Release F: Coordinated Service Exposure

JIRA Ticket

NONRTRIC-634 - Getting issue details... STATUS

ISTIO

Istio is a service mesh which provides a dedicated infrastructure layer that you can add to your applications. It adds capabilities like observability, traffic management, and security, without adding them to your own code.

To populate its own **service** registry, **Istio** connects to a **service discovery** system. For example, if you've installed **Istio** on a Kubernetes cluster, then **Isti** automatically detects the services and endpoints in that cluster. Using this **service registry**, the Envoy proxies can then direct traffic to the relevant services.

Istio Ingress Gateway can be used as a **API-Gateway** to securely expose the APIs of your micro services. It can be easily configured to provide access control for the APIs i.e. allowing you to apply policies defining who can access the APIs, what operations they are allowed to perform and much more conditions.

The Istio API traffic management features available are: Virtual services: **Configure request routing to services within the service mesh**. Each virtual service can contain a series of routing rules, that are evaluated in order. Destination rules: Configures the destination of routing rules within a virtual service.

Destination Rule

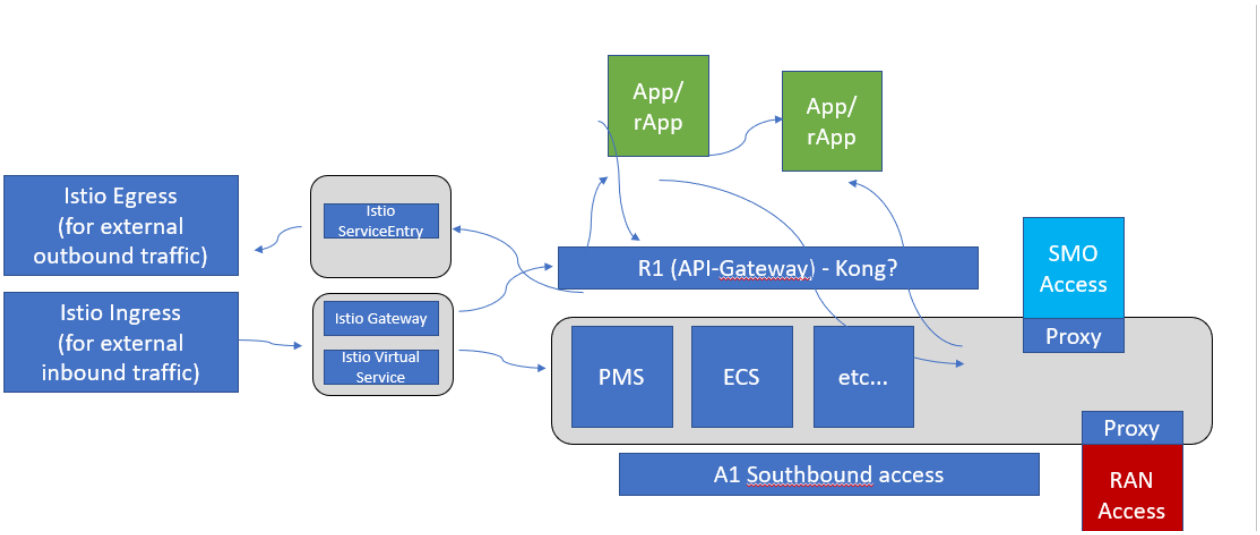
```
apiVersion: networking.istio.io/v1alpha3
kind: DestinationRule
metadata:
  name: bookinfo-ratings
spec:
  host: ratings.prod.svc.cluster.local
  trafficPolicy:
    loadBalancer:
      simple: LEAST_CONN
  subsets:
  - name: testversion
    labels:
      version: v3
    trafficPolicy:
      loadBalancer:
        simple: ROUND_ROBIN
```

Istio provisions the DNS names and **secret** names for the DNS **certificates** based on configuration you provide. The DNS **certificates** provisioned are signed by the **Kubernetes** CA and stored in the **secrets** following your configuration. **Istio** also manages the lifecycle of the DNS **certificates**, including their rotations and regenerations.

With Mutual TLS (mTLS) the client and server both verify each other's certificates and use them to encrypt traffic using TLS.. With Istio, you can enforce mutual TLS automatically.

PeerAuthentication

```
apiVersion: "security.istio.io/v1beta1"
kind: "PeerAuthentication"
metadata:
  name: "default"
  namespace: "istio-system"
spec:
  mtls:
    mode: STRICT
```



JWT

JSON Web Token (JWT) is an open standard (RFC 7519) that defines a compact and self-contained way for securely transmitting information between parties as a JSON object.

JWT is mostly used for Authorization. Once the user is logged in, each subsequent request will include the JWT, allowing the user to access routes, services, and resources that are permitted with that token (User context). You can pass the original jwt as an embedded jwt or pass original jwt in the http header (Istio / JWTRule).

JWT can also contain information about the client that sent the request (client context).

We can use **Istio**'s RequestAuthentication resource to configure **JWT** policies for your services.

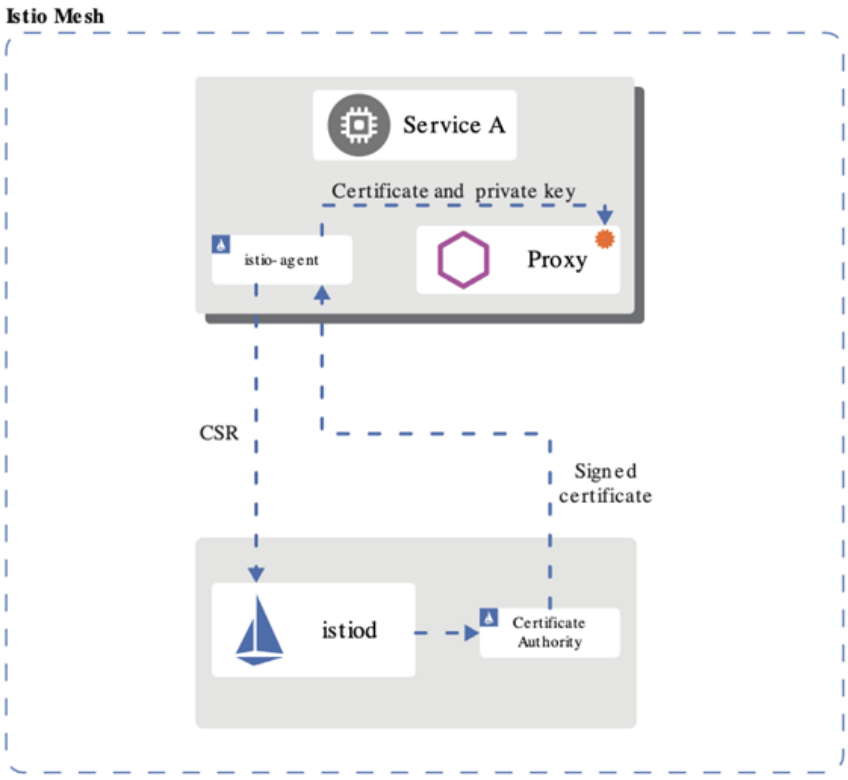
Request Authentication

```
apiVersion: security.istio.io/v1beta1
kind: RequestAuthentication
metadata:
  name: httpbin
  namespace: foo
spec:
  selector:
    matchLabels:
      app: httpbin
  jwtRules:
  - issuer: "issuer-foo"
    jwksUri: https://example.com/.well-known/jwks.json
---
apiVersion: security.istio.io/v1beta1
kind: AuthorizationPolicy
metadata:
  name: httpbin
  namespace: foo
spec:
  selector:
    matchLabels:
      app: httpbin
  rules:
  - from:
    - source:
        requestPrincipals: ["*"]
```

JWT can also be used for service level authorization (SLA)

Authorization Policy

```
apiVersion: security.istio.io/v1beta1
kind: AuthorizationPolicy
metadata:
  name: httpbin
  namespace: foo
spec:
  selector:
    matchLabels:
      app: httpbin
  rules:
  - from:
    - source:
        requestPrincipals: ["*"]
  - to:
    - operation:
        paths: ["/healthz"]
```



Use Case

1. A client makes a request on a specific port.
2. The `Load Balancer` listens on this port and forwards the request to one of the workers in the cluster (on the same or a new port).
3. Inside the cluster the request is routed to the `Istio IngressGateway Service` which is listening on the port the load balancer forwards to.
4. The `Service` forwards the request (on the same or a new port) to an `Istio IngressGateway Pod` (managed by a Deployment).
5. The `IngressGateway Pod` is configured by a `Gateway` (!) and a `VirtualService`.
6. The `Gateway` configures the ports, protocol, and certificates.
7. The `VirtualService` configures routing information to find the correct `Service`
8. The `Istio IngressGateway Pod` routes the request to the `application Service`.
9. And finally, the `application Service` routes the request to an `application Pod` (managed by a deployment).

KUBERNETES

K8S RBAC (Role Based Access Control) - supported by default in kubernetes.

K8S Service Account

- Kube use service account (sa) to validate api access
- SAs can be lined to a role via a binding
- A default sa, with no permissions (no bindings), is created in each namespace – pods uses this namespace unless otherwise specified
- Pods can be specified to run with a specific sa
- The helm manger needs a SA with cluster wide permission (to be able to list installed charts etc)
  However, during installation the pod running the helm install/upgrade/delete should run with a sa with only namespace permission to ensure not other modification is made to kube objects outside the namespace

K8S RBAC - controlling access to kubernetes resources

- Role and and rolebinding objects defines who (sa, user or group) is allowed to do what in the kubernetes api
- **Role** object
  - Sets permissions on resources in a specific namespace
- **ClusterRole** object
  - Sets permission on non-namespaced resources or across namespaces
- **RoleBinding** object
  - Binds one or more Role or a ClusterRole object(s) to a user, group or service account
- **ClusterRoleBinding** object
  - Binds one or more ClusterRole object(s) to a user, group or service account
- No installation requried – RBAC enabled by default

Network Policies

- K8S supports Network Policy objects but a provider need to be install for the polcies to take effect, e.g. Calico
- Network policies can control ingress and/or egress traffic by selecting applicable pods - bacially controlling traffic between pods and/or network endpoints
- Several providers: Calico, Cillium etc

- Allow traffic from ns: **kong** (the gateway), **nonrtric** and **onap**
- Deny traffic from any other ns

```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: np-nrt-ingress
  namespace: nonrtric
spec:
  podSelector: {}
  policyTypes:
  - Ingress
  ingress:
  - from:
    - namespaceSelector:
        matchLabels:
          kubernetes.io/metadata.name: kong
    - namespaceSelector:
        matchLabels:
          kubernetes.io/metadata.name: onap
    - namespaceSelector:
        matchLabels:
          kubernetes.io/metadata.name: nonrtric
```

KONG

Kong is Orchestration Microservice API Gateway. Kong provides a flexible abstraction layer that securely manages communication between clients and microservices via API. Also known as an API Gateway, API middleware or in some cases Service Mesh.

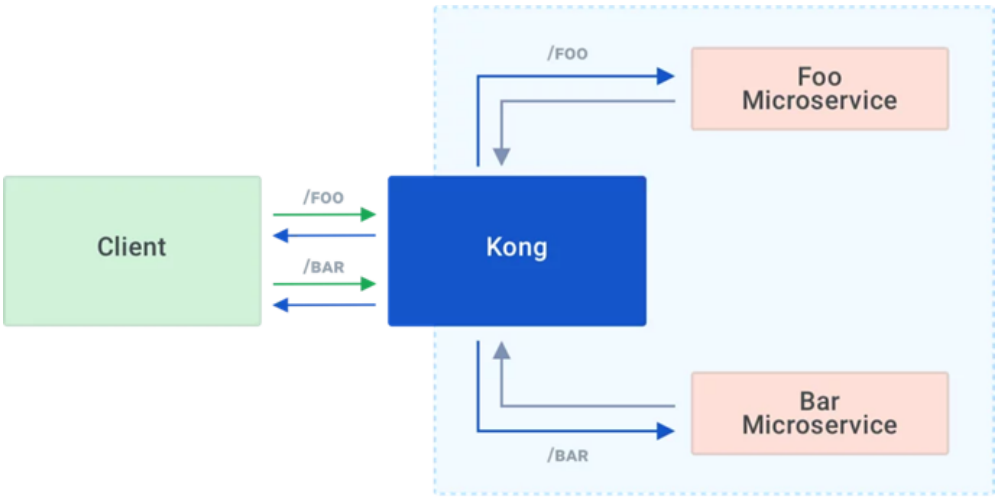
- Kong can be used as an API gateway:
- Hiding internal microservice structure
- Could be used as R1 API front-end

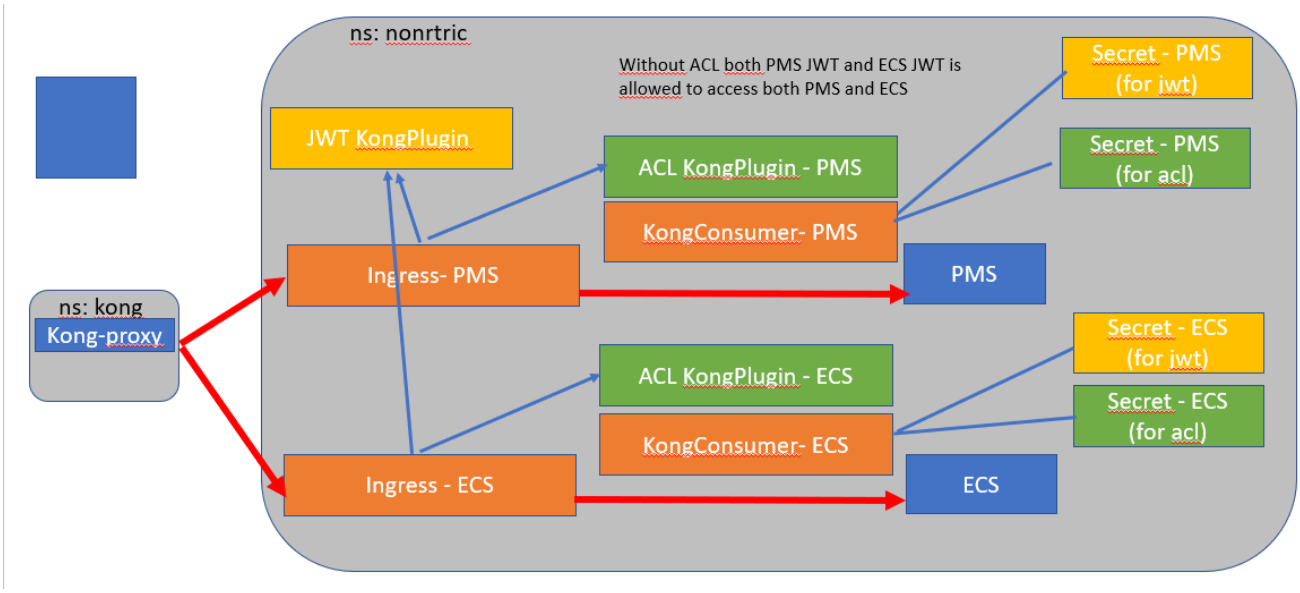
Kong acts as the service registry, **keeping a record of the available target instances for the upstream services**. When a target comes online, it must register itself with Kong by sending a request to the Admin API. Each upstream service has its own ring balancer to distribute requests to the available targets.

With client-side discovery, the client or API gateway making the request is responsible for identifying the location of the service instance and routing the request to it. The client begins by querying the service registry to identify the location of the available instances of the service and then determines which instance to use. See https://konghq.com/learning-center/microservices/service-discovery-in-a-microservices-architecture/

Kong datastore

Kong uses an external datastore to store its configuration such as registered APIs, Consumers and Plugins. Plugins themselves can store every bit of information they need to be persisted, for example rate-limiting data or Consumer credentials. See https://konghq.com/faqs/#:~:text=PostgreSQL%20is%20an%20established%20SQL%20database%20for%20use,Cassandra%20or%20PostgreSQL%2C%20Kong%20maintains%20its%20own%20cache.





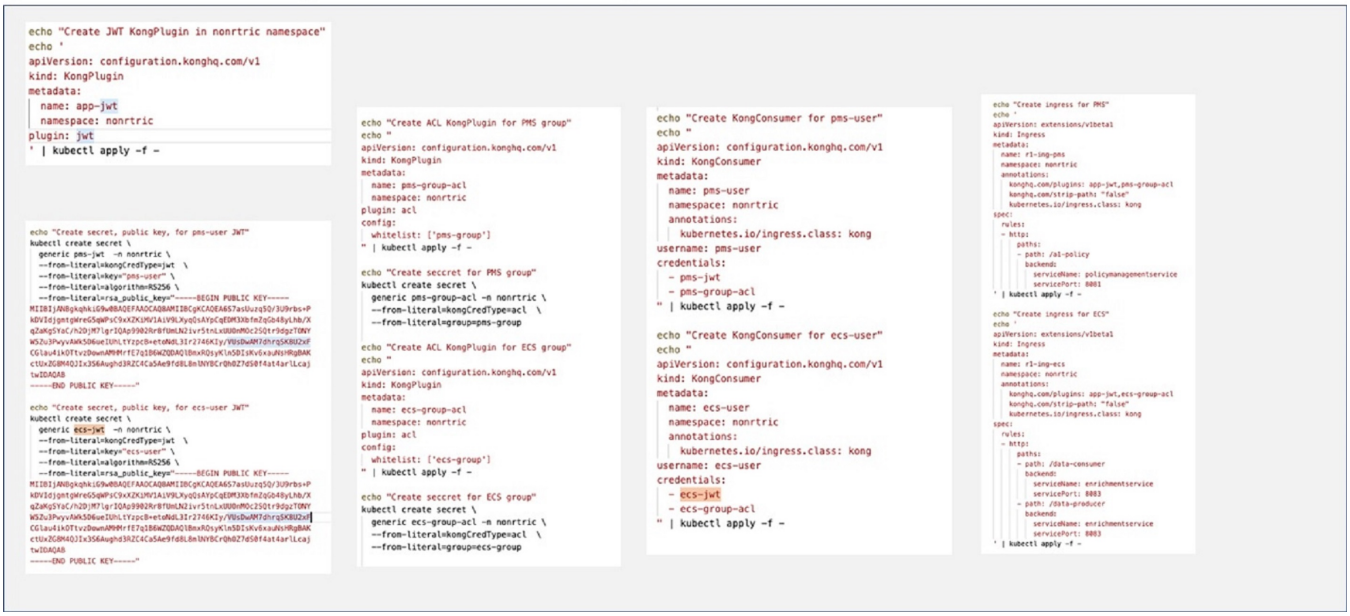
Kong Demo

Demo of Kong gateway access control already available.

JWT tokens are used to grant access to particular services for different users.

See also https://konghq.com/blog/jwt-kong-gateway

Kube objects for Kong



Network Policy

```
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: networkpolicy-nr
  namespace: nonrtric
spec:
  podSelector: {}
  policyTypes:
  - Ingress
  ingress:
  - from:
    - namespaceSelector:
        matchLabels:
          kubernetes.io/metadata.name: kong
    - namespaceSelector:
        matchLabels:
          kubernetes.io/metadata.name: onap
    - namespaceSelector:
        matchLabels:
          kubernetes.io/metadata.name: nonrtric
```

Kong Gateway JWT

```
apiVersion: configuration.konghq.com/v1
kind: KongPlugin
metadata:
  name: app-jwt-kp
  namespace: nonrtric
plugin: jwt
---
apiVersion: v1
```

```
kind: Secret
metadata:
  name: pms-jwt-sec
  namespace: nonrtric
type: Opaque
stringData:
  kongCredType: jwt
  key: pms-issuer
  algorithm: RS256
  rsa_public_key: |
    -----BEGIN PUBLIC KEY-----
    MIIBIjANBgkqhkiG9w0BAQEFAAOCAQ8AMIIBCgKCAQEAwetu4+suoz6c7e1kQz7I
    Jmujci8zHpp4qh3nsmEL8e3QOKzMVsLuQPcF8lO1bBoChSA+KMNJ5rEixGWSxClp
    9XroBSgrvjDsKtpPIlBQMnyOUYRSXWnIodmN+7wA72pTxo7JtAypPzRscSgi0OZt
    9dtmv50RLr9Wph5cI+IE9OtgW58OKtdFRGigGHfdUEwrT/MPw2rOU85YRFaEgT/i
    wcuQCe+Zmf2S2gVgK62u51ZFFn2VycJT1LcOt9cdqrSXYZAPfVKnQ/EgYvDdzFL1
    x73JkrrSEP3pfrN4bXOnc7cS/S9Y2qk/I+QCR6a6XKmqk5SnWJSyXvKdYQJrgxJp
    lQIDAQAB
    -----END PUBLIC KEY-----
---
apiVersion: v1
kind: Secret
metadata:
  name: ecs-jwt-sec
  namespace: nonrtric
type: Opaque
stringData:
  kongCredType: jwt
  key: ecs-issuer
  algorithm: RS256
  rsa_public_key: |
    -----BEGIN PUBLIC KEY-----
    MIIBIjANBgkqhkiG9w0BAQEFAAOCAQ8AMIIBCgKCAQEAtminzTtNs5oqPCbg4uC1
    L7MfR3B+uyYvkSKr3NFieRCxp6VhrgodJJXYc3SqXbaTVBkTwU24wG4UvJCnoRQd
    0VhSawtLkN8XNAdCiD831dKUYMJPs43ZY/gO5CHVqUMdSHlp8dn7jNren59dvRRS
    3xC1D3etXuEU01XGuLi/5qJLAKqDbYs3bH1vslTjndg1WTsrkU8GEIT1NphSYg25
    s6rSLTIBfk8FjKquYHw3wYVSQK9rg2mqddJpRWkfZnazMHTmSNjOJpiNb77VLGSx
    9qDbbLjurCl2mAG5Z+w76uKfKGgOo68SU0TL1sPybsKhAoZZg1gF06mvMln5eq5C
    RQIDAQAB
    -----END PUBLIC KEY-----
---
apiVersion: configuration.konghq.com/v1
kind: KongPlugin
metadata:
  name: pms-group-acl-kp
  namespace: nonrtric
plugin: acl
config:
  whitelist: ['pms-group']
---
apiVersion: v1
kind: Secret
metadata:
  name: pms-group-acl-sec
  namespace: nonrtric
type: Opaque
stringData:
  kongCredType: acl
  group: pms-group
---
apiVersion: configuration.konghq.com/v1
kind: KongPlugin
metadata:
  name: ecs-group-acl-kp
  namespace: nonrtric
plugin: acl
config:
  whitelist: ['ecs-group']
---
apiVersion: v1
kind: Secret
```

```
metadata:
  name: ecs-group-acl-sec
  namespace: nonrtric
type: Opaque
stringData:
  kongCredType: acl
  group: ecs-group
---
apiVersion: configuration.konghq.com/v1
kind: KongPlugin
metadata:
  name: all-group-acl-kp
  namespace: nonrtric
plugin: acl
config:
  whitelist: ['ecs-group', 'pms-group']
---
apiVersion: configuration.konghq.com/v1
kind: KongConsumer
metadata:
  name: pms-user-kc
  namespace: nonrtric
  annotations:
    kubernetes.io/ingress.class: kong
username: pms-user
credentials:
  - pms-jwt-sec
  - pms-group-acl-sec
---
apiVersion: configuration.konghq.com/v1
kind: KongConsumer
metadata:
  name: ecs-user-kc
  namespace: nonrtric
  annotations:
    kubernetes.io/ingress.class: kong
username: ecs-user
credentials:
  - ecs-jwt-sec
  - ecs-group-acl-sec
---
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: r1-pms-ing
  namespace: nonrtric
  annotations:
    konghq.com/plugins: app-jwt-kp,pms-group-acl-kp
    konghq.com/strip-path: "false"
spec:
  ingressClassName: kong
  rules:
  - http:
      paths:
      - path: /a1-policy
        pathType: ImplementationSpecific
        backend:
          service:
            name: policymanagementservice
            port:
              number: 8081
---
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: r1-ecs-ing
  namespace: nonrtric
  annotations:
    konghq.com/plugins: app-jwt-kp,ecs-group-acl-kp
    konghq.com/strip-path: "false"
spec:
```

```
  ingressClassName: kong
  rules:
  - http:
      paths:
      - path: /data-consumer
        pathType: ImplementationSpecific
        backend:
          service:
            name: enrichmentservice
            port:
              number: 8083
      - path: /data-producer
        pathType: ImplementationSpecific
        backend:
          service:
            name: enrichmentservice
            port:
              number: 8083
---
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: r1-echo-ing
  namespace: nonrtric
  annotations:
    konghq.com/plugins: app-jwt-kp,all-group-acl-kp
    konghq.com/strip-path: "true"
spec:
  ingressClassName: kong
  rules:
  - http:
      paths:
      - path: /echo
        pathType: ImplementationSpecific
        backend:
          service:
            name: httpecho
            port:
              number: 80
```

