

# Terraform Cookbook

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Efficiently define, launch, and manage Infrastructure as Code across various cloud platforms

**Mikael Krief**

Foreword by Mitchell Hashimoto, Creator of Terraform, Founder of HashiCorp



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**Mikael Krief**



BIRMINGHAM - MUMBAI

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**Production Designer:** Alishon Mendonca

First published: September 2020

Production reference: 2091120

Published by Packt Publishing Ltd.

Livery Place

35 Livery Street

Birmingham

B3 2PB, UK.

ISBN 978-1-80020-755-4

[www.packt.com](http://www.packt.com)

# Foreword

It wasn't long ago that most infrastructure was managed by point-and-click user interfaces. Public clouds were new and still seen as immature for real world use. The most interesting innovation with public cloud for me is that it brought a complete API over all infrastructure components. I dreamed of "coding" my infrastructure in the same way I did my applications.

In 2014, I helped build and release Terraform to make this dream a reality. It separated itself from other tools by supporting all major cloud platforms and by having a community-extensible plugin model to support new systems. Over time, Terraform has grown to be officially supported by most major cloud platforms and hundreds of other vendors.

The utility of Terraform has further expanded as the tech world has become increasingly API-driven. In addition to cloud infrastructure, Terraform is used today to manage calendars, GitHub repositories, physical networking equipment, and more. One intrepid community member even extended Terraform to order pizza for home delivery. If it has an API, Terraform can manage it. In many cases, representing API objects as code is exactly what you want (though, the pizza use case is certainly questionable).

Today, Terraform has been downloaded millions of times to manage everything from hobbyist setups to the infrastructure of the world's largest companies. It has grown beyond my wildest expectations! I'm most proud of the community that has grown around it.

Mikael Krief has been a member of the Terraform community for many years, and he has now written this book to share practical guides and examples of how to use Terraform in the real world. Connecting the dots between abstract idea and physical reality is an important task to make a tool useful and Mikael does this beautifully for Terraform.

I hope this book gets you excited about Terraform and helps you adopt it with ease. Most importantly, I hope this book allows you to not only get the job done with Terraform but have fun doing it.

**Mitchell Hashimoto**

Creator of Terraform, Founder of HashiCorp

*I would like to dedicate this book to my wife and children, who are my source of happiness.*



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# About the author

**Mikael Krief** lives in France and works as a DevOps engineer. He came to believe that Infrastructure as Code is a fundamental practice in DevOps culture. He is therefore interested in HashiCorp products and specializes in the use of Terraform in several company contexts. He loves to share his passion through various communities, such as the HashiCorp User Groups. In 2019, he wrote the book *Learning DevOps* (Packt Publishing), and he also contributes to many public projects, writes blogs and other books, and speaks at conferences. For all his contributions and passion, he was nominated and selected as a HashiCorp Ambassador, and he has been awarded the Microsoft Most Valuable Professional (MVP) award for 5 years.

*I would like to extend my thanks to my family for accepting that I needed to work long hours on this book during family time. I would like to thank Meeta Rajani for giving me the opportunity to write this second book, which was a very enriching experience. Special thanks go to Romy Dias, Radek Simko, and Arun Nadar for their valuable input and time spent reviewing this book, and thanks to the entire Packt team for their support during the course of writing this book.*

## About the reviewer

**Radek Simko** has been a senior software engineer at HashiCorp since 2017. He has been involved in various parts of the Terraform ecosystem for the last 5 years. He contributed to maintaining the AWS provider, created the official Kubernetes provider, and bootstrapped the initial decoupled version of the plugin SDK. Since early 2020, he has been focusing on improving support for Terraform in editors via a dedicated language server. Prior to HashiCorp, he worked at Time Inc. for over 3 years, where he pioneered Terraform and internally contributed to relevant fixes and features. Radek was born and raised in the Czech Republic, but he calls the UK his second home and enjoys traveling in his free time.

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# Preface

**Infrastructure as Code**, more commonly known as **IaC**, is a practice that is a pillar of DevOps culture. IaC entails writing your desired architecture configuration in code. Among other advantages, IaC allows the automation of infrastructure deployments, which reduces or eliminates the need for manual intervention, and thus the risk of configuration errors, and the need to create templates and standardize infrastructure with modular and scalable code.

Among all the DevOps tools, there are many that allow IaC. One of them is **Terraform**, from HashiCorp, which is very popular today because, in addition to being open source and multi-platform, it has the following advantages:

- It allows you to preview the changes that will be applied to your infrastructure.
- It allows the parallelization of operations, taking into account the management of dependencies.
- It has a multitude of providers.

In this book dedicated to Terraform, we will first discuss the installation of Terraform for local development, the writing of Terraform configurations, and the construction of several environments in a dynamic way.

Then, we will learn how to use the Terraform **command-line interface (CLI)** and how to share and use Terraform modules.

Once configuration writing and commands in Terraform are understood, we will discuss Terraform's practical use for building infrastructure in one of the leading cloud providers, Azure.

Finally, we will finish this book by looking at advanced uses of Terraform, including Terraform testing, integrating Terraform into a **continuous integration/continuous deployment (CI/CD)** pipeline, and using Terraform Cloud, which is Terraform's collaboration platform for teams and companies.

This book will guide you through several recipes on best practices for writing Terraform configurations and commands, and it will also cover recipes on Terraform's integration with other tools, such as Terragrunt, kitchen-terraform, and Azure Pipelines.

Most of the Terraform configurations described in this book are based on the Azure provider for illustration, but you can apply these recipes for all other Terraform providers.

In writing this book, which is in a cookbook format, I wanted to share my experience of real and practical Terraform-based scenarios that I have been able to acquire by working with customers and companies for several years.

## Who this book is for

This book is intended for everyone who already knows the basics about IaC and DevOps culture and also has some basic knowledge of Terraform. The book does not require any development or operating system experience.

## What this book covers

Chapter 1, *Setting Up the Terraform Environment*, details the different ways of installing Terraform manually, with scripts, or by using a Docker container, and it also details the Terraform migration configuration process.

Chapter 2, *Writing Terraform Configuration*, concerns the writing of Terraform configurations for a provider, variables, outputs, external data, built-in functions, condition expressions, file manipulation, and the execution of local programs with Terraform.

Chapter 3, *Building Dynamic Environments with Terraform*, discusses building dynamic environments with Terraform by going further with Terraform configuration writing using loops, maps, and collections.

Chapter 4, *Using the Terraform CLI*, explains the use of Terraform's CLI to clean code, destroy resources provisioned by Terraform, use workspaces, import existing resources, generate dependency graphs, and debug the execution of Terraform.

Chapter 5, *Sharing Terraform Configuration with Modules*, covers the creation, use, and sharing of Terraform modules. It also shows testing module practices and the implementation of CI/CD pipelines for Terraform modules.

Chapter 6, *Provisioning Azure Infrastructure with Terraform*, illustrates the use of Terraform in a practical scenario of the cloud provider Azure. It covers topics such as authentication, remote backends, ARM templates, Azure CLI execution, and Terraform configuration generation for an existing infrastructure.

Chapter 7, *Deep Diving into Terraform*, discusses topics that go further with Terraform, such as the execution of Terraform configuration tests, zero-downtime deployment, Terraform wrappers with Terragrunt, and the implementation of CI/CD pipelines to execute Terraform configurations.

Chapter 8, *Using Terraform Cloud to Improve Collaboration*, explains the use of Terraform Cloud to run Terraform in a team with the sharing of Terraform modules in a private registry, the use of remote backends for Terraform state, running Terraform remotely, and writing compliance tests with Sentinel.

## To get the most out of this book

The following is the list of software/hardware prerequisites for this book:

Software/hardware covered in the book	OS requirements
Terraform version >= 12.0	Any OS
Terraform Cloud	NA
Azure	Any OS
PowerShell scripting	Windows/Linux
Shell scripting	Linux
Azure CLI	Any OS
Azure DevOps	NA
GitHub	NA
Git	Any OS
Ruby version 2.6	Any OS
Docker	Any OS

If you are using the digital version of this book, we advise you to type the code yourself or access the code via the GitHub repository (link available in the next section). Doing so will help you avoid any potential errors related to the copying and pasting of code.

## Download the example code files

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We also have other code bundles from our rich catalog of books and videos available at <https://github.com/PacktPublishing/>. Check them out!

## Code in Action

Code in Action videos for this book can be viewed at <https://bit.ly/3h7cNME>.

## Download the color images

We also provide a PDF file that has color images of the screenshots/diagrams used in this book. You can download it here: [https://static.packt-cdn.com/downloads/9781800207554\\_ColorImages.pdf](https://static.packt-cdn.com/downloads/9781800207554_ColorImages.pdf).

## Conventions used

There are a number of text conventions used throughout this book.

**CodeInText:** Indicates code words in text, database table names, folder names, filenames, file extensions, pathnames, dummy URLs, user input, and Twitter handles. Here is an example: "Note that the `current_version` property, which contains the latest Terraform version, is a value."

A block of code is set as follows:

```
TERRAFORM_VERSION=$(curl -s  
https://checkpoint-api.hashicorp.com/v1/check/terraform | jq -r  
.current_version)  
  
....
```

When we wish to draw your attention to a particular part of a code block, the relevant lines or items are set in bold:

```
FROM golang:latest  
ENV TERRAFORM_VERSION=0.12.29  
RUN apt-get update && apt-get install unzip \  
&& curl -Os
```

Any command-line input or output is written as follows:

```
docker exec tfapp terraform init  
docker exec tfapp terraform plan  
docker exec tfapp terraform apply --auto-approve
```

**Bold:** Indicates a new term, an important word, or words that you see onscreen. For example, words in menus or dialog boxes appear in the text like this. Here is an example: "Do this by clicking on the **Install** button of the extension."

Warnings or important notes appear like this.



Tips and tricks appear like this.



## Get in touch

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# 1

# Setting Up the Terraform Environment

Before you start writing the Terraform configuration file, it is necessary to install and configure a local development environment. This development environment will allow Terraform's configuration file to be written and validated as it is developed.

In the recipes in this chapter, we will learn how to download and install Terraform manually on a Windows machine, as well as how to install it using a script on Windows and Linux. We will also learn how to use Terraform in a Docker container before learning how to migrate the Terraform configuration written in version 0.11 to version 0.13.

In this chapter, we'll cover the following recipes:

- Downloading and installing Terraform manually
- Installing Terraform using a script on Linux
- Installing Terraform using a script on Windows
- Executing Terraform in a Docker container
- Writing Terraform configuration in VS Code
- Migrating your Terraform configuration to Terraform 0.13

Let's get started!

# Technical requirements

This chapter does not require that you have any specific technical knowledge. We will mainly use graphical user interfaces and simple Linux and Windows scripts. However, knowledge of Docker is also recommended so that you can complete the *Executing Terraform in a Docker container* recipe.

Finally, for the IDE, we will use Visual Studio Code, which is available for free at <https://code.visualstudio.com/>.

The source code for this chapter is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP01>.

Check out the following video to see the code in action: <https://bit.ly/3h9noXz>

# Downloading and installing Terraform manually

In this recipe, we will learn how to download and install Terraform on a local machine under a Windows operating system.

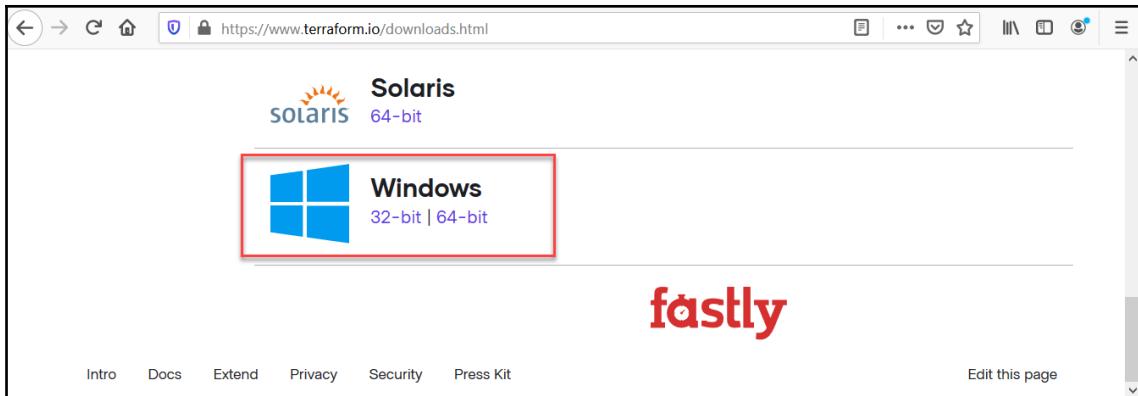
## Getting ready

To complete this recipe, the only prerequisite is that you're on a Windows operating system.

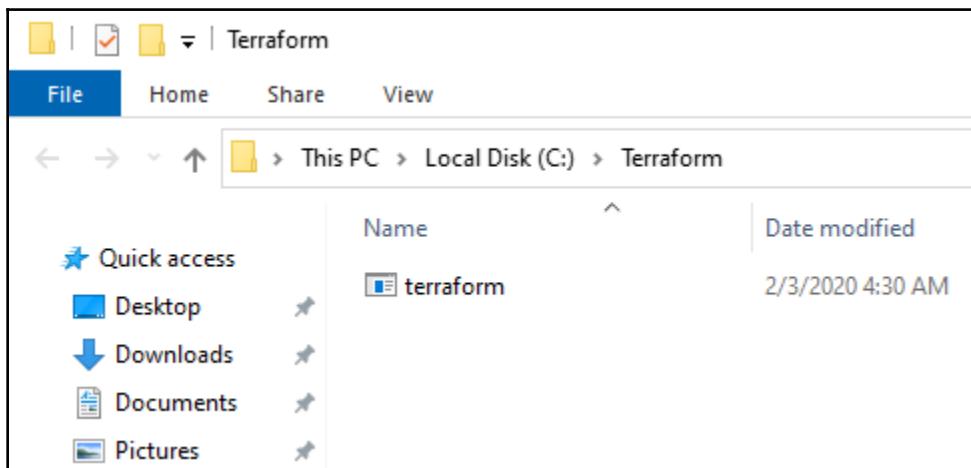
## How to do it...

Perform the following steps:

1. Open Windows File Explorer. Choose a location and create a folder called Terraform. We will use this to store the Terraform binary; for example, C:/Terraform.
2. Launch a web browser and go to <https://www.terraform.io/downloads.html>.
3. Scroll down the page until you reach the package for **Windows**:



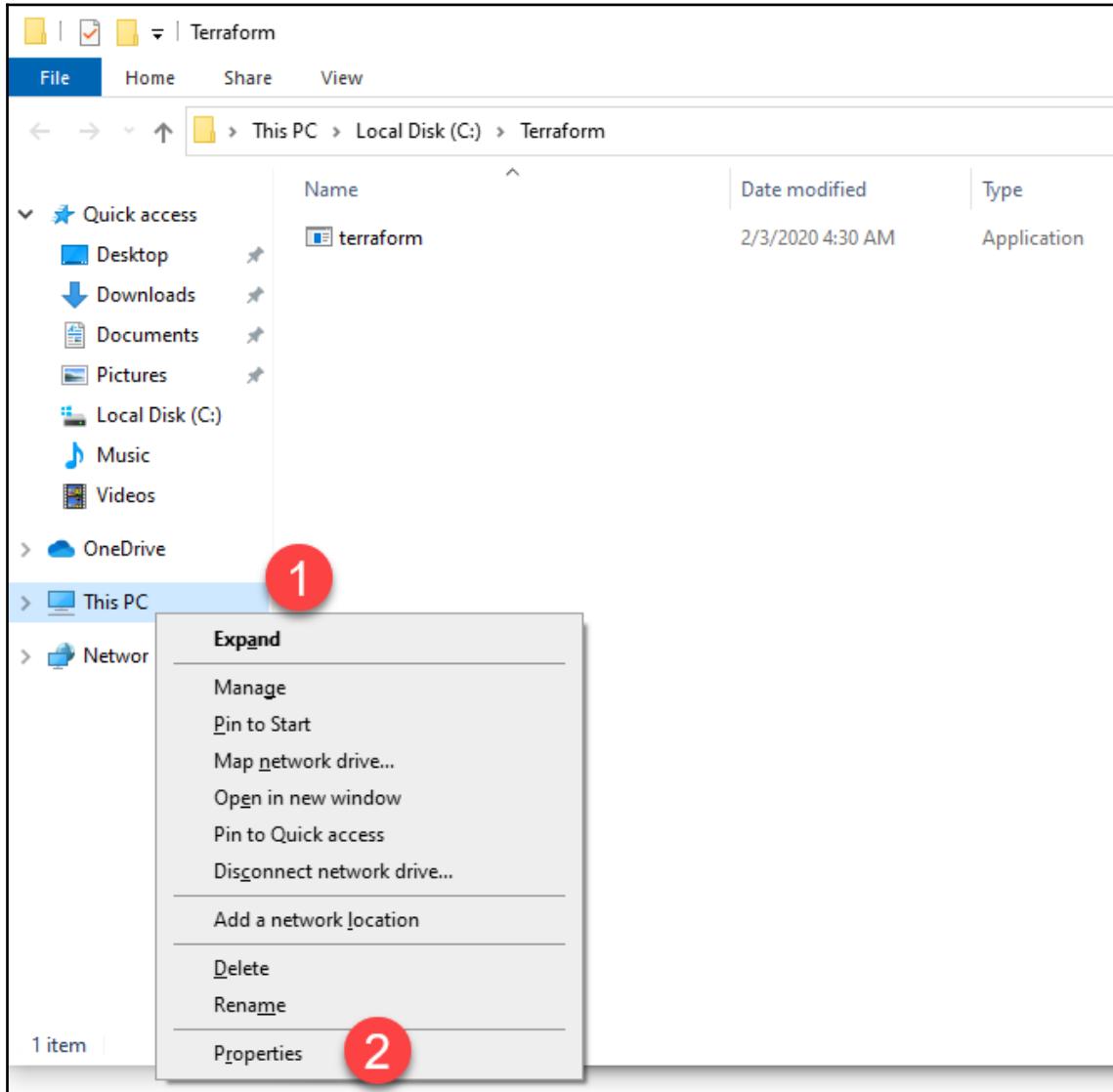
4. Click on the **64-bit** link, which targets the Terraform ZIP package for the Windows 64-bit operating system. The package will be downloaded locally.
5. Unzip the content of the downloaded ZIP file into the `Terraform` folder that we created in *step 1*:



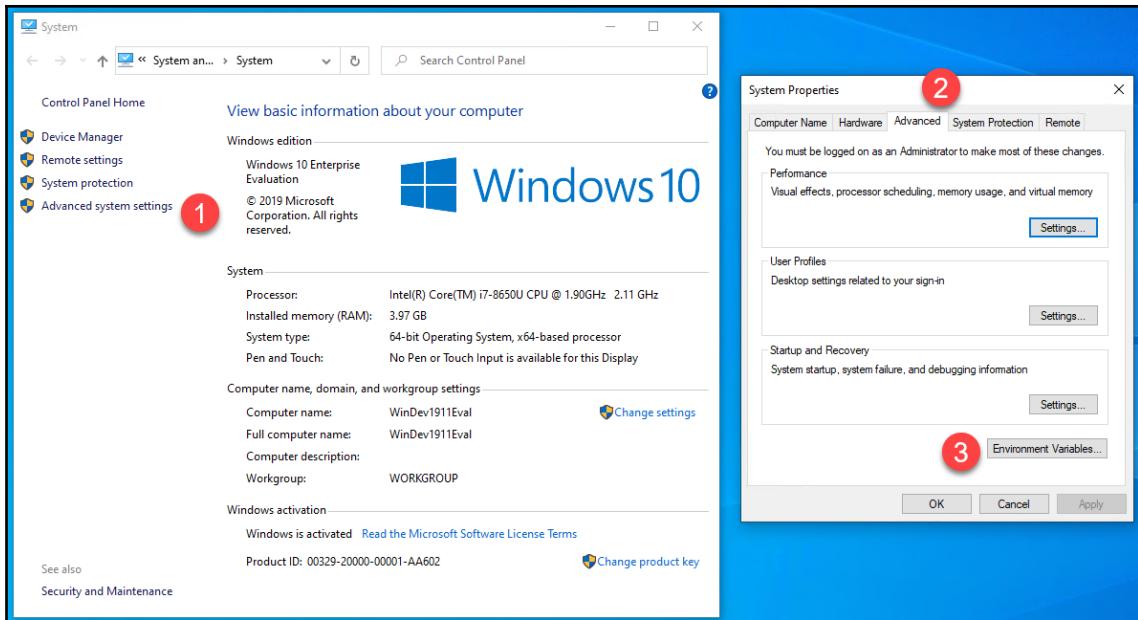
The last thing we need to do to install Terraform is configure the **Path** environment variable by adding the path of the Terraform binary folder.

To do this, follow these steps:

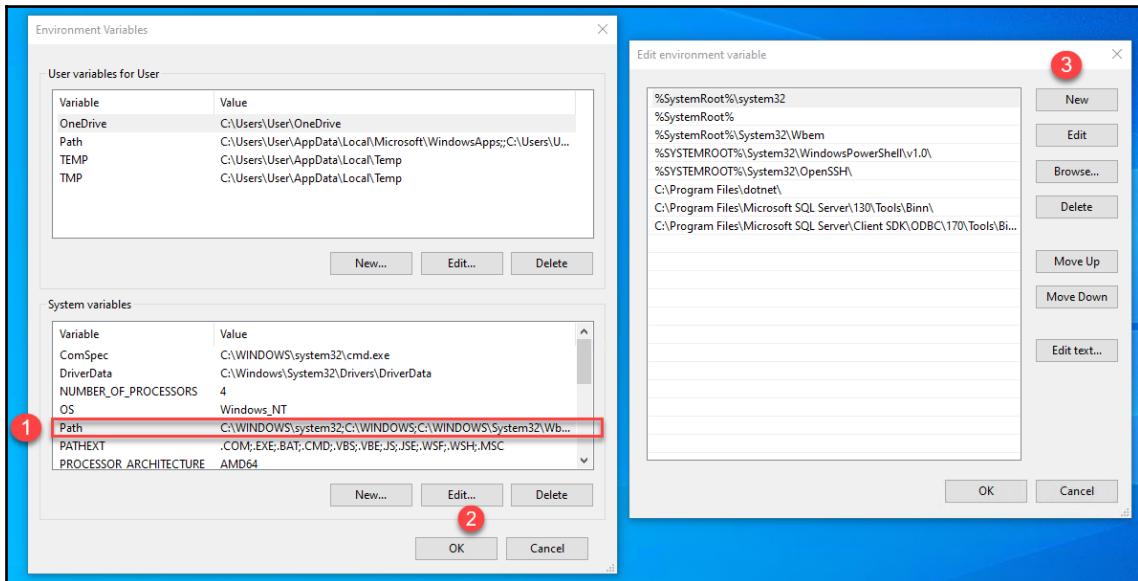
1. In File Explorer, right-click on the **This PC** menu and choose **Properties**:



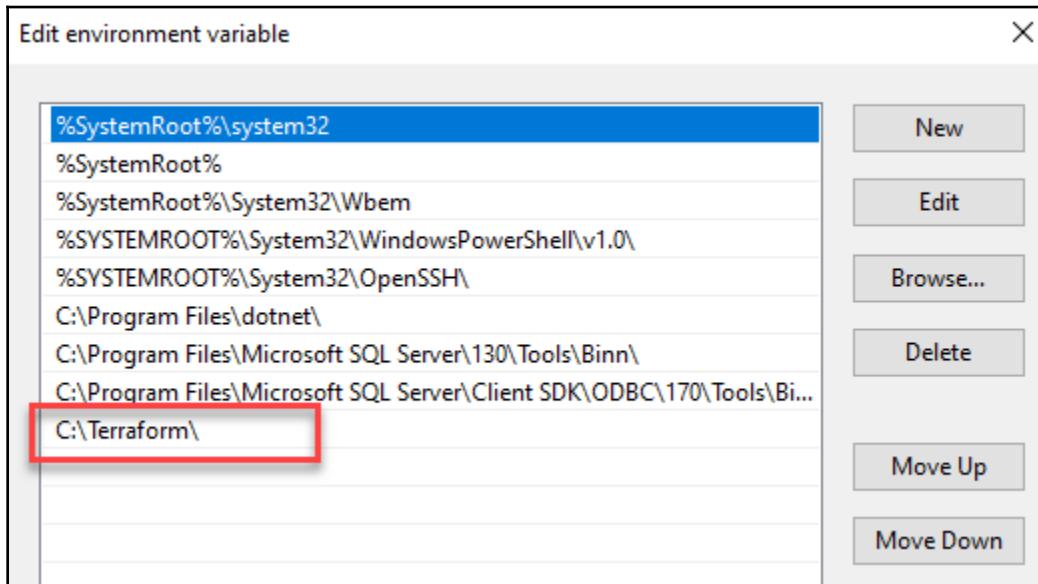
2. Click on the **Advanced system settings** link and click the **Environment variables** button of the newly opened window:



3. When provided with a list of environments, select **User variables** or **Systems variables** (choose this option to apply the environment variable to all users of the workstation), and select the **Path** variable. Then, click on the **Edit** button:



4. From the list of paths, add the folder we created; that is, C:\Terraform\:



Finally, we validate all the open windows by clicking on the **OK** button, which is present at the bottom of every open window.

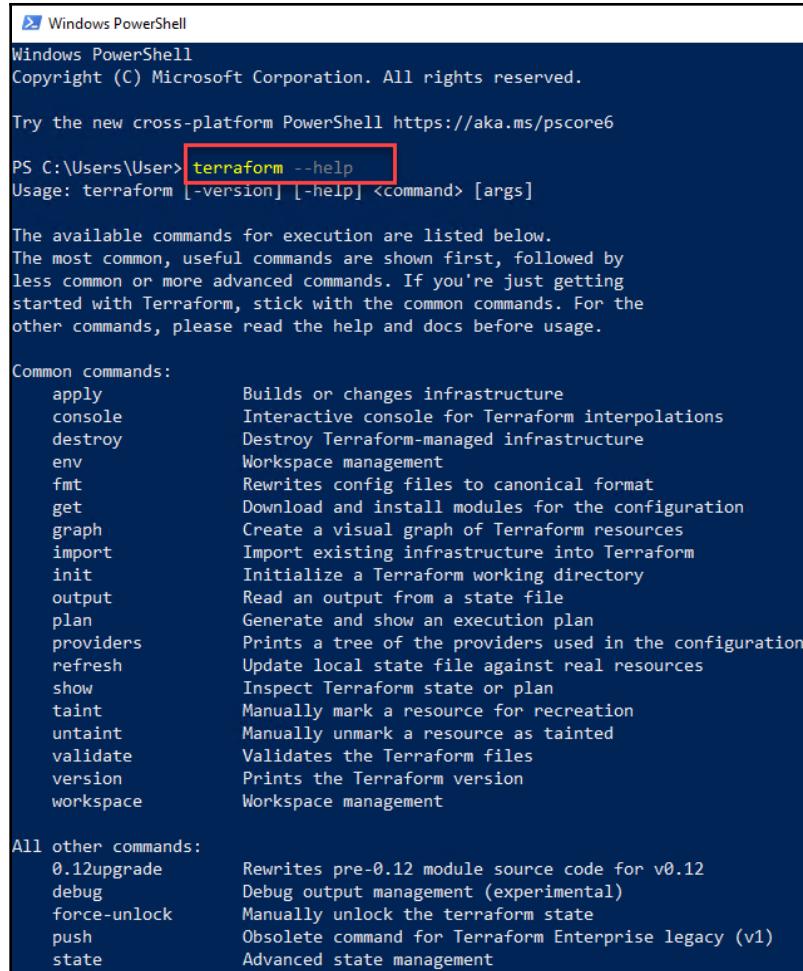
## How it works...

Downloading and installing Terraform is simple, and adding the path of the Terraform binary to the `PATH` environment variable makes it possible to execute the Terraform command line from any terminal location.

After completing all these steps, we can check that Terraform is working properly by opening a command-line terminal or PowerShell and executing the following command:

```
terraform --help
```

The result of executing the preceding command is shown in the following screenshot:



The screenshot shows a Windows PowerShell window. The command `terraform --help` is highlighted with a red box. The output lists various Terraform commands with their descriptions.

```
Windows PowerShell
Copyright (C) Microsoft Corporation. All rights reserved.

Try the new cross-platform PowerShell https://aka.ms/pscore6

PS C:\Users\Users> terraform --help
Usage: terraform [-version] [-help] <Command> [args]

The available commands for execution are listed below.
The most common, useful commands are shown first, followed by
less common or more advanced commands. If you're just getting
started with Terraform, stick with the common commands. For the
other commands, please read the help and docs before usage.

Common commands:
  apply      Builds or changes infrastructure
  console    Interactive console for Terraform interpolations
  destroy    Destroy Terraform-managed infrastructure
  env        Workspace management
  fmt        Rewrites config files to canonical format
  get        Download and install modules for the configuration
  graph     Create a visual graph of Terraform resources
  import    Import existing infrastructure into Terraform
  init      Initialize a Terraform working directory
  output    Read an output from a state file
  plan      Generate and show an execution plan
  providers Prints a tree of the providers used in the configuration
  refresh   Update local state file against real resources
  show      Inspect Terraform state or plan
  taint     Manually mark a resource for recreation
  untaint   Manually unmark a resource as tainted
  validate  Validates the Terraform files
  version   Prints the Terraform version
  workspace Workspace management

All other commands:
  0.12upgrade  Rewrites pre-0.12 module source code for v0.12
  debug       Debug output management (experimental)
  force-unlock Manually unlock the terraform state
  push        Obsolete command for Terraform Enterprise legacy (v1)
  state       Advanced state management
```

By doing this, the list of Terraform commands will be displayed in the terminal.

## Installing Terraform using a script on Linux

In this recipe, we will learn how to install Terraform on a Linux machine using a script.

## Getting ready

To complete this recipe, the only prerequisites are that you are running a Linux operating system and that you have an *unzip* utility installed. The `gpg`, `curl`, and `shasum` tools must be installed; they are often installed by default on all Linux distributions.

## How to do it...

Perform the following steps:

1. Open a command-line terminal and execute the following script:

```
TERRAFORM_VERSION="0.12.29"

curl -Os
https://releases.hashicorp.com/terraform/${TERRAFORM_VERSION}/terra
form_${TERRAFORM_VERSION}_linux_amd64.zip \
&& curl -Os
https://releases.hashicorp.com/terraform/${TERRAFORM_VERSION}/terra
form_${TERRAFORM_VERSION}_SHA256SUMS \
&& curl https://keybase.io/hashicorp/pgp_keys.asc | gpg --import \
&& curl -Os
https://releases.hashicorp.com/terraform/${TERRAFORM_VERSION}/terra
form_${TERRAFORM_VERSION}_SHA256SUMS.sig \
&& gpg --verify terraform_${TERRAFORM_VERSION}_SHA256SUMS.sig
terraform_${TERRAFORM_VERSION}_SHA256SUMS \
&& shasum -a 256 -c terraform_${TERRAFORM_VERSION}_SHA256SUMS 2>&1
| grep "${TERRAFORM_VERSION}_linux_amd64.zip:\$OK" \
&& unzip -o terraform_${TERRAFORM_VERSION}_linux_amd64.zip -d
/usr/local/bin
```



The source code for this script is also available in this book's GitHub repository: [https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP01/install\\_terraform\\_linux.sh](https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP01/install_terraform_linux.sh)

2. After executing this script, we can check the installation of Terraform by executing the following command:

```
terraform --version
```

The preceding command displays the installed version of Terraform, which means we can check that Terraform is correctly installed and that the desired version is installed.

## How it works...

In this script, in the first line, the `TERRAFORM_VERSION` variable is filled in with the Terraform version that we want to install. This variable is only mentioned here since we don't want to keep repeating the version of Terraform we're using throughout the script.



In this recipe, the 0.12.29 version of Terraform is used, but we are free to modify this.

With the `curl` tool, the script downloads the ZIP file containing the Terraform binary. Then, the script checks the security integrity of the packaged. This is called `shasum`.

In the last line, the script unzips the downloaded package inside the local directory, `/usr/local/bin`, which is already mentioned by default in the `PATH` environment variable.

You can check that the version of Terraform you have installed corresponds to the one mentioned in the script by executing the following command:

```
terraform --version
```

This command displays the installed version of Terraform, as shown in the following screenshot:

```
root@LP-FYLZ2X2:/mnt/c/Users/mkrief# terraform --version
Terraform v0.12.29
```

As we can see, here, the version of Terraform we have is 0.12.29.

## There's more...

In this Terraform installation script, we have specified the version number of Terraform to be installed.

If you want to install the latest version without having to know the version number, it is also possible to dynamically retrieve the version number of the latest version using the following API: <https://checkpoint-api.hashicorp.com/v1/check/terraform>. This retrieves information about the current version of Terraform.

The following screenshot shows our current version:



Note that the `current_version` property, which contains the latest Terraform version, is a value.

With this API, we can perfectly modify the first line of the installation script with the following code:

```
TERRAFORM_VERSION=$(curl -s
https://checkpoint-api.hashicorp.com/v1/check/terraform | jq -r
.current_version)

....
```

The complete script for installing Terraform with this block is available at [https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP01/install\\_terraform\\_linux\\_v2.sh](https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP01/install_terraform_linux_v2.sh).

This block of code uses the `curl` command to retrieve the API return and parses its contents to retrieve the value of the `current_version` property with the `jq` tool (available at <https://stedolan.github.io/jq/>).

In addition, the `terraform --version` command shows whether the latest version is installed. If you have installed an old version, this command displays a message indicating the latest version:

```
PS C:\Users\mkrief> terraform --version
Terraform v0.12.28

Your version of Terraform is out of date! The latest version
is 0.12.29. You can update by downloading from https://www.terraform.io/downloads.html
```

Here, we can see that we have installed version 0.12.28 and that the latest version is 0.12.29 (at the time of writing this recipe).

Finally, HashiCorp announced that the Terraform binary will soon be available in the Linux package manager. For more information, take a look at the following article: <https://www.hashicorp.com/blog/announcing-the-hashicorp-linux-repository>

## See also

For more information on verifying the downloaded package, you can consult the HashiCorp documentation at <https://www.hashicorp.com/security.html>.

# Installing Terraform using a script on Windows

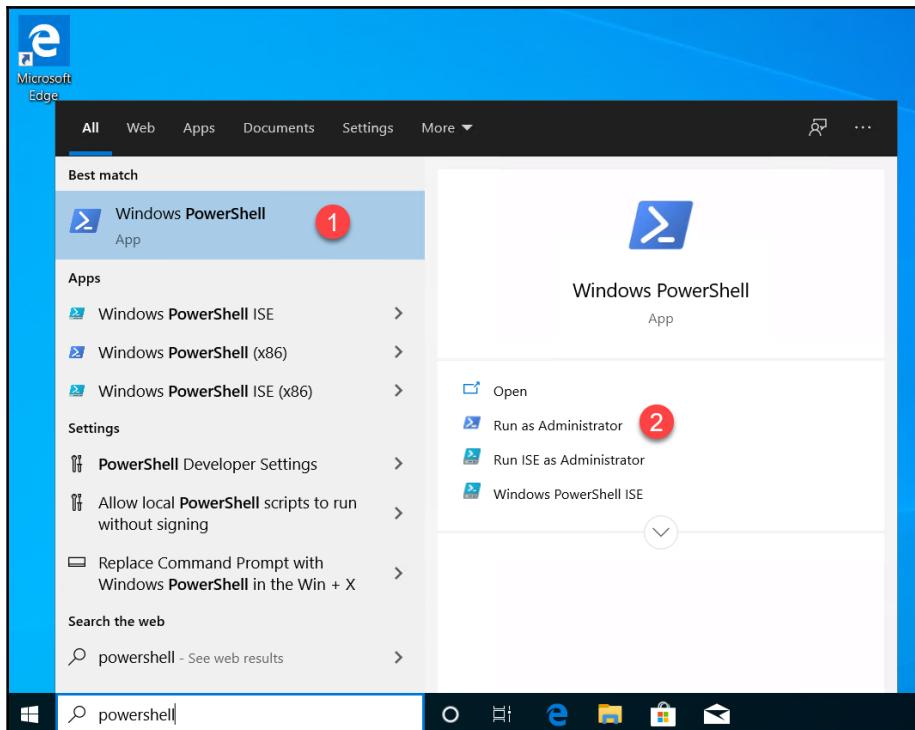
In this recipe, we will learn how to install Terraform on a Windows machine using a script that uses the **Chocolatey** software package manager.

## Getting ready

To complete this recipe, you'll need to be using a Windows operating system and have Chocolatey (<https://chocolatey.org/>) installed, which is a Windows software package manager.

If you don't have Chocolatey installed, you can easily install it by following these steps:

1. Open a PowerShell terminal in administrator mode, as shown in the following screenshot:



2. Then, execute this following script in the terminal:

```
Set-ExecutionPolicy Bypass -Scope Process -Force;
[System.Net.ServicePointManager]::SecurityProtocol =
[System.Net.ServicePointManager]::SecurityProtocol -bor 3072; iex
((New-Object
System.Net.WebClient).DownloadString('https://chocolatey.org/install
1.ps1'))
```

The complete installation documentation for Chocolatey is available at  
<https://chocolatey.org/install>.



## How to do it...

Perform the following steps:

1. Open a PowerShell command-line terminal in administrator mode.
2. Execute the following command:

```
choco install -y terraform
```

The following screenshot shows the execution of this command:

A screenshot of a Windows PowerShell window titled "Administrator: Windows PowerShell". The command "choco install -y terraform" is being run. The output shows Chocolatey v0.18.15 installing Terraform v0.12.20. It details the download of the Terraform ZIP file from https://releases.hashicorp.com/terraform/0.12.20/terraform\_0.12.20\_windows\_amd64.zip, its extraction to C:\ProgramData\chocolatey\lib\terraform\tools, and the creation of a shim for terraform.exe. The process is completed successfully.

```
PS C:\Users\mikael> choco install -y terraform
Chocolatey v0.18.15
Installing the following packages:
terraform
By installing you accept licenses for the packages.
Progress: Downloading terraform 0.12.20... 100%
terraform v0.12.20 [Approved]
Terraform package files install completed. Performing other installation steps.
Removing old terraform plugins
Downloading terraform 64 bit
  from 'https://releases.hashicorp.com/terraform/0.12.20/terraform_0.12.20_windows_amd64.zip'
Progress: 100% - Completed download of C:\Users\mikael\AppData\Local\Temp\chocolatey\terraform\0.12.20\terraform_0.12.20_windows_amd64.zip (15.47 MB).
Download of terraform_0.12.20_windows_amd64.zip (15.47 MB) completed.
Hashes match.
Extracting C:\Users\mikael\AppData\Local\Temp\chocolatey\terraform\0.12.20\terraform_0.12.20_windows_amd64.zip to C:\ProgramData\chocolatey\lib\terraform\tools...
C:\ProgramData\chocolatey\lib\terraform\tools
  ShimGen has successfully created a shim for terraform.exe
  The install of terraform was successful.
  Software installed to 'C:\ProgramData\chocolatey\lib\terraform\tools'

Chocolatey installed 1/1 packages.
See the log for details (C:\ProgramData\chocolatey\logs\chocolatey.log).

Enjoy using Chocolatey? Explore more amazing features to take your
experience to the next level at
  https://chocolatey.org/compare
```

The `-y` option is optional. It allows us to accept the license agreement automatically.

## How it works...

When Chocolatey installs the Terraform package, it executes the scripts in the package source code, available at <https://github.com/jamestoyer/chocolatey-packages/tree/master/terraform>.

Then, by executing the script available at <https://github.com/jamestoyer/chocolatey-packages/blob/master/terraform/tools/chocolateyInstall.ps1>, Chocolatey downloads the Terraform ZIP file into the binary directory of Chocolatey's packages, which is already included in the PATH environment variable.

## There's more...

When upgrading Terraform, it is possible to upgrade it directly with Chocolatey by executing the `choco upgrade -y terraform` command.

By default, the `choco install` command installs the latest version of the mentioned package. It is also possible to specify a specific version by adding the `--version` option to the command, which in our case would give us, for example, the following:

```
choco install -y terraform --version "0.12.28"
```

In this example, we have specified that we want to install version `0.12.28` of Terraform and not the latest version.



Be aware that the Terraform package from Chocolatey can have a time lag regarding the latest official version of Terraform, while in the Linux script, as shown in the *Installing Terraform on Linux* recipe, you can specify the latest version that has just been released.

## See also

To learn about all the commands provided with Chocolatey, I suggest reading the following documentation: <https://chocolatey.org/docs/commands#commands>

## Executing Terraform in a Docker container

In the previous recipes of this chapter, we discussed how to install Terraform locally, either manually or via a script, depending on the local operating system.

In this recipe, we will learn how to run Terraform in a Docker container, which will allow us to enjoy the following benefits:

- There is no need to install Terraform locally.
- We can have a Terraform runtime environment independent of the local operating system.
- We can test our Terraform configuration with different versions of Terraform.

Let's get started!

## Getting ready

To complete this recipe, you'll need to know about Docker and its commands, as well as how to write Dockerfiles. Please read the documentation for more information: <https://docs.docker.com/get-started/overview/>

On our local computer, we installed Docker using a tool called Docker Desktop for Windows.



For Docker installation guides for other operating systems, please read the Docker installation documentation at <https://docs.docker.com/get-docker/>.

We also have a Terraform configuration file already written, which will not be detailed here. This will be executed in our Docker container.

You will also need the respective Terraform commands, `init`, `plan`, and `apply`, which will not be explained in the context of this recipe.

## How to do it...

Perform the following steps:

1. At the root of the folder that contains the Terraform configuration, we need to create a Dockerfile that contains the following code:

```
FROM golang:latest
ENV TERRAFORM_VERSION=0.13.0
RUN apt-get update && apt-get install unzip \
&& curl -Os
https://releases.hashicorp.com/terraform/${TERRAFORM_VERSION}/terra
form_${TERRAFORM_VERSION}_linux_amd64.zip \
&& curl -Os
https://releases.hashicorp.com/terraform/${TERRAFORM_VERSION}/terra
form_${TERRAFORM_VERSION}_SHA256SUMS \
&& curl https://keybase.io/hashicorp/pgp_keys.asc | gpg --
import \    && curl -Os
https://releases.hashicorp.com/terraform/${TERRAFORM_VERSION}/terra
form_${TERRAFORM_VERSION}_SHA256SUMS.sig \
&& gpg --verify terraform_${TERRAFORM_VERSION}_SHA256SUMS.sig
terraform_${TERRAFORM_VERSION}_SHA256SUMS \
&& shasum -a 256 c terraform_${TERRAFORM_VERSION}_SHA256SUMS
2>&1 | grep "${TERRAFORM_VERSION}_linux_amd64.zip:\sOK" \
```

```
&& unzip -o terraform_${TERRAFORM_VERSION}_linux_amd64.zip -d  
/usr/bin  
RUN mkdir /tfcode  
COPY . /tfcode  
WORKDIR /tfcode
```



This source code is also available at <https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP01/terraform-docker/Dockerfile>.

2. Next, we need to create a new Docker image by executing the `docker build` command in a terminal:

```
docker build -t terraform-code:v1.0 .
```

3. Then, we need to instantiate a new container of this image. To do this, we will execute the `docker run` command:

```
docker run -it -d --name tfapp terraform-code:v1.0 /bin/bash
```

4. Now, we can execute the Terraform commands in our container by using the following commands:

```
docker exec tfapp terraform init  
docker exec tfapp terraform plan  
docker exec tfapp terraform apply --auto-approve
```

The following screenshot shows a part of the output of executing these commands (`terraform plan`):

```
mcrief@LP-FYLZ2X2 MINGW64 /c/Program Files/Docker Toolbox
$ docker exec tfapp terraform plan
Refreshing Terraform state in-memory prior to plan...
The refreshed state will be used to calculate this plan, but will not be
persisted to local or remote state storage.

An execution plan has been generated and is shown below.
Resource actions are indicated with the following symbols:
+ create

Terraform will perform the following actions:

# random_string.random will be created
+ resource "random_string" "random" {
    + id      = (known after apply)
    + length  = 16
    + lower   = true
    + min_lower = 0
    + min_numeric = 0
    + min_special = 0
    + min_upper = 0
    + number   = true
    + result   = (known after apply)
    + special   = true
    + upper   = true
}

Plan: 1 to add, 0 to change, 0 to destroy.
```

## How it works...

In *step 1*, we write the composition of the Docker image in the Dockerfile. We do this as follows:

1. We use a Golang base image.
2. We initialize the `TERRAFORM_VERSION` variable with the version of Terraform to be installed.
3. We write the same Terraform installation script we wrote in the *Installing Terraform on Linux* recipe.
4. We copy the Terraform configuration from our local file into a new folder located in the image.
5. We specify that our workspace will be our new folder.

Then, in *steps 2 and 3*, we create a Docker `terraform-code` image with a `v1.0` tag. This tag is used to version our Terraform configuration. Then, we create a `tfapp` instance of this image, which runs with the `bash` tool.

Finally, in *step 4*, in the `tfapp` instance, we execute the Terraform commands in our container workspace.

## There's more...

In this recipe, we studied how to write, build, and use a Docker image that contains the Terraform binary. With this, it is possible to complete this image with other tools such as **Terragrunt**, which are also used to develop the Terraform configuration file.

If you want to use just Terraform, you can use the official image provided by HashiCorp. This is public and available on Docker Hub at <https://hub.docker.com/r/hashicorp/terraform/>.

## See also

- The full Docker commands documentation at <https://docs.docker.com/engine/reference/run/>.
- For an introduction to Docker, please refer to the book *Learning DevOps*, which is available at <https://www.packtpub.com/cloud-networking/learning-devops>.

## Writing Terraform configuration in VS Code

Writing a Terraform configuration file does not require a special code editor. However, popular code editors have adapted and now offer plugins that simplify writing such a file.

In this recipe, we will focus on Visual Studio Code, which has the following benefits:

- It's cross-platform, which means it can be installed on Windows, Linux, and macOS.
- It's free of charge.
- It has a multitude of extensions that cover all the needs of developers on a daily basis.

In this recipe, we will learn how to configure Visual Studio Code so that we can write the Terraform configuration. We'll also see how much faster it is to write code in this way.

## Getting ready

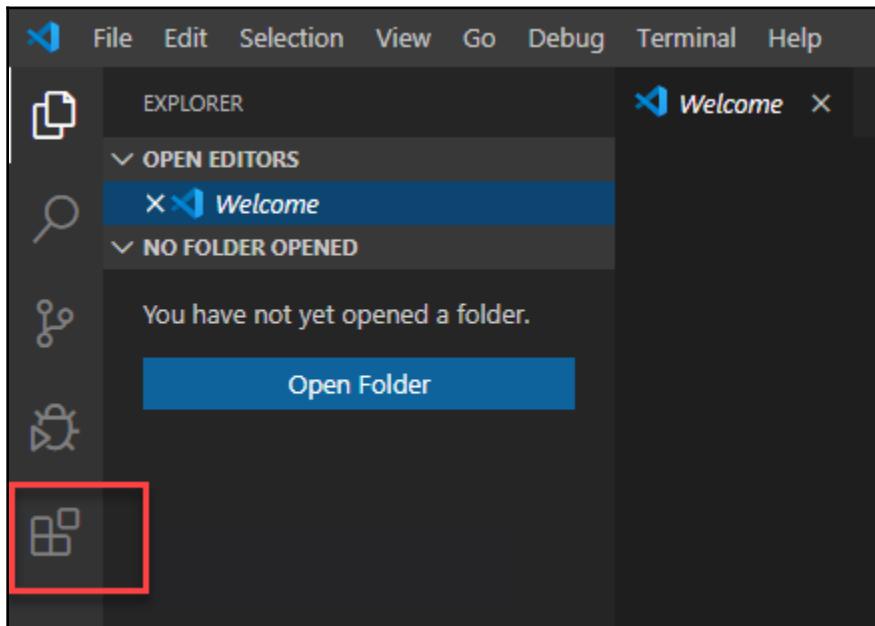
For this recipe, you need to have Visual Studio Code installed on your local machine. You can install it by going to <https://code.visualstudio.com/>.

## How to do it...

To use Visual Studio Code with Terraform, we need to install the respective extension and configure it.

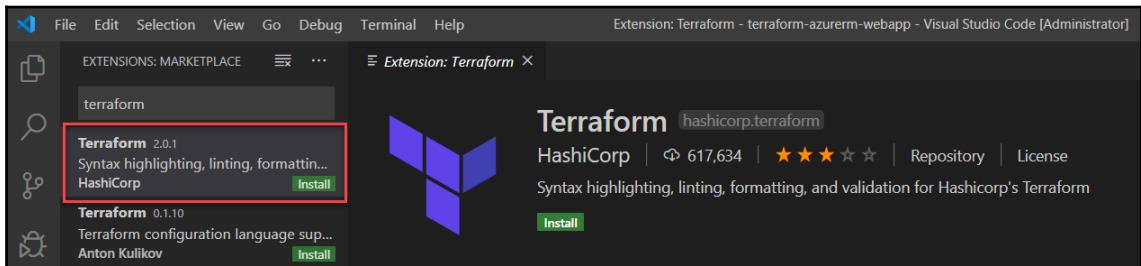
To install this extension, perform the following steps:

1. Open Visual Studio Code and click on the extension tab. This can be found on the sidebar, on the left-hand side of the editor, as shown in the following screenshot:



2. Then, we search for the extension by using the `Terraform` keyword.

3. Install the first extension of the list, called **Terraform**. This is published by *HashiCorp*. Do this by clicking on the **Install** button of the extension:



4. Reload Visual Studio Code to apply the extension.

## How it works...

In the first part of this recipe, we installed the Terraform extension for Visual Studio Code.



When searching for Terraform extensions, several will appear, but the one we chose is one of the most powerful in my opinion.

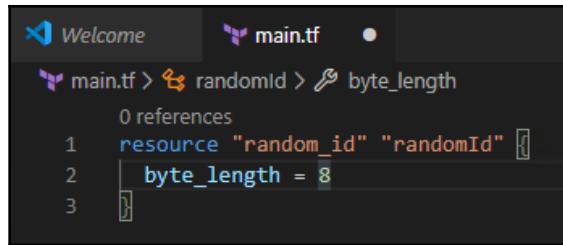
Once installed, this extension offers a lot of functionalities for editing Terraform's configuration, such as autocompletion, validating the configuration, syntax for `tflint`, code formatting, links to the official documentation, and a module explorer.

This component allows Visual Studio Code to function better with Terraform 0.12 – at least when it comes to the extension's functionalities.

## There's more...

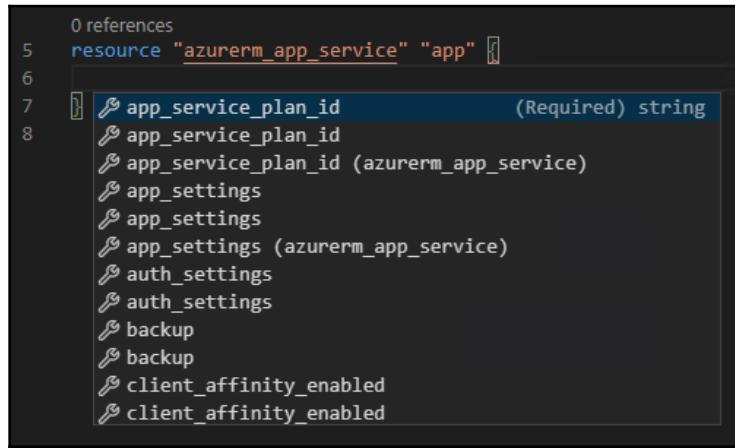
Once the extension has been installed and configured, we can write the Terraform configuration in our `main.tf` file. Here, we have some very useful features we can use to develop the Terraform configuration, some of which are as follows:

- Syntax highlighting:



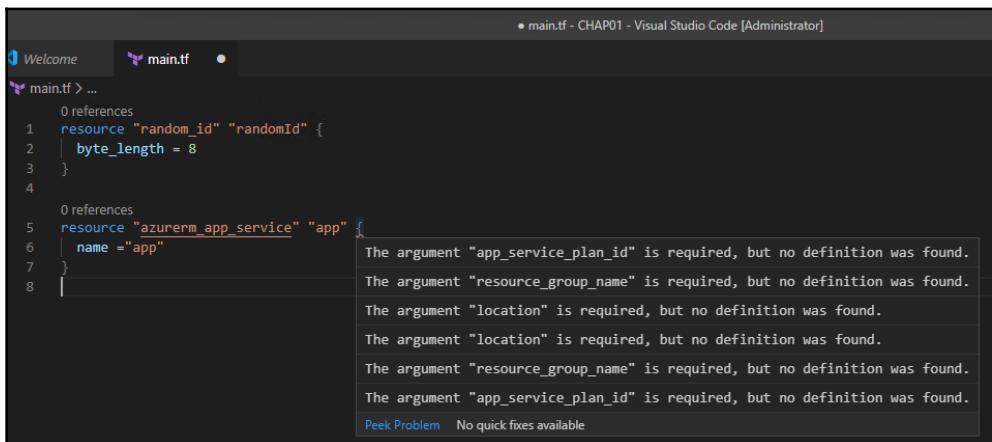
A screenshot of Visual Studio Code showing a code editor with a dark theme. The file is named 'main.tf'. The cursor is on the line 'byte\_length = 8'. A code completion dropdown is open, listing properties for a 'random\_id' resource: 'app\_service\_plan\_id', 'app\_settings', 'auth\_settings', 'backup', 'client\_affinity\_enabled', and 'location'. The 'app\_service\_plan\_id' option is highlighted.

- Autocompletion for resources and properties:



A screenshot of Visual Studio Code showing a code editor with a dark theme. The file is named 'main.tf'. The cursor is on the line 'resource "azurerm\_app\_service" "app"'. A code completion dropdown is open, listing properties for an 'azurerm\_app\_service' resource: 'app\_service\_plan\_id', 'app\_settings', 'auth\_settings', 'backup', 'client\_affinity\_enabled', and 'location'. The 'app\_service\_plan\_id' option is highlighted. Below the code editor, a tooltip provides validation errors for the 'app' resource: 'The argument "app\_service\_plan\_id" is required, but no definition was found.' and 'The argument "resource\_group\_name" is required, but no definition was found.'

- Real-time code validation:



A screenshot of Visual Studio Code showing a code editor with a dark theme. The file is named 'main.tf'. The cursor is on the line 'resource "azurerm\_app\_service" "app"'. A code completion dropdown is open, listing properties for an 'azurerm\_app\_service' resource: 'app\_service\_plan\_id', 'app\_settings', 'auth\_settings', 'backup', 'client\_affinity\_enabled', and 'location'. The 'app\_service\_plan\_id' option is highlighted. Below the code editor, a tooltip provides validation errors for the 'app' resource: 'The argument "app\_service\_plan\_id" is required, but no definition was found.' and 'The argument "resource\_group\_name" is required, but no definition was found.'

- The ability to display the number of references, along with a link to view them:



```
main.tf > ...
1 references
1   resource "random_id" "randomId" {
2     byte_length = 8
3   }
4
5   0 references
6   resource "azurerm_app_service" "app" {
7     name = "app${random_id.randomId.hex}"
8   }
```

## See also

- To see the complete list of features for this extension, please refer to the following documentation: <https://marketplace.visualstudio.com/items?itemName=HashiCorp.terraform>, and its change log: <https://marketplace.visualstudio.com/items/HashiCorp.terraform/changelog>.
- All Visual Studio Code extensions related to Terraform can be found at <https://marketplace.visualstudio.com/search?term=terraform&target=VSCode&category=All%20categories&sortBy=Relevance>.
- To read more about the support provided for this extension by HashiCorp, please go to <https://www.hashicorp.com/blog/supporting-the-hashicorp-terraform-extension-for-visual-studio-code/>.

## Migrating your Terraform configuration to Terraform 0.13

Officially released in May 2019, version 0.12 of Terraform has brought many new features to the language, but also changes, and during this summer 2020, the new Terraform version 0.13 has been released, also providing new features and some changes.

We must take these changes into account before we upgrade the code.

In this recipe, we will discuss how to verify that our Terraform configuration is compatible with version 0.12. After that, we will learn how to migrate our Terraform configuration from version 0.11 to version 0.12 and then to version 0.13.

## Getting ready

Before migrating your code from version 0.11 to the latest version (currently 0.13), you will need to have code that works with the latest version of Terraform 0.11, which is 0.11.14. You can download this version from <https://releases.hashicorp.com/terraform/0.11.14/>.

It is important to know that if your Terraform configuration is in version 0.11, it is not possible to migrate it directly to 0.13. You will first have to upgrade to 0.12 and then migrate to 0.13.

In addition, before any migration, it is strongly advised to read the upgrade documentation provided by HashiCorp (here for 0.12, <https://www.terraform.io/upgrade-guides/0-12.html>, and here for 0.13, <https://github.com/hashicorp/terraform/blob/master/website/upgrade-guides/0-13.html.markdown>). This is because in the upgrade process, as we will study in this recipe, many elements are migrated automatically, but others will have to be done manually.

Finally, it is also recommended by HashiCorp, before performing the migration process, to commit its code in a source code manager (for example, Git) in order to be able to visualize the code changes brought by the migration.

The code source (version 0.11) used for this recipe is available here: <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP01/tf011>

## How to do it...

The upgrade of the Terraform configuration from version 0.11 to version 0.13 takes place in two steps, First the code has to be migrated to 0.12, and then be migrated to 0.13.

To migrate our Terraform configuration from version 0.11 to version 0.12, perform the following steps:

Before migrating this configuration to version 0.12, we must verify that it is compatible with this version. To do this, follow these steps:

1. Using Terraform 0.11.14, in a terminal, execute the following command:

```
terraform 0.12checklist
```

The following screenshot shows the output of executing the preceding command:

```
Administrator: Windows PowerShell
PS C:\Users\mikael\Documents\terraform-cookbook\CHAP01\terraform_simple_script> terraform 0.12checklist
Looks good! We did not detect any problems that ought to be addressed before upgrading to Terraform v0.12.
This tool is not perfect though, so please check the v0.12 upgrade guide for additional guidance, and for next steps:
  https://www.terraform.io/upgrade-guides/0-12.html
```

As we can see, our Terraform configuration is compatible with Terraform version 0.12. Now, we can migrate it.

2. Next, we need to install the latest version of Terraform 0.12 manually, as described in the *Downloading and installing Terraform manually* recipe. We can also do this via a script, according to our operating system, as shown in the *Installing Terraform on Linux* and *Installing Terraform using a script on Windows* recipes.
3. In the folder that contains our code, we execute the `init` command:

```
terraform init
```

4. Then, we execute the following command:

```
terraform 0.12upgrade
```

5. Finally, we confirm the migration by answering `yes` when prompted to enter a value, as shown in the following screenshot:

```
PS C:\Terraform-Cookbook\CHAP01\tf011> terraform 0.12upgrade
This command will rewrite the configuration files in the given directory so
that they use the new syntax features from Terraform v0.12, and will identify
any constructs that may need to be adjusted for correct operation with
Terraform v0.12.

We recommend using this command in a clean version control work tree, so that
you can easily see the proposed changes as a diff against the latest commit.
If you have uncommitted changes already present, we recommend aborting this
command and dealing with them before running this command again.

Would you like to upgrade the module in the current directory?
Only 'yes' will be accepted to confirm.

Enter a value: yes
-----
Upgrade complete!

The configuration files were upgraded successfully. Use your version control
system to review the proposed changes, make any necessary adjustments, and
then commit.
```

Then, to migrate our Terraform configuration from version 0.12 to version 0.13, perform the following steps:

1. Download and install the latest version of Terraform 0.13.
2. Exactly as before for 0.12, run the `terraform 0.13upgrade` command to upgrade the configuration to 0.13:

```
PS C:\Terraform-Cookbook\CHAP01\tf011> terraform.exe 0.13upgrade
This command will update the configuration files in the given directory to use
the new provider source features from Terraform v0.13. It will also highlight
any providers for which the source cannot be detected, and advise how to
proceed.

We recommend using this command in a clean version control work tree, so that
you can easily see the proposed changes as a diff against the latest commit.
If you have uncommitted changes already present, we recommend aborting this
command and dealing with them before running this command again.

Would you like to upgrade the module in the current directory?
Only 'yes' will be accepted to confirm.

Enter a value: yes
-----
Upgrade complete!

Use your version control system to review the proposed changes, make any
necessary adjustments, and then commit.
```

## How it works...

In *step 1*, we verified that our Terraform configuration is compatible with the language evolution (HCL 2) included in Terraform 0.12.

Then, we installed Terraform 0.12 locally and started the migration process by executing the `terraform init` command, which is necessary to download the different providers that will be called in our code.

We migrated the Terraform configuration to the 0.12 version using the `terraform 0.12upgrade` command, which upgrades the Terraform configuration directly.

Finally, to upgrade the Terraform configuration to the 0.13 version, we installed the Terraform 0.13 binary and executed the command `terraform 0.13upgrade`.

## There's more...

Please note that the migration procedure only changes the current Terraform configuration. If our Terraform configuration calls for modules, it is necessary to migrate the code of the modules beforehand.

## See also

For more information on the migration procedure for Terraform to version 0.12, please refer to the technical documentation at <https://www.terraform.io/upgrade-guides/0-12.html>.

To find out more about the evolution of Terraform and the changes that were made in this new major version, take a look at the following documentation and related articles:

- <https://www.hashicorp.com/resources/a-2nd-tour-of-terraform-0-12>
- <https://www.hashicorp.com/blog/announcing-terraform-0-12/>

Finally, the following is the official repository for Terraform: <https://github.com/hashicorp/terraform-guides/tree/master/infrastructure-as-code/terraform-0.12-examples>. It contains multiple code examples for Terraform 0.12, all of which we will look at throughout this book.

Regarding the Terraform 0.13, the upgrade guide is available here – <https://github.com/hashicorp/terraform/blob/master/website/upgrade-guides/0-13.html.markdown>, and the change log is available here – <https://github.com/hashicorp/terraform/blob/master/CHANGELOG.md>.

# 2

# Writing Terraform Configuration

When you start writing Terraform configuration, you will notice very quickly that the language provided by Terraform is very rich and allows for a lot of manipulation.

In the recipes in this chapter, you will learn how to use the Terraform language effectively in order to apply it to real-life business scenarios. We will discuss how to specify the versions of the provider to be used, as well as how to make the code more dynamic with variables and outputs. Then, we will use these concepts to provision several environments with Terraform. After that, we will consider the use of functions and conditions.

We will also learn how to retrieve data from external systems with data blocks, other Terraform state files, and external resources. Finally, we will cover the use of Terraform for local operations, such as running a local executable and manipulating local files.

In this chapter, we will cover the following recipes:

- Configuring Terraform and the provider version to use
- Manipulating variables
- Using local variables for custom functions
- Using outputs to expose Terraform provisioned data
- Provisioning infrastructure in multiple environments
- Obtaining external data with data sources
- Using external resources from other state files
- Querying external data with Terraform
- Calling Terraform built-in functions
- Writing conditional expressions
- Manipulating local files with Terraform
- Executing local programs with Terraform
- Generating passwords with Terraform

Let's get started!

## Technical requirements

For this chapter, you will need to have the Terraform binary installed on your computer. The source code for this chapter is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP02>.

Check out the following video to see the code in action: <https://bit.ly/3hcZNVR>

## Configuring Terraform and the provider version to use

The default behavior of Terraform is that, when executing the `terraform init` command, the version of the Terraform binary (which we will call the **Command-Line Interface (CLI)**, as explained here: <https://www.terraform.io/docs/glossary.html#cli>) used is the one installed on the local workstation. In addition, this command downloads the latest version of the providers used in the code.

However, for compatibility reasons, it is always advisable to avoid surprises so that you can specify which version of the Terraform binary is going to be used in the Terraform configuration. The following are some examples:

- A Terraform configuration written with HCL 2 must indicate that it has to be executed with a Terraform version greater than or equal to 0.12.
- A Terraform configuration that contains new features such as `count` and `for_each` in modules must indicate that it has to be executed with a Terraform version greater than or equal to 0.13.



For more details about the HCL syntax, read the documentation at <https://www.terraform.io/docs/configuration/syntax.html>.

In the same vein and for the same reasons of compatibility, we may want to specify the provider version to be used.

In this recipe, we will learn how to specify the Terraform version, as well as the provider version.

## Getting ready

To start this recipe, we will write a basic Terraform configuration file that contains the following code:

```
variable "resource_group_name" {
  default = "rg_test"
}

resource "azurerm_resource_group" "rg" {
  name        = var.resource_group_name
  location    = "West Europe"
}

resource "azurerm_public_ip" "pip" {
  name          = "bookip"
  location      = "West Europe"
  resource_group_name = azurerm_resource_group.rg.name
  public_ip_address_allocation = "Dynamic"
  domain_name_label       = "bookdevops"
}
```

This example code provides resources in Azure (a Resource Group and a public IP address). For more details, read the following documentation about the Terraform AzureRM provider: <https://www.terraform.io/docs/providers/azurerm/index.html>



In addition, this code contains the improvements that were made to the HCL 2.0 language since Terraform 0.12. For more details about these HCL enhancements, go to <https://www.slideshare.net/mitchp/terraform-012-deep-dive-hcl-2-0-for-infrastructure-as-code-remote-plan-apply-125837028>.

Finally, when executing the `terraform plan` command inside this code, we get the following warning message:

```
PS C:\terrafrom-Cookbook\CHAP02> terraform plan
Refreshing Terraform state in-memory prior to plan...
The refreshed state will be used to calculate this plan, but will not be
persisted to local or remote state storage.

-----
Warning: "public_ip_address_allocation": [DEPRECATED] this property has been deprecated in favor of `allocation_method`
to better match the api

on specific-version.tf line 24, in resource "azurerm_public_ip" "pip":
  24: resource "azurerm_public_ip" "pip" {
```

This means that, currently, this Terraform configuration is still compatible with the latest version of the provider but that in a future version of the provider, this property will be changed and therefore this code will no longer work.

Now, let's discuss the steps we need to follow to make the following compliances:

- This configuration can only be executed if Terraform 0.13 (at least) is installed on the local computer.
- Our current configuration can be executed even if the azurerm provider evolves with breaking changes.



Regarding the new features provided by Terraform 0.13, read the change log here – <https://github.com/hashicorp/terraform/blob/master/CHANGELOG.md>, and the upgrade guide here – <https://github.com/hashicorp/terraform/blob/master/website/upgrade-guides/0-13.html.markdown>.

We'll take a look at this next.

## How to do it...

To specify the Terraform version to be installed on the local workstation, do the following:

1. In the Terraform configuration, add the following block:

```
terraform {  
    required_version = ">= 0.13"  
}
```

2. To specify the provider source and version to use, we need to add the required\_provider block inside the same terraform configuration block:

```
terraform {  
    ...  
    required_providers {  
        azurerm = {  
            source = "hashicorp/azurerm"  
            version = "2.10.0"  
        }  
    }  
}
```

## How it works...

When executing the `terraform init` command, Terraform will check that the version of the installed Terraform binary that executes the Terraform configuration file corresponds to the version specified in the `required_version` property of the `terraform` block.

If it matches, it won't throw an error as it is greater than version 0.13. Otherwise, it will throw an error:

```
PS [REDACTED] \terraform-Cookbook\CHAP02> terraform init
Error: Unsupported Terraform Core version

This configuration does not support Terraform version 0.12.28. To proceed,
either choose another supported Terraform version or update the root module's
version constraint. Version constraints are normally set for good reason, so
updating the constraint may lead to other errors or unexpected behavior.
```

With regard to the specification of the provider version, when executing the `terraform init` command, if no version is specified, Terraform downloads the latest version of the provider, otherwise it downloads the specified version, as shown in the following two screenshots.

The following screenshot shows the provider plugin being downloaded from the specified source without us specifying the required version (at the time of writing, the latest version of the provider is 2.20.0):

```
PS [REDACTED] \terraform-Cookbook\CHAP02> terraform init
Initializing the backend...
Initializing provider plugins...
- Checking for available provider plugins...
- Downloading plugin for provider "azurerm" (hashicorp/azurerm) 2.20.0...
Terraform has been successfully initialized!
```

As we can see, the latest version of the `azurerm` provider (2.20.0) has been downloaded.

In addition, the following screenshot shows the `azurerm` provider plugin being downloaded when we specify the required version (2.10.0):

```
PS C:\Users\...\terraform-Cookbook\CHAP02> terraform init
Initializing the backend...
Initializing provider plugins...
- Checking for available provider plugins...
- Downloading plugin for provider "azurerm" (hashicorp/azurerm) 2.10.0...
Terraform has been successfully initialized!
```

As we can see, the specified version of the `azurerm` provider (2.10.0) has been downloaded.



For more details about the `required_version` block and provider versions, go to <https://www.terraform.io/docs/configuration/terraform.html#specifying-required-provider-versions>.

In this `required_version` block, we also add the `source` property, which was introduced in version 0.13 of Terraform and is documented here: <https://github.com/hashicorp/terraform/blob/master/website/upgrade-guides/0-13.html.markdown#explicit-provider-source-locations>

## There's more...

In this recipe, we learned how to download the `azurerm` provider in various ways. What we did here applies to all providers you may wish to download.

