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Outline

- Introduction to Access Control
- User Identity in Kubernetes
- Using kubeconfig
- RBAC
- Network Policy
- Security Context
- Security Best Practices

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Introduction to Access Control

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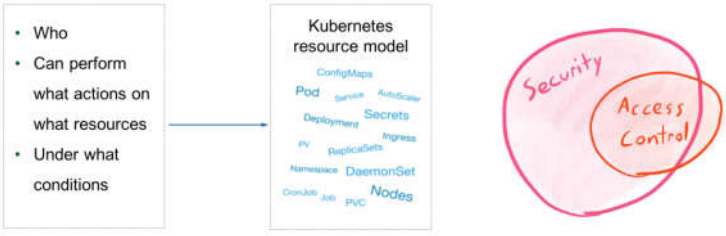
Access control

- **Access control is an important part of Kubernetes security.**
- **Access control can be abstractly defined as the control over who can perform what operations on what resources under what conditions.**
  - Resources refer to the resource models in Kubernetes, such as pods, ConfigMaps, Deployments, and Secrets.



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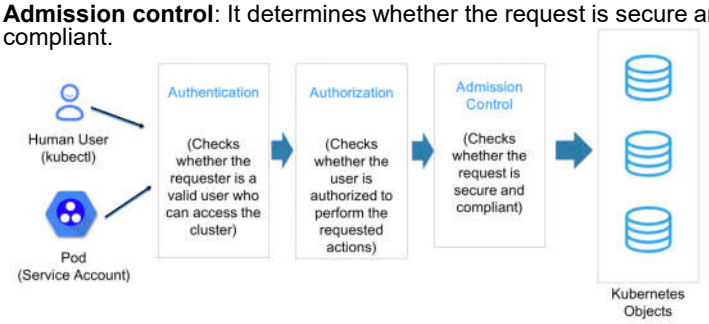
Controlling access

Kubernetes API Requests

- **The API server enables access control after receiving the request. Access control is divided into three phases:**
  - **Authentication**: The API server determines whether the requester is a valid user allowed to access the cluster
  - **Authorization**: If the requester is valid, the API server determines whether the requester is authorized to perform the requested operation
  - **Admission control**: It determines whether the request is secure and compliant.



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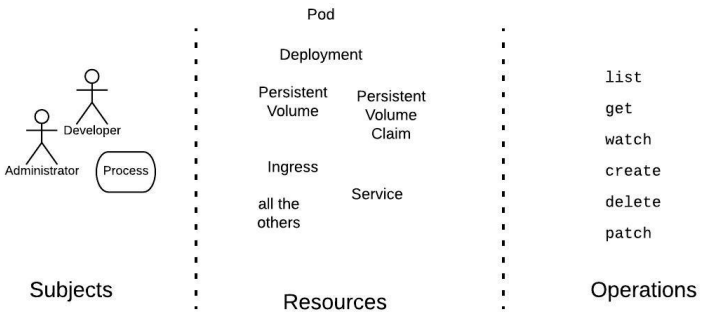
Controlling access

Role-based access control (RBAC)

- **RBAC in Kubernetes is the way that you restrict who can access what within the cluster.**
  - A user or group is given permission to perform actions upon certain 'resources'. The association of operations to resources is what is known as a Role.



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User Identity in Kubernetes

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User Identity in Kubernetes

- **Kubernetes distinguishes between two kinds of clients connection to API Server**
  - **Users (Actual human user)**
    - Kubernetes doesn't have built in user account management system
    - It should use integrate with external identity management system like OpenID Connect (OAuth2)/Webhook
  - **Service account (Machine like Pod)**
    - Identity of Pod to call API
      - Create : kubectl create serviceaccount {service account name}
      - List : kubectl list sa
      - Assign SA to POD

```
apiVersion: v1
kind: Pod
metadata:
  name: my-pod
spec:
  serviceAccountName: build-robot
  automountServiceAccountToken: false
  ...
```


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Authenticate

- **User identity is used for authenticating request for API Server**
- **How to authenticate user request**
  - Basic HTTP Auth
  - Access token via HTTP Header
  - **Client cert (X509 Certificates)**
  - Custom made
- **X.509 Certificate Authentication (The most commonly used)**
  - The API server starts the Transport Layer Security (TLS)-based handshake process when receiving an access request.
    - The request is initiated through the client certificate which is signed by the cluster-dedicated Certificate Authority (CA) or by the trusted CA in the API server's client CA.
  - By default, it is used by Kubernetes components to authenticate each other and provides access credentials that are often used by kube-config for the kubectl client.
  - X.509 authentication uses JSON Web Tokens (JWTs) that contain metadata such as the issuer, user identity, and expiration time.

