Advanced DevOps Lab
Experiment 4

Aim: To install Kubectl and execute Kubectl commands to manage the Kubernetes cluster and deploy Your First Kubernetes Application.

Theory:

Overview of Kubernetes and Kubectl

What is Kubernetes?

Kubernetes, often referred to as K8s, is an open-source container orchestration platform that automates the deployment, scaling, and management of containerized applications. Originally developed by Google, it has become the industry standard for managing container workloads due to its flexibility and robust features.

Core Concepts of Kubernetes

1. Containers: These are lightweight, portable packages that include everything needed to run an application, ensuring consistency across different environments.
2. Pods: The smallest deployable units in Kubernetes, pods can contain one or more containers that share storage and network resources.
3. Nodes: A node is a worker machine in the Kubernetes cluster that runs at least one pod. Nodes can be either physical or virtual machines.
4. Clusters: A cluster comprises multiple nodes that run containerized applications. The control plane manages the cluster's state.
5. Services: Services provide stable endpoints for accessing pods and facilitate load balancing and service discovery.
6. Deployments: A deployment manages the lifecycle of pods, allowing users to specify the number of replicas and facilitating rolling updates and rollbacks.

Architecture of Kubernetes

Kubernetes follows a client-server architecture consisting of:

- Control Plane: Manages the cluster and includes components like the API server (the front-end for the control plane), scheduler (assigns pods to nodes), controller manager (regulates cluster state), and etcd (a distributed key-value store for cluster data).
- Worker Nodes: Each node runs components like kubelet (ensures containers are running), kube-proxy (manages network communication), and a container runtime (e.g., Docker).

Role of Kubectl in Kubernetes

What is Kubectl?

Kubectl is the command-line interface used to interact with the Kubernetes API server. It enables users to manage resources within a Kubernetes cluster effectively.

Key Functions of Kubectl

1. Resource Management: Users can create, update, delete, and retrieve information about various resources such as deployments, services, and pods.
2. Configuration Management: Users can apply configuration files written in YAML or JSON format to define resource structures and behaviors.
3. Monitoring and Debugging: Kubectl allows users to inspect resource statuses, view logs from containers, and describe resource configurations for troubleshooting.
4. Access Control: Supports role-based access control (RBAC) to define permissions for users interacting with the cluster.
5. Namespace Management: Facilitates the creation and management of namespaces to organize resources across teams or projects.

Configuration Files

Configuration files are essential for defining how resources should be created or modified within Kubernetes. Users can employ declarative configurations (using YAML/JSON files) or imperative commands directly in the terminal.

Deploying Applications on Kubernetes

Application Deployment Lifecycle

1. Define Application Requirements: Identify necessary resources such as CPU, memory, storage, etc.
2. Create Deployment Configurations: Write deployment manifests specifying container images, replicas for scaling, health checks, etc.
3. Deploying with Kubectl: Use kubectl commands like `kubectl apply` to deploy applications based on these configurations.
4. Monitoring and Scaling Applications: Monitor performance metrics and adjust deployments based on traffic demands.
5. Updating Applications: Modify deployment configurations for updates; Kubernetes supports rolling updates by default.
6. Rollback Capabilities: If an update causes issues, kubectl allows easy rollback to previous versions using commands like `kubectl rollout undo`.

Best Practices for Application Deployment

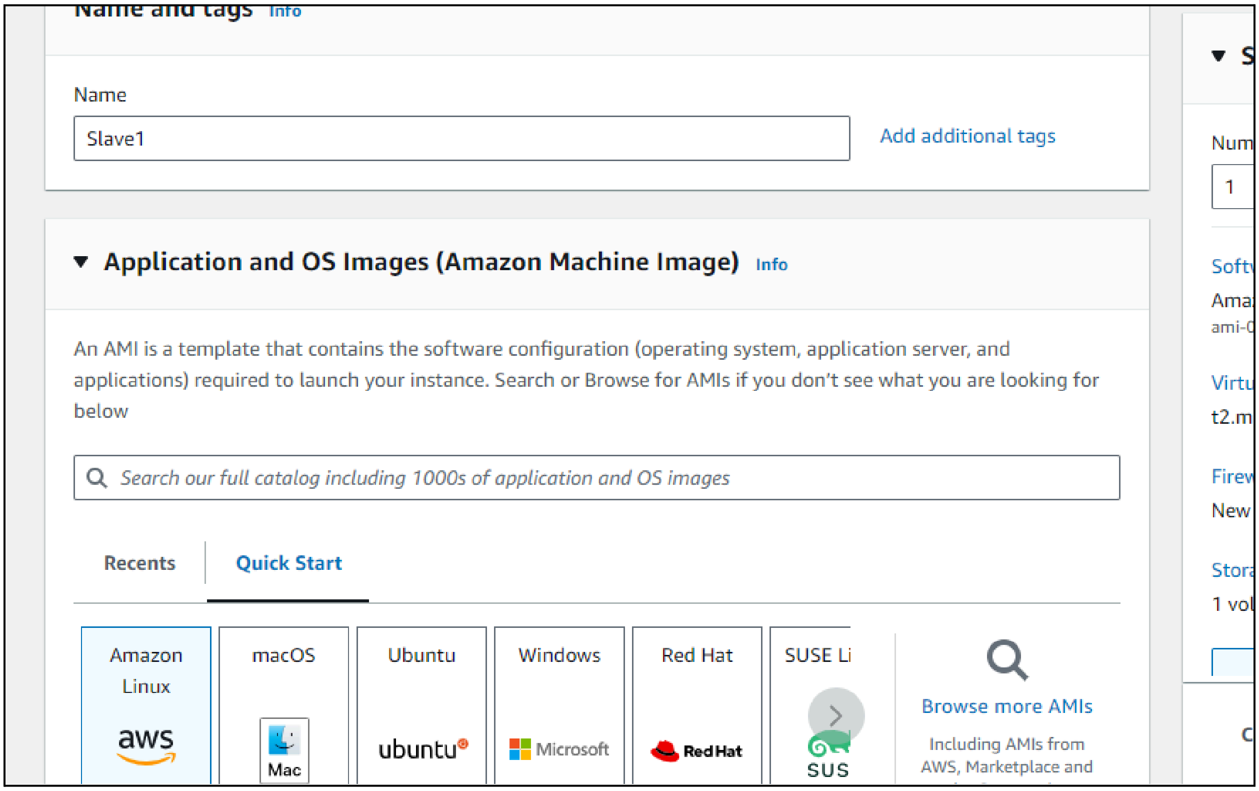
- Use versioned images for consistency.
- Implement health checks to manage application availability.
- Utilize namespaces for better organization.

