Advanced DevOps Lab
Experiment:3

Aim: To understand the Kubernetes Cluster Architecture, install and Spin Up a Kubernetes Cluster on Linux Machines/Cloud Platforms.

Theory:

Container-based microservices architectures have profoundly changed the way development and operations teams test and deploy modern software. Containers help companies modernize by making it easier to scale and deploy applications, but containers have also introduced new challenges and more complexity by creating an entirely new infrastructure ecosystem.

Large and small software companies alike are now deploying thousands of container instances daily, and that's a complexity of scale they have to manage. So how do they do it?

Enter the age of Kubernetes.

Originally developed by Google, Kubernetes is an open-source container orchestration platform designed to automate the deployment, scaling, and management of containerized applications. In fact, Kubernetes has established itself as the defacto standard for container orchestration and is the flagship project of the Cloud Native Computing Foundation (CNCF), backed by key players like Google, AWS, Microsoft, IBM, Intel, Cisco, and Red Hat.

Kubernetes makes it easy to deploy and operate applications in a microservice architecture. It does so by creating an abstraction layer on top of a group of hosts so that development teams can deploy their applications and let Kubernetes manage the following activities:

- Controlling resource consumption by application or team
- Evenly spreading application load across a hosting infrastructure
- Automatically load balancing requests across the different instances of an application ● Monitoring resource consumption and resource limits to automatically stop applications from consuming too many resources and restarting the applications again
- Moving an application instance from one host to another if there is a shortage of resources in a host, or if the host dies
- Automatically leveraging additional resources made available when a new host is added to the cluster
- Easily performing canary deployments and rollbacks

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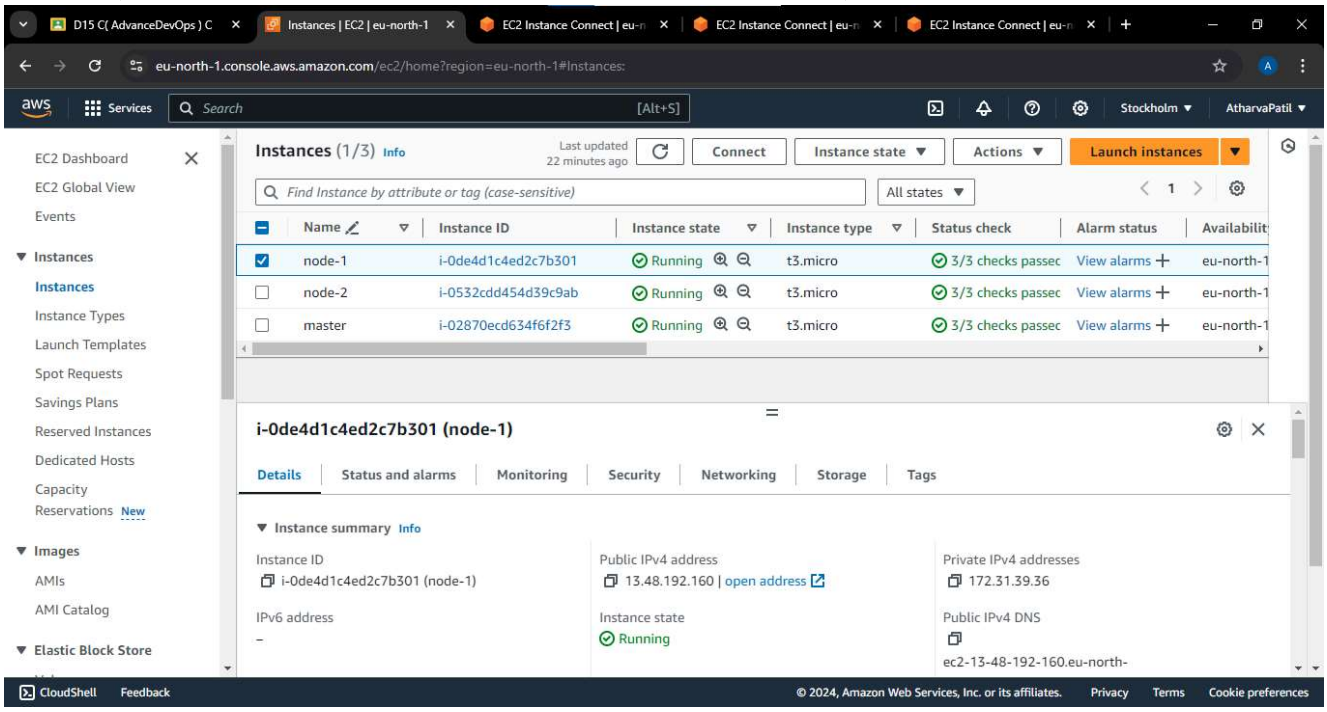
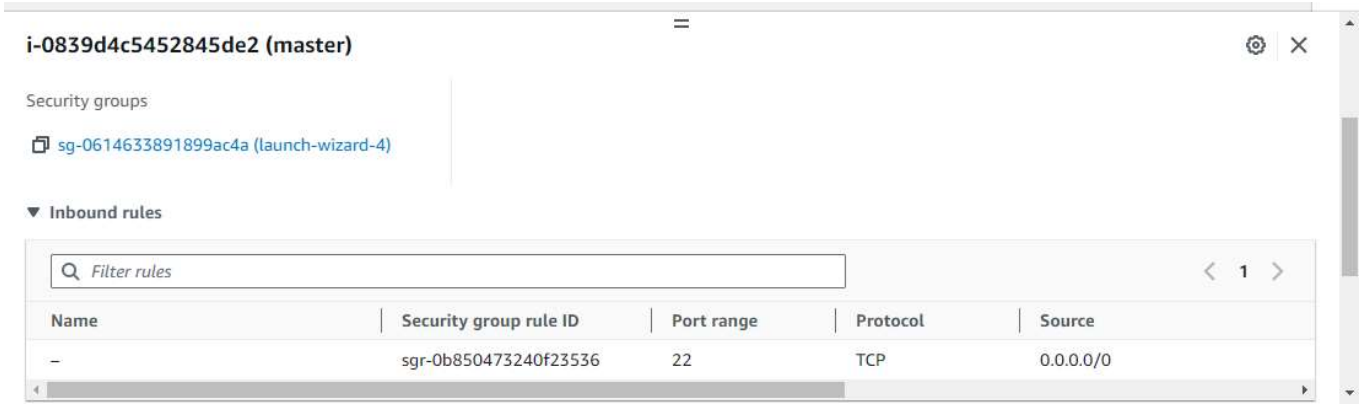
Steps:

