Deployments

A Deployment manages a set of Pods to run an application workload, usually one that doesn't maintain state.

A *Deployment* provides declarative updates for Pods and ReplicaSets.

You describe a *desired state* in a Deployment, and the Deployment Controller changes the actual state to the desired state at a controlled rate. You can define Deployments to create new ReplicaSets, or to remove existing Deployments and adopt all their resources with new Deployments.

> **Note:**
> Do not manage ReplicaSets owned by a Deployment. Consider opening an issue in the main Kubernetes repository if your use case is not covered below.

Use Case

The following are typical use cases for Deployments:

- Create a Deployment to rollout a ReplicaSet. The ReplicaSet creates Pods in the background. Check the status of the rollout to see if it succeeds or not.
- Declare the new state of the Pods by updating the PodTemplateSpec of the Deployment. A new ReplicaSet is created, and the Deployment gradually scales it up while scaling down the old ReplicaSet, ensuring Pods are replaced at a controlled rate. Each new ReplicaSet updates the revision of the Deployment.
- Rollback to an earlier Deployment revision if the current state of the Deployment is not stable. Each rollback updates the revision of the Deployment.
- Scale up the Deployment to facilitate more load.
- Pause the rollout of a Deployment to apply multiple fixes to its PodTemplateSpec and then resume it to start a new rollout.
- Use the status of the Deployment as an indicator that a rollout has stuck.
- Clean up older ReplicaSets that you don't need anymore.

Creating a Deployment

The following is an example of a Deployment. It creates a ReplicaSet to bring up three `nginx` Pods:

controllers/nginx-deployment.yaml

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-deployment
  labels:
    app: nginx
spec:
  replicas: 3
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - name: nginx
        image: nginx:1.14.2
        ports:
        - containerPort: 80
```

In this example:

- A Deployment named `nginx-deployment` is created, indicated by the `.metadata.name` field. This name will become the basis for the ReplicaSets and Pods which are created later. See Writing a Deployment Spec for more details.
- The Deployment creates a ReplicaSet that creates three replicated Pods, indicated by the `.spec.replicas` field.
- The `.spec.selector` field defines how the created ReplicaSet finds which Pods to manage. In this case, you select a label that is defined in the Pod template (`app: nginx`). However, more sophisticated selection rules are possible, as long as the Pod template itself satisfies the rule.

> **Note:**
> The `.spec.selector.matchLabels` field is a map of {key,value} pairs. A single {key,value} in the `matchLabels` map is equivalent to an element of `matchExpressions`, whose `key` field is "key", the `operator` is "In", and the `values` array contains only "value". All of the requirements, from both `matchLabels` and `matchExpressions`, must be satisfied in order to match.

- The `.spec.template` field contains the following sub-fields:
  - The Pods are labeled `app: nginx` using the `.metadata.labels` field.
  - The Pod template's specification, or `.spec` field, indicates that the Pods run one container, `nginx` , which runs the `nginx` Docker Hub image at version 1.14.2.
  - Create one container and name it `nginx` using the `.spec.containers[0].name` field.

Before you begin, make sure your Kubernetes cluster is up and running. Follow the steps given below to create the above Deployment:

1. Create the Deployment by running the following command:

```
kubectl apply -f https://k8s.io/examples/controllers/nginx-deployment.yaml
```

2. Run `kubectl get deployments` to check if the Deployment was created.

   If the Deployment is still being created, the output is similar to the following:

```
NAME               READY   UP-TO-DATE   AVAILABLE   AGE
nginx-deployment   0/3     0            0           1s
```

   When you inspect the Deployments in your cluster, the following fields are displayed:

   - `NAME` lists the names of the Deployments in the namespace.
   - `READY` displays how many replicas of the application are available to your users. It follows the pattern ready/desired.
   - `UP-TO-DATE` displays the number of replicas that have been updated to achieve the desired state.
   - `AVAILABLE` displays how many replicas of the application are available to your users.
   - `AGE` displays the amount of time that the application has been running.

   Notice how the number of desired replicas is 3 according to `.spec.replicas` field.

3. To see the Deployment rollout status, run `kubectl rollout status deployment/nginx-deployment` .

   The output is similar to:

```
Waiting for rollout to finish: 2 out of 3 new replicas have been updated...
deployment "nginx-deployment" successfully rolled out
```

4. Run the `kubectl get deployments` again a few seconds later. The output is similar to this:

```
NAME               READY   UP-TO-DATE   AVAILABLE   AGE
nginx-deployment   3/3     3            3           18s
```

Notice that the Deployment has created all three replicas, and all replicas are up-to-date (they contain the latest Pod template) and available.

5. To see the ReplicaSet (`rs`) created by the Deployment, run `kubectl get rs` . The output is similar to this:

```
NAME                          DESIRED   CURRENT   READY   AGE
nginx-deployment-75675f5897   3         3         3       18s
```

ReplicaSet output shows the following fields:

- `NAME` lists the names of the ReplicaSets in the namespace.
- `DESIRED` displays the desired number of *replicas* of the application, which you define when you create the Deployment. This is the *desired state*.
- `CURRENT` displays how many replicas are currently running.
- `READY` displays how many replicas of the application are available to your users.
- `AGE` displays the amount of time that the application has been running.

Notice that the name of the ReplicaSet is always formatted as `[DEPLOYMENT-NAME]-[HASH]` . This name will become the basis for the Pods which are created.

The `HASH` string is the same as the `pod-template-hash` label on the ReplicaSet.

6. To see the labels automatically generated for each Pod, run `kubectl get pods --show-labels` . The output is similar to:

```
NAME                                READY     STATUS    RESTARTS   AGE       LABELS
nginx-deployment-75675f5897-7ci7o   1/1       Running   0          18s       app=nginx,pod-template-hash=75675f5897
nginx-deployment-75675f5897-kzszj   1/1       Running   0          18s       app=nginx,pod-template-hash=75675f5897
nginx-deployment-75675f5897-qqcnn   1/1       Running   0          18s       app=nginx,pod-template-hash=75675f5897
```

The created ReplicaSet ensures that there are three `nginx` Pods.

> **Note:**
> You must specify an appropriate selector and Pod template labels in a Deployment (in this case, `app: nginx`).
>
> Do not overlap labels or selectors with other controllers (including other Deployments and StatefulSets). Kubernetes doesn't stop you from overlapping, and if multiple controllers have overlapping selectors those controllers might conflict and behave unexpectedly.

Pod-template-hash label

> **Caution:**
> Do not change this label.

The `pod-template-hash` label is added by the Deployment controller to every ReplicaSet that a Deployment creates or adopts.

This label ensures that child ReplicaSets of a Deployment do not overlap. It is generated by hashing the `PodTemplate` of the ReplicaSet and using the resulting hash as the label value that is added to the ReplicaSet selector, Pod template labels, and in any existing Pods that the ReplicaSet might have.

Updating a Deployment

> **Note:**
> A Deployment's rollout is triggered if and only if the Deployment's Pod template (that is, `.spec.template`) is changed, for example if the labels or container images of the template are updated. Other updates, such as scaling the Deployment, do not trigger a rollout.

Follow the steps given below to update your Deployment:

1. Let's update the nginx Pods to use the `nginx:1.16.1` image instead of the `nginx:1.14.2` image.

```
kubectl set image deployment.v1.apps/nginx-deployment nginx=nginx:1.16.1
```

or use the following command:

```
kubectl set image deployment/nginx-deployment nginx=nginx:1.16.1
```

where `deployment/nginx-deployment` indicates the Deployment, `nginx` indicates the Container the update will take place and `nginx:1.16.1` indicates the new image and its tag.

The output is similar to:

```
deployment.apps/nginx-deployment image updated
```

Alternatively, you can `edit` the Deployment and change `.spec.template.spec.containers[0].image` from `nginx:1.14.2` to `nginx:1.16.1`:

```
kubectl edit deployment/nginx-deployment
```

The output is similar to:

```
deployment.apps/nginx-deployment edited
```

2. To see the rollout status, run:

```
kubectl rollout status deployment/nginx-deployment
```

The output is similar to this:

```
Waiting for rollout to finish: 2 out of 3 new replicas have been updated...
```

or

```
deployment "nginx-deployment" successfully rolled out
```

Get more details on your updated Deployment:

- After the rollout succeeds, you can view the Deployment by running `kubectl get deployments`. The output is similar to this:

```
NAME               READY   UP-TO-DATE   AVAILABLE   AGE
nginx-deployment   3/3     3            3           36s
```

- Run `kubectl get rs` to see that the Deployment updated the Pods by creating a new ReplicaSet and scaling it up to 3 replicas, as well as scaling down the old ReplicaSet to 0 replicas.

```
kubectl get rs
```

The output is similar to this:

```
NAME                          DESIRED   CURRENT   READY   AGE
nginx-deployment-1564180365   3         3         3       6s
nginx-deployment-2035384211   0         0         0       36s
```

- Running `get pods` should now show only the new Pods:

```
kubectl get pods
```

The output is similar to this:

```
NAME                                READY     STATUS    RESTARTS   AGE
nginx-deployment-1564180365-khku8   1/1       Running   0          14s
nginx-deployment-1564180365-nacti   1/1       Running   0          14s
nginx-deployment-1564180365-z9gth   1/1       Running   0          14s
```

Next time you want to update these Pods, you only need to update the Deployment's Pod template again.

Deployment ensures that only a certain number of Pods are down while they are being updated. By default, it ensures that at least 75% of the desired number of Pods are up (25% max unavailable).

Deployment also ensures that only a certain number of Pods are created above the desired number of Pods. By default, it ensures that at most 125% of the desired number of Pods are up (25% max surge).

For example, if you look at the above Deployment closely, you will see that it first creates a new Pod, then deletes an old Pod, and creates another new one. It does not kill old Pods until a sufficient number of new Pods have come up, and does not create new Pods until a sufficient number of old Pods have been killed. It makes sure that at least 3 Pods are available and that at max 4 Pods in total are available. In case of a Deployment with 4 replicas, the number of Pods would be between 3 and 5.

- Get details of your Deployment:

```
kubectl describe deployments
```

The output is similar to this:

