

Kubernetes for Machine Learning

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**GLOBAL AI
BOOTCAMP
2018**



\$whoami

```
{
```

```
  "name" : "Nilesh Gule",
  "website" : "https://www.HandsOnArchitect.com",
  "github" : "https://github.com/NileshGule"
  "twitter" : "@nileshgule",
  "linkedin" : "https://www.linkedin.com/in/nileshgule",
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  "likes" : "Technical Evangelism, Cricket"
}
```



Agenda

- ML Workflow
- Containerize ML Model
- AKS Deployment
- Deploy on GPU nodes
- Distributed training

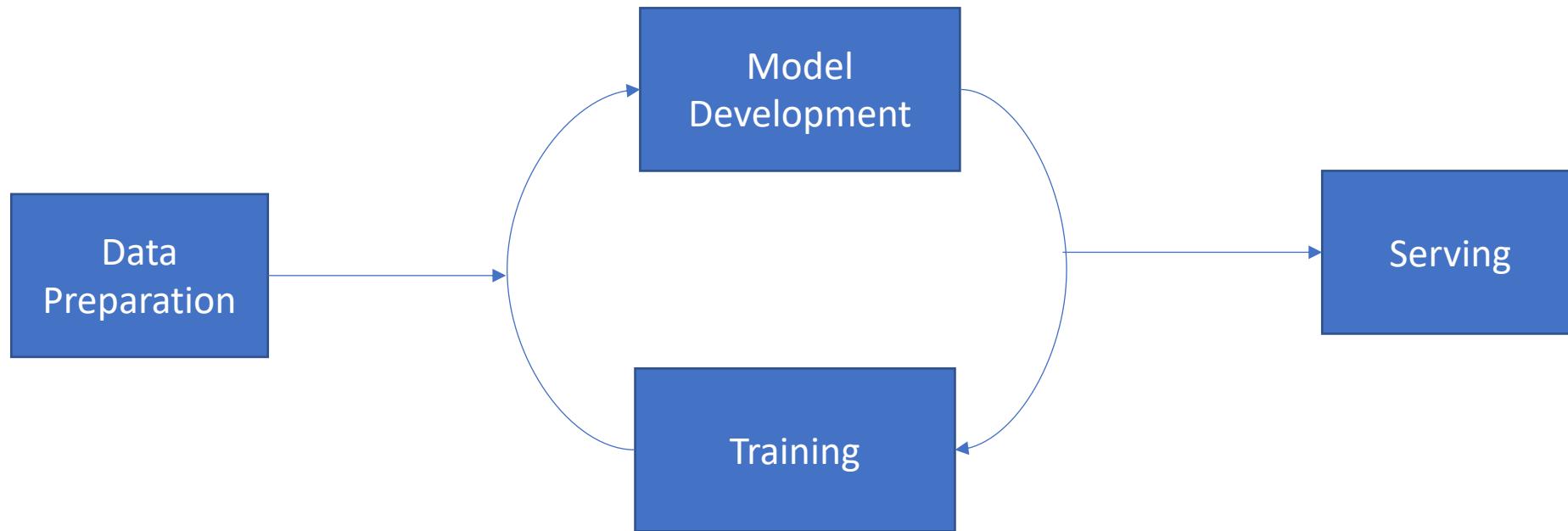
Assumption

- Basic understanding of ML
- TensorFlow
- Docker, Kubernetes
- Azure (RG, AKS, Files)



