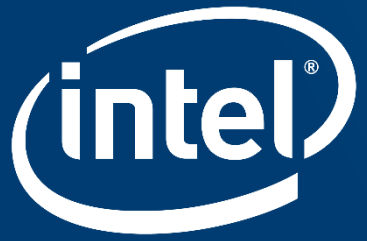

SPARK ON KUBERNETES - JD.COM CASE STUDY

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ABOUT US

Zhen Fan

Software Development Engineer at JD.com

Zhen is a software development engineer at JD.com, where he focuses on big data and machine learning platform development and management.

Weiting Chen(William)

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Weiting is a senior software engineer in Intel's Software Service Group, where he works on big data on cloud solutions. One of his responsibilities is helping customers integrate big data solutions into their cloud infrastructure.

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AGENDA

BACKGROUND

SPARK ON KUBERNETES
- Why use Spark-on-K8s
- How it works

JD.COM CASE STUDY
- JD.com's MoonShot
- Network Choice
- Storage Choice

SUMMARY

BACKGROUND

ABOUT SPARK-ON-KUBERNETES

https://github.com/apache-spark-on-k8s/spark

Spark* on Kubernetes*(K8s) is a new project proposed by the companies including Bloomberg, Google, Intel, Palantir, Pepperdata, and Red Hat.

The goal is to bring native support for Spark to use Kubernetes as a cluster manager like Spark Standalone, YARN*, or Mesos*.

The feature has been merged into Spark 2.3.0 release(SPARK-18278).

