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GitOps Cookbook

Kubernetes Automation in Practice

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GitOps Cookbook

Kubernetes Automation in Practice

Natale Vinto and Alex Soto Bueno



Beijing • Boston • Farnham • Sebastopol • Tokyo

GitOps Cookbook

by Natale Vinto and Alex Soto Bueno

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[LSI]

Dedication

To Alessia and Sofia, the most beautiful chapters of my life.

—Natale

[Ada i Alexandra] Sabeu que sou flipants, encara que sortiu del fang.

—Alex

Foreword

A few years ago, during a trip to Milan for a Red Hat event, I ran into a passionate colleague at the Red Hat office. We spoke at length about how customers in Italy adopt containers to speed up application development on OpenShift. While his name slipped my mind at the time, his enthusiasm about the subject didn't, especially since he was also hospitable enough to take me to an espresso bar near the office to show me what real coffee tastes like. A while later, I was introduced to a developer advocate in a meeting who would speak at a conference about CI/CD using products like OpenShift Pipelines and OpenShift GitOps that my teams delivered at the time. At that moment, I instantly recognized Natale. Many who attended that talk thought it was insightful, given his firsthand grasp of challenges that customers experience when delivering applications and his hands-on approach to technology.

Application delivery is a complex process involving many systems and teams with numerous handoffs between these parties, often synonymous with delays and back-and-forth talks at each point. Automation has long been a key enabler for improving this process and has become particularly popular within the DevOps movement. Continuous integration, infrastructure as code, and numerous other practices became common in many organizations as they navigated their journey toward adopting DevOps.

More recently, and coinciding with the increased adoption of Kubernetes, GitOps as a blueprint for implementing a subset of DevOps practices has become an area I frequently get asked about. While neither the term nor the practices GitOps advocates are new, it does combine. It presents the existing knowledge in a workflow that is simple, easy to understand, and can be implemented in a standard way across many teams.

Although the path to adopting the GitOps workflow is simple and concrete, many technical choices need to be made to fit within each organization's security, compliance, operational, and other requirements. Therefore, I am particularly thrilled about the existence of this book and the practical guides

it provides to assist these teams in making choices that are right for their applications, teams, and organizations.

Siamak Sadeghianfar

Product Management, Red Hat

Preface

We wrote this book for builders. Whether you are a developer, DevOps engineer, site reliability engineer (SRE), or platform engineer dealing with Kubernetes, you are building some good stuff. We would like to share our experience from what we have learned in the field and in the community about the latest Kubernetes automation insights for pipelines and CI/CD workloads. The book contains a comprehensive list of the most popular available software and tools in the Kubernetes and cloud native ecosystem for this purpose. We aim to provide a list of practical recipes that might help your daily job or are worth exploring further. We are not sticking to a particular technology or project for implementing Kubernetes automation. However, we are opinionated on some of our choices to deliver a concise GitOps pathway.

The book is organized in sequential chapters, from the basics to advanced topics in the Kubernetes ecosystem, following the GitOps principles. We hope you'll find these recipes valuable and inspiring for your projects!

- [Chapter 1](#) is an introduction to GitOps principles and why they are continuously becoming more common and essential for any new IT project.
- [Chapter 2](#) covers the installation requirements to run these recipes in a Kubernetes cluster. Concepts and tools like Git, Container Registry, Container Runtime, and Kubernetes are necessary for this journey.
- [Chapter 3](#) walks you through a complete overview of containers and why they are essential for application development and deployment today. Kubernetes is a container-orchestration platform; however, it doesn't build containers out of the box. Therefore, we'll provide a list of practical recipes for making container apps with the most popular tools available in the cloud native community.

- [Chapter 4](#) gives you an overview of Kustomize, a popular tool for managing Kubernetes resources. Kustomize is interoperable, and you find it often used within CI/CD pipelines.
- [Chapter 5](#) explores Helm, a trendy tool to package applications in Kubernetes. Helm is also a templating system that you can use to deploy apps in CI/CD workloads.
- [Chapter 6](#) walks you through cloud native CI/CD systems for Kubernetes. It gives a comprehensive list of recipes for the continuous integration part with Tekton, the Kubernetes-native CI/CD system. Additionally, it also covers other tools such as Drone and GitHub Actions.
- [Chapter 7](#) kicks off the pure GitOps part of the book as it sticks to the Continuous Deployment phase with Argo CD, a popular GitOps tool for Kubernetes.
- [Chapter 8](#) goes into the advanced topics for GitOps with Argo CD, such as secrets management, progressive application delivery, and multicloud deployments. This concludes the most common use cases and architectures you will likely work with today and tomorrow following the GitOps approach.

Conventions Used in This Book

The following typographical conventions are used in this book:

Italic

Indicates new terms, URLs, email addresses, filenames, and file extensions.

Constant width

Used for program listings, as well as within paragraphs to refer to program elements such as variable or function names, databases, data types, environment variables, statements, and keywords.

Constant width bold

Shows commands or other text that should be typed literally by the user.

Constant width italic

Shows text that should be replaced with user-supplied values or by values determined by context.

TIP

This element signifies a tip or suggestion.

NOTE

This element signifies a general note.

WARNING

This element indicates a warning or caution.

Using Code Examples

Supplemental material (code examples, exercises, etc.) is available for download at <https://github.com/gitops-cookbook>.

If you have a technical question or a problem using the code examples, please send email to bookquestions@oreilly.com.

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Alex Soto

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Last but certainly not least, I'd like to acknowledge Anna for being here; my parents Mili and Ramon for buying my first computer; my daughters Ada and Alexandra, "sou les ninetes dels meus ulls."

Natale Vinto

Special thanks to Alessia for the patience and motivation that helped me while writing this book. And to my parents for everything they made for me, grazie mamma e papà, you are the best!

Chapter 1. Introduction

With the advent of practices such as infrastructure as code (IaC), software development has pushed the boundaries of platforms where you can run applications. This becomes more frequent with programmable, API-driven platforms such as public clouds and open source infrastructure solutions. While some years ago developers were only focusing on application source code, today they also have the opportunity to code the infrastructure where their application will run. This gives control and enables automation, which significantly reduces lead time.

A good example is with Kubernetes, a popular open source container workload orchestration platform and the de facto standard for running production applications, either on public or private clouds. The openness and extensibility of the platform enables automation, which reduces risks of delivery and increases service quality. Furthermore, this powerful paradigm is extended by another increasingly popular approach called GitOps.

1.1 What Is GitOps?

GitOps is a methodology and practice that uses Git repositories as a single source of truth to deliver infrastructure as code. It takes the pillars and approaches from DevOps culture and provides a framework to start realizing the results. The relationship between DevOps and GitOps is close, as GitOps has become the popular choice to implement and enhance DevOps, platform engineering, and SRE.

GitOps is an agnostic approach, and a GitOps framework can be built with tools such as Git, Kubernetes, and CI/CD solutions. The three main pillars of GitOps are:

- Git is the single source of truth
- Treat everything as code

- Operations are performed through Git workflows

There is an active community around GitOps, and the [GitOps Working Group](#) defines a set of GitOps Principles (currently in version 1.0.0) available at [OpenGitOps](#):

Declarative

A system managed by GitOps must have its desired state expressed declaratively.

Versioned and immutable

The desired state is stored in a way that enforces immutability and versioning and retains a complete version history.

Pulled automatically

Software agents automatically pull the desired state declarations from the source.

Continuously reconciled

Software agents continuously observe the actual system state and attempt to apply the desired state.

1.2 Why GitOps?

Using the common Git-based workflows that developers are familiar with, GitOps expands upon existing processes from application development to deployment, app lifecycle management, and infrastructure configuration.

Every change throughout the application lifecycle is traced in the Git repository and is auditable. This approach is beneficial for both developers and operations teams as it enhances the ability to trace and reproduce issues quickly, improving overall security. One key point is to reduce the risk of unwanted changes (drift) and correct them before they go into production.

Here is a summary of the benefits of the GitOps adoption in four key aspects:

Standard workflow

Use familiar tools and Git workflows from application development teams

Enhanced security

Review changes beforehand, detect configuration drifts, and take action

Visibility and audit

Capture and trace any change to clusters through Git history

Multicloud consistency

Reliably and consistently configure multiple environments and multiple Kubernetes clusters and deployment

1.3 Kubernetes CI/CD

Continuous integration (CI) and continuous delivery (CD) are methods used to frequently deliver apps by introducing automation into the stages of app development. CI/CD pipelines are one of the most common use cases for GitOps.

In a typical CI/CD pipeline, submitted code checks the CI process while the CD process checks and applies requirements for things like security, infrastructure as code, or any other boundaries set for the application framework. All code changes are tracked, making updates easy while also providing version control should a rollback be needed. CD is the GitOps domain and it works together with the CI part to deploy apps in multiple environments, as you can see in [Figure 1-1](#).

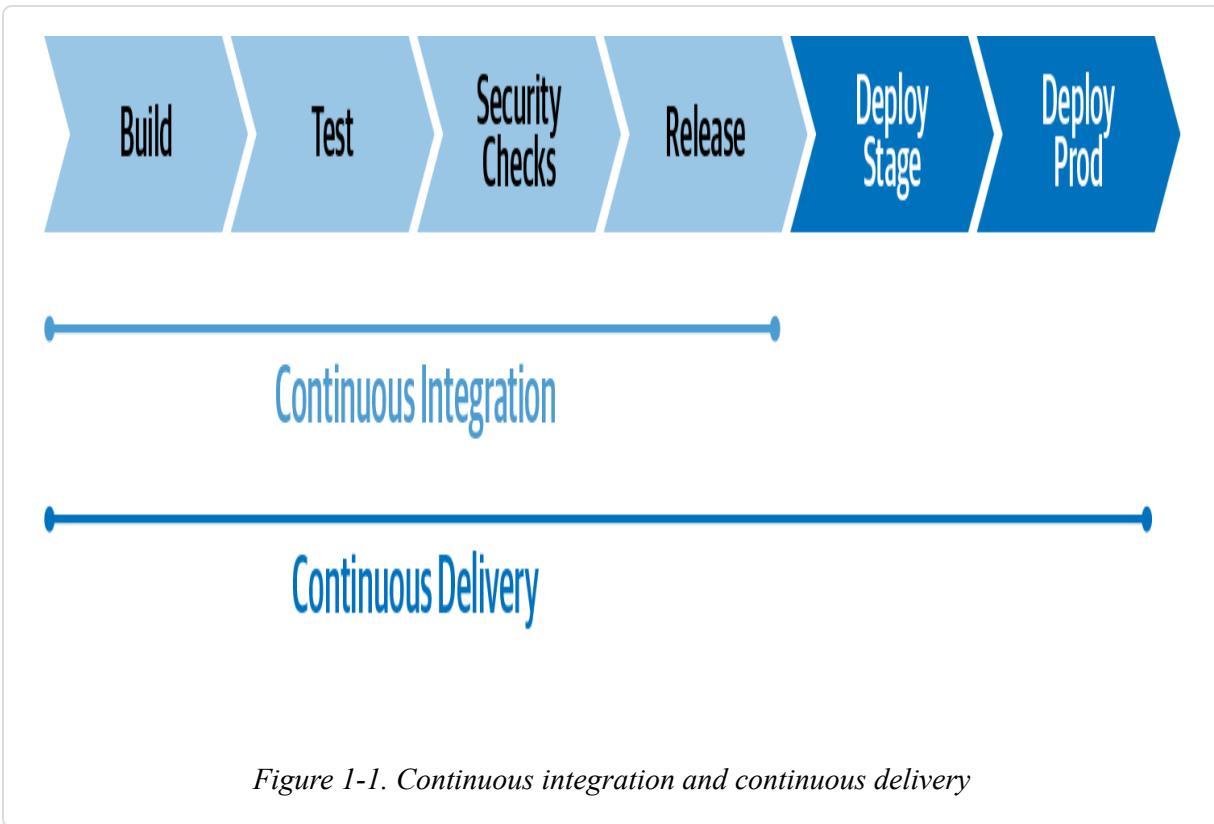


Figure 1-1. Continuous integration and continuous delivery

With Kubernetes, it's easy to implement an in-cluster CI/CD pipeline. You can have CI software create the container image representing your application and store it in a container image registry. Afterward, a Git workflow such as a pull request can change the Kubernetes manifests illustrating the deployment of your apps and start a CD sync loop, as shown in [Figure 1-2](#).

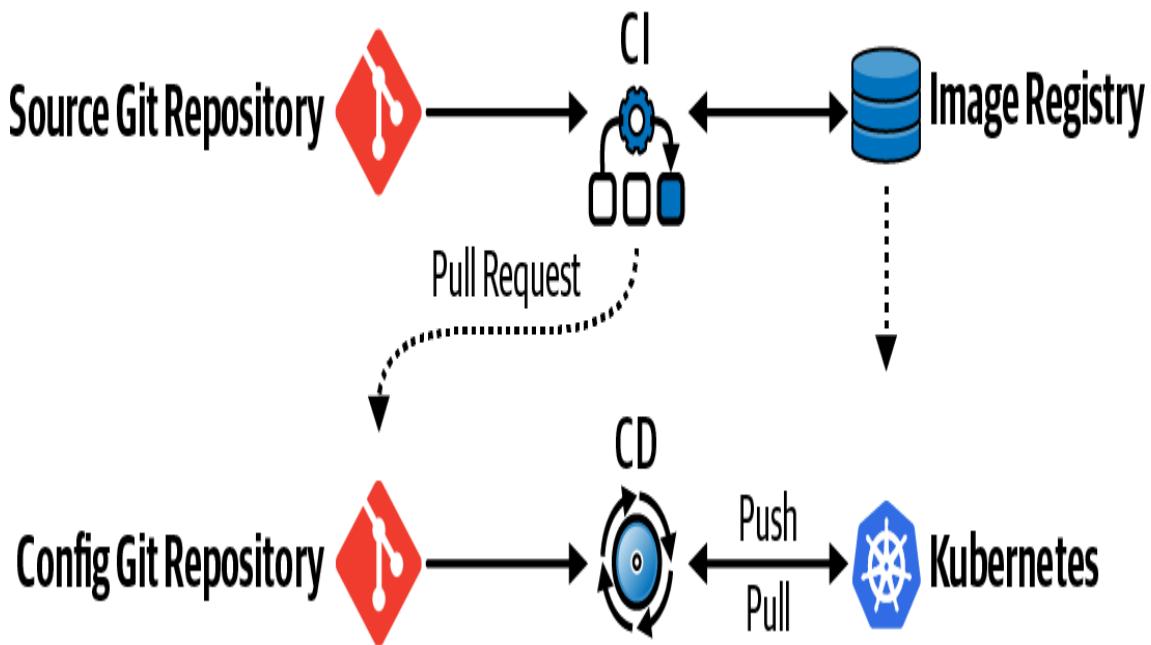


Figure 1-2. Application deployment model

This cookbook will show practical recipes for implementing this model on Kubernetes acting as a CI/CD and GitOps platform.

1.4 App Deployment with GitOps on Kubernetes

As GitOps is an agnostic, platform-independent approach, the application deployment model on Kubernetes can be either in-cluster or multicloud. An external GitOps tool can use Kubernetes just as a target platform for deploying apps. At the same time, in-cluster approaches run a GitOps engine inside Kubernetes to deploy apps and sync manifests in one or more Kubernetes clusters.

The GitOps engine takes care of the CD part of the CI/CD pipeline and accomplishes a GitOps loop, which is composed of four main actions as shown in [Figure 1-3](#):

Deploy

Deploy the manifests from Git.

Monitor

Monitor either the Git repo or the cluster state.

Detect drift

Detect any change from what is described in Git and what is present in the cluster.

Take action

Perform an action that reflects what is on Git (rollback or three-way diff). Git is the source of truth, and any change is performed via a Git workflow.

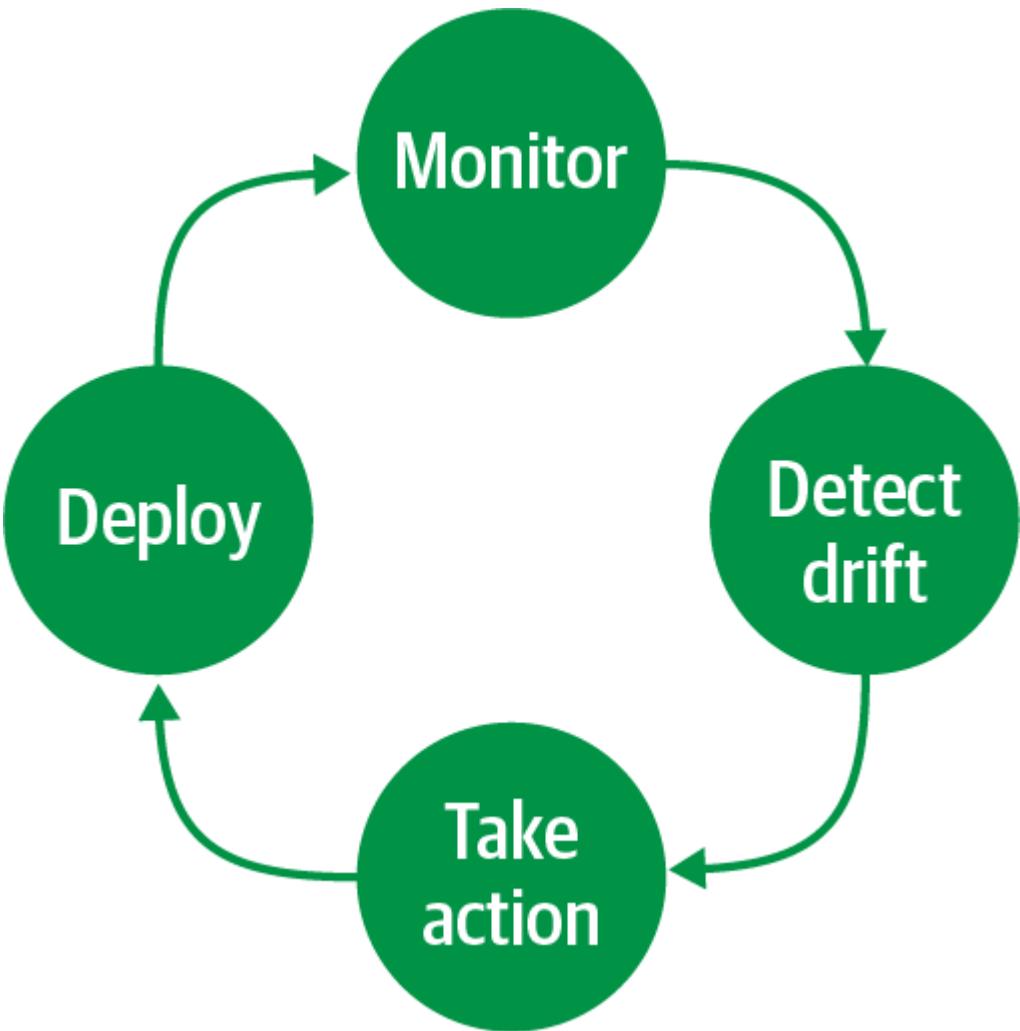


Figure 1-3. GitOps loop

In Kubernetes, application deployment using the GitOps approach makes use of at least two Git repositories: one for the app source code, and one for the Kubernetes manifests describing the app's deployment (Deployment, Service, etc.).

[Figure 1-4](#) illustrates the structure of a GitOps project on Kubernetes.

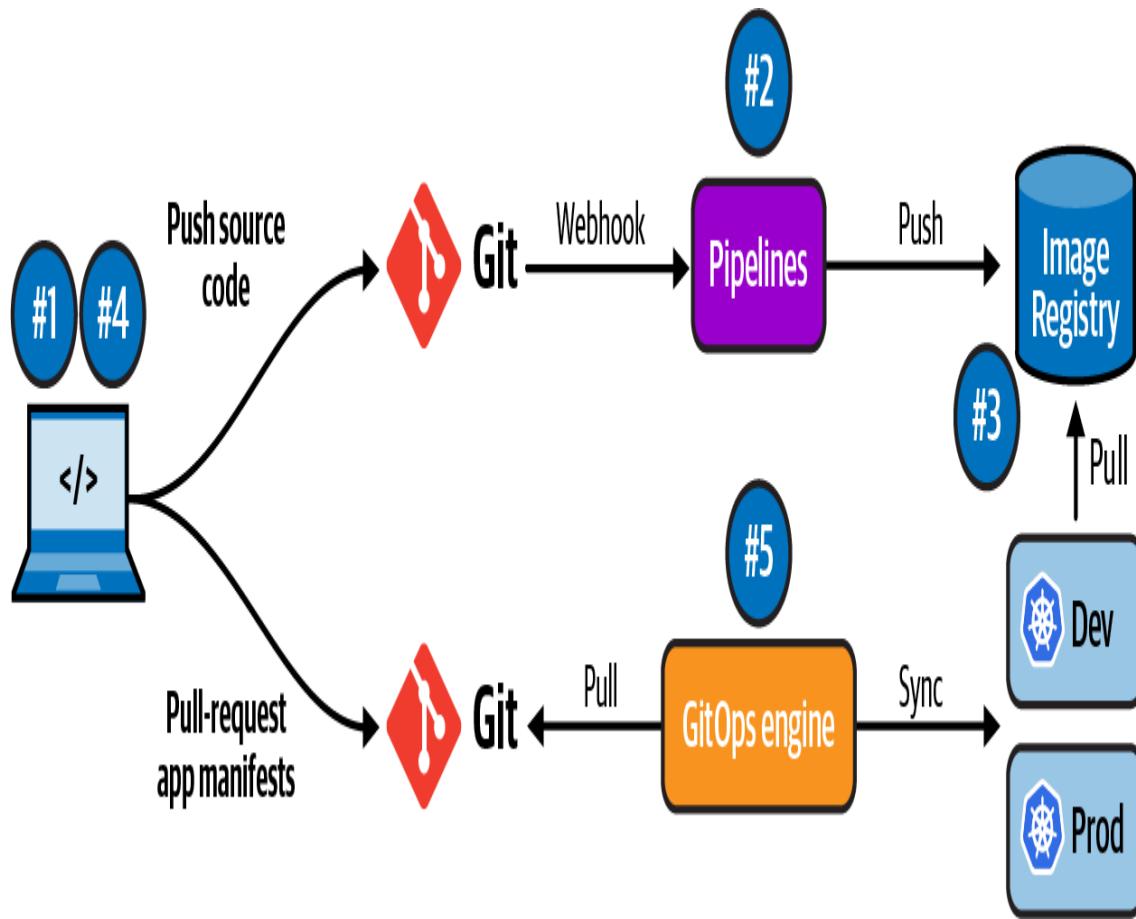


Figure 1-4. Kubernetes GitOps loop

The following list outlines the items in the workflow:

1. App source code repository
2. CI pipeline creating a container image
3. Container image registry
4. Kubernetes manifests repository
5. GitOps engine syncing manifests to one or more clusters and detecting drifts

1.5 DevOps and Agility

GitOps is a developer-centric approach to continuous delivery and infrastructure operations, and a developer workflow through Git for automating processes. As DevOps is complementary to Agile software development, GitOps is complementary to DevOps for infrastructure automation and application lifecycle management. As you can see in [Figure 1-5](#), it's a developer workflow for automating operations.

One of the most critical aspects of the Agile methodology is to reduce the [lead time](#), which is described more abstractly as the time elapsed between identifying a requirement and its fulfillment.

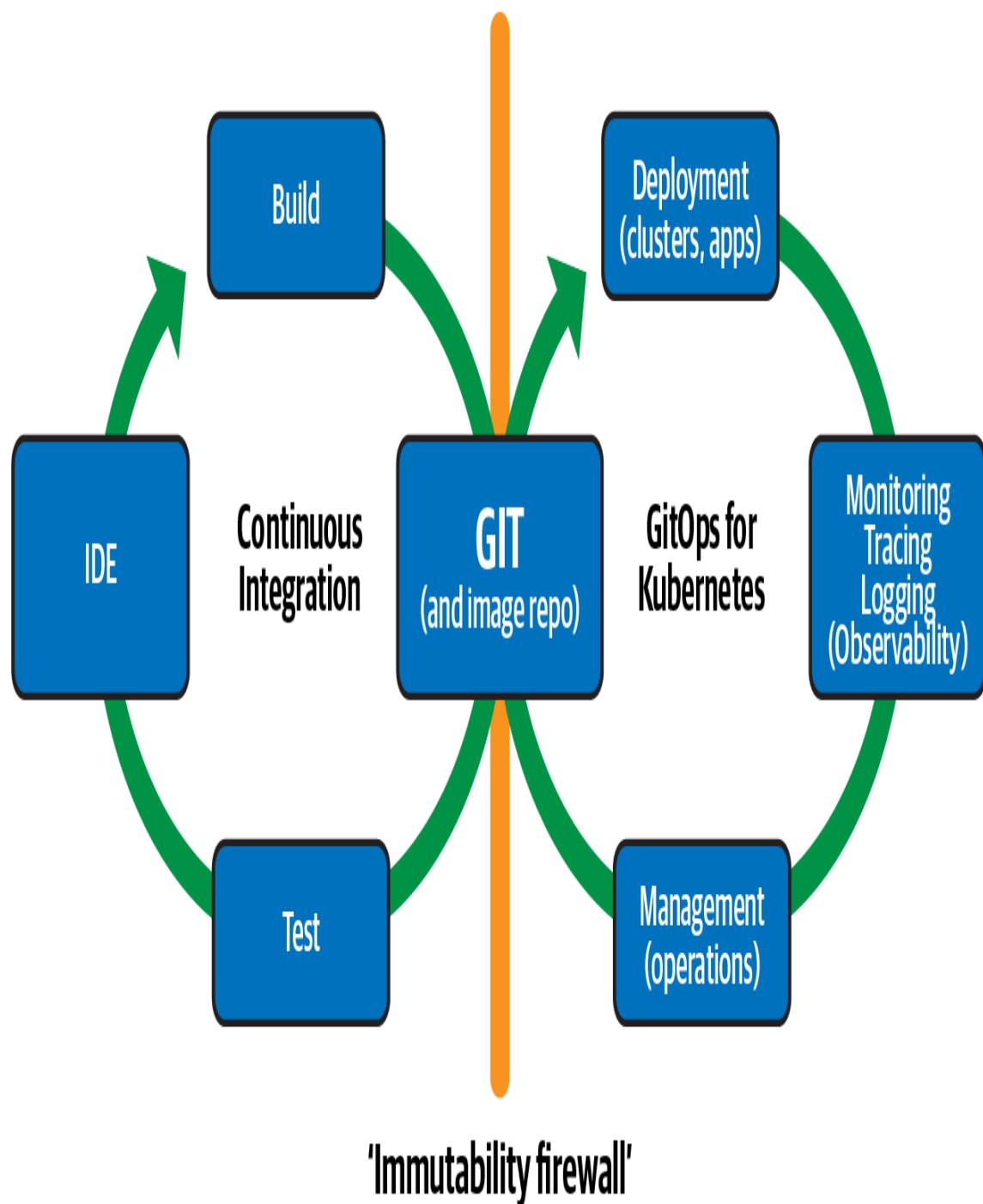


Figure 1-5. GitOps development cycle

Reducing this time is fundamental and requires a cultural change in IT organizations. Seeing applications live provides developers with a feedback loop to redesign and improve their code and make their projects thrive.

Similarly to DevOps, GitOps also requires a cultural adoption in business processes. Every operation, such as application deployment or infrastructure change, is only possible through Git workflows. And sometimes, this means a cultural shift.

The [“Teaching Elephants to Dance \(and Fly!\)](#) speech from Burr Sutter gives a clear idea of the context. The elephant is where your organization is today. There are phases of change between traditional and modern environments powered by GitOps tools. Some organizations have the luxury of starting from scratch, but for many businesses, the challenge is teaching their lumbering elephant to dance like a graceful ballerina.

Chapter 2. Requirements

This book is about GitOps and Kubernetes, and as such, you'll need a container registry to publish the containers built throughout the book (see [Recipe 2.1](#)).

Also, a Git service is required to implement GitOps methodologies; you'll learn how to register to public Git services like GitHub or GitLab (see [Recipe 2.2](#)).

Finally, it would be best to have a Kubernetes cluster to run the book examples. Although we'll show you how to install Minikube as a Kubernetes cluster (see [Recipe 2.3](#)), and the book is tested with Minikube, any Kubernetes installation should work as well.

Let's prepare your laptop to execute the recipes provided in this book.

2.1 Registering for a Container Registry

Problem

You want to create an account for a container registry service so you can store generated containers.

Solution

You may need to publish some containers into a public container registry as you work through this book. Use Docker Hub (`docker.io`) to publish containers.

If you already have an account with `docker.io`, you can skip the following steps. Otherwise, keep reading to learn how to sign up for an account.

Discussion

Visit [DockerHub](#) to sign up for an account. The page should be similar to [Figure 2-1](#).



Search for great content (e.g., mysql)

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Build and Ship any Application Anywhere

Docker Hub is the world's easiest way to create, manage, and deliver your teams' container applications.

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Already have an account? [Sign In](#)

Docker ID

Email

Password



Send me occasional product updates and announcements.

I agree to the [Subscription Service Agreement](#), [Privacy Policy](#), and [Data Processing Terms](#).

I'm not a robot



reCAPTCHA
Privacy - Terms

Sign Up

Figure 2-1. DockerHub registration page

When the page is loaded, fill in the form by setting a Docker ID, Email, and Password, and click the Sign Up button.

When you are registered and your account confirmed, you'll be ready to publish containers under the previous step's Docker ID.

See Also

Another popular container registry service is quay.io. It can be used on the cloud (like docker.io) or installed on-premises.

Visit [the website](#) to get more information about Quay. The page should be similar to [Figure 2-2](#).



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SIGN IN

Quay.io now supports Red Hat Single Sign-On Services exclusively. If you haven't done so already, you need to link your Quay.io login to a redhat.com account in order to be able to login to the web interface by going to the recovery endpoint. CLI tokens and robot accounts are not impacted. Read more about this change in the FAQ.

Quay [builds, analyzes, distributes] your container images

TRY FOR FREE ON PREMISES

TRY FOR FREE ON CLOUD



podman



docker



Orkt



Figure 2-2. Quay registration page

2.2 Registering for a Git Repository

Problem

You want to create an account for a Git service so you can store source code in a repository.

Solution

You may need to publish some source code into a public Git service in this book. Use GitHub as a Git service to create and fork Git repositories.

If you already have an account with GitHub, you can skip the following steps, otherwise keep reading to learn how to sign up for an account.

Discussion

Visit the [GitHub web page](#) to sign up for an account. The page should be similar to [Figure 2-3](#).



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Sign in

Sign up

Where the world builds software

Millions of developers and companies build, ship, and maintain their software on GitHub—the largest and most advanced development platform in the world.

Email address

Sign up for GitHub

73+ million
Developers

4+ million
Organizations

200+ million
Repositories

84%
Fortune 100





Figure 2-3. GitHub welcome page to register

When the page is loaded, click the Sign up for GitHub button (see [Figure 2-3](#)) and follow the instructions. The Sign in page should be similar to [Figure 2-4](#).

Already have an account? [Sign in](#) →

Welcome to GitHub!

Let's begin the adventure

Enter your email



Continue

By creating an account, you agree to the [Terms of Service](#). For more information about GitHub's privacy practices, see the [GitHub Privacy Statement](#). We'll occasionally send you account-related emails.



Figure 2-4. Sign In GitHub page

When you are registered and your account confirmed, you'll be ready to start creating or forking Git repositories into your GitHub account.

Also, you'll need to fork the [book source code repository](#) into your account. Click the Fork button shown in [Figure 2-5](#).

Search or jump to... / Pull requests Issues Marketplace Explore

gitops-cookbook/gitops-cookbook-sc Public

Edit Pins Unwatch 1 Fork 1 Star 1

Code Issues Pull requests Actions Projects Wiki Security Insights

main ▾ 2 branches 0 tags Go to file Add file Code About

No description, website, or topics provided.

lordofthejars Adds PR example 3e63da1 27 days ago 20 commits

apps/bubbles-frontend Adds Bubbles 3 months ago

ch07 Adds PR example 27 days ago

ch08 Adds PR example 27 days ago

.gitignore Adds Bubbles 3 months ago

1 star 1 watching 1 fork

Releases

Help people interested in this repository understand your project by adding a README.

Add a README

No releases published Create a new release



Figure 2-5. Fork button

Then select your account in the Owner section, if not selected yet, and click the button “Create fork” button as shown in [Figure 2-6](#).

Create a new fork

A *fork* is a copy of a repository. Forking a repository allows you to freely experiment with changes without affecting the original project. View existing forks.

Owner *



Repository name *

 / A text input field for the repository name, containing 'gitops-cookbook-sc'. To its right is a separator bar with a checkmark icon, indicating the name has been confirmed or saved.

By default, forks are named the same as their parent repository. You can customize the name to distinguish it further.

Description (optional)

Copy the `main` branch only

Contribute back to [gitops-cookbook/gitops-cookbook-sc](#) by adding your own branch. [Learn more](#).

 You are creating a fork in your personal account.





Figure 2-6. Create fork button

To follow along with the example in the following chapters, you can clone this book's repositories locally. When not mentioned explicitly, we will refer to the examples available in [the chapters repo](#):

```
git clone https://github.com/gitops-cookbook/chapters
```

See Also

Another popular Git service is GitLab. It can be used on the cloud or installed on-premises.

Visit [GitLab](#) for more information.

2.3 Creating a Local Kubernetes Cluster

Problem

You want to spin up a Kubernetes cluster locally.

Solution

In this book, you may need a Kubernetes cluster to run most recipes. Use Minikube to spin up a Kubernetes cluster in your local machine.

Discussion

Minikube uses container/virtualization technology like Docker, Podman, Hyperkit, Hyper-V, KVM, or VirtualBox to boot up a Linux machine with a Kubernetes cluster installed inside.

For simplicity and to use an installation that will work in most of the platforms, we are going to use VirtualBox as a virtualization system.

To install VirtualBox (if you haven't done it yet), visit [the home page](#) and click the Download link as shown in [Figure 2-7](#).

NOTE

For those using macOS, the following instructions have been tested on a Mac AMD64 with macOS Monterey and VirtualBox 6.1. At the time of writing this book, there were some incompatibilities when using the ARM version or macOS Ventura.



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VirtualBox is a powerful x86 and AMD64/Intel64 [virtualization](#) product for enterprise as well as home use. Not only is VirtualBox an extremely feature rich, high performance product for enterprise customers, it is also the only professional solution that is freely available as Open Source Software under the terms of the GNU General Public License (GPL) version 2. See "[About VirtualBox](#)" for an introduction.

Presently, VirtualBox runs on Windows, Linux, Macintosh, and Solaris hosts and supports a large number of [guest operating systems](#) including but not limited to Windows (NT 4.0, 2000, XP, Server 2003, Vista, Windows 7, Windows 8, Windows 10), DOS/Windows 3.x, Linux (2.4, 2.6, 3.x and 4.x), Solaris and OpenSolaris, OS/2, and OpenBSD.

VirtualBox is being actively developed with frequent releases and has an ever growing list of features, supported guest operating systems and platforms it runs on. VirtualBox is a community effort backed by a dedicated company: everyone is encouraged to contribute while Oracle ensures the product always meets professional quality criteria.



Hot picks:

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[VirtualBox 6.1.30 released!](#)
Oracle today released a 6.1 maintenance release which improves stability and fixes regressions. See the [Changelog](#) for details.
- **New** October 19th, 2021
[VirtualBox 6.1.28 released!](#)
Oracle today released a 6.1 maintenance release which improves stability and fixes regressions. See the [Changelog](#) for details.
- **New** July 28th, 2021
[VirtualBox 6.1.26 released!](#)
Oracle today released a 6.1 maintenance release which improves stability and fixes regressions. See the [Changelog](#) for details.
- **New** July 20th, 2021
[VirtualBox 6.1.24 released!](#)
Oracle today released a 6.1 maintenance release which improves stability and fixes regressions. See the [Changelog](#) for details.
- **New** April 29th, 2021
[VirtualBox 6.1.22 released!](#)



Figure 2-7. VirtualBox home page

Select the package based on the operating system, download it, and install it on your computer. After installing VirtualBox (we used the 6.1.x version), the next step is to download and spin up a cluster using Minikube.

Visit [the GitHub repo](#), unfold the Assets section, and download the Minikube file that matches your platform specification. For example, in the case of an AMD Mac, you should select *minikube-darwin-amd64* as shown in [Figure 2-8](#).

Uncompress the file (if necessary) and copy it with the name *minikube* in a directory accessible by the PATH environment variable such as (/usr/local/bin) in Linux or macOS.

With VirtualBox and Minikube installed, we can spin up a Kubernetes cluster in the local machine. Let's install Kubernetes version 1.23.0 as it was the latest version at the time of writing (although any other previous versions can be used as well).

▼ Assets 49

 docker-machine-driver-hyperkit	8.35 MB
 docker-machine-driver-hyperkit.sha256	65 Bytes
 docker-machine-driver-kvm2	11.4 MB
 docker-machine-driver-kvm2-1.24.0-0.x86_64.rpm	3.35 MB
 docker-machine-driver-kvm2-amd64	11.4 MB
 docker-machine-driver-kvm2-amd64.sha256	65 Bytes
 docker-machine-driver-kvm2-arm64	11 MB
 docker-machine-driver-kvm2-arm64.sha256	65 Bytes
 docker-machine-driver-kvm2-x86_64	11.4 MB
 docker-machine-driver-kvm2.sha256	65 Bytes
 docker-machine-driver-kvm2_1.24.0-0_amd64.deb	5.01 MB
 docker-machine-driver-kvm2_1.24.0-0_arm64.deb	4.47 MB
 minikube-1.24.0-0.aarch64.rpm	25.1 MB
 minikube-1.24.0-0.armv7hl.rpm	25 MB
 minikube-1.24.0-0.ppc64le.rpm	24.5 MB
 minikube-1.24.0-0.s390x.rpm	26.6 MB
 minikube-1.24.0-0.x86_64.rpm	15 MB
 minikube-darwin-amd64	65.7 MB
 minikube-darwin-amd64.sha256	65 Bytes
 minikube-darwin-amd64.tar.gz	30.1 MB

Figure 2-8. Minikube release page

Run the following command in a terminal window to spin up the Kubernetes cluster with 8 GB of memory assigned:

```
minikube start --kubernetes-version='v1.23.0' /  
--driver='virtualbox' --memory=8196 -p gitops ❶ ❷ ❸
```

- ❶ Creates a Kubernetes cluster with version 1.23.0
- ❷ Uses VirtualBox as virtualization tool
- ❸ Creates a profile name (gitops) to the cluster to refer to it later

The output lines should be similar to:

```
[gitops] Minikube v1.24.0 on Darwin 12.0.1  
Using the virtualbox driver based on user configuration  
Starting control plane node gitops in cluster gitops ❶  
Creating virtualbox VM (CPUs=2, Memory=8196MB, Disk=20000MB) ...  
    > kubeadm.sha256: 64 B / 64 B [-----]  
100.00% ? p/s 0s  
    > kubelet.sha256: 64 B / 64 B [-----]  
100.00% ? p/s 0s  
    > kubectl.sha256: 64 B / 64 B [-----]  
100.00% ? p/s 0s  
    > kubeadm: 43.11 MiB / 43.11 MiB [-----] 100.00%  
3.46 MiB p/s 13s  
    > kubectl: 44.42 MiB / 44.42 MiB [-----] 100.00%  
3.60 MiB p/s 13s  
    > kubelet: 118.73 MiB / 118.73 MiB [-----] 100.00%  
6.32 MiB p/s 19s  
  
    • Generating certificates and keys ...  
    • Booting up control plane ... ❷  
    • Configuring RBAC rules ...  
    • Using image gcr.io/k8s-minikube/storage-provisioner:v5  
...  
  
Verifying Kubernetes components...  
Enabled addons: storage-provisioner, default-storageclass  
  
/usr/local/bin/kubectl is version 1.21.0, which  
may have incompatibilities with Kubernetes 1.23.0. ❸
```

```
▪ Want kubectl v1.23.0? Try 'minikube kubectl -- get pods -A'  
Done! kubectl is now configured to use "gitops" cluster and  
"default" namespace by default ④
```

- ❶ Starts the gitops cluster
- ❷ Boots up the Kubernetes cluster control plane
- ❸ Detects that we have an old kubectl tool
- ❹ Cluster is up and running

To align the Kubernetes cluster and Kubernetes CLI tool version, you can download the kubectl 1.23.0 version running from <https://dl.k8s.io/release/v1.23.0/bin/darwin/amd64/kubectl>.

NOTE

You need to change darwin/amd64 to your specific architecture. For example, in Windows it might be windows/amd64/kubectl.exe.

Copy the kubectl CLI tool in a directory accessible by the PATH environment variable such as (/usr/local/bin) in Linux or macOS.

See Also

There are other ways to run Kubernetes in a local machine.

One that is very popular is [kind](#).

Although the examples in this book should work in any Kubernetes implementation as only standard resources are used, we've only tested with Minikube.

Chapter 3. Containers

Containers are a popular and standard format for packaging applications. The format is an open standard promoted by the [Open Container Initiative \(OCI\)](#), an open governance structure for the express purpose of creating open industry standards around container formats and runtimes. The openness of this format ensures portability and interoperability across different operating systems, vendors, platforms, or clouds. Kubernetes runs containerized apps, so before going into the GitOps approach to managing apps on Kubernetes, we provide a list of recipes useful for understanding how to package your application as a container image.

The first step for creating images is to use a container engine for packaging your application by building a layered structure containing a base OS and additional layers on top such as runtimes, libraries, and applications. Docker is a widespread open source implementation of a container engine and runtime, and it can generate a container image by specifying a manifest called a Dockerfile (see [Recipe 3.1](#)).

Since the format is open, it's possible to create container images with other tools. Docker, a popular container engine, requires the installation and the execution of a *daemon* that can handle all the operations with the container engine. Developers can use a software development kit (SDK) to interact with the Docker daemon or use *dockerless* solutions such as Jib to create container images (see [Recipe 3.2](#)).

If you don't want to rely on a specific programming language or SDK to build container images, you can use another *daemonless* solution like Buildah (see [Recipe 3.3](#)) or Buildpacks (see [Recipe 3.4](#)). Those are other popular open source tools for building OCI container images. By avoiding dependencies from the OS, such tools make automation more manageable and portable (see [Chapter 6](#)).

Kubernetes doesn't provide a native mechanism for building container images. However, its highly extensible architecture allows interoperability with external tools and the platform's extensibility to create container images. Shipwright is an open source framework for building container images on Kubernetes, providing an abstraction that can use tools such as kaniko, Buildpacks, or Buildah (see [Recipe 3.5](#)) to create container images.

At the end of this chapter, you'll learn how to create OCI-compliant container images from a Dockerfile, either from a host with Docker installed, or using tools such as Buildah and Buildpacks.

3.1 Building a Container Using Docker

Problem

You want to create a container image for your application with Docker.

Solution

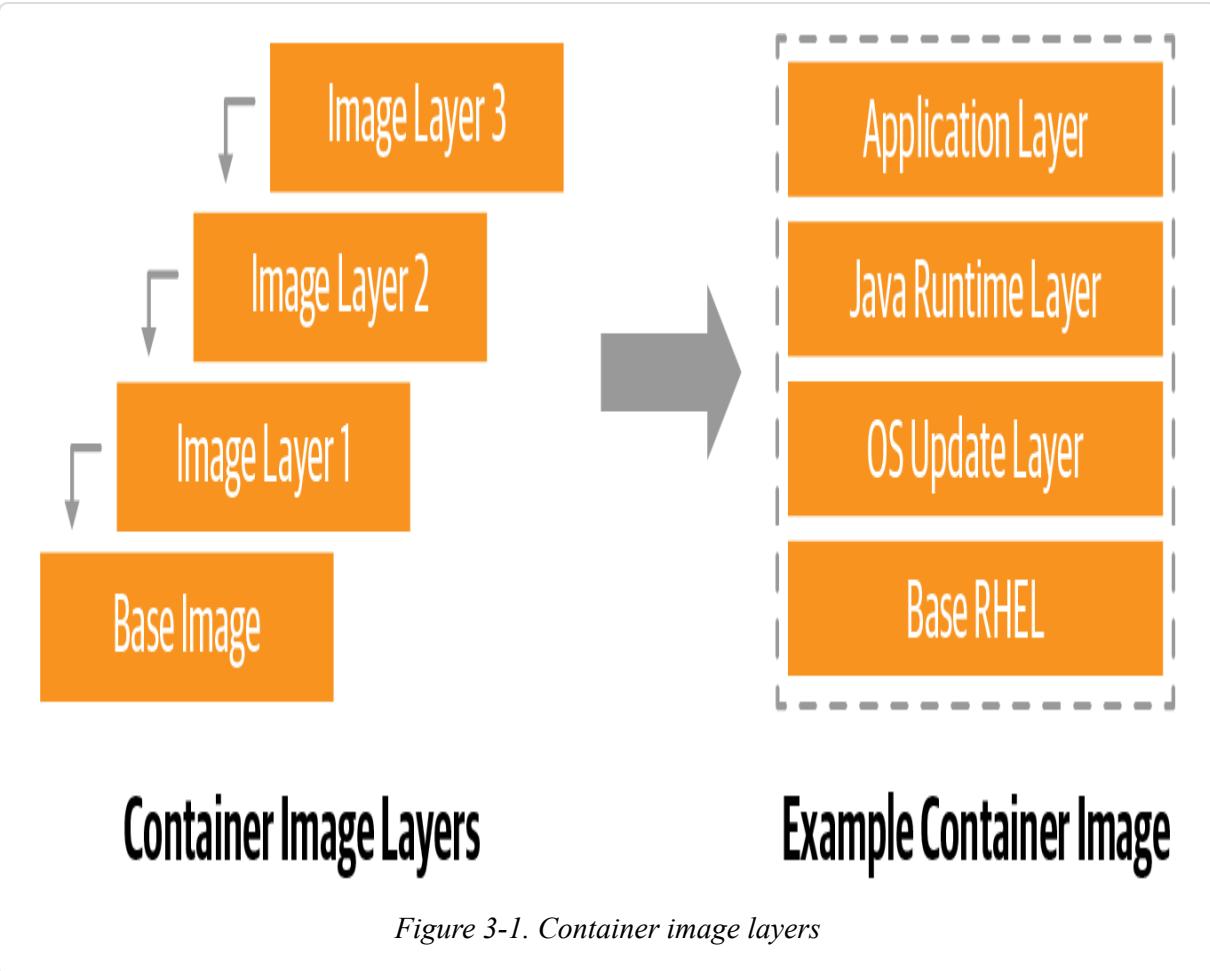
The first thing you need to do is install [Docker](#).

NOTE

Docker is available for Mac, Windows, and Linux. Download the installer for your operating system and refer to the [documentation](#) to start the Docker service.

Developers can create a container image by defining a *Dockerfile*. The best definition for a Dockerfile comes from the [Docker documentation](#) itself: “A Dockerfile is a text document that contains all the commands a user could call on the command line to assemble an image.”

Container images present a layered structure, as you can see in [Figure 3-1](#). Each container image provides the foundation layer for a container, and any update is just an additional layer that can be committed on the foundation.



You can create a Dockerfile like the one shown here, which will generate a container image for Python apps. You can also find this example in [this book's repository](#).

```

FROM registry.access.redhat.com/ubi8/python-39 ①
ENV PORT 8080 ②
EXPOSE 8080 ③
WORKDIR /usr/src/app ④

COPY requirements.txt ./ ⑤
RUN pip install --no-cache-dir -r requirements.txt ⑥

COPY . .

ENTRYPOINT ["python"] ⑦
CMD ["app.py"] ⑧

```

- ❶ FROM: always start from a base image as a foundational layer. In this case we start from a Universal Base Image (UBI), publicly available based on RHEL 8 with Python 3.9 runtime.
- ❷ ENV: set an environment variable for the app.
- ❸ EXPOSE: expose a port to the container network, in this case port TCP 8080.
- ❹ WORKDIR: set a directory inside the container to work with.
- ❺ COPY: copy the assets from the source code files on your workstation to the container image layer, in this case, to the WORKDIR.
- ❻ RUN: run a command inside the container, using the tools already available within the base image. In this case, it runs the pip tool to install dependencies.
- ❼ ENTRYPOINT: define the entry point for your app inside the container. It can be a binary or a script. In this case, it runs the Python interpreter.
- ❽ CMD: the command that is used when starting a container. In this case it uses the name of the Python app app.py.

You can now create your container image with the following command:

```
docker build -f Dockerfile -t quay.io/gitops-cookbook/pythonapp:latest
```

NOTE

Change the container image name with the your registry, user, and repo. Example:
quay.io/youruser/yourrepo:latest. See [Chapter 2](#) for how to create a new account on registries such as Quay.io.

Your container image is building now. Docker will fetch existing layers from a public container registry (DockerHub, Quay, Red Hat Registry, etc.) and add a new layer with the content specified in the Dockerfile. Such

layers could also be available locally, if already downloaded, in special storage called a *container cache* or *Docker cache*.

```
STEP 1: FROM registry.access.redhat.com/ubi8/python-39
Getting image source signatures
Copying blob adffa6963146 done
Copying blob 4125bdfaec5e done
Copying blob 362566a15abb done
Copying blob 0661f10c38cc done
Copying blob 26f1167feaf7 done
Copying config a531ae7675 done
Writing manifest to image destination
Storing signatures
STEP 2: ENV PORT 8080
--> 6dbf4ac027e
STEP 3: EXPOSE 8080
--> f78357fe402
STEP 4: WORKDIR /usr/src/app
--> 547bf8ca5c5
STEP 5: COPY requirements.txt ./
--> 456cab38c97
STEP 6: RUN pip install --no-cache-dir -r requirements.txt
Collecting Flask
    Downloading Flask-2.0.2-py3-none-any.whl (95 kB)
    |██████████| 95 kB 10.6 MB/s
Collecting itsdangerous>=2.0
    Downloading itsdangerous-2.0.1-py3-none-any.whl (18 kB)
Collecting Werkzeug>=2.0
    Downloading Werkzeug-2.0.2-py3-none-any.whl (288 kB)
    |██████████| 288 kB 1.7 MB/s
Collecting click>=7.1.2
    Downloading click-8.0.3-py3-none-any.whl (97 kB)
    |██████████| 97 kB 31.9 MB/s
Collecting Jinja2>=3.0
    Downloading Jinja2-3.0.3-py3-none-any.whl (133 kB)
    |██████████| 133 kB 38.8 MB/s
STEP 7: COPY ..
--> 3e6b73464eb
STEP 8: ENTRYPOINT ["python"]
--> acabca89260
STEP 9: CMD ["app.py"]
STEP 10: COMMIT quay.io/gitops-cookbook/pythonapp:latest
--> 52e134d39af
52e134d39af013a25f3e44d25133478dc20b46626782762f4e46b1ff6f0243bb
```

Your container image is now available in your Docker cache and ready to be used. You can verify its presence with this command:

```
docker images
```

You should get the list of available container images from the cache in output. Those could be images you have built or downloaded with the `docker pull` command:

REPOSITORY	TAG	IMAGE ID
CREATED\,		
SIZE		
quay.io/gitops-cookbook/pythonapp	latest	52e134d39af0 6
minutes ago\,		
907 MB		

Once your image is created, you can consume it locally or push it to a public container registry to be consumed elsewhere, like from a CI/CD pipeline.

You need to first log in to your public registry. In this example, we are using Quay:

```
docker login quay.io
```

You should get output similar to this:

```
Login Succeeded!
```

Then you can push your container image to the registry:

```
docker push quay.io/gitops-cookbook/pythonapp:latest
```

As confirmed, you should get output similar to this:

```
Getting image source signatures
Copying blob e6e8a2c58ac5 done
Copying blob 3ba8c926eef9 done
Copying blob 558b534f4e1b done
Copying blob 25f82e0f4ef5 done
Copying blob 7b17276847a2 done
Copying blob 352ba846236b done
Copying blob 2de82c390049 done
Copying blob 26525e00a8d8 done
```

```
Copying config 52e134d39a done
Writing manifest to image destination
Copying config 52e134d39a [-----]
-] 0.0b / 5.4KiB
Writing manifest to image destination
Storing signatures
```

Discussion

You can create container images in this way with Docker from your workstation or any host where the Docker service/daemon is running.

TIP

Additionally, you can use functionalities offered by a public registry such as [Quay.io](#) that can directly create the container image from a Dockerfile and store it to the registry.

The build requires access to all layers, thus an internet connection to the registries storing base layers is needed, or at least having them in the container cache. Docker has a layered structure where any change to your app is committed on top of the existing layers, so there's no need to download all the layers each time since it will add only deltas for each new change.

