CLOUD NATIVE
COMPUTING FOUNDATION

Nezha: A Kubernetes Native Big Data Accelerator For Machine Learning

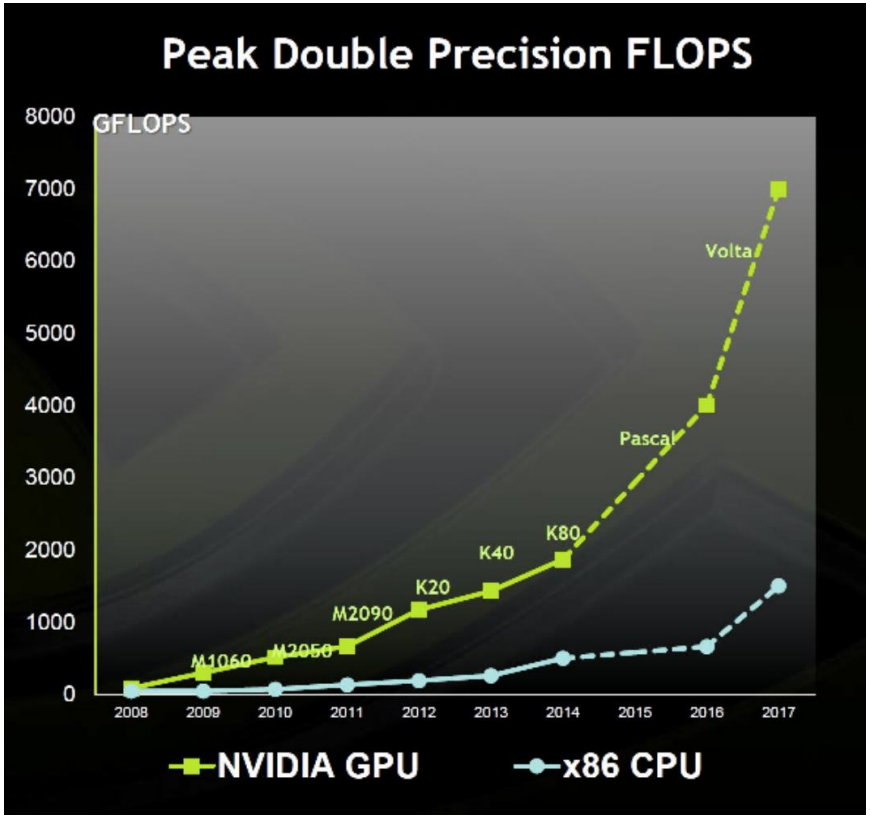
Huamin Chen - Red Hat
Yuan Zhou - Intel
Dec, 2018

- Background and Motivations
- Architecture Overview
- Use Cases in kubeflow(Deep Learning) and Spark-SQL(Data Analytics)
- Summary & Next Step

Deep Learning Accelerators

- Hardware Accelerator
  - CPU, GPU, TPU, FPGA
- Software Accelerator
  - Better Algorithms
  - In-memory Software Stack

While Compute Is Accelerated



Source: https://nar.ucar.edu/2017/ral/gpu-accelerated-microscale-modeling-fasteddy

Data Link Is Lagging

Dataset Name	Size	Download Time	Training Time (with GPU)
MNIST	10+M	0.5~2 minutes	minutes
CIFAR 10/100	100+M	2~30 minutes	minutes
COCO 2017	26G	2~Many hours	hours~days

