# Enforcing Bespoke Policies
## in Cloud Native Systems

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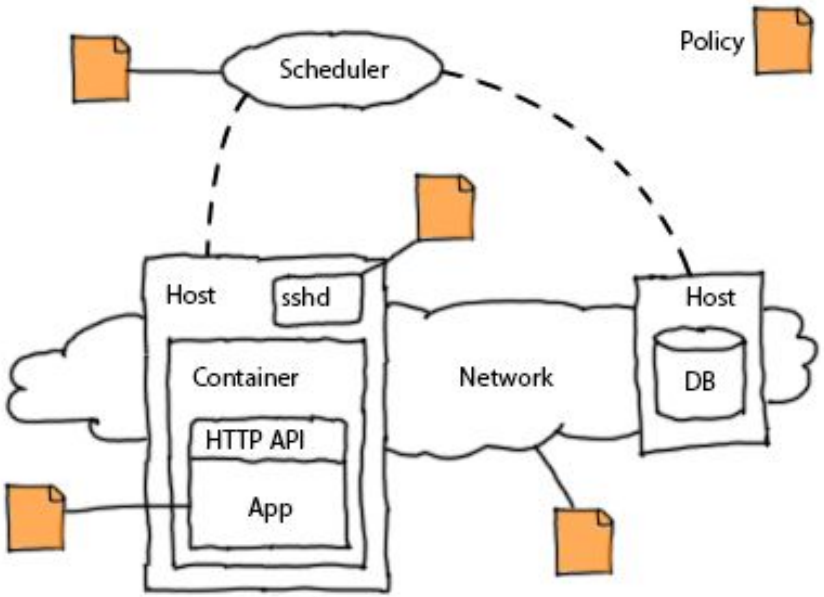
openpolicyagent.org

# Overview

- What Is Policy?
- Example Scenario
- Admission Control (Before & After 1.7)
- Custom Resource Definitions
- Open Policy Agent

# What Is Policy?

- Every organization has unique requirements that affect the entire stack and change over time

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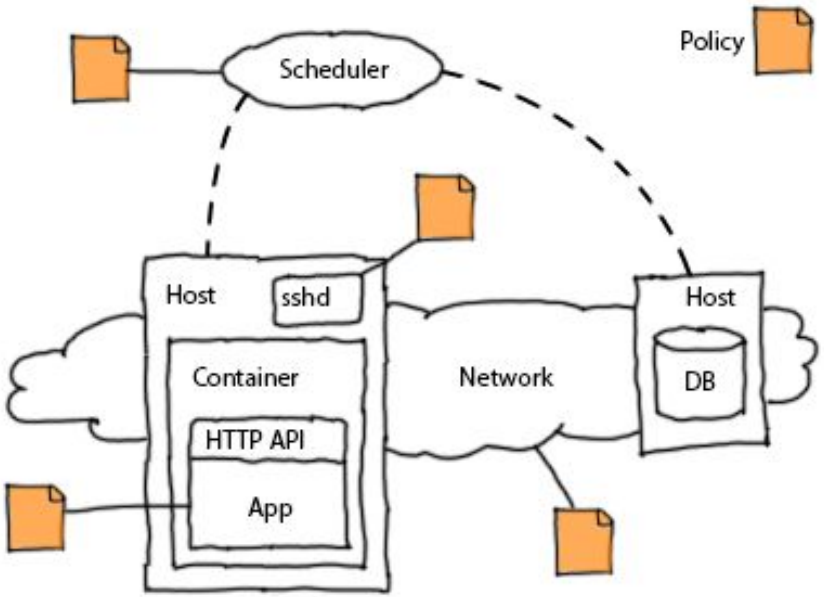


