Networking, Load Balancing, and Security

INTRODUCTION TO KUBERNETES

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More on Labels and Selectors

Labels:

- Key/Value pairs attached to Kubernetes objects like Pods or Nodes
- Can be used to organize subsets of objects
- Can be modified at any time
- Examples:
 - environment: prod
 - o app: my_cool_app
 - o has_GPU: true

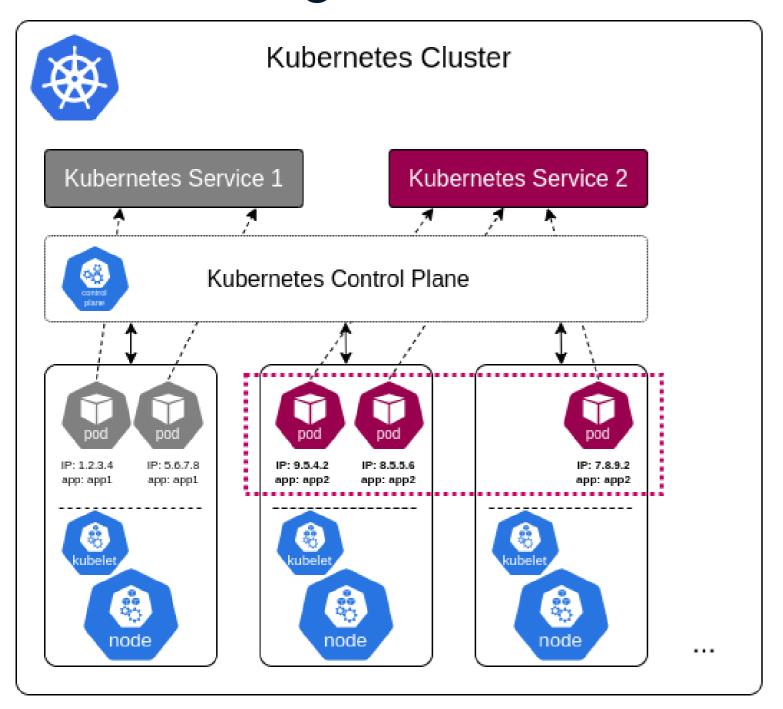
Selectors:

- Can be used to identify objects via labels
- Examples:

```
selector:
    environment: prod
    app: my_cool_app
o ...
```

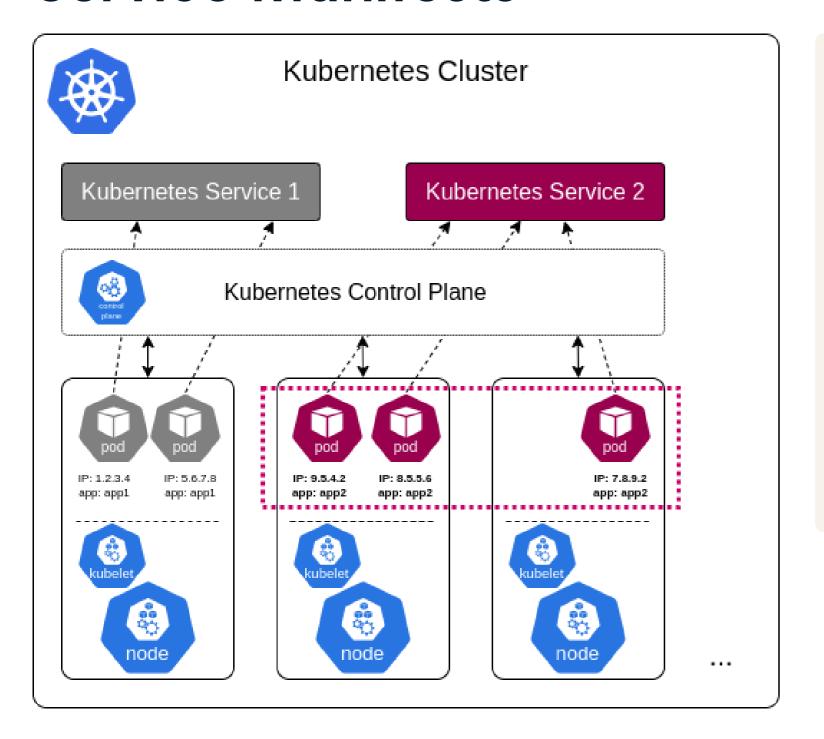
```
nodeSelector:
   has_GPU: true
...
```

