NOVATEC

Secure Development on Kubernetes

Container / K8s Security

Andreas Falk

Agenda

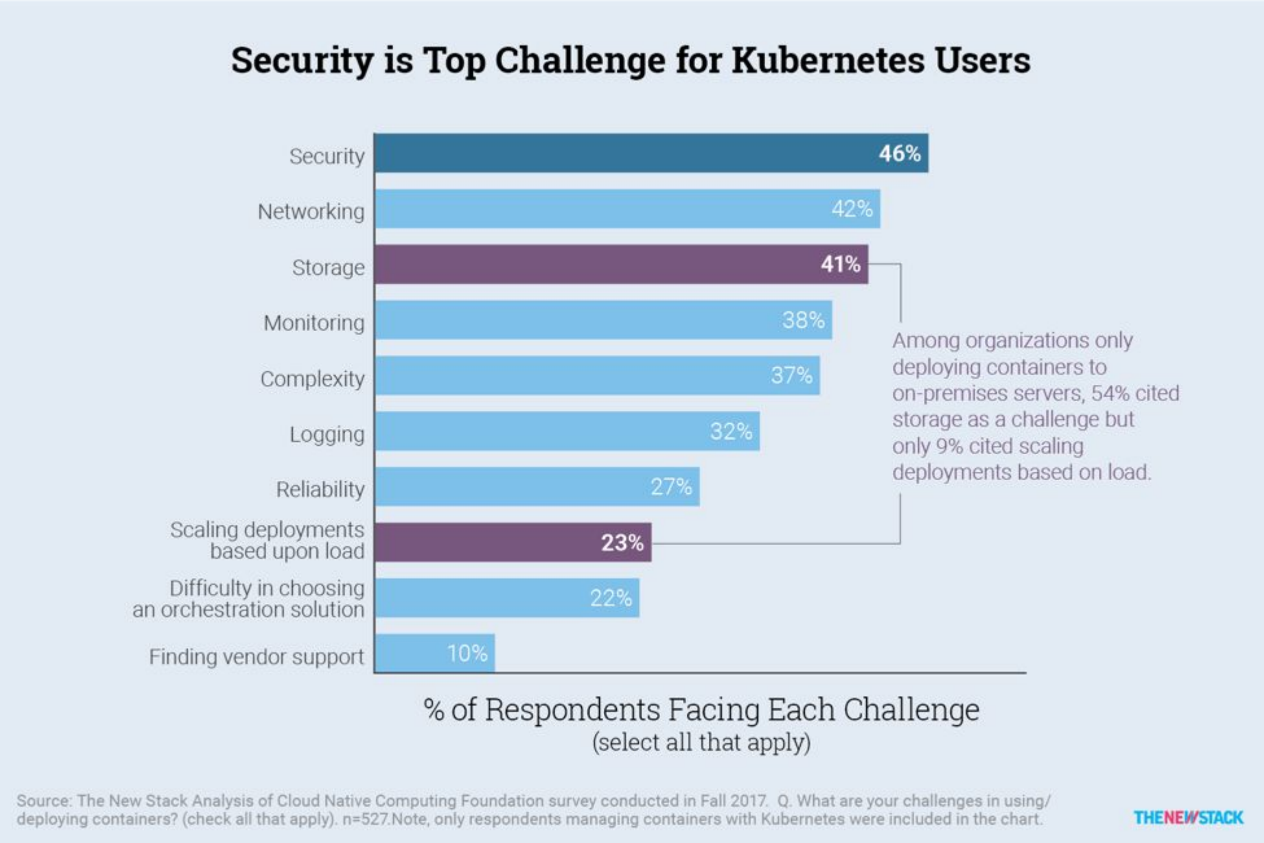
1. What can go wrong
2. Application Security
3. Container Security
4. Kubernetes Security
5. Kubernetes Secrets

What can go wrong?

Introduction

Top Challenges in Kubernetes

Source: https://thenewstack.io



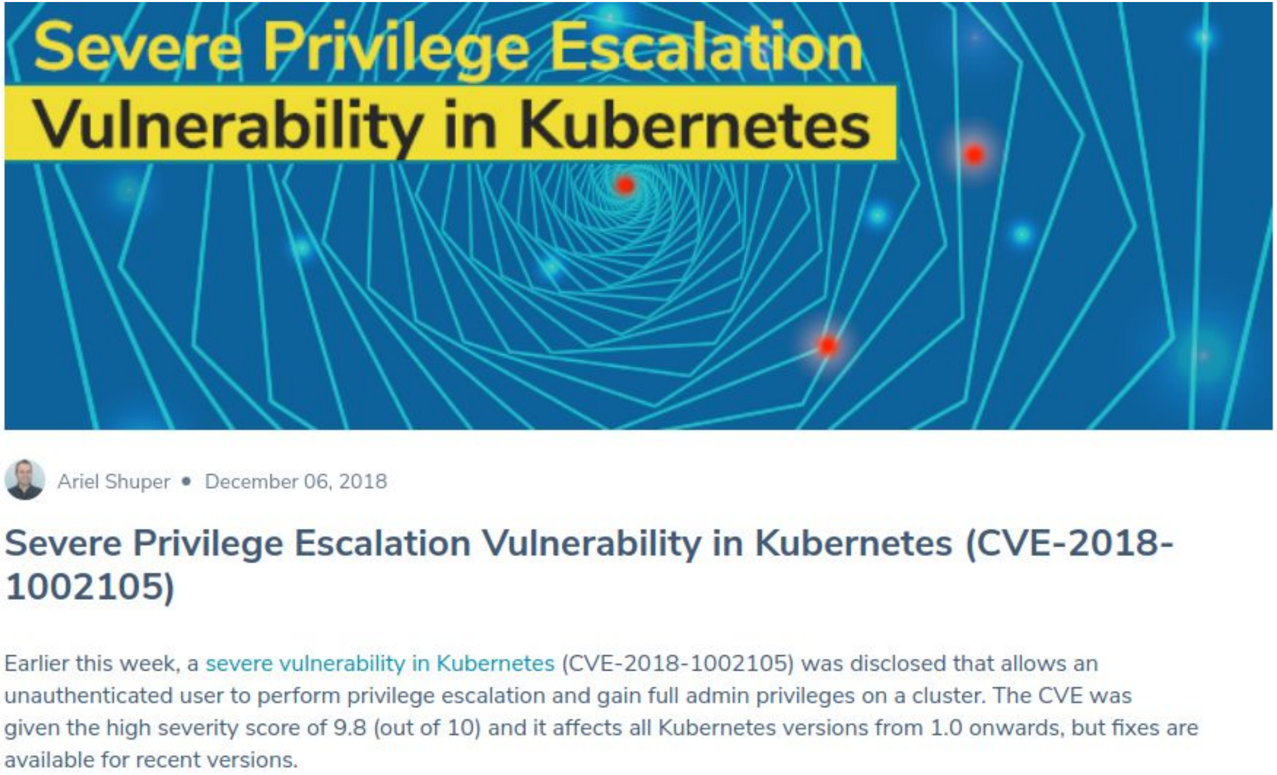
Security is Top Challenge for Kubernetes Users

Among organizations only deploying containers to on-premises servers, 54% cited storage as a challenge but only 9% cited scaling deployments based on load.

Source: The New Stack Analysis of Cloud Native Computing Foundation survey conducted in Fall 2017. Q. What are your challenges in using/deploying containers? (check all that apply). n=527.Note, only respondents managing containers with Kubernetes were included in the chart.

Severe Vulnerability in Kubernetes

Source: https://blog.aquasec.com



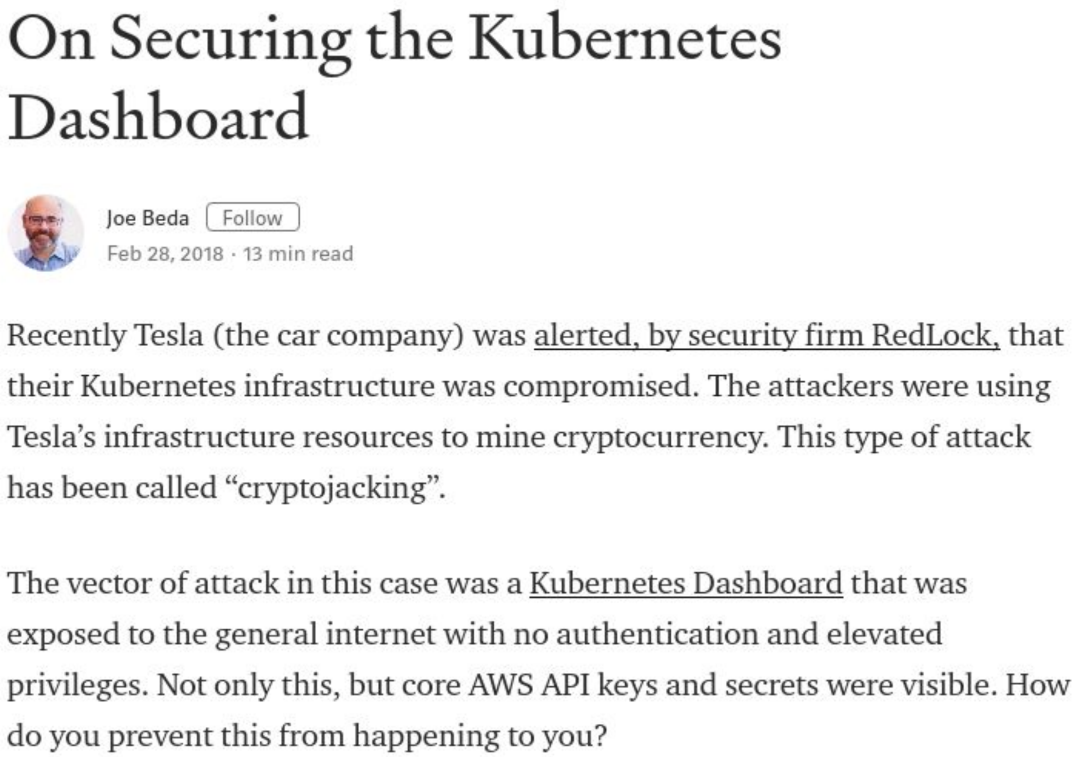
Ariel Shuper • December 06, 2018

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.

