Lab Exercise 10- Implementing Resource Quota in Kubernetes

Objective:

In Kubernetes, Resource Quotas are used to control the resource consumption of namespaces. They help in managing and enforcing limits on the usage of resources like CPU, memory, and the number of objects (e.g., Pods, Services) within a namespace. This exercise will guide you through creating and managing Resource Quotas to limit the resources used by applications in a specific namespace.

Step 1: Understand Resource Quotas

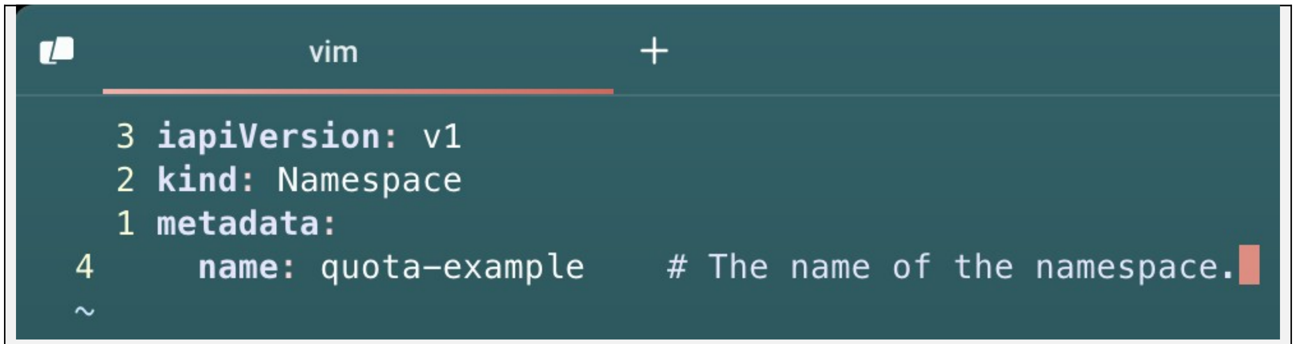
Resource Quotas allow you to:

- Limit the amount of CPU and memory a namespace can use.
- Control the number of certain types of resources (e.g., Pods, Services, PersistentVolumeClaims) in a namespace.
- Prevent a namespace from consuming more resources than allocated, ensuring fair usage across multiple teams or applications.

Step 2: Create a Namespace

First, create a namespace where you will apply the Resource Quota. This helps in isolating and controlling resource usage within that specific namespace.
Create a YAML file named ***quota-namespace.yaml*** with the following content:

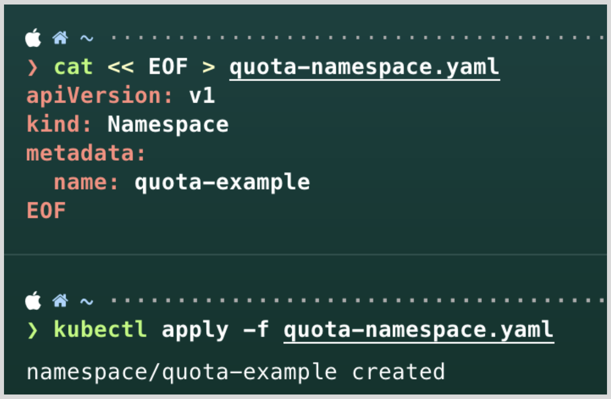
```
apiVersion: v1
kind: Namespace
metadata:
  name: quota-example    # The name of the namespace.
```


vim

```
iapiVersion: v1
kind: Namespace
metadata:
    name: quota-example     # The name of the namespace.
~
```

Apply the YAML to create the namespace:

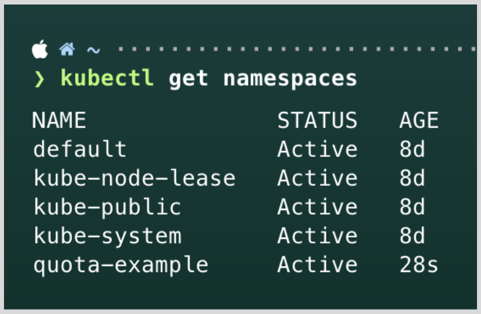
kubectl apply -f quota-namespace.yaml



```
❯ cat << EOF > quota-namespace.yaml
apiVersion: v1
kind: Namespace
metadata:
  name: quota-example
EOF

❯ kubectl apply -f quota-namespace.yaml
namespace/quota-example created
```

