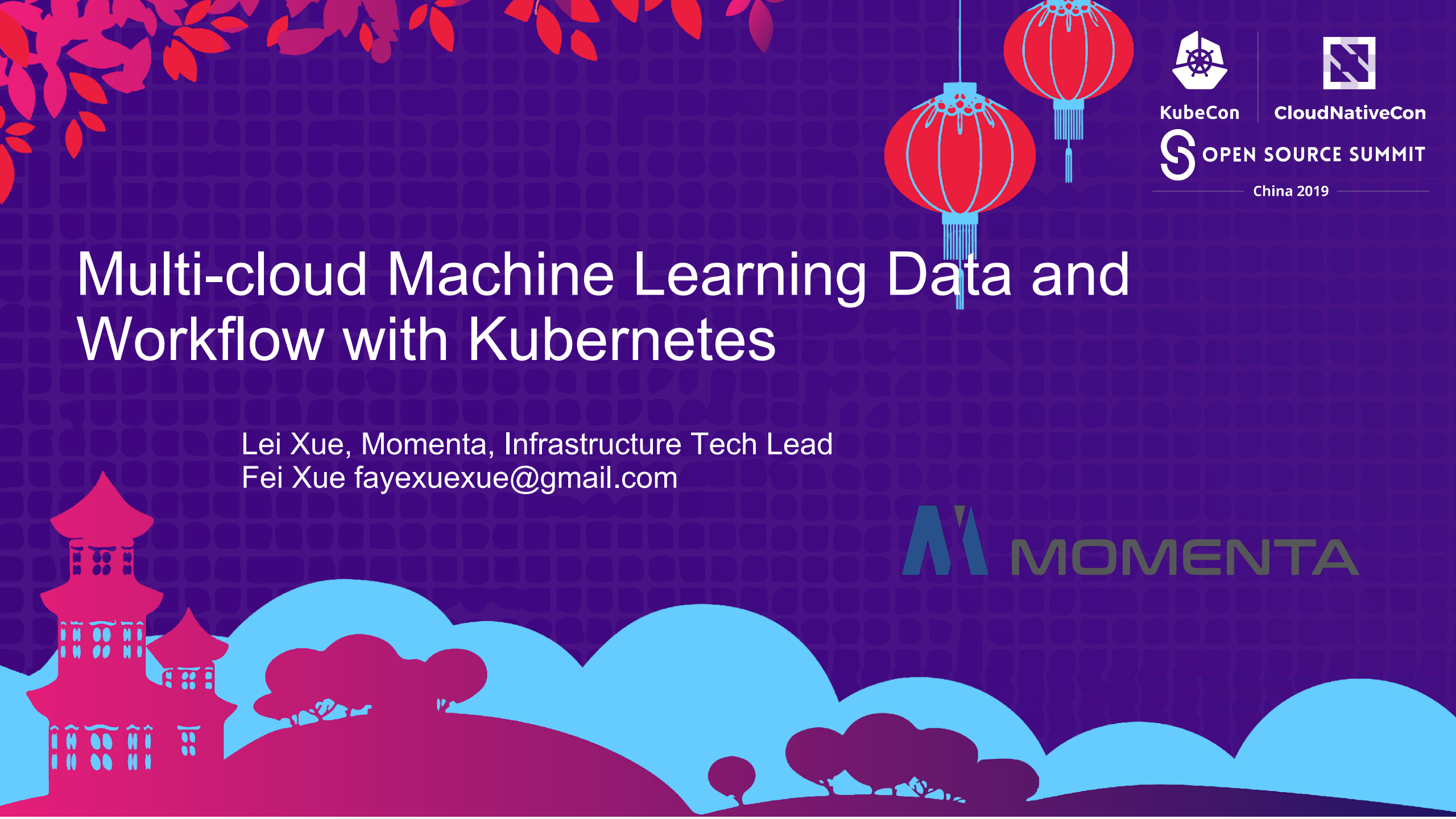

KubeCon
CloudNativeCon
OPEN SOURCE SUMMIT
China 2019



Multi-cloud Machine Learning Data and Workflow with Kubernetes

Lei Xue, Momenta, Infrastructure Tech Lead
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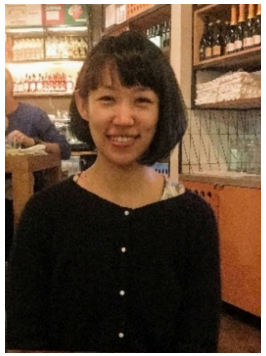
MOMENTA

About Us

Lei Xue

- Infrastructure Tech Lead of Momenta
- Contributor of KubeFlow
- Creator of KubeFlow Caffe2 operator
- Maintainer of Kubernetes RDMA device plugin
- Current Interest: AI infrastructure, Storage



Fei Xue

- Early member of the KubeFlow team at Google
- Interests: ML infrastructure, distributed systems

