Terraform Associate Certification

What is IaC?

Infrastructure as code (IaC) means to manage your IT infrastructure using configuration files.

Why IaC?

Historically, managing IT infrastructure was a manual process. People would physically put servers in place and configure them. Only after the machines were configured to the correct settings required by the OS and dependencies would those people deploy the application.

Businesses are making a transition where traditionally managed infrastructure can no longer meet the demands of today's businesses. IT organizations are quickly adopting the public cloud, which is predominantly API-driven.

To meet customer demands and save costs, application teams are architecting their applications to support a much higher level of elasticity, supporting technology like containers and public cloud resources. These resources may only live for a matter of hours; therefore, the traditional method of raising a ticket to request resources is no longer a viable option.

Benefits of IaC

Speed

IaC benefits a company's IT architecture and workflow as it uses automation to substantially increase the provisioning speed of the infrastructure's development, testing, and production.

Consistency

Since it is code, it generates the same result every time. It provisioned the same environment every time, enabling improved infrastructure consistency at all times.

Cost

One of the main benefits of IaC is, without a doubt, lowering the costs of infrastructure management. With everything automated and organized, engineers save up on time and cost which can be wisely invested in performing other manual tasks and higher-value jobs.

Minimum Risk

IaC allows server configuration that can be documented, logged, and tracked later for reference. Configuration files will be reviewed by a person or policy as a code (sentinel) for security leakages.

Everything Codified

The main benefit of IaC is explicit coding to configure files in use. You can share codes with the team, test them to ensure accuracy, maintain uniformity and update your infrastructure into the same flow of IaC.

Version Controlled, Integrated

Since the infrastructure configurations are codified, we can check-in into version control like GitHub and start versioning it.

IaC allows you to track and give insight on what, who, when, and why anything changed in the process of deployment. This has more transparency which we lack in traditional infrastructure management.

Now, we know what Infrastructure as Code is means, now let's deep dive into Terraform...

Terraform

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 which has been developed by HashiCorp.

A provider is responsible for understanding API interactions and exposing resources. Most of the available providers correspond to one cloud or on-premises infrastructure platform and offers resource types that correspond to each of the features of that platform.

To make a provider available on Terraform, we need to make a `terraform init`, these commands download any plugins we need for our providers. If for example, we need to copy the plugin directory manually, we can do it, moving the files to `.terraform.d/plugins`

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

If the plugin is already installed, terraform init will not download again unless to upgrade the version, run terraform init -upgrade.

Multiple Providers

You can optionally define multiple configurations for the same provider and select which one to use on a per-resource or per-module basis.

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

# reference this as `aws.west`.
provider "aws" {
  alias  = "west"
  region = "us-west-2"
}
```

Versioning

The required_version setting can be used to constrain which version of the Terraform CLI can be used with your configuration. If the running version of Terraform doesn't match the constraints specified, Terraform will produce an error and exit without taking any further actions.

```
terraform {
  required_version = ">= 0.12"
}
```

The value for required_version is a string containing a comma-separated list of constraints. Each constraint is an operator followed by a version number, such as > 0.12.0. The following constraint operators are allowed:

- = (or no operator): exact version equality

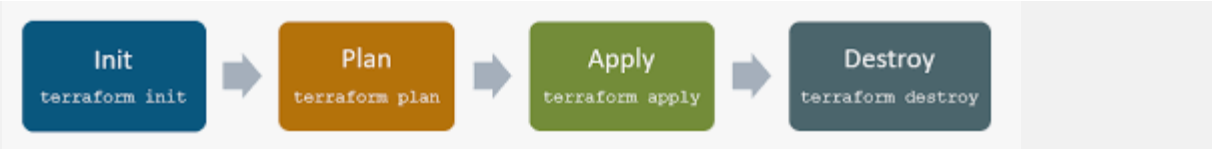
- `!=`: version not equal
- `>`, `>=`, `<`, `<=`: version comparison, where "greater than" is a larger version number
- `~>`: pessimistic constraint operator, constraining both the oldest and newest version allowed. For example, `~> 0.9` is equivalent to `>= 0.9, < 1.0`, and `~> 0.8.4`, is equivalent to `>= 0.8.4, < 0.9`

We can also specify a provider version requirement

