Dask: A Quick Introduction

Dask is a flexible library for parallel computing in Python.

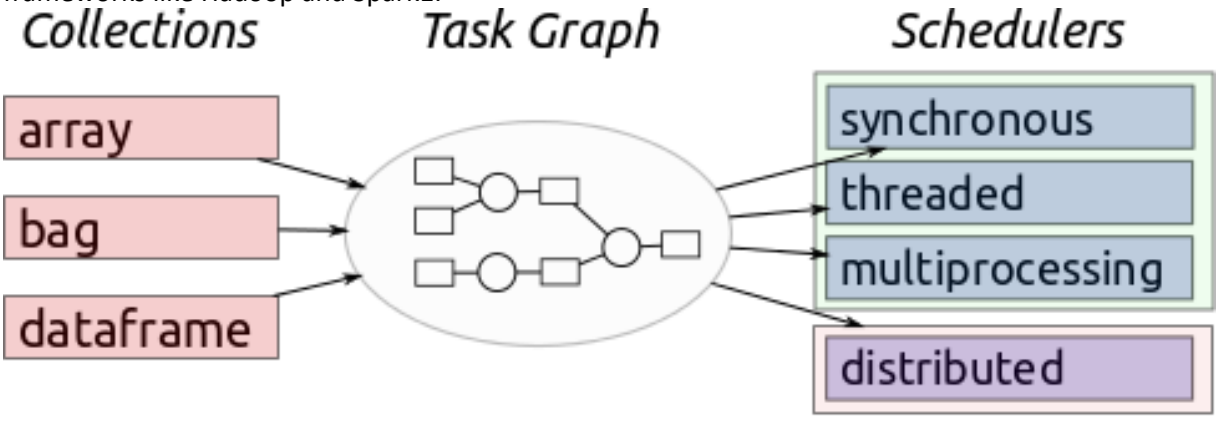
Dask is composed of two parts:

- Dynamic task scheduling optimized for computation. This is like Airflow, Luigi, Celery, or Make, but optimized for interactive computational workloads.
- "Big Data" collections like parallel arrays, dataframes, and lists that extend common interfaces like NumPy, Pandas, or Python iterators to larger-than-memory or distributed environments. These parallel collections run on top of dynamic task schedulers.

At its core Dask looks a lot like a tweaked Airflow/Luigi/Celery. There is a central task scheduler that sends jobs (Python functions) out to lots of worker processes either on the same machine or on a cluster:

- Worker A, please compute x = f(1), Worker B please compute y = g(2).
- Worker A, when g(2) is done please get y from Worker B and compute z = h(x, y).

Where Dask differs is that while Airflow/Luigi/Celery were primarily designed for long-ish running data engineering jobs, Dask was designed for computation and interactive data science. It is focused less on running jobs regularly (like Airflow) or integrating with lots of Data engineering services (like Luigi) and much more on millisecond response times, inter-worker data sharing, Jupyter notebook integration, etc. On top of this task scheduler, Dask has inbuilt higher-level array, dataframe, and list interfaces that mimic NumPy, Pandas, and Python iterators. This pushes Dask into the space of the popular "Big Data" frameworks like Hadoop and Spark1.



Installing Dask

Local computer:

You can install dask with conda, with pip, or by installing from source, using the following commands;

- conda install dask
- pip install "dask[complete]"

The installation with pip installs both Dask and dependencies like NumPy, Pandas, and so on that are necessary for different workloads.

