Deploying a First (Stateless) Application

INTRODUCTION TO KUBERNETES

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More on "kubectl"

- `kubectl` : main command to interact with Kubernetes objects
- Objects are, e.g., `pod` , `service` , etc.

- Typical usage patterns:
  - `kubectl create -f <Manifest.yml>` : create new objects, with `-f` for "filename"
  - `kubectl apply -f <Manifest.yml>` : create new objects & change the state of objects
  - `kubectl get <object>` : overview about objects deployed on Kubernetes
  - `kubectl describe <object>` : detailed information about an object

- Detailed help available via command line option `--help`

More on Manifests

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-deployment
  labels:
    app: nginx
spec:
  replicas: 5
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - name: nginx
        image: nginx:1.25.4
        ports:
        - containerPort: 80
```

- Remember: Manifests are **declarative**
- Typically YAML, but also in JSON format
- Two important sections:
  - **metadata:** essential information about the object or resource
  - **spec:** defines the specifications, or desired state, of the object or resource
- Sections can be quite deep, depending on the resource to be deployed

Stateless Applications

- Stateless apps:
  - General concept
  - Not specific to Kubernetes
  - Do not save an internal state, or context of processed data
- When interrupted, a new replica of the stateless app is recreated and starts operating.

- Examples:
  - The database frontend querying a database backend
  - A search app querying a full text index
  - A data stream app that converts temperature readings from an IoT sensor from °F to °C

Kubernetes Deployments

- "Stateless applications" translate to "Kubernetes Deployments"
- A sample Manifest consists of:
  - `apiVersion` and `kind`
  - `metadata` and `spec`
- `spec` defines number of `replicas`, a `selector`, and a `template`
- More on `selector` later
- `template` describes details for the creation the pods in the Deployment

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: <deployment name>
  labels:
    app: <a label for the application>
spec:
  replicas: <number of initial replicas>
  selector:
    matchLabels:
      app: <matches the label above>
  template:
    metadata:
      labels:
        app: <label to be given to each pod>
    spec:
      containers:
      - name: <container name>
        image: <the image to be used>
        ports:
        - containerPort: <ports for networking>
```

Deploying to a Kubernetes Cluster

- `kubectl apply -f <manifest.yml>` for creating pods and applying changes.
- Kubernetes Control Plane will schedule the Deployment on Nodes.
  - Then, Pods created is triggered on the Nodes.
- Pods get a unique, but random (unpredictable) identifier, each Pod is "as good as any other"

Let's practice!

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Scaling and Monitoring an Application

