

# Terraform Developer





## WORKFORCE DEVELOPMENT



PARTICIPANT GUIDE



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1

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# logistics



- Class Hours:
- Instructor will provide class start and end times.
- Breaks throughout class.

- Lunch:
  - Yes, 1 hour and 15 minutes
  - Extra time for email, phone calls, or simply a walk.



- Telecommunication:
  - Turn off or set electronic devices to vibrate
  - Reading or attending to devices can be distracting to other students

- Miscellaneous
  - Courseware
  - Bathroom

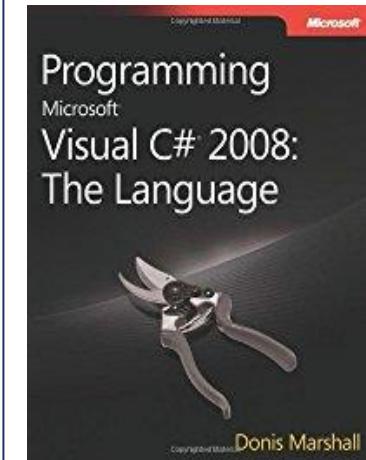
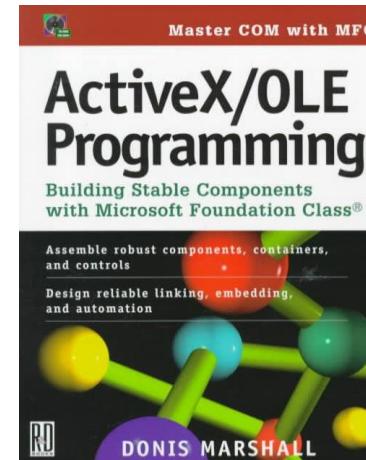
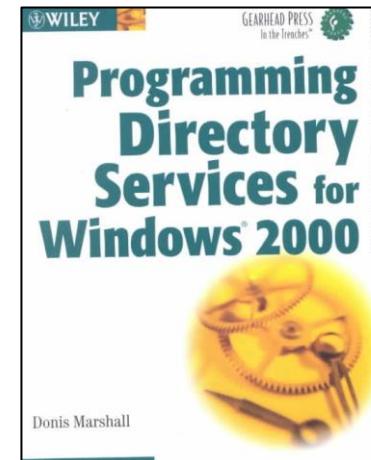
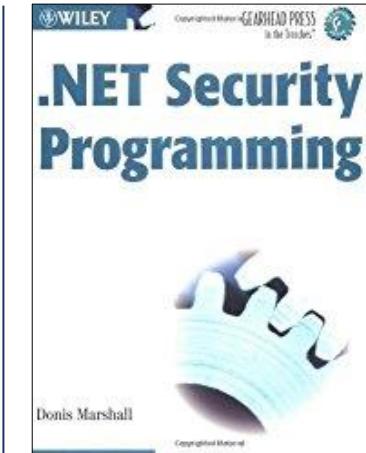
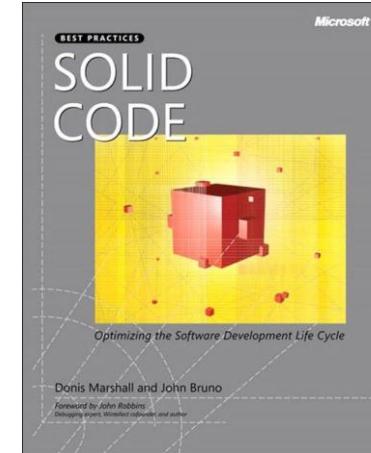
# Course Objectives



- Explain Infrastructure-as-Code and some of tools for implementing it.
- Describe what Configuration Drift is and how to avoid it.
- Understand benefits of using Terraform
- Manage Terraform State
- Learn best practices for building secure Terraform configurations.
- Use Terraform to automate infrastructure management.
- Write custom Terraform providers.

# DONIS MARSHALL

Terraform Developer  
Microsoft MVP  
Microsoft Certified  
C++ Certified  
Author



# Introduce yourself

Time to introduce yourself:

- Name
- What is your role in the organization
- Indicate Terraform experience
- Indicate Ansible experience

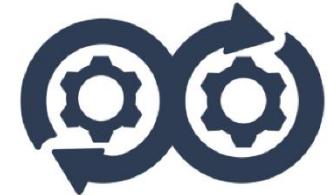


# Course Labs

<https://jruels.github.io/tf-dev>



# Configuration Management



# Configuration Drift



**POTHOLE**

- Your infrastructure requirements change
- Configuration of a server falls out of policy
- Manage with Infrastructure as Code (IAC)
  - Terraform
  - Ansible
  - Chef
  - Puppet

# Manual



# POP QUIZ: Manual tasks



What manual tasks do you deal with repeatedly?

Can they be automated?

# Common manual tasks

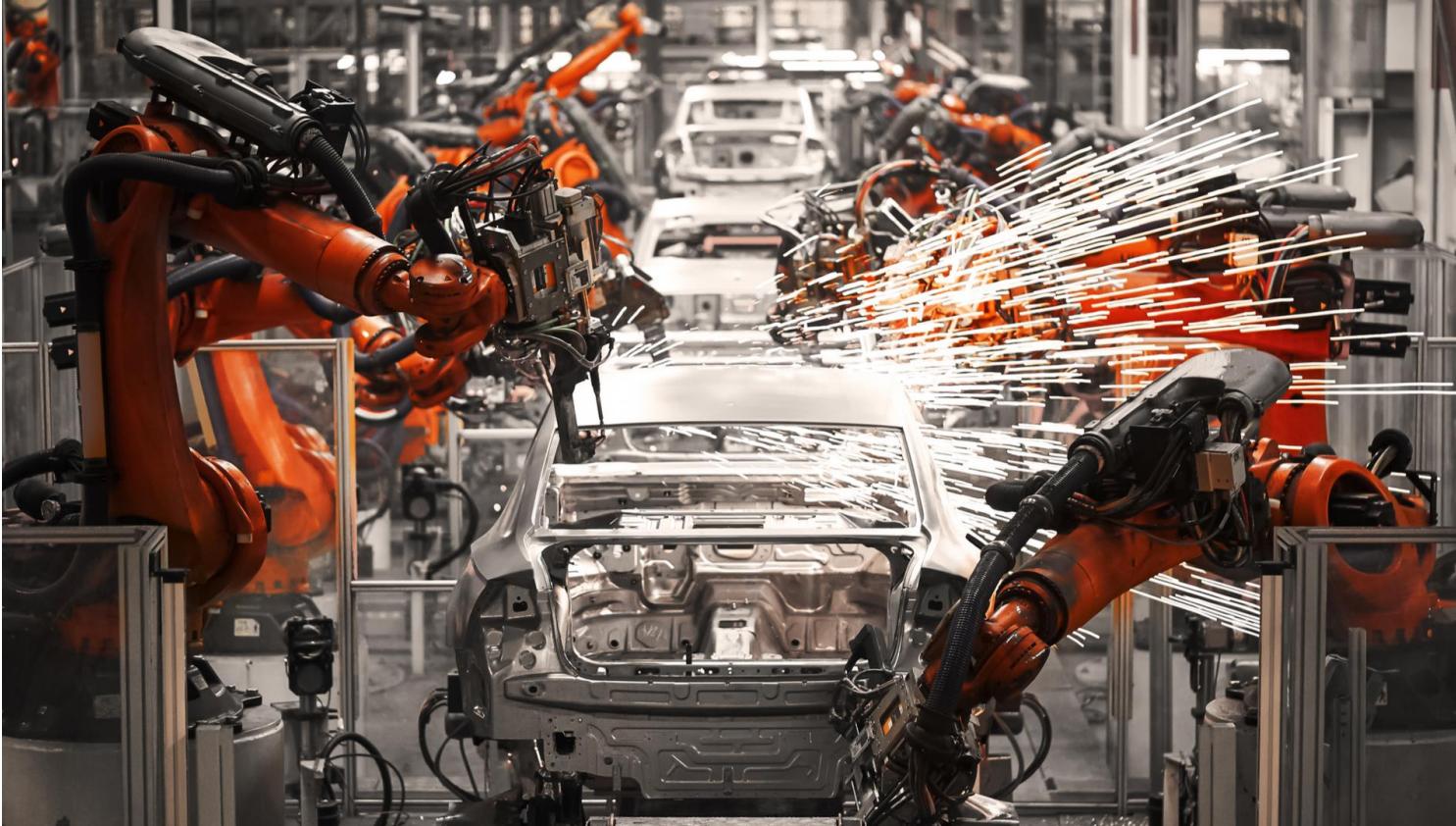


## Installation and configuration:

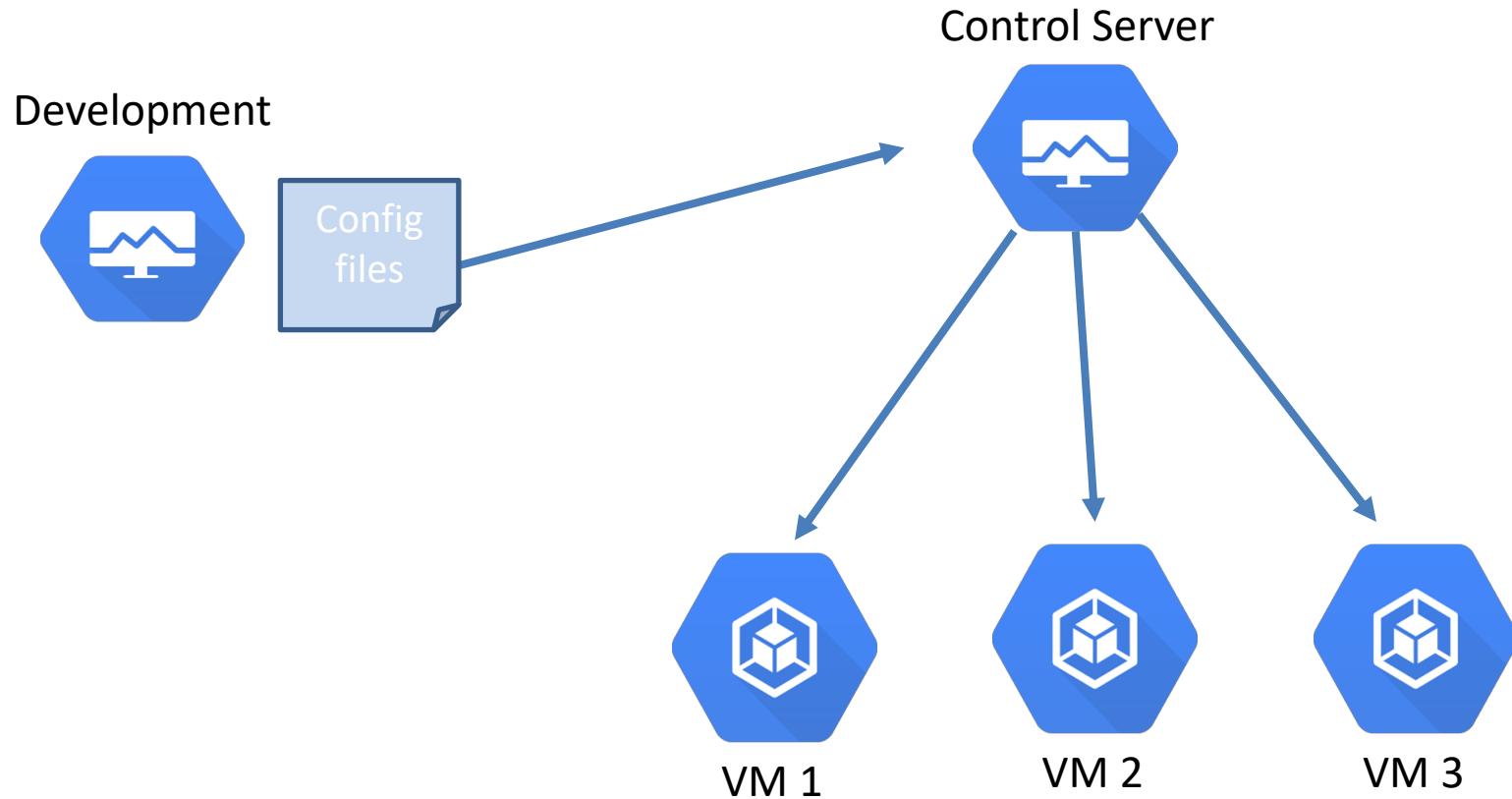
- Operating System
- Runtime
- Libraries
- Utilities
- Configuration files

