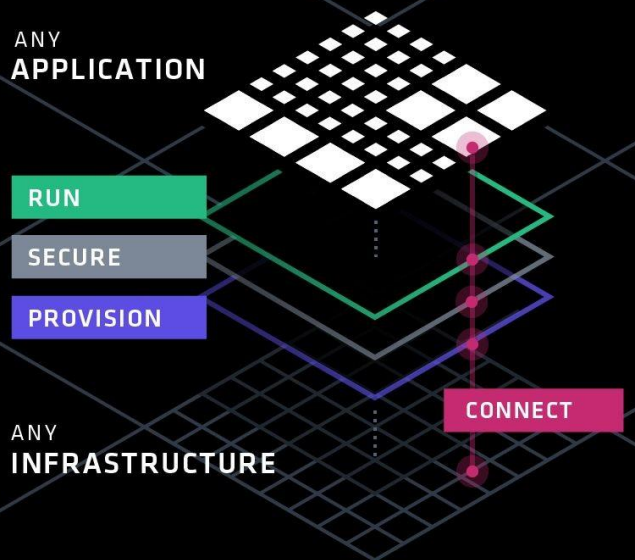
Terraform – Getting Started

HashiCorp Suite



OPEN SOURCE

- HashiCorp Nomad
- HashiCorp Vault
- HashiCorp Terraform
- HashiCorp Packer
- HashiCorp Vagrant
- HashiCorp Consul

Provisioning infrastructure through software to achieve consistent and predictable environments.

Core Concepts

Defined in code

Stored in source control

Declarative or imperative

Idempotent and consistent

Push or pull

Infrastructure as Code Benefits

Automated deployment

Consistent environments

Repeatable process

Reusable components

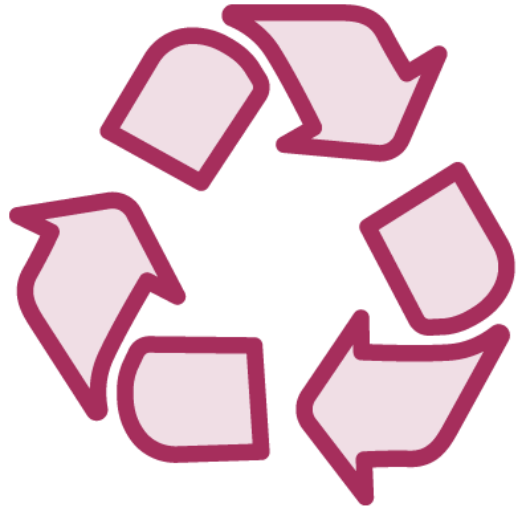
Documented architecture

Automating Infrastructure Deployment

Provisioning Resources

Planning Updates

Using Source Control



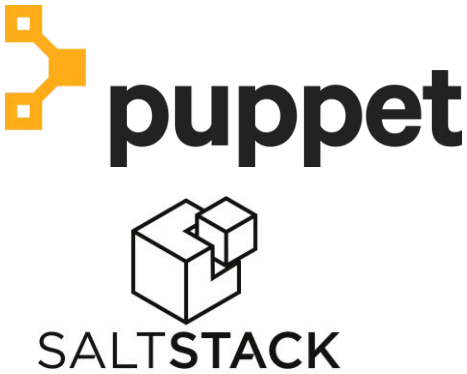
Reusing Templates

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 you infrastructure, safely and predictably
- Applies Graph Theory to IaaC
- Terraform is a multipurpose composition tool:
  - Composes multiple tiers (SaaS/PaaS/IaaS)
  - A plugin-based architecture model
- Open source. Backed by Hashicorp company and Hashicorp Tao (Guide/Principles/Design)

Other tools

- Cloudformation, Heat, etc.
- Ansible, Chef, Puppet, etc.
- Boto, fog, apache-libcloud, etc.
- Custom tooling and scripting

AWS Cloudformation VS OpenStack Orchestration (Heat)

- AWS Locked-in
- Initial release in 2011
- Sources hidden behind a scene
- AWS Managed Service / Free
- Cloudformation Designer
  - Drag-and-drop interface.
- Json, Yaml (since 2016)
- Rollback actions for stack updates
- Change sets (since 2016)

- Open source
- Initial release around 2012
- Heat provides CloudFormation-compatible Query API for Openstack
- UI: Heat Dashboard
- Yaml

Ansible, Chef, Puppet, etc

- Created for the purpose to be a configuration management tool.
- Suggestion: don’t try to mix configuration management and resource orchestration.
- Different approaches:
  - Declarative: Puppet, Salt
  - Imperative: Ansible, Chef
- The steep learning curve if you want to use orchestration capabilities of some of these tools.
- Different languages and approaches:
  - Chef - Ruby
  - Puppet - Json-like syntax / Ruby
  - Ansible – Yaml | python

Boto, fog, apache-libcloud, etc.

- low-level access to APIs
- Some libs focused on specific cloud providers, others provide common interface for few different clouds
- Inspires to create custom tooling

Custom tooling and scripting

- Error-prone and tedious
- Requires many human-hours
- The minimum viable features
- Slowness or impossibility to evolve, adopt to quickly changing environments

Terraform is not a cloud agnostic tool

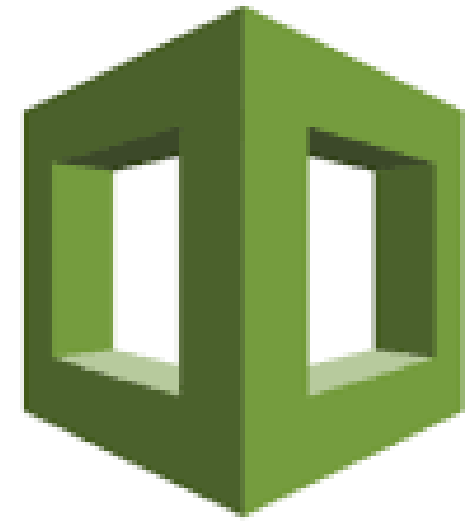
It’s not a magic wand that gives you power over all clouds and systems.

