Introduction to Kubernetes!

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Introduction

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Agenda

Part 1: Containers & Docker

Part 2: Kubernetes

Part 3: Kubernetes Architecture

Part 4: Kubernetes Components

Part 5: Hands-On Demo

Part 6: Wrap-Up and Q&A

Part 1: Containers & Docker

Traditional Virtual Machines and Local Setups

Traditional virtual machines (VMs) virtualize an entire operating system, and running applications locally on a single OS can lead to conflicts.

Disadvantages:

- Heavy Resource Usage: VMs replicate the whole operating system, consuming substantial resources (RAM, CPU) on each VM instance.
- Lack of Consistency: Running apps locally can result in version conflicts (dependencies, environment variables)
- Inefficient Scaling: Spinning up a new VM is slower and requires more storage

What are Containers?

Containers package an application with its dependencies, letting it run consistently across any environment.

Key Points:

- Containers occupy a smaller footprint compared traditional VMs.
- Containers allow consistency by packaging everything the application needs.
- Containers can be moved between environments without issues.

Why Use Containers?

Benefits:

- Portability
- Efficiency
- Resource Isolation

Docker

Docker is the tool used to create and manage containers.

Key Commands:

docker build: Assembles the container image.

docker run: Runs the container.

docker pull: Downloads Docker images from the Docker Hub.

docker ps: Lists running containers, providing information about their status and configurations.

Running a Container with Docker

Run an Nginx container:

```
docker run --name my-nginx -p 8080:80 nginx
```

Open a browser and visit localhost:8080 to see the Nginx welcome page.

Running a Container with Docker

```
docker run --name my-nginx -p 8080:80 nginx
```

- --name my-nginx: Names the container instance my-nginx.
- -p 8080:80: Maps port 80 in the container to port 8080 on the host, making the application accessible locally.
- nginx: Specifies the image to use (in this case, the latest Nginx image from Docker Hub).

Part 2: Kubernetes

Why Do We Need Kubernetes?

Complexity at Scale: Managing multiple containers across distributed environments is resource-intensive and complex.

- Scaling Needs: Adjusting container numbers manually to match traffic spikes or dips requires significant oversight.
- Configuration Drift: Without consistent orchestration, container configurations can drift across environments, causing reliability issues.

Why Do We Need Kubernetes?

High Availability & Resilience:

- Fault Tolerance: Detecting and recovering from container or node failures promptly is crucial to avoid downtime.
- Service Discovery: Ensuring containers can locate each other (especially when they're dynamically scheduled across nodes) is challenging without orchestration.

Why Do We Need Kubernetes?

Load Distribution:

- Traffic Management: Balancing incoming traffic across containers to avoid overload or resource wastage is difficult to manage manually.

