

Terraform – Getting Started



Provisioning infrastructure
through software to achieve
consistent and predictable
environments.

Infrastructure as Code Benefits



- Automated deployment**
- Consistent environments**
- Repeatable process**
- Reusable components**
- Documented architecture**

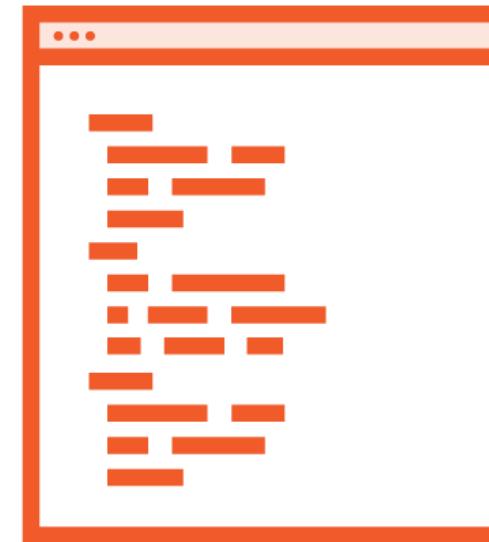
Automating Infrastructure Deployment



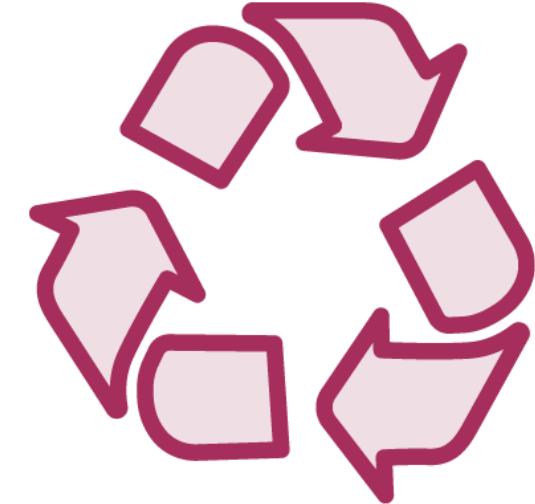
**Provisioning
Resources**



**Planning
Updates**



**Using Source
Control**



**Reusing
Templates**

Terraform

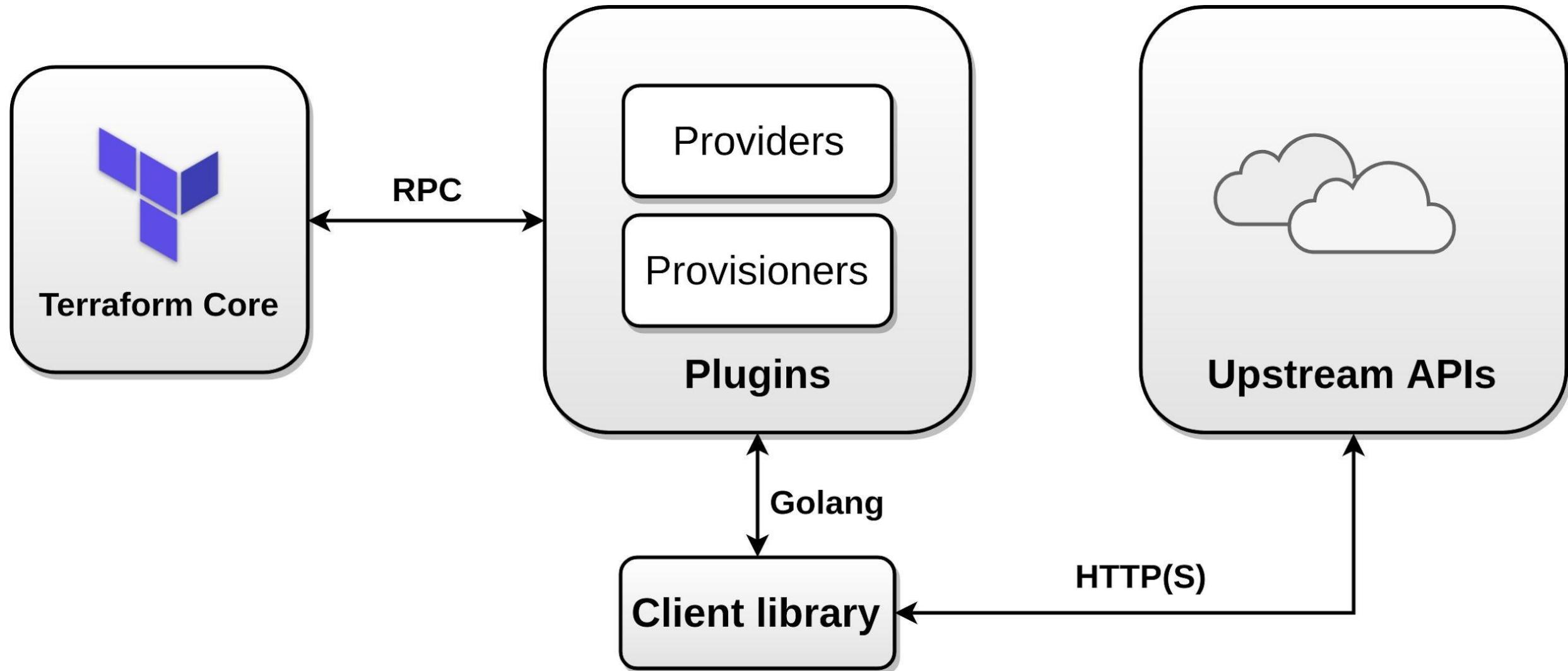
- A provisioning declarative tool that based on Infrastructure as a Code paradigm
- Uses own syntax - HCL (Hashicorp Configuration Language)
- Written in Golang.
- Helps to evolve your infrastructure, safely and predictably

Terraform is not a cloud agnostic tool

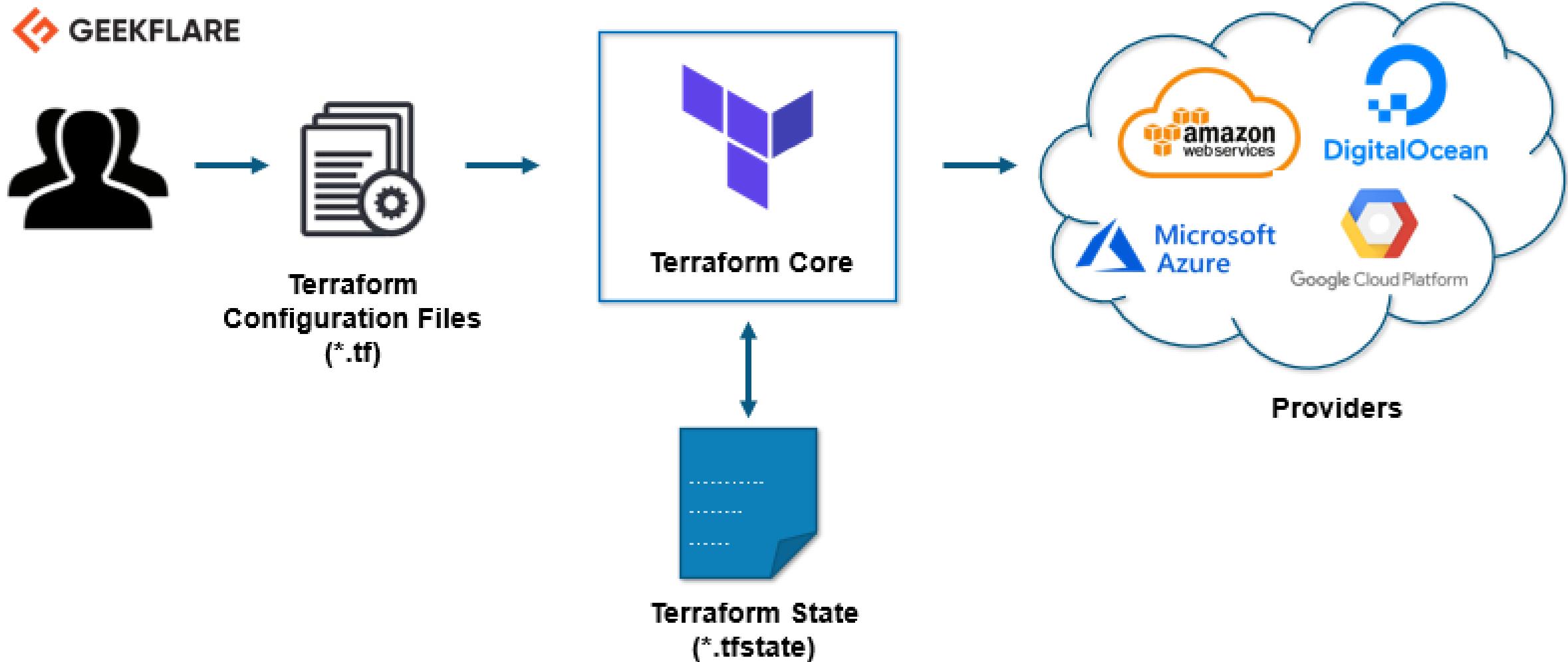
It's not a magic wand that gives you power over all clouds and systems.

It embraces all major Cloud Providers and provides common language to orchestrate your infrastructure resources.

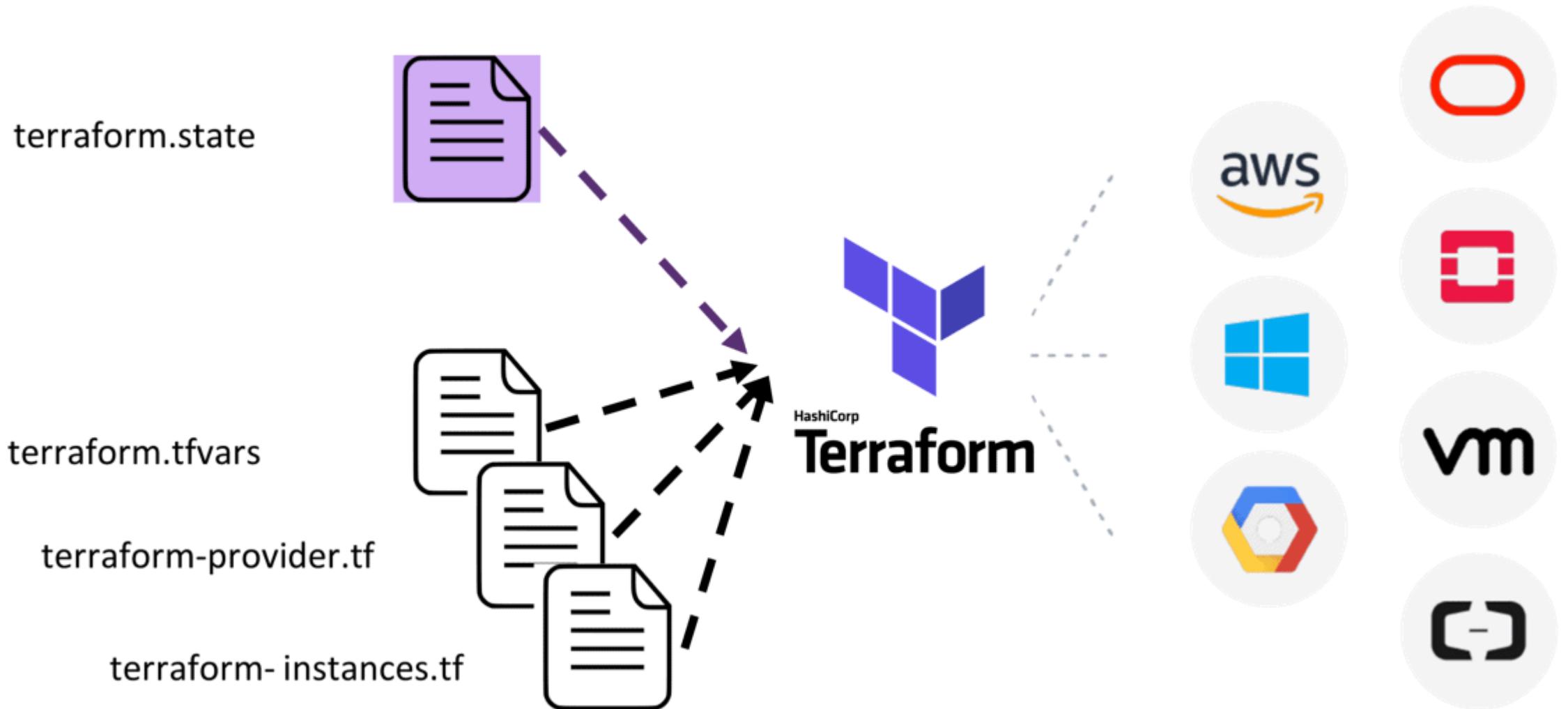
Architecture



Architecture



Architecture



Terraform Components

Terraform Executable

Terraform File

Terraform Providers

Terraform Statefile

API

Terraform config file

Terraform Providers

Terraform Providers



IaaS, PaaS, and SaaS

Community and HashiCorp

- AWS, Azure, GCP, and Oracle

Open source using APIs

Resources and data sources

Multiple instances

Terraform: Providers (Plugins)

1125+ infrastructure providers

Major Cloud Partners



ORACLE®



Google Cloud Platform



vmware®

Terraform: Providers

Can be integrated with any API using providers framework

- Note: Terraform Docs → Extending Terraform → Writing Custom Providers



- GitLab
- GitHub
- BitBucket



- Template
- Random
- Null
- External
(escape hatch)
- Archive



- OpenFaaS
- **OpenAPI**
- Generic Rest API
- Stateful

- DNS
- Palo Alto Networks
- F5 BIG-IP

- NewRelic
- Datadog
- PagerDuty

- Docker
- Kubernetes
- Nomad
- Consul
- Vault
- Terraform :)

- Digital Ocean
- Fastly
- OpenStack
- Heroku

Provider Example

```
provider "azurerm" {  
    subscription_id = "subscription-id"  
    client_id = "principal-used-for-access"  
    client_secret = "password-of-principal"  
    tenant_id = "tenant-id"  
    alias = "arm-1"  
}
```

Terraform Code

Terraform Syntax



HashiCorp configuration language

Why not JSON?

Human readable and editable

Interpolation

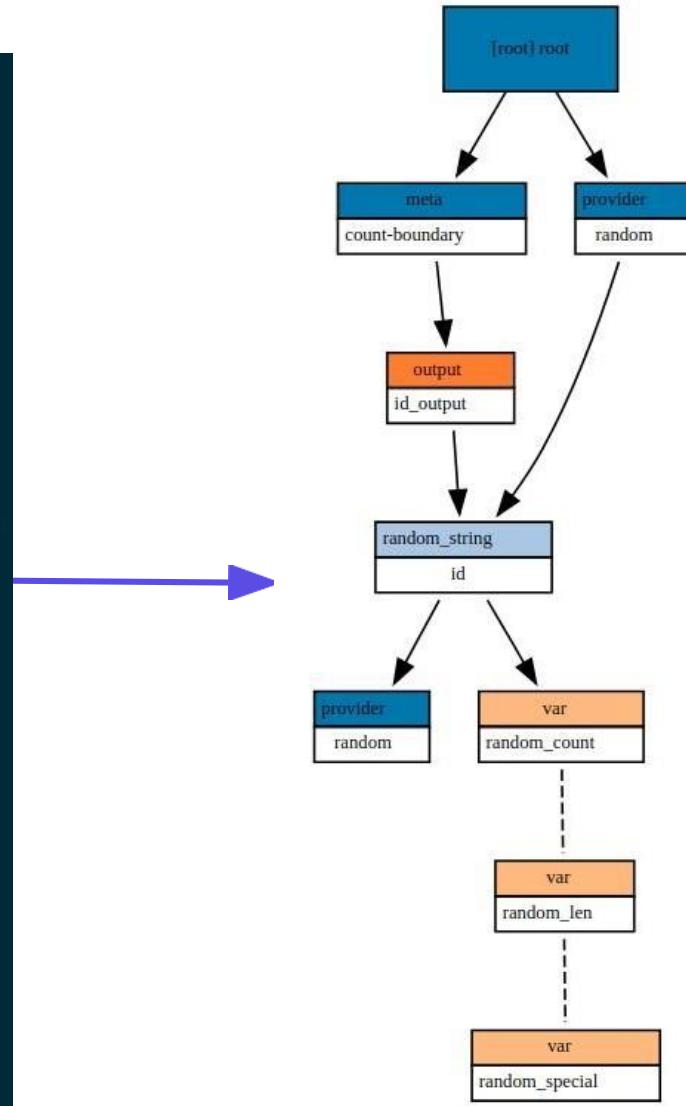
Conditional, functions, templates

Terraform: Example (Simple resource)



Terraform: Example (Simple local resource)

```
# file: main.tf
resource "random_string" "id" {
  count          = "${var.random_count}"
  special        = "${var.random_special}"
  length         = "${var.random_len}"
  override_special = "#"
  min_special    = 1
}
# file: outputs.tf
output "id_output" {
  value      = "${formatlist("secret:%s",random_string.id.*.result)}"
  sensitive = false
}
# file: variables.tf
variable "random_count" {
  default = 1
}
variable "random_len" {
  default = 32
}
variable "random_special" {
  default = true
}
```



```
variable "aws_access_key" {}
```

```
variable "aws_secret_key" {}
```

```
provider "aws" {
```

```
    access_key = "access_key"
```

```
    secret_key = "secret_key"
```

```
    region = "us-east-1"
```

```
}
```

□ **Variables**

□ **Provider**

```
resource "aws_instance" "ex" {  
    ami = "ami-c58c1dd3"  
    instance_type = "t2.micro"  
}  
  
output "aws_public_ip" {  
    value =  
    "${aws_instance.ex.public_dns}"  
}
```

□ Resource

□ Output

Code Example

```
provider "azurerm" {  
    subscription_id = "subscription-id"  
    client_id = "principal-used-for-access"  
    client_secret = "password-of-principal"  
    tenant_id = "tenant-id"  
    alias = "arm-1"  
}  
  
resource "azurerm_resource_group" {  
    name = "resource-group-name"  
    location = "East US"  
    provider = "azurerm.arm-1"  
}
```

Terraform Syntax

```
#Create a variable
```

```
variable var_name {  
    key = value #type, default, description  
}
```

```
#Use a variable
```

```
 ${var.name} #get string  
 ${var.map["key"]} #get map element  
 ${var.list[idx]} #get list element
```

Terraform Syntax

#Create provider

```
provider provider_name {
```

```
    key = value #depends on resource, use alias as needed
```

```
}
```

#Create data object

```
data data_type data_name {}
```

#Use data object

```
 ${data_type.data_name.attribute(args)}
```

Terraform Syntax

#Create resource

```
resource resource_type resource_name {  
    key = value #depends on resource  
}
```

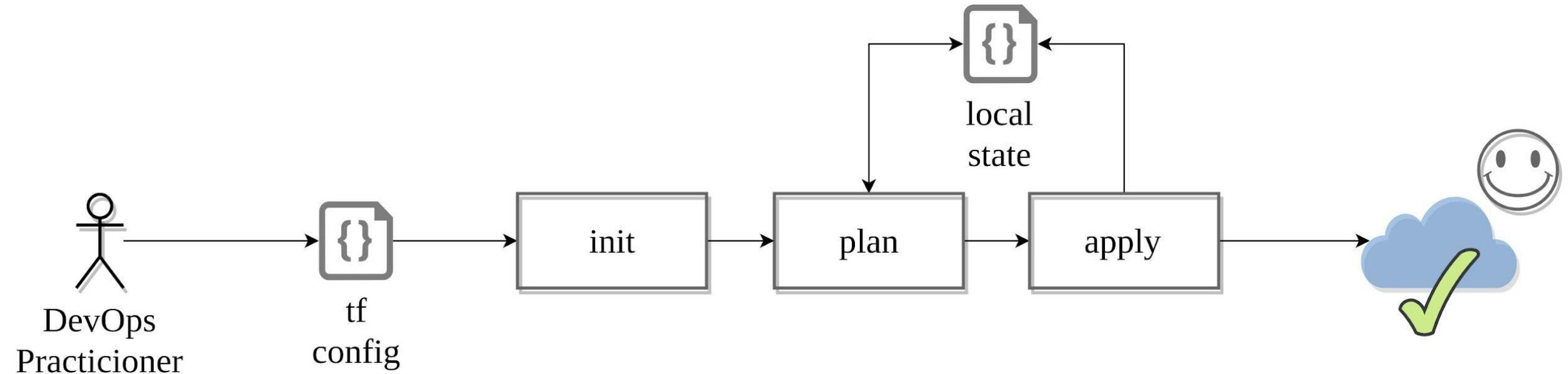
#Reference resource

```
 ${resource_type.resource_name.attribute(args) }
```

Terraform Workflow

Workflow: Adoption stages

Single
contributor



Terraform Core: Init

1. This command will never delete your existing configuration or state.
2. Checkpoint → <https://checkpoint.hashicorp.com/>
3. .terraformrc → enable plugin_cache_dir, disable checkpoint
4. Parsing configurations, syntax check
5. Checking for provisioners/providers (by precedence, only once)→
“.”, terraform_bin_dir, terraform.d/plugins/linux_amd64
.terraform/plugins/linux_amd64
6. File lock.json contains sha-512 plugin hashes (.terraform)
7. Loading backend config (if it's available, local instead)
Backend Initialization: Storage for terraform state file.

Terraform Core: Plan + Apply

1. Starting Plugins: Provisioners/Providers
2. Building graph
 - a. Terraform core traverses each vertex and requests each provider using parallelism
3. Providers syntax check: resource validation
4. If backend == <nil>, use local
5. If “-out file.plan” provided - save to file - the file is not encrypted
6. Terraform Core calculates the difference between the last-known state and the current state
7. Presents this difference as the output of the terraform plan operation to user in their terminal

Terraform Core: Destroy

1. Measure twice, cut once
2. Consider -target flag
3. Avoid run on production
4. No “Retain” flag - Remove resource from state file instead
5. `terraform destroy` tries to evaluate outputs that can refer to non existing resources #18026
6. `prevent_destroy` should let you succeed #3874
7. You can't destroy a single resource with count in the list

Terraform state

Terraform State

- Terraform keeps the remote state of the infrastructure
- It stores it in a file called `terraform.tfstate`
- There is also a backup of the previous state in `terraform.tfstate.backup`
- When you execute `terraform apply`, a new `terraform.tfstate` and backup is written
- This is how terraform keeps track of the remote state
 - If the remote state changes and you hit `terraform apply` again, terraform will make changes to meet the correct remote state again
 - e.g. you terminate an instance that is managed by terraform, after `terraform apply` it will be started again

Terraform State

The terraform state can be saved remote, using the backend functionality in terraform.

The default is a local backend (the local terraform state file)

Other backbend's include:

s3 (with a looking mechanism using dynamoDB)

consul (with locking)

terraform enterprise (the commercial solution)

Terraform Command Overview

Command	Description
terraform apply	Applies state
destroy	Destroys all terraform managed state (use with caution)
fmt	Rewrite terraform configuration files to a canonical format and style
get	Download and update modules
graph	Create a visual representation of a configuration or execution plan
import [options] ADDRESS ID	Import will try and find the infrastructure resource identified with ID and import the state into terraform.tfstate with resource id ADDRESS

Terraform Command Overview

Command	Description
output [options] [NAME]	Output any of your resources. Using NAME will only output a specific resource
plan	terraform plan, show the changes to be made to the infrastructure
push	Push changes to Atlas, Hashicorp's Enterprise tool that can automatically run terraform from a centralized server
refresh	Refresh the remote state. Can identify differences between state file and remote state
remote	Configure remote state storage
show	Show human readable output from a state or a plan

Terraform Command Overview

Command	Description
state	Use this command for advanced state management, e.g. Rename a resource with <code>terraform state mv aws_instance.example aws_instance.production</code>
taint	Manually mark a resource as tainted, meaning it will be destroyed and recreated at the next apply
validate	validate your terraform syntax
untaint	undo a taint

Activate Window

Terraform Functions

Terraform Functions

The Terraform language includes a number of built-in functions that you can call from within expressions to transform and combine values. The general syntax for function calls is a function name followed by comma-separated arguments in parentheses:

```
max(5, 12, 9)
```

Terraform Types

- [Numeric Functions](#)
 - [String Functions](#)
 - [Collection Functions](#)
 - [Encoding Functions](#)
 - [Filesystem Functions](#)
 - [Date and Time Functions](#)
 - [Hash and Crypto Functions](#)
 - [IP Network Functions](#)
 - [Type Conversion Functions](#)
-

Terraform Functions

```
#Configure networking

variable network_info {
    default = "10.0.0.0/8" #type, default, description
}

#Returns 10.1.0.0/16

cidr_block = ${cidrsubnet(var.network_info, 8, 1) }

#Returns 10.2.0.0/16

cidr_block = ${cidrsubnet(var.network_info, 8, 2) }
```

Terraform functions

Function	Description	Example
basename(path)	Returns the filename (last elements) of a path	Basename("/home/Edward / file.txt") returns file.txt
coalesce(string1, string2, ...) coalescelist(list1, list2, ...)	Returns the first non-empty value Returns the first non-empty list	coalesce("", "", "hello") returns hello
elements(list, index)	Returns a single element from a list at the given index	element(module.vpc.public_subnets, count.index)
format(format, args, ...) formatlist(format, args, ...)	Formats a string/list according to the given format	format("server-%03d", count.index+1) returns server-001, server-002

Terraform functions

Function	Description	Example
index(list, elem)	Finds the index of a given element in a list	index(aws_instance.foo.*.tags.Env, "prod")
join(delim, list)	Joins a list together with a delimiter	join(",", var.AMIS) returns "ami-123,ami-456,ami-789"
list(item1, item2, ...)	create a new list	join(":", list("a","b","c")) returns a:b:c
lookup(map, key, [default])	Perform a lookup on a map, using "key". Returns value representing "key" in the map	lookup(map("k", "v"), "k", "not found") returns "v"

Terraform functions

Function	Description	Example
Split(delim, string)	splits a string into a list	split(",","a,b,c,d") returns ["a","b","c","d"]
substr(string, offset, length)	extract substring from string	substr("abcde", -3, 3) returns cde
timestamp()	returns RFC 3339 timestamp	"Server started at \${timestamp()}" server started at 2018-06-16T18:46:46Z
upper(string)	Returns uppercased string	upper ("string") returns STRING

Terraform functions

Function	Description	Example
lower(string)	returns lowercase value of "string"	lower("Hello") returns hello
map(key, value, ...)	returns a new map using key:value	map("k", "v", "k2", "v2") returns: { "k" = "v", "k2" = "v2" }
merge(map1, map2, ...)	Merges maps (union)	merge(map("k", "v"), map("k2", "v2")) returns: { "k" = "v", "k2" = "v2" }
replace(string, search, replace)	Performs a search and replace on string	replace("aaab", "a", "b") returns bbbb

