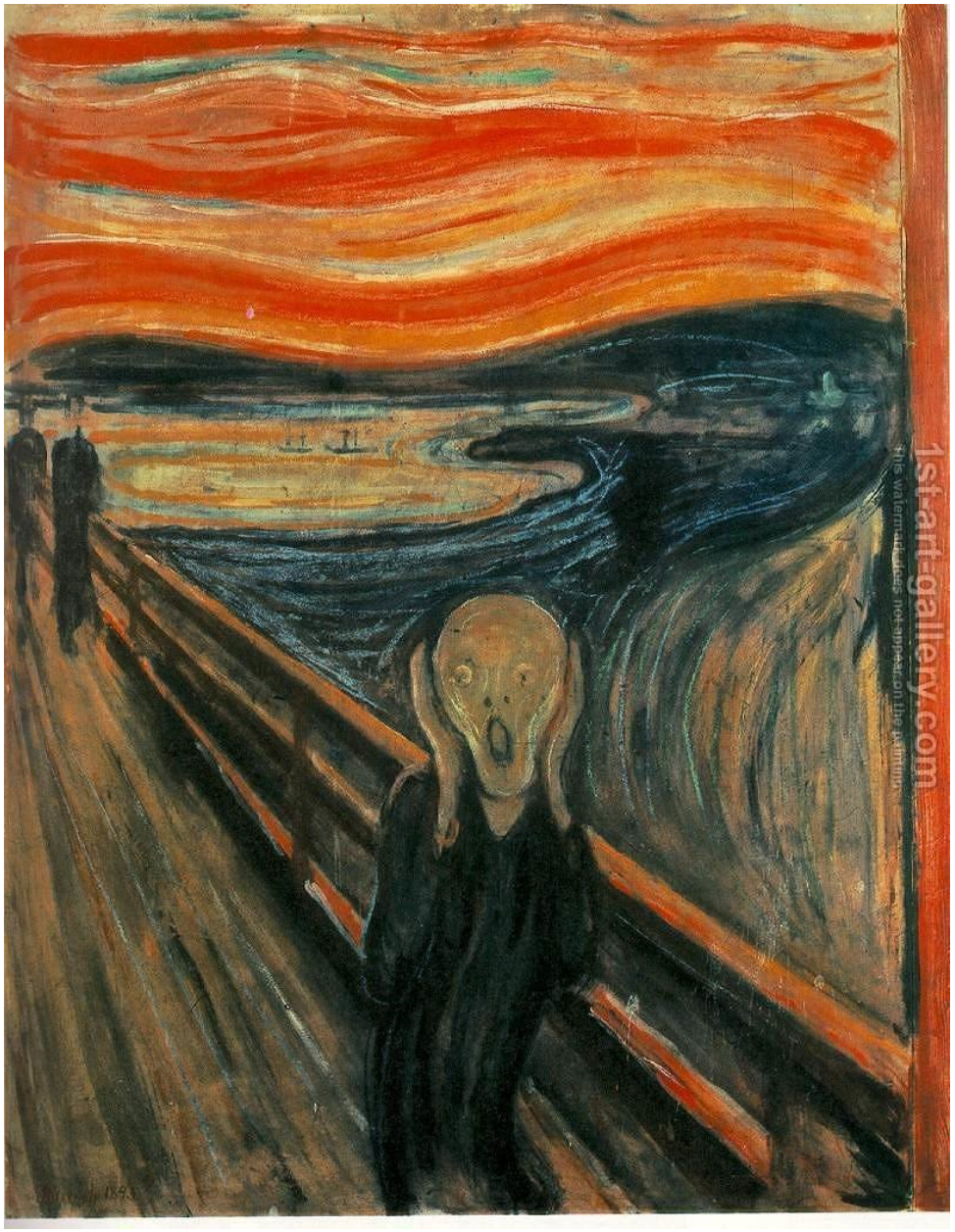
How to Test Terraform Code

DevOps World is Full of Fear



The Plan

- Manual tests
  - Manual testing basics
  - Cleaning up after tests
- Automated tests
  - Unit tests
  - Integration tests
  - End-to-end tests
  - Other testing approaches