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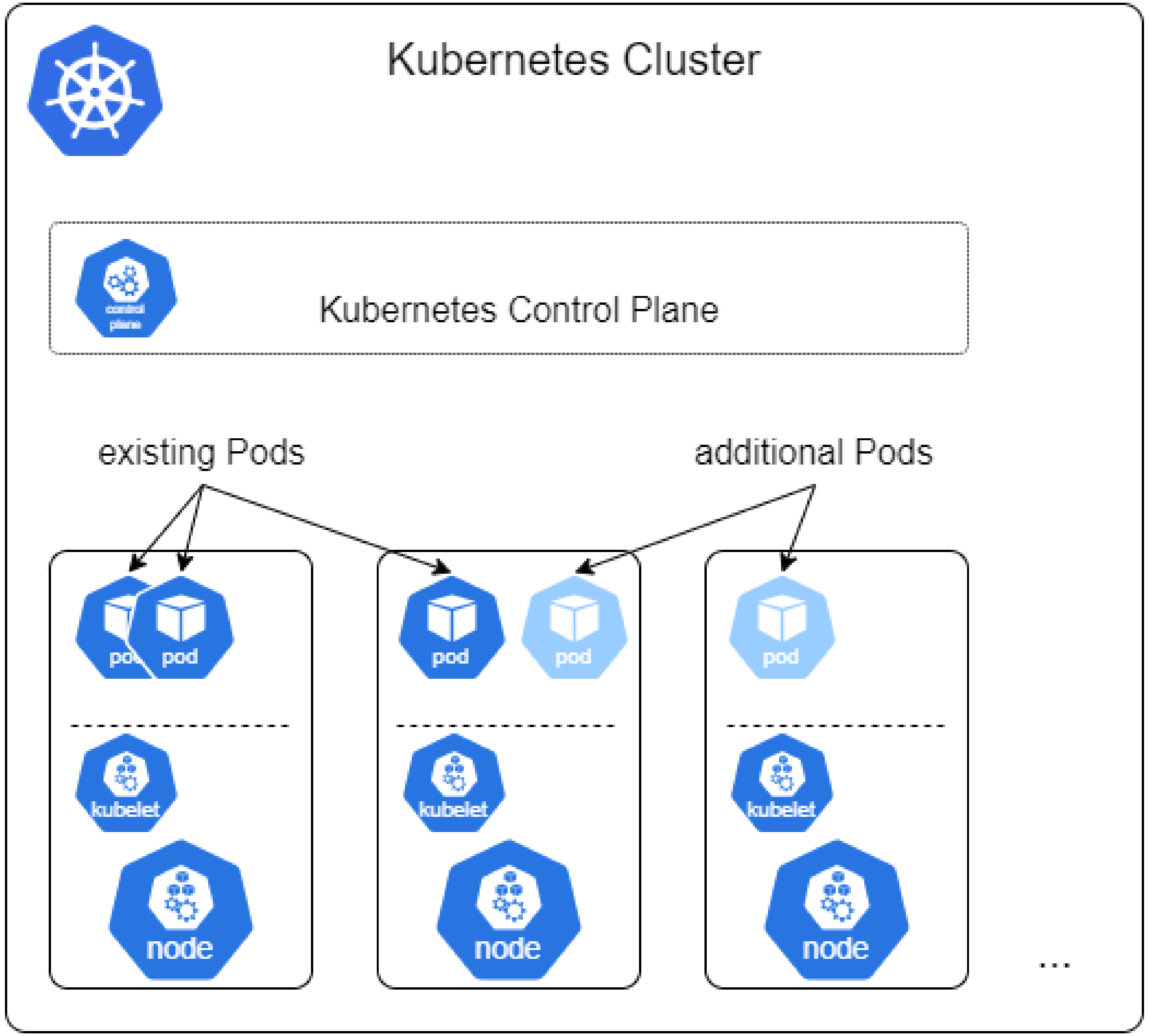
Scaling on Kubernetes



- Scaling is a technique to add (scale up) or remove (scale down) resources:
  - Scale up: react to increasing load
  - Scale down: save resources
- Scaling the number of Pods is easy:
  - Either change the number of `replicas` in the Manifest and re-apply,
  - Or use the command `kubectl scale deployment ...`
  - with `--replicas <number>`

Scalability and Cloud Nativeness

- An application needs to be designed for scalability
- Legacy applications, in particular monoliths, are typically not scalable in the way shown here
- Modern, cloud native applications are designed with the the goal to be easily scalable

Monitoring an Application

- Monitoring: observing applications in real-time
  - Enables reaction to all kind of problems
- Examples of modern monitoring application for Kubernetes:
  - Prometheus, Grafana, or `kubectl`
- Here, we use `kubectl` for basic monitoring tasks

- Typical command: `kubectl get <object to be monitored>`
- **Example 1:** `kubectl get pods` returns all pods
- **Example 2:** `kubectl get services` returns all services

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Deploying, Scaling, and Monitoring a Stateful Application

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Recap Stateless Applications

- Short recap: stateless applications map to "Deployments" in Kubernetes
- Used when each Pod of the applications has exactly the same tasks
- Stateful applications need Pods that belong together in set, but may work on different tasks and different data
- Much of what we have learned about Deployments can be applied to StatefulSets as well

Stateful Applications

- Stateful apps:
  - general concept
  - fit well to Kubernetes
  - save some state
- When interrupted or stopped, a new replica (Pod) can read the saved state and continue operating from this state

- Example:
  - A database backend (e.g. PostgreSQL) delivers data to a frontend using 3 Pods.
  - Each time we update data using any of the Pods, that data needs to be persisted
  - When a Pod terminates, a new one is created and needs to pick up the saved state

