

# GITOPS, IAC & PULUMI

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(CLOUD) INFRASTRUCTURE AS CODE DONE RIGHT (?)  
... A JOURNEY FROM KUBECTL APPLY TO GIT PUSH

ANDREAS TELL

CADEC 2023.01.19 & 2023.01.25 | CALLISTAENTERPRISE.SE

CALLISTA

# AGENDA

- GitOps
  - Definition
  - Implementation
- Infrastructure as Code (IaC)
  - Pulumi
- Demo
- Wrap Up

# WHAT'S GITOPS?

A set of principles for operating and managing software systems with  
*Git, CI/CD (Automation) and IaC (Infrastructure as Code)*

## Infrastructure as Code (IaC)

CADEC 2021

is the managing and provisioning of infrastructure through machine-readable definition files\* instead of through manual processes.

2020 : GitOps

2021 (Oct)

\* Proprietary syntaxes, JSON, YAML  
or  
General Purpose Programming  
Languages

CLOUD NATIVE  
COMPUTING FOUNDATION

1.0 published

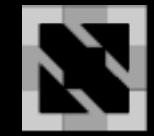
# WHAT'S GITOPS?

A set of principles for operating and managing software systems with  
*Git, CI/CD (Automation) and IaC (Infrastructure as Code)*

... leverages existing and widely adopted best practices

... with a strong “Kubernetes-affinity”

2017 : First coined by CTO of Weaveworks Inc.

2020 : GitOps working group founded  **CLOUD NATIVE COMPUTING FOUNDATION**

2021 (October) : GitOps principles v1.0.0 published

# GitOps Principles

v1.0.0

2021-10-08  
[HTTPS://OPENGITOPS.DEV/BLOG/1.0-ANNOUNCEMENT/](https://opengitops.dev/blog/1.0-announcement/)

IaC ←

1 Declarative

A system managed by GitOps must have its desired state expressed declaratively.

Git ←

2 Versioned and Immutable

Desired state is stored in a way that enforces immutability, versioning and retains a complete version history.



3 Pulled Automatically

“Embedded CD process”  
a.k.a. “Reconciler”

Software agents automatically pull the desired state declarations from the source.



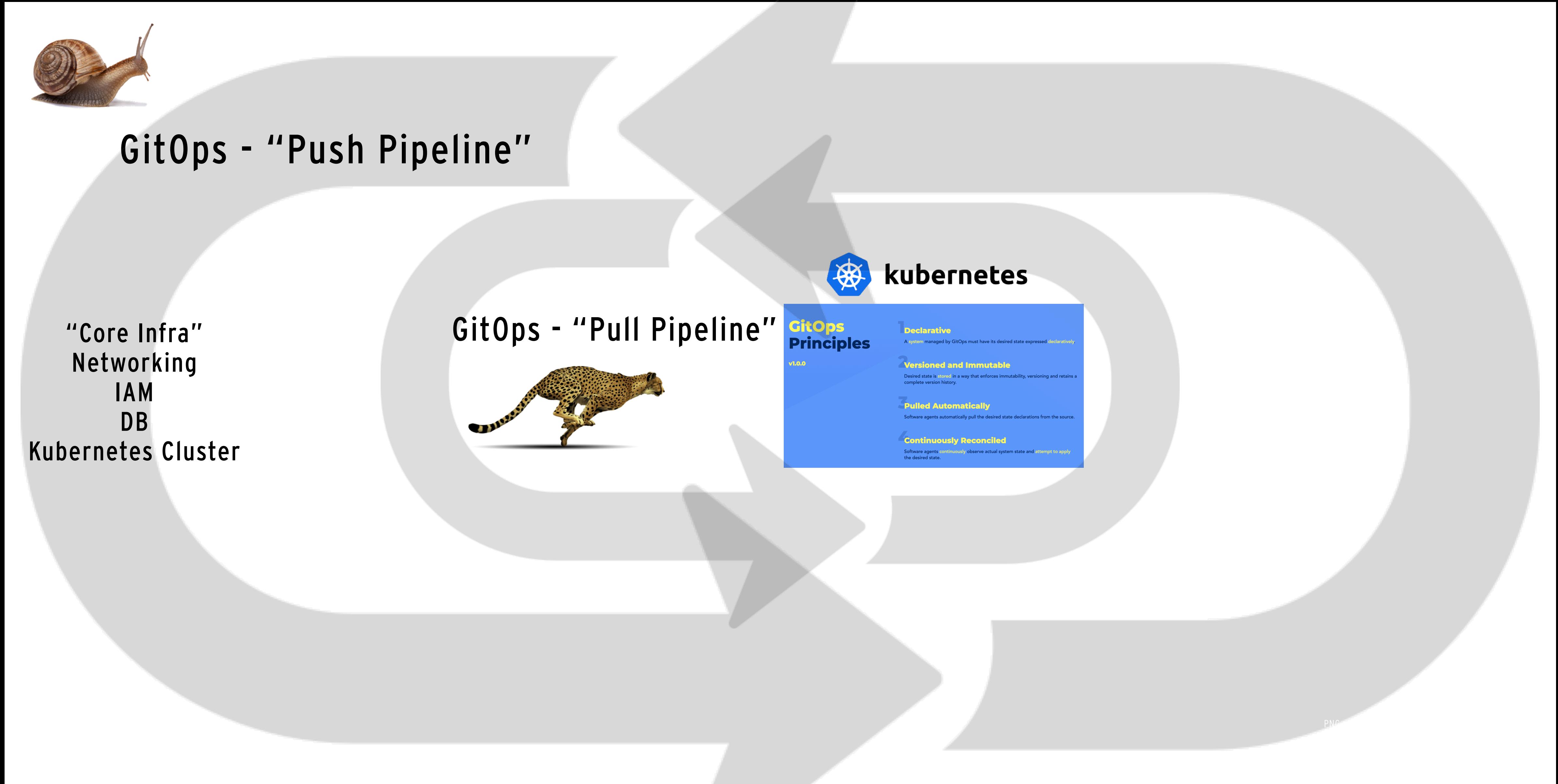
4 Continuously Reconciled

Software agents continuously observe actual system state and attempt to apply the desired state.

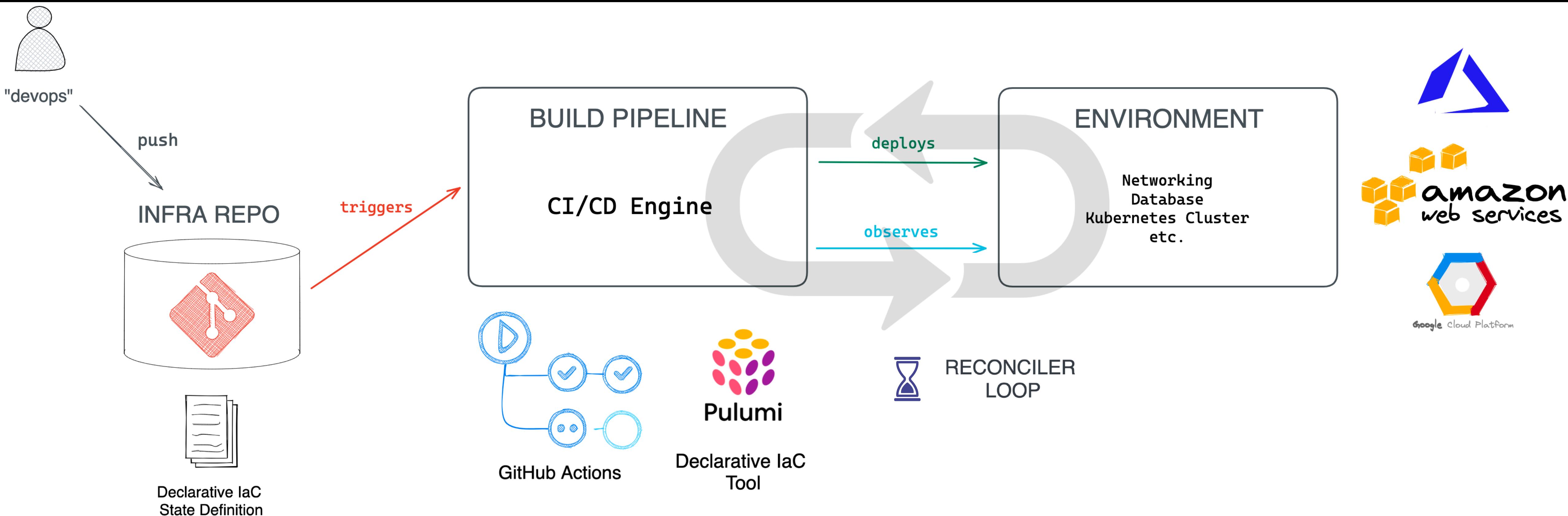
## DESIRED STATE

The aggregate of all configuration data that is sufficient to recreate the system so that instances of the system are behaviourally indistinguishable...

