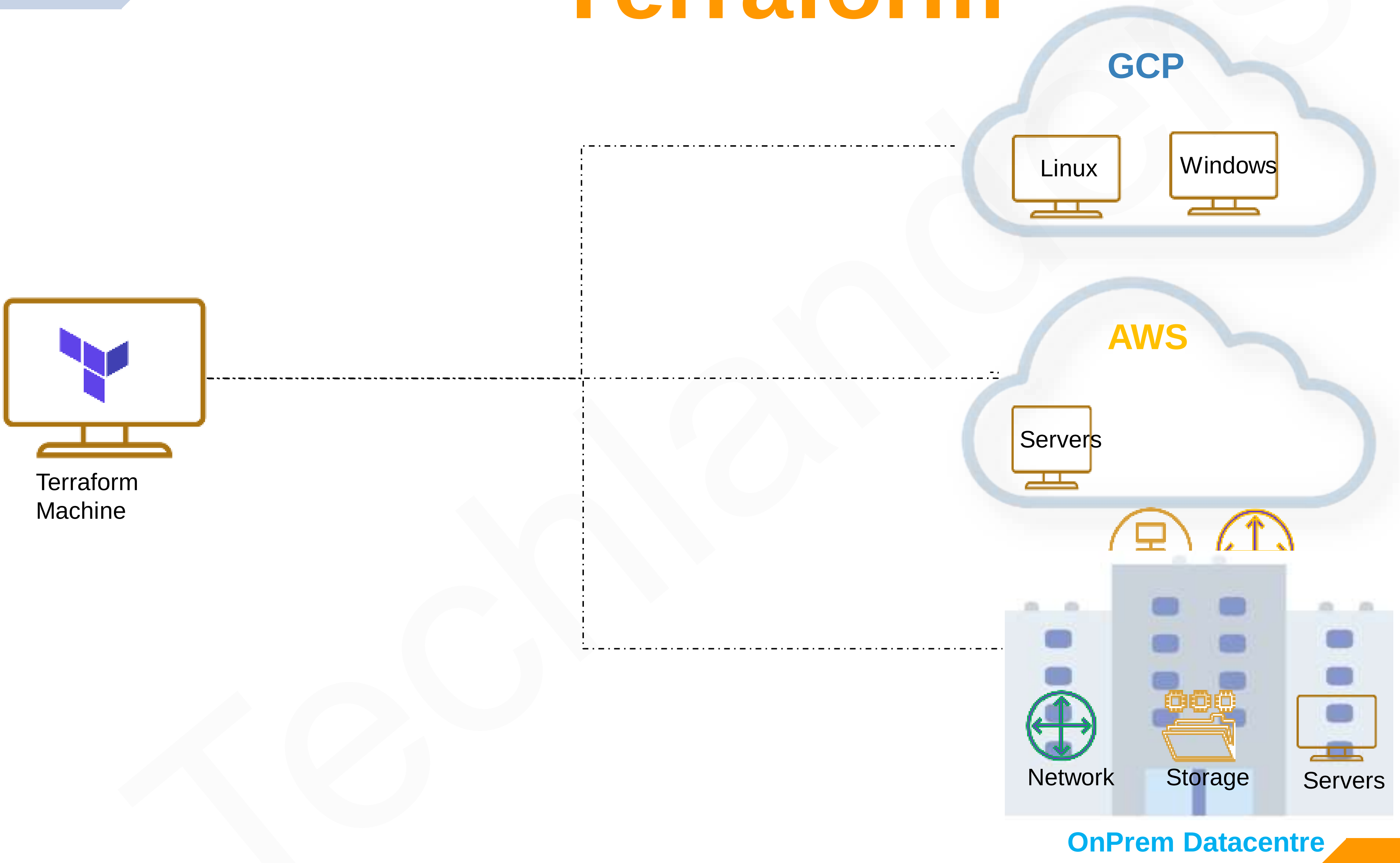
DevOps IaaC

Terraform

Ajit Singh

Terraform



GCP
Linux
Windows
AWS
Servers
Terraform
Machine
Network
Storage
Servers
OnPrem Datacentre

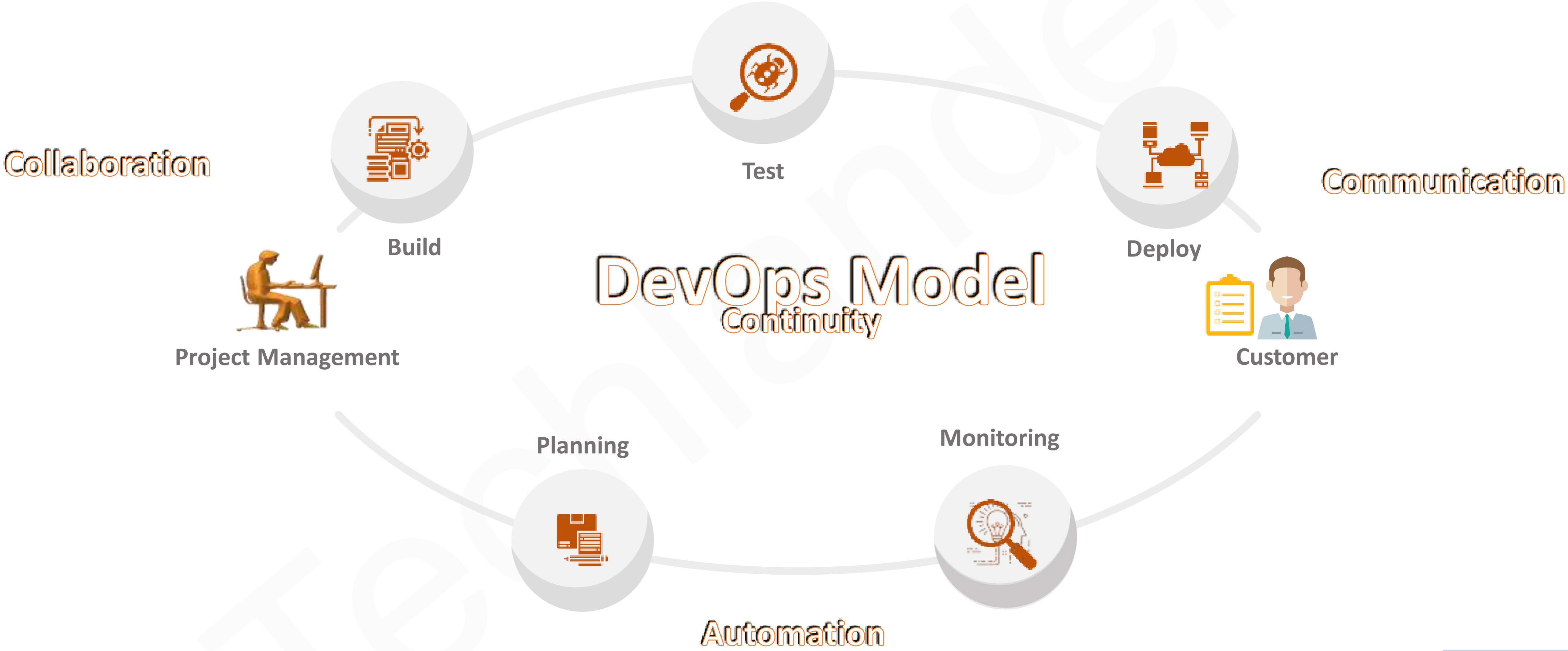
GUI vs CLI vs IAC

- **GUI (Graphical User Interface)**
  - ✓ Best for end user experience
  - ✓ Easy management
  - ✓ Bad for Automation
  - ✓ Not helpful for Administrators

- **CLI (Command Line Interface)**
  - Best for Admin Experience
  - Easy management for Admin level tasks
  - Bad for end user experience
  - Bad for maintaining desired state and consistency

- **IaC (Infrastructure as Code)**
  - Best for Admin Experience
  - Easy management for Admin tasks
  - Easy to understand for end users too
  - Can easily maintain consistency and desired state
  - Infrastructure is written in files, so can be versioned

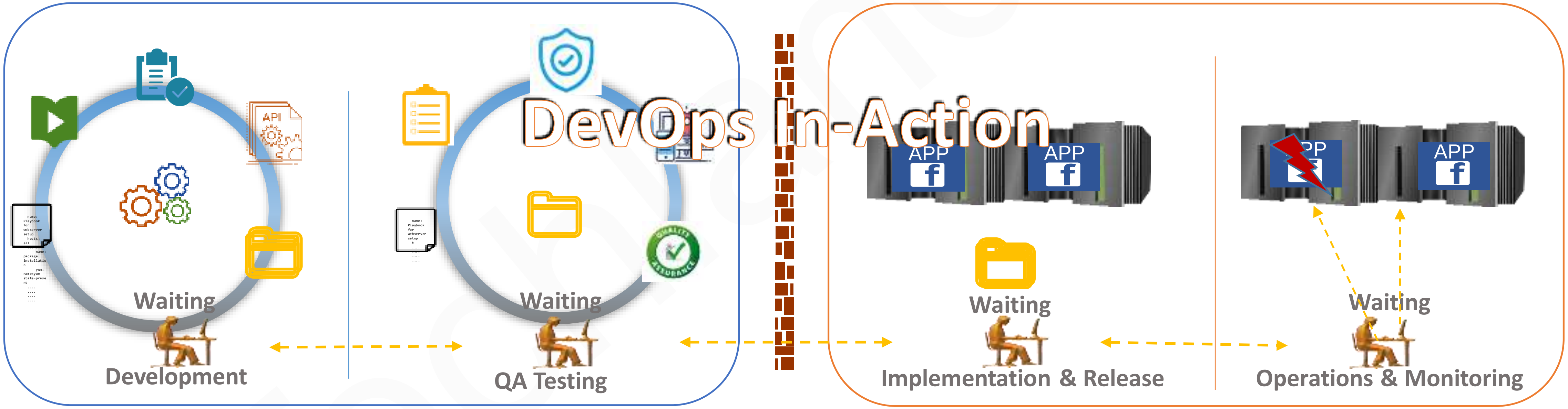
DevOps


Test
Collaboration
Build
Communication
Deploy
DevOps Model
Continuity
Project Management
Customer
Planning
Monitoring
Automation