Terraform functions

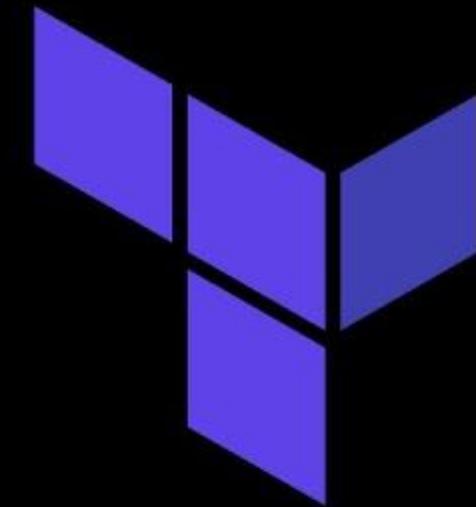
Function	Description	Example
uuid()	Returns a UUID string in RFC 4122 v4 format	uuid() returns: 65b8cf0a-685d-3295-73c1-1393e f71bcd6
values(map)	returns values of a map	values(map("k","v","k2","v2")) returns

```
prateek@:~$ terraform console
> lower("PRATEEK")
prateek
> upper("prateek")
PRATEEK
> title("prateek")
Prateek
```

```
prateek@:~$ terraform console
> split(" ","Prateek Singh")
[
  "Prateek",
  "Singh",
]
> join(" ",["Prateek","Singh"])
Prateek Singh
>

> replace("Password@123","a","@")
P@sword@123
>
```

```
prateek@:~$ terraform console
> max(10,9,8)
10
> min(10,9,8)
8
> pow(2,3)
8
> log(8,2)
3
>
```



Lookup function in Terraform

Terraform Functions

```
#Create ami map

variable "amis" {

    type = "map"

    default = {

        us-east-1 = "ami-1234"

        us-west-1 = "ami-5678"

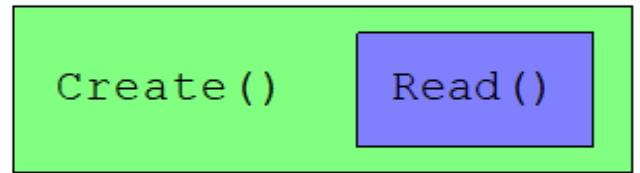
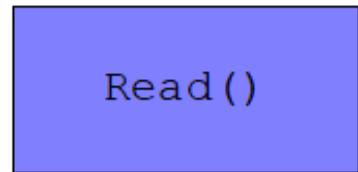
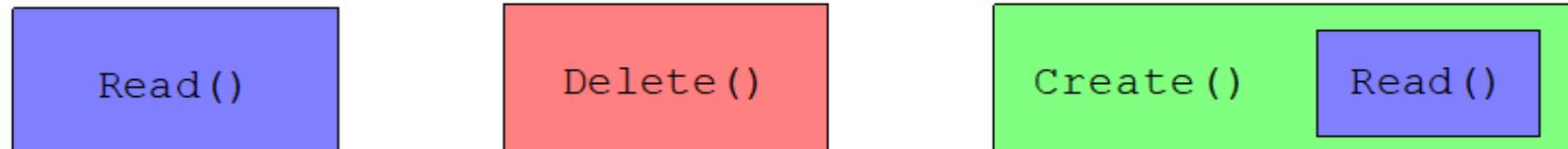
    }

}

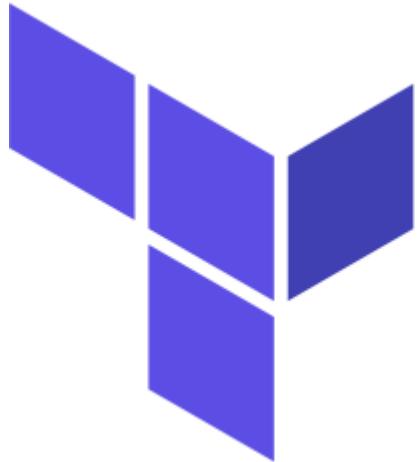
ami = ${lookup(var.amis, "us-east-1")}
```

```
[root@node1 functions_demo]# terraform console
> max(10,20,30)
30
> min(10,20,30)
10
> lookup({a="ay", b="bee"}, "a", "what?")
ay
> lookup({a="ay", b="bee"}, "b", "what?")
bee
> lookup({a="ay", b="bee"}, "c", "what?")
what?
> element(["a", "b", "c"], 1)
b
> element(["a", "b", "c"], 0)
a
> element(["a", "b", "c"], 2)
c
> element(["a", "b", "c"], 3)
a
>
```

Terraform Workflow Functions

Step #	Command	Invoked Functions
1	terraform apply (initial deploy)	
2	terraform plan	
3	terraform apply (update)	
4	terraform apply (force new update)	
5	terraform destroy	

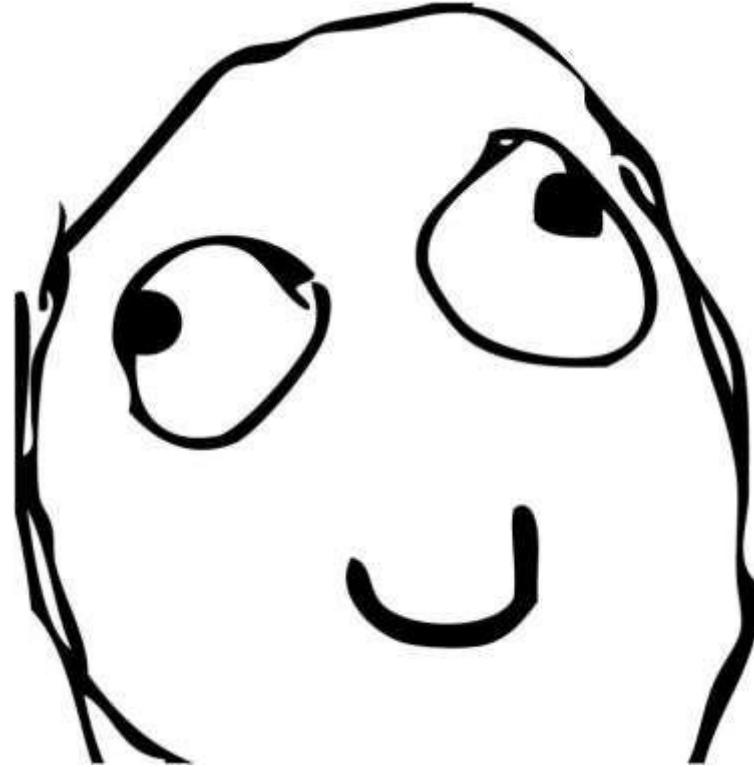
<https://www.terraform.io/docs/language/functions/index.html>



Reusable, composable, battle-tested

TERRAFORM MODULES

**Your project is code complete
and it's time to deploy it!**



I know, I'll use AWS!

Amazon Web Services

Compute

-  **EC2**
Virtual Servers in the Cloud
-  **EC2 Container Service**
Run and Manage Docker Containers
-  **Elastic Beanstalk**
Run and Manage Web Apps
-  **Lambda**
Run Code in Response to Events

Storage & Content Delivery

-  **S3**
Scalable Storage in the Cloud
-  **CloudFront**
Global Content Delivery Network
-  **Elastic File System** PREVIEW
Fully Managed File System for EC2
-  **Glacier**
Archive Storage in the Cloud
-  **Import/Export Snowball**
Large Scale Data Transport
-  **Storage Gateway**
Hybrid Storage Integration

Database

-  **RDS**
Manage Relational Database Service
-  **DynamoDB**
Managed NoSQL Database
-  **ElastiCache**
In-Memory Cache
-  **Redshift**
Fast, Simple, Cost-Effective Data Warehousing
-  **DMS**
Managed Database Migration Service

Networking

-  **VPC**
Isolated Cloud Resources
-  **Direct Connect**
Dedicated Network Connector to AWS
-  **Route 53**
Scalable DNS and Domain Name Registration

Developer Tools

-  **CodeCommit**
Store Code in Private Git Repositories
-  **CodeDeploy**
Automate Code Deployments
-  **CodePipeline**
Release Software Using Continuous Delivery

Management Tools

-  **CloudWatch**
Monitor Resources and Applications
-  **CloudFormation**
Create and Manage Resources with Templates
-  **CloudTrail**
Track User Activity and API Usage
-  **Config**
Track Resource Inventory and Changes
-  **OpsWorks**
Automate Operations with Chef
-  **Service Catalog**
Create and Use Standardized Products
-  **Trusted Advisor**
Optimize Performance and Security

Security & Identity

-  **Identity & Access Management**
Manage User Access and Encryption Keys
-  **Directory Service**
Host and Manage Active Directory
-  **Inspector** PUBLIC
Analyze Application Security
-  **WAF**
Filter Malicious Web Traffic
-  **Certificate Manager**
Provide, Manage, and Deploy SSL/TLS Certificates

Analytics

-  **EMR**
Manage Hadoop Framework
-  **Data Pipeline**
Orchestrate Job Data-Driven Workflows
-  **Elasticsearch Service**
Run and Scale Elasticsearch Clusters
-  **Machine Learning**

Internet of Things

-  **AWS IoT**
Connect Devices to the Cloud

Game Development

-  **GameLift**
Deploy and Scale Backend-hosted Multiplayer Games

Mobile Services

-  **Mobile Hub**
Build, Test, and Monitor Mobile Apps
-  **Cognito**
User Identity and App Data Synchronization
-  **Device Farm**
Test Android, FireOS, and iOS Apps on Real Devices in the Cloud
-  **Mobile Analytics**
Collect, Visualize, and Export App Analytics
-  **SNS**
Push Notification Service

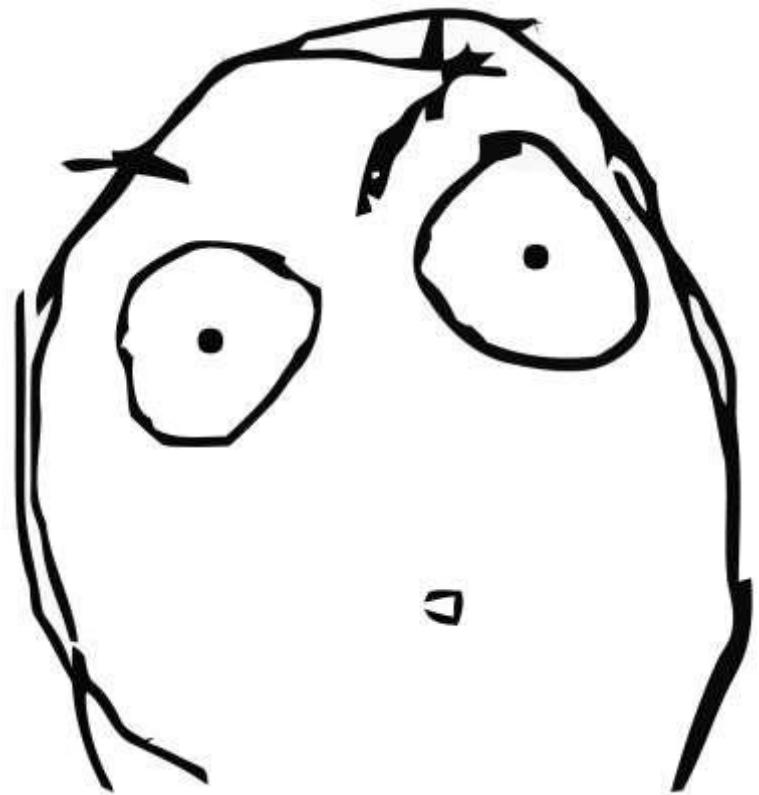
Application Services

-  **API Gateway**
Build, Deploy and Manage APIs
-  **AppStream**
Low Latency Application Streaming
-  **CloudSearch**
Managed Search Service
-  **Elastic Transcoder**
Easy-to-Use Scalable Media Transcoding
-  **SES**
Email Sending and Receiving Service
-  **SQS**
Message Queue Service
-  **SWF**
Workflow Service for Coordinating Application Components

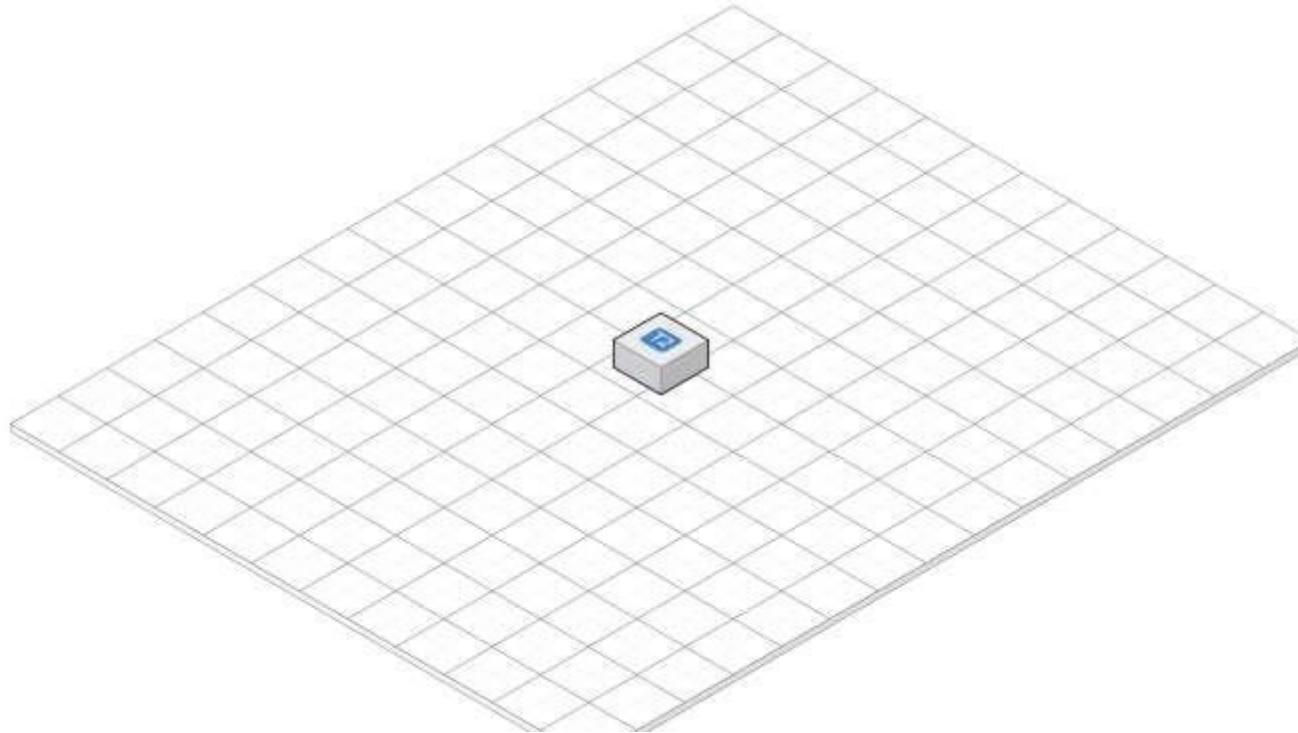
Enterprise Applications

-  **WorkSpaces**
Desktops in the Cloud
-  **WorkDocs**
Secure Enterprise Storage and Sharing Service
-  **WorkMail**
Secure Email and Calendaring Service

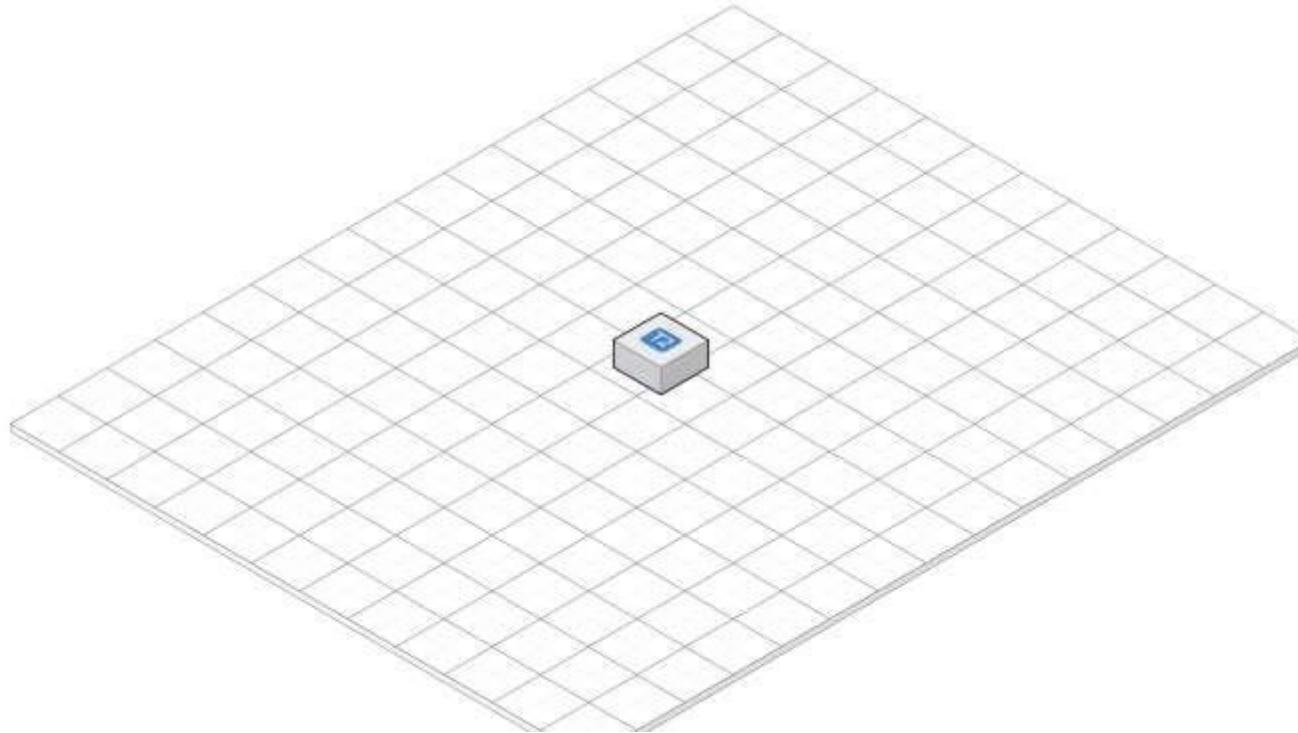
You login to the AWS console



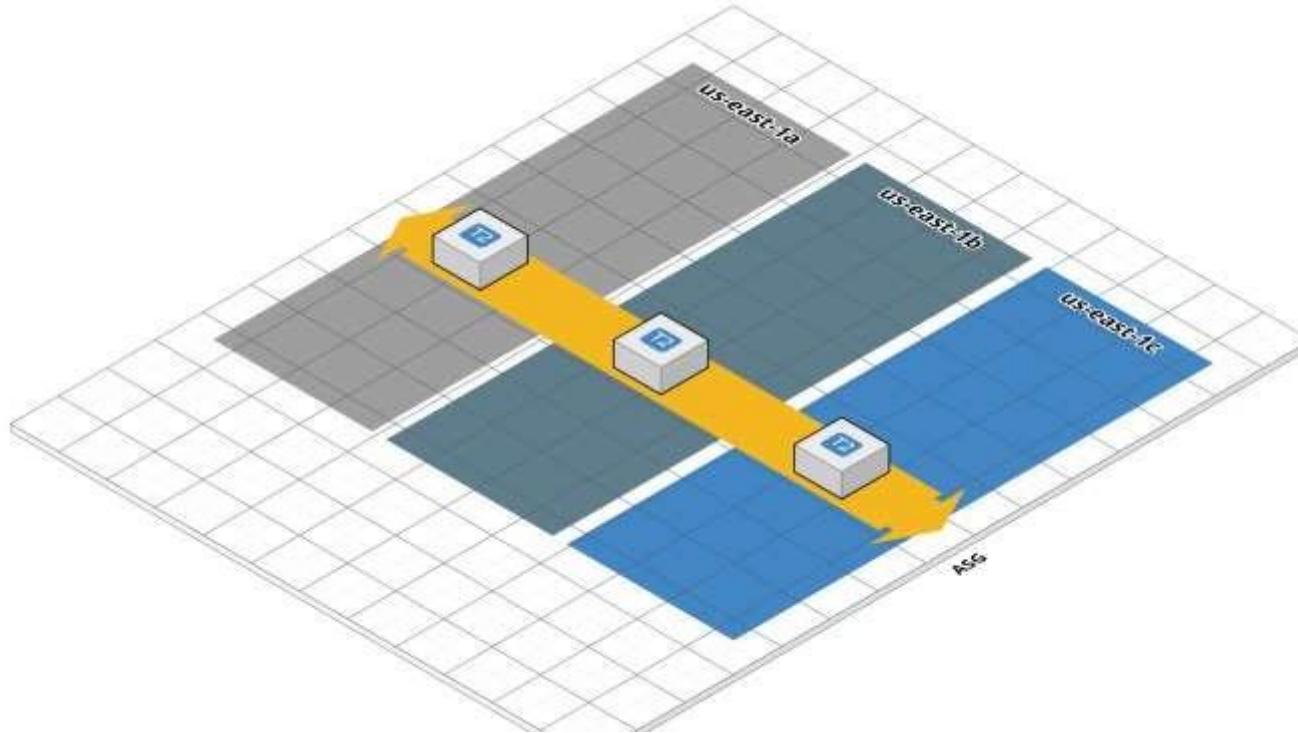
(Spend hours reading docs)



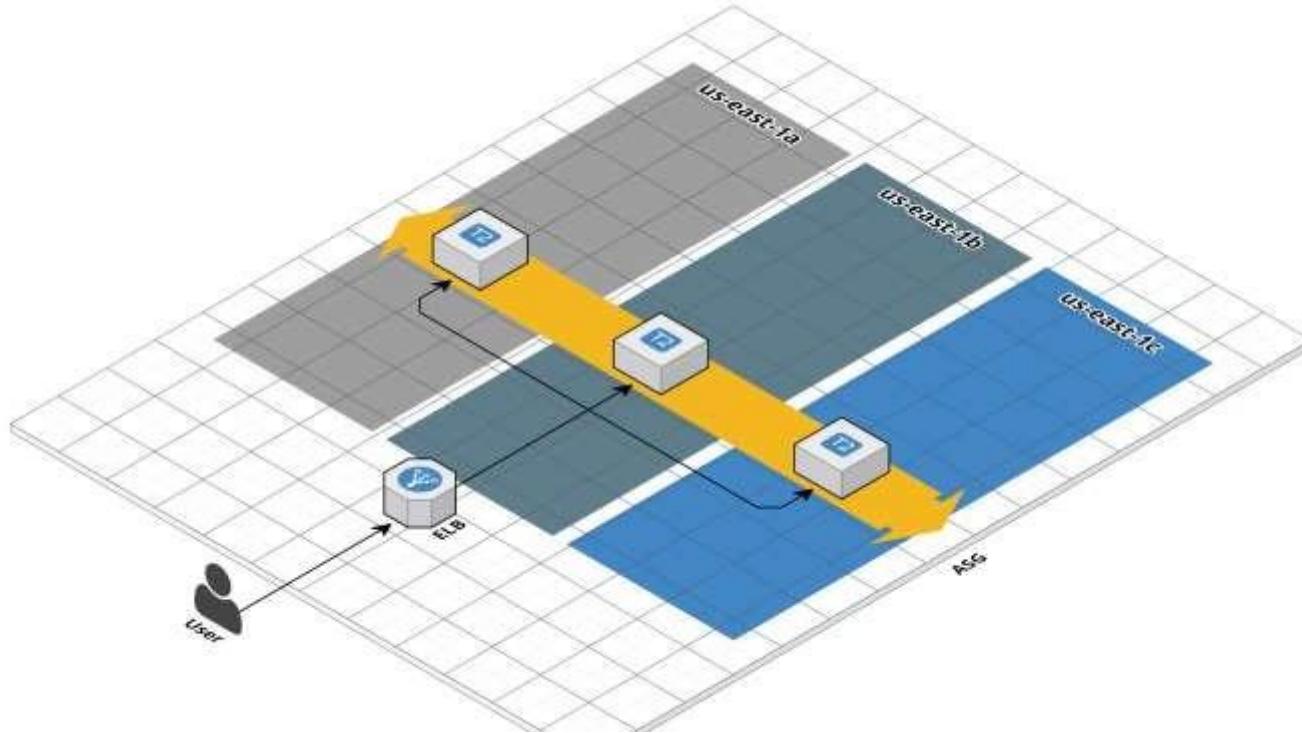
OK, I have a server running!



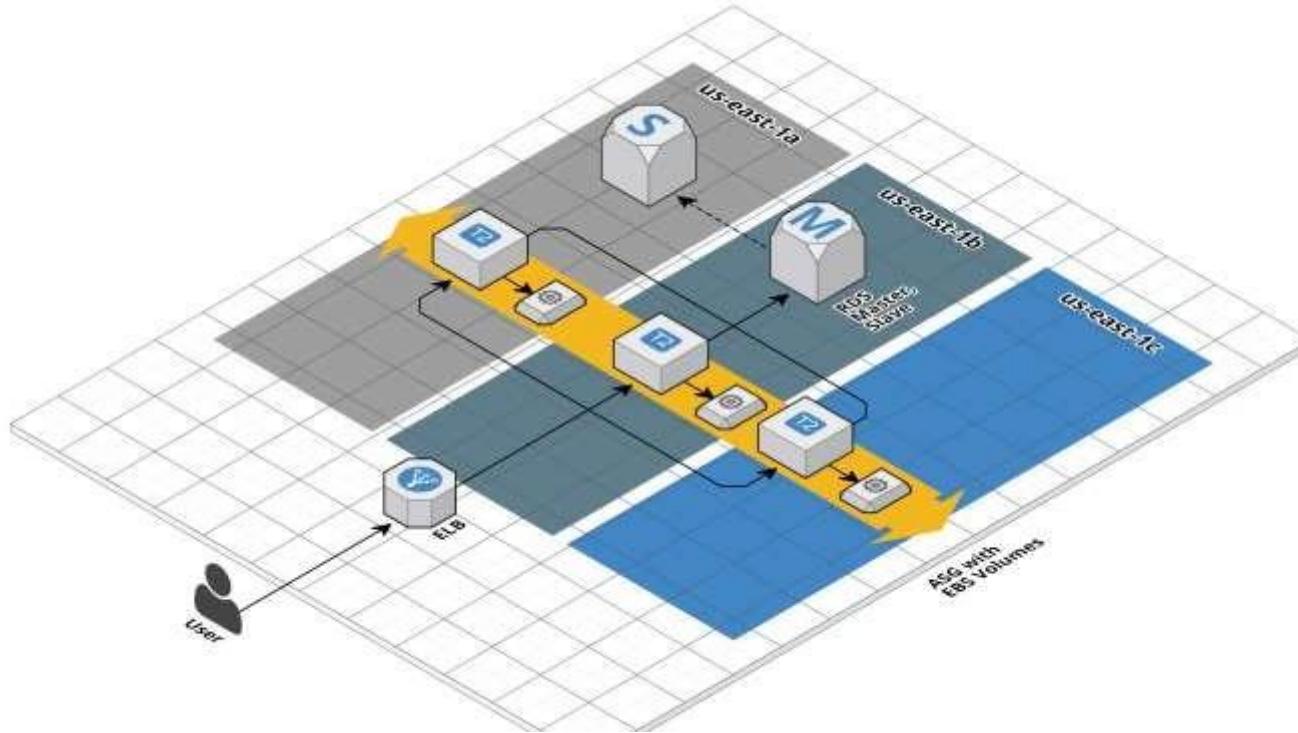
What else do I need?