Crypto Mining Via K8s Dashboard

Source: https://blog.heptio.com



On Securing the Kubernetes Dashboard

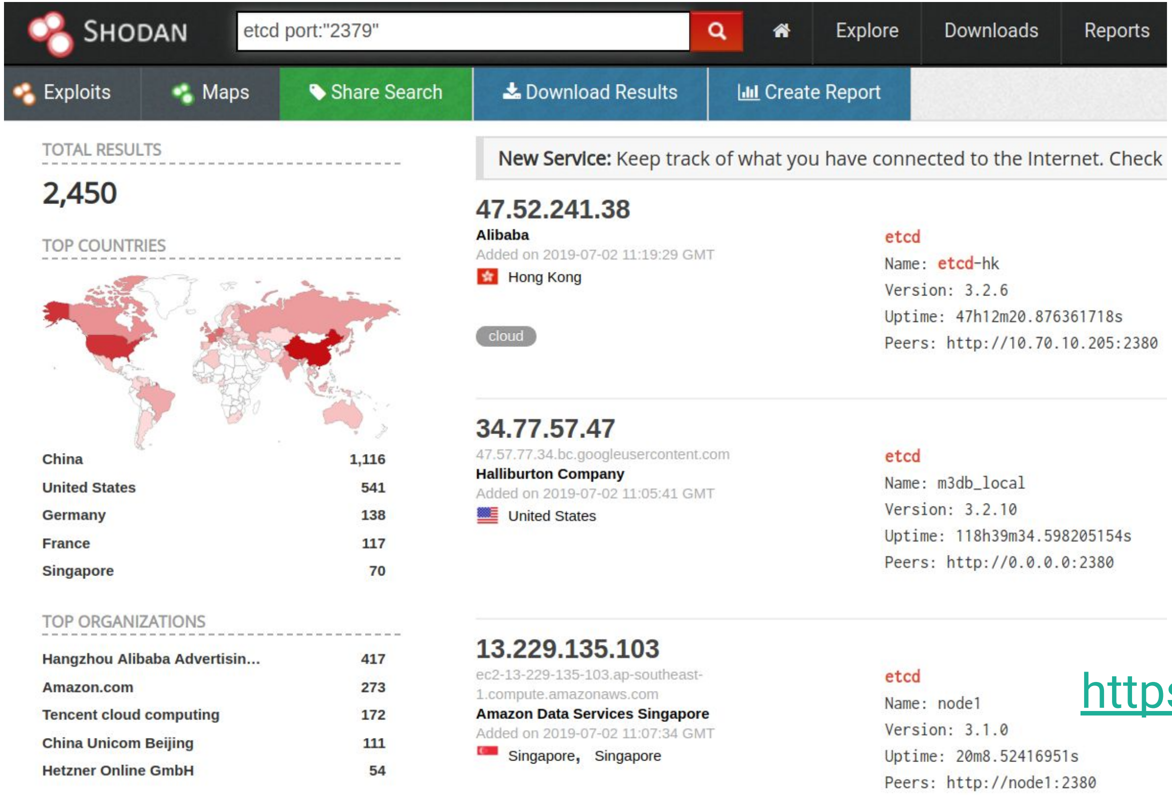
Joe Beda Follow

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)



TOTAL RESULTS

2,450

TOP COUNTRIES

China	1,116
United States	541
Germany	138
France	117
Singapore	70

TOP ORGANIZATIONS

Hangzhou Alibaba Advertisin...	417
Amazon.com	273
Tencent cloud computing	172
China Unicom Beijing	111
Hetzner Online GmbH	54

New Service: Keep track of what you have connected to the Internet. Check

47.52.241.38
Alibaba
Added on 2019-07-02 11:19:29 GMT
Hong Kong
cloud

```
etcd
Name: etcd-hk
Version: 3.2.6
Uptime: 47h12m20.876361718s
Peers: http://10.70.10.205:2380
```

34.77.57.47
47.57.77.34.bc.googleusercontent.com
Halliburton Company
Added on 2019-07-02 11:05:41 GMT
United States

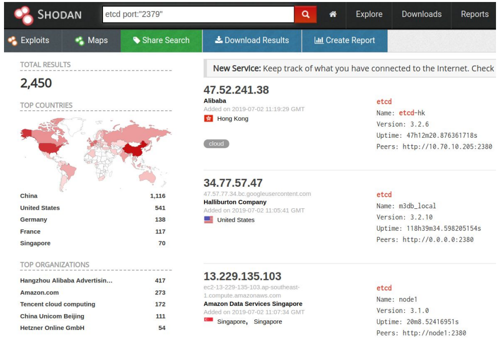
```
etcd
Name: m3db_local
Version: 3.2.10
Uptime: 118h39m34.598205154s
Peers: http://0.0.0.0:2380
```

13.229.135.103
ec2-13-229-135-103.ap-southeast-1.compute.amazonaws.com
Amazon Data Services Singapore
Added on 2019-07-02 11:07:34 GMT
Singapore, Singapore

```
etcd
Name: node1
Version: 3.1.0
Uptime: 20m8.52416951s
Peers: http://node1:2380
```

https://shodan.io

Open ETCD Ports in Kubernetes (2)



New Service: Keep track of what you have connected to the Internet. Check

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ec2-13-229-135-103.ap-southeast-1.compute.amazonaws.com
Amazon Data Services Singapore
Added on 2019-07-02 11:07:34 GMT
Singapore, Singapore

```
etcd
Name: node1
Version: 3.1.0
Uptime: 20m8.52416951s
Peers: http://node1:2380
```

