OWASP NZ 2023 – What Could Possibly Go Wrong in a K8s Cluster?

WILLIAM KOH

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safeadvisory.

Without them, this Conference couldn't happen.

I am…

Security Consultant @ WithSecure Singapore

- Booklover
- Collector
- Self-learner
- OSCP, CRT, CKA, CKS

LinkedIn:

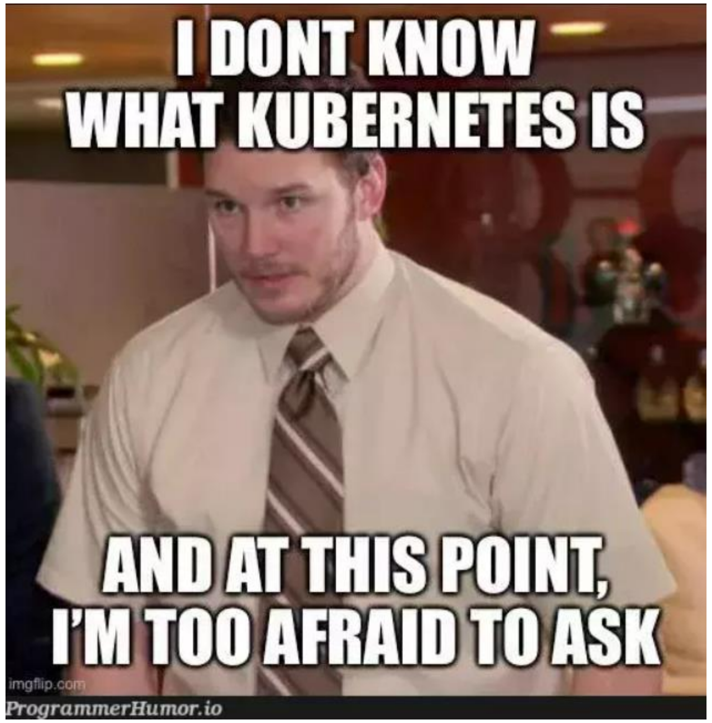
https://www.linkedin.com/in/w-xor/

Agenda

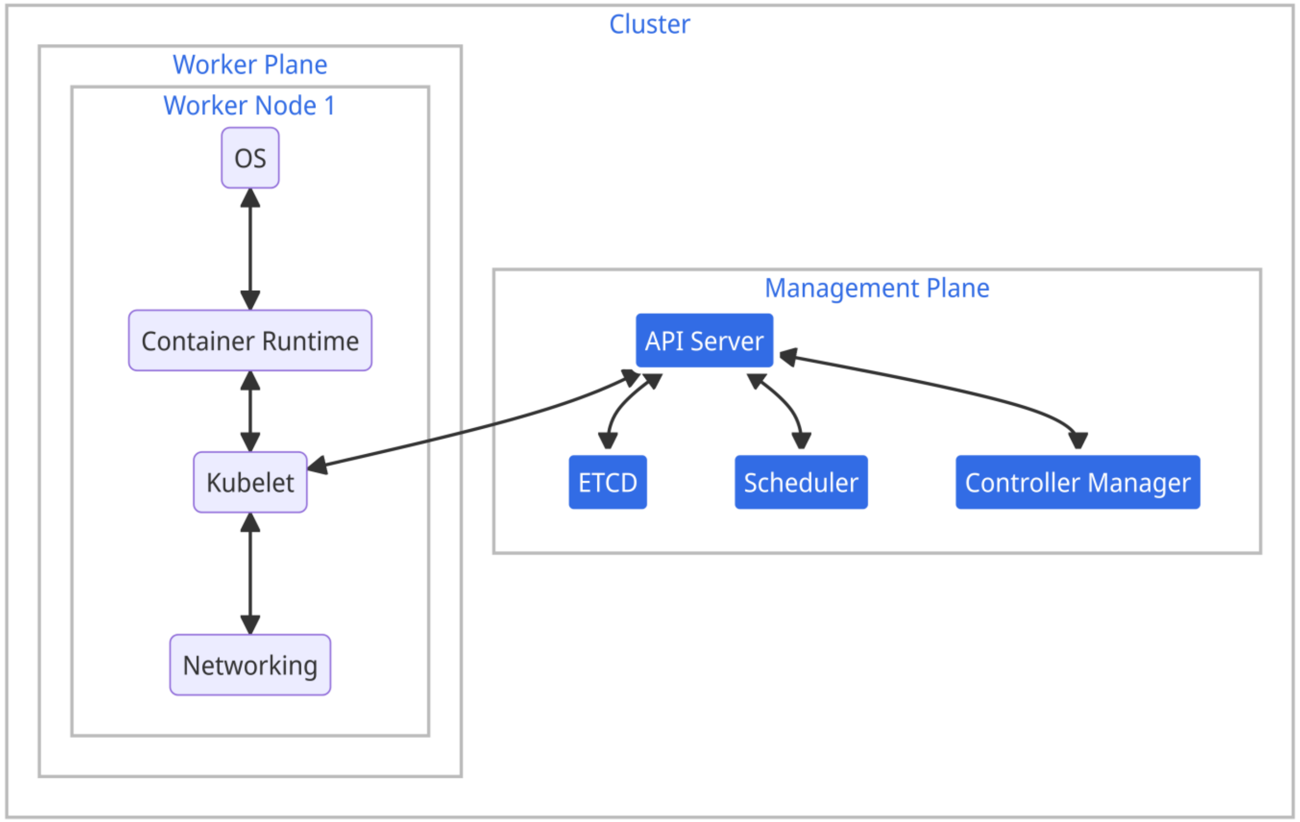
- Background
- Components within a K8s Cluster
- What Could Possibly Go Wrong?

What is Kubernetes?

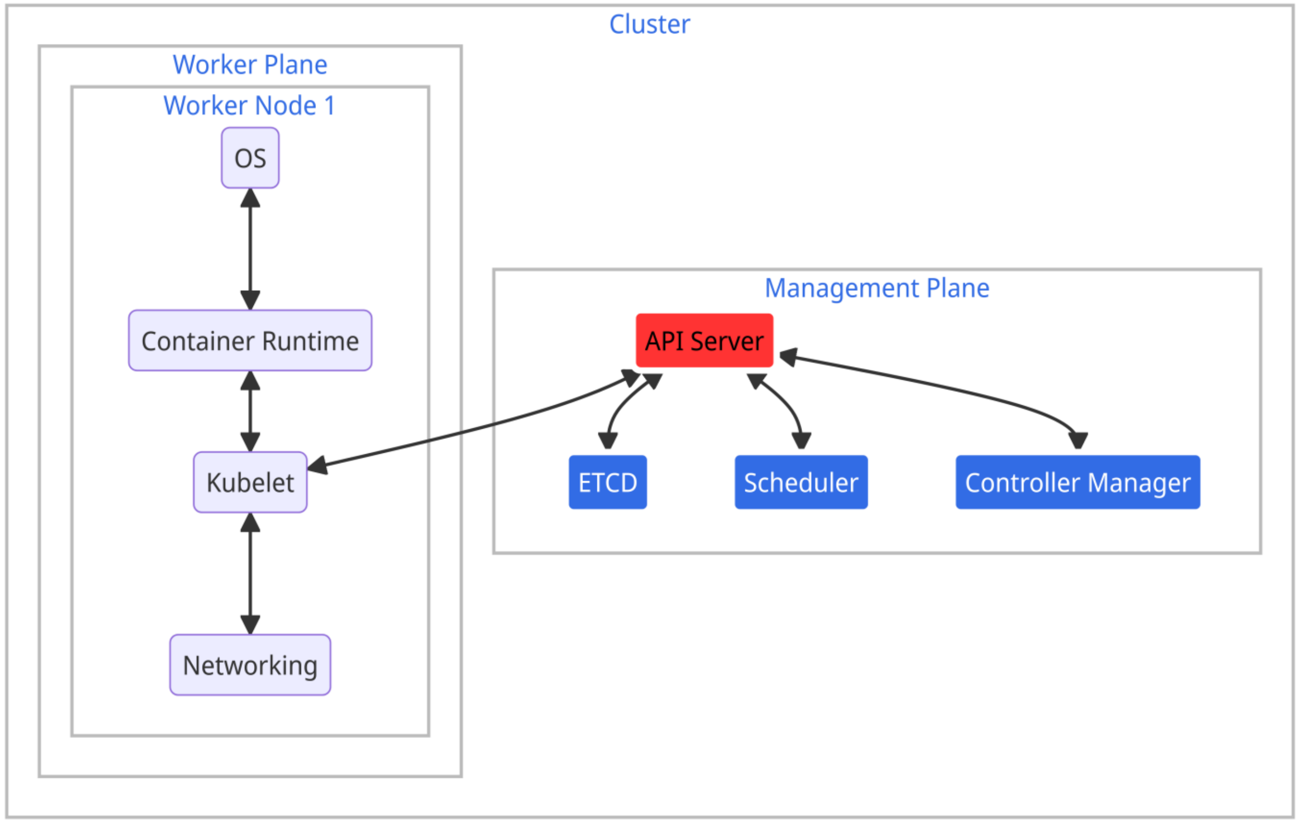
- It means Helmsman or “κυβερνήτης” in Greek
- Containers Orchestrator

