Infrastructure as Code (IaC) in the Cloud Age

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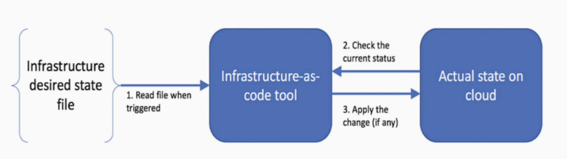
Agenda

1. Intro
2. Infrastructure as Code principles and core concepts
3. Not too short introduction to Terraform

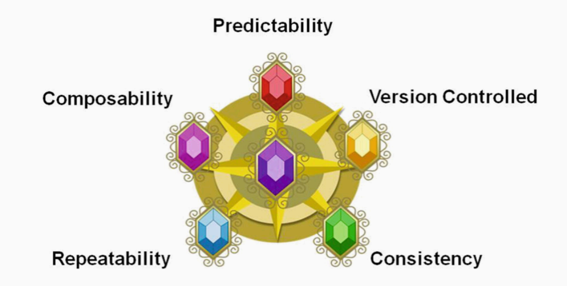
Infrastructure as Code (IaC) explained

- allows to write and execute code to define, deploy, update, and destroy your infrastructure
- gives rise to *mutable* infrastructure as the lifecycle of every infra resource,component is treated via code
- encourages declarative style of code wherein the desired end state and the configuration are present before final state is provisioned
- initially focusing on software, now also on virtualized hardware



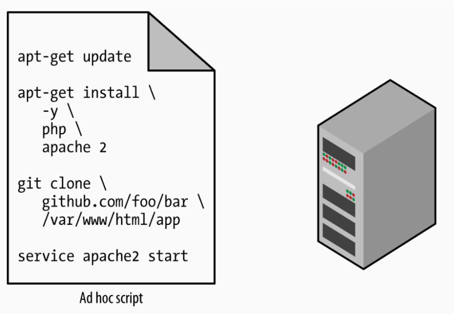
IaC principles

- **Version control** provides traceability of changes
- **Predictability** capability to always provide the same environment
- **Consistency** multiple instances of the same baseline code provide a similar environment
- **Composability** managed in a modular and abstracted format – *reusability*, speed and *safety* and automatic documentation

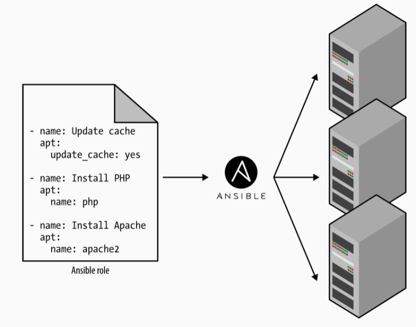


Categories of IaC tools 1/3

- Ad hoc scripts

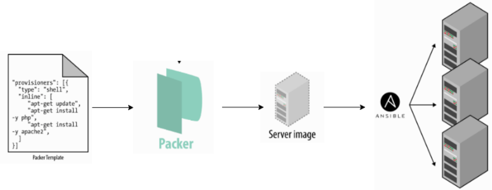


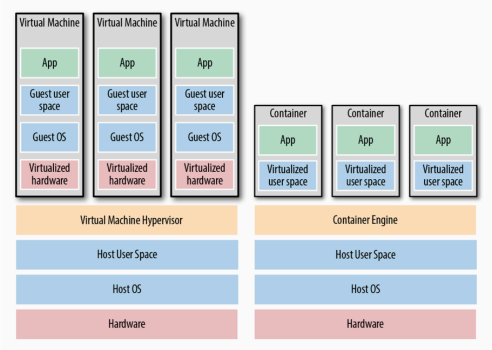
- Configuration management tools



Categories of IaC tools 2/3

- Server Templating Tools (e.g. Docker, Packer)





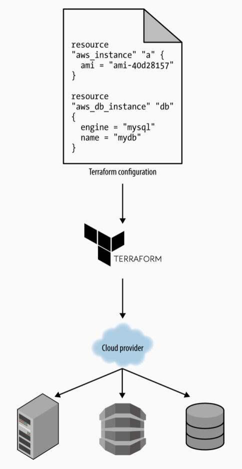
Categories of IaC tools 3/3

- Provisioning Tools (e.g. Terraform, Pulumi)

```
resource "aws_instance" "example" {
  ami           = "ami-0c55b159cbfafe1f0"
  instance_type = "t2.micro"
}

resource "google_dns_record_set" "a" {
  name         = "demo.google-example.com"
  managed_zone = "example-zone"
  type         = "A"
  ttl          = 300
  rrdatas      = [aws_instance.example.public_ip]
}
```

- not only VM instances, also VPC (Networking), Managed Services (e.g. Dataproc), etc.