#globalaibootcamp

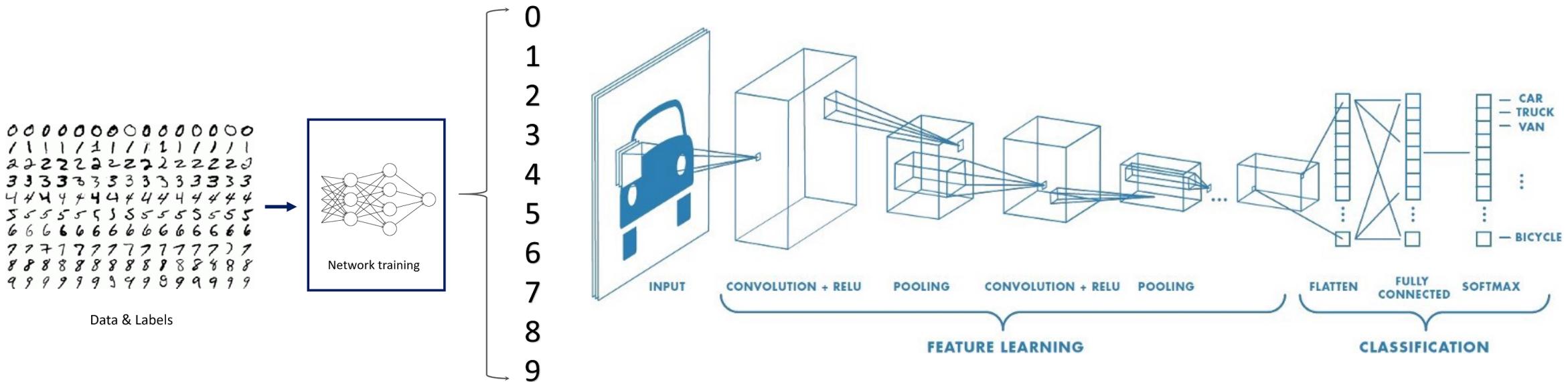
Simplified ML Workflow



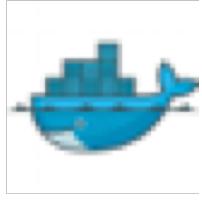
Challenges with ML

- Reproducibility
- Scalability
- Sequential & slow training
- Hard to setup distributed training
- High cost

Example: Image classification with Mnist dataset

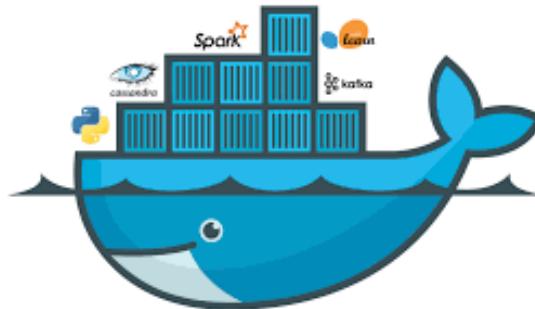


<https://towardsdatascience.com/image-classification-in-10-minutes-with-mnist-dataset-54c35b77a38d>



Docker

- Portability
- Uniformity
- Packages application with all its dependencies

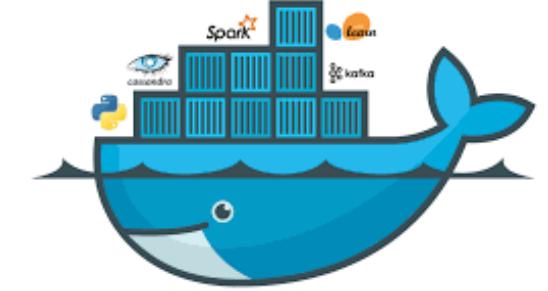


Demo – Containerize TensorFlow Model



Kubernetes to the rescue

- Scale deployment to multi node cluster
- GPU support
- Better utilization of resources
- Distributed training



