

Multi-cluster, multi-app deployments with App Sets

GitOpsCon US

Kostis Kapelonis | December 2025

Kostis Kapelonis



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<http://learning.octopus.com>



Agenda

- 1 **Understand Application Sets**
- 2 **Group Application Sets with App-of-Apps files**
- 3 **Avoid the Helm sandwich**
- 4 **Employ Cluster groups with Tags**
- 5 **Create Many Application Sets**
- 6 **Use the PR Generator for preview envs**



Introduction




CNCF End User Survey Finds Argo CD as Majority Adopted GitOps Solution for Kubernetes



Nearly 60% of Kubernetes clusters managed by survey respondents now rely on Argo CD, with strong satisfaction fueled by 3.0 performance and security updates

<https://www.cncf.io/announcements/2025/07/24/cncf-end-user-survey-finds-argo-cd-as-majority-adopted-gitops-solution-for-kubernetes/>



argo
v2.11.0+1cffa15

←

Applications

Settings

User Info

Documentation

☐★ Favorites Only

SYNC STATUS

☐Unknown2

☒Synced20

☐OutOfSync0

HEALTH STATUS

☐Unknown0

☐Progressing6

☐Suspended0

☒Healthy20

☐Degraded2

☐Missing0

Applications

APPLICATIONS TILES

+ NEW APP

SYNC APPS

REFRESH APPS

Search applications...

/

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Sort: name▼Items per page: 10▼

argo-events

Project:default

Labels:

Status:♥ Healthy✔ Synced

Reposito...https://github.com/argoproj/argoproj-de...

Target R...HEAD

Path:argo-events

Destinati...in-cluster

Namesp...workflow-playground

Created ...02/22/2024 21:32:40 (6 months ago)

Last Sync:07/13/2024 18:06:35 (a month ago)

SYNC

REFRESH

DELETE

argo-rollouts

Project:default

Labels:

Status:♥ Healthy✔ Synced

Reposito...https://github.com/argoproj/argoproj-de...

Target R...HEAD

Path:argo-rollouts

Destinati...in-cluster

Namesp...argo-rollouts

Created ...02/22/2024 21:32:41 (6 months ago)

Last Sync:02/23/2024 19:36:19 (6 months ago)

SYNC

REFRESH

DELETE

argo-workflows

Project:default

Labels:

Status:♥ Healthy✔ Synced

Reposito...https://github.com/argoproj/argoproj-de...

Target R...HEAD

Path:argo-workflows

Destinati...in-cluster

Namesp...argo

Created ...02/22/2024 21:32:41 (6 months ago)

Last Sync:03/11/2024 13:40:15 (5 months ago)

SYNC

REFRESH

DELETE

argocd-image-updater

Project:default

Labels:

Status:♥ Healthy✔ Synced

Reposito...https://github.com/argoproj/argoproj-de...

Target R...HEAD

Path:argocd-image-updater

Destinati...in-cluster

dex

Project:default

Labels:

Status:♥ Healthy✔ Synced

Reposito...https://github.com/argoproj/argoproj-de...

Target R...HEAD

Path:dex

Destinati...in-cluster

example.guestbook

Project:default

Labels:


Status:♥ Healthy✔ Synced

Reposito...https://github.com/agaudreault/argocd-...

Target R...sync-from-demo

Path:guestbook

Destinati...in-cluster



```
apiVersion: argoproj.io/v1alpha1
kind: Application
metadata:
  name: guestbook
  namespace: argocd
spec:
  project: default
  source:
    repoURL: https://github.com/argoproj/argocd-example-apps.git
    targetRevision: HEAD
    path: guestbook
  destination:
    server: https://kubernetes.default.svc
    namespace: guestbook
```

Name of application

Where to read the Kubernetes manifest from

Which cluster to deploy the application to



Always use ApplicationSets

- Understand the generators
- Learn how to combine them
- Don't miss the PR generator

KUBECTL

**NEW
APP BUTTON**

**APPLICATION
CRD**

APPLICATIONSET



Application Set 101



Same App - different clusters

Cluster A



Cluster B



Cluster C



AppSet

Billing App

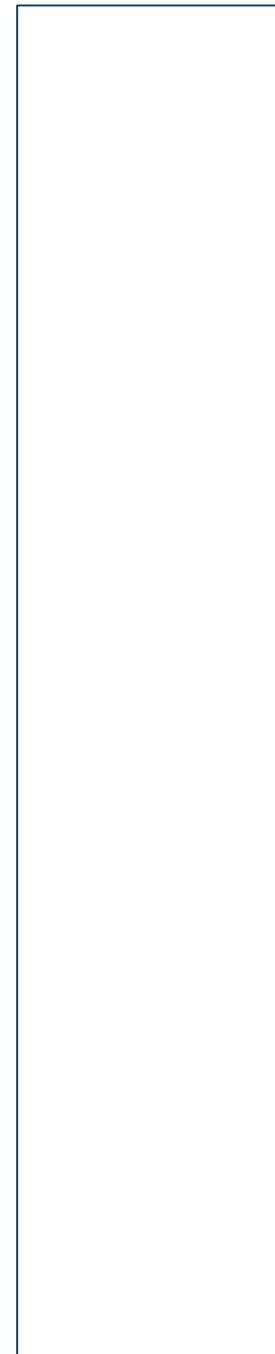
Billing App

Billing App



Same cluster- different apps

AppSet



Cluster



Billing App

Sealed Secrets

Argo Rollouts

Cert Manager



Many Apps - Many Clusters

Cluster A



Cluster B



Cluster C



AppSet

Billing App

Sealed Secrets

Argo Rollouts

Cert Manager

Billing App

Sealed Secrets

Argo Rollouts

Cert Manager

Billing App

Sealed Secrets

Argo Rollouts

Cert Manager



Generators

- List
- Cluster
- Git
- SCM Provider
- Pull Request
- Cluster Decision
- Matrix
- Merge
- Plugin

Combine and Extend
Generators!



Forget individual Aps

```
apiVersion: argoproj.io/v1alpha1
kind: Application
metadata:
  name: guestbook
  namespace: argocd
spec:
  project: default
  source:
    repoURL: https://github.com/argoproj/argocd-example-apps.git
    targetRevision: HEAD
    path: guestbook
  destination:
    server: https://kubernetes.default.svc
    namespace: guestbook
```

Name of application

Where to read the Kubernetes manifest

Which cluster to deploy the application to



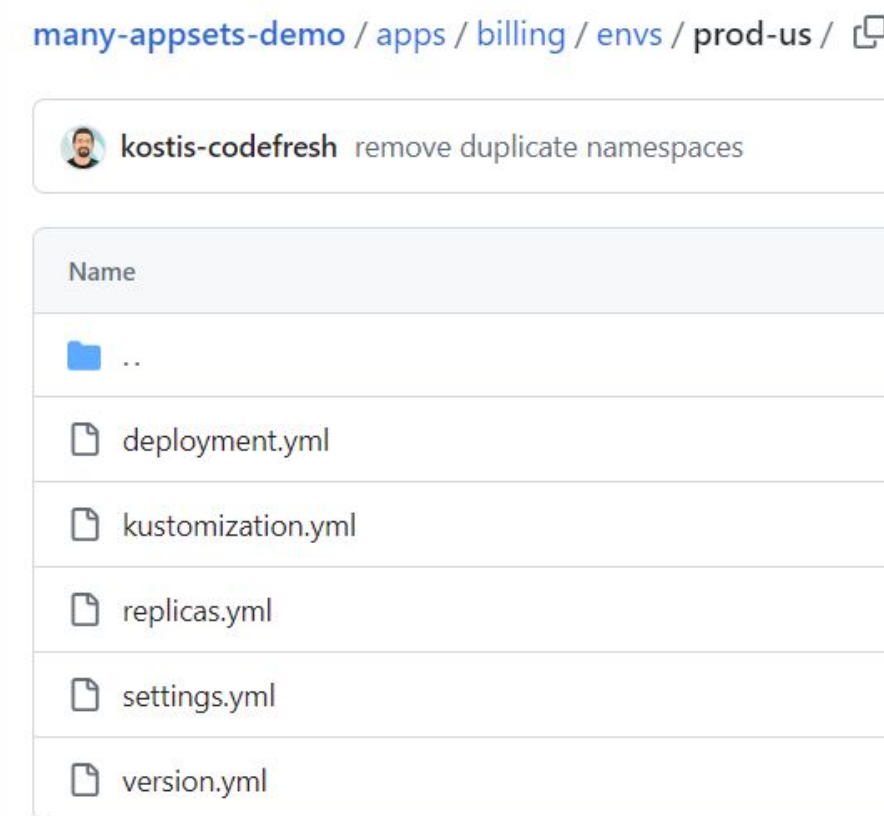
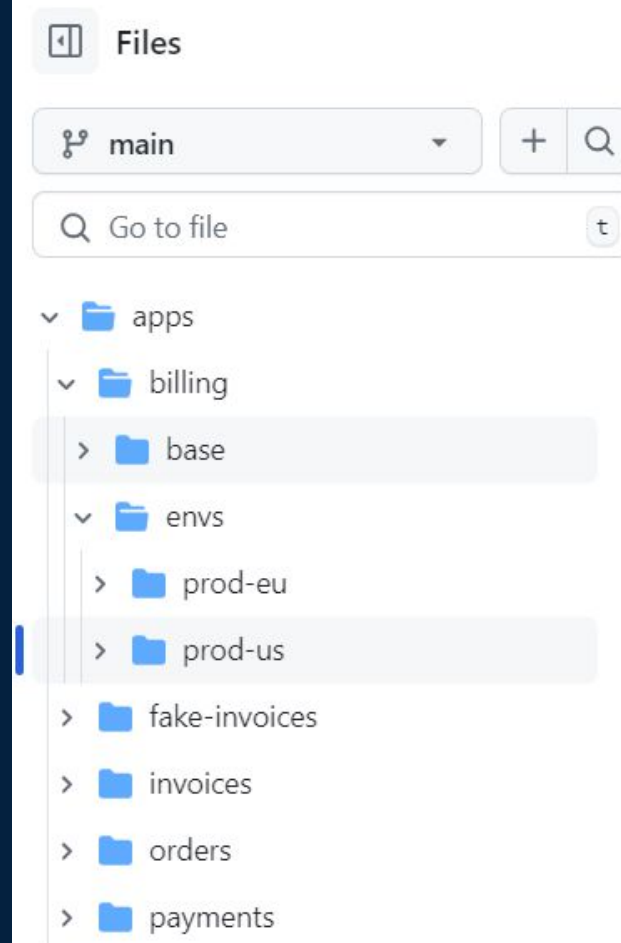

```

apiVersion: argoproj.io/v1alpha1
kind: ApplicationSet
metadata:
  name: my-qa-appset
  namespace: argocd
spec:
  goTemplate: true
  goTemplateOptions: ["missingkey=error"]
  generators:
    - git:
        repoURL: https://github.com/kostis-codefresh/many-appsets-demo.git
        revision: HEAD
        directories:
          - path: apps/*/envs/qa
  template:
    metadata:
      name: '{{index .path.segments 1}}-{{index .path.segments 3}}'
    spec:
      # The project the application belongs to.
      project: default

      # Source of the application manifests
      source:
        repoURL: https://github.com/kostis-codefresh/many-appsets-demo.git
        targetRevision: HEAD
        path: '{{.path.path}}'

      # Destination cluster and namespace to deploy the application
      destination:
        server: https://kubernetes.default.svc
        namespace: '{{index .path.segments 1}}-{{index .path.segments 3}}'

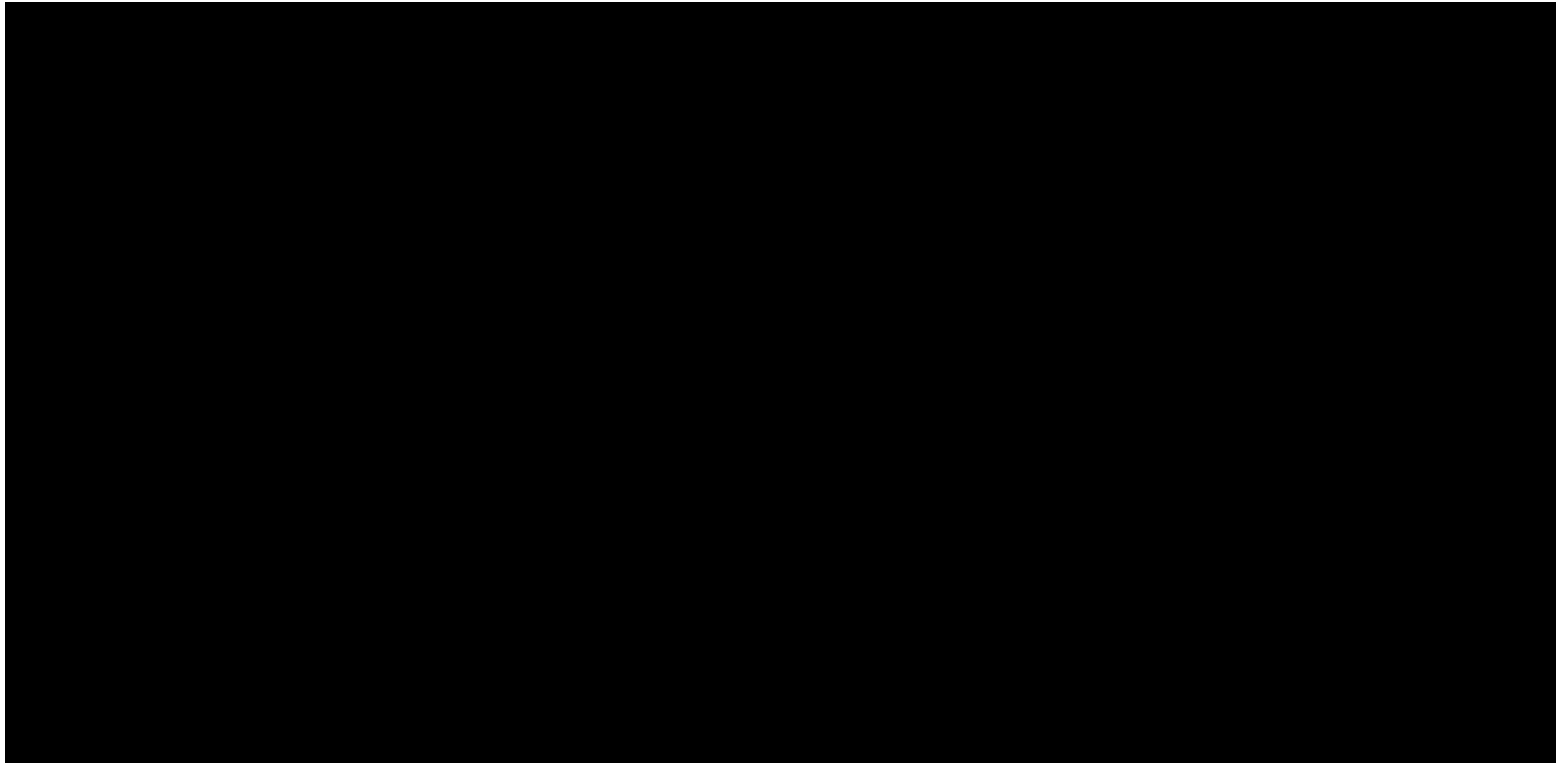
```




