ranges: bytes
```

Image server

Deployment: bootstrap k8s cluster

```
root@metal3-ThinkPad-T14p-Gen-1:~# cat kind.yaml
kind: Cluster
apiVersion: kind.x-k8s.io/v1alpha4
nodes:
- role: control-plane
  # Open ports for Ironic
  extraPortMappings:
  # Ironic httpd
  - containerPort: 6180
    hostPort: 6180
    listenAddress: "0.0.0.0"
    protocol: TCP
  # Ironic API
  - containerPort: 6385
    hostPort: 6385
    listenAddress: "0.0.0.0"
    protocol: TCP
  # Inspector API
  - containerPort: 5050
    hostPort: 5050
    listenAddress: "0.0.0.0"
    protocol: TCP
```

```
root@metal3-ThinkPad-T14p-Gen-1:~# kind create cluster --config kind.yaml
Creating cluster "kind" ...
 ✓ Ensuring node image (kindest/node:v1.30.0) 🖼
 ✓ Preparing nodes 📦
 ✓ Writing configuration 📜
 ✓ Starting control-plane 🕹️
 ✓ Installing CNI 🔌
 ✓ Installing StorageClass 💾
Set kubectl context to "kind-kind"
You can now use your cluster with:

kubectl cluster-info --context kind-kind
```

```
root@metal3-ThinkPad-T14p-Gen-1:~# docker container ps -a
CONTAINER ID   IMAGE                  COMMAND                  CREATED         STATUS         PORTS
                                                                                                NAMES
8cf051f5858d   kindest/node:v1.30.0   "/usr/local/bin/entr…"   2 minutes ago   Up 2 minutes   0.0.0.0:5050->5050/tcp,
0.0.0.0:6180->6180/tcp, 0.0.0.0:6385->6385/tcp, 127.0.0.1:37003->6443/tcp   kind-control-plane
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get pods -A
NAMESPACE            NAME                                         READY   STATUS    RESTARTS   AGE
kube-system          coredns-7db6d8ff4d-dzfxk                     1/1     Running   0          2m15s
kube-system          coredns-7db6d8ff4d-trjs6                     1/1     Running   0          2m15s
kube-system          etcd-kind-control-plane                      1/1     Running   0          2m30s
kube-system          kindnet-wlncg                                1/1     Running   0          2m15s
kube-system          kube-apiserver-kind-control-plane            1/1     Running   0          2m30s
kube-system          kube-controller-manager-kind-control-plane   1/1     Running   0          2m30s
kube-system          kube-proxy-b96kc                             1/1     Running   0          2m15s
kube-system          kube-scheduler-kind-control-plane            1/1     Running   0          2m30s
local-path-storage   local-path-provisioner-988d74bc-hjt2j        1/1     Running   0          2m15s
```

Deployment: cert-manager [5][6]