Manual Tests

- What does manual testing mean in Terraform?
  - How much is it like manual testing in a programming language?
- When testing Terraform code, there is no `localhost`
  - True of most IaC tools
  - You have to deploy to a real environment
  - But *not* a production environment
- This is why it is essential to have examples which can be manually tested in an real environment

Validation Clients

- When we run tests, we normally are using some appropriate client to validate the result of the test
  - For web apps, we use 'curl' or some other tool to check the output at a specific address or URL
  - For databases, we would use a client to run queries on the db so that we can validate the results
- Best practice is to set up a test sandbox
  - There will be a lot a building and tearing down of code
  - Each developer should have their own sandbox
  - The Gold standard would be separate AWS accounts

Cleaning Up After Testing

- Regularly clean up your sandbox environments
  - Running deployments cost money
  - It's easy to overlook infrastructure so that it sort of just hangs around
- At a minimum, use `terraform destroy` before stopping your tests
  - Also consider a regular "scrubbing" of the workspace using a cron job
- Use tools to help line
  - **cloud-nuke** : An open source tool that can delete all the resources in your cloud environment
  - **Janitor Monkey** : An open source tool that cleans up AWS resources on a configurable schedule
  - **aws-nuke** : An open source tool dedicated to deleting everything in an AWS account

Automated Testing

- There are three kinds of automated tests:
- Unit tests
  - Unit tests verify the functionality of a single, small unit of code
  - External dependencies are replaced with test mocks
- Integration tests
  - Integration tests verify that multiple units work together correctly
  - We generally mock out other parts of the system we are not testing
- End to end testing
  - End-to-end tests involve running your entire architecture from the end-user's perspective
  - Typically use real systems everywhere, without any mocks, in an architecture that mirrors production

Unit Testing

- The first step is to identify what a “unit” is in the Terraform world
  - A unit would be a single generic module such as the alb module
  - We can't do pure unit testing in the sense of a programming language in Terraform
  - Most unit testing is designed to work with procedural languages, not declarative ones
- Because we are deploying the module into a real environment, we are essentially doing an integration test
  - But controlling the environment is a lot like mocking it out

Unit Testing Strategy

- This means that the basic strategy for writing unit tests for Terraform is:
  - Create a generic, standalone module
  - Create an easy-to-deploy example for that module
  - Run terraform apply to deploy the example into a real environment
  - Validate that what you just deployed works as expected
  - Run terraform destroy at the end of the test to clean up.
- For automated testing, first write the manual test, then automate
  - Remember to try the automated tests on code that has no errors to ensure the tests are being automated correctly

TerraTest

- This is an automated test tool writen in Go (the same language Terraform is written in)
- Installation steps
  - Install Go: https://golang.org/doc/install
  - Configure the GOPATH environment variable: https://golang.org/doc/code.html#GOPATH
  - Add $GOPATH/bin to your PATH environment variable.
  - Install Dep, a dependency manager for Go: https://golang.github.io/dep/docs/installation.html
  - Create a folder within your GOPATH for your test code: e.g., the default GOPATH is $HOME/go, so you could create $HOME/go/src/terraform-up-and-running
  - Run dep init in the folder you just created. This should create Gopkg.toml, Gopkg.lock, and an empty vendors folder

Test Installation

- Use the following Go code

```
1  package test
2
3  import (
4      "fmt"
5      "testing"
6  )
7
8  func TestGoIsWorking(t *testing.T)  {
9      fmt.Println()
10     fmt.Println("If you see this text, it's working!")
11     fmt.Println()
12 }
```

- Run this test using the go test command and make sure you see the following output:

```
1  $ go test -v
2
3  If you see this text, it's working!
4
5  PASS
6  ok      terraform-up-and-running    0.004s
```