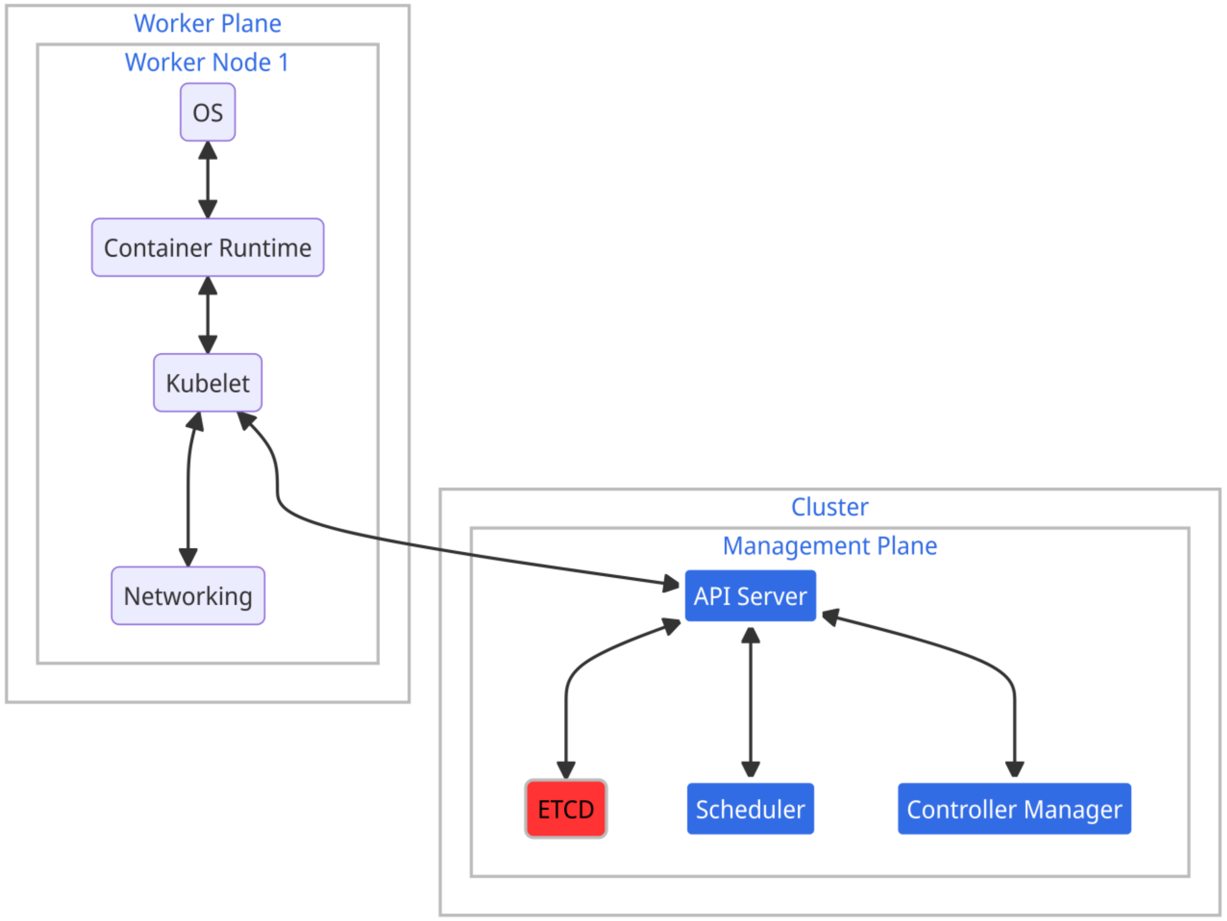


Kubernetes Cluster

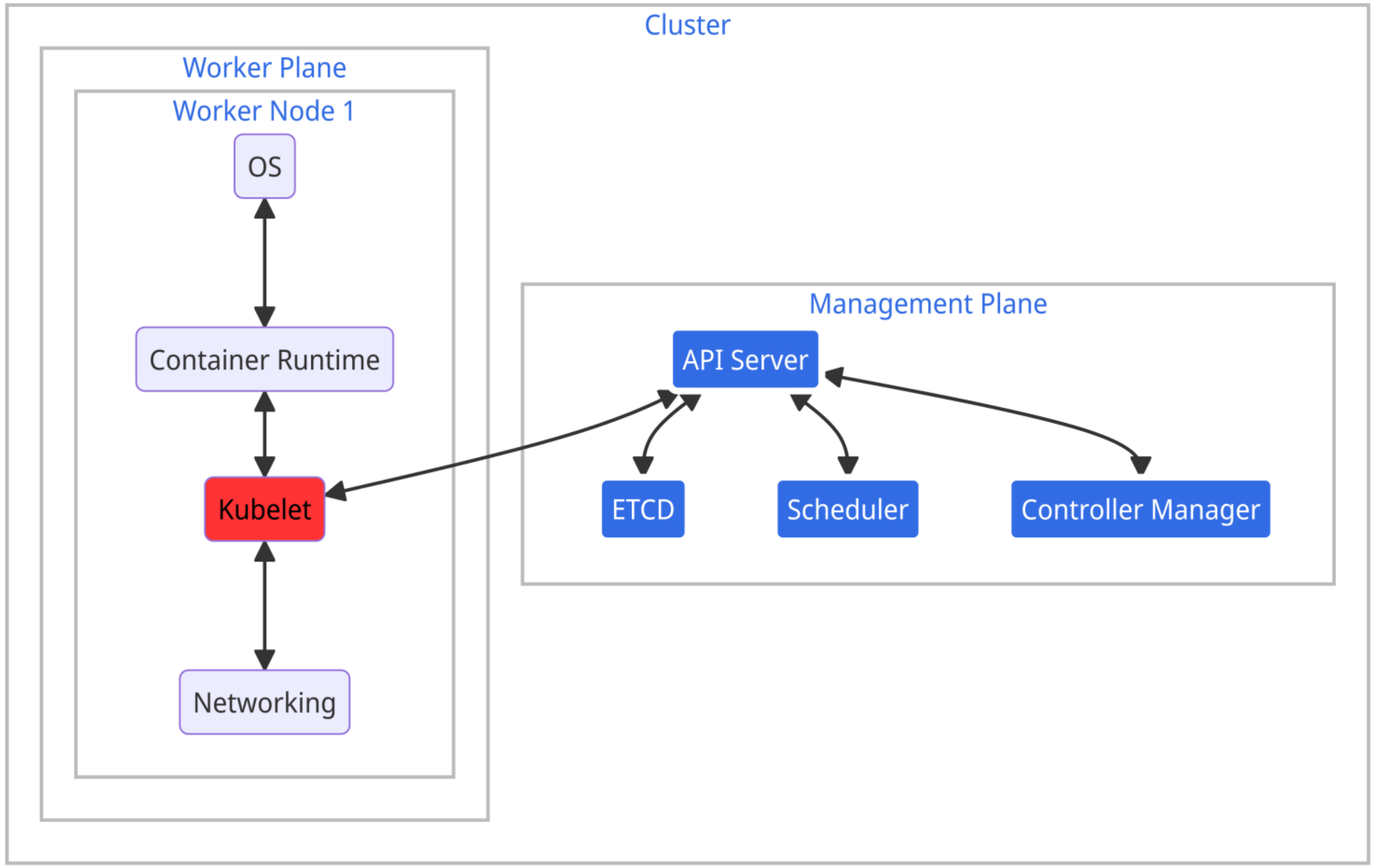


Kubernetes Cluster





Kubernetes Cluster



Kubernetes Cluster

WHAT COULD POSSIBLY GO WRONG?
38
makeameme.org

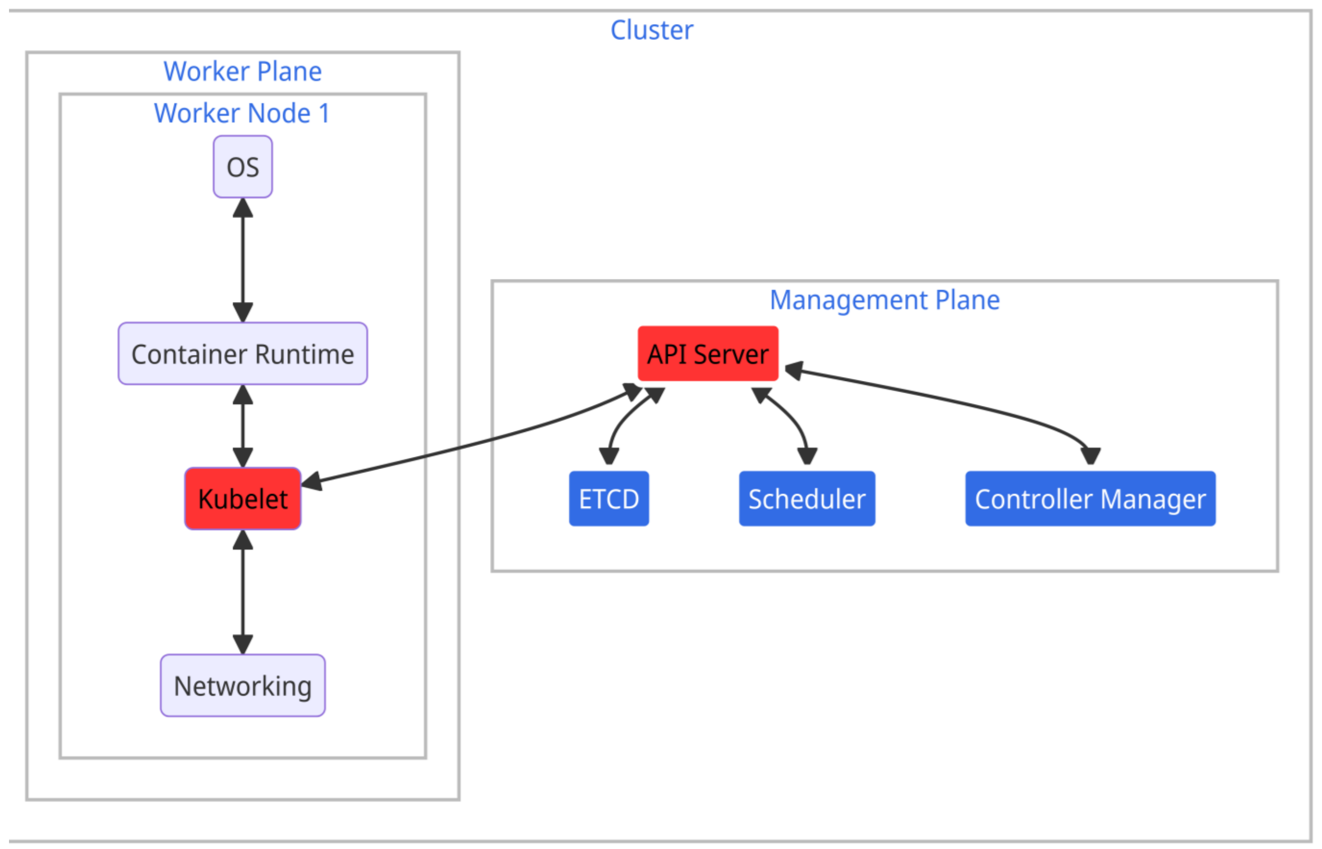
Networking

RBAC

Pod Security

Networking

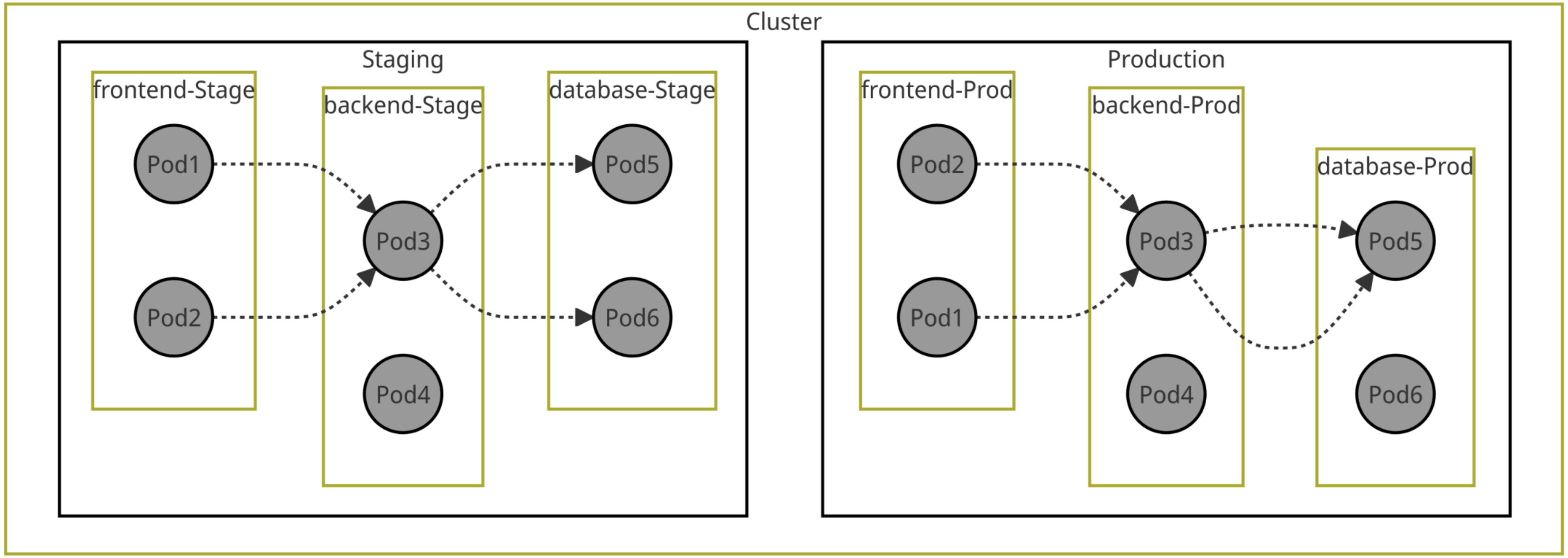
- Everything communicates via REST API
