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Making IoT Simple

Leveraging Akri & Nephio in a Hybrid Cloud Environment

Vitumbiko Mafeni | Jangwon Lee, SSU-IISTRC

Who we are



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Vitumbiko Mafeni
Research Engineer
SSU IISTRC

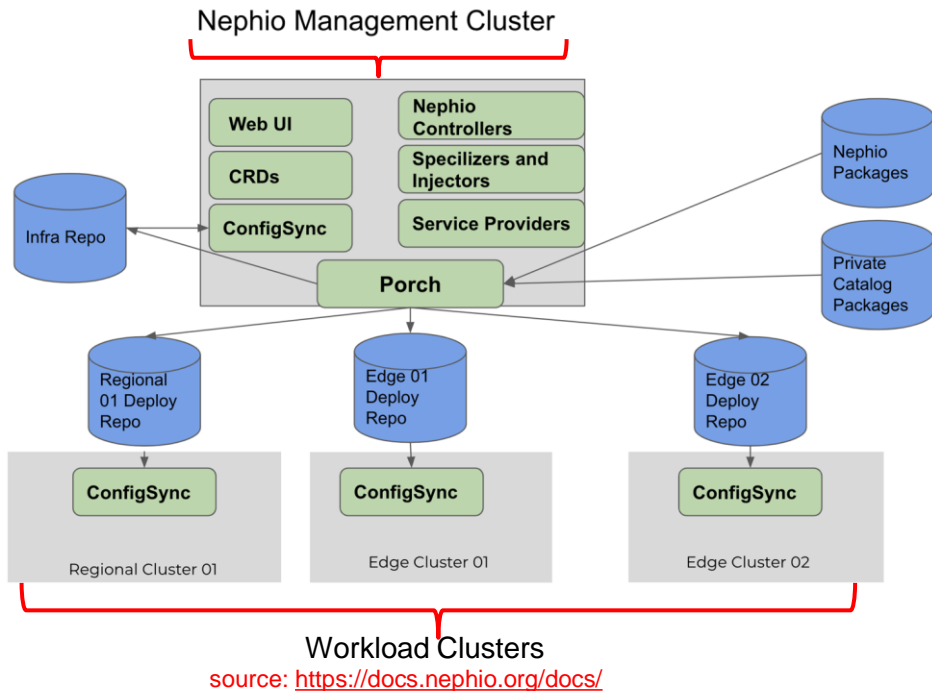


Jangwon Lee
Research Engineer
SSU IISTRC



Akri

What we have on the table: Nephio



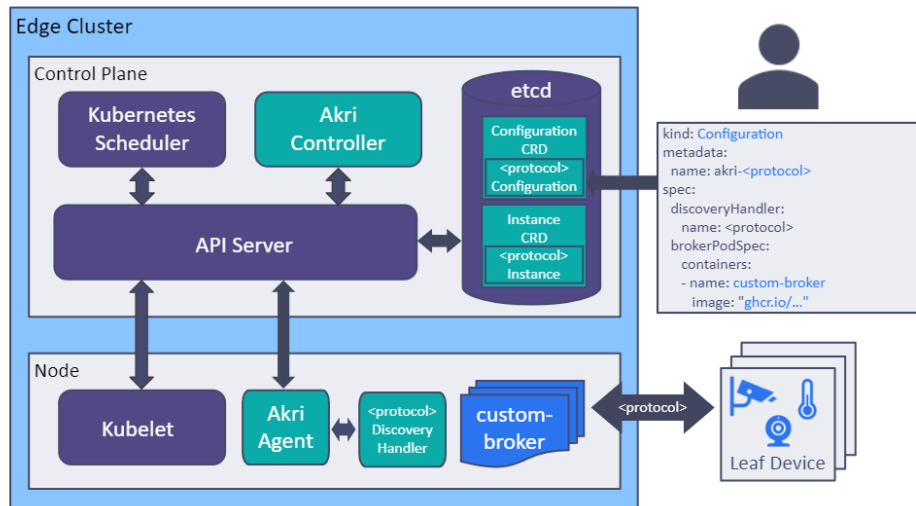
Functionalities

- Create Kubernetes clusters. This functionality is based on cluster API. At this time **only KIND clusters** creation is supported.
- Fully automated deployment of UPF, SMF and AMF services of free5Gc . These are deployed on multiple clusters based on user's intent expressed via CRDs.
- Inter cluster networking setup - containerlab.
- Deployment of other free5gc functions. Some manual configuration such as IP addresses may be needed for these services.