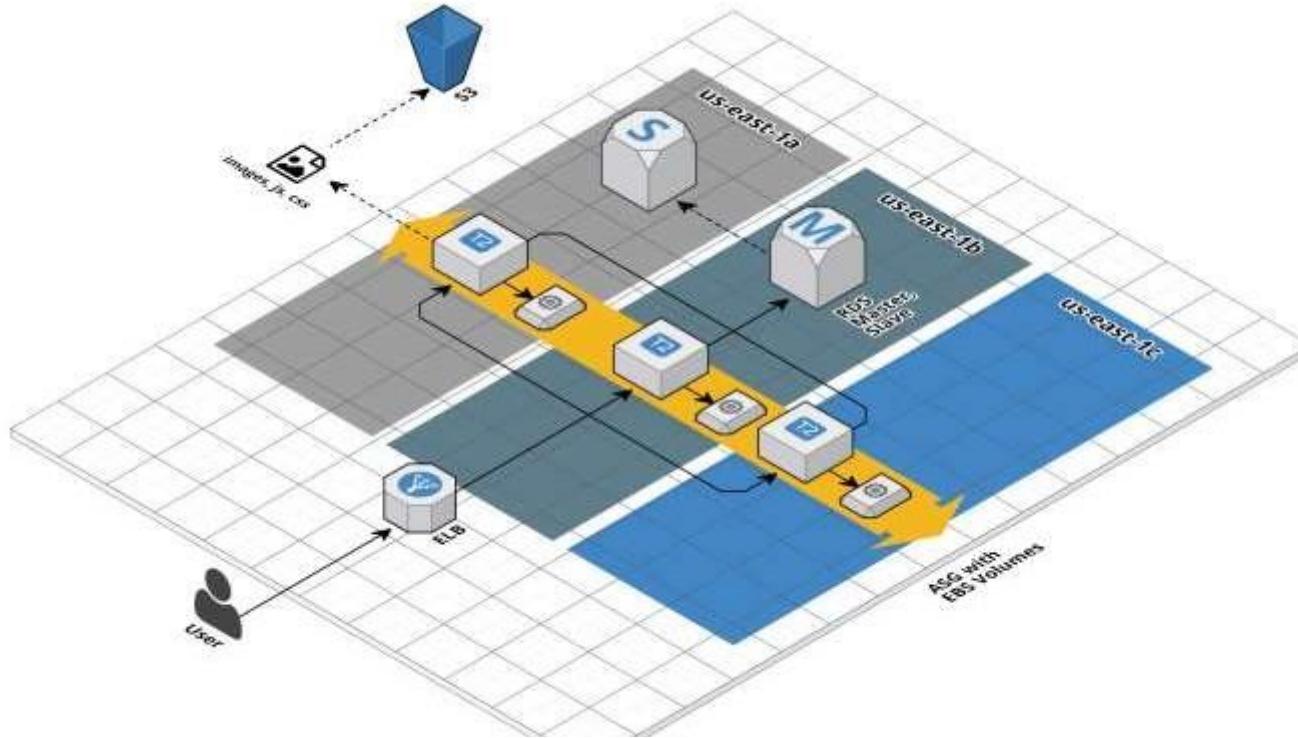
Well, you probably want more than one server for high availability



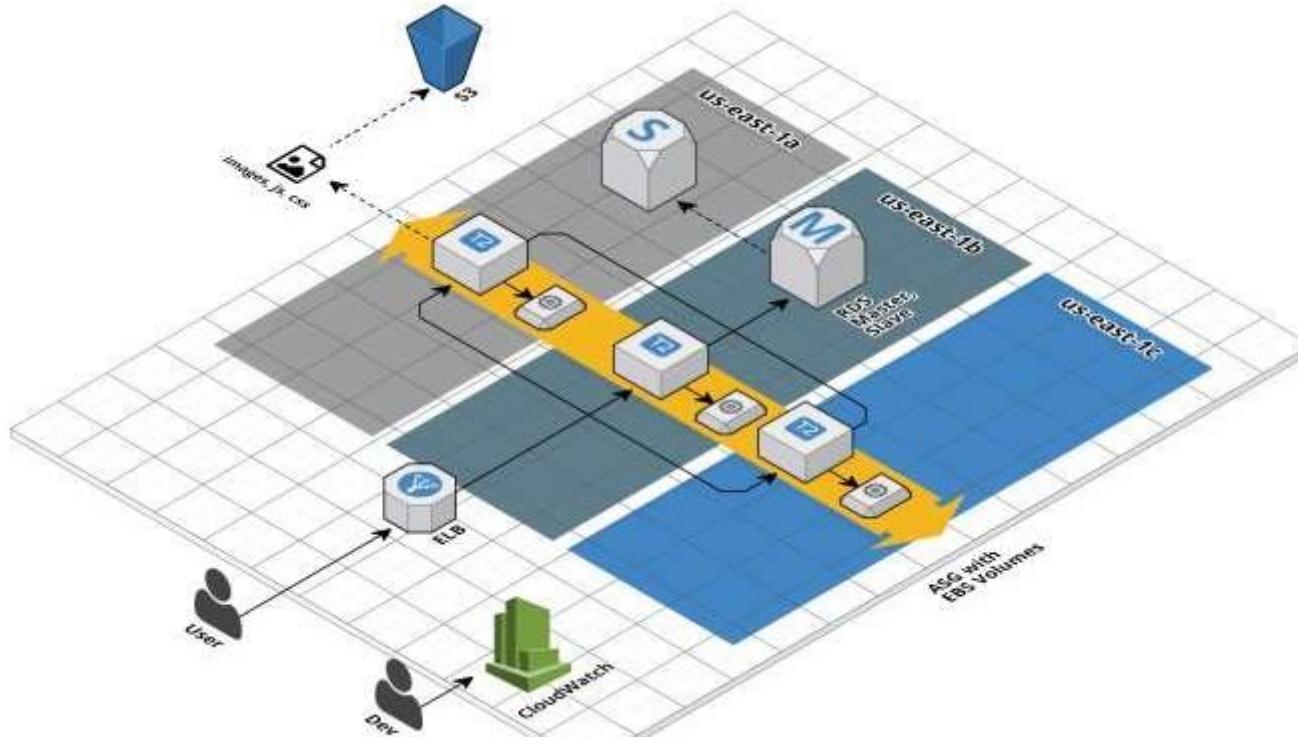
And a load balancer to distribute traffic across those servers



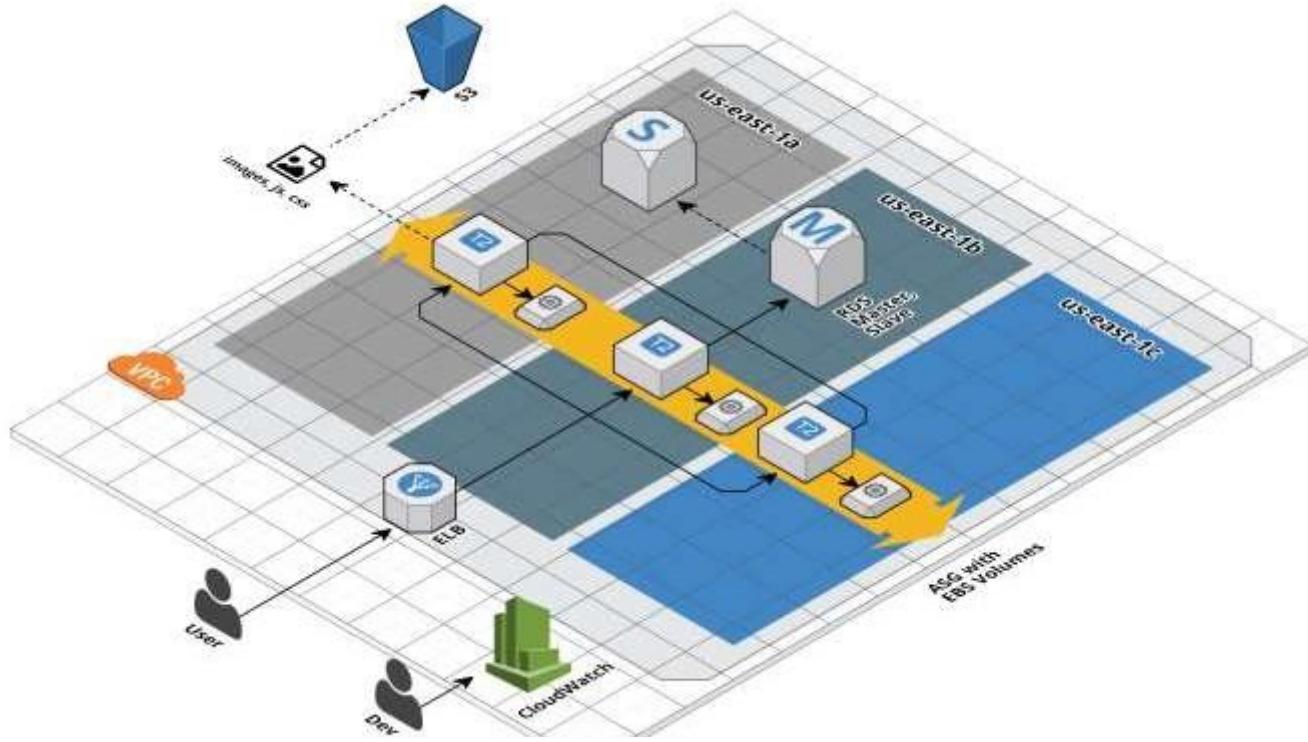
**And EBS Volumes and RDS databases
to store all of your data**



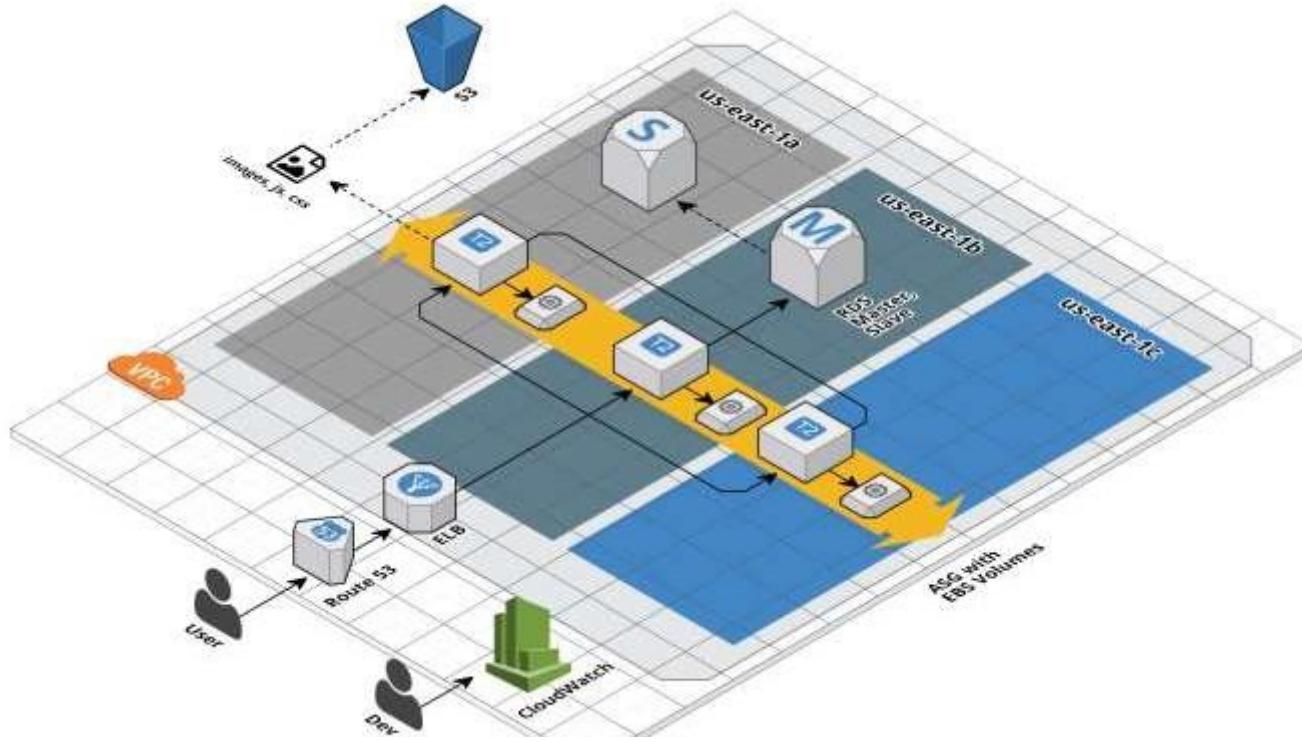
You'll need an S3 bucket for files



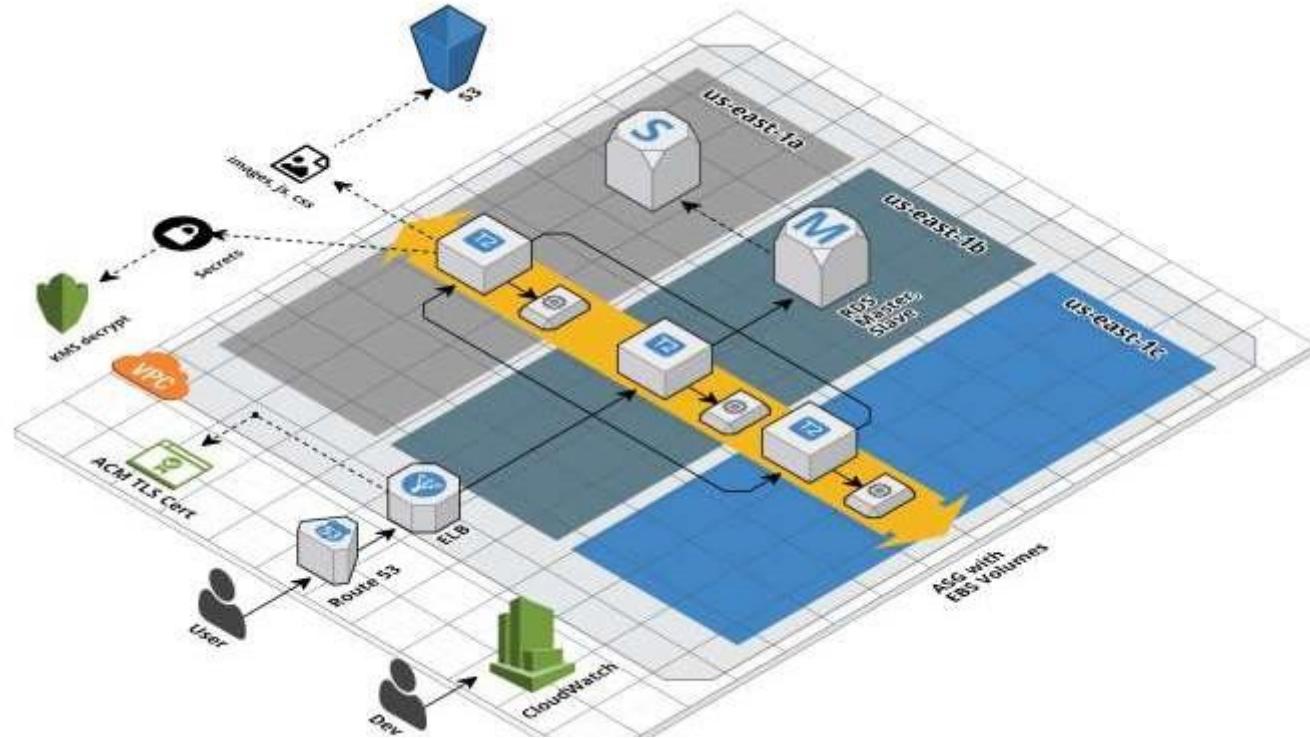
CloudWatch for monitoring



Don't forget the VPC, subnets, route tables, NAT gateways



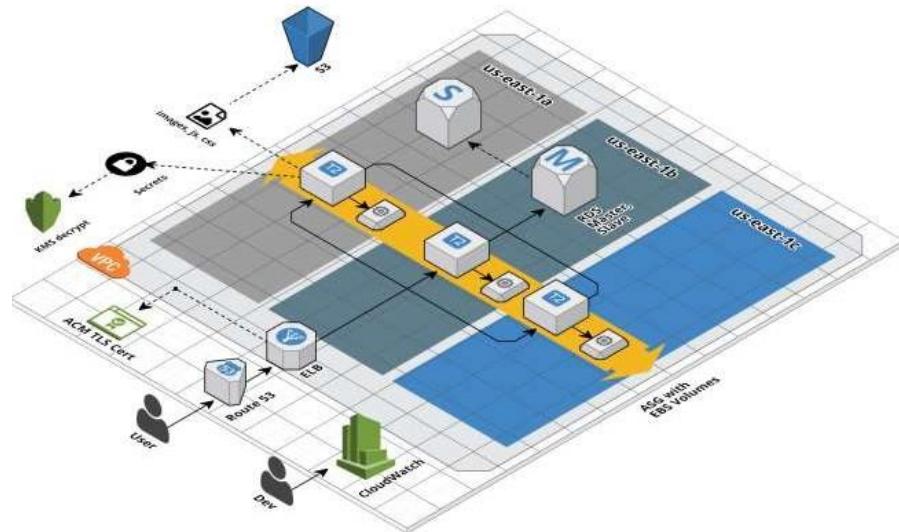
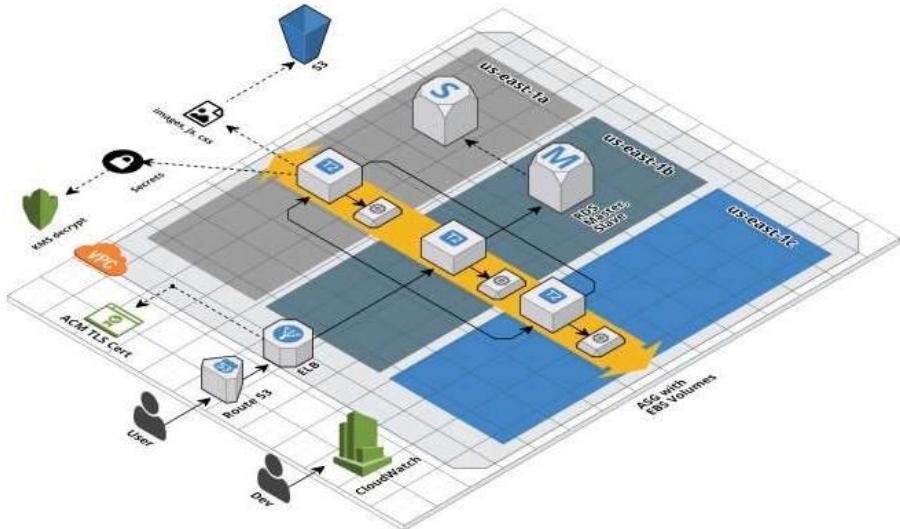
Route 53 for DNS



ACM for SSL/TLS certs and KMS to encrypt / decrypt secrets

stage

prod

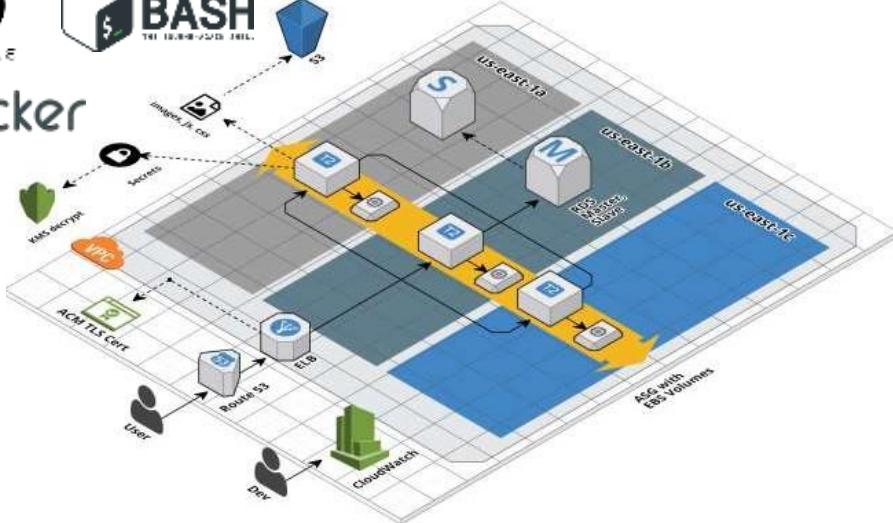
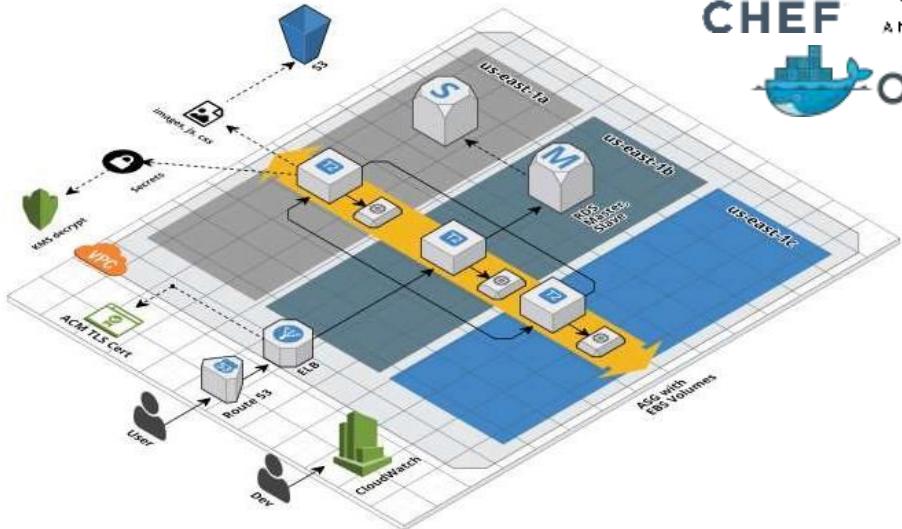


And you need all of that in separate environments for stage and prod

stage



prod

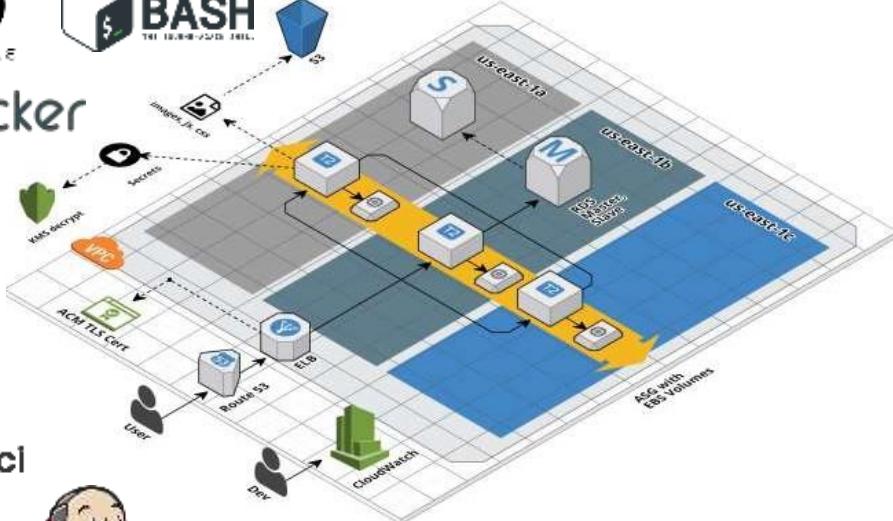
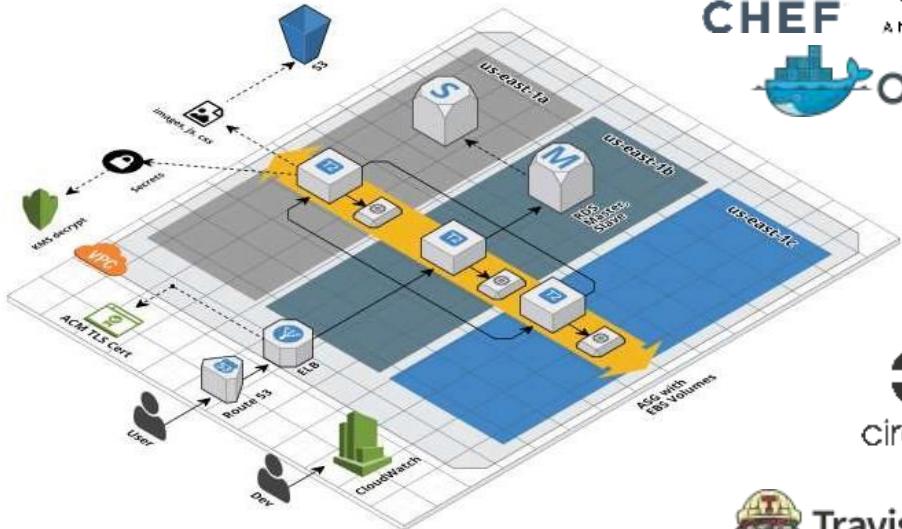


