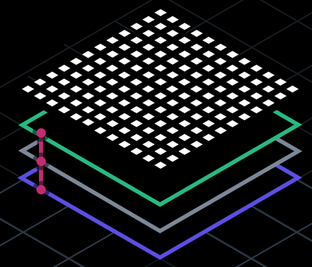
HashiCorp

CLOUD INFRASTRUCTURE AUTOMATION

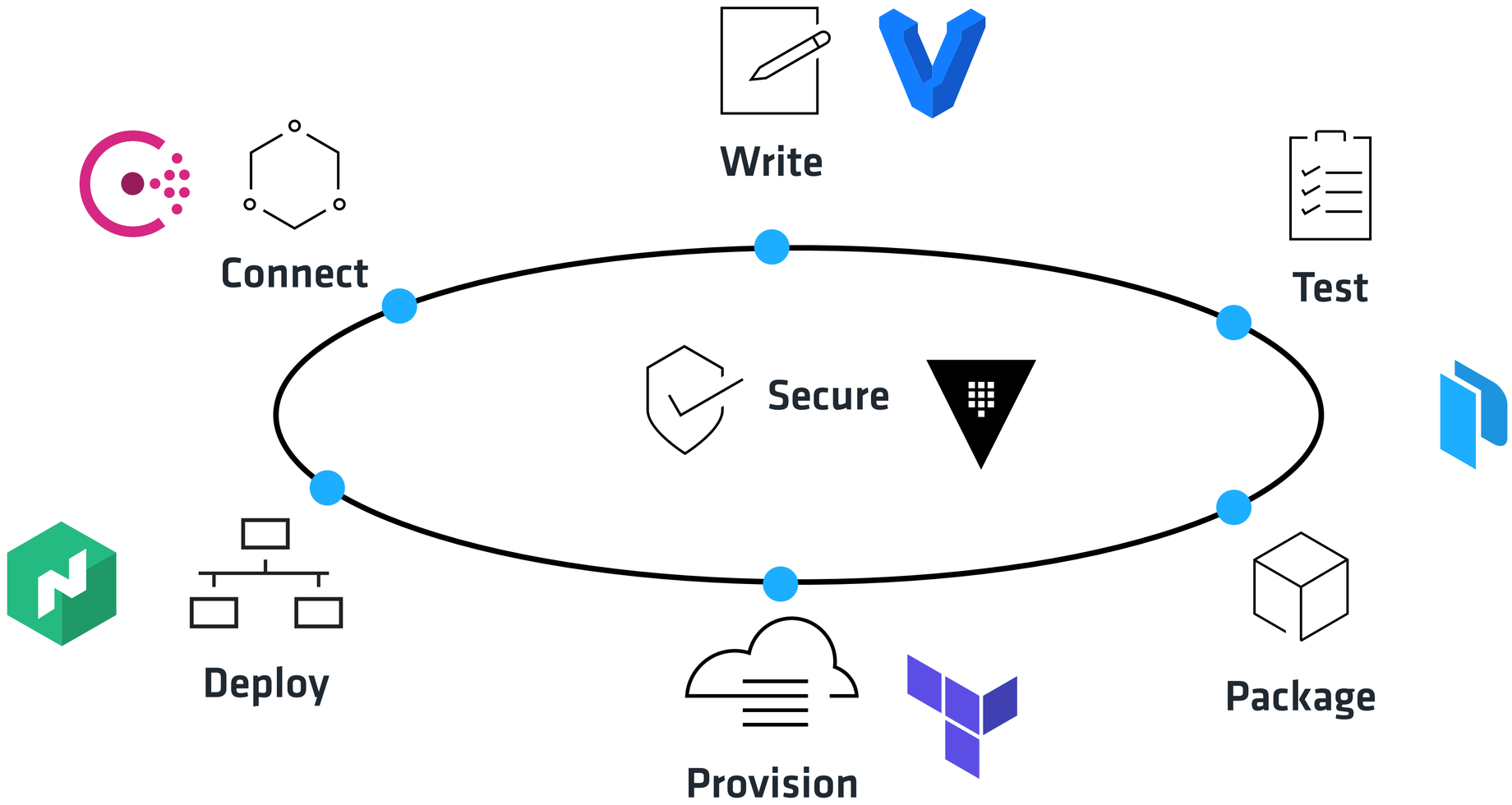


Terraform

ENTERPRISE

Introduction

Application Delivery Lifecycle



https://www.hashicorp.com/resources/application-delivery-hashicorp

Agenda

Syntax Review

Remote State

Cloud State

Teams

TFE Basics

Collaboration

Useful Providers

Packer

Multi-Provider Configs

Lifecycles

Module Registry

Configuration Designer

We will cover

Tools for teams and scale

Hosted Terraform Enterprise

Examples use AWS

Q&A and your requests

We will not cover

Terraform Enterprise API

Private Terraform Enterprise

Source code management tools

Configuration management tools

Every cloud

What You'll Learn

- Use collaborative features of Terraform
- Organize Terraform projects for large scale infrastructure installations
- Use state
- Become confident with supporting tools

Review

Key Terraform Syntax & Features

- Summary of providers, resources, variables, outputs
- Summary of modules
- Tips for upgrading commands and providers

Terraform Syntax

Building infrastructure with Terraform

Providers - Cloud, VCS, Monitoring, etc.

Resources - EC2 Instances, Credentials, etc.

Variables - Input for tagging or defining resources.

Outputs - Used for record keeping or as a variable to pass into other modules.

Leveling up by utilizing modules

TERMINAL

```
my-infrastructure
├── main.tf
├── output.tf
├── terraform.tfvars
├── terraform.tfstate
└── variables.tf
```

CODE EDITOR

```
provider "aws" { }
```

TIP

Secure Credentials with ENV Variables or Cloud Role

For flexibility and to nearly eliminate the possibility of accidentally committing cloud credentials to source code control systems, consider storing cloud credentials in environment variables. Or use cloud role.

If they are named correctly, the appropriate Terraform provider will discover and use them.

```
export AWS_ACCESS_KEY_ID="AAAAAA"
export AWS_SECRET_ACCESS_KEY="XXXXXXXX"
export AWS_DEFAULT_REGION="us-west-2"
```

TERMINAL

```
$ source ~/.config/envs/aws
```

WARNING

Providers Must Be Explicitly Upgraded

We value stability and we respect your control over your environment.

By default, Terraform will lock on to the first version available when you first run `init` on a configuration.

To upgrade, you must explicitly state a version in your configuration, or run this command:

```
terraform init -upgrade
```

CODE EDITOR

```
provider "aws" {
  version = ">= 1.19.0"
}
```

MAIN.TF

```
resource "aws_instance" "web" {
  ami           = "ami-e5d9439a"
  instance_type = "t2.nano"
}
```

MAIN.TF

```
variable "ami" {}

resource "aws_instance" "web" {
  ami           = "${var.ami}"
  instance_type = "t2.nano"
}
```

MAIN.TF

```
variable "ami" {}

resource "aws_instance" "web" {
  ami           = "${var.ami}"
  instance_type = "t2.nano"
}

output "public_ip" {
  value = ["${aws_instance.web.public_ip}"]
}
```

TERRAFORM.TFVARS

```
# ENVIRONMENT VARIABLES
# Define these secrets as environment variables

# AWS_ACCESS_KEY_ID
# AWS_SECRET_ACCESS_KEY

variable "images" {
  type = "map"
  default = {
    us-east-1 = "image-1234"
    us-west-2 = "image-4567"
  }
}
variable "zones" {
  type = "list"
  default = ["us-east-1a", "us-east-1b"]
}
```

TERMINAL

```
vpc_module
├── main.tf
├── output.tf
└── variables.tf
```

MAIN.TF - VPC MODULE EXAMPLE

```
module "vpc" {
  source = "terraform-aws-modules/vpc/aws"
}
```

MAIN.TF - VPC MODULE EXAMPLE

```
module "vpc" {
  source = "terraform-aws-modules/vpc/aws"

  name = "my-vpc"
  cidr = "10.0.0.0/16"

  azs             = ["eu-west-1a", "eu-west-1b"]
  private_subnets = ["10.0.1.0/24", "10.0.2.0/24"]
  public_subnets  = ["10.0.101.0/24", "10.0.102.0/24"]

  enable_nat_gateway = true
  enable_vpn_gateway = true

  tags = {
    Terraform = "true"
    Environment = "dev"
  }
}
```

CODE EDITOR

```
# Useful built-in functions
basename(path)
cidrhost(iprange, hostnum)
concat(list1, list2, ...)
file(path)
join(delim, list)

my-list[7]
```

https://www.terraform.io/docs/configuration/interpolation.html#built-in-functions

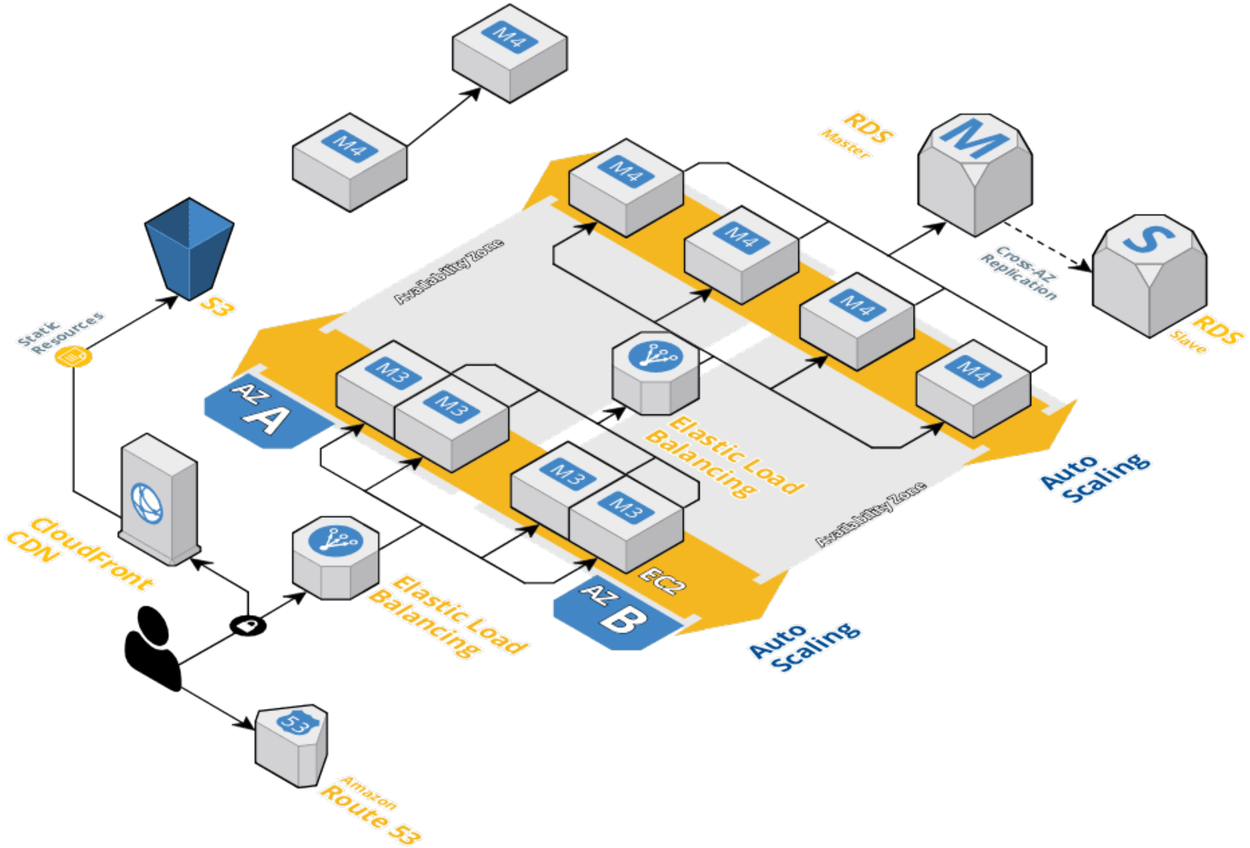
Key Terraform Syntax & Features

- Summary of providers, resources, variables, outputs, modules
- Summary of modules
- Tips for upgrading commands and providers

Remote State

What You'll Learn

- Why it's useful to read state
- Locations where state can be stored
- How to read state from another local project


M4
M4
RDS
Master
M
S
RDS
Slave
Cross-AZ
Replication
S3
Static
Resources
Availability Zone
AZ A
M3
M3
Elastic Load
Balancing
M3
M3
EC2
AZ B
Availability Zone
Auto
Scaling
Auto
Scaling
CloudFront
CDN
Elastic Load
Balancing
53
Amazon
Route 53

WARNING

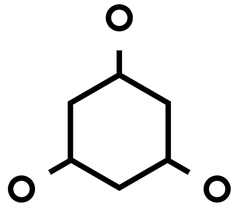
You Know You Need to Refactor Your Monorepo When

An individual can destroy unrelated infrastructure that they don't need to own.

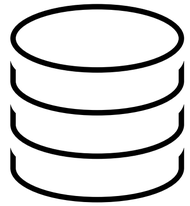
Unneeded resources are defined and created only so that they can be referenced by other resources.

A change to one resource triggers changes to other resources that didn't need to change.

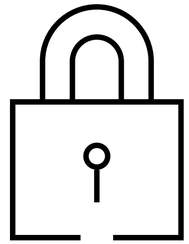
Which of these need to be defined together?



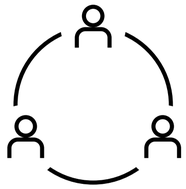
NETWORK



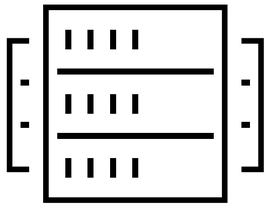
DATABASE



KEYS



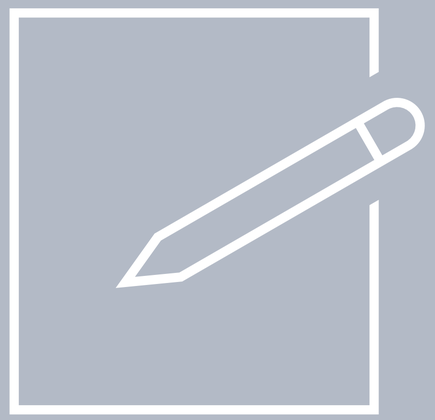
PROFILES



EC2 INSTANCES

VPC

GOOD

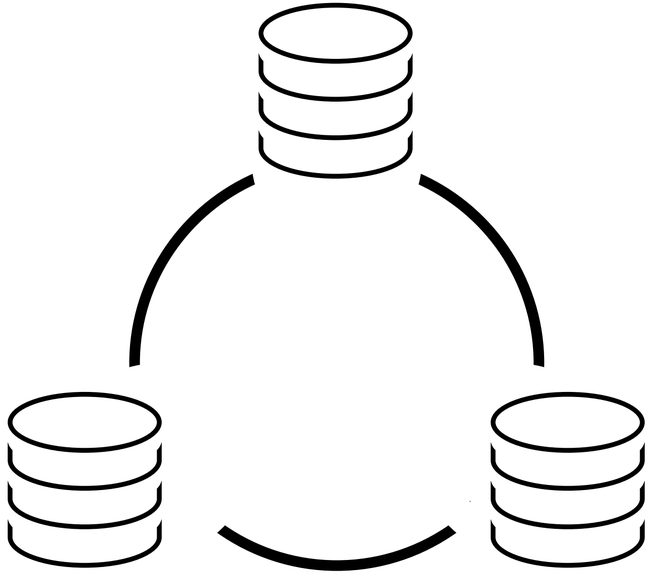


Copy & Paste

BETTER

Environment Variables

BEST



Shared State (Outputs)

CODE EDITOR

```
resource "aws_instance" "workstation" {
  ami             = "${data.aws_ami.app.id}"
  key_name        = "${aws_key_pair.app.id}"

  subnet_id                 = "${aws_subnet.app.id}"
  iam_instance_profile      = "${aws_iam_instance_profile.app.name}"
  vpc_security_group_ids = ["${aws_security_group.app.id}"]

  user_data = "${data.template_cloudinit_config.app.rendered}"
}
```

INSIGHT

What resources do I need to create and control?

What resources do I need to refer to when creating my own?

WARNING

Shortcomings of remote state

Values are read when a configuration is applied, not constantly. A deployment is a snapshot in time.

Remote state can only be read. You cannot write to a remote project or trigger an `apply` from another one.

Your configuration must have read access to the location where the state file is stored.

State & Its Uses

Collaborate on values from infrastructure created by other projects.

Separating state isolates the impact of Terraform's actions.

Read it locally or on a remote disk (cloud storage) or API (Terraform Enterprise).

Terraform

ENTERPRISE

CODE EDITOR

```
# Default
terraform {
  backend "local" {
    path = "terraform.tfstate"
  }
}
```

CODE EDITOR

```
# Read state from another Terraform config's state
data "terraform_remote_state" "vpc" {
  backend = "local"

  config {
    path = "../shared-vpc/terraform.tfstate"
  }
}
```

CODE EDITOR

```
# Elsewhere, use outputs from the state
"${data.terraform_remote_state.vpc.cidr_block}"
```

Issues

State files expose sensitive information. Use encryption, use private storage.

Disaster recovery: Use versioning, logging on S3 buckets, if used.

Top level state must explicitly output values for others to read.

INSIGHT

Remote state is read-only. Remote resources cannot be created or destroyed.

EXERCISE

Read State

Create a new Terraform config in a new directory that reads the `public_ip` value from the existing project's state file (from local storage).

Emit it as an output from the new project.

HINT: This requires only about 10 lines of code in total.

What You Learned

- Why it’s useful to read state
- Where state is stored by default and where it can be stored
- How to read state from another local project

Store State Remotely

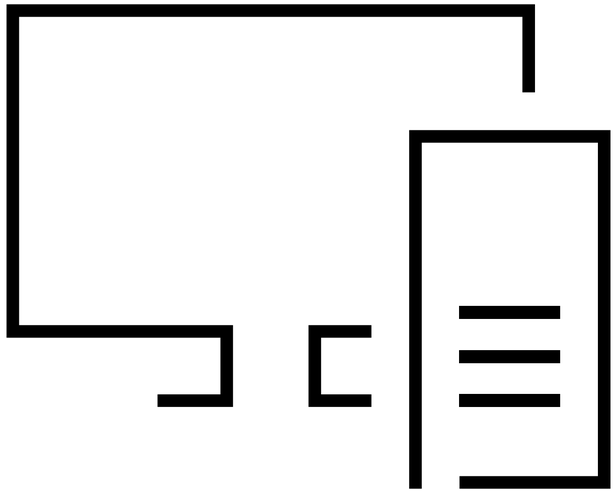
What You'll Learn

- Store state in cloud storage
- Bootstrap an existing project to store state remotely
- Initialize a new project to use cloud storage for its state file
- Read values from remote state

INSIGHT

Terraform state is stored in a JSON file. Any config that can access the file can read state from it.

Local vs Remote State



CODE EDITOR

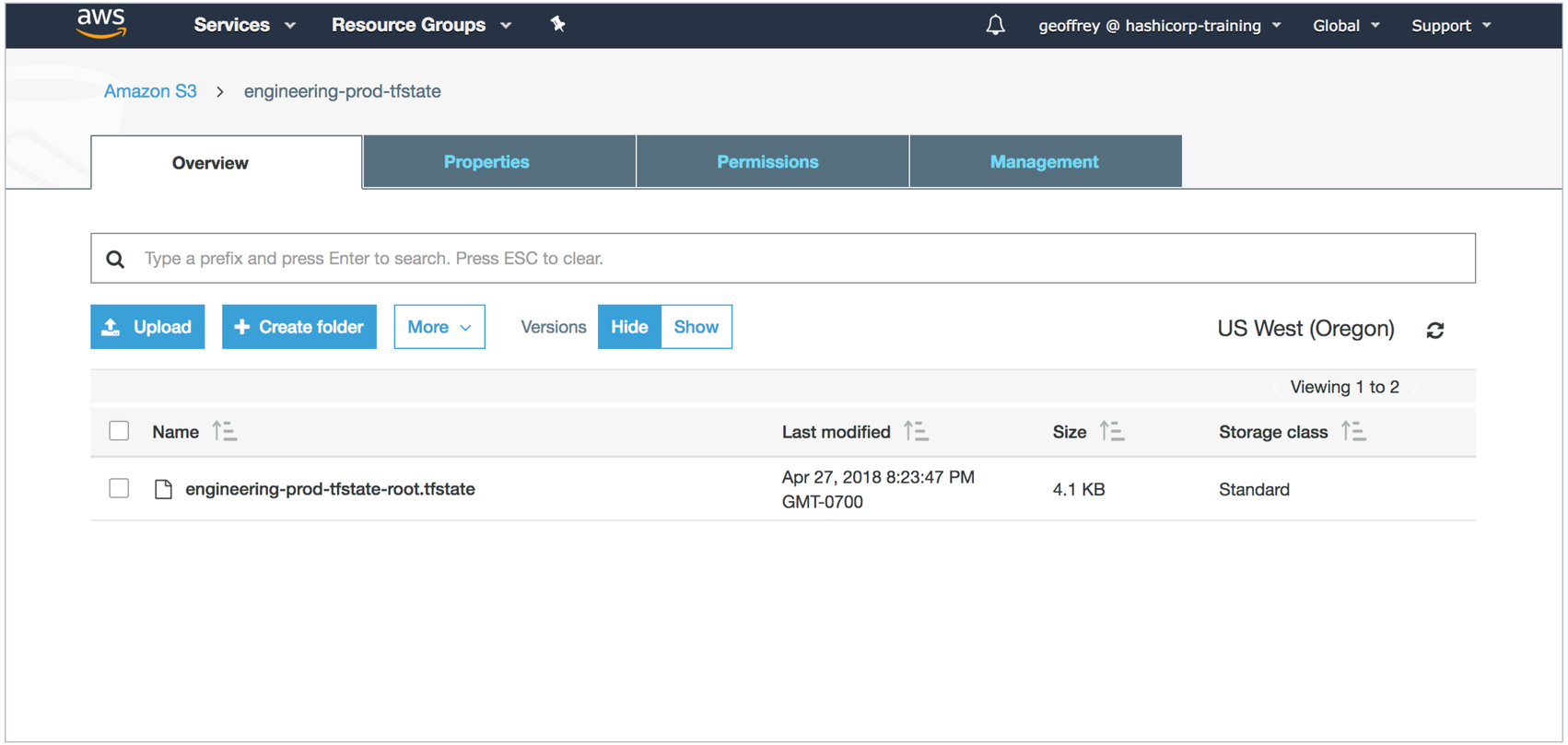
```
export AWS_ACCESS_KEY_ID="abcdef"
export AWS_SECRET_ACCESS_KEY="abcdef"
export AWS_DEFAULT_REGION="us-west-2"
```

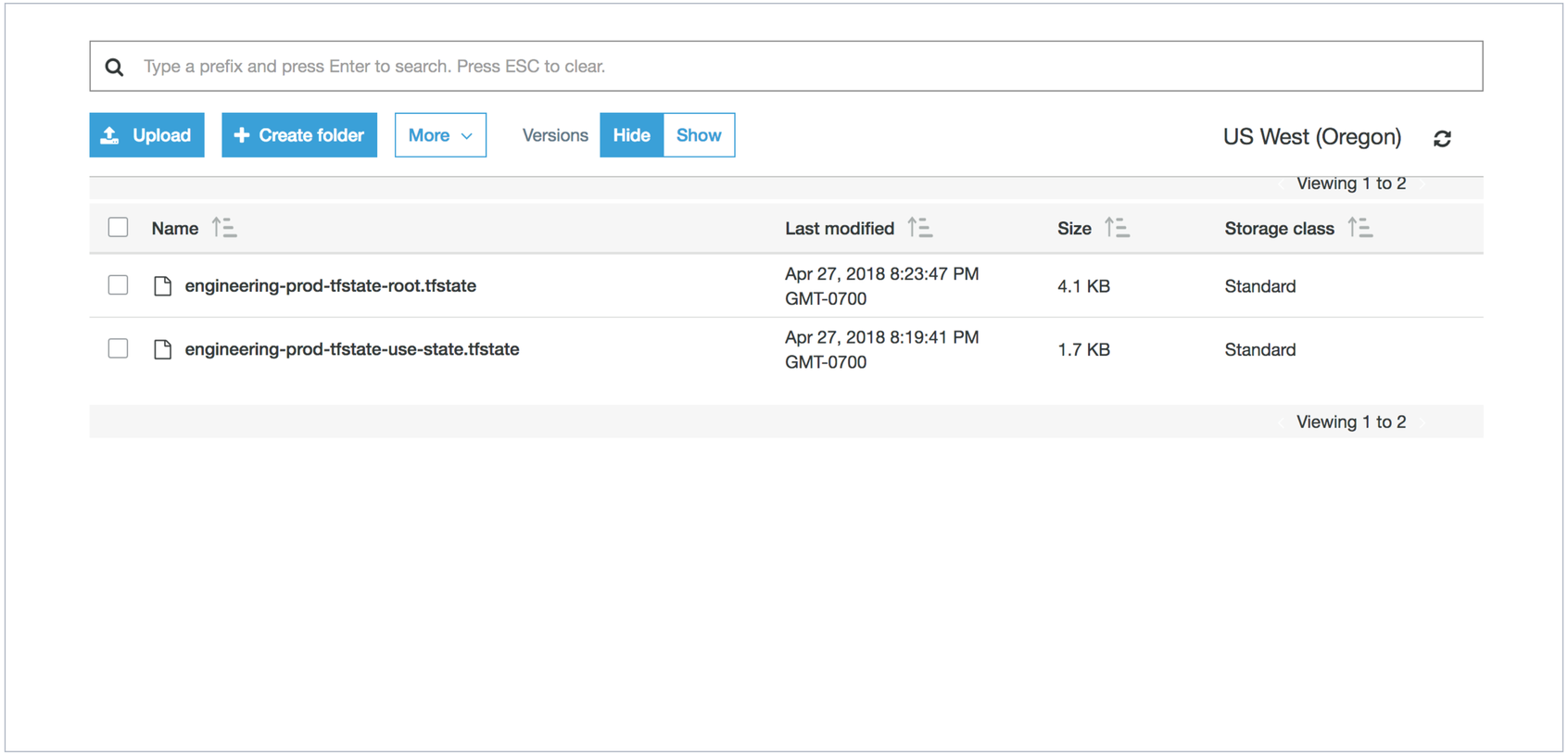
https://docs.aws.amazon.com/cli/latest/userguide/cli-environment.html

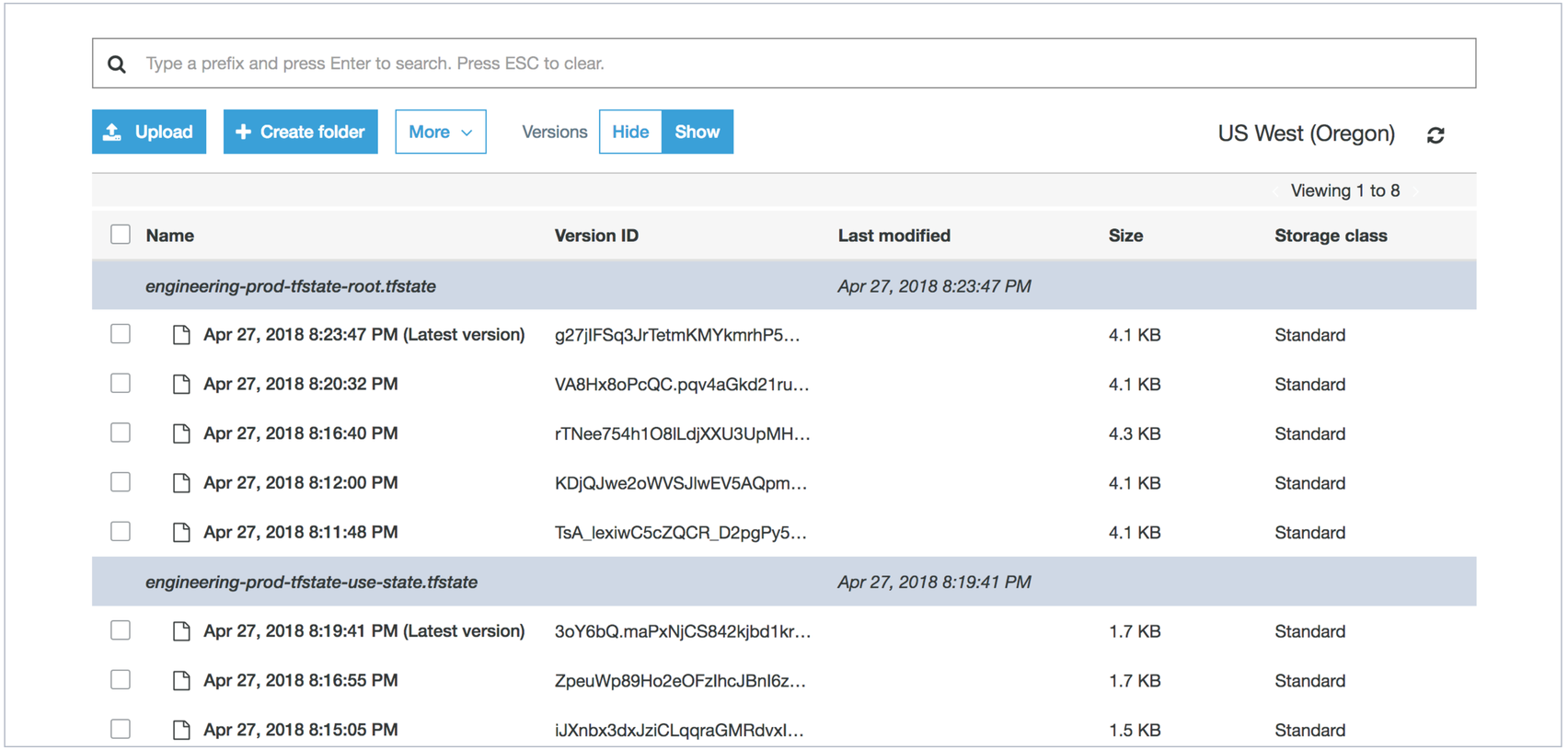
CODE EDITOR

```
terraform {
  backend "s3" {
    bucket  = "engineering-prod-tfstate"
    key     = "root.tfstate"
    encrypt = true
  }
}
```

https://www.terraform.io/docs/backends/types/s3.html


aws
Services
Resource Groups
geoffrey @ hashicorp-training
Global
Support
Amazon S3 > engineering-prod-tfstate
Overview
Properties
Permissions
Management
Type a prefix and press Enter to search. Press ESC to clear.
Upload
Create folder
More
Versions
Hide
Show
US West (Oregon)
Viewing 1 to 2
Name
Last modified
Size
Storage class
engineering-prod-tfstate-root.tfstate
Apr 27, 2018 8:23:47 PM GMT-0700
4.1 KB
Standard


Type a prefix and press Enter to search. Press ESC to clear.
Upload
Create folder
More
Versions
Hide
Show
US West (Oregon)
Viewing 1 to 2
Name
Last modified
Size
Storage class
engineering-prod-tfstate-root.tfstate
Apr 27, 2018 8:23:47 PM GMT-0700
4.1 KB
Standard
engineering-prod-tfstate-use-state.tfstate
Apr 27, 2018 8:19:41 PM GMT-0700
1.7 KB
Standard
Viewing 1 to 2


Type a prefix and press Enter to search. Press ESC to clear.
Upload
Create folder
More
Versions
Hide
Show
US West (Oregon)
Viewing 1 to 8
Name
Version ID
Last modified
Size
Storage class
engineering-prod-tfstate-root.tfstate
Apr 27, 2018 8:23:47 PM
Apr 27, 2018 8:23:47 PM (Latest version)
g27jIFSq3JrTetmKMYkmrhP5…
4.1 KB
Standard
Apr 27, 2018 8:20:32 PM
VA8Hx8oPcQC.pqv4aGkd21ru…
4.1 KB
Standard
Apr 27, 2018 8:16:40 PM
rTNee754h1O8lLdjXXU3UpMH…
4.3 KB
Standard
Apr 27, 2018 8:12:00 PM
KDjQJwe2oWVSJlwEV5AQpm…
4.1 KB
Standard
Apr 27, 2018 8:11:48 PM
TsA_lexiwC5cZQCR_D2pgPy5…
4.1 KB
Standard
engineering-prod-tfstate-use-state.tfstate
Apr 27, 2018 8:19:41 PM
Apr 27, 2018 8:19:41 PM (Latest version)
3oY6bQ.maPxNjCS842kjbd1kr…
1.7 KB
Standard
Apr 27, 2018 8:16:55 PM
ZpeuWp89Ho2eOFzIhcJBnI6z…
1.7 KB
Standard
Apr 27, 2018 8:15:05 PM
iJXnbx3dxJziCLqqraGMRdvxI…
1.5 KB
Standard

TIP

Consider other backends

artifactory

azurerm

consul

etcd

etcdv3

gcs

http

manta

s3

swift

terraform enterprise

https://www.terraform.io/docs/backends/types/index.html

CODE EDITOR

```
output "public_ip" {
  value = "8.8.8.8"
}


output "destination" {
  value = {
    "planet"   = "Mars"
    "distance" = “33900000”
    "date"     = "11 Jan 2058"
  }
}
```

INSIGHT

Remote state is read-only. Resources cannot be created or destroyed except by the configuration whose state they track.