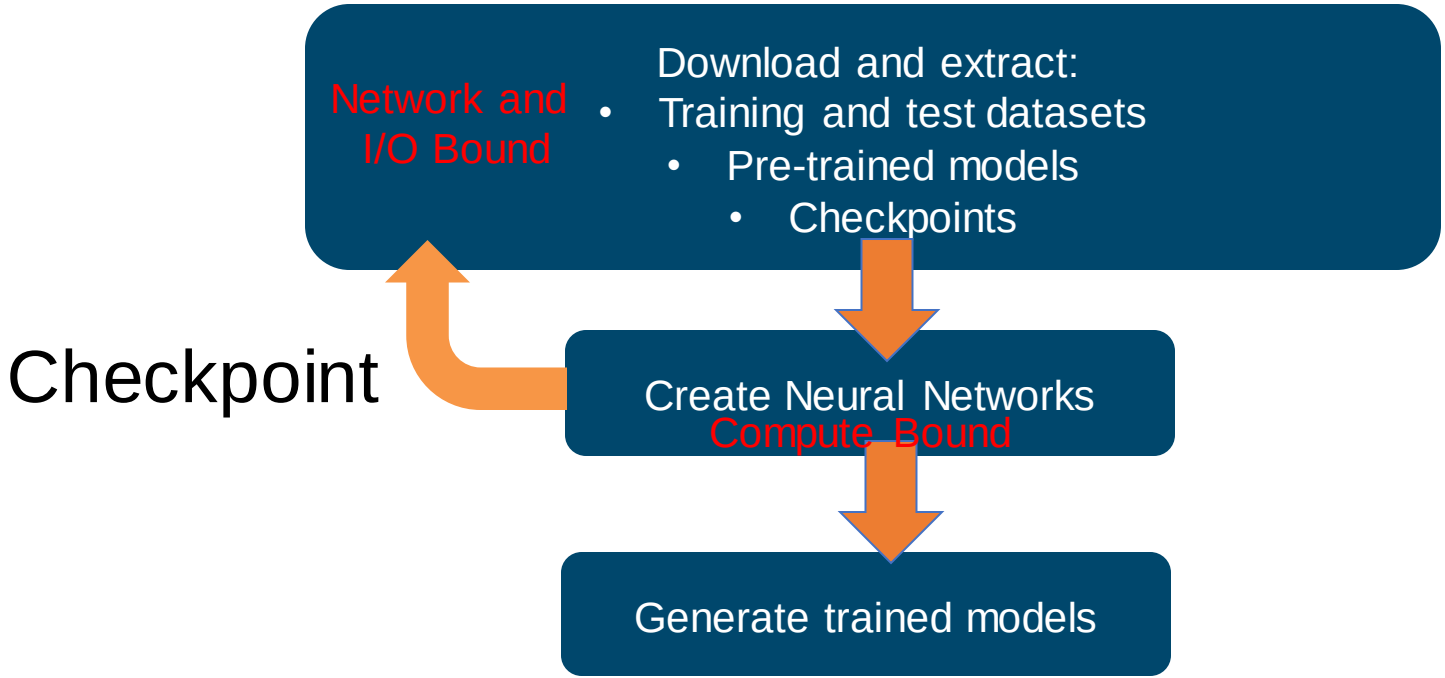
How to Accelerate Data Link?

Solution	Comment
Build a customized filesystem	• Take years to succeed • Very configuration dependent
Cache Dataset on Compute node	At the expense of cost, flexibility, and mobility
Nezha: On-demand cache	Kubernetes native, run everywhere, application transparent

