
cisco
You make possible

How to optimize your K8s infrastructure for AI/ML development with a few clicks!

Meenakshi Kaushik,
Product Manager, Cisco Container Platform
@mkaushik108

PSOCLD: 2982

Cisco Live!
Barcelona | January 27–31, 2020

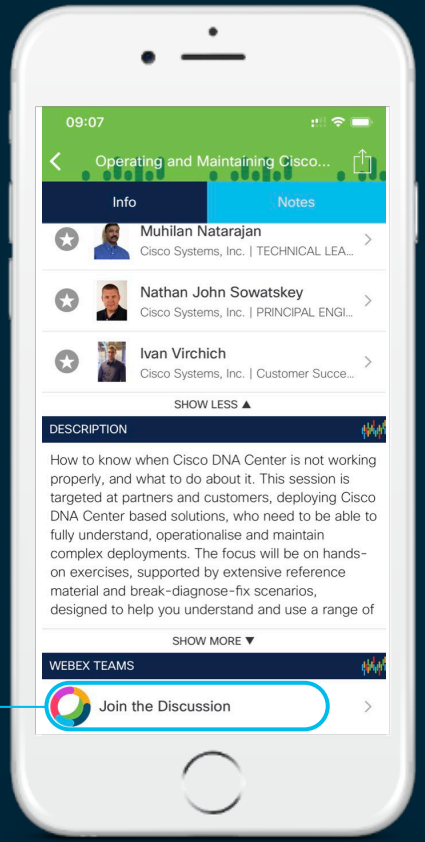
Cisco Webex Teams

Questions?

Use Cisco Webex Teams to chat with the speaker after the session

How

1. Find this session in the Cisco Events Mobile App
2. Click “Join the Discussion”
3. Install Webex Teams or go directly to the team space
4. Enter messages/questions in the team space



Clemson University Use Case

CLEMSON UNIVERSITY

Big Disruptive Biology

The tea leaves say…

In 2019, most R1 biology labs are outsourcing DNA sequencing.
Terascale genomics experiments are common now.

In 2029, every university research lab will have a DNA sequencer.
R1 research labs will move to the peta-/exascale in this PhD generation.

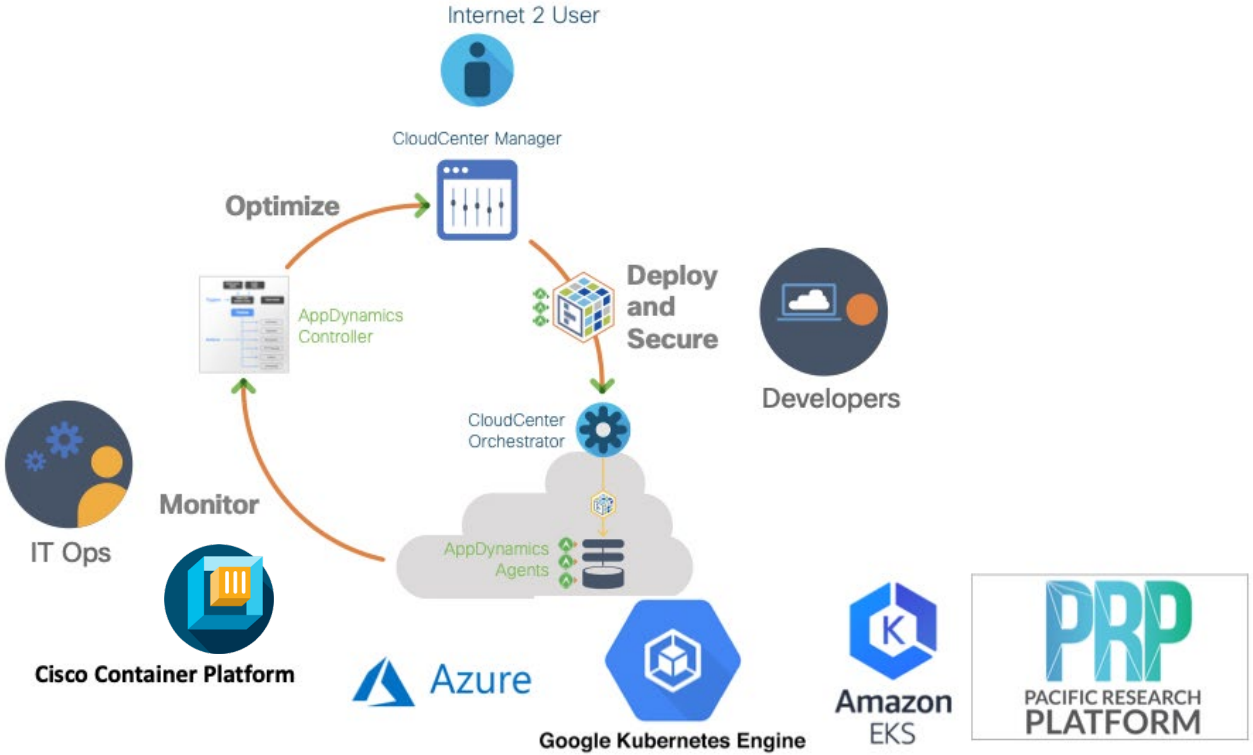
In 2034, all pharmacies, subways, hospitals, police stations, etc will have DNA sequencers.
These IoT DNA "sensors" will generate exabytes of data in aggregate each week.

I am only talking DNA Sequencers…not CryoEM, Simulations, Medical Imaging

amazon web services™ | INTERNET 2 | CVS pharmacy | 23andMe

Source - https://docs.google.com/presentation/d/1rVKnLR9rjwYW3AAMDc4ZBnIEjHLPSo_yEtDFmd3tMM/edit?usp=sharing

Clemson University Use Case

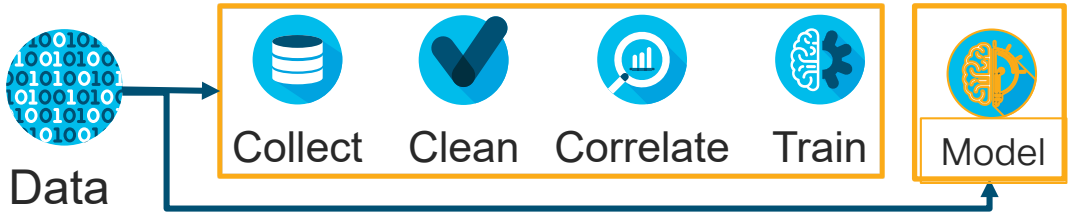


Source - https://docs.google.com/presentation/d/1rVKnLR9rjwYW3AAMDc4ZBnIEjHLPSo_yEtDFmd3tMM/edit?usp=sharing

Agenda

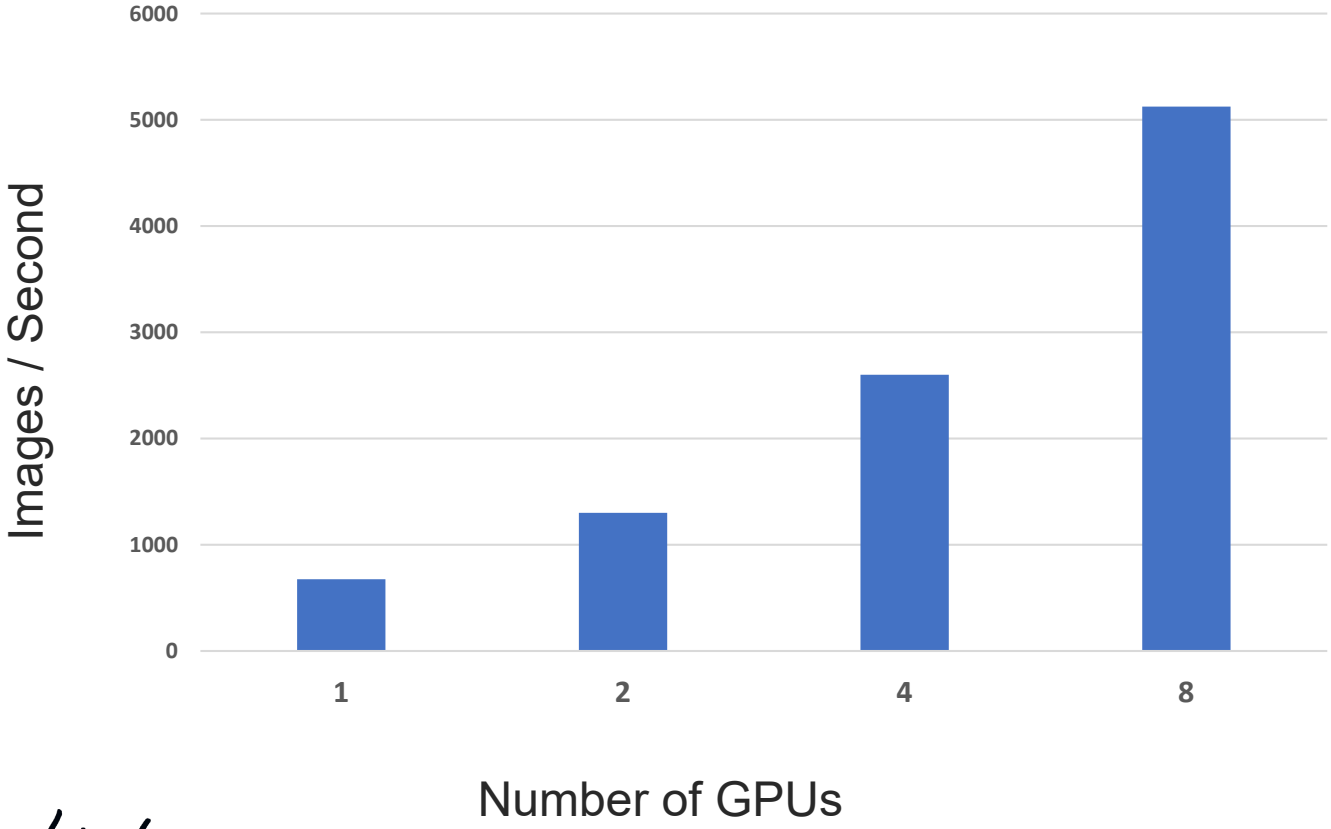
- What is the Opportunity?
- Introduction to Cisco Container Platform (CCP)
- Introduction to KubeFlow
- Distributed machine learning
- Demo
- Summary

What is the Opportunity?