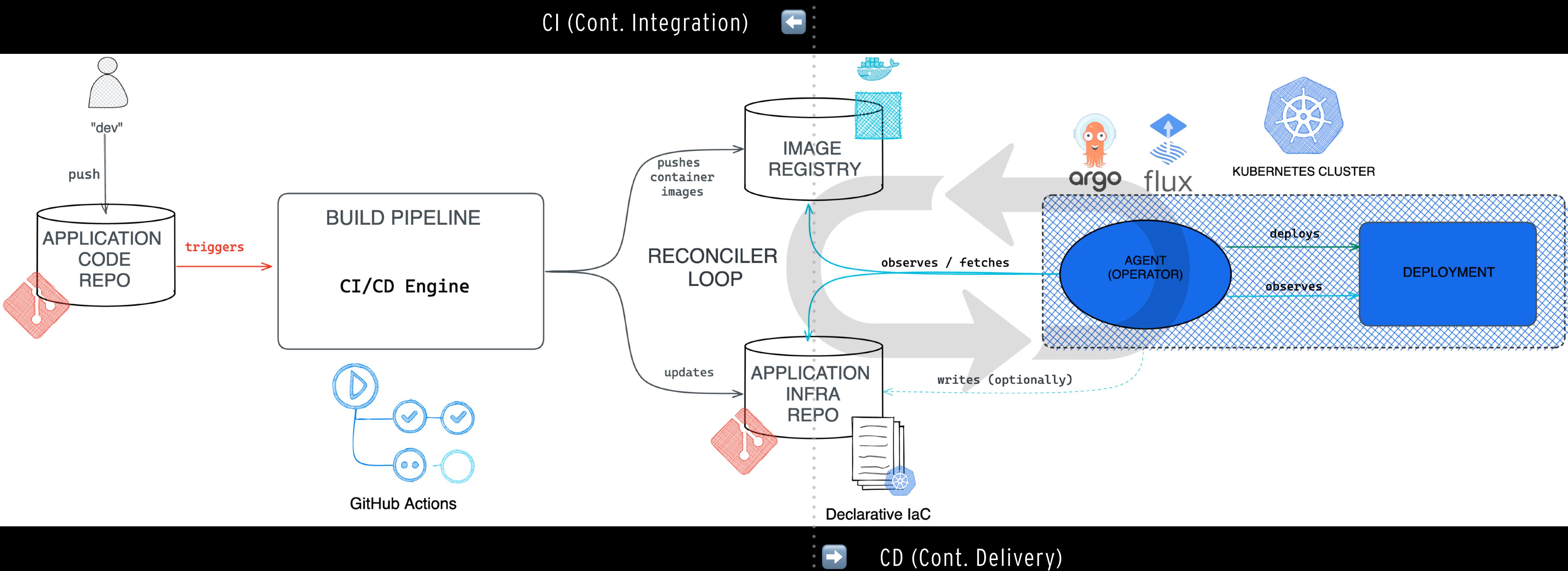
# IMPLEMENTING GITOPS - PULL & PUSH PIPELINES