Kong-Gateway-JWT.zip

ISTIO Demo

1. Install ISTIO on minikube using instruction here: Istio Installation - Simplified Learning (waytoeasylearn.com)
2. cd to the istio directory and install the demo application
    a. `kubectl create ns foo`
    b. `kubectl apply -f <(istioctl kube-inject -f samples/httpbin/httpbin.yaml) -n foo`
3. Create a python script to generate a JWT token using the code from here: https://medium.com/intelligentmachines/istio-jwt-step-by-step-guide-for-micro-services-authentication-690b170348fc . Install python_jwt using pip if it's not already installed.
4. Create jwt-example.yaml using the public key generated by the python script:
   `kubectl create -f  jwt-example.yaml`

jwt-example.yaml

```
apiVersion: "security.istio.io/v1beta1"
kind: "RequestAuthentication"
metadata:
  name: "jwt-example"
  namespace: istio-system
spec:
  selector:
    matchLabels:
      istio: ingressgateway
  jwtRules:
  - issuer: "ISSUER"
    jwks: |
      { "keys":[{"e":"AQAB","kty":"RSA","n":"x_yYl4uW5c6NHOA-bDDh0MThFggBWl-
vYJr77b9F1LmAtTlJVM0rL5klTfv2DmlAmD9eZPrWeUOoOGhSpe58XiSAvxyeaOrZhtyUjT3aglrSys0YBsB19ItNGMuoIuzPpWOrdtKw
Ha9rPbrdc6q7vb93qu2UVaIz-3FJmGFtSA5t8FK_5bZKF-oOzRLwqeVQ3n0Bu_dFDuGeZjQWMZF32QupyA-GF-
tDGGriPLy9sutlB1NQyZ4qiSZx5UMxcfLwsWfQxHemdwLeZXWKWNBov8RmbZy2Jz-dwg6XjHBWAjTnCGG9p-
bp63nUlnELI3LcEGhGOugZBqcpNT5dEAQ0fQ"}]}
```

5. Export the JWT token generated by the python script as an environment variable:
   export TOKEN="eyJhbGciOiJSUzI1NiIsInR5cCI6IkpXVCJ9.
   eyJhdWQiOiJBVURJRU5DRSIsImV4cCI6MTYzNzI1NDkxNSwiaWF0IjoxNjM3MjUxOTE1LCJpc3MiOiJJU1NVRVIiLCJqdGkiOiJCcmhDdEstcC00
   ZTF0RlBrZmpuSmhRIiwibmJmIjoxNjM3MjUxOTE1LCJwZXJtaXNzaW9uIjoicmVhZCIsInJvbGUiOiJ1c2VyIiwic3ViIjoiU1VCSkVDVCJ9.
   HrQCLPZXf0VkFe7JUVGXq-sHJQhVibqhToG4r63py-iwHWlUL02_WfoWRoxapgqGwImDdSlt1uG8RR-
   6VMqzWwGlcqBIRhFTG0nmzmtQjnOUs6QAKSUpA3PyWBIYHV0BwZbpo8Zq1Bo-sELy400fU-
   MCQ_054fSsG7JMBMmrnj8NyJmD2lNN0VSFGO53SPl2tQSVlc9OwAr8Uu0jfLPfUmh6yq43qFuxnVRfBGLLPNOt29aOfAetKLc72qlphtnbDx2a9te
   P5AIbkIWyIlhTytEnQRCwU4x8gDrEdkrHui4qCtzpl_uoITSwPe3AFsi7gQHB6rJoDj-j2zPc4rUTAA"
6. export INGRESS_HOST=$(minikube ip)
7. export INGRESS_PORT=$(kubectl -n istio-system get service istio-ingressgateway -o jsonpath='{.spec.ports[?(@.name=="http2")].nodePort}')
8. Test the service:
   curl --header "Authorization: Bearer $TOKEN" $INGRESS_HOST:$INGRESS_PORT/headers -s -o /dev/null -w "%{http_code}\n"
9. You should get a response code of 200
10. Update the token to something invalid
11. The response will be 401

Istio Service JWT Test

istio-test.yaml (uses the default namespace)

export TOKEN="eyJhbGciOiJSUzI1NiIsInR5cCI6IkpXVCJ9.
eyJhdWQiOiJBVURJRU5DRSIsImV4cCI6MTYzODA4ODYzOSwiaWF0IjoxNjM3NjU2NjM5LCJpc3MiOiJJU1NVRVIiLCJqdGkiOiJXMW1ldEJISTlQWnJLZ
GZuTG54V0ZBIiwibmJmIjoxNjM3NjU2NjM5LCJwZXJtaXNzaW9uIjoicmVhZCIsInJvbGUiOiJ1c2VyIiwic3ViIjoiU1VCSkVDVCJ9.C8zVi4XpqaK-
VVhDviCGO5SChNsUWe_WmP2Z-JXkM3VzMVQnc2w7ResUI-
g8DxXQLXojc7BZiDA74VCRRzdSXtDrBbikd9riCN1D9UVXWaCdIv0gU9b23mOp2jUP7G8FgdKTjtcyx3pPmliHH1OnDhrsQUeTMezRurBa96sRf_9XF5B_
SBXiTy65UhqzL-
kKmbaTCXWO6F5d4mJ8gPJQ4BGQdl1CMfytg0RB1Tuyj72dDTetfWMStqRw0nEh76oAC5bDZAUhwpAUMbXTG0Iba9MSAhImha6grthU1_VY39LbmbZ7
W7OfRV1mAI9PrDl0nwWWobvJ-iIg93luqvGrlA"

kubectl label namespace default istio-injection=enabled --overwrite

export INGRESS_HOST=$(minikube ip)

export INGRESS_PORT=$(kubectl -n istio-system get service istio-ingressgateway -o jsonpath='{.spec.ports[?(@.name=="http2")].nodePort}')

curl --header "Authorization: Bearer $TOKEN" $INGRESS_HOST:$INGRESS_PORT/data-producer

curl --header "Authorization: Bearer $TOKEN" $INGRESS_HOST:$INGRESS_PORT/a1-policy

curl --header "Authorization: Bearer $TOKEN" $INGRESS_HOST:$INGRESS_PORT/data-consumer

You can use different tokens for different deployments.

Currently we use the same token for both jwt-ecs and jwt-pms. They match on the deployment labels nonrtric-ecs and nonrtric-pms.

You can also change the token issuer to one for your particular service(s).

You can also change the expiry time.

Please refer to the python script in the link above.

You can move these objects to their own namespace if you prefer:

e.g.

kubectl create ns istio-nonrtric
namespace/istio-nonrtric created

kubectl label namespace istio-nonrtric istio-injection=enabled --overwrite
namespace/istio-nonrtric labeled

replace the default name space in the yaml above with the new ns name.

You can also update the AuthorizationPolicy to check the JWT issuer/subject

e.g.

rules:
- from:
- source:
requestPrincipals: ["ECSISSUER/SUBJECT"]

See the latest version here: istio-test-latest.yaml

Istio with Keycloak

If you are using minikube on Ubuntu WSL you need to run "minikube service keycloak" to see keycloak ui.

Run the following command to get the keycloak URLs:

KEYCLOAK_URL=http://$(minikube ip):$(kubectl get services/keycloak -o go-template='{{(index .spec.ports 0).nodePort}}')/auth &&
o "" &

echo "" &&
echo "Keycloak: $KEYCLOAK_URL" &&

echo "Keycloak Admin Console: $KEYCLOAK_URL/admin" &&

echo "Keycloak Account Console: $KEYCLOAK_URL/realms/myrealm/account" &&
echo ""

Retrieve public key using : http(s)://<hostname>/auth/realms/<realm name>

Enable keycloak with Istio

Setup a new realm, user and client as shown here : https://www.keycloak.org/getting-started/getting-started-kube

Note the id of the new user, this will be used as the sub field in the token e.g. 81b2051b-52d9-4e4e-88a6-00ca04b7b73d"

The iss field is url of the realm e.g. http://192.168.49.2:30869/auth/realms/myrealm

Edit the jwt-pms RequestAuthentication definition above, replace the issuer with the keycloak iss and remove the jwks field and replace it with the jwksUri pointing to your keycloak certs

RequestAuthentication

```
apiVersion: security.istio.io/v1beta1
kind: RequestAuthentication
metadata:
  name: "jwt-pms"
  namespace: istio-nonrtric
spec:
  selector:
    matchLabels:
      apptype: nonrtric-pms
  jwtRules:
  - issuer: "http://192.168.49.2:30869/auth/realms/myrealm"
    jwksUri: "http://192.168.49.2:30869/auth/realms/myrealm/protocol/openid-connect/certs"
```

Modify the AuthorizationPolicy named pms-policy, change the issuer and subject to the keycloak iss/sub

AuthorizationPolicy

```
apiVersion: "security.istio.io/v1beta1"
kind: "AuthorizationPolicy"
metadata:
  name: "pms-policy"
  namespace: istio-nonrtric
spec:
  selector:
    matchLabels:
      apptype: nonrtric-pms
  action: ALLOW
  rules:
  - from:
    - source:
       requestPrincipals: ["http://192.168.49.2:30869/auth/realms/myrealm/81b2051b-52d9-4e4e-88a6-00ca04b7b73d"]
```

Reapply the yaml file

to generate a token use the following command:

curl -X POST "$KEYCLOAK_URL" \
-H "Content-Type: application/x-www-form-urlencoded" \
-d "username=$USERNAME" \
-d "password=$PASSWORD" \
-d 'grant_type=password' \
-d "client_id=$CLIENT_ID" | jq -r '.access_token'

e.g.

curl -X POST http://192.168.49.2:30869/auth/realms/myrealm/protocol/openid-connect/token \
-H "Content-Type: application/x-www-form-urlencoded" \
-d "username=user" \
-d "password=secret" \
-d 'grant_type=password' \
-d "client_id=myclient" | jq -r '.access_token'

Note: you may need to install the jq utility on your system for this to work - sudo apt-get install jq

Test the a1-policy service with your new token

TOKEN=$(curl -X POST http://192.168.49.2:30869/auth/realms/myrealm/protocol/openid-connect/token -H "Content-Type: application/x-www-form-urlencoded" -d username=user -d password=secret -d 'grant_type=password' -d client_id=myclient | jq -r '.access_token')

curl --header "Authorization: Bearer $TOKEN" $INGRESS_HOST:$INGRESS_PORT/a1-policy
Hello a1-policy

Note: The iss of the token will differ depending on how you retrieve it. If it's retrieved from within the cluster for URL will start with http://keycloak.default:8080/ otherwise it will be something like : http://192.168.49.2:31560/ (http://(minikube ip): (keycloak service nodePort))

Keycloak database

Keycloak uses the H2 database by default.

To configure keycloak to use a different database follow these steps.

1. Install either postgres or mariadb using these yaml files: postgres.yaml or mariadb.yaml. These will setup the keycloak db along with the username and password. You just need to change the directory for your persistent storage to an appropiate directory on your host.
2. Update the keycloak installation script https://raw.githubusercontent.com/keycloak/keycloak-quickstarts/latest/kubernetes-examples/keycloak.yaml

Keycloak Environment

```
        env:
        - name: KEYCLOAK_USER
          value: "admin"
        - name: KEYCLOAK_PASSWORD
          value: "admin"
        - name: PROXY_ADDRESS_FORWARDING
          value: "true"
        - name: DB_VENDOR
          value: "postgres"
        - name: DB_ADDR
          value: "postgres"
        - name: DB_PORT
          value: "5432"
        - name: DB_DATABASE
          value: "keycloak"
        - name: DB_USER
          value: "keycloak"
        - name : DB_PASSWORD
          value: "keycloak"
```

You can also add the following code block to make sure keycloak only start once the database is up and running

Wait For Database

```
      initContainers:
      - name: init-postgres
        image: busybox
        command: ['sh', '-c', 'until nc -vz postgres 5432; do echo waiting for postgres db; sleep 2; done;']
```

Note: you may also want to update the keycloak service to specify a value for nodePort.

Keycloak Service

```
apiVersion: v1
kind: Service
metadata:
  name: keycloak
  labels:
    app: keycloak
spec:
  ports:
  - name: http
    port: 8080
    targetPort: 8080
    nodePort: 31560
  selector:
    app: keycloak
  type: LoadBalancer
```

You can also add a wait for keycloak to your deployment containers

Wait for Keycloak

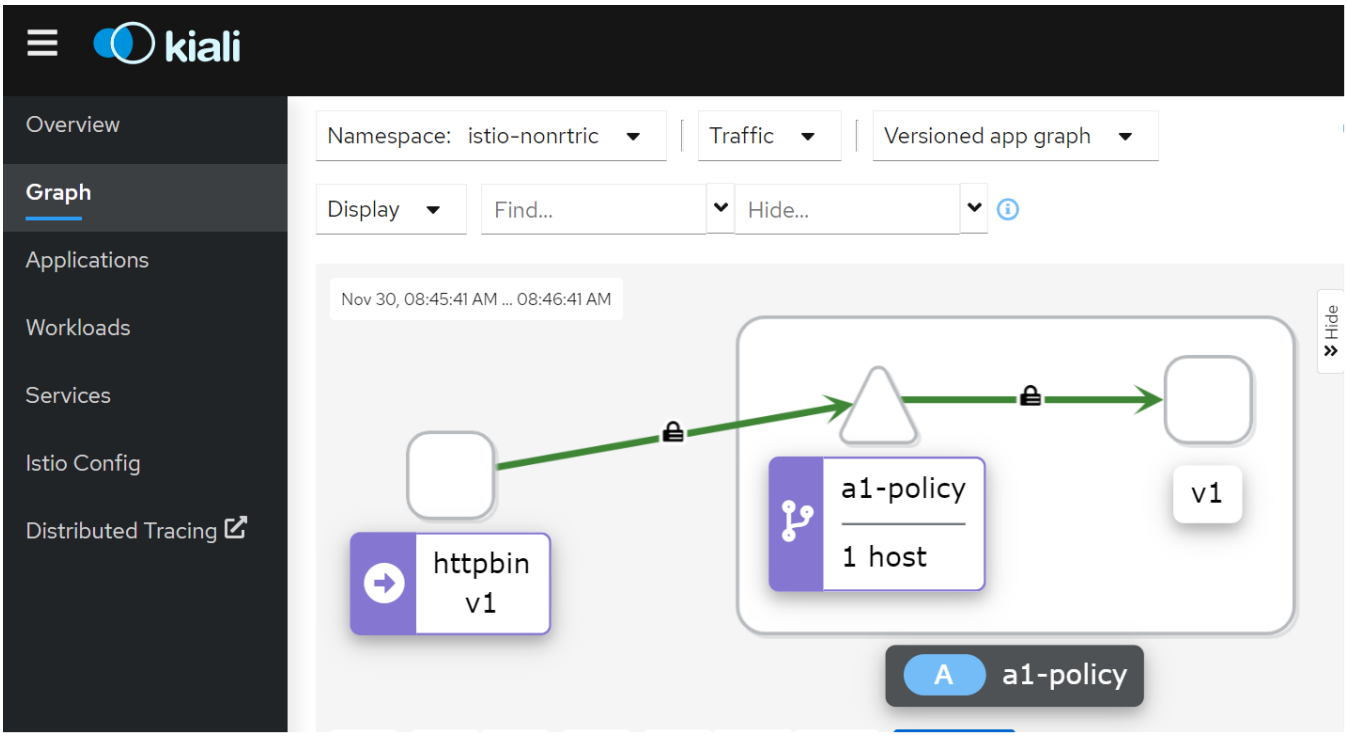
```
    spec:
      initContainers:
      - name: init-keycloak
        image: busybox
        command: ['sh', '-c', 'until nc -vz keycloak.default 8080; do echo waiting for keycloak; sleep 2;
done;']
      containers:
      - name: a1-policy
        image: hashicorp/http-echo
        ports:
        - containerPort: 5678
        args:
        - -text
        - "Hello a1-policy"
```

See also: keycloak.yaml

Istio mTLS

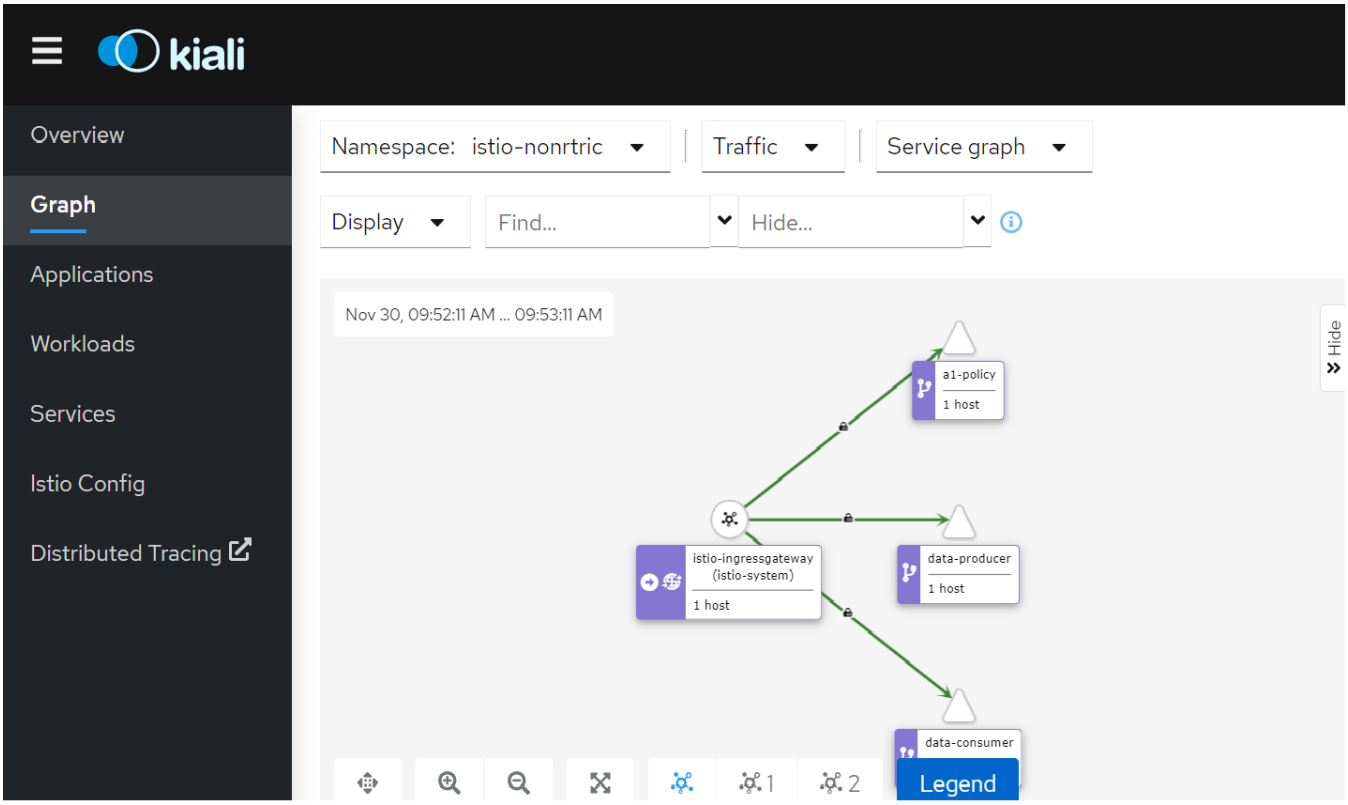
Test: Istio / Mutual TLS Migration

To see mTLS in kiali go to the display menu and check the security check box.



Running curl --header "Authorization: Bearer $TOKEN" ai-policy from the httpbin pod.

The padlock icon indicates mTLS is being used for communication between the pods.



Policy to enforce mTLS between PODs in the istio-nonrtric namespace in STRICT mode:

PeerAuthentication

```
apiVersion: security.istio.io/v1beta1
kind: PeerAuthentication
metadata:
  name: "default"
  namespace: istio-nonrtric
spec:
  mtls:
    mode: STRICT
```

Change the mode to PERMISSIVE to allow communication from pods without istio sidecar.

Change namespace to istio-system to apply mTLS for the entire cluster.

