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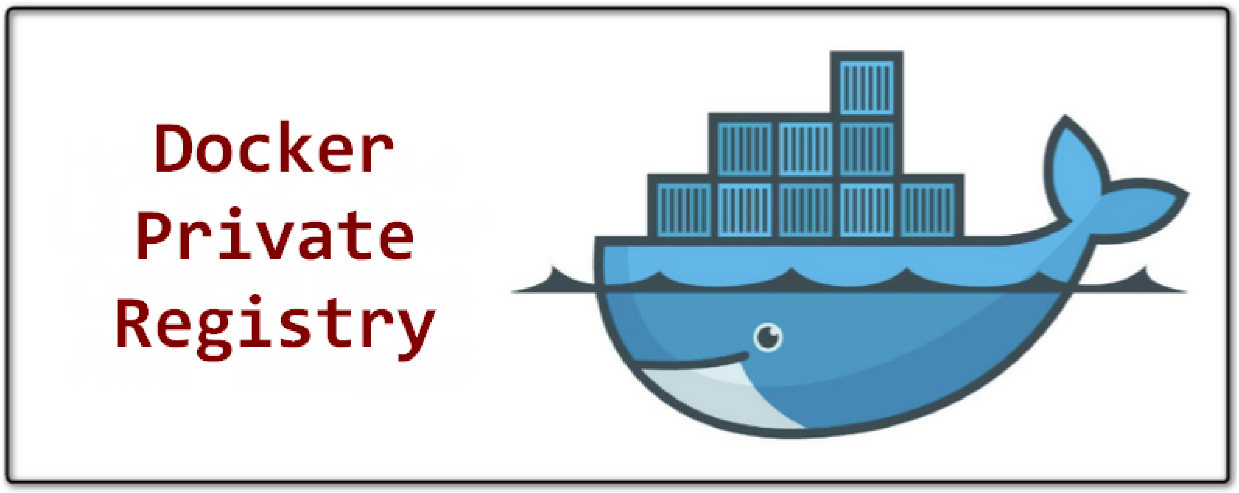
Deploy Your Private Docker Registry as a Pod in Kubernetes



Docker Registry is an application that helps you in storing and distributing container images. The most popular container registry is DockerHub, which is the standard public registry for Docker and Kubernetes. But you might face a situation where you will not want your image to be publicly available over the internet. In that case, setting up a Private Docker Registry provides you with multiple storage and authentication options which can be customized as per your requirement.

In this tutorial, we shall look at deploying a TLS-enabled Private Docker Registry as a Pod in a Kubernetes environment. This will help us to push our custom built images to the registry, which later can be pulled by any of the worker nodes and run as containers in Pods. My k8s cluster here consists of 4 Ubuntu 18.04.4 (Bionic Beaver) VMs with 1 master and 3 worker nodes.

```
root@master1:~# docker -v
Docker version 19.03.12, build 48a66213fe
root@master1:~# kubectl version --short
Client Version: v1.18.5
Server Version: v1.18.5
root@master1:~# kubectl get nodes
NAME      STATUS   ROLES    AGE   VERSION
master1   Ready    master   65d   v1.18.5
```

```
worker1   Ready    <none>   65d   v1.18.5
worker2   Ready    <none>   65d   v1.18.5
worker3   Ready    <none>   65d   v1.18.5
root@master1:~#
```

Step 1: Creating files for authentication

Let us start by creating self-signed certificates and user authentication to boost the security for our private Docker registry. The TLS certificates are created using `openssl` where we need to specify the name, with which we want to access our registry, in the Common Name "`/CN=`" field. Here, I wish to access my registry using the name `docker-registry`.

```
root@master1:~# mkdir -p /registry && cd "$_"
root@master1:/registry# mkdir certs
root@master1:/registry# openssl req -x509 -newkey
rsa:4096 -days 365 -nodes -sha256 -keyout certs/tls.key -
out certs/tls.crt -subj "/CN=docker-registry" -addext
"subjectAltName = DNS:docker-registry"
Generating a RSA private key
.........................................................
.........................................................
.........................++++
.........................................................
....++++
writing new private key to 'certs/tls.key'
-----
root@master1:/registry#
```