It is also important to mention that the version of the Terraform binary that's used is specified in the Terraform state file. This is to ensure that nobody applies this Terraform configuration with a lower version of the Terraform binary, thus ensuring that the format of the Terraform state file conforms with the correct version of the Terraform binary.

## See also

- For more information about the properties of the Terraform block, go to <https://www.terraform.io/docs/configuration/terraform.html>.
- For more information about the properties of the providers, go to <https://www.terraform.io/docs/configuration/providers.html>.
- More information about Terraform binary versioning is documented at <https://www.terraform.io/docs/extend/best-practices/versioning.html>.
- The upgrade guide for the azurerm provider (to version 2.0) is available at <https://www.terraform.io/docs/providers/azurerm/guides/2.0-upgrade-guide.html>.

## Manipulating variables

When you write a Terraform configuration file where all the properties are hardcoded in the code, you often find yourself faced with the problem of having to duplicate it in order to reuse it.

In this recipe, we'll learn how to make the Terraform configuration more dynamic by using variables.

## Getting ready

To begin, we are going to work on the `main.tf` file, which contains a basic Terraform configuration:

```
resource "azurerm_resource_group" "rg" {
    name      = "My-RG"
    location  = "West Europe"
}
```

As we can see, the `name` and `location` properties have values written in the code in a static way.

Let's learn how to make them dynamic using variables.

## How to do it...

Perform the following steps:

1. In the same `main.tf` file, add the following variable declarations:

```
variable "resource_group_name" {
    description ="The name of the resource group"
}
variable "location" {
    description ="The name of the Azure location"
    default ="West Europe"
}
```

2. Then, modify the Terraform configuration we had at the beginning of this recipe so that it refers to our new variables, as follows:

```
resource "azurerm_resource_group" "rg" {
    name      = var.resource_group_name
    location  = var.location
}
```

3. Finally, in the same folder that contains the `main.tf` file, create a new file called `terraform.tfvars` and add the following content:

```
resource_group_name = "My-RG"
location          = "westeurope"
```

## How it works...

In *step 1*, we wrote the declaration of the two variables, which consists of the following elements:

- A variable name: This must be unique to this Terraform configuration and must be explicit enough to be understood by all the contributors of the code.
- A description of what this variable represents: This description is optional, but is recommended because it can be displayed by the CLI and can also be integrated into the documentation, which is automatically generated.
- A default value: This is optional. Not setting a default value makes it mandatory to enter a default value.

Then, in *step 2*, we modified the Terraform configuration to use these two variables. We did this using the `var.<name of the variable>` syntax.

Finally, in *step 3*, we gave values to these variables in the `terraform.tfvars` file, which is used natively by Terraform.

The result of executing this Terraform configuration is shown in the following screenshot:

```
PS                                     \CHAP02\variables> terraform plan
Refreshing Terraform state in-memory prior to plan...
The refreshed state will be used to calculate this plan, but will not be
persisted to local or remote state storage.

-----
An execution plan has been generated and is shown below.
Resource actions are indicated with the following symbols:
+ create

Terraform will perform the following actions:

# azurerm_resource_group.rg will be created
+ resource "azurerm_resource_group" "rg" {
    + id      = (known after apply)
    + location = "westus"
    + name    = "My-RG"
    + tags     = (known after apply)
}

Plan: 1 to add, 0 to change, 0 to destroy.
```

## There's more...

Setting a value in the variable is optional in the `terraform.tfvars` file since we have set a default value for the variable.

Apart from this `terraform.tfvars` file, it is possible to give a variable a value using the `-var` option of the `terraform plan` and `terraform apply` commands, as shown in the following command:

```
terraform plan -var "location=westus"
```

So, with this command, the `location` variable declared in our code will have a value of `westus` instead of `westeurope`.

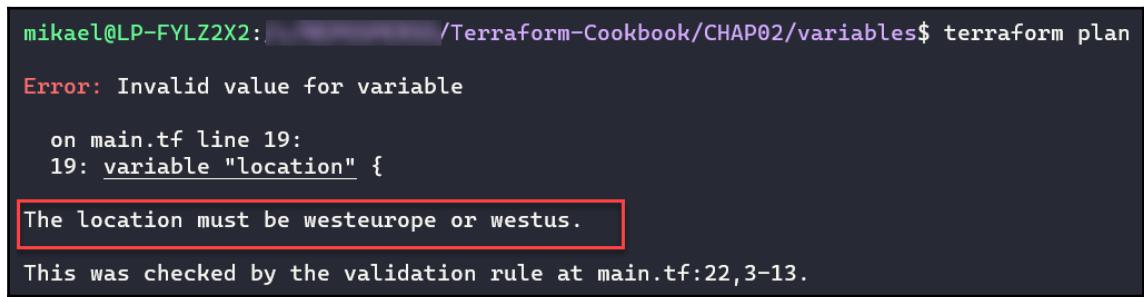
In addition, with the 0.13 version of Terraform released in August 2020, we can now create custom validation rules for variables which makes it possible for us to verify a value during the `terraform plan` execution.

In our recipe, we can complete the `location` variable with a validation rule in the validation block as shown in the following code:

```
variable "location" {
  description = "The name of the Azure location"
  default     = "West Europe"
  validation {
    # TF 0.13
    condition = can(index(["westerurope", "westus"], var.location) >= 0)
    error_message = "The location must be westerurope or westus."
  }
}
```

In the preceding configuration, the rule checks that if the value of the `location` variable is `westerurope` or `westus`.

The following screenshot shows the `terraform plan` command in execution if we put another value in the `location` variable, such as `westus2`:



```
mikael@LP-FYLZ2X2: /Terraform-Cookbook/CHAP02/variables$ terraform plan
Error: Invalid value for variable

on main.tf line 19:
  19: variable "location" {

The location must be westerurope or westus.

This was checked by the validation rule at main.tf:22,3-13.
```

For more information about variable custom rules validation read the documentation at <https://www.terraform.io/docs/configuration/variables.html#custom-validation-rules>.

Finally, there is another alternative to setting a value to a variable, which consists of setting an environment variable called `TF_VAR_<variable_name>`. As in our case, we can create an environment variable called `TF_VAR_location` with a value of `westus` and then execute the `terraform plan` command in a classical way.



Note that using the `-var` option or the `TF_VAR_<name of the variable>` environment variable doesn't hardcode these variable's values inside the Terraform configuration. They make it possible for us to give values of variables to the flight. But be careful – these options can have consequences if the same code is executed with other values initially provided in parameters and the plan's output isn't reviewed carefully.

## See also

In this recipe, we looked at the basic use of variables. We will look at more advanced uses of these when we learn how to manage environments in the *Managing infrastructure in multiple environments* recipe, later in this chapter.

For more information on variables, refer to the documentation here: <https://www.terraform.io/docs/configuration/variables.html>

# Using local variables for custom functions

In the previous recipe, we learned how to use variables to dynamize our Terraform configuration. Sometimes, this use can be a bit more tedious when it comes to using combinations of variables.

In this recipe, we will learn how to implement local variables and use them as custom functions.

## Getting ready

To start with, we will use the following Terraform configuration:

```
variable "application_name" {
    description = "The name of application"
}
variable "environment_name" {
    description = "The name of environment"
}
variable "country_code" {
    description = "The country code (FR-US-...)"
}
resource "azurerm_resource_group" "rg" {
    name = "XXXX" # VARIABLE TO USE
```

```
    location = "West Europe"
}
resource "azurerm_public_ip" "pip" {
  name = "XXXX" # VARIABLE TO USE
  location = "West Europe"
  resource_group_name = azurerm_resource_group.rg.name
  allocation_method = "Dynamic"
  domain_name_label = "mydomain"
}
```

The goal of this recipe is to consistently render the names of the Azure resources. We must provide them with the following nomenclature rule:

CodeAzureResource - Name Application - Environment name - Country Code

## How to do it...

Perform the following steps:

1. In the `main.tf` file, which contains our Terraform configuration, we will add a local variable called `resource_name`, along with the following code:

```
locals {
  resource_name = "${var.application_name}-${var.environment_name}-
${var.country_code}"
}
```

2. We then use this local variable in the resources with the following code:

```
resource "azurerm_resource_group" "rg" {
  name = "RG-${local.resource_name}"
  location = "West Europe"
}
resource "azurerm_public_ip" "pip" {
  name = "IP-${local.resource_name}"
  location = "West Europe"
  resource_group_name = azurerm_resource_group.rg.name
  public_ip_address_allocation = "Dynamic"
  domain_name_label = "mydomain"
}
```

## How it works...

In *step 1*, we created a variable called `resource_name` that is local to our Terraform configuration. This allows us to create a combination of several Terraform variables (which we will see the result of in the *Using outputs to expose Terraform provisioned data* recipe of this chapter).

Then, in *step 2*, we used this local variable with the `local.<name of the local variable>` expression. Moreover, in the `name` property, we used it as a concatenation of a variable and static text, which is why we used the `"${{ }}` syntax.

The result of executing this Terraform configuration is as follows:

```
# azurerm_resource_group.rg will be created
+ resource "azurerm_resource_group" "rg" {
    + id      = (known after apply)
    + location = "westeurope"
    + name    = "RG-myappdemo-dev-fr"
    + tags    = (known after apply)
}
Plan: 2 to add, 0 to change, 0 to destroy.
```

In the previous screenshot, we can see the output of executing the `terraform plan` command with the `name` of the Resource Group that we calculated with the `locals` variable.

## See also

For more information on local variables, take a look at the following documentation: <https://www.terraform.io/docs/configuration/locals.html>

## Using outputs to expose Terraform provisioned data

When using Infrastructure as Code tools such as Terraform, it is often necessary to retrieve output values from the provisioned resources after code execution.

One of the uses of these output values is that they can be used after execution by other programs. This is often the case when the execution of the Terraform configuration is integrated into a CI/CD pipeline.

For example, we can use these output values in a CI/CD pipeline that creates an Azure App Service with Terraform and also deploys the application to this Azure App Service. In this example, we can have the name of the App Service (web app type) as the output of the Terraform configuration. These output values are also very useful for transmitting information through modules, which we will see in detail in Chapter 5, *Sharing Terraform Configuration with Modules*.

In this recipe, we will learn how to implement output values in Terraform's configuration.

## Getting ready

To proceed, we are going to add some Terraform configuration that we already have in the existing `main.tf` file.

The following is an extract of this existing code, which provides an App Service in Azure:

```
...
resource "azurerm_app_service" "app" {
  name          = "${var.app_name}-${var.environment}"
  location      = azurerm_resource_group.rg-app.location
  resource_group_name = azurerm_resource_group.rg-app.name
  app_service_plan_id = azurerm_app_service_plan.plan-app.id
}
...
```

## How to do it...

To ensure we have an output value, we will just add the following code to this `main.tf` file:

```
output "webapp_name" {
  description = "output Name of the webapp"
  value       = azurerm_app_service.app.name
}
```

## How it works...

The `output` block of Terraform is defined by a name, `webapp_name`, and a value, `azurerm_app_service.app.name`. These refer to the name of the Azure App Service that is provided in the same Terraform configuration. Optionally, we can add a description that describes what the output returns, which can also be very useful for autogenerated documentation or in the use of modules.

It is, of course, possible to define more than one output in the same Terraform configuration.

The outputs are stored in the Terraform state file and are displayed when the `terraform apply` command is executed, as shown in the following screenshot:

```
PS C:\terraforms-Cookbook\CHAP02\sample-app> terraform apply
azurerm_resource_group.rg-app: Refreshing state... [id=/subscriptions/... /resourceGroup
s/RG-App-demo-DEV1]
azurerm_application_insights.appinsight-app: Refreshing state... [id=/subscriptions/...
/resourceGroups/RG-App-demo-DEV1/providers/microsoft.insights/components/MyApp-demo-DEV1]
azurerm_app_service_plan.plan-app: Refreshing state... [id=/subscriptions/... /resourceG
roups/RG-App-demo-DEV1/providers/Microsoft.Web/serverfarms/Plan-App-demo-DEV1]
azurerm_app_service.app: Refreshing state... [id=/subscriptions/... /resourceGroups/RG-A
pp-demo-DEV1/providers/Microsoft.Web/sites/MyApp-demo-DEV1]

Apply complete! Resources: 0 added, 0 changed, 0 destroyed.

Outputs:
webapp_hostname = myapp-demo-dev1.azurewebsites.net
webapp_name = MyApp-demo-DEV1
```

Here, we see two output values that are displayed at the end of the execution.

## There's more...

There are two ways to retrieve the values of the output in order to exploit them, as follows:

- By using the `terraform output` command in the Terraform CLI, which we will see in the *Exporting the output in JSON* recipe in Chapter 4, *Using the Terraform CLI*
- By using the `terraform_remote_state` data source object, which we will discuss in the *Using external resources from other state files* recipe, later in this chapter

## See also

Documentation on Terraform outputs is available at <https://www.terraform.io/docs/configuration/outputs.html>.

# Provisioning infrastructure in multiple environments

In the same way that we deploy an application to several environments (dev, test, QA, and production), we also need to provision infrastructure on these different environments.

The question that often arises is how to write a maintainable and scalable Terraform configuration that would allow us to provision infrastructure for multiple environments.

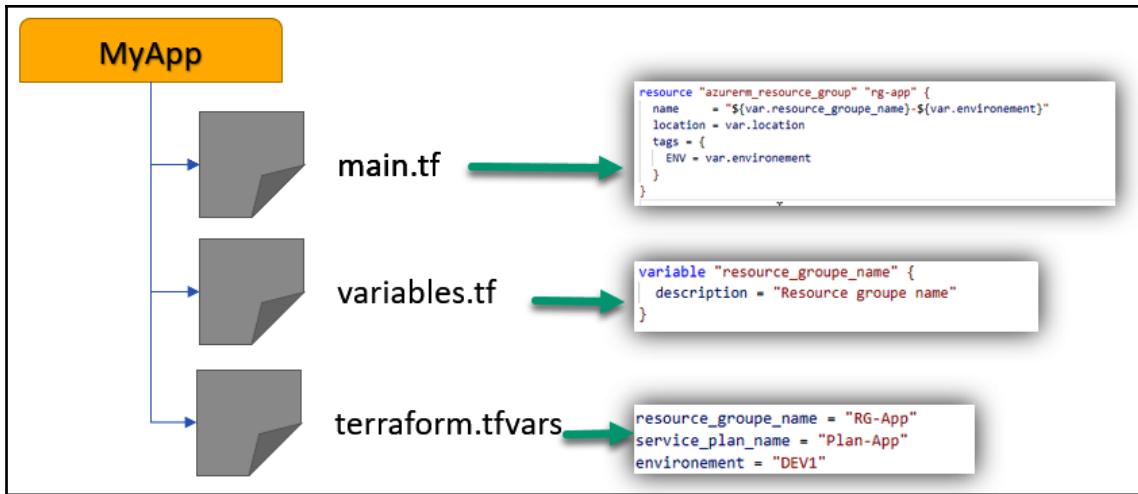
To answer this question, it is important to know that there are several solutions for organizing Terraform configuration topologies that will allow for this provisioning.

In this recipe, we will look at two Terraform configuration structure topologies that will allow us to deploy an Azure infrastructure to multiple environments.

## Getting ready

To fully understand this recipe, you will need to have a good understanding of the notion of variables, as discussed in the *Manipulating variables* recipe of this chapter.

The goal of the Terraform configuration that we are going to write is to deploy an Azure App Service for a single environment. Its code is distributed in the following files:



In the preceding diagram, we can see the following:

- The `main.tf` file contains the Terraform configuration of the resources to be provisioned.
- The `variables.tf` file contains the declaration of the variables.
- The `terraform.tfvars` file contains the values of the variables.

The Terraform source code for this basic example is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP02/myApp/simple-env>.

What is important in this recipe is not the content of the code, but the folder structure and the Terraform commands to be executed.

## How to do it...

Follow these steps to implement the first Terraform configuration folder topology:

1. In an empty folder, create a separate directory per environment: one for dev, one for test, one for QA, and one for production.
2. Copy the Terraform base configuration into each of these directories identically.

3. Then, in each of these directories, modify the values of the `terraform.tfvars` file with the information that is specific to the environment. Here is an extract of each of these `terraform.tfvars` files:

```
resource_group_name = "RG-App"
service_plan_name = "Plan-App"
environment = "DEV" #name of the environment to change
```

4. Finally, to provision each of these environments, inside each of these directories, execute the classical Terraform execution workflow by running the `terraform init`, `terraform plan`, and `terraform apply` commands.

Follow these steps to implement the second topology of the Terraform configuration folder:

1. In the folder that contains our basic Terraform configuration, create three subdirectories: `dev`, `test`, and `production`.
2. Then, in each of these subdirectories, copy only the `terraform.tfvars` base file, in which we modify the variables with the correct values of the target environments. The following is an extract from each `terraform.tfvars` file:

```
resource_group_name = "RG-App"
service_plan_name = "Plan-App"
environment = "DEV" #name of the environment to change
```

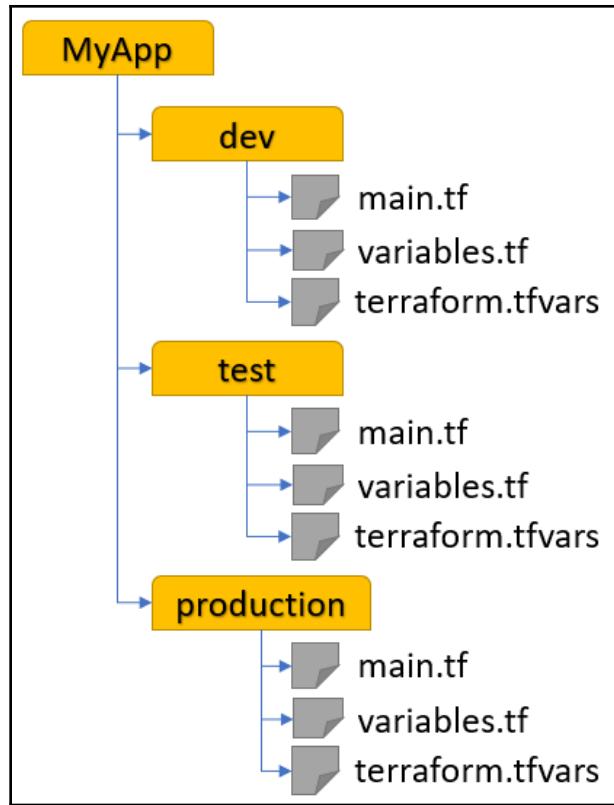
3. Finally, to provision each of these environments, go to the root folder of the Terraform configuration and execute the following commands:

```
terraform init
terraform plan -var-file=<environment folder>/terraform.tfvars"
terraform apply -var-file=<environment folder>/terraform.tfvars"
```

## How it works...

In the first topology, we duplicate the same Terraform configuration for each environment and just change the values of the variables in the `terraform.tfvars` file of each folder.

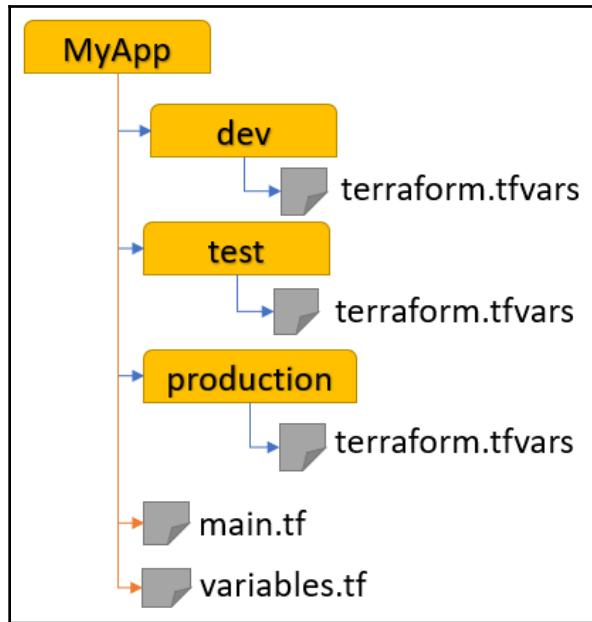
By doing this, we get the following folder structure:



Terraform is then executed with the basic Terraform commands. This structure can be used if the infrastructure does not contain the same resources for each environment. This is because duplicating all the Terraform configuration in each environment folder offers us the advantage of being able to easily add or remove resources for one environment without affecting the other environments.

However, this is duplicate code, which implies that this code must be maintained several times (we must modify the infrastructure for all environments, make changes to the Terraform configuration, and so on).

In the second topology, we kept the Terraform configuration in the common base for all environments and have just one `terraform.tfvars` file per environment. By doing this, we get the following folder structure:



As for the execution of the Terraform configuration, we have added the `-var-file` option to the `plan` and `apply` commands. This structure can be used if the infrastructure is the same for all environments but only the configuration changes.

The advantage of this topology is that we have only one common piece of Terraform resource code (in the `main.tf` and `variables.tf` files), and just one `terraform.tfvars` file to fill in, so we will have to make a few changes in case of code evolution or a new environment.

On the other hand, the changes that were made to the Terraform `main.tf` code will apply to all the environments, which in this case requires more testing and verification.

## See also

- There are other solutions to Terraform configuration folder structure topologies, as we will discuss in Chapter 5, *Sharing Terraform Configuration with Modules*.
- Documentation regarding the `-var-file` option of the `plan` and `apply` commands is available at <https://www.terraform.io/docs/commands/plan.html>.
- An article explaining the best practices surrounding Terraform configuration can be found at <https://www.terraform-best-practices.com/code-structure>.
- The following blog post explains the folder structure for production Terraform configuration: <https://www.hashicorp.com/blog/structuring-hashicorp-terraform-configuration-for-production>

## Obtaining external data with data sources

When infrastructure is provisioned with Terraform, it is sometimes necessary to retrieve information about the already existing resources. Indeed, when deploying resources to a certain infrastructure, there is often a need to place ourselves in an existing infrastructure or link it to other resources that have already been provisioned.

In this recipe, we will learn how, in our Terraform configuration, to retrieve information about resources already present in an infrastructure.

## Getting ready

For this recipe, we will use an existing Terraform configuration that provides an Azure App Service in the Azure cloud. This source code is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP02/data>.

This code is incomplete because, for this project, we need to store the App Service in an existing Service Plan. This Service Plan is the one we will use for the entire App Service.

## How to do it...

Perform the following steps:

1. In our file that contains our Terraform configuration, add the following data block:

```
data "azurerm_app_service_plan" "myplan" {  
    name          = "app-service-plan"  
    resource_group_name = "rg-service_plan"  
}
```

In the properties sections, specify the name and the Resource Group of the Service Plan to be used.

2. Then, complete the existing App Service configuration, as follows:

```
resource "azurerm_app_service" "app" {  
    name          = "${var.app_name}-${var.environement}"  
    location      = azurerm_resource_group.rg-app.location  
    resource_group_name = azurerm_resource_group.rg-app.name  
    app_service_plan_id = data_azurerm_app_service_plan.myplan.id  
}
```

## How it works...

In *step 1*, a data block is added to query existing resources. In this data block, we specify the Resource Group and the name of the existing Service Plan.

In *step 2*, we use the ID of the Service Plan that was retrieved by the data block we added in *step 1*.

The result of executing this Terraform configuration can be seen in the following screenshot:

```
PS C:\CHAP02\data> terraform plan
Refreshing Terraform state in-memory prior to plan...
The refreshed state will be used to calculate this plan, but will not be
persisted to local or remote state storage.

data.azurerm_app_service_plan.myplan: Refreshing state...

An execution plan has been generated and is shown below.
Resource actions are indicated with the following symbols:
+ create

Terraform will perform the following actions:

# azurerm_app_service.app will be created
+ resource "azurerm_app_service" "app" {
  + app_service_plan_id = "/subscriptions/.../resourceGroups/rg-service_plan/providers/Microsoft.Web/sites/appServicePlan"
  + app_settings        = (known after apply)
  + client_affinity_enabled = (known after apply)
  + default_site_hostname = (known after apply)
  + enabled             = true
```

As we can see, we have the ID of the Service Plan that was retrieved by the data block.

## There's more...

What's interesting about the use of data blocks is that when executing the `terraform destroy` command on our Terraform configuration, Terraform does not perform a destroy action on the resource called by the data block.

Moreover, the use of data blocks is to be preferred to the use of IDs written in clear text in the code, which can change because the data block recovers the information dynamically.

Finally, the data block is also called when executing the `terraform plan` command, so your external resource must be present before you execute the `terraform plan` and `terraform apply` commands.

If this external resource is not already present, we get the following error in the `terraform plan` command:

```
PS C:\CHAP02\data> terraform plan
Refreshing Terraform state in-memory prior to plan...
The refreshed state will be used to calculate this plan, but will not be
persisted to local or remote state storage.

data.azurerm_app_service_plan.myplan: Refreshing state...

Error: Error: App Service Plan "app-service-plan" (Resource Group "rg-service_plan") was not found
on main.tf line 25, in data "azurerm_app_service_plan" "myplan":
25: data "azurerm_app_service_plan" "myplan" {
```



You need to know which providers to use in your Terraform configuration since not all providers implement data blocks.

## See also

For more information about data blocks, take a look at the following documentation: <https://www.terraform.io/docs/configuration/data-sources.html>

# Using external resources from other state files

In the previous recipe, we saw that it's possible to retrieve information about resources already present in the infrastructure using data blocks.

In this recipe, we will learn that it is also possible to retrieve external information that is present in other Terraform state files.

## Getting ready

For this recipe, we will, similar to the previous recipe, use a Terraform configuration that provisions an Azure App Service that must be part of an already provisioned Service Plan.

Unlike the previous recipe, we will not use individual data sources; instead, we will read outputs from an existing Terraform state file that was used to provision the Service Plan.

As a prerequisite, in the Terraform configuration that was used to provision the Service Plan, we must have an output value (see the *Using outputs to expose Terraform provisioned data* recipe in this chapter) that returns the identifier of the Service Plan, as shown in the following code:

```
resource "azurerm_app_service_plan" "plan-app" {
  name = "MyServicePlan"
  location = "westeurope"
  resource_group_name = "myrg"
  sku {
    tier = "Standard"
```

```
    size = "S1"
  }
}

output "service_plan_id" {
  description = "output Id of the service plan"
  value = azurerm_app_service_plan.plan-app.id
}
```

In addition, we used a remote backend version of Azure Storage (see the *Protecting state files in an Azure remote backend* recipe in Chapter 6, *Provisioning Azure Infrastructure with Terraform*, for more information) to store the Terraform state file of the Service Plan.

## How to do it...

Perform the following steps:

1. In the Terraform configuration that provides the Azure App Service, add and configure the `terraform_remote_state` block, as follows:

```
data "terraform_remote_state" "service_plan_tfstate" {
  backend = "azurerm"
  config = {
    resource_group_name = "rg_tfstate"
    storage_account_name = "storstate"
    container_name = "tfbackends"
    key = "serviceplan.tfstate"
  }
}
```

2. Then, in the Terraform configuration of the Azure App Service, use the created output of the Service Plan, as follows:

```
resource "azurerm_app_service" "app" {
  name = "${var.app_name}-${var.environement}"
  location = azurerm_resource_group.rg-app.location
  resource_group_name = azurerm_resource_group.rg-app.name
  app_service_plan_id =
  data.terraform_remote_state.service_plan_tfstate.service_plan_id
}
```

## How it works...

In *step 1*, we added the `terraform_remote_state` block, which allows us to retrieve outputs present in another Terraform state file. In its block, we specified the remote backend information, which is where the given Terraform state is stored (in this recipe, we used Azure Storage).

In *step 2*, we used the ID returned by the output present in the Terraform state file.

The result of executing this code is exactly the same as what we saw in the *Using external resources with data blocks* recipe.

## There's more...

This technique is very practical when separating the Terraform configuration that deploys a complex infrastructure.

Separating the Terraform configuration is a good practice because it allows better control and maintainability of the Terraform configuration. It also allows us to provision each part separately, without it impacting the rest of the infrastructure.

To know when to use a data block or a `terraform_remote_state` block, the following recommendations must be kept in mind:

- The `data` block is used in the following cases:
  - When external resources have not been provisioned with Terraform configuration (it has been built manually or with a script)
  - When the user providing the resources of our Terraform configuration does not have access to another remote backend
- The `terraform_remote_state` block is used in the following cases:
  - External resources have not been provisioned with Terraform configuration
  - When the user providing the resources of our Terraform configuration has read access to the other remote backend
  - When the external Terraform state file contains the output of the property we need in our Terraform configuration

## See also

The documentation for the `terraform_remote_state` block is available at [https://www.terraform.io/docs/providers/terraform/d/remote\\_state.html](https://www.terraform.io/docs/providers/terraform/d/remote_state.html).

# Querying external data with Terraform

In the previous two recipes, we learned that it is possible to use either the `data` block or the `terraform_remote_state` block to retrieve external data. However, there are scenarios where the `data` block does not exist in the provider or `terraform_remote_state` cannot be used, such as when we need to process with an external API or need to use a local tool and process its output.

To meet this need, there is an `external` resource in Terraform that allows you to call an external program and retrieve its output data so that it can be used in the Terraform configuration.



Use of the `external` provider imposes prerequisites that may not be obvious (for example, in this case, we expect a particular version of PowerShell) or may be difficult to communicate other than through `README` files or documentation. Also, Terraform is generally designed to work the same cross-platform (operating system/architecture), but this essentially restricts the configuration to particular platforms that can (and do) run PowerShell – presumably just Windows. These requirements apply to both CI and local environments.

In this recipe, we will learn how to call an external program and retrieve its output so that we can reuse it.

## Getting ready

For this recipe, we will use an existing Terraform configuration that allows us to provision a Resource Group in Azure.

Here, we want a Resource Group to be in a different Azure region (location), depending on the environment (dev or production).

The source code for this recipe is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP02/external>.

# How to do it...

Perform the following steps:

1. In the directory that contains our `main.tf` file, create a PowerShell `GetLocation.ps1` script that contains the following content:

```
# Read the JSON payload from stdin
$jsonpayload = [Console]::In.ReadLine()

# Convert JSON to a string
$json = ConvertFrom-Json $jsonpayload
$environment = $json.environment

if($environment -eq "Production"){
    $location="westeurope"
} else{
    $location="westus"
}

# Write output to stdout
Write-Output "{ ""location"" : """$location"" }"
```

2. In the `main.tf` file, add the `external` block, as follows:

```
data "external" "getlocation" {
  program = ["Powershell.exe", "./GetLocation.ps1"]
  query = {
    environment = "${var.environment_name}"
  }
}
```

3. Then, modify the code of the Resource Group to make its location more dynamic, as follows:

```
resource "azurerm_resource_group" "rg" {
  name = "RG-${local.resource_name}"
  location = data.external.getlocation.result.location
}
```

4. Optionally, you can add an `output` value that has the following configuration:

```
output "locationname" {
  value = data.external.getlocation.result.location
}
```

## How it works...

In *step 1*, we wrote the PowerShell `GetLocation.ps1` script, which will be called by Terraform locally. This script takes `environment` as an input parameter in JSON format. Then, this PowerShell script makes a condition on this input environment and returns the right Azure region as output so that we can use it in our Terraform configuration.

Then, in *step 2*, we used the Terraform `external` resource, which calls this PowerShell script and provides it with the contents of the `environment_name` variable as a parameter.

Finally, in *step 3*, we used the return value of this `external` block in the `location` property of the Resource Group.

The following screenshot shows the output of executing `terraform plan` with the `environment_name` variable, which is set to Dev:

```
PS C:\REPOSPERSO\Terraform-Cookbook\CHAP02\external> terraform plan -var "environment_name=Dev"
Refreshing Terraform state in-memory prior to plan...
The refreshed state will be used to calculate this plan, but will not be
persisted to local or remote state storage.

data.external.getlocation: Refreshing state... ←

-----
An execution plan has been generated and is shown below.
Resource actions are indicated with the following symbols:
+ create

Terraform will perform the following actions:

# azurerm_resource_group.rg will be created
+ resource "azurerm_resource_group" "rg" {
    + id      = (known after apply)
    + location = "westus" ←
    + name    = "RG-myappdemo-Dev-fr"
    + tags    = (known after apply)
}

Plan: 1 to add, 0 to change, 0 to destroy.
```

As you can see, the regional location of the Resource Group is `westus`.

The following screenshot shows the output executing `terraform plan` with the `environment_name` variable, which is set to Production:

```
PS \CHAP02\external> terraform plan -var "environment_name=Production"
Refreshing Terraform state in-memory prior to plan...
The refreshed state will be used to calculate this plan, but will not be
persisted to local or remote state storage.

data.external.getlocation: Refreshing state...

-----
An execution plan has been generated and is shown below.
Resource actions are indicated with the following symbols:
+ create

Terraform will perform the following actions:

# azurerm_resource_group.rg will be created
+ resource "azurerm_resource_group" "rg" {
    + id      = (known after apply)
    + location = "westeurope"  
    + name    = "RG-myappdemo-Production-fr"
    + tags     = (known after apply)
}

Plan: 1 to add, 0 to change, 0 to destroy.
```

As you can see, the location of the Resource Group is `westeurope`.



As we saw in the *Manipulating variables* recipe, in this example, we used the `-var` option of the `terraform plan` command, which allows us to assign a value to a variable upon executing the command.

Optionally, we can also add a Terraform `output` that exposes this value. This can be displayed upon executing Terraform. This can also be exploited at other places in the Terraform configuration.

The following screenshot shows the output after running the `terraform apply` command:

```
PS \terrafbok\CHAP02\external> terraform apply
data.external.getlocation: Refreshing state...
azurerm_resource_group.rg: Refreshing state... [id=/subscriptions/REDACTED/resourceGroups/RG-myappdemo-Production-fr]

Apply complete! Resources: 0 added, 0 changed, 0 destroyed.

Outputs:
locationname = westeurope
```

As we can see, the `terraform output` command displays the right `locationname` value.

## There's more...

In this recipe, we used a PowerShell script, but this script also works with all the other scripting languages and tools that are installed on your local machine.

This external resource contains specifics about the protocol, the format of the parameters, and its output. I advise that you read its documentation to learn more: [https://www.terraform.io/docs/providers/external/data\\_source.html](https://www.terraform.io/docs/providers/external/data_source.html)

## See also

The following are some example articles regarding how to use the external Terraform resource:

- <https://dzone.com/articles/lets-play-with-terraform-external-provider>
- <https://thegrayzone.co.uk/blog/2017/03/external-terraform-provider-powershell/>

## Calling Terraform built-in functions

When provisioning infrastructure or handling resources with Terraform, it is sometimes necessary to use transformations or combinations of elements provided in the Terraform configuration.

For this purpose, the language supplied with Terraform (HCL2) includes functions that are built-in and can be used in any Terraform configuration.

In this recipe, we will discuss how to use built-in functions to apply transformations to code.

## Getting ready

To complete this recipe, we will start from scratch regarding the Terraform configuration, which will be used to provision a Resource Group in Azure. This Resource Group will be named according to the following naming convention:

RG-<APP NAME>-<ENVIRONMENT>

This name should be entirely in uppercase.

The source code for this recipe is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP02/fct>.

## How to do it...

Perform the following steps:

1. In a new local folder, create a file called `main.tf`.
2. In this `main.tf` file, write the following code:

```
variable "app_name" {
    description = "Name of application"
}
variable "environement" {
    description = "Environement Name"
}
```

3. Finally, in this `main.tf` file, write the following Terraform configuration:

```
resource "azurerm_resource_group" "rg-app" {
    name      = upper(format("RG-%s-%s", var.app-
name, var.environement))
    location = "westeurope"
}
```

## How it works...

In *step 3*, we defined the property name of the resource with a Terraform `format` function, which allows us to format text. In this function, we used the `%s` verb to indicate that it is a character string that will be replaced, in order, by the name of the application and the name of the environment.

Furthermore, to capitalize everything inside, we encapsulate the `format` function in the `upper` function, which capitalizes all its contents.

The result of executing these Terraform commands on this code can be seen in the following screenshot:

```
PS C:\CHAP02\fct> terraform plan
Refreshing Terraform state in-memory prior to plan...
The refreshed state will be used to calculate this plan, but will not be
persisted to local or remote state storage.

-----
An execution plan has been generated and is shown below.
Resource actions are indicated with the following symbols:
+ create

Terraform will perform the following actions:

# azurerm_resource_group.rg-app will be created
+ resource "azurerm_resource_group" "rg-app" {
    + id      = (known after apply)
    + location = "westeurope"
    + name    = "RG-MYAPP-DEV" + name
    + tags    = (known after apply)
}

Plan: 1 to add, 0 to change, 0 to destroy.
```

Thus, thanks to these functions, it is possible to control the properties that will be used in the Terraform configuration. This also allows us to apply transformations automatically, without having to impose constraints on the user using the Terraform configuration.

## See also

There are a multitude of predefined functions in Terraform. The full list can be found at <https://www.terraform.io/docs/configuration/functions.html> (see the left menu).

## Writing conditional expressions

When writing the Terraform configuration, we may need to make the code more dynamic by integrating various conditions. In this recipe, we will discuss an example of an equal condition operation.

## Getting ready

For this recipe, we will use the Terraform configuration we wrote in the previous recipe, whose code is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP02/fct>.

We will complete this code by adding a condition to the name of the Resource Group. This condition is as follows: if the name of the environment is equal to `Production`, then the name of the Resource Group will be in the form `RG-<APP NAME>`; otherwise, the name of the Resource Group will be in the form `RG-<APP NAME>-<ENVIRONMENT NAME>`.

## How to do it...

In the Terraform configuration of the `main.tf` file, modify the code of the Resource Group, as follows:

```
resource "azurerm_resource_group" "rg-app" {
    name = var.environment == "Production" ? upper(format("RG-%s", var.app-name)) : upper(format("RG-%s-%s", var.app-name, var.environment))
    location = "westeurope"
}
```

## How it works...

Here, we added the following condition:

```
condition ? true assert : false assert
```

The result of executing Terraform commands on this code if the `environment` variable is equal to `production` can be seen in the following screenshot:

```
PS \CHAP02\fct> terraform plan
Refreshing Terraform state in-memory prior to plan...
The refreshed state will be used to calculate this plan, but will not be
persisted to local or remote state storage.

-----
An execution plan has been generated and is shown below.
Resource actions are indicated with the following symbols:
+ create

Terraform will perform the following actions:

# azurerm_resource_group.rg-app will be created
+ resource "azurerm_resource_group" "rg-app" {
    + id      = (known after apply)
    + location = "westeurope"
    + name    = "RG-MYAPP"
    + tags    = (known after apply)
}

Plan: 1 to add, 0 to change, 0 to destroy.
```

If the environment variable is not equal to production, we'll get the following output:

```
PS \CHAP02\fct> terraform plan
Refreshing Terraform state in-memory prior to plan...
The refreshed state will be used to calculate this plan, but will not be
persisted to local or remote state storage.

-----
An execution plan has been generated and is shown below.
Resource actions are indicated with the following symbols:
+ create

Terraform will perform the following actions:

# azurerm_resource_group.rg-app will be created
+ resource "azurerm_resource_group" "rg-app" {
    + id      = (known after apply)
    + location = "westeurope"
    + name    = "RG-MYAPP-DEV"
    + tags    = (known after apply)
}

Plan: 1 to add, 0 to change, 0 to destroy.
```

## See also

Documentation on the various conditions of Terraform can be found at <https://www.terraform.io/docs/configuration/expressions.html#conditional-expressions>.

# Manipulating local files with Terraform

Terraform is very popular due to its Infrastructure as Code functionality for cloud providers. But it also has many providers that allow us to manipulate the local system.

In the *Querying external data with Terraform* recipe, we discussed local script executions that are performed by Terraform to get data for external data sources.

In this recipe, we will study another type of local operation that involves creating and archiving local files with Terraform.

## Getting ready

For this recipe, we don't need any prerequisites or base code – we will write the code from scratch.

The source code for this recipe is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP02/files>.

## How to do it...

Perform the following steps:

1. In a new folder called `files`, create a `main.tf` file. Write the following code inside it:

```
resource "local_file" "myfile" {
    content = "This is my text"
    filename = "../mytextfield.txt"
}
```

2. In a command-line terminal, navigate to the `files` directory and execute Terraform's workflow commands, which are as follows:

```
terraform init
terraform plan -out="app.tfplan"
terraform apply "app.tfplan"
```

3. In a new archive folder, create a `main.tf` file and write the following Terraform configuration inside it:

```
data "archive_file" "backup" {
  type = "zip"
  source_file = ".../mytextfile.txt"
  output_path = "${path.module}/archives/backup.zip"
}
```

4. Then, using the command-line terminal, navigate to the `archive` directory and execute the following Terraform commands:

```
terraform init
terraform plan
```

## How it works...

In *step 1*, we wrote a piece of Terraform configuration that uses the `local` provider and the `local_file` resource. This resource creates a file called `mytextfile.txt` and adds `This is my text to it.`

Then, in *step 2*, we executed Terraform on this code. By doing this, we obtained the `mytextfile.txt` file on our local disk.

The result of executing the `terraform plan` command on this code can be seen in the following screenshot:

```
An execution plan has been generated and is shown below.
Resource actions are indicated with the following symbols:
+ create

Terraform will perform the following actions:

# local_file myfile will be created
+ resource "local_file" "myfile" {
    + content          = "This is my text"  I
    + directory_permission = "0777"
    + file_permission   = "0777"
    + filename          = "../mytextfile.txt"
    + id                = (known after apply)
}

Plan: 1 to add, 0 to change, 0 to destroy.
```

After we executed `terraform apply`, the `mytextfile.txt` file became available on our local filesystem.

In the second part of this recipe, in *step 3*, we wrote a piece of Terraform configuration that uses the `archive` provider and the `archive_file` resource to create a ZIP file that contains the file we created in *steps 1* and *2*.

After we executed `terraform apply`, the ZIP archive `backup.zip` file became available on our local filesystem, in the `archives` folder.

## There's more...

As we can see, the `archive_file` resource we used in the second part of this recipe is of the `data` block type (which we learned about in the *Obtaining external data with data sources* recipe of this chapter) and is therefore based on an element that already exists before we execute the `terraform plan` command.

In our case, the file to be included in the archive must already be present on the local disk.

## See also

- Documentation on the `local_file` resource is available at <https://www.terraform.io/docs/providers/local/r/file.html>.
- Documentation on the `archive_file` resource is available at [https://www.terraform.io/docs/providers/archive/d/archive\\_file.html](https://www.terraform.io/docs/providers/archive/d/archive_file.html).

# Executing local programs with Terraform

As we saw in the previous recipe regarding file manipulation, apart from infrastructure provisioning, Terraform also allows you to run programs or scripts that are located on the local workstation where Terraform has been installed.

In this recipe, we will learn how to execute a local program inside the Terraform configuration.

## Getting ready

For this recipe, we will complete the Terraform configuration that we used in the previous recipe to write a file on the local machine. Our goal will be to execute a PowerShell command with Terraform that will read and display the contents of the file that we have written using Terraform.

Of course, we will have to run this Terraform script on a Windows operating system.

The source code for this recipe is available at [https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP02/files\\_local\\_exec](https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP02/files_local_exec).

## How to do it...

Perform the following steps:

1. In the `main.tf` file, which is in the `files` directory of the source code from the previous recipe, complete the Terraform configuration with the following code:

```
resource "null_resource" "readcontentfile" {
  provisioner "local-exec" {
    command = "Get-Content -Path ../mytextfile.txt"
    interpreter = ["PowerShell", "-Command"]
```

```
    }  
}
```

2. Then, in a command-line terminal, execute the Terraform workflow commands, as follows:

```
terraform init  
terraform plan -out="app.tfplan"  
terraform apply "app.tfplan"
```

## How it works...

In this recipe, we used `null_resource`, which is a `null` provider resource. This resource doesn't allow us to create resources, but rather run programs locally.

In this resource, we have the `provisioner` block, which is of the `local-exec` type, which operates on our local machine. Then, in this block, we indicate the command to execute, which is the `-Content` command of PowerShell. With this, we are telling Terraform to use the PowerShell interpreter to execute this command.

When executing the respective Terraform commands, we get the following result:

```
Plan: 2 to add, 0 to change, 0 to destroy.  
  
Do you want to perform these actions?  
  Terraform will perform the actions described above.  
  Only 'yes' will be accepted to approve.  
  
Enter a value: yes  
  
null_resource.readcontentfile: Creating...  
null_resource.readcontentfile: Provisioning with 'local-exec'...  
null_resource.readcontentfile (local-exec): Executing: ["PowerShell" "-Command" "Get-Content -Path ..\mytextfile.txt"]  
local_file myfile: Creating...  
local_file myfile: Creation complete after 0s [id=2a29c5a983236a8f5c0fde5c48b7d15a5cb7d47b]  
null_resource.readcontentfile (local-exec): This is my text ←  
null_resource.readcontentfile: Creation complete after 1s [id=8451305302740975700]  
  
Apply complete! Resources: 2 added, 0 changed, 0 destroyed.
```

As you can see, the text `This is my text`, which we had written in the file (in the `local_file` resource), is displayed in the Terraform runtime output.

## There's more...

In this recipe, we looked at a simple `local-exec` command being executed with Terraform. It is also possible to execute several commands that are stored in a script file (Bash, PowerShell, and so on) with a sample Terraform configuration, as shown here:

```
resource "null_resource" "readcontentfile" {
  provisioner "local-exec" {
    command = "myscript.ps1"
    interpreter = ["PowerShell", "-Command"]
  }
}
```



The `local-exec` provisioner sets expectations on the local system, which may not be obvious. This is usually otherwise mitigated by cross-platform builds from providers and Terraform itself, where the implementation should generally work the same on any supported platform (macOS/Linux/Windows).

In addition, it is important to know that the `local-exec` provisioner, once executed, ensures that the Terraform state file cannot be executed a second time by the `terraform apply` command.

To be able to execute the `local-exec` command based on a trigger element, such as a resource that has been modified, it is necessary to add a `trigger` object inside `null_resource` that will act as the trigger element of the `local-exec` resource.

The following example code uses a trigger, based on `timestamp`, to execute the `local-exec` code at each execution step of Terraform:

```
resource "null_resource" "readcontentfile" {
  triggers = {
    trigger = timestamp()
  }
  provisioner "local-exec" {
    command = "Get-Content -Path ..\mytextfile.txt"
    interpreter = ["PowerShell", "-Command"]
  }
}
```

In this example, the trigger is a timestamp that will have a different value each time Terraform is run.

We will look at another concrete use case of `local-exec` in the *Executing Azure CLI commands in Terraform* recipe in Chapter 6, *Provisioning Azure Infrastructure with Terraform*.

## See also

The `local-exec` provisioner documentation is available at <https://www.terraform.io/docs/provisioners/local-exec.html>.

# Generating passwords with Terraform

When provisioning infrastructure with Terraform, there are some resources that require passwords in their properties, such as VMs and databases.

To ensure better security by not writing passwords in clear text, you can use a Terraform provider, which allows you to generate passwords.

In this recipe, we will discuss how to generate a password with Terraform and assign it to a resource.

## Getting ready

In this recipe, we need to provision a VM in Azure that will be provisioned with an administrator password generated dynamically by Terraform.

To do this, we will base ourselves on an already existing Terraform configuration that provisions a VM in Azure.

The source code for this recipe is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP02/password>.

## How to do it...

Perform the following steps:

1. In the Terraform configuration file for the VM, add the following code:

```
resource "random_password" "password" {  
    length = 16  
    special = true  
    override_special = "_%@"  
}
```

2. Then, in the code of the resource itself, modify the password property with the following code:

```
resource "azurerm_virtual_machine" "myterraformvm" {  
    name = "myVM"  
    location = "westeurope"  
    resource_group_name =  
        azurerm_resource_group.myterraformgroup.name  
    network_interface_ids =  
        [azurerm_network_interface.myterraformnic.id]  
    vm_size = "Standard_DS1_v2"  
    ...  
    os_profile {  
        computer_name = "vmdemo"  
        admin_username = "admin"  
        admin_password = random_password.password.result  
    }  
    ...  
}
```

## How it works...

In *step 1*, we added the Terraform `random_password` resource from the `random` provider, which allows us to generate strings according to the properties provided. These will be sensitive, meaning that they're protected by Terraform.

Then, in *step 2*, we used its result (with the `result` property) in the `password` property of the VM.

The result of executing the `terraform plan` command on this code can be seen in the following screenshot:

```
# random_password.password will be created
+ resource "random_password" "password" {
    + id          = (known after apply)
    + length      = 16
    + lower       = true
    + min_lower   = 0
    + min_numeric = 0
    + min_special = 0
    + min_upper   = 0
    + number      = true
    + override_special = "%@"
    + result      = (sensitive value)
    + special     = true
    + upper       = true
}
Plan: 8 to add, 0 to change, 0 to destroy.
```

As we can see, the result is sensitive value.



Please note that the fact a property is sensitive in Terraform means that it cannot be displayed when using the Terraform `plan` and `apply` commands in the console output display.

On the other hand, it will be present in clear text in the Terraform state file.

## See also

- To find out more about the `random_password` resource, read the following documentation: <https://www.terraform.io/docs/providers/random/r/password.html>.
- Documentation regarding sensitive data in Terraform state files is available at <https://www.terraform.io/docs/state/sensitive-data.html>.

# 3

# Building Dynamic Environments with Terraform

In the previous chapter, we learned how to use Terraform's language concepts to provision an infrastructure efficiently with Terraform. One of the advantages of **Infrastructure as Code (IaC)** is that it allows you to provision infrastructure on a large scale much faster than manual provisioning.

When writing IaC, it is also important to apply the development and clean code principles that developers have already acquired over the years.

One of these principles is **Don't Repeat Yourself (DRY)**, which means not duplicating the code (<https://thevaluable.dev/dry-principle-cost-benefit-example/>). In this chapter, we will learn how to use expressions from the Terraform language, such as count, maps, collections, and dynamic. We will learn that these notions will allow us to write simple Terraform configuration to provide an infrastructure with multiple resources without having to duplicate code.

In this chapter, we will cover the following recipes:

- Provisioning multiple resources with the count property
- Using a table of key-value variables with maps
- Looping over object collections
- Generating multiple blocks with dynamic expressions

## Technical requirements

This chapter does not have any technical prerequisites. However, it is advisable to have already read the previous chapter.

The source code of this chapter is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP03>.

Check out the following video to see the Code in Action: <https://bit.ly/2R5GSBN>

## Provisioning multiple resources with the count property

In corporate scenarios, there is a need to provide infrastructure and to take into account the so-called horizontal scalability, that is,  $N$  identical resources that will reduce the load on individual resources (such as compute instances) and the application as a whole.

The challenge we will have to face is as follows:

- Writing Terraform configuration that does not require duplicate code for each instance of identical resources to be provisioned
- Being able to rapidly increase or reduce the number of instances of these resources

We will see in this recipe how Terraform makes it possible to provision  $N$  instances of resources quickly and without the duplication of code.

## Getting ready

To begin, we will use a Terraform configuration that allows us to provision one Azure App Service, which is in a `main.tf` file and of which the following is an extract:

```
resource "azurerm_app_service" "app" {
    name          = "${var.app_name}-${var.environment}"
    location      = azurerm_resource_group.rg-app.location
    resource_group_name = azurerm_resource_group.rg-app.name
    app_service_plan_id = azurerm_app_service_plan.plan-app.id
}
```

The purpose of this recipe is to apply and modify this Terraform configuration to provision  $N$  Azure App Service instances identical to the one already described in the base code, with just a slight difference in the names, which use an incremental index number starting at 1.

The source code of this recipe is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP03/count>.

## How to do it...

To create multiple identical resources, perform the following steps:

1. In the `variables.tf` file, we add the following variable:

```
variable "nb_webapp" {
    description = "Number of App Service to create"
}
```

2. In the `terraform.tfvars` file, we give a value for this new variable as follows:

```
nb_webapp = 2
```

3. In the `main.tf` file, we modify the resource code of `azurerm_app_service` in the following way:

```
resource "azurerm_app_service" "app" {  
    count = var.nb_webapp  
    name = "${var.app_name}-${var.environement}-${count.index+1}"  
    location = azurerm_resource_group.rg-app.location  
    resource_group_name = azurerm_resource_group.rg-app.name  
    app_service_plan_id = azurerm_app_service_plan.plan-app.id  
}
```

4. (Optional:) In a new `outputs.tf` file, we add the output values with the following code:

```
output "app_service_names" {  
    value = azurerm_app_service.app[*].name  
}
```

## How it works...

In *step 1*, we add an `nb_webapp` variable, which will contain the number of Azure App Service instances to write, which we then instantiate in *step 2* in the `terraform.tfvars` file.

Then in *step 3*, in the `azurerm_app_service` resource, we add the Terraform `count` property (which is available for all resources and data Terraform blocks) and takes as a value the `nb_webapp` variable created previously.

Moreover, in the name of the `azurerm_app_service` resource, we add the suffix with the current index of the count that we increment by 1 (starting from 1, and not from 0, to reflect the fact that count indexes start with zero) with the Terraform instruction `count.index + 1`.

Finally, and optionally, in *step 4*, we add an output that will contain the names of the App Service instances that have been provisioned.

When executing the `terraform plan` command of this recipe with the `nb_webapp` variable equal to 2, we can see that the two App Service instances have been provisioned.

The following screenshots show an extract of this `terraform plan` command, with the first image displaying the preview changes for the first App Service:

```
Terraform will perform the following actions:

# azurerm_app_service.app[0] will be created ←
+ resource "azurerm_app_service" "app" {
    + app_service_plan_id          = (known after apply)
    + app_settings                 = (known after apply)
    + client_affinity_enabled     = (known after apply)
    + default_site_hostname       = (known after apply)
    + enabled                      = true
    + https_only                  = false
    + id                           = (known after apply)
    + location                     = "westeurope"
    + name                         = "MyApp-DEV1-1"
    + outbound_ip_addresses        = (known after apply)
```

This following screenshot, which is the continuation of the `terraform plan` command, displays the preview changes of the second App Service instance:

```
# azurerm_app_service.app[1] will be created ←
+ resource "azurerm_app_service" "app" {
    + app_service_plan_id          = (known after apply)
    + app_settings                 = (known after apply)
    + client_affinity_enabled     = (known after apply)
    + default_site_hostname       = (known after apply)
    + enabled                      = true
    + https_only                  = false
    + id                           = (known after apply)
    + location                     = "westeurope"
    + name                         = "MyApp-DEV1-2"
    + outbound_ip_addresses        = (known after apply)
```

And when the changes are applied, the output is displayed:

```
Apply complete! Resources: 4 added, 0 changed, 0 destroyed.

Outputs:

app_service_names = [
    "MyApp-DEV1-1",
    "MyApp-DEV1-2",
]
```

As you can see in the output, we have a list containing the names of the two generated App Service instances.

## There's more...

As we discussed in the *Manipulating variables* recipe in the previous chapter, we can also use the `-var` option of the `terraform plan` and `apply` commands to very easily increase or decrease the number of instances of this resource without having to modify the Terraform configuration.

In our case, for example, we could use the following `plan` and `apply` command:

```
terraform plan -var "nb_webapp=5"
```

However, with this option, we lose the benefits of IaC, which is the fact of writing everything in code and thus having a history of changes made to the infrastructure.

Moreover, it should be noted that lowering the `nb_webapp` value removes the last resources from the index, and it is not possible to remove resources that are in the middle of the index, which has been improved with the `for_each` expression that we will see in the *Looping over object collections* recipe in this chapter.

In addition, thanks to the `count` property we have just seen and the condition expressions we have studied in the *Writing conditional operations* recipe of Chapter 2, *Writing Terraform Configuration*, we can make the provisioning of resources optional in a dynamic way, as shown in the following code snippet:

```
resource "azurerm_application_insights" "appinsight-app" {
  count = use_appinsight == true ? 1 : 0
  ...
}
```

In this code, we have indicated to Terraform that if the `use_appinsight` variable is `true`, then the `count` property is `1`, which will allow us to provision one Azure Application Insights resource. In the opposite case, where the `use_appinsight` variable is `false`, the `count` property is `0` and in this case, Terraform does not provide an Application Insight resource instance.

And so Terraform configuration can be put in a generic way for all environments or all applications and make their provisioning dynamic and conditional according to variables.



This technique, also called **feature flags**, is applied in the development world, but we see here that we can also apply it to IaC.

As we have seen in this recipe, the `count` property allows you to quickly provision several resources that are identical in their characteristics.

We will study in the *Looping over object collections* recipe of this chapter how to provision several resources of the same nature, but with different properties.

## See also

For more information on the `count` property, refer to the documentation at <https://www.terraform.io/docs/configuration/resources.html#count--multiple-resource-instances-by-count>.

# Using a table of key-value variables with maps

So far in this book, we have studied sample code using standard variable types (string, numeric, or Boolean). However, the Terraform language has other types of variables such as lists, maps, tuples, and even more complex object variables.

Among these variable types are maps, which are represented by a collection of key-value elements and are widely used to write dynamic and scalable Terraform configurations.

Maps can have several uses, which are as follows:

- To put all the properties of a block in a Terraform resource into a single variable
- To avoid the declaration of several variables of the **same type** and thus put all the values of these variables in a single variable of the `map` type
- To have a key-value reference table of elements that will be used in the Terraform configuration

In this recipe, we will see a simple and practical case of using a map variable to dynamically define all the tags of an Azure resource.

## Getting ready

For this recipe, we start with a basic Terraform configuration that allows us to provision a Resource Group and an App Service instance in Azure.

The source code for this recipe is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP03/map>.

In this recipe, we will illustrate the use of maps in two use cases, which are as follows:

- The implementation of the tags of this Resource Group
- The App settings properties of the App Service

## How to do it...

Perform the following steps:

1. In the `variables.tf` file, we add the following variable declarations:

```
variable "tags" {
  type = map(string)
  description = "Tags"
  default = {}
}

variable "app_settings" {
  type = map(string)
  description = "App settings of the App Service"
  default = {}
}
```

2. Then, in the `terraform.tfvars` file, we add this code:

```
tags = {
  ENV = "DEV1"
  CODE_PROJECT = "DEMO"
}

app_settings = {
  KEY1 = "VAL1"
}
```

3. Finally, we modify the `main.tf` file with the following code:

```
resource "azurerm_resource_group" "rg-app" {
    name = "${var.resource_group_name}-${var.environement}"
    location = var.location
    tags = var.tags
}

resource "azurerm_app_service" "app" {
    name = "${var.app_name}-${var.environement}"
    location = azurerm_resource_group.rg-app.location
    resource_group_name = azurerm_resource_group.rg-app.name
    app_service_plan_id = azurerm_app_service_plan.plan-app.id

    site_config {
        dotnet_framework_version = "v4.0"
    }
    app_settings = var.app_settings
}
```

## How it works...

In *step 1*, we have declared two variables for which we have specified their type, which is `map (string)`. That is to say, it will be composed of elements of the key-value type and the value is in `string` format. Moreover, given that these variables can be omitted and their values are therefore optional, we have assigned them an empty default value, which is `{}` for `map`.

Then, in *step 2*, we defined the values of these two variables with the tags for the resources, as well as the `app_settings` for the App Service.

Finally, in *step 3*, we use these variables in the Terraform configuration that provides the Resource Group and the App Service.

The following screenshot shows a sample of the execution of the `terraform plan` command in this recipe:

```
# azurerm_app_service.app will be created
+ resource "azurerm_app_service" "app" {
+   app_service_plan_id          = (known after apply)
+   app_settings                  = {
+     + "KEY1" = "VAL1"
+   }
+   client_affinity_enabled      = (known after apply)
+   default_site_hostname         = (known after apply)

# azurerm_resource_group.rg-app will be created
+ resource "azurerm_resource_group" "rg-app" {
+   id           = (known after apply)
+   location     = "westeurope"
+   name         = "RG-App-DEV1"
+   tags         = {
+     + "CODE_PROJECT" = "DEMO"
+     + "ENV"          = "DEV1"
+   }
}
```

We can see in the previous screenshot that the `app_settings` and `tags` properties are populated with the values of the `map` variables.

## There's more...

Maps thus allow us to simplify the use of blocks of objects in resources, but be careful – it is not possible to put a variable inside `map`. A `map` type variable is therefore to be considered as a single block of variables.

To go further, we can see that it is also possible to merge maps; that is, to merge two maps, we can use the `merge` function, which is native to Terraform.

The following steps show how to use this function to merge the app settings properties of the App Service:

1. In the `variables.tf` file, we create a `custom_app_settings` variable that will contain the custom app settings provided by the user:

```
variable "custom_app_settings" {
  description = "Custom app settings"
  type = map(string)
  default = {}
}
```

2. In the `terraform.tfvars` file, we instantiate this variable with a custom map:

```
custom_app_settings = {
    CUSTOM_KEY1 = "CUSTOM_VAL1"
}
```

3. Finally, in the `main.tf` file, we use a local variable to define the default app settings, and in the `azurerm_app_service` resource, we use the `merge` function to merge the default app settings with the custom app settings:

```
locals {
    default_app_settings = {
        "DEFAULT_KEY1" = "DEFAULT_VAL1"
    }
}

resource "azurerm_app_service" "app" {
    name = "${var.app_name}-${var.environment}"
    location = azurerm_resource_group.rg-app.location
    resource_group_name = azurerm_resource_group.rg-app.name
    app_service_plan_id = azurerm_app_service_plan.plan-app.id

    site_config {
        dotnet_framework_version = "v4.0"
        scm_type = "LocalGit"
    }
}

app_settings =
merge(local.default_app_settings,var.custom_app_settings)
}
```

In the preceding code, we have defined default app settings properties for the Azure App Service, and the user can enrich these settings if needed by adding custom app settings.

Moreover, it is also possible to create a `map` object on the fly, directly in the code, without having to use a variable.

For this, we can use the `{ . . . }` syntax integrated to Terraform, which takes in a list of key values as parameters, as seen in the following code:

```
app_settings = {"KEY1" = "VAL1", "KEY2" = "VAL2"}
```

In this recipe, we studied the use of maps. But if we want to use more complex maps with key-values of different types, then we will use object variables, as explained in the documentation at <https://www.terraform.io/docs/configuration/types.html#object->.

In the following recipe, we will discuss how to iterate on the list of key-value elements that constitute a map variable.

## See also

The documentation relating to the merge function is available at <https://www.terraform.io/docs/configuration/functions/merge.html>.

# Looping over object collections

We have seen in the previous recipes of the chapter the use of the `count` property, which allows us to provision  $N$  identical resources, as well as the use of map variables, which allow key-value objects.

In this recipe, we will discuss how to provision  $N$  resources of the same type but with different properties using the loop functionalities included in Terraform since version 0.12.

## Getting ready

To get started, we start with a basic Terraform configuration that allows you to deploy a single App Service in Azure.

The basic Terraform configuration is as follows:

```
resource "azurerm_app_service" "app" {
    name = "${var.app_name}-${var.environement}"
    location = azurerm_resource_group.rg-app.location
    resource_group_name = azurerm_resource_group.rg-app.name
    app_service_plan_id = azurerm_app_service_plan.plan-app.id
}
```

The source code for this recipe is available at [https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP03/list\\_map](https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP03/list_map).

## How to do it...

Perform the following steps:

1. In the `variables.tf` file, we add the following Terraform configuration:

```
variable "web_apps" {
  description = "List of App Service to create"
  type = any
}
```

2. In the `terraform.tfvars` file, we add the following configuration:

```
web_apps = {
  webapp1 = {
    "name" = "webappdemobook1"
    "location" = "West Europe"
    "dotnet_framework_version" = "v4.0"
    "serverdatabase_name" = "server1"
  },

  webapp2 = {
    "name" = "webapptestbook2"
    "dotnet_framework_version" = "v4.0"
    "serverdatabase_name" = "server2"
  }
}
```

3. In the `main.tf` file, we modify the code of the App Service with the following configuration:

```
resource "azurerm_app_service" "app" {
  for_each = var.web_apps
  name = each.value["name"]
  location = lookup(each.value, "location", "West Europe")
  resource_group_name = azurerm_resource_group.rg-app.name
  app_service_plan_id = azurerm_app_service_plan.plan-app.id

  site_config {
    dotnet_framework_version =
    each.value["dotnet_framework_version"]
  }

  connection_string {
    name = "DataBase"
    type = "SQLServer"
    value = "Server=${each.value["serverdatabase_name"]};Integrated
Security=SSPI"
```

```
    }  
}
```

- Finally, in the `outputs.tf` file, we add the following code:

```
output "app_service_names" {  
    value = [for app in azurerm_app_service.app : app.name]  
}
```

## How it works...

In *step 1*, we declared a new variable of type `any`, that is, we do not specify its type because it is complex.



It is worth noting that complex variables can be declared. It does make the code more verbose, but it can be very helpful in validation.

In *step 2*, we instantiate this variable with a list of map objects that will be the properties of each App Service. In this list, we have two App Service instances in which we specify the properties in the form of a map with the name, version of the framework, the Azure region location, and the name of the database server of the application that will be used in the App Service.

In *step 3*, in the `azurerm_app_service` resource, we don't use the `count` property anymore, but rather the `for_each` expression (which is included in Terraform 0.12), which allows us to loop on lists.

Then, for each property of `azurerm_app_service` resource, we can use the short expression `each.value["<property name>"]` or the `lookup` function integrated in Terraform that takes in the following parameters:

- The current element of the `for_each` expression with `each.value`, thus the line of the list.
- The name of the property of the map, which in our sample is `location`.
- Then comes the third parameter of this `lookup` function, which is not mandatory. It allows you to specify the value to use if the property is not present in the map. We used the Azure **West Europe** region, which is the default value.

Finally, in *step 4*, we created an output that uses the `for` expression to iterate on the list of resources that have been provisioned, and export their names as output.

The result of this output is shown in the following screenshot:

```
Apply complete! Resources: 4 added, 0 changed, 0 destroyed.

Outputs:

app_service_names = [
  "webappdemobook1",
  "webapptestbook2",
]
```

In the previous screenshot, we can see the result of the output, which displays the name of two provisioned Azure App Service instances in the console.

## There's more...

In this recipe, we have learned expressions and functions from the Terraform language that allows for the provisioning of resource collections.

I advise you to take a good look at the articles and documentation on the `for` and `for_each` expressions. Regarding the `lookup` and `element` functions, they can be used, but it is preferable to use the native syntax instead (such as `var_name[42]` and `var_map["key"]`) to access elements of a map, list, or set.

It is obvious that in this recipe, we have used simple resources such as Azure App Service, but these methods can also be applied to more property-rich resources such as virtual machines.

## See also

- Documentation on loops with `for` and `for_each` is available at <https://www.terraform.io/docs/configuration/resources.html>, and the article on these loops can be found at <https://www.hashicorp.com/blog/hashicorp-terraform-0-12-preview-for-and-for-each/>.
- The documentation on the `lookup` function is available at <https://www.terraform.io/docs/configuration/functions/lookup.html>.

# Generating multiple blocks with dynamic expressions

Terraform resources are defined by the following elements:

- Properties that are in the form `property name = value`, which we have seen several times in this book
- Blocks that represent a grouping of properties, such as the `site_config` block inside the `azurerm_app_service` resource

Depending on the Terraform resource, a block can be present once or even multiple times in the same resource, such as the `security_rule` block inside the `azurerm_network_security_group` resource (see the documentation, for example, at [https://www.terraform.io/docs/providers/azurerm/r/network\\_security\\_group.html](https://www.terraform.io/docs/providers/azurerm/r/network_security_group.html)).

Until Terraform version 0.12, it was not possible to make these blocks present several times in the same resource dynamically using, for example, a variable of `list` type.

One of the great novelties of Terraform 0.12 is the new `dynamic` expression that allows us to loop the blocks in resources.

In this recipe, we will see how to use the `dynamic` expression to provision an `azurerm_network_security_group` resource in Azure, which contains a list of security rules.

## Getting ready

To get started, we don't need any basic Terraform configuration. In this recipe, we will use a Terraform file that allows us to create an Azure Resource Group in which we will create a Network Security Group.

The source code for this recipe is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP03/dynamics>.

## How to do it...

To use dynamic expressions, perform the following steps:

1. In the `variables.tf` file, we add the following code:

```
variable "ngs_rules" {
  description = "List of NSG rules"
  type = any
}
```

2. In the `terraform.tfvars` file, we add the following code:

```
ngs_rules = [
  {
    name = "rule1"
    priority = 100
    direction = "Inbound"
    access = "Allow"
    protocol = "Tcp"
    source_port_range = "*"
    destination_port_range = "80"
    source_address_prefix = "*"
    destination_address_prefix = "*"
  },
  {
    name = "rule"
    priority = 110
    direction = "Inbound"
    access = "Allow"
    protocol = "Tcp"
    source_port_range = "*"
    destination_port_range = "22"
    source_address_prefix = "*"
    destination_address_prefix = "*"
  }
]
```

3. In the `main.tf` file, we add the code for the Network Security Group with the following code:

```
resource "azurerm_network_security_group" "example" {
  name = "acceptanceTestSecurityGroup1"
  location = azurerm_resource_group.rg.location
  resource_group_name = azurerm_resource_group.rg.name

  dynamic "security_rule" {
    for_each = var.ngs_rules
```

```
content {
    name = security_rule.value["name"]
    priority = security_rule.value["priority"]
    direction = security_rule.value["direction"]
    access = security_rule.value["access"]
    protocol = security_rule.value["protocol"]
    source_port_range = security_rule.value["source_port_range"]
    destination_port_range =
        security_rule.value["destination_port_range"]
    source_address_prefix =
        security_rule.value["source_address_prefix"]
    destination_address_prefix =
        security_rule.value["destination_address_prefix"]
    }
}
}
```

## How it works...

In *step 1*, we create an `nsg_rules` variable of type `any`, which will contain the list of rules in map format.