Plus DevOps tooling to manage it all

stage



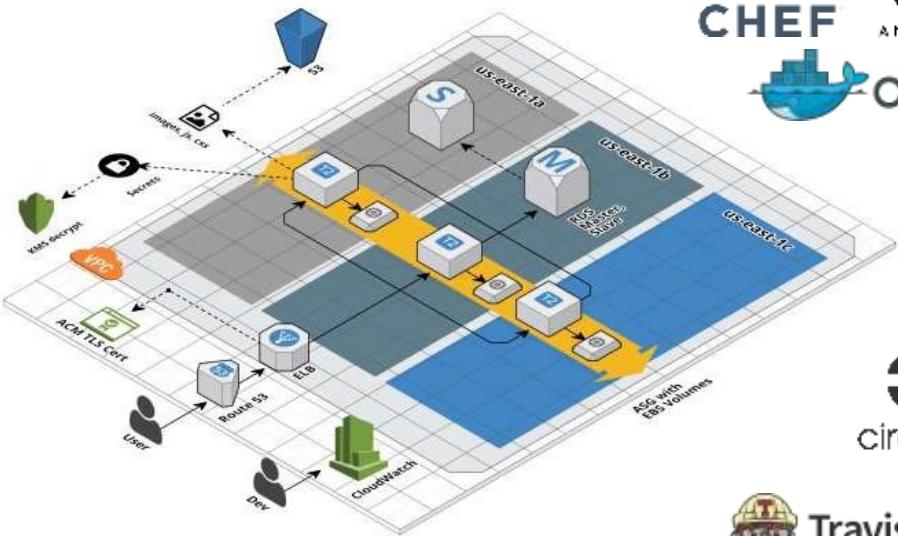
prod



Travis CI



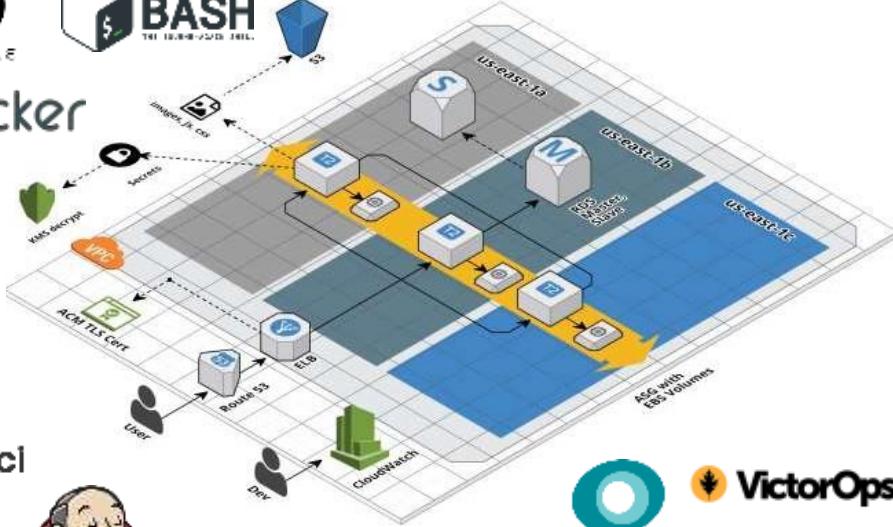
And a CI server to test it all



Travis CI



A
ANSIBLE



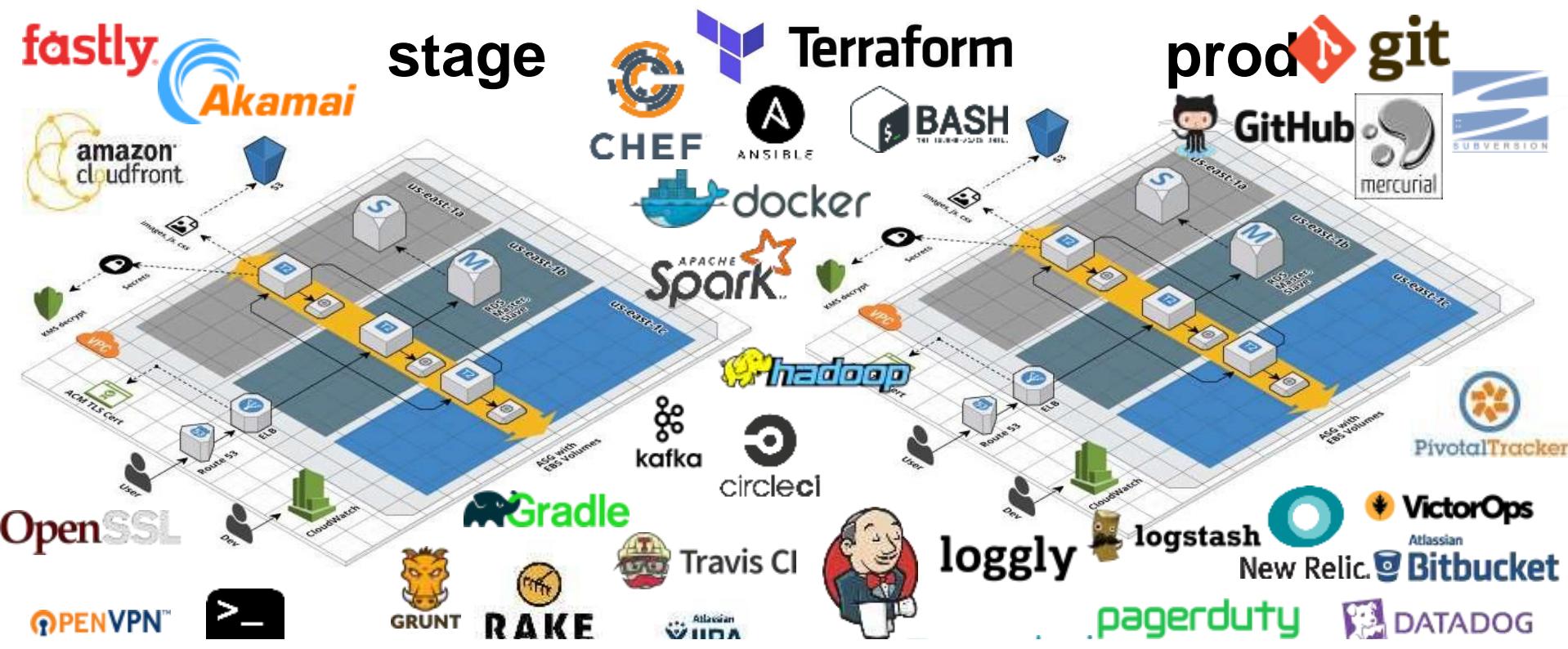
 VictorOps

New Relic



 DATADOG

**Plus alerts and on-call rotation to
notify you when it all breaks**



And also...



FFFFFFF
FFFFFFF
FFFFFFF
FFFUU
UUUU
UUUU
UUUU
UUUU-
UUUU-

**And you have to maintain it all.
Forever.**

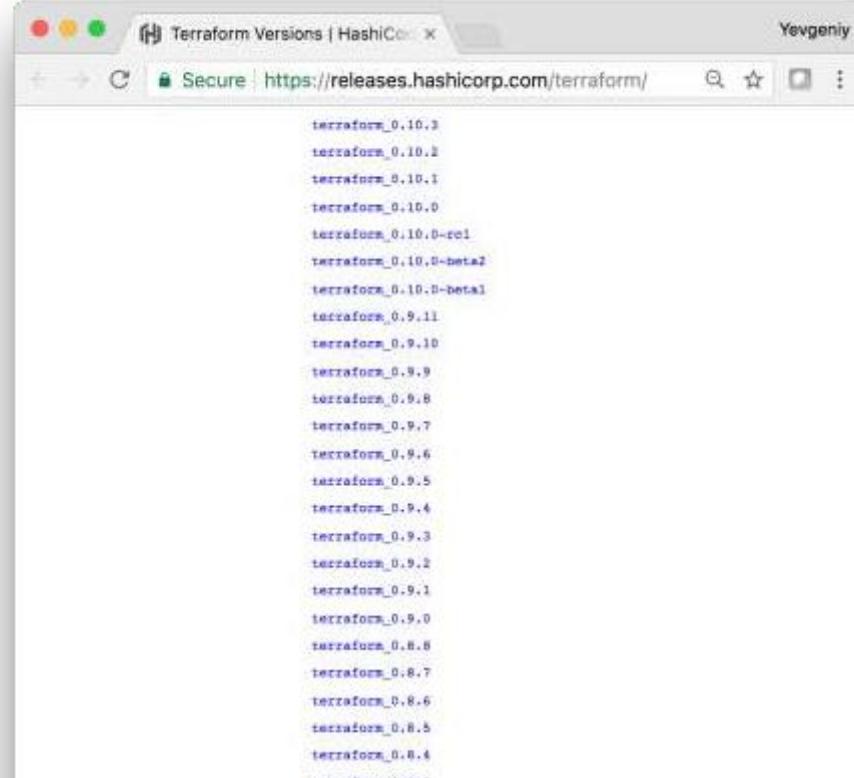
AWS shoots for total cloud domination

All of this is bad news for competitors like IBM, Google and Microsoft (not to mention, Oracle and Alibaba), but AWS isn't just dominating because it was first (although that's part of it), it's also continuing to innovate at an astonishing rate, adding around 1000 new features every single year up from 722 just last year, according to a chart posted by CEO Andy Jassy during his re:Invent keynote.

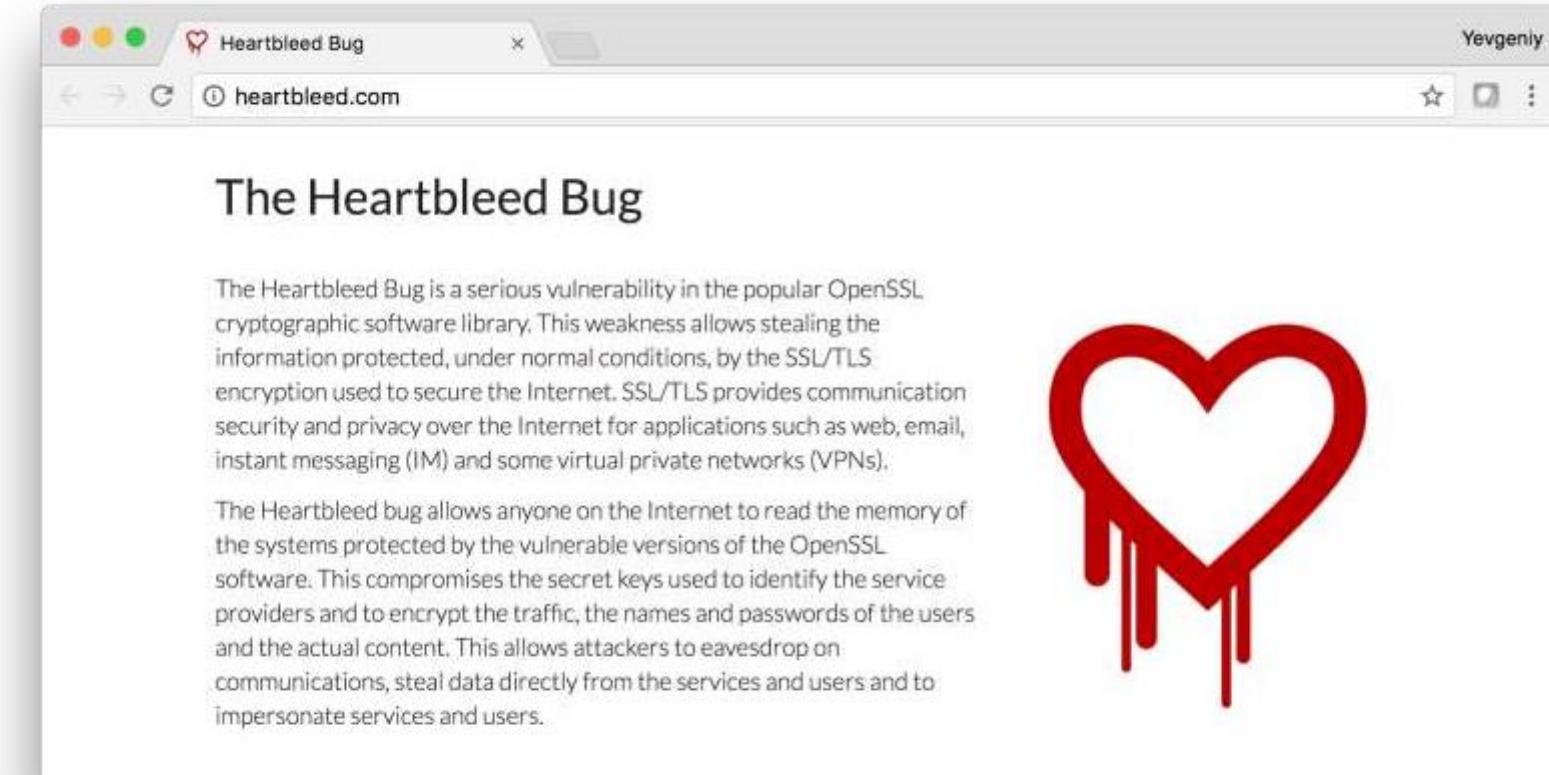
The chart shows a steady increase in the number of new AWS features added daily over time. The data points are:

Year	New Capabilities Daily
2014	24
2015	48
2016	61
2017	82
2018	159
2019	280
2020	516
2021	722
2022	~1000

AWS: 1,000 new releases in 2021



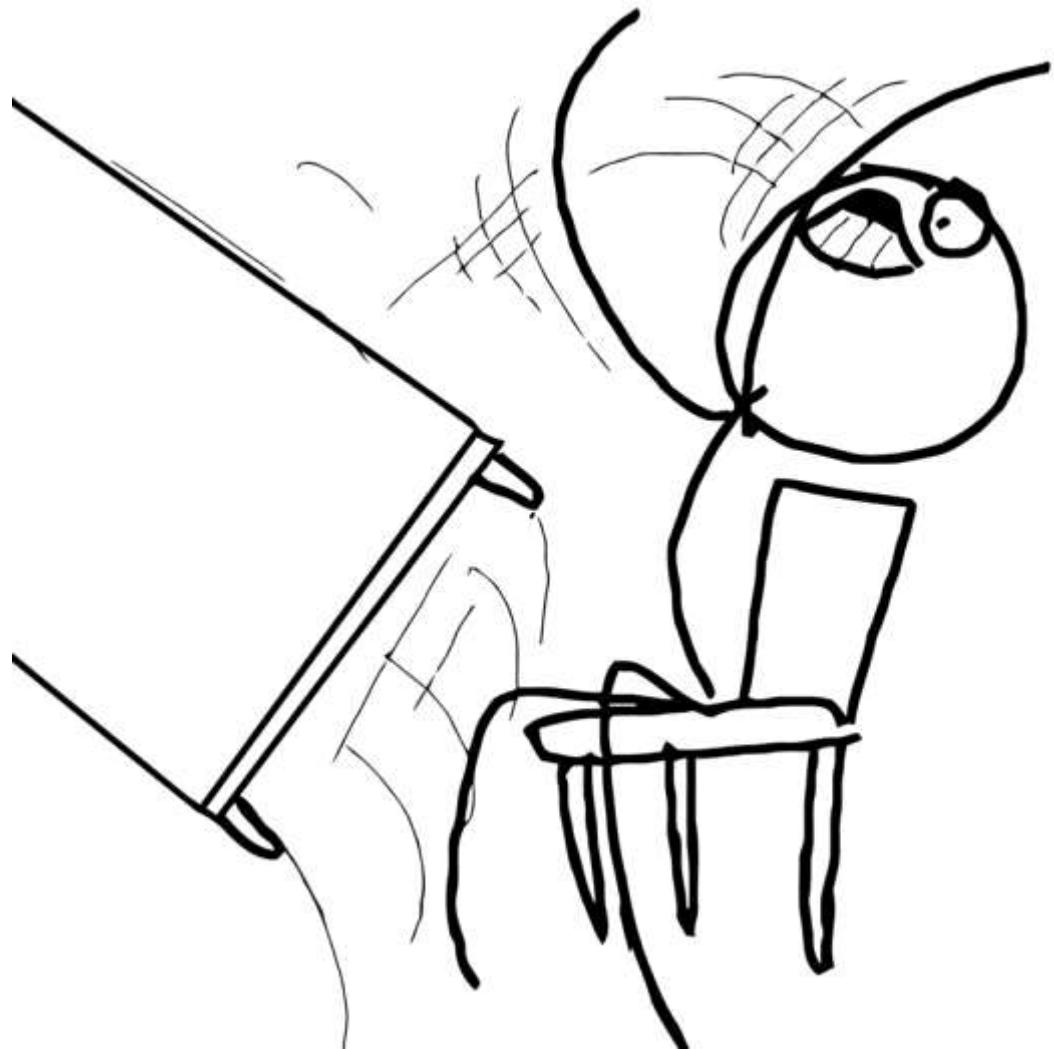
Terraform: release every ~2 weeks

A screenshot of a web browser window. The title bar says "Heartbleed Bug". The address bar shows "heartbleed.com". The main content area has a large title "The Heartbleed Bug". Below it is a detailed description of the bug, followed by another paragraph explaining its impact. To the right of the text is a large red heart outline with red liquid dripping down from the bottom, symbolizing the vulnerability.

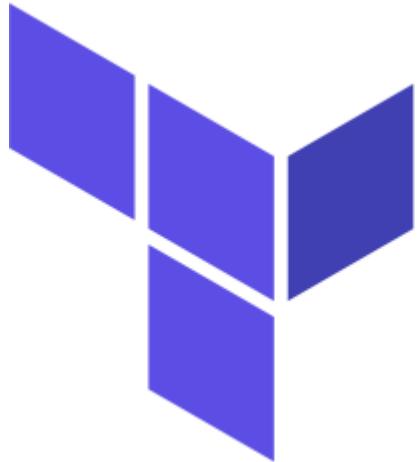
The Heartbleed Bug is a serious vulnerability in the popular OpenSSL cryptographic software library. This weakness allows stealing the information protected, under normal conditions, by the SSL/TLS encryption used to secure the Internet. SSL/TLS provides communication security and privacy over the Internet for applications such as web, email, instant messaging (IM) and some virtual private networks (VPNs).

The Heartbleed bug allows anyone on the Internet to read the memory of the systems protected by the vulnerable versions of the OpenSSL software. This compromises the secret keys used to identify the service providers and to encrypt the traffic, the names and passwords of the users and the actual content. This allows attackers to eavesdrop on communications, steal data directly from the services and users and to impersonate services and users.

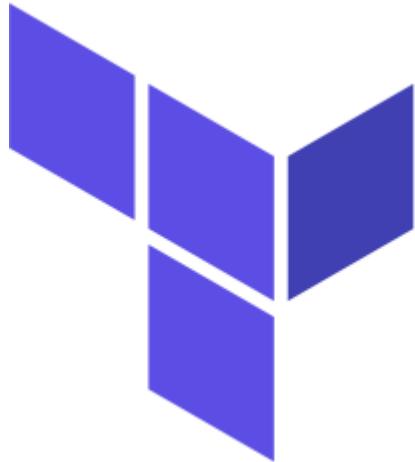
Security vulnerabilities: daily



**There's a better way to deploy
and manage infrastructure:**



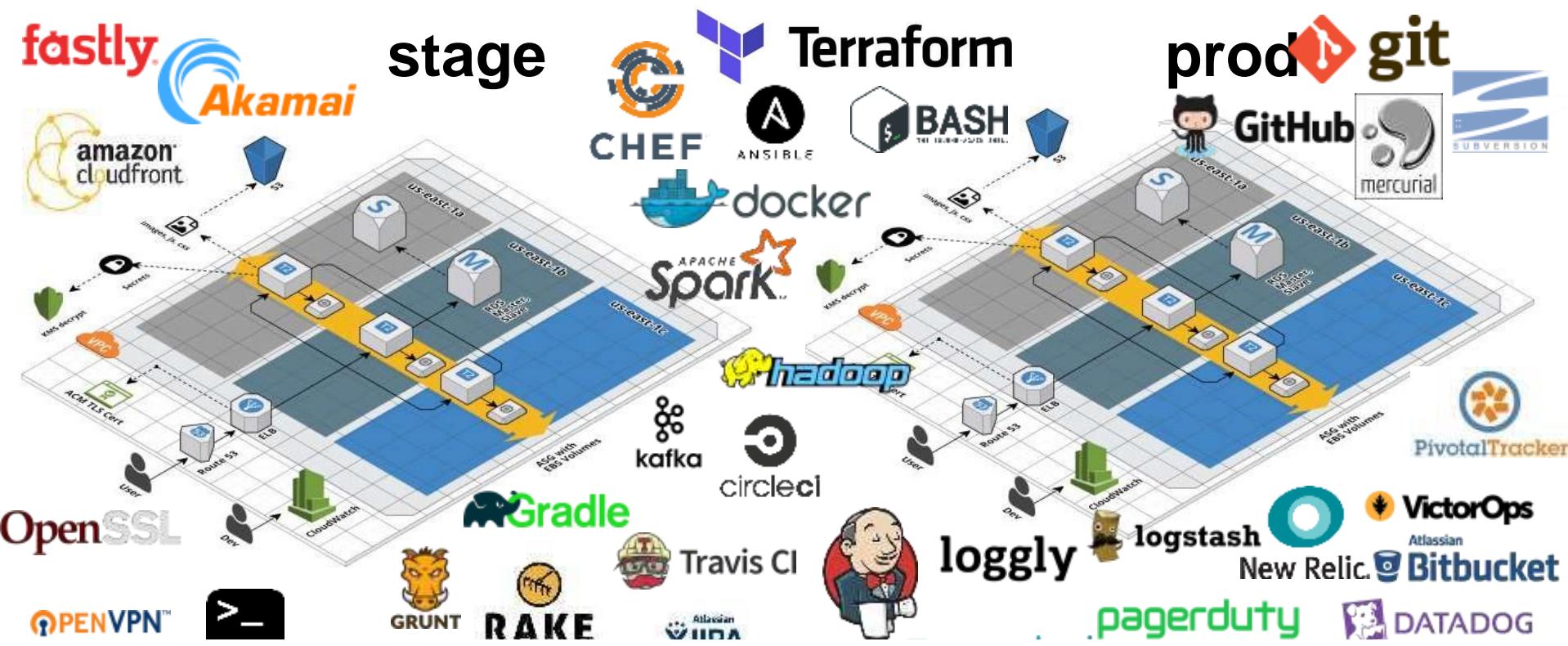
TERRAFORM MODULES



TERRAFORM MODULES

*Reusable, composable, battle-tested
infrastructure code*

I'll show you
How Terraform Modules work?



**And how they will allow you to do all
of this...**

```
> terraform init <..>
```

```
> terraform apply
```

In just a few simple commands

Outline

1. What's a Module
2. How to use a Module
3. How Modules work
4. The future of Modules

Outline

1. What's a Module
2. How to use a Module
3. How Modules work
4. The future of Modules

Terraform Modules



Code reuse

Remote or local source

Terraform evaluation

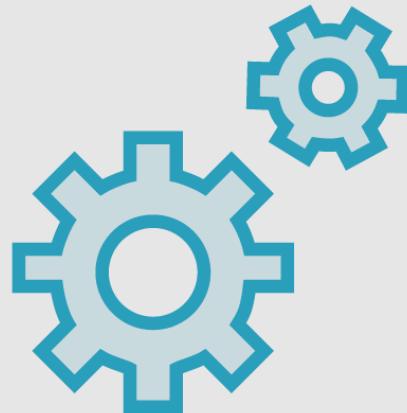
Mini-Terraform configuration

Multiple instances (no count)

Module Components



Variables



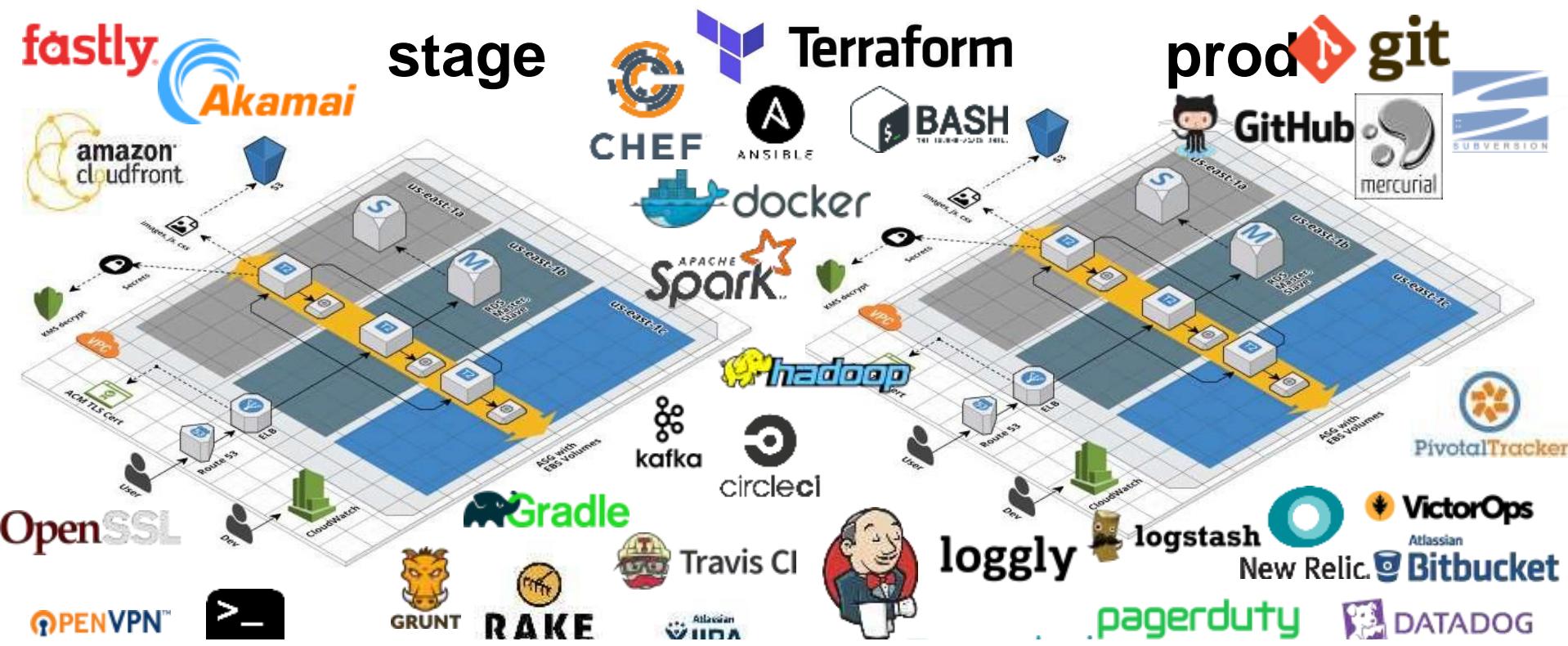
Resources



Outputs



**Platform as a Service (PaaS): e.g.,
Heroku, Docker Cloud, Engine Yard**



But that requires dealing with this...