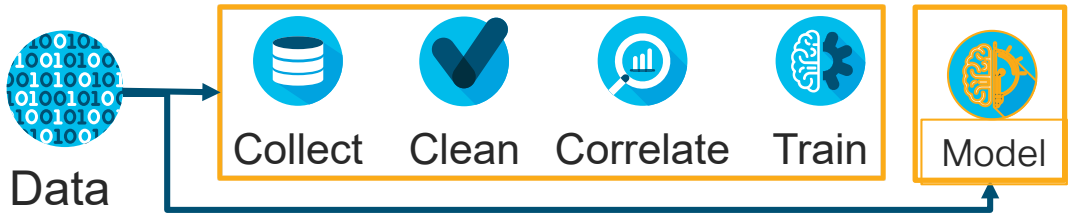


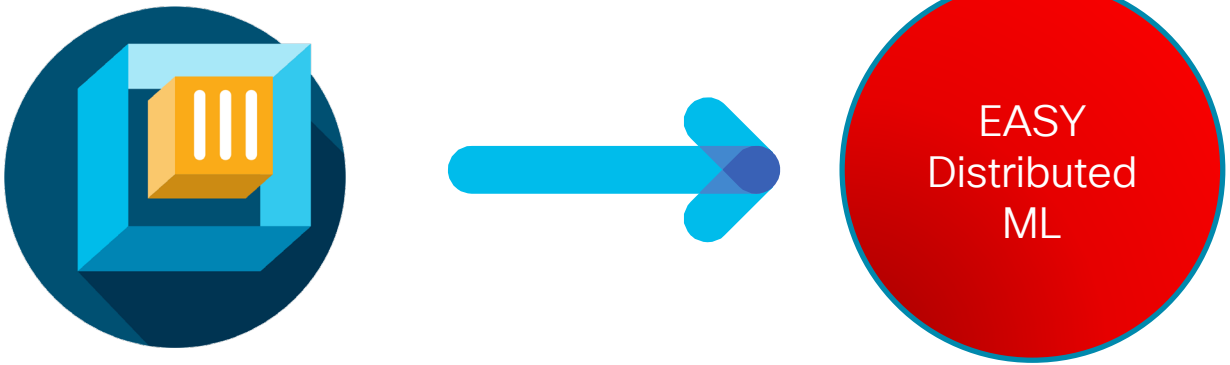
EASY
Distributed
ML

Scaling with UCS C480 ML and CCP



Easy distributed ML with Cisco Container Platform



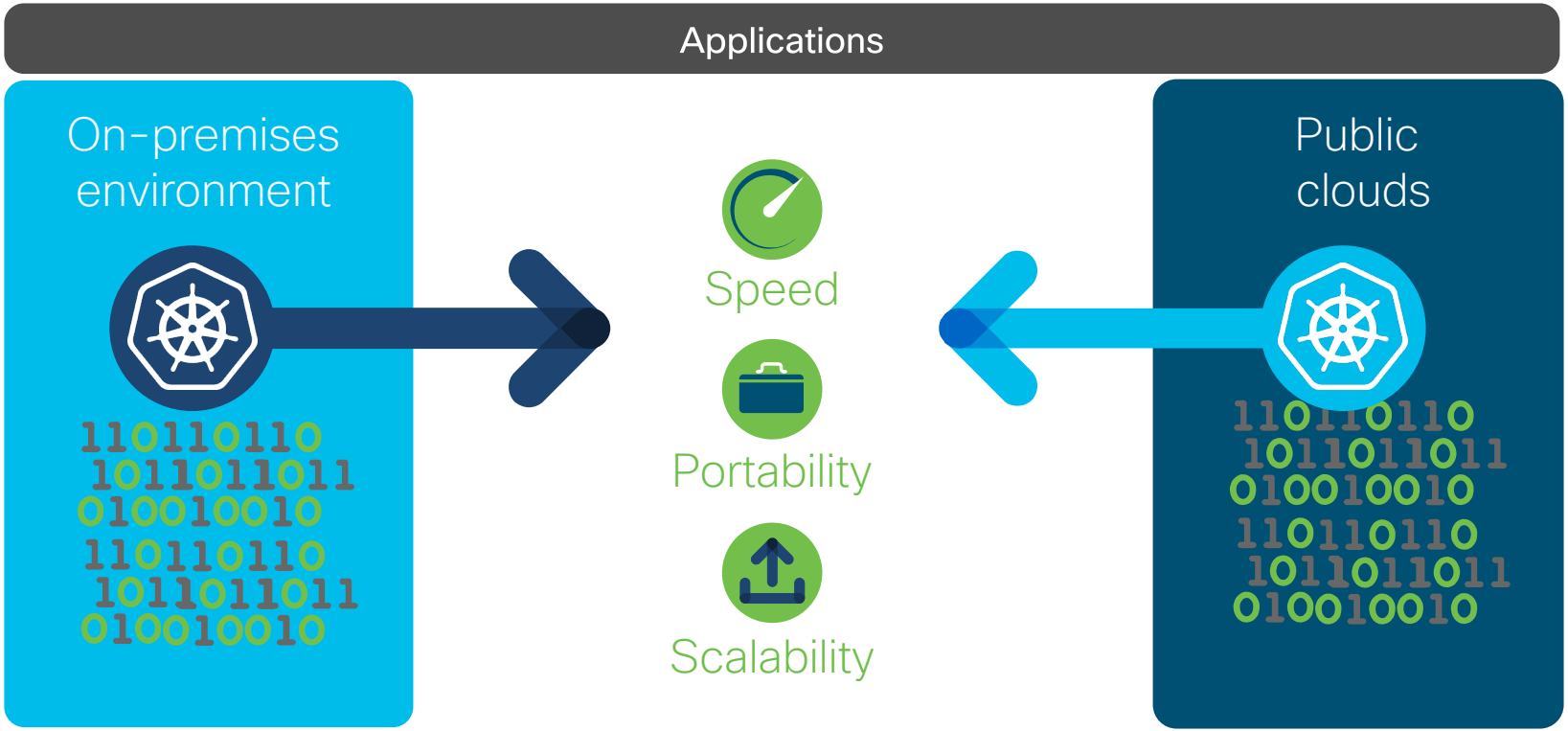


Cisco Container Platform

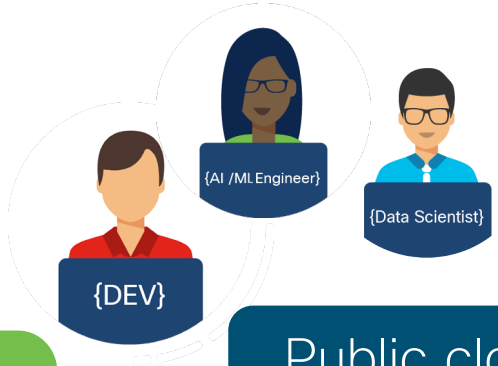
Cisco Container Platform (HX-AP)

Production-grade multicloud Kubernetes

Kubernetes as the new platform of choice



Developers want K8s to be...



On-premises environment

Campus

Branch

DC/Colo

IoT/Edge

- delivered fast
- consistent, on-prem and in public clouds
- open - 100% upstream
- configured with storage, networking, monitoring
- secure, high-available
- optimized for AI/ML development

Public clouds

aws

...

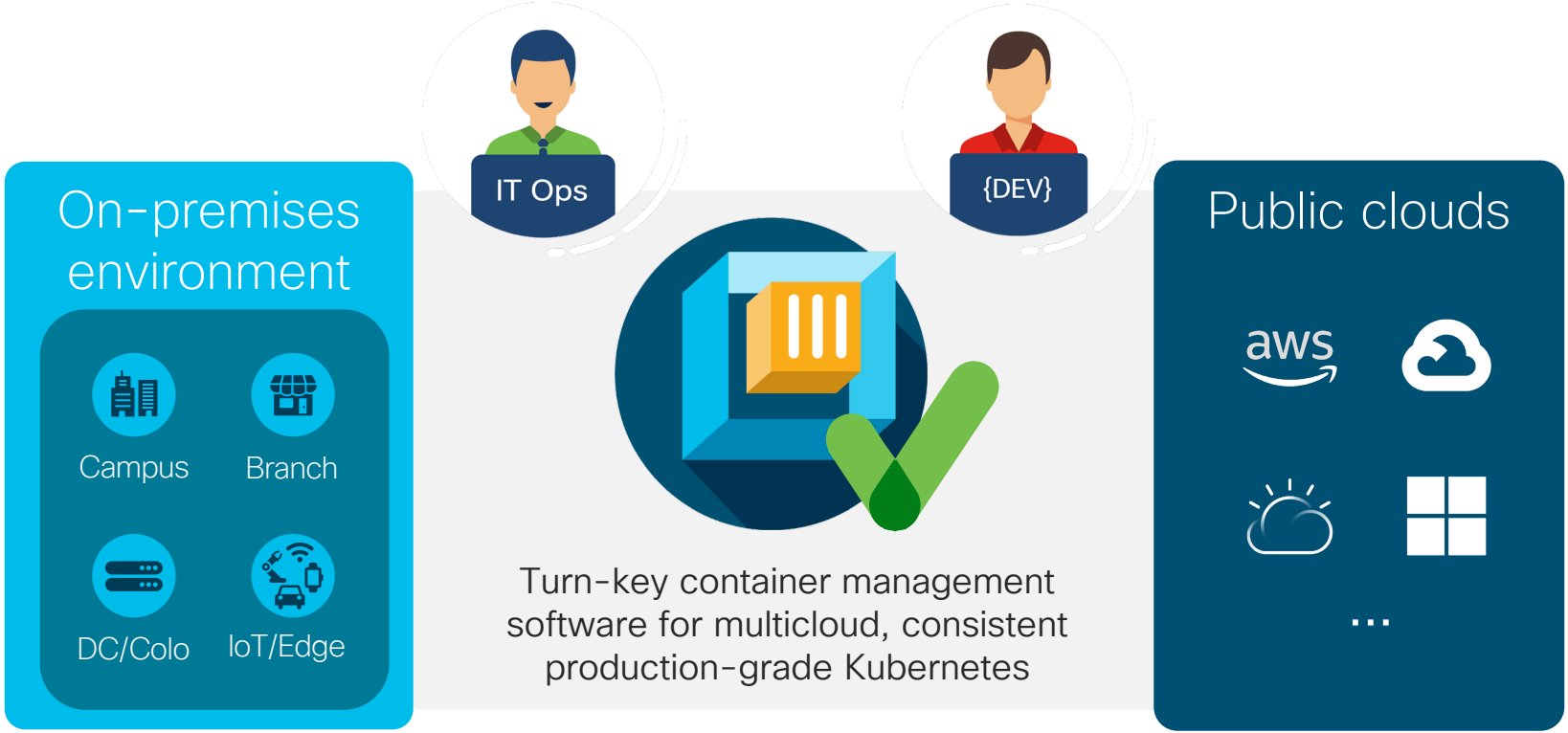
But it can be difficult to deliver

- Download and install Kubernetes
- Set up clusters
- Configure storage and networking
- Configure security: identities, secrets and RBAC
- Install logging, monitoring, set up registries, load balancing
- Manage upgrades and patches
- AI/ML lifecycle management
- Repeat for public clouds to match on-prem configuration?
- How to support it

On-premises environment

Public clouds

Cisco Container Platform makes it easier



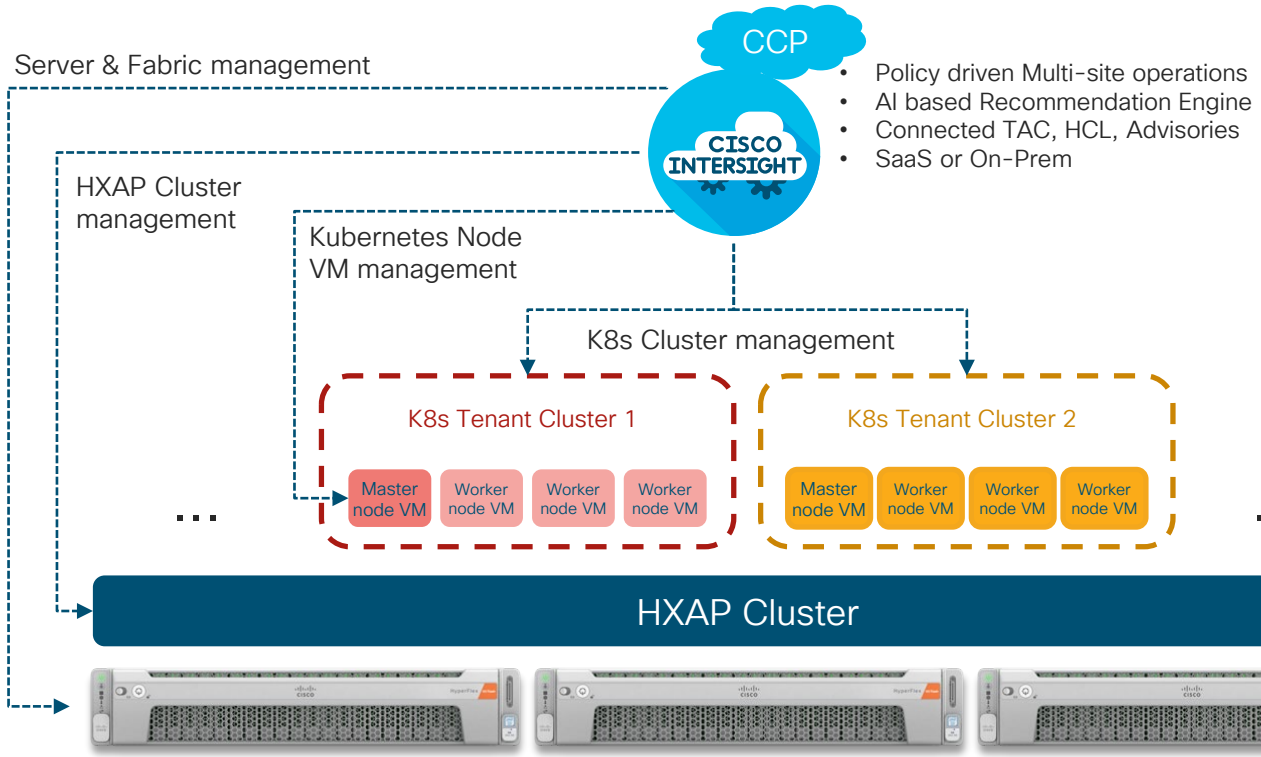
Cisco Container Platform (CCP)

Turn-key container management software for multicloud, consistent production-grade Kubernetes

- ❖ Runs on ANY infrastructure* as a lightweight self-hosted software (optimized for Cisco HX and UCS)
- ❖ Automates the installation and deployment of self-service,100% upstream K8s clusters
- ❖ Includes all the necessary networking, storage, logging/monitoring, load balancing and registry tooling
- ❖ Integrates natively with EKS, AKS and GKE (coming soon!)
- ❖ Built for the enterprise with hardened security and enhanced availability features like multi-master and self-healing
- ❖ Optimized for AI/ML workloads with multi-GPU support
- ❖ Supported end-to-end by Cisco

Deployed on top of VMware vSphere, OpenStack/CVIM, bare metal (coming soon)

HyperFlex Application Platform (HXAP) Management



- Policy driven Multi-site operations
- AI based Recommendation Engine
- Connected TAC, HCL, Advisories
- SaaS or On-Prem

K8s Tenant Cluster mgmt. Master/Worker golden Image, Install/Upgrade, Auto-scaling, Node pools, Version match w/ upstream, Logging/Monitoring, Interoperability, Security compliance, RBAC etc.

K8s-Node (Master/Worker) VM mgmt. Tenancy groups for Isolation, Quota & Auth. VM operations including CRUD, Placement, Affinity/Anti-Affinity, HA, Clones, Monitoring/Telemetry etc.

HXAP mgmt including Compute/Storage cluster Install, Upgrade, Expand, Monitor, Capacity/Perf reporting etc.

