Lab 12. Securing Kafka

In all the earlier labs, you learned how to use Kafka. In this lab, our focus is more towards securing Kafka. Securing Kafka is one of the important aspect in enterprise adoption of Kafka. Organizations have lot of sensitive information that needs to be stored in secure environment to ensure security compliance. In this lab, we focus on ways of securing sensitive information in Kafka. We will focus on the different security aspects of Apache Kafka and will cover the following topics:

- Kerberos SASL for authentication
- Understanding ACL and authorization
- Understanding Zookeeper authentication
- Apache Ranger for authorization
- Best practices for Kafka security

Steps to enable SSL in Kafka

Let's now look into the steps to enable SSL in Kafka. Before you begin, you should generate the key, SSL certificate, keystore, and truststore that will be used by Kafka clients and brokers. You can follow the link https://kafka.apache.org/documentation/#security_ssl_key to create broker keys and certificate, the link https://kafka.apache.org/documentation/#security_ssl_ca to create your own certificate authority, and the link https://kafka.apache.org/documentation/#security_ssl_signing to sign the certificates. You should perform the same activity for clients (producer and consumer applications) as well. Once you are done creating certificates, you can enable Kafka SSL using the following steps.

Configuring SSL for Kafka Broker

The following changes are required in each broker server:

1. To enable `SSL` for communications between brokers, make the following changes in the broker properties:

```
security.inter.broker.protocol = SSL
```

2. To configure communication protocols and set `SSL` ports, make the following changes in server properties:

```
listeners=SSL://host.name1:port,SSL://host.name2:port
```

Note

If you have not set SSL for inter-broker communication, you will need to set listeners properties such as this: `listeners=PLAINTEXT://host.name:port,SSL://host.name:port`

3. To give `SSL` keystore and truststores path for each broker, you should make the following changes in the server properties of each broker:

```
ssl.keystore.location = /path/to/kafka.broker.server.keystore.jks
ssl.keystore.password = keystore_password
ssl.key.password = key_password
ssl.truststore.location = /path/to/kafka.broker.server.truststore.jks
ssl.truststore.password = truststore_password
```

Note

Some other additional properties like security.inter.broker.protocol can also be used. Use the link https://kafka.apache.org/documentation/#security_configbroker for additional properties.

Configuring SSL for Kafka clients

The configuration properties for Kafka producer and consumer are the same. The following are the configuration properties you need to set for enabling SSL. If client authentication is not required (`ssl.client.auth = none`), you need to set the following properties:

```
security.protocol = SSL
ssl.truststore.location = /path/to/kafka.client.truststore.jks
ssl.truststore.password = trustore_password
```

Note

Technically, you can use truststore without a password, but we strongly recommend using a truststore password, as it helps in integrity checks.

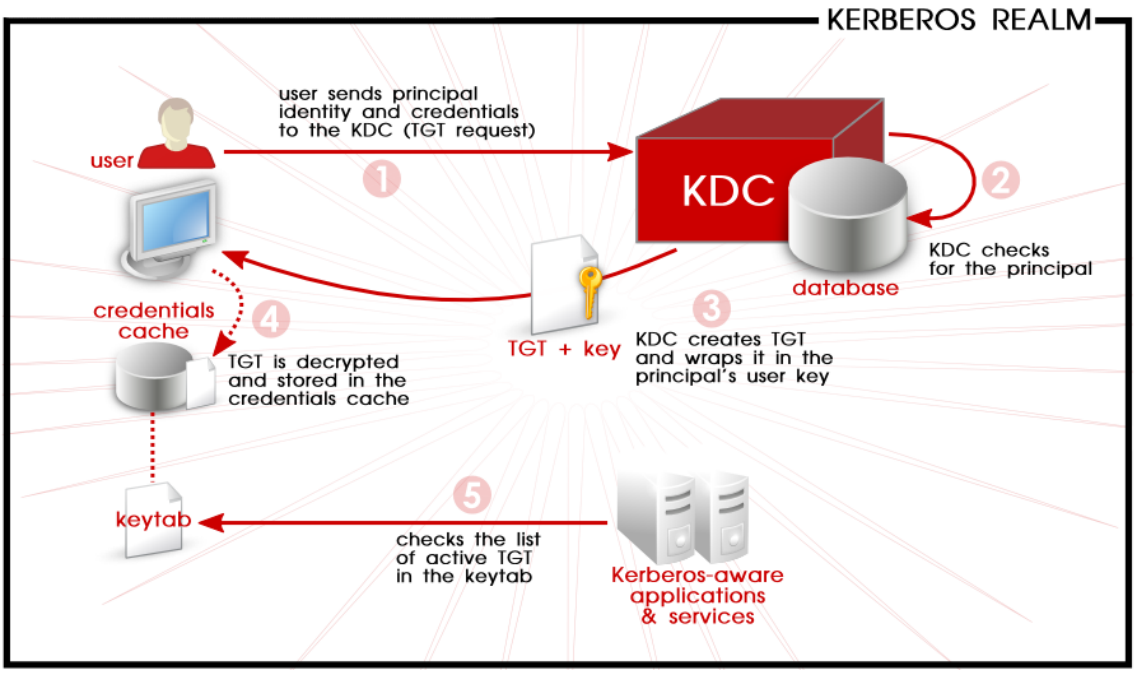
If client authentication is required (`ssl.client.auth = required`), you need to set the following properties:

```
security.protocol = SSL
ssl.truststore.location = /path/to/kafka.client.truststore.jks
ssl.truststore.password = trustore_password
ssl.keystore.location = /path/to/kafka.client.keystore.jks
ssl.keystore.password = keystore_password
ssl.key.password = key_password
```

