Kubernetes Admission Controller

kubernetes

Ali Akil

"The future belongs to those who believe in ~~the beauty of their dreams~~ enforcing policies for Kubernetes workloads." - Eleanor Kubevelt


ADMISSION CONTROLLER
POLICY ENGINE
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Policies? Why?

- Enhanced Security
  - Ensuring compliance with security best practices and preventing misconfigurations
- Resource Management
  - Efficiently allocate and regulate resources
- Consistency
  - Maintaining standardization and reduces the likelihood of misconfigurations
- Compliance and Governance
  - Ensuring alignment with both external regulations and internal organizational policies
- Automation
  - Automatically modifying resource configurations or generate complementary resources to meet compliance requirements

Kubernetes Policy Types

Validate

- Disallow Privileged Containers
- Restrict Image Registries
- Require limits and requests
- Require network policies

Mutate

- Add Default Resources
- Add emptyDir sizeLimit
- Add Labels
- Add Default securityContext

Generate

- Add Network Policy
- Add Pod Disruption Budget
- Add Namespace Quota

Kubernetes Admission Chain

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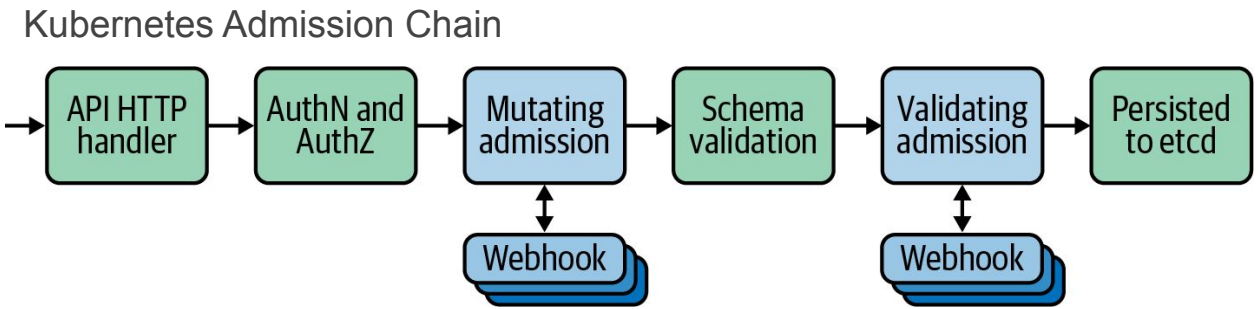
Admission Controllers

Validating and mutating requests to the Kubernetes API server before they are persisted in etcd




Mutating admission
Validating admission
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Mutating Admission Controller

- These controllers are able to generate and modify the resource attributes before they pass onto future phases
- Ordering is important
    - Setting fields in mutating admission controllers before the object is validated
- Service Account controller (Built in and enabled by default)
    - Generation example
        - When a namespace is created the service account controller and the token controller the default service account the corresponding secret
    - Mutation example:
        - When a Pod is submitted, the Service Account controller inspects the Pod's spec to ensure that it has the serviceAccount (SA) field set.
        - If not, then it adds the field and sets it to the default SA for the Namespace.
        - It also adds ImagePullSecrets and a Volume

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Validating Admission Controller

- Final stage before the object is persisted to etcd is for it to pass through validating admission controllers
- These can be built-in controllers or calls to external (out-of-tree) validating webhooks
- Only able to admit or reject the request, not modify the payload
- Differ from the prior schema validation step in that they are concerned with validating against operational logic, not a standardized schema

In-tree Admission controllers

In-tree Admission controllers

Default admission controllers

- DefaultIngressClass
- DefaultStorageClass
- LimitRanger
- NamespaceLifecycle
- ResourceQuota
- RuntimeClass
- ServiceAccount
- …

Non-Default admission controllers

- PodNodeSelector
- AlwaysPullImages
- NamespaceExists
- …

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Webhooks

Webhooks

- Allows configuring the Kubernetes API server to send API requests to external webhook endpoints and receive decisions.
- Two types of admission webhooks, validating admission webhook and mutating admission webhook.
- The receiving web server can be written in any language that can expose an HTTPS listener
- Can be run in or out of cluster
    - Utilizing in-cluster execution by leveraging the discovery and operator primitives available.
    - Implementing reusable functionality in serverless functions for out-of-cluster execution

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Writing Webhooks

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Plain HTTPS Handler

Implement webhooks from scratch

+ Provides the most flexibility in terms of language choices and deployment options to integrate with the current stacks
- Requires more domain knowledge
- Limited functionality and features out of the box
- Harder to maintain and troubleshoot over time

