
NOVATEC
Secure Development on Kubernetes
Container / K8s Security
Andreas Falk

Agenda

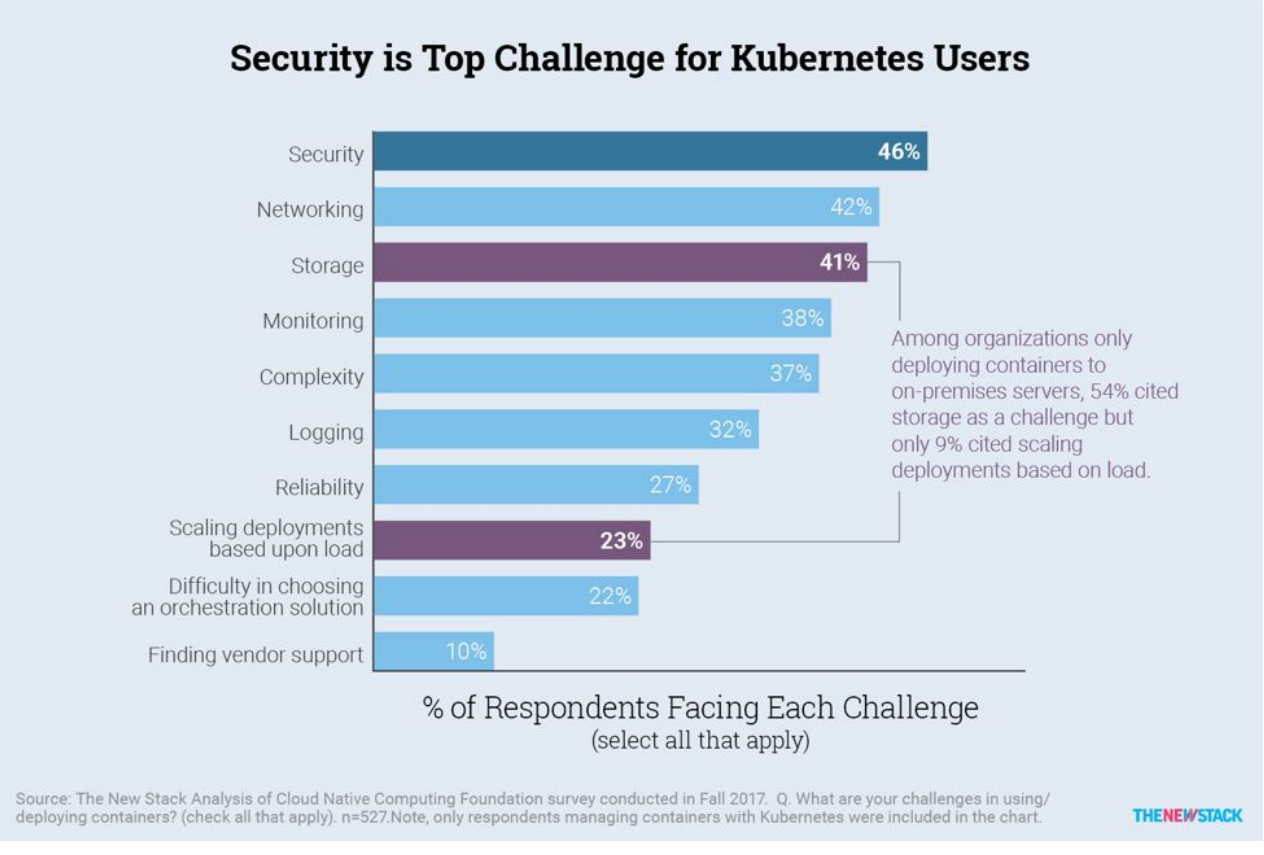
1. What can go wrong
2. Application Security
3. Container Security
4. Kubernetes Security
5. Kubernetes Secrets

What can go wrong?

Introduction

Top Challenges in Kubernetes

Source: https://thenewstack.io



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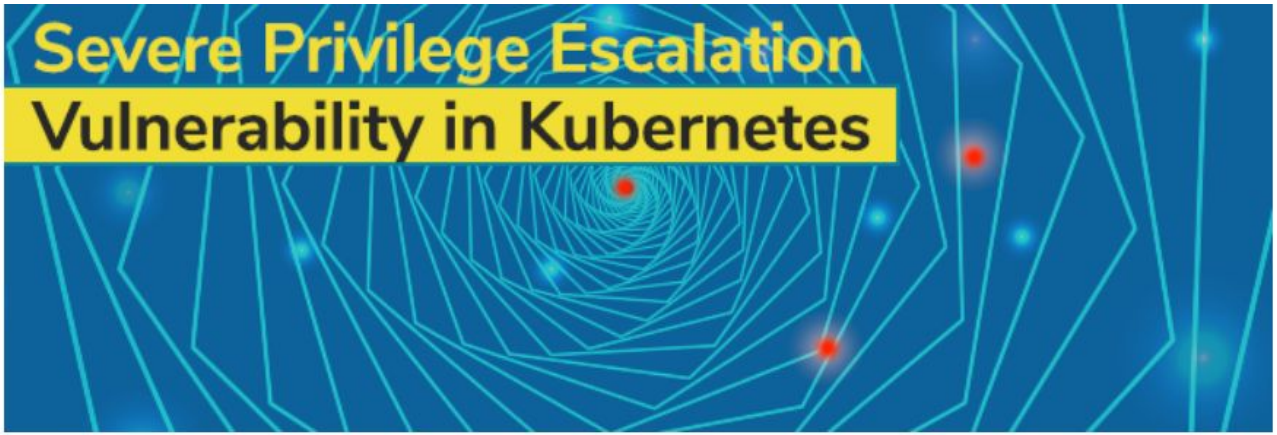
Severe Vulnerability in Kubernetes

Source: https://blog.aquasec.com



Ariel Shuper • December 06, 2018

Severe Privilege Escalation Vulnerability in Kubernetes (CVE-2018-1002105)

Earlier this week, a severe vulnerability in Kubernetes (CVE-2018-1002105) was disclosed that allows an unauthenticated user to perform privilege escalation and gain full admin privileges on a cluster. The CVE was given the high severity score of 9.8 (out of 10) and it affects all Kubernetes versions from 1.0 onwards, but fixes are available for recent versions.

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Crypto Mining Via K8s Dashboard

