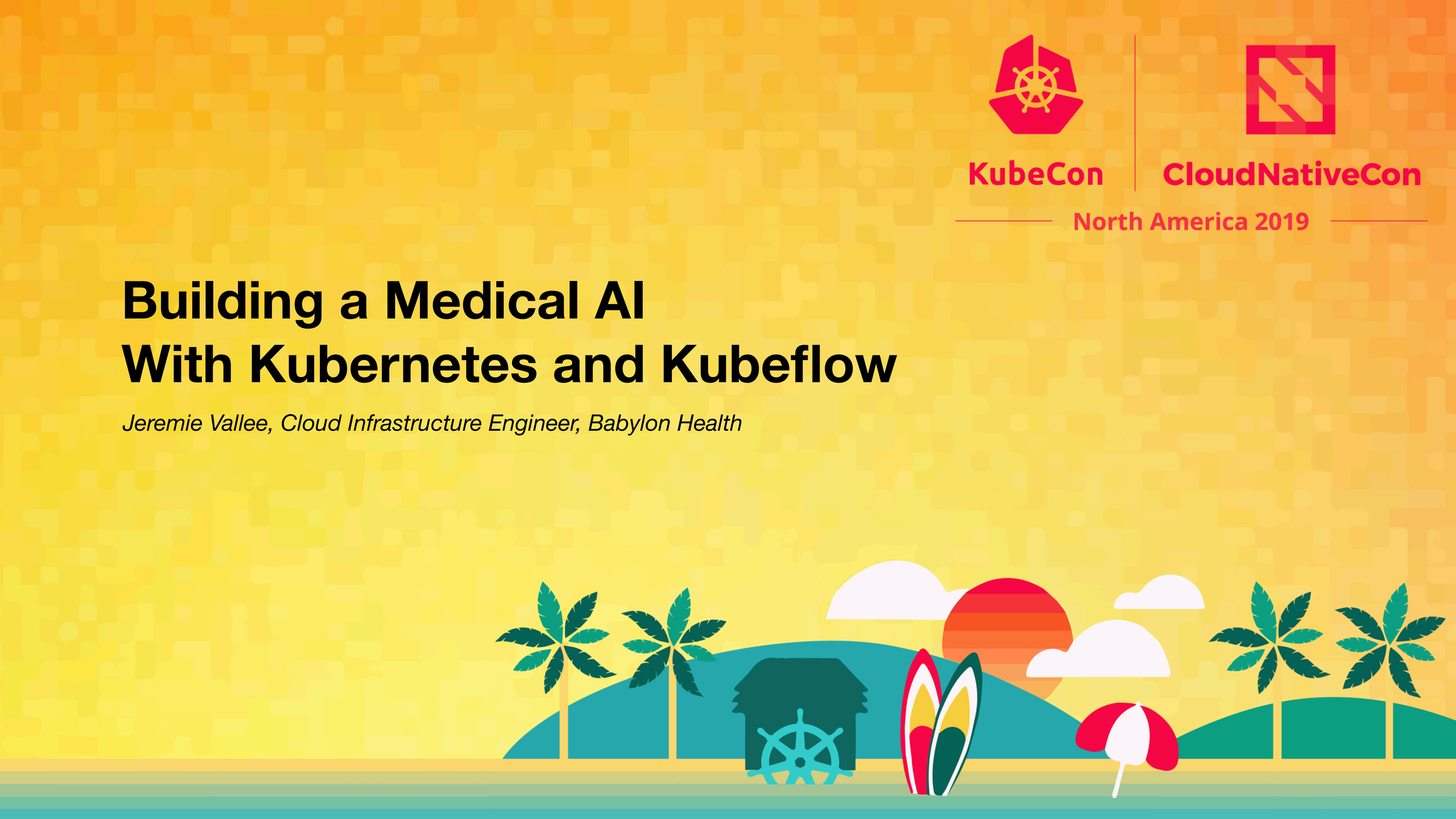
KubeCon
CloudNativeCon
North America 2019



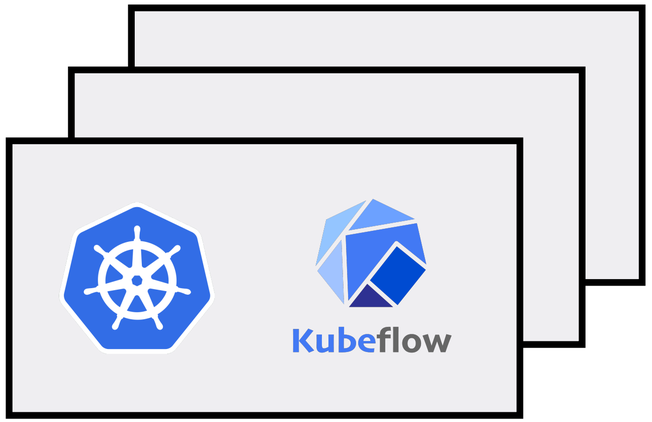
Building a Medical AI With Kubernetes and Kubeflow

Jeremie Vallee, Cloud Infrastructure Engineer, Babylon Health

From

“Hi! 👋
Is anyone running a training job
on the server? My notebook is super slow…”

To



Self-service
Multi Region
Multi Cloud

Research and Training Platform

babylon

We believe it is possible to put an **accessible** and **affordable** health service in the hands of every person on earth.

Accessibility

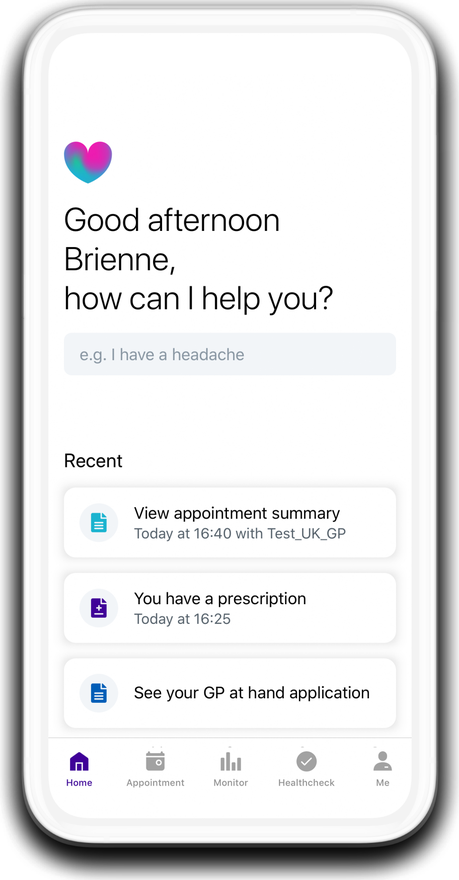
50% of the world population lacks access to essential health services, however **67% have access to mobile phones**.

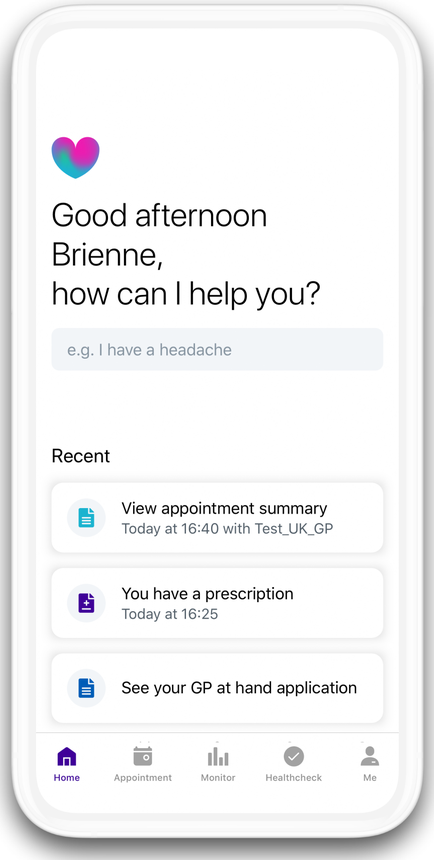
In 2014:
Digital consultation with a doctor from your mobile phone.