Then, in *step 2*, we instantiate this `nsg_rules` variable with the list of rules and their properties.

Finally, in *step 3*, in the `azurerm_network_security_group` resource, we add the `dynamic` instruction, which allows us to generate  $N$  blocks of `security_rule`.

In this `dynamic` Terraform expression, we make a `for_each` loop (as seen in the *Looping over object collections* recipe earlier in this chapter), which will iterate on the lines of the `nsg_rules` variable and will map each property of the resource to the maps of the list.

This following screenshot shows the execution of the `terraform plan` command:

```
+ security_rule      = [
+ {
+   access                      = "Allow"
+   description                  = ""
+   destination_address_prefix  = "*"
+   destination_address_prefixes = []
+   destination_application_security_group_ids = []
+   destination_port_range      = "22"
+   destination_port_ranges    = []
+   direction                    = "Inbound"
+   name                        = "rule"
+   priority                    = 110
+   protocol                    = "Tcp"
+   source_address_prefix       = "*"
+   source_address_prefixes    = []
+   source_application_security_group_ids = []
+   source_port_range           = "*"
+   source_port_ranges          = []
},
+
+ {
+   access                      = "Allow"
+   description                  = ""
+   destination_address_prefix  = "*"
+   destination_address_prefixes = []
+   destination_application_security_group_ids = []
+   destination_port_range      = "80"
+   destination_port_ranges    = []
+   direction                    = "Inbound"
+   name                        = "rule1"
+   priority                    = 100
+   protocol                    = "Tcp"
+   source_address_prefix       = "*"
+   source_address_prefixes    = []
+   source_application_security_group_ids = []
+   source_port_range           = "*"
}
```

We can see the list of security rules in the preceding output.

## There's more...

If you want to render the presence of a block conditionally, you can also use the conditions in the `dynamic` expression, as shown in the following code example:

```
resource "azurerm_linux_virtual_machine" "virtual_machine" {
  ...
  dynamic "boot_diagnostics" {
    for_each = local.use_boot_diagnostics == true ? [1] : []
  }
}
```

```
    content {
      storage_account_uri = "https://storageboot.blob.core.windows.net/"
    }
}
```

In this example, in the `for_each` expression of the dynamic expression, we have a condition that returns a list with one element if the local value, `use_boot_diagnostics`, is true. Otherwise, this condition returns an empty list that will not make the `boot_diagnostics` block appear in the `azurerm_virtual_machine` resource.

## See also

- Documentation on dynamic expressions is available at <https://www.terraform.io/docs/configuration/expressions.html#dynamic-blocks>.
- Another example of a Terraform guide on dynamic expressions is available at <https://github.com/hashicorp/terraform-guides/tree/master/infrastructure-as-code/terraform-0.12-examples/advanced-dynamic-blocks>.

# 4

## Using the Terraform CLI

Terraform is an **Infrastructure as Code** (IaC) tool that consists of two linked elements: the Terraform configuration, written in **HashiCorp Configuration Language** (HCL), which describes the infrastructure we want to provision, and the Terraform client tool, which will analyze and execute our Terraform configuration. In the previous two chapters, we have studied a variety of recipes on writing Terraform configuration using variables, functions, and expressions of HCL.

In this chapter, we will focus on the use of Terraform with its command lines and options. We will discuss how to have the code well presented, the destruction of resources, and the use of workspaces. Then we will learn how to import already existing resources, the taint functionality, and finally, we will see how to generate a dependency graph and debug the execution of Terraform.

We will cover the following recipes in this chapter:

- Keeping your Terraform configuration clean
- Validating the code syntax
- Destroying infrastructure resources
- Using workspaces for managing environments
- Importing existing resources
- Exporting the output in JSON
- Tainting resources
- Generating the graph dependencies
- Debugging the Terraform execution

## Technical requirements

Contrary to the previous two chapters, the code examples provided in this chapter are not fundamental, since we will focus on the execution of Terraform command lines.



In this chapter, to provide Terraform configuration samples, we will manage resources in Azure cloud; it is obvious that this also applies to all other Terraform providers. If you want to apply these recipes and don't have an Azure account, you can create an Azure account for free at this site: <https://azure.microsoft.com/en-us/free/>.

The code examples in this chapter are available here:

<https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP04>

Check out the following video to see the Code in Action: <https://bit.ly/3m3oh07>

## Keeping your Terraform configuration clean

In any application with code, it is very important that the code is clean and clearly readable by all contributors (current and future) who will be involved in the maintenance and evolution of this code.

In IaC and with Terraform, it is even more important to have clear code because written code serving as documentation is an advantage of IaC.

In this recipe, we will look at how to use Terraform's command line to properly format its code and we will also see some tips for automating it.

## Getting ready

To get started, we will start with a `main.tf` file that contains the following Terraform configuration:

```
variable "rg_name"{
  description="Name of the resource group"
}

variable "location"{
  description ="location"
  default="westeurope"
}

resource "azurerm_resource_group" "rg-app" [
  name=var.rg_name
  location=var.location
  tags={
    ENV="DEMO"
}
```

As we can see, this code is not very readable; it needs to be better formatted.



To execute Terraform commands with the CLI, we use a command-line terminal (CMD, PowerShell, Bash, and so on) and the execution folder will be the folder containing the Terraform configuration of the recipe. This will apply to all recipes in this chapter.

## How to do it...

To fix the code indentation, execute the `terraform fmt` command as follows:

```
terraform fmt
```

## How it works...

The `terraform fmt` command makes it easier to arrange the code with the correct indentation.

At the end of its execution, this command displays the list of files that have been modified, as shown in the following screenshot:

```
PS C:\Users\...\Terraform-Cookbook\CHAP04> terraform fmt
main.tf
```

We can see that executing the `terraform fmt` command modified our `main.tf` file.

Then, we open the `main.tf` file and read it:

```
variable "rg_name" {
  description = "Name of the resource group"
}

variable "location" {
  description = "location"
  default     = "westeurope"
}

resource "azurerm_resource_group" "rg-app" {
  name      = var.rg_name
  location  = var.location
  tags      = {
    ENV = "DEMO"
  }
}
```

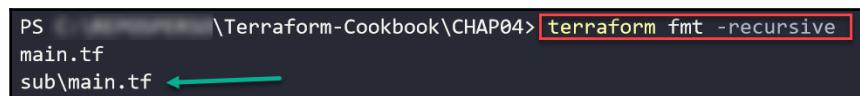
We can see in the preceding screenshot that the code has been well indented and so is more easily readable.

## There's more...

In this recipe, we have learned that the `terraform fmt` command executed in its most basic way, that is, without any additional options.

This default command indents the Terraform file code, which is at the root of the current folder. We can also execute this command recursively, that is, it can also indent the code in subfolders of the current folder.

To do this, we execute the `terraform fmt` command with the `-recursive` option and its output is shown in the following screenshot:



```
PS C:\Terraform-Cookbook\CHAP04> terraform fmt -recursive
main.tf
sub\main.tf ←
```

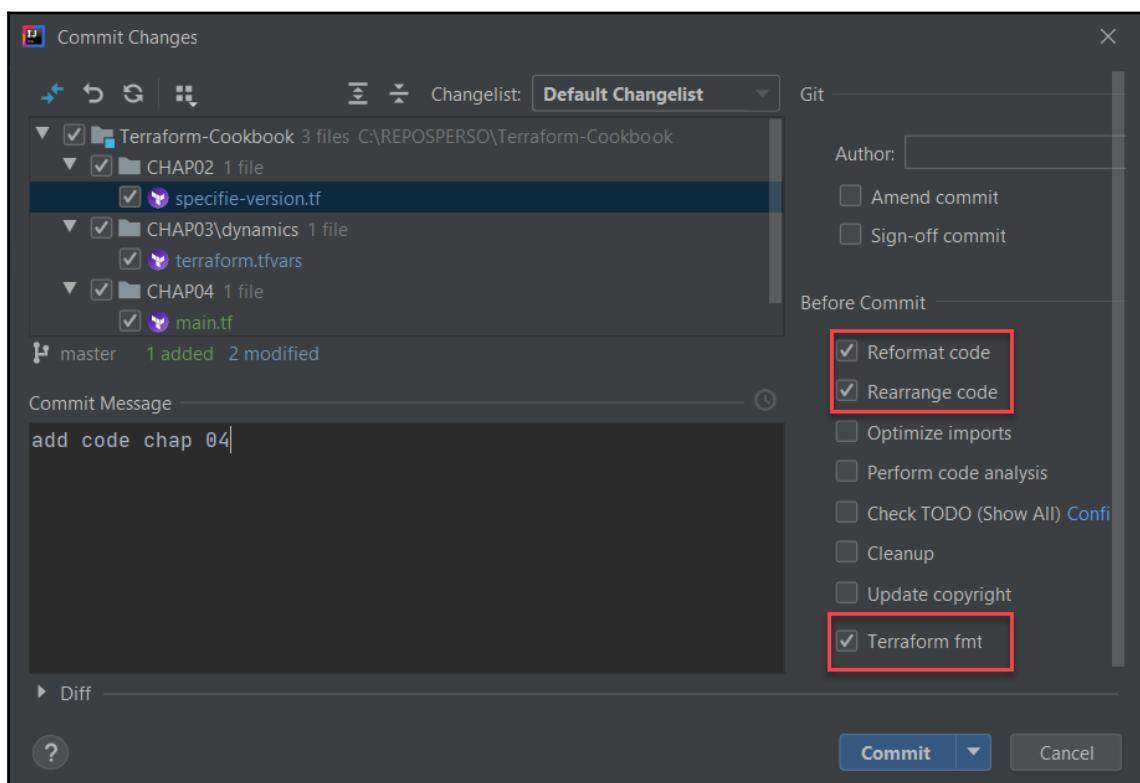
We see that the command has also formatted the `main.tf` file in the `sub` folder.

Among the other options of this command, there is also the `-check` option, which can be added and allows you to preview the files that will be indented, without applying the changes in the file(s).

Finally, it's also possible to automate the execution of this command, because apart from running it manually in a command terminal, as seen in this recipe, we can automate it to ensure that every time we save or commit a file in Git, the code provided and shared with the rest of the contributors will always be properly indented.

Thus, the IDEs that support Terraform have integrated the execution of this command natively with the writing of the code:

- With the Terraform extension of Visual Studio Code, we can have every Terraform file saved and formatted with the `terraform fmt` command. For more information, read the pertinent documentation: <https://marketplace.visualstudio.com/items?itemName=HashiCorp.terraform>.
- In IntelliJ, the **Save action** plugin enables the code to be formatted every time it is saved and the **Terraform** plugin has a large integration of the `terraform fmt` command within the IDE. Furthermore, with this Terraform plugin, it is possible to execute the `terraform fmt` command and arrange the code at every code commit, as shown in the following screenshot:





For more information on the **Save action** plugin, refer to <https://plugins.jetbrains.com/plugin/7642-save-actions> and for the Terraform plugin, refer to <https://plugins.jetbrains.com/plugin/7808-hashicorp-terraform--hcl-language-support>.

For Git commits, it's possible to automate the execution of the `terraform fmt` command before each commit by using pre-commits that are hooks to Git: <https://git-scm.com/book/en/v2/Customizing-Git-Git-Hooks>.

To use pre-commits with Terraform, refer to this list of hooks provided by *Gruntwork*: <https://github.com/gruntwork-io/pre-commit>.

## See also

The complete `terraform fmt` command documentation is available here: <https://www.terraform.io/docs/commands/fmt.html>.

## Validating the code syntax

When writing a Terraform configuration, it is important to be able to validate the syntax of the code we are writing before executing it, or even before archiving it in a Git repository.

We will see in this recipe how, by using the Terraform client tool, we can check the syntax of a Terraform configuration.

## Getting ready

For this recipe, we will start with the following Terraform configuration, which is written in a `main.tf` file:

```
variable "rg_name" {
  description = "Name of the resource group"
}

variable "location" {
  description = "location"
  default     = "westeurope"
}

resource "azurerm_resource_group" "rg-app" {
  name      = var.rg_name
  location = var.location
  tags     = {
    ENV = var.environment
  }
}
```

What we notice in the preceding code is that the declaration of the `environment` variable is missing.

## How to do it...

To validate our Terraform configuration syntax, perform the following steps:

1. To start, initialize the Terraform context by running the following command:

```
terraform init
```

2. Then, validate the code by executing the `validate` command:

```
terraform validate
```

## How it works...

In *step 1*, we initialize the Terraform context by executing the `terraform init` command.

Then, we perform a check of the code validity by executing the `terraform validate` command.

At the end of the execution of this command, we get the following output:

```
PS [REDACTED] \Terraform-Cookbook\CHAP04> terraform validate
Error: Reference to undeclared input variable

  on main.tf line 19, in resource "azurerm_resource_group" "rg-app":
19:   ENV = var.environment }

An input variable with the name "environment" has not been declared. This
variable can be declared with a variable "environment" {} block.
```

We see that there is one syntax error in the Terraform configuration, which indicates that we call the variable `var.environment`, which has not been declared.

So, we correct the code and run the `terraform validate` command again until we have no more errors, as shown in the following screenshot:

```
PS [REDACTED] \Terraform-Cookbook\CHAP04> terraform validate
Success! The configuration is valid.
```

The output shows us that the Terraform configuration is valid.

## There's more...

This validation command is useful in local development mode, but also in code integration in a **continuous integration (CI)** pipeline, so as to not execute the `terraform plan` command if the `terraform validate` command returns syntax errors.

The following PowerShell code shows an example of return code following the execution of this command:

```
> terraform validate
> $LASTEXITCODE
```

The PowerShell variable, `$LASTEXITCODE`, which is native to PowerShell, will return 0 if there is no error, otherwise 1 if there is an error.

It is also possible to get the output of this command in JSON format by adding the `-json` option to this command, as shown in the following screenshot:

```
PS C:\Terraform-Cookbook\CHAP04> terraform validate -json
{
  "valid": false,
  "error_count": 1,
  "warning_count": 0,
  "diagnostics": [
    {
      "block": {},
      "range": {
        "filename": "main.tf",
        "start": {
          "line": 19,
          "column": 9,
          "byte": 364
        },
        "end": {
          "line": 19,
          "column": 24,
          "byte": 379
        }
      }
    }
  ]
}
```

The JSON result can then be parsed with third-party tools such as **jq** and used in your workflow.

Be careful, however. This command only allows validation of the syntax of the configuration with, for example, the correct use of functions, variables, and object types, and not validation of the execution of the result of the Terraform configuration.

If the Terraform configuration contains a backend block, then, for this validation of the configuration, we don't need to connect to this state file. We can add the `-backend=false` option to the `terraform init` command.

Finally, if the execution of this Terraform configuration requires variables passed with the `-var` argument, or with the `-var-file` option, you cannot use this command. Instead, use the `terraform plan` command, which performs validation during its execution.

## See also

The `terraform validate` command documentation is available here: <https://www.terraform.io/docs/commands/validate.html>

# Destroying infrastructure resources

As we have said many times in this book, IaC allows the rapid provisioning of infrastructure.

Another advantage of IaC is that it allows a quick build and the cleaning up of resources that have been provisioned.

Indeed, we may need to clean up an infrastructure for different reasons. Here are a few examples:

- We destroy an infrastructure with a view to rebuild it better in accordance with new specifications.
- We provide an infrastructure that is called on demand, which means it is temporary for a specific need (such as to test a new feature or a new branch of the application). And this infrastructure must be capable of being built and destroyed quickly and automatically.
- We want to remove an unused infrastructure and, at the same time, no longer pay for it.

In this recipe, we will discuss how to destroy an infrastructure that has been provisioned with Terraform.

## Getting ready

To get started, we are going to provide an infrastructure in Azure that is composed of an Azure App Service.

For this we use the Terraform configuration, which can be found here: <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP04/sample-app>

Then, to provision it, we execute the basic Terraform workflow with the following commands:

```
> terraform init  
> terraform plan -out="app.tfplan"  
> terraform apply "app.tfplan"
```

At the end of its execution, we have a Resource Group, a Service Plan, an App Service, and an Application Insights resource in Azure.

The goal of this recipe is to completely destroy this infrastructure using Terraform commands.

## How to do it...

For clean resources with Terraform, perform the following steps:

1. To start, initialize the Terraform context by running the `init` command:

```
terraform init
```

2. Then, to clean the resources, we execute the following command:

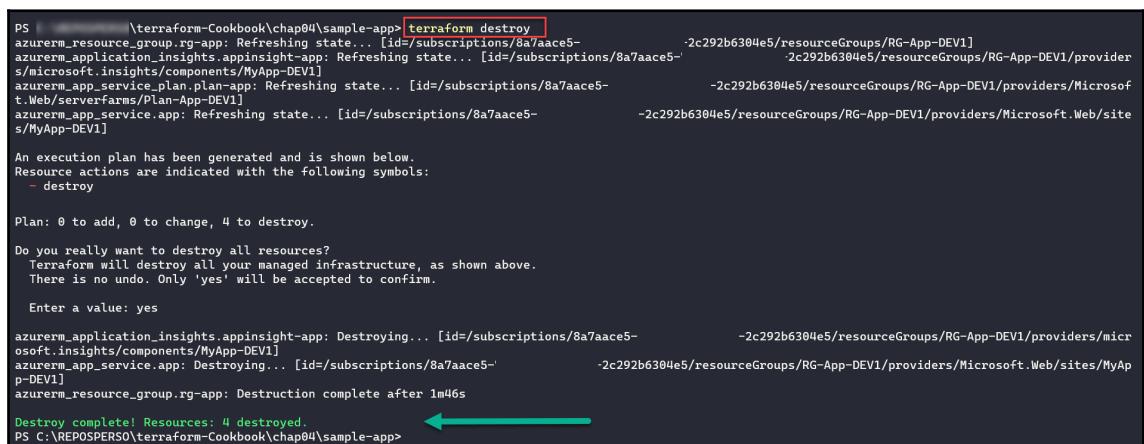
```
terraform destroy
```

At the beginning of its execution, this command displays all resources that will be destroyed and asks for confirmation to delete the resources. Validation is then confirmed by typing the word `yes`.

## How it works...

In *step 2*, we are destroying all the provisioned resources by executing the `terraform destroy` command.

The following screenshot shows the extracted output of this command:



```

PS C:\REPOS\REPO\terraforms-Cookbook\chap04\sample-app> terraform destroy
azurerm_resource_group.rg-app: Refreshing state... [id=/subscriptions/8a7aaace5-          -2c292b6304e5/resourceGroups/RG-App-DEV1]
azurerm_application_insights.appinsight-app: Refreshing state... [id=/subscriptions/8a7aaace5-          -2c292b6304e5/resourceGroups/RG-App-DEV1/providers/
providers/microsoft.insights/components/MyApp-DEV1]
azurerm_app_service_plan.plan_app: Refreshing state... [id=/subscriptions/8a7aaace5-          -2c292b6304e5/resourceGroups/RG-App-DEV1/providers/Microsoft.
Web/serverfarms/Plan-App-DEV1]
azurerm_app_service.app: Refreshing state... [id=/subscriptions/8a7aaace5-          -2c292b6304e5/resourceGroups/RG-App-DEV1/providers/Microsoft.Web/sites/
/MyApp-DEV1]

An execution plan has been generated and is shown below.
Resource actions are indicated with the following symbols:
  - destroy

Plan: 0 to add, 0 to change, 4 to destroy.

Do you really want to destroy all resources?
Terraform will destroy all your managed infrastructure, as shown above.
There is no undo. Only 'yes' will be accepted to confirm.

Enter a value: yes

azurerm_application_insights.appinsight-app: Destroying... [id=/subscriptions/8a7aaace5-          -2c292b6304e5/resourceGroups/RG-App-DEV1/providers/microsoft.
osoft.insights/components/MyApp-DEV1]
azurerm_app_service.app: Destroying... [id=/subscriptions/8a7aaace5-          -2c292b6304e5/resourceGroups/RG-App-DEV1/providers/Microsoft.Web/sites/
p-DEV1]
azurerm_resource_group.rg-app: Destruction complete after 1m46s

Destroy complete! Resources: 4 destroyed.
PS C:\REPOS\REPO\terraforms-Cookbook\chap04\sample-app>

```

At the end of the command execution, Terraform reports that the resources have been successfully destroyed.

## There's more...

In this recipe, we have studied how to destroy all the resources that have been described and provisioned with a Terraform configuration.



Since the `terraform destroy` command deletes all the resources tracked in the Terraform state file, it is important to break the Terraform configuration by separating it into multiple state files to reduce the room for error when changing the infrastructure.

If you need to destroy a single resource and not all the resources tracked in the state file, you can add the `-target` option to the `terraform destroy` command, which allows you to target the resource to be deleted. The following is an example of this command with the `target` option:

```
terraform destroy -target azurerm_application_insights.appinsight-app
```

In this example, only the Application Insights resource is destroyed. For more details, read the pertinent documentation here: <https://www.terraform.io/docs/commands/plan.html#resource-targeting>



Note that the targeting mechanism should only be used as a last resort. In an ideal scenario, the configuration stays in sync with the state file (as applied without any extra `target` flags). The risk of executing a targeted `apply` or `destroy` operation is that other contributors may miss the context and, more importantly, it becomes much more difficult to apply further changes after changing the configuration.

In addition, if the `terraform plan` command in this Terraform configuration requires the `-var-file` option to specify or override values to the variables, then the same options must also be added to the `terraform destroy` command.



In most cases, all options that apply to the `terraform plan` command also apply to the `terraform destroy` command.

## See also

- The documentation pertaining to the `terraform destroy` command is available here: <https://www.terraform.io/docs/commands/destroy.html>
- The documentation pertaining to addressing the resource target is available here: <https://www.terraform.io/docs/internals/resource-addressing.html>

# Using workspaces for managing environments

In Terraform, there is the concept of **workspaces**, which enables the same Terraform configuration to be used in order to build multiple environments.

Each of these configurations will be written to a different Terraform state file and will thus be isolated from the other configurations. Workspaces can be used to create several environments of our infrastructure.

In this recipe, we will study the use of Terraform workspaces in the Terraform configuration, with the execution of Terraform commands.

## Getting ready

The purpose of this recipe is for an application to create a Resource Group for each of its environments (`dev` and `prod`).

Regarding the Terraform configuration, no prerequisites are necessary. We will see it in the steps of the recipe.

The Terraform configuration for this recipe is available here: <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP04/workspaces>

## How to do it...

To manage a Terraform workspace, perform the following steps:

1. In a new `main.tf` file, we write the following Terraform configuration:

```
resource "azurerm_resource_group" "rg-app" {  
    name      = "RG-APP-${terraform.workspace}"  
    location  = "westeurope"  
}
```

2. In a command terminal, we navigate into the folder that contains this Terraform configuration and execute the following command:

```
terraform workspace new dev
```

3. To provision the `dev` environment, we run the basic commands of the Terraform workflow, which are as follows:

```
> terraform init  
> terraform plan -out="outdev.tfplan"  
> terraform apply "outdev.tfplan"
```

4. Then, we execute the `workspace new` command with the name of the production workspace to be created:

```
terraform workspace new prod
```

5. To finish and provision the `prod` environment, we execute the basic commands of the Terraform workflow production, which are as follows:

```
> terraform init  
> terraform plan -out="outprod.tfplan"  
> terraform apply "outprod.tfplan"
```

## How it works...

In *step 1*, in the Terraform configuration we wrote, we provide a Resource Group in Azure that will have a name composed of an `RG-APP` prefix and a dynamic suffix, `terraform.workspace`, which will be the name of the workspace we are going to create.

In *step 2*, we create the workspace that corresponds to the `dev` environment, and for this we use the `terraform workspace new` command followed by the workspace name (in this case, `dev`).

Once created, Terraform is automatically placed in this workspace, as you can see in the following screenshot:

```
PS C:\Terraform-Cookbook\CHAP04\workspaces> terraform workspace new dev
Created and switched to workspace "dev"

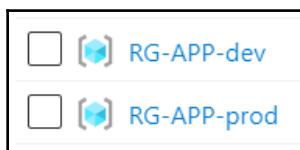
You're now on a new, empty workspace. Workspaces isolate their state,
so if you run "terraform plan" Terraform will not see any existing state
for this configuration.
```

After we've created the workspace, we just execute the basic commands of the Terraform workflow, which we do in *step 3*.

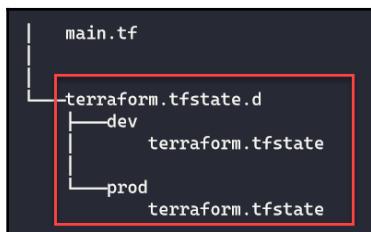
Note that here we have added the `-out` option to the `terraform plan` command to save the result of the plan in the `outdev.tfplan` file. Then, to apply the changes, we specifically add this file as an argument to the `terraform apply` command.

Then, to provision the `prod` environment, we repeat exactly the same *steps 2* and *3*, but this time creating a workspace called `prod`.

At the end of the execution of all these steps, we can see in the Azure portal that we have our two Resource Groups that contain in the suffix the name of their workspace, as you can see in the following screenshot:



In addition, we also notice two Terraform state files, one for each workspace, which were created automatically, as shown in the following screenshot:



In this screenshot, we can see two `terraform.tfstate` files, one in the `dev` directory and another in the `prod` directory.

## There's more...

In any Terraform configuration execution, there is a default workspace that only names default.

It is possible to see the list of workspaces in our code by executing the following command:

```
terraform workspace list
```

The following screenshot shows the execution of this command in the case of our recipe:



```
PS C:\Terraform-Cookbook\CHAP04\workspaces> terraform workspace list
default
dev
* prod
```

We can clearly see our dev and prod workspace, and that the current workspace is prod (marked with an \* in front of its name).

If you want to switch to another workspace, execute the `terraform workspace select` command, followed by the name of the workspace to be selected; for example:

```
terraform workspace select dev
```

Finally, you can also delete a workspace by executing the `terraform workspace delete` command, followed by the name of the workspace to be deleted; for example:

```
terraform workspace delete dev
```



Be careful when deleting a workspace that it does not delete the associated resources. That's why, in order to delete a workspace, you must first delete the resources provided by that workspace using the `terraform destroy` command. Otherwise, if this operation is not carried out, it will no longer be possible to manage these resources with Terraform because the Terraform state file of this workspace will have been deleted.

In addition, by default, it is not possible to delete a workspace whose state file is not empty. However, we can force the destruction of this workspace by adding the `-force` option to the `terraform workspace delete -force` command, as documented here: <https://www.terraform.io/docs/commands/workspace/delete.html>.

## See also

- The general documentation for workspaces is available here: <https://www.terraform.io/docs/state/workspaces.html>
- The CLI documentation for the `terraform workspace` command is available here: <https://www.terraform.io/docs/commands/workspace/index.html>
- Read this blog post for a more complete use of workspaces: <https://colinsalmcorner.com/terraform-all-the-things-with-vsts/>

## Importing existing resources

So far in this book, we have seen the normal use of Terraform, which is to write a Terraform configuration that is going to be executed and applied by Terraform. This execution will provision or apply changes to an infrastructure that will be reflected in the Terraform state file.

In certain scenarios, however, it may be necessary to import resources that have already been provisioned into the Terraform state file. Examples of such scenarios include the following:

- Resources have been provisioned manually (or by scripts) and now it is desired that their configuration is in the Terraform configuration and in the state file.
- A Terraform state file that contains the configuration of an infrastructure has been corrupted or deleted and regeneration is desirable.

In this recipe, we will discuss how, with the assistance of Terraform commands, we can import the configuration of resources that have already been provisioned into the Terraform state file.

## Getting ready

For this recipe, we will use the following Terraform configuration, which we have already written, in order to provision a Resource Group:

```
resource "azurerm_resource_group" "rg-app" {
    name      = "RG-APP-IMPORT"
    location  = "westeurope"
}
```

This code is also available here: <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP04/import>

Also, in the Azure portal, we have created this Resource Group called RG-APP-IMPORT manually, as explained in the pertinent documentation: <https://docs.microsoft.com/en-us/azure/azure-resource-manager/management/manage-resource-groups-portal>

The following screenshot shows this Resource Group in Azure:



At this point, if we run Terraform on this code, the `terraform apply` command will try to create this Resource Group. It will fail and return the error that the Resource Group already exists and cannot be created, as shown in the following screenshot:

```
PS C:\Terraform-Cookbook\CHAP04\import> terraform apply -auto-approve
azurerm_resource_group.rg-app: Creating ...
Error: A resource with the ID "/subscriptions/8a7aac5-74aa-43c3-8f2d-000000000000/resourceGroups/RG-APP-IMPORT" already exists - to be managed via Terraform this resource needs to be imported into the State. Please see the resource documentation for "azurerm_resource_group" for more information.

on main.tf line 10, in resource "azurerm_resource_group" "rg-app":
  10: resource "azurerm_resource_group" "rg-app" {
```

It is therefore necessary to use a resource import directly in the Terraform state file.



In this recipe, we will perform an import operation with one Resource Group in Azure. But it is important to note that each Terraform provider has different target parameters for the `import` command.

The goal of this recipe is to import the configuration of this Resource Group in the Terraform state file corresponding to our Terraform configuration.

## How to do it...

Perform the following steps:

1. We initialize the Terraform context by executing the `init` command:

```
terraform init
```

2. Then, we execute the `terraform import` command as follows:

```
terraform import azurerm_resource_group.rg-app
/subscriptions/8a7aace5-xxxx-xxx/resourceGroups/RG-APP-IMPORT
```

## How it works...

In *step 1*, the Terraform context is initialized with the `terraform init` command.

Then, in *step 2*, we execute the `terraform import` command, which takes the reference of the Terraform resource as the first parameter and the Azure identifier of the Resource Group as the second parameter.

The following screenshot shows the output of the execution of this command:

```
PS C:\Terraform-Cookbook\CHAP04\import> terraform import azurerm_resource_group.rg-app /subscriptions/8a7aace5-74aa-416f-8d42-330945ff3bf4/resourceGroups/RG-APP-IMPORT
azurerm_resource_group.rg-app: Importing from ID "/subscriptions/8a7aace5-74aa-416f-8d42-330945ff3bf4/resourceGroups/RG-APP-IMPORT" ...
azurerm_resource_group.rg-app: Import prepared!
  Prepared azurerm_resource_group for import
azurerm_resource_group.rg-app: Refreshing state ... [id=/subscriptions/8a7aace5-74aa-416f-8d42-330945ff3bf4/resourceGroups/RG-APP-IMPORT]
Import successful!

The resources that were imported are shown above. These resources are now in
your Terraform state and will henceforth be managed by Terraform.
```

We can see that the resource was indeed imported into the Terraform state file.

We now have the Terraform configuration, the Terraform state file, and the resources in Azure up to date.

## There's more...

To check the execution of the resource import, we execute the `terraform plan` command and we have to have a situation where no changes are required, as can be seen in the following screenshot:

```
PS C:\Terraform-Cookbook\CHAP04\import> terraform plan
Refreshing Terraform state in-memory prior to plan...
The refreshed state will be used to calculate this plan, but will not be
persisted to local or remote state storage.

azurerm_resource_group.rg-app: Refreshing state ... [id=/subscriptions/8a7aace5-74aa-0000-0000-000000000000/resourceGroups/RG-APP-IMPORT]

-----
No changes. Infrastructure is up-to-date.

This means that Terraform did not detect any differences between your
configuration and real physical resources that exist. As a result, no
actions need to be performed.
```



If you are provisioning resources in Azure, there are rather interesting tools that generate the Terraform configuration and the corresponding Terraform state file from Azure resources that have already been created. This open source **Az2Tf** tool is available at <https://github.com/andyt530/py-az2tf>. Alternatively, there is **TerraCognita**, which is available at <https://github.com/cycloidio/terracognita/blob/master/README.md>.

## See also

The documentation pertaining to the `import` command is available here: <https://www.terraform.io/docs/commands/import.html>

## Exporting the output in JSON

We discussed in the *Looping over object collections* recipe of Chapter 3, *Building Dynamic Environments with Terraform*, the use of Terraform's outputs that allow you to have output values for the execution of the Terraform configuration. Indeed, we have seen how to declare an output in the Terraform configuration, and we learned that these outputs and their values were displayed at the end of the execution of the `terraform apply` command.

The advantage of these outputs is that they can be retrieved by a program and thus be used for another operation; for example, in a CI/CD pipeline.

In this recipe, we will see how the values of the outputs can be retrieved in JSON format so that they can be used in an external program.

## Getting ready

For this recipe, we will use only the Terraform configuration that we studied in Chapter 3, *Building Dynamic Environments with Terraform*, and whose sources can be found here:

[https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP03/list\\_map](https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP03/list_map)

In this code, we add another output that returns the list of App Service URLs as shown:

```
output "app_service_urls" {
  value = {for x in azurerm_app_service.app : x.name =>
    x.default_site_hostname }
}
```

To exploit the values of the output, we need to use a tool that allows us to work on JSON. For this, you can use any framework and library according to your scripting languages. In this recipe, we will use **jq**, which is a free tool that allows you to easily manipulate JSON on the command line. The documentation on jq is available here <https://stedolan.github.io/jq/>.

The purpose of this recipe is to provision two Azure App Services using Terraform configuration and then, with a script, perform a response check of the URL of the first App Service.

## How to do it...

Perform the following steps to use the output:

1. Execute the Terraform workflow with the following commands:

```
> terraform init
> terraform plan -out="app.tfplan"
> terraform apply "app.tfplan"
```

2. Then, run the `terraform output` command:

```
terraform output
```

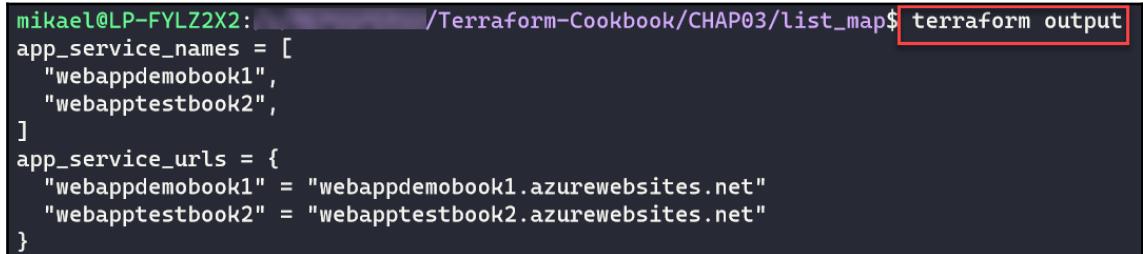
- Finally, to retrieve the URL of the created App Service, we execute the following command in the command terminal:

```
urlwebapp1=$(terraform output -json | jq -r  
.app_service_urls.value.webappdemobook1) &&  
curl -sL "%{http_code}" -I "$urlwebapp1/hostingstart.html"
```

## How it works...

In *step 1*, we execute the basic commands of the Terraform workflow. After executing the `terraform apply` command, the command displays the output.

Then, in *step 2*, we visualize the output of this Terraform configuration more clearly by executing the `terraform output` command, as shown in the following screenshot:



```
mikael@LP-FYLZ2X2: ~ /Terraform-Cookbook/CHAP03/list_map$ terraform output
```

```
app_service_names = [  
    "webappdemobook1",  
    "webapptestbook2",  
]  
app_service_urls = {  
    "webappdemobook1" = "webappdemobook1.azurewebsites.net"  
    "webapptestbook2" = "webapptestbook2.azurewebsites.net"  
}
```

In the preceding screenshot, we can see that this command returns the two outputs declared in the code, which are as follows:

- `app_service_names`: This returns a list of App Service names provided.
- `app_service_urls`: This returns a list of the URLs of provisioned App Services.

Finally, in *step 3*, we run a script that checks the URL of the `webappdemobook1` App Service. In the first line of this script, we execute the `terraform output -json` command, which enables the result of the output to be returned in JSON format, as you can see in the following screenshot:

```
mikael@LP-FYLZ2X2: /Terraform-Cookbook/CHAP03/list_map$ terraform output -json
{
  "app_service_names": {
    "sensitive": false,
    "type": [
      "tuple",
      [
        "string",
        "string"
      ]
    ],
    "value": [
      "webappdemobook1",
      "webapptestbook2"
    ]
  },
  "app_service_urls": {
    "sensitive": false,
    "type": [
      "object",
      {
        "webappdemobook1": "string",
        "webapptestbook2": "string"
      }
    ],
    "value": {
      "webappdemobook1": "webappdemobook1.azurewebsites.net",
      "webapptestbook2": "webapptestbook2.azurewebsites.net"
    }
  }
}
```

Then, with this result in JSON, we use the `jq` tool on it by retrieving the URL of the `webappdemobook1` App Service. The returned URL is put in a variable called `urlwebapp1`.

Then, in the second line of this script, we use the `curl` command on this URL by passing options to return only the HTTP header of this URL.

The result of the execution of this script is shown in the following screenshot:

```
mikael@LP-FYLZ2X2: /Terraform-Cookbook/CHAP03/list_map$ urlwebapp1=$(terraform output -json | jq -r .app_service_urls.value.webappdemobook1)
mikael@LP-FYLZ2X2: /Terraform-Cookbook/CHAP03/list_map$ curl -sI "%{http_code}" -I "$urlwebapp1/hostingstart.html"
HTTP/1.1 200 OK
Content-Length: 3499
Content-Type: text/html
Last-Modified: Tue, 28 Apr 2020 12:30:10 GMT
Accept-Ranges: bytes
ETag: "c6f6c2581dd61:0"
Server: Microsoft-IIS/10.0
X-Powered-By: ASP.NET
Set-Cookie: ARRAffinity=9bfcc5d1cc011b1d989c47453347b28e7ed30ce1227470a6d28ed0f9ce4bf3802; Path=/; HttpOnly; Domain=webappdemobook1.azurewebsites.net
Date: Tue, 28 Apr 2020 16:29:27 GMT
```

You can see that the result of the check is `OK`, with a status code of 200.

## There's more...

In this recipe, we learned how to retrieve all the outputs of a Terraform configuration. It is also possible to retrieve the value of a particular output by executing the `terraform output <output name>` command.

In our case, we could have executed the `app_service_urls` command to display the value of the output:

```
terraform output app_service_urls
```

The following screenshot shows the execution of this command:

```
mikael@LP-FYLZ2X2: ~ /Terraform-Cookbook/CHAP03/List_map$ terraform output -json app_service_urls
{"webappdemobook1": "webappdemobook1.azurewebsites.net", "webapptestbook2": "webapptestbook2.azurewebsites.net"}
```

Then, we would run the following command to check the URL:

```
urlwebapp1=$(terraform output app_service_urls -json | jq -r
.webappdemobook1) &&
curl -sL "%{http_code}" -I "$urlwebapp1/hostingstart.html"
```

We see in this script that the command used is `terraform output app_service_urls -json`, which is more simplistic than `$(terraform output -json | jq -r .app_service_urls.value.webappdemobook1)`.

## See also

- The `terraform output` command documentation is available here: <https://www.terraform.io/docs/commands/output.html>
- `jq`'s website can be found here: <https://stedolan.github.io/jq/>

## Tainting resources

Earlier, in the *Destroying infrastructure resources* recipe, we learned how to destroy resources that have been provisioned with Terraform.

However, in certain situations, you may need to destroy a particular resource in order to rebuild it immediately. Examples of such situations may include modifications that have been made manually on that resource.

To destroy and rebuild a resource, you could perform the `terraform destroy -target <resource>` command, followed by the `apply` command. However, the problem is that between the `destroy` and `apply` commands, there may be other changes in the Terraform configuration that will be applied that are not desired.

So, in this recipe, we will see how to perform this operation using the Terraform notion of tainting.

## Getting ready

In order to apply this recipe, we have first provisioned the infrastructure composed of a Resource Group, a Service Plan, an App Service, and an Application Insights resource. The Terraform configuration used for this provisioning can be found here: <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP04/sample-app>.

The goal of this recipe is to destroy and then rebuild the App Service in a single operation using the `taint` command of Terraform.

## How to do it...

To apply the `taint` operation, perform the following steps:

1. Run the `terraform init` command to initialize the context.
2. Then, execute the `terraform taint` command to flag the resource as *tainted*:

```
terraform taint azurerm_app_service.app
```

3. Finally, to rebuild the App Service, execute the following command:

```
terraform apply
```

## How it works...

In *step 1*, we execute the `terraform init` command to initialize the context. Then, in *step 2*, we execute the `terraform taint` command to flag the `azurerm_app_service.app` resource as tainted; that is, to be destroyed and rebuilt.



This command does not affect the resource itself, but only marks it as tainted in the Terraform state file.

The following screenshot shows the result of the `taint` command:

```
PS C:\Terraform-Cookbook\CHAP02\myApp\simple-env> terraform taint azurerm_app_service.app
Resource instance azurerm_app_service.app has been marked as tainted.
```

Finally, in *step 3*, we execute the `terraform apply` command and, when it is executed, we can see that Terraform will delete and then recreate the Azure App Service, as shown in the following screenshot:

```
PS C:\Terraform-Cookbook\CHAP02\myApp\simple-env> terraform apply
azurerm_resource_group.rg-app: Refreshing state... [id=/subscriptions/8a7aac5-...
azurerm_application_insights.appinsight-app: Refreshing state... [id=/subscriptions/8a7aac...
providers/microsoft.insights/components/MyApp-DEV1] /resourceGroups/RG-App-DEV1]
[resourceGroups/RG-App-DEV1] /resourceGroups/RG-App-DEV1/providers/Microsoft.Web/sites/MyApp-DEV1

Terraform will perform the following actions:

# azurerm_app_service.app is tainted, so must be replaced
-/+ resource "azurerm_app_service" "app" {
    app_service_plan_id      = "/subscriptions/8a7aac5-74aa...
    /resourceGroups/RG-App-DEV1/providers/Microsoft.Web/sites/MyApp-DEV1"
    - app_settings           = {
        - "WEBSITE_NODE_DEFAULT_VERSION" = "6.9.1"
    } => (known after apply)
    - client_affinity_enabled = true => (known after apply)
    - client_cert_enabled     = false => null
    - default_site_hostname   = "myapp-dev1.azurewebsites.net" => (known after apply)
    enabled                  = true
    https_only                = false
}

Apply complete! Resources: 1 added, 0 changed, 1 destroyed.
```

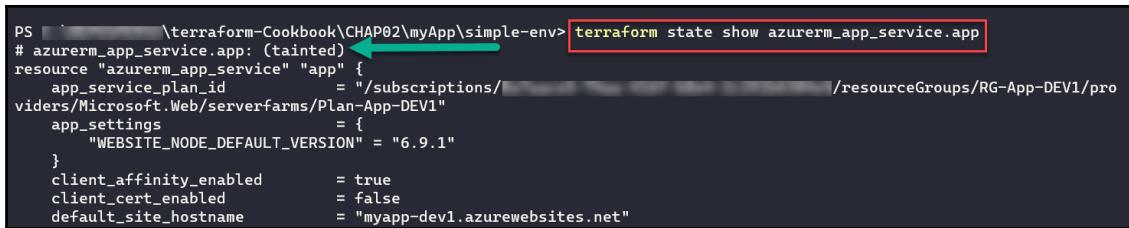
We can see in the preceding screenshot that Terraform destroys the App Service resource and then recreates it.

## There's more...

To go further, we can display in the terminal the status of this resource flagged in the Terraform state file by executing the `terraform state show` command, which displays the contents of the state file in the command terminal (documented here: <https://www.terraform.io/docs/commands/state/show.html>) as follows:

```
terraform state show azurerm_app_service.app
```

The following screenshot shows the result of this command:



```
PS C:\Terraform-Cookbook\CHAP02\myApp\simple-env> terraform state show azurerm_app_service.app
# azurerm_app_service.app: (tainted)
resource "azurerm_app_service" "app" {
    app_service_plan_id      = "/subscriptions/.../resourceGroups/RG-App-DEV1/providers/Microsoft.Web/serverfarms/Plan-App-DEV1"
    app_settings              = {
        "WEBSITE_NODE_DEFAULT_VERSION" = "6.9.1"
    }
    client_affinity_enabled   = true
    client_cert_enabled       = false
    default_site_hostname     = "myapp-dev1.azurewebsites.net"
```

We can see that the resource App Service has the flag tainted.

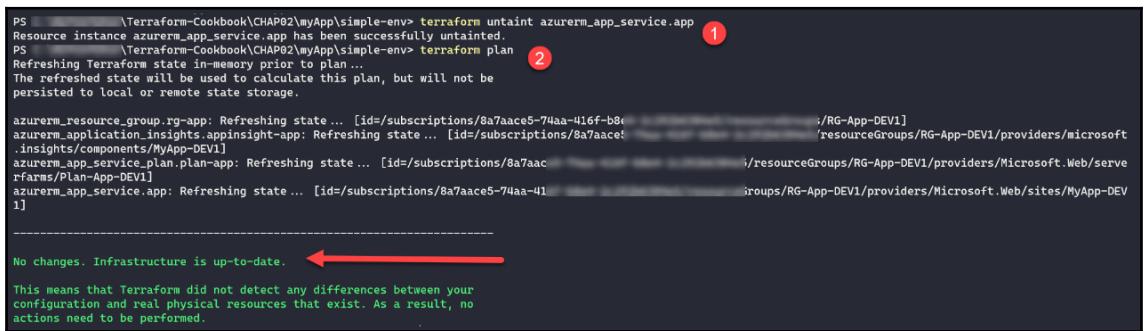


We have used the `terraform state` command to display the contents of the state, since it is strongly discouraged to read and modify the state file manually, as documented here: <https://www.terraform.io/docs/state/index.html#inspection-and-modification>

Moreover, in order to cancel the taint flag applied with the `terraform taint` command, we can execute the inverse command, which is `terraform untaint`. This command can be executed like this:

```
terraform untaint azurerm_app_service.app
```

Then, if we execute the `terraform plan` command, we can see that there is no change, as shown in the following screenshot:



```
PS C:\Terraform-Cookbook\CHAP02\myApp\simple-env> terraform untaint azurerm_app_service.app
Resource instance azurerm_app_service.app has been successfully untainted.
PS C:\Terraform-Cookbook\CHAP02\myApp\simple-env> terraform plan
① Refreshing Terraform state in-memory prior to plan...
The refreshed state will be used to calculate this plan, but will not be persisted to local or remote state storage.

azurerm_resource_group.rg-app: Refreshing state ... [id=/subscriptions/8a7aace5-74aa-416f-b8e...]:/RG-App-DEV1]
azurerm_application_insights.appinsight-app: Refreshing state ... [id=/subscriptions/8a7aace5-74aa-416f-b8e...]:/resourceGroups/RG-App-DEV1/providers/microsoft.insights/components/MyApp-DEV1]
azurerm_app_service_plan.plan-app: Refreshing state ... [id=/subscriptions/8a7aac...]:/resourceGroups/RG-App-DEV1/providers/Microsoft.Web/serverfarms/Plan-App-DEV1]
azurerm_app_service.app: Refreshing state ... [id=/subscriptions/8a7aace5-74aa-416f-b8e...]:/resourceGroups/RG-App-DEV1/providers/Microsoft.Web/sites/MyApp-DEV1]

② -----
No changes. Infrastructure is up-to-date.
This means that Terraform did not detect any differences between your configuration and real physical resources that exist. As a result, no actions need to be performed.
```

We see in this screenshot that the `untaint` command has cancelled the effect of the `taint` command and, during the execution of the `plan` command, no changes will be applied to the infrastructure.

## See also

- The `terraform taint` command documentation is available here: <https://www.terraform.io/docs/commands/taint.html>
- The `terraform untaint` command documentation is available here: <https://www.terraform.io/docs/commands/untaint.html>
- The `terraform state` command documentation is available here: <https://www.terraform.io/docs/commands/state/index.html>
- An article that explains the `taint` and `untaint` commands really well can be found here: <https://www.devopsschool.com/blog/terraform-taint-and-untaint-explained-with-example-programs-and-tutorials/>

## Generating the graph dependencies

One of the interesting features of Terraform is the ability to generate a dependency graph of the resource dependencies mentioned in the Terraform configuration.

In this recipe, we will see how to generate and visualize this dependency graph.

## Getting ready

For this recipe, we need to use a third-party drawing generation tool called **Graphviz**, which is available for download at <https://graphviz.gitlab.io/download/>. You will need to download and install the package corresponding to your operating system.

Moreover, as an example, we will take the Terraform configuration available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP04/sample-app>.

## How to do it...

To generate the graph dependencies, perform the following steps:

1. Execute the `terraform graph` command:

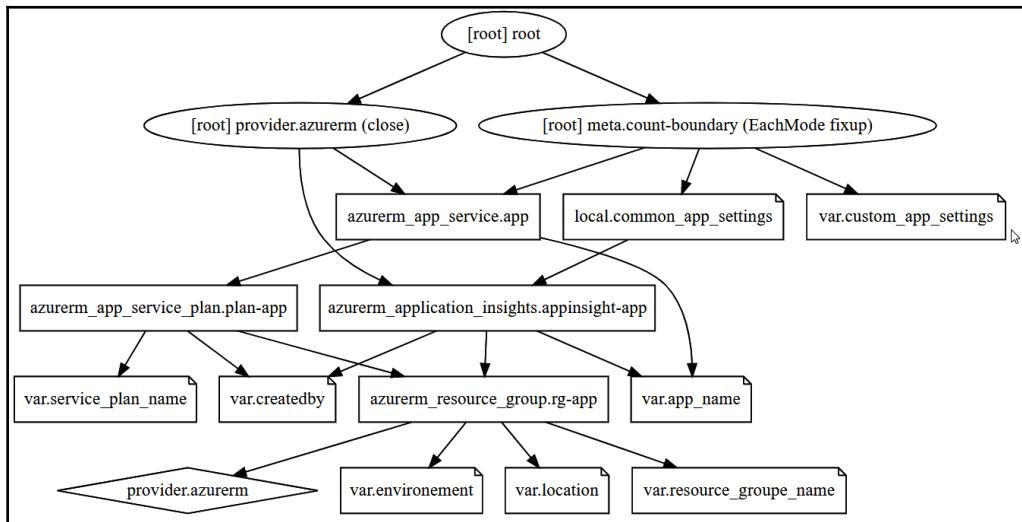
```
terraform graph | dot -Tsvg > graph.svg
```

2. Open the file explorer and navigate inside the folder that contains the Terraform configuration and open the file called `graph.svg`.

## How it works...

In *step 1*, we will execute the `terraform graph` command. Then, we send the result of this graph command to the `dot` utility that was previously installed with Graphviz. This `dot` utility will generate a `graph.svg` file, which contains the graphical representation of the Terraform configuration.

In *step 2*, we open the `graph.svg` file and we see the dependency graph as shown in the following diagram:



In the preceding diagram, we can see the dependencies between variables, resources, and the provider.

## See also

- The `terraform graph` command documentation is available here: <https://www.terraform.io/docs/commands/graph.html>
- Documentation relating to Graphviz is available here: <https://graphviz.gitlab.io/>
- An excellent video about the generation of graph dependencies can be found here: <https://techsnips.io/snips/how-to-use-graphviz-with-terraform-to-visualize-your-infrastructure/>

# Debugging the Terraform execution

When we execute Terraform commands, the display output of the console is quite simple and clear.

In this recipe, we will study how to activate the debug mode in Terraform, which will allow us to display more information about its execution.

## Getting ready

For this recipe, we will use the Terraform configuration available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP04/sample-app>.

Furthermore, for the purposes of this demonstration, we will run it on a Windows operating system, but the operation is exactly the same on other operating systems.

## How to do it...

To activate the debug on Terraform, perform the following steps:

1. In the PowerShell command-line terminal, execute the following command:

```
$env:TF_LOG = "TRACE"
```

2. Now, we can execute the Terraform workflow commands with display logs activated:

```
> terraform init  
> terraform plan -out=app.tfplan  
> terraform apply app.tfplan
```

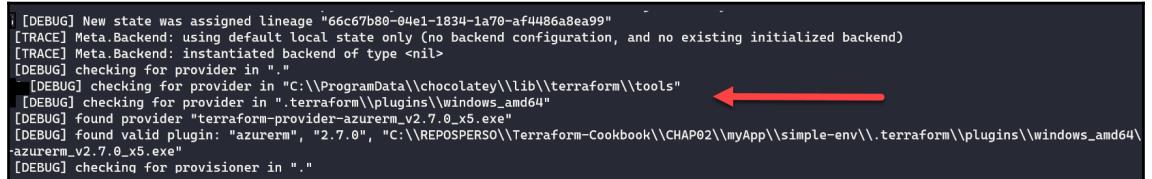
## How it works...

In *step 1*, we create a Terraform environment variable, `TF_LOG`, which enables Terraform's verbose mode to be activated, indicating that we want to see all traces of Terraform's execution displayed.



Here, in this recipe, we used the `$env` command to set this environment variable because we are working on Windows. You can, of course, do the same on other operating systems with the correct syntax.

Then, in *step 2*, we execute the commands of the Terraform workflow and we can see in the output all traces of this execution, as shown in the following screenshot:



```
[DEBUG] New state was assigned lineage "66c67b80-04e1-1834-1a70-af4496a8ea99"
[TRACE] Meta.Backend: using default local state only (no backend configuration, and no existing initialized backend)
[TRACE] Meta.Backend: instantiated backend of type <nil>
[DEBUG] checking for provider in "."
[DEBUG] checking for provider in "C:\ProgramData\chocolatey\lib\terraform\tools"
[DEBUG] checking for provider in ".terraform\plugins\windows_amd64" -----^
[DEBUG] found provider "terraform-provider-azurerm_v2.7.0_x5.exe"
[DEBUG] found valid plugin: "azurerm", "2.7.0", "C:\REPOSERSON\Terraform-Cookbook\CHAP02\myApp\simple-env\.terraform\plugins\windows_amd64\azurerm_v2.7.0_x5.exe"
[DEBUG] checking for provisioner in ".
```

In this screenshot, which is an extract of the execution of Terraform, you can see all the steps involved in the execution of Terraform.

## There's more...

Instead of having all these traces displayed in the console output, it is also possible to save them in a file.

To do this, just create a second environment variable, `TF_LOG_PATH`, which will contain as a value the path to the log file. Indeed, the logs are often very verbose and difficult to read on the console output. That's why we prefer that the output of the logs is written in a file that can be read more easily.

Moreover, to disable these traces, the `TF_LOG` environment variable must be emptied by assigning it an empty value as follows:

```
$env:TF_LOG = ""
```

## See also

- The documentation on the Terraform debug is available here: <https://www.terraform.io/docs/internals/debugging.html>
- Documentation on Terraform's environment variables is available here: <https://www.terraform.io/docs/commands/environment-variables.html>

# 5

# Sharing Terraform Configuration with Modules

The real challenge for developers and software factories in recent years has been to stop writing the portions of code that are repeated between applications and even between teams. Hence the emergence of language, framework, and software packages that are easily reusable in several applications and that can be shared between several teams (such as NuGet, NPM, Bower, PyPI, RubyGems, and many others). In **Infrastructure as Code (IaC)** in general, we also encounter the same problems of code structure, its homogenization, and its sharing in the company.

We learned in the *Provisioning infrastructure in multiple environments* recipe of Chapter 2, *Writing Terraform Configuration*, some topologies of the structure of the Terraform configuration, that gave us a partial answer to the question of how to structure a Terraform configuration well. But that doesn't stop there—Terraform also allows you to create modules with which you can share Terraform configuration between several applications and several teams.

In this chapter, we will study the main stages of the modules, which are: the creation, use, and publishing of Terraform modules. We will learn about the creation of a Terraform module and its local use, as well as the rapid bootstrapping of the code of a module. We will also study the use of Terraform modules using the public registry or a Git repository. Finally, we will study how to test a module as well as an example of a CI/CD pipeline of a Terraform module in Azure Pipelines and GitHub Actions.

In this chapter, we cover the following recipes:

- Creating a Terraform module and using it locally
- Using modules from the public registry
- Sharing a Terraform module using GitHub
- Using another file inside a custom module
- Using the Terraform module generator

- Generating module documentation
- Using a private Git repository for sharing Terraform modules
- Applying a Terrafile pattern for using modules
- Testing Terraform module code with Terratest
- Building CI/CD for Terraform modules in Azure Pipelines
- Building a workflow for Terraform modules using GitHub Actions

## Technical requirements

In this chapter, for some recipes, we will need certain prerequisites, which are as follows:

- **To have Node.js and NPM installed on your computer:** The download website is here: <https://nodejs.org/en/>.
- **To have a GitHub account:** If you don't have one, the creation of the account is free and can be done here: <https://github.com/>.
- **To have an Azure DevOps organization:** You can create one with a Live or GitHub account here: <https://azure.microsoft.com/en-in/services/devops/>.
- **To have a basic knowledge of Git commands and workflow:** The documentation is available here: <https://git-scm.com/doc>.
- **To know about Docker:** The documentation is here: <https://docs.docker.com/>.
- **To install Golang on our workstation:** The documentation is here: <https://golang.org/doc/install>. We will see the main steps of its installation in the *Testing a Terraform module using Terratest* recipe.

The complete source code for this chapter is available on GitHub at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP05>.

Check out the following video to see the Code in Action: <https://bit.ly/3ibKgH2>

## Creating a Terraform module and using it locally

A Terraform module is a Terraform configuration that contains one or more Terraform resource. Once created, this module can be used in several Terraform configuration files either locally or even remotely.

In this recipe, we will look at the basics of a Terraform module with the steps involved in creating a module and using it locally.

## Getting ready

To start this recipe, we will use the Terraform configuration that we have already written in the *Provisioning infrastructure in multiple environments* recipe in Chapter 2, *Writing Terraform Configuration*, and whose sources can be found at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP05/sample-app>.

The module we will create in this recipe will be in charge of providing a Service Plan, one App Service, and an Application Insights resource in Azure. Its source code is available here: <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP05/moduledemo/Modules/webapp>. Then, we will write a Terraform configuration that uses this module and the code is here: <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP05/moduledemo/MyApp>.

## How to do it...

To create the module, perform the following steps:

1. In a new folder called moduledemo, create the Modules and webapp folders.
2. In the webapp folder, create a new variables.tf file with the following code:

```
variable "resource_group_name" {
    description = "Resource group name"
}

variable "location" {
    description = "Location of Azure resource"
    default     = "West Europe"
}

variable "service_plan_name" {
    description = "Service plan name"
}

variable "app_name" {
    description = "Name of application"
}
```

3. Then, create the `main.tf` file with the following code:

```
resource "azurerm_app_service_plan" "plan-app" {  
    name          = var.service_plan_name  
    location      = var.location  
    resource_group_name = var.resource_group_name  
    sku {  
        tier = "Standard"  
        size = "S1"  
    }  
}  
  
resource "azurerm_app_service" "app" {  
    name          = var.app_name  
    location      = var.location  
    resource_group_name = var.resource_group_name  
    app_service_plan_id = azurerm_app_service_plan.plan-app.id  
    app_settings = {  
        "INSTRUMENTATIONKEY" = azurerm_application_insights.appinsight-  
        app.instrumentation_key  
    }  
}  
  
resource "azurerm_application_insights" "appinsight-app" {  
    name          = var.app_name  
    location      = var.location  
    resource_group_name = var.resource_group_name  
    application_type = "web"  
}
```

4. Finally, create the `output.tf` file with the following code:

```
output "webapp_id" {  
    value = azurerm_app_service.app.id  
}  
  
output "webapp_url" {  
    value = azurerm_app_service.app.default_site_hostname  
}
```

5. Inside the `moduledemo` folder, create a subfolder called `MyApp`.
6. Inside the `MyApp` folder, create a `main.tf` file with the following code:

```
resource "azurerm_resource_group" "rg-app" {  
    name      = "RG_MyAPP_demo"  
    location  = "West Europe"  
}  
  
module "webapp" {  
    source  = "../Modules/webapp"  
    service_plan_name = "spmyapp"  
    app_name = "myappdemo"  
    location = azurerm_resource_group.rg-app.location  
    resource_group_name = azurerm_resource_group.rg-app.name  
}  
  
output "webapp_url" {  
    value = module.webapp.webapp_url  
}
```

## How it works...

In *step 1*, we create the `moduledemo` directory, which will contain the code for all modules with one subdirectory per module. So, we create a `WebApp` subdirectory for our recipe, which will contain the Terraform configuration of the `webapp` module. Then in *steps 2, 3, and 4*, we create the module code, which is the standard Terraform configuration and contains the following files:

- `main.tf`: This file contains the code of the resources that will be provided by the module.
- `variables.tf`: This file contains the input variables needed by the module.
- `outputs.tf`: This file contains the outputs of the module that can be used in the main Terraform configuration.

In *step 5*, we created the directory that will contain the Terraform configuration of our application. Finally, in *step 6*, we created the Terraform configuration of our application with the `main.tf` file.

In the code of this file, we have three Terraform elements:

- There is the Terraform `azurerm_resource_group` resource, which provides a Resource Group.
- The Terraform configuration that uses the module we created, using the `module "<module name>"` expression. In this module type block, we used the `source` properties whose value is the relative path of the directory that contains the `webapp` module.

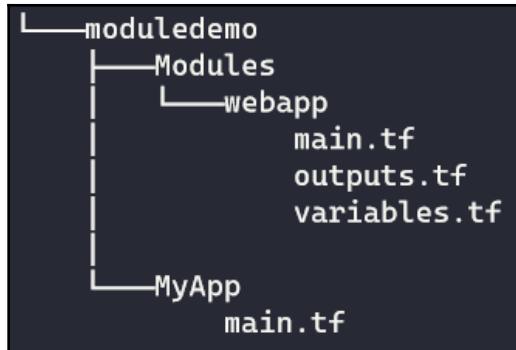


Note that if some variables of the module are defined with default values, then in some cases, it will not be necessary to instantiate them when calling the module.

- We also have the Terraform output, `webapp_url`, which gets the output of the module to use it as output for our main Terraform configuration.

## There's more...

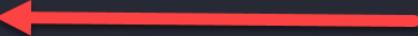
At the end of all of these steps, we obtain the following directory tree:



To apply this Terraform configuration, you have to navigate in a command terminal to the `MyApp` folder containing the Terraform configuration and then execute the following Terraform workflow commands:

```
terraform init
terraform plan -out=app.tfplan
terraform apply app.tfplan
```

When executing the `terraform init` command, Terraform will get the module's code and hence integrate its configuration with that of the application, as shown in the following screenshot:

```
PS C:\Terraform-Cookbook\CHAP05\moduledemo\MyApp> terraform init
Initializing modules...
- webapp in ..\Modules\webapp   

  Initializing the backend...  

  Initializing provider plugins...  

  - Checking for available provider plugins...  

  - Downloading plugin for provider "azurerm" (hashicorp/azurerm) 2.8.0...
```

Finally, at the end of the execution of the `terraform apply` command, the value of the output is displayed in the terminal, as shown in the following screenshot:

```
Outputs:  
webapp_url = myappdemobook.azurewebsites.net
```

Our Terraform configuration has therefore retrieved the output of the module and used it as the output of our main code.

In this recipe, we have shown the basics of the creation of a Terraform module and its local use. In this chapter, we will see how to generate the structure of a module and how to use remote modules in the *Using the Terraform module generator* recipe.

## See also

- The documentation on module creation is available at <https://www.terraform.io/docs/modules/index.html>
- General documentation on the modules is available at <https://www.terraform.io/docs/configuration/modules.html>
- Terraform's learning lab on module creation is available at <https://learn.hashicorp.com/terraform/modules/creating-modules>

# Using modules from the public registry

In the previous recipe, we studied how to create a module and how to write a Terraform configuration that uses this module locally.

To facilitate the development of Terraform configuration, HashiCorp has set up a public Terraform module registry.

This registry actually solves several problems, such as the following:

- Discoverability with search and filter
- The quality provided via a partner verification process
- Clear and efficient versioning strategy, which is otherwise impossible to solve universally across other existing module sources (HTTP, S3, and Git)

These public modules published in this registry are developed by cloud providers, publishers, communities, or even individual users who wish to share their modules publicly. In this recipe, we will see how to access this registry and how to use a module that has been published in this public registry.

## Getting ready

In this recipe, we will write a Terraform code from scratch that does not require any special prerequisite.

The purpose of this recipe is to provision a Resource Group and network resources in Azure, which are a Virtual Network and Subnet. We will see the public module call but we won't look at the Terraform configuration of the module in detail.

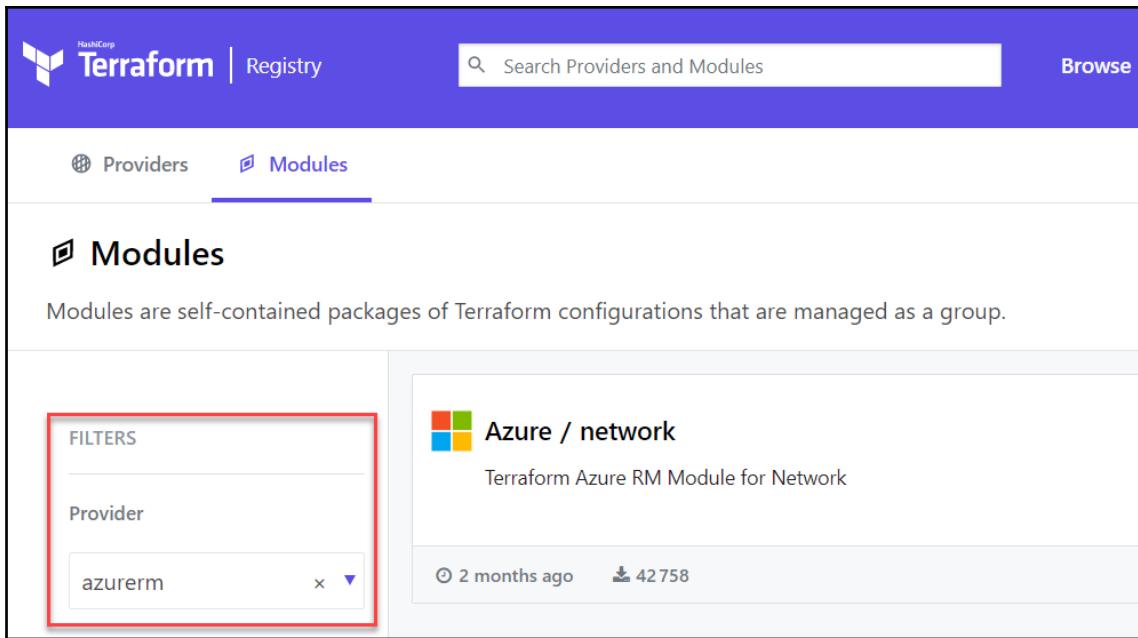
The code source of this recipe is available here: <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP05/publicmodule>.

## How to do it...

To use the Terraform module from a public registry, perform the following steps:

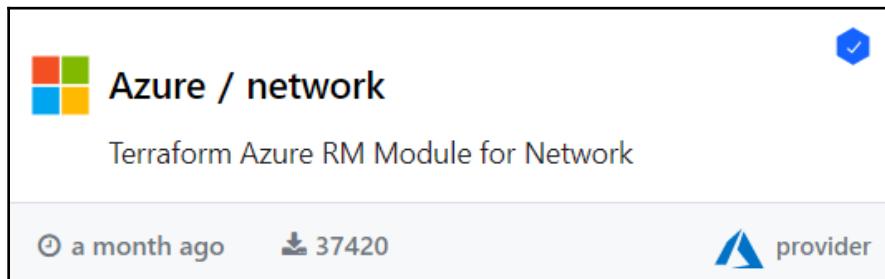
1. In a web browser, go to the URL: <https://registry.terraform.io/browse/modules>.

2. On this page, in the FILTERS list in the left panel, choose **azurerm**:



The screenshot shows the HashiCorp Terraform Registry interface. At the top, there's a navigation bar with the Terraform logo, 'Registry', a search bar ('Search Providers and Modules'), and a 'Browse' button. Below the navigation, there are two tabs: 'Providers' and 'Modules', with 'Modules' being the active tab. The main content area is titled '**Modules**' and contains a brief description: 'Modules are self-contained packages of Terraform configurations that are managed as a group.' To the left, a sidebar labeled 'FILTERS' includes a 'Provider' dropdown menu where 'azurerm' is selected. To the right, a module card for 'Azure / network' is displayed, showing its title, description, last updated time ('2 months ago'), download count ('42 758'), and a checkmark icon.

3. In the results list, click on the first result, that is, the **Azure / network** module:



This is a detailed view of the 'Azure / network' module card. It features the Microsoft logo and the module name 'Azure / network'. Below the name is the description 'Terraform Azure RM Module for Network'. To the right, there's a blue hexagonal icon with a white checkmark. At the bottom, it shows the last update time ('a month ago'), the download count ('37420'), and a 'provider' icon.