- Flat network
- No transport level encryption by default



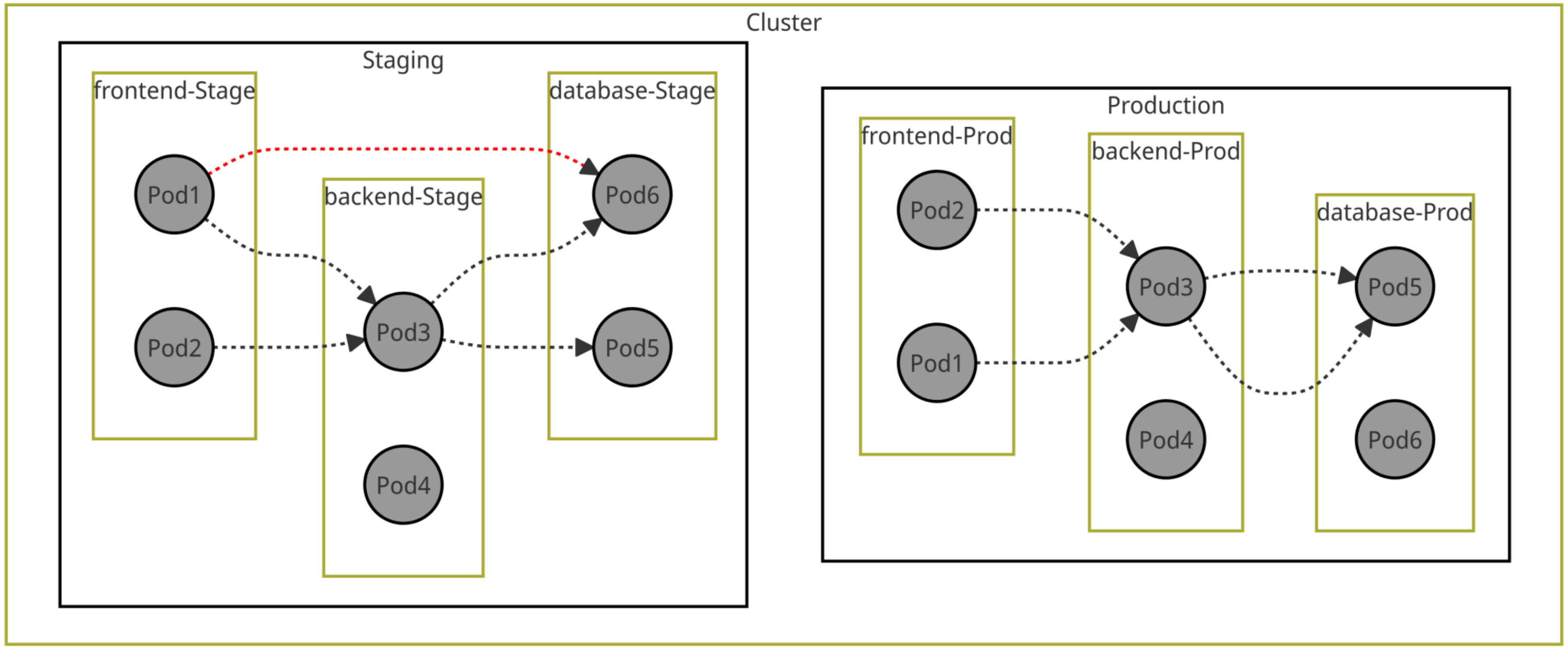
Possible Entry Points From The Outside

Networking

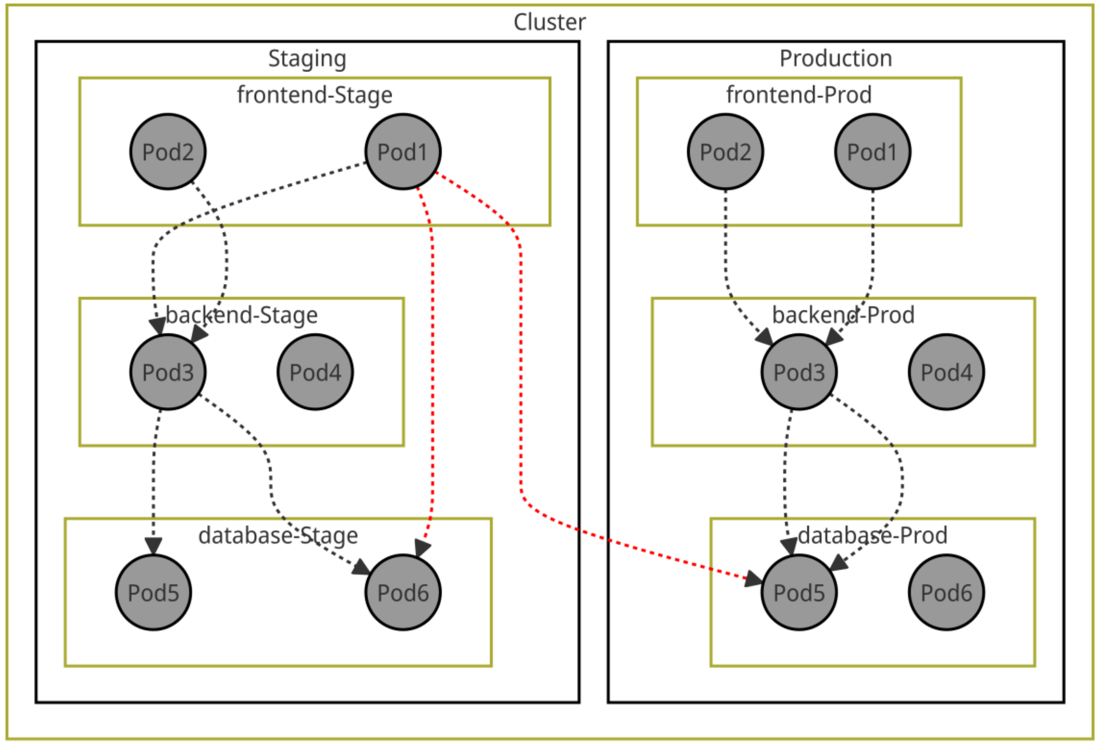
- (Un)authorised access to kubelet - /exec, /pods
- Privileged pods on the hunt
- RCE to the pods
- Privileged Service Account token
- Move laterally



