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

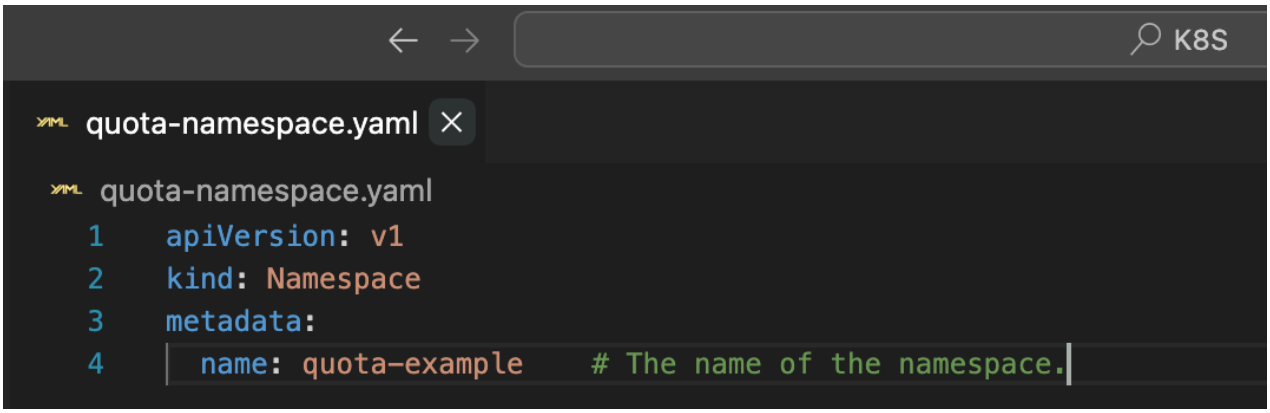
Resource Quotas allow you to:

- 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.
```



Apply the YAML to create the namespace:

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

```
sai@Sais-Mac K8S % kubectl apply -f quota-namespace.yaml
namespace/quota-example created
```

Verify that the namespace is created:

```
kubectl get namespaces
```

```
sai@Sais-Mac K8S % kubectl get ns
NAME              STATUS   AGE
default           Active   14h
kube-node-lease   Active   14h
kube-public       Active   14h
kube-system       Active   14h
quota-example     Active   31s
```

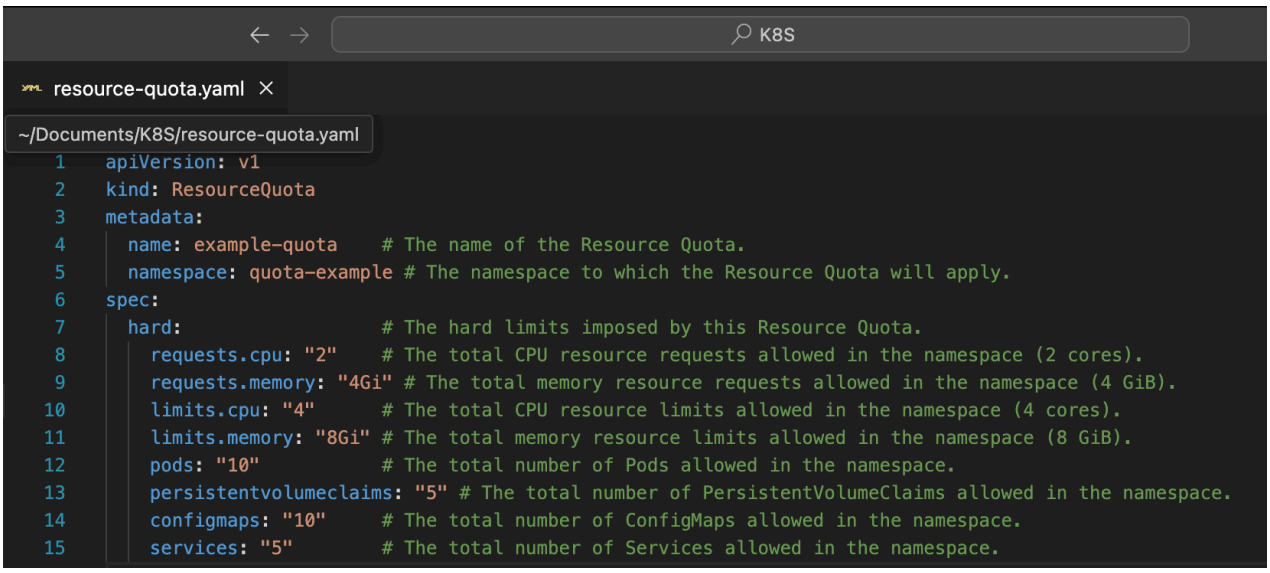
You should see quota-example listed in the output.

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.
```