For the purposes of Nephio deployment, two categories of Nephio:

- **Management cluster:** This is where the majority of Nephio components are installed. It is dedicated to manage the deployment and lifecycle management of network functions that will be deployed on workload clusters.
- **Workload cluster:** This is where the actual network function workloads are deployed and running.

What we have on the table: Akri



source: <https://docs.akri.sh/>

Extending Kubernetes to the Edge with Akri

- Edge environment includes various sensors, controllers, and MCU class devices producing data and performing actions.
- Kubernetes clusters need to easily utilize heterogeneous “leaf devices” at the edge.
- Many leaf devices are too small to run Kubernetes natively.
- Akri: Open-source project to expose leaf devices as resources in Kubernetes clusters.
- Akri extends Kubernetes' **device plugin framework**, originally designed for cloud hardware like GPUs.
- Akri adapts the framework for edge devices with unique communication protocols and intermittent availability.

There are two Akri CRDs:

- **Configuration:** Akri users will create Configurations to describe what resources should be discovered and what pod should be deployed on the nodes that discover a resource.
- **Instance:** Each Instance represents an individual resource that is visible to the cluster. So, if there are 5 IP cameras visible to the cluster, there will be 5 Instances.

The Challenge in IoT environment



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- **Automating** IoT infrastructure provisioning.
- Deploying and configuring IoT applications across **multiple** cloud providers.
- Managing **thousands** of IoT devices across **different** geographic locations.

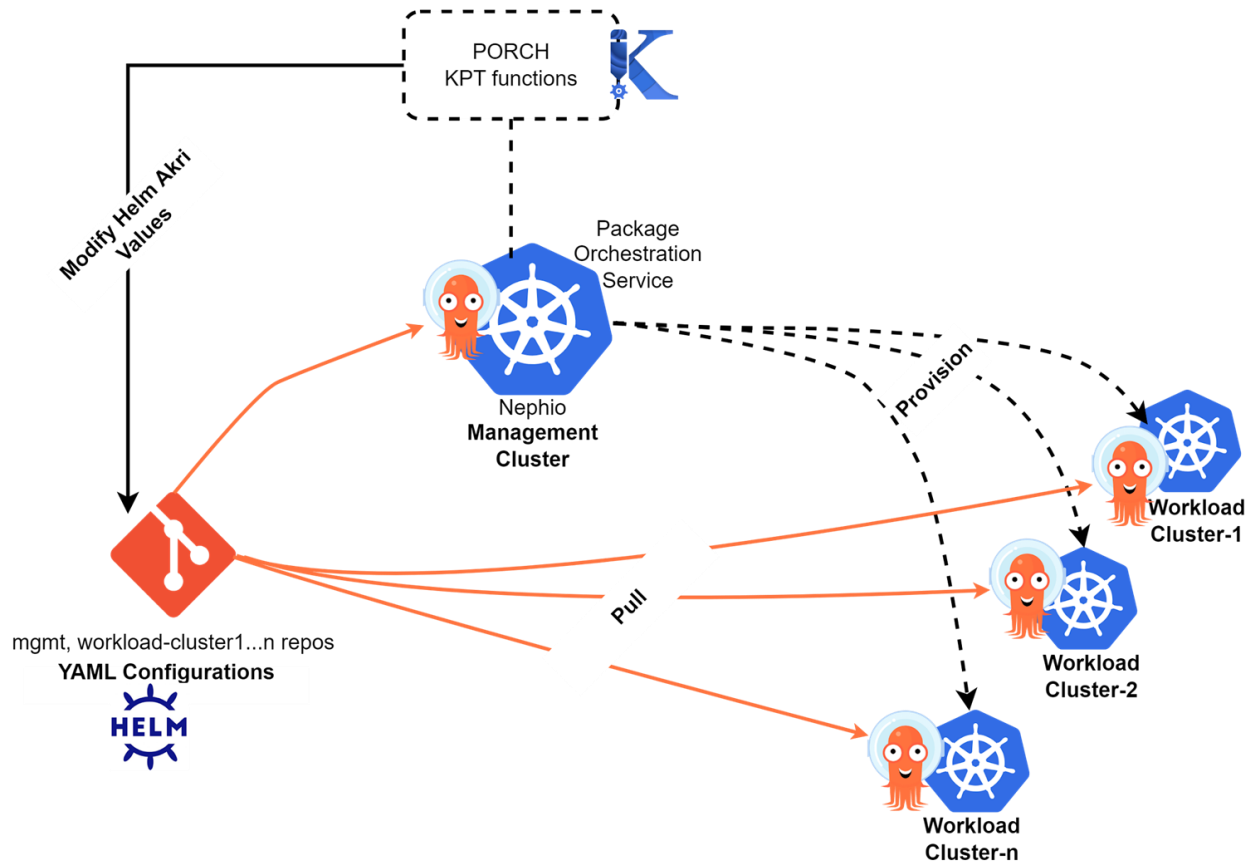
We can solve these challenges with Nephio and Akri