# IMPLEMENTATION : GITOPS STYLE - "PUSH PIPELINE" - SETUP CORE INFRA



# IMPLEMENTATION : TRUE GITOPS - "PULL PIPELINE"

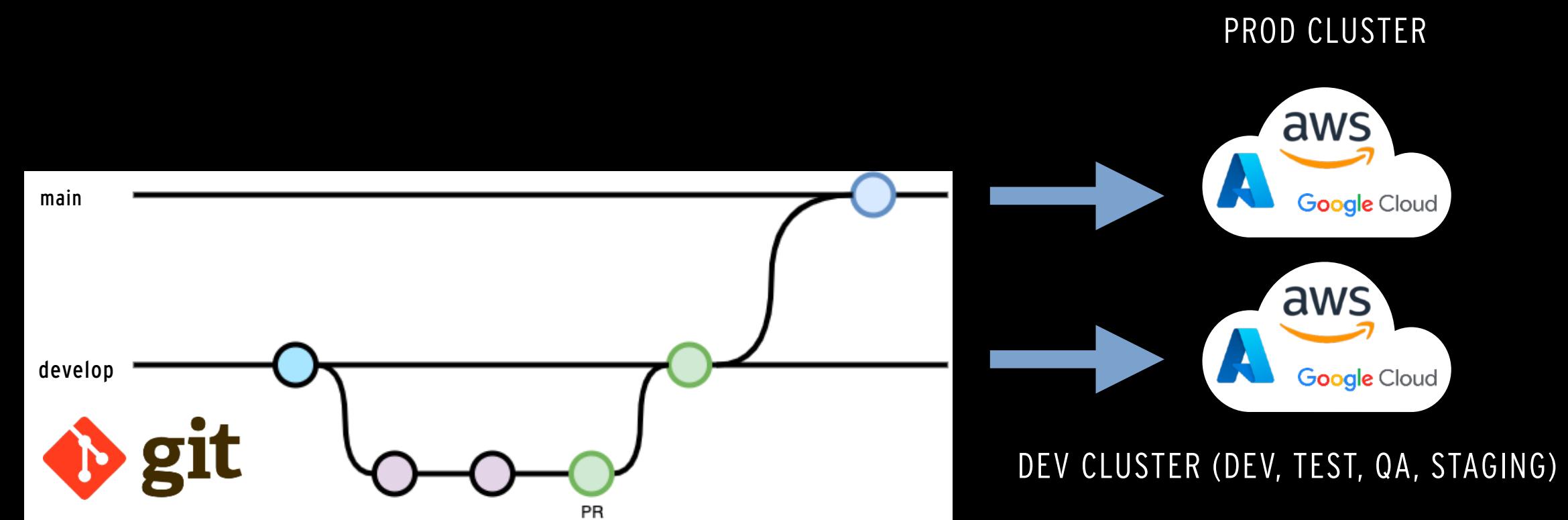


Purpose: Application Cont. Deployment



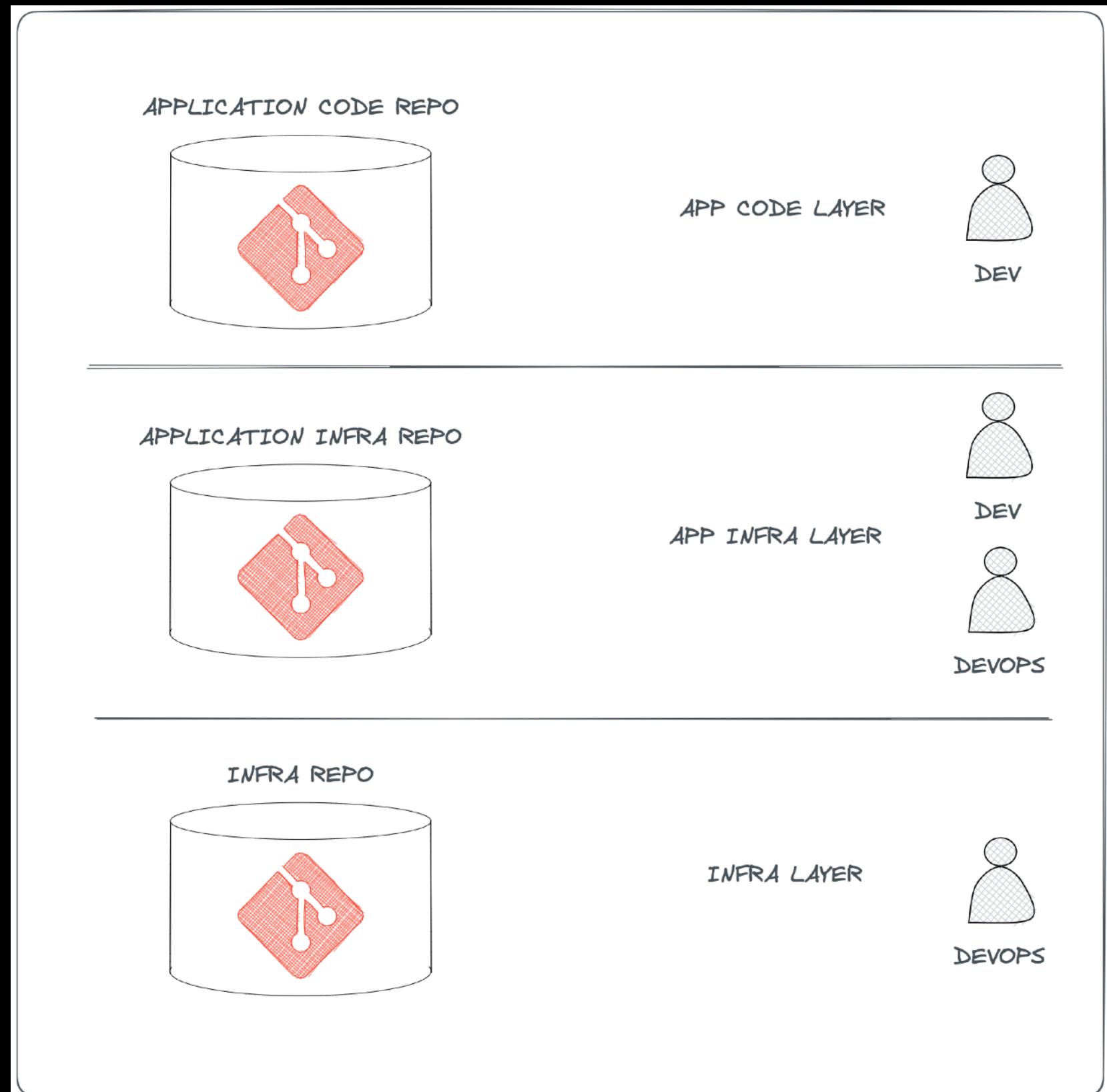
# IMPLEMENTING GITOPS - “OPS BY PULL REQUEST”

- Operations become “a function of Git interaction” (always)
  - Bonus: no need for RW access to infrastructure (Cloud, Kubernetes etc.)
- Branches protected by Pull/Merge requests (e.g. “main” -> “Production”)
  - control gate / quality assurance
- Dedicated config repos
  - Segregation of configuration based on intended usage, access accordingly



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## CLAIMED BENEFITS / VALUE PROPOSITION

GitOps =>

Increased Developer & Operational Productivity

Shorter MTTR

Improved DX

**Improved collaboration**

Improved consistency, predictability and repeatability

Higher Reliability

**Improved Security**

**Reduce Cost**

**Increase Speed**

**Minimize Risk**

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- **Infrastructure as Code (IaC) - Pulumi**
- Demo
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# IAC TOOLS FOR CLOUD

## Single cloud / Vendor Proprietary

AWS CloudFormation

AWS CDK



Azure Resource Manager (ARM)

Azure Bicep



Google Cloud Deployment Manager

Google Cloud

...

## Multi cloud / Multi purpose

Pulumi



Terraform



Crossplane



Ansible

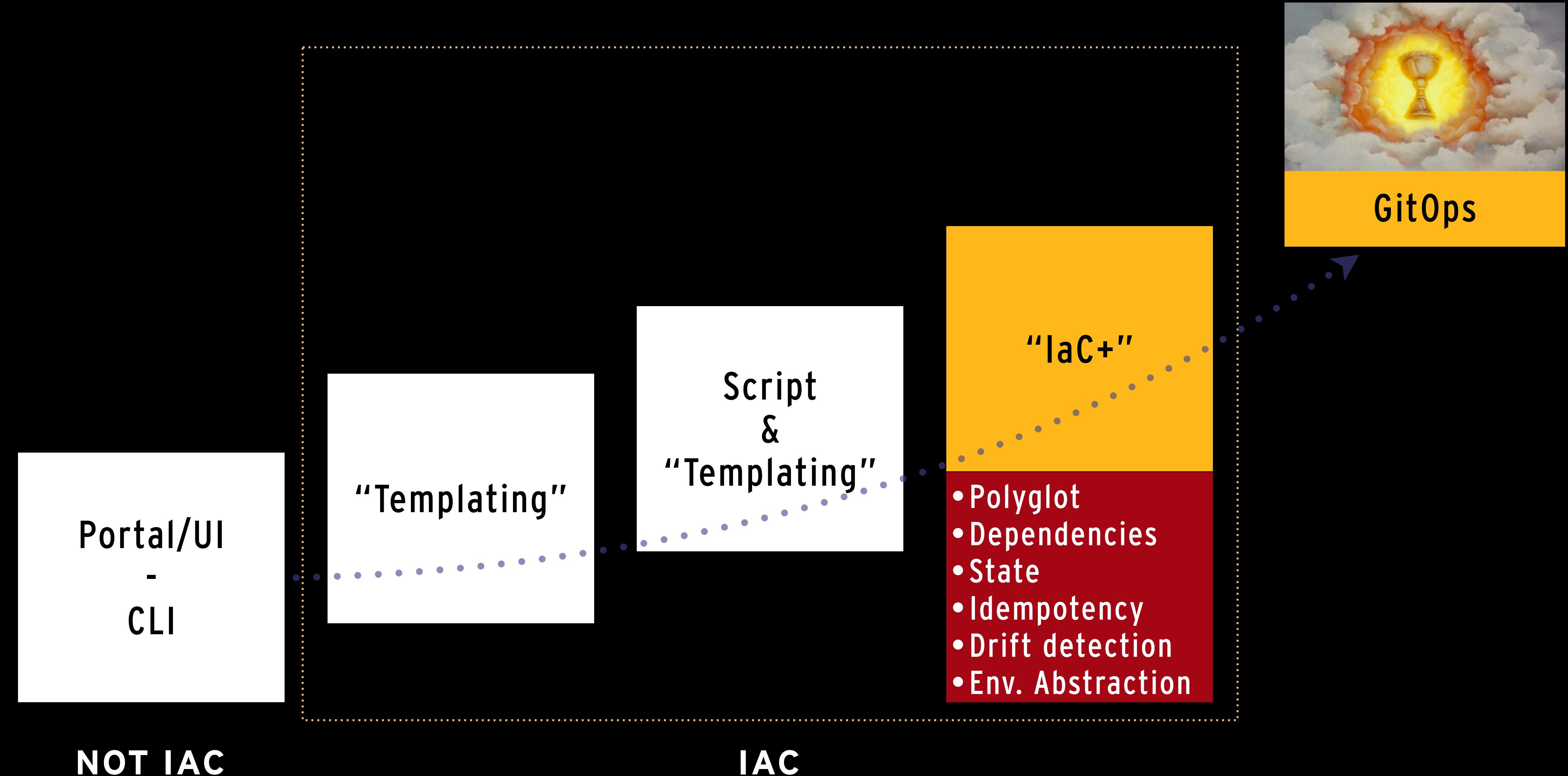


Red Hat

...



