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Introduction to Kubernetes I: Basic Concepts

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What is Kubernetes (K8s) ?

kubernetes

- Container orchestration framework
- Open sourced by Google in 2014: Managed by CNCF
    - Based on a Google internal framework called Borg
- The de-facto standard container orchestration framework
    - Adopted by most cloud providers: GCP (GKE), AWS (EKS), Azure (AKS),...
- Other competing frameworks got pushed out:
    - Apache Mesos -> mainly for deploying infrastructure
    - Docker swarm -> nowadays irrelevant

Kubernetes - Infrastructure

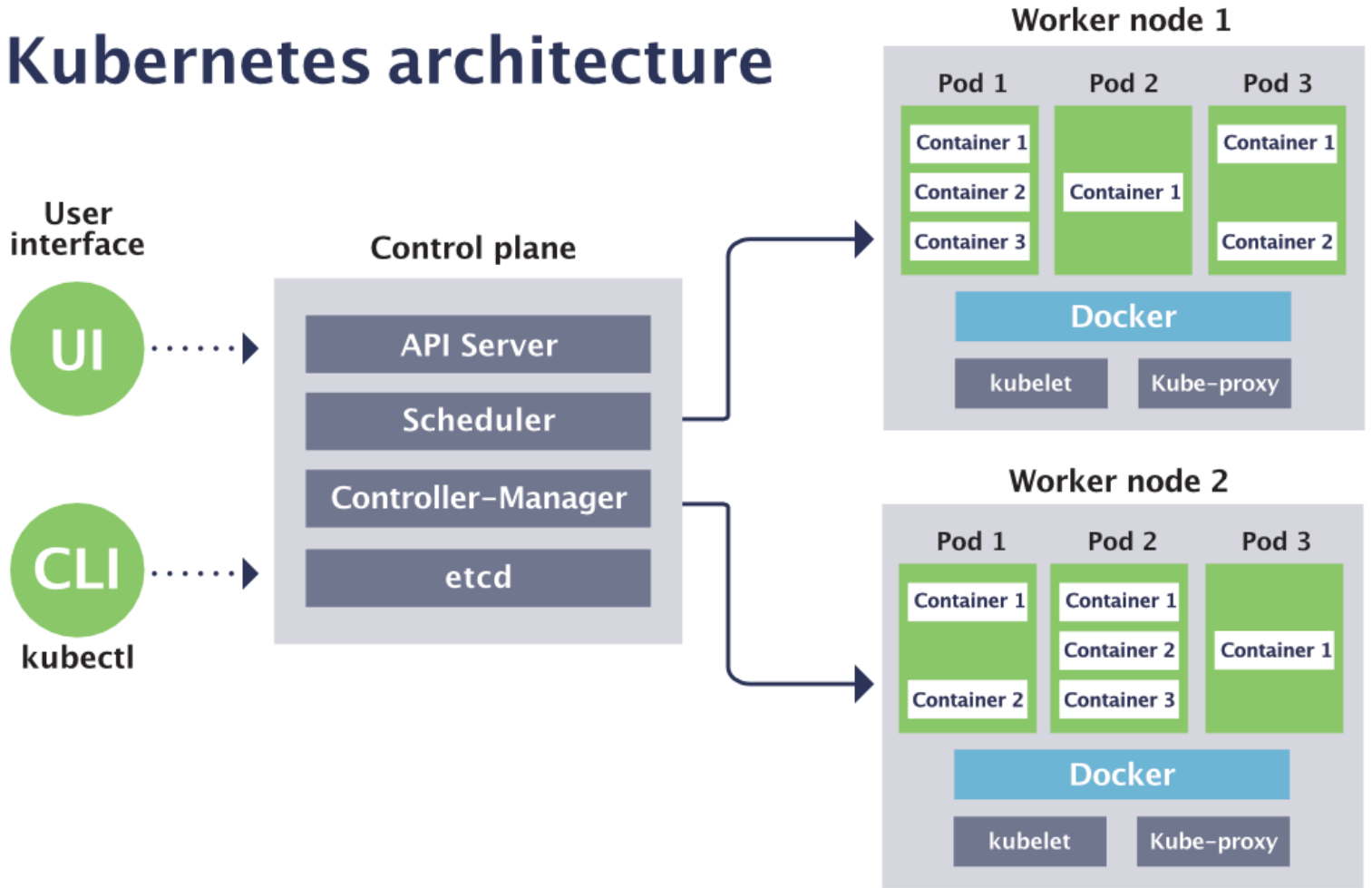


Figure 1: Basic overview of the infrastructure layout of Kubernetes Source: https://sensu.io/blog/how-kubernetes-works

