How to Communicate with Kubernetes (API Server)

Overview

In this lab, we will build a foundational understanding of the Kubernetes API server and the various ways of interacting with it. We will learn how kubectl and other HTTP clients communicate with the Kubernetes API server. We will use some practical demonstrations to trace these communications and see the details of HTTP requests. Then, we will also see how we can look up the API details so that you can write your own API request from scratch. By the end of this lab, you will be able to create API objects by directly communicating with the API server using any HTTP client, such as curl, to make RESTful API calls to the API server.

Introduction

As you will recall from *Lab 2*, *An Overview of Kubernetes*, the API server acts as the central hub that communicates with all the different components in Kubernetes. In the previous lab, we took a look at how we can use kubectl to instruct the API server to do various things.

In this lab, we will take a further look into the components that make up the API server. As the API server is at the center of our entire Kubernetes system, it is important to learn how to effectively communicate with the API server itself and how API requests are processed. We will also look at various API concepts, such as resources, API groups, and API versions, which will help you understand the HTTP requests and responses that are made to the API server. Finally, we will interact with the Kubernetes API using multiple REST clients to achieve many of the same results we did in the previous lab using the kubectl command-line tool.

The Kubernetes API Server

In Kubernetes, all communications and operations between the control plane components and external clients, such as kubectl, are translated into **RESTful API** calls that are handled by the API server. Effectively, the API server is a RESTful web application that processes RESTful API calls over HTTP to store and update API objects in the etcd datastore.

The API server is also a frontend component that acts as a gateway to and from the outside world, which is accessed by all clients, such as the kubectl command-line tool. Even the cluster components in the control plane interact with each other only through the API server. Additionally, it is the only component that interacts directly with the etcd datastore. Since the API server is the only way for clients to access the cluster, it must be properly configured to be accessible by clients. You will usually see the API server implemented as `kube-apiserver`.

Note

We will explain the RESTful API in more detail in the *The Kubernetes API* section later in this lab.

Now, let's recall how the API server looks in our Minikube cluster by running the following command:

```
kubectl get pods -n kube-system
```

You should see the following response:

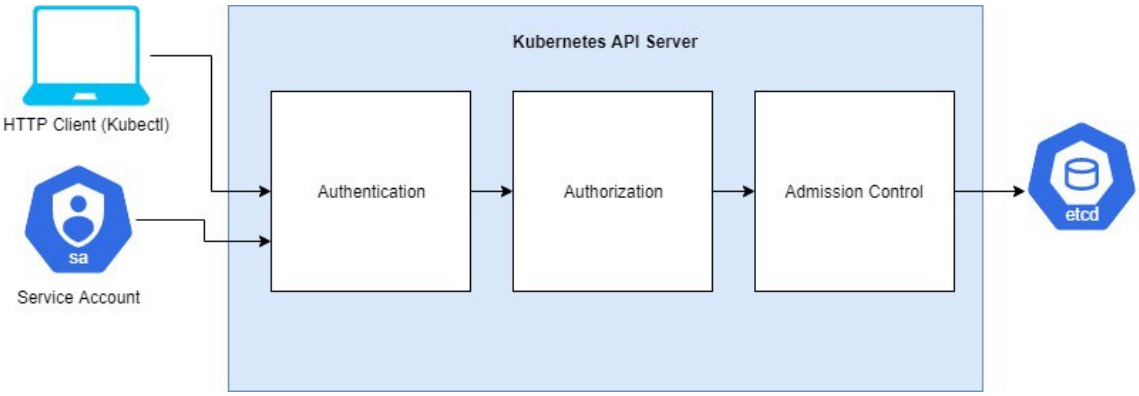
```
NAME                                 READY   STATUS    RESTARTS   AGE
coredns-5644d7b6d9-gxrgx             1/1     Running   0          8m27s
coredns-5644d7b6d9-tv4g7             1/1     Running   0          8m27s
etcd-minikube                        1/1     Running   0          7m27s
kube-addon-manager-minikube          1/1     Running   0          8m30s
kube-apiserver-minikube              1/1     Running   0          7m40s
kube-controller-manager-minikube     1/1     Running   0          7m30s
kube-proxy-hgwpr                     1/1     Running   0          8m27s
kube-scheduler-minikube              1/1     Running   0          7m19s
storage-provisioner                  1/1     Running   1          8m27s
```

As we saw in previous labs, in the Minikube environment, the API server is referred to as `kube-apiserver-minikube` in the `kube-system` namespace. As you can see in the preceding screenshot, we have a single instance of the API server: `kube-apiserver-minikube`.

The API server is stateless (that is, its behavior will be consistent regardless of the state of the cluster) and is designed to scale horizontally. Usually, for the high availability of clusters, it is recommended to have at least three instances to handle the load and fault tolerance better.

Kubernetes HTTP Request Flow

As we learned in earlier labs, when we run any `kubectl` command, the command is translated into an HTTP API request in JSON format and is sent to the API server. Then, the API server returns a response to the client, along with any requested information. The following diagram shows the API request life cycle and what happens inside the API server when it receives a request:



As you can see in the preceding figure, the HTTP request goes through the authentication, authorization, and admission control stages. We will take a look at each of these in the following subtopics.

Authentication

In Kubernetes, every API call needs to authenticate with the API server, regardless of whether it comes from outside the cluster, such as those made by kubectl, or a process inside the cluster, such as those made by kubelet.

When an HTTP request is sent to the API server, the API server needs to authenticate the client sending this request. The HTTP request will contain the information required for authentication, such as the username, user ID, and group. The authentication method will be determined by either the header or the certificate of the request. To deal with these different methods, the API server has different authentication plugins, such as ServiceAccount tokens, which

are used to authenticate ServiceAccounts, and at least one other method to authenticate users, such as X.509 client certificates.

Note

The cluster administrator usually defines authentication plugins during cluster creation. You can learn more about the various authentication strategies and authentication plugins at https://kubernetes.io/docs/reference/access-authn-authz/authentication/.

We will take a look at the implementation of certificate-based authentication in *Lab 11*, *Build Your Own HA Cluster*.

The API server will call those plugins one by one until one of them authenticates the request. If all of them fail, then the authentication fails. If the authentication succeeds, then the authentication phase is complete and the request proceeds to the authorization phase.

Authorization

After authentication is successful, the attributes from the HTTP request are sent to the authorization plugin to determine whether the user is permitted to perform the requested action. There are various levels of privileges that different users may have; for example, can a given user create a pod in the requested namespace? Can the user delete a Deployment? These kinds of decisions are made in the authorization phase.

Consider an example where you have two users. A user called **ReadOnlyUser** (just a hypothetical name) should be allowed to list pods in the `default` namespace only, and **ClusterAdmin** (another hypothetical name) should be able to perform all tasks across all namespaces:

User	Privileges	Namespace
ClusterAdmin	Can perform all tasks	All namespaces
ReadOnlyUser	Can read pod status	default

To understand this better, take a look at the following demonstration:

Note

We will not dive into too much detail about how to create users as this will be discussed in *Lab 13*, *Runtime and Network Security in Kubernetes*. For this demonstration, the users, along with their permissions, are already set up, and the limitation of their privileges is demonstrated by switching contexts.

```
abutaleb@AbuTalebPC:~$ kubectl config use-context ReadOnlyUser
Switched to context "ReadOnlyUser".
abutaleb@AbuTalebPC:~$
abutaleb@AbuTalebPC:~$
abutaleb@AbuTalebPC:~$ kubectl get pods -n default
NAME                       READY   STATUS    RESTARTS   AGE
mynginx-8668b9977f-mgcq6   1/1     Running   0          11m
abutaleb@AbuTalebPC:~$
abutaleb@AbuTalebPC:~$
abutaleb@AbuTalebPC:~$ kubectl delete pod mynginx-8668b9977f-mgcq6
Error from server (Forbidden): pods "mynginx-8668b9977f-mgcq6" is forbidden:
 User "system:serviceaccount:default:readonlysa" cannot delete resource "pod
s" in API group "" in the namespace "default"
abutaleb@AbuTalebPC:~$
abutaleb@AbuTalebPC:~$
abutaleb@AbuTalebPC:~$ kubectl get pods --all-namespaces
Error from server (Forbidden): pods is forbidden: User "system:serviceaccoun
t:default:readonlysa" cannot list resource "pods" in API group "" at the clu
ster scope
abutaleb@AbuTalebPC:~$
```

Notice, from the preceding screenshot, that the `ReadOnlyUser` can only **list** pods in the default namespace, but when trying to perform other tasks, such as deleting a pod in the `default` namespace or listing pods in other namespaces, the user will get a `Forbidden` error. This `Forbidden` error is returned by the authorization plugin.

kubectl provides a tool that you can call by using `kubectl auth can-i` to check whether an action is allowed for the current user.

Let's consider the following examples in the context of the previous demonstration. Let's say that the `ReadOnlyUser` runs the following commands:

```
kubectl auth can-i get pods --all-namespaces
kubectl auth can-i get pods -n default
```

The user should see the following responses:

```
abutaleb@AbuTalebPC:~$ kubectl auth can-i get pods --all-namespaces
no
abutaleb@AbuTalebPC:~$ kubectl auth can-i get pods -n default
yes
```

Now, after switching context, let's say that the `ClusterAdmin` user runs the following commands:

```
kubectl auth can-i delete pods
kubectl auth can-i get pods
kubectl auth can-i get pods --all-namespaces
```

The user should see the following response:

```
abutaleb@AbuTalebPC:~$ kubectl auth can-i delete pods
yes
abutaleb@AbuTalebPC:~$ kubectl auth can-i get pods
yes
abutaleb@AbuTalebPC:~$ kubectl auth can-i get pods --all-namespaces
yes
```

Unlike authentication phase modules, authorization modules are checked in sequence. If multiple authorization modules are configured, and if any authorizer approves or denies a request, that decision is immediately returned, and no other authorizer will be contacted.

Admission Control

After the request is authenticated and authorized, it goes to the admission control modules. These modules can modify or reject requests. If the request is only trying to perform a READ operation, it bypasses this stage; but if it is trying to create, modify, or delete, it will be sent to the admission controller plugins. Kubernetes comes with a set of predefined admission controllers, although you can define custom admission controllers as well.

These plugins may modify the incoming object, in some cases to apply system-configured defaults or even to deny the request. Like authorization modules, if any admission controller module rejects the request, then the request is dropped and it will not process further.

Some examples are as follows:

- If we configure a custom rule that every object should have a label (which you will learn how to do in *Lab 16*, *Kubernetes Admission Controllers*), then any request to create an object without a label will be rejected by the admission controllers.
- When you delete a namespace, it goes to the **Terminating** state, where Kubernetes will try to evict all the resources in it before deleting it. So, we cannot create any new objects in this namespace. `NamespaceLifecycle` is what prevents that.
- When a client tries to create a resource in a namespace that does not exist, the `NamespaceExists` admission controller rejects the request.

Out of the different modules included in Kubernetes, not all of the admission control modules are enabled by default, and the default modules usually change based on the Kubernetes version. Providers of cloud-based Kubernetes solutions, such as **Amazon Web Services** (**AWS**), Google, and Azure, control which plugins can be enabled by default. Cluster administrators can also decide which modules to enable or disable when initializing the API server. By using the `--enable-admission-plugins` flag, administrators can control which modules should be enabled other than the default ones. On the other hand, the `--disable-admission-plugins` flag controls which modules from the default modules should be disabled.

Note

You will learn more about admission controllers, including creating custom ones, in *Lab 16*, *Kubernetes Admission Controllers*.

As you will recall from *Lab 2*, *An Overview of Kubernetes*, when we created a cluster using the `minikube start` command, Minikube enabled several modules for us by default. Let's take a closer look at that in the next exercise in which we will not only view the different API modules enabled for us by default but also start Minikube with a custom set of modules.