INSIGHT

Remote shared state does not need to be merged like files in a Git repo. State should be locked and only written by one instance of Terraform at a time.

EXERCISE

Work with remote state storage

Create a Terraform config that creates an S3 bucket. We'll use it to store state.

Store the project's own state on the S3 backend.

Create a second project and read output from the first project's remote state stored in S3.

Re-emit it as your own output.

What You Learned

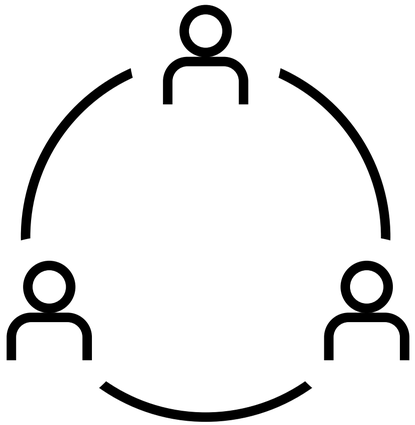
- Store state in cloud storage
- Bootstrap an existing project to store state remotely
- Initialize a new project to use cloud storage for its state file
- Read values from remote state

Code Organization for Teams

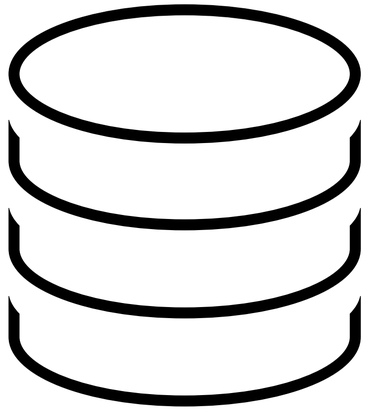
What You'll Learn

- How Terraform projects evolve
- When to use modules vs a new project
- How to use shared state to manage complexity

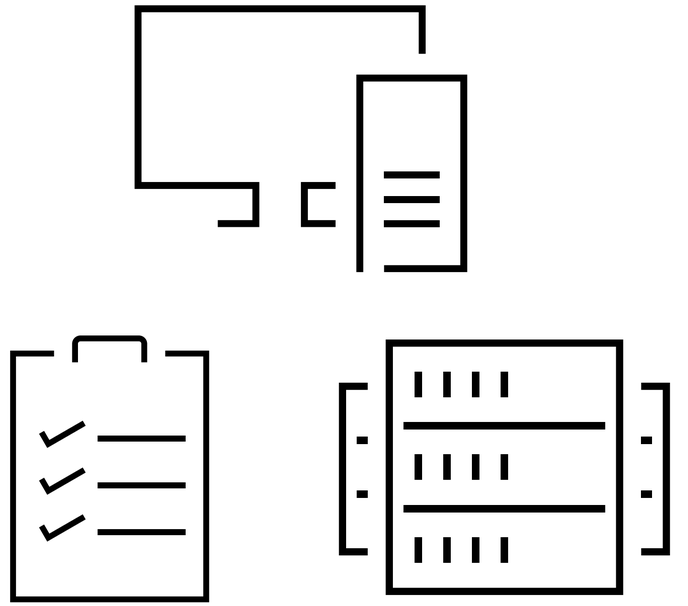
Ways a Project Grows



Larger Team



More Resources



Dev, Test, Staging, Prod

Nicki Watt

Evolving Your Infrastructure with Terraform

OpenCredo

HashiCorp

Terraform Collaboration Questions

Is this config owned by one team?

Is this config used by more than one team?

Does this config create resources which host other resources? (or needed by other resources)

Complexity, Capability

A more expansive infrastructure will need a more complex Terraform project layout, but also requires more communication and additional layers of code management.

Don’t start with complexity 7 if you don’t need it.

Stable	Dynamic
DRY	Explicit
Isolated	Shared
Reusable	Customizable
Consistent	Creative
Complex	Simple

Many Remote State Files

Versioned Modules

Many Repositories

Limited Configuration

Limited Access

Single Local State

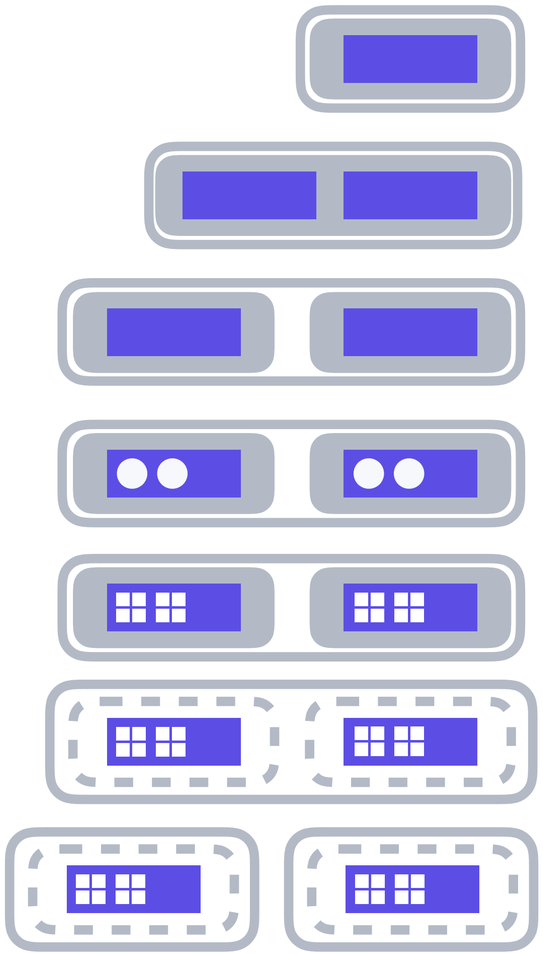
Root Module

Single Directory

Freeform Code

Full Control

Evolution of a Terraform Project



1.Single File

2.Separate Environments

3.State per Environment

4.Modules

5.Nested Modules

6.Distributed State

7.Repository Isolation

Single file

main.tf

TERMINAL

```
├── 1-single-file
    ├── main.tf
    ├── terraform.tfstate
    └── terraform.tfvars
```

Multiple Environments

May contain test and prod (“web_test”, “web_prod”)

Possibly in different files with a single repo

TERMINAL

```
├── 2-environments
    ├── main-prod.tf
    ├── main-test.tf
    ├── terraform.tfstate
    └── terraform.tfvars
```

Separate States

Limit the impact of provisioning one configuration

Control timing and release schedule of provisioning

TERMINAL

```
├── 3-states
    ├── prod
    |   ├── main.tf
    |   ├── terraform.tfstate
    |   └── terraform.tfvars
    └── test
        ├── main.tf
        ├── terraform.tfstate
        └── terraform.tfvars
```

Resources in Modules

Improves long term maintenance

Eases reuse

Encourages consistency in design

TERMINAL

```
── 4-modules
   ├── envs
   |   ├── prod
   |   |   ├── main.tf
   |   |   ├── terraform.tfstate
   |   |   └── terraform.tfvars
   |   └── test
   |       ├── main.tf
   |       ├── terraform.tfstate
   |       └── terraform.tfvars
   └── modules
       ├── core
       |   ├── input.tf
       |   ├── main.tf
       |   └── output.tf
       ├── db
       ├── network
       └── webapp
```

Nested Modules

A more complex system outgrows single modules

Able to isolate parts of the system that co-exist but don't depend on each other

TERMINAL

```
── 5-nested
   ├── envs
   |   ├── prod
   |   └── test
   |       ├── core
   |       |   └── terraform.tfstate
   |       ├── db
   |       |   └── terraform.tfstate
   |       ├── network
   |       |   └── terraform.tfstate
   |       └── webapp
   |           └── terraform.tfstate
   └── modules
       ├── common
       |   └── aws
       |       ├── compute
       |       |   ├── db
       |       |   └── web
       |       └── network
       |           ├── priv_subnet
       |           ├── pub_subnet
       |           └── vpc
       └── project
           ├── core
           └── webapp
```

Distributed State

Necessary for teams

Further isolates individual environments and deployments

TERMINAL

```
── 6-distributed
   ├── envs
   |   ├── prod
   |   └── test
   |       ├── core
   |       |   └── terraform.tfstate
   |       ├── db
   |       |   └── terraform.tfstate
   |       ├── network
   |       |   └── terraform.tfstate
   |       └── webapp
   |           └── terraform.tfstate
   └── modules
       ├── common
       |   └── aws
       |       ├── compute
       |       |   ├── db
       |       |   └── web
       |       └── network
       |           ├── priv_subnet
       |           ├── pub_subnet
       |           └── vpc
       └── project
           ├── core
           └── webapp
```

State/Repo Per Component

Full isolation

Control team read/write permissions on each repo

Full control over authorization per state

Limit Terraform Enterprise apply actions

TERMINAL

```
── 7-repo-isolation
    ├── envs
    |   ├── prod
    |   └── test
    |       ├── core
    |       |   └── terraform.tfstate
    |       ├── db
    |       |   └── terraform.tfstate
    |       ├── network
    |       |   └── terraform.tfstate
    |       └── webapp
    |           └── terraform.tfstate
    └── modules
        ├── common
        |   └── aws
        |       ├── compute
        |       |   ├── db
        |       |   └── web
        |       └── network
        |           ├── priv_subnet
        |           ├── pub_subnet
        |           └── vpc
        └── project
            ├── core
            └── webapp
```

Terraform Collaboration Answers

Is this config owned by one team?

Make a separate repository. Producing infrastructure

Is this config used by more than one team?

Publish a module. Creating infrastructure

Does this config create resources?

Publish outputs. Existing within infrastructure

TIP

Remote State is Read Only

If the cloud provider's API supports adding children to a parent resource, then repository isolation can work as a code organization technique. For example, Google Cloud Platform load balancers expose a tag which can be implemented by child instances in order to join the load balancer.

If a parent resource needs to be modified directly to manage a child resource, then the parent repository may need to be re-deployed (with knowledge of the child's state).

Terraform Enterprise Basics

HashiCorp

What You'll Learn

- Create a repository at GitHub
- Push your code to GitHub
- Create an organization at Terraform Enterprise
- Connect to GitHub via OAuth
- Add a workspace that references a GitHub repo
- Commit changes and create infrastructure

