Kubernetes Security

SRINIVASARAO KOTIPALLI (@srini0x00)
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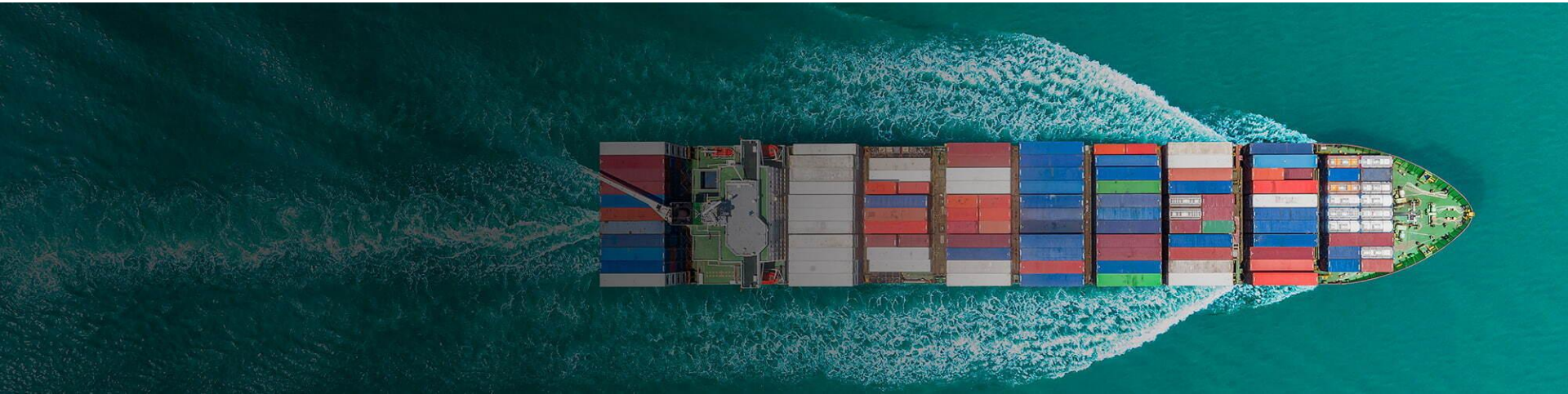
Agenda

1. Introduction to containers and Kubernetes
2. Kubernetes Attack Surface
3. Securing Kubernetes Clusters
4. Tools for Automated Assessments
5. Conclusion and Road Ahead

Introduction to containers

- Containers are a solution to the problem of how to get software to run reliably when moved from one computing environment to another.
- Examples of container runtimes: Docker, CoreOS rkt, Apache Mesos, LXC etc.



Introduction to Docker

What is Docker?

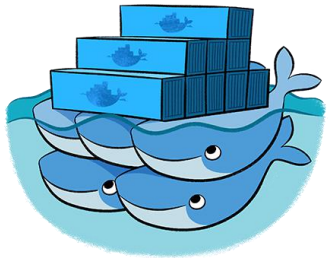
- Docker is a tool for OS virtualization - Containers
- Docker is a tool to create, deploy, and run applications by using containers.