```
provider "aws" {
    region = "us-east-1"
    version = ">= 2.9.0"
}
```

Show version: `$ terraform version`

Terraform Workflow



Terraform Init

The `terraform init` command is used to initialise a working directory containing Terraform configuration files.

During init, the configuration is searched for module blocks, and the source code for referenced modules is retrieved from the locations given in their source arguments.

Terraform must initialize the provider before it can be used.

Initialization downloads and installs the provider's plugin so that it can later be

executed.

Initializes the backend configuration.

It will not create any sample files like example.tf

Init Terraform and don't ask any input

```
$ terraform init input= false
```

Change backend configuration during the init

`$ terraform init •backend•config=cfg/s3.dev.tf • reconfigure` is used in order to tell terraform to not copy the existing state to the new remote state location.

Terraform plan

The terraform plan command is used to create an execution plan.

It will not modify things in infrastructure.

Terraform performs a refresh, unless explicitly disabled, and then determines what actions are necessary to achieve the desired state specified in the configuration files.

This command is a convenient way to check whether the execution plan for a set of changes matches your expectations without making any changes to real resources or to the state.

```
$ terraform plan
```

Terraform Apply

The terraform apply command is used to apply the changes required to reach the desired state of the configuration.

Terraform apply will also write data to the terraform.tfstate file.

Once the application is completed, resources are immediately available.

```
$ terraform apply
```

Apply and auto approve

```
$ terraform apply •auto•approve
```

Apply and define new variables value

```
$ terraform apply •auto•approve •var
tags•repository_url=${GIT_URL}
```

Apply only one module

```
$ terraform apply •target=module.s3
```

This -target option works with terraform plan too.

Terraform Refresh

The terraform refresh command is used to reconcile the state Terraform knows about (via its state file) with the real-world infrastructure.
This does not modify infrastructure but does modify the state file.

Terraform Destroy

The terraform destroy command is used to destroy the Terraform-managed infrastructure.
terraform destroy command is not the only command through which infrastructure can be destroyed.

```
$ terraform destroy
```

You can remove the resource block from the configuration and run terraform apply this way you can destroy the infrastructure.

A deletion plan can be created before:

```
$ terraform plan -destroy
```

•target option allow to destroy only one resource, for example a S3 bucket:

```
$ terraform destroy •target aws_s3_bucket.my_bucket
```

Terraform Validate

The terraform validate command validates the configuration files in a directory.
Validate runs checks that verify whether a configuration is syntactically valid and thus primarily useful for general verification of reusable modules, including the correctness of attribute names and value types.
It is safe to run this command automatically, for example, as a post-save check in a text editor or as a test step for a reusable module in a CI system. It can run before the terraform plan.
Validation requires an initialized working directory with any referenced plugins and modules installed.

```
$ terraform validate
```

Provisioners

Provisioners can be used to model specific actions on the local machine or on a remote machine to prepare servers or other infrastructure objects for service.
Provisioners are inside the resource block.
Note: Provisioners should only be used as a last resort. For most common situations there are better alternatives.

file Provisioner

The file provisioner is used to copy files or directories from the machine executing Terraform to the newly created resource.

```
resource "aws_instance" "web" {
  # ...

  # Copies the myapp.conf file to /etc/myapp.conf
  provisioner "file" {
    source      = "conf/myapp.conf"
    destination = "/etc/myapp.conf"
  }
```

local-exec Provisioner

The local-exec provisioner requires no other configuration, but most other provisioners must connect to the remote system using SSH or WinRM.

```
resource "aws_instance" "web" {
  # ...
  provisioner "local-exec" {
    command = "echo The server's IP address is
${self.private_ip}"
  }
}
```

remote-exec Provisioner

The remote-exec provisioner invokes a script on a remote resource after it is created. This can be used to run a configuration management tool, bootstrap into a cluster, etc.