Terraform Enterprise Features

Collaboration and Governance

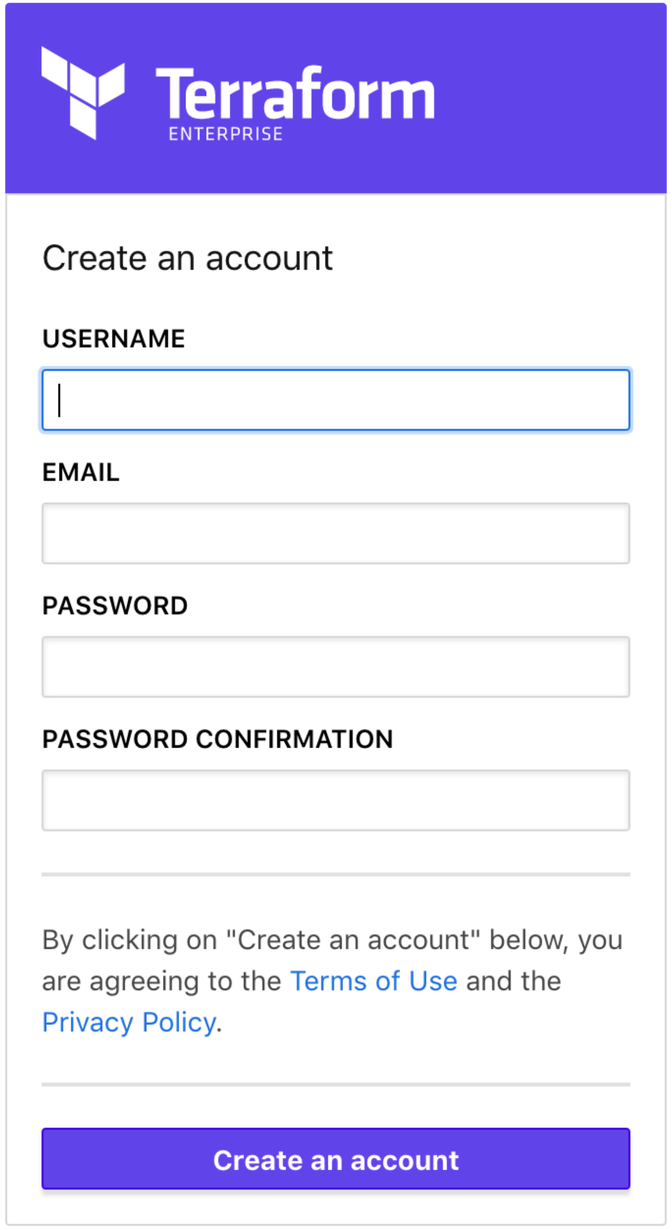
Private install or hosted

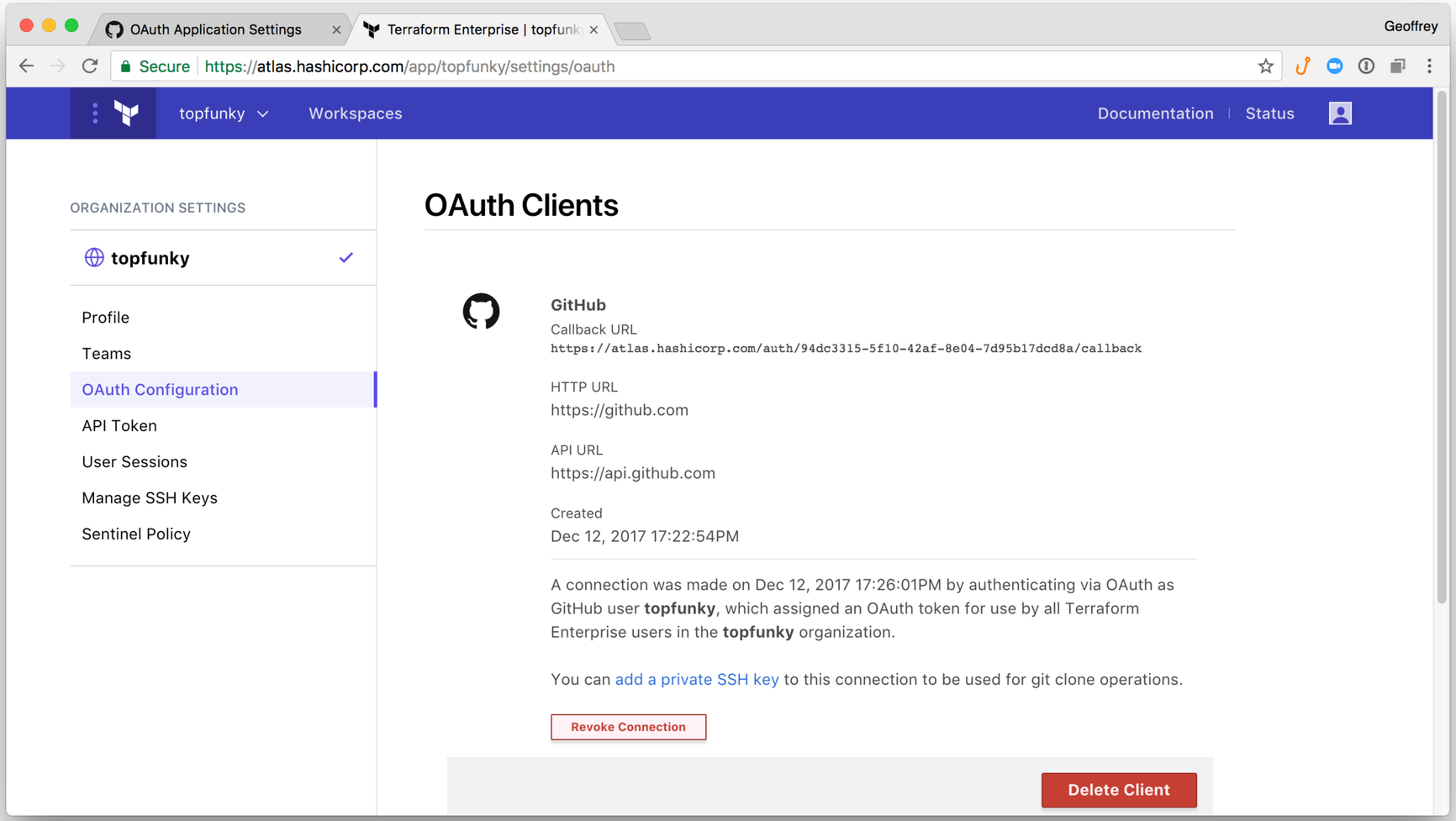
SCM integration

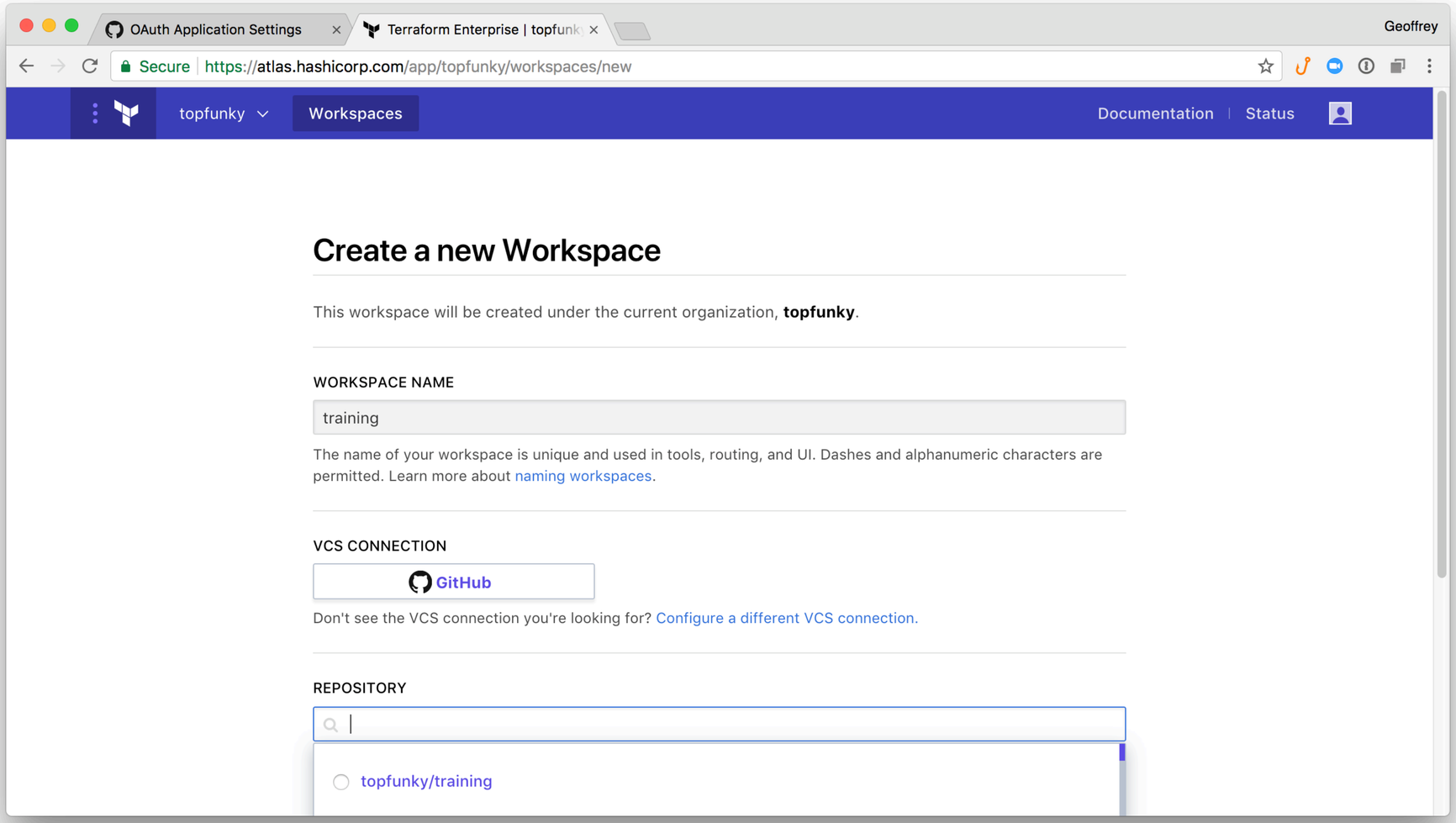
Central service registry

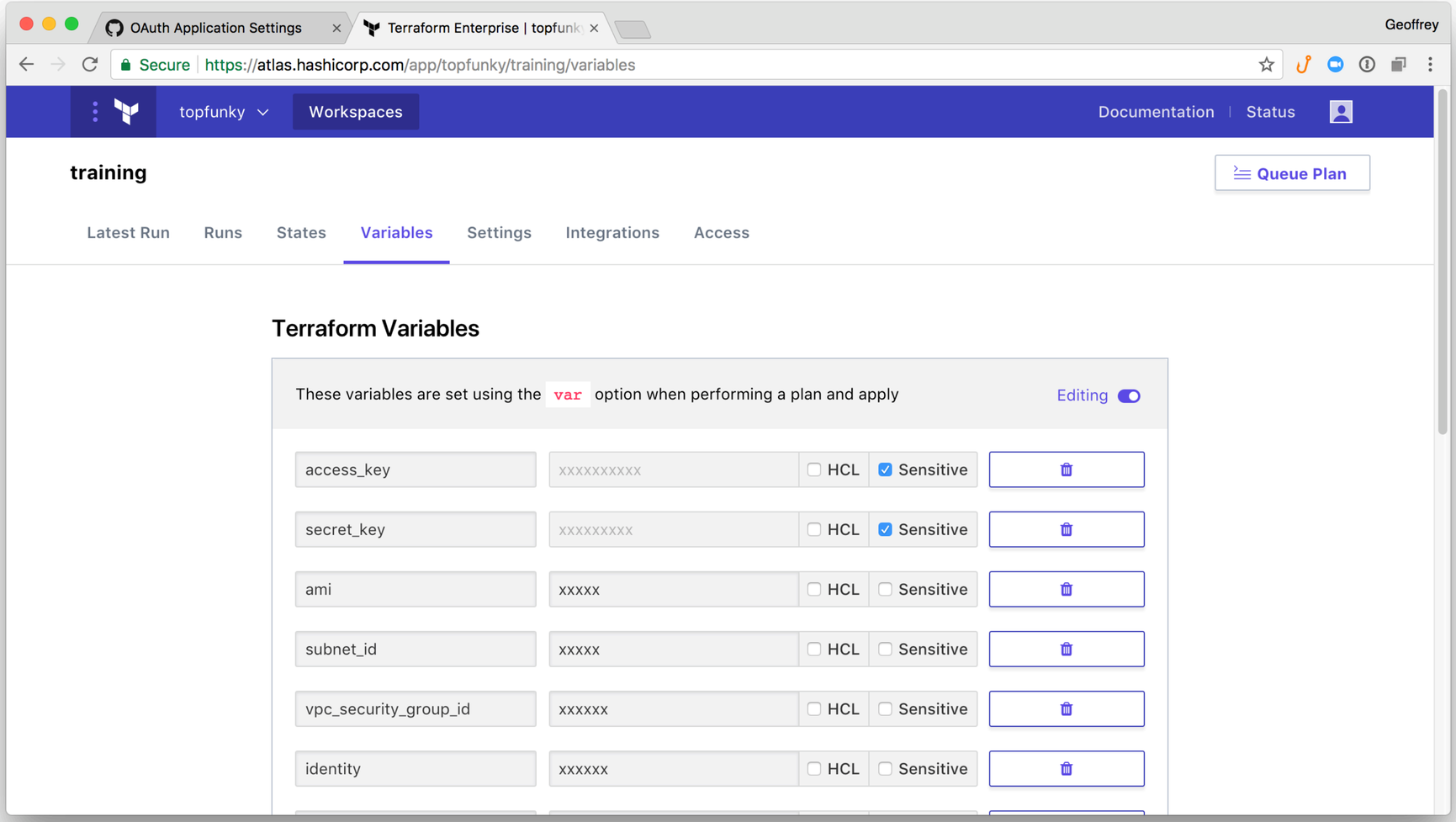
Provision at scale

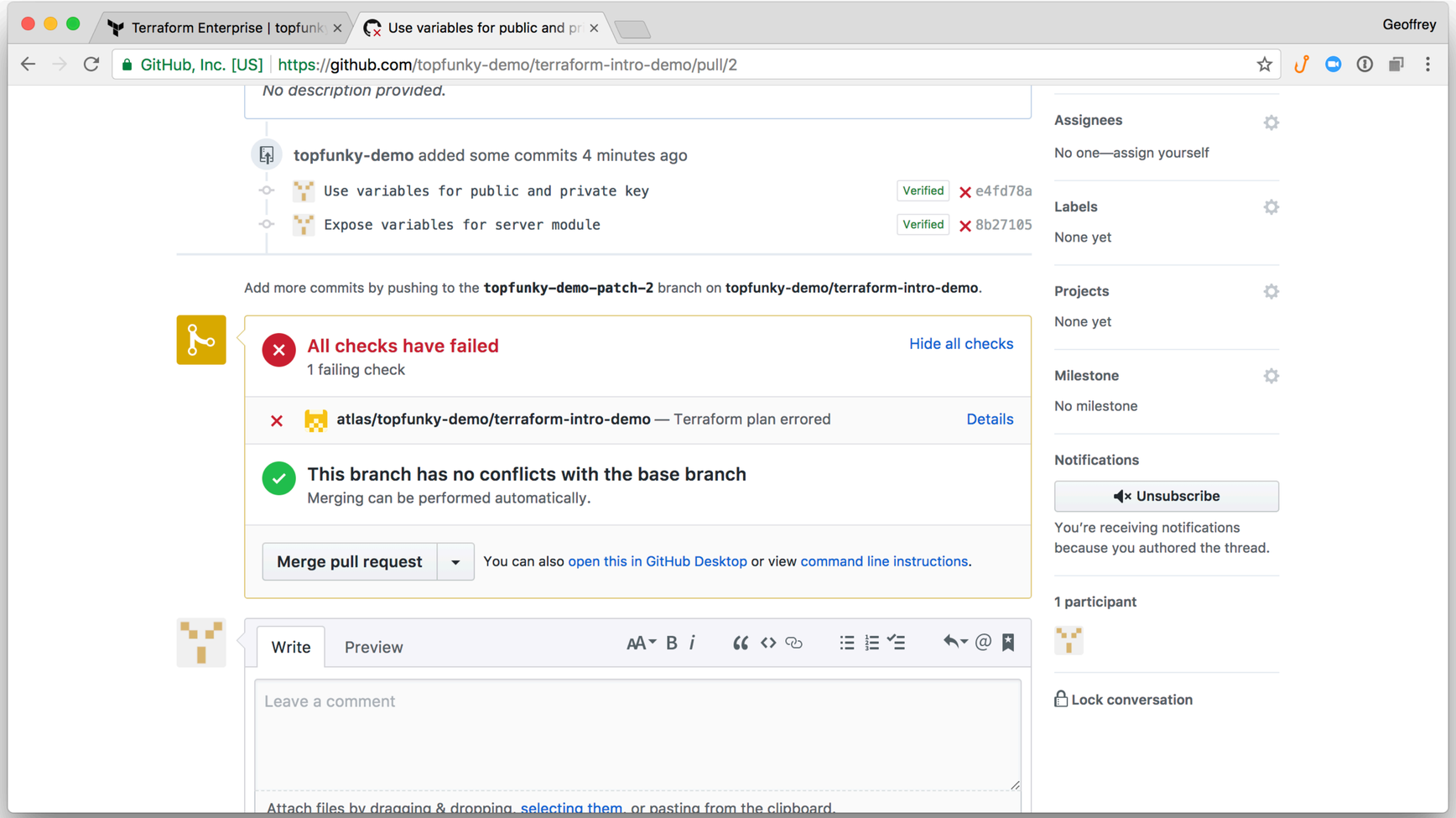
https://app.terraform.io/account/new

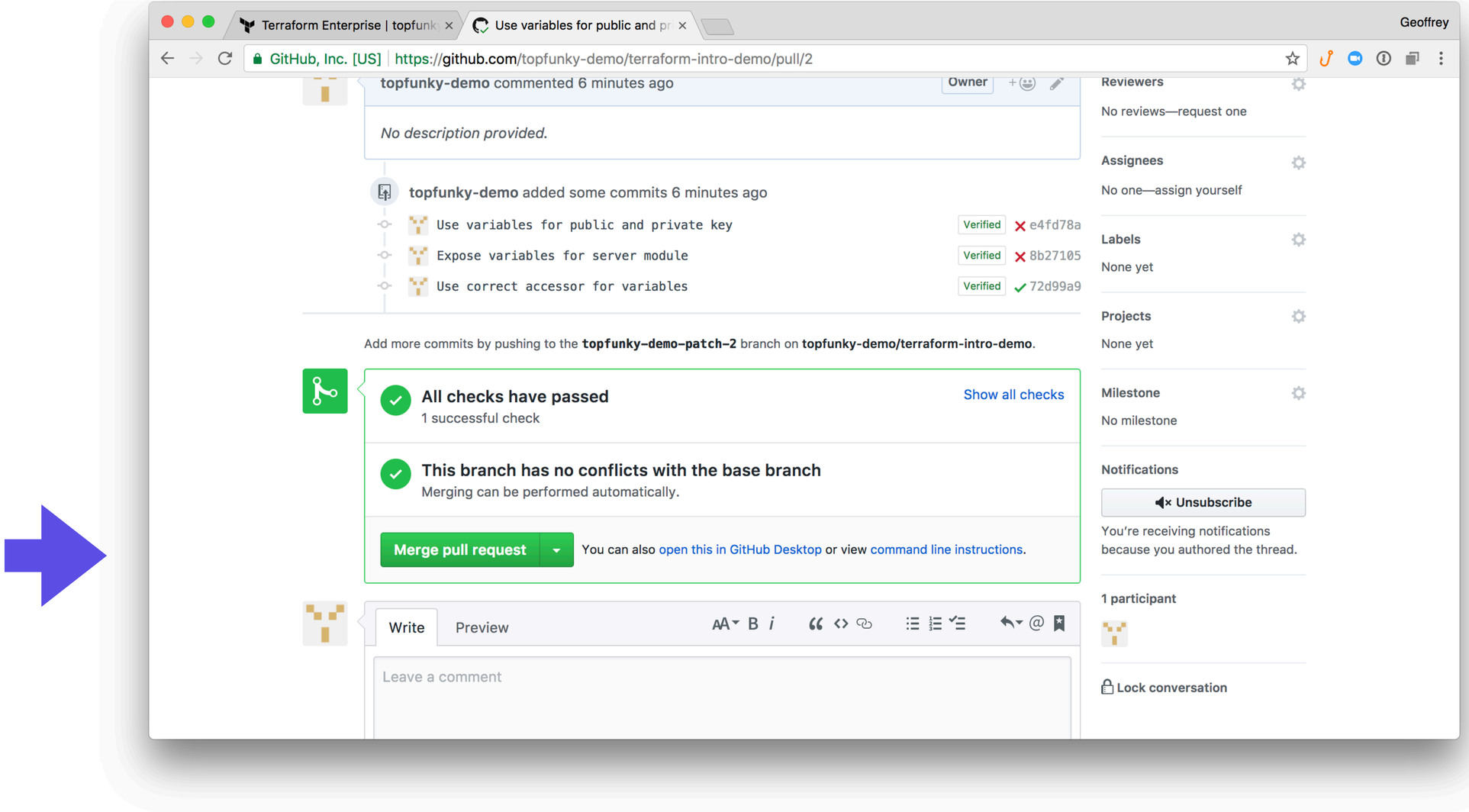


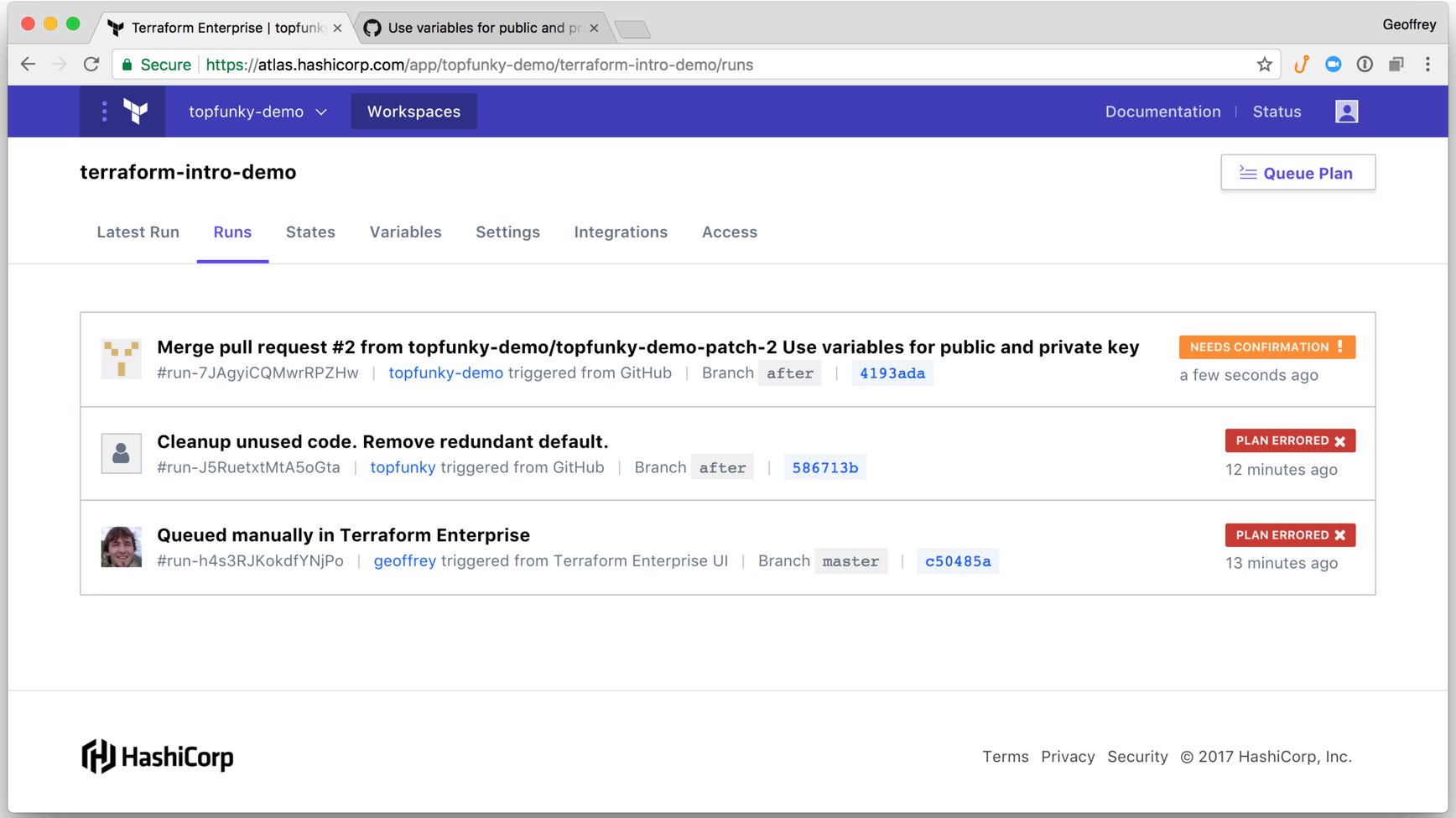

OAuth Application Settings
Terraform Enterprise | topfunky
Geoffrey
Secure | https://atlas.hashicorp.com/app/topfunky/settings/oauth
topfunky
Workspaces
Documentation | Status
ORGANIZATION SETTINGS
topfunky
Profile
Teams
OAuth Configuration
API Token
User Sessions
Manage SSH Keys
Sentinel Policy
OAuth Clients
GitHub
Callback URL
https://atlas.hashicorp.com/auth/94dc3315-5f10-42af-8e04-7d95b17dcd8a/callback
HTTP URL
https://github.com
API URL
https://api.github.com
Created
Dec 12, 2017 17:22:54PM
A connection was made on Dec 12, 2017 17:26:01PM by authenticating via OAuth as GitHub user topfunky, which assigned an OAuth token for use by all Terraform Enterprise users in the topfunky organization.
You can add a private SSH key to this connection to be used for git clone operations.
Revoke Connection
Delete Client

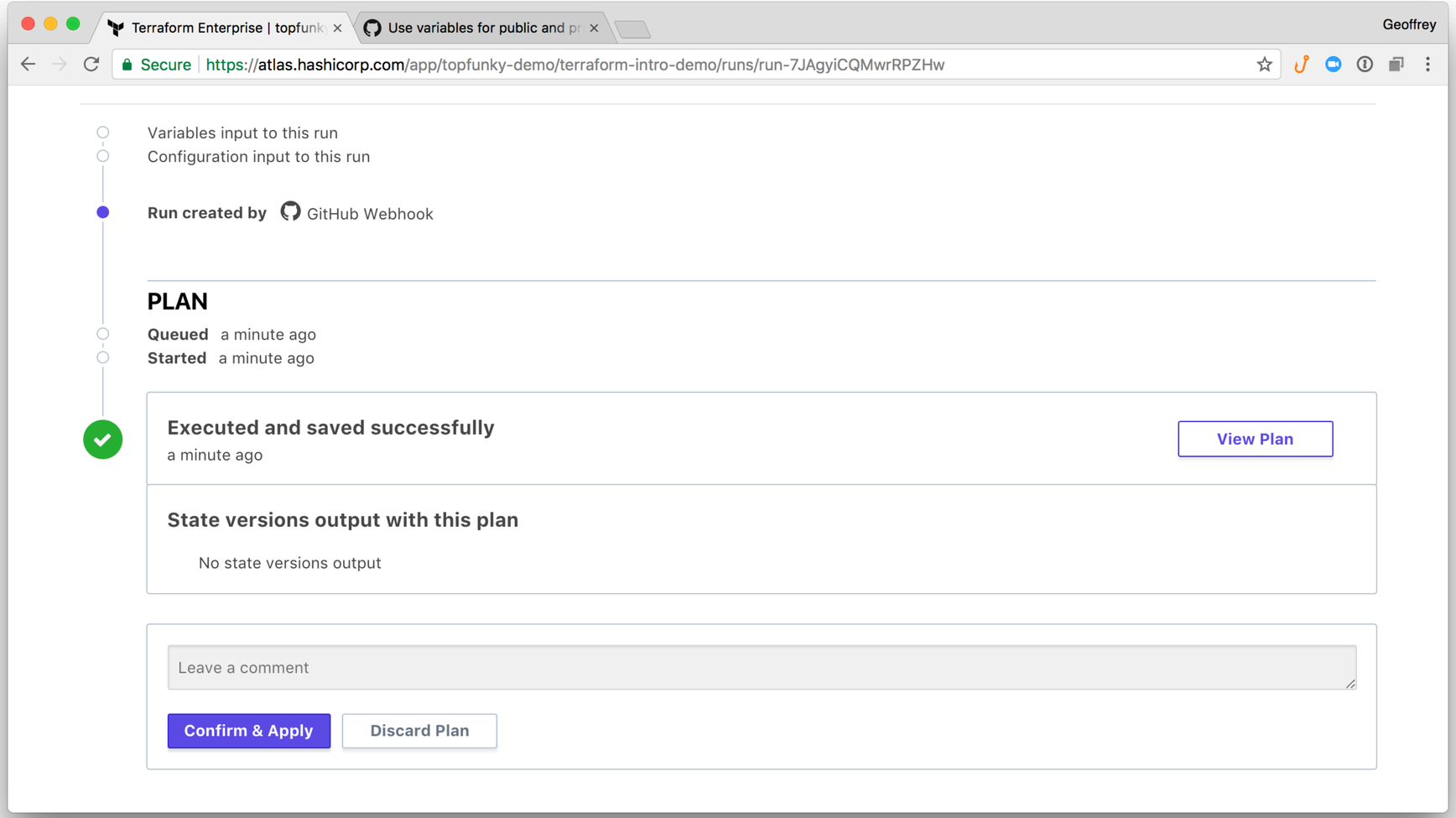

OAuth Application Settings
Terraform Enterprise | topfunky
Geoffrey
Secure
https://atlas.hashicorp.com/app/topfunky/workspaces/new
topfunky
Workspaces
Documentation
Status
Create a new Workspace
This workspace will be created under the current organization, topfunky.
WORKSPACE NAME
training
The name of your workspace is unique and used in tools, routing, and UI. Dashes and alphanumeric characters are permitted. Learn more about naming workspaces.
VCS CONNECTION
GitHub
Don't see the VCS connection you're looking for? Configure a different VCS connection.
REPOSITORY
topfunky/training

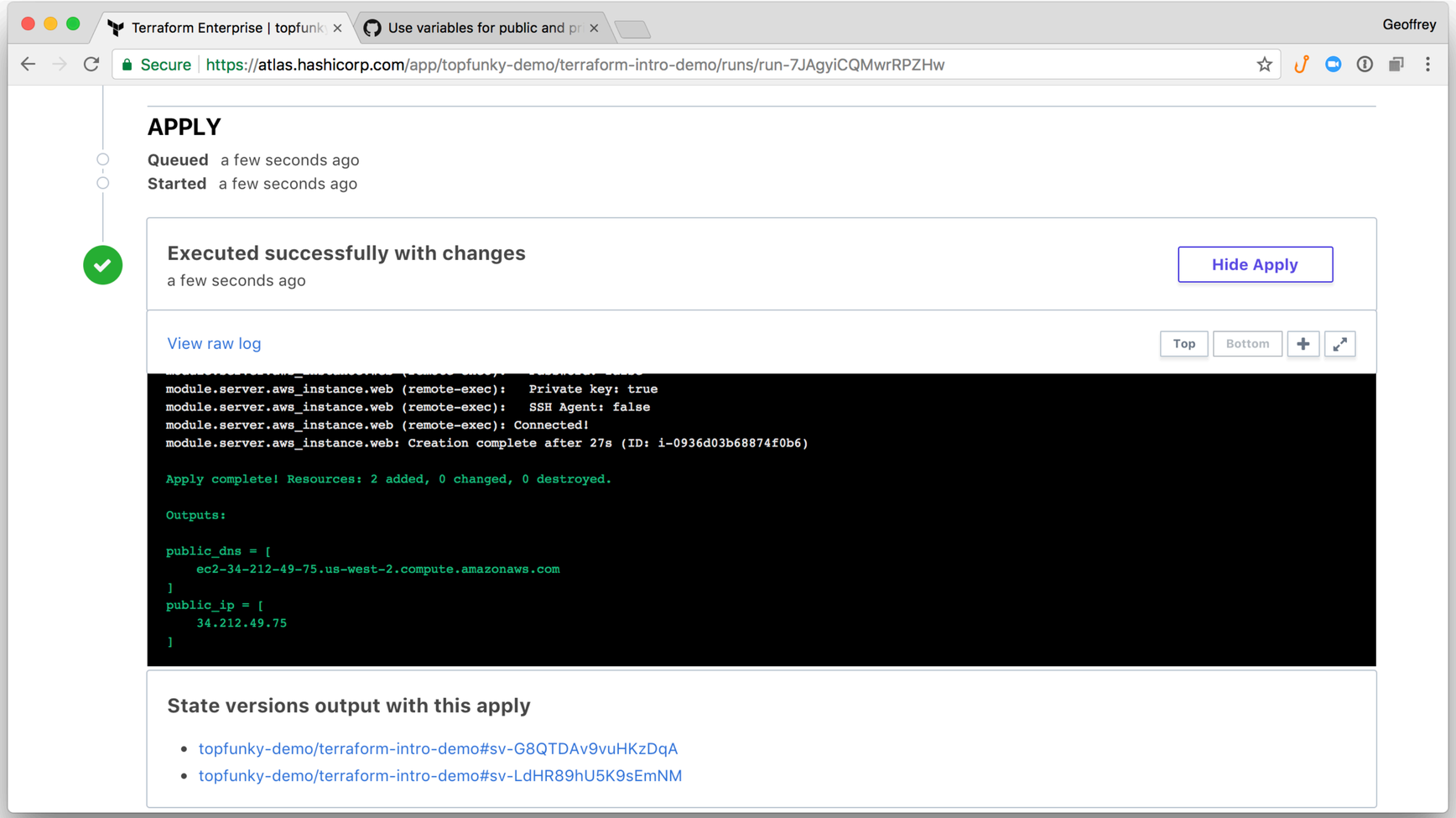

OAuth Application Settings
Terraform Enterprise | topfunky
Geoffrey
Secure
https://atlas.hashicorp.com/app/topfunky/training/variables
topfunky
Workspaces
Documentation
Status
training
Queue Plan
Latest Run
Runs
States
Variables
Settings
Integrations
Access
Terraform Variables
These variables are set using the var option when performing a plan and apply
Editing
access_key
xxxxxxxxxx
HCL
Sensitive
secret_key
xxxxxxxxx
HCL
Sensitive
ami
xxxxx
HCL
Sensitive
subnet_id
xxxxx
HCL
Sensitive
vpc_security_group_id
xxxxxx
HCL
Sensitive
identity
xxxxxx
HCL
Sensitive


Terraform Enterprise | topfunk
Use variables for public and pr
Geoffrey
GitHub, Inc. [US] | https://github.com/topfunky-demo/terraform-intro-demo/pull/2
No description provided.
topfunky-demo added some commits 4 minutes ago
Use variables for public and private key
Verified
e4fd78a
Expose variables for server module
Verified
8b27105
Add more commits by pushing to the topfunky-demo-patch-2 branch on topfunky-demo/terraform-intro-demo.
All checks have failed
1 failing check
Hide all checks
atlas/topfunky-demo/terraform-intro-demo — Terraform plan errored
Details
This branch has no conflicts with the base branch
Merging can be performed automatically.
Merge pull request
You can also open this in GitHub Desktop or view command line instructions.
Write
Preview
Leave a comment
Attach files by dragging & dropping, selecting them, or pasting from the clipboard.
Assignees
No one—assign yourself
Labels
None yet
Projects
None yet
Milestone
No milestone
Notifications
Unsubscribe
You're receiving notifications because you authored the thread.
1 participant
Lock conversation


Terraform Enterprise | topfunk
Use variables for public and pr
Geoffrey
GitHub, Inc. [US] | https://github.com/topfunky-demo/terraform-intro-demo/pull/2
topfunky-demo commented 6 minutes ago
Owner
No description provided.
topfunky-demo added some commits 6 minutes ago
Use variables for public and private key
Verified
e4fd78a
Expose variables for server module
Verified
8b27105
Use correct accessor for variables
Verified
72d99a9
Add more commits by pushing to the topfunky-demo-patch-2 branch on topfunky-demo/terraform-intro-demo.
All checks have passed
1 successful check
Show all checks
This branch has no conflicts with the base branch
Merging can be performed automatically.
Merge pull request
You can also open this in GitHub Desktop or view command line instructions.
Write
Preview
Leave a comment
Reviewers
No reviews—request one
Assignees
No one—assign yourself
Labels
None yet
Projects
None yet
Milestone
No milestone
Notifications
Unsubscribe
You're receiving notifications because you authored the thread.
1 participant
Lock conversation


Terraform Enterprise | topfunk
Use variables for public and pr
Geoffrey
Secure | https://atlas.hashicorp.com/app/topfunky-demo/terraform-intro-demo/runs
topfunky-demo
Workspaces
Documentation | Status
terraform-intro-demo
Queue Plan
Latest Run
Runs
States
Variables
Settings
Integrations
Access
Merge pull request #2 from topfunky-demo/topfunky-demo-patch-2 Use variables for public and private key
#run-7JAgyiCQMwrRPZHw | topfunky-demo triggered from GitHub | Branch after | 4193ada
NEEDS CONFIRMATION
a few seconds ago
Cleanup unused code. Remove redundant default.
#run-J5RuetxtMtA5oGta | topfunky triggered from GitHub | Branch after | 586713b
PLAN ERRORED
12 minutes ago
Queued manually in Terraform Enterprise
#run-h4s3RJKokdfYNjPo | geoffrey triggered from Terraform Enterprise UI | Branch master | c50485a
PLAN ERRORED
13 minutes ago
HashiCorp
Terms Privacy Security © 2017 HashiCorp, Inc.


Terraform Enterprise | topfunk
Use variables for public and pr
Geoffrey
Secure
https://atlas.hashicorp.com/app/topfunky-demo/terraform-intro-demo/runs/run-7JAgyiCQMwrRPZHw
Variables input to this run
Configuration input to this run
Run created by
GitHub Webhook
PLAN
Queued
a minute ago
Started
a minute ago
Executed and saved successfully
a minute ago
View Plan
State versions output with this plan
No state versions output
Leave a comment
Confirm & Apply
Discard Plan


Terraform Enterprise | topfunk
Use variables for public and pr
Geoffrey
Secure
https://atlas.hashicorp.com/app/topfunky-demo/terraform-intro-demo/runs/run-7JAgyiCQMwrRPZHw
APPLY
Queued a few seconds ago
Started a few seconds ago
Executed successfully with changes
a few seconds ago
Hide Apply
View raw log
Top
Bottom
module.server.aws_instance.web (remote-exec): Private key: true
module.server.aws_instance.web (remote-exec): SSH Agent: false
module.server.aws_instance.web (remote-exec): Connected!
module.server.aws_instance.web: Creation complete after 27s (ID: i-0936d03b68874f0b6)
Apply complete! Resources: 2 added, 0 changed, 0 destroyed.
Outputs:
public_dns = [
ec2-34-212-49-75.us-west-2.compute.amazonaws.com
]
public_ip = [
34.212.49.75
]
State versions output with this apply
topfunky-demo/terraform-intro-demo#sv-G8QTDAv9vuHKzDqA
topfunky-demo/terraform-intro-demo#sv-LdHR89hU5K9sEmNM

EXERCISE

Connect GitHub to TFE and Fork a GitHub Repo

Fork the GitHub repository at

`hashicorp/demo-terraform-101`

Connect Terraform Enterprise to GitHub

Create variables on Terraform Enterprise

What You Learned

- Create a repository at GitHub
- Push your code to GitHub
- Create an organization at Terraform Enterprise
- Connect to GitHub via OAuth
- Add a workspace that references a GitHub repo
- Commit changes and create infrastructure

Collaborating with TFE

What You'll Learn

- Understand the role of Terraform Enterprise in modern continuous provisioning workflows
- Understand the components of Terraform Enterprise: users, organizations, teams, workspaces

TIP

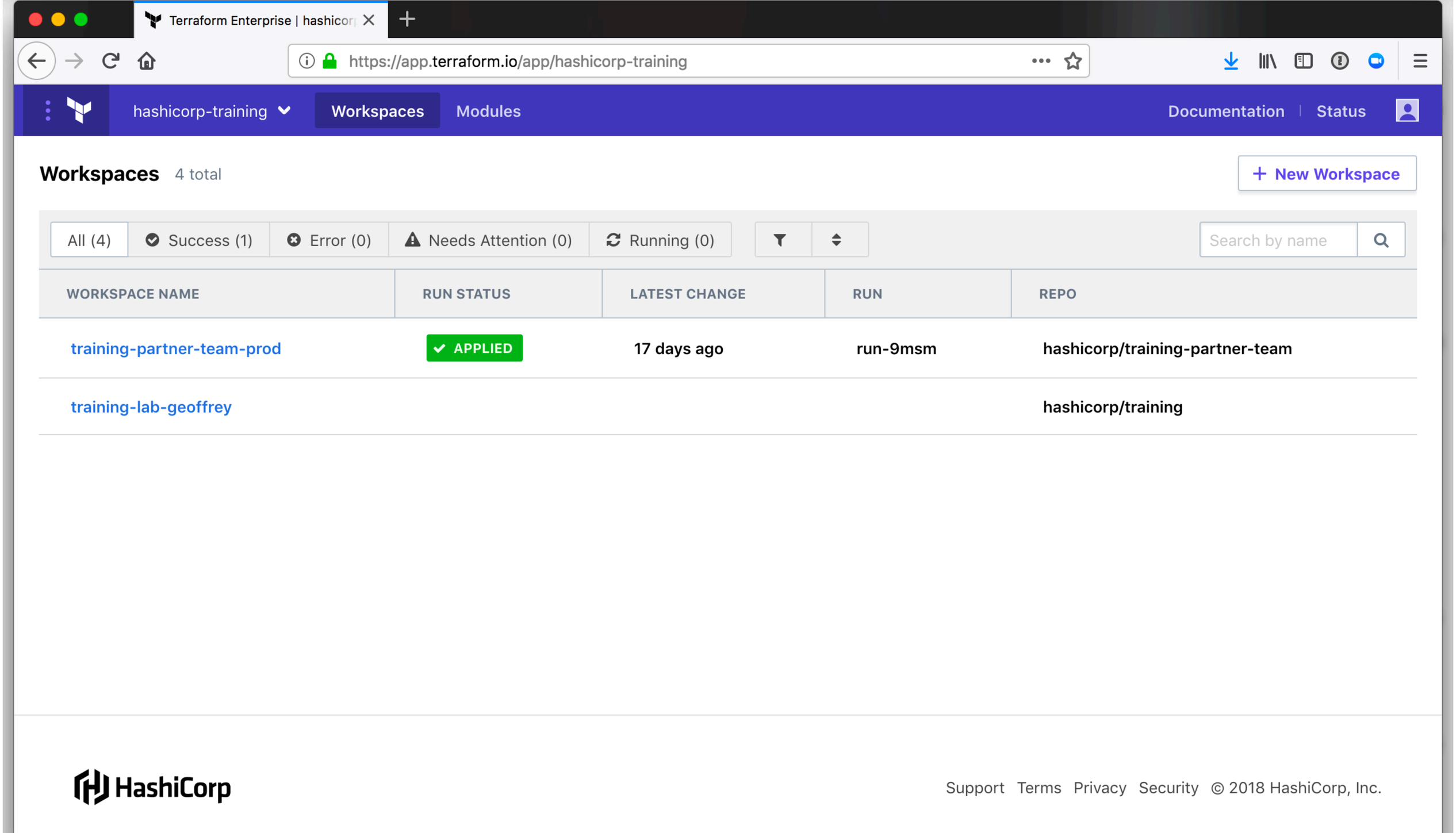
Follow Along in Your Terraform Enterprise Account

Initial setup of a Terraform Enterprise account is quick and easy.

Full import of repositories, code, users, and teams can take longer.

Follow along with this chapter as much as you can with the resources that have been setup in your specific account.

NOTE: Private installations of Terraform Enterprise are nearly identical to what you'll see here.


Terraform Enterprise | hashicor
https://app.terraform.io/app/hashicorp-training
hashicorp-training
Workspaces
Modules
Documentation
Status
Workspaces 4 total
+ New Workspace
All (4)
Success (1)
Error (0)
Needs Attention (0)
Running (0)
Search by name
WORKSPACE NAME
RUN STATUS
LATEST CHANGE
RUN
REPO
training-partner-team-prod
APPLIED
17 days ago
run-9msm
hashicorp/training-partner-team
training-lab-geoffrey
hashicorp/training
HashiCorp
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What Is Terraform Enterprise?

Platform for collaboration and governance with Terraform

Central module registry

Connection to version control for Terraform configuration code

Runs Terraform `plan` and `apply`

Log of provisioning actions

Stores state securely

Shares state within organizations

Configurable permissions for user and team access

HashiCorp Terraform

https://www.hashicorp.com/products/terraform?utm_source=oss&utm_medium=he

Open Source

Provision any infrastructure

Download Free

- Infrastructure as code
- Separation of infrastructure plans and applies
- Multi-provider support
- Public module registry

Pro ENTERPRISE

Collaboration and operations features for teams

Request Info

All Open Source features plus

- Workspace management and GUI
- Version control connection
- Secure variable management
- Remote plans, applies, state storage, locking, state rollback

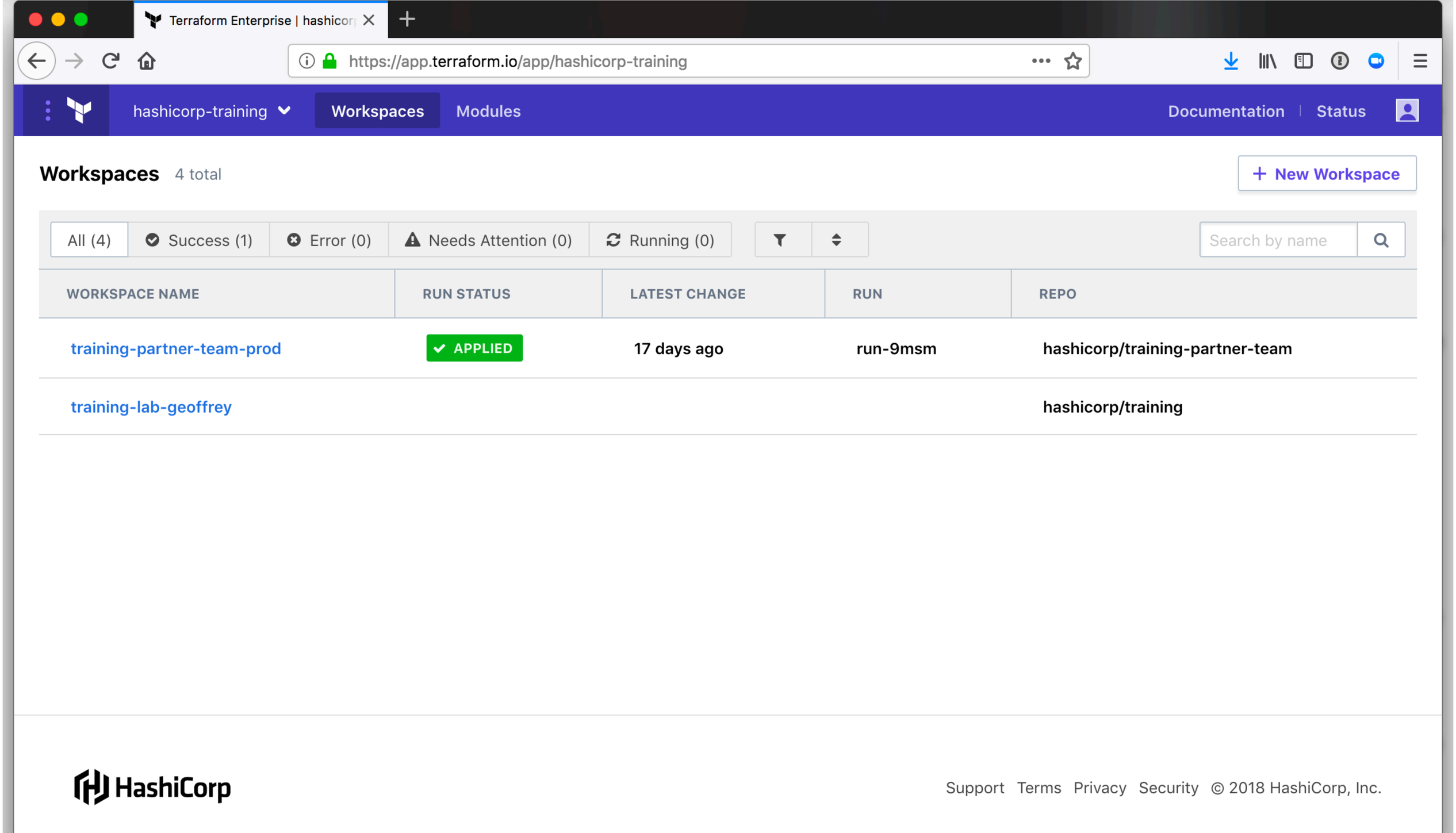
Premium ENTERPRISE

Governance and policy features for organizations

Request Info

All Pro features plus

- Policy as code management
- SSO with SAML
- Track infrastructure changes with audit logs
- Private install


Terraform Enterprise | hashicor
https://app.terraform.io/app/hashicorp-training
hashicorp-training
Workspaces
Modules
Documentation
Status
Workspaces 4 total
+ New Workspace
All (4)
Success (1)
Error (0)
Needs Attention (0)
Running (0)
Search by name
WORKSPACE NAME
RUN STATUS
LATEST CHANGE
RUN
REPO
training-partner-team-prod
APPLIED
17 days ago
run-9msm
hashicorp/training-partner-team
training-lab-geoffrey
hashicorp/training
HashiCorp
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Terraform Enterprise | geoffrey

https://app.terraform.io/app/geoffrey-org/training-lab-dev/runs/run-3U6iULTSvYY4UpNR

geoffrey-org | Workspaces | Modules | Documentation | Status

training-lab-dev

Queue Plan

Current Run | Runs | States | Variables | Settings | Version Control | Access

run-3U6i triggered from Terraform Enterprise UI 4 days ago

APPLIED 4 days ago

Use updated repo for code

By geoffrey-hashicorp | Commit `d756a0b` | Branch master | Repo geoffrey-hashicorp/training-lab

