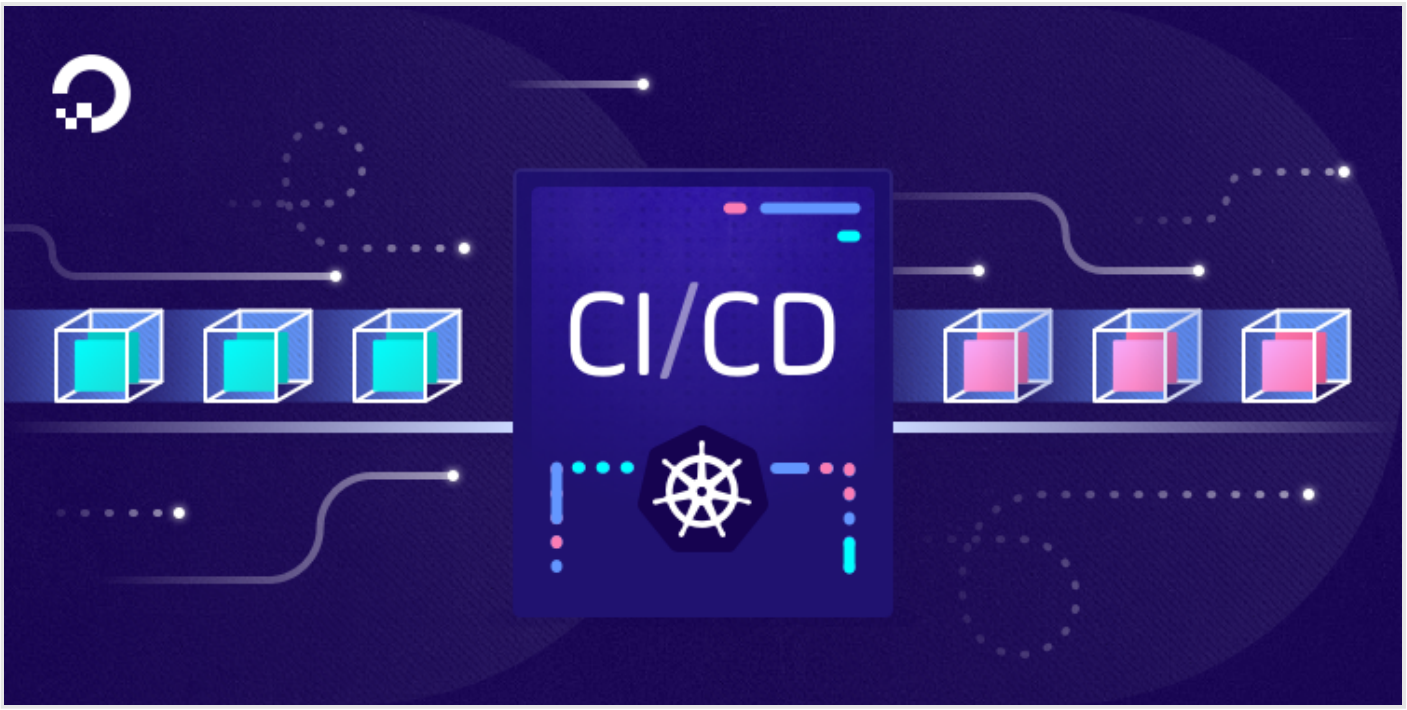

How To Automate Deployments to DigitalOcean Kubernetes with CircleCI

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Introduction

Having an automated deployment process is a requirement for a scalable and resilient application, and *GitOps*, or Git-based DevOps, has rapidly become a popular method of organizing CI/CD with a Git repository as a "single source of truth." Tools li

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integrate with your GitHub repository, allowing you to test and deploy your code

automatically every time you make a change to your repository. When this kind of CI/CD is combined with the flexibility of Kubernetes infrastructure, you can build an application that scales easily with changing demand.

In this article you will use CircleCI to deploy a sample application to a DigitalOcean Kubernetes (DOKS) cluster. After reading this tutorial, you'll be able to apply these same techniques to deploy other CI/CD tools that are buildable as Docker images.

Prerequisites

To follow this tutorial, you'll need to have:

- A DigitalOcean account, which you can set up by following the Sign up for a DigitalOcean Account documentation.
- Docker installed on your workstation, and knowledge of how to build, remove, and run Docker images. You can install Docker on Ubuntu 18.04 by following the tutorial on How To Install and Use Docker on Ubuntu 18.04.
- Knowledge of how Kubernetes works and how to create deployments and services on it. It's highly recommended to read the Introduction to Kubernetes article.
- The `kubectl` command line interface tool installed on the computer from which you will control your cluster.
- An account on Docker Hub to be used to store your sample application image.
- A GitHub account and knowledge of Git basics. You can follow the tutorial series Introduction to Git: Installation, Usage, and Branches and How To Create a Pull Request on GitHub to build this knowledge.

For this tutorial, you will use Kubernetes version `1.13.5` and `kubectl` version `1.10.7`.

Step 1 — Creating Your DigitalOcean Kubernetes Cluster

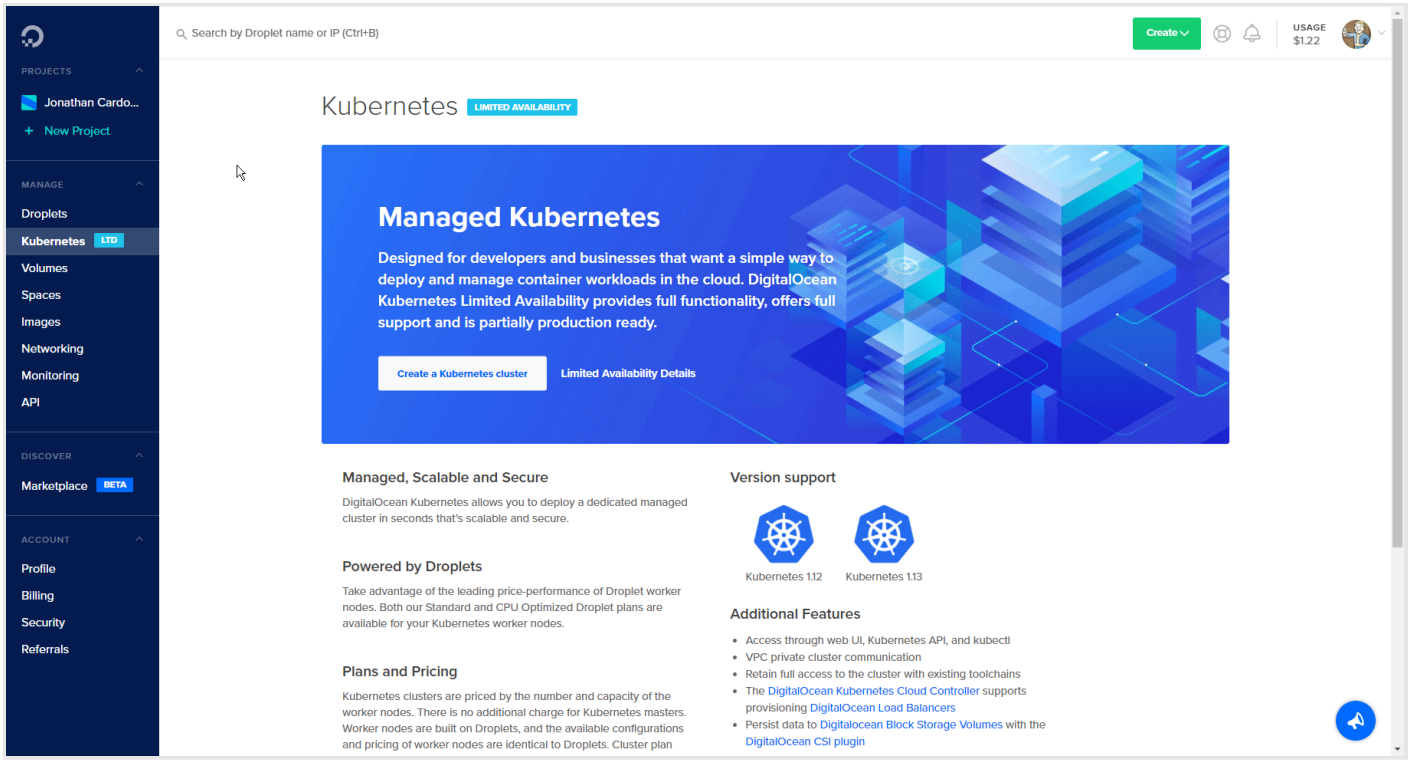
Note: You can skip this section if you already have a running DigitalOcean Kubernetes cluster.

In this first step, you will create the DigitalOcean Kubernetes (DOKS) cluster from which you will deploy your sample application. The `kubectl` commands executed fr

machine will change or retrieve information directly from the Kubernetes cluster.