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


HashiCorp
Terraform
VS
Azure

Feature Comparison

Feature	ARM	Terraform
Infrastructure as Code (IaC)	Yes	Yes
Readability	JSON	HashiCorp Config Language (HCL)
Execution plans	No	**Yes**
Dependencies	Yes (Explicit)	Yes (Implied)
Multi-Cloud	No	**Yes**
Configuration	Limited	Limited (can do some storage tasks)
Rollback State	Yes – deploy prior template / rollback	Yes – maintains state
Azure Preview features	Yes	Yes – inline ARM snippets
KeyVault support	Yes	Yes
Corrupted State	**State not needed**	Can be an issue
Supports Dev Ops	Yes	Yes
Cost / Support	**Free**, uses Azure support	Free / Paid (purchase support)
Parallel deployments	Yes	Yes
Runs "Locally"	**ARM template is uploaded / deployed in Azure**	Terraform uses REST calls via a client machine
Delete resource in portal and not worry about state	**Yes**	No
Support Comments	Via an Attribute	**Yes** including block comments
Speed	Can take a while	Can be fast since it can deploy just a single item based upon its plan
Math Functions	Yes	Yes
Count / Loops	Yes	Yes
Sub-Templates/Modules	Yes – Linked Templates	Yes – Modules
Deploy to multiple resource groups	Requires many template	Can be done in one template
Reference existing resources	Variable w/resource id path	"data" resource type
Reverse Engineer resources	Export and Visual Studio	Object by Object by importing



AWS
Cloudformation

VS

HashiCorp
Terraform

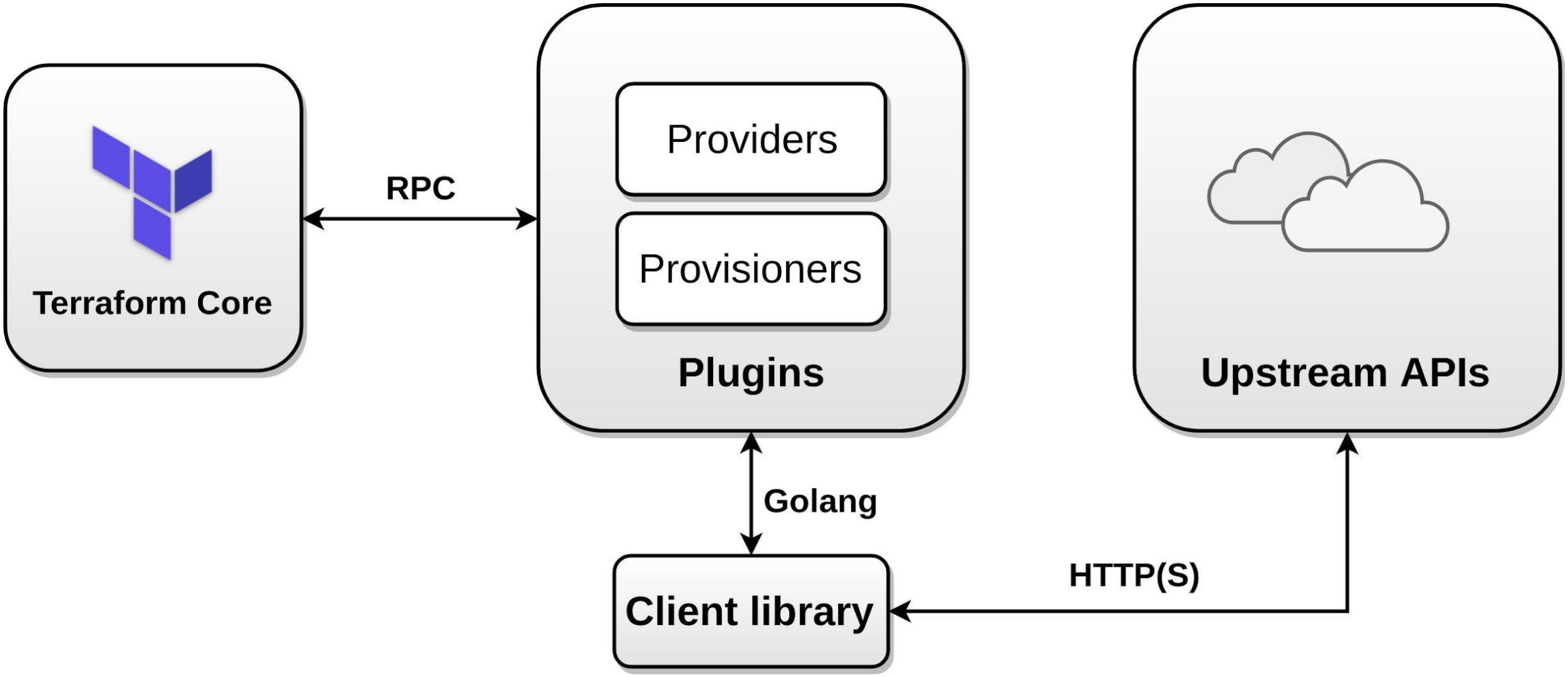
Cloudformation	Terraform
Closed Source, maintained/updated by AWS	Open source, many contributors
Suitable for working on AWS Cloud	Cloud Agnostic: Suitable for working with multi-cloud workloads
GUI access for no cost	GUI access requires expensive enterprise licence
No need to Manage State	Need to Manage State yourself
Supports **YAML** and **JSON** for configuration language	Supports **JSON** and **HCL** for configuration language
Nested Stacks lets you work with multiple templates. This concept is hard to grasp for beginners and has limitations	Working with multiple tf files easier .

	CloudFormation	Terraform
Scope	CloudFormation covers most parts of AWS.	Terraform covers most AWS resources. It also supports other cloud providers and 3rd party services.
License and Support	CloudFormation is a managed service offered by AWS for free. AWS provides support as per the selected support plan.	Terraform is an open-source project. HashiCorp offers support plans like Terraform SaaS and Enterprise.
Syntax	JSON and YAML-based templates are somewhat convoluted.	HCL (HashiCorp Configuration Language)-based templates are easier to interpret.
Modularization	CloudFormation does not use modules, though it offers multiple ways to create 'modules' with some limitations.	Handling modules with Terraform is simple and they help in creating a reproducible infrastructure.
User Experience	CloudFormation provides a user interface to create, modify, and present resource dependencies graphically.	The open-source version of Terraform can be used only via a command-line interface (CLI). Terraform SaaS and Enterprise provide a user interface.
State Management	CloudFormation manages state within an out-of-the-box managed service.	Terraform stores its state on disk by default. It also offers a remote state where you can configure the 'remote state' yourself.
Import the Existing Infrastructure	CloudFormation cannot be used to manage resources created outside of CloudFormation.	Terraform supports the import and management of resources created outside of Terraform.
Verify Changes	CloudFormation offers changesets that you can use to verify changes.	Terraform provides a command named plan, which gives a very detailed overview of what will be modified if you apply your blueprint.
Rolling Updates and Rollback	CloudFormation can perform the rolling update of Auto Scaling Groups, including a rollback in case of a failure.	No support for rolling updates of Auto Scaling groups or automatic rollback.