4. Then, on the **Details** page of this module, copy the code from the **Usage** section:

### Usage

```
resource "azurerm_resource_group" "test" {
    name      = "my-resources"
    location  = "West Europe"
}

module "network" {
    source          = "Azure/network/azurerm"
    resource_group_name = azurerm_resource_group.test.name
    address_space     = "10.0.0.0/16"
    subnet_prefixes   = ["10.0.1.0/24", "10.0.2.0/24", "10.0.3.0/24"]
    subnet_names      = ["subnet1", "subnet2", "subnet3"]

    tags = {
        environment = "dev"
        costcenter  = "it"
    }
}
```

5. Finally, in your workstation, create a new file, `main.tf`, then paste the preceding code and update it as follows:

```
resource "azurerm_resource_group" "rg" {
    name      = "my-rg"
    location  = "West Europe"
}

module "network" {
    source          = "Azure/network/azurerm"
    resource_group_name = azurerm_resource_group.rg.name
    vnet_name       = "vnetdemo"
    address_space    = "10.0.0.0/16"
    subnet_prefixes  = ["10.0.1.0/24"]
    subnet_names     = ["subnetdemo"]
}
```

## How it works...

In *steps 1 to 2*, we explored Terraform's public registry to look for a module that allows the provisioning of resources for Azure (using the `azurerm` filter).

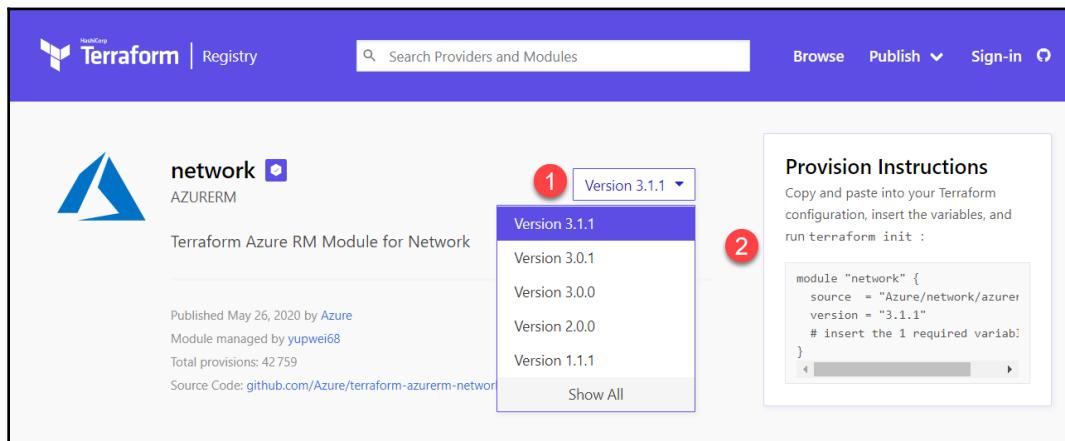
Then, in *steps 3 and 4*, we accessed the **Details** page of the **Network** module published by the Azure team.

In *step 5*, we used this module by specifying these necessary input variables with the `source` property, which is worth of a public module-specific alias, `Azure/network/azurerm`, provided by the registry.

## There's more...

We have seen in this recipe that using a module from the public registry saves development time. Here, in our recipe, we used a verified module but you can perfectly use the other community modules.

It is possible to use the versioning of these modules by choosing the desired version of the module in the version drop-down list:



And so in the module call, use the `Version` property with the chosen version number.

Note that, like all modules or community packages, you must check that their code is clean and secure before using them by manually reviewing the code inside their GitHub repository. Indeed, in each of these modules, there is a link to the GitHub repository, which contains the sources.



In the *Sharing a Terraform module using GitHub* recipe of this chapter, we will see how to publish a module in the public registry.

Also, before using a module in a company project, you must take into account that in case of a request for correction or evolution of a module, you need to create an issue or make a pull request in the GitHub repository of this module. This requires waiting for a period of time (validation waiting time and merge of the pull request) before it can be used with the fixed or the requested evolution.

However, it's worth using these modules daily, as they are very handy and save a lot of time for demonstrations, labs, and sandbox projects.



We have seen the use of the public registry in this recipe; we will study in Chapter 8, *Using Terraform Cloud to Improve Collaboration*, how to use a private registry of modules in Terraform.

## See also

The documentation on the Terraform module registry is available at <https://www.terraform.io/docs/registry/>.

# Sharing a Terraform module using GitHub

In the *Creating a Terraform module and using it locally* recipe of this chapter, we studied how to create a module and in the previous recipe, *Using a module from the public registry*, of this chapter, how to use a module from the public registry.

In this recipe, we'll see how to publish a module in the public registry by storing its code on GitHub.

## Getting ready

To apply this recipe, we need to have a GitHub account (which is currently the only Git provider available for publishing public modules) that you can create here: <https://github.com/join>. Also, you'll need to know the basics of Git commands and workflow (<https://www.hostinger.com/tutorials/basic-git-commands>).

Concerning the code of the module we are going to publish, we will use the code of the module we created in the first recipe of this chapter, the sources of which are available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP05/moduleddemo/Modules/webapp>.

## How to do it...

To share our custom module in the public registry, perform the following steps:

1. In our GitHub account, create a new repository named `terraform-azurerm-webapp` with basic configuration, as shown in the following screenshot:

**Create a new repository**

A repository contains all project files, including the revision history. Already have a project repository elsewhere? [Import a repository](#).

**Owner**      **Repository name \***

 **mikaelkrief** / **terraform-azurerm-webapp**  **1**

Great repository names are short and memorable. Need inspiration? How about **urban-chainsaw**?

**Description (optional)**

Terraform module for provision Azure Service plan, App service (web app) and Application Insight

**2**  
  **Public**  
Anyone can see this repository. You choose who can commit.

 **Private**  
You choose who can see and commit to this repository.

Skip this step if you're importing an existing repository.

**Initialize this repository with a README** **3**  
This will let you immediately clone the repository to your computer.

**4** Add .gitignore: **Terraform** Add a license: **None** 

**5** **Create repository**

2. In the local workstation, execute the Git command to clone this repository:

```
git clone  
https://github.com/mikaelkrief/terraform-azurerm-webapp.git
```

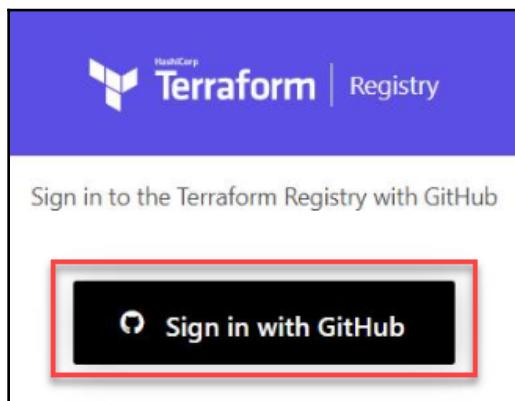
3. Copy the sources code from <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP05/moduleddemo/Modules/webapp> and paste it inside the new folder created by the git clone command.
4. Update the content of the `Readme.md` file with more description of the module role.
5. Commit and push all files in this folder; to perform this action, you can use Visual Studio Code or Git commands (`commit` and `push`)
6. Add and push a Git tag on this commit with the name `v0.0.1`, by executing this command:

```
git tag v1.0.0  
git push origin v1.0.0
```

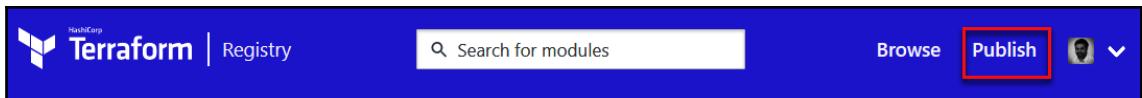
7. In a web browser, go to the URL <https://registry.terraform.io/>.
8. On this page, click on the **Sign-in** link on the top menu:



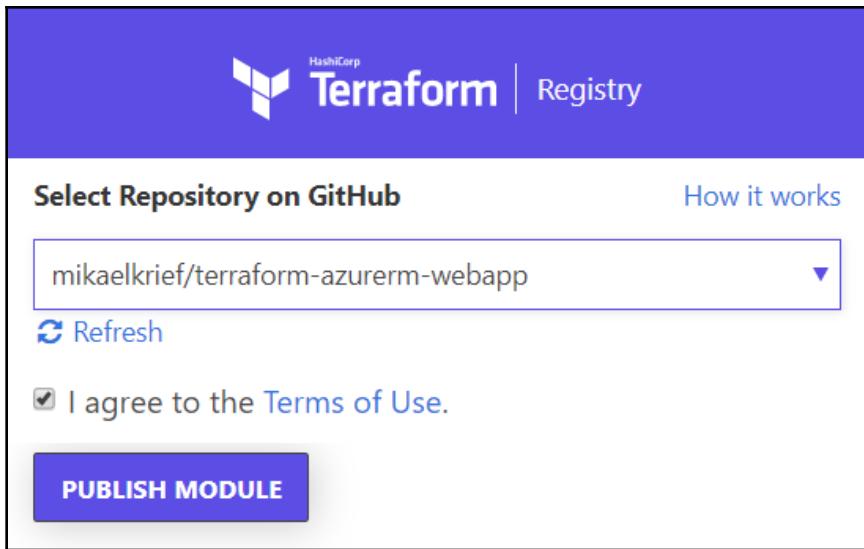
9. On the newly opened window, click on the **Sign in with GitHub** button, and if prompted, authorize HashiCorp to read your repositories:



10. Once authenticated, click on the **Publish** link on the top menu:



11. On the next page, select the **mikaelkrief/terraform-azurerm-webapp** repository, which contains the code of the module to publish, and check the **I agree to the Terms of Use** checkbox:



12. Click on the **PUBLISH MODULE** button and wait for the module page to load.

## How it works...

In *steps 1* and *2*, we created a Git repository in GitHub and cloned it locally, and in *steps 3* to *6*, we wrote the Terraform configuration for the module (using an existing code). We also edited the `Readme.md` file that will be used as documentation to use the module.

Then, we made a commit and pushed this code in the remote Git repository, and we added a tag that will be in the form `vX.X.X` and will be used to version the module.

Finally, in *steps 7 to 12*, we published this module in the public registry, by logging in with our GitHub credentials in the registry and then selecting the repository that contains the module code.

The registry automatically detects the version of the module in relation to the Git tag that was pushed (in *step 6*).

After all of these steps, the module is available in Terraform's public registry, as shown in the following screenshot:

The screenshot shows the Terraform Registry interface. At the top, there is a search bar labeled "Search for modules". Below the search bar, there are "Browse" and "Publish" buttons. On the left, there is a logo for "AZURERM" and a thumbnail image of the "webapp" module. To the right of the thumbnail, the module name "webapp" and its provider "AZURERM" are displayed. Below the name, a brief description states: "Terraform module for provision Azure Service plan, App service (web app) and Application Insight". There are two buttons: "Manage Module" and "Version 1.0.0". Further down, publication details are listed: "Published May 6, 2020 by mikaelkrief", "Total provisions: < 100", and a link to the GitHub source: "Source: [github.com/mikaelkrief/terraform-azurerm-webapp](https://github.com/mikaelkrief/terraform-azurerm-webapp) (report an issue)". On the far right, a box titled "Provision Instructions" contains Terraform code: 

```
module "webapp" {  
  source = "mikaelkrief/webapp/azurerm"  
  version = "1.0.0"  
}  
# insert the 3 required variables here
```

The module is publicly accessible; the instructions for use are displayed in the right panel and the `Readme.md` text is displayed as documentation in the content of the page.

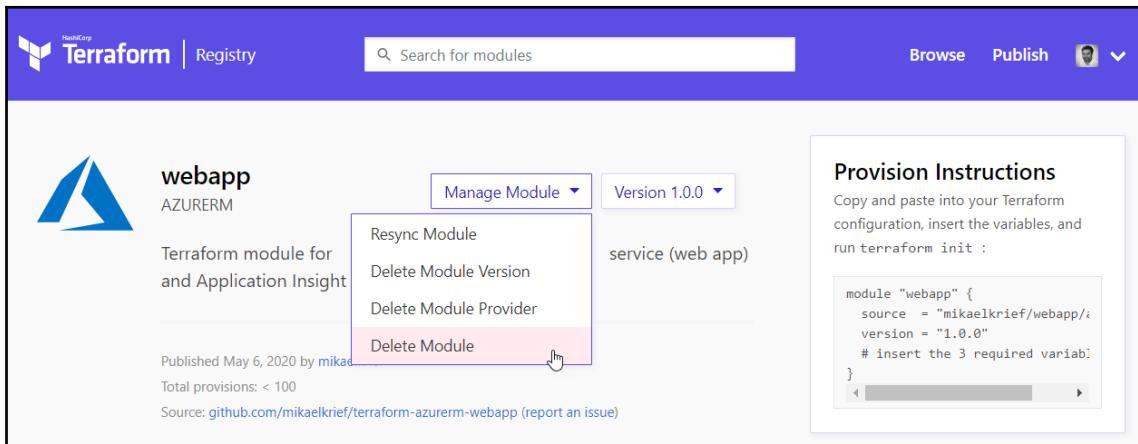
## There's more...

Concerning the name of the repository that will contain the module code, it must be composed as follows:

```
terraform-<provider>-<name>
```

Similarly, for the Git tag, it must be in the form `vX.X.X` to be integrated into the registry. To learn more about module resumes, see the documentation: <https://www.terraform.io/docs/registry/modules/publish.html#requirements>.

Once published, it is possible to delete a module by choosing **Delete module** from the **Manage Module** drop-down list:



Be careful: after deleting it from the registry, the module becomes unusable.

## See also

- Module publishing documentation is available here: <https://www.terraform.io/docs/registry/modules/publish.html>.
- Documentation on the Registry APIs is available here: <https://www.terraform.io/docs/registry/api.html>.

## Using another file inside a custom module

In the *Creating Terraform module and using it locally* recipe of this chapter, we studied the steps to create a basic Terraform module.

We can have scenarios where we need to use another file in the module that doesn't describe the infrastructure via Terraform (.tf extension), for example, in the case where the module needs to execute a script locally for operating an internal program.

In this recipe, we will study how to use another file in a Terraform module.

## Getting ready

For this recipe, we don't need any prerequisites; we will write the Terraform configuration for the module from scratch.

The goal of this recipe is to create a Terraform module that will execute a Bash script that will perform actions on the local computer (for this recipe, a `hello world` display will suffice).

Since we will be running a Bash script as an example, we will run Terraform under a Linux system.



It is important to keep in mind that provisioners such as this reduce the reusability of your configuration by assuming that the system where Terraform runs has Bash installed. This is otherwise usually not a limiting factor in Terraform as it offers builds for different OSes and architectures and runs cross-platform.

The source code of the created module in this recipe is available here: <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP05/moduleddemo/Modules/execscript>.

## How to do it...

Perform the following steps to use the file inside the module:

1. In a new folder called `execscript` (inside the `Modules` folder) that will contain the code of the module, we create a new file, `script.sh`, with the following content:

```
echo "Hello world"
```

2. Create a `main.tf` file in this module and write the following code inside it:

```
resource "null_resource" "execfile" {
  provisioner "local-exec" {
    command = "${path.module}/script.sh"
    interpreter = ["/bin/bash"]
  }
}
```

3. Then, in the Terraform configuration, call this module using the following code:

```
module "execfile" {
  source = "../Modules/execscript"
}
```

4. Finally, in a command-line terminal, navigate to the folder of the Terraform configuration and execute the basic Terraform workflow with the following commands:

```
terraform init
terraform plan -out="app.tfplan"
terraform apply app.tfplan
```

## How it works...

In *steps 1 and 2*, we created a module that executes a script locally using the `resource local_exec` (<https://www.terraform.io/docs/provisioners/local-exec.html>).

`local_exec` executes a script that is in a `script.sh` file that is stored inside the module. To configure the path relative to this `script.sh` file, which can be used during the execution of Terraform, we used the `path.module` expression, which returns the complete path relative to the module.

Then, in *step 3*, we wrote the Terraform configuration that calls this module. Finally, in *step 4*, we run Terraform on this code and we get the following result:

```
mikael@LP-FYLZ2X2: /Terraform-Cookbook/CHAP05/moduleddemo/Helloworld$ terraform apply

An execution plan has been generated and is shown below.
Resource actions are indicated with the following symbols:
+ create

Terraform will perform the following actions:

# module.execfile.null_resource.execfile will be created
+ resource "null_resource" "execfile" {
  + id = (known after apply)
}

Plan: 1 to add, 0 to change, 0 to destroy.

Do you want to perform these actions?
Terraform will perform the actions described above.
Only 'yes' will be accepted to approve.

Enter a value: yes

module.execfile.null_resource.execfile: Creating...
module.execfile.null_resource.execfile: Provisioning with 'local-exec'...
module.execfile.null_resource.execfile (local-exec): Executing: ["#!/bin/bash" ".../Modules/execscript/script.sh"]
module.execfile.null_resource.execfile (local-exec): Hello world
module.execfile.null_resource.execfile: Creation complete after 0s [id=6621299200818088901]

Apply complete! Resources: 1 added, 0 changed, 0 destroyed.
```

You can see that the script executed successfully and it displays Hello World in the console.

## There's more...

Let's see what would happen if we hadn't used the `path.module` expression in the code of this module and we had written the module code in the following way:

```
resource "null_resource" "execfile" {
  provisioner "local-exec" {
    command = "script.sh"
    interpreter = ["/bin/bash"]
  }
}
```

When executing the `apply` command, the following error would have occurred:

```
module.execfile.null_resource.execfile: Creating...
module.execfile.null_resource.execfile: Provisioning with 'local-exec'...
module.execfile.null_resource.execfile (local-exec): Executing: ["/bin/bash" "script.sh"]

Error: Error running command 'script.sh': exec: "/bin/bash": file does not exist. Output:
```

This is because Terraform runs in the `main.tf` file, which does not have access to the relative path of the `script.sh` file in the module directory.

## See also

Documentation on the `Path.Module` expression is available here: <https://www.terraform.io/docs/configuration/expressions.html#references-to-named-values>.

# Using the Terraform module generator

We learned how to create, use, and share a Terraform module and we studied the module's files structure good practices, which consists of having a main file, another for variables, and another that contains the outputs of the module. In the *Sharing a Terraform module using GitHub* recipe, we also discussed that we could document the use of the module with a `Readme.md` file.

Apart from these standard files for the operation of the module, we can also add scripts, tests (which we will see in the *Testing Terraform module code with Terratest* recipe), and other files.

For company projects with large infrastructures and a lot of resources to be provided with Terraform, we will need to create a lot of Terraform modules.

To facilitate the creation of the structure of the modules, Microsoft has published a tool that allows us to generate the basic structure (also called a **template**) of a Terraform module.

In this recipe, we will see how to create the base of a module using the module generator.

## Getting ready

The software prerequisites to use this module generator are in the following order:

1. Install Node.js (6.0+) locally; its download documentation is available at <https://nodejs.org/en/download/>.
2. Then install the npm package, Yeoman (<https://www.npmjs.com/package/yo>), by executing the following command:

```
npm install -g yo
```

To illustrate this recipe, we will use this generator to create the structure of a module that will be in charge of provisioning a Resource Group.

A sample of the generated module from this recipe is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP05/generatedmodule>.

## How to do it...

To generate a structure for a Terraform module perform the following steps:

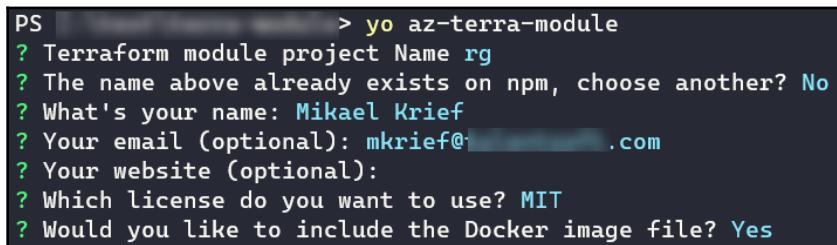
1. In a command-line terminal, execute the command:

```
npm install -g generator-az-terra-module
```

2. Create a new folder with the name of the module as `terraform-azurerm-rg`.
3. Then, in this folder, in the command-line terminal, execute this command:

```
yo az-terra-module
```

4. Finally, the generator will ask some questions; type the responses like this following screenshot:



```
PS [REDACTED] > yo az-terra-module
? Terraform module project Name rg
? The name above already exists on npm, choose another? No
? What's your name: Mikael Krief
? Your email (optional): mkrief@[REDACTED].com
? Your website (optional):
? Which license do you want to use? MIT
? Would you like to include the Docker image file? Yes
```

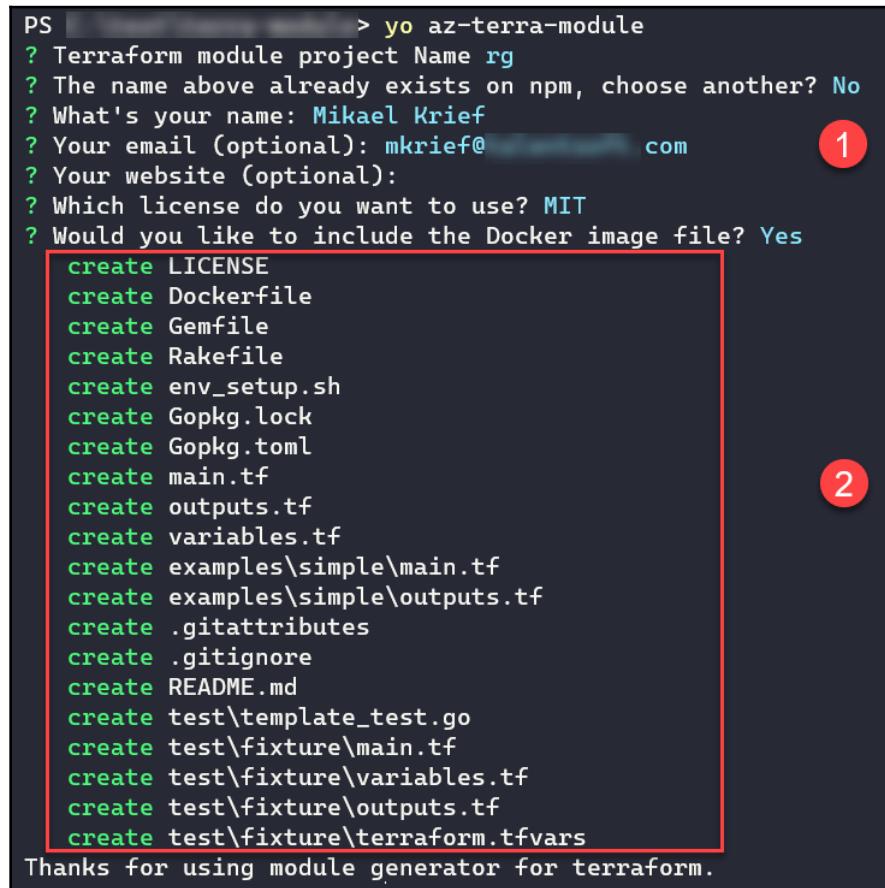
## How it works...

In *step 1*, we installed the module generator, which is an `npm` package called `generator-az-terra-module`. So we used the classical `npm` command line, which installs a package globally, that is to say, for the whole machine.

In *step 2*, we created the folder that will contain the code of the module; for our recipe, we used the nomenclature required by the Terraform registry.

In *steps 3 and 4*, we executed the `az-terra-module` generator. During its execution, this generator asks the user questions that will allow the customization of the module template that will be generated. The first question concerns the name of the module. The second one concerns the existence of the module in `npm`; we answered `No`. Then, the next three questions concern the module metadata. Finally, the last question is to know whether we want to add to the module code a Dockerfile that will be used to run the tests on the module—we answer `Yes`.

At the end of all of these questions, the generator copies all of the files necessary for the module in our directory:

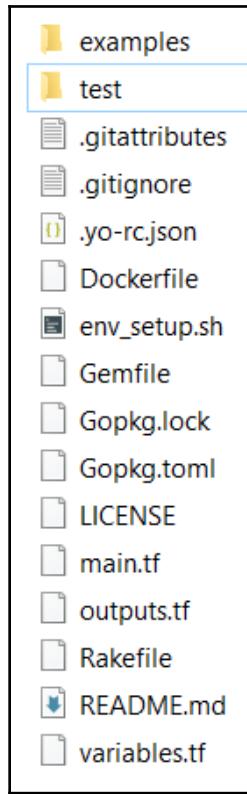


```
PS |          > yo az-terra-module
? Terraform module project Name rg
? The name above already exists on npm, choose another? No
? What's your name: Mikael Krief
? Your email (optional): m k r i e f @ . c o m
? Your website (optional):
? Which license do you want to use? MIT
? Would you like to include the Docker image file? Yes
  create LICENSE
  create Dockerfile
  create Gemfile
  create Rakefile
  create env_setup.sh
  create Gopkg.lock
  create Gopkg.toml
  create main.tf
  create outputs.tf
  create variables.tf
  create examples\simple\main.tf
  create examples\simple\outputs.tf
  create .gitattributes
  create .gitignore
  create README.md
  create test\template_test.go
  create test\fixture\main.tf
  create test\fixture\variables.tf
  create test\fixture\outputs.tf
  create test\fixture\terraform.tfvars

Thanks for using module generator for terraform.
```

As you can see in this screen, the generator displays in the terminal the list of folders and files that have been created.

Finally, in our file explorer, we can actually see all of these files:



The basic structure of our Terraform module is well generated.

## There's more...

In this recipe, we have seen that it is possible to generate the file structure of a Terraform module. At the end of the execution of this generator, the directory of the created module contains the Terraform files of the module, which will be edited afterward with the code of the module. This folder will also contain other test files and a Dockerfile whose usefulness we will see in the *Testing a Terraform module with Terratest* recipe of this chapter.

Also, although this generator is published by Microsoft, it can be used to generate the structure of any Terraform modules you need to create even if it does not provide anything in Azure.

## See also

- The source code for the module generator is available on GitHub at <https://github.com/Azure/generator-az-terra-module>.
- Documentation on the use of the generator is available at <https://docs.microsoft.com/en-us/azure/developer/terraform/create-a-base-template-using-yeoman>.
- Yeoman documentation is available at <https://yeoman.io/>.
- The npm package of the generator is available at <https://www.npmjs.com/package/generator-az-terra-module>.

## Generating module documentation

We have learned from the previous recipes that in the composition of a Terraform module we have input variables, as well as outputs.

As with all packages that are made available to other teams or even publicly, it is very important to document your Terraform module.

The problem with this documentation is that it is tedious to update the document with each change and therefore quickly becomes obsolete.

Among all of the tools in the Terraform toolbox, there is `terraform-docs`, an open source, cross-platform tool that allows the documentation of a Terraform module to be generated automatically.

We will discuss in this recipe how to automatically generate the markdown documentation of a module with `terraform-docs`.

## Getting ready

For this recipe, we are going to generate the documentation of the module we created in the *Creating a Terraform module and using it locally* recipe of this chapter, which allowed us to create a web app in Azure, the sources of which are here: <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP05/moduledemo/Modules/webapp>.

If you are working on a Windows OS, you will need to install **Chocolatey** by following this documentation: <https://chocolatey.org/install>. The documentation we will generate for the webapp module is available at <https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP05/moduleddemo/Modules/webapp/Readme.md>.

## How to do it...

Perform the following steps to generate the module documentation:

1. If you work on a Linux OS, execute the following script in a command-line terminal:

```
curl -L
https://github.com/segmentio/terraform-docs/releases/download/v0.9.1/terraform-docs-v0.9.1-linux-amd64 -o terraform-docs-v0.9.1-linux-amd64
tar -xf terraform-docs-v0.9.1-linux-amd64
chmod u+x terraform-docs-v0.9.1-linux-amd64
sudo mv terraform-docs-v0.9.1-linux-amd64 /usr/local/bin/terraform-docs
```

If you work on a Windows OS, execute the following script:

```
choco install terraform-docs -y
```

2. Execute the following script to test the installation:

```
terraform-docs --version
```

3. In a command-line terminal, navigate inside the `moduledemo` folder and execute the following command:

```
terraform-docs markdown Modules/webapp/ > Modules/webapp/Readme.md
```

## How it works...

In step 1, we install `terraform-docs` according to the operating system. For Linux, the provided script downloads the `terraform-docs` package from GitHub, decompresses it with the TAR tool, gives it execution rights with `chmod`, and finally copies it to the local directory, `/usr/bin/local` (which is already configured in the `PATH` environment variable).

The following screenshot shows the installation in Linux:

```
root@LP-FYLVZ2X2:/c/Users/mkrief# curl -L https://github.com/segmentio/terraform-docs/releases/download/v0.9.1/terraform-docs-v0.9.1-linux-amd64 -o terraform-docs-v0.9.1-linux-amd64
% Total    % Received % Xferd  Average Speed   Time   Time     Current
          Dload  Upload Total Spent    Left Speed
100  644  100  644    0      0  3659      0 --:--:--:--:--:--:--:--:--:--:--:--:3659
100 10.6M  100 10.6M   0      0  316k      0 0:00:34 0:00:34 --:--:--:678k
root@LP-FYLVZ2X2:/c/Users/mkrief# tar -xf terraform-docs-v0.9.1-linux-amd64
tar: This does not look like a tar archive
tar: Skipping to next header
tar: Exiting with failure status due to previous errors
root@LP-FYLVZ2X2:/c/Users/mkrief# chmod u+x terraform-docs-v0.9.1-linux-amd64
root@LP-FYLVZ2X2:/c/Users/mkrief# sudo mv terraform-docs-v0.9.1-linux-amd64 /usr/local/bin/terraform-docs
```

For Windows, the script uses the `choco install` command from **Chocolatey** to download the `terraform-docs` package.

The following screenshot shows the installation in Windows:

```
PS C:\WINDOWS\system32> choco install terraform-docs -y
Chocolatey v0.10.15
Installing the following packages:
  terraform-docs
By installing you accept licenses for the packages.
Error retrieving packages from source 'http://srv-rd-packages.talentsoft.com/nuget/TalentsoftChoco':
  Le nom distant n'a pas pu être résolu: 'srv-rd-packages.talentsoft.com'

Terraform-Docs v0.8.2 [Approved]
terraformation-docs package files install completed. Performing other installation steps.
Downloading terraform-docs 64 bit
  from 'https://github.com/segmentio/terraform-docs/releases/download/v0.8.2/terraform-docs-v0.8.2-windows-amd64.exe'
Progress: 100% - Completed download of C:\ProgramData\chocolatey\lib\Terraform-Docs\tools\terraform-docs-v0.8.2-windows-amd64.exe (8.71 MB).
Download of terraform-docs-v0.8.2-windows-amd64.exe (8.71 MB) completed.
Hashes match.
C:\ProgramData\chocolatey\lib\Terraform-Docs\tools\terraform-docs-v0.8.2-windows-amd64.exe
Environment Vars (like PATH) have changed. Close/reopen your shell to
see the changes (or in powershell/cmd.exe just type `refreshenv`).
ShimGen has successfully created a shim for terraform-docs.exe
The install of terraform-docs was successful.
  Software install location not explicitly set, could be in package or
  default install location if installer.

Chocolatey installed 1/1 packages.
See the log for details (C:\ProgramData\chocolatey\logs\chocolatey.log).
```

Then, in *step 2*, we check its installation by running `terraform-docs` and adding the `--version` option. This command displays the installed version of `terraform-docs`, as shown in the following screenshot:

```
root@LP-FYLVZ2X2:~/Terraform-Cookbook/CHAP05/moduleddemo# terraform-docs --version
terraform-docs version v0.9.1 7f761d3 linux/amd64 BuildDate: 2020-04-02T21:58:38+0000
```

Finally, in *step 3*, we execute `terraform-docs` specifying in the first argument the type of format of the documentation. In our case, we want it in `markdown` format. Then, in the second argument, we specify the path of the `modules` directory. At this stage, we could execute the command this way and during its execution, the documentation is displayed in the console, as shown in the following screenshot:

```
root@LP-FYLZ2X2: /Terraform-Cookbook/CHAP05/moduledemo# terraform-docs markdown Modules/webapp/
## Requirements 1 2
No requirements.

## Providers

| Name | Version |
|-----|-----|
| azurerm | n/a |

## Inputs

| Name | Description | Type | Default | Required |
|-----|-----|-----|-----|
| app\_\_name | Name of application | `any` | n/a | yes |
| location | Location of Azure resource | `string` | `West Europe` | no |
| resource\_\_group\_\_name | Resource group name | `any` | n/a | yes |
| service\_\_plan\_\_name | Service plan name | `any` | n/a | yes |

## Outputs

| Name | Description |
|-----|-----|
| webapp\_\_id | n/a |
| webapp\_\_url | n/a |
```

But to go further, we added the `> Modules/webapp/Readme.md` command, which indicates that the content of the generated documentation will be written in the `Readme.md` file that will be created in the module directory.

At the end of the execution of this command, a new `Readme.md` file can be seen inside the module folder that contains the module documentation. The generated documentation is composed of the providers used in the module, the input variables, and the outputs.

## There's more...

In our recipe, we chose to generate `markdown` documentation, but it is also possible to generate it in `JSON`, `XML`, `YAML`, or `text (pretty)` format. To do so, you have to add the `format` option to the `terraform-docs` command. To know more about the available generation formats, read the documentation here: [https://github.com/segmentio/terraform-docs/blob/master/docs/FORMATS\\_GUIDE.md](https://github.com/segmentio/terraform-docs/blob/master/docs/FORMATS_GUIDE.md).

You can also improve your processes by automating the generation of documentation by triggering the execution of `terraform-docs` every time you commit code in Git. For this, you can use a pre-commit Git Hook, as explained in the documentation here: [https://github.com/segmentio/terraform-docs/blob/master/docs/USER\\_GUIDE.md#integrating-with-your-terraform-repository](https://github.com/segmentio/terraform-docs/blob/master/docs/USER_GUIDE.md#integrating-with-your-terraform-repository).

Also, to get the latest version of `terraform-docs`, follow the release here: <https://github.com/segmentio/terraform-docs/releases>, as well as CHANGELOG here: <https://github.com/segmentio/terraform-docs/blob/master/CHANGELOG.md>, to see the changes.



If you want to publish your module in the Terraform registry as we have seen in the *Sharing a Terraform module using GitHub* recipe in this chapter, you do not need to generate this documentation because it is already included in the registry's functionalities.

## See also

- Source code for `terraform-docs` is available here: <https://github.com/segmentio/terraform-docs>.
- The Chocolatey `terraform-docs` package page is available here: <https://chocolatey.org/packages/Terraform-Docs>.

# Using a private Git repository for sharing a Terraform module

In this chapter dedicated to Terraform modules, we have seen that it is possible to put the code of a module in a GitHub repository to publish it in the Terraform public registry.

However, in enterprises, there is a need to create modules without exposing the code of these modules publicly by archiving them in GitHub repositories, which are public, that is, accessible by everyone.

What you need to know is that there are several types of Terraform module sources, as indicated in this documentation: <https://www.terraform.io/docs/modules/sources.html>.

In this recipe, we will study how to expose a Terraform module through a private Git repository. That is to say, either this Git is installed internally (so-called on-premises) or in cloud mode, SaaS, but requires authentication.

## Getting ready

For this recipe, we will use a Git repository in **Azure Repos** (Azure DevOps), which is free and requires authentication to access it. For more information and how to create a free Azure DevOps account, go to <https://azure.microsoft.com/en-us/services/devops/>.

As a prerequisite, we need a project that has already been created; it can be named, for example, `Terraform-modules`, and it will contain the Git repository of all of the modules.

The next screenshot shows the form to create this Azure DevOps project:

The screenshot shows the 'Create new project' dialog box. At the top, there is a 'Project name \*' field containing 'Terraform-modules'. Below it is a 'Description' field with the placeholder 'Contain all Terraform Modules'. Under 'Visibility', there are two options: 'Public' (disabled) and 'Private' (selected). The 'Private' option is described as 'Only people you give access to will be able to view this project.' Below the visibility section is an 'Advanced' button. At the bottom, there are 'Version control' (set to 'Git') and 'Work item process' (set to 'Basic') dropdowns, along with 'Cancel' and 'Create' buttons.



The purpose of this recipe is not to focus on the use of Azure DevOps; we will use it just to have an example of a private repository.

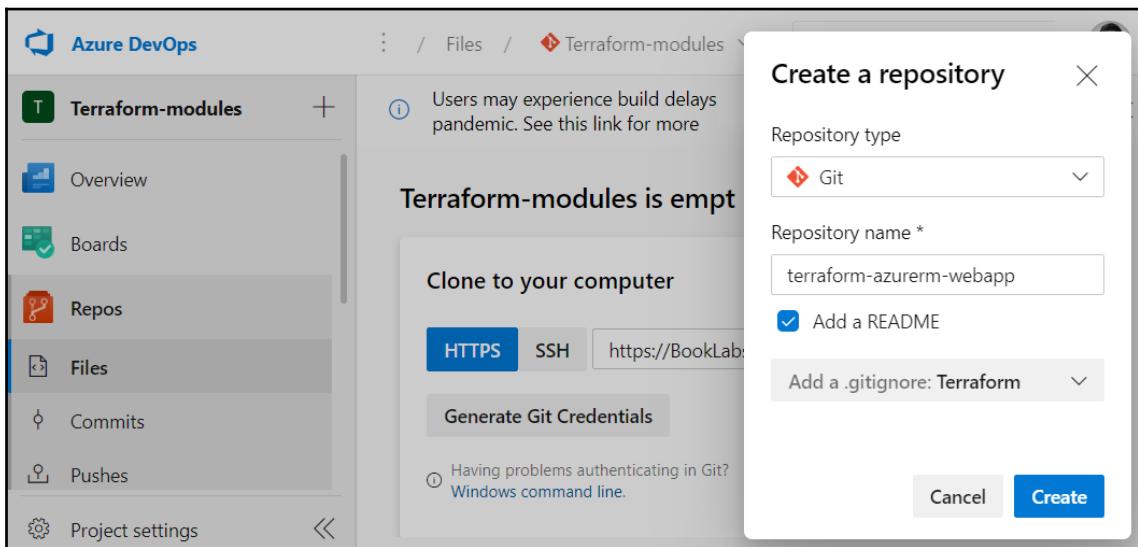
You will also need to know the basics of the commands and workflow of Git: <https://www.hostinger.com/tutorials/basic-git-commands>.

Concerning the code of the module that we are going to put in Azure Repos, we are going to use the code of the module that we created in the first recipe of this chapter, the source code for which is available here: <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP05/moduleddemo/Modules/webapp>.

## How to do it...

To use a private module repository, we need to perform the following steps:

1. In the Azure DevOps project, `Terraform-modules`, create a new Git repository named `terraform-azurerm-webapp` with basic configuration, as shown in the following screenshot:



2. In a local workstation, execute the Git command for cloning this repository:

```
git clone  
https://dev.azure.com/<account>/Terraform-modules/_git/terraform-azurerm-webapp
```

3. During the first operation, you will have to enter your Azure DevOps login and password for identification.

4. Copy the source code from <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP05/moduledemo/Modules/webapp> and paste it the new folder created by the Git clone.
5. Update the content of the `Readme.md` file with more of a description of the module role.
6. Commit and push all files in this folder; to perform this action, you can use VS Code or Git commands:

```
git add .
git commit -m "add code"
git push origin master
```

7. Add and push a Git tag on this commit with the name, `v0.0.1`, by executing this command:

```
git tag v1.0.0
git push origin v1.0.0
```



This operation can also be done via the web interface of Azure Repos, in the **Tags** tab of the repository.

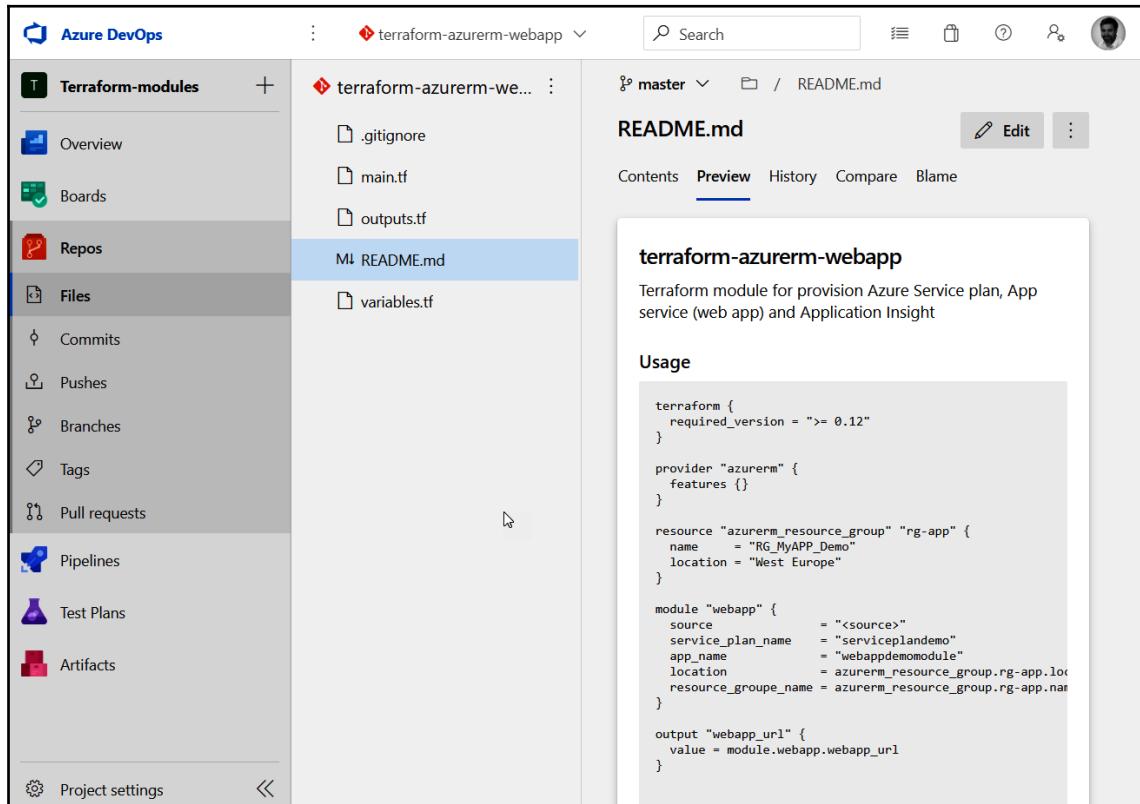
8. Finally, in the Terraform `main.tf` file, the following code is written that uses the module:

```
resource "azurerm_resource_group" "rg-app" {
    name      = "RG_MyAPP_Demo2"
    location  = "West Europe"
}

module "webapp" {
    source      =
    "git::https://dev.azure.com/BookLabs/Terraform-modules/_git/terraform-azurerm-webapp?ref=v1.0.0"
    service_plan_name      = "spmyapp2"
    app_name              = "myappdemobook2"
    location               = azurerm_resource_group.rg-app.location
    resource_group_name    = azurerm_resource_group.rg-app.name
}
output "webapp_url" {
    value = module.webapp.webapp_url
}
```

## How it works...

In *steps 1 and 2*, we created a Git repository in Azure Repos and cloned it locally. Then, in *steps 3 to 7*, we wrote the Terraform configuration for the module (using an already existing code). We also edited the `Readme.md` file that will be used as a documentation for the use of the module. Then, we made a commit and pushed this code into the remote Git Azure repository. The following screenshot shows the remote repository in Azure Repos:



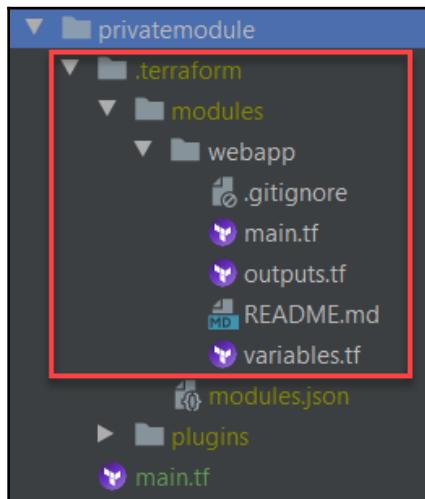
And finally, we added a Git tag, which will be in the form `vX.X.X` and which will be used to version the module.

Finally, in *step 8*, we wrote the Terraform configuration, which remotely uses this module with a Git type source. For this, we specified the `source` property of the module with the Git URL of the repository. In addition to this URL, we added the `ref` parameter to which we give as a value the Git tag we created.

It will be during the execution of the `terraform init` command that Terraform will clone the repository locally:

```
PS C:\Terraform-Cookbook\CHAP05\privatemodule> terraform init
Initializing modules...
Downloading git::https://dev.azure.com/BookLabs/Terraform-modules/_git/terraform-azurerm-webapp?ref=v1.0.0 for webapp...
- webapp in .terraform\modules\webapp
```

The module code will be cloned into the Terraform context directory, as shown in the following screenshot:



The `webapp` module is downloaded inside the `.terraform` folder.

## There's more...

In this recipe, the majority of the steps are identical to the ones already studied in the *Sharing a Terraform module using GitHub* recipe in which we stored the module code in GitHub and shared it in the public registry. The difference is that, in *step 8* of this recipe, we filled the value of the `source` property with the Git repository URL.

The advantages of using a private Git repository are, on the one hand, that it's only accessible by people who have permissions for that repository. On the other hand, in the `ref` parameter that we put in the module call URL, we used a specific version of the module using a Git tag. We can also perfectly name a specific Git branch, which is very useful when we want to evolve the module without impacting the master branch.

We could also very well store the module's code in a GitHub repository and fill the `source` properties with the GitHub repository URL, as shown in this documentation: <https://www.terraform.io/docs/modules/sources.html#github>.

In this recipe, we took a Git repository in Azure DevOps as an example, but it works very well with other Git repository providers such as Bitbucket (<https://www.terraform.io/docs/modules/sources.html#bitbucket>).

Regarding Git repository authentication, you can check out this documentation at <https://www.terraform.io/docs/modules/sources.html#generic-git-repository>, for information on access to and authentication of the Git repository in HTTPS or SSH.

## See also

The module source documentation is available here: <https://www.terraform.io/docs/modules/sources.html>.

# Applying a Terrafile pattern for using modules

We have seen throughout this chapter's recipes how to create Terraform modules and how to use them either locally or remotely with the public registry or Git repositories.

However, when you have a Terraform configuration that uses many modules, managing these modules can become complicated. This is indeed the case when the versions of these modules change; it is necessary to browse through all of the Terraform configurations to make version changes. Moreover, we do not have global visibility on all of the modules called in this Terraform configuration as well as their versions.

Analogous to the classic package managers (NPM and NuGet), a pattern has been exposed by several people that allows users to gather the configuration of the Terraform modules used in a Terraform configuration in a centralized file called a **Terrafile**.

In this recipe, we will study how to use the Terrafile pattern to manage the sources of the Terraform modules.

## Getting ready

For this recipe, we will use the Terraform source code that is already written and available here: <https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP05/terraform/initial/main.tf>. This Terraform configuration is at first classically configured—it calls several modules and in each of the calls to these modules, we use the source property with the GitHub repositories' URLs.

Moreover, we will execute a code written in Ruby with Rake (<https://github.com/ruby/rake>). For this, we need to have Ruby installed on our computer. The installation documentation is available here: <https://www.ruby-lang.org/en/documentation/installation/>. However, no prior Ruby knowledge is required; the complete script is provided in the source code of this recipe.

The goal of this recipe will be to integrate the Terrafile pattern in this code by centralizing the management of the modules to be used. The code source of this recipe is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP05/terraform>.

## How to do it...

Perform the following steps to use the Terrafile pattern:

1. Copy the content of `main.tf` available at <https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP05/terraform/initial/main.tf> inside a new folder.
2. In this new folder, create a new file called `Terrafile` (without an extension) with the following content:

```
rg-master:  
  source:  
    "https://github.com/mikaelkrief/terraform-azurerm-resource-group.git"  
    version: "master"  
webapp-1.0.0:  
  source:  
    "https://github.com/mikaelkrief/terraform-azurerm-webapp.git"  
    version: "v1.0.0"  
network-3.0.1:  
  source:  "https://github.com/Azure/terraform-azurerm-network.git"  
  version: "v3.0.1"
```

3. Create another new file, `Rakefile` (without an extension), with the following content (the complete source code is at <https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP05/terrafile/new/Rakefile>):

```
.....
desc 'Fetch the Terraform modules listed in the Terrafile'
task :get_modules do
  terrafile = read_terrafile
  create_modules_directory
  delete_cached_terraform_modules
  terrafile.each do |module_name, repository_details|
    source = repository_details['source']
    version = repository_details['version']
    puts "[*] Checking out #{version} of #{source}"
    ...".colorize(:green)
    Dir.mkdir(modules_path) unless Dir.exist?(modules_path)
    Dir.chdir(modules_path) do
      #puts "git clone -b #{version} #{source} #{module_name} &>
      /dev/null".colorize(:green)
      'git clone -q -b #{version} #{source} #{module_name}''
    end
  end
end
```

4. In `main.tf`, update all source module properties with the following content:

```
module "resourcegroup" {
  source = "./modules/rg-master"
  ...
}

module "webapp" {
  source = "./modules/webapp-1.0.0"
  ...
}

module "network" {
  source = "./modules/network-3.0.1"
  ...
}
```

5. In a command-line terminal, inside this folder, execute the following script:

```
bundle install
rake get_modules
```

## How it works...

The mechanism of the Terrafile pattern is that instead of using the Git sources directly in module calls, we reference them in a file in Terrafile YAML format. In the Terraform configuration, in the module call, we instead use a local path relative to the `modules` folder. Finally, before executing the Terraform workflow, we execute a script that runs through this `Terrafile` file and will locally clone each of these modules referenced in its specific folder (which is in the module call).

In *step 1*, we created the `Terrafile` file, which is in YAML format and contains the repository of the modules we are going to use in the Terraform configuration. For each of the modules, we indicate the following:

- The name of the folder where the module will be copied
- The URL of the Git repository of the module
- Its version, which is the Git tag or its branch

In *step 2*, we wrote the Ruby Rake script called `Rakefile`, which, when executed, will browse the `Terrafile` and will execute the `git clone` command on all modules into the specified folder.

Then, in *step 3*, we modify the Terraform configuration to call the modules, no longer with the Git URL but earlier with the relative path of their specified folder in the `Terrafile`.

Finally, in *step 4*, we execute the `Rakefile` script by calling the `get_modules` function of this script, which will make a Git clone of all of these modules in their folders.

Once these steps are done, we can execute the classic Terraform workflow commands with `init`, `plan`, and `apply`.

## There's more...

As we have learned in this recipe, we have created a `Terrafile` file that serves as a repository for the modules we will use in our Terraform configuration. It allows for better management and maintenance of the modules and versions to be used.

In this Terrafile, for each module, we have specified its destination folder, and as you can see, we have added the version number in the folder name. Hence, the name of the folder is unique and will allow us to use several versions of the same module in the Terraform configuration. The following code shows an extract of a Terrafile with two different versions of the same module:

```
network-3.0.1:  
  source: "https://github.com/Azure/terraform-azurerm-network.git"  
  version: "v3.0.1"  
network-2.0.0:  
  source: "https://github.com/Azure/terraform-azurerm-network.git"  
  version: "v2.0.0"
```

Also, it allows you to specify, if necessary, the authorized Git credentials to clone the module code. Be careful, however, not to write passwords in this file, which will be archived in a Git repository.

In this recipe, the Rakefile script was provided and is available in the original article of the Terrafile pattern (<https://bensnape.com/2016/01/14/terraform-design-patterns-the-terrafile/>). You are free to adapt it according to your needs.

Finally, the essentials of the Terrafile pattern is not the script, the language, or the format used but, rather, its working principle. There are alternative scripts and tools to this Rakefile with, for example, a Python script available at <https://github.com/claranet/python-terrafile>, or a tool written in Go available at <https://github.com/coretech/terrafile>.

## See also

- The main reference article on the Terrafile pattern is available here: <https://bensnape.com/2016/01/14/terraform-design-patterns-the-terrafile/>.
- The Python Terrafile package is available here: <https://pypi.org/project/terrafile/> and its use is described here <https://github.com/claranet/python-terrafile>.
- The Terrafile tool written in Go is available here: <https://github.com/coretech/terrafile>.

# Testing Terraform module code with Terratest

When developing a Terraform module that will be used in multiple Terraform configurations and shared with other teams, there is one step that is often neglected and that is the testing of the module.

Among the Terraform framework and testing tools is the **Terratest** framework, created by the *Gruntwork* community (<https://gruntwork.io/static/>), which is popular and allows testing on code written in the Go language.

In this recipe, we will study how to use Terratest to write and run integration tests on Terraform configuration and modules in particular.

## Getting ready

The **Terratest** test framework is written in Golang (Go language) and the tests run on the Go runtime. That's why, as a prerequisite, we need to install Go by going to <https://golang.org/>.



The minimum Go version required for Terratest is specified here: <https://terratest.gruntwork.io/docs/getting-started/quick-start/#requirements>.

Here are some important steps to install Go: for the Windows OS, you can install the Golang package using Chocolatey (<https://chocolatey.org/packages/golang>) by executing this command:

```
choco install golang -y
```

For the Linux OS, run the following script:

```
GOLANG_VERSION="1.14.6"
GOLANG_OS_ARCH=linux-amd64

mkdir "$HOME/go"
mkdir "$HOME/go/bin"
mkdir "$HOME/go/src"

curl -Os
https://storage.googleapis.com/golang/go${GOLANG_VERSION}. ${GOLANG_OS_ARCH}.tar.gz >/dev/null 2>&1 &&
```

```
tar -zxvf go${GOLANG_VERSION}.${GOLANG_OS_ARCH}.tar.gz -C /usr/local/  
>/dev/null  
  
# Refresh Go environment.  
export GOPATH="$HOME/go"  
export PATH="/usr/local/go/bin:$GOPATH/bin:$PATH"
```

The preceding script creates the workspace directories of Go (`bin` and `src`), then downloads the Go SDK, and sets the environment variables, `GOPATH` and `PATH`.



If you are on Linux, you will also need the `gcc` package that you can install by running the `apt install gcc` command.

The goal of this recipe is to write the integration tests for a very simple module that we will also write in this recipe to serve as a demonstration.

The source code of this chapter with the module and its test is available here: <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP05/testing-terratest>.

## How to do it...

This recipe is in two parts. The first part concerns the writing of the module and its tests and the second part concerns the execution of the tests.

To write the module and its tests, we perform the following steps:

1. We create a new `module` folder that will contain the Terraform configuration of the module.
2. In this `module` folder, we create a `main.tf` file, which contains the following code:

```
variable "string1" {}  
  
variable "string2" {}  
  
## PUT YOUR MODULE CODE  
## _____
```

```
output "stringfct" {
    value = format("This is test of %s with %s", var.string1,
upper(var.string2))
}
```

3. In this module folder, we create the `fixture` folder inside a `test` folder.
4. Then, in this `fixture` folder, we create a `main.tf` file, which contains the following Terraform configuration:

```
module "demo" {
  source  = "../.."
  string1 = "module"
  string2 = "terratest"
}

output "outmodule" {
  value = module.demo.stringfct
}
```

5. In the `test` folder, we create a `test_module.go` file, which contains the following code:

```
package test

import (
    "testing"
    "github.com/gruntwork-io/terratest/modules/terraform"
    "github.com/stretchr/testify/assert"
)

func TestTerraformModule(t *testing.T) {
    terraformOptions := &terraform.Options{
        // path to the terraform configuration
        TerraformDir: "./fixture",
    }

    // lean up resources with "terraform destroy" at the end of the
    // test.
    defer terraform.Destroy(t, terraformOptions)

    // Run "terraform init" and "terraform apply". Fail the test if
    // there are any errors.
    terraform.InitAndApply(t, terraformOptions)

    // Run `terraform output` to get the values of output variables
    // and check they have the expected values.
    output := terraform.Output(t, terraformOptions, "outmodule")
```

```
        assert.Equal(t, "This is test of module with TERRATEST", output)
    }
```

To execute the tests, we perform the following steps:

1. The first step is to download the `terratest` Go package by executing the following command:

```
go get github.com/gruntwork-io/terratest/modules/terraform
```

2. Then, in the directory that contains the `test_module.go` file, we execute this command:

```
go test -v
```

## How it works...

In the first part of this recipe, we worked on the development of the module and its tests with the Terratest framework. In *step 2*, we wrote the module's code, which is extremely simple and focuses on the module's output. In *step 3*, in the `fixture` folder, we wrote a Terraform configuration that uses the module locally and that we will use to test it. What is important in this configuration is to have an output in the module. Indeed, in Terratest, we will use the outputs to test that the module correctly returns the correct expected value.

In *step 4*, we write the module tests in a file written in Golang. The code is composed as follows: in the first lines of this code, we import the libraries needed to run the tests, including the `terratest` and `assert` libraries. Then, we create a `TestTerraformModule` function, which takes `testing.T` as a parameter, which is a Go pointer that indicates that it is a test code.

Following are the details of the code of this function, which is composed of five lines of code.

In the first line, we define the test options with the folder containing the Terraform configuration that will be executed during the tests:

```
terraformOptions := &terraform.Options{
    // path to the terraform configuration
    TerraformDir: "./fixture",
}
```

Then, we define the `terraform.Destroy` function, which allows us to execute the `terraform destroy` command at the end of the tests, as described in the following code:

```
defer terraform.Destroy(t, terraformOptions)
```

Then, we call the `terraform.InitAndApply` function, which allows us to execute the `terraform init` and `apply` commands, as described in the following code:

```
terraform.InitAndApply(t, terraformOptions)
```

After executing the `apply` command, we will retrieve the value of the output, which is called `outmodule`:

```
output := terraform.Output(t, terraformOptions, "outmodule")
```

Finally, we use `assert`, testing the previously recovered value of the output with the value we expect:

```
assert.Equal(t, "This is test of module with TERRATEST", output)
```

Then, in the second part of this recipe, we work on the execution of the tests. The first step is to download the Terratest Go package with the `go get <package source>` command.



We can also run the `go get -v -t -d ./...` command to get all required package dependencies.

Then, inside the `test` folder, we run the tests by executing this command:

```
go test -v
```

During this execution, Terratest will carry out the following actions in order:

1. Execute the `terraform init` and `terraform apply` commands on the Terraform test code located in the fixture folder.
2. Get the value of the `outmodule` output.
3. Compare this value with the expected value.
4. Execute the `terraform destroy` command.
5. Display the test results.

The next screenshot shows the execution of the tests on our module:

```
root@LP-FYLZ2X2:~/go/src/module/tests# go test -v
== RUN TestTerraformModule
TestTerraformModule 2020-05-19T14:46:29+02:00 retry.go:72: terraform [init --upgrade=false]
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66: Running command terraform with args [init --upgrade=false] ①
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66: Initializing modules...
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66: - demo in ../..
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66:
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66: Initializing the backend...
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66:
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66: Terraform has been successfully initialized!
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66:
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66: You may now begin working with Terraform. Try running "terraform plan" to see
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66: any changes that are required for your infrastructure. All terraform commands
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66: should now work.
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66:
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66: If you ever set or change modules or backend configuration for Terraform,
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66: rerun this command to reinitialize your working directory. If you forget, other
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66: commands will detect it and remind you to do so if necessary.
TestTerraformModule 2020-05-19T14:46:29+02:00 retry.go:72: terraform [get --update]
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66: Running command terraform with args [get --update]
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66: - demo in ../..
TestTerraformModule 2020-05-19T14:46:29+02:00 retry.go:72: terraform [apply --input=false --auto-approve --lock=false]
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66: Running command terraform with args [apply --input=false --auto-approve --lock=false]
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66:
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66: Apply complete! Resources: 0 added, 0 changed, 0 destroyed. ②
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66:
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66: Outputs:
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66:
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66: outmodule = This is test of module with TERRATEST
TestTerraformModule 2020-05-19T14:46:29+02:00 retry.go:72: terraform [output --no-color outmodule]
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66: Running command terraform with args [output --no-color outmodule]
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66: This is test of module with TERRATEST ③
TestTerraformModule 2020-05-19T14:46:29+02:00 retry.go:72: terraform [destroy --auto-approve --input=false --lock=false]
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66: Running command terraform with args [destroy --auto-approve --input=false --lock=false]
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66:
TestTerraformModule 2020-05-19T14:46:29+02:00 logger.go:66: Destroy complete! Resources: 0 destroyed.
--- PASS: TestTerraformModule (0.33s)
PASS
ok    module/tests    0.393s ④
```

You can see, in this screenshot, the different operations that have been executed by the `go test -v` command as well as the result of the tests.

## There's more...

Terratest allows you to execute integration tests on Terraform configuration with a powerful routine that allows you to provision resources, execute the tests, and finally destroy the resources.

We have seen in the prerequisites of this recipe that the setup of the Golang development environment requires actions that can vary from one operating system to another. To facilitate this task, you can execute your Terratest tests in a Docker container that already has an environment configured. The Dockerfile corresponding to this container is available here: <https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP05/testing-terratest/Dockerfile>.



If Terraform modules provide resources in cloud providers, the authentication parameters must be set before running tests.

Finally, as said in the introduction of this recipe, Terratest is not limited to Terraform—it also allows testing on Packer, Docker, and Kubernetes code. But it goes further by also doing tests on cloud providers such as AWS, Azure, and GCP.

The following code snippet shows how to test the existence of the VM in Azure based on Terraform's output:

```
azureVmName := terraform.Output(t, terraformOptions, "vm_name")
resourceGroupName := terraform.Output(t, terraformOptions, "rg_name")
actualVMSize := azure.GetSizeOfVirtualMachine(t, vmName, resourceGroupName,
      "")
expectedVMSize := compute.VirtualMachineSizeTypes("Standard_DS2_v2")
```

In the next recipes, we will study its integration in a CI/CD pipeline in Azure Pipelines and then in GitHub with GitHub Actions.

## See also

- Terratest's official website is available here: <https://terratest.gruntwork.io/>.
- Terratest's documentation is available here: <https://terratest.gruntwork.io/docs/>.
- Sample Terratest code is available here: <https://github.com/gruntwork-io/terratest/tree/master/examples>.
- Read this great article about Terratest: <https://blog.octo.com/en/test-your-infrastructure-code-with-terratest/>.

## Building CI/CD for Terraform modules in Azure Pipelines

Throughout this chapter, we have studied recipes for creating, using, and testing Terraform modules. On the other hand, in the *Using a private Git repository for sharing a Terraform module* recipe in this chapter, we discussed the possibility of using a private Git repository, such as Azure DevOps, to store and version your Terraform modules.

In a DevOps context, when the module is created and the tests have been written, we need to create a DevOps CI/CD pipeline that will automate all of the steps we discussed for the execution of the tests that we performed manually.

There are many CI/CD pipeline platforms; in this recipe, we will see the implementation of a CI/CD pipeline to automate the tests and the publication of a Terraform module in Azure Pipelines.

## Getting ready

To start this recipe, we must first create a Terraform module and tests with Terratest. For this, we will use the same module and its tests that we created in the previous recipe, the source code for which is available from <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP05/testing-terratest/module>.

Also, as far as the Azure Pipeline is concerned, you will assume that we have already archived the module code in Azure Repos as we saw in the *Using a private Git repository for sharing a Terraform module* recipe of this chapter.

To avoid having to install the tools needed to run tests in an Azure Pipelines agent, we will use a Docker image. You should, therefore, have a basic knowledge of Docker and the Docker Hub by referring to the documentation here: <https://docs.docker.com/>.

Finally, in Azure Pipelines, we will use the YAML pipelines, which allows us to have pipelines as code, the documentation for which is here: <https://docs.microsoft.com/en-us/azure/devops/pipelines/yaml-schema?view=azure-devopstabs=schema%2Cparameter-schema>.

## How to do it...

Perform the following steps to create a pipeline for the module in Azure Pipelines:

1. In the module directory, we will create a Dockerfile with the following content:

```
FROM mikaelkrief/go-terraform:0.12.25

ARG ARG_MODULE_NAME="module-test"
ENV MODULE_NAME=${ARG_MODULE_NAME}

# Set work directory.
RUN mkdir /go/src/${MODULE_NAME}
COPY ./module /go/src/${MODULE_NAME}
```

```
WORKDIR /go/src/${MODULE_NAME}

RUN chmod +x runtests.sh
ENTRYPOINT [ "./runtests.sh" ]
```

2. In this same directory, we create a `runtests.sh` file with the following content:

```
#!/bin/bash
echo "==> Get Terratest modules"
go get github.com/gruntwork-io/terratest/modules/terraform
echo "==> go test"
go test -v ./tests/ -timeout 30m
```

3. Then, we create an `azure-pipeline.yaml` file with the following extract YAML code:

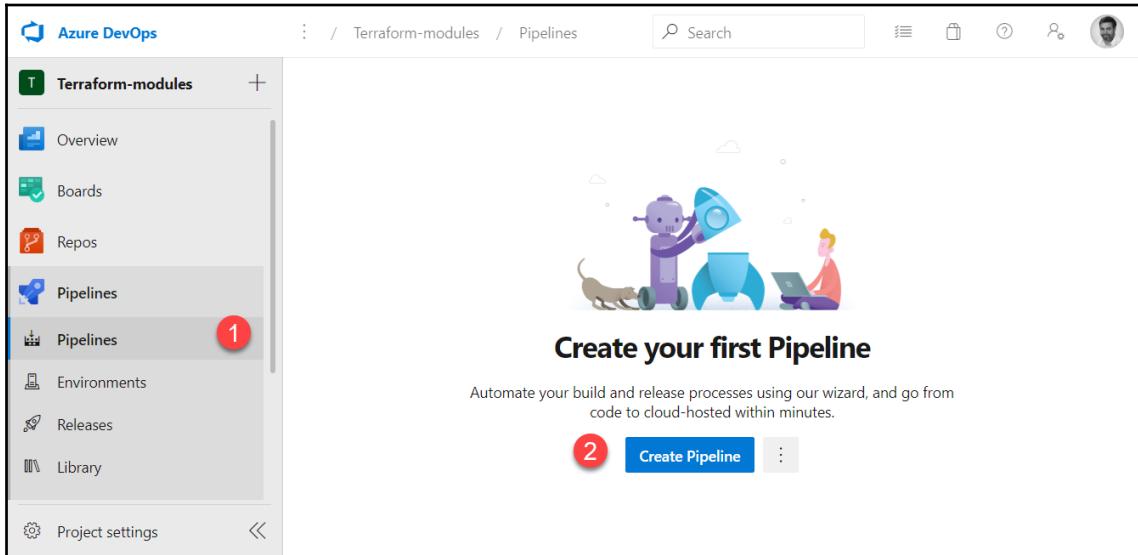
```
- script: |
  docker build -t module-test:${tag} .
  workingDirectory: "${Build.SourcesDirectory}/CHAP05/testing-
terratest/"
  displayName: "Docker build"
- script: |
  docker run module-test:${tag}
  workingDirectory: "${Build.SourcesDirectory}/CHAP05/testing-
terratest/"
  displayName: "Docker run"
- task: PowerShell@2
  displayName: "Tag code"
  inputs:
    targetType: 'inline'
    script: |
      $env:GIT_REDIRECT_STDERR` = '2>&1'
      $tag = "v${Build.BuildNumber}"
      git tag $tag
      Write-Host "Successfully created tag $tag"
      git push --tags
      Write-Host "Successfully pushed tag $tag"
  failOnStderr: false
```



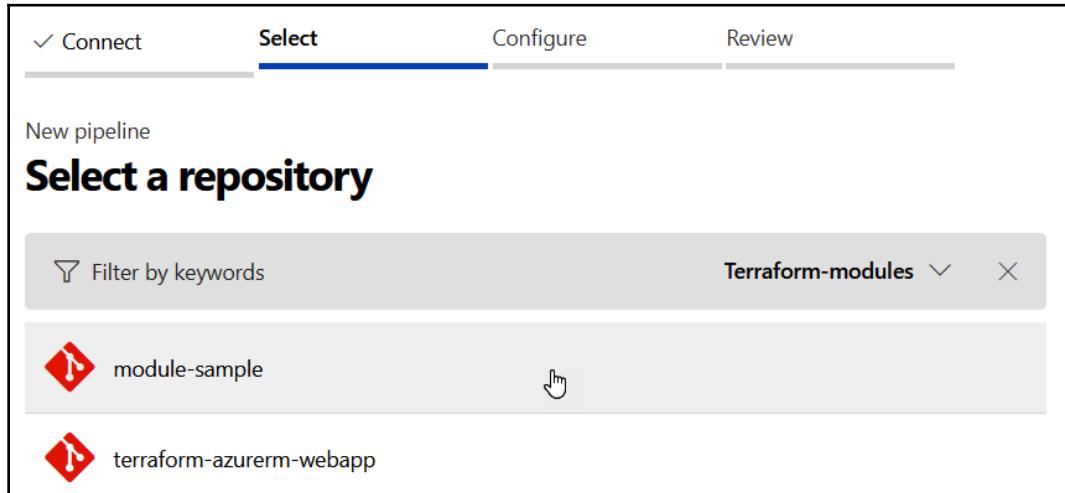
The complete code source of this file is available here: <https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP05/testing-terratest/azure-pipeline.yaml>.