```
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl apply -f cert-manager.yaml
namespace/cert-manager created
customresourcedefinition.apiextensions.k8s.io/certificaterequests.cert-manager.io created
customresourcedefinition.apiextensions.k8s.io/certificates.cert-manager.io created
customresourcedefinition.apiextensions.k8s.io/challenges.acme.cert-manager.io created
customresourcedefinition.apiextensions.k8s.io/clusterissuers.cert-manager.io created
customresourcedefinition.apiextensions.k8s.io/issuers.cert-manager.io created
customresourcedefinition.apiextensions.k8s.io/orders.acme.cert-manager.io created
serviceaccount/cert-manager-cainjector created
serviceaccount/cert-manager created
serviceaccount/cert-manager-webhook created
clusterrole.rbac.authorization.k8s.io/cert-manager-cainjector created
clusterrole.rbac.authorization.k8s.io/cert-manager-controller-issuers created
clusterrole.rbac.authorization.k8s.io/cert-manager-controller-clusterissuers created
clusterrole.rbac.authorization.k8s.io/cert-manager-controller-certificates created
clusterrole.rbac.authorization.k8s.io/cert-manager-controller-orders created
clusterrole.rbac.authorization.k8s.io/cert-manager-controller-challenges created
clusterrole.rbac.authorization.k8s.io/cert-manager-controller-ingress-shim created
clusterrole.rbac.authorization.k8s.io/cert-manager-cluster-view created
clusterrole.rbac.authorization.k8s.io/cert-manager-view created
clusterrole.rbac.authorization.k8s.io/cert-manager-edit created
clusterrole.rbac.authorization.k8s.io/cert-manager-controller-approve:cert-manager-io created
clusterrole.rbac.authorization.k8s.io/cert-manager-controller-certificatesigningrequests created
clusterrole.rbac.authorization.k8s.io/cert-manager-webhook:subjectaccessreviews created
clusterrolebinding.rbac.authorization.k8s.io/cert-manager-cainjector created
clusterrolebinding.rbac.authorization.k8s.io/cert-manager-controller-issuers created
clusterrolebinding.rbac.authorization.k8s.io/cert-manager-controller-clusterissuers created
clusterrolebinding.rbac.authorization.k8s.io/cert-manager-controller-certificates created
clusterrolebinding.rbac.authorization.k8s.io/cert-manager-controller-orders created
clusterrolebinding.rbac.authorization.k8s.io/cert-manager-controller-challenges created
clusterrolebinding.rbac.authorization.k8s.io/cert-manager-controller-ingress-shim created
clusterrolebinding.rbac.authorization.k8s.io/cert-manager-controller-approve:cert-manager-io created
clusterrolebinding.rbac.authorization.k8s.io/cert-manager-controller-certificatesigningrequests created
clusterrolebinding.rbac.authorization.k8s.io/cert-manager-webhook:subjectaccessreviews created
role.rbac.authorization.k8s.io/cert-manager-cainjector:leaderelection created
role.rbac.authorization.k8s.io/cert-manager:leaderelection created
role.rbac.authorization.k8s.io/cert-manager-webhook:dynamic-serving created
rolebinding.rbac.authorization.k8s.io/cert-manager-cainjector:leaderelection created
rolebinding.rbac.authorization.k8s.io/cert-manager:leaderelection created
rolebinding.rbac.authorization.k8s.io/cert-manager-webhook:dynamic-serving created
service/cert-manager created
service/cert-manager-webhook created
deployment.apps/cert-manager-cainjector created
deployment.apps/cert-manager created
deployment.apps/cert-manager-webhook created
mutatingwebhookconfiguration.admissionregistration.k8s.io/cert-manager-webhook created
validatingwebhookconfiguration.admissionregistration.k8s.io/cert-manager-webhook created
```

```
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get pods -n cert-manager
NAME                                       READY   STATUS    RESTARTS   AGE
cert-manager-c96b66c4c-rkksp               1/1     Running   0          3h22m
cert-manager-cainjector-54668df7b7-6stt2   1/1     Running   0          3h22m
cert-manager-webhook-5bdfbff59c-9f4n7      1/1     Running   0          3h22m
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get deployment -n cert-manager
NAME                      READY   UP-TO-DATE   AVAILABLE   AGE
cert-manager              1/1     1            1           3h23m
cert-manager-cainjector   1/1     1            1           3h23m
cert-manager-webhook      1/1     1            1           3h23m
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get svc -n cert-manager
NAME                  TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)    AGE
cert-manager          ClusterIP   10.96.192.76    <none>        9402/TCP   3h23m
cert-manager-webhook  ClusterIP   10.96.142.98    <none>        443/TCP    3h23m
```

Deployment: Ironic

```
root@metal3-ThinkPad-T14p-Gen-1:~# tree ironic
ironic
├── ironic-auth-config
├── ironic_bmo.env
├── ironic-htpasswd
├── ironic-inspector-auth-config
├── ironic-inspector-htpasswd
├── ironic-patch.yaml
└── kustomization.yaml

0 directories, 7 files
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl apply -k ironic
namespace/baremetal-operator-system created
configmap/ironic-bmo-configmap-62d56kgg9b created
secret/ironic-auth-config-bg7m7k8m4g created
secret/ironic-htpasswd-d5k7t7m64b created
secret/ironic-inspector-auth-config-45b7m2mbm7 created
secret/ironic-inspector-htpasswd-5f2f82b75k created
deployment.apps/ironic created
certificate.cert-manager.io/ironic-cacert created
certificate.cert-manager.io/ironic-cert created
issuer.cert-manager.io/ca-issuer created
issuer.cert-manager.io/selfsigned-issuer created
```

```
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get deployments -n baremetal-operator-system
NAME     READY   UP-TO-DATE   AVAILABLE   AGE
ironic   1/1     1            1           14m
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get pods -n baremetal-operator-system
NAME                      READY   STATUS    RESTARTS   AGE
ironic-6494c4f65-zwjgg    3/3     Running   0          13m
```

Deployment: baremetal-operator (1)