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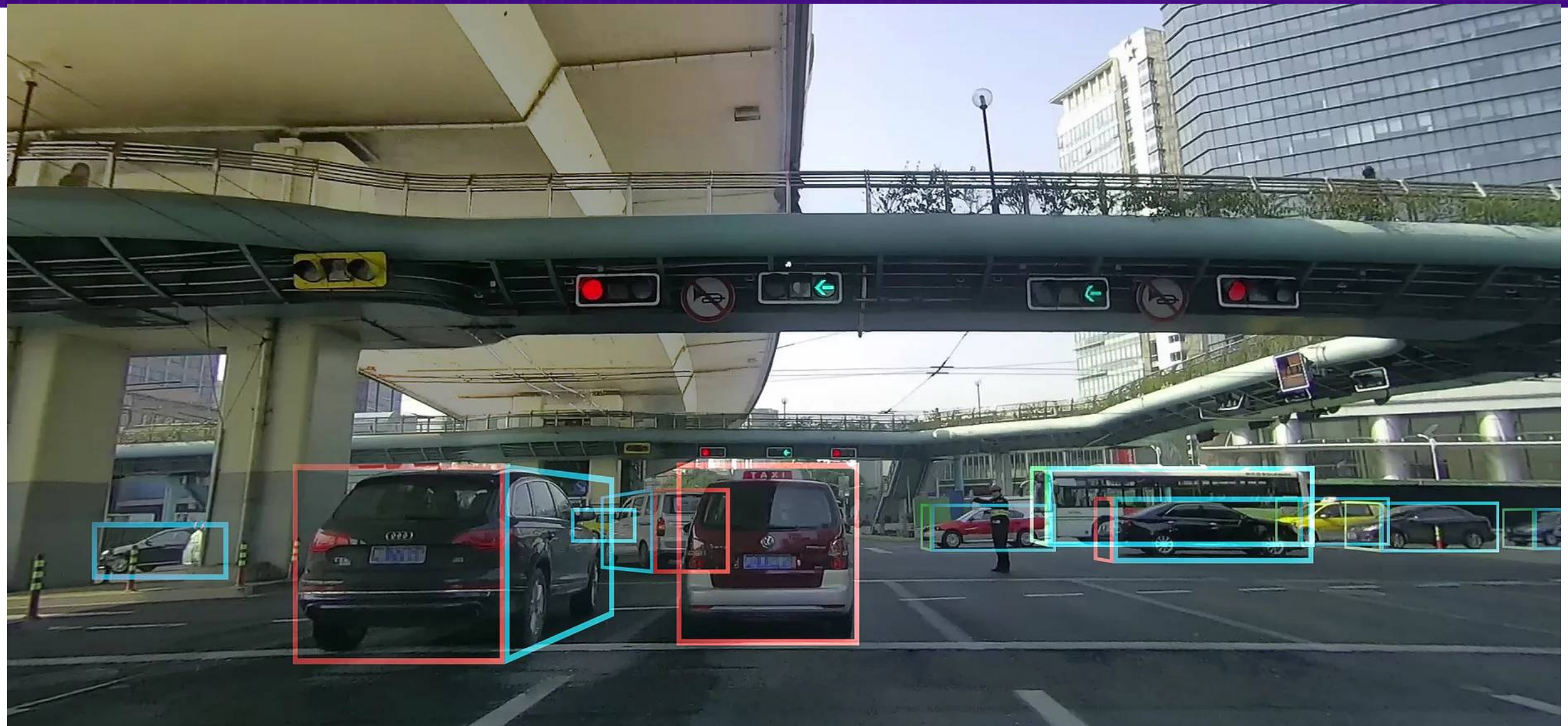
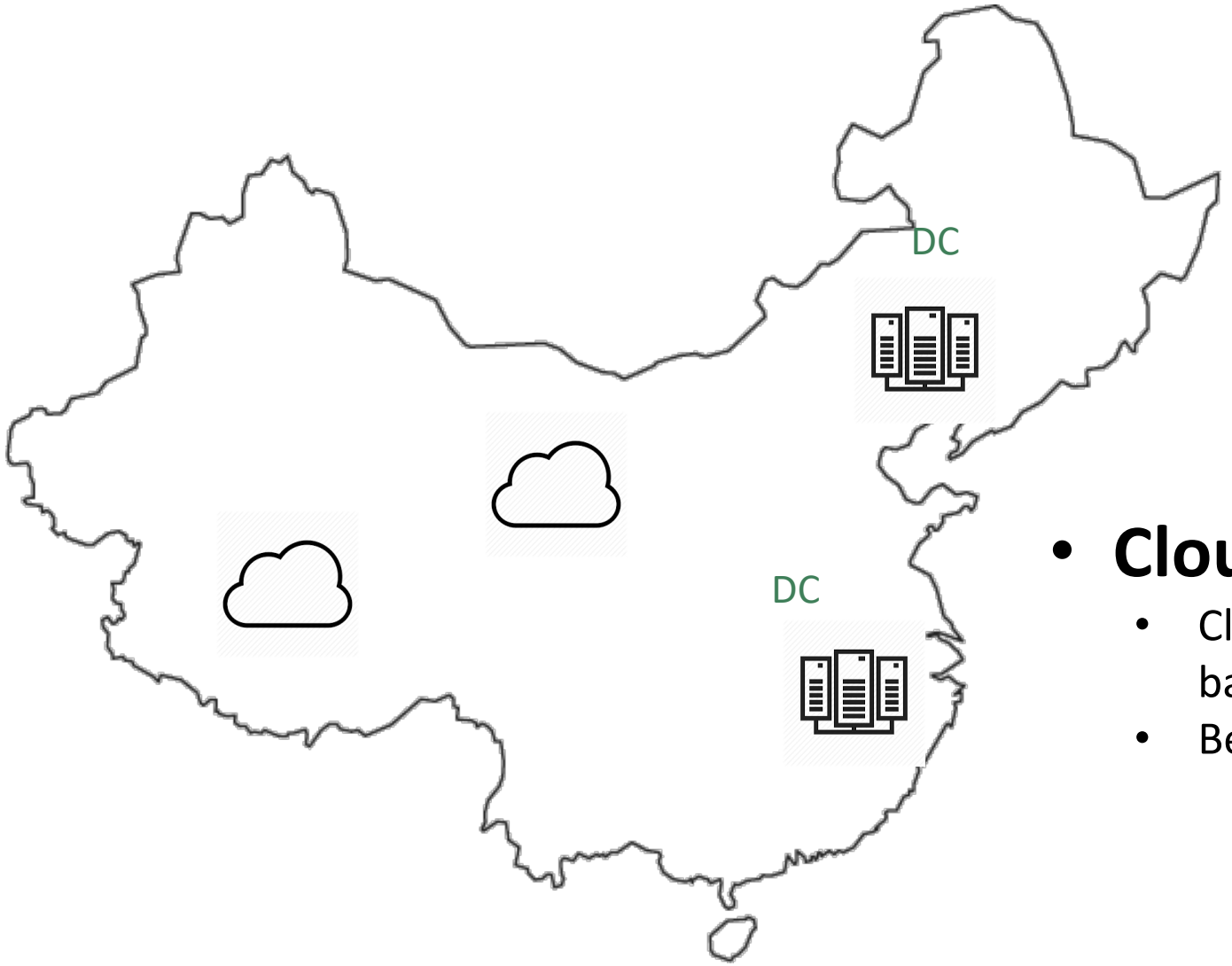
ML-enabled Self-driving



Why Kubernetes for ML?

Portability
Scalability
Isolation

Why multi/hybrid-cloud?

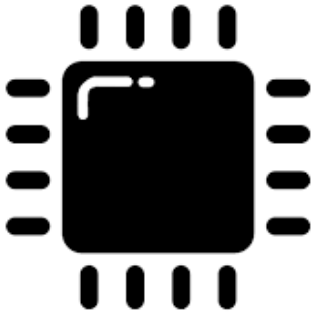


- **On-prem**
  - Built DCs around 2016
  - Customized CPU/memory/network
- **Cloud**
  - Cloud vendors provided stronger GPU/high bandwidth network
  - Better scalability and infrastructure