Source: https://blog.heptio.com

On Securing the Kubernetes Dashboard

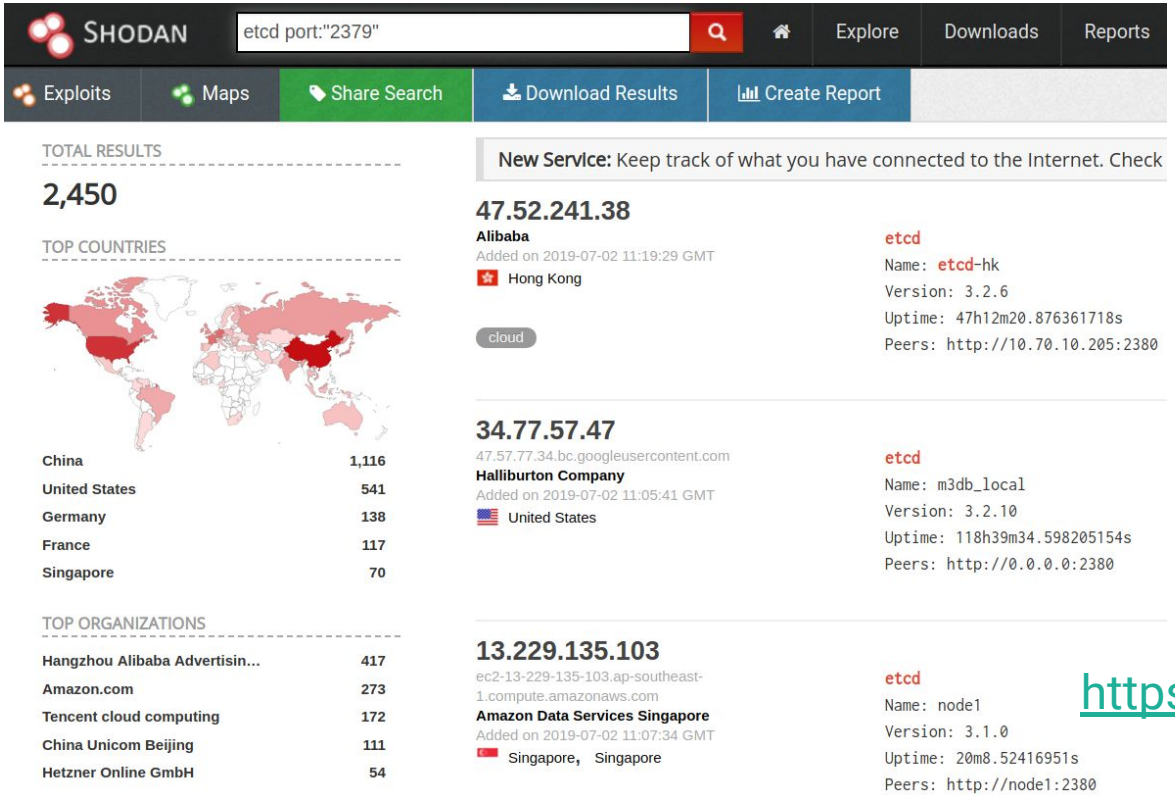
Joe Beda Follow

Feb 28, 2018 · 13 min read

Recently Tesla (the car company) was alerted, by security firm RedLock, that their Kubernetes infrastructure was compromised. The attackers were using Tesla's infrastructure resources to mine cryptocurrency. This type of attack has been called "cryptojacking".

The vector of attack in this case was a Kubernetes Dashboard that was exposed to the general internet with no authentication and elevated privileges. Not only this, but core AWS API keys and secrets were visible. How do you prevent this from happening to you?

Open ETCD Ports in Kubernetes (1)



https://shodan.io

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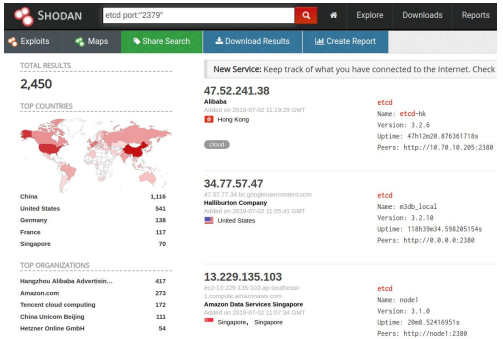
Open ETCD Ports in Kubernetes (2)




```
$ etcdctl --endpoints=http://xx.xx.xx.xx:2379
cluster-health

member b97ee4034db41d17 is healthy: got healthy
result
from http://xx.xx.xx.xx:2379
cluster is healthy
```

https://github.com/etcd-io/etcd/releases

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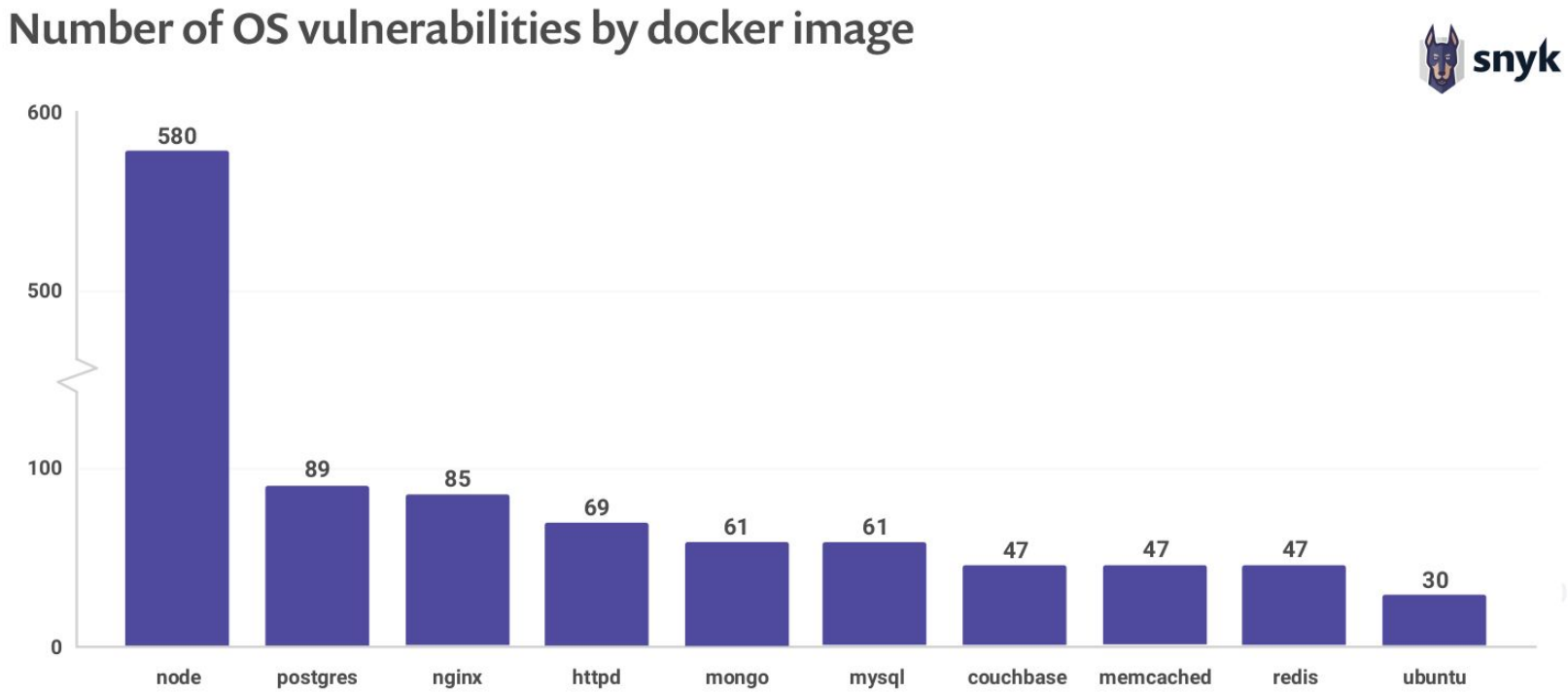
Vulnerable Docker Images

Source: The state of open source security report (snyk.io)



