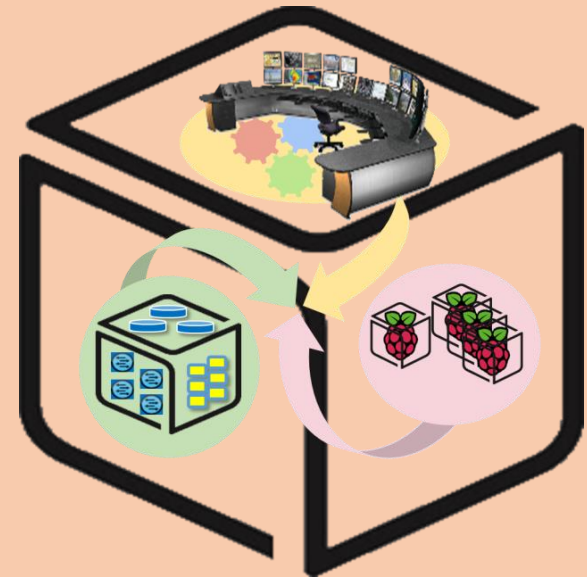


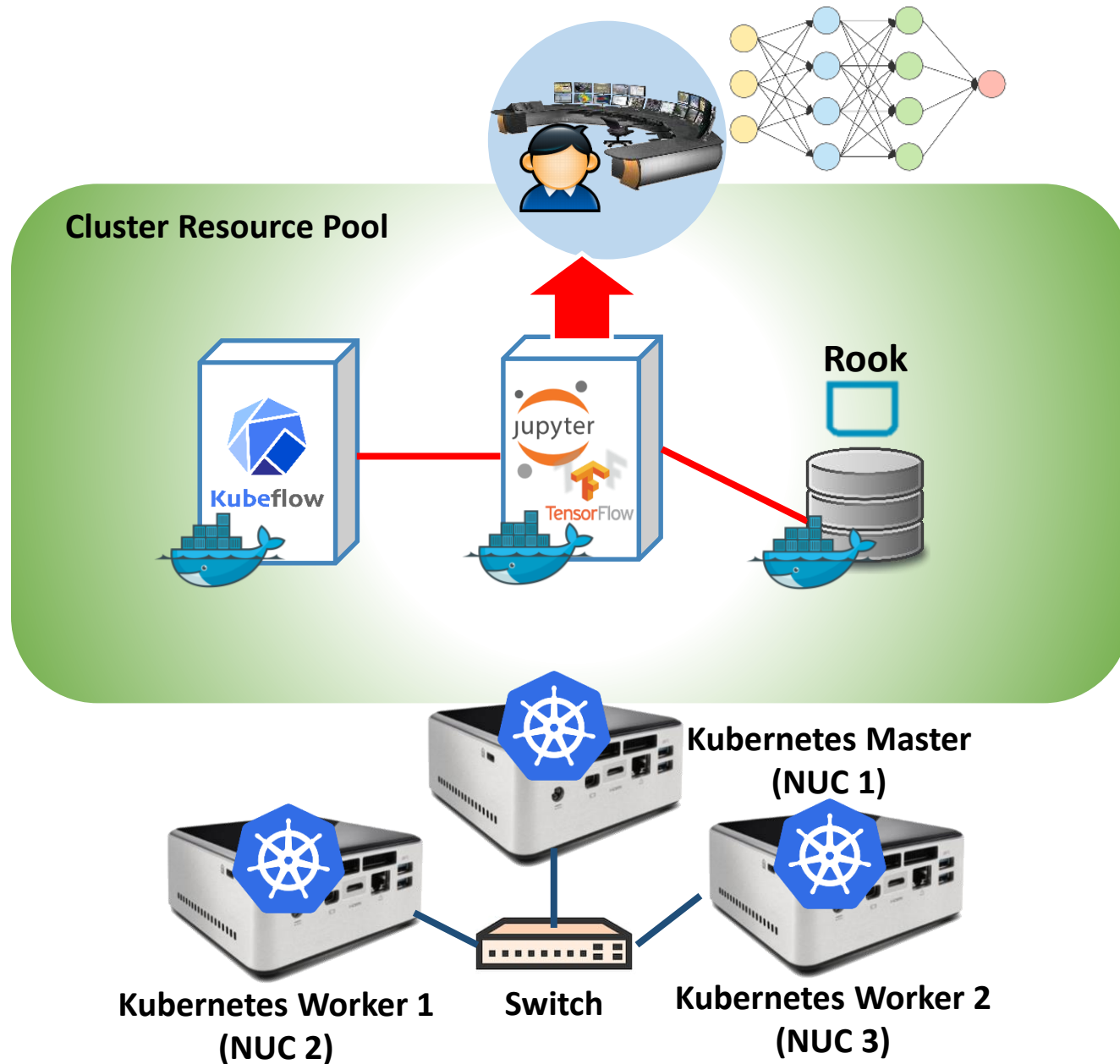
Computer Systems For AI-inspired Cloud Theory & Lab.