Project Goals

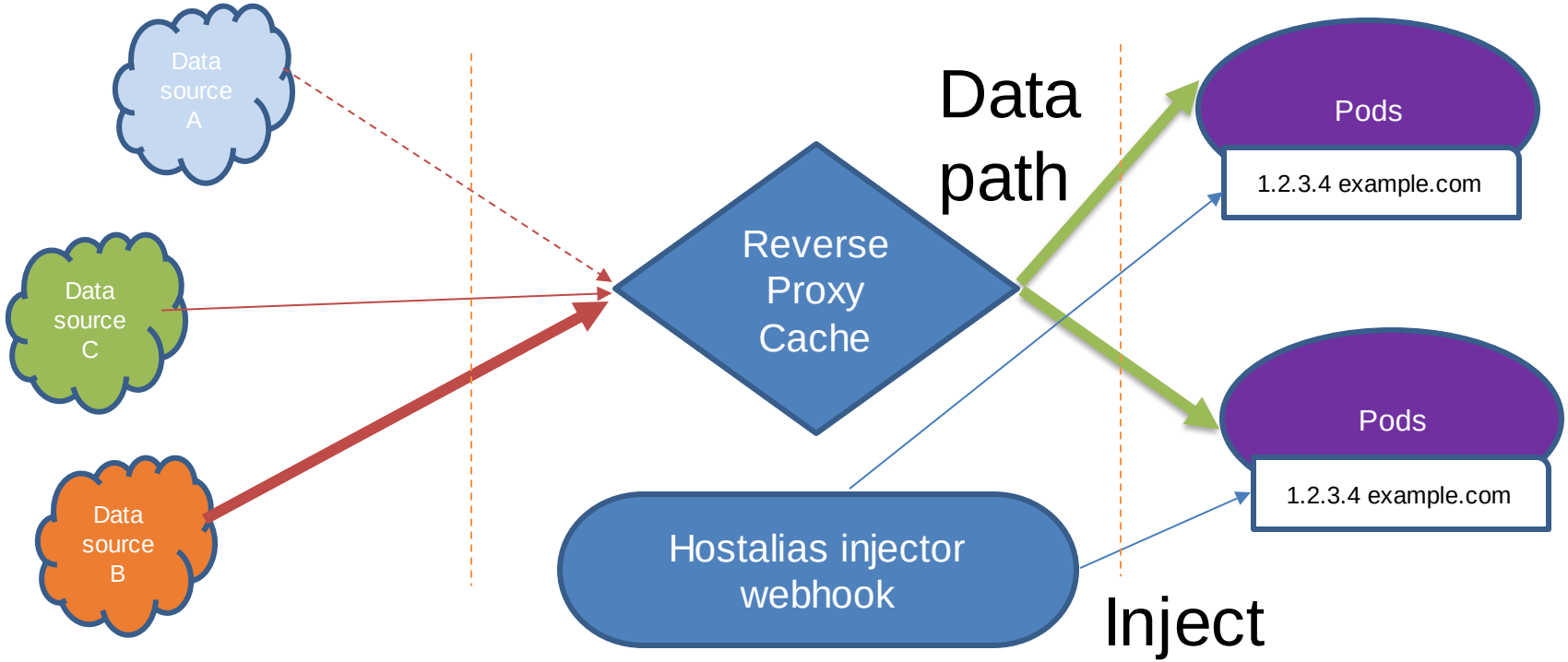
- Nezha aims to accelerate large dataset download and extract to keep input pipeline at high rate.
  - Network : Reverse Proxy Cache
  - I/O: Bring data close to compute
- Kubernetes Native
  - Services, Deployments, HostAlias, Persistent Volumes, and WebHook.
- *(Almost) transparent to end users!*
  - *Though TLS certificate issue requires some head scratching...*