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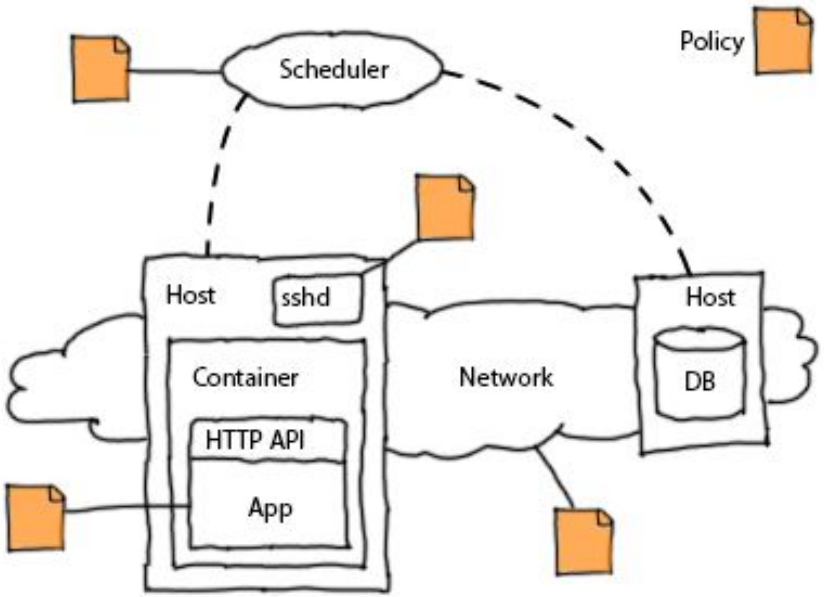
# What Is Policy?

- Every organization has unique requirements that affect the entire stack and change over time
- Policies are sets of rules that govern how the system *should* behave
- Policies are vital to the long-term success of organizations

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# Example Scenario

- **Alice** and **Bob** work for AcmeCorp

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Platform Engineer

**Bob**
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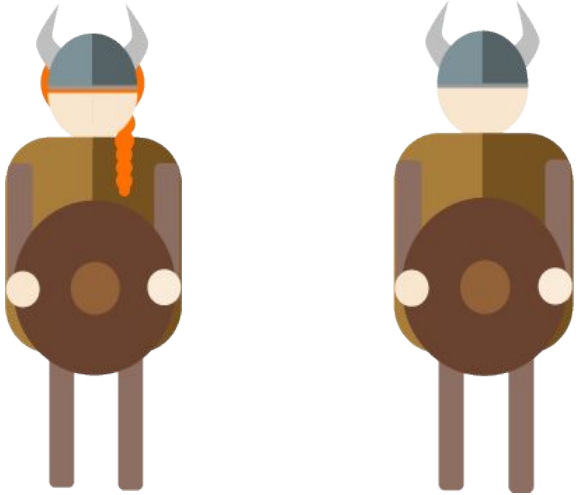
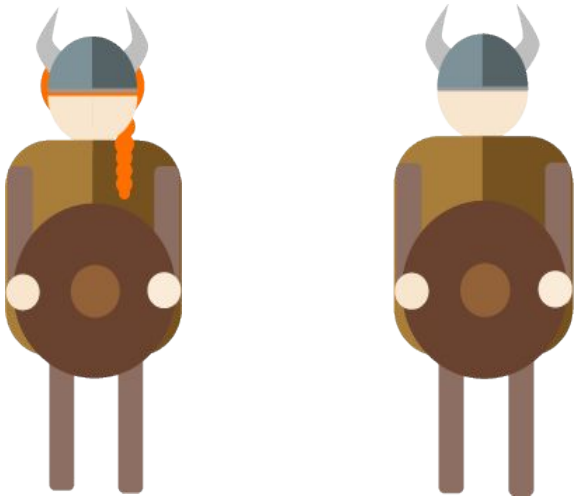


**Alice**
Platform Engineer

**Bob**
App Engineer

# Example Scenario

- **Alice** and **Bob** work for AcmeCorp
- Bob needs shell access to containers running on Kubernetes
- Bob cannot be trusted with access to **privileged containers** running in the **production namespace**