Lab #6: Analytics

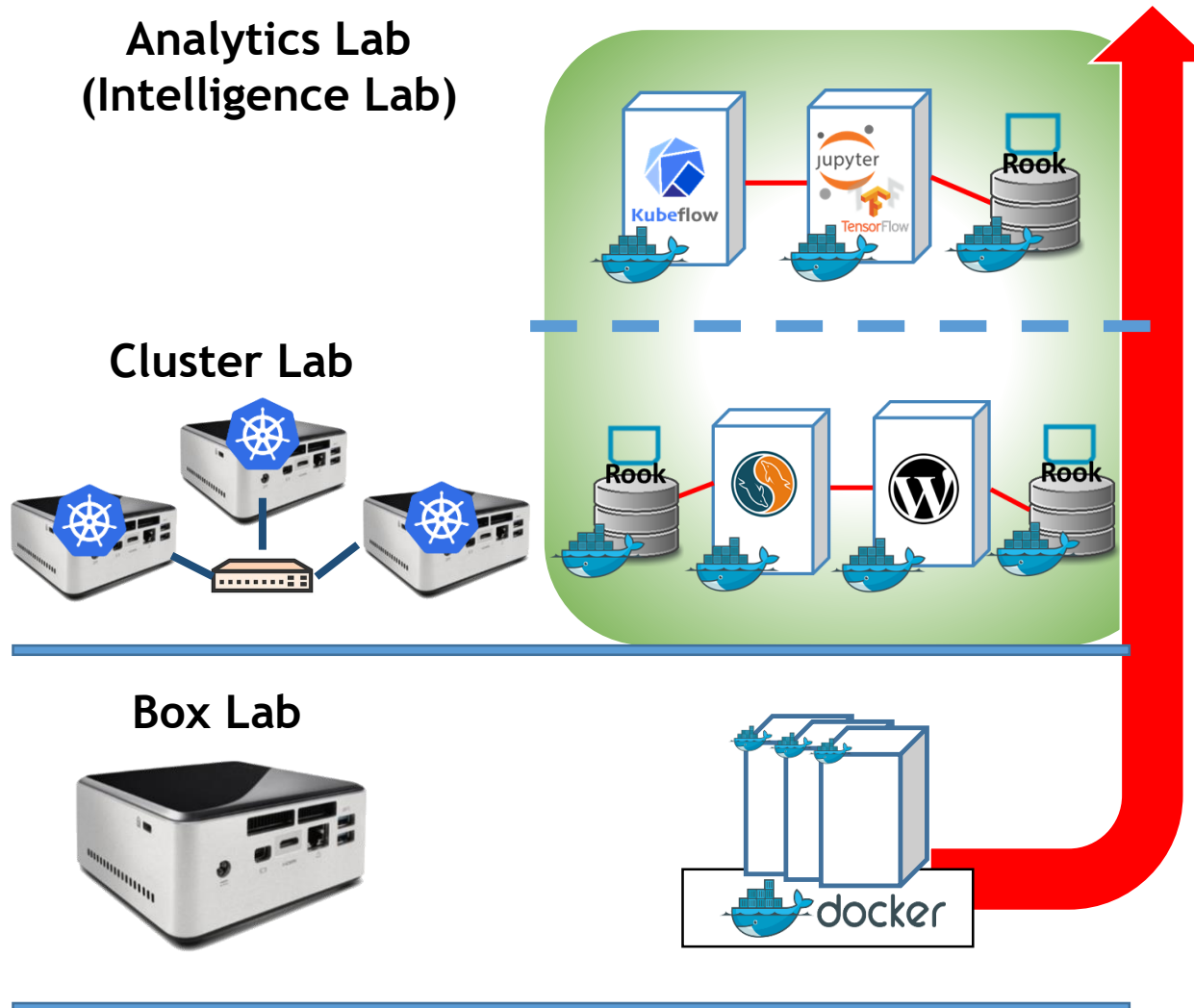


<https://github.com/SmartX-Labs/SmartX-Mini-MOOC>

Analytics Lab: Concept



SmartX Labs #1/#5/#6: Relationship

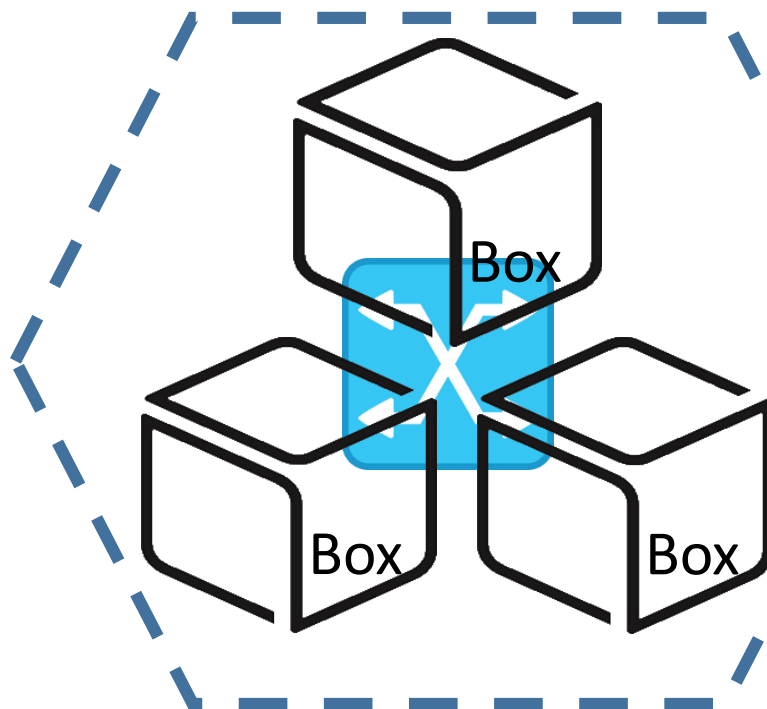


Theory

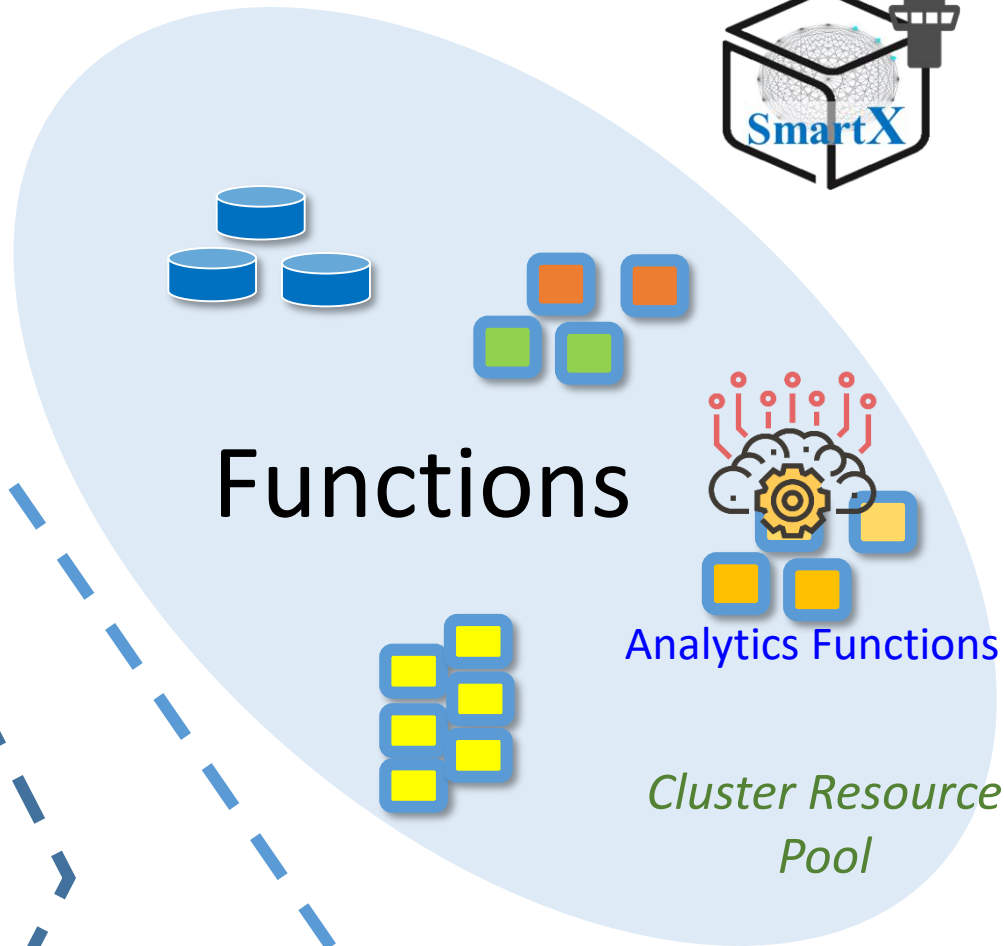


SmartX Cluster: Inter-connected SmartX Boxes

Computing Cluster is a form of computing in which a group of computers are linked together so that they can act like a single entity