Kerberos SASL for authentication

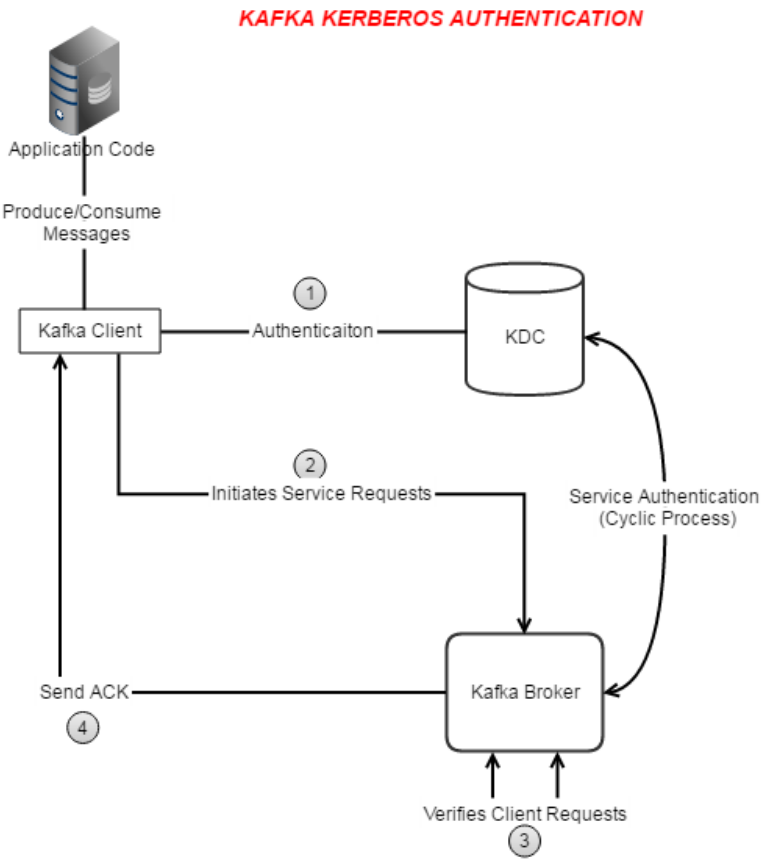
Kerberos is an authentication mechanism of clients or servers over secured network. It provides authentication without transferring the password over the network. It works by using time-sensitive tickets that are generated using symmetric key cryptography.

The following diagram represents how Kerberos authentication works:



Kerberos User Authentication(Ref: access.redhat.com)

To further explore this, let's now look into how Kafka SASL authentication works. The following diagram represents the steps involved in Kafka Kerberos authentication:



Kafka Kerberos User Authentication Steps

Steps to enable SASL/GSSAPI - in Kafka

In the following paragraphs, we will walk you through configurations that are required for enabling Kerberos authentication in Kafka. We will divide our conversation into two parts--one is about broker [**SASL**] ([**Simple Authentication and Secure Layer**]) configurations, and the other is about client SASL configurations.