1. Create 3 EC2 Ubuntu Instances on AWS.

   (Name 1 as Master, the other 2 as worker-1 and worker-2)



2. Edit the Security Group Inbound Rules to allow SSH



3. SSH into all 3 machines

   Now open the folder in the terminal 3 times for Master, Node1& Node 2 where our .pem key is stored and paste the Example command (starting with ssh -i .....) in the terminal.(ssh -i "Master_Ec2_Key.pem" ubuntu@ec2-54-196-129-215.compute-1.amazonaws.com)

   Master:

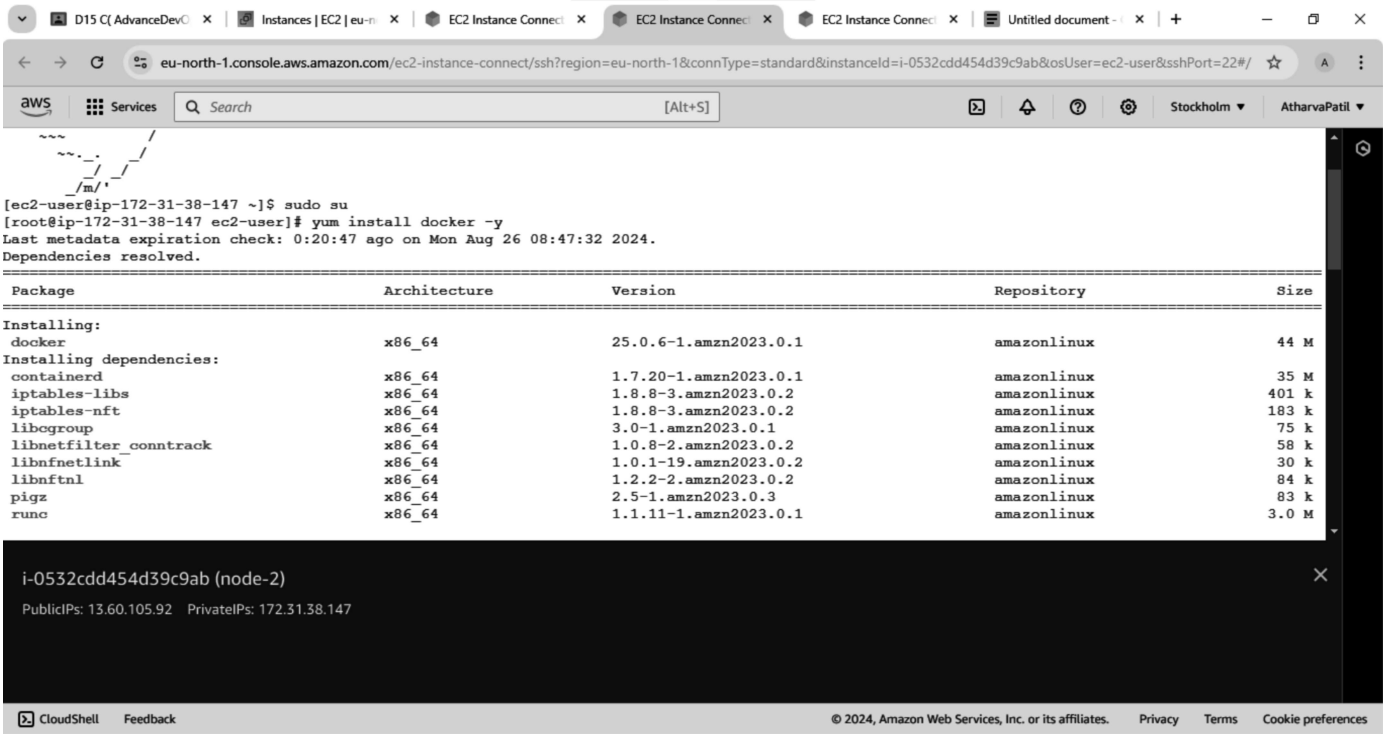
4. From now on, until mentioned, perform these steps on all 3 machines.

Install Docker
curl -fsSL https://download.docker.com/linux/ubuntu/gpg | sudo apt-key add -

curl -fsSL https://download.docker.com/linux/ubuntu/gpg | sudo tee

/etc/apt/trusted.gpg.d/docker.gpg > /dev/null

sudo add-apt-repository "deb [arch=amd64]
https://download.docker.com/linux/ubuntu$(lsb_release -cs) stable"



sudo apt-get update
sudo apt-get install -y docker-ce

Then, configure cgroup in a daemon.json file.

sudo mkdir -p /etc/docker

cat <<EOF | sudo tee /etc/docker/daemon.json

{

"exec-opts": ["native.cgroupdriver=systemd"]

}

EOF

{

"exec-opts": ["native.cgroupdriver=systemd"]

}

```
sudo systemctl enable docker
sudo systemctl daemon-reload
sudo systemctl restart docker
```

Install Kubernetes on all 3 machines
curl -fsSL https://pkgs.k8s.io/core:/stable:/v1.31/deb/Release.key | sudo gpg --dearmor -o/etc/apt/keyrings/kubernetes-apt-keyring.gpg

echo 'deb [signed-by=/etc/apt/keyrings/kubernetes-apt-keyring.gpg]

https://pkgs.k8s.io/core:/stable:/v1.31/deb/ /' | sudo tee /etc/apt/sources.list.d/kubernetes.list

Package	Architecture	Version	Repository	Size
Installing:				
kubeadm	x86_64	1.31.1-150500.1.1	kubernetes	11 M
kubectl	x86_64	1.31.1-150500.1.1	kubernetes	11 M
kubelet	x86_64	1.31.1-150500.1.1	kubernetes	15 M
Installing dependencies:				
conntrack-tools	x86_64	1.4.6-2.amzn2023.0.2	amazonlinux	208 k
cri-tools	x86_64	1.31.1-150500.1.1	kubernetes	6.9 M
kubernetes-cni	x86_64	1.5.1-150500.1.1	kubernetes	7.1 M
libnetfilter_cthelper	x86_64	1.0.0-21.amzn2023.0.2	amazonlinux	24 k
libnetfilter_cttimeout	x86_64	1.0.0-19.amzn2023.0.2	amazonlinux	24 k
libnetfilter_queue	x86_64	1.0.5-2.amzn2023.0.2	amazonlinux	30 k