4. We commit and push these three files to the Azure Repos of the Terraform module.

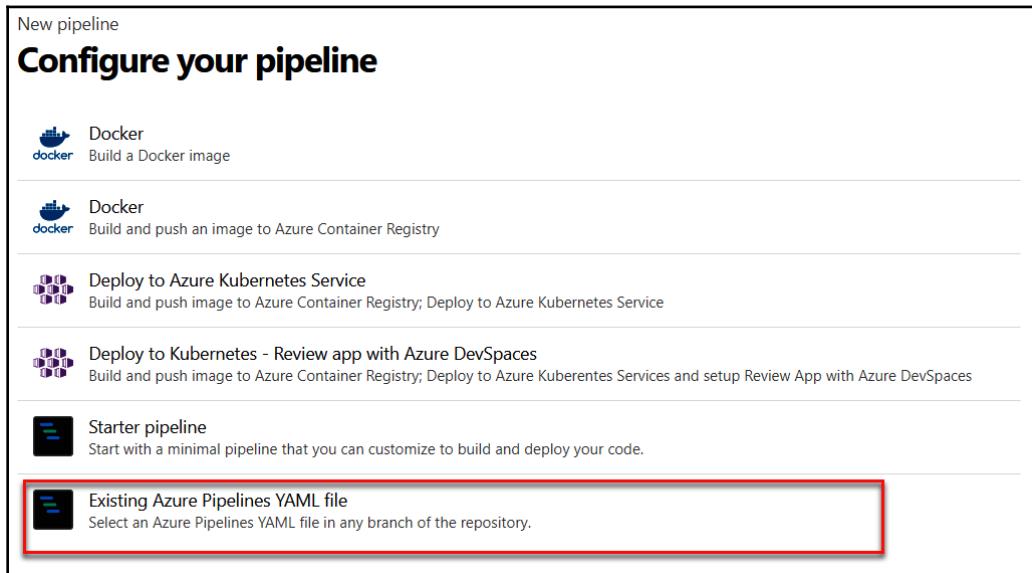
5. In Azure Pipelines, in the **Pipelines** section, we click on the **Create Pipeline** button:



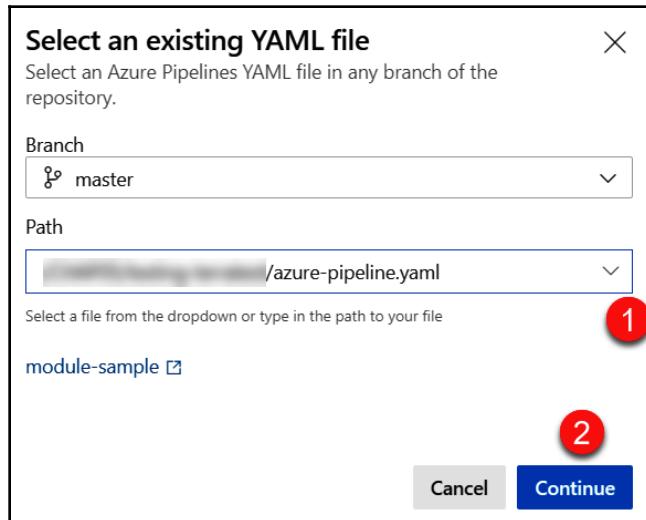
6. Then, we choose the repository in Azure Repos that contains the code of the module:



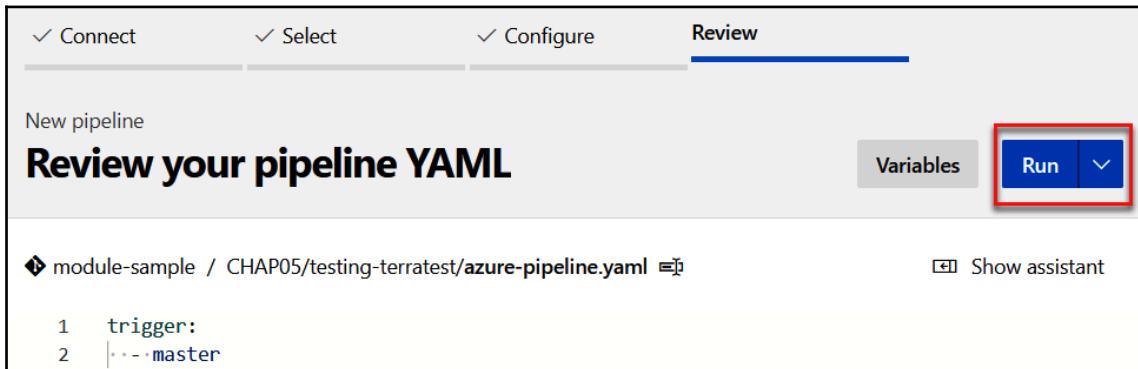
7. Then, select the **Existing Azure Pipelines YAML file** option in the pipeline configuration window:



8. In the layout that opens on the right, we choose the `azure-pipeline.yaml` file that we wrote in *step 3*, then we validate it by clicking on the **Continue** button:



9. Finally, the next page displays the contents of the YAML file of the pipeline we have selected. To trigger the pipeline, we click on the **Run** button:



The screenshot shows the 'Review' step of an Azure Pipeline. At the top, there are four tabs: 'Connect' (with a checkmark), 'Select' (with a checkmark), 'Configure' (with a checkmark), and 'Review' (which is underlined). Below the tabs, it says 'New pipeline'. The main area is titled 'Review your pipeline YAML'. It shows a YAML snippet from 'module-sample / CHAP05/testing-terratest/azure-pipeline.yaml':

```
◆ module-sample / CHAP05/testing-terratest/azure-pipeline.yaml ↗  
1 trigger:  
2 |---master
```

On the right side, there are two buttons: 'Variables' and 'Run'. The 'Run' button is highlighted with a red box. There is also a small dropdown arrow icon next to the 'Run' button.

## How it works...

In *step 1*, we wrote the Dockerfile that will run the Terratest tests—this Docker image is based on an image called `go-terraform` that I created and already contains Terraform and the Go SDK.



This `go-terraform` image is publicly available in Docker Hub (<https://hub.docker.com/repository/docker/mikaelkrief/go-terraform>) and the source code is available at <https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP05/testing-terratest/Dockerfile-go-terraform>.

The following code is the `FROM` instruction of the Dockerfile:

```
FROM mikaelkrief/go-terraform:0.12.25
```

Then, in this Dockerfile, we create the `src` folder and copy the module sources into this `src` directory, as shown in the following code:

```
RUN mkdir /go/src/${MODULE_NAME}  
COPY ./module /go/src/${MODULE_NAME}  
WORKDIR /go/src/${MODULE_NAME}
```

Finally, we give the execution rights to the `runtests.sh` script, and we define `entrypoint` on this script, as shown in the following code:

```
RUN chmod +x runtests.sh  
ENTRYPOINT [ "./runtests.sh" ]
```

In *step 2*, we write the code of the shell script, `runtests.sh`, which will be in charge of executing the Terratest tests using the `dep ensure` and `go test -v` commands as we learned in the *Testing a Terraform module with Terratest* recipe in this chapter.

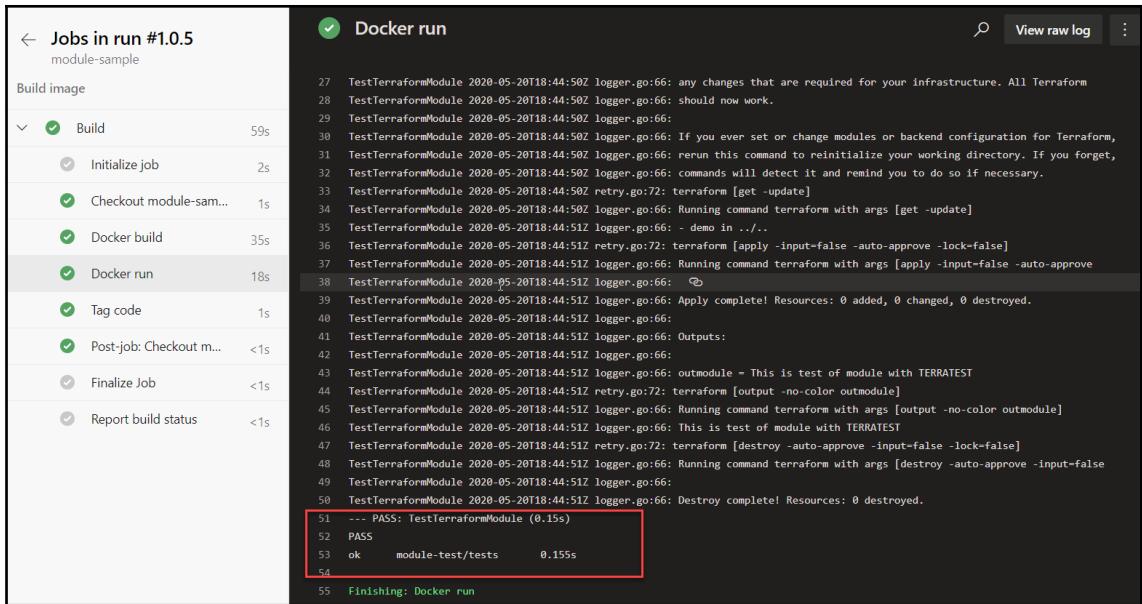
In *step 3*, we write the YAML code of the Azure DevOps pipeline, which consists of three steps:

- Build the Docker image using the `docker build` command.
- Instantiate a new container with this image using the `docker run` command, which will run the tests.
- Version-control the module code by adding a tag to the module code.

Then, we `commit` and push these files to the Azure Repos repository of the module.

Finally, in *steps 5 to 8*, we create a new pipeline in Azure Pipelines by choosing the module repository and the YAML file that contains the pipeline definition.

In *step 9*, we execute the pipeline and wait for the end of its execution. As soon as the pipeline ends, you can see that all of the steps have been executed successfully, as shown in the following screenshot:



The screenshot shows a CI pipeline interface with a sidebar on the left and a main log viewer on the right.

**Jobs in run #1.0.5**

- Build image
- Build (59s) - Status: Success
- Initialize job (2s)
- Checkout module-sample... (1s)
- Docker build (35s)
- Docker run (18s) - Status: Success
- Tag code (1s)
- Post-job: Checkout m... (<1s)
- Finalize Job (<1s)
- Report build status (<1s)

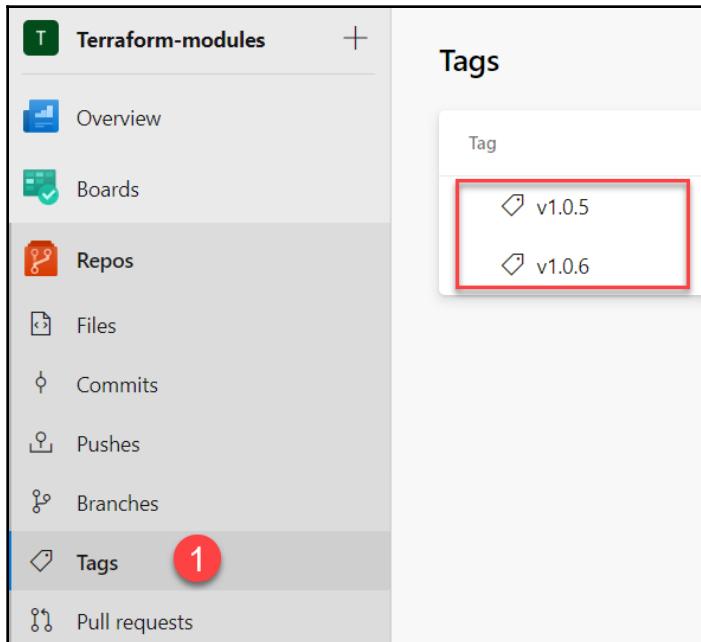
**Docker run**

```

27 TestTerraformModule 2020-05-20T18:44:50Z logger.go:66: any changes that are required for your infrastructure. All Terraform
28 TestTerraformModule 2020-05-20T18:44:50Z logger.go:66: should now work.
29 TestTerraformModule 2020-05-20T18:44:50Z logger.go:66:
30 TestTerraformModule 2020-05-20T18:44:50Z logger.go:66: If you ever set or change modules or backend configuration for Terraform,
31 TestTerraformModule 2020-05-20T18:44:50Z logger.go:66: rerun this command to reinitialize your working directory. If you forget,
32 TestTerraformModule 2020-05-20T18:44:50Z logger.go:66: commands will detect it and remind you to do so if necessary.
33 TestTerraformModule 2020-05-20T18:44:50Z retry.go:72: terraform [get -update]
34 TestTerraformModule 2020-05-20T18:44:50Z logger.go:66: Running command terraform with args [get -update]
35 TestTerraformModule 2020-05-20T18:44:51Z logger.go:66: - demo in ../..
36 TestTerraformModule 2020-05-20T18:44:51Z logger.go:66: Running command terraform with args [apply -input=false -auto-approve -lock=false]
37 TestTerraformModule 2020-05-20T18:44:51Z logger.go:66: Running command terraform with args [apply -input=false -auto-approve]
38 TestTerraformModule 2020-05-20T18:44:51Z logger.go:66: 
39 TestTerraformModule 2020-05-20T18:44:51Z logger.go:66: Apply complete! Resources: 0 added, 0 changed, 0 destroyed.
40 TestTerraformModule 2020-05-20T18:44:51Z logger.go:66:
41 TestTerraformModule 2020-05-20T18:44:51Z logger.go:66: Outputs:
42 TestTerraformModule 2020-05-20T18:44:51Z logger.go:66:
43 TestTerraformModule 2020-05-20T18:44:51Z logger.go:66: outmodule - This is test of module with TERRATEST
44 TestTerraformModule 2020-05-20T18:44:51Z retry.go:72: terraform [output -no-color outmodule]
45 TestTerraformModule 2020-05-20T18:44:51Z logger.go:66: Running command terraform with args [output -no-color outmodule]
46 TestTerraformModule 2020-05-20T18:44:51Z logger.go:66: This is test of module with TERRATEST
47 TestTerraformModule 2020-05-20T18:44:51Z retry.go:72: terraform [destroy -auto-approve -input=false -lock=false]
48 TestTerraformModule 2020-05-20T18:44:51Z logger.go:66: Running command terraform with args [destroy -auto-approve -input=false]
49 TestTerraformModule 2020-05-20T18:44:51Z logger.go:66:
50 TestTerraformModule 2020-05-20T18:44:51Z logger.go:66: Destroy complete! Resources: 0 destroyed.
51 --- PASS: TestTerraformModule (0.15s)
52 PASS
53 ok    module-test/tests      0.155s
54
55 Finishing: Docker run

```

And the new tag version is applied to the code:



This added tag will be used to version the Terraform module so that it can be used when calling the module.

Hence, with this implementation, when calling the module, we will use a version of the module that has been automatically tested by the pipeline.

## There's more...

In this recipe, we have studied the basic steps of the YAML pipeline installation in Azure Pipelines. It is possible to go further by additionally using the reporting of the tests in the pipeline. To learn more, read this blog post: <https://blog.jcoriolan.io/archives/2019/09/25/terraform-microsoft-azure-ci-docker-azure-pipeline.html>.

In the next recipe, we will see the same pipeline process but for a Terraform module that is stored in GitHub and that we want to publish in the Terraform public registry.

## See also

Documentation for Azure Pipelines is available here: <https://docs.microsoft.com/en-us/azure/devops/pipelines/?view=azure-devops>.

# Building a workflow for Terraform modules using GitHub Actions

In the *Sharing a Terraform module using GitHub* recipe of this chapter, we studied how to publish a Terraform module in the Terraform public registry by putting its code on GitHub. Then, we learned in the *Testing a Terraform module with Terratest* recipe how to write and run module tests using Terratest.

We will go further in this recipe by studying the implementation of an automated module publishing workflow using GitHub Actions.

## Getting ready

To start this recipe, you must have assimilated the two recipes, *Sharing a Terraform module using GitHub* and *Testing a Terraform module with Terratest*, which include all of the bases and artifacts necessary for this recipe.

In this recipe, we will use the module code we wrote in the *Testing Terraform module code with Terratest* recipe, the source code for which is available here: <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP05/testing-terratest/module>.

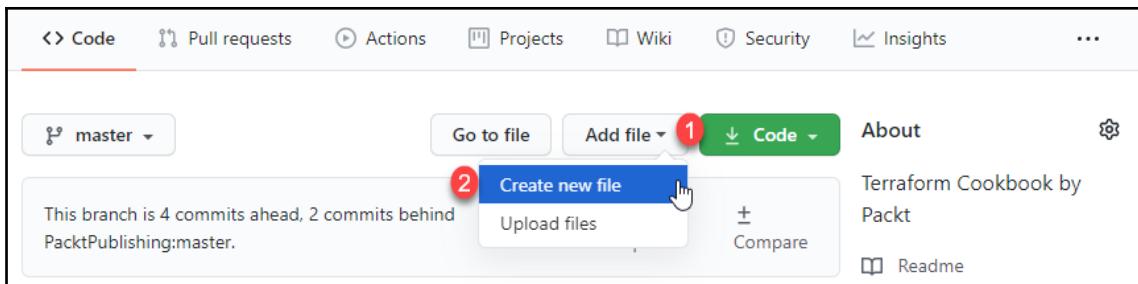
Also, we will be using GitHub Actions, which is a free service for public GitHub repositories, the documentation for which is available here: <https://github.com/features/actions>.

The source code for this recipe is available here: <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP05/githubaction>.

## How to do it...

Perform the following steps to use GitHub Actions on our Terraform module:

1. In the root of the GitHub repository that contains the module code, we create, via the GitHub web interface, a new file called `integration-test.yaml` in the `.github/workflows` folder:

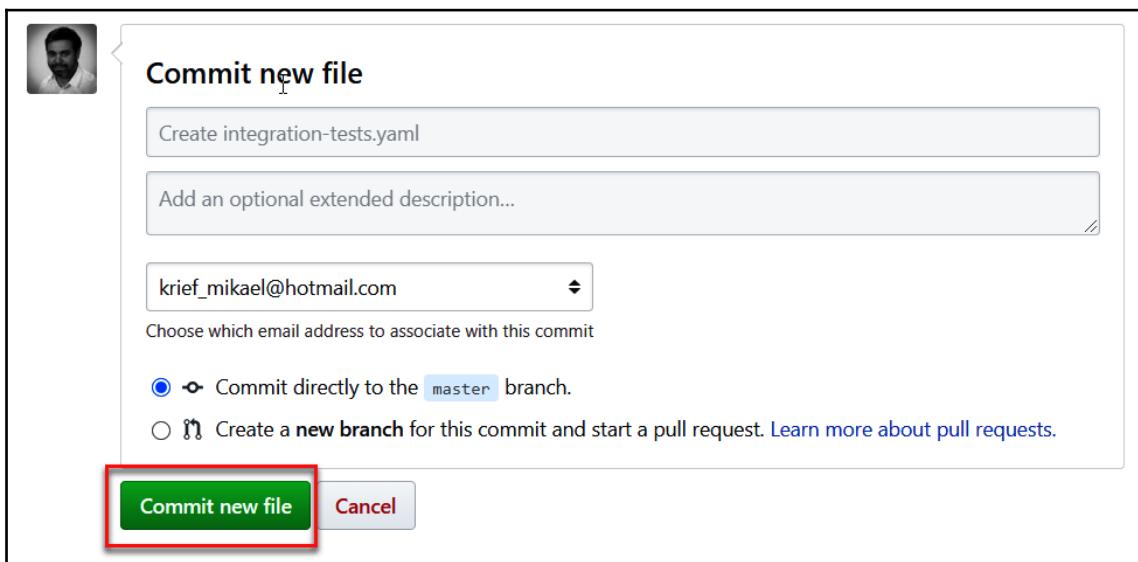


2. In this file, we write the following extract YAML code (the complete code is here: <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP05/githubaction>):

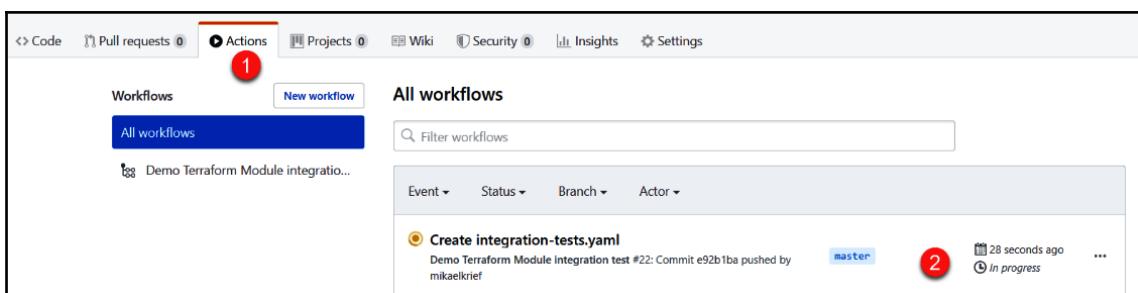
```
...
steps:
- name: Check out code
  uses: actions/checkout@v1
- name: Set up Go 1.14
  uses: actions/setup-go@v1
  with:
    go-version: 1.14
    id: go
- name: Get Go dependencies
```

```
run: go get -v -t -d ./...
- name: Run Tests
  working-directory: "CHAP05/testing-terratest/module/tests/"
  run: |
    go test -v -timeout 30m
- name: Bump version and push tag
  uses: mathieudutour/github-tag-action@v4
  with:
    github_token: ${{ secrets.GITHUB_TOKEN }}
```

3. Then, we validate the page by clicking on the **Commit new file** button at the bottom of the page:



4. Finally, we click on the **Actions** tab of our repository and we can see the workflow that has been triggered:



## How it works...

To create the workflow in GitHub Actions, we have created a new YAML file in the repository that contains the module code, in the specific `.github/workflows` folder that contains the steps that the GitHub Action agent will perform.

The steps of our workflow are as follows:

1. The first step is to do a checkout to retrieve the repository code:

```
- name: Check out code
  uses: actions/checkout@v1
```

2. Then, we install the SDK for Go with the following code:

```
- name: Set up Go 1.14
  uses: actions/setup-go@v1
  with:
    go-version: 1.14 #need to be >=1.13
    id: go
```



For more information about the minimum Go version, read the documentation here: <https://terratest.gruntwork.io/docs/getting-started/quick-start/#requirements>.

3. Then, we download the dependencies with this code:

```
- name: Get Go dependencies
  run: go get -v -t -d ./...
```

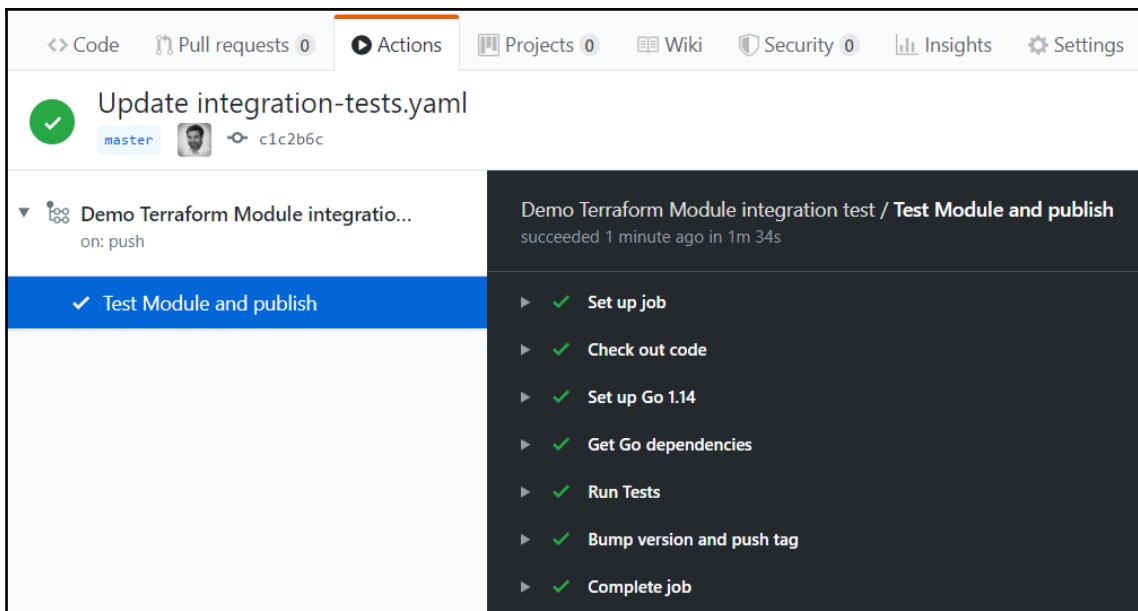
4. We run the Terratest tests with the following code:

```
- name: Run Tests
  working-directory: "CHAP05/testing-terratest/module/tests/"
  run: |
    go test -v -timeout 30m
```

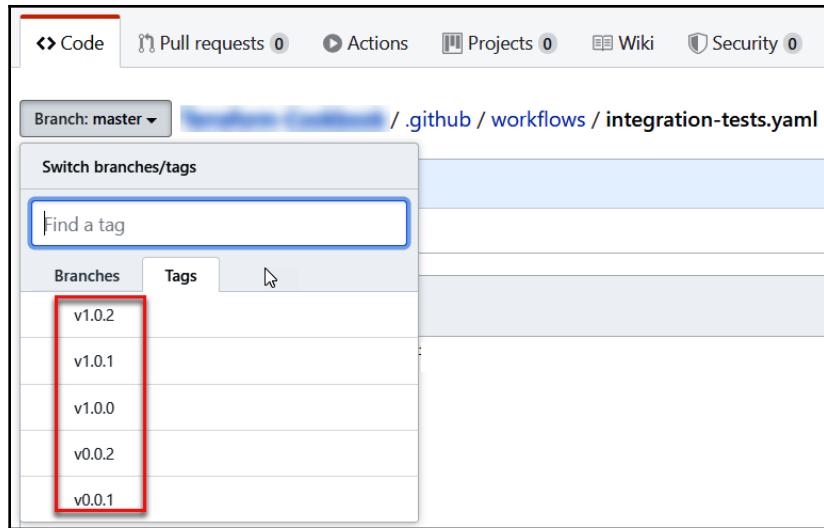
5. Finally, the last step is to add a tag to the code. To do this, we use the Github-tag action provided by the `mathieudutour/github-tag-action@v4` repository and we use the built-in `GITHUB_TOKEN` variable that allows the agent to authenticate itself to perform Git commands on the repository:

```
- name: Bump version and push tag
  uses: mathieudutour/github-tag-action@v4
  with:
    github_token: ${{ secrets.GITHUB_TOKEN }}
```

At the end of the execution of the workflow, you can see the results, as in the following screenshot:



If the workflow runs correctly, a new tag will be added to the code, as shown in the following screenshot:



And if this module is published in the public registry, a new version of this module will be available.

## There's more...

The incrementing of the tag in the repository (major, minor, or patch) is done automatically and will depend on the content of the commit description that triggered the action. For more information, read the documentation at <https://github.com/angular/angular.js/blob/master/DEVELOPERS.md#git-commit-guidelines>.

## See also

- Documentation on the GitHub-Tag action is available here: <https://github.com/marketplace/actions/github-tag>.
- Read this blog post about Terratest and GitHub Actions, provided by HashiCorp: <https://www.hashicorp.com/blog/continuous-integration-for-terraform-modules-with-github-actions/>.

# 6

# Provisioning Azure Infrastructure with Terraform

Terraform contains a multitude of providers that enable the provisioning of various types of infrastructure, whether in the cloud or on-premise.

In the previous chapters of this book, we have studied the basic concepts of the Terraform language, as well as the main Terraform commands line and we have seen the sharing of Terraform configuration using modules. In addition, all the recipes we have seen in the previous chapters are generic and can be used by all Terraform providers.

In this chapter, we will focus on using Terraform to provision a cloud infrastructure in Azure. We will start with its integration into Azure Cloud Shell, its secure authentication, and the protection of the Terraform state file in an Azure storage. You will learn how to run ARM templates and Azure CLI scripts with Terraform and how to retrieve the Azure resource list with Terraform. Then we'll look at how to protect sensitive data in Azure Key Vault using Terraform. We will write two case studies in Azure, with the first showing the provisioning and configuration of an IaaS infrastructure consisting of VMs, and the second showing the provisioning of a PaaS infrastructure in Azure. Finally, we will go further with the generation of Terraform configuration from an already existing infrastructure.

In this chapter, we will cover the following recipes:

- Using Terraform in Azure Cloud Shell
- Protecting the Azure credential provider
- Protecting the state file in the Azure remote backend
- Executing ARM templates in Terraform
- Executing Azure CLI commands in Terraform
- Using Azure Key Vault with Terraform to protect secrets
- Getting a list of Azure resources in Terraform
- Provisioning and configuring an Azure VM with Terraform

- Building Azure serverless infrastructure with Terraform
- Generating a Terraform configuration for existing Azure infrastructure

## Technical requirements

To apply the recipes in this chapter, you must have an Azure subscription. If you don't have one, you can create an Azure account for free at this site: <https://azure.microsoft.com/en-us/free/>

The complete source code for this chapter is available here: <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP06>

Check out the following video to see the Code in Action: <https://bit.ly/2ZmEcnJ>

## Using Terraform in Azure Cloud Shell

In Chapter 1, *Setting Up the Terraform Environment*, of this book, we studied the steps involved in installing Terraform on a local machine.

In the Azure Shell console, known as **Azure Cloud Shell**, Microsoft has integrated Terraform in the list of tools that are installed by default.

In this recipe, we will see how to write a Terraform configuration and use Terraform in Azure Cloud Shell.

## Getting ready

The prerequisite for this recipe is to have an Azure subscription and to be connected to this subscription via the Azure portal, which is accessible here: <https://portal.azure.com/>

Note that this prerequisite applies to all recipes in this chapter.



In addition, you need to associate your Cloud Shell with an existing Azure Storage Account or create a new one, as explained in the following documentation: <https://docs.microsoft.com/en-us/azure/cloud-shell/persisting-shell-storage>.

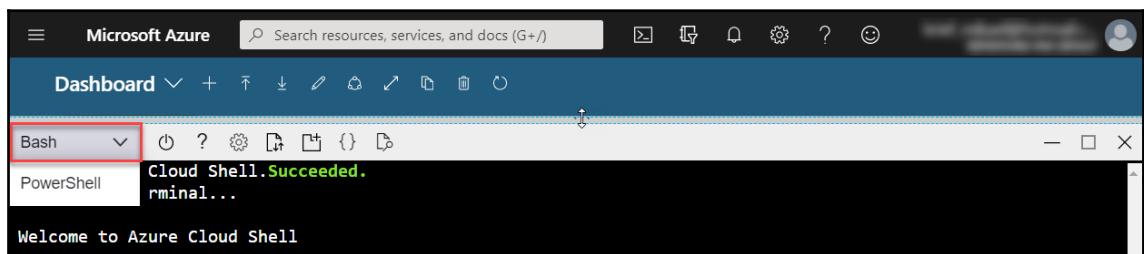
## How to do it...

In order to use Terraform in Azure Cloud Shell, perform the following steps:

1. In the Azure portal, open Azure Cloud Shell by clicking the Cloud Shell button in the top menu, as shown in the following screenshot:



2. Inside the Cloud Shell panel, in the top menu, in the dropdown, choose **Bash** mode:



3. In the Cloud Shell terminal, create a new folder, `demotf`, inside the default `clouddrive` folder by executing the following command:

```
mkdir clouddrive/demotf
```

Inside this new folder, enter the `cd clouddrive/demotf` command.

4. To write a Terraform configuration inside an integrated Visual Studio Code instance, execute the `code` command.

5. In the editor, in the opened blank page, write the Terraform configuration with the following sample code:

```
terraform {  
    required_version = ">= 0.12"  
}  
  
provider "azurerm" {  
    features {}  
}  
  
resource "azurerm_resource_group" "rg-app" {  
    name      = "RG-TEST-DEMO"  
    location  = "westeurope"  
}
```

6. Save this file by using the *Ctrl + S* shortcut and name this file `main.tf`.
7. Finally, to apply this Terraform configuration to the Cloud Shell terminal, execute the classical Terraform workflow as follows:

```
> terraform init  
> terraform plan -out=app.tfplan  
> terraform apply app.tfplan
```

## How it works...

In this recipe, we used the integrated environment of Azure Cloud Shell, which consists of a command-line terminal that we chose to use in Bash mode. In addition, in *steps 5 and 6*, we used the built-in Visual Studio Code editor, using the `code` command, to write a Terraform configuration, which also has syntax highlighting for Terraform files. And finally, in *step 7*, we used the Terraform client, which is already installed in this Cloud Shell environment to provision our infrastructure with the execution of the Terraform workflow commands.

The following screenshot shows Azure Cloud Shell with Terraform execution:

A screenshot of the Microsoft Azure Cloud Shell interface. The top panel is a Visual Studio Code editor showing a file named 'main.tf' with Terraform code. The bottom panel is a terminal window displaying the execution of the Terraform command.

```
1 terraform {
2   required_version = ">= 0.12"
3 }
4
5 provider "azurerm" {
6   features {}
7 }
8
9 resource "azurerm_resource_group" "rg-app" {
10   name     = "RG-TEST-DEMO"
11   location = "westeurope"
12 }
```

# azurerm\_resource\_group.rg-app will be created  
+ resource "azurerm\_resource\_group" "rg-app" {  
+ id = (known after apply)  
+ location = "westeurope"  
+ name = "RG-TEST-DEMO"  
}  
Plan: 1 to add, 0 to change, 0 to destroy.  
Do you want to perform these actions?  
Terraform will perform the actions described above.  
Only 'yes' will be accepted to approve.  
Enter a value: yes  
azurerm\_resource\_group.rg-app: Creating...  
azurerm\_resource\_group.rg-app: Creation complete after 0s [id=/subscriptions/4df82e26-6953-4c19-a43f-777c936a8105/resourceGroups/RG-TEST-DEMO]  
Apply complete! Resources: 1 added, 0 changed, 0 destroyed.  
mikael@Azure:~/clouddrive/demott\$

We can see in the preceding screenshot the top panel with the integrated Visual Studio Code editor, and, in the bottom panel, the command line with the execution of the Terraform command.

## There's more...

For this recipe, we chose the option to edit the Terraform files directly in Visual Studio Code, which is in Cloud Shell, but the following alternative options are available:

- The Terraform files could be created and edited using the **Vim** tool (Linux editor: <https://www.linux.com/training-tutorials/vim-101-beginners-guide-vim/>), which is built into Cloud Shell.
- We could also have edited the Terraform files locally on our machine and then copied them to the Azure Storage service that is connected to Azure Cloud Shell.
- If the files are stored in a Git repository, we could also have cloned the repository directly into the Cloud Shell storage by running a `git clone` command in the Cloud Shell command-line terminal.

Also, regarding Terraform's authentication to perform actions in Azure, we did not take any action because Azure Cloud Shell allows direct authentication to our Azure subscriptions and Terraform, which is in Cloud Shell, automatically inherits that authentication.

On the other hand, if you have several subscriptions, prior to executing the Terraform workflow, you have to choose the subscription target by executing the following command:

```
az account set -s <subscription _id>
```

This chosen subscription then becomes the subscription by default during execution. Refer to the documentation at <https://docs.microsoft.com/en-us/cli/azure/account?view=azure-cli-latest#az-account-set>.

Regarding the version of Terraform that is installed on the Cloud Shell, in general, it is the latest public version, which you can check by running the `terraform --version` command. You need to check that your Terraform configuration is compatible with this version before executing.

Finally, as regards the recommended use of Azure Cloud Shell for Terraform, it can only be used for development and testing. It cannot be integrated into a CI/CD pipeline and uses your personal permissions on Azure to provision resources. For this reason, in the next recipe, we will look at how to securely authenticate Terraform to Azure.

## See also

- Refer to this blog post, which also shows the use of Terraform in Azure Cloud Shell: <https://cloudskills.io/blog/terraform-azure-01>
- Documentation that explains the use of Azure Cloud Shell: <https://docs.microsoft.com/en-us/azure/cloud-shell/using-cloud-shell-editor>
- A tutorial that shows how to use and configure locally installed Visual Studio Code to execute a Terraform configuration in Azure Cloud Shell: <https://docs.microsoft.com/en-us/azure/developer/terraform/configure-vs-code-extension-for-terraform>

## Protecting the Azure credential provider

In order for the Terraform Azure provider to provision and manipulate resources in Azure, the provider must authenticate in Azure using an Azure account and that account must have the correct authorizations.

In the previous recipe, we studied how to automatically authenticate the Terraform context in Azure Cloud Shell with our personal account and permissions. However, in corporate projects, as well as in production, it is very bad practice to use your personal account as this could expire, be deleted, or, even worse, be misused.

This is why one of the options we have when running Terraform in Azure is to use an **App Registration** account (also known as **Service Principal**) that is not linked to a physical person.

In this recipe, we will first study the creation of this Service Principal and then we will see how to use it securely in order to run a Terraform configuration.

## Getting ready

To apply the first part of this recipe, you must have user account creation permissions in Azure Active Directory. Moreover, to create this Service Principal, we will do it using the command line with the **az cli** tool, documentation relating to which is available at <https://docs.microsoft.com/en-us/cli/azure/?view=azure-cli-latest>.

In addition, we need to retrieve our ID of the subscription in which resources will be provisioned. For this, we can get it in Azure Cloud Shell by running the `az account list` command to display our subscription details:

```
mikael@Azure:~$ az account list
A few accounts are skipped as they don't have 'Enabled' state. Use '--all' to display them.
[{"cloudName": "AzureCloud",
"homeTenantId": "REDACTED",
"id": "1da42ac9-ee3e-4fdbREDACTED",
"isDefault": false,
"managedByTenants": [],
"name": "DEMO",
"state": "Enabled",
"tenantId": "REDACTED",
"user": {
"cloudShellID": true,
"name": "live.com#REDACTED",
"type": "user"
}},
{}]
```

Also, get the `id` property of the subscription concerned.

## How to do it...

This recipe comprises two parts, which are as follows: the creation of the Service Principal, and the configuration of Terraform authentication using this Service Principal.

To create this Service Principal, perform the following steps:

1. Open Azure Cloud Shell and execute the following command:

```
az ad sp create-for-rbac --name="BookDemoTerraform" --role="Contributor" --scopes="/subscriptions/<Subscription Id>"
```

2. Retrieve all the identification information provided in the output of the previous command by making a note (because we won't be able to retrieve the password after closing this console) of `appId`, `password`, and `tenant`, as shown in the following screenshot:

The screenshot shows a Microsoft Azure Cloud Shell interface. The terminal window displays the command execution process. The output shows the creation of a service principal named "BookDemoTerraform". It provides the application ID, display name, name, password, and tenant ID. The password is redacted. Three numbers (1, 2, 3) are overlaid on the JSON output to indicate specific fields for note-taking:

```
mikael@Azure:~$ az ad sp create-for-rbac --name="BookDemoTerraform" --role="Contributor" --scopes="/subscriptions/1da42ac9-e3e-4fdb-b294-f7a607f589d5"
Changing "BookDemoTerraform" to a valid URI of "http://BookDemoTerraform", which is the required format used for service principal names
Creating a role assignment under the scope of "/subscriptions/1da42ac9-e3e-4fdb-b294-f7a607f589d5"
Retrying role assignment creation: 1/36
Retrying role assignment creation: 2/36
{
  "appId": "282936c6-298d-48bc-890b-", 1
  "displayName": "BookDemoTerraform",
  "name": "http://BookDemoTerraform",
  "password": "62e36b75-16aa-4c33-8fb0-", 2
  "tenant": "2e3a33f9-66b1-4eza-8b95-", 3
}
```

Now that the Service Principal is created, we can use it to provision Azure infrastructure with Terraform by performing the following steps:

1. In the command-line terminal, set four new variable environments as follows:

```
export ARM_SUBSCRIPTION_ID=<subscription_id>
export ARM_CLIENT_ID=<appId>
export ARM_CLIENT_SECRET=<password>
export ARM_TENANT_ID=<tenant id>
```

2. Then, we can apply the Terraform configuration by executing the following Terraform workflow:

```
> terraform init
> terraform plan -out=app.tfplan
> terraform apply app.tfplan
```

## How it works...

In the first part of this recipe, we created a Service Principal and gave it its permissions on a subscription, using the command line `az ad sp`. To this command, we added the following arguments:

- `name`, which is the name of the Service Principal we're going to create.
- `role`, which is the role that the Service Principal will have on the subscription; here, we specify `Contributor`.
- `scopes`, where we specify the Azure ID of the resource on which the Service Principal will have contributor permissions. In our case, this is the subscription ID in which the resources will be provisioned by Terraform.

This command will therefore create the Service Principal with a generated password and will give it the `Contributor` role on the specified subscription.

At the end of its execution, this command displays the information of the Service Principal, including `AppId`, `password`, and `tenant`. As explained in *step 2*, we need to retrieve this information and store it in a safe place because this password cannot be retrieved later. Then, we check that the Service Principal has the permissions on subscription, as you can see in the following screenshot:

The screenshot shows the Azure portal's 'Access control (IAM)' blade for a subscription named 'DEMO'. The left sidebar includes links for Overview, Activity log, Access control (IAM), Tags, Diagnose and solve problems, Security, Events, Cost Management, and Cost analysis. The main area displays the following information:

- Number of role assignments for this subscription:** 8 (out of 2000)
- Filtering:** Name, Type (All), Role (Contributor), Scope (All scopes)
- Result:** 5 items (3 Service Principals, 2 Unknown)

Name	Type	Role
BookDemoTerraform	App	Contributor
(Unknown)		
(Unknown)		

In the second part of this recipe, we used this Service Principal to authenticate the Terraform Azure provider. For this, there are several solutions, the most secure one being to use specific Azure provider environment variables because these environment variables will not be visible in code and will only be persistent during the execution session. So, we have set four environment variables, which are as follows:

- ARM\_SUBSCRIPTION\_ID: This contains the Azure subscription ID.
- ARM\_CLIENT\_ID: This contains the Service Principal ID, called AppId.
- ARM\_CLIENT\_SECRET: This contains the password of the Service Principal.
- ARM\_TENANT\_ID: This contains the ID of the Azure Active Directory tenant.



In the recipe, we used the `export` command of the Linux system. On Windows PowerShell, we can use the `$env` command. In addition, in all the recipes in this chapter, we will use these environment variables before executing Terraform.

Then, once these environment variables are set, we can execute the basic Terraform workflow.

## There's more...

Regarding the creation of the Service Principal, we made the choice to use the Azure CLI tool, but we could also have done it directly via the Azure portal, as detailed in the following documentation available at <https://docs.microsoft.com/en-us/azure/active-directory/develop/howto-create-service-principal-portal>, or we could have used the Azure PowerShell commands (<https://docs.microsoft.com/en-us/azure/active-directory/develop/howto-authenticate-service-principal-powershell>).

In addition, as regards the configuration of the Terraform Azure provider, we have used environment variables, but we can also put this information directly into the Terraform configuration, as shown in the following code snippet:

```
provider "azurerm" {  
    ...  
    subscription_id = "<Subscription ID>"  
    client_id      = "<Client ID>"  
    client_secret  = "<Client Secret>"  
    tenant_id      = "<Tenant ID>"  
}
```

This solution does not require an extra step (the set of environment variables) to be implemented prior to executing the Terraform configuration, but it leaves identification information in clear text in the code, and hardcoding credentials in code is generally considered a bad practice from the security perspective, since the leakage of code also leaks credentials and makes it impossible to share the code with anyone without exposing the credentials. And in the case where the Terraform configuration provides resources for several environments that are in different subscriptions, Terraform variables will have to be added, which can add complexity to the code.

Finally, the use of environment variables offers the advantage of being easily integrated into a CI/CD pipeline while preserving the security of the authentication data.

## See also

- The Azure documentation and Terraform configuration is available here: <https://docs.microsoft.com/en-us/azure/developer/terraform/install-configure>
- Documentation on the configuration of the Azure provider, along with the other authentication options, is available here: <https://www.terraform.io/docs/providers/azurerm/index.html>

## Protecting the state file in the Azure remote backend

When executing the Terraform workflow commands, which are mainly `terraform plan`, `terraform apply`, and `terraform destroy`, Terraform has a mechanism that allows it to identify which resources need to be updated, added, or deleted. To perform this mechanism, Terraform maintains a file called a Terraform state file that contains all the details of the resources provisioned by Terraform. This Terraform state file is created the first time the `terraform plan` command is run and is updated with each action (`apply` or `destroy`).

In a enterprise, this file contains certain interesting aspects, which are as follows:

- Sensitive information on the provisioned resources is mentioned in clear text.
- If several people are working together, this file must be shared by everyone or, by default, this file is created on the local workstation or on the workstation that contains the Terraform binary.

- Even if it is archived in a Git source code manager, once it is retrieved on the local workstation, it does not allow several people to work on the same file.
- With this locally stored file, managing multi-environments can quickly become complicated and risky.
- Any deletion of this local file or poor manual editing can affect the execution of Terraform configuration.

A solution to all these problems is the use of a remote backend, which consists of storing this file in a remote, shared, and secure store.

In the use of Terraform, there are several types of remote backends, such as S3, azurerm, Artifactory, and many others, which are listed in the menu on the following page: <https://www.terraform.io/docs/backends/types/index.html>

In this recipe, we will study the use of a remote backend, `azurerm`, in Azure by storing this Terraform state file in an Azure Storage Account.

## Getting ready

For this recipe, we will use Azure Cloud Shell and Azure CLI commands to create the Storage Account.

The source code for this recipe and the script used are available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP06/remotebackend>.

## How to do it...

This recipe consists of two parts. In the first part, we will create the Storage Account, and in the second part, we will configure Terraform to use the `azurerm` remote backend:

1. In Azure Cloud Shell, execute the following Azure CLI script (available at <https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP06/remotebackend/create-backend.sh>) to create the Storage Account with a blob container in the Resource Group:

```
# 1- Create Resource Group
az group create --name "RG-TFBACKEND" --location westeurope

# 2- Create storage account
az storage account create --resource-group "RG-TFBACKEND" --name
"storagetfbackend" --sku Standard_LRS --encryption-services blob
```

```
# 3- Create blob container
az storage container create --name "tfstate" --account-name
"storagetfbackend"

# 4- Get storage account key
ACCOUNT_KEY=$(az storage account keys list --resource-group "RG-
TFBACKEND" --account-name "storagetfbackend" --query [0].value -o
tsv)

echo $ACCOUNT_KEY
```

2. Then, we configure the Terraform state backend by adding the following code to the `main.tf` file:

```
terraform {
  backend "azurerm" {
    resource_group_name  = "RG-TFBACKEND"
    storage_account_name = "storagetfbackend"
    container_name       = "tfstate"
    key                 = "myapp.tfstate"
  }
}
```

3. Finally, to execute the Terraform configuration, we set a new environment variable, `ARM_ACCESS_KEY`, with the following command:

```
export ARM_ACCESS_KEY = <access key>
```

Then, we execute the basic commands of the Terraform workflow.

## How it works...

In the first step, we used a script that performs the following actions in sequence:

1. It creates a Resource Group called `RG-TFBACKEND`.
2. In this Resource Group, we use the `az storage account create` command to create a Storage Account named `storagetfbackend`.
3. Then, this script creates a blob container in this Storage Account with the `az storage container create` command.
4. Finally, we retrieve the account key of the Storage Account created and display its value.

Then, in *step 2*, we configure Terraform to use this Storage Account as a remote backend to store the Terraform state file. In this configuration, which is located in a `backend "azurerm"` block, we indicate, on the one hand, the Storage Account information, and, on the other, the blob with the properties:

- `resource_group_name`: This is the name of the Resource Group that contains the Storage Account.
- `storage_account_name`: This is the name of the Storage Account.
- `container_name`: This is the name of the blob container.
- `key`: This is the name of the Terraform state file.

Finally, we define a new environment variable, `ARM_ACCESS_KEY`, that contains the account key for the Storage Account we retrieved from the script we ran in *step 1*. This variable is used to authenticate the Storage Account. Then, we execute the `init`, `plan`, and `apply` commands of Terraform.

Based on what we studied in the previous recipe, *Protecting the Azure credential provider*, here is the complete script for executing this Terraform script in Azure:

```
export ARM_SUBSCRIPTION_ID=<subscription_id>
export ARM_CLIENT_ID=<appId>
export ARM_CLIENT_SECRET=<password>
export ARM_TENANT_ID=<tenant id>
export ARM_ACCESS_KEY=<account key>

> terraform init
> terraform plan -out=app.tfplan
> terraform apply app.tfplan
```

So, we used the four authentication environment variables, as well as the `ARM_ACCESS_KEY` environment variable, for authentication to the Storage Account and we executed the Terraform commands.

## There's more...

In this recipe, we used an environment variable to specify the value of the access key to protect this sensitive data. We could have specified it in the remote backend configuration, using the `access_key` property, as in the following example (but as mentioned in the *Protecting the Azure credential provider* recipe of this chapter, it isn't good practice to leave sensitive keys as plain text):

```
terraform {  
  backend "azurerm" {  
    resource_group_name  = "RG-TFBACKEND"  
    storage_account_name = "storagetfbackend"  
    container_name       = "tfstate"  
    key                 = "myapp.tfstate"  
    access_key          = ██████████-██████-████-█████████████████████  
  }  
}
```

Moreover, if our Terraform configuration is designed to be deployed on multiple environments, we can create  $N$  configurations of the `azurerm` backend with the following steps:

1. The `main.tf` file contains the following code with the `backend "azurerm"` block empty:

```
terraform {  
  required_version = ">= 0.12"  
  backend "azurerm" {  
  }  
}
```

2. We create one `backend.tfvars` file per environment (in a specific folder for this environment) with the following code:

```
resource_group_name  = "RG-TFBACKEND"  
storage_account_name = "storagetfbackend"  
container_name       = "tfstate"  
key                 = "myapp.tfstate"
```

3. Finally, in the execution of the `init` command, we specify the `backend.tfvars` file to be used with the following command, as specified in the `init` command documentation, which is available at <https://www.terraform.io/docs/backends/config.html#partial-configuration>:

```
terraform init -backend-config=<path>/backend.tfvars"
```

Finally, if the Service Principal that was used to authenticate with Terraform has permissions on this Storage Account, then this environment variable is not mandatory.

## See also

- Documentation relating to the `azurerm` remote backend is available here: <https://www.terraform.io/docs/backends/types/azurerm.html>
- Terraform's learning module with the `azurerm` remote backend is available here: [https://learn.hashicorp.com/terraform/azure/remote\\_az#azurerm](https://learn.hashicorp.com/terraform/azure/remote_az#azurerm)
- Azure documentation relating to the Terraform remote backend is available here: <https://docs.microsoft.com/en-us/azure/developer/terraform/store-state-in-azure-storage>

## Executing ARM templates in Terraform

Among all the **Infrastructure as Code (IaC)** tools and languages, there is one provided by Azure called **Azure Resource Manager (ARM)**, based on JSON format files, that contains the description of the resources to be provisioned.



To learn more about ARM templates, read the following documentation: <https://docs.microsoft.com/en-us/azure/azure-resource-manager/templates/overview>

When using Terraform to provision resources in Azure, you may need to use resources that are not yet available in the Terraform `azurerm` provider. Indeed, the `azurerm` provider is open source and community-based on GitHub, and has a large community of contributors, but this is not enough to keep up with all the changes in Azure's functionalities in real time. This is due to several reasons:

- New releases of Azure resources are very frequent.
- The Terraform `azurerm` provider is highly dependent on the Azure Go SDK (<https://github.com/Azure/azure-sdk-for-go>), which does not contain real-time Azure updates on new features or even on features that are still in preview.

To partially solve this problem, and for organizations that wish to remain in full Terraform, there is a Terraform `azurerm_template_deployment` resource that allows you to execute ARM code using Terraform.

In this recipe, we will discuss the execution of ARM code with Terraform.

## Getting ready

The Terraform configuration of this recipe will provision an Azure App Service that includes an extension. Since the extension App Service resource is not available in the azurerm provider at the time of writing this book, the Azure App Service code will be written in **HashiCorp Configuration Language (HCL)**, and its extension will be provisioned using an ARM template that will be executed with Terraform.



The purpose of the recipe is not to detail the code of the ARM template of the extension but to study its execution with Terraform.

In this recipe, we will present only the key code extracts. The complete source code for this chapter is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP06/arm-template>.

## How to do it...

To execute the ARM template with Terraform, perform the following steps:

1. Inside the folder that will contain the Terraform configuration, create a new file called `ARM_siteExtension.json`, which contains the following extract ARM JSON template:

```
{  
  ...  
  "parameters": {  
    "appserviceName": { ... },  
    "extensionName": { ... },  
    "extensionVersion": { ... }  
  },  
  "resources": [  
    {  
      "type": "Microsoft.Web/sites/siteextensions",  
      "name": "[concat(parameters('appserviceName'), '/',  
parameters('extensionName'))]",  
      ...  
      "properties": {  
        "version": "[parameters('extensionVersion')]"  
      }  
    }  
  ]  
}
```

```
        }
    ]
}
```

The complete source code of this file is available here: [https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP06/arm-template/ARM\\_siteExtension.json](https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP06/arm-template/ARM_siteExtension.json)

2. In the `main.tf` file, add the following Terraform extract code:

```
resource "azurerm_template_deployment" "extension" {
    name          = "extension"
    resource_group_name = azurerm_resource_group.rg-app.name
    template_body      = file("ARM_siteExtension.json")

    parameters = {
        appserviceName    = azurerm_app_service.app.name
        extensionName     = "AspNetCoreRuntime.2.2.x64"
        extensionVersion   = "2.2.0-preview3-35497"
    }

    deployment_mode = "Incremental"
}
```

The complete source code of this file is available here: <https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP06/arm-template/main.tf>

3. Then, we can execute the basic Terraform workflow with the following:

- Authentication with four Azure variable environments, as discussed in the *Protecting the Azure credential provider* recipe of this chapter
- The execution of the `init`, `plan` and `apply` commands, as mentioned previously and in earlier chapters

## How it works...

In *step 1*, in the directory that contains the Terraform configuration, we created a JSON file that contains the ARM code for creating an extension for a App Service. In this ARM file, we have the following three input parameters:

- `appserviceName`: This corresponds to the name of the App Service.
- `extensionName`: This corresponds to the name of the extension to be added (from the extension catalog).

- `extensionVersion`: This corresponds to the version of the extension to be added.

Then, the rest of this file describes the site extension resource to be added in Azure using the three parameters.

Then, in *step 2*, in the Terraform configuration, we used the Terraform resource `azurerm_template_deployment`, which allows execution of an ARM template with the following properties:

- `template_body`: This is the ARM code in JSON format. Here, in our example, we used the `file` function to indicate that it is a file.
- `parameters`: In this block, we fill in the input properties of the ARM template, which are `appserviceName`, `extensionName`, and `extensionVersion`. In our recipe, we install the `AspNetCoreRuntime.2.2.x64` extension of version `2.2.0-preview3-35497`.

Finally, to provision this Azure App Service and its extension, the Terraform workflow commands are executed.

The following screenshot shows the result in the Azure portal:

The screenshot shows the Microsoft Azure portal interface. The top navigation bar includes 'Microsoft Azure', a search bar, and a user profile icon. Below the navigation bar, the breadcrumb navigation shows 'Dashboard > DEMO | Resource groups > RG-DEMO >'. The main content area has a title 'AppDemoARM | Extensions' and a sub-header 'App Service'. On the left, there is a sidebar with links: 'Advanced Tools', 'App Service Editor (Preview)', 'Resource explorer', 'Extensions' (which is selected), 'API', 'API Management', 'API definition', 'CORS', and 'Monitoring'. The main content area has a heading 'Extensions' with a sub-instruction: 'Extensions add functionality to your App Service. Click add to see the list of available extensions.' Below this, a table lists the installed extension:

Name	Version	Update Available
ASP.NET Core 2.2 (x64) Runtime	2.2.0-preview3-35497	No

We can see the extension provisioned inside the App Service.

## There's more...

In this recipe, we have studied the possibility of running an ARM template with Terraform. This method allows you to provision elements in Azure that are not available in the `azurerm` provider, but it is important to know that Terraform knows the resources described in this ARM template when it is executed.

That is to say that these resources (here, in our resource, it is the extension) do not follow the life cycle of the Terraform workflow and are not registered in the Terraform state file. The only thing that is written in the Terraform state file is the configuration of the resource, `azurerm_template_deployment`, and, as a consequence, for example, if you run the `terraform destroy` command on the Terraform configuration, these resources provided by the ARM template will not be destroyed. Instead, only the `azurerm_template_deployment` resource will be removed from Terraform state file. For this reason, it is advisable that you use this type of deployment only to complete resources that have been provisioned with Terraform HCL code.

This indeed was our case, since the extension is an integrated complement to the App Service, and if we run `terraform destroy`, the App Service will be destroyed as well as all its extensions that are integrated in it.



We have seen the impact on the `destroy` command, but it is the same problem on other commands, such as the `plan`, `import`, or `refresh` commands. The resources provided by the ARM template are not known by Terraform.

In addition, the use of an ARM template in Terraform is only effective for a complete ARM resource, as is the case here with an extension, which can be executed as is with the ARM scripts provided by Azure.

In the next recipe, we will stay on the same topic, but instead of using an ARM template, we will see how to use Azure CLI commands with Terraform.

## See also

- Documentation pertaining to the `azurerm_template_deployment` resource of the `azurerm` provider is available here: [https://www.terraform.io/docs/providers/azurerm/r/template\\_deployment.html](https://www.terraform.io/docs/providers/azurerm/r/template_deployment.html)
- A blog article that also explains how to get the JSON code of the ARM template is available at <https://www.phillipsj.net/posts/applying-azure-app-service-extensions-with-arm/>.

# Executing Azure CLI commands in Terraform

In the previous recipe, we studied how to run ARM templates with Terraform in a situation where the provisioned resource is not yet available in the `azurerm` provider.

However, there are cases where the use of an ARM template is not possible, such as the following:

- We want to fill in one or more properties of a resource, which are not autonomous in an ARM template.
- The ARM template is not available for the resource to be provisioned.

For these situations, there is another solution that entails executing Azure CLI commands with Terraform.

This recipe is a practical application of the *Executing local programs with Terraform* recipe from Chapter 2, *Writing Terraform Configuration*. We will study the Terraform configuration and its execution to integrate Azure CLI commands with Terraform.

## Getting ready

For this recipe, it is necessary to have read beforehand the *Executing local programs with Terraform* recipe from Chapter 2, *Writing Terraform Configuration*, which provides the basis of the Terraform configuration we are going to write.

Moreover, it will also be necessary to have already installed the Azure CLI tool, documentation pertaining to which is available here: <https://docs.microsoft.com/en-us/cli/azure/?view=azure-cli-latest>

To demonstrate the use of the Azure CLI command in Terraform, in this recipe, we will set up an Azure Storage Account by configuring the properties of a static website feature on it.



As with the previous recipe, the purpose of this recipe is to show how to use Azure CLI commands with Terraform, but we will not focus on the Azure CLI command used because, since version 2.0.0 of the `azurerm` provider, the properties of a static website have been added to the Terraform resource (<https://github.com/terraform-providers/terraform-provider-azurerm/blob/master/CHANGELOG-v2.md#200-february-24-2020>).

The source code for this recipe is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP06/az%20cli>.

## How to do it...

Perform the following steps to execute Azure CLI commands with Terraform:

1. In the `main.tf` file that contains the Terraform code, write the following configuration for provision to the Storage Account:

```
resource "azurerm_storage_account" "sa" {  
    name          = "saazclidemo"  
    resource_group_name = azurerm_resource_group.rg.name  
    location      = "westeurope"  
    account_tier   = "Standard"  
    account_kind    = "StorageV2"  
    account_replication_type = "GRS"  
}
```

2. In the same Terraform configuration, add the code to configure the static website using the Azure CLI command:

```
resource "null_resource" "webapp_static_website" {  
    triggers = {  
        account = azurerm_storage_account.sa.name  
    }  
  
    provisioner "local-exec" {  
        command = "az storage blob service-properties update --account-name ${azurerm_storage_account.sa.name} --static-website true --index-document index.html --404-document 404.html"  
    }  
}
```

3. Then, in our command-line terminal, we log in to Azure by executing the following command:

```
az login --service-principal --username APP_ID --password PASSWORD  
--tenant TENANT_ID
```

4. Finally, we can execute the basic Terraform workflow with the following:

- Authentication with four Azure variable environments, as discussed in the *Protecting the Azure credential provider* recipe of this chapter
- The execution of the `init`, `plan`, and `apply` commands, as mentioned previously and in earlier chapters

## How it works...

In *step 1*, there is nothing special. We just wrote the Terraform configuration to provision a StorageV2 Storage Account, which is required to activate the static website feature.

In *step 2*, we completed this code by adding `null_resource` that contains a `local-exec` provisioner. In the `command` property of `local-exec`, we put the command Azure CLI that must be executed to activate and configure the static website functionality on the Storage Account we wrote in *step 1*.



We added the trigger block with the name of the storage as an argument, so that if the name of the storage changes, then provisioning will be re-executed.

Then, in *step 3*, we executed the `az login` command to authenticate the context of the Azure CLI. On this command, we added the authentication parameters with a Service Principal (see the *Protecting the Azure credential provider* recipe in this chapter), as documented here: <https://docs.microsoft.com/en-us/cli/azure/create-an-azure-service-principal-azure-cli?view=azure-cli-latest#sign-in-using-a-service-principal>.

## There's more...

In the implementation of this recipe, there are two important points:

- The first point is that we used `null_resource` with the `local-exec` provisioner that we had already studied in detail in the *Executing local programs with Terraform* recipe from Chapter 2, Writing Terraform Configuration. The only novelty brought here is the fact that the executed command is an Azure CLI command. It could also be a file that contains a script with several Azure CLI commands.
- The second point is that Terraform's authentication for Azure with the four environment variables does not allow authentication of the Azure CLI context that will be executed by Terraform. This is why, in step 3, we also had to authenticate the Azure CLI context with the `az login` command by passing the credentials of the Service Principal as parameters.

The advantage of executing Azure CLI commands in this way is that we can integrate the variables and expressions of the Terraform language into them, just as we did when we passed the name of the Storage Account as a parameter.



Note that, as with any local provisioner, this restricts where the configuration can be applied as it assumes existence of the Azure CLI (the Azure CLI becomes a hidden dependency).

As with the ARM templates, we learned in the previous recipe, *Executing ARM templates in Terraform*, that Terraform does not know the resources manipulated in the Azure CLI command or script. These resources do not follow the Terraform life cycle and are not registered in the Terraform state file. On the other hand, in the `local-exec` provisioner of `null_resource`, we can specify a command to be executed in the case of execution of the `terraform destroy` command.

The following is an example of the configuration that I used to create a CosmosDB database (before the `azurerm` provider supported it) that demonstrates the following:

```
resource "null_resource" "cosmosdb_database" {
  provisioner "local-exec" {
    command = "az cosmosdb database create --name ${var.cosmosdb_name} --
db-name ${var.app_name} --resource-group ${var.cosmosdb_rg} --throughput
${var.cosmosdb_throughput}"
  }

  provisioner "local-exec" {
    when      = "destroy"
```

```
    command = "az cosmosdb database delete --name ${var.cosmosdb_name} --  
    db-name ${var.app_name} --resource-group ${var.cosmosdb_rg}"  
}  
}
```

In this example, in the provisioner, we used the `when=destroy` property to specify that the Azure CLI command, `az cosmosdb database delete`, will be executed to delete the CosmosDB database in the case of `terraform destroy`.

## See also

- Documentation pertaining to the `az login` command and its parameters is available here: <https://docs.microsoft.com/en-us/cli/azure/authenticate-azure-cli?view=azure-cli-latest>
- Documentation pertaining to the Terraform provisioner is available here: <https://www.terraform.io/docs/provisioners/index.html>
- Documentation pertaining to the `when` property of provisioner is available here: <https://www.terraform.io/docs/provisioners/index.html#destroy-time-provisioners>

## Using Azure Key Vault with Terraform to protect secrets

One of the challenges of IaC is the protection of sensitive information that is part of the infrastructure.

Indeed, one of the advantages of IaC is the possibility to version the code in a Git repository and so this code benefits from the Git workflow of versioning and validation of the code. However, with this approach, we tend to write *everything* in this code, sometimes forgetting that some data that is sensitive, such as passwords or login strings, can be misused if they end up in the wrong hands.

In this recipe, we will study how to protect this sensitive data by storing it in Azure's secret manager, which is Azure Key Vault, and then using it in the Terraform configuration.

## Getting ready

For this recipe, we assume the use of Azure Key Vault. For more information, you can refer to the following documentation available at <https://docs.microsoft.com/en-us/azure/key-vault/>.

In an Azure Key Vault that we have created in Azure, as regards the application of this recipe, we store a secret that protects the connection string of the SQL Server database of our application hosted in an Azure web application.

This connection string is as follows:

```
Data Source=mysever.com;initial catalog=databasedemo;User  
ID=useradmin;Password=demobook
```

Here is the output of the Azure CLI command, `az keyvault secret show`, which shows its storage and properties in Azure Key Vault:

```
mikael@Azure:~$ az keyvault secret show -n ConnectionStringApp --vault-name keyvdemobook  
{  
    "attributes": {  
        "created": "2020-06-03T09:41:33+00:00",  
        "enabled": true,  
        "expires": null,  
        "notBefore": null,  
        "recoveryLevel": "Recoverable+Purgeable",  
        "updated": "2020-06-03T09:41:33+00:00"  
    },  
    "contentType": null,  
    "id": "https://keyvdemobook.vault.azure.net/secrets/ConnectionStringApp/af0164c179e647b3952de55b63e4308b",  
    "kid": null,  
    "managed": null,  
    "name": "ConnectionStringApp",  
    "tags": null,  
    "value": "Data Source=mysever.com;initial catalog=databasedemo;User ID=useradmin;Password=demobook"  
}
```

In the preceding screenshot, we can see the connection string of the database stored in the `value` property of the `secret` object.

The goal of this recipe is to write the Terraform configuration that requests the value of this secret to use it in the properties of an Azure App Service.

The source code for this recipe is available here: <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP06/keyvault>

## How to do it...

To get and use an Azure Key Vault secret in Terraform, perform the following steps:

1. In Azure Key Vault, we add access policy properties by granting the Service Principal that will be used by Terraform for Azure to have permission to get and list secrets:

The screenshot shows the 'Add access policy' page in the Microsoft Azure portal. The 'Secret permissions' dropdown is highlighted with a red circle labeled '1'. Below it, a search input field contains the text 'BookDemoTerraform' with a red circle labeled '2'. At the bottom left, a blue 'Add' button is highlighted with a red circle labeled '3'.

2. In the `main.tf` file, we add the following code to get the Key Vault secret:

```
data "azurerm_key_vault" "keyvault" {  
    name          = "keyvdemobook"  
    resource_group_name = "rg_keyvault"  
}
```

```
data "azurerm_key_vault_secret" "app-connectionstring" {
    name          = "ConnectionStringApp"
    key_vault_id = data.azurerm_key_vault.keyvault.id
}
```

3. Then, in the Terraform configuration of the App Service resource, in the `main.tf` file, we add the following code:

```
resource "azurerm_app_service" "app" {
    name          = "demovaultbook"
    location      = azurerm_resource_group.rg-app.location
    resource_group_name = azurerm_resource_group.rg-app.name
    app_service_plan_id = azurerm_app_service_plan.plan-app.id

    connection_string {
        name      = "Database"
        type      = "SQLServer"
        value     = data.azurerm_key_vault_secret.app-
connectionstring.value
    }
}
```

4. Finally, we run the basic Terraform workflow for Azure with set variable environments and execute `init`, `plan`, and `apply`, as mentioned previously and in earlier chapters.

## How it works...

In *step 1*, we gave permission to the Service Principal used by Terraform to read and list the secrets of Azure Key Vault.



We can do this either via the Azure portal or on the command line with the Azure CLI, as explained in the following documentation: <https://docs.microsoft.com/en-us/cli/azure/keyvault?view=azure-cli-latest#az-keyvault-set-policy>

If we had not carried out this step, we would have obtained the following error when executing the `terraform plan` command:

```
PS C:\CHAP06\keyvault> terraform plan
Refreshing Terraform state in-memory prior to plan...
The refreshed state will be used to calculate this plan, but will not be
persisted to local or remote state storage.

data.azurerm_key_vault.keyvault: Refreshing state...
data.azurerm_key_vault_secret.app-connectionstring: Refreshing state...

Error: Error making Read request on Azure KeyVault Secret secret-sauce: keyvault.BaseClient#GetSecret: Failure responding to request: StatusCode=403 -- Original Error: autorest/azure: Service returned an error. Status=403 Code="Forbidden" Message="The user, group or application 'appid=282936c6-298d-40bc-890b-0906b7d9c107;oid=e7f17718-47bd-40fb-8e96-887f20cadf79;iss=https://sts.windows.net/2e3a33f9-66b1-4e2a-8b95-74102ad857c2/' does not have secrets get permission on key vault 'keydemobook;location=westeurope'. For help resolving this issue, please see https://go.microsoft.com/fwlink/?linkid=2125287" InnerError={"code":"AccessDenied"}"

on main.tf line 17, in data "azurerm_key_vault_secret" "app-connectionstring":
  17: data "azurerm_key_vault_secret" "app-connectionstring" {
```

Then, in *step 2*, we wrote the Terraform configuration, which contains two data sources:

- The first data source, `azurerm_key_vault`, enables retrieval of the Azure ID of the Azure Key Vault resource.
- The second data source, `azurerm_key_vault_secret`, is used to retrieve the secret that contains the database connection string as a value.



For more information about Terraform block data, read the *Using external resources with a data block* recipe from Chapter 2, *Writing Terraform Configuration*.