Kubernetes Overview

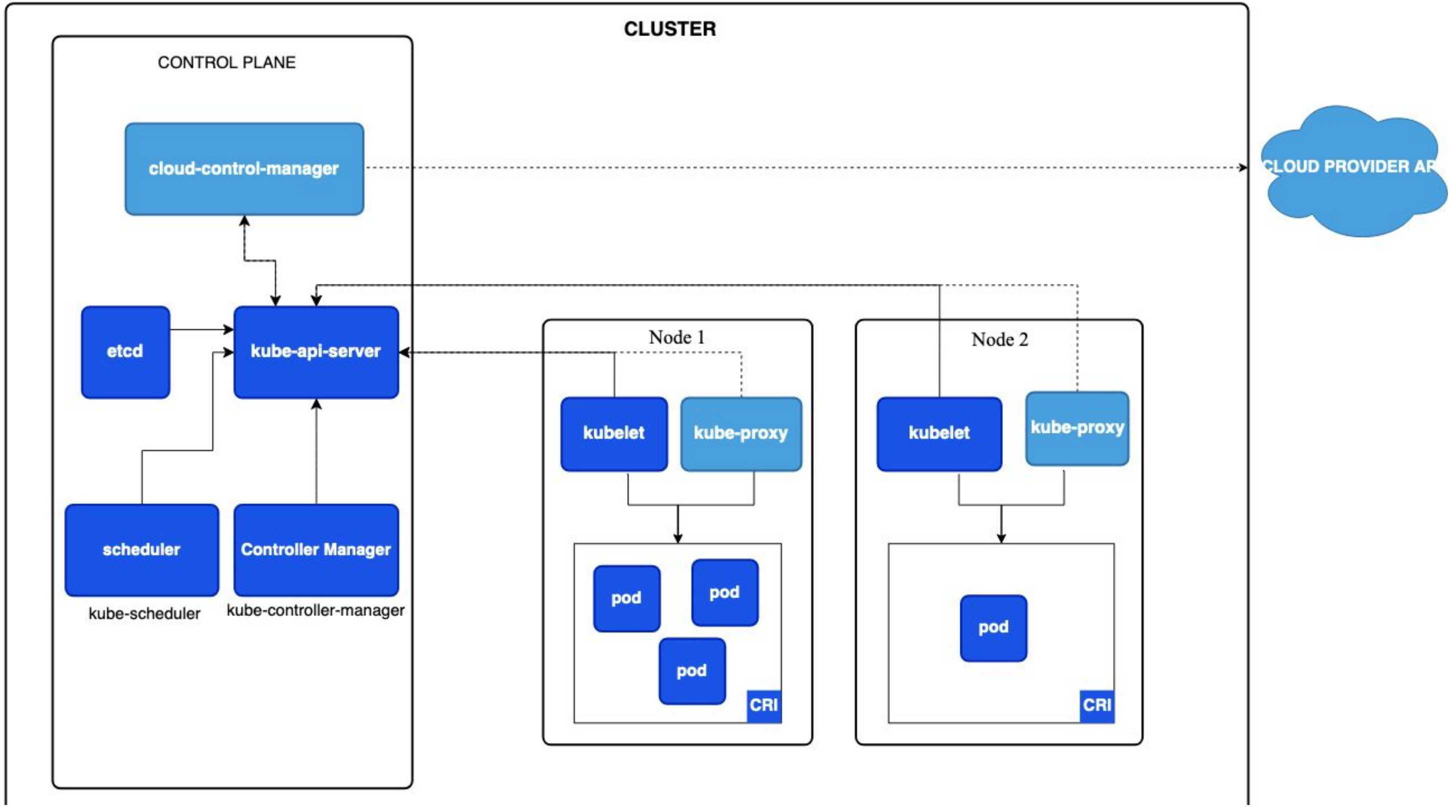
An orchestration platform that automates the deployment, scaling, and management of containerized applications.

Main Responsibilities:

- Scaling: Automatically adjusts the number of running containers based on real-time demand, adding or removing instances as needed.
- Load Balancing: Distributes incoming network traffic evenly across containers, ensuring efficient resource utilization and application performance.
- Self-Healing: Monitors container health, automatically replacing or restarting containers that fail, maintaining application availability and reliability.

Part 3: Kubernetes Architecture

Kubernetes Architecture



Pic credits: https://kubernetes.io/docs/concepts/architecture/

Kubernetes Control Plane

Control Plane: The core management layer of Kubernetes that maintains the desired state of the cluster.

- API Server: The central component that exposes the Kubernetes API and serves as the communication point for all Kubernetes operations.
- Scheduler: Assigns Pods to available nodes based on resource requirements and policies.
- Controller Manager: Ensures the actual state matches the desired state, handling tasks such as maintaining replicas and managing node lifecycles.
- etcd: A highly available key-value store that stores all cluster data, configurations, and states.

Kubernetes Worker Nodes

Worker Nodes: Nodes that run containerized applications and provide compute capacity to the cluster.

- Kubelet: An agent that manages Pod operations on each node, ensuring containers are running and healthy.
- Kube-proxy: A network proxy that manages network communication, routing traffic to the appropriate Pods within the cluster.

Part 4. Kubernetes Concepts

Pods

A Pod is the smallest deployable unit in Kubernetes, consisting of one or more tightly coupled containers that share storage, network, and a single IP address.

