CSCS
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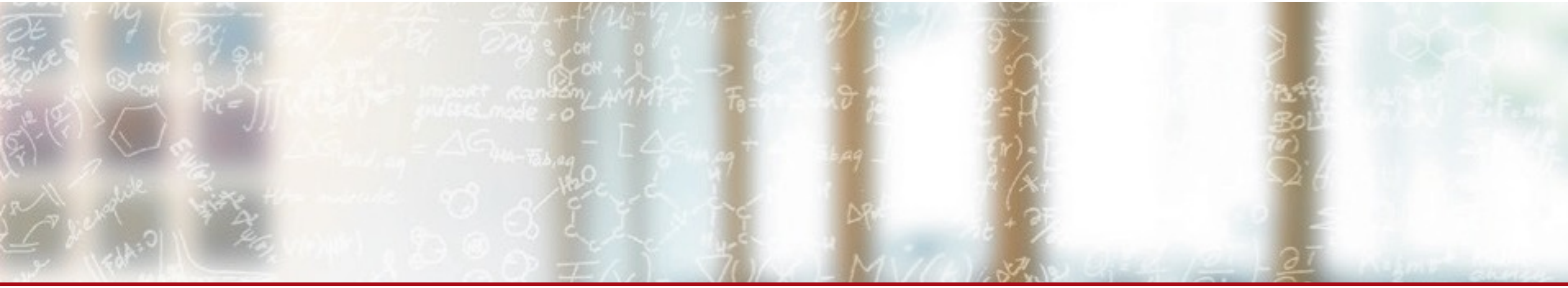

Hyper-converged cloud infrastructure at CSCS

Dino Conciatore – System Engineer
Elia Oggian – System Engineer

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Background

- Operating a **multi-tenant Kubernetes** cluster can be very complex
  - Based on past experience with *fulen*, a multi-tenant cluster with multiple VLANs and users with varying requirements and workflows

- Improvements were necessary to ensure a **greater user experience**

- **Simplify the deployment** of CSCS internal services

- **Security and Isolation**:
  - network isolation should be implemented per cluster or purpose

Introducing Key Components

Introduction to Harvester

Harvester is an open-source hyperconverged infrastructure solution.

- **Kubernetes** as orchestration engine
- Based on **KVM** and **KubeVirt**, which enable virtualization and orchestration of VMs
- **Storage** management through Longhorn to provide a persistent storage
- **Networking** based on **Multus** enables isolation on multiple VLANs

Introduction to Rancher

Rancher is an open-source Kubernetes clusters manager.

- Centrally manage **multiple Kubernetes clusters**
- Simplified **provisioning and scaling** of clusters, node management, and upgrades.
- Strong **security features**, including role-based access control (RBAC), network policies and integration with identity providers to enhance security and compliance.
- Rancher has its own Kubernetes distribution called RKE2

Introduction to ArgoCD

Argo CD is an open-source continuous delivery tool specifically designed for Kubernetes that follows the GitOps methodology.

- **Application deployments** are declared using Kubernetes manifests or Helm charts stored in Git repositories.
  - Argo CD then ensures that the actual cluster state matches the desired configuration

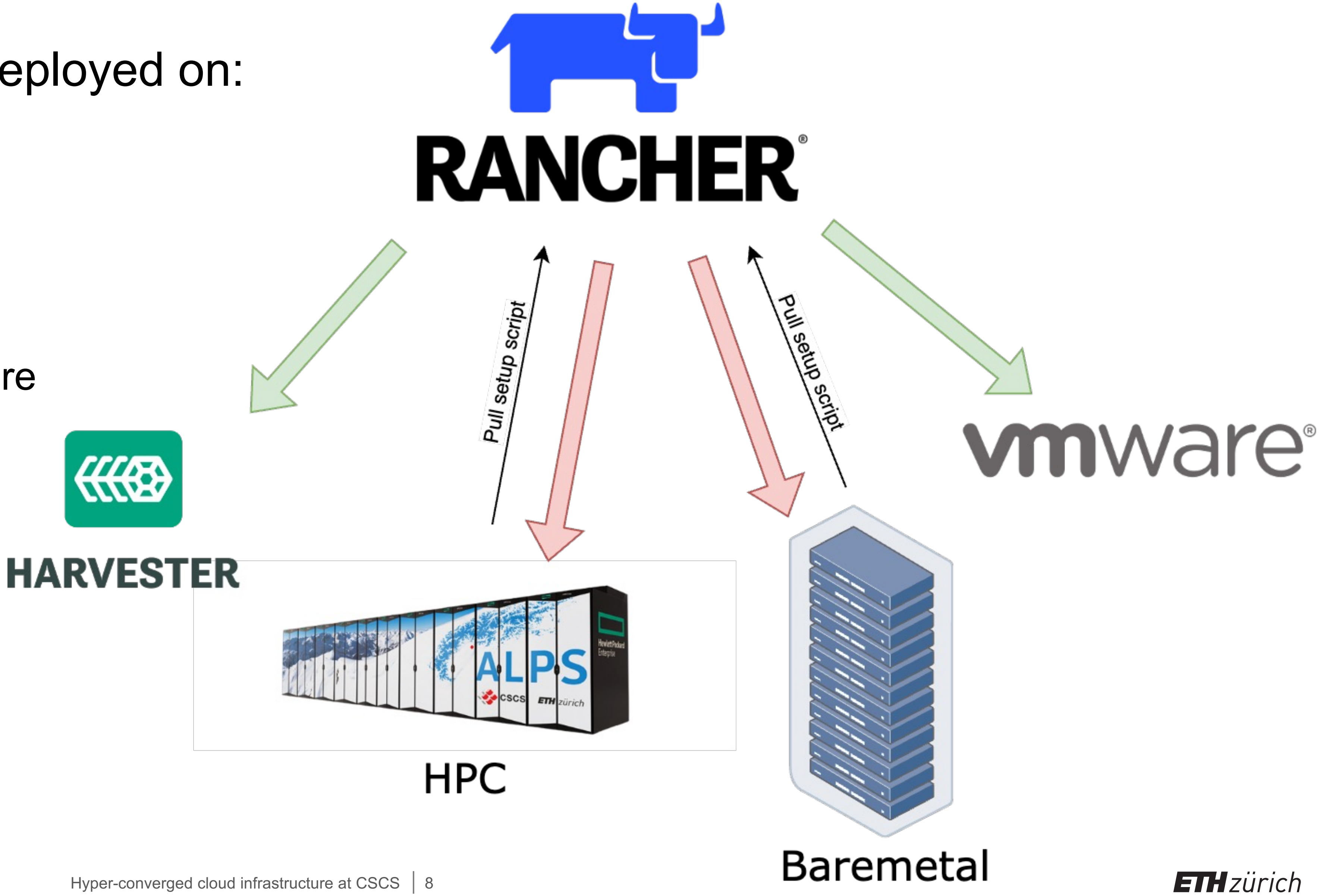
- **Graphical UI** for visualizing and managing application deployments status. Additionally, it offers a command-line interface (CLI) for scripting and automation.