Verify that the namespace is created:

kubectl get namespaces



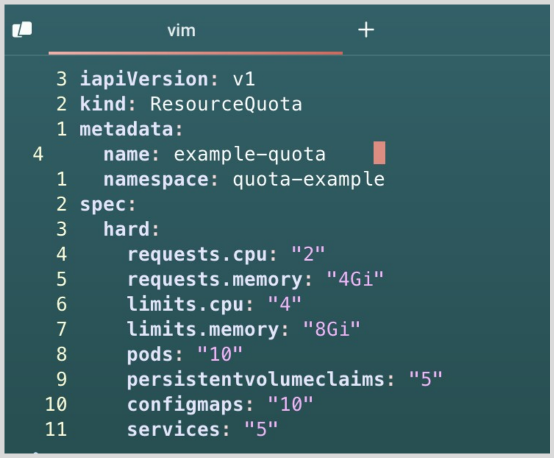
```
❯ kubectl get namespaces
NAME                 STATUS   AGE
default              Active   8d
kube-node-lease      Active   8d
kube-public          Active   8d
kube-system          Active   8d
quota-example        Active   28s
```

You should see quota-example listed in the output.

Step 3: Define a Resource Quota

Next, create a Resource Quota YAML file named ***resource-quota.yaml*** with the following content:

```
apiVersion: v1
kind: ResourceQuota
metadata:
  name: example-quota    # The name of the Resource Quota.
  namespace: quota-example # The namespace to which the Resource Quota will apply.
spec:
  hard:                  # The hard limits imposed by this Resource Quota.
    requests.cpu: "2"    # The total CPU resource requests allowed in the namespace (2 cores).
    requests.memory: "4Gi" # The total memory resource requests allowed in the namespace (4 GiB).
    limits.cpu: "4"      # The total CPU resource limits allowed in the namespace (4 cores).
    limits.memory: "8Gi" # The total memory resource limits allowed in the namespace (8 GiB).
    pods: "10"           # The total number of Pods allowed in the namespace.
    persistentvolumeclaims: "5" # The total number of PersistentVolumeClaims allowed in the namespace.
    configmaps: "10"     # The total number of ConfigMaps allowed in the namespace.
    services: "5"        # The total number of Services allowed in the namespace.
```

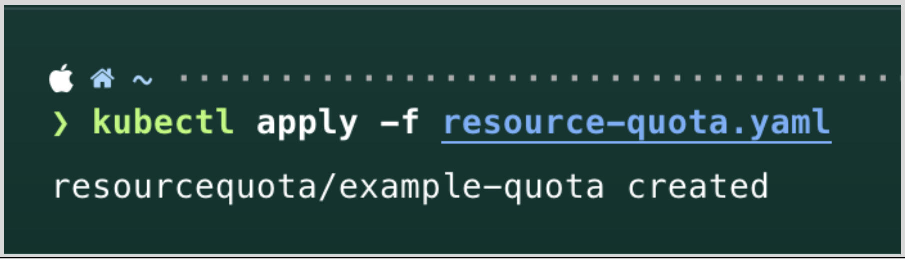


```
iapiVersion: v1
kind: ResourceQuota
metadata:
  name: example-quota
  namespace: quota-example
spec:
  hard:
    requests.cpu: "2"
    requests.memory: "4Gi"
    limits.cpu: "4"
    limits.memory: "8Gi"
    pods: "10"
    persistentvolumeclaims: "5"
    configmaps: "10"
    services: "5"
```

Step 4: Apply the Resource Quota

Apply the Resource Quota YAML to the namespace:

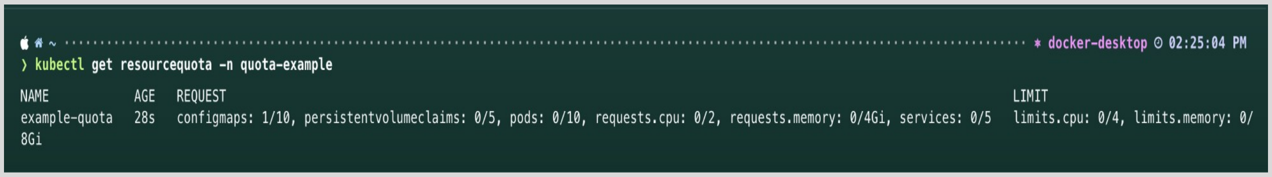
```
kubectl apply -f resource-quota.yaml
```



```
~ ........................................
❯ kubectl apply -f resource-quota.yaml
resourcequota/example-quota created
```

Verify that the Resource Quota is applied:

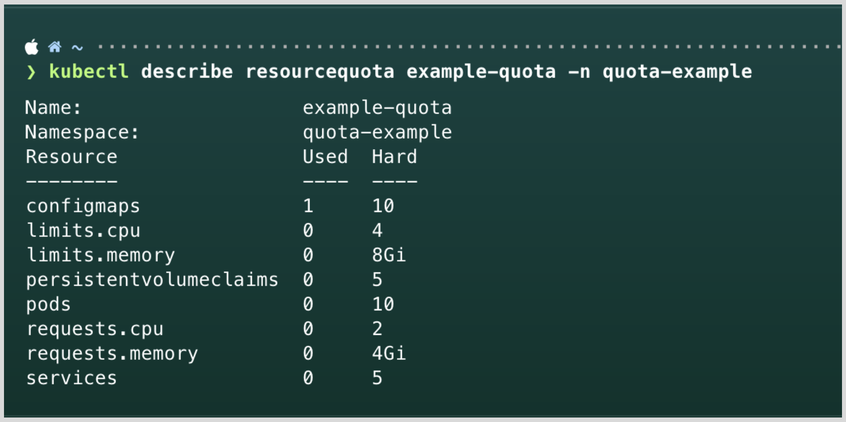
```
kubectl get resourcequota -n quota-example
```



```
~ ............................................ * docker-desktop ⊙ 02:25:04 PM
❯ kubectl get resourcequota -n quota-example
NAME            AGE   REQUEST                                                                                                            LIMIT
example-quota   28s   configmaps: 1/10, persistentvolumeclaims: 0/5, pods: 0/10, requests.cpu: 0/2, requests.memory: 0/4Gi, services: 0/5   limits.cpu: 0/4, limits.memory: 0/
8Gi
```

To see the details of the applied Resource Quota:

```
kubectl describe resourcequota example-quota -n quota-example
```



```
~ ................................................................
❯ kubectl describe resourcequota example-quota -n quota-example
Name:                   example-quota
Namespace:              quota-example
Resource                Used  Hard
--------                ----  ----
configmaps              1     10
limits.cpu              0     4
limits.memory           0     8Gi
persistentvolumeclaims  0     5
pods                    0     10
requests.cpu            0     2
requests.memory         0     4Gi
services                0     5
```

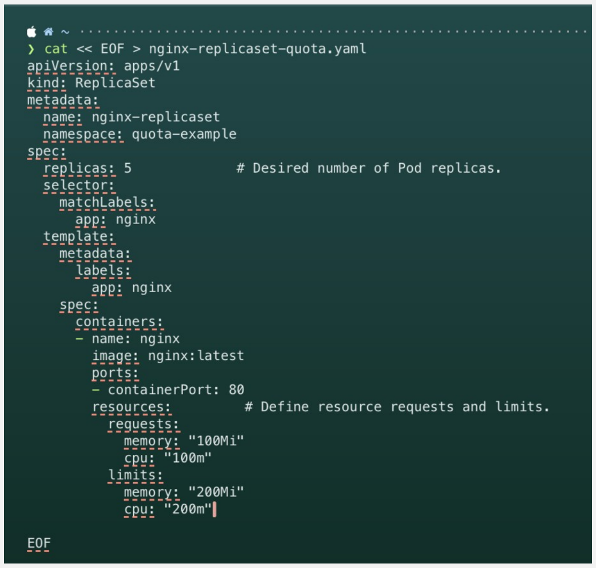
Step 5: Test the Resource Quota

Let's create some resources in the quota-example namespace to see how the Resource Quota affects them.