Generate applications from Git folders



Cluster bootstrapping



argo
v2.10.6+d504d2b

←

Applications

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Documentation

☐★ Favorites Only

SYNC STATUS

☐🕒 Unknown0

☒✅ Synced13

☐⬆️ OutOfSync0

HEALTH STATUS

☐❓ Unknown0

☐🔄 Progressing12

☐⏸️ Suspended0

☐💚 Healthy1

☐💔 Degraded0

☐👻 Missing0

LABELS

LABELS

PROJECTS

Applications

APPLICATIONS LIST

+ NEW APP

↻ SYNC APPS

↻ REFRESH APPS

🔍 Search applications...

/

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Sort: name ▾Items per page: 10 ▾

☆	Project: default Name: all-apps	Source: https://github.com/kostis-codefresh/many-appsets-demo.git/appsets Destination: in-cluster/argocd	HEAD	💚 Healthy ✅ Synced	⋮
☆	Project: default Name: billing-prod-eu	Source: https://github.com/kostis-codefresh/many-appsets-demo.git/apps/billing/envs/prod-eu Destination: in-cluster/billing-prod-eu	HEAD	🔄 Progressing ✅ Synced	⋮
☆	Project: default Name: billing-prod-us	Source: https://github.com/kostis-codefresh/many-appsets-demo.git/apps/billing/envs/prod-us Destination: in-cluster/billing-prod-us	HEAD	🔄 Progressing ✅ Synced	⋮
☆	Project: default Name: fake-invoices-qa	Source: https://github.com/kostis-codefresh/many-appsets-demo.git/apps/fake-invoices/envs/qa Destination: in-cluster/fake-invoices-qa	HEAD	🔄 Progressing ✅ Synced	⋮
☆	Project: default Name: invoices-prod-eu	Source: https://github.com/kostis-codefresh/many-appsets-demo.git/apps/invoices/envs/prod-eu Destination: in-cluster/invoices-prod-eu	HEAD	🔄 Progressing ✅ Synced	⋮
☆	Project: default Name: invoices-prod-us	Source: https://github.com/kostis-codefresh/many-appsets-demo.git/apps/invoices/envs/prod-us Destination: in-cluster/invoices-prod-us	HEAD	🔄 Progressing ✅ Synced	⋮
☆	Project: default Name: invoices-qa	Source: https://github.com/kostis-codefresh/many-appsets-demo.git/apps/invoices/envs/qa Destination: in-cluster/invoices-qa	HEAD	🔄 Progressing ✅ Synced	⋮
☆	Project: default Name: invoices-staging	Source: https://github.com/kostis-codefresh/many-appsets-demo.git/apps/invoices/envs/staging Destination: in-cluster/invoices-staging	HEAD	🔄 Progressing ✅ Synced	⋮
☆	Project: default Name: orders-prod-us	Source: https://github.com/kostis-codefresh/many-appsets-demo.git/apps/orders/envs/prod-us Destination: in-cluster/orders-prod-us	HEAD	🔄 Progressing ✅ Synced	⋮
☆	Project: default Name: orders-qa	Source: https://github.com/kostis-codefresh/many-appsets-demo.git/apps/orders/envs/qa Destination: in-cluster/orders-qa	HEAD	🔄 Progressing ✅ Synced	⋮

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A good starting point

- Store your applications with Kustomize Overlays OR
- Store your applications with Helm value Hierarchies
- Use [the Git generator](#) to load apps
- Use the [Cluster generator](#) to assign apps to clusters
- Create one applicationset per environment or cluster type





BEST PRACTICES

How to Structure Your Argo CD Repositories Using Application Sets

21 min read



Kostis Kapelonis May 17, 2024



<https://codefresh.io/blog/how-to-structure-your-argo-cd-repositories-using-application-sets/>



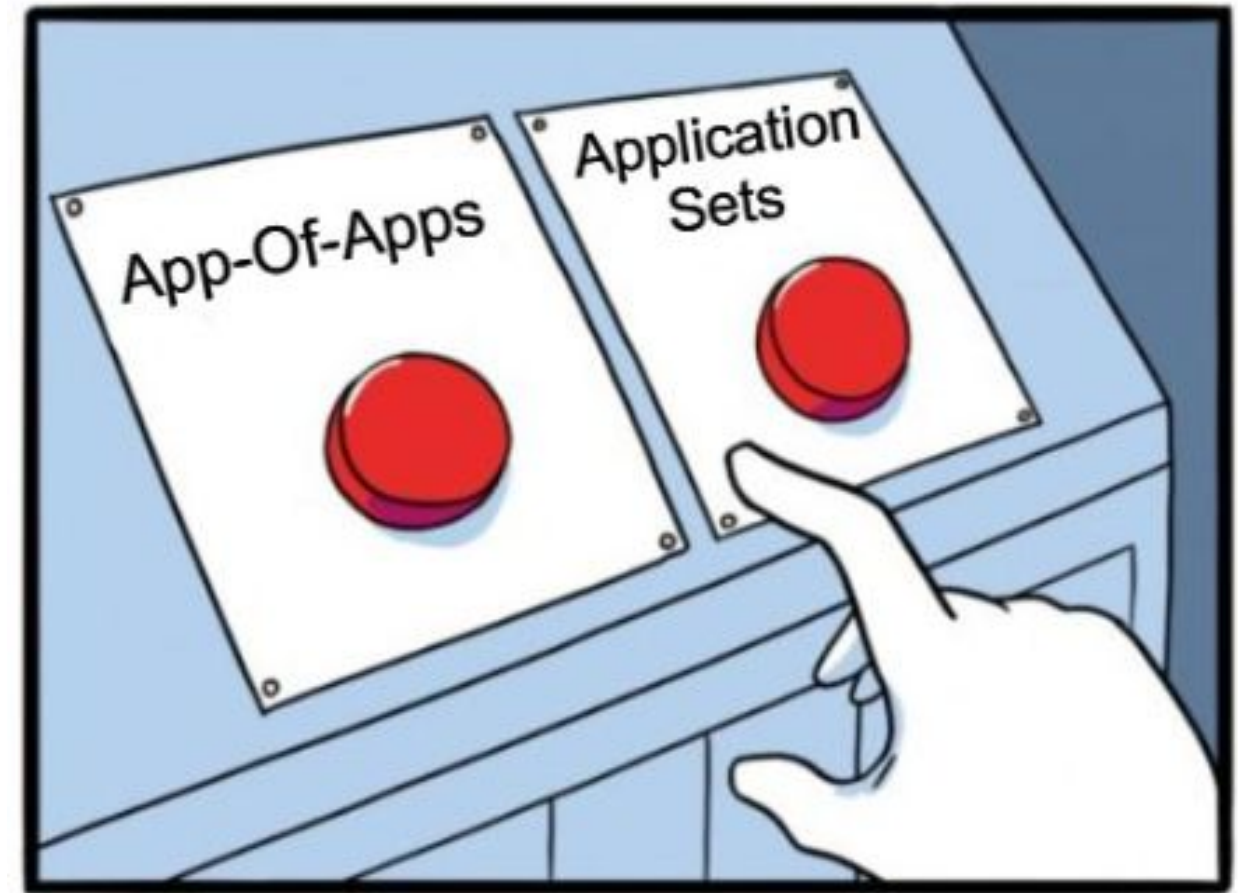
Confusion with App-of-Apps

They are not mutually exclusive



What to choose?

“Should I use Application Sets or App of Apps”?