- Build application
- Test application
- Deploy application

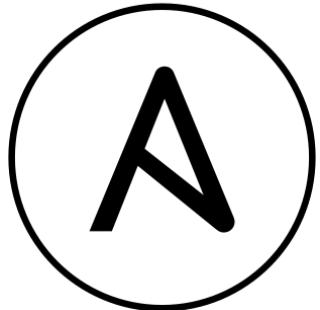
# Automated



# Automated



# Automation tools



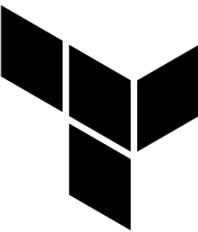
ANSIBLE



CHEF



puppet



HashiCorp  
Terraform

# Infrastructure as Code



## What is IaC?

Infrastructure as code (IaC) is the process of managing and provisioning computer data centers through machine-readable definition files

Used with bare-metal as well as virtual machines and many other resources.

Normally a declarative approach

# Infrastructure as Code



- Programmatically provision and configure components
- Treat like any other code base
  - Version control
  - Automated testing
  - Data backup

# Infrastructure as Code



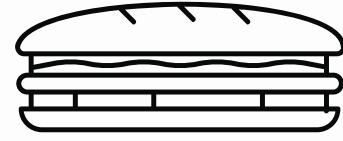
Provisioning infrastructure through software to achieve consistent and predictable environments.

# Core Concepts



- Defined in code
- Stored in source control
- Declarative or imperative

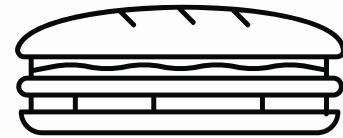
# Imperative



```
# Make a sandwich  
get bread  
get mayo  
get turkey  
get lettuce
```

```
spread mayo on bread  
put lettuce in between bread  
put turkey in between bread  
on top of turkey
```

# Declarative



```
# Make a sandwich
food sandwich "turkey" {
    ingredients = [
        "bread", "turkey",
        "mayo", "lettuce"
    ]
}
```

# POP QUIZ:

What challenges does Infrastructure as Code solve?



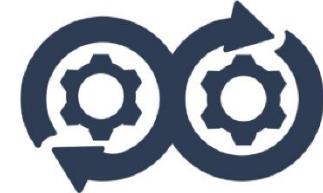
## POP QUIZ:

What challenges does Infrastructure as Code solve?

- Eliminates manual configuration errors
- Improves consistency and repeatability
- Enables faster recovery and scaling



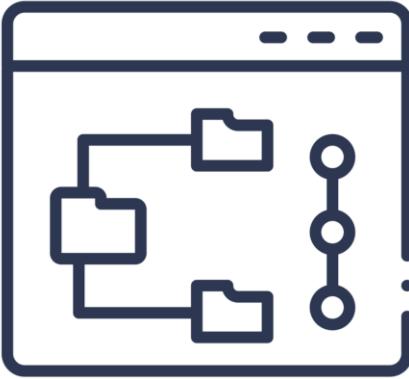
# Terraform Introduction



# Automating Infrastructure



Provisioning resources



Version Control

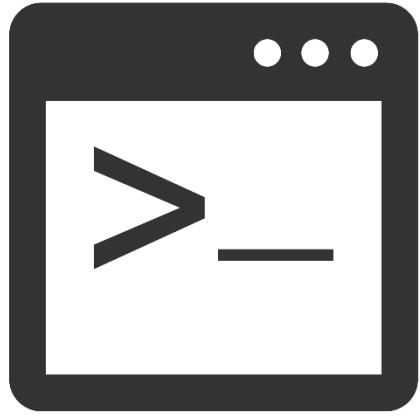


Plan Updates

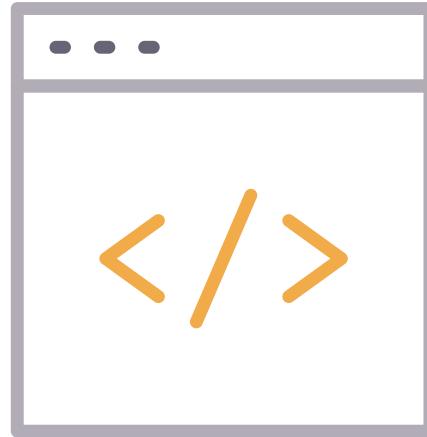


Reusable  
Templates

# Terraform components



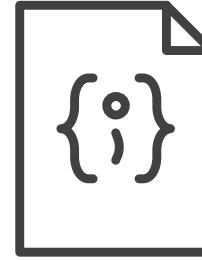
Terraform executable



Terraform files

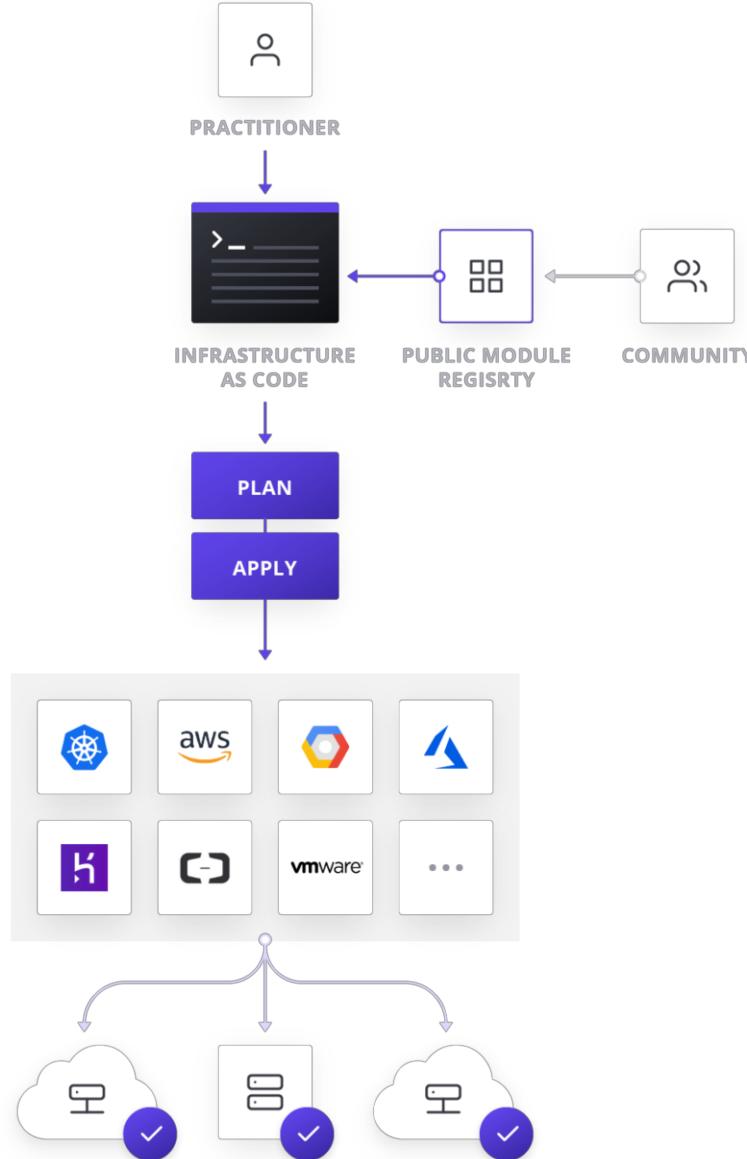


Terraform  
plugins



Terraform  
state

# Terraform architecture



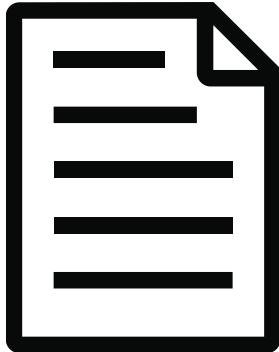
# Terraform files



```
##Amazon Infrastructure
provider "aws" {
    region = "${var.aws_region}"
}
```

- Provider defines what infrastructure Terraform will be managing
  - Pass variables to provider
    - Region, *Flavor, Credentials*

# Terraform files

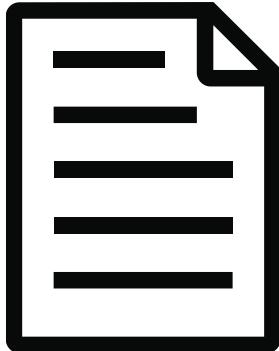


```
data "aws_ami" "ubuntu" {
    most_recent = true

    filter {
        name    = "name"
        values  = ["ubuntu/images/hvm-ssd/ubuntu-xenial-16.04-amd64-server-*"]
    }
    filter {
        name    = "virtualization-type"
        values  = ["hvm"]
    }
    owners = ["099720109477"] # Canonical
}
```

- Data sources
  - Queries AWS API for latest Ubuntu 16.04 image.
  - Stores results in a variable which is used later.

