Getting started with CI/CD Pipelines for Cloud Infrastructure

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What’s on the menu today

1. Motivation

Things gone wrong

2. Quick recap on CI/CD and IaC

CI/CD revisited
3 core principles of IaC
The infrastructure stack

3. Testing infrastructure code

The testing pyramid & the swiss cheese model
Offline & online tests

4. Design your Infrastructure Pipeline

One stack to rule ‘em all
Promotion

5. Challenges

What’s so special about infrastructure code?

6. Summary

What you should take away from this talk

Why CI/CD for infrastructure?

> We have a situation: one of the team members applied **terraform locally** with a version of the terraform binary older than what was used in the pipeline. Due to that we ran into a **terraform state conflict** that resulted in terraform trying to **re-create all resources**

A fellow Thoughtworker

Three core principles of Infrastructure as Code

Infrastructure as Code is an approach to building infrastructure that embraces continuous change for high reliability and quality.

1.

Everything as Code

2.

Continuously test and deliver all work in progress

3.

Small, simple pieces that you can change independently

Further motivation

Avoid snowflake environments

- Environment as configuration
- Artefact promotion across environments (dev, int, prod)

Avoid configuration drift

- There is one way and one way only to apply changes to your infrastructure

Audit log

- Since there is only one way to apply changes, we can easily get an audit log

Quick recap: CI/CD

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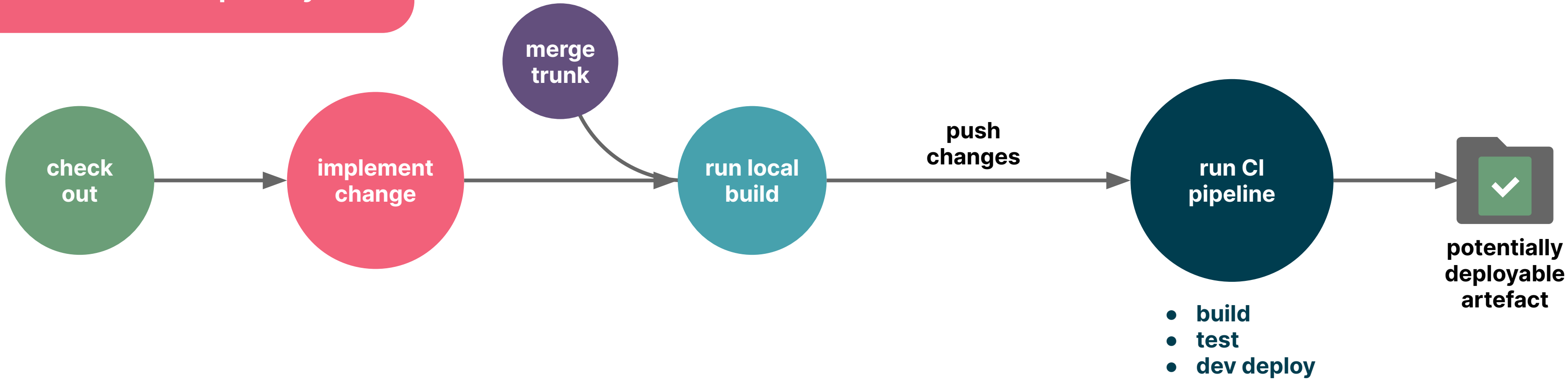
Continuous Integration

It's "CI Theatre", if you don't integrate all your code changes at least once per day

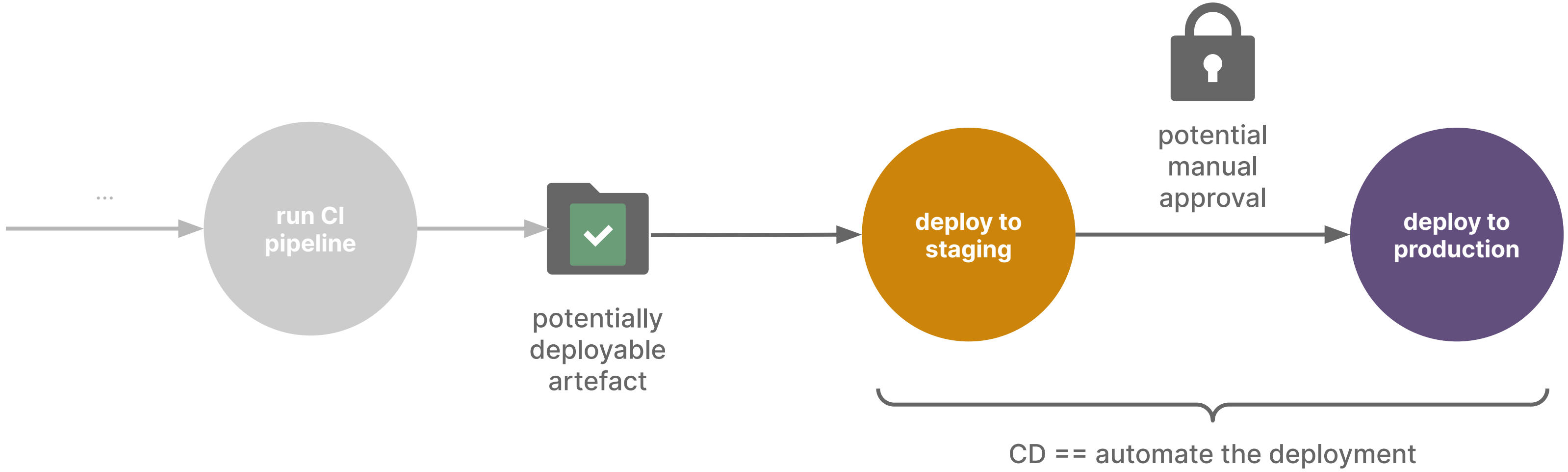


- build
- test
- dev deploy

Requires a good safety net of automated tests

visualisation of https://martinfowler.com/articles/continuousIntegration.html

Continuous Delivery


...
run CI pipeline
potentially deployable artefact
deploy to staging
potential manual approval
deploy to production
CD == automate the deployment

The infrastructure stack

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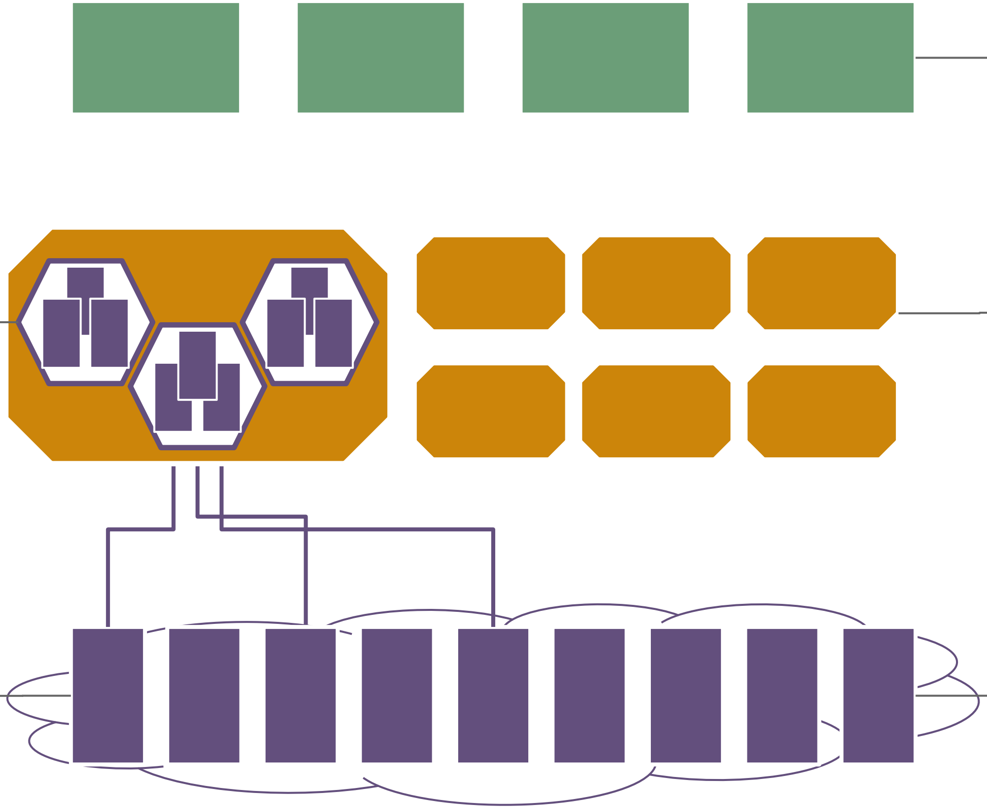
Key units of infrastructure architecture