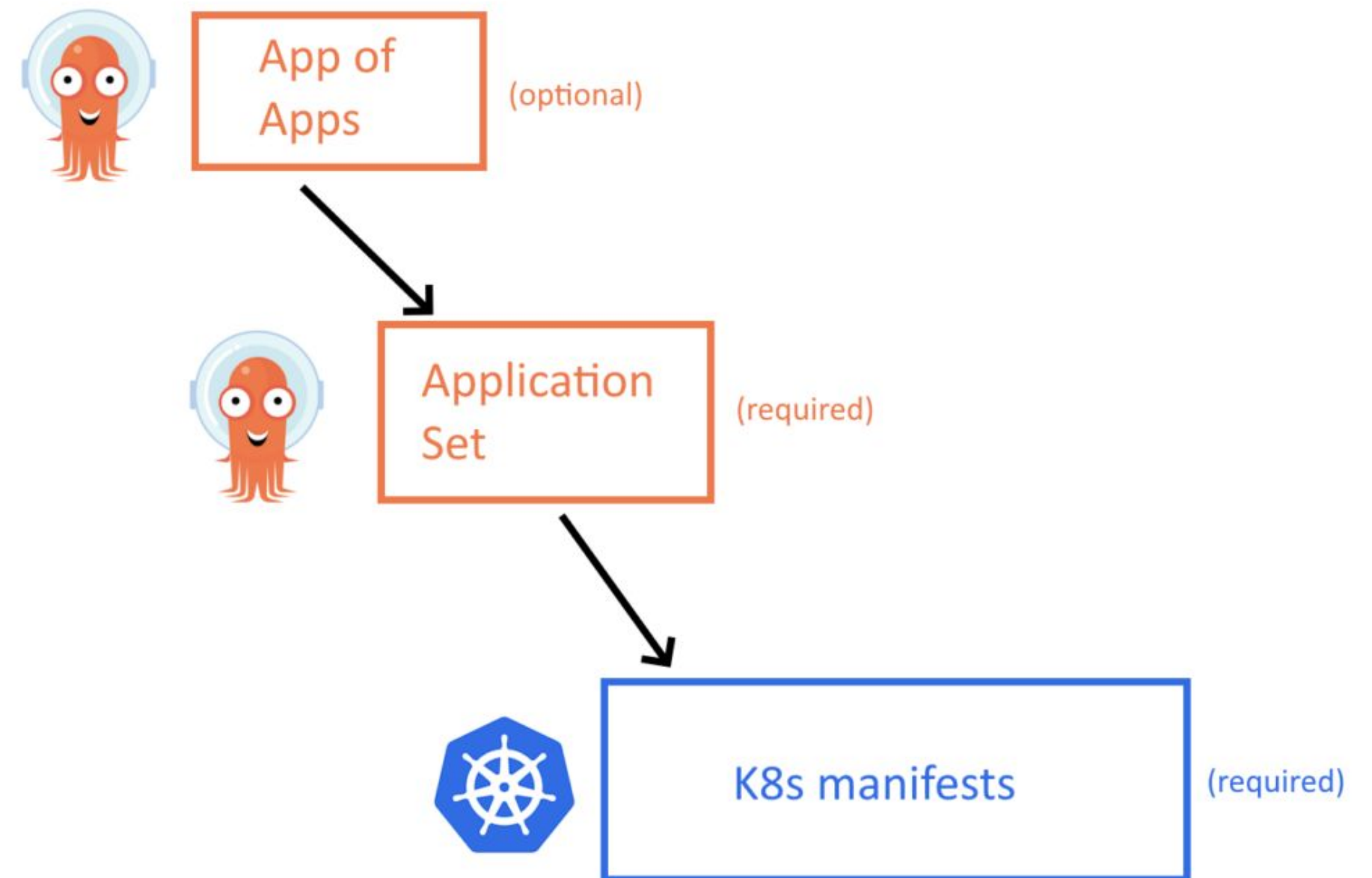
“Choosing” between App-of-apps and App Sets

- “I prefer app-of-apps and not application sets”
- “I haven’t explored application sets yet. Still using App-of-Apps”
- “I tried Application Sets but found them too complex. Now using App-of-Apps”
- “I am using App-Of-Apps to do X. Can I do X with ApplicationSets?”
- “This is my setup. Do you recommend App-Of-Apps or Application Sets?”



ApplicationSets AND App-Of-Apps

- Application Sets are NOT a replacement for App-of-apps
- You should use them together
- Group many ApplicationSets in a root App
- Great for cluster bootstrapping



Don't use Helm

...for Argo CD manifests



How do we template
Kubernetes manifests?



Ops

Let's use Helm !



Do



Ops



How do we template
Argo CD Applications?



Don't



Ops

Let's use Helm !

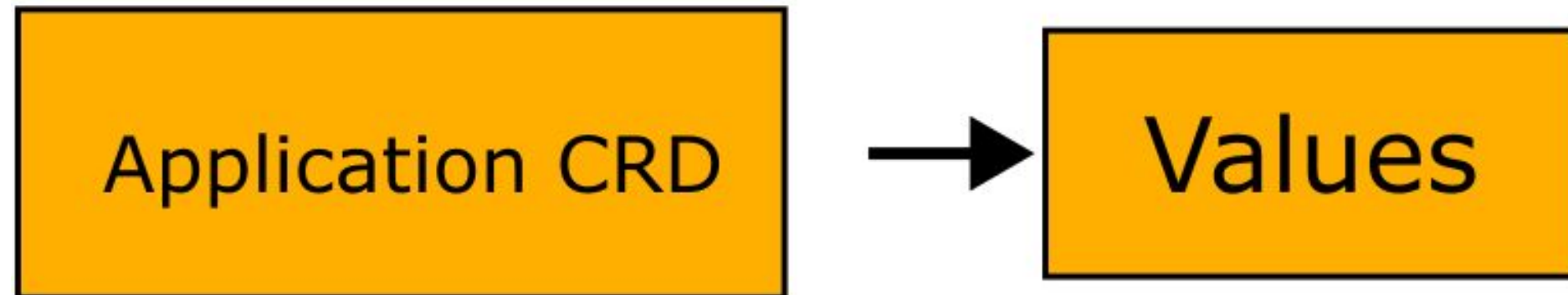


Ops

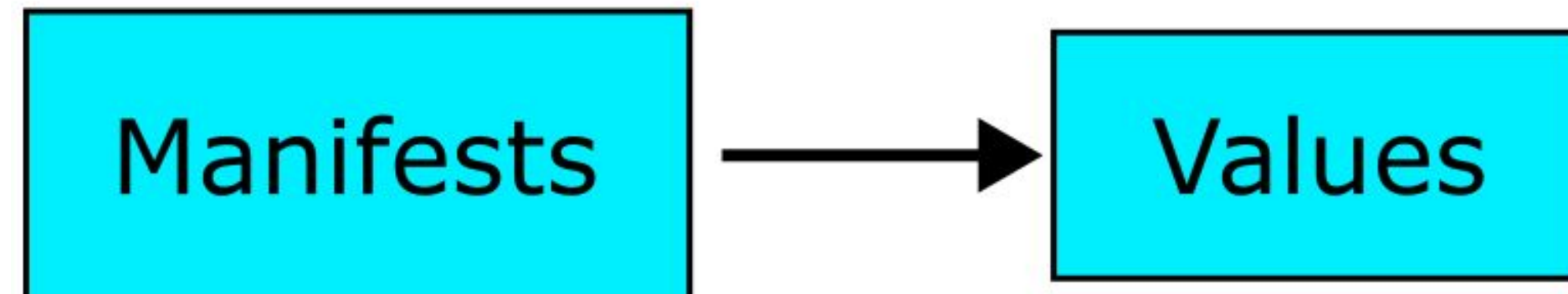


Two layers of Helm - “Helm Sandwich”

Helm Chart (Level 2)



Helm Chart (Level 1)