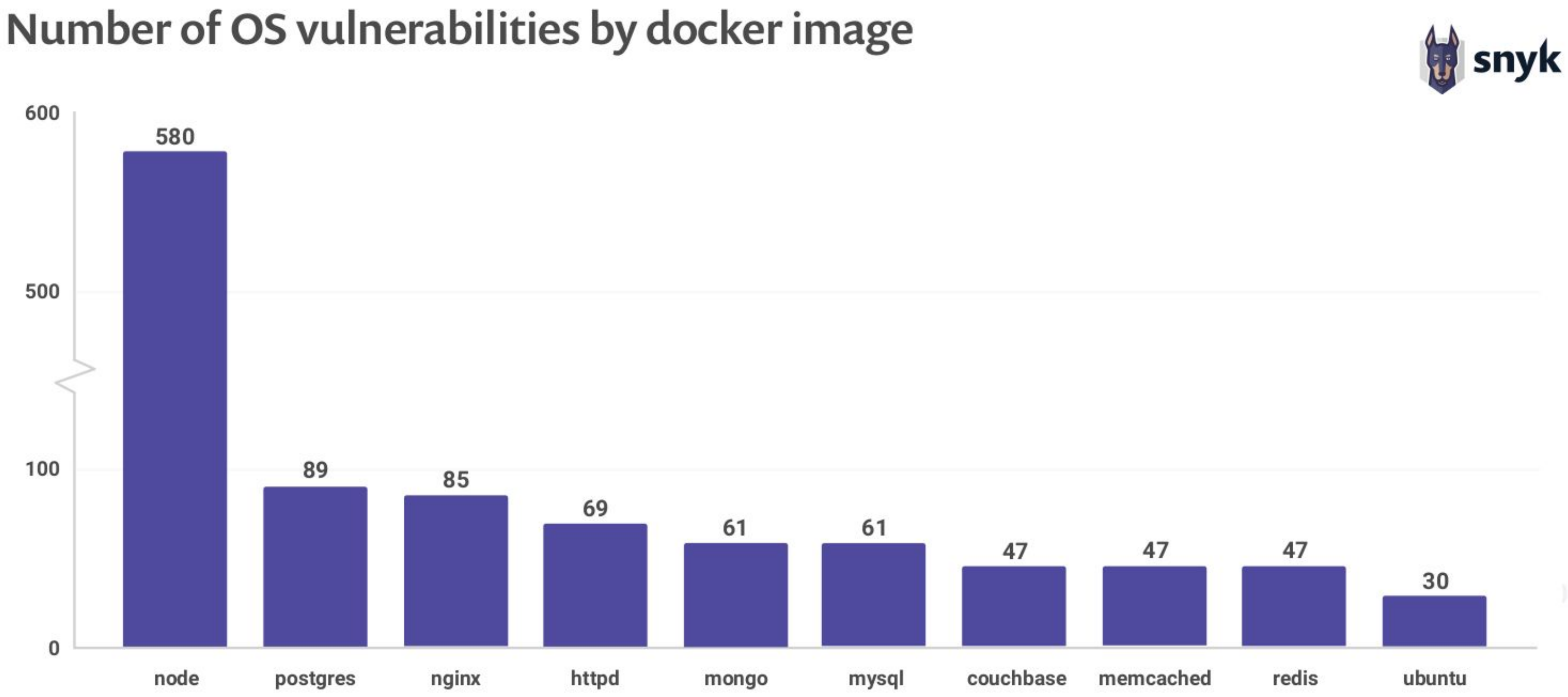
```
$ etcdctl --endpoints=http://xx.xx.xx.xx:2379
cluster-health

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

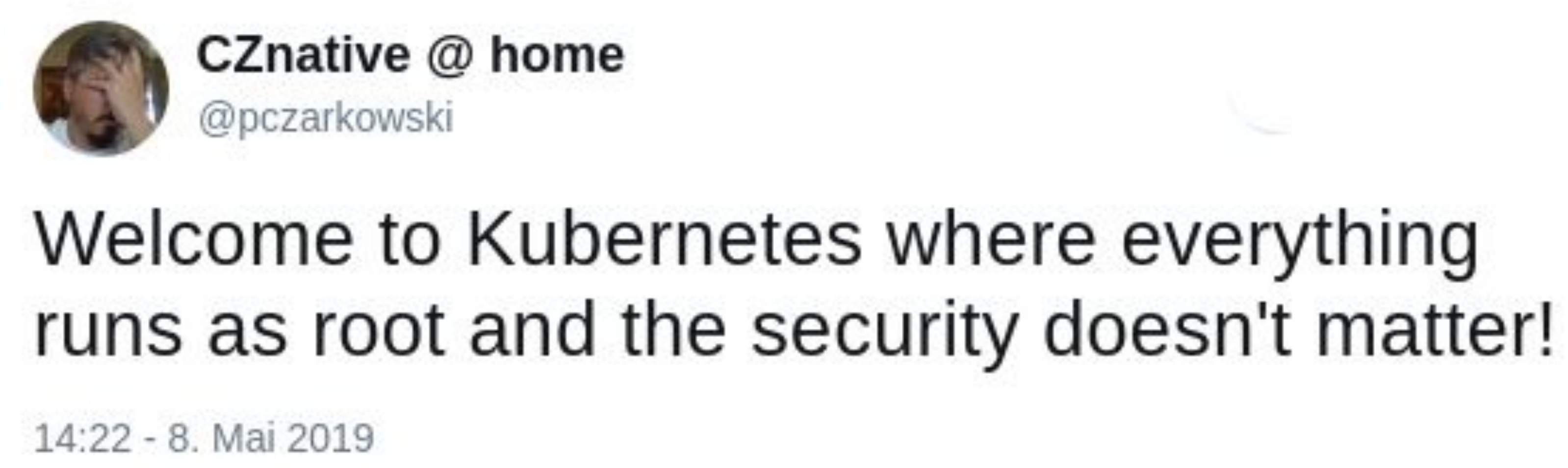
https://github.com/etcd-io/etcd/releases

Vulnerable Docker Images

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



All is Root 😱



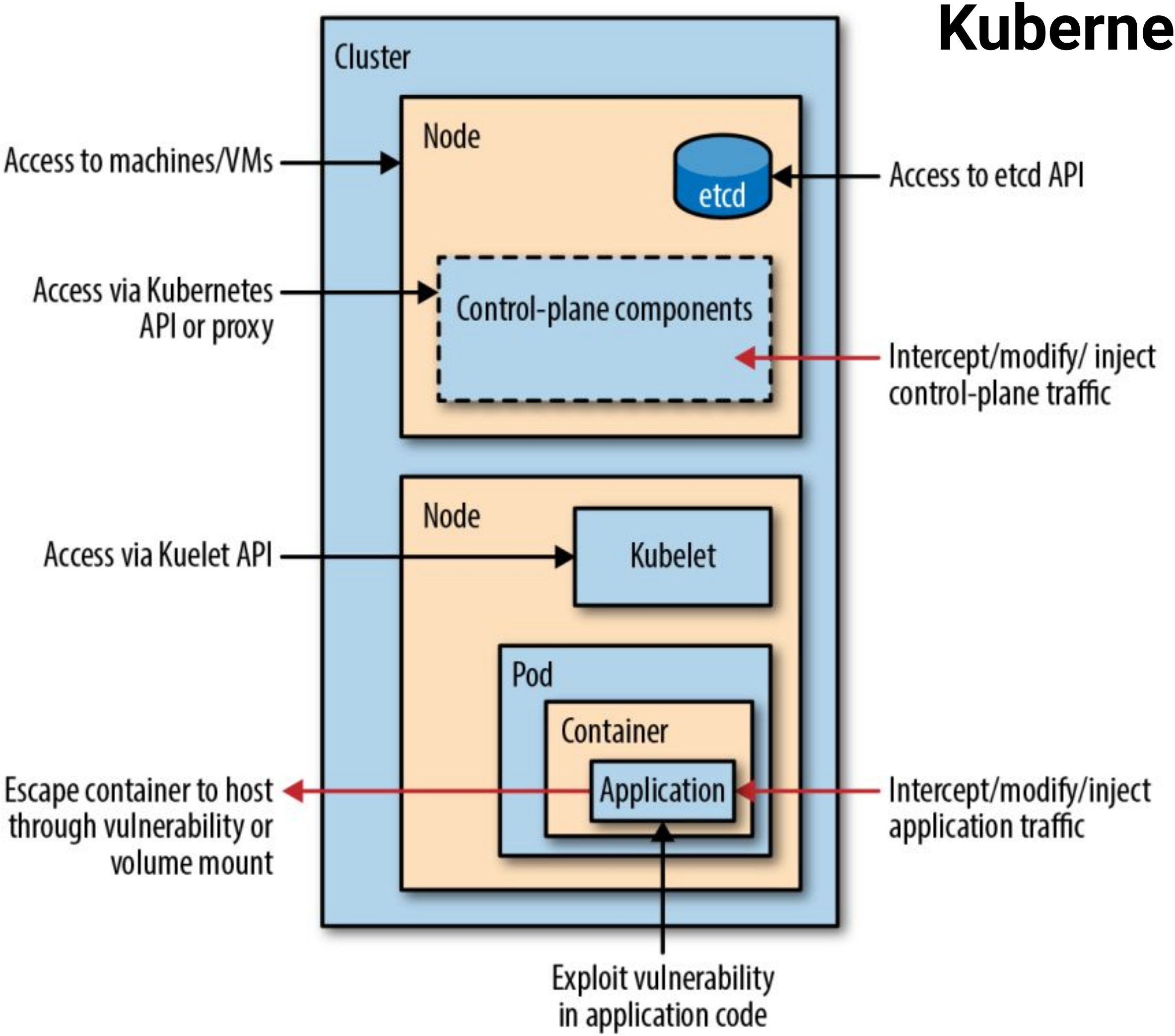
CZnative @ home
@pczarkowski

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

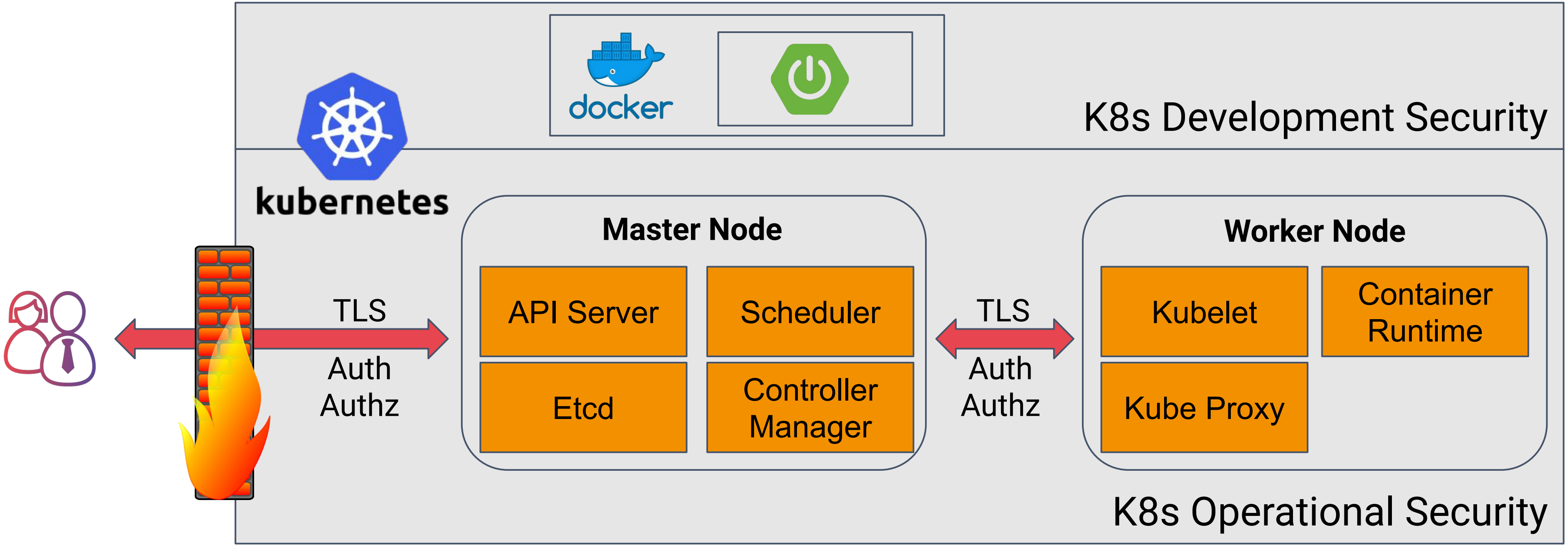
14:22 - 8. Mai 2019

Kubernetes attack vectors

Source:
Kubernetes Security, O’Reilly, 2018


Cluster
Node
etcd
Control-plane components
Node
Kubelet
Pod
Container
Application
Access to machines/VMs
Access via Kubernetes API or proxy
Access via Kuelet API
Escape container to host through vulnerability or volume mount
Access to etcd API
Intercept/modify/ inject control-plane traffic
Intercept/modify/inject application traffic
Exploit vulnerability in application code

Operational / Development Kubernetes Security



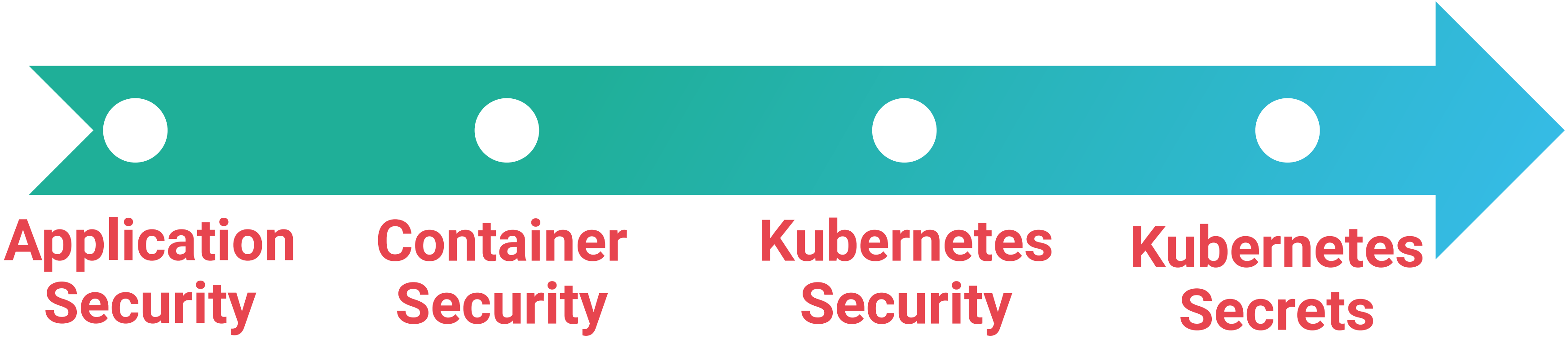