Deploy a ReplicaSet with Resource Requests and Limits
Create a YAML file named ***nginx-replicaset-quota.yaml*** with the following content:

```
apiVersion: apps/v1
kind: ReplicaSet
metadata:
  name: nginx-replicaset
  namespace: quota-example
spec:
  replicas: 5            # Desired number of Pod replicas.
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - name: nginx
        image: nginx:latest
        ports:
        - containerPort: 80
        resources:         # Define resource requests and limits.
          requests:
```

```
          memory: "100Mi"
          cpu: "100m"
        limits:
          memory: "200Mi"
          cpu: "200m"
```



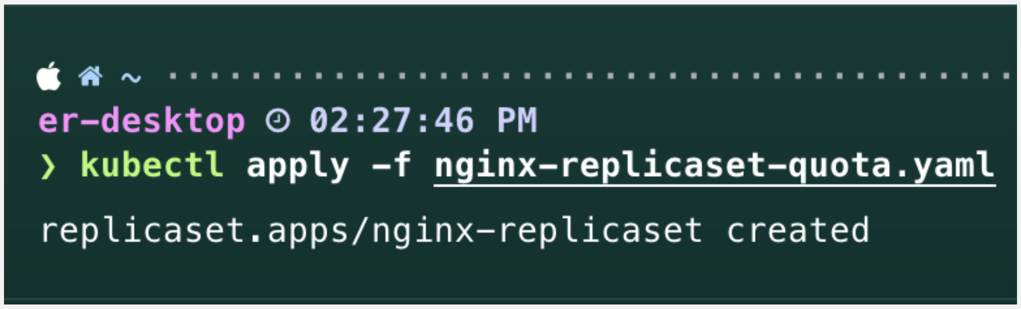
```
~ ........................................................
❯ cat << EOF > nginx-replicaset-quota.yaml
apiVersion: apps/v1
kind: ReplicaSet
metadata:
  name: nginx-replicaset
  namespace: quota-example
spec:
  replicas: 5             # Desired number of Pod replicas.
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - name: nginx
        image: nginx:latest
        ports:
        - containerPort: 80
        resources:          # Define resource requests and limits.
          requests:
            memory: "100Mi"
            cpu: "100m"
          limits:
            memory: "200Mi"
            cpu: "200m"

EOF
```

Explanation:

This ReplicaSet requests a total of 500m CPU and 500Mi memory across 5 replicas. It also limits each replica to use a maximum of 200m CPU and 200Mi memory.

Apply this YAML to create the ReplicaSet:

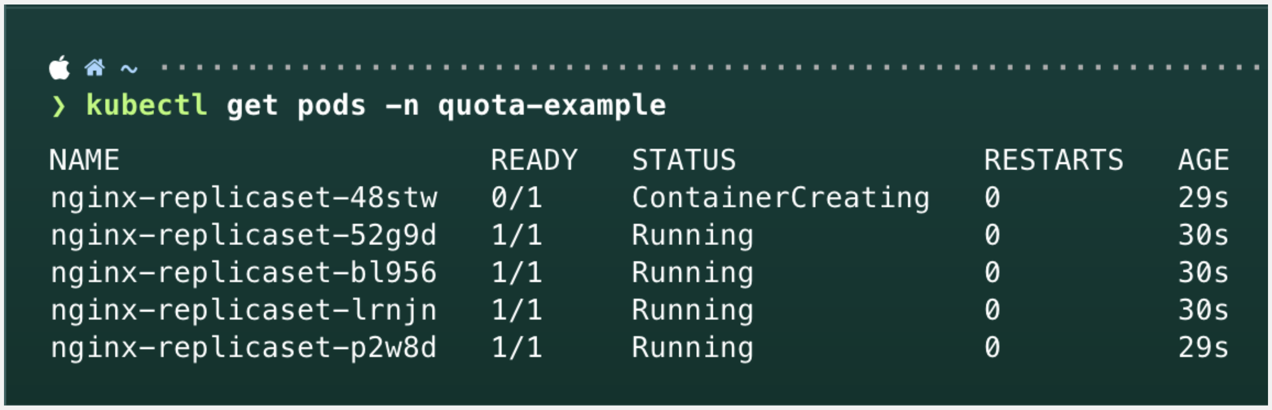
```
kubectl apply -f nginx-replicaset-quota.yaml
```



```
~ ...................................
er-desktop ⊙ 02:27:46 PM
❯ kubectl apply -f nginx-replicaset-quota.yaml
replicaset.apps/nginx-replicaset created
```