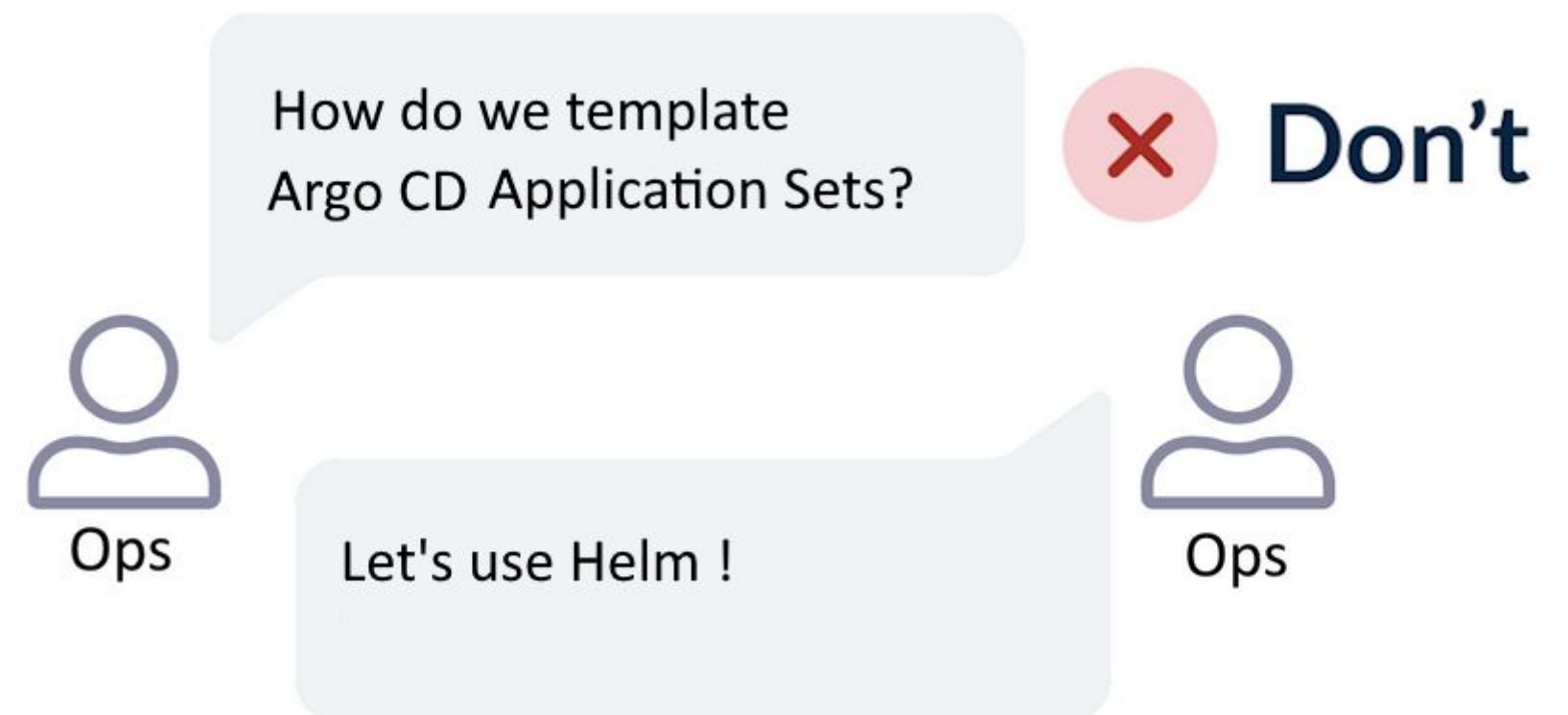


⊗ Don't

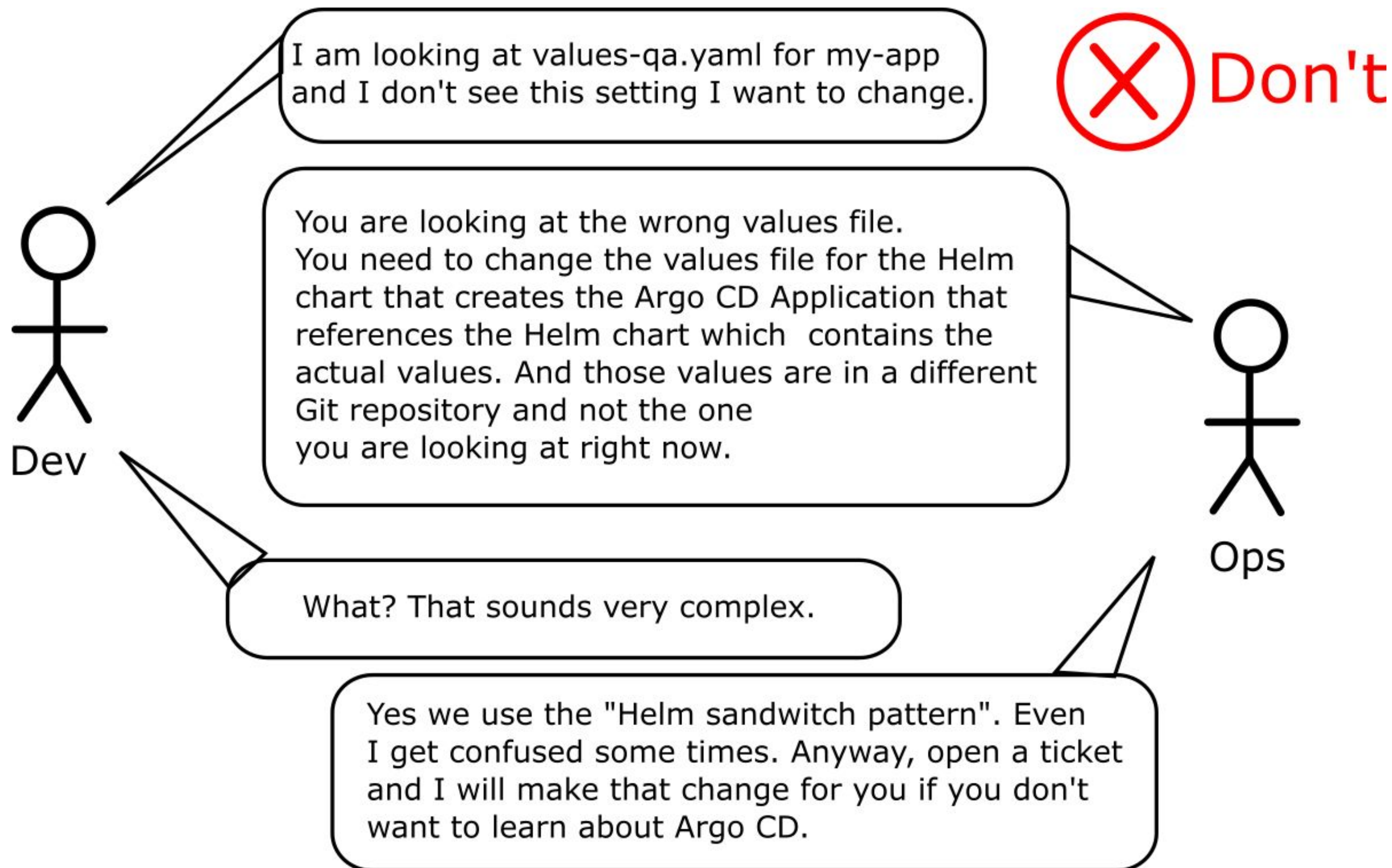


Application Sets already support templating

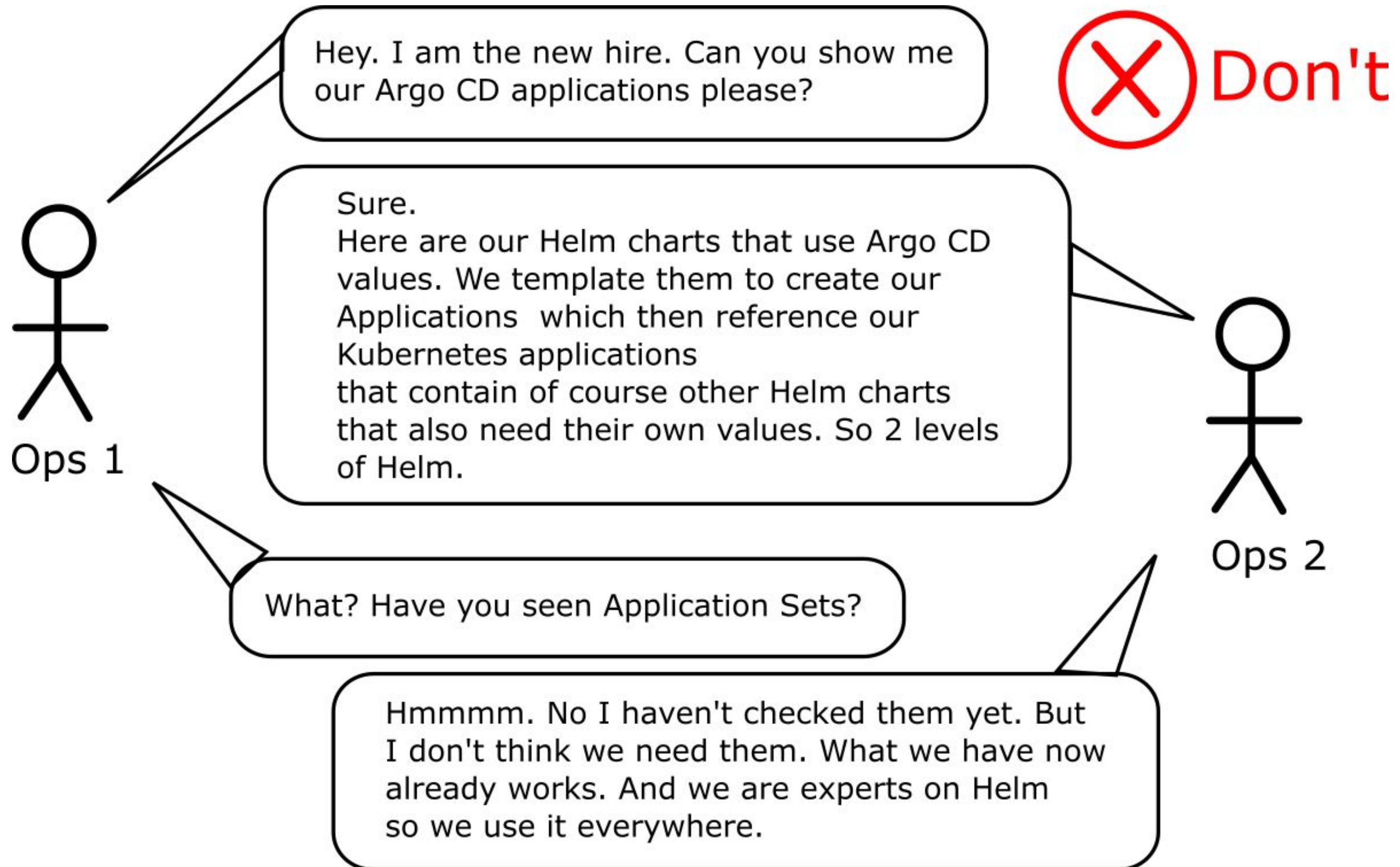
- Don't use Helm as a hammer...
- No need for extra complexity
- It is difficult to debug Helm Application CRDs that point to Helm charts



Dev experience



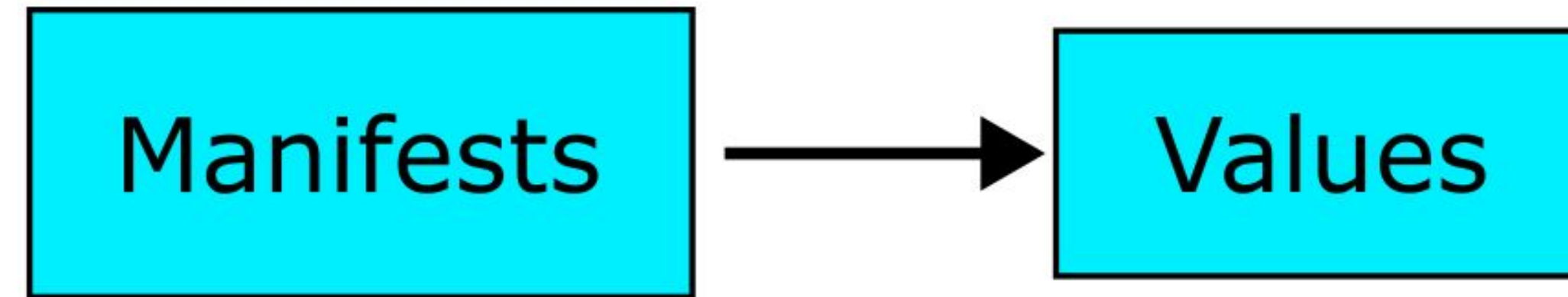
Ops experience



Solution: use Application Sets

Application Sets

Helm Chart



Application Set templating

Sprig Function Documentation

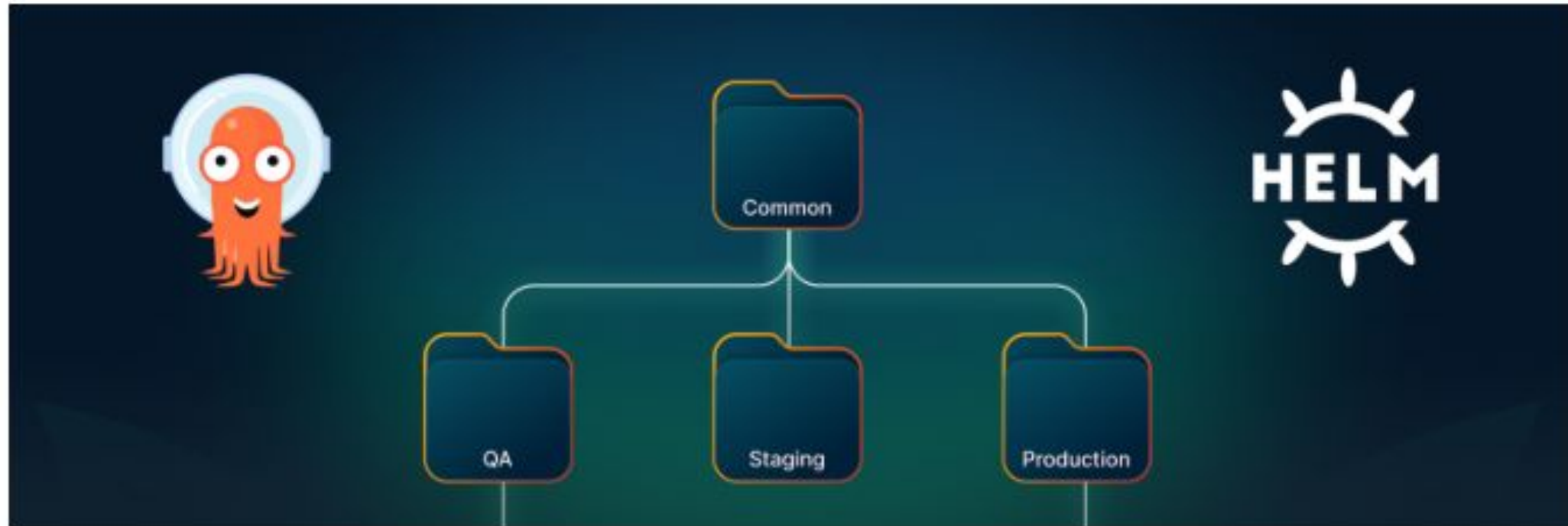
The Sprig library provides over 70 template functions for Go's template language.