Step 4: Apply the Resource Quota

Apply the Resource Quota YAML to the namespace:

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

Verify that the Resource Quota is applied:

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

To see the details of the applied Resource Quota:

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

```
sai@Sais-Mac K8S % 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

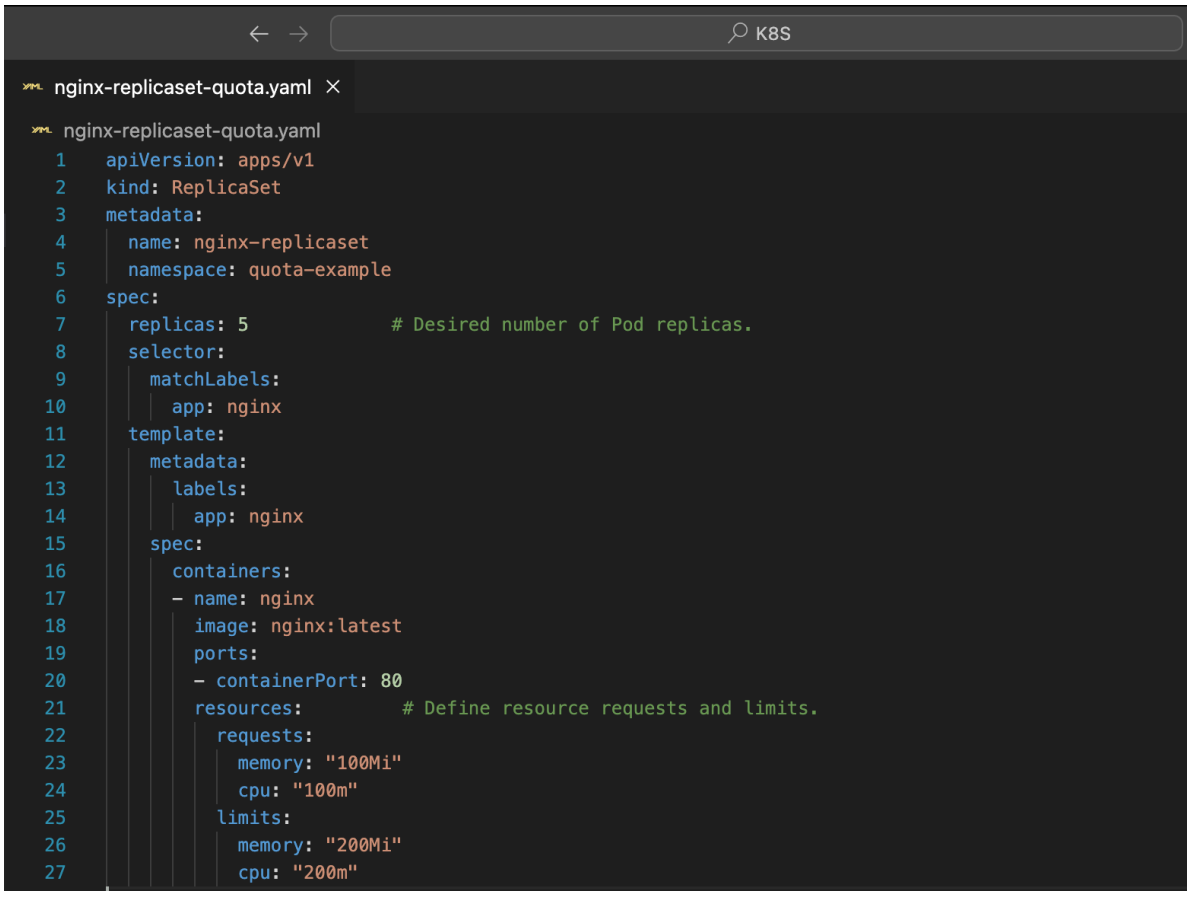
Let's create some resources in the quota-example namespace to see how the Resource Quota affects them.

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"
```