NOTE

Container images typically start from a base OS layer such as Fedora, CentOS, Ubuntu, Alpine, etc. However, they can also start from `scratch`, an empty layer for super-minimal images containing only the app's binary. See the [scratch documentation](#) for more info.

If you want to run your previously created container image, you can do so with this command:

```
docker run -p 8080:8080 -ti quay.io/gitops-
cookbook/pythonapp:latest
```

`docker run` has many options to start your container. The most common are:

`-p`

Binds the port of the container with the port of the host running such container.

`-t`

Attaches a TTY to the container.

`-i`

Goes into an interactive mode.

`-d`

Goes in the background, printing a hash that you can use to interact asynchronously with the running container.

The preceding command will start your app in the Docker network and bind it to port 8080 of your workstation:

```
* Serving Flask app 'app' (lazy loading)
* Environment: production
  WARNING: This is a development server. Do not use it in a
  production deployment.
    Use a production WSGI server instead.
* Debug mode: on
* Running on all addresses.
  WARNING: This is a development server. Do not use it in a
  production deployment.
* Running on http://10.0.2.100:8080/ (Press CTRL+C to quit)
* Restarting with stat
* Debugger is active!
* Debugger PIN: 103-809-567
```

From a new terminal, try accessing your running container:

```
curl http://localhost:8080
```

You should get output like this:

Hello, World!

See Also

- [Best practices for writing Dockerfiles](#)
- [Manage Docker images](#)

3.2 Building a Container Using Dockerless Jib

Problem

You are a software developer, and you want to create a container image without installing Docker or any additional software on your workstation.

Solution

As discussed in [Recipe 3.1](#), you need to install the Docker engine to create container images. Docker requires permissions to install a service running as a daemon, thus a privileged process in your operating system. Today, *dockerless* solutions are also available for developers; a popular one is Jib.

[Jib](#) is an open source framework for Java made by Google to build OCI-compliant container images, without the need for Docker or any container runtime. Jib comes as a library that Java developers can import in their Maven or Gradle projects. This means you can create a container image for your app without writing or maintaining any Dockerfiles, delegating this complexity to Jib.

We see the benefits from this approach as the following:¹

Pure Java

No Docker or Dockerfile knowledge is required. Simply add Jib as a plug-in, and it will generate the container image for you.

Speed

The application is divided into multiple layers, splitting dependencies from classes. There's no need to rebuild the container image like for Dockerfiles; Jib takes care of modifying the layers that changed.

Reproducibility

Unnecessary updates are not triggered because the same contents generate the same image.

The easiest way to kickstart a container image build with Jib on existing Maven is by adding the plug-in via the command line:

```
mvn compile com.google.cloud.tools:jib-maven-plugin:3.2.0:build -Dimage=<MY IMAGE>
```

Alternatively, you can do so by adding Jib as a plug-in into your *pom.xml*:

```
<project>
  ...
  <build>
    <plugins>
      ...
      <plugin>
        <groupId>com.google.cloud.tools</groupId>
        <artifactId>jib-maven-plugin</artifactId>
        <version>3.2.0</version>
        <configuration>
          <to>
            <image>myimage</image>
          </to>
        </configuration>
      </plugin>
    ...
  </plugins>
</build>
...
</project>
```

In this way, you can also manage other settings such as authentication or parameters for the build.

Let's now add Jib to an existing Java application, a Hello World application in Spring Boot that you can find in the [book's repository](#).

Run the following command to create a container image without using Docker, and push it directly to a container registry. In this example, we use Quay.io, and we will store the container image at *quay.io/gitops-cookbook/jib-example:latest*, so you will need to provide your credentials for the registry:

```
mvn compile com.google.cloud.tools:jib-maven-plugin:3.2.0:build \
-Dimage=quay.io/gitops-cookbook/jib-example:latest \
-Djib.to.auth.username=<USERNAME> \
-Djib.to.auth.password=<PASSWORD>
```

The authentication here is handled with command-line options, but Jib can manage existing authentication with Docker CLI or read credentials from your *settings.xml* file.

The build takes a few moments, and the result is a Java-specific container image, based on the *adoptOpenJDK* base image, built locally and pushed directly to a registry. In this case, to Quay.io:

```
[INFO] Scanning for projects...
[INFO]
[INFO] -----
[INFO] Building hello 0.0.1-SNAPSHOT
[INFO] -----
[INFO] ...
[INFO] Containerizing application to quay.io/gitops-cookbook/jib-example...
[INFO] Using credentials from <to><auth> for quay.io/gitops-cookbook/jib-example
[INFO] The base image requires auth. Trying again for eclipse-temurin:11-jre...
[INFO] Using base image with digest:\
sha256:83d92ee225e443580cc3685ef9574582761cf975abc53850c2bc44ec47
d7d9430]
[INFO]
[INFO] Container entrypoint set to [java, -cp, @/app/jib-
classpath-file, \
com.redhat.hello.HelloApplication]FO]
[INFO]
[INFO] Built and pushed image as quay.io/gitops-cookbook/jib-
example
```

```
[INFO] Executing tasks:  
[INFO] [=====] 100, 0% complete  
[INFO]  
[INFO] -----  
-----  
[INFO] BUILD SUCCESS  
[INFO] -----  
-----  
[INFO] Total time: 41.366 s  
[INFO] Finished at: 2022-01-25T19:04:09+01:00  
[INFO] -----  
-----
```

NOTE

If you have Docker and run the command `docker images`, you won't see this image in your local cache!

Discussion

Your container image is not present in your local cache, as you don't need any container runtime to build images with Jib. You won't see it with the `docker images` command, but you can pull it from the public container registry afterward, and it will store it in your cache.

This approach is suitable for development velocity and automation, where the CI system doesn't need to have Docker installed on the nodes where it runs. Jib can create the container image without any Dockerfiles.

Additionally, it can push the image to a container registry.

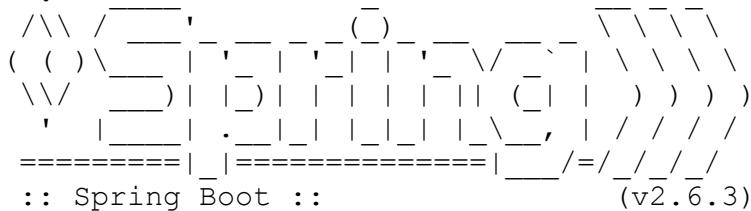
If you also want to store it locally from the beginning, Jib can connect to Docker hosts and do it for you.

You can pull your container image from the registry to try it:

```
docker run -p 8080:8080 -ti quay.io/gitops-cookbook/jib-example
```

```
Trying to pull quay.io/gitops-cookbook/jib-example:latest...  
Getting image source signatures  
Copying blob ea362f368469 done  
Copying blob d5cc550bb6a0 done  
Copying blob bcc17963ea24 done
```

```
Copying blob 9b46d5d971fa done
Copying blob 51f4f7c353f0 done
Copying blob 43b2cdffa19bb done
Copying blob fd142634d578 done
Copying blob 78c393914c97 done
Copying config 346462b8d3 done
Writing manifest to image destination
Storing signatures
```



```
2022-01-25 18:36:24.762 INFO 1 --- [ main]
com.redhat.hello.HelloApplication,
    : Starting HelloApplication using Java 11.0.13 on
a719cf76f440 with PID 1,
        (/app/classes started by root in '/')
2022-01-25 18:36:24.765 INFO 1 --- [ main]
com.redhat.hello.HelloApplication,
    : No active profile set, falling back to default
profiles: default
2022-01-25 18:36:25.700 INFO 1 --- [ main]
o.s.b.w.embedded.tomcat.TomcatWebServer,
    : Tomcat initialized with port(s): 8080 (http)
2022-01-25 18:36:25.713 INFO 1 --- [ main]
o.apache.catalina.core.StandardService,
    : Starting service [Tomcat]
2022-01-25 18:36:25.713 INFO 1 --- [ main]
org.apache.catalina.core.StandardEngine,
    : Starting Servlet engine: [Apache Tomcat/9.0.56]
2022-01-25 18:36:25.781 INFO 1 --- [ main] o.a.c.c.C.[Tomcat].
[localhost].[]|,
    : Initializing Spring embedded WebApplicationContext
2022-01-25 18:36:25.781 INFO 1 --- [ main]
w.s.c.ServletWebServerApplicationContext,
    : Root WebApplicationContext: initialization completed in 947 ms
2022-01-25 18:36:26.087 INFO 1 --- [ main]
o.s.b.w.embedded.tomcat.TomcatWebServer,
    : Tomcat started on port(s): 8080 (http) with context path ''
2022-01-25 18:36:26.096 INFO 1 --- [ main]
com.redhat.hello.HelloApplication,
    : Started HelloApplication in 1.778 seconds (JVM running
for 2.177)
```

Get the `hello` endpoint:

```
curl localhost:8080/hello
{"id":1,"content":"Hello, World!"}
```

See Also

- [Using Jib with Quarkus projects](#)

3.3 Building a Container Using Buildah

Problem

Sometimes installing or managing Docker is not possible. Dockerless solutions for creating container images are useful in use cases such as local development or CI/CD systems.

Solution

The OCI specification is an open standard, and this favors multiple open source implementations for the container engine and the container image building mechanism. Two growing popular examples today are [Podman](#) and [Buildah](#).

NOTE

While Docker uses a single monolithic application for creating, running, and shipping container images, the codebase for container management functionalities here has been split between different projects like Podman, Buildah, and Skopeo. Podman support is already available on Mac and Windows, however Buildah is currently only available on Linux or Linux subsystems such as WSL2 for Windows. See the [documentation](#) to install it on your workstation.

Those are two complementary open source projects and command-line tools that work on OCI containers and images; however, they differ in their

specialization. While Podman specializes in commands and functions that help you to maintain and modify container images, such as pulling, tagging, and pushing, Buildah specializes in building container images. Decoupling functions in different processes is done by design, as the authors wanted to move from the single privileged process Docker model to a lightweight, rootless, daemonless, and decoupled set of tools to improve agility and security.

TIP

Following the same approach, you find [Skopeo](#), a tool used to move container images; and [CRI-O](#), a container engine complaint with the Kubernetes container runtime interface for running applications.

Buildah supports the Dockerfile format, but its goal is to provide a lower-level interface to build container images without requiring a Dockerfile. Buildah is a daemonless solution that can create images inside a container without mounting the Docker socket. This functionality improves security and portability since it's easy to add Buildah builds on the fly to a CI/CD pipeline where the Linux or Kubernetes nodes do not require a Docker installation.

As we discussed, you can create a container image with or without a Dockerfile. Let's now create a simple HTTPD container image without a Dockerfile.

You can start from any base image such as CentOS:

```
buildah from centos
```

You should get output similar to this:

```
Resolved short name "centos" to a recorded short-name alias\n  (origin: /etc/containers/registries.conf.d/shortnames.conf)\nGetting image source signatures\nCopying blob 926a85fb4806 done\nCopying config 2f3766df23 done
```

```
Writing manifest to image destination
Storing signatures
centos-working-container
```

TIP

Similarly to Docker and docker images, you can run the command buildah containers to get the list of available images from the container cache. If you also have installed Podman, this is similar to podman images.

In this case, the container image ID is centos-working-container, and you can refer to it for creating the other layers.

Now let's install the httpd package inside a new layer:

```
buildah run centos-working-container yum install httpd -y
```

You should get output similar to this:

```
CentOS Linux 8 - AppStream          9.0 MB/s |
8.4 MB    00:00
CentOS Linux 8 - BaseOS            436 kB/s |
4.6 MB    00:10
CentOS Linux 8 - Extras            23 kB/s |
10 kB     00:00
Dependencies resolved.
=====
=====
      Package           Arch   Version       Repository
Size
=====
=====
Installing:
httpd                  x86_64  2.4.37-
43.module_el8.5.0+1022+b541f3b1
Installing dependencies:
apr                    x86_64  1.6.3-12.el8
apr-util               x86_64  1.6.1-6.el8
brotli                x86_64  1.0.6-3.el8
centos-logos-httpd    noarch  85.8-2.el8
httpd-filesystem      noarch  2.4.37-
43.module_el8.5.0+1022+b541f3b1
httpd-tools             x86_64  2.4.37-
```

```
43.module_el8.5.0+1022+b541f3b1
 mailcap                      noarch  2.1.48-3.el8
 mod_http2                     x86_64  1.15.7-
3.module_el8.4.0+778+c970deab
Installing weak dependencies:
 apr-util-bdb                  x86_64  1.6.1-6.el8
 apr-util-openssl               x86_64  1.6.1-6.el8
Enabling module streams:
...
Complete!
```

Now let's copy a welcome HTML page inside the container running HTTPD. You can find the source code in [this book's repo](#):

```
<html>
  <head>
    <title>GitOps CookBook example</title>
  </head>
  <body>
    <h1>Hello, World!</h1>
  </body>
</html>
```

```
buildah copy centos-working-container index.xhtml
/var/www/html/index.xhtml
```

For each new layer added, you should get output with the new container image hash, similar to the following:

```
78c6e1dcd6f819581b54094fd38a3fd8f170a2cb768101e533c964e04aacab2e

buildah config --entrypoint "/usr/sbin/httpd -DFOREGROUND"
centos-working-container

buildah commit centos-working-container quay.io/gitops-
cookbook/gitops-website
```

You should get output similar to this:

```
Getting image source signatures
Copying blob 618ce6bf40a6 skipped: already exists
Copying blob eb8c13ba832f done
Copying config b825e91208 done
Writing manifest to image destination
```

```
Storing signatures
b825e91208c33371e209cc327abe4f53ee501d5679c127cd71c4d10cd03e5370
```

Your container image is now in the container cache, ready to run or push to another registry.

As mentioned before, Buildah can also create container images from a Dockerfile. Let's make the same container image from the Dockerfile listed here:

```
FROM centos:latest
RUN yum -y install httpd
COPY index.xhtml /var/www/html/index.xhtml
EXPOSE 80
CMD ["/usr/sbin/httpd", "-DFOREGROUND"]

buildah bud -f Dockerfile -t quay.io/gitops-cookbook/gitops-
website

STEP 1: FROM centos:latest
Resolved short name "centos" to a recorded short-name alias,
  (origin: /etc/containers/registries.conf.d/shortnames.conf)
Getting image source signatures
Copying blob 926a85fb4806 done
Copying config 2f3766df23 done
Writing manifest to image destination
Storing signatures
STEP 2: RUN yum -y install httpd
CentOS Linux 8 - AppStream          9.6 MB/s | 8.4 MB
00:00
CentOS Linux 8 - BaseOS            7.5 MB/s | 4.6 MB
00:00
CentOS Linux 8 - Extras             63 kB/s | 10 kB
00:00
Dependencies resolved.

...
Complete!
STEP 3: COPY index.xhtml /var/www/html/index.xhtml
STEP 4: EXPOSE 80
STEP 5: CMD ["/usr/sbin/httpd", "-DFOREGROUND"]
STEP 6: COMMIT quay.io/gitops-cookbook/gitops-website
Getting image source signatures
Copying blob 618ce6bf40a6 skipped: already exists
Copying blob 1be523a47735 done
Copying config 3128caf147 done
Writing manifest to image destination
Storing signatures
```

```
--> 3128caf1475  
3128caf147547e43b84c13c241585d23a32601f2c2db80b966185b03cb6a8025
```

If you have also installed Podman, you can run it this way:

```
podman run -p 8080:80 -ti quay.io/gitops-cookbook/gitops-website
```

Then you can test it by opening the browser on <http://localhost:8080>.

Discussion

With Buildah, you have the opportunity to create container images from scratch or starting from a Dockerfile. You don't need to install Docker, and everything is designed around security: rootless mechanism, daemonless utilities, and more refined control of creating image layers.

Buildah can also build images from scratch, thus it creates an empty layer similar to the `FROM scratch` Dockerfile statement. This aspect is useful for creating very lightweight images containing only the packages needed to run your application, as you can see in [Figure 3-2](#).

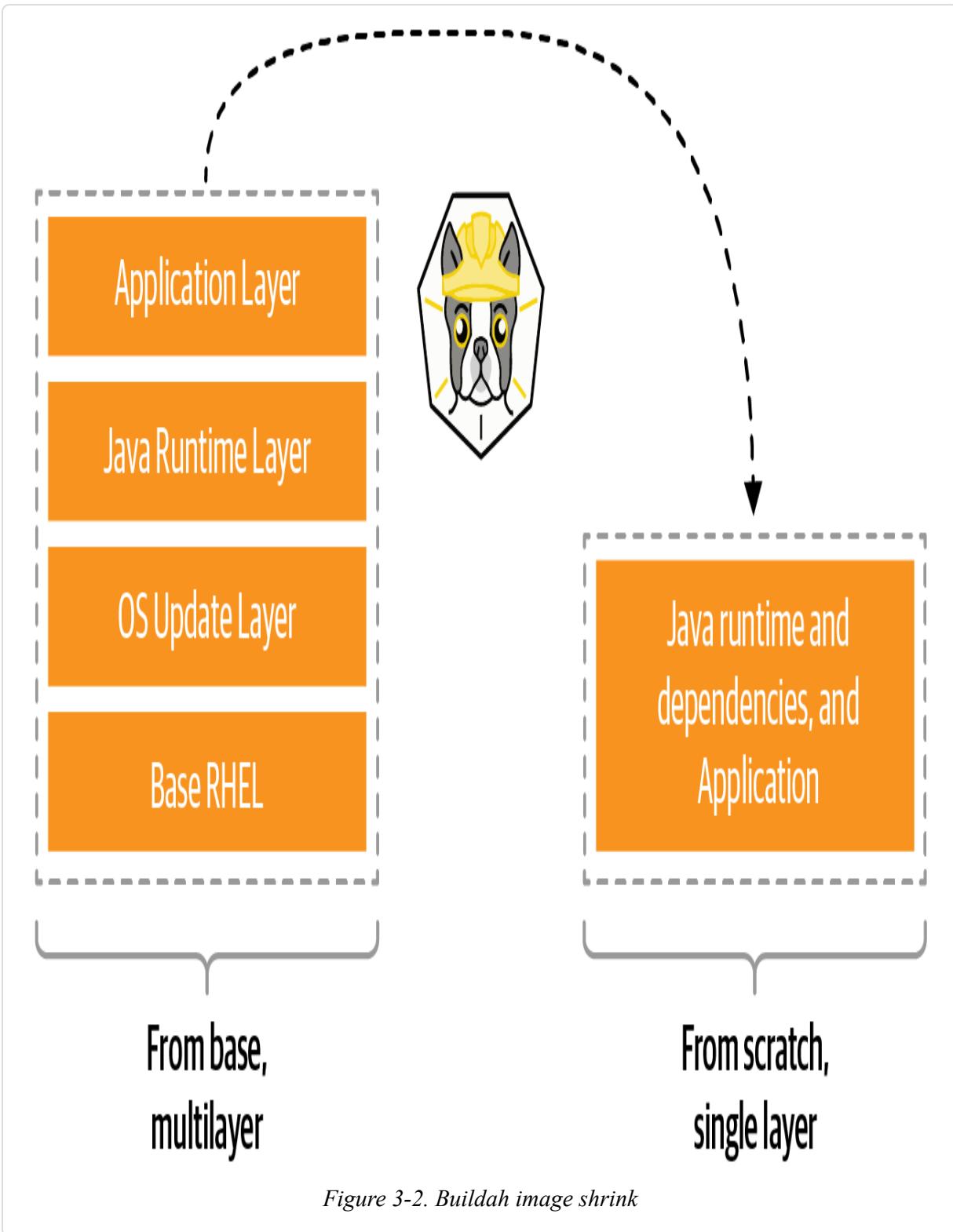


Figure 3-2. Buildah image shrink

A good example use case for a scratch build is considering the development images versus staging or production images. During development, container

images may require a compiler and other tools. However, in production, you may only need the runtime or your packages.

See Also

- [Running Buildah inside a container](#)

3.4 Building a Container with Buildpacks

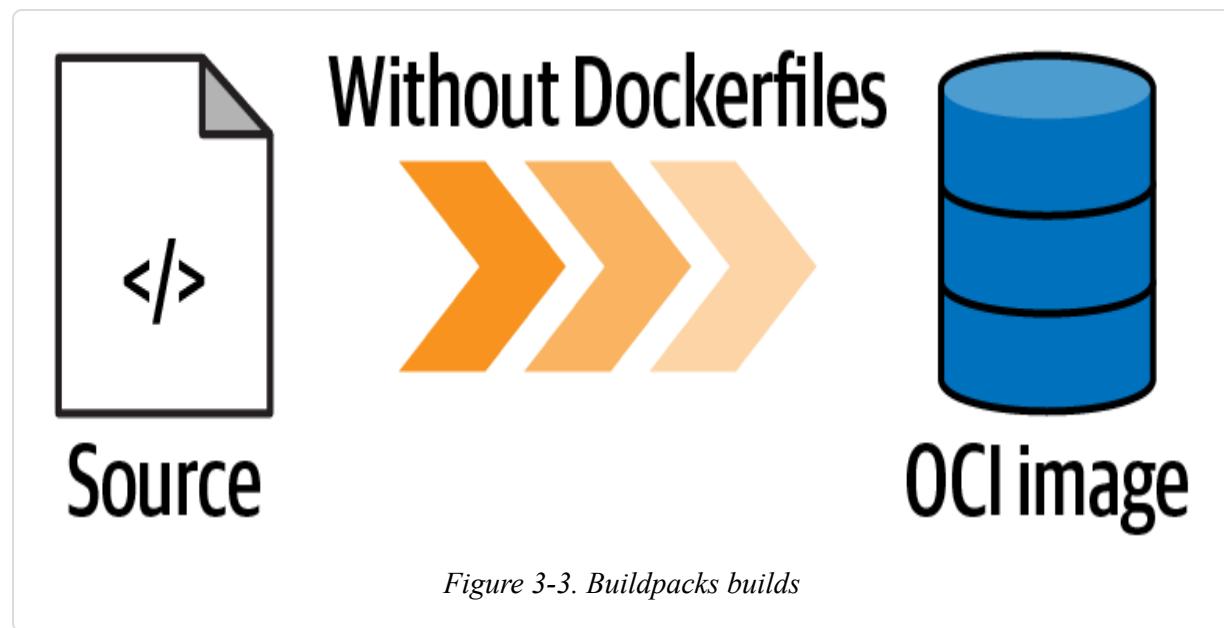
Problem

Creating container image by using Dockerfiles can be challenging at scale. You want a tool complementing Docker that can inspect your application source code to create container images without writing a Dockerfile.

Solution

[Cloud Native Buildpacks](#) is an open source project that provides a set of executables to inspect your app source code and to create a plan to build and run your application.

Buildpacks can create OCI-compliant container images without a Dockerfile, starting from the app source code, as you can see in [Figure 3-3](#).



This mechanism consists of two phases:

Detection

Buildpacks tooling will navigate your source code to discover which programming language or framework is used (e.g., POM, NPM files, Python requirements, etc.) and assign a suitable buildpack for the build.

Building

Once a buildpack is found, the source is compiled and Buildpacks creates a container image with the appropriate entry point and startup scripts.

To use Buildpacks, you have to download the [pack](#) CLI for your operating system (Mac, Windows, Linux), and also have Docker installed.

TIP

On macOS, pack is available through [Homebrew](#) as follows:

```
brew install buildpacks/tap/pack
```

Now let's start creating our container image with Buildpacks from a sample Node.js app. You can find the app source code in this [book's repository](#):

```
cd chapters/ch03/nodejs-app
```

The app directory structure contains a *package.json* file, a manifest listing Node.js packages required for this build, which helps Buildpacks understand which buildpack to use.

You can verify it with this command:

```
pack builder suggest
```

You should get output similar to this:

```
Suggested builders:
  Google:           gcr.io/buildpacks/builder:v1,
                    Ubuntu 18 base image with buildpacks for .NET, Go,
Java, Node.js,,
                    and Python
  Heroku:           heroku/buildpacks:18,
                    Base builder for Heroku-18 stack, based on
ubuntu:18.04 base,
                    image
  Heroku:           heroku/buildpacks:20,
                    Base builder for Heroku-20 stack, based on
ubuntu:20.04 base,
                    image
  Paketo Buildpacks: paketobuildpacks/builder:base,
                    Ubuntu bionic base image with buildpacks for Java,
.NET Core,,
                    Node.js, Go, Python, Ruby, NGINX and Procfile
  Paketo Buildpacks: paketobuildpacks/builder:full,
                    Ubuntu bionic base image with buildpacks for Java,
.NET Core,,
                    Node.js, Go, Python, PHP, Ruby, Apache HTTPD,
NGINX and Procfile
  Paketo Buildpacks: paketobuildpacks/builder:tiny,
                    Tiny base image (bionic build image, distroless-
like run image),
                    with buildpacks for Java, Java Native Image and Go
```

Now you can decide to pick one of the suggested buildpacks. Let's try the `paketobuildpacks/builder:base`, which also contains the Node.js runtime:

```
pack build nodejs-app --builder paketobuildpacks/builder:base
```

TIP

Run `pack builder inspect paketobuildpacks/builder:base` to know the exact content of libraries and frameworks available in this buildpack.

The building process should start accordingly, and after a while, it should finish, and you should get output similar to this:

```
base: Pulling from paketobuildpacks/builder
bf99a8b93828: Pulling fs layer
...
Digest:
sha256:7034e52388c11c5f7ee7ae8f2d7d794ba427cc2802f687dd9650d96a70
ac0772
Status: Downloaded newer image for paketobuildpacks/builder:base
base-cnb: Pulling from paketobuildpacks/run
bf99a8b93828: Already exists
9d58a4841c3f: Pull complete
77a4f59032ac: Pull complete
24e58505e5e0: Pull complete
Digest:
sha256:59aa1da9db6d979e21721e306b9ce99a7c4e3d1663c4c20f74f9b3876c
ce5192
Status: Downloaded newer image for paketobuildpacks/run:base-cnb
====> ANALYZING
Previous image with name "nodejs-app" not found
====> DETECTING
5 of 10 buildpacks participating
paketo-buildpacks/ca-certificates 3.0.1
paketo-buildpacks/node-engine      0.11.2
paketo-buildpacks/npm-install       0.6.2
paketo-buildpacks/node-module-bom  0.2.0
paketo-buildpacks/npm-start         0.6.1
====> RESTORING
====> BUILDING
...
Paketo NPM Start Buildpack 0.6.1
```

```
Assigning launch processes
  web: node server.js

====> EXPORTING
Adding layer 'paketo-buildpacks/ca-certificates:helper'
Adding layer 'paketo-buildpacks/node-engine:node'
Adding layer 'paketo-buildpacks/npm-install:modules'
Adding layer 'launch.sbom'
Adding 1/1 app layer(s)
Adding layer 'launcher'
Adding layer 'config'
Adding layer 'process-types'
Adding label 'io.buildpacks.lifecycle.metadata'
Adding label 'io.buildpacks.build.metadata'
Adding label 'io.buildpacks.project.metadata'
Setting default process type 'web'
Saving nodejs-app...
*** Images (82b805699d6b):
  nodejs-app
Adding cache layer 'paketo-buildpacks/node-engine:node'
Adding cache layer 'paketo-buildpacks/npm-install:modules'
Adding cache layer 'paketo-buildpacks/node-module-bom:cyclonedx-node-module'
Successfully built image nodejs-app
```

Now let's run it with Docker:

```
docker run --rm -p 3000:3000 nodejs-app
```

You should get output similar to this:

```
Server running at http://0.0.0.0:3000/
```

View the running application:

```
curl http://localhost:3000/
```

You should get output similar to this:

```
Hello Buildpacks!
```

Discussion

Cloud Native Buildpacks is an incubating project in the Cloud Native Computing Foundation (CNCF), and it supports both Docker and Kubernetes. On Kubernetes, it can be used with [Tekton](#), a Kubernetes-native CI/CD system that can run Buildpacks as a Tekton Task to create container images. It recently adopted the [Boson Project](#) to provide a functions-as-a-service (FaaS) experience on Kubernetes with Knative, by enabling the build of functions via buildpacks.

See Also

- [Using Buildpacks with Tekton Pipelines](#)
- [FaaS Knative Boson project's buildpacks](#)

3.5 Building a Container Using Shipwright and kaniko in Kubernetes

Problem

You need to create a container image, and you want to do it with Kubernetes.

Solution

Kubernetes is well known as a container orchestration platform to deploy and manage apps. However, it doesn't include support for building container images out-of-the-box. Indeed, according to [Kubernetes documentation](#): "(Kubernetes) Does not deploy source code and does not build your application. Continuous Integration, Delivery, and Deployment (CI/CD) workflows are determined by organization cultures and preferences as well as technical requirements."

As mentioned, one standard option is to rely on CI/CD systems for this purpose, like Tekton (see [Chapter 6](#)). Another option is to use a framework

to manage builds with many underlying tools, such as the one we discussed in the previous recipes. One example is Shipwright.

[Shipwright](#) is an extensible framework for building container images on Kubernetes. It supports popular tools such as Buildah, Cloud Native Buildpacks, and kaniko. It uses Kubernetes-style APIs, and it runs workloads using Tekton.

The benefit for developers is a simplified approach for building container images, by defining a minimal YAML file that does not require any previous knowledge of containers or container engines. This approach makes this solution agnostic and highly integrated with the Kubernetes API ecosystem.

The first thing to do is to install Shipwright to your Kubernetes cluster, say kind or Minikube (see [Chapter 2](#)), following the [documentation](#) or from [OperatorHub.io](#).

TIP

Using Operators and Operator Lifecycle Manager (OLM) gives consistency for installing/uninstalling software on Kubernetes, along with dependency management and lifecycle control. For instance, the Tekton Operator dependency is automatically resolved and installed if you install Shipwright via the Operator. Check the OLM [documentation](#) for details with this approach.

Let's follow the standard procedure from the documentation. First you need to install the Tekton dependency. At the time of writing this book, it is version 0.30.0:

```
kubectl apply -f \
  https://storage.googleapis.com/tekton-
  releases/pipeline/previous/v0.30.0/release.yaml
```

Then you install Shipwright. At the time of writing this book, it is version 0.7.0:

```
kubectl apply -f \
  https://github.com/shipwright-
  io/build/releases/download/v0.7.0/release.yaml
```

Finally, you install Shipwright build strategies:

```
kubectl apply -f \
  https://github.com/shipwright-
  io/build/releases/download/v0.7.0/sample-strategies.yaml
```

Once you have installed Shipwright, you can start creating your container image build using one of these tools:

- kaniko
- Cloud Native Buildpacks
- BuildKit
- Buildah

Let's explore kaniko.

[kaniko](#) is another dockerless solution to build container images from a Dockerfile inside a container or Kubernetes cluster. Shipwright brings additional APIs to Kubernetes to use tools such as kaniko to create container images, acting as an abstract layer that can be considered an extensible building system for Kubernetes.

Let's explore the APIs that are defined from Cluster Resource Definitions (CRDs):

`ClusterBuildStrategy`

Represents the type of build to execute.

`Build`

Represents the build. It includes the specification of one `ClusterBuildStrategy` object.

`BuildRun`

Represents a running build. The build starts when this object is created.

Run the following command to check all available ClusterBuildStrategy (CBS) objects:

```
kubectl get cbs
```

You should get a list of available CBSs to consume:

NAME	AGE
buildah	26s
buildkit	26s
buildpacks-v3	26s
buildpacks-v3-heroku	26s
kaniko	26s
kaniko-trivy	26s
ko	26s
source-to-image	26s
source-to-image-redhat	26s

NOTE

This CRD is cluster-wide, available for all namespaces. If you don't see any items, please install the Shipwright build strategies as discussed previously.

Shipwright will generate a container image on the Kubernetes nodes container cache, and then it can push it to a container registry.

You need to provide the credentials to push the image to the registry in the form of a Kubernetes Secret. For example, if you use Quay you can create one like the following:

```
REGISTRY_SERVER=quay.io
REGISTRY_USER=<your_registry_user>
REGISTRY_PASSWORD=<your_registry_password>
EMAIL=<your_email>
kubectl create secret docker-registry push-secret \
    --docker-server=$REGISTRY_SERVER \
    --docker-username=$REGISTRY_USER \
    --docker-password=$REGISTRY_PASSWORD \
    --docker-email=$EMAIL
```

TIP

With Quay, you can use an encrypted password instead of using your account password. See the documentation for more details.

Now let's create a *build-kaniko.yaml* file containing the Build object that will use kaniko to containerize a Node.js sample app. You can find the source code in this [book's repository](#):

```
apiVersion: shipwright.io/v1alpha1
kind: Build
metadata:
  name: buildpack-nodejs-build
spec:
  source:
    url: https://github.com/shipwright-io/sample-nodejs ❶
    contextDir: docker-build ❷
  strategy:
    name: kaniko ❸
    kind: ClusterBuildStrategy
  output:
    image: quay.io/gitops-cookbook/sample-nodejs:latest ❹
    credentials:
      name: push-secret ❺
```

- ❶ Repository to grab the source code from.
- ❷ The directory where the source code is present.
- ❸ The ClusterBuildStrategy to use.
- ❹ The destination of the resulting container image. Change this with your container registry repo.
- ❺ The secret to use to authenticate to the container registry and push the image.

Now, let's create the Build object:

```
kubectl create -f build-kaniko.yaml
```

You should get output similar to this:

```
build.shipwright.io/kaniko-nodejs-build created
```

Let's list the available builds:

```
kubectl get builds
```

You should get output similar to the following:

NAME	REGISTERED	REASON	BUILDSTRATEGY	KIND
	BUILDSTRATEGY	NAME	CREATIONTIME	
kaniko-nodejs-build	True	Succeeded	ClusterBuildStrategy	
			kaniko	13s

At this point, your Build is REGISTERED, but it's not started yet. Let's create the following object in order to start it:

```
apiVersion: shipwright.io/v1alpha1
kind: BuildRun
metadata:
  generateName: kaniko-nodejs-buildrun-
spec:
  buildRef:
    name: kaniko-nodejs-build
```

```
kubectl create -f buildrun.yaml
```

If you check the list of running pods, you should see one being created:

```
kubectl get pods
```

NAME	READY	STATUS
RESTARTS		
AGE		
kaniko-nodejs-buildrun-b9mmb-qbrgl-pod-dk7xt	0/3	
PodInitializing	0	
	19s	

When the STATUS changes, the build will start, and you can track the progress by checking the logs from the containers used by this pod to run the build in multiple steps:

step-source-default

The first step, used to get the source code

step-build-and-push

The step to run the build, either from source code or from a Dockerfile like in this case with kaniko

step-results

The result of the build

Let's check the logs of the building phase:

```
kubectl logs -f kaniko-nodejs-buildrun-b9mmb-qbргl-pod-dk7xt -c  
step-build-and-push
```

```
INFO[0001] Retrieving image manifest ghcr.io/shipwright-  
io/shipwright-samples/node:12  
INFO[0001] Retrieving image ghcr.io/shipwright-io/shipwright-  
samples/node:12  
from registry ghcr.io  
INFO[0002] Built cross stage deps: map[]  
INFO[0002] Retrieving image manifest ghcr.io/shipwright-  
io/shipwright-samples/node:12  
INFO[0002] Returning cached image manifest  
INFO[0002] Executing 0 build triggers  
INFO[0002] Unpacking rootfs as cmd COPY . /app requires it.  
INFO[0042] COPY . /app  
INFO[0042] Taking snapshot of files...  
INFO[0042] WORKDIR /app  
INFO[0042] cmd: workdir  
INFO[0042] Changed working directory to /app  
INFO[0042] No files changed in this command, skipping  
snapshotting.  
INFO[0042] RUN      pwd &&      ls -l &&      npm install &&  
      npm run print-http-server-version  
INFO[0042] Taking snapshot of full filesystem...  
INFO[0052] cmd: /bin/sh  
INFO[0052] args: [-c pwd &&      ls -l &&      npm install &&  
      npm run print-http-server-version]  
INFO[0052] Running: [/bin/sh -c pwd &&      ls -l &&      npm
```

```
install &&[
    npm run print-http-server-version]
/app
total 44
-rw-r--r-- 1 node node 261 Jan 27 14:29 Dockerfile
-rw-r--r-- 1 node node 30000 Jan 27 14:29 package-lock.json
-rw-r--r-- 1 node node 267 Jan 27 14:29 package.json
drwxr-xr-x 2 node node 4096 Jan 27 14:29 public
npm WARN npm-simple-renamed@0.0.1 No repository field.
npm WARN npm-simple-renamed@0.0.1 No license field.

added 90 packages from 40 contributors and audited 90 packages in
6.405s

10 packages are looking for funding
  run `npm fund` for details

found 0 vulnerabilities

> npm-simple-renamed@0.0.1 print-http-server-version /app
> serve -v

13.0.2
INFO[0060] Taking snapshot of full filesystem...
INFO[0062] EXPOSE 8080
INFO[0062] cmd: EXPOSE
INFO[0062] Adding exposed port: 8080/tcp
INFO[0062] CMD ["npm", "start"]
INFO[0070] Pushing image to quay.io/gitops-cookbook/sample-
nodejs:latest
INFO[0393] Pushed image to 1 destinations
```

The image is built and pushed to the registry, and you can check the result from this command as well:

```
kubectl get buildruns
```

And on your registry, as shown in [Figure 3-4](#).



EXPLORE APPLICATIONS REPOSITORIES TUTORIAL

bluesma...

Quay.io now supports Red Hat Single Sign-On Services exclusively. If you haven't done so already, you need to link your Quay.io login to a redhat.com account in order to be able to login to the web interface by going to the [recovery endpoint](#). CLI tokens and robot accounts are not impacted. Read more about this change in the [FAQ](#).

◀ Repositories

gitops-cookbook / sample-nodejs



Repository Tags

Compact Expanded



1-1 of 1

Filter Tags...

TAG

LAST MODIFIED ↓ SECURITY SCAN

SIZE

EXPIRES

MANIFEST

latest

10 minutes ago Queued

337.7 MB Never

SHA256: 8c09c31bafab

Figure 3-4. Image pushed to Quay

Discussion

Shipwright provides a convenient way to create container images on Kubernetes, and its agnostic approach makes it robust and interoperable. The project aims at being the Build API for Kubernetes, providing an easier path for developers to automate on Kubernetes. As Tekton runs under the hood creating builds, Shipwright also makes transitioning from micropipeline to extended pipeline workflows on Kubernetes easier.

As a reference, if you would like to create a build with Buildah instead of kaniko, it's just a ClusterBuildStrategy change in your Build object:

```
apiVersion: shipwright.io/v1alpha1
kind: Build
metadata:
  name: buildpack-nodejs-build
spec:
  source:
    url: https://github.com/shipwright-io/sample-nodejs
    contextDir: source-build ❶
  strategy:
    name: buildah ❷
    kind: ClusterBuildStrategy
  output:
    image: quay.io/gitops-cookbook/sample-nodejs:latest
    credentials:
      name: push-secret
```

- ❶ As we discussed previously in [Recipe 3.3](#), Buildah can create the container image from the source code. It doesn't need a Dockerfile.
- ❷ Selecting Buildah as the ClusterBuildStrategy.

3.6 Final Thoughts

The container format is the de facto standard for packaging applications, and today many tools help create container images. Developers can create images with Docker or with other tools and frameworks and then use the same with any CI/CD system to deploy their apps to Kubernetes.

While Kubernetes per se doesn't build container images, some tools interact with the Kubernetes API ecosystem to add this functionality. This aspect improves development velocity and consistency across environments, delegating this complexity to the platform.

In the following chapters, you will see how to control the deployment of your containers running on Kubernetes with tools such as Kustomize or Helm, and then how to add automation to support highly scalable workloads with CI/CD and GitOps.

¹ For a presentation about Jib, see Appu Goundan and Qingyang Chen's [presentation from Velocity San Jose 2018](#).

Chapter 4. Kustomize

Deploying to a Kubernetes cluster is, in summary, applying some YAML files and checking the result.

The hard part is developing the initial YAML files version; after that, usually, they suffer only small changes such as updating the container image tag version, the number of replicas, or a new configuration value. One option is to make these changes directly in the YAML files—it works, but any error in this version (modification of the wrong line, deleting something by mistake, putting in the wrong whitespace) might be catastrophic.

For this reason, some tools let you define base Kubernetes manifests (which change infrequently) and specific files (maybe one for each environment) for setting the parameters that change more frequently. One of these tools is Kustomize.

In this chapter, you'll learn how to use Kustomize to manage Kubernetes resource files in a template-free way without using any DSL.

The first step is to create a Kustomize project and deploy it to a Kubernetes cluster (see [Recipe 4.1](#)).

After the first deployment, the application is automatically updated with a new container image, a new configuration value, or any other field, such as the replica number (see Recipes [4.2](#) and [4.3](#)).

If you've got several running environments (i.e., staging, production, etc.), you need to manage them similarly. Still, with its particularities, Kustomize lets you define a set of custom values per environment (see [Recipe 4.4](#)).

Application configuration values are properties usually mapped as a Kubernetes ConfigMap. Any change (and its consequent update on the cluster) on a ConfigMap doesn't trigger a rolling update of the

application, which means that the application will run with the previous version until you manually restart it.

Kustomize provides some functions to automatically execute a rolling update when the ConfigMap of an application changes (see [Recipe 4.5](#)).

4.1 Using Kustomize to Deploy Kubernetes Resources

Problem

You want to deploy several Kubernetes resources at once.

Solution

Use [Kustomize](#) to configure which resources to deploy.

Deploying an application to a Kubernetes cluster isn't as trivial as just applying one YAML/JSON file containing a Kubernetes Deployment object. Usually, other Kubernetes objects must be defined like Service, Ingress, ConfigMaps, etc., which makes things a bit more complicated in terms of managing and updating these resources (the more resources to maintain, the more chance to update the wrong one) as well as applying them to a cluster (should we run multiple kubectl commands?).

Kustomize is a CLI tool, integrated within the kubectl tool to manage, customize, and apply Kubernetes resources in a *template-less* way.

With Kustomize, you need to set a base directory with standard Kubernetes resource files (no placeholders are required) and create a *kustomization.yaml* file where resources and customizations are declared, as you can see in [Figure 4-1](#).

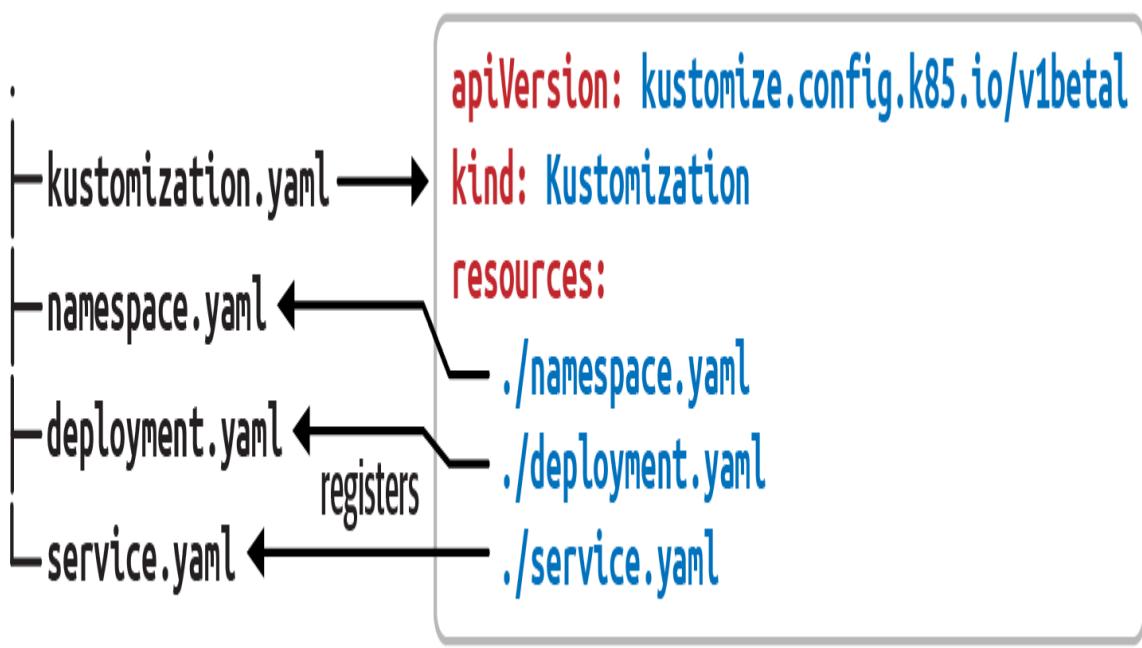


Figure 4-1. Kustomize layout

Let's deploy a simple web page with HTML, JavaScript, and CSS files.

First, open a terminal window and create a directory named *pacman*, then create three Kubernetes resource files to create a Namespace, a Deployment, and a Service with the following content.

The namespace at *pacman/namespace.yaml*:

```

apiVersion: v1
kind: Namespace
metadata:
  name: pacman

```

The deployment file at *pacman/deployment.yaml*:

```

apiVersion: apps/v1
kind: Deployment
metadata:
  name: pacman-kikd
  namespace: pacman
  labels:
    app.kubernetes.io/name: pacman-kikd

```

```

spec:
  replicas: 1
  selector:
    matchLabels:
      app.kubernetes.io/name: pacman-kikd
  template:
    metadata:
      labels:
        app.kubernetes.io/name: pacman-kikd
  spec:
    containers:
      - image: lordofthejars/pacman-kikd:1.0.0
        imagePullPolicy: Always
        name: pacman-kikd
    ports:
      - containerPort: 8080
        name: http
        protocol: TCP

```

The service file at *pacman/service.yaml*:

```

apiVersion: v1
kind: Service
metadata:
  labels:
    app.kubernetes.io/name: pacman-kikd
  name: pacman-kikd
  namespace: pacman
spec:
  ports:
    - name: http
      port: 8080
      targetPort: 8080
  selector:
    app.kubernetes.io/name: pacman-kikd

```

Notice that these files are Kubernetes files that you could apply to a Kubernetes cluster without any problem as no special characters or placeholders are used.

The second thing is to create the *kustomization.yaml* file in the *pacman* directory containing the list of resources that belongs to the application and are applied when running Kustomize:

```

apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization ❶

```

```
resources: ②
- ./namespace.yaml
- ./deployment.yaml
- ./service.yaml
```

① Kustomization file

② Resources belonging to the application processed in depth-first order

At this point, we can apply the kustomization file into a running cluster by running the following command:

```
kubectl apply --dry-run=client -o yaml \ ①
-k ./ ② ③
```

- ① Prints the result of the kustomization run, without sending the result to the cluster
- ② With `-k` option sets `kubectl` to use the kustomization file
- ③ Directory with parent *kustomization.yaml* file

NOTE

We assume you've already started a *Minikube* cluster as shown in [Recipe 2.3](#).

The output is the YAML file that would be sent to the server if the `dry-run` option was not used:

```
apiVersion: v1
items: ①
- apiVersion: v1
  kind: Namespace ②
  metadata:
    name: pacman
- apiVersion: v1
  kind: Service ③
  metadata:
    labels:
      app.kubernetes.io/name: pacman-kikd
```

```

    name: pacman-kikd
    namespace: pacman
  spec:
    ports:
      - name: http
        port: 8080
        targetPort: 8080
    selector:
      app.kubernetes.io/name: pacman-kikd
  - apiVersion: apps/v1
    kind: Deployment ④
    metadata:
      labels:
        app.kubernetes.io/name: pacman-kikd
      name: pacman-kikd
      namespace: pacman
    spec:
      replicas: 1
      selector:
        matchLabels:
          app.kubernetes.io/name: pacman-kikd
      template:
        metadata:
          labels:
            app.kubernetes.io/name: pacman-kikd
      spec:
        containers:
          - image: lordofthejars/pacman-kikd:1.0.0
            imagePullPolicy: Always
            name: pacman-kikd
            ports:
              - containerPort: 8080
                name: http
                protocol: TCP
    kind: List
    metadata: {}

```

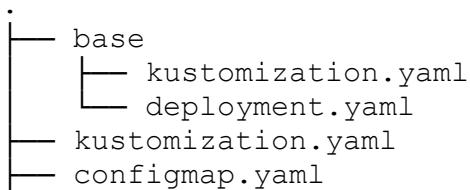
- ❶ List of all Kubernetes objects defined in *kustomization.yaml* to apply
- ❷ The namespace document
- ❸ The service document
- ❹ The deployment document

Discussion

The `resources` section supports different inputs in addition to directly setting the YAML files.

For example, you can set a base directory with its own `kustomization.yaml` and Kubernetes resources files and refer it from another `kustomization.yaml` file placed in another directory.

Given the following directory layout:



And the Kustomization definitions in the `base` directory:

```
apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization
resources:
- ./deployment.yaml
```

You'll see that the root directory has a link to the `base` directory and a ConfigMap definition:

```
apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization
resources:
- ./base
- ./configmap.yaml
```

So, applying the root kustomization file will automatically apply the resources defined in the base kustomization file.

Also, `resources` can reference external assets from a URL following the [HashiCorp URL](#) format. For example, we refer to a GitHub repository by setting the URL:

```
resources:
- github.com/lordofthejars/mysql ❶
- github.com/lordofthejars/mysql?ref=test ❷
```

- ❶ Repository with a root-level *kustomization.yaml* file
- ❷ Repository with a root-level *kustomization.yaml* file on branch test

You've seen the application of a Kustomize file using `kubectl`, but Kustomize also comes with its own CLI tool offering a set of commands to interact with Kustomize resources.

The equivalent command to build Kustomize resources using `kustomize` instead of `kubectl` is:

```
kustomize build
```

And the output is:

```
apiVersion: v1
kind: Namespace
metadata:
  name: pacman
---
apiVersion: v1
kind: Service
metadata:
  labels:
    app.kubernetes.io/name: pacman-kikd
  name: pacman-kikd
  namespace: pacman
spec:
  ports:
  - name: http
    port: 8080
    targetPort: 8080
  selector:
    app.kubernetes.io/name: pacman-kikd
---
apiVersion: apps/v1
kind: Deployment
metadata:
  labels:
    app.kubernetes.io/name: pacman-kikd
  name: pacman-kikd
  namespace: pacman
spec:
  replicas: 1
  selector:
    matchLabels:
```

```
    app.kubernetes.io/name: pacman-kikd
  template:
    metadata:
      labels:
        app.kubernetes.io/name: pacman-kikd
  spec:
    containers:
      - image: lordofthejars/pacman-kikd:1.0.0
        imagePullPolicy: Always
        name: pacman-kikd
      ports:
        - containerPort: 8080
          name: http
          protocol: TCP
```

If you want to apply this output generated by kustomize to the cluster, run the following command:

```
kustomize build . | kubectl apply -f -
```

See Also

- [Kustomize](#)
- [kustomize/v4.4.1 on GitHub](#)
- [HashiCorp URL format](#)

4.2 Updating the Container Image in Kustomize

Problem

You want to update the container image from a deployment file using Kustomize.

Solution

Use the `images` section to update the container image.

One of the most important and most-used operations in software development is updating the application to a newer version either with a bug fix or with a new feature. In Kubernetes, this means that you need to create a new container image, and name it accordingly using the `tag` section (`<registry>/<username>/<project>:<tag>`).

Given the following partial deployment file:

```
spec:  
  containers:  
    - image: lordofthejars/pacman-kikd:1.0.0 ❶  
      imagePullPolicy: Always  
      name: pacman-kikd
```

- ❶ Service 1.0.0 is deployed

We can update the version tag to 1.0.1 by using the `images` section in the `kustomization.yaml` file:

```
apiVersion: kustomize.config.k8s.io/v1beta1  
kind: Kustomization  
resources:  
- ./namespace.yaml  
- ./deployment.yaml  
- ./service.yaml  
images: ❶  
- name: lordofthejars/pacman-kikd ❷  
  newTag: 1.0.1 ❸
```

- ❶ `images` section
- ❷ Sets the name of the image to *update*
- ❸ Sets the new tag value for the image

Finally, use `kubectl` in `dry-run` or `kustomize` to validate that the output of the deployment file contains the new tag version. In a terminal window, run the following command:

```
kustomize build
```

The output of the preceding command is:

```
...
apiVersion: apps/v1
kind: Deployment
metadata:
  labels:
    app.kubernetes.io/name: pacman-kikd
  name: pacman-kikd
  namespace: pacman
spec:
  replicas: 1
  selector:
    matchLabels:
      app.kubernetes.io/name: pacman-kikd
  template:
    metadata:
      labels:
        app.kubernetes.io/name: pacman-kikd
    spec:
      containers:
        - image: lordofthejars/pacman-kikd:1.0.1 ❶
          imagePullPolicy: Always
          name: pacman-kikd
          ports:
            - containerPort: 8080
              name: http
              protocol: TCP
```

❶ Version set in the `kustomize.yaml` file

NOTE

Kustomize is not intrusive, which means that the original `deployment.yaml` file still contains the original tag (1.0.0).