Physical Infra mgmt including BIOS/Boot policies, Firmware, HCL, Networking, security patches etc.

Cisco Container Platform Feature Set

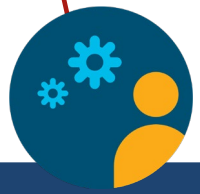
Kubernetes-as-a-Service

Setup

- Deploy Kubernetes clusters on HyperFlex, vSphere, CVIM, EKS, AKS, GKE*, HX-AP*
- CNI and Istio service mesh
- Persistent storage
- L4 / L7 Load Balancing
- Container Registry

Consume

- AD Authentication / RBAC
- Resource based node pools
- **Multi-GPU -as-a-Service**
- **Kubeflow** (tech preview)
- UI – Kubernetes, API
- Security (policies, encryption)



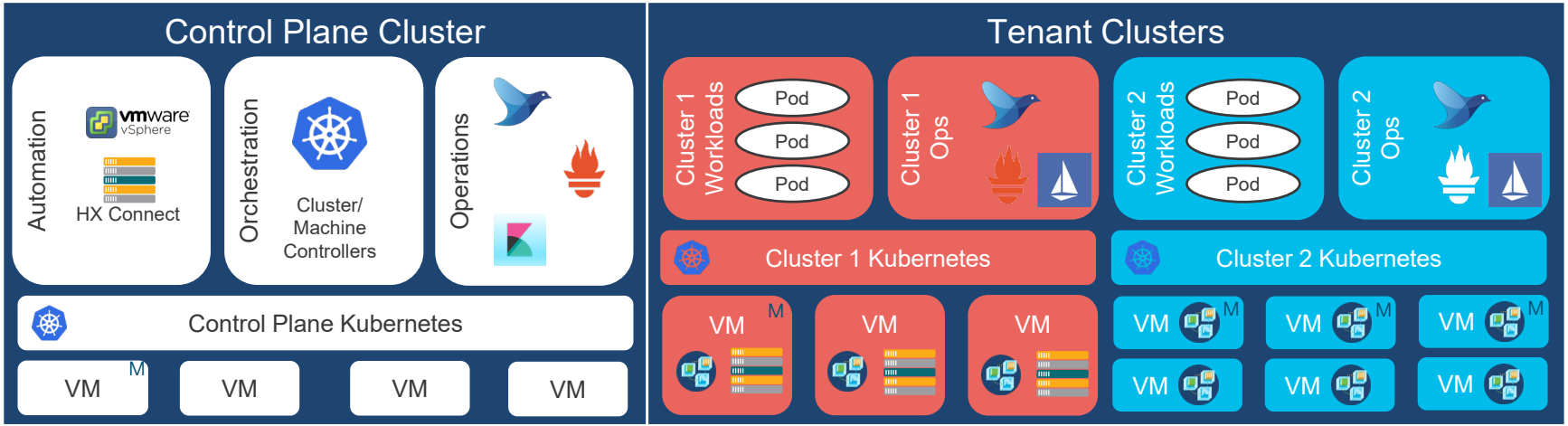
Manage

- Add / remove Kubernetes nodes
- Lifecycle management (OS updates, Kubernetes upgrades)
- Prometheus/Grafana Monitoring
- EFK Logging
- **Self-healing Kubernetes clusters**
- **Multi-master nodes**

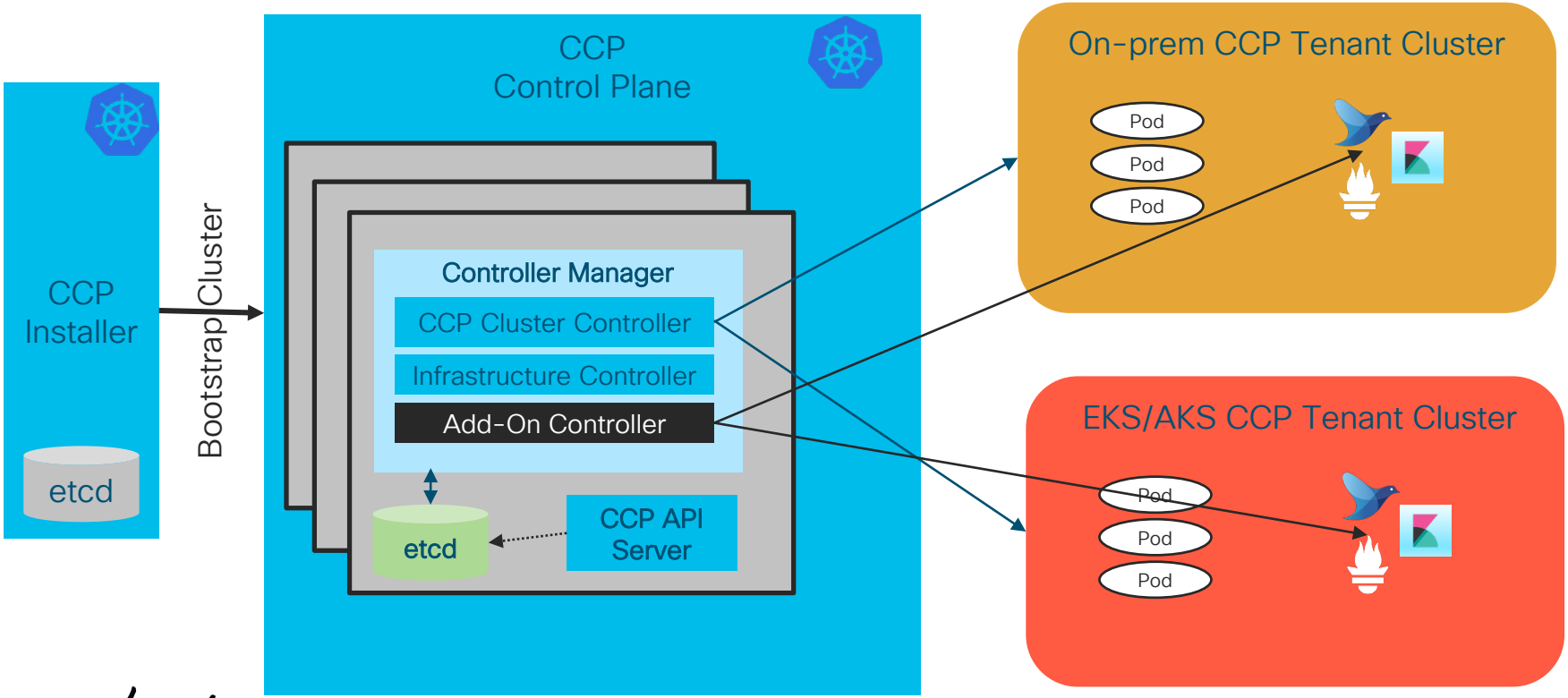
cisco Live!

* → Coming soon

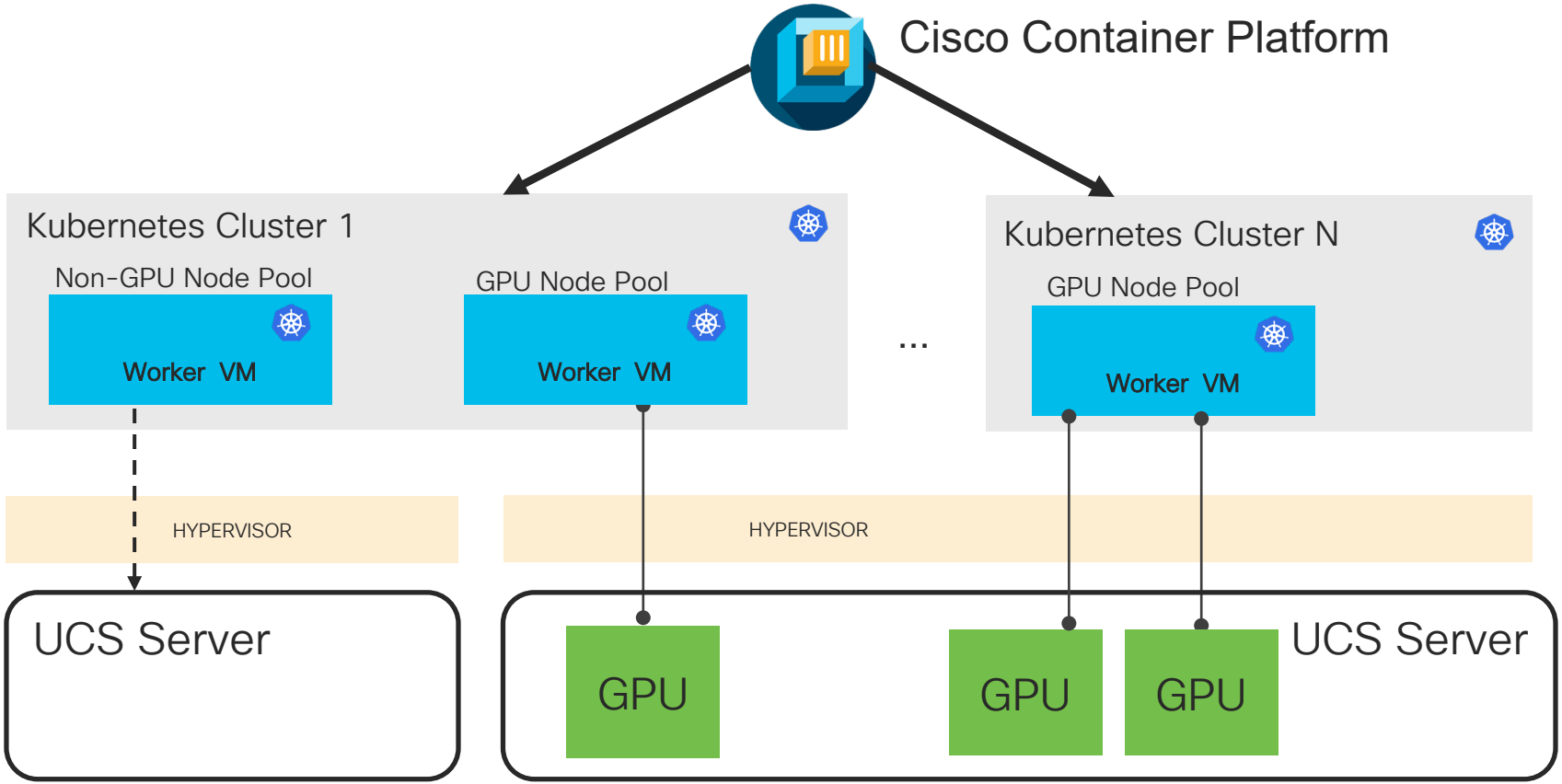
Cisco Container Platform Multi-Master



Declarative Life Cycle Manager - Self Healing Clusters



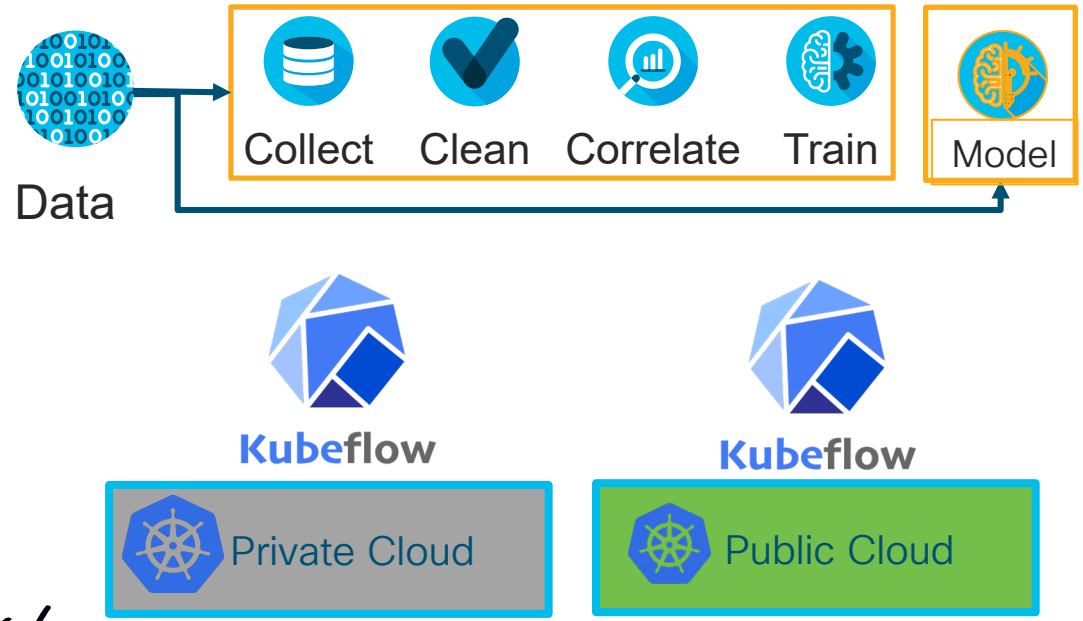
Multi-GPU as a Service



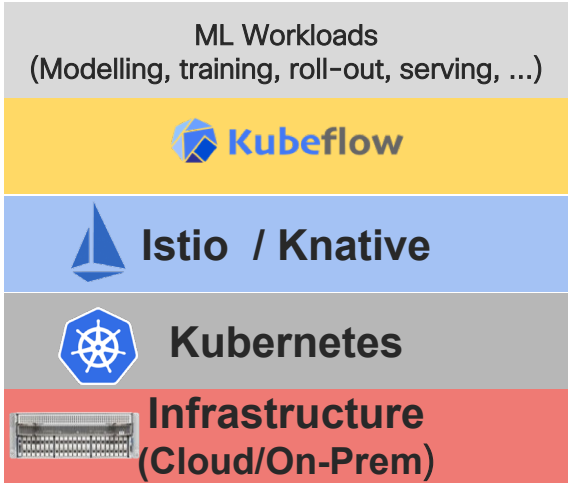
Kubeflow (CCP Tech Preview)