Go to the Kubernetes page on your DigitalOcean account.

Click **Create a Kubernetes cluster**, or click the green **Create** button at the top right of the page and select **Clusters** from the dropdown menu.



The next page is where you are going to specify the details of your cluster. On **Select a Kubernetes version** pick version **1.13.5-do.0**. If this one is not available, choose a higher one.

For **Choose a datacenter region**, choose the region closest to you. This tutorial will use **San Francisco - 2**.

You then have the option to build your **Node pool(s)**. On Kubernetes, a node is a worker machine, which contains the services necessary to run pods. On DigitalOcean, each node is a Droplet. Your node pool will consist of a single **Standard node**. Select the **2GB/1vCPU** configuration and change to **1 Node** on the number of nodes.

You can add extra tags if you want; this can be useful if you plan to use DigitalOcean API or just to better organize your node pools.

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On **Choose a name**, for this tutorial, use `kubernetes-deployment-tutorial`. This will make it easier to follow throughout while reading the next sections. Finally, click the green **Create Cluster** button to create your cluster.

After cluster creation, there will be a button on the UI to download a configuration file called **Download Config File**. This is the file you will be using to authenticate the `kubectl` commands you are going to run against your cluster. Download it to your `kubectl` machine.

The default way to use that file is to always pass the `--kubeconfig` flag and the path to it on all commands you run with `kubectl`. For example, if you downloaded the config file to `Desktop`, you would run the `kubectl get pods` command like this:

```
$ kubectl --kubeconfig ~/Desktop/kubernetes-deployment-tutorial-kubeconfig.yaml get pc
```

This would yield the following output:

```
Output
No resources found.
```

This means you accessed your cluster. The `No resources found.` message is correct, since you don't have any pods on your cluster.

If you are not maintaining any other Kubernetes clusters you can copy the kubeconfig file to a folder on your home directory called `.kube`. Create that directory in case it does not exist:

```
$ mkdir -p ~/.kube
```

Then copy the config file into the newly created `.kube` directory and rename it `config`:

```
$ cp current_kubernetes-deployment-tutorial-kubeconfig.yaml_file_path ~/.kube/config
```

The config file should now have the path `~/.kube/config`. This is the file that `kubectl` reads by default when running any command, so there is no need to pass `--kubeconfig` anymore. Run the following:

```
$ kubectl get pods
```

You will receive the following output:

```
Output
No resources found.
```

Now access the cluster with the following:

```
$ kubectl get nodes
```

You will receive the list of nodes on your cluster. The output will be similar to this:

```
Output
NAME                                    STATUS    ROLES     AGE       VERSION
kubernetes-deployment-tutorial-1-7pto   Ready     <none>    1h        v1.13.5
```

In this tutorial you are going to use the `default` namespace for all `kubectl` commands and *manifest files*, which are files that define the workload and operating parameters of work in Kubernetes. *Namespaces* are like virtual clusters inside your single physical cluster. You can change to any other namespace you want; just make sure to always pass it using the `--namespace` flag to `kubectl`, and/or specifying it on the Kubernetes manifests metadata field. They are a great way to organize the deployments of your team and their running environments; read more about them in the official Kubernetes overview on Namespaces.

By finishing this step you are now able to run `kubectl` against your cluster. In the next step, you will create the local Git repository you are going to use to house your sample application.

Step 2 — Creating the Local Git Repository

You are now going to structure your sample deployment in a local Git repository. You will also create some Kubernetes manifests that will be global to all deployments you are going to do on your cluster.

> **Note:** This tutorial has been tested on Ubuntu 18.04, and the individual commands are styled to match this OS. However, most of the commands here can be applied to other Linux distributions with little to no change needed, and commands like `kubectl` are platform-agnostic.

First, create a new Git repository locally that you will push to GitHub later on. Create an empty folder called `do-sample-app` in your home directory and `cd` into it:

```
$ mkdir ~/do-sample-app
$ cd ~/do-sample-app
```

Now create a new Git repository in this folder with the following command:

```
$ git init .
```

Inside this repository, create an empty folder called `kube`:

```
$ mkdir ~/do-sample-app/kube/
```

This will be the location where you are going to store the Kubernetes resources manifests related to the sample application that you will deploy to your cluster.

Now, create another folder called `kube-general`, but this time outside of the Git repository you just created. Make it inside your home directory:

```
$ mkdir ~/kube-general/
```

This folder is outside of your Git repository because it will be used to store manifests that are not specific to a single deployment on your cluster, but common to multiple ones. This will allow you to reuse these general manifests for different deployments.

With your folders created and the Git repository of your sample application in place, it's time to arrange the authentication and authorization of your DOKS cluster.

Step 3 — Creating a Service Account

It's generally not recommended to use the default **admin** user to authenticate from other *Services* into your Kubernetes cluster. If your keys on the external provider got compromised, your whole cluster would become compromised.

Instead you are going to use a single Service Account with a specific Role, which is all part of the RBAC Kubernetes authorization model.

This authorization model is based on *Roles* and *Resources*. You start by creating a *Service Account*, which is basically a user on your cluster, then you create a Role, in which you specify what resources it has access to on your cluster. Finally, you create a *Role Binding*, which is used to make the connection between the Role and the Service Account previously created, granting to the Service Account access to all resources the Role has access to.

The first Kubernetes resource you are going to create is the Service Account for your CI/CD user, which this tutorial will name `cicd`.

Create the file `cicd-service-account.yml` inside the `~/kube-general` folder, and open it with your favorite text editor:

```
$ nano ~/kube-general/cicd-service-account.yml
```

Write the following content on it:

~/kube-general/cicd-service-account.yml

```
apiVersion: v1
kind: ServiceAccount
metadata:
  name: cicd
  namespace: default
```

This is a YAML file; all Kubernetes resources are represented using one. In this case you are saying this resource is from Kubernetes API version `v1` (internally `kubectl` creates resources by calling Kubernetes HTTP APIs), and it is a `ServiceAccount`.

The `metadata` field is used to add more information about this resource. In this case, you are giving this `ServiceAccount` the name `cicd`, and creating it on the `default` namespace.

You can now create this Service Account on your cluster by running `kubectl apply`, like the following:

```
$ kubectl apply -f ~/kube-general/
```

You will recieve output similar to the following:

```
Output
serviceaccount/cicd created
```

To make sure your Service Account is working, try to log in to your cluster using it. To do that you first need to obtain their respective access token and store it in an environment variable. Every Service Account has an access token which Kubernetes stores as a *Secret*.

You can retrieve this secret using the following command:

```
cret | grep cicd-token | awk '{print $1}') -o jsonpath='{.data.token}' | base64 --decode
```

Some explanation on what this command is doing:

```
$(kubectl get secret | grep cicd-token | awk '{print $1}')
```

This is used to retrieve the name of the secret related to our `cicd` Service Account. `kubectl get secret` returns the list of secrets on the default namespace, then you use `grep` to search for the lines related to your `cicd` Service Account. Then you return the name, since it is the first thing on the single line returned from the `grep`.

```
kubectl get secret preceding-command -o jsonpath='{.data.token}' | base64 --decode
```

This will retrieve only the secret for your Service Account token. You then a
field using `jsonpath`, and pass the result to `base64 --decode`. This is necessary because

the token is stored as a Base64 string. The token itself is a JSON Web Token.

You can now try to retrieve your pods with the `cicd` Service Account. Run the following command, replacing `server-from-kubeconfig-file` with the server URL that can be found after `server:` in `~kube/config`. This command will give a specific error that you will learn about later in this tutorial:

```
ify --kubeconfig="/dev/null" --server=server-from-kubeconfig-file --token=$TOKEN get pod
```

`--insecure-skip-tls-verify` skips the step of verifying the certificate of the server, since you are just testing and do not need to verify this. `--kubeconfig="/dev/null"` is to make sure `kubectl` does not read your config file and credentials but instead uses the token provided.

The output should be similar to this:

```
Output
Error from server (Forbidden): pods is forbidden: User "system:serviceaccount:default:
```

This is an error, but it shows us that the token worked. The error you received is about your Service Account not having the neccessary authorization to list the resource `secrets`, but you were able to access the server itself. If your token had not worked, the error would have been the following one:

```
Output
error: You must be logged in to the server (Unauthorized)
```

Now that the authentication was a success, the next step is to fix the authorization error for the Service Account. You will do this by creating a role with the necessary permissions and binding it to your Service Account.

Step 4 — Creating the Role and the Role Binding

Kubernetes has two ways to define roles: using a `Role` or a `ClusterRole` r
difference between the former and the latter is that the first one applies to a single

namespace, while the other is valid for the whole cluster.

As you are using a single namespace on this tutorial, you will use a `Role`.