Networking and Services



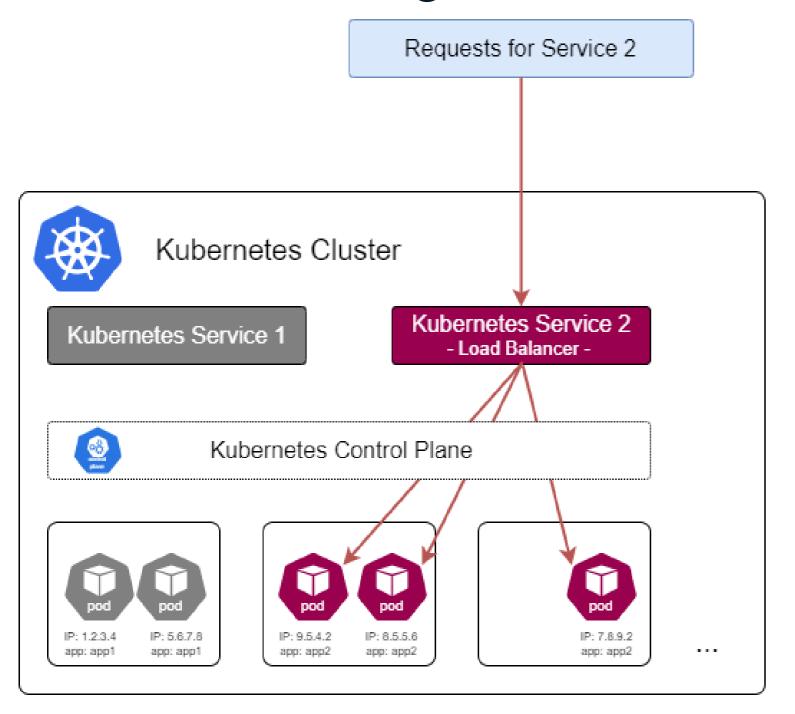
- Each Pod gets its own cluster-wide IP (internet address)
- Can be used for communication between Pods
- Not very useful, as Pods can restart at any time, and will get a new IP
- Services are used to attach Pods to, and offer stable connectivity

Service Manifests



```
apiVersion: v1
kind: Service
metadata:
  name: Kubernetes_Service_2
spec:
  type: ...
  selector:
    app: app2
```

Load Balancing



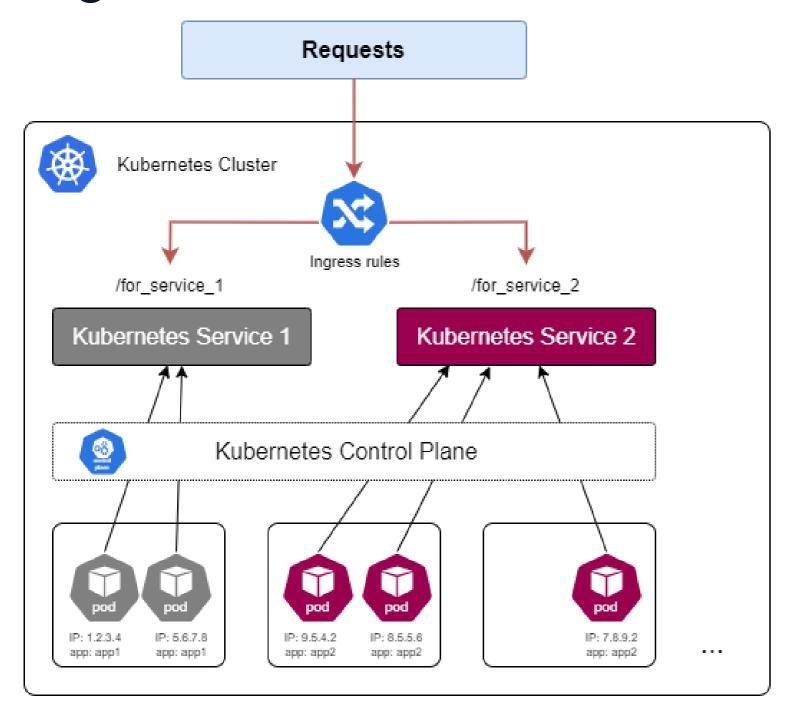
- A load balancer in Kubernetes distributes load over Pods
- Avoids uneven load on resources, increases efficiency and lowers response times
- Example:
 - providing a service from multiple Pods
 - load balancer will distribute load evenly to Pods