A Walk of Deep Learning Training



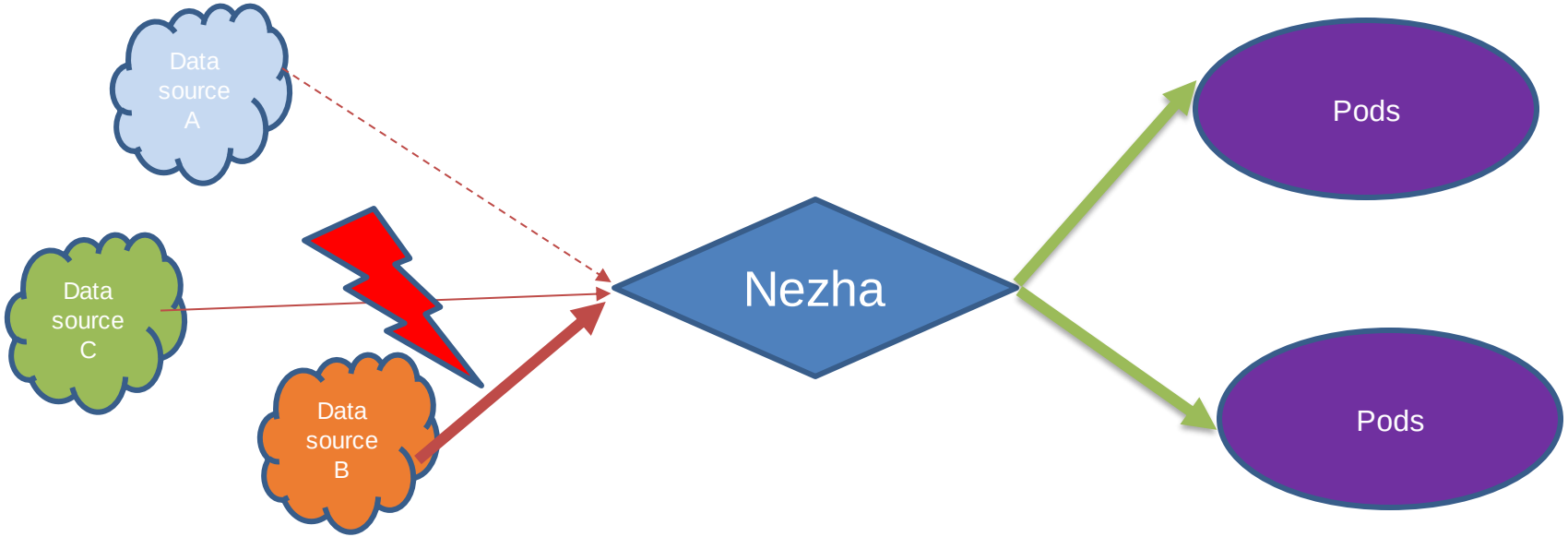
Nezha Architecture

https://github.com/fast-ml/nezha

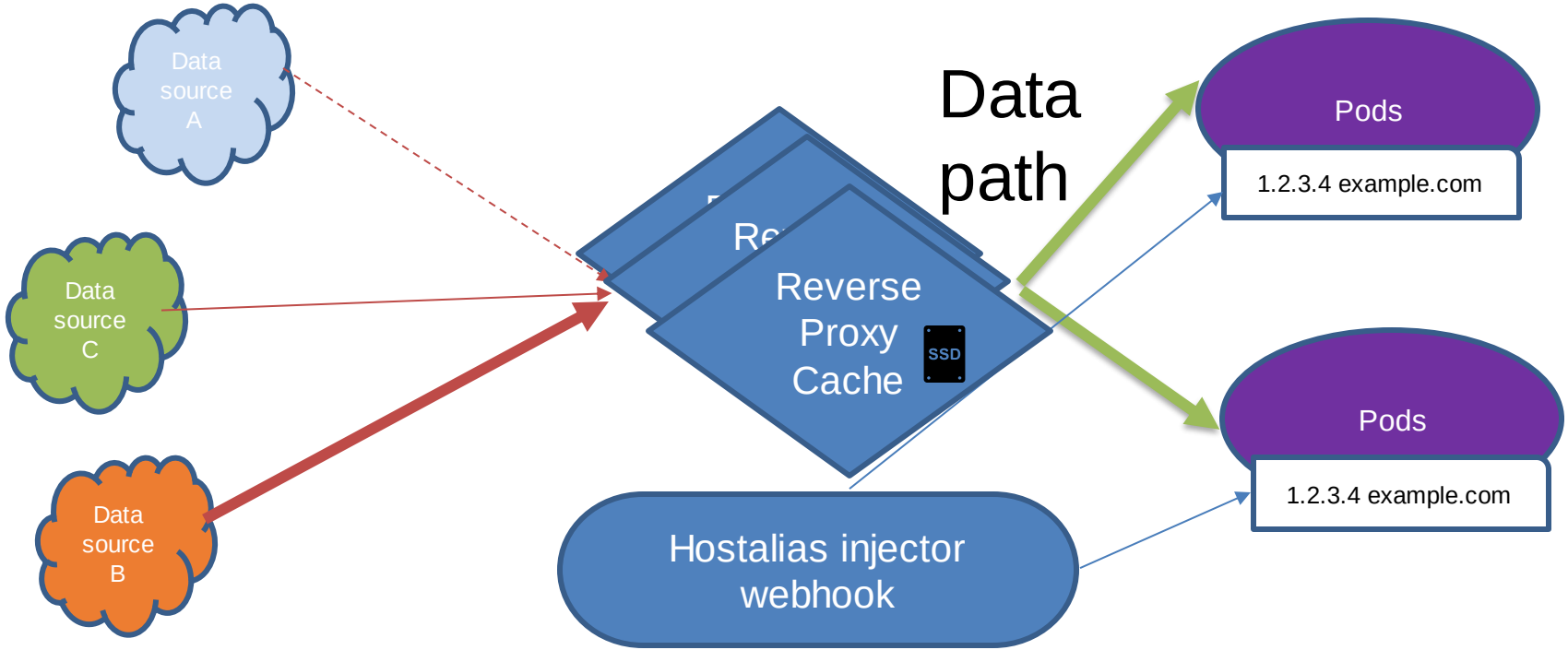


Nezha: No More Data Silos