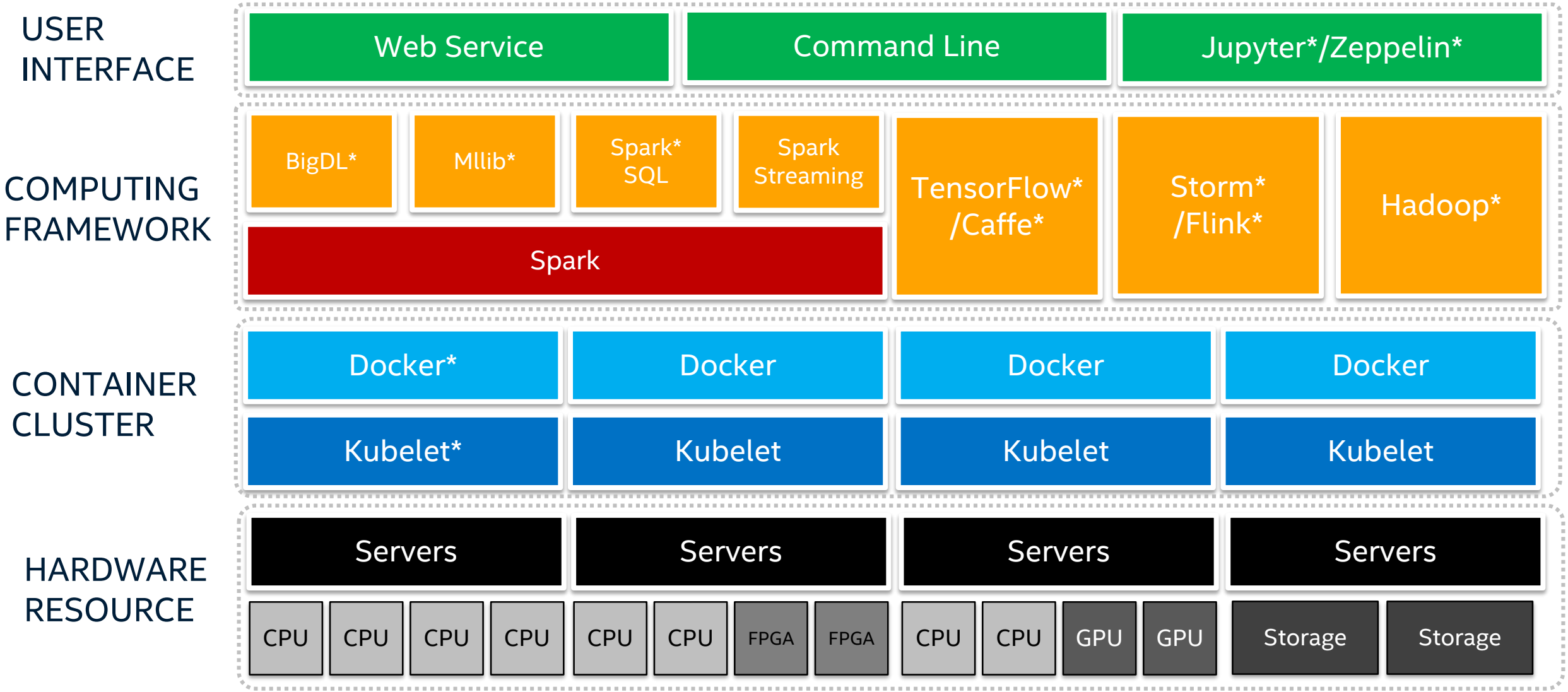
WHY JD.COM CHOOSE SPARK-ON-K8S

HETEROGENEOUS COMPUTING

CPU + GPU + FPGA

Customers are asking to use an unified cloud platform to manage their applications. Based on Kubernetes*, we can ease to set up a platform to support CPU, GPU, as well as FPGA resources for Big Data/AI workloads.

HETEROGENEOUS CLOUD SOLUTION



SPARK ON KUBERNETES

SPARK ON DOCKER SOLUTIONS

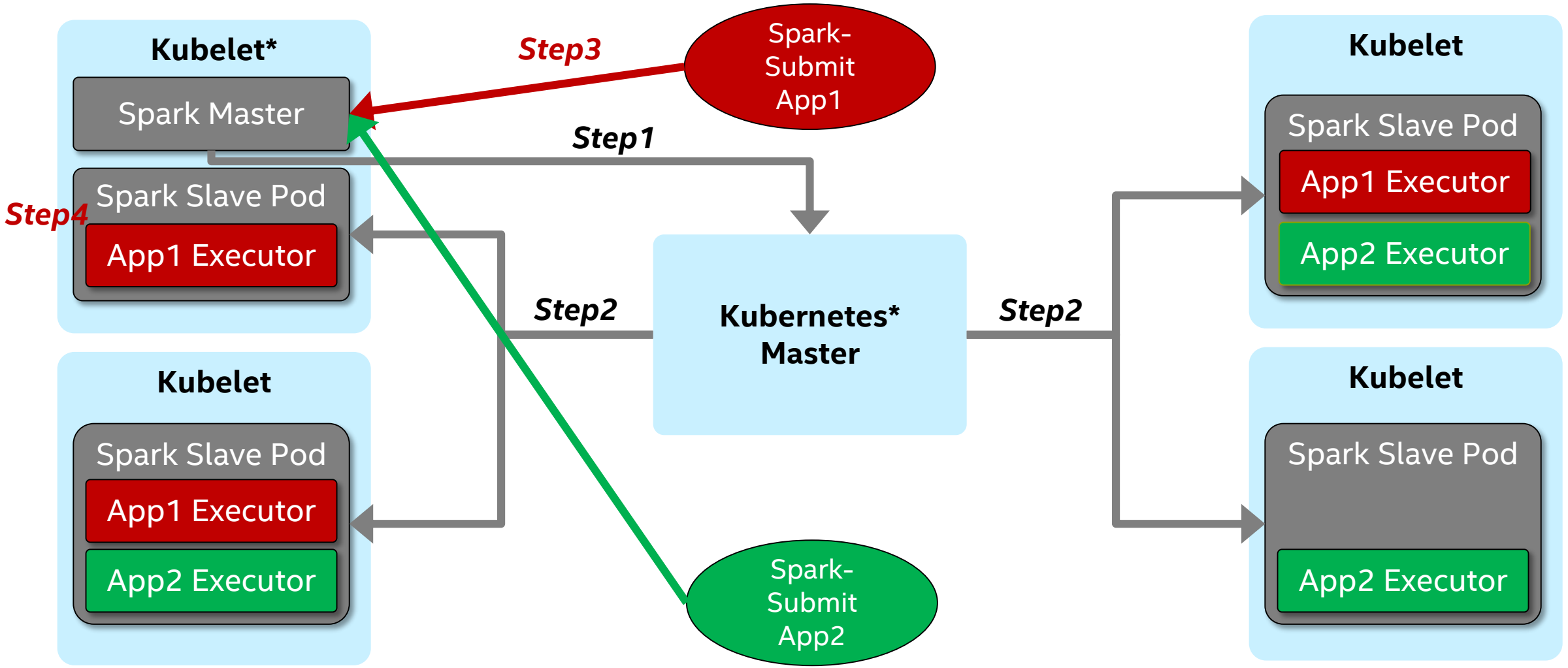
Solution1 - Spark* Standalone on Docker*

- Run Spark standalone cluster in Docker.
- Two-tiers resource allocation(K8s->Spark Cluster->Spark Applications).
- Less efforts to migrate existing architecture into container environment.