Multi-Cloud ML Challenges

Data Management

Workflow Orchestration



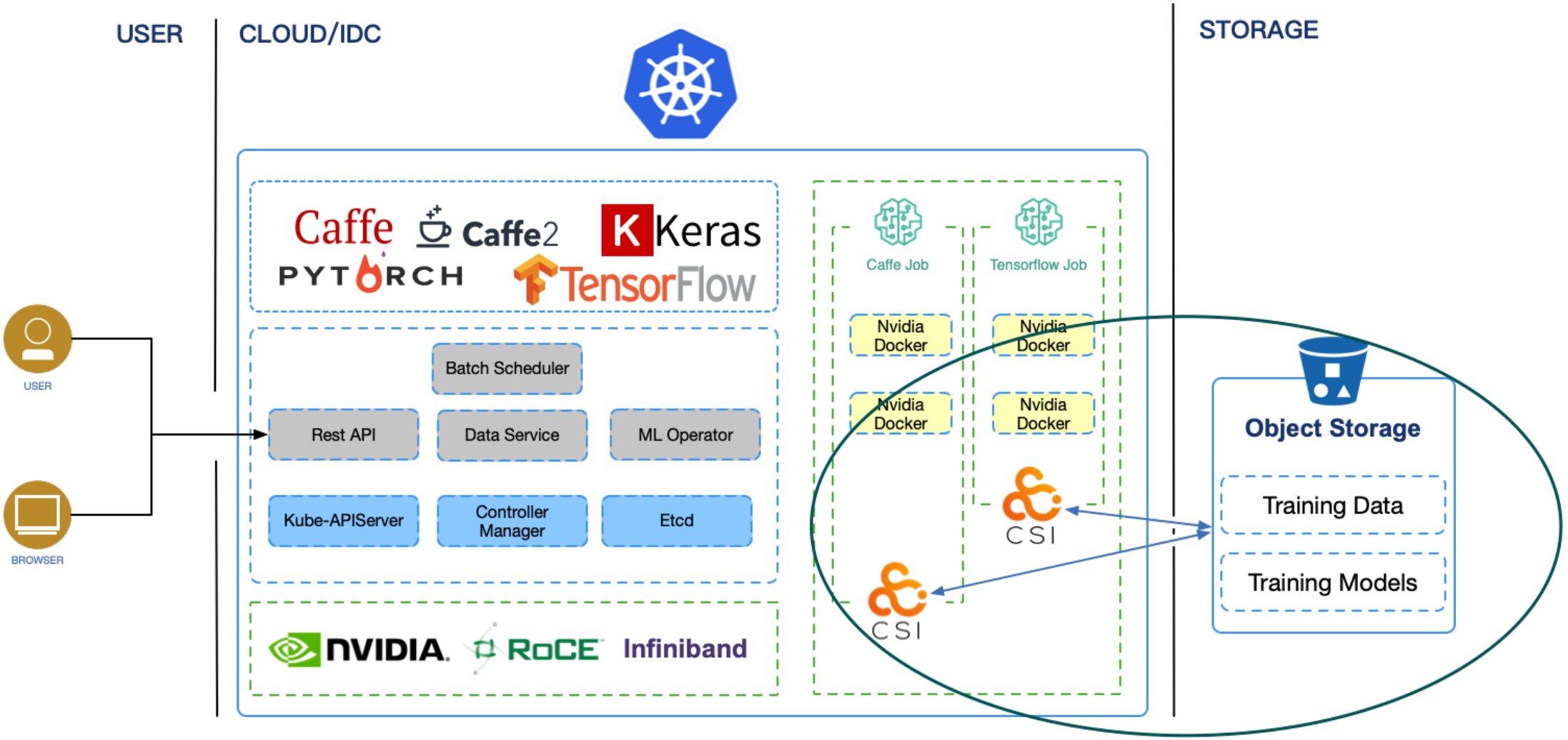
Heterogeneous Hardware

Challenge #1 Data Management

Data Management Challenges

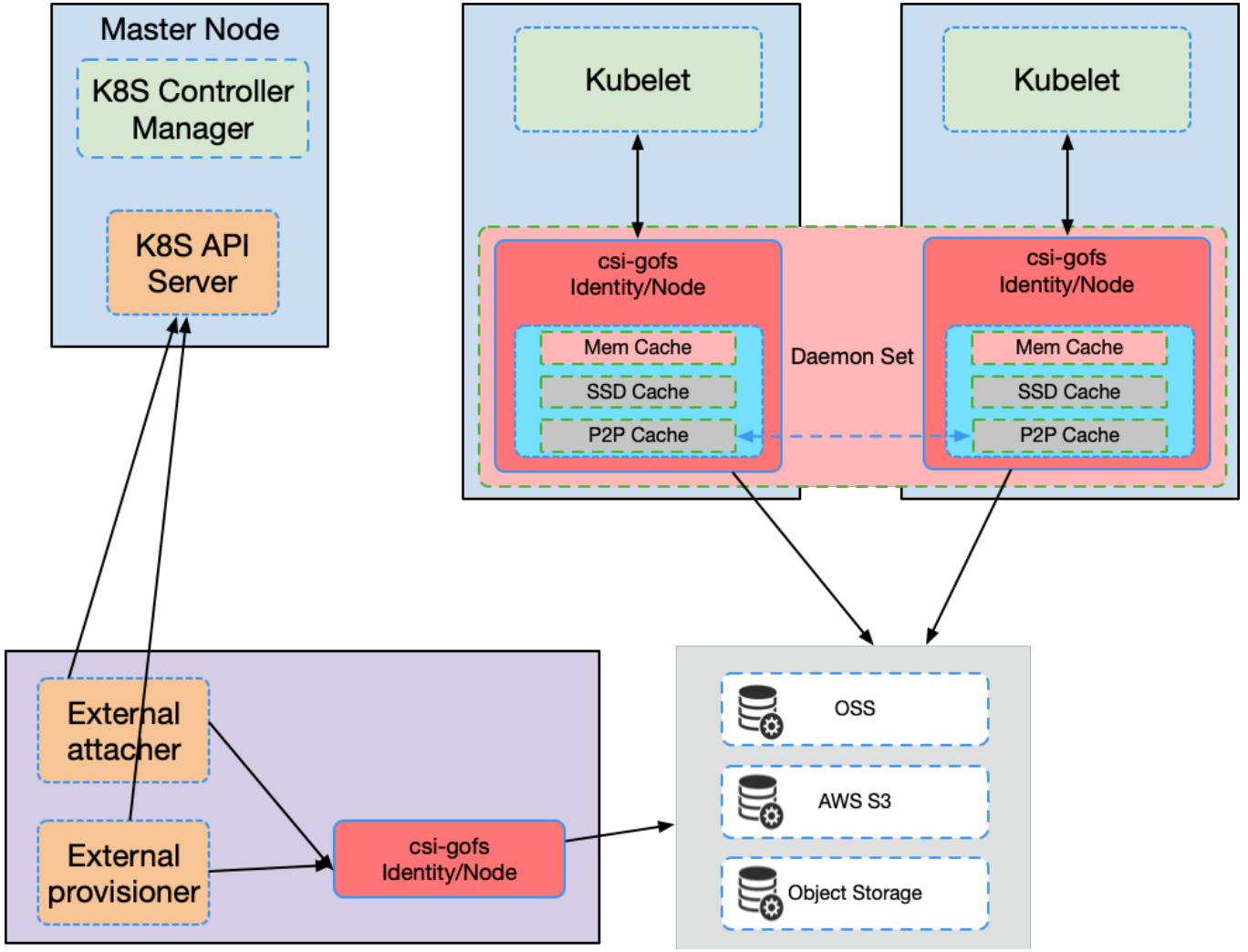
- Data is critical in deep learning use cases
- Copying data among multiple DCs and cloud regions is a huge pain
- Training job each
  - consumes images in the 10M~
  - Image size 16KB – 5MB
- Typical large-scale small file access problem
  - High requirement for read latency
  - No modification needed to files
- CephFS and NFS are easy to use for training
  - Both CephFS and NFS can be mounted by multiple readers
  - Both of them are “in-tree” in Kubernetes main repository
  - However, it is hard to customize for AI training

