Kubernetes for Machine Learning

Nilesh Gule

GLOBAL AI BOOTCAMP 2018

Microsoft

$whoami

{

“name” : “Nilesh Gule”,
“website” : “https://www.HandsOnArchitect.com",
“github” : “https://github.com/NileshGule"
“twitter” : “@nileshgule”,
“linkedin” : “https://www.linkedin.com/in/nileshgule”,
“email” : “nileshgule@gmail.com",
“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)

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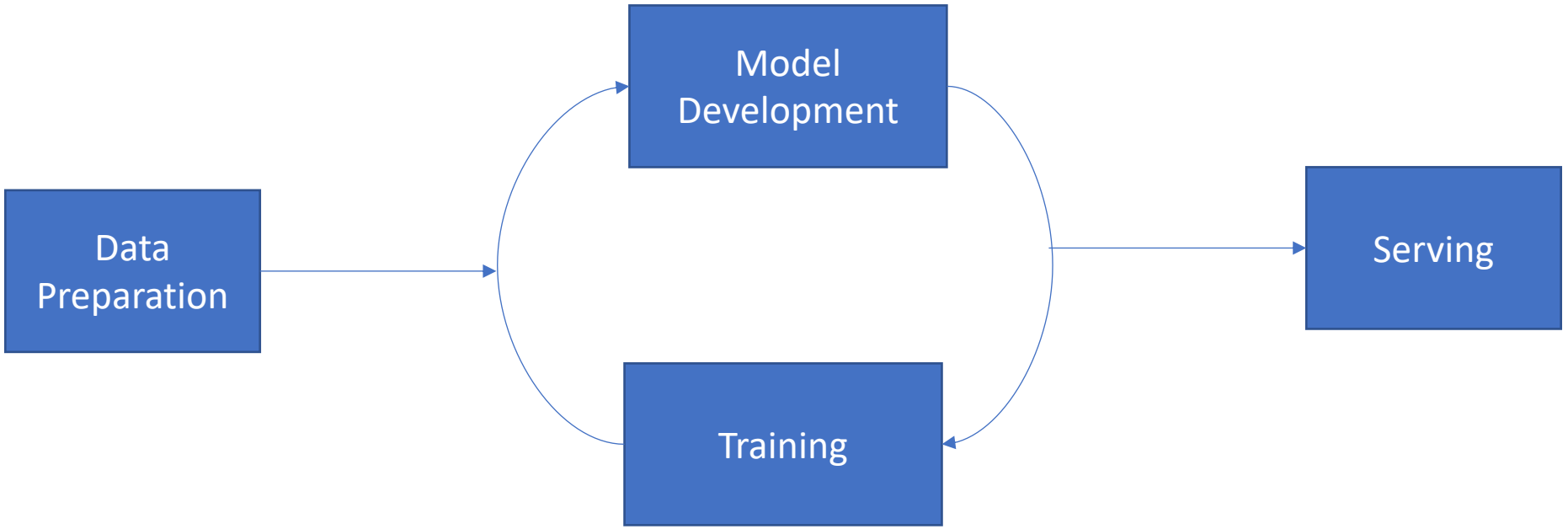
Simplified ML Workflow