- **String Functions:** `trim`, `wrap`, `randAlpha`, `plural`, etc.
 - **String List Functions:** `splitList`, `sortAlpha`, etc.
- **Integer Math Functions:** `add`, `max`, `mul`, etc.
 - **Integer Slice Functions:** `until`, `untilStep`
- **Float Math Functions:** `addf`, `maxf`, `mulf`, etc.
- **Date Functions:** `now`, `date`, etc.
- **Defaults Functions:** `default`, `empty`, `coalesce`, `fromJson`, `toJson`, `toPrettyJson`, `toRawJson`, `ternary`
- **Encoding Functions:** `b64enc`, `b64dec`, etc.
- **Lists and List Functions:** `list`, `first`, `uniq`, etc.
- **Dictionaries and Dict Functions:** `get`, `set`, `dict`, `hasKey`, `pluck`, `dig`, `deepCopy`, etc.
- **Type Conversion Functions:** `atoi`, `int64`, `toString`, etc.
- **Path and Filepath Functions:** `base`, `dir`, `ext`, `clean`, `isAbs`, `osBase`, `osDir`, `osExt`, `osClean`, `osIsAbs`
- **Flow Control Functions:** `fail`
- **Advanced Functions**
 - **UUID Functions:** `uuidv4`
 - **OS Functions:** `env`, `expandenv`
 - **Version Comparison Functions:** `semver`, `semverCompare`
 - **Reflection:** `typeOf`, `kindIs`, `typeIsLike`, etc.
 - **Cryptographic and Security Functions:** `derivePassword`, `sha256sum`, `genPrivateKey`, etc.
 - **Network:** `getHostByName`
 - **URL:** `urlParse`, `urlJoin`

Usage example

```
apiVersion: argoproj.io/v1alpha1
kind: ApplicationSet
metadata:
  name: test-appset
spec:
  ...
  template:
    metadata:
      name: 'hellos3-{{.name}}-{{ cat .branch | slugify 23 }}'
    annotations:
      label-1: '{{ cat .branch | slugify }}'
      label-2: '{{ cat .branch | slugify 23 }}'
      label-3: '{{ cat .branch | slugify 50 false }}'
```





BEST PRACTICES

Using Helm Hierarchies in Multi-Source Argo CD Applications for Promoting to Different GitOps Environments

14 min read



<https://codefresh.io/blog/helm-values-argocd/>



Use Cluster Groups with tags

Pet vs Cattle



Many Apps - Many Clusters

Cluster A



Cluster B



Cluster C



AppSet

Billing App

Sealed Secrets

Argo Rollouts

Billing App

Sealed Secrets

Argo Rollouts

Cert Manager

Billing App

Argo Rollouts

Cert Manager



```
- merge:
  mergeKeys:
    - app
  generators:
    - list:
        elements:
          - app: external-dns
            appPath: infra/helm-charts/external-dns
            namespace: dns
          - app: argocd
            appPath: infra/helm-charts/argocd
            namespace: argocd
          - app: external-secrets
            appPath: infra/helm-charts/external-secrets
            namespace: external-secrets
          - app: kyverno
            appPath: infra/helm-charts/kyverno
            namespace: kyverno
    - list:
        elements:
          - app: external-dns
            enabled: "true"
          - app: argocd
            enabled: "true"
          - app: external-secrets
            enabled: "false"
          - app: kyverno
            enabled: "true"
  selector:
    matchLabels:
      enabled: "true"
```

Trying to define exactly what goes into each cluster

REJECTED



Tag your clusters




QA

Non-prod

AWS

Region B



Region A

Non-prod

GCP

Staging



US-East



Region A

Prod

GCP

US-West



Region A

Prod

GCP

Non-prod

AWS

Region B



Load Testing



EU

Prod

AWS

Region B



Labels are in cluster secrets



```
apiVersion: v1
data:
  [...snip...]
kind: Secret
metadata:
  annotations:
    managed-by: argocd.argoproj.io
  labels:
    argocd.argoproj.io/secret-type: cluster
    cloud: gcp
    department: billing
    env: qa
    region: eu
    type: workload
name: cluster-k3d-qa-eu-serverlb-1347542961
namespace: argocd
```

This cluster belongs to the:

- gcp
 - qa
 - EU
 - workload
 - billing
- ...cluster groups



Use Tags with apps



- “In all my AWS clusters I want these apps” -> Create application Set
- “In all my Prod clusters I want these apps “ -> Create Application Set
- “In all my US Region clusters I want these apps” -> Create Application Set
- “In all my Staging clusters I want these apps” -> Create Application Set



Choose cluster group (And mode)



```
spec:
  goTemplate: true
  goTemplateOptions: ["missingkey=error"]
  generators:
    - matrix:
        generators:
          - git:
              repoURL: https://github.com/somerepo.git
              revision: HEAD
              directories:
                - path: simple-apps/*
          - clusters:
              selector:
                matchLabels:
                  type: "workload"
                  region: "asia"
                  env: "prod"
```

Choose all clusters that are
in Production AND in Asia
AND with type "workload"



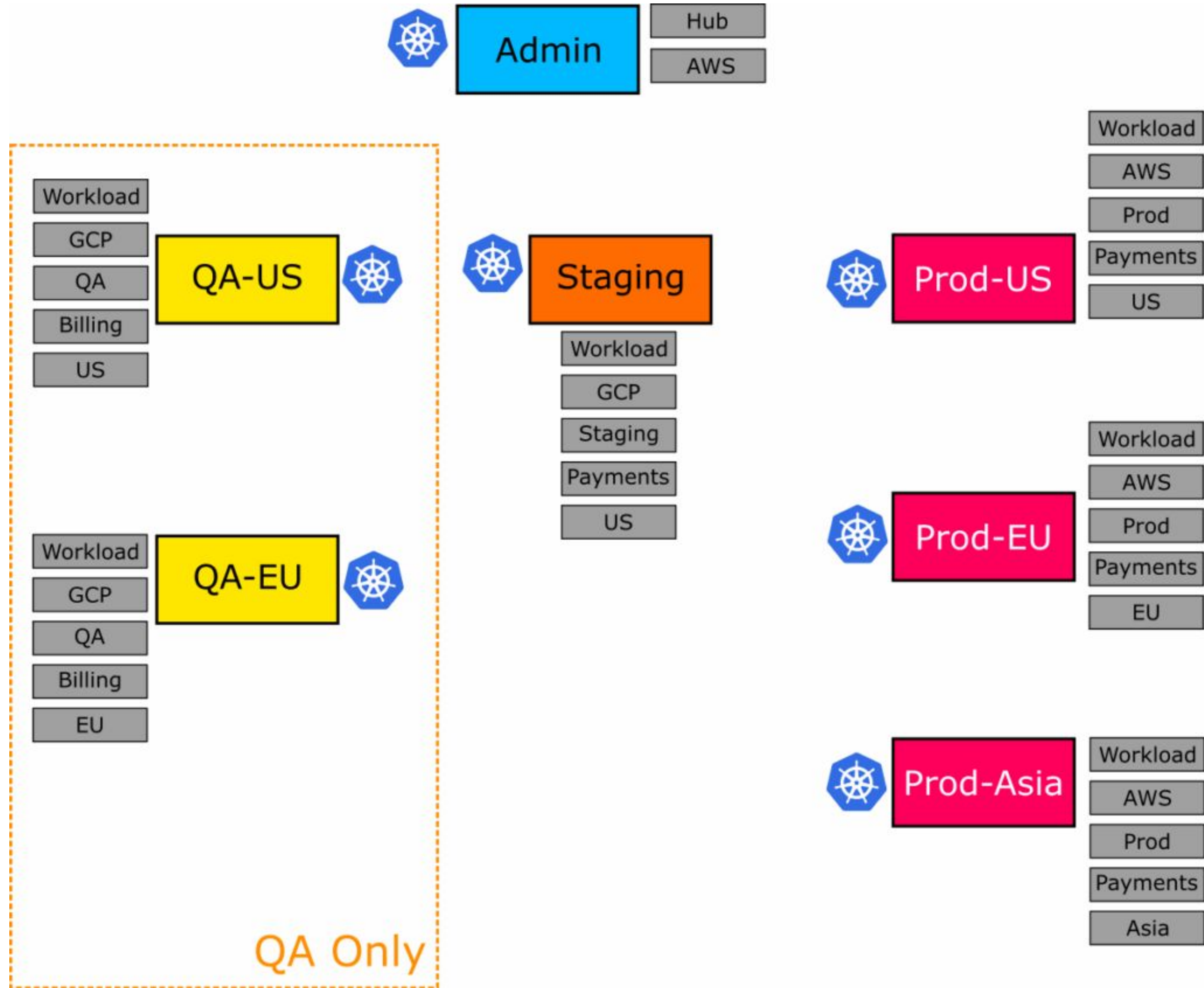
Choose cluster group (Or mode)