Transaction Summary

```
sudo apt-get update
sudo apt-get install -y kubelet kubeadm kubectl
sudo apt-mark hold kubelet kubeadm kubectl
```

```
sudo systemctl enable --now kubelet
sudo apt-get install -y containerd
```

```
ubuntu@ip-172-31-27-176:~$ sudo apt-get install -y containerd
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following packages were automatically installed and are no longer requir
ed:
  docker-buildx-plugin docker-ce-cli docker-ce-rootless-extras
  docker-compose-plugin libltdl7 libslirp0 pigz slirp4netns
Use 'sudo apt autoremove' to remove them.
The following additional packages will be installed:
  runc
The following packages will be REMOVED:
  containerd.io docker-ce
The following NEW packages will be installed:
  containerd runc
0 upgraded, 2 newly installed, 2 to remove and 133 not upgraded.
Need to get 47.2 MB of archives.
After this operation, 53.1 MB disk space will be freed.
```

```
sudo mkdir -p /etc/containerd
sudo containerd config default | sudo tee /etc/containerd/config.toml
```

```
ubuntu@ip-172-31-27-176:~$ sudo mkdir -p /etc/containerd
sudo containerd config default | sudo tee /etc/containerd/config.toml
disabled_plugins = []
imports = []
oom_score = 0
plugin_dir = ""
required_plugins = []
root = "/var/lib/containerd"
state = "/run/containerd"
temp = ""
version = 2

[cgroup]
  path = ""

[debug]
  address = ""
  format = ""
  gid = 0
  level = ""
  uid = 0

[grpc]
  address = "/run/containerd/containerd.sock"
  gid = 0
```

```
sudo systemctl restart containerd
sudo systemctl enable containerd
sudo systemctl status containerd
```

```
ubuntu@ip-172-31-27-176:~$ sudo systemctl restart containerd
sudo systemctl enable containerd
sudo systemctl status containerd
● containerd.service - containerd container runtime
     Loaded: loaded (/usr/lib/systemd/system/containerd.service; enabled; p>
     Active: active (running) since Mon 2024-09-16 15:31:58 UTC; 210ms ago
       Docs: https://containerd.io
   Main PID: 4763 (containerd)
      Tasks: 7
     Memory: 13.9M (peak: 14.4M)
        CPU: 50ms
     CGroup: /system.slice/containerd.service
             └─4763 /usr/bin/containerd

Sep 16 15:31:58 ip-172-31-27-176 containerd[4763]: time="2024-09-16T15:31:5>
Sep 16 15:31:58 ip-172-31-27-176 containerd[4763]: time="2024-09-16T15:31:5>
Sep 16 15:31:58 ip-172-31-27-176 containerd[4763]: time="2024-09-16T15:31:5>
Sep 16 15:31:58 ip-172-31-27-176 containerd[4763]: time="2024-09-16T15:31:5>
Sep 16 15:31:58 ip-172-31-27-176 containerd[4763]: time="2024-09-16T15:31:5>
Sep 16 15:31:58 ip-172-31-27-176 containerd[4763]: time="2024-09-16T15:31:5>
Sep 16 15:31:58 ip-172-31-27-176 containerd[4763]: time="2024-09-16T15:31:5>
Sep 16 15:31:58 ip-172-31-27-176 containerd[4763]: time="2024-09-16T15:31:5>
Sep 16 15:31:58 ip-172-31-27-176 containerd[4763]: time="2024-09-16T15:31:5>
Sep 16 15:31:58 ip-172-31-27-176 systemd[1]: Started containerd.service - c>
```

sudo apt-get install -y socat

```
ubuntu@ip-172-31-27-176:~$  sudo apt-get install -y socat
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following packages were automatically installed and are no longer requir
ed:
  docker-buildx-plugin docker-ce-cli docker-ce-rootless-extras
  docker-compose-plugin libltdl7 libslirp0 pigz slirp4netns
Use 'sudo apt autoremove' to remove them.
The following NEW packages will be installed:
  socat
0 upgraded, 1 newly installed, 0 to remove and 133 not upgraded.
Need to get 374 kB of archives.
After this operation, 1649 kB of additional disk space will be used.
Get:1 http://us-east-1.ec2.archive.ubuntu.com/ubuntu noble/main amd64 socat
amd64 1.8.0.0-4build3 [374 kB]
Fetched 374 kB in 0s (11.2 MB/s)
Selecting previously unselected package socat.
(Reading database ... 68108 files and directories currently installed.)
Preparing to unpack .../socat_1.8.0.0-4build3_amd64.deb ...
Unpacking socat (1.8.0.0-4build3) ...
Setting up socat (1.8.0.0-4build3) ...
Processing triggers for man-db (2.12.0-4build2) ...
Scanning processes...
Scanning linux images...

Running kernel seems to be up-to-date.

No services need to be restarted.

No containers need to be restarted.
```

