Applied Accelerated Artificial Intelligence

DeepOps: Deep Dive into Kubernetes with deployment of various AI based Services
Session II – Kubernetes

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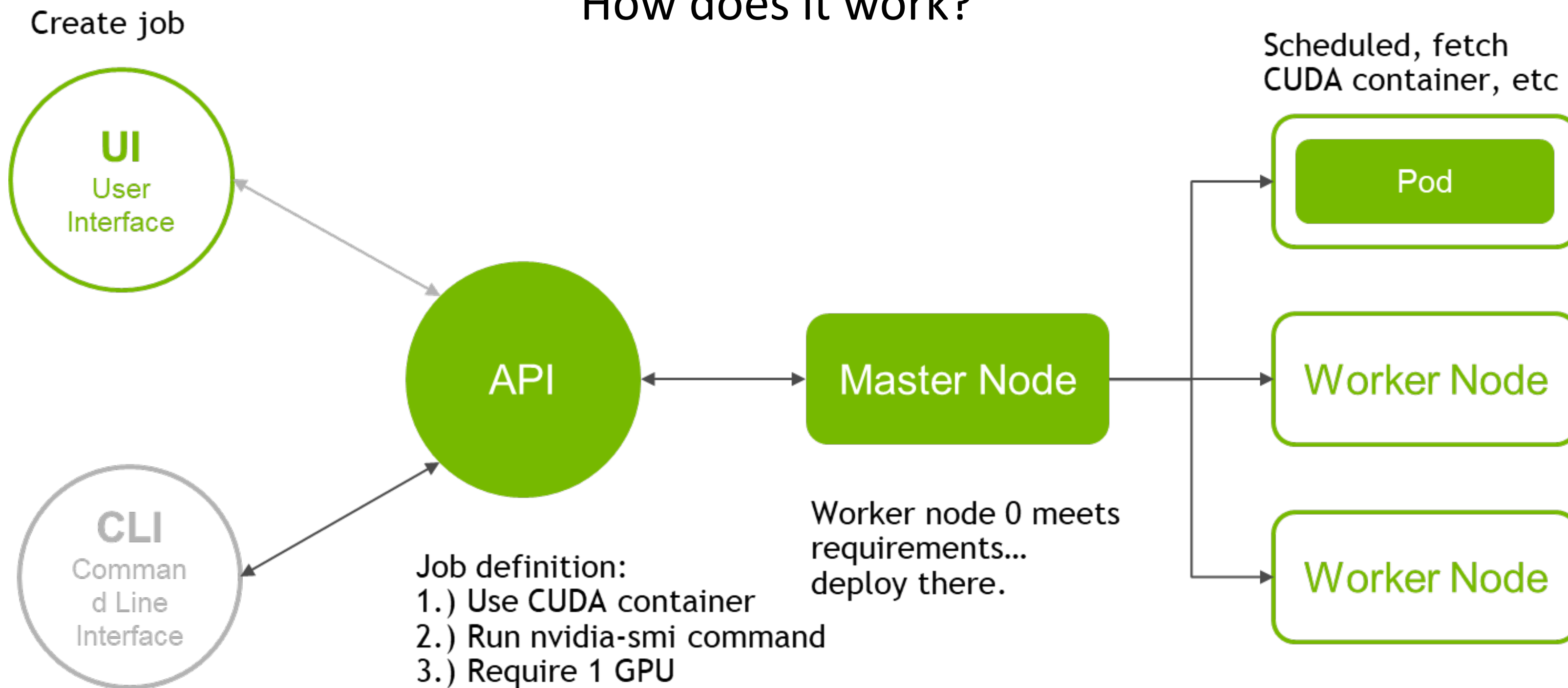
Centre for Development of Advanced Computing

Agenda

- Kubernetes and Slurm
- Devops, MLops
- Deepops
- Demo – ML Pod creation
- Demo – Dashboard

KUBERNETES

How does it work?

Create job

UI
User Interface

CLI
Command Line Interface

API

Job definition:
1.) Use CUDA container
2.) Run nvidia-smi command
3.) Require 1 GPU

Master Node

Worker node 0 meets requirements... deploy there.

Scheduled, fetch CUDA container, etc

Pod

Worker Node

Worker Node

KUBERNETES BASICS

Terms

|	
kubelet	the agent which runs on each node in the cluster and is responsible for making sure that containers are running in a pod.
kubectl	the cli for communication with a k8s cluster, deploying k8s objects, etc
manifest	k8s is configured by editing manifest files full of metadata which define a Kubernetes object - usually, these files are written in YAML, but they may also be written in JSON
node	a server in the k8s cluster
pod	the smallest atomic k8s object, represents set of running containers
job	a finite or batch task that runs to completion, launches a pod
replicas	replicated pods in the cluster, k8s will maintain this amount if failures occur
secret	k8s object to contain secrets/passwords/api keys, useful for storing the ngc api key
service	k8s object which describes how to access applications - can be used to expose a port on a running pod, define a load-balancer, etc
deployment	k8s object which encapsulates an entire application (including pod definition, service, etc)

SLURM

What is it?