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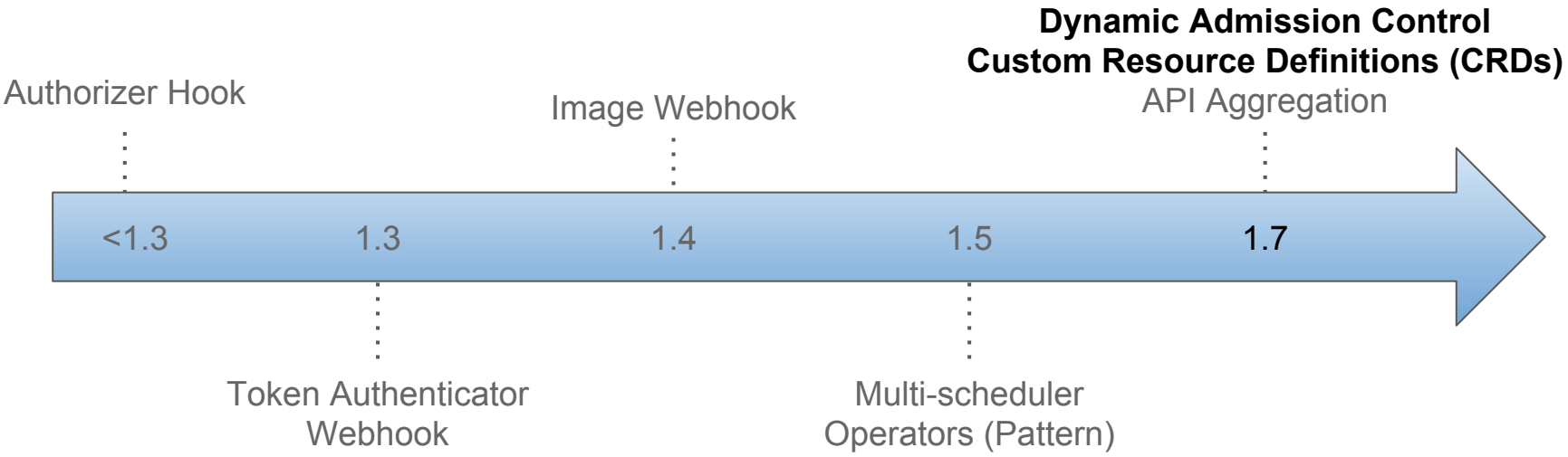
# Kubernetes Extensibility

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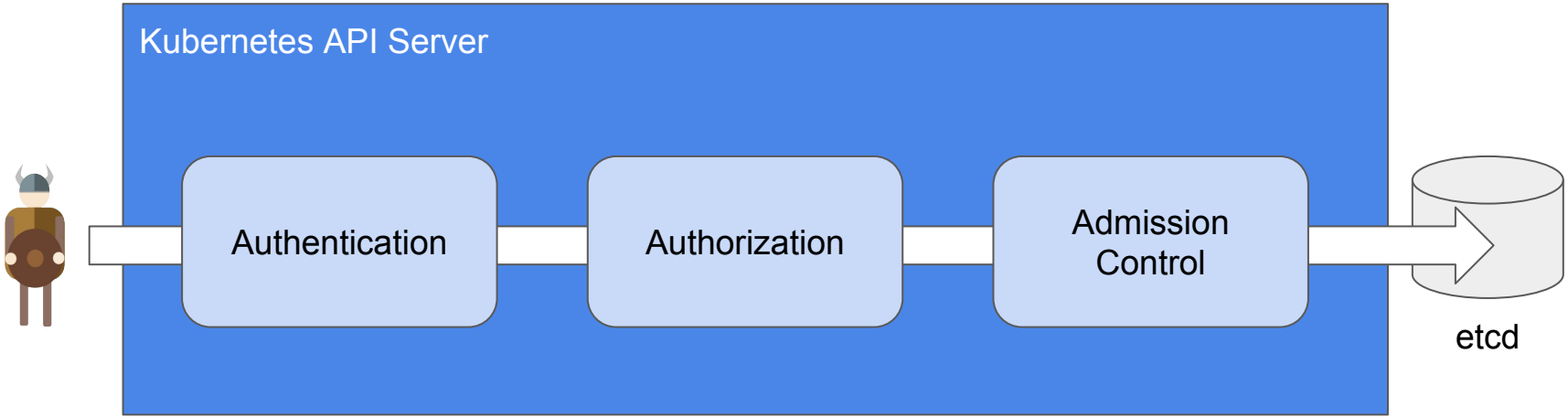
# Admission Control