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
```

```
sai@Sais-Mac K8S % 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
```

```
sai@Sais-Mac K8S % kubectl get pods -n quota-example
NAME                    READY   STATUS    RESTARTS   AGE
nginx-replicaset-6k4mb   1/1     Running   0          37s
nginx-replicaset-cp6sf   1/1     Running   0          37s
nginx-replicaset-fmx8c   1/1     Running   0          37s
nginx-replicaset-lg6wk   1/1     Running   0          37s
nginx-replicaset-tbnkf   1/1     Running   0          37s
sai@Sais-Mac K8S %
```

To describe the Pods and see their resource allocations:

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

Attempt to Exceed the Resource Quota

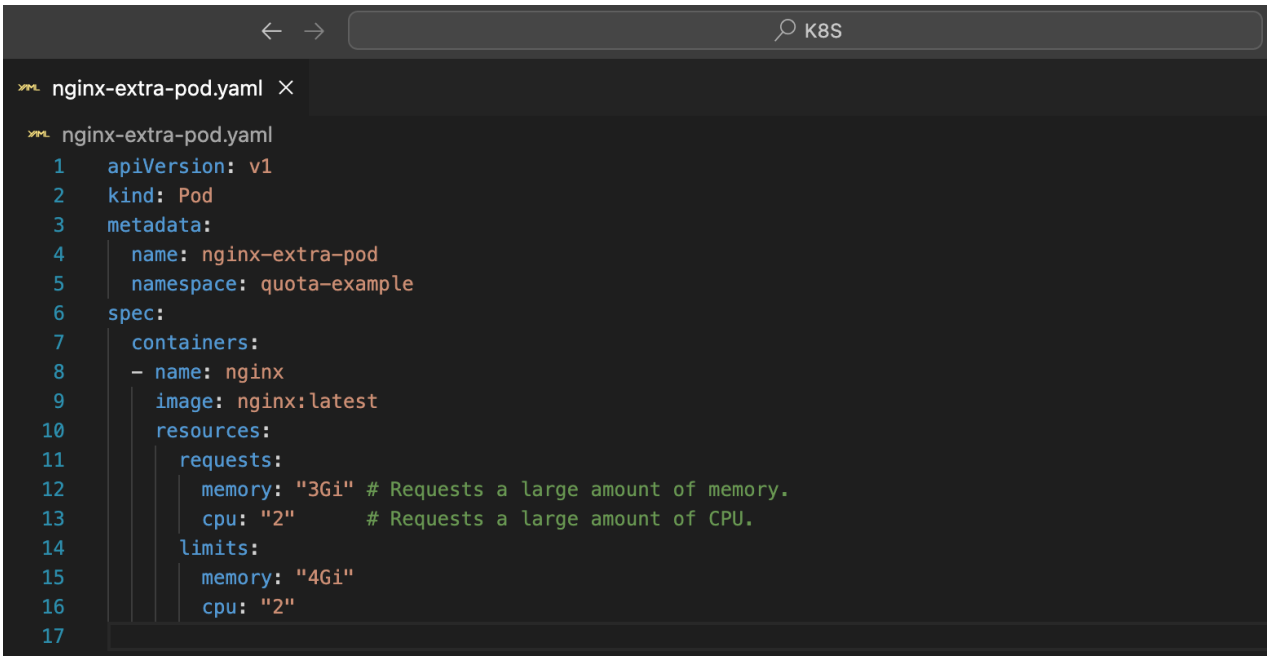
```
sai@Sais-Mac K8S % kubectl describe pods -l app=nginx -n quota-example
Name:             nginx-replicaset-6k4mb
Namespace:        quota-example
Priority:         0
Service Account:  default
Node:             docker-desktop/192.168.65.3
Start Time:       Tue, 12 Nov 2024 01:34:54 +0530
Labels:           app=nginx
Annotations:      <none>
Status:           Running
IP:               10.1.0.19
IPs:
  IP:           10.1.0.19
Controlled By:  ReplicaSet/nginx-replicaset
Containers:
  nginx:
    Container ID:   docker://93a6151480de03309483fb4047e80cd667034800294e555f86202effbeda1337
    Image:          nginx:latest
    Image ID:       docker-pullable://nginx@sha256:28402db69fec7c17e179ea87882667f1e054391138f77ffaf0c3eb388efc3ffb
    Port:           80/TCP
    Host Port:      0/TCP
    State:          Running
      Started:      Tue, 12 Nov 2024 01:35:06 +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-wqdn8 (ro)
Conditions:
  Type                        Status
  PodReadyToStartContainers   True
  Initialized                 True
  Ready                       True
  ContainersReady             True
  PodScheduled                True
Volumes:
  kube-api-access-wqdn8:
    Type:                    Projected (a volume that contains injected data from multiple sources)
    TokenExpirationSeconds:  3607
    ConfigMapName:           kube-root-ca.crt
    ConfigMapOptional:       <nil>
    DownwardAPI:             true
QoS Class:                   Burstable
Node-Selectors:              <none>
Tolerations:                 node.kubernetes.io/not-ready:NoExecute op=Exists for 300s
                             node.kubernetes.io/unreachable:NoExecute op=Exists for 300s
Events:
  Type    Reason     Age   From               Message
  ----    ------     ----  ----               -------
  Normal  Scheduled  106s  default-scheduler  Successfully assigned quota-example/nginx-replicaset-6k4mb to docker-desktop
  Normal  Pulling    105s  kubelet            Pulling image "nginx:latest"
  Normal  Pulled     94s   kubelet            Successfully pulled image "nginx:latest" in 3.241s (11.083s including waiting). Image size: 196880357 bytes.
  Normal  Created    94s   kubelet            Created container nginx
  Normal  Started    94s   kubelet            Started container nginx