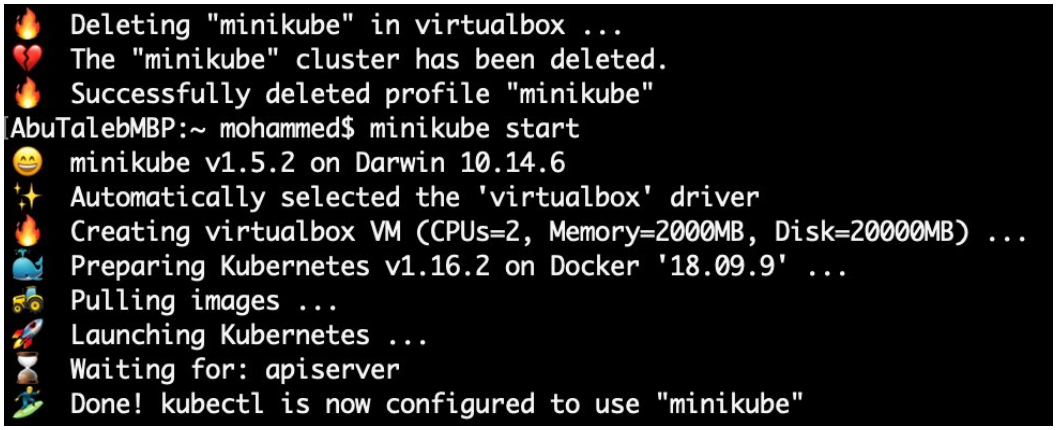
Exercise 4.01: Starting Minikube with a Custom Set of Modules

In this exercise, we will take a look at how to view the different API modules enabled for our instance of Minikube, and then restart Minikube using a custom set of API modules:

1. If Minikube is not already running on your machine, start it up by using the following command:

   ```
   minikube start
   ```

   You should see the following response:

2. Now, let's see which modules are enabled by default. Use the following command:

   ```
   kubectl describe pod kube-apiserver-minikube -n kube-system | grep enable-
   admission-plugins
   ```

   You should see the following response:


```
As you can observe from the preceding output,
Minikube has enabled the following modules for us:
`NamespaceLifecycle`, `LimitRanger`,
`ServiceAccount`, `DefaultStorageClass`,
`DefaultTolerationSeconds`, `NodeRestriction`,
`MutatingAdmissionWebhook`,
`ValidatingAdmissionWebhook`, and
`ResourceQuota`.

Note

To know more about modules, please refer the following link:
[https://kubernetes.io/docs/reference/access-authn-authz/admission-controllers/]
(https://kubernetes.io/docs/reference/access-authn-authz/admission-controllers/%20)
```

3. Another way to check the modules is to view the API server manifest by running the following command:

```
kubectl exec -it kube-apiserver-minikube -n kube-system -- kube-apiserver -h |
grep "enable-admission-plugins" | grep -vi deprecated
```

Note

We used `grep -vi deprecated` because there is another flag, `--admission-control`, that we are discarding from the output, as this flag will be deprecated in future versions.

kubectl has the `exec` command, which allows us to execute a command to our running pods. This command will execute `kube-apiserver -h` inside our `kube-apiserver-minikube` pod and return the output to our shell:

```
      --enable-admission-plugins strings      admission plugins that should be
enabled in addition to default enabled ones (NamespaceLifecycle, LimitRanger, Se
rviceAccount, TaintNodesByCondition, Priority, DefaultTolerationSeconds, Default
StorageClass, StorageObjectInUseProtection, PersistentVolumeClaimResize, Mutatin
gAdmissionWebhook, ValidatingAdmissionWebhook, RuntimeClass, ResourceQuota). Com
ma-delimited list of admission plugins: AlwaysAdmit, AlwaysDeny, AlwaysPullImage
s, DefaultStorageClass, DefaultTolerationSeconds, DenyEscalatingExec, DenyExecOn
Privileged, EventRateLimit, ExtendedResourceToleration, ImagePolicyWebhook, Limi
tPodHardAntiAffinityTopology, LimitRanger, MutatingAdmissionWebhook, NamespaceAu
toProvision, NamespaceExists, NamespaceLifecycle, NodeRestriction, OwnerReferenc
esPermissionEnforcement, PersistentVolumeClaimResize, PersistentVolumeLabel, Pod
NodeSelector, PodPreset, PodSecurityPolicy, PodTolerationRestriction, Priority,
ResourceQuota, RuntimeClass, SecurityContextDeny, ServiceAccount, StorageObjectI
nUseProtection, TaintNodesByCondition, ValidatingAdmissionWebhook. The order of
plugins in this flag does not matter.
```

4. Now, we will start Minikube with our desired configuration. Use the following command:

```
minikube start --extra-config=apiserver.enable-admission-
plugins="LimitRanger,NamespaceExists,NamespaceLifecycle,ResourceQuota,ServiceAccc
```

As you can see here, the `minikube start` command has the `--extra-config` configurator flag, which allows us to pass additional configurations to our cluster installation. In our case, we can use the `--extra-config` flag, along with `--enable-admission-plugins`, and specify the plugins we need to enable. Our command should produce this output:

```
😄  minikube v1.5.2 on Darwin 10.15.1
💡  Tip: Use 'minikube start -p <name>' to create a new cluster, or 'minikube de
lete' to delete this one.
🏃  Using the running virtualbox "minikube" VM ...
⌛  Waiting for the host to be provisioned ...
🐳  Preparing Kubernetes v1.16.2 on Docker '18.09.9' ...
    ▪ apiserver.enable-admission-plugins=LimitRanger,NamespaceExists,NamespaceLi
fecycle,ResourceQuota,ServiceAccount,DefaultStorageClass,MutatingAdmissionWebhoo
k
🔄  Relaunching Kubernetes using kubeadm ...
⌛  Waiting for: apiserver
🏄  Done! kubectl is now configured to use "minikube"
```

5. Now, let's compare this instance of Minikube with our earlier one. Use the following command:

```
kubectl describe pod kube-apiserver-minikube -n kube-system | grep enable-
admission-plugins
```

You should see the following response:

```
      --enable-admission-plugins=LimitRanger,NamespaceExists,NamespaceLifecycle,
ResourceQuota,ServiceAccount,DefaultStorageClass,MutatingAdmissionWebhook
```

If you compare the set of modules seen here to the ones in *Figure 4.7*, you will notice that only the specified plugins were enabled; while the `DefaultTolerationSeconds`, `NodeRestriction`, and `ValidatingAdmissionWebhook` modules are no longer enabled.

Note

You can revert to the default configurations in Minikube by running `minikube start` again.

Validation

After letting the request pass through all three stages, the API server then validates the object---that is, it checks whether the object specification, which is carried in JSON format in the response body, meets the required format and standard.

After successful validation, the API server stores the object in the etcd datastore and returns a response to the client. After that, as you learned in *Lab 2, An Overview of Kubernetes*, other components, such as the scheduler and the controller manager, take over to find a suitable node and actually implement the object on your cluster.

The Kubernetes API

The Kubernetes API uses JSON over HTTP for its requests and responses. It follows the REST architectural style. You can use the Kubernetes API to read and write Kubernetes resource objects.

Note

For more details about the RESTful API, please refer to https://restfulapi.net/.

Kubernetes API allows clients to create, update, delete, or read a description of an object via standard HTTP methods (or HTTP verbs), such as the examples in the following table:

HTTP Verbs	Usage	Example URL path
POST	Creates new resources, such as a new pod	/api/v1/namespaces/{namespace}/pods
PUT	Replaces or updates an existing resource; for example, replaces the status of the specified Deployment	/apis/apps/v1/namespaces/{namespace}/deployments/{name}/status
GET	Retrieves the details of a resource; for example, reading a specified Service	/api/v1/namespaces/{namespace}/services/{name}
PATCH	Partially updates existing resources; for example, updating the image for a pod	/api/v1/namespaces/{namespace}/pods/{name}
DELETE	Deletes resources, such as deleting a pod	/api/v1/namespaces/{namespace}/pods/{name}

In the context of Kubernetes API calls, it is helpful to understand how these HTTP methods map to API request verbs. So, let's take a look at which verbs are sent through which methods:

- `GET`: `get`, `list`, and `watch`

  Some example kubectl commands are `kubectl get pod`, `kubectl describe pod <pod-name>`, and `kubectl get pod -w`.

- `POST`: `create`

  An example kubectl command is `kubectl create -f <filename.yaml>`.

- `PATCH`: `patch`

  An example kubectl command is `kubectl set image deployment/kubeserve nginx=nginx:1.9.1`.

- `DELETE`: `delete`

  An example kubectl command is `kubectl delete pod <pod-name>`.

- `PUT`: `update`

  An example kubectl command is `kubectl apply -f <filename.yaml>`.

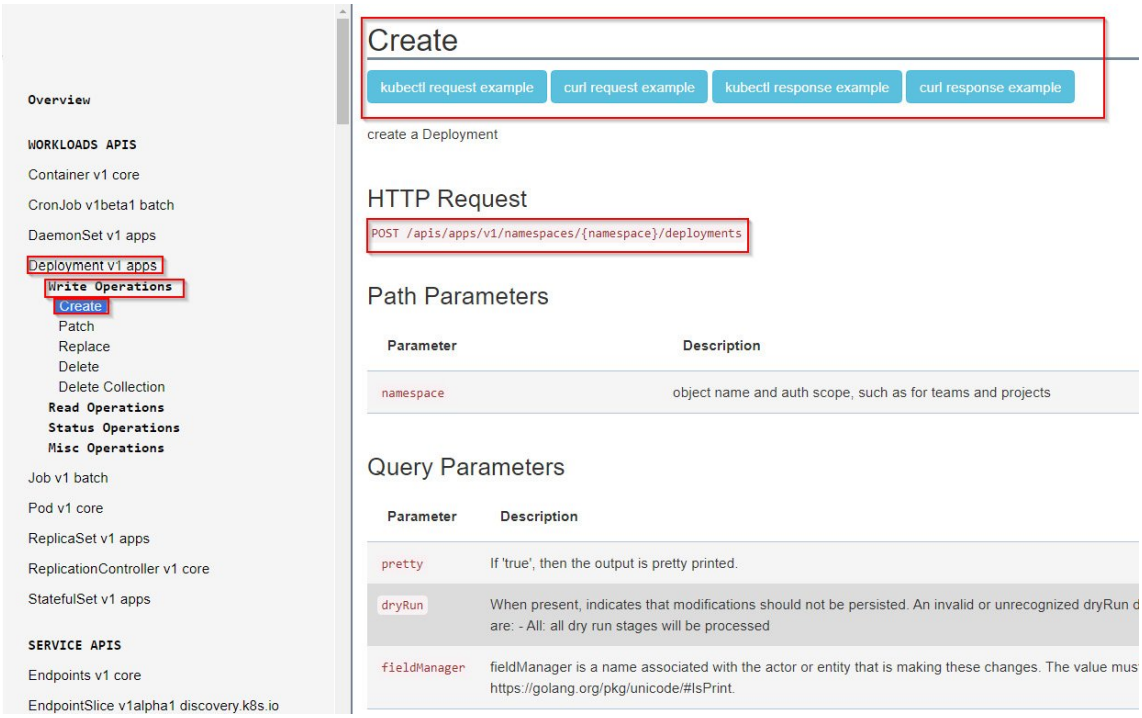
  Note

  If you have not encountered these commands yet, you will in the upcoming labs. Feel free to refer back to this lab or the following Kubernetes documentation to find out how each API request works for any command: https://kubernetes.io/docs/reference/kubernetes-api/.

As mentioned earlier, these API calls carry JSON data, and all of them have a JSON schema identified by the `Kind` and `apiVersion` fields. `Kind` is a string that identifies the type of JSON schema that an object should have, and `apiVersion` is a string that identifies the version of the JSON schema the object should have. The next exercise should give you a better idea about this.

You can refer to the Kubernetes API reference documentation to see the different HTTP methods in action, at https://kubernetes.io/docs/reference/kubernetes-api/.

For example, if you need to create a Deployment in a specific namespace, under `WORKLOADS APIS`, you can navigate to `Deployment v1 apps` > `Write Operations` > `Create`. You will see the HTTP request and different examples using `kubectl` or `curl`. The following page from the API reference docs should give you an idea of how to use this reference:



You will need to keep the version of your API server in mind when you refer to the previously mentioned documentation. You can find your Kubernetes API server version by running `kubectl version --short` command and looking for `Server Version`. For example, if your Kubernetes API server version is running version 1.14, you should navigate to the Kubernetes version 1.14 reference documentation (https://v1-14.docs.kubernetes.io/docs/reference/generated/kubernetes-api/v1.14/) to look up the relevant API information.

The best way to understand this is by tracing a `kubectl` command. Let's do exactly that in the following section.

Tracing kubectl HTTP Requests

Let's try tracing the HTTP requests that kubectl sends to the API server to better understand them. Before we begin, let's get all the pods in the `kube-system` namespace by using the following command:

```
kubectl get pods -n kube-system
```

This command should display the output in a table view, as you can see in the following screenshot:

```
NAME                                READY   STATUS    RESTARTS   AGE
coredns-5644d7b6d9-292kd            1/1     Running   0          6m20s
coredns-5644d7b6d9-2lg9r            1/1     Running   0          6m20s
etcd-minikube                       1/1     Running   0          5m16s
kube-addon-manager-minikube         1/1     Running   0          6m28s
kube-apiserver-minikube             1/1     Running   0          3m
kube-controller-manager-minikube    1/1     Running   0          3m
kube-proxy-cpbjg                    1/1     Running   0          6m21s
kube-scheduler-minikube             1/1     Running   0          5m7s
storage-provisioner                 1/1     Running   0          6m19s
```

Behind the scenes, since kubectl is a REST client, it invokes an HTTP `GET` request to the API server endpoint and requests information from `/api/v1/namespaces/kube-system/pods`.