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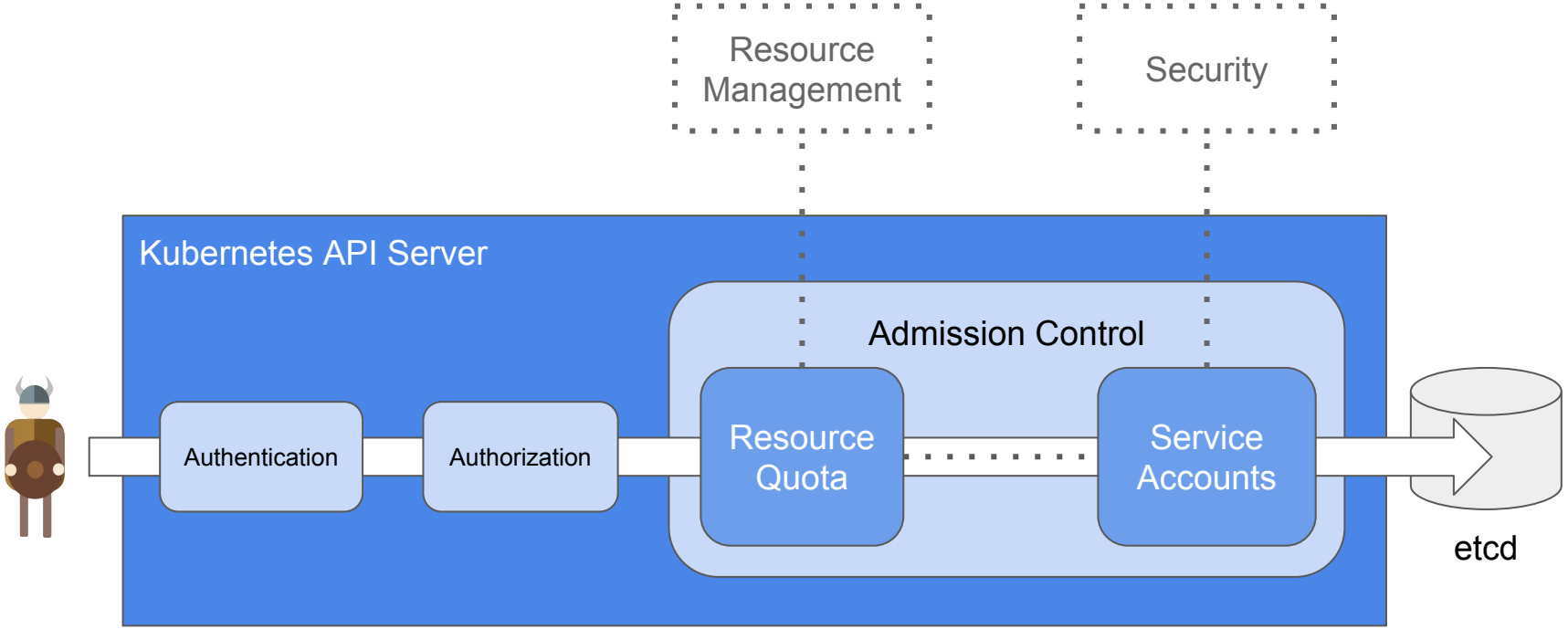
# Admission Control

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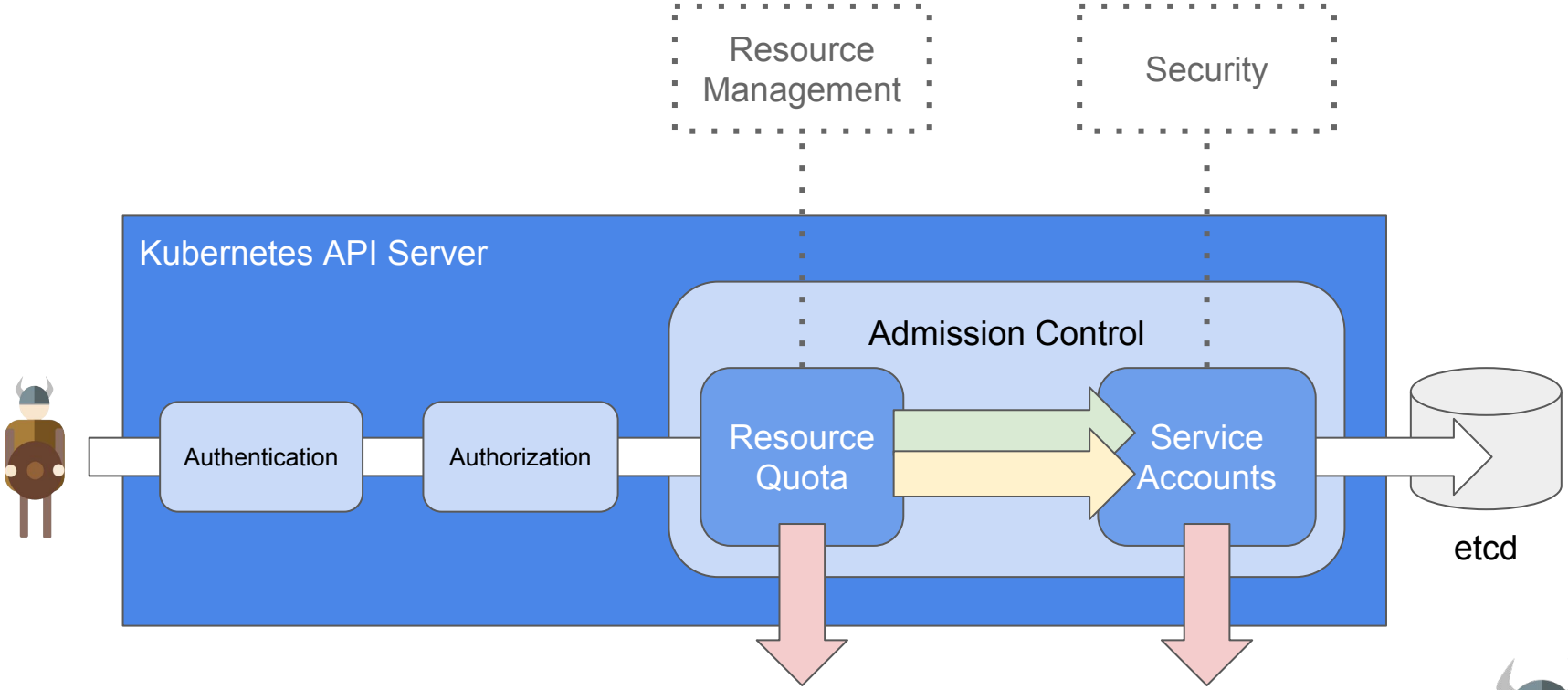
# Admission Control