Discussion

One way to update the `newTag` field is by editing the `kustomization.yaml` file, but you can also use the `kustomize` tool for this purpose.

Run the following command in the same directory as the `kustomization.yaml` file:

```
kustomize edit set image lordofthejars/pacman-kikd:1.0.2
```

Check the content of the *kustomization.yaml* file to see that the `newTag` field has been updated:

```
...
images:
- name: lordofthejars/pacman-kikd
  newTag: 1.0.2
```

4.3 Updating Any Kubernetes Field in Kustomize

Problem

You want to update a field (i.e., number of replicas) using Kustomize.

Solution

Use the `patches` section to specify a change using the JSON Patch specification.

In the previous recipe, you saw how to update the container image tag, but sometimes you might change other parameters like the number of replicas or add annotations, labels, limits, etc.

To cover these scenarios, Kustomize supports the use of JSON Patch to modify any Kubernetes resource defined as a Kustomize resource. To use it, you need to specify the JSON Patch expression to apply and which resource to apply the patch to.

For example, we can modify the number of replicas in the following partial deployment file from one to three:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: pacman-kikd
  namespace: pacman
```

```

labels:
  app.kubernetes.io/name: pacman-kikd
spec:
  replicas: 1
  selector:
    matchLabels:
      app.kubernetes.io/name: pacman-kikd
  template:
    metadata:
      labels:
        app.kubernetes.io/name: pacman-kikd
    spec:
      containers:
...

```

First, let's update the *kustomization.yaml* file to modify the number of replicas defined in the deployment file:

```

apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization
resources:
- ./deployment.yaml
patches: ❶
  - target: ❷
    version: v1
    group: apps
    kind: Deployment
    name: pacman-kikd
    namespace: pacman
    patch: |- ❸
      - op: replace ❹
        path: /spec/relicas ❺
        value: 3 ❻

```

- ❶ Patch resource.
- ❷ target section sets which Kubernetes object needs to be changed. These values match the deployment file created previously.
- ❸ Patch expression.
- ❹ Modification of a value.
- ❺ Path to the field to modify.

⑥ New value.

Finally, use `kubectl` in `dry-run` or `kustomize` to validate that the output of the deployment file contains the new tag version. In a terminal window, run the following command:

```
kustomize build
```

The output of the preceding command is:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  labels:
    app.kubernetes.io/name: pacman-kikd
  name: pacman-kikd
  namespace: pacman
spec:
  replicas: 3
  selector:
    matchLabels:
      app.kubernetes.io/name: pacman-kikd
...
...
```

TIP

The `replicas` value can also be updated using the `replicas` field in the `kustomization.yaml` file.

The equivalent Kustomize file using the `replicas` field is shown in the following snippet:

```
apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization
replicas:
- name: pacman-kikd ①
  count: 3 ②
resources:
- deployment.yaml
```

- ① Deployment to update the replicas
- ② New replicas value

Kustomize lets you add (or delete) values, in addition to modifying a value. Let's see how to add a new label:

```
...
patches:
  - target:
      version: v1
      group: apps
      kind: Deployment
      name: pacman-kikd
      namespace: pacman
    patch: |-  
      - op: replace
        path: /spec/relicas
        value: 3
      - op: add ❶
        path: /metadata/labels/testkey ❷
        value: testvalue ❸
```

- ❶ Adds a new field with value
- ❷ Path with the field to add
- ❸ The value to set

The result of applying the file is:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  labels:
    app.kubernetes.io/name: pacman-kikd
    testkey: testvalue ❶
  name: pacman-kikd
  namespace: pacman
spec:
  replicas: 3
  selector:
...

```

- ❶ Added label

Discussion

Instead of embedding a JSON Patch expression, you can create a YAML file with a Patch expression and refer to it using the `path` field instead of `patch`.

Create an external patch file named `external_patch` containing the JSON Patch expression:

```
- op: replace
  path: /spec/relicas
  value: 3
- op: add
  path: /metadata/labels/testkey
  value: testvalue
```

And change the `patch` field to `path` pointing to the patch file:

```
...
patches:
- target:
  version: v1
  group: apps
  kind: Deployment
  name: pacman-kikd
  namespace: pacman
  path: external_patch.yaml ①
```

① Path to external patch file

In addition to the JSON Patch expression, Kustomize also supports [Strategic Merge Patch](#) to modify Kubernetes resources. In summary, a Strategic Merge Patch (or *SMP*) is an incomplete YAML file that is merged against a completed YAML file.

Only a minimal deployment file with container name information is required to update a container image:

```
apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization
resources:
- ./deployment.yaml
patches:
- target:
  labelSelector: "app.kubernetes.io/name=pacman-kikd" ①
```

```

patch: | - ②
  apiVersion: apps/v1 ③
  kind: Deployment
  metadata:
    name: pacman-kikd
  spec:
    template:
      spec:
        containers:
          - name: pacman-kikd
            image: lordofthejars/pacman-kikd:1.2.0 ④

```

- ① Target is selected using label
- ② Patch is smart enough to detect if it is an SMP or JSON Patch
- ③ This is a minimal deployment file
- ④ Sets only the field to change, the rest is left as is

The generated output is the original *deployment.yaml* file but with the new container image:

```

apiVersion: apps/v1
kind: Deployment
metadata:
  labels:
    app.kubernetes.io/name: pacman-kikd
  name: pacman-kikd
  namespace: pacman
spec:
  replicas: 1
  selector:
    matchLabels:
      app.kubernetes.io/name: pacman-kikd
  template:
    metadata:
      labels:
        app.kubernetes.io/name: pacman-kikd
    spec:
      containers:
        - image: lordofthejars/pacman-kikd:1.2.0
          imagePullPolicy: Always
...

```

TIP

path is supported as well.

See Also

- [RFC 6902: JavaScript Object Notation \(JSON\) Patch](#)
- [Strategic Merge Patch](#)

4.4 Deploying to Multiple Environments

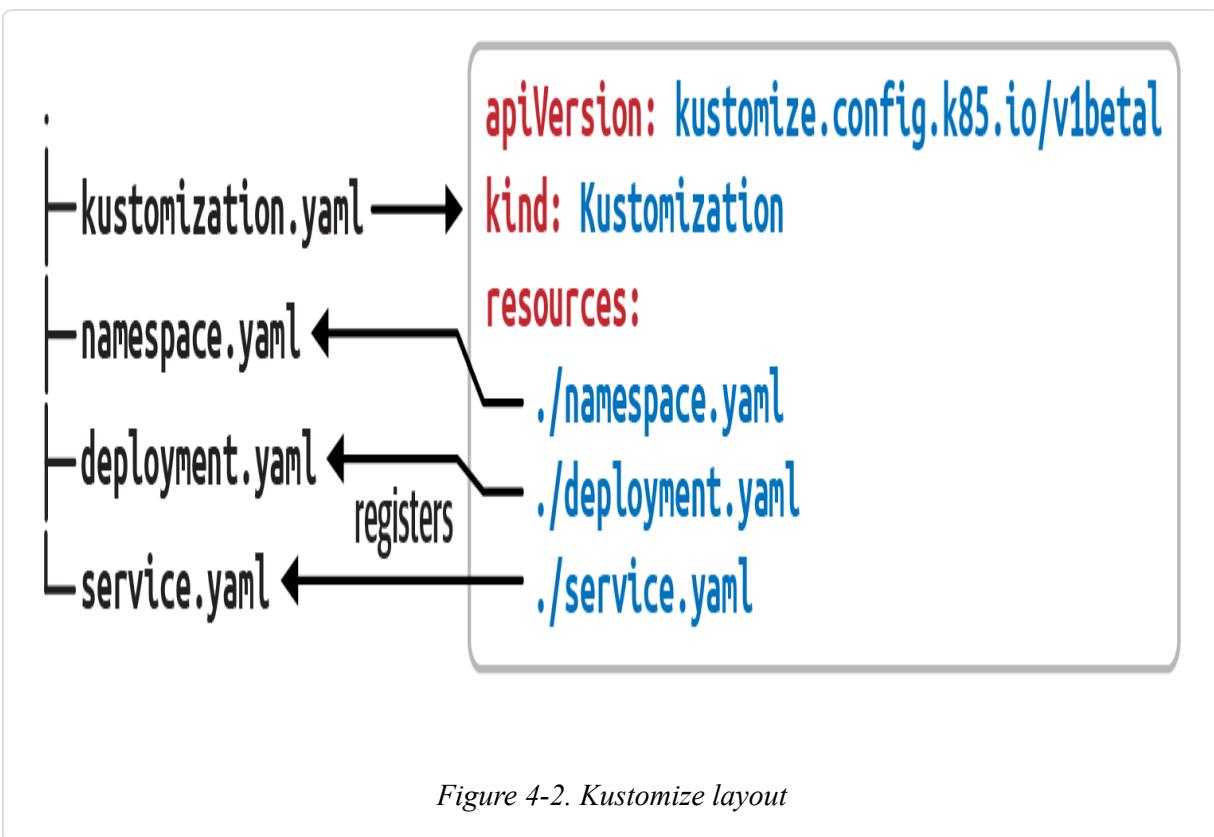
Problem

You want to deploy the same application in different namespaces using Kustomize.

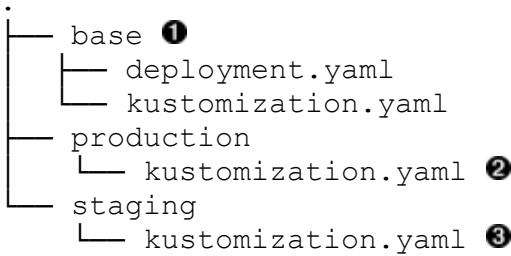
Solution

Use the namespace field to set the target namespace.

In some circumstances, it's good to have the application deployed in different namespaces; for example, one namespace can be used as a *staging* environment, and another one as the *production* namespace. In both cases, the base Kubernetes files are the same, with minimal changes like the namespace deployed, some configuration parameters, or container version, to mention a few. [Figure 4-2](#) shows an example.



kustomize lets you define multiple changes with a different namespace, as overlays on a common base using the `namespace` field. For this example, all base Kubernetes resources are put in the `base` directory and a new directory is created for customizations of each environment:



- ① Base files
 - ② Changes specific to production environment
 - ③ Changes specific to staging environment

The base kustomization file contains a reference to its resources:

```
apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization
resources:
- ./deployment.yaml
```

There is a kustomization file with some parameters set for each environment directory. These reference the *base* directory, the namespace to inject into Kubernetes resources, and finally, the image to deploy, which in production is *1.1.0* but in staging is *1.2.0-beta*.

For the staging environment, *kustomization.yaml* content is shown in the following listing:

```
apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization
resources:
- ../base ①
namespace: staging ②
images:
- name: lordofthejars/pacman-kikd
  newTag: 1.2.0-beta ③
```

- ① References to *base* directory
- ② Sets namespace to *staging*
- ③ Sets the container tag for the *staging* environment

The kustomization file for production is similar to the staging one, but changes the namespace and the tag:

```
apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization
resources:
- ../base
namespace: prod ①
images:
- name: lordofthejars/pacman-kikd
  newTag: 1.1.0 ②
```

- ① Sets namespace for *production*
- ② Sets the container tag for the *production* environment

Running `kustomize` produces different output depending on the directory where it is run; for example, running `kustomize build` in the *staging* directory produces:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  labels:
    app.kubernetes.io/name: pacman-kikd
  name: pacman-kikd
  namespace: staging ①
spec:
  replicas: 1
...
  template:
    metadata:
      labels:
        app.kubernetes.io/name: pacman-kikd
    spec:
      containers:
        - image: lordofthejars/pacman-kikd:1.2.0-beta ②
...
...
```

- ① Namespace value is injected
- ② Container tag for the *staging* environment is injected

But if you run it in the *production* directory, the output is adapted to the production configuration:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  labels:
    app.kubernetes.io/name: pacman-kikd
  name: pacman-kikd
  namespace: prod ①
spec:
  replicas: 1
...
  spec:
    containers:
      - image: lordofthejars/pacman-kikd:1.1.0 ②
...
...
```

- ❶ Injects the *production* namespace
- ❷ Container tag for the *production* environment

Discussion

Kustomize can prepend/append a value to the names of all resources and references. This is useful when a different name in the resource is required depending on the environment, or to set the version deployed in the name:

```
apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization
resources:
- ../base
namespace: staging
namePrefix: staging- ❶
nameSuffix: -v1-2-0 ❷
images:
- name: lordofthejars/pacman-kikd
  newTag: 1.2.0-beta
```

- ❶ Prefix to prepend
- ❷ Suffix to append

And the resulting output is as follows:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  labels:
    app.kubernetes.io/name: pacman-kikd
  name: staging-pacman-kikd-v1-2-0 ❶
  namespace: staging
spec:
  ...
```

- ❶ New name of the deployment file

4.5 Generating ConfigMaps in Kustomize

Problem

You want to generate Kubernetes ConfigMaps using Kustomize.

Solution

Use the `ConfigMapGenerator` feature field to generate a Kubernetes ConfigMap resource on the fly.

Kustomize provides two ways of adding a ConfigMap as a Kustomize resource: either by declaring a ConfigMap as any other resource or declaring a ConfigMap from a `ConfigMapGenerator`.

While using ConfigMap as a resource offers no other advantage than populating Kubernetes resources as any other resource, `ConfigMapGenerator` automatically appends a hash to the ConfigMap metadata name and also modifies the deployment file with the new hash. This minimal change has a deep impact on the application's lifecycle, as we'll see soon in the example.

Let's consider an application running in Kubernetes and configured using a ConfigMap—for example, a database timeout connection parameter. We decided to increase this number at some point, so the ConfigMap file is changed to this new value, and we deploy the application again. Since the ConfigMap is the only changed file, no rolling update of the application is done. A manual rolling update of the application needs to be triggered to propagate the change to the application. [Figure 4-3](#) shows what is changed when a ConfigMap object is updated.

Kubernetes Cluster

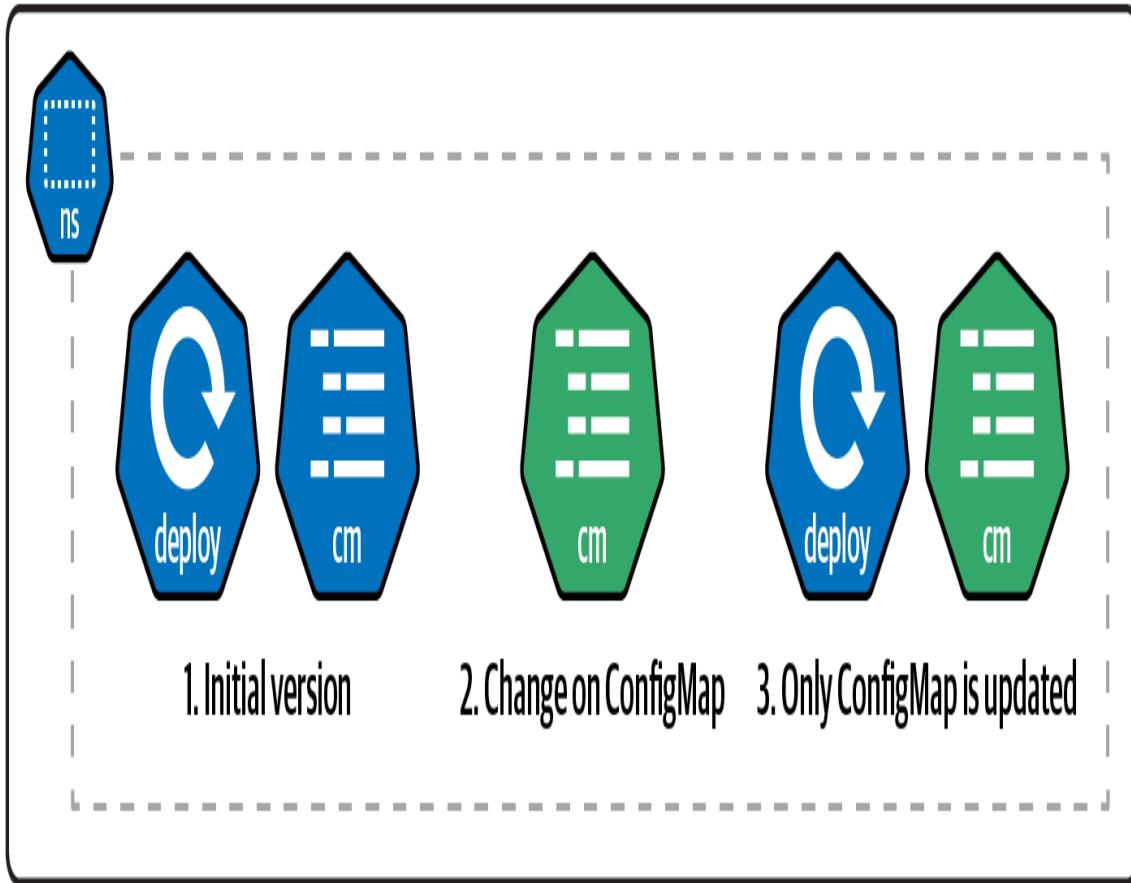


Figure 4-3. Change of a ConfigMap

But, if `ConfigMapGenerator` manages the `ConfigMap`, any change on the configuration file also changes the deployment Kubernetes resource. Since the deployment file has changed too, an automatic rolling update is triggered when the resources are applied, as shown in [Figure 4-4](#).

Moreover, when using `ConfigMapGenerator`, multiple configuration datafiles can be combined into a single `ConfigMap`, making a perfect use case when every environment has different configuration files.

Kubernetes Cluster

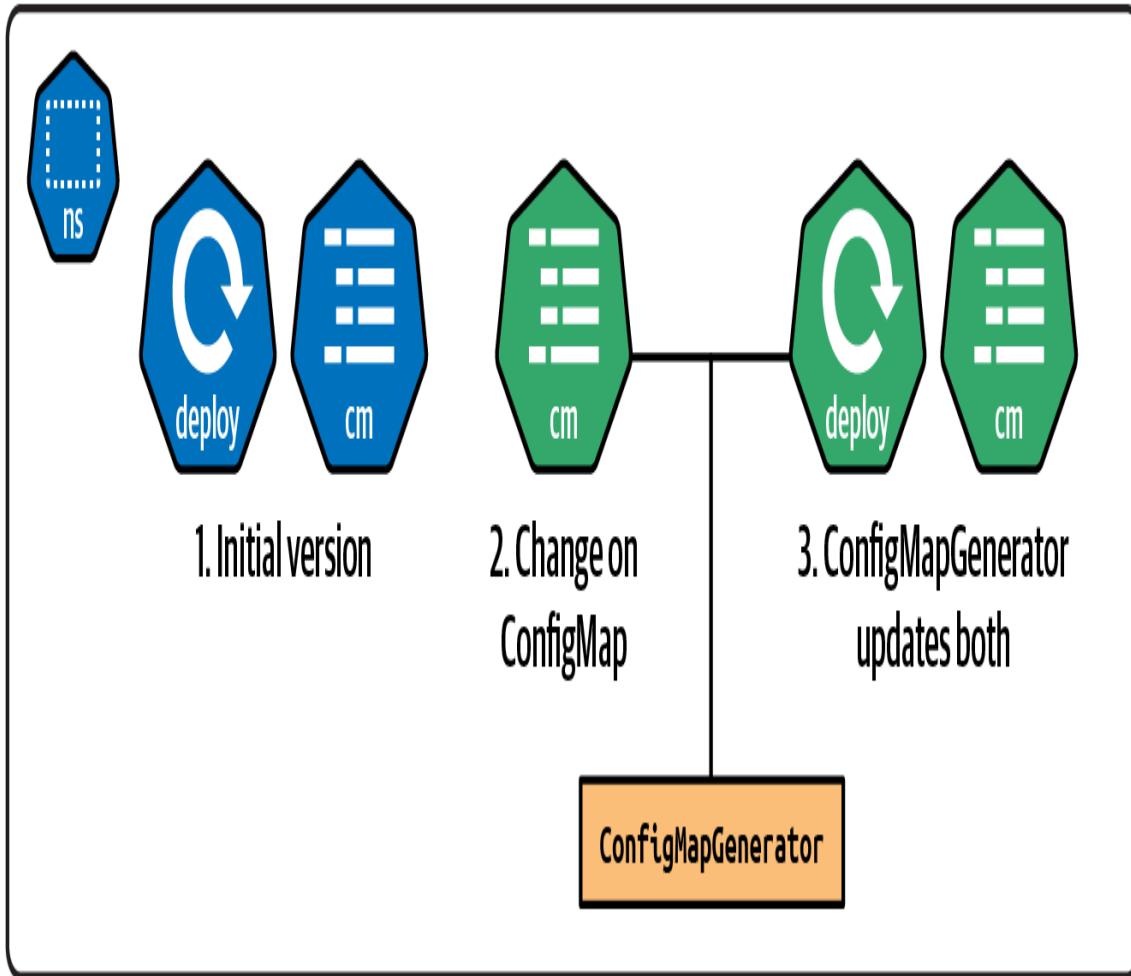


Figure 4-4. Change of a ConfigMap using ConfigMapGenerator

Let's start with a simple example, adding the `ConfigMapGenerator` section in the `kustomization.yaml` file.

The deployment file is similar to the one used in previous sections of this chapter but includes the `volumes` section:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: pacman-kikd
spec:
  replicas: 1
```

```

selector:
  matchLabels:
    app.kubernetes.io/name: pacman-kikd
template:
  metadata:
    labels:
      app.kubernetes.io/name: pacman-kikd
spec:
  containers:
    - image: lordofthejars/pacman-kikd:1.0.0
      imagePullPolicy: Always
      name: pacman-kikd
    volumeMounts:
      - name: config
        mountPath: /config
  volumes:
    - name: config
      configMap:
        name: pacman-configmap ❶

```

❶ ConfigMap name is used in the *kustomization.yaml* file

The configuration properties are embedded within the *kustomization.yaml* file. Notice that the ConfigMap object is created on the fly when the kustomization file is built:

```

apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization
resources:
- ./deployment.yaml
configMapGenerator:
- name: pacman-configmap ❶
  literals: ❷
    - db-timeout=2000 ❸
    - db-username=Ada

```

- ❶ Name of the ConfigMap set in the deployment file
- ❷ Embeds configuration values in the file
- ❸ Sets a key/value pair for the properties

Finally, use `kubectl` in `dry-run` or `kustomize` to validate that the output of the deployment file contains the new tag version. In a terminal window, run the following command:

```
kustomize build
```

The output of the preceding command is a new ConfigMap with the configuration values set in *kustomization.yaml*. Moreover, the name of the ConfigMap is updated by appending a hash in both the generated ConfigMap and deployment:

```
apiVersion: v1
data: ①
  db-timeout: "2000"
  db-username: Ada
kind: ConfigMap
metadata:
  name: pacman-configmap-96kb69b6t4 ②
---
apiVersion: apps/v1
kind: Deployment
metadata:
  labels:
    app.kubernetes.io/name: pacman-kikd
  name: pacman-kikd
spec:
  replicas: 1
  selector:
    matchLabels:
      app.kubernetes.io/name: pacman-kikd
  template:
    metadata:
      labels:
        app.kubernetes.io/name: pacman-kikd
    spec:
      containers:
        - image: lordofthejars/pacman-kikd:1.0.0
          imagePullPolicy: Always
          name: pacman-kikd
          volumeMounts:
            - mountPath: /config
              name: config
      volumes:
        - configMap:
            name: pacman-configmap-96kb69b6t4 ③
            name: config
```

① ConfigMap with properties

② Name with hash

- ③ Name field is updated to the one with the hash triggering a rolling update

Since the hash is calculated for any change in the configuration properties, a change on them provokes a change on the output triggering a rolling update of the application. Open the *kustomization.yaml* file and update the db-timeout literal from 2000 to 1000 and run `kustomize build` again. Notice the change in the ConfigMap name using a new hashed value:

```
apiVersion: v1
data:
  db-timeout: "1000"
  db-username: Ada
kind: ConfigMap
metadata:
  name: pacman-configmap-6952t58tb4 ❶
---
apiVersion: apps/v1
kind: Deployment
...
  volumes:
    - configMap:
        name: pacman-configmap-6952t58tb4
        name: config
```

- ❶ New hashed value

Discussion

ConfigMapGenerator also supports merging configuration properties from different sources.

Create a new *kustomization.yaml* file in the *dev_literals* directory, setting it as the previous directory and overriding the db-username value:

```
apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization
resources:
- ../../literals ❶
configMapGenerator:
- name: pacman-configmap
  behavior: merge ❷
```

```
literals:  
- db-username=Alexandra ③
```

- ① Base directory
- ② Merge properties (can be create or replace too)
- ③ Overridden value

Running the `kustomize build` command produces a ConfigMap containing a merge of both configuration properties:

```
apiVersion: v1  
data:  
  db-timeout: "1000" ①  
  db-username: Alexandra ②  
kind: ConfigMap  
metadata:  
  name: pacman-configmap-ttfdfdk5t8  
---  
apiVersion: apps/v1  
kind: Deployment  
metadata:  
  labels:  
    app.kubernetes.io/name: pacman-kikd  
  name: pacman-kikd  
...
```

- ① Inherits from base
- ② Overrides value

In addition to setting configuration properties as literals, Kustomize supports defining them as *.properties* files.

Create a *connection.properties* file with two properties inside:

```
db-url=prod:4321/db  
db-username=ada
```

The *kustomization.yaml* file uses the `files` field instead of `literals`:

```
apiVersion: kustomize.config.k8s.io/v1beta1  
kind: Kustomization
```

```
resources:
- ./deployment.yaml
configMapGenerator:
- name: pacman-configmap
  files: ❶
    - ./connection.properties ❷
```

- ❶ Sets a list of files to read
- ❷ Path to the properties file

Running the `kustomize build` command produces a ConfigMap containing the name of the file as a key, and the value as the content of the file:

```
apiVersion: v1
data:
  connection.properties: |-  
    db-url=prod:4321/db  
    db-username=ada
kind: ConfigMap
metadata:
  name: pacman-configmap-g9dm2gtt77
---  
apiVersion: apps/v1
kind: Deployment
metadata:
  labels:
    app.kubernetes.io/name: pacman-kikd
  name: pacman-kikd
...
```

See Also

Kustomize offers a similar way to deal with Kubernetes Secrets. But as we'll see in [Chapter 8](#), the best way to deal with Kubernetes Secrets is using Sealed Secrets.

4.6 Final Thoughts

Kustomize is a simple tool, using template-less technology that allows you to define plain YAML files and override values either using a merge

strategy or using JSON Patch expressions. The structure of a project is free as you define the directory layout you feel most comfortable with; the only requirement is the presence of a *kustomization.yaml* file.

But there is another well-known tool to manage Kubernetes resources files, that in our opinion, is a bit more complicated but more powerful, especially when the application/service to deploy has several dependencies such as databases, mail servers, caches, etc. This tool is Helm, and we'll cover it in [Chapter 5](#).

Chapter 5. Helm

In [Chapter 4](#), you learned about Kustomize, a simple yet powerful tool to manage Kubernetes resources. But another popular tool aims to simplify the Kubernetes resources management too: Helm.

Helm works similarly to Kustomize, but it's a template solution and acts more like a package manager, producing artifacts that are versionable, sharable, or deployable.

In this chapter, we'll introduce Helm, a package manager for Kubernetes that helps install and manage Kubernetes applications using the Go template language in YAML files.

The first step is to create a Helm project and deploy it to a Kubernetes cluster (see Recipes [5.1](#) and [5.2](#)). After the first deployment, the application is updated with a new container image, a new configuration value, or any other field, such as the replica number (see [Recipe 5.3](#)).

One of the differences between Kustomize and Helm is the concept of a Chart. A Chart is a packaged artifact that can be shared and contains multiple elements like dependencies on other Charts (see Recipes [5.4](#), [5.5](#), and [5.6](#)).

Application configuration values are properties usually mapped as a Kubernetes ConfigMap. Any change (and its consequent update on the cluster) on a ConfigMap doesn't trigger a rolling update of the application, which means that the application will run with the previous version until you manually restart it.

Helm provides some functions to automatically execute a rolling update when the ConfigMap of an application changes (see [Recipe 5.7](#)).

5.1 Creating a Helm Project

Problem

You want to create a simple Helm project.

Solution

Use the [Helm](#) CLI tool to create a new project.

In contrast to Kustomize, which can be used either within the `kubectl` command or as a standalone CLI tool, Helm needs to be downloaded and installed in your local machine.

Helm is a packager for Kubernetes that bundles related manifest files and packages them into a single logical deployment unit: a Chart. Thus simplified, for many engineers, Helm makes it easy to start using Kubernetes with real applications.

Helm Charts are useful for addressing the installation complexities and simple upgrades of applications.

For this book, we use Helm 3.7.2, which you can download from [GitHub](#) and install in your PATH directory.

Open a terminal and run the following commands to create a Helm Chart directory layout:

```
mkdir pacman
mkdir pacman/templates

cd pacman
```

Then create three files: one that defines the Chart, another representing the deployment template using the Go template language and template functions from the Sprig library, and finally a file containing the default values for the Chart.

A *Chart.yaml* file declares the Chart with information such as version or name. Create the file in the root directory:

```
apiVersion: v2
name: pacman
```

```
description: A Helm chart for Pacman
type: application
version: 0.1.0 ❶
appVersion: "1.0.0" ❷
```

- ❶ Version of the Chart. This is updated when something in the Chart definition is changed.
- ❷ Version of the application.

Let's create a *deployment.yaml* and a *service.yaml* template file to deploy the application.

The *deployment.yaml* file templatizes the deployment's name, the application version, the replica count, the container image and tag, the pull policy, the security context, and the port:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: {{ .Chart.Name }} ❶
  labels:
    app.kubernetes.io/name: {{ .Chart.Name }}
    {{- if .Chart.AppVersion }} ❷
    app.kubernetes.io/version: {{ .Chart.AppVersion | quote }} ❸
    {{- end }}
spec:
  replicas: {{ .Values.replicaCount }} ❹
  selector:
    matchLabels:
      app.kubernetes.io/name: {{ .Chart.Name }}
  template:
    metadata:
      labels:
        app.kubernetes.io/name: {{ .Chart.Name }}
    spec:
      containers:
        - image: "{{ .Values.image.repository }}"
          {{ .Values.image.tag | default .Chart.AppVersion}}" ❽
          {{- ❾
            imagePullPolicy: {{ .Values.image.pullPolicy }} ❿
            securityContext:
              {{- toYaml .Values.securityContext | nindent 14 }}}}
```

```

  name: {{ .Chart.Name }}
  ports:
    - containerPort: {{ .Values.image.containerPort }}
      name: http
      protocol: TCP

```

- ❶ Sets the name from the *Chart.yaml* file
- ❷ Conditionally sets the version based on the presence of the `appVersion` in the *Chart.yaml* file
- ❸ Sets the `appVersion` value but quoting the property
- ❹ Placeholder for the `replicaCount` property
- ❺ Placeholder for the container image
- ❻ Placeholder for the image tag if present and if not, defaults to the *Chart.yaml* property
- ❼ Sets the `securityContext` value as a YAML object and not as a string, indenting it 14 spaces

The *service.yaml* file templatizes the service name and the container port:

```

apiVersion: v1
kind: Service
metadata:
  labels:
    app.kubernetes.io/name: {{ .Chart.Name }}
  name: {{ .Chart.Name }}
spec:
  ports:
    - name: http
      port: {{ .Values.image.containerPort }}
      targetPort: {{ .Values.image.containerPort }}
  selector:
    app.kubernetes.io/name: {{ .Chart.Name }}

```

The *values.yaml* file contains the default values for the Chart. These values can be overridden at runtime, but they provide good initial values.

Create the file in the root directory with some default values:

```

image: ❶
  repository: quay.io/gitops-cookbook/pacman-kikd ❷
  tag: "1.0.0"
  pullPolicy: Always
  containerPort: 8080

replicaCount: 1
securityContext: {} ❸

```

- ❶ Defines the `image` section
- ❷ Sets the `repository` property
- ❸ Empty `securityContext`

Built-in properties are capitalized; for this reason, properties defined in the `Chart.yaml` file start with an uppercase letter.

Since the `toYaml` function is used for the `securityContext` value, the expected value for the `securityContext` property in `values.yaml` should be a YAML object. For example:

```

securityContext:
  capabilities:
    drop:
    - ALL
  readOnlyRootFilesystem: true
  runAsNonRoot: true
  runAsUser: 1000

```

The relationship between all elements is shown in [Figure 5-1](#).

```

apiVersion: apps/v1
kind: Deployment
metadata:
  name: {{ .Chart.Name }} ←
  labels:
    app.kubernetes.io/name: {{ .Chart.Name }}
    {{- if .Chart.AppVersion --}}
    app.kubernetes.io/version: {{ .Chart.AppVersion | quote }} ←
    {{- end --}}
spec:
  replicas: {{ .Values.replicaCount }} ←
  selector:
    matchLabels:
      app.kubernetes.io/name: {{ .Chart.Name }} ←
  template:
    metadata:
      labels:
        app.kubernetes.io/name: {{ .Chart.Name }} ←
    spec:
      containers:
        - image: "{{ .Values.image.repository }}:{{ .Values.image.tag | default .Chart.Appversion }}"
          imagePullPolicy: {{ .Values.image.pullPolicy }} ←
          securityContext:
            {{- toYaml .Values.securityContext | nindent 14 }} ←
            name: {{ .Chart.Name }} ←
          ports:
            - containerPort: {{ .Values.image.containerPort }} ←
              name: http ←
              ...

```

chart.yaml

```

apiVersion: v2
name: pacman
description: A Helm chart for Pacman

type: application
version: 0.1.0
appVersion: "1.0.0"

```

values.yaml

```

replicaCount: 1

image:
  repository: lordofthejars/pacman-kikd
  tag: "1.0.0"
  pullPolicy: Always
  containerPort: 8080

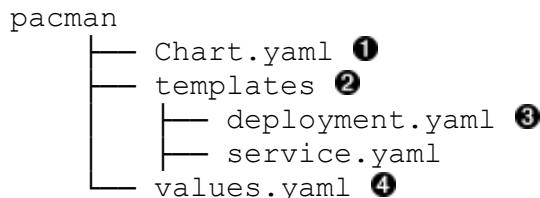
  securityContext: {}

```

protocol: TCP

Figure 5-1. Relationship between Helm elements

At this point the Helm directory layout is created and should be similar to this:



- ① The *Chart.yaml* file is the Chart descriptor and contains metadata related to the Chart.
- ② The *templates* directory contains all template files used for installing a Chart.
- ③ These files are Helm template files used to deploy the application.
- ④ The *values.yaml* file contains the default values for a Chart.

To render the Helm Chart locally to YAML, run the following command in a terminal window:

```
helm template .
```

The output is:

```
---
apiVersion: v1
kind: Service
metadata:
  labels:
    app.kubernetes.io/name: pacman
    name: pacman ①
spec:
  ports:
    - name: http
      port: 8080 ②
      targetPort: 8080
```

```

    selector:
      app.kubernetes.io/name: pacman
---
apiVersion: apps/v1
kind: Deployment
metadata:
  name: pacman
  labels:
    app.kubernetes.io/name: pacman
    app.kubernetes.io/version: "1.0.0" ❸
spec:
  replicas: 1
  selector:
    matchLabels:
      app.kubernetes.io/name: pacman
  template:
    metadata:
      labels:
        app.kubernetes.io/name: pacman
    spec:
      containers:
        - image: "quay.io/gitops-cookbook/pacman-kikd:1.0.0" ❹
          imagePullPolicy: Always
          securityContext: ❺
            {}
          name: pacman
          ports:
            - containerPort: 8080
              name: http
              protocol: TCP

```

- ❶ Name is injected from *Chart.yaml*
- ❷ Port is set in *values.yaml*
- ❸ Version is taken from Chart version
- ❹ Concatenates content from two attributes
- ❺ Empty security context

You can override any default value by using the `--set` parameter in Helm. Let's override the `replicaCount` value from one (defined in *values.yaml*) to three:

```
helm template --set replicaCount=3 .
```

And the `replicas` value is updated:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: pacman
  labels:
    app.kubernetes.io/name: pacman
    app.kubernetes.io/version: "1.0.0"
spec:
  replicas: 3
...
```

Discussion

Helm is a package manager for Kubernetes, and as such, it helps you with the task of versioning, sharing, and upgrading Kubernetes applications.

Let's see how to install the Helm Chart to a Kubernetes cluster and upgrade the application.

With Minikube up and running, execute the following command in a terminal window, and run the `install` command to deploy the application to the cluster:

```
helm install pacman .
```

The Chart is installed in the running Kubernetes instance:

```
LAST DEPLOYED: Sat Jan 22 15:13:50 2022
NAMESPACE: default
STATUS: deployed
REVISION: 1
TEST SUITE: None
```

Get the list of current deployed pods, Deployments, and Services to validate that the Helm Chart is deployed in the Kubernetes cluster:

```
kubectl get pods
```

NAME	READY	STATUS	RESTARTS	AGE
pacman-7947b988-kzjbc	1/1	Running	0	60s

```
kubectl get deployment
```

NAME	READY	UP-TO-DATE	AVAILABLE	AGE
pacman	1/1	1	1	4m50s

```
kubectl get services
```

NAME	TYPE	CLUSTER-IP	EXTERNAL-IP	PORT (S)
pacman	ClusterIP	172.30.129.123	<none>	8080/TCP
				9m55s

Also, it's possible to get history information about the deployed Helm Chart using the `history` command:

```
helm history pacman
```

REVISION	CHART	APP VERSION	UPDATED	DESCRIPTION	STATUS
1	pacman	1.0.0	Sat Jan 22 15:23:22 2022	Install complete	deployed

To uninstall a Chart from the cluster, run `uninstall` command:

```
helm uninstall pacman
```

```
release "pacman" uninstalled
```

Helm is a package manager that lets you share the Chart (package) to other Charts as a dependency. For example, you can have a Chart defining the deployment of the application and another Chart as a dependency setting a database deployment. In this way, the installation process installs the application and the database Chart automatically.

We'll learn about the packaging process and adding dependencies in a later section.

TIP

You can use the `helm create <name>` command to let the Helm tool scaffold the project.

See Also

- [Helm](#)
- [Go template package](#)
- [Sprig Function Documentation](#)

5.2 Reusing Statements Between Templates

Problem

You want to reuse template statements across several files.

Solution

Use `_helpers.tpl` to define reusable statements.

We deployed a simple application to Kubernetes using Helm in the previous recipe. This simple application was composed of a Kubernetes Deployment file and a Kubernetes Service file where the `selector` field was defined with the same value.

As a reminder:

```
...
spec:
  replicas: {{ .Values.replicaCount }}
  selector:
    matchLabels:
      app.kubernetes.io/name: {{ .Chart.Name }}
template:
  metadata:
    labels:
      app.kubernetes.io/name: {{ .Chart.Name }}
...
...
```

```

service.yaml
-----
...
selector:
  app.kubernetes.io/name: {{ .Chart.Name }}
-----

```

If you need to update this field—for example, adding a new label as a selector—you would need to update in three places, as shown in the previous snippets.

Helm lets you create a `_helpers.tpl` file in the `templates` directory defining statements that can be called in templates to avoid this problem.

Let's refactor the previous example to use the `_helpers.tpl` file to define the `selectorLabels`.

Create the `_helpers.tpl` file in the `templates` directory with the following content:

```

{{- define "pacman.selectorLabels" -}} ❶
app.kubernetes.io/name: {{ .Chart.Name }} ❷
{{- end }}

```

❶ Defines the statement name

❷ Defines the logic of the statement

Then replace the template placeholders shown in previous snippets with a call to the `podman.selectorLabels` helper statement using the `include` keyword:

```

spec:
  replicas: {{ .Values.replicaCount }}
  selector:
    matchLabels:
      {{- include "pacman.selectorLabels" . | nindent 6 }} ❶
  template:
    metadata:
      labels:
        {{- include "pacman.selectorLabels" . | nindent 8 }} ❷
  spec:
    containers:

```

- ❶ Calls `pacman.selectorLabels` with indentation
- ❷ Calls `pacman.selectorLabels` with indentation

To render the Helm Chart locally to YAML, run the following command in a terminal window:

```
helm template .
```

The output is:

```
apiVersion: v1
kind: Service
metadata:
  labels:
    app.kubernetes.io/name: pacman
    name: pacman
spec:
  ports:
    - name: http
      port: 8080
      targetPort: 8080
  selector:
    app.kubernetes.io/name: pacman ❶
---
apiVersion: apps/v1
kind: Deployment
metadata:
  name: pacman
  labels:
    app.kubernetes.io/name: pacman
    app.kubernetes.io/version: "1.0.0"
spec:
  replicas: 1
  selector:
    matchLabels:
      app.kubernetes.io/name: pacman ❷
  template:
    metadata:
      labels:
        app.kubernetes.io/name: pacman ❸
    spec:
      containers:
        - image: "quay.io/gitops-cookbook/pacman-kikd:1.0.0"
          imagePullPolicy: Always
          securityContext:
            {}
```

```

name: pacman
ports:
  - containerPort: 8080
    name: http
    protocol: TCP

```

- ❶ Selector is updated with value set in `_helpers.tpl`
- ❷ Selector is updated with value set in `_helpers.tpl`
- ❸ Selector is updated with value set in `_helpers.tpl`

Discussion

If you want to update the selector labels, the only change you need to do is an update to the `_helpers.tpl` file:

```

{{- define "pacman.selectorLabels" -}}
app.kubernetes.io/name: {{ .Chart.Name}}
app.kubernetes.io/version: {{ .Chart.AppVersion}} ❶
{{- end }}

```

- ❶ Adds a new attribute

To render the Helm Chart locally to YAML, run the following command in a terminal window:

```
helm template .
```

The output is:

```

---
# Source: pacman/templates/service.yaml
apiVersion: v1
kind: Service
metadata:
...
  selector:
    app.kubernetes.io/name: pacman
    app.kubernetes.io/version: 1.0.0 ❶
---
apiVersion: apps/v1
kind: Deployment

```

```
metadata:  
  name: pacman  
  labels:  
    app.kubernetes.io/name: pacman  
    app.kubernetes.io/version: "1.0.0"  
spec:  
  replicas: 1  
  selector:  
    matchLabels:  
      app.kubernetes.io/name: pacman  
      app.kubernetes.io/version: 1.0.0 ②  
  template:  
    metadata:  
      labels:  
        app.kubernetes.io/name: pacman  
        app.kubernetes.io/version: 1.0.0 ③  
    spec:  
    ...
```

① Label is added

② Label is added

③ Label is added

TIP

Although it's common to use `_helpers.tpl` as the filename to define functions, you can name any file starting with `_`, and Helm will read the functions too.

5.3 Updating a Container Image in Helm

Problem

You want to update the container image from a deployment file using Helm and upgrade the running instance.

Solution

Use the `upgrade` command.

With Minikube up and running, deploy version 1.0.0 of the pacman application:

```
helm install pacman .
```

With the first revision deployed, let's update the container image to a new version and deploy it.

You can check revision number by running the following command:

```
helm history pacman
```

REVISION	UPDATED	STATUS	CHART	APP
VERSION\,				
DESCRIPTION				
1	Sun Jan 23 16:00:09 2022	deployed	pacman-0.1.0	
1.0.0\,				
Install complete				

To update the version, open *values.yaml* and update the `image.tag` field to the newer container image tag:

```
image:  
  repository: quay.io/gitops-cookbook/pacman-kikd  
  tag: "1.1.0" ❶  
  pullPolicy: Always  
  containerPort: 8080  
  
replicaCount: 1  
securityContext: {}
```

❶ Updates to container tag to 1.1.0

Then update the `appVersion` field of the *Chart.yaml* file:

```
apiVersion: v2  
name: pacman  
description: A Helm chart for Pacman  
  
type: application  
version: 0.1.0  
appVersion: "1.1.0" ❶
```

❶ Version is updated accordingly

TIP

You can use `appVersion` as the tag instead of having two separate fields. Using two fields or one might depend on your use case, versioning strategy, and lifecycle of your software.

After these changes, upgrade the deployment by running the following command:

```
helm upgrade pacman .
```

The output reflects that a new revision has been deployed:

```
Release "pacman" has been upgraded. Happy Helming!
NAME: pacman
LAST DEPLOYED: Mon Jan 24 11:39:28 2022
NAMESPACE: asotobue-dev
STATUS: deployed
REVISION: 2 ❶
TEST SUITE: None
```

❷ New revision

The `history` command shows all changes between all versions:

```
helm history pacman

REVISION UPDATED STATUS CHART
APP VERSION\,
DESCRIPTION
1 Mon Jan 24 10:22:06 2022 superseded pacman-0.1.0
1.0.0\,
Install complete
2 Mon Jan 24 11:39:28 2022 deployed pacman-0.1.0
1.1.0\,
Upgrade complete
```

NOTE

`appVersion` is the application version, so every time you change the application version, you should update that field too. On the other side, `version` is the Chart version and should be updated when the definition of the Chart (i.e., templates) changes, so both fields are independent.

Discussion

Not only you can install or upgrade a version with Helm, but you can also roll back to a previous revision.

In the terminal window, run the following command:

```
helm rollback pacman 1  
Rollback was a success! Happy Helming!
```

Running the `history` command reflects this change too:

```
helm history pacman  
  
REVISION  UPDATED          STATUS        CHART  
APP VERSION  
DESCRIPTION  
1          Mon Jan 24 10:22:06 2022  superseded  pacman-0.1.0  
1.0.0  
Install complete  
2          Mon Jan 24 11:39:28 2022  superseded  pacman-0.1.0  
1.1.0  
Upgrade complete  
3          Mon Jan 24 12:31:58 2022  deployed    pacman-0.1.0  
1.0.0  
Rollback to
```

Finally, Helm offers a way to override values, not only using the `--set` argument as shown in [Recipe 5.1](#), but by providing a YAML file.

Create a new YAML file named `newvalues.yaml` in the root directory with the following content:

```
image:  
  tag: "1.2.0"
```

Then run the `template` command, setting the new file as an override of `values.yaml`:

```
helm template pacman -f newvalues.yaml .
```

The resulting YAML document is using the values set in `values.yaml` but overriding the `images.tag` set in `newvalues.yaml`:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: pacman
...
spec:
  replicas: 1
  selector:
    matchLabels:
      app.kubernetes.io/name: pacman
  template:
    metadata:
      labels:
        app.kubernetes.io/name: pacman
    spec:
      containers:
        - image: "quay.io/gitops-cookbook/pacman-kikd:1.2.0"
          imagePullPolicy: Always
...
...
```

5.4 Packaging and Distributing a Helm Chart

Problem

You want to package and distribute a Helm Chart so it can be reused by others.

Solution

Use the `package` command.

Helm is a package manager for Kubernetes. As we've seen in this chapter, the basic unit in Helm is a Chart containing the Kubernetes files required to

deploy the application, the default values for the templates, etc.

But we've not yet seen how to package Helm Charts and distribute them to be available to other Charts as dependencies or deployed by other users.

Let's package the `pacman` Chart into a `.tgz` file. In the `pacman` directory, run the following command:

```
helm package .
```

And you'll get a message informing you where the archive is stored:

```
Successfully packaged chart and saved it to:!  
gitops-cookbook/code/05_helm/04_package/pacman/pacman-0.1.0.tgz
```

A Chart then needs to be published into a Chart repository. A Chart repository is an HTTP server with an `index.yaml` file containing metadata information regarding Charts and `.tgz` Charts.

To publish them, update the `index.yaml` file with the new metadata information, and upload the artifact.

The directory layout of a repository might look like this:

```
repo  
└── index.yaml  
└── pacman-0.1.0.tgz
```

The `index.yaml` file with information about each Chart present in the repository looks like:

```
apiVersion: v1  
entries:  
  pacman:  
    - apiVersion: v2  
      appVersion: 1.0.0  
      created: "2022-01-24T16:42:54.080959+01:00"  
      description: A Helm chart for Pacman  
      digest:  
        aa3cce809ffcca86172fc793d7804d1c61f157b9b247680a67d5b16b18a0798d  
        name: pacman  
        type: application
```

```
urls:
- pacman-0.1.0.tgz
version: 0.1.0
generated: "2022-01-24T16:42:54.080485+01:00"
```

TIP

You can run `helm repo index` in the root directory, where packaged Charts are stored, to generate the index file automatically.

Discussion

In addition to packaging a Helm Chart, Helm can generate a signature file for the packaged Chart to verify its correctness later.

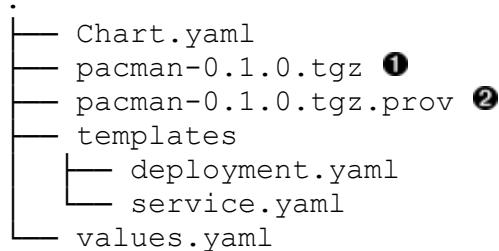
In this way, you can be sure it has not been modified, and it's the correct Chart.

To sign/verify the package, you need a pair of GPG keys in the machine; we're assuming you already have one pair created.

Now you need to call the `package` command but set the `-sign` argument with the required parameters to generate a signature file:

```
helm package --sign --key 'me@example.com' \
--keyring /home/me/.gnupg/secring.gpg .
```

Now, two files are created—the packaged Helm Chart (`.tgz`) and the signature file (`.tgz.prov`):



❶ Chart package

② Signature file

NOTE

Remember to upload both files in the Chart repository.

To verify that a Chart is valid and has not been manipulated, use the `verify` command:

```
helm verify pacman-0.1.0.tgz

Signed by: alexs (book) <asotobu@example.com>
Using Key With Fingerprint:
57C4511D738BC0B288FAF9D69B40EB787040F3CF
Chart Hash Verified: 1
sha256:d8b2e0c5e12a8425df2ea3a903807b93aab4a6ff8277511a7865c847d
e3c0bf ①
```

- ① It's valid

See Also

- [The Chart Repository Guide](#)
- [Helm Provenance and Integrity](#)

5.5 Deploying a Chart from a Repository

Problem

You want to deploy a Helm Chart stored in Chart repository.

Solution

Use the `repo add` command to add the remote repository and the `install` command to deploy it.

Public Helm Chart repositories like [Bitnami](#) are available for this purpose.

To install Charts from a repository (either public or private), you need to register it using its URL:

```
helm repo add bitnami https://charts.bitnami.com/bitnami ❶
```

- ❶ URL of Helm Chart repository where *index.yaml* is placed

List the registered repositories:

```
helm repo list

NAME          URL
stable        https://charts.helm.sh/stable
bitnami       https://charts.bitnami.com/bitnami ❶
```

- ❶ Bitnami repo is registered

TIP

Run `helm repo update` to get the latest list of Charts for each repo.

After registering a repository, you might want to find which Charts are available.

If you want to deploy a PostgreSQL instance in the cluster, use the `search` command to search all repositories for a Chart that matches the name:

```
helm search repo postgresql
```

The outputs are the list of Charts that matches the name, the version of the Chart and PostgreSQL, and a description. Notice the name of the Chart is composed of the repository name and the Chart name, i.e., `bitnami/postgresql`:

NAME	CHART VERSION	APP
VERSION\		
DESCRIPTION		
bitnami/postgresql	10.16.2	11.14.0\
	Chart for PostgreSQL, an object-relational data...	
bitnami/postgresql-ha	8.2.6	11.14.0\
	Chart for PostgreSQL with HA architecture (usin...	
stable/postgresql	8.6.4	11.7.0\
	DEPRECATED Chart for PostgreSQL, an object-rela...	
stable/pgadmin	1.2.2	4.18.0\
	pgAdmin is a web based administration tool for ...	
stable/stolon	1.6.5	0.16.0\
	DEPRECATED - Stolon - PostgreSQL cloud native H...	
stable/gcloud-sqlproxy	0.6.1	1.11\
	DEPRECATED Google Cloud SQL Proxy	
stable/prometheus-postgres-exporter	1.3.1	0.8.0\
	DEPRECATED A Helm chart for prometheus postgres...	