Terraform

Terraform is a tool for defining and managing infrastructure as code

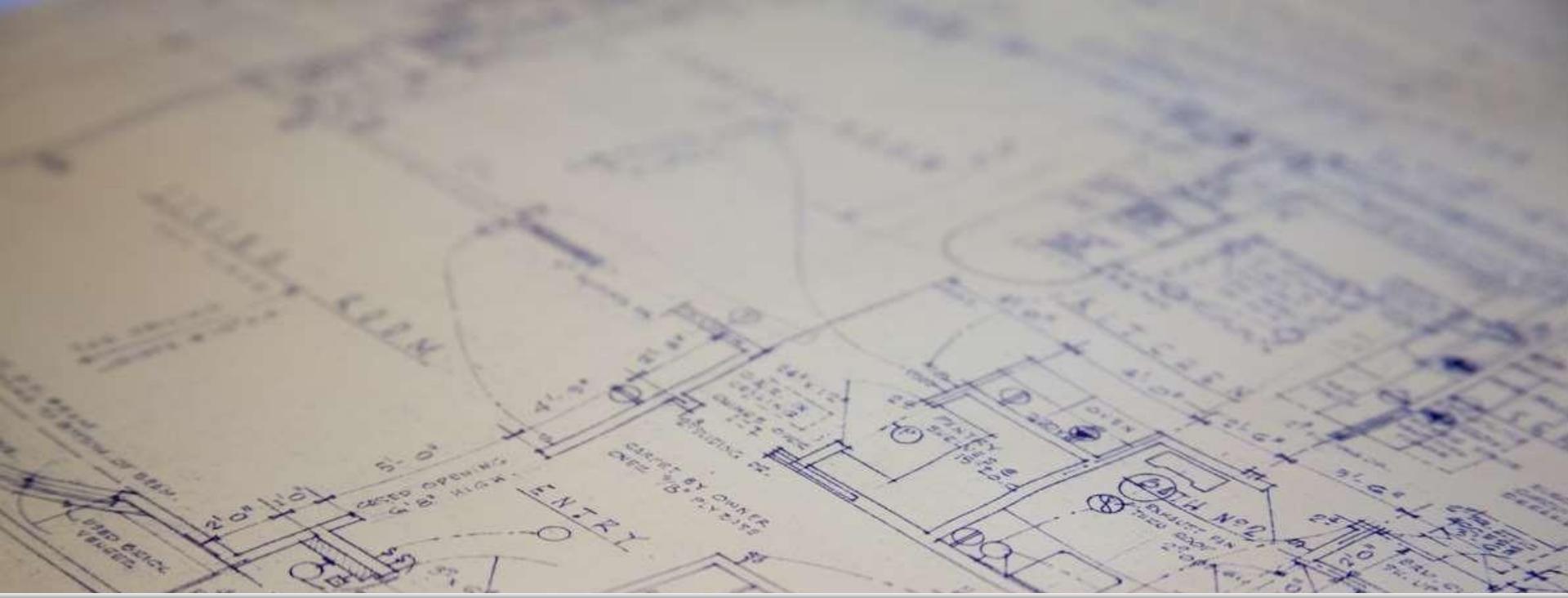
```
provider "aws" {  
    region = "us-east-1"  
}  
  
resource "aws_instance" "example" {  
    ami          = "ami-408c7f28"  
    instance_type = "t2.micro"  
}
```

Example: Terraform code to deploy a server in AWS

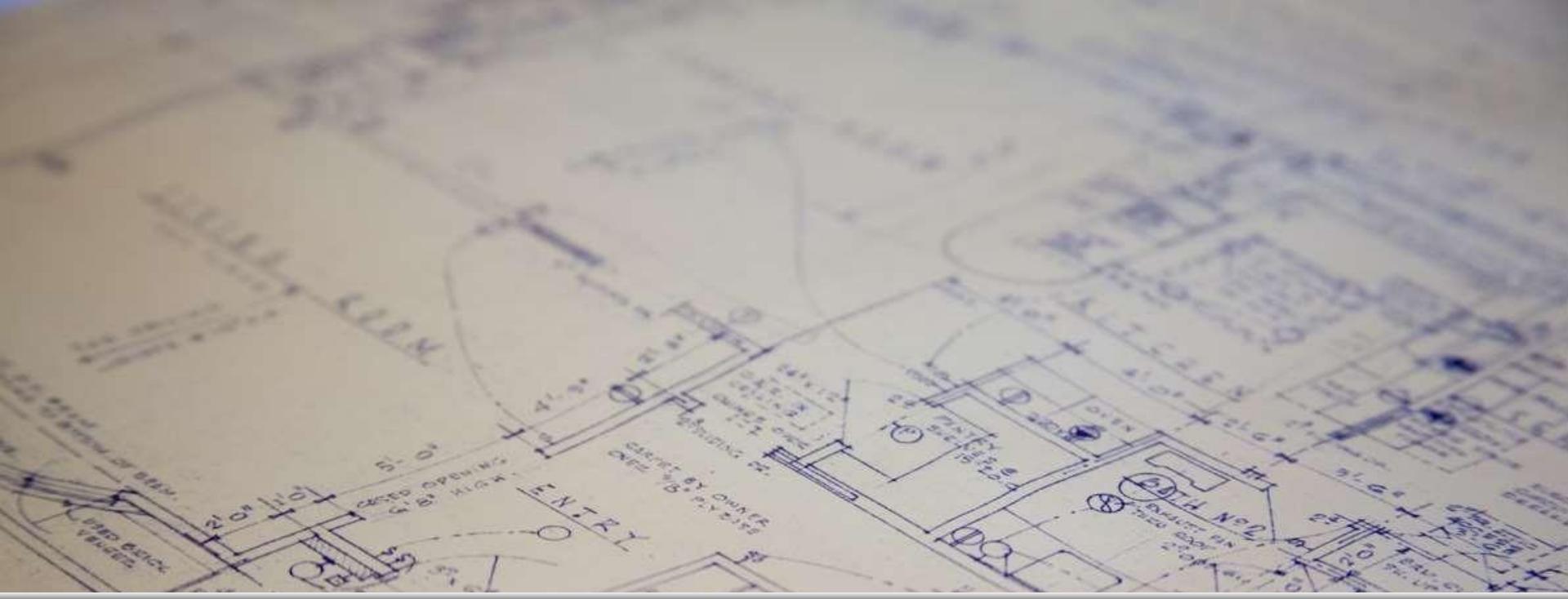
```
> terraform apply
aws_instance.example: Creating...
  ami:          ""  => "ami-408c7f28"
  instance_type: ""  => "t2.micro"
  key_name:      ""  => "<computed>"
  private_ip:    ""  => "<computed>"
  public_ip:     ""  => "<computed>"
aws_instance.example: Creation complete
```

Apply complete! Resources: 1 added, 0 changed, 0 destroyed.

**Run `terraform apply` to deploy
the server**



Terraform supports modules



They are like reusable **blueprints**
for your infrastructure

```
resource "aws_autoscaling_group" "example" {  
    name      = "${var.name}-service"  
    min_size = "${var.num_instances}"  
    max_size = "${var.num_instances}"  
}  
  
resource "aws_launch_configuration" "example" {  
    image_id      = "${var.image_id}"  
    instance_type = "${var.instance_type}"  
    root_block_device {
```

**Example: create a module to
deploy a microservice**

```
module "service_foo" {  
    source      = "/modules/microservice"  
    image_id    = "ami-123asd1"  
    num_instances = 3  
}
```

**Now you can use the module to
deploy one microservice**

```
module "service_foo" {  
    source      = "/modules/microservice"  
    image_id    = "ami-123asd1"  
    num_instances = 3  
}  
module "service_bar" {  
    source      = "/modules/microservice"  
    image_id    = "ami-f2bb05ln"  
    num_instances = 6  
}
```

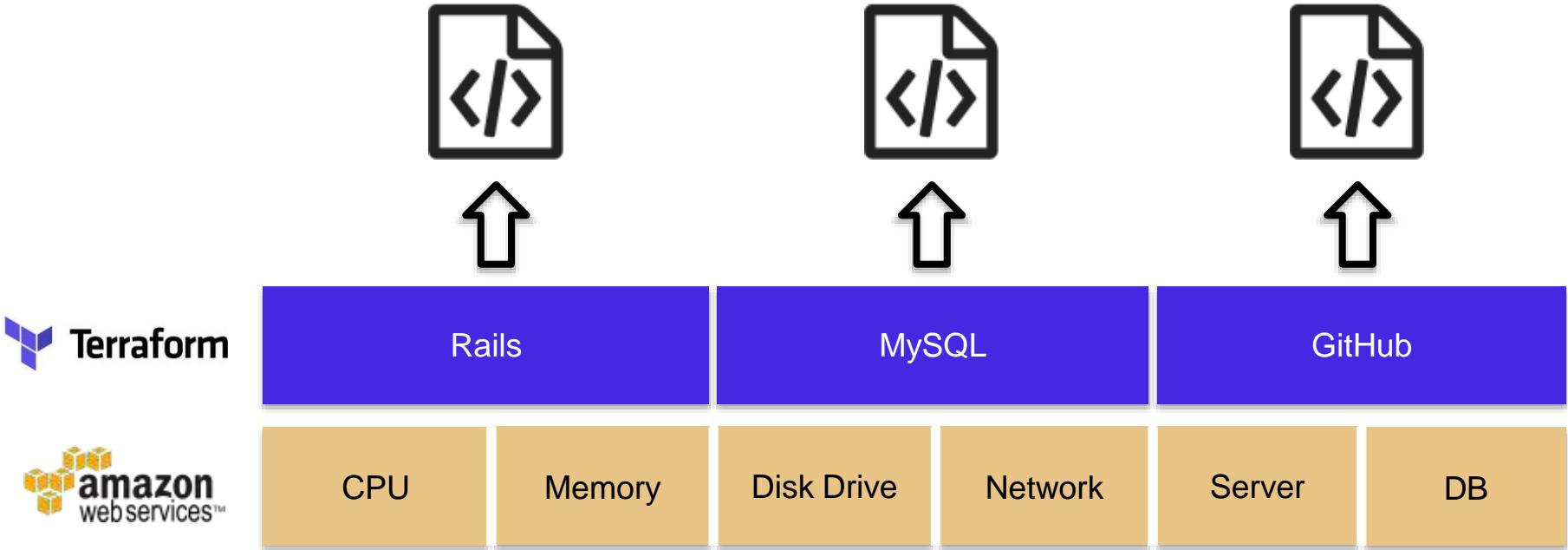
Or multiple microservices



Modules allow you to use your favorite IaaS provider...

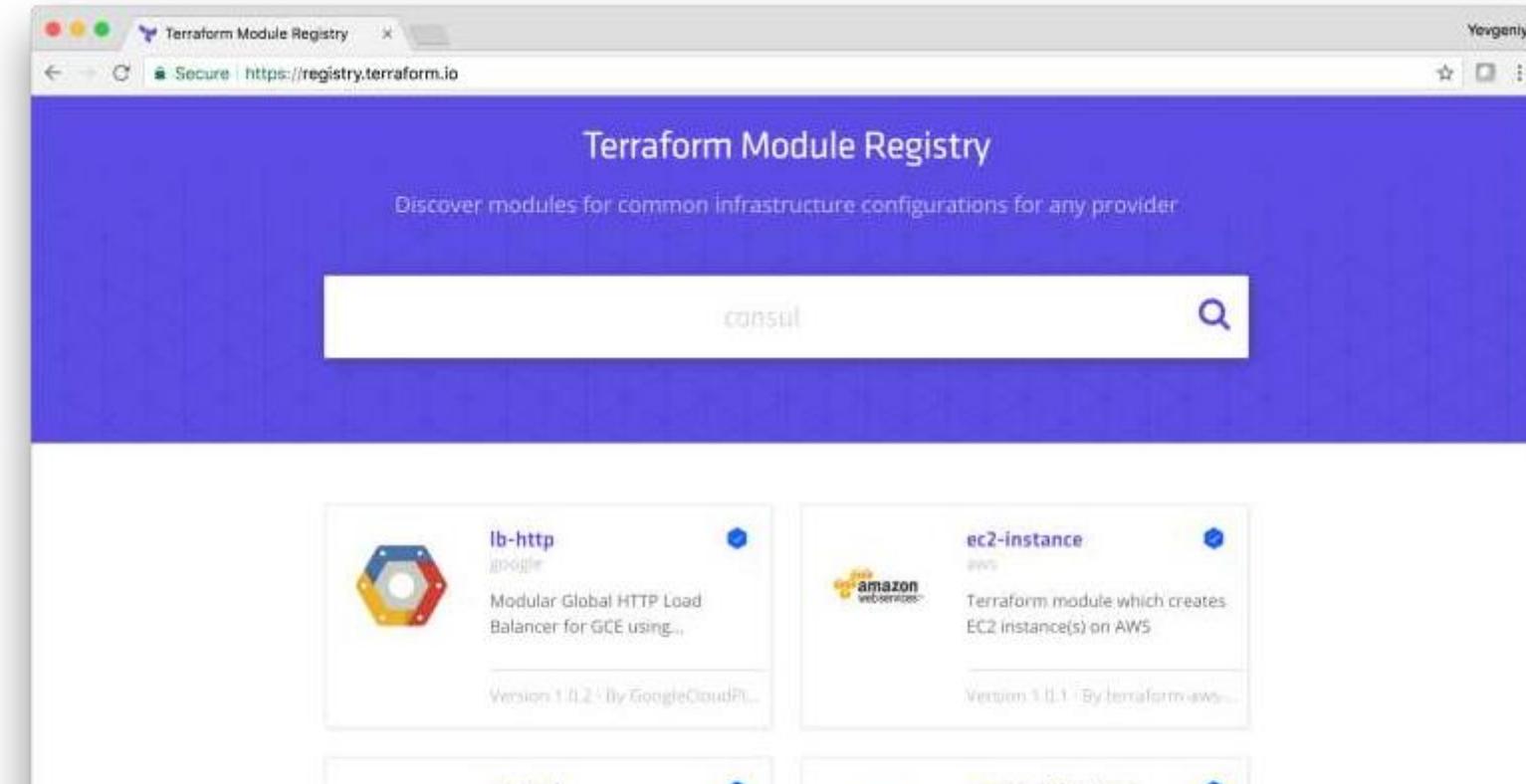


**With easy-to-use, high-level
abstractions, like a PaaS**

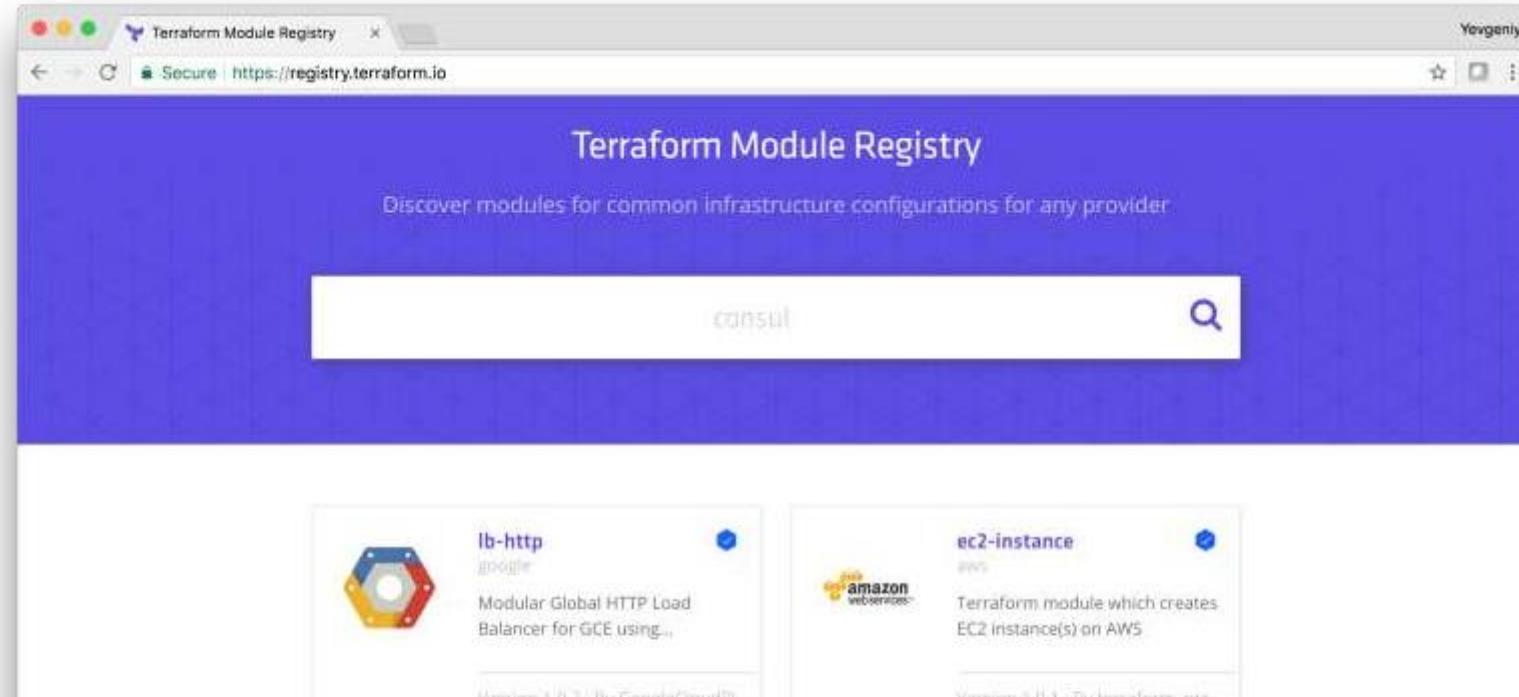


But since you have all the code, you still have full control!

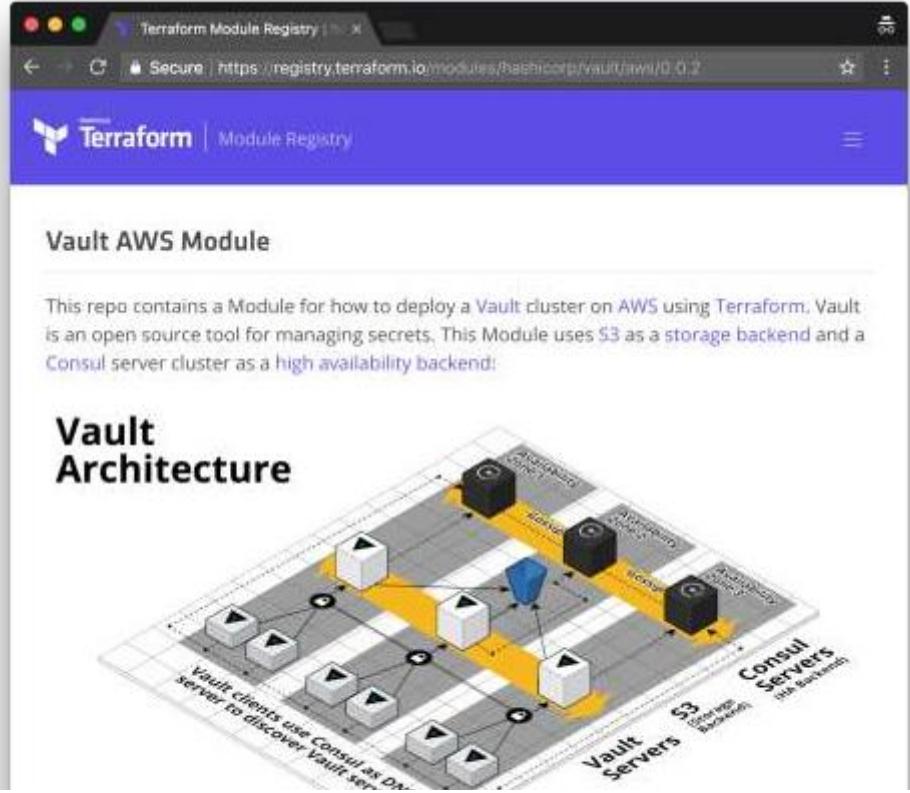
**Best of all: code can be shared
and re-used!**



The Terraform Module Registry



A collection of reusable, verified, supported Modules



Example: Vault Module for AWS

Terraform Module Registry | ×

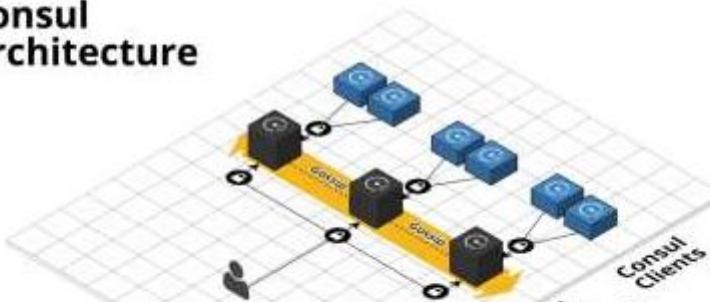
Secure | https://registry.terraform.io/modules/hasticorp/consul/azurerm/0.0.3

 Terraform | Module Registry

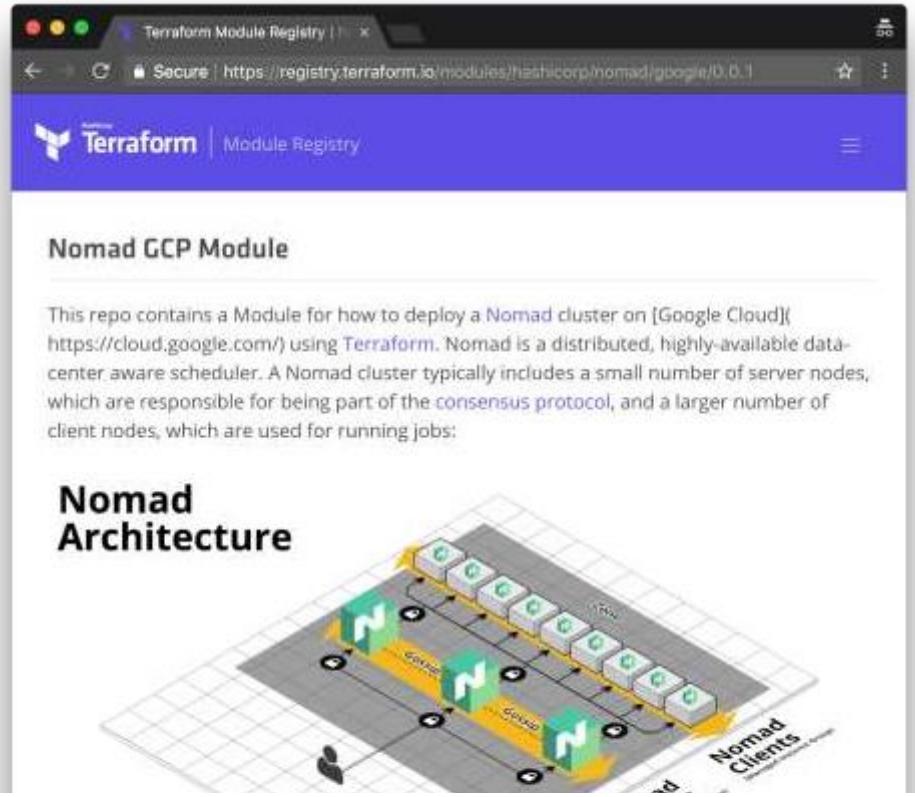
Consul Azure Module

This repo contains a Module for deploying a [Consul](#) cluster on [Azure](#) using [Terraform](#). Consul is a distributed, highly-available tool that you can use for service discovery and key/value storage. A Consul cluster typically includes a small number of server nodes, which are responsible for being part of the [consensus quorum](#), and a larger number of client nodes, which you typically run alongside your apps:

Consul Architecture



Example: Consul for Azure



Example: Nomad for GCP

Outline

1. What's a Module
2. How to use a Module
3. How Modules work
4. The future of Modules



HashiCorp
Vault

A Tool for Managing Secrets

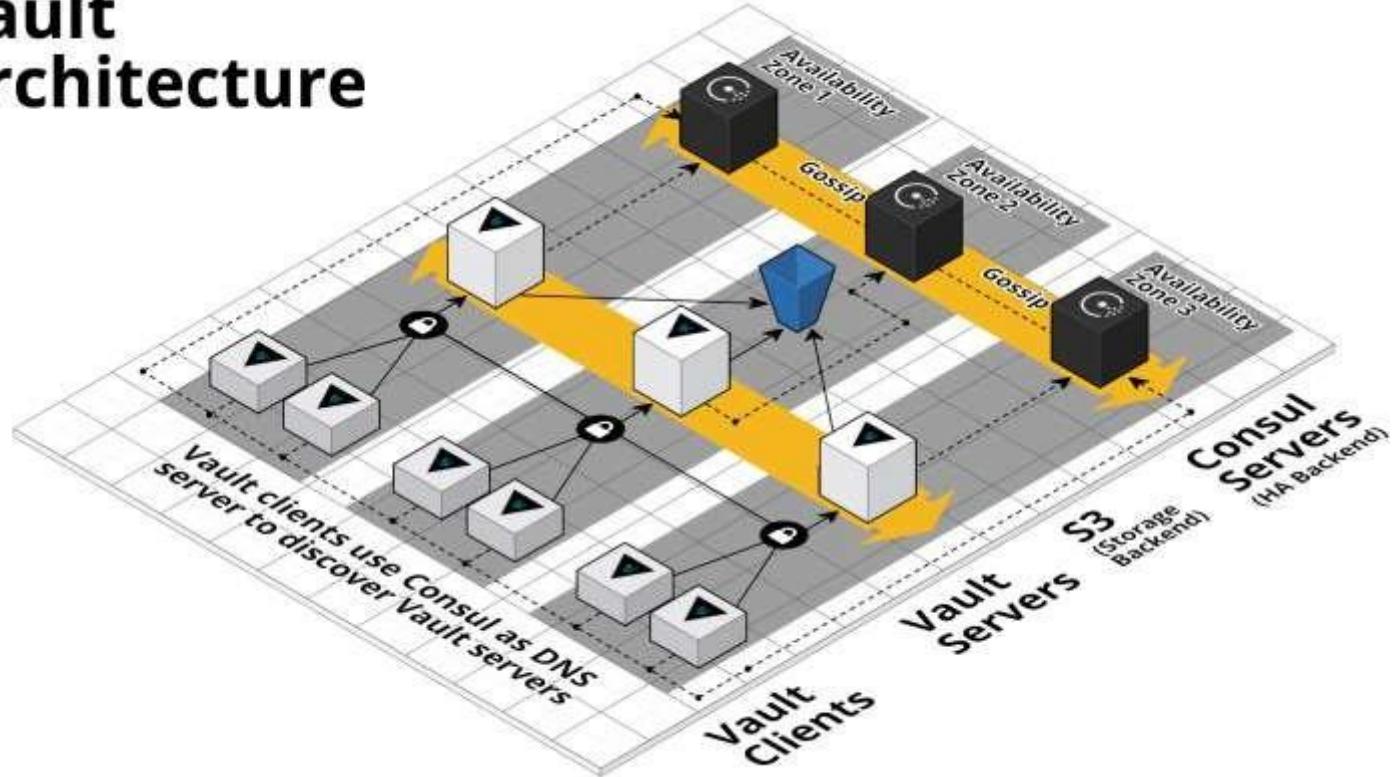
Imagine you wanted to deploy Vault

The old way:

1. Open up the Vault docs
2. Deploy a few servers
3. Install Vault
4. Install supervisord
5. Configure mlock
6. Generate self-signed TLS cert
7. Create Vault config file
8. Create an S3 bucket as storage backend
9. Figure out IAM policies for the S3 bucket
10. Tinker with security group rules
11. Figure out IP addresses to bind to and advertise
12. Fight with Vault for hours because it won't accept your TLS cert
13. Regenerate cert with RSA encryption
14. Update OS certificate store to accept self-signed certs

The new way:

Vault Architecture



And now you have this deployed

As simple as a PaaS!

```
> tree
```

```
.
├── README.md
├── main.tf
├── outputs.tf
├── packer
└── user-data
    └── variables.tf
```

**But you also have all the code.
Feel free to edit it!**

```
module "vault_cluster" {
    source      = "hashicorp/vault/aws"
    cluster_name = "example-vault-cluster"
    cluster_size = 3
    vpc_id      = "${data.aws_vpc.default.id}"
    subnet_ids   = "${data.aws_subnets.default.ids}"
}
module "consul_cluster" {
    source      = "hashicorp/consul/aws"
    cluster_name = "example-consul-cluster"
```

Exam ple: modify main.tf

```
> terraform apply
```

Run **apply** when you're done!