Name:             nginx-replicaset-cp6sf
Namespace:        quota-example
Priority:         0
```

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"
```



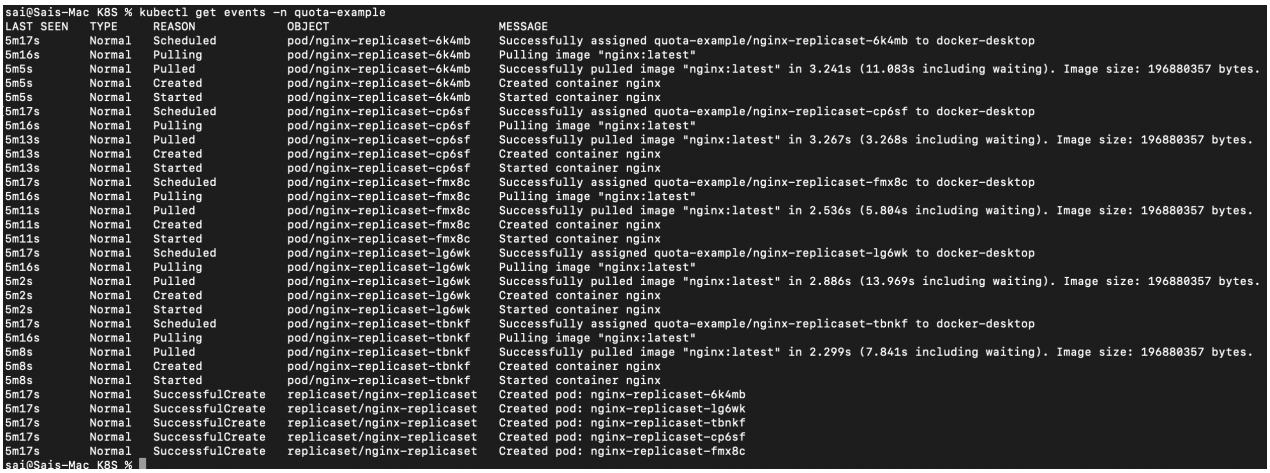
Apply this YAML to create the Pod:

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

```
sai@Sais-Mac K8S % 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: reques
ts.cpu=2, used: requests.cpu=500m, limited: requests.cpu=2
sai@Sais-Mac K8S %
```