Demo – Deploy to AKS



kubernetes



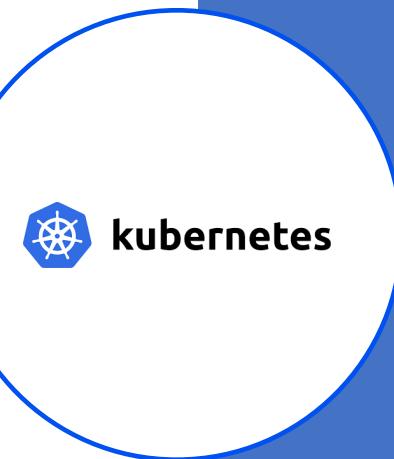
Prerequisites

- Kubernetes version 1.10 and above
- NC series VM for GPU support

```
 Addresses:  
   InternalIP: 10.240.0.5  
   Hostname: aks-nodepool1-17542588-0  
 Capacity:  
   cpu: 6  
   ephemeral-storage: 30428648Ki  
   hugepages-1Gi: 0  
   hugepages-2Mi: 0  
   memory: 57713788Ki  
   nvidia.com/gpu: 1  
   pods: 110  
 Allocatable:  
   cpu: 5916m  
   ephemeral-storage: 28043041951  
   hugepages-1Gi: 0  
   hugepages-2Mi: 0  
   memory: 52368508Ki  
   nvidia.com/gpu: 1  
   pods: 110  
 System Info:  
   Machine ID: dc2fa8f1d735497b9c33dbb6e7608052  
   System UUID: 084EEA2E-C8A7-8343-823C-4EB68B8E99A1  
   Boot ID: ccbeed53-ee0b-4bab-9299-0e2a7722a463  
   Kernel Version: 4.15.0-1030-azure  
   OS Image: Ubuntu 16.04.5 LTS  
   Operating System: linux  
   Architecture: amd64  
   Container Runtime Version: docker://1.13.1  
   Kubelet Version: v1.10.9  
   Kube-Proxy Version: v1.10.9  
   PodCIDR: 10.244.0.0/24
```

Kubernetes objects

- Pod
- Service
- Namespace
- Volume
- Deployment
- Job



```
apiVersion: batch/v1
kind: Job # Our training should be a Job
metadata:
  name: module2-ex1 # Name of our job
spec:
  template: # Template of the Pod that is
    metadata:
      name: module2-ex1 # Name of the pod
    spec:
      containers: # List of containers th
        - name: tensorflow
          image: nileshgule/tf-mnist:gpu #
          args: ["--max_steps", "500"] # O
      resources:
        limits:
          nvidia.com/gpu: 1 # We ask Ku
      volumeMounts:
        - name: nvidia
          mountPath: /usr/local/nvidia
      volumes:
        - name: nvidia
          hostPath:
            path: /usr/local/nvidia
      restartPolicy: OnFailure # restart
```

```
└── kubectl logs module2-ex1-4bmpv
WARNING:tensorflow:From /app/main.py:42: read_data_sets (from tensorflow.contrib.learn.python.learn.datasets.base) is deprecated and will be removed in a future version.
Instructions for updating:
Please use alternatives such as official/mnist/dataset.py from tensorflow/models.
WARNING:tensorflow:From /usr/local/lib/python2.7/dist-packages/tensorflow/contrib/learn/python/learn/flow/contrib.learn.python.learn.datasets.base) is deprecated and will be removed in a future version.
Instructions for updating:
Please write your own downloading logic.
WARNING:tensorflow:From /usr/local/lib/python2.7/dist-packages/tensorflow/contrib/learn/python/learn/contrib.learn.python.learn.datasets.base) is deprecated and will be removed in a future version.
Instructions for updating:
Please use urllib or similar directly.
```

```
└── kubectl get nodes
NAME                  STATUS   ROLES   AGE      VERSION
aks-nodepool1-17542588-0  Ready    agent   3d      v1.10.9
aks-nodepool1-17542588-1  Ready    agent   3d      v1.10.9
aks-nodepool1-17542588-2  Ready    agent   3d      v1.10.9
```



Simplify ML deployment with Kubeflow

Make ML workflows on Kubernetes

- simple,
- portable
- Scalable

Best of breed open source system for ML

Runs on diverse infrastructures



Demo – Kubeflow

Kubeflow

Kubeflow objects

Name	Node	Status	Restarts	Age	CPU (cores)	Memory (bytes)
jupyter-adm	aks-nodepool1-17542588-2	Running	1	5 hours	0	49.461 Mi
tf-hub-0	aks-nodepool1-17542588-0	Running	0	5 hours	0	83.637 Mi
tf-job-dashboard-bfc9c6bc-9jxqj	aks-nodepool1-17542588-2	Running	0	2 days	0	9.953 Mi
tf-job-operator-v1alpha2-756cf9cb97-dwocj	aks-nodepool1-17542588-1	Running	0	2 days	0.003	20.043 Mi
ambassador-849fb9c8c5-ykogg	aks-nodepool1-17542588-4	Running	0	2 days	1.298	5.428 Gi
ambassador-849fb9c8c5-74mh	aks-nodepool1-17542588-2	Running	0	2 days	1.415	5.428 Gi
ambassador-849fb9c8c5-7mmn	aks-nodepool1-17542588-1	Running	0	2 days	0.964	5.569 Gi
centraldashboard-7d774cccb-k8dem	aks-nodepool1-17542588-0	Running	0	2 days	0	15.844 Mi