Products, applications, and business capabilities

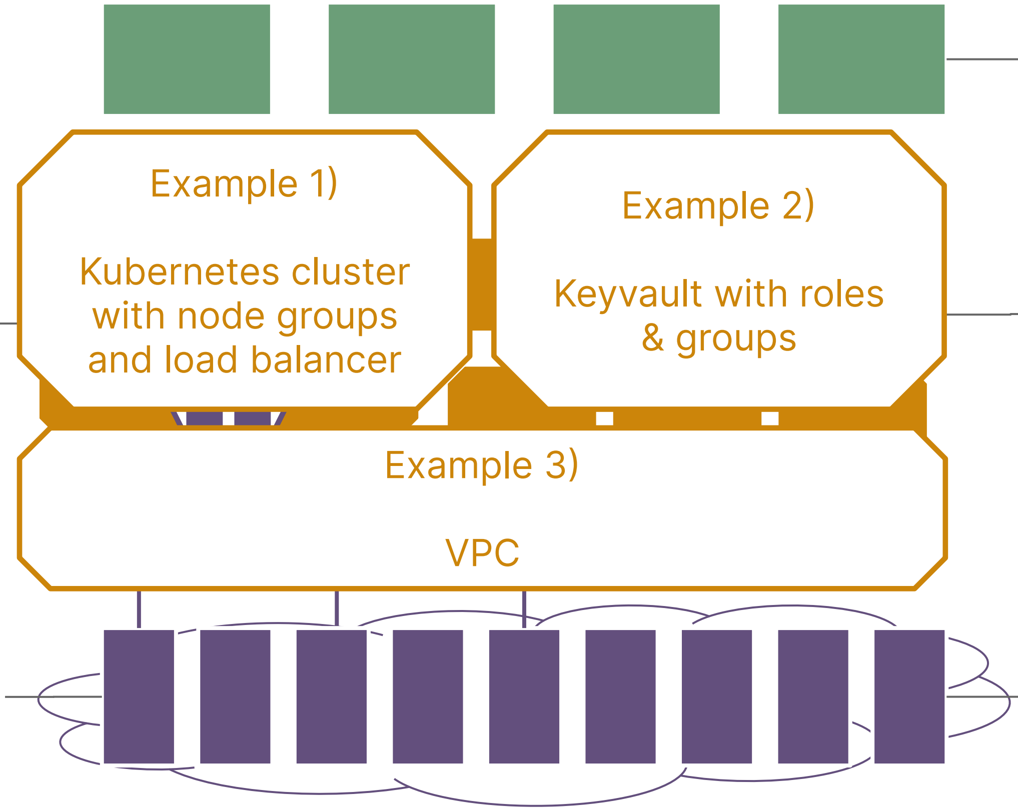
infrastructure stacks

Technology capabilities

An infrastructure stack is a collection of cloud **infrastructure resources** managed as a group

Infrastructure resources

Key units of infrastructure architecture - examples



Example 1)
Kubernetes cluster with node groups and load balancer
Example 2)
Keyvault with roles & groups
Example 3)
VPC

Products, applications, and business capabilities

infrastructure stacks

Technology capabilities

An infrastructure stack is a collection of cloud **infrastructure resources** managed as a group

Infrastructure resources

Testing infrastructure code

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What does this test tell us?

Do not test the framework!

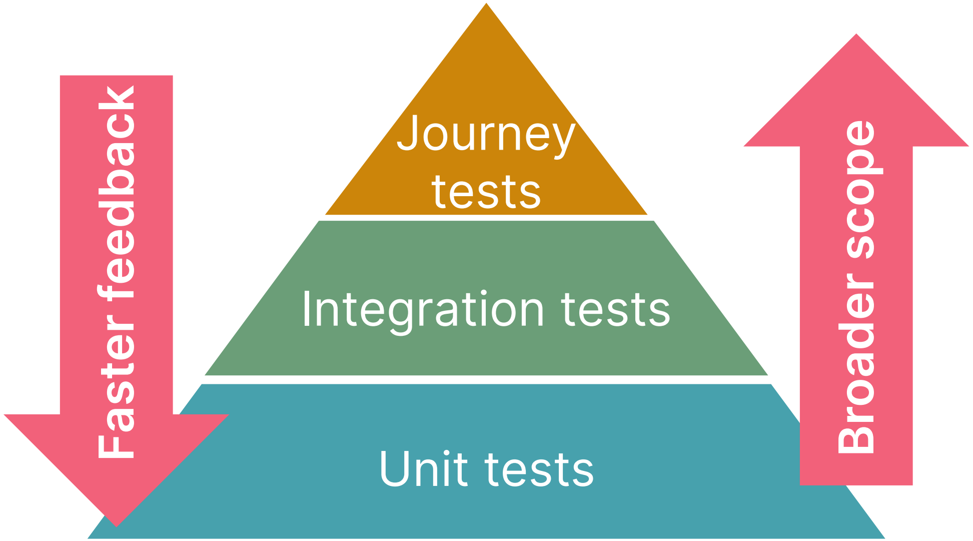
Code:

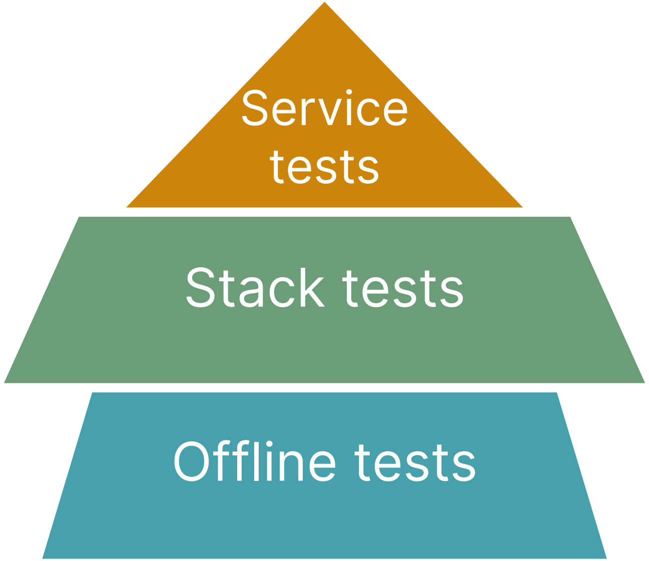
```
subnet:
  name: private_A
  address_range: 192.168.0.0/16
```

Test:

```
Given:
An AWS account
When:
A subnet is created
Then:
the subnet exists and has address block "192.168.0.0/16"
```