In *step 3*, we continue with the writing of the Terraform configuration, putting in the `property` value of the `connection_string` block of the App Service with the expression `data.azurerm_key_vault_secret.app-connectionstring.value`, which is the value obtained from the block data, `azurerm_key_vault_secret`, written in *step 2*.

Finally, in the last step, we execute this Terraform configuration. During this operation, Terraform will first retrieve the values requested in the block data (Key Vault, and then the Key Vault secret) and will then inject the value obtained from the secret into the configuration of the App Service.

This result is obtained in Azure and shown in the following screenshot:

The screenshot shows the Azure portal interface for managing an App Service. The left sidebar lists various settings like Tags, Diagnose and solve problems, Security, Events, Deployment (Quickstart, Deployment slots, Deployment Center), and Settings (Configuration). The 'Configuration' tab is selected and highlighted with a red circle labeled '1'. In the main content area, the title is 'demovaultbook | Configuration'. Below it, there's a table for environment variables with one entry: WEBSITE\_NODE\_DEFAULT\_VERSION with a value of 'Hidden value. Click to show value' and 'App Config' as the source. Under 'Connection strings', it says 'Connection strings are encrypted at rest and transmitted over an encrypted channel.' There are buttons for '+ New connection string', 'Hide values', 'Advanced edit', and 'Filter'. A connection string named 'Database' is listed with the value 'Data Source=mysve' and type 'SQLServer'. A red circle labeled '2' points to this connection string.

We can see that the connection string is well filled in the App Service configuration.

## There's more...

We have learned in this recipe that the connection string, which is sensitive data, has been stored in Azure Key Vault and will be used automatically when Terraform is run. So, thanks to Azure Key Vault, we didn't need to put the sensitive data in clear text in the Terraform configuration.

However, care should still be taken. Although this data is not written in plain text in the Terraform configuration, it will be written in plain text in the Terraform state file, as can be seen in this extract of the Terraform state file content from this recipe:

```
"mode": "data",
"type": "azurerm_key_vault_secret",
"name": "app-connectionstring",
"provider": "provider.azurerm",
"instances": [
{
    "schema_version": 0,
    "attributes": {
        "content_type": "",
        "id": "https://keyvdemobook.vault.azure.net/secrets/ConnectionStringApp/af0164c179e647b3952de55b63e4308b",
        "key_vault_id": "/subscriptions/1da42ac9-ee3e-4fdb-b294-f7a607f589d5/resourceGroups/rg_key_vault/providers/Microsoft.KeyVault/vaults/keyvdemobook",
        "name": "ConnectionStringApp",
        "tags": {},
        "timeouts": null,
        "value": "Data Source=mysever.com;initial catalog=databasedemo;User ID=useradmin;Password=1234567890"
    }
}]
```

That is why, if we need to inspect the contents of this file, it is recommended to use the `terraform state show` or `terraform show` commands, which protect the displaying of sensitive data, as can be seen in the following screenshot:

```
PS C:\terrafrom-Cookbook\CHAP06\keyvault> terraform show
# azurerm_app_service.app:
resource "azurerm_app_service" "app" {
  app_service_plan_id      = "/subscriptions/1da42ac9-ee3e-4fdb-b294-f7a607f589d5/resourceGroups/RG-DEMOVULT/providers/Microsoft.Web/serverFarms/SP-demovault"
  app_settings              =
  "WEBSITE_NODE_DEFAULT_VERSION" = "6.9.1"
}
client_affinity_enabled     = true

connection_string {
  name   = "Database"
  type   = "SQLServer"
  value  = (sensitive value)
}
```

This is one of the reasons why it is necessary to protect this `tfstate` file by storing it in a secure remote backend, as we have seen in the *Protecting the state file in the Azure remote backend* recipe of this chapter, and which is explained in the following documentation: <https://www.terraform.io/docs/state/sensitive-data.html>

Also in this recipe, although we stored the sensitive data in Azure Key Vault, we can also store it in a HashiCorp Vault instance that integrates very well with Terraform. For this, it is advisable that you read the vault provider documentation here: <https://www.terraform.io/docs/providers/vault/index.html>

Finally, as a prerequisite for this recipe, we manually created the secret of the connection string in Azure Key Vault. This could have been done either with Terraform, as documented here ([https://www.terraform.io/docs/providers/azurerm/r/key\\_vault\\_secret.html](https://www.terraform.io/docs/providers/azurerm/r/key_vault_secret.html)), or with the Azure CLI commands, as documented here (<https://docs.microsoft.com/en-us/cli/azure/keyvault/secret?view=azure-cli-latest#az-keyvault-secret-set>). On the other hand, in this case, since the data will be written in clear text in the code, it will be necessary to secure it well by giving read and write permissions only to authorized persons.

## See also

- Documentation on the block data, `azurerm_key_vault_secret`, is available here: [https://www.terraform.io/docs/providers/azurerm/d/key\\_vault\\_secret.html](https://www.terraform.io/docs/providers/azurerm/d/key_vault_secret.html)

# Getting a list of Azure resources in Terraform

In the previous recipe, we learned the practical case of using a `data` block to obtain the properties of an Azure resource.

We will look in this recipe at a data source in the `azurerm` provider that is generic and allows you to get information about any provisioned resource in Azure.

## Getting ready

In this recipe, we will write a Terraform configuration that adds security rules to several **Azure Network Security Groups (NSGs)** already provisioned (manually or by Terraform). Its purpose is to add these rules to all NSGs that have the tag `DEFAULTRULES=TRUE`.

In addition, we have already created three NSGs in the Resource Group called `RG-DEMO`. Among these NSGs, only `NSG1` and `NSG2` have the tag `DEFAULTRULES=TRUE`.

The source code for this recipe is available here: <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP06/listresources>

## How to do it...

Perform the following steps in order to get Azure resources:

1. In the `main.tf` file that contains the Terraform configuration, add the following code to get provisioned NSGs:

```
data "azurerm_resources" "nsg" {
    type             = "Microsoft.Network/networkSecurityGroups"
    resource_group_name = "RG-DEMO"
    required_tags = {
        DEFAULTRULES = "TRUE"
    }
}
```

2. Then, in the same file, add the following code to create rules:

```
resource "azurerm_network_security_rule" "default-rules" {
    for_each           = { for n in
        data.azurerm_resources.nsg.resources
            : n.name => n }
    name              = "${each.key}-SSH"
    priority          = 100
    direction         = "InBound"
    access             = "Allow"
    protocol          = "Tcp"
    source_port_range = "*"
    destination_port_range = "22"
    source_address_prefix = "*"
    destination_address_prefix = "*"
    resource_group_name = "RG-DEMO"
    network_security_group_name = each.key
}
```

3. Finally, we run the basic Terraform workflow for Azure with set variable environments and execute `init`, `plan`, and `apply`, as mentioned previously and in earlier chapters.

## How it works...

In *step 1*, we used the `azurerm_resources` data object, which allows you to obtain the basic properties of any already provisioned Azure resource. To this object, we configured the following properties:

- `type`: This is the type of resource to request. The list of types is documented here: <https://docs.microsoft.com/en-us/azure/azure-resource-manager-management/azure-services-resource-providers>. Here, we filled in the value `Microsoft.Network/networkSecurityGroups`.
- `resource_group_name`: This is the name of the Resource Group in which the NSGs have been provisioned.
- `required_tag`: This is the list of tags on which we want to filter NSGs.

Then, in *step 2*, we completed this Terraform configuration by adding the `azurerm_network_security_rule` resource, which enables the provision of rules in already existing NSGs. In this resource, we first added the expression `for_each`, which facilitates a loop on all NSGs that are returned from the previously instantiated data block. In the construction of this loop, we used the expression

`data.azurerm_resources.nsg.resources`, which contains a list of NSGs retrieved from the data block. Moreover, in the `name` property, we add a prefix, which is the name of the NSG, using the expression `each.key`. Finally, in the `network_security_group_name` property, we also use `each.key` as the name of each NSG iterated in the loop.

For more information on the `for_each` expression and loops in Terraform, refer to the recipes in Chapter 3, *Building Dynamic Environments with Terraform*.

Finally, in *step 3*, we execute the Terraform workflow commands to apply this Terraform configuration.

## There's more...

We have learned in this recipe that by using `azurerm_resources`, in Terraform, we can use any Azure resource that is already provisioned.

In the Terraform configuration, we can also add the following `output` variable, which allows a visualization of the resources returned by the `azurerm_resource` data block:

```
output "nsg" {  
    value = { for n in data.azurerm_resources.nsg.resources : n.name => n }  
}
```

The following screenshot shows the result of this output:

```
PS C:\CHAP06\listresources> terraform output
nsg = {
  "NSG1" = {
    "id" = "/subscriptions/1da42ac9-ee3e-... /resourceGroups/RG-DEMO/providers/Microsoft.Network/networkSecurityGroups/NSG1"
    "location" = "westeurope"
    "name" = "NSG1"
    "tags" = {
      "DEFaulTRULEs" = "TRUE"
    }
    "type" = "Microsoft.Network/networkSecurityGroups"
  }
  "NSG2" = {
    "id" = "/subscriptions/1da42ac9-ee3e-... /resourceGroups/RG-DEMO/providers/Microsoft.Network/networkSecurityGroups/NSG2"
    "location" = "westeurope"
    "name" = "NSG2"
    "tags" = {
      "DEFaulTRULEs" = "TRUE"
    }
    "type" = "Microsoft.Network/networkSecurityGroups"
  }
}
```

We can see in this output result that the `data` block has recovered the two NSGs that are provisioned and has the tag `DEFaulTRULEs=TRUE`. Moreover, you can also see the properties of each resource that it is possible to exploit in the rest of the Terraform configuration.

However, it must be ensured that these resources are provisioned in the same subscription as defined in the environment variable, `ARM_SUBSCRIPTION_ID`, which is set before executing the Terraform commands, as we have seen in the *Protecting the Azure credential provider* recipe of this chapter.

## See also

- Documentation pertaining to the `azurerm_resources` object data of Terraform is available here: <https://www.terraform.io/docs/providers/azurerm/d/resources.html>

# Provisioning and configuring an Azure VM with Terraform

In this recipe, we will study a typical use case of Terraform in Azure in which we will provision and configure a VM in Azure using Terraform.

## Getting ready

For this recipe, we don't need any special prerequisites. We will start the Terraform configuration from scratch. This recipe will only involve writing the Terraform configuration. In its stages of realization, we will study the writing of this code. As for the architecture in Azure, we have already built a network beforehand, which will contain this VM and which is made up of the following resources:

- A **virtual network (VNet)** called VNET-DEMO.
- Inside this VNet, a Subnet named Subnet1 is registered.

In addition, the VM that will be provisioned will have a public IP address so that it can be accessed publicly.

Finally, in keeping the VM's password secret in the code, we protect it in an Azure Key Vault, as studied in the *Using Azure Key Vault with Terraform to protect secrets* recipe of this chapter.

The source code for this chapter is available here: <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP06/vm>

## How to do it...

Write the following Terraform configuration to provision a VM with Terraform:

1. The first resource to build is the Resource Group, with the help of the following code:

```
resource "azurerm_resource_group" "rg" {  
    name      = "RG-VM"  
    location  = "West Europe"  
}
```

2. Then, we write the following code to provision the public IP:

```
resource "azurerm_public_ip" "ip" {  
    name          = "vmdemo-pip"  
    resource_group_name = azurerm_resource_group.rg.name  
    location      = azurerm_resource_group.rg.location  
    allocation_method = "Dynamic"  
}
```

3. We continue by writing the code for the Network Interface:

```
data "azurerm_subnet" "subnet"{
  name = "Default1"
  resource_group_name = "RG_NETWORK"
  virtual_network_name = "VNET-DEMO"
}

resource "azurerm_network_interface" "nic" {
  name           = "vmdemo-nic"
  resource_group_name = azurerm_resource_group.rg.name
  location       = azurerm_resource_group.rg.location

  ip_configuration {
    name           = "vmipconf"
    subnet_id      = data_azurerm_subnet.subnet.id
    private_ip_address_allocation = "Dynamic"
    public_ip_address_id        = azurerm_public_ip.ip.id
  }
}
```

4. We get the VM password by using the keyvault data block:

```
data "azurerm_key_vault" "keyvault" {
  name           = "keyvdemobook"
  resource_group_name = "rg_keyvault"
}

data "azurerm_key_vault_secret" "vm-password" {
  name           = "vmdemoaccess"
  key_vault_id   = data_azurerm_key_vault.keyvault.id
}
```

5. Finally, we write the code for the VM resource, as follows:

```
resource "azurerm_linux_virtual_machine" "vm" {
  name           = "myvmdemo"
  ...
  admin_username     = "adminuser"
  admin_password     =
  data_azurerm_key_vault_secret.vm-password.value
  network_interface_ids = [azurerm_network_interface.nic.id]

  source_image_reference {
    publisher = "Canonical"
    offer     = "UbuntuServer"
    sku       = "18.04-LTS"
    version   = "latest"
```

```
    }
    ...
    provisioner "remote-exec" {
      inline = [
        "apt update",
      ]
      connection {
        host    = self.public_ip_address
        user    = self.admin_username
        password = self.admin_password
      }
    }
}
```

The complete source code for these VM resources is available at <https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP06/vm/main.tf>.

## How it works...

In *step 1*, we wrote the Terraform configuration that will create the Resource Group containing the VM. This step is optional because you can provision the VM in an existing Resource Group, and in this case you can use the `azurerm_resource_group` block `data`, whose documentation is available here: [https://www.terraform.io/docs/providers/azurerm/d/resource\\_group.html](https://www.terraform.io/docs/providers/azurerm/d/resource_group.html)

Then, in *steps 2 and 3*, we wrote the Terraform configuration that provides the following:

- A public IP of the dynamic type, so that we don't have to set the IP address (this IP address will be the first free address of the subnet).
- The Network Interface of the VM that uses this IP address, and which will register in the Subnet that has already been created. To retrieve the subnet ID, we used an `azurerm_subnet` data source.

In *step 4*, we use the `azurerm_key_vault_secret` data source to get the password of the VM (refer to the *Using Azure Key Vault with Terraform to protect secrets* recipe for more details).

Finally, in *step 5*, we write the code that will provision the VM. In this code, we have defined the following properties of the VM:

- Its name and size (which includes its RAM and CPU)
- The basic image used, which is an Ubuntu image
- Authentication information for the VM with a login and a password (an SSH key can also be used)

In this resource, we also added a `remote-exec` provisioner, which allows you to remotely execute commands or scripts directly on the VM that will be provisioned. The use of this provisioner will allow you to configure the VM for administration, security, or even middleware installation tasks.

## There's more...

The interesting and new aspect of this recipe is the addition of the `remote-exec` provisioner, which enables configuration of the VM using commands or scripts. This method can be useful in performing the first steps of VM administration, such as opening firewall ports, creating users, and other basic tasks. Here in our recipe, we used it to update the packages with the execution of the `apt update` command. However, this method requires that this VM is accessible from the computer running Terraform because it connects to the VM (SSH or WinRM) and executes the commands.

If you want to keep a real IaC, it is preferable to use an as-code configuration tool, such as Ansible, Puppet, Chef, or PowerShell DSC. And so, in the case of using Ansible to configure a Windows VM, the `remote-exec` provisioner can perfectly serve to authorize the WinRM SSL protocol on my VM because this port is the port used by Ansible to configure Windows machines.

Moreover, in Azure, you can also use a custom script VM extension, which is another alternative to configuring VMs using a script. In this case, you can provision this VM extension with Terraform using the `azurerm_virtual_machine_extension` resource, as explained in the following documentation: [https://www.terraform.io/docs/providers/azurerm/r/virtual\\_machine\\_extension.html](https://www.terraform.io/docs/providers/azurerm/r/virtual_machine_extension.html)



**Warning:** There can only be one custom script extension per VM. Therefore, you have to put all the configuration operations in a single script.

Apart from providing `remote-exec` and the VM extension, another solution is to use the `custom_data` property of the Terraform resource, `azurerm_virtual_machine`. Documentation pertaining to the `custom_data` property is available at [https://www.terraform.io/docs/providers/azurerm/r/linux\\_virtual\\_machine.html#custom\\_data](https://www.terraform.io/docs/providers/azurerm/r/linux_virtual_machine.html#custom_data), and a complete code sample is available at <https://github.com/terraform-providers/terraform-provider-azurerm/blob/master/examples/virtual-machines/linux/custom-data/main.tf>.

Finally, by way of another alternative for VM configuration, we can also preconfigure the VM image with all the necessary software using **Packer**, which is another open source tool from HashiCorp and allows you to create your own VM image using JSON or HCL2 (as documented at <https://www.packer.io/guides/hcl>). Once this image is created, in the Terraform VM configuration, we will set the name of the image created by Packer instead of the image provided by the Marketplace (Azure or other cloud providers). For more information about Packer, read the following documentation: <https://www.packer.io/>

## See also

Various tutorials and guides are available in the Azure documentation available here: <https://docs.microsoft.com/en-us/azure/developer/terraform/create-linux-virtual-machine-with-infrastructure>

# Building Azure serverless infrastructure with Terraform

In the previous recipe, we studied the implementation of the Terraform configuration that allows the provisioning of an IaaS (that is, a VM) infrastructure in Azure.

In this recipe, we will stay in the same realm as the previous recipe, but this time we will focus on writing the Terraform configuration that is used to provision a PaaS serverless infrastructure with the provisioning of an Azure App Service.

## Getting ready

The purpose of this recipe is to provision and configure an Azure App Service of the Web App type. In addition to provisioning, we will deploy an application in this Web App at the same time as it is being provisioned using Terraform.

Most of the Terraform configuration needed for this recipe has already been studied in several recipes in this book. We will just study the Terraform configuration needed to deploy the application in this Web App.

Regarding the application, it must be packaged in a ZIP file that is in the format <appname>\_<version>.zip, such as, for example, myapp\_v0.1.1.zip, and then we will upload this ZIP file in an Azure blob storage. This ZIP file can be uploaded either via the command line Azure CLI, as indicated in this documentation, <https://docs.microsoft.com/en-us/cli/azure/storage/blob?view=azure-cli-latest#az-storage-blob-upload>, or via Terraform using the azurerm\_storage\_blob resource, whose documentation is available here: [https://www.terraform.io/docs/providers/azurerm/r/storage\\_blob.html](https://www.terraform.io/docs/providers/azurerm/r/storage_blob.html)

The Terraform configuration we will write in this recipe will use this ZIP file in a secure way. The source code for this recipe is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP06/webapp>.

## How to do it...

Perform the following steps to provision a Web App with Terraform:

1. Copy and paste, in a new Terraform file, the Web App Terraform from <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP06/sample-app>.
2. Inside this Terraform file, we add a new azurerm\_storage\_account data block with the following code:

```
data "azurerm_storage_account" "storagezip" {  
    name          = "storappdemo"  
    resource_group_name = "RG-storageApp"  
}
```

3. Then, we add another azurerm\_storage\_account\_sas data block to get a security token with the following extract code:

```
data "azurerm_storage_account_sas" "storage_sas" {  
    connection_string =  
    data.azurerm_storage_account.storagezip.primary_connection_string  
    ...  
    services {  
        blob  = true  
    ...  
    }  
}
```

```
    start  = "2020-06-15"
    expiry = "2021-03-21"
    permissions {
        read   = true
        write  = false
        ...
    }
}
```

The complete code of this block is available at <https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP06/webapp/main.tf>.

4. Finally, we update the code of the Azure Web App in `azurerm_app_resource` by adding the following code:

```
resource "azurerm_app_service" "app" {
    ...
    app_settings = {
        "WEBSITE_RUN_FROM_PACKAGE" =
        "https://${data.azurerm_storage_account.storagezip.name}.blob.core.windows.net/app/myapp_v1.0.0/zip${data.azurerm_storage_account_sas.storage_sas.sas}"
    }
}
```

## How it works...

In *step 1*, we retrieved the Terraform configuration that allows a Web App to be provisioned. In the following steps of the recipe, we will complete it in order to be able to deploy a web application directly in this Web App, with Terraform, at the same time as its provisioning.

Then, in *step 2*, we add the `azurerm_storage_account` data block, which will allow us to retrieve properties from the Storage Account that contains the ZIP file of the application. In *step 3*, we add the `azurerm_storage_account_sas` data block, which will return a security token to the blob.

In this token, we indicate that the access will be read-only, and that we only give access to the blob service.

Finally, in *step 4*, we complete the resource `azurerm_app_service` by adding in the application settings of the `WEBSITE_RUN_FROM_PACKAGE` key, which contains, by way of a value, the complete URL of the ZIP file and in which we concatenated the token key returned in the block.

## There's more...

In this recipe, we have studied the possibility of provisioning an Azure Web App and deploying it with Terraform. There are, however, several other ways to deploy this application in the Web App, as explained in the documentation available at <https://docs.microsoft.com/en-us/azure/app-service/deploy-zip>.

We will learn in the *Building CI/CD pipelines for Terraform configuration in Azure pipelines* recipe in Chapter 7, *Terraform Deep Dive*, how to automate this deployment in a CI/CD pipeline in Azure Pipelines.

## See also

- Documentation pertaining to the WEBSITE\_RUN\_FROM\_PACKAGE app setting of a Web App is available here: <https://docs.microsoft.com/en-us/azure/app-service/deploy-run-package>
- Documentation pertaining to the azurerm\_storage\_account\_sas block data is available here: [https://www.terraform.io/docs/providers/azurerm/d/storage\\_account\\_sas.html](https://www.terraform.io/docs/providers/azurerm/d/storage_account_sas.html)
- Documentation pertaining to the Terraform resource, azurerm\_app\_service, is available here: [https://www.terraform.io/docs/providers/azurerm/r/app\\_service.html](https://www.terraform.io/docs/providers/azurerm/r/app_service.html)

## Generating a Terraform configuration for existing Azure infrastructure

When enterprises want to automate their processes and adopt IaC practices (for example, with Terraform), they face the challenge of how to generate code for an infrastructure that is already provisioned.

Indeed, for new infrastructures, it is sufficient to write the corresponding Terraform configuration and then execute it in order to provision it. On the other hand, for resources that are already provisioned, depending on their number and configuration, it can be long and tedious to write all the Terraform configuration and then execute it to also have the corresponding Terraform state file. In addition, this execution of the Terraform configuration can have side effects on these resources, which may already be being faced in production.

As a partial answer to this problem, we have seen in the *Importing existing resources* recipe from Chapter 4, *Using the Terraform CLI*, that we can use the `terraform import` command to import the configuration of already provisioned resources into the Terraform state file. However, this command requires that, on the one hand, the corresponding Terraform configuration is already written, because this command only updates the Terraform state file, and on the other, this command must be executed in order for each resource to be imported.

With this in mind, and having already had this request from many clients, I asked myself the question: Are there tools or scripts that can be used to generate Terraform configuration and its Terraform state file for resources already provisioned in Azure?

In this recipe, I'm going to share the results of my investigation with you using one of the Terraform configuration generation tools, called **Terraformer**, which is hosted in the GitHub repo of Google Cloud Platform, at <https://github.com/GoogleCloudPlatform/terraformer>.

## Getting ready

To use **Terraformer**, you must first download the version corresponding to the Terraform provider whose code you wish to generate. In our case, we want to generate the Terraform configuration for an Azure infrastructure, so we run the following Linux script:

```
curl -LO
https://github.com/GoogleCloudPlatform/terraformer/releases/download/$(curl
-s
https://api.github.com/repos/GoogleCloudPlatform/terraformer/releases/latest
| grep tag_name | cut -d '"' -f 4)/terraformer-azure-linux-amd64

chmod +x terraformer-azure-linux-amd64

sudo mv terraformer-azure-linux-amd64 /usr/local/bin/terraformer
```

This script downloads the **Terraformer** ZIP package. Unzip it and then copy it inside the `/usr/local/bin` local folder.



For this recipe, we will work on a Linux Terminal, but Terraformer works the same way for Windows, as described in the following documentation: <https://github.com/GoogleCloudPlatform/terraformer#installation>

Once installed, its installation can be checked by executing the `terraform --help` command, and the list of Terraformer commands is displayed:

```
mikael@LP-FYLZ2X2:/c/test/terraform$ terraformer --help
Usage:
  [command]

Available Commands:
  help      Help about any command
  import    Import current state to Terraform configuration
  plan      Plan to import current state to Terraform configuration
  version   Print the version number of Terraformer

Flags:
  -h, --help      help for this command
  --version      version for this command

Use " [command] --help" for more information about a command.
```

The purpose of this recipe is to generate the Terraform configuration and the Terraform state file of an Azure infrastructure, which is composed of several Resource Groups, as shown in the following screenshot:

A screenshot of the Azure portal interface. At the top, there is a search bar labeled "Filter by name..." and a filter button labeled "Location == all" with an "X" icon. Below this, a button says "+ Add filter". The main area displays a list of 8 resource groups, each with a checkbox and a small icon. The resource groups listed are: DefaultResourceGroup-WEU, MyRgRemoteBackend, NetworkWatcherRG, RG-DEMO, RG-DEMOVAULT, RG-VM, rg\_keyvault, and rg\_vmdev. The text "Showing 1 to 8 of 8 records." is displayed above the list.

Name	Location
DefaultResourceGroup-WEU	all
MyRgRemoteBackend	all
NetworkWatcherRG	all
RG-DEMO	all
RG-DEMOVAULT	all
RG-VM	all
rg_keyvault	all
rg_vmdev	all



For the purpose of this recipe, we will limit the generation of the Terraform configuration just to these Resource Groups and not to their contents.

## How to do it...

To generate a Terraform configuration using **Terraformer**, perform the following steps:

1. In the folder that will contain the generated code, we create a `provider.tf` file with the code of the Terraform provider declared as following:

```
provider "azurerm" {  
    features {}  
}
```

2. In the command-line terminal, in this folder, we need to download the `azurerm` provider by running the `terraform init` command.
3. We then set the four Azure environment variables for Terraform authentication:

```
export ARM_SUBSCRIPTION_ID="xxxxxx-xxx-xxxxx-xxxx"  
export ARM_CLIENT_ID="xxxxx-xxxx-xxxx-xxxx"  
export ARM_CLIENT_SECRET="xxxx-xxxxxx-xxxxxx-xxxxxx"  
export ARM_TENANT_ID="xxxxx-xxxxxx-xxxx-xxxx"
```

4. Then, we generate the Terraform configuration by executing the following **Terraformer** command:

```
terraformer import azure --resources=resource_group --compact --  
path-pattern {output}/{provider}/
```

5. Once the Terraform configuration and Terraform state file are generated, we will navigate the generated code in the `generate/azurerm` folder and add the `features {}` expression to the `provider.tf` file as follows:

```
provider "azurerm" {  
    version = "~>v2.14.0"  
    features {}  
}
```

6. Finally, in this folder, we will test the configuration generated by running the basic Terraform workflow with the `terraform init` and `terraform plan` commands:

```
mikael@LP-FYLVZ2X2:/c/test/terraformer/generated/azurerm$ terraform plan
Refreshing Terraform state in-memory prior to plan...
The refreshed state will be used to calculate this plan, but will not be
persisted to local or remote state storage.

data.terraform_remote_state.local: Refreshing state...
azurerm_resource_group.tfer--DefaultResourceGroup-002D-WEU: Refreshing state..
  [id=resourceGroup-WEU]
azurerm_resource_group.tfer--RG-002D-DEMO: Refreshing state... [id=/subscriptions/...
azurerm_resource_group.tfer--RG-002D-VM: Refreshing state... [id=/subscriptions/...
azurerm_resource_group.tfer--rg_keyvault: Refreshing state... [id=/subscriptions/...
azurerm_resource_group.tfer--NetworkWatcherRG: Refreshing state... [id=/subscriptions/...

No changes. Infrastructure is up-to-date.
```

If the output is generated successfully, we should see that the configuration & generated doesn't apply any changes. It corresponds to our infrastructure exactly.

## How it works...

In *step 1*, we created a file that contains the provider declaration to download. Then, we downloaded it with the `terraform init` command we execute in the second step.

*Step 3* corresponds to the set of environment variables for Azure authentication that we detailed in the *Protecting the Azure credential provider* recipe of this chapter. Then, in *step 4*, we used Terraformer to generate the Terraform configuration and Terraform state files for the provisioned Azure group resources and, in the command line used, we specified the following options:

- `resources`: This is the list of Azure resources for which Terraform configuration must be generated.
- `compact`: This enables specification of the fact that all the Terraform configurations will be generated in a single file.
- `path-pattern`: This specifies the pattern of the folder that will contain the generated code.

The following screenshot shows the execution of Terraformer:

```
mikael@LP-FYLZ2X2:/c/test/terraformer$ terraformer import azure --resources=resource_group --compact --path-pattern '{output}/{provider}/'
2020/06/16 18:25:25 Testing if Service Principal / Client Certificate is applicable for Authentication..
2020/06/16 18:25:25 Testing if Multi Tenant Service Principal / Client Secret is applicable for Authentication..
2020/06/16 18:25:25 Testing if Service Principal / Client Secret is applicable for Authentication..
2020/06/16 18:25:25 Using Service Principal / Client Secret for Authentication
2020/06/16 18:25:25 Getting OAuth config for endpoint https://login.microsoftonline.com/ with tenant 2e3a33f9...
2020/06/16 18:25:25 azurerm importing... resource_group
2020/06/16 18:25:28 Refreshing state... azurerm_resource_group.tfer--rg_keyvault
2020/06/16 18:25:28 Refreshing state... azurerm_resource_group.tfer--RG-002D-DEMO
2020/06/16 18:25:28 Refreshing state... azurerm_resource_group.tfer--RG-002D-DEMOVULT
2020/06/16 18:25:28 Refreshing state... azurerm_resource_group.tfer--RG-002D-VM
2020/06/16 18:25:28 Refreshing state... azurerm_resource_group.tfer--rg_vndev
2020/06/16 18:25:28 Refreshing state... azurerm_resource_group.tfer--DefaultResourceGroup-002D-WEU
2020/06/16 18:25:28 Refreshing state... azurerm_resource_group.tfer--MyRgRemoteBackend
2020/06/16 18:25:28 Refreshing state... azurerm_resource_group.tfer--NetworkWatcherRG
2020/06/16 18:25:29 azurerm Connecting....
2020/06/16 18:25:29 azurerm save
2020/06/16 18:25:29 azurerm save tfstate
```

The generated/azurerm folder is created with the Terraform files, as shown in the following screenshot:

outputs.tf	16/06/2020 14:01	Fichier TF	1 Ko
provider.tf	16/06/2020 15:40	Fichier TF	1 Ko
resources.tf	16/06/2020 14:01	Fichier TF	1 Ko
terraform.tfstate	16/06/2020 14:01	Fichier TFSTATE	10 Ko
variables.tf	16/06/2020 14:01	Fichier TF	1 Ko

In this folder, we see the following generated files:

- The Terraform configuration .tf files – resources.tf, provider.tf, outputs.tf, and variables.tf
- The tfstate file – terraform.tfstate

In step 5, we added the features {} expression to the provider declaration that was generated in the generated/azurerm folder.

Finally, in step 6, we verified that the generated code is the infrastructure code by executing a preview of the changes with the execution of the terraform plan command. During its execution, no changes will be applied. The Terraform configuration is well in line with our infrastructure.

## There's more...

Terraformer also contains an option that allows a dry run to preview the code that will be generated.

To do this, we will execute the following command that generates a `plan.json` file, along with a description of the resources that will be generated:

```
terraformer plan azure --resources=resource_group --compact --path-pattern  
{output}/{provider}/
```

We visualize the content of this created JSON file to check its conformity and then, in order to carry out the generation, we execute the following command:

```
terraformer import plan generated/azurerm/plan.json
```

Moreover, before using Terraformer, it is necessary to check that the resources to be generated are well supported. For example, in the case of Azure, the list of resources is available here: <https://github.com/GoogleCloudPlatform/terraform#use-with-azure>.

Finally, among the other Terraform configuration generation tools, there is a very good tool called **az2tf** (<https://github.com/andyt530/py-az2tf>) that used to work on the same Terraformer principle, but unfortunately, this tool is no longer maintained. There is also **TerraCognita** (<https://github.com/cycloidio/terracognita/>), which still integrates a number of resources for Azure, and **Terraforming** (<https://github.com/dtan4/terraforming>), which is only operational for AWS. The problem with all these tools is that they have to follow the evolution of the Terraform language and also the evolution of different providers, which requires a lot of development and maintenance time.

## See also

The source code and the documentation for Terraformer is available here: <https://github.com/GoogleCloudPlatform/terraform>.

# 7

## Deep Diving into Terraform

In this book, we started with recipes for Terraform that concern its installation, the writing of the Terraform configuration, as well as the use of the Terraform CLI commands. Then we studied the sharing of the Terraform configuration by using modules. Finally, we focused on the use of Terraform to build an Azure infrastructure.

Now, in this chapter, we will discuss recipes that allow us to go further in our usage of Terraform. We will learn how to use the templates in Terraform via the generation of an inventory for Ansible using Terraform, and will test the Terraform configuration using the `kitchen-terraform` plugin. We will discuss how to prevent the destruction of resources, how to implement a zero-downtime deployment technique with Terraform, and how to detect the deletion of resources when Terraform applies changes.

Then we will discuss the use of **Terragrunt** to manage the Terraform configuration dependency and its use as a wrapper for the Terraform CLI. Finally, we will study the integration of the Terraform runtime as well as the management of workspaces in a CI/CD pipeline.

In this chapter, we cover the following recipes:

- Creating an Ansible inventory with Terraform
- Testing the Terraform configuration with `kitchen-terraform`
- Preventing resources from getting destroyed
- Zero-downtime deployment with Terraform
- Detecting resources deleted by the `plan` command
- Managing Terraform configuration dependencies using Terragrunt
- Using Terragrunt as a wrapper for Terraform
- Building CI/CD pipelines for Terraform configurations in Azure Pipelines
- Working with workspaces in CI/CD

# Technical requirements

For the recipes in this chapter, we will need the following prerequisites:

- `kitchen-terraform`, which is available at <https://github.com/newcontextoss/kitchen-terraform>, and also Ruby, available to download from <https://www.ruby-lang.org/en/>.
- `Terragrunt`, whose documentation is available at <https://Terragrunt.gruntwork.io/>.
- In addition, we will also use the `jq` utility for parsing JSON. You can download it from <https://stedolan.github.io/jq/>.
- Finally, when working with CI/CD, we will use Azure Pipelines as our CI/CD platform. Azure Pipelines is a service of Azure DevOps. You can create a free account via <https://azure.microsoft.com/en-us/services/devops/>.

The source code for this chapter is available on the book's GitHub repository, at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP07>.

Check out the following video to see the Code in Action: <https://bit.ly/3hhKivD>

## Creating an Ansible inventory with Terraform

Terraform is a very good **Infrastructure-as-Code (IaC)** tool that allows us to build complex infrastructure with code.

As we studied in Chapter 6, *Provisioning Azure Infrastructure with Terraform*, concerning the construction of virtual machines, on all cloud providers, the common objective of Terraform is to build a VM without configuring it, which includes the installation of its middleware and its administration.

Among the **Configuration-as-Code (CaC)** tools that allow us to use Terraform to configure a VM after its creation, there is **Ansible** (<https://www.ansible.com/>), which is very popular in the open source world (much like Chef and Puppet).

One of the advantages of Ansible is that it's agentless, which means you don't need to install an agent on the VMs you want to configure. Thus, to know which VMs to configure, Ansible uses a file called `inventory`, which contains the list of VMs that need configuring.

In this recipe, we will learn how to generate this `inventory` file using Terraform's templating features.

## Getting ready

The purpose of this recipe is not to discuss the installation and use of Ansible but just the automatic creation of its `inventory` file.



To learn more about Ansible, I invite you to read *Chapter 3, Using Ansible for Configuring IaaS Infrastructure*, from my book entitled *Learning DevOps*, also available from Packt at <https://www.packtpub.com/eu/cloud-networking/learning-devops>.

The starting point of our recipe is to use Terraform to create VMs in Azure whose private IP addresses are not known before they are created. In this Terraform configuration of VMs, we use the configuration we have already studied in the *Provisioning and configuring an Azure VM with Terraform* recipe of Chapter 6, *Provisioning Azure Infrastructure with Terraform*. So, to keep it simple, we use the Terraform modules published in the public registry with the following Terraform configuration:

1. Instantiate a `vmhosts` variable that specifies the hostname of the VM we want to create:

```
variable "vmhosts" {  
    type    = list(string)  
    default = ["vmwebdemo1", "vmwebdemo2"]  
}
```

2. Then, use the `network` module and `compute` from the public registry to create the VM inside the network:

```
module "network" {  
    source = "Azure/network/azurerm"  
    resource_group_name = "rg-demoinventory"  
    subnet_prefixes = ["10.0.2.0/24"]  
    subnet_names = ["subnet1"]  
}  
  
module "linuxservers" {  
    source = "Azure/compute/azurerm"
```

```
resource_group_name = "rg-demoinventory"
vm_os_simple = "UbuntuServer"
nb_instances = 2
nb_public_ip = 2
vm_hostname = "vmwebdemo"
public_ip_dns = var.vmhosts
vnet_subnet_id = module.network.vnet_subnets[0]
}
```

In the preceding Terraform configuration, we create a Virtual Network and a Subnet and two Linux VMs that will have private IP addresses.

The goal of this recipe is to generate an `inventory` text file, in the same Terraform configuration, which will contain the list of hosts (along with their IP addresses) that have been created by Terraform. This inventory file will be in the following form:

```
[vm-web]
<host1> ansible_host=<ip 1>
<host2> ansible_host=<ip 2>
```

The complete source code for this recipe is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP07/ansible-inventory>.

## How to do it...

To generate the Ansible inventory with Terraform, perform the following steps:

1. Inside the folder containing the Terraform configuration, we create a new file called `template-inventory.tpl` with the following content:

```
[vm-web]
{% for host, dns in vm_dnshost ~}
${host} ansible_host=${dns}
{% endfor ~}
```

2. Then, in the `main.tf` file of the Terraform configuration that creates a VM, we add the following code to generate the `inventory` file:

```
resource "local_file" "inventory" {
  filename = "inventory"
  content = templatefile("template-inventory.tpl",
  {
    vm_dnshost =
      zipmap(var.vmhosts, module.linuxservers.network_interface_private_ip
  )
```

```
    })
}
```

3. Finally, to create the VMs and generate the `inventory` file, we run the basic Terraform `init`, `plan`, and `apply` workflow commands.

## How it works...

We first create a `template-inventory.tpl` file, which uses Terraform's template format. In this file, we use a `for` loop with the syntax `%{ for host, ip in vm_dnshost ~}`, which allows us to loop the elements of the `vm_dnshost` variable. For each VM in this loop, we use the following syntax:

```
 ${host} ansible_host=${ip}
```

We end the loop with the `%{ endfor ~}` syntax.



For more details on this templating format, read the documentation at <https://www.terraform.io/docs/configuration/expressions.html#string-templates>.

Then in *step 2*, to the Terraform configuration we add a `local_file` resource (which we have already studied in the *Manipulating local files with Terraform* recipe of Chapter 2, *Writing Terraform Configuration*) in which we fill in the following properties:

- `filename`: This contains `inventory` as its value, which is the name of the file that will be generated.



In this recipe, the file will be generated inside the directory that currently contains this Terraform configuration. You are free to enter another folder for generation and storage.

- `content`: This contains the elements that will fill this file. Here, we use the `templatefile` function, passing the following as parameters:
  - The name of the template file, `template-inventory.tpl`, that we created in *step 1*
  - The `vm_dnshost` variable that will fill the content of the template file. We use the built-in Terraform `zipmap` function that allows us to build a map from two lists, one being the keys list and the other the values list.



Documentation on the `zipmap` function is available at <https://www.terraform.io/docs/configuration/functions/zipmap.html>.

- `depend_on`: This parameter is part of the Terraform language and indicates a dependency between two or more resources (the documentation on Terraform dependencies can be found at <https://learn.hashicorp.com/terraform/getting-started/dependencies>). Here, in our case, we indicate a dependency between this `local_file` resource and the VM module so that Terraform only creates the `inventory` file after creating the VM.

Finally, in the last step, we execute the commands of the Terraform workflow, and at the end of its execution we can see that the `inventory` file has indeed been generated with the following content:

```
[vm-web]
vmwebdemo1 ansible_host=10.0.2.5
vmwebdemo2 ansible_host=10.0.2.4
```

Now, all new VMs added to this Terraform configuration will be added dynamically to this Ansible inventory.

## There's more...

The primary objective of this recipe is to show the use of templates with Terraform that we applied on an Ansible inventory. There can be several other use cases for these templates, such as using the `cloud-init` file to configure a VM, which is explained in the article at <https://grantorchard.com/dynamic-cloudinit-content-with-terraform-file-templates/>.

## See also

- The documentation on the Terraform `templatefile` function is available at <https://www.terraform.io/docs/configuration/functions/templatefile.html>.
- The documentation on the `local_file` resource of the `local` provider is available at <https://registry.terraform.io/providers/hashicorp/local/latest/docs/resources/file>.

- A list of books on Ansible from Packt is available at <https://subscription.packtpub.com/search?query=ansible>.
- Here is a list of web articles that deal with the same subject of Ansible inventories generated by Terraform by proposing different solutions:
  - <https://hooks.technology/2020/02/using-terraform-and-ansible-together/>
  - <https://www.linkbynet.com/produce-an-ansible-inventory-with-terraform>
  - <https://gist.github.com/hectorcanto/71f732dc02541e265888e924047d47ed>
  - <https://stackoverflow.com/questions/45489534/best-way-currently-to-create-an-ansible-inventory-from-terraform>

## Testing the Terraform configuration using kitchen-terraform

We have already studied, in the *Testing Terraform module code with Terratest* recipe of Chapter 5, *Sharing Terraform Configuration with Modules*, how to test Terraform modules using the Terratest framework.

In this recipe, we will test a Terraform configuration using another tool: **KitchenCI** and its `kitchen-terraform` plugin.

## Getting ready

`kitchen-terraform` is written in Ruby and is a plugin for **KitchenCI** (more simply called **Kitchen**), which is an IaC testing tool. In order to apply this recipe properly, you must first understand the principles and workflow of Kitchen, documented at <https://kitchen.ci/index.html>.

As Kitchen is written in **Ruby**, you will need to install Ruby (available at <https://www.ruby-lang.org/en/> – make sure to use version 2.4 at a minimum) on your computer by following the installation documentation available at <https://www.ruby-lang.org/en/documentation/installation/>.

In addition to Ruby, we need to install **Bundle**, available from <https://bundler.io/>. This is the package dependency for Ruby packages.

We can install `kitchen-terraform` firstly by using RubyGems (which is the Ruby manager package) by running the following command:

```
gem install kitchen-terraform
```

Or, secondly, we can use the method recommended by Kitchen using gems and bundles by following this procedure:

1. In the folder that contains the Terraform configuration to be tested, we create a Gemfile that contains the list of packages (here, we specify the `kitchen-terraform` package) to install, containing the following:

```
source "https://rubygems.org/" do
  gem "kitchen-terraform", "~> 5.4"
end
```

2. In a terminal, execute the following command to install the packages referenced in the Gemfile:

```
bundle install
```

The execution of the preceding command installs all the packages necessary to run `kitchen-terraform`.

Finally, concerning the writing of the tests, we will use **Inspec**, which is a test framework based on RSpec. Inspec allows you to test local systems or even infrastructures in the cloud. For more information about Inspec, I suggest you read its documentation at <https://www.inspec.io/>.

To illustrate the use of `kitchen-terraform` in a simple way, we will test the proper functioning of the Terraform configuration in this recipe that generates an Ansible inventory file, which we studied in the previous recipe. The purpose of the tests we will write is to test that the `inventory` file has indeed been generated and that it is not empty.



In this recipe, the goal is not to test the creation of the network and the VMs, but only the `inventory` file.

Finally, as with all integration testing, it is preferable to have an isolated system or environment to run the tests.

The source code for this recipe is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP07/kitchen>.

## How to do it...

To test the Terraform configuration execution with `kitchen-terraform`, perform the following steps:

1. Inside the folder containing the Terraform configuration, create the `Inspec test` folder with the following tree:

```
test > integration > kt_suite
```

2. In this `kt_suite` folder, add the Inspec profile file named `inspec.yml` with the following content:

```
---
```

```
name: default
```

3. In the `kt_suite` folder, create a new folder called `controls` that will contain the Inspec tests. Then, inside the `controls` folder, add a new `inventory.rb` file with the following content:

```
control "check_inventory_file" do
  describe file('../inventory') do
    it { should exist }
    its('size') { should be > 0 }
  end
end
```

4. At the root of the Terraform configuration folder, we create a Kitchen configuration file called `kitchen.yml` with the following content:

```
---
```

```
driver:
  name: terraform
```

```
provisioner:
  name: terraform
```

```
verifier:
  name: terraform
```

```
systems:
  - name: basic
    backend: local
```

```
controls:  
  - check_inventory_file  
platforms:  
  - name: terraform  
suites:  
  - name: kt_suite
```

5. In a terminal (running in the root of the Terraform configuration folder), run the following `kitchen` command:

```
kitchen test
```

## How it works...

The execution of this recipe takes place over three phases:

1. Writing the inspection tests
2. Writing the Kitchen configuration
3. Kitchen execution

From *steps 1 to 3*, we wrote the inspection tests with the following steps:

1. First, we created the folder tree that will contain the profile and the Inspec tests. In the `kt_suite` folder, we created the `inspec.yml` file, which is the Inspec profile. In our case, this just contains the `name` property with the `default` value.



To learn more about Inspec profiles, refer to the documentation at <https://www.inspec.io/docs/reference/profiles/>.

2. Then, in the `controls > inventory.rb` file, we wrote the Inspec tests (in RSpec format) by creating a control `"check_inventory_file"` do control that will contain the tests. In these tests, we use the resource `file` Inspec (see the documentation at <https://www.inspec.io/docs/reference/resources/file/>), which allows us to run tests on files. Here, the property of this resource is `inventory`, which is the name of the inventory file generated by Terraform. In this control, we have written two tests:
  - `it { should exist }`: This inventory file must exist on disk.
  - `its('size') { should be > 0 }`: The size of this file must be  $> 0$ , so it must contain some content.

Once the writing of the tests is finished, in *step 4*, we create the `kitchen.yml` file, which contains the Kitchen configuration consisting of three parts, the first one being the driver:

```
driver:  
  name: terraform
```

The driver is the platform that is used for testing. Kitchen supports a multitude of virtual and cloud platforms. In our case, we use the `terraform` driver provided by the `kitchen-terraform` plugin.



Documentation on the drivers supported by Kitchen is available at <https://kitchen.ci/docs/drivers/>.

The second part of the `kitchen.yml` file is the provisioner:

```
provisioner:  
  name: terraform
```

The provisioner is the tool that will configure the VMs. It can use scripts, Chef, Ansible, or **Desired State Configuration (DSC)**. In our case, since in our test we don't provision VMs, we use the `terraform` provisioner provided by `kitchen-terraform`.



Documentation on Kitchen-supported provisioners is available at <https://kitchen.ci/docs/provisioners/>.

The third part is the verifier:

```
verifier:  
  name: terraform  
  systems:  
    - name: basic  
      backend: local  
      controls:  
        - check_inventory_file  
  platforms:  
    - name: terraform  
  suites:  
    - name: kt_suite
```

The verifier is the system that will test the components applied by the provisioner. We can use Inspec, Chef, shell, or pester as our testing framework. In our case, we configure the verifier on the control and the Inspec test suite we wrote in *step 2*. In addition, the `control` property is optional – it allows us to filter the Inspec controls to be executed during the tests.



Documentation on Kitchen-supported verifiers is available at <https://kitchen.ci/docs/verifiers/>.

3. Finally, in the last step, we perform the tests by executing the `kitchen test` command, which, based on the YAML kitchen configuration, will perform the following actions:
  1. Execute the `init` and `apply` commands of the Terraform workflow.
  2. Run the Inspec tests.
  3. Execute the `destroy` Terraform command to delete all resources provisioned for the test.

The result of this execution is shown in the following three screenshots.



In reality, this execution takes place in the same console and the same workflow. I've split this into three screenshots for better visibility because you can't see everything with just one screen.

The following screenshot shows the execution of the `init` and `apply` commands:

```
Terraform has been successfully initialized!
$$$$$ Finished initializing the Terraform working directory.
$$$$$ Creating the kitchen-terraform-kt-suite-terraform Terraform workspace...
$$$$$ Created and switched to workspace "kitchen-terraform-kt-suite-terraform"!

$$$$$ Downloading the modules needed for the Terraform configuration...
$$$$$ Finished downloading the modules needed for the Terraform configuration.
$$$$$ Validating the Terraform configuration files...
Success! The configuration is valid.

$$$$$ Finished validating the Terraform configuration files.
$$$$$ Building the infrastructure based on the Terraform configuration...
local_file.inventory: Creating...
local_file.inventory: Creation complete after 0s [id=c8902b89314e559cd2281e0f9b381677c7a10b16]

Apply complete! Resources: 1 added, 0 changed, 0 destroyed.
```

The following screenshot shows the execution of Inspec:

```
-----> Verifying <kt-suite-terraform>...
$$$$$ Reading the Terraform input variables from the Kitchen instance state...
$$$$$ Finished reading the Terraform input variables from the Kitchen instance state.
$$$$$ Reading the Terraform output variables from the Kitchen instance state...
$$$$$ Finished reading the Terraform output variables from the Kitchen instance state.
$$$$$ Verifying the systems...
$$$$$ Verifying the 'basic' system...

Profile: default
Version: (not specified)
Target: local://

[PASS] check_inventory_file: File ./inventory
[PASS] File ./inventory is expected to exist
[PASS] File ./inventory size is expected to be > 0

Profile Summary: 1 successful control, 0 control failures, 0 controls skipped
Test Summary: 2 successful, 0 failures, 0 skipped
```

This last screenshot shows the `destroy` command:

```
Terraform has been successfully initialized!
$$$$$ Finished initializing the Terraform working directory.
$$$$$ Selecting the kitchen-terraform-kt-suite-terraform Terraform workspace...
$$$$$ Finished selecting the kitchen-terraform-kt-suite-terraform Terraform workspace.
$$$$$ Destroying the Terraform-managed infrastructure...
local_file.inventory: Refreshing state... [id=c8902b89314e559cd2281e0f9b381677c7a10b16]
local_file.inventory: Destroying... [id=c8902b89314e559cd2281e0f9b381677c7a10b16]
local_file.inventory: Destruction complete after 0s

Destroy complete! Resources: 1 destroyed.
```

These three screens show the execution of Terraform, then the successful execution of the Inspec tests, which indicates that my `inventory` file was indeed generated by Terraform, and finally the destruction of the resources that had been allocated for the tests.

## There's more...

To go deeper into the writing of the tests, we could have added the Inspec `its('content')` expression, which allows us to test the content of the file, as explained in the Inspec documentation at <https://www.inspec.io/docs/reference/resources/file/>.

Concerning the execution of the tests in this recipe, we have to execute the `kitchen test` command. In the case of integration tests in which, after executing the tests, we don't want to destroy the resources that have been built with Terraform, we can execute the `kitchen verify` command.

Finally, as mentioned in the introduction, in this recipe we used `kitchen-terraform` to test a Terraform configuration, but we can also use it to test Terraform modules.

## See also

- KitchenCI documentation is available at <https://kitchen.ci/>.
- The source code of the `kitchen-terraform` plugin on GitHub is available at <https://github.com/newcontext-oss/kitchen-terraform>.
- You can find tutorials on `kitchen-terraform` at <https://newcontext-oss.github.io/kitchen-terraform/tutorials/>.
- For more information about the `kitchen test` command, see the documentation at <https://kitchen.ci/docs/getting-started/running-test/>.

## Preventing resources from getting destroyed

The use of IaC requires attention in some cases. Indeed, when the IaC is integrated into a CI/CD pipeline, resources containing important data can be automatically deleted. This can be done either by changing a property of a Terraform resource, which requires the deletion and recreation of this resource, or by executing the `terraform destroy` command.

Fortunately, Terraform includes a configuration in its language that prevents the destruction of sensitive resources.

In this recipe, we will see how to prevent the destruction of resources that are managed in a Terraform configuration.

## Getting ready

For this recipe, we will use a Terraform configuration, the code for which is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP07/sample-app>. The purpose of this configuration is to manage the following resources in Azure:

- A Resource Group
- A Service Plan

- An Azure App Service (web app) instance
- An Azure Application Insights instance

The problem that we often encounter in company projects concerns the resources that contain data. In our example, this is the Application Insights instance containing the logs and metrics of our application, which is in the web app and should not be deleted automatically.

Let's take as a scenario a company that has decided to change the nomenclature of their resources, and we need to update the Terraform configuration with the new nomenclature. When running Terraform, we would get the following result from the `terraform plan` command:

```
# azurerm_application_insights.appinsight-app must be replaced ←
-/+ resource "azurerm_application_insights" "appinsight-app" {
    ~ app_id                      = "4440e9e2-8558-4165-a772-b35942ee0a96" -> (known after apply)
    ~ application_type             = "web"
    ~ daily_data_cap_in_gb        = 100 -> (known after apply)
    ~ daily_data_cap_notifications_disabled = false -> (known after apply)
    ~ disable_ip_masking          = false
    ~ id                          = "/subscriptions/1da42ac9-ee3e-1... /resourceGroups/RG-A
pp-DEV1/providers/microsoft.insights/components/MyApp-DEV1" -> (known after apply)
    ~ instrumentation_key          = (sensitive value)
    ~ location                     = "westeurope"
    ~ name                         = "MyApp-DEV1" -> "MyApp2-DEV1" # forces replacement
    resource_group_name            = "RG-App-DEV1"
    retention_in_days              = 90
    sampling_percentage            = 100
    tags                          = {
        "CreatedBy" = "NA"
        "ENV"       = "DEV1"
    }
}

Plan: 2 to add, 0 to change, 2 to destroy.
```

As you can see, the name change requires the deletion of the Application Insights instance that contains important log metrics.

The purpose of this recipe is to change the Terraform configuration so that the Application Insights resource is never deleted.

The source code of this recipe is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP07/preventdestroy>.

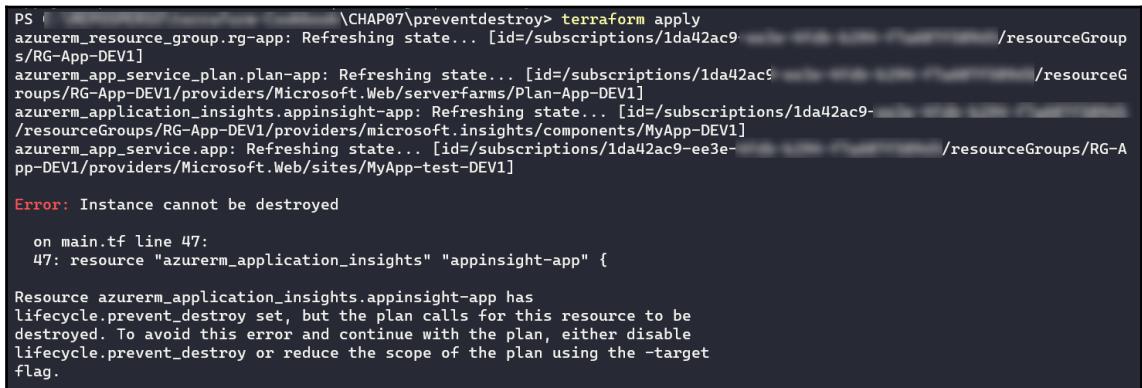
## How to do it...

To prevent the deletion of a resource by Terraform, perform the following steps:

1. Inside the Terraform configuration of the Application Insights resource, add the following `lifecycle` block:

```
resource "azurerm_application_insights" "appinsight-app" {  
    ...  
    lifecycle {  
        prevent_destroy = true  
    }  
}
```

2. In `variables.tf`, change the default value of the `app_name` variable with another name for the Application Insights such as `MyApp2-DEV1`.
3. Execute the Terraform CLI workflow and the result is shown in the following screenshot:



```
PS C:\CHAP07\preventdestroy> terraform apply  
azurerm_resource_group.rg-app: Refreshing state... [id=/subscriptions/1da42ac9-  
s/RG-App-DEV1] /resourceGroup  
azurerm_app_service_plan.plan-app: Refreshing state... [id=/subscriptions/1da42ac9-  
roups/RG-App-DEV1/providers/Microsoft.Web/serverfarms/Plan-App-DEV1] /resourceG  
azurerm_application_insights.appinsight-app: Refreshing state... [id=/subscriptions/1da42ac9-  
/resourceGroups/RG-App-DEV1/providers/microsoft.insights/components/MyApp-DEV1]  
azurerm_app_service.app: Refreshing state... [id=/subscriptions/1da42ac9-ee3e-  
pp-DEV1/providers/Microsoft.Web/sites/MyApp-test-DEV1] /resourceGroups/RG-A  
  
Error: Instance cannot be destroyed  
  
on main.tf line 47:  
  47: resource "azurerm_application_insights" "appinsight-app" {  
  
Resource azurerm_application_insights.appinsight-app has  
lifecycle.prevent_destroy set, but the plan calls for this resource to be  
destroyed. To avoid this error and continue with the plan, either disable  
lifecycle.prevent_destroy or reduce the scope of the plan using the -target  
flag.
```

## How it works...

In this recipe, we have added the Terraform `lifecycle` block, which contains the properties that allow interaction with resource management. Here, in our case, we used the `prevent_destroy` property, which, as its name indicates, prevents the destruction of the specified resource.

## There's more...

As we have discussed, the `prevent_destroy` property allows you to prohibit the deletion of resources.



Note that in our example with Azure, this property does not prohibit the deletion of resources via the Azure portal or the Azure CLI.

However, it should be noted that if a resource in the Terraform configuration contains this property, and this property must be deleted when executing the `terraform apply` command, then this `prevent_destroy` property prevents the application from making changes to all the resources described in the Terraform configuration. This blocks us from applying changes to resources. This is one of the reasons why I personally break up the Terraform configuration, putting the configuration of the sensitive resources that mustn't be destroyed in one folder (and thus a separate Terraform state file), and the other resources in another folder. This way, we can apply changes to the resources without being blocked by our resource destruction prevention settings.



Here, I'm writing about separating the Terraform configuration and the state files, but it's also necessary to separate the workflows in the CI/CD pipeline, with one pipeline that applies the changes and another that destroys the resources.

In addition, mostly to prevent human mistakes, it isn't possible to add variables to the values of the properties of the `lifecycle` block by wanting to make the value of this property dynamic. You might try using a `bool` type variable, such as in the following code:

```
lifecycle {  
  prevent_destroy = var.prevent_destroy_ai  
}
```

However, when executing the `terraform apply` command, the following error occurs:

```
PS C:\CHAP07\preventdestroy> terraform apply

Error: Variables not allowed

  on main.tf line 59, in resource "azurerm_application_insights" "appinsight-app":
59:   prevent_destroy = var.prevent_destroy_ai

Variables may not be used here.

Error: Unsuitable value type

  on main.tf line 59, in resource "azurerm_application_insights" "appinsight-app":
59:   prevent_destroy = var.prevent_destroy_ai

Unsuitable value: value must be known
```

These errors indicate that a variable is not allowed in the `lifecycle` block, so you have to keep true/false values in the code.

## See also

- Documentation on the `prevent_destroy` property is available at [https://www.terraform.io/docs/configuration/resources.html#prevent\\_destroy](https://www.terraform.io/docs/configuration/resources.html#prevent_destroy).
- An interesting article on the HashiCorp blog about drift management can be found at <https://www.hashicorp.com/blog/detecting-and-managing-drift-with-terraform/>.
- Read this article from HashiCorp about feature toggles, blue-green deployments, and canary testing using Terraform, available at <https://www.hashicorp.com/blog/terraform-feature-toggles-blue-green-deployments-canary-test/>.

## Zero-downtime deployment with Terraform

As discussed in the previous recipe, changing certain properties on resources described in the Terraform configuration can lead to their destruction and subsequent recreation.

Resources are destroyed and recreated in the order in which they are run in Terraform. In other words, the first resource to be run will first be destroyed and then it will be recreated, and in a production context, during this time period, it will lead to downtime, that is, a service interruption. This downtime can be greater or smaller depending on the type of resources that will have to be destroyed and then recreated.



For example, in Azure, a VM takes much longer to destroy and rebuild than a web app or a **Network Security Group (NSG)** rule.

In Terraform, there is a mechanism that allows for zero downtime and therefore avoids this service interruption when deleting a resource.

In this recipe, we will study how to implement zero downtime on a resource described in a Terraform configuration.

## Getting ready

For this recipe, we will use the Terraform configuration available from <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP07/sample-app>. The purpose of this configuration is to manage the following resources in Azure:

- A Resource Group
- A Service Plan
- An App Service (web app) instance
- An Application Insights instance

In addition, this Terraform configuration has already been applied to the Azure cloud.

For our use case, let's assume that a company has decided to change the resource name and that we need to update the Terraform configuration with the new name. When running Terraform, the following result would be obtained with the `terraform plan` command:

```
# azurerm_app_service.app must be replaced ←
-/+ resource "azurerm_app_service" "app" {
    app_service_plan_id          = "/subscriptions/1da42ac9-ee3e-4fdb-1... /resourceGroups/RG-App-DEV1/providers/Microsoft.Web/serverfarms
/Plan-App-DEV1"
    ~ app_settings                = {
        "WEBSITE_NODE_DEFAULT_VERSION" = "6.9.1"
    } -> (known after apply)
    ~ client_affinity_enabled     = true -> (known after apply)
    ~ client_cert_enabled         = false -> null
    ~ default_site_hostname       = "myappdemo-dev1.azurewebsites.net" -> (known after apply)
    enabled                       = true
    https_only                    = false
    ~ id                           = "/subscriptions/1da42ac9-ee3e-4fdb-1... /resourceGroups/RG-App-DEV1/providers/Microsoft.Web/sites/MyApp
Demo-DEV1" -> (known after apply)
    location                      = "westeurope"
    ~ name                         = "MyAppDemo-DEV1" -> "MyAppDemo-DEV1-demo" # forces replacement
```

As you can see, the name change requires a deletion of the web app that hosts our web application. This deletion will result in the application not being accessible for a small amount of time while it is recreated. The purpose of this recipe is to modify the Terraform configuration so that even when the App Service resource is deleted, the web application will still be available.

The source code of this recipe is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP07/zerodowntime>.

## How to do it...

To provide zero downtime in a Terraform configuration, perform the following steps:

1. In the Terraform configuration, inside the `azurerm_app_service` resource, add the `lifecycle` block as shown in the following code:

```
resource "azurerm_app_service" "app" {
    name          = "${var.app_name}-${var.environment}"
    ...
    lifecycle {
        create_before_destroy = true
    }
}
```

2. Change the `name` property of the App Service to apply the new nomenclature.
3. Execute the Terraform CLI workflow and the `terraform apply` result will be shown as in the following screenshot:



```
azurerm_app_service.app: Creating...
azurerm_app_service.app: Still creating... [10s elapsed] 1
azurerm_app_service.app: Still creating... [20s elapsed]
azurerm_app_service.app: Creation complete after 28s [id=/subscriptions/1da42ac9-ee3e-4fdb-XXXXXXXXXX/resourceGroups/RG-App-DEV1/providers/Microsoft.Web/sites/MyAppDemo-DEV1-demo]
azurerm_app_service.app: Destroying... [id=/subscriptions/1da42ac9-ee3e-4fdb-XXXXXXXXXX/resourceGroups/RG-App-DEV1/providers/Microsoft.Web/sites/MyAppDemo-DEV1]
azurerm_app_service.app: Destruction complete after 2s 2
Apply complete! Resources: 1 added, 0 changed, 1 destroyed.
```

## How it works...

In step 2, we added the `lifecycle` block to the `azurerm_app_service` resource. In this block, we added the `create_before_destroy` property with its value set to `true`. This property makes the regeneration of a resource possible in the event of destruction by indicating to Terraform to first recreate the resource, and only then to delete the original resource.

## There's more...

As we've seen, by using this property, there is no more interruption of service. As long as the new resource is not created, the old one is not deleted and the application continues to be online.

However, before using `create_before_destroy`, there are some things to consider, as follows:

- The `create_before_destroy` property only works when a configuration change requires the deletion and then regeneration of resources. It only works when executing the `terraform apply` command; it does not work when executing the `terraform destroy` command.
- You must be careful that the names of the resources that will be created have different names than the ones that will be destroyed afterward. Otherwise, if the names are identical, the resource may not be created.

Moreover, this zero-downtime technique is only really effective if the resource that will be impacted is fully operational at the end of its creation. For example, let's take the case of a VM: although Terraform can quickly create it, it still remains after all its configuration has been carried out (the installation of the middleware and deployment of the application). All this configuration can generate downtime, and in order to be efficient in this case, I advise you to use Packer from HashiCorp (<https://www.packer.io/>), which allows you to create images of VMs that are already fully configured.



To implement zero downtime in Azure with Packer and Terraform, read the tutorial at <https://docs.microsoft.com/en-us/azure/developer/terraform/create-vm-scaleset-network-disks-using-packer-hcl>.

Finally, we have seen in this recipe how to implement zero-downtime deployments with Terraform, but according to your provider, there are most likely other practices that are native to them. For example, we can also use load balancers, and for an App Service instance on Azure, we can use slots, as explained in the documentation at <https://docs.microsoft.com/en-us/azure/app-service/deploy-staging-slots>.

## See also

- Read the HashiCorp blog post about the `create_before_destroy` property at <https://www.hashicorp.com/blog/zero-downtime-updates-with-terraform/>.
- A good article on zero downtime can be found at <https://dzone.com/articles/zero-downtime-deployment>.

# Detecting resources deleted by the plan command

One of the key features of Terraform is the possibility to visualize a preview of changes in advance of their application to a given piece of infrastructure with the `terraform plan` command.

We have often discussed in this book displaying a visualization of changes in the terminal, but what we see less often is how to automatically evaluate and analyze the results of the `terraform plan` command.

In this recipe, we will see how to analyze the results of the `terraform plan` command.

## Getting ready

For the application of this recipe, we need to have the `jq` tool installed, available for download for all platforms from <https://stedolan.github.io/jq/>.

In this recipe, we will use `jq` on Windows with PowerShell, but all steps will be identical on other OSes.

The Terraform configuration used is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP07/detectdestroy>, and we must run it on our infrastructure beforehand.

The purpose of this recipe is to detect via a script whether the execution of `terraform plan` will lead to the destruction of a resource.

## How to do it...

Perform the following steps to analyze the results of the `plan` command:

1. Inside the Terraform configuration, we change the value of the `name` property (by adding the word `test`) in the App Service instance, as shown in the following code:

```
resource "azurerm_app_service" "app" {
    name = "${var.app_name}-test-${var.environement}"
    ...
}
```

2. Then, we execute the `terraform init` command, followed by the `terraform plan` command:

```
terraform plan -out="tfout.tfplan"
```

3. Finally, we execute the following PowerShell script, which analyzes the number of deleted resources:

```
$tfplan = terraform show -json tfout.tfplan
$actions = $tfplan | jq.exe .resource_changes[] .change.actions[]
$nbdelete = $actions -match 'delete' | Measure-Object | Select-
Object Count
Write-Host $nbdelete.Count
```



This script is also available at <https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP07/detectdestroy/detectdestroy.ps1>.

## How it works...

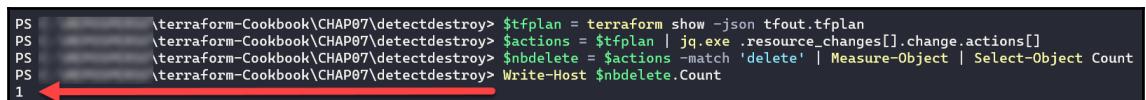
In *step 1*, we modify the Terraform configuration by changing the name of the App Service instance, which will lead to the destruction of this resource during the `apply` command.

Then, in *step 2*, we execute the `terraform plan` command with the option `-out="tfout.tfplan"`, which allows us to get the output of `plan` in a file (in binary format).

Finally, in *step 3*, we write the PowerShell script that analyzes the generated plan for the number of resources that will be destroyed during the application. This script is made up of four lines. Here are the details:

1. In line 1, we use the `terraform show` command on the `tfout.tfplan` file that was generated in *step 2*. To this command we added the `-json` option in order to get an output in JSON format.
2. In line 2, we use `jq` on the JSON result obtained from the previous line and filter the list of actions (which will be applied by Terraform) to obtain an array of actions (`add`, `delete`, and `no-op`).
3. In line 3, we filter on this array all `delete` actions and get the number of this filtered array using the `Count` PowerShell object.
4. In the last line, we display the count value, which corresponds to the number of deleted resources.

The following screenshot shows the result of this script:



```
PS C:\Users\...> terraform show -json > tfout.tfplan
PS C:\Users\...> $tfplan = Get-Content tfout.tfplan | ConvertFrom-Json
PS C:\Users\...> $actions = $tfplan.resource_changes[0].change.actions
PS C:\Users\...> $nbdelete = $actions | Where-Object {$_ -match 'destroy'} | Measure-Object -Property Actions -Sum
PS C:\Users\...> $nbdelete.Sum
1
```

`$nbdelete.Count` returns 1, which is equal to the number of resources that will be deleted.