Kubeflow

Machine learning lifecycle manager that makes it easy to develop, deploy and manage portable, scalable end-to-end ML workflows everywhere



Kubeflow



- **Exploration** using Jupyter notebooks
- **Model training** using different machine learning frameworks such as TensorFlow, PyTorch, Spark, XGBoost, MPIJob, …
- **Hyperparameter tuning and NAS** via Katib
- **Model serving** KFServing
- **Pipelines**

Cisco's Kubeflow Contributions

Source – https://devstats.kubeflow.org/d/5/companies-summary?orgId=1

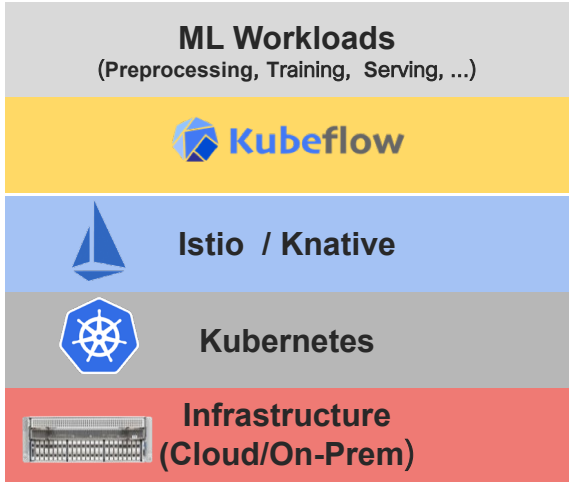
Kubeflow Companies statistics (Contributions, Range: Last decade), bots excluded

Company	Number
All	103897
Google	42663
Cisco	5930
IBM	5142
Caicloud	4468
Red Hat	909
NTT	830
Microsoft	812
Intel	728
Amazon	716
Net EASE	713

- Auth with Istio + Dex
- Katib
- KubeBench

- PyTorch
- On-premise installation

Kubeflow Contribution



Kubeflow

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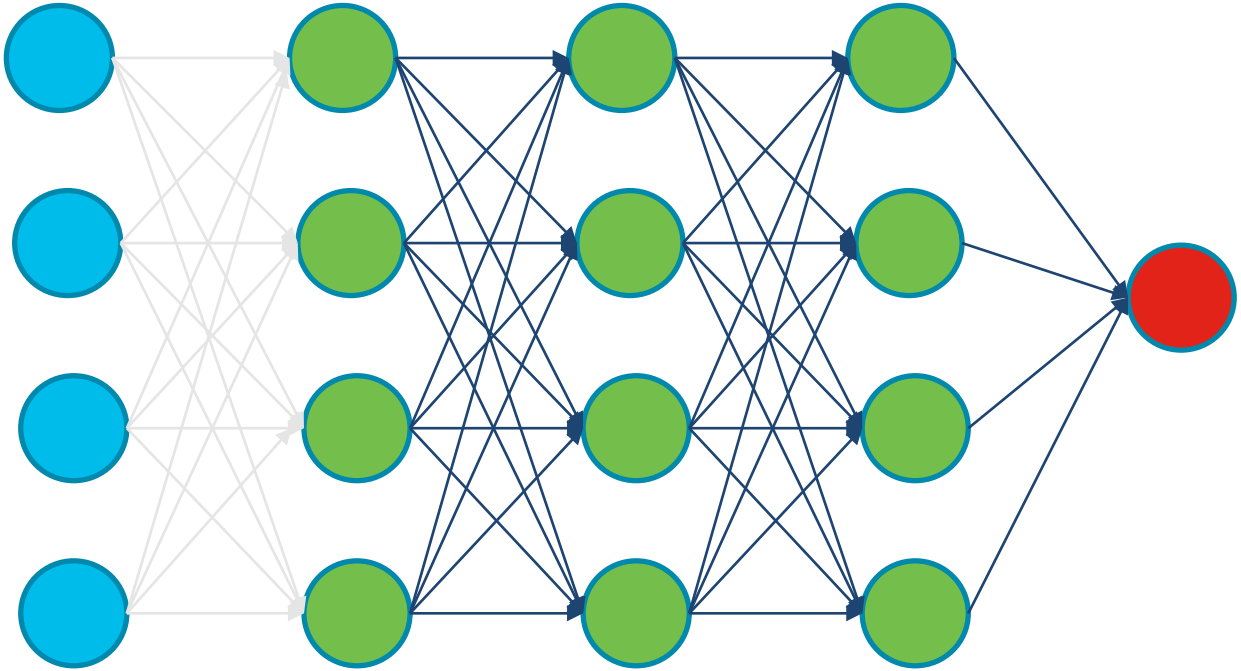
Now Including