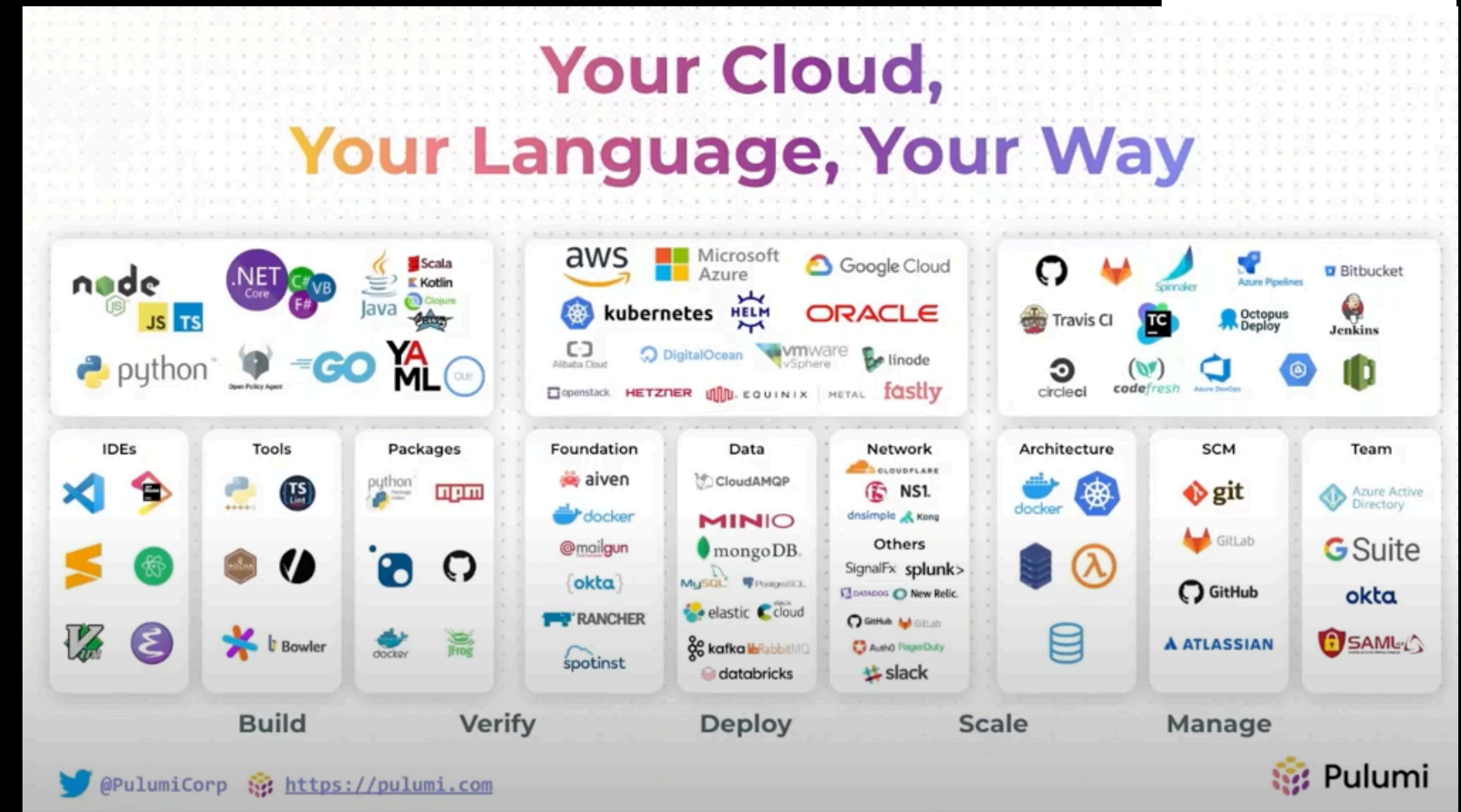
# PROVISIONING CLOUD INFRA - A STEPWISE PROGRESSION



# PULUMI - INTRO

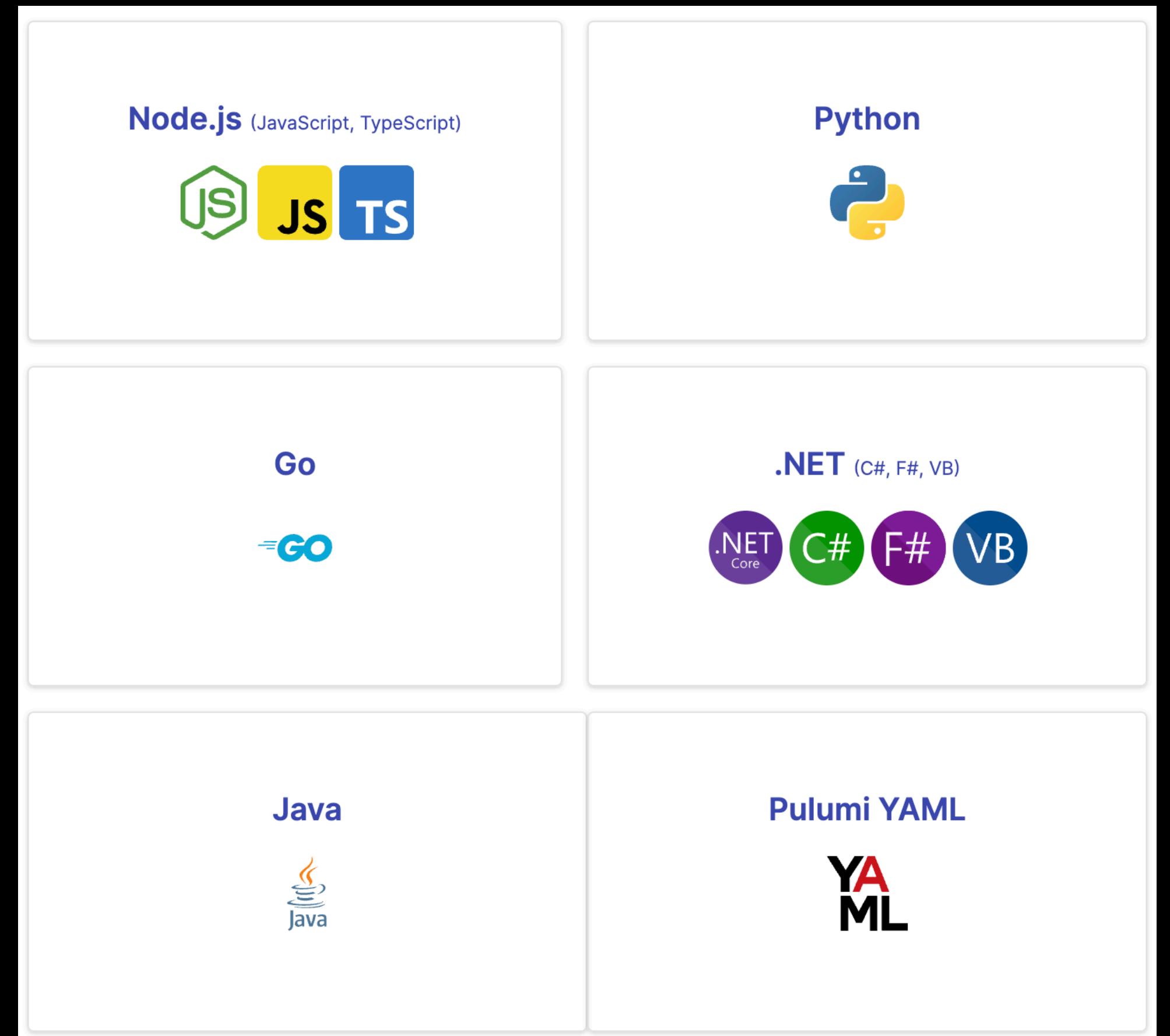
- Infrastructure as Code tool for creating, deploying, and managing infrastructure
  - “modern” & “traditional”
- Supports 70+ providers
- Open source
- Used by
  - Atlassian
  - Meta
  - Mercedes-Benz
  - ...

v1.0 : 2019-09



# PULUMI GOODNESS

- Multi-cloud
- “Infrastructure as Software”
- “Native providers”
  - Same day access to new features
    - » <https://www.pulumi.com/blog/pulumi-up-native-providers/>
- Has properties to support “a GitOps style workflow”:
  - Can observe infrastructure & detect drift
  - Idempotent
- Environment abstraction
- Built in secrets management



# Why use a programming language to describe infrastructure?

- Familiarity (for Devs)
  - Syntax
  - Tooling - IDE
- Auto complete (IDE)
- Type safety
- Modularity
  - Reuse
- Logical constructs
- Testability