https://kubernetes.io/docs/concepts/security/overview/#the-4c-s-of-cloud-native-security

https://kubernetes.io/docs/tasks/administer-cluster/securing-a-cluster

So what can we do as developers?

Application- / Docker- / K8s-Security

The Path for Secure Development on K8s



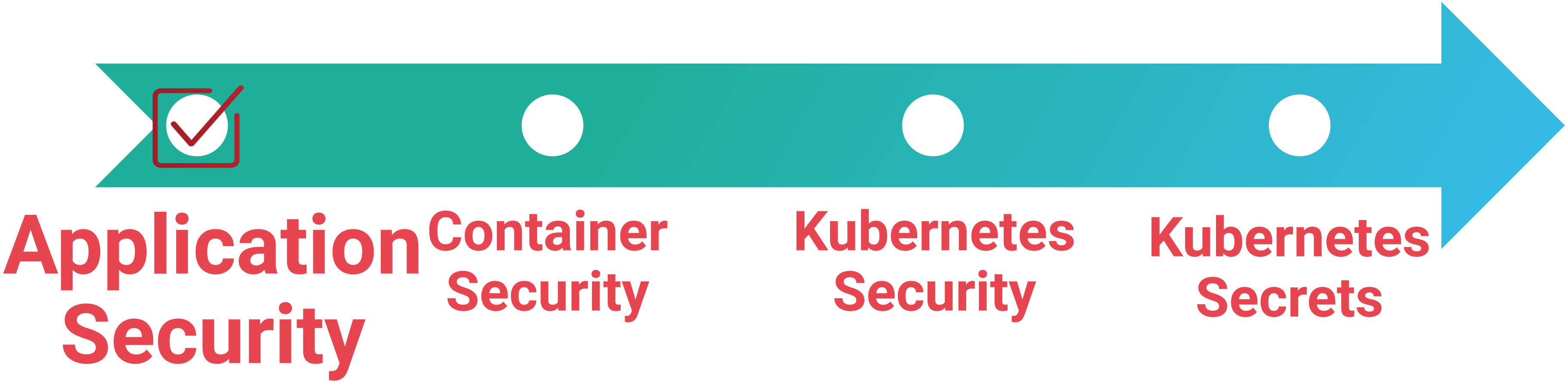
Application Security

Container Security

Kubernetes Security

Kubernetes Secrets

The Path for Secure Development on K8s



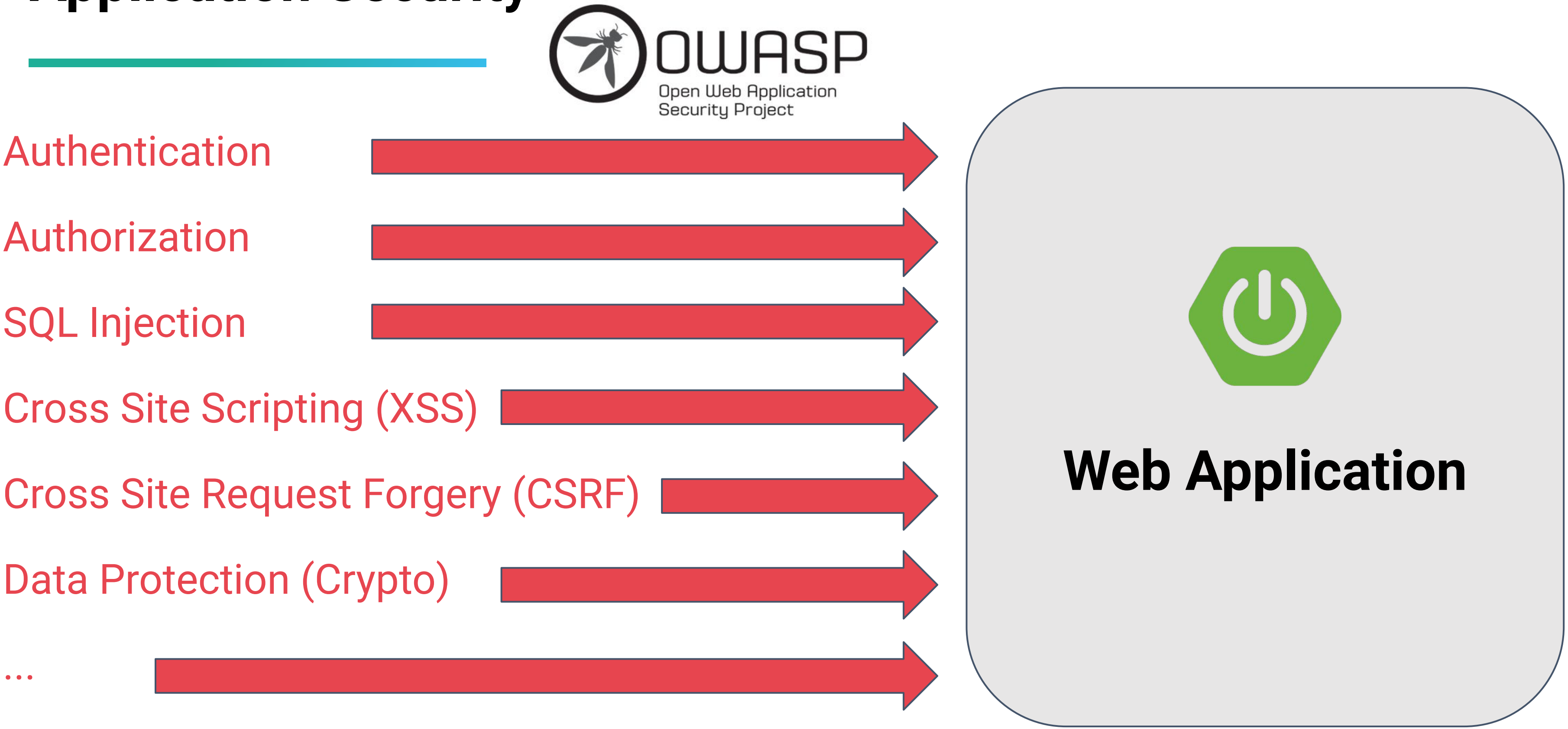
☑ Application Security

Container Security

Kubernetes Security

Kubernetes Secrets

Application Security



OWASP

Open Web Application Security Project

Authentication

Authorization

SQL Injection

Cross Site Scripting (XSS)

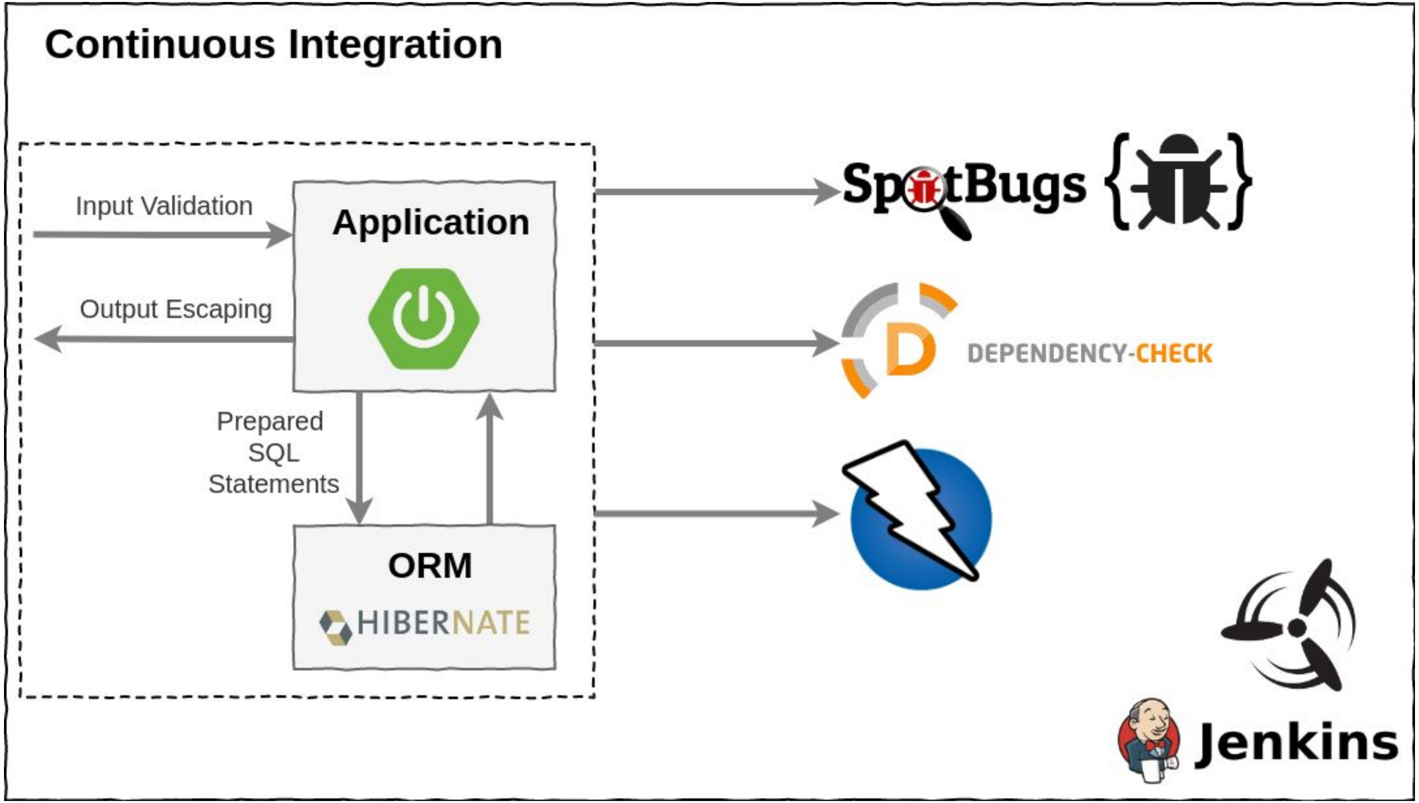
Cross Site Request Forgery (CSRF)

Data Protection (Crypto)

...

Web Application

Application Security

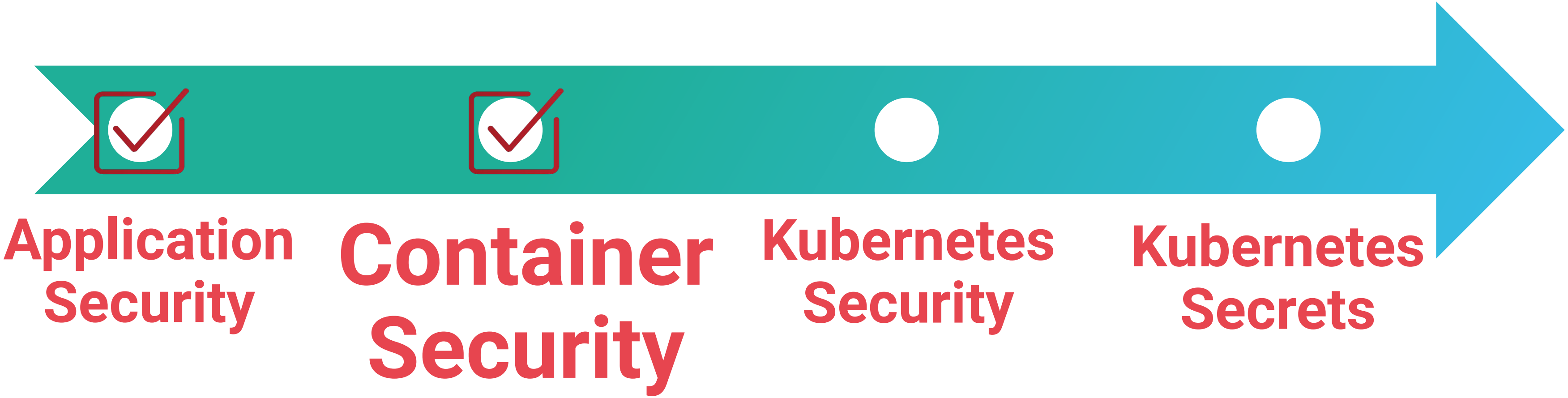


Live Demo: Show me the code

Iteration 1: Application Security

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

The Path for Secure Development on K8s



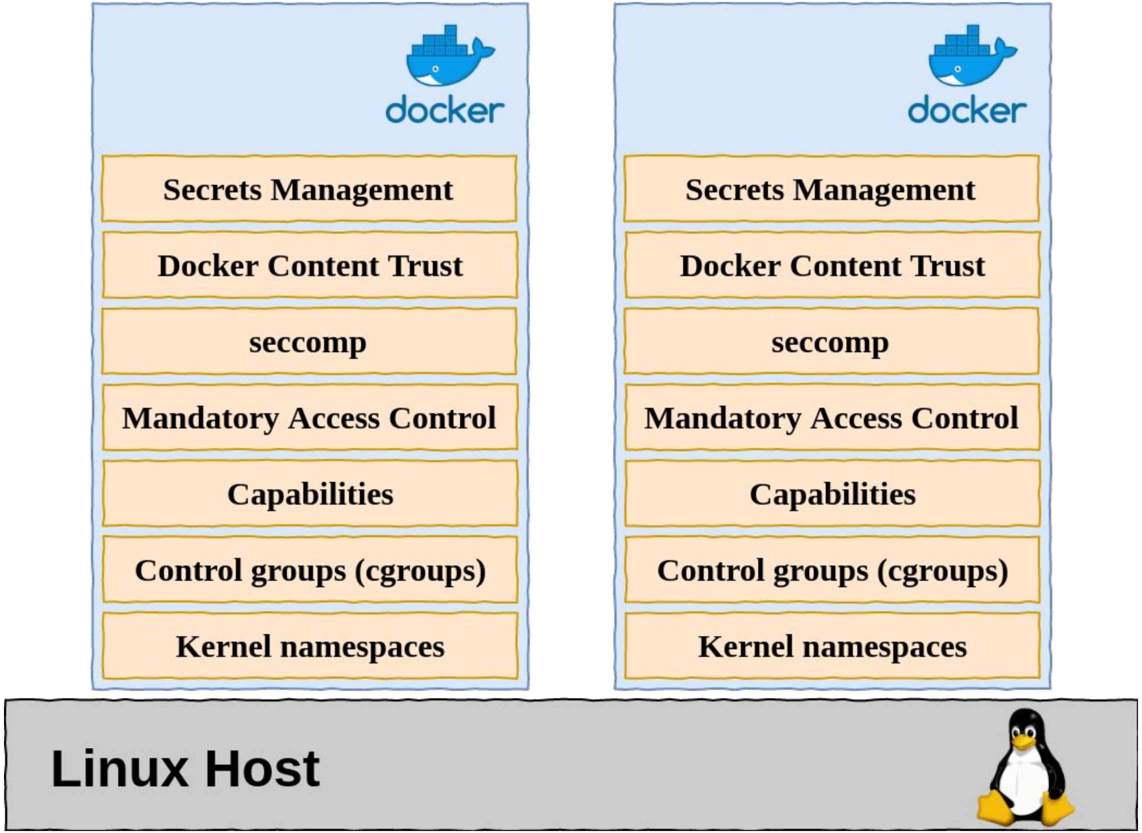
☑ Application Security

☑ Container Security