Load Balancing in Kubernetes

```
apiVersion: v1
kind: Service
metadata:
  name: <service name>
spec:
  type: LoadBalancer
  selector:
    <key1>: <value1>
    <key2>: <value2>
```

- Load balancers are typically pre-configured by Kubernetes Provider (Cloud Provider)
- No need to declare additional manifests for a load balancer - will automatically be created and attached to the service

Ingress



- Ingress objects are used to route HTTP and HTTPS requests (traffic) from outside the cluster to services in the cluster
- Ingress rules define which requests are served by which service
- Typically used in combination with load balancing

Kubernetes Security

- Security in modern IT architectures is an extremely important, but complex field with many facets
- Kubernetes has all necessary components to secure applications running on it, e.g.
 - the "Secret" API for confidential objects like passwords, tokens, keys etc.
 - tools and APIs to enable encrypted network communication
 - methods for authentication of users
 - role-based and attribute-based access control ("RBAC" and "ABAC")

Let's practice!

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Data Pipelines on Kubernetes

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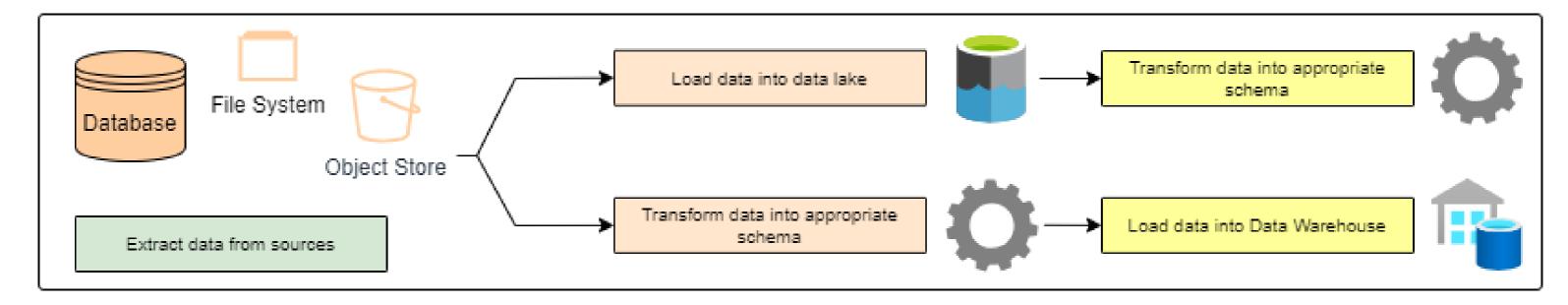
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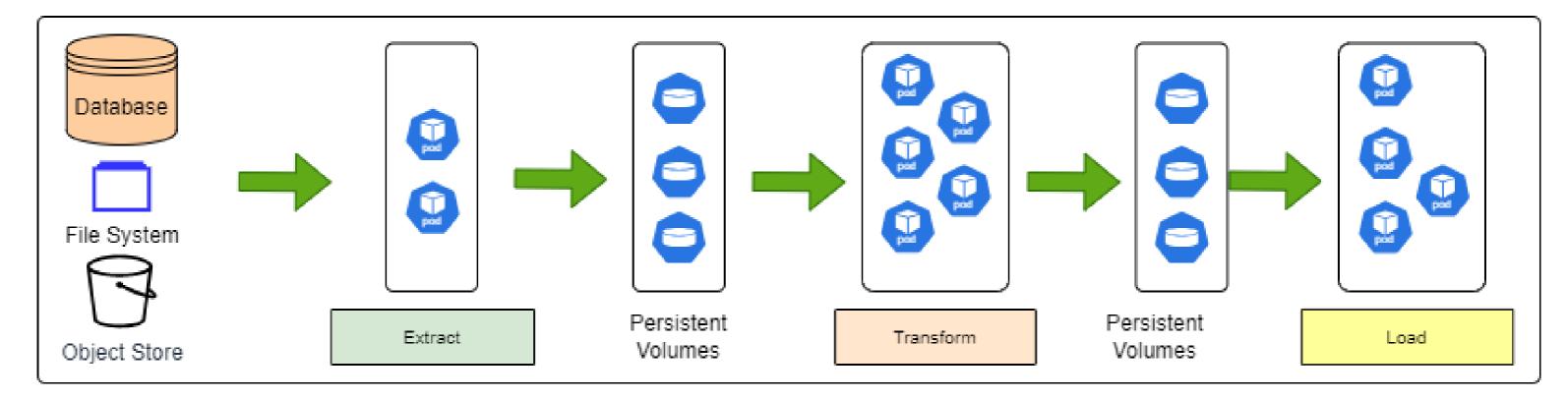
What are Data Pipelines?