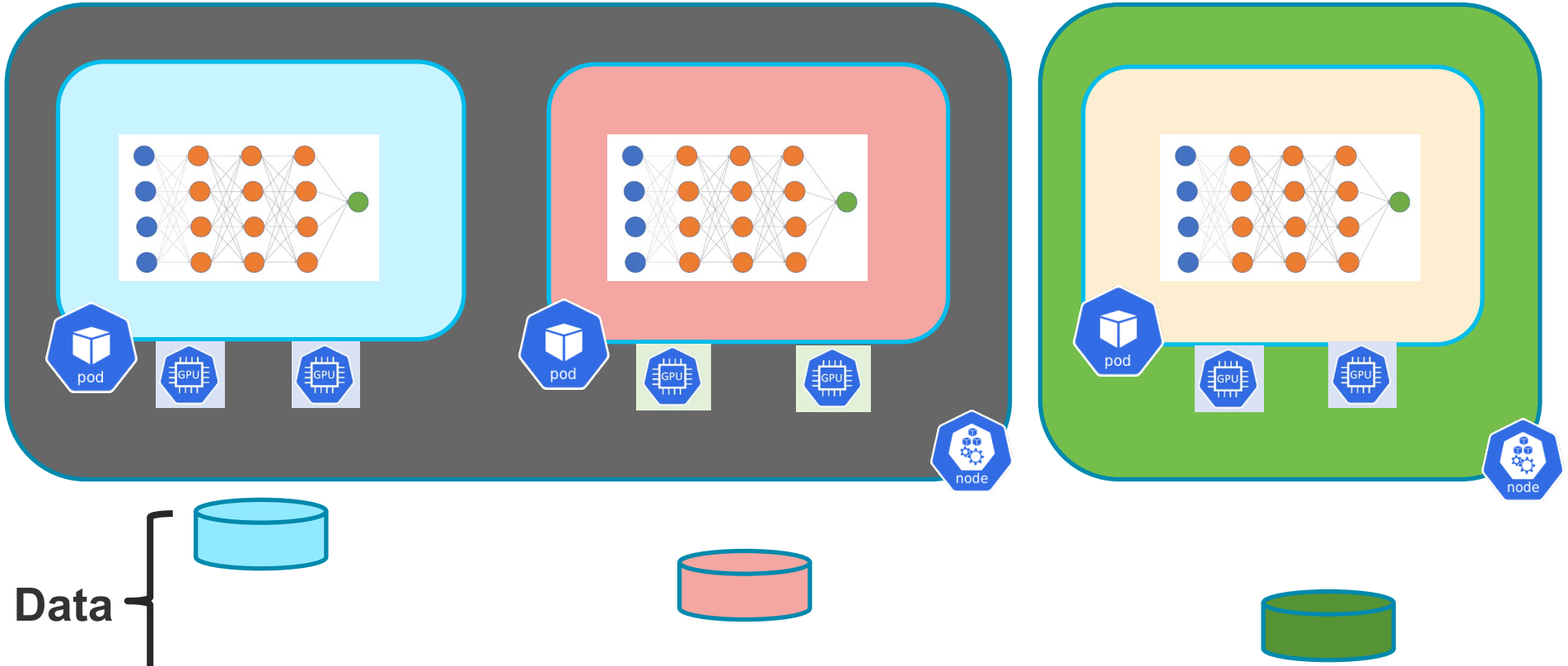
Kubeflow

Distributed End-to-End Machine Learning

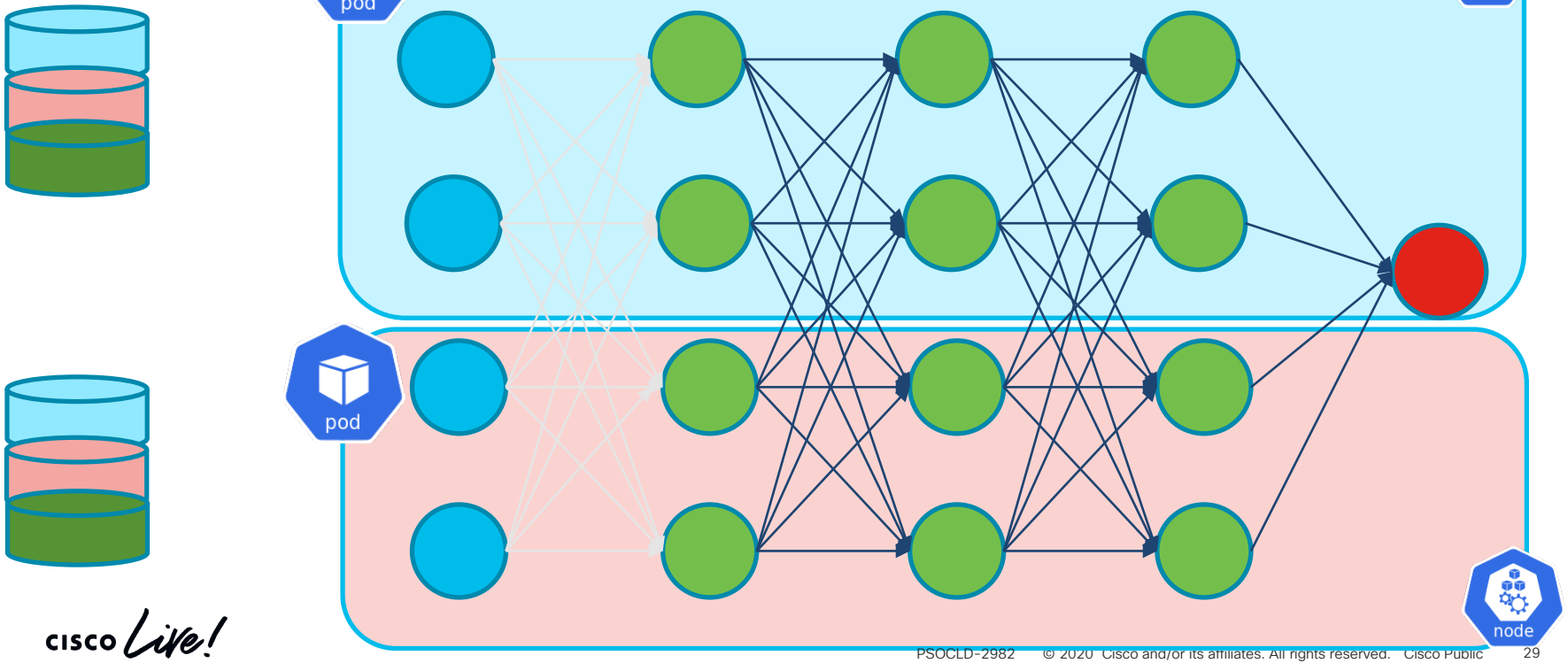
Deep Neural Network



Data Parallelism

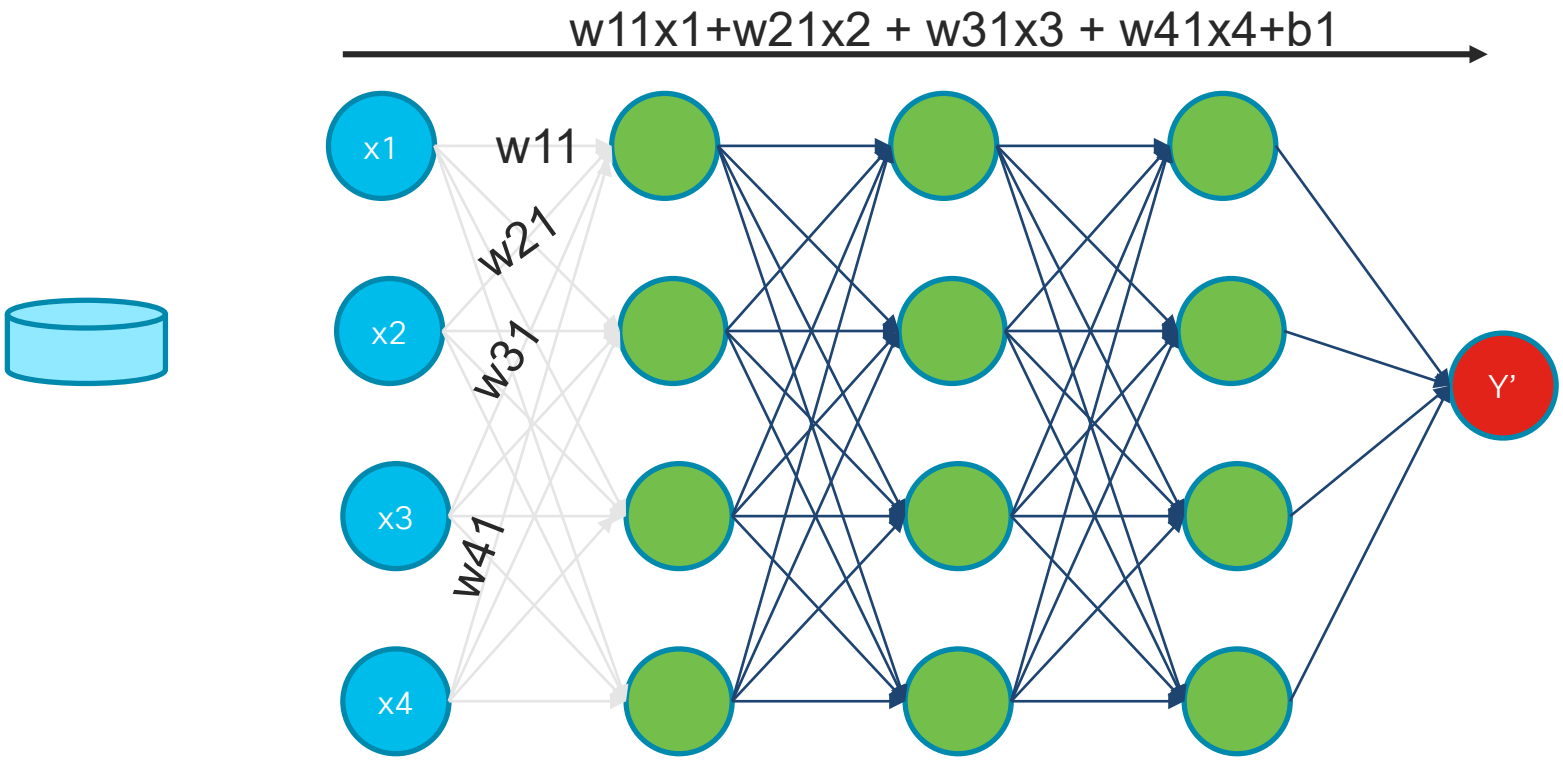


Model Parallelism



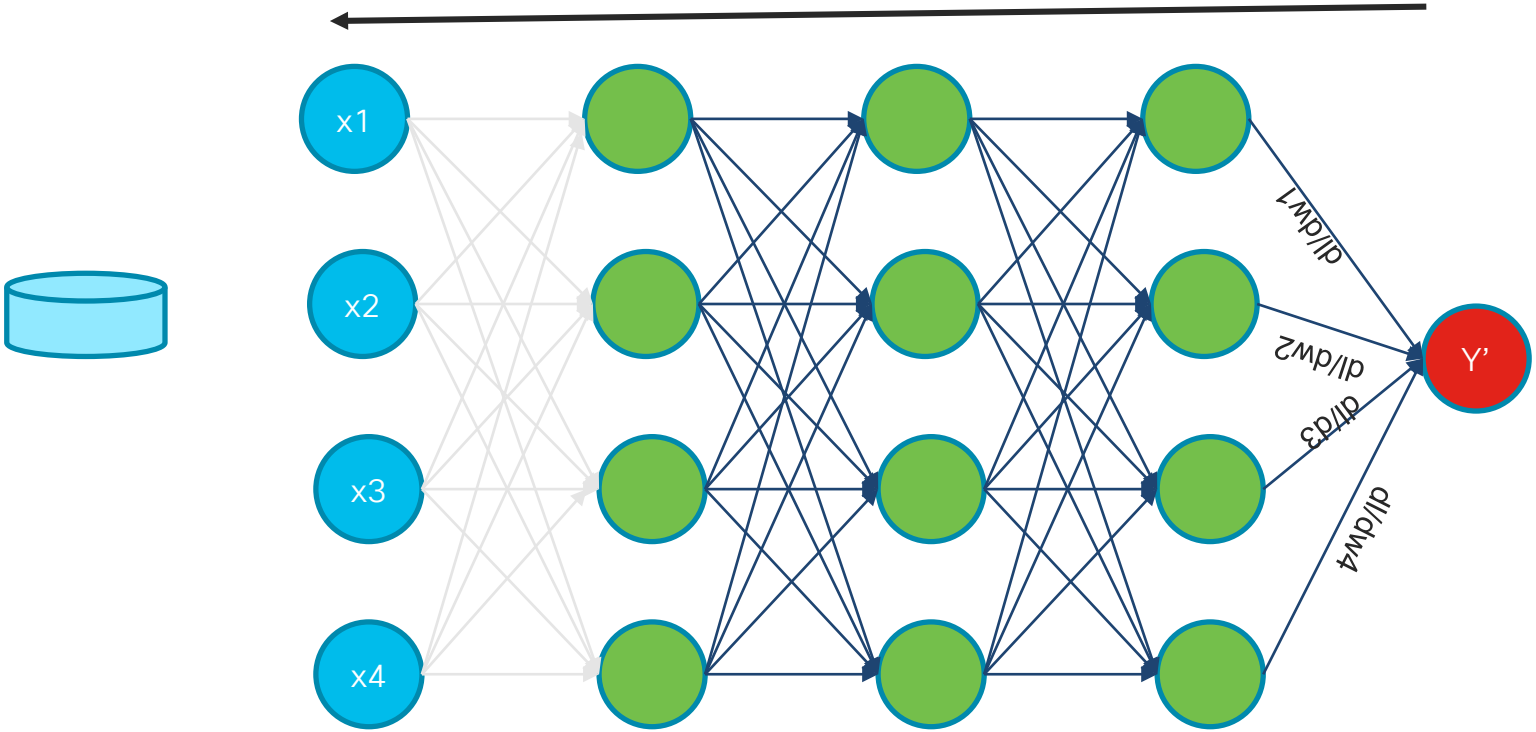
Deep Neural Network

Forward Propagation

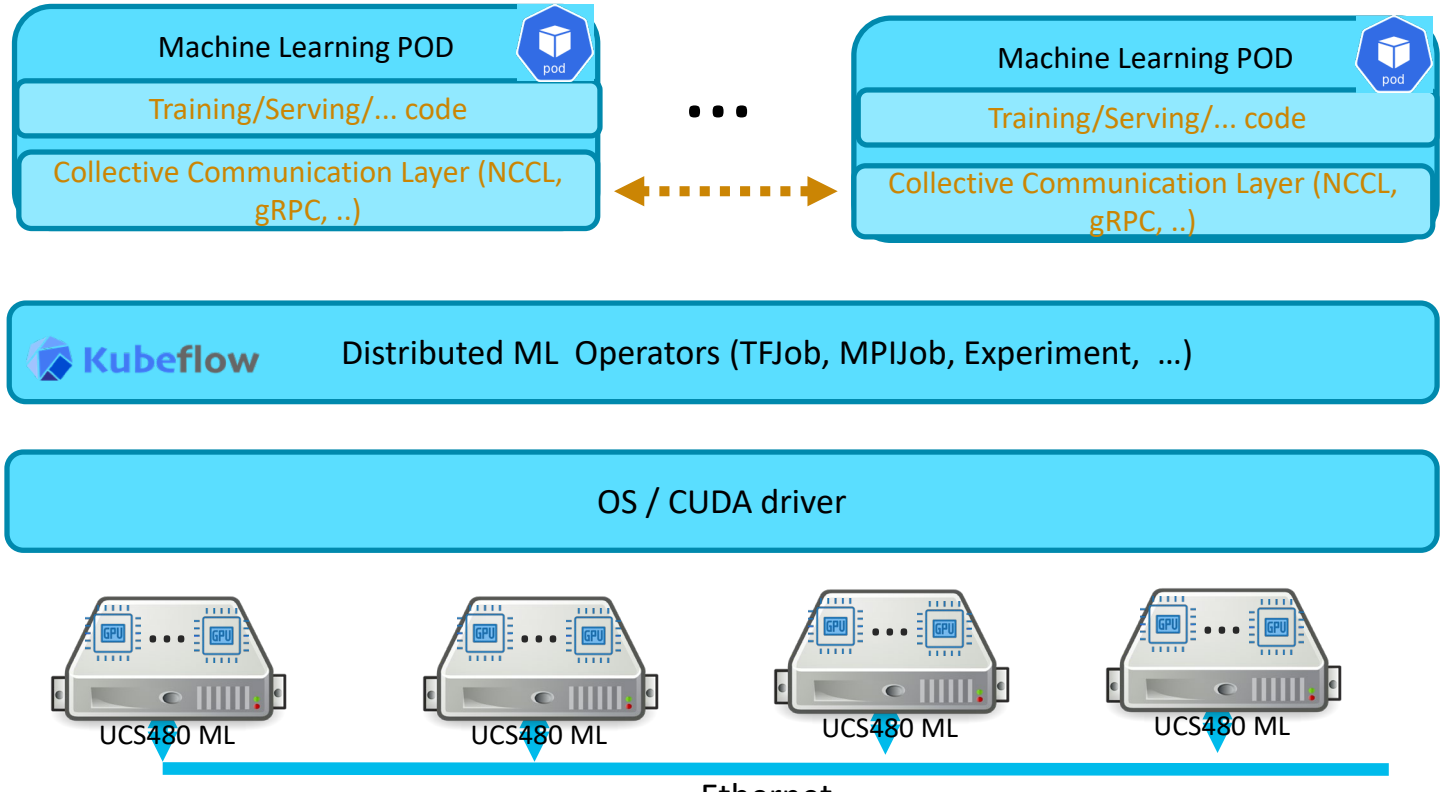


Deep Neural Network

Backward Propagation



Distributed ML with CCP and Kubeflow

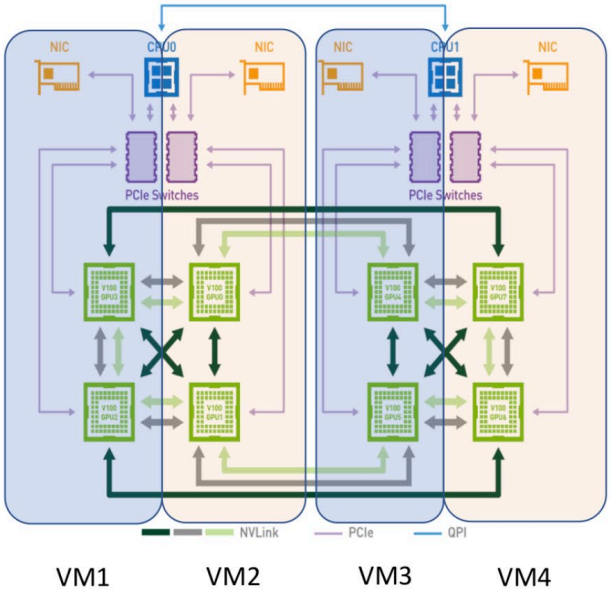


- Fully supported K8s cluster lifecycle
- Multi-GPU-as-A-Service
- Single-click Kuubeflow install
- Optimal NVLINK GPU selection
- GPU passthru for near native performance
- Intra-Node GPU communication via fast NVLINK
- Optimized power usage on 8 GPU