```
resource "aws_instance" "web" {
  # ...

  provisioner "remote-exec" {
    inline = [
      "puppet apply",
      "consul join ${aws_instance.web.private_ip}",
```

```
    ]
  }
}
```

Creation-time Provisioners

By default, provisioners run when the resource they are defined within is created. Creation-time provisioners are only run during creation, not during updating or any other lifecycle. They are meant to perform bootstrapping of a system. If a creation-time provisioner fails, the resource is marked as tainted. A tainted resource will be planned for destruction and recreation upon the next `terraform apply`

Destroy-time Provisioners

if `when = "destroy"` is specified, the provisioner will run when the resource it is defined within is destroyed.

Other Sub-commands

Terraform Format

The `terraform fmt` command is used to rewrite Terraform configuration files to a canonical format and style.
For use-case, where all configurations written by team members needs to have a proper style of code, `terraform fmt` can be used.

Terraform Taint

The `terraform taint` command manually marks a Terraform-managed resource as tainted, forcing it to be destroyed and recreated on the next apply.
This command will not modify infrastructure but does modify the state to mark a resource as tainted.

Once a resource is marked as tainted, the next plan will show that the resource will be destroyed and recreated, and the next application will implement this change.

For multiple sub-modules, the following syntax-based example can be used

```
module.foo.module.bar.aws_instance.baz
```

Terraform Untaint

The terraform untaint command manually unmark a Terraform-managed resource as tainted, restoring it as the primary instance in state.

Terraform Import

Terraform can import existing infrastructure.

This allows you to take resources that you've created by some other means and bring them under Terraform management.

The current implementation of Terraform import can only import resources into the state. It does not generate a configuration.

Because of this, prior to running terraform import, it is necessary to write a resource configuration block manually for the resource, to which the imported object will be mapped.

```
terraform import aws_instance.myec2 instance-id
```

Terraform Show

The terraform show command is used to provide human-readable output from a state or plan file.

terraform show -json will show a JSON representation of the plan, configuration, and current state.

Terraform plan -destroy

The behaviour of any terraform destroy command can be previewed at any time with an equivalent terraform plan -destroy command.

Variables

Variables play an important part in Terraform configuration when you want to manage infrastructure.

Variable Types

Strings, Numbers, Boolean, List, or Maps. We can define a default value.

The type argument in a variable block allows you to restrict the type of value that will be accepted as the value of a variable.

```
variable "vpcname" {
   type = string
   default = "myvpc"
}
```

List: List is the same as array. We can store multiple values Remember the first value is the 0 position. For example, to access the 0 position is var.mylist[0]

```
variable "mylist" {
    type = list(string)
    default = ["Value1", "Value2"]
}
```

Map: Map is a Key-Value pair. Key is needed to access the value.

```
variable "ami_ids" {
    type = map
    default = {
        "mumbai"  = "image-abc"
        "germany" = "image-def"
        "paris"   = "image-xyz"
    }
}
```

use var.ami_ids["paris"] to fetch the corresponding value.

Structural Data Types

A structural type allows multiple values of several distinct types to be grouped together as a single value.

List contains multiple values of the same type while objects can contain multiple values of different types.

Input Variables

Input variables serve as parameters for a Terraform module, allowing aspects of the module to be customized without altering the module's own source code, and allowing modules to be shared between different configurations.

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

Input variables are created by a `variable` block, but you reference them as attributes on an object named `var`.

```
resource "aws_instance" "example" {
  instance_type = "t2.micro"
  ami           = var.image_id
}
```

Because the input variables of a module are part of its user interface, you can briefly describe the purpose of each variable using the optional `description` argument:

```
variable "image_id" {
  type        = string
  description = "The id of the machine image (AMI) to use for
the server."
}
```

The description should concisely explain the purpose of the variable and what kind of value is expected.

Assigning Values to Input Variables

When variables are declared in a module or configurations, they can be set in a number of ways.

1. **Manually set** a variable when we run Terraform plan

   If values are set, then it will ask atruntime.

```
var.image_id
  The id of the machine image (AMI) to use for the server.