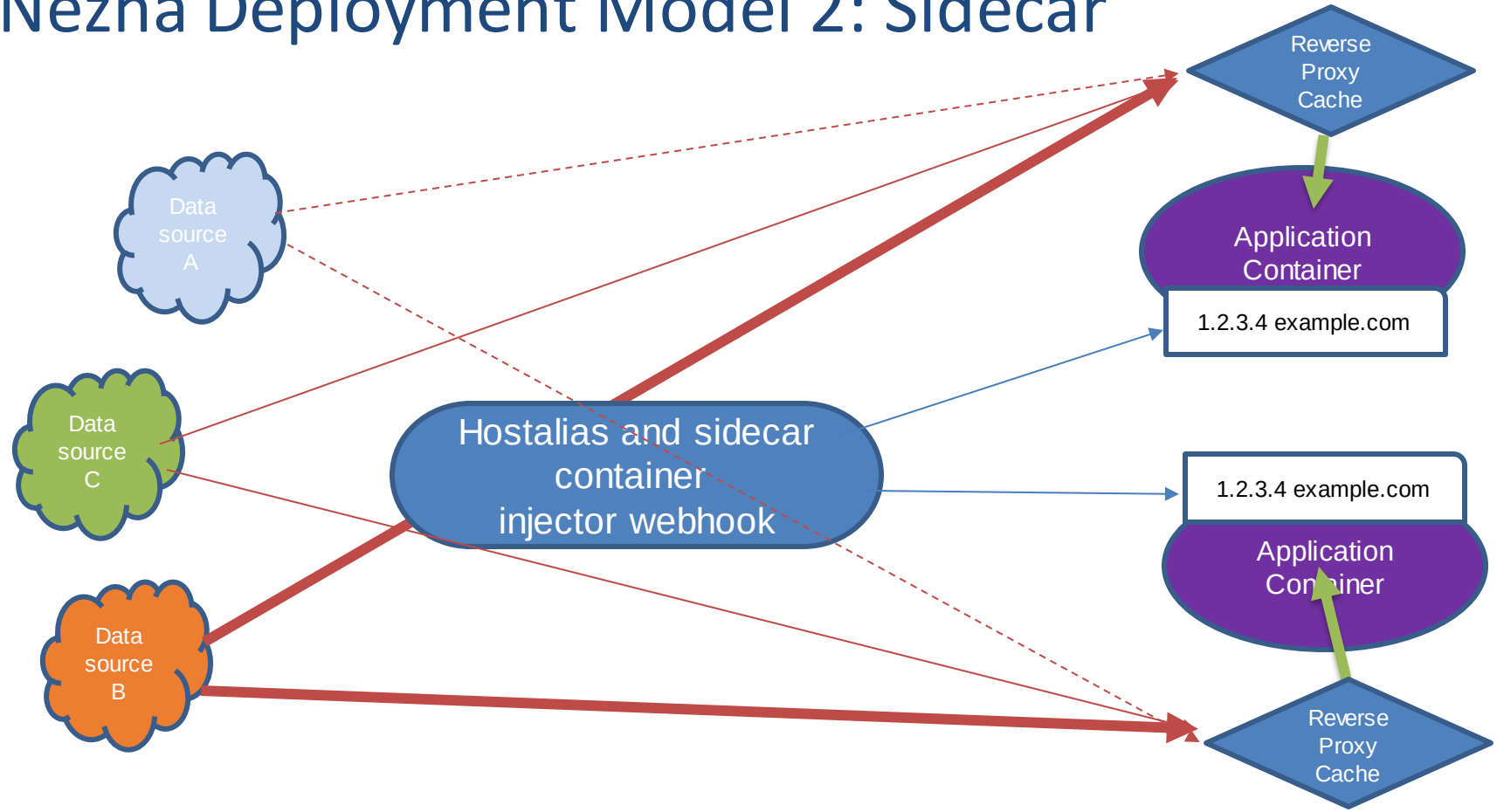
- Nezha aggregates data sources, brings *consistent* I/O performance and *high availability*, without big price ticket or proprietary technologies.