Istio cert manager

https://istio.io/latest/docs/ops/integrations/certmanager/

Go Http Request Handler for Testing

nonrtric-server-go

nonrtric-server-go

```
package main

import (
        "fmt"
        "log"
        "github.com/gorilla/mux"
        "net/http"
        "encoding/json"
        "io/ioutil"
        "strings"
)

func requestHandler(w http.ResponseWriter, r *http.Request) {
        w.Header().Set("Content-Type", "application/json")
        params := mux.Vars(r)
        var id = params["id"]
        var data = params["data"]
        var prefix = strings.Split(r.URL.Path, "/")[1]

    switch r.Method {
                case "GET":
                    if id == "" {
                                fmt.Println( "Received get request for "+ prefix +", params: nil\n")
                                fmt.Fprintf(w, "Response to get request for "+ prefix +", params: nil\n")
                        }else {
                                fmt.Println("Received get request for "+ prefix +", params: id=" + id + "\n")
                                fmt.Fprintf(w, "Response to get request for "+ prefix +", params: id=" + id +
"\n")
                        }
                case "POST":
                        body, err := ioutil.ReadAll(r.Body)
                        if err != nil {
                        panic(err.Error())
                        }
                        keyVal := make(map[string]string)
                        json.Unmarshal(body, &keyVal)
                        id := keyVal["id"]
                        data := keyVal["data"]
                        fmt.Println("Received post request for "+ prefix +", params: id=" + id +", data=" +
data + "\n")
                        fmt.Fprintf(w, "Response to post request for "+ prefix +", params: id=" + id +", data="
+ data + "\n")
                case "PUT":
                        fmt.Println("Received put request for "+ prefix +", params: id=" + id +", data=" + data
+ "\n")
                        fmt.Fprintf(w, "Response to put request for "+ prefix +", params: id=" + id +", data="
+ data + "\n")
                case "DELETE":
                        fmt.Println("Received delete request for "+ prefix +", params: id=" + id + "\n")
                        fmt.Fprintf(w, "Response to delete request for "+ prefix +", params: id=" + id + "\n")
                default:
                        fmt.Println("Received request for unsupported method, only GET, POST, PUT and DELETE
methods are supported.")
                        fmt.Fprintf(w, "Error, only GET, POST, PUT and DELETE methods are supported.")
        }
}

func main() {
        router := mux.NewRouter()

        var prefixArray [3]string = [3]string{"/a1-policy", "/data-consumer", "/data-producer"}

        for _, prefix := range prefixArray {
                router.HandleFunc(prefix, requestHandler)
                router.HandleFunc(prefix+"/{id}", requestHandler)
                router.HandleFunc(prefix+"/{id}/{data}", requestHandler)
        }

        log.Fatal(http.ListenAndServe(":8080", router))
}
```

Dockerfile

```
FROM golang:1.15.2-alpine3.12 as build
RUN apk add git
RUN mkdir /build
ADD . /build
WORKDIR /build
RUN go get github.com/gorilla/mux
RUN go build -o nonrtric-server-go .

FROM alpine:latest
RUN mkdir /app
WORKDIR /app/

# Copy the Pre-built binary file from the previous stage
COPY --from=build /build .

# Expose port 8080
EXPOSE 8080

# Run Executable
CMD ["/app/nonrtric-server-go"]
```

Testing

Update AuthorizationPolicy to only allow certain operations:

AuthorizationPolicy

```
apiVersion: "security.istio.io/v1beta1"
kind: "AuthorizationPolicy"
metadata:
  name: "pms-policy"
  namespace: istio-nonrtric
spec:
  selector:
    matchLabels:
      apptype: nonrtric-pms
  action: ALLOW
  rules:
  - from:
    - source:
        requestPrincipals: ["http://192.168.49.2:31560/auth/realms/pmsrealm/fab53fd0-3315-4e2f-bd17-
6984fb7745f2"]
    to:
    - operation:
        methods: ["GET", "POST", "PUT"]
        paths: ["/a1-policy*"]
```

AuthorizationPolicy

```
apiVersion: "security.istio.io/v1beta1"
kind: "AuthorizationPolicy"
metadata:
  name: "ics-policy"
  namespace: istio-nonrtric
spec:
  selector:
    matchLabels:
      apptype: nonrtric-ics
  action: ALLOW
  rules:
  - from:
    - source:
        requestPrincipals: ["http://192.168.49.2:31560/auth/realms/icsrealm/ad83e4ea-c114-4549-be29-
b3aaf92148a5"]
    to:
    - operation:
        methods: ["GET", "PUT", "DELETE"]
        paths: ["/data-*"]
```

Shell script to test AuthorizationPolicy

service_exposure_tests.sh

```
#!/bin/bash
INGRESS_HOST=$(minikube ip)
INGRESS_PORT=$(kubectl -n istio-system get service istio-ingressgateway -o jsonpath='{.spec.ports[?(@.name=="
http2")].nodePort}')
TESTS=0
PASSED=0
FAILED=0
TEST_TS=$(date +%F-%T)
TOKEN=""

function get_token
{
    local prefix="${1}"
    url="http://192.168.49.2:31560/auth/realms"
    if [[ "$prefix"  =~ ^a1-policy* ]]; then
         TOKEN=$(curl -s -X POST ${url}/pmsrealm/protocol/openid-connect/token -H \
                 "Content-Type: application/x-www-form-urlencoded" -d username=pmsuser -d password=secret \
                 -d 'grant_type=password' -d client_id=pmsclient | jq -r '.access_token')
   else
         TOKEN=$(curl -s -X POST $url/icsrealm/protocol/openid-connect/token -H \
                 "Content-Type: application/x-www-form-urlencoded" -d username=icsuser -d password=secret \
                 -d 'grant_type=password' -d client_id=icsclient | jq -r '.access_token')
    fi
}

function run_test
{
    local prefix="${1}" type=${2} msg="${3}" data=${4}
    TESTS=$((TESTS+1))
    echo "Test ${TESTS}: Testing $type /${prefix}"
    get_token $prefix
    url=$INGRESS_HOST:$INGRESS_PORT"/"$prefix
    if [ "$data" != "" ]; then
      result=$(curl -s -X ${type} -H "Content-type: application/json" -H "Authorization: Bearer $TOKEN" -d
${data} $url)
    else
      result=$(curl -s -X ${type} -H "Content-type: application/json" -H "Authorization: Bearer $TOKEN" $url)
    fi
    echo $result
    if [ "$result" != "$msg" ]; then
            echo "FAIL"
            FAILED=$((FAILED+1))
    else
            echo "PASS"
            PASSED=$((PASSED+1))
    fi
    echo ""
}


run_test "a1-policy" "GET" "Received get request for a1-policy, params: nil" ""
run_test "a1-policy/1001" "GET" "Received get request for a1-policy, params: id=1001" ""
run_test "a1-policy/1002/xyz" "PUT" "Received put request for a1-policy, params: id=1002, data=xyz" ""
run_test "a1-policy/1001" "DELETE" "RBAC: access denied" ""
run_test "a1-policy" "POST" "Received post request for a1-policy, params: id=1003, data=abc" '{"id":"1003","
data":"abc"}'
run_test "data-consumer" "GET" "Received get request for data-consumer, params: nil" ""
run_test "data-consumer/3001" "DELETE" "Received delete request for data-consumer, params: id=3001" ""
run_test "data-producer/2001/xyz" "PUT" "Received put request for data-producer, params: id=2001, data=xyz" ""
run_test "data-consumer" "POST" "RBAC: access denied" '{"id":"1004","data":"abc"}'
run_test "data-producer" "POST" "RBAC: access denied" '{"id":"1005","data":"abc"}'

echo
echo "------------------------------------------------------------------------"
echo "Number of Tests: $TESTS, Tests Passed: $PASSED, Tests Failed: $FAILED"
echo "Date: $TEST_TS"
echo "------------------------------------------------------------------------"
```

Results:

./service_exposure_tests.sh
Test 1: Testing /a1-policy GET
Received get request for a1-policy, params: nil
PASS

Test 2: Testing /a1-policy/1001 GET
Received get request for a1-policy, params: id=1001
PASS

Test 3: Testing /a1-policy/1002/xyz PUT
Received put request for a1-policy, params: id=1002, data=xyz
PASS

Test 4: Testing /a1-policy/1001 DELETE
RBAC: access denied
PASS

Test 5: Testing /a1-policy POST
Received post request for a1-policy, params: id=1003, data=abc
PASS

Test 6: Testing /data-consumer GET
Received get request for data-consumer, params: nil
PASS

Test 7: Testing /data-consumer/3001 DELETE
Received delete request for data-consumer, params: id=3001
PASS

Test 8: Testing /data-producer/2001/xyz PUT
Received put request for data-producer, params: id=2001, data=xyz
PASS

Test 9: Testing /data-consumer POST
RBAC: access denied
PASS

Test 10: Testing /data-producer POST
RBAC: access denied
PASS

Number of Tests: 10, Tests Passed: 10, Tests Failed: 0
Date: 2021-12-06-14:48:33

Go Http Client for running inside cluster

nonrtric-client-go

nonrtric-client-go

```
package main

import (
        "fmt"
        "net/http"
        "net/url"
        "encoding/json"
        "time"
        "io/ioutil"
        "math/rand"
        "strings"
        "bytes"
        "strconv"
        "flag"
)
```

```
type Jwttoken struct {
        Access_token string
        Expires_in int
        Refresh_expires_in int
        Refresh_token string
        Token_type string
    Not_before_policy int
    Session_state string
    Scope string
  }

var gatewayHost string
var gatewayPort string
var keycloakHost string
var keycloakPort string
var useGateway string
var letters = []rune("abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ")

func randSeq(n int) string {
    b := make([]rune, n)
    for i := range b {
        b[i] = letters[rand.Intn(len(letters))]
    }
    return string(b)
}


func getToken(user string, password string, clientId string, realmName string) string {
    keycloakUrl := "http://"+keycloakHost+":"+keycloakPort+"/auth/realms/"+realmName+"/protocol/openid-connect
/token"
        resp, err := http.PostForm(keycloakUrl,
        url.Values{"username": {user}, "password": {password}, "grant_type": {"password"}, "client_id":
{clientId}})
        if err != nil {
                fmt.Println(err)
                panic("Something wrong with the credentials or url ")
        }
        defer resp.Body.Close()
        body, err := ioutil.ReadAll(resp.Body)
        var jwt Jwttoken
     json.Unmarshal([]byte(body), &jwt)
         return jwt.Access_token;
}


func MakeRequest(client *http.Client, prefix string, method string, ch chan<-string) {
        var id = rand.Intn(1000)
        var data = randSeq(10)
        var service = strings.Split(prefix, "/")[1]
        var gatewayUrl = "http://"+gatewayHost+":"+gatewayPort
        var token = ""
        var jsonValue []byte = []byte{}
        var restUrl string = ""
        if strings.ToUpper(useGateway) != "Y" {
                gatewayUrl = "http://"+service+".istio-nonrtric:80"
                //fmt.Println(gatewayUrl)
        }

        if service == "a1-policy" {
                token = getToken("pmsuser", "secret","pmsclient", "pmsrealm")
         }else{
                token = getToken("icsuser", "secret","icsclient", "icsrealm")
         }



        if method == "POST" {
                values := map[string]string{"id": strconv.Itoa(id), "data": data}
                jsonValue, _  = json.Marshal(values)
                restUrl = gatewayUrl+prefix
        } else if method == "PUT"  {
```

```
                restUrl = gatewayUrl+prefix+"/"+strconv.Itoa(id)+"/"+data
        } else {
                restUrl = gatewayUrl+prefix+"/"+strconv.Itoa(id)
        }

        req, err := http.NewRequest(method, restUrl, bytes.NewBuffer(jsonValue))
        if err != nil {
                fmt.Printf("Got error %s", err.Error())
        }
        req.Header.Set("Content-type", "application/json")
        req.Header.Set("Authorization", "Bearer "+token)

        resp, err := client.Do(req)
        if err != nil {
                fmt.Printf("Got error %s", err.Error())
        }
        defer resp.Body.Close()
        body, _ := ioutil.ReadAll(resp.Body)
        respString := string(body[:])
        if respString == "RBAC: access denied"{
                respString += " for "+service+" "+strings.ToLower(method)+" request\n"
        }
        ch <- fmt.Sprintf("%s", respString)
  }

func main() {
        flag.StringVar(&gatewayHost, "gatewayHost", "192.168.49.2", "Gateway Host")
        flag.StringVar(&gatewayPort, "gatewayPort" , "32162", "Gateway Port")
        flag.StringVar(&keycloakHost, "keycloakHost", "192.168.49.2", "Keycloak Host")
        flag.StringVar(&keycloakPort, "keycloakPort" , "31560", "Keycloak Port")
        flag.StringVar(&useGateway, "useGateway" , "Y", "Connect to services hrough API gateway")
        flag.Parse()

    client := &http.Client{
        Timeout: time.Second * 10,
    }


        ch := make(chan string)
        var prefixArray [3]string = [3]string{"/a1-policy", "/data-consumer", "/data-producer"}
        var methodArray [4]string = [4]string{"GET", "POST", "PUT", "DELETE"}
        for true {
                for _,prefix := range prefixArray{
                        for _,method := range methodArray{
                                go MakeRequest(client, prefix, method, ch)
                        }
                }

                for i := 0; i < len(prefixArray); i++ {
                        for j := 0; j < len(methodArray); j++ {
                                fmt.Println(<-ch)
                        }
                }
                time.Sleep(30 * time.Second)
    }
}
```

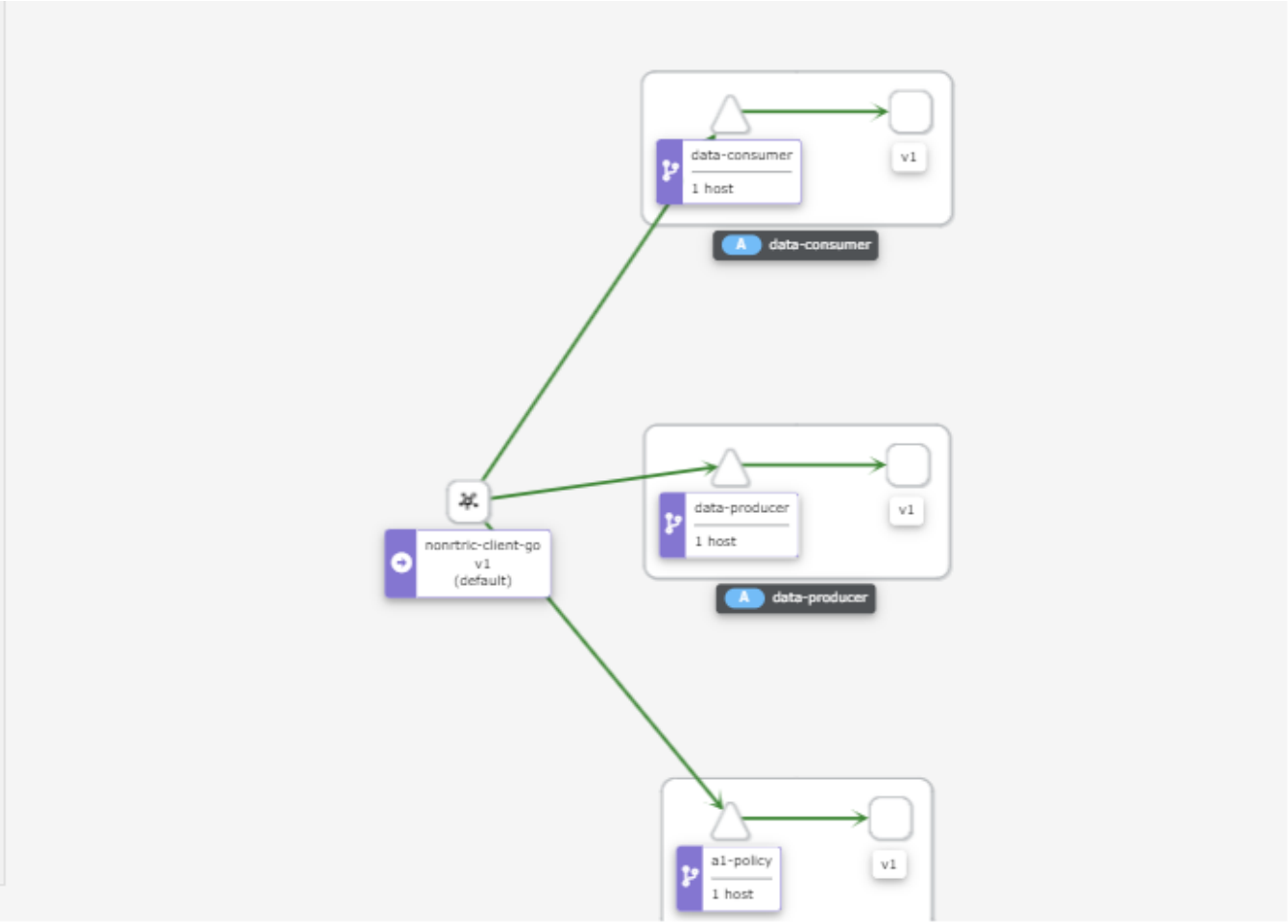
Dockerfile

```
FROM golang:1.15.2-alpine3.12 as build
RUN apk add git
RUN mkdir /build
ADD . /build
WORKDIR /build
RUN go build -o nonrtric-client-go .

FROM alpine:latest
RUN mkdir /app
WORKDIR /app/

# Copy the Pre-built binary file from the previous stage
COPY --from=build /build .

# Expose port 8080
EXPOSE 8080

# Run Executable
ENTRYPOINT  [ "/app/nonrtric-client-go", \
              "-gatewayHost", "istio-ingressgateway.istio-system", \
              "-gatewayPort", "80", \
              "-keycloakHost", "keycloak.default", \
              "-keycloakPort", "8080", \
              "-useGateway", "N" ]
```

Update AuthorizationPolicy

AuthorizationPolicy

```
apiVersion: "security.istio.io/v1beta1"
kind: "AuthorizationPolicy"
metadata:
  name: "ics-policy"
  namespace: istio-nonrtric
spec:
  selector:
    matchLabels:
      apptype: nonrtric-ics
  action: ALLOW
  rules:
  - from:
    - source:
        namespaces: ["default"]
    to:
    - operation:
        methods: ["GET", "POST", "PUT", "DELETE"]
        paths: ["/data-*"]
        hosts: ["data-consumer*", "data-producer*"]
        ports: ["8080"]
---
apiVersion: "security.istio.io/v1beta1"
kind: "AuthorizationPolicy"
metadata:
  name: "pms-policy"
  namespace: istio-nonrtric
spec:
  selector:
    matchLabels:
      apptype: nonrtric-pms
  action: ALLOW
  rules:
  - from:
    - source:
        principals: ["cluster.local/ns/default/sa/goclient"]
    to:
    - operation:
        methods: ["GET", "POST", "PUT", "DELETE"]
        paths: ["/a1-policy*"]
        hosts: ["a1-policy*"]
        ports: ["8080"]
    when:
    - key: request.auth.claims[preferred_username]
      values: ["pmsuser"]
```



Request are sent from the nonrtric-client-go pod to the services directly from within the cluster.

In the above example I'm using principals and namespaces for authorization.

Both of these require MTLS to be enabled.

If istio is not enabled for the client you can inject the individual pod with the istio proxy : istioctl kube-inject -f client.yaml | kubectl apply -f -

I have also included a "when" condition which checks one of the JWT fields, in this case "preferred_username": "icsuser".

The hosts and ports fields refer to the destination host(s) and post(s).

To use JWT inside the cluster you need to update the RequestAuthentication policy to include the internal address for the jwksUri

jwtRules

```
  jwtRules:
  - issuer: "http://192.168.49.2:31560/auth/realms/pmsrealm"
    jwksUri: "http://192.168.49.2:31560/auth/realms/pmsrealm/protocol/openid-connect/certs"
  - issuer: "http://keycloak.default:8080/auth/realms/pmsrealm"
    jwksUri: "http://keycloak.default:8080/auth/realms/pmsrealm/protocol/openid-connect/certs"
```

You also need to update the AuthorizationPolicy to include the internal source

Rules

```
  rules:
  - from:
    - source:
        requestPrincipals: ["http://192.168.49.2:31560/auth/realms/pmsrealm/fab53fd0-3315-4e2f-bd17-
6984fb7745f2"]
    - source:
        requestPrincipals: ["http://keycloak.default:8080/auth/realms/pmsrealm/fab53fd0-3315-4e2f-bd17-
6984fb7745f2"]
    to:
    - operation:
        methods: ["GET", "POST", "PUT", "DELETE"]
        paths: ["/a1-policy*"]
```

You can change the contents (fields) of your JWT token by using client mappers.

Create a new roles pms_admin

The assign the role to your user: role mapping(tab) available roles add selected

Then in you client select mappers create Mapper Type: User Realm Role, Token claim name : role

The following field will be added to your JWT:

"role": [
"pms_admin"
],

you can then use this in you when clause to alow/block access to cetain endpoints:

- key: request.auth.claims[role]
values: ["pms_admin"]

Create another role pms_viewer and assign it to a second user pmsuser2

We can then configure the AuthorizationPolicy to grant differnt access to different roles

AuthorizationPolicy

```
apiVersion: "security.istio.io/v1beta1"
kind: "AuthorizationPolicy"
metadata:
  name: "pms-policy"
  namespace: istio-nonrtric
spec:
  selector:
    matchLabels:
      apptype: nonrtric-pms
  action: ALLOW
  rules:
  - from:
    - source:
        requestPrincipals: ["http://192.168.49.2:31560/auth/realms/pmsrealm/fab53fd0-3315-4e2f-bd17-
6984fb7745f2"]
    - source:
        requestPrincipals: ["http://keycloak.default:8080/auth/realms/pmsrealm/fab53fd0-3315-4e2f-bd17-
6984fb7745f2"]
    to:
    - operation:
        methods: ["GET", "POST", "PUT", "DELETE"]
        paths: ["/a1-policy*"]
    when:
    - key: request.auth.claims[role]
      values: ["pms_admin"]
  - from:
    - source:
        requestPrincipals: ["http://192.168.49.2:31560/auth/realms/pmsrealm/f96255ec-d553-4c2e-b106-
0ed586ccab70"]
    - source:
        requestPrincipals: ["http://keycloak.default:8080/auth/realms/pmsrealm/f96255ec-d553-4c2e-b106-
0ed586ccab70"]
    to:
    - operation:
        methods: ["GET"]
        paths: ["/a1-policy*"]
    when:
    - key: request.auth.claims[role]
      values: ["pms_viewer"]
```

pms_admin role:

Test 1: Testing GET /a1-policy
Received get request for a1-policy, params: nil

Test 2: Testing GET /a1-policy/1001
Received get request for a1-policy, params: id=1001

Test 3: Testing PUT /a1-policy/1002/xyz
Received put request for a1-policy, params: id=1002, data=xyz

Test 4: Testing DELETE /a1-policy/1001
Received delete request for a1-policy, params: id=1001

Test 5: Testing POST /a1-policy
Received post request for a1-policy, params: id=1003, data=abc

pms_viewer role:

Test 1: Testing GET /a1-policy
Received get request for a1-policy, params: nil

Test 2: Testing GET /a1-policy/1001
Received get request for a1-policy, params: id=1001

Test 3: Testing PUT /a1-policy/1002/xyz
RBAC: access denied

Test 4: Testing DELETE /a1-policy/1001
RBAC: access denied

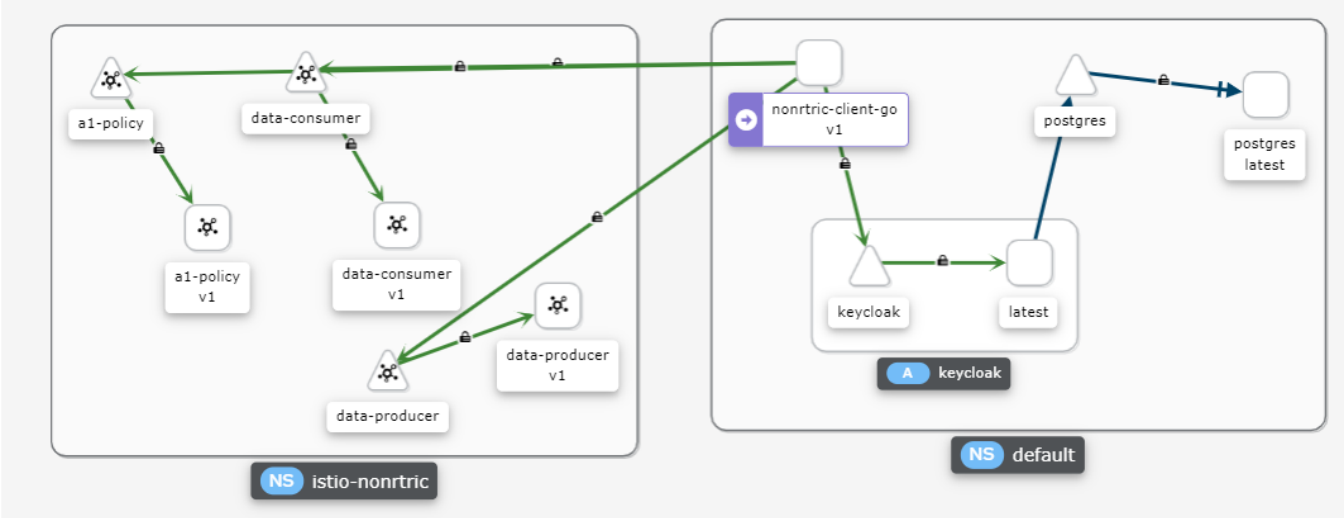
Test 5: Testing POST /a1-policy
RBAC: access denied

You can also leave out the from clause and just use to and when in the rules:

Rules

```
rules:
- to:
  - operation:
      methods: ["GET", "POST", "PUT", "DELETE"]
      paths: ["/a1-policy*"]
  when:
  - key: request.auth.claims[role]
    values: ["pms_admin"]
- to:
  - operation:
      methods: ["GET"]
      paths: ["/a1-policy*"]
  when:
  - key: request.auth.claims[role]
    values: ["pms_viewer"]
```

Further details on authorization policies are avaiable here



Istio network policy is enforced at the pod level (in the Envoy proxy), in user-space, (layer 7), as opposed to Kubernetes network policy, which is in kernel-space (layer 4), and is enforced on the host. By operating at application layer, Istio has a richer set of attributes to express and enforce policy in the protocols it understands (e.g. HTTP headers).