Kubernetes - Resources

- Everything in Kubernetes is a resource
- Resources are managed by dedicated controllers
- You can extend K8s with own resources and controllers (CRDs)

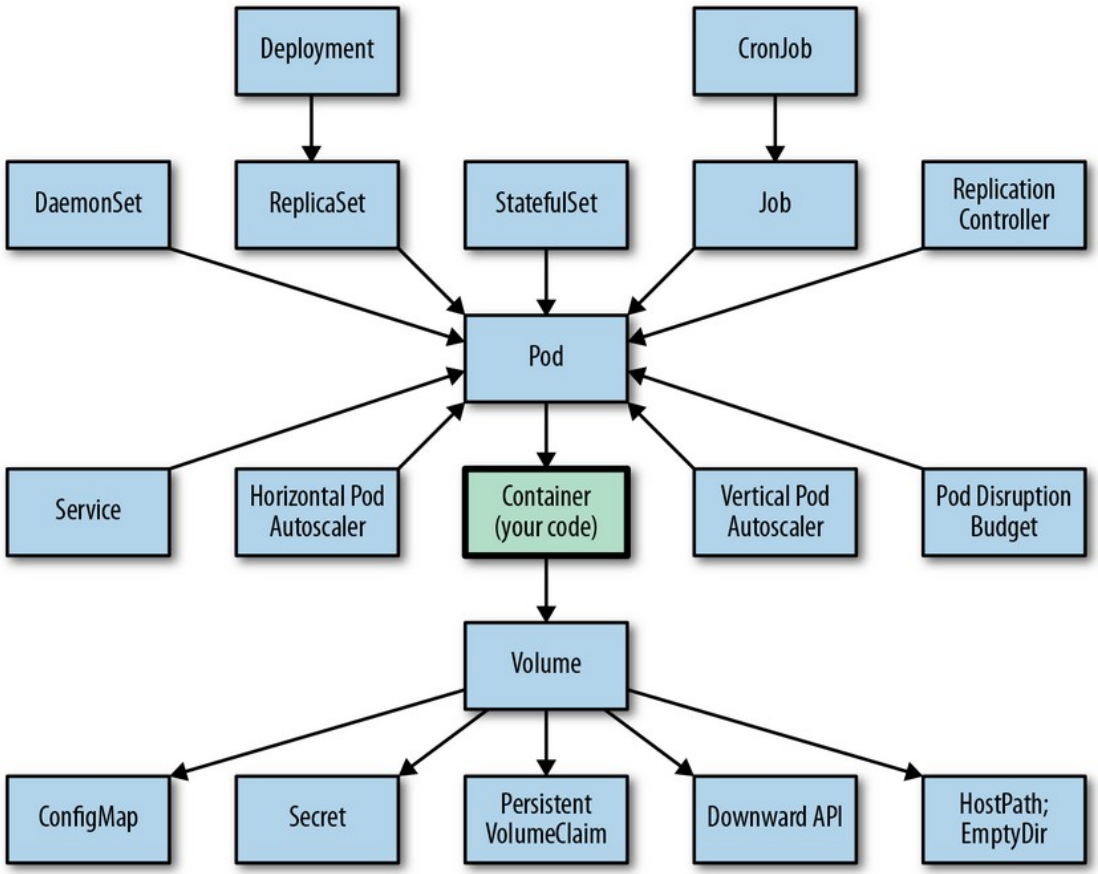


Figure 2: Basic overview of resources that interact with the pod resource: https://dev4devs.com/2019/10/20/what-are-the-kubernetes-resources-which-are-most-useful-for-developers/

Kubernetes – Core Concepts I

- **Infrastructure**
  - ControlPlane-Worker (ControlPlane – Node) architecture
    - ControlPlane runs API, etcd, Scheduler, …
    - Nodes run kubelet, kube-proxy, …
- **Deployment units**
  - Pod
    - Basic deployment unit
    - Runs 1..n container
  - Replica set
    - Creates 0..n replicas of Pods
  - Deployment
    - Manages replica sets
    - Helps with upgrading (rolling updates/rollbacks)
  - Stateful set
    - Pods that stay on a node and retain ”state” -> Databases
  - Jobs & Cronjobs
    - Pods that run to ”completion” -> Workflows
  - …

Kubernetes - Concepts II

- **Networking**
  - Flat overlay network
    - By default: Every pod can see every other pod
  - Each pod has an individual (non-public) IP
- **High-level organization**
  - Service: pods can be grouped by a single name -> (internal) DNS
  - Ingress: Routes external traffic
    - Multiple implementation, in our case: nginx ingress
- **Scheduling**
  - Fully automated based on resource requests
  - Resources:
    - CPU -> 0.5 CPU is a valid resource requests/quota
    - RAM
    - Storage -> Can separate various storage classes
    - GPUs