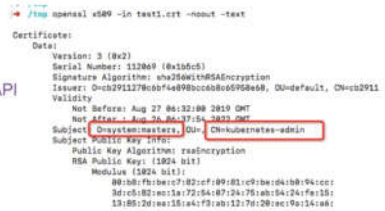
Certificate Authentication

- **The cluster contains a root CA that signs the certificates required by all cluster components to communicate with each other.**
  - A certificate contains the common name (CN) and organization (O), which are the fields related to identity credentials.

•CA

Public key /etc/kubernetes/pki/ca.crt Private key /etc/kubernetes/pki/ca.key

- The certificates used by cluster components to communicate with each other are signed by the cluster's
- A certificate contains two important fields related to identity credentials:
  - Comman Name(CN):indicates a specific user when the API server implements authentication.
  - Organization(O):indicates a specific group when the API server implements authentication.



Controlling access

User Certificate signing

- **User certificate signing consists of the following steps:**

Developer

- Create a private key through a certificate tool such as OpenSSL.

```
openssl genrsa –out test.key 2048
```

- Create a CSR.

```
openssl req –new –key test.key –out test.csr –subj "/CN=dahu/O=devs"
```

user group

- Create a Kubernetes CSR instance through an API, or submit the created CSR file to the administrator.

Cluster administrator

- Sign a certificate through the cluster's CA keypair based on the CSR file or instance. The following is an example.

```
openssl x509 –req –in dahu.csr –CA CA_LOCATION/ca.crt –Cakey CA_LOCATION/ca.key –
Cacreateserial –out dahu.crt –days 365
```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Controlling access

Service Account Authentication

- **The API server also supports service account authentication in addition to certificate authentication.**

- A service account is an access credential for the API server and is also the only credential in Kubernetes that can be managed through APIs.
- The service account is typically used by the business process of a pod to interact with the API server.
- After a namespace is created, a default service account and a secret instance are also created in this namespace.
- You can also create a differently named service account through an API and attach this service account to a pod in the namespace during runtime.

```
kubectl get serviceaccounts

kubectl get serviceaccounts/build-robot -o yaml
kubectl delete serviceaccount/build-robot

kubectl patch serviceaccount default -p
'{"imagePullSecrets": [{"name": "myregistrykey"}]}'
```

```
kubectl apply -f - <<EOF
apiVersion: v1
kind: Secret
metadata:
  name: build-robot-secret
  annotations:
    kubernetes.io/service-account.name: build-robot
type: kubernetes.io/service-account-token
EOF
```


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Using kubeconfig

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How to Create kubeconfig ?

- **kubeconfig is an important access credential for connecting a local device to a Kubernetes cluster. This section describes how to configure and use kubeconfig.**

Configure kubeconfig locally as follows:

- Download the cluster CA.
- Add the cluster connection information through kubectl.

```
kubectl config set-cluster sandbox --certificate-authority=ca.pem --embed-certs=true -server=https://<
public IP address of the target cluster>:6443
```

- Add the new key information to the kubectl configuration.

```
kubectl config set-credentials dahu --client-certificate=dahu.crt --client-key=dahu.key  --embed-
certs=true
```

- Add the new context portal to the kubectl configuration.

```
kubectl config set-context sandbox-dahu --cluster=sandbox --user=dahu
```


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How to Use kubeconfig

- **In order to access your Kubernetes cluster, kubectl uses a configuration file. The default kubectl configuration file is located at ~/.kube/config and is referred to as the kubeconfig file.**
- **kubeconfig files organize information about clusters, users, namespaces, and authentication mechanisms. The kubectl command uses these files to find the information it needs to choose a cluster and communicate with it.**
- **The loading order follows these rules:**
  1. If the **--kubeconfig** flag is set, then only the given file is loaded. The flag may only be set once and no merging takes place.

     ```
     kubectl get pods --kubeconfig=file1
     ```
  2. If the **$KUBECONFIG** environment variable is set, then it is parsed as a list of filesystem paths according to the normal path delimiting rules for y our system.

     ```
     KUBECONFIG=file1 kubectl get pods
     ```
  3. Otherwise, the **${HOME}/.kube/config** file is used and no merging takes place.
- **Tip : Merging kubeconfig files :**

```
KUBECONFIG=file1:file2:file3 kubectl config view --merge --flatten > out.txt
```