Create the file `~/kube-general/cicd-role.yml` and open it with your favorite text editor:

```
$ nano ~/kube-general/cicd-role.yml
```

The basic idea is to grant access to do everything related to most Kubernetes resources in the `default` namespace. Your `Role` would look like this:

~/kube-general/cicd-role.yml

```
kind: Role
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: cicd
  namespace: default
rules:
  - apiGroups: ["", "apps", "batch", "extensions"]
    resources: ["deployments", "services", "replicasets", "pods", "jobs", "cronjobs"]
    verbs: ["*"]
```

This YAML has some similarities with the one you created previously, but here you are saying this resource is a `Role`, and it's from the Kubernetes API `rbac.authorization.k8s.io/v1`. You are naming your role `cicd`, and creating it on the same namespace you created your `ServiceAccount`, the `default` one.

Then you have the `rules` field, which is a list of resources this role has access to. In Kubernetes resources are defined based on the API group they belong to, the resource kind itself, and what actions you can do on then, which is represented by a verb. Those verbs are similar to the HTTP ones.

In our case you are saying that your `Role` is allowed to do everything, `*`, on the following resources: `deployments`, `services`, `replicasets`, `pods`, `jobs`, and `cronjobs`. This also applies to those resources belonging to the following API groups: `""` (empty string), `apps`, `batch`, and `extensions`. The empty string means the root API group. If you `apiVersion: v1` when creating a resource it means this resource is part of this API group.

A `Role` by itself does nothing; you must also create a `RoleBinding`, which binds a `Role` to something, in this case, a `ServiceAccount`.

Create the file `~/kube-general/cicd-role-binding.yml` and open it:

```
$ nano ~/kube-general/cicd-role-binding.yml
```

Add the following lines to the file:

~/kube-general/cicd-role-binding.yml

```
kind: RoleBinding
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: cicd
  namespace: default
subjects:
  - kind: ServiceAccount
    name: cicd
    namespace: default
roleRef:
  kind: Role
  name: cicd
  apiGroup: rbac.authorization.k8s.io
```

Your `RoleBinding` has some specific fields that have not yet been covered in this tutorial. `roleRef` is the `Role` you want to bind to something; in this case it is the `cicd` role you created earlier. `subjects` is the list of resources you are binding your role to; in this case it's a single `ServiceAccount` called `cicd`.

Note: If you had used a `ClusterRole`, you would have to create a `ClusterRoleBinding` instead of a `RoleBinding`. The file would be almost the same. The only difference would be that it would have no `namespace` field inside the `metadata`.

With those files created you will be able to use `kubectl apply` again. Create those new resources on your Kubernetes cluster by running the following command:


```
$ kubectl apply -f ~/kube-general/
```

You will receive output similar to the following:

```
Output
rolebinding.rbac.authorization.k8s.io/cicd created
role.rbac.authorization.k8s.io/cicd created
serviceaccount/cicd created
```

Now, try the command you ran previously:

```
$ kubectl --insecure-skip-tls-verify --kubeconfig="/dev/null" --server=server-from-kub
```

Since you have no pods, this will yield the following output:

```
Output
No resources found.
```

In this step, you gave the Service Account you are going to use on CircleCI the necessary authorization to do meaningful actions on your cluster like listing, creating, and updating resources. Now it's time to create your sample application.

Step 5 — Creating Your Sample Application

> **Note:** All commands and files created from now on will start from the folder `~/do-sample-app` you created earlier. This is becase you are now creating files specific to the sample application that you are going to deploy to your cluster.

The Kubernetes `Deployment` you are going to create will use the Nginx image as a base, and your application will be a simple static HTML page. This is a great start because it allows you to test if your deployment works by serving a simple HTML directly from Nginx. As you will see later on, you can redirect all traffic coming to a local `address:port` to your deployment on your cluster to test if it's working.

Inside the repository you set up earlier, create a new `Dockerfile` file and o
text editor of choice:

```
$ nano ~/do-sample-app/Dockerfile
```

Write the following on it:

~/do-sample-app/Dockerfile

```
FROM nginx:1.14

COPY index.html /usr/share/nginx/html/index.html
```

This will tell Docker to build the application container from an `nginx` image.

Now create a new `index.html` file and open it:

```
$ nano ~/do-sample-app/index.html
```

Write the following HTML content:

~/do-sample-app/index.html

```
<!DOCTYPE html>
<title>DigitalOcean</title>
<body>
  Kubernetes Sample Application
</body>
```

This HTML will display a simple message that will let you know if your application is working.

You can test if the image is correct by building and then running it.

First, build the image with the following command, replacing `dockerhub-username` with your own Docker Hub username. You must specify your username here so when you push it later on to Docker Hub it will just work:

```
$ docker build ~/do-sample-app/ -t dockerhub-username/do-kubernetes-sample-app
```

Now run the image. Use the following command, which starts your image a

local traffic on port `8080` to the port `80` inside the image, the port Nginx listens to by default:

```
$ docker run --rm -it -p 8080:80 dockerhub-username/do-kubernetes-sample-app
```

The command prompt will stop being interactive while the command is running. Instead you will see the Nginx access logs. If you open `localhost:8080` on any browser it should show an HTML page with the content of `~/do-sample-app/index.html`. In case you don't have a browser available, you can open a new terminal window and use the following `curl` command to fetch the HTML from the webpage:

```
$ curl localhost:8080
```

You will receive the following output:

```
Output
<!DOCTYPE html>
<title>DigitalOcean</title>
<body>
  Kubernetes Sample Application
</body>
```

Stop the container (`CTRL + C` on the terminal where it's running), and submit this image to your Docker Hub account. To do this, first log in to Docker Hub:

```
$ docker login
```

Fill in the required information about your Docker Hub account, then push the image with the following command (don't forget to replace the `dockerhub-username` with your own):

```
$ docker push dockerhub-username/do-kubernetes-sample-app
```

You have now pushed your sample application image to your Docker Hub account. In the next step, you will create a Deployment on your DOKS cluster from this image.

Step 6 — Creating the Kubernetes Deployment and Service

With your Docker image created and working, you will now create a manifest telling Kubernetes how to create a *Deployment* from it on your cluster.

Create the YAML deployment file `~/do-sample-app/kube/do-sample-deployment.yml` and open it with your text editor:

```
$ nano ~/do-sample-app/kube/do-sample-deployment.yml
```

Write the following content on the file, making sure to replace `dockerhub-username` with your Docker Hub username:

~/do-sample-app/kube/do-sample-deployment.yml

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: do-kubernetes-sample-app
  namespace: default
  labels:
    app: do-kubernetes-sample-app
spec:
  replicas: 1
  selector:
    matchLabels:
      app: do-kubernetes-sample-app
  template:
    metadata:
      labels:
        app: do-kubernetes-sample-app
    spec:
      containers:
        - name: do-kubernetes-sample-app
          image: dockerhub-username/do-kubernetes-sample-app:latest
          ports:
            - containerPort: 80
              name: http
```

Kubernetes deployments are from the API group `apps`, so the `apiVersion` of your manifest is set to `apps/v1`. On `metadata` you added a new field you have not used previously, called `metadata.labels`. This is useful to organize your deployments. The field s

the behavior specification of your deployment. A deployment is responsible for managing one or more pods; in this case it's going to have a single replica by the `spec.replicas` field. That is, it's going to create and manage a single pod.

To manage pods, your deployment must know which pods it's responsible for. The `spec.selector` field is the one that gives it that information. In this case the deployment will be responsible for all pods with tags `app=do-kubernetes-sample-app`. The `spec.template` field contains the details of the `Pod` this deployment will create. Inside the template you also have a `spec.template.metadata` field. The `labels` inside this field must match the ones used on `spec.selector`. `spec.template.spec` is the specification of the pod itself. In this case it contains a single container, called `do-kubernetes-sample-app`. The image of that container is the image you built previously and pushed to Docker Hub.

This YAML file also tells Kubernetes that this container exposes the port `80`, and gives this port the name `http`.

To access the port exposed by your `Deployment`, create a Service. Make a file named `~/do-sample-app/kube/do-sample-service.yml` and open it with your favorite editor:

```
$ nano ~/do-sample-app/kube/do-sample-service.yml
```

Next, add the following lines to the file:

~/do-sample-app/kube/do-sample-service.yml

```
apiVersion: v1
kind: Service
metadata:
  name: do-kubernetes-sample-app
  namespace: default
  labels:
    app: do-kubernetes-sample-app
spec:
  type: ClusterIP
  ports:
    - port: 80
      targetPort: http
      name: http
  selector:
    app: do-kubernetes-sample-app
```

This file gives your `Service` the same labels used on your deployment. This is not required, but it helps to organize your applications on Kubernetes.

The service resource also has a `spec` field. The `spec.type` field is responsible for the behavior of the service. In this case it's a `ClusterIP`, which means the service is exposed on a cluster-internal IP, and is only reachable from within your cluster. This is the default `spec.type` for services. `spec.selector` is the label selector criteria that should be used when picking the pods to be exposed by this service. Since your pod has the tag `app: do-kubernetes-sample-app`, you used it here. `spec.ports` are the ports exposed by the pod's containers that you want to expose from this service. Your pod has a single container which exposes port `80`, named `http`, so you are using it here as `targetPort`. The service exposes that port on port `80` too, with the same name, but you could have used a different port/name combination than the one from the container.

With your `Service` and `Deployment` manifest files created, you can now create those resources on your Kubernetes cluster using `kubectl`:

```
$ kubectl apply -f ~/do-sample-app/kube/
```

You will receive the following output:

```
Output
deployment.apps/do-kubernetes-sample-app created
service/do-kubernetes-sample-app created
```

Test if this is working by forwarding one port on your machine to the port that the service is exposing inside your Kubernetes cluster. You can do that using `kubectl port-forward`:

```
$ kubectl port-forward $(kubectl get pod --selector="app=do-kubernetes-sample-app" --c
```

The subshell command `$(kubectl get pod --selector="app=do-kubernetes-sample-app" --output jsonpath='{.items[0].metadata.name}')` retrieves the name of the pod matching the tag you used. Otherwise you could have retrieved it from the using `kubectl get pods`.

After you run `port-forward`, the shell will stop being interactive, and will instead output the requests redirected to your cluster:

```
Output
Forwarding from 127.0.0.1:8080 -> 80
Forwarding from [::1]:8080 -> 80
```

Opening `localhost:8080` on any browser should render the same page you saw when you ran the container locally, but it's now coming from your Kubernetes cluster! As before, you can also use `curl` in a new terminal window to check if it's working:

```
$ curl localhost:8080
```

You will receive the following output:

```
Output
<!DOCTYPE html>
<title>DigitalOcean</title>
<body>
  Kubernetes Sample Application
</body>
```

Next, it's time to push all the files you created to your GitHub repository. To do this you must first create a repository on GitHub called `digital-ocean-kubernetes-deploy`.

In order to keep this repository simple for demonstration purposes, do not initialize the new repository with a `README`, `license`, or `.gitignore` file when asked on the GitHub UI. You can add these files later on.

With the repository created, point your local repository to the one on GitHub. To do this, press `CTRL + C` to stop `kubectl port-forward` and get the command line back, then run the following commands to add a new remote called `origin`:

```
$ cd ~/do-sample-app/
$ git remote add origin https://github.com/your-github-account-userr
```

There should be no output from the preceding command.

Next, commit all the files you created up to now to the GitHub repository. First, add the files:

```
$ git add --all
```

Next, commit the files to your repository, with a commit message in quotation marks:

```
$ git commit -m "initial commit"
```

This will yield output similar to the following:

```
Output
[master (root-commit) db321ad] initial commit
 4 files changed, 47 insertions(+)
 create mode 100644 Dockerfile
 create mode 100644 index.html
 create mode 100644 kube/do-sample-deployment.yml
 create mode 100644 kube/do-sample-service.yml
```

Finally, push the files to GitHub:

```
$ git push -u origin master
```

You will be prompted for your username and password. Once you have entered this, you will see output like this:

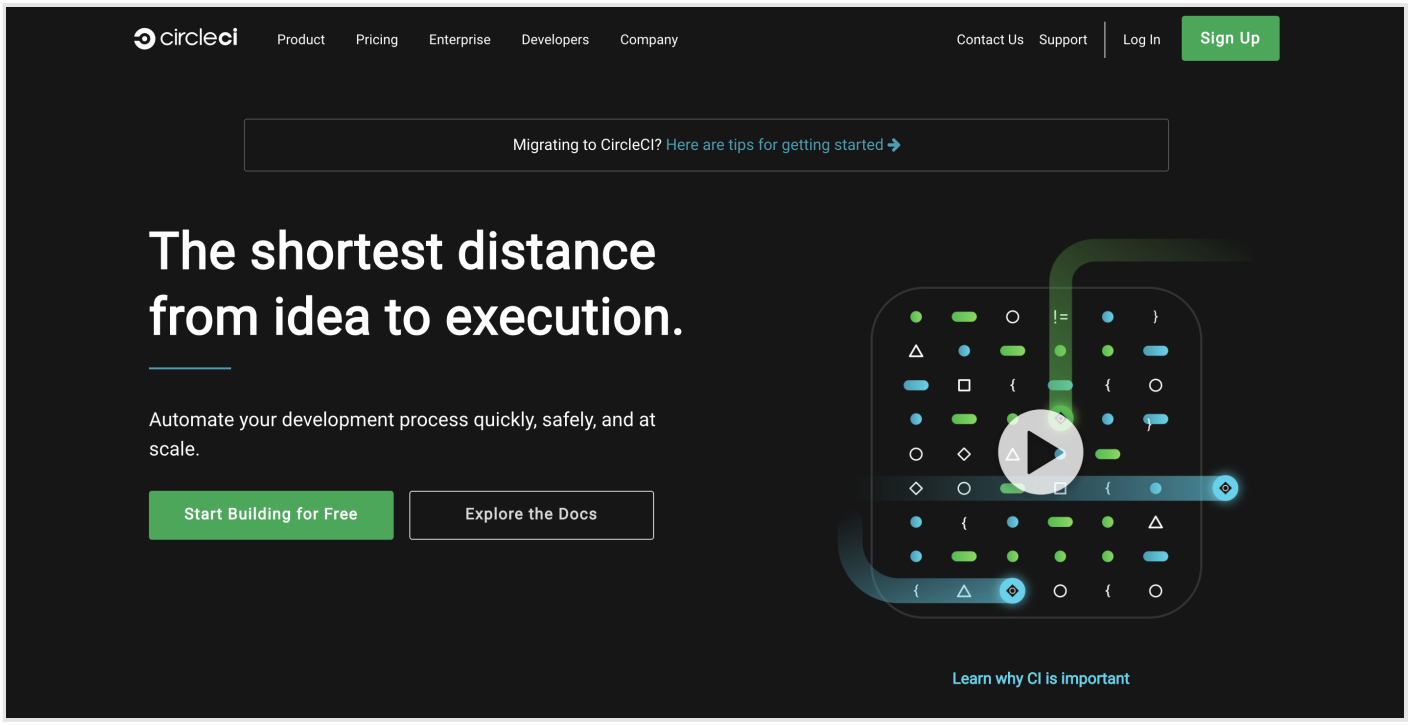
```
Output
Counting objects: 7, done.
Delta compression using up to 8 threads.
Compressing objects: 100% (7/7), done.
Writing objects: 100% (7/7), 907 bytes | 0 bytes/s, done.
Total 7 (delta 0), reused 0 (delta 0)
To github.com:your-github-account-username/digital-ocean-kubernetes-deploy.git
 * [new branch]      master -> master
Branch master set up to track remote branch master from origin.
```

If you go to your GitHub repository page you will now see all the files there. With your project up on GitHub, you can now set up CircleCI as your CI/CD tool.

Step 7 — Configuring CircleCI

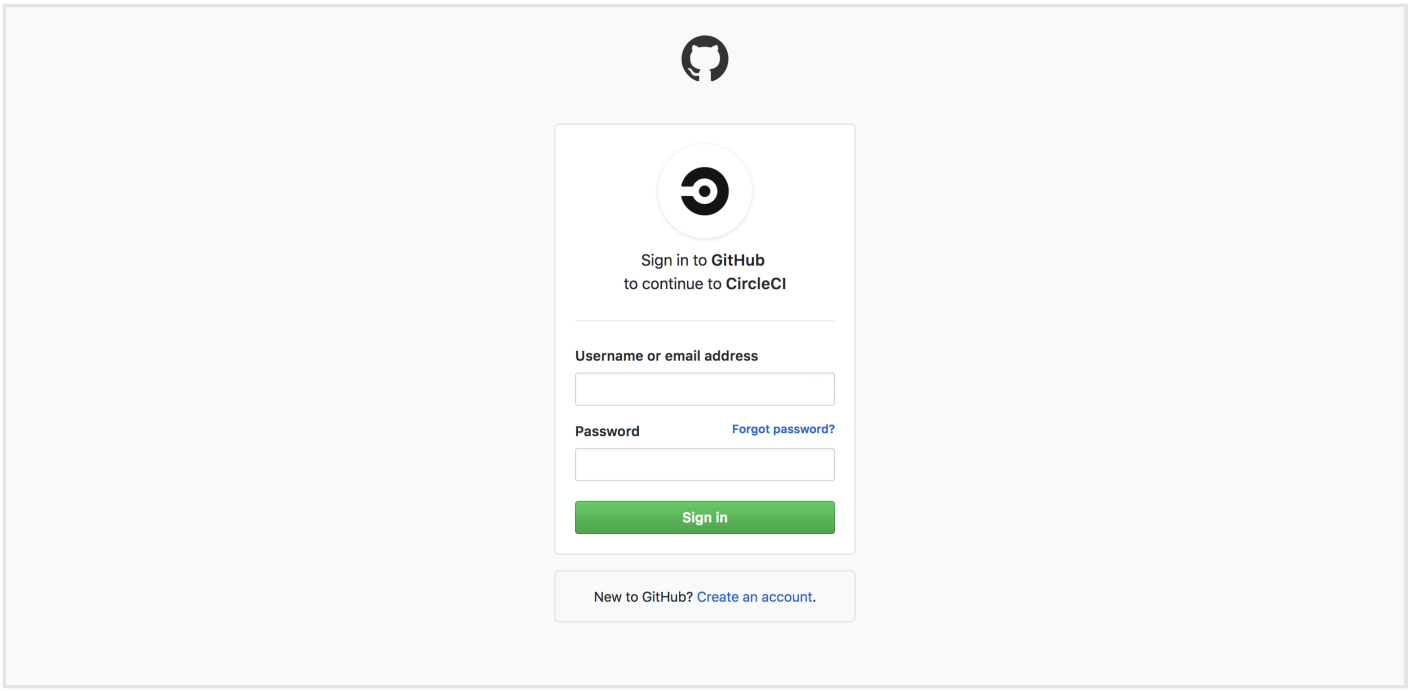
For this tutorial, you will use CircleCI to automate deployments of your application whenever the code is updated, so you will need to log in to CircleCI using your GitHub account and set up your repository.

First, go to their homepage `https://circleci.com`, and press **Sign Up**.

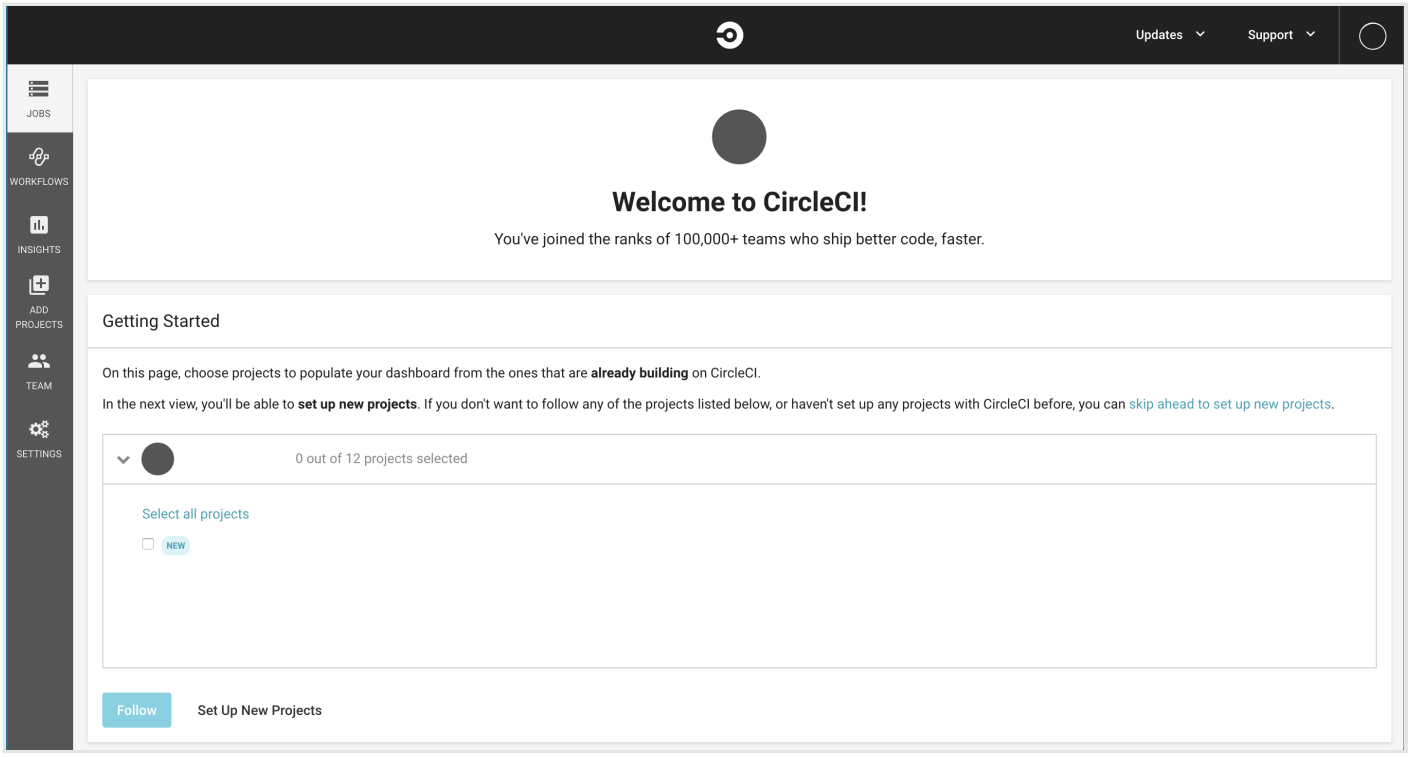


You are using GitHub, so click the green **Sign Up with GitHub** button.

CircleCI will redirect to an authorization page on GitHub. CircleCI needs some permissions on your account to be able to start building your projects. This allows CircleCI to obtain your email, deploy keys and permission to create hooks on your repositories, and add SSH keys to your account. If you need more information on what CircleCI is going to do with your data, check their documentation about GitHub integration.



After authorizing CircleCI you will be redirected to their dashboard.



Next, set up your GitHub repository in CircleCI. Click on **Set Up New Projects** from the CircleCI Dashboard, or as a shortcut, open the following link changing the highlighted text with your own GitHub username: `https://circleci.com/setup-project/gh/your-github-username/digital-ocean-kubernetes-deploy`.

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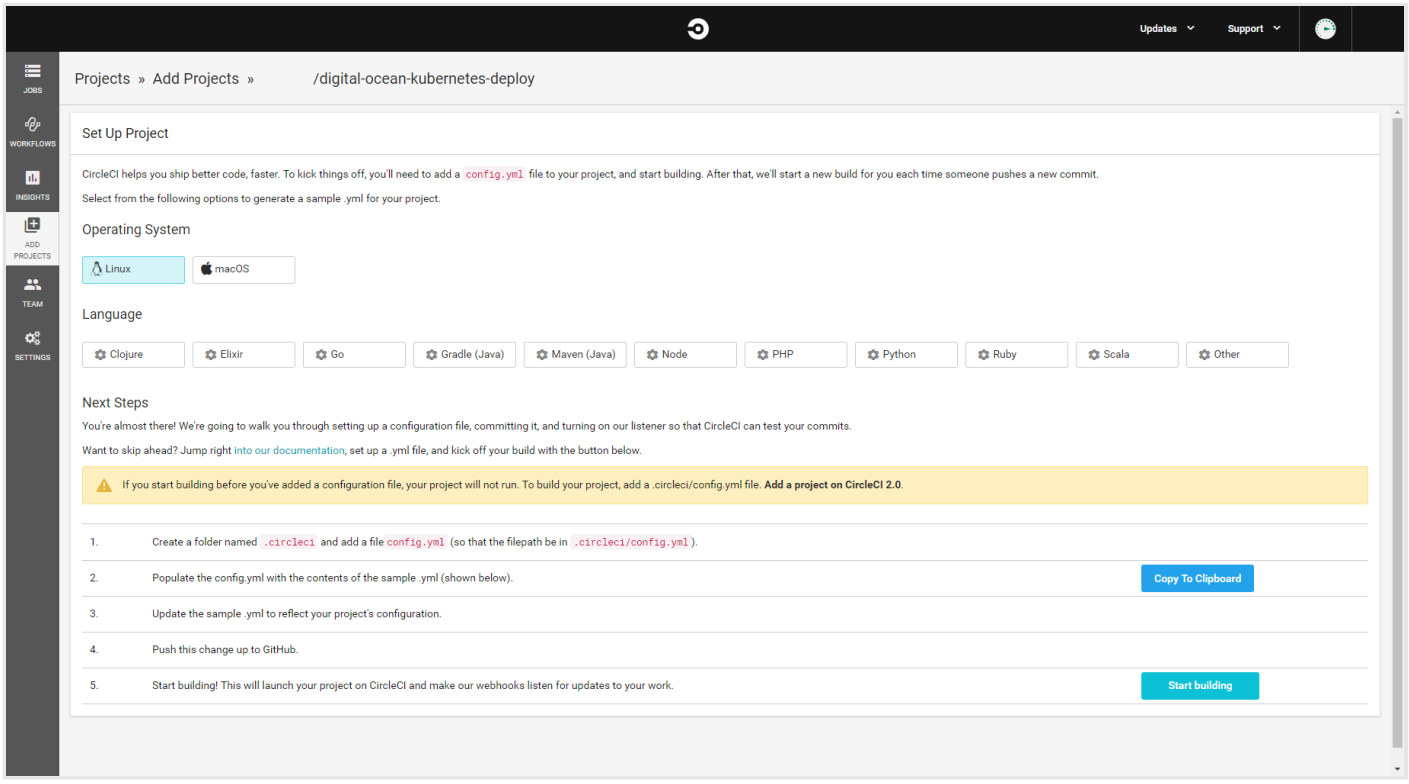
After that press **Start Building**. Do not create a config file in your repository just yet, and don't worry if the first build fails.



Next, specify some environment variables in the CircleCI settings. You can find the settings of the project by clicking on the small button with a cog icon on the top right section of the page then selecting **Environment Variables**, or you can go directly to the environment variables page by using the following URL (remember to fill in your username): `https://circleci.com/gh/your-github-username/digital-ocean-kubernetes-deploy/edit#env-vars`. Press **Add Variable** to create new environment variables.

First, add two environment variables called `DOCKERHUB_USERNAME` and `DOCKERHUB_PASS` which will be needed later on to push the image to Docker Hub. Set the values to your Docker Hub username and password, respectively.

Then add three more: `KUBERNETES_TOKEN`, `KUBERNETES_SERVER`, and `KUBERNETES_CLUSTER_CERTIFICATE`.

The value of `KUBERNETES_TOKEN` will be the value of the local environment variable you used earlier to authenticate on your Kubernetes cluster using your Service Account user. If you have closed the terminal, you can always run the following command to retrieve it again:

```
$ kubectl get secret $(kubectl get secret | grep cicd-token | awk '{print $1}') -o jsc
```

`KUBERNETES_SERVER` will be the string you passed as the `--server` flag to `kubectl` when you logged in with your `cicd` Service Account. You can find this after `server:` in the `~/.kube/config` file, or in the file `kubernetes-deployment-tutorial-kubeconfig.yaml` downloaded from the DigitalOcean dashboard when you made the initial setup of your Kubernetes cluster.

`KUBERNETES_CLUSTER_CERTIFICATE` should also be available on your `~/.kube/config` file. It's the `certificate-authority-data` field on the `clusters` item related to your cluster. It should be a long string; make sure to copy all of it.

Those environment variables must be defined here because most of them contain sensitive information, and it is not secure to place them directly on the CircleCI YAML config file.

With CircleCI listening for changes on your repository, and the environment variables configured, it's time to create the configuration file.

Make a directory called `.circleci` inside your sample application repository:

```
$ mkdir ~/do-sample-app/.circleci/
```

Inside this directory, create a file named `config.yml` and open it with your favorite editor:

```
$ nano ~/do-sample-app/.circleci/config.yml
```

Add the following content to the file, making sure to replace `dockerhub-username` with your Docker Hub username:

~/do-sample-app/.circleci/config.yml

```
version: 2.1
jobs:
  build:
    docker:

      - image: circleci/buildpack-deps:stretch
    environment:
```

```
      IMAGE_NAME: dockerhub-username/do-kubernetes-sample-app
    working_directory: ~/app
    steps:
      - checkout
      - setup_remote_docker
      - run:
          name: Build Docker image
          command: |
            docker build -t $IMAGE_NAME:latest .
      - run:
          name: Push Docker Image
          command: |
            echo "$DOCKERHUB_PASS" | docker login -u "$DOCKERHUB_USERNAME" --password-
            docker push $IMAGE_NAME:latest
workflows:
  version: 2
  build-master:
    jobs:
      - build:
          filters:
            branches:
              only: master
```

This sets up a Workflow with a single job, called `build`, that runs for every commit to the `master` branch. This job is using the image `circleci/buildpack-deps:stretch` to run its steps, which is an image from CircleCI based on the official `buildpack-deps` Docker image, but with some extra tools installed, like Docker binaries themselves.

The workflow has four steps:

- `checkout` retrieves the code from GitHub.
- `setup_remote_docker` sets up a remote, isolated environment for each build. This is required before you use any `docker` command inside a job step. This is necessary because as the steps are running inside a docker image, `setup_remote_docker` allocates another machine to run the commands there.
- The first `run` step builds the image, as you did previously locally. For that you are using the environment variable you declared in `environment:`, `IMAGE_NAME` (remember to change the highlighted section with your own information).

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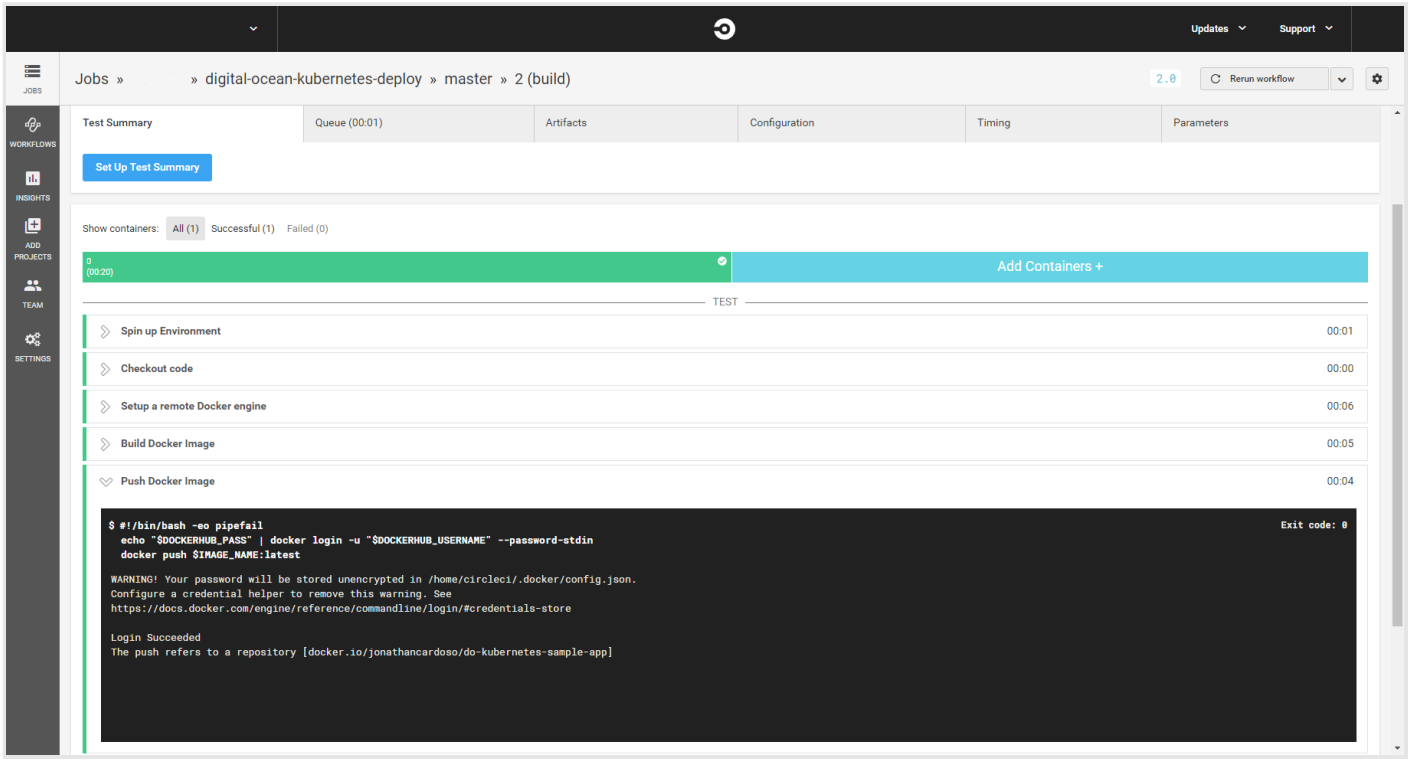
- The last `run` step pushes the image to Dockerhub, using the environment variables you configured on the project settings to authenticate.

Commit the new file to your repository and push the changes upstream:

```
$ cd ~/do-sample-app/
$ git add .circleci/
$ git commit -m "add CircleCI config"
$ git push
```

This will trigger a new build on CircleCI. The CircleCI workflow is going to correctly build and push your image to Docker Hub.



Now that you have created and tested your CircleCI workflow, you can set your DOKS cluster to retrieve the up-to-date image from Docker Hub and deploy it automatically when changes are made.

Step 8 — Updating the Deployment on the Kubernetes Cluster

Now that your application image is being built and sent to Docker Hub every time you push changes to the `master` branch on GitHub, it's time to update your deployment on your Kubernetes cluster so that it retrieves the new image and uses it as a base f

To do that, first fix one issue with your deployment: it's currently depending on an image with the `latest` tag. This tag does not tell us which version of the image you are using. You cannot easily lock your deployment to that tag because it's overwritten everytime you push a new image to Docker Hub, and by using it like that you lose one of the best things about having containerized applications: Reproducibility.

You can read more about that on this article about why depending on Docker latest tag is a anti-pattern.

To correct this, you first must make some changes to your `Push Docker Image` build step in the `~/do-sample-app/.circleci/config.yml` file. Open up the file:

```
$ nano ~/do-sample-app/.circleci/config.yml
```

Then add the highlighted lines to your `Push Docker Image` step:

~/do-sample-app/.circleci/config.yml:16-22

```
...
      - run:
          name: Push Docker Image
          command: |
            echo "$DOCKERHUB_PASS" | docker login -u "$DOCKERHUB_USERNAME" --password-
            docker tag $IMAGE_NAME:latest $IMAGE_NAME:$CIRCLE_SHA1
            docker push $IMAGE_NAME:latest
            docker push $IMAGE_NAME:$CIRCLE_SHA1
...
```

Save and exit the file.

CircleCI has some special environment variables set by default. One of them is `CIRCLE_SHA1`, which contains the hash of the commit it's building. The changes you made to `~/do-sample-app/.circleci/config.yml` will use this environment variable to tag your image with the commit it was built from, always tagging the most recent build with the latest tag. That way, you always have specific images available, without overwriting them when you push something new to your repository.

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Next, change your deployment manifest file to point to that file. This would be simple if inside `~/do-sample-app/kube/do-sample-deployment.yml` you could set your image as `dockerhub-username/do-kubernetes-sample-app:$COMMIT_SHA1`, but `kubectl` doesn't do variable substitution inside the manifests when you use `kubectl apply`. To account for this, you can use `envsubst`. `envsubst` is a cli tool, part of the GNU gettext project. It allows you to pass some text to it, and if it finds any variable inside the text that has a matching environment variable, it's replaced by the respective value. The resulting text is then returned as their output.

To use this, you will create a simple bash script which will be responsible for your deployment. Make a new folder called `scripts` inside `~/do-sample-app/`:

```
$ mkdir ~/do-sample-app/scripts/
```

Inside that folder create a new bash script called `ci-deploy.sh` and open it with your favorite text editor:

```
$ nano ~/do-sample-app/scripts/ci-deploy.sh
```

Inside it write the following bash script:

~/do-sample-app/scripts/ci-deploy.sh

```
#! /bin/bash
# exit script when any command ran here returns with non-zero exit code
set -e

COMMIT_SHA1=$CIRCLE_SHA1

# We must export it so it's available for envsubst
export COMMIT_SHA1=$COMMIT_SHA1

# since the only way for envsubst to work on files is using input/output redirection,
#  it's not possible to do in-place substitution, so we need to save the output to ano
#  and overwrite the original with that one.
envsubst <./kube/do-sample-deployment.yml >./kube/do-sample-deployment.yml.out
mv ./kube/do-sample-deployment.yml.out ./kube/do-sample-deployment.yml

echo "$KUBERNETES_CLUSTER_CERTIFICATE" | base64 --decode > cert.crt
```

```
./kubectl \
  --kubeconfig=/dev/null \
  --server=$KUBERNETES_SERVER \
  --certificate-authority=cert.crt \
  --token=$KUBERNETES_TOKEN \
  apply -f ./kube/
```

Let's go through this script, using the comments in the file. First, there is the following:

```
set -e
```

This line makes sure any failed command stops the execution of the bash script. That way if one command fails, the next ones are not executed.

```
COMMIT_SHA1=$CIRCLE_SHA1
export COMMIT_SHA1=$COMMIT_SHA1
```

These lines export the CircleCI `$CIRCLE_SHA1` environment variable with a new name. If you had just declared the variable without exporting it using `export`, it would not be visible for the `envsubst` command.

```
envsubst <./kube/do-sample-deployment.yml >./kube/do-sample-deployment.yml.out
mv ./kube/do-sample-deployment.yml.out ./kube/do-sample-deployment.yml
```

`envsubst` cannot do in-place substitution. That is, it cannot read the content of a file, replace the variables with their respective values, and write the output back to the same file. Therefore, you will redirect the output to another file and then overwrite the original file with the new one.

```
echo "$KUBERNETES_CLUSTER_CERTIFICATE" | base64 --decode > cert.crt
```

The environment variable `$KUBERNETES_CLUSTER_CERTIFICATE` you created earlier on CircleCI's project settings is in reality a Base64 encoded string. To use it with `kubectl` you must decode its contents and save it to a file. In this case you are saving it t

`cert.crt` inside the current working directory.

```
./kubectl \
  --kubeconfig=/dev/null \
  --server=$KUBERNETES_SERVER \
  --certificate-authority=cert.crt \
  --token=$KUBERNETES_TOKEN \
  apply -f ./kube/
```

Finally, you are running `kubectl`. The command has similar arguments to the one you ran when you were testing your Service Account. You are calling `apply -f ./kube/`, since on CircleCI the current working directory is the root folder of your project. `./kube/` here is your `~/do-sample-app/kube` folder.

Save the file and make sure it's executable:

```
$ chmod +x ~/do-sample-app/scripts/ci-deploy.sh
```

Now, edit `~/do-sample-app/kube/do-sample-deployment.yml`:

```
$ nano ~/do-sample-app/kube/do-sample-deployment.yml
```

Change the tag of the container image value to look like the following one:

~/do-sample-app/kube/do-sample-deployment.yml

```
# ...
containers:
  - name: do-kubernetes-sample-app
    image: dockerhub-username/do-kubernetes-sample-app:$COMMIT_SHA1
    ports:
      - containerPort: 80
        name: http
```

Save and close the file. You must now add some new steps to your CI configuration file to update the deployment on Kubernetes.

Open `~/do-sample-app/.circleci/config.yml` on your favorite text editor:

```
$ nano ~/do-sample-app/.circleci/config.yml
```

Write the following new steps, right below the `Push Docker Image` one you had before:

~/do-sample-app/.circleci/config.yml

```
...
      - run:
          name: Install envsubst
          command: |
            sudo apt-get update && sudo apt-get -y install gettext-base
      - run:
          name: Install kubectl
          command: |
            curl -LO https://storage.googleapis.com/kubernetes-release/release/$(curl
            chmod u+x ./kubectl
      - run:
          name: Deploy Code
          command: ./scripts/ci-deploy.sh
```

The first two steps are installing some dependencies, first `envsubst`, and then `kubectl`. The `Deploy Code` step is responsible for running our deploy script.

To make sure the changes are really going to be reflected on your Kubernetes deployment, edit your `index.html`. Change the HTML to something else, like:

~/do-sample-app/index.html

```
<!DOCTYPE html>
<title>DigitalOcean</title>
<body>
  Automatic Deployment is Working!
</body>
```

Once you have saved the above change, commit all the modified files to the repository, and push the changes upstream:

```
$ cd ~/do-sample-app/
$ git add --all
$ git commit -m "add deploy script and add new steps to circleci co
```

```
$ git push
```

You will see the new build running on CircleCI, and successfully deploying the changes to your Kubernetes cluster.

Wait for the build to finish, then run the same command you ran previously:

```
$ kubectl port-forward $(kubectl get pod --selector="app=do-kubernetes-sample-app" --c
```

Make sure everything is working by opening your browser on the URL `localhost:8080` or by making a `curl` request to it. It should show the updated HTML:

```
$ curl localhost:8080
```

You will receive the following output:

```
Output
<!DOCTYPE html>
<title>DigitalOcean</title>
<body>
  Automatic Deployment is Working!
</body>
```

Congratulations, you have set up automated deployment with CircleCI!

Conclusion

This was a basic tutorial on how to do deployments to DigitalOcean Kubernetes using CircleCI. From here, you can improve your pipeline in many ways. The first thing you can do is create a single `build` job for multiple deployments, each one deploying to different Kubernetes clusters or different namespaces. This can be extremely useful when you have different Git branches for development/staging/production environments, ensuring that the deployments are always separated.

You could also build your own image to be used on CircleCI, instead of using `buildpack-deps`. This image could be based on it, but could already have `kubectl` and

dependencies installed.

If you would like to learn more about CI/CD on Kubernetes, check out the tutorials for our CI/CD on Kubernetes Webinar Series, or for more information about apps on Kubernetes, see Modernizing Applications for Kubernetes.

By Jonathan Cardoso

Editor: Timothy Nolan

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klaudioz *May 2, 2019*

0 This process is not working for me at the last step:

- run: name: Deploy Code command: ./scripts/ci-deploy.sh

I got file not found all the time. So i tried the following trying to find the file:

sudo find / -type f -name “ci-deploy.sh” -exec ’{}’ ’;’

And the file doesn’t exist but I can see it in my github repo, folder scripts. Please help me with this issue.

jonathancardoso *May 2, 2019*

0 Hi @klaudioz

is the repo public? If yes can you share a link to it?

Make sure you have the `checkout` step, and that the file is executable

klaudioz *May 3, 2019*

0 Thank for your answer. My repository is: https://github.com/Klaudioz/resumeyaml-container

I fixed the issue replacing:

command: ./scripts/ci-deploy.sh

with:

command: |
curl -O https://raw.githubusercontent.com/Klaudioz/resumeyaml-container/master/scripts/ci-deploy.sh
chmod u+x ./ci-deploy.sh
./ci-deploy.sh

Basically getting the file directly but when the deployment process run the file ./ci-deploy.sh I’m getting again the same issue:

./ci-deploy.sh: line 13: ./kube/do-sample-deployment.yml: No such fi

Exited with code 1

It looks like CircleCI is not getting the files from my repository.

Thanks for your reply.

curl -O https://raw.githubusercontent.com/Klaudioz/resumeyaml-container/master/scripts/ci-deploy.sh

klaudioz *May 3, 2019*

0 Thanks for your help, you were right about the checkout step.

Right now I'm still having issue running ci-deploy.sh.

I'm getting:

unable to recognize "kube/do-sample-deployment.yml": Unauthorized
unable to recognize "kube/do-sample-service.yml": Unauthorized
Exited with code 1

My repo is: https://github.com/Klaudioz/resumeyaml-container

Thanks.

jonathancardoso *May 3, 2019*

0 This error probably means the `kubectl` cli could not authenticate with the server, make sure you have created the environment variables `KUBERNETES_TOKEN`, `KUBERNETES_SERVER` and `KUBERNETES_CLUSTER_CERTIFICATE` on CircleCI project settings and set their values correctly.

You should be able to test locally if the ./script/ci-deploy.sh works by running it passing the required environment variables:

```
cd your-project-folder
export CIRCLE_SHA1="commit-sha-1"
export KUBERNETES_CLUSTER_CERTIFICATE="the long string"
export KUBERNETES_SERVER="your Kubernetes server URL"
export KUBERNETES_TOKEN="the service account token"
./scripts/ci-deploy.sh
```

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klaudioz *May 4, 2019*

0 Thanks for your answer.

I double checked the environment variables over CircleCI and I'm very sure these are fine. Also I tried locally and I got the following error:

error: certificate-authority-data and certificate-authority are both specified for do-sfo2-k8s-cluster. certificate-authority-data will override.

jonathancardoso *May 4, 2019*

0 @klaudioz that is weird, can you verify if you can run this? (answering here because we hit the thread limit)

```
./kubectl --kubeconfig=/dev/null --server=$KUBERNETES_SERVER --certi
```

klaudioz *May 6, 2019*

0 Thanks, I tried two things:

kubectl –kubeconfig=/dev/null –server=$KUBERNETES*SERVER –certificate-authority=cert.crt –token=$KUBERNETES*TOKEN get nodes
error: You must be logged in to the server (Unauthorized)

kubectl –server=$KUBERNETES*SERVER –certificate-authority=cert.crt –token=$KUBERNETES*TOKEN get nodes
error: certificate-authority-data and certificate-authority are both specified for do-sfo2-k8s-cluster. certificate-authority-data will override.

kubectl is linked with my DO k8s cluster right now.

jonathancardoso *May 6, 2019*

0 Thanks, I tried two things:

> kubectl –kubeconfig=/dev/null –server=$KUBERNETESSERVER –certificate-authority=cert.crt –token=$KUBERNETESTOKEN get nodes
> error: You must be logged in to the server (Unauthorized)
>
> kubectl –server=$KUBERNETESSERVER –certificate-authority=cert.crt –token=$KUBERNETESTOKEN get nodes
> error: certificate-authority-data and certificate-authority are both specified for do-sfo2-k8s-cluster. certificate-authority-data will override.
>
> kubectl is linked with my DO k8s cluster right now.

This means the token stored on `$KUBERNETESTOKEN` is invalid, make sure it's correct, see the steps above to retrieve it again.

The second step shows another error because you omitted the `--kubeconfig=/dev/null`, and so it's going to read your `~/.kube/config` file. You should always pass `--kubeconfig=/dev/null` when passing the other parameters directly, to not mix with the data on your config file.

klaudioz *May 6, 2019*

0

If I do:

TOKEN=$(kubectl get secret $(kubectl get secret | grep cicd-token | awk '{print $1}') -o jsonpath='{.data.token}' | base64 –decode)

or echo $KUBERNETES_TOKEN I got the same.

If I do:

kubectl –kubeconfig=/dev/null –server=$KUBERNETES*SERVER –certificate-authority=cert.crt –token=$KUBERNETES*TOKEN get nodes

I got:

error: You must be logged in to the server (Unauthorized)

I can run normal kubectl commands without any issue:

kubectl get nodes
NAME STATUS ROLES AGE VERSION
pool-kul6sprkq-qkna Ready <none> 4d21h v1.14.1

kubectl get services
NAME TYPE CLUSTER-IP EXTERNAL-IP PORT(S) AGE
kubernetes ClusterIP 10.245.0.1 <none> 443/TCP 4d21h
resumeyaml ClusterIP 10.245.219.89 <none> 4000/TCP 4d20h
kubectl get pods
NAME READY STATUS RESTARTS AGE
resumeyaml-57df795c4d-dsm9s 0/1 InvalidImageName 0 3d21h
resumeyaml-85d5f45d9b-65r5h 1/1 Running 0 4d20h

tapanhalani *June 24, 2019*

0 This process works perfectly on my system, and is actually a solution I am looking for my CI/CD setup on DO kubernetes cluster. But I have read in DO k8s known- issues that the DigitalOcean cluster's certificate-authority-data, client-certificate and client-key, all of which present in kubeconfig as you mentioned, are auto-rotated every 7 days.

Sources:

(1.)https://www.digitalocean.com/docs/kubernetes/overview/#known-issues
(2.) https://www.digitalocean.com/community/questions/can-i-stop-my-kubeconfig-file-from-expiring-every-7-days

If this is the scenario, then we also need to automate downloading new kubeconfig every 6 days, and modify the certificate-authority-data that will be used in kubectl to deploy/upgrade.

Am I correct with this conclusion ? I basically don't want to use doctl along with kubectl to allow kubectl to connect without having the headache of certificate management. Is there any other solution for certificate-management with kubectl and DO clusters?

jonathancardoso *June 25, 2019*

1 Hi @tapanhalani, glad you liked the post.

About the certificate, I had the cluster I used while writing this article running for more than 1 month without having to do anything else. The only part that is used from the original kubeconfig is the `certificate-authority-data`, the other details come from the service account token.

I'm pretty sure at the time of writing this, the `certificate-authority-d` rotated, and if it was, it didn't impact on the deployment.

If you do find problems, one solution that would not require any additional step, is to just disable the certificate validation by adding `--insecure-skip-tls-verify` to `kubectl`.

Other option, is to use `doctl` on CI to retrieve an updated `kubeconfig` and retrieve the `certificate-authority-data` from there, instead of using an environment variable on CircleCI.

Let me know if you have any other questions

> tapanhalani *June 25, 2019*
>
> 0 Thank you @jonathancardoso for the insight. I will definitely use the service account token approach firstly.

ckwagaba *July 19, 2019*

1 Saved my day! :clap: :clap:

ckwagaba *July 29, 2019*

1 Thanks for this.
Works perfectly well - was actually using this on a different cloud provider ;-)

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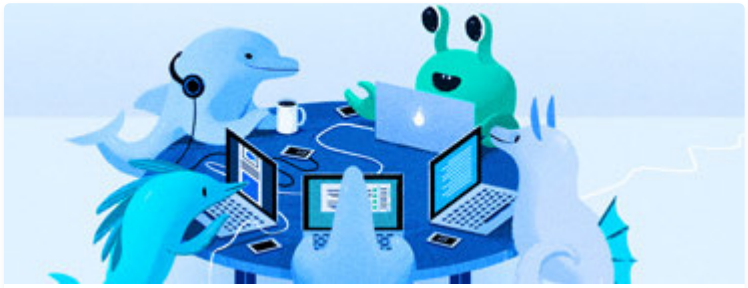

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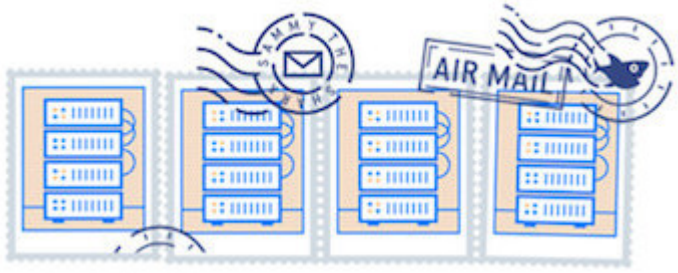

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