Kubernetes - Concepts III

- RBAC for tenancy and authorization
- Namespaces can be used to support tenancy
- Most resources created by users are bound to a namespace
  - Some (especially internal) resources are not bound to a namespace
- Namespaces do not handle multi-tenancy well
  - Addons and distros can add additional capabilities
- Containers (Docker) also have drawbacks for hard multi-tenancy
  - Docker got mostly replaced by plain containerd

Kubernetes - API

- **RESTful API**
  - Uses standard HTTP verbs to define actions (POST, DELETE, UPDATE, …)
- **Verbs applied to resource types (pod, deployments, …)**
  - Resource types are represented as “kind”
  - kinds are strictly versioned (mostly semantic versioning)
- **Kubectl: CLI**
  - Verbs are slightly different (create, get, describe, delete, …)
  - Similar syntax -> kubectl verb resource [options]
  - Example:
    - kubectl get pods -n namespace
  - Create command often used along with YAML files
    - YAML file contain declarative resource configurations

Excursus - YAML

YAML Ain't Markup Language is a human-readable data-serialization language and super-set of JSON.

- Indentation matters (similar to Python)
- You can separate resources with three dashes - - -
- Hierarchical structure, - indicates lists.

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: hello
spec:
  template:
    # This is the pod template
    spec:
      containers:
      - name: hello
        image: busybox
        command: ['sh', '-c', 'echo "Hello, Kubernetes!" && sleep 3600']