5. Perform this **ONLY on the Master machine**

Initialize the Kubecluster

```
sudo kubeadm init --pod-network-cidr=10.244.0.0/16
```

--ignore-preflight-errors=all Copy the join command and keep it in a notepad, we'll need it later.

```
[kubelet-finalize] Updating "/etc/kubernetes/kubelet.conf" to point to a rotatable kubelet client certificate and key
[addons] Applied essential addon: CoreDNS
[addons] Applied essential addon: kube-proxy

Your Kubernetes control-plane has initialized successfully!

To start using your cluster, you need to run the following as a regular user:

  mkdir -p $HOME/.kube
  sudo cp -i /etc/kubernetes/admin.conf $HOME/.kube/config
  sudo chown $(id -u):$(id -g) $HOME/.kube/config

Alternatively, if you are the root user, you can run:

  export KUBECONFIG=/etc/kubernetes/admin.conf

You should now deploy a pod network to the cluster.
Run "kubectl apply -f [podnetwork].yaml" with one of the options listed at:
  https://kubernetes.io/docs/concepts/cluster-administration/addons/

Then you can join any number of worker nodes by running the following on each as root:

kubeadm join 172.31.40.173:6443 --token a84ptk.jhdjs1nesolmhfuf \
```

Copy the mkdir and chown commands from the top and execute them

```
  mkdir -p $HOME/.kube
  sudo cp -i /etc/kubernetes/admin.conf $HOME/.kube/config
  sudo chown $(id -u):$(id -g) $HOME/.kube/config

Alternatively, if you are the root user, you can run:

  export KUBECONFIG=/etc/kubernetes/admin.conf
```

Check the created pod using this command

Now, keep a watch on all nodes using the following command

```
watch kubectl get nodes
```

```
[root@ip-172-31-40-173 ec2-user]# kubectl get nodes
NAME                                          STATUS     ROLES           AGE     VERSION
ip-172-31-40-173.eu-north-1.compute.internal   NotReady   control-plane   6m55s   v1.31.1
[root@ip-172-31-40-173 ec2-user]#
```

6. Perform this **ONLY on the worker machines**

```
sudo kubeadm join 172.31.27.176:6443 --token ttay2x.n0sqeukjai8sgfg3 \
--discovery-token-ca-cert-hash
sha256:d6fc5fb7e984c83e2807780047fec6c4f2acfe9da9184ecc028d77157608fbb6
```

```
[preflight] Running pre-flight checks
        [WARNING FileExisting-tc]: tc not found in system path
[preflight] Reading configuration from the cluster...
[preflight] FYI: You can look at this config file with 'kubectl -n kube-system get cm kubeadm-config -o ya
[kubelet-start] Writing kubelet configuration to file "/var/lib/kubelet/config.yaml"
[kubelet-start] Writing kubelet environment file with flags to file "/var/lib/kubelet/kubeadm-flags.env"
[kubelet-start] Starting the kubelet
[kubelet-start] Waiting for the kubelet to perform the TLS Bootstrap...

This node has joined the cluster:
* Certificate signing request was sent to apiserver and a response was received.
* The Kubelet was informed of the new secure connection details.

Run 'kubectl get nodes' on the control-plane to see this node join the cluster.

[root@ip-172-31-89-46 ec2-user]#
```

Now, notice the changes on the master terminal

```
[root@ip-172-31-85-89 ec2-user]# kubectl get nodes
NAME                          STATUS     ROLES           AGE   VERSION
ip-172-31-85-89.ec2.internal   NotReady   control-plane   72s   v1.26.0
[root@ip-172-31-85-89 ec2-user]# kubectl get nodes
NAME                          STATUS     ROLES           AGE    VERSION
ip-172-31-85-89.ec2.internal   NotReady   control-plane   105s   v1.26.0
ip-172-31-89-46.ec2.internal   NotReady   <none>          5s     v1.26.0
[root@ip-172-31-85-89 ec2-user]# kubectl get nodes
NAME                          STATUS     ROLES           AGE    VERSION
ip-172-31-85-89.ec2.internal   NotReady   control-plane   119s   v1.26.0
ip-172-31-89-46.ec2.internal   NotReady   <none>          19s    v1.26.0
ip-172-31-94-70.ec2.internal   NotReady   <none>          12s    v1.26.0
[root@ip-172-31-85-89 ec2-user]#
```