Solution Overview



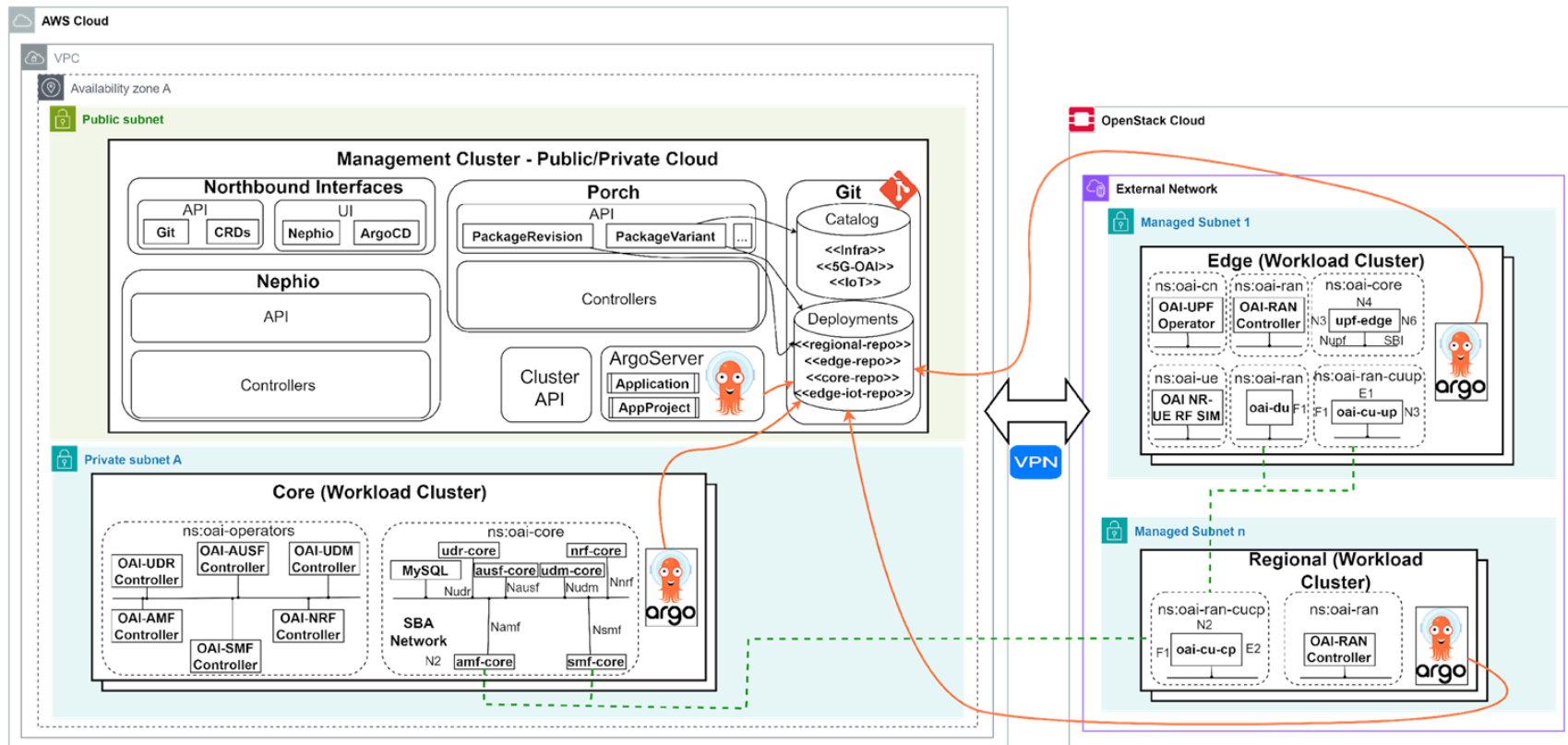
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Base Infrastructure in Hybrid cloud