Flat Network



Flat Network



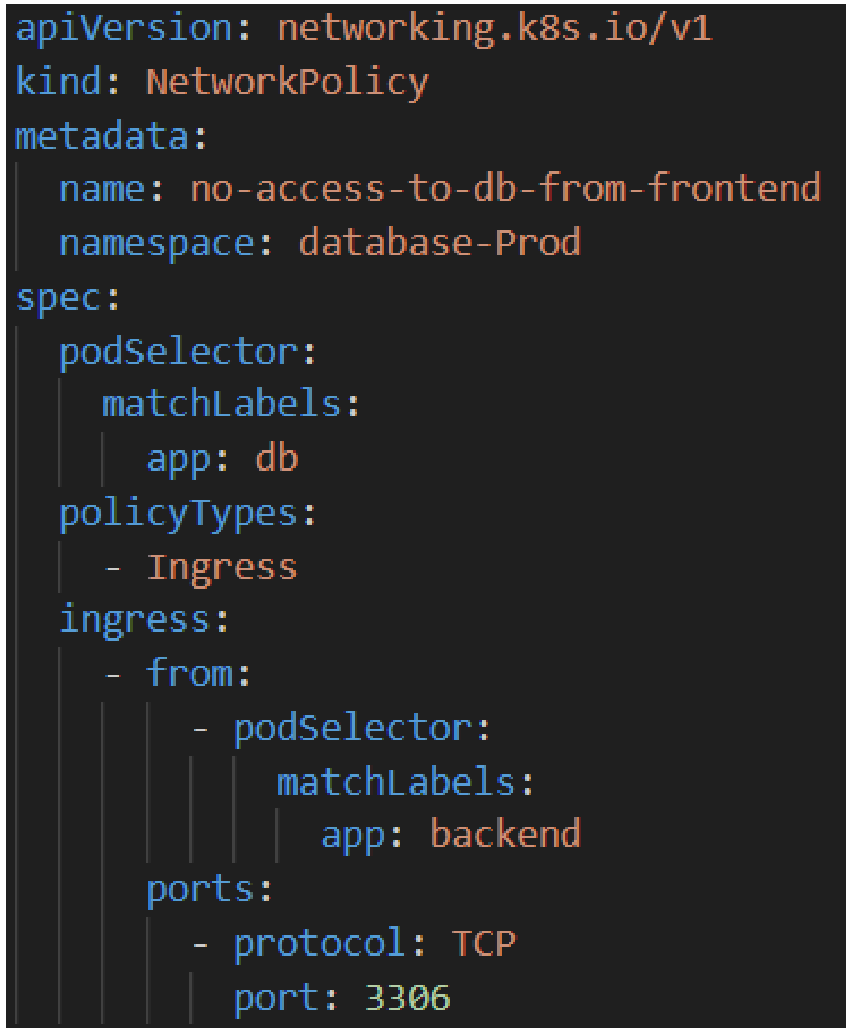
Flat Network

Network Policy

No worries! Network policy comes to our rescue!

Network Policy

- Can be defined through YAML manifest
- 2 types of policies: **Ingress** & **Egress**
- Enforce access controls based on several conditions
  - IP addresses
  - Namespace’s label
  - Pod’s label
  - Port



```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: no-access-to-db-from-frontend
  namespace: database-Prod
spec:
  podSelector:
    matchLabels:
      app: db
  policyTypes:
    - Ingress
  ingress:
    - from:
        - podSelector:
            matchLabels:
              app: backend
      ports:
        - protocol: TCP
          port: 3306
```

Network Policy

This should be stopping the “frontend” pods from accessing the “database” pods in Production. Now it should be secure… Right?

Common Misconfigurations

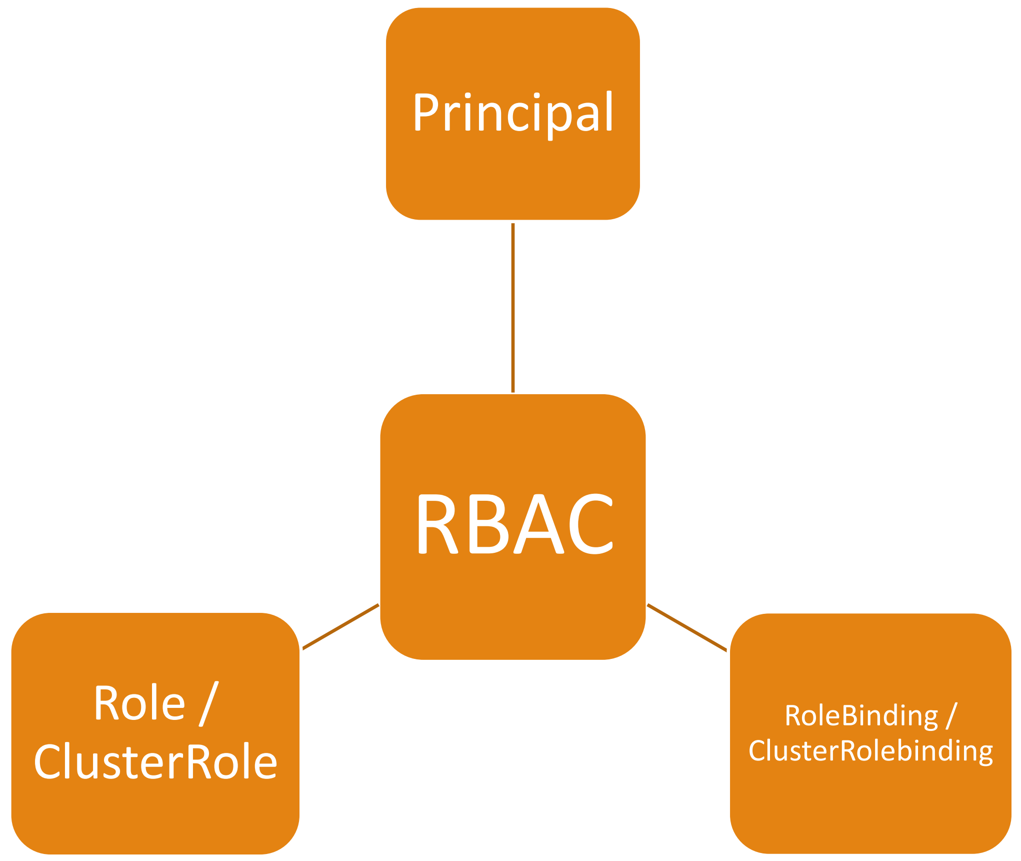
- Lack of network policies
- Network policies not being accurate / fine-grained

Networking

RBAC

Pod Security

RBAC – High-level Concept



RBAC – High-level Concept

Principal

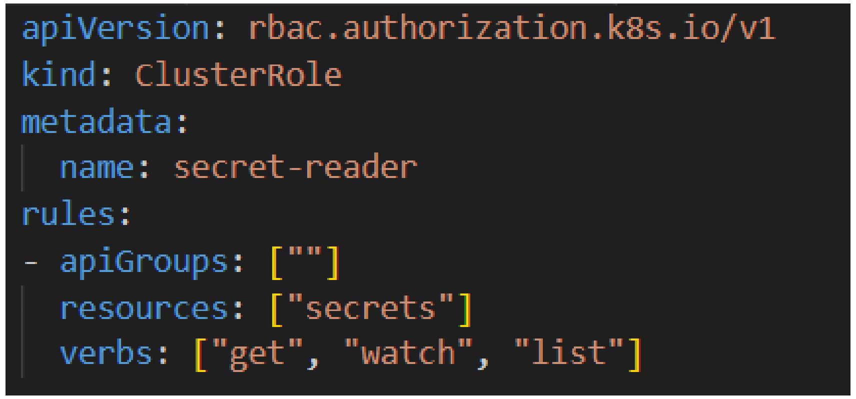
SERVICE ACCOUNT

USER / GROUP

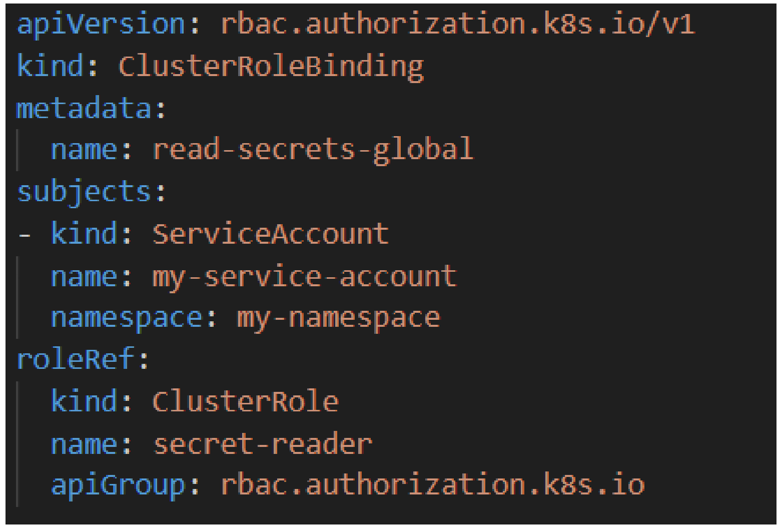
EXTERNAL USER

RBAC – High-level Concept

Role binding to a specific user / SA



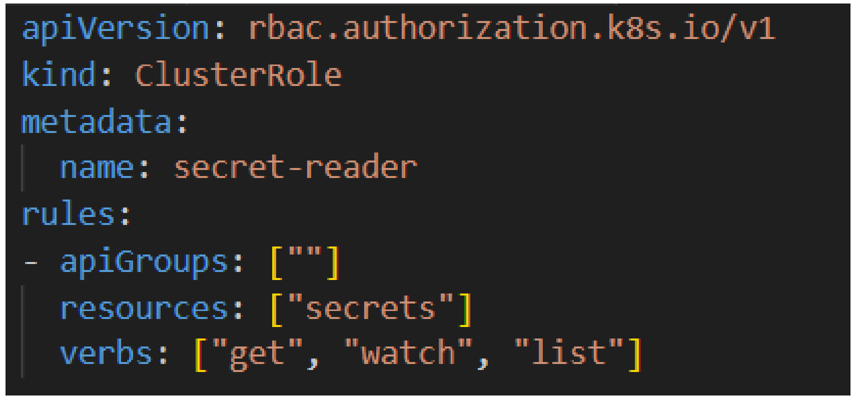
```yaml
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: secret-reader
rules:
- apiGroups: [""]
  resources: ["secrets"]
  verbs: ["get", "watch", "list"]
```



```yaml
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRoleBinding
metadata:
  name: read-secrets-global
subjects:
- kind: ServiceAccount
  name: my-service-account
  namespace: my-namespace
roleRef:
  kind: ClusterRole
  name: secret-reader
  apiGroup: rbac.authorization.k8s.io
```