      restartPolicy: OnFailure
    # The pod template ends here
```

Figure 3: Basic overview of a Pod YAML. Source: https://kubernetes.io/docs/concepts/workloads/pods/

Pods

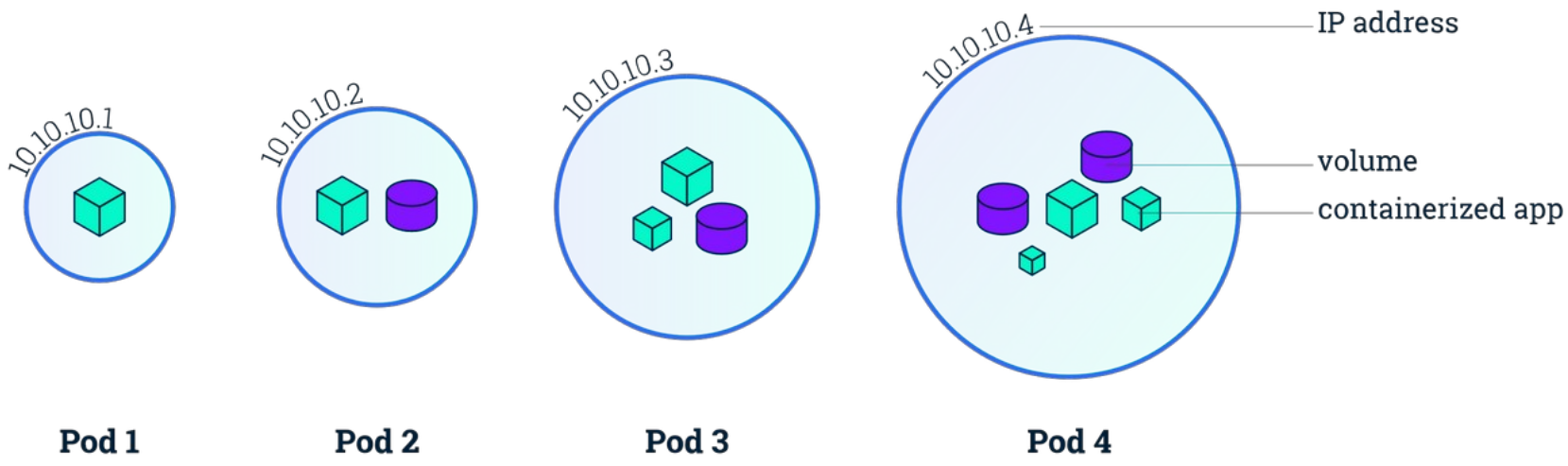


Figure 4: Basic overview of a Job. Source: https://kubernetes.io/docs/tutorials/kubernetes-basics/explore/explore-intro/

Additional features for pods:

- Liveness probes
- Init containers
- Lifecycle: Pending, Running, Succeeded, Failed, Unknown

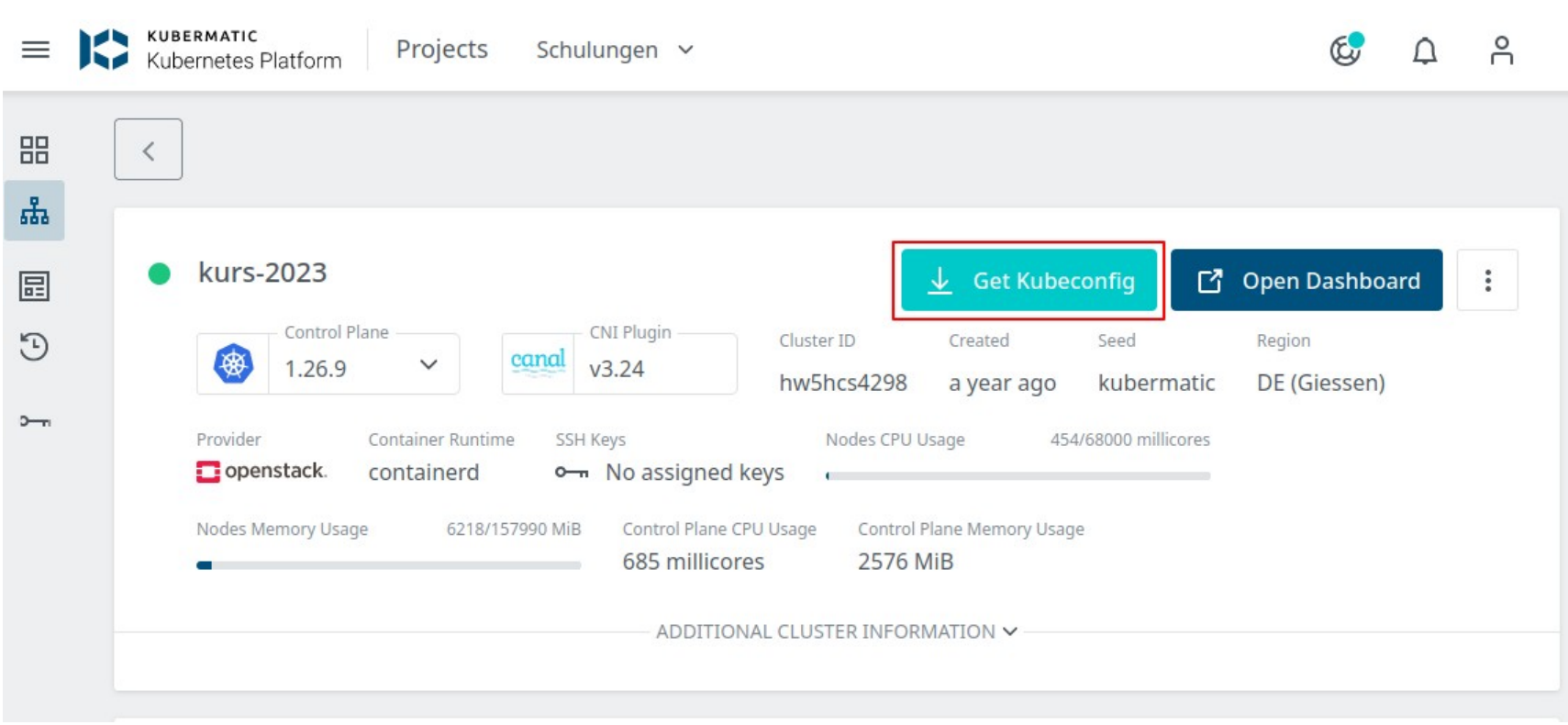
Jobs and Cronjobs

Jobs are pods that run to completion until the status is either *succeeded* or *failed*. **CronJobs** are jobs that run in a periodic interval.

```yaml
apiVersion: batch/v1
kind: CronJob
metadata:
  name: hello
spec:
  schedule: "*/1 * * * *"
  jobTemplate:
    spec:
      template:
        spec:
          containers:
          - name: hello
            image: busybox
            imagePullPolicy: IfNotPresent
            command:
            - /bin/sh
            - -c
            - date; echo Hello from the Kubernetes cluster
          restartPolicy: OnFailure
```

Figure 5: Basic overview of a CronJob. Source: https://kubernetes.io/docs/concepts/workloads/controllers/cron-jobs/

Excursus - Kubermatic WebUI



- Kubermatic is one of many Kubernetes distributions
  - Easier cluster deployment
  - Web GUI for Users and Admins
  - Openstack integration to automatically provision clusters
- For now we use it to get the kubectl config
- https://www.k8s.gi.denbi.de

Questions?