Istio Network Policy

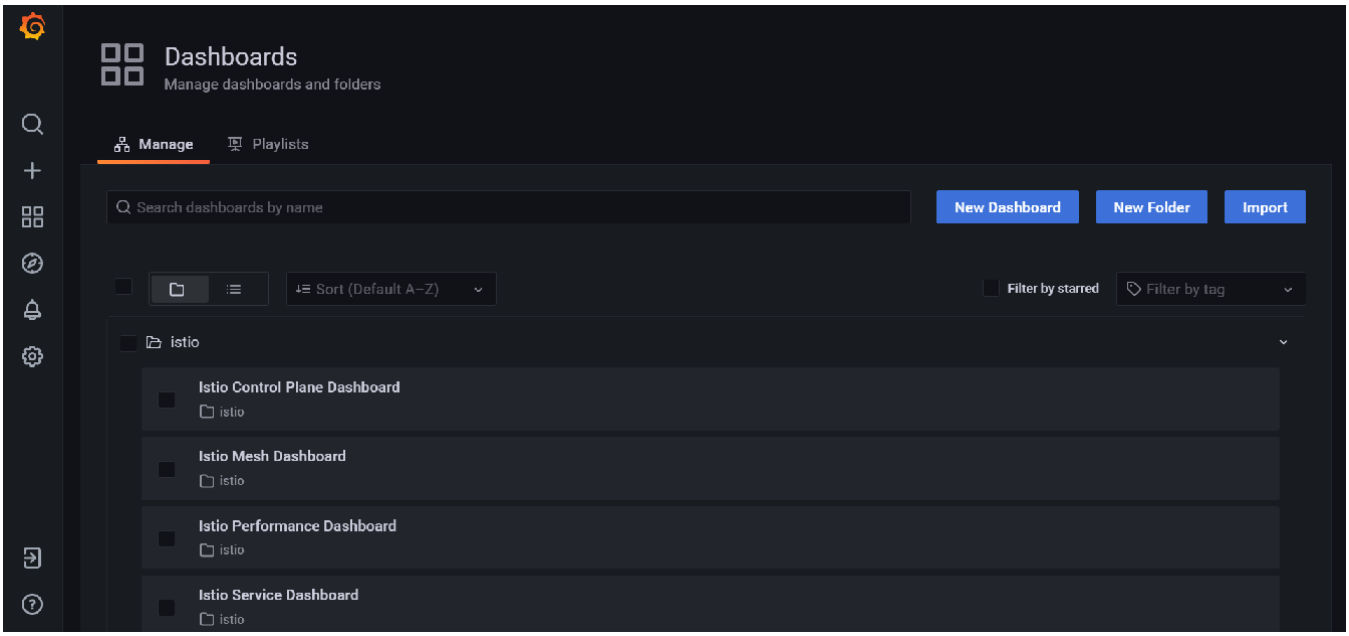
Grafana

Istio also comes with grafana, to start it run : istioctl dashboard grafana

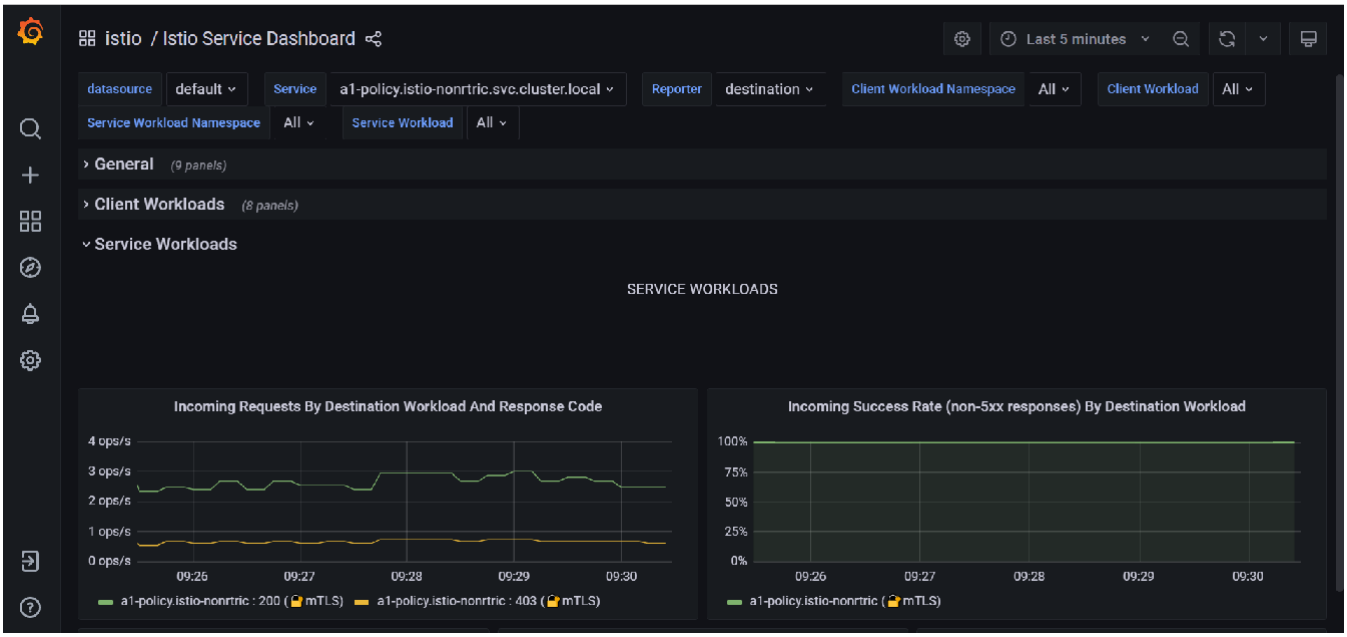
This will bring up the grafana home page

From the side menu select dashboards Manage

The istio dashboards are installed by default



Select the Istio Service dashboard service workloads to see the incoming requests



You can elasticsearch as a datasource to grafana.

Add the URL for your elasticsearch instance.

Set basic auth to on.

Add your elasticsearch username and password.

Add your index name (e.g. logstash-*)

Set the version to 7.10+

Set Max concurrent shard requests to 1

Save and test.

You data source is now setup.

To view the data being collected, download the grafana elasticseach dashboard and import it.

This does not really work for a single shard instance like the one we are using.

Prometheus

Start the prometheus dashboard by running: istioctl dashboard prometheus

See the following link on Querying Metrics from Prometheus for more information.

You can setup your own dashboard in grafana to view these metrics if the default dashboards don't meet your needs.

You can also insert your own customer metrics into your code: INSTRUMENTING A GO APPLICATION FOR PROMETHEUS

Code Snippet

```
import (
        "github.com/prometheus/client_golang/prometheus"
        "github.com/prometheus/client_golang/prometheus/promhttp"
)
var (
        reqDuration = prometheus.NewHistogramVec(prometheus.HistogramOpts{
                Name:    "rapp_http_request_duration_seconds",
                Help:    "Duration of the last request call.",
                Buckets: []float64{0.05, 0.1, 0.25, 0.5, 1, 2.5, 5, 10},
        }, []string{"app", "func", "handler", "method", "code"})
        reqBytes = prometheus.NewSummaryVec(prometheus.SummaryOpts{
                Name: "rapp_bytes_summary",
                Help: "Summary of bytes transferred over http",
        }, []string{"app", "func", "handler", "method", "code"})
)

func getToken() string {
               resp := &http.Response{}
        ...
                timer := prometheus.NewTimer(prometheus.ObserverFunc(func(v float64) {
                        reqDuration.WithLabelValues("rapp-jwt-invoker", "getToken", resp.Request.URL.Path, resp.
Request.Method,
                                resp.Status).Observe(v)
                }))
                defer timer.ObserveDuration()
                resp, err = http.PostForm(keycloakUrl, url.Values{"client_assertion_type":
{client_assertion_type},
                                                                   "client_assertion": {client_assertion},
"grant_type": {"client_credentials"},
                                                                   "client_id": {clientId}, "scope": {scope}})

                if err != nil {
                        fmt.Println(err)
                        panic("Something wrong with the credentials or url ")
                }

                defer resp.Body.Close()
                body, err := ioutil.ReadAll(resp.Body)
                json.Unmarshal([]byte(body), &jwt)
                reqBytes.WithLabelValues("rapp-jwt-invoker", "getToken", resp.Request.URL.Path, resp.Request.
Method,
                        resp.Status).Observe(float64(resp.ContentLength))
        ....
}
       ....
func main() {
        prometheus.Register(reqDuration)
        prometheus.Register(reqBytes)
        http.Handle("/metrics", promhttp.Handler())
        go func() {
                http.ListenAndServe(":9000", nil)
        }()
       ....
}
```

Lastly you need to update the scrape_configs section in prometheus.yaml

scrape_configs:
- job_name: rapp
scrape_interval: 10s
metrics_path: /metrics
static_configs:
- targets:
- rapp-jwt-invoker.istio-nonrtric:80

You can then create your own dashboard in grafana using these metrics: rapps-requests.json

OAuth2 Proxy

Welcome to OAuth2 Proxy | OAuth2 Proxy (oauth2-proxy.github.io)

Calico network policy

https://docs.projectcalico.org/security/calico-network-policy

Calico can be used with Istio to enforce network policies : Enforce Calico network policy using Istio

For example we can limit connections to the keycloak database to only pods using the keycloak service account

GlobalNetworkPolicy

```
apiVersion: projectcalico.org/v3
kind: GlobalNetworkPolicy
metadata:
  name: postgres
spec:
  selector: app == 'postgres'
  ingress:
    - action: Allow
      source:
        serviceAccounts:
          names: ["keycloak"]
  egress:
    - action: Allow
```

Following the example in the link above I installed the test application in a separate namespace (calico-test). Using curl I was able to access the database prior to applying the GlobalNetworkPolicy. After applying the policy the request timed out rather than return a 403 forbidden message.

Logging

Elasticsearch

We can use elasticsearch, kibana and fluentd to aggregate and visualize the kubernetes logs.

You can use the following files to setup a single node ELK stack on minikube

elastic.yaml

kibana.yaml

fluentd-rbac.yaml

fluentd-daemonset.yaml

Latest version of files (8.1.2)

elastic-8.1.2.yaml

kibana-8.1.2.yaml

fluentd.yaml

- elastic.yaml includes a persistence volume that mounts the /usr/share/elasticsearch/data directory to a host path. This prevents loss of data when the pod is restarted. (You may ned to change the hostPath path value to a directory on your own host)
- Both elastic.yaml and kibana.yaml contain a config map for configuring the component on start up.
- xpack.security.enabled is set to true to enable security.
- This is a single-node minkube setup, you may want to alter this for your own installation.
- elastic-8.1.2.yaml and kibana-8.1.2.yaml use the most up to date images.
- fluentd.yaml combines fluentd-rbac.yaml and fluentd-daemonset.yaml into 1 file and includes certificte configuration for version 8.1.2.

- They all add additional persistent volumes for storing the keys/certificates - please modify these values to suit your own requirements.

Please ensure to create the logging namespace before applying these files.

Once elasticsearch is up and running, log into kibana and create a new index for the logstash-* pipeline.

Once this is done use the discover tab to create a query against your logs:

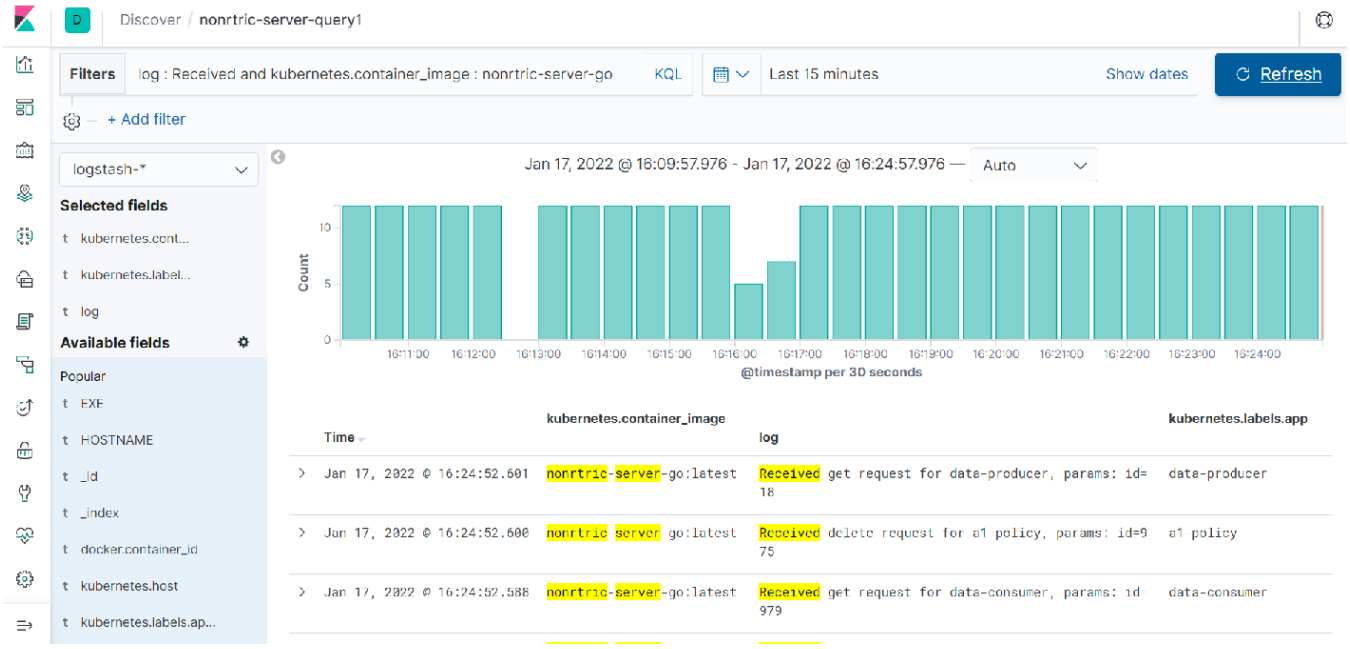
Select the timeStamp, kubernetes.container_image, log and kuberentes.label.app for you fields

Use the filters input textbox to only show the logs you want log : Received and kubernetes.container_image : nonrtric-server-go

Change the date field to the last 15 minutes.

Save your query.

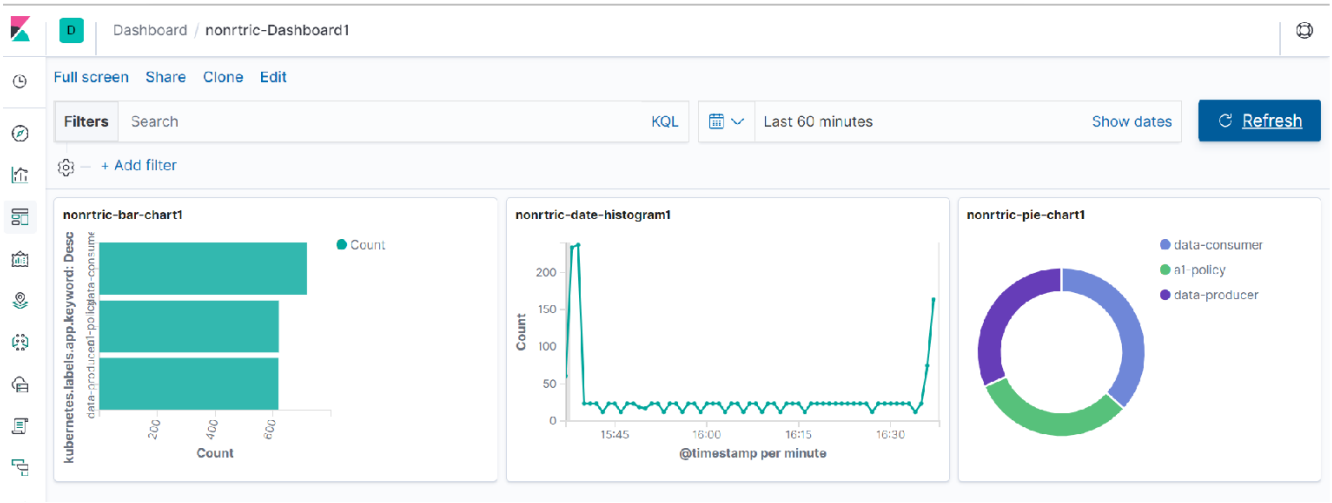
This will produce a report like the following:



This shows the number of requests made to the nonrtric-server-go.

Go to the visualize tab.

Here you can create different charts to display your data and then add them to a dashboard.



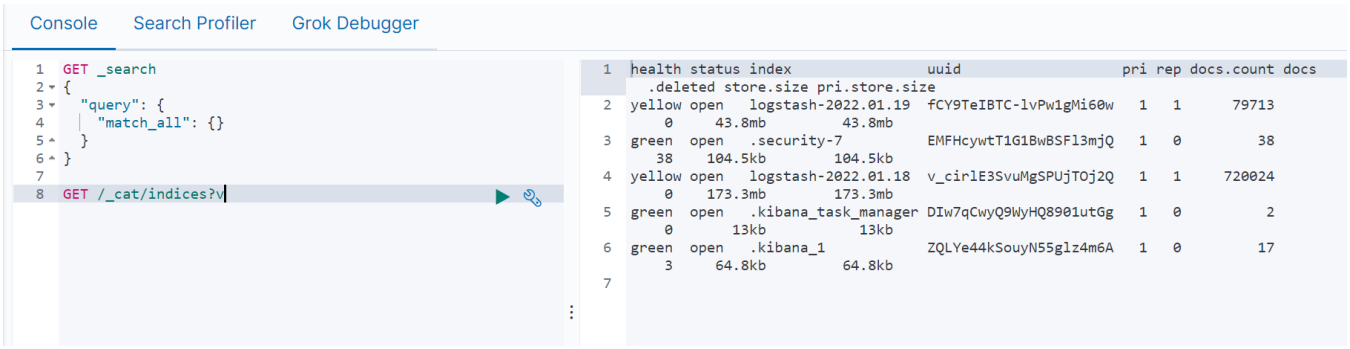
Here you can see 3 graphs, the first one shows the number of requests received by each NONRTRIC componet in he last 60 minutes.

The second one is a histogram showing the total number of requests broken down by timeStamp.

The last one is a pie chart showing the distribution of requests across components.

Click the Dev tools tab to use the elasticsearch console

Run GET /_cat/indices?v to see the list of indices currently in use



You can delete indices that are no longer required by running the following command:

DELETE /<index name> e.g. DELETE /logstash-2022.01.18

You can create a policy to remove logstash indices older than 1 day

Delete logstash indices policy

```
PUT /_ilm/policy/cleanup_policy
{
      "policy": {
        "phases": {
          "hot": {
            "actions": {}
          },
          "delete": {
            "min_age": "1d",
            "actions": { "delete": {} }
          }
        }
      }
}

PUT /logstash-*/_settings
{ "lifecycle.name": "cleanup_policy" }


PUT /_template/logging_policy_template
{
      "index_patterns": ["logstash-*"],
      "settings": { "index.lifecycle.name": "cleanup_policy" }
}
```