# Terraform files



```
resource "aws_instance" "aws-k8s-master" {
    subnet_id          = "${var.aws_subnet_id}"
    depends_on         = [ "aws_security_group.k8s_sg" ]
    ami                = "${data.aws_ami.ubuntu.id}"
    instance_type      = "${var.aws_instance_size}"
    vpc_security_group_ids = ["${aws_security_group.k8s_sg.id}"]
    key_name           = "${var.aws_key_name}"
    count              = "${var.aws_master_count}"
    root_block_device {
        volume_type      = "gp2"
        volume_size       = 20
        delete_on_termination = true
    }
    tags {
        Name = "k8s-master-${count.index}"
        role = "k8s-master"
    }
}
```

- Resource: Defines specifications for creation of infrastructure.

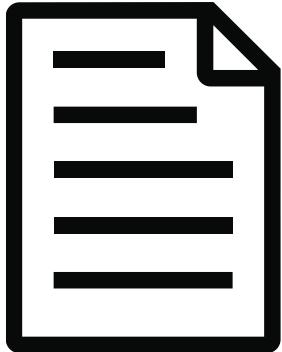
# Terraform files



```
resource "aws_instance" "aws-k8s-master" {
    subnet_id          = "${var.aws_subnet_id}"
    depends_on         = ["aws_security_group.k8s_sg"]
    ami                = "${data.aws_ami.ubuntu.id}"
    instance_type      = "${var.aws_instance_size}"
    vpc_security_group_ids = ["${aws_security_group.k8s_sg.id}"]
    key_name           = "${var.aws_key_name}"
    count              = "${var.aws_master_count}"
    root_block_device {
        volume_type      = "gp2"
        volume_size       = 20
        delete_on_termination = true
    }
    tags {
        Name = "k8s-master-${count.index}"
        role = "k8s-master"
    }
}
```

- ami is set by results of previous data source query

# Terraform files



```
##AWS Specific Vars
variable "aws_master_count" {
| default = 10
}

variable "aws_worker_count" {
| default = 20
}

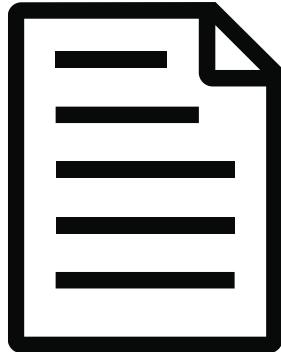
variable "aws_key_name" {
| default = "k8s"
}

variable "aws_instance_size" {
| default = "t2.small"
}

variable "aws_region" {
| default = "us-west-1"
}
```

- Define sane defaults in variables.tf

# Terraform files



```
resource "aws_instance" "aws-k8s-master" {
    subnet_id          = "${var.aws_subnet_id}"
    depends_on         = [ "aws_security_group.k8s_sg" ]
    ami                = "${data.aws_ami.ubuntu.id}"
    instance_type      = "${var.aws_instance_size}"
    vpc_security_group_ids = [ "${aws_security_group.k8s_sg.id}" ]
    key_name           = "${var.aws_key_name}"
    count              = "${var.aws_master_count}"

    root_block_device {
        volume_type      = "gp2"
        volume_size       = 20
        delete_on_termination = true
    }

    tags {
        Name = "k8s-master-${count.index}"
        role = "k8s-master"
    }
}
```

- Value is 'count' is setup by variable in variables.tf

# POP QUIZ:

What is Terraform used for?



# POP QUIZ:

## What is Terraform used for?

- Automates the creation of cloud and on-prem infrastructure
- Maintains consistent setups across environments
- Enables version-controlled, repeatable infrastructure deployments



# Terraform CLI

Run `terraform` command

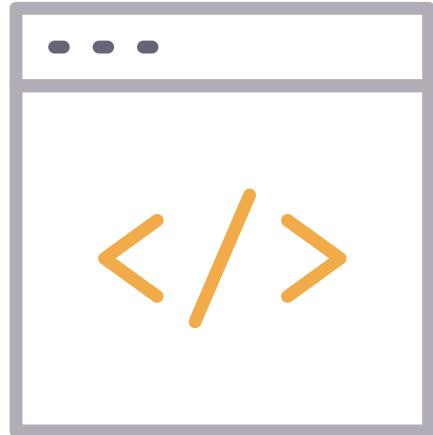
Output:

```
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	Destroy Terraform-managed infrastructure
env	Workspace management
fmt	Rewrites config files to canonical format
get	Download and install modules for the
configuration	
graph	Create a visual graph of Terraform
resources	



# Terraform CLI

Command:

```
terraform init
```

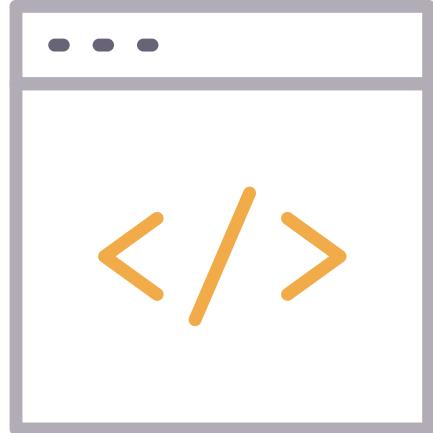
Output:

```
Initializing the backend...
```

```
Initializing provider plugins...
```

- Checking for available provider plugins...
- Downloading plugin for provider "docker"...

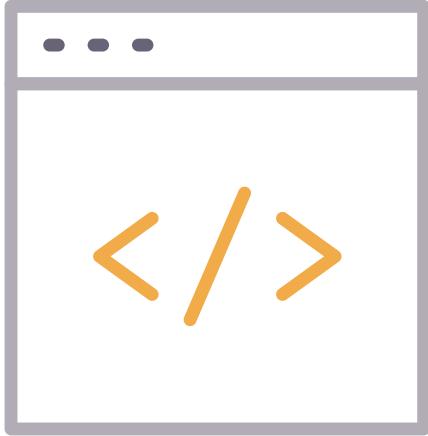
Terraform fetches any required providers and modules and stores them in the .terraform directory. Check it out and you'll see a plugins folder.



# Terraform CLI

Command:

```
terraform validate
```



Validate all of the Terraform files in the current directory. Validation includes basic syntax check as well as all variables declared in the configuration are specified.

# Terraform CLI

Command:

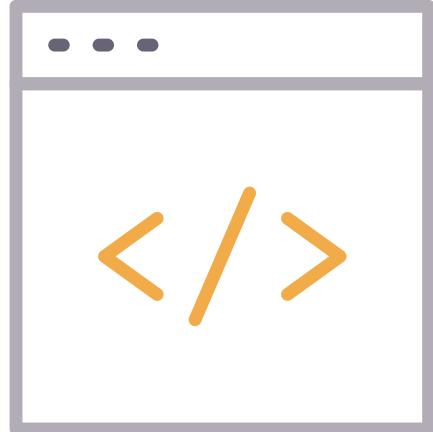
```
terraform plan
```

Output:

```
Terraform will perform the following actions:
```

```
+ aws_instance.aws-k8s-master
  id: <computed>
  ami: "ami-01b45..."
  instance_type: "t3.small"
```

Plan is used to show what Terraform will do if applied. It is a dry run and does not make any changes.



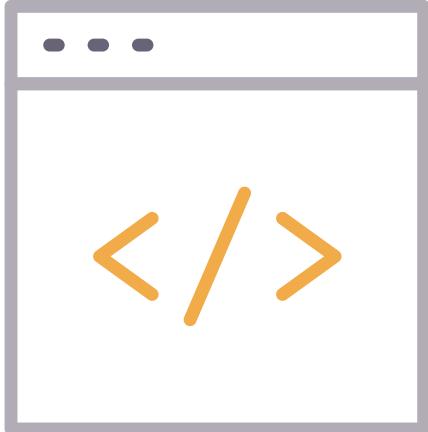
# Terraform CLI

Command:

```
terraform apply
```

Output:

```
aws_security_group.k8s_sg: Creating...
  arn:                               "" => "<computed>"
  description:                      "" => "Allow all
    inbound traffic necessary for k8s"
  egress.#:                          "" => "1"
  egress.482069346.cidr_blocks.#:   "" => "1"
  egress.482069346.cidr_blocks.0:   "" => "0.0.0.0/0"
```



Performs the actions defined in the plan

# Terraform CLI

Command:

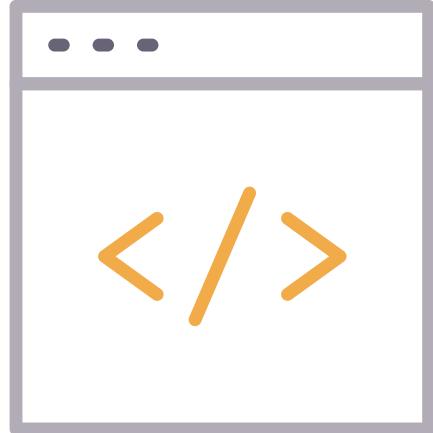
```
terraform state show <resource>
```

```
terraform state show aws_instance.lab2-tf-example
```

Output:

```
ami                      = "ami-830c94e3"  
availability_zone          = "us-west-2b"  
cpu_core_count             = 1  
...
```

Shows information about provided resource.



# Terraform CLI

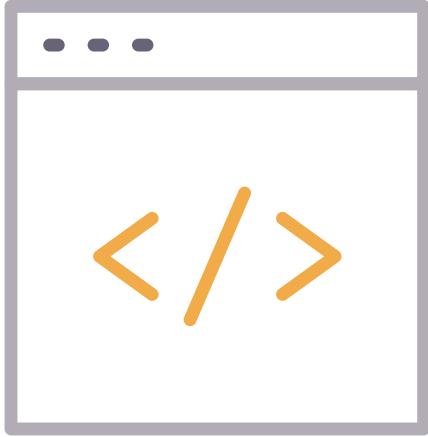


The `terraform refresh` command is used to reconcile the state Terraform knows about (via its state file) with the real-world infrastructure. This can be used to detect any drift from the last-known state, and to update the state file. This does not modify infrastructure but does modify the state file. If the state is changed, this may cause changes to occur during the next `plan` or `apply`.

# Terraform CLI

Command:

```
terraform destroy [-auto-approve]
```



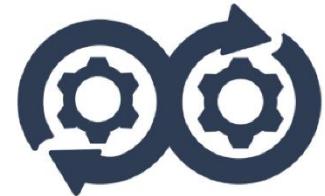
Destroys all the resources in the state file.

-auto-approve (don't prompt for confirmation)

# Lab: Setup VM



# Lab: Build first instance



# Terraform CLI



Terraform is normally run from inside the directory containing the \*.tf files for the root module. Terraform checks that directory and automatically executes them.

In some cases, it makes sense to run the Terraform commands from a different directory. This is true when wrapping Terraform with automation. To support that Terraform can use the global option `-chdir=...` which can be included before the name of the subcommand.

# Terraform CLI



The `chdir` option instructs Terraform to change its working directory to the given directory before running the given subcommand. This means that any files that Terraform would normally read or write in the current working directory will be read or written in the given directory instead.

# Terraform CLI

Command:

```
terraform -chdir=environments/dev (apply|plan|destroy|other)
```

Output:

```
> terraform apply
aws_security_group.k8s_sg: Creating...
  arn:                                     "" => "<computed>"
  description:                            "" => "Allow all
    inbound traffic necessary for k8s"
  egress.#:                                "" => "1"
  egress.482069346.cidr_blocks.#:          "" => "1"
  egress.482069346.cidr_blocks.0:           "" => "0.0.0.0/0"
```

Performs the subcommand in the specified directory.

# Terraform CLI



It can be time consuming to update a configuration file and run `terraform apply` repeatedly to troubleshoot expressions not working.

Terraform has a `console` subcommand that provides an interactive console for evaluating these expressions.

# Terraform CLI



```
variable "x" {  
  
  default = [  
    {  
      name = "first",  
      condition = {  
        age = "1"  
      }  
      action = {  
        type = "Delete"  
      }  
    }, {  
      name = "second",  
      condition = {  
        age = "2"  
      }  
      action = {  
        type = "Delete"  
      }  
    }  
  ]  
}
```

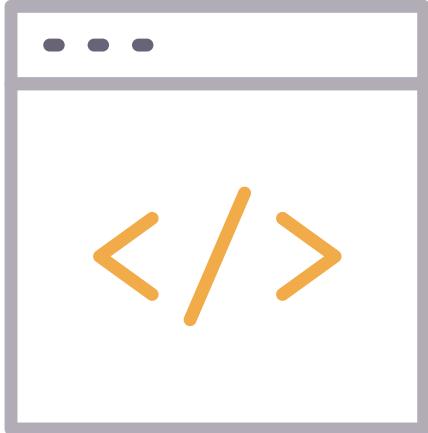
# Terraform CLI

Command:

```
terraform console
```

Output:

```
> var.x[1].name  
"second"  
  
var.x[0].condition  
{  
  "age" = "1"  
}
```



Test expressions and interpolations interactively.

# Terraform CLI



Terraform includes a graph command for generating visual representation of the configuration or execution plan. The output is in DOT format, which can be read by other tools. For example, GraphViz uses DOT to generate charts.

# Terraform CLI

Command:

```
terraform graph
```

Output:

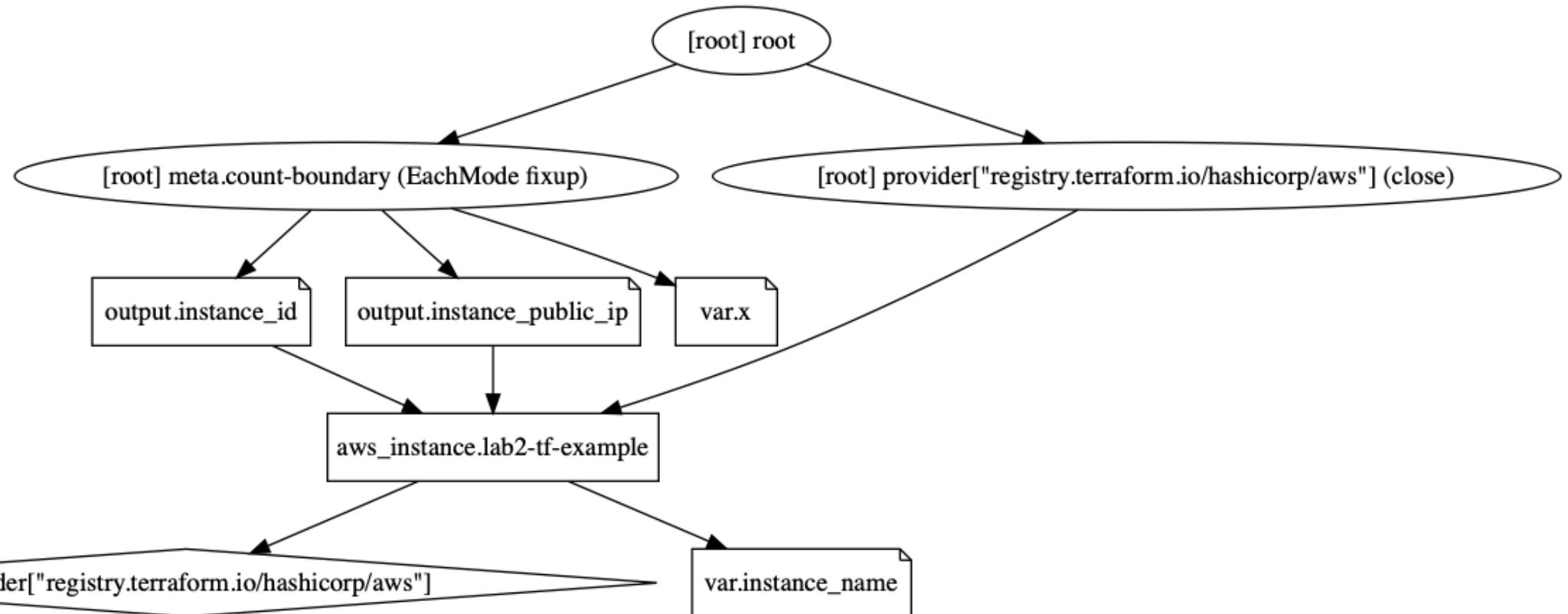
```
digraph {  
    compound = "true"  
    newrank = "true"  
    subgraph "root" {  
        "[root] aws_instance.lab2-tf-example (expand)"  
        [label = "aws_instance.lab2-tf-example", shape = "box"]  
        ...  
    }  
}
```

Create a visual graph of Terraform resources

```
terraform graph | dot -Tsvg > graph.svg
```

# Terraform CLI

```
terraform graph | dot -Tsvg > graph.svg
```



# Terraform vs JSON

ARM JSON:

```
"name" : "[concat(parameters('PilotServerName'), '3')]",
```

Terraform:

```
name = "${var.PilotServerName}3"
```

Terraform code (HCL) is "easy" to learn and "easy" to read. It is also more compact than equivalent JSON configuration.

# terraform model

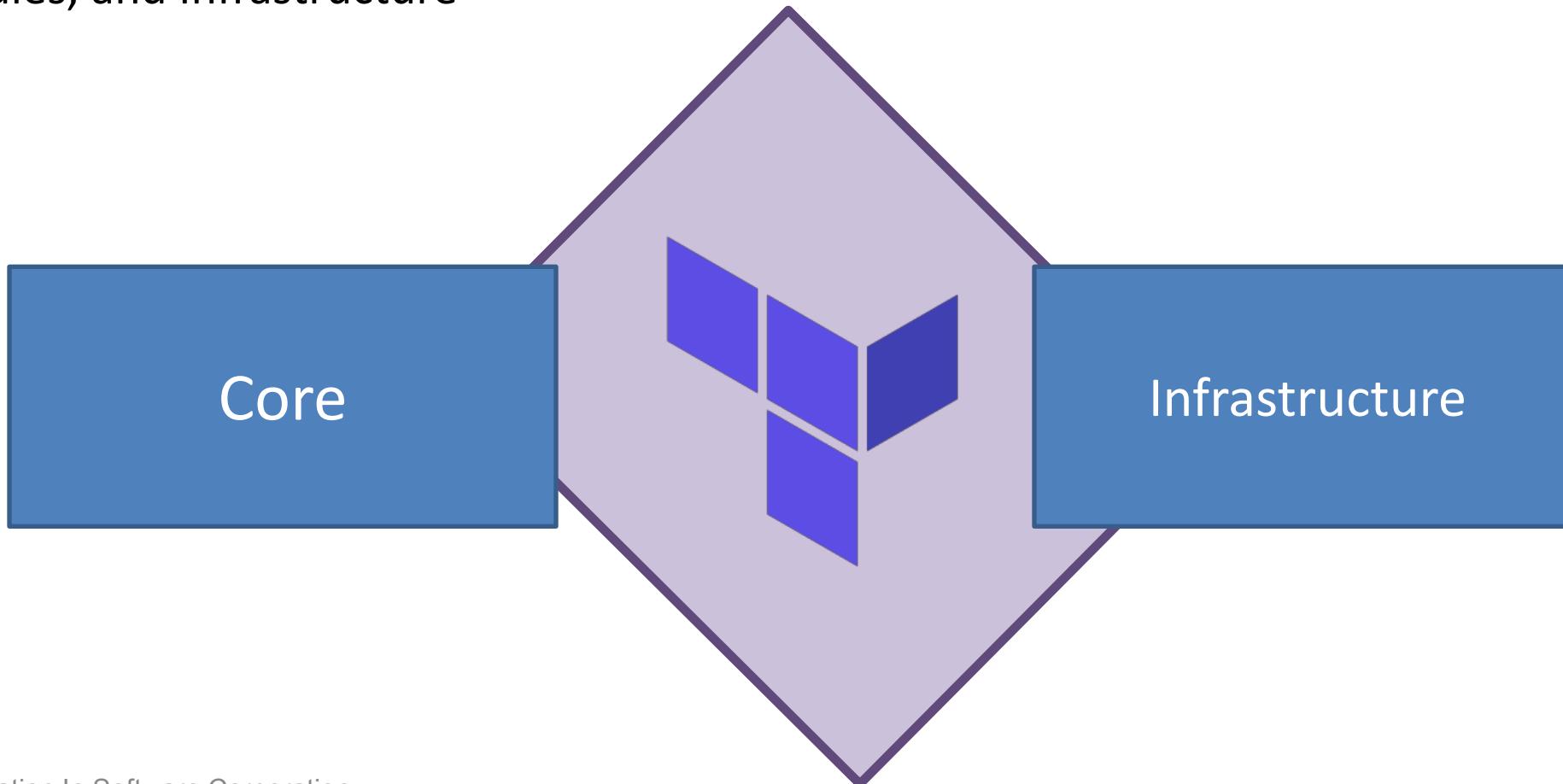
Terraform code is broken into three parts: Core Terraform, Modules and Providers

Core

Infrastructure

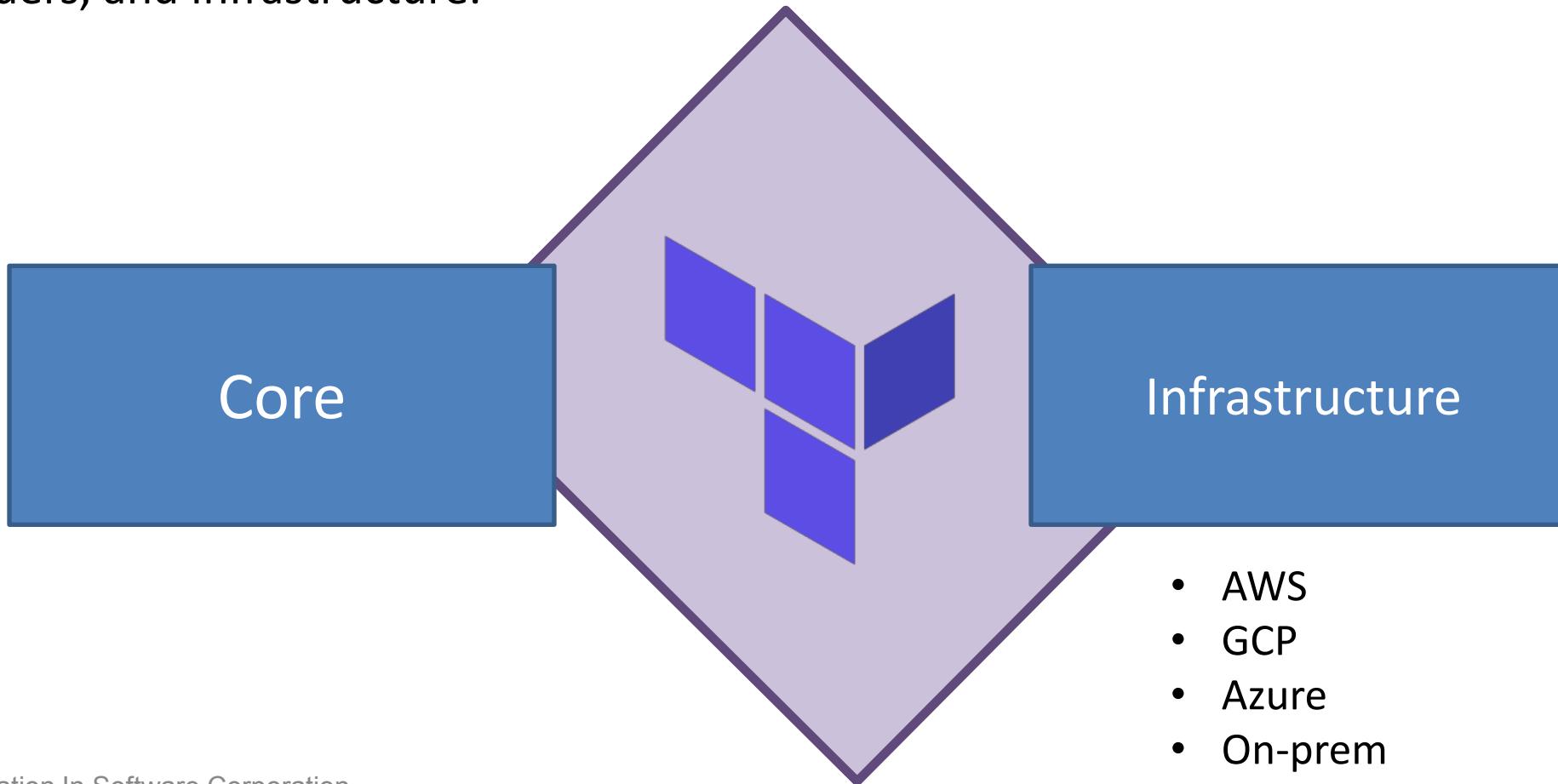
# terraform model

Terraform code is broken into three parts: Core Terraform, Providers and Modules, and Infrastructure

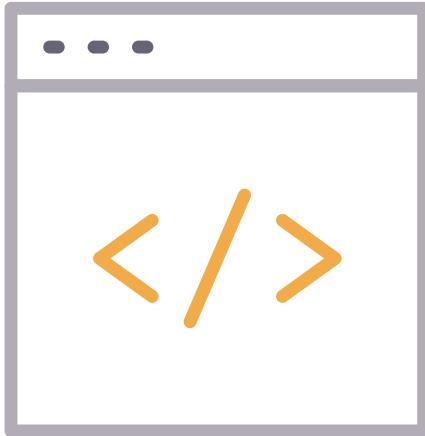


# terraform model

Terraform code is broken into three parts: Core Terraform, Modules and Providers, and Infrastructure.



# configuration files



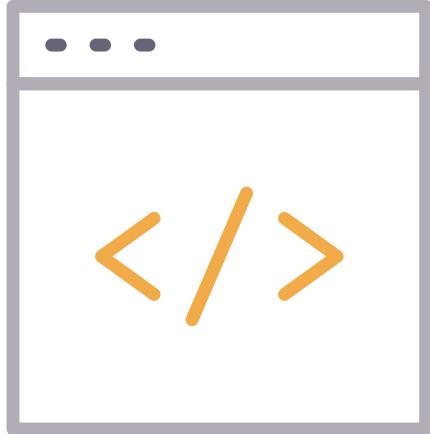
Terraform has a pretty confusing file hierarchy. We are going to start with the basics.

`provider.tf` - specify provider information

`main.tf` - Create infrastructure resources.

`variables.tf` - define values for variables in `main.tf`

# Terraform files



- core = Terraform language, logic, and tooling.
- provider = Pluggable code to allow Terraform to talk to vendor APIs
- modules = A container for multiple resources that are used together.

# Terraform providers



Terraform relies on plugins called "providers" to interface with remote systems.

Terraform configurations must declare which providers they require so that Terraform can install and use them. Additionally, some providers require configuration (like endpoint URLs or cloud regions) before they can be used.

# Terraform providers

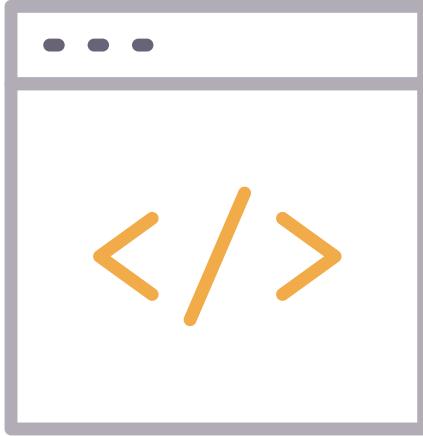


Each provider adds resources and/or data sources that Terraform manages.

Every resource type is implemented by a provider. Terraform can't manage any kind of infrastructure without providers.

Providers are used to configure infrastructure platforms (either cloud or self-hosted). Providers also offer utilities for tasks like generating random numbers for unique resource names.

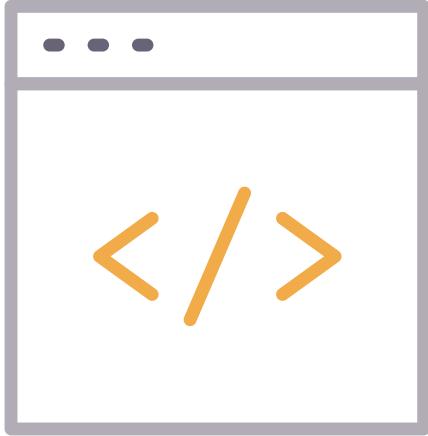
# Terraform files



```
##Amazon Infrastructure
provider "aws" {
    region = "${var.aws_region}"
}
```

- Provider defines what infrastructure Terraform will be managing
  - Pass variables to provider
    - Region, *Flavor, Credentials*

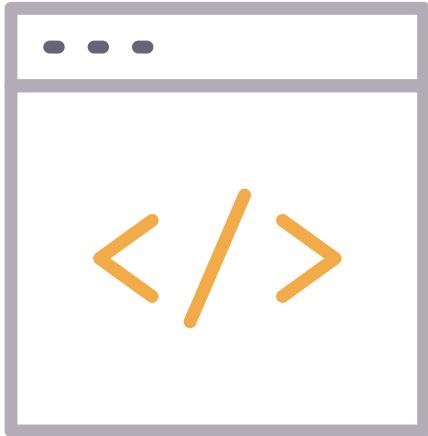
# Terraform provider configuration



```
required_providers {  
    aws = {  
        source  = "hashicorp/aws"  
        version = "5.29.0"  
    }  
}
```

Terraform allows you to configure the providers in code.  
configure specific versions or pull in latest.

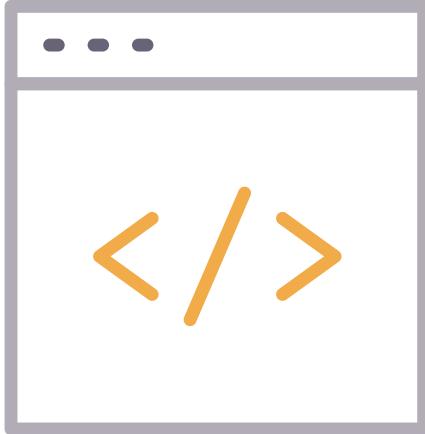
# Terraform provider configuration



```
provider "azurerm" {
    subscription_id = "SUBSCRIPTION-ID"
    client_id       = "CLIENT-ID"
    client_secret   = "CLIENT-SECRET"
    tenant_id        = "TENANT_ID"
}
```

Providers allow you to authenticate in the code block. **This is a very BAD idea.**

# Terraform provider configuration

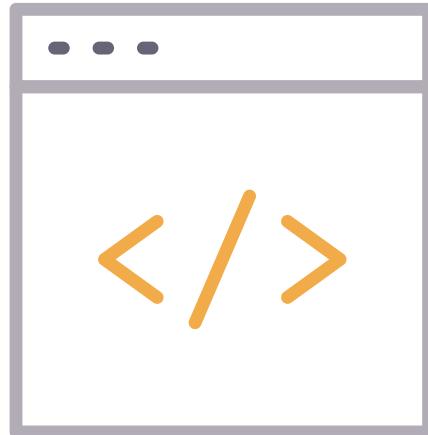


For Azure that can be az login, Managed Service Identity, or environment variables.