Outline

1. What's a Module
2. How to use a Module
3. How Modules work
4. The future of Modules

```
def add(x, y):  
    return x + y
```

Most programming languages
support functions

```
def add(x, y):  
    return x + y
```

The function has a **name**

```
def add(x, y):  
    return x + y
```

It can take in **inputs**

```
def add(x, y):  
    return x + y
```

And it can return **outputs**

```
def add(x, y):  
    return x + y
```

```
add(3, 5)  
add(10, 35)  
add(-45, 6)
```

Key idea: code reuse

```
def add(x, y):  
    return x + y  
  
assert add(3, 5) == 8  
assert add(10, 35) == 45  
assert add(-45, 6) == -39
```

Key idea: testing

```
def add( x, y ):  
    return x + y
```

```
def sub( x, y ):  
    return x - y
```

```
sub(add( 5, 3 ), add( 4, 7 ))
```

Key idea: composition

**Modules are Terraform's
equivalent of functions**

A simple module:

```
> tree mini mal- module
```

```
.
├── main.tf
├── outputs.tf
└── variables.tf
└── README.md
```

It's just Terraform code in a folder!

```
variable "name" {
    description = "The name of the EC2 instance"
}

variable "image_id" {
    description = "The ID of the AMI to run"
}

variable "port" {
    description = "The port to listen on for HTTP requests"
```

The **inputs** are in **variables.tf**

```
output "url" {  
    value = "http://${aws_instance.example.ip}:${var.port}"  
}
```

The **outputs** are in **outputs.tf**

```
resource "aws_autoscaling_group" "example" {  
    name      = "${var.name}-service"  
    min_size = "${var.num_instances}"  
    max_size = "${var.num_instances}"  
}
```

```
resource "aws_launch_configuration" "example" {  
    image_id      = "${var.image_id}"  
    instance_type = "${var.instance_type}"  
    root_block_device {  
        volume_type = "gp2"  
        volume_size = 200
```

The **resources** are in **main.tf**

Foo Module for AWS

This is a Terraform Module to deploy
[Foo](<http://www.example.com>) on AWS, including:

- * foo
- * bar
- * baz

Documentation is in README.md

A more complicated module:

```
> tree complete-module
```

```
.-  
|   main.tf  
|   outputs.tf  
|   variables.tf  
|   README.MD  
|  
+-- modules  
+-- examples  
+-- test
```

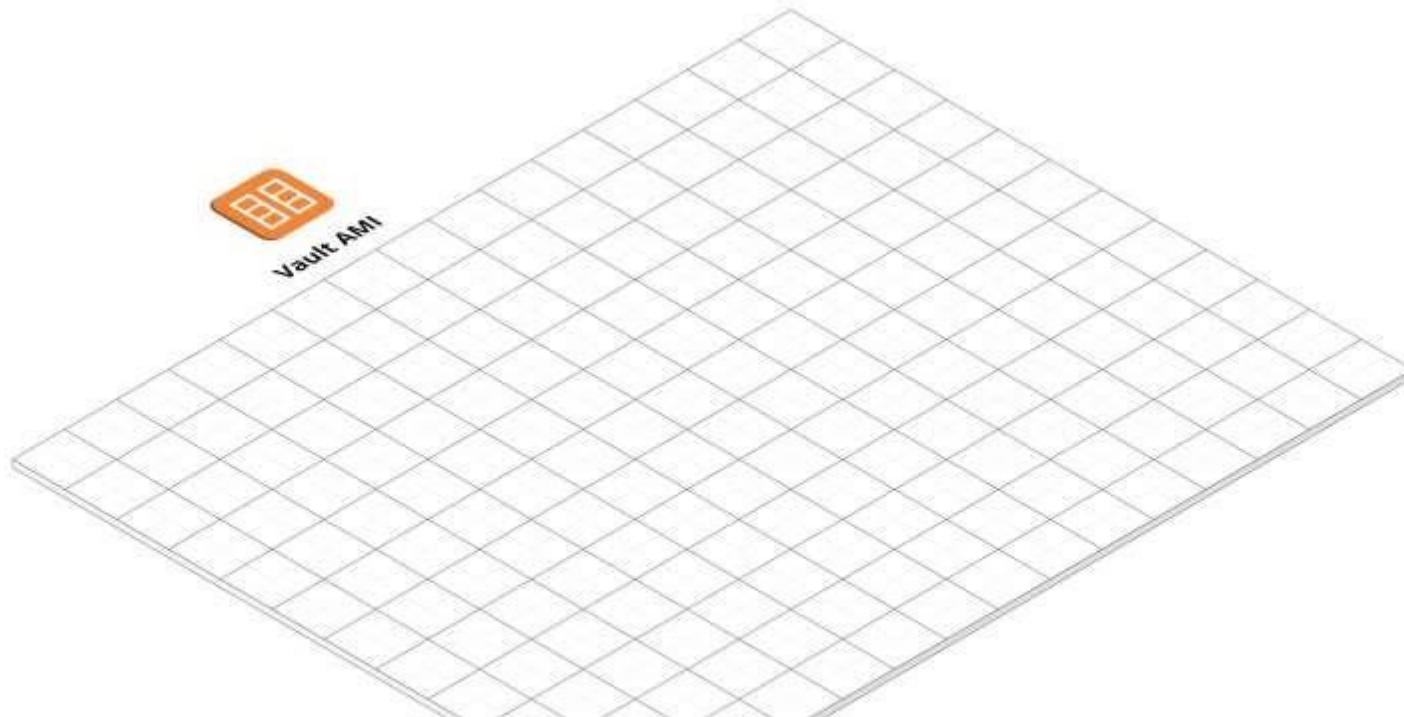
**We add three new folders:
modules, examples, test**

```
>tree complete-module/modules
modules/
└── submodule-bar
    ├── main.tf
    ├── outputs.tf
    └── variables.tf
└── submodule-foo
    ├── main.tf
    ├── outputs.tf
    └── variables.tf
```

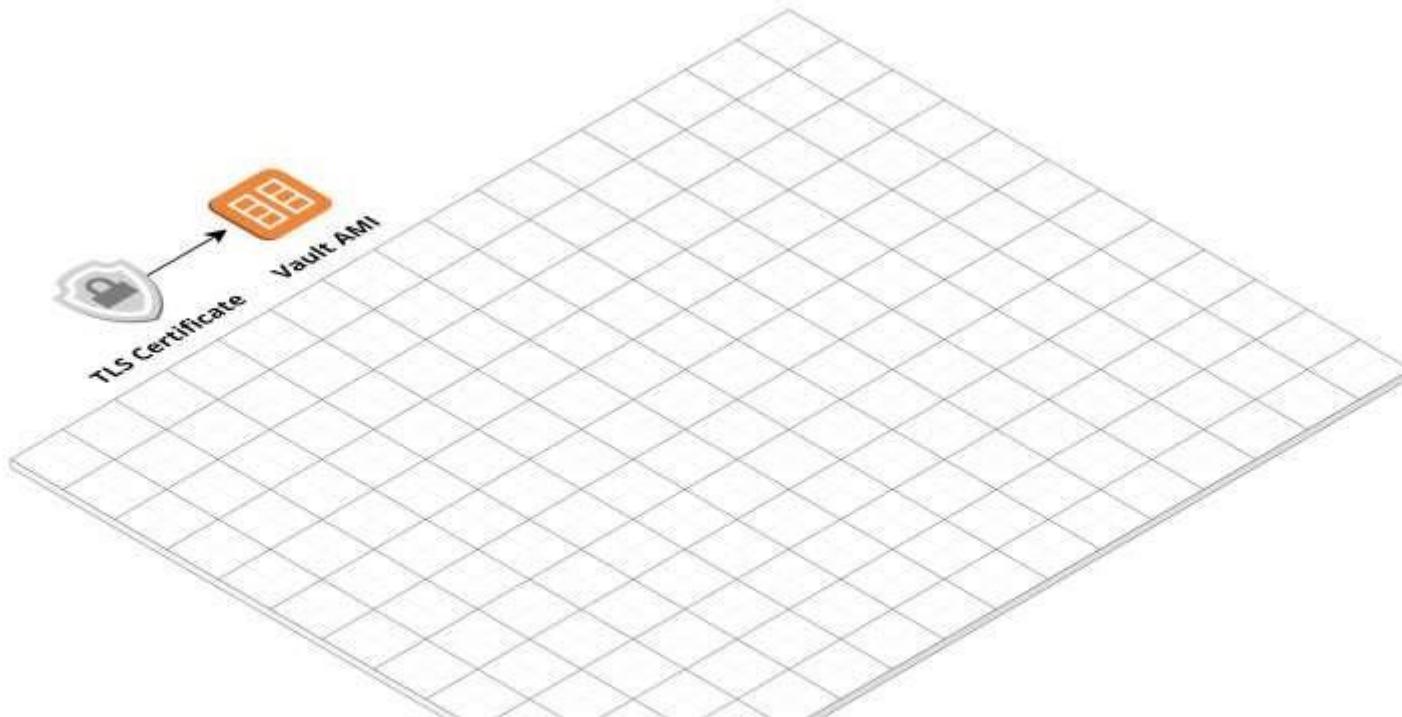
The modules folder contains
standalone “submodules”

```
>tree  complete-module/modules  
modules/  
└── submodule-bar  
    ├── install-vault.sh  
    └── run-vault.sh  
└── submodule-foo  
    └── main.go
```

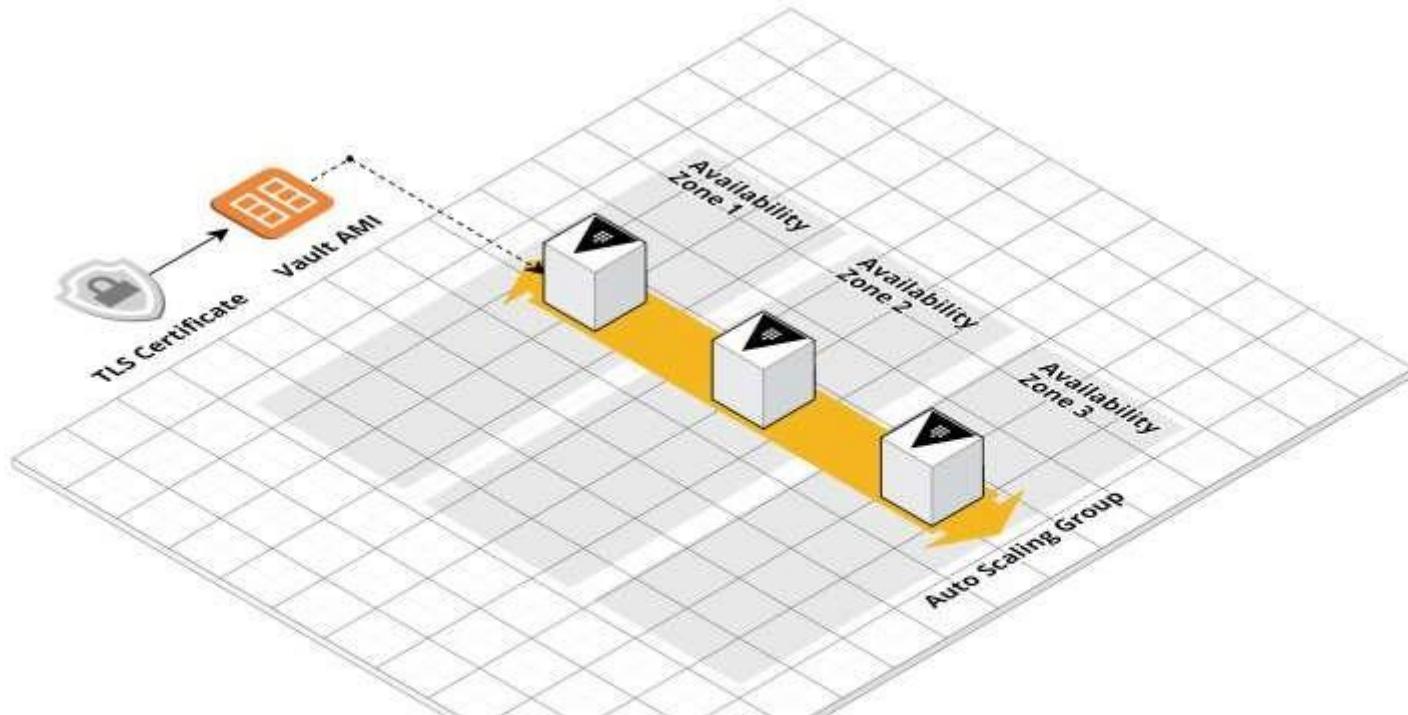
Some of the submodules may not even be Terraform code



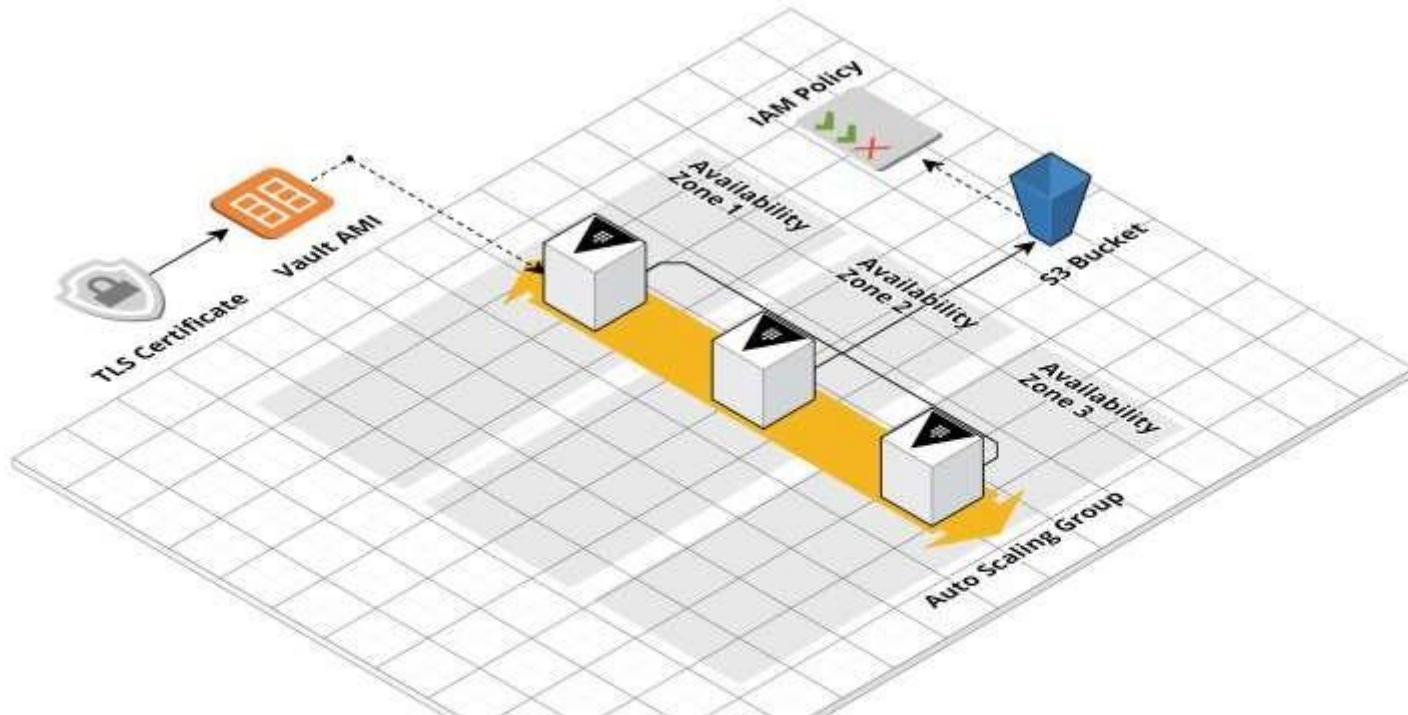
For example, one submodule can be used to install Vault in an AMI



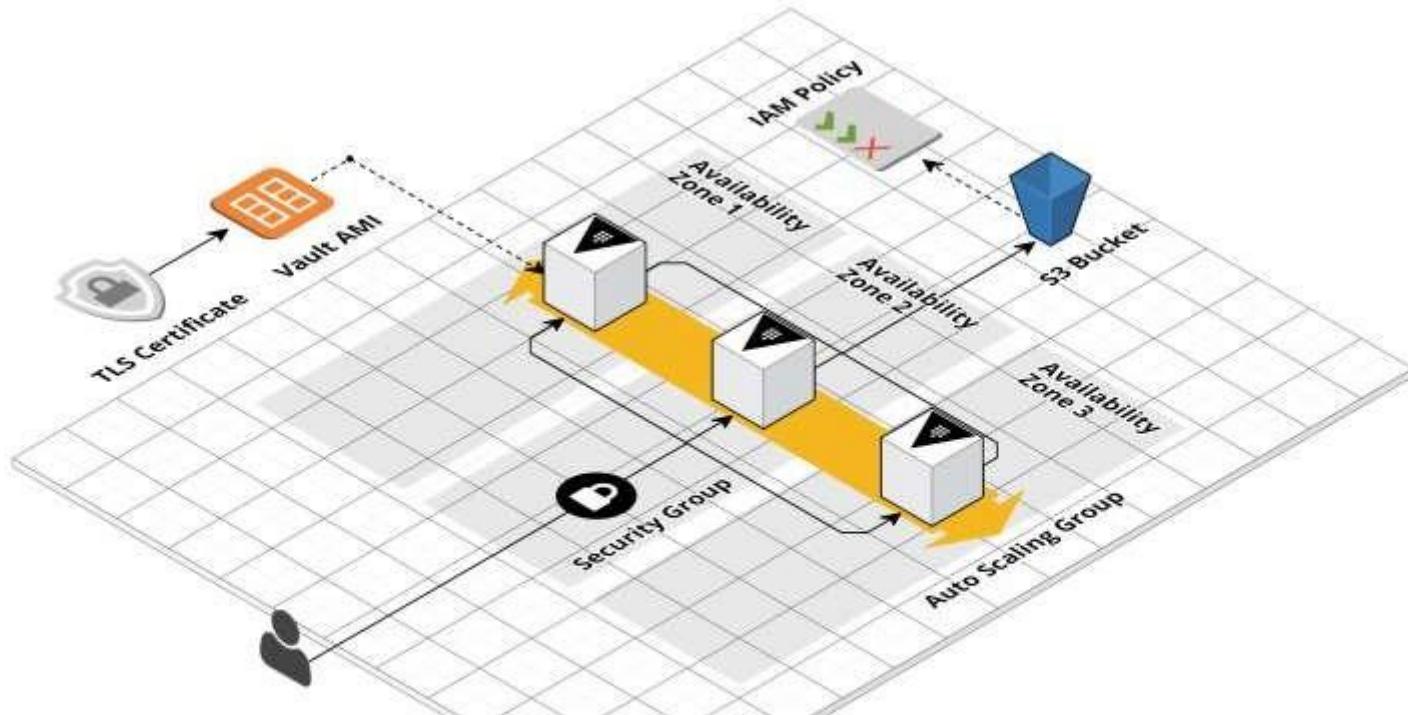
Another to create self-signed TLS certificates



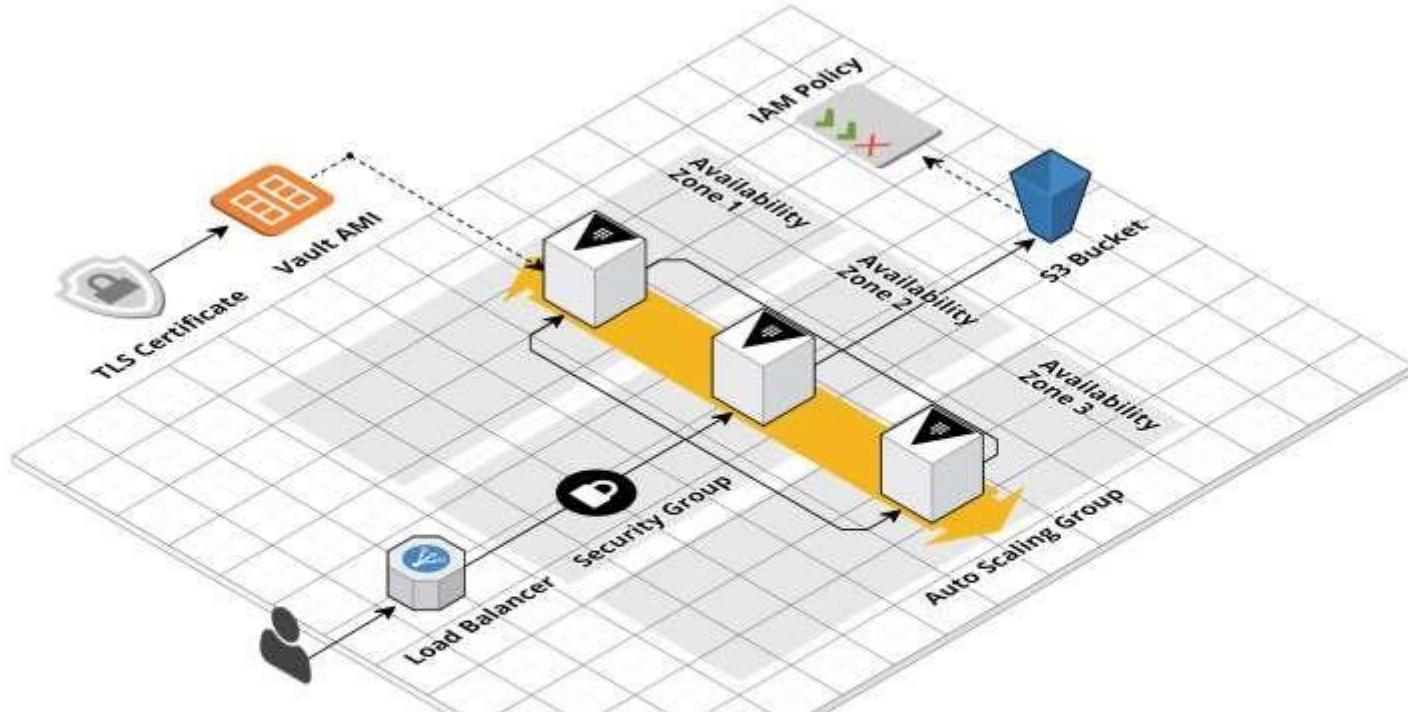
Another to deploy the AMI across an Auto Scaling Group (ASG)



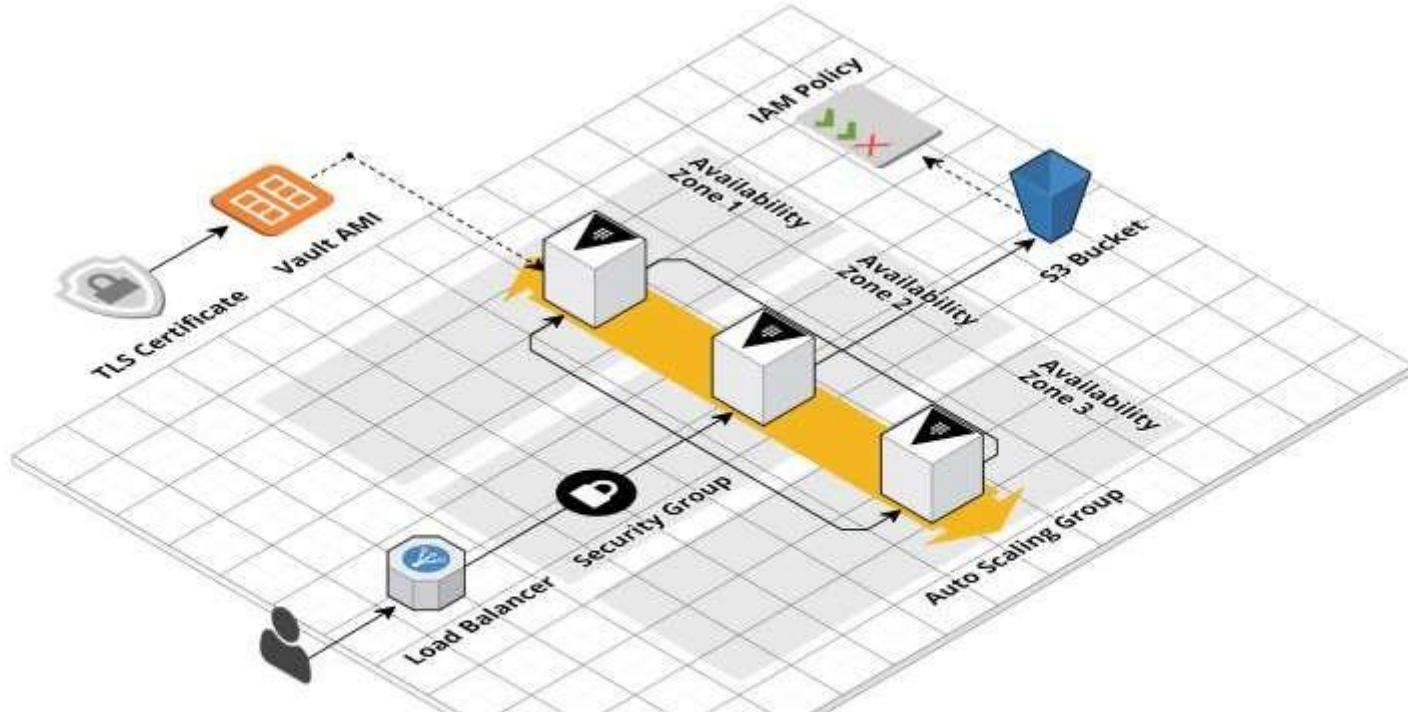
Another to create an S3 bucket and IAM policies as a storage backend