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All is Root

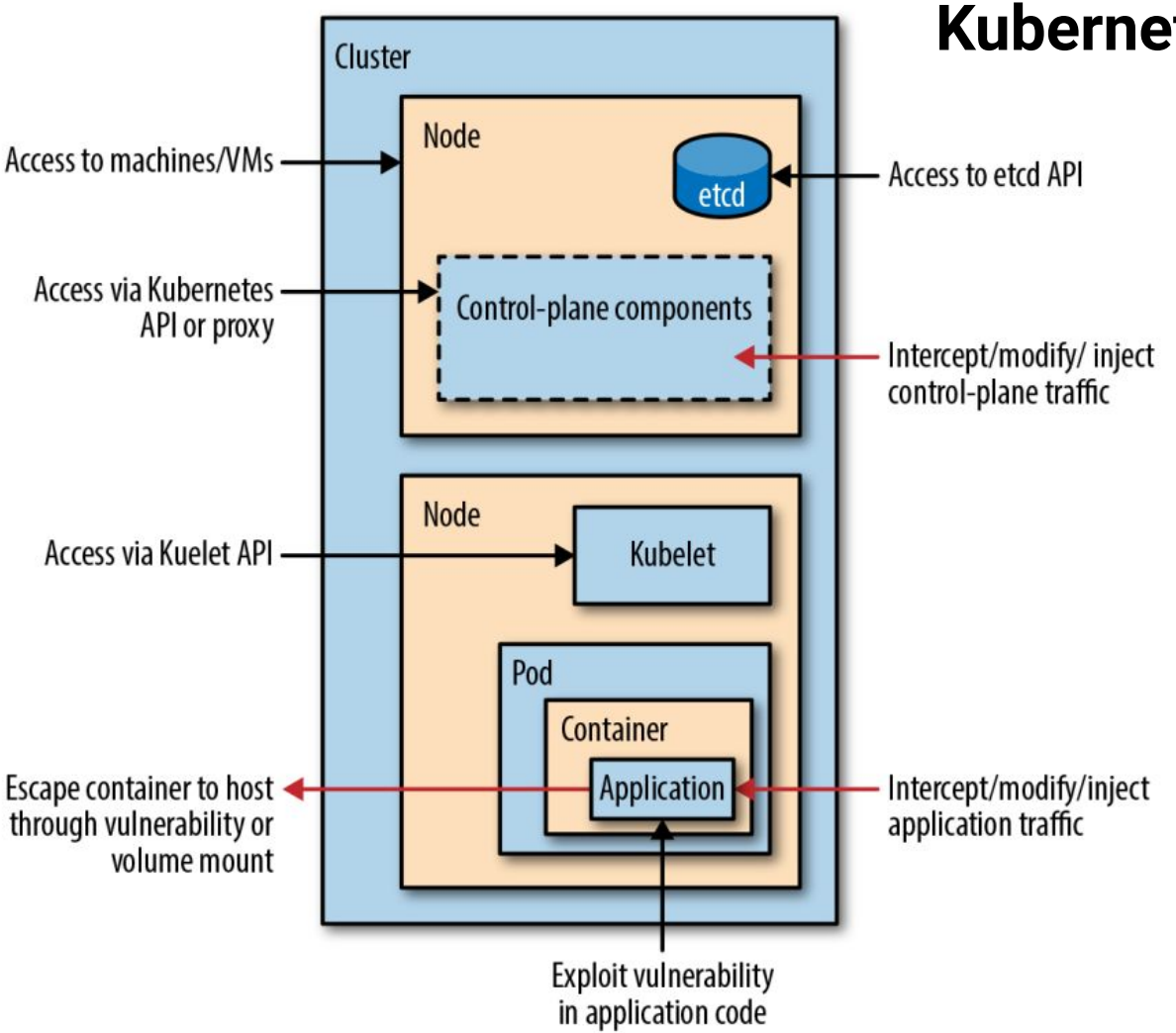
CZnative @ home
@pczarkowski

Welcome to Kubernetes where everything runs as root and the security doesn't matter!

14:22 - 8. Mai 2019

Kubernetes attack vectors

Source:
Kubernetes Security, O'Reilly, 2018



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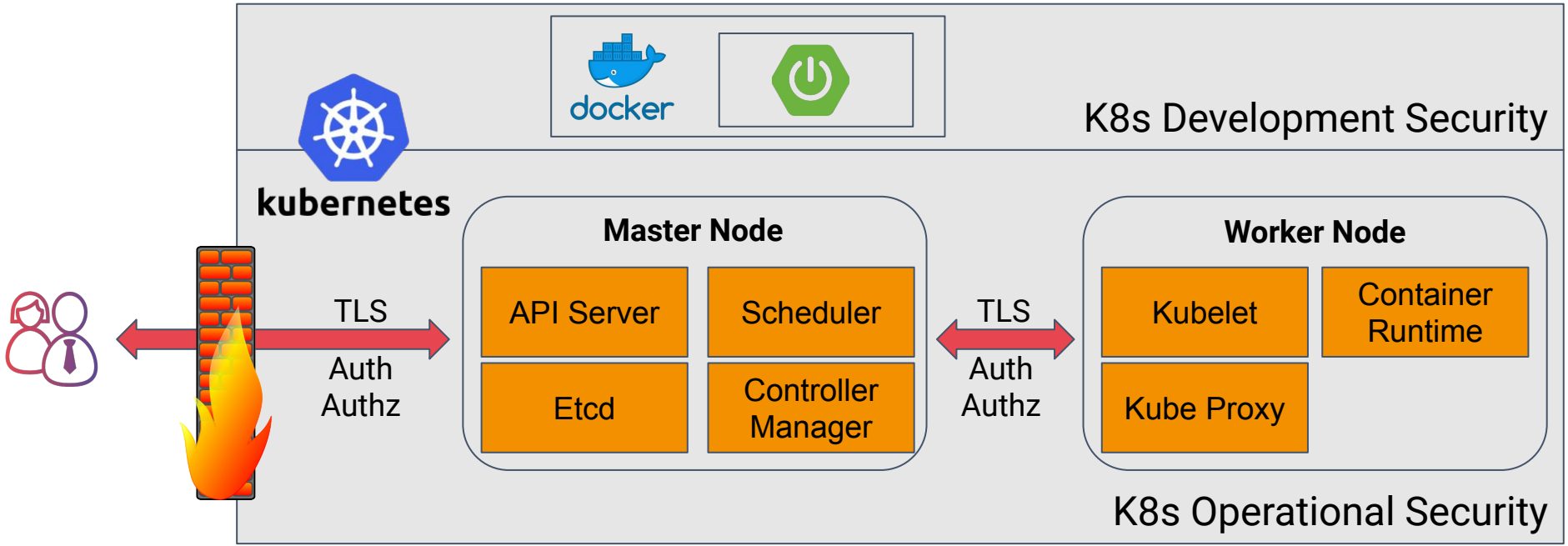
Operational / Development Kubernetes Security



https://kubernetes.io/docs/concepts/security/overview/#the-4c-s-of-cloud-native-security
https://learnk8s.io/production-best-practices/

So what can we do as developers?

Application- / Docker- / K8s-Security

The Path for Secure Development on K8s

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The Path for Secure Development on K8s

Application Security

Authentication

Authorization

SQL Injection

Cross Site Scripting (XSS)

Cross Site Request Forgery (CSRF)

Data Protection (Crypto)

...

