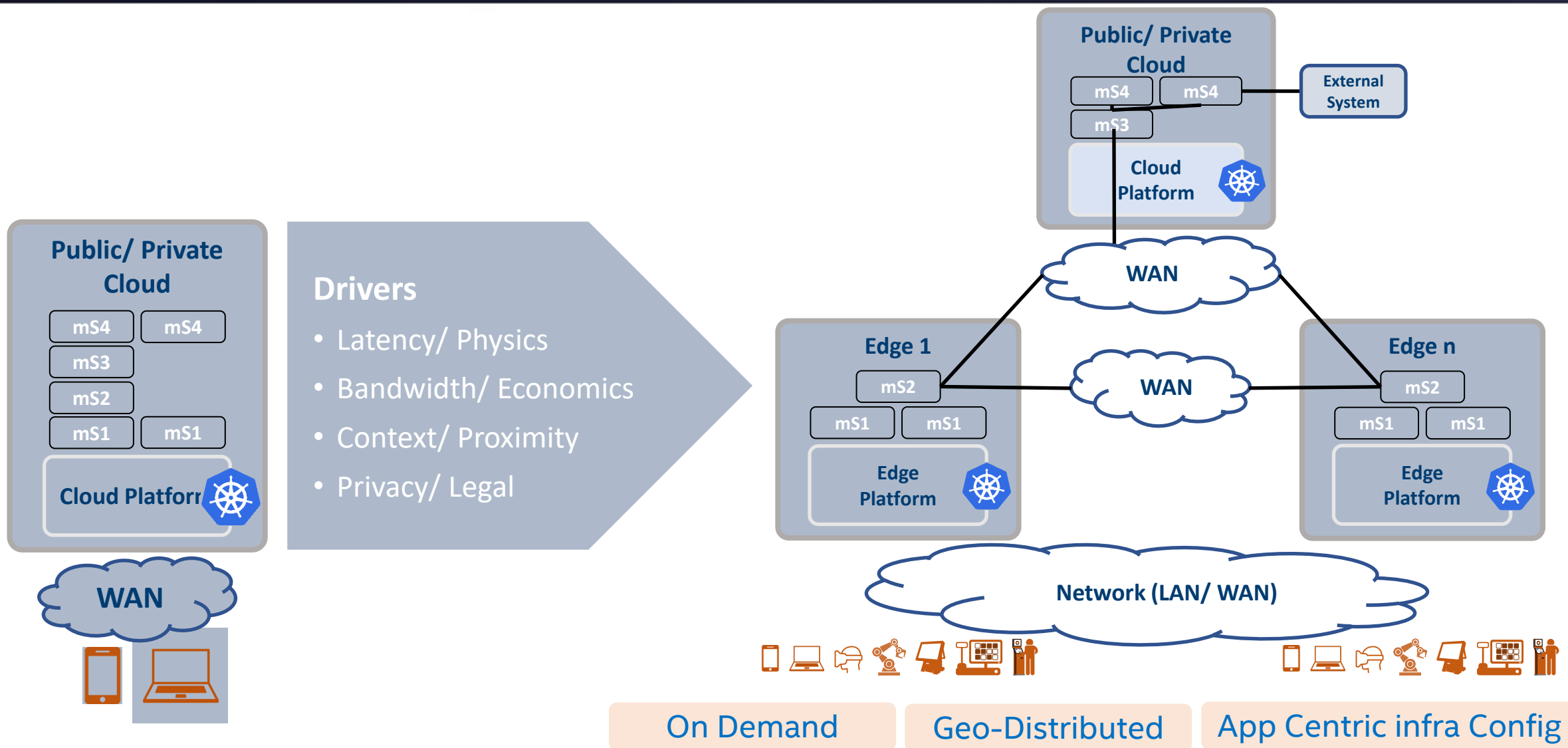# Overview of Challenges and Solutions for Orchestrating Applications to Multiple DC and Edge Clusters
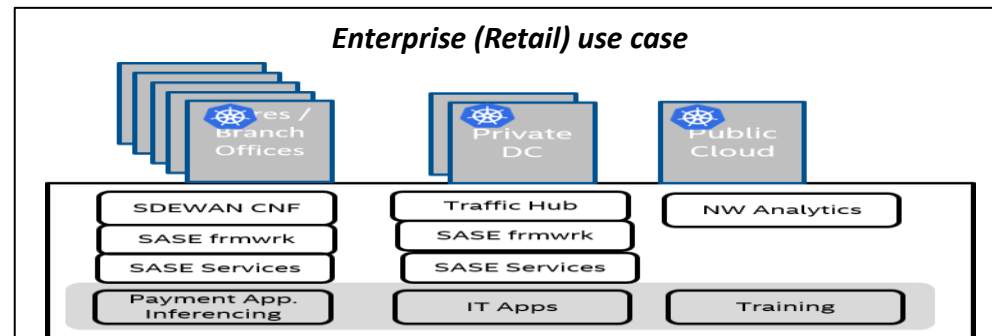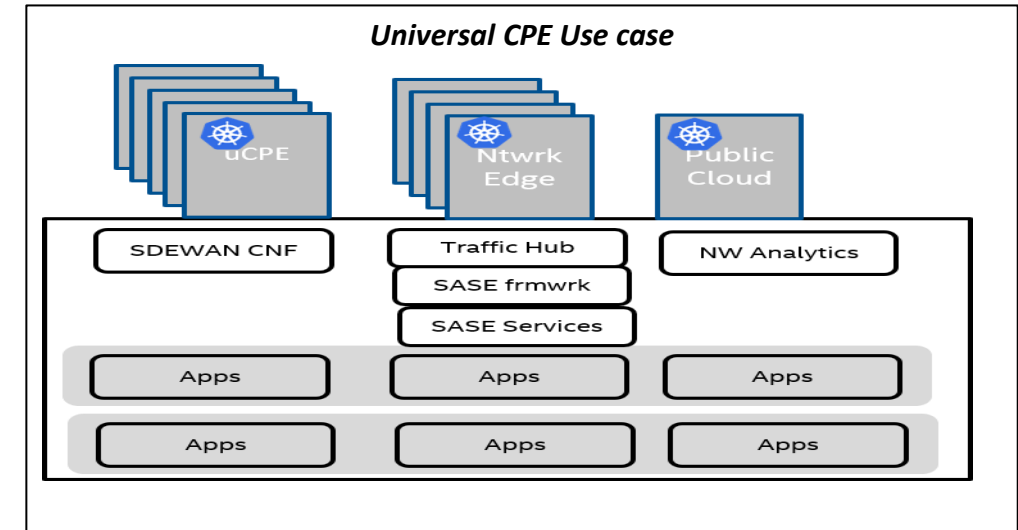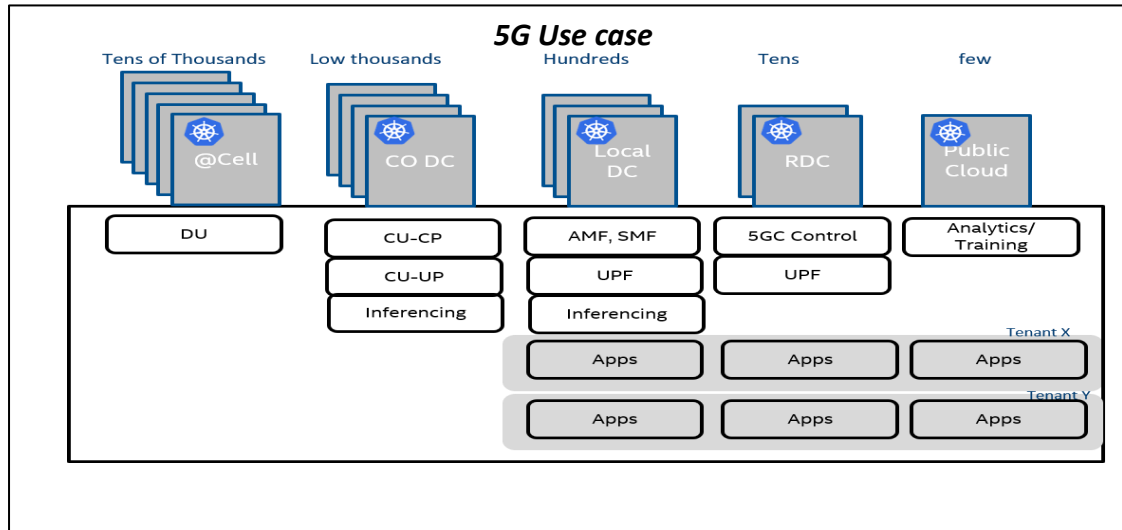
Ritu Sood, Cloud Architect/Engineer, Intel
Cathy Zhang, Senior Principal Architect/Engineer, Intel