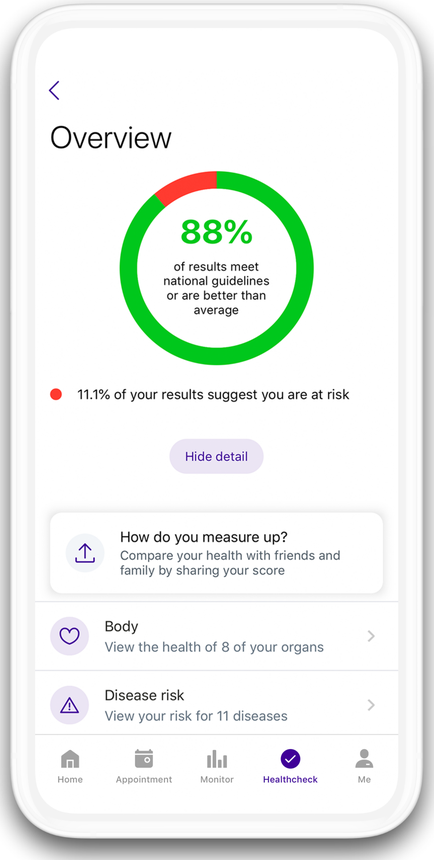
Now:
We've had 2+ million digital consultations in the world.

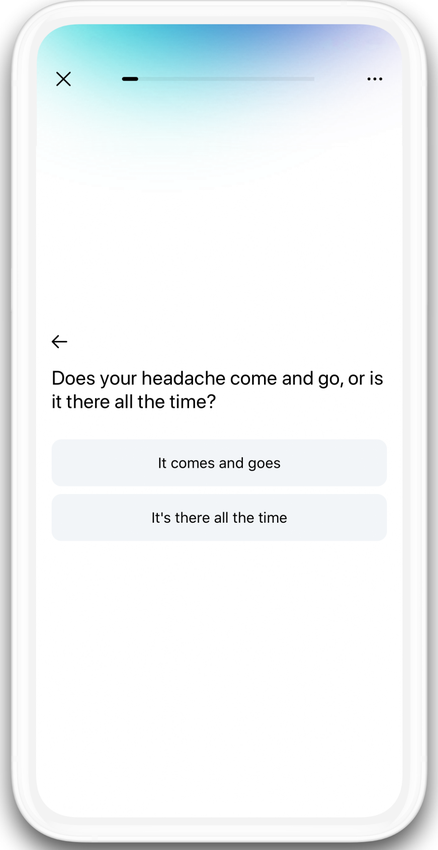
Affordability?

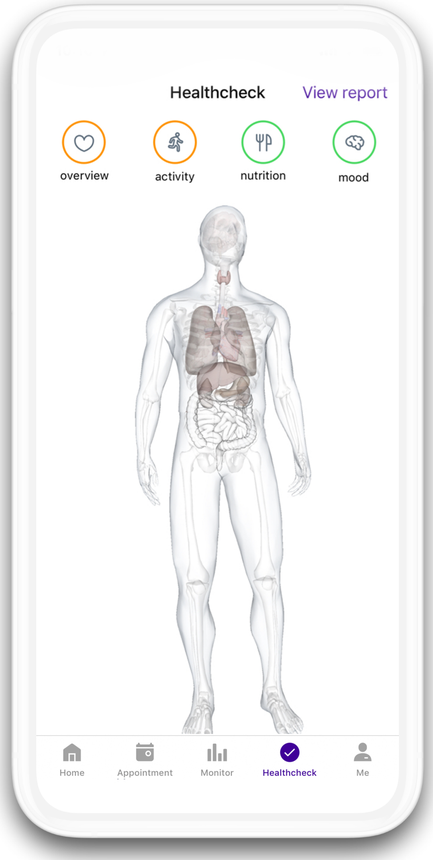
Affordability



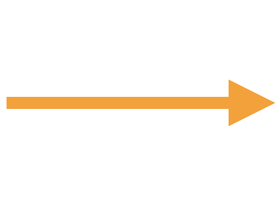

Good afternoon
Brienne,
how can I help you?
e.g. I have a headache
Recent
View appointment summary
Today at 16:40 with Test_UK_GP
You have a prescription
Today at 16:25
See your GP at hand application
Home
Appointment
Monitor
Healthcheck
Me


Overview
88%
of results meet national guidelines or are better than average
11.1% of your results suggest you are at risk
Hide detail
How do you measure up?
Compare your health with friends and family by sharing your score
Body
View the health of 8 of your organs
Disease risk
View your risk for 11 diseases
Home
Appointment
Monitor
Healthcheck
Me


Does your headache come and go, or is it there all the time?
It comes and goes
It's there all the time


Healthcheck
View report
overview
activity
nutrition
mood
Home
Appointment
Monitor
Healthcheck
Me

How it started



Graph-based
Neural Networks

Hyperparameter Tuning

On-prem server

On-prem server

❌ Not enough compute

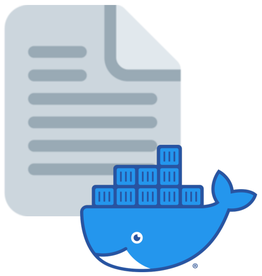
❌ Not enough orchestration

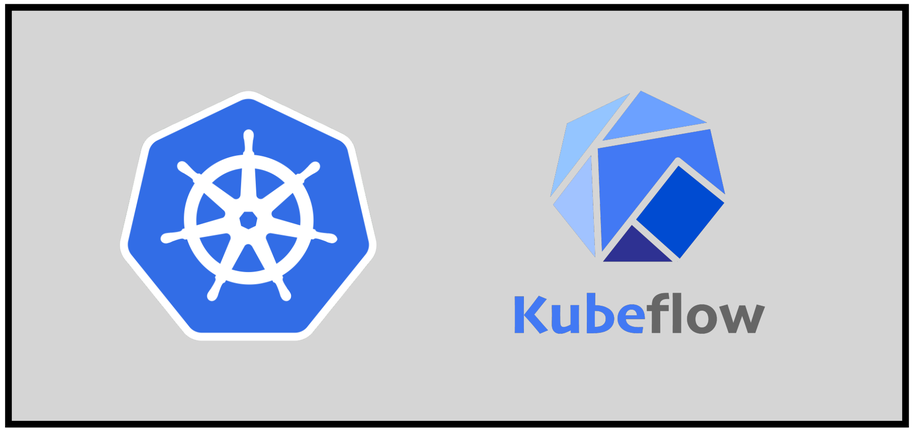
Compute

Kubeflow

HP Tuning
Orchestration

Hyperparameter Tuning with Katib





1600 CPU

3.2TB RAM

Challenges & motivation

Growing company

Increasing need for | compute access
AI Research & Engineering tooling

Global footprint

Let's talk about:

Kubernetes Infrastructure

Cluster Bootstrapping

Networking

Project Isolation

Kubeflow

Monitoring

Multi Cluster

Use cases

Next steps

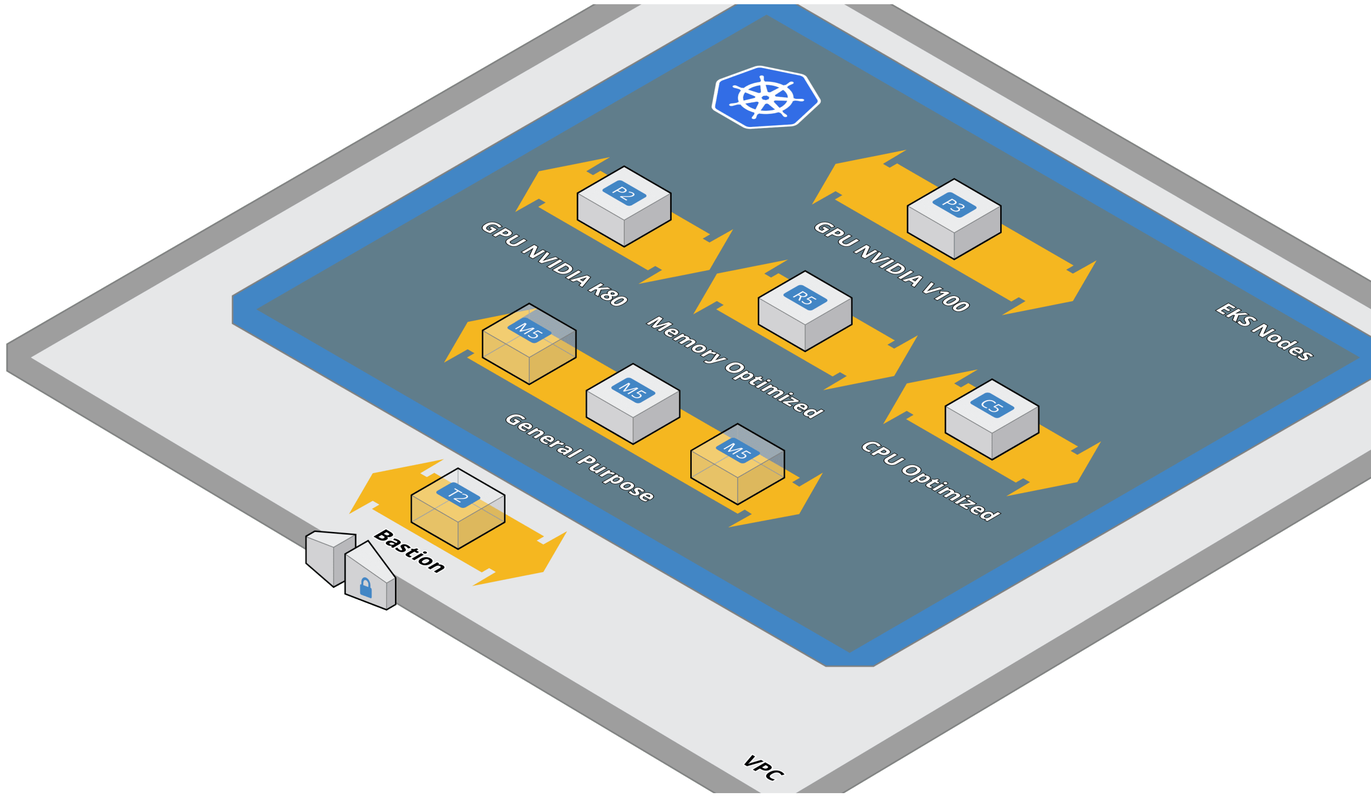
Kubernetes Infrastructure

Prepare for different workload types

Harden your nodes

Make Kubernetes API private

Encrypt your nodes (root volumes + others)