Run Timeline

Variables input to this run

Configuration input to this run

Run created by geoffrey Queued from Terraform Enterprise UI

APPLY

Queued 4 days ago
Started 4 days ago

Executed successfully with changes

4 days ago

Hide Apply

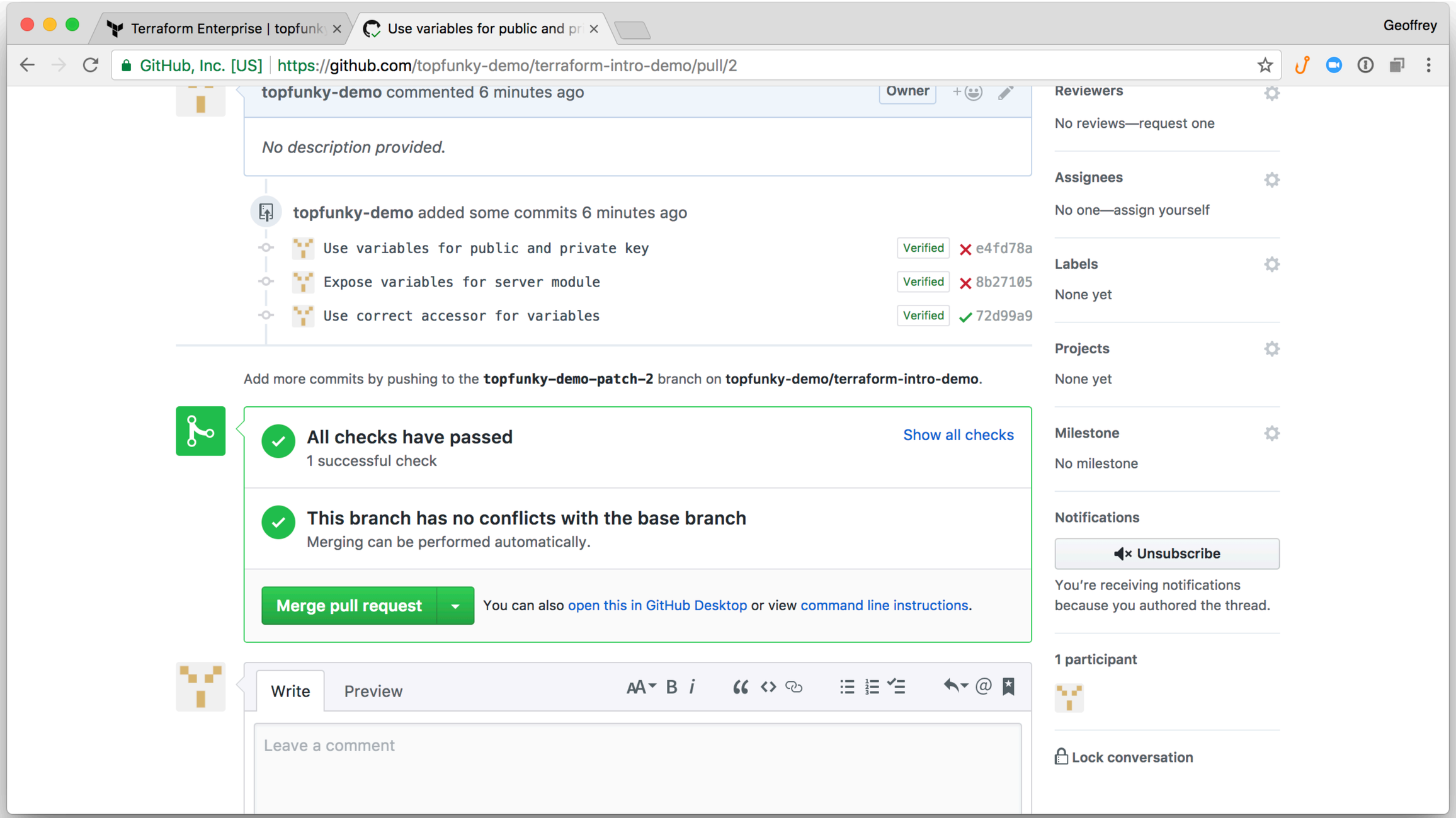
View raw log

Top Bottom + ⤢

```
servers = [
    35.166.219.112,
    54.200.186.220,
    54.244.179.158
]
vault-lb = demo-geoffrey-vault-40338213.us-west-2.elb.amazonaws.com
vault-root-token = demo-geoffrey-87527beded15210f
workstations = [
    18.236.126.204,
    34.217.101.207,
    54.187.133.88,
    35.164.123.169,
    34.214.7.120
]
```

State versions output with this apply

- geoffrey-org/training-lab-dev#sv-gS4yfAF7v6NQJzyT
- geoffrey-org/training-lab-dev#sv-d1K1AnjNCfgMQy1j


Terraform Enterprise | topfunk
Use variables for public and pr
Geoffrey
GitHub, Inc. [US] https://github.com/topfunky-demo/terraform-intro-demo/pull/2
topfunky-demo commented 6 minutes ago
Owner
No description provided.
topfunky-demo added some commits 6 minutes ago
Use variables for public and private key
Verified
e4fd78a
Expose variables for server module
Verified
8b27105
Use correct accessor for variables
Verified
72d99a9
Add more commits by pushing to the topfunky-demo-patch-2 branch on topfunky-demo/terraform-intro-demo.
All checks have passed
1 successful check
Show all checks
This branch has no conflicts with the base branch
Merging can be performed automatically.
Merge pull request
You can also open this in GitHub Desktop or view command line instructions.
Write
Preview
Leave a comment
Reviewers
No reviews—request one
Assignees
No one—assign yourself
Labels
None yet
Projects
None yet
Milestone
No milestone
Notifications
Unsubscribe
You're receiving notifications because you authored the thread.
1 participant
Lock conversation

User

Individual account on app.terraform.io

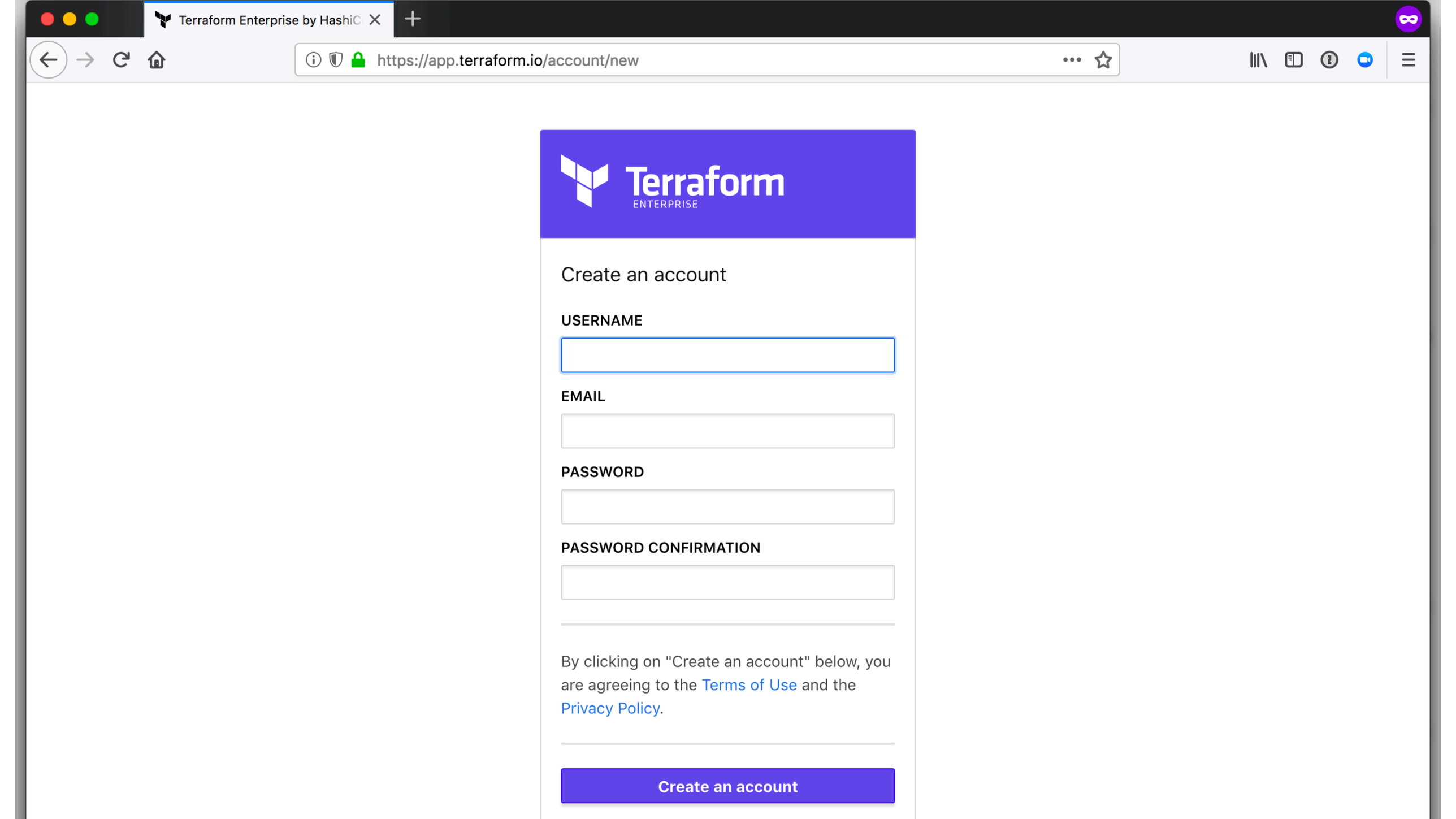
Can be a member of multiple teams and organizations

Signup is global at:

https://app.terraform.io/account/new

Usernames are global across all terraform.io users

https://www.terraform.io/docs/enterprise/users-teams-organizations/users.html


Terraform Enterprise by HashiC
https://app.terraform.io/account/new
Terraform
ENTERPRISE
Create an account
USERNAME
EMAIL
PASSWORD
PASSWORD CONFIRMATION
By clicking on "Create an account" below, you are agreeing to the Terms of Use and the Privacy Policy.
Create an account

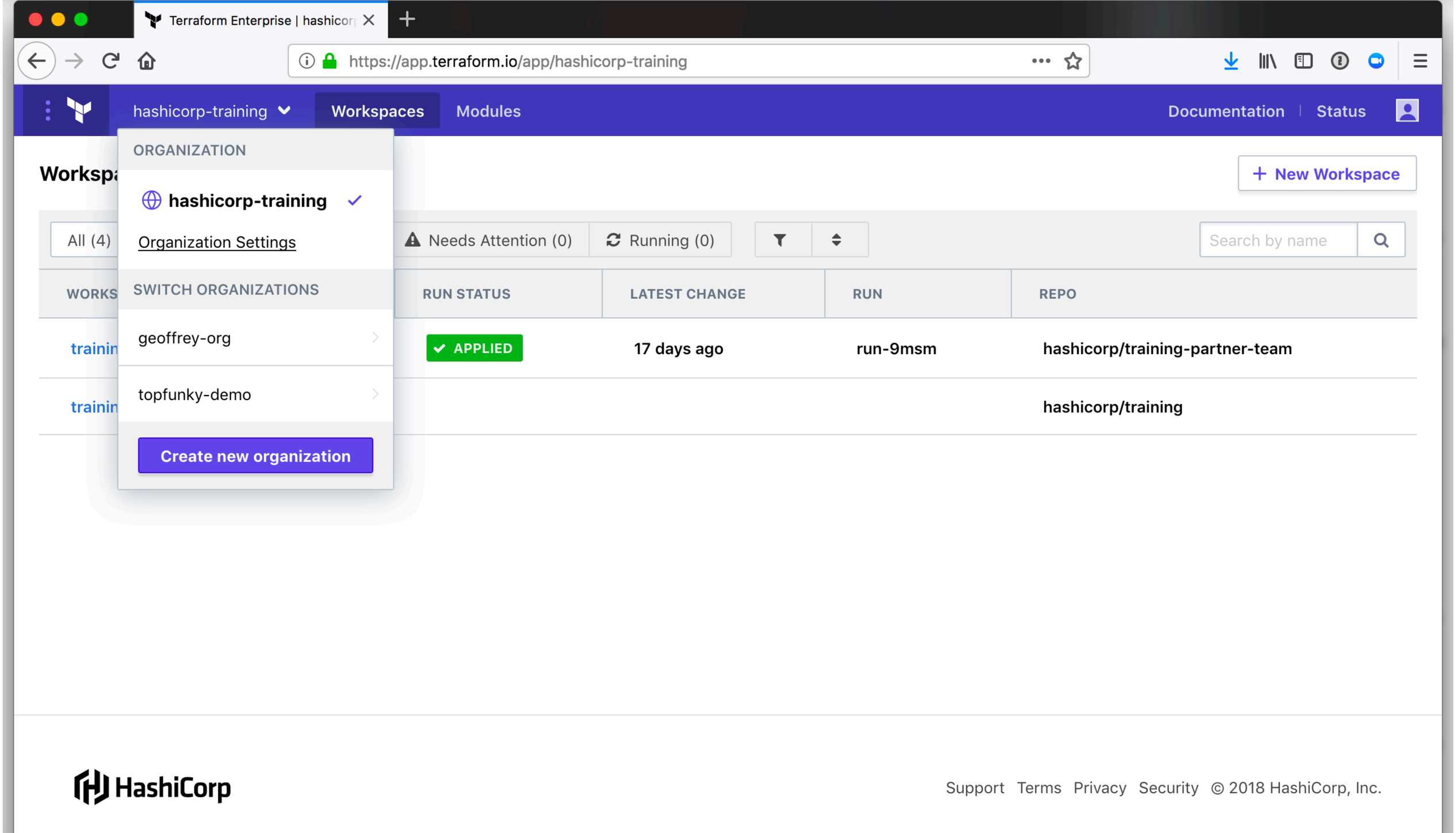
Organization

Shared spaces for teams to collaborate on workspaces.

Organizations can have many teams.

Sentinel policies run at the organization level across all workspaces.

https://www.terraform.io/docs/enterprise/users-teams-organizations/index.html


Terraform Enterprise | hashicor
https://app.terraform.io/app/hashicorp-training
hashicorp-training
Workspaces
Modules
Documentation
Status
ORGANIZATION
hashicorp-training
Organization Settings
SWITCH ORGANIZATIONS
geoffrey-org
topfunky-demo
Create new organization
Workspa
+ New Workspace
All (4)
Needs Attention (0)
Running (0)
Search by name
WORKS
RUN STATUS
LATEST CHANGE
RUN
REPO
trainin
APPLIED
17 days ago
run-9msm
hashicorp/training-partner-team
trainin
hashicorp/training
HashiCorp
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Terms
Privacy
Security
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Team

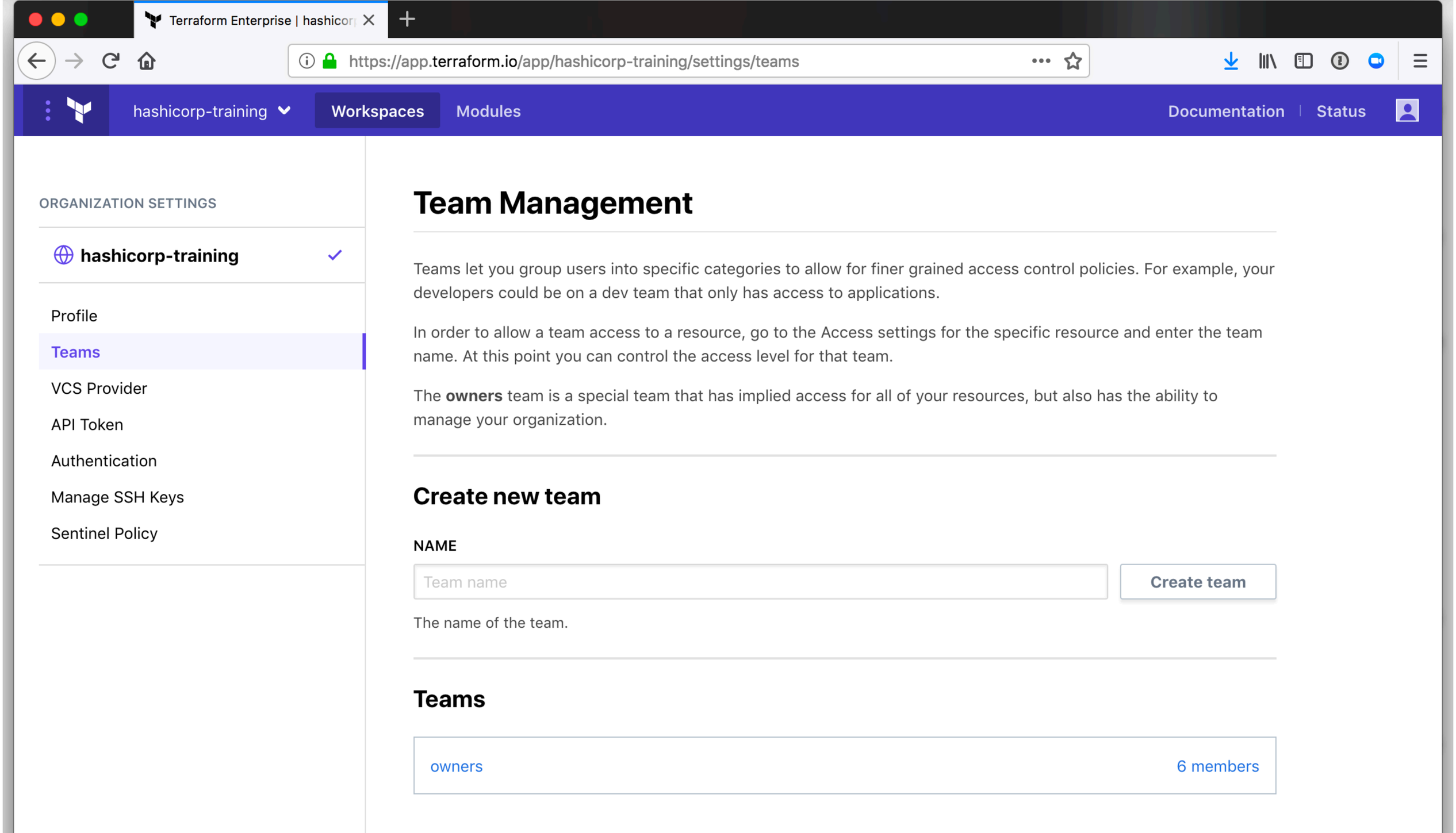
Groups of users that reflect your company's organization or project structure.

Teams can be granted read, write, and admin permissions to workspaces.

Teams are created under the organization settings.

Permissions are configured under workspace access settings.

https://www.terraform.io/docs/enterprise/users-teams-organizations/teams.html


Terraform Enterprise | hashicor
https://app.terraform.io/app/hashicorp-training/settings/teams
hashicorp-training
Workspaces
Modules
Documentation
Status
ORGANIZATION SETTINGS
hashicorp-training
Profile
Teams
VCS Provider
API Token
Authentication
Manage SSH Keys
Sentinel Policy
Team Management
Teams let you group users into specific categories to allow for finer grained access control policies. For example, your developers could be on a dev team that only has access to applications.
In order to allow a team access to a resource, go to the Access settings for the specific resource and enter the team name. At this point you can control the access level for that team.
The owners team is a special team that has implied access for all of your resources, but also has the ability to manage your organization.
Create new team
NAME
Team name
Create team
The name of the team.
Teams
owners
6 members

Workspaces

Workspaces are how Terraform Enterprise tracks infrastructure.

One Terraform configuration linked to a version control repository.

Values for variables used by the configuration.

Persistent stored state.

Historical state and run logs.

https://www.terraform.io/docs/enterprise/workspaces/index.html

Workspace Approaches

One approach is to have one workspace per environment per config, named accordingly.

- billing-app-dev
- billing-app-stage
- billing-app-prod
- networking-dev
- networking-stage
- networking-prod

https://www.terraform.io/docs/enterprise/workspaces/index.html

Alternate Workspace Approaches

Or, you could create a separate organization for development, test, or staging environments.

Organizations cannot share state, so this keeps them isolated.

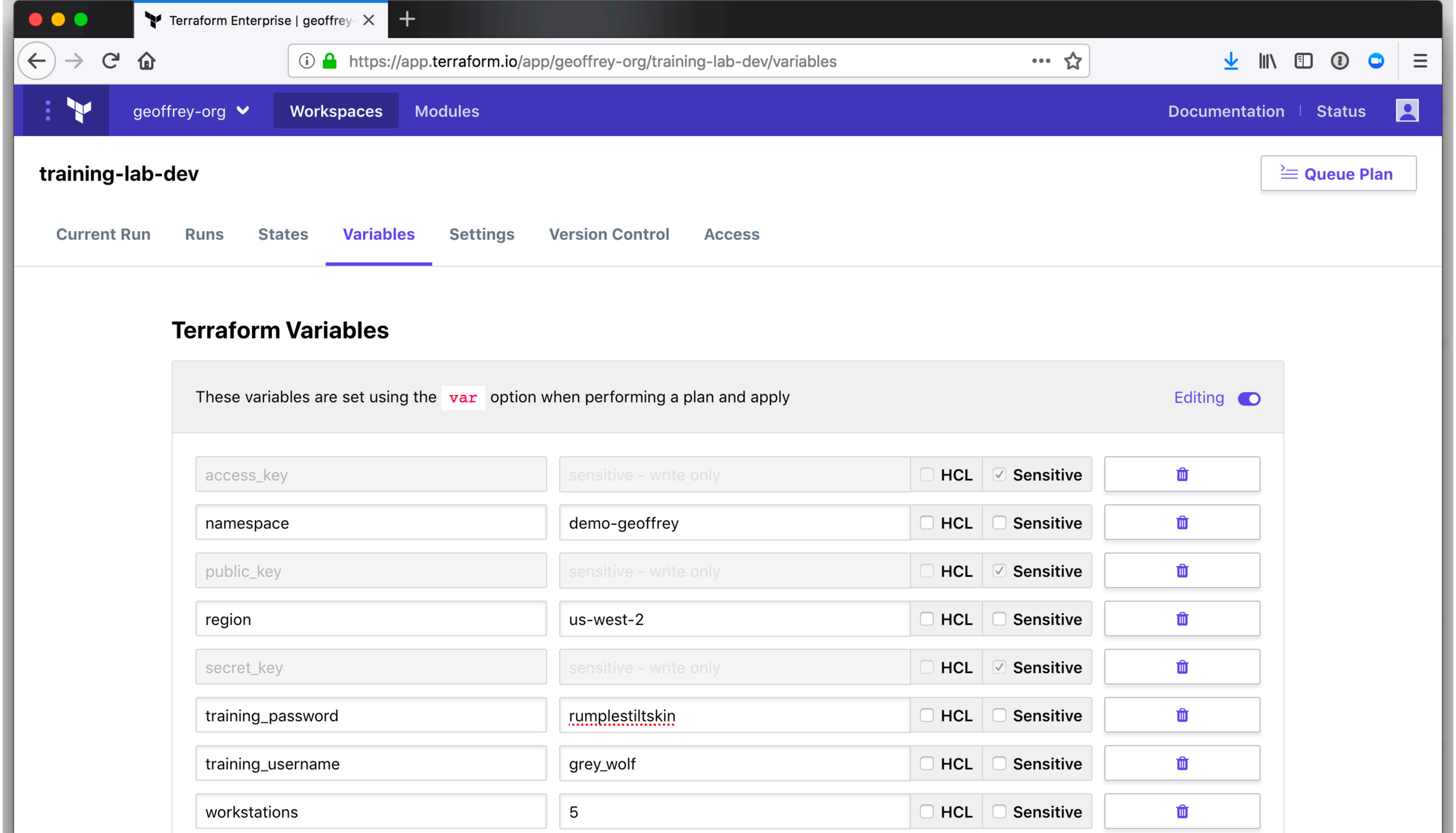
https://www.terraform.io/docs/enterprise/workspaces/index.html

Variables

Terraform Enterprise variables replace both `terraform.tfvars` and any environment variables that you would use on a local machine.

Variables can be marked as *sensitive*, in which case they will not be displayed in the UI on subsequent visits.

Variables must be saved before they will be used.


Terraform Enterprise | geoffrey
https://app.terraform.io/app/geoffrey-org/training-lab-dev/variables
geoffrey-org
Workspaces
Modules
Documentation
Status
training-lab-dev
Queue Plan
Current Run
Runs
States
Variables
Settings
Version Control
Access
Terraform Variables
These variables are set using the var option when performing a plan and apply
Editing
access_key
sensitive - write only
HCL
Sensitive
namespace
demo-geoffrey
HCL
Sensitive
public_key
sensitive - write only
HCL
Sensitive
region
us-west-2
HCL
Sensitive
secret_key
sensitive - write only
HCL
Sensitive
training_password
rumplestiltskin
HCL
Sensitive
training_username
grey_wolf
HCL
Sensitive
workstations
5
HCL
Sensitive

How your team works

TFE can be used as a part of your team's existing workflows, or you can evolve your team workflows to take advantage of TFE features.

- **Manual:** Queue runs on demand
- **Semi-auto:** `plan` runs on VCS commit
- **Continuous Infrastructure:** `apply` on VCS commit

https://www.terraform.io/docs/enterprise/guides/recommended-practices/part2.html

API

Terraform Enterprise provides a comprehensive API. Many companies drive workflows entirely through the API.

Due to the uniqueness of applications and the depth of features offered, we won't discuss it here.

See the documentation for more details:

https://www.terraform.io/docs/enterprise/api/index.html

API Tokens

Three kinds of API tokens are offered: organization, team, or user.

Accessing state from outside TFE requires a user token.

Team tokens are useful for triggering plans and applies from external CI/CD tools.

Organization tokens only modify teams and workspaces. They cannot trigger `plan` or `apply`.

https://www.terraform.io/docs/enterprise/api/index.html

CODE EDITOR

```
data "terraform_remote_state" "vpc" {
  backend = "atlas"
  config {
    name = "phoenixbank/vpc-prod"
  }
}

# Elsewhere, use outputs from the state
"${data.terraform_remote_state.vpc.cidr_block}"
```

What You Learned

- Understand the role of Terraform Enterprise in modern continuous provisioning workflows
- Understand the components of Terraform Enterprise: users, organizations, teams, workspaces

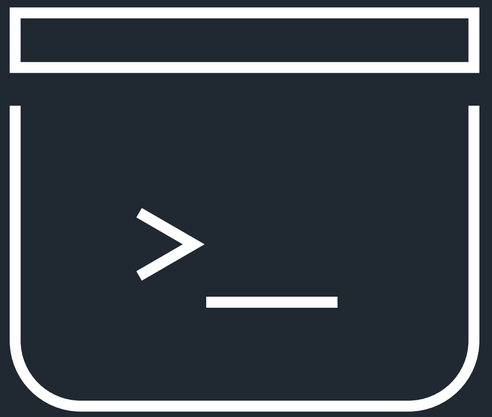
Template File Provider

What You'll Learn

- Use the template_file provider
- Render an IAM policy from a template
- Understand real world scenarios for using templates

Plain Text
Template

Variables from Cloud or
Other Resources



Render with
Terraform


TERMINAL
~
$ mkdir -p tfproject/templates && cd $_
~/tfproject/templates
$ touch iampolicy.tpl.json

IAMPOLICY.TPL.JSON

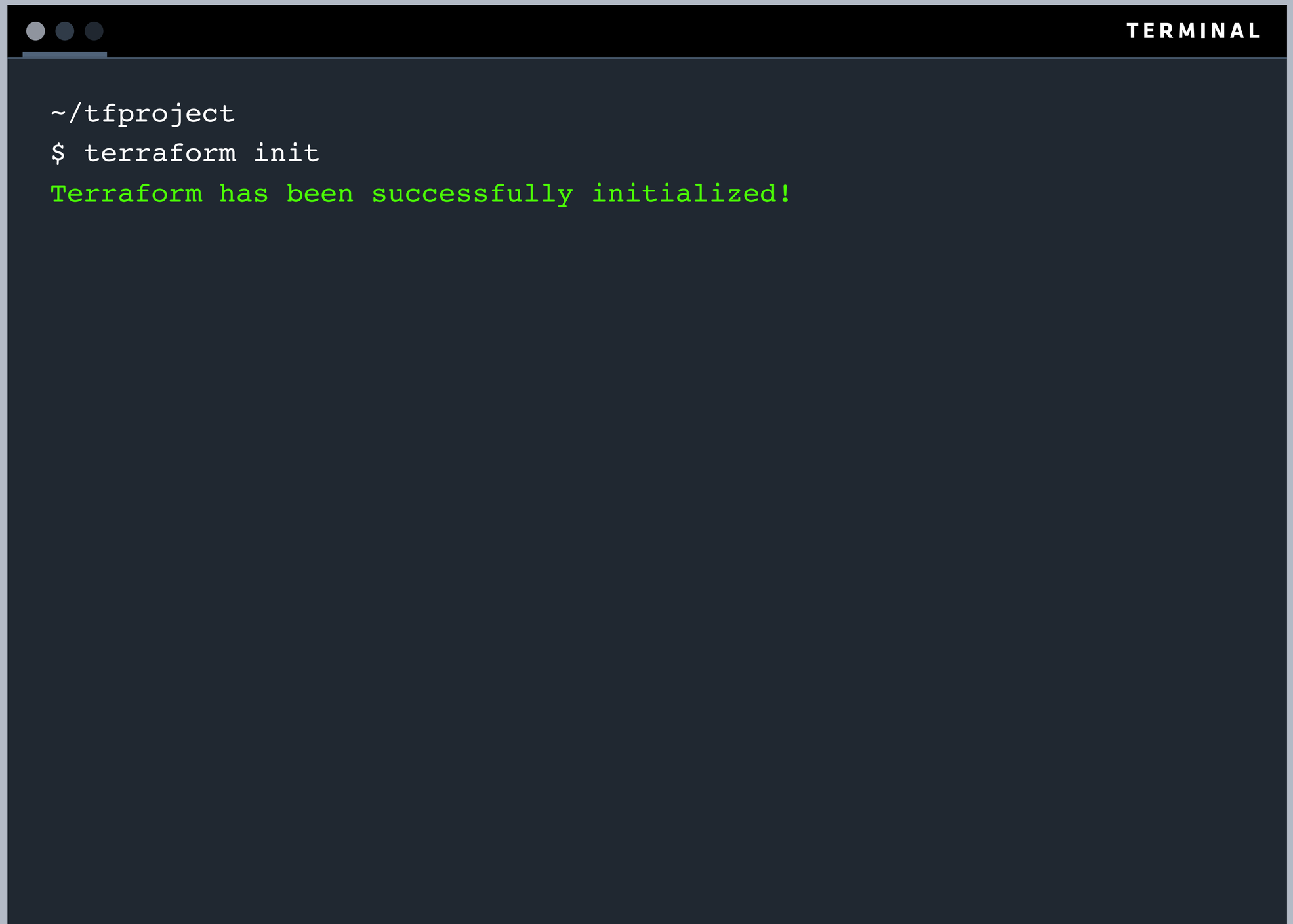
```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "RestrictInstanceLifecycle",
      "Effect": "Allow",
      "Action": [
        "ec2:StartInstances",
        "ec2:StopInstances",
        "ec2:TerminateInstances"
      ],
      "Resource": [
        "arn:aws:ec2:us-west-1a:1234567890:instance/*"
      ]
    }
  ]
}
```

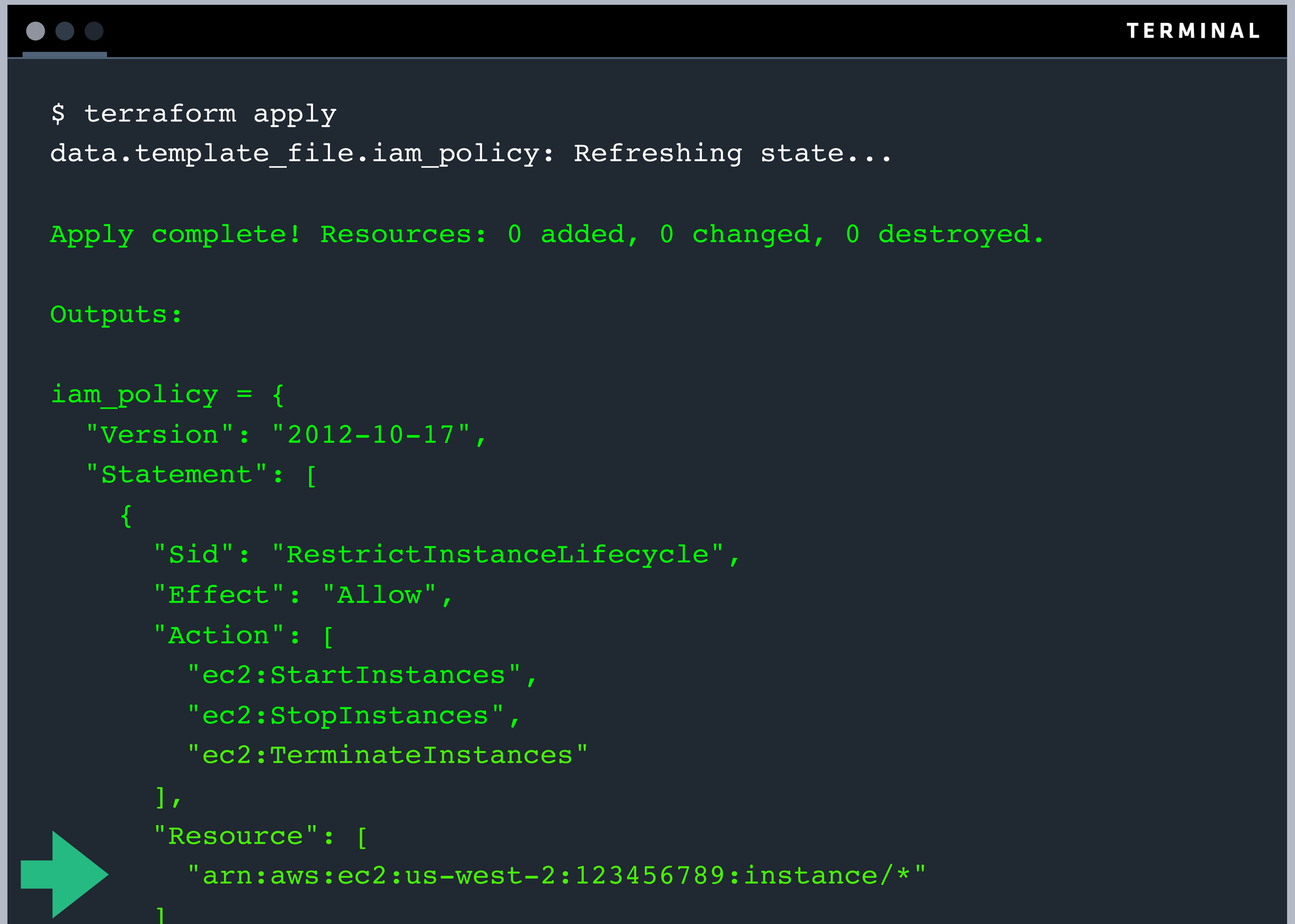
IAMPOLICY.TPL.JSON

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "RestrictInstanceLifecycle",
      "Effect": "Allow",
      "Action": [
        "ec2:StartInstances",
        "ec2:StopInstances",
        "ec2:TerminateInstances"
      ],
      "Resource": [
        "arn:aws:ec2:${region}:${owner_id}:instance/*"
      ]
    }
  ]
}
```

MAIN.TF

```
variable "region" {
  default = "us-west-2"
}

variable "owner_id" {
  default = "1234567890"
}

data "template_file" "iam_policy" {
  template = "${file("templates/iam_policy.tpl.json")}"

  vars {
    region   = "${var.region}"
    owner_id = "${var.owner_id}"
  }
}

output "iam_policy" {
  value = "${data.template_file.iam_policy.rendered}"
}
```


TERMINAL
~/tfproject
$ terraform init
Terraform has been successfully initialized!


TERMINAL
$ terraform apply
data.template_file.iam_policy: Refreshing state...
Apply complete! Resources: 0 added, 0 changed, 0 destroyed.
Outputs:
iam_policy = {
"Version": "2012-10-17",
"Statement": [
{
"Sid": "RestrictInstanceLifecycle",
"Effect": "Allow",
"Action": [
"ec2:StartInstances",
"ec2:StopInstances",
"ec2:TerminateInstances"
],
"Resource": [
"arn:aws:ec2:us-west-2:123456789:instance/*"

Real world scenarios

Pass custom scripts to an instance's `user_data`

Create a new IAM policy with the `policy` argument

Customize a configuration file, such as a startup script or a Consul config

Code Editor

```
resource "aws_iam_policy" "policy" {
  name = "service_policy"
  path = "/"
  description = "Service policy"

  policy = "${data.template_file.policy.rendered}"
}
```

Code Editor

```
resource "aws_instance" "web" {
  ami = "ubuntu"
  instance_type = "t2.micro"

  user_data = "${data.template_file.user_data.rendered}"
}
```

CODE EDITOR

```
data "template_file" "init" {
  template = "${file("${path.module}/init.tpl")}"

  vars {
    consul_address = "${aws_instance.consul.private_ip}"
  }
}
```

TIP

Build Absolute Paths With `path.module`

When rendering templates from within modules, it's possible to end up in the wrong directory.

To fix this, use `path.module` when supplying the path to a template. This builds an absolute path to the current module.