Agenda

- Industry Trend on Geo Distributed Computing
- Use Cases
- Requirements and Challenges
- Solutions
  - KubeEdge
  - ArgoCD ApplicationSets
  - Karmada
  - EMCO

Trend : Geo Distributed Computing trend with Edge-computing

Geo-Distributed Computing - few use cases

5G Use case

Tens of Thousands	Low thousands	Hundreds	Tens	few
@Cell	CO DC	Local DC	RDC	Public Cloud

DU	CU-CP	AMF, SMF	5GC Control	Analytics/ Training
	CU-UP	UPF	UPF	
	Inferencing	Inferencing		

Tenant X

	Apps	Apps	Apps

Tenant Y

	Apps	Apps	Apps

Universal CPE Use case

uCPE	Ntwrk Edge	Public Cloud

SDEWAN CNF	Traffic Hub	NW Analytics
	SASE frmwrk	
	SASE Services	

Apps	Apps	Apps
Apps	Apps	Apps

Enterprise (Retail) use case

Stores / Branch Offices	Private DC	Public Cloud

SDEWAN CNF	Traffic Hub	NW Analytics
SASE frmwrk	SASE frmwrk	
SASE Services	SASE Services	
Payment App. Inferencing	IT Apps	Training

Multi Edge/Cloud computing scale is similar (or even higher) to Hyper-scalers' scale
Now Telcos, MSPs and Enterprises need @scale Orchestration and Automation solutions

Multi-Cloud Challenges and Requirements

One Click deployment
across large number of
K8s clusters

Per Cluster
Customizations

Push and Pull (GitOps
based - Flux, Azure Arc,
Anthos, etc.) clusters
types

Selection of the best
cluster

Tenant Management

**Comprehensive Status
monitoring**

Complex applications

Cluster Resources

**Automation of the
Infrastructure Services**

Multiple Infrastructure
Services require
configuration

Service discovery across
clusters

Service Mesh
configurations (ex Istio,
Linkerd and others)
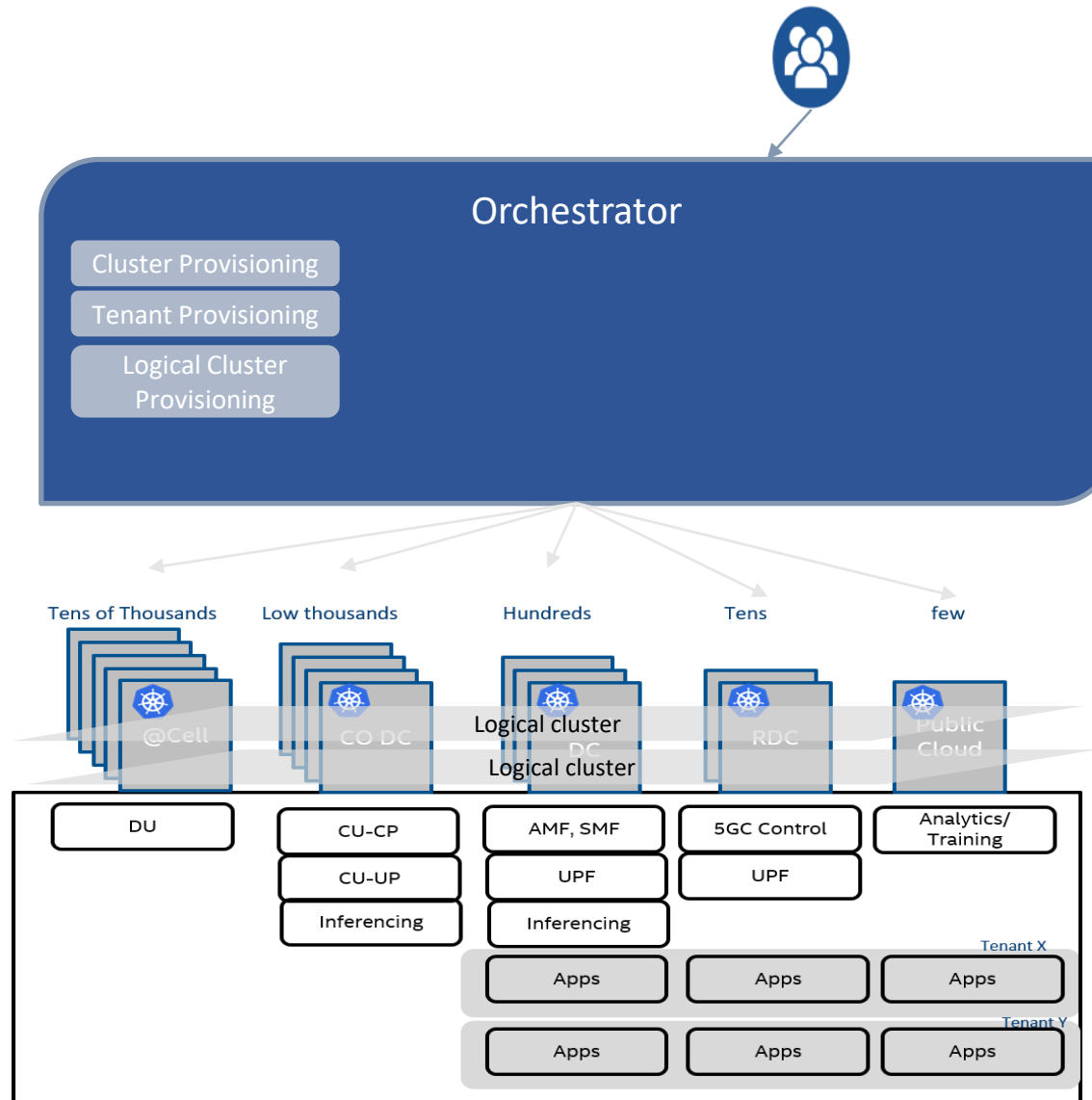
**Automation of compute
resources**