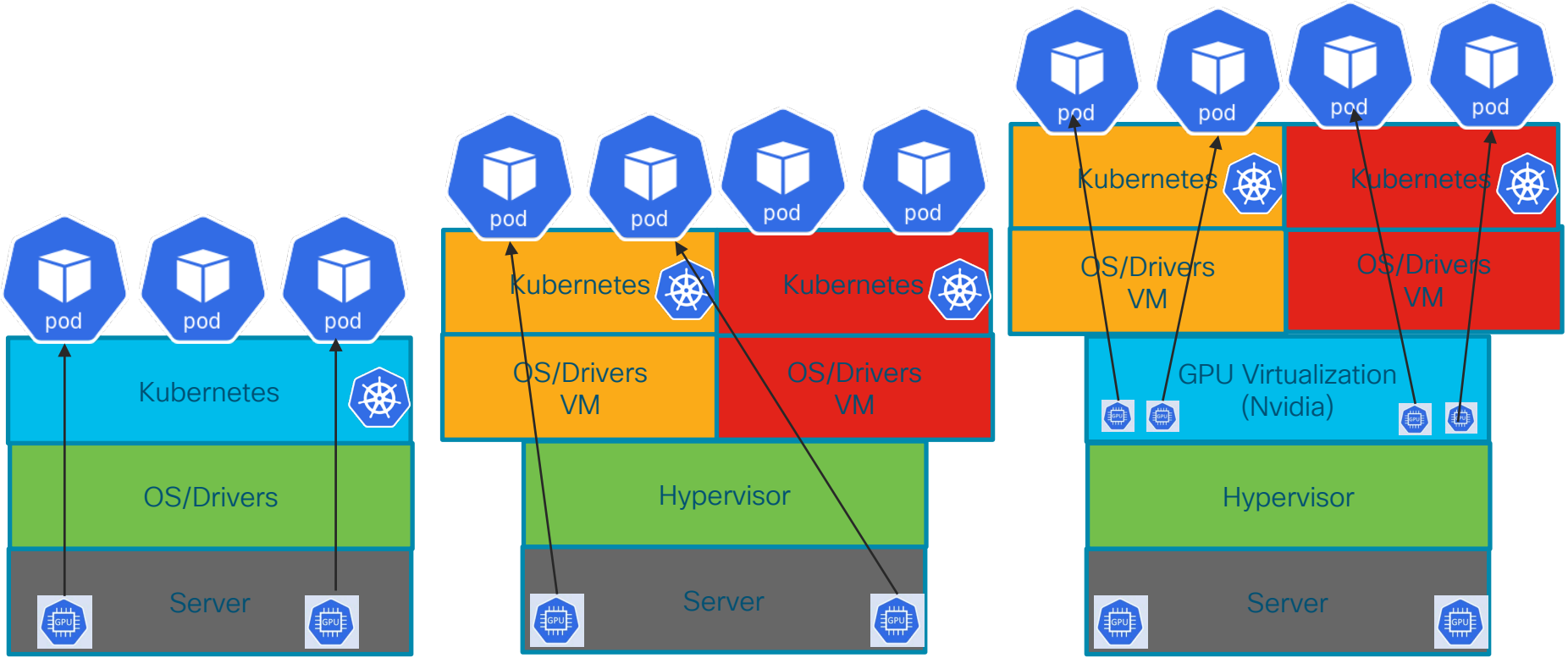
CCP and UCS C480 ML Cost Savings

Potential Cost Savings at Colocation

- **Cisco Container Platform Enables**
  - For Colocation environments CCP and flexible GPU configurations enable cost savings an performance gains.
    - Example : a 2GPU system is typically 2RU worth of rack space. Typically 2 GPU systems are PCIe connected.
    - With CCP and c480ML, we can provide 4 2GPU systems in 4 RU as compared to 8 RU. Further, because the GPUs are NVLINK connected, we can out perform typical 2 PCIe connected GPUs.



Kubernetes GPU Configurations

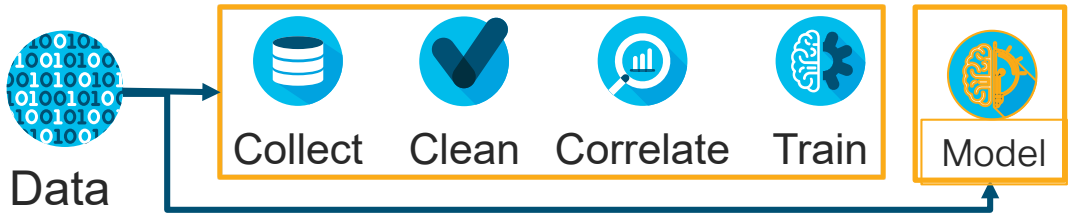


Bare metal

VMs with PCI Passthru

VMs with vGPUs

Easy distributed ML with Cisco Container Platform



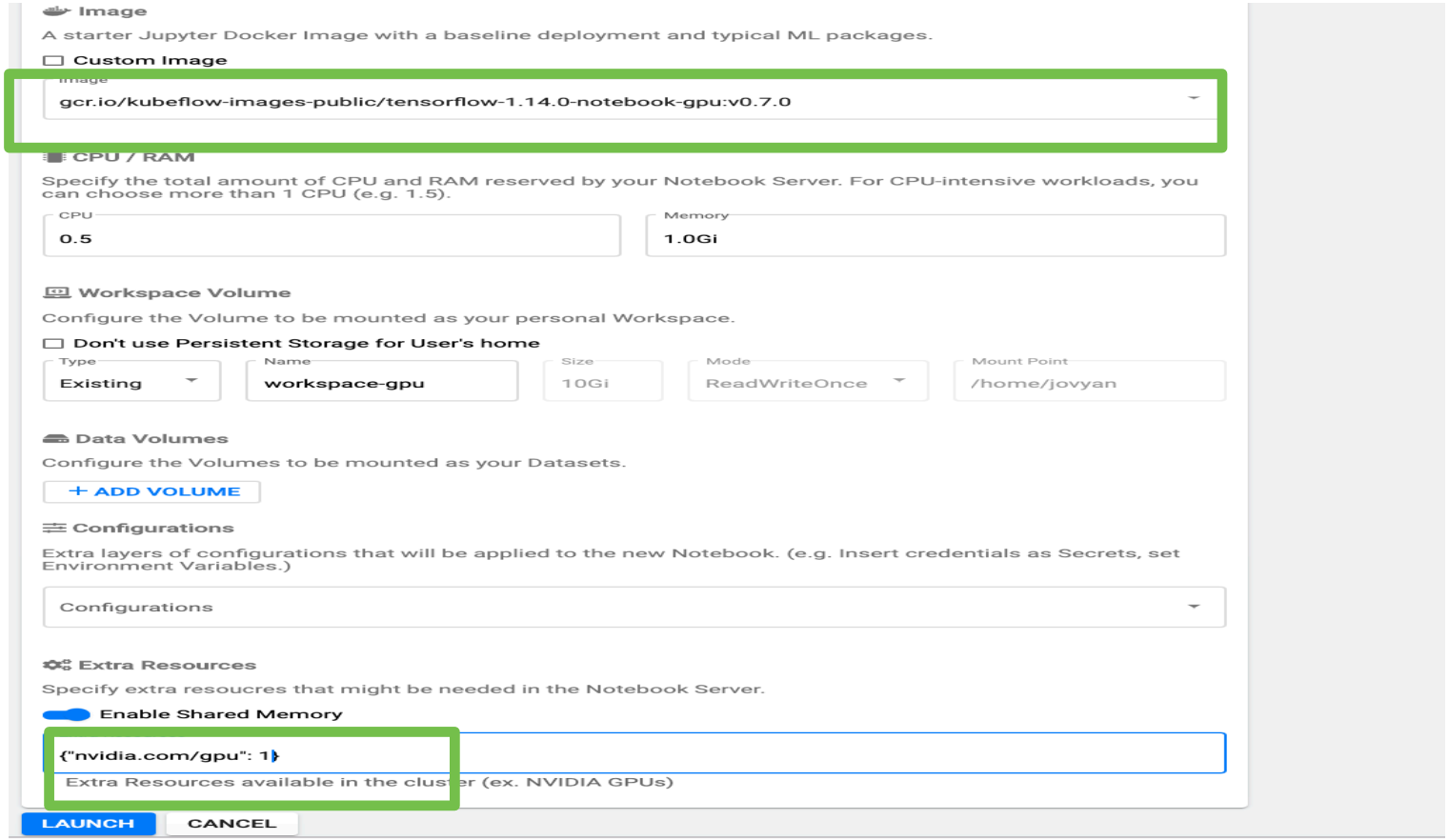
Cisco Container Platform

Now Including

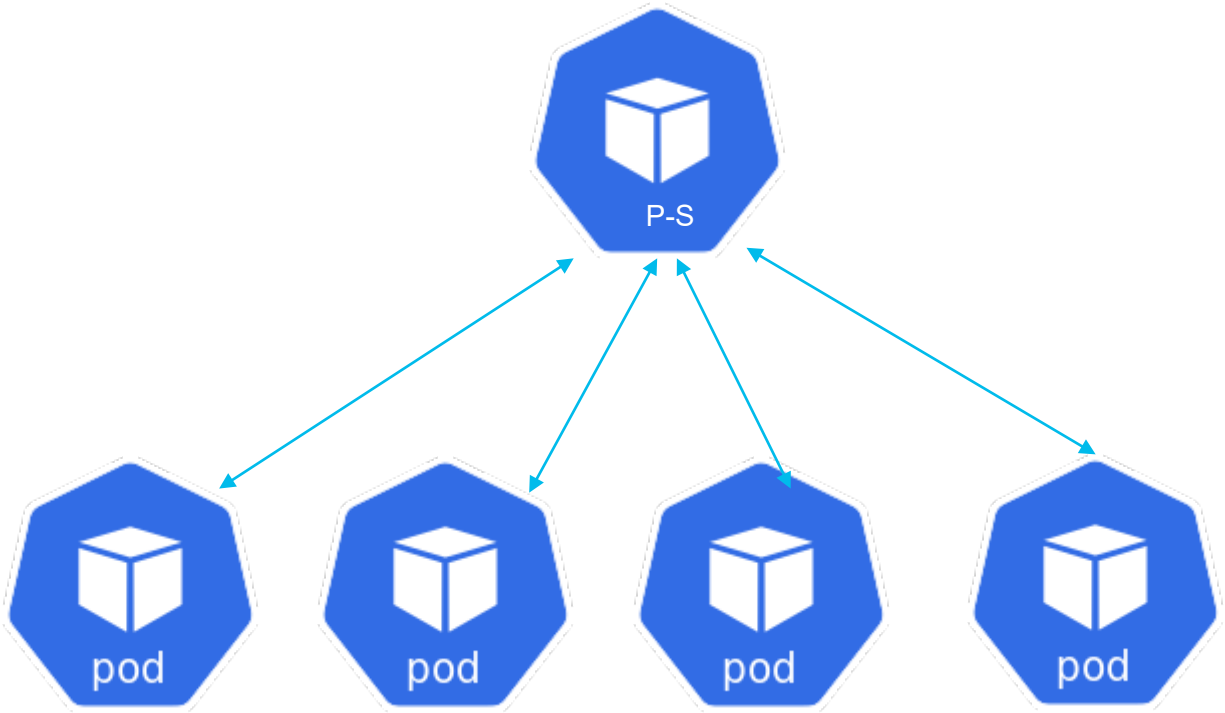
Kubeflow

Demo

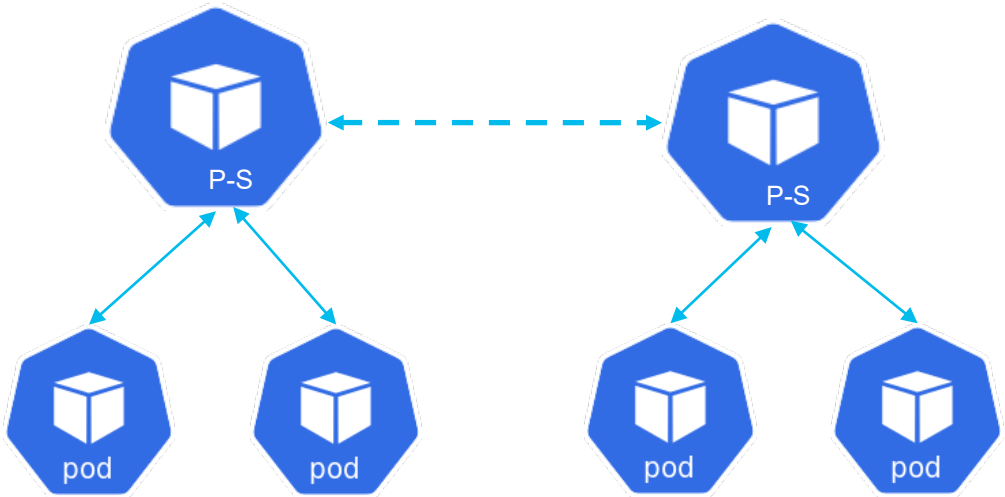
Jupyter Notebooks



Parameter Server

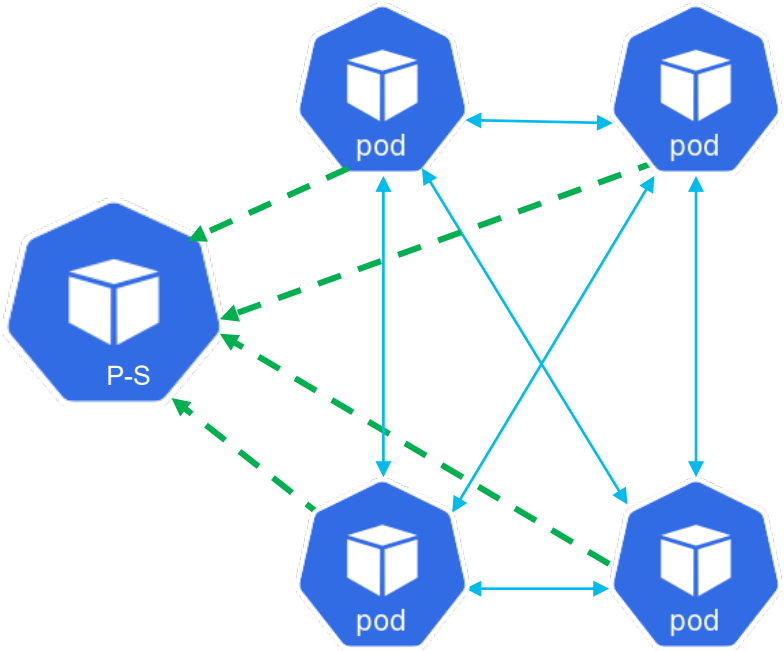


Async Parameter Server




```
apiVersion: "kubeflow.org/v1"
kind: "TFJob"
spec:
  tfReplicaSpecs:
    PS:
      replicas: 2
      template:
        spec:
          containers:
            - name: tensorflow
    Worker:
      replicas: 4
      template:
        spec:
          containers:
            - name: tensorflow
```