- Regularly monitor resource usage and adjust accordingly.
- Automate deployment processes using CI/CD pipelines integrated with kubectl commands.

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)



Name and tags Info

Name: Slave1

Add additional tags

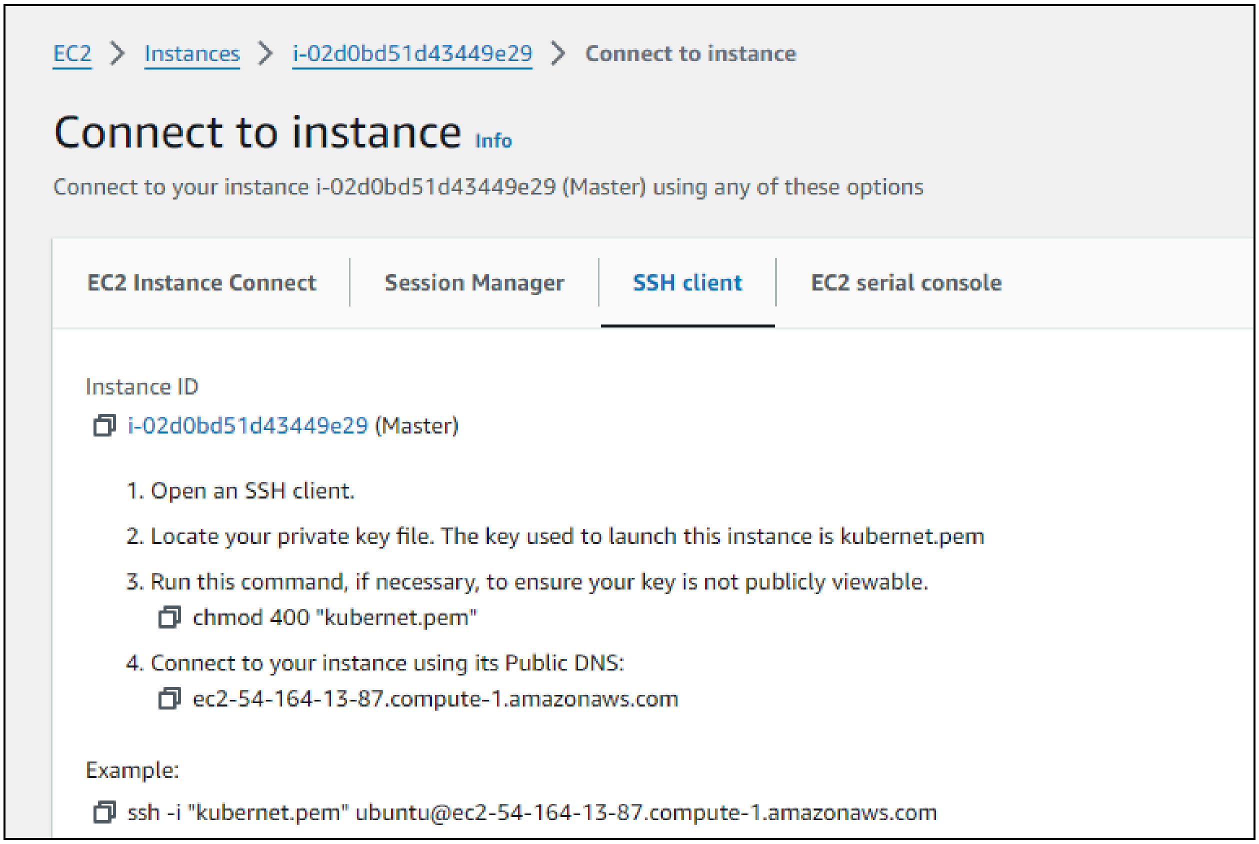
Application and OS Images (Amazon Machine Image) Info

An AMI is a template that contains the software configuration (operating system, application server, and applications) required to launch your instance. Search or Browse for AMIs if you don't see what you are looking for below

Search our full catalog including 1000s of application and OS images

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)



Connect to instance

Connect to your instance i-02d0bd51d43449e29 (Master) using any of these options

Instance ID

i-02d0bd51d43449e29 (Master)

1. Open an SSH client.
2. Locate your private key file. The key used to launch this instance is kubernet.pem
3. Run this command, if necessary, to ensure your key is not publicly viewable.