```
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl apply -k bmo/
namespace/baremetal-operator-system unchanged
customresourcedefinition.apiextensions.k8s.io/baremetalhosts.metal3.io created
customresourcedefinition.apiextensions.k8s.io/bmceventsubscriptions.metal3.io created
customresourcedefinition.apiextensions.k8s.io/dataimages.metal3.io created
customresourcedefinition.apiextensions.k8s.io/firmwareschemas.metal3.io created
customresourcedefinition.apiextensions.k8s.io/hardwaredata.metal3.io created
customresourcedefinition.apiextensions.k8s.io/hostfirmwarecomponents.metal3.io created
customresourcedefinition.apiextensions.k8s.io/hostfirmwaresettings.metal3.io created
customresourcedefinition.apiextensions.k8s.io/preprovisioningimages.metal3.io created
serviceaccount/baremetal-operator-controller-manager created
role.rbac.authorization.k8s.io/baremetal-operator-leader-election-role created
clusterrole.rbac.authorization.k8s.io/baremetal-operator-manager-role created
clusterrole.rbac.authorization.k8s.io/baremetal-operator-metrics-reader created
clusterrole.rbac.authorization.k8s.io/baremetal-operator-proxy-role created
rolebinding.rbac.authorization.k8s.io/baremetal-operator-leader-election-rolebinding created
clusterrolebinding.rbac.authorization.k8s.io/baremetal-operator-manager-rolebinding created
clusterrolebinding.rbac.authorization.k8s.io/baremetal-operator-proxy-rolebinding created
configmap/baremetal-operator-manager-config created
configmap/ironic created
secret/ironic-credentials created
secret/ironic-inspector-credentials created
service/baremetal-operator-controller-manager-metrics-service created
service/baremetal-operator-webhook-service created
deployment.apps/baremetal-operator-controller-manager created
certificate.cert-manager.io/baremetal-operator-serving-cert created
issuer.cert-manager.io/baremetal-operator-selfsigned-issuer created
validatingwebhookconfiguration.admissionregistration.k8s.io/baremetal-operator-validating-webhook-configuration created
```

```
root@metal3-ThinkPad-T14p-Gen-1:~# tree bmo/
bmo/
├── ironic.env
├── ironic-inspector-password
├── ironic-inspector-username
├── ironic-password
├── ironic-username
└── kustomization.yaml

0 directories, 6 files
```

Deployment: baremetal-operator (2)

```
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get services -n baremetal-operator-system
NAME                                                TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)    AGE
baremetal-operator-controller-manager-metrics-service   ClusterIP   10.96.115.226   <none>        8443/TCP   2m30s
baremetal-operator-webhook-service                  ClusterIP   10.96.253.200   <none>        443/TCP    2m30s
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get deployments -n baremetal-operator-system
NAME                                READY   UP-TO-DATE   AVAILABLE   AGE
baremetal-operator-controller-manager   1/1     1            1           2m47s
ironic                              1/1     1            1           19m
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get pods -n baremetal-operator-system
NAME                                                READY   STATUS    RESTARTS   AGE
baremetal-operator-controller-manager-6b798b7865-5wbwm   2/2     Running   0          3m3s
ironic-6494c4f65-zwjgg                              3/3     Running   0          17m
```

Deployment: BareMetalHost (CRD) (1)

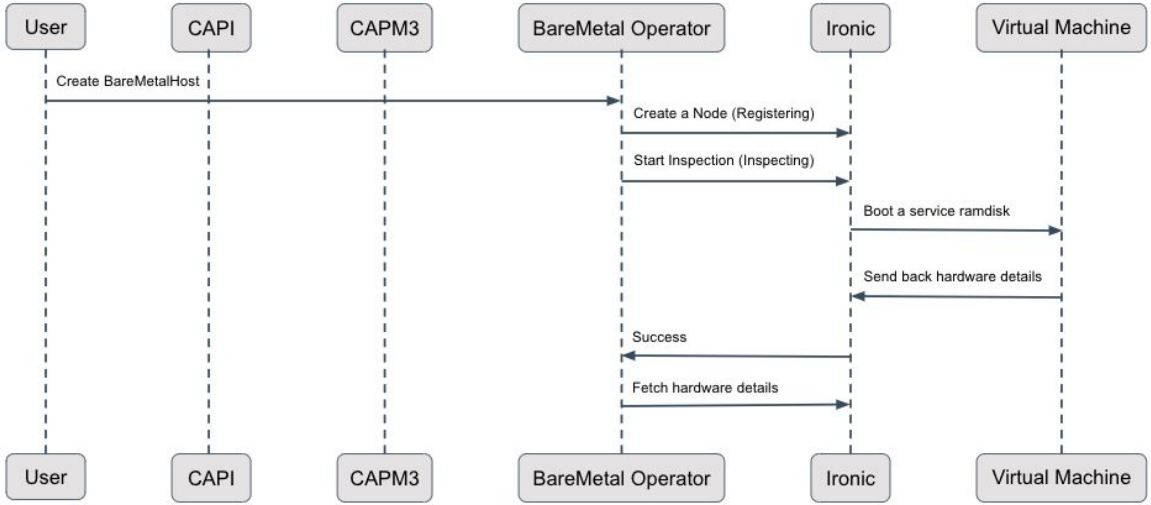
```
root@metal3-ThinkPad-T14p-Gen-1:~# cat bmh-vm-02.yaml
apiVersion: v1
kind: Secret
metadata:
  name: bml-02
type: Opaque
stringData:
  username: replaceme
  password: replaceme