RBAC – High-level Concept

Role binding to a group of users / SAs



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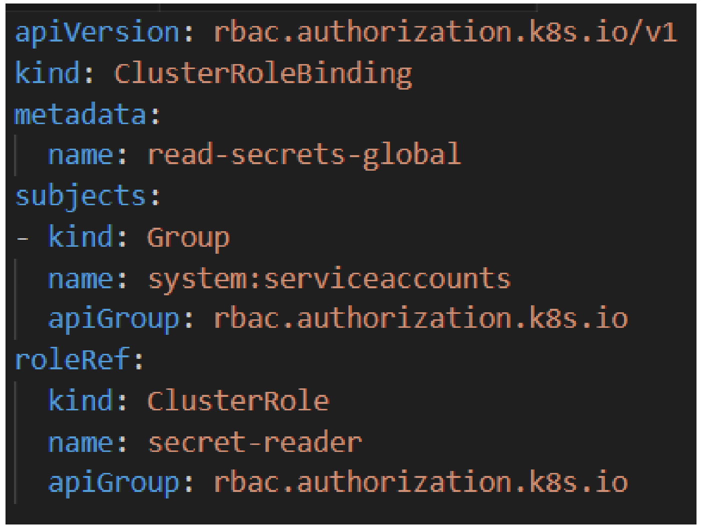
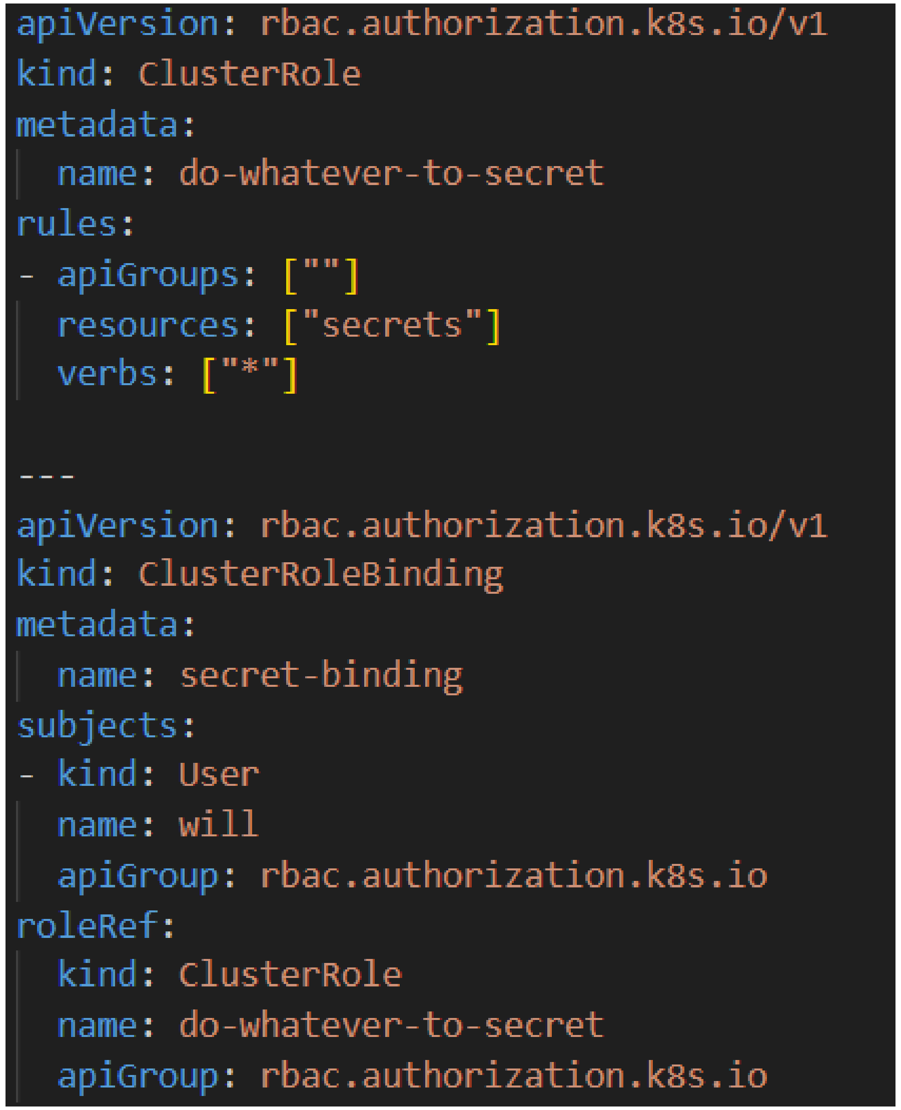


```yaml
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRoleBinding
metadata:
  name: read-secrets-global
subjects:
- kind: Group
  name: system:serviceaccounts
  apiGroup: rbac.authorization.k8s.io
roleRef:
  kind: ClusterRole
  name: secret-reader
  apiGroup: rbac.authorization.k8s.io
```

Common Misconfigurations

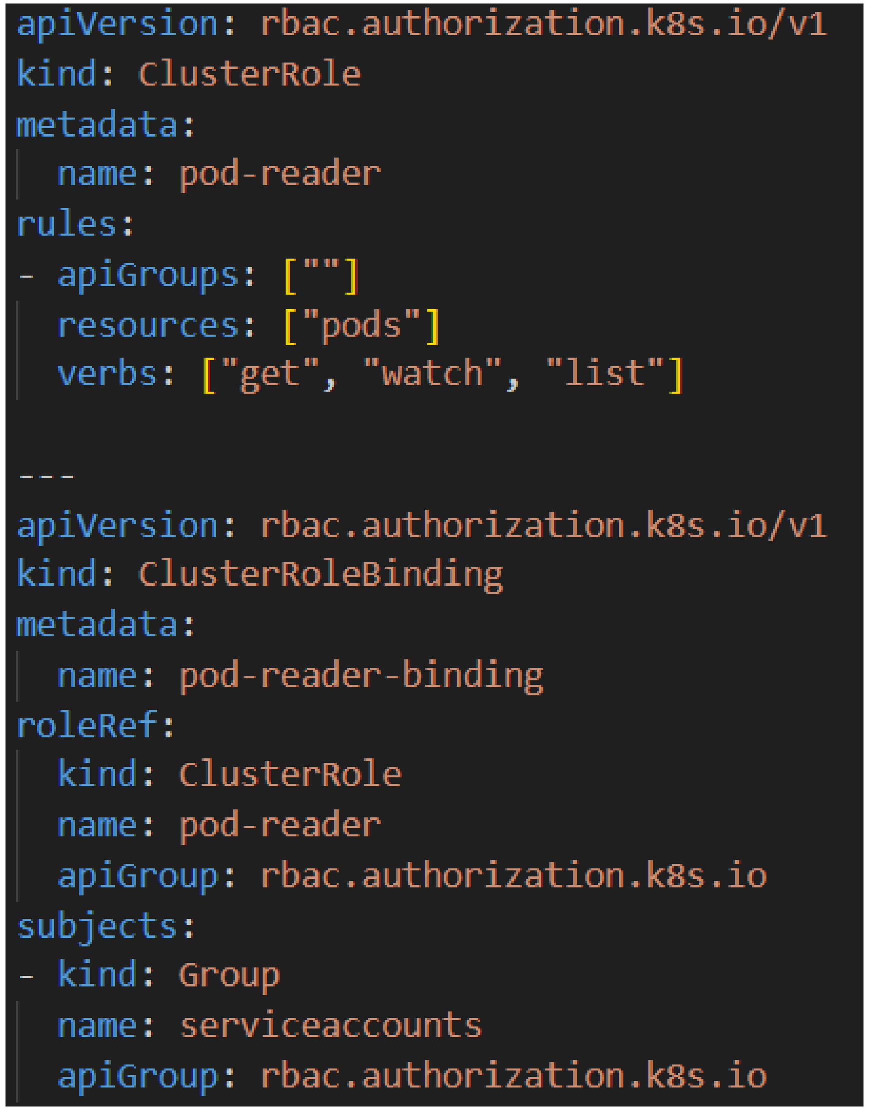
- Use of Wildcard
- Overly provisioned groups
- Cluster Role == Role


```yaml
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: do-whatever-to-secret
rules:
- apiGroups: [""]
  resources: ["secrets"]
  verbs: ["*"]

---
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRoleBinding
metadata:
  name: secret-binding
subjects:
- kind: User
  name: will
  apiGroup: rbac.authorization.k8s.io
roleRef:
  kind: ClusterRole
  name: do-whatever-to-secret
  apiGroup: rbac.authorization.k8s.io
```

