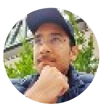
Running Apache Spark with HDFS on Kubernetes cluster

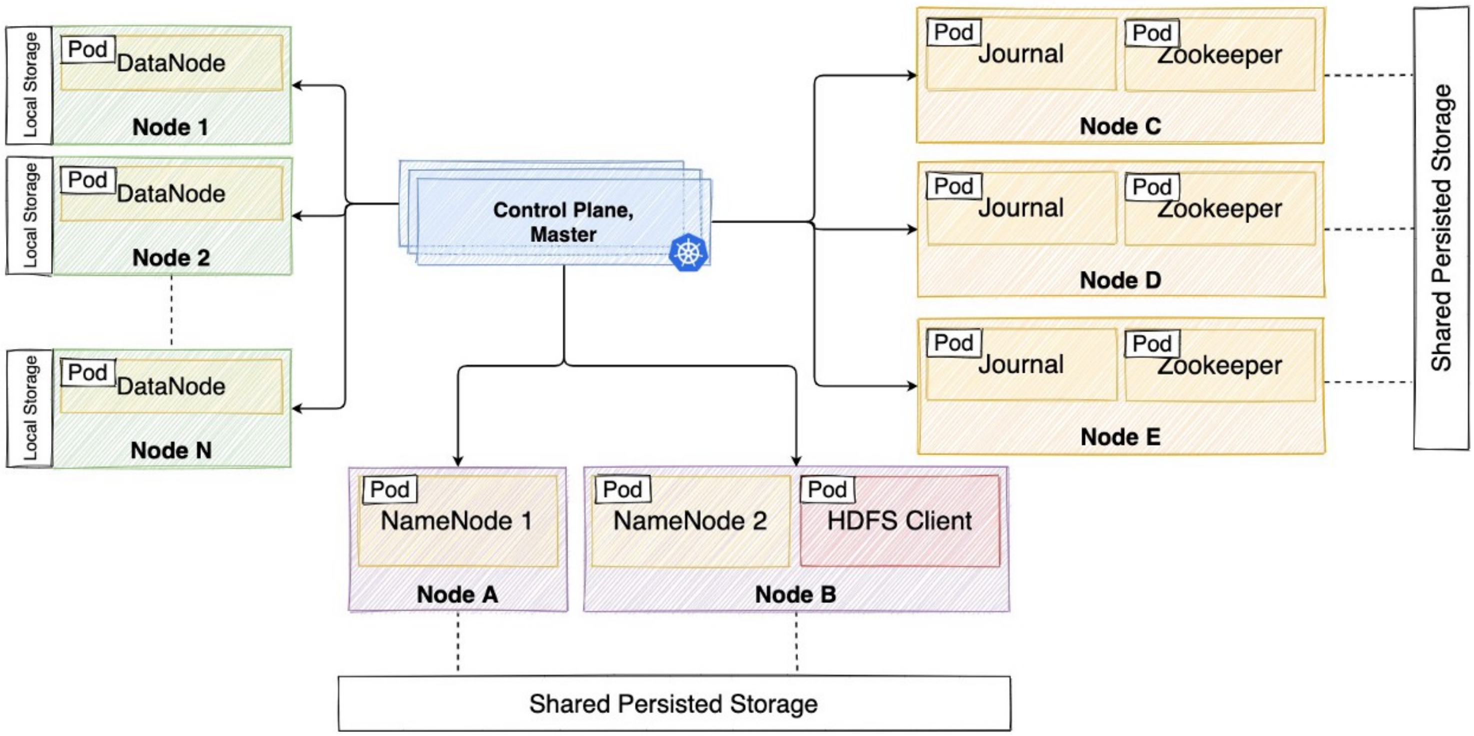


Shubhomoy Biswas Follow
Mar 12 · 5 min read ★

Why on Kubernetes?