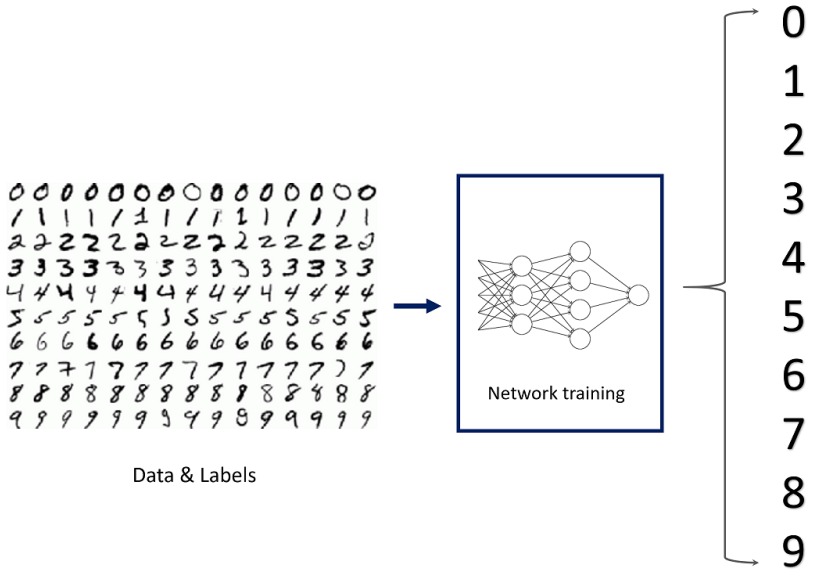


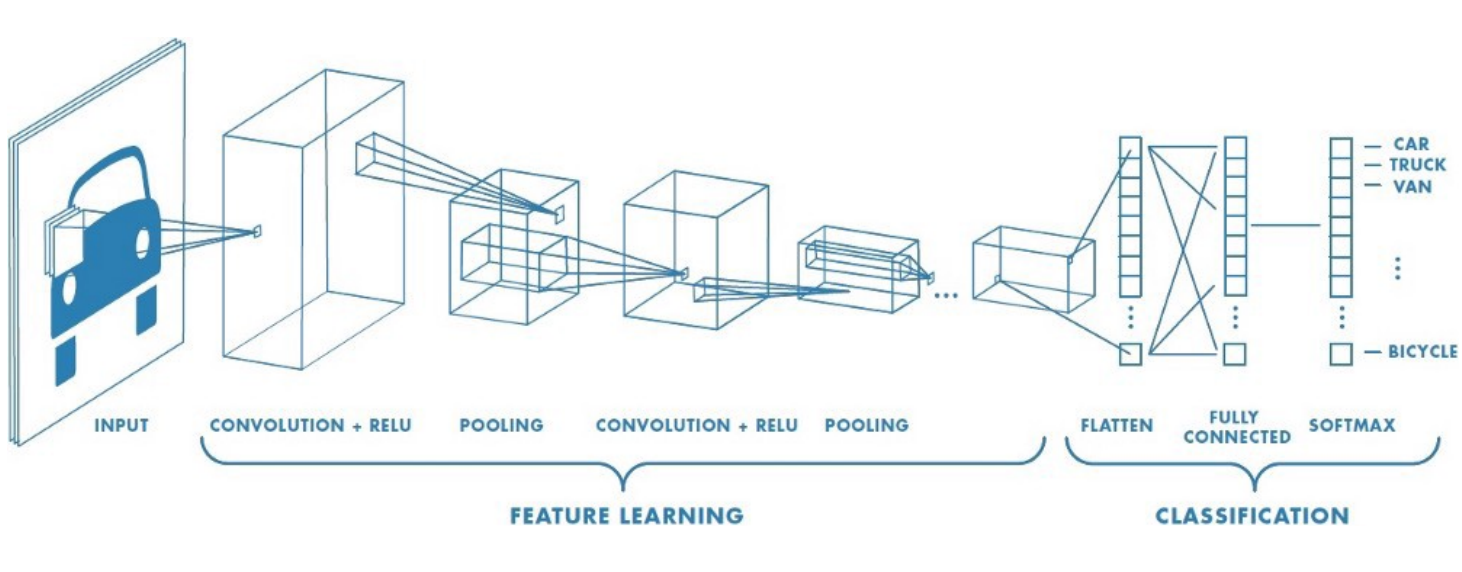
Challenges with ML

- Reproducibility
- Scalability

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

Example: Image classification with Mnist dataset

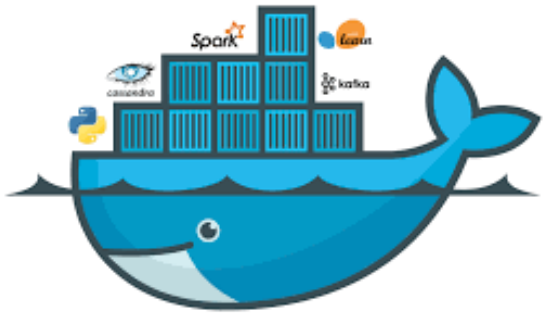




https://towardsdatascience.com/image-classification-in-10-minutes-with-mnist-dataset-54c35b77a38d