```
az login
```

```
export ARM_TENANT_ID=
export ARM_SUBSCRIPTION_ID=
export ARM_CLIENT_ID=
export ARM_CLIENT_SECRET=
```

# Terraform provider configuration



Terraform will use the native tool's method of authentication.  
Environment variables, shared credentials files or static  
credentials.

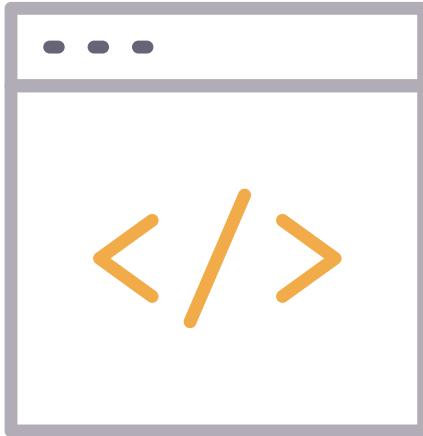
```
provider "aws" { }
```

```
set AWS_ACCESS_KEY_ID=your-access-key-id  
set AWS_SECRET_ACCESS_KEY= =your-secret-access-key
```

Powershell:

```
$env:AWS_ACCESS_KEY_ID="your-access-key-id"  
$env:AWS_SECRET_ACCESS_KEY="your-secret-access-key"
```

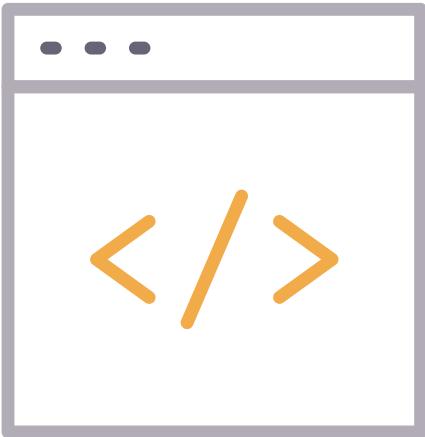
# Terraform provider configuration



Terraform will use the native tool's method of authentication. Environment variables, shared credentials files or static credentials.

```
provider "aws" {  
    region                  = "us-west-2"  
    # shared_credentials_file = "~/.aws/credentials"  
    profile                 = "customprofile"  
}
```

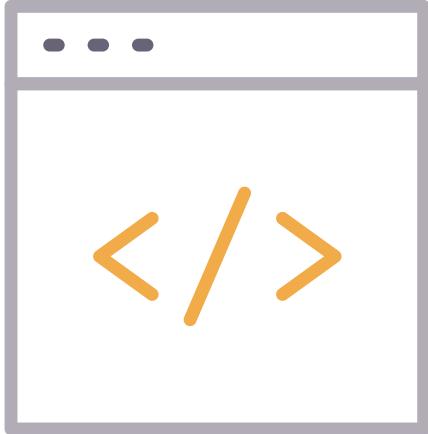
# Terraform provider configuration



Terraform will use the native tool's method of authentication.  
Environment variables, shared credentials files or static  
credentials.

```
provider "aws" {  
    access_key      = "MYKEY"  
    secret_key      = "MYSECRET"  
}
```

# Terraform ASA provider



```
provider "ciscoasa" {
    api_url          = "https://10.0.0.5"
    username         = "admin"
    password         = "YOUR SECRET PASSWORD"
    ssl_no_verify    = false
}
```

Providers allow you to authenticate in the code block. **This is a very BAD idea.**

Use environment variables:

CISCOASA\_USER

CISCOASA\_PASSWORD

# Terraform resources



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

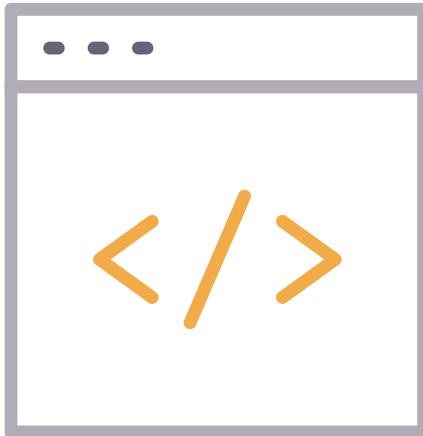
# Terraform resources



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.

# Terraform resources



Every Terraform resource is structured the exact same way.

```
resource "type" "name" {  
    parameter = "foo"  
    parameter2 = "bar"  
    list = ["one", "two", "three"]
```

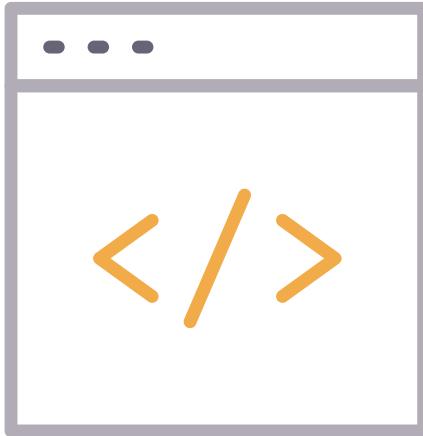
*resource* = top level keyword

# Terraform resources



Within the block body (between { and }) are the configuration arguments for the resource itself. Most arguments in this section depend on the resource type, and indeed in this example both ami and instance\_type are arguments defined specifically for the aws\_instance resource type.

# Terraform resources

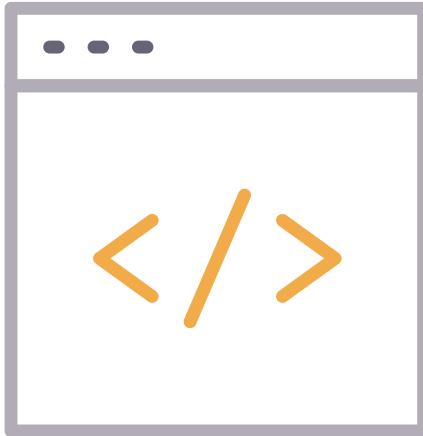


Every Terraform resource is structured the exact same way.

```
resource "type" "name" {  
    parameter = "foo"  
    parameter2 = "bar"  
    list = ["one", "two", "three"]
```

*type* = this is the name of the resource. The first part tells you which provider is belongs to. Example: `azurerm_virtual_machine`. This means the provider is Azure and the specific type of resources is a virtual machine.

# Terraform resources

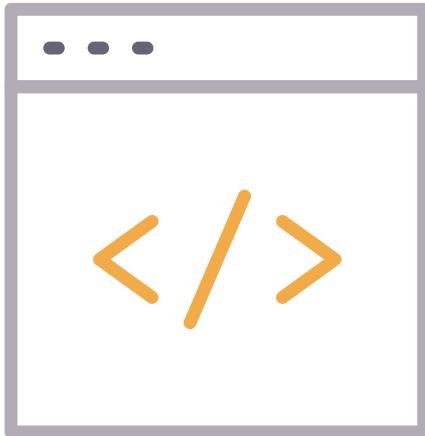


Every Terraform resource is structured the exact same way.

```
resource "type" "name" {  
    parameter = "foo"  
    parameter2 = "bar"  
    list = ["one", "two", "three"]
```

*name* = arbitrary name to refer to resource. Used internally by TF and cannot be a variable.

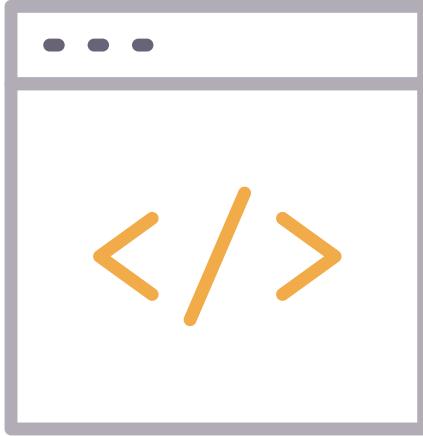
# Terraform ASA ACL resource



```
resource "ciscoasa_acl" "foo" {  
    name = "aclname"  
    rule {  
        source          = "192.168.10.5/32"  
        destination    = "192.168.15.0/25"  
        destination_service = "tcp/443"  
    }  
    rule {  
        source          = "192.168.10.0/24"  
    }  
}
```

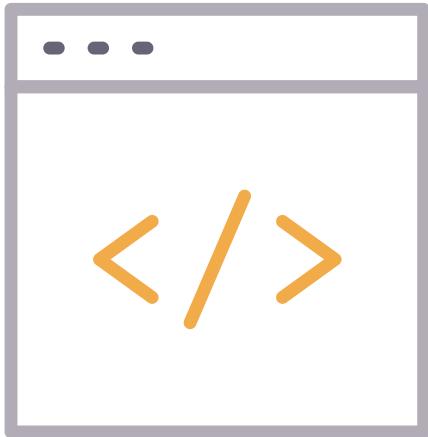
Example of creating ACL

# Terraform ASA static route resource



```
resource "ciscoasa_static_route" "ipv4_static_route" {  
    interface          = "inside"  
    network           = "10.254.0.0/16"  
    gateway          = "192.168.10.20"  
}  
  
resource "ciscoasa_static_route" "ipv6_static_route" {  
    interface          = "inside"  
    network           = "fd01:1337::/64"  
    gateway          = "fd01:1338::1"
```

# resources (building blocks)

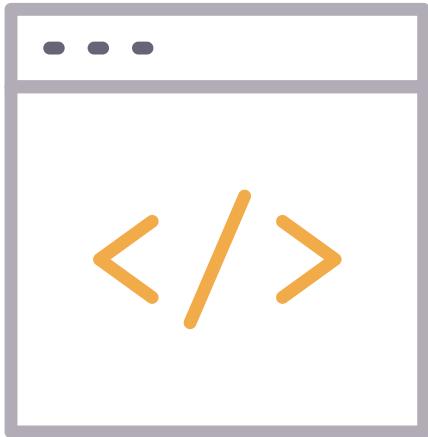


Create an Azure Resource Group.

- Azure requires all resources be assigned to a resource group.

```
resource "azurerm_resource_group" "training" {  
    name        = "training-workshop"  
    location    = "westus"  
}
```

# resources (building blocks)



**TIP:** You can assign random names to resources.