Different resource
requirement based on
cluster types

**Applications
Configurations**

May require Restful API's

Workflows needed for
unreliable connections

Needs/Requirements – Preparation

Orchestrator

- Cluster Provisioning
- Tenant Provisioning
- Logical Cluster Provisioning

Tens of Thousands	Low thousands	Hundreds	Tens	few
@Cell	CO DC	DC	RDC	Public Cloud

Logical cluster
Logical cluster

DU	CU-CP	AMF, SMF	5GC Control	Analytics/ Training
	CU-UP	UPF	UPF	
	Inferencing	Inferencing		

Tenant X

Apps	Apps	Apps

Tenant Y

Apps	Apps	Apps

Registration of Clusters

*Cluster labels
(Example: Cell tower Edge, CO Edge etc..)
Needed for identifying multiple clusters*

*Cluster specific configuration
(Few: ISTIO CA provisioning;
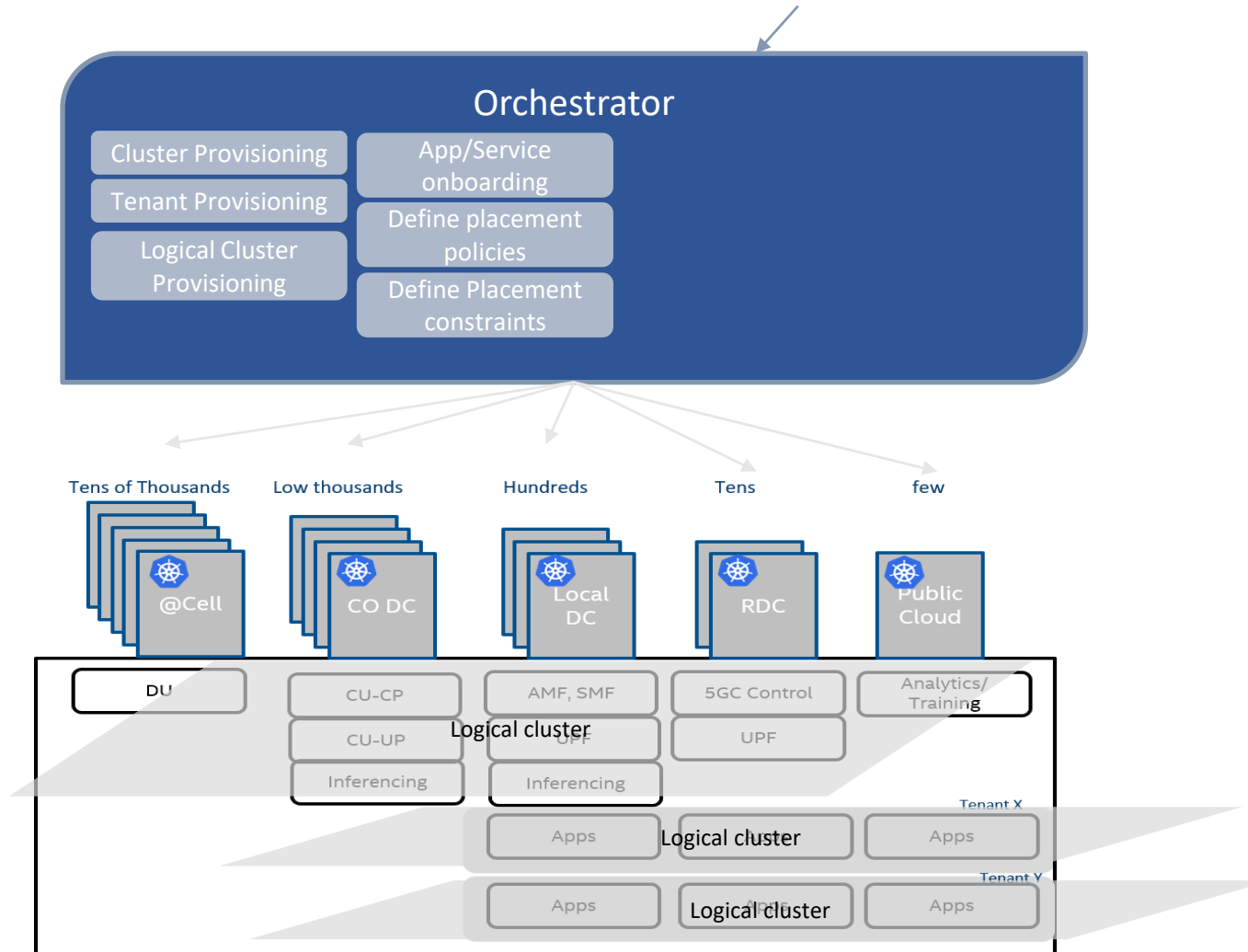Virtual/Provider network preparation)*

*Tenant registration
Ability to use tenant specific OAUTH2
servers for authenticating tenant admins*

Tenant level isolation via RBAC rules

*Logical Cluster provisioning across
multiple selected clusters*

*Logical Cluster user and permission
provisioning*

Orchestrator

- Cluster Provisioning
- Tenant Provisioning
- Logical Cluster Provisioning
- App/Service onboarding
- Define placement policies
- Define Placement constraints