Creating a

- Set up the test skeleton and set the options parameter to the `alb` sample directory

```
package test

import (
    "github.com/gruntwork-io/terratest/modules/terraform"
    "testing"
)

func TestAlbExample(t *testing.T)  {
    opts := &terraform.Options{
        // You should update this relative path to point at your alb
        // example directory!
        TerraformDir: "../examples/alb",
    }
}
```

```
$ dep ensure -add github.com/gruntwork-io/terratest/modules/terraform@v0.15.9
```

Add code for

- We add the code to run the Terraform 'init' and 'apply' commands

```
unc TestAlbExample(t *testing.T)  {
opts := &terraform.Options{
    // You should update this relative path to point at your alb
    // example directory!
    TerraformDir: "../examples/alb",
}

terraform.Init(t, opts)
terraform.Apply(t, opts)
// or
// terraform.InitAndApply(t, opts)
}
```

Testing Output Variables

- There is a testable output from here

```
output "alb_dns_name" {
    value       = module.alb.alb_dns_name
    description = "The domain name of the load balancer"
}
```

```
func TestAlbExample(t *testing.T)  {
opts := &terraform.Options{
    // You should update this relative path to point at your alb
    // example directory!
    TerraformDir: "../examples/alb",
}

// Deploy the example
terraform.InitAndApply(t, opts)

// Get the URL of the ALB
albDnsName := terraform.OutputRequired(t, opts, "alb_dns_name")
url := fmt.Sprintf("http://%s", albDnsName)
}
```

The Expected Values

- A critical part of every test is the expected values that we use to compare our actual results to
- We can add those in the test code along with a method that will make an HTTP request

```
1  func TestAlbExample(t *testing.T)  {
2  (...)
3  terraform.InitAndApply(t, opts)
4
5  // Get the URL of the ALB
6  albDnsName := terraform.OutputRequired(t, opts, "alb_dns_name")
7  url := fmt.Sprintf("http://%s", albDnsName)
8
9  // Test that the ALB's default action is working and returns a 404
10
11 expectedStatus := 404
12 expectedBody := "404: page not found"
13
14 http_helper.HttpGetWithValidation(t, url, expectedStatus, expectedBody)
15 }
```

Timing Issues

- Because of timing issues, our tests may fail because they are run before the app is fully ready
  - We can set some parameters to retry the request a number of times

```
1  func TestAlbExample(t *testing.T)  {
2      (...)
3      expectedStatus := 404
4      expectedBody := "404: page not found"
5
6      maxRetries := 10
7      timeBetweenRetries := 10 * time.Second
8
9      http_helper.HttpGetWithRetry(
10         t,
11         url,
12         expectedStatus,
13         expectedBody,
14         maxRetries,
15         timeBetweenRetries,
16     )
17 }
```

The Test Framework

- Go has a built-in test system which is keeping track of the test being run (the *testing.T struct) and will report the results
- We also have to clean up and call `terrraform destroy`

```
1  func TestAlbExample(t *testing.T)  {
2      (...)
3
4  // Clean up everything at the end of the test
5  defer terraform.Destroy(t, opts)
6
7  // Deploy the example
8  terraform.InitAndApply(t, opts)
9
10 // Get the URL of the ALB
11 (...)
12
13 }
```

Automated Testing Pointers

- Manual testing should be done in a sandbox account
  - For automated testing, this is even more important
  - A totally separate account is recommended.
  - As your automated test suite grows, you might be spinning up hundreds or thousands of resources in every test suite, so keeping them isolated from everything else is essential
  - Teams should consider a completely separate environment just for automated testing
  - This is separate even from the sandbox environments you use for manual testing.
- Go test can be run with a time limit (10 minutes by default) which it kills the the test environment
  - At this point all the tests fail but the environment is not destroyed

```
1 go test -v -timeout 30m
```