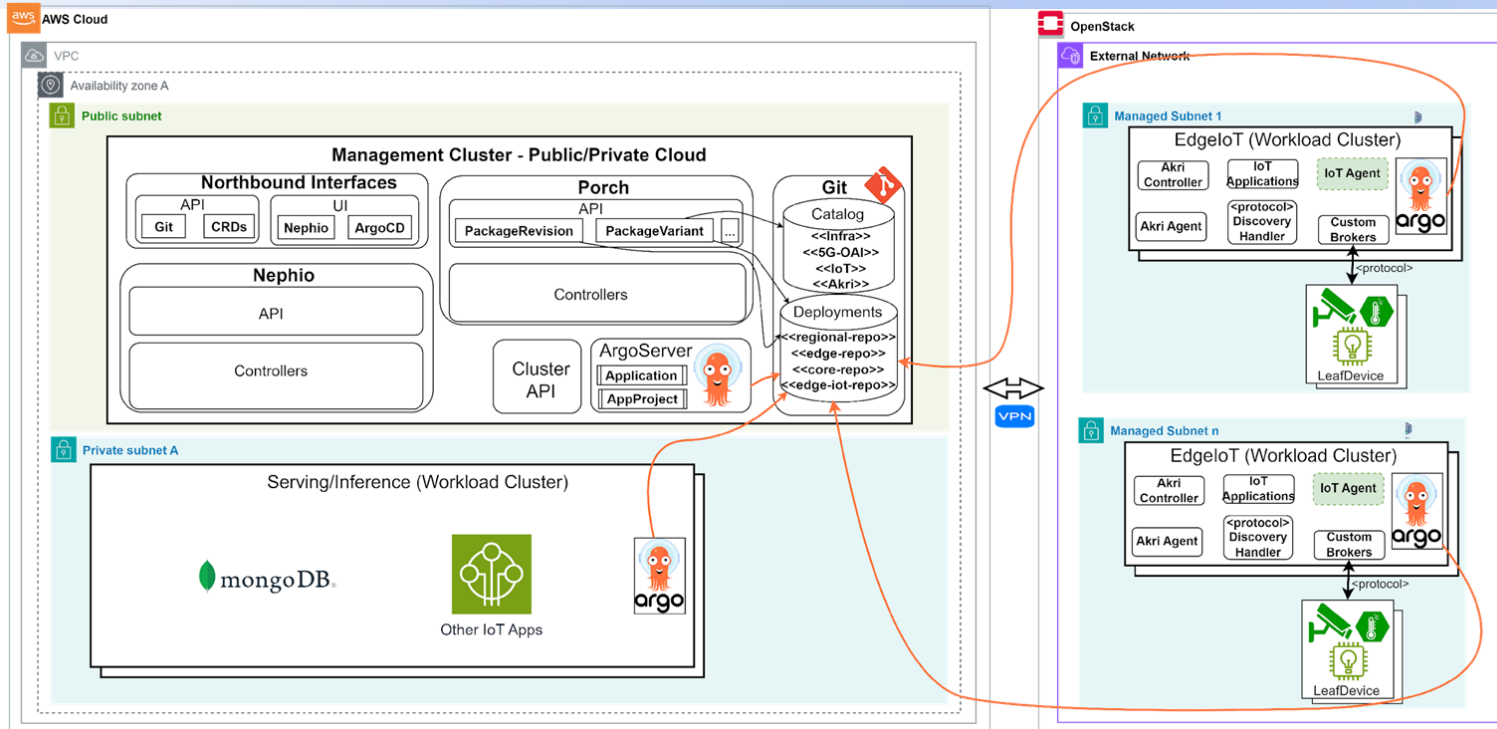
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Nephio Akri Integration – IoT PoC



