Kubernetes: Zero to Hero Guide (Based on *Mastering Kubernetes*)

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- What is Kubernetes and why it matters
- Use cases: microservices, ML pipelines, CI/CD, multi-cloud workloads
- When not to use Kubernetes: small-scale projects, real-time low-latency systems, monoliths

Kubernetes Architecture

- Master and node components
- API server, etcd, controller manager, scheduler, kubelet, kube-proxy
- Container runtimes: containerd, CRI-O
- Integrations: container runtime interface, CSI for storage

Setting Up Kubernetes Clusters

- Minikube and Kind (local dev)
- kubeadm (manual setup)
- kOps, Kubespray, Rancher
- Cloud-managed: GKE, EKS, AKS
- Production-grade patterns: HA control plane, external etcd

Kubernetes Core Concepts

- Pods, ReplicaSets, Deployments, Services, Namespaces
- ConfigMaps and Secrets
- Labels, selectors, and annotations
- Jobs, CronJobs
- Use of readiness and liveness probes for health checks

Networking Deep Dive

- CNI plugins: Flannel, Calico, Cilium
- Service types: ClusterIP, NodePort, LoadBalancer, ExternalName
- Ingress controllers: NGINX, Traefik, Istio Gateway
- DNS in Kubernetes
- Network Policies and how to enforce them
- Choosing the right service type based on traffic exposure and scalability

Storage in Kubernetes

- Volumes, Persistent Volumes (PV), Persistent Volume Claims (PVC)
- StorageClasses, dynamic provisioning
- Volume plugins: hostPath, CephFS, NFS, EBS, AzureDisk
- StatefulSet storage management
- Use cases: ephemeral data, persistent databases, logging

Security and RBAC

- Authentication and Authorization (RBAC, ABAC)
- Network Policies, PodSecurityPolicies, OPA/Gatekeeper

- Secrets management (KMS, Vault integration)
- TLS, mTLS with Istio/Linkerd
- Use cases: securing sensitive workloads, tenant isolation
- When to enforce PodSecurityAdmission and Gatekeeper policies

Observability: Logging, Monitoring, Tracing
- Metrics: Prometheus, kube-state-metrics, node-exporter
- Dashboards: Grafana
- Logs: Fluentd, Loki, Elasticsearch
- Tracing: Jaeger, OpenTelemetry
- When to implement tracing vs logs

Deployments, Updates, and Scaling
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- Horizontal Pod Autoscaler, Cluster Autoscaler, VPA
- Resource requests/limits, quota management
- Readiness/Liveness probes
- When to autoscale vs statically scale

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- Helm charts, templates, values.yaml
- Repositories and lifecycle commands
- Dependency management
- Best practices: chart versioning, secrets handling
- When to use Helm vs Kustomize

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- Writing custom resources (CRDs)
- Building controllers with client-go and Kubebuilder
- Operator pattern
- Webhooks and Admission Controllers
- Use cases: extending Kubernetes, domain-specific automation

Stateful Applications and Databases

- StatefulSets and Headless Services
- Persistent storage design
- Examples: Cassandra, MySQL, PostgreSQL
- Service discovery and identity
- When to use StatefulSets vs Deployments

Multi-cluster and Federation

- Kubefed v2 basics
- Use cases: disaster recovery, hybrid cloud, geo-distributed workloads
- DNS federation and sync controllers
- When federation is overkill or unnecessary

GitOps and CI/CD Integration

- Tools: Argo CD, Flux
- CI/CD pipelines with Tekton, JenkinsX, GitLab
- Secrets and environment promotion
- Best practices for repo structure and branching
- When to adopt GitOps vs traditional CI/CD

Advanced Use Cases and Patterns

- Multi-tenancy
- Multi-version deployments
- Sidecar and Ambassador patterns
- Service meshes (Istio, Linkerd)
- Cost optimization with node/pod affinity, taints, tolerations

Kubernetes Ecosystem & When Not to Use It

- When K8s is overkill: simple apps, no ops team, tight budget
- Tradeoffs: complexity, learning curve, operational overhead
- Alternatives: Nomad, Docker Swarm, ECS
- How to evaluate the need for Kubernetes

Appendix: Tools, Resources, and References

- [Official Kubernetes Docs](https://kubernetes.io/docs/)
- CNCF Projects: Helm, Prometheus, Envoy, etc.
- Learning platforms: Katacoda, Play with K8s
- Books: Kubernetes Up & Running, The Kubernetes Book