DevOps in Action

Continuous Feedback | Continuous Improvement | Continuous Planning

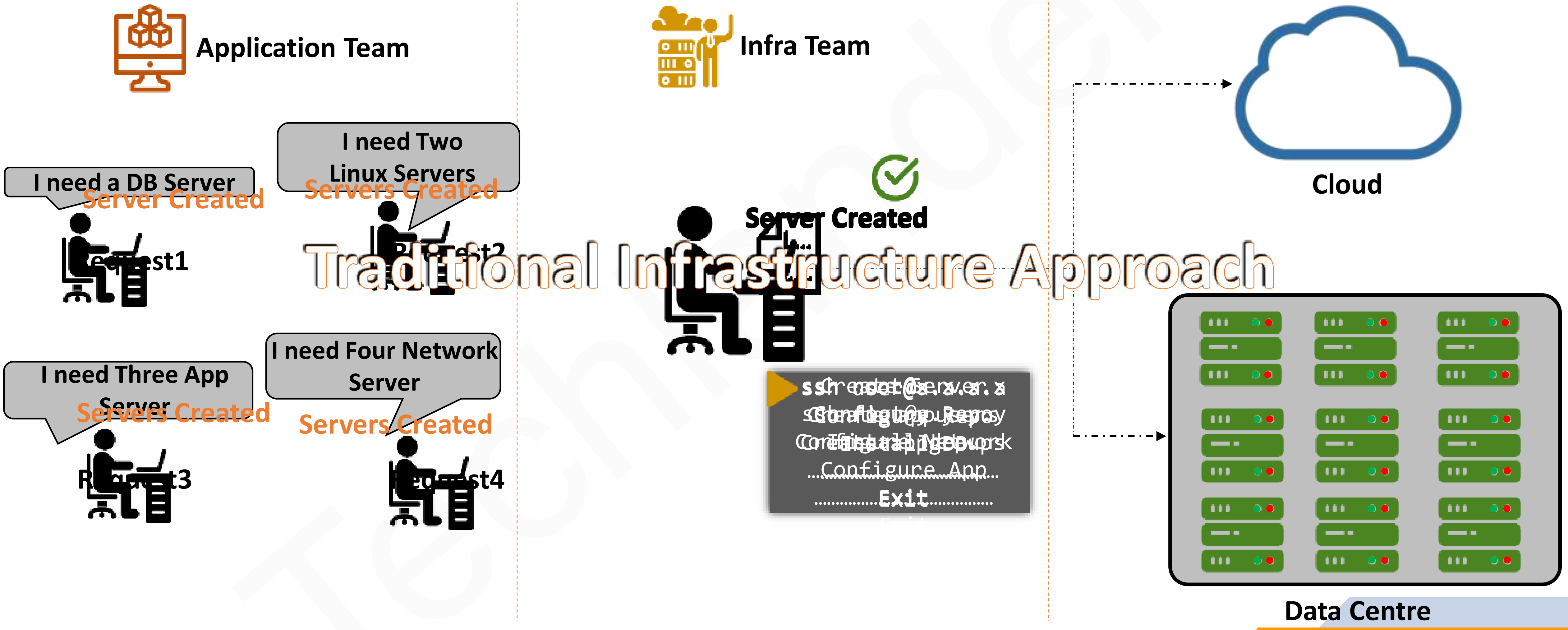
Continuous Delivery | Continuous Deployment | Continuous Monitoring



Development

Operations

Why DevOps IaC



IAC (Infrastructure as Code)

Application Team

I need DB Server
Server Created
Request1

I need Two Linux Servers
Servers Created
Request2

I need Three Linux Servers
Servers Created
Request3

I need Four Linux Servers
Servers Created
Request4

Infra Team

```
File is: main.tf
provider "aws" {
  region = "us-east-1"
}
resource "aws_instance" “requestfour" {
  count = "4"
  ami = "ami-[illegible]"
  instance_type = "t2.micro"
  tags = {
    Name = "DevOpsInAction"
  }
}
output "myawsserver" {
  value =
"${aws_instance.myawsserver.public_ip}"
}
```

Cloud

Data Centre

IaC is Managing Infrastructure in files rather than manually configuring resources in a user interface

Terraform

Terraform is an easy-to-use IT Orchestration & Automation Software for System Administrators & DevOps Engineers.

- It is the infrastructure as code offering from Hashicorp.
- It is a tool for building, changing, and managing infrastructure in a safe, repeatable way.
- Configuration language called the HashiCorp Configuration Language (HCL) is used to configure the Infrastructure.
- Compatible with almost all major public and private Cloud service provider

Terraform

What is Terraform?

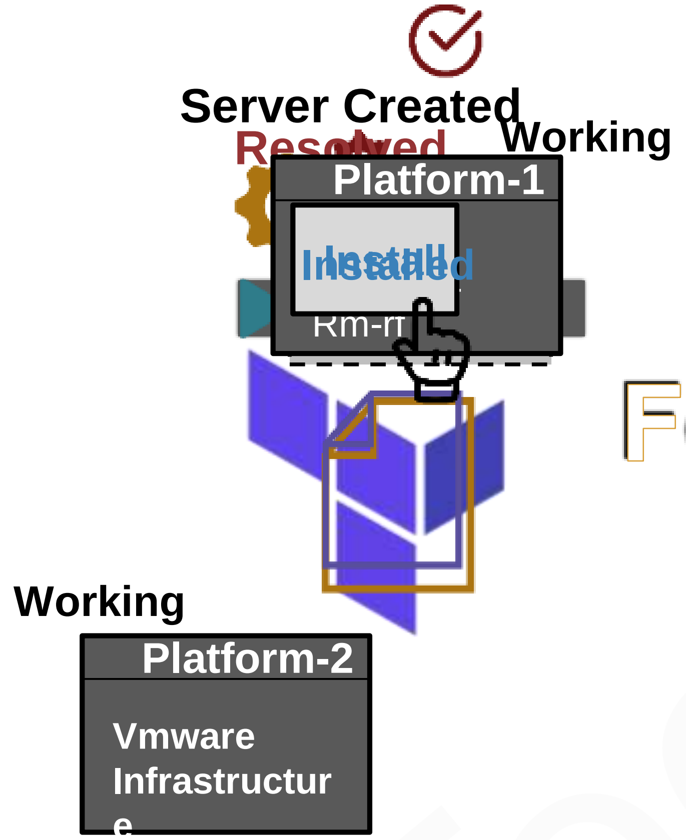
Infrastructure as code (IAC)

July 2014, HashiCorp

Opensource / Enterprise

HCL (Hashicorp Configuration Language)

Terraform



Feature & Advantages

- Easy Installation
- Declarative in Nature
- Idempotent
- Intelligent Dependency Resolver
- Platform Agnostic
- Simple and easy to use

Terraform

Terraform Terminologies

Providers

Variables

Resources

Provisioners

DataSources

Outputs

Modules

File extension
.tf

Terraform

Terraform File (Sample Code)

main.tf

```
provider "aws" {
  region = "us-east-1"
}

resource "aws_instance" "myserver" {
  ami = "ami-030ff268bd7b4e8b5"
  instance_type = "t2.micro"
  tags = {
    Name = "DevOpsInAction"
  }
}

output "myserveroutputs" {
  description = "Display Servers Public IP"
  value = "${aws_instance.myserver.public_ip}"
}
```

Provider Block

Resource Block

Output Block

Why Terraform?

- Infrastructure as Code – Write stuff in files, Version it, share it and collaborate with team on same.
- Declarative in Nature
- Automated provisioning
- Clearly mapped Resource Dependencies
- Can plan before you apply
- Consistent
- Compatible with multiple providers and infra can be combined on multiple providers
- 50+ list of official and verified providers
- Approx. 2500+ Modules readily available to work with
- Both Community and Enterprise versions available
- A best fit in DevOps IaC model

Why Terraform?

- **Platform Agnostic –** Manage Heterogeneous Environment
- **Perfect State Management –** Maintains the state and Refreshes the state before each apply action.

  Terraform state is the source of truth. If a change is made or a resource is appended to a configuration, Terraform compares those changes with the state file to determine what changes result in a new resource or resource modifications.
- **Confidence**: Due to easily repeatable operations and a planning phase to allow users to ensure the actions taken by Terraform will not cause disruption in their environment.

Terraform and its Peers

- Chef
- Puppet
- SaltStack
- Ansible
- CloudFormation
- Terraform
- Kubernetes

Terraform and its Peers

Many tools available in Market. Few things to consider, before selecting any tool:

- Configuration Management vs Orchestration
- Mutable Infrastructure vs Immutable Infrastructure
- Procedural vs Declarative
- Client/Server Architecture vs Client-Only Architecture

Terraform and its Peers

	Chef	Puppet	Ansible	SaltStack	CloudFormation	Terraform
Code	Open source	Open source	Open source	Open source	Closed source	Open source
Cloud	All	All	All	All	AWS only	All
Type	Config Mgmt	Config Mgmt	Config Mgmt	Config Mgmt	Orchestration	Orchestration
Infrastructure	Mutable	Mutable	Mutable	Mutable	Immutable	Immutable
Language	Procedural	Declarative	Declarative	Declarative	Declarative	Declarative
Architecture	Client/Server	Client/Server	Client-Only	Client/Server	Client-Only	Client-Only

Summary: Terraform

Terraform is an easy-to-use IT Orchestration & Automation, Software for System Administrators & DevOps Engineers.