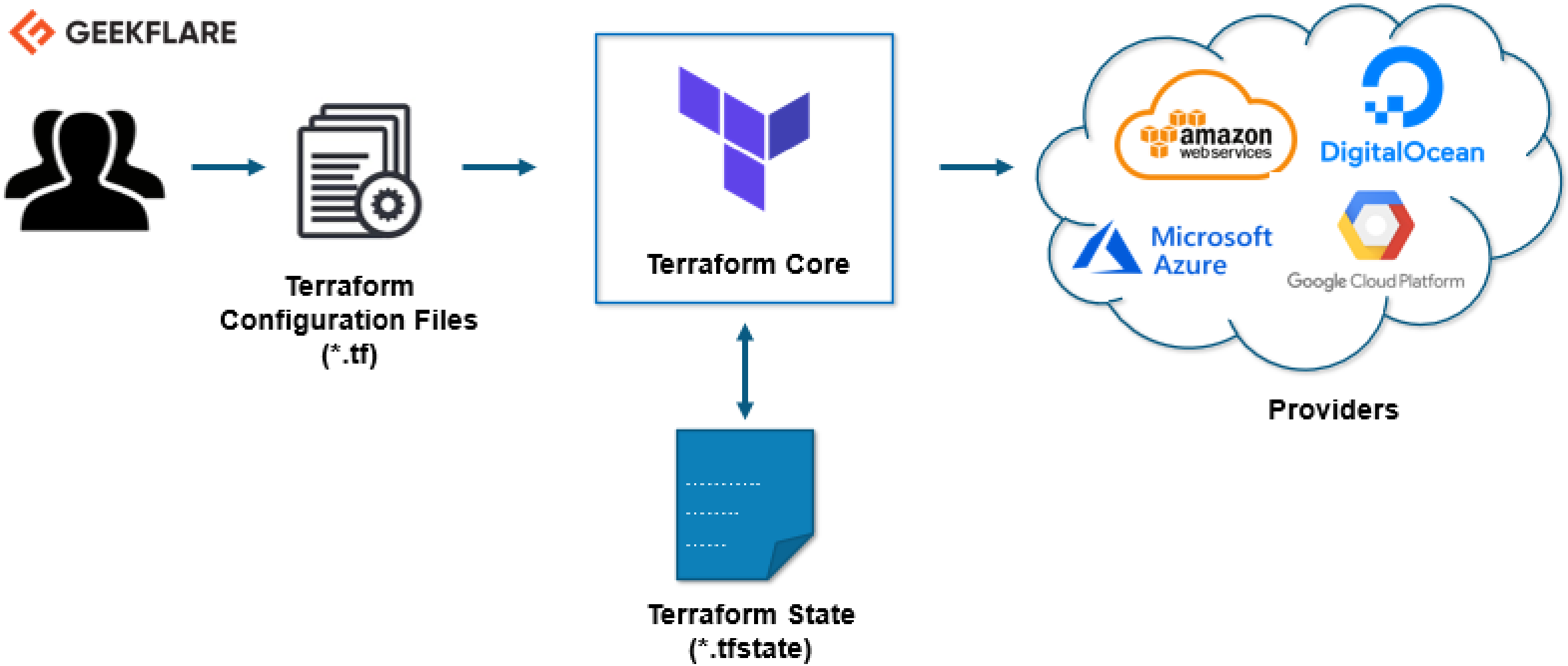
Image 3: Comparative Analysis of Terraform and CloudFormation

	ARM	TERRAFORM	CLOUDFORMATION
CONFIGURATION LANGUAGE	9	12	9
CODE READABILITY	6	11	6
EXCEPTIONS	9	3	9
ERROR TRACKING	9	6	7
AUDIT	9	3	9
TRACKING CAPABILITIES	11	6	11
DEPLOYMENT MONITORING	9	7	9
TOOLING SUPPORT	14	11	11
MODULARITY	8	12	9
VERSIONING AND MANAGEMENT OF THE STATE	6	8	9
VALIDATION MECHANISM	5	9	5
MAINTAINABILITY	5	9	5
MULTI-PLATFORM	0	15	0