We can enable verbose output by adding `--v=8` to our `kubectl` command. `v` indicates the verbosity of the command. The higher the number, the more details we get in the response. This number can range from `0` to `10`. Let's see the output with verbosity of `8`:

```
kubectl get pods -n kube-system --v=8
```

This should give output as follows:

```
I1123 15:04:42.086493    5477 loader.go:375] Config loaded from file:  /Users/mohammed/.kube/config
I1123 15:04:42.096144    5477 round_trippers.go:420] GET https://192.168.99.110:8443/api/v1/namespaces/kube-system/pods?limit=500
I1123 15:04:42.096166    5477 round_trippers.go:427] Request Headers:
I1123 15:04:42.096175    5477 round_trippers.go:431]     Accept: application/json;as=Table;v=v1beta1;g=meta.k8s.io, application/j
son
I1123 15:04:42.096181    5477 round_trippers.go:431]     User-Agent: kubectl/v1.16.3 (darwin/amd64) kubernetes/b3cbbae
I1123 15:04:42.107066    5477 round_trippers.go:446] Response Status: 200 OK in 10 milliseconds
I1123 15:04:42.107092    5477 round_trippers.go:449] Response Headers:
I1123 15:04:42.107115    5477 round_trippers.go:452]     Cache-Control: no-cache, private
I1123 15:04:42.107128    5477 round_trippers.go:452]     Content-Type: application/json
I1123 15:04:42.107145    5477 round_trippers.go:452]     Date: Sat, 23 Nov 2019 13:04:42 GMT
I1123 15:04:42.107397    5477 request.go:968] Response Body: {"kind":"Table","apiVersion":"meta.k8s.io/v1beta1","metadata":{"self
Link":"/api/v1/namespaces/kube-system/pods","resourceVersion":"1051"},"columnDefinitions":[{"name":"Name","type":"string","format
":"name","description":"Name must be unique within a namespace. Is required when creating resources, although some resources may
allow a client to request the generation of an appropriate name automatically. Name is primarily intended for creation idempotenc
e and configuration definition. Cannot be updated. More info: http://kubernetes.io/docs/user-guide/identifiers#names","priority":
0},{"name":"Ready","type":"string","format":"","description":"The aggregate readiness state of this pod for accepting traffic.","
priority":0},{"name":"Status","type":"string","format":"","description":"The aggregate status of the containers in this pod.","pr
iority":0},{"name":"Restarts","type":"integer","format":"","description":"The number of times the containers in this pod have bee
n restarted.","priority":0},{"name":"Age","type":"str [truncated 9336 chars]
NAME                                READY   STATUS    RESTARTS   AGE
coredns-5644d7b6d9-292kd            1/1     Running   0          8m25s
coredns-5644d7b6d9-2lg9r            1/1     Running   0          8m25s
etcd-minikube                       1/1     Running   0          7m21s
kube-addon-manager-minikube         1/1     Running   0          8m33s
kube-apiserver-minikube             1/1     Running   0          5m5s
kube-controller-manager-minikube    1/1     Running   0          5m5s
kube-proxy-cpbjg                    1/1     Running   0          8m26s
kube-scheduler-minikube             1/1     Running   0          7m12s
storage-provisioner                 1/1     Running   0          8m24s
```

Let's examine the preceding output bit by bit to get a better understanding of it:

- The first part of the output is as follows:

```
42.086493    5477 loader.go:375] Config loaded from file:  /Users/mohammed/.kube/config
```

file

From this, we can see that kubectl loaded the configuration from our kubeconfig file, which has the API server endpoint, port, and credentials, such as the certificate or the authentication token.

- This is the next part of the output:

```
5477 round_trippers.go:420] GET https://192.168.99.110:8443/api/v1/namespaces/kube-system/pods?limit=500
```

In this, you can see the `HTTP GET` request mentioned as `GET https://192.168.99.100:8443/api/v1/namespaces/kube-system/pods?limit=500`. This line contains the operation that we need to perform against the API server, and `/api/v1/namespaces/kube-system/pods` is the API path. You can also see `limit=500` at the end of the URL path, which is the chunk size; kubectl fetches a large number of resources in chunks to improve latency. We will see some examples relating to retrieving large results sets in chunks later in this lab.

- The next part of the output is as follows:

```
5477 round_trippers.go:427] Request Headers:
5477 round_trippers.go:431]     Accept: application/json;as=Table;v=v1beta1;g=meta.k8s.io, application/json
5477 round_trippers.go:431]     User-Agent: kubectl/v1.16.3 (darwin/amd64) kubernetes/b3cbbae
```

As you can see in this part of the output, `Request Headers` describes the resource to be fetched or the client requesting the resource. In our example, the output has two parts for content negotiation:

a) `Accept`: This is used by HTTP clients to tell the server what content types they'll accept. In our example, we can see that kubectl informed the API server about the `application/json` content type. If this does not exist in the request header, the server will return the default preconfigured representation type, which is the same as `application/json` for the Kubernetes API as it uses the JSON schema. We can also see that it is requesting the output as a table view, which is indicated by `as=Table` in this line.

b) `User-Agent`: This header contains information about the client that is requesting this information. In this case, we can see that kubectl is providing information about itself.

- Let's examine the next part:

```
5477 round_trippers.go:446] Response Status: 200 OK in 10 milliseconds
```

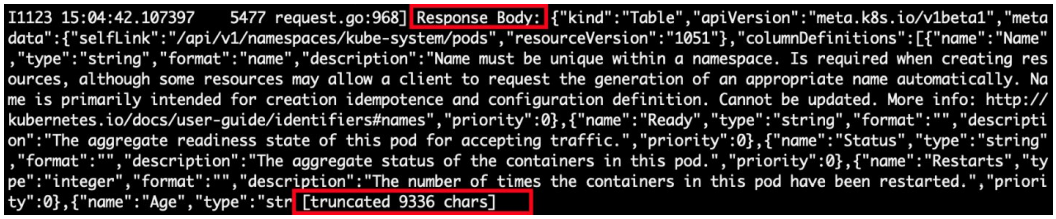
Here, we can see that the API server returns the `200 OK` HTTP status code, which indicates that the request has been processed successfully on the API server. We can also see the time taken to process this request, which is 10 milliseconds.

- Let's look at the next part:

```
5477 round_trippers.go:449] Response Headers:
5477 round_trippers.go:452]     Cache-Control: no-cache, private
5477 round_trippers.go:452]     Content-Type: application/json
5477 round_trippers.go:452]     Date: Sat, 23 Nov 2019 13:04:42 GMT
```

As you can see, this part shows the `Response Headers`, which include details such as the date and time of the request, in our example.

- Now, let's come to the main response sent by the API server:



The `Response Body` contains the resource data that was requested by the client. In our case, this is information about the pods in the `kube-system` namespace. Here, this information is in raw JSON format before kubectl can present it as a neat table. However, the highlighted section at the end of the previous screenshot shows that the response body does not have all the JSON output that we requested; part of the `Response Body` is truncated. This is because `--v=8` displays the HTTP request content with truncation of the response content.

To see the full response body, you can run the same command with `--v=10`, which does not truncate the output at all. The command would look like as follows:

```
kubectl get pods -n kube-system --v=10
```

We will not examine the command with `--v=10` verbosity for the sake of brevity.

- Now, we come to the final part of the output that we are examining:

NAME	READY	STATUS	RESTARTS	AGE
coredns-5644d7b6d9-292kd	1/1	Running	0	8m25s
coredns-5644d7b6d9-2lg9r	1/1	Running	0	8m25s
etcd-minikube	1/1	Running	0	7m21s
kube-addon-manager-minikube	1/1	Running	0	8m33s
kube-apiserver-minikube	1/1	Running	0	5m5s
kube-controller-manager-minikube	1/1	Running	0	5m5s
kube-proxy-cpbjg	1/1	Running	0	8m26s
kube-scheduler-minikube	1/1	Running	0	7m12s
storage-provisioner	1/1	Running	0	8m24s

This is the final output as a table, which is what was requested. kubectl has taken the raw JSON data and formatted it as a neat table for us.

Note

You can learn more about kubectl verbosity and debugging flags at https://kubernetes.io/docs/reference/kubectl/cheatsheet/#kubectl-output-verbosity-and-debugging.

API Resource Type

In the previous section, we saw that the HTTP URL was made up of an API resource, API group, and API version. Now, let's learn about the resource type defined in the URL, such as pods, namespaces, and services. In JSON form, this is called `Kind`:

- **Collection of resource**: This represents a collection of instances for a resource type, such as all pods in all namespaces. In a URL, this would be as follows:

```
GET /api/v1/pods
```

- **Single resource**: This represents a single instance of a resource type, such as retrieving details of a specific pod in a given namespace. The URL for this case would be as follows:

  ```
  GET /api/v1/namespaces/{namespace}/pods/{name}
  ```

Now that we have learned about various aspects of a request made to the API server, let's learn about the scope of API resources in the next section.

Scope of API Resources

All resource types can either be cluster-scoped resources or namespace-scoped resources. The scope of a resource affects the access of that resource and how that resource is managed. Let's look at the differences between namespace and cluster scope.

Namespace-Scoped Resources

As we saw in *Lab 2*, *An Overview of Kubernetes*, Kubernetes makes use of Linux namespaces to organize most Kubernetes resources. Resources in the same namespace share the same control access policies and authorization checks. When a namespace is deleted, all resources in that namespace are also deleted.

Let's see what forms the request paths for interacting with namespace-scoped resources take:

- Return the information about a specific pod in a namespace:

  ```
  GET /api/v1/namespaces/{my-namespace}/pods/{pod-name}
  ```

- Return the information about a collection of all Deployments in a namespace:

  ```
  GET /apis/apps/v1/namespaces/{my-namespace}/deployments
  ```

- Return the information about all instances of the resource type (in this case, services) across all namespaces:

  ```
  GET /api/v1/services
  ```

  Notice that when we are looking for information against all namespaces, it will not have `namespace` in the URL.

You can get a full list of namespace-scoped API resources by using the following command:

```
kubectl api-resources --namespaced=true
```

You should see a response similar to this:

```
NAME                              SHORTNAMES   APIGROUP                       NAMESPACED   KIND
bindings                                                                      true         Binding
configmaps                        cm                                          true         ConfigMap
endpoints                         ep                                          true         Endpoints
events                            ev                                          true         Event
limitranges                       limits                                      true         LimitRange
persistentvolumeclaims            pvc                                         true         PersistentVolumeClaim
pods                              po                                          true         Pod
podtemplates                                                                  true         PodTemplate
replicationcontrollers            rc                                          true         ReplicationController
resourcequotas                    quota                                       true         ResourceQuota
secrets                                                                       true         Secret
serviceaccounts                   sa                                          true         ServiceAccount
services                          svc                                         true         Service
controllerrevisions                            apps                           true         ControllerRevision
daemonsets                        ds           apps                           true         DaemonSet
deployments                       deploy       apps                           true         Deployment
replicasets                       rs           apps                           true         ReplicaSet
statefulsets                      sts          apps                           true         StatefulSet
localsubjectaccessreviews                      authorization.k8s.io           true         LocalSubjectAccessRevie
horizontalpodautoscalers          hpa          autoscaling                    true         HorizontalPodAutoscaler
cronjobs                          cj           batch                          true         CronJob
jobs                                           batch                          true         Job
leases                                         coordination.k8s.io            true         Lease
events                            ev           events.k8s.io                  true         Event
ingresses                         ing          extensions                     true         Ingress
ingresses                         ing          networking.k8s.io              true         Ingress
networkpolicies                   netpol       networking.k8s.io              true         NetworkPolicy
poddisruptionbudgets              pdb          policy                         true         PodDisruptionBudget
rolebindings                                   rbac.authorization.k8s.io      true         RoleBinding
roles                                          rbac.authorization.k8s.io      true         Role
```

Cluster-Scoped Resources

Most Kubernetes resources are namespace-scoped, but the namespace resource itself is not namespace-scoped. Resources that are not scoped within namespaces are cluster-scoped. Other examples of cluster-scoped resources are nodes. Since a node is cluster-scoped, you can deploy a pod on the desired node regardless of what namespace you want the pod to be in, and a node can host different pods from different namespaces.

Let's see how the request paths for interacting with cluster-scoped resources look:

- Return the information about a specific node in the cluster:

  ```
  GET /api/v1/nodes/{node-name}
  ```

- Return the information of all instances of the resource type (in this case, nodes) in the cluster:

  ```
  GET /api/v1/nodes
  ```

- You can get a full list of cluster-scoped API resources by using the following command:

  ```
  kubectl api-resources --namespaced=false
  ```

  You should see an output similar to this:

```
NAME                              SHORTNAMES   APIGROUP                       NAMESPACED   KIND
componentstatuses                 cs                                          false        ComponentStatus
namespaces                        ns                                          false        Namespace
nodes                             no                                          false        Node
persistentvolumes                 pv                                          false        PersistentVolume
mutatingwebhookconfigurations                  admissionregistration.k8s.io   false        MutatingWebhookC
onfiguration
validatingwebhookconfigurations                admissionregistration.k8s.io   false        ValidatingWebhoo
kConfiguration
customresourcedefinitions         crd,crds     apiextensions.k8s.io           false        CustomResourceDe
finition
apiservices                                    apiregistration.k8s.io         false        APIService
tokenreviews                                   authentication.k8s.io          false        TokenReview
selfsubjectaccessreviews                       authorization.k8s.io           false        SelfSubjectAcces
sReview
selfsubjectrulesreviews                        authorization.k8s.io           false        SelfSubjectRules
Review
subjectaccessreviews                           authorization.k8s.io           false        SubjectAccessRev
iew
certificatesigningrequests        csr          certificates.k8s.io            false        CertificateSigni
ngRequest
runtimeclasses                                 node.k8s.io                    false        RuntimeClass
podsecuritypolicies               psp          policy                         false        PodSecurityPolic
y
clusterrolebindings                            rbac.authorization.k8s.io      false        ClusterRoleBindi
ng
clusterroles                                   rbac.authorization.k8s.io      false        ClusterRole
priorityclasses                   pc           scheduling.k8s.io              false        PriorityClass
csidrivers                                     storage.k8s.io                 false        CSIDriver
csinodes                                       storage.k8s.io                 false        CSINode
storageclasses                    sc           storage.k8s.io                 false        StorageClass
volumeattachments                              storage.k8s.io                 false        VolumeAttachment
```

API Groups

An API group is a collection of resources that are logically related to each other. For example, Deployments, ReplicaSets, and DaemonSets all belong to the apps API group: `apps/v1`.

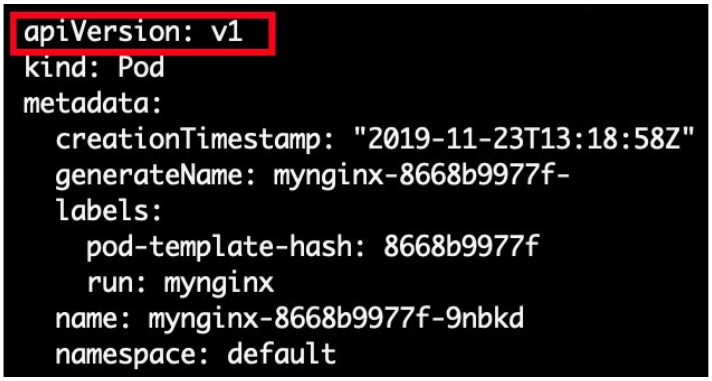
Note

You will learn about Deployments, ReplicaSets, and DaemonSets in detail in *Lab 7*, *Kubernetes Controllers*. In fact, this lab will talk about many API resources that you will encounter in later labs.