Hyperconverged Cloud Infrastructure at CSCS

Where we run kubernetes

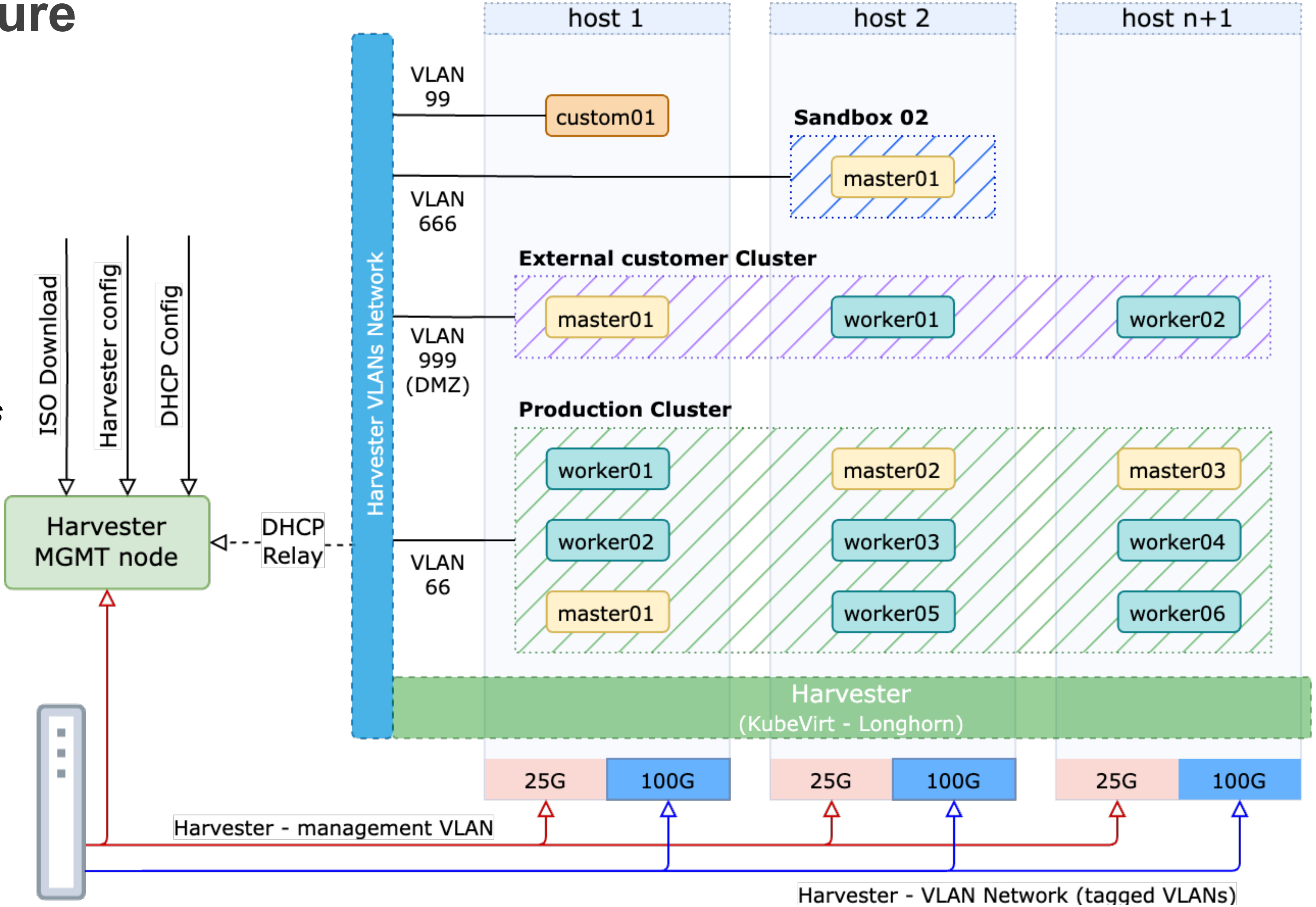
Kubernetes clusters deployed on:

- Harvester
- VMware
- Bare metal
  - Commodity Hardware
  - HPC (CSCS Alps)



Harvester architecture

- **Harvester host:**
  - Management (25G)
    - *Kubernetes overlay*
    - *VMs Live migration*
    - *Harvester StorageClass*
  - VLANs (100G)
    - *Downstream clusters*
  - Local NVMEs
  - 512G ram
  - 64 Cores
- **Management node:**
  - DHCP Relay for VMs
  - Hosts setup
    - iPXE Boot
    - ISO Repository
    - Hosts config