Check the status of the Pods and ensure they are created within the constraints of the Resource Quota:

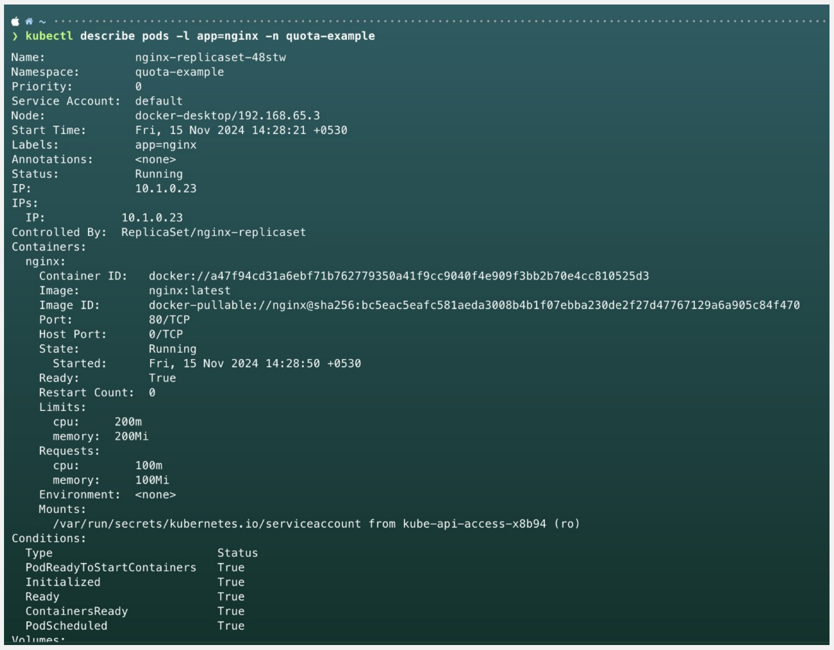
```
kubectl get pods -n quota-example
```



```
❯ kubectl get pods -n quota-example
NAME                     READY   STATUS              RESTARTS   AGE
nginx-replicaset-48stw   0/1     ContainerCreating   0          29s
nginx-replicaset-52g9d   1/1     Running             0          30s
nginx-replicaset-bl956   1/1     Running             0          30s
nginx-replicaset-lrnjn   1/1     Running             0          30s
nginx-replicaset-p2w8d   1/1     Running             0          29s
```

To describe the Pods and see their resource allocations:

```
kubectl describe pods -l app=nginx -n quota-example
```