○ Kubernetes Security

○ Kubernetes Secrets

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

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)

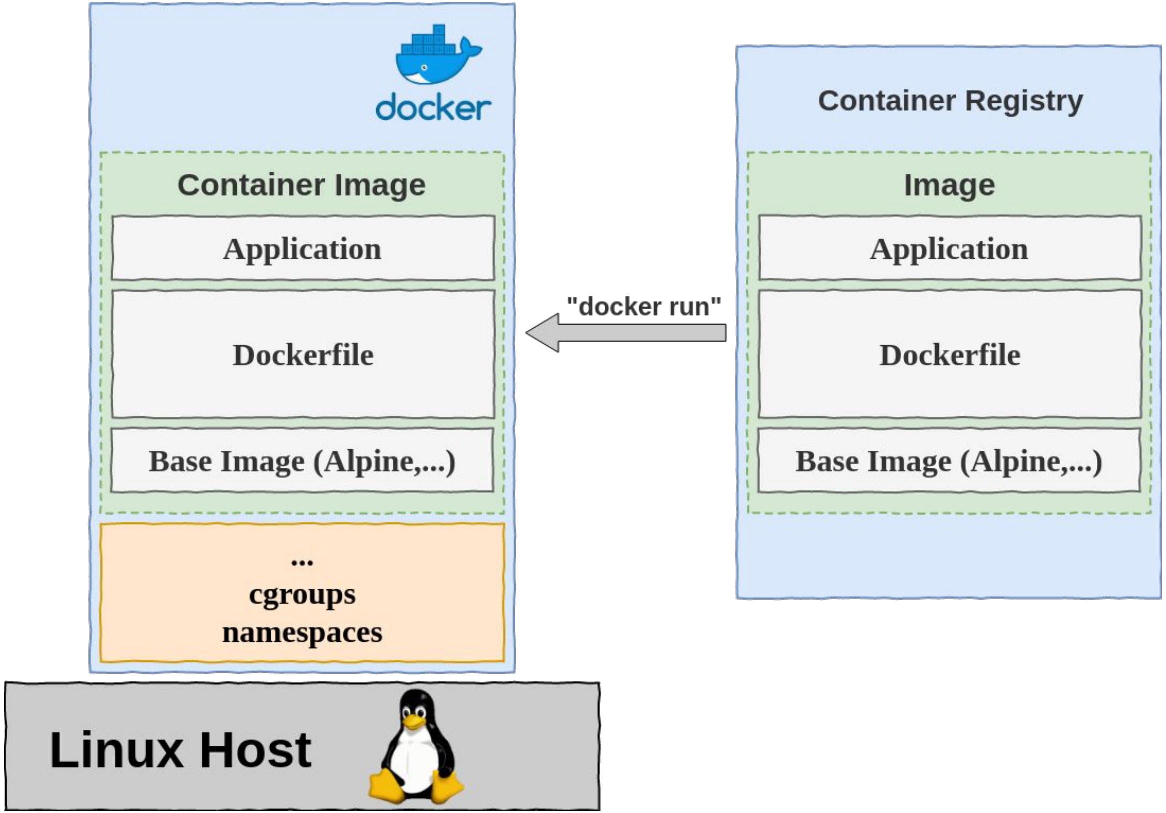
https://gitlab.com/apparmor/apparmor/wikis/home
https://github.com/SELinuxProject

Secure Computing Mode (SecComp)

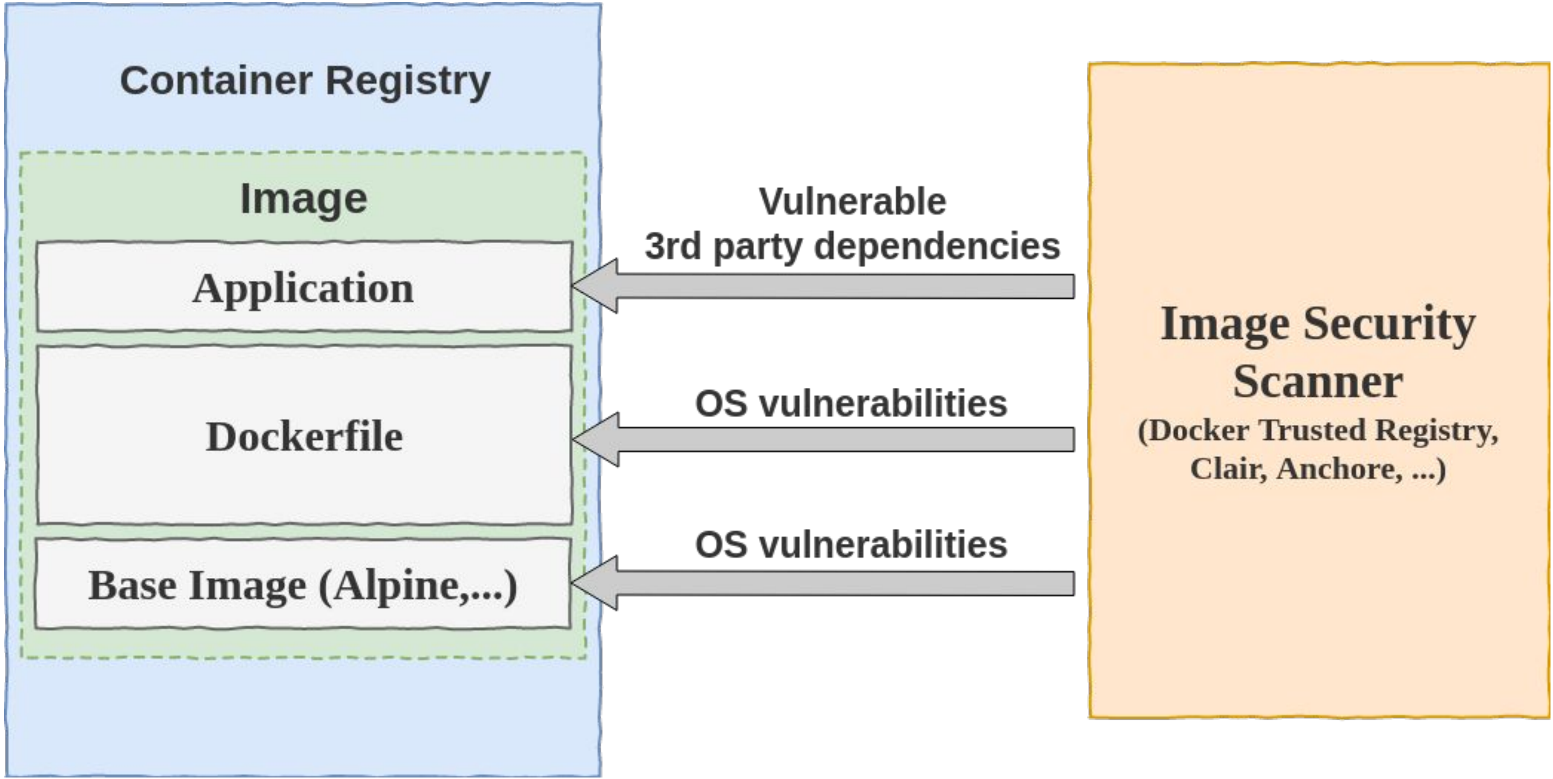
- Deny critical system calls by default
  - reboot
  - mount
  - swapon
  - …

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

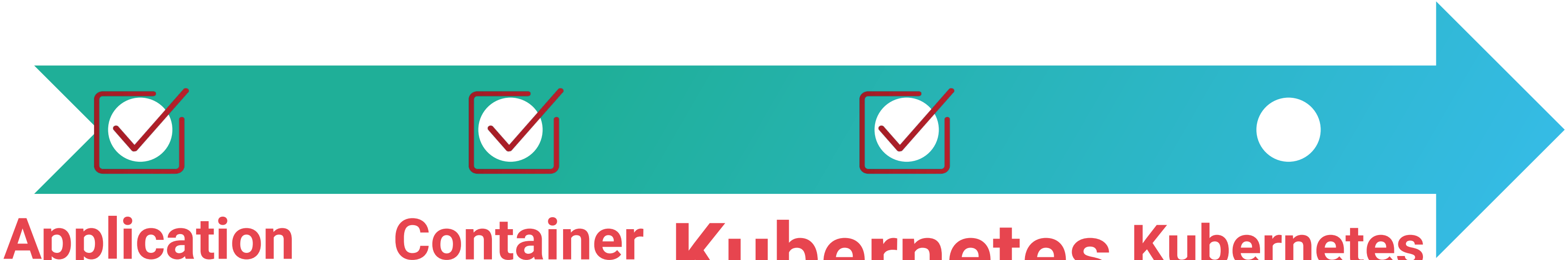
https://www.owasp.org/index.php/OWASP_Docker_Top_10

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



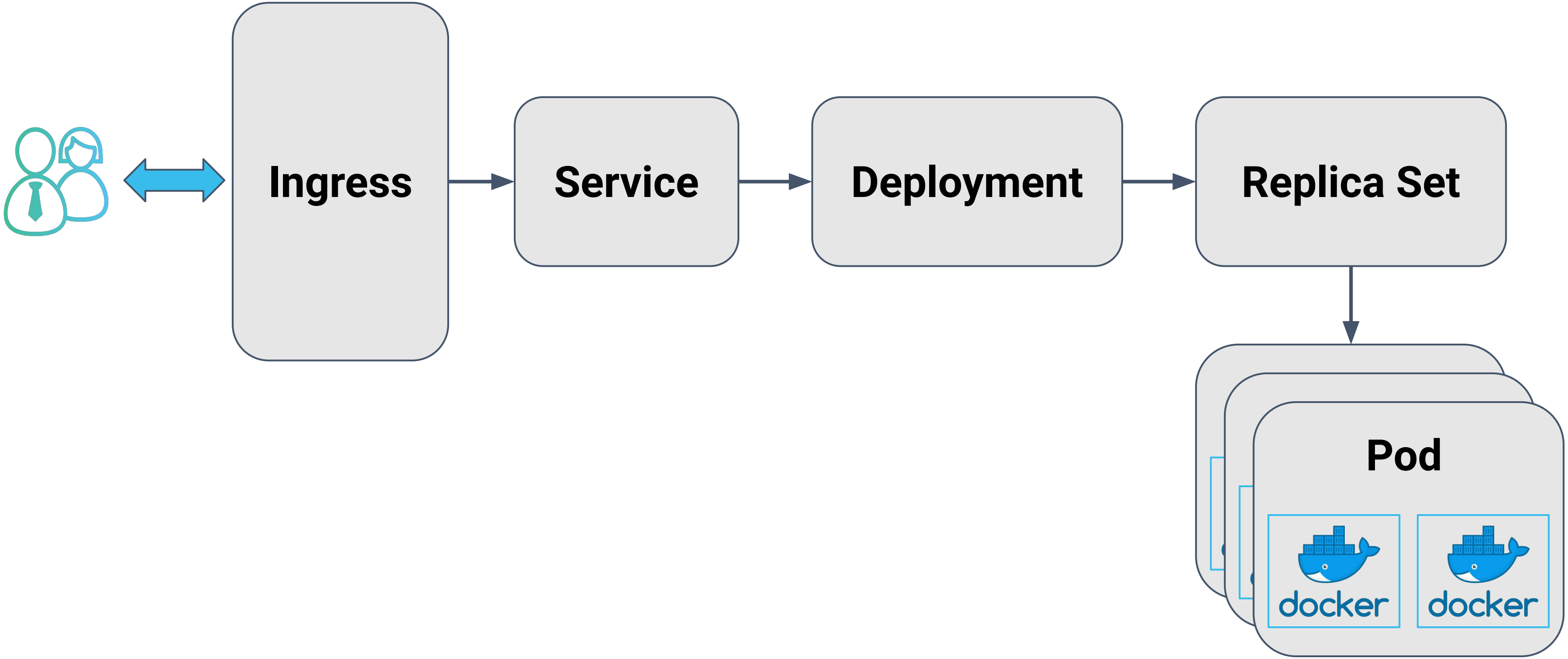
☑ Application Security

☑ Container Security

☑ **Kubernetes Security**

○ Kubernetes Secrets

Kubernetes Basics



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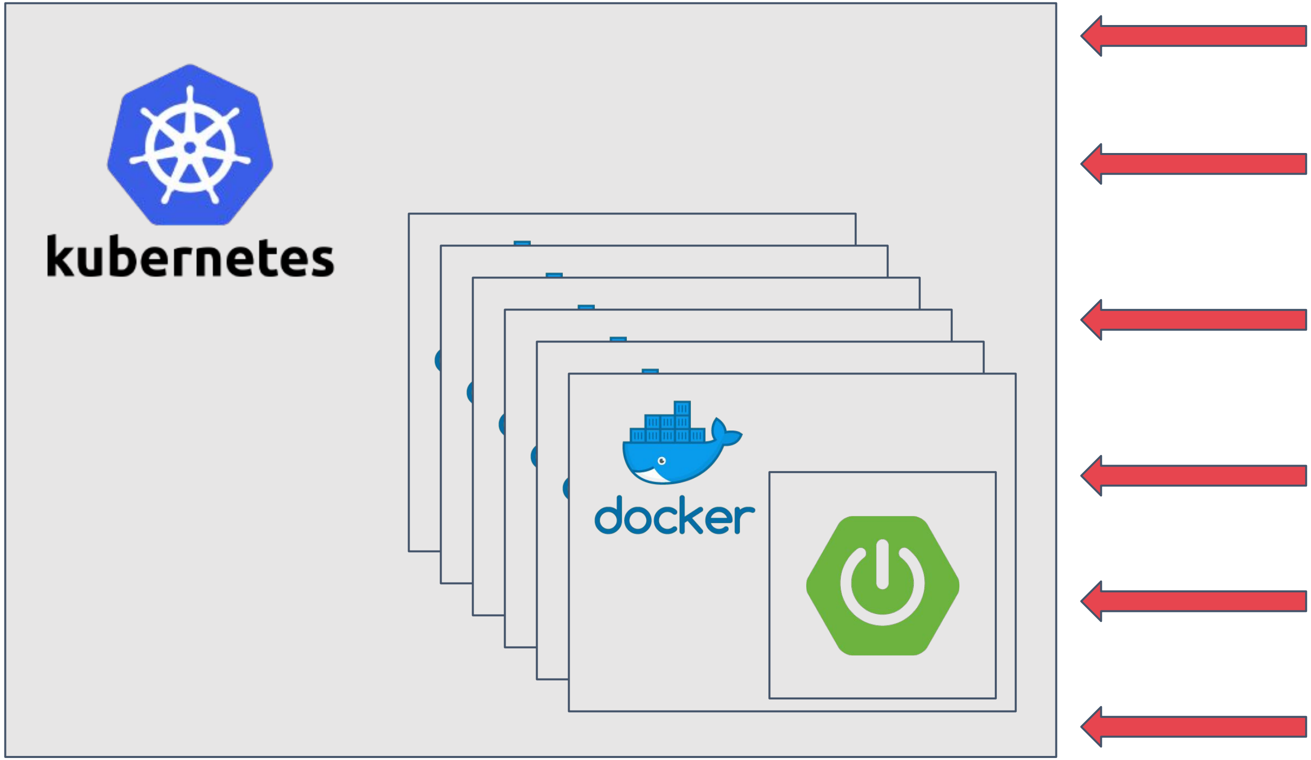
Kubernetes Security



Kubernetes Auditing

Network Policies

Role Based Access Control (RBAC)

Resource Limits

Pod Security Context

Pod Security Policy

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
```