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Akri Components running on Nephio Workload clusters, inferencing intensive services running on Nephio Workload cluster on AWS

Nephio Package Management



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New Registered Akri package

The screenshot shows the Backstage Package Management interface. The left sidebar has 'Backstage' and 'Nephio' links. The main content area is titled 'Package Management' and 'Package Management'. It has tabs for 'Dashboard' and 'Repositories'. The 'Dashboard' tab is active, showing 'Deployments' (1 repository registered, 0 deployments published) and 'Team Blueprints' (1 repository registered, 0 team blueprints published). Below these are 'External Blueprints' (9 repositories registered, 58 external blueprints published). A red circle highlights the 'External Blueprints' section, which lists repositories: 'argo-akri-app', 'catalog-distros-sandbox', 'catalog-infra-capi', 'catalog-nephio-core', 'catalog-nephio-optional', 'catalog-workloads-freeform', 'catalog-workloads-oai-ran', 'catalog-workloads-tools', and 'oai-packages'.

IoT cluster creation on OpenStack with Akri Packages

The screenshot shows the Nephio Package Management interface for the 'edge-iot draft revision'. The left sidebar has 'Nephio' and 'edge-iot draft revision' links. The main content area is titled 'edge-iot draft revision' and has tabs for 'Resources', 'Conditions', 'Revisions', 'Related', and 'Advanced'. The 'Resources' tab is active, showing a table of root resources. The table has columns for 'KIND', 'NAME', and 'NAME SPACE'. The resources listed are:

KIND	NAME	NAME SPACE
Kptfile	edge-iot	
Apply/Replacements	propagate-name	
ConfigMap	kptfile.kpt.dev	
PackageVariant	edge-iot-iot-argoapp	
PackageVariant	edge-iot-iot-argoapp-akri	
PackageVariant	edge-iot-iot-argood	
PackageVariant	edge-iot-iot-calico	

Helm currently not supported in the Nephio UI*

Clusters Created



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openstack. Default • thang

Project / Compute / Instances

Instances

Instance ID = Filter [Launch Instance](#) [Delete Instances](#) [More Actions](#)

Displaying 10 Items

<input type="checkbox"/>	Instance Name	Image Name	IP Address	Flavor	Key Pair	Status	Availability Zone	Task	Power State	Age	Actions
<input type="checkbox"/>	edge-iot-md-0-z4vrk-nqpzz	Ubuntu2204-CAPI	10.6.0.87	m1.large	nephio	Active	compute	None	Running	30 minutes	Create Snapshot
<input type="checkbox"/>	edge-iot-control-plane-m5fkv	Ubuntu2204-CAPI	10.6.0.135, 192.168.40.216	m1.large	nephio	Active	compute	None	Running	1 hour, 14 minutes	Create Snapshot