Tens of Thousands	Low thousands	Hundreds	Tens	few
@Cell	CO DC	Local DC	RDC	Public Cloud

DU	CU-CP	AMF, SMF	5GC Control	Analytics/ Training
	CU-UP	UPF	UPF	
	Inferencing	Inferencing		

Logical cluster

Apps	Logical cluster	Apps

Tenant X

Apps	Logical cluster	Apps

Tenant Y
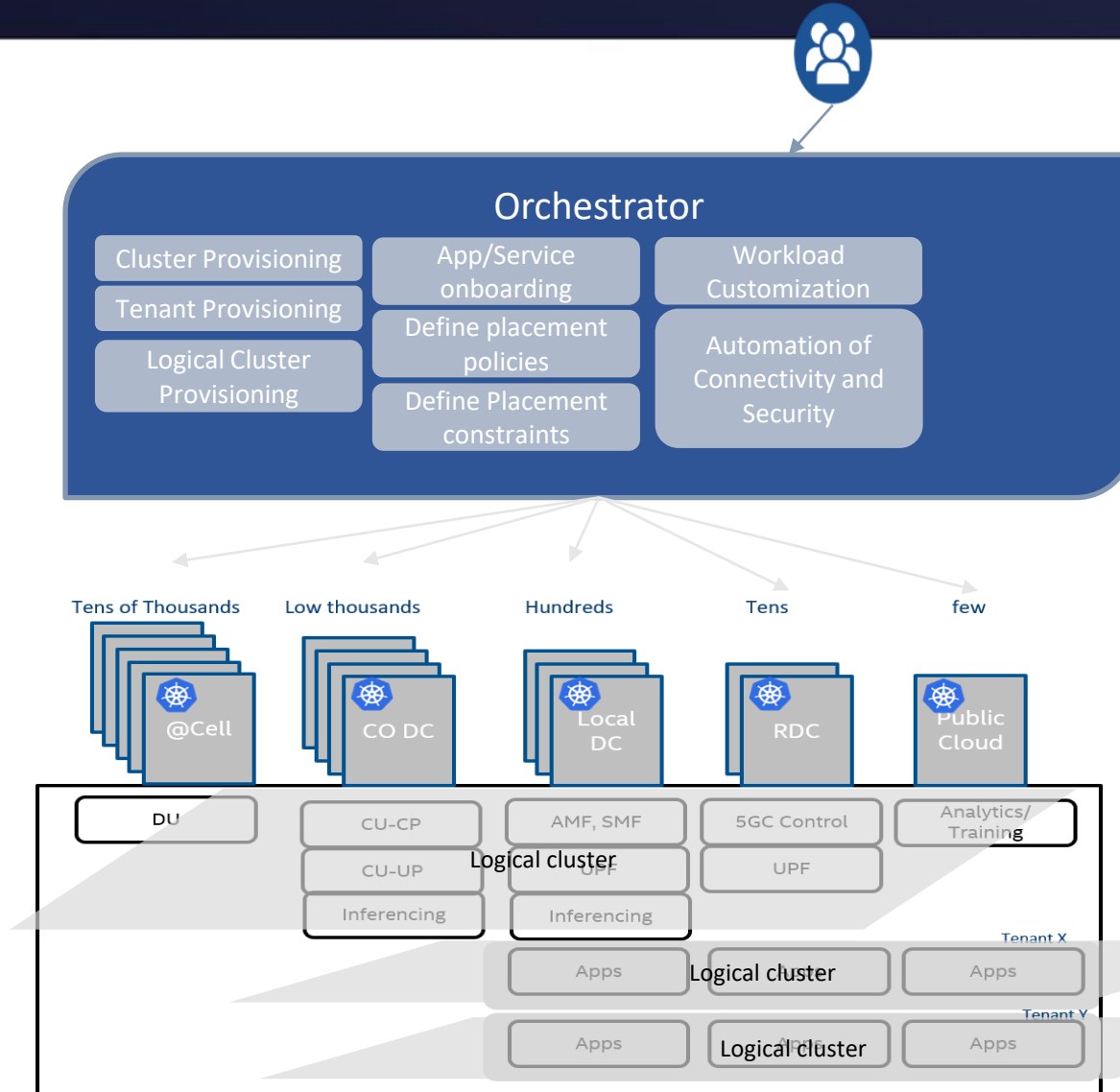
App Onboarding (Complex Apps & Network Services)

Multiple deployment profiles to ensure same APP can be instantiated multiple times

Placement policies to replicate and distribute workloads across clusters

Placement constraints : Affinity and Anti-Affinity; Platform capabilities; Latency; Cost

Requirements – Workload Customization & Connectivity

Orchestrator

- Cluster Provisioning
- Tenant Provisioning
- Logical Cluster Provisioning
- App/Service onboarding
- Define placement policies
- Define Placement constraints
- Workload Customization
- Automation of Connectivity and Security

Tens of Thousands	Low thousands	Hundreds	Tens	few
@Cell	CO DC	Local DC	RDC	Public Cloud

DU	CU-CP	AMF, SMF	5GC Control	Analytics/ Training
	CU-UP	UPF	UPF	
	Inferencing	Inferencing		

Logical cluster

| | | Apps | Apps | Apps |
Logical cluster
Tenant X

| | | Apps | Apps | Apps |
Logical cluster
Tenant Y

No changes to helm charts/K8s description of applications

Each deployment may have its own customization

Connectivity intent provisioning
- *Enabling inter-micro service communication within or across clusters*
- *Enabling communication to external entitles*
- *With/Without Mutual TLS*
- *Multi Cluster DNS management*

Dynamic provisioning with LCM of Applications

Extensible framework to add new capability controllers

Requirements – Operations

Orchestrator

Cluster Provisioning	App/Service onboarding	Workload Customization	Continuous App monitoring
Tenant Provisioning	Define placement policies	Automation of connectivity and security	Analytics & Closed loop automation
Logical Cluster Provisioning	Define Placement constraints		Day2 Config Controllers

Tens of Thousands — @Cell
Low thousands — CO DC
Hundreds — Local DC
Tens — RDC
few — Public Cloud

Logical cluster

DU	CU–CP	AMF, SMF	5GC Control	Analytics/ Training
	CU–UP	UPF	UPF	
	Inferencing	Inferencing		

Logical cluster

	Apps	Logical cluster	Apps	Tenant X
	Apps	Logical cluster	Apps	Tenant Y

Continuous monitoring of complex Application (Across clusters, apps and micro-services)

Comprehensive report on the application status

Analytics framework
- *Metric collection across clusters & apps*
- *Long term central store (Time Series)*
- *Training framework*
- *Closed loop policy management*