Name	Labels	Pods	Age	Images
tf-job-dashboard	app.kubernetes.io/deploy:manager: ksonnet.io/component: kubeflow-core	1 / 1	2 days	gcr.io/kubeflow-images-public/tf_operator: v1.0.0
tf-job-operator-v1alpha2	app.kubernetes.io/deploy:manager: ksonnet.io/component: kubeflow-core	1 / 1	2 days	gcr.io/kubeflow-images-public/tf_operator: v1.0.0
ambassador	app.kubernetes.io/deploy:manager: ksonnet.io/component: kubeflow-core	3 / 3	2 days	quay.io/datalwire/ambassador:0.30.1
centraldashboard	app.kubernetes.io/deploy:manager: ksonnet.io/component: kubeflow-core	1 / 1	2 days	gcr.io/kubeflow-images-public/centraldash: v1.0.0

Name	Labels	Pods	Age	Images
tf-job-dashboard-bfc9c6bc	name: tf-job-dashboard pod-template-hash: 697567267	1 / 1	2 days	gcr.io/kubeflow-images-public/tf_operator: v1.0.0
tf-job-operator-v1alpha2-756cf9cb97	name: tf-job-operator pod-template-hash: 3127957653	1 / 1	2 days	gcr.io/kubeflow-images-public/tf_operator: v1.0.0
ambassador-849fb9c8c5	service: ambassador	3 / 3	2 days	quay.io/datalwire/ambassador:0.30.1
centraldashboard-7d774cccb	app: centraldashboard pod-template-hash: 383300776	1 / 1	2 days	gcr.io/kubeflow-images-public/centraldash: v1.0.0

TF Job & Kubernetes CRD

TFJob & Kubernetes CRD

- Kubernetes Custom Resource (CRD)
- Contains
 - **Chief** – orchestrates training & checkpointing
 - **Ps** – parameter servers
 - **Worker** – train the model
 - **Evaluator** – compute evaluation metrics
- ReplicaSpec
 - **Replicas**
 - **Template**
 - **restartPolicy**

Azure Files Storage

```
apiVersion: kubeflow.org/v1alpha2
kind: TFJob
metadata:
  name: module6-ex2-gpu
spec:
  tfReplicaSpecs:
    MASTER:
      replicas: 1
      template:
        spec:
          containers:
            - image: nileshgule/tf-mnist:gpu
              name: tensorflow
              resources:
                limits:
                  nvidia.com/gpu: 1
            volumeMounts:
              - name: azurefile
                subPath: module6-ex2-gpu
                mountPath: /tmp/tensorflow
      restartPolicy: OnFailure
    volumes:
      - name: azurefile
        persistentVolumeClaim:
          claimName: azurefile
```