Cluster



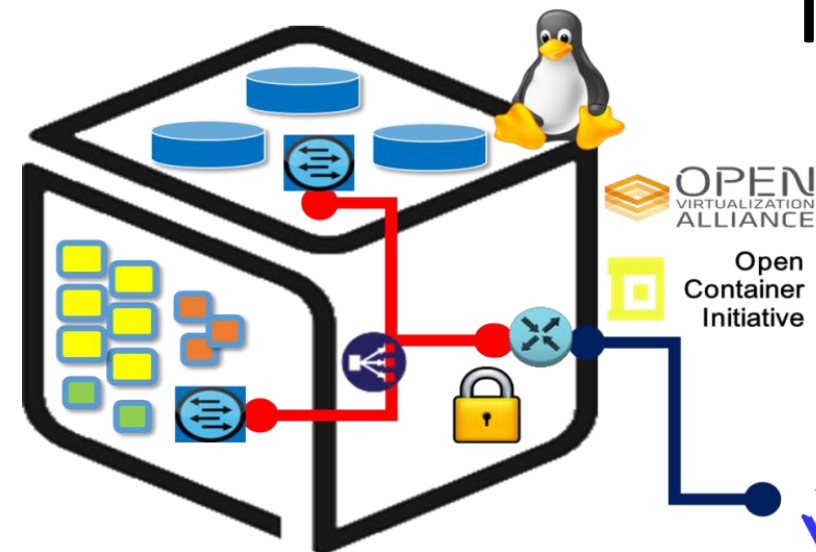


Inter-Connected Functions inside a Box & across Clusters

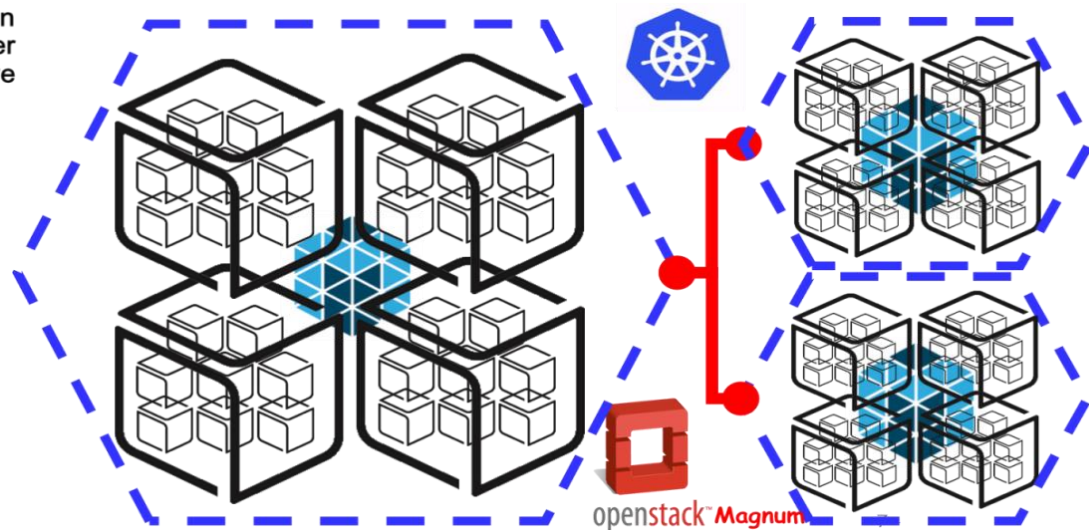
p+v+c Harmonization Challenge:

p(Baremetal) + **v**(VM) + **c**(Container)

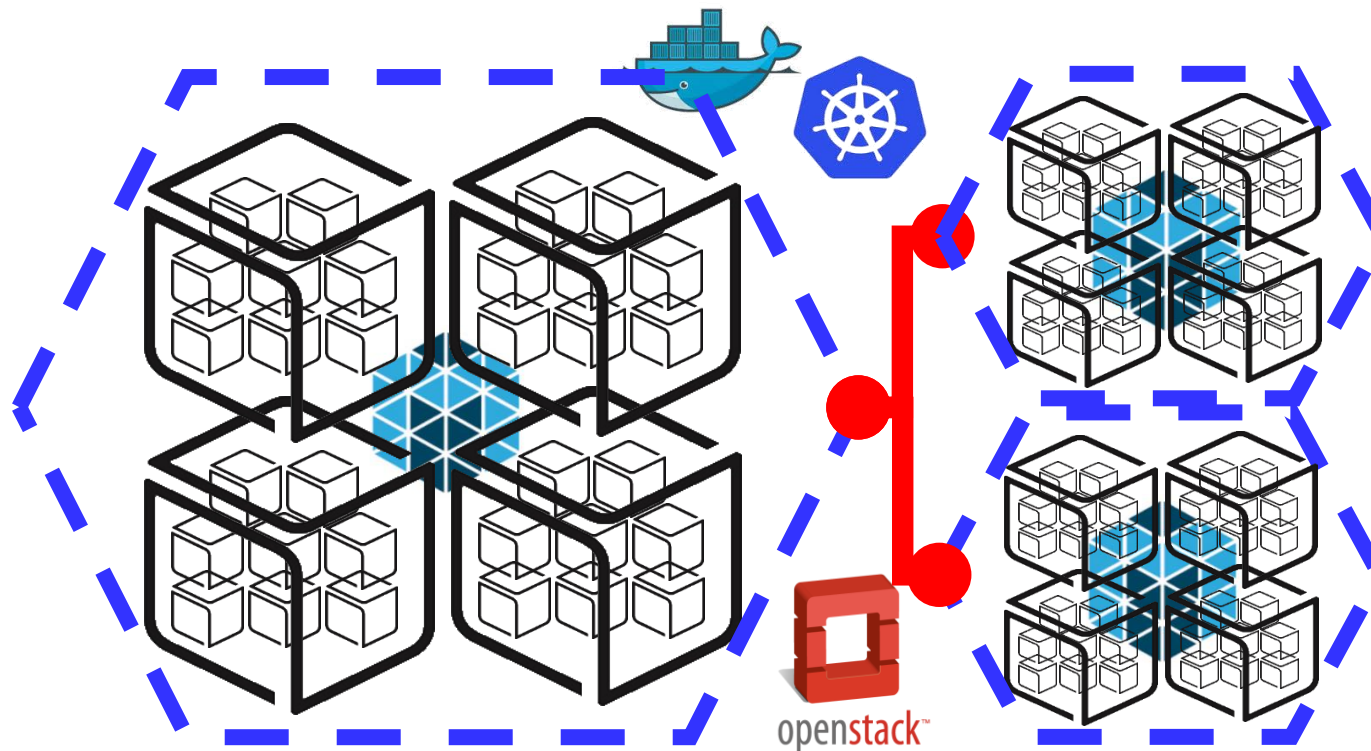
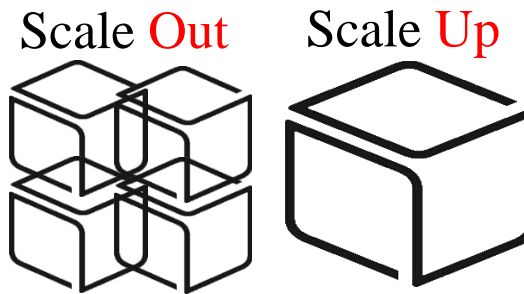
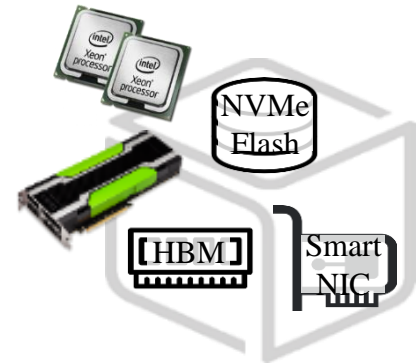
Inside a Box