Sync Parameter Server




```
apiVersion: "kubeflow.org/v1"
kind: "TFJob"
spec:
  tfReplicaSpecs:
    Worker:
      replicas: 4
      template:
        spec:
          containers:
            - name: tensorflow
              image: gcr.io/kubeflow-examples/distributed_worker:v20181031-513e107c
```

Use Case: Improve Model Performance

Learned Model

Accuracy – 0.9674

Output

5

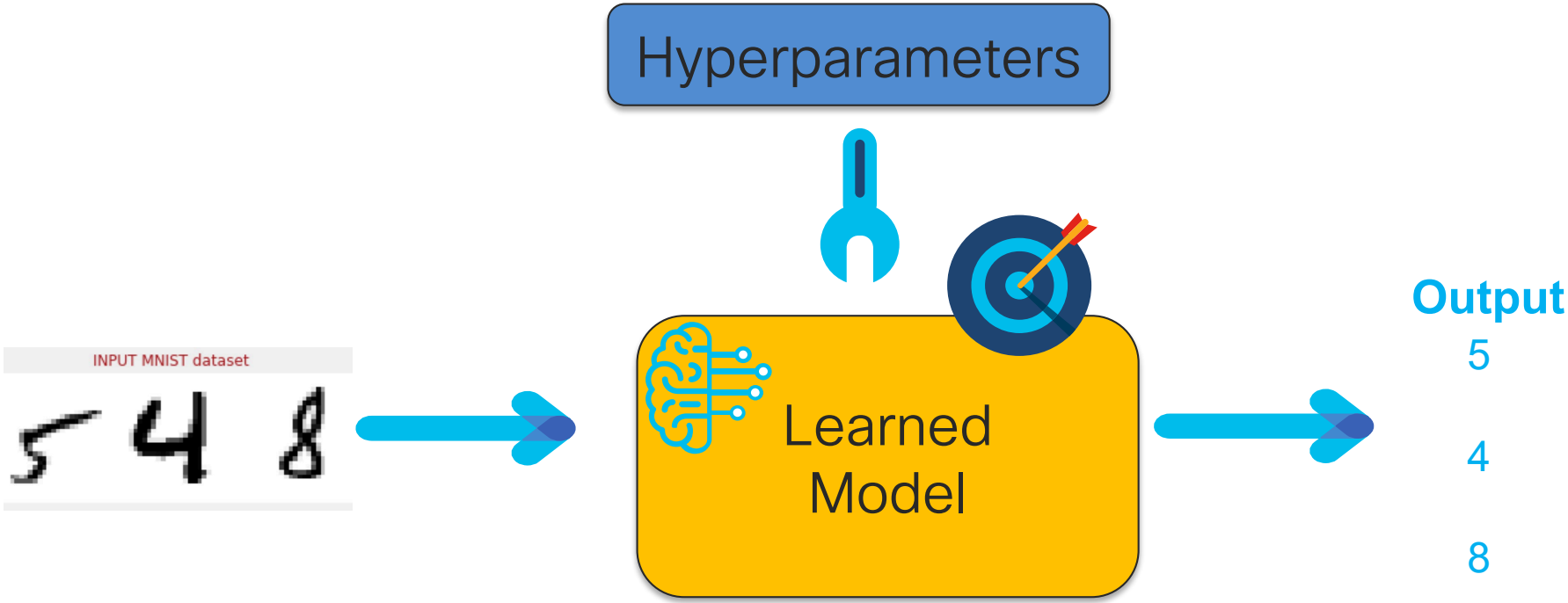
4

8

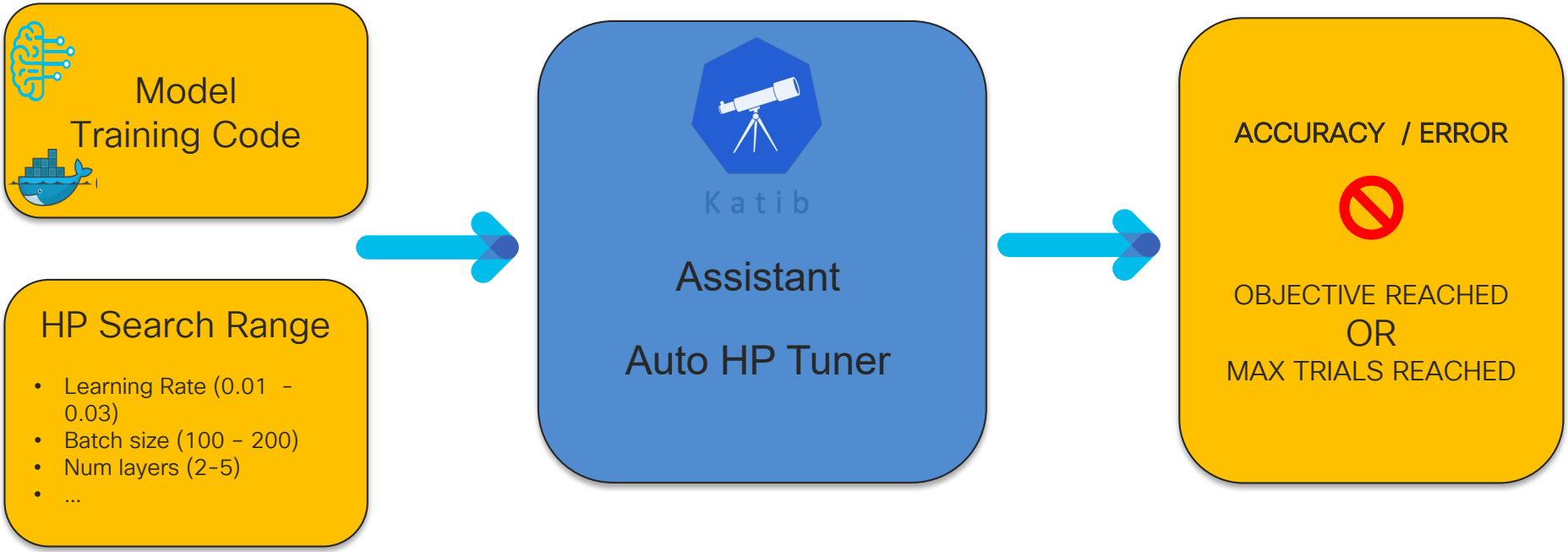
How to improve model prediction accuracy 0.9674 ?

https://github.com/kubeflow/tf-operator/blob/master/examples/v1/mnist_with_summaries/mnist_with_summaries.py

What is Hyperparameter



Who is Katib?



Katib Config

```
containers:
  - name: tensorflow
    image: gcr.io/kubeflow-ci/tf-mnist-with-summaries:1.0
```

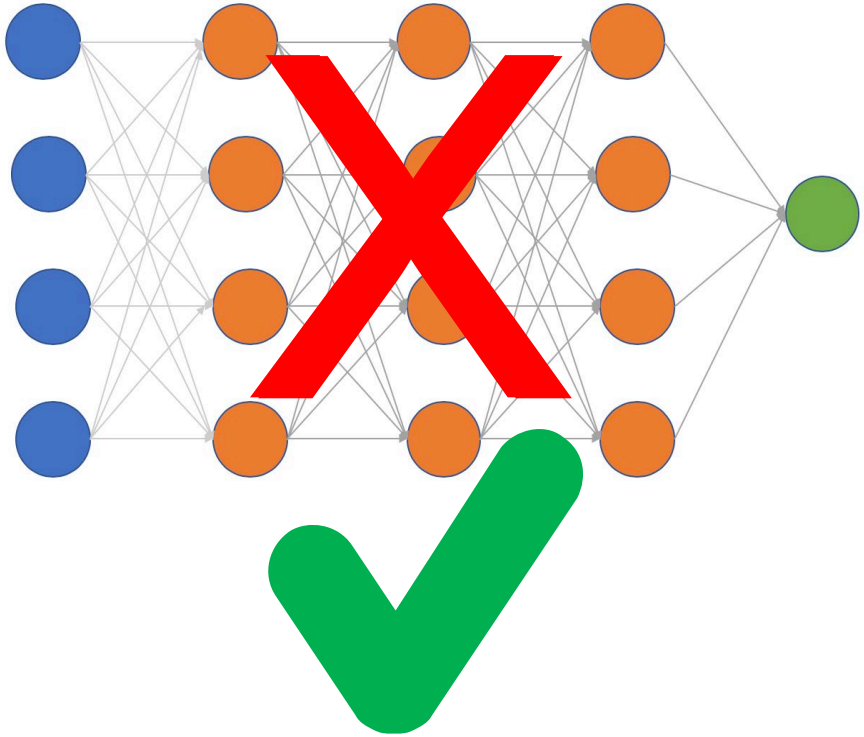
```
parameters:
  - name: --learning_rate
    parameterType: double
    feasibleSpace:
      min: "0.01"
      max: "0.05"
  - name: --batch_size
    parameterType: int
    feasibleSpace:
      min: "100"
      max: "200"
```


```
algorithm:
  algorithmName: random
```

```
spec:
  parallelTrialCount: 3
  maxTrialCount: 12
  maxFailedTrialCount: 3
  objective:
    type: maximize
    goal: 0.99
    objectiveMetricName: accuracy_1
```

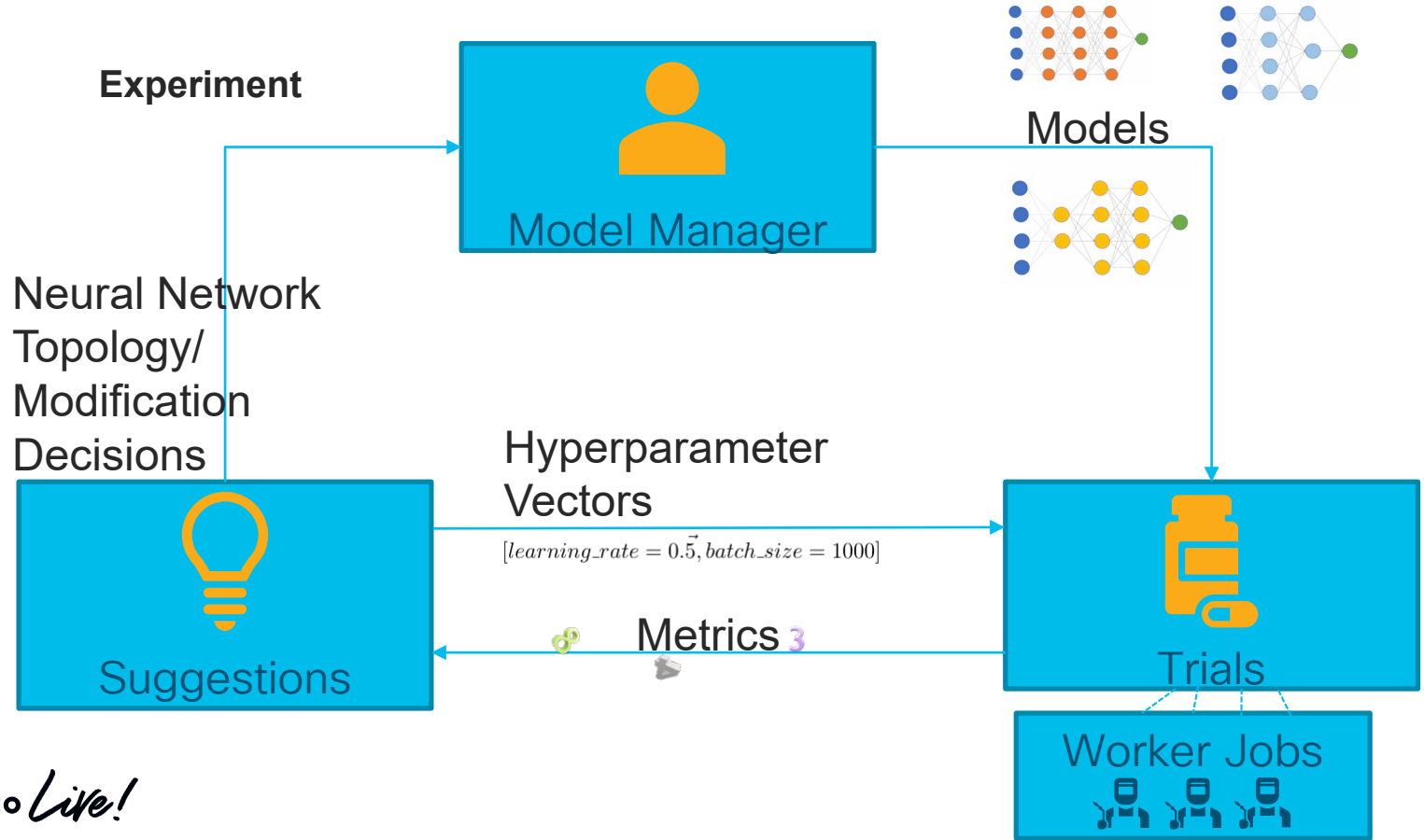
```
  Message:                Experiment has succeed
d because max trial count has reached
  Reason:                 ExperimentSucceeded
  Status:                 True
  Type:                   Succeeded
Current Optimal Trial:
  Observation:
    Metrics:
      Name:   accuracy_1
      Value:  0.970499992371
  Parameter Assignments:
    Name:           --learning_rate
    Value:          0.011776169865117337
    Name:           --batch_size
    Value:          152
```