---
apiVersion: metal3.io/v1alpha1
kind: BareMetalHost
metadata:
  name: bml-vm-02
spec:
  online: true
  bootMACAddress: 00:60:2f:31:81:02
  bootMode: UEFI # use 'legacy' for Scenario 2
  hardwareProfile: libvirt
  bmc:
    address: redfish-virtualmedia+http://192.168.222.1:8000/redfish/v1/Systems/793a6fbf-355b-4a47-a85f-5d6668e70afd
    credentialsName: bml-02

root@metal3-ThinkPad-T14p-Gen-1:~# kubectl apply -f bmh-vm-02.yaml
secret/bml-02 created
baremetalhost.metal3.io/bml-vm-02 created
```

```
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get bmh -A
NAMESPACE   NAME        STATE       CONSUMER   ONLINE   ERROR   AGE
default     bml-vm-01   available              true             9m47s
default     bml-vm-02   available              true             3m16s
```

Deployment: BareMetalHost (CRD) (2)

{"level":"info","ts":1723187450.737525,"logger":"controllers.BareMetalHost","msg":"new credentials","baremetalhost":{"name":"bml-vm-01","namespace":"default"},"provisioningState":"registering"}
{"level":"info","ts":1723187450.74549,"logger":"provisioner.ironic","msg":"looking for existing node by MAC","host":"default~bml-vm-01","MAC":"00:60:2f:31:81:01"}
{"level":"info","ts":1723187450.749142,"logger":"provisioner.ironic","msg":"port with address doesn't exist","host":"default~bml-vm-01","MAC":"00:60:2f:31:81:01"}
{"level":"info","ts":1723187450.7491608,"logger":"provisioner.ironic","msg":"registering host in ironic","host":"default~bml-vm-01"}
{"level":"info","ts":1723187450.7837772,"logger":"provisioner.ironic","msg":"creating PXE enabled ironic port for node","host":"default~bml-vm-01","NodeUUID":"1dc1e6be-70c2-4176-8cf0-7a8335030aa7","MAC":"00:60:2f:31:81:01"}
{"level":"info","ts":1723187450.8183138,"logger":"controllers.BareMetalHost","msg":"saving host status","baremetalhost":{"name":"bml-vm-01","namespace":"default"},"provisioningState":"registering","operational status":"OK","provisioning state":"registering"}
{"level":"info","ts":1723187450.822675,"logger":"controllers.BareMetalHost","msg":"publishing event","baremetalhost":{"name":"bml-vm-01","namespace":"default"},"reason":"Registered","message":"Registered new host"}
{"level":"info","ts":1723187460.9433064,"logger":"controllers.BareMetalHost","msg":"changing provisioning state","baremetalhost":{"name":"bml-vm-01","namespace":"default"},"provisioningState":"registering","old":"registering","new":"inspecting"}
{"level":"info","ts":1723187460.9433167,"logger":"controllers.BareMetalHost","msg":"saving host status","baremetalhost":{"name":"bml-vm-01","namespace":"default"},"provisioningState":"registering","operational status":"OK","provisioning state":"inspecting"}
{"level":"info","ts":1723187460.9473038,"logger":"controllers.BareMetalHost","msg":"publishing event","baremetalhost":{"name":"bml-vm-01","namespace":"default"},"reason":"BMCAccessValidated","message":"Verified access to BMC"}
{"level":"info","ts":1723187460.9690096,"logger":"provisioner.ironic","msg":"retrieved BIOS settings for node","host":"default~bml-vm-01","node":"1dc1e6be-70c2-4176-8cf0-7a8335030aa7","size":10}
{"level":"info","ts":1723187460.9820738,"logger":"provisioner.ironic","msg":"firmware component added for node","host":"default~bml-vm-01","component":"bios","node":"1dc1e6be-70c2-4176-8cf0-7a8335030aa7"}
{"level":"info","ts":1723187460.9820952,"logger":"provisioner.ironic","msg":"firmware component added for node","host":"default~bml-vm-01","component":"bmc","node":"1dc1e6be-70c2-4176-8cf0-7a8335030aa7"}
{"level":"info","ts":1723187461.016777,"logger":"controllers.BareMetalHost","msg":"publishing event","baremetalhost":{"name":"bml-vm-01","namespace":"default"},"reason":"InspectionStarted","message":"Hardware inspection started"}
{"level":"info","ts":1723187576.337832,"logger":"provisioner.ironic","msg":"inspection finished successfully","host":"default~bml-vm-01","data":{"inventory":{"bmc_address":"0.0.0.0","bmc_v6address":"::/0","boot":{"current_boot_mode":"uefi","pxe_interface":null},
"cpu":{"architecture":"x86_64","count":2,"flags":["fpu","vme","de","pse","tsc","msr","pae","mce","cx8","apic","sep","mtrr","pge","mca","cmov","pat","pse36","clflush","mmx","fxsr","sse","sse2","ss","syscall","nx","pdpe1gb","rdtscp","lm","constant_tsc","rep_good",