   chmod 400 "kubernet.pem"
4. Connect to your instance using its Public DNS:

   ec2-54-164-13-87.compute-1.amazonaws.com

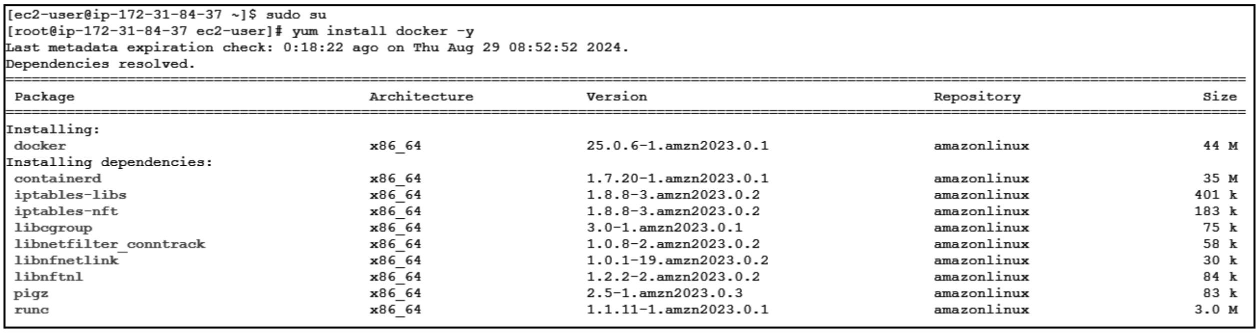
Example:

ssh -i "kubernet.pem" ubuntu@ec2-54-164-13-87.compute-1.amazonaws.com

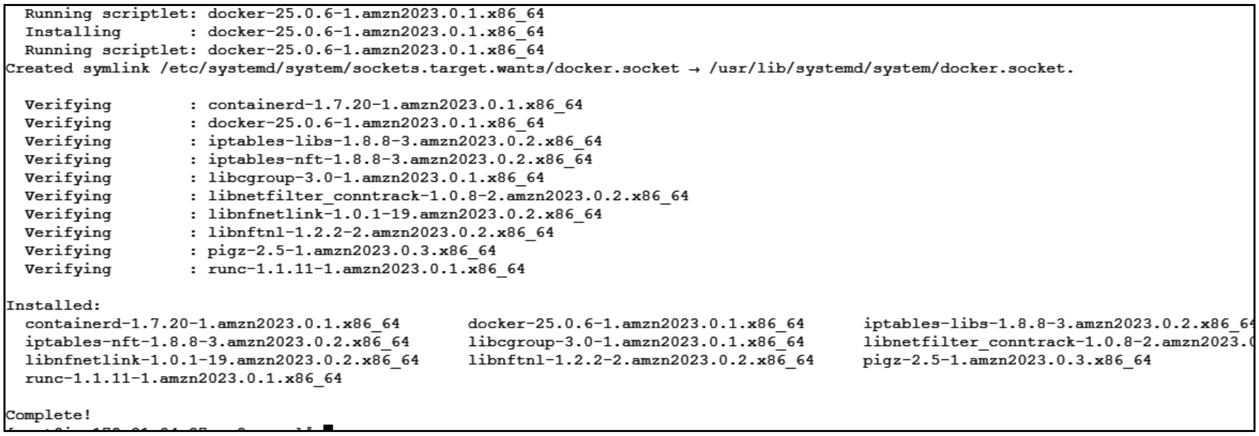
Commands:

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

5. After this type on GitBash
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_64
  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.amzn2023.0
  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!
```

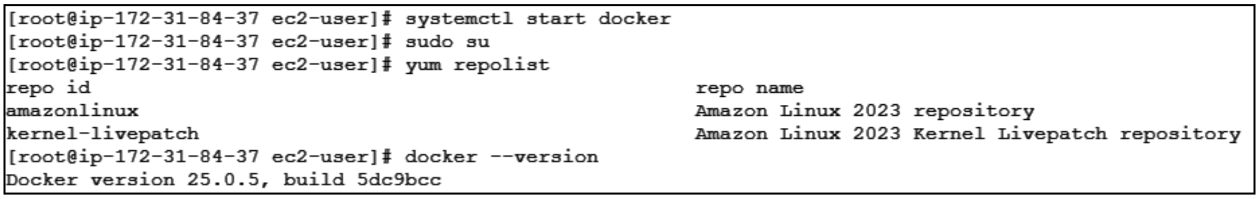
6. To start the docker perform this command:

Systemctl start docker

Extra

7. To check if docker is Installed successfully:

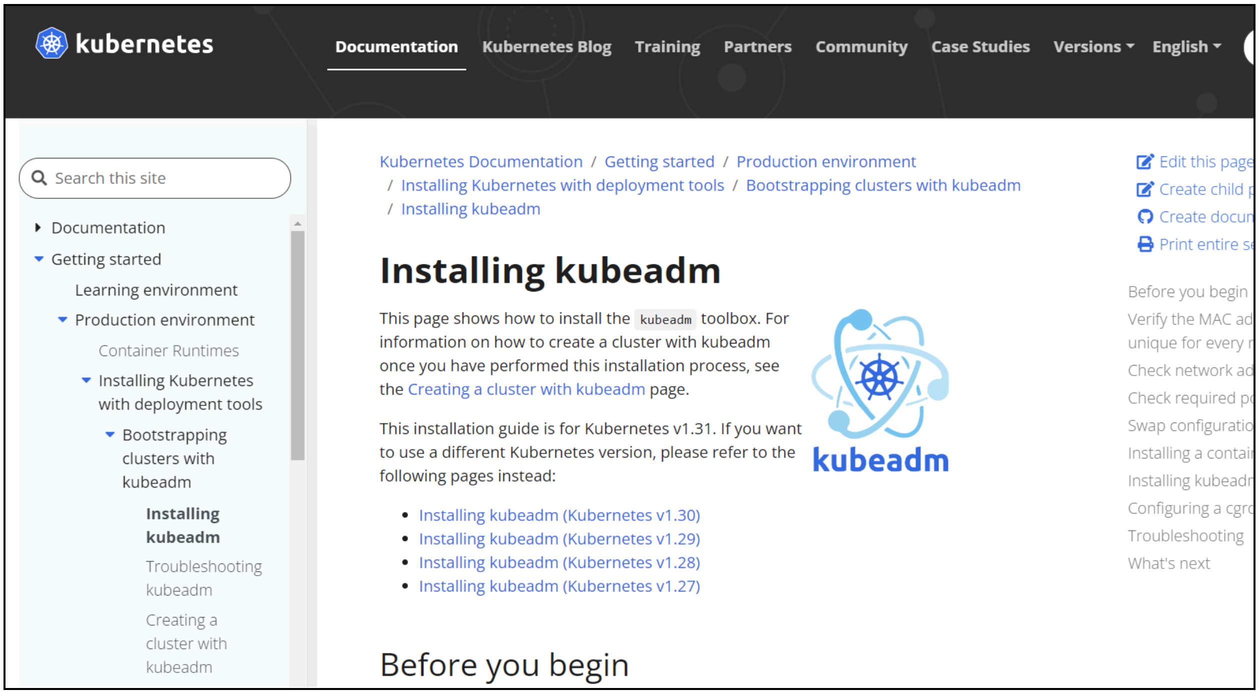
Docker -v or Docker –version