- Terraform is a tool for building, changing, and versioning infrastructure safely and efficiently.
- Terraform can manage existing and popular service providers as well as custom in-house solutions.
- Maintain Desired State
- Highly scalable and can create a complete datacenters in minutes
- Agentless solution
- Declaration in nature than Procedural
- Uses Providers API to provision the Infrastructure
- Terraform creates a dependency graph to determine the correct order of operations.

Terraform Installation

Installation of Terraform

- Terraform is distributed as a single binary. Install Terraform by unzipping it and moving it to a directory included in your system's PATH

- Current Version of Terraform: 0.13.2

- Download the latest version: https://www.terraform.io/downloads.html

- You can verify the checksum at https://releases.hashicorp.com/terraform/0.13.2/terraform_0.13.2_SHA256SUMS

- Older versions can be downloaded from: https://releases.hashicorp.com/terraform/

Installation of Terraform

- Check SHA256SUM of your downloaded zip file (Mandatory for Production Security):

  [root@TechLanders ~]# **sha256sum terraform_0.13.0_linux_amd64.zip**

  9ed437560faf084c18716e289ea712c784a514bdd7f2796549c735d439dbe378 terraform_0.13.0_linux_amd64.zip

  [root@TechLanders ~]#

- Unzip your downloaded file and copy the terraform executable binary to your /usr/bin or set the environment variable for executable path.

- Run Terraform –version to check the installation and integrity of binary:

  [root@TechLanders ~]# **terraform -version**

  Terraform v0.13.0

  [root@TechLanders ~]#

Installation of Terraform

```
[root@TechLanders ~]# terraform -version
Terraform v0.13.0
[root@TechLanders ~]#

[root@TechLanders ~]# terraform --help
Usage: terraform [-version] [-help] <command> [args]

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

Common commands:
    apply        Builds or changes infrastructure
    console      Interactive console for Terraform interpolations
    destroy      Terraform-managed infrastructure
    env          Workspace management
```

Installation of Terraform

- Sub-command help can be taken using –help with subcommand:

```
[root@ip-172-31-6-233 ~]# terraform -help plan
Usage: terraform plan [options] [DIR]
Generates an execution plan for Terraform.
Options:
  -compact-warnings   If Terraform produces any warnings that are not
                      accompanied by errors, show them in a more compact form
                      that includes only the summary messages.
```

- To install auto-complete for sub-commands(for bash and zsh), enable auto-complete:

```
[root@ip-172-31-6-233 ~]# terraform -install-autocomplete
[root@ip-172-31-6-233 ~]# terraform    //double-tab
0.12upgrade    debug      force-unlock    init             output      refresh    untaint
0.13upgrade    destroy    get             internal-plugin  plan        show       validate
apply          env        graph           login            providers   state      version
console        fmt        import          logout           push        taint      workspace
[root@ip-172-31-6-233 ~]# terraform
```

Terraform Upgrade

- You have to relook at your Terraform configuration file (HCL) in case you are changing the Terraform version, as there are several enhancements, bugfixes and older commands deprecations.

- Changes of the latest release can be found at :

  https://github.com/hashicorp/terraform/blob/master/CHANGELOG.md

- Changes (Enhancements and Bug fixes) of previous releases can be found at same link with Version number instead of master: https://github.com/hashicorp/terraform/blob/v0.12/CHANGELOG.md

- Terraform supports upgrade tools and features only for one major release upgrade at a time.

- For errors and issue, you can raise a case at Terraform community forum - https://discuss.hashicorp.com/

Terraform Fundamentals

Providers

A provider is responsible for understanding API interactions and exposing resources. Most providers configure a specific infrastructure platform (either cloud or self-hosted).

Terraform automatically discovers provider requirements from your configuration, including providers used in child modules.

To see the requirements and constraints, run "terraform providers".

```
C:\Users\gagandeep\terra>terraform providers
Providers required by configuration:
.
└── provider[registry.terraform.io/hashicorp/aws]
C:\Users\gagandeep\terra>
```

A provider is responsible for creating and managing resources.

Multiple provider blocks can exist if a Terraform configuration manages resources from different providers.

Copyrights @TechLanders Solutions

Resources

- Resources are the most important element in the Terraform language. Each resource block describes one or more infrastructure objects, such as virtual networks, compute instances, or higher-level components such as DNS records.

```
resource "aws_instance" "web" {
  ami           = "ami-a1b2c3d4"
  instance_type = "t2.micro"
}
```

A resource block declares a resource of a given type ("aws_instance") with a given local name ("web"). The name is used to refer to this resource from elsewhere in the same Terraform module but has no significance outside that module's scope.

The resource type and name together serve as an identifier for a given resource and so must be unique within a module.

Resource names must start with a letter or underscore, and may contain only letters, digits, underscores, and dashes.

Provisioners

- Terraform uses provisioners to upload files, run shell scripts, or install and trigger other software like configuration management tools.
- Multiple provisioner blocks can be added to define multiple provisioning steps.
- Terraform treats provisioners differently from other arguments. Provisioners only run when a resource is created but adding a provisioner does not force that resource to be destroyed and recreated.

Configuration files

- Whatever you want to achieve(deploy) using terraform will be achieved with configuration files.
- Configuration files ends with .tf extension (tf.json for json version).
- Terraform uses its own configuration language, designed to allow concise descriptions of infrastructure.
- The Terraform language is declarative, describing an intended goal rather than the steps to reach that goal.
- A group of resources can be gathered into a module, which creates a larger unit of configuration.
- As Terraform's configuration language is declarative, the ordering of blocks is generally not significant. Terraform automatically processes resources in the correct order based on relationships defined between them in configuration

Example

- You can write up the terraform code in hashicorp Language – HCL.
- Your configuration file will always endup with .tf extension

```
provider "aws" {
  region = "us-east-2"
 access_key = "AKIAJB2KQBDLH56XQEYA"
  secret_key = "rNNWWuzvBpp+v//OXCB10Zr2OVuPI3iayxXXStPs"
}

resource "aws_instance" "myawsserver" {
  ami = "ami-0603cbe34fd08cb81"
  instance_type = "t2.micro"

  tags = {
    Name = "Techlanders-aws-ec2-instance"
  }
}

output "myawsserver" {
  value = "${aws_instance.myawsserver.public_ip}"
}
```

Terraform Workflow

Few Steps to work with terraform:

1) Set the Scope - Confirm what resources need to be created for a given project.

2) Author - Create the configuration file in HCL based on the scoped parameters

3) Run terraform init to initialize the plugins and modules

4) Run terraform validate to validate the template

5) Do terraform plan

6) Run terraform apply to apply the changes

Terraform validate

- Terraform validate will validate the terraform configuration file
- It'll through error for syntax issues:

```
[root@TechLanders aws]# terraform validate
Success! The configuration is valid.

[root@TechLanders aws]#
```

Terraform init

- Terraform init will initialize the modules and plugins.

- If you ever set or change modules or backend configuration for Terraform, rerun this command to reinitialize your working directory.

- If you forget running init, terraform plan/apply will remind you about initialization.

- Terraform init will download the connection plugins from Repository "registry.terraform.io" under your current working directory/.terraform:

```
[root@TechLanders plugins]# pwd
/root/aws/.terraform/plugins
[root@TechLanders plugins]# ls -l
total 4
drwxr-xr-x. 3 root root  23 Aug 15 07:06 registry.terraform.io
-rw-r--r--. 1 root root 136 Aug 15 07:06 selections.json
[root@TechLanders plugins]#
```

- Important concept:
  - Always make a best practice to initialize the terraform modules with versions. i.e.
    hashicorp/aws: version = "~> 3.2.0"

Example

- Perform Terraform Init:

```
[root@TechLanders aws]# terraform init

Initializing the backend...

Initializing provider plugins...
- Finding latest version of hashicorp/aws...
- Installing hashicorp/aws v3.2.0...
- Installed hashicorp/aws v3.2.0 (signed by HashiCorp)

The following providers do not have any version constraints in configuration,
so the latest version was installed.
To prevent automatic upgrades to new major versions that may contain breaking
changes, we recommend adding version constraints in a required_providers block
in your configuration, with the constraint strings suggested below.
* hashicorp/aws: version = "~> 3.2.0"

Terraform has been successfully initialized!

If you ever set or change modules or backend configuration for Terraform,
rerun this command to reinitialize your working directory. If you forget, other
commands will detect it and remind you to do so if necessary.
[root@TechLanders aws]#
```

Terraform plan

- terraform plan will create an execution plan and will update you what changes it going to make.
- It'll update you upfront what its gonna add, change or destroy.
- Terraform will automatically resolve the dependency between components- which to be created first and which in last.

```
[root@TechLanders aws]# terraform plan

Refreshing Terraform state in-memory prior to plan...

The refreshed state will be used to calculate this plan but will not be persisted to local or remote state storage.

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

  + create

Terraform will perform the following actions:

  # aws_instance.myserver will be created

  + resource "aws_instance" "myserver" {

      + ami                          = "ami-06b35f67f1340a795"

      + arn                          = (known after apply)

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

Terraform apply

- Terraform apply will apply the changes.
- Before it applies changes, it'll showcase changes again and will ask to confirm to move ahead:

[root@TechLanders aws]# terraform apply

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

+ create

Do you want to perform these actions?   Terraform will perform the actions described above.   Only 'yes' will be accepted to approve.

Enter a value: yes

aws_instance.myserver: Creating...

aws_instance.myserver: Still creating... [10s elapsed]

aws_instance.myserver: Still creating... [20s elapsed]

aws_instance.myserver: Creation complete after 21s [id=i-0a63756c96d338801]

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

[root@TechLanders aws]#

Terraform apply

- Terraform apply will create **tfstate** file to maintain the desired state:

```
[root@TechLanders aws]# ls -l
total 8
-rw-r--r--. 1 root root  234 Aug 15 07:06 myinfra.tf
-rw-r--r--. 1 root root 3209 Aug 15 08:02 terraform.tfstate
[root@TechLanders aws]# cat terraform.tfstate
{
  "version": 4,
  "terraform_version": "0.13.0",
  "serial": 1,
  "lineage": "7f7e0e15-95ef-d8fa-b1cd-12024aed5fa6",
  "outputs": {},
  "resources": [
   "provider": "provider[\"registry.terraform.io/hashicorp/aws\"]",
     "instances": [
       {
         "schema_version": 1,
         "attributes": {
           "ami": "ami-06b35f67f1340a795",
           "arn": "arn:aws:ec2:us-east-2:677729060277:instance/i-0a63756c96d338801",
```

- Note: -auto-approve option can be given alongwith terraform apply to avoid the human intervention.

Terraform show

- Terraform show will show the current state of the environment been created by your config file:

```
[root@ip-172-31-6-233 aws]# terraform show
# aws_instance.myserver:
resource "aws_instance" "myserver" {
    ami                          = "ami-06b35f67f1340a795"
    arn                          = "arn:aws:ec2:us-east-2:677729060277:instance/i-0a63756c96d338801"
    associate_public_ip_address  = true
    availability_zone            = "us-east-2a"
    cpu_core_count               = 1
    cpu_threads_per_core         = 1
----
----
```

Idempotency

- Run Terraform apply again and check the status of the server.

  [root@TechLanders aws]# terraform apply
  aws_instance.myserver: Refreshing state... [id=i-0a63756c96d338801]

  Apply complete! Resources: 0 added, 0 changed, 0 destroyed.
  [root@TechLanders aws]#

- Stop the server and then check. You'll have no change, as server still exists, its just stopped.
- Run Terraform Plan to check the status:

[root@TechLanders aws]# terraform plan

Refreshing Terraform state in-memory prior to plan...

The refreshed state will be used to calculate this plan, but will not be persisted to local or remote state storage.

aws_instance.myserver: Refreshing state... [id=i-0a63756c96d338801]

No changes. Infrastructure is up-to-date.

This means that Terraform did not detect any differences between your configuration and real physical resources that exist. As a result, no actions need to be performed.

[root@TechLanders aws]#

Desired State Maintenance (DSC)

- Delete the newly created server and then check for the terraform plan

```
[root@TechLanders aws]# terraform plan
Refreshing Terraform state in-memory prior to plan...
The refreshed state will be used to calculate this plan, but will not be
persisted to local or remote state storage.

aws_instance.myserver: Refreshing state... [id=i-0a63756c96d338801]
An execution plan has been generated and is shown below.
Resource actions are indicated with the following symbols:
  + create
Terraform will perform the following actions:
  # aws_instance.myserver will be created
  + resource "aws_instance" "myserver" {
```

- Run terraform apply command again and witness the provisioning of new server on console.

```
[root@TechLanders aws]# terraform apply
aws_instance.myserver: Refreshing state... [id=i-0a63756c96d338801]
An execution plan has been generated and is shown below.
Resource actions are indicated with the following symbols:
  + create
Terraform will perform the following actions:
  # aws_instance.myserver will be created
```

Infrastructure as Code

- Modify your template file to change the instance size from t2.micro to t2.small and plan/apply the changes:

```
[root@TechLanders aws]# cat myinfra.tf
resource "aws_instance" "myserver" {
ami = "ami-06b35f67f1340a795"
instance_type = "t2.small"
}
[root@TechLanders aws]#
```

- Run terraform plan and apply again to check the differences

```
[root@TechLanders aws]# terraform apply
aws_instance.myserver: Refreshing state... [id=i-0a1f8a600cb968c7c]
An execution plan has been generated and is shown below.
Resource actions are indicated with the following symbols:
  ~ update in-place
Plan: 0 to add, 1 to change, 0 to destroy.
Do you want to perform these actions?
  Terraform will perform the actions described above.
  Only 'yes' will be accepted to approve.
  Enter a value: yes
aws_instance.myserver: Modifying... [id=i-0a1f8a600cb968c7c]
```

Refreshing the state

- In case the requirement is to just check for any updates been done in the running environment, we can run terraform refresh command:

```
C:\Users\gagandeep\Desktop\terraform>terraform refresh

google_compute_network.vpc_network: Refreshing state... [id=projects/accenture-286519/global/networks/terraform-net3]

google_compute_address.vm_static_ip: Refreshing state... [id=projects/accenture-286519/regions/us-central1/addresses/terraform-static-ip1]

google_compute_instance.vm_instance1: Refreshing state... [id=projects/accenture-286519/zones/us-central1-b/instances/terraform-instance1]


C:\Users\gagandeep\Desktop\terraform>
```

Destroying Infra in one go

- Terraform destroy will destroy the infrastructure in one go by using your tfstate file.

```
[root@TechLanders aws]# terraform destroy
aws_instance.myserver: Refreshing state... [id=i-0a1f8a600cb968c7c]
An execution plan has been generated and is shown below.
Resource actions are indicated with the following symbols:
  - destroy
Terraform will perform the following actions:
  # aws_instance.myserver will be destroyed
  - resource "aws_instance" "myserver" {
      - ami  = "ami-06b35f67f1340a795“
 Enter a value: yes
aws_instance.myserver: Destroying... [id=i-0a1f8a600cb968c7c]
aws_instance.myserver: Still destroying... [id=i-0a1f8a600cb968c7c, 10s elapsed]
aws_instance.myserver: Still destroying... [id=i-0a1f8a600cb968c7c, 20s elapsed]
aws_instance.myserver: Destruction complete after 29s
Destroy complete! Resources: 1 destroyed.
```

Destroying Infra

- Terraform destroy can also delete selected resources given with –target option and can also be auto-approved with –auto-approve option. But it is always recommended to modify the configuration file instead of –target.

C:\Users\gagandeep\Desktop\terraform>terraform destroy -target=google_compute_instance.vm_instance2 -auto-approve

google_compute_network.vpc_network: Refreshing state... [id=projects/accenture-286519/global/networks/terraform-net3]

google_compute_instance.vm_instance2: Refreshing state... [id=projects/accenture-286519/zones/us-central1-b/instances/terraform-instance2]

google_compute_instance.vm_instance2: Destroying... [id=projects/accenture-286519/zones/us-central1-b/instances/terraform-instance2]

google_compute_instance.vm_instance2: Still destroying... [id=projects/accenture-286519/zones/us-central1-b/instances/terraform-instance2, 10s elapsed]

google_compute_instance.vm_instance2: Still destroying... [id=projects/accenture-286519/zones/us-central1-b/instances/terraform-instance2, 20s elapsed]

google_compute_instance.vm_instance2: Destruction complete after 24s

Warning: Resource targeting is in effect

You are creating a plan with the -target option, which means that the result of this plan may not represent all of the changes requested by the current configuration.

The -target option is not for routine use and is provided only for exceptional situations such as recovering from errors or mistakes, or when Terraform specifically suggests to use it as part of an error message.

Note: Multiple –target options are supported as well.

Output from a run

Terraform provides output for every run and same can be used to list the resources details which are created using help of Terraform:

```
provider "aws" {
  region = "us-east-2"
 access_key = "AKIAJB2KQH56XQEYA"
  secret_key = "rNNWWuzvBpp+v"
}
resource "aws_instance" "myawsserver" {
  ami = "ami-0a54aef4ef3b5f881"
  instance_type = "t2.small"
  tags = {
    Name = "Techlanders-aws-ec2-instance"
    Env = "Prod"
  }
}
output "myawsserver-ip" {
  value = "${aws_instance.myawsserver.public_ip}"
}
```

Using Resource values

Create a GCP instance with network instance: Add below code to the file:

```
resource "google_compute_instance" "vm_instance" {
  name         = "terraform-instance"
  machine_type = "f1-micro"

  boot_disk {
    initialize_params {
      image = "debian-cloud/debian-9"
    }
  }

  network_interface {
    network = google_compute_network.vpc_network.name
    access_config {
    }
  }
}
```

Working with change

Modify your terraform file and add tags/labels to it and run terraform plan/apply again:

```
resource "google_compute_instance" "vm_instance" {
  name         = "terraform-instance"
  machine_type = "f1-micro“
  tags  = [“web”, “dev”]

  boot_disk {
    initialize_params {
      image = "debian-cloud/debian-9"
    }
  }

  network_interface {
    network = google_compute_network.vpc_network.name
    access_config {
    }
  }
}
```

Notedown the output of terraform plan stating it’ll be an in-place upgrade

Working with change

Changes are of two types:

- Up-date In-place
- Disruptive

So always be careful with what you are adding/modifying

Update in-place

Update in-place will ensure your existing resources intact and modify the existing resources only. Here also based on what configuration is required to be changed, server may or may-not shutdown.

- For example, if you add IP address to a server, reboot will not be required.