"nopl","xtopology","cpuid","tsc_known_freq","pni","pclmulqdq","vmx","ssse3","fma","cx16","sse4_1","sse4_2","x2apic","movbe","popcnt","tsc_deadline_timer","aes","xsave","avx","f16c","rdrand","hypervisor","lahf_lm","abm","3dnowprefetch","cpuid_fault","ssbd","ibrs"
,"ibpb","stibp","ibrs_enhanced","tpr_shadow","flexpriority","ept","vpid","ept_ad","fsgsbase","tsc_adjust","bmi1","avx2","smep","bmi2","erms","invpcid","rdseed","adx","smap","clflushopt","clwb","sha_ni","xsaveopt","xsavec","xgetbv1","xsaves","avx_vnni","arat","vn
mi","umip","pku","ospke","waitpkg","gfni","vaes","vpclmulqdq","rdpid","movdiri","movdir64b","fsrm","md_clear","serialize","arch_capabilities"],"frequency":"","model_name":"13th Gen Intel(R) Core(TM) i9-13900H","socket_count":2},"disks":[{"by_path":"/dev/disk/by-
path/pci-0000:04:00.0","hctl":null,"model":null,"name":"/dev/vda","rotational":true,"serial":null,"size":26843545600,"vendor":"0x1af4","wwn":null,"wwn_vendor_extension":null,"wwn_with_extension":null}],"hostname":"localhost.localdomain","interfaces":[{"biosdevna
me":null,"client_id":null,"has_carrier":true,"ipv4_address":"192.168.222.100","ipv6_address":"fe80::e32d:1a19:61c:5ea3%enp1s0","lldp":[],"mac_address":"00:60:2f:31:81:01","name":"enp1s0","product":"0x0001","speed_mbps":null,"vendor":"0x1af4"}],"memory":{"physica
l_mb":8192,"total":8306290688},"system_vendor":{"firmware":{"build_date":"02/06/2015","vendor":"EFI Development Kit II / OVMF","version":"0.0.0"},"manufacturer":"QEMU","product_name":"Standard PC (Q35 + ICH9, 2009)","serial_number":""}},"plugin_data":{"all_inter
faces":{"enp1s0":{"biosdevname":null,"client_id":null,"has_carrier":true,"ipv4_address":"192.168.222.100","ipv6_address":"fe80::e32d:1a19:61c:5ea3","lldp":[],"mac_address":"00:60:2f:31:81:01","name":"enp1s0","product":"0x0001","pxe_enabled":false,"speed_mbps":nu
ll,"vendor":"0x1af4"}},"boot_interface":null,"configuration":{"collectors":["default","logs"],"managers":[{"name":"generic_hardware_manager","version":"1.2"}]},"error":null,"macs":["00:60:2f:31:81:01"],"root_disk":{"by_path":"/dev/disk/by-path/pci-0000:04:00.0",
"hctl":null,"model":null,"name":"/dev/vda","rotational":true,"serial":null,"size":26843545600,"vendor":"0x1af4","wwn":null,"wwn_vendor_extension":null,"wwn_with_extension":null},"valid_interfaces":{"enp1s0":{"biosdevname":null,"client_id":null,"has_carrier":true
,"ipv4_address":"192.168.222.100","ipv6_address":"fe80::e32d:1a19:61c:5ea3","lldp":[],"mac_address":"00:60:2f:31:81:01","name":"enp1s0","product":"0x0001","pxe_enabled":false,"speed_mbps":null,"vendor":"0x1af4"}}}}}
{"level":"info","ts":1723187576.350381,"logger":"controllers.BareMetalHost","msg":"Created hardwareData \"bml-vm-01\" in \"default\" namespace\n","baremetalhost":{"name":"bml-vm-01","namespace":"default"},"provisioningState":"inspecting"}
{"level":"info","ts":1723187576.3503926,"logger":"controllers.BareMetalHost","msg":"changing provisioning state","baremetalhost":{"name":"bml-vm-01","namespace":"default"},"provisioningState":"inspecting","old":"inspecting","new":"preparing"}
{"level":"info","ts":1723187576.3504012,"logger":"controllers.BareMetalHost","msg":"saving host status","baremetalhost":{"name":"bml-vm-01","namespace":"default"},"provisioningState":"inspecting","operational status":"OK","provisioning state":"preparing"}
{"level":"info","ts":1723187576.3548908,"logger":"controllers.BareMetalHost","msg":"publishing event","baremetalhost":{"name":"bml-vm-01","namespace":"default"},"reason":"InspectionComplete","message":"Hardware inspection completed"}
{"level":"info","ts":1723187576.4007328,"logger":"controllers.BareMetalHost","msg":"preparing","baremetalhost":{"name":"bml-vm-01","namespace":"default"},"provisioningState":"preparing"}
{"level":"info","ts":1723187576.4050114,"logger":"controllers.BareMetalHost","msg":"changing provisioning state","baremetalhost":{"name":"bml-vm-01","namespace":"default"},"provisioningState":"preparing","old":"preparing","new":"available"}
{"level":"info","ts":1723187576.4050248,"logger":"controllers.BareMetalHost","msg":"saving host status","baremetalhost":{"name":"bml-vm-01","namespace":"default"},"provisioningState":"preparing","operational status":"OK","provisioning state":"available"}

Workflow: From Virtual Machine to BareMetalHost (CRD)



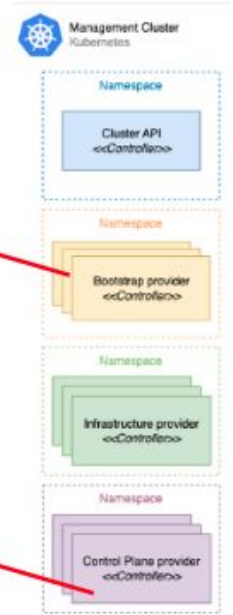