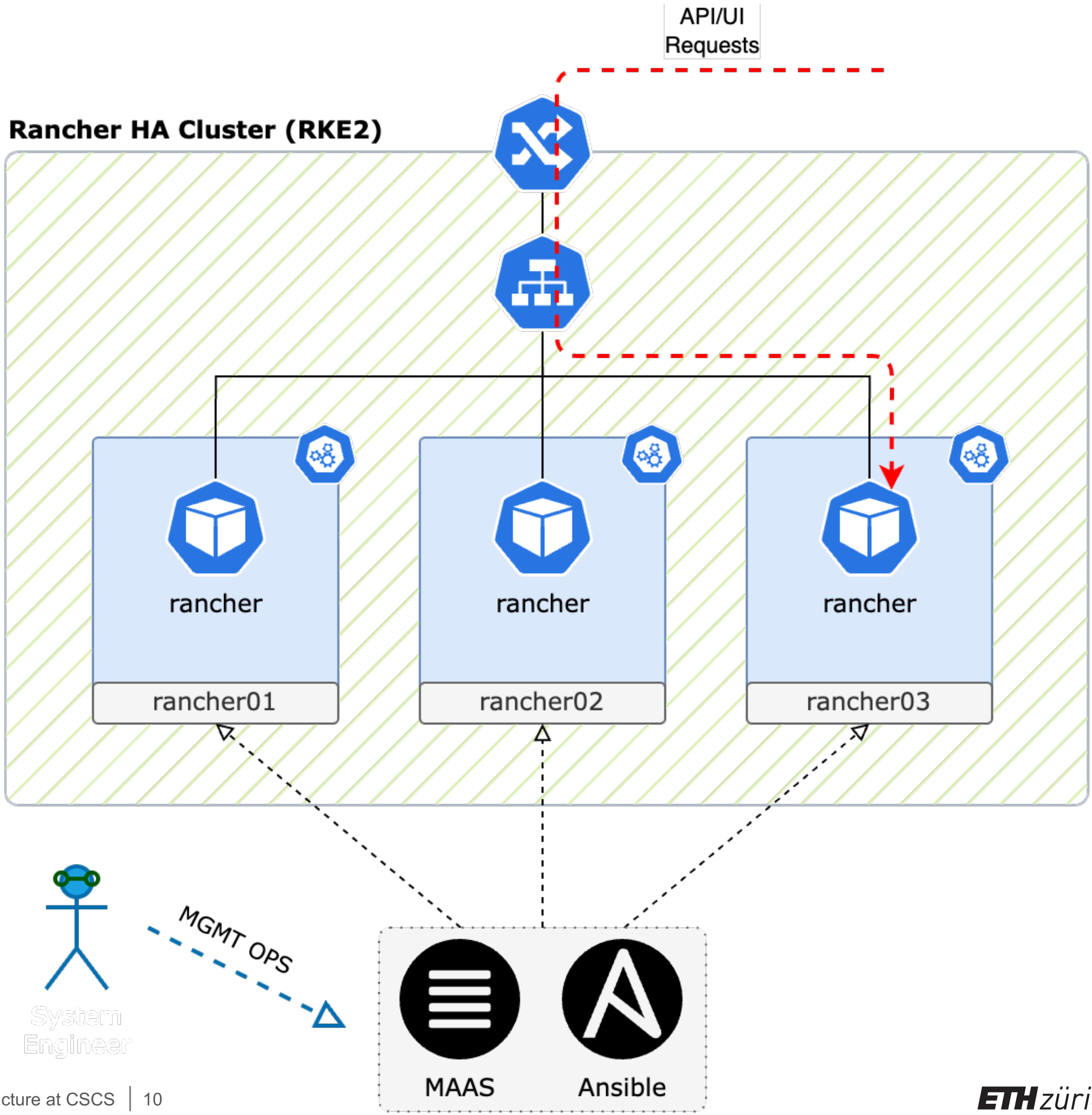


Rancher cluster architecture

- RKE2 Cluster
- 3 nodes both master and worker
- Each node is expected to have a Rancher pod
- kube-vip enables external access to the UI/API

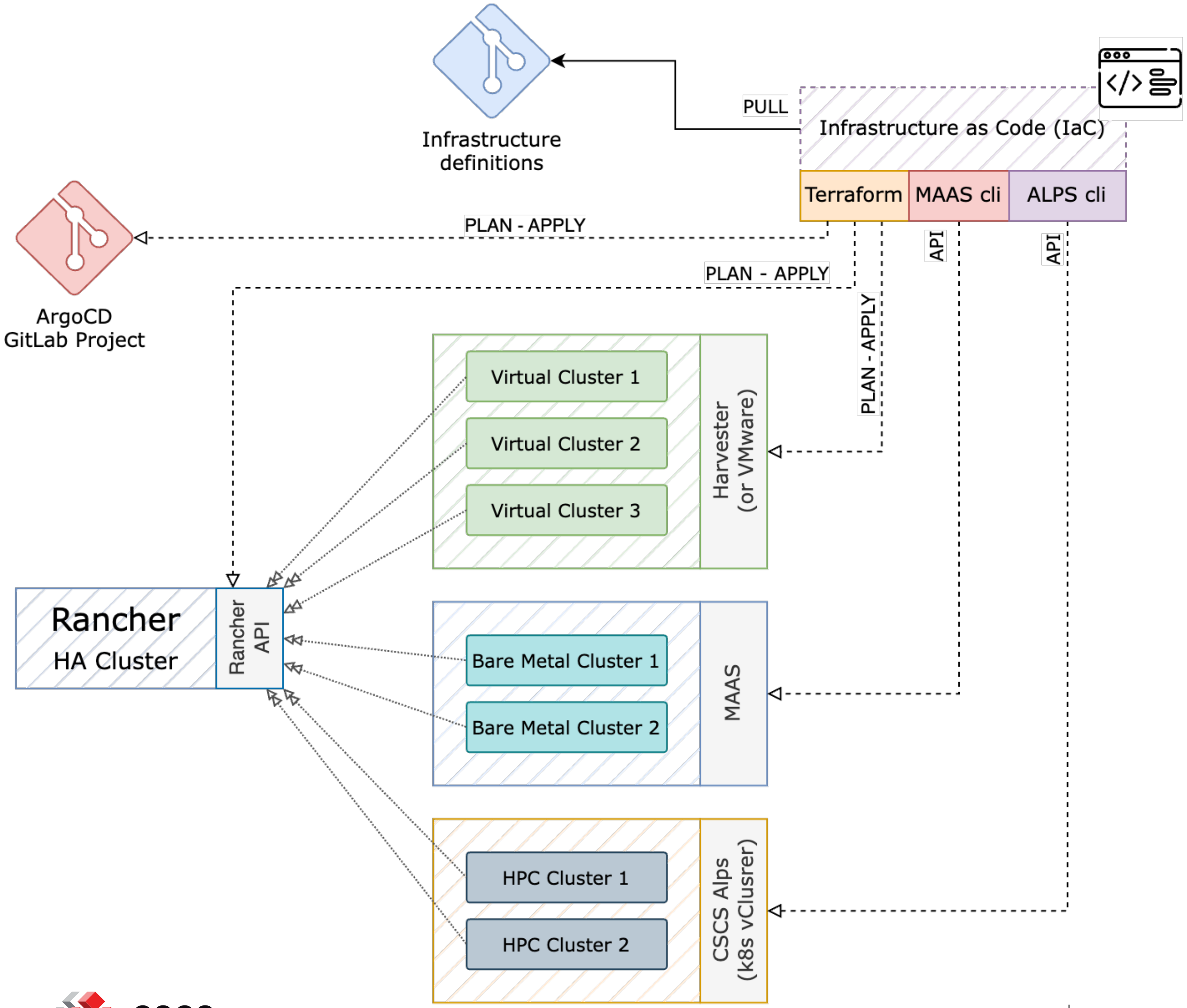
Node management:

- Node lifecycle through MAAS
- RKE2 installed and managed with Ansible
- Rancher deployment managed with Helm



Infrastructure as a code and GitOps

Infrastructure as a code



- **Harvester (or VMware)**
  - Define the cluster and git push:
    - CPUs, Ram, Nodes, VLAN

```
$ terraform apply
```

  - Triggers the VMs creation (masters/workes)
  - Rancher will run the cluster join command on the newly created VMs

- **MAAS (Bare Metal nodes)**
  - Define the cluster and git push:

```
$ terraform apply
```

```
$ ansible-playbook deploy-rke2.yml
```