[1] https://www.kdnuggets.com/2016/09/introducing-dask-parallel-programming.html

```
C:\Users\byron>PIP install "dask[complete]"
Requirement already satisfied: dask[complete] in c:\programdata\anaconda4\lib\site-packages (0.17.5)
Requirement already satisfied: numpy>=1.11.0; extra == "complete" in c:\programdata\anaconda4\lib\site-packages (from dask[complete]) (1.14.3)
Requirement already satisfied: toolz>=0.7.3; extra == "complete" in c:\programdata\anaconda4\lib\site-packages (from dask[complete]) (0.9.0)
Requirement already satisfied: pandas>=0.19.0; extra == "complete" in c:\programdata\anaconda4\lib\site-packages (from dask[complete]) (0.23.0)
Requirement already satisfied: partd>=0.3.8; extra == "complete" in c:\programdata\anaconda4\lib\site-packages (from dask[complete]) (0.3.8)
Requirement already satisfied: distributed>=1.21; extra == "complete" in c:\programdata\anaconda4\lib\site-packages (from dask[complete]) (1.21.8)
Requirement already satisfied: cloudpickle>=0.2.1; extra == "complete" in c:\programdata\anaconda4\lib\site-packages (from dask[complete]) (0.5.3)
Requirement already satisfied: pytz>=2011k in c:\programdata\anaconda4\lib\site-packages (from pandas>=0.19.0; extra == "complete"->dask[complete]) (2018.4)
Requirement already satisfied: python-dateutil>=2.5.0 in c:\programdata\anaconda4\lib\site-packages (from pandas>=0.19.0; extra == "complete"->dask[complete]) (2.7.3)
Requirement already satisfied: locket in c:\programdata\anaconda4\lib\site-packages (from partd>=0.3.8; extra == "complete"->dask[complete]) (0.2.0)
Requirement already satisfied: click>=6.6 in c:\programdata\anaconda4\lib\site-packages (from distributed>=1.21; extra == "complete"->dask[complete]) (6.7)
Requirement already satisfied: msgpack in c:\programdata\anaconda4\lib\site-packages (from distributed>=1.21; extra == "complete"->dask[complete]) (0.5.6)
Requirement already satisfied: psutil in c:\programdata\anaconda4\lib\site-packages (from distributed>=1.21; extra == "complete"->dask[complete]) (5.4.5)
Requirement already satisfied: six in c:\programdata\anaconda4\lib\site-packages (from distributed>=1.21; extra == "complete"->dask[complete]) (1.11.0)
Requirement already satisfied: sortedcontainers in c:\programdata\anaconda4\lib\site-packages (from distributed>=1.21; extra == "complete"->dask[complete]) (1.5.10)
Requirement already satisfied: tblib in c:\programdata\anaconda4\lib\site-packages (from distributed>=1.21; extra == "complete"->dask[complete]) (1.3.2)
Requirement already satisfied: tornado>=4.5.1 in c:\programdata\anaconda4\lib\site-packages (from distributed>=1.21; extra == "complete"->dask[complete]) (5.0.2)
Requirement already satisfied: zict>=0.1.3 in c:\programdata\anaconda4\lib\site-packages (from distributed>=1.21; extra == "complete"->dask[complete]) (0.1.3)
Requirement already satisfied: heapdict in c:\programdata\anaconda4\lib\site-packages (from zict>=0.1.3->distributed>=1.21; extra == "complete"->dask[complete]) (1.0.0)
You are using pip version 18.0, however version 18.1 is available.
You should consider upgrading via the 'python -m pip install --upgrade pip' command.

C:\Users\byron>
```

Installing Dask on the Cloud

Installing dask on the cloud especially if you have a huge workload and would like to use a cluster to process the data can get a bit tricky. The installation process that we went through was through AWS and it required us to create a dns domain, create a cluster using kubernetes and then install dask on top of Kubernetes cluster.

Kubernetes is a portable, extensible open-source platform for managing containerized workloads and services, that facilitates both declarative configuration and automation2.

We setup a Kubernetes cluster on AWS cloud environment using a tool called KOPS. kops is a provisioning system with; Fully automated installation, uses DNS to identify clusters, has self-healing: everything runs in Auto-Scaling Groups and has High-Availability support

2.1 Pre-requisites

As a part of the setup, we needed an Ubuntu or Debian instance with latest updates and other supporting utility/tools like AWS-CLI, S3 bucket, Hosted Zone on Route 53 and a registered domain.

Ubuntu Installation

We installed an instance of Ubuntu using VirtualBox and made sure that it had the latest updates by running the following commands

sudo apt-get update: To update all the latest packages

```
byron@byron-VirtualBox:~$ sudo apt-get update
[sudo] password for byron:
Hit:1 http://us.archive.ubuntu.com/ubuntu xenial InRelease
Get:2 http://us.archive.ubuntu.com/ubuntu xenial-updates InRelease [109 kB]
Get:3 http://security.ubuntu.com/ubuntu xenial-security InRelease [107 kB]
Get:5 http://security.ubuntu.com/ubuntu xenial-security/main amd64 Packages [568 kB]
Hit:4 https://packages.cloud.google.com/apt kubernetes-xenial InRelease
Get:6 http://us.archive.ubuntu.com/ubuntu xenial-backports InRelease [107 kB]
Get:7 http://us.archive.ubuntu.com/ubuntu xenial-updates/main amd64 Packages [860 kB]
Get:8 http://security.ubuntu.com/ubuntu xenial-security/main i386 Packages [490 kB]
39% [7 Packages 844 kB/860 kB 98%] [8 Packages 421 kB/490 kB 86%]
Get:10 http://security.ubuntu.com/ubuntu xenial-security/main Translation-en [238 kB]
```