Architecture at Momenta



Data Service - CSI

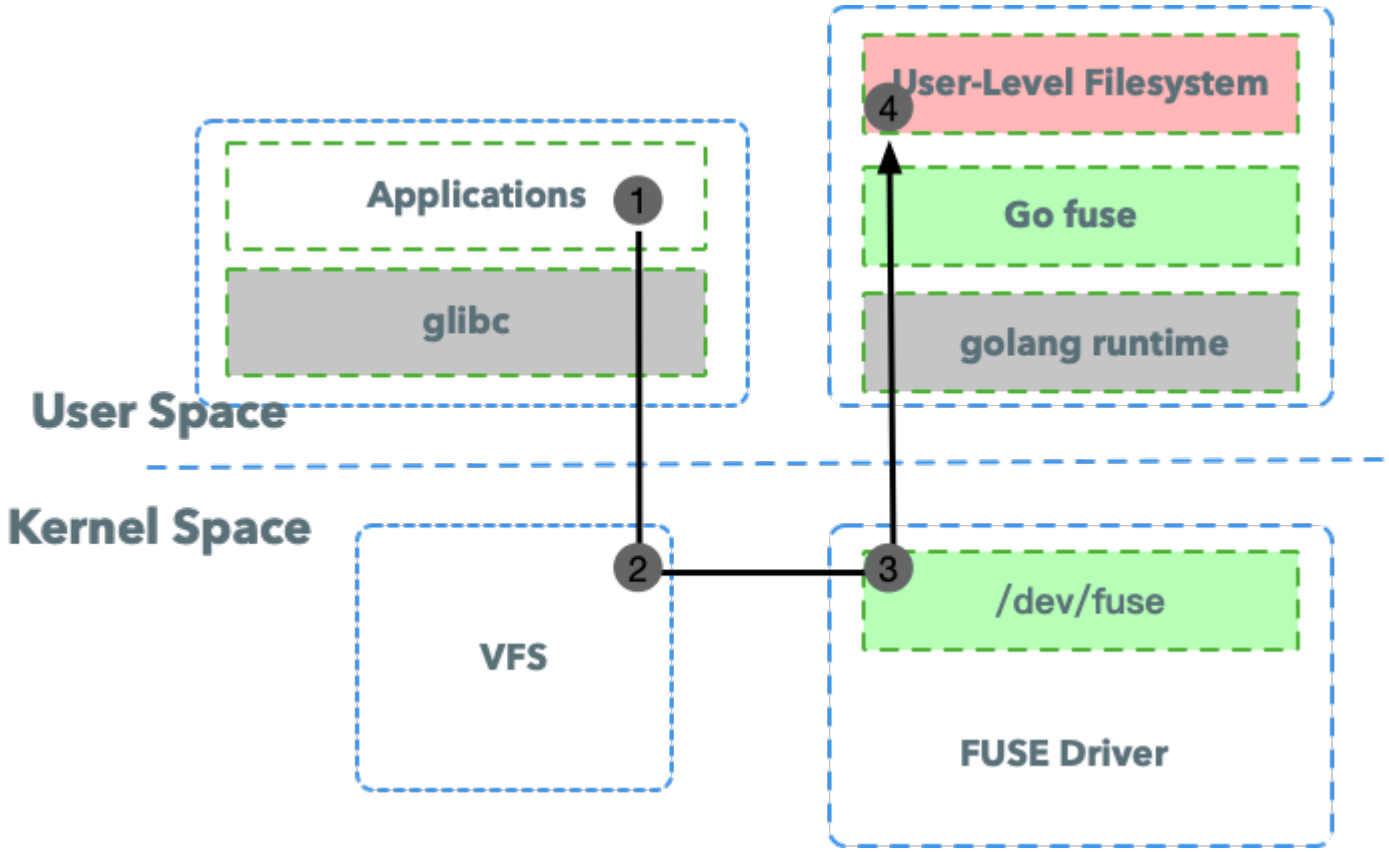
expose storage systems in K8s
GA in v1.13



Data Service - fuse

FUSE (Filesystem in Userspace) is an interface for userspace programs to export a filesystem to the Linux kernel. The FUSE project consists of two components:

- *fuse* kernel
- *gofuse* userspace library: gofuse provides the reference implementation for communicating with the FUSE kernel module.



Data Service – Cache for AI/ML

NR (Not Replacement)

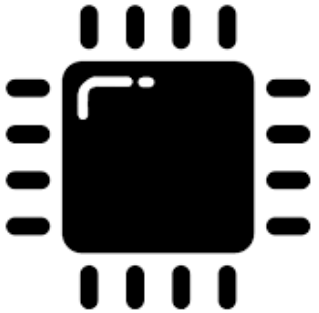
- The dataset of AI/ML are always bigger than memory
- The dataset will be read to process for each epoch
- NR will keep the hit ratio for each epoch

Size(GB) / Policy	10	50	100	160	200
Radom	0~6.25	0~31.25	0~62.5	100	100
LRU	0~6.25	0~31.25	0~62.5	100	100
FIFO	0~6.25	0~31.25	0~62.5	100	100
NR	6.25	31.25	62.5	100	100

Multi-Cloud ML Challenges

Data Management

Workflow Orchestration



Heterogeneous Hardware

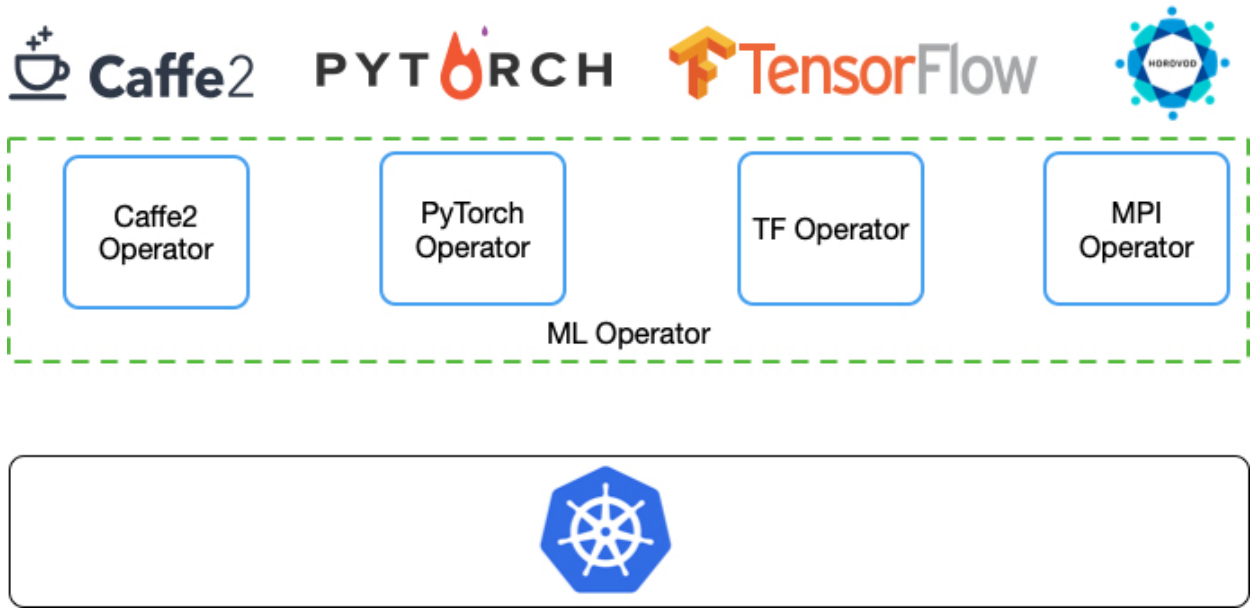
Challenge #2
Machine Learning Workflow Orchestration

ML Operator

A Machine Learning Operator is a method of packaging, deploying and managing Machine Learning task on a Kubernetes cluster.