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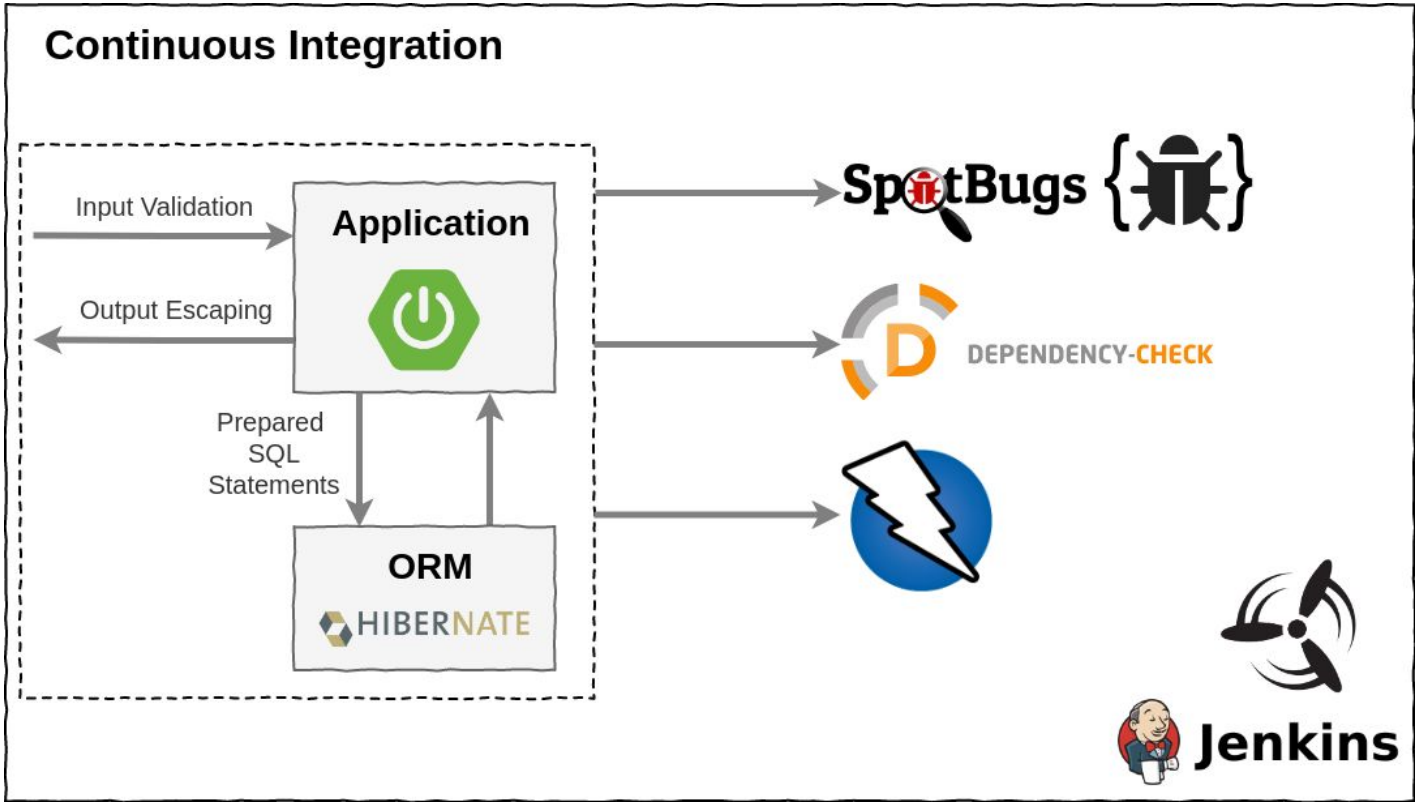
Application Security



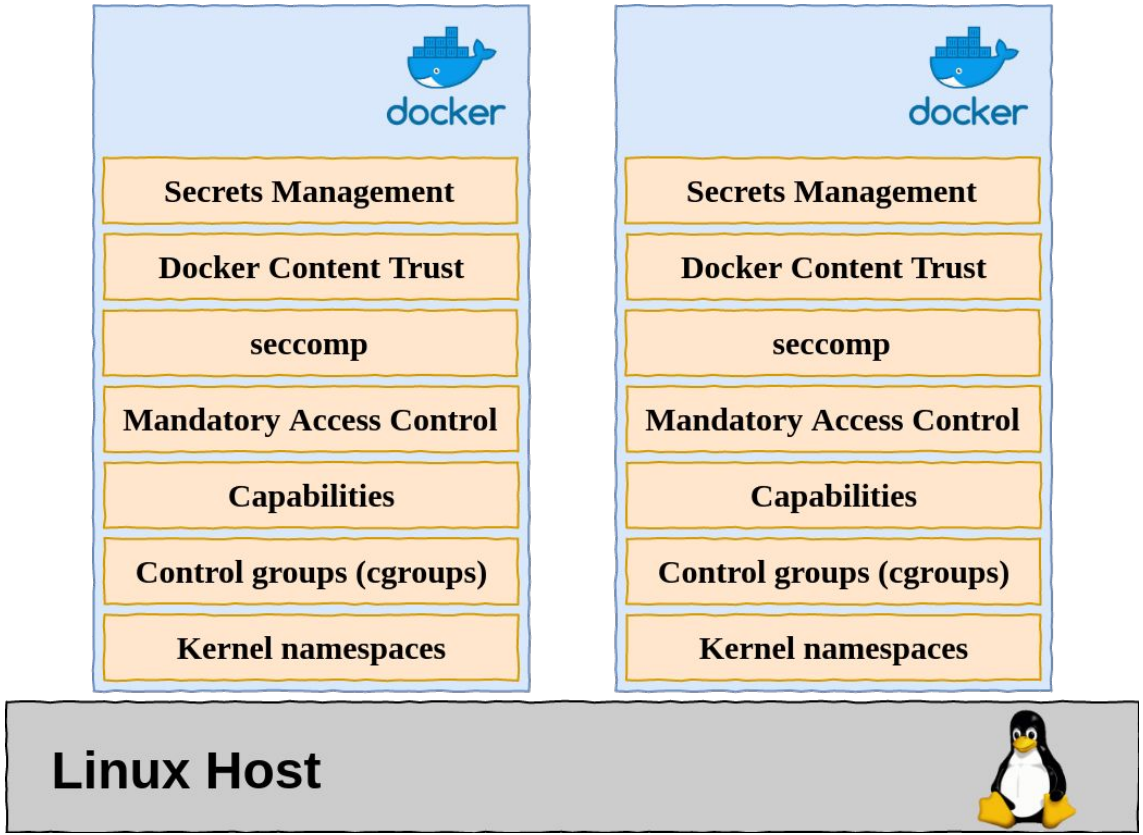
Live Demo: Show me the code

Iteration 1: Application Security

https://github.com/andifalk/secure-development-on-kubernetes

The Path for Secure Development on K8s

Docker Security Basics



Linux Kernel Namespaces

- Process ID (pid)
- Network (net)
- Filesystem/mount (mnt)
- Inter-Process Communication (ipc)
- User (user)
- UTS (hostname)

Linux Control Groups (CGroups)

- Resource Limits
  - CPU
  - Memory
  - Devices
  - Processes
  - Network

For Java this only works with container aware JDK versions as of **OpenJDK 8u192** or above

Linux Capabilities

- Break up root privileges into smaller units
  - CAP_SYS_ADMIN
  - CAP_NET_ADMIN
  - CAP_NET_BIND_SERVICE
  - CAP_CHOWN
  - ...

```
$ docker run --cap-drop=ALL --cap-add=NET_BIND_SERVICE
```

http://man7.org/linux/man-pages/man7/capabilities.7.html

Mandatory Access Control (MAC)

- AppArmor
- Security Enhanced Linux (SELinux)