- Set of processes to move, transform, or analyze data
- Typical steps:
 - ETL: Extract data from various data sources, then Transform into a meaningful schema, finally Load into a target data sink (e.g., a data warehouse)
 - ELT: Extract data from various data sources, then Load into a target data sink (e.g., a data lake), finally Transform data into meaningful schema when needed



Data Pipelines on Kubernetes

- The steps of a data pipeline map nicely to Kubernetes objects:
 - Extract, Transform, Load steps: Pods (Deployment or StatefulSet)
 - Extracted and Transformed Data: Persistent Volumes
- Kubernetes can scale out Deployments and Storage as required, hence increase throughput



Open-Source Tools for Data Pipelines

- Many open-source software exists that is readily deployable on Kubernetes
- Some examples:
 - Extract: Apache NiFi, Apache Kafka with Kafka Connect
 - Transform: Apache Spark, Apache Kafka, PostgreSQL
 - Load: Apache Spark, Apache Kafka with KSQL, PostgreSQL
 - Storage on top of PVs: Minio, Ceph
- This list is by no means complete

Let's practice!

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MLOps on Kubernetes

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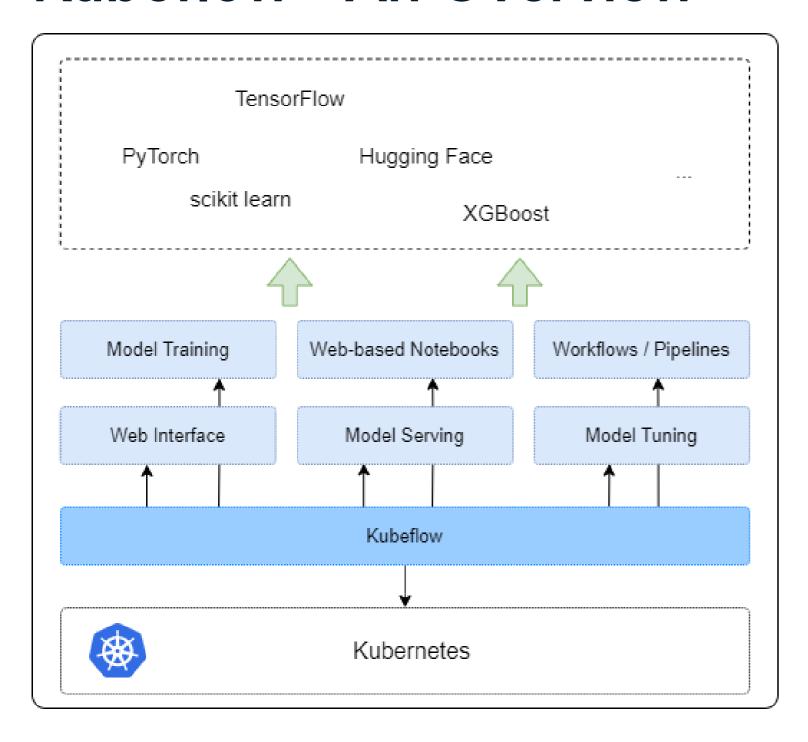
What is MLOps?