- Simple Linux Utility for Resource Management

- Free and open source software

- HPC resource management and job scheduling system

- Simple to use and administer

- Used on 60% of the TOP500 supercomputers

- Highly scalable
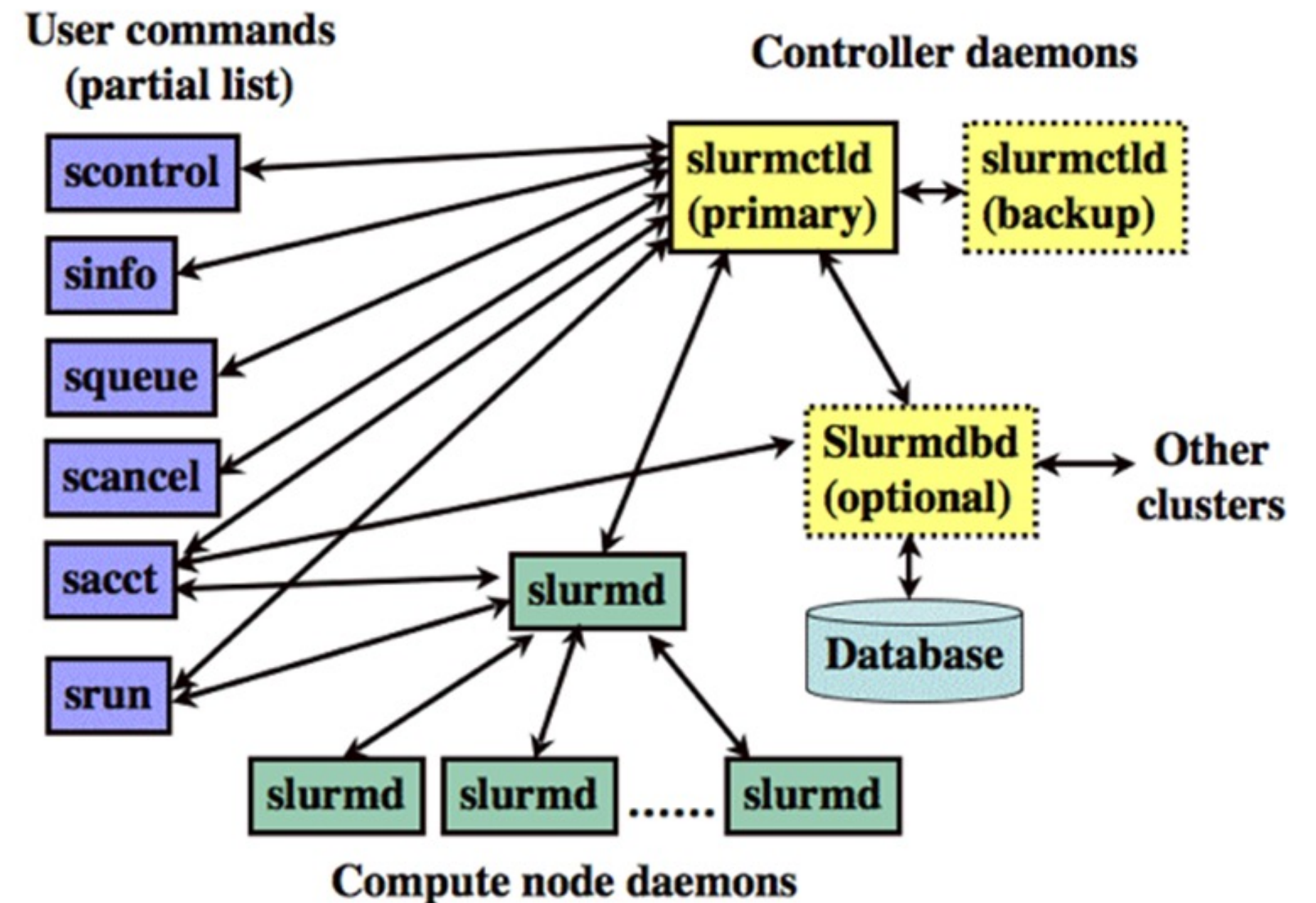
CUSTOMER NEEDS

Basic: Kubernetes

Share nodes, schedule jobs for GPUs on a node (current best solution: Excel spreadsheet)

Covers data permissions and security (LDAP, file permissions)

Adds analytics and monitoring (important also for justification of purchase)

Advanced: SLURM

Multi-node jobs

Job dependencies, workflows, DAGs

Advanced reservations

Intelligent scheduling (not just FIFO)

Other HPC-like scheduling functionality

KUBERNETES VS SLURM

Cloud vs HPC

|	
Service oriented	Batch job oriented
Containerized	Bare metal
Meant to scale	Efficiently allocates resources
Distributes load	Fine-grained user control
Keeps applications running	Maximizes system utilization

DEVOps ?