The `--api-group` flag can be used to scope the output to a specific API group, as we will see in the following sections. Let's take a closer look at the various API groups in the following sections.

Core Group

This is also called the legacy group. It contains objects such as pods, services, nodes, and namespaces. The URL path for these is `/api/v1`, and nothing other than the version is specified in the `apiVersion` field. For example, consider the following screenshot where we are getting information about a pod:

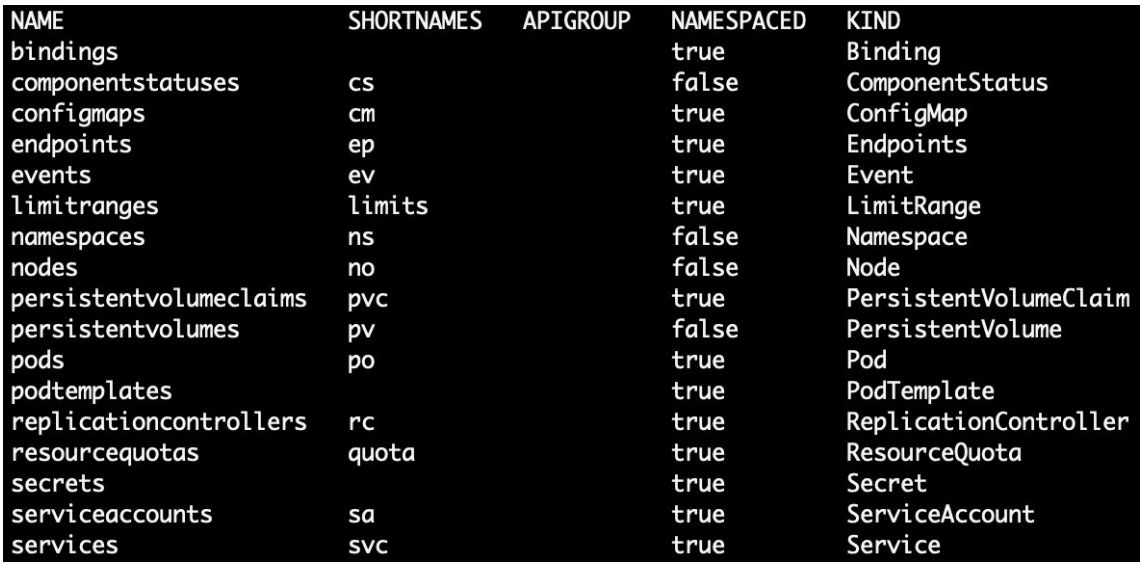


As you can see here, the `apiVersion: v1` field indicates that this resource belongs to the core group.

Resources showing a blank entry in the `kubectl api-resources` command output are part of the core group. You can also specify an empty argument flag (`--api-group=''`) to only display the core group resources, as follows:

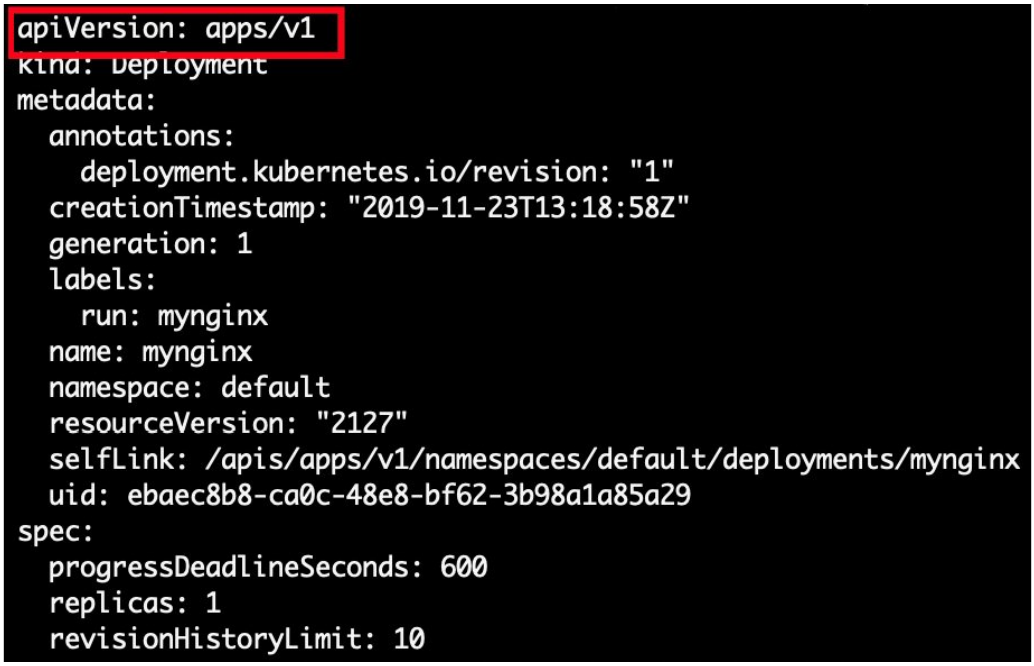
```
kubectl api-resources --api-group=''
```

You should see an output as follows:



Named Group

This group includes objects for whom the request URL is in the `/apis/$NAME/$VERSION` format. Unlike the core group, named groups contain the group name in the URL. For example, let's consider the following screenshot where we have information about a Deployment:

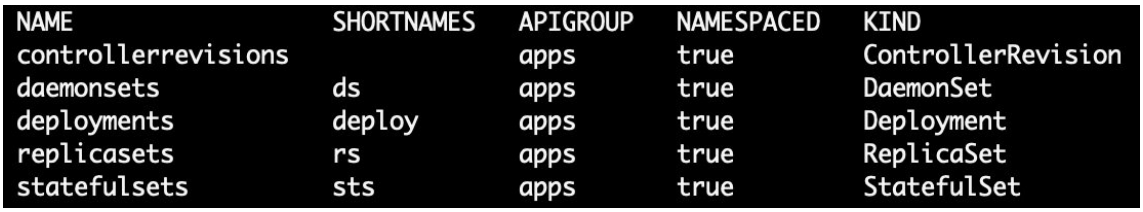


As you can see, the highlighted field showing `apiVersion: apps/v1` indicates that this resource belongs to the `apps` API group.

You can also specify the `--api-group='<NamedGroup Name>'` flag to display the resources in that specified named group. For example, let's list out the resources under the `apps` API group by using the following command:

```
kubectl api-resources --api-group='apps'
```

This should give the following response:



All of these resources in the preceding screenshot are clubbed together because they are part of the `apps` named group, which we specified in our query command.

As another example, let's look at the `rbac.authorization.k8s.io API group`, which has resources to determine authorization policies. We can look at the resources in that group by using the following command:

```
kubectl api-resources --api-group='rbac.authorization.k8s.io'
```

You should see the following response:

```
NAME                  SHORTNAMES   APIGROUP                       NAMESPACED   KIND
clusterrolebindings                rbac.authorization.k8s.io      false        ClusterRoleBinding
clusterroles                       rbac.authorization.k8s.io      false        ClusterRole
rolebindings                       rbac.authorization.k8s.io      true         RoleBinding
roles                              rbac.authorization.k8s.io      true         Role
```

API group

System-Wide

This group consists of system-wide API endpoints, such as `/version`, `/healthz`, `/logs`, and `/metrics`. For example, let's consider the output of the following command:

```
kubectl version --short --v=6
```

This should give an output similar to this:

```
I1123 15:25:14.635404    7930 loader.go:375] Config loaded from file:  /Users/mohammed/.kube/config
I1123 15:25:14.653550    7930 round_trippers.go:443] GET https://192.168.99.110:8443/version?timeout=32s 20
0 OK in 14 milliseconds
Client Version: v1.16.3
Server Version: v1.16.2
```

As you can see in this screenshot, when you run `kubectl --version`, this goes to the `/version special entity`, as seen in the `GET` request URL.

API Versions

In the Kubernetes API, there is the concept of API versioning; that is, the Kubernetes API supports multiple versions of a type of resource. These different versions may act differently. Each one has a different API path, such as `/api/v1` or `/apis/extensions/v1beta1`.

The different API versions differ in terms of stability and support:

- **Alpha**: This version is indicated by `alpha` in the `apiVersion` field---for example, `/apis/batch/v1alpha1`. The alpha version of resources is disabled by default as it is not intended for production clusters but can be used by early adopters and developers who are willing to provide feedback and suggestions and report bugs. Also, support for alpha resources may be dropped without notice by the time the final stable version of Kubernetes is finalized.
- **Beta**: This version is indicated by `beta` in the `apiVersion` field---for example, `/apis/certificates.k8s.io/v1beta1`. The beta version of resources is enabled by default, and the code behind it is well tested. However, using it is recommended for scenarios that are not business-critical because it is possible that changes in subsequent releases may reduce incompatibilities; that is, some features may not be supported for a long time.
- **Stable**: For these versions, the `apiVersion` field just contains the version number without any mention of `alpha` or `beta`---for example, `/apis/networking.k8s.io/v1`. The Stable version of resources is supported for many subsequent versions releases of Kubernetes. So, this version of API resources is recommended for any critical use cases.

You can get a complete list of the API versions enabled in your cluster by using the following command:

```
kubectl api-versions
```

You should see a response similar to this:

An interesting thing that you may observe in this screenshot is that some API resources, such as `autoscaling`, have multiple versions; for example, for `autoscaling`, there is `v1beta1`, `v1beta2`, and `v1`. So, what is the difference between them and which one should you use?

Let's again consider the example of `autoscaling`. This feature allows you to scale the number of pods in a replication controller, such as Deployments, ReplicaSets, or StatefulSets, based on specific metrics. For example, you can autoscale the number of pods from 3 to 10 if the average CPU load exceeds 50%.

In this case, the difference in the versions is that of feature support. The Stable release for autoscaling is `autoscaling/v1`, which only supports scaling the number of pods based on the average CPU metric. The beta release for autoscaling, which is `autoscaling/v2beta1`, supports scaling based on CPU and memory utilization. The newer version in the beta release, which is `autoscaling/v2beta2`, supports scaling the number of pods based on custom metrics in addition to CPU and memory. However, since the beta release is still not meant to be used for business-critical scenarios when you create an autoscaling resource, it will use the `autoscaling/v1`

version. However, you can still use other versions to use additional features by specifying the beta version in the YAML file until the required features are added to the stable release.

All of this information can seem overwhelming. However, Kubernetes provides ways to access all the information you need to navigate your way around the API resources. You can use kubectl to access the Kubernetes docs and get the necessary information about the various API resources. Let's see how that works in the following exercise.

Exercise 4.02: Getting Information about API Resources

Let's say that we want to create an ingress object. For the purposes of this exercise, you don't need to know much about ingress; we will learn about it in the upcoming labs.

We will use kubectl to get more information about the Ingress API resource, determine which API versions are available, and find out which groups it belongs to. If you recall from previous sections, we need this information for the `apiVersion` field of our YAML manifest. Then, we also get the information required for the other fields of our manifest file:

1. Let's first ask our cluster for all the available API resources that match the `ingresses` keyword:

   ```
   kubectl api-resources | grep ingresses
   ```

   This command will filter the list of all the API resources by the `ingresses` keyword. You should get the following output:

   ```
   ingresses     ing     extensions            true         Ingress
   ingresses     ing     networking.k8s.io     true         Ingress
   ```

   We can see that we have ingress resources on two different API groups--- `extensions` and `networking.k8s.io`.

2. We have also seen how we can get API resources belonging to specific groups. Let's check the API groups that we saw in the previous step:

   ```
   kubectl api-resources --api-group="extensions"
   ```

   You should get the following output:

   ```
   NAME       SHORTNAMES     APIGROUP     NAMESPACED      KIND
   ingresses  ing            extensions   true            Ingress
   ```

   Now, let's check the other group:

   ```
   kubectl api-resources --api-group="networking.k8s.io"
   ```

   You should see the following output:

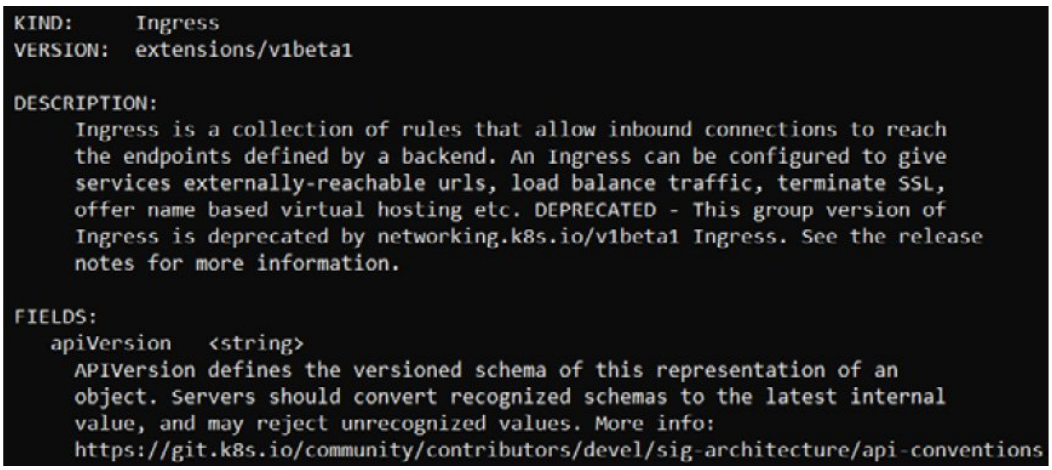
   ```
   NAME              SHORTNAMES   APIGROUP             NAMESPACED   KIND
   ingresses         ing          networking.k8s.io    true         Ingress
   networkpolicies   netpol       networking.k8s.io    true         NetworkPolicy
   ```

   However, if we were to use an ingress resource, we still don't know whether we should use the one from the `extensions` group or the `networking.k8s.io` group. In the next step, we will get some more information that will help us decide that.

