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Microservices

Container - Kubernetes (K8s)

Content

- Challenges in distributed container platforms
- Container orchestration platforms
- Kubernetes

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Container orchestration platforms

Why clustering & orchestration platforms?

- High availability
- Scalability
- "Scale out" instead of "scale up"
- Simplify the maintenance of cluster nodes (updating, replacement, hardware maintenance,...)

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Challenges in distributed container platforms

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Persistence

Persistence - challenges

How to store the data?

- NFS
- vSphere volumes
- SAN storages (EMC, HPE 3PAR,…)
- Cloud storages…

Persistence - tasks

Choose one or multiple persistence drivers that are available for Docker and K8s:

- Azure File and Disk
- AWS EBS
- GCE PD
- Glusterfs
- Ceph RBD
- vSphere

Persistence - conclusion

- The choice of a persistence driver depends on the environment (on premise vs. cloud)
- Which level of latency is required (SSD vs. HDD storage)
- Which kind of access is required? (Exclusiv vs. shared access of volumes)
- Is there already storage infrastructure available?
- What kind of deployment is planned? (Development, staging, production)

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Networking

Networking - challenges

- Load balancing
- Service publishing (especially from outside the cluster)
- Service discovery (cross service calls)

Networking - tasks

- Application publishing - how to route traffic to container running within a cluster system
- Cross container communication - how to access a container running on a different node transparently
- How to isolate applications within the cluster system - how to run multiple environments (e.g. staging and production) side-by-side
- Service Discovery - how to access other services without knowing their IP addresses (and probably the port used by the container)

Configuration and secrets

Configuration and secrets - tasks

- Central management of configuration elements
- Mounting configuration elements into container instances (via file system mounts or environment variables)
- Sharing of configuration elements across nodes and container instances
- Storing secret variables e.g. AWS credentials, certificates,...

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Scaling

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Scaling - challenges

- When to scale up and down?
- When to consider the new instance for new requests?
- How to avoid service interruptions by scaling down while an instance is still processing a request?
- How to automatically reconfigure load balancers?

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Hardware access

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Hardware access - challenges

- How to enable containers to access hardware devices e.g. GPUs
- How to ensure that container is scheduled on a node where the expected device is available
- How to manage drivers so that the driver used within the container equals the one of the host system (if not provided by the kernel)

Hardware access - solutions

- Device plugins API to abstract hardware access of containers
- Device plugins for GPUs:
  - NVIDIA/k8s-device-plugin
  - intel/intel-device-plugins-for-kubernetes
  - RadeonOpenCompute/k8s-device-plugin
- Some of them (like the Nvidia GPU plugin) are also available for Docker (nvidia-docker) to enable local debugging

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Kubernetes

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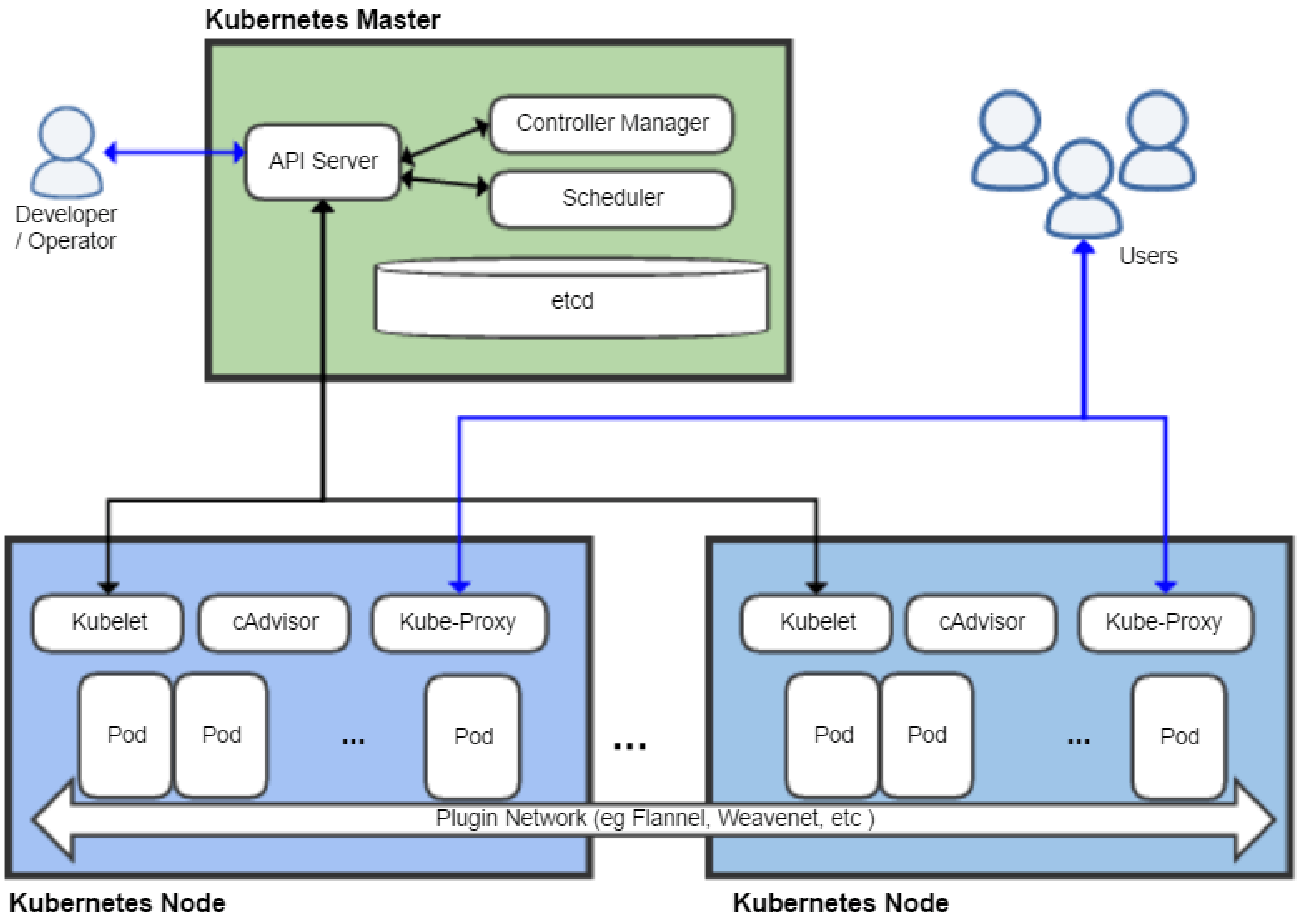
Kubernetes architecture