- DevOps is a set of practices that have made it possible to ship software to production in minutes and to keep it running reliably.
- DevOps relies on tools, automation and workflows to abstract away the accidental complexity and let developers focus on the actual problems that need to be solved.
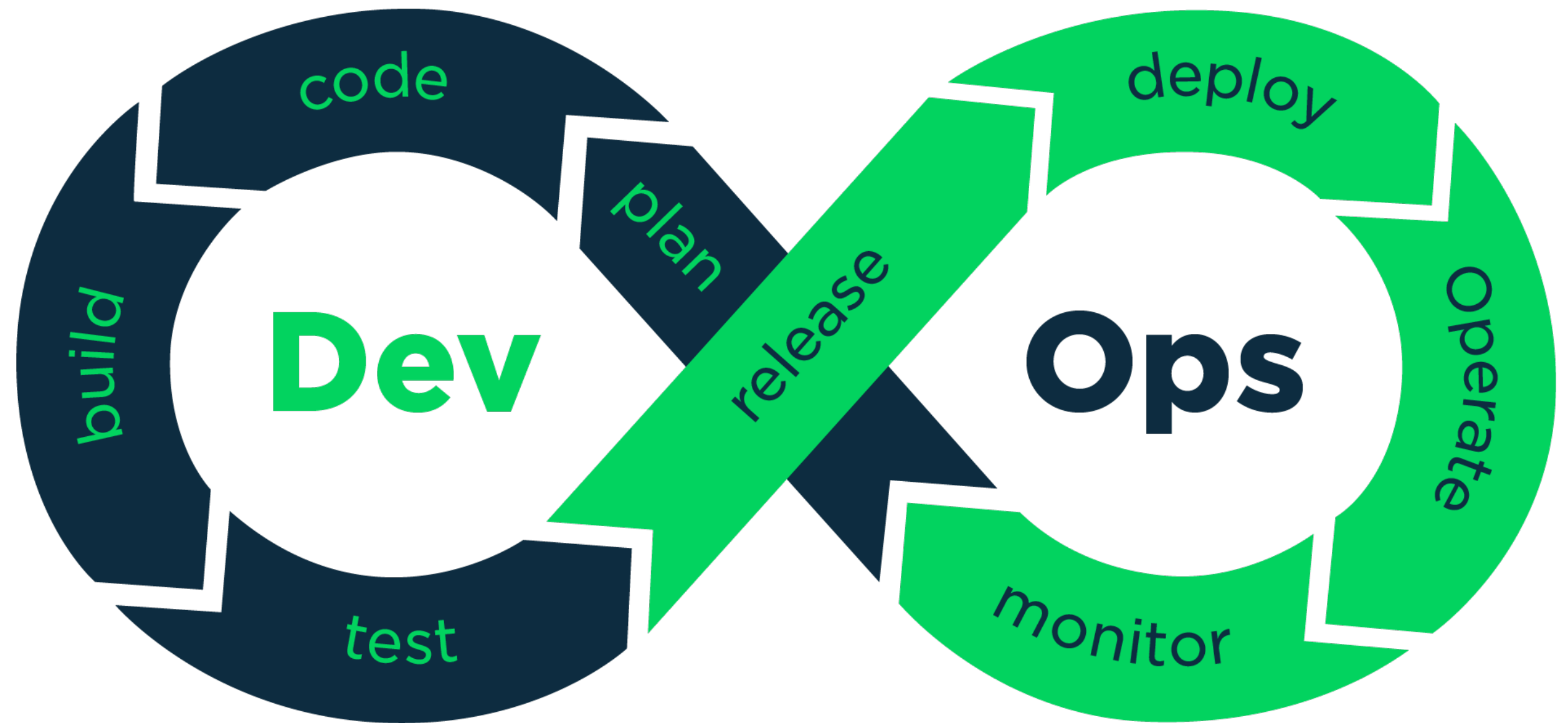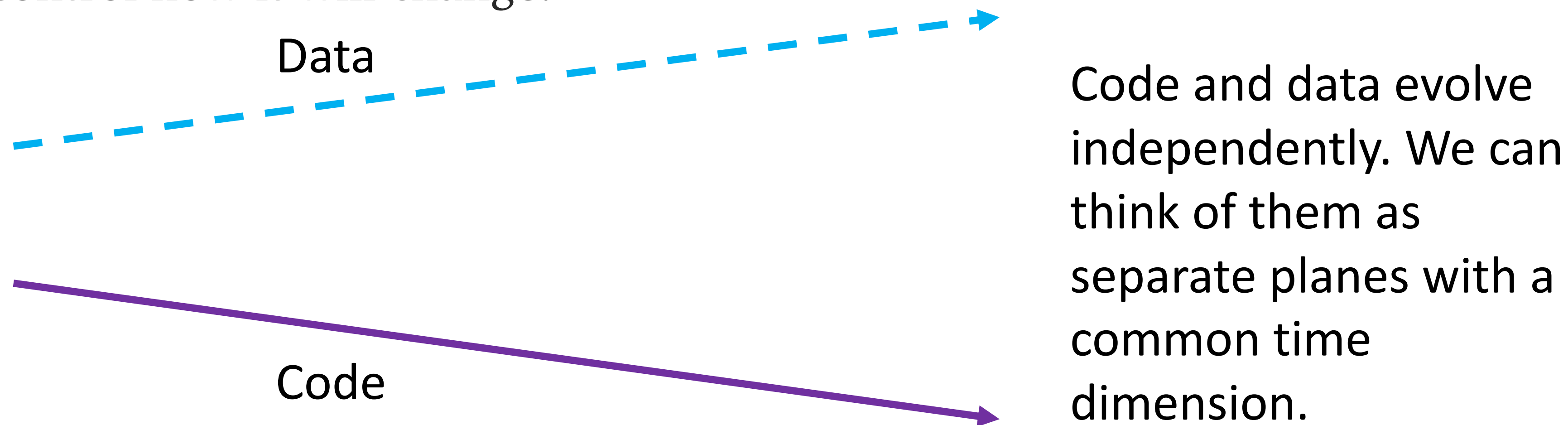
MLOps?