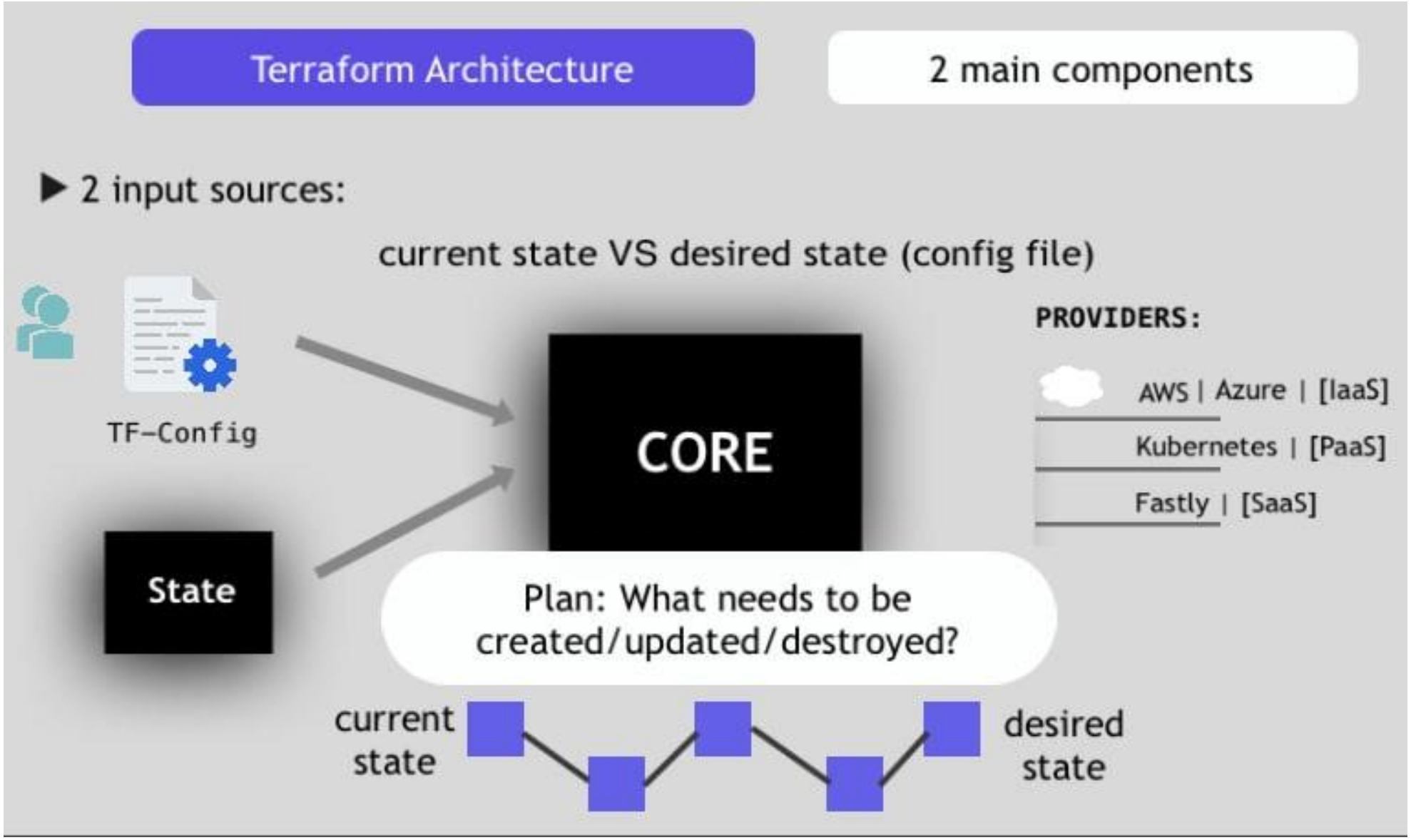
Architecture



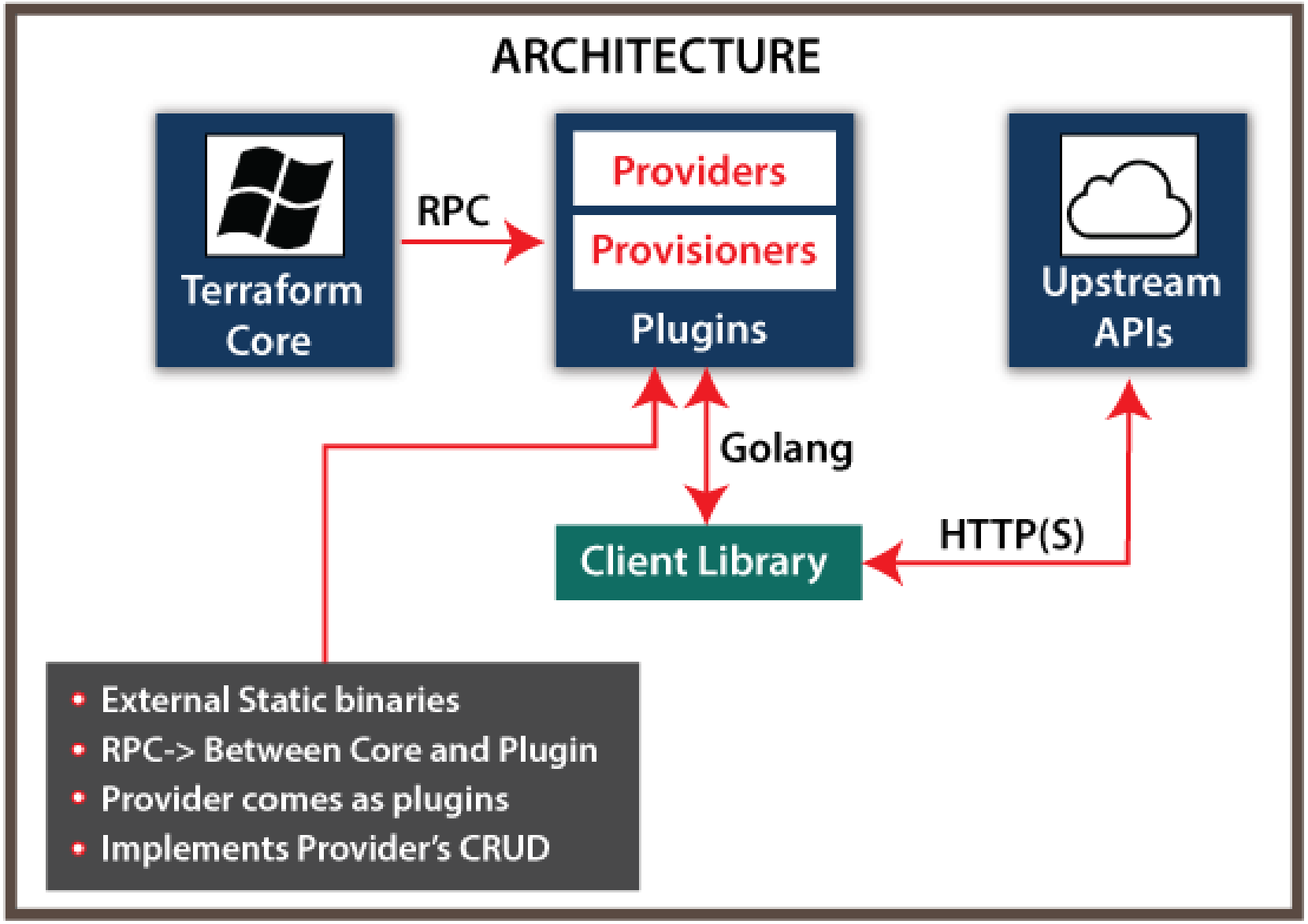
Architecture



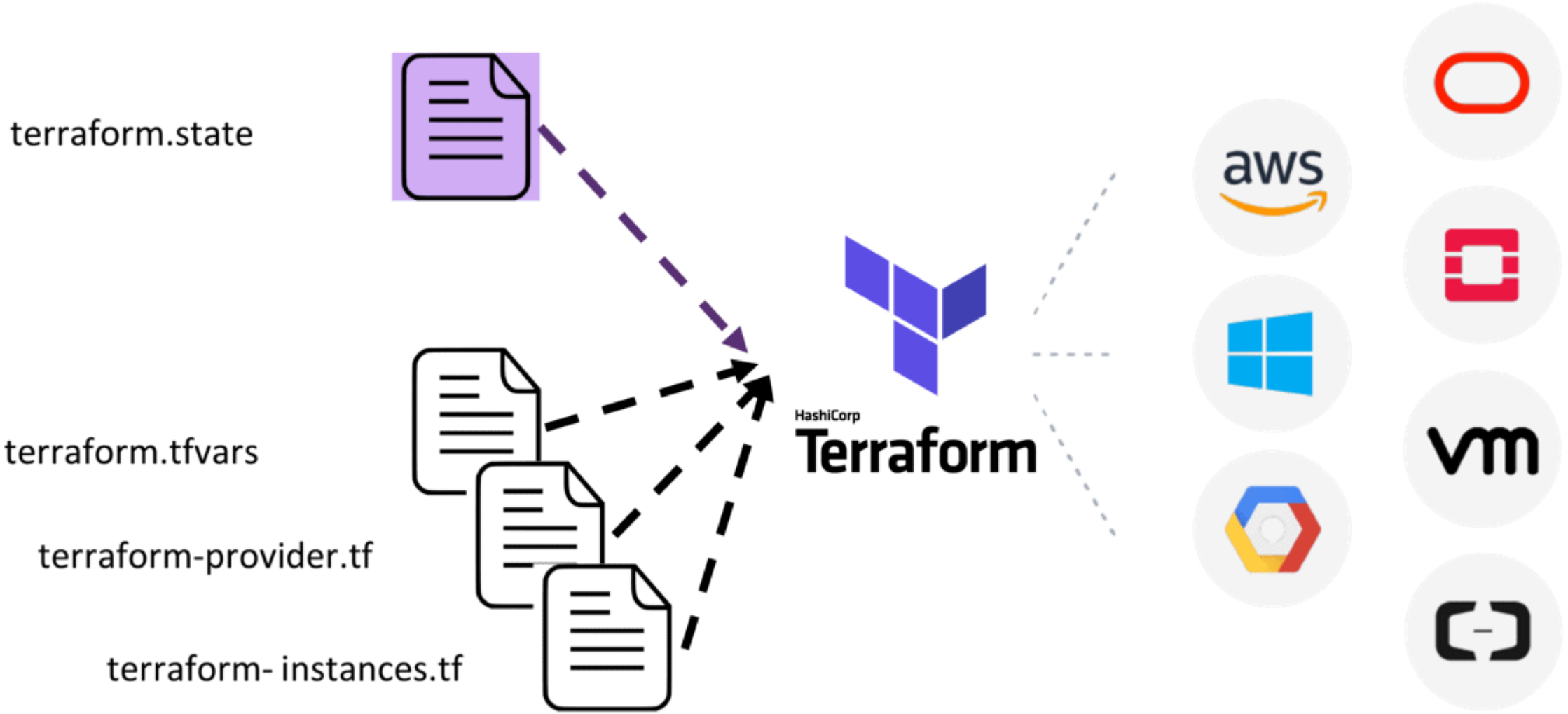
Architecture



Architecture



Architecture



Terraform Components

Terraform Executable

Terraform Providers

API

Terraform File

Terraform Statefile