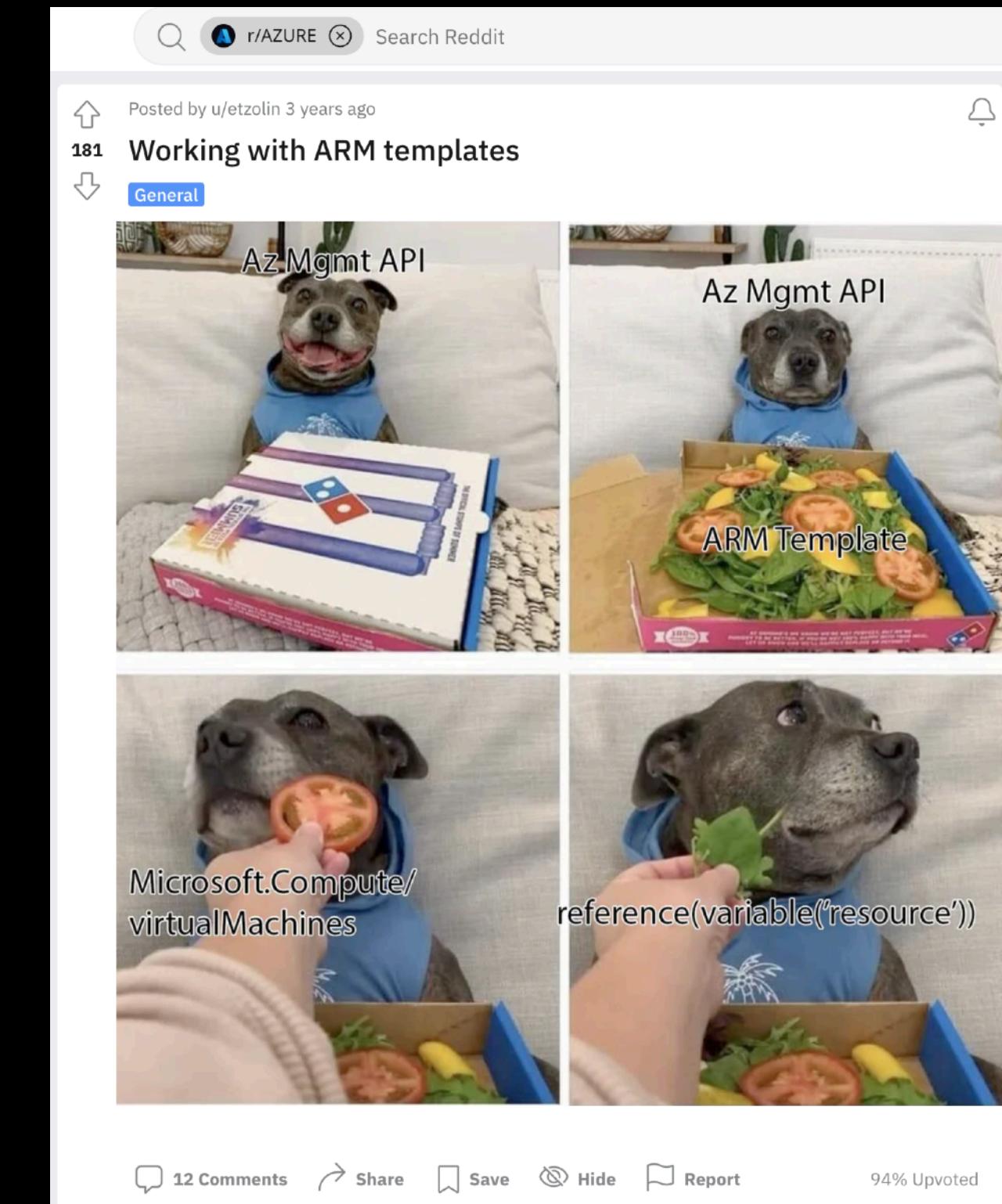
Cadec 2021 : AWS Cloud Development Kit

PROS & CONS	
CLOUDFORMATION	CDK
<ul style="list-style-type: none"><li>+ General perks of Infrastructure-as-Code</li><li>- Syntax of YAML and JSON</li><li>- No type safety</li><li>- Demands good knowledge of underlying services</li></ul>	<ul style="list-style-type: none"><li>+ Existing IDE</li><li>+ Type safety</li><li>+ Abstraction</li><li>+ Export self-made constructs</li><li>+ Improved readability</li><li>+ Logical constructs</li><li>- Risk of erroneous configuration (abstraction)</li><li>- Some constructs require work-arounds</li></ul>

# IAC EXAMPLE - AZURE STORAGE ACCOUNT

```
{  
  "$schema": "https://schema.management.azure.com/schemas/2019-04-01/deploymentTemplate.json#",  
  "contentVersion": "1.0.0.0",  
  "parameters": {  
    "location": {  
      "type": "string",  
      "defaultValue": "[resourceGroup().location]"  
    },  
    "storageAccountName": {  
      "type": "string",  
      "defaultValue": "[concat('storage', uniqueString(resourceGroup().id))]"  
    }  
  },  
  "resources": [  
    {  
      "type": "Microsoft.Storage/storageAccounts",  
      "apiVersion": "2021-06-01",  
      "name": "[parameters('storageAccountName')]",  
      "location": "[parameters('location')]",  
      "sku": {  
        "name": "Standard_LRS"  
      },  
      "kind": "StorageV2",  
      "properties": {  
        "accessTier": "Hot"  
      }  
    }  
  ]  
}
```

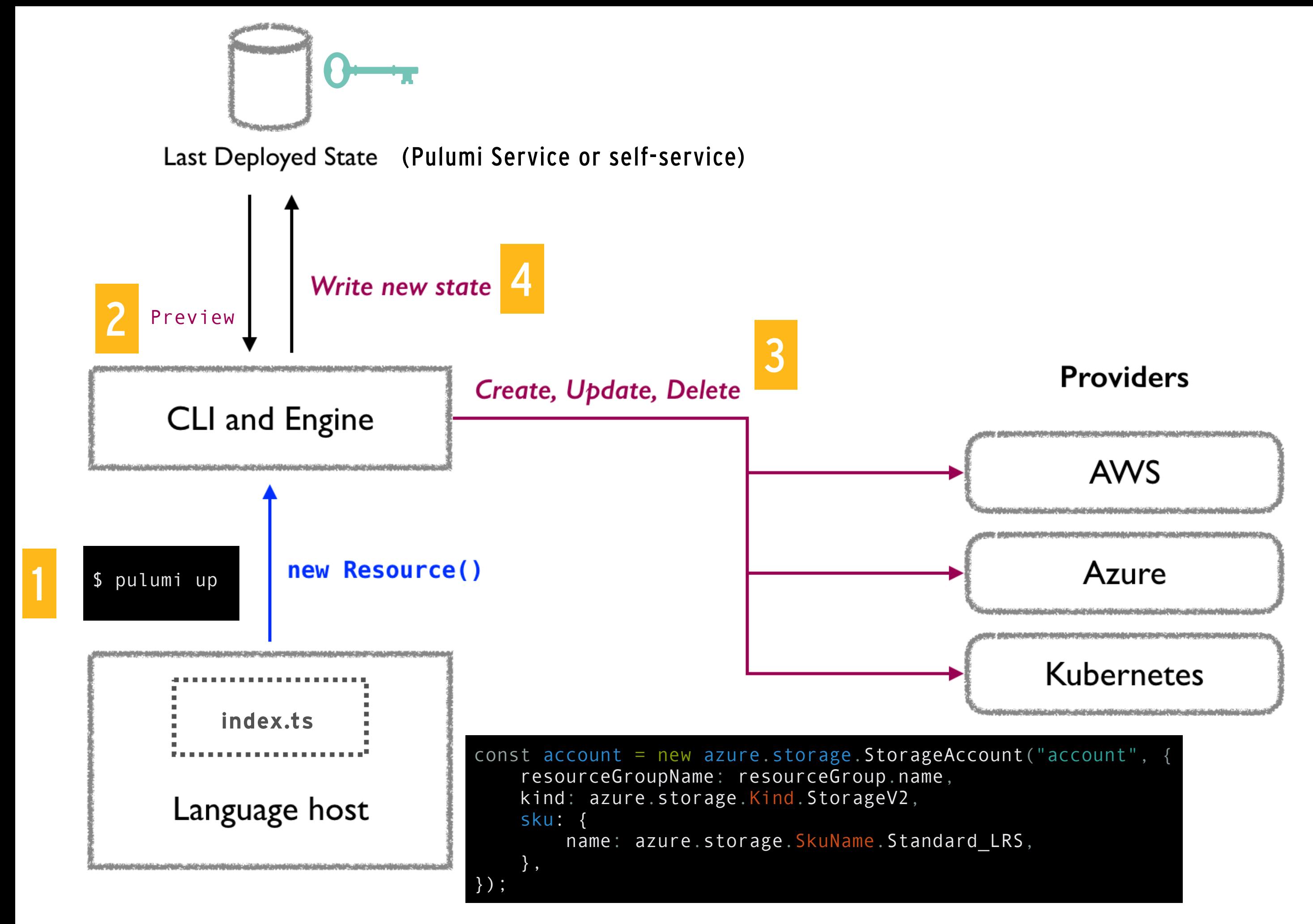
ARM Template



```
const account = new azure.storage.StorageAccount("account", {  
  resourceGroupName: resourceGroup.name,  
  kind: azure.storage.Kind.StorageV2,  
  sku: {  
    name: azure.storage.SkuName.Standard_LRS,  
  },  
});
```