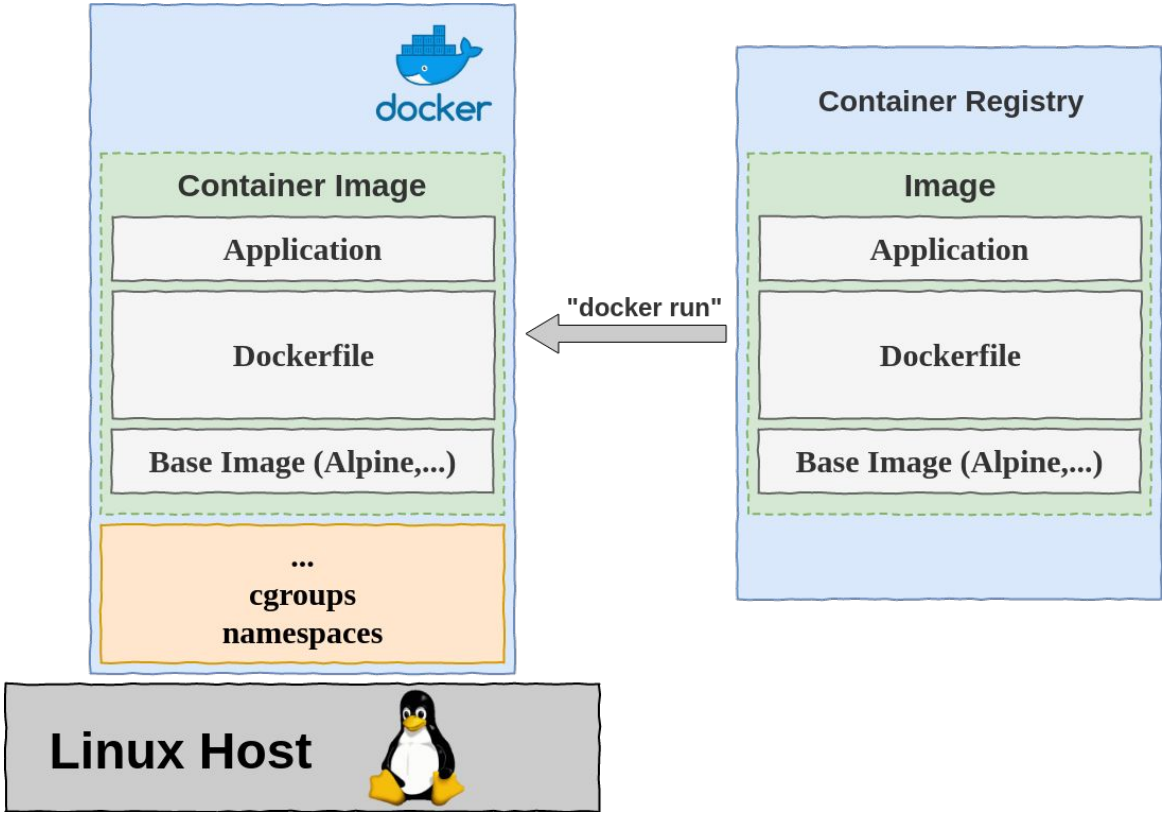
https://gitlab.com/apparmor/apparmor/wikis/home
https://github.com/SELinuxProject

Secure Computing Mode (SecComp)

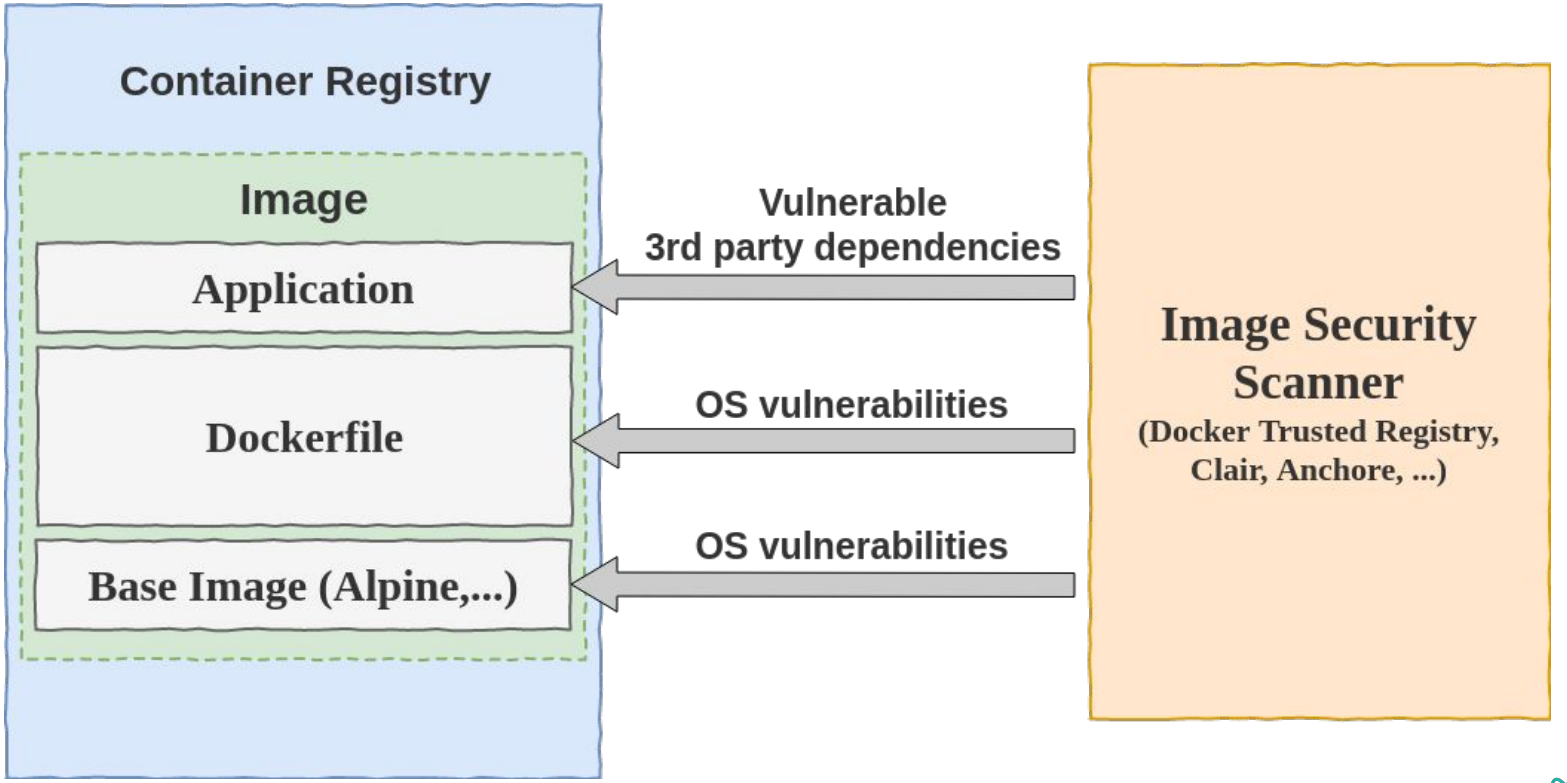
- Deny critical system calls by default
  - reboot
  - mount
  - swapon
  - ...

http://man7.org/linux/man-pages/man2/seccomp.2.html
https://docs.docker.com/engine/security/seccomp

Docker Images



Docker Image Security



Say No To Root!

USER directive in Dockerfile

```
FROM openjdk:11-jre-slim
COPY hello-spring-kubernetes-1.0.0-SNAPSHOT.jar app.jar
EXPOSE 8080
RUN addgroup --system --gid 1002 app && adduser
    --system --uid 1002 --gid 1002 appuser
USER 1002
ENTRYPOINT java -jar /app.jar
```

https://opensource.com/article/18/3/just-say-no-root-containers

Say No To Root!