Use of Wildcard

- Does one really need all permissions?



```yaml
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: pod-reader
rules:
- apiGroups: [""]
  resources: ["pods"]
  verbs: ["get", "watch", "list"]

---
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRoleBinding
metadata:
  name: pod-reader-binding
roleRef:
  kind: ClusterRole
  name: pod-reader
  apiGroup: rbac.authorization.k8s.io
subjects:
- kind: Group
  name: serviceaccounts
  apiGroup: rbac.authorization.k8s.io
```

Overly Provisioned groups

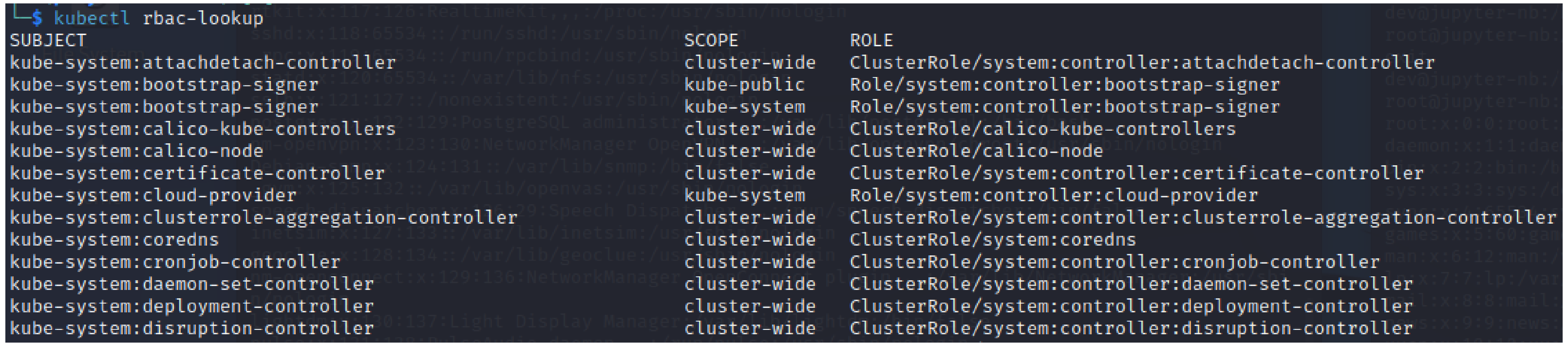
- Do all SAs require the same permission?

Cluster Role ≈ Role

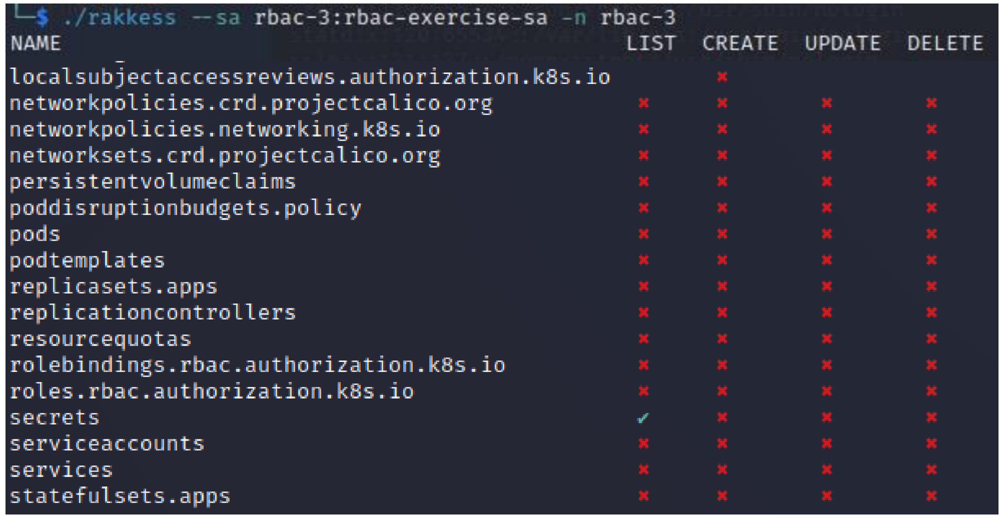
- Future-proof
- For convenience's sake
- Or sometimes people are just confused…

How to Find Out Overly Provisioned Principal?

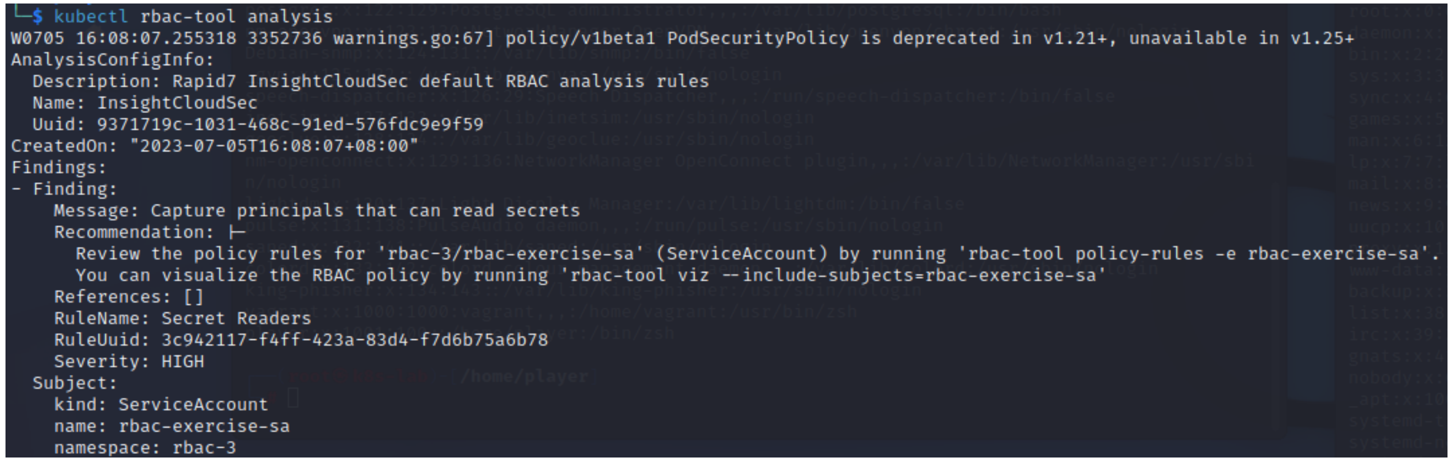
- rakkess
- rbac-tool
- rbac-lookup



```
└─$ kubectl rbac-lookup
SUBJECT                                             SCOPE          ROLE
kube-system:attachdetach-controller                 cluster-wide   ClusterRole/system:controller:attachdetach-controller
kube-system:bootstrap-signer                        kube-public    Role/system:controller:bootstrap-signer
kube-system:bootstrap-signer                        kube-system    Role/system:controller:bootstrap-signer
kube-system:calico-kube-controllers                 cluster-wide   ClusterRole/calico-kube-controllers
kube-system:calico-node                             cluster-wide   ClusterRole/calico-node
kube-system:certificate-controller                  cluster-wide   ClusterRole/system:controller:certificate-controller
kube-system:cloud-provider                          kube-system    Role/system:controller:cloud-provider
kube-system:clusterrole-aggregation-controller      cluster-wide   ClusterRole/system:controller:clusterrole-aggregation-controller
kube-system:coredns                                 cluster-wide   ClusterRole/system:coredns
kube-system:cronjob-controller                      cluster-wide   ClusterRole/system:controller:cronjob-controller
kube-system:daemon-set-controller                   cluster-wide   ClusterRole/system:controller:daemon-set-controller
kube-system:deployment-controller                   cluster-wide   ClusterRole/system:controller:deployment-controller
kube-system:disruption-controller                   cluster-wide   ClusterRole/system:controller:disruption-controller
```



```
└─$ ./rakkess --sa rbac-3:rbac-exercise-sa -n rbac-3
NAME                                         LIST  CREATE  UPDATE  DELETE
localsubjectaccessreviews.authorization.k8s.io      ✗
networkpolicies.crd.projectcalico.org         ✗     ✗       ✗       ✗
networkpolicies.networking.k8s.io             ✗     ✗       ✗       ✗
networksets.crd.projectcalico.org             ✗     ✗       ✗       ✗
persistentvolumeclaims                        ✗     ✗       ✗       ✗
poddisruptionbudgets.policy                   ✗     ✗       ✗       ✗
pods                                          ✗     ✗       ✗       ✗
podtemplates                                  ✗     ✗       ✗       ✗
replicasets.apps                              ✗     ✗       ✗       ✗
replicationcontrollers                        ✗     ✗       ✗       ✗
resourcequotas                                ✗     ✗       ✗       ✗
rolebindings.rbac.authorization.k8s.io        ✗     ✗       ✗       ✗
roles.rbac.authorization.k8s.io               ✗     ✗       ✗       ✗
secrets                                       ✓     ✗       ✗       ✗
serviceaccounts                               ✗     ✗       ✗       ✗
services                                      ✗     ✗       ✗       ✗
statefulsets.apps                             ✗     ✗       ✗       ✗
```



```
└─$ kubectl rbac-tool analysis
W0705 16:08:07.255318 3352736 warnings.go:67] policy/v1beta1 PodSecurityPolicy is deprecated in v1.21+, unavailable in v1.25+
AnalysisConfigInfo:
  Description: Rapid7 InsightCloudSec default RBAC analysis rules
  Name: InsightCloudSec
  Uuid: 9371719c-1031-468c-91ed-576fdc9e9f59
CreatedOn: "2023-07-05T16:08:07+08:00"
Findings:
- Finding:
    Message: Capture principals that can read secrets
    Recommendation: ⊢
      Review the policy rules for 'rbac-3/rbac-exercise-sa' (ServiceAccount) by running 'rbac-tool policy-rules -e rbac-exercise-sa'.
      You can visualize the RBAC policy by running 'rbac-tool viz --include-subjects=rbac-exercise-sa'
    References: []
    RuleName: Secret Readers
    RuleUuid: 3c942117-f4ff-423a-83d4-f7d6b75a6b78
    Severity: HIGH
  Subject:
    kind: ServiceAccount
    name: rbac-exercise-sa
    namespace: rbac-3
```