```
network_interface {
  network = google_compute_network.vpc_network.name
  access_config {
   nat_ip = google_compute_address.vm_static_ip.address
  }
 }
}
resource "google_compute_address" "vm_static_ip" {
  name = "terraform-static-ip"
}
```

- On the other side modifying the server size can't be done live. It needs a stop and start of the server. For same you need to grant permission in configuration file:

```
resource "google_compute_instance" "vm_instance" {
  name         = "terraform-instance"
  machine_type = "g1-small"
  tags = ["web", "dev", "client1"]
  allow_stopping_for_update = true
  boot_disk {
    initialize_params {
      image = "cos-cloud/cos-stable"
    }
  }
```

Update - Disruptive

Disruptive updates require a resource to be deleted and recreated.

For example, modifying the image type for an instance will require instance to be deleted and re-created.

Modify the image type to g1-small in config file and check the output of terraform plan:

```
machine_type = "g1-small"
C:\Users\gagandeep\terra>terraform plan
Refreshing Terraform state in-memory prior to plan...
The refreshed state will be used to calculate this plan, but will not be
persisted to local or remote state storage.
An execution plan has been generated and is shown below.
Resource actions are indicated with the following symbols:
-/+ destroy and then create replacement
Terraform will perform the following actions:
  # google_compute_instance.vm_instance must be replaced
Plan: 1 to add, 0 to change, 1 to destroy.
```

Working with change

Now let's see an example of **disruptive** change:

Replace the boot disk of your configuration with cos-cloud/cos-stable or any other AMI and re-run terraform plan:

```
C:\Users\gagandeep\terra>terraform plan

Resource actions are indicated with the following symbols:

-/+ destroy and then create replacement

Terraform will perform the following actions:

  # google_compute_instance.vm_instance must be replaced

-/+ resource "google_compute_instance" "vm_instance" {

--

 ~ initialize_params {

          ~ image    =  "https://www.googleapis.com/compute/v1/projects/debian-cloud/global/images/debian-9-stretch-v20200805"  ->  "cos-cloud/cos-stable"  # forces replacement

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

Changes outside of terraform

Changes which occurred outside of terraform are unwanted changes and if anything which is modified outside of terraform is detected, same will be marked in state files and will be corrected at next apply.

- Run terraform show command to check current required state of infrastructure.
- Modify the Labels (add a label) of a terraform instance from GCP console.
- Run terraform plan to check the behavior of terraform against the changes
- Check the terraform show command to view state file
- Check terraform refresh command to update the state frontend
- Run terraform apply to revert the changes
- Check the terraform refresh/show command as well as console again to validate the reversion of changes.

Resource Dependencies

- There are two types of dependencies available in terraform:

  - Implicit - Dependency automatically detected and Hierarchy map automatically created by terraform

  - Explicit - The depends_on argument can be added to any resource and accepts a list of resources to create explicit dependencies on resources.

- Terraform uses dependency information to determine the correct order in which to create and update different resources.

Implicit Dependencies

- Real-world infrastructure has a diverse set of resources and resource types.
- Dependencies among resources are obvious and should be maintained during provisioning. For e.g. Creating a network first than a Virtual machine; and creating a static IP before a VM is initialized and attaching that IP to it.
- Try adding below resource to your configuration file and add a link of same in your Instance network interface:

```
network_interface {
network = google_compute_network.vpc_network.self_link
access_config {
nat_ip = google_compute_address.vm_static_ip.address
 }
 }
resource "google_compute_address" "vm_static_ip" {
 name = "terraform-static-ip"
}
```

Implicit Dependencies

In the previous example, when Terraform reads this configuration, it will:

- Ensure that vm_static_ip is created before vm_instance
- Save the properties of vm_static_ip in the state
- Set nat_ip to the value of the vm_static_ip.address property

You can put your resources here and there in configuration file and terraform will automatically build a dependency map between them.

Implicit dependencies via interpolation expressions are the primary way to inform Terraform about these relationships, and should be used whenever possible.

Explicit Dependencies

- Sometimes there are dependencies between resources that are not visible to Terraform. The depends_on argument can be added to any resource and accepts a list of resources to create explicit dependencies for.
- For example, perhaps an application we will run on our instance expects to use a specific Cloud Storage bucket, but that dependency is configured inside the application code and thus not visible to Terraform. In that case, we can use depends_on to explicitly declare the dependency.

```
resource "google_storage_bucket" "example_bucket" {
  name     = "<UNIQUE-BUCKET-NAME>"
  location = "US"
  website {
    main_page_suffix = "index.html"
    not_found_page   = "404.html"
  }
}
resource "google_compute_instance" "another_instance" {
depends_on = [google_storage_bucket.example_bucket]
  name         = "terraform-instance-2"
  machine_type = "f1-micro"
  boot_disk {
    initialize_params {
      image = "cos-cloud/cos-stable"
    }
  }
  network_interface {
    network = google_compute_network.vpc_network.self_link
    access_config {
    }
  }
}
```

Explicit Dependencies

- Multiple resource dependencies can also be created:

```
# Create a new instance that uses the bucket
resource "google_compute_instance" "another_instance" {
  # Tells Terraform that this VM instance must be created only after the
  # storage bucket has been created.
  depends_on = [google_storage_bucket.example_bucket1, google_compute_instance.vm_instance]
  name         = "terraform-instance-2"
  machine_type = "f1-micro"

  boot_disk {
    initialize_params {
      image = "cos-cloud/cos-stable"
    }
  }

  network_interface {
    network = google_compute_network.vpc_network.self_link
    access_config {
    }
  }
}
```

Backup

- Just run terraform destroy or terraform apply and cancel it. Cross-check for terraform.tfstate.backup file which is being created as backup for your statefile.

```
C:\Users\gagandeep\terra>dir

16-08-2020  00:24    <DIR>          .
16-08-2020  00:24    <DIR>          ..
16-08-2020  00:12    <DIR>          .terraform
16-08-2020  00:24               226 .terraform.tfstate.lock.info
16-08-2020  00:08               243 myinfra.tf
15-08-2020  11:45        85,426,504 terraform.exe
16-08-2020  00:22             3,203 terraform.tfstate
16-08-2020  00:22             3,205 terraform.tfstate.backup
               5 File(s)     85,433,381 bytes
               3 Dir(s)  735,488,614,400 bytes free

C:\Users\gagandeep\terra>
```

Note: Terraform determines the order in which things must be destroyed. For e.g. GCP/AWS won't allow a VPC network to be deleted if there are resources still in it, so Terraform waits until the instance is destroyed before destroying the network.

Terraform Advanced

Provisioners

- Provisioners can be used to model specific actions on the local machine or on a remote machine in order to prepare servers or other infrastructure objects for service.
- Running Provisioners can help you to execute stuff as per requirement
- The local-exec provisioner executes a command locally on the machine running Terraform, not the VM instance itself.
- Terraform don't encourage the use of provisioners, as they add complexity and uncertainty to terraform usage. Hashicorp recommends resolving your requirement using other techniques first, and use provisioners only if there is no other option left.
- When deploying virtual machines or other similar compute resources, we often need to pass in data about other related infrastructure that the software on that server will need to do its job.
- **Note:** Provisioners should only be used as a last resort. For most common situations there are better alternatives.

Provisioners

- Provisioners also add a considerable amount of complexity and uncertainty to Terraform usage.
- Firstly, Terraform cannot model the actions of provisioners as part of a plan because they can in principle take any action.
- Secondly, successful use of provisioners requires coordinating many more details than Terraform usage usually requires - direct network access to your servers, issuing Terraform credentials to log in, making sure that all of the necessary external software is installed, etc.
- Some use cases:
  - Passing data into virtual machines and other compute resources
  - Running configuration management software

Local-exec Provisioners

- Running Provisioners can help you to execute stuff as per requirement
- The local-exec provisioner executes a command locally on the machine running Terraform, not the VM instance itself.

```
resource "aws_instance" "myawsserver" {
  ami = "ami-0603cbe34fd08cb81"
  instance_type = "t2.micro"
  key_name = "test1"

  tags = {
    Name = "Techlanders-aws-ec2-instance"
    env = "test"
  }
  provisioner "local-exec" {
    command = "echo The servers IP address is ${self.private_ip} && echo ${self.private_ip} myawsserver >> /etc/hosts"
  }
```

Remote-Exec Provisioners

- Remote-Exec provisioner helps you to execute commands on next machine:

```
resource "aws_instance" "myawsserver" {
  ami = "ami-0603cbe34fd08cb81"
  instance_type = "t2.micro"
  key_name = "test1"
provisioner "remote-exec" {
    inline = [
     "touch /tmp/gagandeep",
      "sudo mkdir /root/gagan"
     ]
 connection {
    type     = "ssh"
    user     = "ec2-user"
    insecure = "true"
    private_key = "${file("test1.pem")}"
    host     =  aws_instance.myawsserver.public_ip
  }
}
}
```

Multiple Providers

- Same Providers with multiple alias can be given for region or attributes change:

```
provider "aws" {
  region = "us-east-2"
  access_key = "AKIAJB2KQBDL56XQEYA"
  secret_key = "rNNWuzvBpp+v//XCB10Zr2OVuPI3iayxXXStPs"
  alias  = "useast2"
}

provider "aws" {
  region = "us-east-1"
  access_key = "AKIAJB2KQBD56XQEYA"
  secret_key = "rNNWuzvBpp//B10Zr2OVuPI3iayxXXStPs"
  alias  = "useast1"
}
```