Key Features:

- Shared Resources: Containers within a Pod share network interfaces and storage volumes.
- Use Case: Often used to run a single container, but can contain multiple containers that need to work closely together.

Example: A web application Pod might contain both the main web server container and a sidecar container for logging or monitoring.

Deployments

A Deployment is a Kubernetes object that defines and manages the desired state for a set of Pods, specifying the number of replicas, the container image version, and the update strategy.

Key Features:

- Scaling: Automatically increases or decreases the number of replicas based on demand.
- Rolling Updates: Ensures zero-downtime updates by gradually replacing old versions of Pods with new ones.
- Self-Healing: Automatically replaces failed Pods to maintain the specified replica count.

Example: A Deployment for a front-end application might specify three replicas, ensuring that three instances of the application are always available.

Services

A Service is a Kubernetes resource that defines a stable IP and DNS name for a set of Pods, enabling communication between different parts of an application or external access to Pods.

Types of Services:

- ClusterIP: Exposes the Service within the cluster, allowing communication between internal Pods.
- NodePort: Exposes the Service on a static port on each node, allowing external access.
- LoadBalancer: Provisions an external load balancer, useful for cloud-based applications.

Example: A Service can expose a group of web server Pods to other Pods within the cluster or to external users, ensuring continuous access even if individual Pods are replaced or rescheduled.

Namespaces

Namespaces allows for the separation and organization of resources.

Use Cases:

- Environment Isolation: Use namespaces to separate resources for different environments (e.g., dev, staging, prod).
- Multi-Tenancy: In shared clusters, namespaces can segregate resources for different teams or projects, ensuring they don’t interfere with one another.
- Resource Management: Namespaces allow for applying resource quotas and policies at the namespace level, helping enforce resource limits.

Built-in Namespaces:

- default: The default namespace for resources that don’t specify another namespace.
- kube-system: Contains resources for Kubernetes system components.
- kube-public: A publicly readable namespace, typically used for cluster-wide information sharing.
- kube-node-lease: Contains node lease objects used to improve the node heartbeats.

Part 5: Kubernetes in Action

Demo

- Deploy a cluster using Kind
- Create an nginx webserver deployment
- Expose the deployment using a Service object
- Scale the Deployment
- Delete a pod and watch the deployment

KIND - Kubernetes IN Docker

Kind is a tool that runs Kubernetes clusters in Docker containers, enabling lightweight, local clusters for development and testing.

- Local Development: Kind is ideal for running Kubernetes clusters on a local machine without requiring cloud infrastructure or complex setup.
- Testing Environments: Kind clusters can be quickly created and destroyed, making it easy to test new configurations, updates, and deployments.

Key Features:

- Multi-Node Support: Kind can simulate multi-node clusters, allowing developers to test Kubernetes features like scheduling, networking, and scaling.
- Docker-Based: Runs clusters inside Docker containers, so you can work with Kubernetes on any system that supports Docker (e.g., Windows, macOS, Linux).
- Lightweight and Fast: Kind clusters are fast to spin up and resource-efficient, making it a practical choice for experimentation and development.

Part 6: Resources and Q/A

Recap & Further Resources

- Containers: Provide consistent, portable application packaging by bundling code and dependencies. They enable reliable application deployment across diverse environments.
- Kubernetes: An orchestration platform that automates container management, ensuring scalability, fault tolerance, and efficient resource allocation for containerized applications.
    - Kind: A lightweight tool for running Kubernetes clusters locally, ideal for development, testing, and hands-on learning with Kubernetes.

Recap & Further Resources

- Docker Tutorials: Resources for understanding Docker and containerization fundamentals – https://www.docker.com/101-tutorial/

- Kubernetes Documentation: In-depth guides on Kubernetes concepts, architecture, and components – kubernetes.io/docs

- Kind Documentation: Learn more about setting up and managing local clusters – https://kind.sigs.k8s.io/docs/user/quick-start/

Recap & Further Resources

- Link to slides: https://github.com/savitharaghunathan/101-kubernetes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THANK YOU :) :)