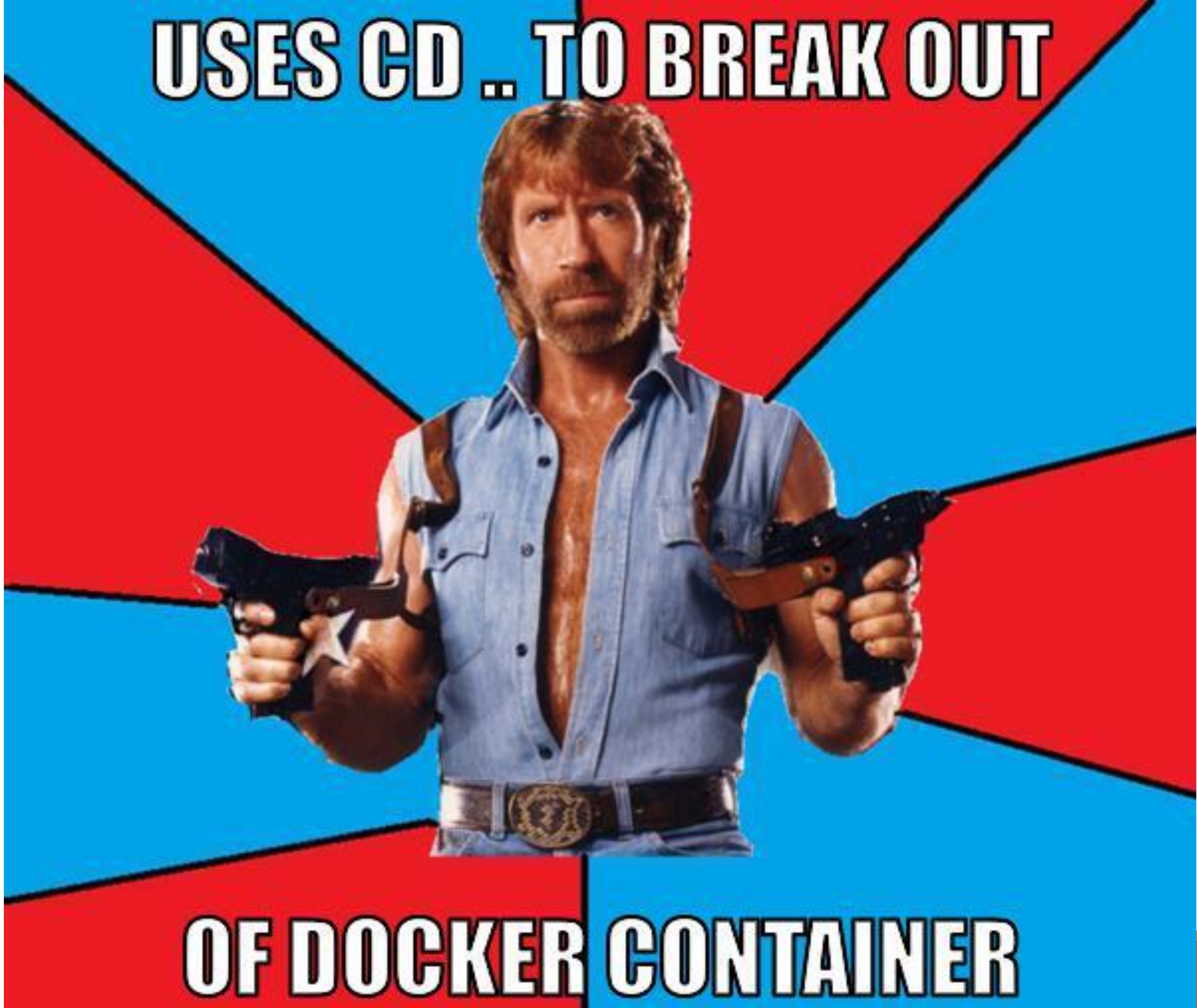
Networking

RBAC

Pod Security

Pod Security

What is the first thing that always pops up to people mind when it comes to pod security?



Pod Security

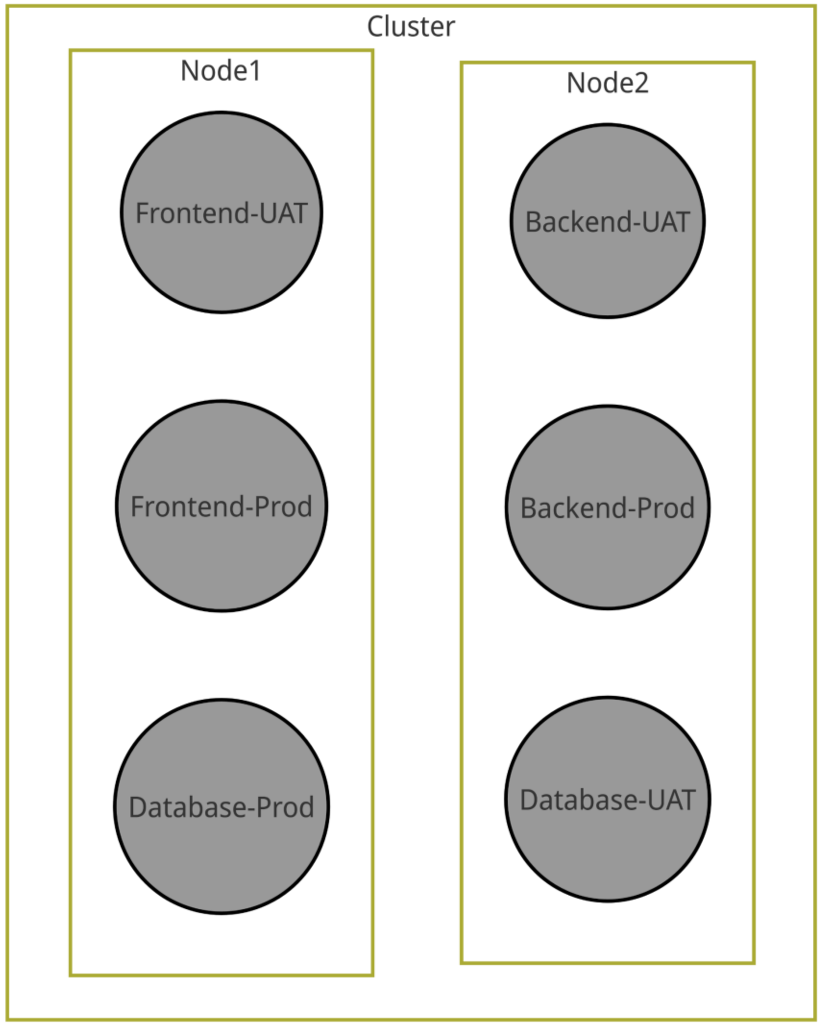
- A container is essentially a process running in isolation on a host
- Shares kernel resources / features of host operating system
  - Namespaces
  - Control Groups (cgroups)
  - Chroot
  - Capabilities
  - FileSystems

Security Context

- Defines how much privileges and level of access to kernel resources a pod or container is getting
- Some examples of security context:
  - allowPrivilegeEscalation
  - privileged
  - readOnlyRootFilesystem
  - runAsNonRoot

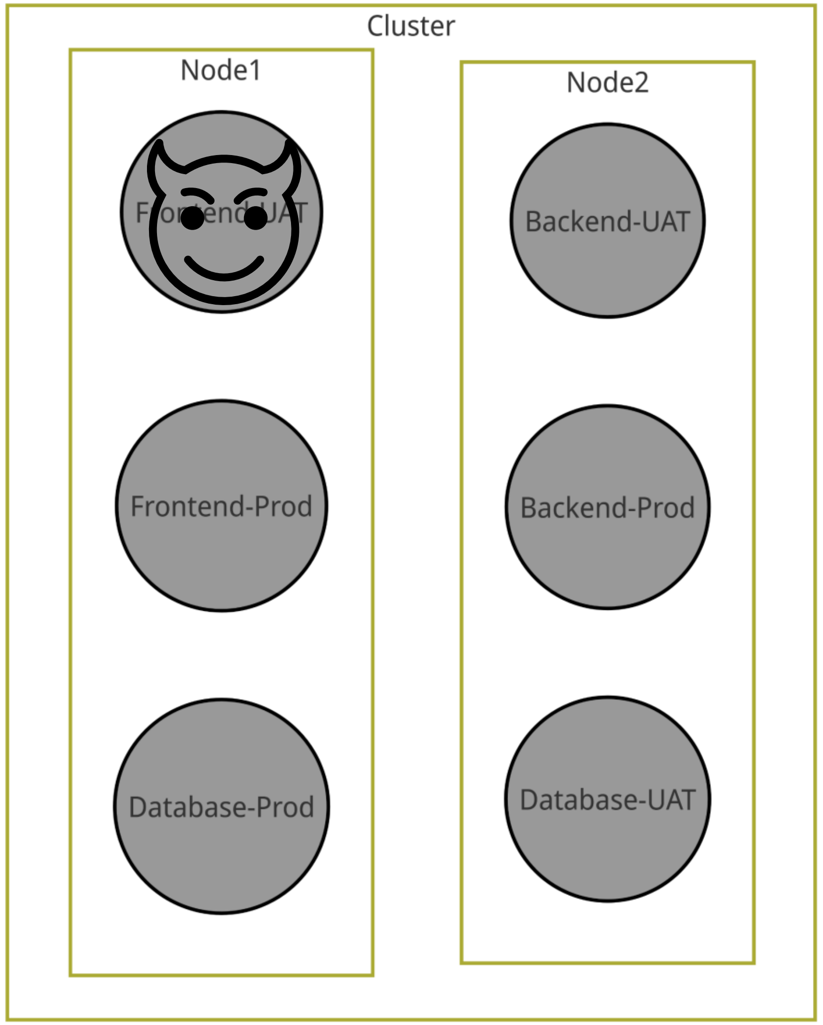
Pod (Container) Breakout

- Some techniques / misconfigurations could be utilized to break out a container:
  - Privileged pod (Overly permissive capabilities)
  - Kernel exploit
  - Host volumes mount