```
[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 :

Installing kubeadm:
Go the official documentation off kubeadm.



Kubernetes Documentation / Getting started / Production environment / Installing Kubernetes with deployment tools / Bootstrapping clusters with kubeadm / Installing kubeadm

Installing kubeadm

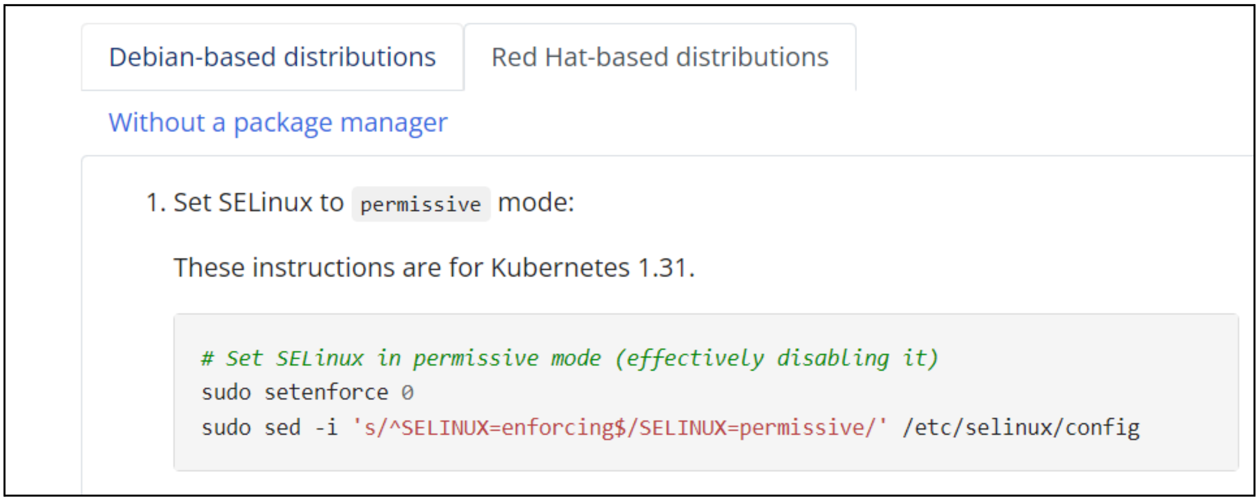
This page shows how to install the `kubeadm` toolbox. For information on how to create a cluster with kubeadm once you have performed this installation process, see the Creating a cluster with kubeadm page.

This installation guide is for Kubernetes v1.31. If you want to use a different Kubernetes version, please refer to the following pages instead:

- Installing kubeadm (Kubernetes v1.30)
- Installing kubeadm (Kubernetes v1.29)
- Installing kubeadm (Kubernetes v1.28)
- Installing kubeadm (Kubernetes v1.27)

Before you begin

9. Scroll down and select Red Hat based distributions:


Debian-based distributions
Red Hat-based distributions
Without a package manager

1. 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
```

10. Now copy the command:

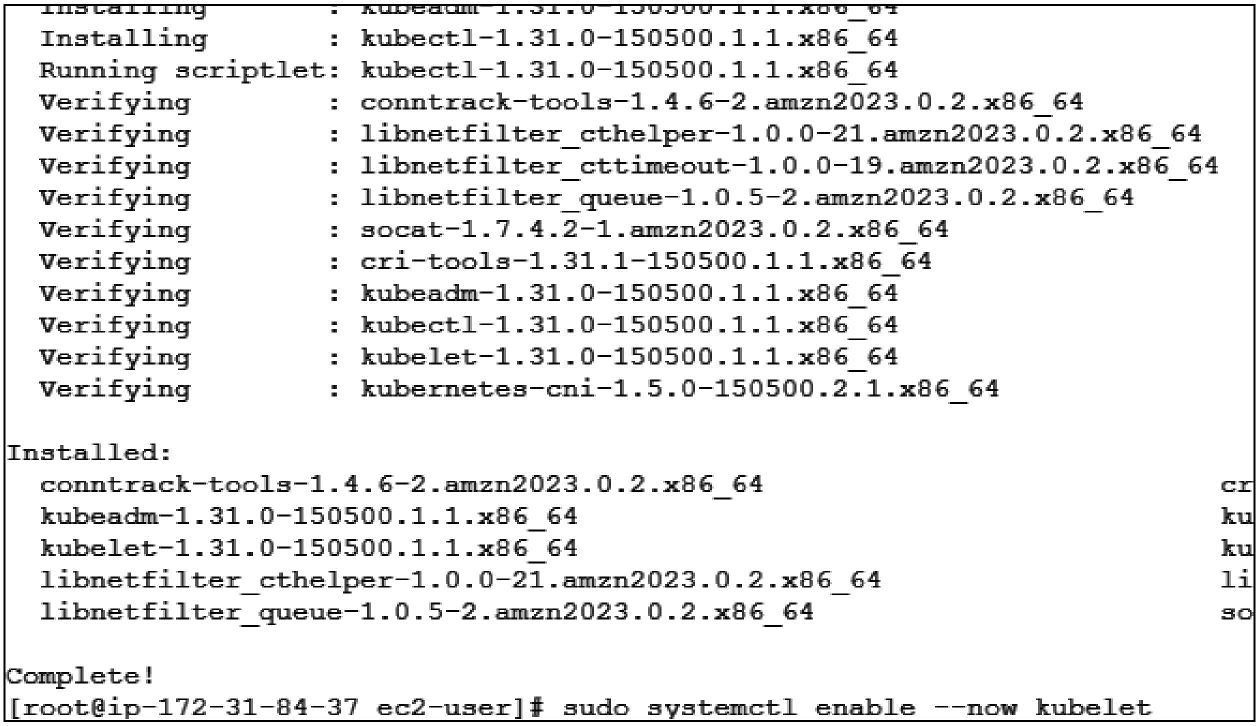
Set SELinux to permissive mode:

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
```