```
template = "${file("${path.module}/init.tpl")}"
```

EXERCISE

Write and Render a Template

Create a template file to reference an IAM Policy

Edit variables of template for Terraform to interpolate

Pass template files into Terraform configurations with data providers

Visualize actual output after applying new policy

Packer for Machine Images

HashiCorp

What You'll Learn

- The workflow for building images with Packer
- How to use Packer JSON with cloud image APIs
- How to copy files and run scripts
- Tips and tricks for achieving a successful result quickly and without frustration

WARNING

It's Too Easy To Rely Too Much on Terraform Provisioners

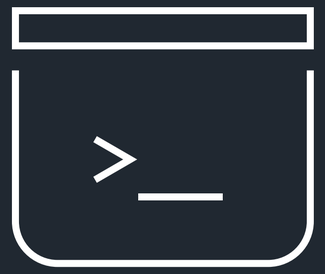
Provisioners were designed to defer to a configuration management system, not run 700 lines of user data shell scripts.

Terraform was not designed to report errors that occur inside machine images (`cloud_init.log`).

Modifying existing images line by line at provision time is slow.

The solution is to build custom images with Packer.

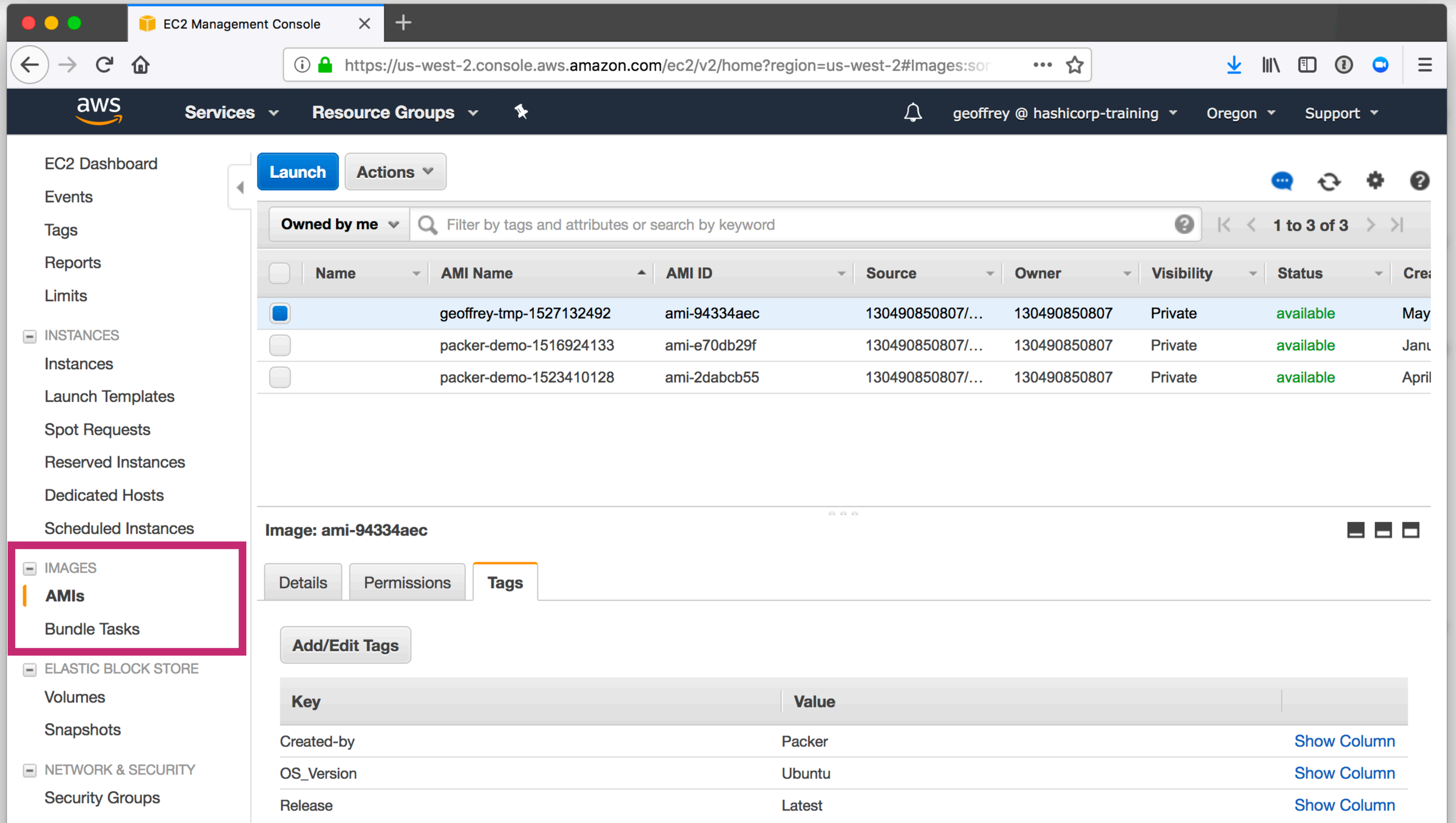
JSON

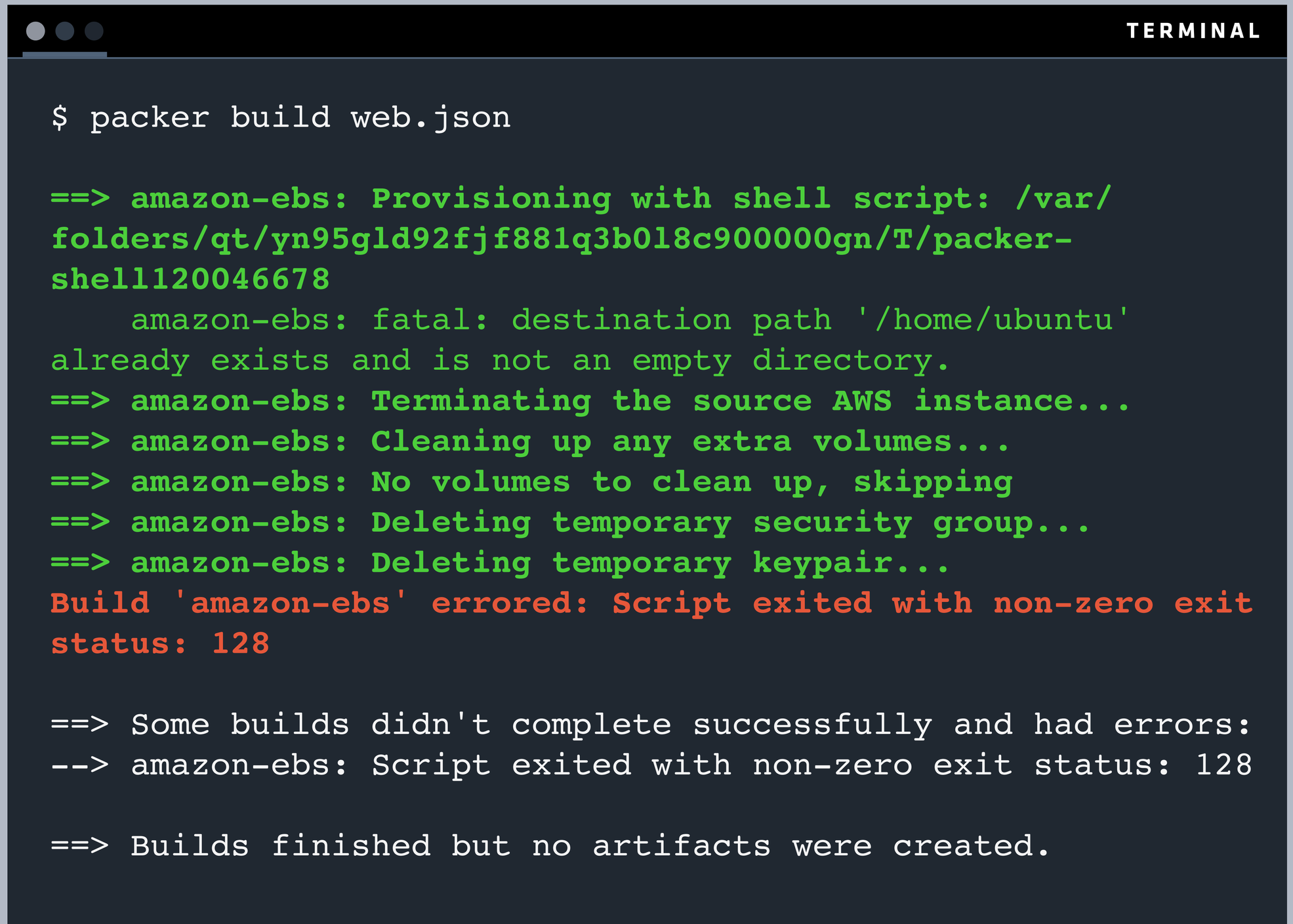


Build

EC2

ami-d3f8ae


EC2 Management Console
https://us-west-2.console.aws.amazon.com/ec2/v2/home?region=us-west-2#Images:sor
aws
Services
Resource Groups
geoffrey @ hashicorp-training
Oregon
Support
EC2 Dashboard
Events
Tags
Reports
Limits
INSTANCES
Instances
Launch Templates
Spot Requests
Reserved Instances
Dedicated Hosts
Scheduled Instances
IMAGES
AMIs
Bundle Tasks
ELASTIC BLOCK STORE
Volumes
Snapshots
NETWORK & SECURITY
Security Groups
Launch
Actions
Owned by me
Filter by tags and attributes or search by keyword
1 to 3 of 3
Name
AMI Name
AMI ID
Source
Owner
Visibility
Status
geoffrey-tmp-1527132492 ami-94334aec 130490850807/... 130490850807 Private available May
packer-demo-1516924133 ami-e70db29f 130490850807/... 130490850807 Private available Janu
packer-demo-1523410128 ami-2dabcb55 130490850807/... 130490850807 Private available April
Image: ami-94334aec
Details
Permissions
Tags
Add/Edit Tags
Key
Value
Created-by Packer Show Column
OS_Version Ubuntu Show Column
Release Latest Show Column


TERMINAL
$ packer build web.json
==> amazon-ebs: Provisioning with shell script: /var/folders/qt/yn95gld92fjf881q3b0l8c900000gn/T/packer-shell120046678
amazon-ebs: fatal: destination path '/home/ubuntu' already exists and is not an empty directory.
==> amazon-ebs: Terminating the source AWS instance...
==> amazon-ebs: Cleaning up any extra volumes...
==> amazon-ebs: No volumes to clean up, skipping
==> amazon-ebs: Deleting temporary security group...
==> amazon-ebs: Deleting temporary keypair...
Build 'amazon-ebs' errored: Script exited with non-zero exit status: 128
==> Some builds didn't complete successfully and had errors:
--> amazon-ebs: Script exited with non-zero exit status: 128
==> Builds finished but no artifacts were created.

Packer Syntax & Features

Declared as JSON.

Variables can be provided on the command line or in the file. Predates Terraform so the syntax is slightly different.

Packer can build images for multiple platforms (AWS, Azure, GCP).

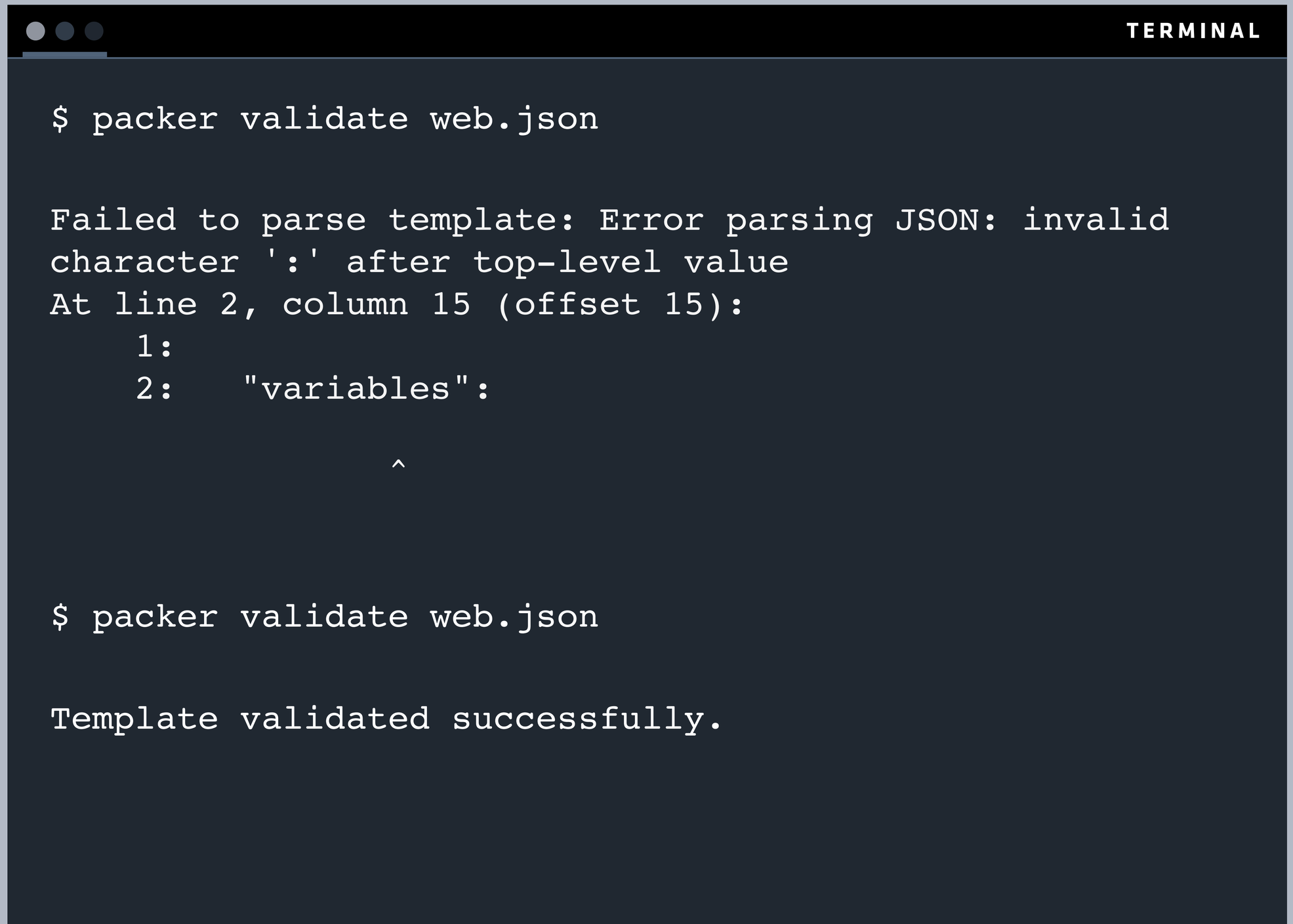
Provisioners handoff to a configuration management tool or run shell commands or scripts.

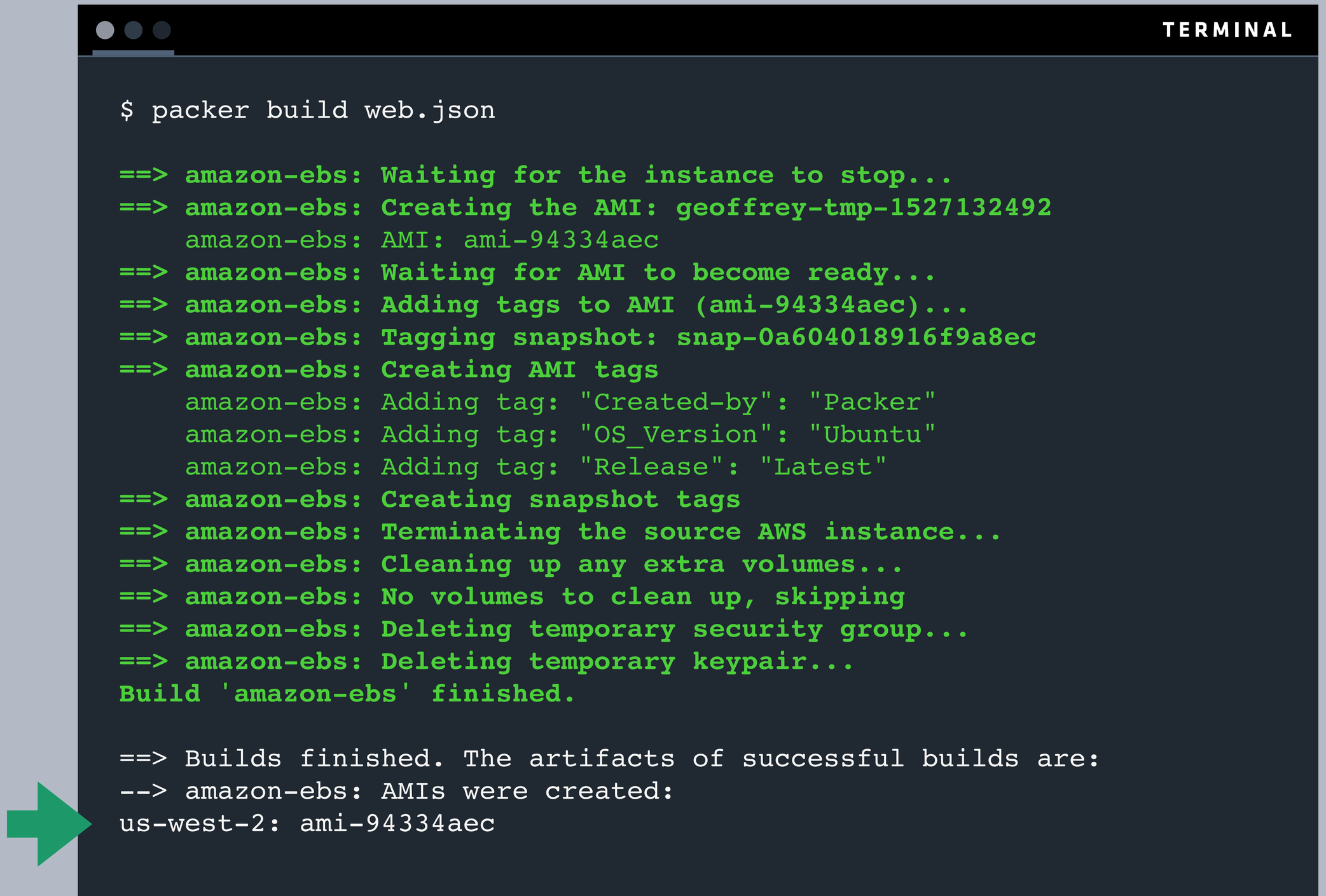
Builders

Alicloud ECS	File	Null	QEMU
Amazon EC2	Google Cloud	1&1	Scaleway
Azure	Hyper-V	OpenStack	Triton
CloudStack	LXC	Oracle	VirtualBox
DigitalOcean	LXD	Parallels	VMware
Docker	NAVER Cloud	ProfitBricks	

CODE EDITOR

```
{
  "variables": {
    "aws_source_ami": "ami-bd8f33c5"
  },
  "builders": [
    {
      "type": "amazon-ebs",
      "source_ami": "{{user `aws_source_ami`}}",
      "ami_name": "geoffrey-tmp-{{timestamp}}",
      "tags": {
        "Created-by": "Packer",
        "OS_Version": "Ubuntu",
        "Release": "Latest"
      }
    }
  ],
  "provisioners": [
    {
      "type": "shell",
      "inline": [
        "git clone https://github.com/hashicorp/demo-terraform-101.git",
        "sudo sh setup-web.sh"
      ]
    }
  ]
}
```


TERMINAL
$ packer validate web.json
Failed to parse template: Error parsing JSON: invalid character ':' after top-level value
At line 2, column 15 (offset 15):
1:
2: "variables":
^
$ packer validate web.json
Template validated successfully.


TERMINAL
$ packer build web.json
==> amazon-ebs: Waiting for the instance to stop...
==> amazon-ebs: Creating the AMI: geoffrey-tmp-1527132492
amazon-ebs: AMI: ami-94334aec
==> amazon-ebs: Waiting for AMI to become ready...
==> amazon-ebs: Adding tags to AMI (ami-94334aec)...
==> amazon-ebs: Tagging snapshot: snap-0a604018916f9a8ec
==> amazon-ebs: Creating AMI tags
amazon-ebs: Adding tag: "Created-by": "Packer"
amazon-ebs: Adding tag: "OS_Version": "Ubuntu"
amazon-ebs: Adding tag: "Release": "Latest"
==> amazon-ebs: Creating snapshot tags
==> amazon-ebs: Terminating the source AWS instance...
==> amazon-ebs: Cleaning up any extra volumes...
==> amazon-ebs: No volumes to clean up, skipping
==> amazon-ebs: Deleting temporary security group...
==> amazon-ebs: Deleting temporary keypair...
Build 'amazon-ebs' finished.
==> Builds finished. The artifacts of successful builds are:
--> amazon-ebs: AMIs were created:
us-west-2: ami-94334aec

TIP

Workflow for Developing Machine Images

Launch an instance with your desired base AMI

Write a script to install packages, etc.

Run the script and debug it on the live machine.

Copy the script to your local machine or to a repository that can be cloned.

Run the script from Packer with a `script` attribute. (Do not try to run dozens of individual inline commands explicitly inside Packer).

TIP

Know Your OS

Lean on `systemd` or your OS-provided process launching and running facility.

Use OS-native commands to install packages rather than building from source.

Reboot the machine a few times to ensure all services start automatically.

For a simple example, see:

`https://github.com/hashicorp/demo-terraform-101/tree/master/assets`

EXERCISE

Validate and Build an Image With Packer

Using an existing Ubuntu image, write a Packer JSON file that clones a Git repo and runs a setup script contained within.

The setup script will copy a Go web application to the appropriate location. It will also install `systemd` startup scripts so the application is started on boot.

Multi-Provider

What You'll Learn

- How to configure multiple providers
- How to use attributes of one provider as arguments in another

Providers

Alicloud	Archive	AWS
Azure	Bitbucket	CenturyLinkCloud
Chef	Circonus	Cloudflare
CloudScale.ch	CloudStack	Cobbler
Consul	Datadog	DigitalOcean
DNS	DNSMadeEasy	DNSimple
Docker	Dyn	External
Fastly	GitHub	Gitlab
Google Cloud	Grafana	Heroku
HTTP	Icinga2	Ignition
InfluxDB	Kubernetes	Librato
Local	Logentries	LogicMonitor
Mailgun	MySQL	New Relic
Nomad	NS1	Null

1&1	OpenStack	OpenTelekomC
OpsGenie	Oracle Public Cloud	Oracle Cloud Pl
OVH	Packet	PagerDuty
Palo Alto Networks	PostgreSQL	PowerDNS
ProfitBricks	RabbitMQ	Rancher
Random	Rundeck	Runscope
Scaleway	SoftLayer	StatusCake
Spotinst	Template	Terraform
Terraform Enterprise	TLS	Triton
UltraDNS	Vault	VMware vCloud
VMware NSX-T	VMware vSphere	

CODE EDITOR