```
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get bmh -A
NAMESPACE   NAME        STATE         CONSUMER   ONLINE   ERROR   AGE
default     bml-vm-01   registering              true             10s
default     bml-vm-02   available                true             2d19h
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get bmh -A
NAMESPACE   NAME        STATE        CONSUMER   ONLINE   ERROR   AGE
default     bml-vm-01   inspecting              true             12s
default     bml-vm-02   available                true             2d19h
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get bmh -A
NAMESPACE   NAME        STATE       CONSUMER   ONLINE   ERROR   AGE
default     bml-vm-01   available               true             3m12s
default     bml-vm-02   available               true             2d20h
```

Deployment: management k8s cluster, CAPI and CAPM3 (1)

```
root@metal3-ThinkPad-T14p-Gen-1:~# clusterctl init --infrastructure metal3
Fetching providers
Skipping installing cert-manager as it is already installed
Installing provider="cluster-api" version="v1.7.4" targetNamespace="capi-system"
Installing provider="bootstrap-kubeadm" version="v1.7.4" targetNamespace="capi-kubeadm-bootstrap-system"
Installing provider="control-plane-kubeadm" version="v1.7.4" targetNamespace="capi-kubeadm-control-plane-system"
Installing provider="infrastructure-metal3" version="v1.7.1" targetNamespace="capm3-system"