Let's use `htpasswd` to add user authentication for registry access. My credentials for the private registry would be `myuser/mypasswd`.

```
root@master1:/registry# mkdir auth
root@master1:/registry# docker run --rm --entrypoint
htpasswd registry:2.6.2 -Bbn myuser mypasswd >
auth/htpasswd
Unable to find image 'registry:2.6.2' locally
2.6.2: Pulling from library/registry
486039affc0a: Pulling fs layer
ba51a3b098e6: Pulling fs layer
470e22cd431a: Pulling fs layer
```

```
1048a0cdabb0: Pulling fs layer
ca5aa9d06321: Pulling fs layer
1048a0cdabb0: Waiting
ca5aa9d06321: Waiting
ba51a3b098e6: Verifying Checksum
ba51a3b098e6: Download complete
486039affc0a: Verifying Checksum
486039affc0a: Pull complete
470e22cd431a: Verifying Checksum
470e22cd431a: Download complete
ba51a3b098e6: Pull complete
1048a0cdabb0: Verifying Checksum
1048a0cdabb0: Download complete
ca5aa9d06321: Verifying Checksum
ca5aa9d06321: Download complete
470e22cd431a: Pull complete
1048a0cdabb0: Pull complete
ca5aa9d06321: Pull complete
Digest:
sha256:c4bdca23bab136d5b9ce7c06895ba54892ae6db0ebfc3a2f1a
c413a470b17e47
Status: Downloaded newer image for registry:2.6.2
root@master1:/registry#
```

At this point, our `/registry` directory looks like this:

```
root@master1:/# ls -R /registry/
/registry/:
auth  certs

/registry/auth:
htpasswd

/registry/certs:
tls.crt  tls.key
root@master1:/#
```

Step 2: Using Secrets to mount the certificates

In Kubernetes, a `Secret` is a resource that will enable you to inject sensitive data into a container when it starts up. This data can be anything like password, OAuth tokens or ssh keys. They can be exposed inside a container as mounted files or volumes or environment variables.

The below command creates a Secret of type `tls` named `certs-secret` in the `default` namespace from the pair of public/private keys we just created.

```
root@master1:/# kubectl create secret tls certs-secret --
cert=/registry/certs/tls.crt --
key=/registry/certs/tls.key
secret/certs-secret created
root@master1:/#
```

The Secret `auth-secret` that we create from the htpasswd file is of type `generic` which means the Secret was created from a local file.

```
root@master1:/# kubectl create secret generic auth-secret
--from-file=/registry/auth/htpasswd
secret/auth-secret created
root@master1:/#
```

Step 3: Creating Persistent Volume and Claim for repository storage

The images that are pushed to our registry should be placed in a consistent storage location. Hence, we will be using a `Persistent Volume` of 1 GB hosted at a temporary location in the node where our registry Pod will be running. The Pod uses a `Persistent Volume Claim` which will be bound to the newly created volume as a one-to-one mapping.

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: docker-repo-pv
spec:
  capacity:
    storage: 1Gi
  accessModes:
  - ReadWriteOnce
  hostPath:
    path: /tmp/repository
---
apiVersion: v1
```

```
kind: PersistentVolumeClaim
metadata:
  name: docker-repo-pvc
spec:
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 1Gi
```

Copy the above content into a yaml file, say `repository-volume.yaml` and execute the below command:

```
root@master1:/# kubectl create -f repository-volume.yaml
persistentvolume/docker-repo-pv created
persistentvolumeclaim/docker-repo-pvc created
root@master1:/#
```

Step 4: Creating the Registry Pod

Next, let us create the actual Pod and a corresponding Service to access it. In the yaml file `docker-registry-pod.yaml` below, the image that we use for our registry is called `registry` which is downloaded from DockerHub. The images pushed to this registry will be saved in `/var/lib/registry` directory internally, hence we mount our Persistent Volume using the Claim `docker-repo-pvc` to persist the images permanently. The environment variables which are required by the registry container are taken care by the Secrets that we mount as volumes.

The Service is named `docker-registry`, with which we want to access our docker private registry. Note that this was the exact name that was given in the Common Name "/CN=" field while generating the TLS certificates. The registry container by default is exposed at port `5000` and we bind our Service to this port accordingly.