Pulumi Typescript

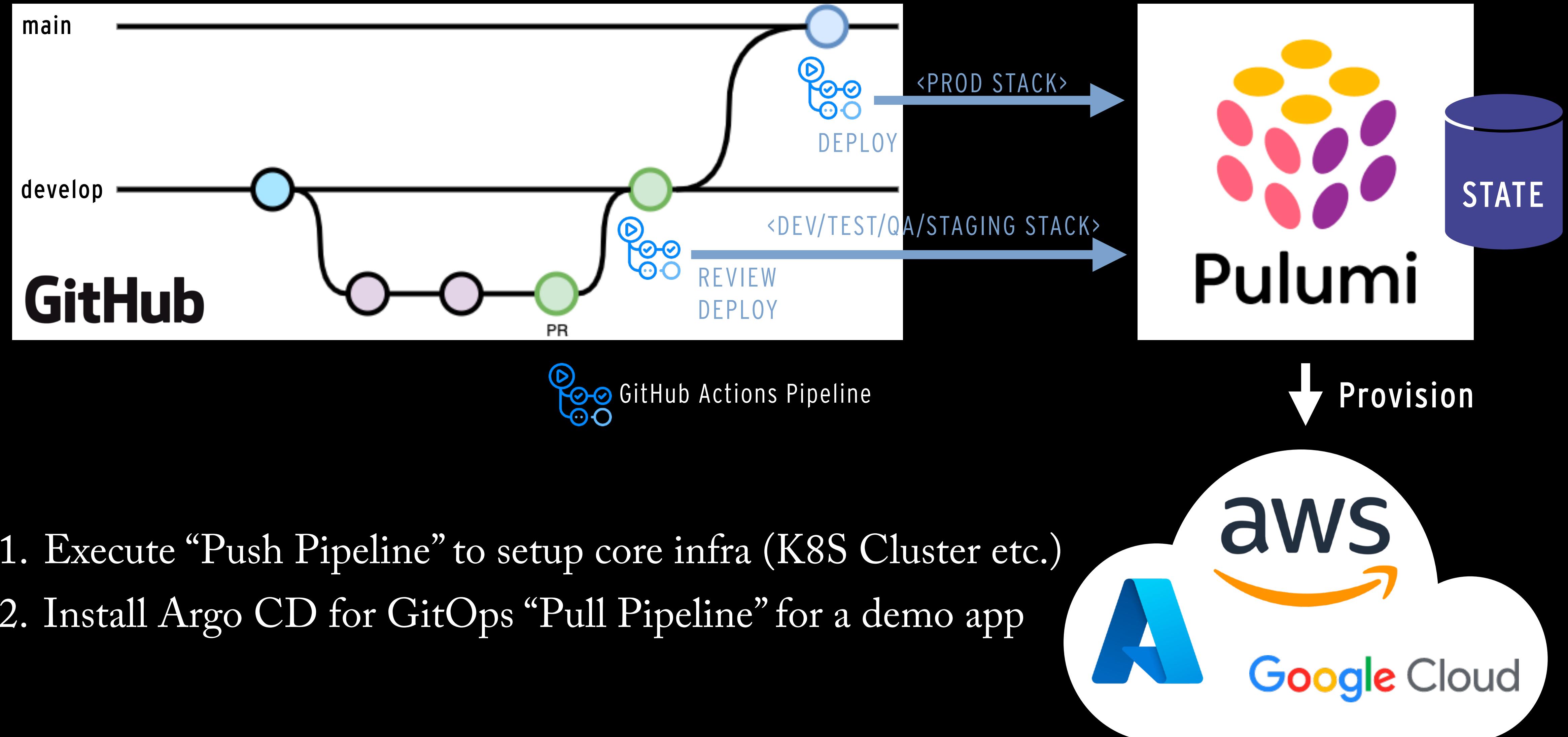
# PULUMI ARCHITECTURE



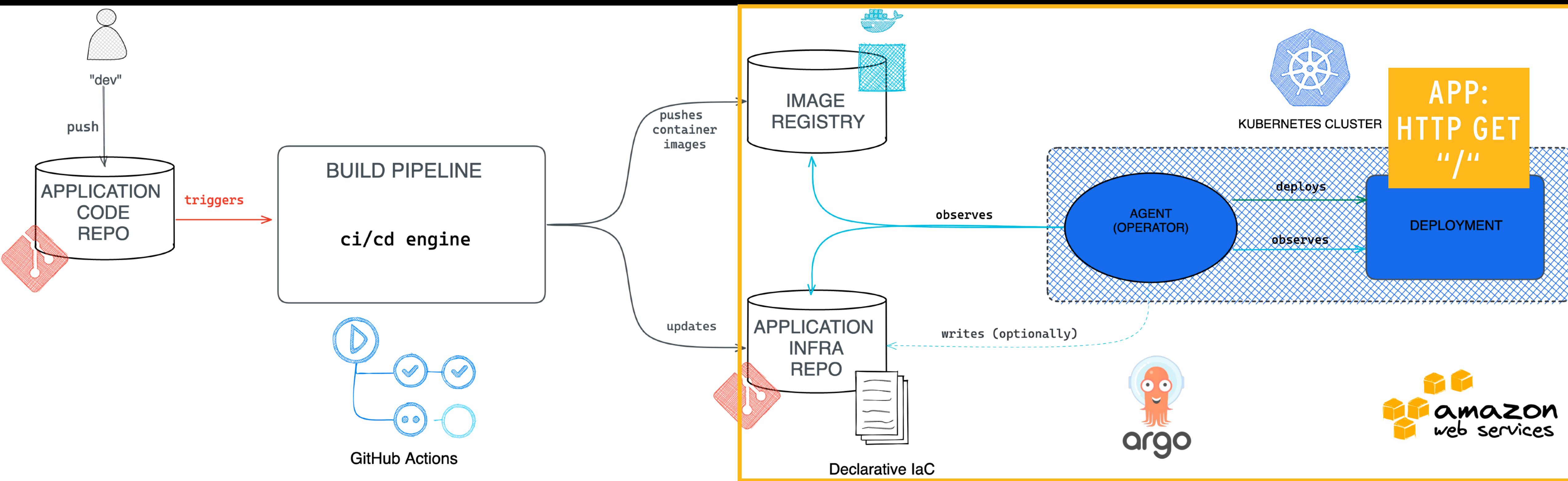
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## DEMO - STEP 1 - INFRA SETUP