ML is not just code, it's code plus data.

Data → Training Process → Model
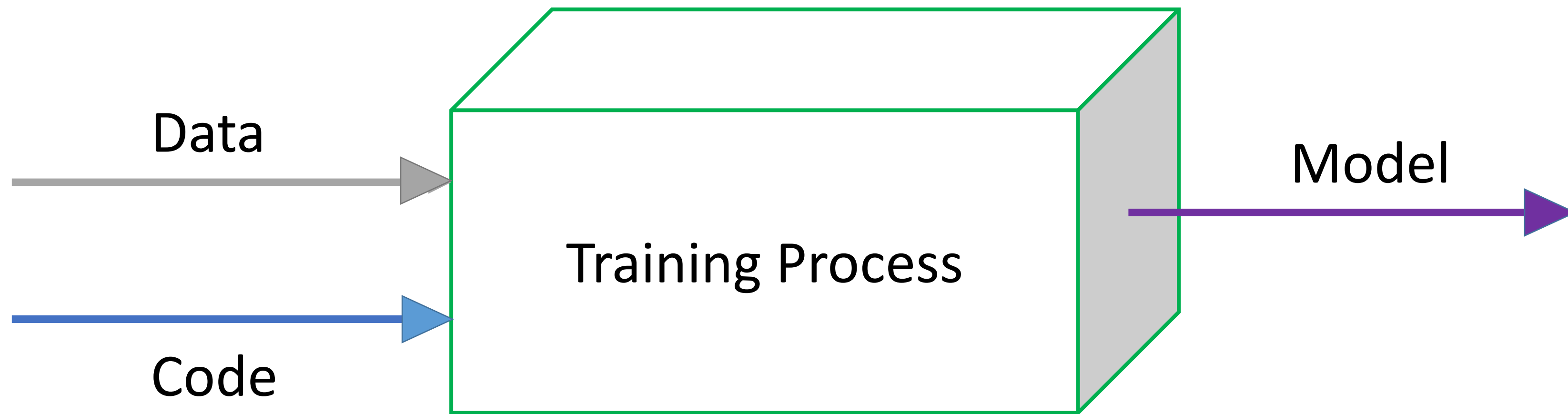
Code →

MLOps?

While code is carefully written in a restricted development environment. Data comes from the real world, It never stops changing, and you can't control how it will change.

Data

Code and data evolve independently. We can think of them as separate planes with a common time dimension.

Code

The challenge of an ML process is to create a bridge between these two planes in a controlled way.

