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:

To understand Kubernetes Cluster Architecture and how to install and spin up a Kubernetes cluster on Linux machines or cloud platforms, it's essential to grasp the fundamental components and design principles of Kubernetes.

Overview of Kubernetes

Kubernetes is an open-source container orchestration platform developed by Google, designed to automate the deployment, scaling, and management of containerized applications. It provides a robust infrastructure that supports microservices architecture, offering features such as self-healing, scaling, and zero-downtime deployments. Kubernetes can run on various environments, including public clouds (like AWS and Azure), private clouds, and bare metal servers.

Kubernetes Architecture

Kubernetes architecture is primarily composed of two main components: the Control Plane and the Data Plane.

Control Plane

The Control Plane manages the overall state of the Kubernetes cluster and includes several key components:

- kube-apiserver: The API server acts as the gateway for all interactions with the cluster, processing REST requests and managing the state of the cluster.
- etcd: A distributed key-value store that holds the configuration data and state of the cluster, ensuring consistency and availability.
- kube-scheduler: Responsible for assigning Pods to worker nodes based on resource availability and other constraints.
- kube-controller-manager: Manages controllers that regulate the state of the cluster, ensuring that the desired state matches the actual state.
- cloud-controller-manager (optional): Integrates with cloud provider APIs to manage resources specific to the cloud environment.

Data Plane

The Data Plane consists of the worker nodes that run the containerized applications. Each worker node includes:

- kubelet: An agent that ensures containers are running in Pods. It communicates with the Control Plane to receive instructions.
- kube-proxy: Maintains network rules and facilitates communication between Pods and services.
- Container Runtime: Software responsible for running containers, such as Docker or containerd.

Core Concepts

Key concepts in Kubernetes include:

- Pods: The smallest deployable units in Kubernetes, which can contain one or more containers.
- Services: Abstracts a set of Pods, providing a stable network endpoint for accessing them.
- Deployments: Define the desired state for Pods and manage their lifecycle, including scaling and updates.

Installing and Spinning Up a Kubernetes Cluster

To install and set up a Kubernetes cluster, follow these general steps:

1. Choose an Environment: Decide whether to deploy on local machines or a cloud platform. For cloud platforms, services like Google Kubernetes Engine (GKE), Amazon EKS, or Azure AKS can simplify the process.
2. Install Prerequisites: Ensure that you have the necessary tools installed, such as kubectl (the command-line tool for interacting with the cluster) and a container runtime.
3. Set Up the Control Plane: This can be done using tools like kubeadm, which helps bootstrap the cluster by initializing the Control Plane components.
4. Join Worker Nodes: Once the Control Plane is set up, you can join worker nodes to the cluster using the token generated during the initialization.
5. Deploy Applications: After the cluster is up and running, you can deploy your applications using YAML configuration files that define the desired state of your Pods and Services.

Best Practices

When setting up a Kubernetes cluster, consider the following best practices:

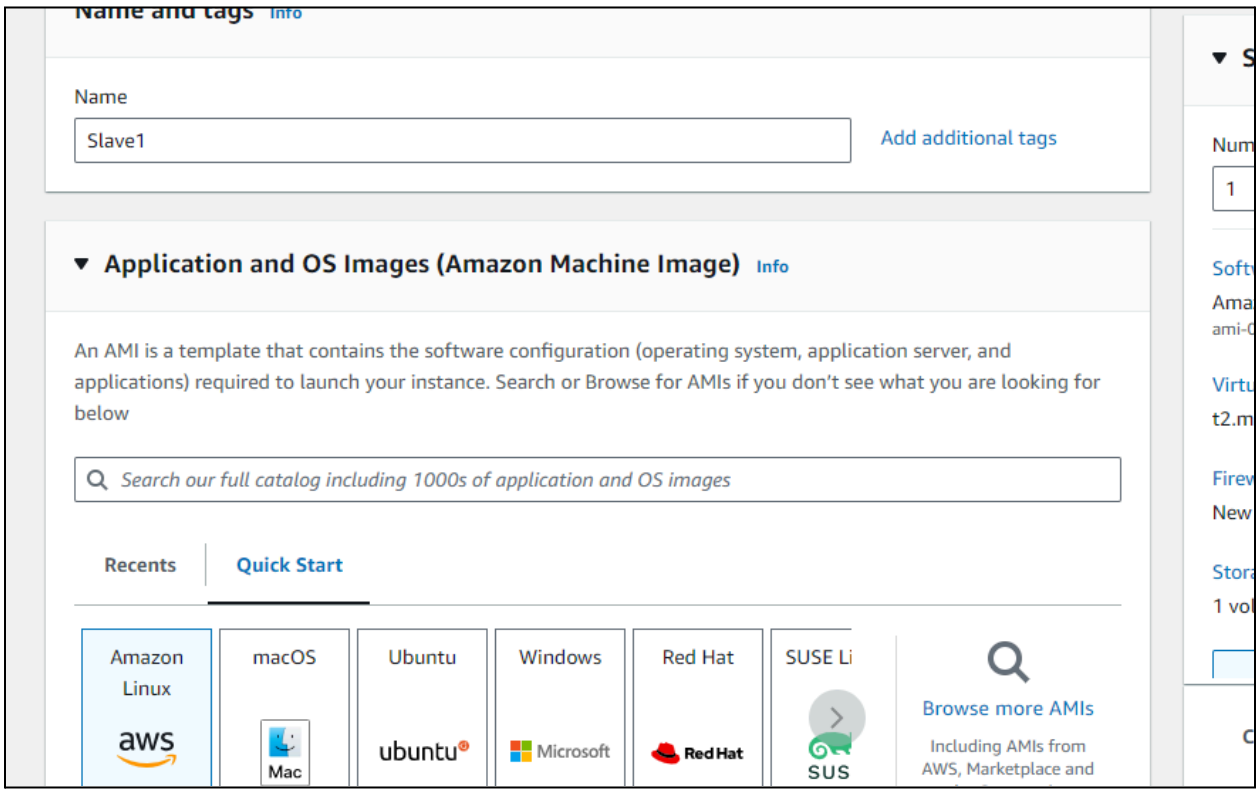
- Resource Management: Define resource requests and limits for Pods to ensure efficient utilization of cluster resources.
- High Availability: Use multiple Control Plane nodes to avoid single points of failure.
- Networking: Implement network policies to secure communication between Pods and manage external access.
- Monitoring and Logging: Integrate monitoring tools and logging solutions to keep track of cluster performance and troubleshoot issues.

By understanding the architecture and following the installation steps and best practices, you can effectively manage a Kubernetes cluster, enabling efficient deployment and scaling of containerized applications.

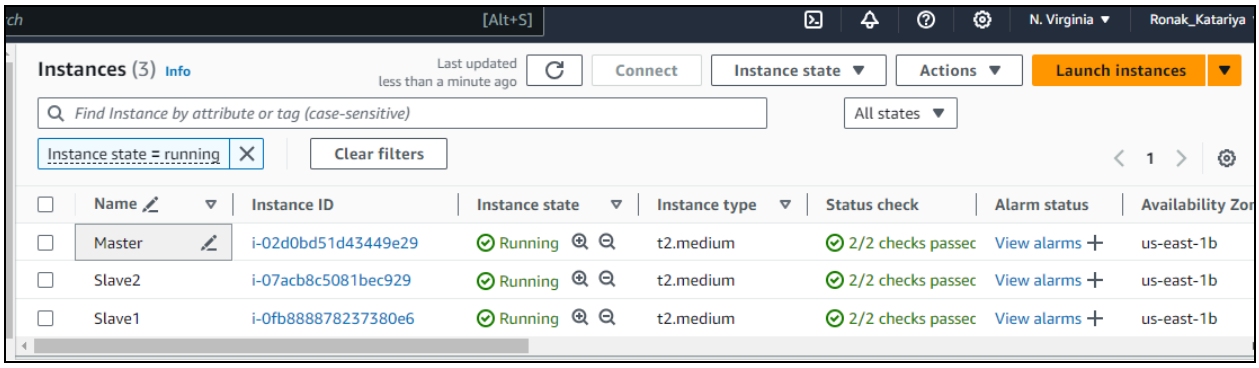
Steps:

1. Create 3 EC2 Ubuntu Instances on AWS.

Extra:
When we select ubuntu we have to select an older version - 22.04.
(Name 1 as Master, the other 2 as Slave1 and Slave2)

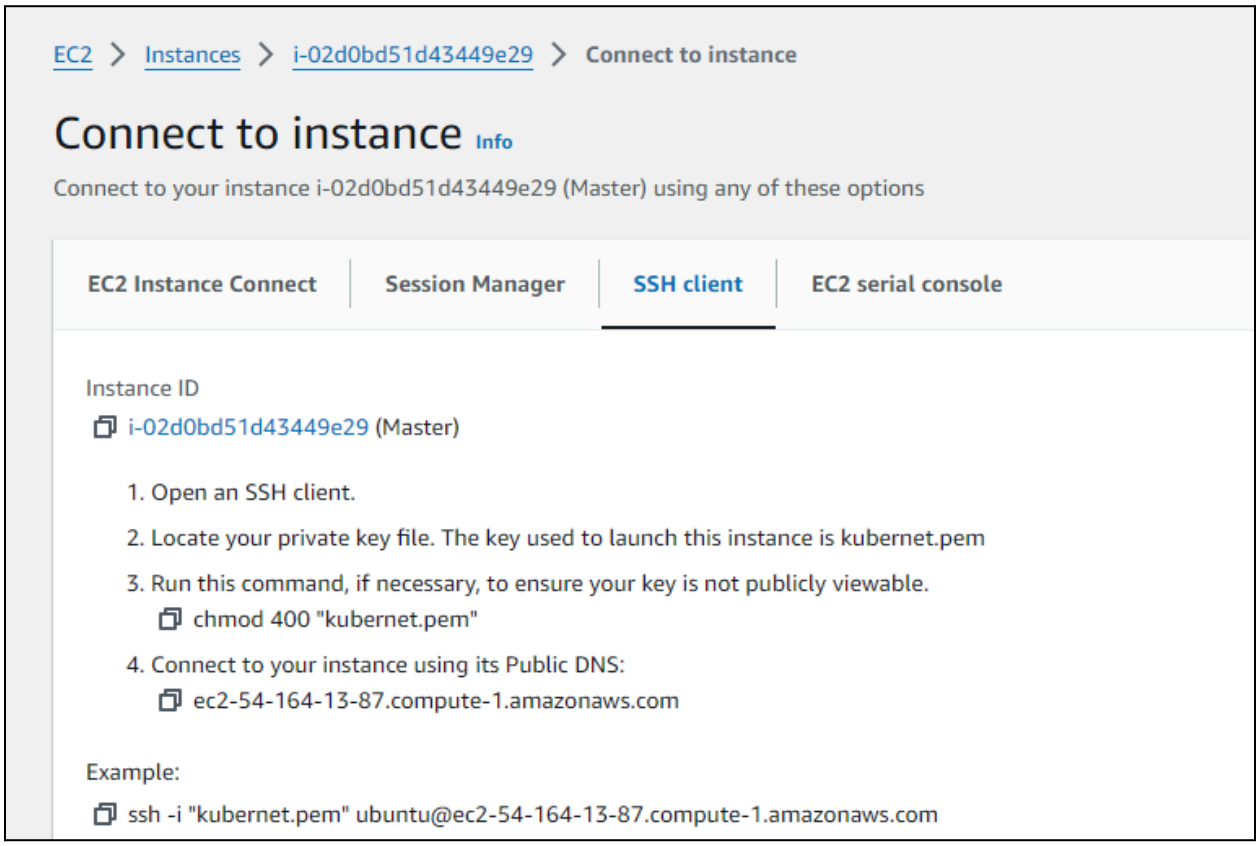


Created a master and 2 slaves:



2. Now click on connect to instance, then click on SSH client.

3. Now copy the ssh from the example and paste it on command prompt.(I used gitbash)



Commands:

4. Now since you are on GitBash, first type sudo su to perform the command as a root user.

5. After this type on all 3 machines
Yum install docker -y

```
[ec2-user@ip-172-31-84-37 ~]$ sudo su
[root@ip-172-31-84-37 ec2-user]# yum install docker -y
Last metadata expiration check: 0:18:22 ago on Thu Aug 29 08:52:52 2024.
Dependencies resolved.
==========================================================================================================================================
 Package                          Architecture          Version                              Repository                              Size
==========================================================================================================================================
Installing:
 docker                           x86_64                25.0.6-1.amzn2023.0.1                amazonlinux                             44 M
Installing dependencies:
 containerd                       x86_64                1.7.20-1.amzn2023.0.1                amazonlinux                             35 M
 iptables-libs                    x86_64                1.8.8-3.amzn2023.0.2                 amazonlinux                            401 k
 iptables-nft                     x86_64                1.8.8-3.amzn2023.0.2                 amazonlinux                            183 k
 libcgroup                        x86_64                3.0-1.amzn2023.0.1                   amazonlinux                             75 k
 libnetfilter_conntrack           x86_64                1.0.8-2.amzn2023.0.2                 amazonlinux                             58 k
 libnfnetlink                     x86_64                1.0.1-19.amzn2023.0.2                amazonlinux                             30 k
 libnftnl                         x86_64                1.2.2-2.amzn2023.0.2                 amazonlinux                             84 k
 pigz                             x86_64                2.5-1.amzn2023.0.3                   amazonlinux                             83 k
 runc                             x86_64                1.1.11-1.amzn2023.0.1                amazonlinux                            3.0 M
```

```
  Running scriptlet: docker-25.0.6-1.amzn2023.0.1.x86_64
  Installing       : docker-25.0.6-1.amzn2023.0.1.x86_64
  Running scriptlet: docker-25.0.6-1.amzn2023.0.1.x86_64
Created symlink /etc/systemd/system/sockets.target.wants/docker.socket → /usr/lib/systemd/system/docker.socket.

  Verifying        : containerd-1.7.20-1.amzn2023.0.1.x86_64
  Verifying        : docker-25.0.6-1.amzn2023.0.1.x86_64
  Verifying        : iptables-libs-1.8.8-3.amzn2023.0.2.x86_64
  Verifying        : iptables-nft-1.8.8-3.amzn2023.0.2.x86_64
  Verifying        : libcgroup-3.0-1.amzn2023.0.1.x86_64
  Verifying        : libnetfilter_conntrack-1.0.8-2.amzn2023.0.2.x86_64
  Verifying        : libnfnetlink-1.0.1-19.amzn2023.0.2.x86_64
  Verifying        : libnftnl-1.2.2-2.amzn2023.0.2.x86_64
  Verifying        : pigz-2.5-1.amzn2023.0.3.x86_64
  Verifying        : runc-1.1.11-1.amzn2023.0.1.x86_64

Installed:
  containerd-1.7.20-1.amzn2023.0.1.x86_64       docker-25.0.6-1.amzn2023.0.1.x86_64       iptables-libs-1.8.8-3.amzn2023.0.2.x86_6
  iptables-nft-1.8.8-3.amzn2023.0.2.x86_64      libcgroup-3.0-1.amzn2023.0.1.x86_64       libnetfilter_conntrack-1.0.8-2.amzn2023.
  libnfnetlink-1.0.1-19.amzn2023.0.2.x86_64     libnftnl-1.2.2-2.amzn2023.0.2.x86_64      pigz-2.5-1.amzn2023.0.3.x86_64
  runc-1.1.11-1.amzn2023.0.1.x86_64

Complete!
```