Infrastructure testing & the testing pyramid





Swiss cheese testing model

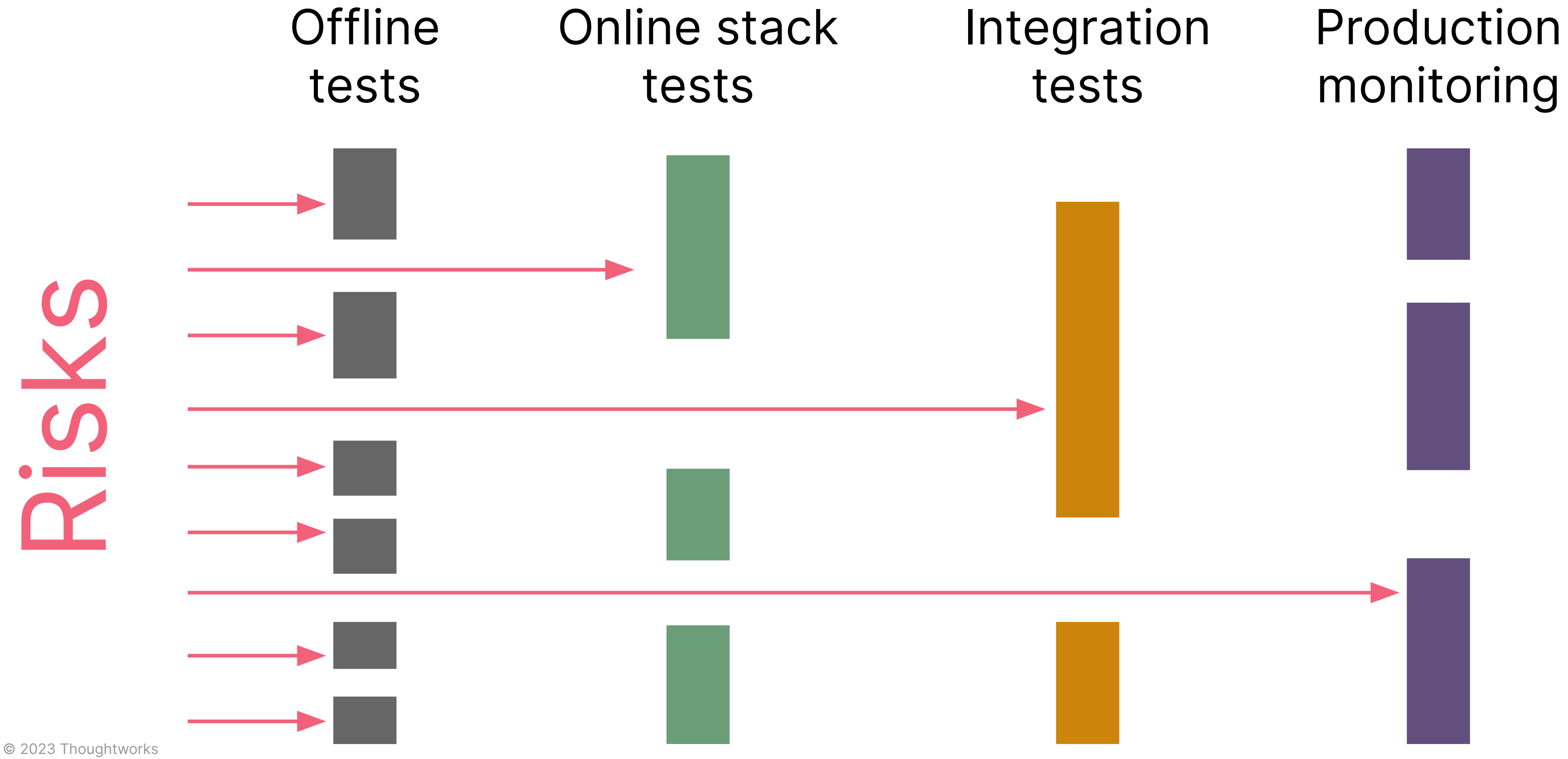
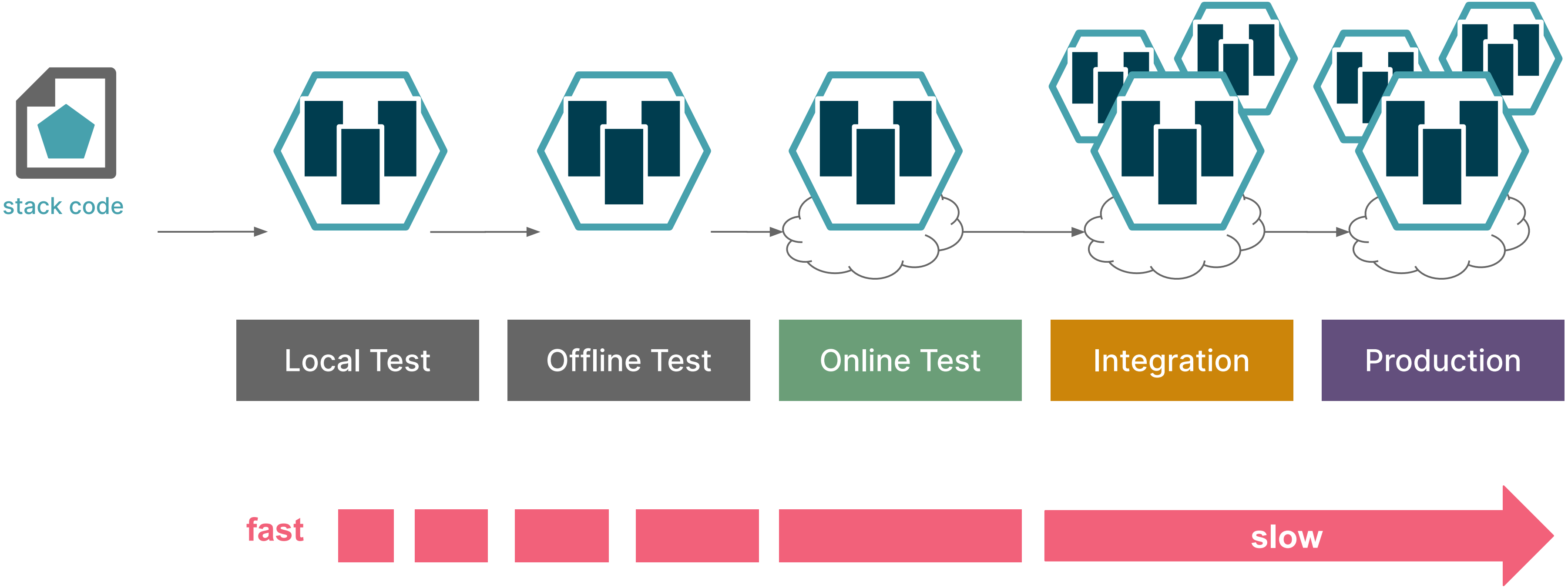