To deploy the PostgreSQL Chart, run the `install` command but change the location of the Helm Chart from a local directory to the full name of the Chart (`<repo>/<chart>`):

```
helm install my-db \ ❶
--set postgresql.postgresqlUsername=my-default,postgresql.\
postgresqlPassword=postgres,postgresql.postgresqlDatabase=mydb,\
postgresql.persistence.enabled=false \ ❷
bitnami/postgresql ❸
```

- ❶ Sets the name of the deployment
- ❷ Overrides default values to the ones set in the command line
- ❸ Sets the PostgreSQL Chart stored in the Bitnami repo

And a detailed output is shown in the console:

```
NAME: my-db
LAST DEPLOYED: Mon Jan 24 22:33:56 2022
NAMESPACE: asotobue-dev
STATUS: deployed
REVISION: 1
TEST SUITE: None
NOTES:
CHART NAME: postgresql
CHART VERSION: 10.16.2
```

APP VERSION: 11.14.0

** Please be patient while the chart is being deployed **

PostgreSQL can be accessed via port 5432 on the following DNS names, from within your cluster:

my-db-postgresql.asotobue-dev.svc.cluster.local - Read/Write connection

To get the(((("passwords", "Helm Charts")))((("Helm", "Charts", "passwords")))((("Charts", "passwords")))) password for "postgres" run:

```
export POSTGRES_ADMIN_PASSWORD=$(kubectl get secret \
--namespace asotobue-dev my-db-postgresql -o \
jsonpath='{.data.postgresql-postgres-password}' | base64 --decode)
```

To get the password for "my-default" run:

```
export POSTGRES_PASSWORD=$(kubectl get secret \
--namespace asotobue-dev my-db-postgresql -o \
jsonpath='{.data.postgresql-password}' | base64 --decode)
```

To connect to your database run the following command:

```
kubectl run my-db-postgresql-client --rm --tty -i --restart='Never' \
--namespace asotobue-dev \
--image docker.io/bitnami/postgresql:11.14.0-debian-10-r28 \
--env="PGPASSWORD=$POSTGRES_PASSWORD" \
--command -- psql --host my-db-postgresql -U my-default -d mydb \
-p 5432
```

To connect to your (((("Helm", "Charts", "connecting to databases")))((("Charts", "databases", "connecting to")))((("databases", "connecting to", "Helm Charts")))) database from outside the cluster execute the following commands:

```
kubectl port-forward --namespace asotobue-dev svc/my-db-postgresql 5432:5432 &
PGPASSWORD="$POSTGRES_PASSWORD" psql --host 127.0.0.1 -U my-default -d mydb -p 5432
```

Inspect the installation by listing pods, Services, StatefulSets, or Secrets:

```
kubectl get pods
```

NAME	READY	STATUS	RESTARTS	AGE
my-db-postgresql-0	1/1	Running	0	23s

```
kubectl get services
```

NAME	TYPE	CLUSTER-IP	EXTERNAL-IP
my-db-postgresql	ClusterIP	172.30.35.1	<none>
5432/TCP	3m33s		
my-db-postgresql-headless	ClusterIP	None	<none>
5432/TCP	3m33s		

```
kubectl get statefulset
```

NAME	READY	AGE
my-db-postgresql	1/1	4m24s

```
kubectl get secrets
```

NAME	TYPE
DATA AGE	
my-db-postgresql	Opaque
2 5m23s	
sh.helm.release.v1.my-db.v1	helm.sh/release.v1
1 5m24s	

Discussion

When a third party creates a Chart, there is no direct access to default values or the list of parameters to override. Helm provides a `show` command to check these values:

```
helm show values bitnami/postgresql
```

And shows all the possible values:

```
## @section Global parameters
## Global Docker image parameters
## Please, note that this will override the image parameters,
## including dependencies
```

```

## configured to use the global value
## Current available global Docker image parameters:
imageRegistry, imagePullSecrets
## and storageClass
##

## @param global.imageRegistry Global Docker image registry
## @param global.imagePullSecrets Global Docker registry secret
## names as an array
## @param global.storageClass Global StorageClass for Persistent
## Volume(s)
##
global:
  imageRegistry: ""
  ## E.g.
  ## imagePullSecrets:
  ##   - myRegistryKeySecretName
  ##
  imagePullSecrets: []
...

```

5.6 Deploying a Chart with a Dependency

Problem

You want to deploy a Helm Chart that is a dependency of another Chart.

Solution

Use the `dependencies` section in the `Chart.yaml` file to register other Charts. So far, we've seen how to deploy simple services to the cluster, but usually a service might have other dependencies like a database, mail server, distributed cache, etc.

In the previous section, we saw how to deploy a PostgreSQL server in a Kubernetes cluster. In this section, we'll see how to deploy a service composed of a Java service returning a list of songs stored in a PostgreSQL database. The application is summarized in [Figure 5-2](#).

Kubernetes Cluster

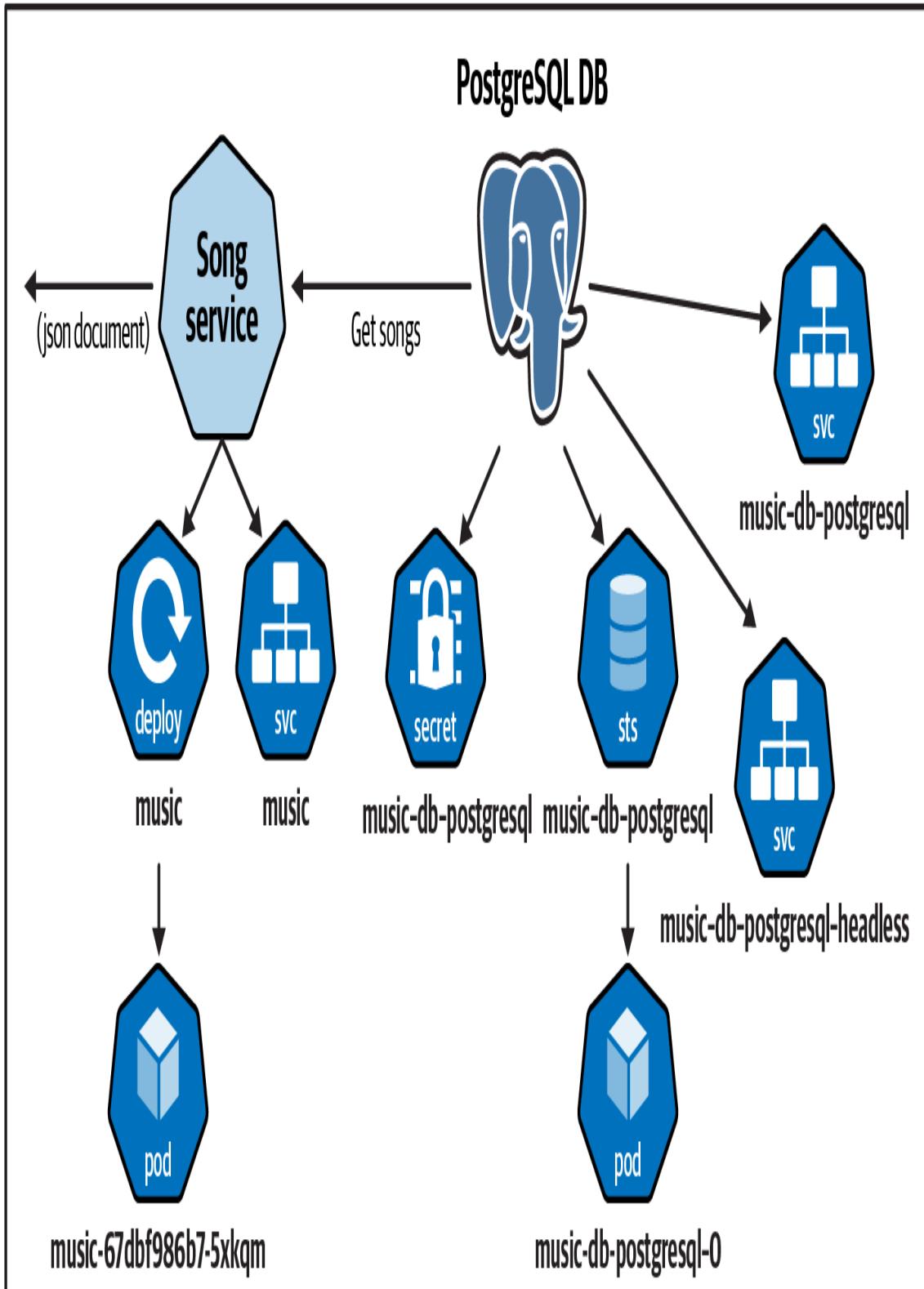


Figure 5-2. Music application overview

Let's start creating the Chart layout shown in [Recipe 5.1](#):

```
mkdir music
mkdir music/templates

cd music
```

Then create two template files to deploy the music service.

The *templates/deployment.yaml* file contains the Kubernetes Deployment definition:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: {{ .Chart.Name }}
  labels:
    app.kubernetes.io/name: {{ .Chart.Name }}
    {{- if .Chart.AppVersion }}
    app.kubernetes.io/version: {{ .Chart.AppVersion | quote }}
    {{- end }}
spec:
  replicas: {{ .Values.replicaCount }}
  selector:
    matchLabels:
      app.kubernetes.io/name: {{ .Chart.Name }}
  template:
    metadata:
      labels:
        app.kubernetes.io/name: {{ .Chart.Name }}
    spec:
      containers:
        - image: "{{ .Values.image.repository }}:{{ .Values.image.tag | default .Chart.AppVersion }}"
          imagePullPolicy: {{ .Values.image.pullPolicy }}
          name: {{ .Chart.Name }}
        ports:
          - containerPort: {{ .Values.image.containerPort }}
            name: http
            protocol: TCP
      env:
        - name: QUARKUS_DATASOURCE_JDBC_URL
          value: {{ .Values.postgresql.server }} {{ .Values.postgresql.port }} {{ .Values.postgresql.name }}
```

```

        default (printf "%s-postgresql" ( .Release.Name
)) | quote {}}
- name: QUARKUS_DATASOURCE_USERNAME
value: {{ .Values.postgresql.postgresqlUsername | 
\

        default (printf "postgres" ) | quote {}}
- name: QUARKUS_DATASOURCE_PASSWORD
valueFrom:
secretKeyRef:
name: {{ .Values.postgresql.secretName | \
default (printf "%s-postgresql" (
.Release.Name )) | quote {}}
key: {{ .Values.postgresql.secretKey }}}
```

The *templates/service.yaml* file contains the Kubernetes Service definition:

```

apiVersion: v1
kind: Service
metadata:
labels:
  app.kubernetes.io/name: {{ .Chart.Name }}
  name: {{ .Chart.Name }}
spec:
ports:
  - name: http
    port: {{ .Values.image.containerPort }}
    targetPort: {{ .Values.image.containerPort }}
selector:
  app.kubernetes.io/name: {{ .Chart.Name }}
```

After the creation of the templates, it's time for the Chart metadata *Chart.yaml* file. In this case, we need to define the dependencies of this Chart too. Since the music service uses a PostgreSQL database, we can add the Chart used in [Recipe 5.5](#) as a dependency:

```

apiVersion: v2
name: music
description: A Helm chart for Music service

type: application
version: 0.1.0
appVersion: "1.0.0"

dependencies: ❶
  - name: postgresql ❷
```

```
version: 10.16.2 ❸
repository: "https://charts.bitnami.com/bitnami" ❹
```

- ❶ Dependencies section
- ❷ Name of the Chart to add as dependency
- ❸ Chart version
- ❹ Repository

The final file is *Values.yaml* with default configuration values. In this case, a new section is added to configure music deployment with PostgreSQL instance parameters:

```
image:
  repository: quay.io/gitops-cookbook/music
  tag: "1.0.0"
  pullPolicy: Always
  containerPort: 8080

replicaCount: 1

postgresql: ❶
  server: jdbc:postgresql://music-db-postgresql:5432/mydb
  postgresqlUsername: my-default
  secretName: music-db-postgresql
  secretKey: postgresql-password
```

❶ PostgreSQL section

With the Chart in place, the next thing to do is download the dependency Chart and store it in the *charts* directory. This process is automatically done by running the `dependency update` command:

```
helm dependency update
```

The command output shows that one Chart has been downloaded and saved:

```
Hang tight while we grab the latest from your chart
repositories...
```

```
...Successfully got an update from the "stable" chart repository
...Successfully got an update from the "bitnami" chart repository
Update Complete. *Happy Helm-ing!*
Saving 1 charts
Downloading postgresql from repo
https://charts.bitnami.com/bitnami
Deleting outdated charts
```

The directory layout looks like this:

```
music
├── Chart.lock
├── Chart.yaml
└── charts
    └── postgresql-10.16.2.tgz ❶
└── templates
    ├── deployment.yaml
    └── service.yaml
└── values.yaml
```

❶ PostgreSQL Chart is placed in the correct directory

Finally, we deploy the Chart, setting configuration PostgreSQL deployment values from the command line:

```
helm install music-db --set
postgresql.postgresqlPassword=postgres
postgresql.postgresqlDatabase=mydb,postgresql.persistence.enabled
=false .
```

The installation process shows information about the deployment:

```
NAME: music-db
LAST DEPLOYED: Tue Jan 25 17:53:17 2022
NAMESPACE: default
STATUS: deployed
REVISION: 1
TEST SUITE: None
```

Inspect the installation by listing pods, Services, StatefulSets, or Secrets:

```
kubectl get pods
```

NAME	READY	STATUS	RESTARTS	AGE
------	-------	--------	----------	-----

```

music-67dbf986b7-5xkqm    1/1      Running   1  (32s ago)   39s
music-db-postgresql-0      1/1      Running   0           39s

kubectl get statefulset

NAME                  READY   AGE
music-db-postgresql  1/1     53s

kubectl get services

NAME              TYPE        CLUSTER-IP      EXTERNAL-
IP    PORT(S)      AGE
kubernetes       ClusterIP   10.96.0.1      <none>
443/TCP          40d
music            ClusterIP   10.104.110.34  <none>
8080/TCP         82s
music-db-postgresql ClusterIP  10.110.71.13  <none>
5432/TCP         82s
music-db-postgresql-headless ClusterIP None        <none>
5432/TCP         82s

```

We can validate the access to the music service by using port forwarding to the Kubernetes Service.

Open a new terminal window and run the following command:

```

kubectl port-forward service/music 8080:8080
Forwarding from 127.0.0.1:8080 -> 8080
Forwarding from [::1]:8080 -> 8080

```

The terminal is blocked and it's normal until you stop the `kubectl port-forward` process. Thanks to port forwarding, we can access the music service using the `localhost` address and port 8080.

In another terminal, `curl` the service:

```
curl localhost:8080/song
```

The request is sent to the music service deployed in Kubernetes and returns a list of songs:

```
[  
  {  
    "id": 1,  
    "artist": "DT",  
    "name": "Quiero Munchies"  
  },  
  {  
    "id": 2,  
    "artist": "Lin-Manuel Miranda",  
    "name": "We Don't Talk About Bruno"  
  },  
  {  
    "id": 3,  
    "artist": "Imagination",  
    "name": "Just An Illusion"  
  },  
  {  
    "id": 4,  
    "artist": "Txarango",  
    "name": "Tanca Els Ulls"  
  },  
  {  
    "id": 5,  
    "artist": "Halsey",  
    "name": "Could Have Been Me"  
  }  
]
```

5.7 Triggering a Rolling Update Automatically

Problem

You want to trigger a rolling update of deployment when a ConfigMap object is changed.

Solution

Use the sha256sum template function to generate a change on the deployment file.

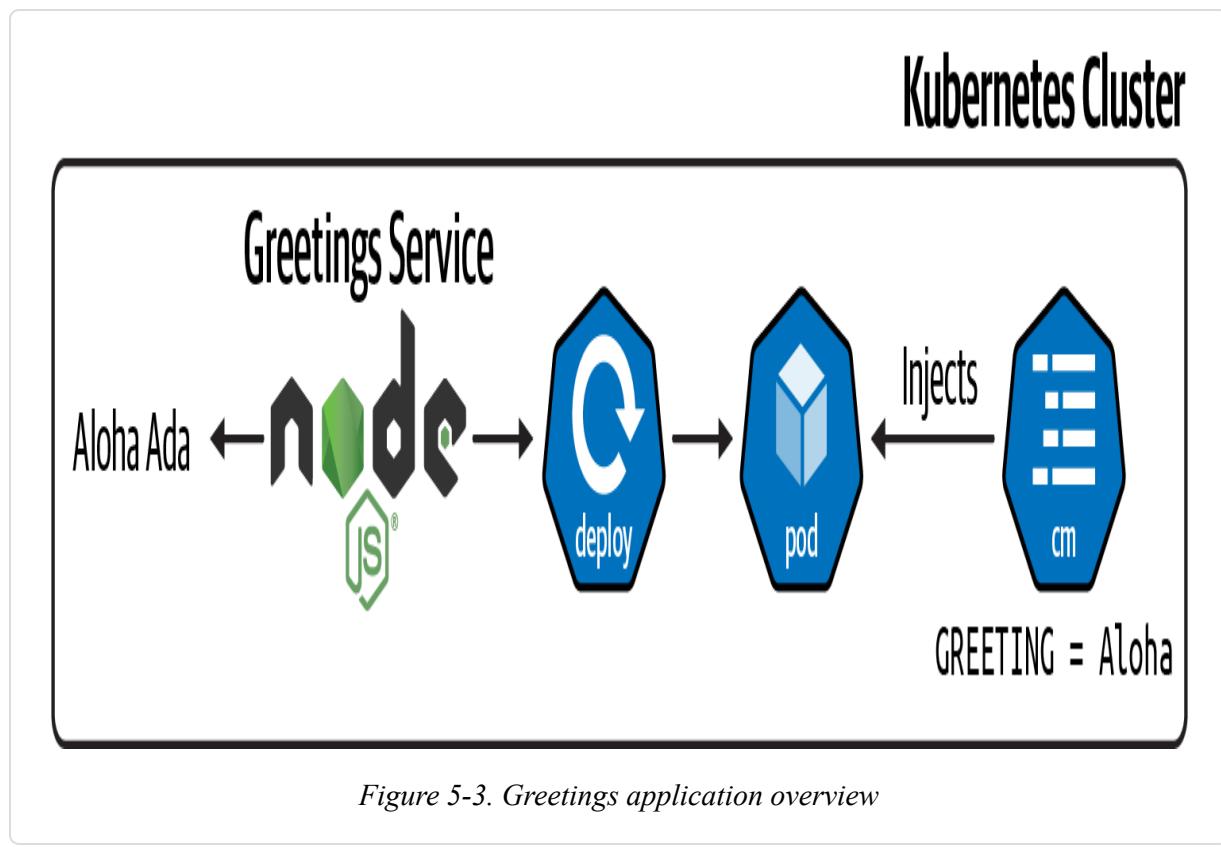
In [Recipe 4.5](#), we saw that Kustomize has a ConfigMapGenerator that automatically appends a hash to the ConfigMap metadata name and

modifies the deployment file with the new hash when used. Any change on the ConfigMap triggers a rolling update of the deployment.

Helm doesn't provide a direct way like Kustomize does to update a deployment file when the ConfigMap changes, but there is a template function to calculate a SHA-256 hash of any file and embed the result in the template.

Suppose we've got a Node.js application that returns a greeting message. An environment variable configures this greeting message, and in the Kubernetes Deployment, this variable is injected from a Kubernetes ConfigMap.

[Figure 5-3](#) shows an overview of the application.



Let's create the Helm Chart for the Greetings application; note that we're not covering the entire process of creating a Chart, but just the essential parts. You can refer to [Recipe 5.1](#) to get started.

Create a deployment template that injects a ConfigMap as an environment variable. The following listing shows the file:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: {{ .Chart.Name}}
  labels:
    app.kubernetes.io/name: {{ .Chart.Name}}
    {{- if .Chart.AppVersion }}
    app.kubernetes.io/version: {{ .Chart.AppVersion | quote }}
    {{- end }}
spec:
  replicas: {{ .Values.replicaCount }}
  selector:
    matchLabels:
      app.kubernetes.io/name: {{ .Chart.Name}}
  template:
    metadata:
      labels:
        app.kubernetes.io/name: {{ .Chart.Name}}
    spec:
      containers:
        - image: "{{ .Values.image.repository }}:{{ .Values.image.tag | default .Chart.AppVersion }}"
          imagePullPolicy: {{ .Values.image.pullPolicy }}
          name: {{ .Chart.Name}}
          ports:
            - containerPort: {{ .Values.image.containerPort }}
              name: http
              protocol: TCP
      env:
        - name: GREETING
          valueFrom:
            configMapKeyRef:
              name: {{ .Values.configmap.name }} ❶
              key: greeting ❷
```

❶ ConfigMap name

❷ Property key of the ConfigMap

The initial ConfigMap file is shown in the following listing:

```
apiVersion: v1
kind: ConfigMap
metadata:
```

```
  name: greeting-config ①
  data:
    greeting: Aloha ②
```

- ① Sets ConfigMap name

- ② Key/value

Create a Kubernetes Service template to access the service:

```
apiVersion: v1
kind: Service
metadata:
  labels:
    app.kubernetes.io/name: {{ .Chart.Name }}
  name: {{ .Chart.Name }}
spec:
  ports:
    - name: http
      port: {{ .Values.image.containerPort }}
      targetPort: {{ .Values.image.containerPort }}
  selector:
    app.kubernetes.io/name: {{ .Chart.Name }}
```

Update the *values.yaml* file with the template configmap parameters:

```
image:
  repository: quay.io/gitops-cookbook/greetings
  tag: "1.0.0"
  pullPolicy: Always
  containerPort: 8080

replicaCount: 1

configmap:
  name: greeting-config ①
```

- ① Refers to ConfigMap name

Finally, install the Chart using the `install` command:

```
helm install greetings .
```

When the Chart is deployed, use the `kubectl port-forward` command in one terminal to get access to the service:

```
kubectl port-forward service/greetings 8080:8080
```

And `curl` the service in another terminal window:

```
curl localhost:8080  
Aloha Ada ❶
```

- ❶ Configured greeting is used

Now, let's update the `ConfigMap` file to a new greeting message:

```
apiVersion: v1  
kind: ConfigMap  
metadata:  
  name: greeting-config  
data:  
  greeting: Hola ❶
```

- ❶ New greeting message

Update the `appVersion` field from the `Chart.yaml` file to `1.0.1` and upgrade the Chart by running the following command:

```
helm upgrade greetings .
```

Restart the `kubectl port-forward` process and `curl` the service again:

```
curl localhost:8080  
Aloha Alexandra ❶
```

- ❶ Greeting message isn't updated

The `ConfigMap` object is updated during the upgrade, but since there are no changes in the `Deployment` object, there is no restart of the pod; hence

the environment variable is not set to the new value. Listing the pods shows no execution of the rolling update:

```
kubectl get pods
```

NAME	READY	STATUS	RESTARTS	AGE
greetings-64ddfc649-m5pml	1/1	Running	0	2m21s ①

- ① Age value shows no rolling update

[Figure 5-4](#) summarizes the change.

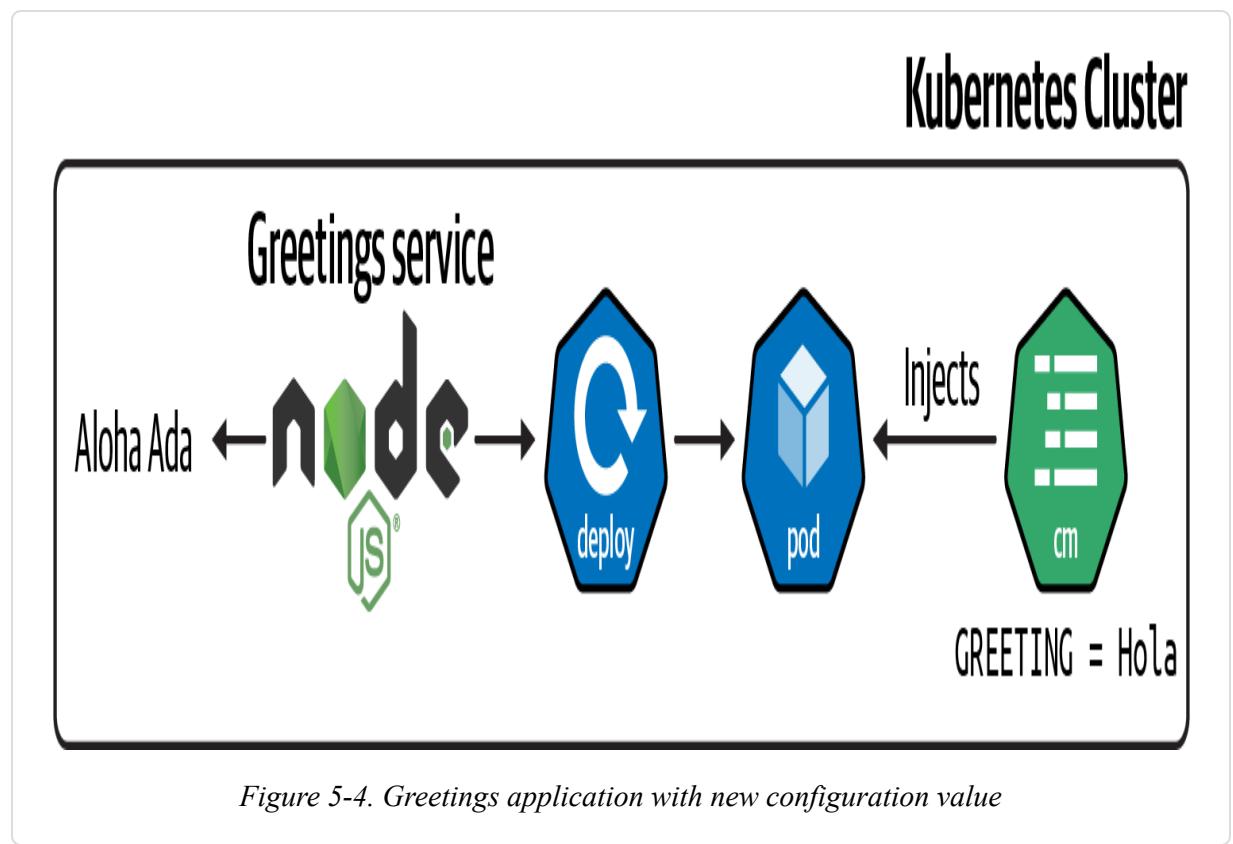


Figure 5-4. Greetings application with new configuration value

Let's use the `sha256sum` function to calculate an SHA-256 value of the `configmap.yaml` file content and set it as a pod annotation, which effectively triggers a rolling update as the pod definition has changed:

```
spec:  
  replicas: {{ .Values.replicaCount }}  
  selector:  
    matchLabels:
```

```
    app.kubernetes.io/name: {{ .Chart.Name }}  
  template:  
    metadata:  
      labels:  
        app.kubernetes.io/name: {{ .Chart.Name }}  
    annotations:  
      checksum/config: {{ include (print $.Template.BasePath  
"/configmap.yaml") }}  
      . | sha256sum }} ❶
```

- ❶ Includes the *configmap.yaml* file, calculates the SHA-256 value, and sets it as an annotation

Update the ConfigMap again with a new value:

```
apiVersion: v1  
kind: ConfigMap  
metadata:  
  name: greeting-config  
data:  
  greeting: Namaste ❶
```

- ❶ New greeting message

Update the `appVersion` field from *Chart.yaml* to `1.0.1` and upgrade the Chart by running the following command:

```
helm upgrade greetings .
```

Restart the `kubectl port-forward` process and `curl` the service again:

```
curl localhost:8080  
Namaste Alexandra ❶
```

- ❶ Greeting message is the new one

List the pods deployed in the cluster again, and you'll notice that a rolling update is happening:

```
kubectl get pods
```

NAME	READY	STATUS	RESTARTS
AGE			
greetings-5c6b86dbbd-2p9bd ① 3s	0/1	ContainerCreating	0
greetings-64ddfc649-m5pml 2m21s	1/1	Running	0

① A rolling update is happening

Describe the pod to validate that the annotation with the SHA-256 value is present:

```
kubectl describe pod greetings-5c6b86dbbd-s4n7b
```

The output shows all pod parameters. The important one is the annotations placed at the top of the output showing the checksum/config annotation containing the calculated SHA-256 value:

```
Name: greetings-5c6b86dbbd-s4n7b
Namespace: asotobue-dev
Priority: -3
Priority Class Name: sandbox-users-pods
Node: ip-10-0-186-34.ec2.internal/10.0.186.34
Start Time: Thu, 27 Jan 2022 11:55:02 +0100
Labels: app.kubernetes.io/name=greetings
        pod-template-hash=5c6b86dbbd
Annotations: checksum/config:①
59e9100616a11d65b691a914cd429dc6011a34e02465173f5f53584b4aa7cba8
```

① Calculated value

[Figure 5-5](#) summarizes the elements that changed when the application was updated.

Kubernetes Cluster

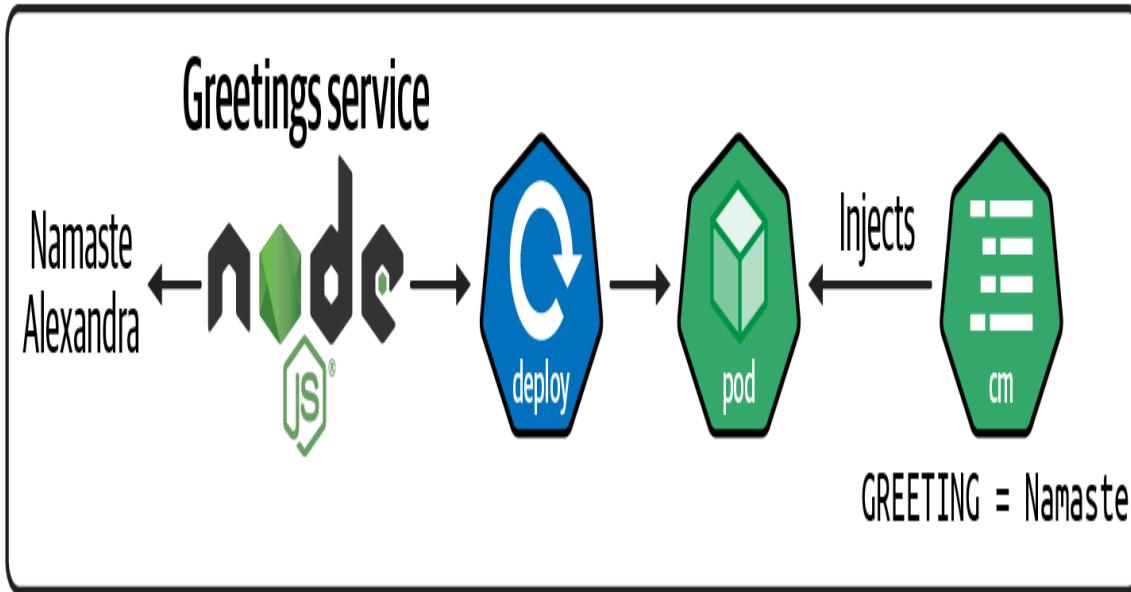


Figure 5-5. Final overview of the Greetings application

5.8 Final Thoughts

In the previous chapter, we saw Kustomize; in this chapter, we've seen another tool to help deploy Kubernetes applications.

When you need to choose between Kustomize or Helm, you might have questions on which one to use.

In our experience, the best way to proceed is with Kustomize for simple projects, where only simple changes might be required between new deployments.

If the project is complex with external dependencies, and several deployment parameters, then Helm is a better option.

Chapter 6. Cloud Native CI/CD

In the previous chapter you learned about Helm, a popular templating system for Kubernetes. All the recipes from previous chapters represent a common tooling for creating and managing containers for Kubernetes, and now it's time to think about the automation on Kubernetes using such tools. Let's move our focus to the cloud native continuous integration/continuous deployment (CI/CD).

Continuous integration is an automated process that takes new code created by a developer and builds, tests, and runs that code. The cloud native CI refers to the model where cloud computing and cloud services are involved in this process. The benefits from this model are many, such as portable and reproducible workloads across clouds for highly scalable and on-demand use cases. And it also represents the building blocks for GitOps workflows as it enables automation through actions performed via Git.

[Tekton](#) is a popular open source implementation of a cloud native CI/CD system on top of Kubernetes. In fact, Tekton installs and runs as an extension on a Kubernetes cluster and comprises a set of Kubernetes Custom Resources that define the building blocks you can create and reuse for your pipelines.¹ (See [Recipe 6.1](#).)

The Tekton engine lives inside a Kubernetes cluster and through its API objects represents a declarative way to define the actions to perform. The core components such as *Tasks* and *Pipelines* can be used to create a pipeline to generate artifacts and/or containers from a Git repository (see Recipes [6.2](#), [6.3](#), and [6.4](#)).

Tekton also supports a mechanism for automating the start of a Pipeline with *Triggers*. These allow you to detect and extract information from events from a variety of sources, such as a webhook, and to start Tasks or Pipelines accordingly (see [Recipe 6.8](#)).

Working with private Git repositories is a common use case that Tekton supports nicely (see [Recipe 6.4](#)), and building artifacts and creating containers can be done in many ways such as with Buildah (see [Recipe 6.5](#)) or Shipwright, which we discussed in [Chapter 3](#). It is also possible to integrate Kustomize (see [Recipe 6.9](#)) and Helm (see [Recipe 6.10](#)) in order to make the CI part dynamic and take benefit of the rich ecosystem of Kubernetes tools.

Tekton is Kubernetes-native solution, thus it's universal; however, it's not the only cloud native CI/CD citizen in the market. Other good examples for GitOps-ready workloads are Drone ([Recipe 6.11](#)) and GitHub Actions ([Recipe 6.12](#)).

6.1 Install Tekton

Problem

You want to install Tekton in order to have cloud native CI/CD on your Kubernetes cluster.

Solution

[Tekton](#) is a Kubernetes-native CI/CD solution that can be installed on top of any Kubernetes cluster. The installation brings you a set of [Kubernetes Custom Resources \(CRDs\)](#) that you can use to compose your Pipelines, as shown in [Figure 6-1](#):

Task

A reusable, loosely coupled number of steps that perform a specific function (e.g., building a container image). Tasks get executed as Kubernetes pods, while steps in a Task map onto containers.

Pipeline

A list Tasks needed to build and/or deploy your apps.

TaskRun

The execution and result of running an instance of a Task.

PipelineRun

The execution and result of running an instance of a Pipeline, which includes a number of TaskRuns.

Trigger

Detects an event and connects to other CRDs to specify what happens when such an event occurs.

Pipeline

Build

Test

Package

Task

Git
repository

Image

Inputs & Outputs

PipelineRun
A

PipelineRun
B

PipelineRun
C

...

Scheduled at
2 am today

Scheduled at
6 pm today

Scheduled at
2 am tomorrow



To install Tekton, you just need `kubectl` CLI and a Kubernetes cluster such as Minikube (see [Chapter 2](#)).

Tekton has a modular structure. You can install all components separately or all at once (e.g., with an Operator):

Tekton Pipelines

Contains Tasks and Pipelines

Tekton Triggers

Contains Triggers and EventListeners

Tekton Dashboard

A convenient dashboard to visualize Pipelines and logs

Tekton CLI

A CLI to manage Tekton objects (start/stop Pipelines and Tasks, check logs)

TIP

You can also use a Kubernetes Operator to install and manage Tekton components on your cluster. See more details on how from [OperatorHub](#).

First you need to install the [Tekton Pipelines](#) component. At the time of writing this book, we are using version 0.37.0:

```
kubectl apply \
-f https://storage.googleapis.com/tekton-
releases/pipeline/previous/v0.37.0/release.yaml
```

The installation will create a new Kubernetes namespace called `tekton-pipelines` and you should see output similar to the following:

```
namespace/tekton-pipelines created
podsecuritypolicy.policy/tekton-pipelines created
clusterrole.rbac.authorization.k8s.io/tekton-pipelines-
controller-cluster-access created
clusterrole.rbac.authorization.k8s.io/tekton-pipelines-
controller-tenant-access created
clusterrole.rbac.authorization.k8s.io/tekton-pipelines-webhook-
cluster-access created
role.rbac.authorization.k8s.io/tekton-pipelines-controller
created
role.rbac.authorization.k8s.io/tekton-pipelines-webhook created
role.rbac.authorization.k8s.io/tekton-pipelines-leader-election
created
role.rbac.authorization.k8s.io/tekton-pipelines-info created
serviceaccount/tekton-pipelines-controller created
serviceaccount/tekton-pipelines-webhook created
clusterrolebinding.rbac.authorization.k8s.io/tekton-pipelines-
controller-cluster-access created
clusterrolebinding.rbac.authorization.k8s.io/tekton-pipelines-
controller-tenant-access created
clusterrolebinding.rbac.authorization.k8s.io/tekton-pipelines-
webhook-cluster-access created
rolebinding.rbac.authorization.k8s.io/tekton-pipelines-controller
created
rolebinding.rbac.authorization.k8s.io/tekton-pipelines-webhook
created
rolebinding.rbac.authorization.k8s.io/tekton-pipelines-
controller-leaderelection created
rolebinding.rbac.authorization.k8s.io/tekton-pipelines-webhook-
leaderelection created
rolebinding.rbac.authorization.k8s.io/tekton-pipelines-info
created
customresourcedefinition.apiextensions.k8s.io/clustertasks.tekton
.dev created
customresourcedefinition.apiextensions.k8s.io/pipelines.tekton.de
v created
customresourcedefinition.apiextensions.k8s.io/pipelineruns.tekton
.dev created
customresourcedefinition.apiextensions.k8s.io/resolutionrequests.
resolution.tekton.dev created
customresourcedefinition.apiextensions.k8s.io/pipelineresources.t
ekton.dev created
customresourcedefinition.apiextensions.k8s.io/runs.tekton.dev
created
customresourcedefinition.apiextensions.k8s.io/tasks.tekton.dev
created
customresourcedefinition.apiextensions.k8s.io/taskruns.tekton.dev
created
secret/webhook-certs created
validatingwebhookconfiguration.admissionregistration.k8s.io/valid
```

```
ation.webhook.pipeline.tekton.dev created
mutatingwebhookconfiguration.admissionregistration.k8s.io/webhook
.pipeline.tekton.dev created
validatingwebhookconfiguration.admissionregistration.k8s.io/confi
g.webhook.pipeline.tekton.dev created
clusterrole.rbac.authorization.k8s.io/tekton-aggregate-edit
created
clusterrole.rbac.authorization.k8s.io/tekton-aggregate-view
created
configmap/config-artifact-bucket created
configmap/config-artifact-pvc created
configmap/config-defaults created
configmap/feature-flags created
configmap/pipelines-info created
configmap/config-leader-election created
configmap/config-logging created
configmap/config-observability created
configmap/config-registry-cert created
deployment.apps/tekton-pipelines-controller created
service/tekton-pipelines-controller created
horizontalpodautoscaler.autoscaling/tekton-pipelines-webhook
created
deployment.apps/tekton-pipelines-webhook created
service/tekton-pipelines-webhook created
```

You can monitor and verify the installation with the following command:

```
kubectl get pods -w -n tekton-pipelines
```

You should see output like this:

NAME	READY	STATUS
RESTARTS	AGE	
tekton-pipelines-controller-5fd68749f5-tz8dv	1/1	Running
0	3m4s	
tekton-pipelines-webhook-58dcdbfd9b-hswpk	1/1	Running
0	3m4s	

NOTE

The preceding command goes in watch mode, thus it remains appended. Press Ctrl+C in order to stop it when you see the controller and webhook pods in Running status.

Then you can install [Tekton Triggers](#). At the time of writing this book, we are using version 0.20.1:

```
kubectl apply \
-f https://storage.googleapis.com/tekton-
releases/triggers/previous/v0.20.1/release.yaml
```

You should see the following output:

```
podsecuritypolicy.policy/tekton-triggers created
clusterrole.rbac.authorization.k8s.io/tekton-triggers-admin
created
clusterrole.rbac.authorization.k8s.io/tekton-triggers-core-
interceptors created
clusterrole.rbac.authorization.k8s.io/tekton-triggers-core-
interceptors-secrets created
clusterrole.rbac.authorization.k8s.io/tekton-triggers-
eventlistener-roles created
clusterrole.rbac.authorization.k8s.io/tekton-triggers-
eventlistener-clusterroles created
role.rbac.authorization.k8s.io/tekton-triggers-admin created
role.rbac.authorization.k8s.io/tekton-triggers-admin-webhook
created
role.rbac.authorization.k8s.io/tekton-triggers-core-interceptors
created
role.rbac.authorization.k8s.io/tekton-triggers-info created
serviceaccount/tekton-triggers-controller created
serviceaccount/tekton-triggers-webhook created
serviceaccount/tekton-triggers-core-interceptors created
clusterrolebinding.rbac.authorization.k8s.io/tekton-triggers-
controller-admin created
clusterrolebinding.rbac.authorization.k8s.io/tekton-triggers-
webhook-admin created
clusterrolebinding.rbac.authorization.k8s.io/tekton-triggers-
core-interceptors created
clusterrolebinding.rbac.authorization.k8s.io/tekton-triggers-
core-interceptors-secrets created
rolebinding.rbac.authorization.k8s.io/tekton-triggers-controller-
admin created
rolebinding.rbac.authorization.k8s.io/tekton-triggers-webhook-
admin created
rolebinding.rbac.authorization.k8s.io/tekton-triggers-core-
interceptors created
rolebinding.rbac.authorization.k8s.io/tekton-triggers-info
created
customresourcedefinition.apiextensions.k8s.io/clusterinterceptors
.triggers.tekton.dev created
customresourcedefinition.apiextensions.k8s.io/clustertriggerbindi
```

```
ngs.triggers.tekton.dev created
customresourcedefinition.apiextensions.k8s.io/eventlisteners.trig
gers.tekton.dev created
customresourcedefinition.apiextensions.k8s.io/triggers.triggers.t
ekton.dev created
customresourcedefinition.apiextensions.k8s.io/triggerbindings.tri
ggers.tekton.dev created
customresourcedefinition.apiextensions.k8s.io/triggertemplates.tr
iggers.tekton.dev created
secret/triggers-webhook-certs created
validatingwebhookconfiguration.admissionregistration.k8s.io/vali
dation.webhook.triggers.tekton.dev created
mutatingwebhookconfiguration.admissionregistration.k8s.io/webhook
.triggers.tekton.dev created
validatingwebhookconfiguration.admissionregistration.k8s.io/confi
g.webhook.triggers.tekton.dev created
clusterrole.rbac.authorization.k8s.io/tekton-triggers-aggregate-
edit created
clusterrole.rbac.authorization.k8s.io/tekton-triggers-aggregate-
view created
configmap/config-defaults-triggers created
configmap/feature-flags-triggers created
configmap/triggers-info created
configmap/config-logging-triggers created
configmap/config-observability-triggers created
service/tekton-triggers-controller created
deployment.apps/tekton-triggers-controller created
service/tekton-triggers-webhook created
deployment.apps/tekton-triggers-webhook created
deployment.apps/tekton-triggers-core-interceptors created
service/tekton-triggers-core-interceptors created
clusterinterceptor.triggers.tekton.dev/cel created
clusterinterceptor.triggers.tekton.dev/bitbucket created
clusterinterceptor.triggers.tekton.dev/github created
clusterinterceptor.triggers.tekton.dev/gitlab created
secret/tekton-triggers-core-interceptors-certs created
```

You can monitor and verify the installation with the following command:

```
kubectl get pods -w -n tekton-pipelines
```

You should see three new pods created and running—tekton-
triggers-controller, tekton-triggers-core-
interceptors, and tekton-triggers-webhook:

NAME	READY
STATUS RESTARTS AGE	
tekton-pipelines-controller-5fd68749f5-tz8dv	1/1
Running 0 27m	
tekton-pipelines-webhook-58dcdbfd9b-hswpk	1/1
Running 0 27m	
tekton-triggers-controller-854d44fd5d-8jf9q	1/1
Running 0 105s	
tekton-triggers-core-interceptors-5454f8785f-dhsrb	1/1
Running 0 104s	
tekton-triggers-webhook-86d75f875-zmjf4	1/1
Running 0 105s	

After this you have a fully working Tekton installation on top of your Kubernetes cluster, supporting Pipelines and automation via event Triggers. In addition to that, you could install the [Tekton Dashboard](#) in order to visualize Tasks, Pipelines, and logs via a nice UI. At the time of writing this book, we are using version 0.28.0:

```
kubectl apply \
-f https://storage.googleapis.com/tekton-
releases/dashboard/previous/v0.28.0/tekton-dashboard-release.yaml
```

You should have output similar to the following:

```
customresourcedefinition.apiextensions.k8s.io/extensions.dashboard.tekton.dev created
serviceaccount/tekton-dashboard created
role.rbac.authorization.k8s.io/tekton-dashboard-info created
clusterrole.rbac.authorization.k8s.io/tekton-dashboard-backend created
clusterrole.rbac.authorization.k8s.io/tekton-dashboard-tenant created
rolebinding.rbac.authorization.k8s.io/tekton-dashboard-info created
clusterrolebinding.rbac.authorization.k8s.io/tekton-dashboard-backend created
configmap/dashboard-info created
service/tekton-dashboard created
deployment.apps/tekton-dashboard created
clusterrolebinding.rbac.authorization.k8s.io/tekton-dashboard-tenant created
```

You can monitor and verify the installation with the following command:

```
kubectl get pods -w -n tekton-pipelines
```

You should see a new pod created and running—tekton-dashboard:

NAME	READY	STATUS
RESTARTS	AGE	
tekton-dashboard-786b6b5579-sscgz	1/1	Running
0 (7m16s ago) 2m25s		
tekton-pipelines-controller-5fd68749f5-tz8dv	1/1	Running
1 (7m16s ago) 5d7h		
tekton-pipelines-webhook-58dcdbfd9b-hswpk	1/1	Running
1 (7m6s ago) 5d7h		
tekton-triggers-controller-854d44fd5d-8jf9q	1/1	Running
2 (7m9s ago) 5d7h		
tekton-triggers-core-interceptors-5454f8785f-dhsrb	1/1	Running
1 (7m7s ago) 5d7h		
tekton-triggers-webhook-86d75f875-zmjf4	1/1	Running
2 (7m9s ago) 5d7h		

By default, the Dashboard is not exposed outside the Kubernetes cluster. You can access it by using the following command:

```
kubectl port-forward svc/tekton-dashboard 9097:9097 -n tekton-pipelines
```

TIP

There are several ways to expose internal services in Kubernetes; you could also create an [Ingress](#) for that as shown in the Tekton Dashboard [documentation](#).

You can now browse to `http://localhost:9097` to access your Dashboard, as shown in [Figure 6-2](#).

You can download and install the [Tekton CLI](#) for your OS to start creating Tasks and Pipelines from the command line. At the time of writing this book, we are using version 0.25.0.

Tekton Dashboard

- Tekton resources
- Pipelines
- PipelineRuns
- PipelineResources
- Tasks
- ClusterTasks
- TaskRuns
- EventListeners
- Triggers
- TriggerBindings
- ClusterTriggerBindings
- TriggerTemplates
- ClusterInterceptors

Import resources

About Tekton

Settings

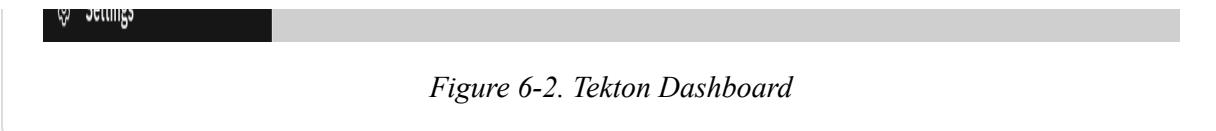
About Tekton

Tekton is a powerful and flexible open-source framework for creating CI/CD systems, allowing developers to build, test, and deploy across cloud providers and on-premises systems.



Environment details

Dashboard	Pipelines	Triggers
Namespace	Namespace	Namespace
tekton-pipelines	tekton-pipelines	tekton-pipelines
Version	Version	Version
v0.28.0	v0.37.0	v0.20.1



Finally, verify that `tkn` and Tekton are configured correctly:

```
tkn version
```

You should get the following output:

```
Client version: 0.25.0
Pipeline version: v0.37.0
Triggers version: v0.20.1
Dashboard version: v0.28.0
```

See Also

- [Tekton Getting Started](#)

6.2 Create a Hello World Task

Problem

You want to start using Tekton by exploring Tasks and creating a sample one.

Solution

In Tekton, a Task defines a series of steps that run sequentially to perform logic that the Task requires. Every [Task](#) runs as a pod on your Kubernetes cluster, with each step running in its own container. While steps within a Task are sequential, Tasks can be executed inside a Pipeline in parallel. Therefore, Tasks are the building blocks for running Pipelines with Tekton.

Let's create a Hello World Task:

```
apiVersion: tekton.dev/v1beta1
kind: Task ①
```

```
metadata:  
  name: hello ②  
spec:  
  steps: ③  
    - name: say-hello ④  
      image: registry.access.redhat.com/ubi8/ubi ⑤  
      command:  
        - /bin/bash  
      args: ['-c', 'echo Hello GitOps Cookbook reader!']
```

- ① The API as an object of kind Task
- ② The name of the Task
- ③ The list of steps contained within this Task, in this case just one
- ④ The name of the step
- ⑤ The container image where the step starts

First you need to create this resource in Kubernetes:

```
kubectl create -f helloworld-task.yaml
```

You should get the following output:

```
task.tekton.dev/hello created
```

You can verify that the object has been created in your current Kubernetes namespace:

```
kubectl get tasks
```

You should get output similar to the following:

NAME	AGE
hello	90s

Now you can start your Tekton Task with `tkn` CLI:

```
tkn task start --showlog hello
```

You should get output similar to the following:

```
TaskRun started: hello-run-8bmzz
Waiting for logs to be available...
[say-hello] Hello World
```

NOTE

A TaskRun is the API representation of a running Task. See [Recipe 6.3](#) for more details.

See Also

- [Tekton Task documentation](#)

6.3 Create a Task to Compile and Package an App from Git

Problem

You want to automate compiling and packaging an app from Git on Kubernetes with Tekton.

Solution

As seen in [Recipe 6.2](#), Tekton Tasks have a flexible mechanism to add a list of sequential steps to automate actions. The idea is to create a list of Tasks with a chain of input/output that can be used to compose Pipelines. Therefore a Task can contain a series of optional fields for a better control over the resource:

inputs

The resources ingested by the Task.

outputs

The resources produced by the Task.

`params`

The parameters that will be used in the Task steps. Each parameter has:

`name`

The name of the parameter.

`description`

The description of the parameter.

`default`

The default value of the parameter.

`results`

The names under which Tasks write execution results.

`workspaces`

The paths to volumes needed by the Task.

`volumes`

The Task can also mount external volumes using the `volumes` attribute.

The following example, as illustrated in [Figure 6-3](#), shows a Task named `build-app` that clones the sources using the `git` command and lists the source code in output.