Across Clusters



Computer System: Resource Scaling/Pooling with Clustering



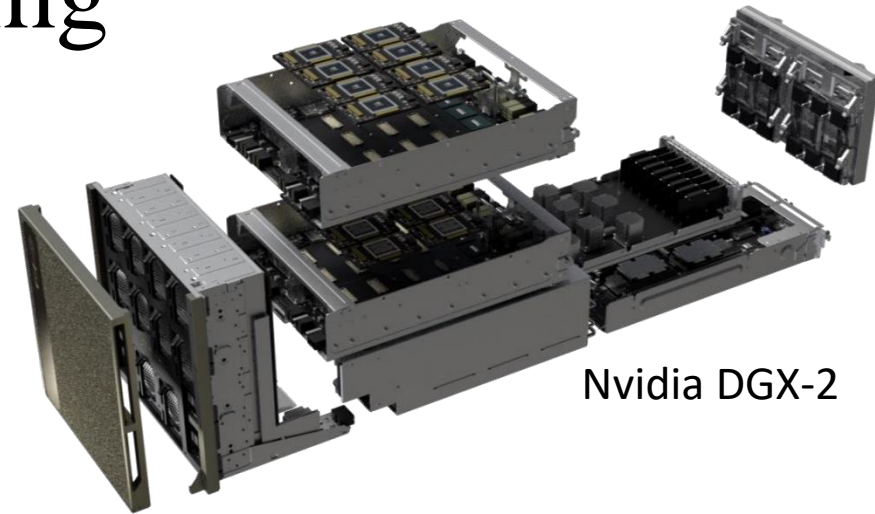
HPC +
HPDA (BigData)

➔ AI (ML/DL)

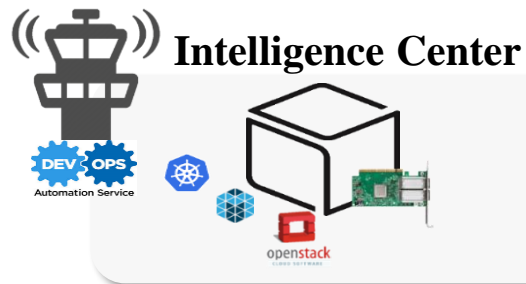
Cluster for AI Computing

HPC + HPDA (BigData)

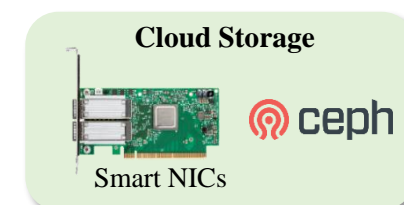
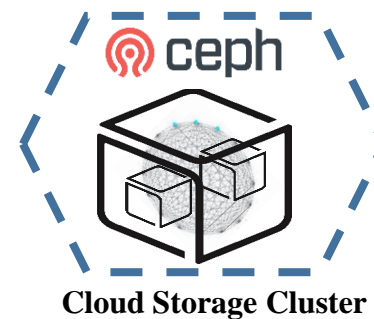
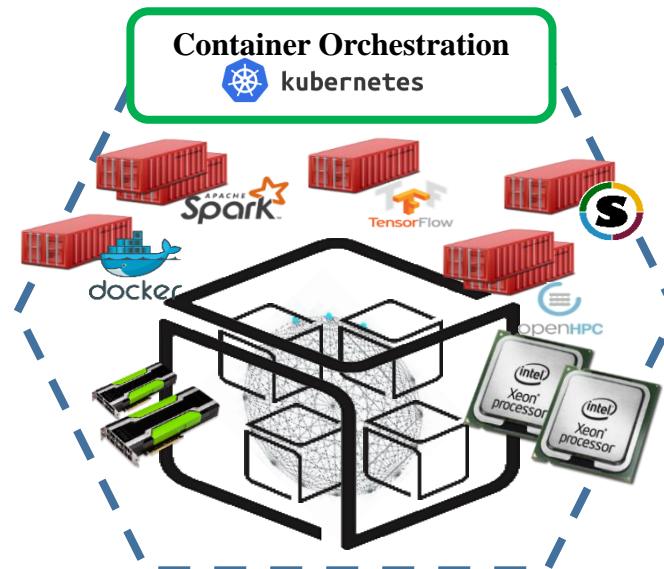
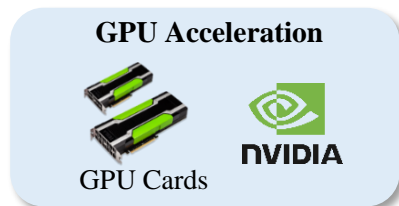
➔ AI (ML/DL)



Nvidia DGX-2



**Multi-node AI Computing Cluster
with Optimized DL Tools**

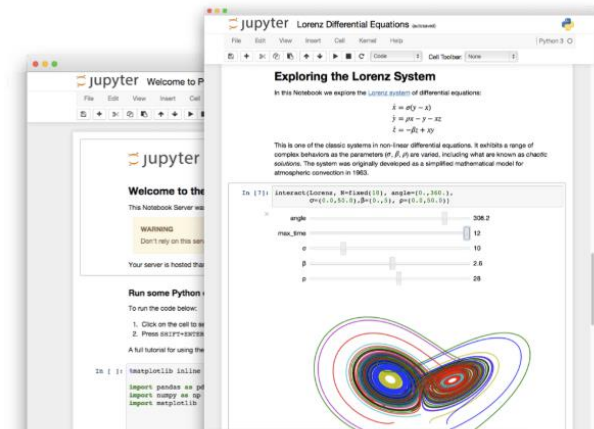


Machine Learning: TensorFlow & Jupyter Notebook



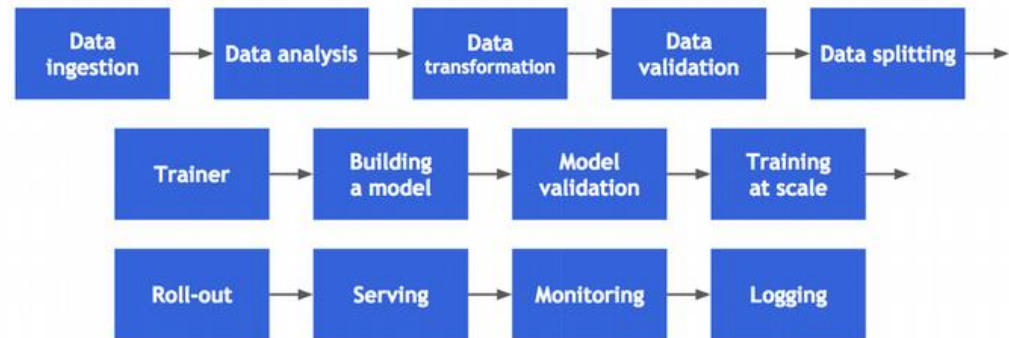
TensorFlow is an **open-source machine learning library** for research and production. TensorFlow offers APIs for beginners and experts to develop for desktop, mobile, web, and cloud.

<https://github.com/tensorflow/tensorflow>



Jupyter Notebook is an open-source web application that allows you to create and share documents that contain live code, equations, visualizations and narrative text. Uses include: data cleaning and transformation, numerical simulation, statistical modeling, data visualization, **machine learning**, and much more.

Machine Learning: Kubeflow



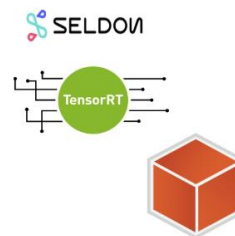
The **Kubeflow** project is dedicated to making deployments of machine learning (ML) workflows on Kubernetes simple, portable and scalable. Our goal is not to recreate other services, but to provide a straightforward way to deploy best-of-breed open-source systems for ML to diverse infrastructures. Anywhere you are running Kubernetes, you should be able to run Kubeflow.