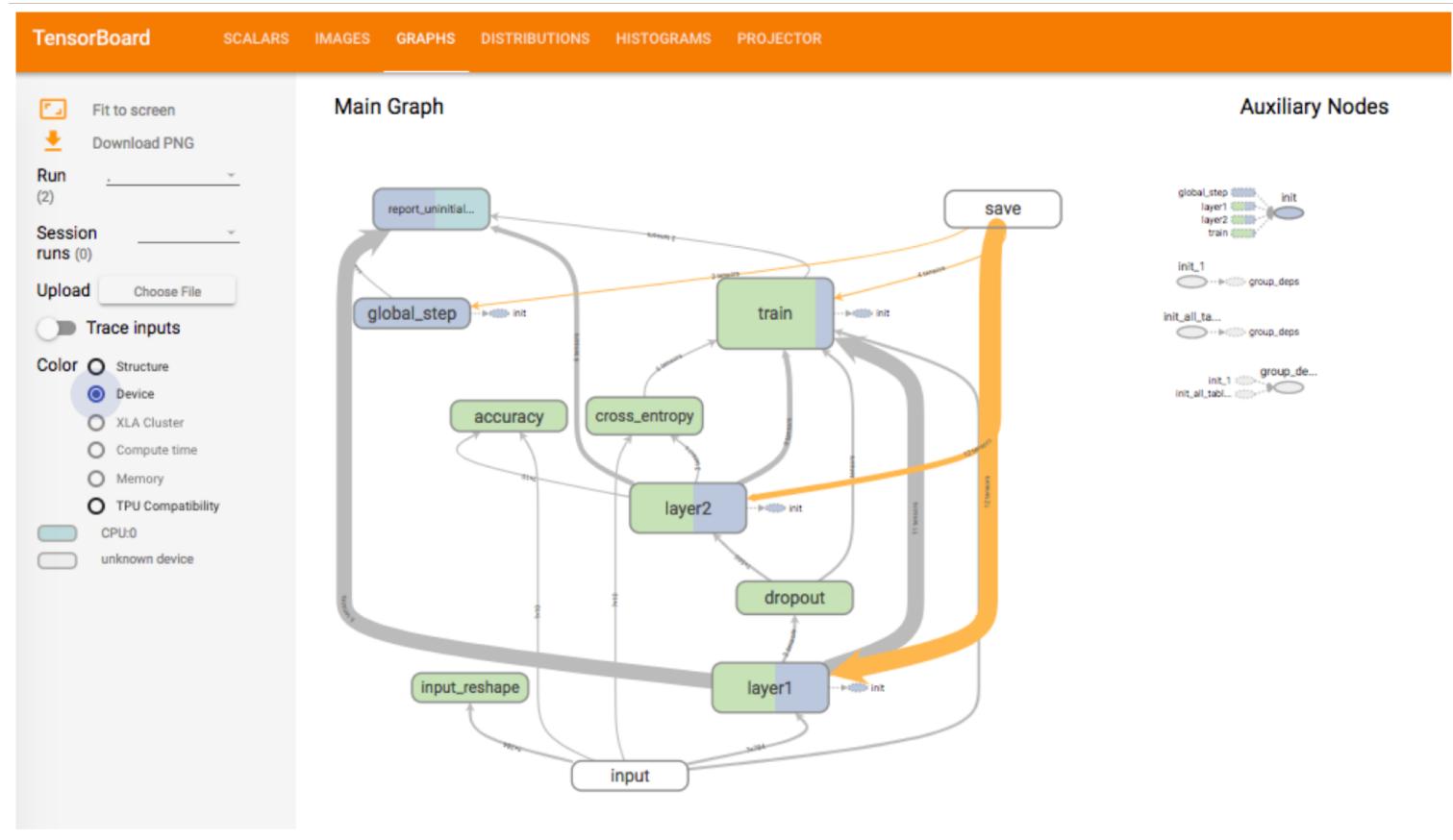
```
tfReplicaSpecs:
  MASTER:
    replicas: 1
    template:
      spec:
        volumes:
          - name: azurefile
            persistentVolumeClaim:
              claimName: azurefile
        containers:
          - image: nileshgule/tf-mnist:distributedgpu
            name: tensorflow
            imagePullPolicy: Always
            resources:
              limits:
                nvidia.com/gpu: 1
            volumeMounts:
              - mountPath: /tmp/tensorflow
                subPath: module7-ex1-gpu
                name: azurefile
      restartPolicy: OnFailure
```

```
WORKER:
  replicas: 2
  template:
    spec:
      containers:
        - image: nileshgule/tf-mnist:distributedgpu
          name: tensorflow
          imagePullPolicy: Always
          resources:
            limits:
              nvidia.com/gpu: 1
            volumeMounts:
              restartPolicy: OnFailure
```