3. Use the following command to get more information:

```
kubectl explain ingress
```

You should get this response:




```
extensions API group

As you can see, the `kubectl explain` command describes
the API resource, as well as the details about the fields associated
with it. We can also see that ingress uses the
`extensions/v1beta1` API version, but if we read the
`DESCRIPTION`, it mentions that this group version of
ingress is deprecated by `networking.k8s.io/v1beta1`.
Deprecated means that the standard is in the process of being phased
out, and even though it is currently supported, it is not
recommended for use.

Note

If you compare this to the different versions of
`autoscaling` that we saw just before this exercise, you
may think that the logical upgrade path from `v1beta`
would be `v2beta`, and that would totally make sense.
However, the ingress resource was moved from the
`extensions` group to the `networking.k8s.io`
group, and so this bucks the naming trend.
```

4. It is not a good idea to use a deprecated version, so let's say that you want to use the `networking.k8s.io/v1beta1` version instead. However, we need to get more information about it first. We can add a flag to the `kubectl explain` command to get information about a specific version of an API resource, as follows:

```
kubectl explain ingress --api-version=networking.k8s.io/v1beta1
```

You should see this response:

```
KIND:     Ingress
VERSION:  networking.k8s.io/v1beta1

DESCRIPTION:
     Ingress is a collection of rules that allow inbound connections to reach
     the endpoints defined by a backend. An Ingress can be configured to give
     services externally-reachable urls, load balance traffic, terminate SSL,
     offer name based virtual hosting etc.
```

5. We can also filter the output of the `kubectl explain` command by using the `JSONPath` identifier. This allows us to get information about the various fields that we need to specify while defining the YAML manifest. So, for example, if we would like to see the `spec` fields for Ingress, the command will be as follows:

   ```
   kubectl explain ingress.spec --api-version=networking.k8s.io/v1beta1
   ```

   This should give a response as follows:

   ```
   KIND:     Ingress
   VERSION:  networking.k8s.io/v1beta1

   RESOURCE: spec <Object>

   DESCRIPTION:
        Spec is the desired state of the Ingress. More info:
        https://git.k8s.io/community/contributors/devel/sig-architecture/api
   s.md#spec-and-status

        IngressSpec describes the Ingress the user wishes to exist.

   FIELDS:
      backend      <Object>
        A default backend capable of servicing requests that don't match any
        At least one of 'backend' or 'rules' must be specified. This field i
        optional to allow the loadbalancer controller or defaulting logic to
        specify a global default.

      rules        <[]Object>
        A list of host rules used to configure the Ingress. If unspecified,
        rule matches, all traffic is sent to the default backend.

      tls  <[]Object>
        TLS configuration. Currently the Ingress only supports a single TLS
        443. If multiple members of this list specify different hosts, they
        multiplexed on the same port according to the hostname specified thr
        the SNI TLS extension, if the ingress controller fulfilling the ingr
        supports SNI.
   ```

6. We can dive deeper to get more details about the nested fields. For example, if you wanted to get more details about the `backend` field of ingress, we can specify `ingress.spec.backend` to get the required information:

   ```
   kubectl explain ingress.spec.backend --api-version=networking.k8s.io/v1beta1
   ```

   This will give the following output:

```
KIND:     Ingress
VERSION:  networking.k8s.io/v1beta1

RESOURCE: backend <Object>

DESCRIPTION:
     A default backend capable of servicing requests that don't match any rule.
     At least one of 'backend' or 'rules' must be specified. This field is
     optional to allow the loadbalancer controller or defaulting logic to
     specify a global default.

     IngressBackend describes all endpoints for a given service and port.

FIELDS:
   serviceName  <string> -required-
     Specifies the name of the referenced service.

   servicePort  <string> -required-
     Specifies the port of the referenced service.
```

Similarly, we can repeat this for any field that you need information about, which is handy for building or modifying a YAML manifest. So, we have seen that the `kubectl explain` command is very useful when you are looking for more details and documentation about an API resource. It is also very useful when creating or modifying objects using YAML manifest files.

How to Enable/Disable API Resources, Groups, or Versions

In a typical cluster, not all API groups are enabled by default. It depends on the cluster use case as determined by the administrators. For example, some Kubernetes cloud providers disable resources that use the alpha level for stability and security reasons. However, those can still be enabled on the API server by using the `--runtime-config` flag, which accepts comma-separated lists.

To be able to create any resource, the group and version should be enabled in the cluster. For example, when you try to create a `CronJob` that uses `apiVersion: batch/v2alpha1` in its manifest file, if the group/version is not enabled, you will get an error similar to the following:

```
No matches for kind "CronJob" in version "batch/v2alpha1".
```

To enable `batch/v2alpha1`, you will need to set `--runtime-config=batch/v2alpha1` on the API server. This can be done either during the creation of the cluster or by updating the `/etc/kubernetes/manifests/kube-apiserver.yaml` manifest file. The flag also supports disabling an API group or version by setting a `false` value to the specific version---for example, `--runtime-config=batch/v1=false`.

`--runtime-config` also supports the `api/all` special key, which is used to control all API versions. For example, to turn off all API versions except `v1`, you can pass the `--runtime-config=api/all=false,api/v1=true` flag. Let's try our own hands-on example of creating and disabling API groups and versions in the following exercise.

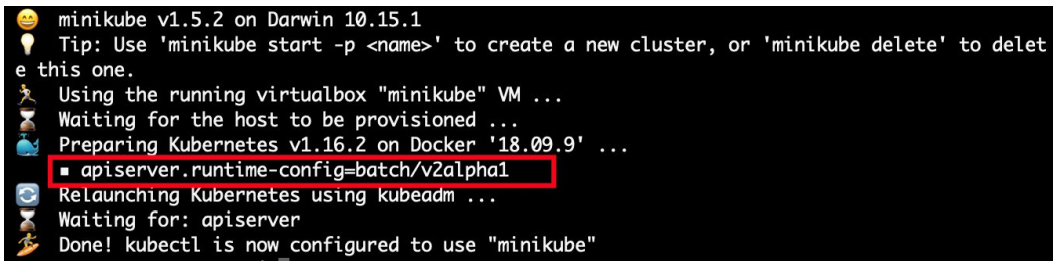
Exercise 4.03: Enabling and Disabling API Groups and Versions on a Minikube Cluster

In this exercise, we will create specific API versions while starting up Minikube, disable certain API versions in our running cluster, and then enable/disable resources in an entire API group:

1. Start Minikube with the flag shown in the following command:

   ```
   minikube start --extra-config=apiserver.runtime-config=batch/v2alpha1
   ```

   You should see the following response:

2. You can confirm it is enabled by checking the details about the `kube-apiserver-minikube` pod. Use the `describe pod` command and filter the results by the `runtime` keyword:

   ```
   kubectl describe pod kube-apiserver-minikube -n kube-system | grep runtime
   ```

   You should see the following response:

   ```
   --runtime-config=batch/v2alpha1
   ```

3. Another way to confirm this is by looking at the enabled API versions by using the following command:

   ```
   kubectl api-versions | grep batch/v2alpha1
   ```

   You should see the following response:

   ```
   batch/v2alpha1
   ```

4. Now, let's create a resource called a `CronJob`, which uses `batch/v2alpha1` to confirm that our API server accepts the API. Create a file named `sample-cronjob.yaml` with the following contents:

   ```
   apiVersion: batch/v2alpha1
   kind: CronJob
   metadata:
     name: hello
   spec:
     schedule: "*/1 * * * *"
     jobTemplate:
       spec:
         template:
           spec:
             containers:
             - name: hello
               image: busybox
               args:
   ```

```
            - /bin/sh
            - -c
            - date; echo Hello from the Kubernetes cluster
          restartPolicy: OnFailure
```

5. Now, create a `CronJob` by using this YAML file:

   ```
   kubectl create -f sample-cronjob.yaml
   ```

   You should see the following output:

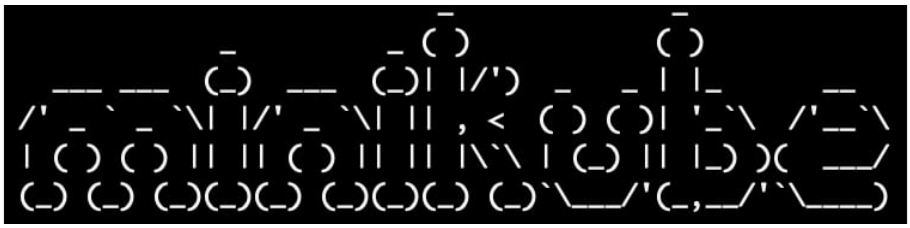
   ```
   cronjob.batch/hello created
   ```

   As you can see, the API server accepted our YAML file and the `CronJob` is created successfully.

6. Now, let's disable `batch/v2alpha1` on our cluster. To do that, we need to access the Minikube virtual machine (VM) using SSH, as demonstrated in previous labs:

   ```
   minikube ssh
   ```

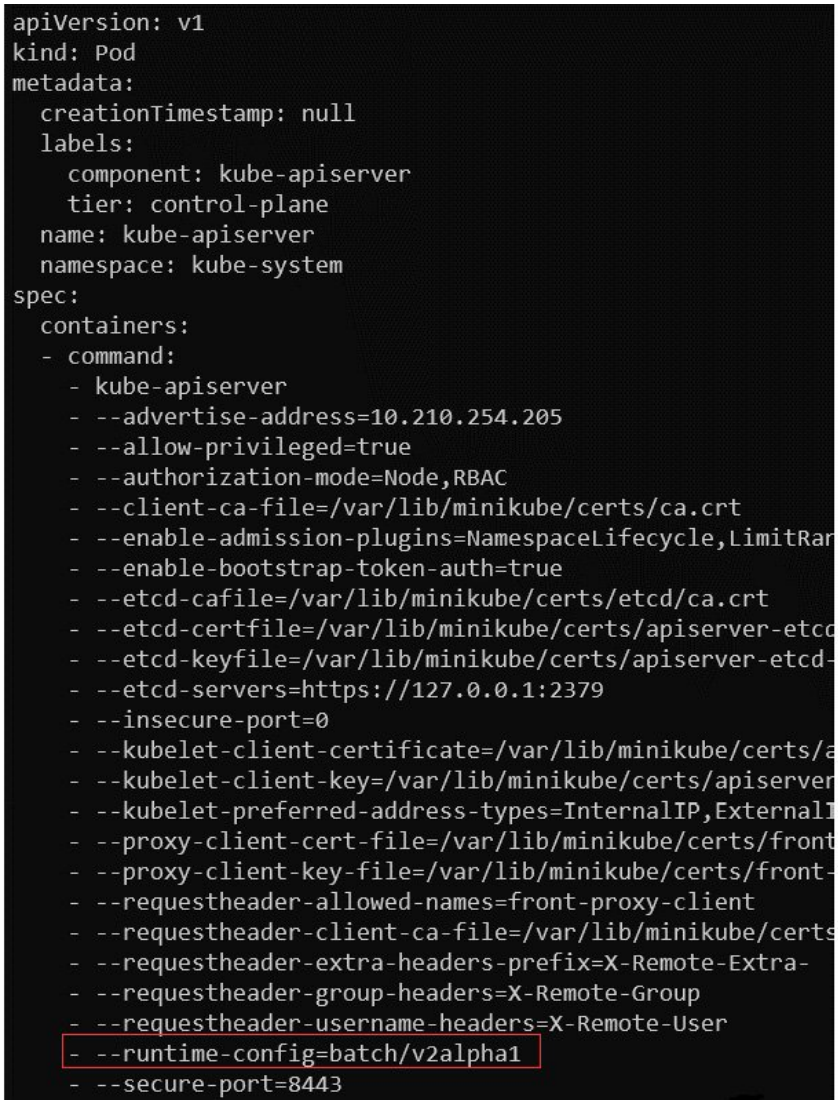
   You should see this response:

7. Open the API server manifest file. This is the template Kubernetes uses for the API server pods. We will use vi to modify this file, although you can use any text editor of your preference:

   ```
   sudo vi /etc/kubernetes/manifests/kube-apiserver.yaml
   ```

   You should see a response like the following:




```
Look for the line that contains
`--runtime-config=batch/v2alpha1` and change it to
`--runtime-config=batch/v2alpha1=false`. Then, save the
modified file.
```

8. End the SSH session by using the following command:

   ```
   exit
   ```

9. For the changes in the API server manifest to take effect, we need to restart the API server and the controller manager. Since these are deployed as stateless pods, we can simply delete them and they will automatically get deployed again. First, let's delete the API server by running this command:

   ```
   kubectl delete pods -n kube-system -l component=kube-apiserver
   ```

   You should see this output:

```
pod "kube-apiserver-minikube" deleted
```

Now, let's delete the controller manager:

```
kubectl delete pods -n kube-system -l component=kube-controller-manager
```

You should see this output:

```
pod "kube-controller-manager-minikube" deleted
```

Note that for both of these commands, we did not delete the pods by their names. The `-l` flag looks for labels. These commands deleted all the pods in the `kube-system` namespace that had labels that match the ones specified after the `-l` flag.

10. We can confirm that `batch/v2alpha1` is no longer shown in API versions by using the following command:

```
kubectl api-versions | grep batch/v2alpha1
```

This command will not give you any response, indicating that we have disabled `batch/v2alpha1`.