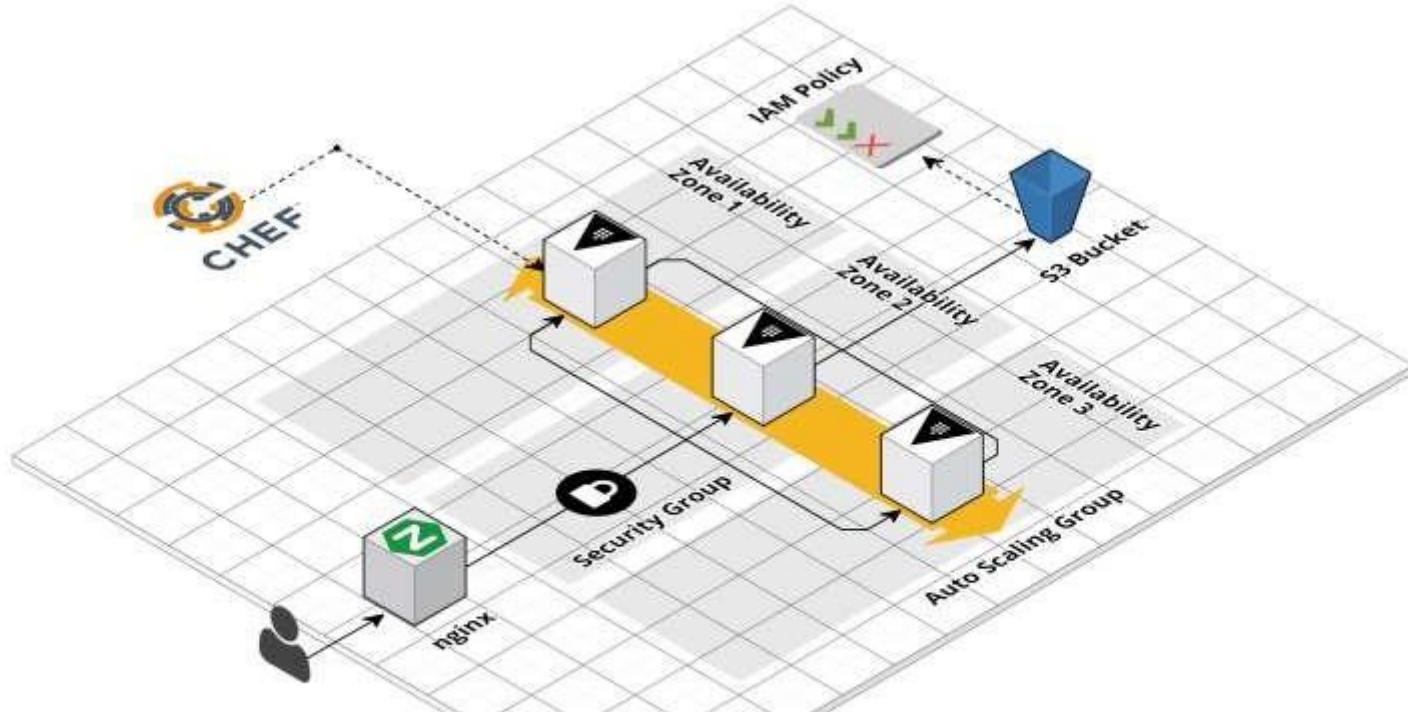
Another to configure the Security Group settings



And one more to deploy a load balancer (ELB)



You can use all the submodules



**Or pick the ones you want and swap
in your own for the rest**

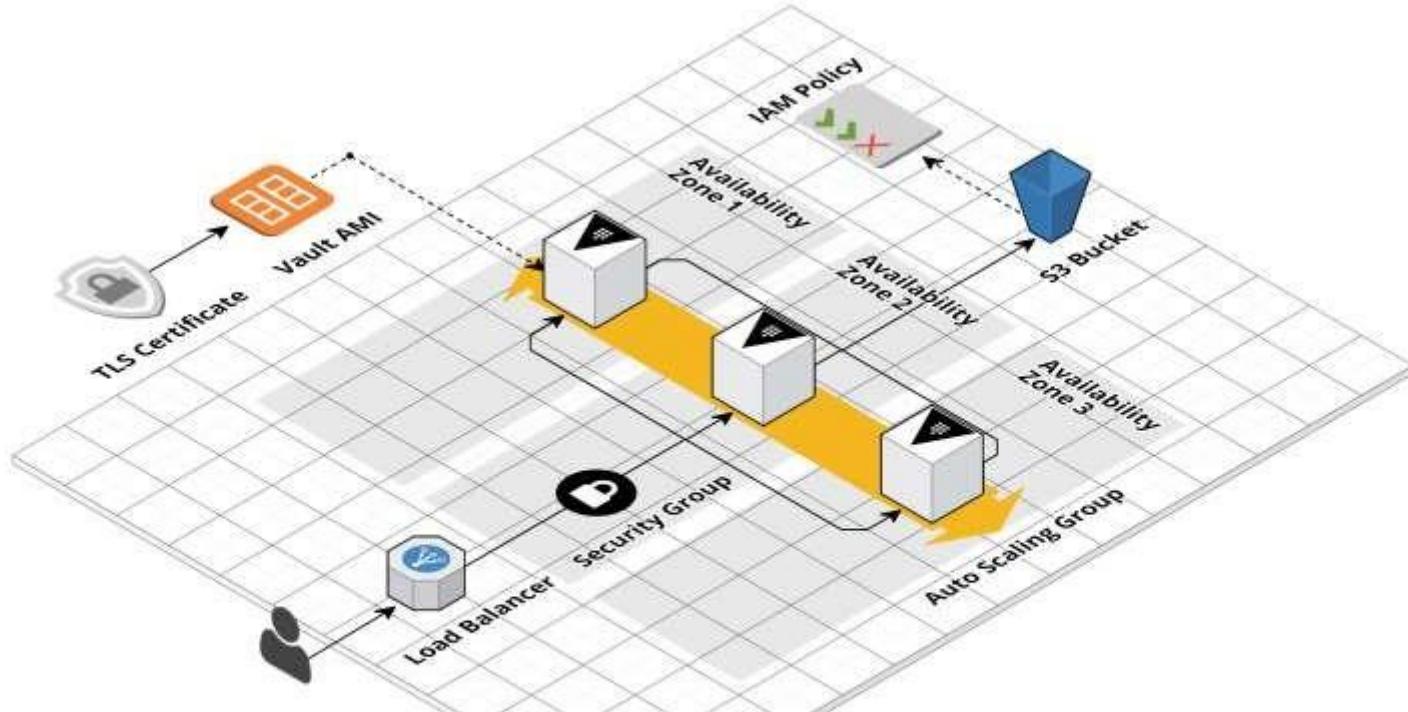
```
>tree complete-module/examples  
examples/  
└── example-foo  
    ├── main.tf  
    ├── outputs.tf  
    └── variables.tf  
└── example-bar  
    ├── main.tf  
    ├── outputs.tf  
    └── variables.tf
```

The examples folder shows how to use the submodules

```
> tree complete-module
```

```
.-  
|   main.tf  
|   outputs.tf  
|   variables.tf  
|   README.MD  
|  
+-- modules  
+-- examples  
+-- test
```

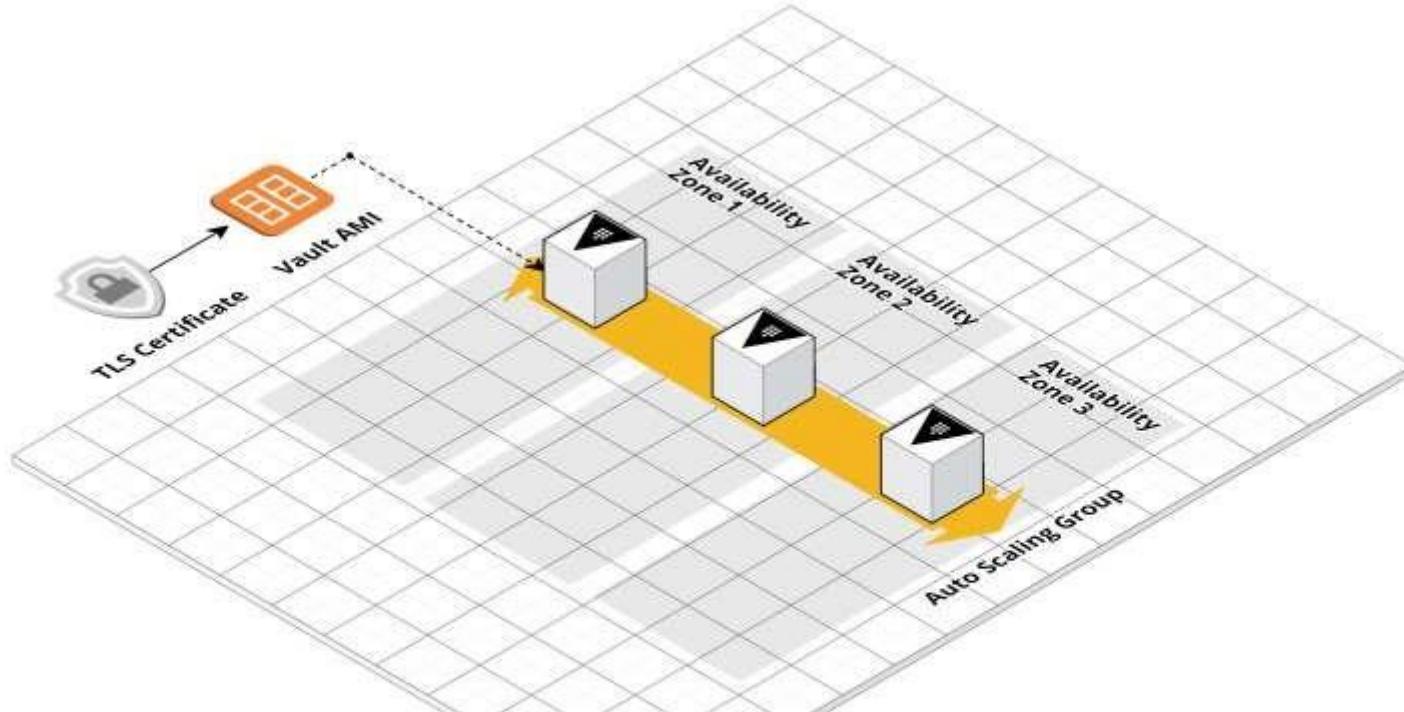
**Note: the code in the root is
usually a “canonical” example**



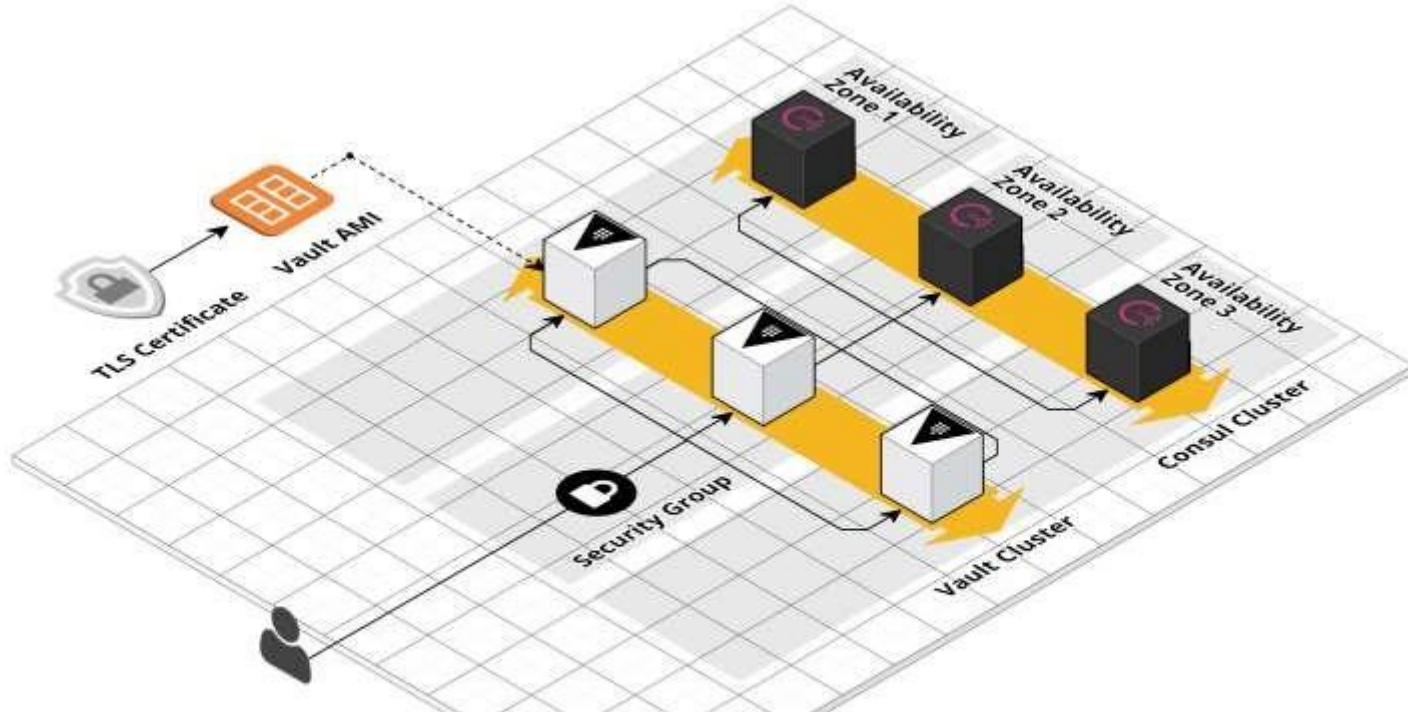
It's typically an opinionated way to use all the submodules together

```
>tree complete-module/examples  
examples/  
└── example-foo  
    ├── main.tf  
    ├── outputs.tf  
    └── variables.tf  
└── example-bar  
    ├── main.tf  
    ├── outputs.tf  
    └── variables.tf
```

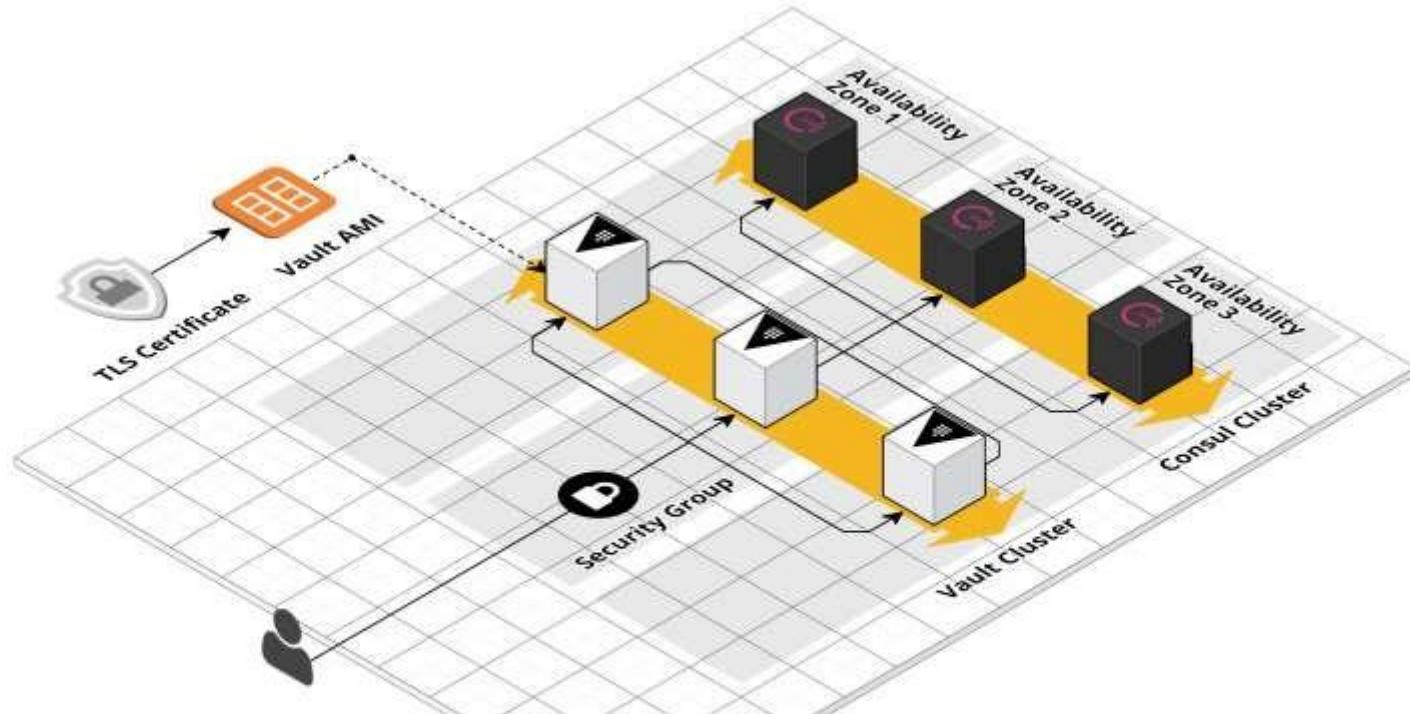
The code in examples shows other possible permutations



E.g., How to use just one or two of the submodules together



Or how to combine with other
modules (e.g., Vault + Consul)



This is like function composition!

```
>tree complete-module/test  
test/  
└── example_foo_test.go  
└── example_bar_test.go
```

The test folder contains automated tests

```
>tree complete-module/test  
test/  
└── example_foo_test.go  
└── example_bar_test.go
```

The tests are typically “integration tests”

```
func vaultTest(t *testing.T, options *terratest.Options) {
    tIsCert := generateSelfSignedTlsCert(t)
    defer cleanupSelfSignedTlsCert(t, tIsCert)

    amild := buildVaultAmi(t)
    defer cleanupAmi(t, amild)

    terratest.Apply(options)
    defer terratest.Destroy(options)

    assertCanInitializeAndUnsealVault(t, options)
}
```

Example test case for Vault

```
func vaultTest(t *testing.T, options *terratest.Options) {
    tIsCert := generateSelfSignedTlsCert(t)
    defer cleanupSelfSignedTlsCert(t, tIsCert)

    amild := buildVaultAmi(t)
    defer cleanupAmi(t, amild)

    terratest.Apply(options)
    defer terratest.Destroy(options)

    assertCanInitializeAndUnsealVault(t, options)
}
```

Create test-time resources

```
func vaultTest(t *testing.T, options *terratest.Options) {
    tIsCert := generateSelfSignedTlsCert(t)
    defer cleanupSelfSignedTlsCert(t, tIsCert)

    amild := buildVaultAmi(t)
    defer cleanupAmi(t, amild)

    terratest.Apply(options)
    defer terratest.Destroy(options)

    assertCanInitializeAndUnsealVault(t, options)
}
```

Run terraform apply

```
func vaultTest(t *testing.T, options *terratest.Options) {
    tIsCert := generateSelfSignedTlsCert(t)
    defer cleanupSelfSignedTlsCert(t, tIsCert)

    amild := buildVaultAmi(t)
    defer cleanupAmi(t, amild)

    terratest.Apply(options)
    defer terratest.Destroy(options)

    assertCanInitializeAndUnsealVault(t, options)
}
```

Run terraform destroy at the end

```
func vaultTest(t *testing.T, options *terratest.Options) {
    tIsCert := generateSelfSignedTlsCert(t)
    defer cleanupSelfSignedTlsCert(t, tIsCert)

    amild := buildVaultAmi(t)
    defer cleanupAmi(t, amild)

    terratest.Apply(options)
    defer terratest.Destroy(options)

    assertCanInitializeAndUnsealVault(t, options)
}
```

Check the Vault cluster works!

Using a module:

```
module "service_foo" {  
    source    = "./minimal-module"  
  
    name      = "Foo"  
    image_id  = "ami-123asd1"  
    port      = 8080  
}
```

**For simple Modules and learning,
deploy the root**

```
module "submodule_foo" {  
    source      = "./complete-module/modules/submodule-foo"  
    param_foo  = "foo"  
    param_bar  = 8080  
}  
module "submodule_bar" {  
    source      = "./complete-module/modules/submodule-bar"  
    param_foo  = "abcdef"  
    param_bar  = 9091  
}
```

**For more complicated use-cases,
use the **submodules****

```
module "service_foo" {  
    source    = "./minimal-module"  
    name      = "Foo"  
    image_id  = "ami-123asd1"  
    port      = 8080  
}
```

**Abstraction: simple Module API
for complicated infrastructure**

```
module "service_foo" {  
    source    = "./minimal-module"  
    name      = "Foo"  
    image_id  = "ami-123asd1"  
    port      = 8080  
}  
  
module "service_bar" {  
    source    = "./minimal-module"  
    name      = "Bar"  
    image_id  = "ami-abcd1234"
```

} **Re-use: create a Module once,
deploy it many times**

Versioning:

```
module "service_foo" {  
    source    = "./foo"  
  
    name      = "Foo"  
    image_id  = "ami-123asd1"  
    port      = 8080  
}
```

You can set **source** to point to
modules at local file paths

```
module "service_foo" {  
    source    = "hashicorp/vault/aws"  
  
    name      = "Foo"  
    image_id  = "ami-123asd1"  
    port      = 8080  
}
```

**Alternatively, you can use
Terraform registry URLs**

```
module "service_foo" {  
    source    = "git::git@github.com:foo/bar.git"  
  
    name      = "Foo"  
    image_id = "ami-123asd1"  
    port      = 8080  
}
```

Or arbitrary Git URLs

```
module "service_foo" {  
    source    = "git::git@github.com:foo/bar.git?ref=v1.0.0"  
  
    name      = "Foo"  
    image_id = "ami-123asd1"  
    port      = 8080  
}
```

You can even link to a specific Git tag (recommended!)

```
module "service_foo" {  
    source    = "git::git@github.com:foo/bar.git?ref=v1.0.0"  
  
    name      = "Foo"  
    image_id = "ami-123asd1"  
    port      = 8080  
}
```

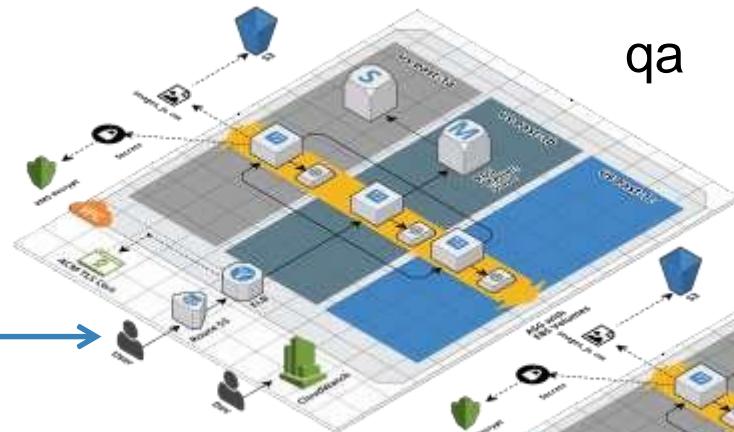
Modules use semantic versioning

```
module "service_foo" {  
    source    = "git::git@github.com:foo/bar.git?ref=v2.0.0"  
  
    name      = "Foo"  
    image_id = "ami-123asd1"  
    port      = 8080  
}
```

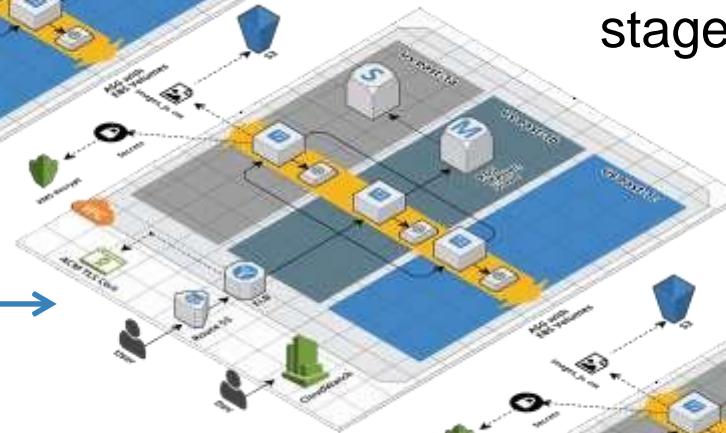
**So upgrading infrastructure is just
a version number bump**