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RBAC

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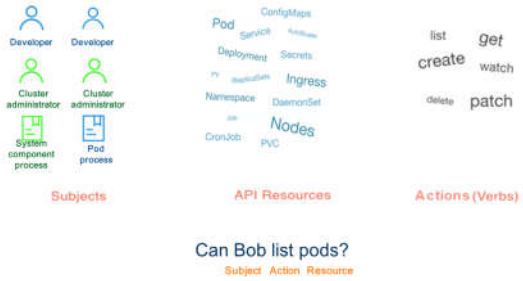
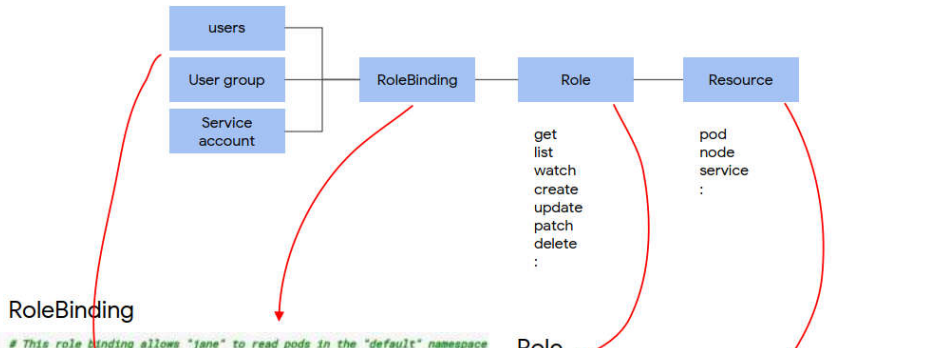
Three Elements of RBAC

- **Subjects** may be natural persons such as developers and cluster administrators, system component processes, or logical processes in pods.
- **API resources** are the access targets of requests. API resources include all types of resources in a Kubernetes cluster.
- **Verbs** indicate the actions that can be performed on the requested object resources, such as Add, Delete, Modify, Query, List, Get, and Watch.



Role and RoleBinding



RoleBinding

```yaml
# This role binding allows "jane" to read pods in the "default" namespace
kind: RoleBinding
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: read-pods
  namespace: default
subjects:
- kind: User
  name: jane # Name is case sensitive
  apiGroup: rbac.authorization.k8s.io
roleRef:
  kind: Role #this must be Role or ClusterRole
  name: pod-reader # this must match the name of the Role or ClusterRole
  apiGroup: rbac.authorization.k8s.io
```

Role

```yaml
kind: Role
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  namespace: default
  name: pod-reader
rules:
- apiGroups: [""] # "" indicates the core API group
  resources: ["pods"]
  verbs: ["get", "watch", "list"]
```

Controlling access

Role vs. ClusterRole

- **Role & RoleBinding are namespaced resource, ClusterRole & ClusterRoleBinding are Cluster wide resource**
  - For example, the permissions for resources such as persistent volumes (PVs) and nodes in a namespace are invisible, but you can define these permissions through a cluster role.

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

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

The only difference

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Controlling access

Default Cluster Role Bindings

Default ClusterRole	Default ClusterRoleBinding	Description
system:basic-user	**system:authenticated** group	Allows a user read-only access to basic information about themselves. Prior to v1.14, this role was also bound to `system:unauthenticated` by default.
system:discovery	**system:authenticated** group	Allows read-only access to API discovery endpoints needed to discover and negotiate an API level. Prior to v1.14, this role was also bound to `system:unauthenticated` by default.
system:public-info-viewer	**system:authenticated** and **system:unauthenticated** groups	Allows read-only access to non-sensitive information about the cluster. Introduced in Kubernetes v1.14.

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Network Policy

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What is a Network Policy ?

- **Network policies are Kubernetes resources that control the traffic between pods and/or network endpoints.**
  - They control traffic flow at the IP address or port level (OSI layer 3 or 4)
  - They use labels to select pods and specify the traffic that is directed toward those pods using rules.
- **NetworkPolicies are an application-centric construct which allow you to specify how a pod is allowed to communicate with various network "endpoints" and "services"**
- **Network policy can control ingress & egress traffic for Pod**
  - It is based on
    - Label (label selector)
    - Protocol (TCP/UDP), Port
    - IP range (CIDR)

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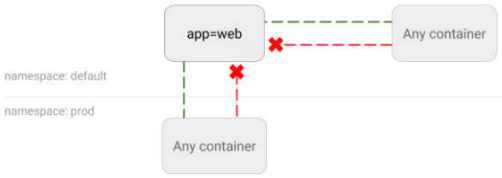
Controlling access

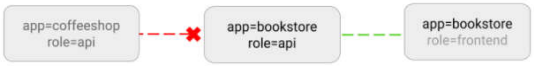
Ingres Control

- Deny all ingress traffic to Pod




```yaml
kind: NetworkPolicy
apiVersion: networking.k8s.io/v1
metadata:
  name: web-deny-all
spec:
  podSelector:
    matchLabels:
      app: web
  ingress: []
```

- LIMIT traffic to an application




```yaml
kind: NetworkPolicy
apiVersion: networking.k8s.io/v1
metadata:
  name: api-allow
spec:
  podSelector:
    matchLabels:
      app: bookstore
      role: api
  ingress:
  - from:
      - podSelector:
          matchLabels:
            app: bookstore
```