```
provider "github" {
  token        = "${var.github_token}"
  organization = "hashicorp"
}

provider "aws" {
  version = ">= 1.19.0"
}


data "github_ip_ranges" "test" {}

egress {
  from_port   = 0
  to_port     = 0
  protocol    = "-1"
  cidr_blocks = ["${data.github_ip_ranges.test.pages}"]
}
```

EXERCISE

Use GitHub IP Addresses to Constrain an AWS Security Group

Configure a GitHub provider and an AWS provider.

Define a data source for GitHub IP address ranges.

Configure an AWS security group so that egress traffic is only allowed to access GitHub IP address ranges.

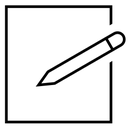
Verify by sending a `ping` to a GitHub IP address as well as to `hashicorp.com`

Resource Lifecycles

What You'll Learn

- How Terraform creates and destroys resources
- How to diverge from the default behavior
- What code organization techniques go with which lifecycle behavior

Default Behavior



MODIFY

When possible

EXAMPLES

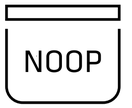
Add a tag
Change SSH user (GCP)

DESTROY

Freely

EXAMPLES

Rename an instance
Change machine type
Decrease count
Refactor to modules
Change startup script

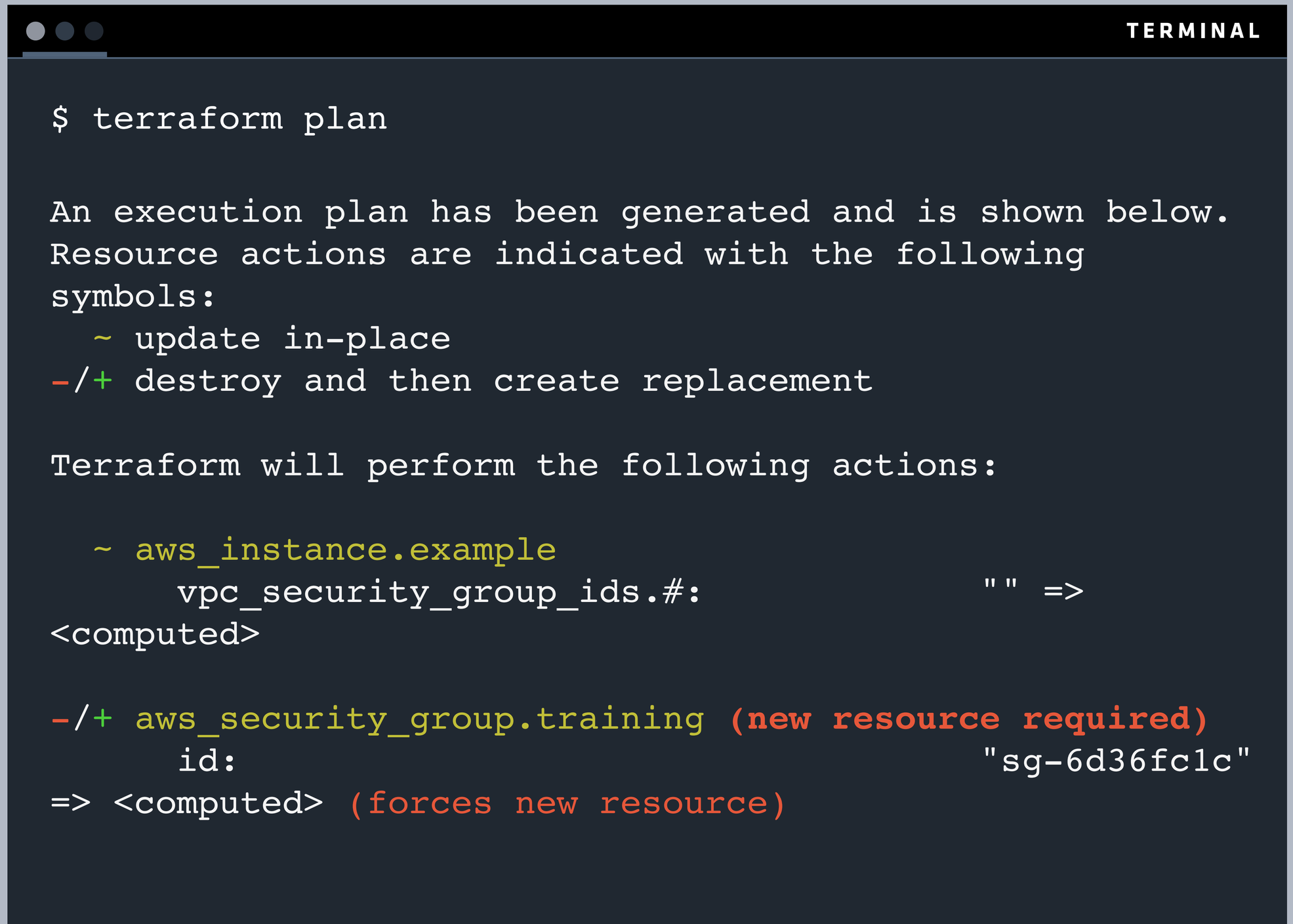


Do Nothing

Occasionally

EXAMPLES

Change provisioner
Add an output
Refactor to variables

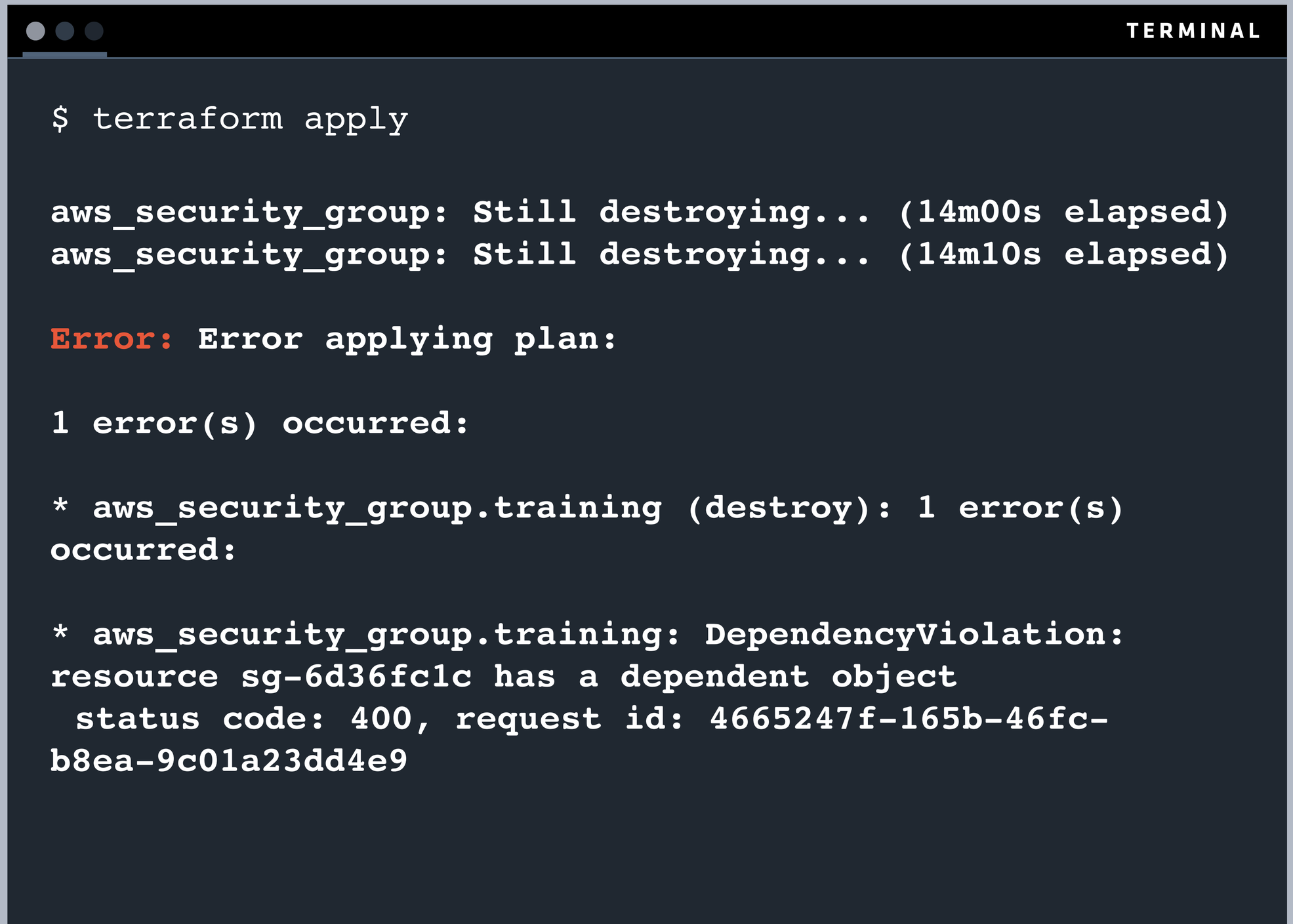

TERMINAL
$ terraform plan
An execution plan has been generated and is shown below.
Resource actions are indicated with the following
symbols:
~ update in-place
-/+ destroy and then create replacement
Terraform will perform the following actions:
~ aws_instance.example
vpc_security_group_ids.#: "" =>
<computed>
-/+ aws_security_group.training (new resource required)
id: "sg-6d36fc1c"
=> <computed> (forces new resource)

WARNING

Destroy, Then Create

Existing resources are first destroyed before new ones are created.

If the destruction succeeded cleanly, then and only then are replacement resources created.

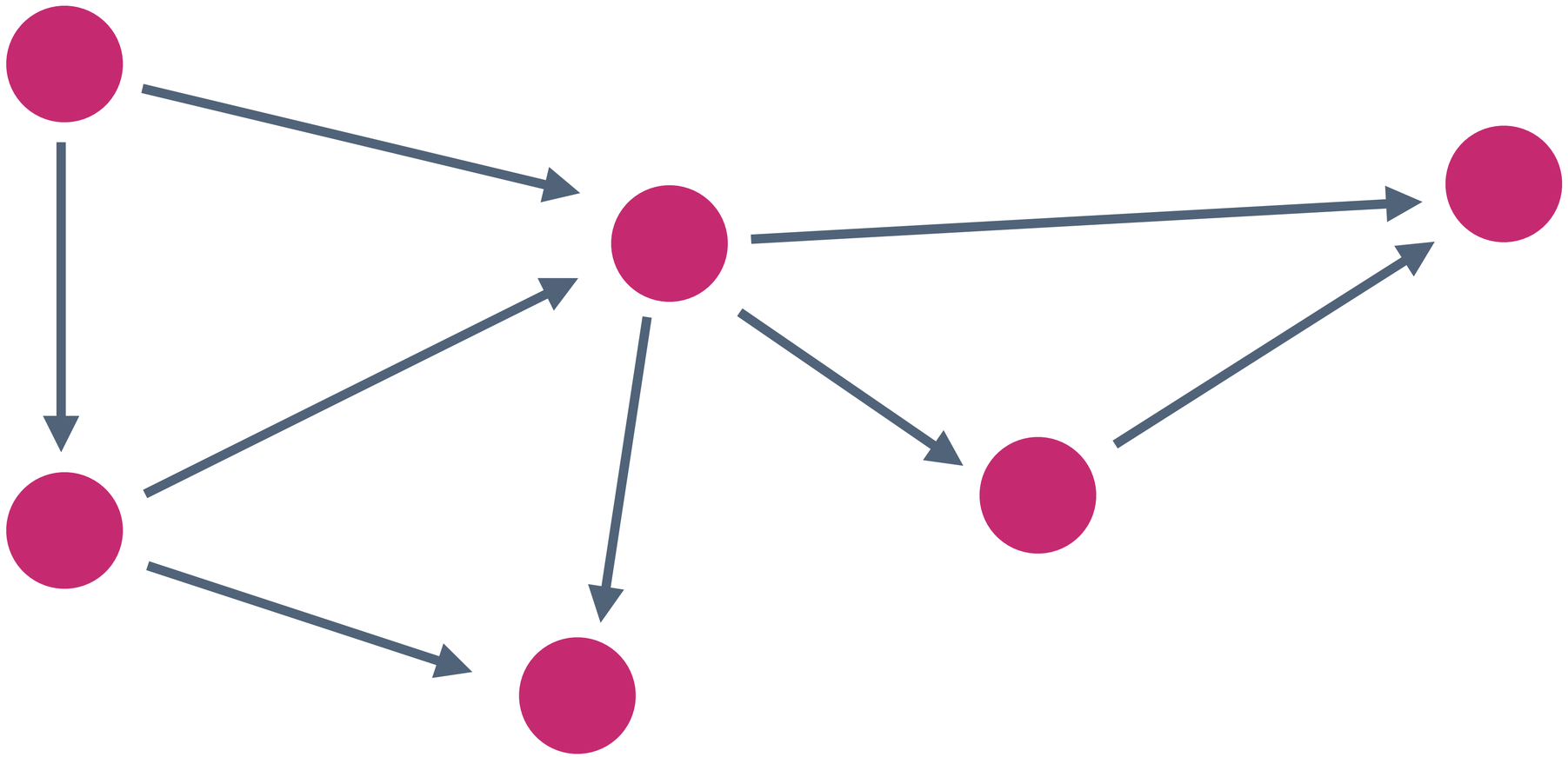

TERMINAL
$ terraform apply
aws_security_group: Still destroying... (14m00s elapsed)
aws_security_group: Still destroying... (14m10s elapsed)
Error: Error applying plan:
1 error(s) occurred:
* aws_security_group.training (destroy): 1 error(s) occurred:
* aws_security_group.training: DependencyViolation: resource sg-6d36fc1c has a dependent object
status code: 400, request id: 4665247f-165b-46fc-b8ea-9c01a23dd4e9

CODE EDITOR

```
lifecycle {
  create_before_destroy = true
  prevent_destroy = true
}
```

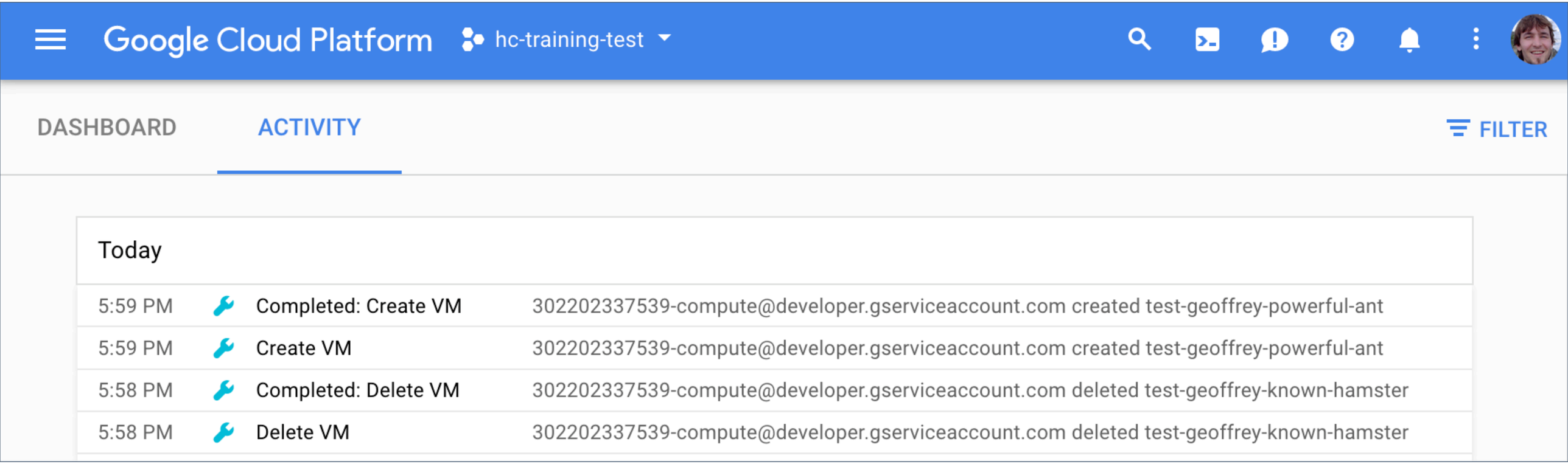
https://www.terraform.io/docs/configuration/resources.html

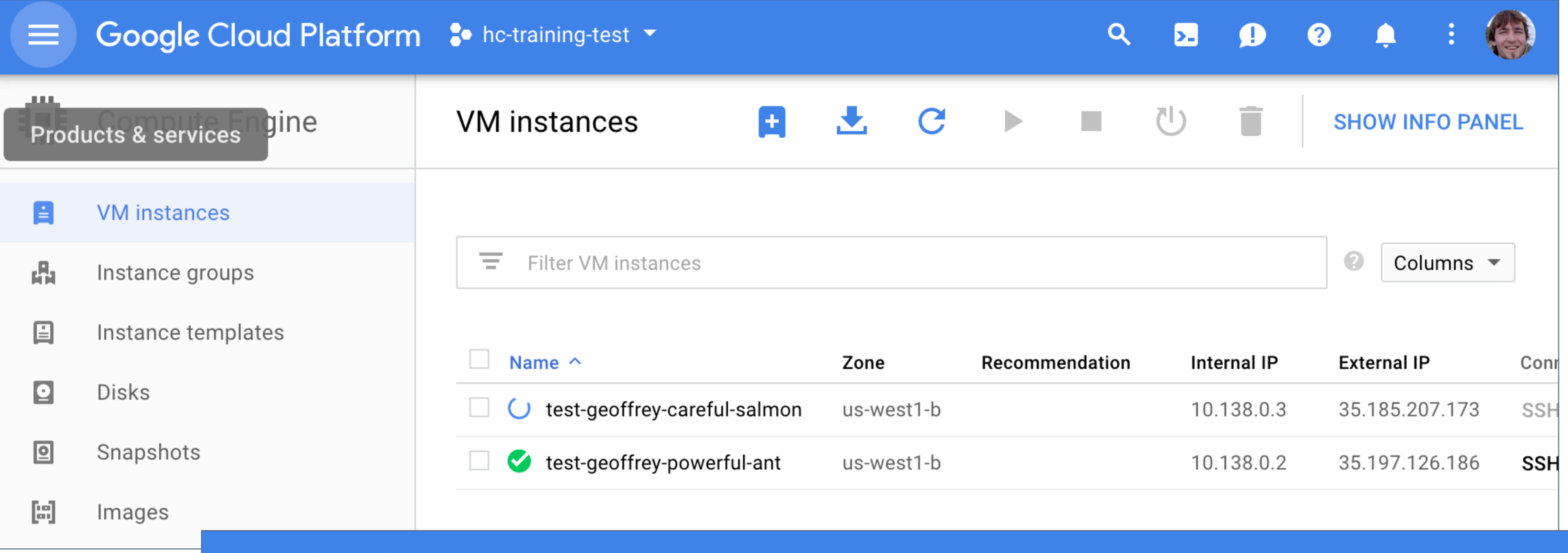
Improved Application of Graph Theory

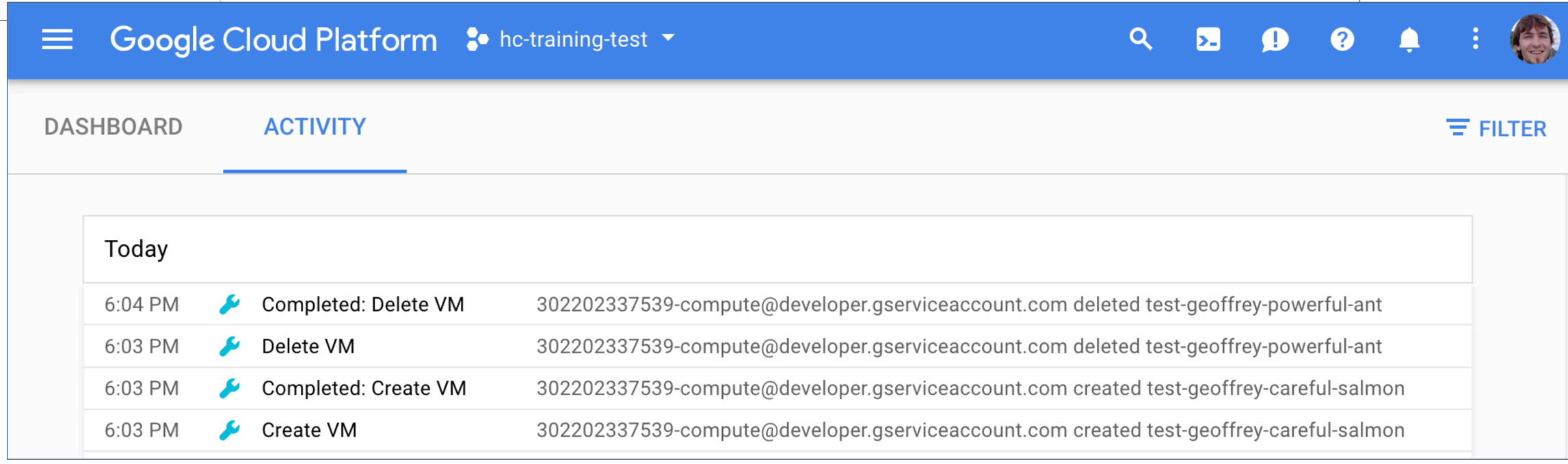


CODE EDITOR

```
# Within an instance stanza
lifecycle {
  create_before_destroy = true
}
```


Google Cloud Platform
hc-training-test
DASHBOARD
ACTIVITY
FILTER
Today
5:59 PM Completed: Create VM 302202337539-compute@developer.gserviceaccount.com created test-geoffrey-powerful-ant
5:59 PM Create VM 302202337539-compute@developer.gserviceaccount.com created test-geoffrey-powerful-ant
5:58 PM Completed: Delete VM 302202337539-compute@developer.gserviceaccount.com deleted test-geoffrey-known-hamster
5:58 PM Delete VM 302202337539-compute@developer.gserviceaccount.com deleted test-geoffrey-known-hamster


Google Cloud Platform
hc-training-test
Products & services
Compute Engine
VM instances
SHOW INFO PANEL
VM instances
Instance groups
Instance templates
Disks
Snapshots
Images
Filter VM instances
Columns
Name
Zone
Recommendation
Internal IP
External IP
test-geoffrey-careful-salmon
us-west1-b
10.138.0.3
35.185.207.173
test-geoffrey-powerful-ant
us-west1-b
10.138.0.2
35.197.126.186
SSH


Google Cloud Platform
hc-training-test
DASHBOARD
ACTIVITY
FILTER
Today
6:04 PM
Completed: Delete VM
302202337539-compute@developer.gserviceaccount.com deleted test-geoffrey-powerful-ant
6:03 PM
Delete VM
302202337539-compute@developer.gserviceaccount.com deleted test-geoffrey-powerful-ant
6:03 PM
Completed: Create VM
302202337539-compute@developer.gserviceaccount.com created test-geoffrey-careful-salmon
6:03 PM
Create VM
302202337539-compute@developer.gserviceaccount.com created test-geoffrey-careful-salmon

CODE EDITOR

```
# Within an instance stanza
provisioner "local-exec" {
  command = "curl --max-time 60 http://${self.public_ip}"
}
```

TIP

Two local-exec Tips

Within a provisioner, use `self.ATTRIBUTE` to access values that would usually be accessed from outputs. For example, `self.public_ip`

Know your health check tool. For example, curl will return error (`$? > 0`) if no server is found, but won't return error if a 404 page is served.

INSIGHT

Does this resource need to be managed by this project?

WARNING

Plan Does Not Reflect Lifecycle Directives

Even while using `create_before_destroy`, the output of `terraform plan` will describe the default (destroy first).

```
-/+ destroy and then create replacement
```

TIP

Partial Applies Will Clean Up On The Next Apply

When using `create_before_destroy`, it's possible to encounter a runtime error where Terraform cannot complete the `apply`.

This could leave both the old and the new instances intact.

The old instance is stored in `terraform.tfstate` under a `deposed` key. It will be destroyed after the next successful `apply`.

Prevent Destroy

Warns if any change would result in destroying a resource

All resources that this resource depends on must also be set to `prevent_destroy`

CODE EDITOR

```
lifecycle {
  prevent_destroy = true
}
```

TERMINAL

```
Error: Error running plan: 1 error(s) occurred:

* google_compute_instance.test: 1 error(s) occurred:

* google_compute_instance.test:
google_compute_instance.test: the plan would destroy this
resource, but it currently has lifecycle.prevent_destroy
set to true. To avoid this error and continue with the
plan, either disable lifecycle.prevent_destroy or adjust
the scope of the plan using the -target flag.
```

TIP

Failure is the Only Option!

Some practitioners want the ability to see a warning but continue anyway.

That workflow is not supported. If an error is encountered, the rest of the execution will stop until it is resolved.

Sentinel

Agenda

Why Sentinel?

Syntax

Data structure

Debugging

Common use cases

Workflow + API

Testing

Deployment

Architecture

Why Write Policy as Code with Sentinel?

Sandboxing

Codification

Version Control

Testing

Automation

What Sentinel Does

Policy as code

Run between `plan` and `apply`

Analyzes current state plus values that can be calculated before `apply`

Analyzes state of configuration

Analyzes state of system at deploy time

Multi-cloud, multi-provider

Should be a piece of your deployment security strategy, together with IAM policies

What Sentinel Does Not Do

Continuous security checks

Audit previously deployed systems

Analyze executable contents of a VM/container/etc.

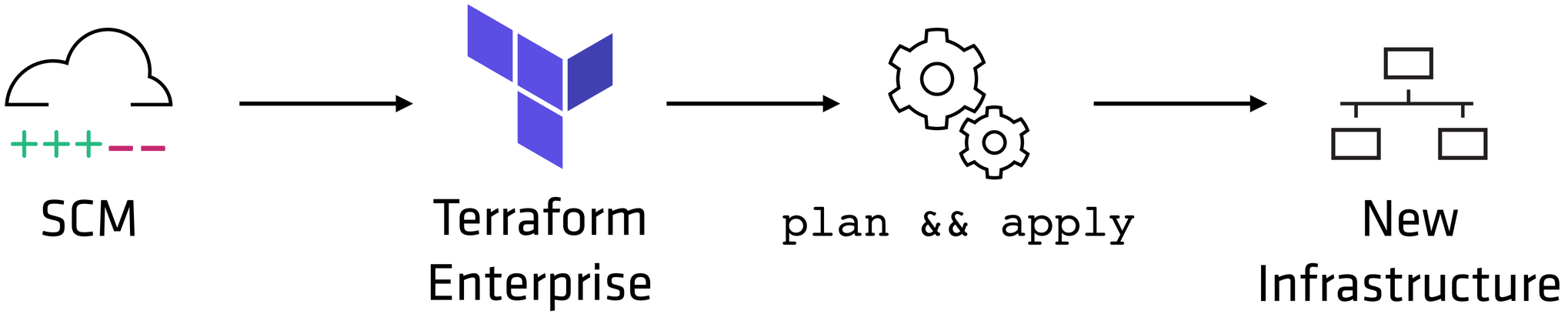
Limit runtime actions of deployed applications

INSIGHT

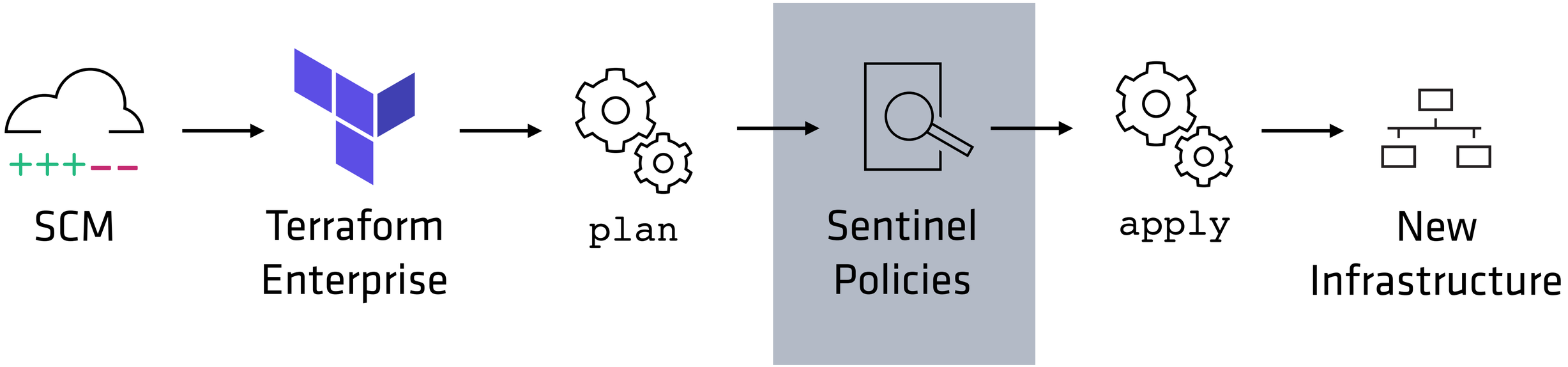
In its current implementation, Sentinel is a tool for preventing mistakes by operators acting in good faith.

– Martin Atkins (Terraform Tech Lead)

How it works without Sentinel



How it works with Sentinel



TIP

Become Familiar With All Sentinel Documentation

Main Sentinel docs:

https://docs.hashicorp.com/sentinel/

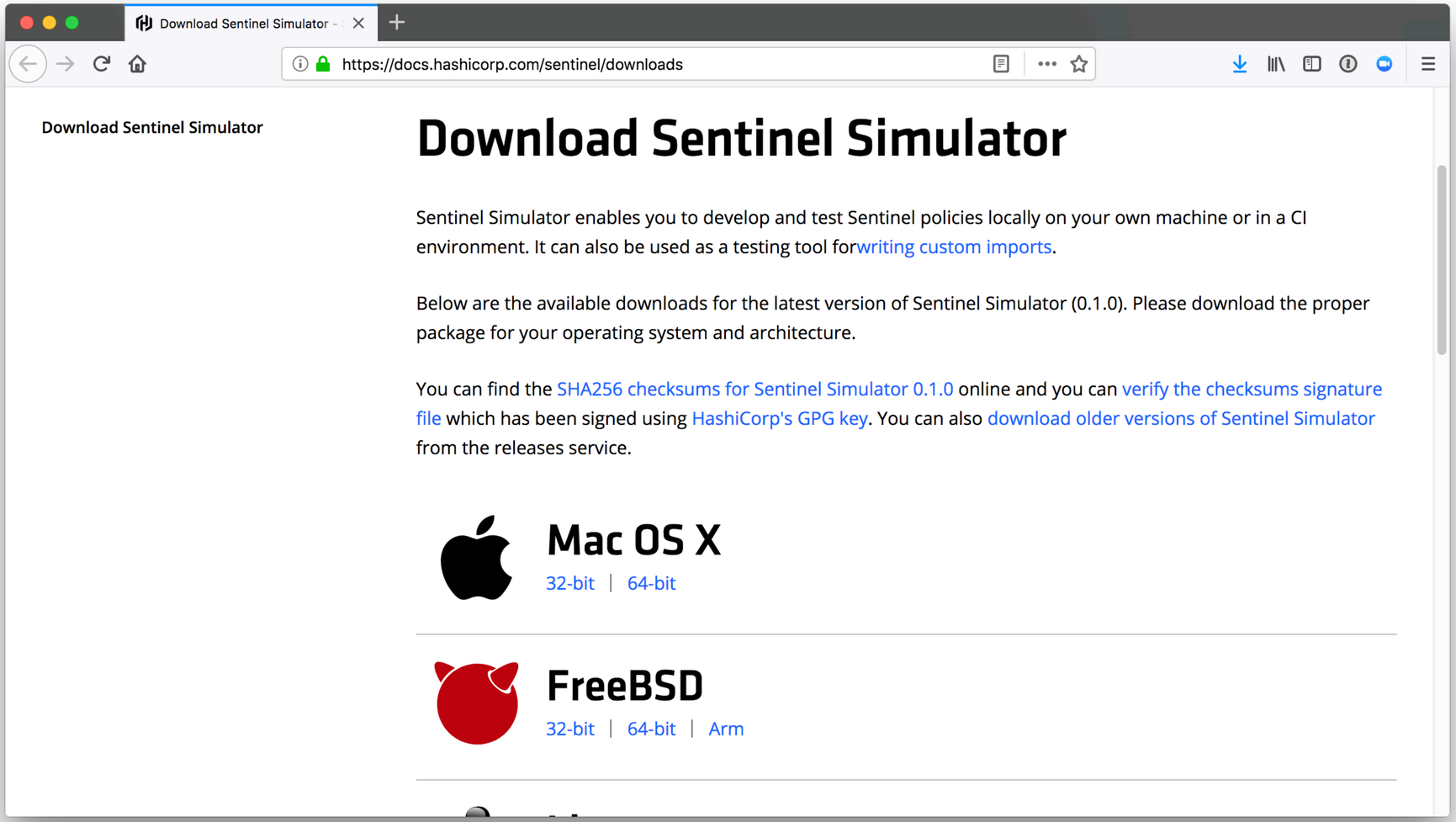
Terraform Enterprise docs:

https://www.terraform.io/docs/enterprise/sentinel/index.html

Blog articles:

https://www.hashicorp.com/blog/category/sentinel

Your First Policy


Download Sentinel Simulator
https://docs.hashicorp.com/sentinel/downloads
Download Sentinel Simulator
Download Sentinel Simulator
Sentinel Simulator enables you to develop and test Sentinel policies locally on your own machine or in a CI environment. It can also be used as a testing tool forwriting custom imports.
Below are the available downloads for the latest version of Sentinel Simulator (0.1.0). Please download the proper package for your operating system and architecture.
You can find the SHA256 checksums for Sentinel Simulator 0.1.0 online and you can verify the checksums signature file which has been signed using HashiCorp's GPG key. You can also download older versions of Sentinel Simulator from the releases service.
Mac OS X
32-bit | 64-bit
FreeBSD
32-bit | 64-bit | Arm

EXERCISE

Run Task 1 in Lab

Download Sentinel Simulator, copy to $PATH

Try a simple policy named `simple.sentinel`:

```
main = rule { true }
```

Syntax

What you'll learn

- Basic syntax
- Rules, variables, loops, functions, conditionals

CODE EDITOR

```
main = rule { true }
```

CODE EDITOR

```
# Conditional rule
# Is true if is_docker is false
# Otherwise examines has_exposed_ports
main = rule when is_docker { has_exposed_ports }
```

CODE EDITOR

```
==        equal
!=        not equal
<         less
<=        less or equal
>         greater
>=        greater or equal
"is"      equal
"is not" not equal
```

TIP

Use as Precise a Comparator as You Can

For equality, use `is` rather than `contains`

Boolean Values

```
undefined or true          = true
undefined or false         = undefined
undefined or undefined     = undefined
undefined and true         = undefined
undefined and false        = undefined
undefined and undefined    = undefined
undefined xor true         = undefined
undefined xor false        = undefined
undefined xor undefined    = undefined
```

Rules Are Aggressively Memoized

Rules are lazy and memoized (will not be recomputed unless absolutely necessary).

```
rule when Y { Z == true }
```

TIP

Write small rules

It's slightly easier to debug policies if the rules are short and there are many of them.

