Terraform - Infrastructure-as-Code (IaC)

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IMT Atlantique

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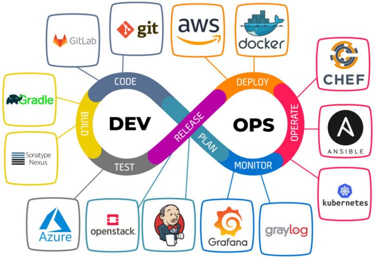
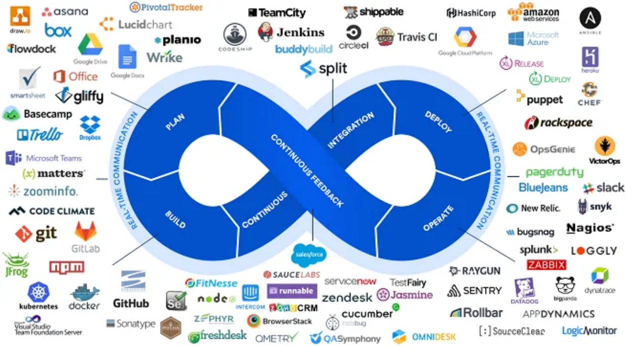
Introduction

DevOps

DevOps practices tries to reduce the time of release cycles, make more flexible (agile) software development etc., by bridging the gap between development and operation.





Relationship between DevOps and Cloud computing?

Lots of applications are now migrated to micro-serivces architectures and are deployed in the Cloud because

- servers are operated by a tiers
- companies pay only what they consume
- easy elasticity
- etc.

$\rightarrow$ **DevOps cycles very often integrate Cloud operations.**

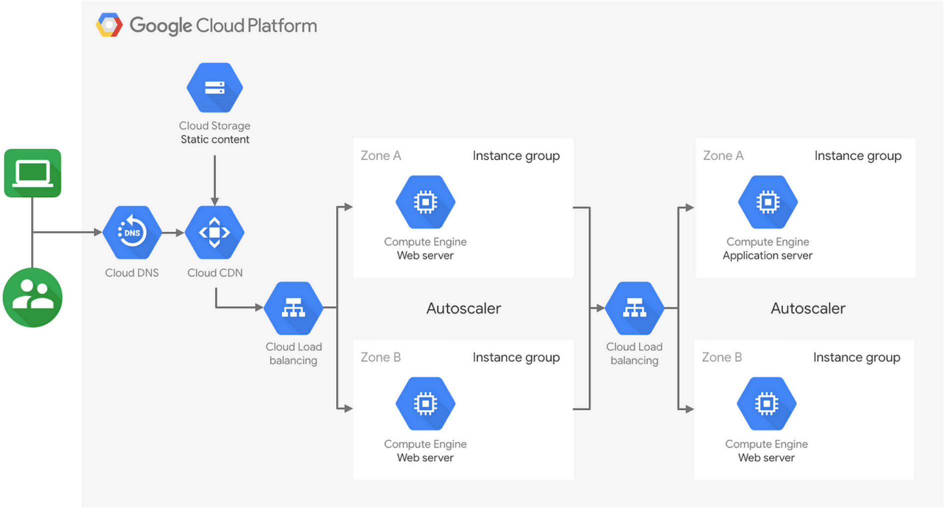
Infrastructures = APIs

The Cloud computing paradigm has transformed infrastructure (also platforms and software) to external APIs to request.

Nowadays infrastructures are like any piece of software offering services.

- request for a bucket to store content,
- request for a GKE cluster to host micro-services applications,
- request for VMs to install databases or larger software,
- etc.

Example


Google Cloud Platform
Cloud Storage
Static content
Cloud DNS
Cloud CDN
Cloud Load
balancing
Zone A
Instance group
Compute Engine
Web server
Autoscaler
Zone B
Instance group
Compute Engine
Web server
Cloud Load
balancing
Zone A
Instance group
Compute Engine
Application server
Autoscaler
Zone B
Instance group
Compute Engine
Web server

What is Infrastructure-as-Code?

Infrastructure-as-Code (IaC)

- Avoid manual or ad-hoc way of handling (create, update, delete) complex infrastructures,
- see infrastructure management as codes that can be shared, versioned, automated etc..