Recap - Key Parts of the Test

- Running terraform init
- Running terraform apply
- Reading output variables using terraform output
- Repeatedly making HTTP requests to the ALB
- Running terraform destroy

Integration Tests

- We have been treating modules as our basic units in Terraform
- An integration test would deploy several modules and see that they work correctly
  - If the modules should not have anything in them hard-coded for the staging environment
- We never do any integration tests unless all of the modules have been thoroughly unit tested
- To do an integration test of the webserver and the database backend:
  - First deploy the `mysql` server
  - Then deploy the `hello-world-app`
  - Run the test
  - Undeploy the `hello-world-app`
  - Undeploy `mysql`

Running the Integration Test

- The test code to run the integration test would look something like this:

```
// Replace these with the proper paths to your modules
const dbDirStage = "../live/stage/data-stores/mysql"
const appDirStage = "../live/stage/services/hello-world-app"

func TestHelloWorldAppStage(t *testing.T)  {
    t.Parallel()

    // Deploy the MySQL DB
    dbOpts := createDbOpts(t, dbDirStage)
    defer terraform.Destroy(t, dbOpts)
    terraform.InitAndApply(t, dbOpts)

    // Deploy the hello-world-app
    helloOpts := createHelloOpts(dbOpts, appDirStage)
    defer terraform.Destroy(t, helloOpts)
    terraform.InitAndApply(t, helloOpts)

    // Validate the hello-world-app works
    validateHelloApp(t, helloOpts)
}
```

- One issue that has to be dealt with is where each component is storing their state
  - We don't want the testing to overwrite the actual state file

Faster Integration Testing

- Running the stages mentioned earlier may be unnecessary if all we are doing is making changes to the `hello-world-app`
- In this case we can eliminate overhead by doing:
  - Run `terraform apply` on the `mysql` module
  - Run `terraform apply` on the `hello-world-app` module
  - Work on the module
    - Make changes to `hello-world-app`
    - Run `terraform apply` on the `hello-world-app` module to implement updates
    - Validate
    - If it all works go to step 4, else go back to step 3
  - Run `terraform destroy` on the `hello-world-app` module
  - Run `terraform destroy` on the `mysql` module

Terratest Support

- Terratest supports this natively with the test_structure package
  - Each stage of your test in a function with a name
  - Terratest can skip some of those names by setting environment variables
  - Each test stage stores test data on disk so that it can be read back from disk on subsequent test runs

```
1  func TestHelloWorldAppStageWithStages(t *testing.T) {
2      t.Parallel()
3
4      // Store the function in a short variable name solely to make the
5      // code examples fit better in the book.
6      stage := test_structure.RunTestStage
7
8      // Deploy the MySQL DB
9      defer stage(t, "teardown_db", func() { teardownDb(t, dbDirStage) })
10     stage(t, "deploy_db", func() { deployDb(t, dbDirStage) })
11
12     // Deploy the hello-world-app
13     defer stage(t, "teardown_app", func() { teardownApp(t, appDirStage) })
14     stage(t, "deploy_app", func() { deployApp(t, dbDirStage, appDirStage) })
15
16     // Validate the hello-world-app works
17     stage(t, "validate_app", func() { validateApp(t, appDirStage) })
18 }
```

Test Stages

- The `RunTestStage` method takes three arguments:
  - `t` : the built in thest structure that manages the state of the test - for example, calling `t.Fail()` causes the test to fail
  - `Stage name` : the name for this test stage
  - `Code to execute` : Any function to execute
- The code to mplement `deployDB` qnd `teardownDb` would be

```
1 func deployDb(t *testing.T, dbDir string) {
2 dbOpts := createDbOpts(t, dbDir)
3
4     // Save data to disk so that other test stages executed at a later
5     // time can read the data back in
6     test_structure.SaveTerraformOptions(t, dbDir, dbOpts)
7
8     terraform.InitAndApply(t, dbOpts)
9 }
```

```
1 func teardownDb(t *testing.T, dbDir string) {
2     dbOpts := test_structure.LoadTerraformOptions(t, dbDir)
3     defer terraform.Destroy(t, dbOpts)
4 }
```