```
Name:                   nginx-deployment
Namespace:              default
CreationTimestamp:      Thu, 30 Nov 2017 10:56:25 +0000
Labels:                 app=nginx
Annotations:            deployment.kubernetes.io/revision=2
Selector:               app=nginx
Replicas:               3 desired | 3 updated | 3 total | 3 available | 0 unavailable
StrategyType:           RollingUpdate
MinReadySeconds:        0
RollingUpdateStrategy:  25% max unavailable, 25% max surge
Pod Template:
  Labels:  app=nginx
   Containers:
    nginx:
      Image:        nginx:1.16.1
      Port:         80/TCP
      Environment:  <none>
      Mounts:       <none>
    Volumes:        <none>
  Conditions:
    Type           Status  Reason
    ----           ------  ------
    Available      True    MinimumReplicasAvailable
    Progressing    True    NewReplicaSetAvailable
  OldReplicaSets:  <none>
  NewReplicaSet:   nginx-deployment-1564180365 (3/3 replicas created)
  Events:
    Type    Reason             Age   From                   Message
    ----    ------             ----  ----                   -------
    Normal  ScalingReplicaSet  2m    deployment-controller  Scaled up replica set nginx-deployment-2035384211 to 3
    Normal  ScalingReplicaSet  24s   deployment-controller  Scaled up replica set nginx-deployment-1564180365 to 1
    Normal  ScalingReplicaSet  22s   deployment-controller  Scaled down replica set nginx-deployment-2035384211 to 2
    Normal  ScalingReplicaSet  22s   deployment-controller  Scaled up replica set nginx-deployment-1564180365 to 2
    Normal  ScalingReplicaSet  19s   deployment-controller  Scaled down replica set nginx-deployment-2035384211 to 1
    Normal  ScalingReplicaSet  19s   deployment-controller  Scaled up replica set nginx-deployment-1564180365 to 3
    Normal  ScalingReplicaSet  14s   deployment-controller  Scaled down replica set nginx-deployment-2035384211 to 0
```

Here you see that when you first created the Deployment, it created a ReplicaSet (nginx-deployment-2035384211) and scaled it up to 3 replicas directly. When you updated the Deployment, it created a new ReplicaSet (nginx-deployment-1564180365) and scaled it up to 1 and waited for it to come up. Then it scaled down the old ReplicaSet to 2 and scaled up the new ReplicaSet to 2 so that at least 3 Pods were available and at most 4 Pods were created at all times. It then continued scaling up and down the new and the old ReplicaSet, with the same rolling update strategy. Finally, you'll have 3 available replicas in the new ReplicaSet, and the old ReplicaSet is scaled down to 0.

> **Note:**
> Kubernetes doesn't count terminating Pods when calculating the number of `availableReplicas`, which must be between `replicas - maxUnavailable` and `replicas + maxSurge`. As a result, you might notice that there are more Pods than expected during a rollout, and that the total resources consumed by the Deployment is more than `replicas + maxSurge` until the `terminationGracePeriodSeconds` of the terminating Pods expires.

Rollover (aka multiple updates in-flight)

Each time a new Deployment is observed by the Deployment controller, a ReplicaSet is created to bring up the desired Pods. If the Deployment is updated, the existing ReplicaSet that controls Pods whose labels match `.spec.selector` but whose template does not match `.spec.template` is scaled down. Eventually, the new ReplicaSet is scaled to `.spec.replicas` and all old ReplicaSets is scaled to 0.

If you update a Deployment while an existing rollout is in progress, the Deployment creates a new ReplicaSet as per the update and start scaling that up, and rolls over the ReplicaSet that it was scaling up previously -- it will add it to its list of old ReplicaSets and start scaling it down.

For example, suppose you create a Deployment to create 5 replicas of `nginx:1.14.2`, but then update the Deployment to create 5 replicas of `nginx:1.16.1`, when only 3 replicas of `nginx:1.14.2` had been created. In that case, the Deployment immediately starts killing the 3 `nginx:1.14.2` Pods that it had created, and starts creating `nginx:1.16.1` Pods. It does not wait for the 5 replicas of `nginx:1.14.2` to be created before changing course.

Label selector updates

It is generally discouraged to make label selector updates and it is suggested to plan your selectors up front. In any case, if you need to perform a label selector update, exercise great caution and make sure you have grasped all of the implications.

> **Note:**
> In API version `apps/v1`, a Deployment's label selector is immutable after it gets created.

- Selector additions require the Pod template labels in the Deployment spec to be updated with the new label too, otherwise a validation error is returned. This change is a non-overlapping one, meaning that the new selector does not select ReplicaSets and Pods created with the old selector, resulting in orphaning all old ReplicaSets and creating a new ReplicaSet.
- Selector updates changes the existing value in a selector key -- result in the same behavior as additions.
- Selector removals removes an existing key from the Deployment selector -- do not require any changes in the Pod template labels. Existing ReplicaSets are not orphaned, and a new ReplicaSet is not created, but note that the removed label still exists in any existing Pods and ReplicaSets.

Rolling Back a Deployment

Sometimes, you may want to rollback a Deployment; for example, when the Deployment is not stable, such as crash looping. By default, all of the Deployment's rollout history is kept in the system so that you can rollback anytime you want (you can change that by modifying revision history limit).

> **Note:**
> A Deployment's revision is created when a Deployment's rollout is triggered. This means that the new revision is created if and only if the Deployment's Pod template (`.spec.template`) is changed, for example if you update the labels or container images of the template. Other updates, such as scaling the Deployment, do not create a Deployment revision, so that you can facilitate simultaneous manual- or auto-scaling. This means that when you roll back to an earlier revision, only the Deployment's Pod template part is rolled back.

- Suppose that you made a typo while updating the Deployment, by putting the image name as `nginx:1.161` instead of `nginx:1.16.1`：

  ```
  kubectl set image deployment/nginx-deployment nginx=nginx:1.161
  ```

  The output is similar to this:

  ```
  deployment.apps/nginx-deployment image updated
  ```

- The rollout gets stuck. You can verify it by checking the rollout status:

  ```
  kubectl rollout status deployment/nginx-deployment
  ```

  The output is similar to this:

  ```
  Waiting for rollout to finish: 1 out of 3 new replicas have been updated...
  ```

- Press Ctrl-C to stop the above rollout status watch. For more information on stuck rollouts, read more here.
- You see that the number of old replicas (adding the replica count from `nginx-deployment-1564180365` and `nginx-deployment-2035384211`) is 3, and the number of new replicas (from `nginx-deployment-3066724191`) is 1.

  ```
  ```

```
kubectl get rs
```

The output is similar to this:

```
NAME                          DESIRED   CURRENT   READY   AGE
nginx-deployment-1564180365   3         3         3       25s
nginx-deployment-2035384211   0         0         0       36s
nginx-deployment-3066724191   1         1         0       6s
```

- Looking at the Pods created, you see that 1 Pod created by new ReplicaSet is stuck in an image pull loop.

```
kubectl get pods
```

The output is similar to this:

```
NAME                                READY     STATUS             RESTARTS   AGE
nginx-deployment-1564180365-70iae   1/1       Running            0          25s
nginx-deployment-1564180365-jbqqo   1/1       Running            0          25s
nginx-deployment-1564180365-hysrc   1/1       Running            0          25s
nginx-deployment-3066724191-08mng   0/1       ImagePullBackOff   0          6s
```

> **Note:**
> The Deployment controller stops the bad rollout automatically, and stops scaling up the new ReplicaSet. This depends on the rollingUpdate parameters (`maxUnavailable` specifically) that you have specified. Kubernetes by default sets the value to 25%.

- Get the description of the Deployment:

```
kubectl describe deployment
```

The output is similar to this:

```
Name:           nginx-deployment
Namespace:      default
CreationTimestamp:  Tue, 15 Mar 2016 14:48:04 -0700
Labels:         app=nginx
Selector:       app=nginx
Replicas:       3 desired | 1 updated | 4 total | 3 available | 1 unavailable
StrategyType:       RollingUpdate
MinReadySeconds:    0
RollingUpdateStrategy:  25% max unavailable, 25% max surge
Pod Template:
  Labels:  app=nginx
  Containers:
   nginx:
    Image:        nginx:1.161
    Port:         80/TCP
    Host Port:    0/TCP
    Environment:  <none>
    Mounts:       <none>
  Volumes:        <none>
Conditions:
  Type           Status  Reason
  ----           ------  ------
  Available      True    MinimumReplicasAvailable
  Progressing    True    ReplicaSetUpdated
OldReplicaSets:     nginx-deployment-1564180365 (3/3 replicas created)
NewReplicaSet:      nginx-deployment-3066724191 (1/1 replicas created)
Events:
  FirstSeen LastSeen    Count   From                    SubObjectPath   Type        Reason              Message
  --------- --------    -----   ----                    -------------   --------    ------              -------
  1m        1m          1       {deployment-controller }                Normal      ScalingReplicaSet   Scaled up replica
  22s       22s         1       {deployment-controller }                Normal      ScalingReplicaSet   Scaled up replica
  22s       22s         1       {deployment-controller }                Normal      ScalingReplicaSet   Scaled down repli
  22s       22s         1       {deployment-controller }                Normal      ScalingReplicaSet   Scaled up replica
  21s       21s         1       {deployment-controller }                Normal      ScalingReplicaSet   Scaled down repli
  21s       21s         1       {deployment-controller }                Normal      ScalingReplicaSet   Scaled up replica
  13s       13s         1       {deployment-controller }                Normal      ScalingReplicaSet   Scaled down repli
  13s       13s         1       {deployment-controller }                Normal      ScalingReplicaSet   Scaled up replica
```

To fix this, you need to rollback to a previous revision of Deployment that is stable.

Checking Rollout History of a Deployment

Follow the steps given below to check the rollout history:

1. First, check the revisions of this Deployment:

```
kubectl rollout history deployment/nginx-deployment
```

The output is similar to this:

```
deployments "nginx-deployment"
REVISION    CHANGE-CAUSE
1           <none>
2           <none>
3           <none>
```

`CHANGE-CAUSE` is copied from the Deployment annotation `kubernetes.io/change-cause` to its revisions upon creation. You can specify the `CHANGE-CAUSE` message by:

- Annotating the Deployment with `kubectl annotate deployment/nginx-deployment kubernetes.io/change-cause="image updated to 1.16.1"`
- Manually editing the manifest of the resource.
- Using tooling that sets the annotation automatically.

> **Note:**
> In older versions of Kubernetes, you could use the `--record` flag with kubectl commands to automatically populate the `CHANGE-CAUSE` field. This flag is deprecated and will be removed in a future release.

2. To see the details of each revision, run:

```
kubectl rollout history deployment/nginx-deployment --revision=2
```

The output is similar to this:

```
deployments "nginx-deployment" revision 2
  Labels:       app=nginx
          pod-template-hash=1159050644
  Containers:
   nginx:
    Image:      nginx:1.16.1
    Port:       80/TCP
     QoS Tier:
        cpu:      BestEffort
        memory:   BestEffort
    Environment Variables:      <none>
  No volumes.
```

Rolling Back to a Previous Revision

Follow the steps given below to rollback the Deployment from the current version to the previous version, which is version 2.

1. Now you've decided to undo the current rollout and rollback to the previous revision:

```
kubectl rollout undo deployment/nginx-deployment
```

The output is similar to this:

```
deployment.apps/nginx-deployment rolled back
```

Alternatively, you can rollback to a specific revision by specifying it with `--to-revision`:

```
kubectl rollout undo deployment/nginx-deployment --to-revision=2
```

The output is similar to this:

```
deployment.apps/nginx-deployment rolled back
```

For more details about rollout related commands, read `kubectl rollout`.

The Deployment is now rolled back to a previous stable revision. As you can see, a `DeploymentRollback` event for rolling back to revision 2 is generated from Deployment controller.

2. Check if the rollback was successful and the Deployment is running as expected, run:

```
kubectl get deployment nginx-deployment
```

The output is similar to this:

```
NAME               READY   UP-TO-DATE   AVAILABLE   AGE
nginx-deployment   3/3     3            3           30m
```

3. Get the description of the Deployment:

```
kubectl describe deployment nginx-deployment
```

The output is similar to this:

```
Name:                   nginx-deployment
Namespace:              default
CreationTimestamp:      Sun, 02 Sep 2018 18:17:55 -0500
Labels:                 app=nginx
Annotations:            deployment.kubernetes.io/revision=4
Selector:               app=nginx
Replicas:               3 desired | 3 updated | 3 total | 3 available | 0 unavailable
StrategyType:           RollingUpdate
MinReadySeconds:        0
RollingUpdateStrategy:  25% max unavailable, 25% max surge
Pod Template:
  Labels:  app=nginx
  Containers:
   nginx:
    Image:        nginx:1.16.1
    Port:         80/TCP
    Host Port:    0/TCP
    Environment:  <none>
    Mounts:       <none>
  Volumes:        <none>
Conditions:
  Type           Status  Reason
  ----           ------  ------
  Available      True    MinimumReplicasAvailable
  Progressing    True    NewReplicaSetAvailable
OldReplicaSets:  <none>
NewReplicaSet:   nginx-deployment-c4747d96c (3/3 replicas created)
Events:
  Type    Reason             Age   From                   Message
  ----    ------             ----  ----                   -------
  Normal  ScalingReplicaSet  12m   deployment-controller  Scaled up replica set nginx-deployment-75675f5897 to 3
  Normal  ScalingReplicaSet  11m   deployment-controller  Scaled up replica set nginx-deployment-c4747d96c to 1
  Normal  ScalingReplicaSet  11m   deployment-controller  Scaled down replica set nginx-deployment-75675f5897 to 2
  Normal  ScalingReplicaSet  11m   deployment-controller  Scaled up replica set nginx-deployment-c4747d96c to 2
  Normal  ScalingReplicaSet  11m   deployment-controller  Scaled down replica set nginx-deployment-75675f5897 to 1
  Normal  ScalingReplicaSet  11m   deployment-controller  Scaled up replica set nginx-deployment-c4747d96c to 3
  Normal  ScalingReplicaSet  11m   deployment-controller  Scaled down replica set nginx-deployment-75675f5897 to 0
  Normal  ScalingReplicaSet  11m   deployment-controller  Scaled up replica set nginx-deployment-595696685f to 1
  Normal  DeploymentRollback 15s   deployment-controller  Rolled back deployment "nginx-deployment" to revision 2
  Normal  ScalingReplicaSet  15s   deployment-controller  Scaled down replica set nginx-deployment-595696685f to 0
```

Scaling a Deployment

You can scale a Deployment by using the following command:

```
kubectl scale deployment/nginx-deployment --replicas=10
```

The output is similar to this:

```
deployment.apps/nginx-deployment scaled
```

Assuming horizontal Pod autoscaling is enabled in your cluster, you can set up an autoscaler for your Deployment and choose the minimum and maximum number of Pods you want to run based on the CPU utilization of your existing Pods.

```
kubectl autoscale deployment/nginx-deployment --min=10 --max=15 --cpu-percent=80
```

The output is similar to this:

```
deployment.apps/nginx-deployment scaled
```

Proportional scaling

RollingUpdate Deployments support running multiple versions of an application at the same time. When you or an autoscaler scales a RollingUpdate Deployment that is in the middle of a rollout (either in progress or paused), the Deployment controller balances the additional replicas in the existing active ReplicaSets (ReplicaSets with Pods) in order to mitigate risk. This is called *proportional scaling*.

For example, you are running a Deployment with 10 replicas, maxSurge=3, and maxUnavailable=2.

- Ensure that the 10 replicas in your Deployment are running.

  ```
  kubectl get deploy
  ```

  The output is similar to this:

  ```
  NAME                DESIRED   CURRENT   UP-TO-DATE   AVAILABLE   AGE
  nginx-deployment    10        10        10           10          50s
  ```

- You update to a new image which happens to be unresolvable from inside the cluster.

  ```
  kubectl set image deployment/nginx-deployment nginx=nginx:sometag
  ```

  The output is similar to this:

  ```
  deployment.apps/nginx-deployment image updated
  ```

- The image update starts a new rollout with ReplicaSet nginx-deployment-1989198191, but it's blocked due to the `maxUnavailable` requirement that you mentioned above. Check out the rollout status:

  ```
  kubectl get rs
  ```

  The output is similar to this:

  ```
  NAME                          DESIRED   CURRENT   READY     AGE
  nginx-deployment-1989198191   5         5         0         9s
  nginx-deployment-618515232    8         8         8         1m
  ```

- Then a new scaling request for the Deployment comes along. The autoscaler increments the Deployment replicas to 15. The Deployment controller needs to decide where to add these new 5 replicas. If you weren't using proportional scaling, all 5 of them would be added in the new ReplicaSet. With proportional scaling, you spread the additional replicas across all ReplicaSets. Bigger proportions go to the ReplicaSets with the most replicas and lower proportions go to ReplicaSets with less replicas. Any leftovers are added to the ReplicaSet with the most replicas. ReplicaSets with zero replicas are not scaled up.

In our example above, 3 replicas are added to the old ReplicaSet and 2 replicas are added to the new ReplicaSet. The rollout process should eventually move all replicas to the new ReplicaSet, assuming the new replicas become healthy. To confirm this, run:

```
kubectl get deploy
```

The output is similar to this:

```
NAME                DESIRED   CURRENT   UP-TO-DATE   AVAILABLE   AGE
nginx-deployment    15        18        7            8           7m
```

The rollout status confirms how the replicas were added to each ReplicaSet.

```
kubectl get rs
```

The output is similar to this:

```
NAME                          DESIRED   CURRENT   READY     AGE
nginx-deployment-1989198191   7         7         0         7m
nginx-deployment-618515232    11        11        11        7m
```

Pausing and Resuming a rollout of a Deployment

When you update a Deployment, or plan to, you can pause rollouts for that Deployment before you trigger one or more updates. When you're ready to apply those changes, you resume rollouts for the Deployment. This approach allows you to apply multiple fixes in between pausing and resuming without triggering unnecessary rollouts.

- For example, with a Deployment that was created:

  Get the Deployment details:

  ```
  kubectl get deploy
  ```

  The output is similar to this:

  ```
  NAME      DESIRED   CURRENT   UP-TO-DATE   AVAILABLE   AGE
  nginx     3         3         3            3           1m
  ```

  Get the rollout status:

  ```
  kubectl get rs
  ```

  The output is similar to this:

  ```
  NAME               DESIRED   CURRENT   READY     AGE
  nginx-2142116321   3         3         3         1m
  ```

- Pause by running the following command:

  ```
  kubectl rollout pause deployment/nginx-deployment
  ```

  The output is similar to this:

```
deployment.apps/nginx-deployment paused
```

- Then update the image of the Deployment:

```
kubectl set image deployment/nginx-deployment nginx=nginx:1.16.1
```

The output is similar to this:

```
deployment.apps/nginx-deployment image updated
```

- Notice that no new rollout started:

```
kubectl rollout history deployment/nginx-deployment
```

The output is similar to this:

```
deployments "nginx"
REVISION  CHANGE-CAUSE
1   <none>
```

- Get the rollout status to verify that the existing ReplicaSet has not changed:

```
kubectl get rs
```

The output is similar to this:

```
NAME               DESIRED   CURRENT   READY     AGE
nginx-2142116321   3         3         3         2m
```

- You can make as many updates as you wish, for example, update the resources that will be used:

```
kubectl set resources deployment/nginx-deployment -c=nginx --limits=cpu=200m,memory=512Mi
```

The output is similar to this:

```
deployment.apps/nginx-deployment resource requirements updated
```

The initial state of the Deployment prior to pausing its rollout will continue its function, but new updates to the Deployment will not have any effect as long as the Deployment rollout is paused.

- Eventually, resume the Deployment rollout and observe a new ReplicaSet coming up with all the new updates:

```
kubectl rollout resume deployment/nginx-deployment
```

The output is similar to this:

```
deployment.apps/nginx-deployment resumed
```

- Watch the status of the rollout until it's done.