Nezha Deployment Model 1: Centralized



Nezha Deployment Model 2: Sidecar



Deployment Comparision

	Non Nezha	Nezha: Centralized	Nezha: Sidecar
Network Performance	Subject to external network performance	Subject to internal network performance	Subject to local container network performance
Data Availability	All compute tasks are subject to data source and network availability	All compute tasks are subject to proxy container availability	Individual compute task is subject to its sidecar container availability

Deploy Nezha in Kubernetes

- Instructions can be found at github repo
- Get to know what labels the applications use
- Kubeflow job deployed by ksonnet has the following signature

```
apiVersion: batch/v1
kind: Job
metadata:
  labels:
    app.kubernetes.io/deploy-manager: ksonnet
```

Configuration in the ConfigMap

```
apiVersion: v1
kind: ConfigMap
data:
  config: |
    - name: dataset
      app: app.kubernetes.io/deploy-manager
      label: ksonnet
      hostAliases:
      - ip: "10.106.122.174"
        hostnames:
        - "download.tensorflow.org"
        - "yann.lecun.com"
        - "www.cs.toronto.edu"
        - "storage.googleapis.com"
        - "images.cocodataset.org"
```

Kubeflow label

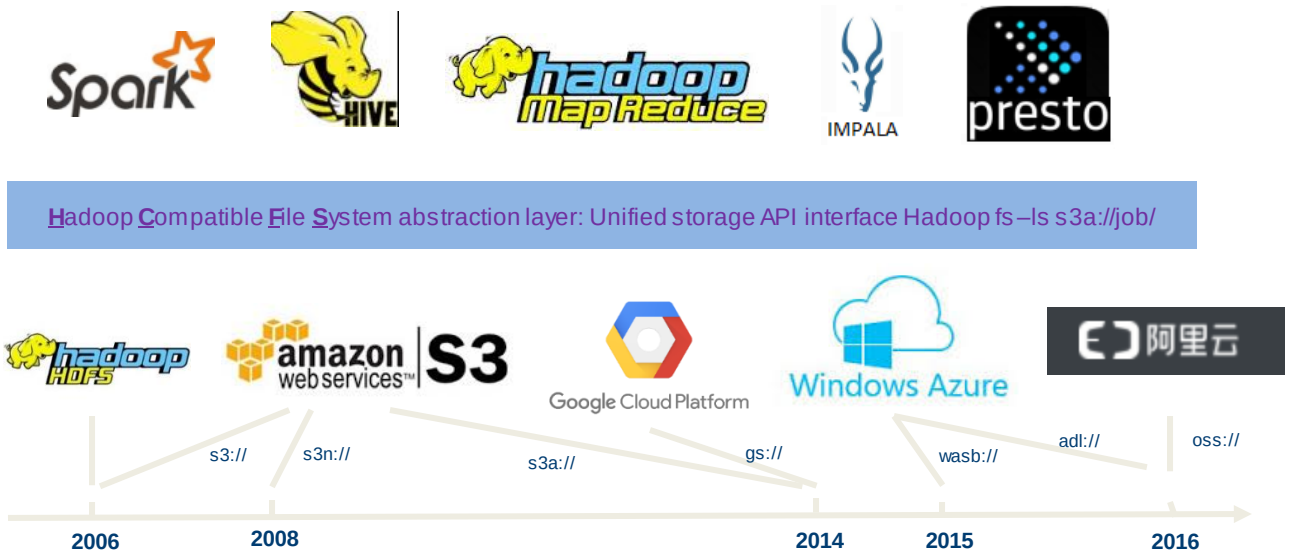
Proxy service IP

Upstream servers

Hostaliases Injection in Action

```
spec:
  containers:
  - args:
    - http://images.cocodataset.org/zips/train2017.zip
    image: mwendler/wget
    imagePullPolicy: Always
    name: wget
  hostAliases:
  - hostnames:
    - download.tensorflow.org
    - yann.lecun.com
    - www.cs.toronto.edu
    - storage.googleapis.com
    - images.cocodataset.org
    ip: 10.106.122.174
```