Core concepts for beginners

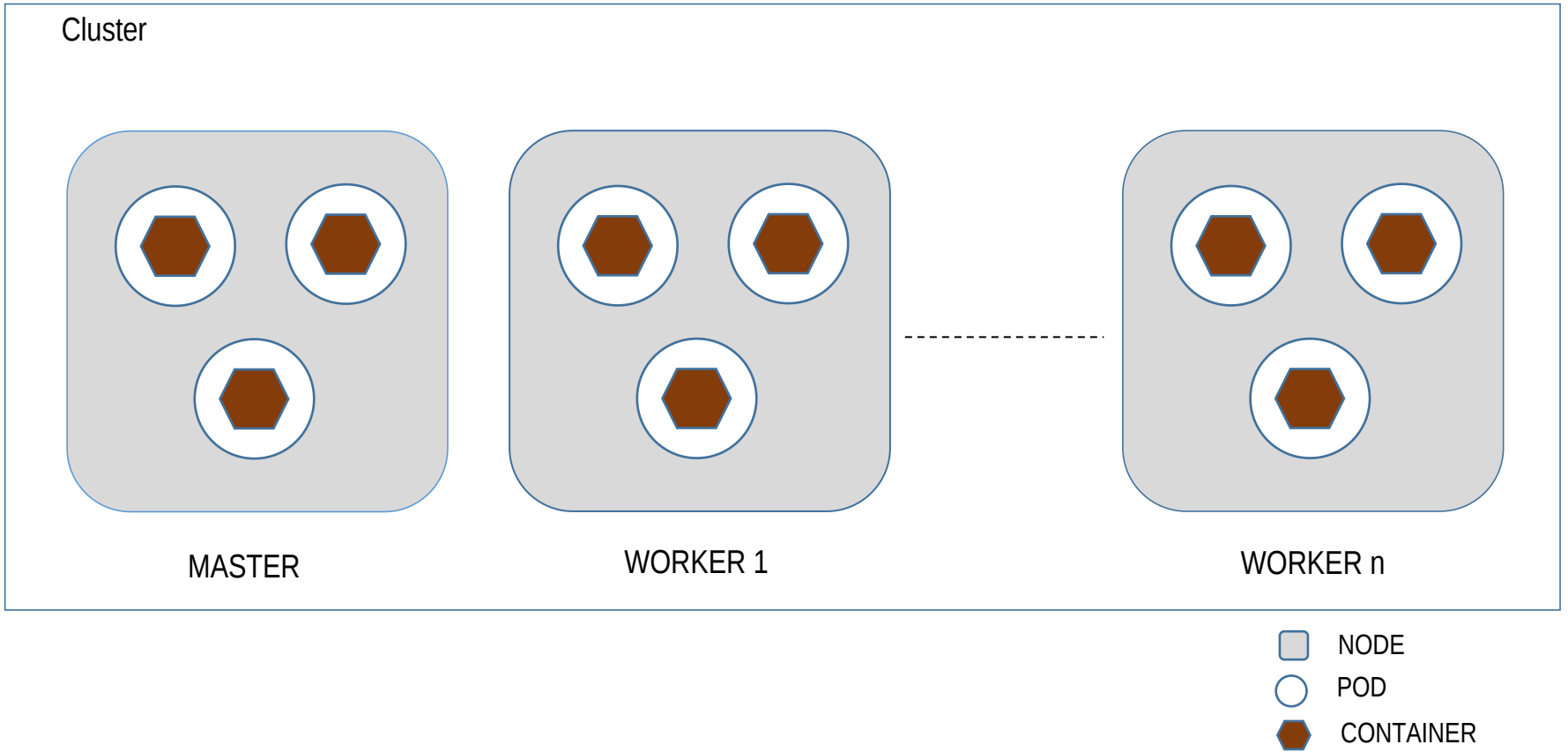
- Images
- Containers
- Docker Daemon
- Docker CLI
- Docker Registry