```
main = rule {
  bacon_is_eggs and
    pancake_is_maple and
    has_id
}
```

Collections

```
all collection as index, item { } # Returns bool

any ... # Returns bool

for ... # NOTE: Does not return

contains

matches
```

WARNING

Lists Need an Iterator

There is sometimes no way to access a value except with a loop (such as `tfplan.animals.0.id`)

Functions

```
a = func(x) { return x*2 }
```

Must return (or return undefined)

Testing

Understanding Sentinel Tests

Terraform code is the implementation (outside your Sentinel project)

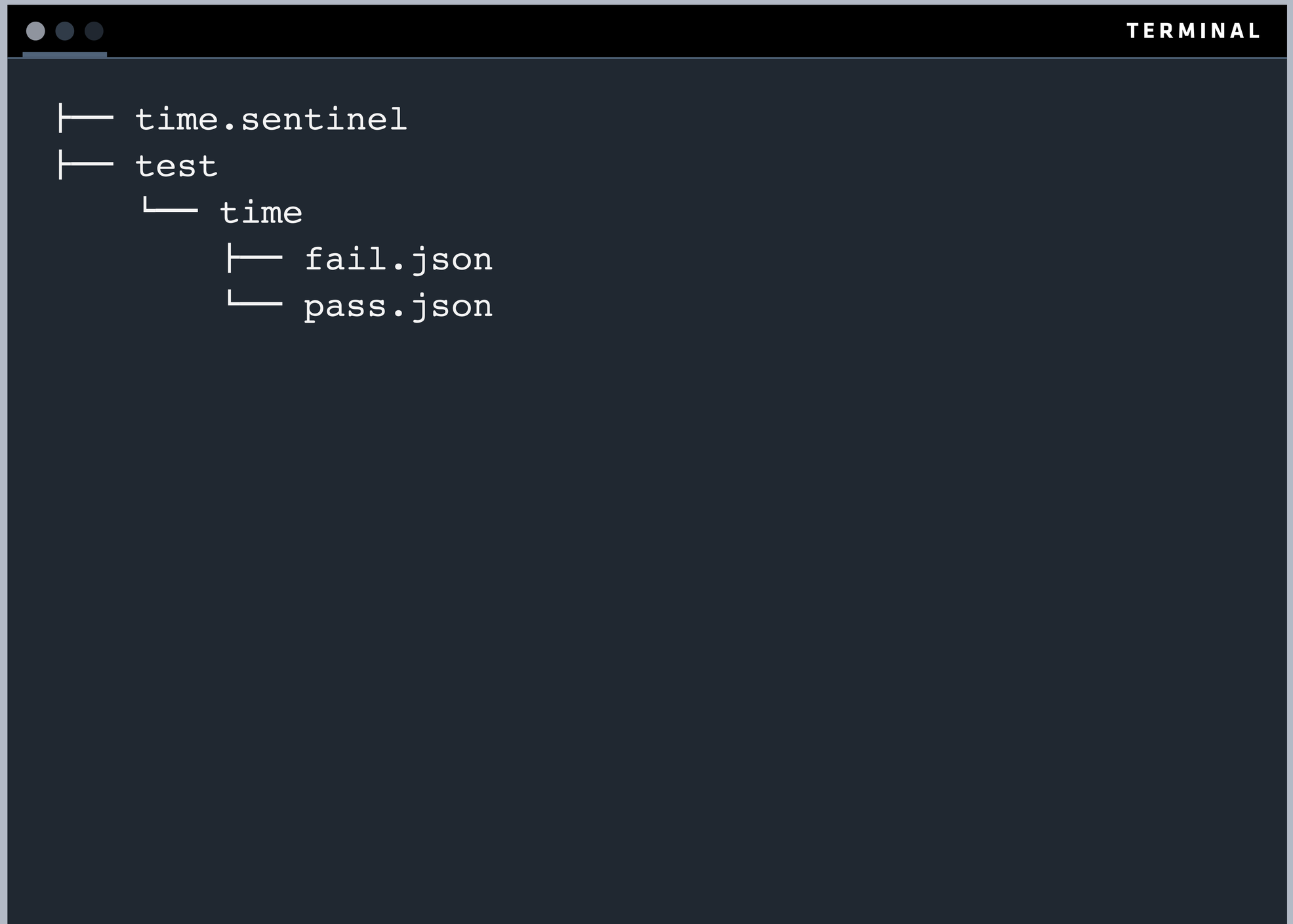
The state of your infrastructure is the result, but it needs to be verified against the policy before it is built. So only the JSON output of the plan is tested.

The policy itself is the test.

A JSON data file is both the fixture and the expectation.

CODE EDITOR

```
main = rule { true }
```


TERMINAL
├── time.sentinel
├── test
└── time
├── fail.json
└── pass.json

PASS.JSON

```
{
  "test": {
    "main": true
  }
}
```

PASS.JSON

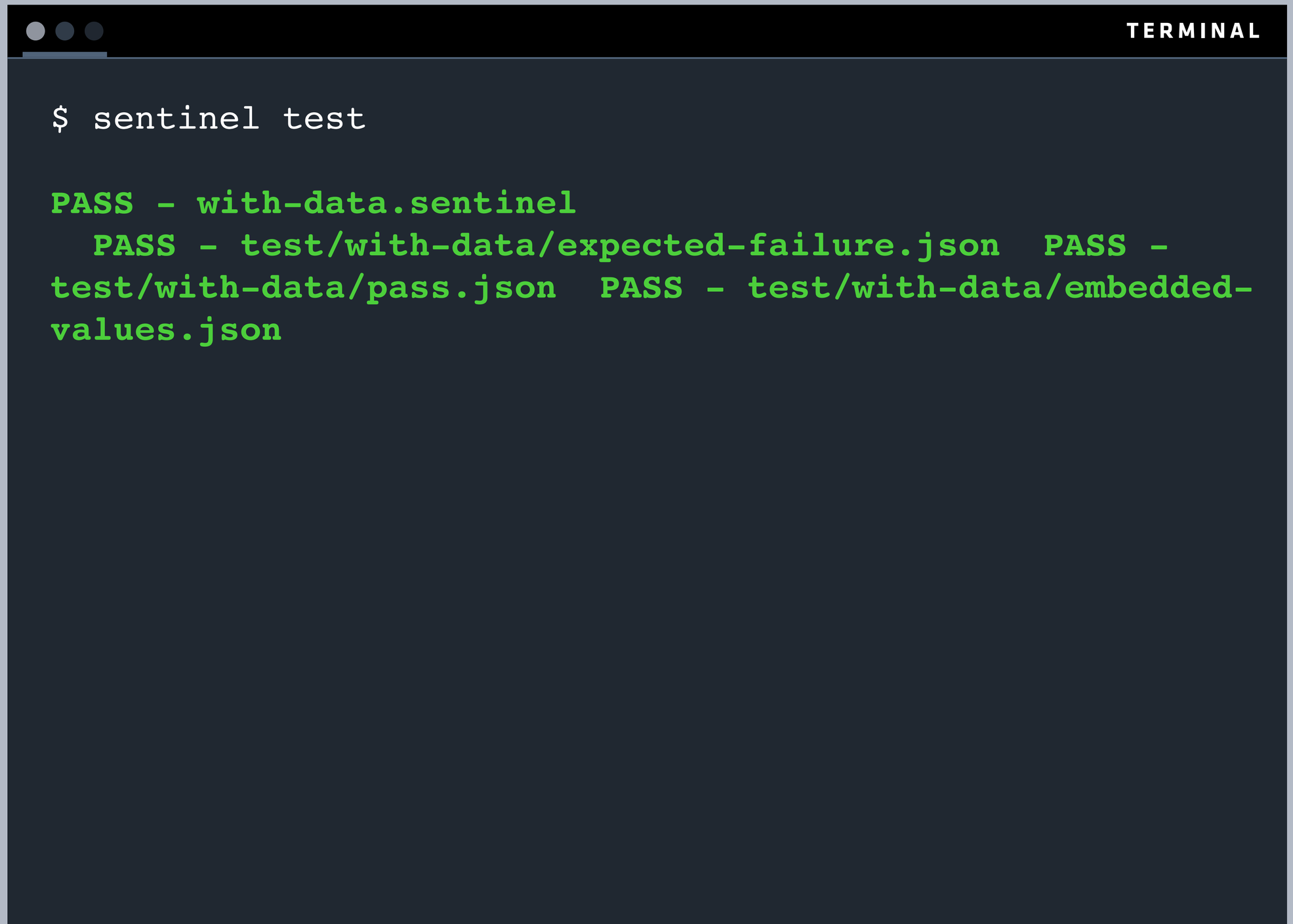
```
{
  "test": {
    "main": true
  },
  "mock": {
    "timespace": {
      "hour":     10,
      "weekday":   2
    }
  }
}
```

CODE EDITOR

```
{
  "test": {
    "main": true
  },
  "global": {
    "environment": "staging"
  }
}
```

TERMINAL

```
$ sentinel --help test

Test cases are expected to be in "test/<policy>/*.json"
files where "<policy>" is the name of the policy filename
without an extension.
```


TERMINAL
$ sentinel test
PASS - with-data.sentinel
PASS - test/with-data/expected-failure.json PASS - test/with-data/pass.json PASS - test/with-data/embedded-values.json

EXERCISE

Implement Task 2 in Lab

Create a Sentinel policy that works with slightly more real-world data structures.

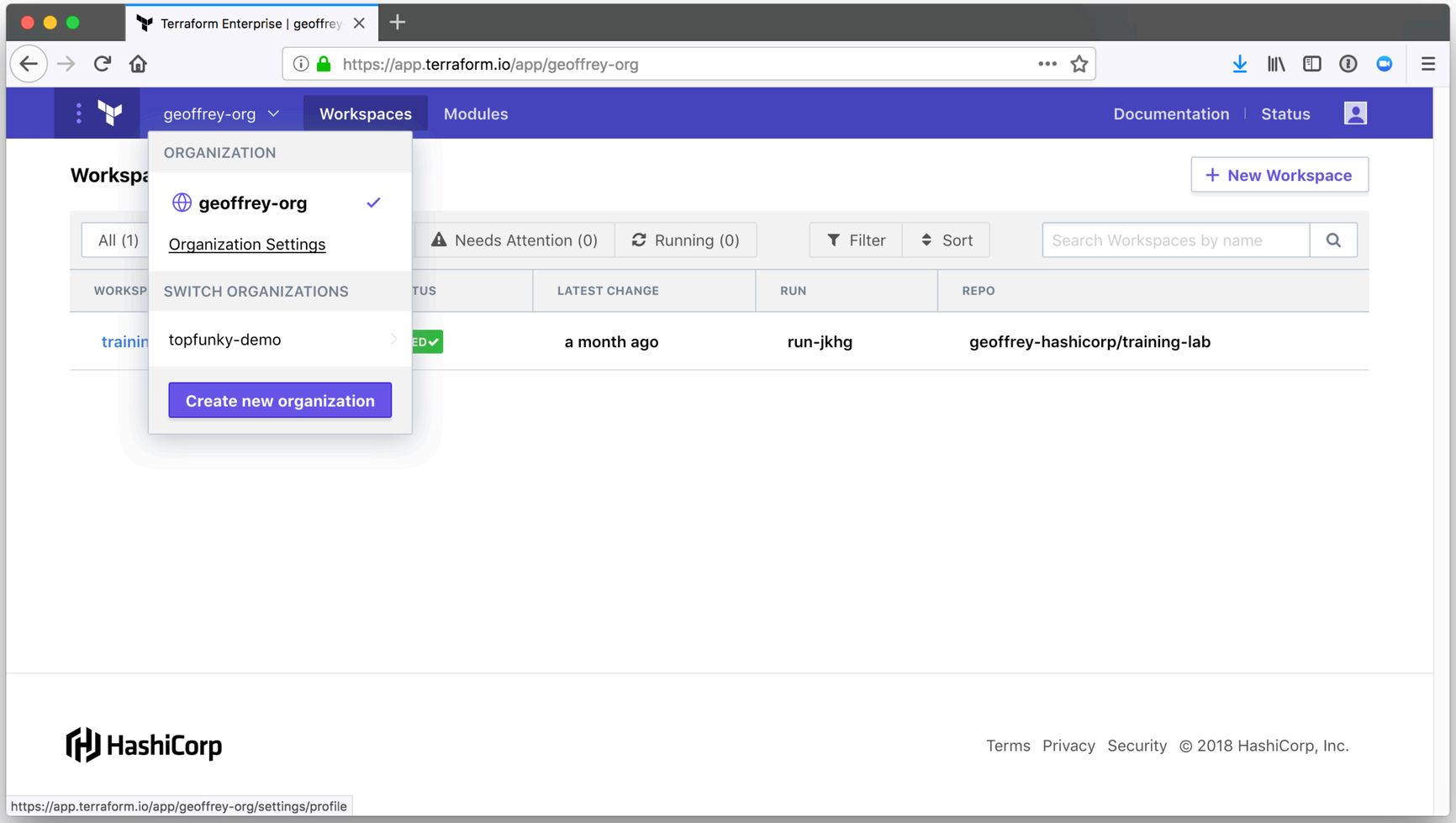
WARNING

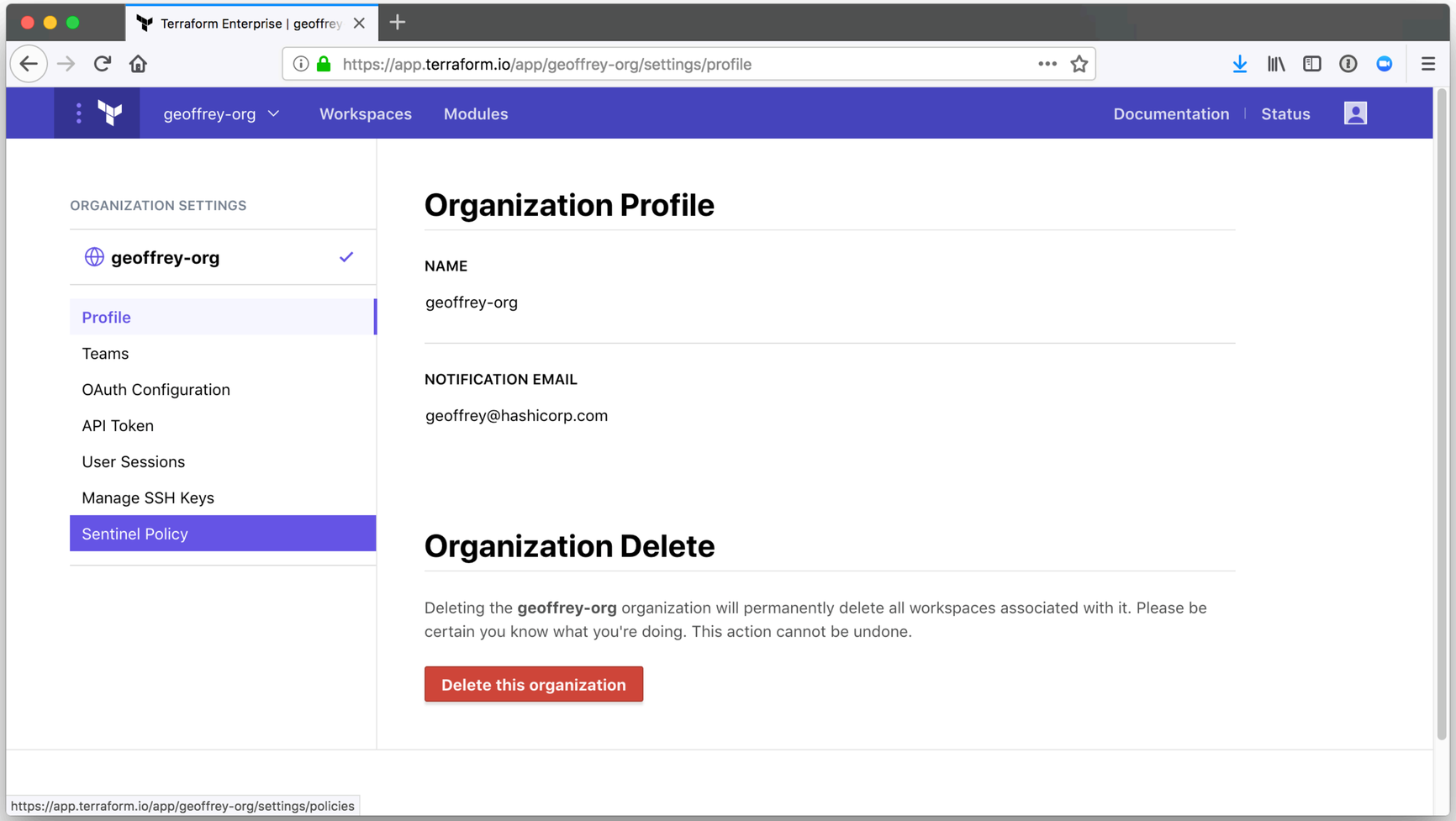
Errors are minimal

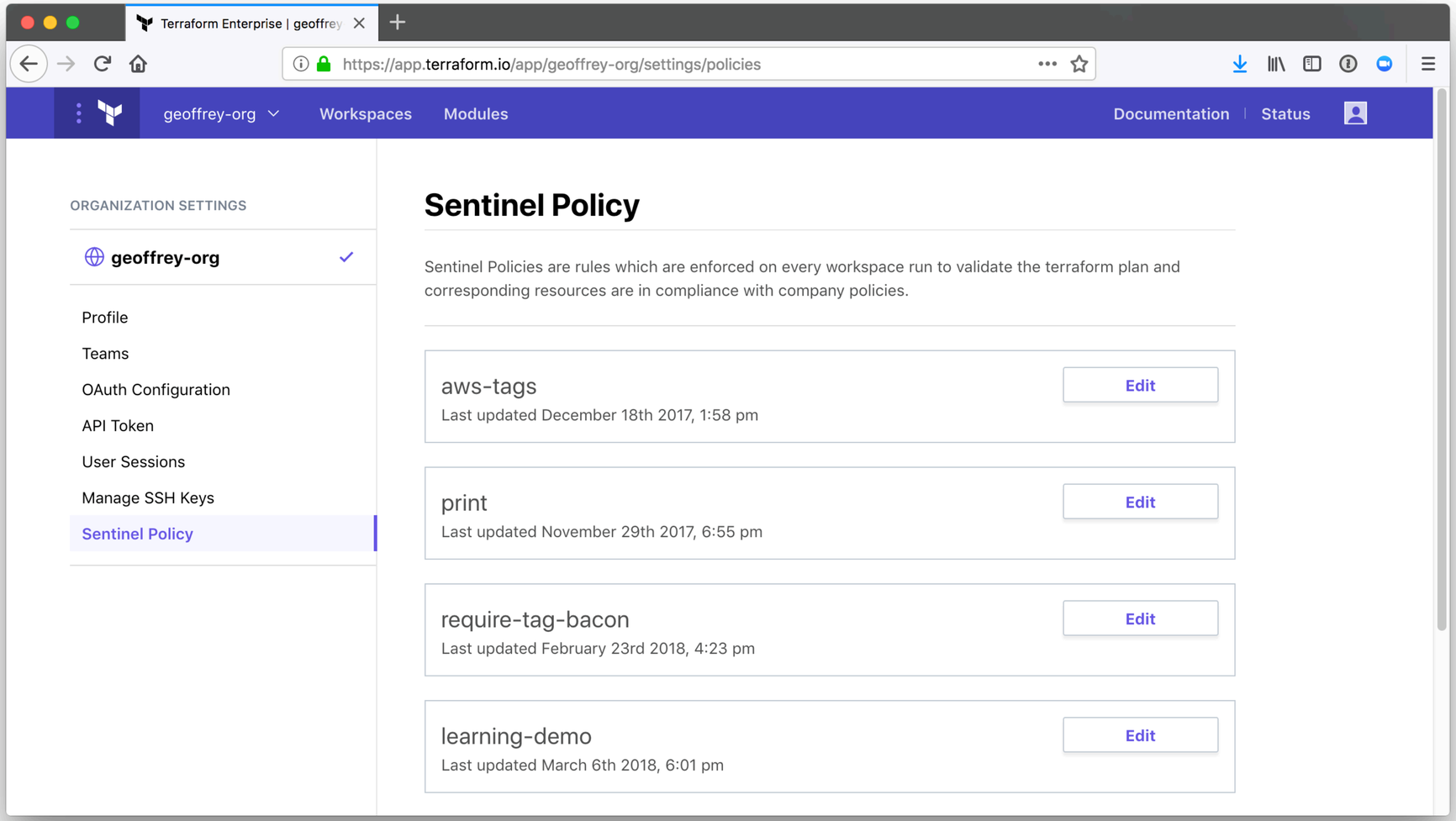
You might see that a test fails but not have a clear reason, even with --verbose

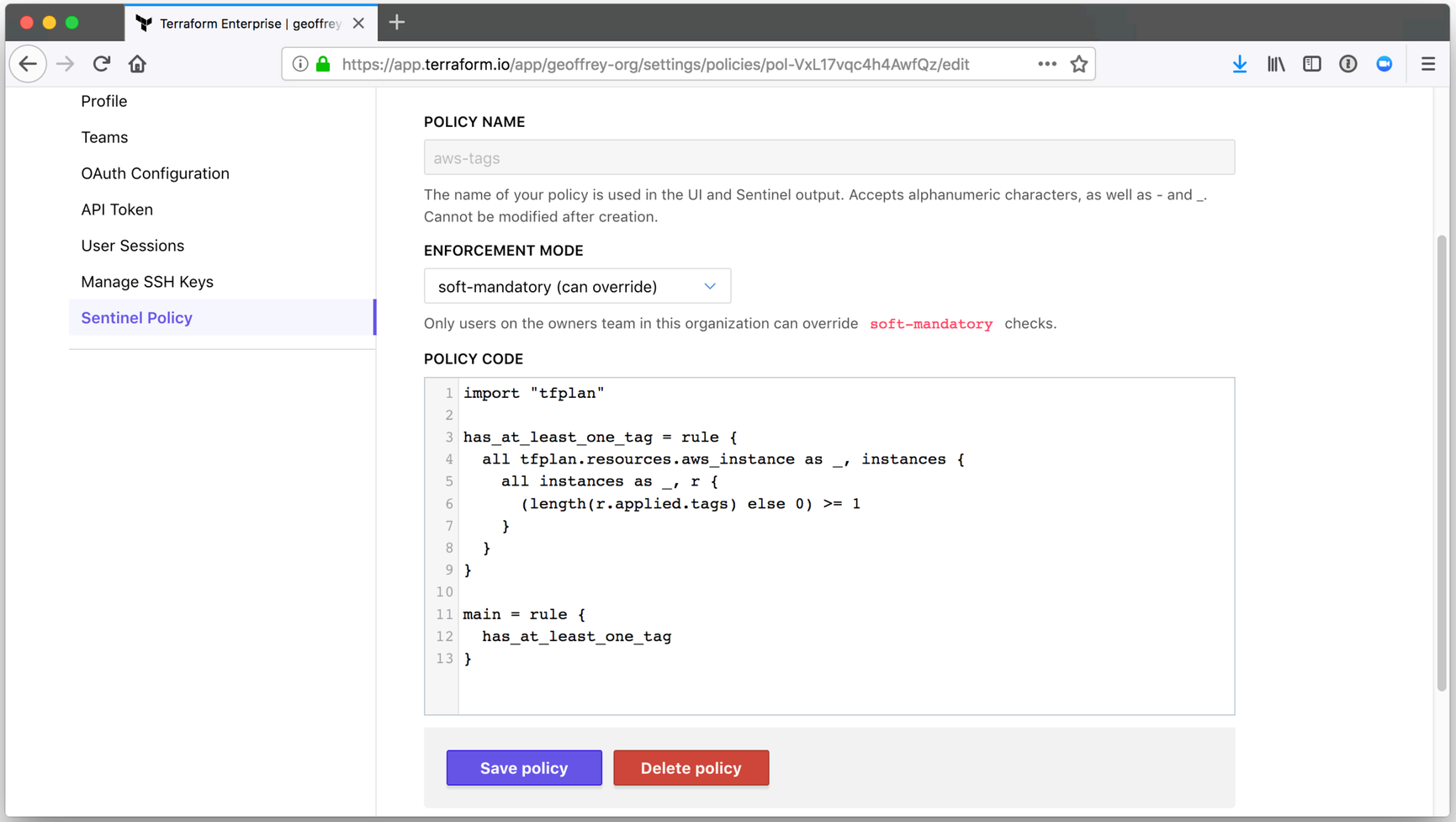
For example, doing `import "tfplan"` in a policy will cause the test to fail unless mocked (because it can't get to the import).

Within TFE


Terraform Enterprise | geoffrey
https://app.terraform.io/app/geoffrey-org
geoffrey-org
Workspaces
Modules
Documentation
Status
ORGANIZATION
geoffrey-org
Organization Settings
SWITCH ORGANIZATIONS
topfunky-demo
Create new organization
+ New Workspace
All (1)
Needs Attention (0)
Running (0)
Filter
Sort
Search Workspaces by name
WORKSP
TUS
LATEST CHANGE
RUN
REPO
trainin
a month ago
run-jkhg
geoffrey-hashicorp/training-lab
HashiCorp
Terms
Privacy
Security
© 2018 HashiCorp, Inc.
https://app.terraform.io/app/geoffrey-org/settings/profile


Terraform Enterprise | geoffrey
https://app.terraform.io/app/geoffrey-org/settings/profile
geoffrey-org
Workspaces
Modules
Documentation
Status
ORGANIZATION SETTINGS
geoffrey-org
Profile
Teams
OAuth Configuration
API Token
User Sessions
Manage SSH Keys
Sentinel Policy
Organization Profile
NAME
geoffrey-org
NOTIFICATION EMAIL
geoffrey@hashicorp.com
Organization Delete
Deleting the geoffrey-org organization will permanently delete all workspaces associated with it. Please be certain you know what you're doing. This action cannot be undone.
Delete this organization
https://app.terraform.io/app/geoffrey-org/settings/policies


Terraform Enterprise | geoffrey
https://app.terraform.io/app/geoffrey-org/settings/policies
geoffrey-org
Workspaces
Modules
Documentation
Status
ORGANIZATION SETTINGS
geoffrey-org
Profile
Teams
OAuth Configuration
API Token
User Sessions
Manage SSH Keys
Sentinel Policy
Sentinel Policy
Sentinel Policies are rules which are enforced on every workspace run to validate the terraform plan and corresponding resources are in compliance with company policies.
aws-tags
Last updated December 18th 2017, 1:58 pm
Edit
print
Last updated November 29th 2017, 6:55 pm
Edit
require-tag-bacon
Last updated February 23rd 2018, 4:23 pm
Edit
learning-demo
Last updated March 6th 2018, 6:01 pm
Edit


Terraform Enterprise | geoffrey
https://app.terraform.io/app/geoffrey-org/settings/policies/pol-VxL17vqc4h4AwfQz/edit
Profile
Teams
OAuth Configuration
API Token
User Sessions
Manage SSH Keys
Sentinel Policy
POLICY NAME
aws-tags
The name of your policy is used in the UI and Sentinel output. Accepts alphanumeric characters, as well as - and _. Cannot be modified after creation.
ENFORCEMENT MODE
soft-mandatory (can override)
Only users on the owners team in this organization can override soft-mandatory checks.
POLICY CODE
import "tfplan"
has_at_least_one_tag = rule {
all tfplan.resources.aws_instance as _, instances {
all instances as _, r {
(length(r.applied.tags) else 0) >= 1
}
}
}
main = rule {
has_at_least_one_tag
}
Save policy
Delete policy

Enforcement Levels

hard-mandatory

soft-mandatory

advisory

CODE EDITOR


```
"tfplan": {
      "random_pet": {
        "server": {
          "0": {
            "applied": {
              "id": "deciding-pegasus",
              "length": "2",
              "separator": "-"
            },
            "diff": {}
          }
        }
      }
    }
```

TIP

Read Complex Examples on GitHub

HashiCorp staff frequently build and publish sample policies.

Find them in places such as the `terraform-guides` repository:

https://github.com/hashicorp/terraform-guides/blob/master/governance/aws/restrict-aws-region.sentinel

TIP

Read documentation on imports

Read, understand, and refer to the documentation on imports (tfplan, tfconfig, tfstate):

https://www.terraform.io/docs/enterprise/sentinel/import/index.html

EXERCISE

Task 3: Run a policy within Terraform Enterprise

Log into TFE

Link GitHub repo if it's not already there (demo-terraform-101)

Add policy

Make change on GitHub

View output of policy

Debugging

WARNING

app.terraform.io is not an IDE

Don't try to develop in the browser.

Work on the local machine, write tests. Work in small increments if possible.

Run a syntax check with `fmt` if nothing else is possible.

The cycle of write-execute-observe is long in TFE, especially if your core Terraform plan is large.

WARNING

Warnings are minimal

You won't be warned if you use an outer variable. No printout of what didn't match.

WARNING

Computed values can be loopholes

When possible, use a whitelist instead of a blacklist.

Example: no cidr 0.0.0.0/0 vs 192.168.0.0/16

Whitelists are more secure than blacklists, in general.

Example: 000.000.000.000/0 is a valid IP that could evade checks for 0.0.0.0/0

WARNING

The `applied` data structure is most useful

When examining the `tfplan` data structure, look for `applied` to find the values that will be deployed

Authoring with the Registry

What You'll Learn

- Use standard module structure to build a module
- Publish a module to the repository
- Use the published module from another Terraform configuration
- Understand how to version and update a module
- Use the module configuration designer

Modules

Collaboration, Reuse, Consistency

EXAMPLES

AWS Networking
App Server
DB Cluster

SCM

Access Control,
Pull Request Workflow, CI

EXAMPLES

GitHub
Bitbucket (private)

Terraform Registry

Versioning, Documentation, Search

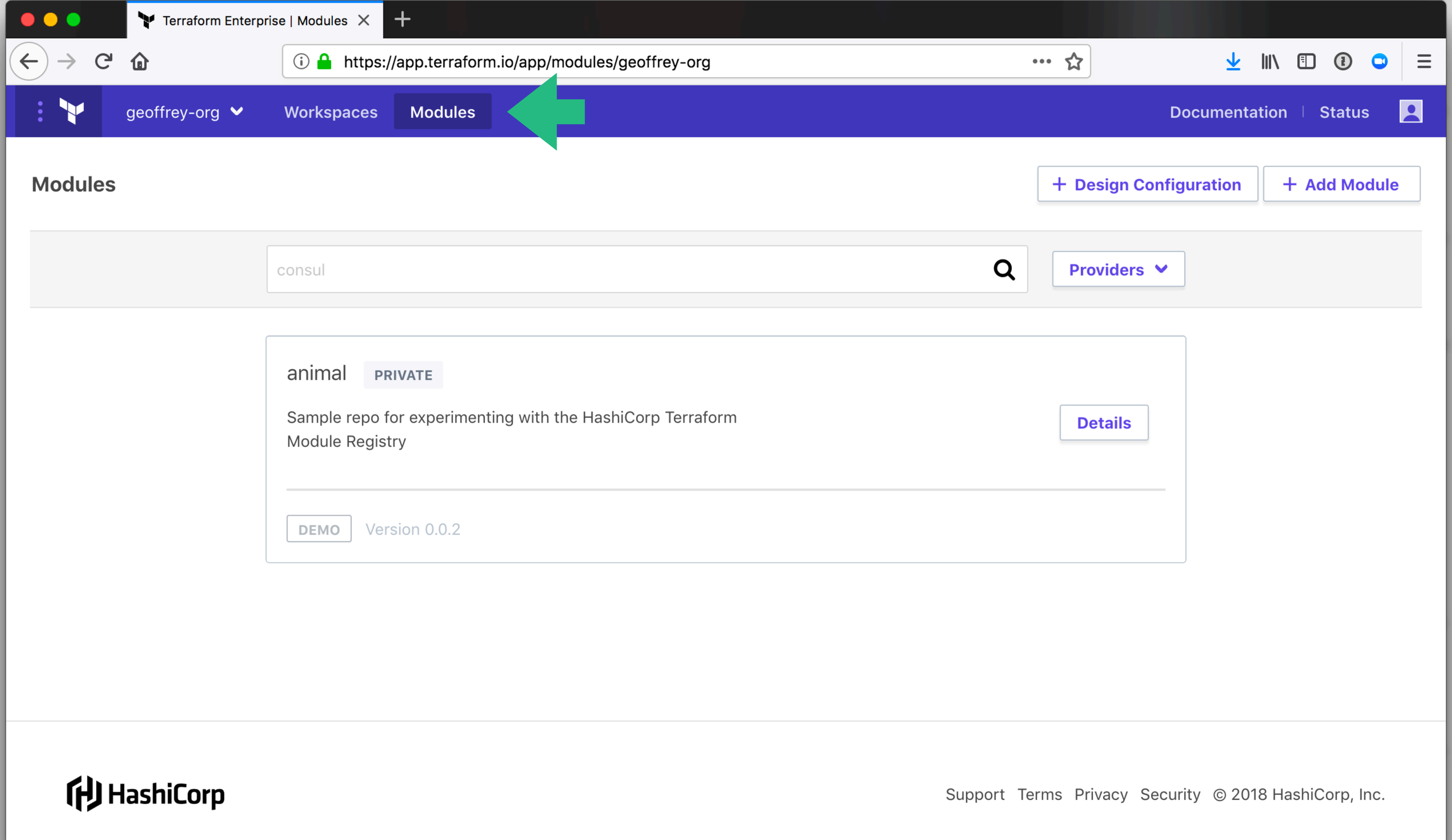
EXAMPLES

terraform-aws-networking
terraform-go-server
terraform-pg-cluster

TIP

Private Module Registry

Both the hosted and private instances of Terraform include your own private module registry which can be used to securely and privately publish modules within your company.


Terraform Enterprise | Modules
https://app.terraform.io/app/modules/geoffrey-org
geoffrey-org
Workspaces
Modules
Documentation
Status
Modules
+ Design Configuration
+ Add Module
consul
Providers
animal
PRIVATE
Sample repo for experimenting with the HashiCorp Terraform Module Registry
Details
DEMO
Version 0.0.2
HashiCorp
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Security
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Module Registry Workflow: Git

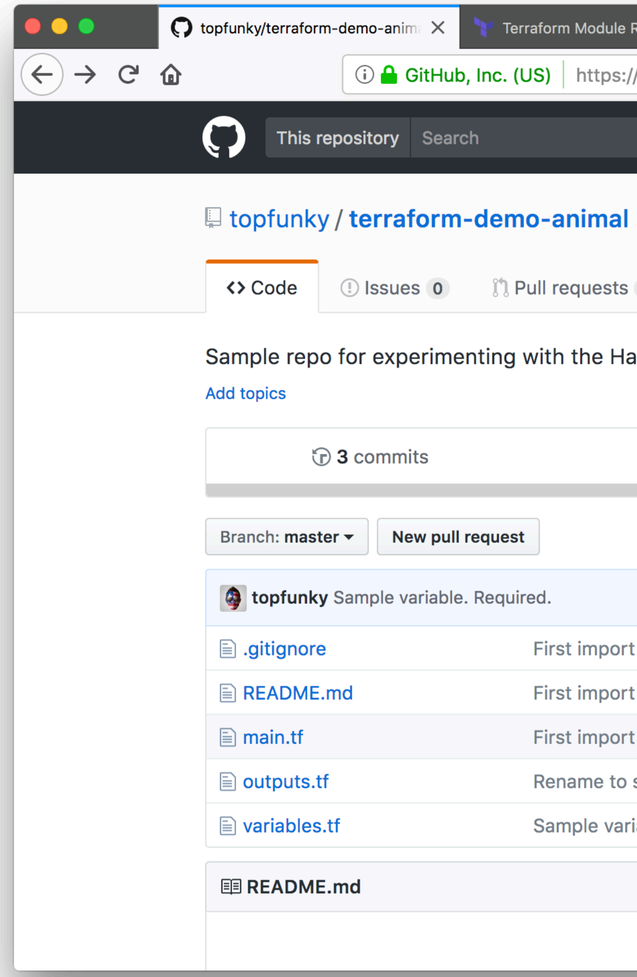
Push code to GitHub or Bitbucket. The repository must be named in the format:

`terraform-PROVIDER-MODULE`

Examples:

`terraform-aws-peering`

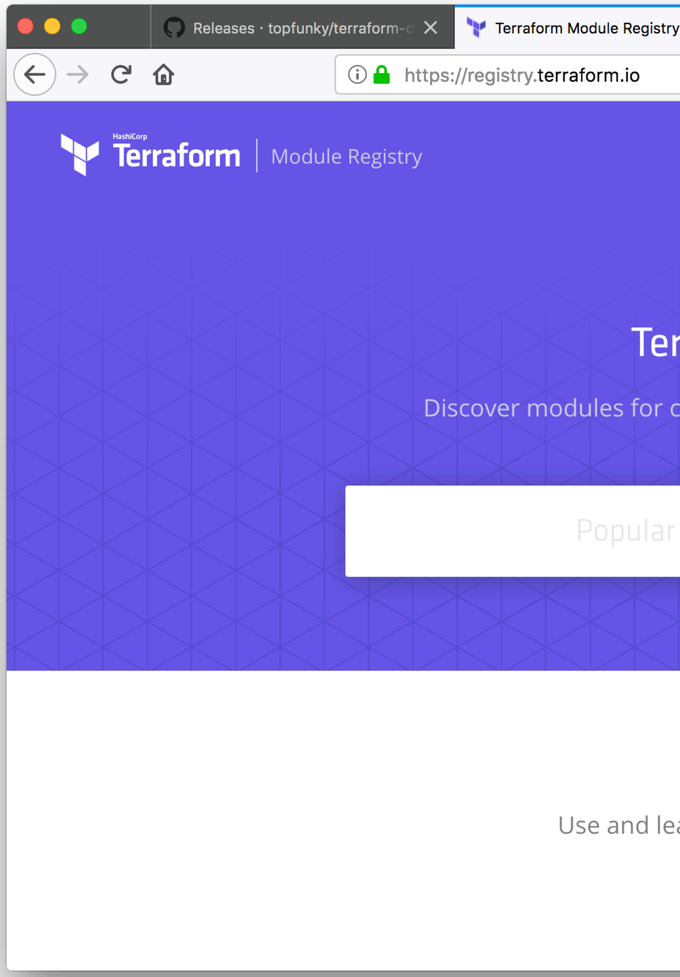
`terraform-azure-autoscaling`



Module Registry Workflow: Registry

Connect your SCM account to the Terraform Registry.
Publish a module. Tagged commits will be synced automatically.

`v1.0.6`



Module Registry Workflow: Config

Use the code snippet from the registry to reference the module from your code. Provide all necessary variables.

Run `init` to pull in the correct version of the module.