Day 2 Configuration
- *Configuration of apps/network-functions that are already deployed.*
- *Various types of configurations (CR based, RESTful based or Netconf/yang based)*

KubeEdge

- Manage Smart/IoT Devices at the Edge, massive amount of devices

- Data Storage and Processing on Edge
  - Real time decision making
  - Data Stored at the edge

- Network connectivity Challenges

- Limited resources edges

- Remote Node Architecture

- Optimized Node components

- Websocket based communication with the Edge Nodes

- Device Modelling

- Edge Mesh

- Scheduling based on Pod labels
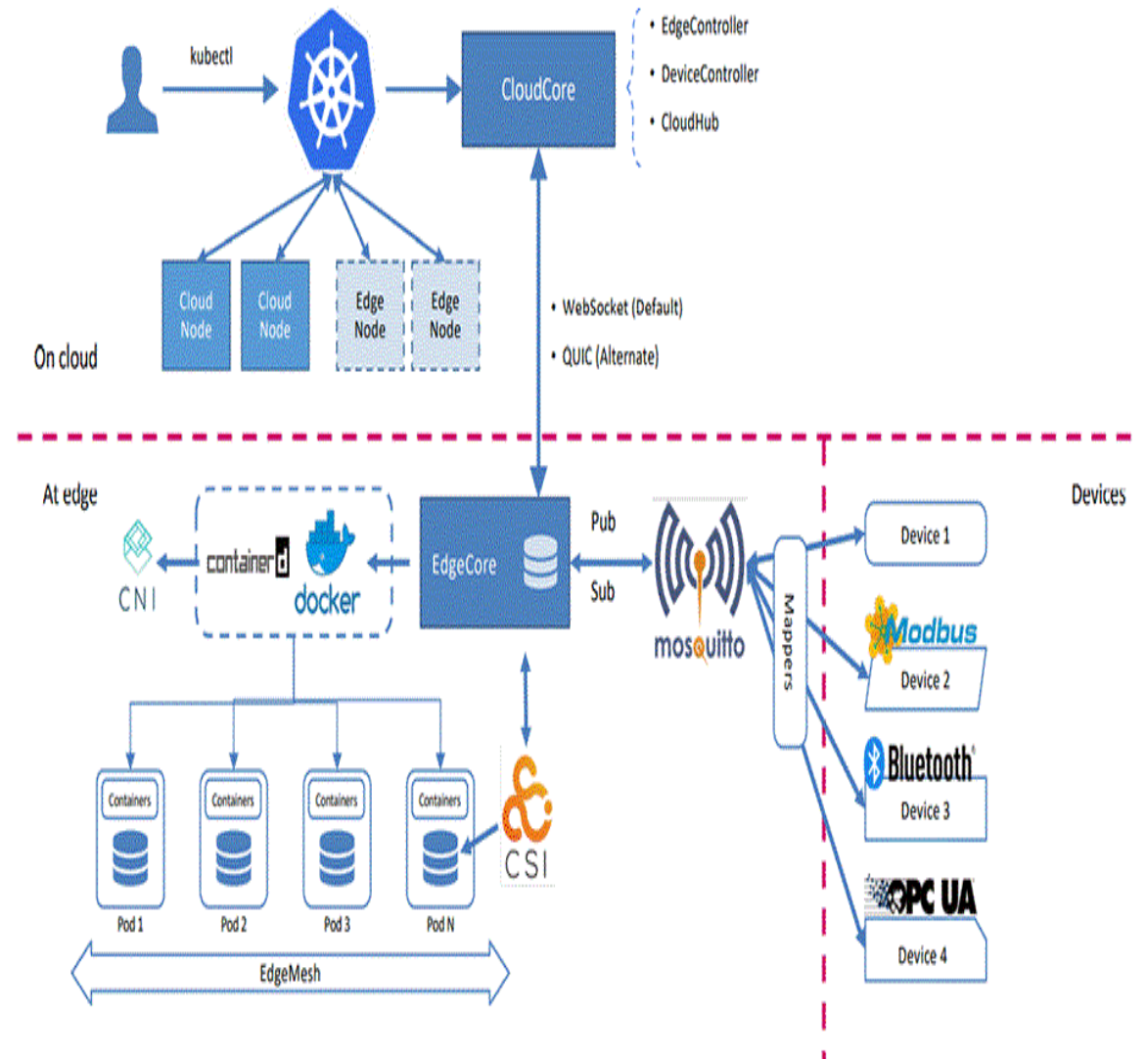
Deploy App to Edge Node
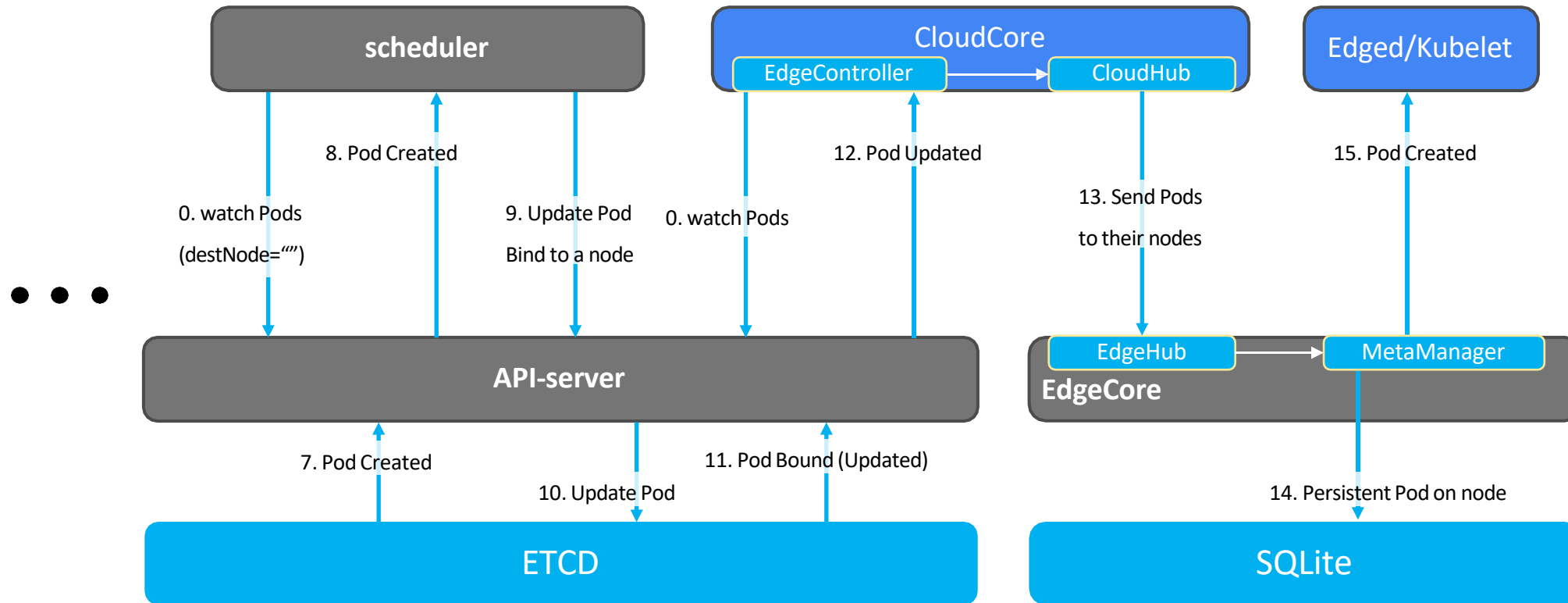
Argo CD Application Sets