- A paradigm to deploy and maintain machine learning models in production
- A set of best-practice workflows with focus on continuous development of such models
- Inspired by DevOps:
 - Machine learning models are developed and tested in isolated experimental systems, and then deployed to production
 - When in production, continuous monitoring; retraining may be triggered
- Data scientists, data engineers, and IT teams can work on deployed models synchronously and ensure model accuracy

Implementing MLOps on Kubernetes

- The MLOps paradigm maps very well to Kubernetes:
 - Isolated experimental systems: can be realized via Pods and Kubernetes Storage
 - Monitoring production ML models: enabled via lifecycle of Pods (and deployed image versions)
 - Synchronous work on model accuracy: built in from the very beginning by Kubernetes architecture
- Several frameworks for MLOps exist; the two best-known open-source solutions are
 - o mlflow
 - Kubeflow

Kubeflow - An Overview



- Kubeflow allows simple deployments of ML workflows specifically on Kubernetes
- Covers each step of the ML model lifecycle
- Consists of several components which cover these steps, working independently
- Python can be used to develop and deploy ML models via an API
 - no need to use kubectl

Let's practice!

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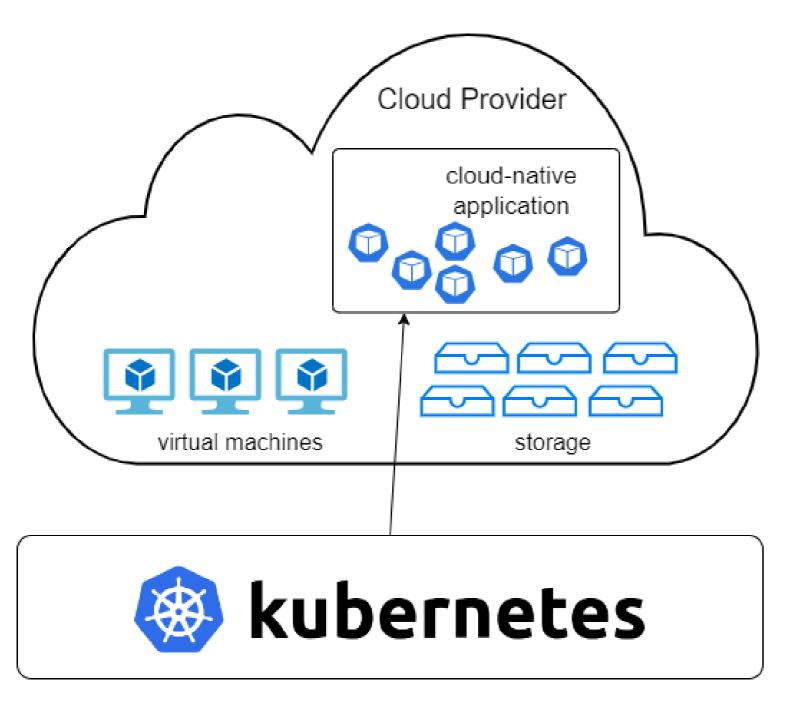
Wrap-Up INTRODUCTION TO KUBERNETES