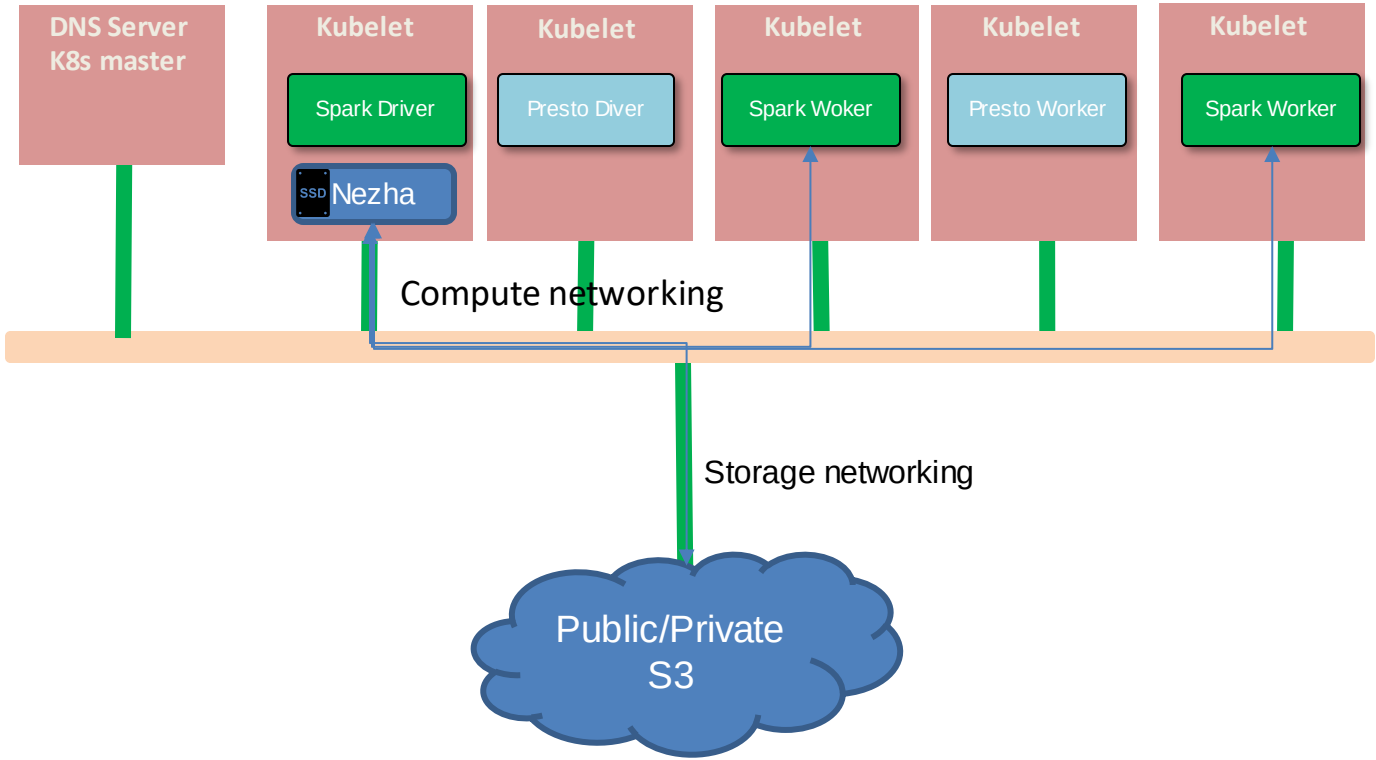
Bigdata analytics are moving to cloud



Hadoop object store connector

- Bigdata can now talk to public object stores directly
  - S3a: Amazon Simple Storage Service
  - Wasb: Windows Azure Storage Blob
  - Adl: Azure Data Lake Store
  - Gs: Google Cloud Storage
- Usually data reading is slower due to separate storage networking