Terraform config file

Terraform Executable

Terraform Providers

Terraform Providers

IaaS, PaaS, and SaaS

Community and HashiCorp
- AWS, Azure, GCP, and Oracle

Open source using APIs

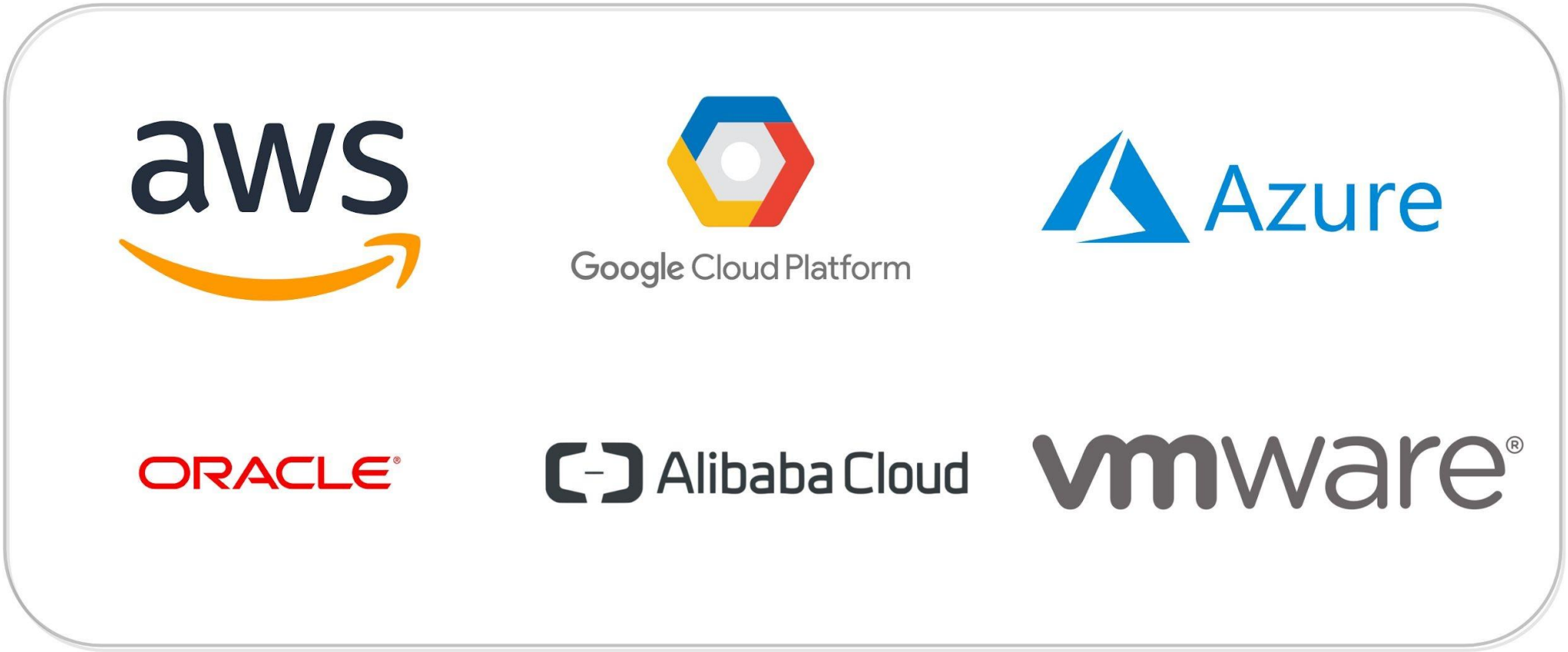
Resources and data sources

Multiple instances

Terraform: Providers (Plugins)