```
kubectl get rs --watch
```

The output is similar to this:

```
NAME              DESIRED   CURRENT   READY     AGE
nginx-2142116321  2         2         2         2m
nginx-3926361531  2         2         0         6s
nginx-3926361531  2         2         1         18s
nginx-2142116321  1         2         2         2m
nginx-2142116321  1         2         2         2m
nginx-3926361531  3         2         1         18s
nginx-3926361531  3         2         1         18s
nginx-2142116321  1         1         1         2m
nginx-3926361531  3         3         1         18s
nginx-3926361531  3         3         2         19s
nginx-2142116321  0         1         1         2m
nginx-2142116321  0         1         1         2m
nginx-2142116321  0         0         0         2m
nginx-3926361531  3         3         3         20s
```

- Get the status of the latest rollout:

```
kubectl get rs
```

The output is similar to this:

```
NAME              DESIRED   CURRENT   READY     AGE
nginx-2142116321  0         0         0         2m
nginx-3926361531  3         3         3         28s
```

> **Note:**
> You cannot rollback a paused Deployment until you resume it.

Deployment status

A Deployment enters various states during its lifecycle. It can be progressing while rolling out a new ReplicaSet, it can be complete, or it can fail to progress.

Progressing Deployment

Kubernetes marks a Deployment as *progressing* when one of the following tasks is performed:

- The Deployment creates a new ReplicaSet.
- The Deployment is scaling up its newest ReplicaSet.
- The Deployment is scaling down its older ReplicaSet(s).
- New Pods become ready or available (ready for at least MinReadySeconds).

When the rollout becomes “progressing”, the Deployment controller adds a condition with the following attributes to the Deployment's `.status.conditions`:

- `type: Progressing`
- `status: "True"`
- `reason: NewReplicaSetCreated` | `reason: FoundNewReplicaSet` | `reason: ReplicaSetUpdated`

You can monitor the progress for a Deployment by using `kubectl rollout status`.

Complete Deployment

Kubernetes marks a Deployment as *complete* when it has the following characteristics:

- All of the replicas associated with the Deployment have been updated to the latest version you've specified, meaning any updates you've requested have been completed.
- All of the replicas associated with the Deployment are available.
- No old replicas for the Deployment are running.

When the rollout becomes “complete”, the Deployment controller sets a condition with the following attributes to the Deployment's `.status.conditions`:

- `type: Progressing`
- `status: "True"`
- `reason: NewReplicaSetAvailable`

This `Progressing` condition will retain a status value of `"True"` until a new rollout is initiated. The condition holds even when availability of replicas changes (which does instead affect the `Available` condition).

You can check if a Deployment has completed by using `kubectl rollout status`. If the rollout completed successfully, `kubectl rollout status` returns a zero exit code.

```
kubectl rollout status deployment/nginx-deployment
```

The output is similar to this:

```
Waiting for rollout to finish: 2 of 3 updated replicas are available...
deployment "nginx-deployment" successfully rolled out
```

and the exit status from `kubectl rollout` is 0 (success):

```
echo $?
```

```
0
```

Failed Deployment

Your Deployment may get stuck trying to deploy its newest ReplicaSet without ever completing. This can occur due to some of the following factors:

- Insufficient quota
- Readiness probe failures
- Image pull errors
- Insufficient permissions
- Limit ranges
- Application runtime misconfiguration

One way you can detect this condition is to specify a deadline parameter in your Deployment spec: (`.spec.progressDeadlineSeconds`). `.spec.progressDeadlineSeconds` denotes the number of seconds the Deployment controller waits before indicating (in the Deployment status) that the Deployment progress has stalled.

The following `kubectl` command sets the spec with `progressDeadlineSeconds` to make the controller report lack of progress of a rollout for a Deployment after 10 minutes:

```
kubectl patch deployment/nginx-deployment -p '{"spec":{"progressDeadlineSeconds":600}}'
```

The output is similar to this:

```
deployment.apps/nginx-deployment patched
```

Once the deadline has been exceeded, the Deployment controller adds a DeploymentCondition with the following attributes to the Deployment's `.status.conditions`:

- `type: Progressing`
- `status: "False"`
- `reason: ProgressDeadlineExceeded`

This condition can also fail early and is then set to status value of `"False"` due to reasons as `ReplicaSetCreateError`. Also, the deadline is not taken into account anymore once the Deployment rollout completes.

See the Kubernetes API conventions for more information on status conditions.

> **Note:**
> Kubernetes takes no action on a stalled Deployment other than to report a status condition with `reason: ProgressDeadlineExceeded`. Higher level orchestrators can take advantage of it and act accordingly, for example, rollback the Deployment to its previous version.

> **Note:**
> If you pause a Deployment rollout, Kubernetes does not check progress against your specified deadline. You can safely pause a Deployment rollout in the middle of a rollout and resume without triggering the condition for exceeding the deadline.

You may experience transient errors with your Deployments, either due to a low timeout that you have set or due to any other kind of error that can be treated as transient. For example, let's suppose you have insufficient quota. If you describe the Deployment you will notice the following section:

```
kubectl describe deployment nginx-deployment
```

The output is similar to this:

```
<...>
Conditions:
  Type            Status  Reason
  ----            ------  ------
  Available       True    MinimumReplicasAvailable
  Progressing     True    ReplicaSetUpdated
  ReplicaFailure  True    FailedCreate
<...>
```

If you run `kubectl get deployment nginx-deployment -o yaml`, the Deployment status is similar to this:

```
status:
  availableReplicas: 2
  conditions:
  - lastTransitionTime: 2016-10-04T12:25:39Z
    lastUpdateTime: 2016-10-04T12:25:39Z
    message: Replica set "nginx-deployment-4262182780" is progressing.
    reason: ReplicaSetUpdated
    status: "True"
    type: Progressing
  - lastTransitionTime: 2016-10-04T12:25:42Z
    lastUpdateTime: 2016-10-04T12:25:42Z
    message: Deployment has minimum availability.
    reason: MinimumReplicasAvailable
    status: "True"
    type: Available
  - lastTransitionTime: 2016-10-04T12:25:39Z
    lastUpdateTime: 2016-10-04T12:25:39Z
    message: 'Error creating: pods "nginx-deployment-4262182780-" is forbidden: exceeded quota:
      object-counts, requested: pods=1, used: pods=3, limited: pods=2'
    reason: FailedCreate
    status: "True"
    type: ReplicaFailure
  observedGeneration: 3
  replicas: 2
  unavailableReplicas: 2
```

Eventually, once the Deployment progress deadline is exceeded, Kubernetes updates the status and the reason for the Progressing condition:

```
Conditions:
  Type            Status  Reason
  ----            ------  ------
  Available       True    MinimumReplicasAvailable
  Progressing     False   ProgressDeadlineExceeded
  ReplicaFailure  True    FailedCreate
```

You can address an issue of insufficient quota by scaling down your Deployment, by scaling down other controllers you may be running, or by increasing quota in your namespace. If you satisfy the quota conditions and the Deployment controller then completes the Deployment rollout, you'll see the Deployment's status update with a successful condition (`status: "True"` and `reason: NewReplicaSetAvailable`).

```
Conditions:
  Type          Status  Reason
  ----          ------  ------
  Available     True    MinimumReplicasAvailable
  Progressing   True    NewReplicaSetAvailable
```

`type: Available` with `status: "True"` means that your Deployment has minimum availability. Minimum availability is dictated by the parameters specified in the deployment strategy. `type: Progressing` with `status: "True"` means that your Deployment is either in the middle of a rollout and it is progressing or that it has successfully completed its progress and the minimum required new replicas are available (see the Reason of the condition for the particulars - in our case `reason: NewReplicaSetAvailable` means that the Deployment is complete).

You can check if a Deployment has failed to progress by using `kubectl rollout status` . `kubectl rollout status` returns a non-zero exit code if the Deployment has exceeded the progression deadline.

```
kubectl rollout status deployment/nginx-deployment
```

The output is similar to this:

```
Waiting for rollout to finish: 2 out of 3 new replicas have been updated...
error: deployment "nginx" exceeded its progress deadline
```

and the exit status from `kubectl rollout` is 1 (indicating an error):

```
echo $?
```

```
1
```

Operating on a failed deployment

All actions that apply to a complete Deployment also apply to a failed Deployment. You can scale it up/down, roll back to a previous revision, or even pause it if you need to apply multiple tweaks in the Deployment Pod template.

Clean up Policy

You can set `.spec.revisionHistoryLimit` field in a Deployment to specify how many old ReplicaSets for this Deployment you want to retain. The rest will be garbage-collected in the background. By default, it is 10.

> **Note:**
> Explicitly setting this field to 0, will result in cleaning up all the history of your Deployment thus that Deployment will not be able to roll back.

The cleanup only starts **after** a Deployment reaches a complete state. If you set `.spec.revisionHistoryLimit` to 0, any rollout nonetheless triggers creation of a new ReplicaSet before Kubernetes removes the old one.

Even with a non-zero revision history limit, you can have more ReplicaSets than the limit you configure. For example, if pods are crash looping, and there are multiple rolling updates events triggered over time, you might end up with more ReplicaSets than the `.spec.revisionHistoryLimit` because the Deployment never reaches a complete state.

Canary Deployment

If you want to roll out releases to a subset of users or servers using the Deployment, you can create multiple Deployments, one for each release, following the canary pattern described in managing resources.

Writing a Deployment Spec

As with all other Kubernetes configs, a Deployment needs `.apiVersion`, `.kind`, and `.metadata` fields. For general information about working with config files, see deploying applications, configuring containers, and using kubectl to manage resources documents.

When the control plane creates new Pods for a Deployment, the `.metadata.name` of the Deployment is part of the basis for naming those Pods. The name of a Deployment must be a valid DNS subdomain value, but this can produce unexpected results for the Pod hostnames. For best compatibility, the name should follow the more restrictive rules for a DNS label.

A Deployment also needs a `.spec` section.

Pod Template

The `.spec.template` and `.spec.selector` are the only required fields of the `.spec`.

The `.spec.template` is a Pod template. It has exactly the same schema as a Pod, except it is nested and does not have an `apiVersion` or `kind`.

In addition to required fields for a Pod, a Pod template in a Deployment must specify appropriate labels and an appropriate restart policy. For labels, make sure not to overlap with other controllers. See selector.

Only a `.spec.template.spec.restartPolicy` equal to `Always` is allowed, which is the default if not specified.

Replicas

`.spec.replicas` is an optional field that specifies the number of desired Pods. It defaults to 1.

Should you manually scale a Deployment, example via `kubectl scale deployment deployment --replicas=X`, and then you update that Deployment based on a manifest (for example: by running `kubectl apply -f deployment.yaml`), then applying that manifest overwrites the manual scaling that you previously did.

If a HorizontalPodAutoscaler (or any similar API for horizontal scaling) is managing scaling for a Deployment, don't set `.spec.replicas`.

Instead, allow the Kubernetes control plane to manage the `.spec.replicas` field automatically.

Selector

`.spec.selector` is a required field that specifies a label selector for the Pods targeted by this Deployment.

`.spec.selector` must match `.spec.template.metadata.labels`, or it will be rejected by the API.

In API version `apps/v1`, `.spec.selector` and `.metadata.labels` do not default to `.spec.template.metadata.labels` if not set. So they must be set explicitly. Also note that `.spec.selector` is immutable after creation of the Deployment in `apps/v1`.

A Deployment may terminate Pods whose labels match the selector if their template is different from `.spec.template` or if the total number of such Pods exceeds `.spec.replicas`. It brings up new Pods with `.spec.template` if the number of Pods is less than the desired number.

> **Note:**
> You should not create other Pods whose labels match this selector, either directly, by creating another Deployment, or by creating another controller such as a ReplicaSet or a ReplicationController. If you do so, the first Deployment thinks that it created these other Pods. Kubernetes does not stop you from doing this.

If you have multiple controllers that have overlapping selectors, the controllers will fight with each other and won't behave correctly.

Strategy

`.spec.strategy` specifies the strategy used to replace old Pods by new ones. `.spec.strategy.type` can be "Recreate" or "RollingUpdate". "RollingUpdate" is the default value.

Recreate Deployment

All existing Pods are killed before new ones are created when `.spec.strategy.type==Recreate`.

> **Note:**
> This will only guarantee Pod termination previous to creation for upgrades. If you upgrade a Deployment, all Pods of the old revision will be terminated immediately. Successful removal is awaited before any Pod of the new revision is created. If you manually delete a Pod, the lifecycle is controlled by the ReplicaSet and the replacement will be created immediately (even if the old Pod is still in a Terminating state). If you need an "at most" guarantee for your Pods, you should consider using a StatefulSet.

Rolling Update Deployment

The Deployment updates Pods in a rolling update fashion (gradually scale down the old ReplicaSets and scale up the new one) when `.spec.strategy.type==RollingUpdate`. You can specify `maxUnavailable` and `maxSurge` to control the rolling update process.

Max Unavailable

`.spec.strategy.rollingUpdate.maxUnavailable` is an optional field that specifies the maximum number of Pods that can be unavailable during the update process. The value can be an absolute number (for example, 5) or a percentage of desired Pods (for example, 10%). The absolute number is calculated from percentage by rounding down. The value cannot be 0 if `.spec.strategy.rollingUpdate.maxSurge` is 0. The default value is 25%.

For example, when this value is set to 30%, the old ReplicaSet can be scaled down to 70% of desired Pods immediately when the rolling update starts. Once new Pods are ready, old ReplicaSet can be scaled down further, followed by scaling up the new ReplicaSet, ensuring that the total number of Pods available at all times during the update is at least 70% of the desired Pods.

Max Surge

`.spec.strategy.rollingUpdate.maxSurge` is an optional field that specifies the maximum number of Pods that can be created over the desired number of Pods. The value can be an absolute number (for example, 5) or a percentage of desired Pods (for example, 10%). The value cannot be 0 if `maxUnavailable` is 0. The absolute number is calculated from the percentage by rounding up. The default value is 25%.

For example, when this value is set to 30%, the new ReplicaSet can be scaled up immediately when the rolling update starts, such that the total number of old and new Pods does not exceed 130% of desired Pods. Once old Pods have been killed, the new ReplicaSet can be scaled up further, ensuring that the total number of Pods running at any time during the update is at most 130% of desired Pods.

Here are some Rolling Update Deployment examples that use the `maxUnavailable` and `maxSurge`:

Max Unavailable | Max Surge | Hybrid

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
 name: nginx-deployment
 labels:
   app: nginx
spec:
 replicas: 3
 selector:
   matchLabels:
     app: nginx
 template:
   metadata:
     labels:
       app: nginx
   spec:
     containers:
     - name: nginx
       image: nginx:1.14.2
       ports:
       - containerPort: 80
 strategy:
   type: RollingUpdate
   rollingUpdate:
     maxUnavailable: 1
```