  - Nodes will join the cluster

- **CSCS Alps (HPC)**

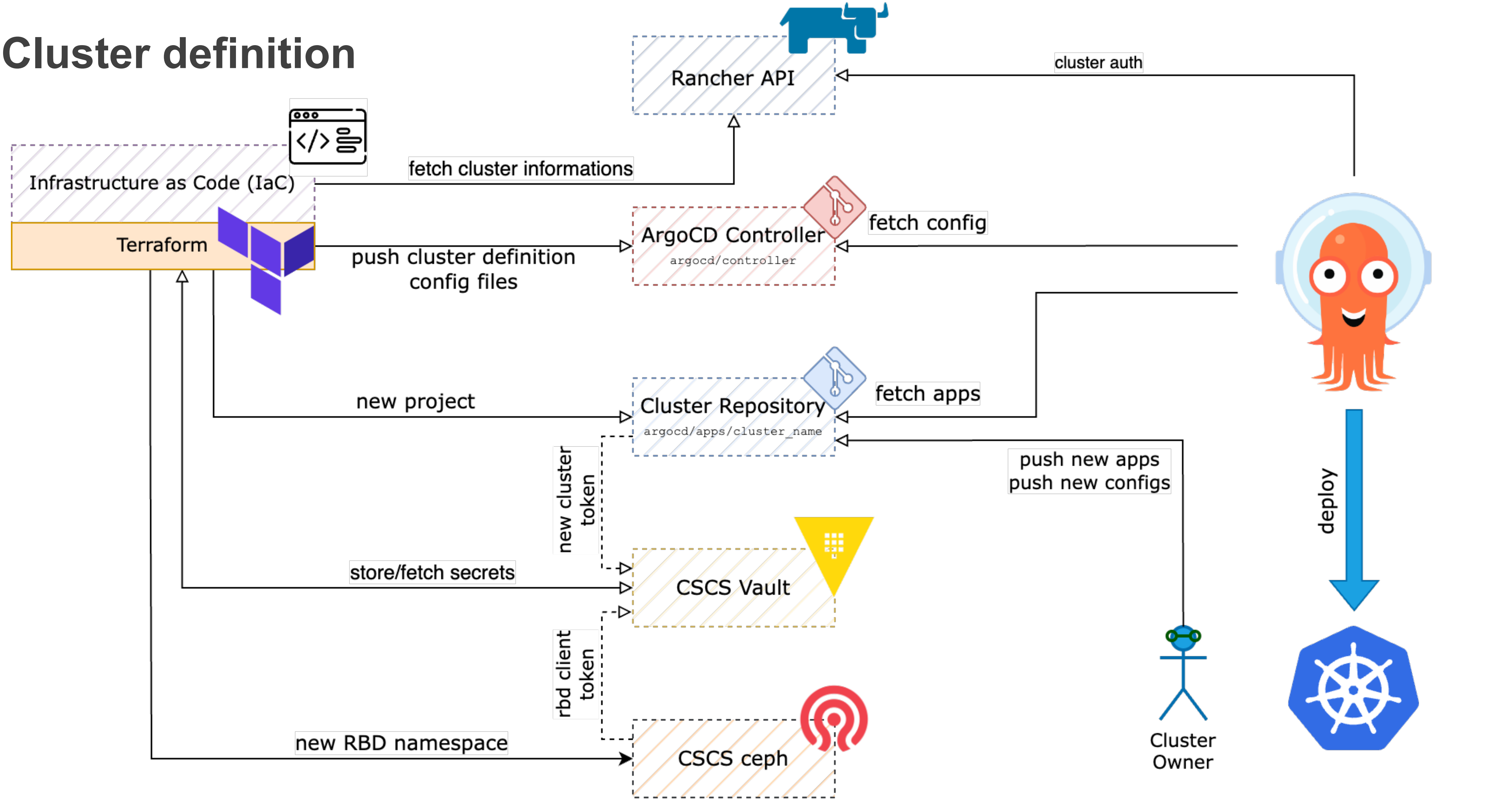
```
$ terraform apply
```

  - Master nodes creation on Harvester
    - And join

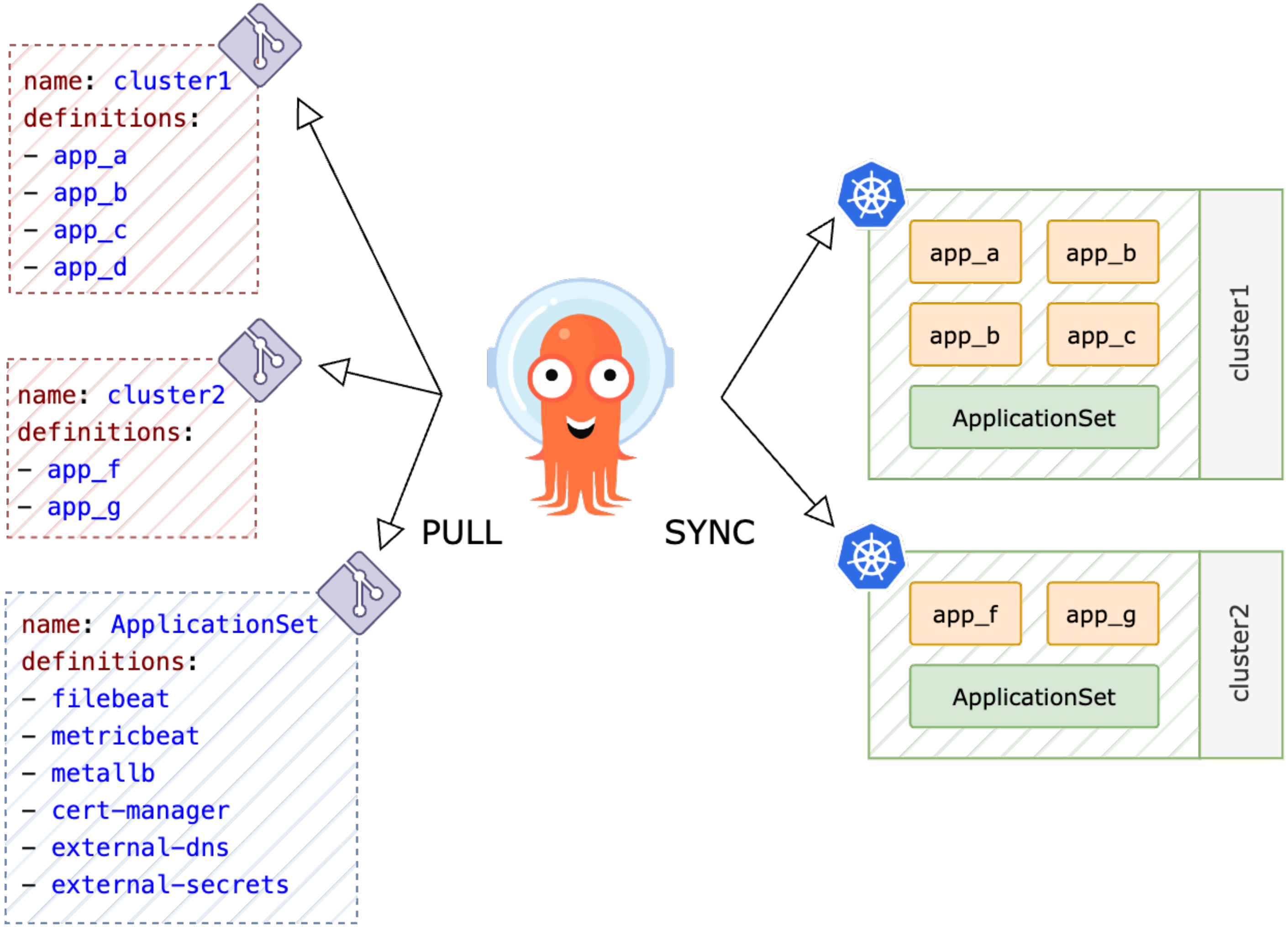
```
$ ./rancher-agent-install.sh
```

  - Worker nodes will join the cluster

Cluster definition



GitOps with ArgoCD



```
name: cluster1
definitions:
- app_a
- app_b
- app_c
- app_d
```

```
name: cluster2
definitions:
- app_f
- app_g
```

```
name: ApplicationSet
definitions:
- filebeat
- metricbeat
- metallb
- cert-manager
- external-dns
- external-secrets
```