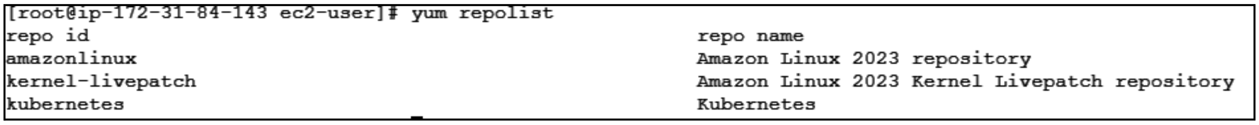
11. Now copy all the commands on the GitBash:

```
# 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
```

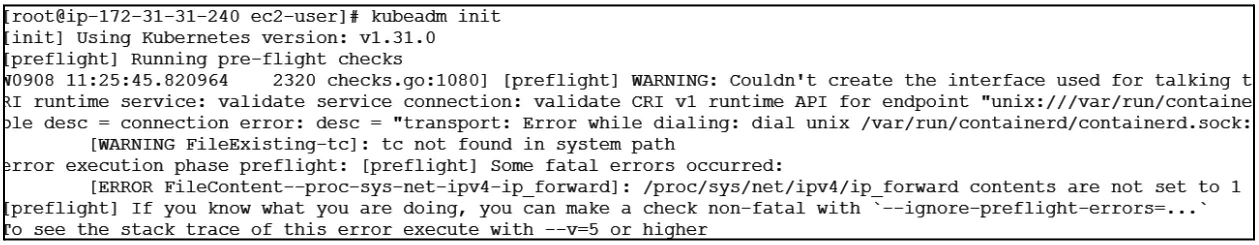
12. Type yum repolist to check the repository of kubernetes



```
[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

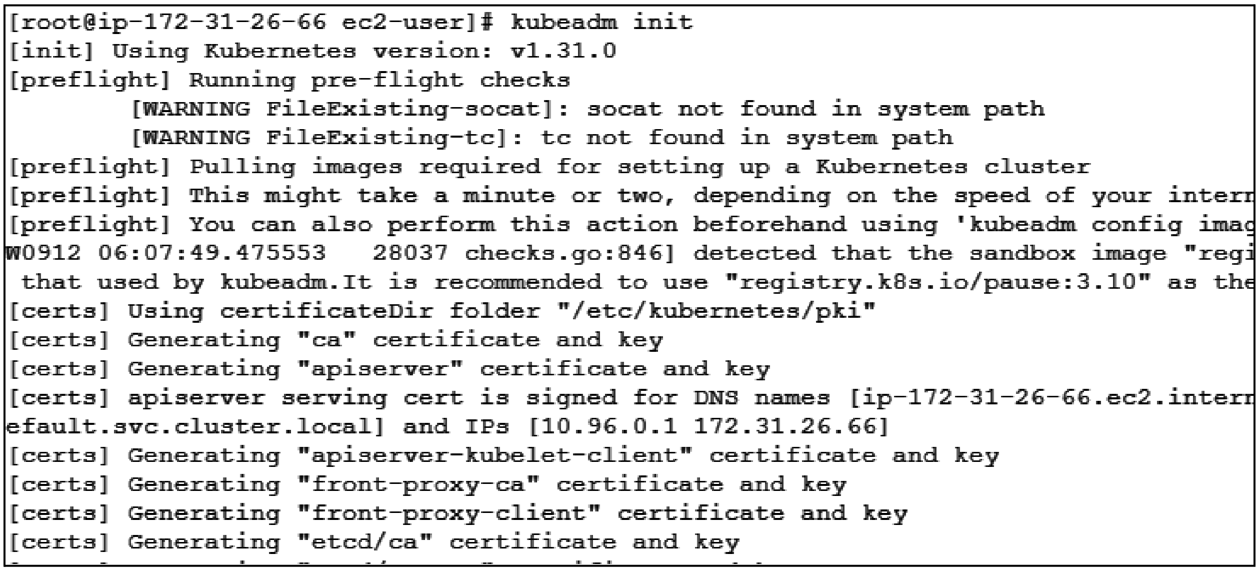


```
[root@ip-172-31-31-240 ec2-user]# kubeadm init
[init] Using Kubernetes version: v1.31.0
[preflight] Running pre-flight checks
W0908 11:25:45.820964    2320 checks.go:1080] [preflight] WARNING: Couldn't create the interface used for talking t
RI runtime service: validate service connection: validate 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 :