Elasticsearch SDK

SDK Example

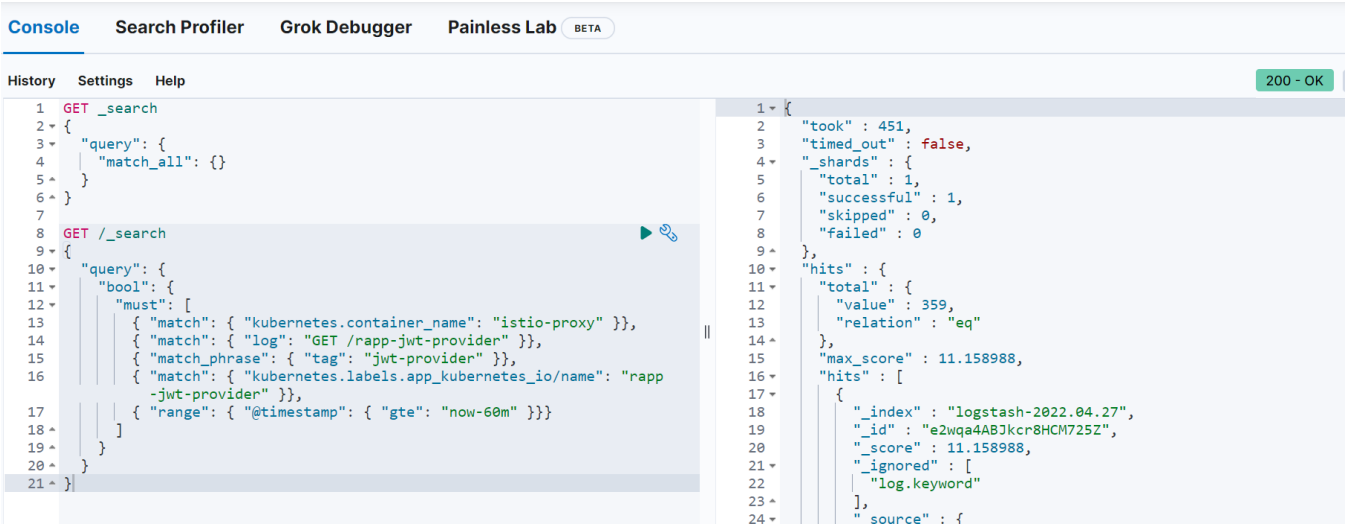
```
package main

import (
        "bytes"
        "context"
        "encoding/json"
        "fmt"
        "github.com/elastic/go-elasticsearch/esapi"
        "github.com/elastic/go-elasticsearch/v8"
        "io/ioutil"
        "log"
        "os/exec"
        "strings"
)

func main() {
        cmd := exec.Command("minikube", "ip")
        stdout, err := cmd.Output()
        ingressHost := strings.TrimSpace(string(stdout))

        cmd = exec.Command("minikube", "ssh-key")
        stdout, err = cmd.Output()
        ingressKey := strings.TrimSpace(string(stdout))

        // copy ca cert
        cmd = exec.Command("scp", "-i", ingressKey, "docker@"+ingressHost+":/var/elasticsearch/config/certs/ca
/ca.crt", "/mnt/c/Users/ktimoney/go/elastic/")
        stdout, err = cmd.Output()

        // get the elasticsearch service nodePort
        cmd = exec.Command("kubectl", "get", "service", "elasticsearch", "-n", "logging",
                "-o", "jsonpath={.spec.ports[?(@.port==9200)].nodePort}")
        stdout, err = cmd.Output()
        secureIngressPort := strings.TrimSpace(string(stdout))
```

```
clusterURLs := []string{"https://" + ingressHost + ":" + secureIngressPort}
username := "elastic"
password := "secret"
cert, _ := ioutil.ReadFile("./ca.crt")

// client configuration
cfg := elasticsearch.Config{
        Addresses: clusterURLs,
        Username:  username,
        Password:  password,
        CACert:    cert,
}
ctx := context.Background()

es, err := elasticsearch.NewClient(cfg)
if err != nil {
        log.Fatalf("Error creating the client: %s", err)
}
log.Println(elasticsearch.Version)

resp, err := es.Info()
if err != nil {
        log.Fatalf("Error getting response: %s", err)
}
defer resp.Body.Close()
log.Println(resp)

// Index Query
indexResp, err := esapi.CatIndicesRequest{Format: "json", Pretty: true}.Do(ctx, es)
if err != nil {
        return
}
indexBody := &indexResp.Body
defer indexResp.Body.Close()

fmt.Println(indexResp.String())

body, err := ioutil.ReadAll(*indexBody)

var results []map[string]interface{}
json.Unmarshal(body, &results)
fmt.Printf("Index: %+v\n", results)
indexName := fmt.Sprintf("%v", results[len(results)-1]["index"])
query := `{"query": {"match" : {"log": "token"}},"size": 3}`
runQuery(es, ctx, indexName, query)
query = `
        {
         "query": {
          "bool": {
            "must": [
              { "match": { "kubernetes.container_name": "istio-proxy" }},
              { "match": { "log": "token" }},
              { "match": { "kubernetes.labels.app_kubernetes_io/name": "rapp-jwt-invoker" }},
              { "range": { "@timestamp": { "gte": "now-60m" }}}
             ]
           }
         },"size": 1
        }
`
runQuery(es, ctx, indexName, query)
query = `
        {
         "query": {
          "bool": {
            "must": [
              { "match": { "kubernetes.container_name": "istio-proxy" }},
              { "match": { "log": "GET /rapp-jwt-provider" }},
              { "match": { "kubernetes.labels.app_kubernetes_io/name": "rapp-jwt-provider" }},
              { "match_phrase": { "tag": "jwt-provider" }},
              { "range": { "@timestamp": { "gte": "now-60m" }}}
             ]
```

```
                  }
                 },"size": 1
                }
        `
        runQuery(es, ctx, indexName, query)

}

func runQuery(es *elasticsearch.Client, ctx context.Context, indexName string, query string) {
        // Query indexName
        var mapResp map[string]interface{}
        var buf bytes.Buffer
        var b strings.Builder
        b.WriteString(query)
        read := strings.NewReader(b.String())

        // Attempt to encode the JSON query and look for errors
        if err := json.NewEncoder(&buf).Encode(read); err != nil {
                log.Fatalf("Error encoding query: %s", err)

                // Query is a valid JSON object
        } else {
                fmt.Println("\njson.NewEncoder encoded query:", read, "\n")
        }

        // Pass the JSON query to client's Search() method
        searchResp, err := es.Search(
                es.Search.WithContext(ctx),
                es.Search.WithIndex(indexName),
                es.Search.WithBody(read),
                es.Search.WithTrackTotalHits(true),
                es.Search.WithPretty(),
        )

        if err != nil {
                log.Fatalf("Elasticsearch Search() API ERROR:", err)
        }
        defer searchResp.Body.Close()

        // Decode the JSON response and using a pointer
        if err := json.NewDecoder(searchResp.Body).Decode(&mapResp); err != nil {
                log.Fatalf("Error parsing the response body: %s", err)
        }

        // Iterate the document "hits" returned by API call
        for _, hit := range mapResp["hits"].(map[string]interface{})["hits"].([]interface{}) {

                // Parse the attributes/fields of the document
                doc := hit.(map[string]interface{})

                // The "_source" data is another map interface nested inside of doc
                source := doc["_source"]

                // Get the document's _id and print it out along with _source data
                docID := doc["_id"]
                fmt.Println("docID:", docID)
                fmt.Println("_source:", source, "\n")
                // extract the @timestamp field
                timeStamp := fmt.Sprintf("%v", source.(map[string]interface{})["@timestamp"])
                fmt.Println("timeStamp:", timeStamp)
                // extract the tag field
                tag := fmt.Sprintf("%v", source.(map[string]interface{})["tag"])
                fmt.Println("tag:", tag)
                // extract the log field
                k8slog := fmt.Sprintf("%v", source.(map[string]interface{})["log"])
                fmt.Println("log:", k8slog)
        }
        hits := int(mapResp["hits"].(map[string]interface{})["total"].(map[string]interface{})["value"].
(float64))
        fmt.Println("Matches:", hits)
```

```
}
```

You can run the same query in elasticsearch dev-tools:



Quick Installation Guide

1. Download and install istio: istioctl install --set profile=demo
2. cd to the samples/addons/ directory and install the dashboards e.g. kubectl create -f kiali.yaml
3. Install postgres: istioctl kube-inject -f postgres.yaml | kubectl apply -f - (change the hostPath path value to a path on your host)
4. Install keycloak: istioctl kube-inject -f keycloak.yaml | kubectl apply -f -
5. Open the keycloak admin console and setup the required realms, users and clients
6. Setup the "pms_admin" and "pms_viewer" roles for pmsuser and pmsuser2 respectively.
7. Install nonrtric-server-go: docker build -t nonrtric-server-go:latest .
8. Create the istio-nonrtric namespace: kubectl create namespace istio-nonrtric
9. Enable istio for the istio-nonrtric namespace: kubectl label namespace istio-nonrtric istio-injection=enabled
10. Edit the istio-test.yaml so the host ip specified matches yours.
11. Also change the userid in the requestPrincipals field to match yours
12. Install istio-test.yaml : kubectl create -f istio-test.yaml
13. Install nonrtric-client-go: docker build -t nonrtric-client-go:latest .
14. Install the test client: istioctl kube-inject -f client.yaml | kubectl apply -f -
15. Open the kiali dashboard to check your services are up and running
16. Open the grafana to view the istio dashboard
17. Optionally install elasticsearch

ONAP

ONAP Next Generation Security & Logging Architecture

GO Client

Create kubernetes jobs in golang

Building stuff with the Kubernetes API

There is also a helm sdk you can use:

HELM SDK

Helm Deploy

```
package main
```

```
import (
    "fmt"
    "os"
    "log"
    "k8s.io/cli-runtime/pkg/genericclioptions"
    "k8s.io/client-go/rest"
    "helm.sh/helm/v3/pkg/action"
    "helm.sh/helm/v3/pkg/chart/loader"
)

func main() {
    chartPath := "/tmp/wordpress-12.3.3.tgz"
    chart, err := loader.Load(chartPath)

    releaseName := "wordpress"
    releaseNamespace := "default"

    actionConfig, err := getActionConfig(releaseNamespace)
    if err != nil {
        panic(err)
    }

    listAction := action.NewList(actionConfig)
    releases, err := listAction.Run()
    if err != nil {
        log.Println(err)
    }
    for _, release := range releases {
        log.Println("Release: " + release.Name + " Status: " + release.Info.Status.String())
    }

    iCli := action.NewInstall(actionConfig)
    iCli.Namespace = releaseNamespace
    iCli.ReleaseName = releaseName
    rel, err := iCli.Run(chart, nil)
    if err != nil {

        fmt.Println(err)
    }
   fmt.Println("Successfully installed release: ", rel.Name)
}

func getActionConfig(namespace string) (*action.Configuration, error) {
        actionConfig := new(action.Configuration)
        // Create the rest config instance with ServiceAccount values loaded in them
        config, err := rest.InClusterConfig()
        if err != nil {
        // fallback to kubeconfig
        home, exists := os.LookupEnv("HOME")
        if !exists {
            home = "/root"
        }
        kubeconfigPath := filepath.Join(home, ".kube", "config")
         if envvar := os.Getenv("KUBECONFIG"); len(envvar) >0 {
            kubeconfigPath = envvar
         }
         if err := actionConfig.Init(kube.GetConfig(kubeconfigPath, "", namespace), namespace, os.Getenv
("HELM_DRIVER"),
                   func(format string, v ...interface{}) {
                   fmt.Sprintf(format, v)
         }); err != nil {
             panic(err)
         }
        } else {
           // Create the ConfigFlags struct instance with initialized values from ServiceAccount
           var kubeConfig *genericclioptions.ConfigFlags
           kubeConfig = genericclioptions.NewConfigFlags(false)
           kubeConfig.APIServer = &config.Host
           kubeConfig.BearerToken = &config.BearerToken
           kubeConfig.CAFile = &config.CAFile
           kubeConfig.Namespace = &namespace
```

```
            if err := actionConfig.Init(kubeConfig, namespace, os.Getenv("HELM_DRIVER"), func(format string, v
...interface{}) {
                fmt.Sprintf(format, v)
            }); err != nil {
                panic(err)
            }
        }
        return actionConfig, nil
}
```

The method getActionConfig works for both in-cluster deployments and from the localhost. It determines which one to use by calling the rest. InClusterConfig() function.

GO CLIENT SDK

Here are another couple of programs that demonstrate how to use the go client:

hello-world.go

hello-world-del.go

You can also use the client with YAML : job.go

There is also support for istio in client go Istio client-go

ISTIO SDK

AuthorizationPolicy

```
package main

import (
    "context"
    "bytes"
    "fmt"
    "os"
    "log"
    "path/filepath"
    k8Yaml "k8s.io/apimachinery/pkg/util/yaml"
    metav1 "k8s.io/apimachinery/pkg/apis/meta/v1"
    clientcmd "k8s.io/client-go/tools/clientcmd"
    versioned "istio.io/client-go/pkg/clientset/versioned"
    v1beta1 "istio.io/client-go/pkg/apis/security/v1beta1"
    securityv1beta1 "istio.io/api/security/v1beta1"
    typev1beta1 "istio.io/api/type/v1beta1"
)

const (
        NAMESPACE = "default"
)

const authorizationPolicyManifest = `
apiVersion: "security.istio.io/v1beta1"
kind: "AuthorizationPolicy"
metadata:
  name: "pms-policy"
  namespace: default
spec:
  selector:
    matchLabels:
      apptype: nonrtric-pms
  action: ALLOW
  rules:
  - from:
    - source:
        principals: ["cluster.local/ns/default/sa/goclient"]
```

```
    to:
    - operation:
        methods: ["GET", "POST", "PUT", "DELETE"]
        paths: ["/a1-policy*"]
        hosts: ["a1-policy*"]
        ports: ["8080"]
    when:
    - key: request.auth.claims[role]
      values: ["pms_admin"]
`

func connectToK8s() *versioned.Clientset {
    home, exists := os.LookupEnv("HOME")
    if !exists {
        home = "/root"
    }

    configPath := filepath.Join(home, ".kube", "config")

    config, err := clientcmd.BuildConfigFromFlags("", configPath)
    if err != nil {
        log.Fatalln("failed to create K8s config")
    }

   ic, err := versioned.NewForConfig(config)
   if err != nil {
        log.Fatalf("Failed to create istio client: %s", err)

    return ic
}

func createAuthorizationPolicy(clientset *versioned.Clientset) {
        authClient := clientset.SecurityV1beta1().AuthorizationPolicies(NAMESPACE)

        auth := &v1beta1.AuthorizationPolicy{}
        dec := k8Yaml.NewYAMLOrJSONDecoder(bytes.NewReader([]byte(authorizationPolicyManifest)), 1000)

        if err := dec.Decode(&auth); err != nil {
               fmt.Println(err)
        }

        result, err := authClient.Create(context.TODO(), auth, metav1.CreateOptions{})

        if err!=nil {
                panic(err.Error())
        }

        fmt.Printf("Create Authorization Policy %s \n", result.GetName())
}

func createAuthorizationPolicy2(clientset *versioned.Clientset) {
        authClient := clientset.SecurityV1beta1().AuthorizationPolicies(NAMESPACE)

        auth := &v1beta1.AuthorizationPolicy{
                ObjectMeta: metav1.ObjectMeta{
                        Name: "ics-policy",
                },
                Spec: securityv1beta1.AuthorizationPolicy {
                  Selector: &typev1beta1.WorkloadSelector{
                             MatchLabels: map[string]string{
                             "apptype" : "nonrtric-ics",
                           },
                  },
                  Action: securityv1beta1.AuthorizationPolicy_ALLOW,
                  Rules: []*securityv1beta1.Rule{{
                         From: []*securityv1beta1.Rule_From{{
                              Source: &securityv1beta1.Source{
                                Namespaces : []string{
                                        "default",
                                },
                              },
```

```
                        },},
                        To: []*securityv1beta1.Rule_To{{
                             Operation:  &securityv1beta1.Operation{
                               Methods : []string{
                                     "GET", "POST", "PUT", "DELETE",
                               },
                               Paths : []string{
                                     "/data-*",
                               },
                               Hosts : []string{
                                     "data-consumer*", "data-producer*",
                               },
                               Ports : []string{
                                     "8080",
                               },
                             },
                        },},
                   },},
              },
        }

        result, err := authClient.Create(context.TODO(), auth, metav1.CreateOptions{})

        if err!=nil {
                panic(err.Error())
        }

        fmt.Printf("Create Authorization Policy %s \n", result.GetName())
}

func main() {
    clientset := connectToK8s()
    createAuthorizationPolicy(clientset)
    createAuthorizationPolicy2(clientset)
}
```

keycloak aslo has a client called gocloak

GOCLOAK SDK

gocloak

```
package main

import (
        "github.com/Nerzal/gocloak/v10"
        "context"
        "fmt"
)

func main(){
 client := gocloak.NewClient("http://192.168.49.2:31560")
 ctx := context.Background()
 token, err := client.LoginAdmin(ctx, "admin", "admin", "master")
 if err != nil {
  fmt.Println(err)
  panic("Something wrong with the credentials or url")
 }

 realmRepresentation := gocloak.RealmRepresentation{
  ID: gocloak.StringP("testRealm"),
  Realm: gocloak.StringP("testRealm"),
  DisplayName: gocloak.StringP("testRealm"),
  Enabled:   gocloak.BoolP(true),
 }
```

```
 realm, err := client.CreateRealm(ctx, token.AccessToken, realmRepresentation)
 if err != nil {
  fmt.Println(err)
  panic("Oh no!, failed to create realm :(")
 } else {
  fmt.Println("Created new realm", realm)
 }

 newClient := gocloak.Client{
  ClientID: gocloak.StringP("testClient"),
  Enabled:   gocloak.BoolP(true),
  DirectAccessGrantsEnabled: gocloak.BoolP(true),
  BearerOnly: gocloak.BoolP(false),
  PublicClient: gocloak.BoolP(true),
 }
 clientId, err := client.CreateClient(ctx, token.AccessToken, realm, newClient)
 if err != nil {
  fmt.Println(err)
  panic("Oh no!, failed to create client :(")
 } else {
  fmt.Println("Created new client", clientId)
 }


 newUser := gocloak.User{
  FirstName: gocloak.StringP("Bob"),
  LastName:  gocloak.StringP("Uncle"),
  Email:     gocloak.StringP("something@really.wrong"),
  Enabled:   gocloak.BoolP(true),
  Username:  gocloak.StringP("testUser"),
 }

 userId, err := client.CreateUser(ctx, token.AccessToken, realm, newUser)
 if err != nil {
  fmt.Println(err)
  panic("Oh no!, failed to create user :(")
 } else {
  fmt.Println("Created new user", userId)
}

 err = client.SetPassword(ctx, token.AccessToken, userId, realm, "secret", false)
 if err != nil {
  fmt.Println(err)
  panic("Oh no!, failed to set password :(")
 } else {
  fmt.Println("Set password for user")
 }

 removeRoles := []gocloak.Role{}
 origRoles, err := client.GetRealmRoles(ctx, token.AccessToken, realm, gocloak.GetRoleParams{})
  if err != nil {
  fmt.Println(err)
  panic("Oh no!, failed to retreive roles :(")
 } else {
  fmt.Println("Retrieved roles")
 }
 for _, r := range origRoles {
   removeRoles = append(removeRoles, *r)
 }

 newRole := gocloak.Role{
  Name: gocloak.StringP("testRole"),
 }
 roleName, err := client.CreateRealmRole(ctx, token.AccessToken, realm, newRole)
 if err != nil {
  fmt.Println(err)
  panic("Oh no!, failed to create role :(")
 } else {
  fmt.Println("Created new role", roleName)
 }
```

```
 role, err := client.GetRealmRole(ctx, token.AccessToken, realm, roleName)
 if err != nil {
  fmt.Println(err)
  panic("Oh no!, failed to retrieve role :(")
 } else {
  fmt.Println("Retrieved role")
 }

 roles := []gocloak.Role{}
 roles = append(roles, *role)
 err = client.AddRealmRoleToUser(ctx, token.AccessToken, realm, userId, roles)
 if err != nil {
  fmt.Println(err)
  panic("Oh no!, failed to add role to user :(")
 } else {
  fmt.Println("Role added to user")
 }

 err = client.DeleteRealmRoleFromUser(ctx, token.AccessToken, realm, userId, removeRoles)
 if err != nil {
  fmt.Println(err)
  panic("Oh no!, failed to remove roles from user :(")
 } else {
  fmt.Println("Roles removed from user")
 }

 newMapper := gocloak.ProtocolMapperRepresentation{
   ID:             gocloak.StringP("testMapper"),
   Name:           gocloak.StringP("testMapper"),
   Protocol:       gocloak.StringP("openid-connect"),
   ProtocolMapper: gocloak.StringP("oidc-usermodel-realm-role-mapper"),
   Config: &map[string]string{
                               "access.token.claim":   "true",
                               "aggregate.attrs":      "",
                               "claim.name":           "role",
                               "id.token.claim":       "true",
                               "jsonType.label":       "String",
                               "multivalued":          "",
                               "userinfo.token.claim": "true",
                       },
  }
 _, err = client.CreateClientProtocolMapper(ctx, token.AccessToken, realm, clientId, newMapper)
 if err != nil {
  fmt.Println(err)
  panic("Oh no!, failed to add roleampper to client :(")
 } else {
  fmt.Println("Rolemapper added to client")
 }

}
```

If you want to create a confidential client you can use these settings instead:

newClient := gocloak.Client{
ClientID: gocloak.StringP("testClient"),
Enabled: gocloak.BoolP(true),
DirectAccessGrantsEnabled: gocloak.BoolP(true),
BearerOnly: gocloak.BoolP(false),
PublicClient: gocloak.BoolP(false),
ServiceAccountsEnabled: gocloak.BoolP(true),
ClientAuthenticatorType: gocloak.StringP("client-secret"),
Secret: gocloak.StringP("secret"),
}

You can then access the token with the following URL: curl -X POST http://<keycloak host ip>:<keycloak port>/auth/realms/testRealm/protocol/openid-connect/token "Content-Type: application/x-www-form-urlencoded" -d client_id=testClient -d client_secret=secret -d 'grant_type=client_credentials'

using client credentials instead of user credentials

You will also need to create a client role and use the "Hardcoded role" mapper to include the client role in the JWT.

This can be done in gocloak like this:

goclock client role

```
clientRole := gocloak.Role{
 Name: gocloak.StringP("icsClientRole"),
}
clientRoleName, err := client.CreateClientRole(ctx, token.AccessToken, realm, clientId, clientRole)
if err != nil {
 fmt.Println(err)
 panic("Oh no!, failed to create client role :(")
} else {
 fmt.Println("Created new client role", clientRoleName)
}

clientRole := *newClient.ClientID + "." + clientRoleName
fmt.Println("clientRole", clientRole)

hardcodedMapper := gocloak.ProtocolMapperRepresentation{
  ID:             gocloak.StringP("testMapper2"),
  Name:           gocloak.StringP("testMapper2"),
  Protocol:       gocloak.StringP("openid-connect"),
  ProtocolMapper: gocloak.StringP("oidc-hardcoded-role-mapper"),
  Config: &map[string]string{
                                "role": clientRole,
                      },
 }
_, err = client.CreateClientProtocolMapper(ctx, token.AccessToken, realm, clientId, hardcodedMapper)
if err != nil {
 fmt.Println(err)
 panic("Oh no!, failed to add hardcoded roleampper to client :(")
} else {
 fmt.Println("Hardcoded rolemapper added to client")
}
```

This will produce a JWT token with the client role nested inside "resource_access"

JWT snippet

```
{
  "exp": 1645458971,
  "iat": 1645458671,
  "jti": "54fd719a-bf5b-4638-afd5-828ff10b7537",
  "iss": "http://192.168.49.2:31560/auth/realms/icsrealm",
  "aud": "account",
  "sub": "e9ebe72f-3729-4cd5-88da-79f9bfb23cfb",
  "typ": "Bearer",
  "azp": "icsclient",
  "acr": "1",
  "realm_access": {
    "roles": [
      "offline_access",
      "uma_authorization",
      "default-roles-icsrealm"
    ]
  },
  "resource_access": {
    "icsclient": {
      "roles": [
        "icsclientrole"
      ]
    },
```

You can then setup your AuthorizationPolicy like this:

AuthorizationPolicy

```
apiVersion: "security.istio.io/v1beta1"
kind: "AuthorizationPolicy"
metadata:
  name: "ics-policy"
  namespace: istio-nonrtric
spec:
  selector:
    matchLabels:
      apptype: nonrtric-ics
  action: ALLOW
  rules:
  - from:
    - source:
        requestPrincipals: ["http://192.168.49.2:31560/auth/realms/icsrealm/"]
    - source:
        requestPrincipals: ["http://keycloak.default:8080/auth/realms/icsrealm/"]
  - to:
    - operation:
        methods: ["GET", "POST", "PUT", "DELETE"]
        paths: ["/data-*"]
    when:
    - key: request.auth.claims[resource_access][icsclient][roles]
      values: ["icsclientrole"]
```

You don't ned to include the userId with the requestPrincipals.

keycloak secrets can be (re)generated and retrieved using the following code:

keycloak client secret

```
_, err = client.RegenerateClientSecret(ctx, token.AccessToken, realm, clientId)
 if err != nil {
 fmt.Println(err)
 panic("Oh no!, failed to regenerate client secret :(")
} else {
 fmt.Println("Regenerated Secret")
}

cred, err := client.GetClientSecret(ctx, token.AccessToken, realm, clientId)
 if err != nil {
 fmt.Println(err)
 panic("Oh no!, failed to get client secret :(")
} else {
 fmt.Println("Client Secret", *cred.Value)
}
```

Instead of using the hardcoded mapper you can call the GetClientServiceAccount method to get the service a/c user.

You can then add the client role to the service account user with the AddClientRoleToUser method.

Instead of using the hardcoded mapper you can use a client role mapper to include the client role in the JWT.

Finally you can set the default client scpe to "email" to mininmize the size of you token.