Controller Runtime

Controller-runtime is a subproject of Kubebuilder

- Set of Go libraries/SDK for building controllers
- \+ Simplifies building admission controllers by minimizing boilerplate and allowing developers to focus on implementing the desired logic
- \- Learning curve
- \- Limited language support

Example

```yaml
apiVersion: admissionregistration.k8s.io/v1
kind: ValidatingWebhookConfiguration
metadata:
  name: "pod-policy.example.com"
webhooks:
- name: "pod-policy.example.com"
  rules:
  - apiGroups:   [""]
    apiVersions: ["v1"]
    operations:  ["CREATE"]
    resources:   ["pods"]
    scope:       "Namespaced"
  clientConfig:
    service:
      namespace: "example-namespace"
      name: "example-service"
    caBundle: <CA_BUNDLE>
  admissionReviewVersions: ["v1"]
  sideEffects: None
  timeoutSeconds: 5
```

Centralized Policy Systems

- Policy as a Code
- Centralizing policy logic into one place and using standardized languages to express the allow/deny rules
- Components:
  - A policy language that can express conditions on whether an object should be admitted or rejected.
  - A controller that sits in the cluster serving as an admission controller

\+ Programming knowledge is not required to create admission controllers

  - Changes to logic do not require rebuilding and redeploying the controller each time

\+ Policies and rules are stored in a single location for viewing, editing, and auditing

\+ Policy catalog

\- Learning configuration language

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Gatekeeper

- Kubernetes-specific implementation of a lower-level tool called Open Policy Agent (general-purpose policy engine)
- Uses a specialized programming language (Rego) in order to implement the logic necessary for policy decisions

\+ Capable of expressing very complex policy

\+ Multiple replicas for scaling and availability are supported

\+ Extensible ConstraintTemplate model

\- learning curve of new programming language (Rego)

\- No generation ability

Example: Disallow Privileged Containers

Constraints template

```
spec:
  crd:
    spec:
      names:
        kind: K8sPSPPrivilegedContainer
      validation:
        openAPIV3Schema:
          type: object
          description: >-
            Controls the ability of any container to enable privileged mode.
            Corresponds to the `privileged` field in a PodSecurityPolicy. For more
            information, see
            https://kubernetes.io/docs/concepts/policy/pod-security-policy/#privileged
          properties:
            exemptImages:
              description: >-
                Any container that uses an image that matches an entry in this list will be excluded
                from enforcement. Prefix-matching can be signified with `*`. For example: `my-image-*`.

                It is recommended that users use the fully-qualified Docker image name (e.g. start with a domain name)
                in order to avoid unexpectedly exempting images from an untrusted repository.
              type: array
              items:
                type: string
  targets:
    - target: admission.k8s.gatekeeper.sh
      rego: |
        package k8spspprivileged

        import data.lib.exempt_container.is_exempt

        violation[{"msg": msg, "details": {}}] {
            c := input_containers[_]
            not is_exempt(c)
            c.securityContext.privileged
            msg := sprintf("Privileged container is not allowed: %v, securityContext: %v", [c.name, c.securityContext])
        }
```

Constraint

```
apiVersion: constraints.gatekeeper.sh/v1beta1
kind: K8sPSPPrivilegedContainer
metadata:
  name: psp-privileged-container
spec:
  match:
    kinds:
      - apiGroups: [""]
        kinds: ["Pod"]
    excludedNamespaces: ["kube-system"]
```

Kyverno 

- Open-source Kubernetes policy-engine originally from Nirmata and later donated to the CNCF
- Utilizes yaml to implement the logic necessary for policy decisions

\+ Validation, mutation, image verification and resource generation abilities

\+ Does not require knowledge of a specialized programming language

\- Highly complex policy may not be possible since no programming language is exposed

\- Less mature than OPA but still has a fast-growing community

Example: Disallow Privileged Containers

Cluster Policy

```yaml
spec:
  validationFailureAction: audit
  background: true
  rules:
    - name: privileged-containers
      match:
        any:
        - resources:
            kinds:
              - Pod
      validate:
        message: >-
          Privileged mode is disallowed. The fields spec.containers[*].securityContext.privileged
          and spec.initContainers[*].securityContext.privileged must be unset or set to `false`.
        pattern:
          spec:
            =(ephemeralContainers):
              - =(securityContext):
                  =(privileged): "false"
            =(initContainers):
              - =(securityContext):
                  =(privileged): "false"
            containers:
              - =(securityContext):
                  =(privileged): "false"
```

Other tools

-  Kubewarden https://github.com/kubewarden
-  Datree https://github.com/datreeio

Thanks!

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"Two things are infinite: the Kubernetes ecosystem and the number of times you'll say, 'Who let that pod through?' " - Albert Kubestein