Associated concepts

- imperative/declarative
- idempotence

Different types of Infrastructure-as-Code

Configuration management

Originally made to automate and make more reusable and flexible the configuration of servers, machines, virtual machines

- Puppet
- Chef
- Ansible

Different types of Infrastructure-as-Code

Provisioning tools

Originally made to automate and make more reusable, flexible and safe the management of Cloud infrastructures

- Heat (OpenStack)
- Cloud Formation (AWS)
- Terraform
- Pulumi

Different types of Infrastructure-as-Code

Orchestration tools

Made to orchestrate the lifespans of a large set of containers and their deployment on servers

- Dockerswarm
- Kubernetes
- Nomad

Provisioning

In this module we focus on one **declarative provisioning tool**: terraform

- state: the current state of the infrasturcture and the desired state specified by the user. Both can change over time.
- reconciliation: declarative IaC provisioning tools try to reconcile the current state with the desired state.
- plan: to reconcile, declarative IaC tools automatically generate a plan to execute/apply.

Why using a provisioning tool?

I can do that through the graphical interfaces of Cloud providers! Yes but...

- Long and error-prone manual procedures.
- Difficult and error-prone when collaborating.
- No clear/central vision of the state of your infrastructure.
- Not scalable.

I can do that with Cloud providers CLIs and scripts! Yes but...

- You have to know as many CLIs as the number of Cloud providers you are using.
- A script is less specialized and structured than IaC, more difficult to write/read and maintain.
- You have to manually handle the state of your infrastructure which is difficult and error prone.

Other Provisioning IaC Tools

Specific to Cloud Providers

- *CloudFormation*: Typescript classes for AWS
- *Azure Resource Manager (ARM)*: custom DSL for Azure
- *Heat*: YAML templates for OpenStack

Comparatively, Terraform can handle *all* cloud providers within a single state file.

Pulumi

- Competitor of Terraform. Same purposes.
- Reuses Terraform providers
- Agnostic of the Language: DevOps can use Python, NodeJS, .NET, Go or YAML

Concepts Terraform

Concepts of Terraform

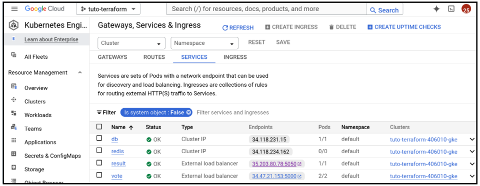
Google Cloud openstack docker

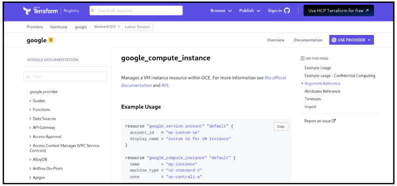
Providers

- Schema for *Resources*, *data sources* and *provider credential*
- Implementation CRUD API calls

Users

- HCL *Resources* and *Providers* configuration
- CLI commands
- Managed State






```
# vm.tf

resource "google_compute_instance" "vm" {
  name          = "redis"
  machine_type = "e2-medium"
  network_interface {
    network = var.network-name
  }
}
```

Automatic ordering

Declarative state : declare *what* not *how*

The desired state is written by the DevOps in `.tf` files.

- The order of provisioning is determined automatically.
- Terraform will create infrastructure in the right order.

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- Terraform will create infrastructure in the right order.
- The order is defined when resources refer to each other.
- Changes in the declared state are compared against the state file.

We can create multiple versions of the same replicated infrastructure (e.g. dev, prod).

Basic Architecture

Resources

- A resource can represent anything. e.g. VM, docker image, virtual network, ip, user, account, role, etc.
- Providers furnish an API that lists
    1. Available resource types.
    2. For each of them their parameters.

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Terraform Core

- Configuration : every `.tf` files $\Rightarrow$ provider and resource declarations.
- The current directory constitutes the root module.
- State file : contains the current state of resources under Terraform's management.
- Upon each CLI call, the state file is refreshed with the actual resources.

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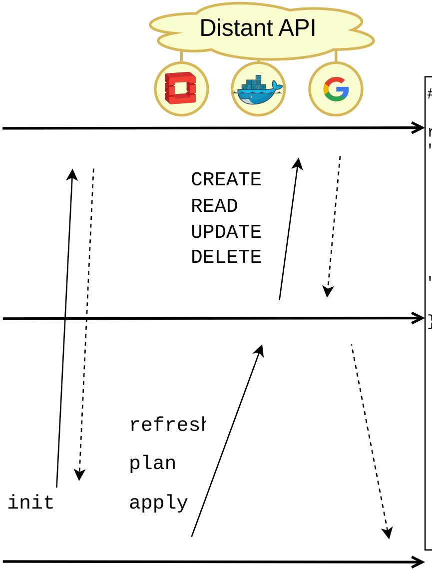
Terraform detects changes in the configuration and plan API calls accordingly.