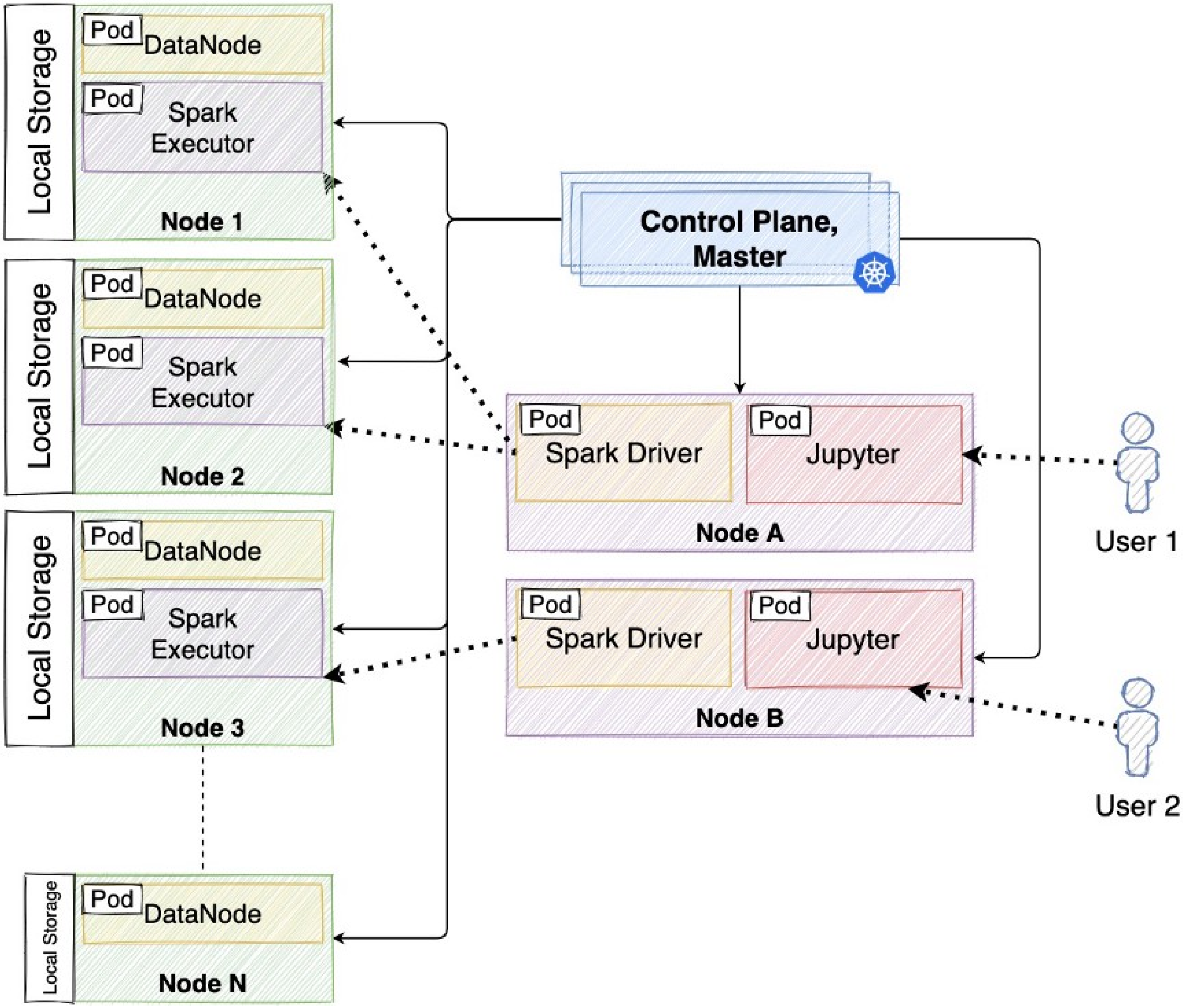
From the numerous advantages that *Kubernetes* offers, I particularly find it beneficial to deploy *HDFS* on *K8s* because of the **ease of scalability** K8s provides and requires fewer management tasks. Data is ever-increasing, and one needs to have a stable and easy horizontal scalable architecture to accommodate terabytes of data while providing fault tolerance. By having *HDFS* on *Kubernetes*, one needs to add new nodes to an existing cluster and let *Kubernetes* handle the configuration for the new *HDFS Datanodes* (as pods)!

Below is an overview of a *HDFS* HA setup running on *Kubernetes*.



Also by making our *Spark Executors* spin up dynamically inside our *Kubernetes* cluster offers additional benefits. First, you can configure them to spin up in the nodes where your *HDFS Datanode* pods reside. Second, you will have the native out-of-the-box isolation that *Kubernetes* provide using `namespaces` .

Below is a typical *Apache Spark* deployment on *Kubernetes*.



Oh, and did I mention *Jupyter*? If your team need tools such as *Jupyter* notebooks to analyze the data interactively, you can spin up these notebooks inside the *Kubernetes* cluster and connect them with their respective *Spark* drivers. This way, multiple users can have their separate Jupyter environment and Spark Executors, as and when needed in the same cluster with complete isolation!

Deploy HDFS

HDFS can be easily deployed using a ready-made **Helm chart** provided here. The Helm chart provides HA as well as a simple *HDFS* setup. As of writing this article, I used **Kubernetes version 1.20** and as such, I had to make certain modifications to the charts.

1. Update the *apiVersion* for *StatefulSets* and *DaemonSets* as they are now in *apps/v1*

2. Make sure you have dynamic provisioning enabled for your cluster. If not, then you need to create *PersistantVolumes* for the *StatefulSets* (that includes *Journal*, *Zookeeper* and *Namenodes*).

3. In `requirements.yaml` file (inside *hdfs-k8s* directory), change the *Zookeeper* repository to https://charts.helm.sh/incubator and version to *2.1.6*

4. There was no option to update the storage class of *Zookeeper* inside `values.yaml` , so you can update that section as below.

```
zookeeper:
  ## Configure Zookeeper resource requests and limits
  ## ref: http://kubernetes.io/docs/user-guide/compute-resources/
  resources: ~
  persistence:
    storageClass: <YOUR_STORAGE_CLASS_NAME>
    accessMode: ReadWriteMany
  ## The JVM heap size to allocate to Zookeeper
  env:
    ZK_HEAP_SIZE: 1G

  ## The number of zookeeper server to have in the quorum.
  replicaCount: 1
```

HDFS Datanodes will be deployed as *DaemonSet*, so whenever a new K8s node is added, a new *Datanode pod* will get attached to the *HDFS* cluster! Keep those terabytes of data coming… The Helm chart also provides a client pod from where you can execute all the *HDFS/HADOOP* commands and the WebUI can be accessed from the *NameNode's* K8s service.