JWT

```
  "iat": 1646152642,
  "jti": "e55fd625-d3e5-476f-aeb7-5a0189380151",
  "iss": "http://192.168.49.2:31560/auth/realms/hwrealm",
  "sub": "d2f705d1-ca27-437d-979f-4d0b80d500d7",
  "typ": "Bearer",
  "azp": "hwclient",
  "acr": "1",
  "scope": "email",
  "email_verified": false,
  "clientHost": "127.0.0.6",
  "clientId": "hwclient",
  "clientRole": [
    "hwclientrole"
  ],
  "clientAddress": "127.0.0.6"
}
```

In your Istio AuthorizationPolicy use the following when clause :

Istio

```
    when:
    - key: request.auth.claims[clientRole]
      values: ["hwclientrole"]
```

Keycloak Client Authenticator

Using X509 certificates

Create the server side certificates using the following script

server_certs.sh

```
#!/bin/sh


CA_SUBJECT="/C=IE/ST=/L=/O=/OU=EST/CN=est.tech/emailAddress=ca@mail.com"
SERVER_SUBJECT="/C=IE/ST=/L=/O=/OU=EST/CN=est.tech/emailAddress=server@mail.com"
PW=changeit
IP=$(minikube ip)

echo $PW > secretfile.txt

openssl req -x509 -sha256 -days 3650 -newkey rsa:4096 -keyout rootCA.key -subj "$CA_SUBJECT" -passout file:
secretfile.txt -out rootCA.crt

openssl req -new -newkey rsa:4096 -keyout tls.key -subj "$SERVER_SUBJECT" -out tls.csr -nodes

echo "subjectKeyIdentifier   = hash" > x509.ext
echo "authorityKeyIdentifier = keyid:always,issuer:always" >> x509.ext
echo "basicConstraints       = CA:TRUE" >> x509.ext
echo "keyUsage               = digitalSignature, nonRepudiation, keyEncipherment, dataEncipherment,
keyAgreement, keyCertSign" >> x509.ext
echo "subjectAltName         = DNS.1:localhost, IP.1:127.0.0.1, DNS.2:minikube, IP.2:${IP}, DNS.3:keycloak.
default, DNS.4:keycloak.est.tech" >> x509.ext
echo "issuerAltName          = issuer:copy" >> x509.ext
echo "[ ca ]" >> x509.ext
echo "# X509 extensions for a ca" >> x509.ext
echo "keyUsage                = critical, cRLSign, keyCertSign" >> x509.ext
echo "basicConstraints        = CA:TRUE, pathlen:0" >> x509.ext
echo "subjectKeyIdentifier    = hash" >> x509.ext
echo "authorityKeyIdentifier  = keyid:always,issuer:always" >> x509.ext
echo "" >> x509.ext
echo "[ server ]" >> x509.ext
echo "# X509 extensions for a server" >> x509.ext
echo "keyUsage                = critical,digitalSignature,keyEncipherment" >> x509.ext
echo "extendedKeyUsage        = serverAuth,clientAuth" >> x509.ext
echo "basicConstraints        = critical,CA:FALSE" >> x509.ext
echo "subjectKeyIdentifier    = hash" >> x509.ext
echo "authorityKeyIdentifier  = keyid,issuer:always" >> x509.ext

openssl x509 -req -CA rootCA.crt -CAkey rootCA.key -in tls.csr -passin file:secretfile.txt -out tls.crt -days
365 -CAcreateserial -extfile x509.ext

rm secretfile.txt x509.ext 2>/dev/null
```

This will produce the following files: tls.key, tls.crt and rootCA.crt.

These need to be copied to a location where keycloak can pick them up when starting.

Add a PersistentVolume and PersistentVolumeClaim to map the hostPath on your localhost to the /etc/x509/https directory on the keycloak server.

This will automatically pick up the tls.key, tls.crt files and convert them into https-keystore files in the /opt/jboss/keycloak/standalone/configuration /keystores directory.

You will need to map the rootCA.crt file using an environment variable like this:

env:
- name : X509_CA_BUNDLE
value: /etc/x509/https/rootCA.crt

You'll also need to create a port mapping for the keycloak https port in your deployment:

env:
- name: KEYCLOAK_HTTPS_PORT
value: "8443"

ports:
- name: http
containerPort: 8080
- name: https
containerPort: 8443

and include the https port in your service:

ports:
- name: https
port: 8443
targetPort: 8443
nodePort: 31561

keycloak is now ready to accept https connections.

You can generate your client certificates using the following code:

client_certs

```
#!/bin/sh

CLIENT_SUBJECT="/C=IE/ST=/L=/O=/OU=EST/CN=est.tech/emailAddress=client@mail.com"
PW=changeit
CERTNAME=client
IP=$(minikube ip)

echo $PW > secretfile.txt

echo "subjectKeyIdentifier   = hash" > x509.ext
echo "authorityKeyIdentifier = keyid:always,issuer:always" >> x509.ext
echo "basicConstraints       = CA:TRUE" >> x509.ext
echo "keyUsage               = digitalSignature, nonRepudiation, keyEncipherment, dataEncipherment,
keyAgreement, keyCertSign" >> x509.ext
echo "subjectAltName         = DNS.1:localhost, IP.1:127.0.0.1, DNS.2:minikube, IP.2:${IP}, DNS.3:keycloak.
default, DNS.4:keycloak.est.tech" >> x509.ext
echo "issuerAltName          = issuer:copy" >> x509.ext

openssl req -new -newkey rsa:4096 -nodes -keyout ${CERTNAME}.key -subj "$CLIENT_SUBJECT" -out ${CERTNAME}.csr

openssl x509 -req -CA rootCA.crt -CAkey rootCA.key -in ${CERTNAME}.csr -passin file:secretfile.txt -out
${CERTNAME}.crt -days 365 -CAcreateserial -extfile x509.ext


openssl pkcs12 -export -clcerts -in ${CERTNAME}.crt -inkey ${CERTNAME}.key -passout file:secretfile.txt -out
${CERTNAME}.p12

openssl pkcs12 -in ${CERTNAME}.p12 -password pass:$PW -passout file:secretfile.txt -out ${CERTNAME}.pem -
clcerts -nodes

rm secretfile.txt x509.ext 2>/dev/null
```

This will generate a client.crt and a client.key which you can use separtley, it also generates client.pem which combined the certificate and key into 1 file.

If you use this as your cert file then you don't need to specifiy a key file parameter.

You now need to setup your realm and add an X.509 Direct Grant Flow.

See this link on how to do that https://wjw465150.gitbooks.io/keycloak-documentation/content/server_admin/topics/authentication/x509.html

Next setup a client with access type of public.

Change Direct Grant Flow in the "Authentication Flow Overrides" section of your client settings to "x509 direct grant".

Last add a new user with an email address which is the same as the one given the the certificate subject i.e. client@mail.com

Note: The subjectAltName contains a list of DNS and IP entries, you must use one of these in your URL when using the cert.

Note: The CN will be used later on when specifying an SNI host name.

You can test your setup using the following script:

test_cert

```
#!/bin/sh
HOST=$(minikube ip)
KEYCLOAK_PORT=$(kubectl -n default get service keycloak -o jsonpath='{.spec.ports[?(@.name=="https")].
nodePort}')
REALM="x509"
CLIENT="x509client"
curl -k -X POST https://$HOST:$KEYCLOAK_PORT/auth/realms/$REALM/protocol/openid-connect/token  \
        --data "grant_type=password&scope=openid profile&username=&password=&client_id=$CLIENT" \
        --cert client.crt --key client.key


echo ""
```

This will retrieve a JWT token without the need to use a password.

If you are using a confidential client, include the client_secret:

curl -k -X POST https://$HOST:$KEYCLOAK_PORT/auth/realms/$REALM/protocol/openid-connect/token \
--data "grant_type=password&scope=openid profile&client_id=$CLIENT" \
-d client_secret=<client secret> \
--cert client.crt --key client.key

For confidential clients you can also set the Client Authenticator to "X509 certificate" in the credentials tab.

You can then set your subject DN to something like: .*client@mail.com.* and turn on "Allow Regex Pattern Comparison"

The JWT can then be retrieved using a call like the following:

curl -k -X POST https://$HOST:$KEYCLOAK_PORT/auth/realms/$REALM/protocol/openid-connect/token \
--data "grant_type=password&scope=openid profile&client_id=$CLIENT" \
--cert client.pem

Alternatively you can use the -E option to entrypt the pem file

curl -k -X POST https://$HOST:$KEYCLOAK_PORT/auth/realms/$REALM/protocol/openid-connect/token \
--data "grant_type=password&scope=openid profile&client_id=$CLIENT" \
-E client.pem

For more informtion see: X.509 Client Certificate User Authentication

It is not possible to connect to a TLS server with curl using only a client certificate, without the client private key. https://stackoverflow.com/questions/36431179/using-curl-with-cert

Token can also be retrieved using go:

Go X509 Token

```
package main

import (
        "crypto/tls"
        "crypto/x509"
        "fmt"
        "io/ioutil"
        "net/http"
        "net/url"
)

func main() {
        caCert, _ := ioutil.ReadFile("/mnt/c/Users/ktimoney/keycloak-certs/rootCA.crt")
        caCertPool := x509.NewCertPool()
        caCertPool.AppendCertsFromPEM(caCert)

        cert, _ := tls.LoadX509KeyPair("/mnt/c/Users/ktimoney/keycloak-certs/client.crt", "/mnt/c/Users/ktimoney
/keycloak-certs/client.key")

        client := &http.Client{
                Transport: &http.Transport{
                        TLSClientConfig: &tls.Config{
                                RootCAs:      caCertPool,
                                Certificates: []tls.Certificate{cert},
                        },
                },
        }

        keycloakHost := "192.168.49.2"
        keycloakPort := "31561"
        realmName := "x509"
        keycloakUrl := "https://" + keycloakHost + ":" + keycloakPort + "/auth/realms/" + realmName + "/protocol
/openid-connect/token"

        clientId := "x509client"
        scope := "openid profile"
        resp, err := client.PostForm(keycloakUrl,
                url.Values{"username": {""}, "password": {""}, "grant_type": {"password"}, "client_id":
{clientId}, "scope": {scope}})
        if err != nil {
                panic(err)
        }
        defer resp.Body.Close()

        fmt.Println("response Status:", resp.Status)
        fmt.Println("response Headers:", resp.Header)
        body, _ := ioutil.ReadAll(resp.Body)
        fmt.Println("response Body:", string(body))
}
```

Java example available here: X.509 Authentication in Spring Security

Istio CA Certs

To allow istio to work with keycloak you must add your certificate to the istio certs when you're installing.

An istio operator file is used for this: istio.yaml

istioctl install --set profile=demo -f istio.yaml

Further instruction are available here: Custom CA Integration using Kubernetes CSR

Using istio-gateway to obtain JWT tokens.

You may want to avoid connecting directly to the keycloak server for security reasons.

You can connect to it through the istio ingress gateway instead if you wish.

You will need to setup a gateway in PASSTROUGH mode and virtual service that maps the keycloak host to the keycloak SNI host.

The following file can be used to do this for the CN used when creating certificates above: keycloak-gateway.yaml

You can test this using curl:

Test Gateway

```
#!/bin/sh
INGRESS_HOST=$(minikube ip)
SECURE_INGRESS_PORT=$(kubectl -n default get service istio-ingressgateway -n istio-system -o jsonpath='{.spec.
ports[?(@.name=="https")].nodePort}')

curl -v --resolve "keycloak.est.tech:$SECURE_INGRESS_PORT:$INGRESS_HOST" --cacert rootCA.crt "https://keycloak.
est.tech:$SECURE_INGRESS_PORT"

CLIENT="myclient"
REALM="x509"
curl --resolve "keycloak.est.tech:$SECURE_INGRESS_PORT:$INGRESS_HOST" --cacert rootCA.crt \
        -X POST https://keycloak.est.tech:$SECURE_INGRESS_PORT/auth/realms/$REALM/protocol/openid-connect
/token  \
        --data "grant_type=password&scope=openid profile&client_id=$CLIENT" \
        -E client.pem
echo ""
```

The following go code can be used to achieve the same result:

go

```
package main

import (
        "context"
        "crypto/tls"
        "crypto/x509"
        "fmt"
        "io/ioutil"
        "net"
        "net/http"
        "net/url"
        "os/exec"
        "strings"
        "time"
)

func main() {
        caCert, _ := ioutil.ReadFile("/mnt/c/Users/ktimoney/keycloak-certs/rootCA.crt")
        caCertPool := x509.NewCertPool()
        caCertPool.AppendCertsFromPEM(caCert)

        cert, _ := tls.LoadX509KeyPair("/mnt/c/Users/ktimoney/keycloak-certs/client.crt",
                                       "/mnt/c/Users/ktimoney/keycloak-certs/client.key")

        dialer := &net.Dialer{
                Timeout:   30 * time.Second,
                KeepAlive: 30 * time.Second,
                DualStack: true,
        }

        keycloakAlias := "keycloak.est.tech"
        cmd := exec.Command("minikube", "ip")
        stdout, err := cmd.Output()
        ingressHost := strings.TrimSpace(string(stdout))
```

```
        cmd = exec.Command("kubectl", "get", "service", "istio-ingressgateway", "-n", "istio-system",
                           "-o", "jsonpath={.spec.ports[?(@.name==\"https\")].nodePort}")
        stdout, err = cmd.Output()
        secureIngressPort := strings.TrimSpace(string(stdout))
        fmt.Println("secureIngressPort = " + secureIngressPort)

        client := &http.Client{
                Transport: &http.Transport{
                        DialContext: func(ctx context.Context, network, addr string) (net.Conn, error) {
                                fmt.Println("address original =", addr)
                                if addr == keycloakAlias+":"+secureIngressPort {
                                        addr = ingressHost + ":" + secureIngressPort
                                        fmt.Println("address modified =", addr)
                                }
                                return dialer.DialContext(ctx, network, addr)
                        },
                        TLSClientConfig: &tls.Config{
                                RootCAs:      caCertPool,
                                Certificates: []tls.Certificate{cert},
                        },
                },
        }

        realmName := "x509provider"
        keycloakUrl := "https://" + keycloakAlias + ":" + secureIngressPort + "/auth/realms/" +
                        realmName + "/protocol/openid-connect/token"

        clientId := "x509provider-cli"
        clientId = "myclient"
        scope := "email openid"
        resp, err := client.PostForm(keycloakUrl,
                url.Values{"grant_type": {"password"}, "client_id": {clientId}, "scope": {scope}})
        if err != nil {
                panic(err)
        }
        defer resp.Body.Close()

        fmt.Println("response Status:", resp.Status)
        fmt.Println("response Headers:", resp.Header)
        body, _ := ioutil.ReadAll(resp.Body)
        fmt.Println("response Body:", string(body))
}
```

Note: If run outside the cluster the ISS will be "https://keycloak.est.tech:30338/auth/realms/<realm>" (the port number will doffer depending on your setup).

Inside the cluster it will be: "https://keycloak.est.tech:443/auth/realms/<realm>"

Note: Your istio jwksUri won't be able to resolve the host alias so you should use the normal values for this e.g. "https://keycloak.default:8443/auth/realms/<realm>/protocol/openid-connect/certs"

Note: The file above also allows for http calls to keycloak through the gateway, the ISS in this case is: "http://istio-ingressgateway.istio-system:80/auth/realms/<realm>". In this case the jwksUri ahould be set to the default URI for in-cluster keycloak calls i.e. "http://keycloak.default:8080/auth/realms/<realm>/protocol/openid-connect/certs"

Client authentication with signed JWT

Another option for retrieving JWT tokens for confidentail clients is using client authentication with signed JWT.

Create a new confidential client and call it jwtclient.

In the credentials section choose "Signed JWT" from the Client Authenticator dropdown and choose RS256 as the Signature Algorithm.

Then in the Keys tab import the client.crt we generated earlier.

We need to create a self-signed JWT assertion to use this.

Create a public key from your private key with the following command: openssl rsa -in client.key -outform PEM -pubout -out client_pub.key

See the following link on how to do this: Creating and validating a JWT RSA token in Golang

We need to make some modifications to the token.go code to enable it to work for us.

The following fields need to be added to the claims map:

claims["jti"] = "myJWTId" + fmt.Sprint(now.UnixNano())
claims["sub"] = "jwtclient"
claims["iss"] = "jwtclient"
claims["aud"] = "http://192.168.49.2:31560/auth/realms/x509"

Also modify main.go so it uses you public and private keys and only outputs the token value.

Compile and run the code to produce the self-signed JWT assertion.

This can then be used to obtain a JWT access token with the following curl command:

JWT Assertion

```
#!/bin/sh
HOST=$(minikube ip)
KEYCLOAK_PORT=$(kubectl -n default get service keycloak -o jsonpath='{.spec.ports[?(@.name=="http")].nodePort}')
REALM="x509"
CLIENT="jwtclient"


JWT=$(./main)

curl -k -X POST http://$HOST:$KEYCLOAK_PORT/auth/realms/$REALM/protocol/openid-connect/token  \
        -d "grant_type=client_credentials" -d "scope=openid profile" -d client_id=$CLIENT \
        -d "client_assertion_type=urn:ietf:params:oauth:client-assertion-type:jwt-bearer" \
        -d client_assertion=$JWT
echo ""
```

No client secret is required for this authentication.

These self-signed JWT assertions are for one time use only, the jti claim value must have a unique id for every call.

Note: we can also call this using https with some small modifications.

Client authentication with signed JWT with client secret

This is similar to the option above except we sign with the client secret instead of the private key.

We also use a different algorithm.

The following code demonstrates this:

Signed JWT with client secret

```
        secret := "NKTh1bfR9HNwllMhdWrDMKhVJHTvwreC"

        token, err := jwt.NewWithClaims(jwt.SigningMethodHS256, claims).SignedString([]byte(secret))
        if err != nil {
                return "", fmt.Errorf("create: sign token: %w", err)
        }
```

Client keys tab

The client offer many different ways of configuring the authenticatio keys.

To use the JWKS option we need to create a jwks from our private key or public key.

The following code performs this operation:

PEM to JWKS

```
package main

import (
        "crypto/rsa"
        "crypto/sha1"
        "crypto/x509"
        "encoding/base64"
        "encoding/json"
        "encoding/pem"
        "flag"
        "fmt"
        "golang.org/x/crypto/ssh"
        "io/ioutil"
        "math/big"
)

type Jwks struct {
        Keys []Key `json:"keys"`
}
type Key struct {
        Kid string `json:"kid,omitempty"`
        Kty string `json:"kty"`
        Use string `json:"use"`
        N   string `json:"n"`
        E   string `json:"e"`
        X5c []string `json:"x5c"`
        X5t string `json:"x5t"`
}

var keyFile string
var keyType string
var certFile string

func getKeyFromPrivate(key []byte) (*rsa.PublicKey){
        parsed, err := ssh.ParseRawPrivateKey(key)
        if err != nil {
                fmt.Println(err)
        }

        // Convert back to an *rsa.PrivateKey
        privateKey := parsed.(*rsa.PrivateKey)

        publicKey := &privateKey.PublicKey
        return publicKey
}

func getKeyFromPublic(key []byte) (*rsa.PublicKey){
        pubPem, _ := pem.Decode(key)

        parsed, err := x509.ParsePKIXPublicKey(pubPem.Bytes)
        if err != nil {
                fmt.Println("Unable to parse RSA public key", err)
        }

        // Convert back to an *rsa.PublicKey
        publicKey := parsed.(*rsa.PublicKey)

        return publicKey
}

func getCert(cert []byte) *x509.Certificate {
        certPem, _ := pem.Decode(cert)
        if certPem == nil {
                panic("Failed to parse pem file")
```

```
        }

        // pass cert bytes
        certificate, err := x509.ParseCertificate(certPem.Bytes)
        if err != nil {
                fmt.Println("Unable to parse Certificate", err)
        }

        return certificate
}

func main() {
        flag.StringVar(&keyFile, "keyFile", "/mnt/c/Users/ktimoney/keycloak-certs/client_pub.key", "Location of
key file")
        flag.StringVar(&keyType, "keyType", "public", "Type of key file")
        flag.StringVar(&certFile, "certFile", "/mnt/c/Users/ktimoney/keycloak-certs/client.crt", "Location of
cert file")
        flag.Parse()

        key, err := ioutil.ReadFile(keyFile)
        if err != nil {
                fmt.Println(err)
        }

        var publicKey *rsa.PublicKey

        if keyType == "public" {
           publicKey = getKeyFromPublic(key)
        }else{
           publicKey = getKeyFromPrivate(key)
        }

        cert, err := ioutil.ReadFile(certFile)
        if err != nil {
                fmt.Println(err)
        }

        certificate := getCert(cert)
        // generate fingerprint with sha1
        // you can also use md5, sha256, etc.
        fingerprint := sha1.Sum(certificate.Raw)

        jwksKey := Key{
                Kid: "SIGNING_KEY",
                Kty: "RSA",
                Use: "sig",
                N: base64.RawStdEncoding.EncodeToString(publicKey.N.Bytes()),
                E: base64.RawStdEncoding.EncodeToString(big.NewInt(int64(publicKey.E)).Bytes()),
                X5c: []string{base64.RawStdEncoding.EncodeToString(certificate.Raw)},
                X5t: base64.RawStdEncoding.EncodeToString(fingerprint[:]),
        }
        jwksKeys := []Key{jwksKey}
        jwks := Jwks{jwksKeys}

        jwksJson, err := json.Marshal(jwks)
        if err != nil {
                fmt.Println(err)
                return
        }
        fmt.Println(string(jwksJson))

}
```

The output will look like this:

{"keys":[{"kid":"SIGNING_KEY","kty":"RSA","use":"sig","n":"70XsremwRthZafooWzoDbpj1VnebGnHHLBOTT+A87SWv+WLYtnsDRAew
/2XlHA8Q2c1sRU5xeEOtV6tNzk7qk8b4Kp6ZjDSeyUu7IjDEKhJUVaW2rJKj6Cyp9V8Iu82owvMdkyipWp2ZRs7GPtT0CDWSjQnu3nhQ2k0KKybZL9OQ7ev
pEid7q/pzFPZVU3lEUXiNJZAXTx4AIBZTgM2x74NgORg3WDCpxIPoHB1E2lOkOviAhTC6UmOpUBuLhQIrYTrVfpq0FtlgwCho0hf6uMN2fv60d0EOCEvb1a
/8uBLZ2CX5oPvMZ1UfJiLwp/FaYOATmmdRF5CQoLO5AvV7CnOWdisISHIDwq+lMmO9qa8TFbgLZ0OcElgws
/O1qJSHXISvWYiruT36XRuxRGg17ctTiI1Fb8qtyz1B7Rmpn0dG52aYfwJ+fZbhkKXwo4Q9SAUsAO8aPEotpCmHXPDeLbXVhgxzevr0WOE2bInU+yQYaF
43e4AmzuCRPI2EruM4mAogxj8GkG/SCAVT7lWQeuIFyx3BD5wkOgPrniNVsnMeFq7VvXGpIEcbBz4KfVvlMOiNFh8XCP1YIKPtFqdEhx
/NerNLVw0EMWx4iyFlTOr+TSVIi0NDr1GCMwu8SSz5gXHWnWTCZAo7lEFlZevYRV/YphJT310Q78CVyh/uPgE","e":"AQAB","x5c":
["MIIGSjCCBDKgAwIBAgIUaSy+y5O7hsXcOj9lQB
/nYygWXGMwDQYJKoZIhvcNAQELBQAwSjELMAkGA1UEBhMCSUUxDDAKBgNVBAsMA0VTVDERMA8GA1UEAwwIZXN0LnRlY2gxGjAYBgkqhkiG9w
0BCQEWC2NhQG1haWwuY29tMB4XDTIyMDMyOTEyMjMyOFoXDTIzMDMyOTEyMjMyOFowTjELMAkGA1UEBhMCSUUxDDAKBgNVBAsMA0VTVDER
MA8GA1UEAwwIZXN0LnRlY2gxHjAcBgkqhkiG9w0BCQEWD2NsaWVudEBtYWlsLmNvbTCCAiIwDQYJKoZIhvcNAQEBBQADggIPADCCAgoCggIBAO9F
7K3psEbYWWn6KFs6A26Y9VZ3mxpxxywTk0/gPO0lr
/li2LZ7A0QHsP9l5RwPENnNbEVOcXhDrVerTc5O6pPG+CqemYw0nslLuyIwxCoSVFWltqySo+gsqfVfCLvNqMLzHZMoqVqdmUbOxj7U9Ag1ko0J7t54UNp
NCism2S
/TkO3r6RIne6v6cxT2VVN5RFF4jSWQF08eACAWU4DNse+DYDkYN1gwqcSD6BwdRNpTpDr4gIUwulJjqVAbi4UCK2E61X6atBbZYMAoaNIX+rjDdn7+tHd
BDghL29Wv
/LgS2dgl+aD7zGdVHyYi8KfxWmDgE5pnUReQkKCzuQL1ewpzlnYrCEhyA8KvpTJjvamvExW4C2dDnBJYMLPztaiUh1yEr1mIq7k9+l0bsURoNe3LU4iNRW
/Krcs9Qe0ZqZ9HRudmmH8Cfn2W4ZCl8KOEPUgFLADvGjxKLaQph1zw3i211YYMc3r69FjhNmyJ1PskGGheN3uAJs7gkTyNhK7jOJgKIMY
/BpBv0ggFU+5VkHriBcsdwQ+cJDoD654jVbJzHhau1b1xqSBHGwc+Cn1b5TDojRYfFwj9WCCj7RanRIcfzXqzS1cNBDFseIshZUzq
/k0lSItDQ69RgjMLvEks+YFx1p1kwmQKO5RBZWXr2EVf2KYSU99dEO
/Alcof7j4BAgMBAAGjggEiMIIBHjAdBgNVHQ4EFgQUeo9WwYOqFPJ1B9cjg0WsxS28hnYwgYUGA1UdIwR+MHyAFHoCuHWgHsN1cS7TRuJgk1YvdeY7
oU6kTDBKMQswCQYDVQQGEwJJRTEMMAoGA1UECwwDRVNUMREwDwYDVQQDDAhlc3QudGVjaDEaMBgGCSqGSIb3DQEJARYLY2FAbWFpbC5j
b22CFG9pjLDcWd36XS7dJnpjRMErPsglMAwGA1UdEwQFMAMBAf8wCwYDVR0PBAQDAgL8ME8GA1UdEQRIMEaCCWxvY2FsaG9zdIcEfwAAAYIIbWl
uaWt1YmWHBMCoMQKCEGtleWNsb2FrLmRlZmF1bHSCEWtleWNsb2FrLmVzdC50ZWNoMAkGA1UdEgQCMAAwDQYJKoZIhvcNAQELBQADggIBABZ
hxM9RHGrKRZsuRWVGDfhjboMA4NcuE9E2GMiri1gqwnW+C2HlbN1dkmhnED9LFHM64tk1gPOVmvrE2V7nPp58uVCg0xqsQ
/qQNWrDj8Gkv5JRKMCPmW3lCTlE/kOkhC9I4b+0+pD6kyqwCS7ThMff5g0tODbVHVvNhCqsPOMYCKBEdKvJ4jhZatpbO1fLXbhnbhAGnUpva3pl8taN
/x+z4oAr+j+PkU3VCQBk08w30QwvFHSqJ9UTT3i4B8amIiBt61ZkwX0Xr8z+w4avqtOzcH61UgGtz2LrRlDlz0D1QacGh2
/0kGcWUkBT4AU7Fb2RzCaMFB8eiM5bnXXomMTTMLHQSahKig2H6+c/jSJFVLfL9/5i8q1OoPHWBxU6h+OAFF2qWhCuScIvwv+J
/RyOd2JwYeIgU8LJ1cWth2/msCQK2S7UO6myzexlevldmXSjRdvHH
/cDHlNnjYWNVF5FsVyTj4tgRYpUVWAPTuRR22LoT5+gAW42DTsOa56IoI6NclDm0F4U29qekl2Ktf9zCYZf+PLi8dgf0hwb0TisDbXr2kwURw0m0YiEFsffm
L1mtvsptJOlRhBXEcPHn/jLwUGF0odooeC6YY9H3BNYu8sXn2ykAO4AabjBMcoUUh+FGhWXrMjpnG+PSNacPXW/MDijiM30X42YrqcU9zdk"],"x5t":"
IIj3g74+BJHIkUZxKWb4zwZeFuw"}]}

We can paste this into the "JWKS" test box.

Alternativley we can run a web server to produce this output and use the server url in the "JWKS URI" text box instead.

Note: There is also a nodejs utility available for this, running ssh-keygen -e -m pkcs8 -f /tmp/client.key | pem-jwk | jq '{ "keys":[{kid: "something", kty: .kty , use: "sig", n: .n , e: .e }]}'

will produce the same result as above.

You can also upload your private key and certificate to the realm you are using.

Go to Relam Settings Keys - > Providers Add Keystore RSA

Upload both you private key and it's correspoding certificate.

Go to Relam Settings General and click on "OpenID Endpoint configuration"

Search for jwks_url and you should see somthing like the following :

"jwks_uri":"http://127.0.0.1:33409/auth/realms/x509/protocol/openid-connect/certs"

Go to this URL, your jwks should be on the bottom.

For this to work with you JWT code you'll need to copy the "kid" value and update you code so this is included in the header: This is necessary when the JWKS has multiple keys.

JWT snippet

```
        claims["iss"] = "jwtclient3"
        claims["aud"] = "https://192.168.49.2:31561/auth/realms/x509"

        token := jwt.NewWithClaims(jwt.SigningMethodRS256, claims)
        token.Header["kid"] = "AKAwbsKtqu9OmIwIsPOUf5zTJkIC73hzY9Myv4srjTs"
        tokenString, err := token.SignedString(key)
        if err != nil {
                return "", fmt.Errorf("create: sign token: %w", err)
        }


        return tokenString, nil
}
```

Keycloak Authorization code grant

The OAuth Authorization Code Grant flow is recommended if your application support redirects.
e.g. your application is a Web application or a mobile application.

See this link to see how to setup your client - Keycloak: Authorization Code Grant Example

Here is a sample shell script to retrieve an authorization code:

Authorization Code

```
#!/bin/sh
HOST=$(minikube ip)
KEYCLOAK_PORT=$(kubectl -n default get service keycloak -o jsonpath='{.spec.ports[?(@.name=="http")].nodePort}')
REALM="jwtrealm"
CLIENT="jwtsecret"
AUTH_USERNAME="jwtuser"
AUTH_PASSWORD="secret"
STATE=$(uuidgen)

URL="http://$HOST:$KEYCLOAK_PORT/auth/realms/$REALM/protocol/openid-connect/auth?
client_id=$CLIENT&response_type=code&state=$STATE"
STDOUT=$(curl -s -X GET $URL --insecure -D headers.out)
COOKIES=$(cat headers.out | grep set-cookie | cut -f2 -d' ' | tr -d '\n')
LOGIN_URL=$(echo $STDOUT | sed s'/.* action=//g' | cut -f1 -d' ' | sed s'/\"//g' | sed s'/amp;//g')

CURL_OUTPUT=$(curl -s --cookie $COOKIES -X POST "${LOGIN_URL}" -d "username=${AUTH_USERNAME}
&password=${AUTH_PASSWORD}" --insecure -D headers.out)
CODE=$(cat headers.out | grep -i location | sed s'/.*code=//g')
echo CODE=$CODE
echo ACCESS_CODE=$CURL_OUTPUT
rm headers.out 2>/dev/null
```

To set this up so it retrieves the JWT access token once logged in we must configure the keycloak client with a "Valid Redirect URI", in this case it will be "http://192.168.49.2:31233/callback"

The following go sever is running at this URI:

Authorization server callback

```
package main

import (
        "encoding/json"
        "fmt"
        "io/ioutil"
        "net/http"
        "net/url"
)

type Jwttoken struct {
        Access_token       string
        Expires_in         int
        Refresh_expires_in int
        Refresh_token      string
        Token_type         string
        Not_before_policy  int
        Session_state      string
        Scope              string
}

var jwt Jwttoken

func getToken(auth_code string) string {
        clientSecret := "Ctz6aBahmjQvAt7Lwgg8qDNsniuPkNCC"
        clientId := "jwtsecret"
        realmName := "jwtrealm"
        keycloakHost := "keycloak"
        keycloakPort := "8080"
        keycloakUrl := "http://" + keycloakHost + ":" + keycloakPort + "/auth/realms/" + realmName + "/protocol
/openid-connect/token"
        resp, err := http.PostForm(keycloakUrl,
                    url.Values{"code": {auth_code}, "grant_type": {"authorization_code"},
                                "client_id": {clientId}, "client_secret": {clientSecret}})
        if err != nil {
                fmt.Println(err)
                panic("Something wrong with the credentials or url ")
        }
        defer resp.Body.Close()
        body, err := ioutil.ReadAll(resp.Body)
        fmt.Println(string(body))
        json.Unmarshal([]byte(body), &jwt)
        return jwt.Access_token
}

func noprefix(res http.ResponseWriter, req *http.Request) {
        // create response binary data
        data := []byte("Authorization code default") // slice of bytes
        // write `data` to response
        res.Write(data)
}

func callback(res http.ResponseWriter, req *http.Request) {
        query := req.URL.Query()
        code := query.Get("code")
        token := getToken(code)
                res.WriteHeader(http.StatusOK)
                res.Write([]byte(token))
}

func main() {
        // create a new handler
        callbackHandler := http.HandlerFunc(callback)
        http.Handle("/callback", callbackHandler)
        noPrefixHandler := http.HandlerFunc(noprefix)
        http.Handle("/", noPrefixHandler)
        http.ListenAndServe(":9000", nil)
}
```

Login will trigger a call to the /callback endpoint whcih in turn gets the JWT token and returns it to the user.

PKCE

PKCE stands for Proof Key for Code Exchange and the PKCE-enhanced Authorization Code Flow builds upon the standard Authorization Code Flow and it provides an additional level of security for OAuth clients.

For setting up the keycloak realm, client and user please see : PKCE Verification in Authorization Code Grant

In this example I will use a confidential client called oauth2-pkce in the OAuth2Realm.

I have also added an audience mapper to map the client to the the token.

You will need to copy the client secret into the cod for this to work.

Download the go code: oauth2.go

Update the code to match your keycloak setup.

Once the code has compiled create your docker image using: Dockerfile_oauth2

Start the service using: oauth2.yaml

This program uses PKCE code_challenge and code_challenge_method parameters when making the authorization code request and the PKCE code_verifier parameter when exchanging the authorization code for a token.

If running on windows you may need to start a tunnel so your services are accessible from your windows browser (see Accessing apps)

You may also need to update your hosts file to add an alias of keycloak for your local ip. (e.g. 127.0.0.1 keycloak)

This is important because the iss of the token needs to match the keycloak url you provide.

If everything has been setup correctly when you hit the endpoint http://localhost:9000/ you should be redirected to the keycloak login screen.

Enter a username and password for your realm.

The authorization code will be sent to your call back URL (redirect_uri) where it can be exchanged for a token.

The token will be printed on the screen.

It should look something like this:

Token


```
{
    "TokenResponse": {
        "access_token":
"eyJhbGciOiJSUzI1NiIsInR5cCIgOiAiSldUIiwia2lkIiA6ICJic0J4Z0lKd0dxS3B2YmROdjd0WHd2ZnUxSVFRNDZQb0M4SHFrdEYxTjVjIn0
.
eyJleHAiOjE2NTE3NTkzMDIsImlhdCI6MTY1MTc1OTAwMiwiYXV0aF90aW1lIjoxNjUxNzU5MDAyLCJqdGkiOiI1ODU2YWNlYi01NWY1LTQ5Mjgt
YWM2YS1kOWE1NGNkY2QxZTgiLCJpc3MiOiJodHRwOi8va2V5Y2xvYWs6ODA4MC9hdXRoL3JlYWxtcy9PQXV0aDJSZWFsbSIsImF1ZCI6ImFjY291
bnQiLCJzdWIiOiJjYzkwNDUxMy0wY2I3LTRiY2QtOTIyZS0xMTc2MDkzYzk0YTEiLCJ0eXAiOiJCZWFyZXIiLCJhenAiOiJvYXV0aDItcGtjZSIs
InNlc3Npb25fc3RhdGUiOiIxNzRlMTBhZi1kZTRiLTQzZTgtOTE3Zi1mYzQ4ZTE4ODg5Y2EiLCJhY3IiOiIxIiwicmVhbG1fYWNjZXNzIjp7InJv
bGVzIjpbImRlZmF1bHQtcm9sZXMtb2F1dGhyZWFsbSIsIm9mZmxpbmVfYWNjZXNzIiwidW1hX2F1dGhvcml6YXRpb24iXX0sInJlc291cmNlX2Fj
Y2VzcyI6eyJhY2NvdW50Ijp7InJvbGVzIjpbIm1hbmFnZS1hY2NvdW50IiwibWFuYWdlLWFjY291bnQtbGlua3MiLCJ2aWV3LXByb2ZpbGUiXX19
LCJzY29wZSI6Im9wZW5pZCBlbWFpbCBwcm9maWxlIiwic2lkIjoiMTc0ZTEwYWYtZGU0Yi00M2U4LTkxN2YtZmM0OGUxODg4OWNhIiwiZW1haWxf
dmVyaWZpZWQiOmZhbHNlLCJwcmVmZXJyZWRfdXNlcm5hbWUiOiJvYXV0aDJ1c2VyIn0.VRBWjMUqnVgtQJ5PaYjcOnNt-
9PvFkhbLnRw3qBF62N7eJPFexsnPVbB7Hy34TWYy9RKnJIwnIDcgmGAB0mw6XF9iVgQ_3uI0RDa-qbnpOmR9wImzKBFe1DV-
KeQQQJTlZ4vsoJJzpdxWJNRwPCUqU9DCMAYVaVKoSfuAapL8v4Rp4H5zT7fjA-
LXnvJ4rhypZBjQxu7vOb69_UD98f98av8b0ewg1nJxjkNB7gJRLrgA4CnBuCk5K-
zLUWzZU7zub5Am5kjjEf7pBLWw3zsqD9ApBcWe44ySLurB_TRSFHgfL4T9BONG2Y4O1924HxMNlkQ2TaepGXfAuRu4ckuSw",
        "token_type": "Bearer",
        "refresh_token":
"eyJhbGciOiJIUzI1NiIsInR5cCIgOiAiSldUIiwia2lkIiA6ICIyNGE3MzY3Zi1hNzJhLTRhMmYtYjI1OC1lNGZjMDJmNWMzZmIifQ.
eyJleHAiOjE2NTE3NjA4MDIsImlhdCI6MTY1MTc1OTAwMiwianRpIjoiZDZkOGIyYzMtZWJmMS00OGEyLTgyZDUtNWE5YTcwNTUwZDdlIiwiaXNz
IjoiaHR0cDovL2tleWNsb2FrOjgwODAvYXV0aC9yZWFsbXMvT0F1dGggyUmVhbG0iLCJhdWQiOiJodHRwOi8va2V5Y2xvYWs6ODA4MC9hdXRoL3Jl
YWxtcy9PQXV0aDJSZWFsbSIsInN1YiI6ImNjOTA0NTEzLTBjYjctNGJjZC05MjJlLTExNzYwOTNjOTRhMSIsInR5cCI6IlJlZnJlc2giLCJhenAi
OiJvYXV0aDItcGtjZSIsInNlc3Npb25fc3RhdGUiOiIxNzRlMTBhZi1kZTRiLTQzZTgtOTE3Zi1mYzQ4ZTE4ODg5Y2EiLCJzY29wZSI6Im9wZW5p
ZCBlbWFpbCBwcm9maWxlIiwic2lkIjoiMTc0ZTEwYWYtZGU0Yi00M2U4LTkxN2YtZmM0OGUxODg4OWNhIn0.
VFH5KZwtWHLbQyJIHMR0389azqcxKh7Reh6ze52UXsA",
        "expiry": "2022-05-05T14:01:42.0439809Z"
    },
    "IDToken": {
        "exp": 1651759302,
        "iat": 1651759002,
        "auth_time": 1651759002,
        "jti": "4318be76-d806-43a3-bb18-2e2c4b5cf601",
        "iss": "http://keycloak:8080/auth/realms/OAuth2Realm",
        "aud": "oauth2-pkce",
        "sub": "cc904513-0cb7-4bcd-922e-1176093c94a1",
        "typ": "ID",
        "azp": "oauth2-pkce",
        "session_state": "174e10af-de4b-43e8-917f-fc48e18889ca",
        "at_hash": "q0PPpL9nMeJupmHABtdOEw",
        "acr": "1",
        "sid": "174e10af-de4b-43e8-917f-fc48e18889ca",
        "email_verified": false,
        "preferred_username": "oauth2user"
    }
}
```


Copy the access token from the output and paste into an environment variable caled TOKEN

curl -H "Authorization: Bearer $TOKEN" localhost:9000
Hello World OAuth2!

See also: golang oauth2

Keycloak Rest API

Documentation for the keycloak Rest API is available here: Keycloak Admin REST API

Below is some sample code that calls the clients rest api to create a new client:

Keycloak Client Rest API

```
export ADMIN_TKN=$(curl -s -X POST --insecure https://$HOST:$KEYCLOAK_PORT/auth/realms/master/protocol/openid-
connect/token \
 -H "Content-Type: application/x-www-form-urlencoded" \
 -d "username=admin" \
 -d 'password=admin' \
 -d 'grant_type=password' \
 -d 'client_id=admin-cli' | jq -r '.access_token')
echo "ADMIN CLIENT TOKEN = $ADMIN_TKN"

curl -X POST --insecure https://$HOST:$KEYCLOAK_PORT/auth/admin/realms/x509provider/clients \
 -H "authorization: Bearer $ADMIN_TKN" \
 -H "Content-Type: application/json" \
 --data \
 '
  {
    "id": "x509Client",
    "name": "x509Client",
    "enabled": "true",
    "defaultClientScopes": ["email"],
    "redirectUris": ["*"],
    "attributes": {"use.refresh.tokens": "true", "client_credentials.use_refresh_token": "true"}
  }
 '
```

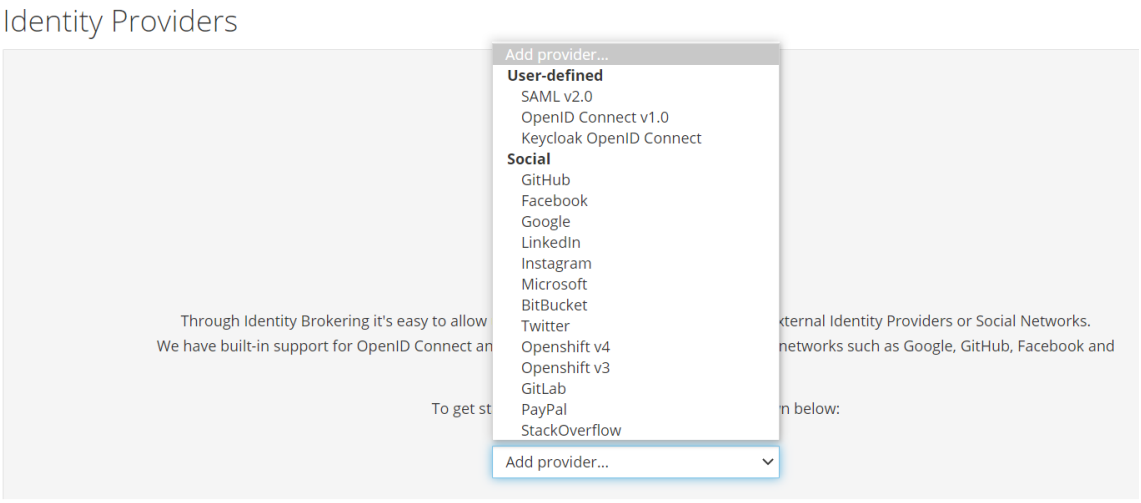
Keycloak SSO & User management

Identity Providers

You can use keycloak for single-sign so users don't have to login to each application individually.

You can also use external identiity providers such as google or github if required.

See the "Identity Providers" menu in the keycloak UI.



User Federation

You can also use existing LDAP, active directory servers or relational databases for user management if this is required.

Open Source Identity and Access Management

See the "User Federation" menu in the keycloak UI.

Keycloak Authorization services

Authorization Services Guide

Keycloak Quickstarts Code Repository

REST Service Protected Using Keycloak Authorization Services

Easily secure your Spring Boot applications with Keycloak

A Quick Guide to Using Keycloak with Spring Boot

Istio External Authorization

Redhat AUTHORIZATION SERVICES

Sample External Authorization Server with Istio

Working example

1. To use keycloak authoriztion services start by creating a confidential client.
2. Set "Authoriztion Enabled" to on.
3. Create 2 roles rapp_admin and rapp_user and assigned them to the service account.
4. Click on the authoriztion tab for the client to setup your authoriztion policies.
5. Start by creating 4 scopes (create,edit, delete and view) in the "Authoriztion scopes" section
6. Next create a resource "Rapp resource", set the URI to /api/resources/* and set the scopes to create,edit, delete and view.
7. Next create a policy "View Policy", select the "rapp_user" role and set required to on.
8. Create an "Admin policy", select the "rapp_admin" role and set required to on.
9. In the permission section, create a "Scope Based" permission - for resouce choose the "Rapp resource" created earlier, scope should be set to view and select the "View Policy" for policy.
10. Create another "Scope Based" permission - for resouce choose the "Rapp resource" created earlier, scope should be set to create, edit and delete and select the "Admin Policy" for policy.

Create a spring-boot application to work with this "resouce server"

The following 4 files are all that is required:

pom.xml

application.properties

MyApplication.java

ApplicationController.java

Use mvn clean package spring-boot:repackage to create the jar file

Use mvn spring-boot:run to run the application from the comand line.

Alternatively you can package the jar into a docker file and run the app as part of your cluster

Dockerfile

rapp-resource-server.yaml

To test use the following script:

test.sh

You should see the following output:

GET request using service account access token
GET resources 1

PUT request using service account access token
PUT resources 1

POST request using service account access token
POST resources id=1

GET request using service account requesting party token
GET resources 1

POST request using service account requesting party token
POST resources id=1

PUT request using service account requesting party token
PUT resources 1

OPA

The Open Policy Agent (OPA) is **an open source, general-purpose policy engine that unifies policy enforcement across the stack**. OPA provides a high-level declarative language that lets you specify policy as code and simple APIs to offload policy decision-making from your software.

OPA policies are expressed in a high-level declarative language called Rego. Rego is purpose-built for expressing policies over complex hierarchical data structures.

It even has a VSCode plugin that lets you highlight and evaluate rules and query policies right within the IDE.

Policy-based control for cloud native environments

Introducing Policy As Code: The Open Policy Agent (OPA)

Istio External Authorization with OPA

Rego playground

OPA and Istio Tutorial

Dynamic Policy Composition for OPA

GO

Go provides a library for opa.