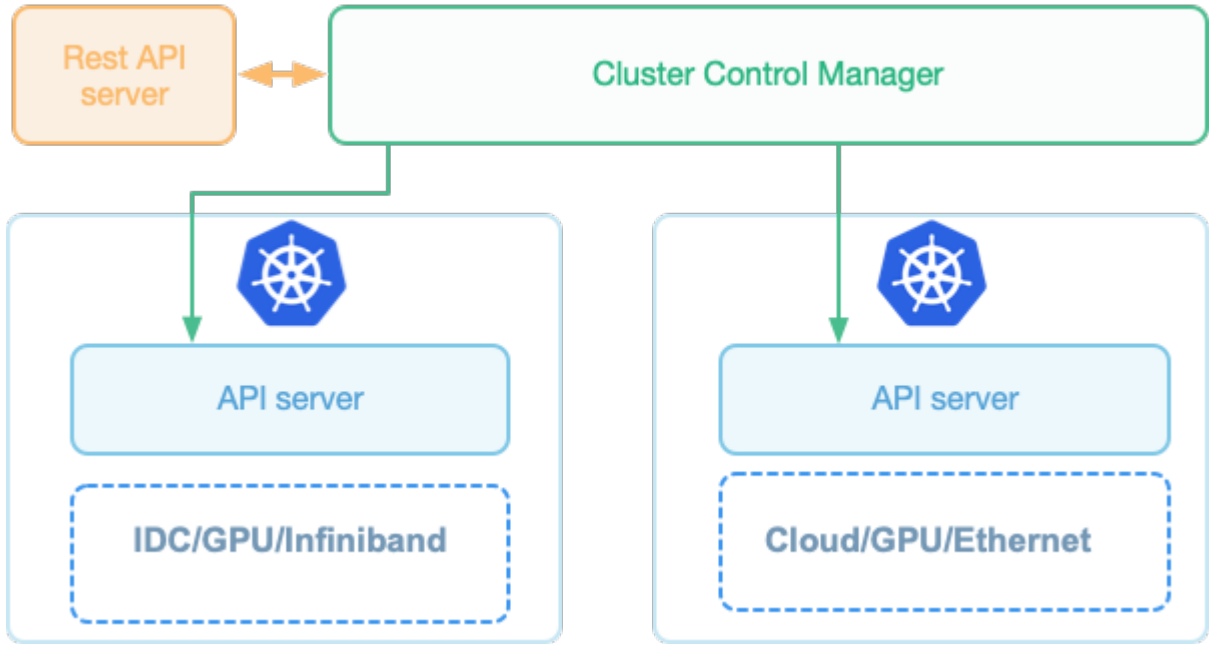
Multiple levels of distributed training
- single node
- multiple node - parameter server/worker
- multiple node with GPU - mpi

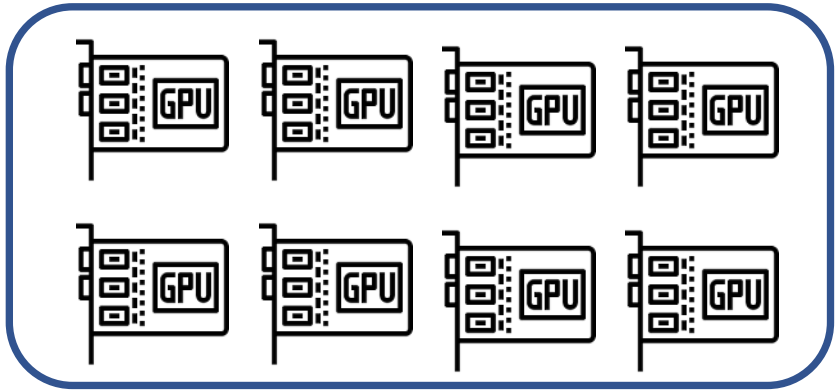
Support multiple training frameworks:
- TensorFlow
- PyTorch
- Caffe & Caffe2
- Horovod

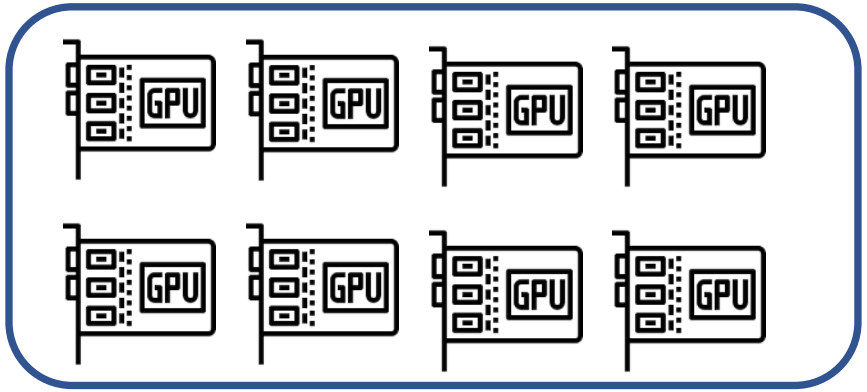


Multi-cluster management

- **Why Multi-cluster?**
  - Single-points of failure
  - Highly customized hardware in our IDC
  - Scaling in the Cloud
- **Sync resources across clusters**
  - Job lifecycle
  - Node Resource
- **Why not federation?**