7. Since Status is NotReady we have to add a network plugin. And also we have to give the name to the nodes.

kubectl apply -f https://docs.projectcalico.org/manifests/calico.yaml

```
ubuntu@ip-172-31-27-176:~$ kubectl apply -f https://docs.projectcalico.org/manifests/calico.yaml
poddisruptionbudget.policy/calico-kube-controllers created
serviceaccount/calico-kube-controllers created
serviceaccount/calico-node created
configmap/calico-config created
customresourcedefinition.apiextensions.k8s.io/bgpconfigurations.crd.projectcalico.org created
customresourcedefinition.apiextensions.k8s.io/bgppeers.crd.projectcalico.org created
customresourcedefinition.apiextensions.k8s.io/blockaffinities.crd.projectcalico.org created
customresourcedefinition.apiextensions.k8s.io/caliconodestatuses.crd.projectcalico.org created
customresourcedefinition.apiextensions.k8s.io/clusterinformations.crd.projectcalico.org created
customresourcedefinition.apiextensions.k8s.io/felixconfigurations.crd.projectcalico.org created
customresourcedefinition.apiextensions.k8s.io/globalnetworkpolicies.crd.projectcalico.org created
customresourcedefinition.apiextensions.k8s.io/globalnetworksets.crd.projectcalico.org created
customresourcedefinition.apiextensions.k8s.io/hostendpoints.crd.projectcalico.org created
customresourcedefinition.apiextensions.k8s.io/ipamblocks.crd.projectcalico.org created
customresourcedefinition.apiextensions.k8s.io/ipamconfigs.crd.projectcalico.org created
customresourcedefinition.apiextensions.k8s.io/ipamhandles.crd.projectcalico.org created
customresourcedefinition.apiextensions.k8s.io/ippools.crd.projectcalico.org created
customresourcedefinition.apiextensions.k8s.io/ipreservations.crd.projectcalico.org created
customresourcedefinition.apiextensions.k8s.io/kubecontrollersconfigurations.crd.projectcalico.org created
customresourcedefinition.apiextensions.k8s.io/networkpolicies.crd.projectcalico.org created
customresourcedefinition.apiextensions.k8s.io/networksets.crd.projectcalico.org created
clusterrole.rbac.authorization.k8s.io/calico-kube-controllers created
clusterrole.rbac.authorization.k8s.io/calico-node created
clusterrolebinding.rbac.authorization.k8s.io/calico-kube-controllers created
clusterrolebinding.rbac.authorization.k8s.io/calico-node created
daemonset.apps/calico-node created
deployment.apps/calico-kube-controllers created
```

Now Run command kubectl get nodes -o wide we can see Status is ready.

```
ubuntu@ip-172-31-27-176:~$ ubuntu@ip-172-31-27-176:~$ kubectl get nodes -o wide
NAME              STATUS   ROLES           AGE     VERSION   INTERNAL-IP     EXTERNAL-IP   OS-IMAGE             KERNEL-VERSION   CONTAINER-RUNTIME
ip-172-31-18-135  Ready    <none>          6m19s   v1.31.1   172.31.18.135   <none>        Ubuntu 24.04 LTS   6.8.0-1012-aws   containerd://1.7.12
ip-172-31-27-176  Ready    control-plane   15m     v1.31.1   172.31.27.176   <none>        Ubuntu 24.04 LTS   6.8.0-1012-aws   containerd://1.7.12
ip-172-31-28-117  Ready    <none>          7m09s   v1.31.1   172.31.28.117   <none>        Ubuntu 24.04 LTS   6.8.0-1012-aws   containerd://1.7.12
```

That’s it, we now have a Kubernetes cluster running across 3 AWS EC2 Instances. This cluster can be used to further deploy applications and their loads being distributed across these machines.

Conclusion: Thus we have understood the Kubernetes cluster architecture and have successfully created Kubernetes cluster on a linux machine with the help of AWS by creating three EC2 instances one master and two nodes, installed docker and kubernetes on all three machines and then initialized a kubernetes control-plane node on the master and then added the worker nodes to the cluster to distribute the workload.