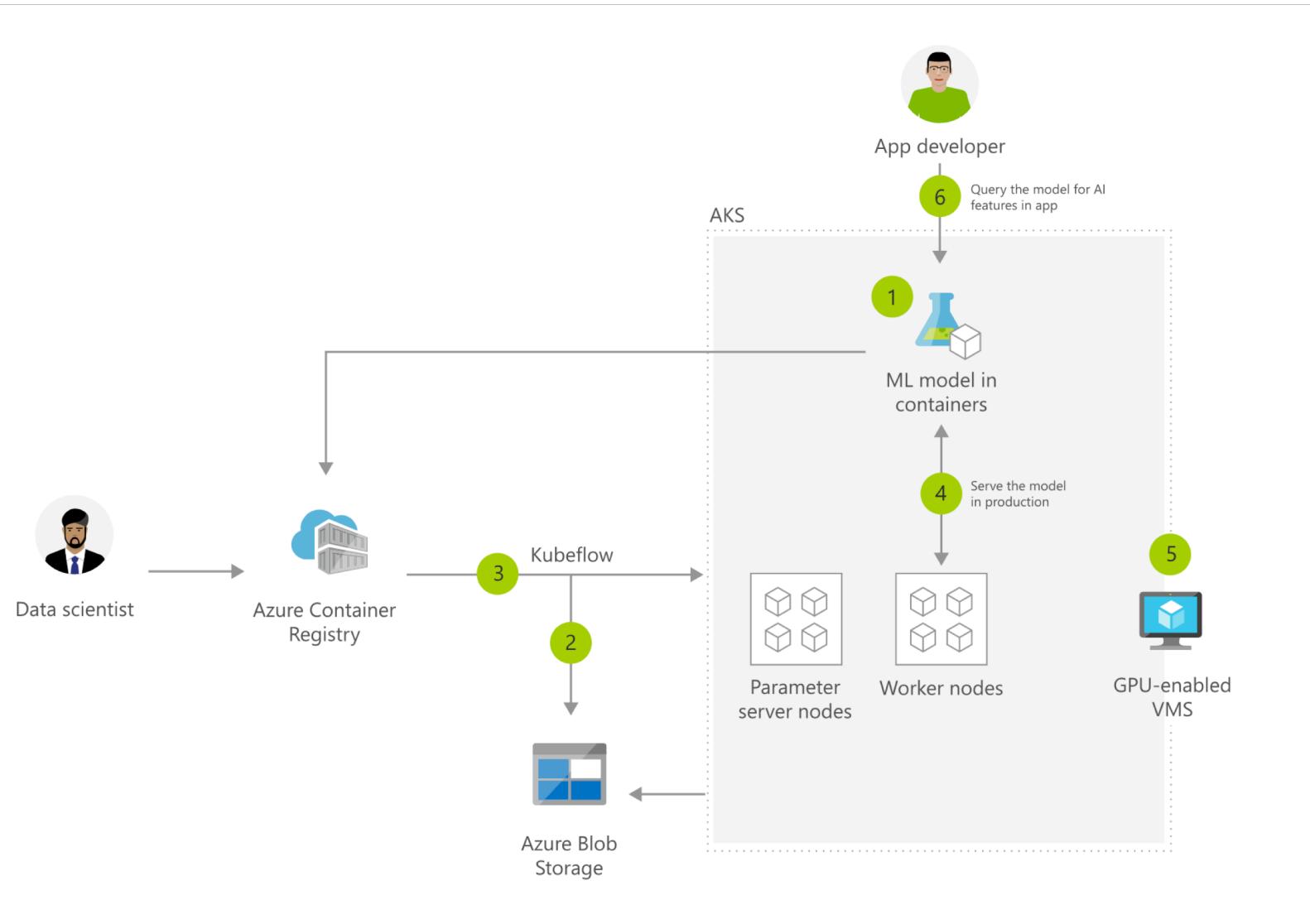
```
PS:
  replicas: 1
  template:
    spec:
      containers:
        - image: nileshgule/tf-mnist:distributedgpu
          name: tensorflow
          imagePullPolicy: Always
          ports:
            - containerPort: 6006
          restartPolicy: OnFailure
```

Distributed Training

Tensorflow Board

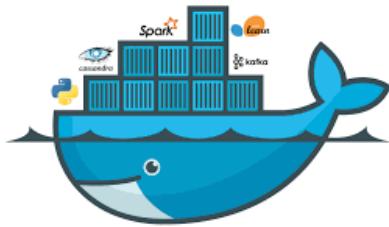


Reference Architecture



<https://azure.microsoft.com/en-gb/solutions/architecture/machine-learning-with-aks/>

Summary



Build / Package



Provision



Kubeflow

Standardize deployment

References

- DMTK - <http://www.dmtk.io/>
- [Image classification with Mnist dataset](#)
- [AKS Deployment Tutorial](#)
- [Kubeflow](#)
- [Ksonnet](#)
- [Tensorflow](#)
- [Azure AKS](#)
- [Enable GPU for Kubernetes](#)
- [TFJob](#)
- [Kubernetes Custom Resource](#)

- [ML pipelines with Docker](#)



- [Open AI keynote](#)



Thank you very much



<https://github.com/NileshGule/kubeflow-labs>

Code with Passion and Strive for Excellence



A classroom setting where a teacher stands at a chalkboard filled with mathematical equations, while several students sit at their desks. One student in the foreground has their hand raised, wearing a green long-sleeved shirt and a colorful striped wristband. The text "Q&A" is overlaid in large white letters.

Q&A