So, we have seen how we can enable or disable a specific group or version of API resources. But this is still a broad approach. What if you wanted to disable a specific API resource?

For our example, let's say that you want to disable ingress. We saw in the previous exercise that we have ingresses in the `extensions` as well as `networking.k8s.io` API groups. If you are targeting a specific API resource, you need to specify its group and version. Let's say that you want to disable ingress from the `extensions` group because it is deprecated. In this group, we have just one version of ingresses, which is `v1beta`, as you can observe from *Figure 4.33*.

To achieve this, all we have to do is modify the `--runtime-config` flag to specify the resource that we want. So, if we wanted to disable ingress from the `extensions` group, the flag would be as follows:

```
--runtime-config=extensions/v1beta1/ingresses=false
```

To disable the resource, we can use this flag when starting up Minikube, as shown in *step 1* of this exercise, or we can add this line to the API server's manifest file, as shown in *step 7* of this exercise. Recall from this exercise that if we instead want to enable the resource, we just need to remove the `=false` part from the end of this flag.

Interacting with Clusters Using the Kubernetes API

Up until now, we've been using the Kubernetes kubectl command-line tool, which made interacting with our cluster quite convenient. It does that by extracting the API server address and authentication information from the client kubeconfig file, which is located in `~/.kube/config` by default, as we saw in the previous lab. In this section, we will look at the different ways to directly access the API server with HTTP clients such as curl.

There are two possible ways to directly access the API server via the REST API---by using kubectl in proxy mode or by providing the location and authentication credentials directly to the HTTP client. We will explore both methods to understand the pros and cons of each one.

Accessing the Kubernetes API Server Using kubectl as a Proxy

kubectl has a great feature called **kubectl proxy**, which is the recommended approach for interacting with the API server. This is recommended because it is easier to use and provides a more secure way of doing so because it verifies the identity of the API server by using a self-signed certificate, which prevents **man-in-the-middle** (**MITM**) attacks.

kubectl proxy routes the requests from our HTTP client to the API server while taking care of authentication by itself. Authentication is also handled by using the current configuration in our kubeconfig file.

In order to demonstrate how to use kubectl proxy, let's first create an NGINX Deployment with two replicas in the default namespace and view it using `kubectl get pods`:

```
kubectl create deployment mynginx --image=nginx:latest
```

This should give an output like the following:

```
deployment.apps/mynginx created
```

Now, we can scale our Deployment to two replicas with the following command:

```
kubectl scale deployment mynginx --replicas=2
```

You should see an output similar to this:

```
deployment.apps/mynginx scaled
```

Let's now check whether the pods are up and running:

```
kubectl get pods
```

This gives an output similar to the following:

```
NAME                         READY    STATUS     RESTARTS   AGE
mynginx-565f67b548-gk5n2     1/1      Running    0          2m30s
mynginx-565f67b548-q6slz     1/1      Running    0          2m30s
```

To start a proxy to the API server, run the `kubectl proxy` command:

```
kubectl proxy
```

This should give output as follows:

```
Starting to serve on 127.0.0.1:8001
```

Note from the preceding screenshot that the local proxy connection is running on `127.0.0.1:8001`, which is the default. We can also specify a custom port by adding the `--port=<YourCustomPort>` flag, while adding an `&` (ampersand) sign at the end of our command to allow the proxy to run in the terminal background so that we can continue working in the same terminal window. So, the command would look like this:

```
kubectl proxy --port=8080 &
```

This should give the following response:

```
[1] 48285
AbuTalebMBP:~ mohammed$ Starting to serve on 127.0.0.1:8080
```

The proxy is run as a background job, and in the preceding screenshot, `[1]` indicates the job number and `48285` indicates its process ID. To exit a proxy running in the background, you can run `fg` to bring the job back to the foreground:

```
fg
```

This will show the following response:

```
kubectl proxy --port=8080
^C
```

After getting the proxy to the foreground, we can simply use *Ctrl + C* to exit it (if there's no other job running).

Note

If you are not familiar with job control, you can learn about it at https://www.gnu.org/software/bash/manual/html_node/Job-Control-Basics.html.

We can now start exploring the API using curl:

```
curl http://127.0.0.1:8080/apis
```

Recall that even though we are mostly using YAML for convenience, the data is stored in etcd in JSON format. You will see a long response that begins something like this:

But how do we find the exact path to query the Deployment we created earlier? Also, how do we query the pods created by that Deployment?

You can start by asking yourself a few questions:

- What are the API version and API group used by Deployments?

  In *Figure 4.27*, we saw that the Deployments are in `apps/v1`, so we can start by adding that to the path:

  ```
  curl http://127.0.0.1:8080/apis/apps/v1
  ```

- Is it a namespace-scoped resource or a cluster-scoped resource? If it is a namespace-scoped resource, what is the name of the namespace?

  We also saw in the scope of the API resources section that Deployments are namespace-scoped resources. When we created the Deployment, since we did not specify a different namespace, it went to the `default` namespace. So, in addition to the `apiVersion` field, we would need to add `namespaces/default/deployments` to our path:

  ```
  curl http://127.0.0.1:8080/apis/apps/v1/namespaces/default/deployments
  ```

  This will return a large output with the JSON data that is stored on this path. This is the part of the response that gives us the information that we need:

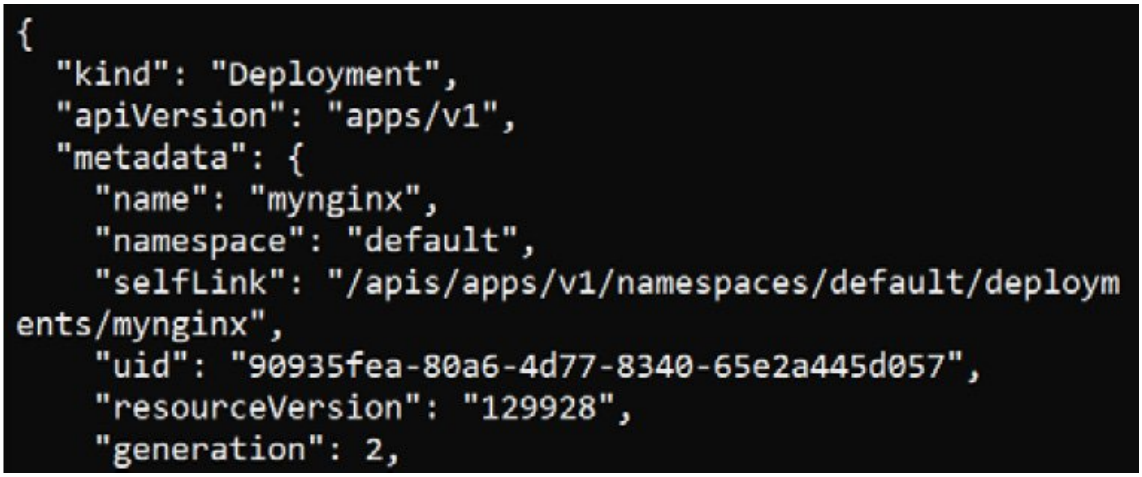

```
{
  "kind": "DeploymentList",
  "apiVersion": "apps/v1",
  "metadata": {
    "selfLink": "/apis/apps/v1/namespaces/default/deploym
ents",
    "resourceVersion": "131356"
  },
  "items": [
    {
      "metadata": {
        "name": "mynginx",
        "namespace": "default",
        "selfLink": "/apis/apps/v1/namespaces/default/dep
loyments/mynginx",
        "uid": "90935fea-80a6-4d77-8340-65e2a445d057",
```


As you can see in this output, this lists all the Deployments in the `default` namespace. You can infer that from `"kind": "DeploymentList"`. Also, note that the response is in JSON format and is not neatly presented as a table.

Now, we can specify a specific Deployment by adding it to our path:

```
curl http://127.0.0.1:8080/apis/apps/v1/namespaces/default/deployments/mynginx
```

You should see this response:



You can use this method with any other resource as well.

Creating Objects Using curl

When you use any HTTP client, such as curl, to send requests to the API server to create objects, you need to change three things:

1. Change the `HTTP` request method to `POST`. By default, curl will use the `GET` method. To create objects, we need to use the `POST` method, as we learned in *The Kubernetes API* section. You can change this using the `-X` flag.
2. Change the HTTP request header. We need to modify the header to inform the API server what the intention of the request is. We can modify the header using the `-H` flag. In this case, we need to set the header to `'Content-Type: application/yaml'`.
3. Include the spec of the object to be created. As you learned in the previous two labs, each API resource is persisted in the etcd as an API object, which is defined by a YAML spec/manifest file. To create an object, you need to use the `--data` flag to pass the YAML manifest to the API server so that it can persist it in etcd as an object.

So, the curl command, which we will implement in the following exercise, will look something like this:

```
curl -X POST <URL-path> -H 'Content-Type: application/yaml' --data <spec/manifest>
```

At times, you will have the manifest files handy. However, that may not always be the case. Also, we have not yet seen what manifests for namespaces look like.

Let's consider a case where we want to create a namespace. Usually, you would create a namespace as follows:

```
kubectl create namespace my-namespace
```

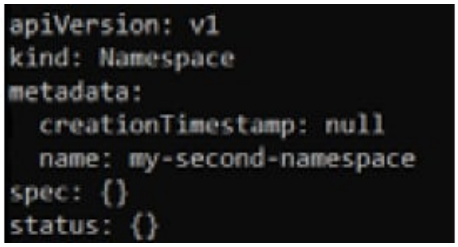
This will give the following response:

```
namespace/my-namespace created
```

Here, you can see that we created a namespace called `my-namespace`. However, for passing the request without using kubectl, we need the spec used to define a namespace. We can get that by using the `--dry-run=client` and `-o` flags:

```
kubectl create namespace my-second-namespace --dry-run=client -o yaml
```

This will give the following response:



When you run a `kubectl` command with the `--dry-run=client` flag, the API server takes it through all the stages of a normal command, except that it does not persist the changes into etcd. So, the command is authenticated, authorized, and validated, but changes are not permanent. This is a great way to test whether a certain command works, and also to get the manifest that the API server would have created for this command, as you can see in the previous screenshot. Let's see how to put this in practice and use curl to create a Deployment.

Exercise 4.04: Creating and Verifying a Deployment Using kubectl proxy and curl

For this exercise, we will create an NGINX Deployment called `nginx-example` with three replicas in a namespace called `example`. We will do this by sending our requests to the API server with curl via kubectl proxy:

1. First, let's start our proxy:

   ```
   kubectl proxy &
   ```

   This should give the following response:

   ```
   [1] 50034
   AbuTalebMBP:~ mohammed$ Starting to serve on 127.0.0.1:8080
   ```

   The proxy started as a background job and is listening on the localhost at port `8001`.

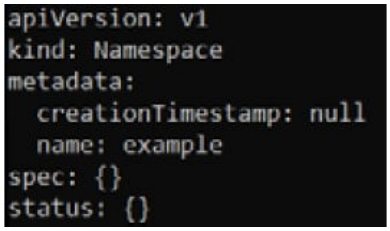
2. Since the `example` namespace does not exist, we should create that namespace before creating the Deployment. As we learned in the previous section, we need to get the spec that should be used to create the namespace. Let's use the following command:

   ```
   kubectl create namespace example --dry-run -o yaml
   ```

   Note

   For Kubernetes versions 1.18+, please use `--dry-run=client`.

   This will give the following output:




```
Now, we have the spec required for creating the namespace.
```

3. Now, we need to send a request to the API server using curl. Namespaces belong to the core group and hence the path will be `/api/v1/namespaces`. The final `curl` command to create the namespace after adding all required parameters should look like the following:

```
curl -X POST http://127.0.0.1:8001/api/v1/namespaces -H 'Content-    Type:
application/yaml' --data "
apiVersion: v1
kind: Namespace
metadata:
  creationTimestamp: null
  name: example
spec: {}
status: {}
"
```

Note

You can discover the required path for any resource, as shown in the previous exercise. In this command, the double-quotes (`"`) after `--data` allow you to enter multi-line input in Bash, which is delimited by another double-quote at the end. So, you can copy the output from the previous step here before the delimiter.

Now, if everything was correct in our command, you should get a response like the following:

4. The same procedure applies to Deployment. So, first, let's use the `kubectl create` command with `--dry-run=client` to get an idea of how our YAML data looks:

   ```
   kubectl create deployment nginx-example -n example --image=nginx:latest --dry-run -o yaml
   ```

   Note

   For Kubernetes versions 1.18+, please use `--dry-run=client`.

   You should get the following response:


```
Note

Notice that the namespace will not show if you are using the
`--dry-run=client` flag because we need to specify it in
our API path.
```

5. Now, the command for creating the Deployment will be constructed similarly to the command for creating the namespace. Note that the namespace is specified in the API path:

```
curl -X POST http://127.0.0.1:8001/apis/apps/v1/namespaces/example/
deployments -H 'Content-Type: application/yaml' --data "
apiVersion: apps/v1
kind: Deployment
metadata:
  creationTimestamp: null
  labels:
    run: nginx-example
  name: nginx-example
spec:
  replicas: 3
  selector:
    matchLabels:
      run: nginx-example
  strategy: {}
  template:
```

```
    metadata:
      creationTimestamp: null
      labels:
        run: nginx-example
    spec:
      containers:
      - image: nginx:latest
        name: nginx-example
        resources: {}
status: {}
"
```

If everything is correct, you should get a response like the following from the API server:

Note that the kubectl proxy process is still running in the background. If you are done with interacting with the API server using kubectl proxy, then you may want to stop the proxy from running in the background. To do that, run the `fg` command to bring the kubectl proxy process to the foreground and then press *Ctrl + C*.