My job acquired 8 GPUs and needs 8 more

My job acquired 8 GPUs and needs 8 more

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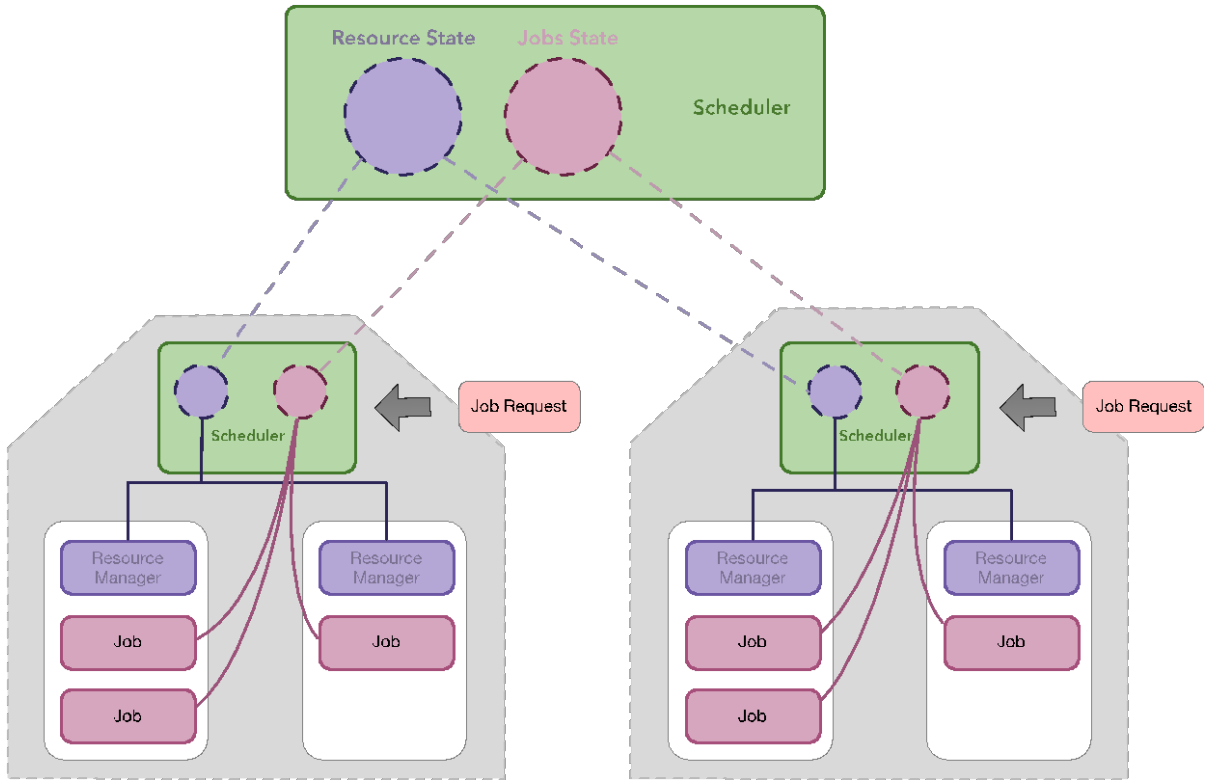
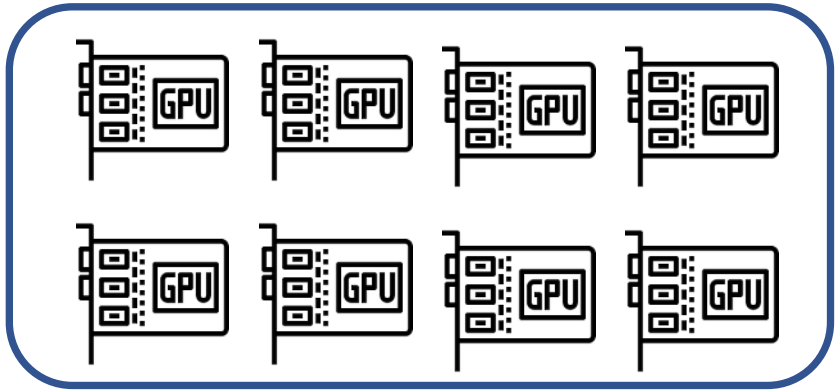
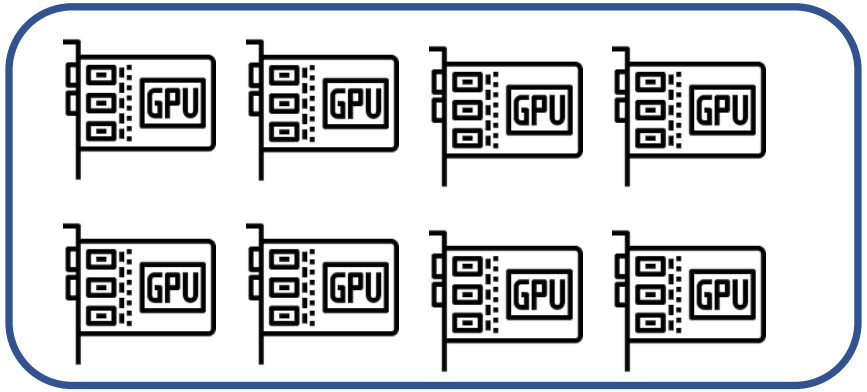
Gang Scheduler

- Gang tasks are a single scheduling unit
  - Admitted, placed, preempted and killed as a group
  - Gang tasks are independent execution units
  - Gang execution is terminated if a gang task fails and cannot be restarted
- Using kube-batch
  - Added priority, preemptive orchestration
  - Connected kube-batch to multiple operators
  - Framework snapshot







My job has lower priority and was preempted…

My job acquired 8 GPUs and needs 8 more

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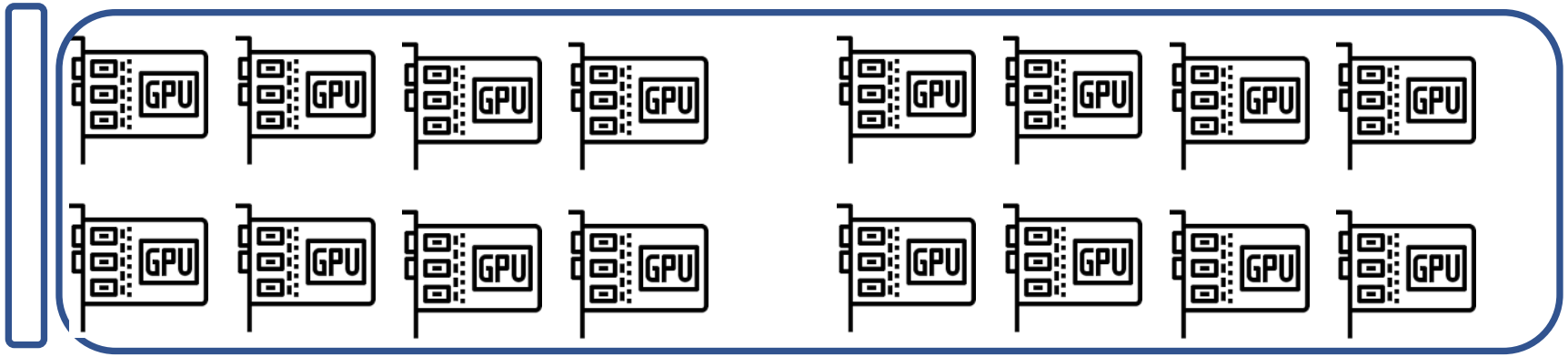

My job has lower priority and was preempted…

My job acquired all 16 GPUs and running

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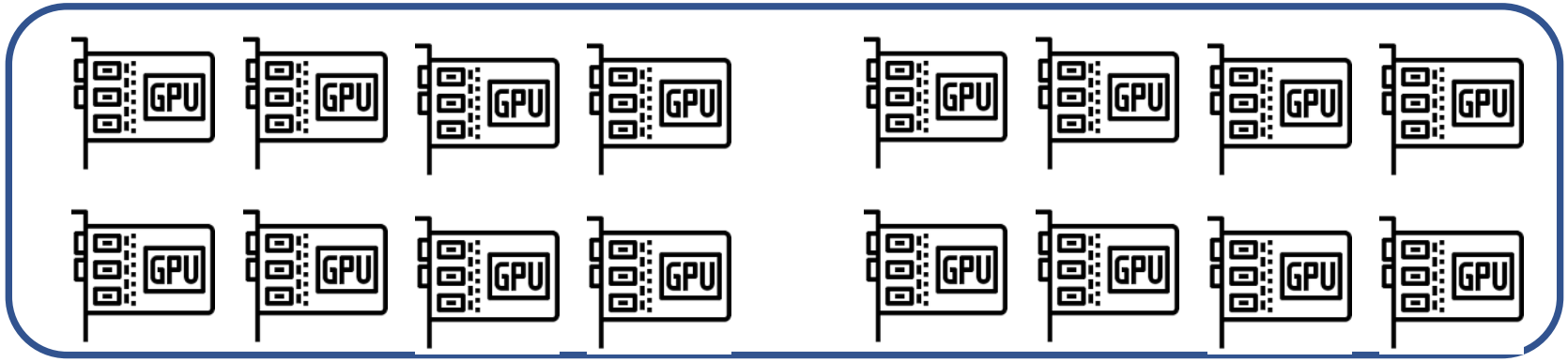

My job was re-submitted and now running

My job is done.