- Deploying various Application sets in different K8s clusters

- Argo CD supports deploying multiple applications to multiple clusters using Application Sets

- Changes made to the parent ApplicationSet are automatically applied to all the child Argo CD Applications

- The ApplicationSet controller is responsible for reconciling the ApplicationSets

- The controller generates one or more Application, based on the contents of the template field of the ApplicationSet

- Dependencies management within an app is available

- Uses templates and Generators
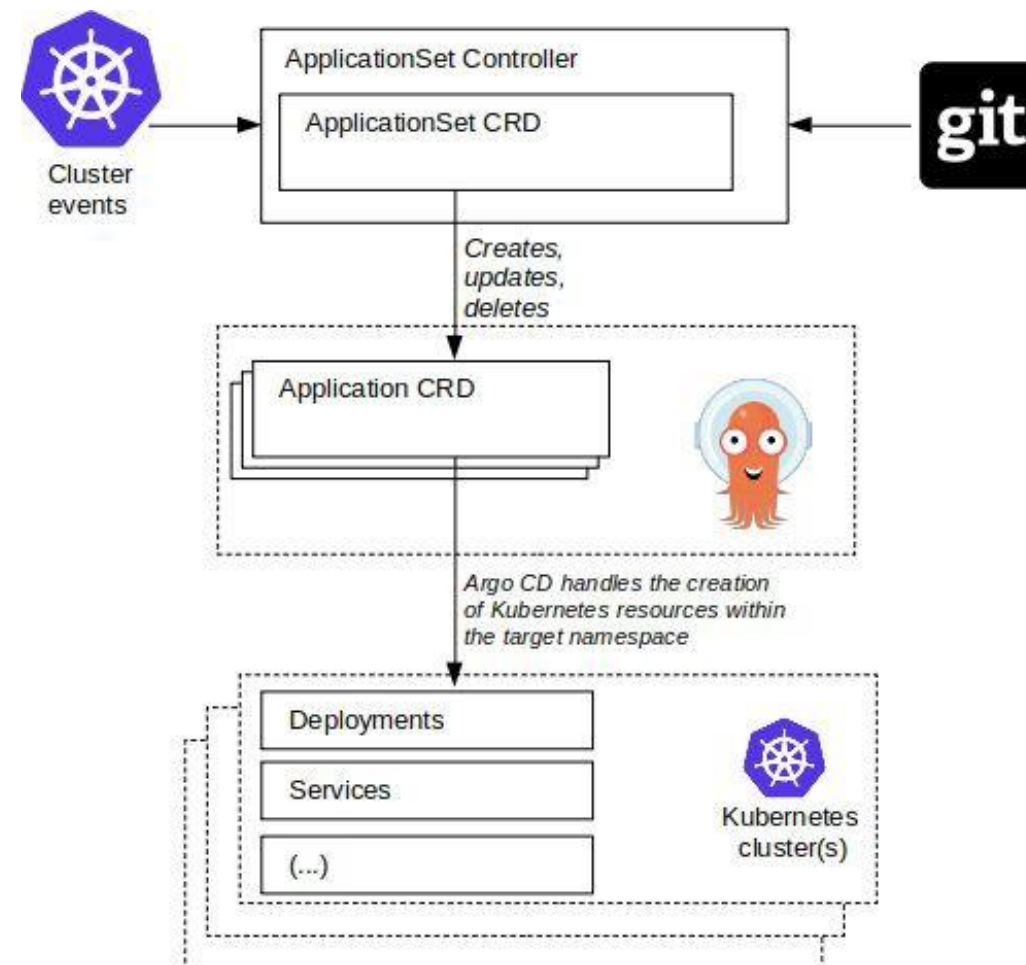
Karmada

- Open, Multi-Cloud, Multi-Cluster Kubernetes Orchestration

- Continuation of the Kubernetes Federation project Kubefed

- Supports deploying multiple applications to multiple clusters

- Cluster mapping policies - Propagation Policy

- Override policies

- Placement is based on cluster affinity and cluster taints/tolerations like node/pod taints/tolerations.