MLOps?
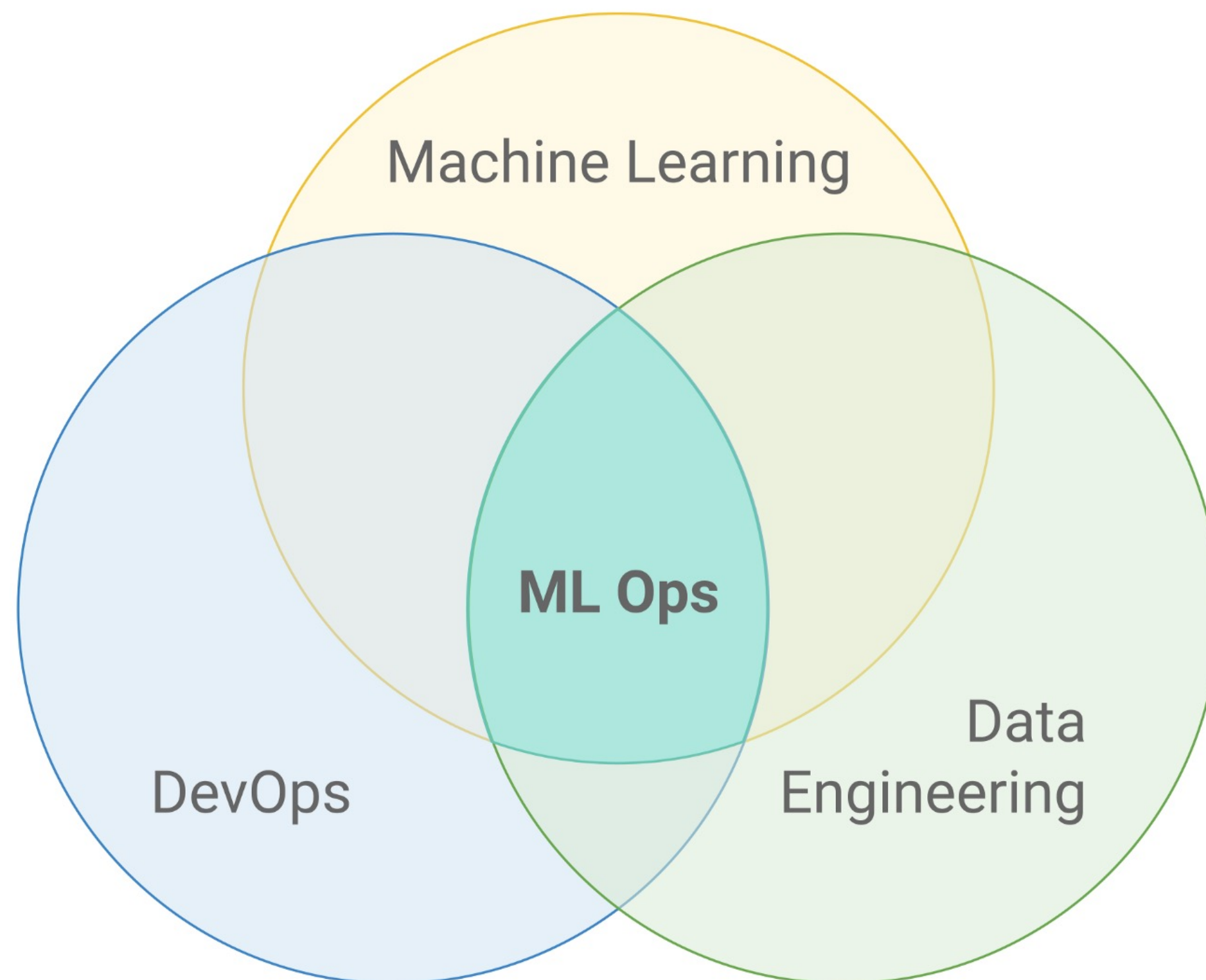
ML Ops is a set of practices that combines Machine Learning, DevOps and Data Engineering, which aims to deploy and maintain ML system in production reliably and efficiently.
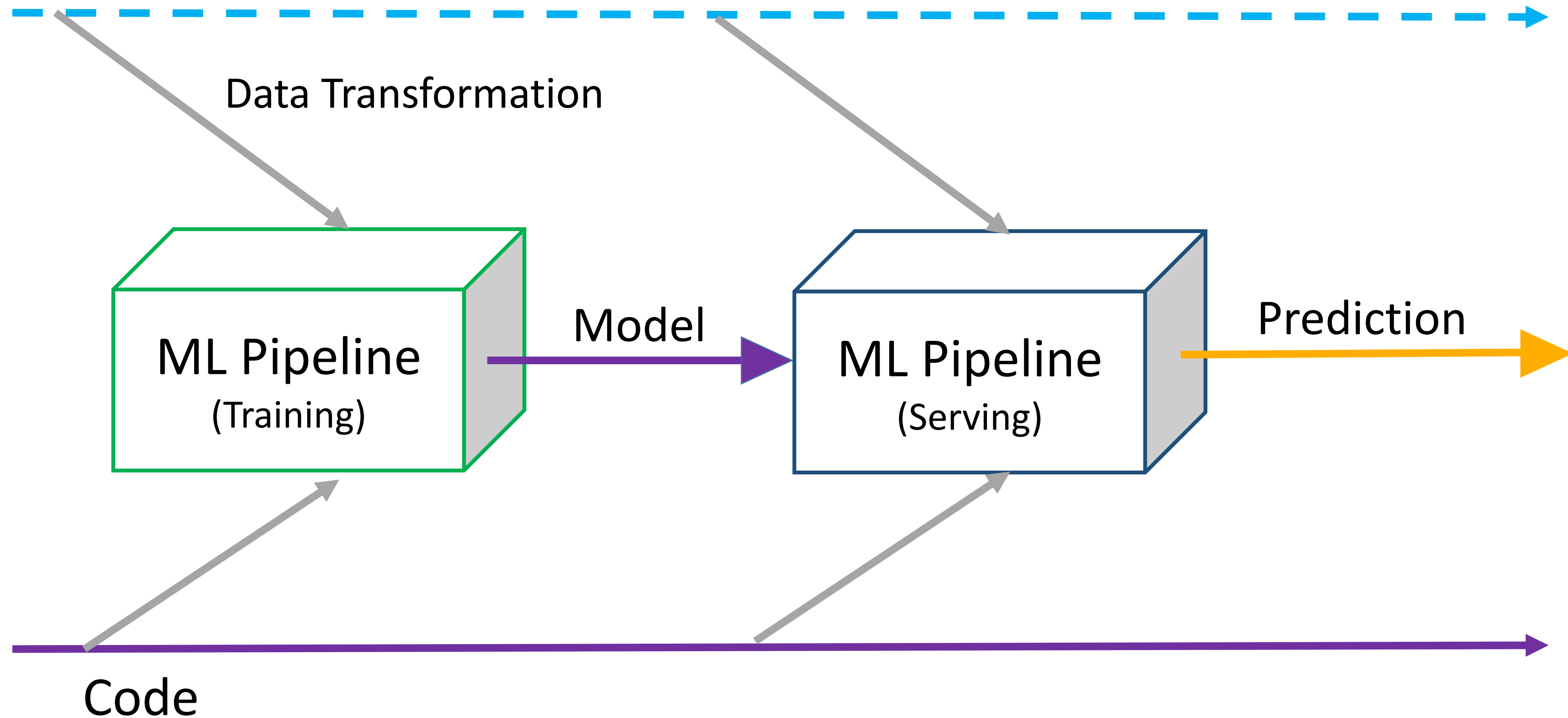
MLOps?