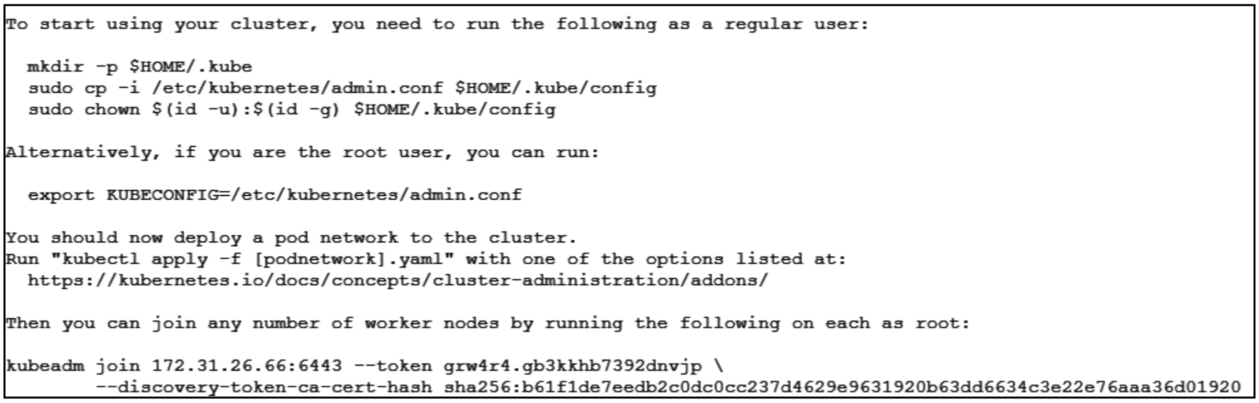
Kubeadm initialized successfully:



```
[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 intern
[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.intern
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.

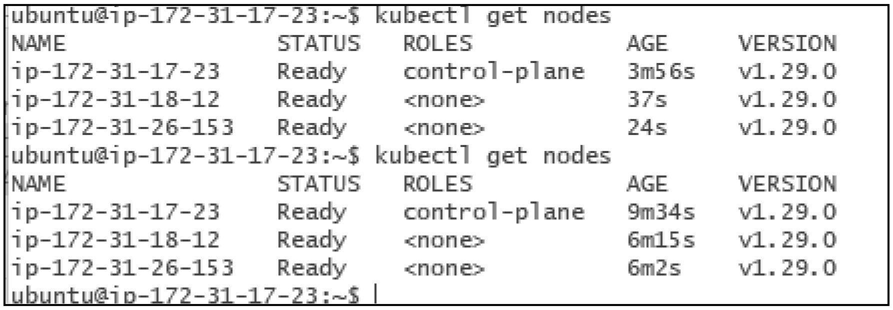
15. Copy them



```
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
```

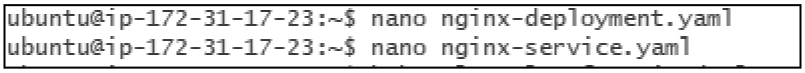
16. After pasting type kubectl get nodes:

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:~$ |
```

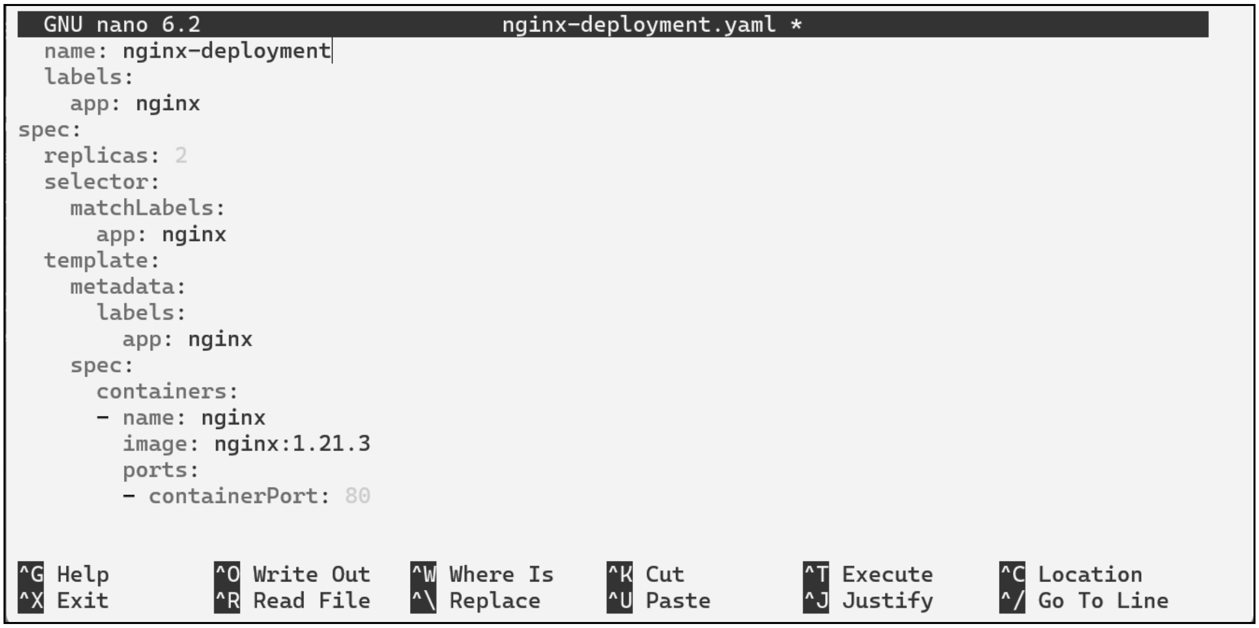
17. Create two YAML files named nginx-deployment.yaml and nginx-service.yaml
(I used nano editor for the same)



```
ubuntu@ip-172-31-17-23:~$ nano nginx-deployment.yaml
ubuntu@ip-172-31-17-23:~$ nano nginx-service.yaml
```