Terraform Workflow Illustration

User Configuration

```
# vm.tf (HCL format)

terraform {
  required_providers {
    google = {
      source = "hashicorp/google"
      version = "5.6.0"
    }
  }
}
provider "google" {
  project = var.gcp_project_id
  region  = var.gcp_region
  credentials = file(var.gcp_key)
}
resource "google_compute_instance" "vm"
{
  name         = "redis"
  machine_type = "e2-medium"
  network_interface {
    network = "default"
  }
}
```



Terraform Managed State

```
# terraform.tfstate (JSON format)

resource "google_compute_instance"
"vm" {
  name        = "redis"
  id          = "projects/tf-80/..."
  instance_id = "3012364625718931000"
  network_interface {
      name       = "nic0"
      network    =
"https://www.googleapis.com/compute"
      network_ip = "10.162.0.20"
}
```

Commands for different stages

`terraform init`

Initialize the working directory by downloading providers and modules.

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Produce a plan and execute it. An execution may fail depending on the provider's implementation and hidden infrastructure constraints.

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`terraform destroy`

Calls the provider to delete managed resources.

HCL Language Syntax (1): Attributes

aka "argument", "field"

Attributes are distinguished with the equal sign `=` meaning *assignment*.

The value can be any expressions: function calls, lists, objects, references, etc.

- `name = "redis server"`
- `credentials = file("./creds.json")`
- `labels = { app = "redis" }`
- `image = docker_image.redis.name`
- etc.

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- `image = docker_image.redis.name`
- etc.

Multiple definitions of an attribute are forbidden. They are *single assignment*.

In addition to arguments within a block, there are a few meta attributes that have special semantics: `count`, `for_each` and `depends_on` and `lifecycle`.

HCL Language Syntax (2): Blocks

Blocks

e.g. `resource "docker_image" "redis" { ... }`

- Have a mandatory key identifier, here `resource`. It have a meaning in the context where it is defined, like standard attributes.
- Strings can be attached, here `docker_image` and `redis`.
- They can be referrenced from another part of the configuration.

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`mounts { volume_options { no_copy = true }}`

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Block can be embedded. e.g. in a container resource:

`mounts { volume_options { no_copy = true }}`

Multiple blocks with identical keyword are allowed and results in an array of objects. e.g. to refer to a particular mount option:

`mounts[0].volume_options[0].no_copy`

Kinds of top-level blocks

Terraform has concepts for each kind of block that can be declared at the top-level.

`resource`, `data`, `provider` and variables

The references for those blocks are found in the provider's documentation at *`https://registry.terraform.io/providers/`*.

- The *`resource`* block is the main state declarations of managed resources.

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- The *`data`* block is for read-only resource.
- The *`provider`* block sets configuration parameters for a provider.
- *`variable`* blocks for input values set from outside of *`.tf`* files.

There are a few other top-level blocks, e.g. *`module`*, *`check`*, *`import`*.

Variables and References

Variables

There is three kinds of user variables depending on how we use them:
Inputs, *Outputs*, and *Locals*.

Declared with the ***`variable`***, ***`output`***, and ***`locals`*** top-level blocks respectively.

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References to resources, data sources and variables

- Resources attributes are referenced with type and name of the resource, e.g.
  `docker_image.redis.image_id`
- To reference a *data source*, we use the keyword ***`data`***, e.g.
  `data.docker_image.redis.image_id`.
- For input and local variables, we use *`var`* and *`local`* keywords, e.g.
  `var.my_input_var`
  `local.my_local_var`
- Terraform has other such special variable keywords, e.g. ***`module`***, ***`each`***, ***`path`***.

Good practices

Good practices

Objective: avoid troubleshooting

- Read and understand carefully each declarations and plan.
- Version control your Terraform codes. *Beware not to commit **secrets**.*
- CI/CD on your Terraform infrastructure.
- Store the Terraform state files on remote storages with lock mechanisms.

Your turn...

Your turn!

- Tutorial with the Docker provider
  - TF calls the local Docker CLI
- Tutorial with the Kubernetes provider
  - TF calls a distant Kubernetes CLI (through *`kubectl`*)
- Project (2 students)
  - Deploy the same App as in FILA2
  - Use Terraform to deploy with
    - Docker only
    - Kubernetes only
    - Kubernetes + Proxmox for Redis