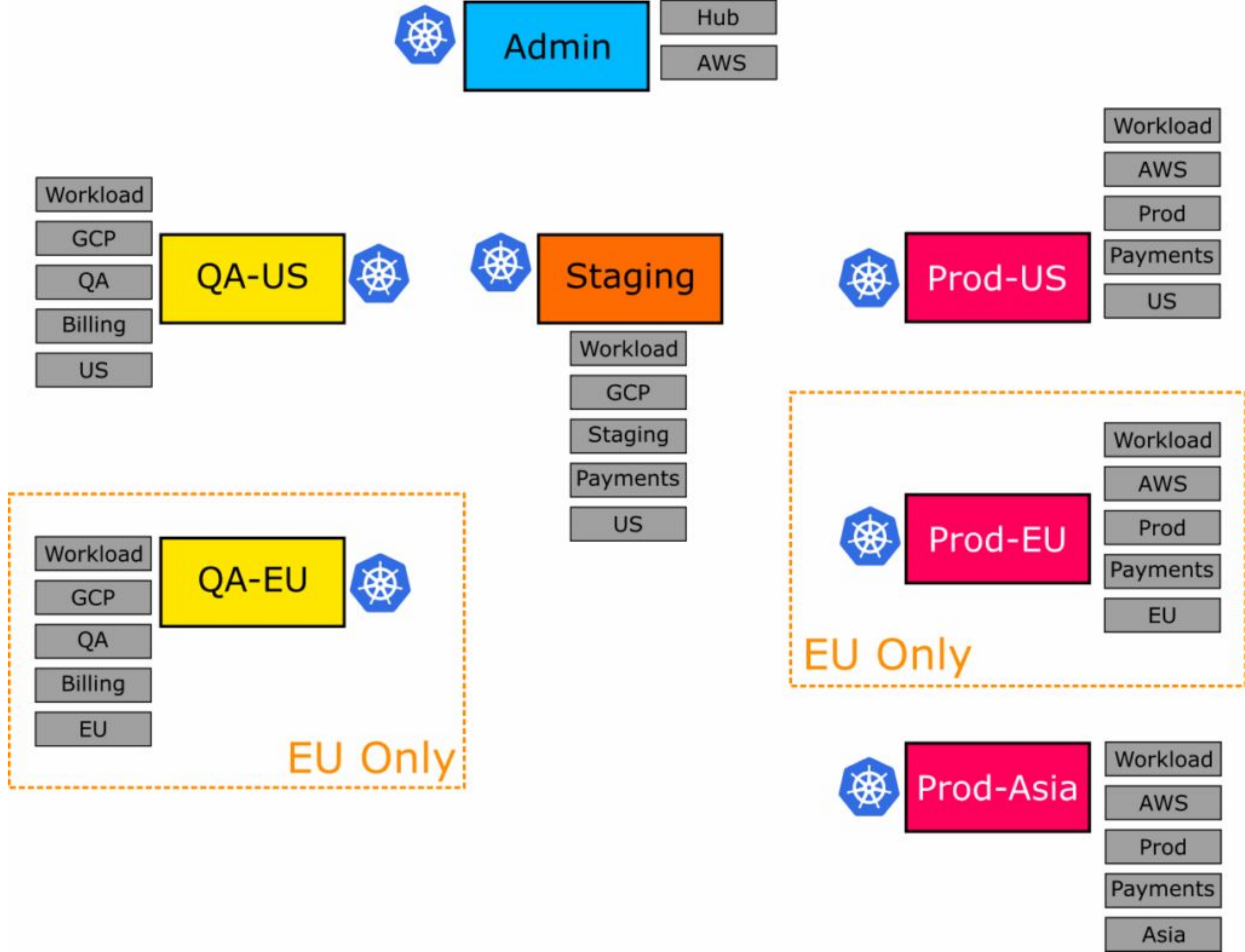


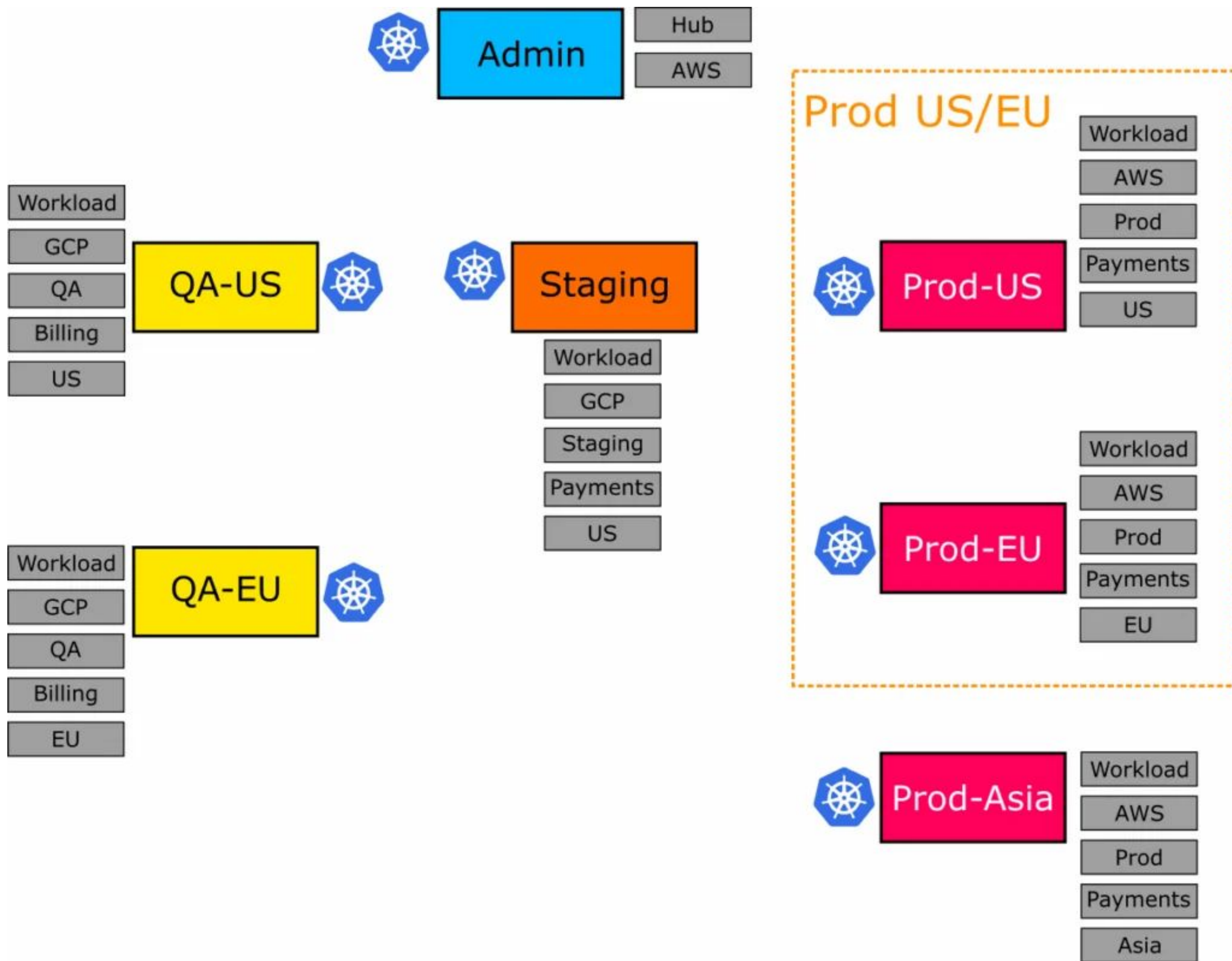
```
spec:
  goTemplate: true
  goTemplateOptions: ["missingkey=error"]
  generators:
    - matrix:
        generators:
          - clusters:
              selector:
                matchLabels:
                  type: "workload"
                  env: "prod"
                matchExpressions:
                  - key: region
                    operator: In
                    values:
                      - "eu"
                      - "us"
            - git:
                repoURL: https://github.com/somerepo.git
                revision: HEAD
                directories:
                  - path: 'kustomize-apps/*/envs/{{.name}}'
```

Choose all clusters that are in
Production AND with type
“workload” and in region EU OR US)

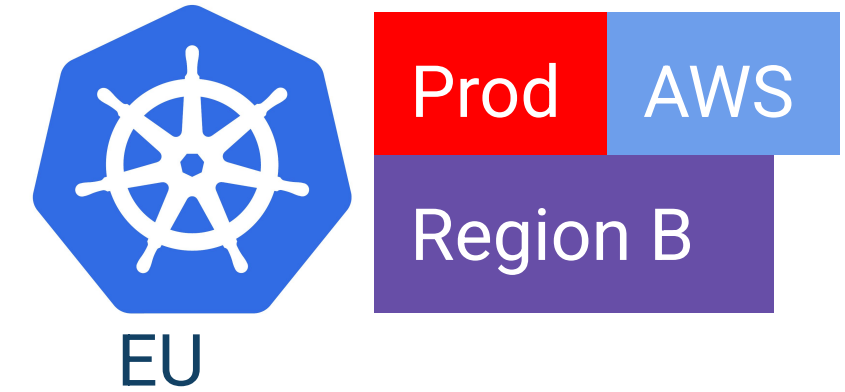
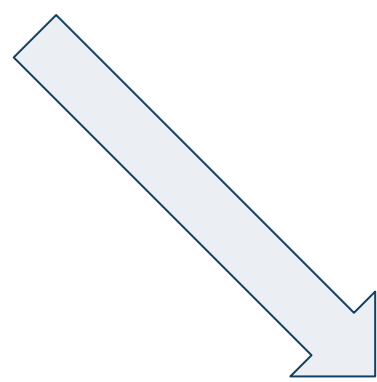
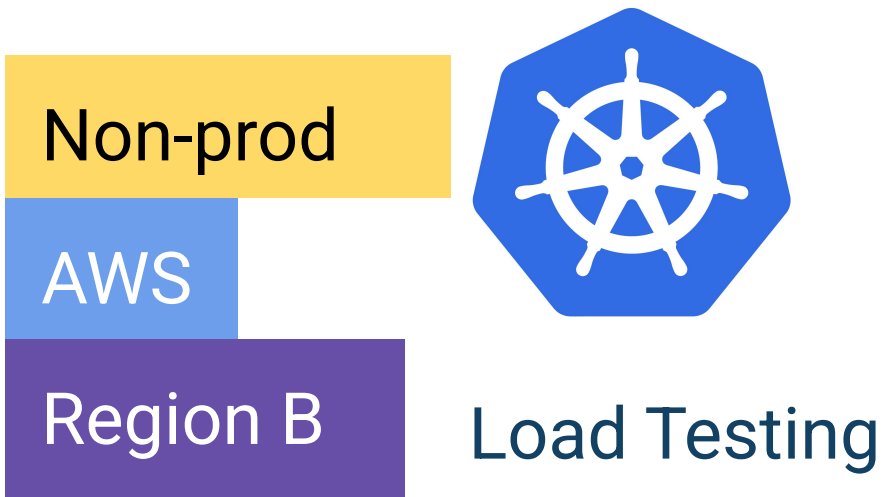
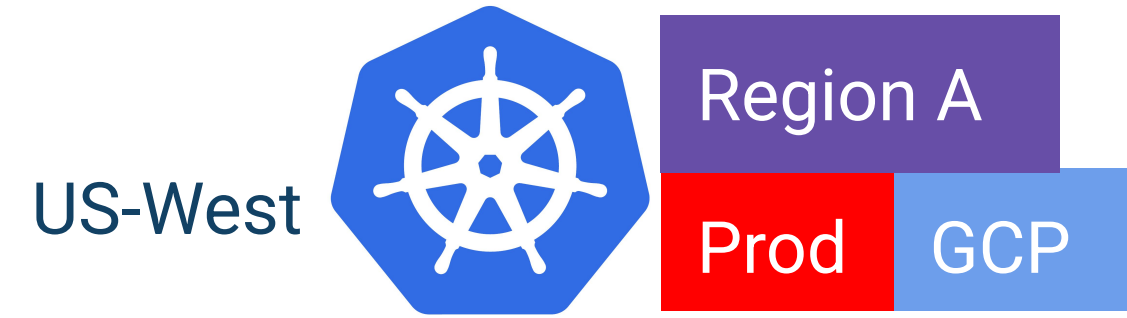
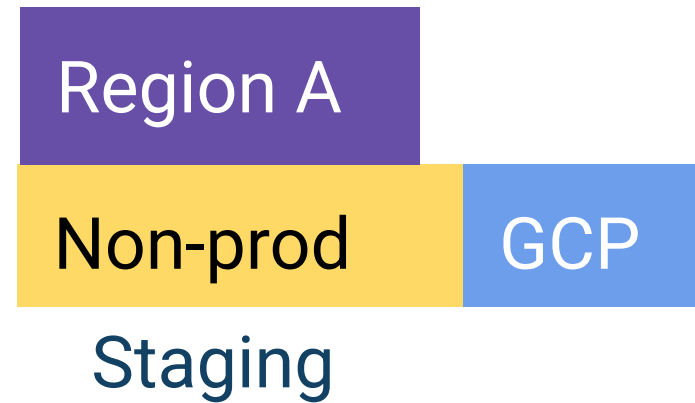
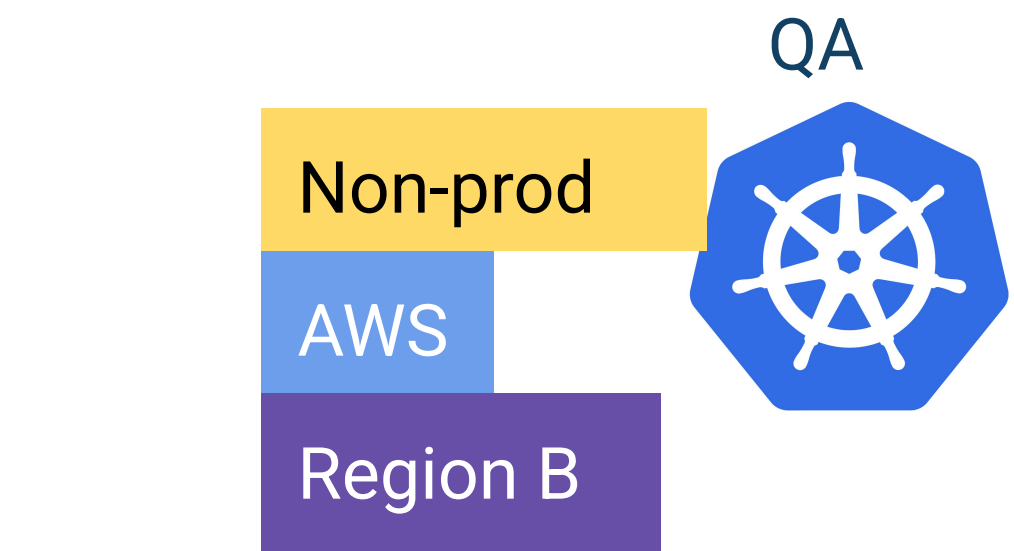








New cluster?