Docker

- Portability
- Uniformity
- Packages application with all its dependencies

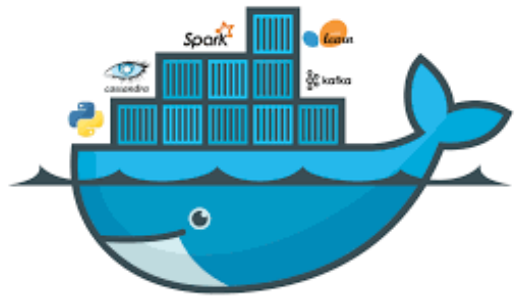


Demo – Containerize TensorFlow Model

kubernetes

Kubernetes to the rescue

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



Demo – Deploy to AKS

kubernetes

TensorFlow

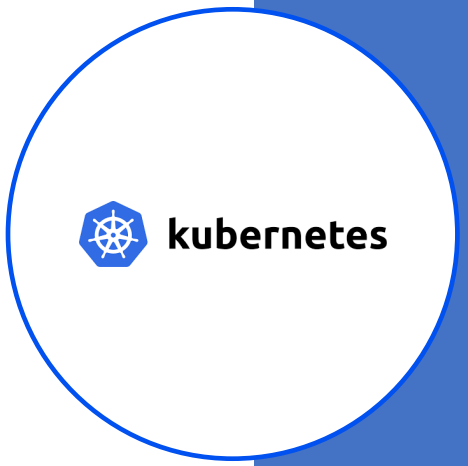
Prerequisites

- 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



```yaml
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"] # Op
        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.da
n 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/d
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/d
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

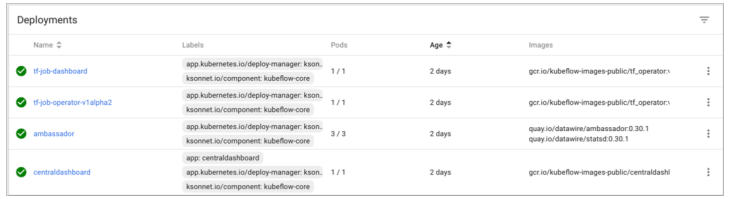
Best of breed open source system for ML

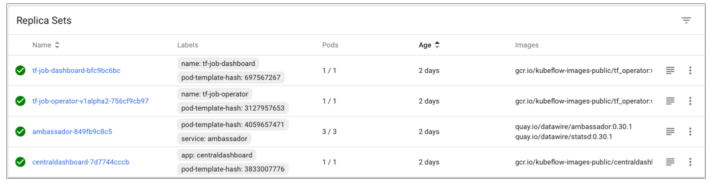
Runs on diverse infrastructures

Demo – Kubeflow

Kubeflow

Kubeflow objects





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