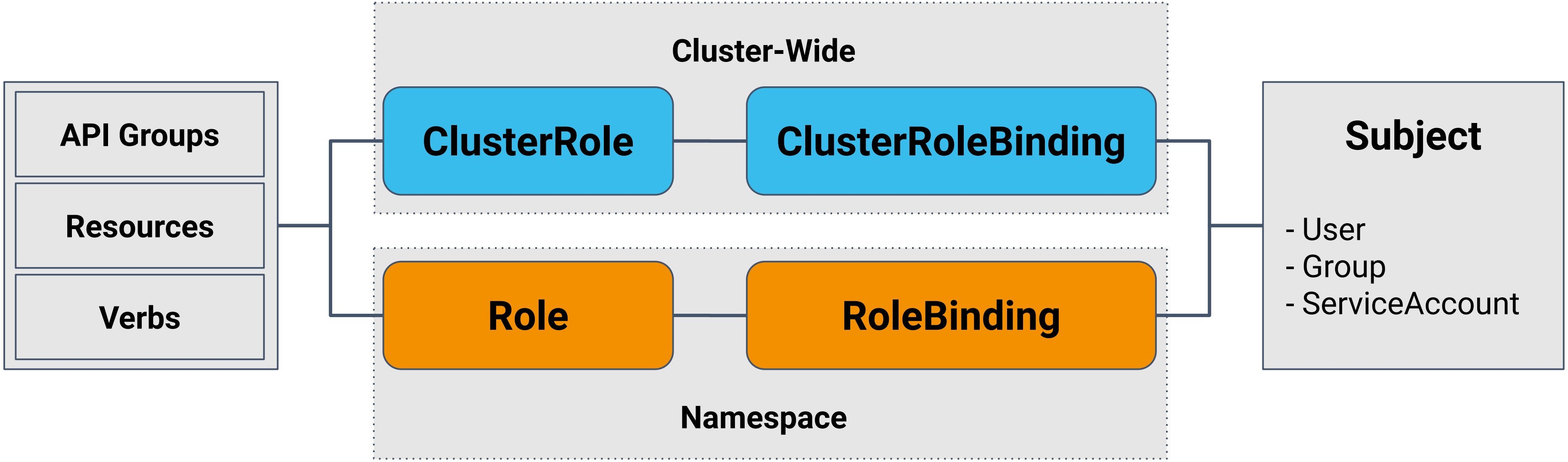
https://kubernetes.io/docs/tasks/configure-pod-container/security-context