IaC differences - „*how*” vs „*what*”

- Configuration management versus provisioning
- Mutable infrastructure versus immutable infrastructure – *configuration drift* problem – mostly software layer – deployment in a form of an immutable *template* - e.g. Docker image, hard drive image
- Procedural language versus declarative language

- Ansible - imperative („*how*”)

```yaml
- ec2:
    count: 10
    image: ami-0c55b159cbfafe1f0
    instance_type: t2.micro
```

- Terraform - declarative („*what*”)

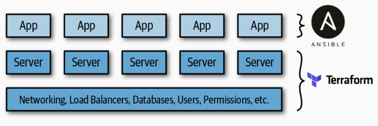
```hcl
resource "aws_instance" "example" {
  count         = 10
  ami           = "ami-0c55b159cbfafe1f0"
  instance_type = "t2.micro"
}
```

Kubernetes ecosystem example - from Pod to SparkApplication

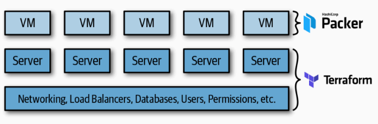
1. resource by resource with a `kubectl` command (e.g. create, run, scale) – imperative/low-level
2. Kubernetes Manifest file and `kubectl apply -f` – declarative (configuration builtin) but still low-level
3. Helm chart - versioning, templating (separation of configuration), reusability – declarative/ higher-level
4. Custom Resource Definition (CRD) and Kubernetes Operator (e.g. SparkOperator) – declarative/highest-level

Using Multiple Tools Together

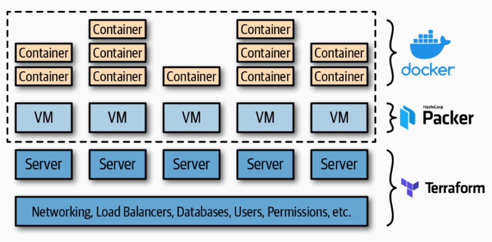
- Provisioning plus configuration management



- Provisioning plus server templating

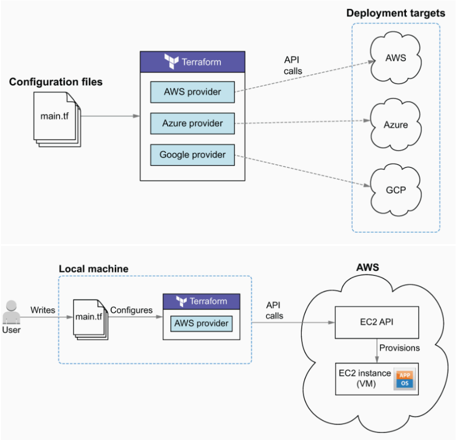


- Provisioning plus server templating plus orchestration (e.g. Google Kubernetes Engine)



Terraform - a provisioning tool

- cloud-agnostic
- open-source written in Golang
- cloud/services providers registry
- declarative programming HashiCorp Configuration Language (HCL)
- OpenTofu alternative



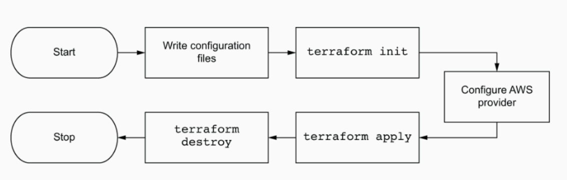
Terraform - a quick start

- macOS

```
brew tap hashicorp/tap
brew install hashicorp/tap/terraform
```

- Linux

```
curl -fsSL
↪ https://apt.releases.hashicorp.com/gpg
↪ | sudo apt-key add -
sudo apt-add-repository "deb
↪ [arch=amd64]
↪ https://apt.releases.hashicorp.com
↪ $(lsb_release -cs) main"
sudo apt-get update && sudo apt-get
↪ install terraform
```