So, we have seen how we can interact with the API server using kubectl proxy, and by using curl, we have been able to create an NGINX Deployment in a new namespace.

Direct Access to the Kubernetes API Using Authentication Credentials

Instead of using kubectl in proxy mode, we can provide the location and credentials directly to the HTTP client. This approach can be used if you are using a client that may get confused by proxies, but it is less secure than using the kubectl proxy due to the risk of MITM attacks. To mitigate this risk, it is recommended that you import the root certificate and verify the identity of the API server when using this method.

When thinking about accessing the cluster using credentials, we need to understand how authentication is configured and what authentication plugins are enabled in our cluster. Several authentication plugins can be used, which allow different ways of authenticating with the server:

- Client certificates
- ServiceAccount bearer tokens
- Authenticating proxy
- HTTP basic auth

  Note

  Note that the preceding list includes only some of the authentication plugins. You can learn more about authentication at https://kubernetes.io/docs/reference/access-authn-authz/authentication/.

Let's check what authentication plugins are enabled in our cluster by looking at the API server running process using the following command and looking at the flags passed to the API server:

```
kubectl exec -it kube-apiserver-minikube -n kube-system -- /bin/sh -c "apt update ;
apt -y install procps ; ps aux | grep kube-apiserver"
```

This command will first install/update `procps` (a tool used to inspect processes) within the API server, which is running as a pod on our Minikube server. Then, it will get the list of processes and filter it by using the `kube-apiserver` keyword. You will get a long output, but here is the part that we are interested in:

```
:31 kube-apiserver --advertise-address=192.168.0.105 --allow-
privileged=true --authorization-mode=Node,RBAC --client-ca-fi
le=/var/lib/minikube/certs/ca.crt --enable-admission-plugins=
NamespaceLifecycle,LimitRanger,ServiceAccount,DefaultStorageC
lass,DefaultTolerationSeconds,NodeRestriction,MutatingAdmissi
onWebhook,ValidatingAdmissionWebhook,ResourceQuota --enable-b
ootstrap-token-auth=true --etcd-cafile=/var/lib/minikube/cert
s/etcd/ca.crt --etcd-certfile=/var/lib/minikube/certs/apiserv
er-etcd-client.crt --etcd-keyfile=/var/lib/minikube/certs/api
server-etcd-client.key --etcd-servers=https://127.0.0.1:2379
--insecure-port=0 --kubelet-client-certificate=/var/lib/minik
ube/certs/apiserver-kubelet-client.crt --kubelet-client-key=/
var/lib/minikube/certs/apiserver-kubelet-client.key --kubelet
-preferred-address-types=InternalIP,ExternalIP,Hostname --pro
xy-client-cert-file=/var/lib/minikube/certs/front-proxy-clien
t.crt --proxy-client-key-file=/var/lib/minikube/certs/front-p
roxy-client.key --requestheader-allowed-names=front-proxy-cli
ent --requestheader-client-ca-file=/var/lib/minikube/certs/fr
ont-proxy-ca.crt --requestheader-extra-headers-prefix=X-Remot
e-Extra- --requestheader-group-headers=X-Remote-Group --reque
stheader-username-headers=X-Remote-User --secure-port=8443 --
service-account-key-file=/var/lib/minikube/certs/sa.pub --ser
vice-cluster-ip-range=10.96.0.0/12 --tls-cert-file=/var/lib/m
inikube/certs/apiserver.crt --tls-private-key-file=/var/lib/m
inikube/certs/apiserver.key
```

The following two flags from this screenshot tell us some important information:

- `--client-ca-file=/var/lib/minikube/certs/ca.crt`
- `--service-account-key-file=/var/lib/minikube/certs/sa.pub`

These flags tell us that we have two different authentication plugins configured---X.509 client certificates (based on the first flag) and ServiceAccount tokens (based on the second flag). We will now learn how to use both of these authentication methods for communicating with the API server.

Method 1: Using Client Certificate Authentication

X.509 certificates are used for authenticating external requests, which is the current configuration in our kubeconfig file. The `--client-ca-file=/var/lib/minikube/certs/ca.crt` flag indicates the certificate authority that is used to validate client certificates, which will authenticate with the API server. An X.509 certificate defines a subject, which is what identifies a user in Kubernetes. For example, the X.509 certificate used for SSL by https://www.google.com/ has a subject containing the following information:

```
Common Name = www.google.com
Organization = Google LLC
Locality = Mountain View
State = California
Country = US
```

When an X.509 certificate is used for authenticating a Kubernetes user, the `Common Name` of the subject is used as the username for the user, and the `Organization` field is used as the group membership of that user.

Kubernetes uses a TLS protocol for all of its API calls as a security measure. The HTTP client that we have been using so far, curl, can work with TLS. Earlier, kubectl proxy took care of communicating over TLS for us, but if we want to do it directly using curl, we need to add three more details to all of our API calls:

- `--cert` : The client certificate path
- `--key` : The private key path
- `--cacert` : The certificate authority path

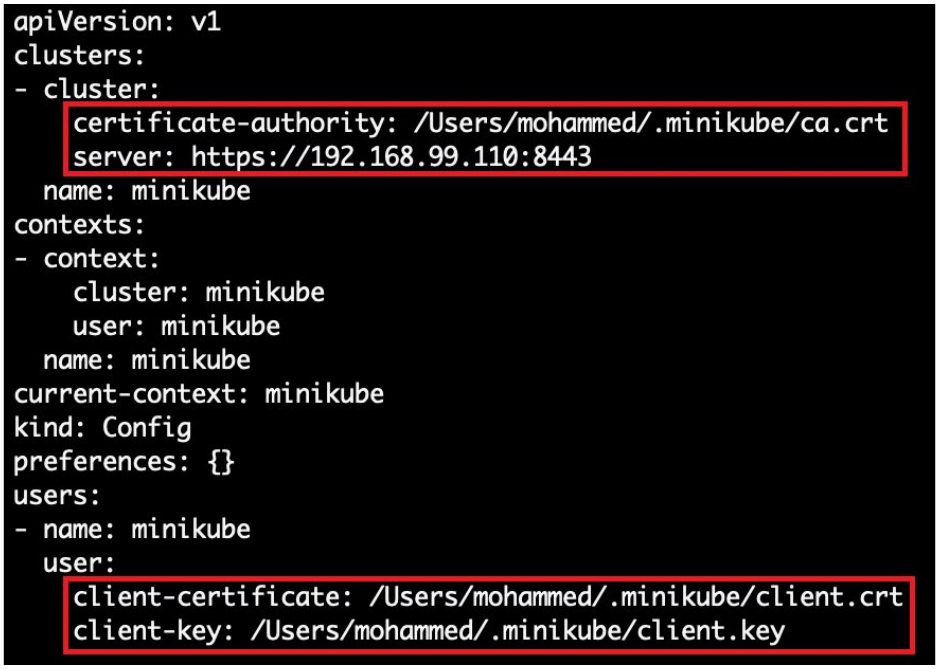
So, if we combine them, the command syntax should look as follows:

```
curl --cert <ClientCertificate> --key <PrivateKey> --cacert <CertificateAuthority>
https://<APIServerAddress:port>/api
```

In this section, we will not create these certificates, but instead, we will be using the certificates that were created when we bootstrapped our cluster using Minikube. All the relevant information can be taken from our kubeconfig file, which was prepared by Minikube when we initialized the cluster. Let's see that file:

```
kubectl config view
```

You should get the following response:

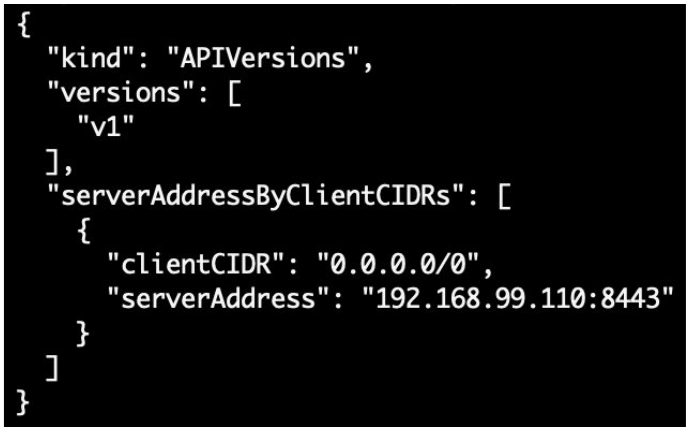


kubeconfig

The final command should look like the following: you can see that we can explore the API:

```
curl --cert ~/.minikube/client.crt --key ~/.minikube/client.key --cacert
~/.minikube/ca.crt https://192.168.99.110:8443/api
```

You should get the following response:



So, we can see that the API server is responding to our calls. You can use this method to achieve everything that we have done in the previous section using kubectl proxy.

Method 2: Using a ServiceAccount Bearer Token

Service accounts are meant to authenticate processes running within the cluster, such as pods, to allow internal communication with the API server. They use signed bearer **JSON Web Tokens** (**JWTs**) to authenticate with the API server. These tokens are stored in Kubernetes objects called **Secrets**, which are a type of entities used to store sensitive information, such as the aforementioned authentication tokens. The information stored inside a Secret is Base64-encoded.

So, each ServiceAccount has a corresponding secret associated with it. When a pod uses a ServiceAccount to authenticate with the API server, the secret is mounted on the pod and the bearer token is decoded and then mounted at the following location inside a pod: `/run/secrets/kubernetes.io/serviceaccount`. This can then be used by any process in the pod to authenticate with the API server. Authentication by use of ServiceAccounts is enabled by a built-in module known as an admission controller, which is enabled by default.

However, ServiceAccounts alone are not sufficient; once authenticated, Kubernetes also needs to permit any actions for that ServiceAccount (which is the authorization phase). This is managed by **Role-Based Access Control** (**RBAC**) policies. In Kubernetes, you can define certain **Roles**, and then use **RoleBinding** to *bind* those Roles to certain users or ServiceAccounts.

A Role defines what actions (API verbs) are allowed and which API groups and resources can be accessed. A RoleBinding defines which user or ServiceAccount can assume that Role. A ClusterRole is similar to a Role, except that a Role is namespace-scoped, while a ClusterRole is a cluster-scoped policy. The same distinction is true for RoleBinding and ClusterRoleBinding.

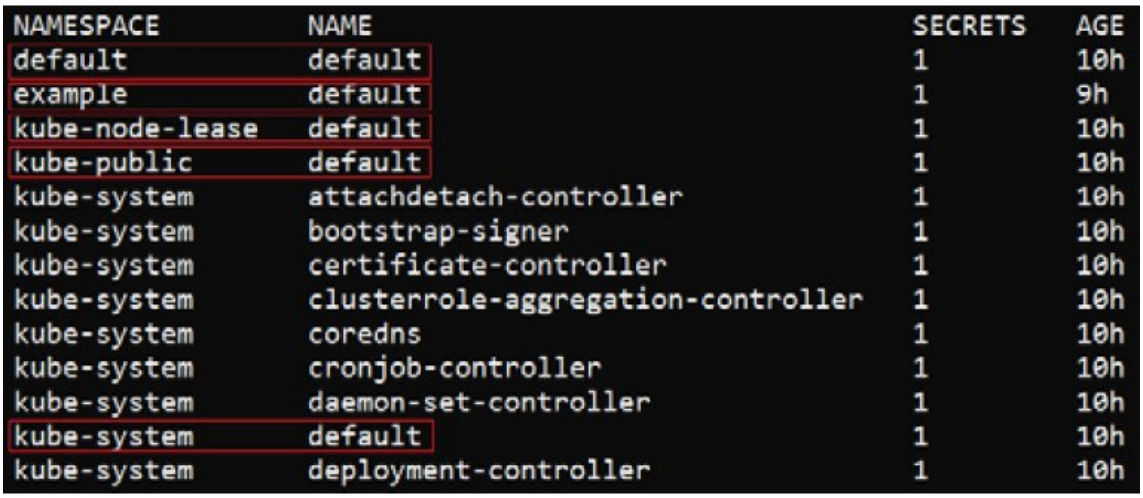
Note

You will learn more about secrets in *Lab 10*, *ConfigMaps and Secrets*; more on RBAC in *Lab 13*, *Runtime and Network Security in Kubernetes*; and admission controllers in *Lab 16*, *Kubernetes Admission Controllers*.

Every namespace contains a ServiceAccount called `default`. We can see that by using the following command:

```
kubectl get serviceaccounts --all-namespaces
```

You should see the following response:



NAMESPACE	NAME	SECRETS	AGE
default	default	1	10h
example	default	1	9h
kube-node-lease	default	1	10h
kube-public	default	1	10h
kube-system	attachdetach-controller	1	10h
kube-system	bootstrap-signer	1	10h
kube-system	certificate-controller	1	10h
kube-system	clusterrole-aggregation-controller	1	10h
kube-system	coredns	1	10h
kube-system	cronjob-controller	1	10h
kube-system	daemon-set-controller	1	10h
kube-system	default	1	10h
kube-system	deployment-controller	1	10h

As mentioned earlier, a ServiceAccount is associated with a secret that contains the CA certificate of the API server and a bearer token. We can view the ServiceAccount-associated secret in the `default` namespace, as follows:

```
kubectl get secrets
```

You should get the following response:

```
NAME                  TYPE                                  DATA   AGE
default-token-wtkk5   kubernetes.io/service-account-token   3      10h
```

We can see that we have a secret named `default-token-wtkk5` (where `wtkk5` is a random string) in our default namespace. We can view the content of the Secret resource by using the following command:

```
kubectl get secrets default-token-wtkk5 -o yaml
```

This command will get the object definition as it is stored in etcd and display it in YAML format so that it is easy to read. This will produce an output as follows:

Note from the preceding secret that `namespace`, `token`, and the CA certificate of the API server (ca.crt) are Base64-encoded. You can decode it using `base64 --decode` in your Linux terminal, as follows:

```
echo "<copied_value>" | base64 --decode
```

Copy and paste the value from `ca.crt` or `token` in the preceding command. This will output the decoded value, which you can then write to a file or a variable for later use. However, in this demonstration, we will show another method to get the values.