```
terraform init
```


TERMINAL
~/projects/terraform-demo-animal
.
├── README.md
├── LICENSE
├── main.tf
├── outputs.tf
└── variables.tf
https://www.terraform.io/docs/modules/create.html#standard-module-structure

CODE EDITOR

```
# main.tf
resource "random_pet" "animal" {}


# outputs.tf
output "animal" {
  value       = "${random_pet.animal.id}"
  description = "Contains the name of a random animal."
}
```

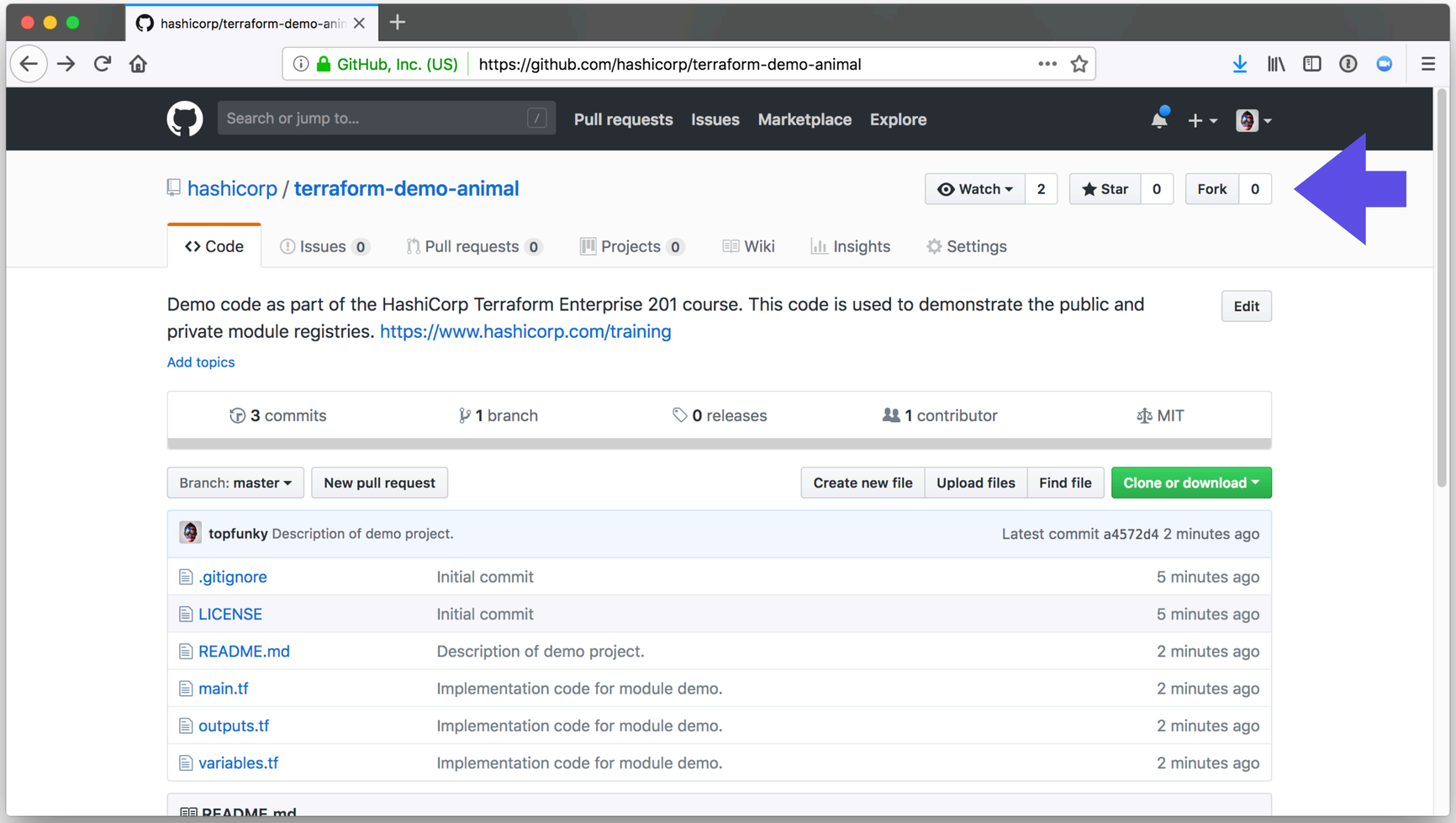
EXERCISE

Fork a GitHub Repository and Tag Your Code

Fork the existing `hashicorp/terraform-demo-animal` public GitHub repository.

Tag a commit with a version number and push that as well:

```
git tag v0.0.1
git push --tags
```


hashicorp/terraform-demo-anim
GitHub, Inc. (US)
https://github.com/hashicorp/terraform-demo-animal
Search or jump to...
Pull requests
Issues
Marketplace
Explore
hashicorp / terraform-demo-animal
Watch 2
Star 0
Fork 0
Code
Issues 0
Pull requests 0
Projects 0
Wiki
Insights
Settings
Demo code as part of the HashiCorp Terraform Enterprise 201 course. This code is used to demonstrate the public and private module registries. https://www.hashicorp.com/training
Edit
Add topics
3 commits
1 branch
0 releases
1 contributor
MIT
Branch: master
New pull request
Create new file
Upload files
Find file
Clone or download
topfunky Description of demo project.
Latest commit a4572d4 2 minutes ago
.gitignore Initial commit 5 minutes ago
LICENSE Initial commit 5 minutes ago
README.md Description of demo project. 2 minutes ago
main.tf Implementation code for module demo. 2 minutes ago
outputs.tf Implementation code for module demo. 2 minutes ago
variables.tf Implementation code for module demo. 2 minutes ago
README.md

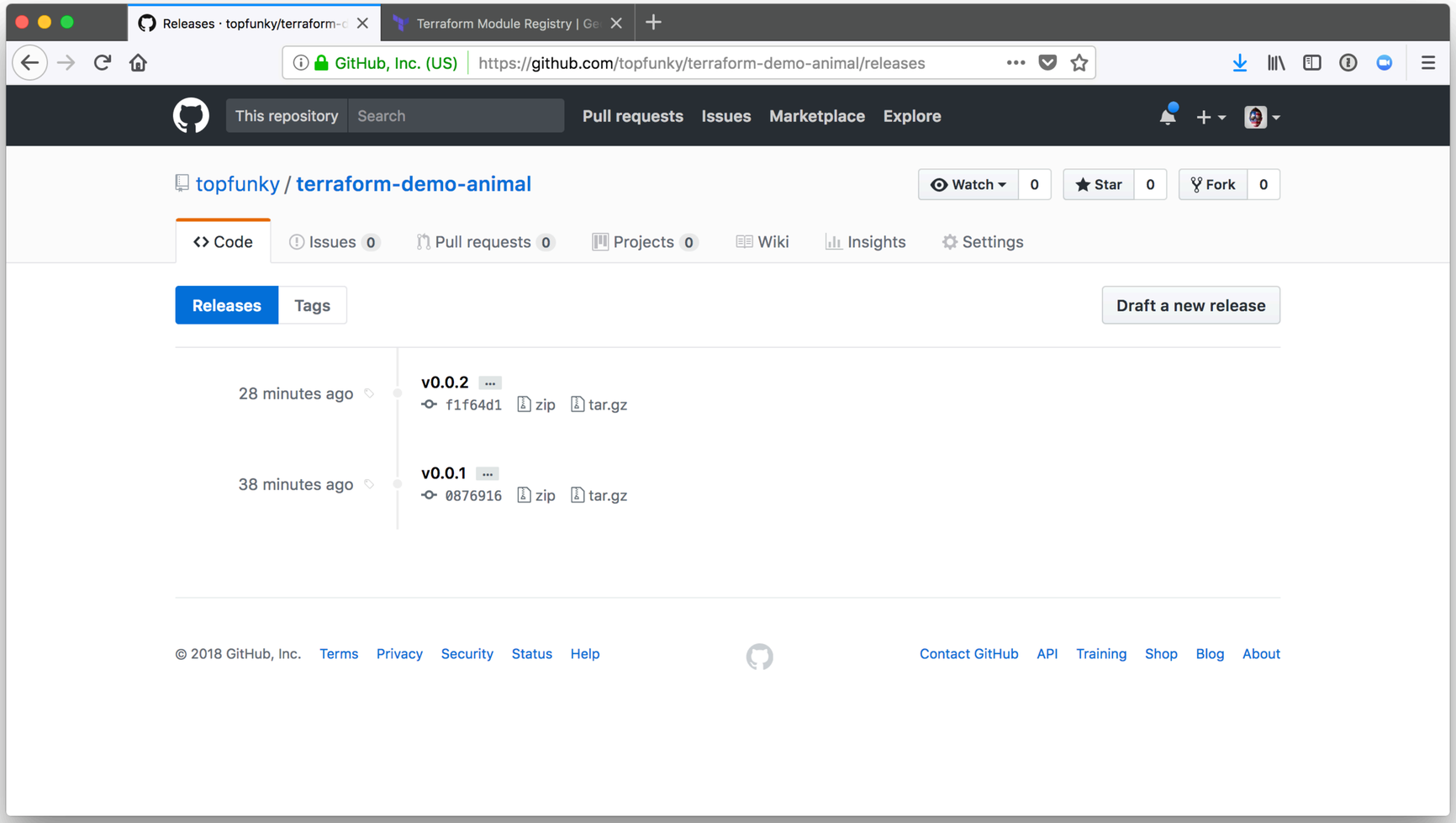
TERMINAL

```
$ git clone https://github.com/$USER/terraform-demo-animal.git

$ cd terraform-demo-animal

$ git tag v0.0.1

$ git push --tags
```


Releases · topfunky/terraform-c
Terraform Module Registry | Ge
GitHub, Inc. (US)
https://github.com/topfunky/terraform-demo-animal/releases
This repository
Search
Pull requests
Issues
Marketplace
Explore
topfunky / terraform-demo-animal
Watch 0
Star 0
Fork 0
Code
Issues 0
Pull requests 0
Projects 0
Wiki
Insights
Settings
Releases
Tags
Draft a new release
28 minutes ago
v0.0.2
f1f64d1 zip tar.gz
38 minutes ago
v0.0.1
0876916 zip tar.gz
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EXERCISE

Publish the Code on Your Private Module Registry

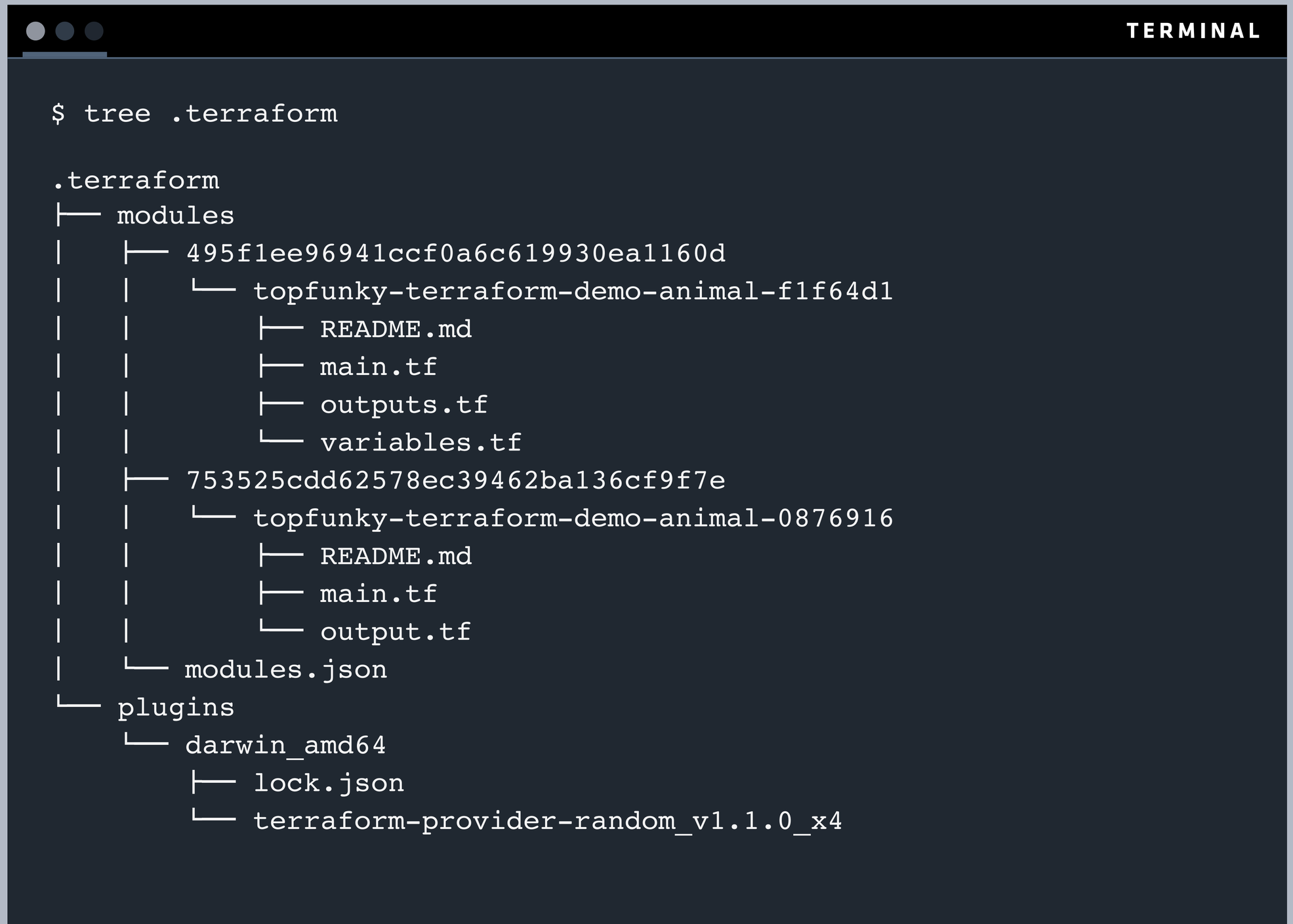
Go to https://app.terraform.io/ and go to the workspaces dashboard.

Click the "Modules" button in the menu bar.

Use the "+ Add Module" button to select your repository and add it to the module registry.

CODE EDITOR

```
# main.tf
provider "random" {
  version = "~> 1.1"
}
```


TERMINAL
$ tree .terraform
.terraform
├── modules
│   ├── 495f1ee96941ccf0a6c619930ea1160d
│   │   └── topfunky-terraform-demo-animal-f1f64d1
│   │   ├── README.md
│   │   ├── main.tf
│   │   ├── outputs.tf
│   │   └── variables.tf
│   ├── 753525cdd62578ec39462ba136cf9f7e
│   │   └── topfunky-terraform-demo-animal-0876916
│   │   ├── README.md
│   │   ├── main.tf
│   │   └── output.tf
│   └── modules.json
└── plugins
    └── darwin_amd64
        ├── lock.json
        └── terraform-provider-random_v1.1.0_x4

.TERRAFORM/MODULES/MODULES.JSON


```
{
    "Modules" : [
        {
            "Root" : "topfunky-terraform-demo-animal-0876916",
            "Version" : "0.0.1",
            "Source" : "topfunky/animal/demo",
            "Key" : "1.animal;topfunky/animal/demo.0.0.1",
            "Dir" : ".terraform/modules/753525cdd62578ec39462ba136cf9f7e"
        },
        {
            "Dir" : ".terraform/modules/495f1ee96941ccf0a6c619930ea1160d",
            "Source" : "topfunky/animal/demo",
            "Key" : "1.animal;topfunky/animal/demo.0.0.2",
            "Version" : "0.0.2",
            "Root" : "topfunky-terraform-demo-animal-f1f64d1"
        }
    ]
}
```

TIP

By Default, Paths are Relative to the Terraform CLI

If you want to reference resources in a published module's own directory, use

```
${path.module}
```

https://www.terraform.io/docs/modules/create.html

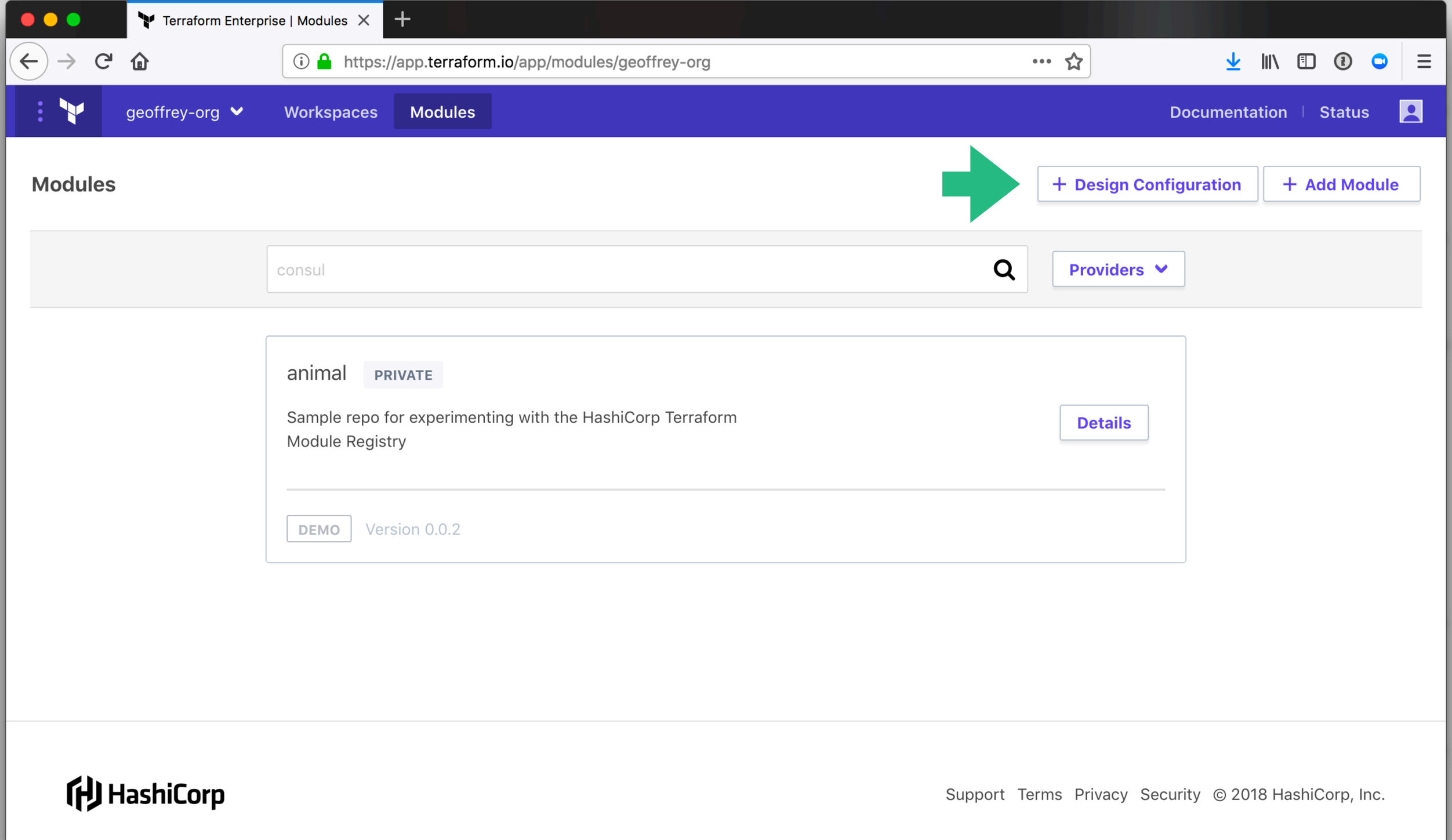
Module Configuration Tool

Module Configuration Tool

User interface for selecting modules and specifying required values

Code generator (write only, no editing)

Explore APIs quickly


Terraform Enterprise | Modules
https://app.terraform.io/app/modules/geoffrey-org
geoffrey-org
Workspaces
Modules
Documentation
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Modules
+ Design Configuration
+ Add Module
consul
Providers
animal
PRIVATE
Sample repo for experimenting with the HashiCorp Terraform Module Registry
Details
DEMO
Version 0.0.2
HashiCorp
Support
Terms
Privacy
Security
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Terraform Enterprise | Modules

https://app.terraform.io/app/modules/geoffrey-org/design/modules

geoffrey-org | Workspaces | Modules | Documentation | Status

Modules / Configuration Designer

Select Modules › Set Variables › Verify › Publish

Next »

consul

Providers

ADD MODULES TO WORKSPACE

animal PRIVATE

Sample repo for experimenting with the HashiCorp Terraform Module Registry

Details | Add Module

DEMO Version 0.0.2

SELECTED MODULES 0

Terraform Enterprise | Modules

https://app.terraform.io/app/modules/geoffrey-org/design/modules

geoffrey-org | Workspaces | Modules | Documentation | Status

Modules / Configuration Designer

Select Modules › Set Variables › Verify › Publish

Next »

consul

Providers

ADD MODULES TO WORKSPACE

animal PRIVATE

Sample repo for experimenting with the HashiCorp Terraform Module Registry

Details Add Module

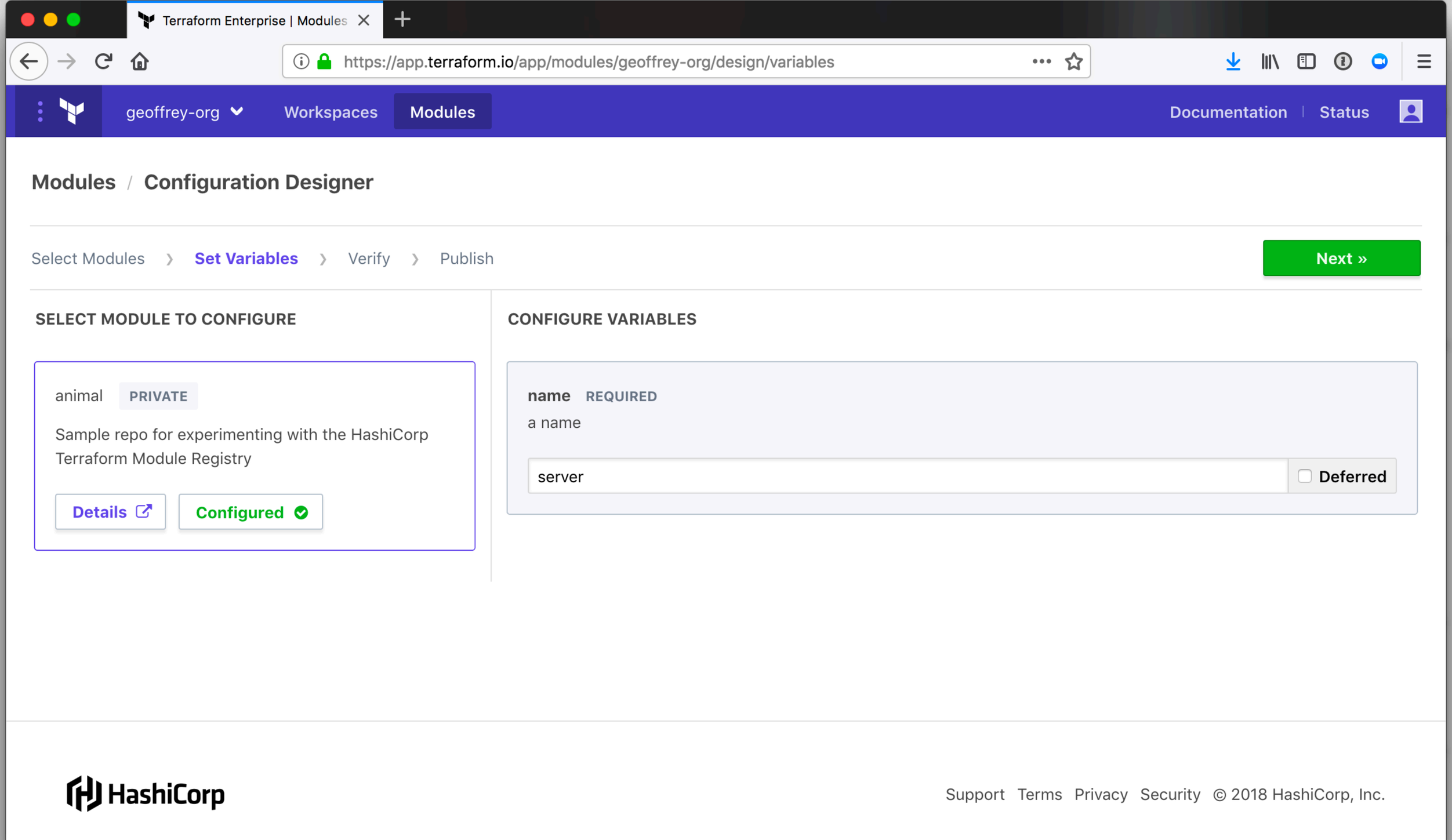
DEMO Version 0.0.2

SELECTED MODULES 1

animal PRIVATE Version 0.0.2

Sample repo for experimenting with the HashiCorp Terraform Module Registry

Details Remove


Terraform Enterprise | Modules
https://app.terraform.io/app/modules/geoffrey-org/design/variables
geoffrey-org
Workspaces
Modules
Documentation
Status
Modules / Configuration Designer
Select Modules
Set Variables
Verify
Publish
Next »
SELECT MODULE TO CONFIGURE
animal
PRIVATE
Sample repo for experimenting with the HashiCorp Terraform Module Registry
Details
Configured
CONFIGURE VARIABLES
name
REQUIRED
a name
server
Deferred
HashiCorp
Support
Terms
Privacy
Security
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Terraform Enterprise | Modules

https://app.terraform.io/app/modules/geoffrey-org/design/verify

geoffrey-org | Workspaces | Modules | Documentation | Status

Modules / Configuration Designer

Select Modules › Set Variables › **Verify** › Publish

Next »

Terraform Configuration

```
1 //-----------------------------------------------------------------
2 // Modules
3 module "animal" {
4   source  = "app.terraform.io/geoffrey-org/animal/demo"
5   version = "0.0.2"
6
7   name = "server"
8 }
```

Module Configuration Designer

Supports the producer/consumer pattern.

Teams can create well-documented modules with clear arguments that can be configured and used by other teams. Only minimal coding ability is required.

Producer teams can define best practices in code. Consuming teams don't need to understand the details, but can comply with infrastructure provisioning and security policies.

What You Learned

- Use standard module structure to build a module
- Publish a module to the repository
- Use the published module from another Terraform configuration
- Understand how to version and update a module
- Use the module configuration designer