  Enter a value:
```

2. CLI Variables

To specify individual variables on the command line, use the -var option when running the terraform plan and terraform apply commands:

```
terraform apply -var="image_id=ami-abc123"
terraform apply -var='image_id_list=["ami-abc123","ami-def456"]'
terraform apply -var='image_id_map={"us-east-1":"ami-abc123","us-east-2":"ami-def456"}'
```

3. TFVARS files

To set lots of variables, it is more convenient to specify their values in a variable definitions file (with a filename ending in either .tfvars or .tfvars.json) and then specify that file on the command line with -var-file:

```
terraform apply -var-file="testing.tfvars"
```

4. Auto tfvars files

Terraform also automatically loads a number of variable definitions files if they are present:

- Files named exactly `terraform.tfvars` or `terraform.tfvars.json`.
- Any files with names ending in `.auto.tfvars` or `.auto.tfvars.json`.

5. Environment Variables

As a fallback for the other ways of defining variables, terraform searches the environment of its own process for environment variables named `TF_VAR_` followed by the name of a declared variable.

```
$ export TF_VAR_image_id=ami-abc123
$ terraform plan
```

Variable 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.

If the same variable is assigned multiple values, terraform uses the last value it finds.

Output Values

The terraform output command is used to extract the value of an output variable from the state file.

```
resource "aws_instance" "myec2" {
  ami           = var.image_id
  instance_type = "t2.micro"
}output "instance_id" {
    value = aws_instance.myec2.id
}
```

If we run a apply we can see the next message:

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

Outputs:

instance_id = i-0f5dc077177047e19
```

Local Values

A local value assigns a name to an expression, allowing it to be used multiple times within a module without repeating it.

The expression of a local value can refer to other locals, but as usual reference cycles are not allowed. That is, a local cannot refer to itself or to a variable that refers (directly or indirectly) back to it.

It's recommended to group together logically related local values into a single block, particularly if they depend on each other.

```
locals {
  # Ids for multiple sets of EC2 instances, merged together
  instance_ids = concat(aws_instance.blue.*.id,
aws_instance.green.*.id)
}
```

Data Source

Data sources allow data to be fetched or computed for use elsewhere in Terraform configuration.

```
data "aws_ami" "example" {
  most_recent = true

  owners = ["self"]
  tags = {
    Name   = "app-server"
    Tested = "true"
  }
}
```

Reads from a specific data source (aws_ami) and exports results under "app_ami"

Dependencies

Explicitly specifying a dependency is only necessary when a resource relies on some other resource's behaviour but doesn't access any of that resource's data in its arguments.

```
resource "aws_instance" "example" {
  ami           = "ami-a1b2c3d4"
  instance_type = "t2.micro"
  depends_on = [aws_iam_role_policy.example]
}
```

Workspace

Terraform starts with a single workspace named "default".

The workspace feature of Terraform allows users to switch between multiple instances of a single configuration with a unique state file.

For local states, terraform stores the workspace states in a directory called **terraform.tfstate.d**.

Workspace commands

1. The `terraform workspace new` command is used to create a new workspace and switched to a new workspace.
2. The `terraform workspace list` command is used to list all existing workspaces.

3. The terraform workspace select command is used to choose a different workspace to use for further operations.

4. The terraform workspace delete command is used to delete an existing workspace.

5. The terraform workspace show command is used to output the current workspace.

Note: Terraform Cloud and Terraform CLI both have features called “workspaces,” but they’re slightly different.

States

Terraform uses state to keep track of the infrastructure it manages. To use Terraform effectively, you must keep your state accurate and secure.

State is a necessary requirement for Terraform to function. It is often asked if it is possible for Terraform to work without state, or for Terraform to not use state and just inspect cloud resources on every run.

Terraform requires some sort of database to map Terraform config to the real world. Alongside the mappings between resources and remote objects, terraform must also track metadata such as resource dependencies. Terraform stores a cache of the attribute values for all resources in the state. This is done to improve performance.

For small infrastructures, terraform can query your providers and sync the latest attributes from all your resources. This is the default behaviour of Terraform: for every plan and application, terraform will sync all resources in your state.

For larger infrastructures, querying every resource is too slow. Larger users of Terraform make heavy use of the `-refresh=false` flag as well as the `-target` flag to work around this. In these scenarios, the cached state is treated as the record of truth.