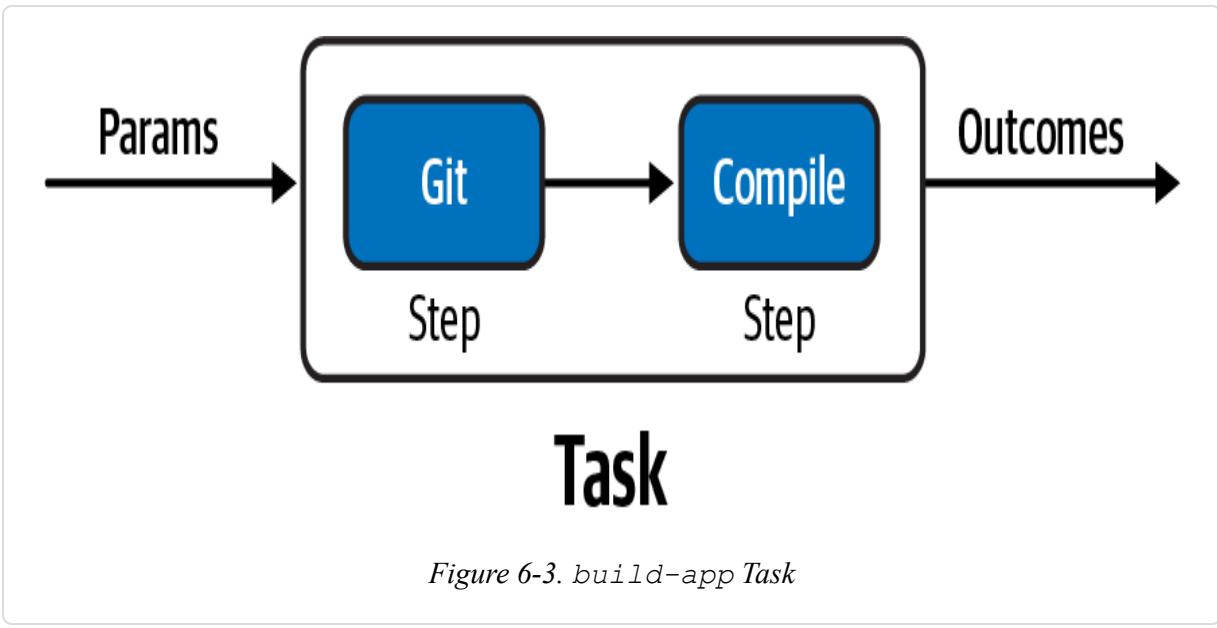


Figure 6-3. build-app Task

```

apiVersion: tekton.dev/v1beta1
kind: Task
metadata:
  name: build-app
spec:
  workspaces: ❶
    - name: source
      description: The git repo will be cloned onto the volume
      backing this workspace
  params: ❷
    - name: contextDir
      description: the context dir within source
      default: quarkus
    - name: tlsVerify
      description: tls verify
      type: string
      default: "false"
    - name: url
      default: https://github.com/gitops-cookbook/tekton-
      tutorial-greeter.git
    - name: revision
      default: master
    - name: subdirectory
      default: ""
    - name: sslVerify
      description: defines if http.sslVerify should be set to
      true or false in the global git config
      type: string
      default: "false"
  steps:
    - image: 'gcr.io/tekton-

```

```

releases/github.com/tektoncd/pipeline/cmd/git-init:v0.21.0'
  name: clone
  resources: {}
  script: |
    CHECKOUT_DIR="$({workspaces.source.path})/${params.subdirectory}"
    cleandir() {
        # Delete any existing contents of the repo directory if it exists.
        #
        # We don't just "rm -rf $CHECKOUT_DIR" because $CHECKOUT_DIR might be "/"
        # or the root of a mounted volume.
        if [[ -d "$CHECKOUT_DIR" ]]; then
            # Delete non-hidden files and directories
            rm -rf "$CHECKOUT_DIR"/*
            # Delete files and directories starting with . but excluding ..
            rm -rf "$CHECKOUT_DIR"/.[!.]*
            # Delete files and directories starting with .. plus any other character
            rm -rf "$CHECKOUT_DIR"/..?*
        fi
    }
    /ko-app/git-init \
        -url "${params.url}" \
        -revision "${params.revision}" \
        -path "$CHECKOUT_DIR" \
        -sslVerify="${params.sslVerify}"
    cd "$CHECKOUT_DIR"
    RESULT_SHA=$(git rev-parse HEAD)"
- name: build-sources
  image: gcr.io/cloud-builders/mvn
  command:
    - mvn
  args:
    - -DskipTests
    - clean
    - install
  env:
    - name: user.home
      value: /home/tekton
  workingDir: "/workspace/source/${params.contextDir}"

```

- ❶ A Task step and Pipeline Task can share a common filesystem via a Tekton workspace. The workspace could be either backed by something

like PersistentVolumeClaim (PVC) and a ConfigMap, or just ephemeral (`emptyDir`).

- ❷ A Task can have parameters; this feature makes the execution dynamic.

Let's create the Task with the following command:

```
kubectl create -f build-app-task.yaml
```

You should get output similar to the following:

```
task.tekton.dev/build-app created
```

You can verify that the object has been created in your current Kubernetes namespace:

```
kubectl get tasks
```

You should get output similar to the following:

NAME	AGE
build-app	3s

You can also list the Task with the `tkn` CLI:

```
tkn task ls
```

You should get output similar to the following:

NAME	DESCRIPTION	AGE
build-app		10 seconds ago

When you start a Task, a new [TaskRun](#) object is created. TaskRuns are the API representation of a running Task; thus you can create it with the `tkn` CLI using the following command:

```
tkn task start build-app \
--param contextDir='quarkus' \
```

```
--workspace name=source,emptyDir="" \
--showlog
```

TIP

When parameters are used inside a Task or Pipeline, you will be prompted to add new values or confirm default ones, if any. In order to use the default values from the Task definition without prompting for values, you can use the `--use-param-defaults` option.

You should get output similar to the following:

```
? Value for param `tlsVerify` of type `string`? (Default is
`false`) false
? Value for param `url` of type `string`? (Default is
`https://github.com/gitops-cookbook/tekton-tutorial-greeter.git`)
https://github.com/gitops-cookbook/tekton-tutorial-greeter.git
? Value for param `revision` of type `string`? (Default is
`master`) master
? Value for param `subdirectory` of type `string`? (Default is
``)
? Value for param `sslVerify` of type `string`? (Default is
`false`) false
TaskRun started: build-app-run-rzcd8
Waiting for logs to be available...
[clone]
{"level":"info","ts":1659278019.0018234,"caller":"git/git.go:169",
 "msg":"Successfully cloned https://github.com/gitops-
 cookbook/tekton-tutorial-greeter.git @
d9291c456db1ce29177b77fffea9b71ad80a50e6 (grafted, HEAD,
origin/master) in path /workspace/source/"}
[clone]
{"level":"info","ts":1659278019.0227938,"caller":"git/git.go:207",
 "msg":"Successfully initialized and updated submodules in path
/workspace/source/"}

[build-sources] [INFO] Scanning for projects...
[build-sources] Downloading from central:
https://repo.maven.apache.org/maven2/io/quarkus/quarkus-universe-
bom/1.6.1.Final/quarkus-universe-bom-1.6.1.Final.pom
Downloaded from central:
https://repo.maven.apache.org/maven2/io/quarkus/quarkus-universe-
bom/1.6.1.Final/quarkus-universe-bom-1.6.1.Final.pom (412 kB at
118 kB/s)
[build-sources] [INFO]
...
[build-sources] [INFO] Installing
```

```

/workspace/source/quarkus/target/tekton-quarkus-greeter.jar to
/root/.m2/repository/com/redhat/developers/tekton-quarkus-
greeter/1.0.0-SNAPSHOT/tekton-quarkus-greeter-1.0.0-SNAPSHOT.jar
[build-sources] [INFO] Installing
/workspace/source/quarkus/pom.xml to
/root/.m2/repository/com/redhat/developers/tekton-quarkus-
greeter/1.0.0-SNAPSHOT/tekton-quarkus-greeter-1.0.0-SNAPSHOT.pom
[build-sources] [INFO] -----
-----
[build-sources] [INFO] BUILD SUCCESS
[build-sources] [INFO] -----
-----
[build-sources] [INFO] Total time:  04:41 min
[build-sources] [INFO] Finished at: 2022-07-31T14:38:22Z
[build-sources] [INFO] -----
-----
```

Or, you can create a TaskRun object manually like this:

```

apiVersion: tekton.dev/v1beta1
kind: TaskRun
metadata:
  generateName: build-app-run- ①
  labels:
    app.kubernetes.io/managed-by: tekton-pipelines
    tekton.dev/task: build-app
spec:
  params:
  - name: contextDir
    value: quarkus
  - name: revision
    value: master
  - name: sslVerify
    value: "false"
  - name: subdirectory
    value: ""
  - name: tlsVerify
    value: "false"
  - name: url
    value: https://github.com/gitops-cookbook/tekton-tutorial-
greeter.git
  taskRef: ②
    kind: Task
    name: build-app
workspaces:
  - emptyDir: {}
    name: source
```

- ❶ If you don't want to specify a name for each TaskRun, you can use the generateName attribute to let Tekton pick a random one from the string you defined.
- ❷ Here you list the Task that the TaskRun is referring to.

And start it in this way:

```
kubectl create -f build-app-taskrun.yaml
```

You should get output similar to the following:

```
taskrun.tekton.dev/build-app-run-65vmh created
```

You can also verify it with the tkn CLI:

```
tkn taskrun ls
```

You should get output similar to the following:

NAME	STARTED	DURATION	STATUS
build-app-run-65vmh	1 minutes ago	2m37s	Succeeded
build-app-run-rzcd8	2 minutes ago	3m58s	Succeeded

You can get the logs from the TaskRun by specifying the name of the TaskRun:

```
tkn taskrun logs build-app-run-65vmh -f
```

See Also

[Debugging a TaskRun](#)

6.4 Create a Task to Compile and Package an App from Private Git

Problem

You want to use a private Git repository to automate compiling and packaging of an app on Kubernetes with Tekton.

Solution

In [Recipe 6.3](#) you saw how to compile and package a sample Java application using a public Git repository, but most of the time people deal with private repos at work, so how do you integrate them? Tekton supports the following authentication schemes for use with Git:

- Basic-auth
- SSH

With both options you can use a Kubernetes [Secret](#) to store your credentials and attach them to the [ServiceAccount](#) running your Tekton Tasks or Pipelines.

TIP

Tekton uses a default service account, however you can override it following the documentation [here](#).

Let's start with a common example of basic authentication and a popular Git service such as GitHub.

NOTE

GitHub uses personal access tokens (PATs) as an alternative to using passwords for authentication. You can use a PAT instead of a clear-text password to enhance security.

First you need to create a Secret. You can do this by creating the following YAML file:

```
apiVersion: v1
kind: Secret
metadata:
  name: github-secret
  annotations:
    tekton.dev/git-0: https://github.com 1
  type: kubernetes.io/basic-auth 2
stringData:
  username: YOUR_USERNAME 3
  password: YOUR_PASSWORD 4
```

- 1** Here you specify the URL for which Tekton will use this Secret, in this case GitHub
- 2** This is the type of Secret, in this case a basic authentication one
- 3** Your Git user, in this case your GitHub user
- 4** Your Git password, in this case your GitHub personal access token

You can now create the Secret with the following command:

```
kubectl create -f git-secret.yaml
```

You should get the following output:

```
secret/git-secret created
```

You can also avoid writing YAML and do everything with `kubectl` as follows:

```
kubectl create secret generic git-secret \
  --type=kubernetes.io/basic-auth \
  --from-literal=username=YOUR_USERNAME \
  --from-literal=password=YOUR_PASSWORD
```

And then you just annotate the Secret as follows:

```
kubectl annotate secret git-secret "tekton.dev/git-
0=https://github.com"
```

Once you have created and annotated your Secret, you have to attach it to the ServiceAccount running your Tekton Tasks or Pipelines.

Let's create a new ServiceAccount for this purpose:

```
apiVersion: v1
kind: ServiceAccount
metadata:
  name: tekton-bot-sa
secrets:
  - name: git-secret ❶
```

❶ List of Secrets attached to this ServiceAccount

```
kubectl create -f tekton-bot-sa.yaml
```

You should get the following output:

```
serviceaccount/tekton-bot-sa created
```

TIP

You can create the ServiceAccount directly with kubectl as follows:

```
kubectl create serviceaccount tekton-bot-sa
```

and then patch it to add the secret reference:

```
kubectl patch serviceaccount tekton-bot-sa -p '{"secrets": [{"name": "git-secret"}]}'
```

Once credentials are set up and linked to the ServiceAccount running Tasks or Pipelines, you can just add the `--serviceaccount=<NAME>` option to your `tkn` command, using the [Recipe 6.3](#) example:

```
tkn task start build-app \
--serviceaccount='tekton-bot-sa' \ ❶
```

```
--param url='https://github.com/gitops-cookbook/tekton-greeter-  
private.git' \ ②  
--param contextDir='quarkus' \  
--workspace name=source,emptyDir="" \  
--showlog
```

- ❶ Here you specify the ServiceAccount to use; this will override the default one at runtime.
- ❷ Here you can override the default repository with one of your choice. In this example there's a private repository that you cannot access, but you can create a private repository on your own and test it like this.

You should get output similar to the following:

```
...  
[clone]  
{"level":"info","ts":1659354692.1365478,"caller":"git/git.go:169"  
, "msg":"Successfully cloned https://github.com/gitops-  
cookbook/tekton-greeter-private.git @  
5250e1fa185805373e620d1c04a0c48129efd2ee (grafted, HEAD,  
origin/master) in path /workspace/source/"}  
[clone]  
{"level":"info","ts":1659354692.1546066,"caller":"git/git.go:207"  
, "msg":"Successfully initialized and updated submodules in path  
/workspace/source/"}  
...  
[build-sources] [INFO] -----  
-----  
[build-sources] [INFO] BUILD SUCCESS  
[build-sources] [INFO] -----  
-----  
[build-sources] [INFO] Total time: 04:30 min  
[build-sources] [INFO] Finished at: 2022-07-31T15:30:01Z  
[build-sources] [INFO] -----  
-----
```

See Also

- [Tekton Authentication](#)

6.5 Containerize an Application Using a Tekton Task and Buildah

Problem

You want to compile, package, and containerize your app with a Tekton Task on Kubernetes.

Solution

Automation is essential when adopting the cloud native approach, and if you decide to use Kubernetes for your CI/CD workloads, you need to provide a way to package and deploy your applications.

In fact, Kubernetes per se doesn't have a built-in mechanism to build containers; it just relies on add-ons such as Tekton or external services for this purpose. That's why in [Chapter 3](#) we did an overview on how to create containers for packaging applications with various open source tools. In [Recipe 3.3](#) we used Buildah to create a container from a Dockerfile.

Thanks to Tekton's extensible model, you can reuse the same Task defined in [Recipe 6.3](#) to add a step to create a container using the outcomes from the previous steps, as shown in [Figure 6-4](#).

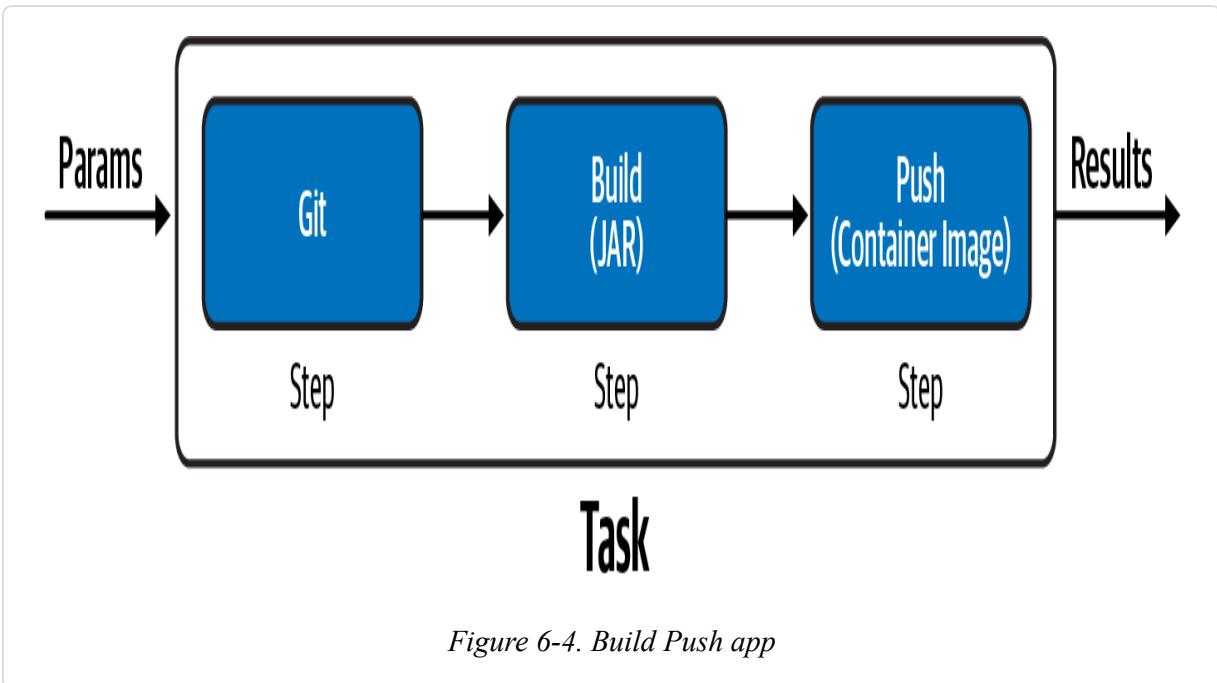


Figure 6-4. Build Push app

The container can be pushed to a public container registry such as DockerHub or Quay.io, or to a private container registry. Similar to what we have seen in [Recipe 6.4](#) for private Git repositories, pushing a container image to a container registry needs authentication. A Secret needs to be attached to the ServiceAccount running the Task as follows. See [Chapter 2](#) for how to register and use a public registry.

```
kubectl create secret docker-registry container-registry-secret \
--docker-server='YOUR_REGISTRY_SERVER' \
--docker-username='YOUR_REGISTRY_USER' \
--docker-password='YOUR_REGISTRY_PASS'

secret/container-registry-secret created
```

Verify it is present and check that the Secret is of type

`kubernetes.io/dockerconfigjson`:

```
kubectl get secrets
```

You should get the following output:

NAME	TYPE	DATA
AGE		
container-registry-secret	kubernetes.io/dockerconfigjson	1

Let's create a ServiceAccount for this Task:

```
kubectl create serviceaccount tekton-registry-sa
```

Then let's add the previously generated Secret to this ServiceAccount:

```
kubectl patch serviceaccount tekton-registry-sa \
-p '{"secrets": [{"name": "container-registry-secret"}]}'
```

You should get the following output:

```
serviceaccount/tekton-registry-sa patched
```

Let's add a new step to create a container image and push it to a container registry. In the following example we use the book's organization repos at Quay.io—quay.io/gitops-cookbook/tekton-greeter:latest:

```
apiVersion: tekton.dev/v1beta1
kind: Task
metadata:
  name: build-push-app
spec:
  workspaces:
    - name: source
      description: The git repo will be cloned onto the volume
      backing this workspace
    params:
      - name: contextDir
        description: the context dir within source
        default: quarkus
      - name: tlsVerify
        description: tls verify
        type: string
        default: "false"
      - name: url
        default: https://github.com/gitops-cookbook/tekton-
        tutorial-greeter.git
```

```

- name: revision
  default: master
- name: subdirectory
  default: ""
- name: sslVerify
  description: defines if http.sslVerify should be set to true or false in the global git config
  type: string
  default: "false"
- name: storageDriver
  type: string
  description: Storage driver
  default: vfs
- name: destinationImage
  description: the fully qualified image name
  default: ""
steps:
- image: 'gcr.io/tekton-releases/github.com/tektoncd/pipeline/cmd/git-init:v0.21.0'
  name: clone
  resources: {}
  script: |
    CHECKOUT_DIR="$({workspaces.source.path})/${params.subdirectory}"
    cleandir() {
        # Delete any existing contents of the repo directory if it exists.
        #
        # We don't just "rm -rf $CHECKOUT_DIR" because $CHECKOUT_DIR might be "/"
        # or the root of a mounted volume.
        if [[ -d "$CHECKOUT_DIR" ]]; then
            # Delete non-hidden files and directories
            rm -rf "$CHECKOUT_DIR"/*
            # Delete files and directories starting with . but excluding ..
            rm -rf "$CHECKOUT_DIR"/.[!.]*
            # Delete files and directories starting with .. plus any other character
            rm -rf "$CHECKOUT_DIR"/..?*
        fi
    }
    /ko-app/git-init \
        -url "${params.url}" \
        -revision "${params.revision}" \
        -path "$CHECKOUT_DIR" \
        -sslVerify="${params.sslVerify}"
    cd "$CHECKOUT_DIR"
    RESULT_SHA=$(git rev-parse HEAD)"
- name: build-sources

```

```

image: gcr.io/cloud-builders/mvn
command:
  - mvn
args:
  - -DskipTests
  - clean
  - install
env:
  - name: user.home
    value: /home/tekton
workingDir: "/workspace/source/${params.contextDir}"
- name: build-and-push-image
  image: quay.io/buildah/stable
  script: |
    #!/usr/bin/env bash
    buildah --storage-driver=$STORAGE_DRIVER --tls-
verify=${params.tlsVerify} bud --layers -t $DESTINATION_IMAGE
$CONTEXT_DIR
    buildah --storage-driver=$STORAGE_DRIVER --tls-
verify=${params.tlsVerify} push $DESTINATION_IMAGE
  docker://$DESTINATION_IMAGE
env:
  - name: DESTINATION_IMAGE
    value: "${params.destinationImage}"
  - name: CONTEXT_DIR
    value: "/workspace/source/${params.contextDir}"
  - name: STORAGE_DRIVER
    value: "${params.storageDriver}"
workingDir: "/workspace/source/${params.contextDir}"
volumeMounts:
  - name: varlibc
    mountPath: /var/lib/containers
volumes:
  - name: varlibc
    emptyDir: {}

```

Let's create this Task:

```
kubectl create -f build-push-app.yaml
```

You should get the following output:

```
task.tekton.dev/build-push-app created
```

Now let's start the Task with the Buildah step creating a container image and with a new parameter destinationImage to specify where to push

the resulting container image:

```
tkn task start build-push-app \
  --serviceaccount='tekton-registry-sa' \
  --param url='https://github.com/gitops-cookbook/tekton-
tutorial-greeter.git' \
  --param destinationImage='quay.io/gitops-cookbook/tekton-
greeter:latest' \❶
  --param contextDir='quarkus' \
  --workspace name=source,emptyDir="" \
  --use-param-defaults \
  --showlog
```

- ❶ Here you can place your registry; in this example we are using the book's organization repos at Quay.io.

You should get output similar to the following:

```
...
Downloaded from central:
https://repo.maven.apache.org/maven2/org/codehaus/plexus/plexus-
utils/3.0.5/plexus-utils-3.0.5.jar (230 kB at 301 kB/s)
[build-sources] [INFO] Installing
/workspace/source/quarkus/target/tekton-quarkus-greeter.jar to
/root/.m2/repository/com/redhat/developers/tekton-quarkus-
greeter/1.0.0-SNAPSHOT/tekton-quarkus-greeter-1.0.0-SNAPSHOT.jar
[build-sources] [INFO] Installing
/workspace/source/quarkus/pom.xml to
/root/.m2/repository/com/redhat/developers/tekton-quarkus-
greeter/1.0.0-SNAPSHOT/tekton-quarkus-greeter-1.0.0-SNAPSHOT.pom
[build-sources] [INFO] -----
-----
[build-sources] [INFO] BUILD SUCCESS
[build-sources] [INFO] -----
-----
[build-sources] [INFO] Total time: 02:59 min
[build-sources] [INFO] Finished at: 2022-08-02T06:18:37Z
[build-sources] [INFO] -----
-----
[build-and-push-image] STEP 1/2: FROM
registry.access.redhat.com/ubi8/openjdk-11
[build-and-push-image] Trying to pull
registry.access.redhat.com/ubi8/openjdk-11:latest...
[build-and-push-image] Getting image source signatures
[build-and-push-image] Checking if image destination supports
signatures
[build-and-push-image] Copying blob
```

```
sha256:1e09a5ee0038fbe06a18e7f355188bbabc387467144abcd435f7544fef  
395aa1  
[build-and-push-image] Copying blob  
sha256:0d725b91398ed3db11249808d89e688e62e511bbd4a2e875ed8493ce1f  
ebdb2c  
[build-and-push-image] Copying blob  
sha256:1e09a5ee0038fbe06a18e7f355188bbabc387467144abcd435f7544fef  
395aa1  
[build-and-push-image] Copying blob  
sha256:0d725b91398ed3db11249808d89e688e62e511bbd4a2e875ed8493ce1f  
ebdb2c  
[build-and-push-image] Copying blob  
sha256:e441d34134fac91baa79be3e2bb8fb3dba71ba5c1ea012cb5daeb7180a  
054687  
[build-and-push-image] Copying blob  
sha256:e441d34134fac91baa79be3e2bb8fb3dba71ba5c1ea012cb5daeb7180a  
054687  
[build-and-push-image] Copying config  
sha256:0c308464b19eaa9a01c3fdd6b63a043c160d4eea85e461bbbb7d01d168  
f6d993  
[build-and-push-image] Writing manifest to image destination  
[build-and-push-image] Storing signatures  
[build-and-push-image] STEP 2/2: COPY target/quarkus-app  
/deployments/  
[build-and-push-image] COMMIT quay.io/gitops-cookbook/tekton-  
greeter:latest  
[build-and-push-image] --> 42fe38b4346  
[build-and-push-image] Successfully tagged quay.io/gitops-  
cookbook/tekton-greeter:latest  
[build-and-push-image]  
42fe38b43468c3ca32262dbea6fd78919aba2bd35981cd4f71391e07786c9e21  
[build-and-push-image] Getting image source signatures  
[build-and-push-image] Copying blob  
sha256:647a854c512bad44709221b6b0973e884f29bcb5a380ee32e95bfb0189  
b620e6  
[build-and-push-image] Copying blob  
sha256:f2ee6b2834726167d0de06f3bbe65962aef79855c5ede0d2ba93b44085  
58d9c9  
[build-and-push-image] Copying blob  
sha256:8e0e04b5c700a86f4a112f41e7e767a9d7c539fe3391611313bf76edb0  
7eeab1  
[build-and-push-image] Copying blob  
sha256:69c55192bed92cbb669c88eb3c36449b64ac93ae466abfff2a575273ce  
05a39e  
[build-and-push-image] Copying config  
sha256:42fe38b43468c3ca32262dbea6fd78919aba2bd35981cd4f71391e0778  
6c9e21  
[build-and-push-image] Writing manifest to image destination  
[build-and-push-image] Storing signatures
```

See Also

- [Buildah](#)
- [Docker Authentication for Tekton](#)

6.6 Deploy an Application to Kubernetes Using a Tekton Task

Problem

You want to deploy an application from a container image to Kubernetes with a Tekton Task.

Solution

While in Recipes [6.3](#), [6.4](#), and [6.5](#) we have listed a Tekton Task that is useful for continuous integration (CI), in this recipe we'll start having a look at the Continuous Deployment (CD) part by deploying an existing container image to Kubernetes.

We can reuse the container image we created and pushed in [Recipe 6.5](#), available at `quay.io/gitops-cookbook/tekton-greeter:latest`:

```
apiVersion: tekton.dev/v1beta1
kind: Task
metadata:
  name: kubectl
spec:
  params:
    - name: SCRIPT
      description: The kubectl CLI arguments to run
      type: string
      default: "kubectl help"
  steps:
    - name: oc
      image: quay.io/openshift/origin-cli:latest ⓘ
      script: |
        #!/usr/bin/env bash
```

```
$ (params.SCRIPT)
```

- ❶ For this example we are using `kubectl` from this container image, which also contains OpenShift CLI and it has a smaller size compared to `gcr.io/cloud-builders/kubectl`.

Let's create this Task:

```
kubectl create -f kubectl-task.yaml
```

You should get the following output:

```
task.tekton.dev/kubectl created
```

As discussed in [Recipe 6.5](#), Tekton uses a default ServiceAccount for running Tasks and Pipelines, unless a specific one is defined at runtime or overridden at a global scope. The best practice is always to create a specific ServiceAccount for a particular action, so let's create one named `tekton-deployer-sa` for this use case as follows:

```
kubectl create serviceaccount tekton-deployer-sa
```

You should get the following output:

```
serviceaccount/tekton-deployer-sa created
```

A ServiceAccount needs permission to deploy an application to Kubernetes. [Roles and RoleBindings](#) are API objects used to map a certain permission to a user or a ServiceAccount.

You first define a Role named `pipeline-role` for the ServiceAccount running the Tekton Task with permissions to deploy apps:

```
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
```

```

name: task-role
rules:
  - apiGroups:
    - ""
      resources:
        - pods
        - services
        - endpoints
        - configmaps
        - secrets
      verbs:
        - "*"
  - apiGroups:
    - apps
      resources:
        - deployments
        - replicaset
      verbs:
        - "*"
  - apiGroups:
    - ""
      resources:
        - pods
      verbs:
        - get
  - apiGroups:
    - apps
      resources:
        - replicaset
      verbs:
        - get

```

Now you need to bind the Role to the ServiceAccount:

```

apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  name: task-role-binding
roleRef:
  kind: Role
  name: task-role
  apiGroup: rbac.authorization.k8s.io
subjects:
  - kind: ServiceAccount
    name: tekton-deployer-sa

```

Now you can create the two resources as follows:

```
kubectl create -f task-role.yaml  
kubectl create -f task-role-binding.yaml
```

You should get the following output:

```
role.rbac.authorization.k8s.io/task-role created  
rolebinding.rbac.authorization.k8s.io/task-role-binding created
```

Finally, you can define a TaskRun as follows:

```
apiVersion: tekton.dev/v1beta1  
kind: TaskRun  
metadata:  
  name: kubectl-taskrun  
spec:  
  serviceAccountName: tekton-deployer-sa  
  taskRef:  
    name: kubectl  
  params:  
    - name: SCRIPT  
      value: |  
        kubectl create deploy tekton-greeter --  
        image=quay.io/gitops-cookbook/tekton-greeter:latest
```

And run it in this way:

```
kubectl create -f kubectl-taskrun.yaml
```

You should get the following output:

```
taskrun.tekton.dev/kubectl-run created
```

You can check the logs to see the results:

```
tkn taskrun logs kubectl-run -f
```

You should get output similar to the following:

```
? Select taskrun: kubectl-run started 9 seconds ago  
[oc] deployment.apps/tekton-greeter created
```

After a few seconds you should see the Deployment in Ready state:

```
kubectl get deploy
```

NAME	READY	UP-TO-DATE	AVAILABLE	AGE
tekton-greeter	1/1	1	0	30s

NOTE

The first time might take a while due to the time it takes to pull the container image.

Check if the app is available, expose the Deployment, and forward Kubernetes traffic to your workstation to test it:

```
kubectl expose deploy/tekton-greeter --port 8080  
kubectl port-forward svc/tekton-greeter 8080:8080
```

In another terminal, run this command:

```
curl localhost:8080
```

You should see the following output:

```
Meeow!! from Tekton ----
```

See Also

- [Tekton Task](#)

6.7 Create a Tekton Pipeline to Build and Deploy an App to Kubernetes

Problem

You want to create a Pipeline to compile, package, and deploy an app on Kubernetes with Tekton.

Solution

In the previous recipes we have seen how to create Tasks to execute one or more steps sequentially to build apps. In this recipe we will discuss [Tekton Pipelines](#), a collection of Tasks that you can define and compose in a specific order of execution, either sequentially or in parallel, as you can see in [Figure 6-5](#).

Pipeline

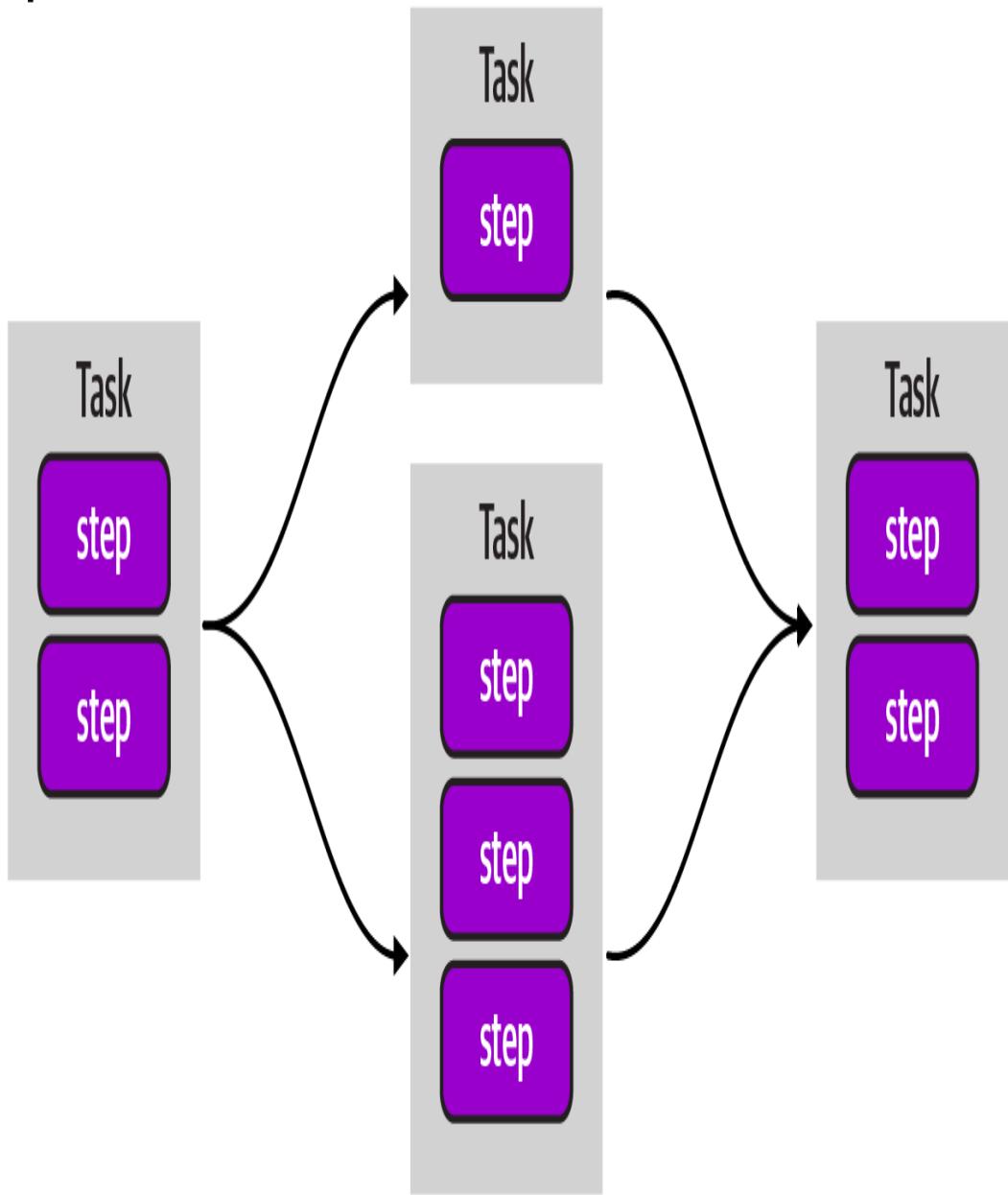


Figure 6-5. Tekton Pipelines flows

Tekton Pipelines supports parameters and a mechanism to exchange outcomes between different Tasks. For instance, using the examples shown in Recipes [6.5](#) and [6.6](#):

```
kubectl patch serviceaccount tekton-deployer-sa \
-p '{"secrets": [{"name": "container-registry-secret"}]}'

apiVersion: tekton.dev/v1beta1
kind: Pipeline
metadata:
  name: tekton-greeter-pipeline
spec:
  params: ❶
    - name: GIT_REPO
      type: string
    - name: GIT_REF
      type: string
    - name: DESTINATION_IMAGE
      type: string
    - name: SCRIPT
      type: string
  tasks: ❷
    - name: build-push-app
      taskRef: ❸
        name: build-push-app
      params:
        - name: url
          value: "${params.GIT_REPO}"
        - name: revision
          value: "${params.GIT_REF}"
        - name: destinationImage
          value: "${params.DESTINATION_IMAGE}"
      workspaces:
        - name: source
    - name: deploy-app
      taskRef:
        name: kubectl
      params:
        - name: SCRIPT
          value: "${params.SCRIPT}"
      workspaces:
        - name: source
      runAfter: ❹
        - build-push-app
  workspaces: ❺
    - name: source
```

- ❶ Pipeline parameters
- ❷ A list of Tasks for the Pipeline
- ❸ The exact name of the Task to use
- ❹ You can decide the order with the `runAfter` field to indicate that a Task must execute after one or more other Tasks
- ❺ One or more common Workspaces used to share data between Tasks

Let's create the Pipeline as follows:

```
kubectl create -f tekton-greeter-pipeline.yaml
```

You should get the following output:

```
pipeline.tekton.dev/tekton-greeter-pipeline created
```

Similarly to TaskRuns, you can run this Pipeline by creating a [PipelineRun](#) resource as follows:

```
apiVersion: tekton.dev/v1beta1
kind: PipelineRun
metadata:
  generateName: tekton-greeter-pipeline-run-
spec:
  params:
    - name: GIT_REPO
      value: https://github.com/gitops-cookbook/tekton-tutorial-
greeter.git
    - name: GIT_REF
      value: "master"
    - name: DESTINATION_IMAGE
      value: "quay.io/gitops-cookbook/tekton-greeter:latest"
    - name: SCRIPT
      value: |
        kubectl create deploy tekton-greeter --
image=quay.io/gitops-cookbook/tekton-greeter:latest
  pipelineRef:
    name: tekton-greeter-pipeline
  workspaces:
    - name: source
      emptyDir: {}
```

You can run the Pipeline by creating this PipelineRun object as follows:

```
kubectl create -f tekton-greeter-pipelinerun.yaml
```

You can check the status:

```
tkn pipelinerun ls
```

NAME	STARTED	DURATION
STATUS		
tekton-greeter-pipeline-run-nt15r	7 seconds ago	---
Running		

Now that you have seen how to reuse existing Tasks within a Pipeline, it's a good time to introduce the [Tekton Hub](#), a web-based platform for developers to discover, share, and contribute Tasks and Pipelines for Tekton (see [Figure 6-6](#)).



TEKTON HUB

?

Login

Welcome to Tekton Hub

Discover, search and share reusable Tasks and Pipelines

Sort By ▾

Kind	Buildpacks	git cli	golang build	jenkins operation	pull request
Pipeline	v0.2	v0.4	v0.3	v0.1	v0.1
Task	The Buildpacks pipeline builds source from a Git repository into a container image and pushes it to a registry, using Cloud Native Buildpacks.	This task can be used to perform git operations. Git command that needs to be run can be passed as a script to the task. This task needs authentication to git in order to push after the git open.	This Task is Golang task to build Go projects.	The following task can be used to interact with the Jenkins REST API.	This Task allows a user to interact with an SCM (source control management) system through an abstracted interface. This Task works with both public SCM instances and self-
Platform	Updated a month ago	Updated 6 days ago	Updated 8 months ago	Updated 9 months ago	Updated a year ago
Catalog	image-build	git	build-tool	build jenkins	SCM
Category	Automation	Cloud	Dependency Analysis	Send-to-telegram	Trigger Jenkins job
	Build Tools	CodeReady	Dependency Analysis	rsync	v0.1
	Cli	RedHat CodeReady	v0.1	v0.1	v0.1
	Cloud	ssh remote commands	The following task can be used to execute commands on remote machine. The following task takes host and required credentials as	send-to-telegram	trigger jenkins job
	Code Quality	v0.1	dependency analysis	v0.1	v0.1
	Continuous Integration	v0.1	v0.1	v0.1	v0.1
	Deployment	v0.1	v0.1	v0.1	v0.1
	Developer Tools	v0.1	v0.1	v0.1	v0.1
	Git	v0.1	v0.1	v0.1	v0.1
	Image Build	v0.1	v0.1	v0.1	v0.1



You can implement the same Pipeline with Tasks already available in the Hub. In our case, we have:

git-clone

Task that clones a repo from the provided URL into the output Workspace.

buildah

Task that builds source into a container image and can push it to a container registry.

kubernetes-actions

The generic kubectl CLI task, which can be used to run all kinds of k8s commands.

First let's add them to our namespace as follows:

```
tkn hub install task git-clone  
tkn hub install task maven  
tkn hub install task buildah  
tkn hub install task kubernetes-actions
```

You should get output similar to the following to confirm they are installed properly in your namespace:

```
Task git-clone(0.7) installed in default namespace  
Task maven(0.2) installed in default namespace  
Task buildah(0.4) installed in default namespace  
Task kubernetes-actions(0.2) installed in default namespace
```

You can cross-check it with the following command:

```
kubectl get tasks
```

You should get output similar to the following:

NAME	AGE
...	
buildah	50s
git-clone	52s
kubernetes-actions	49s
maven	51s
...	

TIP

Some Tekton installations like the one made with the Operator for [OpenShift Pipelines](#) provide a common list of useful Tasks such as those just listed, provided as ClusterTasks. ClusterTasks are Tasks available for all namespaces within the Kubernetes cluster. Check if your installation already provides some with this command: `kubectl get clustertasks`.

Now the Pipeline has four Tasks, as you can see in [Figure 6-7](#).

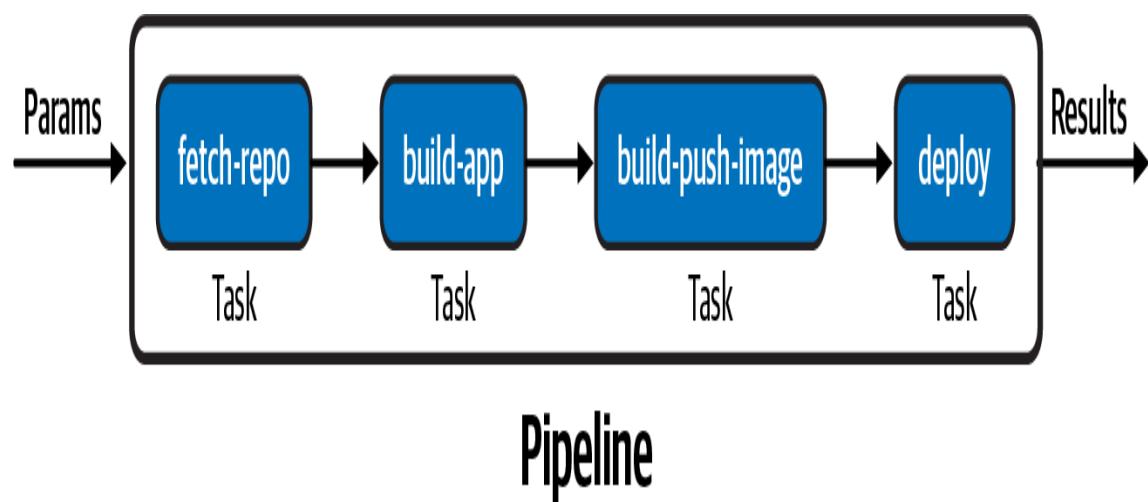


Figure 6-7. Pipeline

In this example you'll see a [PersistentVolumeClaim](#) as a Workspace because here the data is shared among different Tasks so we need to persist it:

```

apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: app-source-pvc
  
```

```
spec:  
  accessModes:  
    - ReadWriteOnce  
  resources:  
    requests:  
      storage: 1Gi
```

As usual, you can create the resource with kubectl:

```
kubectl create -f app-source-pvc.yaml
```

You should see the following output:

```
persistentvolumeclaim/app-source-pvc created  
  
kubectl get pvc  
  
NAME           STATUS  VOLUME          CAPACITY   ACCESS MODES  STORAGECLASS  AGE  
CAPACITY      ACCESS MODES  STORAGECLASS  AGE  
app-source-pvc  Bound    pvc-e85ade46-aaca-4f3f-b644-  
d8ff9fd9d5e   1Gi       RWO             standard     61s
```

NOTE

In Minikube you have a default [StorageClass](#) that provides dynamic storage for the cluster. If you are using another Kubernetes cluster, please make sure you have a dynamic storage support.

The Pipeline definition now is:

```
apiVersion: tekton.dev/v1beta1  
kind: Pipeline  
metadata:  
  name: tekton-greeter-pipeline-hub  
spec:  
  params:  
    - default: https://github.com/gitops-cookbook/tekton-tutorial-  
      greeter.git  
        name: GIT_REPO  
        type: string  
    - default: master  
        name: GIT_REF  
        type: string
```

```
- default: quay.io/gitops-cookbook/tekton-greeter:latest
  name: DESTINATION_IMAGE
  type: string
- default: kubectl create deploy tekton-greeter --
image=quay.io/gitops-cookbook/tekton-greeter:latest
  name: SCRIPT
  type: string
- default: ./Dockerfile
  name: CONTEXT_DIR
  type: string
- default: .
  name: IMAGE_DOCKERFILE
  type: string
- default: .
  name: IMAGE_CONTEXT_DIR
  type: string
tasks:
- name: fetch-repo
  params:
    - name: url
      value: $(params.GIT_REPO)
    - name: revision
      value: $(params.GIT_REF)
    - name: deleteExisting
      value: "true"
    - name: verbose
      value: "true"
  taskRef:
    kind: Task
    name: git-clone
  workspaces:
    - name: output
      workspace: app-source
- name: build-app
  params:
    - name: GOALS
      value:
        - -DskipTests
        - clean
        - package
    - name: CONTEXT_DIR
      value: $(params.CONTEXT_DIR)
  runAfter:
    - fetch-repo
  taskRef:
    kind: Task
    name: maven
  workspaces:
    - name: maven-settings
      workspace: maven-settings
```

```

- name: source
  workspace: app-source
- name: build-push-image
  params:
    - name: IMAGE
      value: $(params.DESTINATION_IMAGE)
    - name: DOCKERFILE
      value: $(params.IMAGE_DOCKERFILE)
    - name: CONTEXT
      value: $(params.IMAGE_CONTEXT_DIR)
  runAfter:
    - build-app
  taskRef:
    kind: Task
    name: buildah
  workspaces:
    - name: source
      workspace: app-source
- name: deploy
  params:
    - name: script
      value: $(params.SCRIPT)
  runAfter:
    - build-push-image
  taskRef:
    kind: Task
    name: kubernetes-actions
  workspaces:
    - name: app-source
    - name: maven-settings

```

Let's create the resource:

```
kubectl create -f tekton-greeter-pipeline-hub.yaml
```

NOTE

We are using the same Secret and ServiceAccount defined in [Recipe 6.5](#) to log in against Quay.io in order to push the container image.

You can now start the Pipeline as follows:

```
tkn pipeline start tekton-greeter-pipeline-hub \
--serviceaccount='tekton-deployer-sa' \
```

```

--param GIT_REPO='https://github.com/gitops-cookbook/tekton-
tutorial-greeter.git' \
--param GIT_REF='master' \
--param CONTEXT_DIR='quarkus' \
--param DESTINATION_IMAGE='quay.io/gitops-cookbook/tekton-
greeter:latest' \
--param IMAGE_DOCKERFILE='quarkus/Dockerfile' \
--param IMAGE_CONTEXT_DIR='quarkus' \
--param SCRIPT='kubectl create deploy tekton-greeter --image=quay.io/gitops-cookbook/tekton-greeter:latest' \
--workspace name=app-source,claimName=app-source-pvc \
--workspace name=maven-settings,emptyDir="" \
--use-param-defaults \
--showlog

[fetch-repo : clone] + CHECKOUT_DIR=/workspace/output/
[fetch-repo : clone] + /ko-app/git-init '-url=https://github.com/gitops-cookbook/tekton-tutorial-greeter.git' '-revision=master' '-refspec=' '-path=/workspace/output/' '-sslVerify=true' '-submodules=true' '-depth=1' '-sparseCheckoutDirectories='
[fetch-repo : clone]
{"level":"info","ts":1660819038.5526028,"caller":"git/git.go:170","msg":"Successfully cloned https://github.com/gitops-cookbook/tekton-tutorial-greeter.git @ d9291c456db1ce29177b77fffea9b71ad80a50e6 (grafted, HEAD, origin/master) in path /workspace/output/"}
[fetch-repo : clone]
{"level":"info","ts":1660819038.5722632,"caller":"git/git.go:208","msg":"Successfully initialized and updated submodules in path /workspace/output/"}
[fetch-repo : clone] + cd /workspace/output/
[fetch-repo : clone] + git rev-parse HEAD
[fetch-repo : clone] +
RESULT_SHA=d9291c456db1ce29177b77fffea9b71ad80a50e6
[fetch-repo : clone] + EXIT_CODE=0
[fetch-repo : clone] + '[' 0 != 0 ] 
[fetch-repo : clone] + printf '%s'
d9291c456db1ce29177b77fffea9b71ad80a50e6
[fetch-repo : clone] + printf '%s' https://github.com/gitops-cookbook/tekton-tutorial-greeter.git
...
[build-app : mvn-goals] [INFO] [org.jboss.threads] JBoss Threads version 3.1.1.Final
[build-app : mvn-goals] [INFO]
[io.quarkus.deployment.QuarkusAugmentor] Quarkus augmentation completed in 1296ms
[build-app : mvn-goals] [INFO] -----
-----
[build-app : mvn-goals] [INFO] BUILD SUCCESS

```

```
[build-app : mvn-goals] [INFO] -----
-----
[build-app : mvn-goals] [INFO] Total time: 03:18 min
[build-app : mvn-goals] [INFO] Finished at: 2022-08-18T10:31:00Z
[build-app : mvn-goals] [INFO] -----
-----
[build-push-image : build] STEP 1/2: FROM
registry.access.redhat.com/ubi8/openjdk-11
[build-push-image : build] Trying to pull
registry.access.redhat.com/ubi8/openjdk-11:latest...
[build-push-image : build] Getting image source signatures
[build-push-image : build] Checking if image destination supports
signatures
[build-push-image : build] Copying blob
sha256:e441d34134fac91baa79be3e2bb8fb3dba71ba5c1ea012cb5daeb7180a
054687
[build-push-image : build] Copying blob
sha256:1e09a5ee0038fbe06a18e7f355188bbabc387467144abcd435f7544fef
395aa1
[build-push-image : build] Copying blob
sha256:0d725b91398ed3db11249808d89e688e62e511bbd4a2e875ed8493ce1f
ebdb2c
[build-push-image : build] Copying blob
sha256:e441d34134fac91baa79be3e2bb8fb3dba71ba5c1ea012cb5daeb7180a
054687
[build-push-image : build] Copying blob
sha256:1e09a5ee0038fbe06a18e7f355188bbabc387467144abcd435f7544fef
395aa1
[build-push-image : build] Copying blob
sha256:0d725b91398ed3db11249808d89e688e62e511bbd4a2e875ed8493ce1f
ebdb2c
[build-push-image : build] Copying config
sha256:0c308464b19eaa9a01c3fdd6b63a043c160d4eea85e461bbbb7d01d168
f6d993
[build-push-image : build] Writing manifest to image destination
[build-push-image : build] Storing signatures
[build-push-image : build] STEP 2/2: COPY target/quarkus-app
/deployments/
[build-push-image : build] COMMIT quay.io/gitops-cookbook/tekton-
greeter:latest
[build-push-image : build] --> c07e36a8e61
[build-push-image : build] Successfully tagged quay.io/gitops-
cookbook/tekton-greeter:latest
[build-push-image : build]
c07e36a8e6104d2e5c7d79a6cd34cd7b44eb093c39ef6c1487a37d7bd2305b8a
[build-push-image : build] Getting image source signatures
[build-push-image : build] Copying blob
sha256:7853a7797845542e3825d4f305e4784ea7bf492cd4364fc93b9afba3ac
0c9553
[build-push-image : build] Copying blob
```

```
sha256:8e0e04b5c700a86f4a112f41e7e767a9d7c539fe3391611313bf76edb0  
7eeab1  
[build-push-image : build] Copying blob  
sha256:647a854c512bad44709221b6b0973e884f29bcb5a380ee32e95fb0189  
b620e6  
[build-push-image : build] Copying blob  
sha256:69c55192bed92cbb669c88eb3c36449b64ac93ae466abfff2a575273ce  
05a39e  
[build-push-image : build] Copying config  
sha256:c07e36a8e6104d2e5c7d79a6cd34cd7b44eb093c39ef6c1487a37d7bd2  
305b8a  
[build-push-image : build] Writing manifest to image destination  
[build-push-image : build] Storing signatures  
[build-push-image : build]  
sha256:12dd3deb6305b9e125309b68418d0bb81f805e0fe7ac93942dc94764ae  
e9f492quay.io/gitops-cookbook/tekton-greeter:latest  
[deploy : kubectl] deployment.apps/tekton-greeter created
```

TIP

You can use the Tekton Dashboard to create and visualize your running Tasks and Pipelines as shown in [Figure 6-8](#).