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Multi-Cloud ML Challenges

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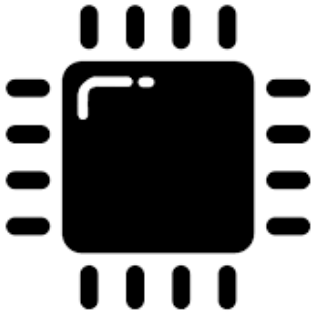


Heterogeneous Hardware

Challenge #3
Heterogeneous Hardware

Heterogeneous hardware

Kubernetes provides a device plugin framework for vendors to advertise their resources to the kubelet without changing Kubernetes core code. Instead of writing custom Kubernetes code, vendors can implement a device plugin that can be deployed manually or as a DaemonSet.
The targeted devices include GPUs, High-performance NICs, FPGAs, InfiniBand, and other similar computing resources that may require vendor specific initialization and setup.

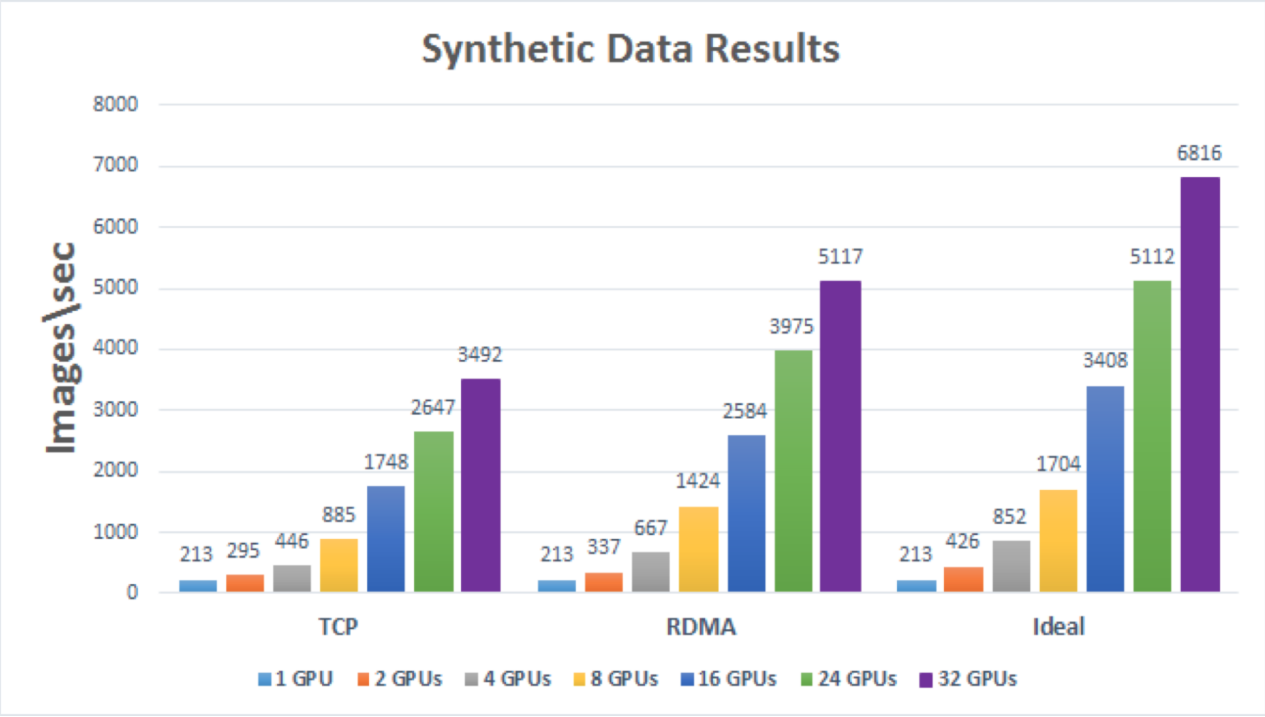
- Nvidia device plugin
- RDMA device plugin

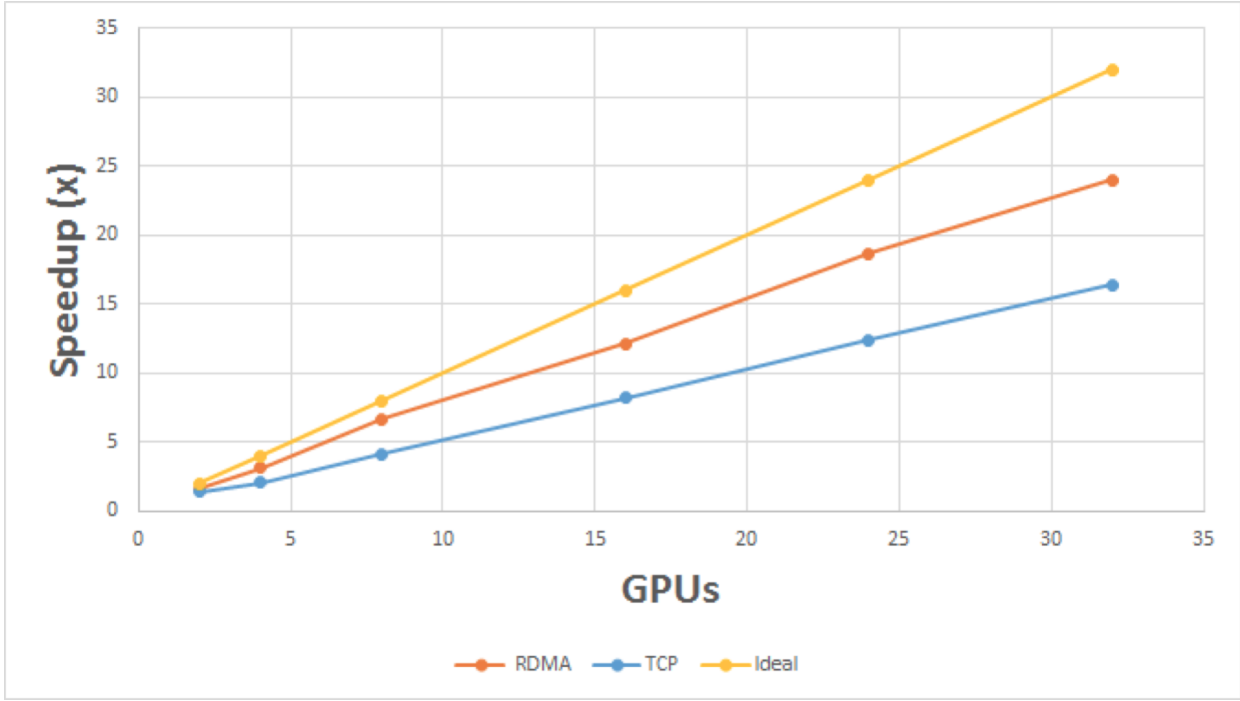
Heterogeneous Network

On-prem		Cloud	
RDMA		Ethernet	
25G	56G	25G	100G Not available in China
RoCE™	Mellanox® TECHNOLOGIES Connect. Accelerate. Outperform.®	Alibaba Cloud	aws