Selective Test Stages

- Staging allows for selective skipping of stages

```
$   SKIP_teardown_db=true \
    SKIP_teardown_app=true \
    go test -timeout 30m -run 'TestHelloWorldAppStageWithStages'

    (...)

    The 'SKIP_deploy_db' environment variable is not set,
    so executing stage 'deploy_db'.

    (...)
    The 'teardown_app' environment variable is set,
    so skipping stage 'deploy_db'.
```

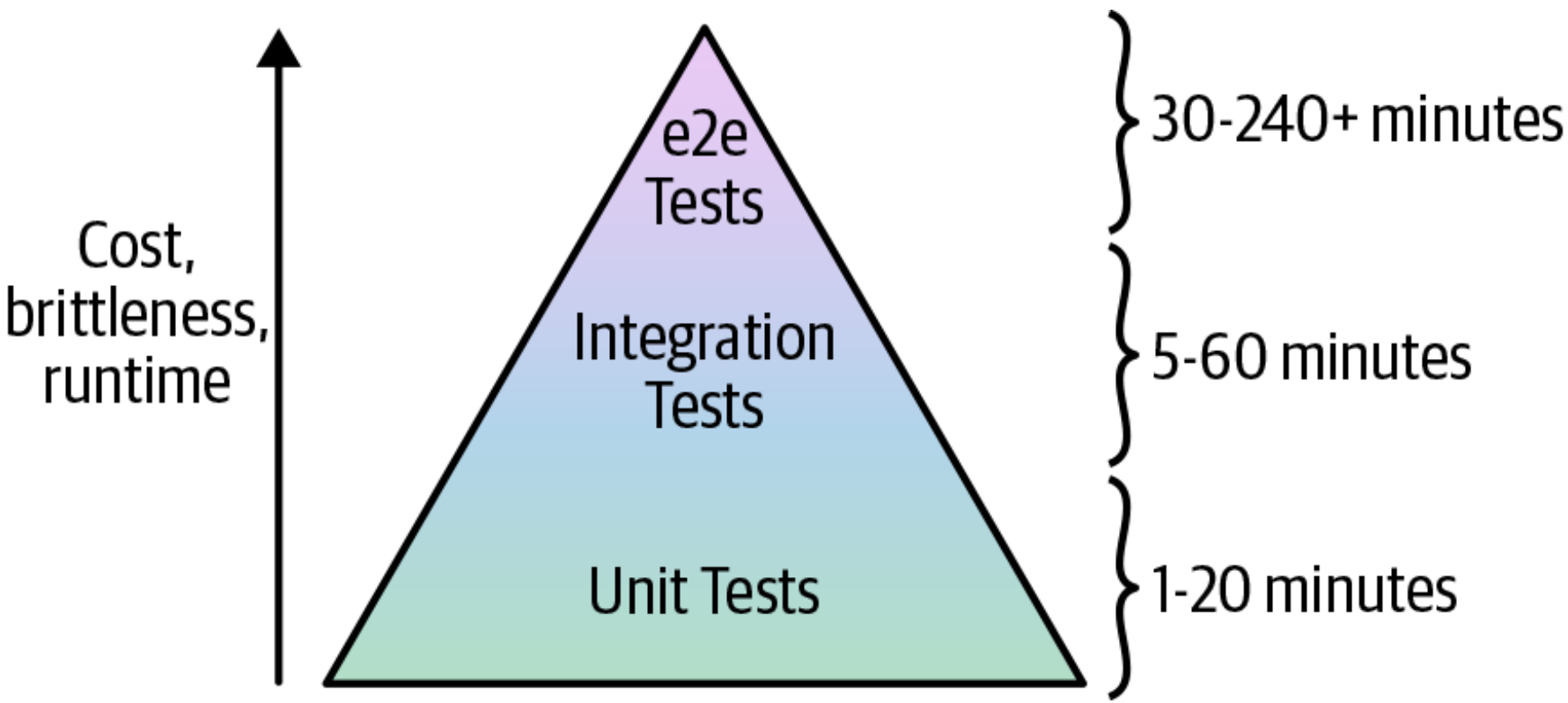
Retries

- Tests can fail for various transient reasons that are random and unpredictable
  - A common way of dealing with false positives is retrying the test on a failure
- Terratest supports automatic retries by setting "retry" options

```
func createHelloOpts(
dbOpts *terraform.Options,
terraformDir string) *terraform.Options {

    return &terraform.Options{
        TerraformDir: terraformDir,

        Vars: map[string]interface{}{
            "db_remote_state_bucket": dbOpts.BackendConfig["bucket"],
            "db_remote_state_key": dbOpts.BackendConfig["key"],
            "environment": dbOpts.Vars["db_name"],
        },

        // Retry up to 3 times, with 5 seconds between retries,
        // on known errors
        MaxRetries: 3,
        TimeBetweenRetries: 5 * time.Second,
        RetryableTerraformErrors: map[string]string{
            "RequestError: send request failed": "Throttling issue?",
        },
    }
}
```

End to End Tests

- As our tests include more an more code, they become longer to execute and more costly to set up and run
- We should plan for a large number of unit tests, smaller number of integration tests and and even smaller number of end-to-end tests



End to End Setup

- With larger and more complicated infrastructure, setting up a stable infrastructure (test environments, namespaces etc) this only becomes more difficult
  - Therefore, you want to do as much of your testing as low in the pyramid as you can because the bottom of the pyramid offers the fastest, most reliable feedback loop
- Deploying a complicated architecture from scratch is untenable for several reasons
- Too slow:
  - The more complex the infrastructure, longer it takes to set up
  - Limits the amount of testing that can be done which means slow feedback
- Too brittle:
  - Constantly redeploying a complex setup increases the likelihood of transient errors