GO OPA

```
package main

import (
        "context"
        "encoding/json"
        "fmt"
        "github.com/open-policy-agent/opa/rego"
        "io/ioutil"
        "net/http"
        "net/url"
        "os"
)

type Jwttoken struct {
        Access_token       string
        Expires_in         int
        Refresh_expires_in int
        Refresh_token      string
        Token_type         string
        Not_before_policy  int
        Session_state      string
        Scope              string
}

var token Jwttoken

var opaPolicy string = `
package authz

import future.keywords.in

default allow = false

jwks := jwks_request("http://keycloak:8080/auth/realms/opa/protocol/openid-connect/certs").body
```

```
filtered_jwks := [ key |
      some key in jwks.keys
      key.use == "sig"
    ]
token_cert := json.marshal({"keys": filtered_jwks})

token = { "isValid": isValid, "header": header, "payload": payload } {
        [isValid, header, payload] := io.jwt.decode_verify(input, { "cert": token_cert, "aud": "account",
"iss": "http://keycloak:808
0/auth/realms/opa"})
}

allow {
    is_token_valid
}

is_token_valid {
        token.isValid
        now := time.now_ns() / 1000000000
        token.payload.iat <= now
        now < token.payload.exp
        token.payload.clientRole = "[opa-client-role]"
}

jwks_request(url) = http.send({
      "url": url,
      "method": "GET",
      "force_cache": true,
      "force_json_decode": true,
      "force_cache_duration_seconds": 3600 # Cache response for an hour
})
`

func getToken() string {
        clientSecret := "63wkv0RUXkp01pbqtNTSwghhTxeMW55I"
        clientId := "opacli"
        realmName := "opa"
        keycloakHost := "keycloak"
        keycloakPort := "8080"
        keycloakUrl := "http://" + keycloakHost + ":" + keycloakPort + "/auth/realms/" + realmName + "/protocol
/openid-connect/token"        resp, err := http.PostForm(keycloakUrl,
                url.Values{"client_secret": {clientSecret}, "grant_type": {"client_credentials"}, "client_id":
{clientId}})
        if err != nil {
                fmt.Println(err)
                panic("Something wrong with the credentials or url ")
        }
        defer resp.Body.Close()
        body, err := ioutil.ReadAll(resp.Body)
        json.Unmarshal([]byte(body), &token)
        return token.Access_token
}

func traceOpa(input string) {
        ctx := context.TODO()

        test := rego.New(
                rego.Query("x = data.authz.allow"),
                rego.Trace(true),
                rego.Module("example.rego", opaPolicy),
                rego.Input(input),
        )

        test.Eval(ctx)
        rego.PrintTraceWithLocation(os.Stdout, test)
}

func evaluateOpa(input string) {
        ctx := context.TODO()

        query, err := rego.New(
```

```
                rego.Query("x = data.authz.allow"),
                rego.Module("example.rego", opaPolicy),
        ).PrepareForEval(ctx)
        if err != nil {
                // Handle error.
                fmt.Println(err.Error())
        }

        results, err := query.Eval(ctx, rego.EvalInput(input))
        // Inspect results.
        if err != nil {
                // Handle evaluation error.
                fmt.Println("Error: " + err.Error())
        } else if len(results) == 0 {
                // Handle undefined result.
                fmt.Println("Results are empty")
        } else {
                // Handle result/decision.
                fmt.Printf("Results = %+v\n", results) //=> [{Expressions:[true] Bindings:map[x:true]}]
        }
  }

func main() {
        tokenStr := getToken()
        traceOpa(tokenStr)
        evaluateOpa(tokenStr)

}
```

OPA bundles and dynamic composition

Method 1

We can combined OPA bundles with dynamic composition to provide different policies for differect services.

In the root directory of your bundle create main.rego

main.rego

```
package main

import input.attributes.request.http as http_request

default allow = false

name := trim_prefix(replace(http_request.path, "-", ""), "/")

router[policy] = data.policies[name][policy].deny

deny[msg] {
    policy := router[_]
    msg := policy[_]
}

allow {
count(deny) == 0
}
```

This main policy will use the request path to determine which policy to apply. (We remove the forward slash and and "-" characters)

Create a directory policies/<app name> off the main directory.

In here create a policy called policy.rego

policy.rego

```
package policies.rappopaprovider.policy

import input.attributes.request.http as http_request
import future.keywords.in

realm_name := "opa"
realm_url := sprintf("http://keycloak:8080/auth/realms/%v", [realm_name])
certs_url := sprintf("%v/protocol/openid-connect/certs", [realm_url])


jwks := jwks_request(certs_url).body
filtered_jwks := [ key |
      some key in jwks.keys
      key.use == "sig"
    ]
token_cert := json.marshal({"keys": filtered_jwks})

token = { "isValid": isValid, "header": header, "payload": payload } {
        [_, encoded] := split(http_request.headers.authorization, " ")
        [isValid, header, payload] := io.jwt.decode_verify(encoded, { "cert": token_cert, "aud": "account",
"iss": realm_url})
 }

deny[msg] {
    not is_token_valid
    msg = "denied by rappopaprovider.policy: not a valid token"
}

is_token_valid {
  token.isValid
  now := time.now_ns() / 1000000000
  token.payload.iat <= now
  now < token.payload.exp
  token.payload.clientRole = "[opa-client-role]"
}

jwks_request(url) = http.send({
      "url": url,
      "method": "GET",
      "force_cache": true,
      "force_json_decode": true,
      "force_cache_duration_seconds": 3600 # Cache response for an hour
})
```

This policy will verify the jwt token, check the token issue time and expiration time against the current time and also ensure the token contains the correct role.

If all these condtions are met the user will be granted access to the resource.

NGINX can be used for the bundles server: nginx.yaml

OPA server: opa.yaml

rapp-opa-provider: rapp-opa-provider.yaml

To test retrieve the access token from keycloak and run the curl command for the rapp-opa-provider url

opa_test.sh

```
#!/bin/bash
INGRESS_HOST=$(minikube ip)
INGRESS_PORT=$(kubectl -n istio-system get service istio-ingressgateway -o jsonpath='{.spec.ports[?(@.name=="
http2")].nodePort}')
TESTS=0
PASSED=0
FAILED=0
TEST_TS=$(date +%F-%T)
TOKEN=""
ACCESS_TOKEN=""
REFRESH_TOKEN=""

function get_token
{
    local prefix="${1}"
    url="http://${KEYCLOAK_HOST}:${KEYCLOAK_PORT}/auth/realms"
         TOKEN=$(curl -s -X POST $url/opa/protocol/openid-connect/token -H \
                 "Content-Type: application/x-www-form-urlencoded" -d
client_secret=63wkv0RUXkp01pbqtNTSwghhTxeMW55I \
                -d 'grant_type=client_credentials' -d client_id=opacli)
        ACCESS_TOKEN=$(echo $TOKEN | jq -r '.access_token')
}

function run_test
{
    local prefix="${1}" type=${2} msg="${3}" data=${4}
    TESTS=$((TESTS+1))
    echo "Test ${TESTS}: Testing $type /${prefix}"
    get_token $prefix
    url=$INGRESS_HOST:$INGRESS_PORT"/"$prefix
    result=$(curl -s -X ${type} -H "Content-type: application/json" -H "Authorization: Bearer $ACCESS_TOKEN"
$url)
    echo $result
    if [ "$result" != "$msg" ]; then
            echo "FAIL"
            FAILED=$((FAILED+1))
    else
            echo "PASS"
            PASSED=$((PASSED+1))
    fi
    echo ""
}


run_test "rapp-opa-provider" "GET" "Hello OPA World!" ""

echo
echo "--------------------------------------------------------------------------"
echo "Number of Tests: $TESTS, Tests Passed: $PASSED, Tests Failed: $FAILED"
echo "Date: $TEST_TS"
echo "--------------------------------------------------------------------------"
```

Method 2

We can also organize the policies in the following way.

Create a new file in your bundle to do the common processing:

Common Rules

```
package policy.common.request

import input.attributes.request.http as http_request
import future.keywords.in

policy_realms := {
    "rappopaprovider": "opa"
}

method = http_request.method
path = input.parsed_path
policy = trim_prefix(replace(http_request.path, "-", ""), "/")

realm_name := policy_realms[policy]
realm_url := sprintf("http://keycloak:8080/auth/realms/%v", [realm_name])
certs_url := sprintf("%v/protocol/openid-connect/certs", [realm_url])

jwks := jwks_request(certs_url).body
filtered_jwks := [ key |
      some key in jwks.keys
      key.use == "sig"
    ]
token_cert := json.marshal({"keys": filtered_jwks})

token = { "isValid": isValid, "header": header, "payload": payload } {
        [_, encoded] := split(http_request.headers.authorization, " ")
        [isValid, header, payload] := io.jwt.decode_verify(encoded, { "cert": token_cert, "aud": "account",
"iss": realm_url})
 }

jwks_request(url) = http.send({
      "url": url,
      "method": "GET",
      "force_cache": true,
      "force_json_decode": true,
      "force_cache_duration_seconds": 3600 # Cache response for an hour
})

user = token.payload.sub
clientRole = token.payload.clientRole
audience = token.payload.aud
exp = token.payload.exp
iat = token.payload.iat
```

Create another rules.rego file for you application e.g. policy/services/rappopaprovider/ingress/rules.rego

Application rules

```
package policy.services.rappopaprovider.ingress

import data.policy.common.request

allow = true {
request.token.isValid
request.method == "GET"
request.path = [ "rapp-opa-provider" ]
now := time.now_ns() / 1000000000
request.iat <= now
now < request.exp
request.clientRole = "[opa-client-role]"
}
```

Lastly create the parent rules file that will call the appropiates policy based on the http request path

Main Rules

```
package policy.ingress

import data.policy.common.request
import data.policy.services

allow = true {
 services[request.policy].ingress.allow
}
```

To use this set of rules make sure opa is pointing to the parent rules file : "–set=plugins.envoy_ext_authz_grpc.query=data.policy.ingress.allow"

Note If you do not wish to validate the jet you can use this code instead:

token = { "isValid": isValid, "payload": payload } {
authorization_header := input.attributes.request.http.headers.authorization
encoded_token := trim_prefix(authorization_header, "Bearer ")
payload := io.jwt.decode(encoded_token)[1]
isValid := true
}

OPA with prometheus and grafana

Add the following job to your prometheus.yaml file in the scrape_configs section:

- job_name: opa
scrape_interval: 10s
metrics_path: /metrics
static_configs:
- targets:
- opa.default:8181

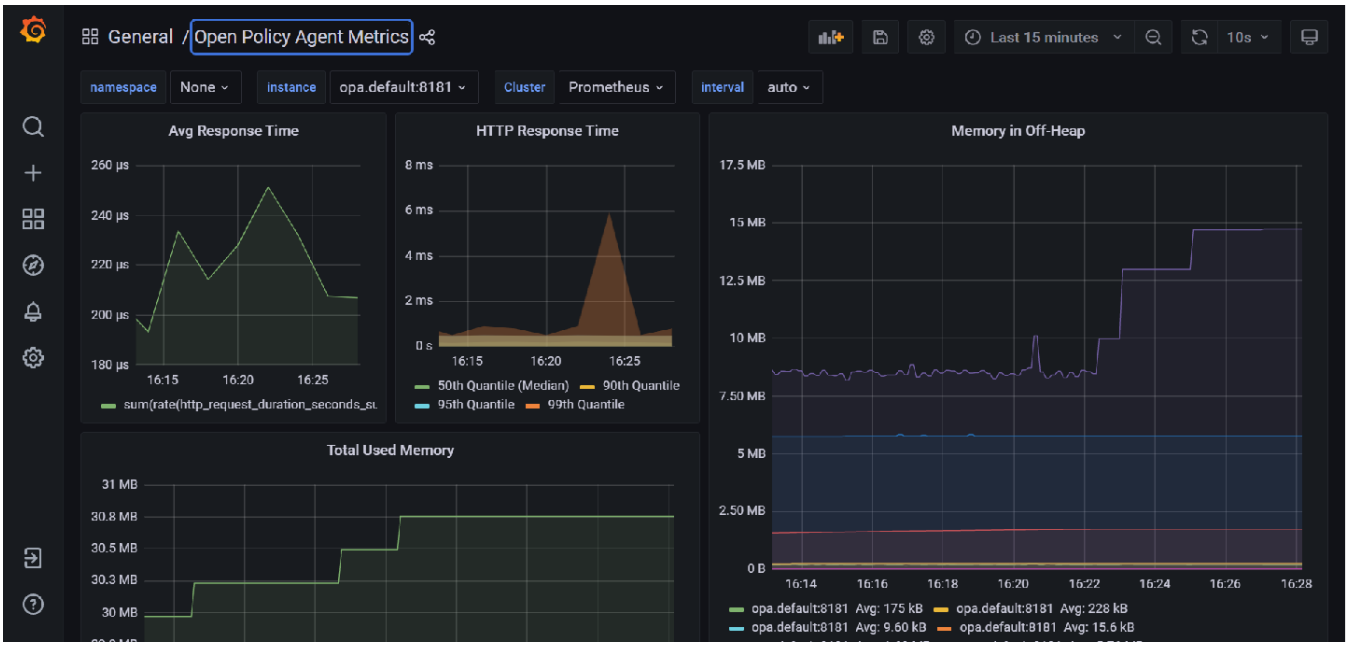
This will enable metric collection from the opa /metrics endpoint:

The full ist is available here: Open Policy Agent Monitoring

Download the OPA metrics dashboard from grafana and import it into your grafance instance Open Policy Agent Metrics Dashboard

In the instance dropdown, type opa.default:8181 (assuming opa is running in the default namespace and metrics are being served on port 8181)

You should see a dashboard similar to the following:



OPA Profiling and Bench Marking

Policy Performance

Below is a sample file we can use for profiling/benchmarking

rbactest.rego

```
package rbactest

import data.policy.common.request
import data.policy.services

input =  {
    "attributes": {
      "destination": {
        "address": {
          "socketAddress": {
            "address": "172.17.0.15",
            "portValue": 9000
          }
        },
        "principal": "spiffe://cluster.local/ns/istio-nonrtric/sa/default"
      },
      "metadataContext": {},
      "request": {
        "http": {
          "headers": {
            ":authority": "192.168.49.2:31000",
            ":method": "GET",
            ":path": "/rapp-opa-provider",
            ":scheme": "http",
            "accept": "*/*",
            "authorization": "Bearer
eyJhbGciOiJSUzI1NiIsInR5cCIgOiAiSldUIiwia2lkIiA6ICJDamJ4a2FONjRVcUdYNThWU2R3WjBxQTdWRmN1TGdEQWhnUWJTVG55UE9JIn0.
eyJleHAiOjE2NTY0MDYwMTYsImlhdCI6MTY1NjQwNTcxNiwianRpIjoiOWE0MzAxODMtZjYzZS00MzY1LTg4NTMtYjc0ZTY2MmFhYTUwIiwiaXNz
IjoiaHR0cDovL2tleWNsb2FrOjgwODAvYXV0aC9yZWFsbXMvb3BhIiwiYXVkIjoiYWNjb3VudCIsInN1YiI6IjU3NGMxODQzLTZiMWEtNGMwZC04
M2U0LTljMDkwYjM5ZjIyZiIsInR5cCI6IkJlYXJlciIsImF6cCI6Im9wYWNsaSIsImFjciI6IjEiLCJyZWFsbV9hY2Nlc3MiOnsicm9sZXMiOlsi
b2ZmbGluZV9hY2Nlc3MiLCJ1bWFfYXV0aG9yaXphdGlvbiIsImRlZmF1bHQtcm9sZXMtb3BhIl19LCJyZXNvdXJjZV9hY2Nlc3MiOnsib3BhY2xp
Ijp7InJvbGVzIjpbIm9wYS1jbGllbnQtcm9sZSJdfSwiYWNjb3VudCI6eyJyb2xlcyI6WyJtYW5hZ2UtYWNjb3VudCIsIm1hbmFnZS1hY2NvdW50
LWxpbmtzIiwidmlldy1wcm9maWxlIl19fSwic2NvcGUiOiJwcm9maWxlIGVtYWlsIiwiY2xpZW50SWQiOiJvcGFjbGkiLCJjbGllbnRIb3N0Ijoi
```

```
MTI3LjAuMC42IiwiZW1haWxfdmVyaWZpZWQiOmZhbHNlLCJjbGllbnRSb2xlIjoiW29wYS1jbGllbnQtcm9sZV0iLCJwcmVmZXJyZWRfdXNlcm5hbWUiOiJzZXJ2aWNlLWFjY291bnQtb3BhY2xpZW50QWRkcmVzcyI6IjEyNy4wLjAuNiJ9.k_NtngXgWyTPB2z8IArnxqvx3iYP18xc-1fWQoZ0Az2BOK3kfWrdSmIngn_ilwLXrTSdX-n_Tx_o2NLlwQ13RMRXN5zoJaCnU2iSXvel7hjYA_PSDZbv3MW1boqOZmqzuTA5ugRXuVAGQ42k0PIPNWqSm6JujUGfVzB_mrc43I3jXNuHuqwx6miat4NmJo2MCxM_Y1s39ixxREfQIovqFz1ky69IKfz8QcxyFhSsCmydjk4T6HufC3_SJO0XaBKWAoJpdcgdom1kYcIeoGxWWn3lX5E0kQ3eL4TH0F6IfCtjLZwFlzlhtDJItD6ddglJpEsc6rcuLw-06_VyjeqzSg",
            "content-type": "application/json",
            "user-agent": "curl/7.68.0",
          },
          "host": "192.168.49.2:31000",
          "id": "15472195549358141958",
          "method": "GET",
          "path": "/rapp-opa-provider",
          "protocol": "HTTP/1.1",
          "scheme": "http"
        },
        "time": "2022-06-28T07:07:47.099076Z"
      },
      "source": {
        "address": {
          "socketAddress": {
            "address": "172.17.0.4",
            "portValue": 54862
          }
        },
        "principal": "spiffe://cluster.local/ns/istio-system/sa/istio-ingressgateway-service-account"
      }
    },
    "parsed_body": null,
    "parsed_path": [
      "rapp-opa-provider"
    ],
    "parsed_query": {},
    "truncated_body": false,
    "version": {
      "encoding": "protojson",
      "ext_authz": "v3"
    }
  }


default allow = false


allow = true {
 services[request.policy].ingress.allow
}
```


opa eval --data rbactest.rego --profile --count=100 --format=pretty 'data.rbactest.allow'
false

METRIC	MIN	MAX	MEAN	90%	99%
timer_rego_external_resolve_ns	300	2400	461	600	2382.9999999999914
timer_rego_load_files_ns	3069300	6160300	4.024052e+06	4.82397e+06	6.152662999999996e+06
timer_rego_module_compile_ns	690400	2288700	983743	1.42366e+06	2.2863819999999986e+06
timer_rego_module_parse_ns	439300	1834400	613517	882270.0000000001	1.832610999999999e+06
timer_rego_query_compile_ns	49500	190100	68390	93410	189761.99999999983
timer_rego_query_eval_ns	25600	423300	40197	42630.00000000001	421415.99999999907
timer_rego_query_parse_ns	44700	674500	70035	81690	671625.9999999986

MIN	MAX	MEAN	90%	99%	NUM EVAL	NUM REDO	LOCATION
14.1µs	404µs	25.251µs	28.82µs	402.438µs	1	1	data.rbactest.allow
9.8µs	27.8µs	12.843µs	16.48µs	27.756µs	1	1	rbactest.rego:62

opa bench --data rbactest.rego 'data.rbactest.allow'

samples	22605
ns/op	47760
B/op	6269
allocs/op	112
histogram_timer_rego_external_resolve_ns_75%	400
histogram_timer_rego_external_resolve_ns_90%	500
histogram_timer_rego_external_resolve_ns_95%	500
histogram_timer_rego_external_resolve_ns_99%	871
histogram_timer_rego_external_resolve_ns_99.9%	29394
histogram_timer_rego_external_resolve_ns_99.99%	29800
histogram_timer_rego_external_resolve_ns_count	22605
histogram_timer_rego_external_resolve_ns_max	29800
histogram_timer_rego_external_resolve_ns_mean	434
histogram_timer_rego_external_resolve_ns_median	400
histogram_timer_rego_external_resolve_ns_min	200
histogram_timer_rego_external_resolve_ns_stddev	1045
histogram_timer_rego_query_eval_ns_75%	31100
histogram_timer_rego_query_eval_ns_90%	37210
histogram_timer_rego_query_eval_ns_95%	47160
histogram_timer_rego_query_eval_ns_99%	91606
histogram_timer_rego_query_eval_ns_99.9%	630561
histogram_timer_rego_query_eval_ns_99.99%	631300
histogram_timer_rego_query_eval_ns_count	22605
histogram_timer_rego_query_eval_ns_max	631300
histogram_timer_rego_query_eval_ns_mean	29182
histogram_timer_rego_query_eval_ns_median	25300
histogram_timer_rego_query_eval_ns_min	15200
histogram_timer_rego_query_eval_ns_stddev	32411

OPA Sidecar injection

First create a namespace for your apps and enable istio and opa

kubectl create ns opa
kubectl label namespace opa opa-istio-injection="enabled"
kubectl label namespace opa istio-injection="enabled"

Create the opa injection obects using:

kubectl create -f opa_inject.yaml

Ensure your istio mesh config has been setup to include grcp local authorizer

kubectl edit configmap istio -n istio-system

extensionProviders

```
    extensionProviders:
    - envoyExtAuthzGrpc:
        port: "9191"
        service: local-opa-grpc.local
      name: opa-local
```

Update your rapp-provider authorization policy to use this provider:

AuthorizationPolicy

```
apiVersion: security.istio.io/v1beta1
kind: AuthorizationPolicy
metadata:
  name: rapp-opa-provider-opa
  namespace: opa
spec:
  selector:
    matchLabels:
      app: rapp-opa-provider
  action: CUSTOM
  provider:
    name: "opa-local"
  rules:
  - to:
    - operation:
        paths: ["/rapp-opa-provider"]
        notPaths: ["/health"]
```

Run the opa_test.sh script above and you should see a message confirming your connection to the service.

Note: References to keycloak need to be updated to include the keycloak schema i.e keycloak.default

Basic Authentication

We can add basic authentication to our NGINX bubdle server by following these steps:

Create a password file using the following command: sudo htpasswd -c .htpasswd <user>, you will be prompted to input the password.

This will produce a file called .htpasswd containing the username and encrypted password

e.g. admin:$apr1$tPQCjrVW$sokcSj4QVkncEDna0Fc2o/

Add the following configmap definitions to your nginx.yaml

configMaps

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: nginx-pwd-config
  namespace: default
data:
  .htpasswd: |
    admin:$apr1$tPQCjrVW$sokcSj4QVkncEDna0Fc2o/
---
apiVersion: v1
kind: ConfigMap
metadata:
  name: nginx-conf-config
  namespace: default
data:
  default.conf: |
   server {
           server_name localhost;

           location ~ ^/bundles/(.*)$ {
           root /usr/share/nginx/html/bundles;
           try_files /$1 =404;
           auth_basic "Restricted";
           auth_basic_user_file /etc/nginx/conf.d/conf/.htpasswd;
           }
   }
---
```

Then update your volumes and volume mounts to include these files with your deployment

Volumes

```
        volumeMounts:
        - name: bundlesdir
          mountPath: /usr/share/nginx/html/bundles
          readOnly: true
        - name: nginx-conf
          mountPath: /etc/nginx/conf.d/default.conf
          subPath: default.conf
        - name: nginx-pwd
          mountPath: /etc/nginx/conf.d/conf/.htpasswd
          subPath: .htpasswd
      volumes:
      - name: bundlesdir
        hostPath:
          # Ensure the file directory is created.
           path: /var/opa/bundles
           type: DirectoryOrCreate
      - name: nginx-conf
        configMap:
          name: nginx-conf-config
          defaultMode: 0644
      - name: nginx-pwd
        configMap:
          name: nginx-pwd-config
          defaultMode: 0644
```

This will add basic authentication to your bundles directory.

Run echo -n <username>:<password> | base64 to encrpt your usename and password

e.g. echo -n admin:admin | base64
YWRtaW46YWRtaW4=

Update the opa-istio-config ConfigMap in the opa_inject.yaml file to include the encrypted string as a token in the cedentials section:

opa-istio-config

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: opa-istio-config
  namespace: opa
data:
  config.yaml: |
    plugins:
      envoy_ext_authz_grpc:
        addr: :9191
        path: policy/ingress/allow
    decision_logs:
      console: true
    services:
      - name: bundle-server
        url: http://bundle-server.default
        credentials:
          bearer:
            token: YWRtaW46YWRtaW4=
            scheme: Basic

    bundles:
      authz:
        service: bundle-server
        resource: bundles/opa-bundle.tar.gz
        persist: true
        polling:
          min_delay_seconds: 10
          max_delay_seconds: 20
---
```

Your bundle is now protected with basic authentication.