```
resource "random_id" "project_name" {
    byte_length = 4
}
resource "azurerm_resource_group" "training" {
    name        = "${random_id.project_name.hex}-training"
    location    = "westus"
}
```

# Terraform resources



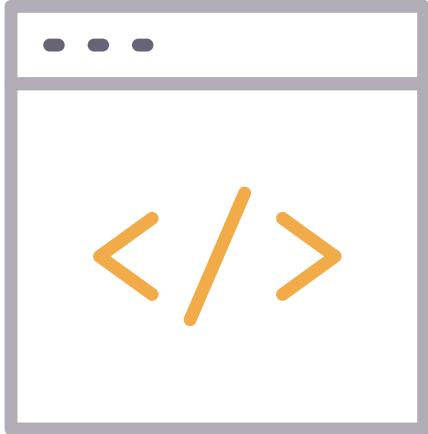
Some resource types provide a special timeouts nested block argument that allows you to customize how long certain operations are allowed to take before being considered to have failed. For example, `aws_db_instance` allows configurable timeouts for create, update and delete operations.

# Terraform resources



Timeouts are handled entirely by the resource type implementation in the provider, but resource types offering these features follow the convention of defining a child block called timeouts that has a nested argument named after each operation that has a configurable timeout value. Each of these arguments takes a string representation of a duration, such as "60m" for 60 minutes, "10s" for ten seconds, or "2h" for two hours.

# Terraform resources



```
resource "aws_db_instance" "example" {  
  # ...  
  
  timeouts {  
    create = "60m"  
    delete = "2h"  
  }  
}
```

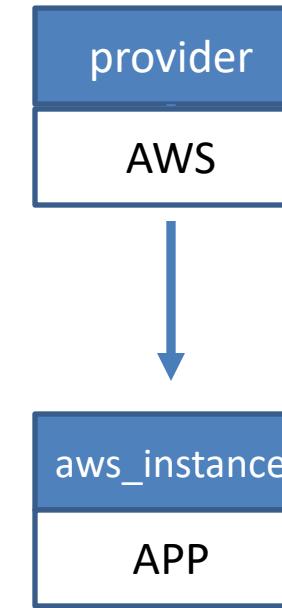
Timeout arguments

# resources (building blocks)

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

  Type
  Name

resource "aws_instance" "app" {
  ami           = "ami-abc12234ee"
  instance_type = "t2.small"
}
```



# Terraform local-only resources



While most resource types correspond to an infrastructure object type that is managed via a remote network API, there are certain specialized resource types that operate only within Terraform itself, calculating some results and saving those results in the state for future use.

For example, you can use local-only resources for:

- Generating private keys
- Issue self-signed TLS certs
- Generating random ids
  
- The behavior of local-only resources is the same as all other resources, but their result data exists only within the Terraform state. "Destroying" such a resource means only to remove it from the state, discarding its data.

# Terraform 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.

When you declare variables in the root module of your configuration, you can set their values using CLI options and environment variables. When you declare them in child modules, the calling module should pass values in the module block.

# Terraform variables

Each input variable accepted by a module must be declared using a variable block.

The label after the variable keyword is a name for the variable, which must be unique among all variables in the same module. This name is used to assign a value to the variable from outside and to reference the variable's value from within the module.

```
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"  
    }  
  ]  
}
```

# Terraform variables

Terraform has some reserved variables:

- source
- version
- providers
- count
- for\_each
- lifecycle
- depends\_on
- locals
- These are reserved for meta-arguments in module blocks.

```
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"  
    }  
  ]  
}
```

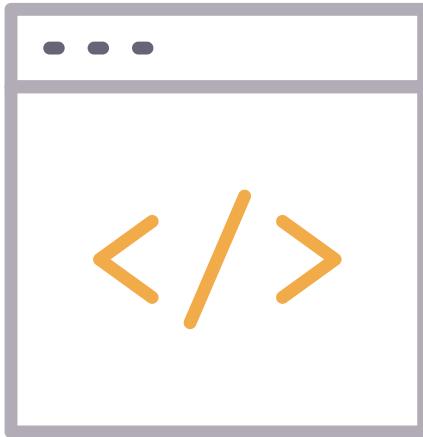
# Terraform variables



Optional variable arguments:

- default: A default value which makes the variable optional
- type: Specifies value type accepted for the variable.
- description: Specifies the variable's documentation
- validation: A block to define validation rules
- sensitive: Does not show value in output

# Terraform variables



Set default values for variables in `variables.tf`  
If default values are omitted, user may be prompted.

```
##AWS Specific Vars
variable "aws_master_count" {
  default = 10
}
variable "aws_worker_count" {
  default = 20
}
variable "aws_key_name" {
  default = "k8s"
}
```

# Terraform variables (type constraint)



Type constraints are optional but highly encouraged. They can serve as reminders for users of the module and help Terraform return helpful errors if the wrong type is used.

The type argument allows you to restrict acceptable value types. If no type constraint is defined, then a value of any type is accepted.

The keyword `any` may be used to indicate that any type is acceptable.

If both the `type` and `default` arguments are specified, the given default value must be convertible to the specified type.

# Terraform variables (type constraint)



Type constraints are created from a mixture of type keywords and constructors.

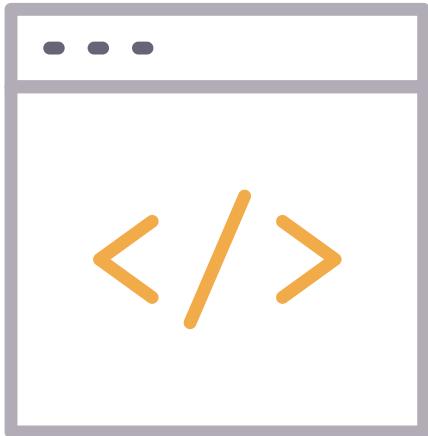
Supported type keywords:

- string
- number
- bool

Type constructors allow you to specify complex types such as collections:

- list (<TYPE>)
- set (<TYPE>)
- map (<TYPE>)
- object ({<ATTR NAME> = <TYPE>, ...})
- tuple ([<TYPE>, ...])

# Terraform variables



Input variables are part of its user interface. You can briefly describe the purpose of each variable using the optional description argument.

```
## Variable description example
variable "image_id" {
  type = string
  description = "The id of the machine image (AMI)"
}
```

# Terraform variables (validation)

In addition to Type Constraints, you can specify arbitrary custom validation rules for a variable.

```
## Variable validation example
variable "image_id" {
  type = string
  description = "The id of the machine image (AMI)"

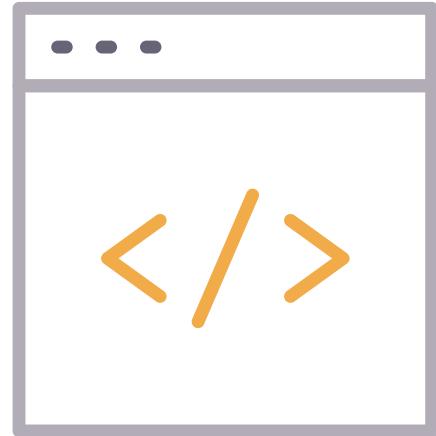
  validation {
    condition = length(var.image_id) > 4 && substr(var.image_id, 0, 4) == "ami-"
    error_message = "The image_id value must be a valid AMI id, starting with
    \"ami-\"."
  }
}
```

# Terraform variables (validation)



A condition argument is an expression that returns true or false.

# Terraform variables



If the failure of an expression is the basis of the validation decision, use the `can` function to detect such errors. For example:

```
## Variable validation example
variable "image_id" {
    type = string
    description = "The id of the machine image (AMI)"

    validation {
        # regex(...) fails if it cannot find a match
        condition = can(regex("^ami-", var.image_id))
        error_message = "The image_id value must be valid."
```

# Lab: Variables and output



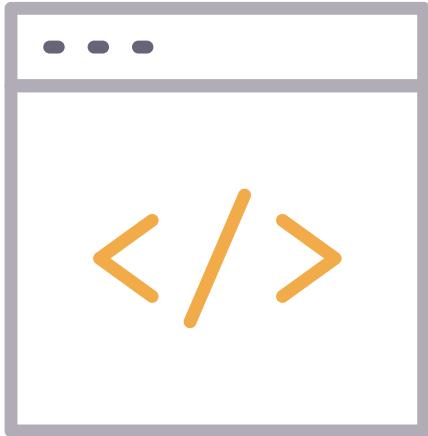
# Lab: Create multi-resource infrastructure



# Terraform state file

Terraform is a *stateful* application.

- Keeps track of everything you build inside of a state file
  - `terraform.tfstate`
- State file is also a source of truth in Terraform



```
{  
  "version": 3,  
  "terraform_version": "0.12.29",  
  "serial": 6,  
  "lineage": "0a209e29-de63-9e87-2cd2-4f2071717cee",  
  "modules": [  
    {  
      "path": [  
        "root"  
      ],  
      "outputs": {  
        "MySQL_Server_FQDN": {  
          "value": "labtest1-mysql-server.azure.com"  
        }  
      }  
    }  
  ]  
}
```

# Terraform state file



Each Terraform configuration can specify a backend, which defines where and how operations are performed, where state snapshots are stored, etc.

# Terraform state file



When starting out with Terraform the best approach is to stick with a local backend. It also makes sense to use a local backend if you are the only one managing the infrastructure.

# Terraform state file



Terraform supports local and remote state file storage.

- Default is local storage
- Remote backends:
  - S3, Azure Storage, Google Cloud Storage