Kubernetes StatefulSets

- Stateful applications translate to "Kubernetes StatefulSets"
- A sample manifest consists of the same sections like:
  - `apiVersion` , `kind` , `metadata` , `spec` , `template`
- `replicas` defines the number of Pods in the `StatefulSet`
- More on `selector` later

```
apiVersion: apps/v1
kind: StatefulSet
metadata:
  name: <deployment name>
  labels:
    app: <a label for the application>
spec:
  replicas: <number of initial replicas>
  selector:
    matchLabels:
      app: <matches the label above>
  template:
    metadata:
      labels:
        app: <label to be given to each pod>
    spec:
      containers:
      - name: <container name>
        image: <the image to be used>
        ports:
        - containerPort: <ports for networking>
```

Deploying to a Kubernetes Cluster

- `StatefulSet` is deployed similar to `Deployments` : `kubectl apply -f <manifest.yml>`
- Once deployed, a `StatefulSet` is created different than a `Deployment` :
  - Pods are created one after the other, not all at once like Pods in a Deployment
  - Pods get predictable names like `pod-0` , `pod-1` , `pod-2` . etc.
- This means: in contrast to the Pods of a Deployment, the Pods of a StatefulSet have an identity, and a state
- Hence, different Pods of a `StatefulSet` with different identity can perform different roles in an application

Scaling A StatefulSet

- Like Deployments, StatefulSets can be scaled up or scaled down:
  - Either change the number of `replicas` in the Manifest and re-apply,
  - Or use the command `kubectl scale statefulsets ...`
- When scaling up, new Pods will be created one after another:
  - e.g, `pod-0` , `pod-1` , `pod-2` first `pod-3` , then `pod-4` will be added
- When scaling down, Pods created last will be deleted first:
  - e.g, first `pod-4` , then `pod-3`

Monitoring a StatefulSet

- Like in the case of Deployments, Monitoring enables reactions to all kind of problems, like outages, load spikes, or missing storage
- Here, we use `kubectl` for basic monitoring tasks
- Typical command: same like with Deployments
- **Example 1:** `kubectl get pods` returns all pods in a StatefulSet with their current status
- **Example 2:** `kubectl get services` returns all services that a StatefulSet may use

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Deploying, Scaling, and Monitoring Kubernetes Storage