Kubernetes Master
Developer / Operator
API Server
Controller Manager
Scheduler
etcd
Users
Kubelet
cAdvisor
Kube-Proxy
Pod
Pod
...
Pod
...
Kubelet
cAdvisor
Kube-Proxy
Pod
Pod
...
Pod
Plugin Network (eg Flannel, Weavenet, etc)
Kubernetes Node
Kubernetes Node

Kubernetes basic elements

- Pods
- Deployments
- Services
- Ingresses
- Jobs
- ConfigMaps
- Secrets
- HPA
- PDB
- ...

Kubernetes basic elements - Pods

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: nginx
spec:
  containers:
  - name: nginx
    image: nginx:1.7.9
    ports:
    - containerPort: 80
```

Kubernetes basic elements - Pods

- Pods are the most atomic element in Kubernetes
- A Pod might contain multiple containers
- A Pod is always scheduled on a single worker/minion
- Containers within a Pod can access each other by calling `localhost` or `127.0.0.1`
- Because all containers of a Pod are scheduled on a single node local volume mounts are available for all containers

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Kubernetes basic elements - Deployments

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-deployment
  labels:
    app: MyApp
spec:
  replicas: 3
  selector:
    matchLabels:
      app: MyApp
  template:
    metadata:
      labels:
        app: MyApp
```

Kubernetes basic elements - Deployments

- Deployments are a high level approach to deploy containerized applications to a Kubernetes cluster
- A deployment triggers always the creation of a `ReplicationController`
- The corresponding `ReplicationController` takes care of the Pod creation for the Deployment
- Because a Deployment 'includes' a `ReplicationController` it is possible to set the number of `replicas` created when the Deployment is created (defaults to 1)
- The `spec` element of a Deployment contains the `template` used to create new Pods (including metadata,...)

Kubernetes basic elements - Services

```yaml
kind: Service
apiVersion: v1
metadata:
  name: my-service
spec:
  selector:
    app: MyApp
  ports:
  - protocol: TCP
    port: 8080
    targetPort: 80
```

Kubernetes basic elements - Services

- Every service has a DNS A record within a Kubernetes cluster - default is `<service-name>.<namespace-name>.svc.cluster.local` (and a SRV record but more on that later)
- Services are the Kubernetes native way of load balancing
- Services normally have a `selector` spec to determine which pods should be used to redirect the traffic to (based on the labels of a pod)
- Available types of a Service:
  - ClusterIP (default)
  - NodePort
  - LoadBalancer
  - ExternalName
- By using the type `ExternalName` it's possible to use the Kubernetes DNS to route traffic to external services

Kubernetes basic elements - Ingresses

```
apiVersion: extensions/v1beta1
kind: Ingress
metadata:
  name: test-ingress
  annotations:
    nginx.ingress.kubernetes.io/rewrite-target: /
spec:
  rules:
  - http:
      paths:
      - path: /testpath
        backend:
          serviceName: test
          servicePort: 80
```

Kubernetes basic elements - Ingresses

- An Ingress resource is basically just a routing rule for an Ingress Controller deployed to the cluster
- The Ingress controller is available e.g. by running a `NodePort` Service of Pods running an Ingress controller immplementation (e.g. kubernetes/ingress-nginx)
- Whenever a new Ingress resource is created the corresponding Ingress Controller should be reconfigured to be able to route traffic accordingly to the created Ingress resource
- A single Ingress resource might contain multiple rules (multiple hosts, multiple paths, multiple schemes,…)

Why Kubernetes for Microservices?

- Kubernetes already includes mechanisms for crucial tasks like service discovery and load balancing
- Kubernetes is able to dynamically scale deployments based on metrics like CPU and memory but also based on custom metrics e.g. avg. response time of HTTP requests
- Kubernetes itself can be scaled out to huge deployments of 500 nodes and thousands of containers
- There's a huge and still growing eco system of tools and frameworks available for Kubernetes (e.g. Knative, Spinnaker, Prometheus-Operator, Istio,...)