```yaml
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
```

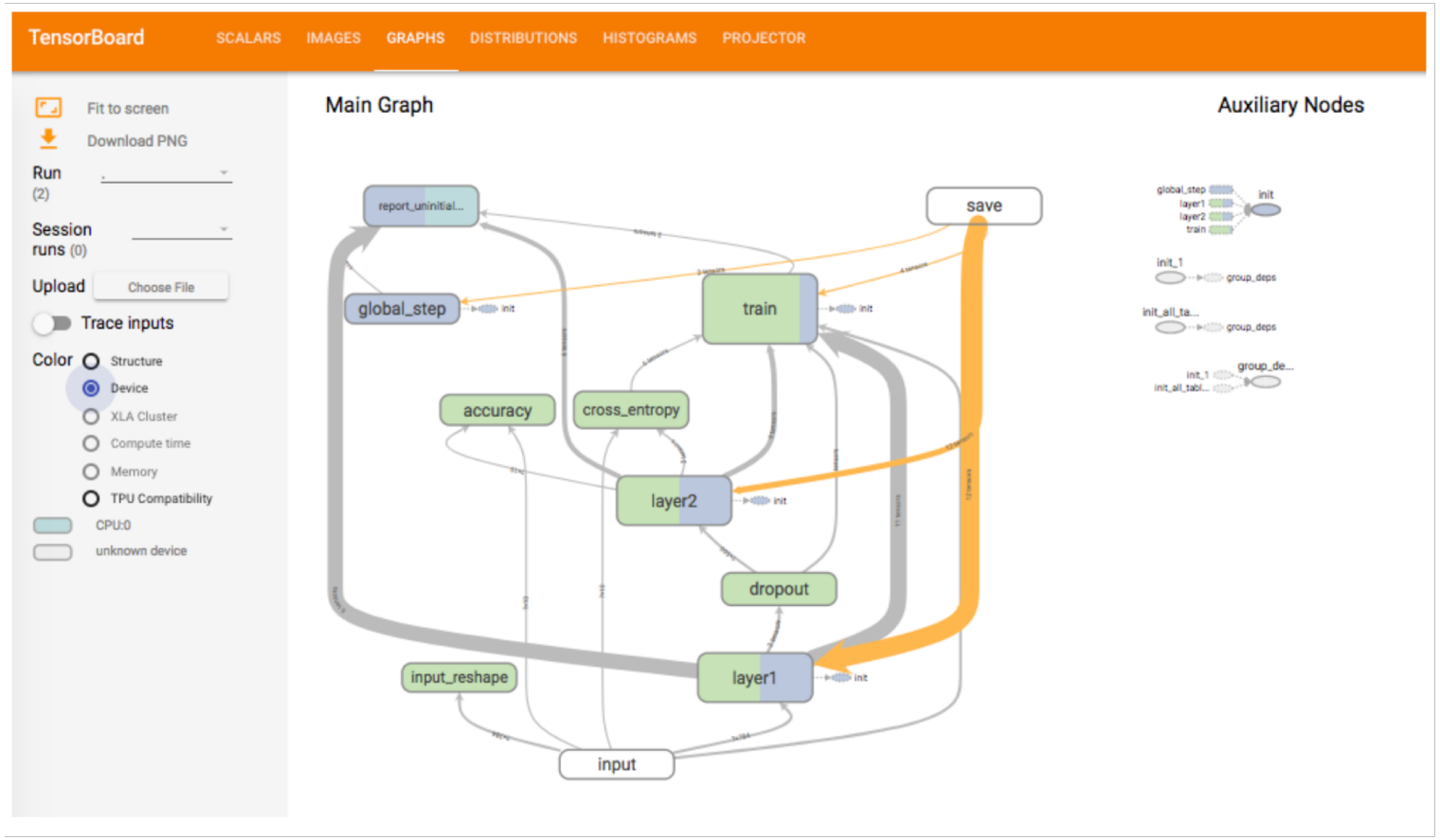
```yaml
tfReplicaSpecs:
  MASTER:
    replicas: 1
    template:
      spec:
        volumes:
          - name: azurefile
            persistentVolumeClaim:
              claimName: azurefile
        containers:
        - image: nileshgule/tf-mnist:distributedgpu
          name: tensorflow
          imagePullPolicy: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