Heterogeneous Network

VM-to-VM network latency is critical to large scale machine learning performance



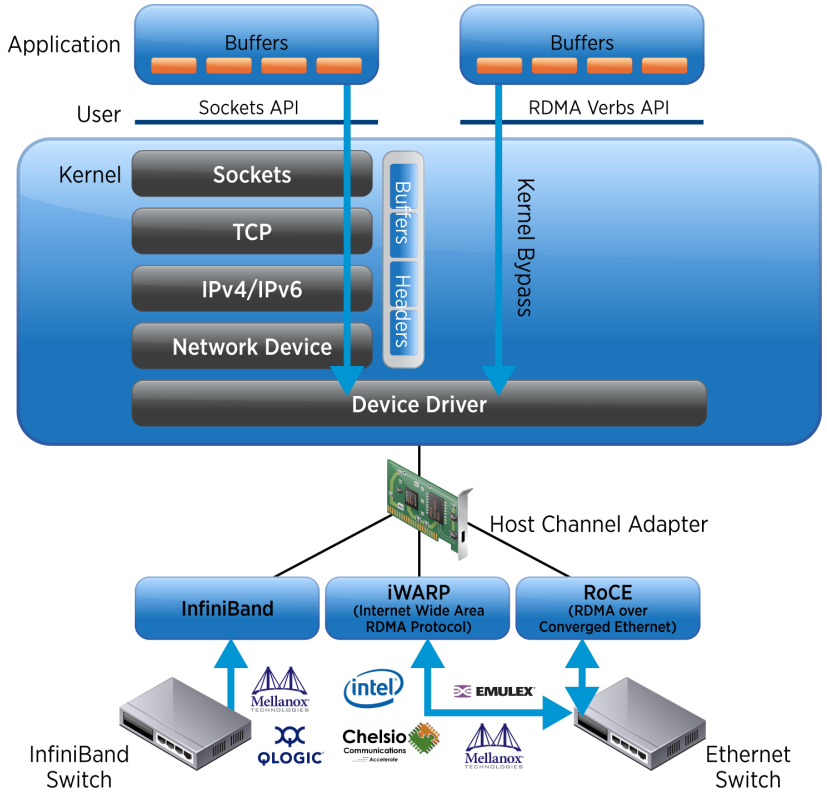


RDMA device plugin

hustcat/k8s-rdma-device-plugin is a device plugin for Kubernetes to manage RDMA device.

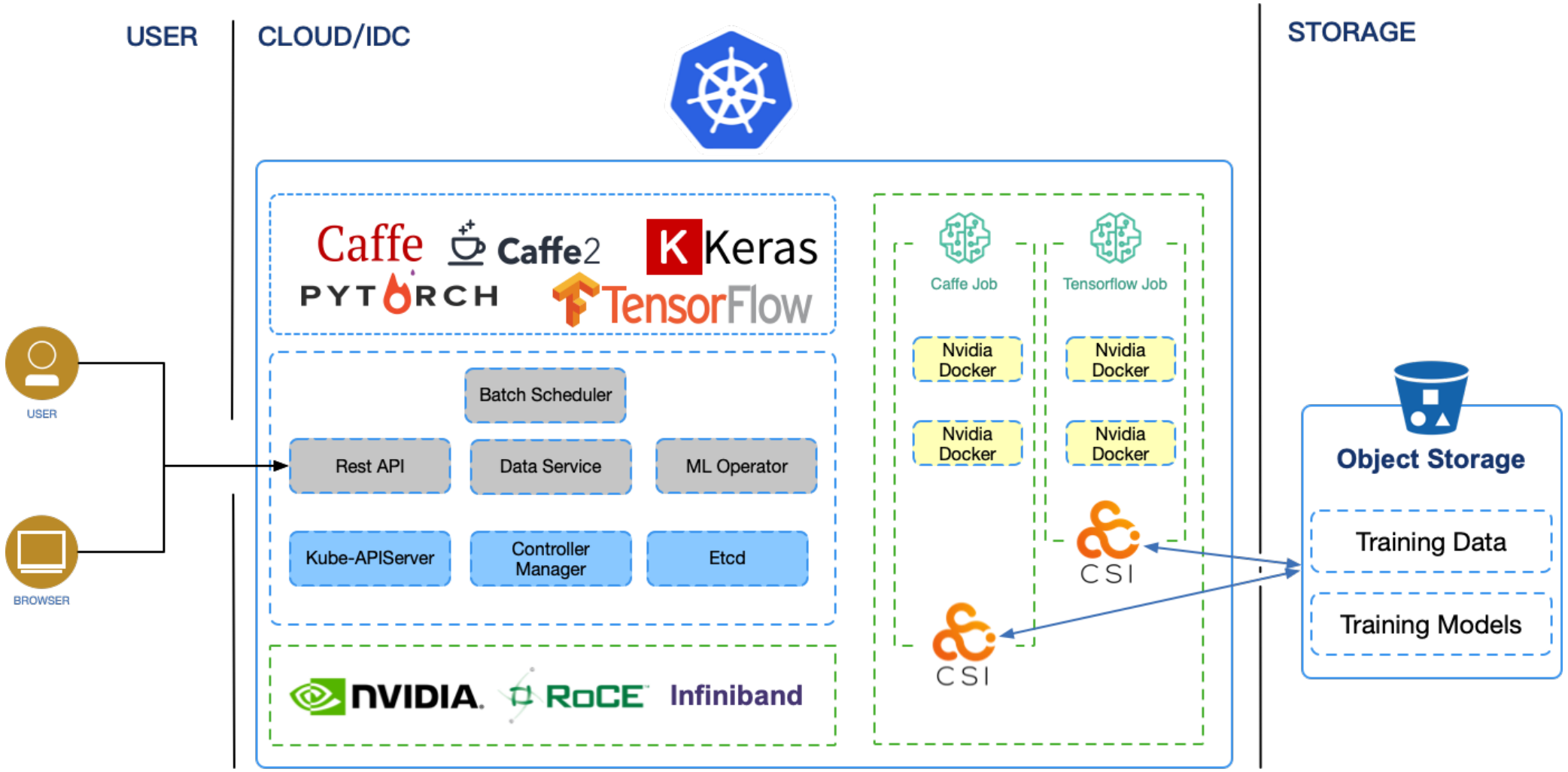
RDMA(remote direct memory access) is a high performance network protocol, which has the following major advantages:

- Zero Copy
- Kernel Bypass - No CPU involvement



DEMO

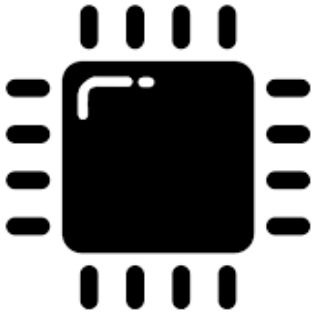
Architecture at Momenta



Multi-Cloud ML Challenges

Data Management

Workflow Orchestration



Heterogeneous Hardware

Questions