Workload Cluster

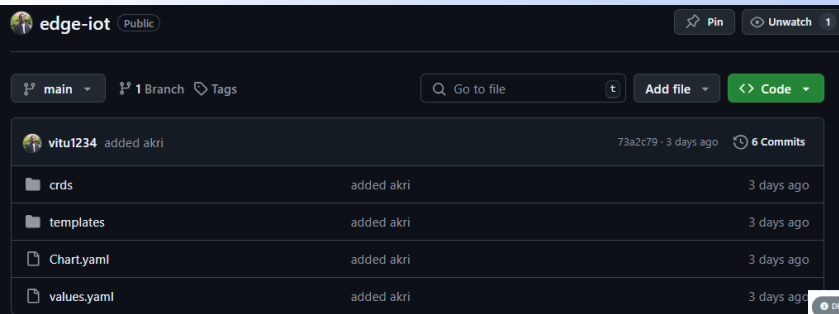
```
root@mgmt-control:~# kubectl get clusters
NAME          CLUSTERCLASS  PHASE          AGE    VERSION
edge-iot              Provisioned    69m
root@mgmt-control:~# kubectl get openstackserver
NAME                                INSTANCESTATE  READY  INSTANCEID                                AGE
edge-iot-control-plane-m5fkv        ACTIVE         true   b04507c2-41b6-48d7-aa9a-9a55276be3c5    69m
edge-iot-md-0-z4vrk-nqpzz           ACTIVE         true   7d1d1e3a-eb2f-46f2-b98f-7c5b6a14737f    24m
```

Created Workload Cluster -> kubectl

ArgoCD Configs + Syncing Akri Components



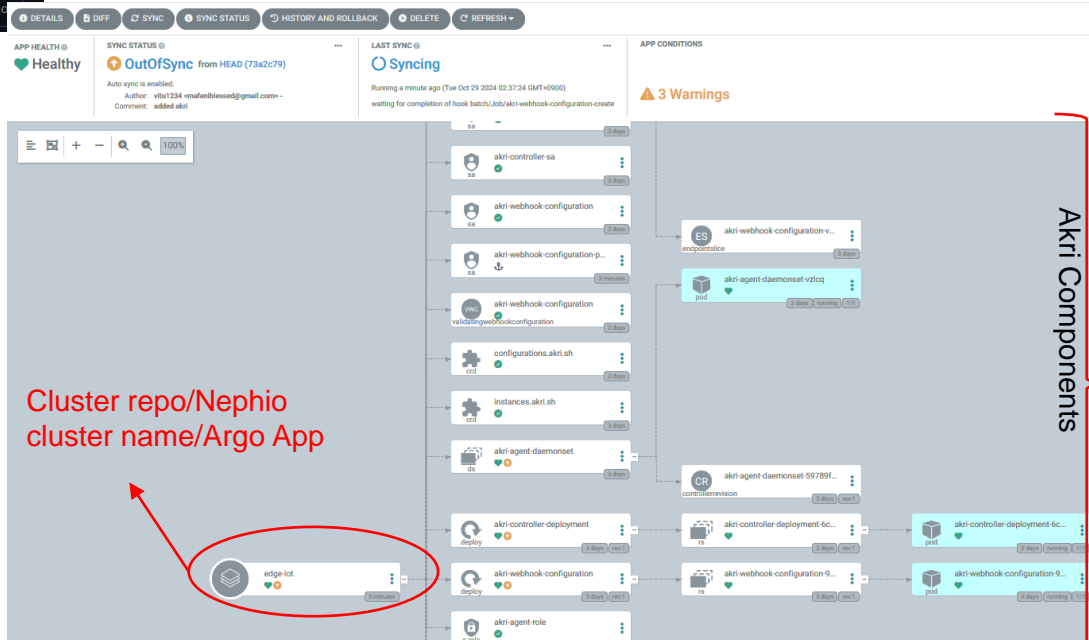
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Repo

```
apiVersion: argoproj.io/v1alpha1
kind: Application
metadata:
  name: edge-iot
  namespace: argocd
spec:
  project: default
  source:
    repoURL: 'https://192.168.3.99/nephio/edge-iot.git'
    targetRevision: HEAD
    path: . # Path to the chart in the repository
  helm:
    valueFiles:
      - values.yaml
  destination:
    server: 'https://kubernetes.default.svc'
    namespace: default
  syncPolicy:
    automated:
      prune: true
      selfHeal: true
```