# DEMO: OUTCOME FROM STEP 1 - ARGO CD DEPLOYS AND TRACKS DEMO APPLICATION



# PULUMI PROGRAM

```
1 config:  
2   aws:region: eu-north-1  
3   aws:defaultTags:  
4     tags:  
5       project: "cadec23"  
6       env: "staging"  
7   eks-gitops:desiredClusterSize: "2"  
8   eks-gitops:eksNodeInstanceType: t3.small  
9   eks-gitops:maxClusterSize: "6"  
10  eks-gitops:minClusterSize: "2"  
11  eks-gitops:vpcNetworkCidr: 10.0.0.0/16  
12  eks-gitops:isMinikube: "false"
```

./Pulumi.staging.yaml

```
8 // Grab some values from the Pulumi configuration (or use default values)  
9 const config = new pulumi.Config();  
10 const minClusterSize = config.getNumber("minClusterSize") || 2;  
11 const maxClusterSize = config.getNumber("maxClusterSize") || 6;  
12 const desiredClusterSize = config.getNumber("desiredClusterSize") || 2;  
13 const eksNodeInstanceType = config.get("eksNodeInstanceType") || "t3.small";  
14 // Problem : no available/free pods if choosing to too small EC2 instance,  
15 // see: https://github.com/awslabs/amazon-eks-ami/blob/master/files/eni-max-pods.txt  
16 const vpcNetworkCidr = config.get("vpcNetworkCidr") || "10.0.0.0/16";  
17 const isMinikube = config.requireBoolean("isMinikube");  
18  
19 // Create a new VPC  
20 const eksVpc = new awsx.ec2.Vpc("eks-vpc", {  
21   enableDnsHostnames: true,  
22   cidrBlock: vpcNetworkCidr,  
23 });  
24  
25 // Create the EKS cluster  
26 const eksCluster = new eks.Cluster(`eks-cluster-${pulumi.getStack()}`, {  
27   // Put the cluster in the new VPC created earlier  
28   vpcId: eksVpc.vpcId,  
29   // Public subnets will be used for load balancers  
30   publicSubnetIds: eksVpc.publicSubnetIds,  
31   // Private subnets will be used for cluster nodes  
32   privateSubnetIds: eksVpc.privateSubnetIds,  
33   // Change configuration values to change any of the following settings  
34   instanceType: eksNodeInstanceType,  
35   desiredCapacity: desiredClusterSize,  
36   minSize: minClusterSize,  
37   maxSize: maxClusterSize,  
38   // Do not give the worker nodes public IP addresses  
39   nodeAssociatePublicIpAddress: false,  
40   version: "1.24",  
41 });  
42  
43 // Export some values for use elsewhere  
44 export const kubeconfig = pulumi.secret(eksCluster.kubeconfig); // K8S credentials  
45 export const vpcId = eksVpc.vpcId;  
46 export const argoCDUrl = setupArgo();  
47  
48 // Create a new Lambda function  
49 const lambdaFunction = new awslambda.Function("lambda-function", {  
50   runtime: "nodejs14.x",  
51   handler: "index.handler",  
52   role: eksVpc.iamRoleForService.  
53   memorySize: 128,  
54   timeout: 10,  
55   environment: {  
56     variables: {  
57       VPC_ID: vpcId,  
58       CLUSTER_NAME: eksCluster.name,  
59       ARGOCLOUD_URL: argoCDUrl,  
60       ARGOCLOUD_TOKEN: process.env.ARGOCLOUD_TOKEN,  
61     },  
62   },  
63   tracing: "Active",  
64   code: {  
65     archive: pulumi.interpolate.interpolateFile("lambda-function.zip"),  
66   },  
67 });  
68  
69 // Create a new CloudWatch Metrics Log Stream  
70 const logStream = new logs.LogStream("log-stream", {  
71   logGroup: eksVpc.logGroup,  
72   name: "lambda-function",  
73   retentionInDays: 30,  
74   deliveryFormatVersion: 1,  
75   fileRetentionInDays: 30,  
76   fileLogDriver: "awslogs",  
77   fileLogDriverConfig: {  
78     logRegion: "eu-central-1",  
79     logGroupArn: eksVpc.logGroup.arn,  
80     logStreamName: logStream.name,  
81     fileRetentionInDays: 30,  
82     fileLogDriverType: "AWSLogs",  
83     fileLogDriverVersion: 1,  
84     fileLogDriverFormat: "LOG_TAIL",  
85     fileLogDriverFormatVersion: 1,  
86     fileLogDriverFileMode: "append",  
87     fileLogDriverFileModeVersion: 1,  
88     fileLogDriverFileOffset: 0,  
89     fileLogDriverFileOffsetVersion: 1,  
90     fileLogDriverFilePosition: 0,  
91     fileLogDriverFilePositionVersion: 1,  
92     fileLogDriverFileSize: 0,  
93     fileLogDriverFileSizeVersion: 1,  
94     fileLogDriverFileTime: 0,  
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426    fileLogDriverFileTimezoneOffsetValue: 0,  
427    fileLogDriverFileTimezone
```

github.com/andtell/cloud-iac-demo-infra/actions/runs/3940026354

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← EKS - Provision 🏗️

● EKS - Provision 🏗️ #34 Cancel workflow ...

Summary

Manually triggered now	Status	Total duration	Artifacts
andtell 736e043	In progress	-	-

Jobs

● provision-eks-with-pulumi

Run details

aws\_eks\_provision.yml  
on: workflow\_dispatch

provision-eks-with-pulumi 12s → install-and-run-argocd-on-eks

Deploying to aws-eks-staging

[Minimize] [-] [+]

**APPLICATION DETAILS NETWORK**

Applications / Q argoapp-demo-app

v2.5.7+6

**APP DETAILS** **APP DIFF** **SYNC** **SYNC STATUS** **HISTORY AND ROLLBACK** **DELETE** **REFRESH ▾**

**APP HEALTH** **Synced** **Healthy**

**CURRENT SYNC STATUS** **Synced** **To develop (6288ed8)**

Author: andtell <andtell@users.noreply.github.com> - Comment: Bumping image version to 2d044074

**LAST SYNC RESULT** **Sync OK** **To 6288ed8**

Succeeded 12 minutes ago (Sun Jan 22 2023 19:39:03 GMT+0100)  
Author: andtell <andtell@users.noreply.github.com> - Comment: Bumping image version to 1b838802

**120%**

The diagram illustrates the deployment flow of the application. It starts with a dark blue cloud icon representing the source code or storage. A dashed blue arrow points from the cloud to a white rectangular box containing a blue Jenkins-like icon and the text "ae52820e275c0434b8cf92b8...". Another dashed blue arrow points from this box to a white rectangular box containing a blue service icon (with three smaller icons below it) and the text "cadec-demo-service". A third dashed blue arrow points from the service box to a light blue rectangular box containing a blue cube icon and the text "cadec-demo-54d68fbf46-stm...". A pink dashed arrow points from the same service box to another light blue rectangular box containing a blue cube icon and the text "cadec-demo-54d68fbf46-ttkcd". A small grey box labeled "3 hours" is positioned between the service and the first pod. Each box contains a green heart icon indicating health.