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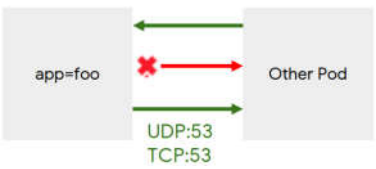
Controlling access

Egress control

- DENY egress traffic from an application


```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: foo-deny-egress
spec:
  podSelector:
    matchLabels:
      app: foo
  policyTypes:
  - Egress
  egress: []
```

- Limit egress traffic




```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: foo-deny-external-egress
spec:
  podSelector:
    matchLabels:
      app: foo
  policyTypes:
  - Egress
  egress:
  - ports:
    - port: 53
      protocol: UDP
    - port: 53
      protocol: TCP
  - to:
    - namespaceSelector: {}
```

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Security Context

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Security Context

- **Security-related feature can be configured on Pod and its containerthrough-out security-Context properties**
- **It can**
  - Specify the user under which the process in the container will run
  - Prevent the container from running as root
  - Privileged mode (full access to it's node's kernel)
  - Fine grained privileged mode (partial access for node's kernel)

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Controlling access

Security context example

- **Prevent container run as root**

```
apiVersion: v1
kind: Pod
metadata:
      name: hello-world
spec:
      containers:
# specification of the pod's containers
# ...
securityContext:
      readOnlyRootFilesystem: true
      runAsNonRoot: true
```

- **Run container with specified user**

```
apiVersion: v1
kind: Pod
metadata:
  name: security-context-demo-2
spec:
  securityContext:
    runAsUser: 1000
  containers:
  - name: sec-ctx-demo-2
    image: gcr.io/google-samples/node-hello:1.0
    securityContext:
      runAsUser: 2000
      allowPrivilegeEscalation: false
```


Controlling access

Security context example

- **Run container with full kernel capabilities (Privileged mode) For example NFS**

```
apiVersion: v1
kind: Pod
metadata:
  name: nfs-server
  labels:
    role: nfs-server
spec:
  containers:
    - name: nfs-server
      image: jsafrane/nfs-data
      ports:
        - name: nfs
          containerPort: 2049
      securityContext:
        privileged: true
```

- **Set capabilities for Container Adding individual kernel capabilities to a container**

```
apiVersion: v1
kind: Pod
metadata:
  name: security-context-demo-4
spec:
  containers:
  - name: sec-ctx-4
    image: gcr.io/google-samples/node-hello:1.0
    securityContext:
      capabilities:
        add: ["NET_ADMIN", "SYS_TIME"]
```

Security Best practices

Reference
https://kubernetes.io/blog/2016/08/security-best-practices-kubernetesdeployment

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Container Image control

- **Implement continuous security vulnerability scanning Include security scanning process in CI/CD pipeline**
- **Regularly apply security updates**
- **Update container image to latest version (ex node.js etc)**
- **Ensure that only authorized images are used in your environment**

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Authorization control

- **Create Administrative Boundaries between Resources**

```
{
  "apiVersion": "abac.authorization.kubernetes.io/v1beta1",
  "kind": "Policy",
  "spec": {
    "user": "alice",
    "namespace": "fronto",
    "resource": "pods",
    "readonly": true
  }
}
```

- **Limit direct access to Kubernetes Nodes**
  - You should limit SSH access to Kubernetes nodes. (instead of that user to use kubectl exec)

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Quota control

- **Define Resource Quota**

```
apiVersion: v1
kind: ResourceQuota
metadata:
  name: compute-resources
spec:
  hard:
    pods: "4"
    requests.cpu: "1"
    requests.memory: 1Gi
    limits.cpu: "2"
    limits.memory: 2Gi
```

```
kubectl create -f ./compute-resources.yaml --namespace=myspace
```

Give resource limit to namespace

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Network control

- Implement network segmentation

```
POST /apis/net.alpha.kubernetes.io/v1alpha1/
namespaces/tenant-a/networkpolicys
{
  "kind": "NetworkPolicy",
  "metadata": {
    "name": "pol1"
  },
  "spec": {
  "allowIncoming": {
    "from": [{
      "pods": { "segment": "frontend" }
    }],
    "toPorts": [{
      "port": 80,
      "protocol": "TCP"
    }]
    },
    "podSelector": {
      "segment": "backend"
    }
  }
}
```


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Security context for Pod

- SecurityContext->runAsNonRoot : Indicates that containers should run as non-root user
- SecurityContext->Capabilities : Controls the Linux capabilities assigned to the container.
- SecurityContext->readOnlyRootFilesystem : Controls whether a container will be able to write into the root filesystem.
- PodSecurityContext->runAsNonRoot: Prevents running a container with 'root' user as part of the pod

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