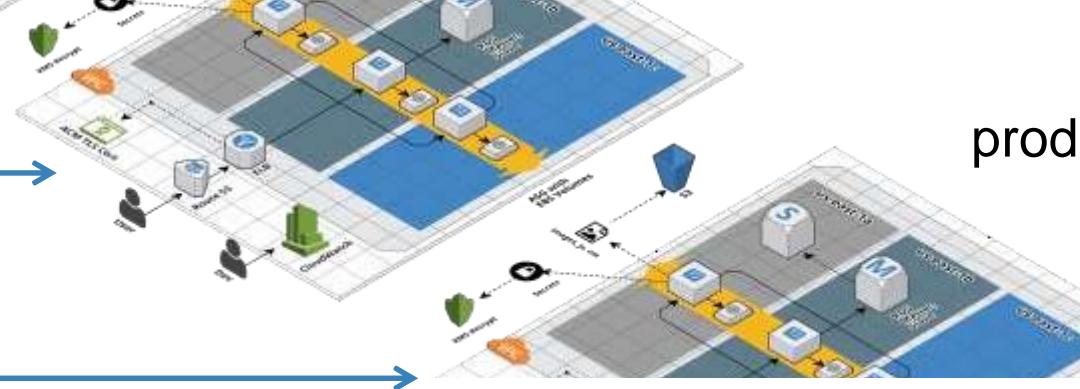
v0.4.0



qa



stage



prod

**Promote immutable, versioned
infrastructure across environments**

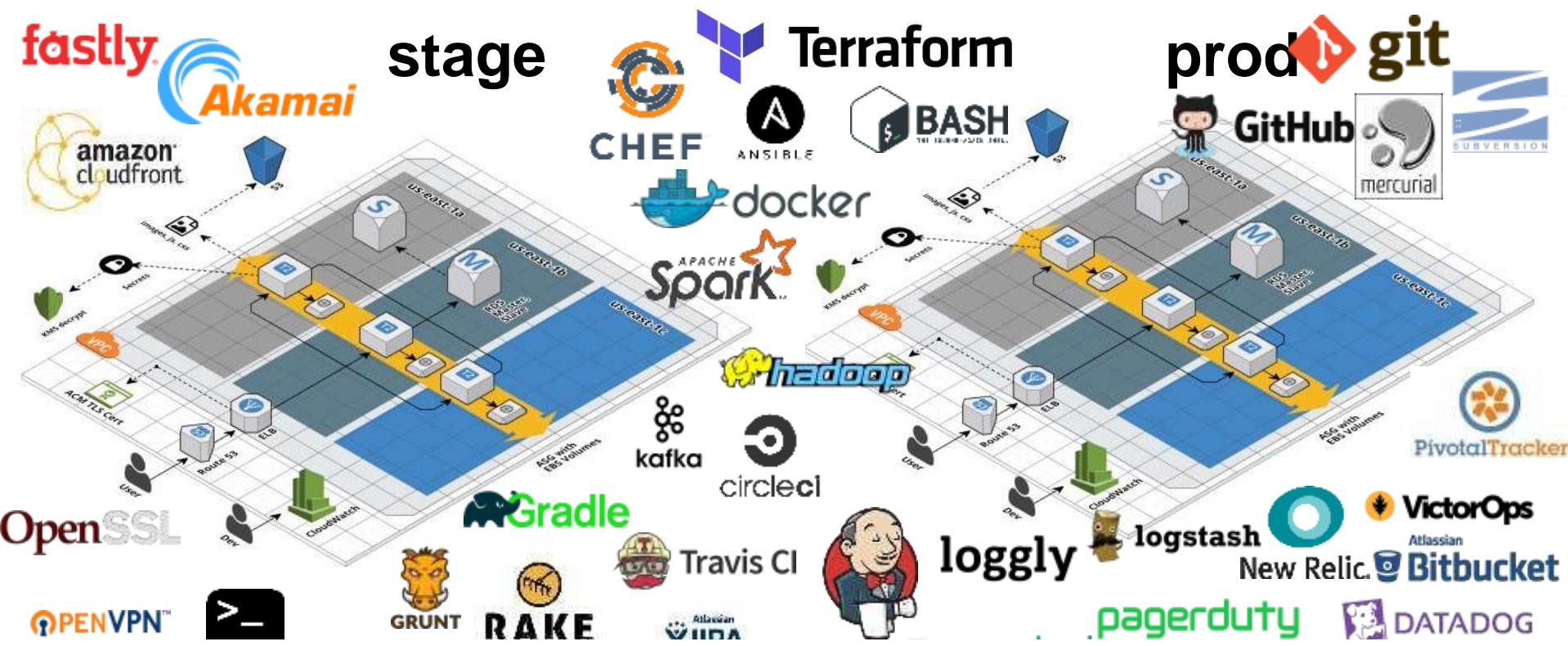
Outline

1. What's a Module
2. How to use a Module
3. How Modules work
4. The future of Modules

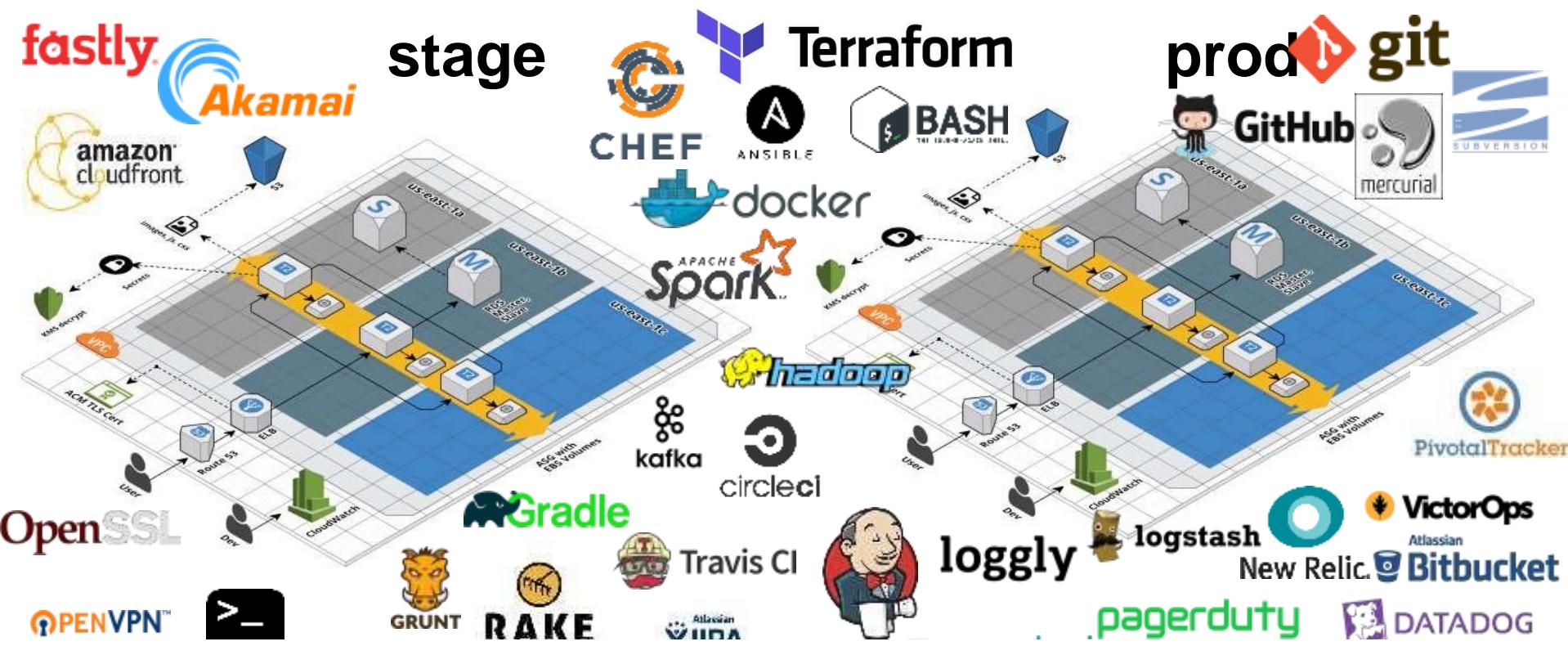


*You are not special. Your
architecture is not a beautiful
and unique snowflake. You
have the same tech debt as
everyone else.”*

'our sysadmin, probably



You need this



And so does everyone else



Stop reinventing the wheel

Start building on top of **battle-tested** code

Start building on top of **commercially-supported** code

Start building on top of code

Advantages of code

1. Reuse
2. Compose
3. Configure
4. Customize
5. Debug
6. Test
7. Version
8. Document



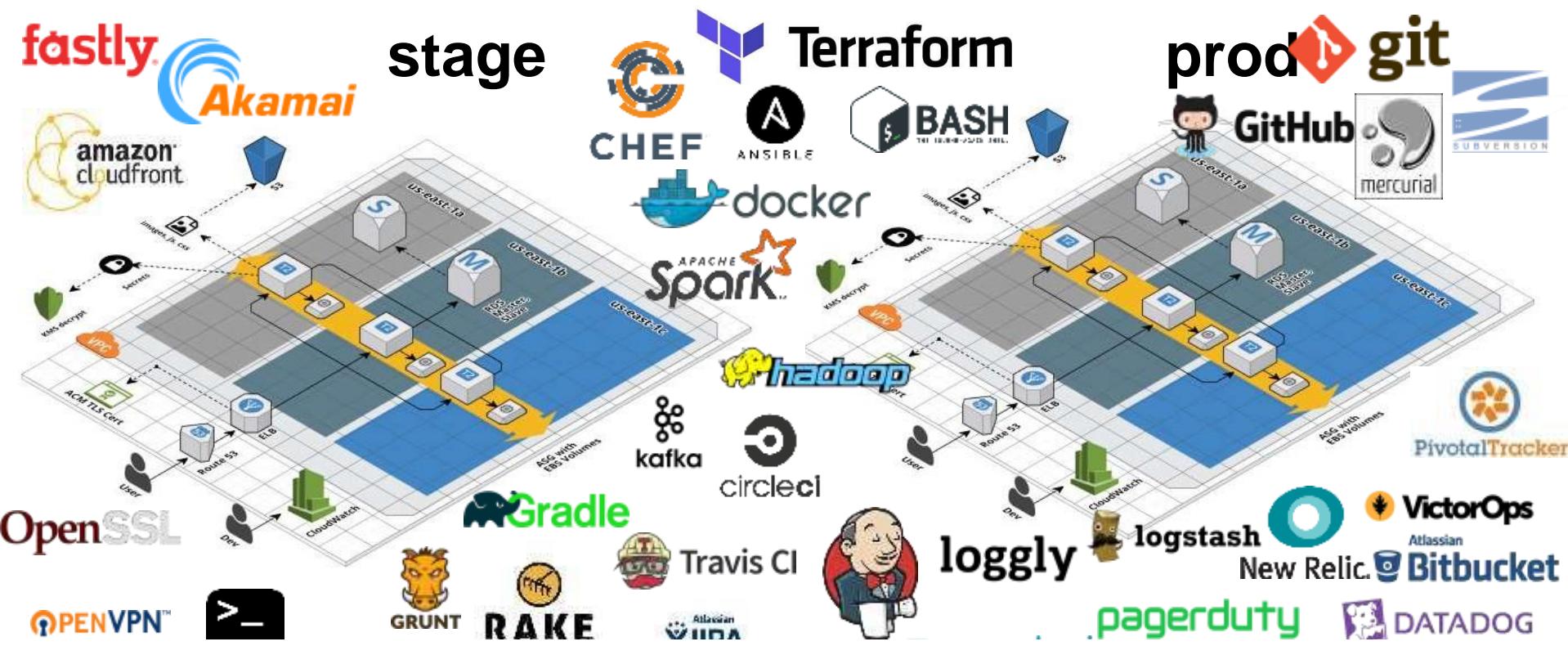
gruntwork.io

**At Gruntwork, we've
been building
Modules for years**



gruntwork.io

**Many companies, all
running on the same
infrastructure code**



Modules allow us to turn this...

```
> terraform init <..>
```

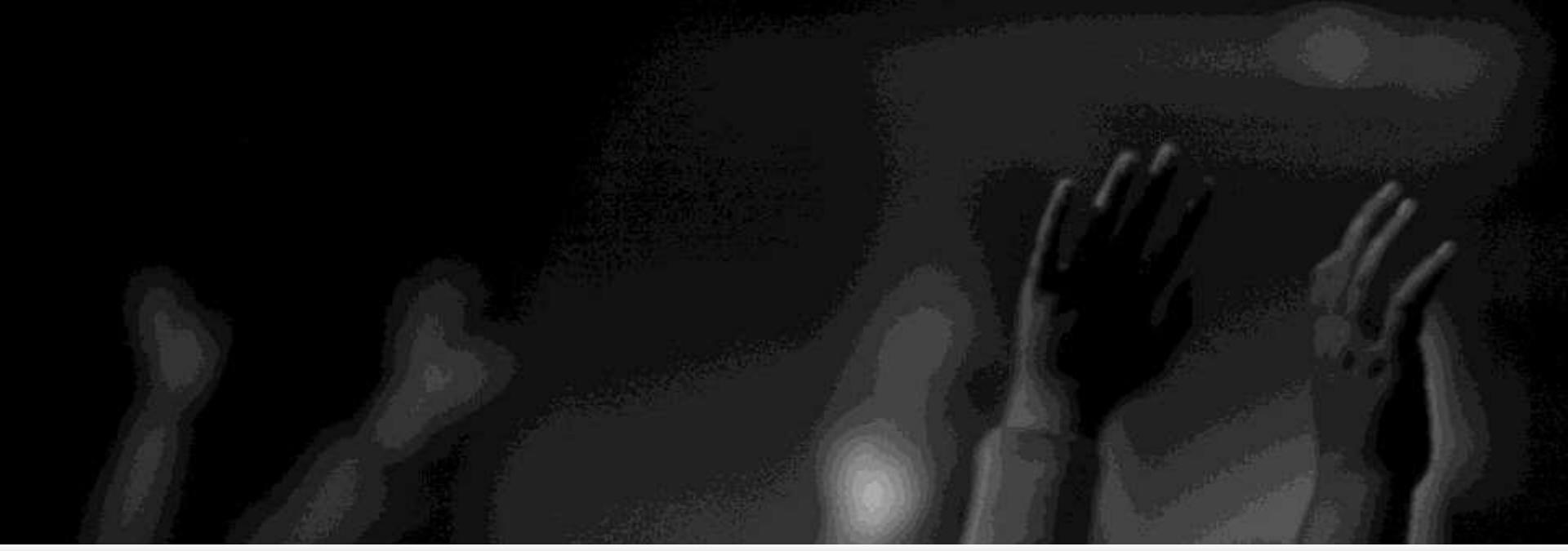
```
> terraform apply
```

... into this

A screenshot of a web browser window displaying the Terraform Module Registry at <https://registry.terraform.io>. The page has a blue header with the title "Terraform Module Registry" and a subtitle "Discover modules for common infrastructure configurations for any provider". A search bar contains the word "consul". Below the search bar, two module cards are visible: "lb-http" by Google and "ec2-instance" by AWS.

Module Name	Provider	Description
lb-http	Google	Modular Global HTTP Load Balancer for GCE using...
ec2-instance	AWS	Terraform module which creates EC2 instance(s) on AWS

With some help from this



Questions?



HashiCorp
Terraform

- init
- plan
- apply

Child Module

- main.tf
- outputs.tf
- variables.tf

Parent Module

- main.tf
- outputs.tf
- variables.tf

Child Module

- main.tf
- outputs.tf
- variables.tf

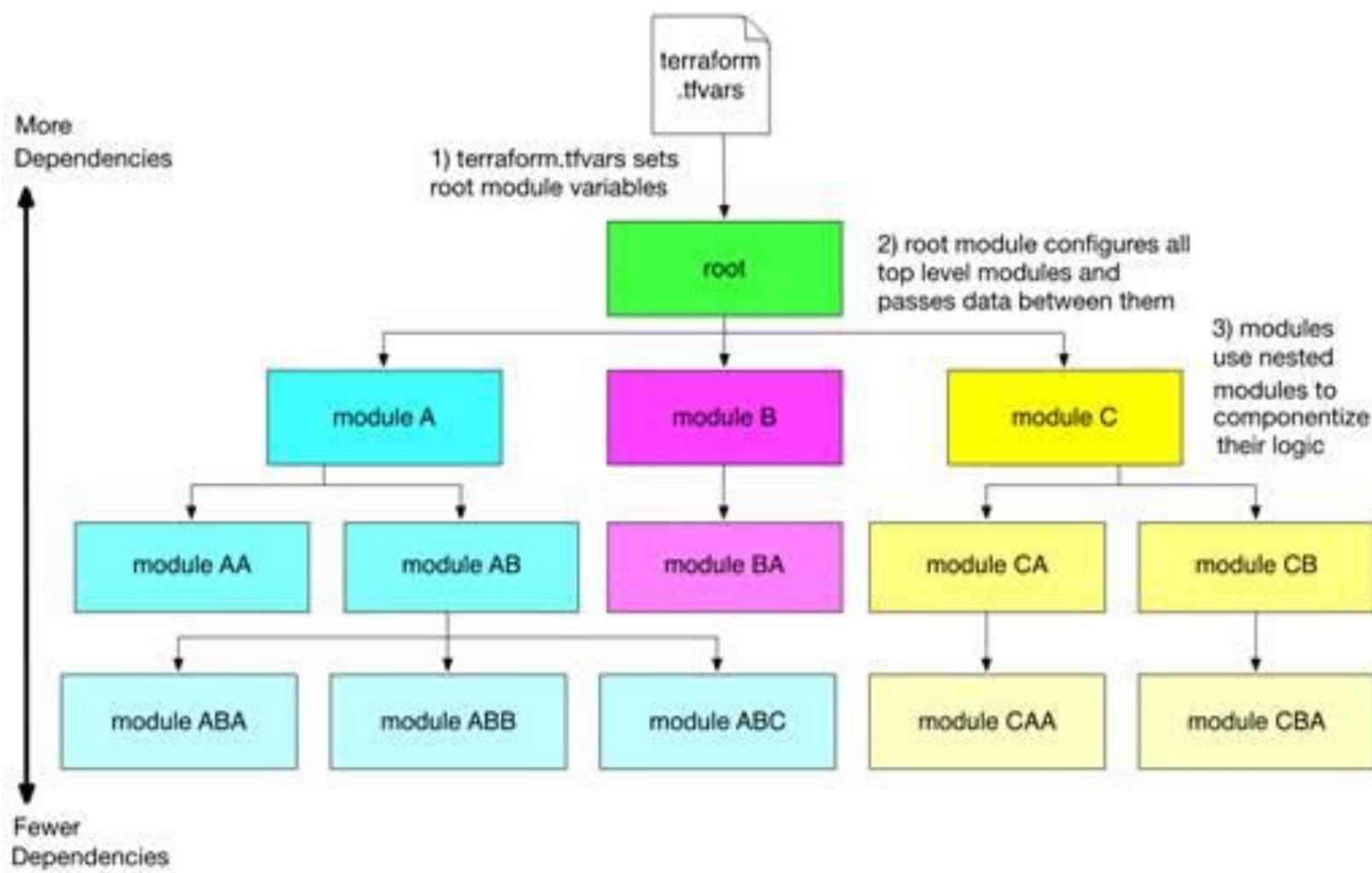
Root Folder

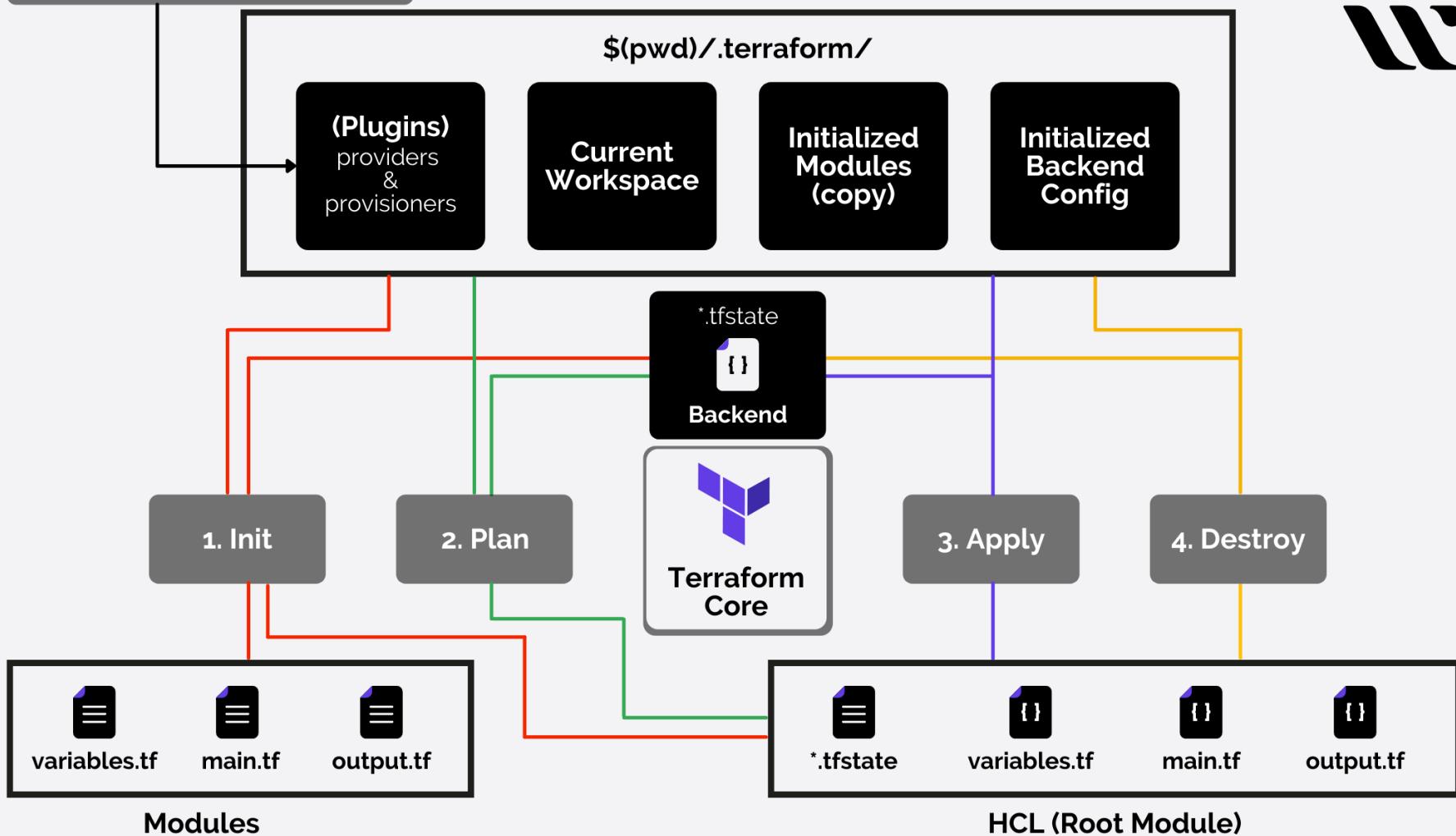
Child Module

- main.tf
- outputs.tf
- variables.tf

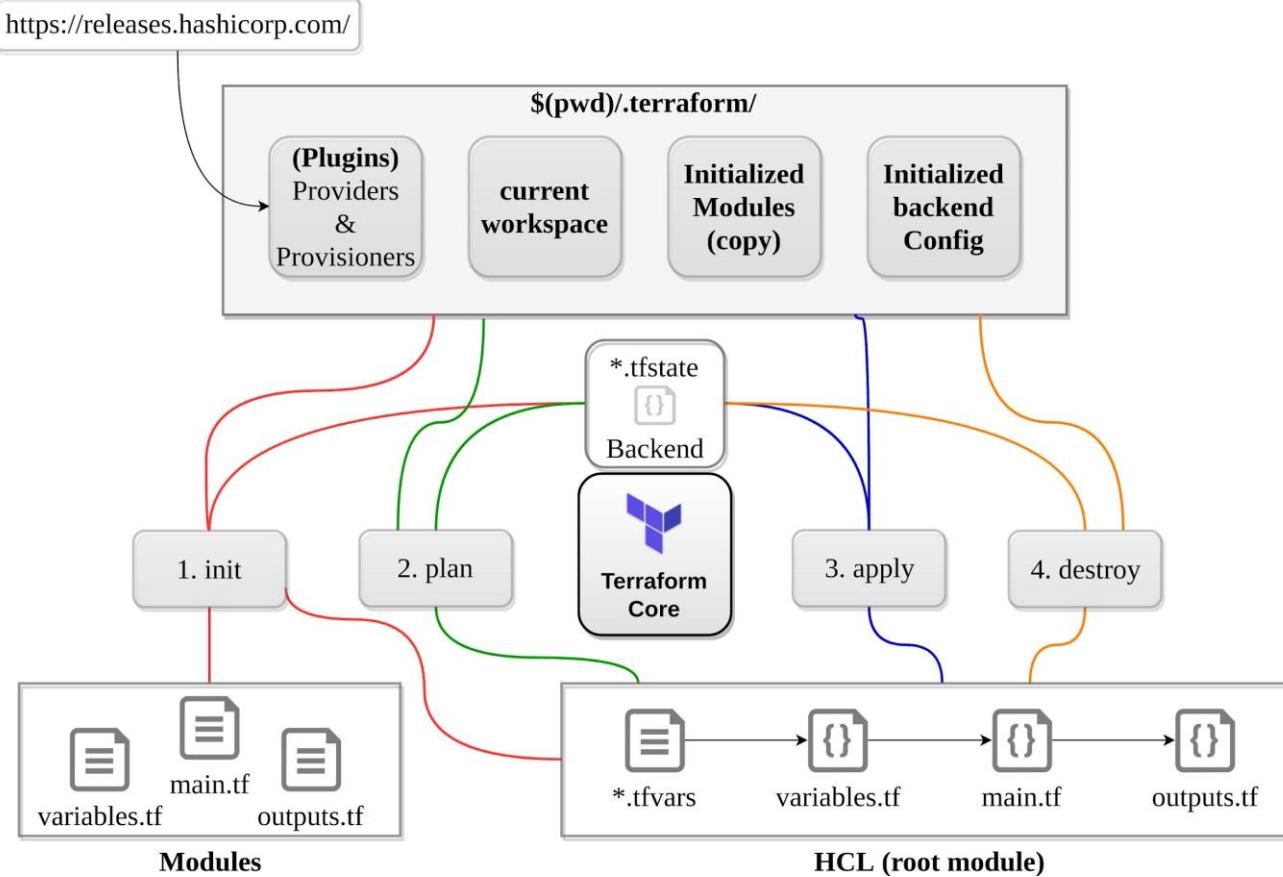
Parent/Child Module Pattern - jloudon.com

Modules Folder



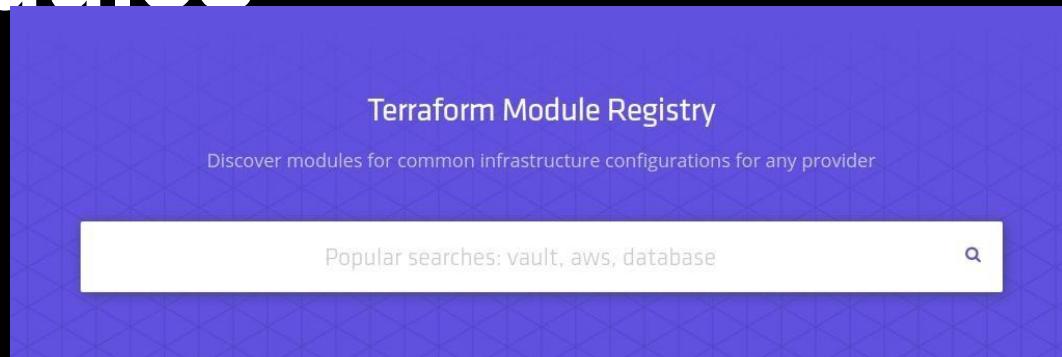


Simple workflow



Workflow: Modules

- Code reuse
- Apply versioning
- Use version constraints
- Store code remotely
- Easier testing
- Encapsulation
- Use and contribute to Module Registry



Workflow: Modules

What is the good terraform module?

- Clean and flexible code
- Well presented default values
- Covered with tests
- Examples
- Documentation
- Changelog
- Secure



Do not overload modules with features:
Terraform does cloning everything

<https://www.endava.com/en/blog/Engineering/2019/11-Things-I-wish-I-knew-before-working-with-Terraform-I>

Terraform Module

```
variable "name" { }

resource "aws_s3_bucket" "bucket" {
    name = "${var.name}"
    [...]
}

output "bucket_id" {
    value = "${aws_s3_bucket.bucket.id}"
}
```

Terraform Module

```
#Create module bucket
module "bucket" {
    name = "MahBucket"
    source = ".\\Modules\\s3"
}

#Use MahBucket
resource "aws_s3_bucket_object" {
    bucket = "${module.bucket.bucket_id}"
    key = "/walrus/bucket.txt"
    source = "./mahbucket.txt"
}
```

Use a Module

Use a module from git

```
module "module-example" {  
    source = "github.com/wardviaene/terraform-module-example"  
}
```

Use a module from a local folder

```
module "module-example" {  
    source = "./module-example"  
}
```

Module Parameter

Pass arguments to the module

```
module "module-example" {  
    source = "./module-example"  
    region = "us-west-1"  
    ip-range = "10.0.0.0/8"  
    cluster-size = "3"  
}
```