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# Admission Control: Before 1.7

- Static compilation & configuration
  - 30+ admission controllers
  - 1-4 added per release
  - Command line arguments
  - Static configuration files

admit
deny
exec
limitranger
namespace
resourcequota
securitycontext
serviceaccount
initialresources
alwayspullimages
antiaffinity
persistentvolume
security
imagepolicy
storageclass
gc
podnodeselector
defaulttolerationseconds
podpreset
initialization
noderestriction
podtolerationrestriction
schedulingpolicy
image/imagelimitrangerplugin
image/imagepolicyplugin
ingress/ingress
project/lifecycle
project/podnodeenvironment
project/projectrequestlimit
quota/quotaclusterresourceoverride
quota/clusterquota
quota/runonceduration
scheduler/podnodeconstraints
security/constraint

# Admission Control: Before 1.7

- Static compilation & configuration
  - 30+ admission controllers
  - 1-4 added per release
  - Command line arguments
  - Static configuration files

- Example Scenario
  - Alice forks Kubernetes into a private repository
  - Alice implements the policy inside the plugin framework
  - Alice now has to build, push, and upgrade Kubernetes itself

admit
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exec
limitranger
namespace
resourcequota
securitycontext
serviceaccount
initialresources
alwayspullimages
antiaffinity
persistentvolume
security
imagepolicy
storageclass
gc
podnodeselector
defaulttolerationseconds
podpreset
initialization
noderestriction
podtolerationrestriction
schedulingpolicy
image/imagelimitrangerplugin
image/imagepolicyplugin
ingress/ingress
project/lifecycle

**bobprotectionpolicy**

project/podnodeenvironment
project/projectrequestlimit
quota/quotaclusterresourceoverride
quota/clusterquota
quota/runonceduration
scheduler/podnodeconstraints
security/constraint

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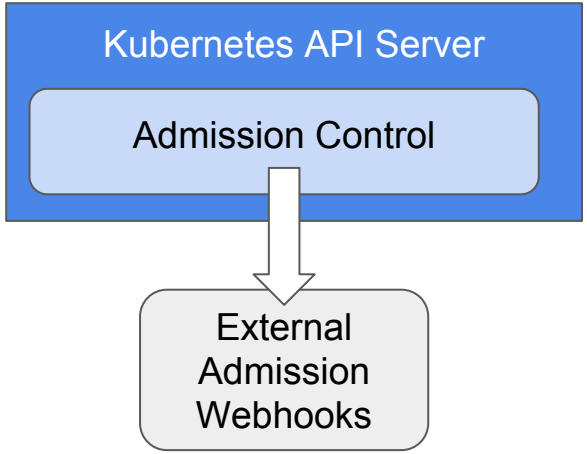
# Admission Control: Webhooks

- In 1.7, admission controllers can be implemented as webhooks that run on top of Kubernetes
- Webhooks can **allow** or **deny** incoming requests
  - Before etcd is updated
  - Before clients are notified
- Webhooks are configured **dynamically** via Kubernetes APIs