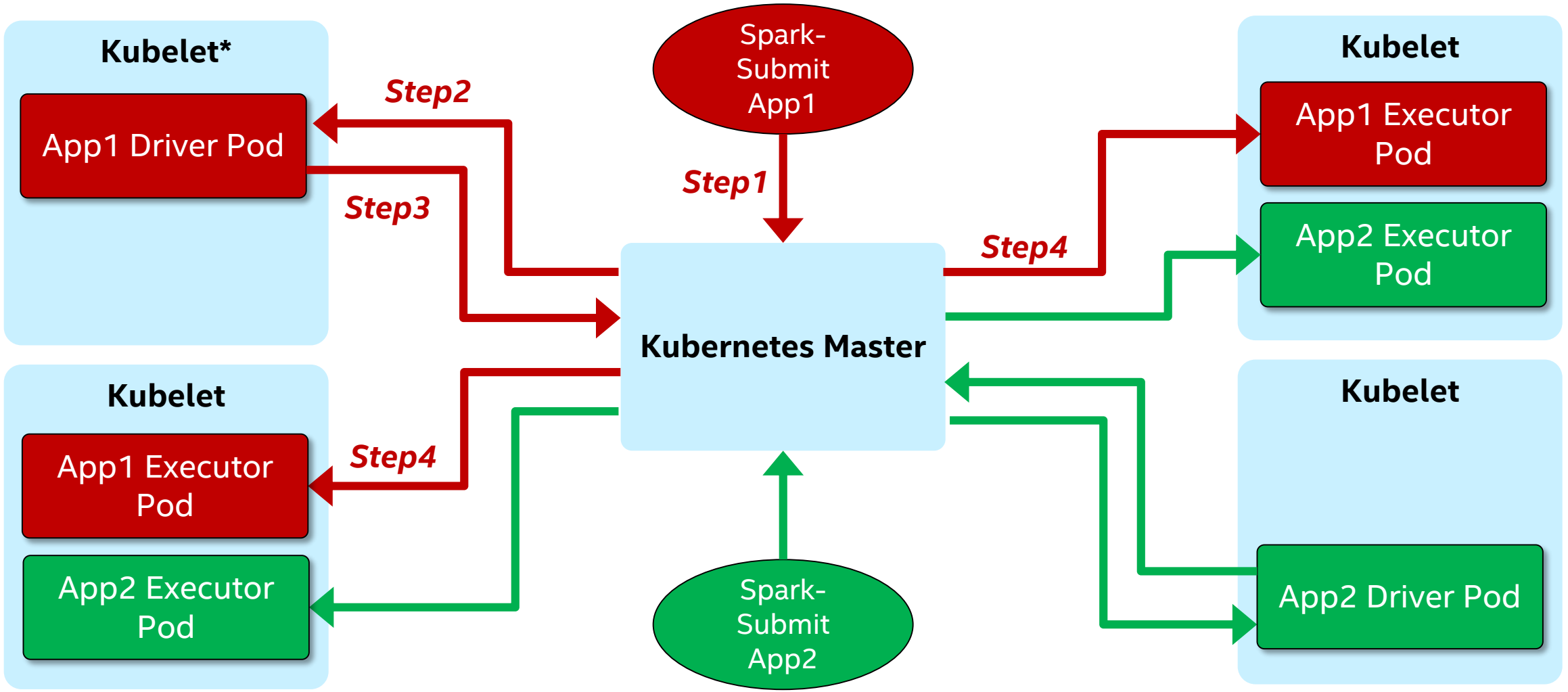
Solution2 - Spark on Kubernetes*

- Use native way to run Spark on Kubernetes like Spark Standalone, YARN, or Mesos.
- Single tier resource allocation(K8s->Spark Applications) for higher utilization.
- Must re-write the entire logical program for resource allocation via K8s.