[2] https://blog.sourcerer.io/a-kubernetes-quick-start-for-people-who-know-just-enough-about-docker-to-get-by-71c5933b4633

sudo apt-get -y upgrade: To ensure that all the present packages are upgraded

```
byron@byron-VirtualBox:~$ sudo apt-get -y upgrade
Reading package lists... Done
Building dependency tree
Reading state information... Done
Calculating upgrade... Done
The following packages were automatically installed and are no longer required:
  libdbusmenu-gtk4 libmircommon5 libqpdf17
Use 'sudo apt autoremove' to remove them.
The following packages have been kept back:
  gnome-software gnome-software-common libdrm-amdgpu1 libdrm2 libegl1-mesa libgbm1 libgl1-mesa-dri libgl1-mesa-glx libglapi-mesa libinpu
  linux-generic linux-headers-generic linux-image-generic modemmanager ubuntu-software
The following packages will be upgraded:
  libsmbclient libsnmp-base libsnmp30 libwbclient0 python3-requests python3-software-properties python3-update-manager samba-libs softwa
  thunderbird-gnome-support thunderbird-locale-en thunderbird-locale-en-us unity-control-center update-manager update-manager-core updat
19 upgraded, 0 newly installed, 0 to remove and 19 not upgraded.
Need to get 49.3 MB of archives.
After this operation, 54.8 MB of additional disk space will be used.
Get:1 http://us.archive.ubuntu.com/ubuntu xenial-updates/main amd64 samba-libs amd64 2:4.3.11+dfsg-0ubuntu0.16.04.17 [5,172 kB]
```

Kops Installation

We installed kops by running the command below changed the permission before moving it to /usr/local/bin;

1. **curl -LO https://storage.googleapis.com/kubernetes-release/release/$(curl -s https://storage.googleapis.com/kubernetes-release/release/stable.txt)/bin/linux/amd64/kubectl**
2. **chmod +x kubectl**
3. **sudo mv kubectl /usr/local/bin/**

```
byron@byron-VirtualBox:~$ wget -O kops https://github.com/kubernetes/kops/releases/download/$(curl -s https://api.github.com/repos/kubernetes/kops/releases/latest | grep tag_name | cut -d '"
linux-amd64
--2018-10-15 18:48:44--  https://github.com/kubernetes/kops/releases/download/1.10.0/kops-linux-amd64
Resolving github.com (github.com)... 192.30.253.112, 192.30.253.113
Connecting to github.com (github.com)|192.30.253.112|:443... connected.
HTTP request sent, awaiting response... 302 Found
Location: https://github-production-release-asset-2e65be.s3.amazonaws.com/62091339/d5c60900-a0cf-11e8-8623-e06af953e312?X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=AKIAIWNJYAX4CSVEH53A%
us-east-1%2Fs3%2Faws4_request&X-Amz-Date=20181015T224844Z&X-Amz-Expires=300&X-Amz-Signature=7a4c958351ad27da56e6a7a3fde51d6229064d941d9acf1f7a6c2c0ce6375cb9&X-Amz-SignedHeaders=host&actor_id=
ntent-disposition=attachment%3B%20filename%3Dkops-linux-amd64&response-content-type=application%2Foctet-stream [following]
--2018-10-15 18:48:44--  https://github-production-release-asset-2e65be.s3.amazonaws.com/62091339/d5c60900-a0cf-11e8-8623-e06af953e312?X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=AKIAIW
A%2F20181015%2Fus-east-1%2Fs3%2Faws4_request&X-Amz-Date=20181015T224844Z&X-Amz-Expires=300&X-Amz-Signature=7a4c958351ad27da56e6a7a3fde51d6229064d941d9acf1f7a6c2c0ce6375cb9&X-Amz-SignedHeaders
d=0&response-content-disposition=attachment%3B%20filename%3Dkops-linux-amd64&response-content-type=application%2Foctet-stream
```

kubectl installation

We downloaded the latest version of the kubectl and changed the permission before moving it to /usr/local/bin