Argo Application helm configuration



Akri Components Over WorkloadCluster

Discovering & Using USB Cameras



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```
udev:
configuration:
  # enabled defines whether to load a udev configuration
  enabled: true
  # name is the Kubernetes resource name that will be created for this
  # udev configuration
  name: akri-udev-video
  # brokerProperties is a map of properties that will be passed to any instances
  # created as a result of applying this udev configuration
  brokerProperties: {}
  discoveryDetails:
    # groupRecursive defines whether to group discovered parent/children under the same instance
    groupRecursive: false
    # udevRules is the list of udev rules used to find instances created as a result of
    # applying this udev configuration
    udevRules:
      - 'KERNEL=="video[0-9]*"'
    # capacity is the capacity for any instances created as a result of
    # applying this udev configuration
    capacity: 3
  brokerPod:
    image:
      # repository is the udev broker container reference
      repository: "ghcr.io/project-akri/akri/udev-video-broker"
```

Akri Helm Values in a git repo
configurations deployed through
ArgoCD and managed through
Nephio Management cluster

ubuntu@mgmt-control:~\$ kubectl get pods,akric,akri,service -o wide --kubeconfig edge-iot.kubeconfig

NAME	READY	STATUS	RESTARTS	AGE	IP	NODE	NOMINATED NODE	READINESS GATES
pod/akri-agent-daemonset-gkxzb	1/1	Running	0	3h25m	172.16.248.198	edge-iot	<none>	<none>
pod/akri-controller-deployment-86cf9c5cf-kx4fb	1/1	Running	0	3h25m	172.16.248.197	edge-iot	<none>	<none>
pod/akri-udev-discovery-daemonset-967pw	1/1	Running	0	29s	172.16.248.202	edge-iot	<none>	<none>
pod/akri-udev-video-246e4d-pod	1/1	Running	0	19s	172.16.248.204	edge-iot	<none>	<none>
pod/akri-udev-video-a0bfc6-pod	1/1	Running	0	18s	172.16.248.205	edge-iot	<none>	<none>
pod/akri-webhook-configuration-69d9bd7d89-96tkx	1/1	Running	0	3h25m	172.16.248.199	edge-iot	<none>	<none>

NAME	CAPACITY	AGE
configuration.akri.sh/akri-udev-video	1	29s

NAME	CONFIG	SHARED	NODES	AGE
instance.akri.sh/akri-udev-video-246e4d	akri-udev-video	false	["edge-iot"]	19s
instance.akri.sh/akri-udev-video-a0bfc6	akri-udev-video	false	["edge-iot"]	18s

NAME	TYPE	CLUSTER-IP	EXTERNAL-IP	PORT(S)	AGE	SELECTOR
service/akri-udev-video-246e4d-svc	ClusterIP	10.107.198.57	<none>	80/TCP	5s	akri.sh/instance=akri-udev-video-246e4d,controller=akri.sh
service/akri-udev-video-a0bfc6-svc	ClusterIP	10.96.63.62	<none>	80/TCP	4s	akri.sh/instance=akri-udev-video-a0bfc6,controller=akri.sh
service/akri-udev-video-svc	ClusterIP	10.96.138.17	<none>	80/TCP	5s	akri.sh/configuration=akri-udev-video,controller=akri.sh
service/akri-webhook-configuration	ClusterIP	10.105.140.60	<none>	443/TCP	3h25m	app.kubernetes.io/instance=akri,app.kubernetes.io/part-of=akri
service/kubernetes	ClusterIP	10.96.0.1	<none>	443/TCP	4h7m	<none>

Akri udev components
Deployed in the edge-iot cluster

Takeaway



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- Multi-Site IoT Challenges
- Nephio and Hybrid Cloud
- Akri Integration



Github



SSU-IISTRC web site

Contact Info

Mafeni Vitumbiko: vitumafeni@dcn.ssu.ac.kr
Jangwon Lee: jangwon.lee@dcn.ssu.ac.kr