Image taken from “Infrastructure as Code - 2nd edition” by Kief Morris

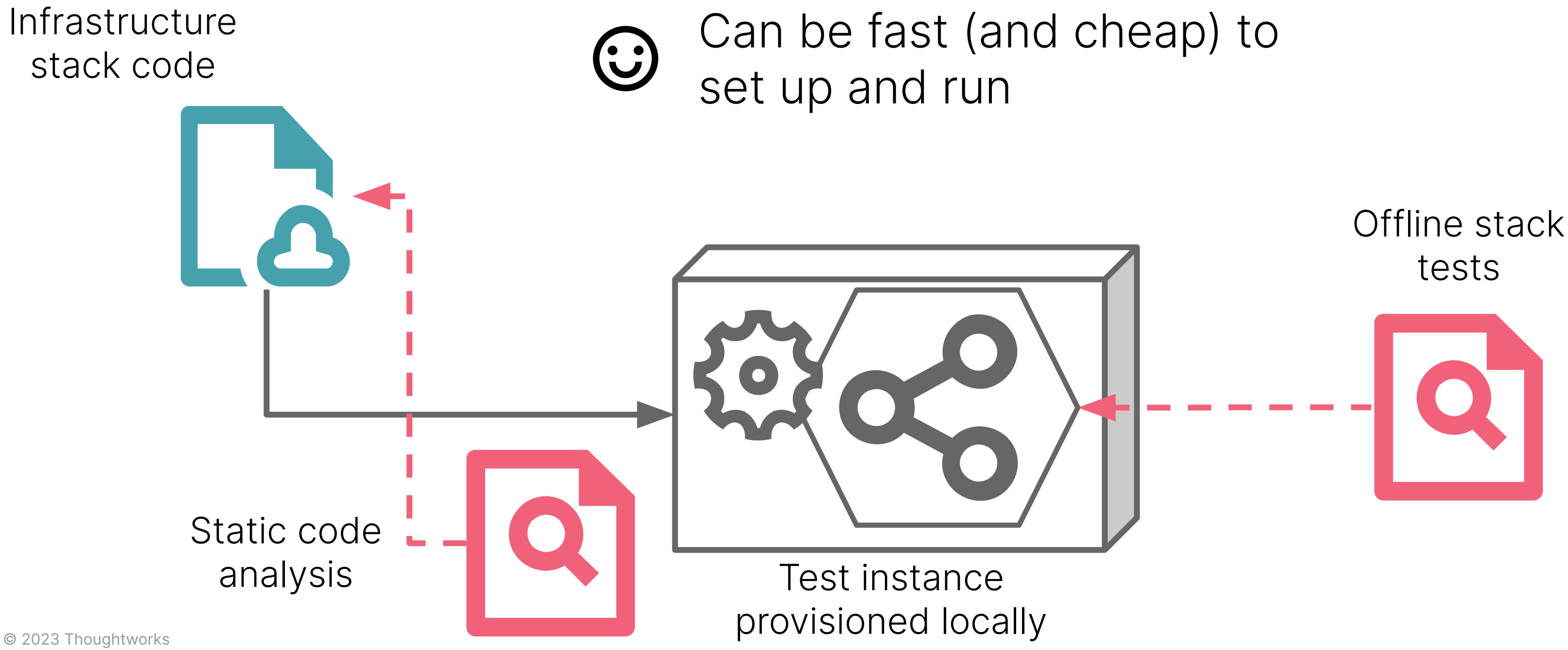
Stack testing



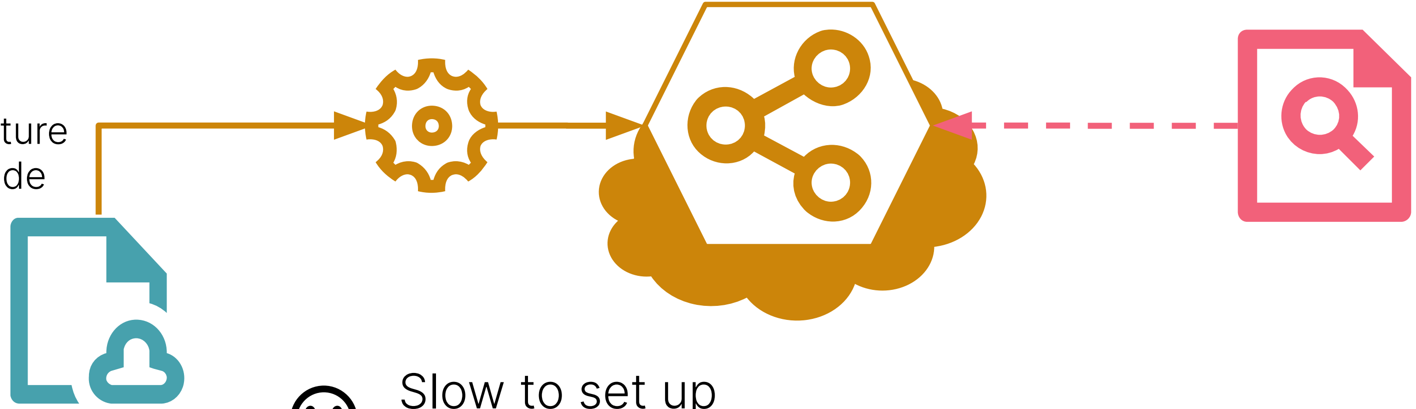
Offline testing

Can run both, as pre-commit hook and in the pipeline

☺ Can be fast (and cheap) to set up and run



Online testing



Infrastructure stack code

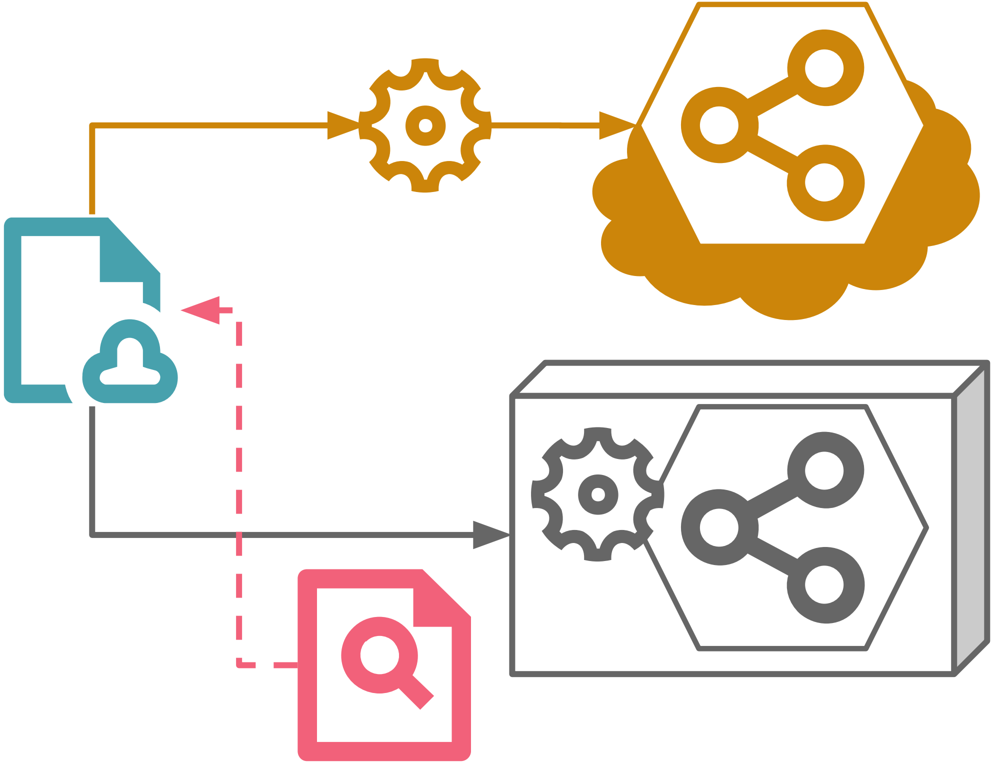
Test instance provisioned in cloud

Online stack tests

☹ Slow to set up and run

☹ Usually costly

The best way to optimize feedback loops



Smaller stacks are faster and easier to test (and fix!)

Designing Infrastructure Delivery Pipeline

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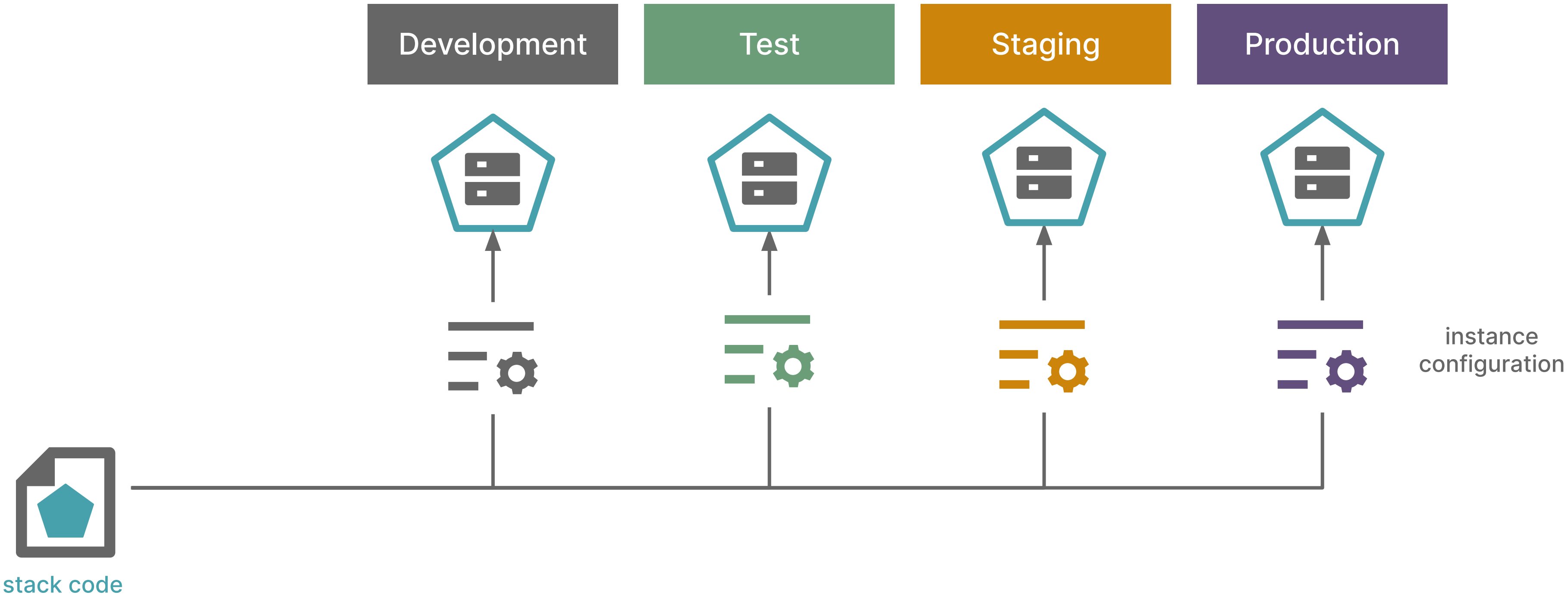
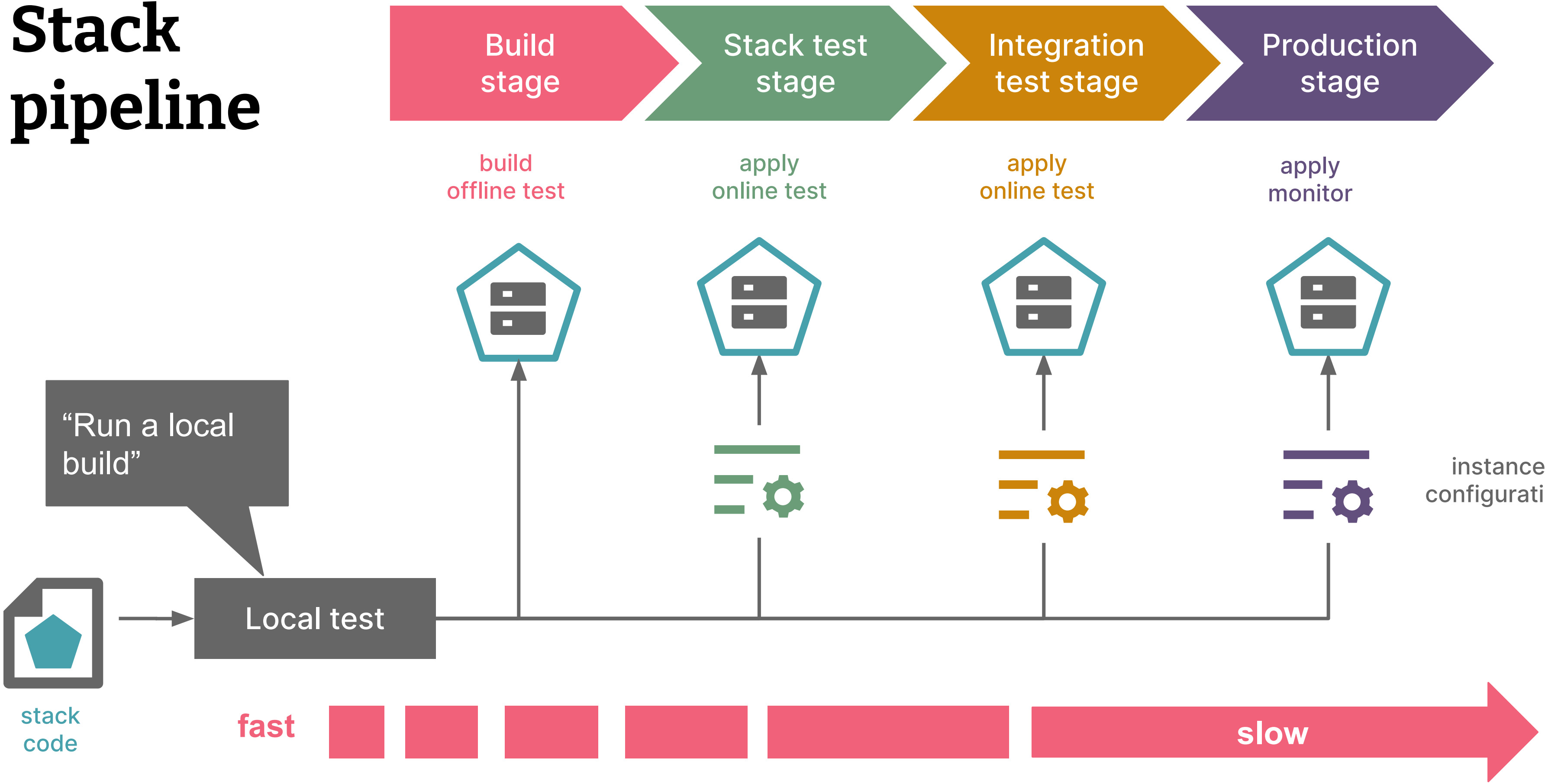
One stack - multiple deployments