1125+ infrastructure providers

Major Cloud Partners



Terraform: Providers

Can be integrated with any API using providers framework

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

- GitLab
- GitHub
- BitBucket

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

- DNS
- Palo Alto Networks
- F5 BIG-IP

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

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

- NewRelic
- Datadog
- PagerDuty

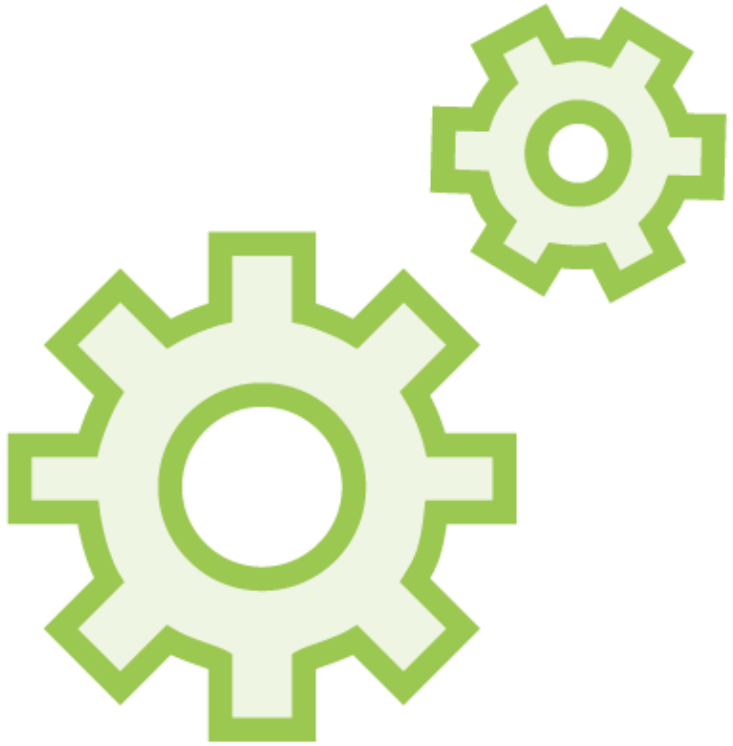
- Digital Ocean
- Fastly
- OpenStack
- Heroku

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

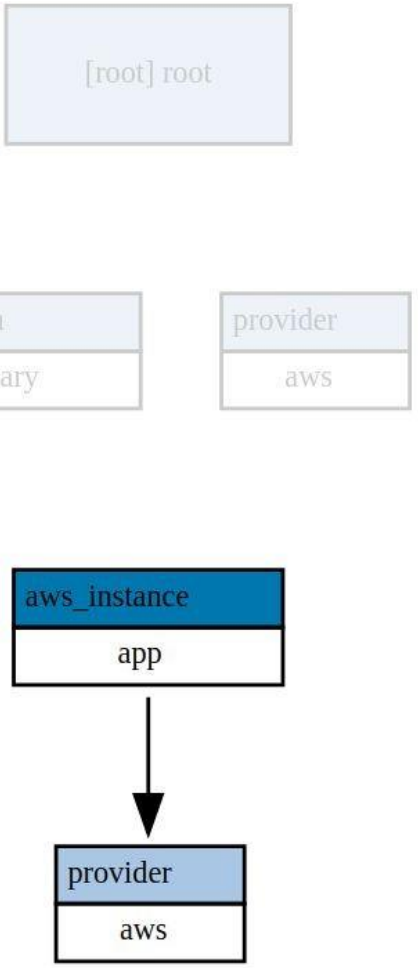
Conditional, functions, templates

Terraform: Example (Simple resource)

Type

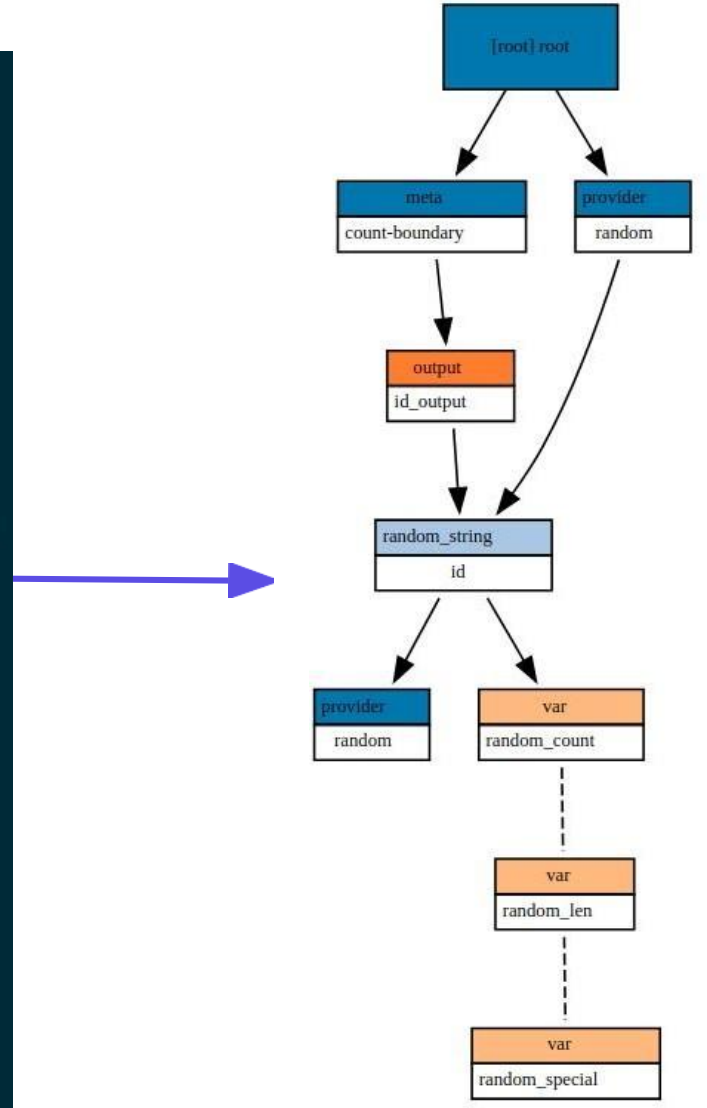
Name

```
resource "aws_instance" "app" {
  ami           = "ami-ab11cd22ee"
  instance_type = "t2.micro"
}
```



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)}
```

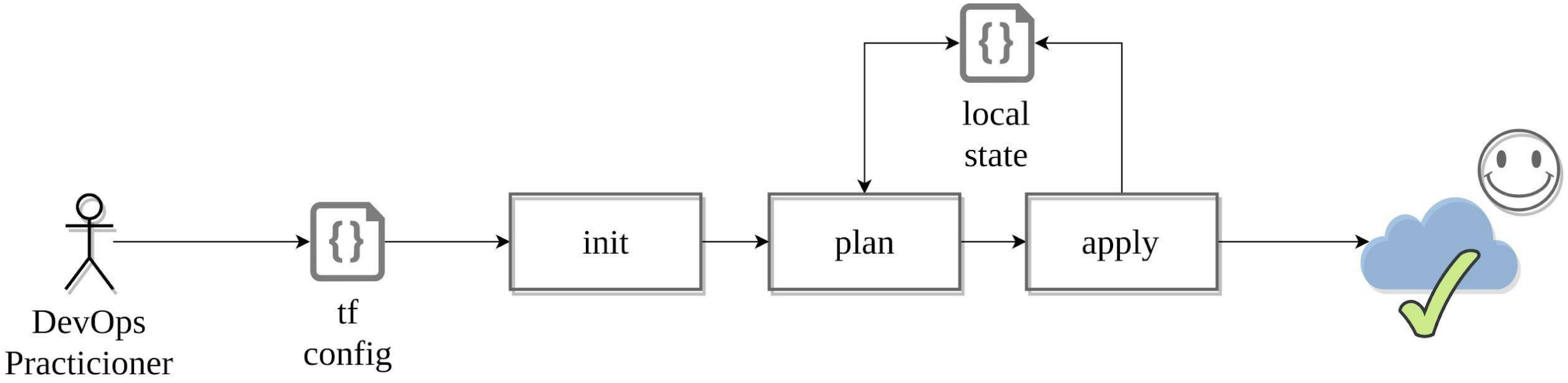
Terraform Syntax