Kubectl installation commands

1. **curl -LO https://storage.googleapis.com/kubernetes-release/release/$(curl -s https://storage.googleapis.com/kubernetes-release/release/stable.txt)/bin/linux/amd64/kubectl**
2. **chmod +x kubectl**
3. **sudo mv kubectl /usr/local/bin/**

```
byron@byron-VirtualBox:~$ curl -LO https://storage.googleapis.com/kubernetes-release/release/$(curl -s https://storage.googleapis.com/k
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
100 54.6M  100 54.6M    0     0  1839k      0  0:00:30  0:00:30 --:--:-- 2192k
byron@byron-VirtualBox:~$
```

AWS CLI

To install AWS CLI, run the following commands

1. **sudo apt-get install python-pip**

2. **pip install --upgrade pip**
3. **sudo pip install awscli**

IAM user creation

On AWS console, I have created a new IAM user (for example kops) with full access and save the access keys as it would be used to configure the AWS CLI. This role will be used to give your CI host permission to create and destroy resources on AWS

- AmazonEC2FullAccess
- IAMFullAccess
- AmazonS3FullAccess
- AmazonVPCFullAccess
- Route53FullAccess (Optional)

Create the IAM User using the following commands

You can create the kops IAM user from the command line using the following:

```
aws iam create-group --group-name kops

aws iam attach-group-policy --policy-arn arn:aws:iam::aws:policy/AmazonEC2FullAccess --group-name kops
aws iam attach-group-policy --policy-arn arn:aws:iam::aws:policy/AmazonRoute53FullAccess --group-name kops
aws iam attach-group-policy --policy-arn arn:aws:iam::aws:policy/AmazonS3FullAccess --group-name kops
aws iam attach-group-policy --policy-arn arn:aws:iam::aws:policy/IAMFullAccess --group-name kops
aws iam attach-group-policy --policy-arn arn:aws:iam::aws:policy/AmazonVPCFullAccess --group-name kops

aws iam create-user --user-name kops

aws iam add-user-to-group --user-name kops --group-name kops

aws iam create-access-key --user-name kops
```

Then we copied both AWS access key ID and AWS secret access key for later usage.
On the EC2 instance, I have configured the newly created AWS IAM user with following commands
$aws configure
AWS Access Key ID [None]:
AWS Secret Access Key [None]: Default region name [None]: < Optional : Please enter the region or blank for default>
Default output format [None]: < Optional : Please enter the output format or blank for default>

Run the ssh-keygen command to generate an ssh key. It will be used to connect to the kubernetes cluster which you are going to create. In my case, the ssh keys by default are stored in .ssh folder of the user home directory.

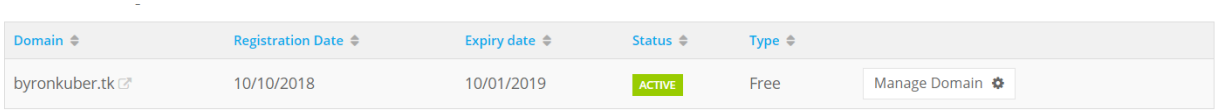
ssh-keygen

Domain Creation

We created a domain for the cluster user "kops" and DNS for discovery which will be used inside the cluster and to reach the kubernetes API server from the client. It should have a valid DNS name. An existing domain or a new domain can be used. In this example, I have created a new domain and hosted it on dot.tk which is a free domain provider.