Light up the Spark!

Apache Spark needs a cluster manager, and while *YARN* and *Apache Mesos* are the most common managers, recently, *Kubernetes* can also be the cluster manager for our *Spark* deployment. The process and architecture are fairly mentioned in the official documentation, but I found a good read here that explains the procedure of setting *Spark on Kubernetes* as **client-mode**. Briefly, it involves,

1. **Creating *Spark Executor* image** and uploading it to a Docker repository where your K8s cluster will pull it in real-time when spinning up the executor pods. The downloaded *Spark* TAR already has the script file (`docker-image-tool.sh`) for building this image.

2. **Deploying the Driver pod from where users can submit *Spark* jobs.** The official PySpark image contains both the Driver as well as the *Jupyter* notebook we can use. We need to create the corresponding *Deployment*, *Service*, and *RBAC* in our *Kubernetes* cluster.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: jupyter-labs
  labels:
    app: jupyter-labs
spec:
  replicas: 1
  selector:
    matchLabels:
      app: jupyter-labs
  template:
    metadata:
      labels:
        app: jupyter-labs
    spec:
      serviceAccountName: spark-sa
      containers:
        - name: jupyter-labs
          image: jupyter/pyspark-notebook
          imagePullPolicy: IfNotPresent
          ports:
            - containerPort: 8888
      restartPolicy: Always

---

apiVersion: v1
kind: Service
metadata:
  name: jupyter-labs
  labels:
    app: jupyter-labs
```

```
spec:
  ports:
    - protocol: TCP
      port: 29413
  selector:
    app: jupyter-labs
  clusterIP: None

---

apiVersion: v1
kind: Service
metadata:
  name: jupyter-labs-ui
  labels:
    app: jupyter-labs-ui
spec:
  ports:
    - protocol: TCP
      port: 8888
  selector:
    app: jupyter-labs
  type: NodePort

---

apiVersion: v1
kind: ServiceAccount
metadata:
  name: spark-sa

---

kind: ClusterRole
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  namespace: default
  name: spark-role
rules:
- apiGroups: [""]
  resources: ["pods", "services", "configmaps" ]
  verbs: ["create", "get", "watch", "list", "post", "delete"  ]

---

kind: ClusterRoleBinding
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: spark-role-binding
subjects:
- kind: ServiceAccount
  name: spark-sa
  namespace: default
```

```
roleRef:
  kind: ClusterRole
  name: spark-role
  apiGroup: rbac.authorization.k8s.io
```

> *The best part is that you can now create multiple Deployments for PySpark (Driver and Jupyter notebook) for multiple users so that each user gets his/her own environment to run Spark jobs.*

Jupyter notebook will be accessible on port 8888 (or the respective *NodePort* if you have created the Service as a *NodePort* type). Type in the below python code that will spin up the requester *Spark Executors* in your cluster!

```
from pyspark import SparkContext, SparkConf
from pyspark.sql import SparkSession

sparkConf = SparkConf()
sparkConf.setMaster("k8s://https://kubernetes.default.svc.cluster.loc
al:443")
sparkConf.setAppName("spark")
sparkConf.set("spark.kubernetes.container.image", "
<YOUR_DOCKER_REPOSITORY_AND_IMAGE_OF_SPARK_EXECUTOR>")
sparkConf.set("spark.kubernetes.namespace", "default")
sparkConf.set("spark.executor.instances", "1")
sparkConf.set("spark.executor.cores", "1")
sparkConf.set("spark.driver.memory", "512m")
sparkConf.set("spark.executor.memory", "512m")
sparkConf.set("spark.kubernetes.authenticate.driver.serviceAccountNam
e", "spark-sa")
sparkConf.set("spark.kubernetes.authenticate.serviceAccountName",
"spark-sa")
sparkConf.set("spark.driver.port", "29413")
sparkConf.set("spark.driver.host", "jupyter-
labs.default.svc.cluster.local")

spark = SparkSession.builder.config(conf=sparkConf).getOrCreate()
sc = spark.sparkContext
```

Make sure to provide the *Spark Executor* docker image repository that you have created above and the correct service name of your Spark driver in the above code snippet (marked in bold).

Conclusion

Overall, I liked the flexibility and ease of setting up *Apache Spark* with *HDFS* inside *Kubernetes* this way. Also, team members have their own isolated *Jupyter* and *Spark* environments inside the same cluster and at the same time provide an efficient resource sharing of the parent nodes.

If you have made it till here, then I would love to know how are you planning or planned to deploy a scalable *Spark* environment? Would love to hear that :)

Apache Spark Hdfs Kubernetes Scalability Big Data