Notebooks



TesorFlow
model Training



Model serving



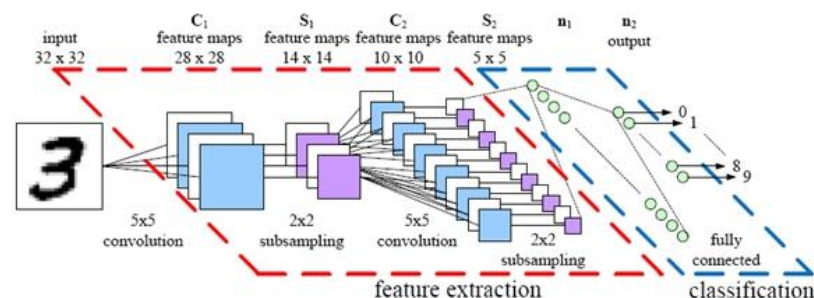
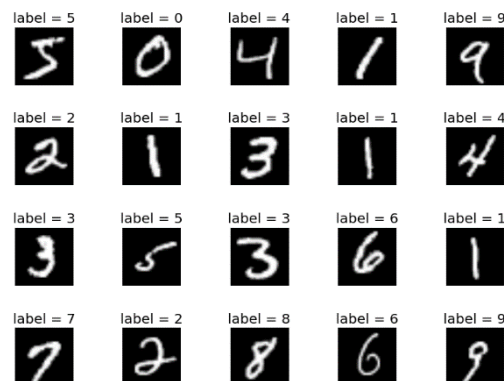
Multi-ML framework

<https://www.kubeflow.org/>

MNIST handwritten digit Classification

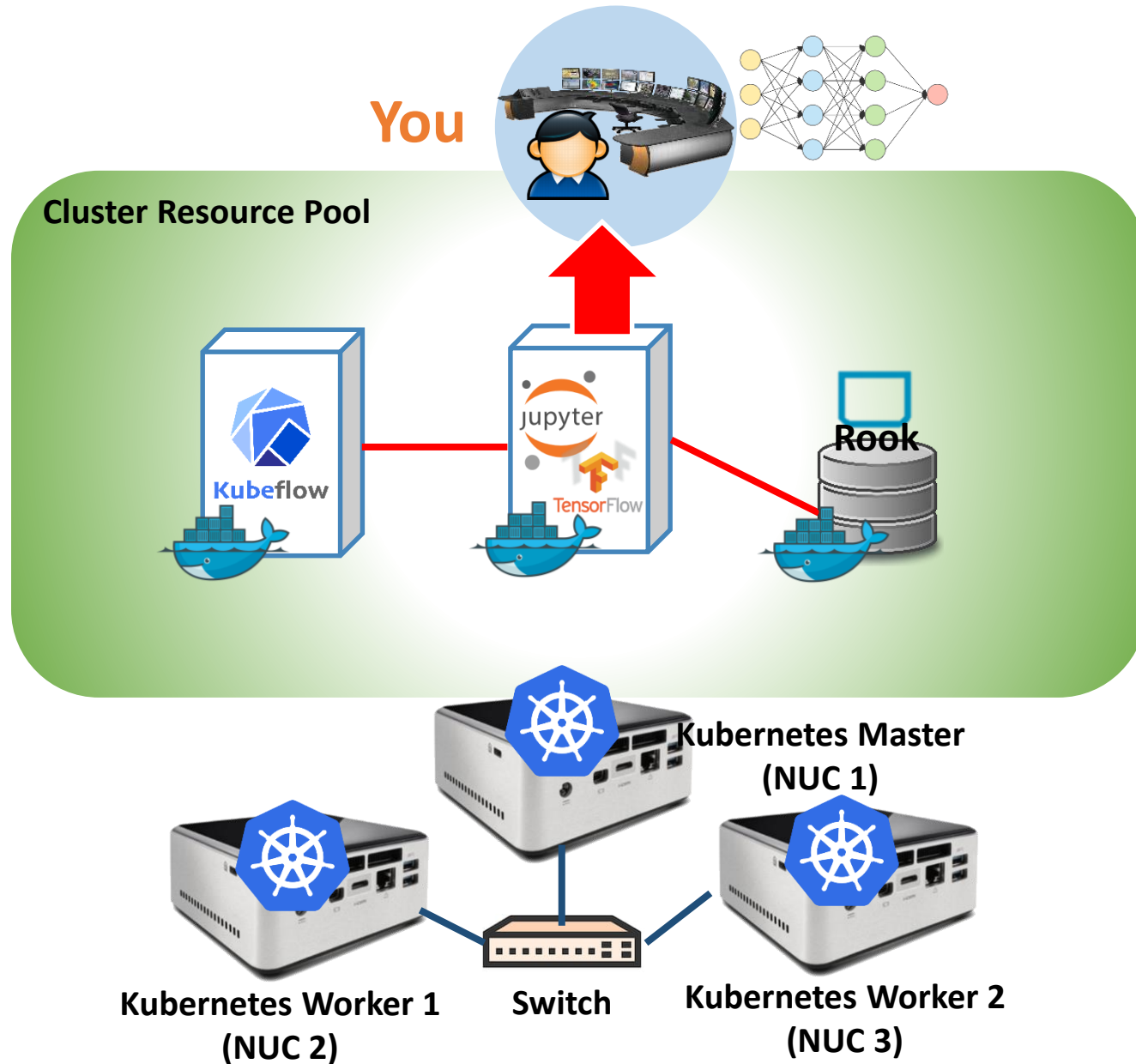


The MNIST database (Modified National Institute of Standards and Technology database) is a large database of handwritten digits that is commonly used for training various image processing systems.[1][2] The database is also widely used for training and testing in the field of machine learning.



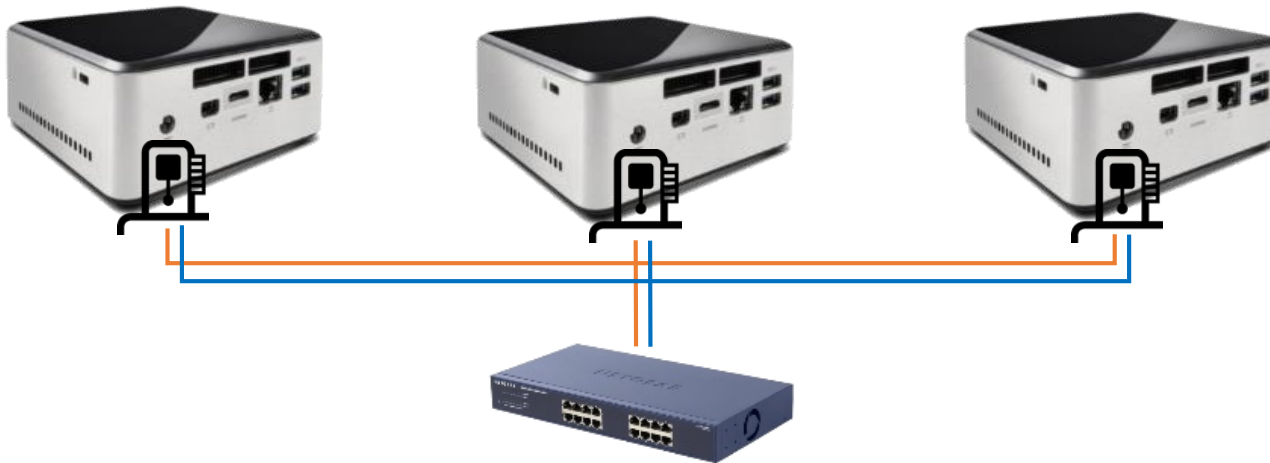
Practice





Wired connection

NAME: NUC5i5MYHE (NUC PC)
CPU: i5-5300U @2.30GHz
CORE: 4
Memory: 16GB DDR3
HDD: 94GB



NAME: netgear prosafe 16 port gigabit switch(Switch)
Network Ports: 16 auto-sensing 10/100/1000 Mbps Ethernet ports

#0 - Lab Preparation (2/2)

- Check your cluster is running healthy



For **NUC1**

\$ kubectl get nodes

```
netcs@nuc01:~$ kubectl get nodes
```

NAME	STATUS	ROLES	AGE	VERSION
nuc01	Ready	master	10d	v1.11.2
nuc02	Ready	<none>	10d	v1.11.2
nuc03	Ready	<none>	10d	v1.11.2

Check all nodes are ready.