```
apiVersion: v1
kind: Pod
```

```yaml
metadata:
  name: docker-registry-pod
  labels:
    app: registry
spec:
  containers:
  - name: registry
    image: registry:2.6.2
    volumeMounts:
    - name: repo-vol
      mountPath: "/var/lib/registry"
    - name: certs-vol
      mountPath: "/certs"
      readOnly: true
    - name: auth-vol
      mountPath: "/auth"
      readOnly: true
    env:
    - name: REGISTRY_AUTH
      value: "htpasswd"
    - name: REGISTRY_AUTH_HTPASSWD_REALM
      value: "Registry Realm"
    - name: REGISTRY_AUTH_HTPASSWD_PATH
      value: "/auth/htpasswd"
    - name: REGISTRY_HTTP_TLS_CERTIFICATE
      value: "/certs/tls.crt"
    - name: REGISTRY_HTTP_TLS_KEY
      value: "/certs/tls.key"
  volumes:
  - name: repo-vol
    persistentVolumeClaim:
      claimName: docker-repo-pvc
  - name: certs-vol
    secret:
      secretName: certs-secret
  - name: auth-vol
    secret:
      secretName: auth-secret
---
apiVersion: v1
kind: Service
metadata:
  name: docker-registry
spec:
  selector:
    app: registry
  ports:
  - port: 5000
    targetPort: 5000
```

Create the Registry Pod and the Service using the following command:

```
root@master1:/# kubectl create -f docker-registry-
pod.yaml
pod/docker-registry-pod created
service/docker-registry created
root@master1:/# kubectl get all
NAME                      READY   STATUS    RESTARTS
AGE
pod/docker-registry-pod   1/1     Running   0
36s

NAME                      TYPE        CLUSTER-IP
EXTERNAL-IP   PORT(S)    AGE
service/docker-registry   ClusterIP   10.107.59.73
<none>        5000/TCP   36s
service/kubernetes        ClusterIP   10.96.0.1
<none>        443/TCP    65d
root@master1:/#
```

Step 5: Allowing access to the registry from all the nodes in the cluster

We observe from the above step that our registry can be accessed at 10.107.59.73:5000, since the ip-address of our Service turned out to be 10.107.59.73. Note that this value will be different in your case.

Let’s make a note of the registry name and its ip-address as environment variables.

```
root@master1:/# export REGISTRY_NAME="docker-registry"
root@master1:/# export REGISTRY_IP="10.107.59.73"
root@master1:/#
```

Now, we shall append the entry "10.107.59.73 docker-registry" to the /etc/hosts file of all the nodes in our cluster so that this ip-address is resolved to the name docker-registry.

The above step can also be done using a single command from the master node (Enter password, if prompted):

```
root@master1:/# for x in $(kubectl get nodes -o
jsonpath='{
$.items[*].status.addresses[?(@.type=="InternalIP")].addr
ess }'); do ssh root@$x "echo '$REGISTRY_IP
$REGISTRY_NAME' >> /etc/hosts"; done
root@master1:/#
```

Next, we must copy the tls.crt that we created earlier as "ca.crt" into a custom /etc/docker/certs.d/docker-registry:5000 directory in all the nodes in our cluster to make sure that our self-signed certificate is trusted by Docker. Note that the directory that is created inside /etc/docker/certs.d should be having the name of the format<registry_name>:<registry_port>.

This step can be done manually or with the help of a single command from the master node as follows:

```
root@master1:/# for x in $(kubectl get nodes -o
jsonpath='{
$.items[*].status.addresses[?(@.type=="InternalIP")].addr
ess }'); do ssh root@$x "rm -rf
/etc/docker/certs.d/$REGISTRY_NAME:5000;mkdir -p
/etc/docker/certs.d/$REGISTRY_NAME:5000"; done
root@master1:/#
root@master1:/# for x in $(kubectl get nodes -o
jsonpath='{
$.items[*].status.addresses[?(@.type=="InternalIP")].addr
ess }'); do scp /registry/certs/tls.crt
root@$x:/etc/docker/certs.d/$REGISTRY_NAME:5000/ca.crt;
done
tls.crt
100% 1822     2.7MB/s   00:00
tls.crt
```