Stack pipeline



Build stage

Stack test stage

Integration test stage

Production stage

build
offline test

apply
online test

apply
online test

apply
monitor

“Run a local build”

Local test

stack code

instance configuration

fast

slow

Local test

Keep your pipeline green

As a quality gate before we send our code off to the pipeline, we want to have a **pre-commit hook** that filters faulty commits. Make it more likely to **keep the pipeline green**.
In this stage we want to **validate** our infrastructure code.

aqua trivy

TFLint

Open Policy Agent

Download Dependencies

Check syntactical correctness

Run linters, formatters & security and compliance checks

Build stage

Validate & package your code

In this stage we want to **validate** our infrastructure code. The outcome of the stage is a **package** that contains all the artifacts we need for applying our infrastructure changes, e.g. validated infrastructure code.

aqua trivy

TFLint

ORAS

Open Policy Agent

- Download Dependencies
- Check syntactical correctness
- Run linters, formatters & security and compliance checks
- Create a promotable artifact

Stack test stage

Apply & validate the stack in isolation

In this stage we want to apply our Infrastructure code run online test. This stage gives us the confidence that our code produces cloud resources that fulfill our requirements.

LocalStack

Terratest
by Gruntwork.io

Open Policy Agent

Plan changes

Check output of the plan

Apply changes

Test applied cloud resources against expected behaviour

Integration test stage

Integrate multiple stacks

On this stage the stack is deployed into a pre-production staging **environment**. If you are integrating multiple stacks you can **validate end-to-end user journeys** here.

Terratest
by Gruntwork.io

Plan and apply changes

Validate user journey

Validate dynamically generated stacks

Promote release artefact

Production stage

Apply, test & promote your package

We **repeat the exact same steps** that we ran in the previous stage - but in our production environment - with the added safety of having run them in pre-production.

kuberhealthy

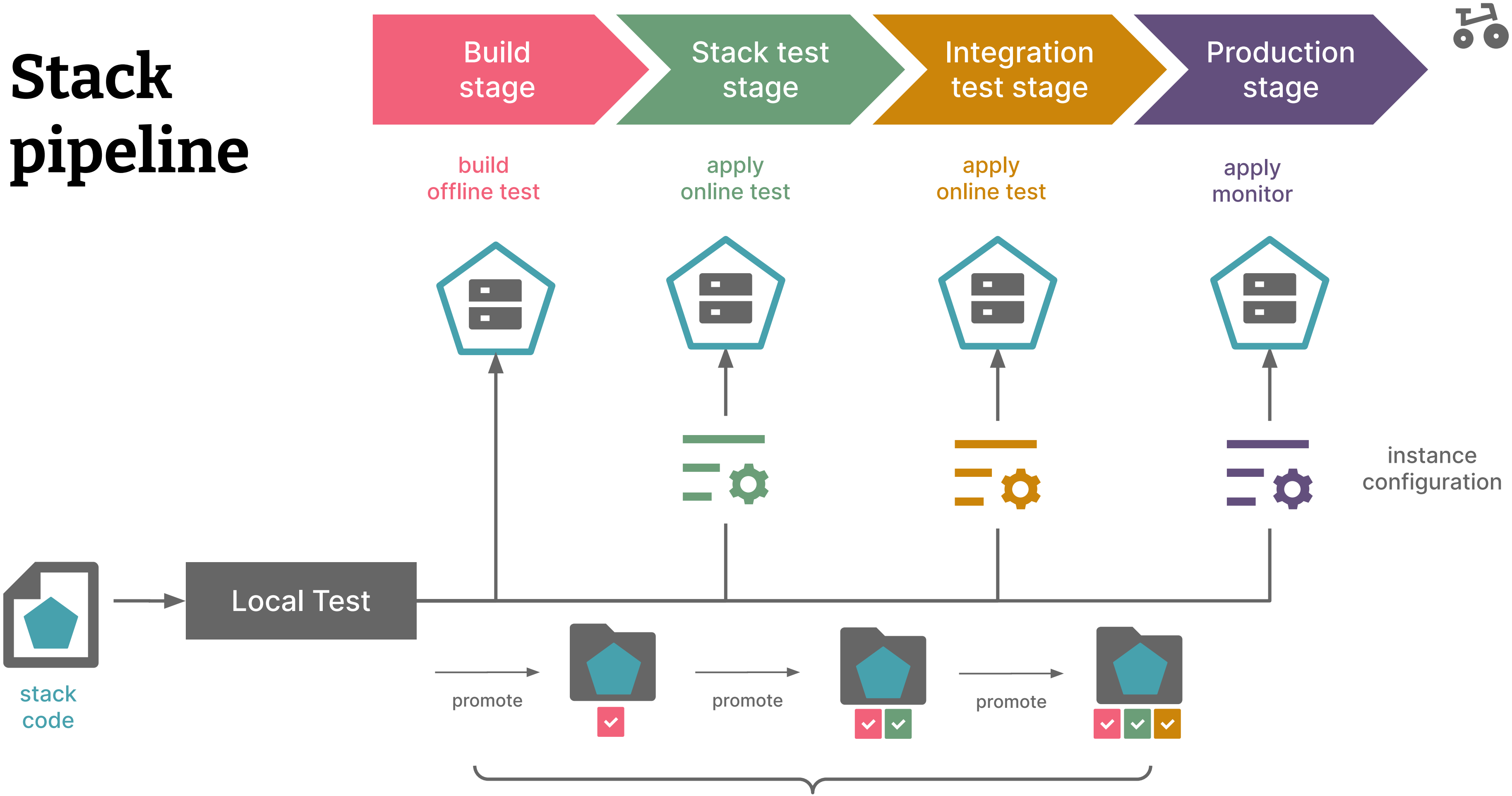
Plan changes

(potentially manual) Approval

Apply changes

Run (smoke) tests and synthetic monitoring

Stack pipeline



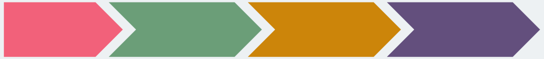
promote stack code across instances without changes