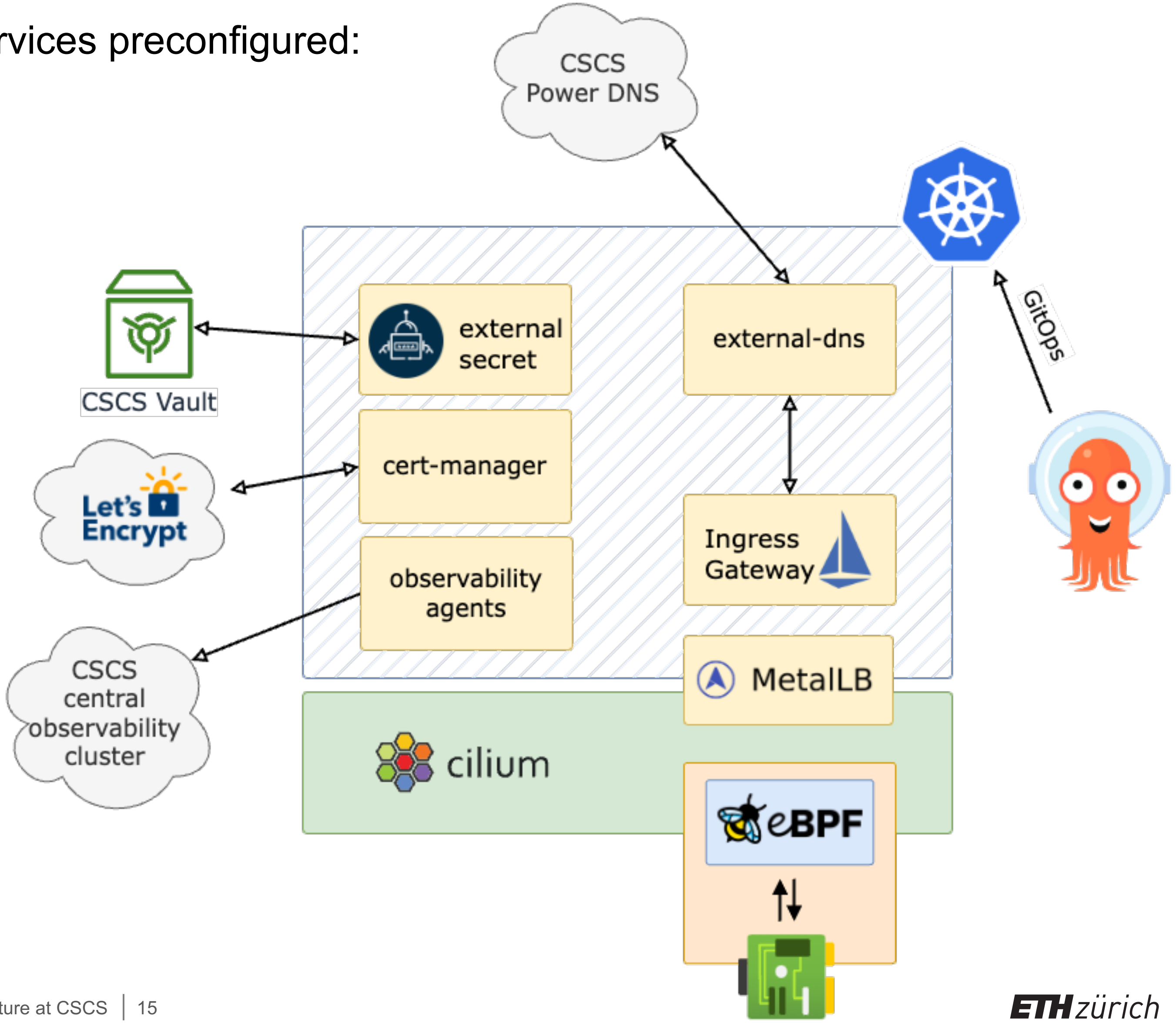
- **Application definitions**
  - Each cluster has its own Git repo with all application manifests (HELM or pure k8s manifests)
- **ApplicationSet**
  - Using ArgoCD Generators common applications can be deployed on all clusters or on clusters with specific labels

Argo CD ensures that the state of apps matches the desired configuration.

Kubernetes clusters common features

All clusters deployed have the following common services preconfigured:

- CNI: Cilium
  - Service mesh (eBPF)
  - Hubble (observability UI)
- CSI:
  - cephfs
  - ceph rbd
- Ingress controller
  - Istio (no sidecars)
    - Started migration to new API Gateway
  - Nginx
- MetalLB
  - Gratuitous ARP
- Automated DNS and Certs
- External Secret
  - For all Vault secrets
- Observability agents
  - Filebeat and Metricbeat

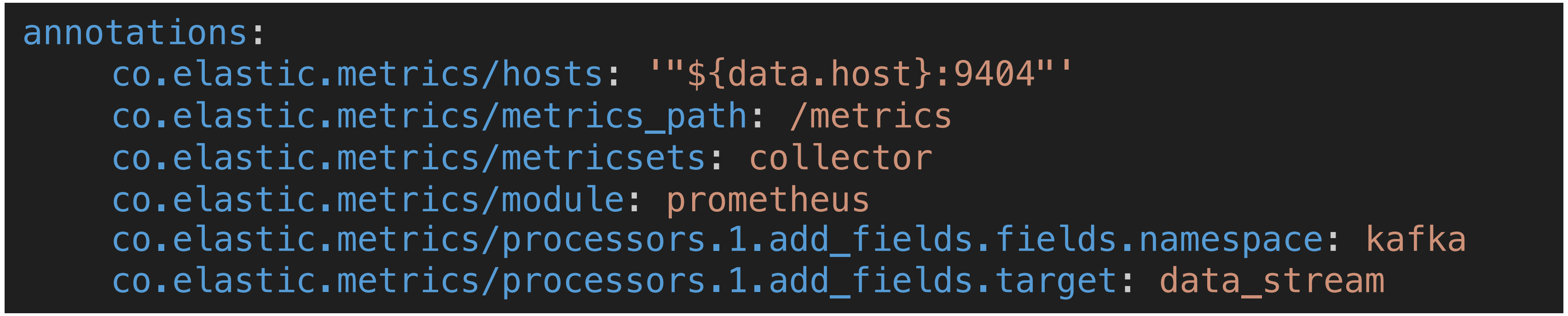


Observability

All clusters come with automatically deployed logs and metrics collectors (ArgoCD ApplicationSet), which send everything to our central Observability Infrastructure.