Pod Placement

- The blast radius could be even bigger with a failed pod placement strategy



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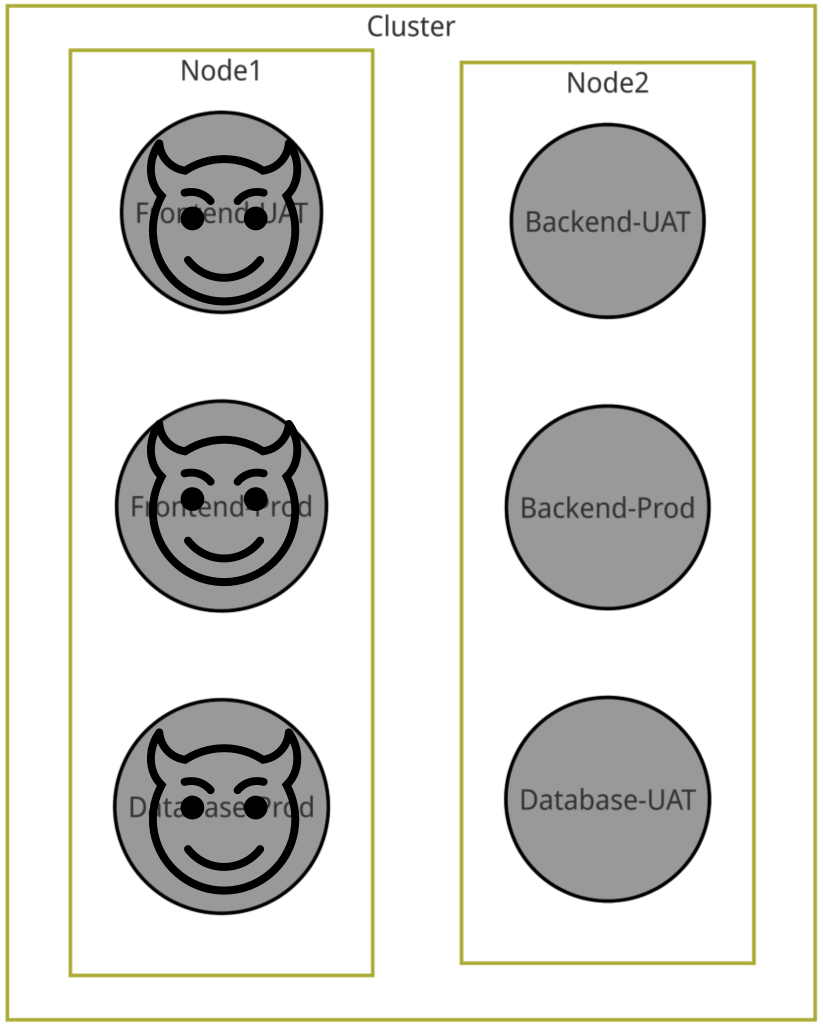
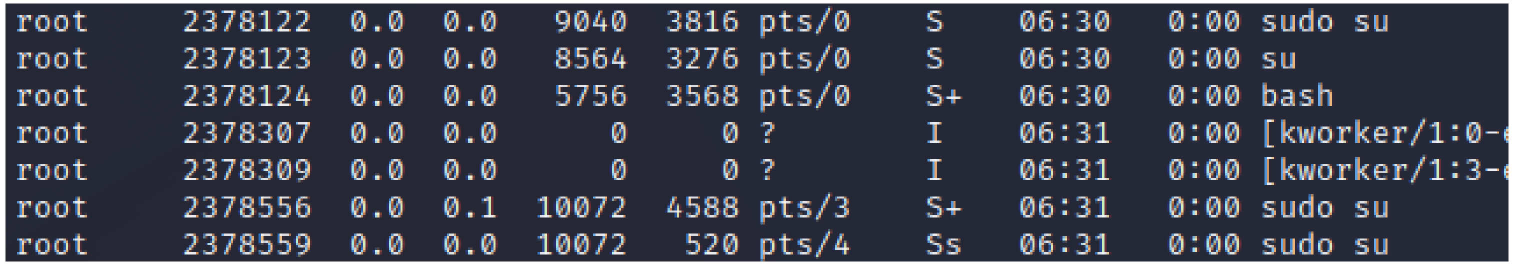


Pod Placement

- The blast radius could be even bigger with a failed pod placement strategy

Observability & Visibility

Do you think you can see what's happening inside a pod?

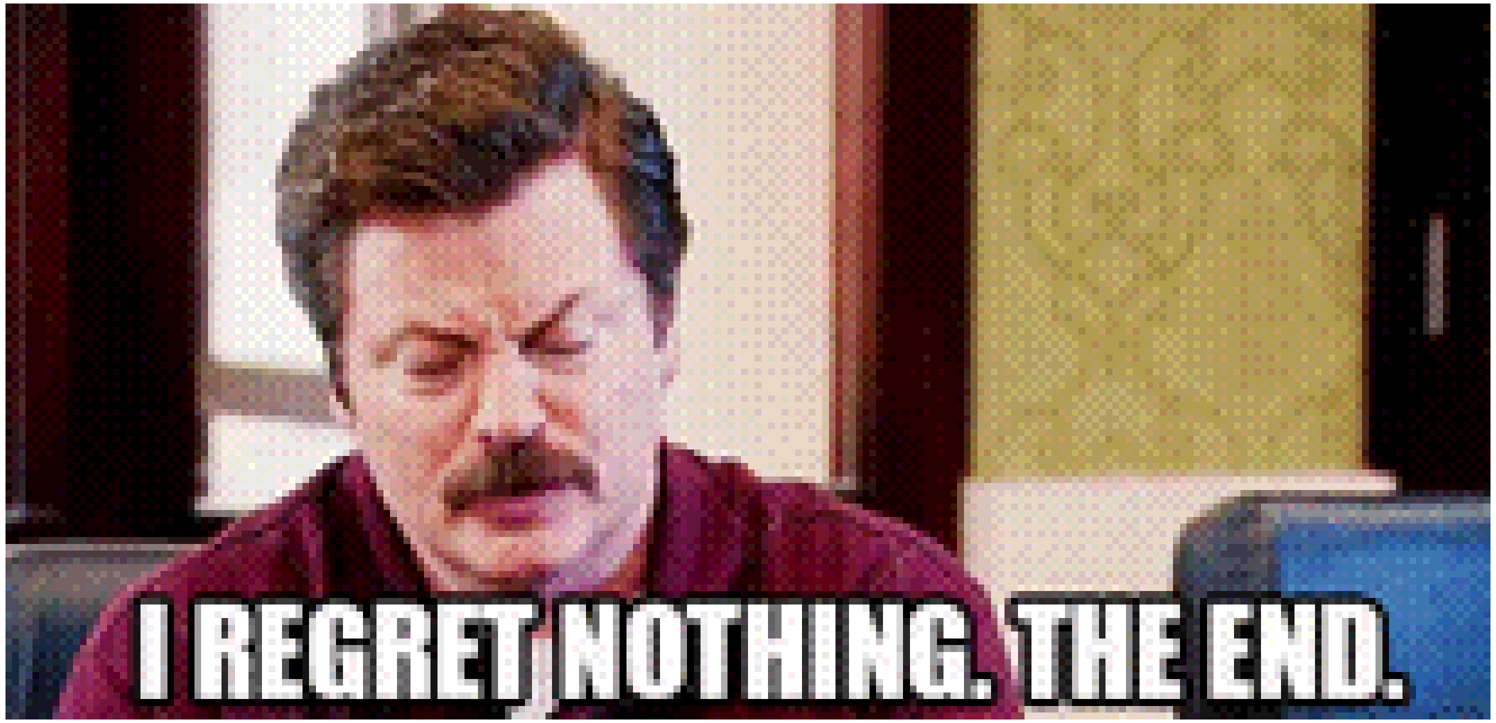


```
root      2378122  0.0  0.0   9040  3816 pts/0    S    06:30   0:00 sudo su
root      2378123  0.0  0.0   8564  3276 pts/0    S    06:30   0:00 su
root      2378124  0.0  0.0   5756  3568 pts/0    S+   06:30   0:00 bash
root      2378307  0.0  0.0      0     0 ?        I    06:31   0:00 [kworker/1:0-
root      2378309  0.0  0.0      0     0 ?        I    06:31   0:00 [kworker/1:3-
root      2378556  0.0  0.1  10072  4588 pts/3    S+   06:31   0:00 sudo su
root      2378559  0.0  0.0  10072   520 pts/4    Ss   06:31   0:00 sudo su
```

Who executed those commands?

Secure Pods!

- Pod Security Admission
- Linux Kernel Security Modules: Seccomp, AppArmor
- nodeSelector
- Observability and visibility solutions, e.g., Falco, Cilium


I REGRET NOTHING. THE END.

Thank you!