## There's more...

Regarding the language used for the scripting of this recipe, we wrote it in PowerShell, but it can of course be written in any scripting language, such as Bash or Python. We can also put this script into a function that was called just after the `terraform plan` command and did not apply the Terraform configuration if that function returned a positive delete number.

There are also other tools for parsing and processing the plan generated by the `terraform plan` command. Among these tools, there are npm packages such as `terraform-plan-parser`, available at <https://github.com/lifeomic/terraform-plan-parser>, or **Open Policy Agent for Terraform** at <https://www.openpolicyagent.org/docs/latest/terraform/>.

## See also

- More detailed documentation on the JSON format of the `terraform plan` command is available at <https://www.terraform.io/docs/internals/json-format.html>.
- The `terraform show` command documentation is available at <https://www.terraform.io/docs/commands/show.html>.

# Managing Terraform configuration dependencies using Terragrunt

In several recipes in this book, we have discussed the organization of the files that contain the Terraform configuration. We examined this more specifically in the *Provisioning infrastructure in multiple environments* recipe in Chapter 2, *Writing Terraform Configuration*, which outlines several architecture solutions.

One of the best practices regarding the structure of the configuration is to separate the Terraform configuration into infrastructure and application components, as explained in the article at <https://www.cloudreach.com/en/resources/blog/how-to-simplify-your-terraform-code-structure/>. The challenge with a structure split into several configurations is the maintenance of dependencies and run schedules between these components.

Among all the third-party tools that revolve around Terraform, there is **Terragrunt** (<https://terragrunt.gruntwork.io/>), developed by Gruntwork. Terragrunt is open source and offers a lot of additional functionality for the organization and execution of Terraform configurations.

In this recipe, we will learn how you can use Terragrunt to manage the dependencies of different Terraform configurations.

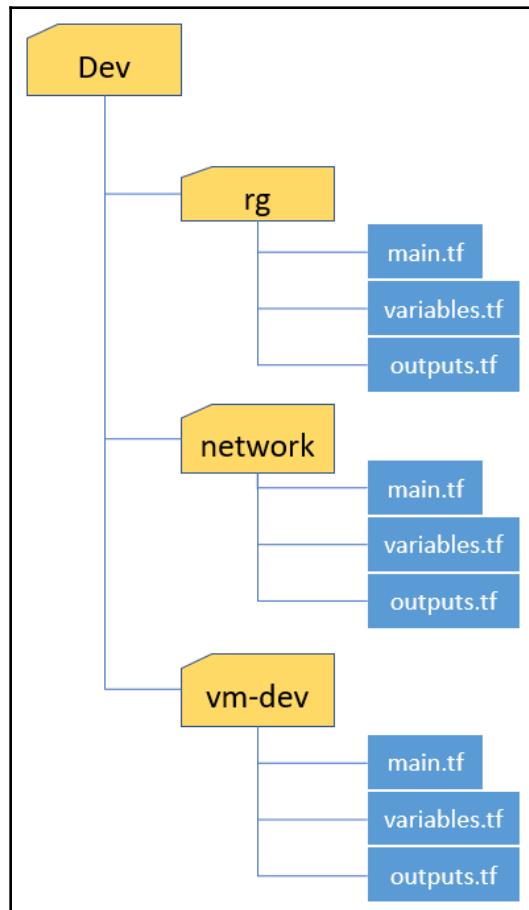
## Getting ready

For this recipe, we must have previously installed the Terragrunt binary on our workstations by following the instructions at <https://terragrunt.gruntwork.io/docs/getting-started/install/#install-terragrunt>.

In this recipe, we will build an infrastructure consisting of the following elements:

- A Resource Group
- A network with a Virtual Network and a Subnet
- A VM

The architecture of the folders containing this Terraform configuration is as follows:



The problem with this architecture is the dependency between configurations, and the fact that they must be executed in a specific order. Indeed, to apply the network, the Resource Group must be applied first, and it's the same for the VM: the network must be created beforehand. With Terraform, in the case of several changes, the Terraform workflow must be executed several times and in the correct order for each of those configurations.



The purpose of this recipe is not to explain all the functionalities of Terragrunt in detail, but to demonstrate one of its features, which is to simplify the execution of Terraform when the Terraform configuration is separated into several folders that are linked by dependencies.

The source code of this recipe is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP07/demogrunt/dev>.

## How to do it...

Perform the following steps to use Terragrunt with Terraform dependencies:

1. To add the dependency between the network and rg configurations, inside the network folder add a new file called `terragrunt.hcl` with the following content:

```
dependencies {  
    paths = ["../rg"]  
}
```

2. Inside the `vm-dev` folder, add a new file called `terragrunt.hcl` with the following content:

```
dependencies {  
    paths = ["../rg", "../network"]  
}
```

3. In a terminal, inside the `network` folder, run the following `terragrunt` commands to create the Resource Group and the network:

```
> terragrunt init  
> terragrunt plan-all  
> terragrunt apply-all
```

## How it works...

The `terragrunt.hcl` file we added contains the configuration for Terragrunt.

Here, in the configuration we wrote in *step 2*, we indicated a dependency between the network configuration and the Resource Group configuration. This is because the Resource Group must be created before executing the network configuration.

In *step 3*, we then executed the Terragrunt commands (`terragrunt init`, `terragrunt plan-all`, and `terragrunt apply-all`) and when executing them, thanks to the configuration we wrote, Terragrunt will first apply Terraform to the Resource Group and then to the network automatically. This without having to apply the Terraform workflow several times on several Terraform configurations and in the right order.

## There's more...

In this recipe, we studied how to improve the dependency between the Terraform configuration using Terragrunt and its configuration. We can go even further with this improvement, by externalizing the configuration (which is redundant between each environment) by reading the documentation available at <https://terragrunt.gruntwork.io/docs/features/execute-terraform-commands-on-multiple-modules-at-once/>.

However, since Terragrunt runs the Terraform binary that is installed on your local computer, you should make sure to install a version of Terragrunt that is compatible with the version of the Terraform binary installed.

In the next recipe, we will complete the configuration of Terragrunt to be able to use it as a wrapper for Terraform by simplifying the Terraform command lines.

## See also

- The detailed documentation of Terragrunt is available at <https://terragrunt.gruntwork.io/docs/#features>.
- The source code for Terragrunt is available on GitHub at <https://github.com/gruntwork-io/terragrunt>.
- A useful blog article on the architecture of the Terraform configuration can be found at <https://www.hashicorp.com/blog/structuring-hashicorp-terraform-configuration-for-production/>.

# Using Terragrunt as a wrapper for Terraform

In the many years that I have been working and supporting customers on Terraform, there is a recurring problem that prevents users from making full use of Terraform's functionality. What I have noticed is that these users do not encounter any problems with the language and the writing of the provider's resource configuration, but they do have difficulty with the automation of the Terraform client through the use of command lines for their workflow.

To simplify the automation of the Terraform workflow, whether for use on a local workstation or in a CI/CD pipeline, we can use Terragrunt as Terraform wrapper that integrates the Terraform workflow.

What we will learn in this recipe is how to use Terragrunt (which we have already studied in the previous recipe) as a Terraform wrapper.

## Getting ready

For this recipe, we must have previously installed the Terragrunt binary on our workstations by following the instructions at <https://Terragrunt.gruntwork.io/docs/getting-started/install/#install-terragrunt>.

The Terraform configuration used in this recipe is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP07/demogrunt-wrapper>. It allows us to build resources in Azure. It uses an `env-dev.tfvars` variable file and a remote backend configuration file (`azurerm`) in the `backend.tfvars` file. To create this infrastructure, the following Terraform commands must be executed:

```
> terraform init -backend-config="backend.tfvars"  
> terraform plan -var-file="env-vars.tfvars"  
> terraform apply -var-file="env-vars.tfvars"
```



The Terraform configuration of this resource creates resources in Azure, but what we will study in this recipe applies to any Terraform configuration.

The purpose of this recipe is to use the Terragrunt configuration to help execute these Terraform commands in an automation context.

## How to do it...

Perform the following steps to use Terragrunt as a Terraform CLI wrapper:

1. Inside the folder that contains the Terraform configuration, create a new file called `terragrunt.hcl`.
2. In this file, add the following configuration section to configure the `init` command:

```
extra_arguments "custom_backend" {  
    commands = [  
        "init"  
    ]  
  
    arguments = [  
        "-backend-config", "backend.tfvars"  
    ]  
}
```

3. Add the following code to configure the `plan` and `apply` commands:

```
extra_arguments "custom_vars-file" {  
    commands = [  
        "apply",  
        "plan",  
        "destroy",  
        "refresh"  
    ]  
  
    arguments = [  
        "-var-file", "env-vars.tfvars"  
    ]  
}
```

4. In the command-line terminal, from the folder that contains the Terraform configuration, run the following Terragrunt command to initialize the Terraform context:

```
terragrunt init
```

5. Finally, run the following Terragrunt commands to apply the changes we've made:

```
> terragrunt plan  
> terragrunt apply
```

## How it works...

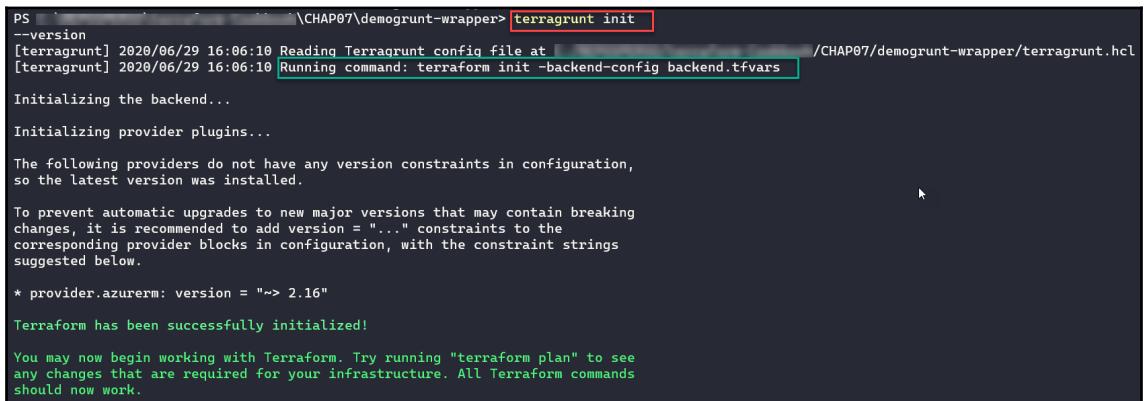
In *step 1*, we created the `terragrunt.hcl` file, which will contain the Terragrunt configuration of the Terraform wrapper. In *step 2*, we described in this file the Terraform execution configuration for the `init` command. In the list of commands, we indicate that this configuration applies for the `init` command and in the list of arguments we put an entry for the `--backend-config` option, which takes as a value the `backend.tfvars` file.

Then in *step 3*, we did the same operation for the `plan` and `apply` commands. In this configuration, we specify the list of commands: `plan`, `apply`, `destroy`, and `refresh`. For the arguments, we indicate the `-var-file="env-vars.tfvars"` option.

Once this configuration file is finished being written, we use it to run Terragrunt. In *step 4*, we execute the `terragrunt init` command, which will use the configuration we wrote and so will execute the following command:

```
terragrunt init --backend-config="backend.tfvars"
```

You can see this in the following screenshot:



```
PS C:\CHAP07\demogrunt-wrapper> terragrunt init
--version
[terragrunt] 2020/06/29 16:06:10 Reading Terragrunt config file at /CHAP07/demogrunt-wrapper/terragrunt.hcl
[terragrunt] 2020/06/29 16:06:10 Running command: terraform init --backend-config backend.tfvars

Initializing the backend...
Initializing provider plugins...
The following providers do not have any version constraints in configuration,
so the latest version was installed.

To prevent automatic upgrades to new major versions that may contain breaking
changes, it is recommended to add version = "..." constraints to the
corresponding provider blocks in configuration, with the constraint strings
suggested below.

* provider.azurerm: version = ">= 2.16"

Terraform has been successfully initialized!

You may now begin working with Terraform. Try running "terraform plan" to see
any changes that are required for your infrastructure. All Terraform commands
should now work.
```

Finally, to preview the changes, we execute the `terragrunt plan` command, which will use the configuration we wrote and will therefore execute the following command:

```
terragrunt plan -var-file="env-vars.tfvars"
```

You can see this in the following screenshot:

```
PS              \CHAP07\demogrunt-wrapper> terragrunt plan
[terragrunt] [  ]                                     \CHAP07\demogrunt-wrapper] 2020/06/29 16:06:18 Running command: terraform --version
[terragrunt] 2020/06/29 16:06:19 Reading Terragrunt config file at                               /CHAP07/demogrunt-wrapper/terragrunt.hcl
[terragrunt] 2020/06/29 16:06:19 Running command: terraform plan -var-file env-vars.tfvars
Refreshing Terraform state in-memory prior to plan...
The refreshed state will be used to calculate this plan, but will not be
persisted to local or remote state storage.
```

If these changes correspond to your expectations, you can use the following Terragrunt command to apply these changes:

```
terragrunt apply
```

## See also

Detailed CLI configuration documentation is available at <https://terragrunt.gruntwork.io/docs/features/keep-your-cli-flags-dry/>.

# Building CI/CD pipelines for Terraform configurations in Azure Pipelines

In all of the previous recipes in this book, we've discussed Terraform configuration, CLI execution, and its benefits for IaC.

Now, in this recipe, we will discuss how we will integrate this Terraform workflow into a CI/CD pipeline in Azure Pipelines using the Terraform extension for Azure DevOps and Pipelines YAML.

## Getting ready

Before automating Terraform in any CI/CD pipeline, it is recommended to read HashiCorp's automation guides with recommendations for Terraform. These guides are available here:

- <https://learn.hashicorp.com/terraform/development/running-terraform-in-automation>
- <https://www.terraform.io/docs/cloud/guides/recommended-practices/part3.html>

The purpose of this recipe is not to explain in detail how Azure Pipelines works, but just to focus on the execution of Terraform in Azure Pipelines. To learn more about Azure Pipelines, I suggest you look at the official documentation at <https://docs.microsoft.com/en-us/azure/devops/pipelines/index?view=azure-devops>.

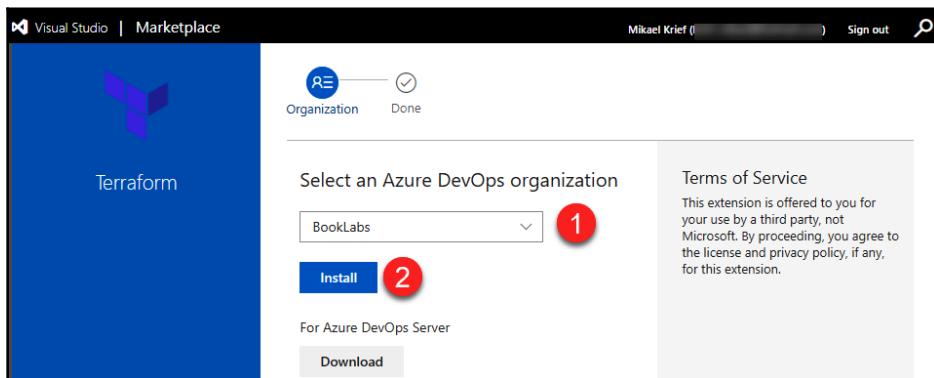
To use Terraform in Azure Pipelines, there are a couple of solutions:

- Using custom scripts (PowerShell and Bash) executing the Terraform CLI commands
- Using Terraform extensions for Azure DevOps

Here in this recipe, we will learn how to use the Terraform extension for Azure DevOps published by Charles Zipp (in the knowledge there are, of course, other extensions available by other publishers).

To install this extension, implement the following steps:

1. Go to <https://marketplace.visualstudio.com/items?itemName=charleszipp.azure-pipelines-tasks-terraform> in your browser and click on **Terraform Build & Release Tasks**.
2. At the top of the page, click on **Get it free**.
3. On the installation page, in the **Organization** dropdown, choose the organization to which the extension will be installed (1), then click on the **Install** button (2):

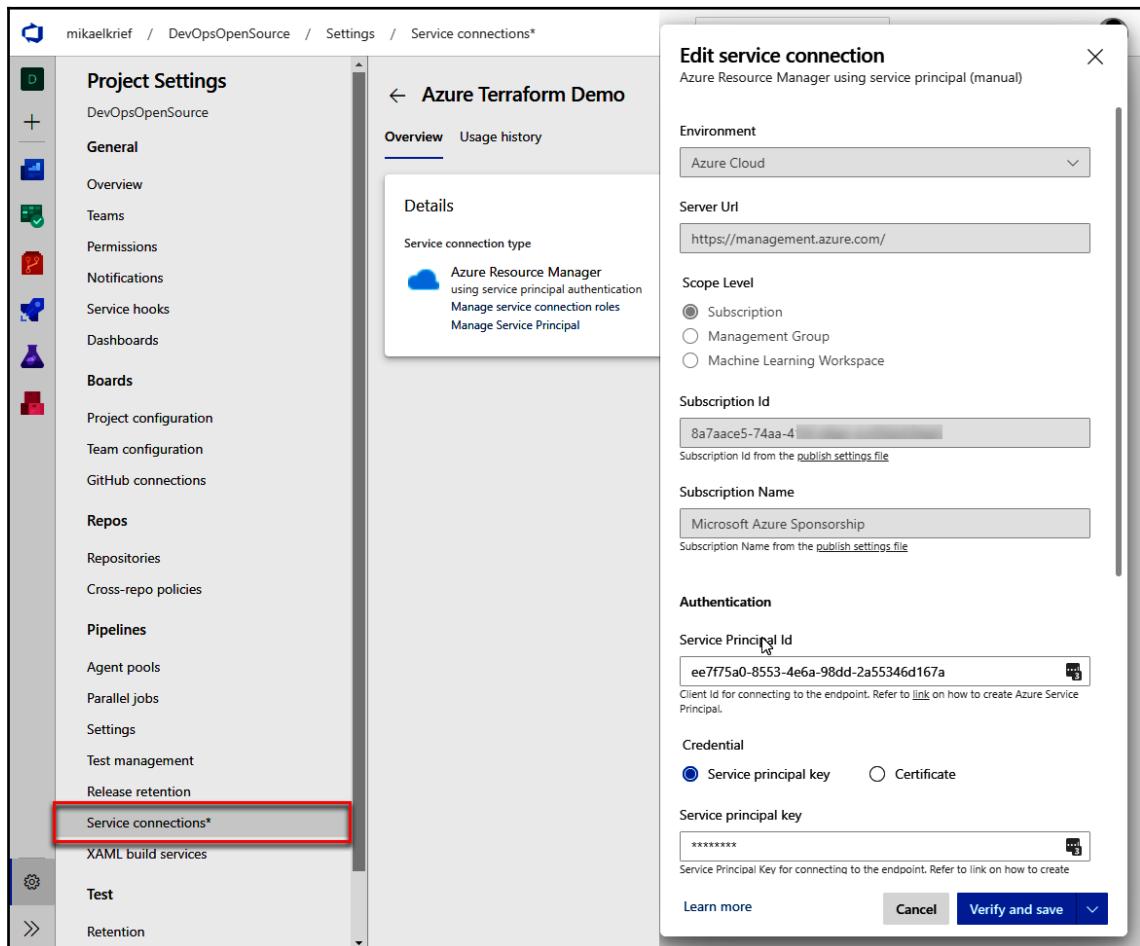


The extension will be installed on your Azure DevOps organization.

Additionally, for the Terraform state file, we will use a remote backend. In order to be able to use it in Azure (Azure Storage, to be precise) with Terraform, we learned in the *Protecting the state file in Azure remote backend* recipe of Chapter 6, *Provisioning Azure Infrastructure with Terraform*, that an Azure service principal must be created.

To create this connection with Azure, in Azure Pipelines, we go to set up a service connection with the information from the created Azure service principal. To operate this, in the project settings, we navigate to the **Service connections** menu. Then we create a new **Azure RM** service connection and configure it with the service properties.

The following screenshot shows the service connection to my **Azure Terraform Demo** configuration:



Finally, the code that contains the Terraform configuration must be stored in a Git repository, such as GitHub or Azure Repos (in this recipe, we will use GitHub).

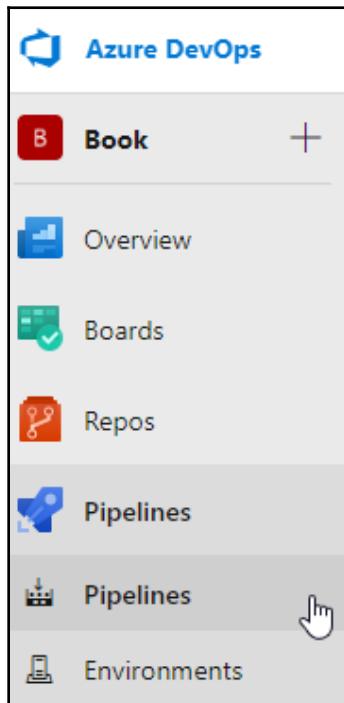
Note that in this recipe, we will not study the deployed Terraform configuration code, which is very basic (it generates a random string) – its purpose is to demonstrate the implementation of the pipeline.

The Terraform configuration source code that will be used in this recipe is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP07/> pipeline.

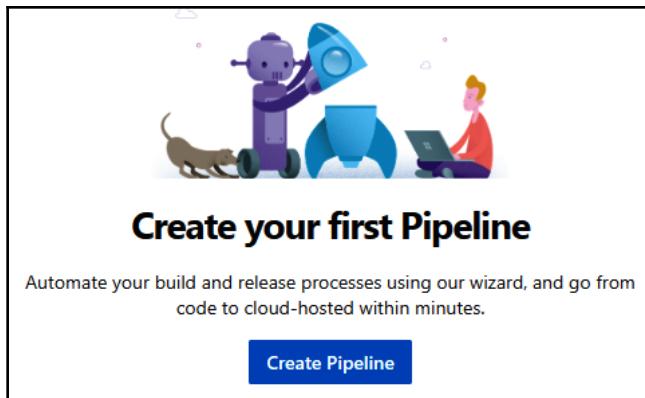
## How to do it...

To create the pipeline, we performing the following steps:

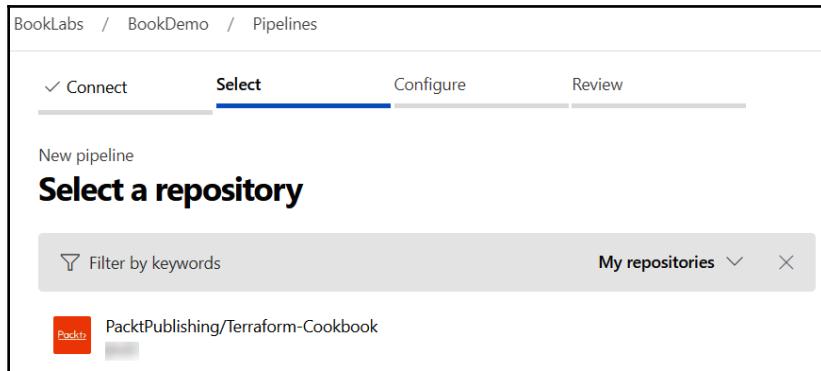
1. In the Azure Pipelines menu, click **Pipelines**:



2. Click on the **Create Pipeline** button:



3. For the code source, select the Git repository that contains the Terraform configuration. For this recipe, we choose our GitHub repository and select the **Starter pipeline** option to start with a new pipeline from scratch:



4. The pipeline editor opens and you can start writing the CI/CD steps directly online. Let's look at the code for this pipeline, which is in YAML format. First, we're going to configure the pipeline options with the following code to use an Ubuntu agent:

```
trigger:  
  - master  
pool:  
  vmImage: 'ubuntu-latest'
```

5. Then, we tell the pipeline to download the desired version of the Terraform binary by adding this code:

```
- task: charleszipp.azure-pipelines-tasks-terraform.azure-pipelines-tasks-terraform-installer.TerraformInstaller@0
  displayName: 'Install Terraform 0.12.26'
  inputs:
    terraformVersion: 0.12.26
```

6. We continue with the first command of the Terraform workflow and execute the `terraform init` command:

```
- task: charleszipp.azure-pipelines-tasks-terraform.azure-pipelines-tasks-terraform-cli.TerraformCLI@0
  displayName: 'terraform init'
  inputs:
    command: init
    workingDirectory: "CHAP07/pipeline/"
    backendType: azurerm
    backendServiceArm: '<Your Service connection name>'
    backendAzureRmResourceGroupName: 'RG_BACKEND'
    backendAzureRmStorageAccountName: storagetfbackendbook
    backendAzureRmContainerName: tfstate
    backendAzureRmKey: myappdemo.tfstate
```

7. After the `init` step, the pipeline executes the `terraform plan` command for preview and displays the changes that the pipeline will apply:

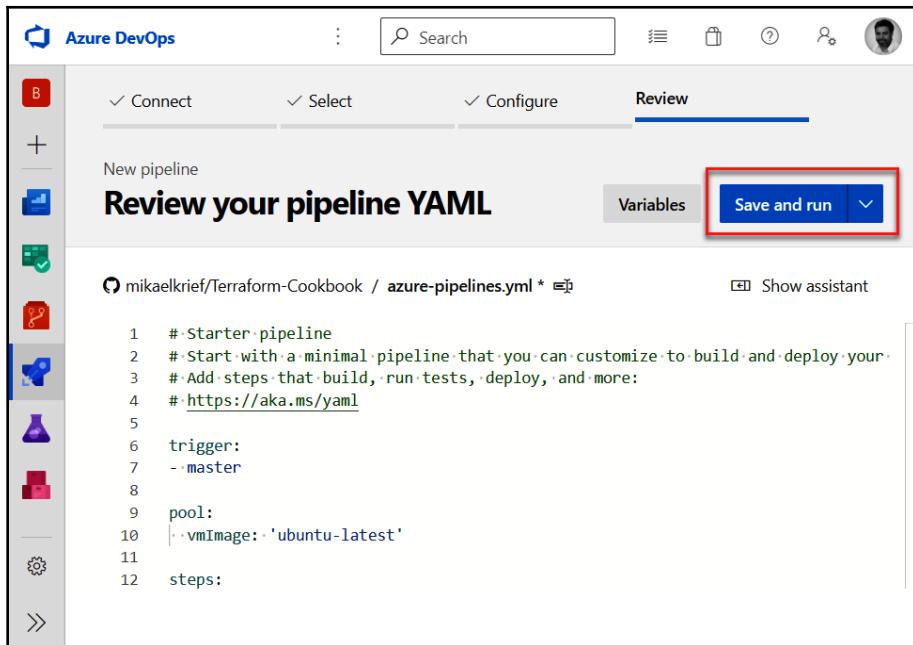
```
- task: charleszipp.azure-pipelines-tasks-terraform.azure-pipelines-tasks-terraform-cli.TerraformCLI@0
  displayName: 'terraform plan'
  inputs:
    command: plan
    workingDirectory: "CHAP07/pipeline/"
    commandOptions: '-out="out.tfplan"'
```

8. And finally, the pipeline runs the `terraform apply` command to apply the changes:

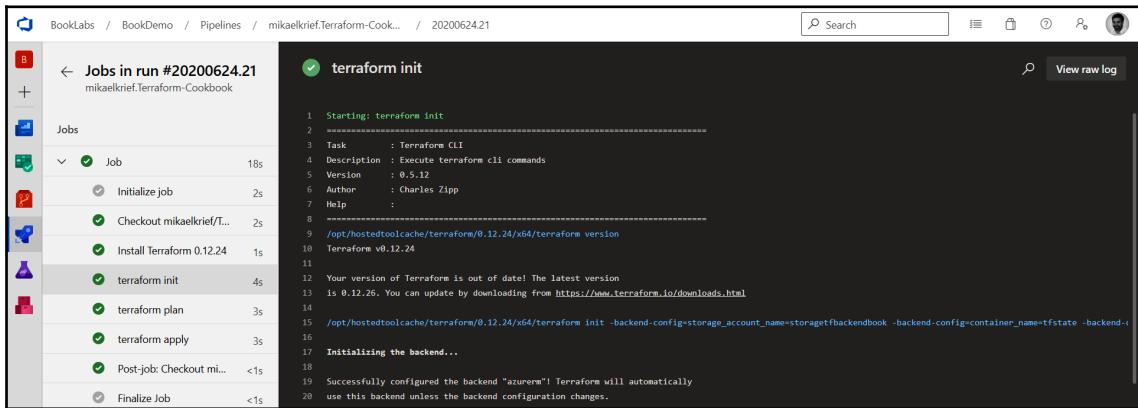
```
- task: charleszipp.azure-pipelines-tasks-terraform.azure-pipelines-tasks-terraform-cli.TerraformCLI@0
  displayName: 'terraform apply'
  inputs:
    command: apply
    workingDirectory: "CHAP07/pipeline/"
    commandOptions: 'out.tfplan'
```

The complete source code of this pipeline in YAML is available at <https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP07/pipeline/azure-pipelines.yml>.

9. After editing the YAML code of the pipeline, we can test it and trigger the execution of the pipeline by clicking on **Save and run** at the top right of the page:



- When the execution of the pipeline is finished, we will be able to see the log results of the execution:



The screenshot shows the Azure Pipelines interface with a pipeline named "mikaelkrief.Terraform-Cookbook" running on 2020-06-24 at 21:20. The pipeline has one job, which has completed successfully. The log output for the "terraform init" step is displayed, showing the command being run and a warning about an outdated version of Terraform.

```
Starting: terraform init
=====
Task : Terraform CLI
Description : Execute terraform cli commands
Version : 0.5.12
Author : Charles Zipp
Help :
=====
/opt/hostedtoolcache/terraform/0.12.24/x64/terraform version
Terraform v0.12.24

Your version of Terraform is out of date! The latest version
is 0.12.26. You can update by downloading from https://www.terraform.io/downloads.html

/opt/hostedtoolcache/terraform/0.12.24/x64/terraform init -backend-config=storage_account_name=storagefbbackendbook -backend-config=container_name=tfsstate -backend-type=azurerm
Initializing the backend...
Successfully configured the backend "azurerm"! Terraform will automatically
use this backend unless the backend configuration changes.
```

## How it works...

In steps 1 to 3 of this recipe, we used Azure Pipelines via the web interface to create a new pipeline that we configured on our GitHub repository. Moreover, we made the choice to configure it by starting with a new YAML file.

Step 4 was dedicated to writing the YAML code for our pipeline in which we defined the following steps:

- We downloaded the Terraform binary and specified the version that is compatible with our Terraform configuration.



Even if you are using an agent hosted by Microsoft that already has Terraform installed, I advise you to download Terraform because the version installed by default may not be compatible with your configuration.

- Then, using the extension installed in the prerequisites, we execute the Terraform workflow with a step for the `terraform init` command and the use of the Azure remote backend. We then execute the `terraform plan` command with the `out` argument, which generates a `plan` output file. Finally, we apply the changes by executing the `terraform apply` command using the generated `plan` file.



The `terraform apply` command used by this last task has the `-auto-approve` option to allow changes to be applied automatically.

Finally, in the last step of the recipe, the pipeline is triggered and it is clear from the output logs that the changes described in the Terraform configuration have been applied.

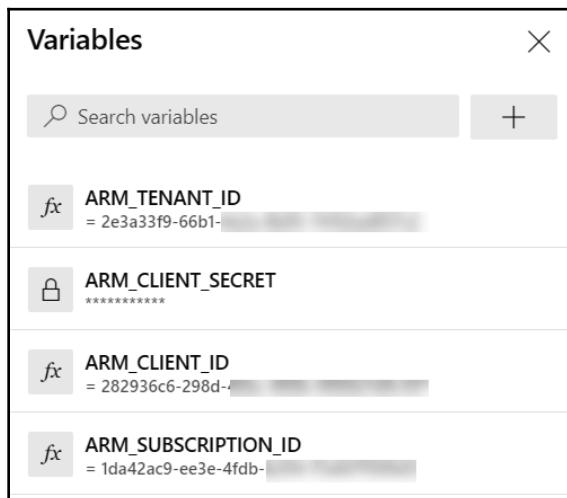
## There's more...

We have seen in this recipe how to create a pipeline for Terraform from an empty YAML file, but you can also create a pipeline using a prewritten YAML file archived in your Git repository.



If you want to use Terraform in an Azure DevOps pipeline using the classic mode (that is, in graphical mode without YAML), you can refer to the hands-on labs at <https://www.azuredevopslabs.com/labs/vstsextend/terraform/>.

If your Terraform configuration deploys an infrastructure in Azure, and you want to use a custom script inside the pipeline instead of the Terraform task, then you will have to add, in the **Variables** tab, the four environment variables of the main service used for authentication in Azure (we studied these in the *Protecting the Azure Credential Provider* recipe of Chapter 6, *Provisioning Azure Infrastructure with Terraform*), as shown in the following screenshot:



These four variables will be automatically loaded as environment variables in the pipeline execution session.

Additionally, in this recipe, we used a CI/CD Azure Pipelines platform as an example, but the automation principle remains the same for all DevOps tools, including Jenkins, GitHub Actions, GitLab, and so on.

## See also

The following is a list of links to articles and videos related to this topic:

- Terraform on Microsoft Azure – *Continuous Deployment using Azure Pipelines*:  
<https://blog.jcoriolan.io/archives/2019/10/02/terraform-microsoft-azure-pipeline-continuous-deployment.html>
- A CI/CD journey with Azure DevOps and Terraform: <https://medium.com/faun/a-ci-cd-journey-with-azure-devops-and-terraform-part-3-8122624efa97> (see part 1 and part 2)
- Deploying Terraform Infrastructure using Azure DevOps Pipelines step by step:  
<https://medium.com/@gmusumeci/deploying-terraform-infrastructure-using-azure-devops-pipelines-step-by-step-d58b68fc666d>
- Terraform deployment with Azure DevOps: <https://www.starwindsoftware.com/blog/azure-devops-terraform-deployment-with-azure-devops-part-1>
- Infrastructure as Code (IaC) with Terraform and Azure DevOps: <https://itnext.io/infrastructure-as-code-iac-with-terraform-azure-devops-f8cd022a3341>
- Terraform all the Things with VSTS: <https://www.colinsalmcorner.com/terraform-all-the-things-with-vsts/>
- Terraform CI/CD with Azure DevOps: <https://www.youtube.com/watch?v=oMacTRQfyI>
- Deploying your Azure Infrastructure with Terraform: <https://www.youtube.com/watch?v=JaesylupZa8>
- Enterprise Deployment to Azure and AWS in Azure DevOps: <https://www.hashicorp.com/resources/enterprise-deployment-to-azure-and-aws-in-azure-devops/>

# Working with workspaces in CI/CD

In the *Using workspaces for managing environments* recipe in Chapter 4, *Using the Terraform CLI*, we studied the use of some Terraform commands to manage and create workspaces. In Terraform's vision, workspaces make it possible to manage several environments by creating several Terraform state files for the same Terraform configuration.

In this recipe, we will go further with the use of workspaces by automating their creation in a CI/CD pipeline.

## Getting ready

The prerequisite for this recipe is to know the Terraform command-line options for the workspaces, the documentation for which is available at <https://www.terraform.io/docs/commands/workspace/index.html>.

Concerning the CI/CD pipeline, we will implement it in Azure Pipelines, which we have already seen in this chapter, in the *Building CI/CD pipelines for Terraform configuration in Azure Pipelines* recipe.

The purpose of this recipe is to illustrate a scenario I recently implemented, which is the creation of on-demand environments with Terraform. These environments will be used to test the functionalities during the development of an application.



To summarize, we want to deploy the code of a branch of a Git repository in a specific environment that will be used to test this development.

In this recipe, we will use the Terraform configuration at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP07/workspace-pipeline> and the YAML pipeline from <https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP07/pipeline/azure-pipelines.yml>. We will just complete it with our workspace management practice. We assume that the name of the workspace we will create will be the name of the Git branch that will be deployed.

The complete source code of this recipe is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP07/workspace-pipeline>.

## How to do it...

To manage workspaces in the YAML pipeline, perform the following steps:

1. Inside the folder that contains the Terraform configuration, add the `ManageWorkspaces.ps1` file with the following content:

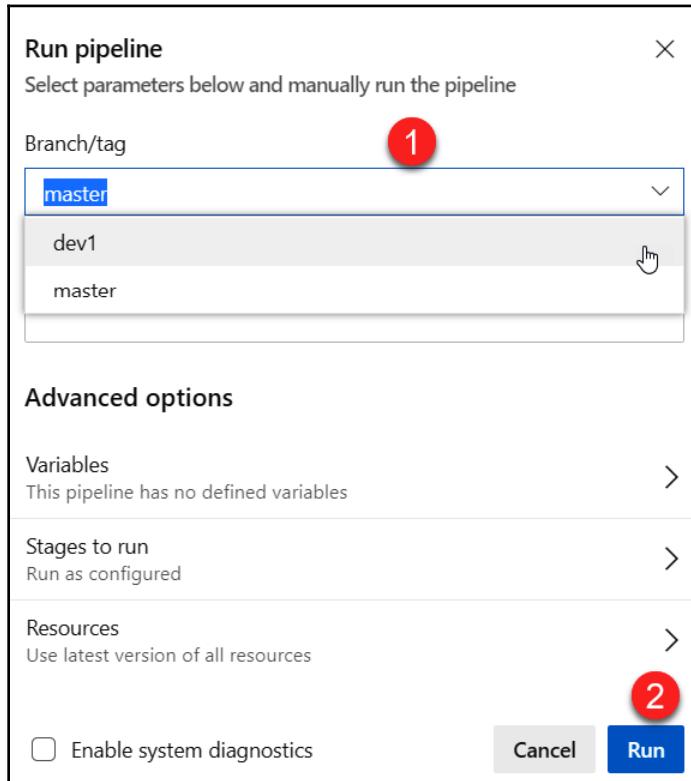
```
$envName=$args[0]
$countws = terraform workspace list -no-color | Select-String
$envName -AllMatches
if ($countws.Matches.Count -eq 0) {
    Write-Host "Create new Workspace $envName"
    terraform workspace new $envName
} else{
    Write-Host "The Workspace $envName already exist and is
selected"
    terraform workspace select $envName
}
```

2. Inside the `azure-pipelines.yaml` file, add the following code just after the `Terraform init` step:

```
- task: PowerShell@2
  inputs:
    filePath: 'CHAP07/workspace-pipeline/ManageWorkspaces.ps1'
    arguments: '$(Build.SourceBranchName)'
    workingDirectory: "CHAP07/workspace-pipeline/"
```

3. Commit and push the PowerShell script that we just created and the YAML pipeline file changes inside your Git repository.

4. In Azure Pipelines, run the pipeline, and during the configuration step, choose the right branch to deploy to from the **Branch/tag** drop-down menu:



Lastly, run the pipeline by clicking on the **Run** button.

## How it works...

In *step 1*, we create a PowerShell script that takes as an input parameter the name of the environment to create (which corresponds to the name of the branch to deploy). Then, in line 2, this script executes the `terraform workspace list` command, which displays the list of workspaces and searches for a workspace with the name of the environment passed as a parameter. If this search does not find a workspace, it executes the `terraform workspace new` command to create it. Otherwise, if the workspace exists, this script executes the `terraform workspace select` command to select it.



Note that the `terraform workspace create` command creates a workspace and selects it as well.

In *step 2*, we complete the YAML pipeline that we created in the previous recipe by inserting between `init` and `plan` the execution of this PowerShell script by passing as an argument the name of the branch that we sectioned.

Then, we commit these code changes (the PowerShell script and the pipeline YAML file) to the Git repository.

Finally, in *step 4*, we execute the pipeline in Azure Pipelines by selecting the branch to be deployed, the name of which will be used as the workspace name.

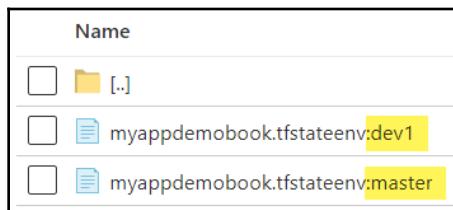
The following screenshot shows the execution result in the pipeline logs:

The screenshot shows the Azure Pipeline interface. On the left, a list of jobs for run #20200702.... under the project mikaelkrief.Terraform-Cookbook. The 'Jobs' section lists several steps: Job (26s), Initialize job (2s), Checkout mikaelkrief/T... (2s), Install Terraform 0.12.28 (2s), terraform init (4s), Manage Workspaces (5s), terraform plan (4s), and terraform apply (4s). The 'Manage Workspaces' step is highlighted with a red box. To the right, the log output for this step is shown in a terminal window titled 'Manage Workspaces'. The log shows the task starting, generating a script, running it, and creating a new workspace named 'dev1'. A yellow box highlights the message 'Created and switched to workspace "dev1"!'. The log concludes with a note about Terraform state isolation.

```
Starting: Manage Workspaces
=====
Task : PowerShell
Description : Run a PowerShell script on Linux, macOS, or Windows
Version : 2.170.1
Author : Microsoft Corporation
Help : https://docs.microsoft.com/azure/devops/pipelines/tasks/utility/powershell
-----
Generating script.
Formatted command: . '/home/vsts/work/1/s/CHAP07/pipeline/ManageWorkspaces.ps1' dev1
-----
Starting Command Output -----
/usr/bin/pwsh -NoLogo -NoProfile -NonInteractive -Command . '/home/vsts/work/_temp/2c4b7571-2026-4b6c-9575-a5727ce36e7.ps1'
Create new Workspace dev1
Created and switched to workspace "dev1"
You're now on a new, empty workspace. Workspaces isolate their state,
so if you run "terraform plan" Terraform will not see any existing state
for this configuration.

```

And in the end, we can see the Terraform state files that were created automatically:



As you can see, the Terraform state files created by the workspaces contain the workspace name at the end.

## There's more...

In this recipe, we have managed the workspaces using a PowerShell script, but you are of course free to write it in another scripting language of your choice, such as Bash or Python.

## See also

- Before using multiple workspaces, make sure to check their compatibility with the backends by following the instructions at <https://www.terraform.io/docs/state/workspaces.html>.
- The documentation on CLI commands for workspaces in Terraform is available at <https://www.terraform.io/docs/commands/workspace/index.html>.

# 8

# Using Terraform Cloud to Improve Collaboration

Throughout this book, we have learned how to write Terraform configurations and use the Terraform CLI throughout different recipes. All this applies to small projects and small teams, but in a corporate context, when working on large infrastructure projects, it is necessary to have a real platform for sharing modules and centralized deployment. This platform, which must be able to be connected to a source control repository with a **Version Control System (VCS)** such as Git, must allow infrastructure changes to be applied to Terraform in an automated and centralized manner for all team members. This is why, since 2019, HashiCorp has published a SaaS platform (known as a cloud) called **Terraform Cloud**. To learn more about Terraform Cloud and its history, please refer to the documentation here: <https://www.terraform.io/docs/cloud/index.html>.

This Terraform Cloud platform (which also exists in an on-premise version called **Terraform Enterprise**), in its free plan in particular, provides functionalities of the remote backend type, a private modules registry, user management for a team of up to five users, and remote execution of Terraform configuration, which is stored in a VCS repository. In its paid plan, Terraform Cloud also integrates more advanced team management functionalities, provides cost estimation for resources that will be managed by Terraform, and supplies integration with **Sentinel**, which is a compliance framework. The complete and detailed list of Terraform Cloud functionalities is available in the documentation here: <https://www.hashicorp.com/products/terraform/pricing/>.

In this last chapter of this book, we will learn how to use the remote backend of Terraform Cloud and how to share Terraform modules in the private registry on Terraform Cloud. Then, we will learn how to perform the remote execution of Terraform configuration directly inside Terraform Cloud and how to use Terraform Cloud using its APIs. Finally, we will end this chapter by exploring the paid features and usage of Sentinel in order to apply compliance tests and visualize cost estimation.

In this chapter, we'll cover the following recipes:

- Using the remote backend in Terraform Cloud
- Using Terraform Cloud as a private module registry
- Executing Terraform configuration remotely in Terraform Cloud
- Automating Terraform Cloud using APIs
- Testing the compliance of Terraform configurations using Sentinel
- Using cost estimation for cloud cost resources governance

Let's get started!

## Technical requirements

The primary prerequisite for this chapter is to have an account on the Terraform Cloud platform. Creating an account is simple and offers a free plan. You can do this at <https://app.terraform.io/signup/account>.



For all the recipes in this chapter, we will already be connected to Terraform Cloud via a web browser.

After registering for an account, it will be necessary (if you haven't done so already) to create an organization by clicking on the **Create organization** link.



For detailed steps regarding how to create an account and organization, follow the Terraform learning process at <https://learn.hashicorp.com/terraform/cloud-getting-started/signup>. For more information on organizations, read the documentation at <https://www.terraform.io/docs/cloud/users-teams-organizations/organizations.html#creating-organizations>.

Finally, it's important that you're familiar with the concept of workspaces in Terraform Cloud (which is a little different from the workspaces we studied in the *Using workspaces to manage environments* recipe in Chapter 4, *Using the Terraform CLI*). Please refer to the documentation at <https://www.terraform.io/docs/cloud/workspaces/index.html> to find out more.

When creating a connection between Terraform Cloud and a Git repository, we will be using GitHub. You can create a free account on GitHub at <https://github.com/>.

The source code for this chapter is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP08>.

Check out the following video to see the code in action: <https://bit.ly/2zl3tyA>

## Using the remote backend in Terraform Cloud

Throughout this book, we have discussed the backend and its importance for storing and sharing the Terraform state file.

In the *Protecting the state file in the Azure remote backend* recipe in Chapter 6, *Provisioning Azure Infrastructure with Terraform*, we had a concrete case of this when we set up and used a backend in Azure (using Azure Storage). However, this recipe can only be applied with an Azure subscription. The different types of backend listed at <https://www.terraform.io/docs/backends/types/index.html> mostly require you to purchase platforms or tools.

One of Terraform's primary features is that it allows you to host a Terraform state file in a managed service, which is called a `remote` backend.

In this recipe, we will learn how to use the `remote` backend in Terraform Cloud.

### Getting ready

The prerequisite for this recipe (as for all the others in this chapter) is that you have an account on Terraform Cloud (<http://app.terraform.io/>) and are logged in. Furthermore, you will need to create a new workspace called `demo-app` manually from the Terraform Cloud UI by following the documentation at <https://www.terraform.io/docs/cloud/workspaces/creating.html> and configuring it without choosing a VCS repository.

The goal of this recipe is to configure and use the `remote` backend for a simple Terraform configuration (for a better understanding that does not depend on a cloud provider). Furthermore, the execution of this Terraform configuration will be configured in Terraform Cloud for execution in `local` mode; that is, on a machine outside Terraform Cloud (which can be a local workstation or a CI/CD pipeline agent).



Note that in this recipe, we will be using local mode. In the next recipe, we will explain how to execute in **remote** mode.

The source code for this recipe is available here: <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP08/app>.

## How to do it...

This recipe will be split into three parts, as follows:

1. Configuring local mode execution in Terraform Cloud
2. Generating a new API token
3. Configuring and using the `remote` backend

For the first part, we will configure local mode execution, as follows:

1. In our new Terraform Cloud workspace (`demo-app`), go to the **Settings** | **General** tab and change the **Execution Mode** option to **Local**:

The screenshot shows the 'General Settings' page for the 'demo-app' workspace. At the top, there are tabs for 'Runs', 'States', and 'Settings' (which is underlined and has a red circle 1 above it). The main area is titled 'General Settings'. It contains fields for 'ID' (ws-SQR1o56Rw6aYVhuP) and 'Name' (demo-app). Below these, there's a 'Execution Mode' section with two options: 'Remote' and 'Local'. The 'Local' option is selected (indicated by a red circle 2) and includes a description: 'Your plans and applies occur on machines you control. Terraform Cloud is only used to store and synchronize state.' At the bottom left is a blue 'Save settings' button (marked with a red circle 3).

2. Click the **Save settings** button to apply these changes.

Now, for the second part, we need to generate a new API token to authenticate with Terraform Cloud. Follow these steps:

1. In the **Settings** tab of the demoBook organization, go to the **API Tokens** tab:

The screenshot shows the Terraform Cloud interface for the 'demoBook' organization. The top navigation bar includes 'demoBook', 'Workspaces', 'Modules', 'Settings' (which has a red circle with '1' indicating notifications), and a user profile icon. The 'Settings' tab is active. Below the navigation is a breadcrumb trail: 'demoBook / Settings / API Tokens'. On the left, there's a sidebar with 'ORGANIZATION SETTINGS' and a list of tabs: 'demoBook', 'General', 'Plan & Billing', 'Users', 'Teams', 'API Tokens' (which has a red circle with '2'), and 'Authentication'. The main content area is titled 'API Tokens' and contains two sections: 'User Tokens' and 'Team Tokens'. The 'User Tokens' section has a descriptive paragraph and a link to 'user settings page'. The 'Team Tokens' section also has a descriptive paragraph and a link to 'Teams page'. A cursor arrow points towards the 'User Tokens' section.

2. Scroll down to the bottom of this page and click on the **Create an authentication token** button to generate a new API token.
3. Keep this generated token safe.

Finally, the last part is to configure and use the `remote` backend. Follow these steps:

1. In the `main.tf` file of the Terraform configuration, add the following backend configuration:

```
terraform {
  backend "remote" {
    hostname      = "app.terraform.io"
    organization = "demoBook"

    workspaces {
      name = "demo-app"
    }
  }
}
```

2. Then, in the appropriate Terraform CLI configuration folder, which is the home directory (documented here: <https://www.terraform.io/docs/commands/cli-config.html>), create a new file called `terraform.rc` (for Windows OS) or `.terraform.rc` (for Linux OS). This will be the Terraform CLI configuration. Inside this file, add the following content:

```
credentials "app.terraform.io" {  
    token = "<your api token generated>"  
}
```

3. Execute the basic workflow Terraform commands with `init`, `plan`, and `apply` from your local workstation.

## How it works...

In the first part of this recipe, we configured the Terraform execution mode of our workspace. In this configuration, we chose local mode, which indicates that Terraform will ensure the configuration is installed on a private machine (either a local development station or a CI/CD pipeline agent). In this case, the created workspace is just used to store the Terraform state.

Then, in the second part, we created a token that allows the Terraform binary to authenticate with our Terraform Cloud workspace.

In the last part, we wrote the Terraform configuration, which describes the settings of our `remote` backend. In this configuration, we used the `remote` backend, in which we added the following parameters:

- `hostname` with the `"app.terraform.io"` value, which is the domain of Terraform Cloud
- `organization`, which contains the `demoBook` name of the organization
- `workspaces` with the name of the `demo-app` workspace that we created manually in the prerequisites of this recipe

Then, in *step 2*, we created the Terraform CLI configuration file by adding the authentication token that was generated in the second part of this recipe.

Finally, in the last step, we executed the Terraform commands workflow.

After executing these commands, on the **States** tab of our workspace, we will see that our status file has been created:



By clicking on this file, you can view its content or download it.

## There's more...

In this recipe, we learned how to centrally store report files in the Terraform Cloud backend.

To do this, we created a workspace manually so that we could configure it and choose the local execution mode. In the *Executing Terraform configuration in Terraform Cloud* recipe of this chapter, if we want to use remote mode, we simply put the name of the workspace in the configuration of the backend, which creates it automatically if it does not exist.

Then, we configured the Terraform CLI with the `terraform.rc` file. Another solution is to use the `terraform login` command, which creates the token, and the `credential.tfrc.json` configuration file.

The following screenshot shows the execution of this command:

```
PS C:\CHAP08\app> terraform login
Terraform will request an API token for app.terraform.io using your browser.

If login is successful, Terraform will store the token in plain text in
the following file for use by subsequent commands:
  C:\Users\mkrief\AppData\Roaming\terraform.d\credentials.tfrc.json

Do you want to proceed? (y/n) y
Terraform must now open a web browser to the tokens page for app.terraform.io.

If a browser does not open this automatically, open the following URL to proceed:
  https://app.terraform.io/app/settings/tokens?source=terraform-login

-----
Generate a token using your browser, and copy-paste it into this prompt.

Terraform will store the token in plain text in the following file
for use by subsequent commands:
  C:\Users\mkrief\AppData\Roaming\terraform.d\credentials.tfrc.json

Token for app.terraform.io:

Retrieved token for user MikaelKrief

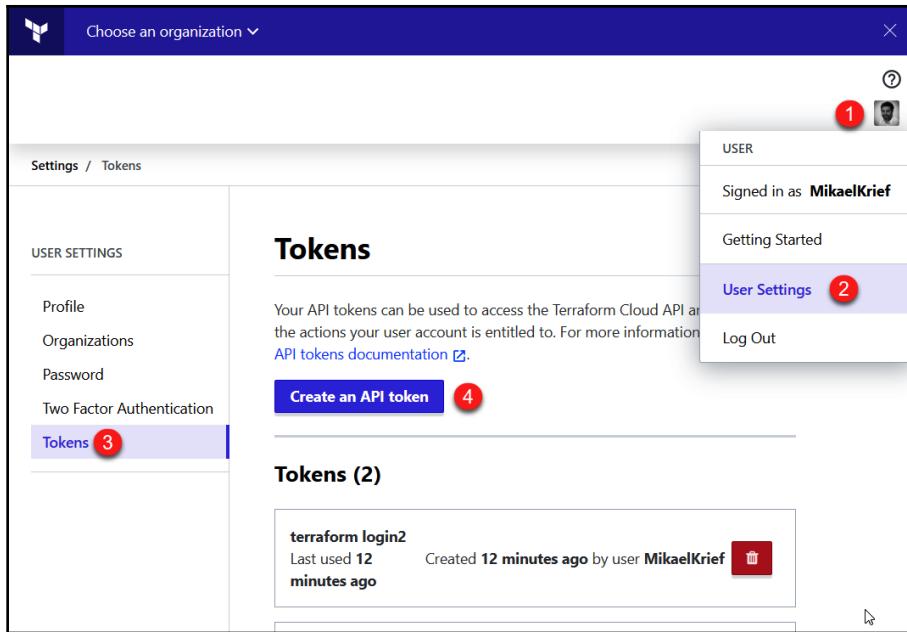
-----
Success! Terraform has obtained and saved an API token.

The new API token will be used for any future Terraform command that must make
authenticated requests to app.terraform.io.
```



This command is not to be used for automation usage as it requires a web browser and manual intervention.

Concerning the token, we created it at the organization level in order to protect Terraform's organization-only executions. To give broader permissions to all organizations in this account, you can create a token on the full account in **User Settings** and then in the **Tokens** tab:



To learn more about the use of API tokens, please refer to the documentation at <https://www.terraform.io/docs/cloud/users-teams-organizations/api-tokens.html>.

Finally, you can read the documentation at <https://www.terraform.io/docs/cloud/architectural-details/data-security.html> to learn more about securing data and the Terraform state file, which are stored in Terraform Cloud. If you already have Terraform configurations with state files that are stored in other types of backends and you would like to migrate them to Terraform Cloud, here is the migration documentation: <https://www.terraform.io/docs/cloud/migrate/index.html>.

## See also

- The documentation on the remote backend is available here: <https://www.terraform.io/docs/backends/types/remote.html>
- The terraform login command documentation is available here: <https://www.terraform.io/docs/commands/login.html>
- Documentation on the configuration of the Terraform CLI is available here: <https://www.terraform.io/docs/commands/cli-config.html>.

# Using Terraform Cloud as a private module registry

In the previous recipe, we learned how to use Terraform Cloud as a remote backend that is centralized, secure, and free of charge.

In this book, we have dedicated [Chapter 5, Sharing Terraform Configuration with Modules](#), to the creation, usage, and sharing of Terraform modules. As a reminder, what we studied was publishing modules in the Terraform public registry, which is publicly accessible by all Terraform users, and sharing Terraform modules privately using a Git repository.

Concerning private module sharing, the Git repository system is efficient but does not offer a centralized platform for sharing and documenting modules like the public registry does. In order to provide companies with a private registry of their Terraform modules, HashiCorp has integrated this functionality into Terraform Cloud/Enterprise.

In this recipe, we will learn how to publish and use a Terraform module in the private registry of the Terraform Cloud.

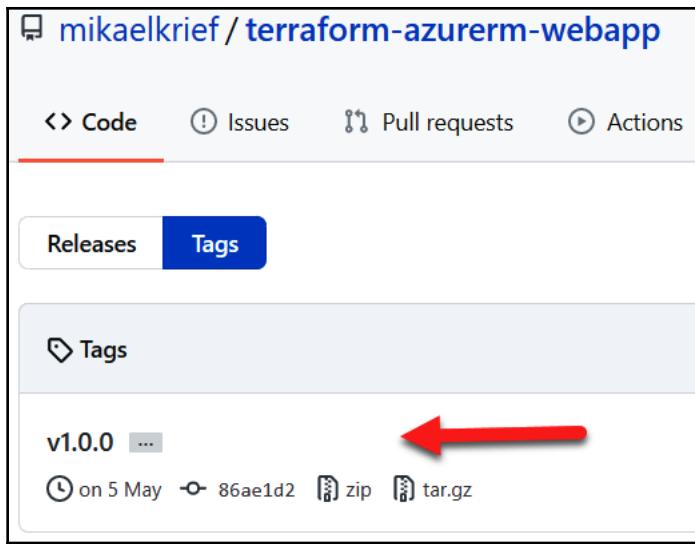
## Getting ready

In order to publish a module in Terraform Registry, you'll need to store your module code in a VCS file that is supported by Terraform Cloud. The list of supported file types can be found at <https://www.terraform.io/docs/cloud/vcs/index.html>.

To start this recipe, in the **Settings** section of the Terraform Cloud organization, we need to create a connection to the VCS provider that contains the Terraform configuration, as described in the documentation at <https://www.terraform.io/docs/cloud/vcs/index.html>.

In our scenario, we will use the GitHub VCS, which contains a `terraform-azurerm-webapp` repository (which creates a Service Plan, an App Service instance, and an Application Insights in Azure). To get this repository, you can fork <https://github.com/mikaelkrief/terraform-azurerm-webapp>.

In addition, as we studied in the *Sharing Terraform module using GitHub* recipe in [Chapter 5, Sharing Terraform Configuration with Modules](#), you need to create a Git tag in this repository that contains the version number of the module. For this recipe, we will create a `v1.0.0` tag, as shown in the following screenshot:



To integrate between Terraform Cloud and GitHub, execute the process documented here: <https://www.terraform.io/docs/cloud/vcs/github-app.html>. At the end of this integration, we get the following screen under **Settings | VCS Providers**:

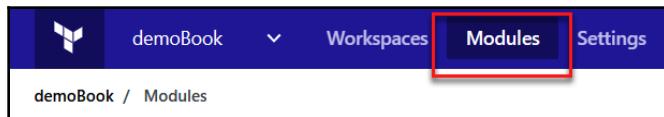
A screenshot of the Terraform Cloud organization settings page for 'demoBook'. The left sidebar shows 'ORGANIZATION SETTINGS' with options like General, Plan &amp; Billing, Users, Teams, API Tokens, Authentication, SSH Keys, and 'VCS Providers' (which is highlighted with a red box). The main area is titled 'VCS Providers' and shows a connection to 'Terraform Cloud (demoBook)'. It lists the Callback URL, HTTP URL, API URL, and creation date (Jul 17, 2020 19:29:48 pm). It also shows the OAuth Token ID and a note about the connection being made via OAuth. Buttons for 'Edit Client' and 'Delete client' are at the bottom.

Our organization now has a connection to the required GitHub account and we can start publishing the module in Terraform Cloud.

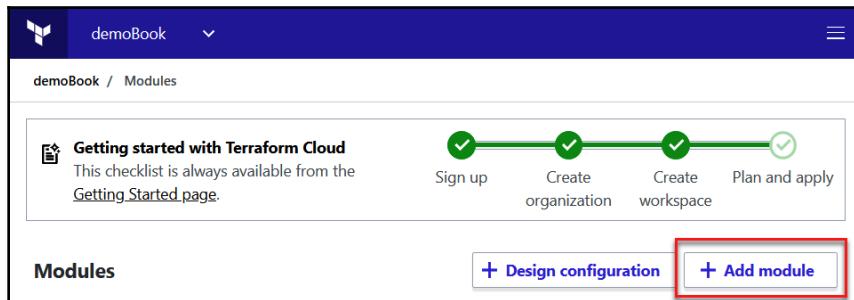
## How to do it...

To publish a Terraform module in Terraform Cloud's private registry, perform the following steps:

1. In our Terraform Cloud organization, click on the **Modules** menu, which is located in the top bar menu:



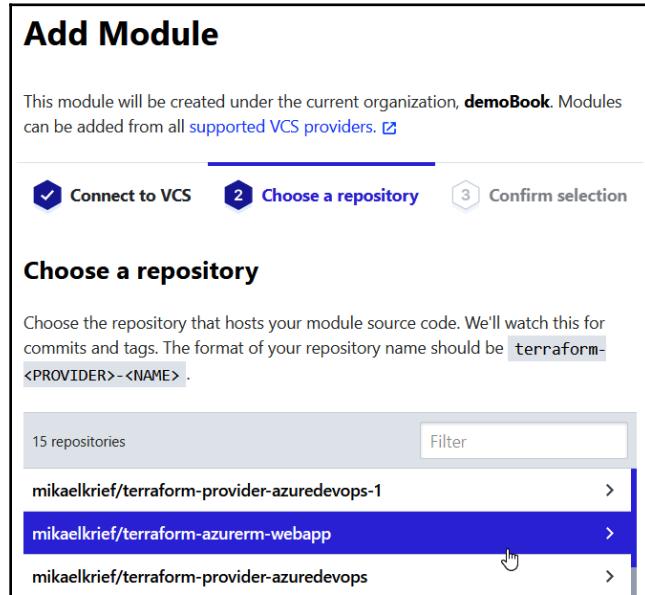
2. To add the module, click on the **Add module** button:



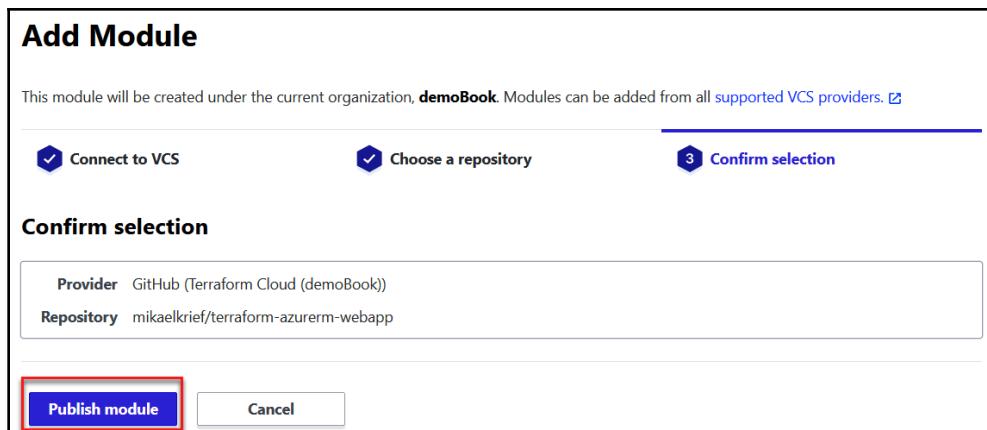
3. Then, in the next layout, in the first step of the wizard, choose **GitHub** as the VCS provider, which we integrated as part of the requirements for this recipe:

The screenshot shows the "Add Module" wizard in progress. The first step, "Connect to VCS", is active. It displays a list of providers: GitHub (selected and highlighted with a red box), Bitbucket, GitLab, and a "Connect to a different VCS" link. The other steps ("Choose a repository" and "Confirm selection") are shown as numbered icons at the top of the wizard.

4. In the second step of the wizard, choose the repository that contains the Terraform module configuration:



5. Finally, in the last step of the wizard, publish the module by clicking on the **Publish module** button:



## How it works...

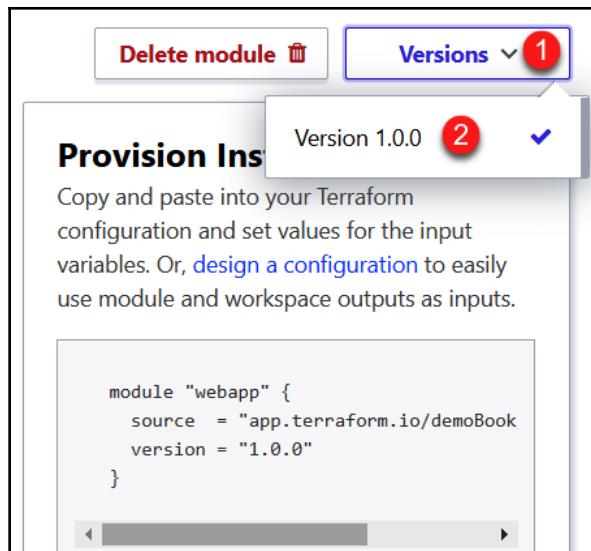
To publish a module in the private registry of Terraform, you just have to follow the steps proposed by the wizard, which consist of choosing a VCS provider and then selecting the repository that contains the Terraform configuration of the module so that it can be published. After doing this, details about the module will be displayed in the layout of the public registry. In the center of this page, you will be able to see the contents of the `Readme.md` file, while on the right-hand side, you will be able to see the technical information about the use of this module.

## There's more...

Once this module has been published in this registry, you can use it in a Terraform configuration. If you're using Terraform Cloud in local execution mode, you must configure the Terraform CLI with the authentication token in the `terraform.rc` file, as described in the previous recipe. Then, you need to use this module in a Terraform configuration and write the following:

```
module "webapp" {  
    source  = "app.terraform.io/demoBook/webapp/azurerm"  
    version = "1.0.0"  
    ...  
}
```

In this configuration, the `source` property is the module identifier in the Terraform Cloud registry, while the `version` property corresponds to the Git tag that's been set in the repository. After doing this, you can select what version you wish to use from the **Versions** drop-down list:



If we change the Terraform configuration of the module and we want to upgrade its version, we just have to add a Git tag to this repository, along with the desired version. By doing this, the module will be automatically updated in the Terraform Cloud registry.

In addition, if your modules have been published in this private registry, you can generate the Terraform configuration that calls them using the design configuration feature of Terraform Cloud. You can find out more about this at <https://www.terraform.io/docs/cloud/registry/design.html>.

Finally, please note that if you have several organizations in Terraform Cloud and you want to use the same modules in all of them, you will have to publish these modules in each of your organizations. As for upgrading their versions, this will be done automatically for each organization.

## See also

Documentation regarding privately registering modules in Terraform Cloud is available here: <https://www.terraform.io/docs/cloud/registry/index.html>.

# Executing Terraform configuration remotely in Terraform Cloud

In the previous two recipes, we studied the use of Terraform Cloud with local runtime settings. This configuration indicates that the Terraform binary that applies the Terraform configuration is installed on a machine outside the Terraform Cloud platform. This machine is therefore private and can be a development workstation or a machine that serves as an agent for a CI/CD pipeline (such as on an Azure pipeline agent or a Jenkins node).

One of the great advantages of Terraform Cloud is its ability to execute Terraform configurations directly within this platform. This feature, called **remote operations**, makes it possible to have free Terraform configuration execution pipelines without having to install, configure, and maintain VMs that serve as agents. In addition, it provides a shared Terraform execution interface for all the members of the organization.

In this recipe, we will look at the steps involved in running a Terraform configuration in Terraform Cloud using the UI workflow.

## Getting ready

The Terraform configuration source code that we will be using in this recipe can be found at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP08/remote>. This configuration creates a Resource Group and an App Service in Azure. If you want to use this Terraform configuration, you will need to make a fork of this repository. This configuration also uses a `terraform-azurerm-webapp` Terraform module, which has been published in the private registry of our Terraform Cloud organization. For more information about publishing a module in the private registry, see the previous recipe, *Using Terraform Cloud as a private module registry*.

Since, in this Terraform configuration, we will be creating Azure resources, we need to create an Azure Service Principal that has sufficient permissions in the subscription. For more information on Azure Service Principals and the authentication of Terraform to Azure, see the *Protecting the Azure credential provider* recipe in Chapter 6, *Provisioning Azure Infrastructure with Terraform*.

Also, since we will be exposing a Terraform configuration in GitHub, we will need to add the GitHub VCS provider, as explained in the documentation here: <https://www.terraform.io/docs/cloud/vcs/github-app.html>.

Finally, all the steps of this recipe will be done in the Terraform Cloud web interface.

## How to do it...

Before we execute the Terraform configuration, we need to create and configure a new workspace. Follow these steps:

1. Inside the **Workspace** section of our organization, click on the **New organization** button to create a new organization.
2. In the first step of the wizard, choose the VCS provider we registered in the requirements. Here, we will choose our GitHub provider:

### Create a new Workspace

Workspaces allow you to organize infrastructure and collaborate on Terraform runs.

1 Connect to VCS      2 Choose a repository      3 Configure settings

#### Connect to a version control provider

Choose the version control provider that hosts the Terraform configuration for this workspace.

**GitHub** Terraform Cloud (demoBook)

Connect to a different VCS

3. Then, in the second step of this wizard, select the GitHub repository that contains the Terraform configuration so that we can execute it in Terraform Cloud:

## Create a new Workspace

Workspaces allow you to organize infrastructure and collaborate on Terraform runs.