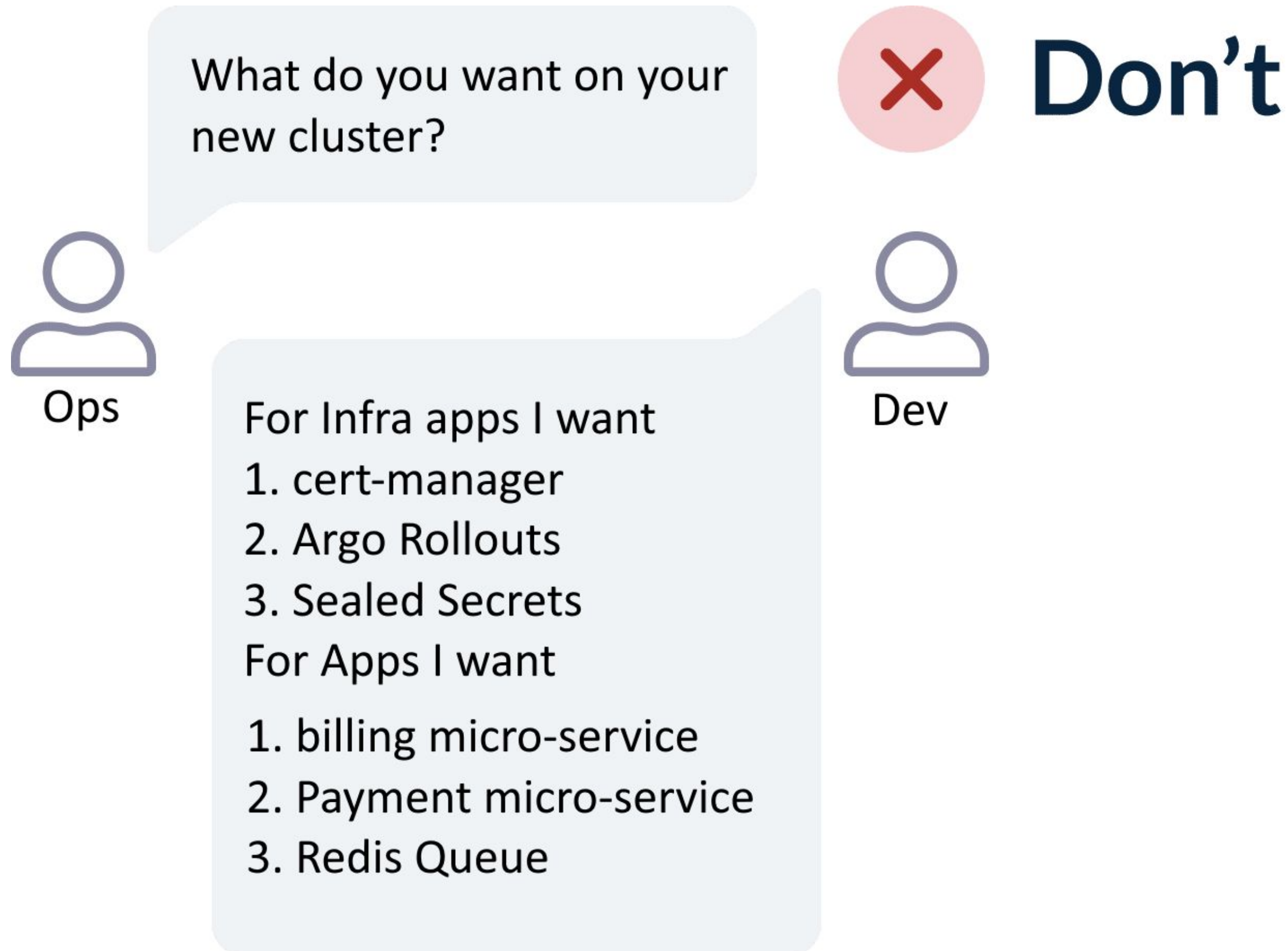
New Cluster bootstrapping

1. Create cluster with Terraform/Pulumi/Crossplane etc.
2. Assign tags to cluster “This is a prod cluster in GCP”
3. Argo CD will take care of everything else

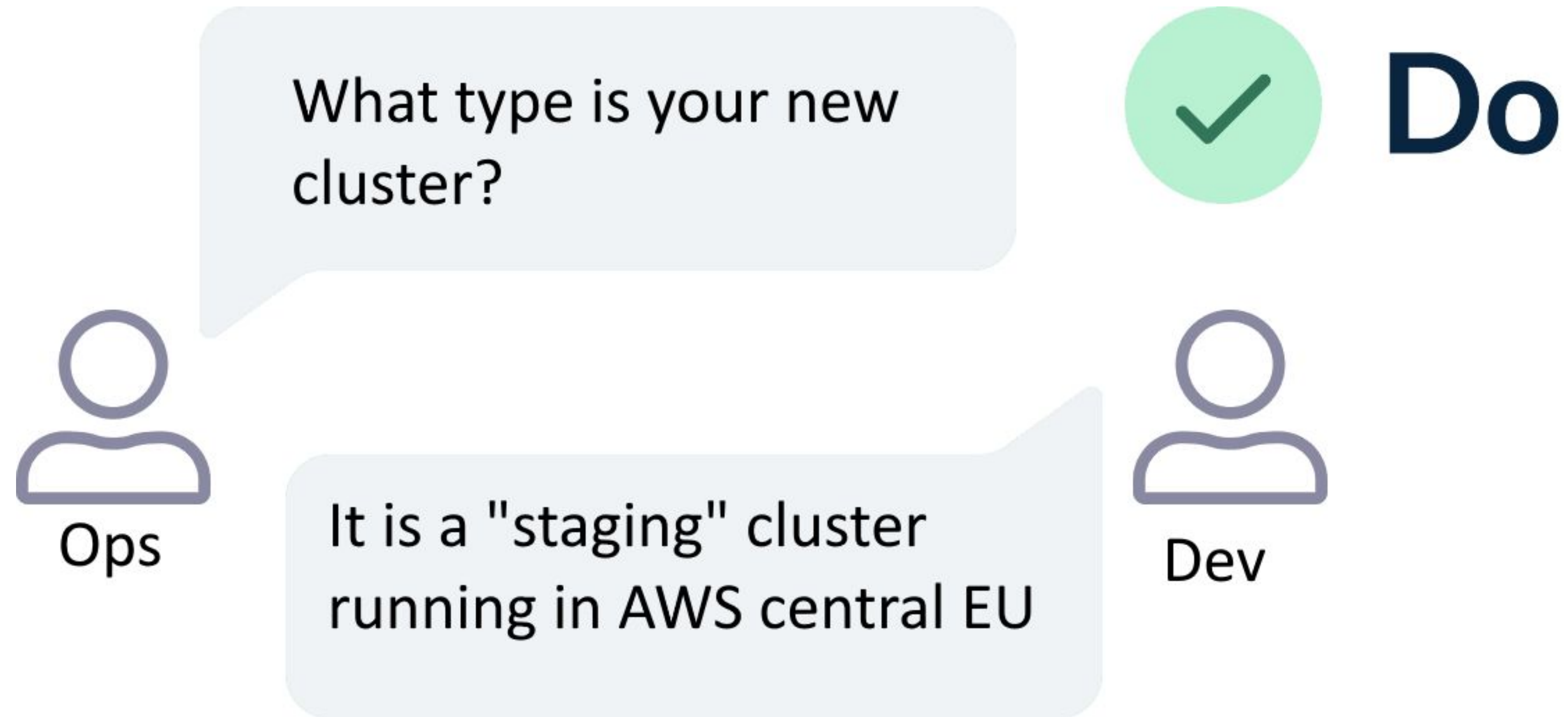
Finished



Communication with developers



Communication with developers





BEST PRACTICES

Distribute Your Argo CD Applications to Different Kubernetes Clusters Using Application Sets

23 min read



<https://codefresh.io/blog/argocd-clusters-labels-with-apps/>



Create many Application Sets

Per team/environment/cloud/department etc.



Many Apps - Many Clusters

Cluster A



Cluster B



Cluster C



AppSet

Billing App

Sealed Secrets

Argo Rollouts

Billing App

Sealed Secrets

Argo Rollouts

Cert Manager

Billing App

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Argo Rollouts

Cert Manager



Use Tags with apps



- “In all my AWS clusters I want these apps” -> Create application Set
- “In all my Prod clusters I want these apps “ -> Create Application Set
- “In all my US Region clusters I want these apps” -> Create Application Set
- “In all my Staging clusters I want these apps” -> Create Application Set





Hey. I am the new hire. Can you show me our Argo CD applications please?

 Don't

Sure.
Here is our single mega-super-duper-extra-mighty Application Set that creates all our apps.
It has 3 levels of merge/matrix generators so be careful when you change it.



What? Why not use many simpler Application Sets?

Hmm. I never thought that I could use multiple application sets. This actually makes sense and it would simplify our setup a lot.