- Multi-cluster Application connectivity

Karmada
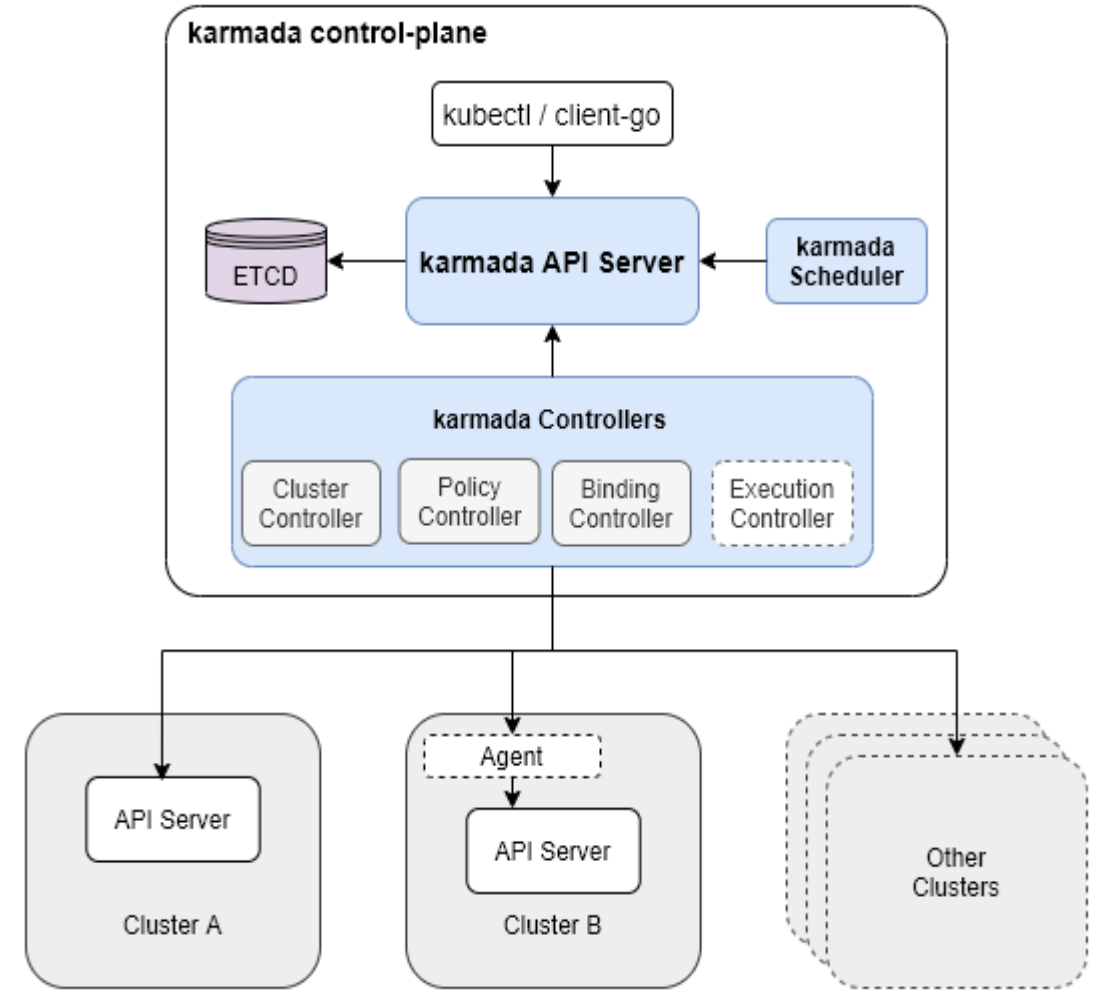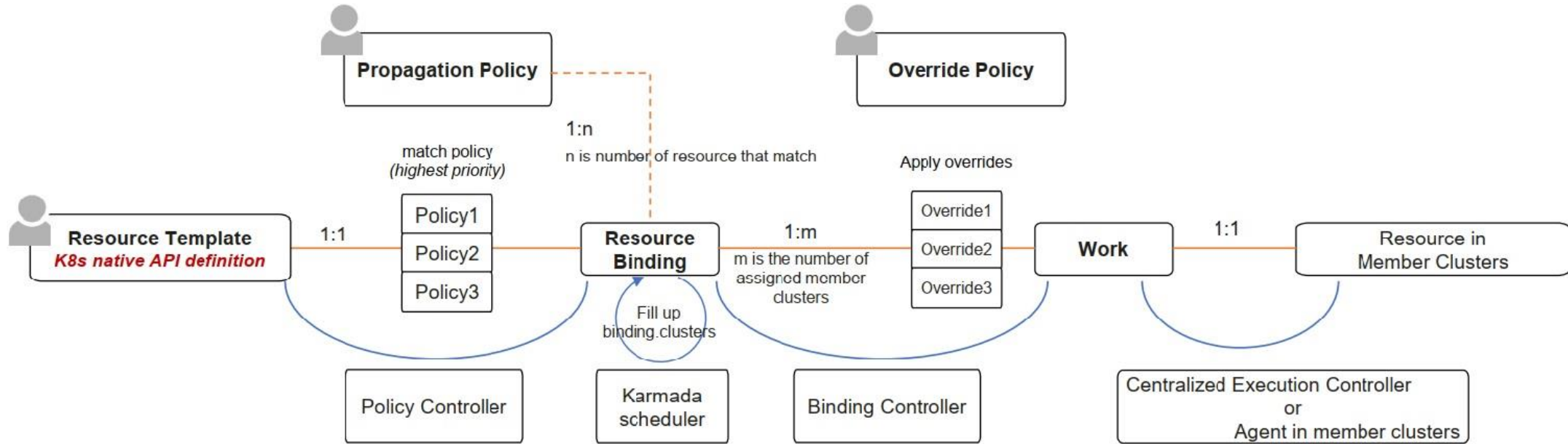
Edge Multi Cluster Orchestrator (EMCO)

- Linux Foundation Networking project project-emco.io
- Intent based architecture
- Various edge locations, cloud/on-prem DCs
  - Support clusters in Public cloud, on-prem or edge
  - GitOps based cluster support
- Highly extensible with in-tree or 3rd party controllers
- Intelligent selection of clusters to place the workloads
- Tenant Isolation using logical clouds
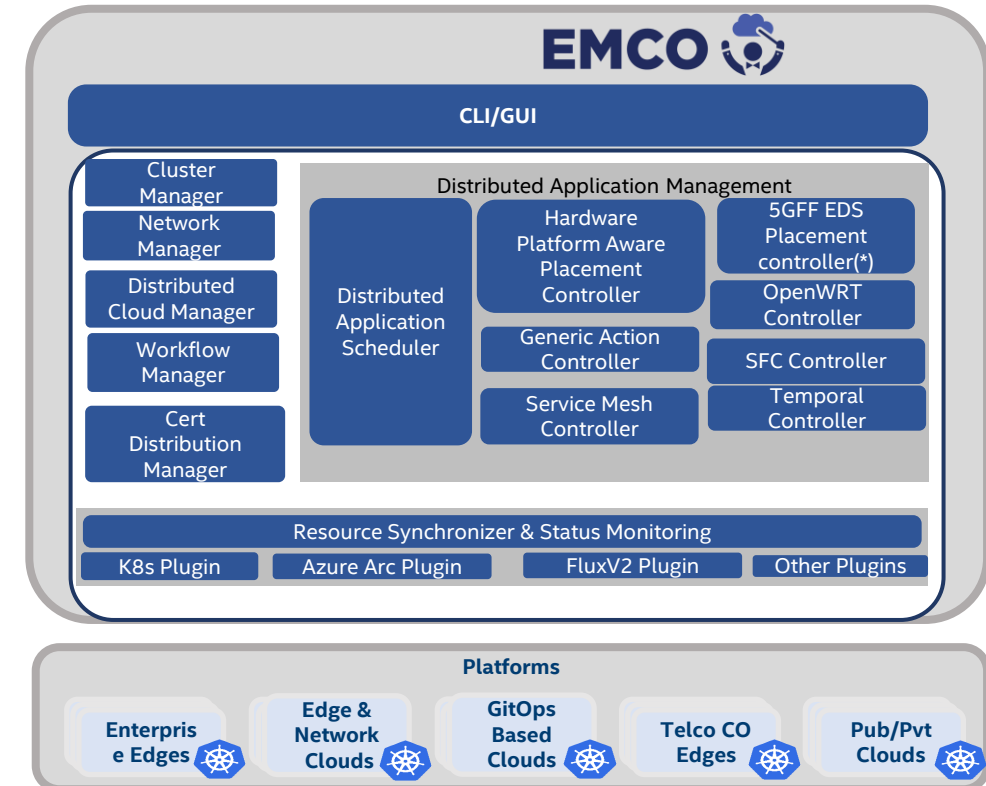
Edge Multi Cluster Orchestrator