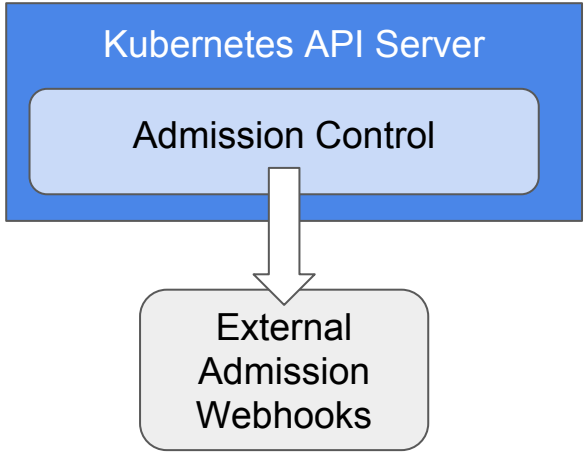
# Admission Control: Webhooks

- The API Server calls webhooks whose configuration rules match the incoming request:

```
match [
  {operations: ["create"], kinds: ["pods"]},
  {operations: ["delete"], kinds: ["services"]}
]
```

- Rules can include wildcards:

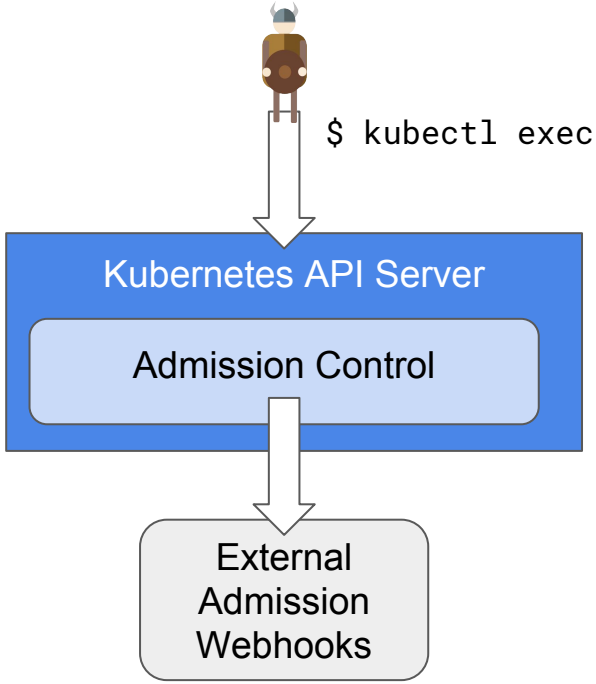
```
match [
  {operations: ["*"], kinds: ["*"]}
]
```



# Admission Control: Webhooks

- The API Server provides the **operation, entire object, and user info** in the webhook call

```
kind: AdmissionReview
spec:
  kind: {kind: Pod, version: v1}
  name: admission-webhook-demo-373699553-8srx8
  namespace: default
  object:
    Options:
      Command: [sh]
      Container: admission-webhook-demo
      ...
    ResourcePath: pods/exec
  operation: CONNECT
  userInfo:
    groups: ['system:masters', 'system:authenticated']
    username: minikube
```

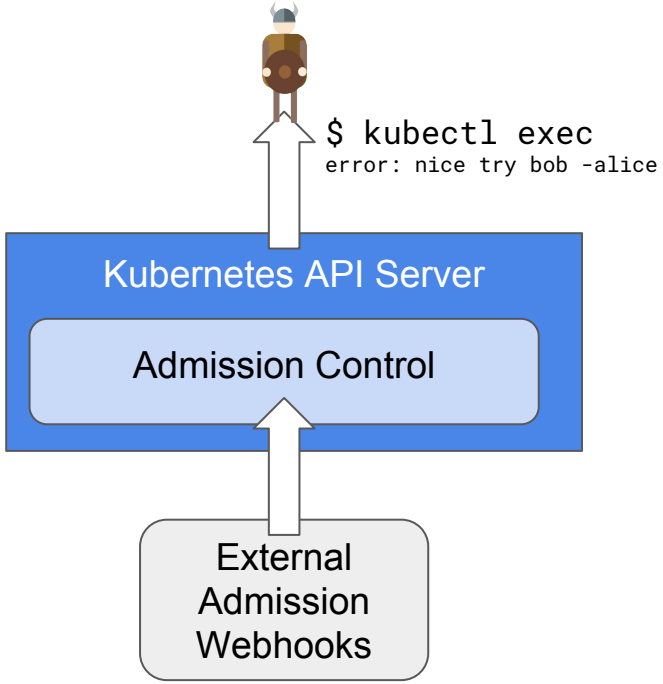


# Admission Control: Webhooks

- Webhooks respond with an **AdmissionReview** that indicates whether to **allow** or **deny** the request

```
kind: AdmissionReview
status:
  allowed: false
  reason:
    message: “nice try bob -alice”
```