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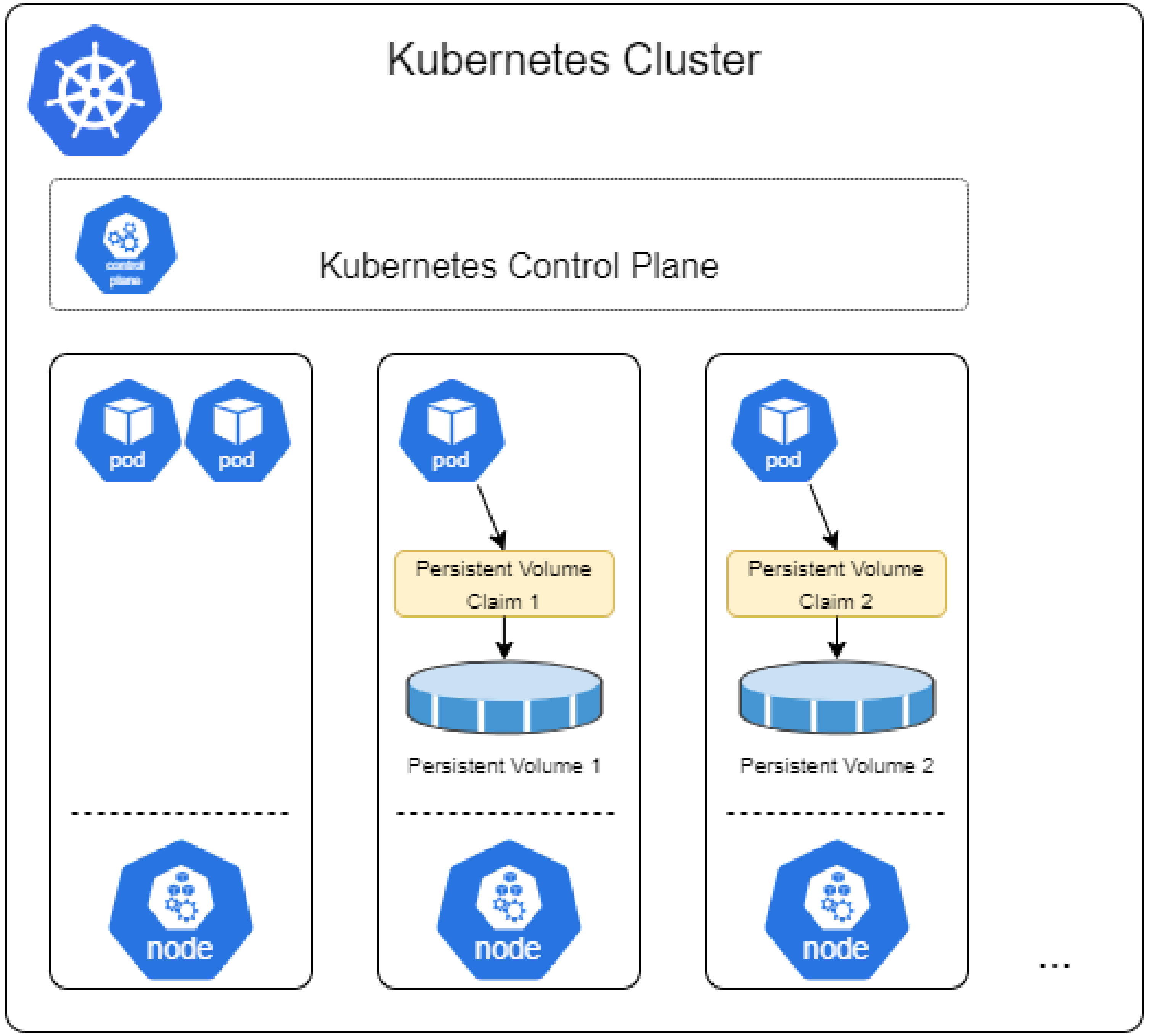
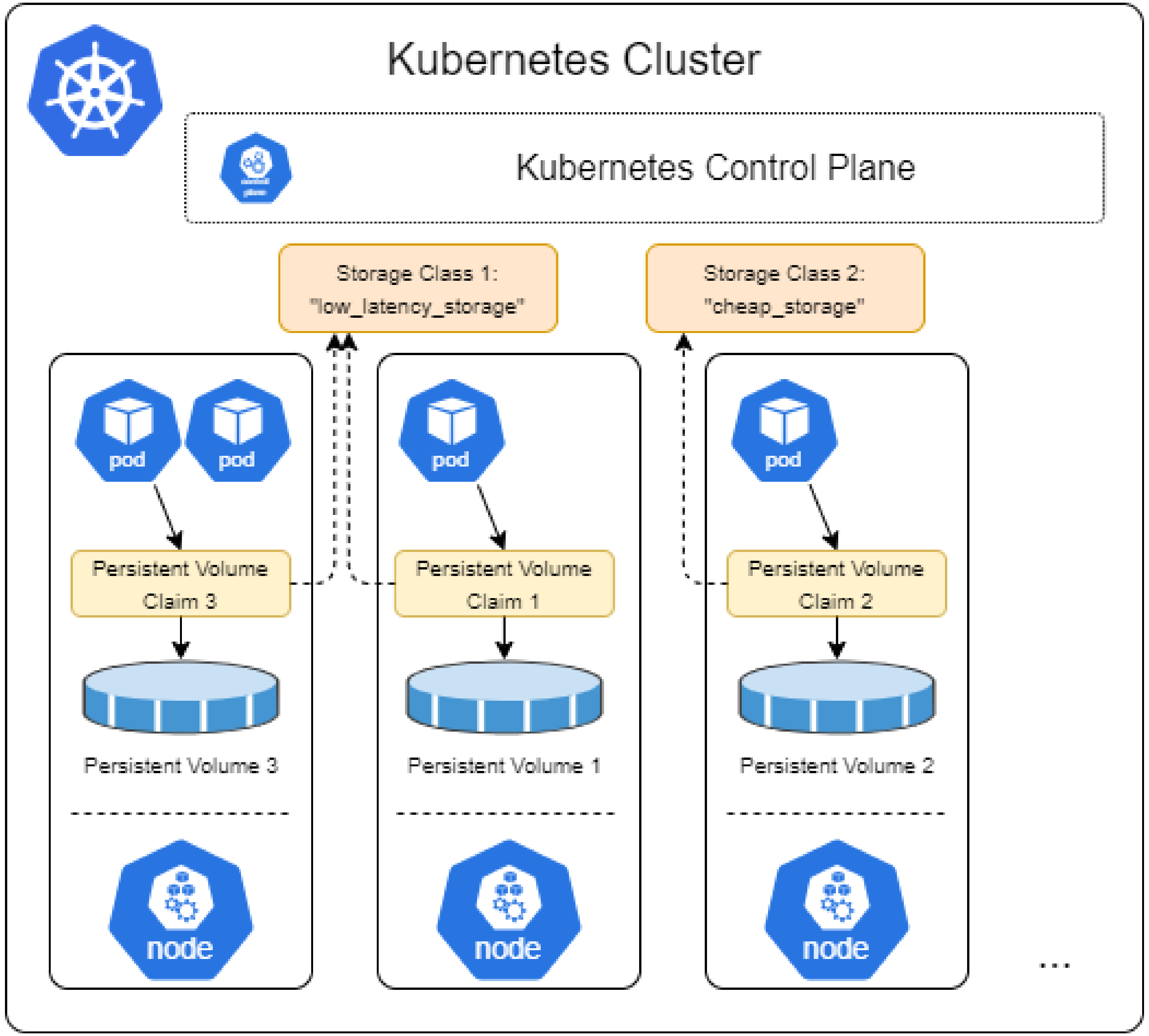
Persistent Volumes and Persistent Volume Claims