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

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



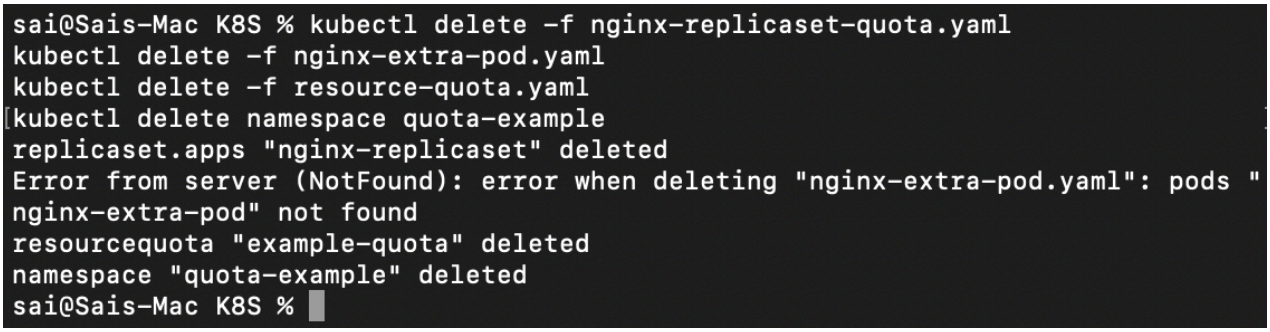
```
sai@Sais-Mac K8S % kubectl get events -n quota-example
LAST SEEN   TYPE     REASON             OBJECT                          MESSAGE
5m17s       Normal   Scheduled          pod/nginx-replicaset-6k4mb      Successfully assigned quota-example/nginx-replicaset-6k4mb to docker-desktop
5m16s       Normal   Pulling            pod/nginx-replicaset-6k4mb      Pulling image "nginx:latest"
5m5s        Normal   Pulled             pod/nginx-replicaset-6k4mb      Successfully pulled image "nginx:latest" in 3.241s (11.083s including waiting). Image size: 196880357 bytes.
5m5s        Normal   Created            pod/nginx-replicaset-6k4mb      Created container nginx
5m5s        Normal   Started            pod/nginx-replicaset-6k4mb      Started container nginx
5m17s       Normal   Scheduled          pod/nginx-replicaset-cp6sf      Successfully assigned quota-example/nginx-replicaset-cp6sf to docker-desktop
5m16s       Normal   Pulling            pod/nginx-replicaset-cp6sf      Pulling image "nginx:latest"
5m13s       Normal   Pulled             pod/nginx-replicaset-cp6sf      Successfully pulled image "nginx:latest" in 3.267s (3.268s including waiting). Image size: 196880357 bytes.
5m13s       Normal   Created            pod/nginx-replicaset-cp6sf      Created container nginx
5m13s       Normal   Started            pod/nginx-replicaset-cp6sf      Started container nginx
5m17s       Normal   Scheduled          pod/nginx-replicaset-fmx8c      Successfully assigned quota-example/nginx-replicaset-fmx8c to docker-desktop
5m16s       Normal   Pulling            pod/nginx-replicaset-fmx8c      Pulling image "nginx:latest"
5m11s       Normal   Pulled             pod/nginx-replicaset-fmx8c      Successfully pulled image "nginx:latest" in 2.536s (5.804s including waiting). Image size: 196880357 bytes.
5m11s       Normal   Created            pod/nginx-replicaset-fmx8c      Created container nginx
5m11s       Normal   Started            pod/nginx-replicaset-fmx8c      Started container nginx
5m17s       Normal   Scheduled          pod/nginx-replicaset-lg6wk      Successfully assigned quota-example/nginx-replicaset-lg6wk to docker-desktop
5m16s       Normal   Pulling            pod/nginx-replicaset-lg6wk      Pulling image "nginx:latest"
5m2s        Normal   Pulled             pod/nginx-replicaset-lg6wk      Successfully pulled image "nginx:latest" in 2.886s (13.969s including waiting). Image size: 196880357 bytes.
5m2s        Normal   Created            pod/nginx-replicaset-lg6wk      Created container nginx
5m2s        Normal   Started            pod/nginx-replicaset-lg6wk      Started container nginx
5m17s       Normal   Scheduled          pod/nginx-replicaset-tbnkf      Successfully assigned quota-example/nginx-replicaset-tbnkf to docker-desktop
5m16s       Normal   Pulling            pod/nginx-replicaset-tbnkf      Pulling image "nginx:latest"
5m8s        Normal   Pulled             pod/nginx-replicaset-tbnkf      Successfully pulled image "nginx:latest" in 2.299s (7.841s including waiting). Image size: 196880357 bytes.
5m8s        Normal   Created            pod/nginx-replicaset-tbnkf      Created container nginx
5m8s        Normal   Started            pod/nginx-replicaset-tbnkf      Started container nginx
5m17s       Normal   SuccessfulCreate   replicaset/nginx-replicaset     Created pod: nginx-replicaset-6k4mb
5m17s       Normal   SuccessfulCreate   replicaset/nginx-replicaset     Created pod: nginx-replicaset-lg6wk
5m17s       Normal   SuccessfulCreate   replicaset/nginx-replicaset     Created pod: nginx-replicaset-tbnkf
5m17s       Normal   SuccessfulCreate   replicaset/nginx-replicaset     Created pod: nginx-replicaset-cp6sf
5m17s       Normal   SuccessfulCreate   replicaset/nginx-replicaset     Created pod: nginx-replicaset-fmx8c
sai@Sais-Mac K8S %
```

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
```



```
sai@Sais-Mac K8S % 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
sai@Sais-Mac K8S %
```