Currently we are using Elastic Beats

- Autodiscovery
  - Triggered on **`New`**, **`Modified`** and **`Deleted`** pod
- Hint based
  - Configure Beat modules via pod Annotations:



```
annotations:
    co.elastic.metrics/hosts: '"${data.host}:9404"'
    co.elastic.metrics/metrics_path: /metrics
    co.elastic.metrics/metricsets: collector
    co.elastic.metrics/module: prometheus
    co.elastic.metrics/processors.1.add_fields.fields.namespace: kafka
    co.elastic.metrics/processors.1.add_fields.target: data_stream
```

Operations

Infrastructure upgrade

- **Harvester**
  - Upgrade triggered automatically via the user interface.
    - RKE2 upgrade
    - Draining one host at a time
      - VMs are live migrated
    - OS Image replacement
- **Rancher**
  - Ansible managed nodes:
    - Drain Kubernetes nodes one by one.
    - Reinstall or upgrade the OS
  - Rancher
    - Upgrade done via Ansible (same playbook used for the installation)
      - `rke2_version: v1.26.9+rke2r1`
      - **NOTE:** Don't skip intermediate minor versions when upgrading, eg. : *v1.28.x* → *1.29.x*
- **ArgoCD**
  - via Helm

Downstream clusters upgrade

- **Kubernetes**
  - Required RKE2 version can be changed using Terraform

    ```
    kubernetes_version = "v1.29.2+rke2r1"
    $ terraform apply
    ```

      - **NOTE:** Don't skip intermediate minor versions when upgrading, eg. : *v1.28.x → 1.29.x*
    - Rancher will handle draining nodes and upgrading
- **OS Upgrades**
  - Harvester nodes (VMs):
    - Required OS can be changed using Terraform
      - `image = "default/ubuntu-jammy”`
      - `$ terraform apply`
  - Ansible managed nodes:
    - Drain Kubernetes nodes one by one.
    - Reinstall or upgrade the OS based on your requirements

Use cases

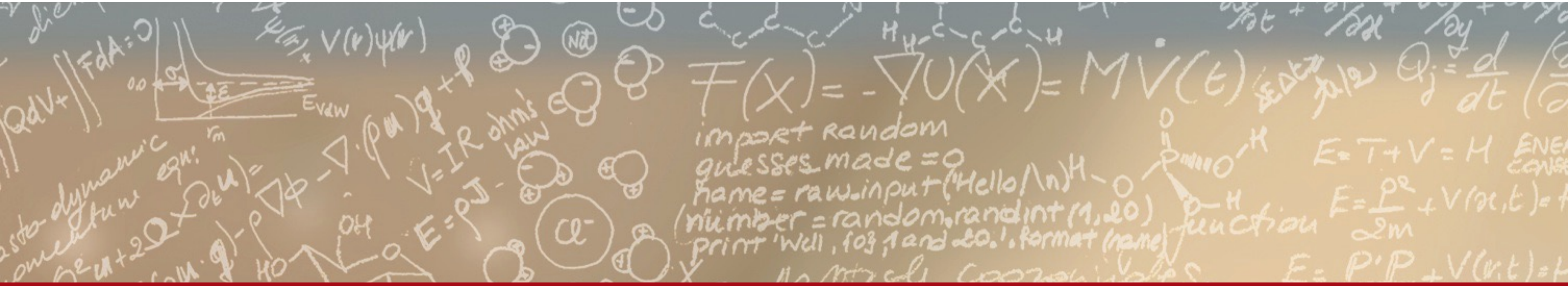
Conclusion and Usecases

We are running a total of ~35 downstream clusters, with ~200 VMs and ~100 bare metal nodes

Here are some of the Kubernetes clusters:

- dCache
  - 16 bare metal nodes
  - ~250 pools
  - 48TiB of PVCs via Ceph RBD (Total 12PB WLCG + CTA)
- WLCG Services
  - Frontier Squid
    - With multus and whereabouts (IPAM)
  - Nordugrid ARC CEs
  - site-bdii

- Observability cluster
  - 92 bare metal nodes
  - Local NVMe storage
    - Local Path for Elasticsearch data nodes
    - Longhorn for all other persistent services
- Central CSCS services
  - Vault
  - Jfrog
  - Gitlab-runners
- HPC Test (Rosa)
  - 3 master on Harvester
  - 4 worker on ALPS (1024 cores)


F(X) = -∇U(X) = MV(t)
import random
guesses_made = 0
name = raw_input('Hello\n')
number = random.randint(1, 20)
print 'Well, {0}, 1 and 20.'.format(name)
V=IR ohm's law
E=ρJ
E = T+V = H
E = p²/2m + V(x,t)
function
Evdw

Questions?

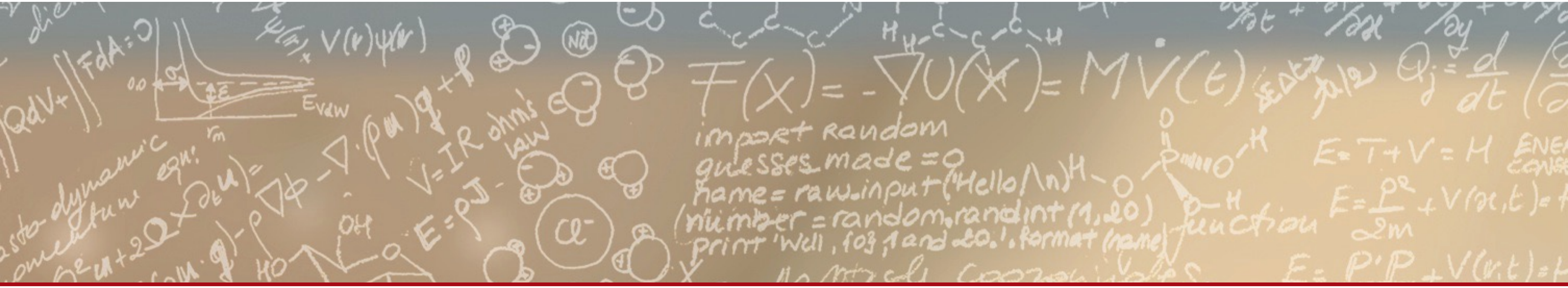
See you at HEPiX Spling 2025 in Lugano

We are pleased to announce the HEPiX workshop, hosted by CSCS, from March 31 to April 4, 2025, in Lugano, Switzerland.