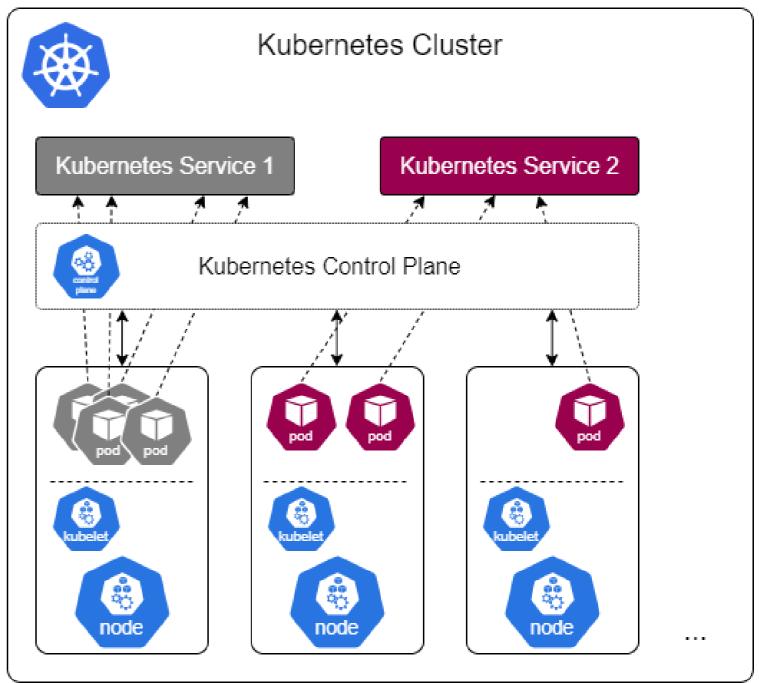


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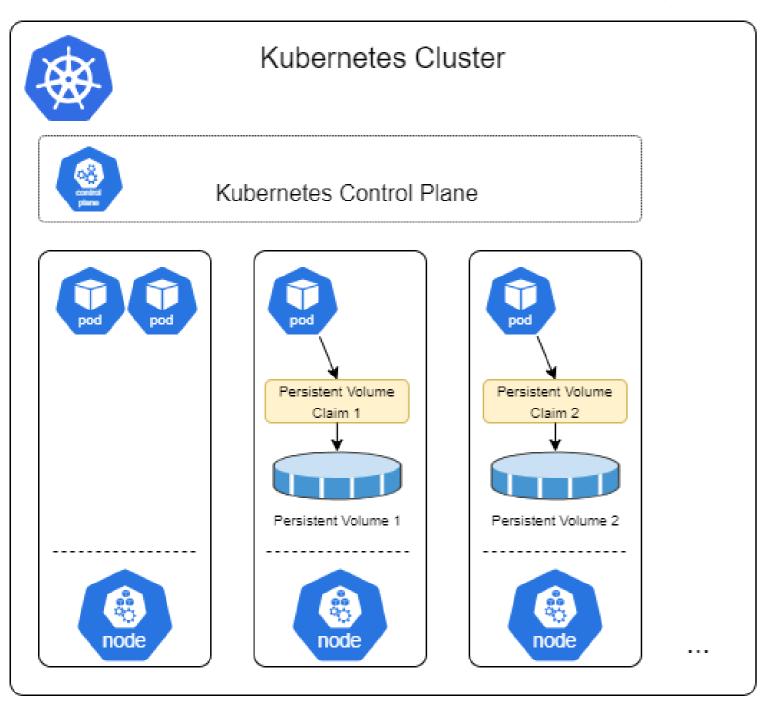


What we have learned (1/2)



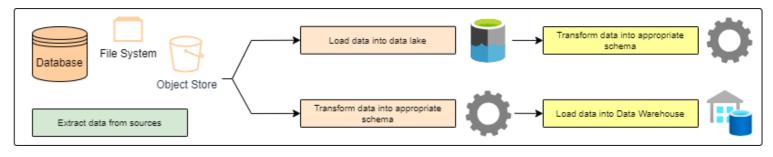


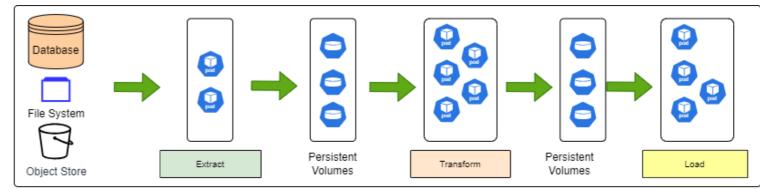
What we have learned (2/2)



kubectl apply ...

apiVersion: apps/v1
kind: Deployment
metadata:
 ...
spec:
 ...





Where to go from here

- Security for cloud-native applications: Service Accounts, Secrets, RBAC, etc.
- Packaging and application lifecycle: Helm Charts and Kubernetes Operators
- Advanced storage concepts: Rook Operators and Ceph
- CI/CD
- Serverless applications: KNative

Thank You!

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