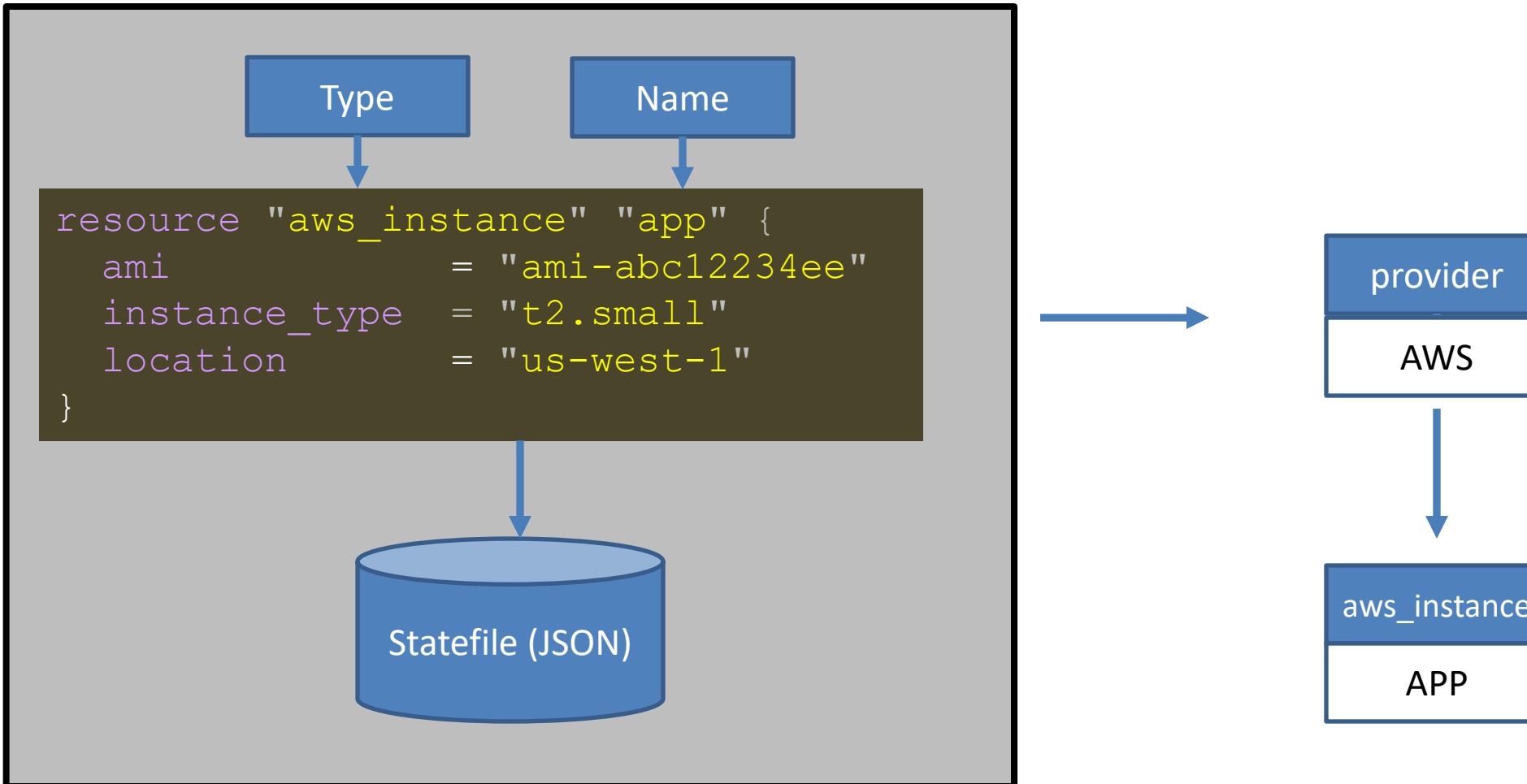
# Terraform state file



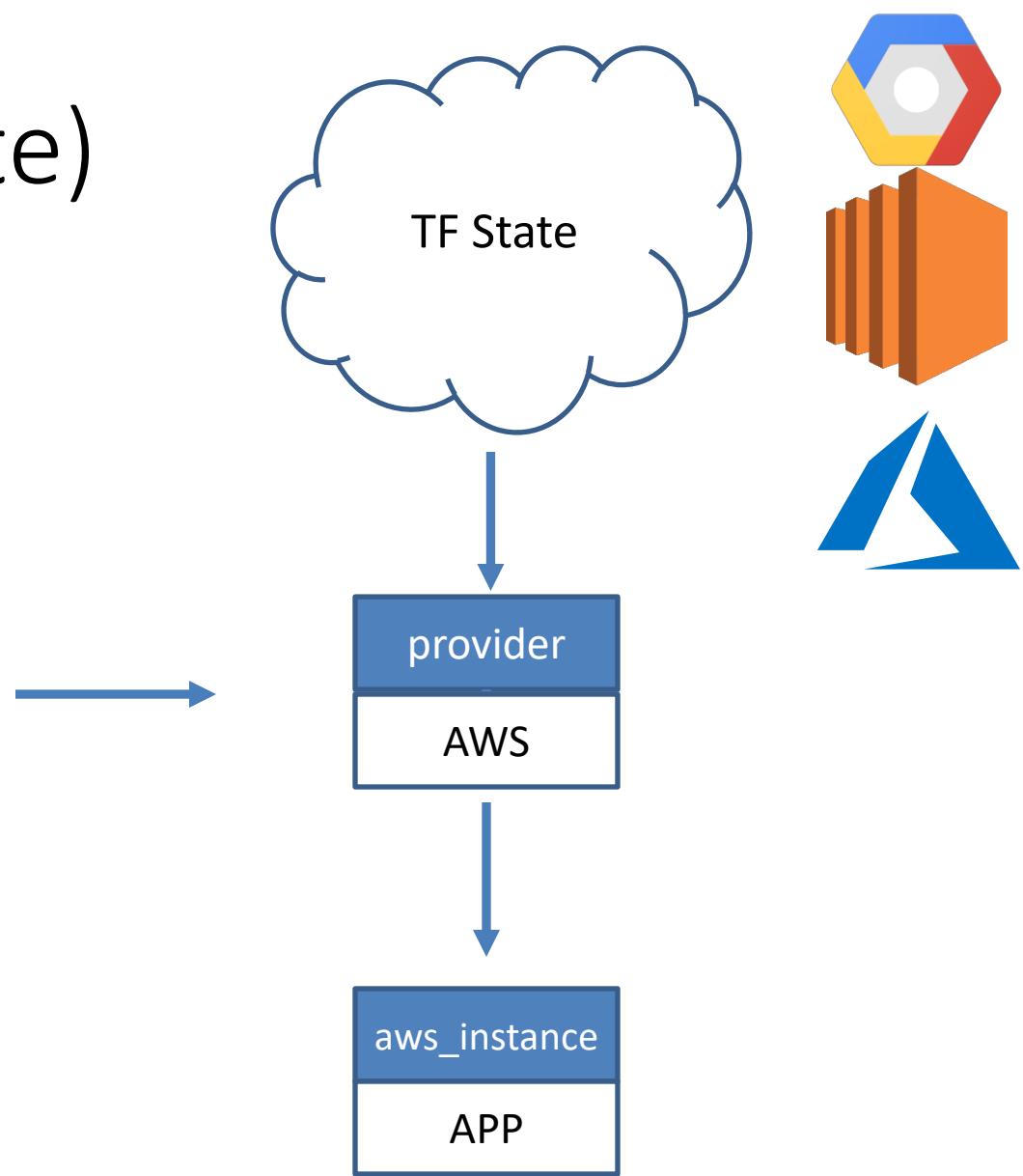
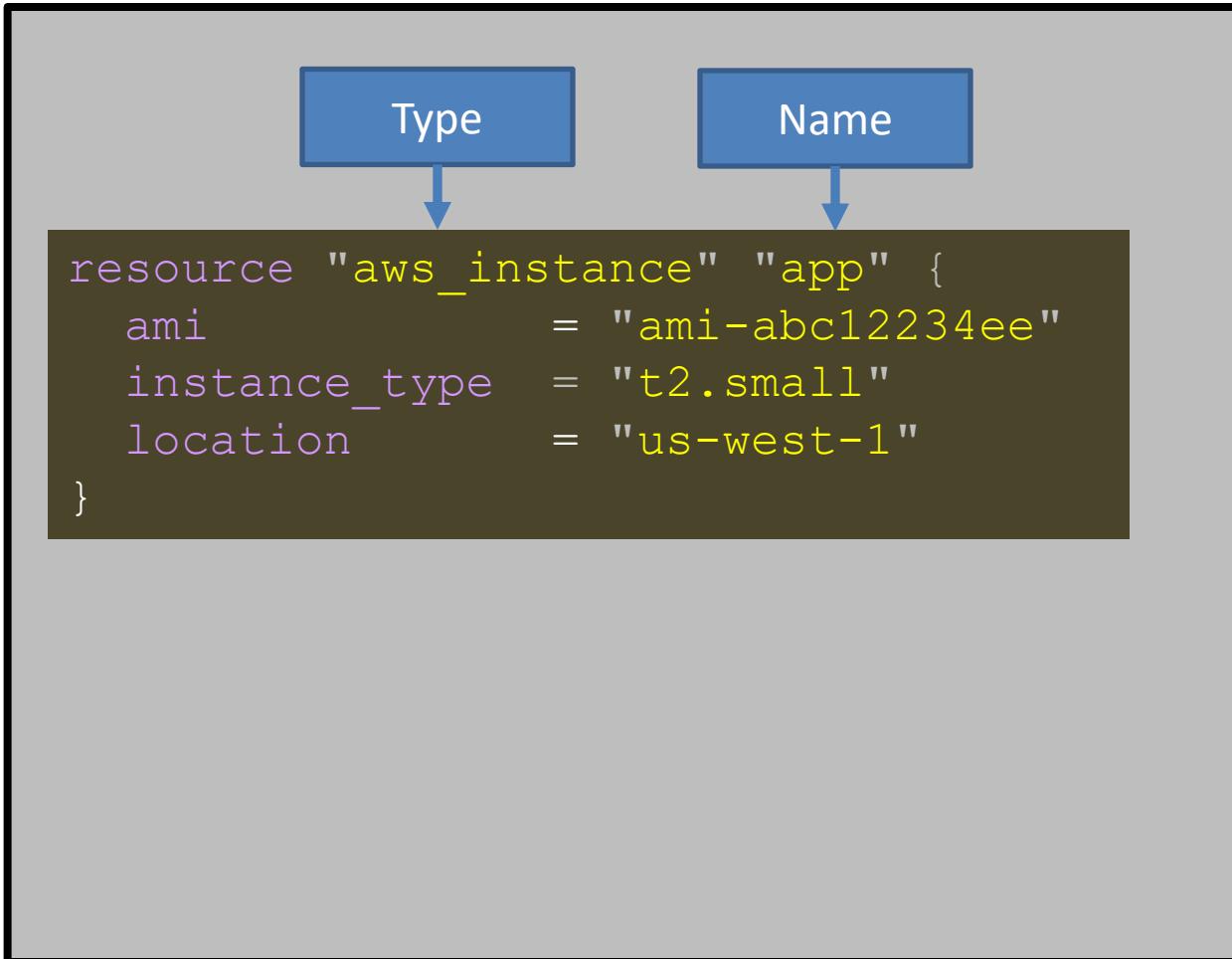
Terraform supports many backends:

- local (default)
- remote (Terraform Enterprise/Terraform Cloud)
- azurerm
- consul
- s3
- gcs
- more...

# Terraform state (local)



# Terraform state (remote)



# Terraform state file locking

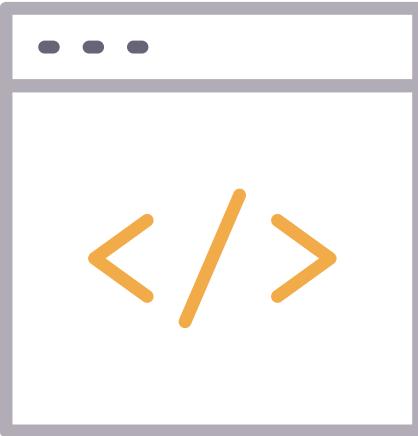


Terraform will lock your state for all operations that could write state if your backend supports it. This prevents others from acquiring the lock and possibly corrupting your state.

State locking automatically happens on all operations that write state.

- azurerm
- consul
- etcdv3
- gcs
- s3 (locking via DynamoDB)

# Terraform state file



Backends are configured with a nested "backend" block within the top-level `terraform` block.

```
terraform {  
  backend "remote" {  
    organization = "foo"  
  }  
}
```

# Lab: Implement bool, strings and numbers



# Lab: Migrate to remote state backend