\$ kubectl get pods -n rook-ceph

```
netcs@nuc01:~$ kubectl get pods -n rook-ceph
```

NAME	READY	STATUS	RESTARTS
rook-ceph-mgr-a-9c44495df-lfs4m	1/1	Running	0
rook-ceph-mon0-5j655	1/1	Running	0
rook-ceph-mon1-rkggs	1/1	Running	0
rook-ceph-mon2-vvp2n	1/1	Running	0
rook-ceph-osd-id-0-8694878c4b-9zz5l	1/1	Running	0
rook-ceph-osd-id-1-756995f97b-9hdhk	1/1	Running	0
rook-ceph-osd-prepare-nuc02-26nj6	0/1	Completed	0
rook-ceph-osd-prepare-nuc03-cf49p	0/1	Completed	0

Check Rook are running healthy on your cluster.



#1-1 Cluster Preparations for ML: Kubeflow Installation (1/3)

For **NUC1**

- **Install prerequisites for kubeflow: Ksonnet Installation**

```
$ sudo su
$ wget https://dl.google.com/go/go1.11.2.linux-amd64.tar.gz
$ tar -C /usr/local -xzf go1.11.2.linux-amd64.tar.gz
$ export PATH=$PATH:/usr/local/go/bin
$ GOPATH=/root/go/
$ go get github.com/ksonnet/ksonnet
$ cd $GOPATH/src/github.com/ksonnet/ksonnet
$ make install
$ exit → Come out of root user
```

- **Set Rook Storageclass to default for kubeflow**

```
$ kubectl patch storageclass rook-ceph-block -p '{"metadata":
{"annotations":{"storageclass.kubernetes.io/is-default-class":"true"}}}'
$ kubectl get storageclasses
```

#1-1 Cluster Preparations for ML: Kubeflow Installation (2/3)



For **NUC1**

- **Install Kubeflow**

```
$ mkdir ~/kubeflow
$ cd ~/kubeflow
$ export KUBEFLOW_TAG=v0.3.1
$ curl https://raw.githubusercontent.com/kubeflow/kubeflow/${KUBEFLOW_TAG}/scripts/download.sh | bash
$ ~/kubeflow/scripts/kfctl.sh init kubeflow_app --platform none
$ cd kubeflow_app
$ ~/kubeflow/scripts/kfctl.sh generate k8s
$ cd ~/kubeflow/kubeflow_app/ks_app
$ ks param set jupyterhub serviceType NodePort
$ cd ~/kubeflow/kubeflow_apps
$ ~/kubeflow/scripts/kfctl.sh apply k8s
```



#1-1 Cluster Preparations for ML: Kubeflow Installation (3/3)

For **NUC1**

- Check Kubeflow is running healthy

\$ kubectl get pods -n kubeflow

- Check the exposed port to access Jupyter hub

\$ kubectl get services -n kubeflow

```
netcs@nuc01:~$ kubectl get services -n kubeflow
```

NAME	TYPE	CLUSTER-IP	EXTERNAL-IP	PORT(S)
ambassador	ClusterIP	10.111.165.80	<none>	80/TCP
ambassador-admin	ClusterIP	10.101.217.43	<none>	8877/TCP
argo-ui	NodePort	10.101.8.20	<none>	80:30681/TCP
centraldashboard	ClusterIP	10.105.124.82	<none>	80/TCP
k8s-dashboard	ClusterIP	10.110.111.206	<none>	443/TCP
modeldb-backend	ClusterIP	10.104.50.63	<none>	6543/TCP
modeldb-db	ClusterIP	10.103.246.44	<none>	27017/TCP
modeldb-frontend	ClusterIP	10.102.138.220	<none>	3000/TCP
statsd-sink	ClusterIP	10.106.86.124	<none>	9102/TCP
tf-hub-0	ClusterIP	None	<none>	8000/TCP
tf-hub-lb	NodePort	10.107.131.150	<none>	80:32290/TCP
tf-job-dashboard	ClusterIP	10.111.220.254	<none>	80/TCP
vizier-core	NodePort	10.96.183.97	<none>	6789:30678/TCP
vizier-db	ClusterIP	10.99.58.20	<none>	3306/TCP
vizier-suggestion-bayesianoptimization	ClusterIP	10.98.249.26	<none>	6789/TCP
vizier-suggestion-grid	ClusterIP	10.100.145.210	<none>	6789/TCP
vizier-suggestion-hyperband	ClusterIP	10.108.171.180	<none>	6789/TCP
vizier-suggestion-random	ClusterIP	10.97.121.224	<none>	6789/TCP

You can access Jupyter hub at this address

http://nuc01_IP:Exposed_port

#1-2 Deploy a ML Container: Create a Jupyter Notebook (1/3)



For **NUC1**

Open a web browser and enter the Jupyter hub address
`http://nuc01_IP:Exposed_port`

JupyterHub - Mozilla Firefox

JupyterHub

203.237.53.71:32290/hub/login

jupyter

Sign in

Warning: JupyterHub seems to be served over an unsecured HTTP connection. We strongly recommend enabling HTTPS for JupyterHub.

Username:

netcs

Password:

Sign In

Enter your username and click 'Sign In' button (you don't have to enter a password)



#1-2 Deploy a ML Container: Create a Jupyter Notebook (2/3)

For **NUC1**

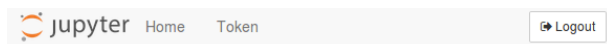
In Spawner page, you can choose container image and the size of resources to create a Jupyter Notebook container for Machine Learning

Select or enter the options as below

Image: gcr.io/kubeflow-images-public/tensorflow-1.9.0-notebook-cpu:v0.3.1

CPU: 2

Memory: 2Gi



Spawner Options

Image

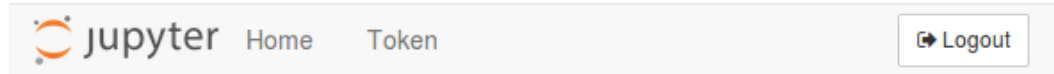
Advanced

CPU

Memory

Extra Resource Limits

Spawn



Your server is starting up.

You will be redirected automatically when it's ready for you.



Spawning server...