Or Use JIB and Distroless Images

```
plugins {
  id 'com.google.cloud.tools.jib' version '...'
}

jib {
 container {
   user = 1002
 }
}
```

https://github.com/GoogleContainerTools/jib

Keep Being Secure

- Perform Image Scanning
  - Anchore
  - Clair
  - Trivy
- Regularly Update Base Images

https://anchore.com/opensource/
https://github.com/coreos/clair
https://github.com/aquasecurity/trivy

OWASP Docker Top 10

D01 - Secure User Mapping
D02 - Patch Management Strategy
D03 - Network Segmentation and Firewalling
D04 - Secure Defaults and Hardening
D05 - Maintain Security Contexts
D06 - Protect Secrets
D07 - Resource Protection
D08 - Container Image Integrity and Origin
D09 - Follow Immutable Paradigm
D10 - Logging

https://www.owasp.org/index.php/OWASP_Docker_Top_10

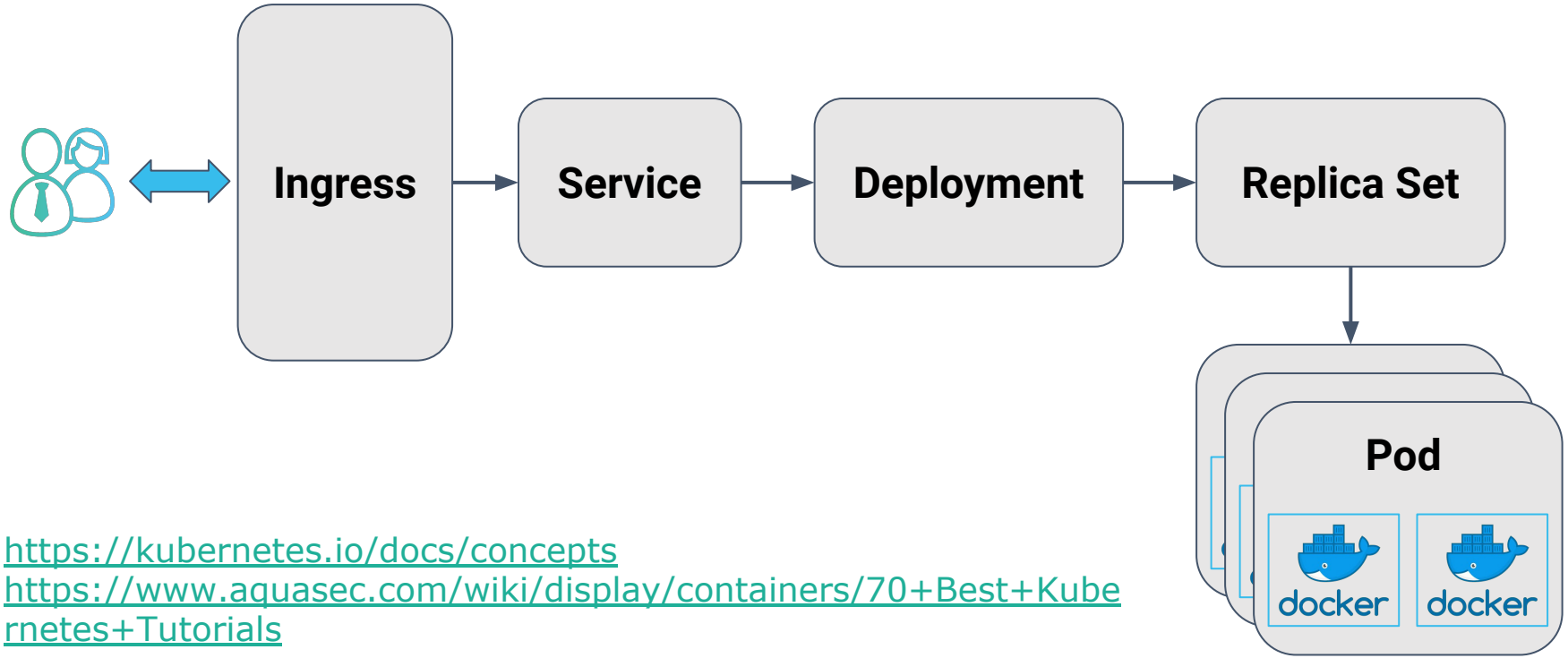
Live Demo: Show me the code

Iteration 2: Container Security

https://github.com/andifalk/secure-development-on-kubernetes

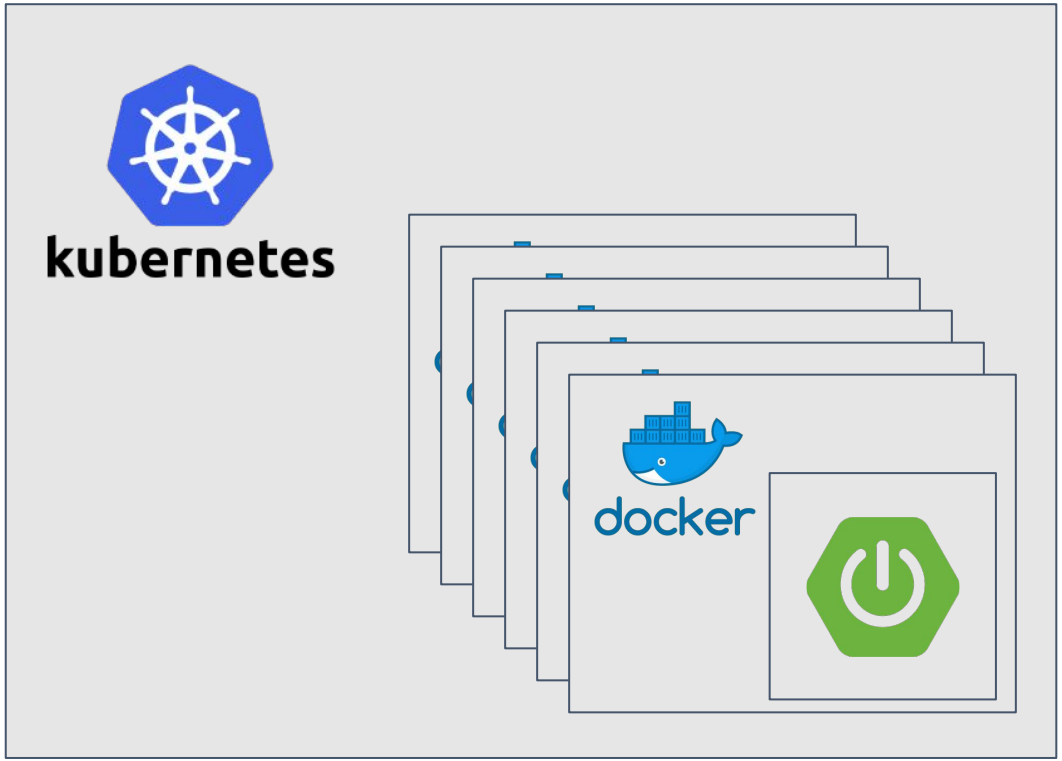
The Path for Secure Development on K8s

Kubernetes Basics



https://kubernetes.io/docs/concepts
https://www.aquasec.com/wiki/display/containers/70+Best+Kubernetes+Tutorials

Kubernetes Security



- Kubernetes Auditing
- Network Policies
- Role Based Access Control (RBAC)
- Resource Limits
- Pod Security Context
- Pod Security Policy

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Resource Limits

```
spec:
  ...
  containers:
    resources:
      limits:
        cpu: "1"
        memory: "512Mi"
      requests:
        cpu: 500m
        memory: "256Mi"
  ...
```

https://kubernetes.io/docs/tasks/configure-pod-container/assign-cpu-resource
https://kubernetes.io/docs/tasks/configure-pod-container/assign-memory-resource