Providers

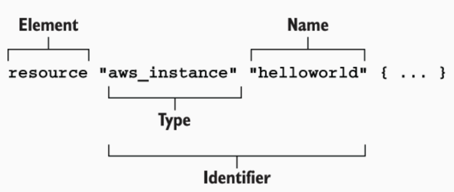
- provider - a plugin with a set of *resource* and *data* types that defines how changes to resources of that type are applied to remote APIs
- local utilities for tasks, like generating random numbers for unique resource names
- version constraints and semanting versioning

```
provider "google" {
  project = var.project_name
  region  = var.region
}
terraform {
  required_providers {
    google = {
      version = "~> 4.8.0"
    }
    random = {
      source  = "hashicorp/random"
      version = "3.1.2"
    }
    kubectl = {
      source  = "gavinbunney/kubectl"
      version = "1.14.0"
    }
  }
}
```

Resources

- Each *resource* has inputs and outputs. Inputs are called *arguments*, and outputs are called *attributes*.
- attributes of resources can be referenced in other resources
- there are computed attributes that are only available after the resource has been created (e.g. cloud resource URLs or IDs)

```
resource "<PROVIDER>_<TYPE>" "<NAME>" {
  [CONFIG ...]
}
```



Data sources

- represent a piece of read-only information that is fetched from the provider
- a way to query the provider's APIs for data and to make that data available to the rest of Terraform code.
- example use case - referencing Ubuntu image 22.04 (with updates)

Definition:

```
data "<PROVIDER>_<TYPE>" "<NAME>" {
  [CONFIG ...]
}
```

Referencing an attribute:

```
data.<PROVIDER>_<TYPE>.<NAME>.<ATTRIBUTE>
```

Variables 1/2

- input

```
variable "environment" {
  type        = string
  description = "Development or
  ↪ production environment"
  default = "dev"
  validation {
    condition     = contains(["dev",
    ↪ "prod"], var.environment)
    error_message = "Valid values
    ↪ for var: test_variable are
    ↪ (dev, prod)."
  }
}
```

- output

```
output "data_generator_lines_num" {
  value       =
  ↪ module.data-generator.lines_number
  description = "Number of lines in
  ↪ a generated file"
}
```

Variables 2/2

Passing input variables to a module:

- environment variables
  `TF_VAR_name`
- "*.tfvars"
- `terraform apply -var-file env/dev/project.tfvars`
- from command prompt
- default values

- local variables for modules

```
locals {
  service_name = "forum"
  owner        = "Community Team"
}
```

- help avoiding repeating the same values or expressions multiple times in a configuration

Implicit and explicit dependencies

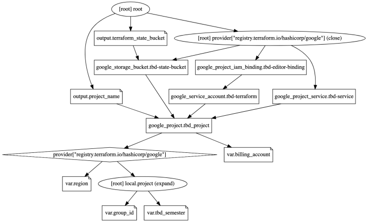
- implicit

```
resource "google_service_account" "tbd-sa"
↪ {
  account_id = "${var.project_name}-sa"
}

resource "google_project_iam_member"
↪  "tbd-sa-role-bindings" {
  project   = var.project_name
  role      = "roles/storage.admin"
  member    =
  ↪  "serviceAccount:${google_service_account.tbd-s
}
```

- explicit

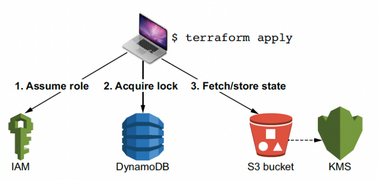
```
module "k8s-spark-operator"
↪  {
  depends_on = [module.gke]
  source     =
  ↪  "./modules/spark-on-k8s-op
}
```



Managing state

Locally(default):

- `terraform.tfstate` file in a JSON format
- error-prone
- not-secure



Shared storage

- requires defining a remote *backend* like S3, GCS
- encryption at rest and in transit(storing secrets)
- versioning
- isolation of environments using a bucket and/or prefix
- team collaboration