- A data pipeline is a series of transformations that are applied to data between its source and a destination.
- ML models always require some type of data transformation, which is usually achieved though scripts or cells in a notebook, making them hard to manage and run reliably.
- Using proper data pipelines provides many advantages in code reuse, run time visibility, management and scalability.
- ML transformation can interpreted as data transformation, It becomes natural to include specific ML steps in the data pipeline itself turning it into ML pipeline. Most versions have 2 pipeline one for traning other for serving.
- The ML Pipeline is a pure code artifact, independent from specific data instances

MLOps?

CI/CD - combined practices of continuous integration and either continuous delivery or continuous deployment.

Devops – MLOps

Practice	DevOps	Data Engineering	ML Ops
Version control	Code version control	Code version control Data lineage	Code version control + Data versioning + Model versioning (linked for reproducibility)
Pipeline	n/a	Data pipeline/ETL	Training ML Pipeline, Serving ML Pipeline
Behavior validation	Unit tests	Unit tests	Model validation
CI/CD	Deploys code to production	Deploys code to data pipeline	Deploys code to production + training ML pipeline
Data validation	n/a	Format and business validation	Statistical validation
Monitoring	SLO-based	SLO-based	SLO + differential monitoring, statistical sliced monitoring

https://towardsdatascience.com/ml-ops-machine-learning-as-an-engineering-discipline-b86ca4874a3f

DEEPOPS

DEEPOPS
What is it?