Tekton Dashboard

Tekton resources

- Pipelines
- PipelineRuns**
- PipelineResources
- Tasks
- ClusterTasks
- TaskRuns
- EventListeners
- Triggers
- TriggerBindings
- ClusterTriggerBindings
- TriggerTemplates
- ClusterInterceptors
- Import resources
- About Tekton
- Settings

tekton-greeter-pipeline-hub-run-db6jz Last updated 3 days ago Rerun ↻

Succeeded Tasks Completed: 4 (Failed: 0, Cancelled 0), Skipped: 0 ↻

fetch-repo ✓ **clone** Completed
Duration: 2s

build-app ✓

build-push-image ✓

deploy ✓

Logs Status Details

```
+ '[' false '=' true ]  
+ '[' false '=' true ]  
+ '[' false '=' true ]  
+ CHECKOUT_DIR=/workspace/output/  
+ '[' true '=' true ]  
+ cleandir  
+ '[' -d /workspace/output/ ]  
+ rm -rf /workspace/output//README.md /workspace/output//k8s /workspace/output//mvnw  
+ rm -rf /workspace/output//.editorconfig /workspace/output//.git /workspace/output//  
+ rm -rf '/workspace/output//...?'  
+ test -z  
+ test -z  
+ test -z  
+ /ko-app/git-init '-url=https://github.com/gitops-cookbook/tekton-tutorial-greeter.g  
{"level": "info", "ts": 166818453.247552, "caller": "git/git.go:170", "msg": "Successfully  
{"level": "info", "ts": 166818453.270237, "caller": "git/git.go:288", "msg": "Successfully  
+ cd /workspace/output/
```

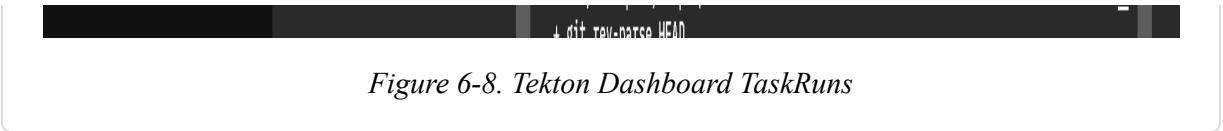


Figure 6-8. Tekton Dashboard TaskRuns

See Also

- [Tekton Catalog](#)

6.8 Using Tekton Triggers to Compile and Package an Application Automatically When a Change Occurs on Git

Problem

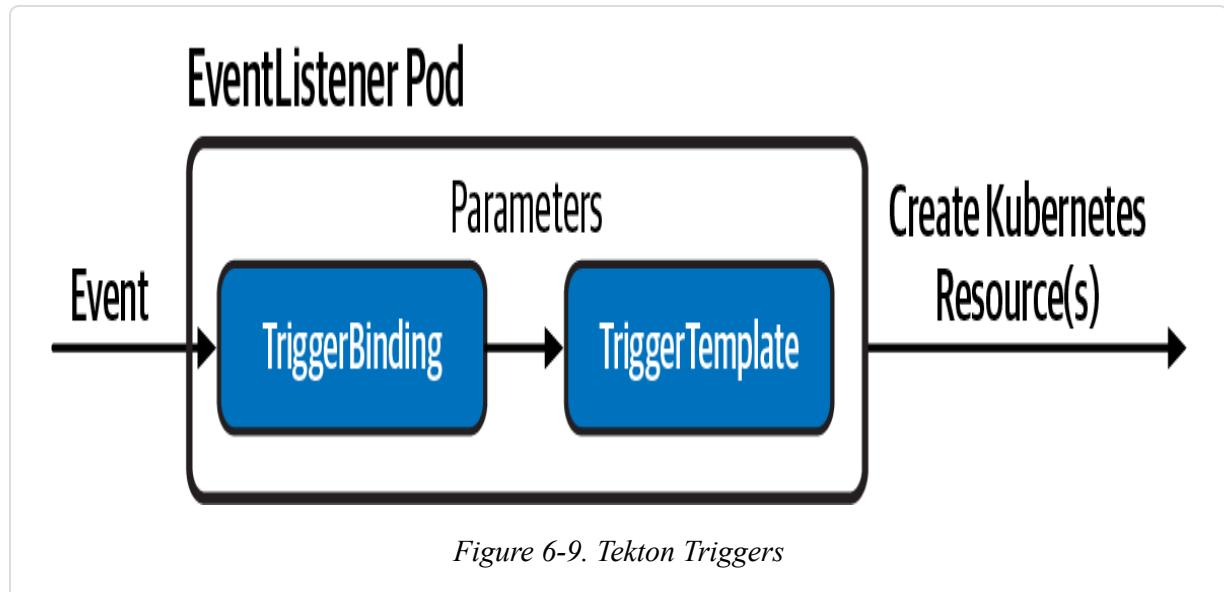
You want to automate your CI/CD Pipelines when a change on Git occurs.

Solution

[Tekton Triggers](#) is the Tekton component that brings automation for Tasks and Pipelines with Tekton. It is an interesting feature for a GitOps strategy for cloud native CI/CD as it supports external events from a large set of sources such as Git events (Git push or pull requests).

Most Git repository servers support the concept of webhooks, calling to an external source via HTTP(S) when a change in the code repository happens. Tekton provides an API endpoint that supports receiving hooks from remote systems in order to trigger builds. By pointing the code repository's hook at the Tekton resources, automated code/build/deploy pipelines can be achieved.

The installation of Tekton Triggers, which we discussed in [Recipe 6.1](#), brings a set of CRDs to manage event handling for Tasks and Pipelines. In this recipe we will use the following, as illustrated also in [Figure 6-9](#):



TriggerTemplate

A template for newly created resources. It supports parameters to create specific PipelineRuns.

TriggerBinding

Validates events and extracts payload fields.

EventListener

Connects TriggerBindings and TriggerTemplates into an addressable endpoint (the event sink). It uses the extracted event parameters from each TriggerBinding (and any supplied static parameters) to create the resources specified in the corresponding TriggerTemplate. It also optionally allows an external service to preprocess the event payload via the interceptor field.

Before creating these resources, you need to set up permissions to let Tekton Triggers create Pipelines and Tasks. You can use the setup available from [the book's repository](#) with the following command:

```
kubectl apply \
-f https://raw.githubusercontent.com/gitops-
cookbook/chapters/main/chapters/ch06/rbac.yaml
```

This will create a new ServiceAccount named `tekton-triggers-sa` that has the permissions needed to interact with the Tekton Pipelines component. As confirmation, from the previous command you should get the following output:

```
serviceaccount/tekton-triggers-sa created
rolebinding.rbac.authorization.k8s.io/triggers-example-
eventlistener-binding configured
clusterrolebinding.rbac.authorization.k8s.io/triggers-example-
eventlistener-clusterbinding configured
```

You can now add automation to your Pipelines like the one we defined in [Recipe 6.7](#) creating these three resources:

```
apiVersion: triggers.tekton.dev/v1alpha1
kind: TriggerTemplate
metadata:
  name: tekton-greeter-triggertemplate
spec:
  params:
    - name: git-revision
    - name: git-commit-message
    - name: git-repo-url
    - name: git-repo-name
    - name: content-type
    - name: pusher-name
  resourceTemplates:
    - apiVersion: tekton.dev/v1beta1
      kind: PipelineRun
      metadata:
        labels:
          tekton.dev/pipeline: tekton-greeter-pipeline-hub
        name: tekton-greeter-pipeline-webhook-$uid
      spec:
        params:
          - name: GIT_REPO
            value: ${tt.params.git-repo-url}
          - name: GIT_REF
            value: ${tt.params.git-revision}
        serviceAccountName: tekton-triggers-example-sa
      pipelineRef:
        name: tekton-greeter-pipeline-hub
    workspaces:
      - name: app-source
    persistentVolumeClaim:
      claimName: app-source-pvc
```

```

- name: maven-settings
emptyDir: {}

apiVersion: triggers.tekton.dev/v1alpha1
kind: TriggerBinding
metadata:
  name: tekton-greeter-triggerbinding
spec:
  params:
  - name: git-repo-url
    value: ${body.repository.clone_url}
  - name: git-revision
    value: ${body.after}

apiVersion: triggers.tekton.dev/v1alpha1
kind: EventListener
metadata:
  name: tekton-greeter-eventlistener
spec:
  serviceAccountName: tekton-triggers-example-sa
  triggers:
  - bindings:
    - ref: tekton-greeter-triggerbinding
      template:
        ref: tekton-greeter-triggertemplate

```

You can create the resources just listed as follows:

```

kubectl create -f tekton-greeter-triggertemplate.yaml
kubectl create -f tekton-greeter-triggerbinding.yaml
kubectl create -f tekton-greeter-eventlistener.yaml

```

You should get the following output:

```

triggertemplate.triggers.tekton.dev/tekton-greeter-
triggertemplate created
triggerbinding.triggers.tekton.dev/tekton-greeter-triggerbinding
created
eventlistener.triggers.tekton.dev/tekton-greeter-eventlistener
created

```

Contextually, a new pod is created representing the EventListener:

```

kubectl get pods

```

You should get output similar to the following:

NAME	READY	STATUS
RESTARTS	AGE	
el-tekton-greeter-eventlistener-5db7b9fcf9-6nrgx	1/1	Running 0
10s		

The EventListener pod listens for events at a specified port, and it is bound to a Kubernetes Service:

```
kubectl get svc
```

You should get output similar to the following:

NAME	TYPE	CLUSTER-IP
EXTERNAL-IP		
PORT (S)	AGE	
el-tekton-greeter-eventlistener	ClusterIP	10.100.36.199
<none>	↳	
8080/TCP, 9000/TCP	10s	
...		

If you are running your Git server outside the cluster (e.g., GitHub or GitLab), you need to expose the Service, for example, with an [Ingress](#). Afterwards you can configure webhooks on your Git server using the EventListener URL associated to your Ingress.

TIP

With Minikube you can add support for Ingresses with this command: `minikube addons enable ingress`. Then you need to map a hostname for the Ingress.

For the purpose of this book we can just simulate the webhook as it would come from the Git server.

First you can map the EventListener Service to your local networking with the following command:

```
kubectl port-forward svc/el-tekton-greeter-eventlistener 8080
```

Then you can invoke the Trigger by making an HTTP request to `http://localhost:8080` using `curl`. The HTTP request must be a POST request containing a JSON payload and it should contain the fields referenced via a TriggerBinding. In our case we mapped `body.repository.clone_url` and `body.after`.

NOTE

Check the documentation of your Git server to get the list of parameters that a webhook can generate. In this example we are using the [GitHub Webhooks reference](#).

To test Triggers, run this command:

```
curl -X POST \
  http://localhost:8080 \
  -H 'Content-Type: application/json' \
  -d '{ "after": "d9291c456db1ce29177b77fffea9b71ad80a50e6",
  "repository": { "clone_url" : "https://github.com/gitops-
  cookbook/tekton-tutorial-greeter.git" } }'
```

You should get output similar to the following:

```
{"eventListener":"tekton-greeter-
eventlistener","namespace":"default","eventListenerUID":"c00567eb-
d798-4c4a-946d-f1732fdfc313","eventID":"17dd25bb-alfe-4f84-8422-
c3abc5f10066"}
```

A new Pipeline now is started and you can check it with the following command:

```
tkn pipelinerun ls
```

You should see it in Running status as follows:

```
tekton-greeter-pipeline-3244b67f-31d3-4597-af1c-3c1aa6693719    4
seconds ago      ---          Running
```

See Also

- [Tekton Triggers examples](#)
- [Getting Started with Tekton Triggers](#)
- [Securing webhooks with event listeners](#)

6.9 Update a Kubernetes Resource Using Kustomize and Push the Change to Git

Problem

You want to use Kustomize in your Tekton Pipelines in order to automate Kubernetes manifests updates.

Solution

As we discussed in [Chapter 4](#), Kustomize is a powerful tool to manage Kubernetes manifests. Kustomize can add, remove, or patch configuration options without forking. In [Recipe 4.2](#) you saw how to update a Kubernetes Deployment with a new container image hash using the `kustomize` CLI.

In this recipe, you'll see how to let Tekton update it using Kustomize. This is very useful for GitOps as it allows an automated update on Git to the manifests describing an application running on Kubernetes, favoring the interconnection with a GitOps tool such as Argo CD in order to sync resources (see [Chapter 7](#)).

When adopting the GitOps approach, it's common to have one or more repositories for the Kubernetes manifests and then one or more repositories for the apps as well.

Thus let's introduce a Task that accepts the Kubernetes manifests repository as a parameter and can update the container image reference as seen in [Recipe 4.2](#):

```

apiVersion: tekton.dev/v1beta1
kind: Task
metadata:
  annotations:
    tekton.dev/pipelines.minVersion: 0.12.1
    tekton.dev/tags: git
  name: git-update-deployment
  labels:
    app.kubernetes.io/version: '0.2'
    operator.tekton.dev/provider-type: community
spec:
  description: >-
    This Task can be used to update image digest in a Git repo
    using kustomize.
    It requires a secret with credentials for accessing the git
    repo.
  params:
    - name: GIT_REPOSITORY
      type: string
    - name: GIT_REF
      type: string
    - name: NEW_IMAGE
      type: string
    - name: NEW_DIGEST
      type: string
    - name: KUSTOMIZATION_PATH
      type: string
  results:
    - description: The commit SHA
      name: commit
  steps:
    - image: 'docker.io/alpine/git:v2.26.2'
      name: git-clone
      resources: {}
      script: >
        rm -rf git-update-digest-workdir

        git clone $(params.GIT_REPOSITORY) -b $(params.GIT_REF)
        git-update-digest-workdir
      workingDir: $(workspaces.workspace.path)
    - image: 'quay.io/wpernath/kustomize-ubi:latest'
      name: update-digest
      resources: {}
      script: >
        cd git-update-digest-workdir/$(params.KUSTOMIZATION_PATH)

        kustomize edit set image
$(params.NEW_IMAGE) @$(params.NEW_DIGEST)

```

```

echo "#####
echo "### kustomization.yaml ###"
echo "#####"

cat kustomization.yaml
workingDir: $(workspaces.workspace.path)
- image: 'docker.io/alpine/git:v2.26.2'
  name: git-commit
  resources: {}
  script: |
    cd git-update-digest-workdir

    git config user.email "tektonbot@redhat.com"
    git config user.name "My Tekton Bot"

    git status
    git add $(params.KUSTOMIZATION_PATH)/kustomization.yaml
    git commit -m "[ci] Image digest updated"

    git push

    RESULT_SHA=$(git rev-parse HEAD | tr -d '\n')
    EXIT_CODE="$?"
    if [ "$EXIT_CODE" != 0 ]
    then
      exit $EXIT_CODE
    fi
    # Make sure we don't add a trailing newline to the
result!
    echo -n "$RESULT_SHA" > $(results.commit.path)
workingDir: $(workspaces.workspace.path)
workspaces:
- description: The workspace consisting of maven project.
  name: workspace

```

This Task is composed of three steps:

`git-clone`

Clones the Kubernetes manifests repository

`update-digest`

Runs `kustomize` to update the Kubernetes Deployment with a container image hash given as a parameter

git-commit

Updates the Kubernetes manifest repo with the new container image hash

You can create the Task with the following command:

```
kubectl create -f git-update-deployment-task.yaml
```

You should get the following output:

```
task.tekton.dev/git-update-deployment created
```

You can now add this Task to a Pipeline similar to the one you saw in [Recipe 6.7](#) in order to automate the update of your manifests with Kustomize:

```
apiVersion: tekton.dev/v1beta1
kind: Pipeline
metadata:
  name: pacman-pipeline
spec:
  params:
    - default: https://github.com/gitops-cookbook/pacman-kikd.git
      name: GIT_REPO
      type: string
    - default: master
      name: GIT_REVISION
      type: string
    - default: quay.io/gitops-cookbook/pacman-kikd
      name: DESTINATION_IMAGE
      type: string
    - default: .
      name: CONTEXT_DIR
      type: string
    - default: 'https://github.com/gitops-cookbook/pacman-kikd-manifests.git'
      name: CONFIG_GIT_REPO
      type: string
    - default: main
      name: CONFIG_GIT_REVISION
      type: string
  tasks:
    - name: fetch-repo
      params:
```

```
- name: url
  value: ${params.GIT_REPO}
- name: revision
  value: ${params.GIT_REVISION}
- name: deleteExisting
  value: "true"
taskRef:
  name: git-clone
workspaces:
- name: output
  workspace: app-source
- name: build-app
taskRef:
  name: maven
params:
- name: GOALS
  value:
    - -DskipTests
    - clean
    - package
- name: CONTEXT_DIR
  value: "${params.CONTEXT_DIR}"
workspaces:
- name: maven-settings
  workspace: maven-settings
- name: source
  workspace: app-source
runAfter:
- fetch-repo
- name: build-push-image
taskRef:
  name: buildah
params:
- name: IMAGE
  value: "${params.DESTINATION_IMAGE}"
workspaces:
- name: source
  workspace: app-source
runAfter:
- build-app
- name: git-update-deployment
params:
- name: GIT_REPOSITORY
  value: ${params.CONFIG_GIT_REPO}
- name: NEW_IMAGE
  value: ${params.DESTINATION_IMAGE}
- name: NEW_DIGEST
  value: ${tasks.build-push-image.results.IMAGE_DIGEST} ⓘ
- name: KUSTOMIZATION_PATH
  value: env/dev
```

```

- name: GIT_REF
  value: $(params.CONFIG_GIT_REVISION)
runAfter:
  - build-push-image
taskRef:
  kind: Task
  name: git-update-deployment
workspaces:
  - name: workspace
    workspace: app-source
workspaces:
  - name: app-source
  - name: maven-settings

```

- ❶ As you can see from this example, you can take a result of a previous Task as an input for the following one. In this case the hash of the container image generated by the build-push-image Task is used to update the manifests with Kustomize.

You can create the Pipeline with the following command:

```
kubectl create -f pacman-pipeline.yaml
```

You should get the following output:

```
pipeline.tekton.dev/pacman-pipeline created
```

The git-commit step requires authentication to your Git server in order to push the updates to the repo. Since this example is on GitHub, we are using a GitHub Personal Access Token (see [Recipe 6.4](#)) attached to the ServiceAccount tekton-bot-sa.

Make sure to add the repo and registry's Kubernetes Secrets as described in [Recipes 6.4](#) and [6.5](#):

```

kubectl patch serviceaccount tekton-bot-sa -p '{"secrets": [{"name": "git-secret"}]}'
kubectl patch serviceaccount tekton-bot-sa \
-p '{"secrets": [{"name": "containerregistry-secret"}]}'

```

NOTE

Make sure you have created a PVC for the Pipeline as defined in [Recipe 6.7](#).

Now you can start the Pipeline as follows:

```
tkn pipeline start pacman-pipeline \
--serviceaccount='tekton-bot-sa' \
--param GIT_REPO='https://github.com/gitops-cookbook/pacman-
kikd.git' \
--param GIT_REVISION='main' \
--param DESTINATION_IMAGE='quay.io/gitops-cookbook/pacman-
kikd:latest' \
--param CONFIG_GIT_REPO='https://github.com/gitops-
cookbook/pacman-kikd-manifests.git' \
--param CONFIG_GIT_REVISION='main' \
--workspace name=app-source,claimName=app-source-pvc \
--workspace name=maven-settings,emptyDir="" \
--use-param-defaults \
--showlog
```

6.10 Update a Kubernetes Resource Using Helm and Create a Pull Request

Problem

You want to automate the deployment of Helm-packaged apps with a Tekton Pipeline.

Solution

In [Chapter 5](#) we discussed Helm and how it can be used to manage applications on Kubernetes in a convenient way. In this recipe you'll see how to automate Helm-powered deployments through a Pipeline in order to install or update an application running on Kubernetes.

As shown in [Recipe 6.7](#), you can use Tekton Hub to find and install Tekton Tasks. In fact, you can use the [`helm-upgrade-from-repo`](#) Task to

have Helm support for your Pipelines.

To install it, run this command:

```
tkn hub install task helm-upgrade-from-repo
```

This Task can install a Helm Chart from a Helm repository. For this example, we provide a Helm repository in [this book's repository](#) that you can add with the following command:

```
helm repo add gitops-cookbook https://gitops-cookbook.github.io/helm-charts/
```

You should get the following output:

```
"gitops-cookbook" has been added to your repositories
```

You can install the Helm Chart with the following command:

```
helm install pacman gitops-cookbook/pacman
```

You should get output similar to the following:

```
NAME: pacman
LAST DEPLOYED: Mon Aug 15 17:02:21 2022
NAMESPACE: default
STATUS: deployed
REVISION: 1
TEST SUITE: None
USER-SUPPLIED VALUES:
{ }
```

The app should be now deployed and running on Kubernetes:

```
kubectl get pods -l=app.kubernetes.io/name=pacman
```

You should get the following output:

NAME	READY	STATUS	RESTARTS	AGE
pacman-6798d65d84-9mt8p	1/1	Running	0	30s

Now let's update the Deployment with a Tekton Task running a helm upgrade with the following TaskRun:

```
apiVersion: tekton.dev/v1beta1
kind: TaskRun
metadata:
  generateName: helm-pacman-run-
spec:
  serviceAccountName: tekton-deployer-sa ❶
  taskRef:
    name: helm-upgrade-from-repo
  params:
    - name: helm_repo
      value: https://gitops-cookbook.github.io/helm-charts/
    - name: chart_name
      value: gitops-cookbook/pacman
    - name: release_version
      value: 0.1.0
    - name: release_name
      value: pacman
    - name: overwrite_values
      value: replicaCount=2 ❷
```

- ❶ The helm-upgrade-from-repo Task needs permission to list objects in the working namespace, so you need a ServiceAccount with special permissions as seen in [Recipe 6.6](#).
- ❷ You can override values in the Chart's *values.yaml* file by adding them in this param. Here we are setting up two replicas for the Pac-Man game.

Run the Task with the following command:

```
kubectl create -f helm-pacman-taskrun.yaml
```

You should get output similar to the following:

```
taskrun.tekton.dev/helm-pacman-run-qghx8 created
```

Check logs with tkn CLI and select the running Task:

```
tkn taskrun logs -f
```

You should get output similar to the following, where you can see the Helm upgrade has been successfully performed:

```
[upgrade-from-repo] current installed helm releases
[upgrade-from-repo] NAME           NAMESPACE      REVISION
UPDATED                      STATUS
CHART          APP VERSION
[upgrade-from-repo] pacman        default        1
2022-08-15 17:02:21.633934129 +0200 +0200    deployed
pacman-0.1.0   1.0.0
[upgrade-from-repo] parsing helms repo name...
[upgrade-from-repo] adding helm repo...
[upgrade-from-repo] "gitops-cookbook" has been added to your
repositories
[upgrade-from-repo] adding updating repo...
[upgrade-from-repo] Hang tight while we grab the latest from your
chart repositories...
[upgrade-from-repo] ...Successfully got an update from the
"gitops-cookbook" chart repository
[upgrade-from-repo] Update Complete. *Happy Helming!*
[upgrade-from-repo] installing helm chart...
[upgrade-from-repo] history.go:56: [debug] getting history for
release pacman
[upgrade-from-repo] upgrade.go:123: [debug] preparing upgrade for
pacman
[upgrade-from-repo] upgrade.go:131: [debug] performing update for
pacman
[upgrade-from-repo] upgrade.go:303: [debug] creating upgraded
release for pacman
[upgrade-from-repo] client.go:203: [debug] checking 2 resources
for changes
[upgrade-from-repo] client.go:466: [debug] Looks like there are
no changes for Service "pacman"
[upgrade-from-repo] wait.go:47: [debug] beginning wait for 2
resources with timeout of 5m0s
[upgrade-from-repo] ready.go:277: [debug] Deployment is not
ready: default/pacman. 1 out of 2 expected pods are ready
[upgrade-from-repo] ready.go:277: [debug] Deployment is not
ready: default/pacman. 1 out of 2 expected pods are ready
[upgrade-from-repo] ready.go:277: [debug] Deployment is not
ready: default/pacman. 1 out of 2 expected pods are ready
[upgrade-from-repo] upgrade.go:138: [debug] updating status for
upgraded release for pacman
[upgrade-from-repo] Release "pacman" has been upgraded. Happy
Helming!
[upgrade-from-repo] NAME: pacman
[upgrade-from-repo] LAST DEPLOYED: Mon Aug 15 15:23:31 2022
[upgrade-from-repo] NAMESPACE: default
[upgrade-from-repo] STATUS: deployed
```

```
[upgrade-from-repo] REVISION: 2
[upgrade-from-repo] TEST SUITE: None
[upgrade-from-repo] USER-SUPPLIED VALUES:
[upgrade-from-repo] replicaCount: 2
[upgrade-from-repo]
[upgrade-from-repo] COMPUTED VALUES:
[upgrade-from-repo] image:
[upgrade-from-repo]   containerPort: 8080
[upgrade-from-repo]   pullPolicy: Always
[upgrade-from-repo]   repository: quay.io/gitops-cookbook/pacman-
kikd
[upgrade-from-repo]   tag: 1.0.0
[upgrade-from-repo]   replicaCount: 2
[upgrade-from-repo]   securityContext: {}
[upgrade-from-repo]
[upgrade-from-repo] HOOKS:
[upgrade-from-repo] MANIFEST:
[upgrade-from-repo] ---
[upgrade-from-repo] # Source: pacman/templates/service.yaml
[upgrade-from-repo] apiVersion: v1
[upgrade-from-repo] kind: Service
[upgrade-from-repo] metadata:
[upgrade-from-repo]   labels:
[upgrade-from-repo]     app.kubernetes.io/name: pacman
[upgrade-from-repo]   name: pacman
[upgrade-from-repo] spec:
[upgrade-from-repo]   ports:
[upgrade-from-repo]     - name: http
[upgrade-from-repo]       port: 8080
[upgrade-from-repo]       targetPort: 8080
[upgrade-from-repo]   selector:
[upgrade-from-repo]     app.kubernetes.io/name: pacman
[upgrade-from-repo] ---
[upgrade-from-repo] # Source: pacman/templates/deployment.yaml
[upgrade-from-repo] apiVersion: apps/v1
[upgrade-from-repo] kind: Deployment
[upgrade-from-repo] metadata:
[upgrade-from-repo]   name: pacman
[upgrade-from-repo] labels:
[upgrade-from-repo]   app.kubernetes.io/name: pacman
[upgrade-from-repo]   app.kubernetes.io/version: "1.0.0"
[upgrade-from-repo] spec:
[upgrade-from-repo]   replicas: 2
[upgrade-from-repo]   selector:
[upgrade-from-repo]     matchLabels:
[upgrade-from-repo]       app.kubernetes.io/name: pacman
[upgrade-from-repo] template:
[upgrade-from-repo]   metadata:
[upgrade-from-repo]     labels:
[upgrade-from-repo]       app.kubernetes.io/name: pacman
```

```
[upgrade-from-repo]      spec:
[upgrade-from-repo]          containers:
[upgrade-from-repo]              - image: "quay.io/gitops-
cookbook/pacman-kikd:1.0.0"
[upgrade-from-repo]          imagePullPolicy: Always
[upgrade-from-repo]          securityContext:
[upgrade-from-repo]              {}
[upgrade-from-repo]          name: pacman
[upgrade-from-repo]          ports:
[upgrade-from-repo]              - containerPort: 8080
[upgrade-from-repo]                  name: http
[upgrade-from-repo]                  protocol: TCP
[upgrade-from-repo]

kubectl get deploy -l=app.kubernetes.io/name=pacman

pacman           2/2            2             2           9s
```

6.11 Use Drone to Create a Pipeline for Kubernetes

Problem

You want to create a CI/CD pipeline for Kubernetes with Drone.

Solution

[Drone](#) is an open source project for cloud native continuous integration (CI). It uses YAML build files to define and execute build pipelines inside containers.

It has two main components:

Server

Integrates with popular SCMs such as GitHub, GitLab, or Gitea

Runner

Acts as an agent running on a certain platform

You can install the Server of your choice following the [documentation](#) and install the [Kubernetes Runner](#).

In this example you will create a Java Maven-based pipeline using the Pac-Man app. First, install the Drone CLI for your OS; you can get it from the official website [here](#).

TIP

On macOS, drone is available through [Homebrew](#) as follows:

```
brew tap drone/drone && brew install drone
```

Then configure Drone, copy the DRONE_TOKEN from your instance under the Drone Account settings page, then create/update the file called *.envrc.local* and add the variables to override:

```
export DRONE_TOKEN="<YOUR-TOKEN>"
```

Ensure the token is loaded:

```
drone info
```

Now activate the repo in Drone:

```
drone repo enable https://github.com/gitops-cookbook/pacman-kikd.git
```

Similarly to Tekton, Drone's pipeline will compile, test, and build the app. Then it will create and push the container image to a registry.

Add credentials to your container registry as follows (here, we're using Quay.io):

```
drone secret add --name image_registry \
--data quay.io https://github.com/gitops-cookbook/pacman-kikd.git
```

```

drone secret add --name image_registry_user \
--data YOUR_REGISTRY_USER https://github.com/gitops-
cookbook/pacman-kikd.git

drone secret add --name image_registry_password \
--data YOUR_REGISTRY_PASS https://github.com/gitops-
cookbook/pacman-kikd.git

drone secret add --name destination_image \
--data quay.io/YOUR_REGISTRY_USER>/pacman-kikd.git
https://github.com/gitops-cookbook/pacman-kikd.git

```

Create a file called *.drone.yaml* as follows:

```

kind: pipeline
type: docker
name: java-pipeline
platform:
  os: linux
  arch: arm64
trigger:
  branch:
    - main
clone:
  disable: true
steps:
  - name: clone sources
    image: alpine/git
    pull: if-not-exists
    commands:
      - git clone https://github.com/gitops-cookbook/pacman-
kikd.git .
      - git checkout $DRONE_COMMIT
  - name: maven-build
    image: maven:3-jdk-11
    commands:
      - mvn install -DskipTests=true -B
      - mvn test -B
  - name: publish
    image: plugins/docker:20.13
    pull: if-not-exists
    settings:
      tags: "latest"
      dockerfile: Dockerfile
      insecure: true
      mtu: 1400
    username:
      from_secret: image_registry_user

```

```
password:  
  from_secret: image_registry_password  
registry:  
  from_secret: image_registry  
repo:  
  from_secret: destination_image
```

Start the pipeline:

```
drone exec --pipeline=java-pipeline
```

TIP

You can also trigger the pipeline to start by pushing to your Git repo.

See Also

- [Example Maven Pipeline from Drone docs](#)
- [Complete Quarkus pipeline example in Drone](#)

6.12 Use GitHub Actions for CI

Problem

You want to use GitHub Actions for CI in order to compile and package an app as a container image ready to be deployed in CD.

Solution

[GitHub Actions](#) are event-driven automation tasks available for any GitHub repository. An event automatically triggers the workflow, which contains a job. The job then uses steps to control the order in which actions are run. These actions are the commands that automate software building, testing, and deployment.

In this recipe, you will add a GitHub Action for building the Pac-Man game container image, and pushing it to the [GitHub Container Registry](#).

TIP

As GitHub Actions are connected to repositories, you can fork the Pac-Man repository from this book's code repositories to add your GitHub Actions. See the documentation about [forking repositories](#) for more info on this topic.

GitHub Actions workflows run into [environments](#) and they can reference an environment to use the environment's protection rules and secrets.

Workflows and jobs are defined with a YAML file containing all the needed steps. Inside your repository, you can create one with the path
.github/workflows/pacman-ci-action.yml:

```
# This is a basic workflow to help you get started with Actions

name: pacman-ci-action ❶

env: ❷
  IMAGE_REGISTRY: ghcr.io/${{ github.repository_owner }}
  REGISTRY_USER: ${{ github.actor }}
  REGISTRY_PASSWORD: ${{ github.token }}
  APP_NAME: pacman
  IMAGE_TAGS: 1.0.0 ${{ github.sha }}

# Controls when the workflow will run
on:
  # Triggers the workflow on push or pull request events but only
  # for the
  # "main" branch
  push: ❸
    branches: [ "main" ]
  pull_request:
    branches: [ "main" ]

# Allows you to run this workflow manually from the Actions tab
workflow_dispatch:

# A workflow run is made up of one or more jobs that can run
# sequentially or in
# parallel
```

```

jobs:
  # This workflow contains a single job called "build-and-push"
  build-and-push: ❸
    # The type of runner that the job will run on
    runs-on: ubuntu-latest

      # Steps represent a sequence of tasks that will be executed
      as part of the
      # job
      steps: ❹
        # Checks-out your repository under $GITHUB_WORKSPACE, so
        your job can
        # access it
        - uses: actions/checkout@v3

        - name: Set up JDK 11
          uses: actions/setup-java@v3
          with:
            java-version: '11'
            distribution: 'adopt'
            cache: maven

        - name: Build with Maven
          run: mvn --batch-mode package

        - name: Buildah Action ❺
          id: build-image
          uses: redhat-actions/buildah-build@v2
          with:
            image: ${{ env.IMAGE_REGISTRY }}/{{ env.APP_NAME }}
            tags: ${{ env.IMAGE_TAGS }}
            containerfiles: |
              ./Dockerfile
        - name: Push to Registry ❻
          id: push-to-registry
          uses: redhat-actions/push-to-registry@v2
          with:
            image: ${{ steps.build-image.outputs.image }}
            tags: ${{ steps.build-image.outputs.tags }}
            registry: ${{ env.IMAGE_REGISTRY }}
            username: ${{ env.REGISTER_USER }}
            password: ${{ env.REGISTER_PASSWORD }}

```

- ❶ Name of the Action.
- ❷ Environment variables to be used in the workflow. This includes [default environment variables](#) and the Secret you added to the environment.

- ③ Here's where you define which type of trigger you want for this workflow. In this case, any change to the repository (Push) to the master branch will trigger the action to start. Check out the documentation for a [full list of triggers](#) that can be used.
- ④ Name of this Job.
- ⑤ List of steps; each step contains an action for the pipeline.
- ⑥ [Buildah Build](#). This action builds container images using Buildah.
- ⑦ [Push to Registry](#). This action is used to push to the GitHub Registry using built-in credentials available for GitHub repository owners.

After each Git push or pull request, a new run of the action is performed as shown in [Figure 6-10](#).

NOTE

GitHub offers its own container registry available at ghcr.io, and container images are referenced as part of the [GitHub Packages](#). By default the images are public. See this [book's repository](#) as a reference.

[!\[\]\(96d5a32d33ce7af46f4cfd0ec580809c_img.jpg\) Summary](#)

build

 Search logs

succeeded 3 hours ago in 1m 3s

Jobs

 build

- >  Set up job 5s
- >  Run actions/checkout@v3 2s
- >  Set up JDK 11 3s
- >  Build with Maven 11s
- >  Buildah Action 20s
- >  Push to Registry 18s
- >  Post Set up JDK 11 0s
- >  Post Run actions/checkout@v3 0s

  Complete job 0s



Figure 6-10. GitHub Actions Jobs

See Also

- [GitHub Actions Jobs](#)
- [Red Hat Actions](#)
- [Deploy to Kubernetes cluster Action](#)

¹ See the [Tekton documentation](#).

Chapter 7. Argo CD

In the previous chapter, you learned about Tekton and other engines such as GitHub Actions to implement the continuous integration (CI) part of a project.

Although CI is important because it's where you build the application and check that nothing has been broken (running unit tests, component tests, etc.), there is still a missing part: how to deploy this application to an environment (a Kubernetes cluster) using the GitOps methodology and not creating a script running `kubectl/helm` commands.

As Daniel Bryant puts it, “If you weren’t using SSH in the past to deploy your application in production, don’t use `kubectl` to do it in Kubernetes.”

In this chapter, we’ll introduce you to Argo CD, a declarative, GitOps continuous delivery (CD) tool for Kubernetes. In the first part of the section, we’ll see the deployment of an application using Argo CD (Recipes [7.1](#) and [7.2](#)).

Argo CD not only supports the deployment of plain Kubernetes manifests, but also the deployment of Kustomize projects ([Recipe 7.3](#)) and Helm projects ([Recipe 7.4](#)).

A typical operation done in Kubernetes is a rolling update to a new version of the container, and Argo CD integrates with another tool to make this process smooth ([Recipe 7.5](#)).

Delivering complex applications might require some orchestration on when and how the application must be deployed and released (Recipes [7.7](#) and [7.8](#)).

We’ll see how to:

- Install and deploy the first application.
- Use automatic deployment and self-healing applications.

- Execute a rolling update when a new container is released.
- Give an order on the execution.

In this chapter, we are using the `https://github.com/gitops-cookbook/gitops-cookbook-sc.git` GitHub repository as source directory. To run it successfully in this chapter, you should fork it and use it in the YAML files provided in the examples.

7.1 Deploy an Application Using Argo CD

Problem

You want Argo CD to deploy an application defined in a Git repository.

Solution

Create an Application resource to set up Argo CD to deploy the application.

To install Argo CD, create the `argocd` namespace and apply the Argo CD installation manifest:

```
kubectl apply -n argocd \
-f https://raw.githubusercontent.com/argoproj/argo-
cd/v2.3.4/manifests/install.yaml
```

OPTIONAL STEPS

It's not mandatory to install the Argo CD CLI tool, or expose the Argo CD server service to access the Argo CD Dashboard. Still, in this book, we'll use them in the recipes to show you the final result after applying the manifests. So, although not mandatory, we encourage you to follow the next steps to be aligned with the book.

To install the `argocd` CLI tool, go to the [Argo CD CLI GitHub release page](#) and in the Assets section, download the tool for your platform.

After installing the `argocd` tool, the `argocd-server` Kubernetes Service needs to be exposed. You can use any technique such as Ingress or set the service as `LoadBalancer` but we'll use the `kubectl port-forward` to connect to the API server without exposing the service:

```
kubectl port-forward svc/argocd-server -n argocd 9090:443
```

At this point, you can access the Argo CD server using `http://localhost:9090`.

The initial password for the `admin` account is generated automatically in a secret named `argocd-initial-admin-secret` in the `argocd` namespace:

```
argoPass=$(kubectl -n argocd get secret argocd-initial-admin-secret -o jsonpath="{.data.password}" | base64 -d)

argoURL=localhost:9090

argocd login --insecure --grpc-web $argoURL --username admin
--password $argoPass

'admin:login' logged in successfully
```

You should use the same credentials to access the Argo CD UI.

Let's make Argo CD deploy a simple web application showing a box with a configured color. The application is composed of three Kubernetes manifest files, including a Namespace, a Deployment, and a Service definition.

The files are located in the [ch07/bgd](#) folder of the book's repository.

All these files are known as an Application in Argo CD. Therefore, you must define it as such to apply these manifests in your cluster.

Let's check the Argo CD Application resource file used for deploying the application:

```
apiVersion: argoproj.io/v1alpha1
kind: Application
metadata:
  name: bgd-app
  namespace: argocd ①
spec:
  destination: ②
    namespace: bgd
    server: https://kubernetes.default.svc
  project: default ③
  source:
    repoURL: https://github.com/gitops-cookbook/gitops-cookbook-
sc.git ④
    path: ch07/bgd ⑤
    targetRevision: main ⑥
```

- ① Namespace where Argo CD is installed
- ② Target cluster and namespace
- ③ Installing the application in Argo CD's default project
- ④ The manifest repo where the YAML resides
- ⑤ The path to look for manifests
- ⑥ Branch to checkout

In the terminal window, run the following command to register the Argo CD application:

```
kubectl apply -f manual-bgd-app.yaml
```

At this point, the application is registered as an Argo CD application.

You can check the status using either `argocd` or the UI; run the following command to list applications using the CLI too:

```
argocd app list
```

And the output is something like:

NAME	CLUSTER	NAMESPACE	PROJECT
bgd-app	https://kubernetes.default.svc	bgd	default

OutOfSync

The important field here is STATUS. It's OutOfSync, which means the application is registered, and there is a drift between the current status (in this case, no application deployed) and the content in the Git repository (the application deployment files).

You'll notice that no pods are running if you get all the pods from the bgd namespace:

```
kubectl get pods -n bgd  
No resources found in bgd namespace.
```

Argo CD doesn't synchronize the application automatically by default. It just shows a divergence, and the user is free to fix it by triggering a synchronized operation.

With the CLI, you synchronize the application by running the following command in a terminal:

```
argocd app sync bgd-app
```

And the ouput of the command shows all the important information regarding the deployment:

```
Name: bgd-app  
Project: default  
Server: https://kubernetes.default.svc  
Namespace: bgd  
URL: https://openshift-gitops-server-openshift-  
gitops.apps.openshift.sotogcp.com/applications/bgd-app  
Repo: https://github.com/lordofthejars/gitops-  
cookbook-sc.git  
Target: main  
Path: ch07/bgd
```

```

SyncWindow:           Sync Allowed
Sync Policy:         <none>
Sync Status:         Synced to main (384cd3d)
Health Status:       Progressing

Operation:           Sync
Sync Revision:       384cd3d21c534e75cb6b1a6921a6768925b81244
Phase:               Succeeded
Start:               2022-06-16 14:45:12 +0200 CEST
Finished:            2022-06-16 14:45:13 +0200 CEST
Duration:            1s
Message:             successfully synced (all tasks run)

GROUP   KIND      NAMESPACE   NAME   STATUS   HEALTH    HOOK
MESSAGE
          Namespace   bgd        bgd    Running  Synced
namespace/bgd created
          Service     bgd        bgd    Synced   Healthy
service/bgd created
          apps       Deployment  bgd    Synced   Progressing
deployment.apps/bgd created
          Namespace   bgd        bgd    Synced

```

You can synchronize the application from the UI as well, by clicking the **SYNC** button as shown in [Figure 7-1](#).

 v2.3.4+

Applications

+ NEW APP ⚙ SYNC APPS ⌂ REFRESH APPS 📁

FILTERS

FAVORITES ONLY

SYNC STATUS

Status	Count
Unknown	0
Synced	0
OutOfSync	1

HEALTH STATUS

Status	Count
Unknown	0
Progressing	0
Suspended	0
Healthy	1
Degraded	0
Missing	0

bgd-app 

Project: default

Labels:

Status:  Healthy  OutOfSync

Repository: <https://github.com/lordofthejars/gitops->

Target R...: main

Path: ch07/bgd

Destinati...: in-cluster

Namesp...: bgd

SYNC **REFRESH** **DELETE**

Figure 7-1. Argo CD web console

If you get all the pods from the `bgd` namespace, you'll notice one pod running:

```
kubectl get pods -n bgd
```

NAME	READY	STATUS	RESTARTS	AGE
bgd-788cb756f7-j119n	1/1	Running	0	60s

And the same for the Service:

```
kubectl get services -n bgd
```

NAME	TYPE	CLUSTER-IP	EXTERNAL-IP	PORT(S)
bgd	ClusterIP	172.30.35.199	<none>	8080:32761/TCP ❶

❶ Exposed port is 32761

In the following sections, you'll need to access the deployed service to validate that it's deployed. There are several ways to access services deployed to Minikube; for the following chapters, we use the Minikube IP and the exposed port of the service.

Run the following command in a terminal window to get the Minikube IP:

```
minikube ip -p gitops
192.168.59.100
```

Open a browser window, set the previous IP followed by the exposed port (in this example `192.168.59.100:32761`), and access the service to validate that the color of the circles in the box is blue, as shown in [Figure 7-2](#).



Figure 7-2. Deployed application

Discussion

Now it's time to update the application deployment files. This time we will change the value of an environment variable defined in the `bgd-deployment.yaml` file.

Open `ch07/bgd/bgd-deployment.yaml` in your file editor and change the COLOR environment variable value from `blue` to `green`:

```
spec:  
  containers:  
    - image: quay.io/redhatworkshops/bgd:latest  
      name: bgd  
      env:  
        - name: COLOR  
          value: "green"
```

In a terminal run the following commands to commit and push the file so the change is available for Argo CD:

```
git add .  
git commit -m "Updates color"  
  
git push origin main
```

With the change pushed, check the status of the application again:

```
argocd app list  
  
NAME      CLUSTER      NAMESPACE      PROJECT  
STATUS  
bgd-app   https://kubernetes.default.svc  bgd      default  Sync
```

We see the application status is Sync. This happens because Argo CD uses a polling approach to detect divergences between what's deployed and what's defined in Git. After some time (by default, it's 3 minutes), the application status will be OutOfSync:

```
argocd app list  
NAME      CLUSTER      NAMESPACE      PROJECT  
STATUS      HEALTH  
bgd-app   https://kubernetes.default.svc  bgd      default  
OutOfSync  Healthy
```

To synchronize the changes, run the sync subcommand:

```
argocd app sync bgd-app
```

After some seconds, access the service and validate that the circles are green, as shown in [Figure 7-3](#).

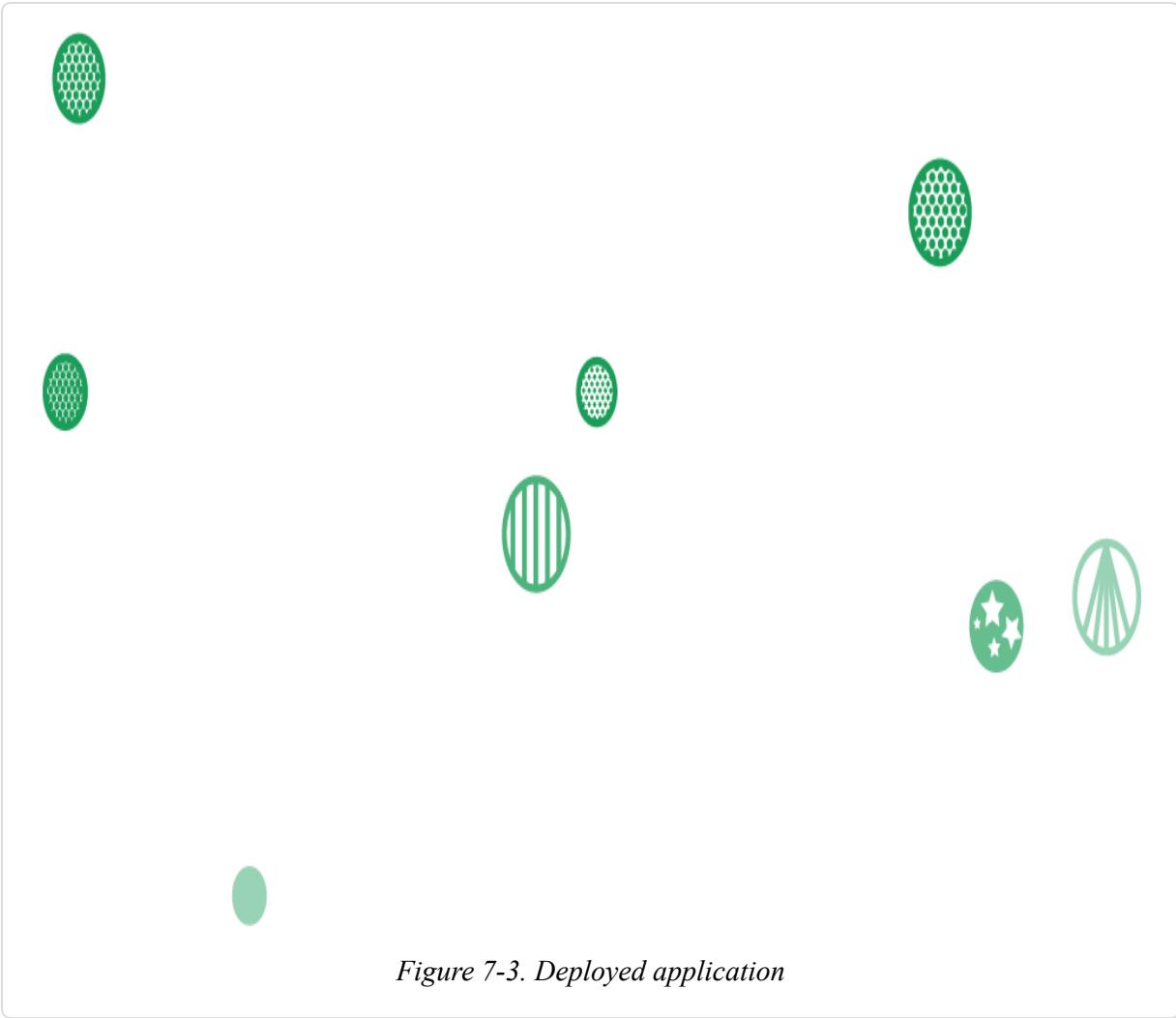


Figure 7-3. Deployed application

To remove the application, use the CLI tool or the UI:

```
argocd app delete bgd-app
```

Also, revert the changes done in the Git repository to get the initial version of the application and push them:

```
git revert HEAD  
git push origin main
```

7.2 Automatic Synchronization

Problem

You want Argo CD to automatically update resources when there are changes.

Solution

Use the `syncPolicy` section with an automated policy.

Argo CD can automatically synchronize an application when it detects differences between the manifests in Git and the Kubernetes cluster.

A benefit of automatic sync is that there is no need to log in to the Argo CD API, with the security implications that involves (managing secrets, network, etc.), and the use of the `argocd` tool. Instead, when a manifest is changed and pushed to the Git repository with the changes to the tracking Git repo, the manifests are automatically applied.

Let's modify the previous Argo CD manifest file (Application), adding the `syncPolicy` section, so changes are deployed automatically:

```
apiVersion: argoproj.io/v1alpha1
kind: Application
metadata:
  name: bgd-app
  namespace: argocd
spec:
  destination:
    namespace: bgd
    server: https://kubernetes.default.svc
  project: default
  source:
    path: ch07/bgd
    repoURL: https://github.com/gitops-cookbook/gitops-cookbook-
sc.git
    targetRevision: main
  syncPolicy: ①
    automated: {} ②
```

- ① Starts the synchronization policy configuration section
- ② Argo CD automatically syncs the repo

At this point, we can apply the Application file into a running cluster by running the following command:

```
kubectl apply -f bgd/bgd-app.yaml
```

Now, Argo CD deploys the application without executing any other command.

Run the `kubectl` command or check in the Argo CD UI to validate that the deployment is happening:

```
kubectl get pods -n bgd
```

NAME	READY	STATUS	RESTARTS	AGE
bgd-788cb756f7-j119n	1/1	Running	0	60s

Access the service and validate that the circles are blue, as shown in [Figure 7-4](#).



Figure 7-4. Deployed application

To remove the application, use the CLI tool or the UI:

```
argocd app delete bgd-app
```

Discussion

Although Argo CD deploys applications automatically, it uses some default conservative strategies for safety reasons.

Two of these are the pruning of deleted resources and the self-healing of the application in case a change was made in the Kubernetes cluster directly instead of through Git.

By default, Argo CD will not delete (prune) any resource when it detects that it is no longer available in Git, and it will be in an `OutOfSync` status. If you want Argo CD to delete these resources, you can do it in two ways.

The first way is by manually invoking a sync with the `--prune` option:

```
argocd app sync --prune
```

The second way is letting Argo CD delete pruned resources automatically by setting the `prune` attribute to `true` in the `automated` section:

```
syncPolicy:  
  automated:  
    prune: true ❶
```

- ❶ Enables automatic pruning

Another important concept affecting how the application is automatically updated is self-healing.

Argo CD is configured not to correct any drift made manually in the cluster. For example, Argo CD will let the execution of a `kubectl patch` directly in the cluster change any configuration parameter of the application.

Let's see it in action.

The color of the circle is set as an environment variable (`COLOR`).

Now, let's change the `COLOR` environment variable to `green` using the `kubectl patch` command.

Run the following command in the terminal:

```
kubectl -n bgd patch deploy/bgd \  
--type='json' -p='[{"op": "replace", "path": "/  
spec/template/spec/containers/0/env/0/value", "value":"green"}]'
```

Wait for the rollout to happen:

```
kubectl rollout status deploy/bgd -n bgd
```

If you refresh the browser, you should see green circles now, as shown in [Figure 7-5](#).

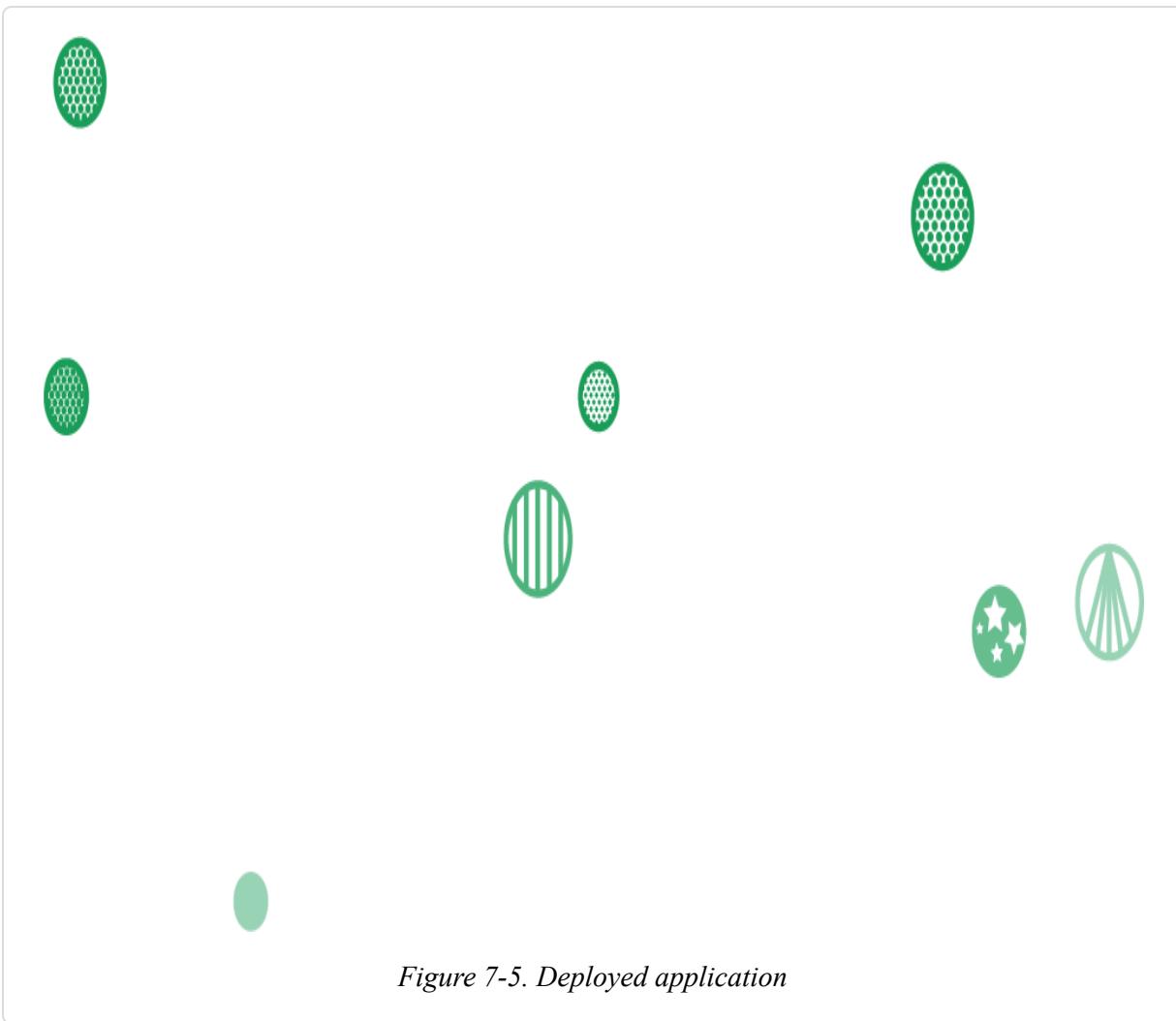


Figure 7-5. Deployed application

Looking over the Argo CD sync status, you'll see that it's `OutOfSync` as the application and the definition in the Git repository (`COLOR: blue`) diverges.