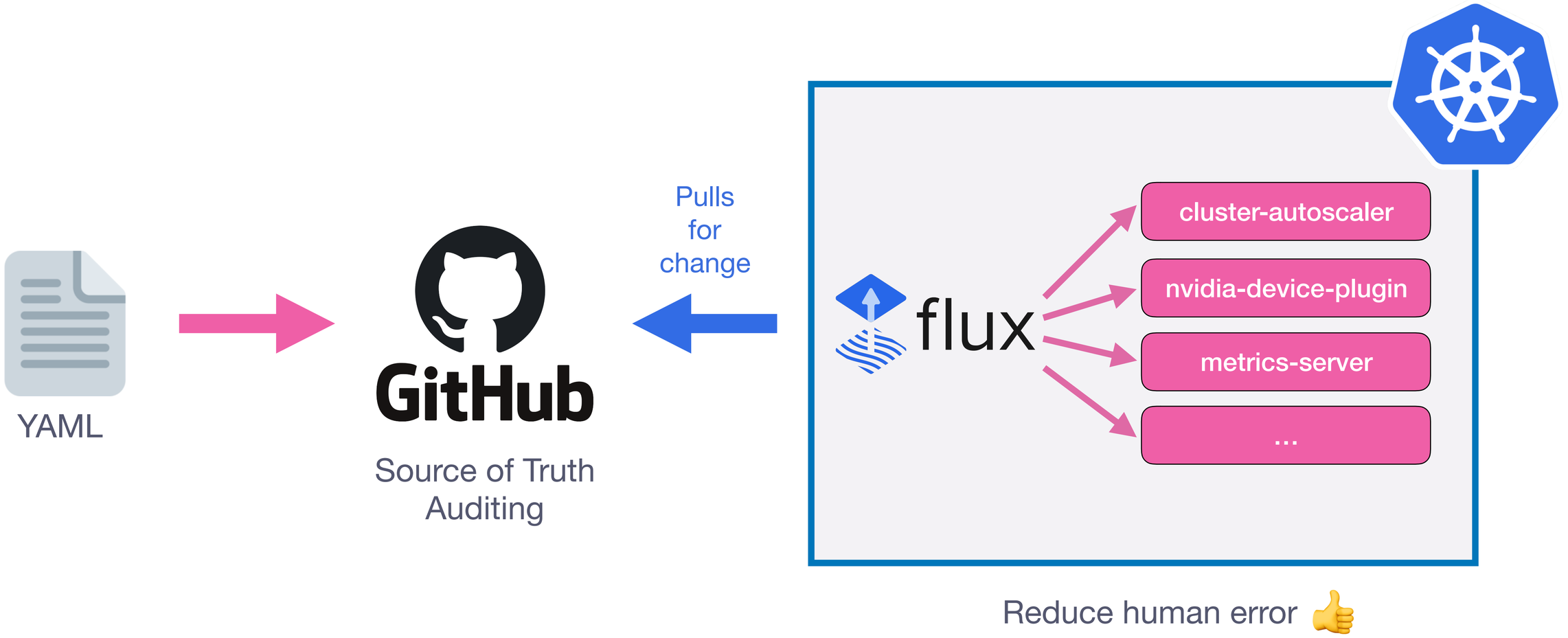


HashiCorp Terraform

HashiCorp Packer

HashiCorp Vault

GitOps Bootstrapping



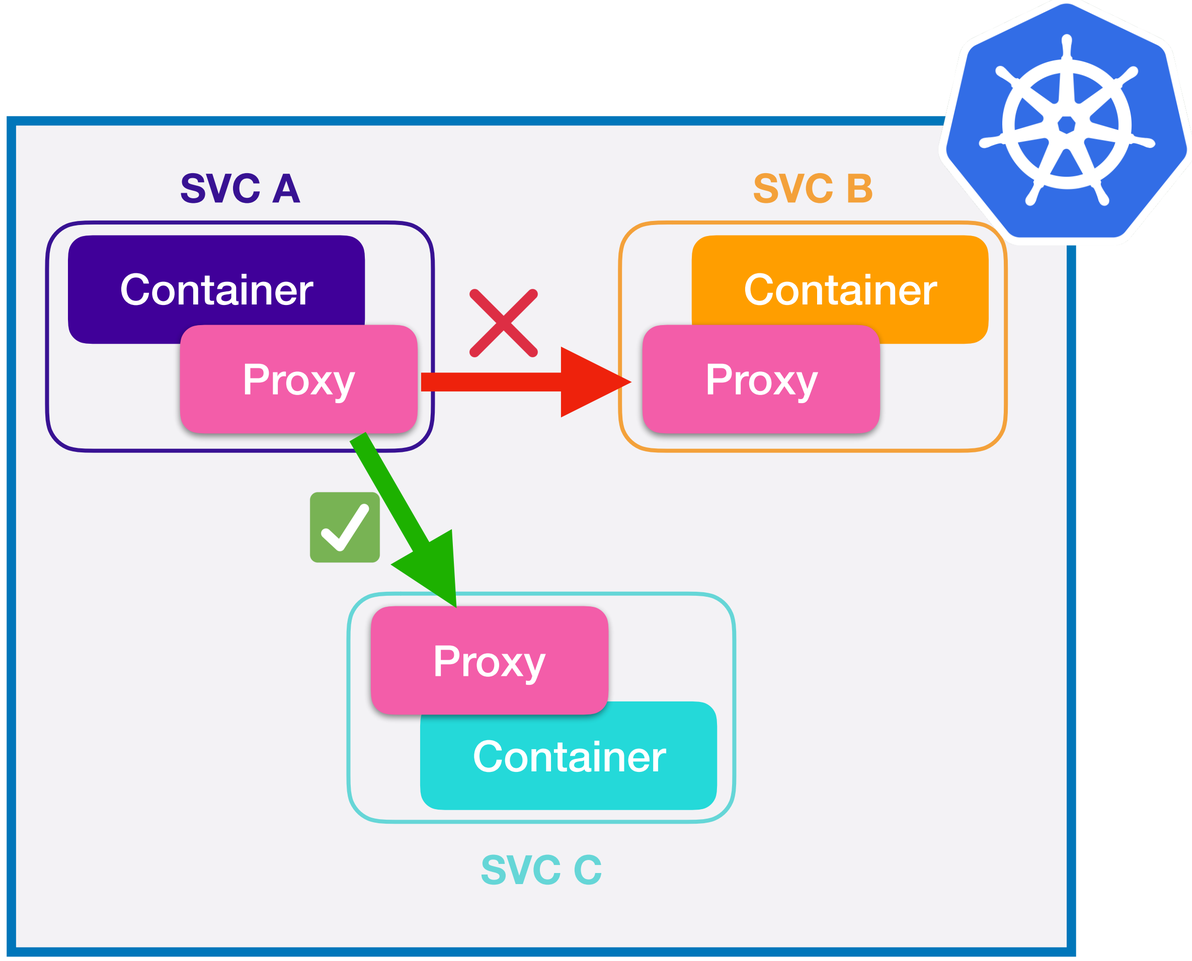
Reduce human error 👍

Networking


```yaml
apiVersion: rbac.istio.io/v1alpha1
kind: ServiceRole
metadata:
  name: c-access-role
  namespace: default
spec:
  rules:
  - methods:
    - '*'
    paths:
    - '*'
    services:
    - c.default.svc.cluster.local
```

```yaml
apiVersion: rbac.istio.io/v1alpha1
kind: ServiceRoleBinding
metadata:
  name: bind-a-to-c
  namespace: default
spec:
  roleRef:
    kind: ServiceRole
    name: c-access-role
  subjects:
  - user: cluster.local/ns/default/sa/a
```

Istio



Zero-trust policy

Mutual TLS

JWT check

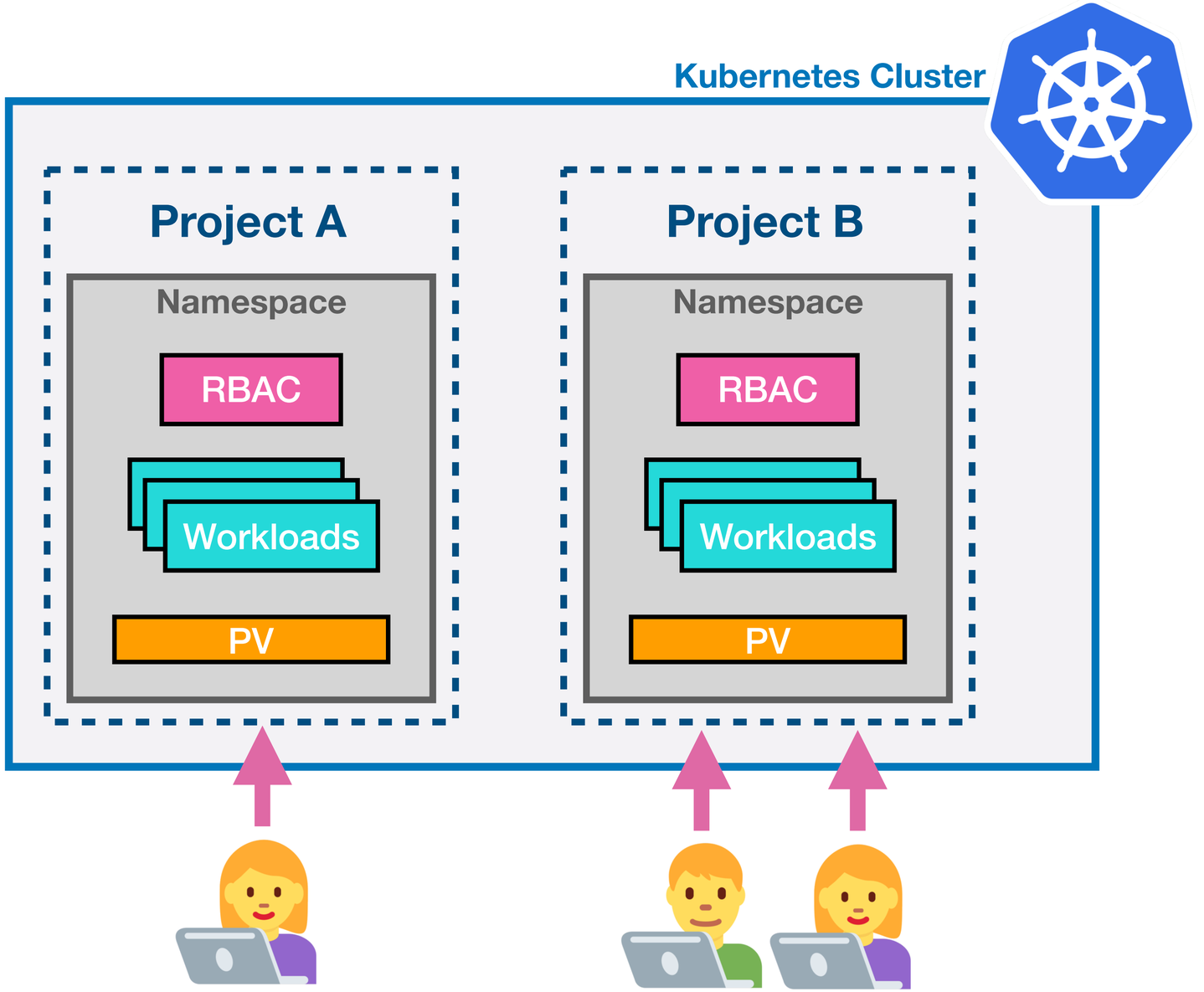
Project Custom Resource

Goal:

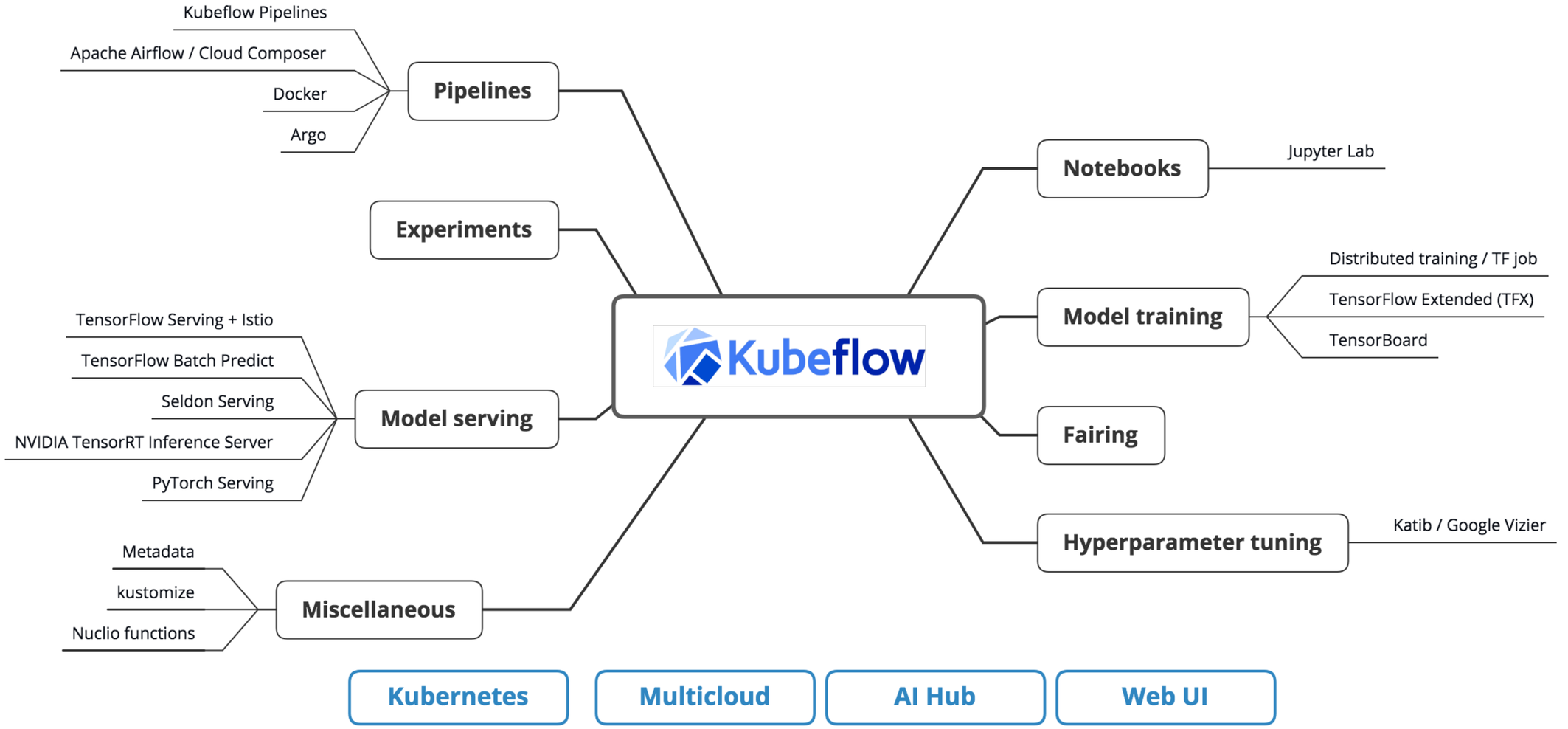
- Isolate workloads
- Enable collaboration (multi-user)
- Provide shared volume per project
- Additional business logic and metadata