Your management cluster has been initialized successfully!
```

```
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get services -n capi-kubeadm-bootstrap-system
NAME                                        TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)   AGE
capi-kubeadm-bootstrap-webhook-service   ClusterIP   10.96.95.124   <none>        443/TCP   16m
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get deployments -n capi-kubeadm-bootstrap-system
NAME                                       READY   UP-TO-DATE   AVAILABLE   AGE
capi-kubeadm-bootstrap-controller-manager   1/1     1            1           26m
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get pods -n capi-kubeadm-bootstrap-system
NAME                                                        READY   STATUS    RESTARTS   AGE
capi-kubeadm-bootstrap-controller-manager-6868fcb86f-vsm84   1/1     Running   0          26m
```

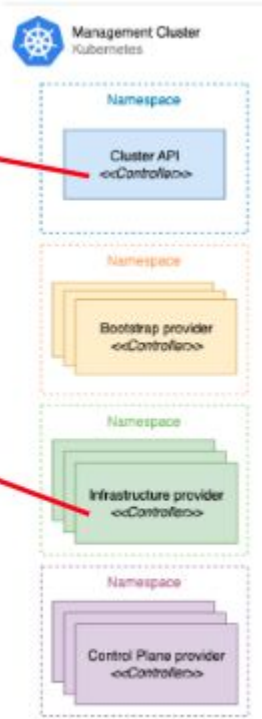
```
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get services -n capi-kubeadm-control-plane-system
NAME                                              TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)   AGE
capi-kubeadm-control-plane-webhook-service   ClusterIP   10.96.188.119   <none>        443/TCP   27m
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get deployments -n capi-kubeadm-control-plane-system
NAME                                             READY   UP-TO-DATE   AVAILABLE   AGE
capi-kubeadm-control-plane-controller-manager   1/1     1            1           27m
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get pods -n capi-kubeadm-control-plane-system
NAME                                                          READY   STATUS    RESTARTS   AGE
capi-kubeadm-control-plane-controller-manager-56bcf9c444-mdw7w   1/1     Running   0          28m
```



Deployment: management k8s cluster, CAPI and CAPM3 (2)