6. To start the docker on master and slave perform this command:

Systemctl start docker

Extra

7. To check if docker is Installed successfully:

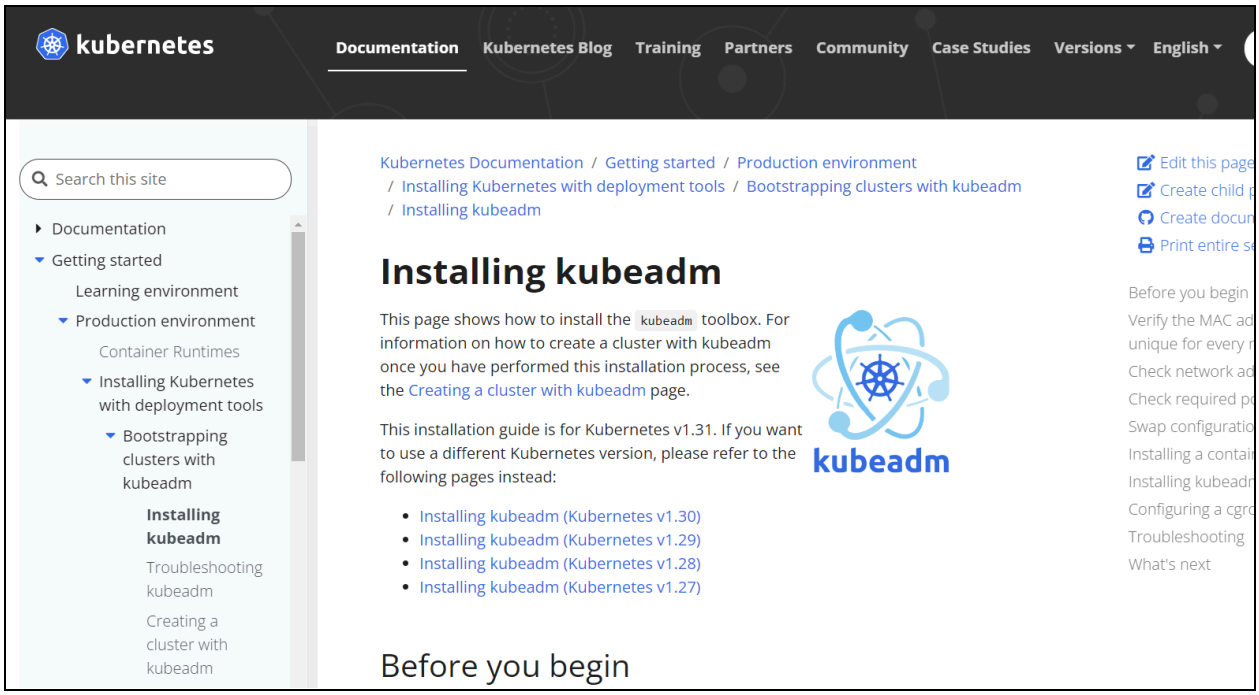
Docker -v or Docker –version

```
[root@ip-172-31-84-37 ec2-user]# systemctl start docker
[root@ip-172-31-84-37 ec2-user]# sudo su
[root@ip-172-31-84-37 ec2-user]# yum repolist
repo id                                                 repo name
amazonlinux                                             Amazon Linux 2023 repository
kernel-livepatch                                        Amazon Linux 2023 Kernel Livepatch repository
[root@ip-172-31-84-37 ec2-user]# docker --version
Docker version 25.0.5, build 5dc9bcc
```