Configuring SASL for Kafka broker

Here is how to configure SASL for Kafka broker:

1. Create JAAS configuration files for each broker server, using the following for the content of JAAS files:

```
KafkaServer {
 com.sun.security.auth.module.Krb5LoginModule required
 useKeyTab=true
 keyTab="/path/to/kafka.service.keytab"
 storeKey=true
 useTicketCache=false
 serviceName="kafka"
 principal="kafka/brokerhost.fqdn@REALM";
 };
```

```
Client { // used for zookeeper connection
 com.sun.security.auth.module.Krb5LoginModule required
 useKeyTab=true
 keyTab="/path/to/kafka.service.keytab"
 storeKey=true
 useTicketCache=false
 serviceName="zookeeper"
 principal="kafka/brokerhost.fqdn@EXAMPLE.COM";
 };
```

2. Once you have saved JAAS configuration to a specific location, you can pass the JAAS file location to each broker's JAVA OPTS as shown in the following code:

```
-Djava.security.auth.login.config=/path/to/kafka_broker_jaas.conf
```

3. Make the following changes into the broker `server.properties` files. If you have SSL enabled in Kafka, make the following property file changes:

```
listeners=SASL_SSL://broker.host.name:port
advertised.listeners=SASL_SSL://broker.host.name:port
security.inter.broker.protocol=SASL_SSL
sasl.mechanism.inter.broker.protocol=GSSAPI
sasl.enabled.mechanisms=GSSAPI
sasl.kerberos.service.name=kafka
```

4. If you do not have SSL enabled in Kafka, make following property file changes:

```
listeners=SASL_PLAINTEXT://broker.host.name:port
advertised.listeners=SASL_PLAINTEXT://broker.host.name:port
security.inter.broker.protocol=SASL_PLAINTEXT
sasl.mechanism.inter.broker.protocol=GSSAPI
sasl.enabled.mechanisms=GSSAPI
sasl.kerberos.service.name=kafka
```

Configuring SASL for Kafka client - producer and consumer

To configure the SASL for Kafka client, follow the following instructions:

1. The first step you should perform is to create JAAS configuration files for each producer and consumer application. Use the following for the content of the JAAS files:

```
sasl.jaas.config=com.sun.security.auth.module.Krb5LoginModule required
useKeyTab=true
storeKey=true
keyTab="/path/to/kafka_client.keytab"
principal="kafka-client@REALM";
```

2. The aforementioned JAAS configuration is for Java processes or for applications acting as producer or consumer. If you want to use SASL authentication for command line tools, use the following configurations:

```
KafkaClient {
    com.sun.security.auth.module.Krb5LoginModule required
```

```
    useTicketCache=true;};
```

3. Once you have saved JAAS configuration to specific location, you can pass the JAAS file location to each client's JAVA OPTS as shown here:

```
-Djava.security.auth.login.config=/path/to/kafka_client_jaas.conf
```

4. Make the following changes to the `producer.properties` or `consumer.properties` files. If you have SSL enabled in Kafka, make the following property file changes:

```
security.protocol=SASL_SSL
sasl.mechanism=GSSAPI
sasl.kerberos.service.name=kafka
```

5. If you do not have SSL enabled in Kafka, make the following property file changes:

```
security.protocol=SASL_PLAINTEXT
sasl.mechanism=GSSAPI
sasl.kerberos.service.name=kafka
```

Note

Kafka has support for other types of SASL mechanisms such as the following:

- Plain (https://kafka.apache.org/documentation/#security_sasl_plain)
- SCRAM-SHA-256 (https://kafka.apache.org/documentation/#security_sasl_scram)
- SCRAM-SHA-512 (https://kafka.apache.org/documentation/#security_sasl_scram)

You can use them as well. However, GSSAPI (Kerberos) is the most frequently adopted as it easily integrates with Kerberos-enabled Hadoop services.

Understanding ACL and authorization

Apache Kafka comes with a pluggable authorizer known as Kafka [**Authorization Command Line**] ([**ACL**]) Interface, which is used for defining users and allowing or denying them to access its various APIs. The default behavior is that only a superuser is allowed to access all the resources of the Kafka cluster, and no other user can access those resources if no proper ACL is defined for those users. The general format in which Kafka ACL is defined is as follows:

[*Principal P is Allowed OR Denied Operation O From Host H On Resource R.*]

The terms used in this definition are as follows:

- Principal is the user who can access Kafka
- Operation is read, write, describe, delete, and so on
- Host is an IP of the Kafka client that is trying to connect to the broker
- Resource refers to Kafka resources such as topic, group, cluster

Let's discuss a few common ACL types:

- [**Broker or server ACL**]: The operation between brokers, such as updating broker and partition metadata, changing the leader of partition, and so on, needs to be authorized. Brokers also need to have access to topic because a broker has to perform replication and some internal operation on topic and it requires read and describe operation access on topic.
- [**Topic**]: The principle using Kafka client to connect to brokers for topic creation will require `Read` and `Describe` permissions to be able to create topic. Sometimes clients are not allowed to create topics on

cluster due to security policies, and in such cases, they need to connect to the Admin to create the topic.

- [**Producer**]: The producer is responsible for producing data for topic and storing it in the topic partition. It requires `Read` and `Write` access on topic resources to do so.
- [**Consumer**]: The consumer reads data from topic, and hence, `Read` operation access is required on the topic's resources.