- The API Server rejects the request **IF ANY** of the webhooks return a denial

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# Demo

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- Webhooks must serve POST requests at https://<ip>:<port>/

# Webhooks: Lessons Learned

- API server connects by IP address => subjectAltName hardcoded
- API server “fails open” if webhook fails (not configurable in alpha)
- API server sends “internal representation” of Kubernetes objects over the wire
- Webhooks must serve POST requests at https://<ip>:<port>/
- Dependency hell with client-go (v4.0.0.beta0) and Kubernetes 1.7

# Webhooks...all the way down?

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- Webhooks & Initializers lay the groundwork for **extensible** policy enforcement
- Policy **decisions** have been decoupled from **enforcement**
- Is there a better way to **author** policies to control system **behaviour**?

```yaml
apiVersion: v1
kind: Pod
metadata:
  labels:
    app: nginx
  name: nginx-1493591563-bvl8q
  namespace: production
spec:
  containers:
  - image: nginx
    imagePullPolicy: Always
    name: nginx
    securityContext:
      privileged: true
  dnsPolicy: ClusterFirst
  nodeName: minikube
  restartPolicy: Always
status:
  containerStatuses:
  - name: nginx
    ready: true
    restartCount: 0
    state:
      running:
        startedAt: 2017-08-01T06:34:22Z
  hostIP: 192.168.99.100
  phase: Running
  podIP: 172.17.0.4
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container.securityContext.privileged = true
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# functions
is_privileged {
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}

# policies
deny {
  review.user      = “bob”
  review.operation = “CONNECT”
  review.namespace = “production”
  is_privileged
  ...
}
```

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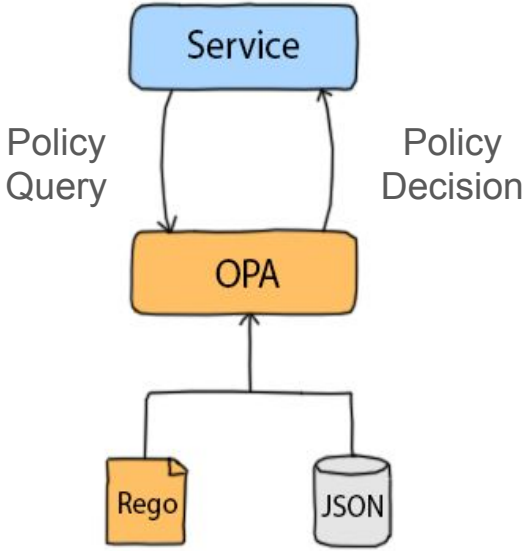
# OPA is an open source, general-purpose policy engine

- Declarative Language (Rego)
- Document-oriented (JSON, YAML)
- Daemon, Library, REPL (Go)
- Policy, Data & Query APIs (HTTP)
- Integration with Kubernetes
  - Federation 1.7 placement policies powered by OPA
- Apache License 2.0

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# Custom Resource Definitions (CRDs)

- Add custom resource types to the Kubernetes API

```
v1/pods
apps/v1beta1/deployments
...
acmecorp.com/v1/policies
```

- Deprecates `ThirdPartyResources`
  - Same wire format
  - Configurable pluralization
  - Cluster versus namespace scope

# Custom Resource Definitions (CRDs)

- Write definitions in YAML and register them via the Kubernetes API

```yaml
apiVersion: apiextensions.k8s.io/v1beta1
kind: CustomResourceDefinition
metadata:
  name: policies.acmecorp.com
spec:
  group: acmecorp.com
  version: v1
  scope: Cluster
  names:
    plural: policies
    singular: policy
    kind: Policy
```

```
alice:~$ kubectl create -f policies-crd.yaml
customresourcedefinition "policies.acmecorp.com" created

alice:~$ kubectl get crd
NAME                   KIND
policies.acmecorp.com CustomResourceDefinition.v1beta1.apiex
```

# Custom Resource Definitions (CRDs)

- Interact with custom resources **the same way** as Deployments, Services, etc.

```yaml
apiVersion: acmecorp.com/v1
kind: Policy
metadata:
  name: internal-image-registry
spec:
  expressions:
    - kind: Pod
      path: "spec.containers[].image"
      match: "acmecorp.io/.*$"
---
apiVersion: acmecorp.com/v1
kind: Policy
metadata:
  name: team-label-exists
spec:
  expressions:
    - kind: "*"
      path: "metadata.labels.team"
      exists: true
```

```
alice:~$ kubectl create -f custom-policies.yaml
policy "internal-image-registry" created
policy "team-label-exists" created

alice:~$ kubectl get policies.acmecorp.com
NAME                        KIND
internal-image-registry     Policy.v1.acmecorp.com
team-label-exists           Policy.v1.acmecorp.com

alice:~$ kubectl delete policies.acmecorp.com team-label-exists
policy "team-label-exists" deleted
```