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

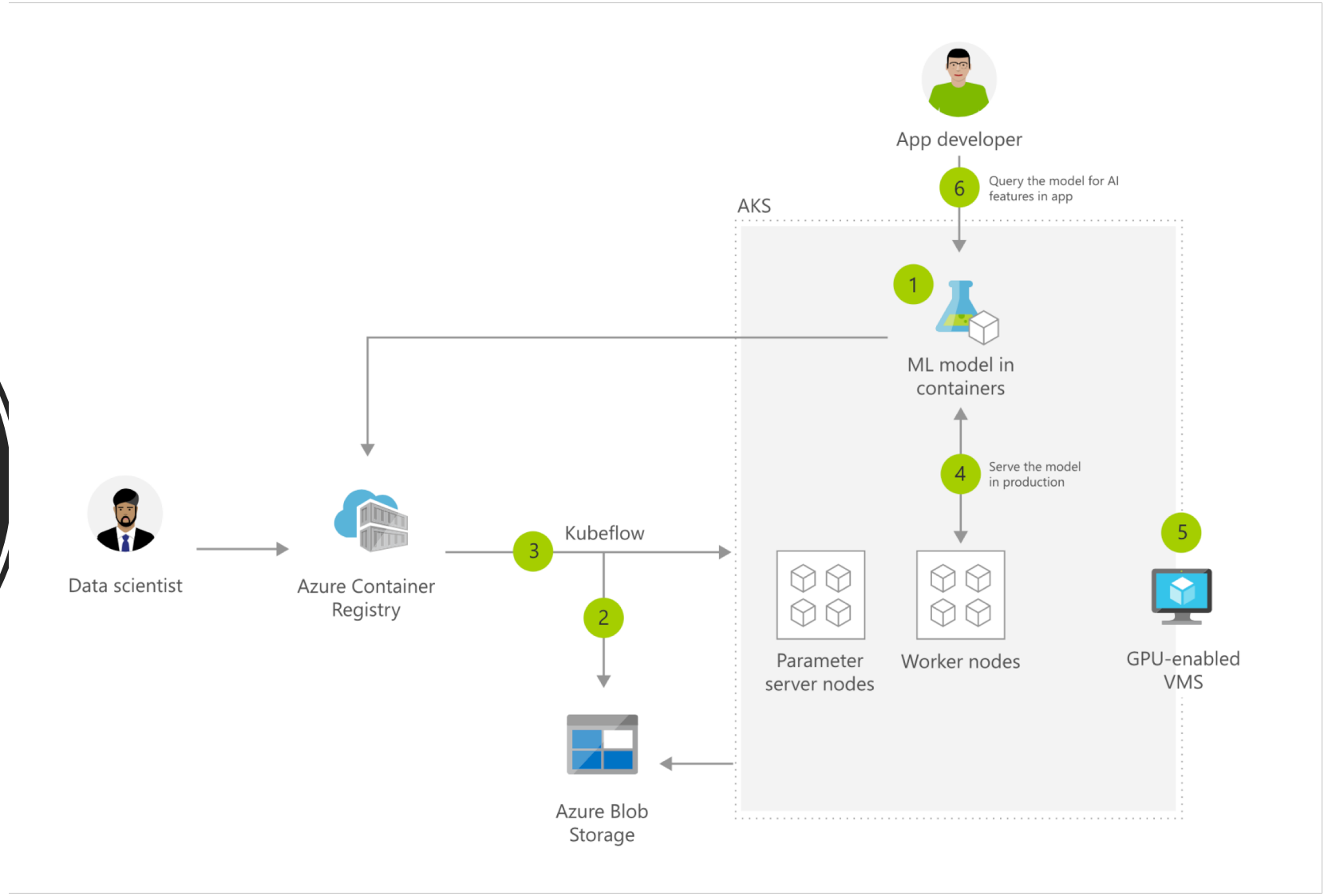
```yaml
PS:
  replicas: 1
  template:
    spec:
      containers:
      - image: nileshgule/tf-mnist:distributed
        name: tensorflow
        imagePullPolicy: Always
        ports:
        - containerPort: 6006
      restartPolicy: OnFailure
```

Distributed Training

Tensorflow Board

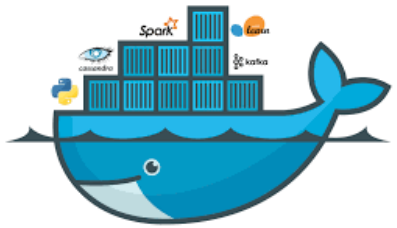


Reference Architecture



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

Summary



Build / Package

Provision

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


Q&A