Katib Hyperparameter Tuning – NAS

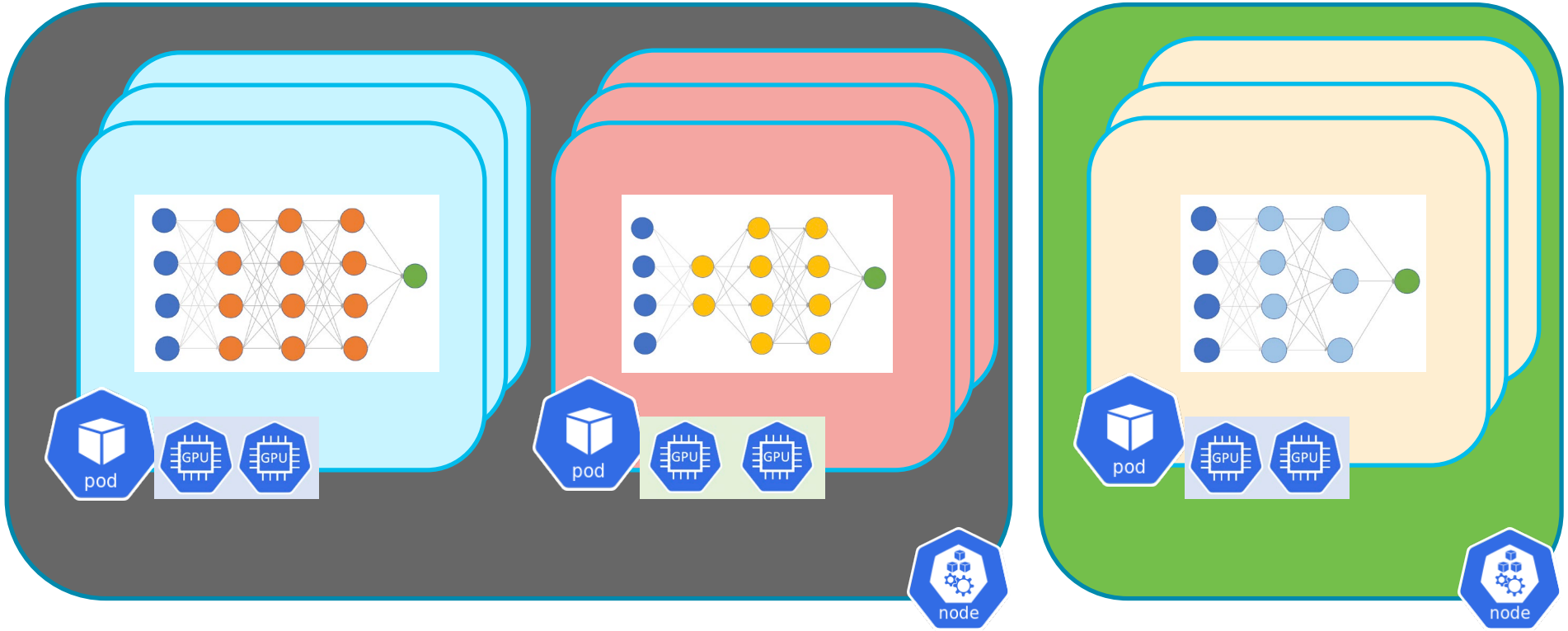


Katib

Katib Hyperparameter Tuning



Multi-Model Parallelism



Katib Experiment Spec

```
apiVersion: "kubeflow.org/v1alpha3
"
kind: Experiment
spec:
  parallelTrialCount: 3
  maxTrialCount: 12
  maxFailedTrialCount: 3
  objective:
    type: maximize
    goal: 0.99
    objectiveMetricName: Validatio
n-Accuracy
  algorithm:
    algorithmName: nasrl
    algorithmSettings:
```

Katib Experiment Spec

```
  trialTemplate:
    goTemplate:
        rawTemplate: |-
          apiVersion: batch/v1
          kind: Job
          metadata:
            name: {{.Trial}}
            namespace: {{.NameSp
ace}}
          spec:
            template:
              spec:
                containers:
                -
```

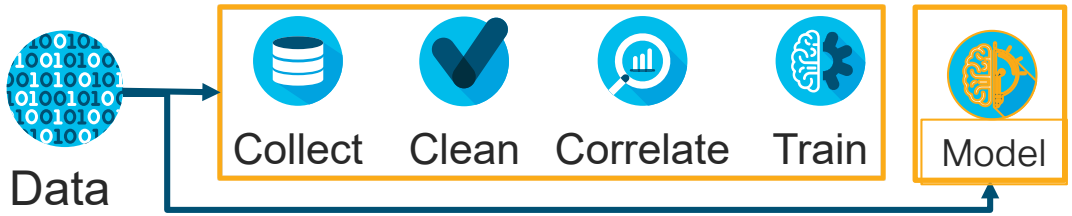
```
command:
- "python3.5"
- "-u"
- "RunTrial.py"
{{- with .HyperParameters}}
{{- range .}}
- "--{{.Name}}={{.Value}}"
{{- end}}
{{- end}}
resources:
  limits:
    nvidia.com/gpu: 1
```

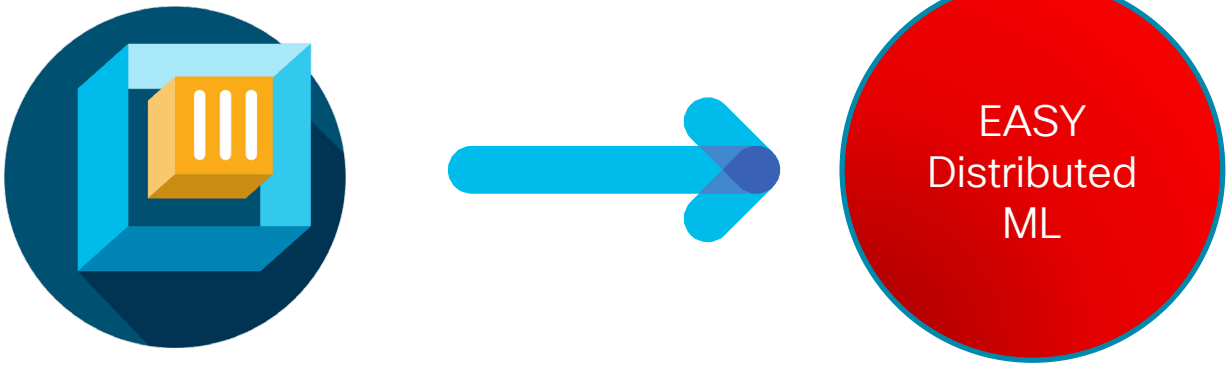
Now Including

Kubeflow

Summary

Easy distributed ML with Cisco Container Platform





Cisco Container Platform

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Thank you

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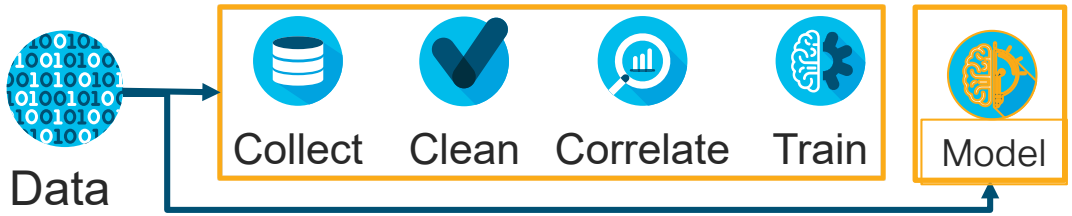
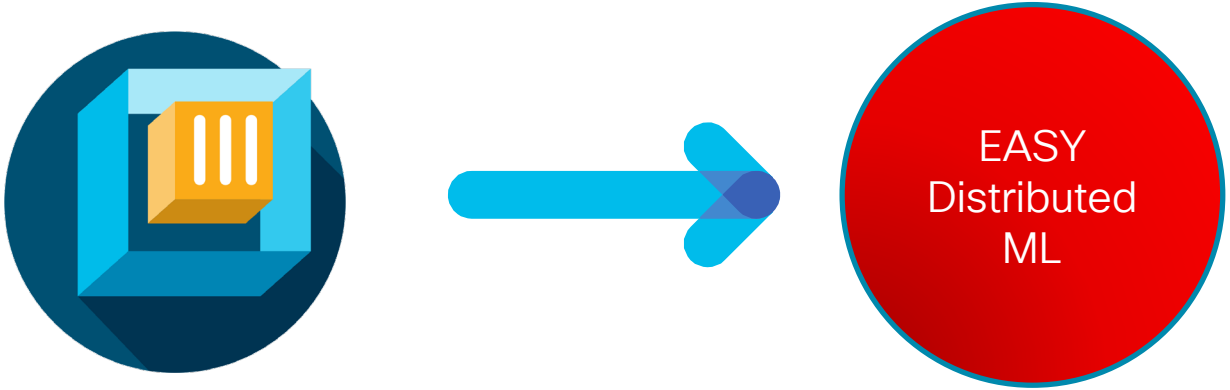
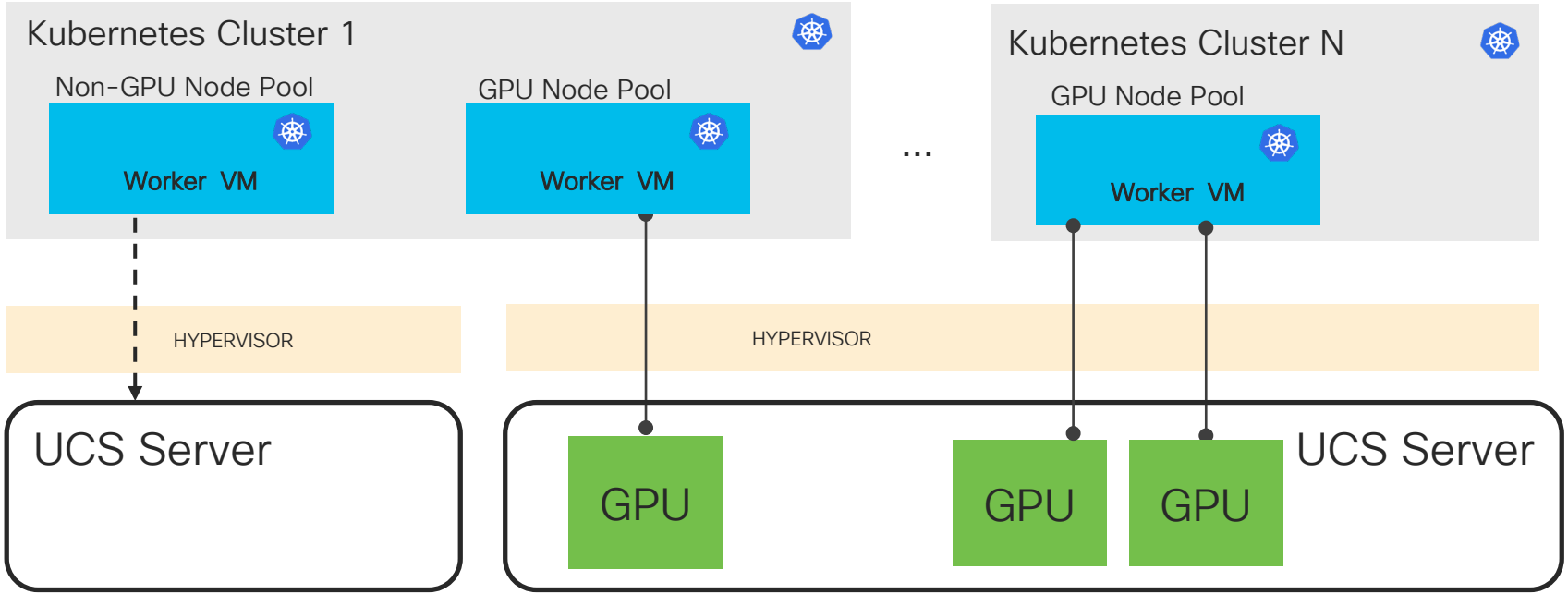
Easy distributed ML with Cisco Container Platform





Cisco Container Platform

Multi-GPU as a Service



Cisco Container Platform v4.x

- Automate AI/ML workload similar to any K8s workload, CCP provides "Multi-GPU as a Service"
  - Multiple GPU per worker node
  - Optimized GPU selection for UCS Servers
  - GPU passthrough (native performance),
  - Auto provisioning of Nvidia CUDA drivers, container runtime, NVIDIA device plugin

You make **possible**