SOLUTION1 - SPARK STANDALONE ON DOCKER



SOLUTION2 - SPARK ON KUBERNETES

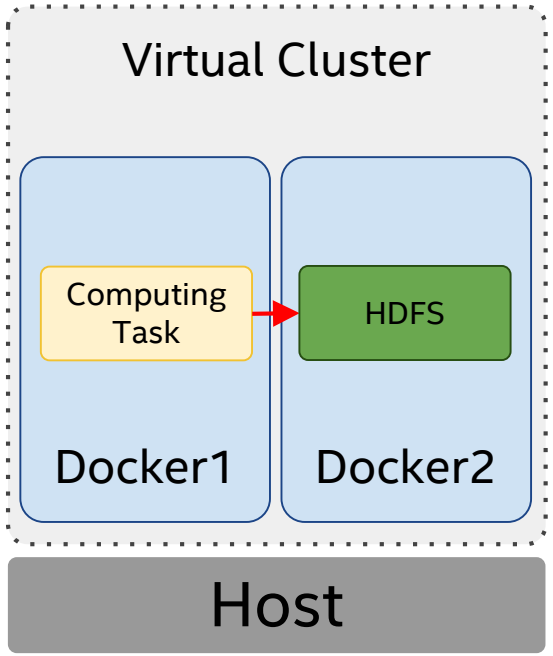


HOW TO USE SPARK ON K8S

```
bin/spark-submit \
  --deploy-mode cluster \
  --class org.apache.spark.examples.SparkPi \
  --master k8s://http://127.0.0.1:8080 \
  --kubernetes-namespace default \
  --conf spark.executor.instances=5 \
  --conf spark.executor.cores=4 \
  --conf spark.executor.memory=4g \
  --conf spark.app.name=spark-pi \
  --conf spark.kubernetes.driver.docker.image=localhost:5000/spark-driver \
  --conf spark.kubernetes.executor.docker.image=localhost:5000/spark-executor \
  --conf spark.kubernetes.initcontainer.docker.image=localhost:5000/spark-init \
  --conf spark.kubernetes.resourceStagingServer.uri=http://$ip:31000 \
  hdfs://examples/jars/spark-examples_2.11-2.1.0-k8s-0.1.0-SNAPSHOT.jar
```

DATA PROCESSING MODEL

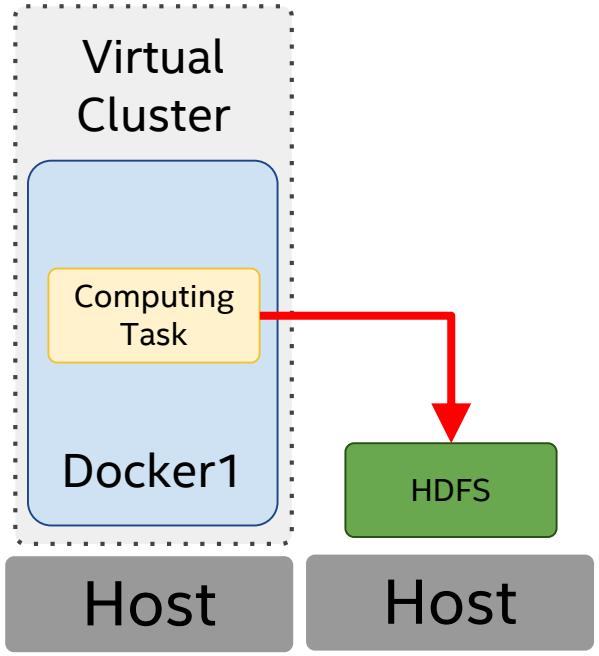
PATTERN 1: Internal HDFS*



Use HDFS as file sharing server.
HDFS runs in the same host to give elasticity to add/reduce compute nodes by request.

Please refer to Spark and HDFS.

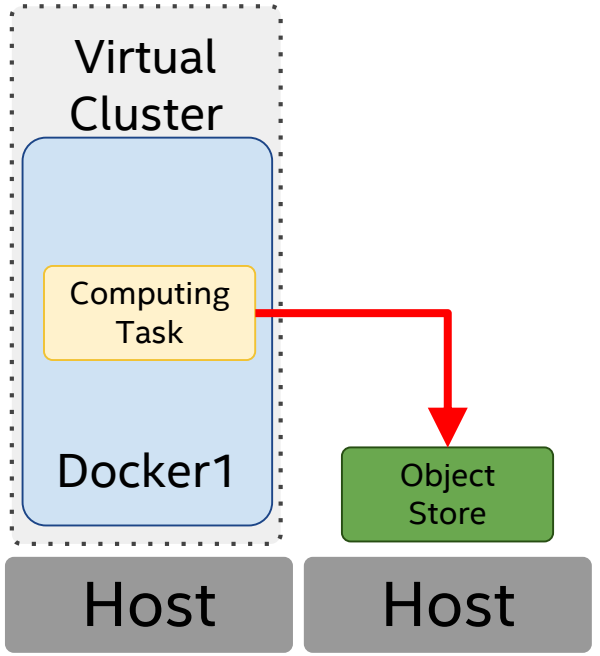
PATTERN 2: External HDFS



Use HDFS as file sharing server.
HDFS runs outside in a long-running cluster to make sure data is persisted.

Please refer to PR-350

PATTERN 3: Object Store



Launch a File Staging Server to share data between nodes.
Input and Output data can put in an object store
Streaming data directly via object level storage like **Amazon S3, Swift**.