Progress Deadline Seconds

`.spec.progressDeadlineSeconds` is an optional field that specifies the number of seconds you want to wait for your Deployment to progress before the system reports back that the Deployment has failed progressing - surfaced as a condition with `type: Progressing`, `status: "False"`. and `reason: ProgressDeadlineExceeded` in the status of the resource. The Deployment controller will keep retrying the Deployment. This defaults to 600. In the future, once automatic rollback will be implemented, the Deployment controller will roll back a Deployment as soon as it observes such a condition.

If specified, this field needs to be greater than `.spec.minReadySeconds`.

Min Ready Seconds

`.spec.minReadySeconds` is an optional field that specifies the minimum number of seconds for which a newly created Pod should be ready without any of its containers crashing, for it to be considered available. This defaults to 0 (the Pod will be considered available as soon as it is ready). To learn more about when a Pod is considered ready, see Container Probes.

Terminating Pods

FEATURE STATE: Kubernetes v1.35 [beta](enabled by default)

You can see the terminating pods only if the `DeploymentReplicaSetTerminatingReplicas` feature gate is enabled on the API server and on the kube-controller-manager

Pods that become terminating due to deletion or scale down may take a long time to terminate, and may consume additional resources during that period. As a result, the total number of all pods can temporarily exceed `.spec.replicas`. Terminating pods can be tracked using the `.status.terminatingReplicas` field of the Deployment.

Revision History Limit

A Deployment's revision history is stored in the ReplicaSets it controls.

`.spec.revisionHistoryLimit` is an optional field that specifies the number of old ReplicaSets to retain to allow rollback. These old ReplicaSets consume resources in `etcd` and crowd the output of `kubectl get rs`. The configuration of each Deployment revision is stored in its ReplicaSets; therefore, once an old ReplicaSet is deleted, you lose the ability to rollback to that revision of Deployment. By default, 10 old ReplicaSets will be kept, however its ideal value depends on the frequency and stability of new Deployments.

More specifically, setting this field to zero means that all old ReplicaSets with 0 replicas will be cleaned up. In this case, a new Deployment rollout cannot be undone, since its revision history is cleaned up.

Paused

`.spec.paused` is an optional boolean field for pausing and resuming a Deployment. The only difference between a paused Deployment and one that is not paused, is that any changes into the PodTemplateSpec of the paused Deployment will not trigger new rollouts as long as it is paused. A Deployment is not paused by default when it is created.

What's next

- Learn more about Pods.
- Run a stateless application using a Deployment.
- Read the Deployment to understand the Deployment API.
- Read about PodDisruptionBudget and how you can use it to manage application availability during disruptions.
- Use kubectl to create a Deployment.

Feedback

Was this page helpful?

Yes No

Last modified November 23, 2025 at 1:47 PM PST: Move HorizontalPodAutoscaler concept page (57e1fdd7f9)