Argo CD will not roll back to correct this drift as the `selfHeal` property default is set to `false`.

Let's remove the application and deploy a new one, but set `selfHeal` to `true` in this case:

```
argocd app delete bgd-app
```

Let's enable the `selfHealing` property, and repeat the experiment:

```
apiVersion: argoproj.io/v1alpha1
kind: Application
metadata:
  name: bgd-app
  namespace: argocd
spec:
  destination:
    namespace: bgd
    server: https://kubernetes.default.svc
  project: default
  source:
    path: ch07/bgd
    repoURL: https://github.com/gitops-cookbook/gitops-cookbook-
sc.git
    targetRevision: main
  syncPolicy:
    automated:
      prune: true
      selfHeal: true ❶
```

❶ `selfHeal` set to `true` to correct any drift

And in the terminal apply the resource:

```
kubectl apply -f bgd/heal-bgd-app.yaml
```

Repeat the previous steps:

1. Open the browser to check that the circles are blue.
2. Reexecute the `kubectl -n bgd patch deploy/bgd ...` command.
3. Refresh the browser and check that the circles are still blue.

Argo CD corrects the drift introduced by the `patch` command, synchronizing the application to the correct state defined in the Git

repository.

To remove the application, use the CLI tool or the UI:

```
argocd app delete bgd-app
```

See Also

- [Argo CD Automated Sync Policy](#)
- [Argo CD Sync Options](#)

7.3 Kustomize Integration

Problem

You want to use Argo CD to deploy Kustomize manifests.

Solution

Argo CD supports several different ways in which Kubernetes manifests can be defined:

- Kustomize
- Helm
- Ksonnet
- Jsonnet

You can also extend the supported ways to custom ones, but this is out of the scope of this book.

Argo CD detects a Kustomize project if there are any of the following files: *kustomization.yaml*, *kustomization.yml*, or *Kustomization*.

Let's deploy the same BGD application, but in this case, deployed as Kustomize manifests.

Moreover, we'll set `kustomize` to override the `COLOR` environment variable to yellow.

The Kustomize file defined in the repository looks like this:

```
apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization
namespace: bgdk
resources:
- ./base ①
- bgdk-ns.yaml ②
patchesJson6902: ③
  - target: ④
    version: v1
    group: apps
    kind: Deployment
    name: bgd
    namespace: bgdk
    patch: |- ⑤
      - op: replace
        path: /spec/template/spec/containers/0/env/0/value
        value: yellow
```

- ① Directory with standard deployment files (blue circles)
- ② Specific file for creating a namespace
- ③ Patches standard deployment files
- ④ Patches the deployment file
- ⑤ Overrides the environment variable value to yellow

NOTE

You don't need to create this file as it's already stored in the Git repository.

Create the following Application file to deploy the application:

```
apiVersion: argoproj.io/v1alpha1
kind: Application
metadata:
```

```

name: bgdk-app
namespace: argocd
spec:
  destination:
    namespace: bgdk
    server: https://kubernetes.default.svc
  project: default
  source:
    path: ch07/bgdk/bgdk
    repoURL: https://github.com/gitops-cookbook/gitops-cookbook-
sc.git
    targetRevision: main
  syncPolicy:
    automated: {}

```

At this point, we can apply the Application file to a running cluster by running the following command:

```
kubectl apply -f bgdk/bgdk-app.yaml
```

Access the service and you'll notice the circles are yellow instead of blue.

To remove the application, use the CLI tool or the UI:

```
argocd app delete bgdk-app
```

Discussion

We can explicitly specify which tool to use, overriding the default algorithm used by Argo CD in the Application file. For example, we can use a plain directory strategy regarding the presence of the *kustomization.yaml* file:

```

source:
  directory: ❶
  recurse: true

```

- ❶ Overrides always use a plain directory strategy

Possible strategies are: `directory`, `chart`, `helm`, `kustomize`, `path`, and `plugin`.

TIP

Everything we've seen about Kustomize is valid when using Argo CD.

See Also

- [Chapter 4](#)
- [argo-cd/application-crd.yaml on GitHub](#)
- [Argo CD Tool Detection](#)

7.4 Helm Integration

Problem

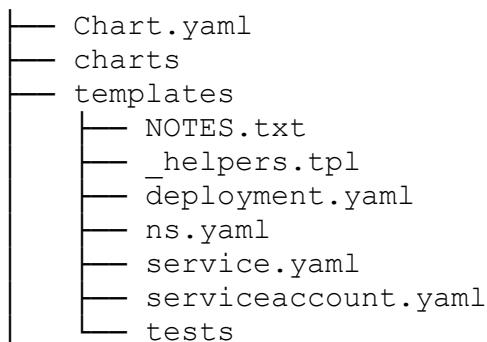
You want to use Argo CD to deploy Helm manifests.

Solution

Argo CD supports installing Helm Charts to the cluster when it detects a Helm project in the deployment directory (when the *Chart.yaml* file is present).

Let's deploy the same BGD application, but in this case, deployed as a Helm manifest.

The layout of the project is a simple Helm layout already created in the GitHub repository you've cloned previously:



```
└── test-connection.yaml  
  └── values.yaml
```

Create a *bgdh/bgdh-app.yaml* file to define the Argo CD application:

```
apiVersion: argoproj.io/v1alpha1  
kind: Application  
metadata:  
  name: bgdh-app  
  namespace: argocd  
spec:  
  destination:  
    namespace: bgdh  
    server: https://kubernetes.default.svc  
  project: default  
  source:  
    path: ch07/bgdh  
    repoURL: https://github.com/gitops-cookbook/gitops-cookbook-  
sc.git  
    targetRevision: main  
  syncPolicy:  
    automated: {}
```

At this point, we can apply the Application file into a running cluster by running the following command:

```
kubectl apply -f bgdh/bgdh-app.yaml
```

Validate the pod is running in the `bgdh` namespace:

```
kubectl get pods -n bgdh  
  
NAME                  READY   STATUS    RESTARTS   AGE  
bgdh-app-556c46fcd6-ctfkf   1/1     Running   0          5m43s
```

To remove the application, use the CLI tool or the UI:

```
argocd app delete bgdh-app
```

Discussion

Argo CD populates build environment variables to Helm manifests (actually also Kustomize, Jsonnet, and custom tools support too).

The following variables are set:

- ARGOCD_APP_NAME
- ARGOCD_APP_NAMESPACE
- ARGOCD_APP_REVISION
- ARGOCD_APP_SOURCE_PATH
- ARGOCD_APP_SOURCE_REPO_URL
- ARGOCD_APP_SOURCE_TARGET_REVISION
- KUBE_VERSION
- KUBE_API VERSIONS

In the following snippet, you can see the usage of the application name:

```
apiVersion: argoproj.io/v1alpha1
kind: Application
metadata:
  name: bgdh-app
  namespace: openshift-gitops
spec:
  destination:
  ...
  source:
    path: ch07/bgd
  ...
  helm: ①
    parameters: ②
    - name: app ③
      value: $ARGOCD_APP_NAME ④
```

- ① Specific Helm section
- ② Extra parameters to set, same as setting them in *values.yaml*, but high preference
- ③ The name of the parameter

- ④ The value of the parameter, in this case from a Build Env var

Argo CD can use a different *values.yaml* file or set parameter values to override the ones defined in *values.yaml*:

```
argocd app set bgdh-app --values new-values.yaml  
argocd app set bgdh-app -p service.type=LoadBalancer
```

Note that values files must be in the same Git repository as the Helm Chart.

NOTE

Argo CD supports Helm hooks too.

See Also

- [Chapter 5](#)
- [*argo-cd/application-crd.yaml* on GitHub](#)

7.5 Image Updater

Problem

You want Argo CD to automatically deploy a container image when it's published.

Solution

Use [Argo CD Image Updater](#) to detect a change on the container registry and update the deployment files.

One of the most repetitive tasks during development is deploying a new version of a container image.

With a pure Argo CD solution, after the container image is published to a container registry, we need to update the Kubernetes/Kustomize/Helm manifest files pointing to the new container image and push the result to the Git repository.

This process implies:

1. Clone the repo
2. Parse the YAML files and update them accordingly
3. Commit and Push the changes

These boilerplate tasks should be defined for each repository during the continuous integration phase. Although this approach works, it could be automated so the cluster could detect a new image pushed to the container registry and update the current deployment file pointing to the newer version.

This is exactly what Argo CD Image Updater (*ArgoCD IU*) does. It's a Kubernetes controller monitoring for a new container version and updating the manifests defined in the Argo CD Application file.

The Argo CD IU lifecycle and its relationship with Argo CD are shown in [Figure 7-6](#).

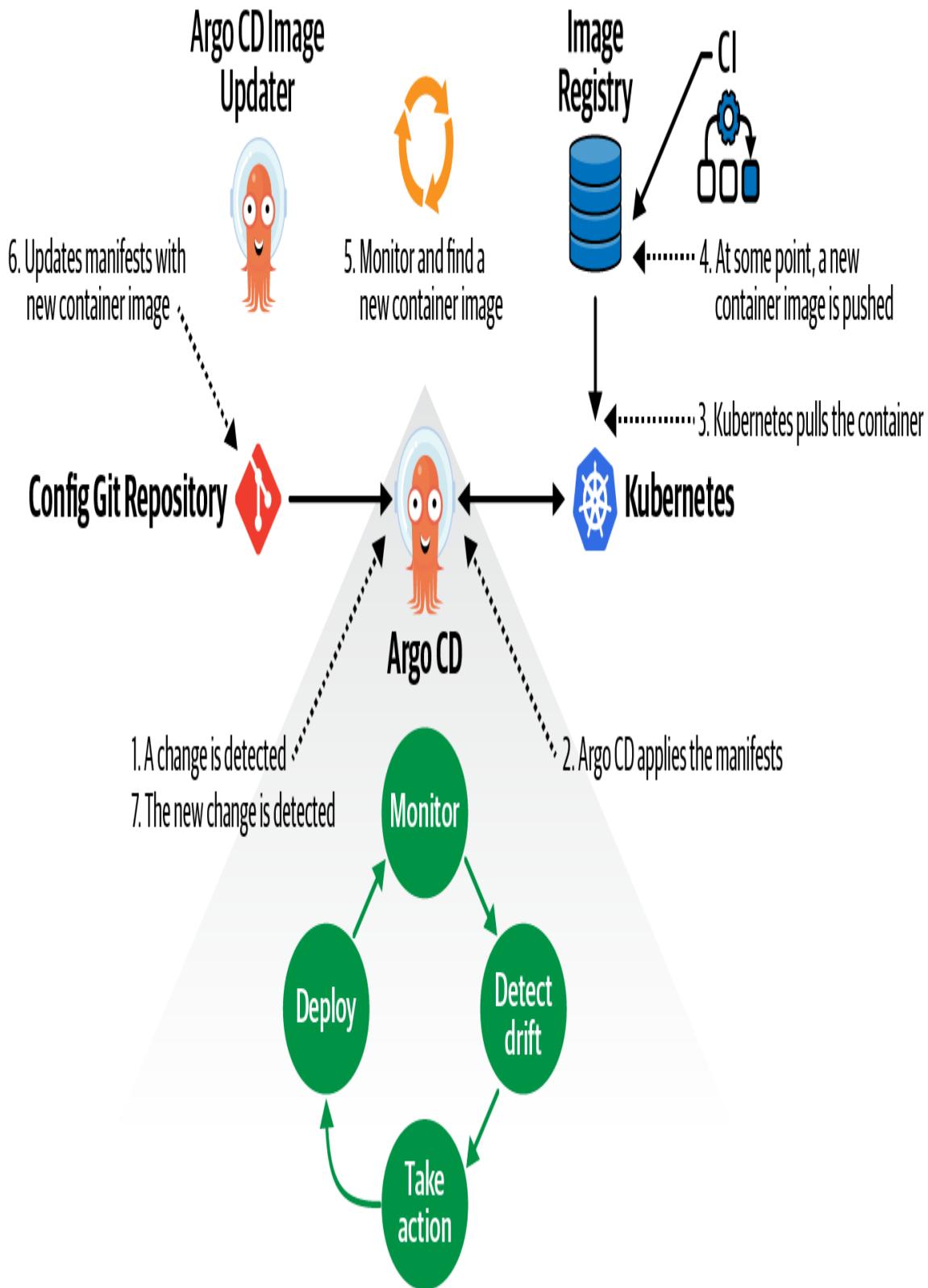


Figure 7-6. Argo CD Image Updater lifecycle

At this time, Argo CD IU only updates manifests of Kustomize or Helm. In the case of Helm, it needs to support specifying the image's tag using a parameter (`image.tag`).

Let's install the controller in the same namespace as Argo CD:

```
kubectl apply -f \
https://raw.githubusercontent.com/argoproj-labs/argocd-
imageupdater/v0.12.0/manifests/install.yaml -n argocd
```

Validate the installation process, checking that the pod status of the controller is Running:

```
kubectl get pods -n argocd

NAME                               READY   STATUS    RESTARTS   AGE
argocd-image-updater-59c45cbc5c-kjjtp   1/1
Running      0          40h
```

Before using Argo CD IU, we create a Kubernetes Secret representing the Git credentials, so the updated manifests can be pushed to the repository. The secret must be at the Argo CD namespace and, in this case, we name it `git-creds`.

```
kubectl -n argocd create secret generic git-creds \ --from-
literal=username=<git_user> \
--from-literal=password=<git_password_or_token>
```

Finally, let's annotate the Application manifest with some special annotations so the controller can start monitoring the registry:

image-list

Specify one or more images (comma-separated-value) considered for updates.

write-back-method

Methods to propagate new versions. There are `git` and `argocd` methods implemented to update to a newer image. The `Git` method

commits the change to the Git repository. Argo CD uses the Kubernetes/ArgoCD API to update the resource.

There are more configuration options, but the previous ones are the most important to get started.

Let's create an Argo CD Application manifest annotated with Argo CD IU annotations:

```
apiVersion: argoproj.io/v1alpha1
kind: Application
metadata:
  name: bgdk-app
  namespace: argocd
  annotations: ①
    argocd-image-updater.argoproj.io/image-list:
myalias=quay.io/rhdevelopers/bgd ②
    argocd-image-updater.argoproj.io/write-back-method:
git:secret:openshift-gitops/git-creds ③
    argocd-image-updater.argoproj.io/git-branch: main ④
spec:
  destination:
    namespace: bgdk
    server: https://kubernetes.default.svc
  project: default
  source:
    path: ch07/bgdui/bgdk
    repoURL: https://github.com/gitops-cookbook/gitops-cookbook-
sc.git
    targetRevision: main
  syncPolicy:
    automated: {}
```

- ① Adds annotations section
- ② Sets the monitored image name
- ③ Configures to use Git as write-back-method, setting the location of the credentials (<namespace>/<secretname>)
- ④ Sets the branch to push changes

Now apply the manifest to deploy the application's first version and enable Argo CD IU to update the repository when a new image is pushed to the

container registry:

```
kubectl apply -f bgdui/bgdui-app.yaml
```

At this point, version 1.0.0 is up and running in the bgdk namespace, and you may access it as we've done before. Let's generate a new container version to validate that the new image is in the repository.

To simplify the process, we'll tag the container with version 1.1.0 as it was a new one.

Go to the Quay repository created at the beginning of this chapter, go to the tags section, push the gear icon, and select Add New Tag to create a new container, as shown in [Figure 7-7](#).

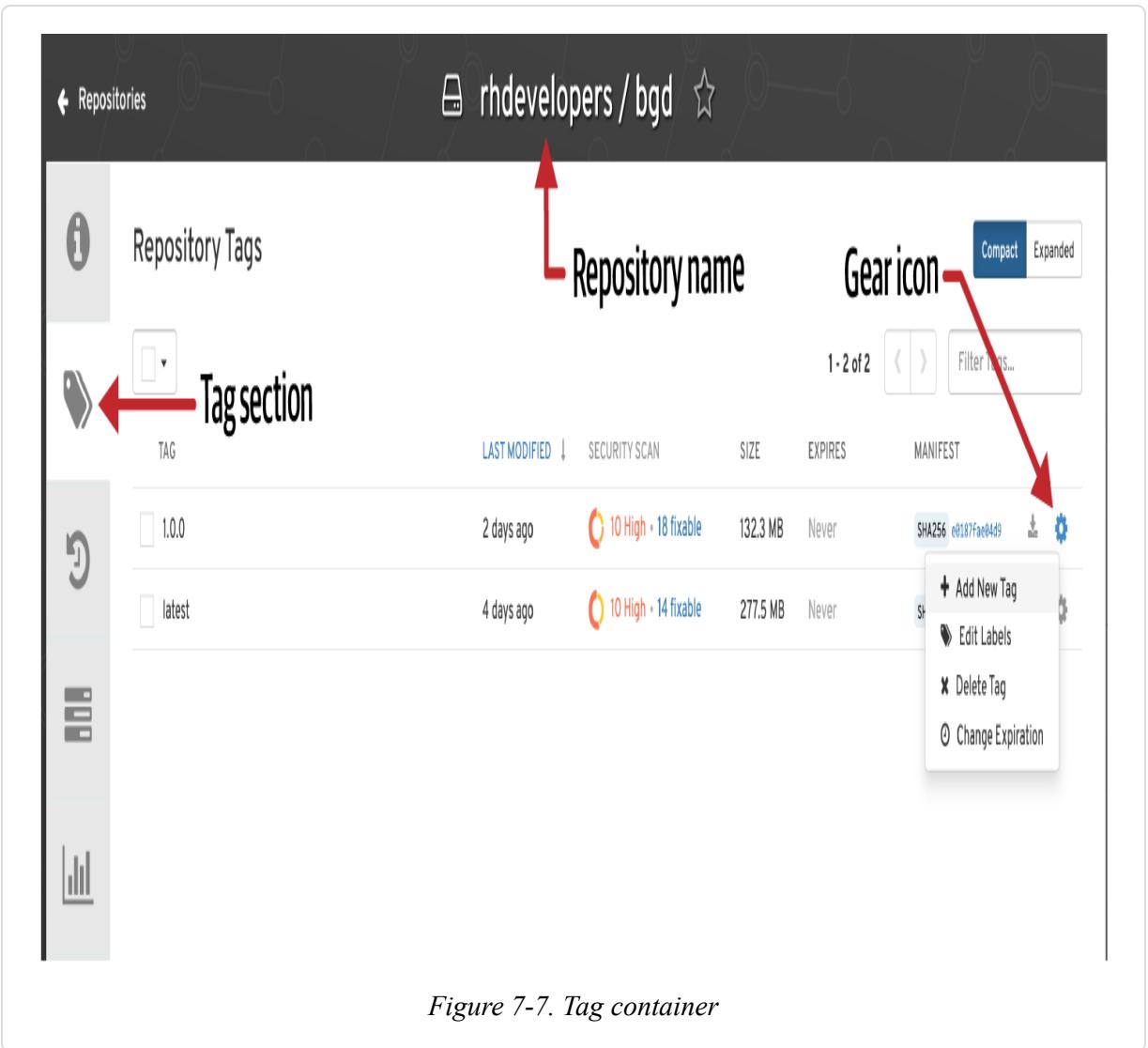


Figure 7-7. Tag container

Set the tag to 1 . 1 . 0 value as shown in the figure [Figure 7-8](#).

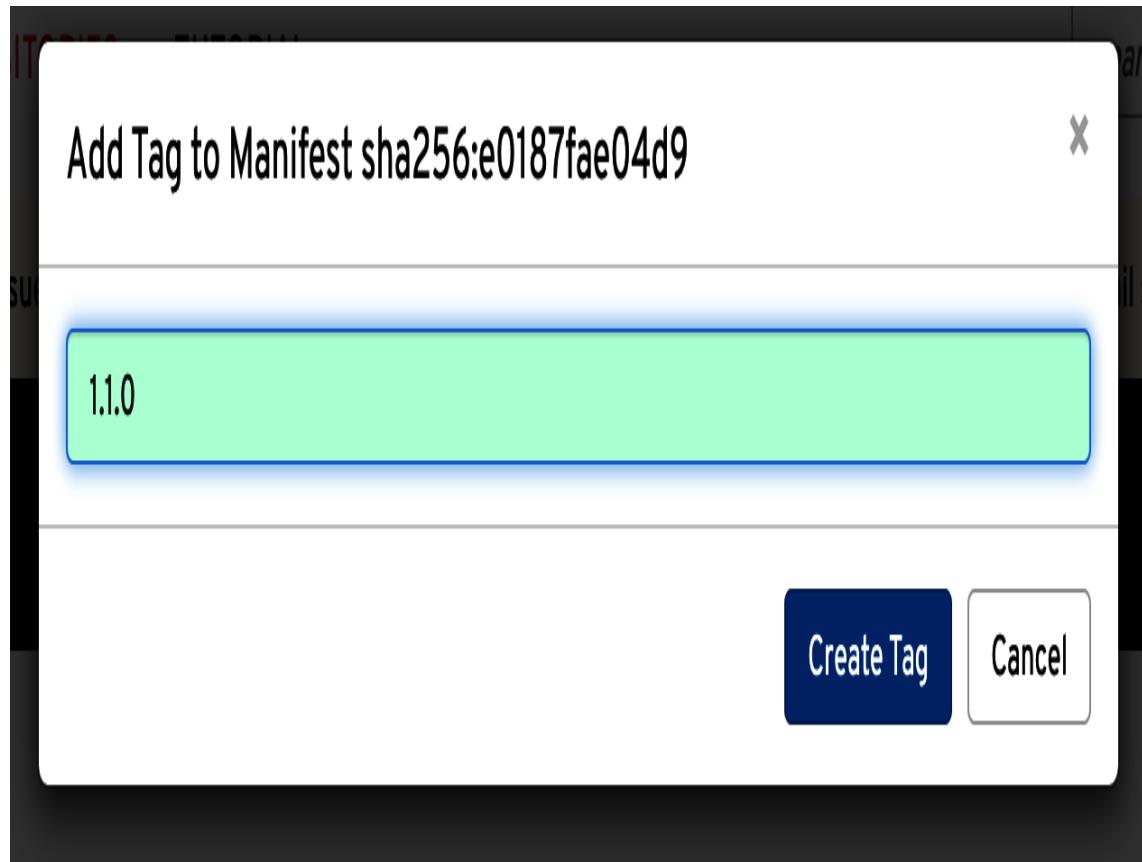


Figure 7-8. Tag container

After this step, you should have a new container created as shown in [Figure 7-9](#).

Wait for around two minutes until the change is detected and the controller triggers the repo update.

The screenshot shows a web-based interface for managing container tags. At the top, there's a header bar with a back arrow labeled "Repositories" and a search bar containing the text "rhdevelopers/bgd". To the right of the search bar is a star icon. Below the header, the title "Repository Tags" is displayed next to an information icon. On the far right, there are two buttons: "Compact" (which is selected) and "Expanded".

On the left side, there's a vertical sidebar with icons for "Tags" (selected), "Manifests", and "Builds". In the center, there's a search bar with a dropdown arrow and a "Filter Tags..." button. Above the main table area, there are navigation controls: "1 - 3 of 3" and arrows for navigating through the tags.

The main content is a table listing three tags:

TAG	LAST MODIFIED	SECURITY SCAN	SIZE	EXPIRES	MANIFEST
1.1.0	a few seconds ago	10 High • 18 fixable	132.3 MB	Never	SHA256 e0187fae04d9 Download Manifest
1.0.0	2 days ago	10 High • 18 fixable	132.3 MB	Never	SHA256 e0187fae04d9 Download Manifest
latest	4 days ago	10 High • 14 fixable	277.5 MB	Never	SHA256 7d954fd94b99 Download Manifest

Figure 7-9. Final result

To validate the triggering process check the logs of the controller:

```
kubectl logs argocd-image-updater-59c45cbc5c-kjjtp -f -n argocd  
...  
time="2022-06-20T21:19:05Z" level=info msg="Setting new image to  
quay.io/rhdevelopers/bgd:1.1.0" alias=myalias application=bgdk-  
app image_name=rhdevelopers/bgd image_tag=1.0.0 registry=quay.io  
time="2022-06-20T21:19:05Z" level=info msg="Successfully updated  
image 'quay.io/rhdevelopers/bgd:1.0.0' to  
'quay.io/rhdevelopers/bgd:1.1.0', but pending spec update (dry  
run=false)" alias=myalias application=bgdk-app  
image_name=rhdevelopers/bgd image_tag=1.0.0 registry=quay.io ❶  
time="2022-06-20T21:19:05Z" level=info msg="Committing 1  
parameter update(s) for application bgdk-app" application=bgdk-  
app  
...
```

❶ Detects the change and updates the image

After that, if you inspect the repository, you'll see a new Kustomize file named `.argocd-source-bgdk-app.yaml`, updating the image value to the new container, as shown in [Figure 7-10](#).

The screenshot shows a user interface for managing a Kustomize file. At the top, there's a navigation bar with a dropdown menu labeled "main" and a path "gitops-cookbook-sc / ch07 / bgdui / bgdk / .argocd-source-bgdk-app.yaml". To the right of the path are two buttons: "Go to file" and "...". Below the navigation is a summary card for the "argocd-image-updater" build, which automatically updates the "bgdk-app". It shows the latest commit "f36ba98" was made 6 minutes ago. There are links to "History" and "Edit". Below this is a section titled "0 contributors". The main content area displays the Kustomize file content:

```
3 lines (3 sloc) | 56 Bytes
```

Raw Blame ⚙️ ▾ ⚡ 📱

```
1 kustomize:  
2   images:  
3     - quay.io/rhdevelopers/bgd:1.1.0
```

Figure 7-10. New Kustomize file updating to the new container

Now Argo CD can detect the change and update the cluster properly with the new image.

To remove the application, use the CLI tool or the UI:

```
argocd app delete bgdk-app
```

Discussion

An update strategy defines how Argo CD IU will find new versions. With no change, Argo CD IU uses a semantic version to detect the latest version.

An optional version constraint field may be added to restrict which versions are allowed to be automatically updated. To only update patch versions, we can change the `image-list` annotation as shown in the following snippet:

```
argocd-image-updater.argoproj.io/image-list:  
myalias=quay.io/rhdevelopers/bgd:1.2.x
```

Argo CD Image Updater can update to the image that has the most recent build date:

```
argocd-image-updater.argoproj.io/myalias.update-strategy: latest  
argocd-image-updater.argoproj.io/myimage.allow-tags: regexp:^[0-  
9a-f]{7} $ ❶
```

- ❶ Restricts the tags considered for the update

The digest update strategy will use image digests to update your applications' image tags:

```
argocd-image-updater.argoproj.io/myalias.update-strategy: digest
```

So far, the container was stored in a public registry. If the repository is private, Argo CD Image Updater needs read access to the repo to detect any change.

First of all, create a new secret representing the container registry credentials:

```
kubectl create -n argocd secret docker-registry quayio --docker-  
server=quay.io --docker-username=$QUAY_USERNAME --docker-  
password=$QUAY_PASSWORD
```

Argo CD Image Updater uses a ConfigMap as a configuration source, which is the place to register the private container registry. Create a new ConfigMap manifest setting the supported registries:

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: argocd-image-updater-config ❶
data:
  registries.conf: |
    registries: ❷
    - name: RedHat Quay ❸
      api_url: https://quay.io ❹
      prefix: quay.io ❺
      insecure: yes
      credentials: pullsecret:argocd/quayio ❻
```

- ❶ Name of the Argo CD IU ConfigMap
- ❷ Place to register all registries
- ❸ A name to identify it
- ❹ URL of the service
- ❺ The prefix used in the container images
- ❻ Gets the credentials from the quayio secret stored at argocd namespace

Argo CD Image Updater commits the update with a default message:

```
commit 3caf0af8b7a26de70a641c696446bbe1cd04cea8 (HEAD -> main,
origin/main)
Author: argocd-image-updater <noreply@argoproj.io>
Date:   Thu Jun 23 09:41:00 2022 +0000

build: automatic update of bgdk-app

updates image rhdevelopers/bgd tag '1.0.0' to '1.1.0'
```

We can update the default commit message to one that fits your requirements. Configure the git.commit-message-template key in

ArgoCD IU argocd-image-updater-config ConfigMap with the message:

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: argocd-image-updater-config ❶
data:
  git.user: alex ❷
  git.email: alex@example.com ❸
  git.commit-message-template: | ❹
    build: automatic update of {{ .AppName }} ❺
    {{ range .AppChanges -}} ❻
      updates image {{ .Image }} tag '{{ .OldTag }}' to '{{ .NewTag
    }}' ❻ ❽ ❾
    {{ end -}}
  
```

- ❶ Argo CD IU ConfigMap
- ❷ Commit user
- ❸ Commmit email
- ❹ Golang text/template content
- ❺ The name of the application
- ❻ List of changes performed by the update
- ❽ Image name
- ❾ Previous container tag
- ❾ New container tag

NOTE

Remember to restart the Argo CD UI controller when the ConfigMap is changed:

```
kubectl rollout restart deployment argocd-image-updater -n  
argocd
```

See Also

- [Argo CD Image Updater](#)

7.6 Deploy from a Private Git Repository

Problem

You want Argo CD to deploy manifests.

Solution

Use Argo CD CLI/UI or YAML files to register the repositories' credential information (username/password/token/key).

In Argo CD, you have two ways to register a Git repository with its credentials. One way is using the Argo CD CLI/Argo CD UI tooling. To register a private repository in Argo CD, set the username and password by running the following command:

```
argocd repo add https://github.com/argoproj/argocd-example-apps \  
--username <username> --password <password>
```

Alternatively, we can use the Argo CD UI to register it too. Open Argo CD UI in a browser, and click the Settings.Repositories button (the one with gears) as shown in [Figure 7-11](#).

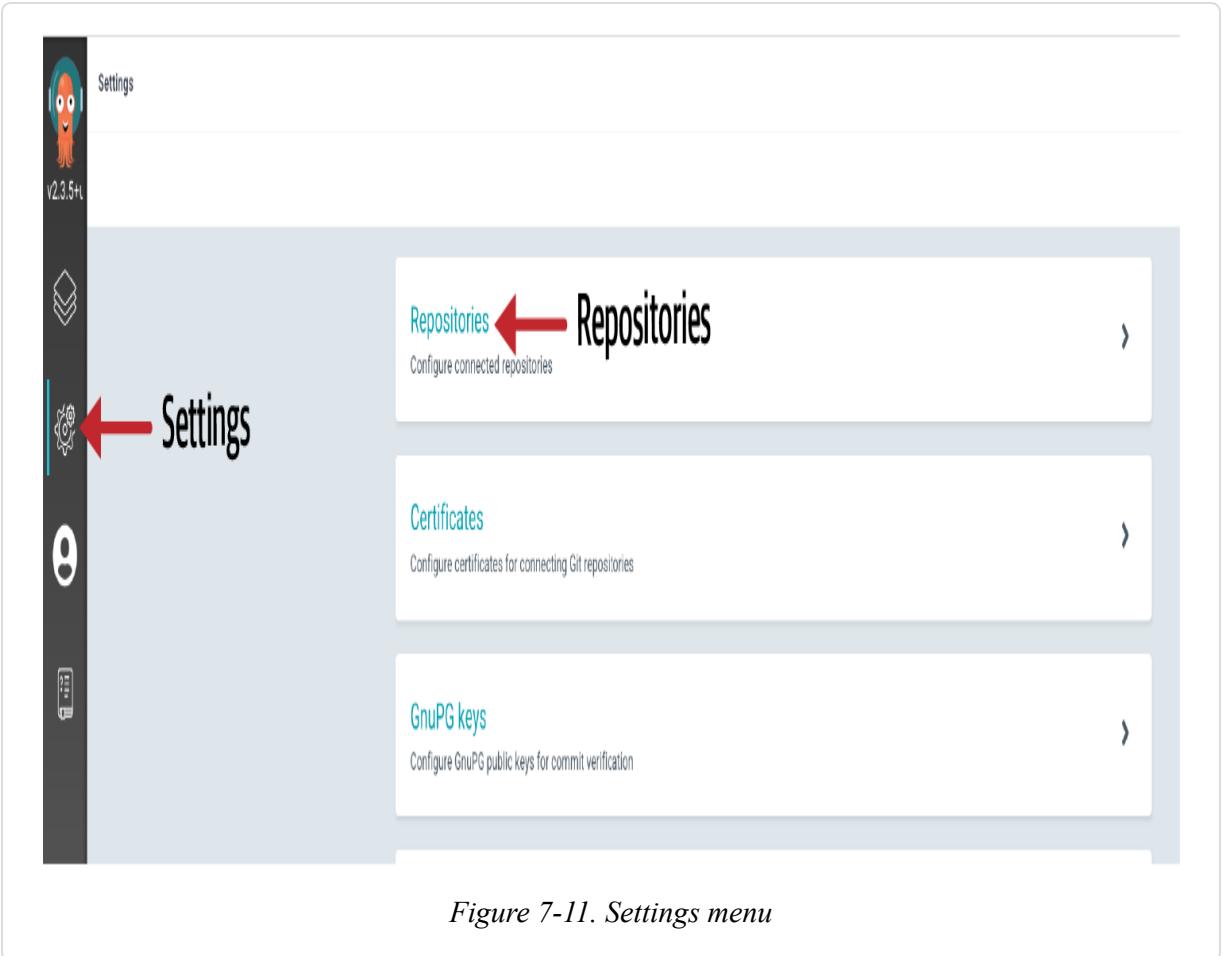


Figure 7-11. Settings menu

Then click the “Connect Repo using HTTPS” button and fill the form with the required data as shown in [Figure 7-12](#).

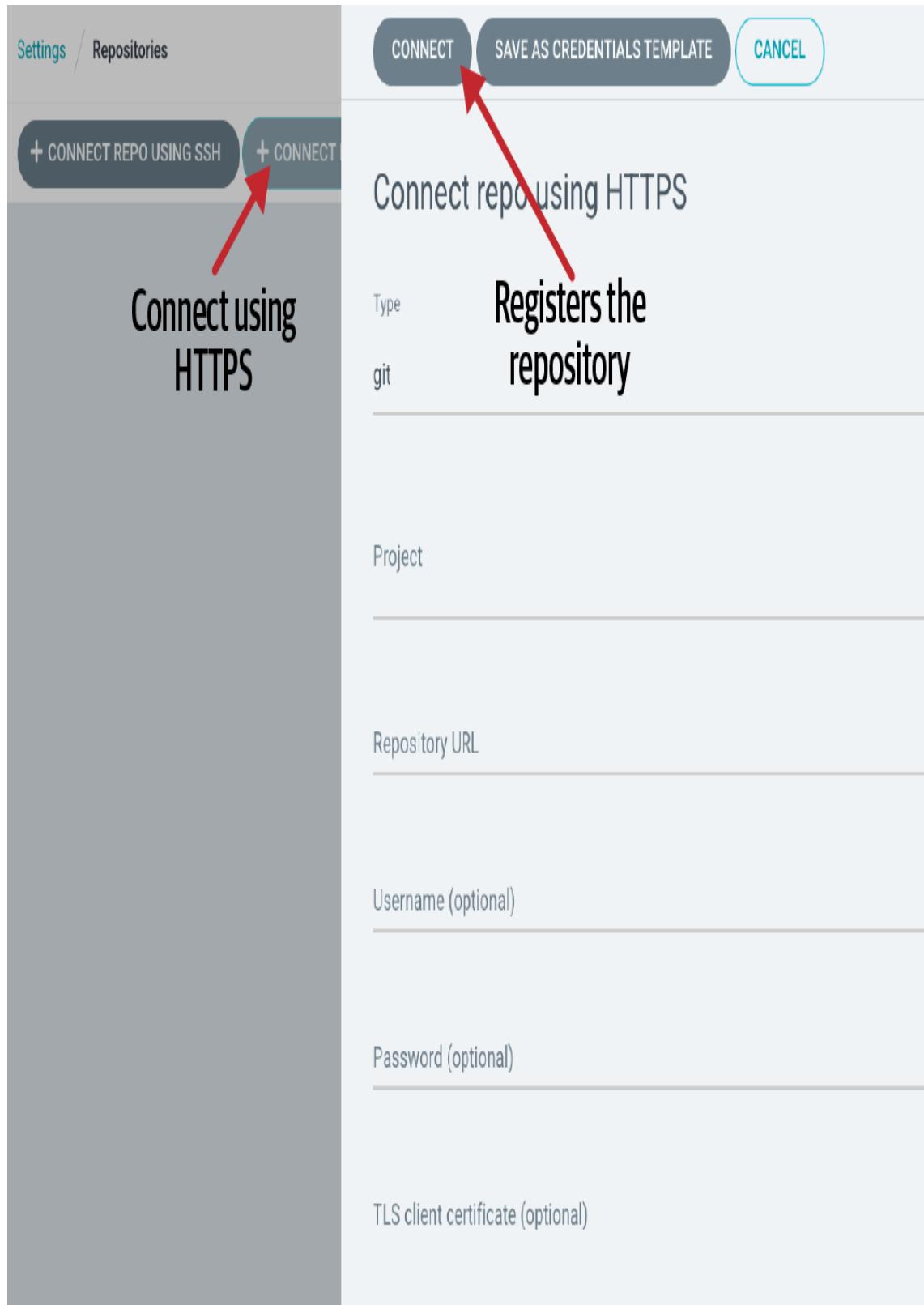


Figure 7-12. Configuration of repository

Finally, click the Connect button to test that it's possible to establish a connection and add the repository into Argo CD.

The other way is to create a Kubernetes Secret manifest file with that repository and credentials information:

```
apiVersion: v1
kind: Secret
metadata:
  name: private-repo
  namespace: argocd ①
  labels:
    argocd.argoproj.io/secret-type: repository ②
stringData:
  type: git
  url: https://github.com/argoproj/private-repo ③
  password: my-password ④
  username: my-username ⑤
```

- ① Create a secret in the Argo CD namespace
- ② Sets secret type as repository
- ③ URL of the repository to register
- ④ Password to access
- ⑤ Username to access

If you apply this file, it will have the same effect as the manual approach.

At this point, every time we define a `repoURL` value in the Application resource with a repository URL registered for authentication, Argo CD will use the registered credentials to log in.

Discussion

In addition to setting credentials such as username and password for accessing a private Git repo, Argo CD also supports other methods such as tokens, TLS client certificates, SSH private keys, or GitHub App credentials.

Let's see some examples using Argo CD CLI or Kubernetes Secrets.

To configure a TLS client certificate:

```
argocd repo add https://repo.example.com/repo.git \
--tls-client-cert-path ~/mycert.crt \
--tls-client-cert-key-path ~/mycert.key
```

For SSH, you just need to set the location of the SSH private key:

```
argocd repo add git@github.com:argoproj/argocd-example-apps.git \
--ssh-privatekey-path ~/.ssh/id_rsa
```

Or using a Kubernetes Secret:

```
apiVersion: v1
kind: Secret
metadata:
  name: private-repo
  namespace: argocd
  labels:
    argocd.argoproj.io/secret-type: repository
stringData:
  type: git
  url: git@github.com:argoproj/my-private-repository
  sshPrivateKey: | ❶
    -----BEGIN OPENSSH PRIVATE KEY-----
    ...
    -----END OPENSSH PRIVATE KEY-----
```

❶ Sets the content of the SSH private key

If you are using the GitHub App method, you need to set the App ID, the App Installation ID, and the private key:

```
argocd repo add https://github.com/argoproj/argocd-example-
apps.git --github-app-id 1 --github-app-installation-id 2 --
github-app-private-key-path test.private-key.pem
```

Or using the declarative approach:

```
apiVersion: v1
kind: Secret
```

```
metadata:  
  name: github-repo  
  namespace: argocd  
  labels:  
    argocd.argoproj.io/secret-type: repository  
stringData:  
  type: git  
  repo: https://ghe.example.com/argoproj/my-private-repository  
  githubAppID: 1 ❶  
  githubAppInstallationID: 2  
  githubAppEnterpriseBaseUrl: https://ghe.example.com/api/v3 ❷  
  githubAppPrivateKeySecret: |  
    -----BEGIN OPENSSH PRIVATE KEY-----  
    ...  
    -----END OPENSSH PRIVATE KEY-----
```

- ❶ Sets GitHub App parameters
- ❷ Only valid if GitHub App Enterprise is used

For the access token, use the account name as the username and the token in the password field.

Choosing which strategy to use will depend on your experience managing Kubernetes Secrets. Remember that a Secret in Kubernetes is not encrypted but encoded in Base64, so it is not secured by default.

We recommend using only the declarative approach when you've got a good strategy for securing the secrets.

NOTE

We've not discussed the Sealed Secrets project yet (we'll do so in the following chapter), but when using Sealed Secrets, the labels will be removed to avoid the `SealedSecret` object having a `template` section that encodes all the fields you want the controller to put in the unsealed Secret:

```
spec:  
...  
template:  
  metadata:  
    labels:  
      "argocd.argoproj.io/secret-type": repository
```

7.7 Order Kubernetes Manifests

Problem

You want to use Argo CD to deploy.

Solution

Use *sync waves* and *resource hooks* to modify the default order of applying manifests.

Argo CD applies the Kubernetes manifests (plain, Helm, Kustomize) in a particular order using the following logic:

1. By kind
 - a. Namespaces
 - b. NetworkPolicy
 - c. Limit Range
 - d. ServiceAccount
 - e. Secret
 - f. ConfigMap

- g. StorageClass
- h. PersistentVolumes
- i. ClusterRole
- j. Role
- k. Service
- l. DaemonSet
- m. Pod
- n. ReplicaSet
- o. Deployment
- p. StatefulSet
- q. Job
- r. Ingress

2. In the same kind, then by name (alphabetical order)

Argo CD has three phases when applying resources: the first phase is executed before applying the manifests (`PreSync`), the second phase is when the manifests are applied (`Sync`), and the third phase is executed after all manifests are applied and synchronized (`PostSync`).

[Figure 7-13](#) summarizes these phases.

Passage of Time

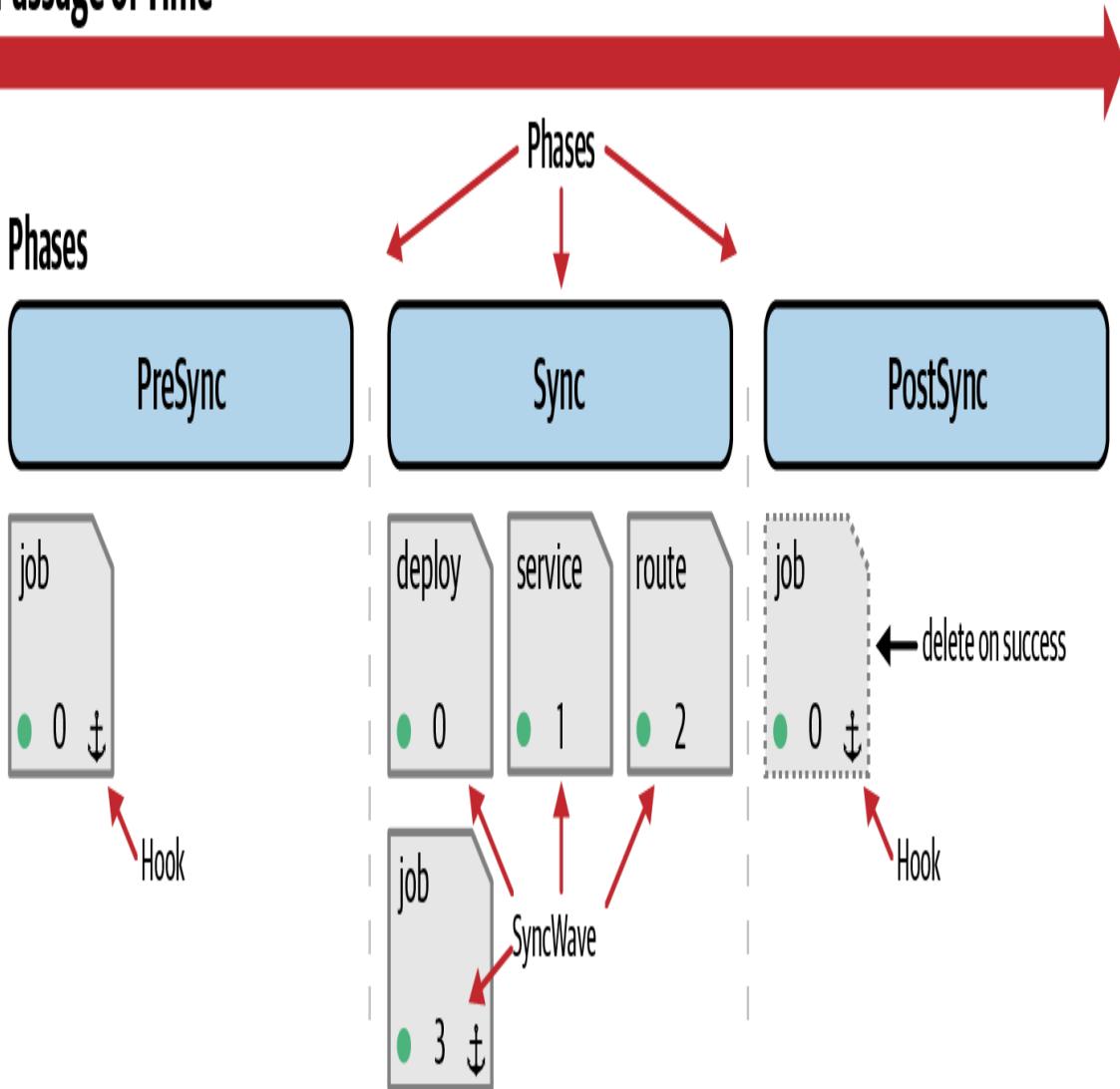


Figure 7-13. Hooks and sync waves

Resource hooks are scripts executed at a given phase, or if the Sync phase failed, you could run some rollback operations.

[Table 7-1](#) lists the available resource hooks.

Table 7-1. Resource hooks

Hook	Description	Use case
------	-------------	----------

Hook	Description	Use case
PreSync	Executes prior to the application of the manifests	Database migrations
Sync	Executes at the same time as manifests	Complex rolling update strategies like canary releases or dark launches
PostSync	Executes after all Sync hooks have completed and were successful (healthy)	Run tests to validate deployment was correctly done
SyncFail	Executes when the sync operation fails	Rollback operations in case of failure
Skip	Skip the application of the manifest	When manual steps are required to deploy the application (i.e., releasing public traffic to new version)

Hooks are defined as an annotation named `argocd.argoproj.io/hook` to a Kubernetes resource. In the following snippet, a `PostSync` manifest is defined:

```

apiVersion: batch/v1
kind: Job
metadata:
  name: todo-insert ①
  annotations:
    argocd.argoproj.io/hook: PostSync ②
  
```

- ① Job's name
- ② Sets when the manifest is applied

DELETION POLICIES

A hook is not deleted when finished; for example, if you run a Kubernetes Job, it'll remain Completed.

This might be the desired state, but we can specify to automatically delete these resources if annotated with `argocd.argoproj.io/hook-delete-policy` and the policy value is set.

Supported policies are:

Policy	Description
<code>HookSucceeded</code>	Deleted after the hook succeeded
<code>HookFailed</code>	Deleted after the hook failed
<code>BeforeHookCreation</code>	Deleted before the new one is created

A *sync wave* is a way to order how Argo CD applies the manifests stored in Git.

All manifests have zero waves by default, and the lower values go first. Use the `argocd.argoproj.io/sync-wave` annotation to set the wave number to a resource.