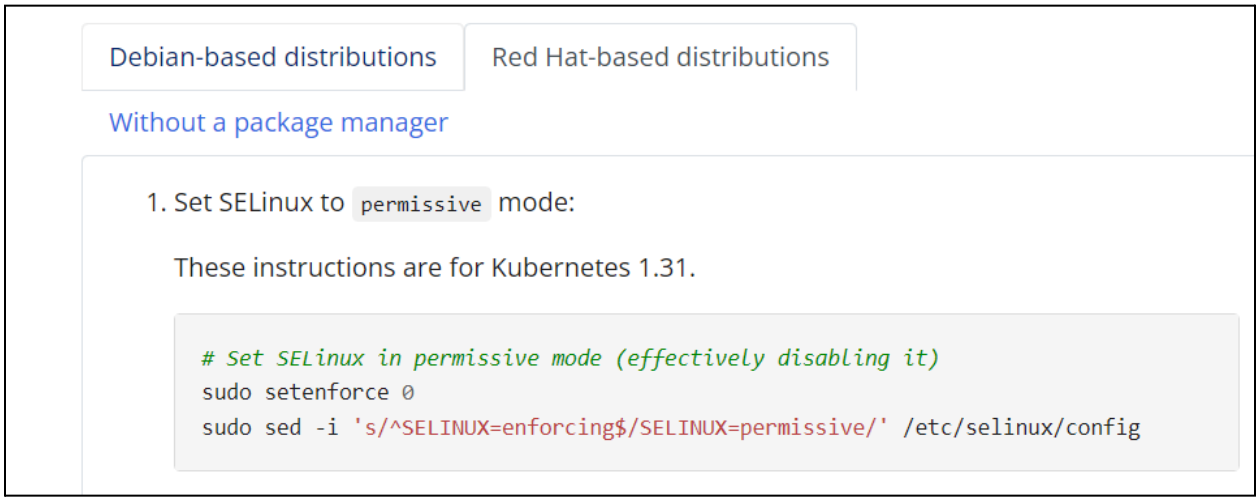
8. Now to install kubeadm on master and slaves :

Installing kubeadm:

Go the official documentation off kubeadm.



9. Scroll down and select Red Hat based distributions:



10. Now copy the command on all 3 machines:

Set SELinux to permissive mode:

These instructions are for Kubernetes 1.31.

```
# Set SELinux in permissive mode (effectively disabling it)
sudo setenforce 0
sudo sed -i 's/^SELINUX=enforcing$/SELINUX=permissive/' /etc/selinux/config
```

11. Now copy all the commands on the GitBash on all the 3 machines:

```
# This overwrites any existing configuration in /etc/yum.repos.d/kubernetes.repo
cat <<EOF | sudo tee /etc/yum.repos.d/kubernetes.repo
[kubernetes]
name=Kubernetes
baseurl=https://pkgs.k8s.io/core:/stable:/v1.31/rpm/
enabled=1
gpgcheck=1
gpgkey=https://pkgs.k8s.io/core:/stable:/v1.31/rpm/repodata/repomd.xml.key
exclude=kubelet kubeadm kubectl cri-tools kubernetes-cni
EOF

#Install kubelet, kubeadm and kubectl:

sudo yum install -y kubelet kubeadm kubectl --disableexcludes=kubernetes

#(Optional) Enable the kubelet service before running kubeadm:

sudo systemctl enable --now kubelet
```

```
  Installing       : kubeadm-1.31.0-150500.1.1.x86_64
  Installing       : kubectl-1.31.0-150500.1.1.x86_64
  Running scriptlet: kubectl-1.31.0-150500.1.1.x86_64
  Verifying        : conntrack-tools-1.4.6-2.amzn2023.0.2.x86_64
  Verifying        : libnetfilter_cthelper-1.0.0-21.amzn2023.0.2.x86_64
  Verifying        : libnetfilter_cttimeout-1.0.0-19.amzn2023.0.2.x86_64
  Verifying        : libnetfilter_queue-1.0.5-2.amzn2023.0.2.x86_64
  Verifying        : socat-1.7.4.2-1.amzn2023.0.2.x86_64
  Verifying        : cri-tools-1.31.1-150500.1.1.x86_64
  Verifying        : kubeadm-1.31.0-150500.1.1.x86_64
  Verifying        : kubectl-1.31.0-150500.1.1.x86_64
  Verifying        : kubelet-1.31.0-150500.1.1.x86_64
  Verifying        : kubernetes-cni-1.5.0-150500.2.1.x86_64

Installed:
  conntrack-tools-1.4.6-2.amzn2023.0.2.x86_64                              cr
  kubeadm-1.31.0-150500.1.1.x86_64                                         ku
  kubelet-1.31.0-150500.1.1.x86_64                                         ku
  libnetfilter_cthelper-1.0.0-21.amzn2023.0.2.x86_64                       li
  libnetfilter_queue-1.0.5-2.amzn2023.0.2.x86_64                           so

Complete!
[root@ip-172-31-84-37 ec2-user]# sudo systemctl enable --now kubelet
```