- **Opensource** project to **facilitate deployment of multi-node GPU clusters** for Deep Learning and HPC environments, in an on-premise, optionally air-gapped datacenter or in the cloud

- DeepOps is also recognized as the **DGX POD Management Software**

- The **modular** nature of the project also allows more experienced administrators to pick and choose items that may be useful, making the process compatible with their existing software or infrastructure

- GitHub: https://github.com/NVIDIA/deepops

DEEPOPS

What is it?

DGXIE

Provides PXE Server for OS installation across cluster

Firmware management

Maintain DGX firmware versions across your cluster

Job Scheduling

Kubernetes, Slurm

Monitoring

DCGM, Prometheus, Grafana

Logging

Filebeat, Elasticsearch and Kibana
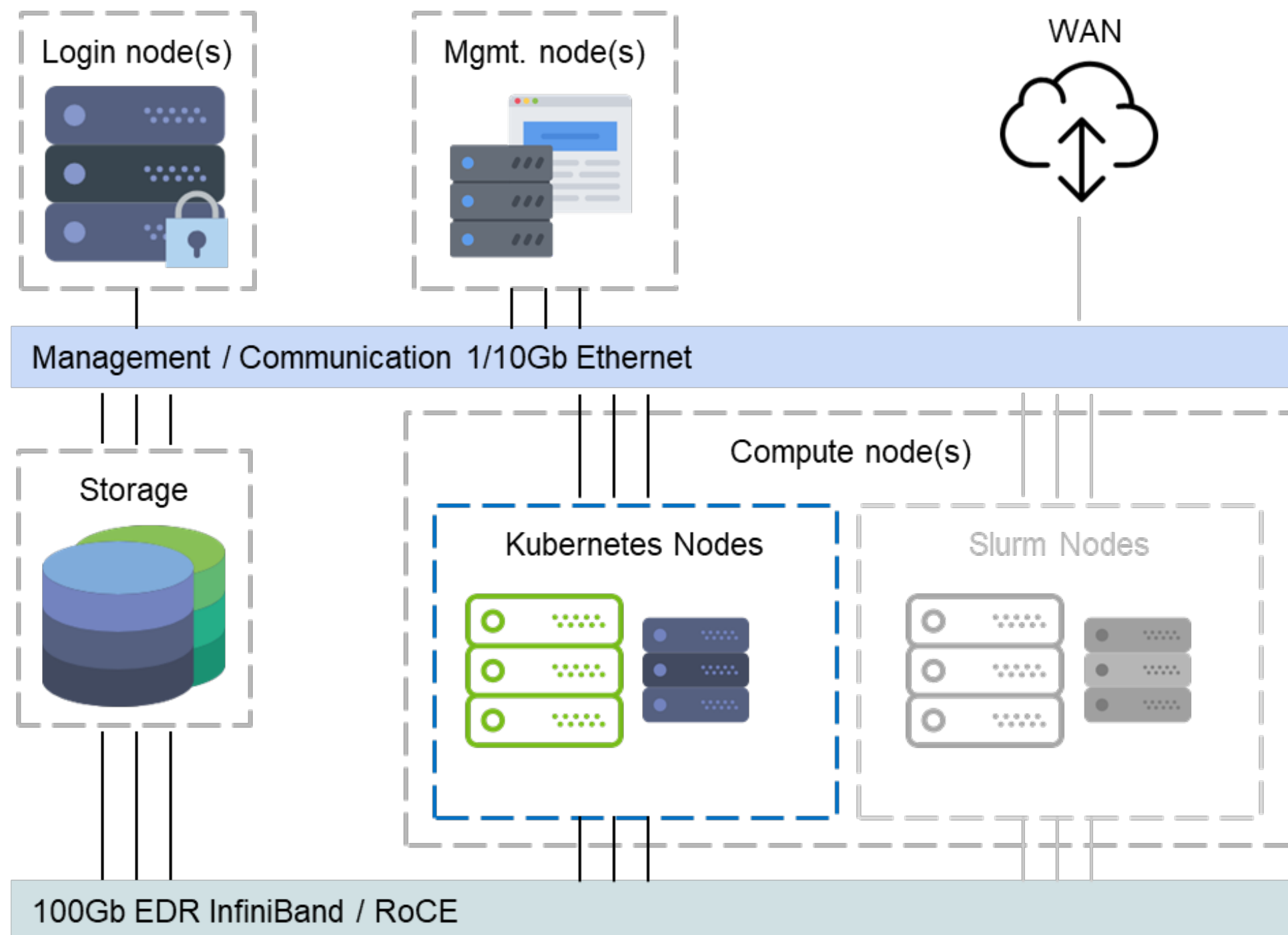
Package repository