Solution:

- "*Project*" CRD and controller
- Integration with Kubeflow "*Profile*" CRD



Kubeflow

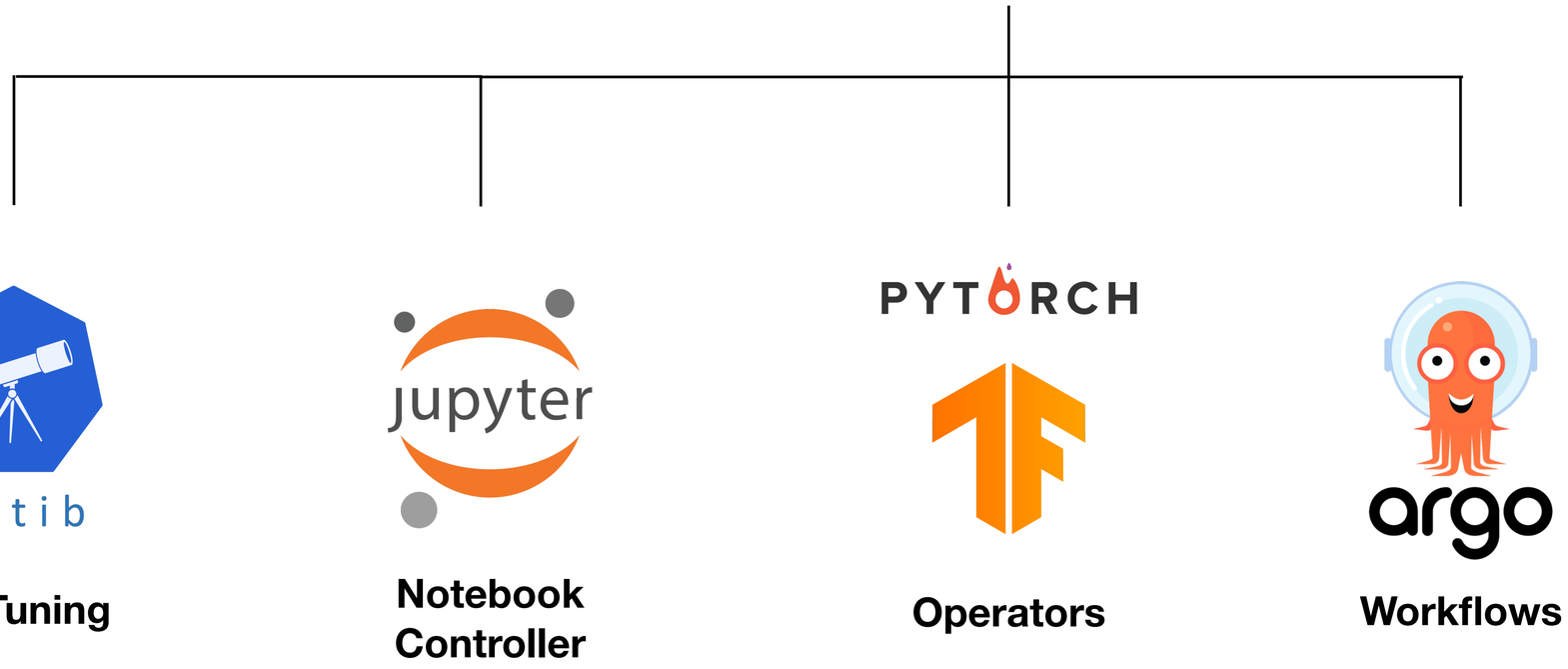


Version 1.1 20190807 @MichalBrys

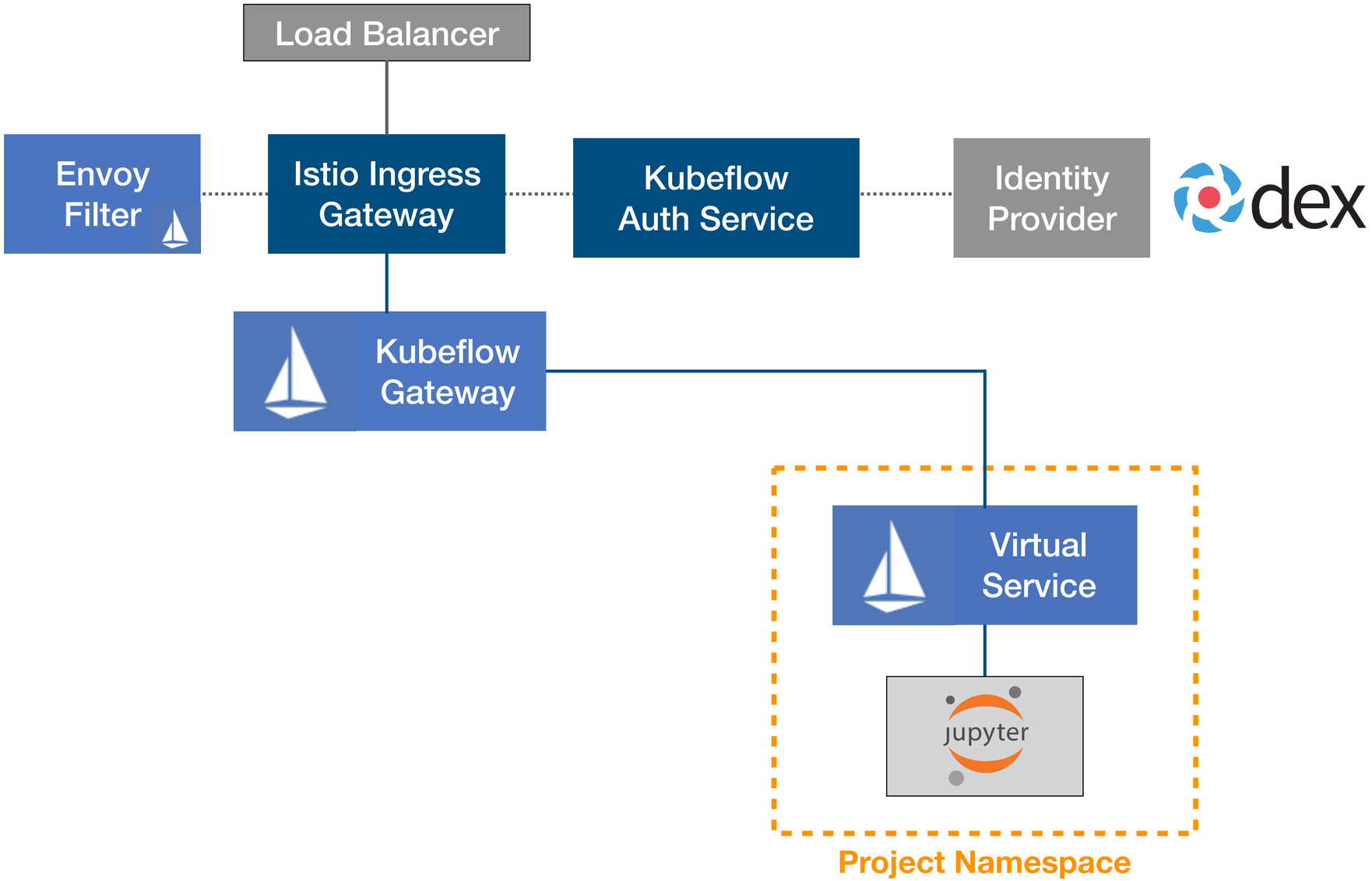
Kubeflow

Modular: install what you need

Deployment: GitOps (Kustomize + Flux)