Pipeline topologies

How to handle multiple stacks creating an environment

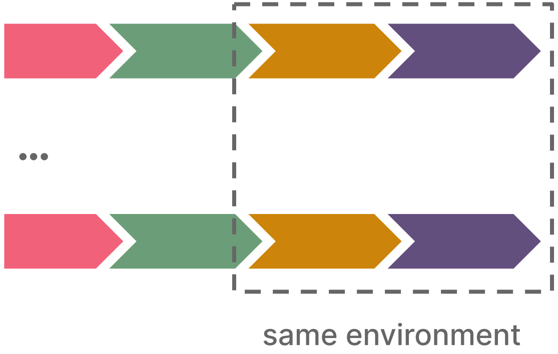
Single stack

environment = single stack, one pipeline



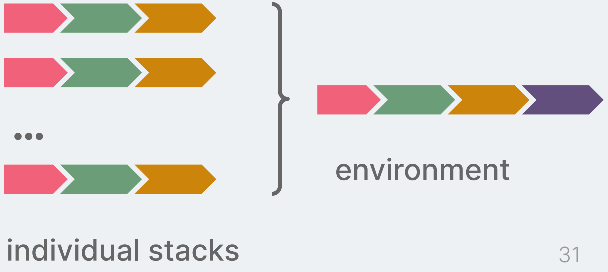
Multiple stacks

multiple pipelines deploy into same env



Wrapper stack

wrapper stack aggregates multiple stacks, deployed via pipeline for wrapper stack



Demo: Handling Environment Config

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Demo project on GitHub

https://github.com/kindlertw/terraform-workspaces-terragrunt-ansible/tree/main/option1b-terraform-tfvars-with-backend-config

Challenges

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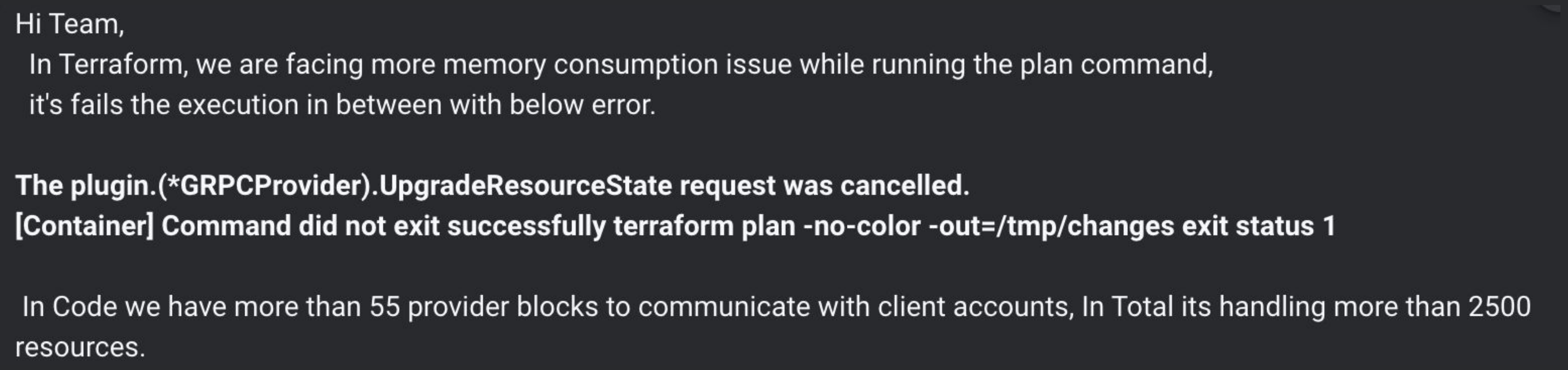


Hi Team,
In Terraform, we are facing more memory consumption issue while running the plan command,
it's fails the execution in between with below error.

The plugin.(*GRPCProvider).UpgradeResourceState request was cancelled.
[Container] Command did not exit successfully terraform plan -no-color -out=/tmp/changes exit status 1

In Code we have more than 55 provider blocks to communicate with client accounts, In Total its handling more than 2500 resources.

Blast Radius

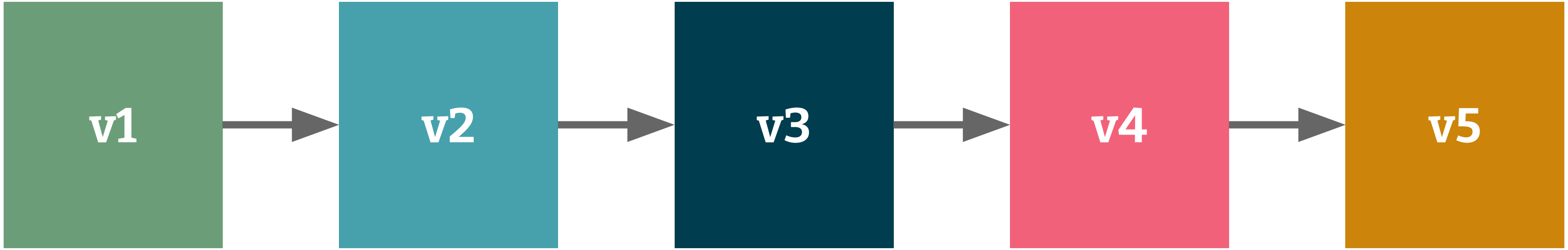
The term *blast radius* describes the potential damage a given change could make to a system. It's usually based on the elements of the system you're changing, what other elements depend on them, and what elements are shared.