Mirror packages for air-gapped environments

NGC Replicator

Mirror GPU containers from NGC

ARCHITECTURE

Building Multi-node GPU Clusters with DeepOps

- 1x CPU-only login node

- Odd number of CPU-only management nodes
  - required for etcd key-value store

- 1/10Gb Ethernet control & management networks
  - Management, connectivity, command & control

- Fully non-blocking fat-tree 100Gb EDR Infiniband topology
  - Use the biggest EDR IB core switch that fits

Hybrid Strategy

- Augment legacy HPC schedulers with new features
  - Cluster management services
  - Jupyter notebooks
  - Deep learning inference deployments (TensorRT)
- Keep data in the same place, no need to have separate clusters
- Free up deep learning researchers to do DL, not become devsecops/sysadmin
- Why not Slurm on Kubernetes?
  - Same reason HPC jobs may not be a good fit for Kubernetes & Containerization
    - Latency sensitive/multi-node comms/direct access to hardware
 - Slurm in containers on Kubernetes adds unneeded complexity

Hybrid Strategy - cont.

- Kubernetes manages cluster infrastructure
    - DHCP, PXE
    - Container registry/repository
    - APT repository
    - Metrics/monitoring/logging collection daemons on every node
    - Graphical interfaces for metrics
    - Alerting
    - Logging
- Kubernetes runs some workloads
    - DL inference tasks
    - Jupyter notebooks
    - Multi-GPU/Multi-node DL training with add-ons like tensorboard
- Slurm runs HPC workloads
    - Traditional non-containerized workloads
    - Containerized workloads via Singularity

Hybrid Kubernetes & Slurm Cluster

Software stack
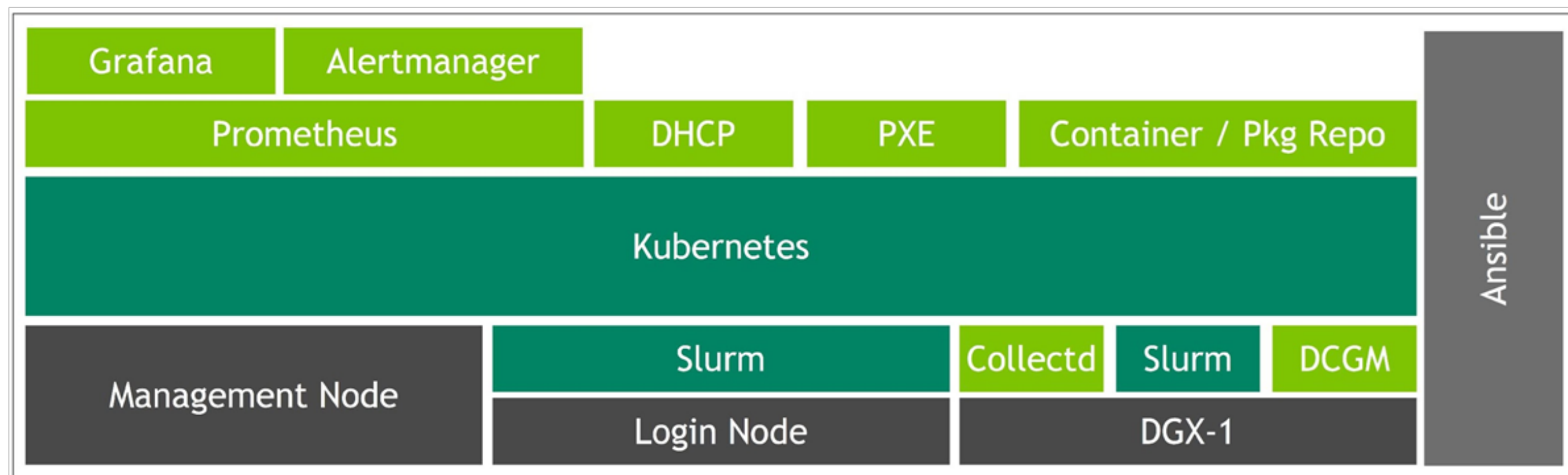
Building the cluster

Management Nodes

- OS installation & bootstrap

- Kubernetes bootstrap

- Ceph persistent storage install & integrate with kubernetes

- Cluster service container deployments

  - DHCP/DNS/PXE

  - APT and container repositories

  - Monitoring

  - Alerting

  - Logging

Building the cluster
Login Node

- OS installation via PXE & bootstrap via Ansible

- Optional: Slurm HPC scheduler install (slurmctld)

Building the cluster

Compute Node

- OS installation via PXE & bootstrap via Ansible

- Kubernetes install

- Optional: Slurm HPC scheduler install (slurmd)

Demo

Reference

- Nvidia

Thank You