Event log

Click Spawn Button and you need to wait for a while



#1-2 Deploy a ML Container: Create a Jupyter Notebook (3/3)

For **NUC1**

You can see your Jupyter notebook container is deployed as a pod on cluster

\$ `kubectl get pods -n kubeflow`

```
netcs@nuc01:~$ kubectl get pods -n kubeflow
NAME                                READY   STATUS    RESTARTS
ambassador-c97f7b448-998gd          3/3     Running   0
ambassador-c97f7b448-c2j2b          3/3     Running   0
ambassador-c97f7b448-dv1kv          3/3     Running   0
argo-ui-7495b79b59-15xh6            1/1     Running   0
centraldashboard-798f8d68d5-5wshd    1/1     Running   0
jupyter-netcs                       1/1     Running   0
jupyter-test                        1/1     Running   0
modeldb-backend-d69695b66-99cqm      1/1     Running   0
modeldb-db-975db58f7-prpzf          1/1     Running   0
```

Now your Jupyter notebook is created...


jupyter
Logout
Control Panel

Files
Running
Clusters

Select items to perform actions on them.

Upload
New ▾
↻

	Name ▾	Last Modified	File size
<input type="checkbox"/> 0 ▾	/		
<input type="checkbox"/>	work	17시간 전	



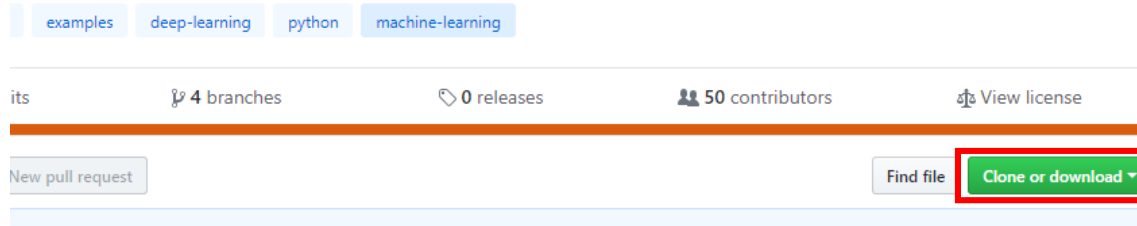
#2-1 Running Analytics code: Running a Sample ML Code (1/3)

For **NUC01**

Download sample notebook including MNIST Machine Learning Code
\$ git clone <https://github.com/aymericdamien/TensorFlow-Examples/>

Or Download from web browser as below. (you need to unzip the file)

I and Examples for Beginners with Latest APIs <https://tensorflow.org>



TensorFlow-Examples-master\notebooks\3_NeuralNetwork\convolutional_network.ipynb

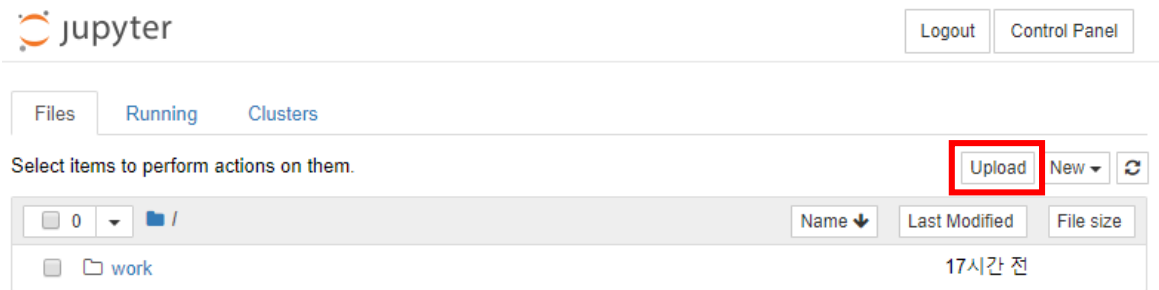
We will upload the sample notebook on your Jupyter and run it.
The notebook include MNIST machine learning example code.

<https://github.com/aymericdamien/TensorFlow-Examples/>



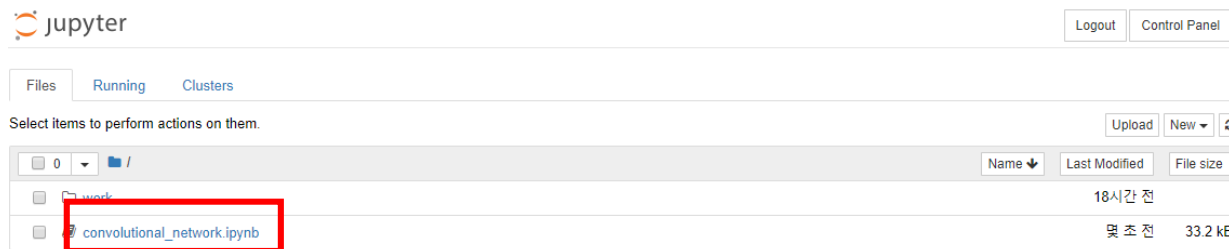
#2-1 Running Analytics code: Running a Sample ML Code (2/3)

For **NUC1**



Remember! we will use this file
TensorFlow-Examples-
master\notebooks\3_NeuralNetwork\convolutio
nal_network.ipynb

Press upload button to upload the sample notebook

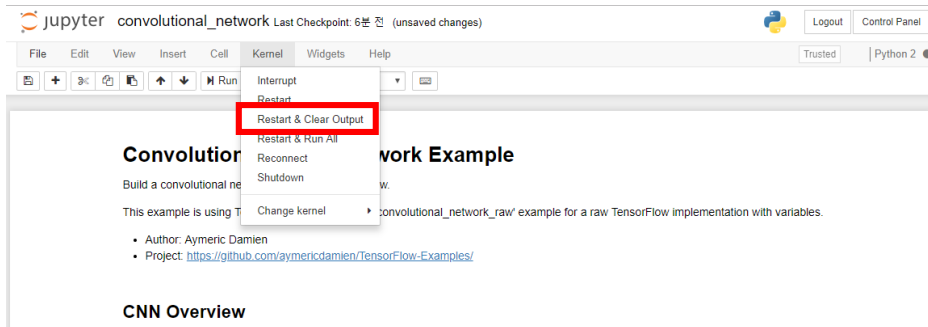


Click it to open the notebook



#2-1 Running Analytics code: Running a Sample ML Code (3/3)

For **NUC1**



Now, you will run the MNIST example code in sample notebook.
Click kernel → “Restart&Clear Output” button → “Restart&Run All” button

```
In [*]: # Define the input function for training
input_fn = tf.estimator.inputs.numpy_input_fn(
    x={'images': mnist.train.images}, y=mnist.train.labels,
    batch_size=batch_size, num_epochs=None, shuffle=True)
# Train the Model
model.train(input_fn, steps=num_steps)

INFO:tensorflow:Calling model_fn.
INFO:tensorflow:Done calling model_fn.
INFO:tensorflow:Create CheckpointSaverHook.
INFO:tensorflow:Graph was finalized.
INFO:tensorflow:Running local_init_op.
INFO:tensorflow:Done running local_init_op.
INFO:tensorflow:Saving checkpoints for 0 into /tmp/tmpp90vpq/model.ckpt.
INFO:tensorflow:loss = 2.3231235, step = 1
INFO:tensorflow:global_step/sec: 7.86675
INFO:tensorflow:loss = 0.09013237, step = 101 (12.681 sec)
INFO:tensorflow:global_step/sec: 7.96045
INFO:tensorflow:loss = 0.087195896, step = 201 (12.562 sec)
INFO:tensorflow:global_step/sec: 7.93652
INFO:tensorflow:loss = 0.07184037, step = 301 (12.600 sec)
INFO:tensorflow:global_step/sec: 7.92234
INFO:tensorflow:loss = 0.15338697, step = 401 (12.622 sec)
...
```

The training takes a few minutes.