**pod** cadec-demo-54d68fbf46-stm... 12 minutes running 1/1

**pod** cadec-demo-54d68fbf46-ttkcd 12 minutes running 1/1

**Log out**

# AGENDA

- GitOps
  - Definition
  - Implementation
- Infrastructure as Code (IaC) - Pulumi
- Demo
- Wrap Up

## WRAP UP : CHALLENGES

- Branching scheme (don't do “branch per env”)
- The foundational infra setup requires a competent IaC tool to work “GitOps style” - e.g. Pulumi
- Separation of concerns in config is not always clear
- PR-workflow might introduce a bottleneck
- Culture: developer-centric (may not sit well with operations engineers)

APR  
2021

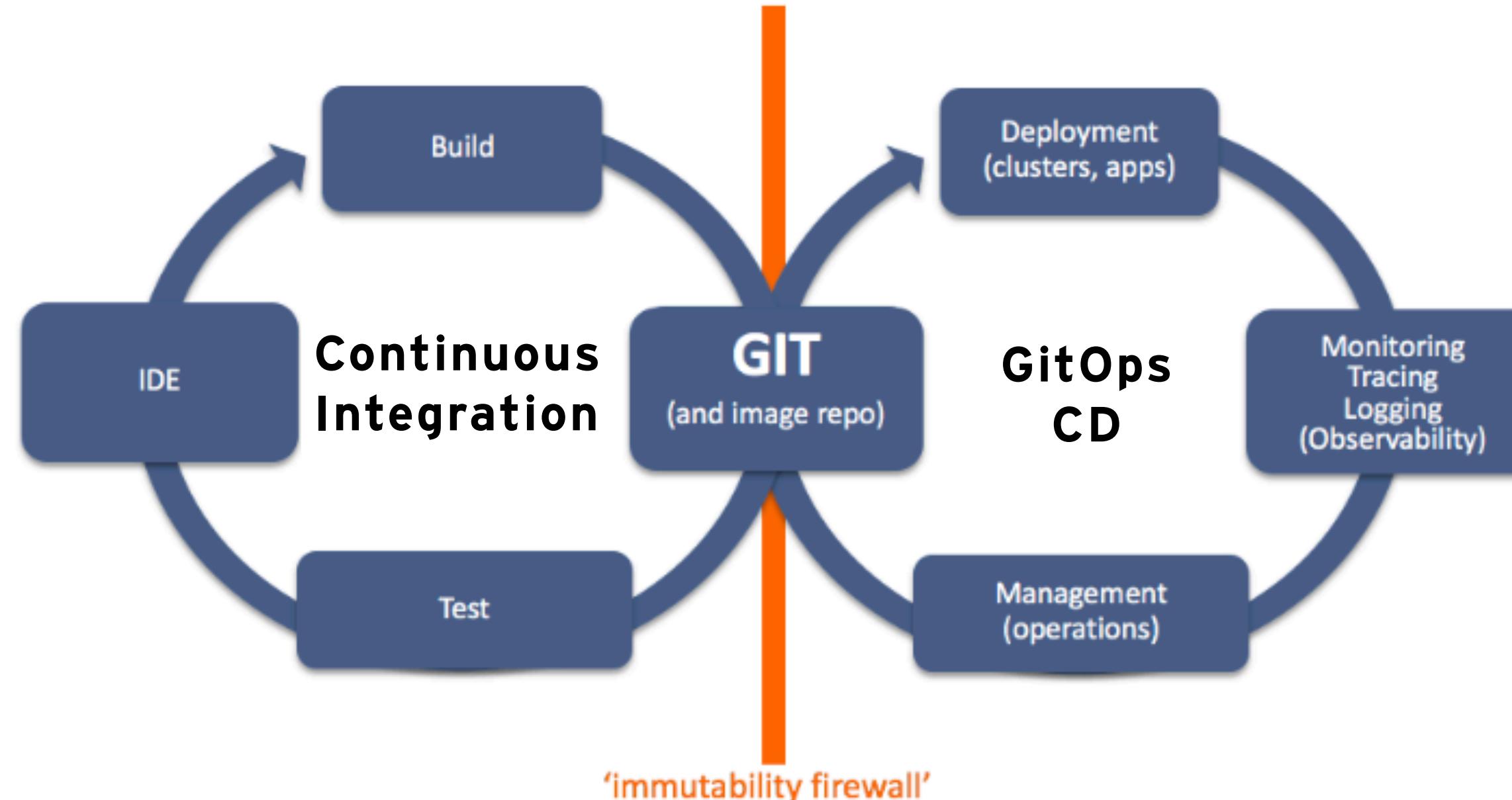
Hold ?

We suggest approaching **GitOps** with a degree of care, especially with regard to branching strategies. GitOps can be seen as a way of implementing infrastructure as code that involves continuously synchronizing and applying infrastructure code from Git into various environments. When used with a "branch per environment" infrastructure, changes are promoted from one environment to the next by merging code. While treating code as the single source of truth is clearly a sound approach, we're seeing branch per environment lead to environmental drift and eventually environment-specific configs as code merges become problematic or even stop entirely. This is very similar to what we've seen in the past with long-lived branches with GitFlow.

<https://www.thoughtworks.com/radar/techniques/gitops>



# WRAP UP : WHAT DID WE GET WITH GITOPS?



**Git as the single source of truth** of a system's desired state

**ALL** intended operations are performed as git push (possibly with pull request), for all environments

**ALL** diffs between Git and observed state are automatically reconciled

**ALL** changes are observable, verifiable and auditable

**Immutable Infrastructure**

**Automation!**  
**No more Cowboy Ops**

\$ git revert HEAD

... at least on K8S 🎉



\$ git log --graph --abbrev-commit

Modified from source: <https://www.weave.works/blog/what-is-gitops-really>

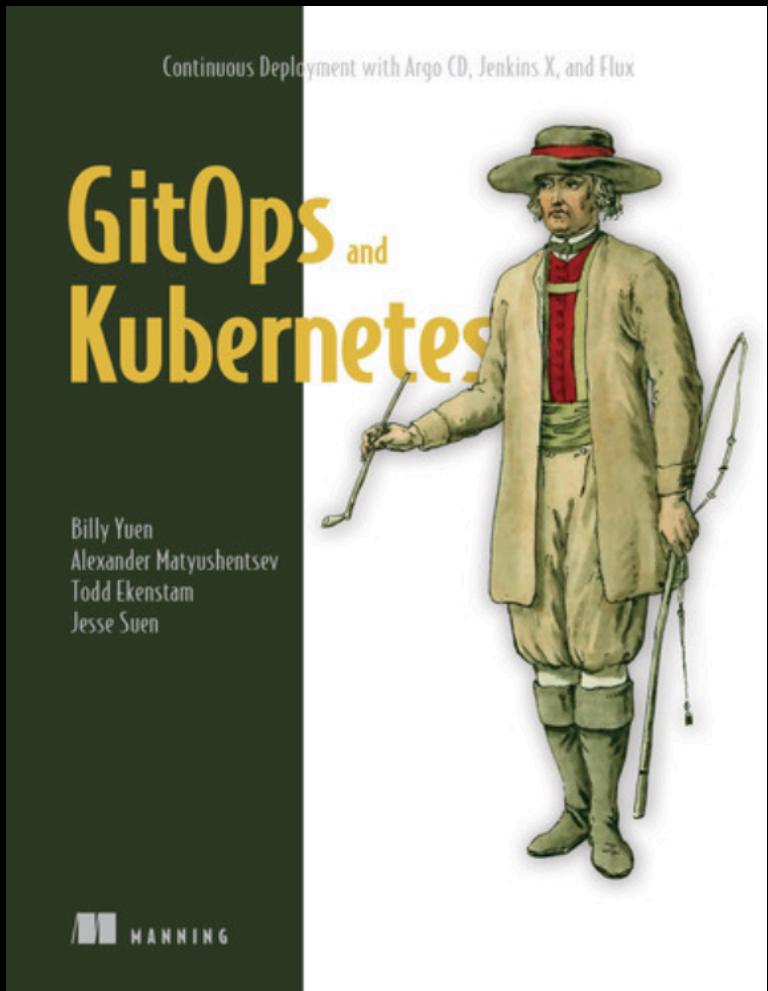
## CLOSING THOUGHTS

- GitOps is 
- Low hanging fruit - a twist on usage of already existing tools / established processes
- Beneficial even if not applying all principles (i.e. in scenarios outside K8S with no “agent”)
- “Infrastructure As Code done right”
- Declarative IaC + programming language is 
- The code should clearly express the **desired state**, over-engineering will lead to poor visibility



# WHERE TO GO FROM HERE

- GitOps for non-Kubernetes runtimes e.g. Serverless
- IaC test automation (unit-, integration-, E2E)
- Pulumi deep-dive
- Argo CD vs Flux CD
- Policy as Code
- Managing secrets
- Other providers (Azure, Google)
- ...



[HTTPS://WWW.MANNING.COM/BOOKS/GITOPS-AND-KUBERNETES](https://www.manning.com/books/gitops-and-kubernetes)

# THANKS FOR LISTENING!



kubectl  
apply  
  
git  
push

andreas.tell@callistaenterprise.se  
<https://www.linkedin.com/in/andreastell>