Storage Plan for Spark* on K8s*

The design rule is based on "whether the data must be persisted".

spark.local.dir:
For Spark Data Shuffling.
Use Ephemeral Volume.
Now it uses docker-storage with diff. storage backend.
EmptyDir is WIP.

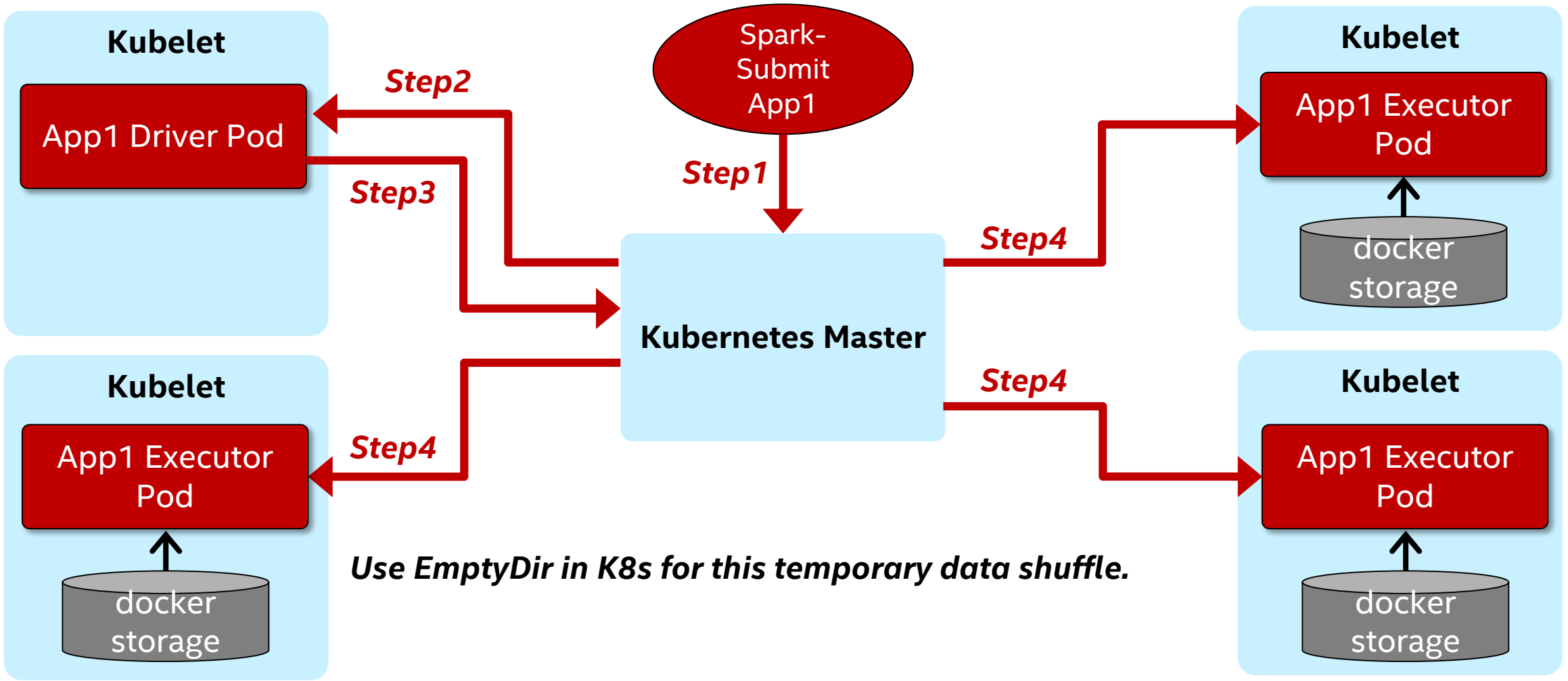
File Staging Server:
For sharing data such as Jar or dependence file between computing nodes.
Now it uses docker-storage.
Local Storage support in Persist Volume(PV) is WIP.

KEY FEATURES

- Support Cluster Mode
- Client Mode Support is under reviewing.
- Support File Staging in local, HDFS, or running a File Stage Server container.
- Support Scala, Java, and PySpark.
- Support Static and Dynamic Allocation for Executors.
- Support running HDFS inside K8s or externally.
- Support for Spark 2.3
- Pre-built docker images