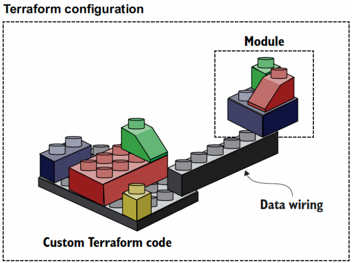
```
terraform init
↪ -backend-config=env/dev/backend.tfvar
↪ -reconfigure
```

Modules

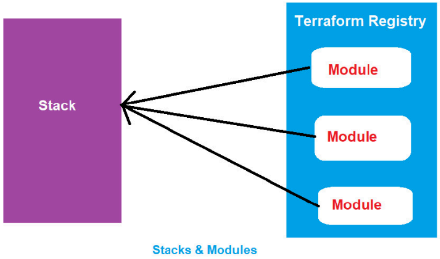
- any set of Terraform configuration files in a folder is a module
- there is always at least a *root* module
- code reusability
- can be stored locally or in a git repo
- versioning
- small, composable and testable

```
module "<NAME>" {
  source = "<SOURCE>"

  [CONFIG ...]
}
```



Modules vs. stacks

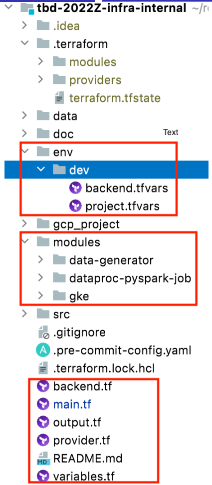


- *stacks* are collections of *modules* that are *logically* connected and defined in a single .tf file or multiple .tf files inside the same directory
- they represent a *single* deployment unit of an infrastructure, e.g. environment or a larger part of it, such as storage system

Benefits of using stacks

- limit *radius blast* of resource changes (separation of state files), i.e. human error boundaries
- speed – managing all resources with a single state file is slow
- different resource lifecycles – e.g. storage vs. compute layer
- separate management responsibilities across team boundaries

Project layout - a simple case



- `.terraform` scratch dir
- `env\/dev` with environment-specific variables
- `modules` local shared modules
- external git-hosted modules
- root module (stack) with `main.tf`
- state isolation per environment (limit radius blast and performance)

Loops

count

```
variable "subnet_ids" {
  type = list(string)
}
resource "aws_instance" "server" {
  # Create one instance for each subnet
  count = length(var.subnet_ids)

  ami           = "ami-a1b2c3d4"
  instance_type = "t2.micro"
  subnet_id     =
   ↪  var.subnet_ids[count.index]

  tags = {
    Name = "Server ${count.index}"
  }
}
```

- a change in the middle of the list ?

for_each

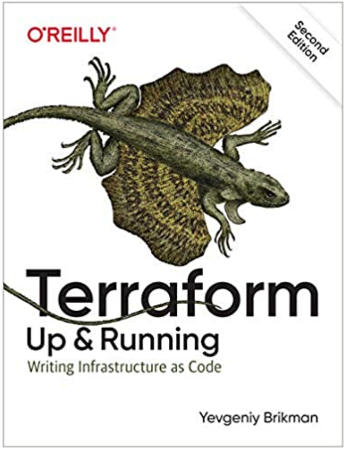
```
resource "google_project_iam_member"
 ↪  "tbd-editor-supervisors" {
  for_each = toset([
    "user:marek.wiewiorka@gmail.com",
    "user:tgambin@gmail.com"
  ])
  project =
   ↪  google_project.tbd_project.project_id
  role    = "roles/editor"
  member  = each.value
}
```

- set vs list updates

Tricks with expressions

- functions
- templating
- conditional expressions with ternary syntax (can be combined with `count` for optional modules)
- types and values
- list comprehensions with `for`
- *dynamic* blocks (within a resource or data type, e.g. configuration key-values)

Books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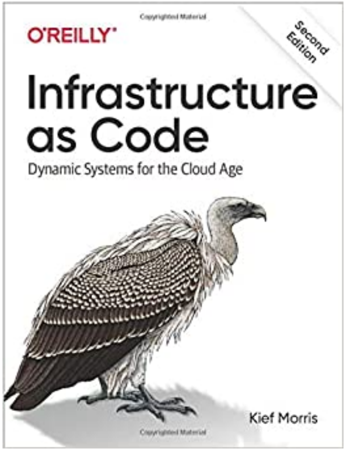
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