```
#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

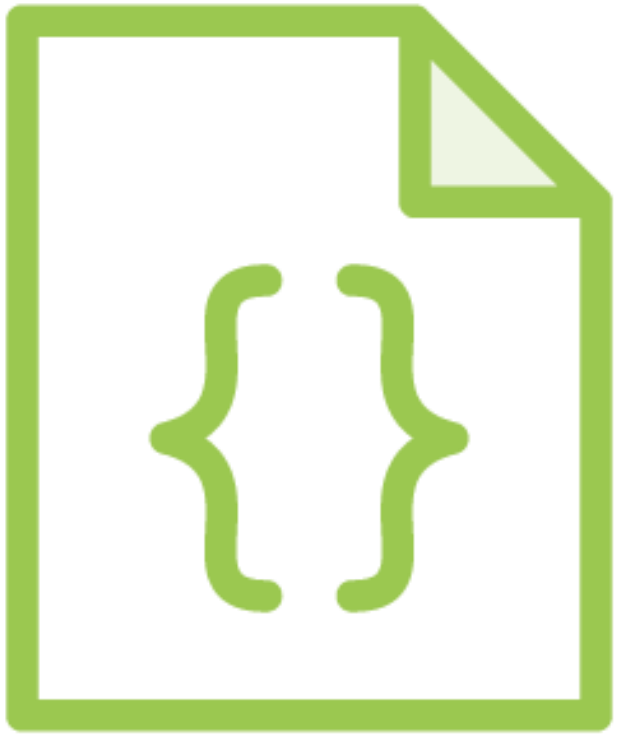
1. Starting Plugins: Provisioners/Providers
2. Building graph
    a. Terraform core traverses each vertex and requests each provider using parallelism
3. Providers syntax check: resource validation
4. If backend == <nil>, use local
5. If “-out file.plan” provided - save to file - the file is not encrypted
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



JSON format (Do not touch!)

Resources mappings and metadata

Locking

Local / remote

Environments

Terraform state file

1. Backup your state files + use Versioning and Encryption
2. Do Not edit manually!
3. Main Keys: cat terraform.tfstate.backup | jq 'keys'
    a. "lineage" - Unique ID, persists after initialization
    b. "modules" - Main section
    c. "serial" - Increment number
    d. "terraform_version" - Implicit constraint
    e. "version" - state format version
4. Use “terraform state” command
    a. mv - to move/rename modules
    b. rm - to safely remove resource from the state. (destroy/retain like)
    c. pull - to observe current remote state
    d. list & show - to write/debug modules

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

- You can keep the terraform.tfstate in version control
- e.g. git
- It gives you a history of your terraform.tfstate file (which is just a big JSON file)
- It allows you to collaborate with other team members
- Unfortunately you can get conflicts when 2 people work at the same time
- Local state works well in the beginning, but when you project becomes bigger, you might want to store your state remote

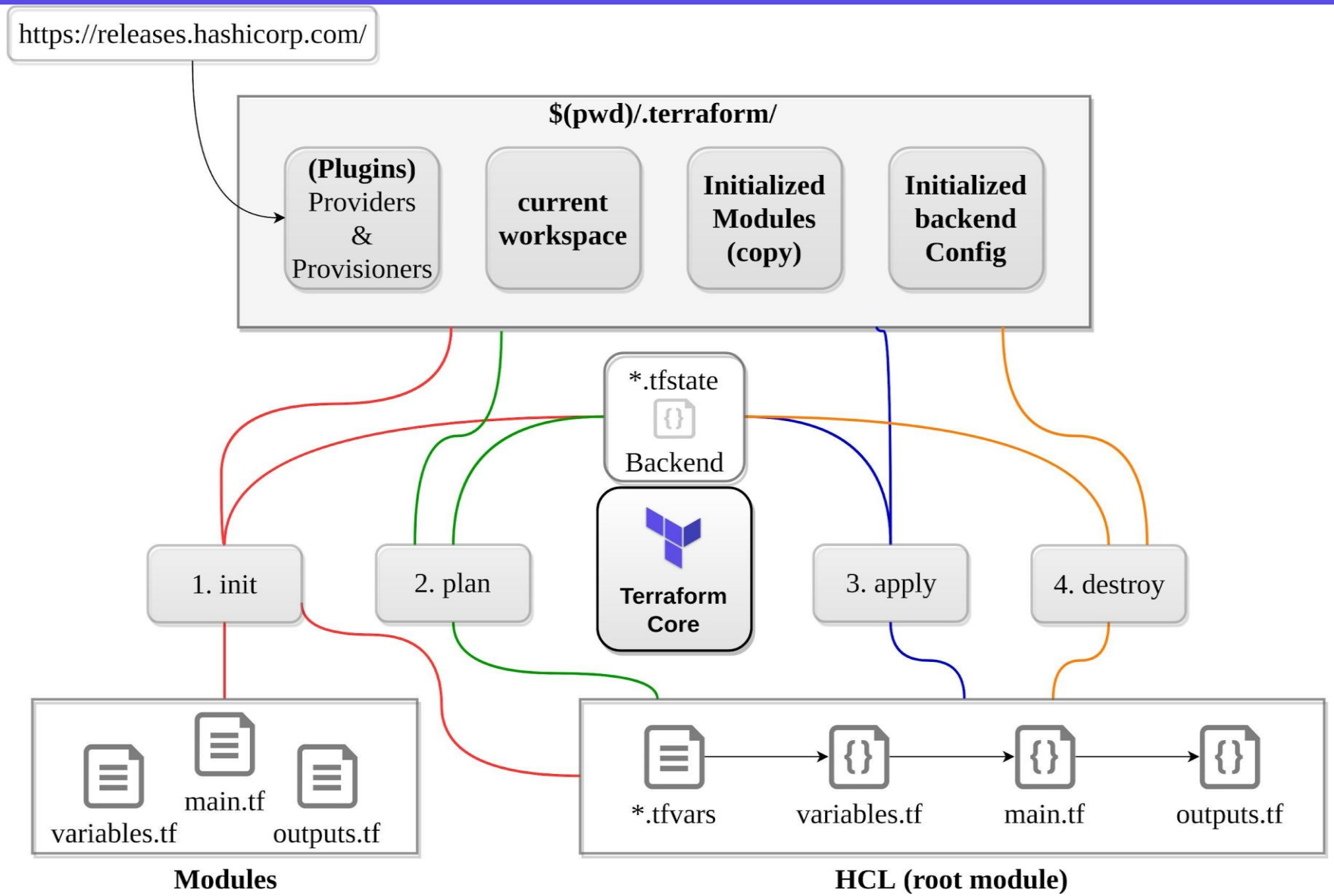
Terraform State

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)