Container Orchestration

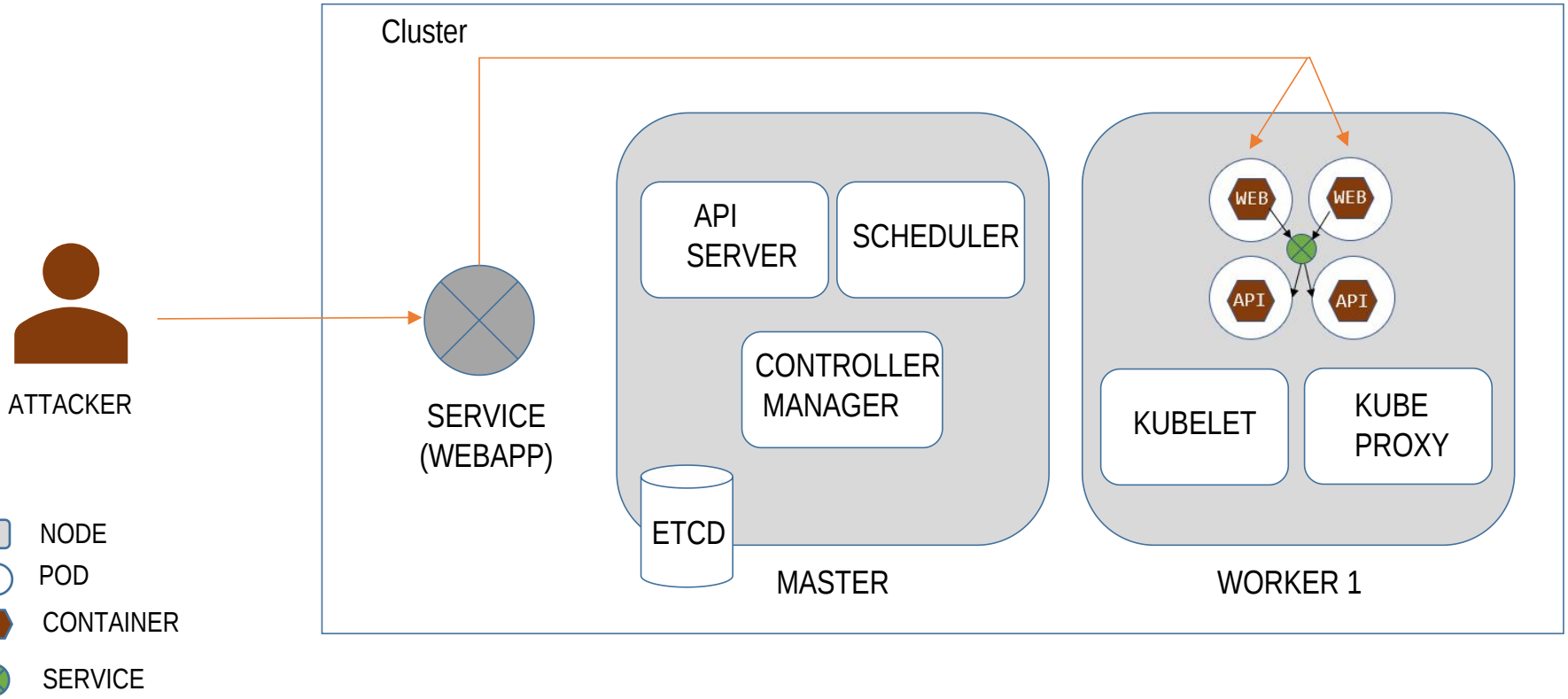
- Containers in enterprise environments are much more complex
- When more and more containers are introduced, managing them gets harder
- A container orchestration tool is needed to manage the containers
- Docker Swarm and Kubernetes are two popular container orchestration tools



Kubernetes Architecture



Sample Kubernetes Cluster



Kubernetes Attack Surface

Initial Access	Execution	Persistence	Privilege Escalation	Defense Evasion	Credential Access	Discovery	Lateral Movement	Impact
Using Cloud credentials	Exec into container	Backdoor container	Privileged container	Clear container logs	List K8S secrets	Access the K8S API server	Access cloud resources	Data Destruction
Compromised images in registry	bash/cmd inside container	Writable hostPath mount	Cluster-admin binding	Delete K8S events	Mount service principal	Access Kubelet API	Container service account	Resource Hijacking
Kubeconfig file	New container	Kubernetes CronJob	hostPath mount	Pod / container name similarity	Access container service account	Network mapping	Cluster internal networking	Denial of service
Application vulnerability	Application exploit (RCE)		Access cloud resources	Connect from Proxy server	Applications credentials in configuration files	Access Kubernetes dashboard	Applications credentials in configuration files	
Exposed Dashboard	SSH server running inside container					Instance Metadata API	Writable volume mounts on the host	
							Access Kubernetes dashboard	
							Access tiller endpoint	