Multiple Providers

- Provide the provider name in resource:

```
resource "aws_instance" "myawsserver1" {
  ami = "ami-0c94855ba95c71c99"
  instance_type = "t2.micro"
  provider = aws.useast1
  tags = {
    Name = "Techlanders-aws-ec2-instance1"
    Env = "Prod"
  }
}
resource "aws_instance" "myawsserver2" {
  ami = "ami-0603cbe34fd08cb81"
  provider = aws.useast2
  instance_type = "t2.micro"

  tags = {
    Name = "Techlanders-aws-ec2-instance2"
    Env = "Prod"
  }
}
```

Variables

- To become truly shareable and version controlled as well as to avoid hardcoding, we need to parameterize the configurations. Same can be achieved through input variables in Terraform. Variables can be defined in different .tf files and usually we define it in variable.tf or files ending with .tfvars file.

```
variable "project" { }

variable "credentials_file" { }

variable "region" {
  default = "us-central1"
}

variable "zone" {
  default = "us-central1-c"
}
```

Variables

- Variables can be of different types, based on terraform versions:
  - Strings

```
variable "project" {
 type = string }
```

  - Numbers

```
variable "web_instance_count" {
 type    = number
 default = 1 }
```

  - Lists

```
variable "cidrs" { default = ["10.0.0.0/16”] }
```

  - Maps

```
variable "machine_types" {
 type    = map
 default = {
   dev  = "f1-micro"
   test = "n1-highcpu-32"
   prod = "n1-highcpu-32"
 }
```

Variables

- Variables can be assigned via different ways:
  - Via UI
  - Via command line flags:

    terraform plan -var 'project=<PROJECT_ID>’

  - From .tfvars file
  - From environment variables like TF_VAR_name

Copyrights @TechLanders Solutions

Variables

```
variable "image_id" {
  type = string
}

variable "availability_zone_names" {
  type    = list(string)
  default = ["us-west-1a"]
}

variable "docker_ports" {
  type = list(object({
    internal = number
    external = number
    protocol = string
  }))
  default = [
    {
      internal = 8300
      external = 8300
      protocol = "tcp"
    }
  ]
}
```

Lab: Variables

1) Declare AMI as variable and use same in your aws_instance resource

2) Define the value of AMI(with AMIID) inside terraform.tfvars file

3) terraform plan

4) Rename terraform.tfvars with abc.tfvars

5) Run terraform plan again

6) Run terraform plan with -var-file=abc.tfvars and see the outputs

7) Run terraform plan with -var ami="AMI_ID"

Variables

```
resource "aws_instance" "myawsserver1" {
  ami = var.ami["us-east-1"]
  instance_type = var.instance_type
  provider = aws.useast1
  tags = {
    Name = "Techlanders-aws-ec2-instance1"
    Env = "Prod"
  }
}
variable "instance_type" {
  default = "t2.micro"
}

variable "ami" {
  type = "map"
default = {
    us-east-1     = "ami-0c94855ba95c71c99"
    us-east-2     = "ami-0603cbe34fd08cb81"
  }
}
```

Variables Definition Precedence

Terraform loads variables in the following order, with later sources taking precedence over earlier ones:

- Environment variables
- The terraform.tfvars file, if present.
- The terraform.tfvars.json file, if present.
- Any *.auto.tfvars or *.auto.tfvars.json files, processed in lexical order of their filenames.
- Any -var and -var-file options on the command line, in the order they are provided. (This includes variables set by a Terraform Cloud workspace.)

Tfvars files

```
[root@ip-172-31-38-249 third-demo]# cat prod.tfvars
instance_type =  "t2.small"

ami = {
   us-east-1     = "ami-0dba2cb6798deb6d8"
   us-east-2     = "ami-07efac79022b86107 "
 }

[root@ip-172-31-38-249 third-demo]# cat dev.tfvars
instance_type =  "t2.medium"

ami = {
   us-east-1     = "ami-0dba2cb6798deb6d8"
   us-east-2     = "ami-07efac79022b86107 "
 }

[root@ip-172-31-38-249 third-demo]#
```

Executions

```
[root@ip-172-31-38-249 third-demo]# terraform plan
An execution plan has been generated and is shown below.
+ resource "aws_instance" "myawsserver1" {
      + ami                       = "ami-0c94855ba95c71c99"
+ instance_type                  = "t2.micro"

[root@ip-172-31-38-249 third-demo]# terraform plan -var-file="dev.tfvars"
Refreshing Terraform state in-memory prior to plan...
 # aws_instance.myawsserver1 will be created
  + resource "aws_instance" "myawsserver1" {
      + ami                       = "ami-0dba2cb6798deb6d8"
+ instance_type                  = "t2.medium"

[root@ip-172-31-38-249 third-demo]# terraform plan -var "instance_type=t2.nano"
Refreshing Terraform state in-memory prior to plan...
 # aws_instance.myawsserver1 will be created
  + resource "aws_instance" "myawsserver1" {
      + ami                       = "ami-0c94855ba95c71c99"
+ instance_type                  = "t2.nano"
```

Loops

- Terraform offers several different looping constructs, each intended to be used in a slightly different scenario:
  - count parameter: loop over resources.
  - for_each expressions: loop over resources and inline blocks within a resource.
  - for expressions: loop over lists and maps.

Copyrights @TechLanders Solutions

Lab Exercise

Create an EC2 instance in Ohio Region with the below details:

1) Create a VPC with your name

2) Create a subnet as a private-yourname under above VPC

3) Create a keypair with your-name-21sep

4) Create a Server under the above VPC/Subnet and with the above keypair

5) Use variable for AMI and it must ask for AMI ID during the runtime

6) Hardware should be defaulted to t2.micro but should be changeable by providing a value as "t2.nano" under terraform.tfvars file

7) Server name it should ask during the runtime

Add-on

1) Check the public IP for your server? Is it there? Why not? Make sure it'll be there now...

2) is the server accessible after PUBLIC IP? Why not?

Loops - count

- Depending on resource types, it'll take count values to create number of resources:

```
provider "aws" {
  region = "us-east-2"
 access_key = "AKIAJB2KQBDLH56XQEYA"
  secret_key = "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"
}
resource "aws_instance" "myawsserver" {
  ami = "ami-0603cbe34fd08cb81"
  instance_type = "t2.micro"
  key_name = "test1"
  count = 2
  tags = {
    Name = "Techlanders-aws-ec2-instance.${count.index}"
    env = "test"
  }
}
output "Private-IP-0" {
 value = aws_instance.myawsserver.0.private_ip
}
output "Private-IP-1" {
 value = aws_instance.myawsserver.1.private_ip
}
```

Loops - count

```
variable "server_names" {
  description = "Create virtual machines with these names"
  type        = list(string)
  default     = ["myvm1", "myvm2"]
}

resource "aws_instance" "myawsserver" {
  ami = "ami-0603cbe34fd08cb81"
  instance_type = "t2.micro"
  key_name = "test1"
  count = length(var.server_names)
  tags = {
    Name = var.server_names[count.index]
    env = "test"
  }
}

output "Private-IP" {
 value = aws_instance.myawsserver[*].private_ip
}
```

for and for-each

- COUNT have its own limitations. Delete a string from count from previous example and then look at the Terraform behavior. If you remove an item from the middle of the list, Terraform will delete every resource after that item and then recreate those resources again from scratch.
- COUNT can't be used with-in resource.
- Based on complexity of your playbook, you can use for and for_each loops in your configuration files.
- This is similar to loops in Programming languages.
- https://www.hashicorp.com/blog/hashicorp-terraform-0-12-preview-for-and-for-each/

Copyrights @TechLanders Solutions

for-each

```
variable "server_names" {
  description = "Create virtual machines with these names"
  type        = list(string)
  default     = ["vm1", "vm2"]
}

resource "aws_instance" "myawsserver" {
  ami = "ami-0603cbe34fd08cb81"
  instance_type = "t2.micro"
  key_name = "test1"
  for_each = toset(var.server_names)
  tags = {
    Name = each.value
    env = "test"
  }
}

output "Private-IP" {
# As for_each loop is a map, you have to modify the syntax to get the values printed
 value = values(aws_instance.myawsserver)[*].private_ip
}
```

For loop

Terraform's for expressions allow you to loop over a map using the following syntax:
[for <KEY>, <VALUE> in <MAP> : <OUTPUT>]

e.g.

```
output "Private-IP" {
value = {
  for instance in aws_instance.myawsserver:
    instance.id => instance.private_ip
 }
}
```

Sensitive values

```
variable "env" {
type = string
default = "dev"
sensitive = "true”
}


output "my-ip" {
value = var.env
sensitive = true
}
```

Terraform allows you to protect your sensitive data from being exposed in outputs and logs

Copyrights @TechLanders Solutions

Statefiles

- Terraform apply will create **tfstate** file to maintain the desired state:

```
[root@TechLanders aws]# ls -l
total 8
-rw-r--r--. 1 root root  234 Aug 15 07:06 myinfra.tf
-rw-r--r--. 1 root root 3209 Aug 15 08:02 terraform.tfstate
[root@TechLanders aws]# cat terraform.tfstate
{
 "version": 4,
 "terraform_version": "0.13.0",
 "serial": 1,
 "lineage": "7f7e0e15-95ef-d8fa-b1cd-12024aed5fa6",
 "outputs": {},
 "resources": [
  "provider": "provider[\"registry.terraform.io/hashicorp/aws\"]",
    "instances": [
     {
      "schema_version": 1,
      "attributes": {
        "ami": "ami-06b35f67f1340a795",
        "arn": "arn:aws:ec2:us-east-2:677729060277:instance/i-0a63756c96d338801",
```

- Note: -auto-approve option can be given alongwith terraform apply to avoid the human intervention.