State Management

State Locking

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 in most commands with the `-lock` flag but it is not recommended.

Terraform has a **force-unlock** command to manually unlock the state if unlocking failed.

Syntax: `terraform force-unlock [options] LOCK_ID [DIR]`

Sensitive Data

Terraform state can contain sensitive data, e.g. database password, etc.
When using a remote state, the state is only ever held in memory when used by Terraform.
The S3 backend supports encryption at rest when the `encrypt` option is enabled. IAM policies and logging can be used to identify any invalid access. Requests for the state go over a TLS connection.

Note: Setting an output value in the root module as sensitive prevents Terraform from showing its value in the list of outputs at the end of `terraform apply`. However, output values are still recorded in the state and so will be visible to anyone who is able to access the state data.

```
output "db_password" {
  value       = aws_db_instance.db.password
  description = "The password for logging in to the database."
  sensitive   = true
}
```

Backend Management

A backend in Terraform determines how state is loaded and how an operation such as apply is executed.

Terraform must initialize any configured backend before use.

Local

By default, terraform uses the “local” backend. After running first terraform apply the **terraform.tfstate** file created in the same directory of main.tf

terraform.tfstate file contains JSON data.
The local backend stores state on the local filesystem, locks the state using system APIs, and performs operations locally.

```
terraform {
  backend "local" {
    path = "relative/path/to/terraform.tfstate"
  }
}
```

Remote

When working with Terraform in a team, the 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 a remote state, terraform writes the state data to a remote data store, which can then be shared between all members of a team.

```
terraform {
  backend "remote" {}
}
```

This is called **partial configuration**

When configuring a remote backend in Terraform, it might be a good idea to purposely omit some of the required arguments to ensure secrets and other relevant data are not inadvertently shared with others.

```
terraform init -backend-config=backend.hcl
```

Standard Backend Types

AWS S3 bucket.

AWS S3 is typically the best bet as a remote backend for the following reason

* It's a managed service, so no need to manage infrastructure.
* It supports encryption at rest.
* It support locking via DynamoDB
* It supports versioning, so you can roll back to an older version.

```
terraform {
  backend "s3" {
    bucket = "mybucket"
    key    = "path/to/my/key"
    region = "us-east-1"    dynamodb table = "terraform-locks"
    encrypt        = true
  }
}
```

Terraform will automatically detect that you already have a state file locally and prompt you to copy it to the new S3 backend. If you type in “yes,” you should see:

```
Successfully configured the backend "s3"! Terraform will automatically use this backend unless the backend configuration changes.
```

After running this command, your Terraform state will be stored in the S3 bucket.

Note: GitHub is not supported as backend type

Terraform State commands

`terraform state list` : List resources within terraform state.

`terraform state mv` : Move items within terraform state. This will be used to resource renaming without destroy, apply command

`terraform state pull` : Manually download and output the state from the state file.

`terraform state push` : Manually upload a local state file to the remote state

terraform state rm : Remove items from the state. Items removed from the state are not physically destroyed. This item no longer managed by Terraform.

terraform state show Show attributes of a single resource in the state.

Modules

A module is a simple directory that contains other .tf files. Using modules we can make the code reusable. Modules are local or remote.

Calling Child Modules

Input variables to accept values from the calling module.
Output values to return results to the calling module, which it can then use to populate arguments elsewhere.
Resources to define one or more infrastructure objects that the module will manage.

```
variable "image_id" {
    type = string
}resource "aws_instance" "myec2" {
  ami           = var.image_id
  instance_type = "t2.micro"
}

output "instance_ip_addr" {
  value = aws_instance.myec2.private_ip
}
```

Call to the module example:

```
module "dbserver" {
     source = "./db"
     image_id = "ami-0528a5175983e7f28"
}
```

Module outputs are very similar to module inputs, an example in a module output:

```
output "privateip" {
     value = aws_instance.myec2.private_ip
}
```

It is recommended to explicitly constraining the acceptable version numbers for each external module to avoid unexpected or unwanted changes.

Version constraints are supported only for modules installed from a module registry, such as the Terraform Registry or Terraform Cloud's private module registry.