Simple workflow



Updating Your Configuration with More Resources

Adding a New Provider to Your Configuration

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

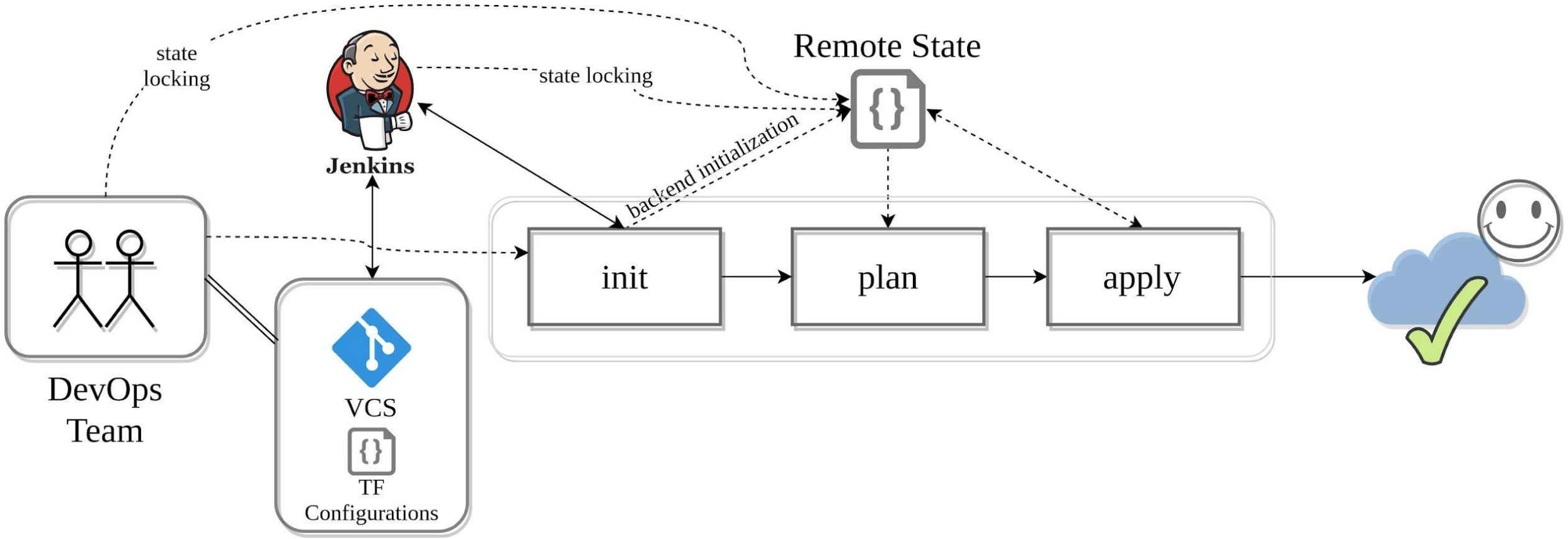
Terraform Command Overview

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

Terraform Advance Workflow

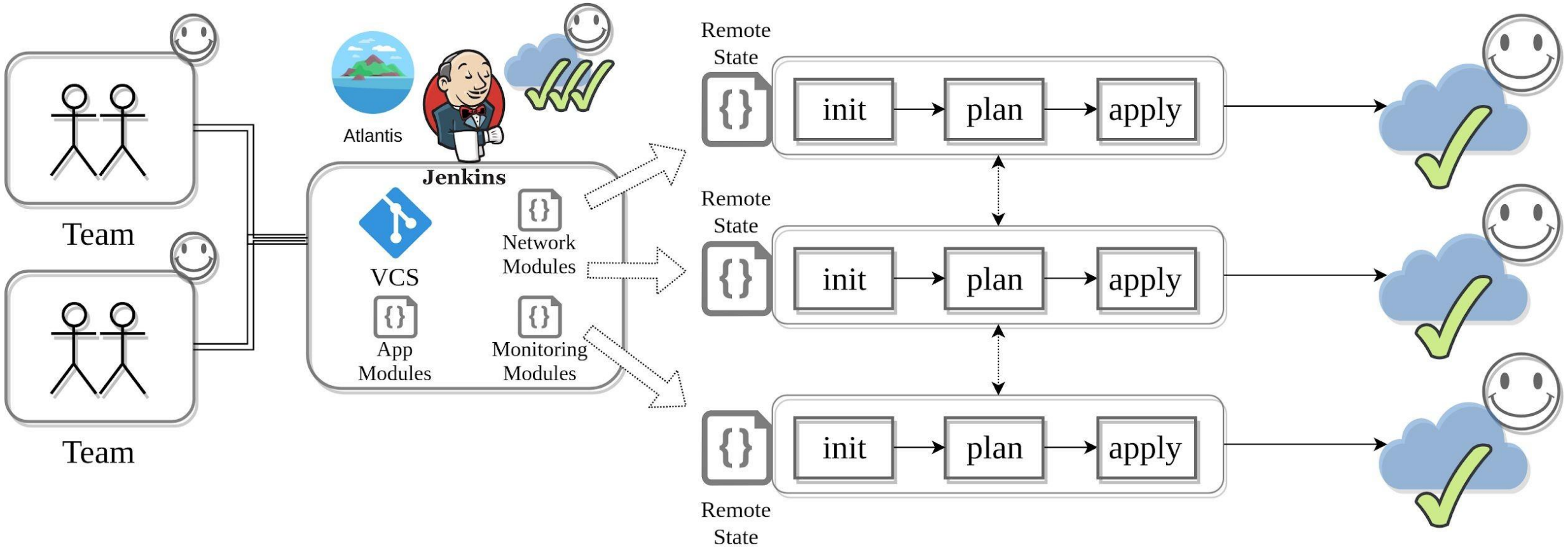
Workflow: Adoption stages

Team Collaboration



Workflow: Adoption stages

Multiple Teams



Demo

Examine the Terraform file

Deploy the configuration

Review the results

Play along!

- AWS account
- Demo files

Demo

Examine the Terraform file

Deploy the configuration

Review the results Play along!

- AWS account
- Azure subscription
- DNS domain
- Terraform software (terraform.io)
- Demo files

Demo

Examine the Terraform file

Deploy the configuration

Review the results

Play along!

- AWS account
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