Terraform lockfile for security

- Terraform acquires a state lock to protect the state from being written by multiple users at the same time.
- Just run terraform apply or destroy and don't provide any input on its confirmation command. Open a new terminal and look for .terraform.tfstate.lock.info file being created in the directory.

```
C:\Users\gagandeep\terra>dir
16-08-2020  00:24    <DIR>          .
16-08-2020  00:24    <DIR>          ..
16-08-2020  00:12    <DIR>          .terraform
16-08-2020  00:24               226 .terraform.tfstate.lock.info
16-08-2020  00:08               243 myinfra.tf
15-08-2020  11:45        85,426,504 terraform.exe
16-08-2020  00:22             3,203 terraform.tfstate
16-08-2020  00:22             3,205 terraform.tfstate.backup
               5 File(s)     85,433,381 bytes
               3 Dir(s)  735,488,614,400 bytes free
C:\Users\gagandeep\terra>
```

- State locking happens automatically on all operations that could write state. You won't see any message that it is happening. If state locking fails, Terraform will not continue.
- You can disable state locking for most commands with the -lock flag but it is not recommended.
- You can unlock terraform with terraform force-unlock LOCK_ID command.

State files

- Terraform must store state about your managed infrastructure and configuration. This state is used by Terraform to map real world resources to your configuration, keep track of metadata, and to improve performance for large infrastructures.
- Terraform uses this local state to create plans and make changes to your infrastructure. Prior to any operation, Terraform does a refresh to update the state with the real infrastructure.
- This state is stored by default in a local file named "terraform.tfstate", but it can also be stored remotely, which works better in a team environment.
- State snapshots are stored in JSON format
- What will happen if multiple people from a team are working on the requirement?
- How code will me managed and how state file will be maintained?

Remote State

- When working with Terraform in a team, use of a local file makes Terraform usage complicated because each user must make sure they always have the latest state data before running Terraform and make sure that nobody else runs Terraform at the same time.

- With remote state, Terraform writes the state data to a remote data store, which can then be shared between all members of a team. Terraform supports storing state in Terraform Cloud, HashiCorp Consul, Amazon S3, Alibaba Cloud OSS, and more.

- Here are some of the benefits of backends:
  - **Working in a team:** Backends can store their state remotely and protect that state with locks to prevent corruption. Some backends such as Terraform Cloud even automatically store a history of all state revisions.
  - **Keeping sensitive information off disk**: State is retrieved from backends on demand and only stored in memory. If you're using a backend such as Amazon S3, the only location the state ever is persisted is in S3.
  - **Remote operations:** For larger infrastructures or certain changes, terraform apply can take a long, long time. Some backends support remote operations which enable the operation to execute remotely. You can then turn off your computer and your operation will still complete. Paired with remote state storage and locking above, this also helps in team environments.

Remote State - AWS

```
terraform {
  backend "s3" {
    bucket  = "techlanders-statefile"
    key  = "terraform/state"
    region = "us-east-2”
#  access_key = "AKIAJLH56XQEYA"
 #  secret_key = "rNNWOXCB10Zr2OVuPI3iayxXXStPs"
  }
}
```

```
[root@ip-172-31-38-249 loops]# terraform init

Initializing the backend...

Successfully configured the backend "s3"! Terraform will automatically

use this backend unless the backend configuration changes.
```

State Locking- AWS

```
terraform {
 backend "s3" {
   bucket  = "techlanders-statefile"
   key  = "terraform/state"
   region = "us-east-2“
   dynamodb_table = "tflock”                          //create a dynamodb table with LockID column –type String for State Locking
 #  access_key = "AKIAJLH56XQEYA"
 #  secret_key = "rNNWOXCB10Zr2OVuPI3iayxXXStPs"
 }
}
```

```
[root@ip-172-31-38-249 loops]# terraform init

Initializing the backend...

Successfully configured the backend "s3"! Terraform will automatically

use this backend unless the backend configuration changes.
```

Importing Resources

Importing existing resources

```
[root@techlanders]# cat resource.tf
resource "aws_instance" "gagan-ec2" {
  ami           = "ami-0c94855ba95c71c99"
  instance_type = "t2.micro"
  availability_zone = "us-east-1e"
}
[root@techlanders]#

#use terraform import command to import state in terraform statefile
[root@techlanders]# terraform import aws_instance.gagan-ec2 i-073cd0c68788f5c57
[root@techlanders]# terraform show
[root@techlanders]# terraform plan
[root@techlanders]# terraform apply
```

Importing existing resources

- You can import existing resources – which are not created using terraform command, into terraform state using terraform import command.
- The current implementation of Terraform import can only import resources into the state. It does not generate configuration. A future version of Terraform will also generate configuration.
- Because of this, prior to running terraform import it is necessary to write a resource configuration block for the resource manually, to which the imported object will be attached.
- This command will not modify your infrastructure, but it will make network requests to inspect parts of your infrastructure relevant to the resource being imported.

Data Sources

Data Sources

- Data sources allow data to be fetched or computed for use elsewhere in Terraform configuration. Use of data sources allows a Terraform configuration to make use of information defined outside of Terraform or defined by another separate Terraform configuration.

- Each provider may offer data sources alongside its set of resource types.

Data Sources

```
#aws ec2 describe-images    --region us-east-2    --image-ids ami-00399ec92321828f5
#
data "aws_ami" "web" {
  owners         = ["099720109477"]
  filter {
    name = "virtualization-type"
    values = ["hvm"]
   }
most_recent = true
}
```

NOTE: Identify Image, Owners, Details from AMI section of AWS GUI

Data Sources

```
provider "aws" {
  region = "us-east-2"
}

data "aws_ami" "amazon_linux" {
  most_recent = true
  owners      = ["amazon"]

  filter {
    name   = "name"
    values = ["amzn2-ami-hvm-*-x86_64-gp2"]
  }
}
data "aws_region" "current" { }
resource "aws_instance" "myawsserver" {
  ami = data.aws_ami.amazon_linux.id
  instance_type = "t2.micro"

  tags = {
    Name = "Techlanders-aws-ec2-instance"
    Env = "Dev"
  }
}
output "myawsserver-ip" {
  value = aws_instance.myawsserver.public_ip
}
output "region" {
 value = data.aws_region.current.name
}
```

Data Sources

```
data "aws_ami" "amazon_linux" {
  most_recent = true
  owners      = ["309956199498"]

  filter {
    name   = "name"
    values = ["RHEL-8.*-x86_64-2-Hourly2-GP2"]
  }
}
```

Terraform Workspace

Workspaces

- Workspace is to create multiple isolated environments in same directory.
- Terraform starts with a single workspace named "default” and same can’t be deleted.
- Named workspaces allow conveniently switching between multiple instances of a single configuration within its single backend.
- A common use for multiple workspaces is to create a parallel, distinct copy of a set of infrastructure in order to test a set of changes before modifying the main production infrastructure. For example, a developer working on a complex set of infrastructure changes might create a new temporary workspace in order to freely experiment with changes without affecting the default workspace.
- It’ll create terraform.tfstate.d directory with internal workspace-name subdirectories to handle state files.

Workspaces

- terraform workspace list
- terraform workspace new {new-workspace-name}
- terraform workspace show
- terraform workspace select {workspace-name}
- terraform workspace delete {workspace-name}

Terraform Modules

Terraform Modules

A module is a container for multiple resources that are used together. Modules can be used to create lightweight abstractions, so that you can describe your infrastructure in terms of its architecture, rather than directly in terms of physical objects.

The .tf files in your working directory when you run terraform plan or terraform apply together form the root module. That module may call other modules and connect them together by passing output values from one to input values of another.

Usual Structure:

```
$ tree minimal-module/
.
├── README.md
├── main.tf
├── variables.tf
├── outputs.tf
```

Terraform Modules

Define variables under one resource file under /root/app1 directory and then use same as module in separate folder/resource file:

```
provider "aws" {
 region = "us-east-2"
}

module "s1" {
source = "/root/app1"
bucket = “my-module-test"
instance_type = "t2.micro"
ami = "ami-00399ec92321828f5"
}
```

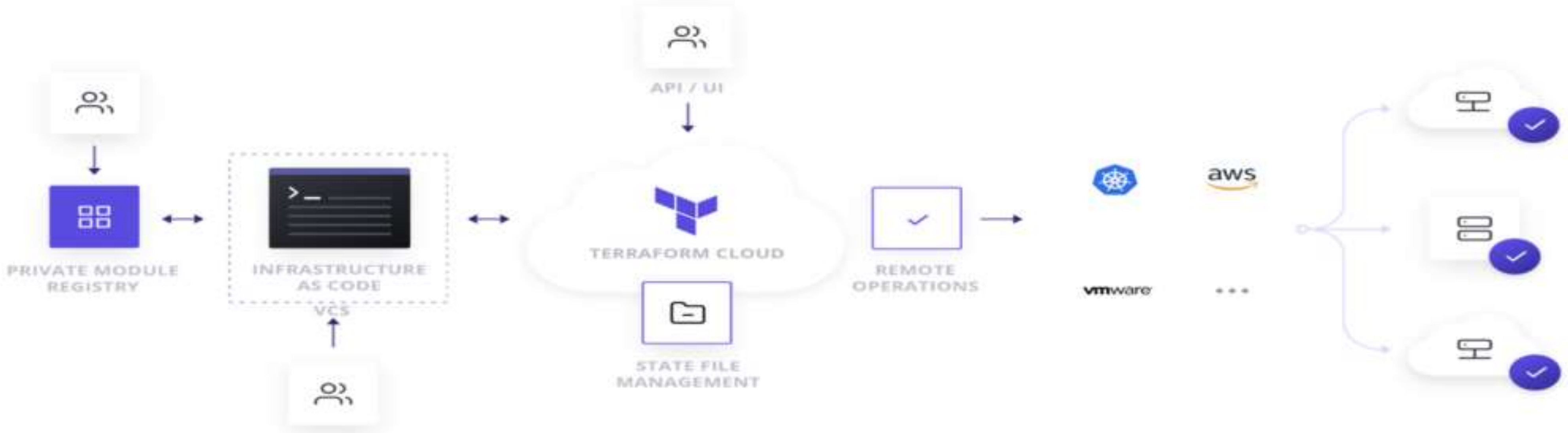
OEM Modules usage

```
provider "aws" {
  region = "us-east-2"
}
module "vpc" {
  source = "terraform-aws-modules/vpc/aws"
  name = "gds-vpc"
  cidr = "10.0.0.0/16"
  azs             = ["us-east-2a", "us-east-2b"]
  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 = false
  enable_vpn_gateway = false
  tags = {
    Terraform = "true"
    Environment = "dev"
  }
}
```

Terraform Cloud

Terraform Cloud

Terraform Cloud is an application that helps teams use Terraform together. It manages Terraform runs in a consistent and reliable environment and includes easy access to shared state and secret data, access controls for approving changes to infrastructure, a private registry for sharing Terraform modules, detailed policy controls for governing the contents of Terraform configurations, and more.