Debugging in Terraform

Terraform has detailed logs that can be enabled by setting the **TF_LOG** environment variable to any value.

You can set TF_LOG to one of the log levels TRACE, DEBUG, INFO, WARN or ERROR to change the verbosity of the logs.

```
export TF_LOG=TRACE
```

To persist logged output, you can set **TF_LOG_PATH**

```
TF_LOG_PATH=./terraform.log
```

Terraform Functions

The Terraform language includes a number of built-in functions that you can use to transform and combine values.

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

The Terraform language does not support user-defined functions, and so only the functions built into the language are available for use

Some other example built-in functions

`element` retrieves a single element from a list.

```
element(["a", "b", "c"], 1)
b
```

`lookup` retrieves the value of a single element from a map, given its key

```
lookup({a="ay", b="bee"}, "c", "what?")
what?
```

Count and Count Index

The count parameter on resources can simplify configurations and let you scale resources by simply incrementing a number.

In resource blocks where the count is set, an additional count object (count.index) is available in expressions, so that you can modify the configuration of each instance.

```
resource "aws_instance" "myec2" {
 ami         = var.image_id
 instance_type = "t2.micro"
 count = 3
}

output "instance_ip_addr" {
 value = aws_instance.myec2[*].private_ip
}
```

```
Apply complete! Resources: 3 added, 0 changed, 0 destroyed.

Outputs:

instance_ip_addr = [
  "172.31.41.113",
  "172.31.35.152",
  "172.31.45.143",
]
```

Terraform Cloud

Terraform Cloud (TFC) is a free to use, self-service SaaS platform that extends the capabilities of the open source Terraform CLI and adds collaboration and automation features.

The remote backend stores Terraform state and may be used to run operations in Terraform Cloud. When using full remote operations, operations like `terraform plan` or `terraform apply` can be executed in Terraform Cloud's run environment, with log output streaming to the local terminal.

Sentinel is an embedded policy-as-code framework integrated with the HashiCorp Enterprise products.
Sentinel is a proactive service.

Note: Terraform Cloud always encrypts the state at rest and protects it with TLS in transit.

Terraform Enterprise

Terraform Enterprise provides several added advantages compared to Terraform Cloud.

Some of these include:

- Single Sign-On
- Auditing
- Private Data Centre Networking
- Clustering

Team & Governance features are not available for Terraform Cloud Free (Paid)

Miscellaneous

1. Terraform Cloud supports the following VCS providers: GitHub, Gitlab, Bitbucket, and Azure DevOps
2. The existence of a provider plugin found locally in the working directory does not itself create a provider dependency. The plugin can exist without any reference to it in Terraform configuration.
3. The overuse of dynamic blocks can make configuration hard to read and maintain.
4. By default, provisioners that fail will also cause the terraform to apply itself to fail. The `on_failure=continue` setting can be used to change this.
5. Terraform Enterprise requires a PostgresSQL for a clustered deployment.
6. Terraform can limit the number of concurrent operations as Terraform walks the graph using the `-parallelism=n` argument. The default value for this

setting is `10`. This setting might be helpful if you're running into API rate limits.

7. terraform.tfstate and *.tfvars contains sensitive data, hence should be configured in .gitingore file.

8. Arbitrary Git repositories can be used by prefixing the address with the special git:: prefix.

9. By default, terraform will clone and use the default branch (referenced by HEAD) in the selected repository. You can override it with `?ref=version`

10. The terraform console command provides an interactive console for evaluating expressions.

11. If Terraform state file is locked then,

Blocked action: - terraform destroy and terraform apply

Non-blocked action: - terraform fmt, terraform validate, terraform state list

Exam Tip:-

Even though this exam is multiple-choice questions, it requires intense practice. Please attempt this exam only if you have done enough hands-on practice and are clear with the concepts.

1. Zeal Vora course in Udemy.
2. Bryan Krausen practice sets in Udemy.
3. Andrew Brown YouTube course for quick revision.
4. Lots of hands-on Labs: Kalyan Reddy Daida + Derek Morgan course in Udemy.