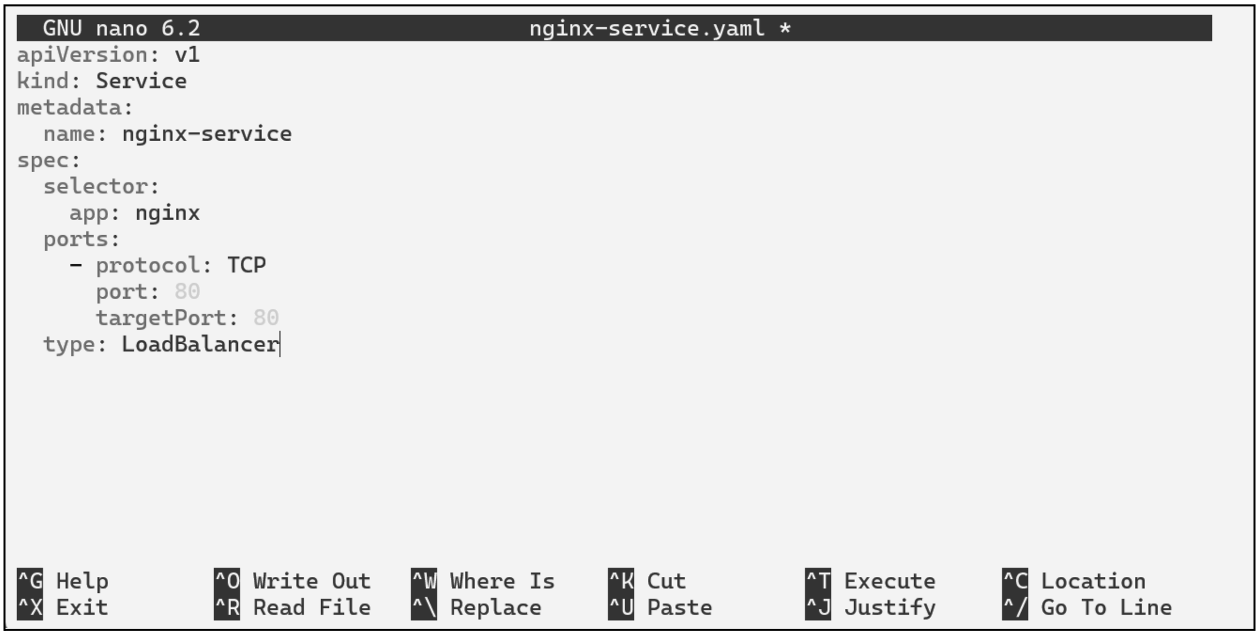
18. Then add the deployment and service configuration in it, respectively:

Deployment:



```
  name: nginx-deployment
  labels:
    app: nginx
spec:
  replicas: 2
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - name: nginx
        image: nginx:1.21.3
        ports:
        - containerPort: 80
```

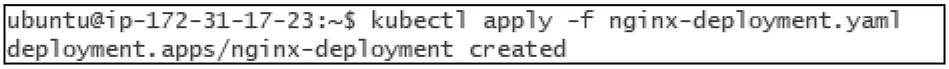
Service:



```
apiVersion: v1
kind: Service
metadata:
  name: nginx-service
spec:
  selector:
    app: nginx
  ports:
    - protocol: TCP
      port: 80
      targetPort: 80
  type: LoadBalancer
```

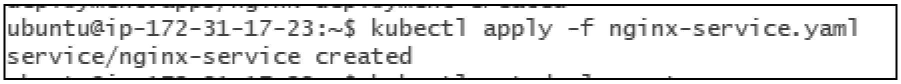
19. Now since we have configured our files we would now proceed for applying both the deployment and the service files.

Deployment :



```
ubuntu@ip-172-31-17-23:~$ kubectl apply -f nginx-deployment.yaml
deployment.apps/nginx-deployment created
```

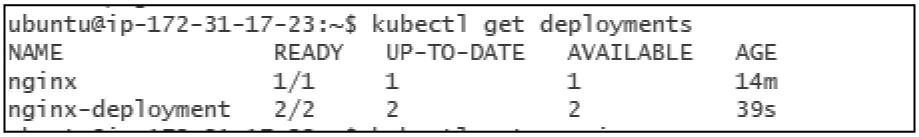
Service:



```
ubuntu@ip-172-31-17-23:~$ kubectl apply -f nginx-service.yaml
service/nginx-service created
```

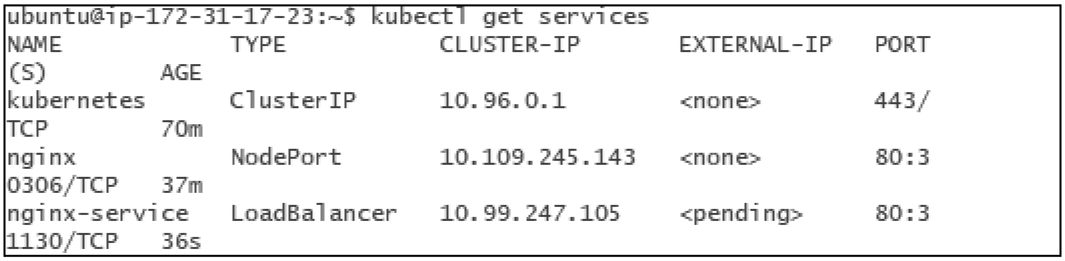
20. After deployment its time for verifying the same:

For deployment:



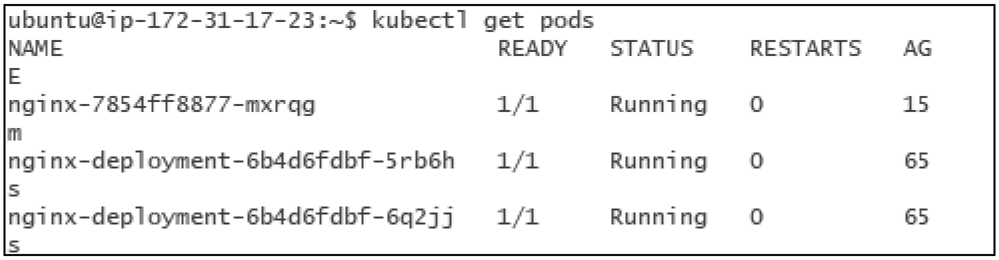
```
ubuntu@ip-172-31-17-23:~$ kubectl get deployments
NAME               READY   UP-TO-DATE   AVAILABLE   AGE
nginx              1/1     1            1           14m
nginx-deployment   2/2     2            2           39s
```

For services:



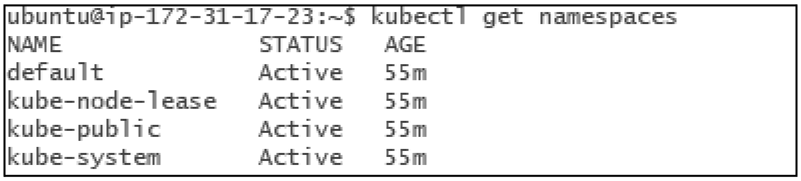
```
ubuntu@ip-172-31-17-23:~$ kubectl get services
NAME            TYPE           CLUSTER-IP       EXTERNAL-IP   PORT
(S)        AGE
kubernetes      ClusterIP      10.96.0.1        <none>        443/
TCP        70m
nginx           NodePort       10.109.245.143   <none>        80:3
0306/TCP   37m
nginx-service   LoadBalancer   10.99.247.105    <pending>     80:3
1130/TCP   36s
```

For pods:



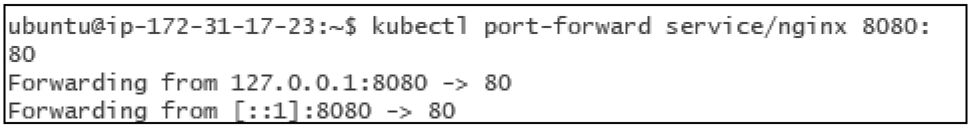
```
ubuntu@ip-172-31-17-23:~$ kubectl get pods
NAME                                READY   STATUS    RESTARTS   AG
E
nginx-7854ff8877-mxrqg              1/1     Running   0          15
m
nginx-deployment-6b4d6fdbf-5rb6h    1/1     Running   0          65
s
nginx-deployment-6b4d6fdbf-6q2jj    1/1     Running   0          65
s
```

Extra:



```
ubuntu@ip-172-31-17-23:~$ kubectl get namespaces
NAME              STATUS   AGE
default           Active   55m
kube-node-lease   Active   55m
kube-public       Active   55m
kube-system       Active   55m
```

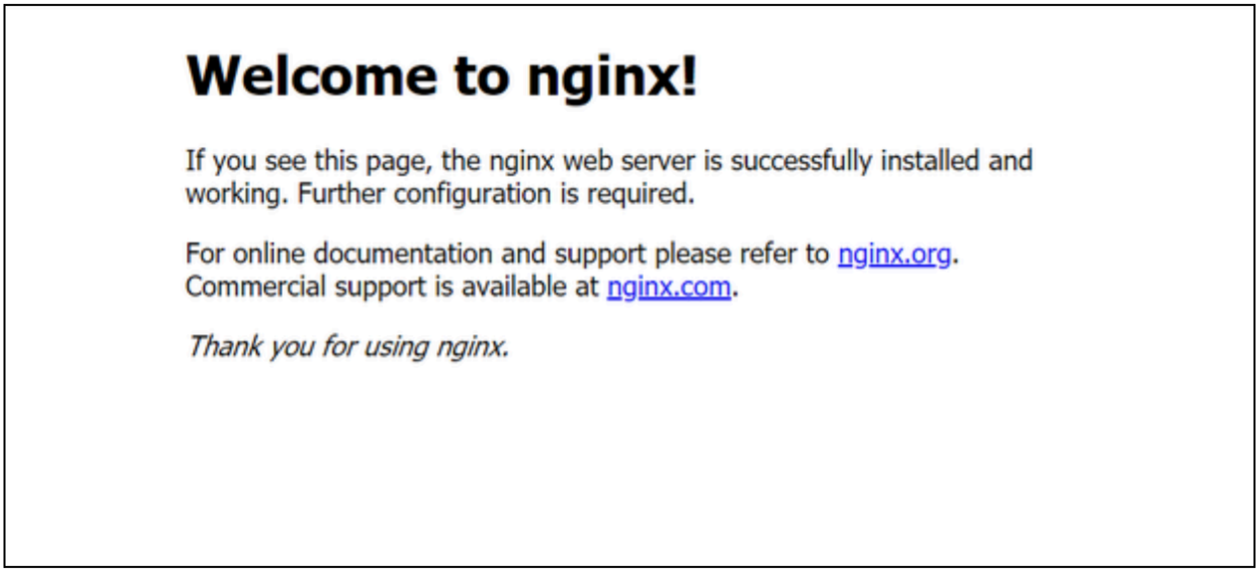
21. Now Lastly, port forward the deployment to your localhost so that you can view it.



```
ubuntu@ip-172-31-17-23:~$ kubectl port-forward service/nginx 8080:
80
Forwarding from 127.0.0.1:8080 -> 80
Forwarding from [::1]:8080 -> 80
```

22. You can open the browser and check on

http://localhost:8080



Welcome to nginx!

If you see this page, the nginx web server is successfully installed and working. Further configuration is required.

For online documentation and support please refer to nginx.org.
Commercial support is available at nginx.com.

Thank you for using nginx.