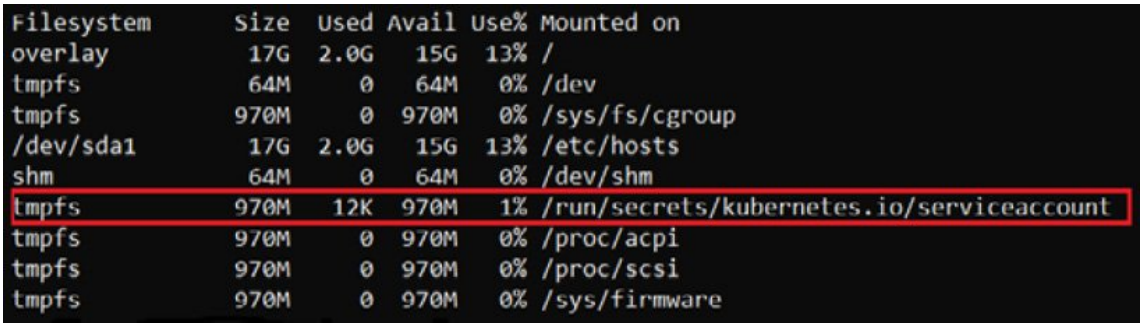
Let's take a peek into one of our pods:

```
kubectl exec -it <pod-name> -- /bin/bash
```

This command enters the pod and then runs a Bash shell on it. Then, once we have the shell running inside a pod, we can explore the various mount points available in the pod:

```
df -h
```

This will give an output similar to the following:



The mount point can be explored further:

```
ls /var/run/secrets/kubernetes.io/serviceaccount
```

You should see an output similar to the following:

```
ca.crt  namespace  token
```

As you can see here, the mount point contains the API server CA certificate, the namespace this secret belongs to, and the JWT bearer token. If you are trying these commands on your terminal, you can exit the pod's shell by entering an `exit`.

If we try to access the API server using curl from inside the pod, we would need to provide the CA path and the token. Let's try to list all the pods in the pod's namespace by accessing the API server from inside a pod.

We can create a new Deployment and start a Bash terminal with the following procedure:

```
kubectl run my-bash --rm --restart=Never -it --image=ubuntu -- bash
```

This may take a few seconds to start up, and then you will get a response similar to this:

```
If you don't see a command prompt, try pressing enter.
root@my-bash: /#
```

This will start up a Deployment running Ubuntu and immediately take us inside the pod and open up the Bash shell. The `--rm` flag in this command will delete the pod after all the processes inside the pod are terminated---that is, after we leave the pod using the `exit` command. But for now, let's install curl:

```
apt update && apt -y install curl
```

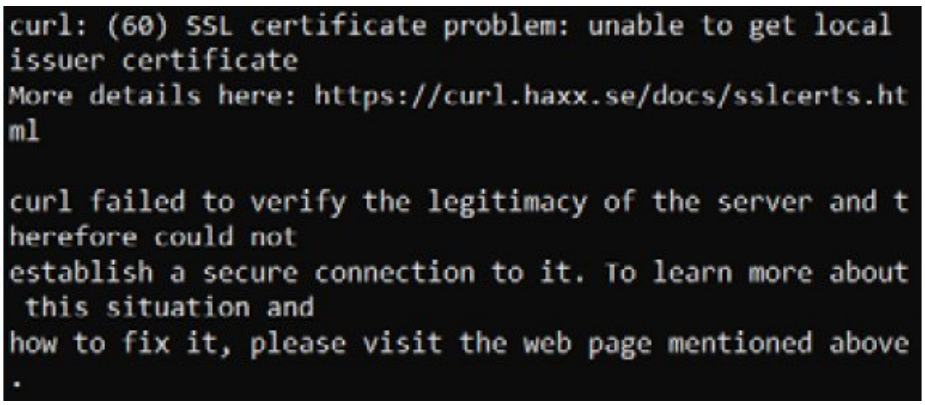
This should produce a response similar to this:

```
Get:1 http://security.ubuntu.com/ubuntu bionic-security InRelease
88.7 kB]
Get:2 http://archive.ubuntu.com/ubuntu bionic InRelease [242 kB]
Get:3 http://security.ubuntu.com/ubuntu bionic-security/restricted
amd64 Packages [23.7 kB]
Get:4 http://archive.ubuntu.com/ubuntu bionic-updates InRelease [8
.7 kB]
Get:5 http://archive.ubuntu.com/ubuntu bionic-backports InRelease
```

Now that we have installed curl, let's try to list the pods using curl by accessing the API path:

```
curl https://kubernetes/api/v1/namespaces/$NAMESPACE/pods
```

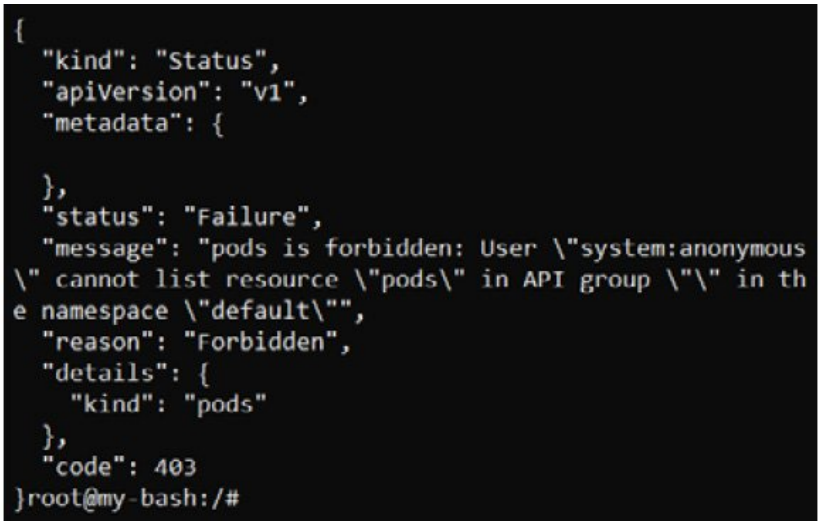
You should see the following response:



Notice that the command has failed. This happened since Kubernetes forces all communication to use TLS, which usually rejects insecure connections (without any authentication tokens). Let's add the `--insecure` flag, which will allow an insecure connection with curl, and observe the results:

```
curl --insecure https://kubernetes/api/v1/namespaces/$NAMESPACE/pods
```

You should get a response as follows:



We can see that we were able to reach the server using an insecure connection. However, the API server treated our request as anonymous since there was no identity provided to our command.

Now, to make commands easier, we can add the namespace, CA certificate (`ca.crt`), and the token to variables so that the API server knows the identity of the service account generating the API request:

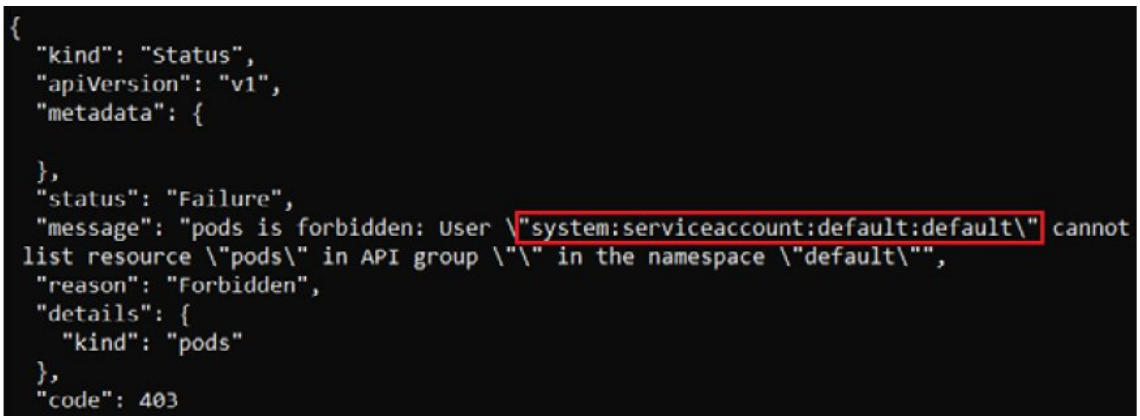
```
CACERT=/run/secrets/kubernetes.io/serviceaccount/ca.crt
TOKEN=$(cat /run/secrets/kubernetes.io/serviceaccount/token)
```

```
NAMESPACE=$(cat /run/secrets/kubernetes.io/serviceaccount/namespace)
```

Note that here we can use the values directly as they are in plaintext (not encoded) when looking from inside a pod, compared to having to decode them from a Secret. Now, we have all the parameters ready. When using bearer token authentication, the client should send this token in the header of the request, which is the authorization header. This should look like this: `Authorization: Bearer <token>`. Since we have added the token into a variable, we can simply use that. Let's run the `curl` command to see whether we can list the pods using the identity of the ServiceAccount:

```
curl --cacert $CACERT -H "Authorization: Bearer $TOKEN"
https://kubernetes/api/v1/namespaces/$NAMESPACE/pods
```

You should get the following response:



Notice that we were able to reach the API server, and the API server verified the `"system:serviceaccount:default:default"` identity, which is represented in this format: `system:<resource_type>:<namespace>:<resource_name>` However, we still got a `Forbidden` error because ServiceAccounts do not have any permissions by default. We need to manually assign permissions to our default ServiceAccount in order to be able to list pods. This can be done by creating a RoleBinding and linking it to the `view` ClusterRole.

Open another terminal window, ensuring that you don't close the terminal session running the `my-bash` pod (because the pod will be deleted and you will lose your progress if you close it). Now, in the second terminal session, you can run the following command to create a `rolebinding defaultSA`-view to attach the `view` ClusterRole to the ServiceAccount:

```
kubectl create rolebinding defaultSA-view \
  --clusterrole=view \
  --serviceaccount=default:default \
  --namespace=default
```

Note

The view ClusterRole should already exist for your Kubernetes cluster, as it is one of the default ClusterRoles available for use.

As you might recall from the previous lab, this is an imperative approach to creating resources; you will learn how to create manifests for RBAC policies in *Lab 13*, *Runtime and Network Security in Kubernetes*. Note that we have to

specify the ServiceAccount as `<namespace>:<ServiceAccountName>`, and we have a `--namespace` flag since a RoleBinding can only apply to the ServiceAccounts within that namespace. You should get the following response:

```
rolebinding.rbac.authorization.k8s.io/defaultSA-view created
```

Now, go back to the terminal window where we accessed the `my-bash` pod. With the necessary permissions set, let's try our curl command again:

```
curl --cacert $CACERT -H "Authorization: Bearer $TOKEN"
https://kubernetes/api/v1/namespaces/$NAMESPACE/pods
```

You should get the following response:

Our ServiceAccount can now authenticate with the API server, and it is authorized to list pods in the default namespace.

It is also valid to use ServiceAccount bearer tokens outside the cluster. You may want to use tokens instead of certificates as an identity for long-standing jobs since the token does not expire as long as the ServiceAccount exists, whereas a certificate has an expiry date set by the certificate-issuing authority. An example of this is CI/CD pipelines, where external services commonly use ServiceAccount bearer tokens for authentication.

Activity 4.01: Creating a Deployment Using a ServiceAccount Identity

In this activity, we will bring together all that we have learned in this lab. We will be using various operations on our cluster and using different methods to access the API server.

Perform the following operations using kubectl:

1. Create a new namespace called `activity-example`.
2. Create a new ServiceAccount called `activity-sa`.

3. Create a new RoleBinding called `activity-sa-clusteradmin` to attach the `activity-sa` ServiceAccount to the `cluster-admin` ClusterRole (which exists by default). This step is to ensure that our ServiceAccount has the necessary permissions to interact with the API server as a cluster admin.

Perform the following operations using curl with bearer tokens for authentication:

1. Create a new NGINX Deployment with the identity of the `activity-sa` ServiceAccount.
2. List the pods in your Deployment. Once you use curl to check the Deployment, if you have successfully gone through the previous steps, you should get a response that looks something like this:

3. Finally, delete the namespace with all associated resources. When using curl to delete a namespace, you should see a response with `phase` set to `terminating` for the `status` field of the namespace resource, as in the following screenshot:

```
"status": {
  "phase": "Terminating"
```

Note

The solution to this activity can be found at the following address: `Activity_Solutions\Solution_Final.pdf` .

Summary

In this lab, we took a closer look at the Kubernetes API server, the way that Kubernetes uses the RESTful API, and how API resources are defined. We learned that all commands from the kubectl command-line utility are translated into RESTful HTTP API calls and are sent to the API server. We learned that API calls go through multiple stages, including authentication, authorization, and admission control. We also had a closer look at each stage and some of the modules involved.

Then, we learned about some API resources, how they are categorized as namespace-scoped or cluster-scoped resources, and their API group and API version. We then learned how we can use this information to build an API path for interacting with the Kubernetes API.

We also applied what we learned by making an API call directly to the API server, using the curl HTTP client to interact with objects by using different authentication methods, such as ServiceAccounts and an X.509 certificate.

In the next few labs, we will inspect most of the commonly used API objects more closely, mainly focusing on the different functionalities offered by these objects to enable us to deploy and maintain our application in a Kubernetes cluster. We will begin this series of labs by taking a look at the basic unit of deployment in Kubernetes (pods) in the next lab.