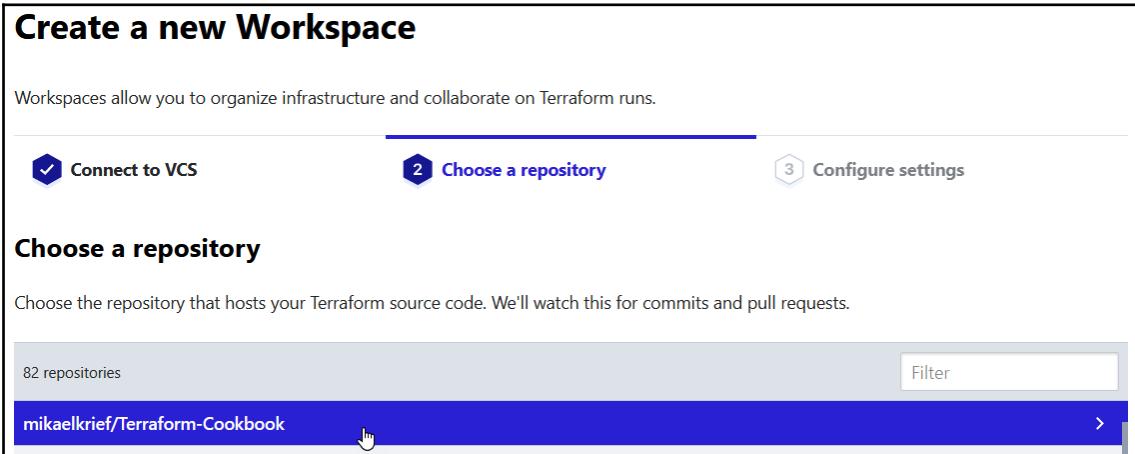
1 Connect to VCS      2 Choose a repository      3 Configure settings

### Choose a repository

Choose the repository that hosts your Terraform source code. We'll watch this for commits and pull requests.

82 repositories      Filter

mikaelkrief/Terraform-Cookbook 



4. Finally, in the last step of the wizard, configure this workspace by specifying the mandatory parameter, which is the name of the workspace. This is `demo-app-remote` in our case:

## Create a new Workspace

Workspaces allow you to organize infrastructure and collaborate on Terraform runs.

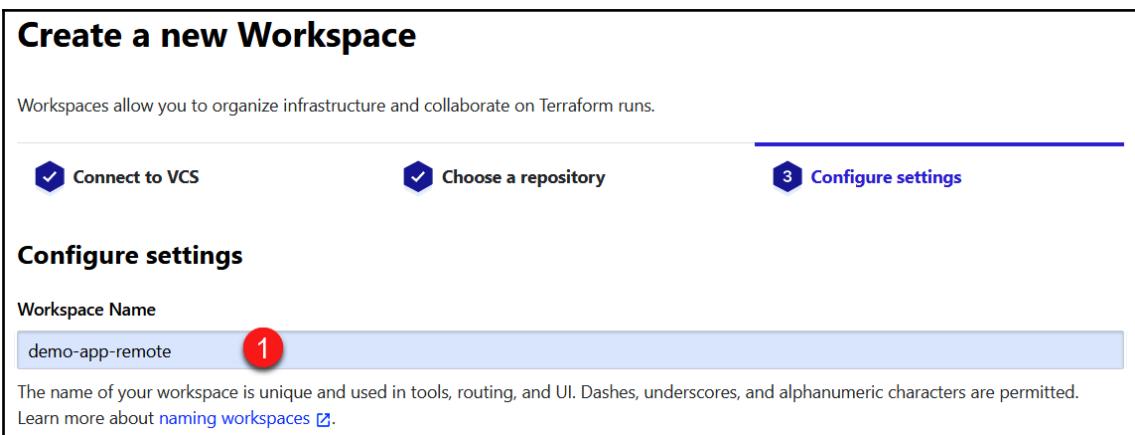
1 Connect to VCS      2 Choose a repository      3 Configure settings

### Configure settings

Workspace Name

demo-app-remote 

The name of your workspace is unique and used in tools, routing, and UI. Dashes, underscores, and alphanumeric characters are permitted.  
Learn more about [naming workspaces](#).



5. In the optional **Advanced options** tab, set the folder path of the Terraform configuration (leave this blank if the Terraform configuration is in the root of your repository). We can also fill in the **Automatic Run Triggering** and **VCS branch** parameters so that they can be run (we leave the master branch empty):

The screenshot shows the Terraform Cloud workspace creation interface. Step 2 highlights the 'Terraform Working Directory' field containing 'CHAP08/remote/'. Step 3 highlights the 'Only trigger runs when files in specified paths change' radio button and the 'Add path' button. Step 4 highlights the 'VCS branch' field with '(default branch)'. Step 5 highlights the 'Create workspace' button.

**Advanced options**

**Terraform Working Directory**

CHAP08/remote/ 2

The directory that Terraform will execute within. This defaults to the root of your repository and is typically set to a subdirectory matching the environment when multiple environments exist within the same repository.

Terraform will change into the `CHAP08/remote/` directory prior to executing any operation. Any modules utilized can be referenced outside of this directory.

**Automatic Run Triggering**

Choose when runs should be triggered by VCS changes.

Always trigger runs

Only trigger runs when files in specified paths change 3

CHAP08/remote/ Working Directory 4 Delete

e.g. /modules Add path

**VCS branch**

(default branch) 4

The branch from which to import new versions. This defaults to the value your version control provides as the default branch for this repository.

Include submodules on clone

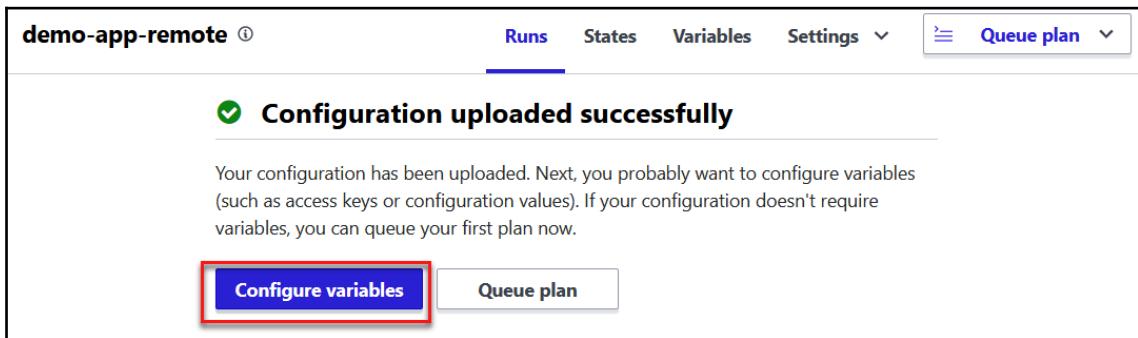
Checking this box will perform a recursive clone of your repositories submodules, making them available in the resulting slug containing your Terraform configuration. Recursive clone is performed with `--depth 1`.

5 Create workspace Cancel

- Finally, click on the **Create workspace** button to finalize the creation of the workspace.

Now that we've created the workspace, because we're deploying resources in Azure, we need to add the four Azure authentication environment variables to the workspace variables settings. Follow these steps:

1. Click on the **Configure variables** button:



2. Then, in the **Environment Variables** section, add our four Terraform Azure provider environment variables, as shown in the following screenshot:

The screenshot shows the 'Environment Variables' section. It displays four variables:

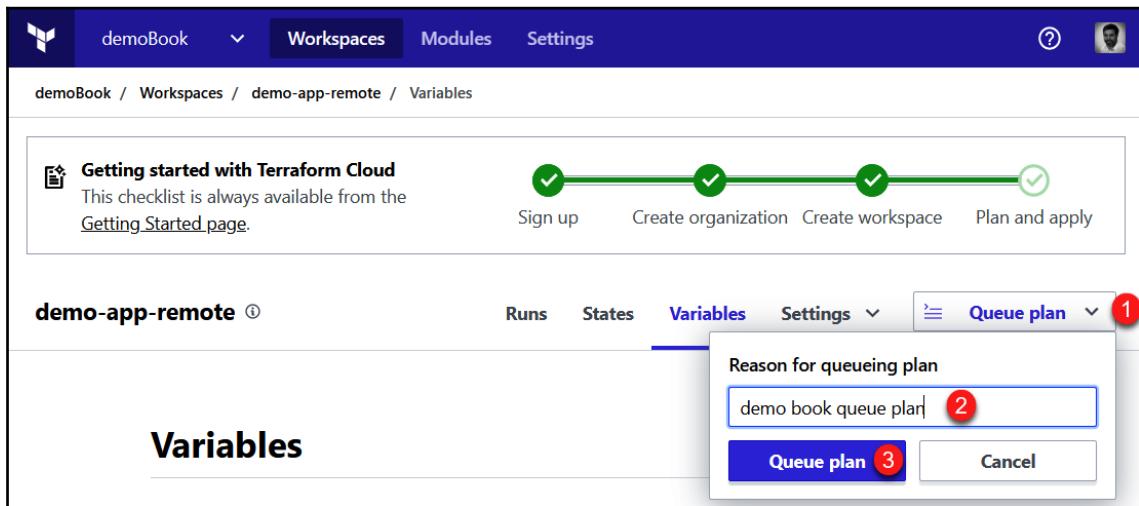
Key	Value	Actions
ARM_SUBSCRIPTION_ID	8a7aace5-74aa-416f-[REDACTED]	...
ARM_CLIENT_ID	282936c6-298d-40bc-[REDACTED]	...
ARM_CLIENT_SECRET	Sensitive - write only SENSITIVE	...
ARM_TENANT_ID	2e3a33f9-66b1-4e2a-[REDACTED]	...

At the bottom left is a '+ Add variable' button.

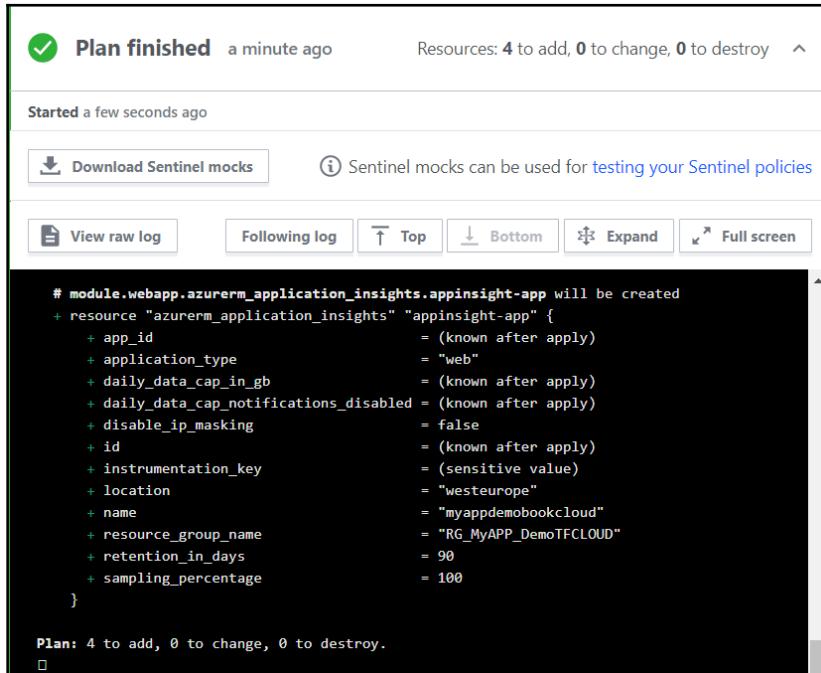
Now that we've configured our workspace, we can execute the Terraform configuration inside Terraform Cloud.

To run the Terraform configuration remotely in Terraform Cloud, perform the following steps:

1. To trigger the execution of the Terraform configuration, click on the **Queue plan** button, enter a reason for doing this, and confirm this by clicking on the **Queue plan** button:



2. Terraform Cloud will launch a new execution for this Terraform configuration. By running the `terraform plan` command, we will be able to see the logs for this execution:



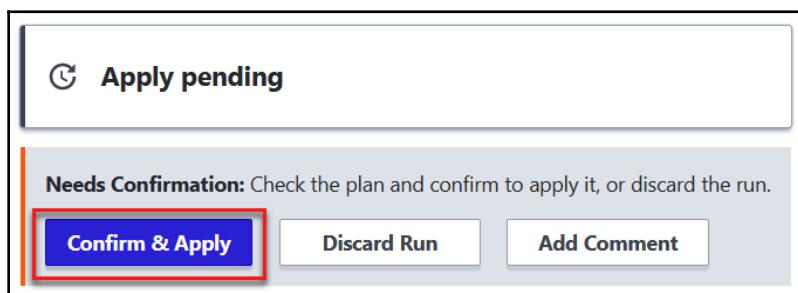
The screenshot shows a "Plan finished" message from Terraform Cloud. It indicates 4 resources to add, 0 to change, and 0 to destroy. The log output shows a Terraform plan for creating an Application Insights resource. The plan includes details like app\_id, application\_type, daily\_data\_cap\_in\_gb, and retention\_in\_days. A note about sentinel mocks is present. The log interface includes buttons for "View raw log", "Following log", "Top", "Bottom", "Expand", and "Full screen".

```
# module.webapp.azurerm_application_insights.appinsight-app will be created
+ resource "azurerm_application_insights" "appinsight-app" {
    + app_id                      = (known after apply)
    + application_type            = "web"
    + daily_data_cap_in_gb        = (known after apply)
    + daily_data_cap_notifications_disabled = (known after apply)
    + disable_ip_masking          = false
    + id                          = (known after apply)
    + instrumentation_key         = (sensitive value)
    + location                     = "westeurope"
    + name                        = "myappdemobookcloud"
    + resource_group_name          = "RG_MyAPP_DemoTFCLOUD"
    + retention_in_days           = 90
    + sampling_percentage          = 100
}

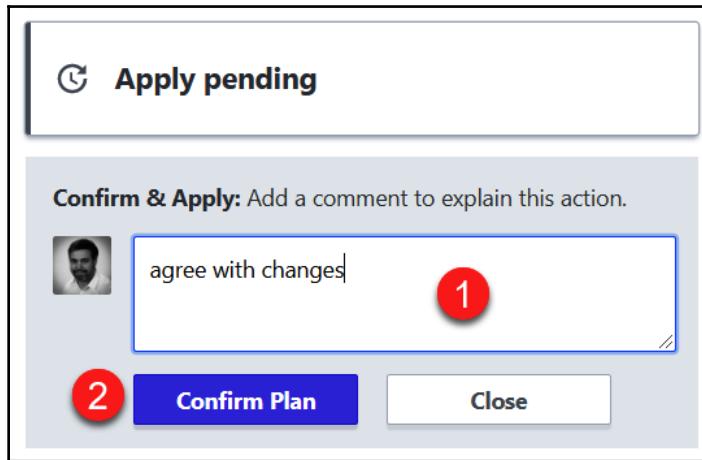
Plan: 4 to add, 0 to change, 0 to destroy.
```

After executing `plan`, Terraform Cloud expects the user to confirm this before the changes are applied.

3. If we agree to the preview changes, we can confirm these changes by clicking on the **Confirm & Apply** button:



Add some comments and click on the **Confirm Plan** button:



Once finished, the result of executing the plan will be provided:

A screenshot of the Terraform Cloud UI showing the results of a plan. The top bar indicates the plan is "APPLIED" and the name is "demo book queue plan".

- Plan finished** 2 hours ago Resources: 4 to add, 0 to change, 0 to destroy
- Apply finished** a few seconds ago Resources: 4 added, 0 changed, 0 destroyed
- MikaelKrief a few seconds ago  
agree

A green bar at the bottom says "Run confirmed". At the bottom of the page, there is a "Comment" section with a placeholder "Comment: Leave feedback or record a decision." and a "Add Comment" button.

## How it works...

In this recipe, we configured a workspace in Terraform Cloud in order to run a Terraform configuration that's in a GitHub repository directly in an instance managed by Terraform Cloud.

In the middle of this configuration, before executing the Terraform configuration, we performed the Azure environment variables configuration, which is an optional step and depends on the resources and cloud providers you wish to manage.

## There's more...

In this recipe, we learned how to run the `plan` and `apply` Terraform Cloud variables directly using the web interface of this platform. In the workspace settings, you can also configure whether you want to apply the plan manually (that is, with a confirmation, like in our recipe) or automatically. You can also choose the version of the Terraform binary you wish to use (by default, it uses the latest stable version that can be found at the time of the workspace's creation; beta versions are not taken into account):

The screenshot shows the Terraform Cloud workspace settings page. It includes sections for 'Apply Method' (with 'Manual apply' selected), 'Terraform Version' (set to 0.12.28), 'Terraform Working Directory' (set to CHAP08/remote/), and a 'Save settings' button.

**Apply Method**

Auto apply  
Automatically apply changes when a Terraform plan is successful. Plans that have no changes will not be applied. If this workspace is linked to version control, a push to the default branch of the linked repository will trigger a plan and apply.

Manual apply  
Require an operator to confirm the result of the Terraform plan before applying. If this workspace is linked to version control, a push to the default branch of the linked repository will only trigger a plan and then wait for confirmation.

**Terraform Version**

0.12.28

The version of Terraform to use for this workspace. Upon creating this workspace, the latest version was selected and will be used until it is changed manually. It will **not upgrade automatically**.

**Terraform Working Directory**

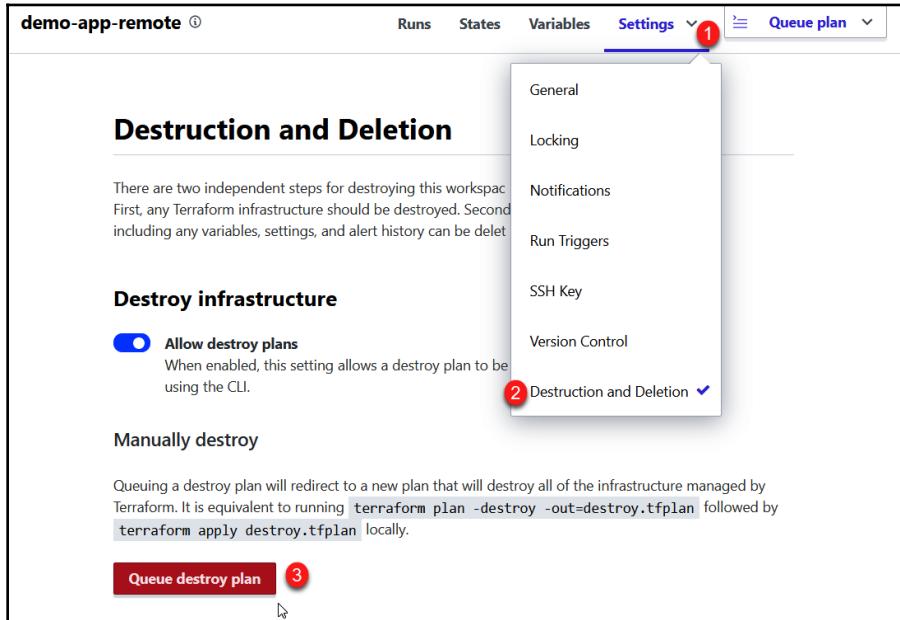
CHAP08/remote/

The directory to execute Terraform commands in. This defaults to the root of the configuration directory, but can be set to a subdirectory if you use a shared repository for multiple Terraform configurations.

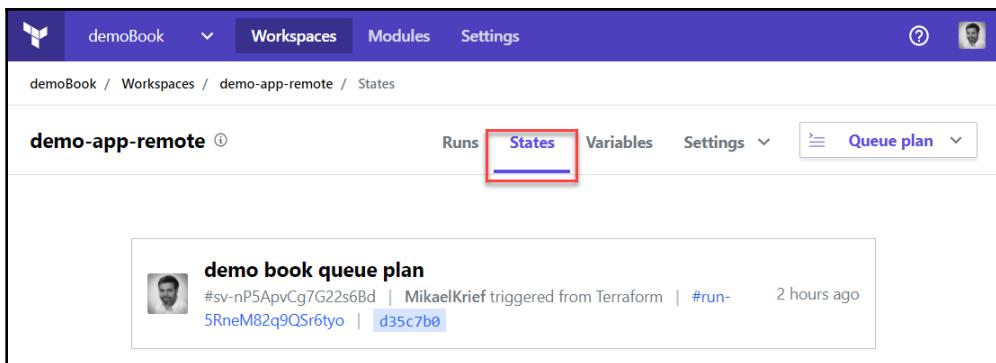
Terraform will change into the `CHAP08/remote/` directory prior to executing any operation.

**Save settings**

You can also destroy all the resources that have been provisioned using the **Destruction and Deletion** feature, which is accessible in the **Settings** | **Destruction and Deletion** menu, and then click on the **Queue destroy plan** button:



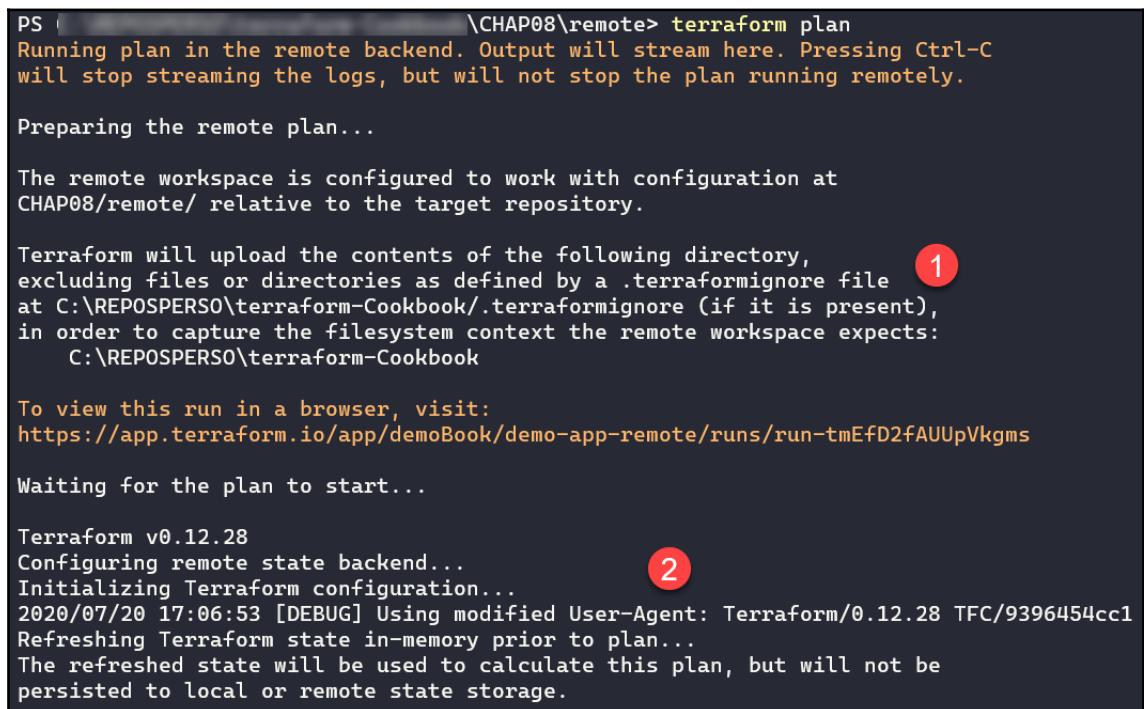
In addition, as you may have noticed, by running the Terraform configuration in Terraform Cloud using the UI, we did not need to configure the remote backend information for the state file, as we discussed in the *Using a remote backend in Terraform Cloud* recipe of this chapter. In our case, the configuration of the Terraform state file is integrated with the workspace. In the **States** tab, we'll notice the presence of the Terraform state file:



Moreover, if you are in a development context and want to check the development before committing to the repository, you can still use this remote mode of Terraform execution to make a plan. This is done by controlling this execution, which takes place in Terraform Cloud using your Terraform binary (or CLI). To do this, simply add the configuration of the remote backend, as in the *Using a remote backend in Terraform Cloud* recipe of this chapter, by using the name of the workspace we created in the first step of that recipe, which corresponds to the following code:

```
terraform {  
  backend "remote" {  
    hostname      = "app.terraform.io"  
    organization = "demoBook"  
  
    workspaces {  
      name = "demo-app-remote"  
    }  
  }  
}
```

Then, on the development station, execute the `terraform plan` command, as shown in the following screenshot:



```
PS C:\REPOSPERSO\CHAP08\remote> terraform plan  
Running plan in the remote backend. Output will stream here. Pressing Ctrl-C  
will stop streaming the logs, but will not stop the plan running remotely.  
  
Preparing the remote plan...  
  
The remote workspace is configured to work with configuration at  
CHAP08/remote/ relative to the target repository.  
  
Terraform will upload the contents of the following directory,  
excluding files or directories as defined by a .terraformignore file ①  
at C:\REPOSPERSO\terraform-Cookbook/.terraformignore (if it is present),  
in order to capture the filesystem context the remote workspace expects:  
C:\REPOSPERSO\terraform-Cookbook  
  
To view this run in a browser, visit:  
https://app.terraform.io/app/demoBook/demo-app-remote/runs/run-tmEfD2fAUUpVkgms  
  
Waiting for the plan to start...  
  
Terraform v0.12.28  
Configuring remote state backend... ②  
Initializing Terraform configuration...  
2020/07/20 17:06:53 [DEBUG] Using modified User-Agent: Terraform/0.12.28 TFC/9396454cc1  
Refreshing Terraform state in-memory prior to plan...  
The refreshed state will be used to calculate this plan, but will not be  
persisted to local or remote state storage.
```

During this execution, your Terraform CLI will create a configuration package and upload it to the Terraform Cloud workspace. The CLI triggers the Terraform Cloud CLI to run Terraform on the uploaded package. Finally, the output of the `plan` command is also available in the command-line terminal. Please also note that, in this case, you do not need to set the environment variables locally since they are already configured in the workspace.



In order to ensure that the changes are applied in one place, you can't run the `terraform apply` command on a workspace that is connected to a VCS. However, if your workspace is not connected to a VCS, then you can also execute the `apply` command from your local CLI.

Finally, if your Terraform configuration includes the provisioning `local-exec` (which we studied in the *Executing local programs with Terraform* recipe in Chapter 2, *Writing Terraform Configuration*) and, in its command, it uses a third-party tool, you will have to ensure that this tool is already present or installed on the Terraform Cloud agent, which will execute the Terraform binary. For more information about additional third-party tools in the execution of Terraform Cloud, I recommend reading the documentation available at <https://www.terraform.io/docs/cloud/run/install-software.html>.

## See also

- The documentation on remote execution in Terraform Cloud is available here: <https://www.terraform.io/docs/cloud/run/index.html>.
- The documentation on using the CLI with remote execution is available here: <https://www.terraform.io/docs/cloud/run/cli.html>.

## Automating Terraform Cloud using APIs

In the previous recipes, we learned how to use the Terraform Cloud platform to store Terraform state files in a remote backend. Then, we used Terraform Cloud as a private registry of modules and learned how to run Terraform configurations remotely in Terraform Cloud.

All these actions were mainly done via the Terraform Cloud UI web interface. In the *There's more...* section of the previous recipe, we discussed that it is also possible to use the Terraform CLI locally to run Terraform remotely.

In a company, we need to automate all of these actions for the following reasons:

- The use of the UI is ergonomic but requires a lot of manual actions, which, with many projects, can be very time- and resource-consuming.
- In Terraform Cloud, the execution workflow in remote mode is fixed with the execution of the `plan` command, as well as the application. It isn't possible to add other actions (which we have studied in this book) such as the execution of integration tests upstream. Due to this, it isn't possible to customize the workflow with the business needs of the company.

Due to the need for automation and customization, HashiCorp has published APIs that allow Terraform Cloud to be managed as it should be with the UI.

In this recipe, we will look at automating the actions of Terraform Cloud using its APIs.

## Getting ready

Before starting, it is good to recall the Terraform Cloud workflow, which is as follows:

- Write the Terraform configuration, then commit it to a VCS repository (such as Git).
- In Terraform Cloud, the workspace retrieves this Terraform configuration and executes the dry run using the `terraform plan` command.
- In manual mode, if the user confirms the plan, Terraform Cloud triggers the application and applies the changes to the infrastructure.
- In automatic mode (auto-apply), the changes are applied automatically after the `plan` command has been issued.

In this recipe, we will use the same scenario and Terraform configuration that we used for the previous recipe, except we will use scripts that call the Terraform Cloud APIs.

As a prerequisite, however, you will need to create an API token in your Terraform Cloud user account settings. This will be used for authentication:

The screenshot shows the Terraform Cloud user settings interface. On the left, there's a sidebar with 'USER SETTINGS' containing links for Profile, Organizations, Password, Two Factor Authentication, and Tokens (which is highlighted with a red circle labeled '3'). The main content area is titled 'Tokens'. It explains that API tokens can be used to access the Terraform Cloud API and lists tokens for the user. One token, 'demoBook', is shown with details: Last used 15 minutes ago, Created an hour ago by user MikaelKrief, and a delete icon (red circle labeled '5'). A 'Create an API token' button is also present (red circle labeled '4'). On the right, a vertical sidebar shows the user is signed in as 'MikaelKrief' with a profile icon, and includes links for Getting Started, User Settings (highlighted with a red circle labeled '2'), and Log Out.

A run is triggered via an API by using a user API token, not an organization token.

In regard to the scripting language used in this recipe, we will use PowerShell. However, you can adapt this and make use of your usual programming languages (shell, Python, C#, and so on).

The source code for this recipe is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP08/api>.

## How to do it...

To automate Terraform Cloud with an API, perform the following steps inside a new folder:

1. Create a JSON file named `workspace.json`. This will contain the definition of the workspace we will be creating. Insert the following content:

```
{  
  "data": {  
    "attributes": {  
      "name": "workspace-demo-api",  
      "auto-apply": true,  
    }  
  }  
}
```

```
        "working-directory": "CHAP08/remote",
        "vcs-repo": {
            "identifier": "mikaelkrief/terraform-Cookbook",
            "oauth-token-id": "ot-Jxxxxxxxxxx",
            "branch": "",
            "default-branch": true,
            "queue-all-runs": true
        }
    },
    "type": "workspaces"
}
}
```



To understand how to get `oauth-token-id`, read the documentation available at <https://www.terraform.io/docs/cloud/api/oauth-tokens.html>.

2. Create a PowerShell script called `tfcloud-workspaces.ps1` that contains the following content:

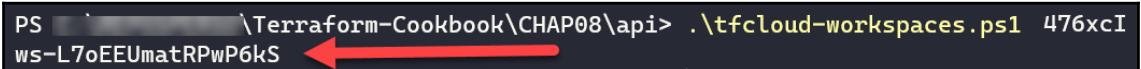
```
$apiToken = $args[0] #API TOKEN
$organization = "demoBook"
$headers = @{
    "Authorization" = "Bearer $apiToken"
    "Content-Type" = "application/vnd.api+json"
}
$uriWorkspaces =
"https://app.terraform.io/api/v2/organizations/$organization/workspaces"
try
{
    $json = Get-Content ("workspace.json")
    $response = Invoke-RestMethod -Uri $uriWorkspaces -Body $json -
    Headers $headers -Method Post
    $workspaceId = $response.data.id
    Write-Host $workspaceId
}
Catch
{
    ...
}
```

The complete source code of this script is available at <https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP08/api/tfcloud-workspaces.ps1>.

3. In a PowerShell terminal, run the following command to create a workspace:

```
.\tfcloud-workspaces.ps1 <your api token>
```

At the end of this execution, the script will display the ID for the created workspace:



```
PS C:\Terraform-Cookbook\CHAP08\api> .\tfcloud-workspaces.ps1 476xcI  
ws-L7oEEUmatRPwP6kS
```

4. Create another JSON file called `variables.json` that will contain the definition of the environment variables to create. Insert the following content:

```
{  
    "vars": [  
        {  
            "data": {  
                "type": "vars",  
                "attributes": {  
                    "key": "ARM_SUBSCRIPTION_ID",  
                    "value": "xxxxxx-xxxxxx-xxxxxx-xxxxxx",  
                    "category": "env",  
                    ....  
                }  
            }  
        },  
        ....  
    ]  
}
```

The complete source code for this JSON script is available at <https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP08/api/variables.json>.

5. Create a PowerShell script called `tfcloud-variables.ps1` that contains the following content:

```
$apiToken = $args[0] #API TOKEN  
$workspaceId = $args[1] # WORKSPACE ID  
$headers = @{}  
$headers["Authorization"] = "Bearer $apiToken"  
$headers["Content-Type"] = "application/vnd.api+json"  
$uriVariables =  
    "https://app.terraform.io/api/v2/workspaces/$workspaceId/vars"  
  
$json = Get-Content("variables.json") | ConvertFrom-Json
```

```
$varList = $json.vars
foreach ($var in $varList)
{
    $varjson = $var | ConvertTo-Json
    Invoke-RestMethod -Uri $uriVariables -Body $varjson -Headers
$headers -Method Post
}
```

The complete source code for this script is available at <https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP08/api/tfcloud-variables.ps1>.

6. In PowerShell, run the preceding script to create environment variables in the workspaces we've created with the following command:

```
.\tfcloud-variables.ps1 <your token id> <workspace id>
```

7. To trigger a new execution of the Terraform configuration, create a JSON file called `run.json` that contains the definition of the queue. Add the following content:

```
{
  "data": {
    "attributes": {
      "is-destroy": false,
      "message": "Run for demo Book"
    },
    "type": "runs",
    "relationships": {
      "workspace": {
        "data": {
          "type": "workspaces",
          "id": "ws-xxxxxxxxxxxx"
        }
      }
    }
  }
}
```

8. Create a PowerShell script called `tfcloud-run.ps1` that contains the following content:

```
$apiToken = $args[0] #API TOKEN
$headers = @{}
$headers["Authorization"] = "Bearer $apiToken"
$headers["Content-Type"] = "application/vnd.api+json"
$uriWorkspaces = "https://app.terraform.io/api/v2/runs"
```

```
$json = Get-Content("run.json")
Invoke-RestMethod -Uri $uriWorkspaces -Body $json -Headers $headers
-Method Post
```

9. In PowerShell, run the following command to queue a new Terraform run:

```
.\tfcloud-run-plan.ps1 <your token api>
```

## How it works...

In this recipe, we automated the implementation of a Terraform workflow in three steps, as follows:

1. Creating and configuring a workspace
2. Creating environment variables in this workspace
3. Triggering a Terraform `run` in the Terraform configuration defined in this workspace

From *steps 1 to 3*, we used the API to create a workspace. To do this, we created a file called `workspace.json` that contains the body (payload) that will be sent as a parameter to the API. In this file, we defined the following properties:

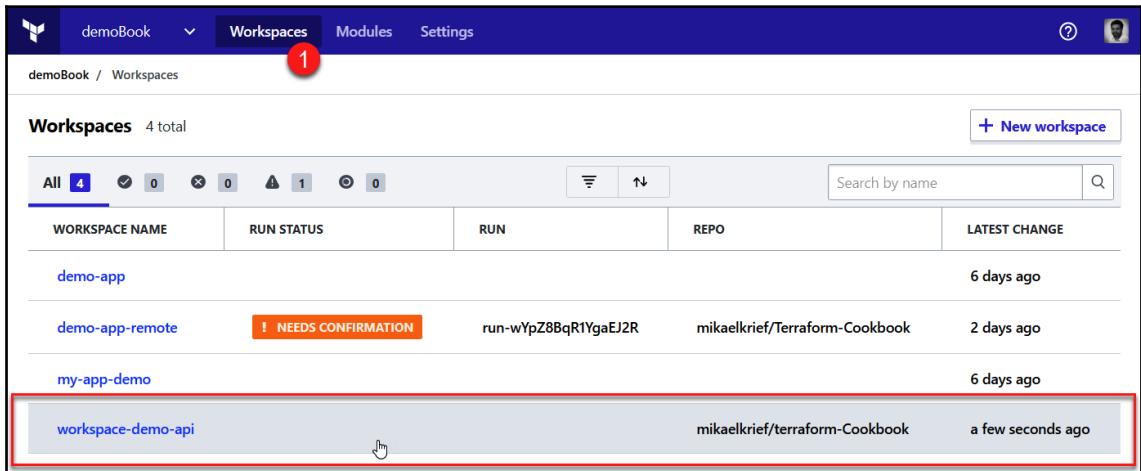
- `name`: The name of the workspace to create.
- `working-directory`: The directory of the repository that contains the Terraform configuration.
- `auto-apply`: This indicates that the runs will be done automatically after the `plan`, without the user having to review this plan (optional property).
- `vcs-repo`: This block contains information about the VCS provider we configured in the organization, which is detailed here: <https://www.terraform.io/docs/cloud/vcs/index.html>. The `oauth-token-id` property is obtained either by the VCS provider's screen or via an API, as detailed here: <https://www.terraform.io/docs/cloud/api/oauth-clients.html>.

Then, we wrote and executed the PowerShell script that calls the workspace creation API. In this script, we defined the user's API token and the name of the organization as a variable before calling the workspace creation API.



The documentation for the workspace API is available here: <https://www.terraform.io/docs/cloud/api/workspaces.html>.

At the end of its execution, this script displays the ID of the created workspace, which will have to be preserved so that we can continue making API calls. In the web interface of Terraform Cloud, we will be able to view this new workspace:



The screenshot shows the Terraform Cloud interface with the 'demoBook' organization selected. The 'Workspaces' tab is active, indicated by a red circle with the number '1'. The page displays four workspaces:

WORKSPACE NAME	RUN STATUS	RUN	REPO	LATEST CHANGE
demo-app				6 days ago
demo-app-remote	NEEDS CONFIRMATION	run-wYpZ8BqR1YgaEJ2R	mikaelkrief/Terraform-Cookbook	2 days ago
my-app-demo				6 days ago
workspace-demo-api			mikaelkrief/terraform-Cookbook	a few seconds ago

Then, from *steps 4 to 6*, we used the API to create the environment variables in this new workspace. To do this, we created a `variables.json` file that contains the four variables of the Azure Service Principal, as well as their body, which will be processed so that the API parameters for its payload are sent to the API. In this file, we defined the following properties for each of the variables:

- name
- value
- category: env (to define it as an environment variable)

Then, we wrote and executed the PowerShell script that calls the workspace creation API for each of these variables.

In this recipe, we created these four environment variables because the Terraform configuration we used as an example manages an Azure infrastructure. This step is optional if you don't need environment variables.



In addition, the documentation for the variables API is available at <https://www.terraform.io/docs/cloud/api/workspace-variables.html>.

At the end of its execution, in the Terraform Cloud UI, we will be able to see the new variable environments:

The screenshot shows the Terraform Cloud UI with the following details:

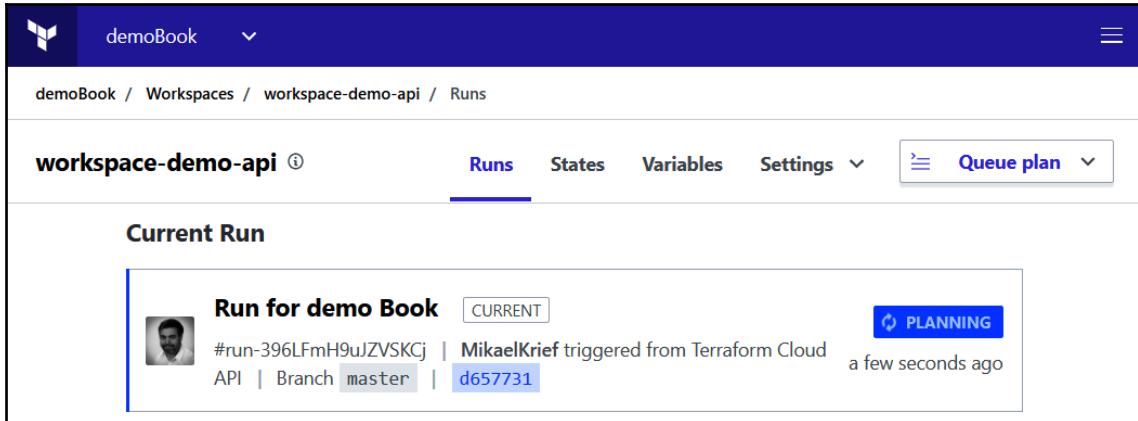
- Header:** demoBook / Workspaces / workspace-demo-api / Variables
- Page Title:** workspace-demo-api
- Navigation:** Runs, States, **Variables**, Settings, Queue plan
- Section:** Variables
- Environment Variables:** A table listing variables set in Terraform's shell environment using `export`.

Key	Value	...
ARM_SUBSCRIPTION_ID	8a7aace5-74aa-416f [REDACTED]	...
ARM_CLIENT_ID	282936c6-298d-40bc [REDACTED]	...
ARM_CLIENT_SECRET	Sensitive - write only The Service Principal Client Secret	...
ARM_TENANT_ID	2e3a33f9-66b1-4e2c [REDACTED]	...
- Add Variable:** A button labeled "+ Add variable".

Finally, in *steps 7 to 9*, we used the API to trigger a run – that is, the execution of the Terraform configuration we defined in the workspace (in the VCS). To do this, we created a file called `run.json` that will also be used as a payload for the API. This contains the following properties:

- `message`: Message about the run
- `workspace.id`: Workspace ID

Then, we wrote and executed the PowerShell script that calls the `run` trigger API. At the end of its execution, we saw that the execution of Terraform is triggered in Terraform Cloud, as shown in the following screenshot:

A screenshot of the Terraform Cloud interface. The top navigation bar shows "demoBook" and a dropdown menu. Below it, the breadcrumb navigation shows "demoBook / Workspaces / workspace-demo-api / Runs". The main content area has a title "workspace-demo-api" with a help icon, followed by tabs for "Runs" (which is selected), "States", "Variables", and "Settings". To the right of these tabs is a "Queue plan" button with a three-line icon. The "Runs" section is titled "Current Run". It displays a single run card for "#run-396LFmH9uJZVSKCj" triggered by "MikaelKrief" from "Terraform Cloud API" on the "master" branch. The status of the run is "CURRENT". To the right of the run card is a "PLANNING" button with a circular arrow icon. The timestamp "a few seconds ago" is also visible.

By using the `auto-apply` property of the workspace, `terraform apply` will complete automatically, without requiring manual configuration by the user.

## There's more...

In this recipe, we looked at the simple and basic use of the Terraform cloud APIs. As always, there are many other scenarios in which we can use them.



Remember to protect the API token and any Azure or similar tokens by not putting them in clear text in your scripts.

Furthermore, to stay in an IaC context, instead of using the APIs directly, you can use the Terraform configuration with the **Terraform Enterprise provider**, which is documented here: <https://www.terraform.io/docs/providers/tfe/index.html>. It is also recommended by HashiCorp for Terraform Cloud administration purposes. You can find more information about this at <https://www.terraform.io/docs/cloud/api/index.html> (first note).

## See also

- The documentation about the various Terraform Cloud APIs is available here: <https://www.terraform.io/docs/cloud/api/index.html>.
- The following is a video demonstration on the use of Terraform Cloud/Enterprise APIs: <https://www.hashicorp.com/resources/demystifying-the-terraform-enterprise-api/>.

# Testing the compliance of Terraform configurations using Sentinel

The aspect of Terraform configuration tests has been discussed several times in this book, such as using `terratest` (in the *Testing Terraform module code with Terratest recipe* of Chapter 5, *Provisioning Azure Infrastructure with Terraform*) and `kitchen-terraform` (in the *Testing Terraform configuration using kitchen-terraform* recipe of Chapter 7, *Deep Diving into Terraform*). The common point of these two tools is that the purpose of the tests is to write and test the changes that have already been applied by Terraform.

All these tests are very beneficial but they are done after the changes have been made. The rollback also requires work from all teams. To be even more in line with the business and financial requirements of the company, there is another level of testing that verifies the compliance of the Terraform configuration before it is applied to the target infrastructure.

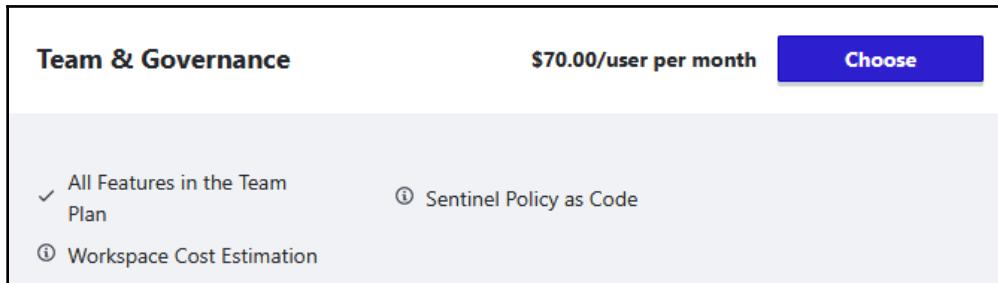
In Terraform, these compliance tests are carried out after the `terraform plan` command is executed. They verify that the result of the `plan` command corresponds to the rules described in the tests. Only if these tests have passed can the `terraform apply` command be executed.

Among the tools and frameworks for compliance testing, Terraform Cloud offers, in its paid plan, the `stack`, which allows us to write tests using the **Sentinel** framework and execute them directly in Terraform Cloud by using the `run` command between `plan` and `apply`.

In this recipe, we will study a simple case of writing compliance tests and executing them in Terraform Cloud.

## Getting ready

The essential requirement for this recipe is to have a Terraform Cloud paid plan. We will be using **Team & Governance**:



If you have the free plan, you can try all the features of the paid plan for 30 days by activating your free trial:

A screenshot of the Terraform Cloud 'Plan & Billing' page. The top navigation bar includes 'demoBook', 'Workspaces', 'Modules', 'Settings' (with a red circle containing the number 1), and a user profile. The left sidebar shows organization settings and lists 'demoBook' under 'General'. Under 'Plan & Billing', 'Plan & Billing' is selected (marked with a red circle containing the number 2). The main content area is titled 'Plan & Billing' and features a blue box with the text 'Start your free trial' and 'This organization is eligible for a 30 day free trial of Terraform Cloud's paid features. Click here to get started' (marked with a red circle containing the number 3). Below this is a 'Current Plan' section showing 'Free with 1 active user' and '\$0.00 / month'. There are 'View plan comparison' and 'Change plan' buttons.

Documentation about the plans, prices, and features is available here: <https://www.terraform.io/docs/cloud/paid.html>.

The Terraform configuration that we will be using has already been discussed and is available at <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP08/remote>. This configuration will create a Resource Group, a Service Plan, and an Azure App Service.

In addition, to use the code written in this recipe in your organization, you need to create a fork of the original repository of this book (<https://github.com/PacktPublishing/Terraform-Cookbook>).

The goal of this recipe is to write the rules, as part of policy sets, that will test the following:

- That the FTP mode for the App Service is configured only with FTPS mode.
- That the Service Plan that will be provisioned to an SKU tier type is either Basic or Standard. This rule prohibits the provisioning of Premium or Premium v2 Service Plan.

Then, we will learn how to apply these policy sets during the execution of Terraform Cloud.

To write these policies, we will use **Sentinel**, which is a test framework provided by HashiCorp. Its documentation is available at <https://www.hashicorp.com/resources/writing-and-testing-sentinel-policies-for-terraform/>.



The purpose of this recipe is not to study all the elements for writing policies (the preceding guide can be used for that). Here, we will be writing some simple code that you can easily reproduce.

Finally, the demo-app-remote workspace must be created and configured in Terraform Cloud, as described in the *Executing Terraform configuration remotely in Terraform Cloud* recipe of this chapter.

The source code for this recipe is available here: <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP08/sentinel-policies>.

## How to do it...

To complete this recipe, we will do three things:

1. Write the policy rules
2. Configure the organization in order to integrate these policies
3. Run the Terraform configuration with these policies

We start by writing the compliance policies, as follows:

The code we will be writing in this part can be in the same repository where the configuration to be tested is located. Alternatively, if its policies are shared, then this code can be put in another repository.



It is still a good practice to put these policies in a separate repository so that you don't mix the Terraform configuration commits of the policy. Another reason to do this would be that this separate repository could be managed by another team (such as ops or security).

In this recipe, for simplicity, we will write our code in the repository that contains the Terraform configuration, which has already been integrated into the VCS providers of our organization.

1. Inside a new folder, `sentinel-policies`, create a new file called `restrict-app-service-to-ftps.sentinel` to test the FTP mode of the App Service instance. Use the following code to do so:

```
import "tfplan-functions" as plan

allAzureAppServices = plan.find_resources("azurerm_app_service")

violatingAzureAppServices =
  plan.filter_attribute_is_not_value(allAzureAppServices,
    "site_config.0.ftps_state", "FtpsOnly"
  , true)

main = rule {
  length(violatingAzureAppServices["messages"]) is 0
}
```

The complete source code for this file is available here: <https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP08/sentinel-policies/restrict-app-service-to-ftps.sentinel>.

2. Create a new file called `allowed-app-service-plan-tiers.sentinel` to test the type of Service Plan SKU. Ensure it contains the following content:

```
import "tfplan-functions" as plan

allowed_tiers = ["Basic", "Standard"]

allAzureServicePlan =
  plan.find_resources("azurerm_app_service_plan")
```

```
violatingAzureServicePlan =
plan.filter_attribute_not_in_list(allAzureServicePlan,
"sku.0.tier", allowed_tiers, true)

main = rule {
  length(violatingAzureServicePlan["messages"]) is 0
}
```

The complete source code for this file (with comments) is available here: <https://github.com/PacktPublishing/Terraform-Cookbook/blob/master/CHAP08/sentinel-policies/allowed-app-service-plan-tiers.sentinel>.

3. Create a new file called `sentinel.hcl`. This will be the entry point for the tests and references of the two preceding policies. Add the following content:

```
module "tfplan-functions" {
  source =
  "https://raw.githubusercontent.com/hashicorp/terraform-guides/master/governance/third-generation/common-functions/tfplan-functions/tfplan-functions.sentinel"
}

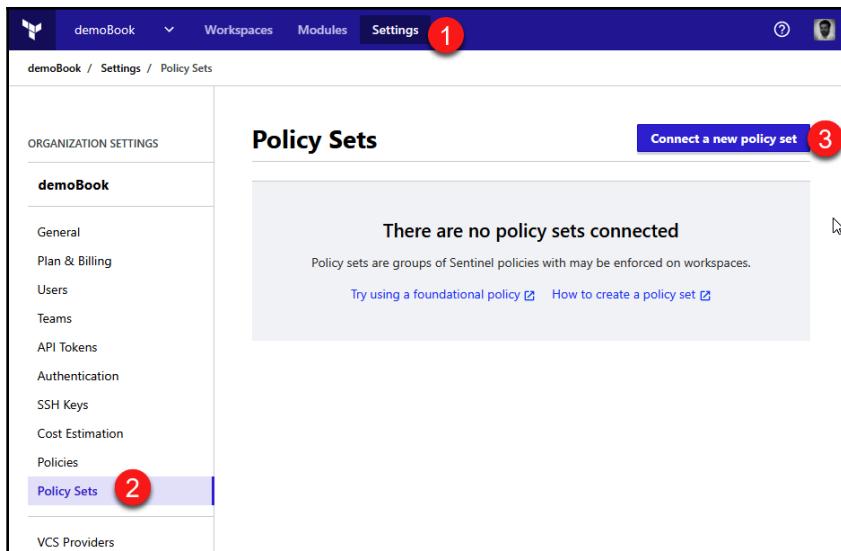
policy "restrict-app-service-to-ftps"{
  source ="./restrict-app-service-to-ftps.sentinel"
  enforcement_level = "hard-mandatory"
}

policy "allowed-app-service-plan-tiers"{
  source ="./allowed-app-service-plan-tiers.sentinel"
  enforcement_level = "hard-mandatory"
}
```

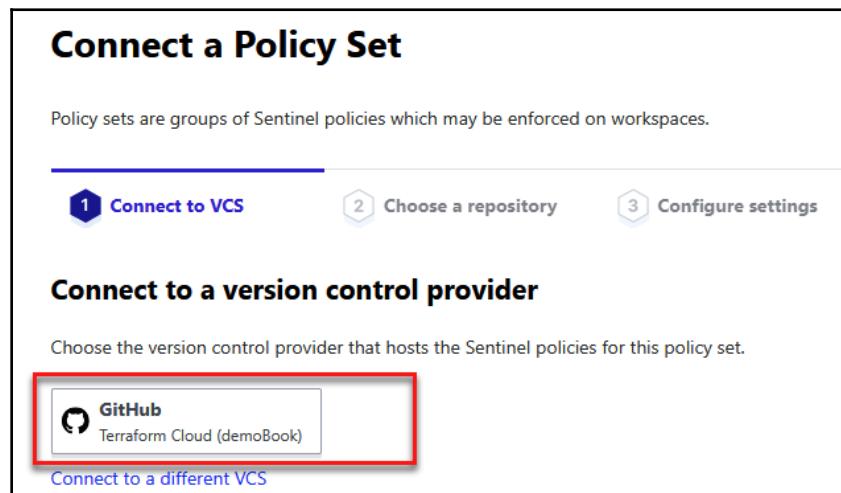
4. Commit and push all the files into the remote repository.

For the second phase, we need to configure **Policy Sets** in our Terraform Cloud organization:

1. In your organization **Settings**, go to the **Policy Sets** tab and click on the **Connect a new policy set** button:



2. In the first step of the wizard, choose the VCS provider that contains the code for the policies we just wrote:



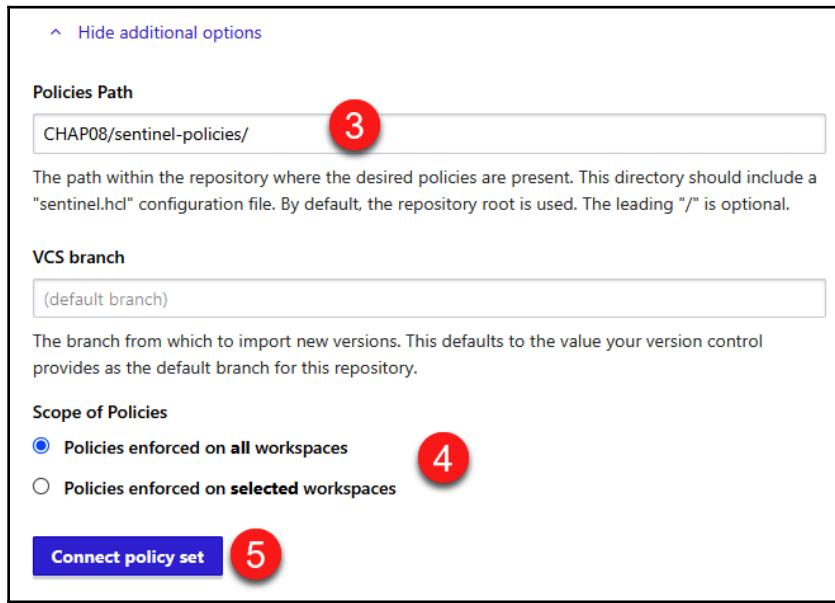
3. In the second step, select the repository that contains the policy's code:

The screenshot shows the 'Choose a repository' step of a three-step wizard. The steps are labeled: 1 Connect to VCS, 2 Choose a repository (which is active), and 3 Configure settings. The title 'Choose a repository' is bolded. A sub-instruction says: 'Choose the repository that hosts your Terraform source code. We'll watch this for commits and pull requests.' Below this, a search bar shows 'Terraform-Cookbook'. A list of repositories shows '1 repository of 84 total' and 'mikaelkrief/Terraform-Cookbook'. A red arrow points to the repository name 'mikaelkrief/Terraform-Cookbook'.

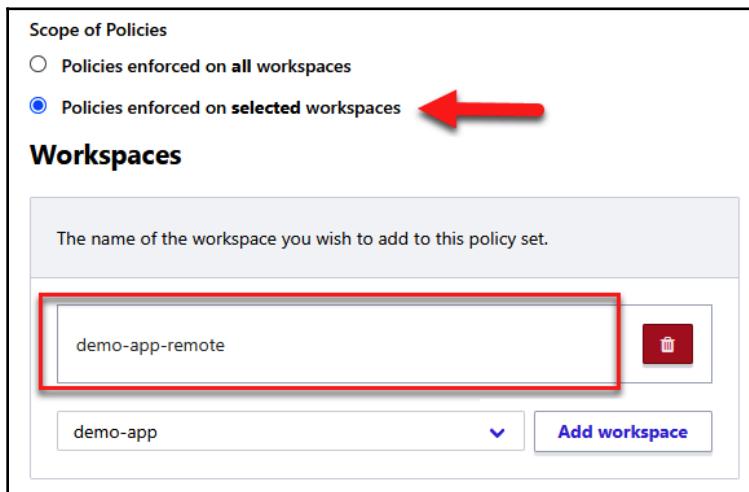
4. In the last step of the wizard, configure the policy set by adding **Name** and **Description** details, as shown in the following screenshot:

The screenshot shows the 'Configure settings' step of the wizard. The left sidebar has a 'Policy Sets' tab selected. The main area shows a description of policy sets and three step icons: 1 Connect to VCS, 2 Choose a repository (which is active), and 3 Configure settings. The 'Configure settings' section has fields for 'Name' (containing 'Demo\_Policies') and 'Description' (containing 'policies check the Terraform version and the Service plan SKU'). Red circles numbered 1 and 2 point to the 'Name' field and the 'Description' field respectively.

Under **Additional options**, specify the folder that contains the code policies and the target workspace that will use these policies:



The following screenshot shows the workspaces you need to choose in order to use the policy set:



5. Click on the **Connect policy set** button to create the policy sets.

Now, we can run the Terraform configuration in Terraform Cloud and check the policies:

1. In the demo-app-remote workspace we created in the *Executing Terraform configuration remotely in Terraform Cloud* recipe of this chapter, we will queue a new Terraform run.
2. In the results of this run, we will be able to see the policy check's result:

The screenshot shows a Terraform Cloud run summary. At the top, a red banner says "! NEEDS CONFIRMATION". Below it, the title "Queued manually in Terraform C..." is followed by a "CURRENT" button. The run was triggered by "MikaelKrief" a few seconds ago. The status bar indicates "Plan finished" 2 minutes ago with 4 resources to add, 0 to change, and 0 to destroy. The policy check passed with 2 policies passed and 0 failed. The history shows it was queued a minute ago and then passed a minute ago. Two specific policies are listed as passed: "Demo\_Policies/allowed-app-service-plan-tiers" and "Demo\_Policies/restrict-app-service-to-ftps".

3. If the policy check is successful, apply the changes by clicking the **Confirm & Apply** button:

The screenshot shows the same Terraform Cloud run summary as before, but with a different outcome. The status bar now says "Apply pending". A message at the bottom states "Needs Confirmation: Check the plan and confirm to apply it, or discard the run." Below this are three buttons: "Confirm & Apply" (highlighted in blue), "Discard Run", and "Add Comment".

## How it works...

In the first part of this recipe, we wrote the compliance tests so that we could test our Terraform configuration using **Sentinel**.

In the `restrict-app-service-to-ftps.sentinel` file, by writing the `import "tfplan-functions"` as `plan` line, we imported a Sentinel function library, which is available at <https://github.com/hashicorp/terraform-guides/tree/master/governance/third-generation/common-functions/tfplan-functions>. The lines after that line search for all `azurerm_app_service` resources in the `terraform plan` command and check that the FTPS state is configured to FTPS only:

```
allAzureAppServices = plan.find_resources("azurerm_app_service")
violatingAzureAppServices = plan.filter_attribute_is_not_value(
    allAzureAppServices,
    "site_config.0.ftps_state",
    "FtpsOnly" , true)
```

This is the call point of the test and sends a message in the event of an error with a non-compliant FTPS state.

In the second file, `allowed-app-service-plan-tiers.sentinel`, we wrote the `allowed_tiers = ["Basic", "Standard"]` line to create a list of SKUs that are allowed for the Service Plan. The lines search for all `azurerm_service_plan` resources in `terraform plan` and check that the SKU is in the list we declared previously:

```
allAzureServicePlan = plan.find_resources("azurerm_app_service_plan")

violatingAzureServicePlan =
  plan.filter_attribute_not_in_list(allAzureServicePlan,
    "sku.0.tier", allowed_tiers, true)
```

This is the call point of the test and sends a message in the event of an error with a non-compliant SKU.

The third file we wrote, `sentinel.hcl`, is the entry point for the test file. We used a module that imports the custom library and the declaration of the two policies that refer to the two files we wrote earlier.



Other examples of Sentinel tests are available here: <https://github.com/hashicorp/terraform-guides/tree/master/governance/third-generation>.

Then, in the second part of this recipe, we configured the policy sets in our Terraform Cloud organization by selecting the repository that contains the Sentinel code and selecting the workspaces that these policies will apply to.

Finally, once the tests had been written and the configuration of the policy sets had been carried out, we triggered a Terraform `run` (in remote mode) on the workspace we selected in the policy sets and the result of the poster with successful compliance tests.

## There's more...

After completing this recipe, all the tests passed successfully, but what is interesting is testing their functionality by testing a case where they fail. To do this, we need to sufficiently modify the Terraform configuration that is used in the workspace by modifying the SKU type of the Service Plan, as follows:

```
module "webapp" {
  source           = "app.terraform.io/demoBook/webapp/azurerm"
  version         = "1.0.4"
  ...
  sp_sku          = "Premium"
}
```

This SKU takes a Premium value that was prohibited in the list of SKUs allowed in the tests. Then, we execute `run`. During its execution, we get the following result:

The screenshot shows a Terraform Cloud plan execution interface. At the top, a green checkmark indicates "Plan finished a few seconds ago". To the right, it says "Resources: 4 to add, 0 to change, 0 to destroy". Below this, a red arrow points to a red X icon next to the message "Policy check hard failed a few seconds ago". Another red arrow points to the "failed" status of the policy "Demo\_Policies/allowed-app-service-plan-tiers". A red box highlights the error log section, which contains the following text:

```
to false. This false was not due to an undefined value or runtime error.  
2 policies evaluated.  
## Policy 1: Demo_Policies/allowed-app-service-plan-tiers (hard-mandatory)  
Result: false  
Description:  
This policy uses the Sentinel tfplan/v2 import to require that all Azure Service plan have tier SKU from an allowed list  
Print messages:  
module.webapp.azurerm_app_service_plan.plan-app has sku.0.tier with value Premium that is not in the allowed list: [Basic, Standard]  
FALSE - ./allowed-app-service-plan-tiers.sentinel:21:1 - Rule "main"  
## Policy 2: Demo_Policies/allowed-terraform-version (soft-mandatory)  
Result: true
```

At the bottom, a red arrow points to the message "Apply will not run".

As we can see, the compliance tests failed after the `terraform plan` command was run and the implementation of the changes is refused.

As far as blocking the application is concerned, this is configured in the `sentinel.hcl` file with the `enforcement_level = "hard-mandatory"` property for each policy. To find out more about the values of this property and their implication, read the documentation at <https://docs.hashicorp.com/sentinel/concepts/enforcement-levels/> and here <https://www.terraform.io/docs/cloud/sentinel/manage-policies.html>.

## See also

- The code for Sentinel functions is available here: <https://github.com/hashicorp/terraform-guides/tree/master/governance/third-generation>.
- The documentation on how to install the Sentinel CLI is available at <https://docs.hashicorp.com/sentinel/intro/getting-started/install/>.
- The guide to writing and installing policies is available here: <https://www.hashicorp.com/resources/writing-and-testing-sentinel-policies-for-terraform/>.
- The basic learning guide for policies is available here: <https://learn.hashicorp.com/terraform/cloud-getting-started/enforce-policies>.
- Read this article to learn more about the use of Sentinel: <https://medium.com/hashicorp-engineering/using-new-sentinel-features-in-terraform-cloud-11ade728cbb0>.
- The following is a video that demonstrates policy testing: <https://www.hashicorp.com/resources/testing-terraform-sentinel-policies-using-mocks/>.
- There are other tools we can use to write and execute Terraform compliance configuration, such as *terraform-compliance* (<https://github.com/eerkunt/terraform-compliance>) and *Open Policy Agent* (<https://www.openpolicyagent.org/docs/latest/terraform/>). They are both free and open source, but beware: they can't be used in a Terraform Cloud execution.

## Using cost estimation for cloud cost resources governance

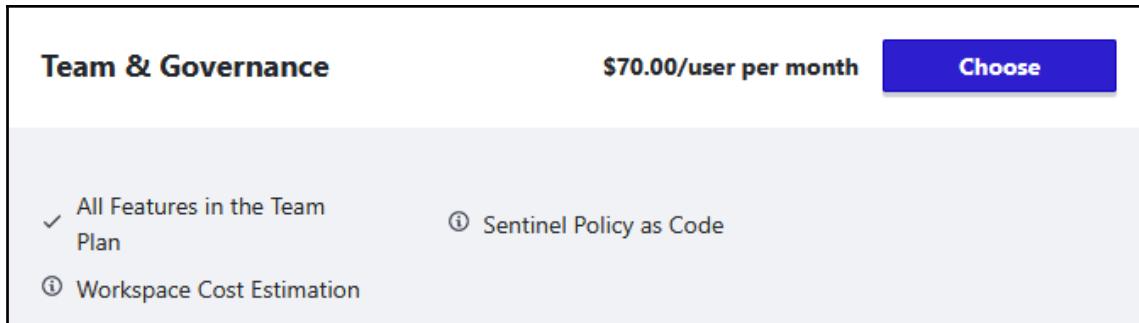
When we create resources in a cloud architecture, we often tend to forget that this incurs a financial cost that depends on the types of resources that are created. This is even more true with automation and IaC, which allow us to create a multitude of resources using a few commands.

One of the interesting features of the version of Terraform Cloud that's integrated into the paid plan is cost estimation, which makes it possible to visualize the cost of the resources that are handled in the Terraform configuration while it's being run.

In this recipe, we will learn how to use cost estimation in Terraform Cloud.

## Getting ready

Before you start this recipe, you must have a paid Terraform Cloud plan or activate the free trial (for a 30-day duration):



After doing this, you need to get to know the cloud providers and the resources that are supported by the cost management functionality. This list is available at <https://www.terraform.io/docs/cloud/cost-estimation/index.html#supported-resources>.

The purpose of this recipe is to provision a virtual machine in Azure with Terraform and to visualize the cost estimation of this resource in the Terraform Cloud interface.

The source code for the Terraform configuration that will be executed in this recipe is available here: <https://github.com/PacktPublishing/Terraform-Cookbook/tree/master/CHAP08/cost>.

## How to do it...

To view the estimation of cost for our resources, perform the following steps:

1. In the **Settings** section of the Terraform Cloud organization, in the **Cost Estimation** tab, check the **Enable Cost Estimation for all workspaces** checkbox:

The screenshot shows the Terraform Cloud interface. At the top, there's a navigation bar with 'demoBook' and other options like 'Workspaces', 'Modules', and 'Settings'. A red circle with the number '1' is positioned at the top right of the header. On the left, there's a sidebar with various settings categories: General, Plan & Billing, Users, Teams, API Tokens, Authentication, SSH Keys, **Cost Estimation** (which has a red circle with '2'), Policies, and Policy Sets. The 'Cost Estimation' section contains a checkbox labeled 'Enable Cost Estimation for all workspaces' (with a red circle containing '3') and a description below it. At the bottom of this section is a blue 'Update settings' button (with a red circle containing '4').

2. In the created workspace that provisions the Azure VM with our Terraform configuration, queue a new run.
3. Just after executing our plan, we can view the evaluated cost of the resource:

The screenshot shows the 'Run Details' page for a pull request. At the top, it says 'Merge pull request #5 from PacktPublishing/master'. Below that, it shows a log entry from 'mikaelkrief' triggering a run. The main area shows a timeline with 'Plan finished' and 'Cost estimation finished' (both 2 minutes ago). A red arrow points to the 'Cost estimation finished' message. Below this, there's a table for the 'azurerm\_virtual\_machine' resource. The table has columns: RESOURCE, NAME, HOURLY COST, MONTHLY COST, and MONTHLY DELTA. The data row is highlighted with a red border. At the bottom, there's a note about 2 resources not being estimable, followed by an 'Apply pending' section and a confirmation dialog.

RESOURCE	NAME	HOURLY COST	MONTHLY COST	MONTHLY DELTA
azurerm_virtual_machine	main	\$0.068	\$48.888	+\$48.888

## How it works...

Once the cost estimation option has been activated, Terraform Cloud uses the APIs of the different cloud providers to evaluate and display the costs of the resources that will be provisioned.

## There's more...

It is important to note that this is only an estimate and that it is necessary to refer to the different price documentations of the cloud providers.

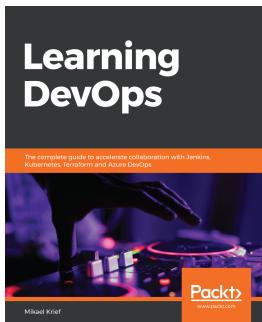
You can also write policies with Sentinel (which we studied in the previous recipe) to integrate compliance rules for estimated costs. For more information, please read the documentation at <https://www.terraform.io/docs/cloud/cost-estimation/index.html#verifying-costs-in-policies>.

## See also

The documentation regarding the cost estimation feature is available here: <https://www.terraform.io/docs/cloud/cost-estimation/index.html>.

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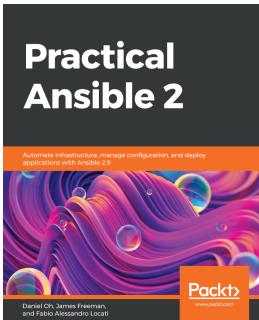


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