```
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get services -n capi-system
NAME                     TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)   AGE
capi-webhook-service     ClusterIP   10.96.101.134   <none>        443/TCP   28m
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get deployments -n capi-system
NAME                       READY   UP-TO-DATE   AVAILABLE   AGE
capi-controller-manager    1/1     1            1           28m
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get pods -n capi-system
NAME                                       READY   STATUS    RESTARTS   AGE
capi-controller-manager-695d4bd786-4bxl6   1/1     Running   0          29m
```

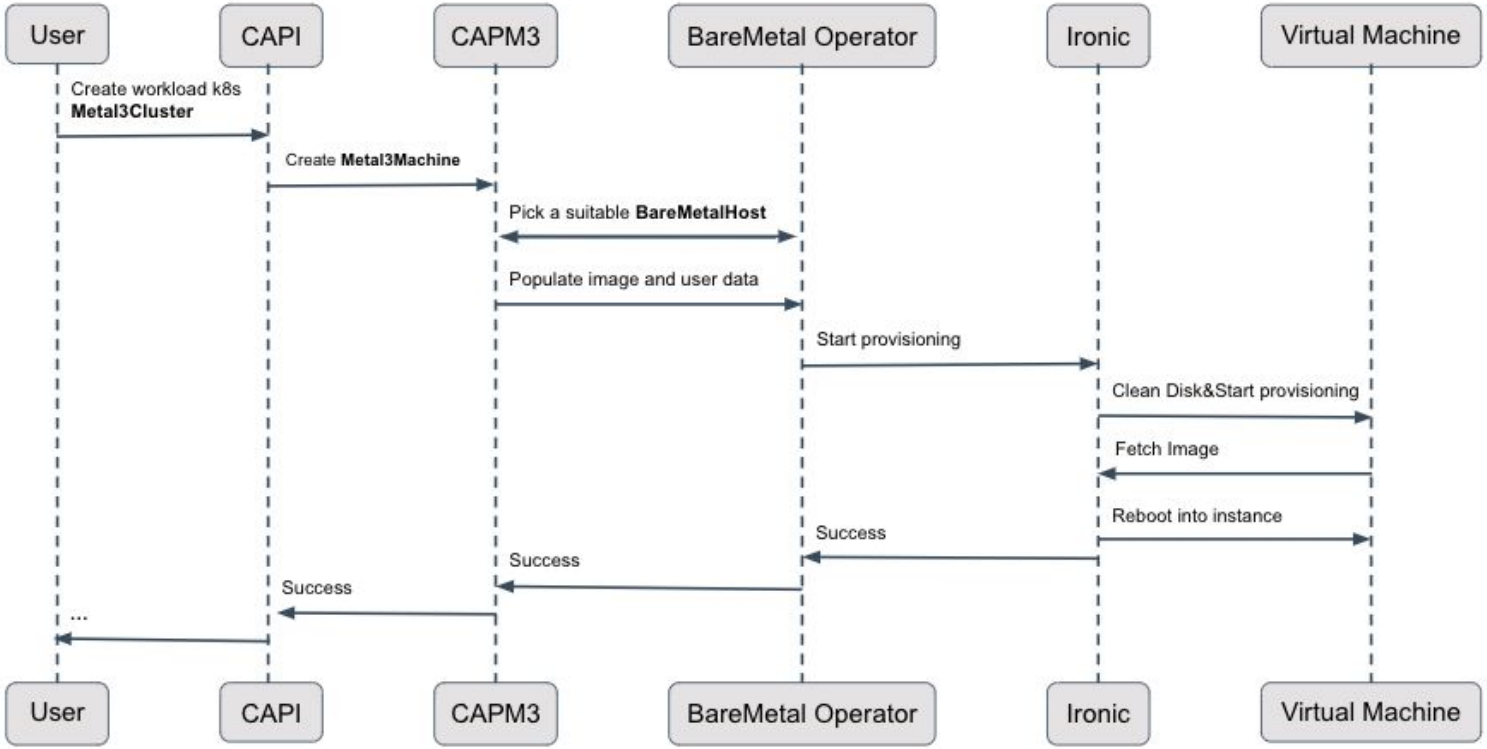
```
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get services -n capm3-system
NAME                     TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)   AGE
capm3-webhook-service    ClusterIP   10.96.13.82     <none>        443/TCP   30m
ipam-webhook-service     ClusterIP   10.96.250.203   <none>        443/TCP   30m
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get deployments -n capm3-system
NAME                       READY   UP-TO-DATE   AVAILABLE   AGE
capm3-controller-manager   1/1     1            1           30m
ipam-controller-manager    1/1     1            1           30m
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get pods -n capm3-system
NAME                                       READY   STATUS    RESTARTS   AGE
capm3-controller-manager-69479c499f-rclw8  1/1     Running   0          30m
ipam-controller-manager-fb5677855-wlf7t    1/1     Running   0          30m
```



Deployment: workload k8s cluster

```
root@metal3-ThinkPad-T14p-Gen-1:~# clusterctl generate cluster my-cluster --control-plane-machine-count 1 --worker-machine-count 1 > my-cluster.yaml
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl apply -f my-cluster.yaml
cluster.cluster.x-k8s.io/my-cluster created
metal3cluster.infrastructure.cluster.x-k8s.io/my-cluster created
kubeadmcontrolplane.controlplane.cluster.x-k8s.io/my-cluster created
metal3machinetemplate.infrastructure.cluster.x-k8s.io/my-cluster-controlplane created
machinedeployment.cluster.x-k8s.io/my-cluster created
metal3machinetemplate.infrastructure.cluster.x-k8s.io/my-cluster-workers created
kubeadmconfigtemplate.bootstrap.cluster.x-k8s.io/my-cluster-workers created
metal3datatemplate.infrastructure.cluster.x-k8s.io/my-cluster-controlplane-template created
metal3datatemplate.infrastructure.cluster.x-k8s.io/my-cluster-workers-template created
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get clusters -A
NAMESPACE   NAME         CLUSTERCLASS   PHASE         AGE   VERSION
default     my-cluster                  Provisioned   8s
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~#
root@metal3-ThinkPad-T14p-Gen-1:~# kubectl get bmh -A
NAMESPACE   NAME        STATE          CONSUMER           ONLINE   ERROR   AGE
default     bml-vm-01   provisioning   my-cluster-9wkmg   true             2d18h
default     bml-vm-02   available                         true             2d18h
```

Workflow: From BareMetalHost (CRD) to workload cluster's node



References

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[5] https://tanzu.vmware.com/content/blog/pattern-recognition-how-cluster-api-reveals-the-core-of-kubernetes