Kief Morris, Infrastructure as Code 2nd Edition

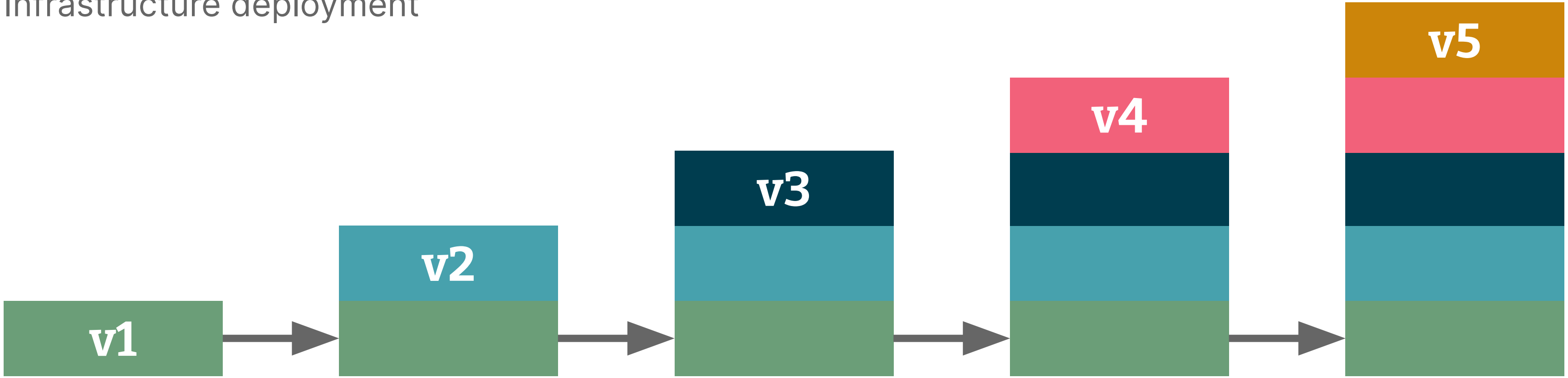
Image Source: commons.wikimedia.org

(Im)mutable deployment

(Modern) application deployment

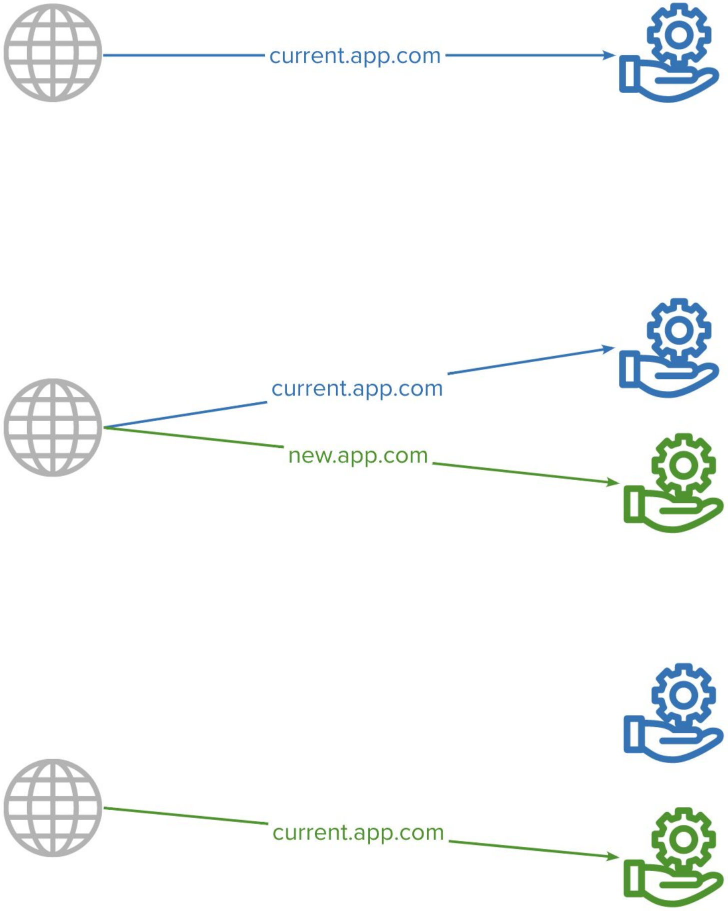


Infrastructure deployment



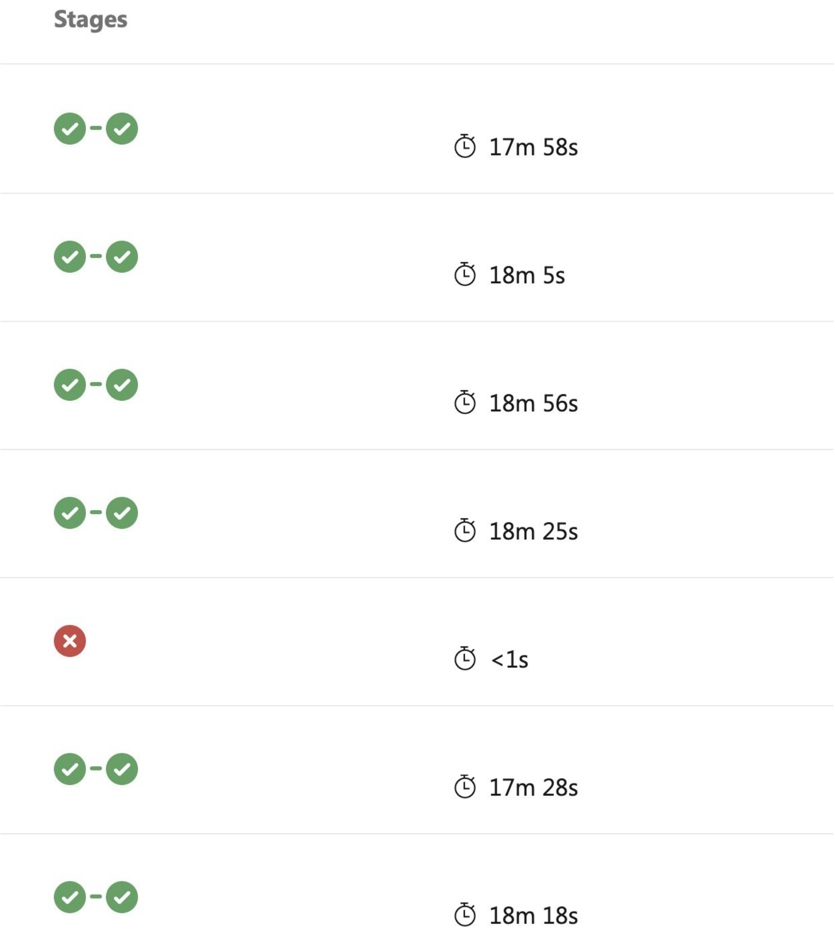
Roll-backs

With infrastructure code, there is **no easy roll-back** of changes. Having infrastructure as code allows for **re-creating every revision** of your setup - but it doesn't prevent you from **potentially losing state**.



Feedback cycles

With infrastructure pipelines we usually face **long feedback loops**. This easily leads to developers working around using the pipelines and can bring you into trouble if you “quickly need to fix something in production”.



Stages	
✓-✓	⏱ 17m 58s
✓-✓	⏱ 18m 5s
✓-✓	⏱ 18m 56s
✓-✓	⏱ 18m 25s
✗	⏱ <1s
✓-✓	⏱ 17m 28s
✓-✓	⏱ 18m 18s

One more thing...

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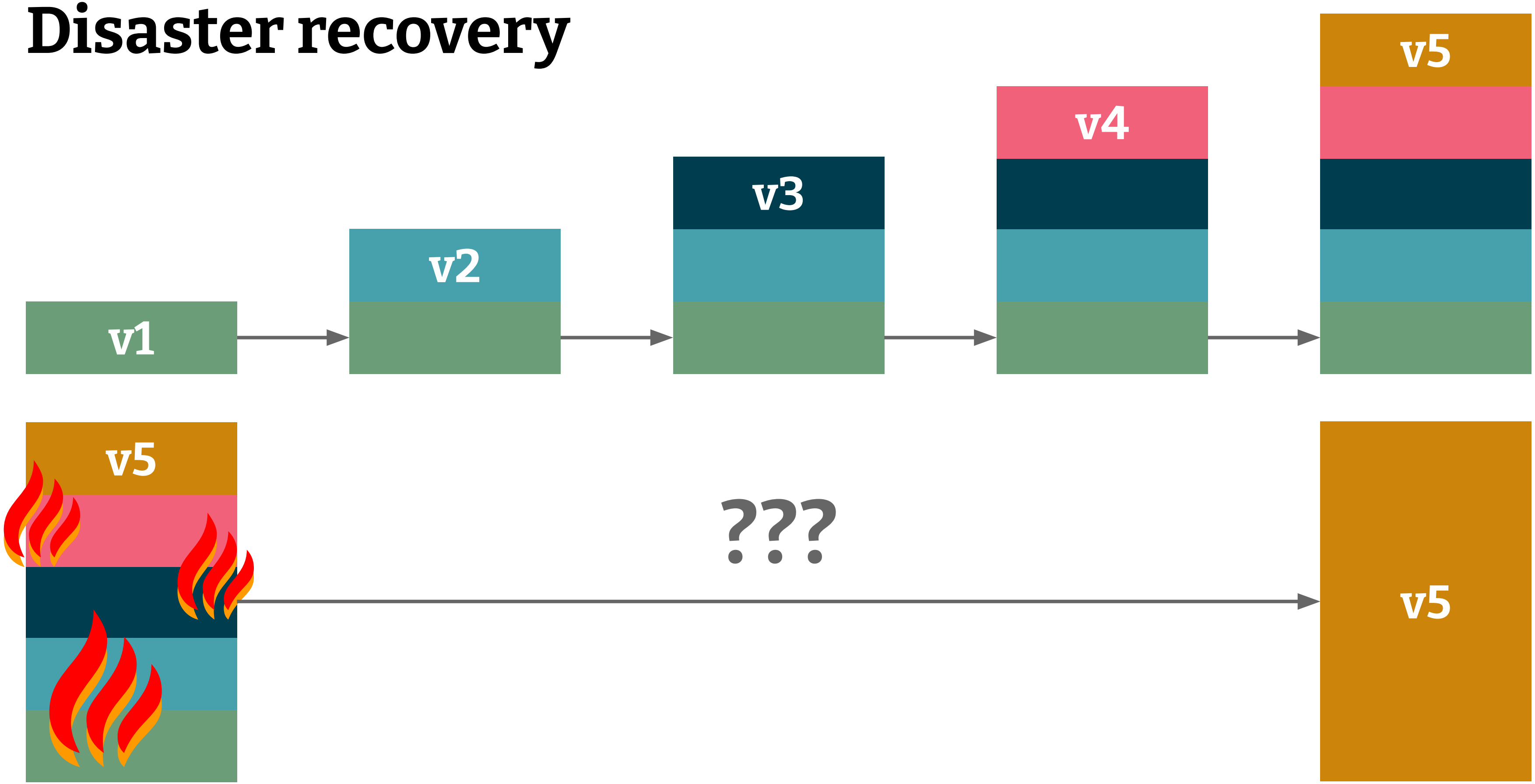
Disaster recovery