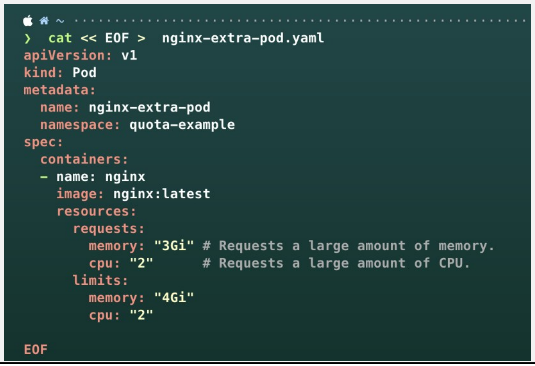
```
❯ kubectl describe pods -l app=nginx -n quota-example
Name:             nginx-replicaset-48stw
Namespace:        quota-example
Priority:         0
Service Account:  default
Node:             docker-desktop/192.168.65.3
Start Time:       Fri, 15 Nov 2024 14:28:21 +0530
Labels:           app=nginx
Annotations:      <none>
Status:           Running
IP:               10.1.0.23
IPs:
  IP:           10.1.0.23
Controlled By:  ReplicaSet/nginx-replicaset
Containers:
  nginx:
    Container ID:   docker://a47f94cd31a6ebf71b762779350a41f9cc9040f4e909f3bb2b70e4cc810525d3
    Image:          nginx:latest
    Image ID:       docker-pullable://nginx@sha256:bc5eac5eafc581aeda3008b4b1f07ebba230de2f27d47767129a6a905c84f470
    Port:           80/TCP
    Host Port:      0/TCP
    State:          Running
      Started:      Fri, 15 Nov 2024 14:28:50 +0530
    Ready:          True
    Restart Count:  0
    Limits:
      cpu:     200m
      memory:  200Mi
    Requests:
      cpu:        100m
      memory:     100Mi
    Environment:  <none>
    Mounts:
      /var/run/secrets/kubernetes.io/serviceaccount from kube-api-access-x8b94 (ro)
Conditions:
  Type                        Status
  PodReadyToStartContainers   True
  Initialized                 True
  Ready                       True
  ContainersReady             True
  PodScheduled                True
Volumes:
```

Attempt to Exceed the Resource Quota

Try creating additional resources to see if they are rejected when exceeding the quota. For example, create more Pods or increase the CPU/memory requests to exceed the quota limits.

Create a YAML file named ***nginx-extra-pod.yaml*** with the following content:

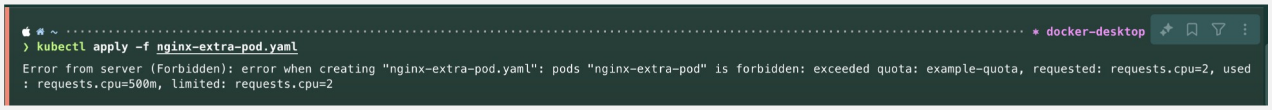
```
apiVersion: v1
kind: Pod
metadata:
  name: nginx-extra-pod
  namespace: quota-example
spec:
  containers:
  - name: nginx
    image: nginx:latest
    resources:
      requests:
        memory: "3Gi" # Requests a large amount of memory.
        cpu: "2"      # Requests a large amount of CPU.
      limits:
        memory: "4Gi"
        cpu: "2"
```



```
❯ cat << EOF >  nginx-extra-pod.yaml
apiVersion: v1
kind: Pod
metadata:
  name: nginx-extra-pod
  namespace: quota-example
spec:
  containers:
  - name: nginx
    image: nginx:latest
    resources:
      requests:
        memory: "3Gi" # Requests a large amount of memory.
        cpu: "2"      # Requests a large amount of CPU.
      limits:
        memory: "4Gi"
        cpu: "2"

EOF
```

Apply this YAML to create the Pod:

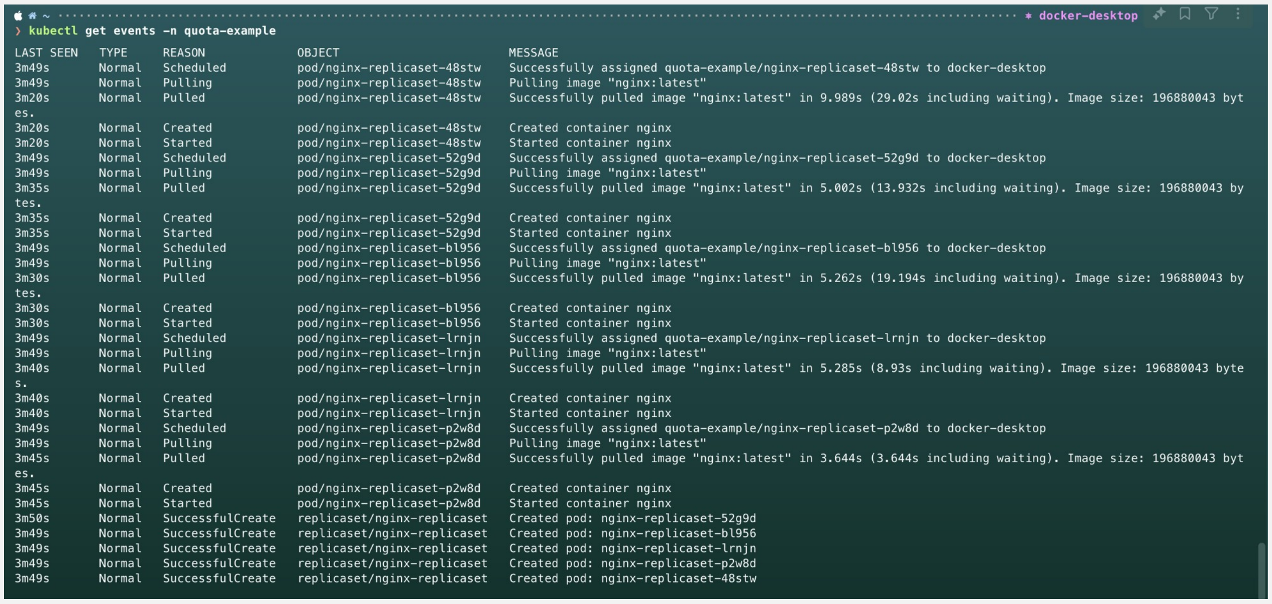
```
kubectl apply -f nginx-extra-pod.yaml
```



```
❯ kubectl apply -f nginx-extra-pod.yaml
Error from server (Forbidden): error when creating "nginx-extra-pod.yaml": pods "nginx-extra-pod" is forbidden: exceeded quota: example-quota, requested: requests.cpu=2, used
: requests.cpu=500m, limited: requests.cpu=2
```

This should fail due to exceeding the Resource Quota. Check the events to see the failure reason:

```
kubectl get events -n quota-example
```