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

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

```yaml
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

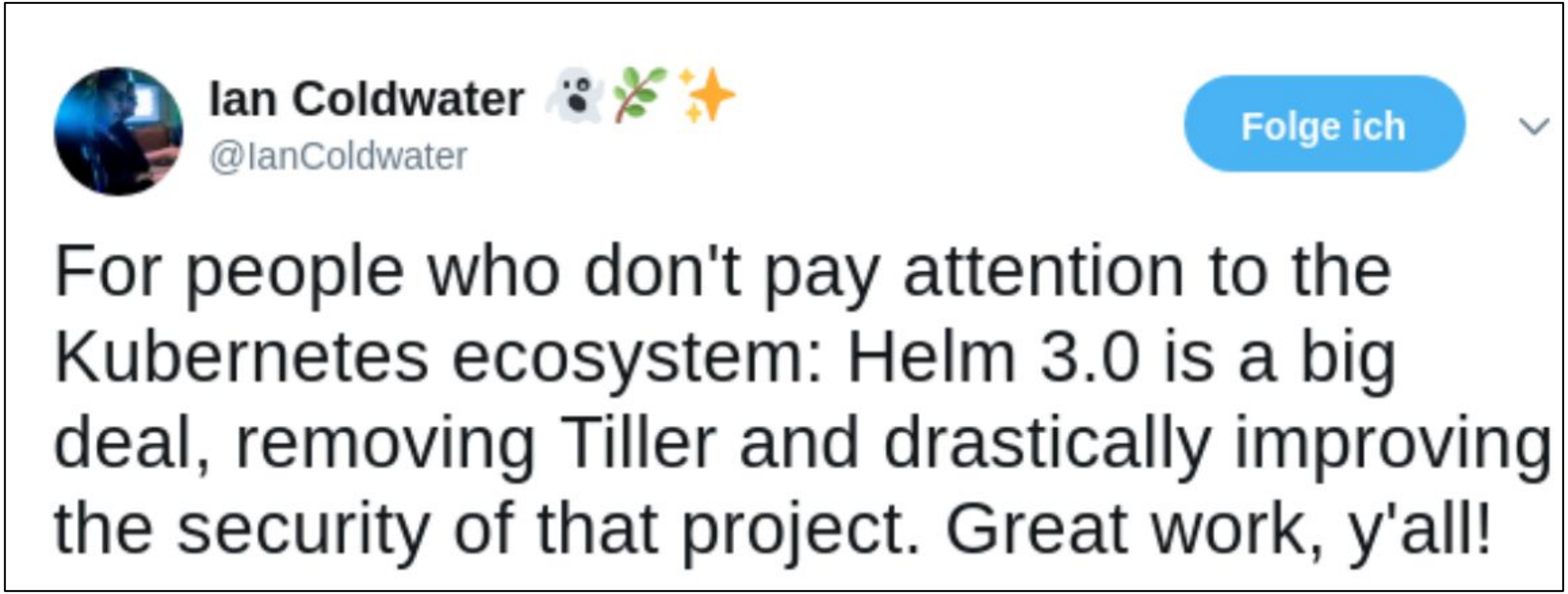
```yaml
apiVersion: v1
kind: ServiceAccount
metadata:
  name: deploy-pod-security-policy
  namespace: default
```

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

Pod Security Policy Role Binding

```yaml
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! 😀



Ian Coldwater 👻🌿✨
@IanColdwater

For people who don't pay attention to the Kubernetes ecosystem: Helm 3.0 is a big deal, removing Tiller and drastically improving the security of that project. Great work, y'all!