STATIC RESOURCE ALLOCATION

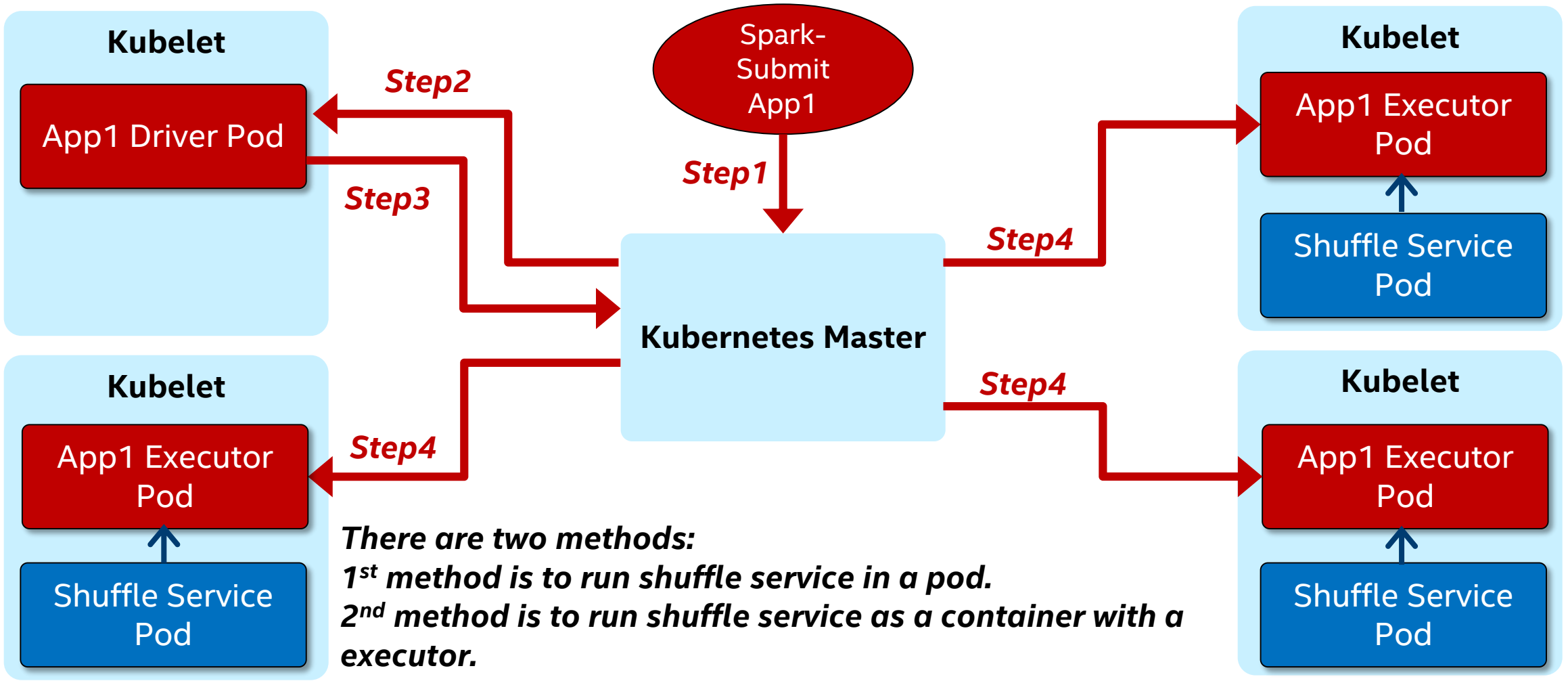
The resources are allocated in the beginning and cannot change during the executors are running.
Static resource allocation uses local storage(docker-storage) for data shuffle.



Use EmptyDir in K8s for this temporary data shuffle.

DYNAMIC RESOURCE ALLOCATION

The resources are allocated in the beginning, but applications can change the resource in run time. Dynamic resource allocation uses shuffle service container for data shuffle.



JD.COM CASE STUDY

JD.com (NASDAQ: JD)

Founded in 2004 in Beijing by CEO, Richard Liu.

Largest online retailer in China

Member of the Fortune Global 500

Business including e-commerce, Internet finance, logistics, cloud computing and smart technology

Technology-driven company, ABC strategy

Joybuy.com for US customers - affiliate to JD.com

JD.com MOONSHOT

JD has used K8s* as cloud infrastructure management for several years.

JD would like to use K8s to manage all the computing resources including CPU, GPU, FPGA, ...etc.