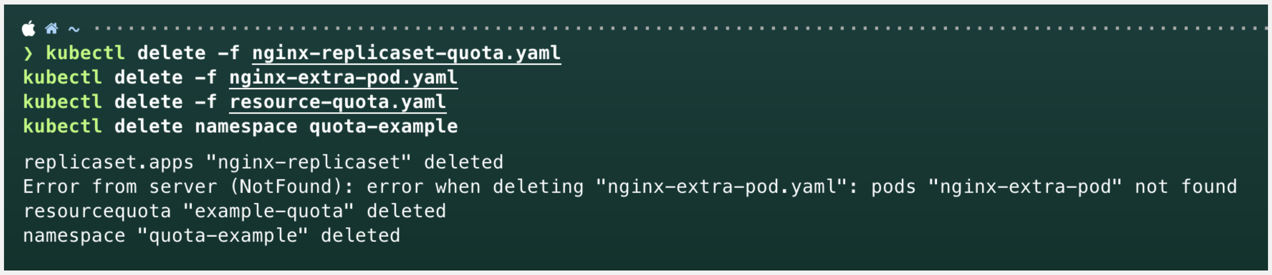
```
❯ kubectl get events -n quota-example
LAST SEEN   TYPE     REASON              OBJECT                         MESSAGE
3m49s       Normal   Scheduled           pod/nginx-replicaset-48stw    Successfully assigned quota-example/nginx-replicaset-48stw to docker-desktop
3m49s       Normal   Pulling             pod/nginx-replicaset-48stw    Pulling image "nginx:latest"
3m20s       Normal   Pulled              pod/nginx-replicaset-48stw    Successfully pulled image "nginx:latest" in 9.989s (29.02s including waiting). Image size: 196880043 byt
es.
3m20s       Normal   Created             pod/nginx-replicaset-48stw    Created container nginx
3m20s       Normal   Started             pod/nginx-replicaset-48stw    Started container nginx
3m49s       Normal   Scheduled           pod/nginx-replicaset-52g9d    Successfully assigned quota-example/nginx-replicaset-52g9d to docker-desktop
3m49s       Normal   Pulling             pod/nginx-replicaset-52g9d    Pulling image "nginx:latest"
3m35s       Normal   Pulled              pod/nginx-replicaset-52g9d    Successfully pulled image "nginx:latest" in 5.002s (13.932s including waiting). Image size: 196880043 by
tes.
3m35s       Normal   Created             pod/nginx-replicaset-52g9d    Created container nginx
3m35s       Normal   Started             pod/nginx-replicaset-52g9d    Started container nginx
3m49s       Normal   Scheduled           pod/nginx-replicaset-bl956    Successfully assigned quota-example/nginx-replicaset-bl956 to docker-desktop
3m49s       Normal   Pulling             pod/nginx-replicaset-bl956    Pulling image "nginx:latest"
3m30s       Normal   Pulled              pod/nginx-replicaset-bl956    Successfully pulled image "nginx:latest" in 5.262s (19.194s including waiting). Image size: 196880043 by
tes.
3m30s       Normal   Created             pod/nginx-replicaset-bl956    Created container nginx
3m30s       Normal   Started             pod/nginx-replicaset-bl956    Started container nginx
3m49s       Normal   Scheduled           pod/nginx-replicaset-lrnjn    Successfully assigned quota-example/nginx-replicaset-lrnjn to docker-desktop
3m49s       Normal   Pulling             pod/nginx-replicaset-lrnjn    Pulling image "nginx:latest"
3m40s       Normal   Pulled              pod/nginx-replicaset-lrnjn    Successfully pulled image "nginx:latest" in 5.285s (8.93s including waiting). Image size: 196880043 byte
s.
3m40s       Normal   Created             pod/nginx-replicaset-lrnjn    Created container nginx
3m40s       Normal   Started             pod/nginx-replicaset-lrnjn    Started container nginx
3m49s       Normal   Scheduled           pod/nginx-replicaset-p2w8d    Successfully assigned quota-example/nginx-replicaset-p2w8d to docker-desktop
3m49s       Normal   Pulling             pod/nginx-replicaset-p2w8d    Pulling image "nginx:latest"
3m45s       Normal   Pulled              pod/nginx-replicaset-p2w8d    Successfully pulled image "nginx:latest" in 3.644s (3.644s including waiting). Image size: 196880043 byt
es.
3m45s       Normal   Created             pod/nginx-replicaset-p2w8d    Created container nginx
3m45s       Normal   Started             pod/nginx-replicaset-p2w8d    Started container nginx
3m50s       Normal   SuccessfulCreate    replicaset/nginx-replicaset   Created pod: nginx-replicaset-52g9d
3m49s       Normal   SuccessfulCreate    replicaset/nginx-replicaset   Created pod: nginx-replicaset-bl956
3m49s       Normal   SuccessfulCreate    replicaset/nginx-replicaset   Created pod: nginx-replicaset-lrnjn
3m49s       Normal   SuccessfulCreate    replicaset/nginx-replicaset   Created pod: nginx-replicaset-p2w8d
3m49s       Normal   SuccessfulCreate    replicaset/nginx-replicaset   Created pod: nginx-replicaset-48stw
```

Look for error messages indicating that the Pod creation was denied due to resource constraints.

Step 6: Clean Up Resources

To delete the resources you created:

```
kubectl delete -f nginx-replicaset-quota.yaml
kubectl delete -f nginx-extra-pod.yaml
kubectl delete -f resource-quota.yaml
kubectl delete namespace quota-example
```



```
 ~
❯ kubectl delete -f nginx-replicaset-quota.yaml
kubectl delete -f nginx-extra-pod.yaml
kubectl delete -f resource-quota.yaml
kubectl delete namespace quota-example

replicaset.apps "nginx-replicaset" deleted
Error from server (NotFound): error when deleting "nginx-extra-pod.yaml": pods "nginx-extra-pod" not found
resourcequota "example-quota" deleted
namespace "quota-example" deleted
```