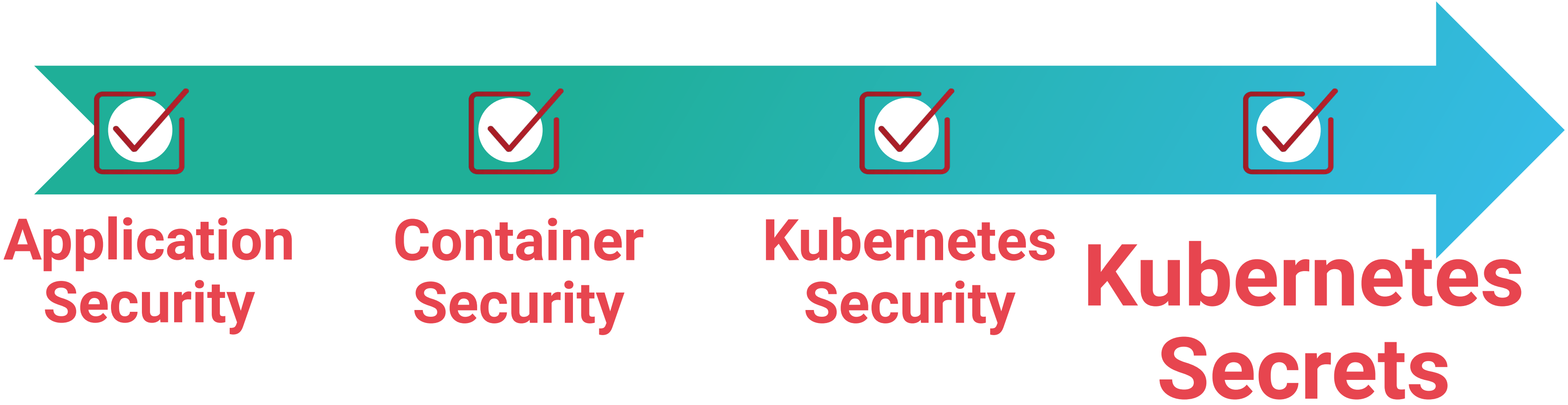
https://v3.helm.sh

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



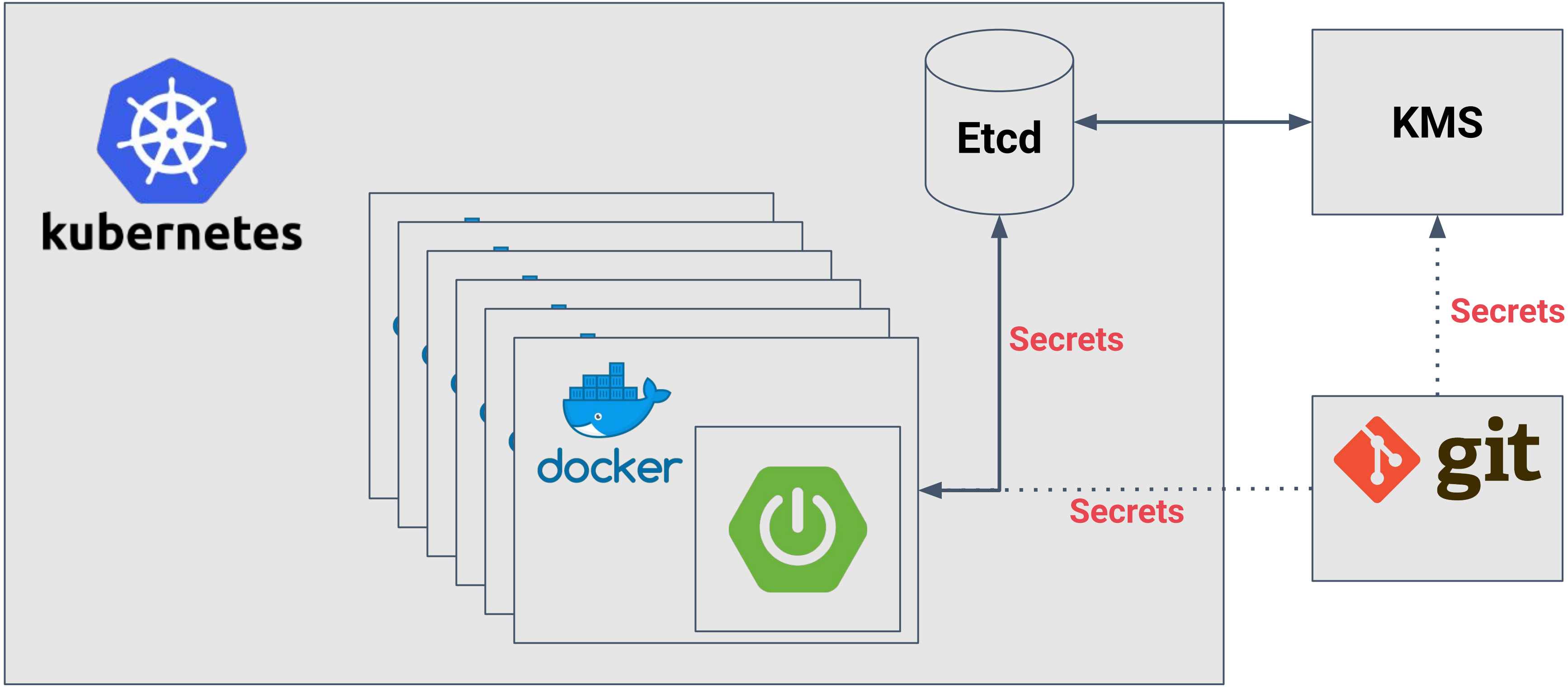
Application Security

Container Security

Kubernetes Security

Kubernetes Secrets

Kubernetes Secrets



kubernetes

Etcd

KMS

docker

git

Secrets

Secrets

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

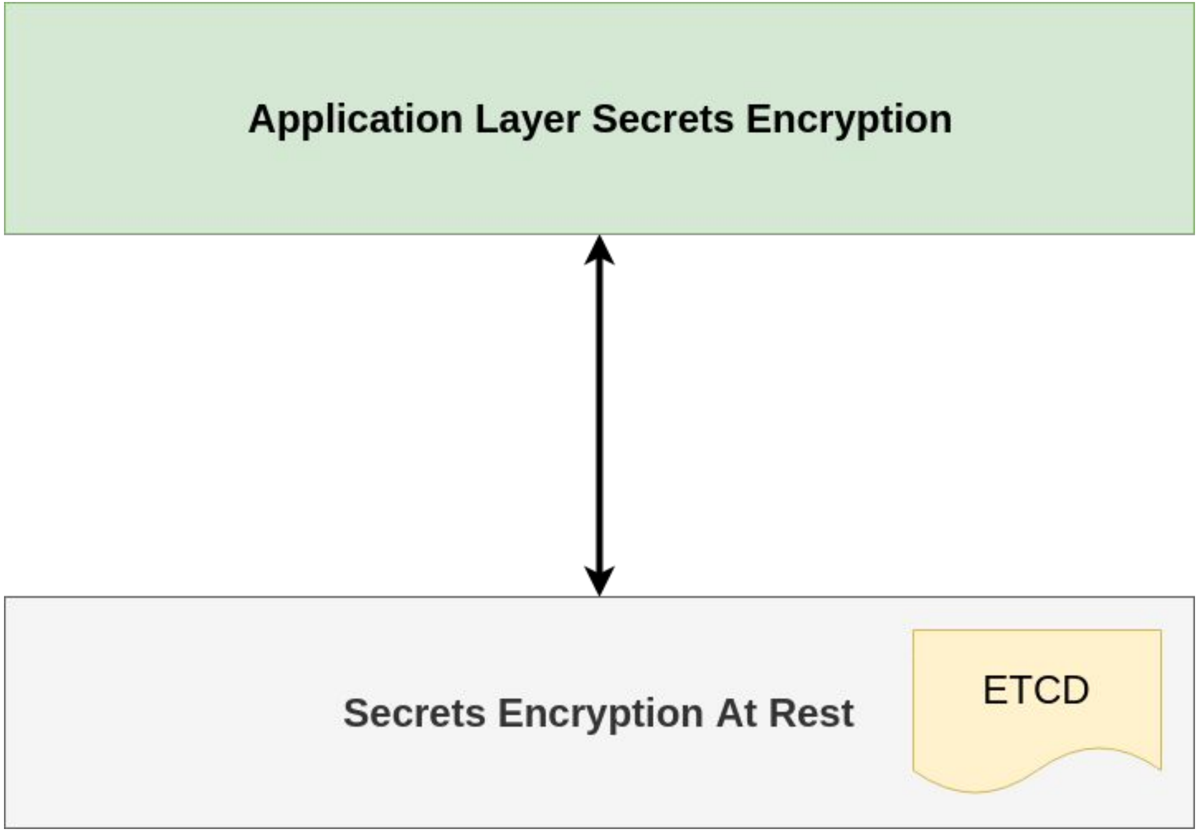
https://kubernetes.io/docs/concepts/configuration/secret/#best-practices
https://kubernetes.io/docs/tasks/administer-cluster/encrypt-data

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

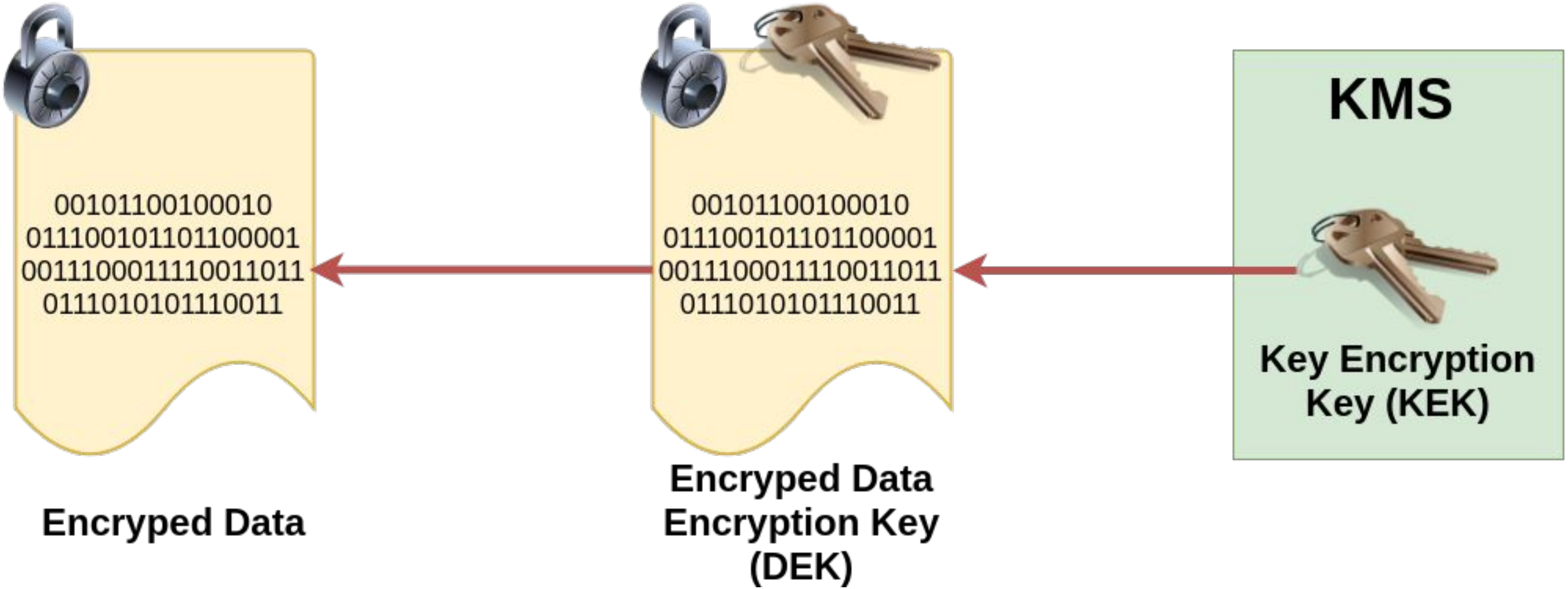


Application Layer Secrets Encryption

Secrets Encryption At Rest

ETCD

Envelope Encryption On Kubernetes



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

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 git

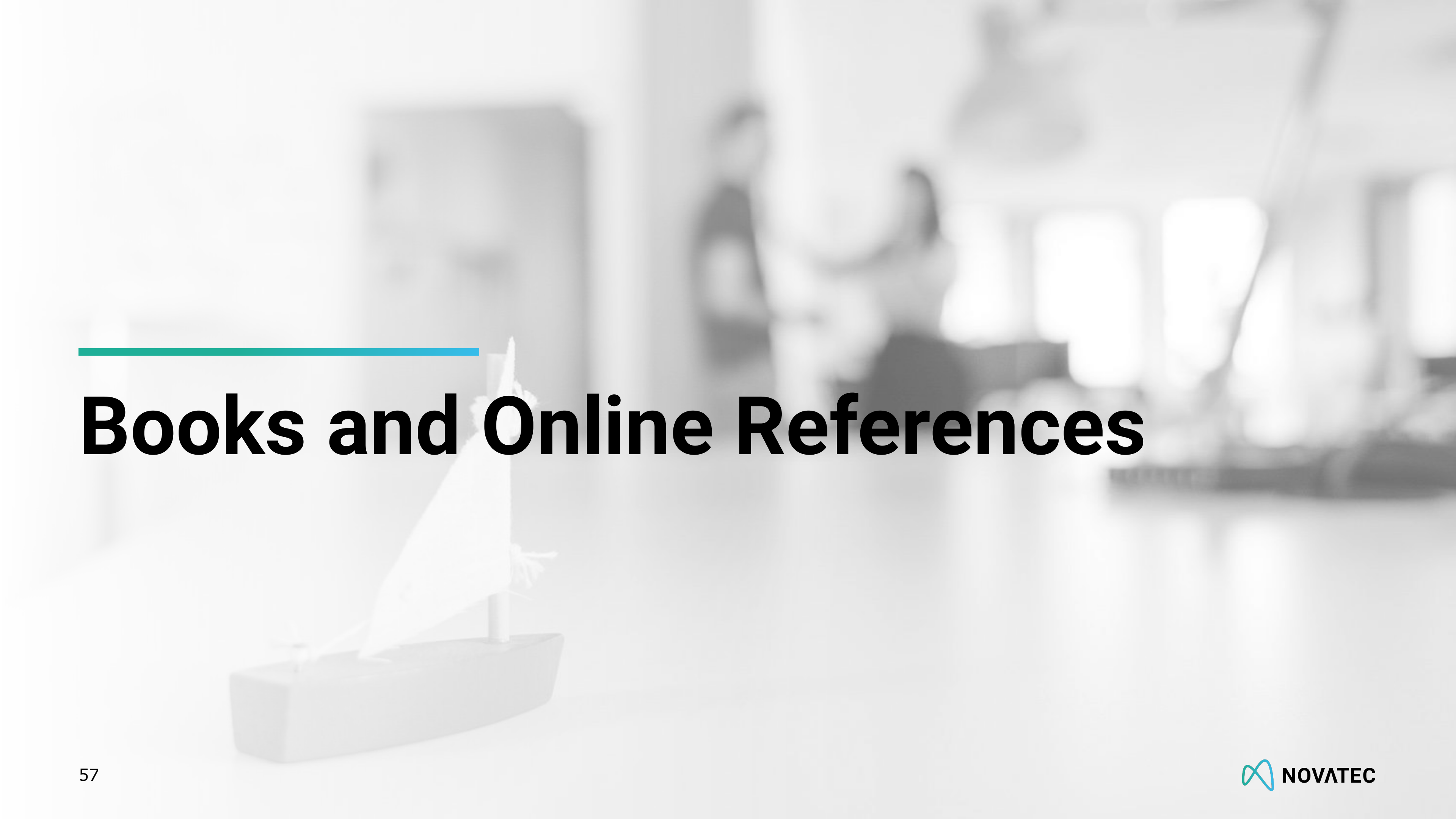
- Sealed Secrets
- Helm Secrets
- Kamus
- Sops
- Hashicorp Vault

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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