Summary

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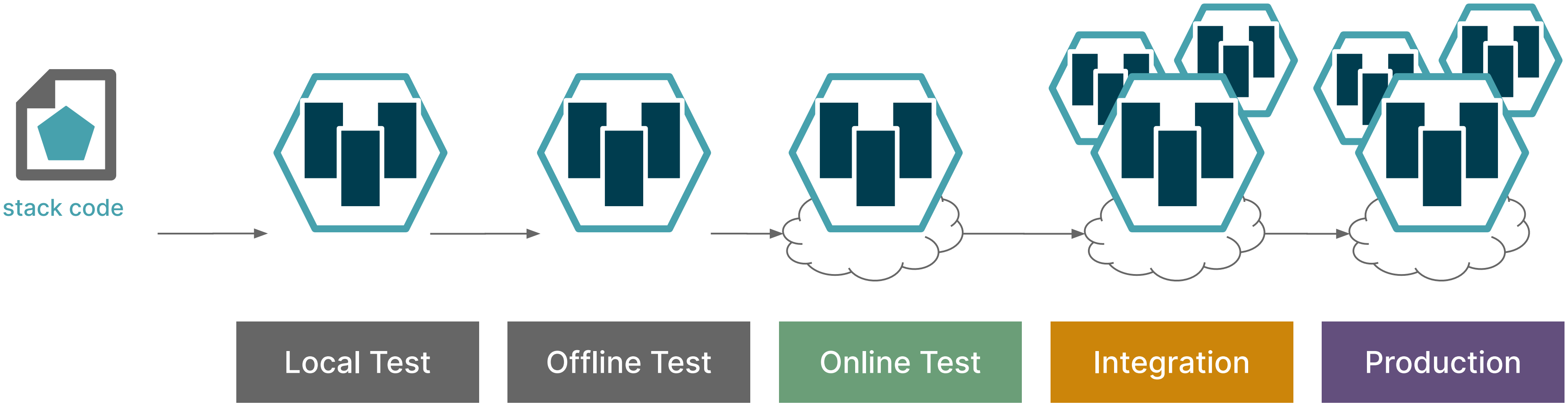
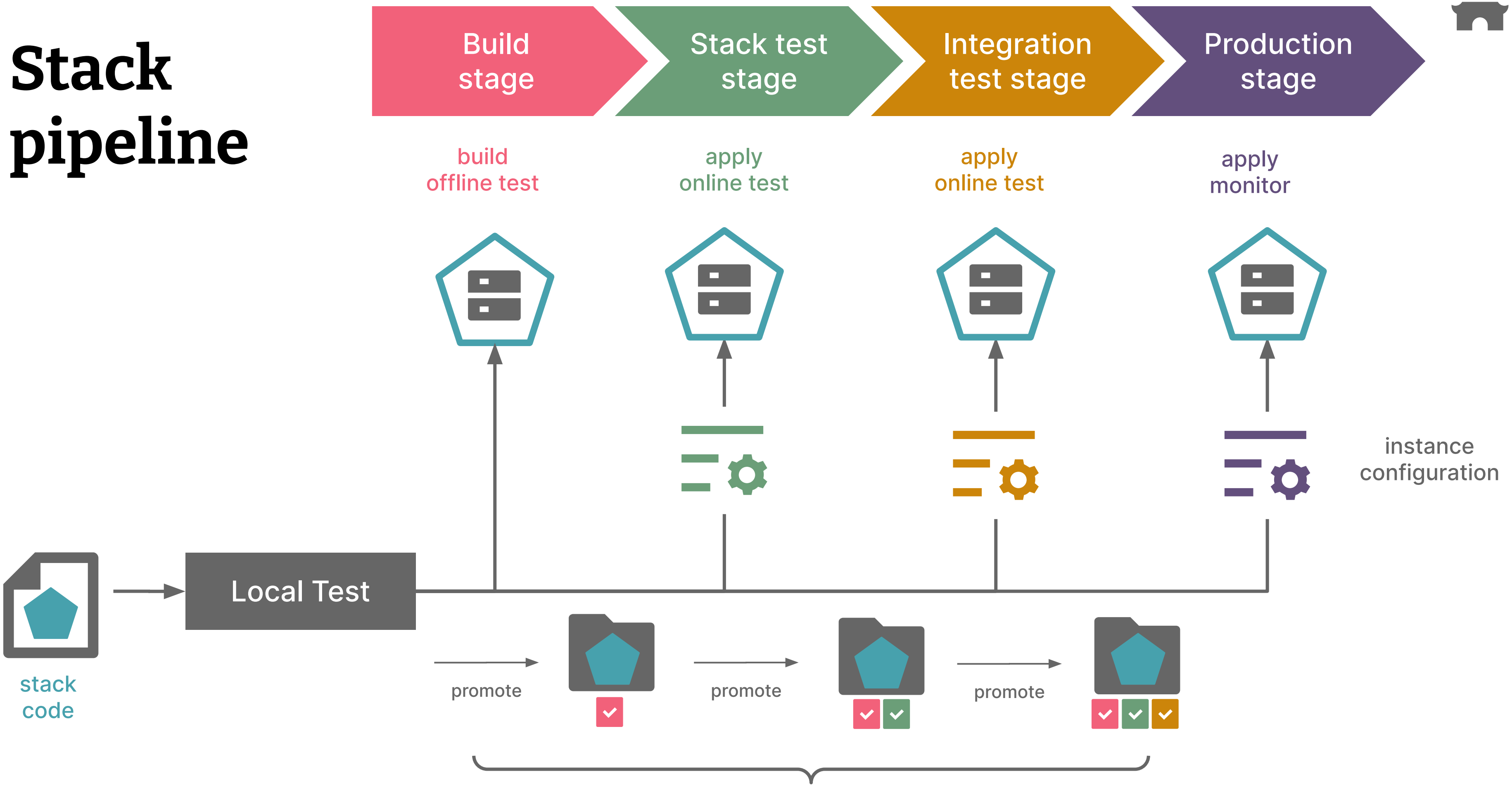
Stack testing

Smaller stacks are faster and easier to test (and fix!)



Stack pipeline



promote stack code across instances without changes

Thank you for your attention 👍

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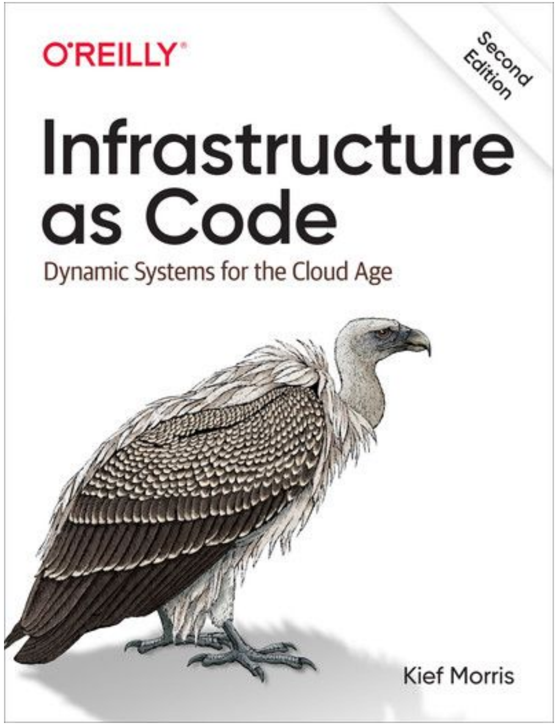
References



Kief Morris, Infrastructure as Code - 2nd Edition

References

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- Structuring Hashicorp Terraform Configuration for Production
- Running Terraform in Automation
- Test-Driven Development for Infrastructure
- Demo Repository: Handling Environment Variables