Example Nezha Deployment For S3 caching

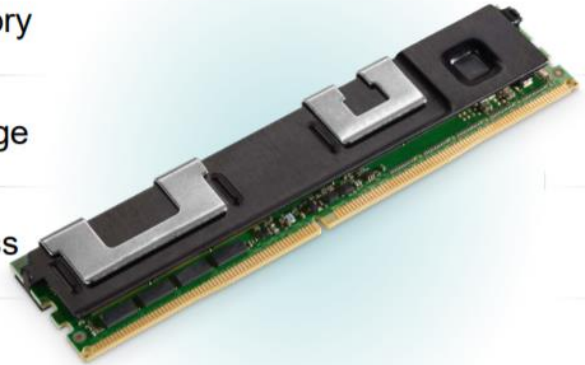


Intel Optane DC Persistent Memory

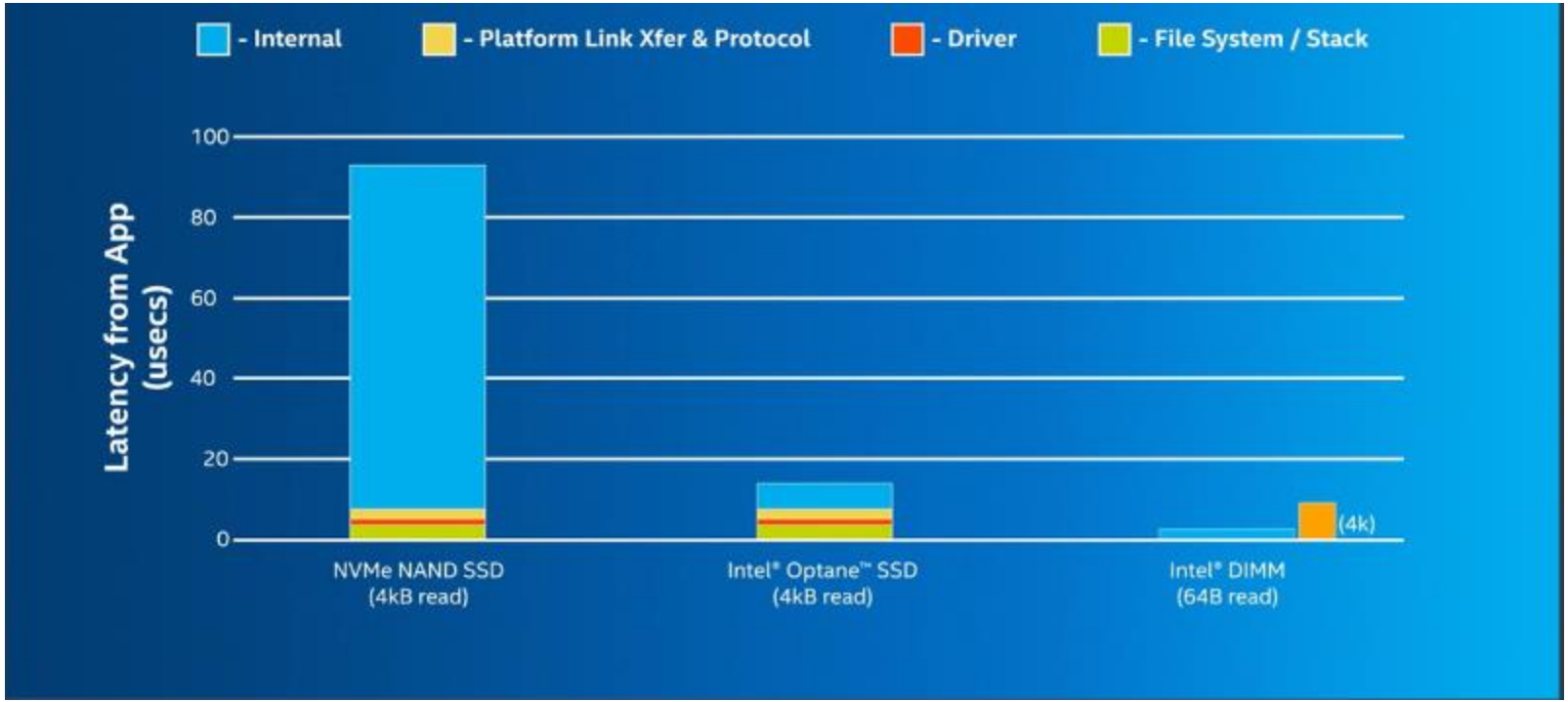
intel OPTANE™ DC PERSISTENT MEMORY

intel XEON PLATINUM inside™

Big and Affordable Memory	128, 256, 512GB
High Performance Storage	DDR4 Pin Compatible
Direct Load/Store Access	Hardware Encryption
Native Persistence	High Reliability



Intel DCPMM Application Latency



Source: https://software.intel.com/en-us/articles/introduction-to-programming-with-persistent-memory-from-intel

Kubernetes CSI plugin for Intel DCPMM

- A new CSI plugin for Intel DCPMM
  - Dynamic provisioning of node-local AEP memory in Kubernetes as block devices, as specified by Kubernetes CSI specification
- Working on this now!
  - https://github.com/intel/pmem-CSI
  - Go to Intel booth for more details

Summary & Next Steps

- Nezha is a Kubernetes Native Big Data Accelerator to improve the input data performance
- HostAlias and webhook used thus it's transparent for application
- Applies to ML/DL workloads, as well as bigdata analytics based on object storage
- Next steps
  - HTTPS/TLS support
  - Explore I/O acceleration via Sidecar container + Burst Buffer