For example, you might want to deploy a database first and then create the database schema; for this case, you should set a `sync-wave` lower in the database deployment file than in the job for creating the database schema, as shown in the following snippet:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: postgresql ①
  namespace: todo
  annotations:
    argocd.argoproj.io/sync-wave: "0" ②
...
apiVersion: batch/v1
kind: Job
metadata:
  name: todo-table ③
```

```
namespace: todo
annotations:
  argocd.argoproj.io/sync-wave: "1" ④
```

- ❶ PostgreSQL deployment
- ❷ Sync wave for PostgreSQL deployment is 0
- ❸ Name of the Job
- ❹ Job executed when PostgreSQL is healthy

Discussion

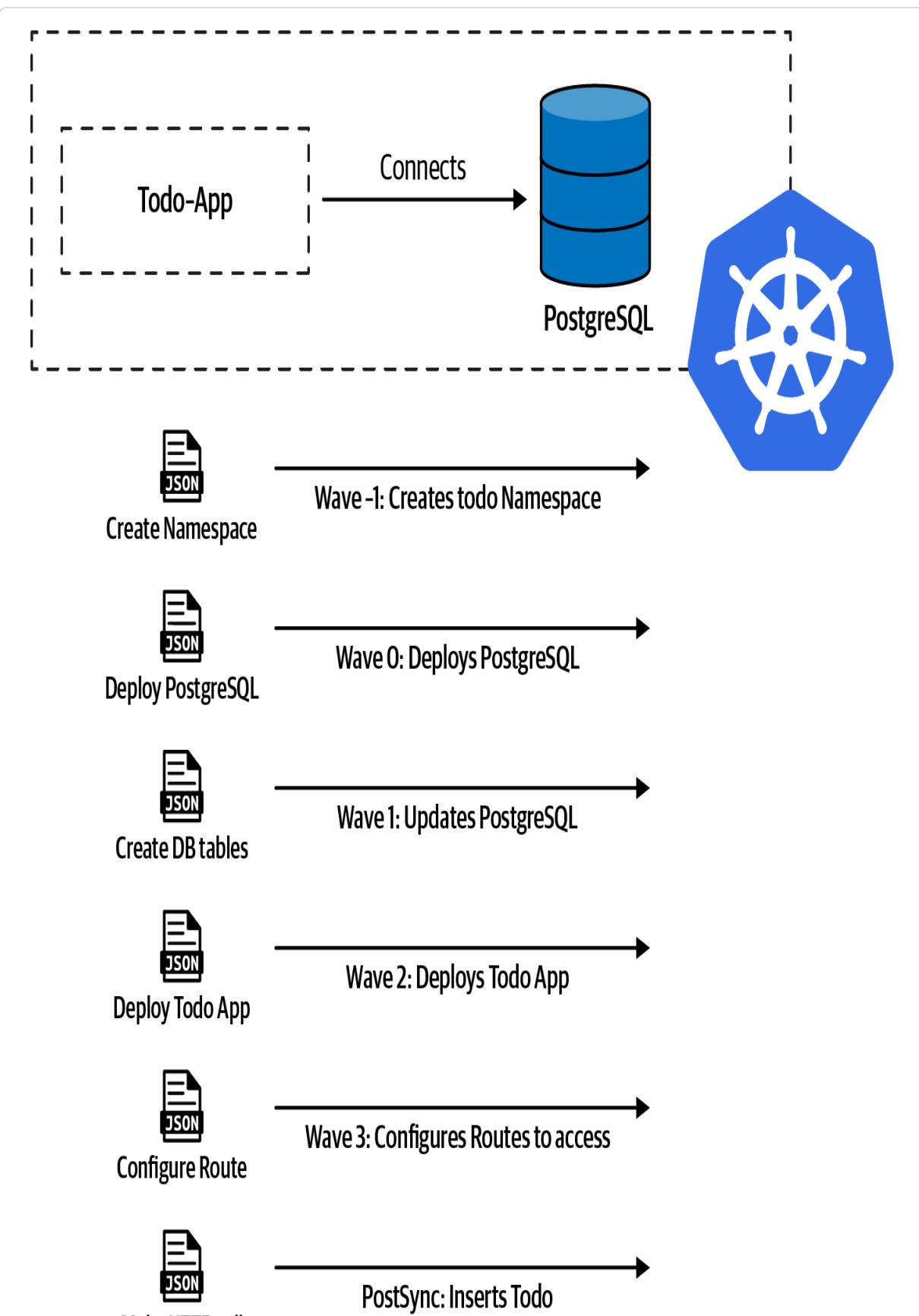
When Argo CD starts applying the manifests, it orders the resources in the following way:

1. Phase
2. Wave (lower precedence first)
3. Kind
4. Name

Let's deploy a more significant application with deployment files, sync waves, and hooks.

The sample application deployed is a TODO application connected with a database (PostgreSQL) to store TODOs. To deploy the application, some particular order needs to be applied; for example, the database server must be running before creating the database schema. Also, when the whole application is deployed, we insert some default TODOs into the database to run a post-sync manifest.

The overall process is shown in [Figure 7-14](#).



Make HTTP call

Figure 7-14. Todo app

Create an Application resource pointing out to the application:

```
apiVersion: argoproj.io/v1alpha1
kind: Application
metadata:
  name: todo-app
  namespace: argocd
spec:
  destination:
    namespace: todo
    server: https://kubernetes.default.svc
  project: default
  source:
    path: ch07/todo
    repoURL: https://github.com/gitops-cookbook/gitops-cookbook-
sc.git
    targetRevision: main
  syncPolicy:
    automated:
      prune: true
      selfHeal: false
  syncOptions:
    - CreateNamespace=true
```

In the terminal, apply the resource, and Argo CD will deploy all applications in the specified order.

See Also

- [gitops-engine/sync_tasks.go on GitHub](#)

7.8 Define Synchronization Windows

Problem

You want Argo CD to block or allow application synchronization depending on time.

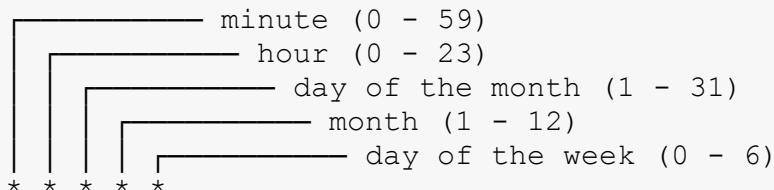
Solution

Argo CD has the *sync windows* concept to configure time windows where application synchronizations (applying new resources that have been pushed to the repository) will either be blocked or allowed.

To define a sync window, create an AppProject manifest setting the kind (either allow or deny), a schedule in cron format to define the initial time, a duration of the window, and which resources the sync window is applied to (Application, namespaces, or clusters).

ABOUT CRON EXPRESSIONS

A cron expression represents a time. It's composed of the following fields:



The AppProject resource is responsible for defining these windows where synchronizations are permitted/blocked.

Create a new file to permit synchronizations only from 22:00 to 23:00 (just one hour) and for Argo CD Applications whose names end in `-prod`:

```
apiVersion: argoproj.io/v1alpha1
kind: AppProject
metadata:
  name: default
spec:
  syncWindows: ①
    - kind: allow ②
      schedule: '0 22 * * *' ③
      duration: 1h ④
      applications: ⑤
        - '*-prod' ⑥
```

- ① List of windows

- ❷ Allow syncs
- ❸ Only at 22:00
- ❹ For 1 hour (23:00)
- ❺ Sets the applications that affect this window
- ❻ Regular expression matching any application whose name ends with -prod

Discussion

We cannot perform a sync of the application (neither automatic nor manual) when it's not the time configured in the time window defined in the AppProject manifest. However, we can configure a window to allow manual syncs.

Using the CLI tool:

```
argocd proj windows enable-manual-sync <PROJECT ID>
```

Also, manual sync can be set in the YAML file. In the following example, we're setting manual synchronization for the namespace default, denying synchronizations at 22:00 for one hour and allowing synchronizations in prod-cluster at 23:00 for one hour:

```
apiVersion: argoproj.io/v1alpha1
kind: AppProject
metadata:
  name: default
  namespace: argocd
spec:
  syncWindows:
    - kind: deny ❶
      schedule: '0 22 * * *'
      duration: 1h
      manualSync: true ❷
      namespaces: ❸
        - bgd
    - kind: allow
      schedule: '0 23 * * *'
```

```
duration: 1h
clusters: ④
- prod-cluster
```

- ❶ Block synchronizations
- ❷ Enable manual sync to default namespace
- ❸ Configure namespaces to block
- ❹ Configure clusters to allow syncs at 23:00

We can inspect the current windows from the UI by going to the Settings → Projects → default → windows tab or by using the argoctl CLI tool:

```
argoctl proj windows list default

ID  STATUS      KIND      SCHEDULE      DURATION  APPLICATIONS
NAMESPACES  CLUSTERS      MANUALSYNC
0   Inactive    deny    0 22 * * *  1h        -
-           Enabled
1   Inactive    allow   0 23 * * *  1h        -
prod-cluster  Disabled
```

Chapter 8. Advanced Topics

In the previous chapter, you had an overview of implementing GitOps workflows using Argo CD recipes. Argo CD is a famous and influential open source project that helps with both simple use cases and more advanced ones. In this chapter, we will discuss topics needed when you move forward in your GitOps journey, and you need to manage security, automation, and advanced deployment models for multicloud scenarios.

Security is a critical aspect of automation and DevOps. DevSecOps is a new definition of an approach where security is a shared responsibility throughout the entire IT lifecycle. Furthermore, the [DevSecOps Manifesto](#) specifies security as code to operate and contribute value with less friction. And this goes in the same direction as GitOps principles, where everything is declarative.

On the other hand, this also poses the question of avoiding storing unencrypted plain-text credentials in Git. As stated in the book *Path to GitOps* by Christian Hernandez, Argo CD luckily currently provides two patterns to manage security in GitOps workflows:

- Storing encrypted secrets in Git, such as with a Sealed Secret (see [Recipe 8.1](#))
- Storing secrets in external services or vaults, then storing only the reference to such secrets in Git (see [Recipe 8.2](#))

The chapter then moves to advanced deployment techniques, showing how to manage webhooks with Argo CD (see [Recipe 8.3](#)) and with ApplicationSets (see [Recipe 8.4](#)). ApplicationSets is a component of Argo CD that allows management deployments of many applications, repositories, or clusters from a single Kubernetes resource. In essence, a templating system for the GitOps application is ready to be deployed and synced in multiple Kubernetes clusters (see [Recipe 8.5](#)).

Last but not least, the book ends with a recipe on Progressive Delivery for Kubernetes with Argo Rollouts ([Recipe 8.6](#)), useful for deploying the application using an advanced deployment technique such as blue-green or canary.

8.1 Encrypt Sensitive Data (Sealed Secrets)

Problem

You want to manage Kubernetes Secrets and encrypted objects in Git.

Solution

[Sealed Secrets](#) is an open source project by Bitnami used to encrypt a Kubernetes Secrets into a `SealedSecret` Kubernetes Custom Resource, representing an encrypted object safe to store in Git.

Sealed Secrets uses public-key cryptography and consists of two main components:

- A Kubernetes controller that has knowledge about the private and public key used to decrypt and encrypt encrypted secrets and is responsible for reconciliation. The controller also supports automatic secret rotation for the private key and key expiration management in order to enforce the re-encryption of secrets.
- `kubeseal`, a CLI used by developers to encrypt their secrets before committing them to a Git repository.

The `SealedSecret` object is encrypted and decrypted only by the `SealedSecret` controller running in the target Kubernetes cluster. This operation is exclusive only to this component, thus nobody else can decrypt the object. The `kubeseal` CLI allows the developer to take a normal Kubernetes Secret resource and convert it to a `SealedSecret` resource definition as shown in [Figure 8-1](#).

In your Kubernetes cluster with Argo CD, you can install the `kubeseal` CLI for your operating system from the [GitHub project's releases](#). At the time of writing this book, we are using version 0.18.2.

TIP

On macOS, `kubeseal` is available through [Homebrew](#) as follows:

```
brew install kubeseal
```

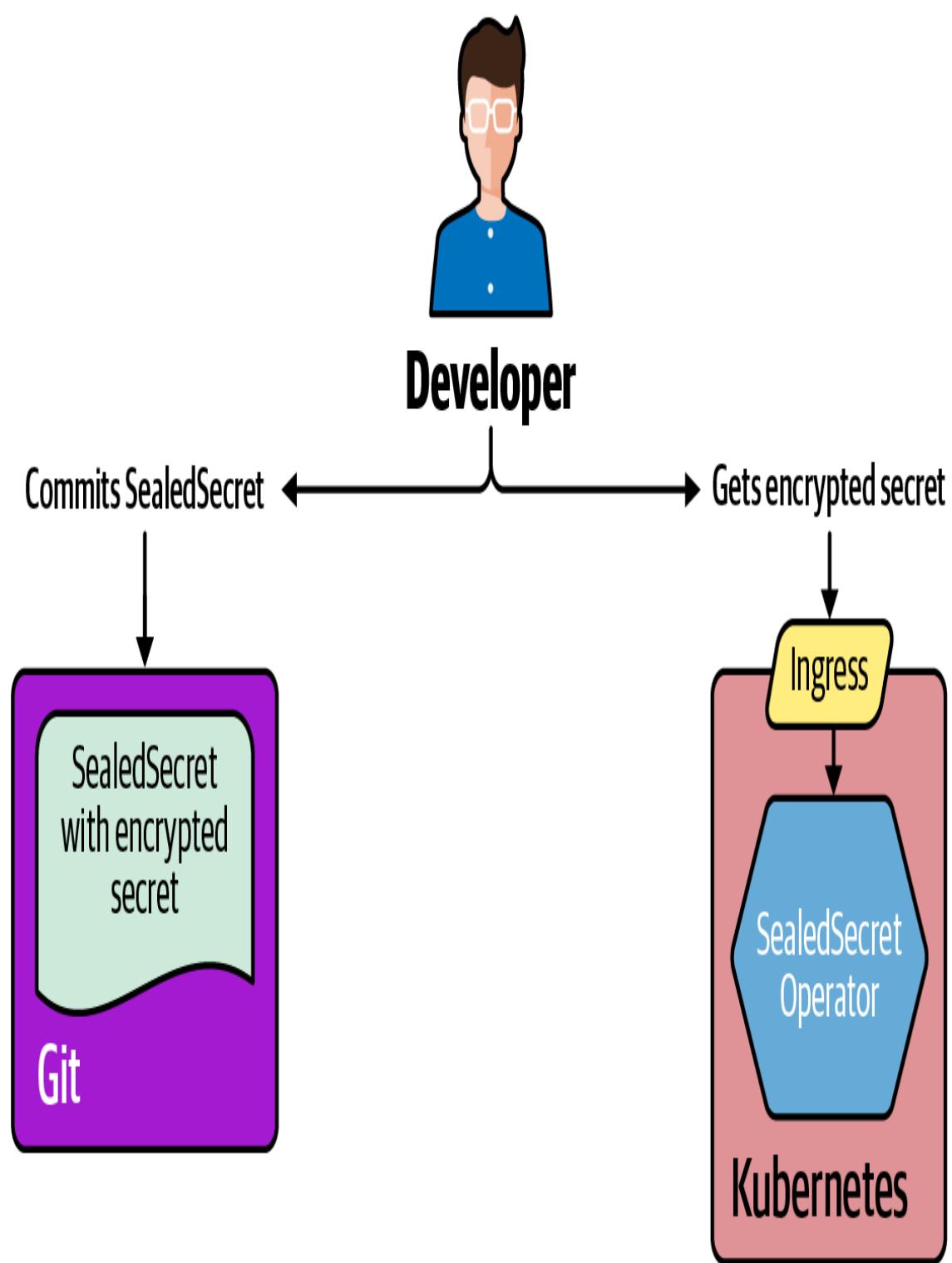


Figure 8-1. Sealed Secrets with GitOps

After you install the CLI, you can install the controller as follows:

```
kubectl create \
-f https://github.com/bitnami-labs/sealed-
secrets/releases/download/0.18.2/controller.yaml
```

You should have output similar to the following:

```
serviceaccount/sealed-secrets-controller created
deployment.apps/sealed-secrets-controller created
customresourcedefinition.apiextensions.k8s.io/sealedsecrets.bitna
mi.com created
service/sealed-secrets-controller created
rolebinding.rbac.authorization.k8s.io/sealed-secrets-controller
created
rolebinding.rbac.authorization.k8s.io/sealed-secrets-service-
proxier created
role.rbac.authorization.k8s.io/sealed-secrets-service-proxier
created
role.rbac.authorization.k8s.io/sealed-secrets-key-admin created
clusterrolebinding.rbac.authorization.k8s.io/sealed-secrets-
controller created
clusterrole.rbac.authorization.k8s.io/secrets-unsealer created
```

As an example, let's create a Secret for the Pac-Man game deployed in [Chapter 5](#):

```
kubectl create secret generic pacman-secret \
--from-literal=user=pacman \
--from-literal=pass=pacman
```

You should have the following output:

```
secret/pacman-secret created
```

And here you can see the YAML representation:

```
kubectl get secret pacman-secret -o yaml
```

```
apiVersion: v1
data:
  pass: cGFjbWFu
  user: cGFjbWFu
```

```

kind: Secret
metadata:
  name: pacman-secret
  namespace: default
type: Opaque

```

Now, you can convert the Secret into a SealedSecret in this way:

```

kubectl get secret pacman-secret -o yaml \
| kubeseal -o yaml > pacman-sealedsecret.yaml

```

```

apiVersion: bitnami.com/v1alpha1
kind: SealedSecret
metadata:
  creationTimestamp: null
  name: pacman-secret
  namespace: default
spec:
  encryptedData: ❶
    pass:
AgBJR1AgZ5Gu5NOVsG1E8SKBcdB3QSDdzZka3RRYuWV7z8g7ccQ0dGc1suVOP8wX/
ZpPmIMp8+urPYG62k4EZRUjuu/Vg2E1nSbsGBh9eKu3NaO6tGSF3eGk6PzN6XtRhD
eER4u7MG5pj/+FXRAKcy8Z6RfzbVEGq/QJQ4z0ecSNdJmG07ERMm1Q+lPNGvph2Sv
x8aCgFLqRsdLhFyvwbTyB3XnmFHRPr+2DynxeN8XVMoMkRYXgVc6GAoxUK7CnC3El
puy7lIdPwc5QBx9kUVfra83LX8/KxeaJwyCqvscIGjtcxUtpTpF5jm1t1DSRRNbC4
m+7pTwTmnRiUuaMVeujaBco4521yTkh5iEPjnjkUt+VzK01NVoeNunqIazp15rFwT
vniQ5PATbiUXpT733zCr60QBgsxPg31vw98+u+RcIHvaMIODCqaXxUdcn2JkUF+bZ
XtxNmIRTAiQVQ1vEPmrZxpvcZcUh/PPC4L/RFWrQWnOzKRyqLq9wRoSLPbKyvMXnax
H0v3USGIktmtJ1GjlXoW/i+HIoSeMFS0mUAzOF5M5gweOhtxKGh3Y74ZDn5PbVA/9
kbkuWgvPNGDZL924Dm6AyM5goHECr/RTm1e22K9bfPASARZuGA6paqb9h1XEeqyqe
sZgM0R8PLiyLuu+tpqydR0SiYLc5V1tdjzpIyyy9Xmw6Aa3/4SB+4tSwXSUUrB5yc
=
  user:
AgBhYDZQzOwinetPceZL897aibTYp4QPGFvP6ZhDyuUAxOWXBQ7jBA3KPUqLvP8vB
cxLAcS7HpKcDSgCdi47D2WhShdBR4jWJu fwKmR3j+ayTdw72t3ALpQhTYI0iMYTiN
dR0/o3vf0jeNMT/oWCrsifqBxZaISHe53rAFEjEA6D7CuCDXu8BHk1DpSr79d5Au4
puzpHVODh+v1T+Yef3k7DUoSnbYEh3CvuRweiug51Y8G0oob28j38wdyxm3GIrex
+M/ZId01hxZ6jz4edv6ejdZfmQNdr3c61mljWwcO+0Ue0MqFi4ZF/YNUsiojI+78
1n1m3K/giKcyPLn0skD7DyeKPoukoN6W5P71OuFSkF+VgIeejDaxuA7bK3PEaUgv7
9KFC9aEEBr/7op7HY7X6aMDahmLUc/+zDhfzQvwnC2wcj4B8M2OBFa2ic2PmGzrI
Wh1Bbs1OgnpehtGSETq+YRDH0alWOfBq1U8qn6QA8Iw6ewu8GTele3z1PLaADi5O
6LrJbIZN1Y0+PutWfjs9ScVVEJy+I9BGdyT6tiA/4v4cxH6ygG6NzWkqxSaYyNrWW
XtLhOlqyCpTZtUwHnF+OLB3gCpDZPx+NwTe2Kn0jY0c83LuLh5PJ090AsWWqZaRQy
ELeL6y6mVekQFWHGfK6t57Vb7Z3+5XJCgQn+xFLkj3S1z0ME5D4+DSSUDS1fyL8uI
=
  template:
    data: null
    metadata:

```

```
creationTimestamp: null
name: pacman-secret
namespace: default
type: Opaque
```

- ❶ Here you find the data encrypted by the Sealed Secrets controller.

Now you can safely push your `SealedSecret` to your Kubernetes manifests repo and create the Argo CD application. Here's an example from [this book's repository](#):

```
argocd app create pacman \
--repo https://github.com/gitops-cookbook/pacman-kikd-
manifests.git \
--path 'k8s/sealedsecrets' \
--dest-server https://kubernetes.default.svc \
--dest-namespace default \
--sync-policy auto
```

Check if the app is running and healthy:

```
argocd app list
```

You should get output similar to the following:

NAME	CLUSTER	NAMESPACE	PROJECT
STATUS	HEALTH ↴		
SYNCPOLICY	CONDITIONS	REPO	
PATH	TARGET		
pacman	https://kubernetes.default.svc	default	default
Synced	Healthy ↴		
<none>	<none>	https://github.com/gitops- cookbook/pacman-kikd-manifests.git	k8s/sealedsecrets

8.2 Encrypt Secrets with ArgoCD (ArgoCD + HashiCorp Vault + External Secret)

Problem

You want to avoid storing credentials in Git and you want to manage them in external services or vaults.

Solution

In [Recipe 8.1](#) you saw how to manage encrypted data in Git following the GitOps declarative way, but how do you avoid storing even encrypted credentials with GitOps?

One solution is [External Secrets](#), an open source project initially created by GoDaddy, which aims at storing secrets in external services or vaults from different vendors, then storing only the reference to such secrets in Git.

Today, External Secrets supports systems such as AWS Secrets Manager, HashiCorp Vault, Google Secrets Manager, Azure Key Vault, and more. The idea is to provide a user-friendly abstraction for the external API that stores and manages the lifecycles of the secrets.

In depth, ExternalSecrets is a Kubernetes controller that reconciles Secrets into the cluster from a Custom Resource that includes a reference to a secret in an external key management system. The Custom Resource SecretStore specifies the backend containing the confidential data, and how it should be transformed into a Secret by defining a template, as you can see in [Figure 8-2](#). The SecretStore has the configuration to connect to the external secret manager.

Thus, the ExternalSecrets objects can be safely stored in Git, as they do not contain any confidential information, but just the references to the external services managing credentials.

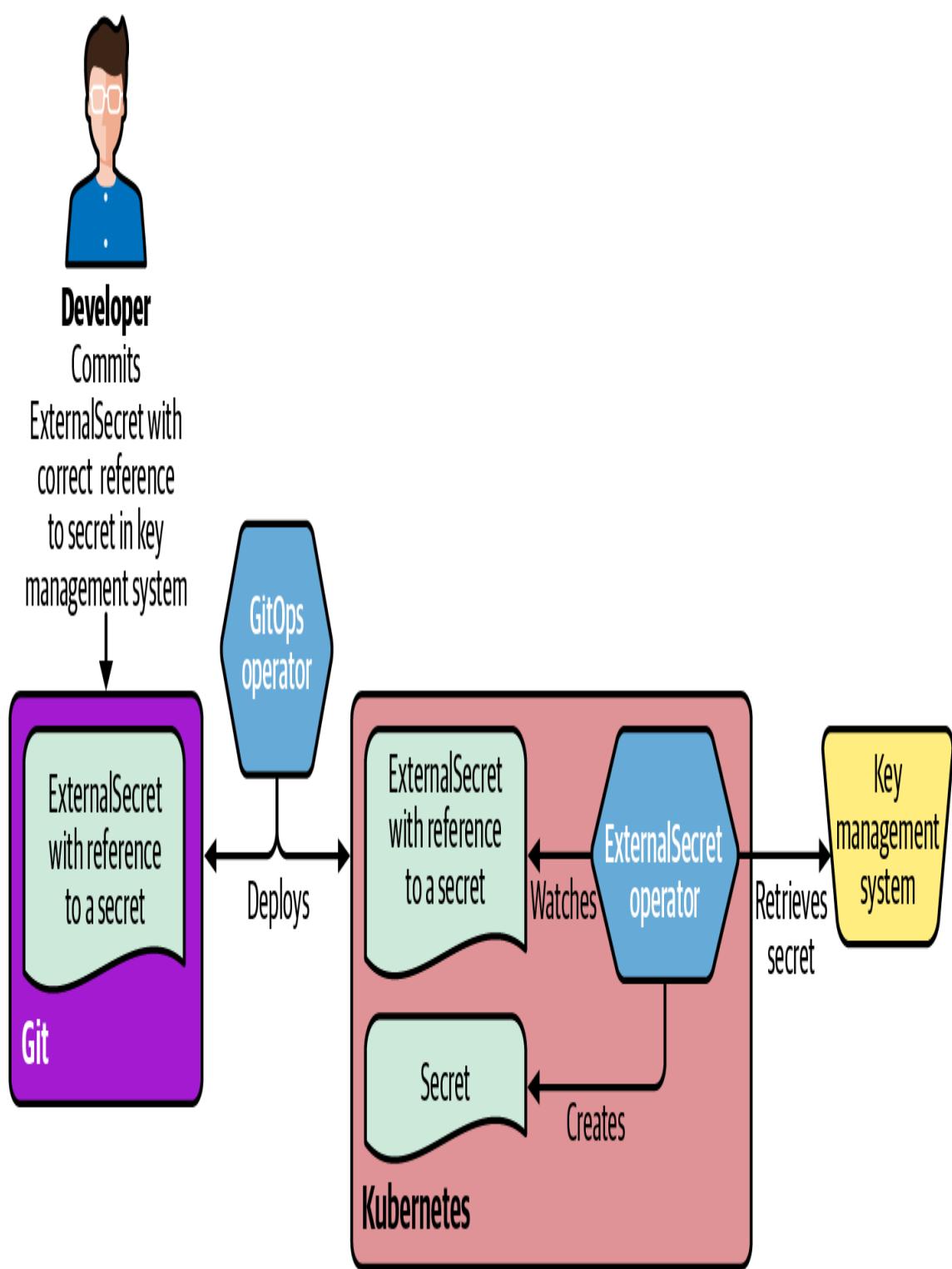


Figure 8-2. External Secrets with Argo CD

You can install External Secrets with a Helm Chart as follows. At the time of writing this book, we are using version 0.5.9:

```
helm repo add external-secrets https://charts.external-secrets.io  
helm install external-secrets \  
  external-secrets/external-secrets \  
  -n external-secrets \  
  --create-namespace
```

You should get output similar to the following:

```
NAME: external-secrets  
LAST DEPLOYED: Fri Sep 2 13:09:53 2022  
NAMESPACE: external-secrets  
STATUS: deployed  
REVISION: 1  
TEST SUITE: None  
NOTES:  
external-secrets has been deployed successfully!
```

In order to begin using ExternalSecrets, you will need to set up a SecretStore or ClusterSecretStore resource (for example, by creating a *vault* SecretStore).

More information on the different types of SecretStores and how to configure them can be found in our [GitHub page](#).

TIP

You can also install the External Secrets Operator with OLM from [OperatorHub.io](#).

As an example with one of the providers supported, such as [HashiCorp Vault](#), you can do the following.

First download and install [HashiCorp Vault](#) for your operating system and get your [Vault Token](#). Then create a Kubernetes Secret as follows:

```
export VAULT_TOKEN=<YOUR_TOKEN>  
kubectl create secret generic vault-token \  

```

```
--from-literal=token=$VAULT_TOKEN \
-n external-secrets
```

Then create a SecretStore as a reference to this external system:

```
apiVersion: external-secrets.io/v1beta1
kind: SecretStore
metadata:
  name: vault-secretstore
  namespace: default
spec:
  provider:
    vault:
      server: "http://vault.local:8200" ❶
      path: "secret"
      version: "v2"
      auth:
        tokenSecretRef:
          name: "vault-token" ❷
          key: "token" ❸
          namespace: external-secrets
```

- ❶ Hostname where your Vault is running
- ❷ Name of the Kubernetes Secret containing the vault token
- ❸ Key to address the value in the Kubernetes Secret containing the vault token content:

```
kubectl create -f vault-secretstore.yaml
```

Now you can create a Secret in your Vault as follows:

```
vault kv put secret/pacman-secrets pass=pacman
```

And then reference it from the ExternalSecret as follows:

```
apiVersion: external-secrets.io/v1beta1
kind: ExternalSecret
metadata:
  name: pacman-externalsecrets
  namespace: default
spec:
```

```

refreshInterval: "15s"
secretStoreRef:
  name: vault-secretstore
  kind: SecretStore
target:
  name: pacman-externalsecrets
data:
- secretKey: token
  remoteRef:
    key: secret/pacman-secrets
    property: pass

kubectl create -f pacman-externalsecrets.yaml

```

Now you can deploy the Pac-Man game with Argo CD using External Secrets as follows:

```

argocd app create pacman \
--repo https://github.com/gitops-cookbook/pacman-kikd-
manifests.git \
--path 'k8s/externalsecrets' \
--dest-server https://kubernetes.default.svc \
--dest-namespace default \
--sync-policy auto

```

8.3 Trigger the Deployment of an Application Automatically (Argo CD Webhooks)

Problem

You don't want to wait for Argo CD syncs and you want to immediately deploy an application when a change occurs in Git.

Solution

While Argo CD polls Git repositories every three minutes to detect changes to the monitored Kubernetes manifests, it also supports an event-driven approach with webhooks notifications from popular Git servers such as GitHub, GitLab, or Bitbucket.

[Argo CD Webhooks](#) are enabled in your Argo CD installation and available at the endpoint /api/webhooks.

To test webhooks with Argo CD using Minikube you can use Helm to install a local Git server such as [Gitea](#), an open source lightweight server written in Go, as follows:

```
helm repo add gitea-charts https://dl.gitea.io/charts/
helm install gitea gitea-charts/gitea
```

You should have output similar to the following:

```
helm install gitea gitea-charts/gitea
"gitea-charts" has been added to your repositories
NAME: gitea
LAST DEPLOYED: Fri Sep  2 15:04:04 2022
NAMESPACE: default
STATUS: deployed
REVISION: 1
NOTES:
1. Get the application URL by running these commands:
  echo "Visit http://127.0.0.1:3000 to use your application"
  kubectl --namespace default port-forward svc/gitea-http
3000:3000
```

TIP

Log in to the Gitea server with the default credentials you find the in the *values.yaml* file from the Helm Chart [here](#) or define new ones via overriding them.

Import the [Pac-Man](#) manifests repo into Gitea.

Configure the Argo app:

```
argocd app create pacman-webhook \
--repo http://gitea-http.default.svc:3000/gitea_admin/pacman-
kikid-manifests.git \
--dest-server https://kubernetes.default.svc \
--dest-namespace default \
--path k8s \
--sync-policy auto
```

To add a webhook to Gitea, navigate to the top-right corner and click Settings. Select the Webhooks tab and configure it as shown in [Figure 8-3](#):

- Payload URL: `http://localhost:9090/api/webhooks`
- Content type: `application/json`

Add Webhook



Integrate Gitea into your repository.

Target URL *

`https://localhost:9090/api/webhook`

HTTP Method

POST

POST Content Type

`application/json`

Secret

Trigger On:

Push Events

All Events

Custom Events...

Branch filter

*

Branch whitelist for push, branch creation and branch deletion events, specified as glob pattern. If empty or *, events for all branches are reported. See github.com/gobwas/glob documentation for syntax. Examples: master, {master, release*}.

Active

Information about triggered events will be sent to this webhook URL.

Add Webhook

Figure 8-3. Gitea Webhooks

TIP

You can omit the Secret for this example; however, it's best practice to configure secrets for your webhooks. Read more from the [docs](#).

Save it and push your change to the repo on Gitea. You will see a new sync from Argo CD immediately after your push.

8.4 Deploy to Multiple Clusters

Problem

You want to deploy an application to different clusters.

Solution

Argo CD supports the ApplicationSet resource to “templetarize” an Argo CD Application resource. It covers different use cases, but the most important are:

- Use a Kubernetes manifest to target multiple Kubernetes clusters.
- Deploy multiple applications from one or multiple Git repositories.

Since the ApplicationSet is a template file with placeholders to substitute at runtime, we need to feed these with some values. For this purpose, ApplicationSet has the concept of *generators*.

A generator is responsible for generating the parameters, which will finally be replaced in the template placeholders to generate a valid Argo CD Application.

Create the following ApplicationSet:

```

apiVersion: argoproj.io/v1alpha1
kind: ApplicationSet
metadata:
  name: bgd-app
  namespace: argocd
spec:
  generators: ①
  - list:
    elements: ②
    - cluster: staging
      url: https://kubernetes.default.svc
      location: default
    - cluster: prod
      url: https://kubernetes.default.svc
      location: app
  template: ③
  metadata:
    name: '{{cluster}}-app' ④
  spec:
    project: default
    source:
      repoURL: https://github.com/gitops-cookbook/gitops-
cookbook-sc.git
      targetRevision: main
      path: ch08/bgd-gen/{{cluster}}
    destination:
      server: '{{url}}' ⑤
      namespace: '{{location}}'
    syncPolicy:
      syncOptions:
      - CreateNamespace=true

```

- ① Defines a generator
- ② Sets the value of the parameters
- ③ Defines the Application resource as a template
- ④ cluster placeholder
- ⑤ url placeholder

Apply the previous file by running the following command:

```
kubectl apply -f bgd-application-set.yaml
```

When this ApplicationSet is applied to the cluster, Argo CD generates and automatically registers two Application resources. The first one is:

```
apiVersion: argoproj.io/v1alpha1
kind: Application
metadata:
  name: staging-app
spec:
  project: default
  source:
    path: ch08/bgd-gen/staging
    repoURL: https://github.com/example/app.git
    targetRevision: HEAD
  destination:
    namespace: default
    server: https://kubernetes.default.svc
  ...
```

And the second one:

```
apiVersion: argoproj.io/v1alpha1
kind: Application
metadata:
  name: prod-app
spec:
  project: default
  source:
    path: ch08/bgd-gen/prod
    repoURL: https://github.com/example/app.git
    targetRevision: HEAD
  destination:
    namespace: app
    server: https://kubernetes.default.svc
  ...
```

Inspect the creation of both Application resources by running the following command:

```
# Remember to login first
argocd login --insecure --grpc-web $argoURL --username admin --
password $argoPass

argocd app list
```

And the output should be similar to (trunked):

NAME	CLUSTER	NAMESPACE
prod-app	https://kubernetes.default.svc	app
staging-app	https://kubernetes.default.svc	default

Delete both applications by deleting the ApplicationSet file:

```
kubectl delete -f bgd-application-set.yaml
```

Discussion

We've seen the simplest generator, but there are eight generators in total at the time of writing this book:

List

Generates Application definitions through a fixed list of clusters.
(It's the one we've seen previously).

Cluster

Similar to *List* but based on the list of clusters defined in Argo CD.

Git

Generates Application definitions based on a JSON/YAML properties file within a Git repository or based on the directory layout of the repository.

SCM Provider

Generates Application definitions from repositories within an organization.

Pull Request

Generates Application definitions from open pull requests.

Cluster Decision Resource

Generates Application definitions using [duck-typing](#).

Matrix

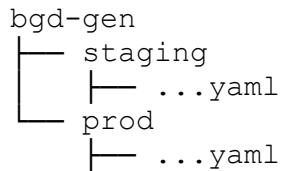
Combines values of two separate generators.

Merge

Merges values from two or more generators.

In the previous example, we created the `Application` objects from a fixed list of elements. This is fine when the number of configurable environments is small; in the example, two clusters refer to two Git folders (`ch08/bgd-gen/staging` and `ch08/bgd-gen/prod`). In the case of multiple environments (which means various folders), we can dynamically use the `Git` generator to generate one `Application` per directory.

Let's migrate the previous example to use the `Git` generator. As a reminder, the `Git` directory layout used was:



Create a new file of type `ApplicationSet` generating an `Application` for each directory of the configured Git repo:

```
apiVersion: argoproj.io/v1alpha1
kind: ApplicationSet
metadata:
  name: cluster-addons
  namespace: openshift-gitops
spec:
  generators:
  - git: ①
    repoURL: https://github.com/gitops-cookbook/gitops-cookbook-sc.git
    revision: main
    directories:
    - path: ch08/bgd-gen/* ②
  template: ③
  metadata:
    name: '{{path[0]}}{{path[2]}}' ④
  spec:
    project: default
    source:
      repoURL: https://github.com/gitops-cookbook/gitops-
```

```

cookbook-sc.git
  targetRevision: main
  path: '{{path}}' ⑤
destination:
  server: https://kubernetes.default.svc
  namespace: '{{path.basename}}' ⑥

```

- ❶ Configures the Git repository to read layout
- ❷ Initial path to start scanning directories
- ❸ Application definition
- ❹ The directory paths within the Git repository matching the path wildcard (staging or prod)
- ❺ Directory path (full path)
- ❻ The rightmost pathname

Apply the resource:

```
kubectl apply -f bgd-git-application-set.yaml
```

Argo CD creates two applications as there are two directories:

```

argocd app list

NAME          CLUSTER          NAMESPACE
ch08prod     https://kubernetes.default.svc  prod
ch08staging   https://kubernetes.default.svc  staging

```

Also, this generator is handy when your application is composed of different components (service, database, distributed cache, email server, etc.), and deployment files for each element are placed in other directories. Or, for example, a repository with all operators required to be installed in the cluster:

```

app
└── tekton-operator
    └── ...yaml
└── prometheus-operator

```

```
└─ ┌ ...yaml  
  istio-operator  
  ┌ ...yaml
```

Instead of reacting to directories, Git generator can create Application objects with parameters specified in JSON/YAML files.

The following snippet shows an example JSON file:

```
{  
  "cluster": {  
    "name": "staging",  
    "address": "https://1.2.3.4"  
  }  
}
```

This is an excerpt of the ApplicationSet to react to these files:

```
apiVersion: argoproj.io/v1alpha1  
kind: ApplicationSet  
metadata:  
  name: guestbook  
spec:  
  generators:  
  - git:  
      repoURL: https://github.com/example/app.git  
      revision: HEAD  
      files:  
        - path: "app/**/config.json" ❶  
  template:  
    metadata:  
      name: '{{cluster.name}}-app' ❷  
....
```

- ❶ Finds all *config.json* files placed in all subdirectories of the app
- ❷ Injects the value set in *config.json*

This ApplicationSet will generate one Application for each *config.json* file in the folders matching the path expression.

See Also

- [Argo CD Generators](#)
- [Duck Types](#)

8.5 Deploy a Pull Request to a Cluster

Problem

You want to deploy a preview of the application when a pull request is created.

Solution

Use the *pull request* generator to automatically discover open pull requests within a repository and create an Application object.

Let's create an ApplicationSet reacting to any GitHub pull request annotated with the `preview` label created on the configured repository.

Create a new file named `bgd-pr-application-set.yaml` with the following content:

```
apiVersion: argoproj.io/v1alpha1
kind: ApplicationSet
metadata:
  name: myapps
  namespace: openshift-gitops
spec:
  generators:
  - pullRequest:
      github: ①
        owner: gitops-cookbook ②
        repo: gitops-cookbook-sc ③
        labels: ④
        - preview
      requeueAfterSeconds: 60 ⑤
  template:
    metadata:
      name: 'myapp-{{branch}}-{{number}}' ⑥
    spec:
      source:
        repoURL: 'https://github.com/gitops-cookbook/gitops-
cookbook-sc.git'
```

```
targetRevision: '{${head_sha}}' ⑦
path: ch08/bgd-pr
project: default
destination:
  server: https://kubernetes.default.svc
  namespace: '${branch}-${number}'
```

- ❶ GitHub pull request generator
- ❷ Organization/user
- ❸ Repository
- ❹ Select the target PRs
- ❺ Polling time in seconds to check if there is a new PR (60 seconds)
- ❻ Sets the name with branch name and number
- ❼ Sets the Git SHA number

Apply the previous file by running the following command:

```
kubectl apply -f bgd-pr-application-set.yaml
```

Now, if you list the Argo CD applications, you'll see that none are registered. The reason is there is no pull request yet in the repository labeled with `preview`:

```
argocd app list
NAME CLUSTER NAMESPACE PROJECT STATUS
```

Create a pull request against the repository and label it with `preview`.

In GitHub, the pull request window should be similar to [Figure 8-4](#).

Update bgd-deployment.yaml #1

[Edit](#)[Code ▾](#)

lordofthejars wants to merge 1 commit into [main](#) from [lordofthejars-patch-1](#)

[Conversation 0](#)[Commits 1](#)[Checks 0](#)[Files changed 1](#)[+2 -2](#)

lordofthejars commented 25 seconds ago

[Member](#)[Reviewers](#)[No reviews](#)[Still in progress? Convert to draft](#)[Commits 1](#)[Verified](#)[78af6f5](#)[Assignees](#)[No one—assign yourself](#)[Comments 1](#)[Labels](#)[preview](#)

Add more commits by pushing to the [lordofthejars-patch-1](#) branch on [gitops-cookbook/gitops-cookbook-sc](#).



This branch has no conflicts with the base branch

Merging can be performed automatically.

[Projects](#)[None yet](#)[Merge pull request](#)

You can also [open this in GitHub Desktop](#) or view [command line instructions](#).

[Milestone](#)



No milestone

Figure 8-4. Pull request in GitHub

Wait for one minute until the ApplicationSet detects the change and creates the Application object.

Run the following command to inspect that the change has been detected and registered:

```
kubectl describe applicationset myapps -n argocd

...
Events:
  Type    Reason     Age           From
Message
  ----  -----  ----
  Normal  created   23s          applicationset-controller
created Application "myapp-lordofthejars-patch-1-1"
  Normal  unchanged  23s (x2 over 23s)  applicationset-controller
unchanged Application "myapp-lordofthejars-patch-1-1"
```

Check the registration of the Application to the pull request:

```
argocd app list
NAME                      CLUSTER
NAMESPACE
myapp-lordofthejars-patch-1-1  https://kubernetes.default.svc
lordofthejars-patch-1-1
```

The Application object is automatically removed when the pull request is closed.

Discussion

At the time of writing this book, the following pull request providers are supported:

- GitHub
- Bitbucket

- Gitea
- GitLab

The ApplicationSet controller polls every `requeueAfterSeconds` interval to detect changes but also supports using webhook events.

To configure it, follow [Recipe 8.3](#), but also enable sending pull requests events too in the Git provider.

8.6 Use Advanced Deployment Techniques

Problem

You want to deploy the application using an advanced deployment technique such as blue-green or canary.

Solution

Use the [Argo Rollouts](#) project to roll out updates to an application.

Argo Rollouts is a Kubernetes controller providing advanced deployment techniques such as blue-green, canary, mirroring, dark canaries, traffic analysis, etc. to Kubernetes. It integrates with many Kubernetes projects like Ambassador, Istio, AWS Load Balancer Controller, NGNI, SMI, or Traefik for traffic management, and projects like Prometheus, Datadog, and New Relic to perform analysis to drive progressive delivery.

To install Argo Rollouts to the cluster, run the following command in a terminal window:

```
kubectl create namespace argo-rollouts

kubectl apply -n argo-rollouts -f
https://github.com/argoproj/argo-
rollouts/releases/download/v1.2.2/install.yaml
...
clusterrolebinding.rbac.authorization.k8s.io/argo-rollouts
created
secret/argo-rollouts-notification-secret created
```

```
service/argo-rollouts-metrics created
deployment.apps/argo-rollouts created
```

Although it's not mandatory, we recommend you install the Argo Rollouts Kubectl Plugin to visualize rollouts. Follow the [instructions](#) to install it. With everything in place, let's deploy the initial version of the BGD application.

Argo Rollouts doesn't use the standard Kubernetes Deployment file, but a specific new Kubernetes resource named `Rollout`. It's like a Deployment object, hence all its options are supported, but it adds some fields to configure the rolling update.

Let's deploy the first version of the application. We'll define the canary release process when Kubernetes executes a rolling update, which in this case follows these steps:

1. Forward 20% of traffic to the new version.
2. Wait until a human decides to proceed with the process.
3. Forward 40%, 60%, 80% of the traffic to the new version automatically, waiting 30 seconds between every increase.

Create a new file named `bgd-rollout.yaml` with the following content:

```
apiVersion: argoproj.io/v1alpha1
kind: Rollout
metadata:
  name: bgd-rollouts
spec:
  replicas: 5
  strategy:
    canary: ❶
    steps: ❷
    - setWeight: 20 ❸
    - pause: {} ❹
    - setWeight: 40
    - pause: {duration: 30s} ❺
    - setWeight: 60
    - pause: {duration: 30s}
    - setWeight: 80
    - pause: {duration: 30s}
  revisionHistoryLimit: 2
  selector:
```

```

matchLabels:
  app: bgd-rollouts
template: ⑥
  metadata:
    creationTimestamp: null
    labels:
      app: bgd-rollouts
spec:
  containers:
    - image: quay.io/rhdevelopers/bgd:1.0.0
      name: bgd
      env:
        - name: COLOR
          value: "blue"
      resources: {}

```

- ① Canary release
- ② List of steps to execute
- ③ Sets the ratio of canary
- ④ Rollout is paused
- ⑤ Pauses the rollout for 30 seconds
- ⑥ template Deployment definition

Apply the resource to deploy the application. Since there is no previous deployment, the canary part is ignored:

```
kubectl apply -f bgd-rollout.yaml
```

Currently, there are five pods as specified in the replicas field:

```
kubectl get pods
```

NAME	READY	STATUS	RESTARTS	AGE
bgd-rollouts-679cdfcf-6z2zf	1/1	Running	0	12m
bgd-rollouts-679cdfcf-8c6kl	1/1	Running	0	12m
bgd-rollouts-679cdfcf-8tb4v	1/1	Running	0	12m
bgd-rollouts-679cdfcf-f4p7f	1/1	Running	0	12m
bgd-rollouts-679cdfcf-tljfr	1/1	Running	0	12m

And using the Argo Rollout Kubectl Plugin:

```
kubectl argo rollouts get rollout bgd-rollouts

Name:          bgd-rollouts
Namespace:     default
Status:        ✓ Healthy
Strategy:      Canary
  Step:        8/8
  SetWeight:   100
  ActualWeight: 100
Images:        quay.io/rhdevelopers/bgd:1.0.0 (stable)
Replicas:
  Desired:    5
  Current:    5
  Updated:    5
  Ready:      5
  Available:  5

NAME                         KIND        STATUS
AGE  INFO
bgd-rollouts                 Rollout    ✓ Healthy
13m
└─# revision:1
    └─ bgd-rollouts-679cdfcfcd             ReplicaSet  ✓ Healthy
    13m stable
        ├─ bgd-rollouts-679cdfcfcd-6z2zf   Pod        ✓ Running
    13m ready:1/1
        ├─ bgd-rollouts-679cdfcfcd-8c6kl   Pod        ✓ Running
    13m ready:1/1
        ├─ bgd-rollouts-679cdfcfcd-8tb4v   Pod        ✓ Running
    13m ready:1/1
        ├─ bgd-rollouts-679cdfcfcd-f4p7f   Pod        ✓ Running
    13m ready:1/1
        └─ bgd-rollouts-679cdfcfcd-tljfr   Pod        ✓ Running
    13m ready:1/1
```

Let's deploy a new version to trigger a canary rolling update. Create a new file named *bgd-rollout-v2.yaml* with exactly the same content as the previous one, but change the environment variable COLOR value to green:

```
...
name: bgd
env:
- name: COLOR
```

```

value: "green"
resources: {}

```

Apply the previous resource and check how Argo Rollouts executes the rolling update. List the pods again to check that 20% of the pods are new while the other 80% are the old version:

```
kubectl get pods
```

NAME	READY	STATUS	RESTARTS	AGE
bgd-rollouts-679cdfcf7-6z2zf	1/1	Running	0	27m
bgd-rollouts-679cdfcf7-8c6kl	1/1	Running	0	27m
bgd-rollouts-679cdfcf7-8tb4v	1/1	Running	0	27m
bgd-rollouts-679cdfcf7-tljfr	1/1	Running	0	27m
bgd-rollouts-c5495c6ff-zfgvn	1/1	Running	0	13s ①

① New version pod

And do the same using the Argo Rollout Kubectl Plugin:

```
kubectl argo rollouts get rollout bgd-rollouts
```

```

...
NAME                                     KIND      STATUS
AGE      INFO
○ bgd-rollouts                           Rollout   || Paused
31m
└─# revision:2
  └─ bpd-rollouts-c5495c6ff             ReplicaSet ✓ Healthy
  3m21s  canary
  └─ bpd-rollouts-c5495c6ff-zfgvn     Pod       ✓ Running
  3m21s  ready:1/1
  └─# revision:1
    └─ bpd-rollouts-679cdfcf7         ReplicaSet ✓ Healthy
    31m  stable
    └─ bpd-rollouts-679cdfcf7-6z2zf  Pod       ✓ Running
    31m  ready:1/1
    └─ bpd-rollouts-679cdfcf7-8c6kl  Pod       ✓ Running
    31m  ready:1/1
    └─ bpd-rollouts-679cdfcf7-8tb4v  Pod       ✓ Running
    31m  ready:1/1
    └─ bpd-rollouts-679cdfcf7-tljfr  Pod       ✓ Running
    31m  ready:1/1

```

Remember that the rolling update process is paused until the operator executes a manual step to let the process continue. In a terminal window, run the following command:

```
kubectl argo rollouts promote bgd-rollouts
```

The rollout is promoted and continues with the following steps, which is substituting the old version pods with new versions every 30 seconds:

```
kubectl get pods
```

NAME	READY	STATUS	RESTARTS	AGE
bgd-rollouts-c5495c6ff-2g7r8	1/1	Running	0	89s
bgd-rollouts-c5495c6ff-7mdch	1/1	Running	0	122s
bgd-rollouts-c5495c6ff-d9828	1/1	Running	0	13s
bgd-rollouts-c5495c6ff-h4t6f	1/1	Running	0	56s
bgd-rollouts-c5495c6ff-zfgvn	1/1	Running	0	11m

The rolling update finishes with the new version progressively deployed to the cluster.

Discussion

Kubernetes doesn't implement advanced deployment techniques natively. For this reason, Argo Rollouts uses the number of deployed pods to implement the canary release.

As mentioned before, Argo Rollouts integrates with Kubernetes products that offer advanced traffic management capabilities like [Istio](#).

Using Istio, the traffic splitting is done correctly at the infrastructure level instead of playing with replica numbers like in the first example. Argo Rollouts integrates with Istio to execute a canary release, automatically updating the Istio `VirtualService` object.

Assuming you already know Istio and have a Kubernetes cluster with Istio installed, you can perform integration between Argo Rollouts and Istio by setting the `trafficRouting` from `Rollout` resource to `Istio`.

First, create a `Rollout` file with Istio configured:

```

apiVersion: argoproj.io/v1alpha1
kind: Rollout
metadata:
  name: bgdapp
  labels:
    app: bgdapp
spec:
  strategy:
    canary: ①
    steps:
      - setWeight: 20
      - pause:
          duration: "1m"
      - setWeight: 50
      - pause:
          duration: "2m"
  canaryService: bgd-canary ②
  stableService: bgd ③
  trafficRouting:
    istio: ④
      virtualService: ⑤
        name: bgd ⑥
        routes:
          - primary ⑦
  replicas: 1
  revisionHistoryLimit: 2
  selector:
    matchLabels:
      app: bgdapp
      version: v1
  template:
    metadata:
      labels:
        app: bgdapp
        version: v1
      annotations:
        sidecar.istio.io/inject: "true" ⑧
  spec:
    containers:
      - image: quay.io/rhdevelopers/bgd:1.0.0
        name: bgd
        env:
          - name: COLOR
            value: "blue"
        resources: {}

```

① Canary section

② Reference to a Kubernetes Service pointing to the new service version

- ③ Reference to a Kubernetes Service pointing to the old service version
- ④ Configures Istio
- ⑤ Reference to the VirtualService where weight is updated
- ⑥ Name of the VirtualService
- ⑦ Route name within VirtualService
- ⑧ Deploys the Istio sidecar container

Then, we create two Kubernetes Services pointing to the same deployment used to redirect traffic to the old or the new one.

The following Kubernetes Service is used in the stableService field:

```
apiVersion: v1
kind: Service
metadata:
  name: bgd
  labels:
    app: bgdapp
spec:
  ports:
  - name: http
    port: 8080
  selector:
    app: bgdapp
```

And the Canary one is the same but with a different name. It's the one used in the canaryService field:

```
apiVersion: v1
kind: Service
metadata:
  name: bgd-canary
  labels:
    app: bgdapp
spec:
  ports:
  - name: http
    port: 8080
  selector:
    app: bgdapp
```

Finally, create the Istio Virtual Service to be updated by Argo Rollouts to update the canary traffic for each service:

```
apiVersion: networking.istio.io/v1alpha3
kind: VirtualService
metadata:
  name: bgd
spec:
  hosts:
  - bgd
  http:
  - route:
    - destination:
        host: bgd ❶
        weight: 100
    - destination:
        host: bgd-canary ❷
        weight: 0
  name: primary ❸
```

❶ Stable Kubernetes Service

❷ Canary Kubernetes Service

❸ Route name

After applying these resources, we'll get the first version of the application up and running:

```
kubectl apply -f bgd-virtual-service.yaml
kubectl apply -f service.yaml
kubectl apply -f service-canary.yaml
kubectl apply -f bgd-isio-rollout.yaml
```

When any update occurs on the `Rollout` object, the canary release will start as described in the Solution. Now, Argo Rollouts updates the *bgd virtual service* weights automatically instead of playing with pod numbers.

See Also

- [Argo Rollouts - Kubernetes Progressive Delivery Controller](#)
- [Istio - Argo Rollouts](#)

- [Istio](#)
- [Istio Tutorial from Red Hat](#)

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Colophon

The animal on the cover of *GitOps Cookbook* is a yellow mongoose (*Cynictis penicillata*). These small mammals are found in sub-Saharan Africa, primarily in forests, woodlands, grasslands, and scrub. They are sometimes referred to as red meerkats. Yellow mongoose are smaller than most other species, weighing only 16–29 ounces. There are 12 subspecies that vary in color, body size (9–13 inches), tail (7–10 inches), and length of coat: the northern subspecies found in Botswana are typically smaller with grizzled grayish coats while the southern populations in South Africa and Namibia are larger and tawny yellow. All subspecies have slender bodies with lighter fur on the chin and underbelly, small ears, pointed noses, and bushy tails.

Yellow mongoose are carnivores that mainly feed on insects, birds, frogs, lizards, eggs and small rodents. They are social species and live in colonies of up to 20 individuals in extensive, permanent burrows with many entrances, chambers, and tunnels. Most of their day is spent foraging or sunbathing outside the burrow. In the wild, they breed from July to September with most females giving birth to two or three offspring in October and November. The young are born in an underground chamber and stay there until they are weaned (about 10 weeks). Yellow mongoose are considered fully grown at 10 months old.

Yellow mongoose are classified as a species of least concern by the IUCN; their populations are stable and they don't face any major threats. They do carry of strain of rabies in the wild and are seen as pests and hunted by farmers in parts of South Africa. Many of the animals on O'Reilly covers are endangered; all of them are important to the world.

The cover illustration is by Karen Montgomery, based on an antique line engraving from *The Pictorial Museum of Animated Nature*. The cover fonts are Gilroy Semibold and Guardian Sans. The text font is Adobe Minion Pro; the heading font is Adobe Myriad Condensed; and the code font is Dalton Maag's Ubuntu Mono.