```
100% 1822     2.4MB/s   00:00
tls.crt
100% 1822     1.6MB/s   00:00
tls.crt
100% 1822     2.1MB/s   00:00
root@master1:/#
```

The above step forces Docker to verify our self-signed certificate even though it is not signed by a known authority.

Step 6: Testing our Private Docker Registry

Now, let us try to login to the registry from the master node, using the same credentials we created earlier:

```
root@master1:/# docker login docker-registry:5000 -u
myuser -p mypasswd
WARNING! Using --password via the CLI is insecure. Use --
password-stdin.
WARNING! Your password will be stored unencrypted in
/root/.docker/config.json.
Configure a credential helper to remove this warning. See
https://docs.docker.com/engine/reference/commandline/logi
n/#credentials-store

Login Succeeded
root@master1:/#
```

Hurray! This worked!!

Before we start using our registry, let us create a Secret of type `docker-registry` which uses the credentials `myuser/mypasswd` for enabling all the nodes in our cluster to authenticate with our private Docker registry.

```
root@master1:/# kubectl create secret docker-registry
reg-cred-secret --docker-server=$REGISTRY_NAME:5000 --
docker-username=myuser --docker-password=mypasswd
secret/reg-cred-secret created
root@master1:/#
```

Let us try to push a custom image to our private Docker registry.

```
root@master1:/# docker pull nginx
Using default tag: latest
latest: Pulling from library/nginx
bf5952930446: Pull complete
cb9a6de05e5a: Pull complete
9513ea0afb93: Pull complete
b49ea07d2e93: Pull complete
a5e4a503d449: Pull complete
Digest:
sha256:b0ad43f7ee5edbc0effbc14645ae7055e21bc1973aee515074
5632a24a752661
Status: Downloaded newer image for nginx:latest
docker.io/library/nginx:latest
root@master1:/#
root@master1:/# docker tag nginx:latest docker-
registry:5000/mynginx:v1
root@master1:/#
root@master1:/# docker push docker-
registry:5000/mynginx:v1
The push refers to repository [docker-
registry:5000/mynginx]
550333325e31: Layer already exists
22ea89b1a816: Layer already exists
a4d893caa5c9: Layer already exists
0338db614b95: Layer already exists
d0f104dc0a1f: Layer already exists
v1: digest:
sha256:179412c42fe3336e7cdc253ad4a2e03d32f50e3037a860cf5e
dbeb1aaddb915c size: 1362
root@master1:/#
```

We can actually verify that our custom image `mynginx`:v1 was indeed saved into our registry.

```
root@master1:/# kubectl exec docker-registry-pod -it --
sh
/ # ls /var/lib/registry/docker/registry/v2/repositories/
mynginx
/ #
```

Finally, let us create a new Pod that uses the image `mynginx`:v1 that we just pushed to our registry.

```
root@master1:/# kubectl run nginx-pod --image=docker-
registry:5000/mynginx:v1 --overrides='{ "apiVersion":
"v1", "spec": { "imagePullSecrets": [{"name": "reg-cred-
secret"}] } }'
pod/nginx-pod created
root@master1:/#
root@master1:/# kubectl get pods -o wide
NAME                  READY   STATUS    RESTARTS   AGE
IP           NODE      NOMINATED NODE   READINESS GATES
docker-registry-pod   1/1     Running   0          46m
10.38.0.1   worker2   <none>           <none>
nginx-pod             1/1     Running   0          38s
10.38.0.2   worker2   <none>           <none>
root@master1:/#
root@master1:/# curl 10.38.0.2:80
<!DOCTYPE html>
<html>
<head>
<title>Welcome to nginx!</title>
<style>
    body {
        width: 35em;
        margin: 0 auto;
        font-family: Tahoma, Verdana, Arial, sans-serif;
    }
</style>
</head>
<body>
<h1>Welcome to nginx!</h1>
<p>If you see this page, the nginx web server is
successfully installed and
working. Further configuration is required.</p>

<p>For online documentation and support please refer to
<a href="http://nginx.org/">nginx.org</a>.<br/>
Commercial support is available at
<a href="http://nginx.com/">nginx.com</a>.</p>

<p><em>Thank you for using nginx.</em></p>
</body>
</html>
root@master1:/#
```

Congratulations on making it this far!! We just created a Private Docker Registry running as a Pod where our images will be stored in a Persistent Volume and can be pulled by any of the worker nodes to run your application.

Happy learning!!

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