

# Kubernetes

## Easy Understanding Concepts of Kubernetes:

### Notes:

#### 1. Kubernetes Basics:

- **Pods:** Smallest deployable units in Kubernetes that can hold one or multiple containers.
- **Nodes:** Worker machines in Kubernetes.
- **Clusters:** A set of worker machines, called nodes, that run containerized applications.
- **Kubectl:** Command-line tool for interacting with a Kubernetes cluster.
- **Kubelet:** An agent running on each node in the cluster.
- **API Server:** Front-end to the cluster's control plane.
- **Etdcd:** Consistent and highly-available key-value store used as Kubernetes' backing store for all cluster data.
- **Control Plane:** The collection of processes that control Kubernetes nodes.
- **Namespace:** Virtual clusters backed by the same physical cluster.

#### 2. Workloads & Controllers:

- **Deployments:** Manages a replicated application.
- **ReplicaSets:** Ensures that a specified number of replicas of a Pod are running at all times.
- **StatefulSets:** Manages the deployment and scaling of a set of Pods, providing guarantees about ordering and uniqueness.
- **DaemonSets:** Ensures that all (or some) nodes run a copy of a Pod.
- **Jobs:** Creates one or more Pods and ensures that a specified number of them successfully terminate.
- **CronJobs:** Manages time-based Jobs, such as running a Job at a specific time or periodic intervals.
- **Horizontal Pod Autoscaler:** Automatically scales the number of Pods in a deployment, replica set, or replication controller based on observed CPU or memory usage.

### 3. Services & Networking:

- **Services:** A way to expose an application running in Pods as a network service.
- **Ingress:** Manages external access to services within a cluster.
- **Network Policies:** Define how Pods communicate with each other.
- **Service Discovery:** Mechanism to connect to services dynamically based on a logical name.
- **Load Balancer:** A service that distributes network traffic across multiple Pods.

### 4. Configuration & Secrets:

- **ConfigMaps:** Manage configuration data separately from container images.
- **Secrets:** Manages sensitive information, such as passwords, OAuth tokens, and ssh keys.
- **Environment Variables:** Used within Kubernetes for service discovery.
- **Volumes:** Persistent storage in Kubernetes.
- **Persistent Volume Claims (PVCs):** Request for storage by a user.

### 5. Monitoring, Logging, and Debugging:

- **Kube-state-metrics:** A simple service that listens to the Kubernetes API server and generates metrics about the state of the objects.
- **Prometheus:** An open-source system monitoring and alerting toolkit.
- **Grafana:** Open platform for beautiful analytics and monitoring (often used with Prometheus).
- **ELK Stack:** Elasticsearch, Logstash, and Kibana used for logging in Kubernetes.
- **Kubernetes Dashboard:** General-purpose web UI for Kubernetes clusters.
- **Kubectl Debug:** Tool for debugging pods.
- **Heapster:** Collects monitoring and performance metrics.

## 6. Security & Authorization:

- **Role-Based Access Control (RBAC):** Access control system.
- **Security Policies:** Security constraints applied to a Pod.
- **Service Account:** Identity attached to Pods to interact with the Kubernetes API Server.
- **Transport Layer Security (TLS):** Protocol for privacy and data integrity.

## 7. Kubernetes Storage:

- **Persistent Volumes (PVs):** Offers storage to the cluster that is independent of Pod life cycles.
- **Storage Classes:** Allow administrators to describe the "classes" of storage offered.

## 8. Kubernetes Cluster Maintenance:

- **Node Maintenance:** Taking a node down for service or replacing a failing node.
- **Cluster Upgrades:** Upgrading the cluster to a newer version.
- **Backup and Disaster Recovery:** Ensuring data continuity and integrity.

## 9. Extending Kubernetes:

- **Custom Resources:** Extension of the Kubernetes API.
- **API Server Extension:** Custom endpoints in the Kubernetes API.
- **Custom Controllers:** Automate handling of Custom Resources.
- **Operators:** Application-specific controllers to create, configure, and manage instances of complex stateful applications.

## 10. Advanced Features:

- **Service Mesh (e.g., Istio):** Manage microservices in a transparent way.
- **Pod Priority & Preemption:** Specifies priorities for Pods and allows preemption of lower-priority Pods.
- **Taints and Tolerations:** Allows a node to repel a set of Pods.