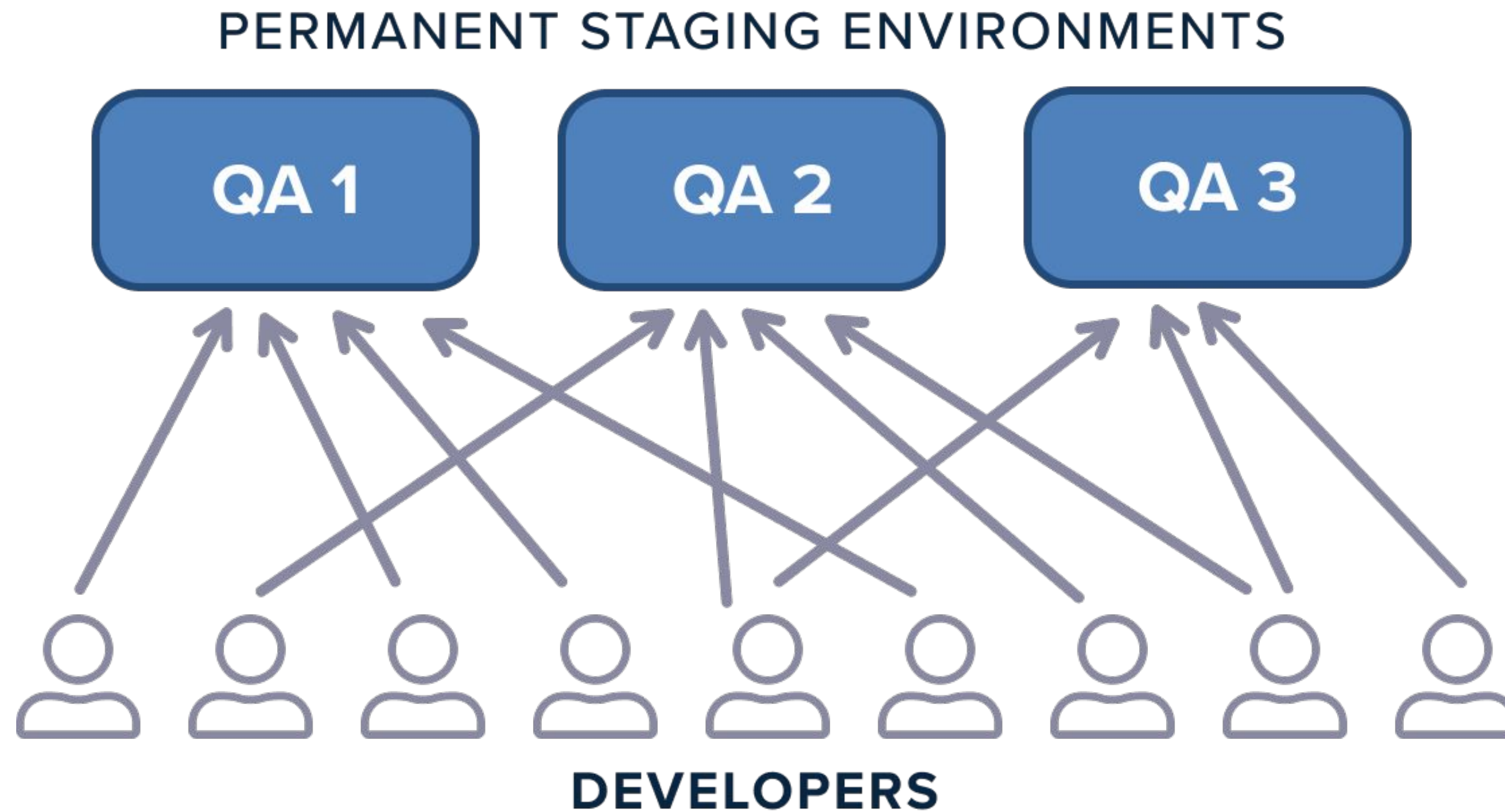


Understand the PR generator

It is perfect for preview/emphemeral/temporary environments



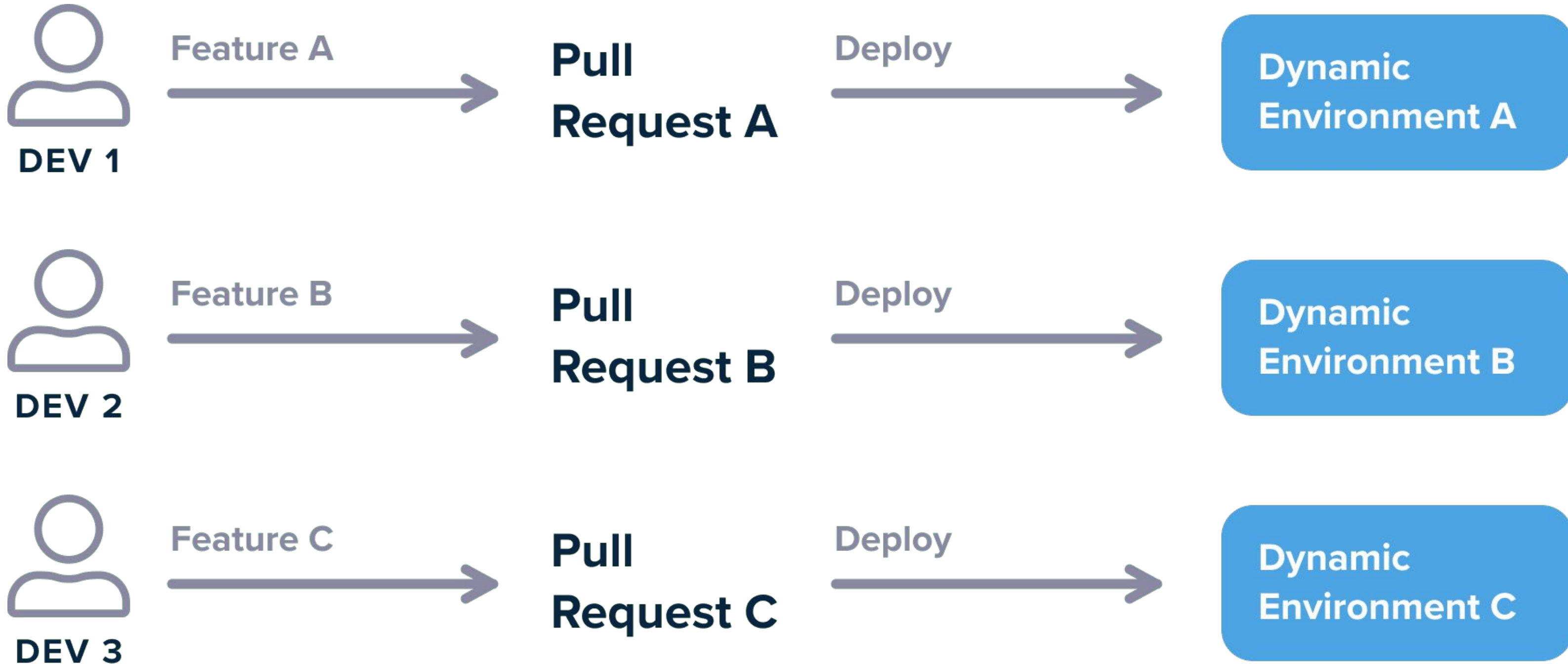
The old way



Don't



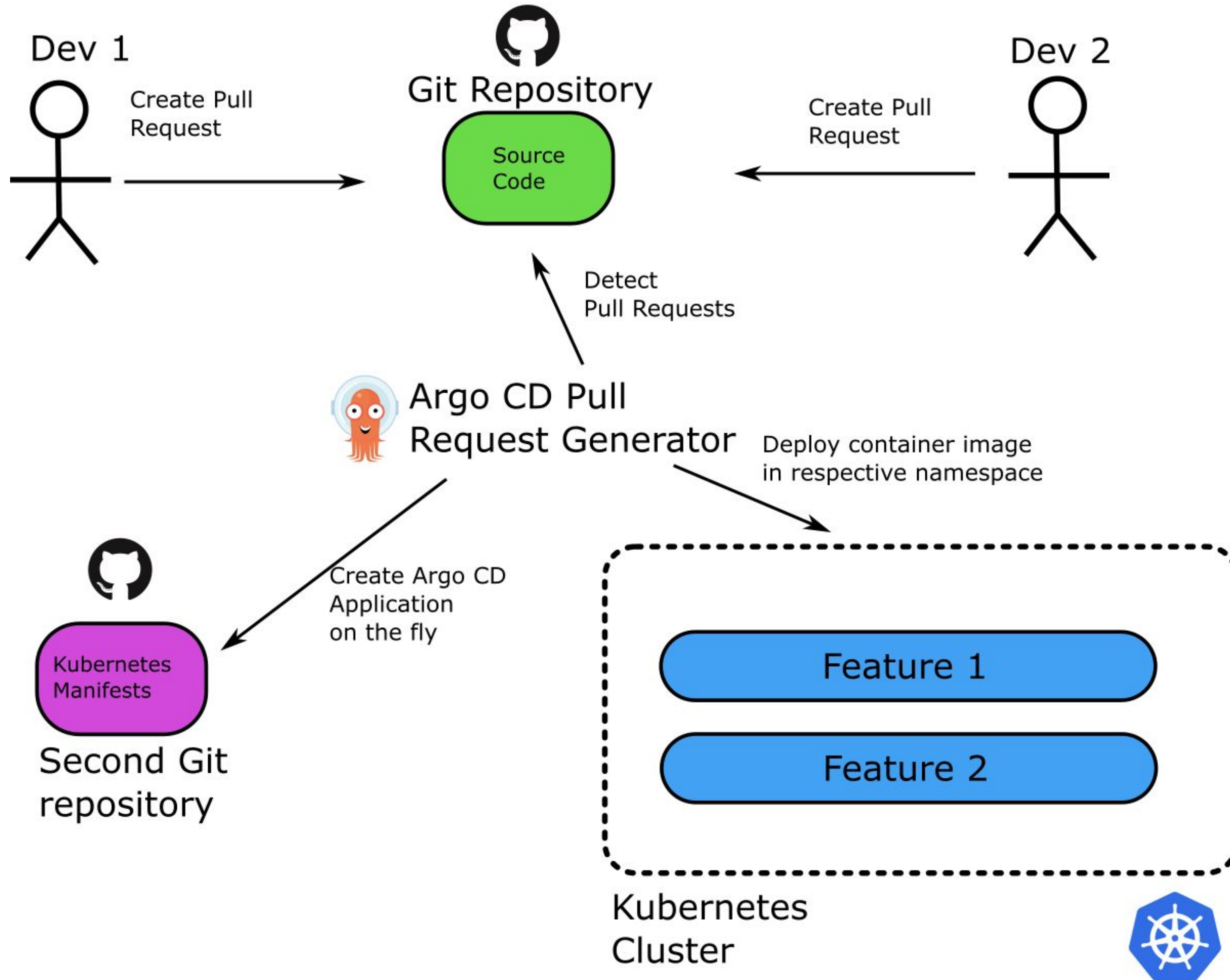
The correct way




Do


Each feature is tested on its own








Dynamic/temporary deployments

argo
v2.10.6+d504d2b

Applications

Settings

User Info

Documentation

☐ ★ Favorites Only

SYNC STATUS

☐ ⌚ Unknown 0

☒ ✓ Synced 2

☐ ⬆️ OutOfSync 0

HEALTH STATUS

☐ ? Unknown 0


☐ 🔄 Progressing 0


Applications


+ NEW APP

↻ SYNC APPS

↻ REFRESH APPS







myapp-fix-queue-size

☆

Project: default

Labels:

Status:  Healthy  Synced

Repository: https://github.com/kostis-codefresh/preview-env-....

Target Revis... HEAD

Path: kustomize-preview-app/

Destination: in-cluster

Namespace: preview-fix-queue-size


Created At: 05/15/2024 14:14:54 (13 minutes ago)

Last Sync: 05/15/2024 14:27:31 (a few seconds ago)

↻ SYNC

↻ REFRESH



✖ DELETE

myapp-my-billing-feature

☆

Project: default

Labels:

Status:  Healthy  Synced

Repository: https://github.com/kostis-codefresh/preview-env-...

Target Revis... HEAD

Path: kustomize-preview-app/

Destination: in-cluster

Namespace: preview-my-billing-feature

Created At: 05/15/2024 14:14:54 (13 minutes ago)

Last Sync: 05/15/2024 14:27:30 (a few seconds ago)

↻ SYNC

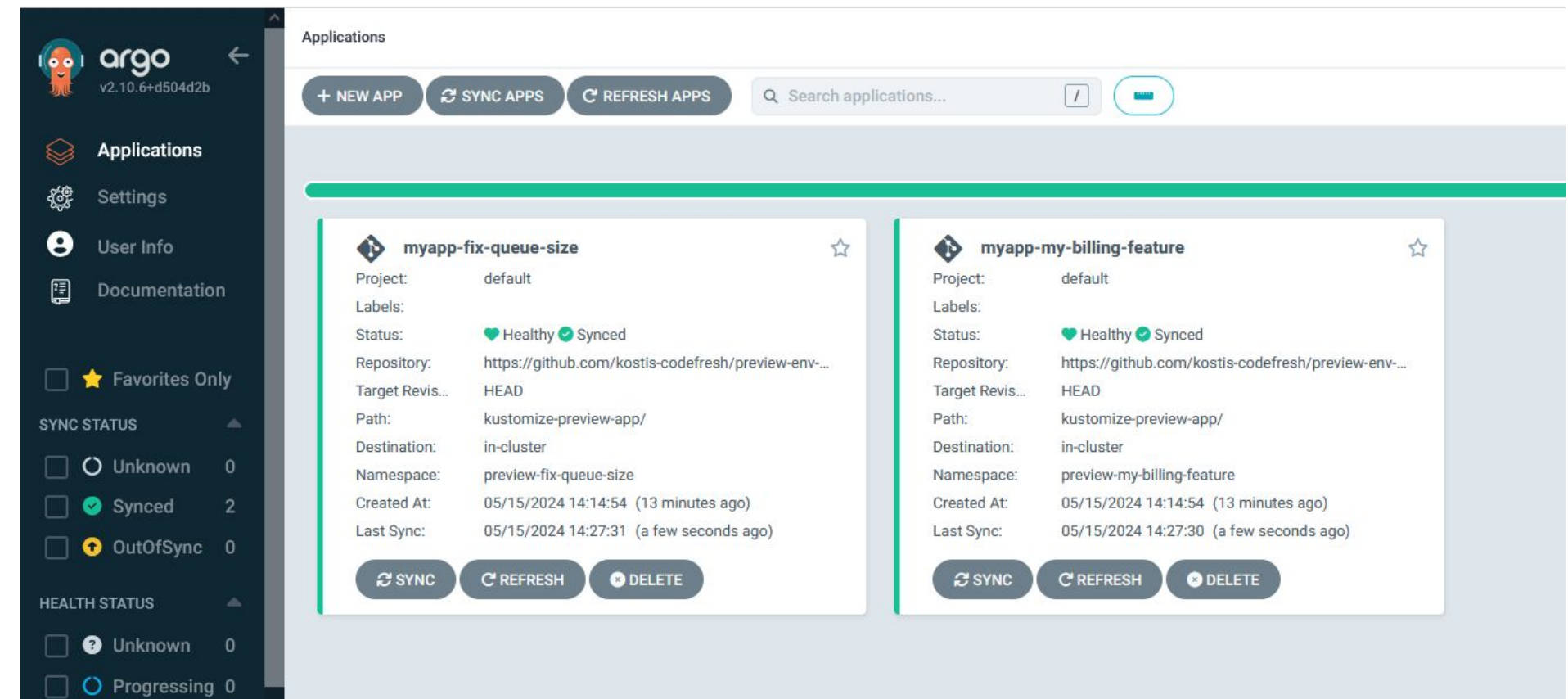
↻ REFRESH

✖ DELETE



Dynamic/temporary deployments

- Create a PR request -> Application deployed
- Close PR -> Application removed
- Merge PR -> Application removed
- Commit again -> Application updated
- Works great with vCluster





TECHNICAL GUIDES

Creating Temporary Preview Environments Based On Pull Requests With Argo CD And Codefresh

11 min read



Kostis Kapelonis May 30, 2024



<https://codefresh.io/blog/creating-temporary-preview-environments-based-pull-requests-argo-cd-codefresh/>



Conclusion

- 1 **Understand Application Sets**
- 2 **Group Application Sets with App-of-Apps files**
- 3 **Avoid the Helm sandwich**
- 4 **Employ Cluster groups with Tags**
- 5 **Create Many Application Sets**
- 6 **Use the PR Generator for preview envs**





Thank you!

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GitOps/Argo CD certification learning.octopus.com

CNCF Slack <https://slack.cncf.io/>

Blog <https://blog.argoproj.io/>

 Octopus Deploy