Terraform Cloud

It is a platform that performs Terraform runs to provision infrastructure, either on demand or in response to various events

Terraform Cloud offers a **team-oriented remote Terraform workflow**, designed to be comfortable for existing Terraform users and easily learned by new users. The foundations of this workflow are remote Terraform execution, a **workspace-based organizational model**, **version control integration**, **command-line integration, remote state management** with cross-workspace data sharing, and a **private Terraform module registry.**

Terraform Cloud runs Terraform on **disposable virtual machines in its own cloud infrastructure**. **Remote Terraform execution** is sometimes referred to as "remote operations."

Terraform Cloud

- Terraform cloud is a GUI based Cloud SaaS solution. It is offered as a multi-tenant SaaS platform and is designed to suit the needs of smaller teams and organizations.
- Benefits of Terraform Cloud:
  - It manages Terraform runs in a consistent and reliable environment.
  - Best for bigger teams, as it provides secure and easy access to shared state and secret data.
  - It offers Remote State Management, Data Sharing, Run Triggers, and Private registry for Terraform modules.
  - Role Based Access Controls (RBAC) for approving changes to infrastructure.
  - Version Control Integration with Major VCS providers like Github, Gitlab, Bitbucket, Azure DevOps
  - Full APIs support for all operations to integrate this with other tools and environments.

Terraform Cloud

- Notifications can be configured with services which support webhooks
- You can run the configuration from existing environment or from terraform cloud-based server.
- **Sentinel Policies:** Terraform Cloud embeds the Sentinel policy-as-code framework, which lets you define and enforce granular policies for how your organization provisions infrastructure. You can limit the size of compute VMs, confine major updates to defined maintenance windows, and much more. Policies can act as firm requirements, advisory warnings, or soft requirements that can be bypassed with explicit approval from your compliance team.
- **Cost Estimation**: Before making changes to infrastructure in the major cloud providers, Terraform Cloud can display an estimate of its total cost, as well as any change in cost caused by the proposed updates.

Terraform Enterprise

- Terraform Enterprise is a self-hosted distribution of Terraform Cloud Application.
- Provides additional security as everything is on-prem.
- It offers enterprises a private instance of the Terraform Cloud application, with no resource limits and with additional enterprise-grade architectural features like audit logging and SAML single sign-on.

Best Practices

Best Practices

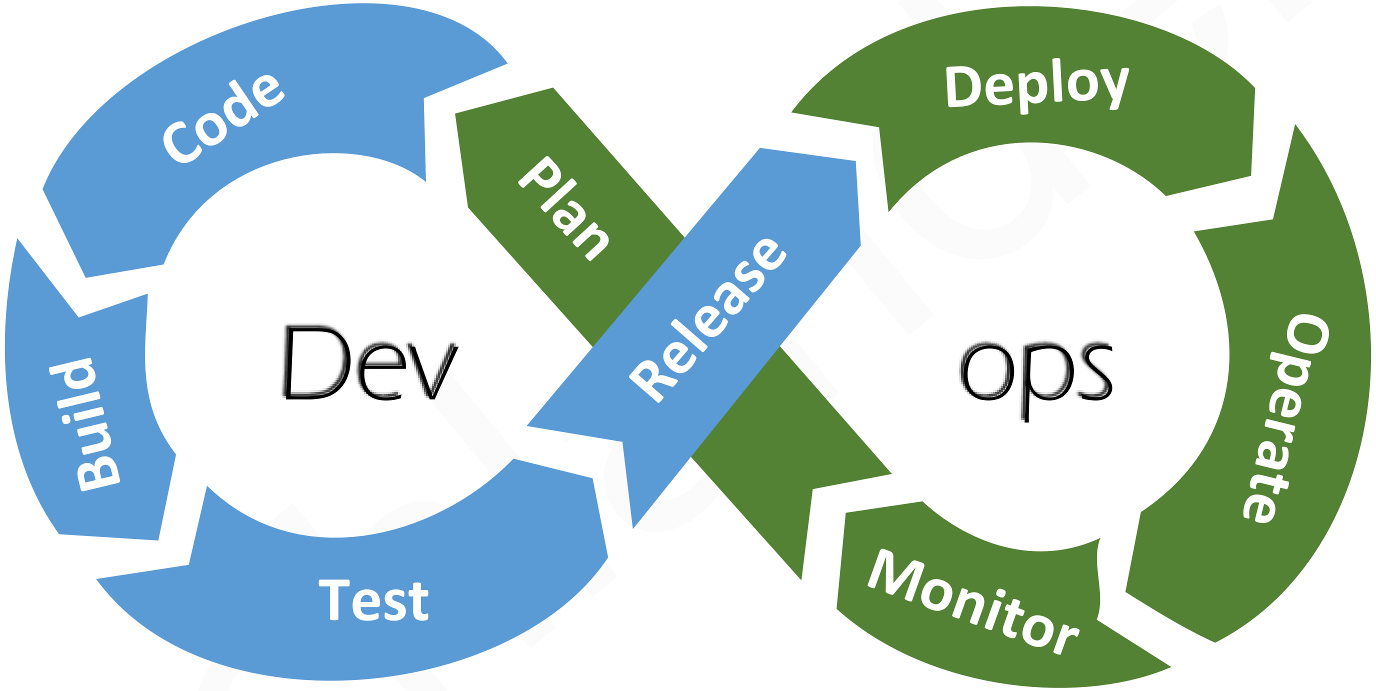
- Terraform recognizes files ending in .tf or .tf.JSON as configuration files and will load them when it runs. When run, Terraform loads all configuration files from the current directory. So, it's a good idea to organize your configurations into separate files like variable.tf, output.tf, main.tf, provider.tf etc and do make sure to have a README.md file to describe your project/Module.
- Successful execution of terraform plan doesn't mean actual implementation will be always successful. It may fail due to provider parameters issues. For example, in case you provide an image name that doesn't exist, terraform will take it and assume it'll be available, and the plan will get successful. So, a real run can only provide you with better assurance.
- Even a Real run sometime will not be helpful if your backend environment is changing. For example, perfect execution of infrastructure deployment in your AWS environment doesn't mean it'll work in a client environment too if you have hardcoded the things. For example, in case you hardcode keypair or network in your configuration file.
- Sometimes even configuration parameters become hardcoded and create a problem. For example, a bucket name must be globally unique in GCP/AWS/Azure. If you have used that name already somewhere in your test/dev account, the same can not be used in prod or client accounts – which are configured under the bucket name section under terraform configuration file. Hence consider this factor too.
- Use lower case names and underscores, wherever possible, instead of first letter capital or all capital letters in resource names (even in AWS names/tags as best practices). Create a standard and ask the team to follow the same standard throughout.

Best Practices

- Use Specific Versions in your configuration and make the same required minimum version(on which you have tested/run your code). Versioning of Terraform, Providers, and Modules; all to be taken care. Terraform and provider versions have usually been used in a way – any version above the tested version. The module version should be specific.
- During working inside a team, always keep your configuration files on a GitHub or similar VCS.
- Keep your remote state on S3/GCS (**with versioning enabled**) for HA and collaborative working.
- Follow DRY Principle. The DRY principle is stated as "Every piece of knowledge must have a single, unambiguous, authoritative representation within a system”. Create centralized modules and use the same across projects.
- Have thumb rule- **Let the expert do its job**. Use Terraform for Infra provisioning only, not for Configuration management. The same rules applied to CM tools (for not to use them for Infra provisioning).
- Do the automation wherever possible.
- Hardcoding will hinder real automation needs. Hence, make sure to put the things in variables wherever possible.
- Use loops, and conditions vigorously.
- **MOST IMP – Have proper comments and keep the config Simple.**

Terraform in DevOps

Terraform in DevOps



Terraform in DevOps

Continuous Integration

Code $\xrightarrow{\text{Auto}}$ Unit Test $\xrightarrow{\text{Auto}}$ Integration Test $\xrightarrow{\text{Auto}}$ Acceptance Test $\xrightarrow{\text{Manual}}$ Deployment

Continuous Deployment

Code $\xrightarrow{\text{Auto}}$ Unit Test $\xrightarrow{\text{Auto}}$ Integration Test $\xrightarrow{\text{Auto}}$ Acceptance Test $\xrightarrow{\text{Auto}}$ Deployment

Terraform in DevOps