More information will follow: https://www.hepix.org/

About HEPiX:

The HEPiX forum brings together worldwide Information Technology staff, including system administrators, system engineers, and managers from the High Energy Physics and Nuclear Physics laboratories and institutes, to foster a learning and sharing experience between sites facing scientific computing and data challenges. Participating sites include ASGC, BNL, CERN, DESY, FNAL, IHEP, IN2P3, INFN, JLAB, KEK, KIT, Nikhef, PIC, RAL, SLAC, TRIUMF and many others. The HEPiX organization was formed in 1991, and its semi-annual meetings are an excellent source of information and sharing for IT experts in scientific computing.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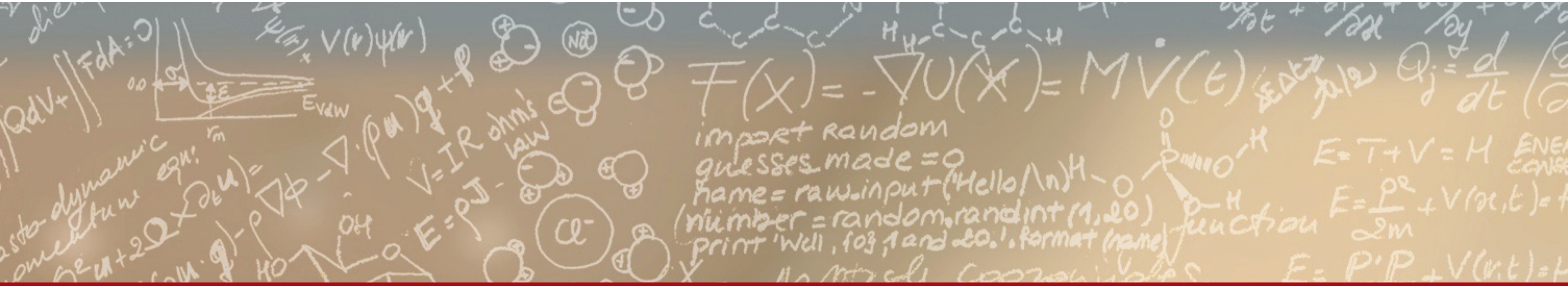
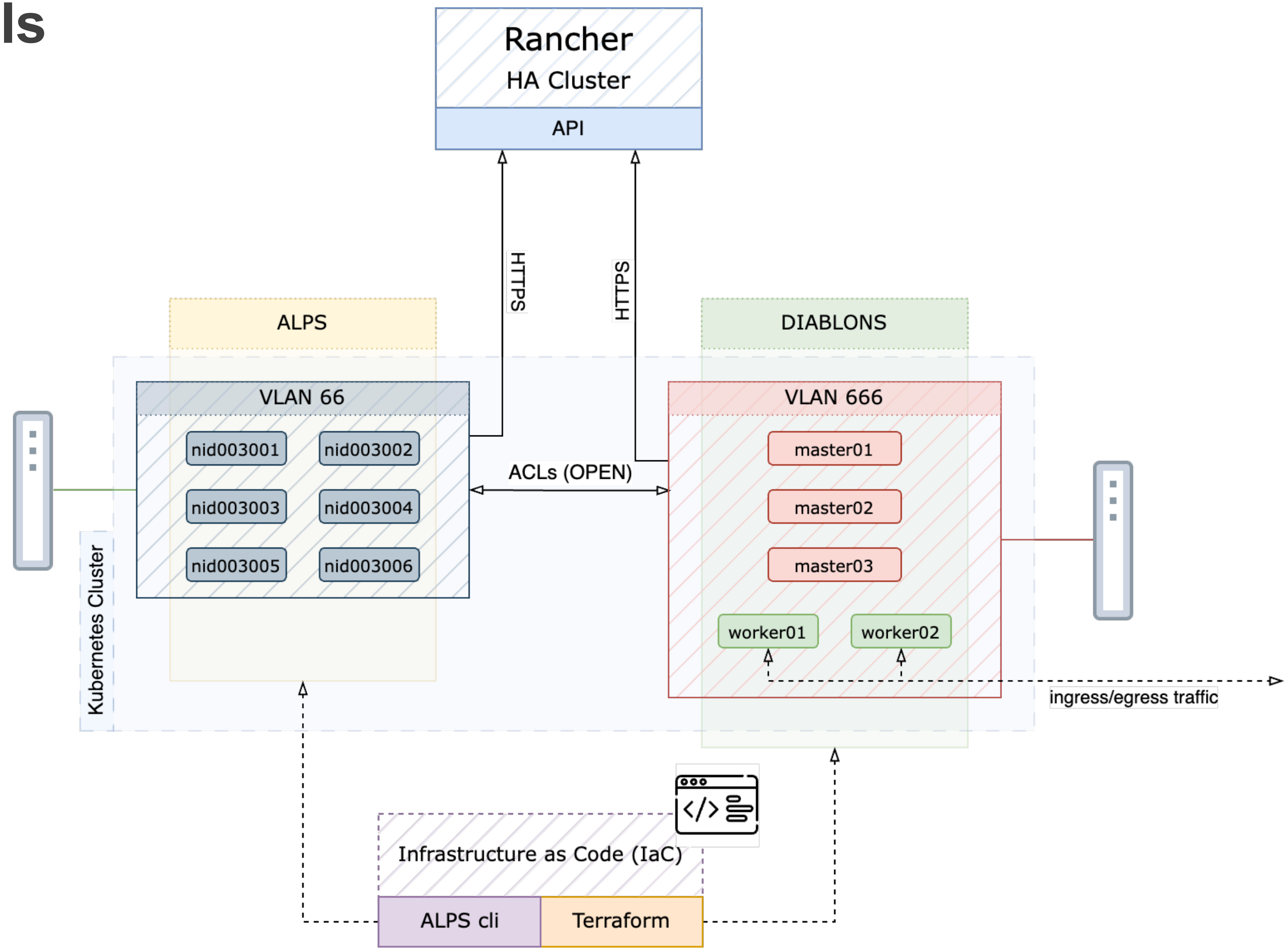
Thank you for your attention.