- Customization of resources in the applications based on clusters

- Comprehensive consolidated status monitoring across clusters

- Automation of service mesh and other connectivity & security infrastructure

- Traffic controllers - Istio Controller for mTLS based cross cluster communication

- Dependency and order of priority of application deployments between clusters

- Update and Rollbacks

- Temporal Workflow Engine Support
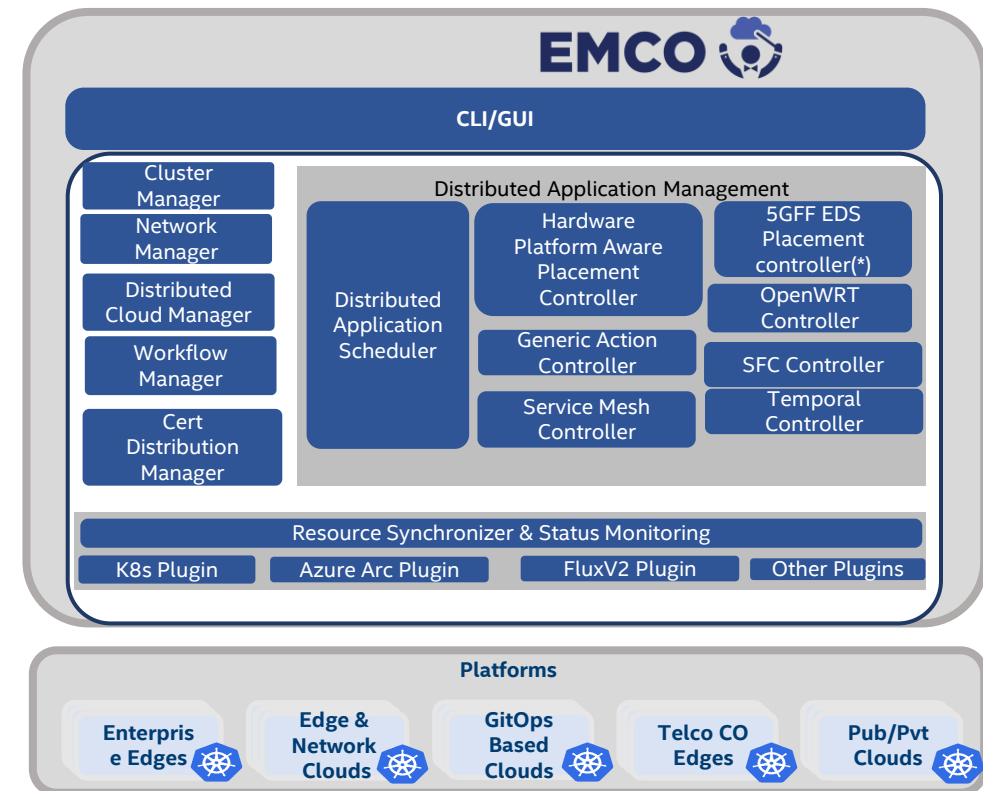
Use cases with EMCO

- 5GC
- Edge Application Relocation
- SASE
- Any Edge Computing application
- Distributed apps spread across multiple clouds and multiple edges
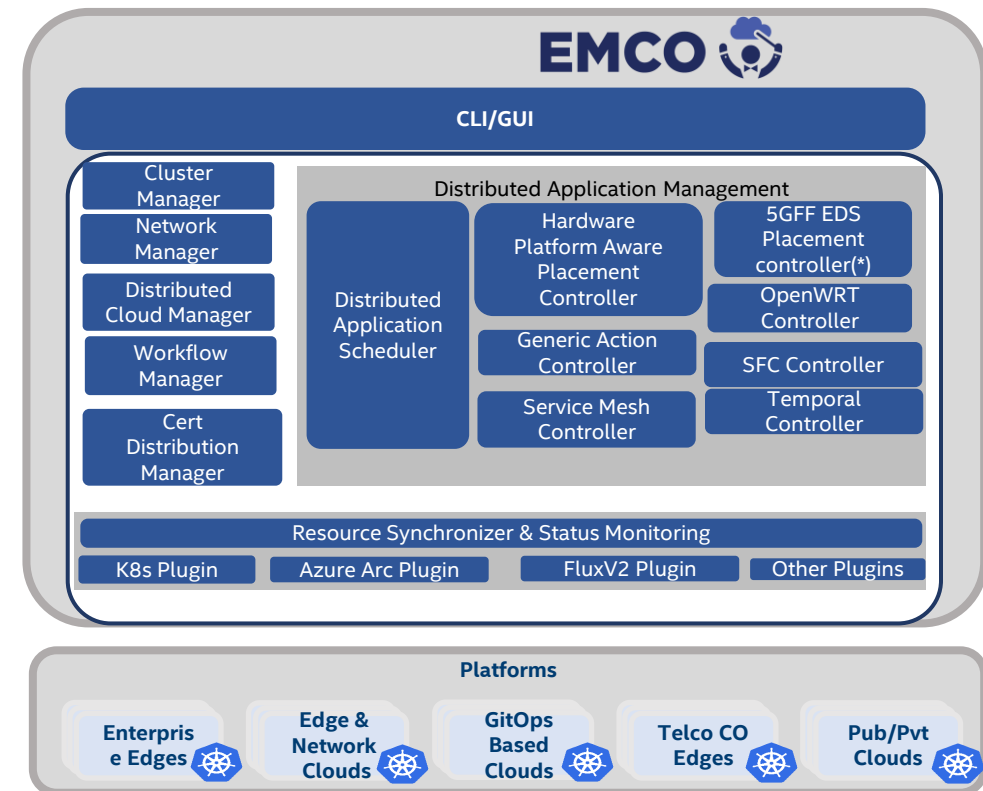
Summary

- Many solutions

- EMCO meets many multi-cluster requirements

- Dynamic application orchestrator along with application automation of infrastructure services

- Selection of Kubernetes cluster matching with various criteria

- Fleet deployment of applications with auto customization based on cluster capabilities

Q&A