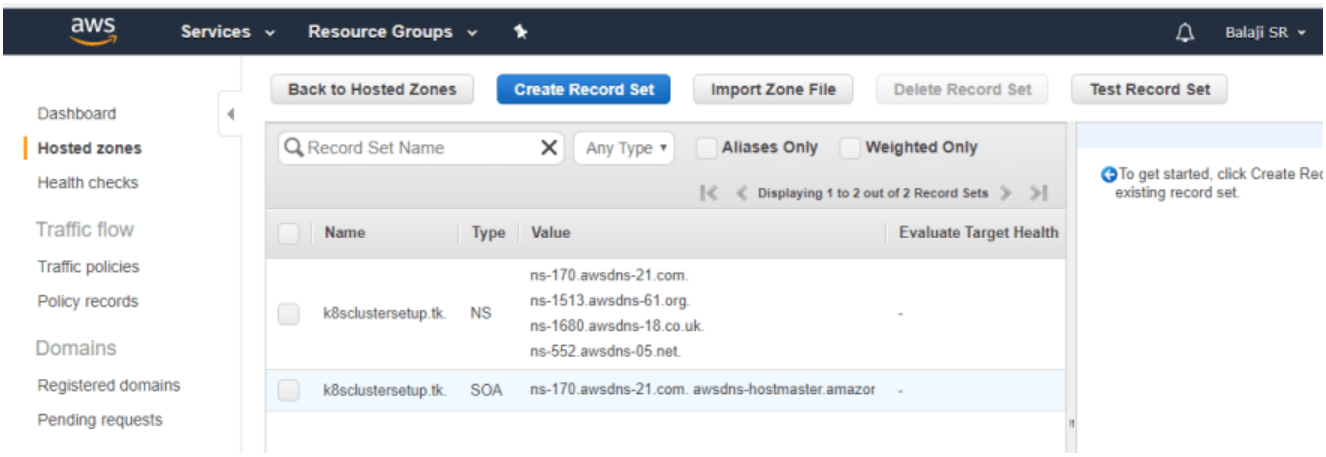
Domain registration on dot.tk / freenom.com:

We have registered a new domain on freenom.com with the name byronkuber.tk which I going to use for my Kubernetes cluster.

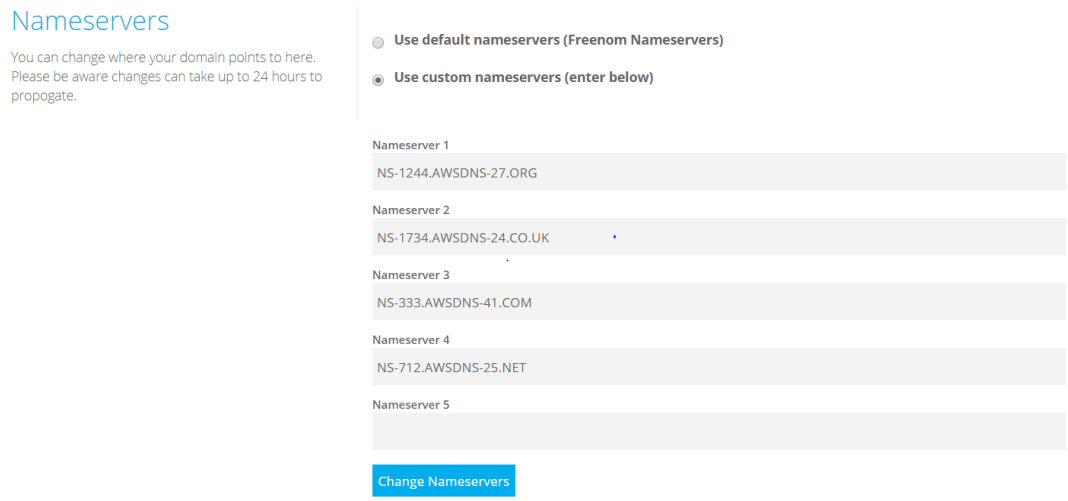


Create Hosted Zone

On AWS console, we created a new Hosted zone on router 53. I have logged into AWS console, navigate to router53 DNS management and created new Hosted Zone. It's advisable to create a subdomain. This creates a set of name servers which can be copied for later usage. I have copied the name server details which starts with ns-xxx.awsdns-xx.com, ns-xxx.awsdns-xx.co.uk, ns-xxx.awsdns-xx.org, ns-xxx.awsdns-xx.net.



These NameServer (NS) values should be updated on the domain service provider. In this setup, we have updated the NS details on freenom.com.



S3 bucket creation

We created a new S3 bucket with a meaningful name (for example "kopsclusterdemo") which is used to store the cluster state. Kubernetes uses S3 to store the cluster details like configuration, keys, etc.
Create a bucket using the following command;

bucket_name=dodge-state-store aws s3api create-bucket --bucket ${bucket_name}
--region us-east-1

Here we created a bucket called dodge-state-store
With this, all the pre-requisite has been setup and the environment is ready to create and launch the Kubernetes cluster.