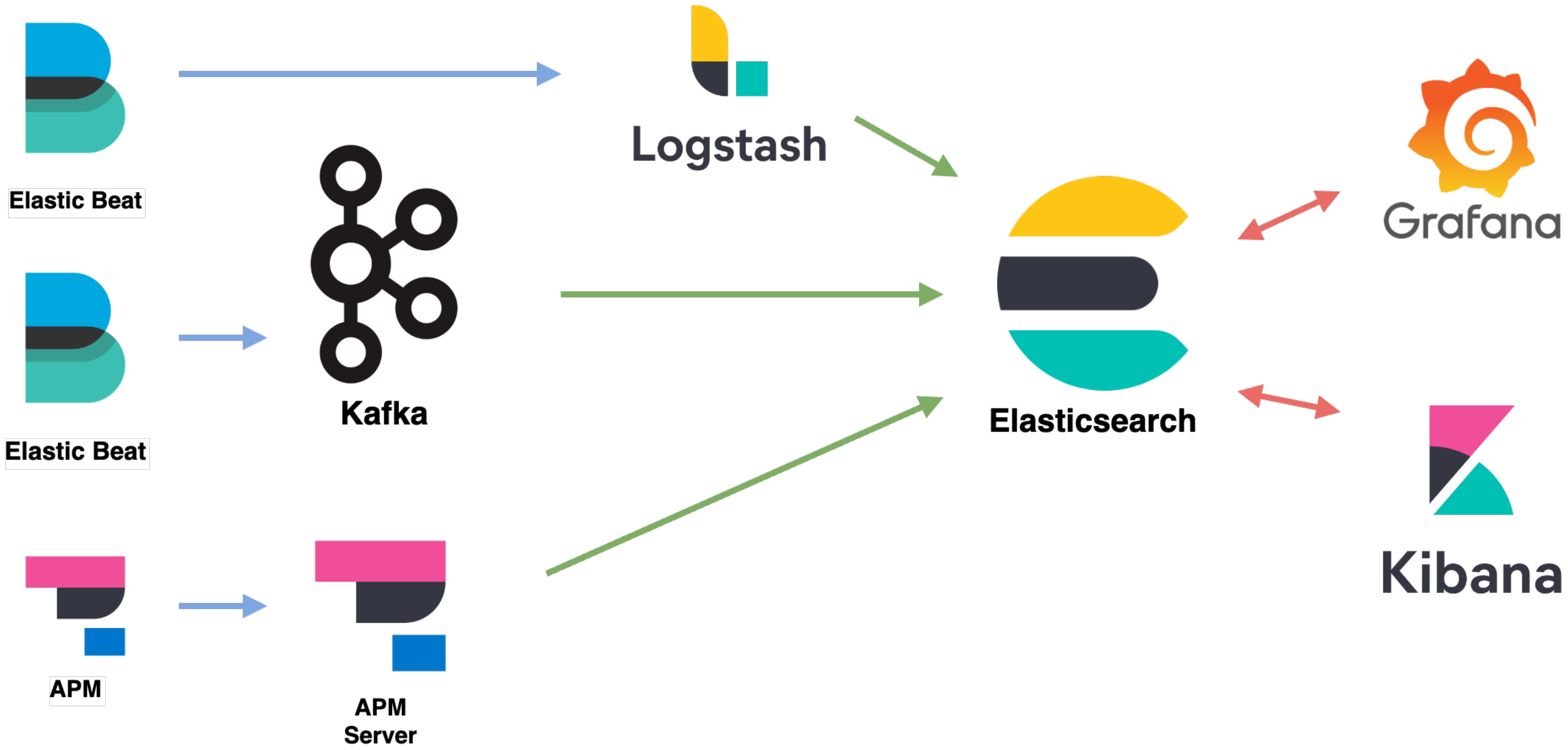
Backup slides…

Kubernetes on alps details

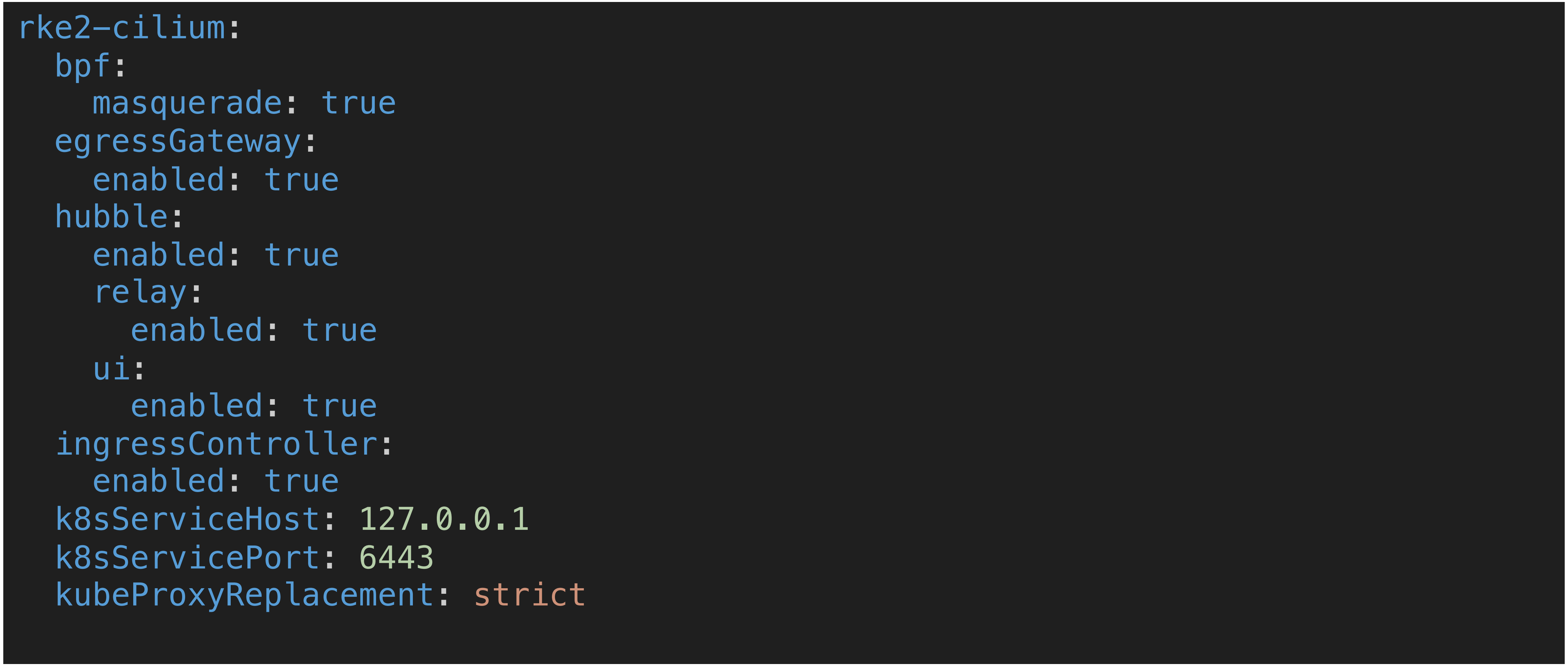
- Harvester (DIABLONS)
  - Master nodes
  - Specific workload workers
    - Ingress Controller
    - Egress Controller
    - Low performance SVC
    - Etc…
- ALPS (HPC)
  - Stateless workernodes



Backup slide: Elastic Stack flow



Cilium tuning



```yaml
rke2-cilium:
  bpf:
    masquerade: true
  egressGateway:
    enabled: true
  hubble:
    enabled: true
    relay:
      enabled: true
    ui:
      enabled: true
  ingressController:
    enabled: true
  k8sServiceHost: 127.0.0.1
  k8sServicePort: 6443
  kubeProxyReplacement: strict
```