- **Node Affinity:** Controls where a Pod runs based on labels on nodes and conditions called node affinity rules.
- **Pod Presets:** Injects information like secrets, volume mounts, and environment variables into pods at creation time.

#### 11. Kubernetes Cloud Integration:

- **Amazon EKS:** Managed Kubernetes service on AWS.
- **Google Kubernetes Engine (GKE):** Managed Kubernetes service on Google Cloud.
- **Azure AKS:** Managed Kubernetes service on Azure.

#### 12. Continuous Deployment/Integration in Kubernetes:

- **Jenkins:** Popular open-source tool to perform continuous integration and build automation.
- **GitLab CI:** Continuous integration service included with GitLab that builds and tests the software whenever a developer pushes code to the application.

#### 13. Helm: Kubernetes Package Manager:

- **Helm Charts:** Packages of pre-configured Kubernetes resources.
- **Helm Repository:** A collection of charts for Kubernetes packages.

#### 14. Kubernetes Custom Scheduling:

- **Custom Scheduler:** You can implement a custom scheduler to have more control over the scheduling of your Pods.

#### 15. Kubernetes Federation:

- **Cluster Federation:** Allows the synchronization of resources across multiple clusters.

## 16. Windows in Kubernetes:

- **Windows Nodes:** Support for windows worker nodes and windows containers in Kubernetes.

## 17. Kubernetes Testing:

- **Kubetest:** Kubernetes end-to-end testing.

## 18. Kubernetes Add-ons:

- **DNS:** DNS server for service name resolution.
- **Web UI (Dashboard):** web-based Kubernetes user interface.
- **Container Resource Monitoring:** Time-series monitoring of resource utilization.
- **Cluster-level Logging:** Save container logs to a logging backend.

## 19. Other Essential Concepts:

- **Quotas:** Constraints applied to resources like Pods, Persistent Volumes.
- **Annotations:** Attach arbitrary non-identifying metadata to objects.
- **Labels and Selectors:** Labels are key/value pairs attached to objects and selectors are used to select objects based on labels.
- **Liveness and Readiness Probes:** Health checks for running applications.

## 20. Kubernetes Failure Handling:

- **Pod Disruption Budgets (PDBs):** Provides constraints that limit voluntary disruptions for Pods.

## 21. Kubernetes Architecture Concepts:

- **Cloud Controller Manager:** Embeds cloud-specific control logic for the cloud provider.
- **Kube-Proxy:** Maintains network rules and enables connection forwarding.
- **Container Runtime:** The software used to run containers, e.g., Docker, containers.

## 22. Kubernetes Community and Development:

- **Special Interest Groups (SIGs):** The Kubernetes project is divided into several Special Interest Groups or SIGs.
- **Contributing to Kubernetes:** Guide to becoming an active contributor to the Kubernetes project.

## 23. Kubernetes Best Practices:

- **Logging Best Practices:** Guidelines for logging in Kubernetes.
- **Monitoring Best Practices:** Guidelines for monitoring in Kubernetes.
- **Security Best Practices:** Guidelines for securing your applications in Kubernetes.
- **Performance Best Practices:** Guidelines for ensuring optimal performance in Kubernetes.

## 24. Kubernetes Automation and Autoscaling:

- **Cluster Autoscaler:** Automatically adjusts the size of the cluster, scaling it up or down as necessary.
- **Vertical Pod Autoscaler:** Automatically adjusts the amount of CPU and memory requested by containers in a Pod.
- **Horizontal Pod Autoscaler (HPA):** Automatically scales the number of Pods in a deployment or replica set based on observed CPU or memory utilization.

## 25. Kubernetes Development Tools:

- **Minikube:** Runs a single-node Kubernetes cluster inside a VM on your laptop for users looking to try out Kubernetes or develop with it day-to-day.
- **Scaffold:** Command line tool that facilitates continuous development for Kubernetes applications.
- **Kompose:** Conversion tool for all Docker Compose users to help them move to Kubernetes.
- **Kubeadm:** Tool for bootstrapping a best-practice Kubernetes cluster.

## 26. Advanced Kubernetes Networking:

- **Network Plugins:** Extend Kubernetes networking.
- **CNI (Container Network Interface):** Standard for writing plugins to configure network interfaces in Linux containers.
- **Flannel:** Overlay network provider.
- **Calico:** Provides secure network connectivity.