Kubeflow + Istio + AuthN

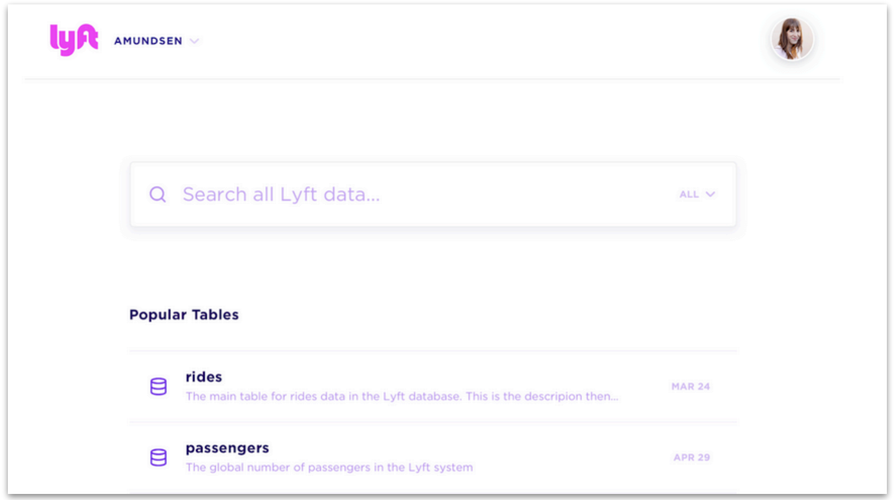


Data and Secrets

Data

Control access to data via an auditable layer

Allow for data discoverability (with tools like ***Amundsen***)



Amundsen
https://github.com/lyft/amundsen

Secrets

Use a secret manager

Pods can authenticate to Vault and get secrets loaded in memory

HashiCorp Vault

Monitoring

Goal:

- Monitor projects for users
- Monitor cluster for MLOps
- Collect any metrics from jobs
- Automated dashboards

Prometheus

Grafana

Lessons learned:

- Grafana Dashboards as *ConfigMaps*
- Allow users to submit dashboards via *GitOps*
- Multiple K8s clusters? Use Federation feature
- Need to scale up prometheus storage? Use *Thanos*

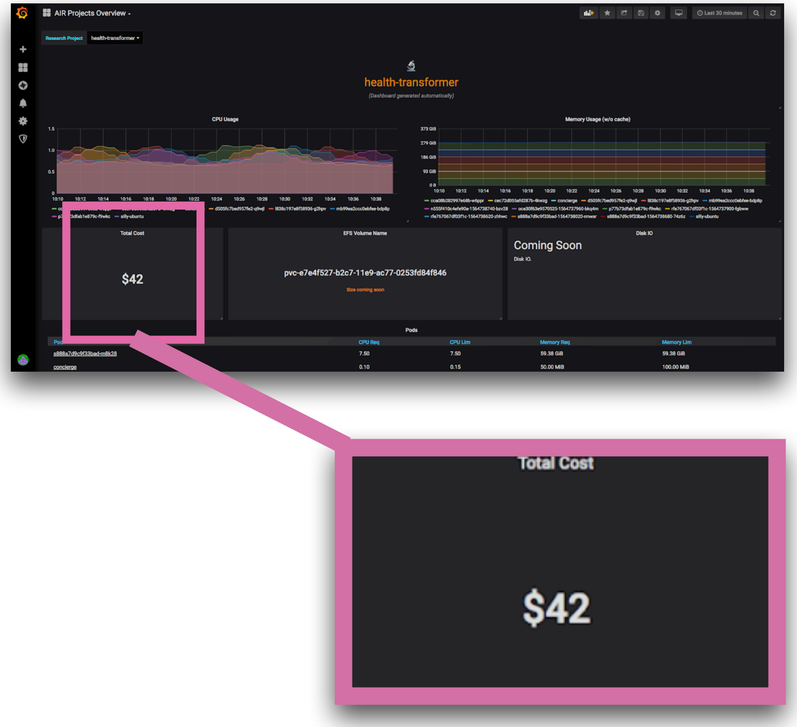
Monitoring cost

Keeping track of cost in a cloud environment is vital especially in AI/ML

Many proprietary options…

One of them open-sourced their cost model engine:

kubecost github.com/kubecost/cost-model



Babylon:

Self-service access to ML Toolkit

CLI-based interface

Monitoring

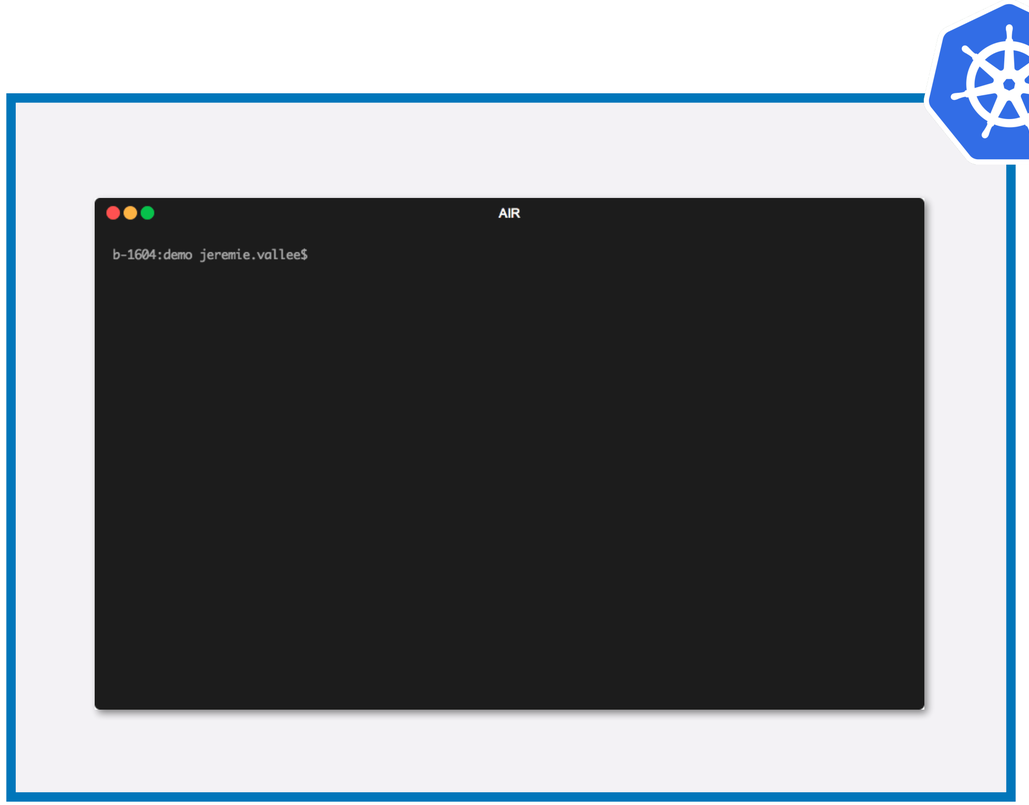
On-demand compute

Network RBAC, mTLS

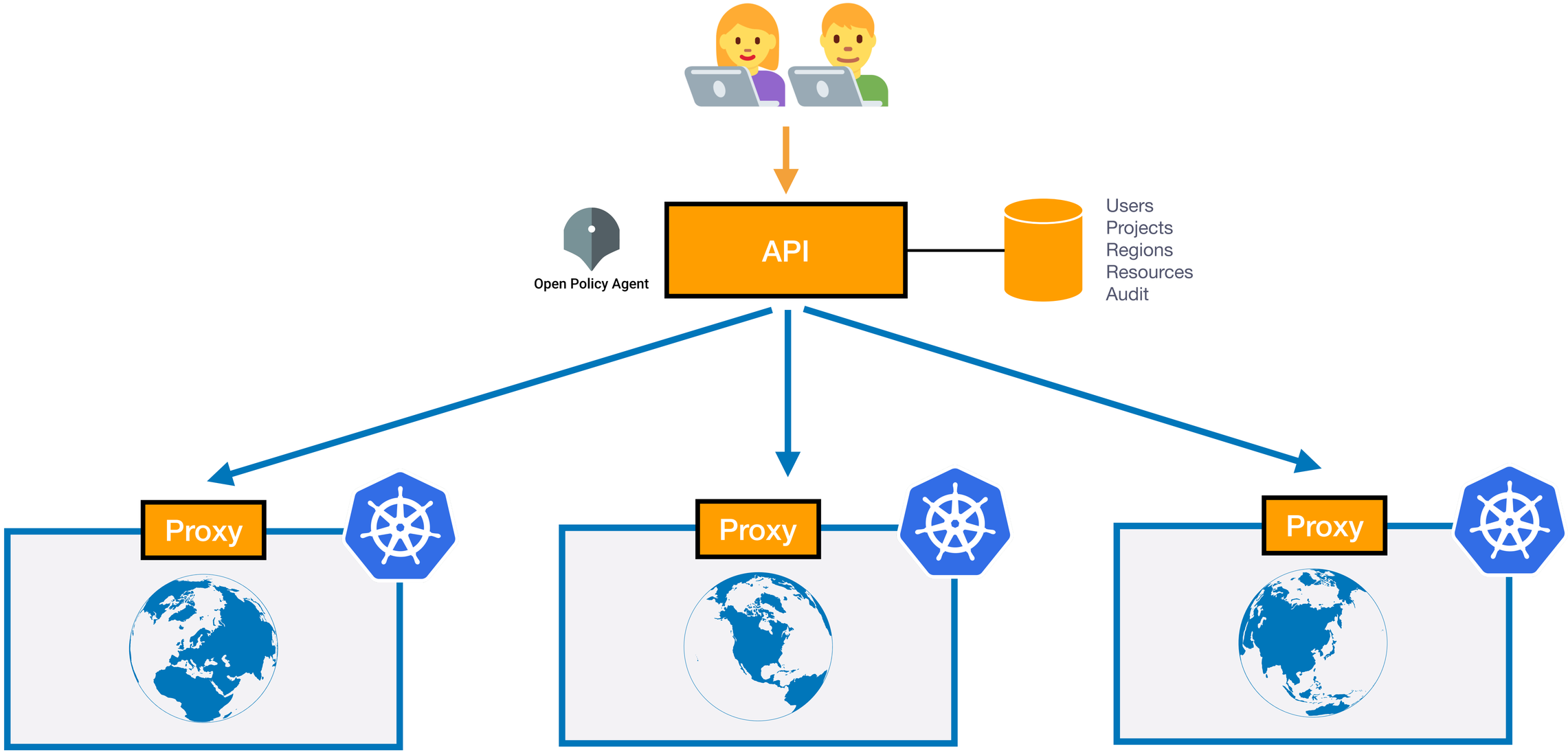
Single cluster

Slow on-boarding (GitOps)

Complex Kubernetes objects



Global platform



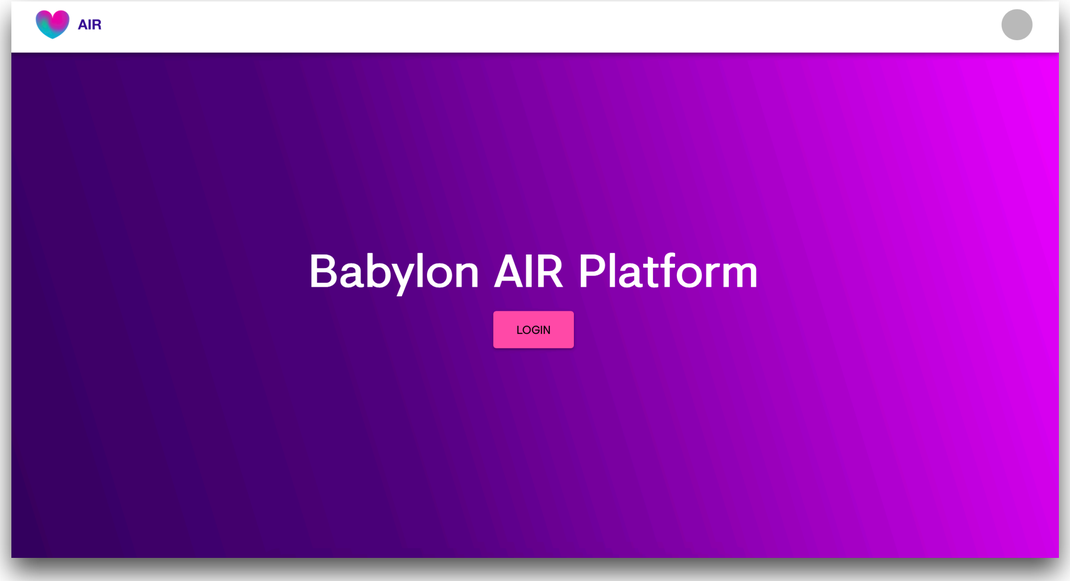
Simplifying resources

```
{
  "kind": "pod",
  "name": "simple-gpu-example",
  "image": "nvidia/cuda:8.0-cudnn5-runtime",
  "command": ["python"],
  "args": ["script.py"],
  "resources": "gpu_medium"
}
```

API

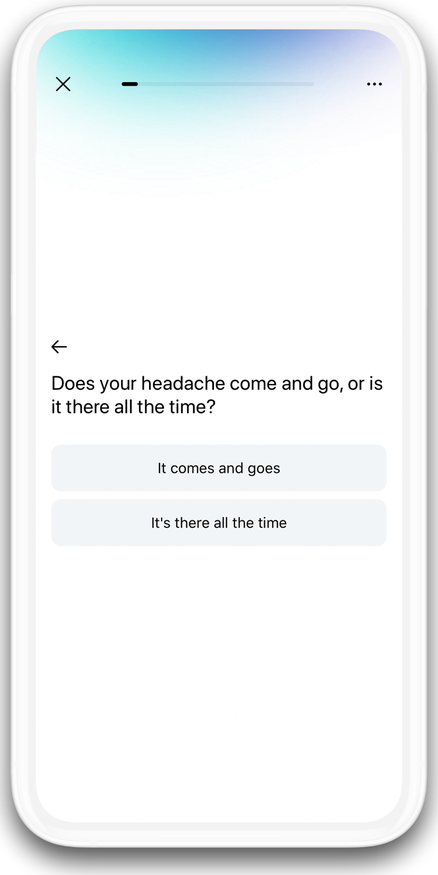
```
---
apiVersion: v1
kind: Pod
metadata:
  name: simple-gpu-example
  namespace: my-project
spec:
  containers:
  - image: nvidia/cuda:8.0-cudnn5-runtime
    command: [ "python" ]
    args: [ "script.py" ]
    name: simple-gpu-example
    resources:
      limits:
        memory: "16Gi"
        cpu: "8000m"
        nvidia.com/gpu: 1
    name: "tensorflow"
    volumeMounts:
    - mountPath: /mnt
      name: efs-storage
  restartPolicy: "OnFailure"
  volumes:
  - name: efs-storage
    persistentVolumeClaim:
      claimName: efs
  imagePullSecrets:
    - name: my-deploy-pull-secret
  tolerations:
  - key: "nvidia.com/gpu"
    operator: "Equal"
    value: "true"
    effect: "NoSchedule"
  nodeSelector:
    accelerator: nvidia-tesla-k80
```

- Self-service access to ML Toolkit
- CLI and/or Web interface
- Monitoring
- On-demand compute
- Network RBAC, mTLS
- Multi region
- Fast on-boarding (UI or API)
- Simpler object definitions (heavy-lifting in the backend)
- Multi user



HELM · HashiCorp Terraform · HashiCorp Packer · Open Policy Agent · argo · Kubeflow · kubernetes · flux · HashiCorp Vault · Prometheus · Grafana · Istio

Use Case:
Clinical Validation of our Symptom Checker



Symptom Checker: Bayesian network

Has two jobs:

1. Get as much relevant evidence from patient as possible
2. Find most likely disease based on evidence received

$$P(D_i \mid E)$$

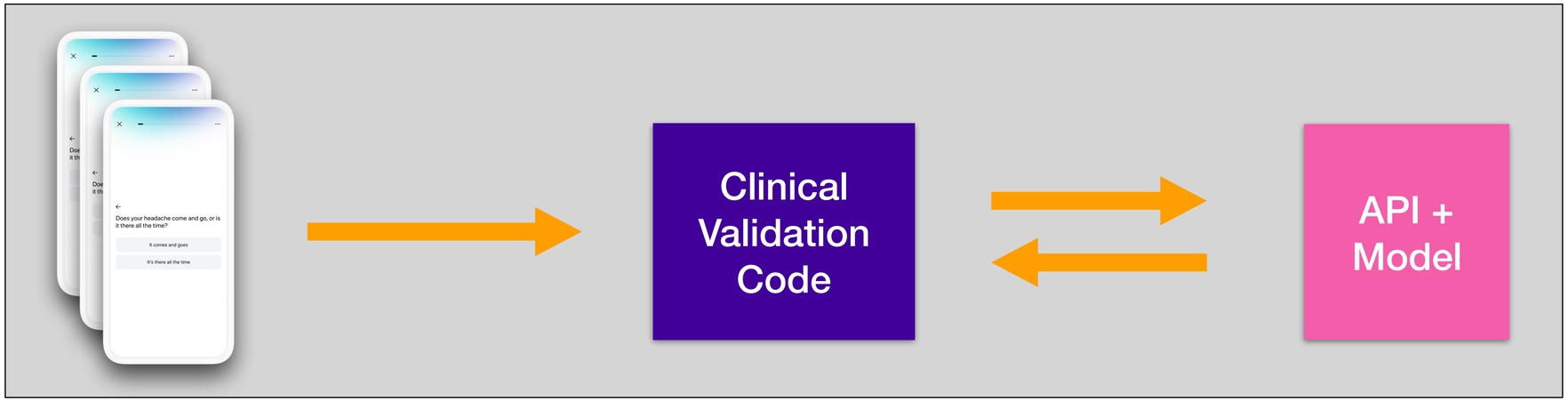
Probability of Disease given Evidence

We want to evaluate how well it performs.

Use Case:
Clinical Validation of our Symptom Checker

Clinical Validation:

- Simulating patient interaction via use cases generated by doctors
- Evaluating both questions asked by model and outcome
- Original duration: **10 hours** ***(and lots of misery)***

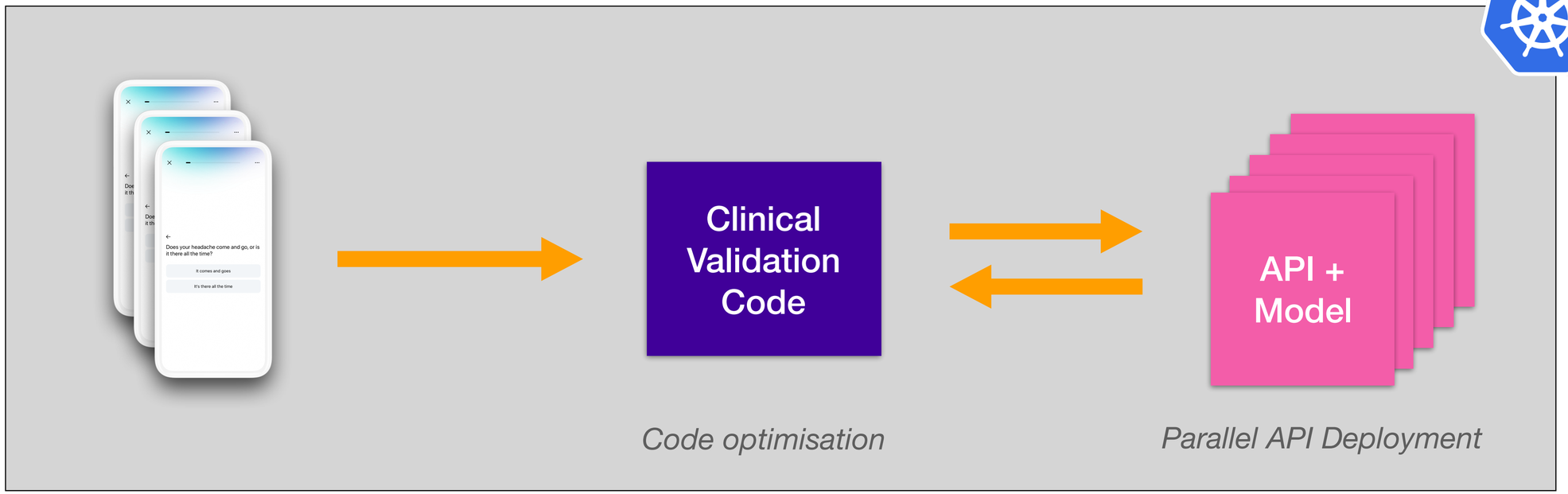


Thousands
of use cases

Managing use cases
+
Assessing results

Serving Model

Use Case:
Clinical Validation of our Symptom Checker



New duration: **< 20 minutes**
Now running on every Pull Request

Improving feedback loop → faster iterations → **increasing safety and quality of models**

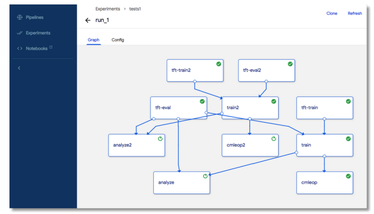
Next steps

KFServing

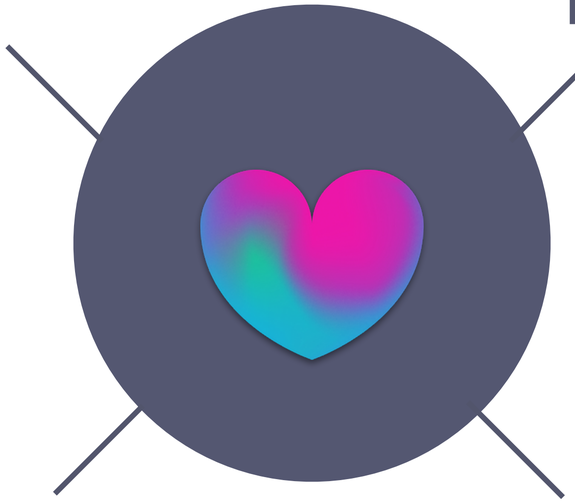
SELDON

ONNX

Better serving



Integrating Kubeflow Pipelines



Kaniko

Improving user experience

Better Metadata Tracking

mlflow

Sacred

Kubeflow Metadata

Wrapping up

Kubeflow:

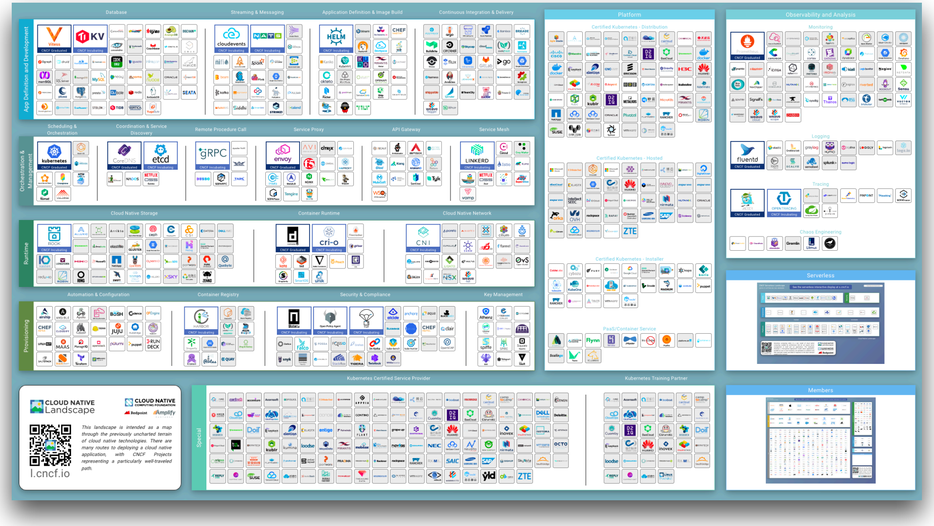
- Most complete ML toolkit for Kubernetes
- Great modularity
- Easy to get started

Security and compliance on K8s:

- Many open-source tools out there can help
- Have a look at the Cloud Native landscape and start from there

MLOps:

- Enabling AI/ML teams with tooling and infrastructure
- Always ask: *what are the big pain points for your AI/ML teams?*
- Focus on 1 pain point, build proof-of-concept, then add as feature



https://landscape.cncf.io/

Thank you!

@jeremievallee

jeremie-vallee

*We're hiring in **UK** and **USA**!*

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North America 2019