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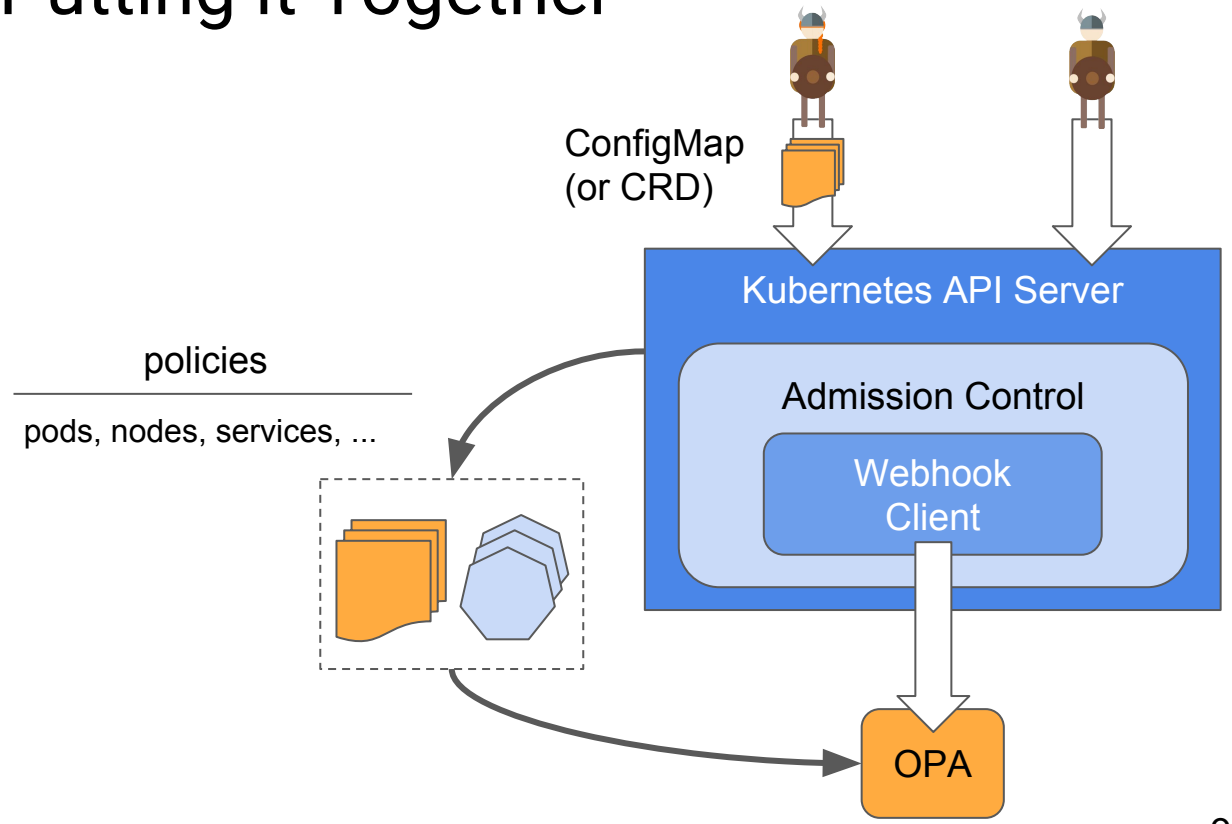
# Demo

# Putting it Together

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# Conclusions

- Think about leveraging Kubernetes 1.7 extensibility features today
  - Initializers & Webhooks in alpha => beta in 1.8
  - Custom Resource Definitions in beta

- Check out the Open Policy Agent (OPA) project
  - Unified, context-aware policies across the stack
  - High-level declarative policy language
  - Rich support for complex/nested data

- Accept uncertainty
  - Requirements evolve => design for change
  - Decouple policy decisions from enforcement

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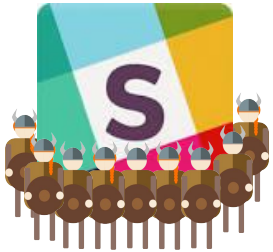
# Thank you!

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github.com/open-policy-agent/opa