- Fundamental Objects for storage: **Persistent Volumes (PV)**, maintained in parallel to Pods
- PVs are mapped to Pods using **Persistent Volume Claims (PVC)**
- A mapped PV allows data persistence when the Pod is stopped, killed, or restarted
- PVs enable the separation of storage and compute

Storage Classes



- PVs: provisioned either
  - manually by an Kubernetes admin
  - dynamically by regular user
- Dynamic provisioning happens via **Storage Classes (SC)** without human intervention
- **Storage Classes (SC):**
  - defined by Kubernetes admin
  - different types (different latency, e.g., SDD vs HDD, different backup strategies)
- If in doubt, use Storage Classes ;-)

Putting it all together

- There are are only three objects that make storage work:
  - `PersistentVolume`
  - `PersistentVolumeClaim`
  - `StorageClass`
- A Pod with demand for persisted data uses a `PersistentVolumeClaim`
- This PVC has Kubernetes create a `PersistentVolume` for the Pod
- This `PersistentVolume` is mapped to the claiming Pod
- A named `StorageClass` is used, which defines details like latency and backup strategy of the PV
- This `PersistentVolume` survives (together with stored data), even when the `Pod` is terminated

Manifest Snippets

Pod with PersistentVolume

```
apiVersion: v1
kind: Pod
...
spec:
  containers:
  ...
    volumeMounts:
    - name: pv-mydata
      mountPath: /mydata
  volumes:
  - name: pv-mydata
    persistentVolumeClaim:
      claimName: datacamp-pvc
```

PersistentVolumeClaim with StorageClass

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: datacamp-pvc
spec:
  storageClassName: "standard"
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 5Gi
```

"kubectl" Commands For Storage

- `kubectl` offers a complete set of commands to create and monitor Kubernetes Storage
- Examples:
  - `kubectl get sc` lists all available Storage Classes
  - `kubectl get pvc` lists all deployed Persistent Volume Claimes
  - `kubectl get pv` lists all deployed Persistent Volumes
  - As usual, `kubectl apply -f <manifest>` can be used to deploy storage resources that are declared in Manifests.

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