#2-2 Running Analytics code: Check ML Training results

For **NUC1**

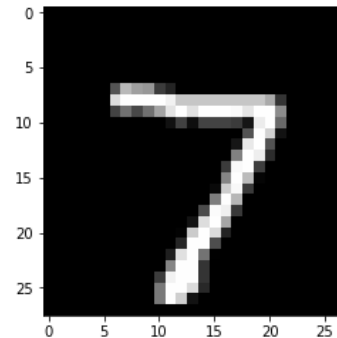
```
In [7]: # Evaluate the Model
# Define the input function for evaluating
input_fn = tf.estimator.inputs.numpy_input_fn(
    x={'images': mnist.test.images}, y=mnist.test.labels,
    batch_size=batch_size, shuffle=False)
# Use the Estimator 'evaluate' method
model.evaluate(input_fn)

INFO:tensorflow:Calling model_fn.
INFO:tensorflow:Done calling model_fn.
INFO:tensorflow:Starting evaluation at 2018-11-25-07:45:59
INFO:tensorflow:Graph was finalized.
INFO:tensorflow:Restoring parameters from /tmp/tmp9DVpG/model.ckpt-2000
INFO:tensorflow:Running local_init_op.
INFO:tensorflow:Done running local_init_op.
INFO:tensorflow:Finished evaluation at 2018-11-25-07:46:03
INFO:tensorflow:Saving dict for global step 2000: accuracy = 0.9892, global_step = 2000, loss = 0.035650674
INFO:tensorflow:Saving 'checkpoint_path' summary for global step 2000: /tmp/tmp9DVpG/model.ckpt-2000
```

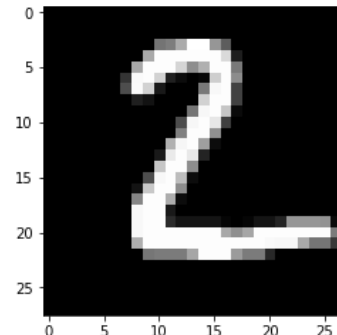
```
Out [7]: {'accuracy': 0.9892, 'global_step': 2000, 'loss': 0.035650674}
```

Check training results

Your model has 98.92% accuracy!



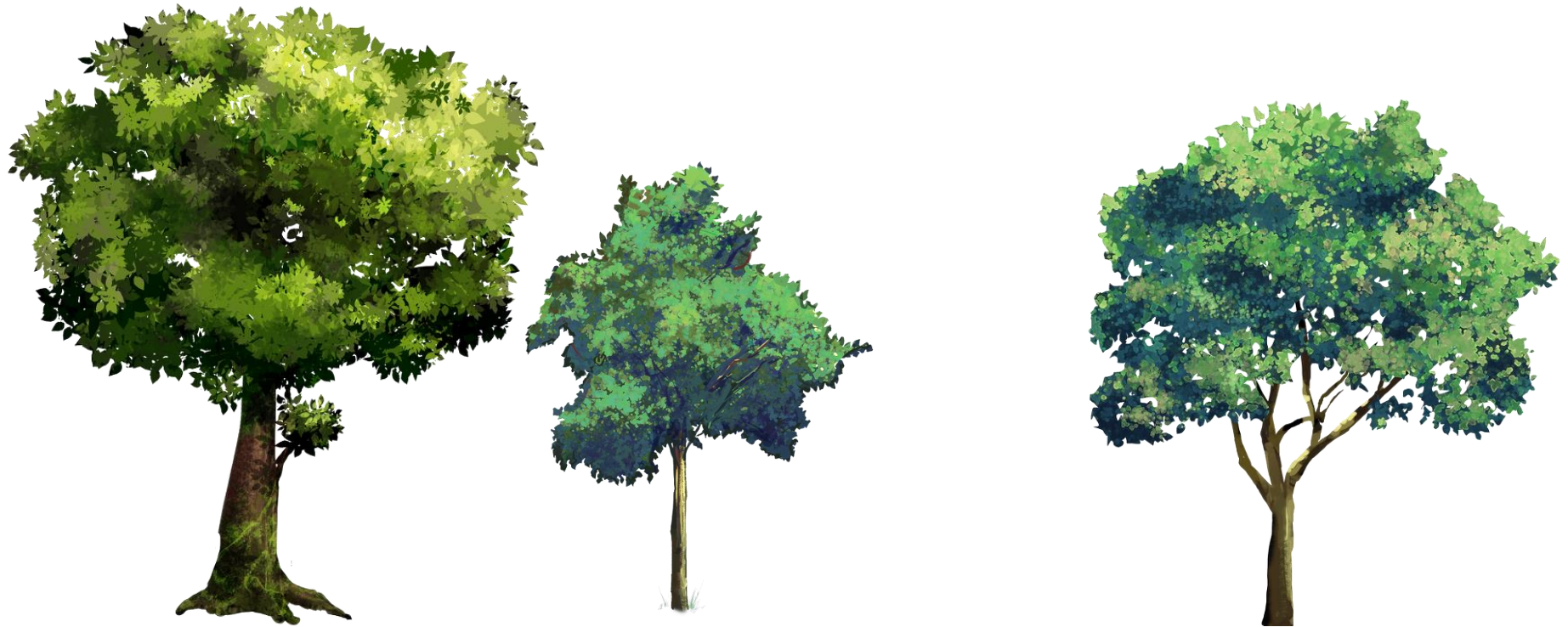
Model prediction: 7



Model prediction: 2

Your Machine Learning model correctly identified the number in the images!

Review

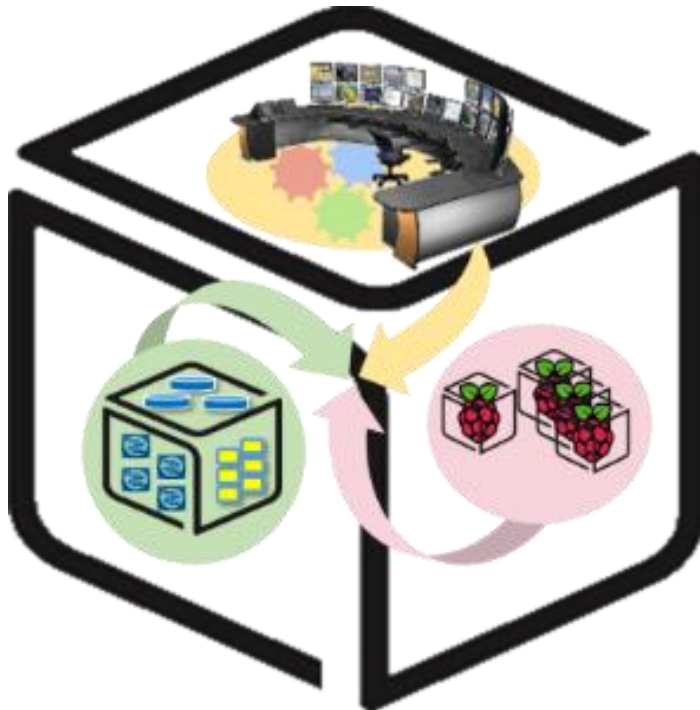


With Analytics (Intelligence) Lab, you have experimented

1. How to create ML/DL environment on a container-orchestrated cluster? (Kubeflow, ...)
2. How to operate desired ML training by testing selected ML code (i.e., neural networks) over the prepared training data?
3. Do you understand the overall workflow for running ML/DL?

Thank You for Your Attention

Any Questions?



mini@smartx.kr