Pod/Container Security Context

```
spec:
  securityContext:
    runAsNonRoot: true
  containers:
    securityContext:
      allowPrivilegeEscalation: false
      privileged: false
      runAsNonRoot: true
      readOnlyRootFilesystem: true
      capabilities:
        drop:
          - ALL
```

https://kubernetes.io/docs/tasks/configure-pod-container/security-context

Pod Security Policy (Still In Beta!)

```
apiVersion: policy/v1beta1
kind: PodSecurityPolicy
metadata:
  name: no-root-policy
spec:
  privileged: false
  allowPrivilegeEscalation: false
  requiredDropCapabilities:
    - ALL
  runAsUser:
    rule: 'MustRunAsNonRoot'
  ...
```

https://kubernetes.io/docs/concepts/policy/pod-security-policy

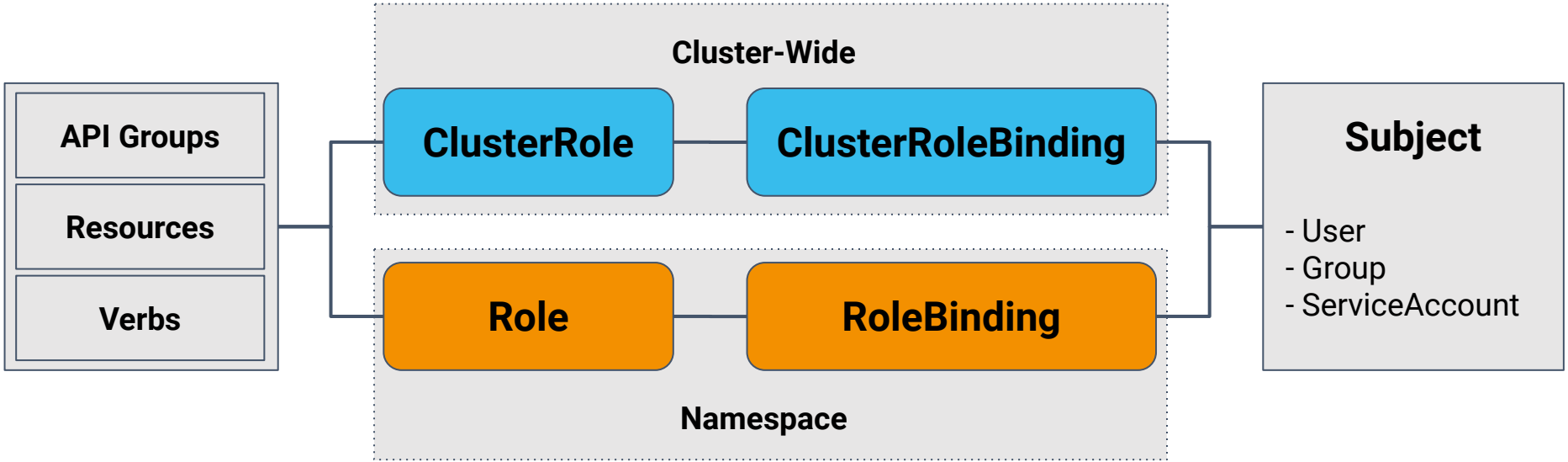
Pod Security Policy (Policy Order)

```
Policy order selection criteria:

1.  Policies which allow the pod as-is are preferred
2.  If pod must be defaulted or mutated, the first
    policy (ordered by name) to allow the pod is
    selected.
```

https://kubernetes.io/docs/concepts/policy/pod-security-policy/#policy-order
https://kubernetes.io/docs/reference/access-authn-authz/admission-controllers

Kubernetes Role Based Access Control (RBAC)



https://kubernetes.io/docs/reference/access-authn-authz/rbac/

Kubernetes Role Based Access Control (RBAC)

apiGroups	extensions, apps, policy, ...
resources	pods, deployments, configmaps, secrets, nodes, services, endpoints, podsecuritypolicies, ...
verbs	get, list, watch, create, update, patch, delete, use, ...

https://kubernetes.io/docs/reference/access-authn-authz/rbac/

Pod Security Policy Role

```
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  name: no-root-policy-role
  namespace: default
rules:
  - apiGroups: ['policy']
    resources: ['podsecuritypolicies']
    verbs:     ['use']
    resourceNames:
      - no-root-policy
```

https://kubernetes.io/docs/concepts/policy/pod-security-policy/#authorizing-policies

Service Account

```
apiVersion: v1
kind: ServiceAccount
metadata:
  name: deploy-pod-security-policy
  namespace: default
```

https://kubernetes.io/docs/concepts/policy/pod-security-policy/#authorizing-policies

Pod Security Policy Role Binding

```
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  name: deploy-pod-security-policy
  namespace: default
roleRef:
  kind: Role
  name: no-root-policy-role
  apiGroup: rbac.authorization.k8s.io
subjects:
  - kind: ServiceAccount
    name: deploy-pod-security-policy
    namespace: default
```

Helm 3 Is Here! 😀

https://v3.helm.sh
https://helm.sh/docs/faq/#removal-of-tiller

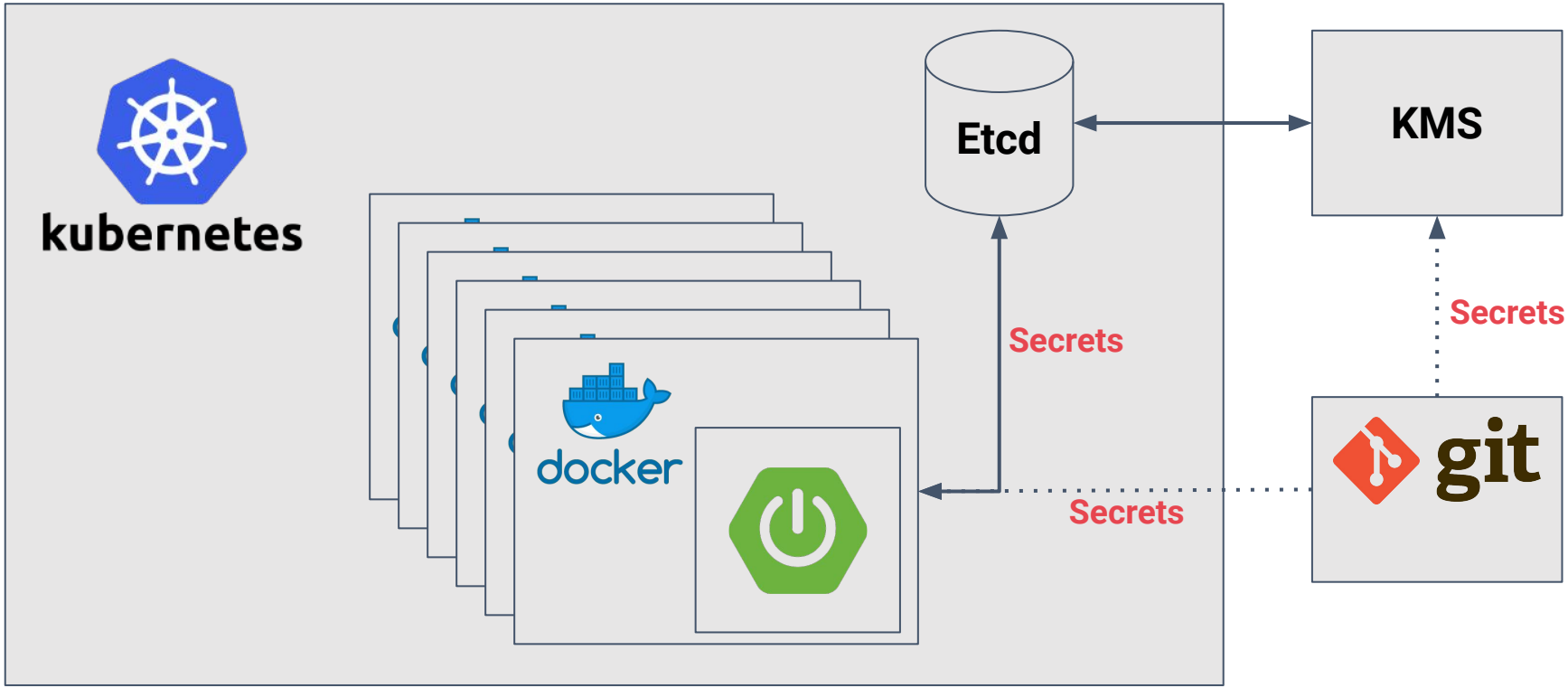
Live Demo: Show me the code

Iteration 3: Kubernetes Security

https://github.com/andifalk/secure-development-on-kubernetes

The Path for Secure Development on K8s

Kubernetes Secrets



Kubernetes Secrets

```
apiVersion: v1
kind: Secret
metadata:
  name: hello-spring-cloud-kubernetes
  namespace: default
type: Opaque
data:
  user.username: dXNlcg==
  user.password: azhzX3VzZXI=
  admin.username: YWRtaW4=
  admin.password: azhzX2FkbWlu
```

https://kubernetes.io/docs/concepts/configuration/secret

Kubernetes Secrets - Best Practices

- Encrypt Secret Data at Rest
  Only Base64 Encoded by Default!
- Applications interacting with secrets API should be limited using RBAC