12. Type yum repolist to check the repository of kubernetes

```
[root@ip-172-31-84-143 ec2-user]# yum repolist
repo id                                                    repo name
amazonlinux                                                Amazon Linux 2023 repository
kernel-livepatch                                           Amazon Linux 2023 Kernel Livepatch repository
kubernetes                                                 Kubernetes
```

EXTRA

Got an error in initialization kubeadm

```
[root@ip-172-31-31-240 ec2-user]# kubeadm init
[init] Using Kubernetes version: v1.31.0
[preflight] Running pre-flight checks
W0908 11:25:45.820964    2320 checks.go:1080] [preflight] WARNING: Couldn't create the interface used for talking t
RI runtime service: validate service connection: validate CRI v1 runtime API for endpoint "unix:///var/run/containe
ble desc = connection error: desc = "transport: Error while dialing: dial unix /var/run/containerd/containerd.sock:
        [WARNING FileExisting-tc]: tc not found in system path
error execution phase preflight: [preflight] Some fatal errors occurred:
        [ERROR FileContent--proc-sys-net-ipv4-ip_forward]: /proc/sys/net/ipv4/ip_forward contents are not set to 1
[preflight] If you know what you are doing, you can make a check non-fatal with `--ignore-preflight-errors=...`
To see the stack trace of this error execute with --v=5 or higher
```

Error was resolved:
(after again starting from scratch)

13. Initialize the kubeadm by the command kubeadm init only on master:

Kubeadm initialized successfully:

```
[root@ip-172-31-26-66 ec2-user]# kubeadm init
[init] Using Kubernetes version: v1.31.0
[preflight] Running pre-flight checks
        [WARNING FileExisting-socat]: socat not found in system path
        [WARNING FileExisting-tc]: tc not found in system path
[preflight] Pulling images required for setting up a Kubernetes cluster
[preflight] This might take a minute or two, depending on the speed of your interr
[preflight] You can also perform this action beforehand using 'kubeadm config imag
W0912 06:07:49.475553   28037 checks.go:846] detected that the sandbox image "regi
 that used by kubeadm.It is recommended to use "registry.k8s.io/pause:3.10" as the
[certs] Using certificateDir folder "/etc/kubernetes/pki"
[certs] Generating "ca" certificate and key
[certs] Generating "apiserver" certificate and key
[certs] apiserver serving cert is signed for DNS names [ip-172-31-26-66.ec2.interr
efault.svc.cluster.local] and IPs [10.96.0.1 172.31.26.66]
[certs] Generating "apiserver-kubelet-client" certificate and key
[certs] Generating "front-proxy-ca" certificate and key
[certs] Generating "front-proxy-client" certificate and key
[certs] Generating "etcd/ca" certificate and key
```

14. After this we will get 3 things:
    - The directory
    - Some export Statement
    - The most important thing - the token to connect the slaves with the master.

15. Copy them one by one and paste it on the slaves:

```
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 172.31.26.66:6443 --token grw4r4.gb3kkhb7392dnvjp \
        --discovery-token-ca-cert-hash sha256:b61f1de7eedb2c0dc0cc237d4629e9631920b63dd6634c3e22e76aaa36d01920
```

16. After pasting type kubectl get nodes:

The nodes are connected successfully:

```
ubuntu@ip-172-31-17-23:~$ kubectl get nodes
NAME               STATUS   ROLES           AGE     VERSION
ip-172-31-17-23    Ready    control-plane   3m56s   v1.29.0
ip-172-31-18-12    Ready    <none>          37s     v1.29.0
ip-172-31-26-153   Ready    <none>          24s     v1.29.0
ubuntu@ip-172-31-17-23:~$ kubectl get nodes
NAME               STATUS   ROLES           AGE     VERSION
ip-172-31-17-23    Ready    control-plane   9m34s   v1.29.0
ip-172-31-18-12    Ready    <none>          6m15s   v1.29.0
ip-172-31-26-153   Ready    <none>          6m2s    v1.29.0
ubuntu@ip-172-31-17-23:~$
```