## 27. Kubernetes Performance Tuning:

- **Kubelet Garbage Collection:** Cleanup of unused images or containers.
- **Kernel Tuning:** Adjusting Linux kernel parameters to optimize performance.

## 28. Kubernetes Service Mesh:

- **Istio:** Open platform to connect, manage, and secure microservices.
- **Linkerd:** Another popular service mesh for Kubernetes.

## Kubernetes Commands & Usages:

### 1- Basic Cluster Information:

- `kubectl cluster-info`: Display information about the cluster.
- `kubectl version`: Display version info.

### 2- Working with Nodes and Cluster:

- `kubectl get nodes`: List nodes in a cluster.
- `kubectl describe node <node-name>`: Show details of a specific node.

### 3- Working with Pods:

- `kubectl get pods`: List all pods in all namespaces.
- `kubectl run <name> --image=<image>`: Deploy a new Pod with a given image.
- `kubectl describe pod <pod-name>`: Describe a specific pod.
- `kubectl logs <pod-name>`: Fetch the logs from a pod.
- `kubectl delete pod <pod-name>`: Delete a specific pod.

### 4- Working with Deployments:

- `kubectl create deployment <name> --image=<image>`: Create a new deployment.
- `kubectl get deployments`: List all deployments.
- `kubectl describe deployment <deployment-name>`: Describe a specific deployment.
- `kubectl scale deployment <deployment-name> --replicas=<num>`: Scale up/down a deployment.

### 5- Working with Services:

- `kubectl expose deployment <name> --type=LoadBalancer --port=8080`: Expose a deployment as a service.
- `kubectl get services`: List all services.
- `kubectl describe service <service-name>`: Describe a specific service.



## 6- Config and Storage:

- `kubectl get configmaps`: List all config maps.
- `kubectl create configmap <name> --from-file=<path>`: Create a config map from a file.
- `kubectl get secrets`: List all secrets.
- `kubectl create secret`: Create a secret.
- `kubectl get pv`: List all persistent volumes.
- `kubectl get pvc`: List all persistent volume claims.

## 7- Namespaces and Context:

- `kubectl get namespaces`: List all namespaces.
- `kubectl config get-contexts`: Show all contexts.
- `kubectl config use-context <context-name>`: Switch to a different context.

## 8- Others:

- `kubectl apply -f <filename>`: Apply a configuration from a file.
- `kubectl delete -f <filename>`: Delete resources defined in a file.
- `kubectl exec -it <pod-name> -- /bin/sh`: Execute a command inside a running pod.
- `kubectl port-forward <pod-name> <local-port>:<pod-port>`: Forward a port from a running pod to a local port.

## 9- Advanced:

- `kubectl get all`: List all resources.
- `kubectl rollout status deployment/<deployment-name>`: View the rollout status of a deployment.
- `kubectl rollout history deployment/<deployment-name>`: View the history of a deployment.
- `kubectl rollout undo deployment/<deployment-name>`: Rollback to a previous version of a deployment.

## 10- Monitoring & Logging:

- `kubectl top nodes`: Display resource (CPU/Memory/Storage) usage of nodes.
- `kubectl top pods`: Display resource (CPU/Memory/Storage) usage of pods.

## 11- Autoscaling:

- `kubectl autoscale deployment <deployment-name> --min=<min-pods> --max=<max-pods> --cpu-percent=<cpu-util-percentage>`: Auto scale a deployment based on CPU utilization.

## 12- Working with Helm:

- `helm list`: List releases.
- `helm install <chart>`: Install a helm chart.
- `helm uninstall <release-name>`: Uninstall a helm release.

## 13- Using Network Policies:

- `kubectl get networkpolicies`: List all network policies.
- `kubectl describe networkpolicy <policy-name>`: Describe a specific network policy.

## 14- Using CronJobs and Jobs:

- `kubectl get cronjobs`: List all cronjobs.
- `kubectl get jobs`: List all jobs.
- `kubectl logs job/<job-name>`: Fetch logs from a job.

## 15- Working with RBAC:

- `kubectl get roles`: List all roles in the current namespace.
- `kubectl get clusterroles`: List all cluster roles.

## 16- Using kubectl Plugins:

- `kubectl krew search`: Search plugins available for kubectl.
- `kubectl krew install <plugin-name>`: Install a kubectl plugin.