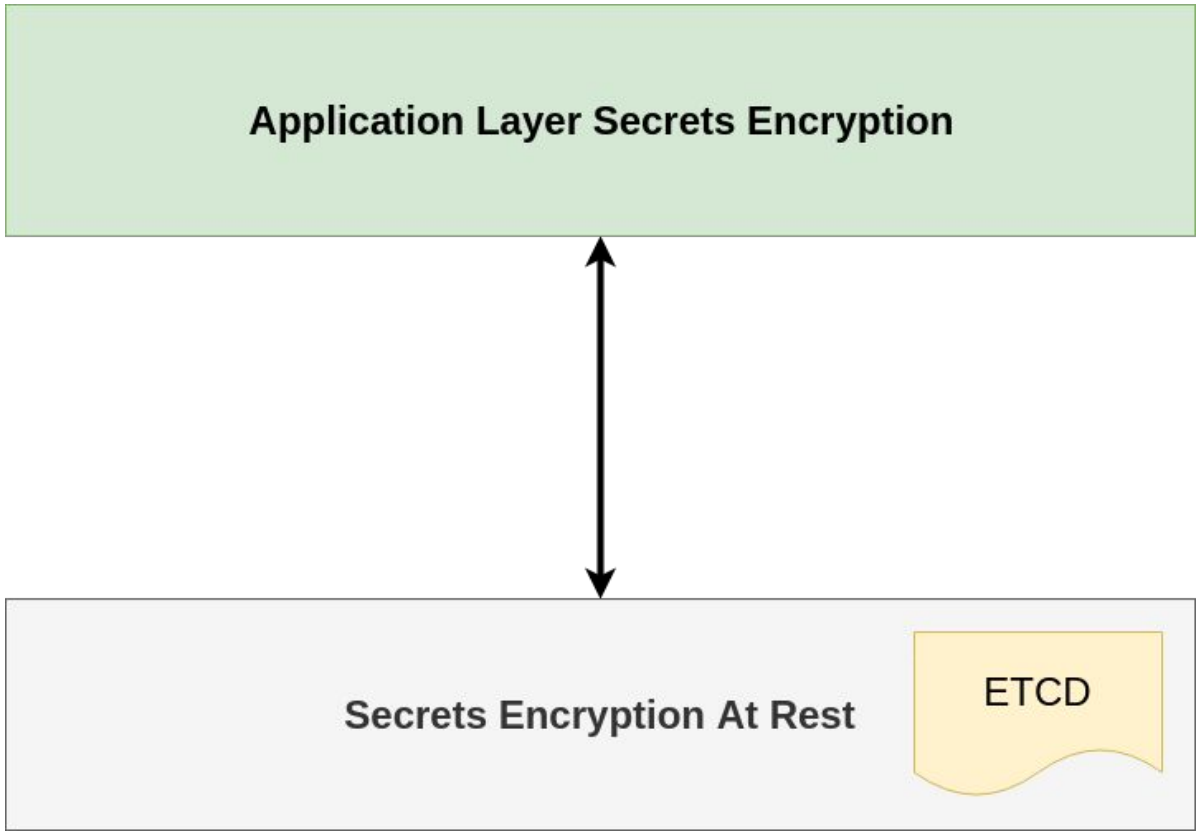
https://kubernetes.io/docs/concepts/configuration/secret/#best-practices
https://kubernetes.io/docs/tasks/administer-cluster/encrypt-data

Pay Attention to Spring Boot Actuator

```
{
      "name": "applicationConfig: ...",
      "properties": {
        "greet.my-sec": {
          "value": "geheim",
          "origin": "class path resource ..."
        },
        "greet.password": {
          "value": "******",
          "origin": "class path resource ..."
        }
}
```

http://localhost:8080/actuator/env

Encryption Layers



Envelope Encryption On Kubernetes

https://cloud.google.com/kms/docs/envelope-encryption
https://kubernetes.io/docs/tasks/administer-cluster/kms-provider

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Key Management System (KMS) Cloud Providers

- Azure Key Vault (Key Vault FlexVolume)
- Google Cloud KMS
- AWS KMS
- ...

https://github.com/Azure/kubernetes-kms
https://github.com/Azure/kubernetes-keyvault-flexvol
https://cloud.google.com/kms
https://aws.amazon.com/de/kms

What about Secrets in 

- Sealed Secrets
- Helm Secrets
- Kamus
- Sops
- Hashicorp Vault

https://learnk8s.io/kubernetes-secrets-in-git
https://github.com/bitnami-labs/sealed-secrets
https://github.com/futuresimple/helm-secrets
https://github.com/Soluto/kamus
https://github.com/mozilla/sops
https://www.vaultproject.io

Conclusion

Conclusion / Key Insights

- Docker runs on Host using Linux Namespaces
- Say NO to root on K8s
- “Least privilege” for service accounts
- Ensure your secrets are encrypted in K8s
- Keep K8s and container images up-to-date

Books and Online References

Books and Online References (1)

- Kubernetes Security, O'Reilly, 2018, ISBN: 978-1-492-04600-4
- Cloud Native DevOps with Kubernetes, O'Reilly, 2019, ISBN: 978-1492040767
- https://github.com/andifalk/secure-development-on-kubernetes
- Crafty Requests: Deep Dive Into Kubernetes CVE-2018-1002105 - Ian Coldwater (Video)
- Ship of Fools: Shoring Up Kubernetes Security - Ian Coldwater (Video)
- https://kubernetes.io/docs/concepts/security/overview/#the-4c-s-of-cloud-native-security
- https://kubernetes.io/docs/tasks/administer-cluster/securing-a-cluster
- https://opensource.com/article/18/3/just-say-no-root-containers
- https://github.com/GoogleContainerTools/jib
- https://anchore.com/opensource/
- https://github.com/coreos/clair
- https://github.com/aquasecurity/trivy
- https://www.owasp.org/index.php/OWASP_Docker_Top_10

Books and Online References (2)

- https://kubernetes.io/docs/tasks/configure-pod-container/assign-cpu-resource
- https://kubernetes.io/docs/tasks/configure-pod-container/assign-memory-resource
- https://kubernetes.io/docs/tasks/configure-pod-container/security-context
- https://kubernetes.io/docs/concepts/policy/pod-security-policy
- https://kubernetes.io/docs/reference/access-authn-authz/rbac/
- https://kubernetes.io/docs/concepts/configuration/secret
- https://kubernetes.io/docs/tasks/administer-cluster/encrypt-data
- https://cloud.google.com/kms/docs/envelope-encryption
- https://kubernetes.io/docs/tasks/administer-cluster/kms-provider
- https://github.com/Azure/kubernetes-kms
- https://cloud.google.com/kms
- https://aws.amazon.com/de/kms

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