Install Helm

Run the following command to install helm

```
$ sudo snap install helm
```

INSTALLING TILLER

Tiller, the server portion of Helm, typically runs inside of your Kubernetes cluster. But for development, it can also be run locally, and configured to talk to a remote Kubernetes cluster.
Easy In-Cluster Installation[3]
The easiest way to install tiller into the cluster is simply to run helm init. This will validate that helm's local environment is set up correctly (and set it up if necessary). Then it will connect to whatever cluster kubectl connects to by default (kubectl config view). Once it connects, it will install tiller into the kube-system namespace.
After helm init, you should be able to run kubectl get pods --namespace kube-systemand see Tiller running.
Create a cluster by running the following command
kops --v=3 create cluster caya.byronkuber.tk --cloud=aws --state=s3://dodge-state-store --zones=us-west-1a --kubernetes-version=1.4.0 --node-count=3 --master-zones=us-west-1a --node-size=t2.small --master-size=t2.large –ssh-public-key=~/.ssh/id_rsa.pub
here, we created a cluster called caya.byronkuber.tk

[3] https://docs.helm.sh/using_helm/#quickstart

Install Dask

Next, we're going to install a Dask chart. Kubernetes Charts are curated application definitions for Helm. To install the Dask chart, we'll update the known Charts channels before installing the stable version of Dask.

We need to create a serviceaccount with API permissions. More details about how to do this are available in the Kubernetes RBAC docs.

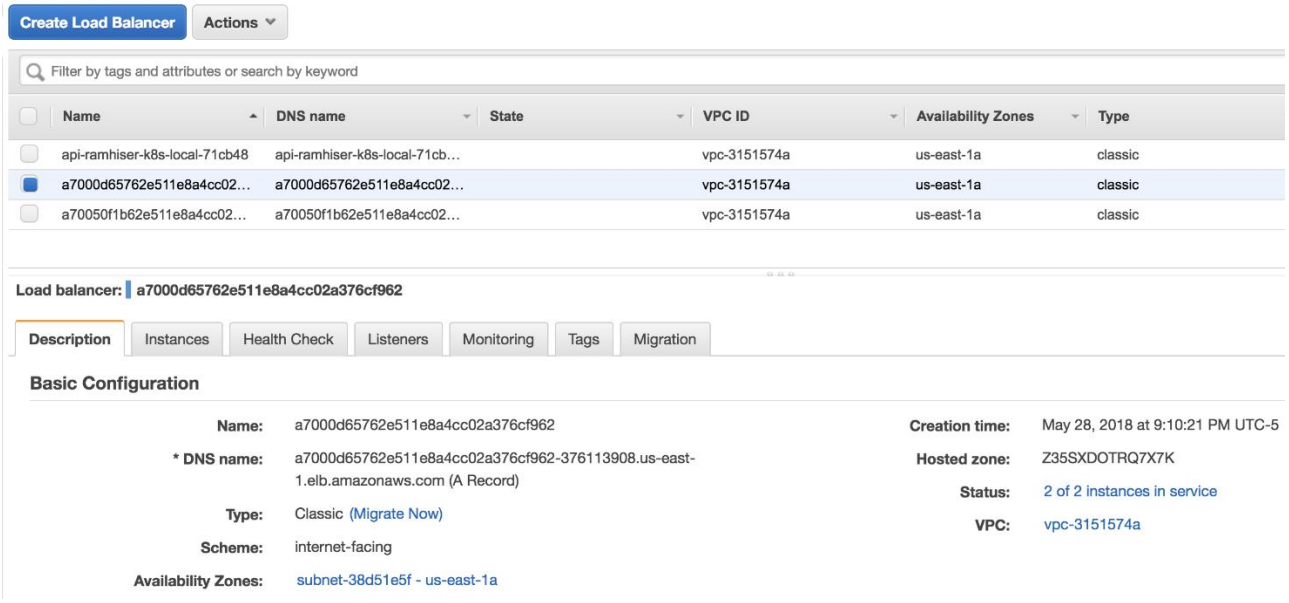
kubectl create serviceaccount --namespace kube-system tiller kubectl create clusterrolebinding tiller-cluster-rule --clusterrole=cluster-admin --serviceaccount=kube-system:tiller kubectl patch deploy --namespace kube-system tiller-deploy -p '{"spec":{"template":{"spec":{"serviceAccount":"tiller"}}}}' helm init --service-account tiller –upgrade