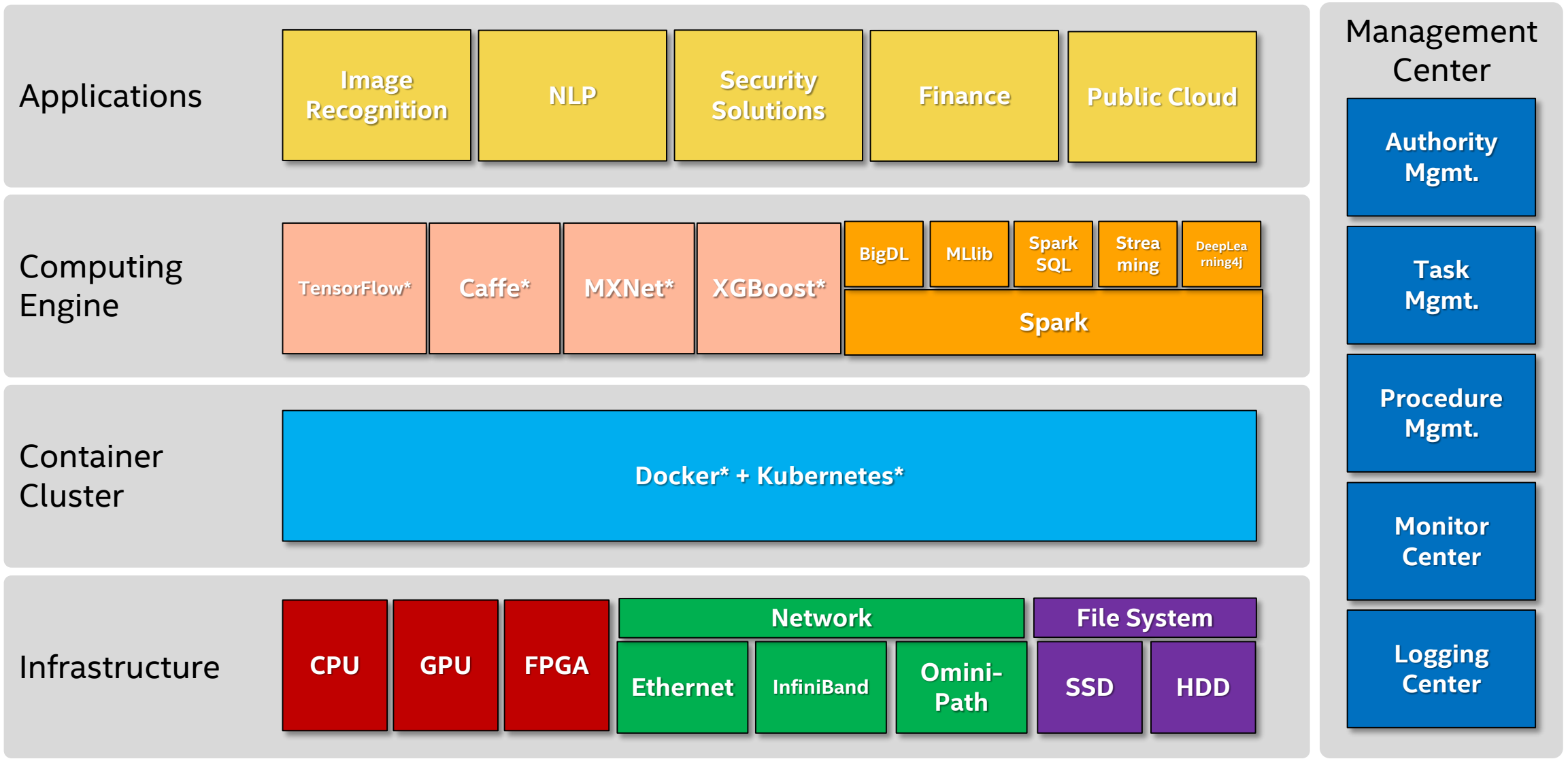
Target for all AI workloads; Using the same cluster for training/inference.

Across multiple Machine Learning framework including Caffe, TensorFlow, XGBoost, MXNet, BigDL ...etc.

To optimize workloads for different resource allocation.

Multi-tenancy support by different user accounts and resource pool.

MOONSHOT ARCHITECTURE



NETWORK CHOICE BY JD.COM

TYPES OF CONTAINER NETWORK

Bridge

Bridge is the default network(docker0) in Docker*. Linux bridge provides a host internal network for each host and leverages iptables for NAT and port mapping. It is simple and easy, but with bad performance.

Host

Container shares its network namespace with the host. This way provides high performance without NAT support, but limits with port conflict issue.

Overlays

Overlays use networking tunnels(such as VXLAN) to communicate across hosts. Overlay network provides the capability to separate the network by projects.

Underlays

Underlays expose host interfaces directly to containers running on the host. It supports many popular drivers like MACvlan, IPvlan, ...etc. Some other ways via Underlay network are Direct Routing, Fan Networking, Point-to-Point.

NETWORK SOLUTIONS

Flannel*

A simple and easy to configure layer 3 network fabric designed for K8s. It runs flanneld on each host to allocate subnet and uses etcd to store network configuration. Flannel supports several backends including VXLAN, host-gw, UDP, ...etc.