  - This means constant retries which inhibit the whole testing effort

End to End Strategy

- A common end-to-end strategy is:
  - A persistent, production-like environment called “test” is deployed which is left running
  - Every time a change is made to the infrastructure, the end-to-end test does the following:
  - Applies the infrastructure change to the test environment
  - Runs validations against the test environment (e.g., use Selenium to test your code from the end-user’s perspective) to make sure everything is working
- More closely mimics how you’ll be deploying those changes in production
  - Also confirms the deployment process also works - for example, the change can be made with zero downtime

Static Analysis

- Static analysis involves running tools that examine the structure of the code without executing it
- Common tools are:
  - `terraform validate` : a command built into Terraform that you can use to check your Terraform syntax and types
  - `tflint` : A "lint" tool for Terraform that can scan Terraform code and catch common errors and potential bugs based on a set of built-in rules
  - `HashiCorp Sentinel` : A "policy as code" framework that allows you to enforce rules across various HashiCorp tools

Property Testing

- These are testing tools like `rspec-terraform` that use Domain Specific Languages to confirm that the infrastructure conforms to a specification
- For example:

```
describe file('/etc/myapp.conf') do
    it { should exist }
    its('mode') { should cmp 0644 }
end

describe apache_conf do
    its('Listen') { should cmp 8080 }
end

describe port(8080) do
    it { should be_listening }
end
```

Key Takeaways

- When testing Terraform code, there is no localhost
  - All manual testing is done by deploying real resources into one or more isolated sandbox environments
- Regularly clean up your sandbox environments
  - Otherwise, the environments will become unmanageable, and costs will spiral out of control
- You cannot do pure unit testing for Terraform code
  - Therefore, all automated testing is done by writing code that deploys real resources into one or more isolated sandbox environments
- You must namespace all of your resources
  - This ensures that multiple tests running in parallel do not conflict with one another
- Smaller modules are easier and faster to test
  - Smaller modules are easier to create, maintain, use, and test.