Install Dask by running the following command

helm install stable/dask

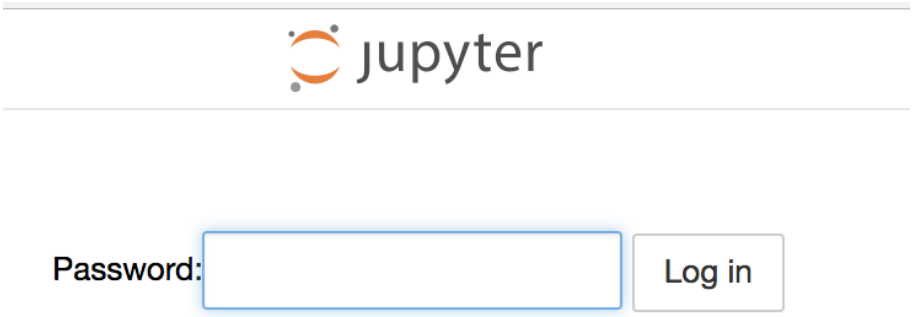
Dask is now installed on the Kubernetes cluster. Notice that Helm has given our deployment the name xxxxxxx-xxx. The resources (pods and services) are all prepended with xxxxxxx-xxx as well.
As you can see, we launched a dask-scheduler, a dask-jupyter, and 3 dask-workerprocesses (default config). Below, we'll walk through customizing the process.
Also, notice the default Jupyter password: dask. We'll use it to login to our Jupyter server later.

Notice that the EXTERNAL-IP displays hex values. These refer to AWS ELB (Elastic Load Balancer)entries you can find in your AWS console: EC2 -> Load Balancers. You can get the exposed DNS entry by matching the EXTERNAL-IP to the appropriate load balancer. For instance, the screenshot below shows that the DNS entry for the Jupyter node is http://xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx.us-east-1.elb.amazonaws.com/.

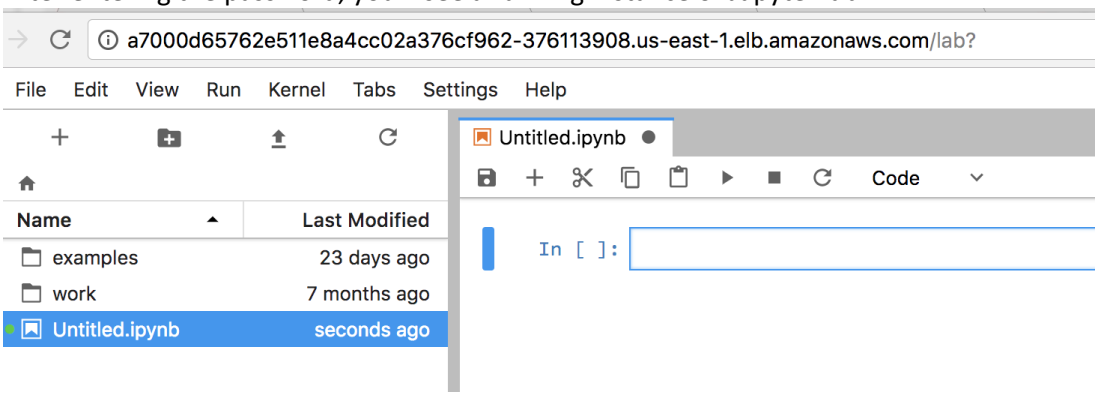


Jupyter Server

Now that we have the DNS entry, let's go to the Jupyter server in the browser at: http://xxxxxxxxxxxxxxxxxxxxxxxxxxxx.us-east-1.elb.amazonaws.com/. The first thing you'll see is a Jupyter password prompt. Recall the default password is: dask.



After entering the password, you'll see a running instance of JupyterLab.



The notebooks include lots of useful information, such as:

- Parallelizing Python code with Dask
- Using Dask futures
- Parallelizing Pandas operations with Dask dataframes

Run a demo

Run the following commands to check the health and status of the cluster and to get the url to the Jupyter lab and the task scheduler

1. For the DNS status: Run dig ns name of ***dns created***
2. To view all the running nodes: *kubectl get nodes*
3. To check the ages of all nodes: *kubectl get pods*
4. To get information about jupyter and the web access: *kubectl get all*

References

https://ramhiser.com/post/2018-05-28-adding-dask-and-jupyter-to-kubernetes-cluster/
http://docs.dask.org/en/latest/_downloads/daskcheatsheet.pdf
https://dev.to/sr_balaji/kubernetes-cluster-setup-on-aws-13m6