Attack Demo

1. Application Security

- Application vulnerabilities are one of the common entry points
- Easiest way to gain initial access to a cluster
- Ensure that applications being deployed into the cluster are well secured

2. Network Exposure

- Network exposure of all security sensitive services must be restricted

- API Server
- Kubelet API
- Kubernetes Dashboard
- etcd

Appropriate authentication controls should be enforced

3. Service Account Privileges

- Care must be taken when creating service accounts and binding them with roles
- Service accounts for the namespace are injected into the pod
- Granting unnecessary privileges is too risky
- Apply principle of least privilege (RBAC)

4. Use of Admission Controllers

- An additional layer of Access Controls
- Comes with plugins that govern and enforce how the cluster is used.
- Act as a gatekeeper that intercept API requests and may change the request object or deny the request altogether, but after the request s authenticated and authorized
- Examples:

- AlwaysPullImages – Blocks if you spin up a container without pulling an image from registry
- PodSecurityPolicy – We will discuss later

AUTHENTICATION | AUTHORIZATION | ADMISSION CONTROLLER

5. Vulnerable Container Images

- Images used to spin up containers can have vulnerabilities (Base images/Custom code)
- Scan container images for security vulnerabilities
- Several automated tools are available for scanning Docker images
- Examples – Trivy, Clair

6. Harden the containers

- Even if images are safe, the way containers are started can cause trouble.
- A container spun up using --privileged flag can give an attacker full access to the underlying host
- If hosts volume is mounted on to the container, it will be accessible from within the container
- Containers are started with root user accounts by default.
- Remove unnecessary capabilities from the containers when running them.
- Automated tools are available to spot missing best practices.

7. Use of Security Context

- A feature that allows us to enforce restrictions when creating a pod or deployment
- Run Pods with non root containers
- Run containers with read only file system
- Drop dangerous container capabilities
- Enforce apparmor profiles – granular control on files
- Enforce seccomp profiles – limit system calls

8. Use of Pod Security Policies

- A Pod Security Policy is a cluster level resource that controls the security sensitive aspects of the pod-specification

- The PodSecurityPolicy objects define a set of conditions that a pod must run with in order to be accepted into the system

- Examples:
  - Privileged Containers
  - Use of host file system
  - Read only root file system
  - Restricting escalation to root privileges

9. Secrets Management

- Applications running in the containers may need access to secrets
- Secrets should be accessible to pods
- Secrets are usually passed using environment variables and mountable volumes
- Kubernetes offers etcd to store the secrets
- Not encrypted by default
- Recommended to use a vault for secrets:

- Encrypt data at rest
- Token to access the secrets
- Token rotation

10. Network Policies

- In our demo, we got a reverse shell using remote code execution vulnerability
- If we have a network rule that blocks outbound connection, reverse shell payload wont work
- Use a networking plugin that supports network policies
- Allows us to enforce ingress and egress rules

Automated Assessments

- Trivy is a tool that can be used for scanning Docker images for known vulnerabilities.
- Kube Bench can be used for assessing the cluster (host, images and containers).
- Kube sec can be used to scan the YAML files.

Conclusion

Key takeaways:

- Kubernetes is a great tool for container orchestration, but with great features come great security issues.
- Kubernetes is prone to several misconfigurations and we must be aware of the exact implications of features being used – A simple misconfiguration can cause serious damage.
- Several tools and techniques are available for hardening the clusters – use them.

Road ahead

- New vulnerabilities are discovered every now and then – keep an eye.
- Get familiar with security concepts of other container orchestration platforms such as Docker Swarm

Additional Resources

- https://kubernetes.io/docs/concepts/security/
- https://kubernetes.io/docs/tasks/administer-cluster/securing-a-cluster/
- https://www.microsoft.com/security/blog/2020/04/02/attack-matrix-kubernetes/
- https://securekubernetes.com/scenario_1_attack/
- https://theoffensivelabs.com/p/hacking-and-securing-kubernetes-clusters
- https://github.com/ksoclabs/awesome-kubernetes-security

THANK YOU