Weave*

Weave creates a virtual network that connects Docker containers across multiple hosts and enables their automatic discovery.

OpenVSwitch*

Calico*

An approach to virtual networking and network security for containers, VMs, and bare metal services, which provides a rich set of security enforcement capabilities running on top of a highly scalable and efficient virtual network fabric. Calico uses BGP to set up the network and it also supports IPIP methods to build up a tunnel network.

Why CALICO?

No overlay required

Little overhead comparing to bare metal. Sometimes, overlay network(encapsulating packets inside an extra IP header) is an option, not MUST. Using Calico with BGP is much faster.

Simple & Scalable

The architecture is simple, the deployment is simple as well. We can easily deploy thousands of nodes in k8s by using yaml file.

Policy-driven network security

In many scenarios of JD.com, for example, multi-tenancy is necessary to make network isolation. Calico enables developers and operators to easily define network policy with fine granularity such as allowed or blocked connections.

Widely deployed, and proven at scale

We leverage the experience from other big companies who share their issues in the community. These experience are very valuable for us at the very beginning of moonshot. Fortunately, Calico has passed the verified in our production environment.

NETWORK PERFORMANCE RESULT

All scenarios use ab command to connect to nginx* server with different IP address.
“ab -n 1000000 -c 100 -H"Host: nginx.jd.local" 172.20.141.72:80/index.html “

No.	Scenario	Concurrency #	Total Time(s)	Request per Second	Response Time(ms)
1	Client -> Nginx	50	50.044	19982	0.05
2	Weave: Client -> iptables -> Weave -> Nginx container	50	132.839	7527	0.133
3	Calico with IPIP: Client -> iptables -> Calico -> Nginx container	50	111.136	8998	0.111
4	Calico with BGP: Client -> iptables -> Calico -> Nginx container	50	59.218	16886	0.059

JD.com decides to pick up Calico since Calico provides similar performance to Bare Metal.

STORAGE CHOICE BY JD.COM

STORAGE CHOICES

Separate Compute and Storage cluster

Use Kubernetes to allocate resources for compute

Use Stand-alone HDFS Cluster for data persistent

Data locality depends on the workload types

DATA LOCALITY IMPACT

Workloads	Types	Locality	Datasize	Cluster Size	Network	Execution Time	Notes
Terasort	IO	Local	320GB	5	1Gb	2119.926sec	1x
Terasort	IO	Remote	320GB	5 Spark + 3 Hadoop	1Gb	4212.029sec	1.98x
Terasort	IO	Local	320GB	5	10Gb	500.198sec	1x
Terasort	IO	Remote	320GB	5 Spark + 3 Hadoop	10Gb	548.549sec	1.10x
Kmeans	CPU	Local	240GB	5	10Gb	1156.235sec	1x
Kmeans	CPU	Remote	240GB	5 Spark + 3 Hadoop	10Gb	1219.138sec	1.05x

Note1: This testing is using 5-nodes bare metal cluster.
Note2: 4 SATA SSD per Spark and Hadoop node
Note3: Performance may impact in different configuration including the number of disk, network bandwidth, as well as different platform.

SUMMARY

CURRENT STATUS & ISSUES

Spark* Shell for Client Mode hasn't been merged and verified.

Data Locality Support

Storage Backend Support

Performance Issues for launching container via Kubernetes

Reliability: Need more verification in larger scale(current 300+ and moving to 1000+)

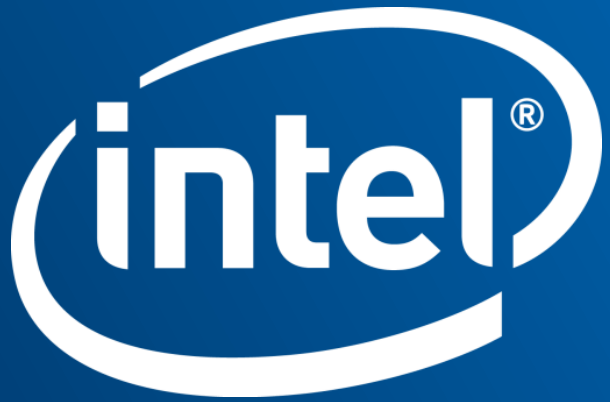
SUMMARY

Spark* on K8s* provides a cloud native way to run Spark on Cloud which not only can get better resource utilization but also integrate with more big data services.

JD.com's MoonShot is a POC to prove Spark on K8s is good enough in a production environment.

JD.com next step is to scale up the size of cluster to thousand level.

Spark on K8s is still under developing and there are many issues/features are waiting to be fixed/implemented.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