Common ACL operations

Let's now look into the basic operations of the ACL:

1. Kafka provides a simple authorizer; to enable this authorizer, add the following line to server properties of Kafka:

```
authorizer.class.name=kafka.security.auth.SimpleAclAuthorizer
```

2. As discussed in previous paragraphs, by default, only a superuser will have access to resources if no ACL is found. However, this behavior can be changed if we want to allow everyone to access resources if no ACL is set. Add the following line to server properties:

```
allow.everyone.if.no.acl.found=true
```

3. You can also add more superusers to your Kafka cluster by adding users to the following property in the server property file:

```
super.users=User:Bob;User:Alice
```

4. [**Adding an ACL**]: An ACL can be added using the command line interface. For example, if you want to add an ACL where `principals User: Chanchal` and `User: Manish` are allowed to perform `Read` and `Write` operations on `topic Fenago` from `10.200.99.104` and `10.200.99.105`, it can be done using the following command:

```
kafka-acls.sh --authorizer kafka.security.auth.SimpleAclAuthorizer --authorizer-
properties zookeeper.connect=localhost:2181 --add --allow-principal User:Chanchal --
allow-principal User:Manish --allow-hosts 10.200.99.104,10.200.99.105 --operations
Read,Write --topic Fenago
```

`--deny-principal` and `--deny-host` options can be used if you want to restrict the user or host from accessing topic.

5. [**Removing ACL**]: The ACL added in the preceding part can be removed using the following command:

```
kafka-acls.sh --authorizer kafka.security.auth.SimpleAclAuthorizer --authorizer-
properties zookeeper.connect=localhost:2181 --remove --allow-principal User:Chanchal -
-allow-principal User:Manish --allow-hosts 10.200.99.104,10.200.99.105--operations
Read,Write --topic Fenago
```

List ACLs

You can also list all the ACLs applied on following resources:

1. For example, if you want to see all ACLs applied in the topic Fenago, you can do it using the following command:

```
kafka-acls.sh --authorizer kafka.security.auth.SimpleAclAuthorizer --authorizer-
properties zookeeper.connect=localhost:2181 --list --topic Fenago
```

2. [**Producer and consumer ACL**]: Adding a user as the producer or consumer is a very common ACL used in Kafka. If you want to add user `Chanchal` as a producer for `topic Fenago`, it can be done using the following simple command:

```
kafka-acls --authorizer-properties zookeeper.connect=localhost:2181\
   --add --allow-principal User:Chanchal \
   --producer --topic Fenago
```

3. To add a consumer ACL where `Manish` will act as the consumer for `topic Fenago` with consumer `group G1`, the following command will be used:

```
kafka-acls --authorizer-properties zookeeper.connect=localhost:2181\
   --add --allow-principal User:Manish \
   --consumer --topic Fenago --group G1
```

4. There are lots of resources for which you can create an ACL list for allowing or not allowing access on particular resources for particular users. Covering all ACLs is out of the scope of this course.

Understanding Zookeeper authentication

Zookeeper is the metadata service for Kafka. SASL-enabled Zookeeper services first authenticate access to metadata stored in Zookeeper. Kafka brokers need to authenticate themselves using Kerberos to use Zookeeper services. If valid, the Kerberos ticket is presented to Zookeeper, it then provides access to the metadata stored in it. After valid authentication, Zookeeper establishes connecting user or service identity. This identity is then used to authorize access to metadata Znodes guarded by ACLs.

One important thing for you to understand is that Zookeeper ACLs restrict modifications to Znodes. Znodes can be read by any client. The philosophy behind this behavior is that sensitive data is not stored in Zookeeper. However, modifications by an unauthorized user can disrupt your cluster's behavior. Hence, Znodes are world readable, but not world modifiable. Although authentication must be established irrespective of what kind of access you have on Znodes, without a valid Kerberos ticket, you cannot access Zookeeper services at all.

In a highly-secured cluster, to mitigate this risk, you can always use network IP filtering via firewalls to restrict Zookeeper service access for selective servers. Zookeeper authentications use **Java Authentication and Authorization Service ** to establish the login context for connecting clients. JAAS establishes the login context using a standard configuration file and it directs the code to use the login context to drive authentication. JAAS login context can be defined in two ways:

1. One is using Kerberos key tabs. An example of such login context can be seen as follows:

```
Client {
  com.sun.security.auth.module.Krb5LoginModule required
  useKeyTab=true
  keyTab="/path/to/client/keytab(Kafka keytab)"
  storeKey=true
  useTicketCache=false
  principal="yourzookeeperclient(Kafka)";
};
```

2. The second one is by user login credential cache. An example of such login context can be seen as follows:

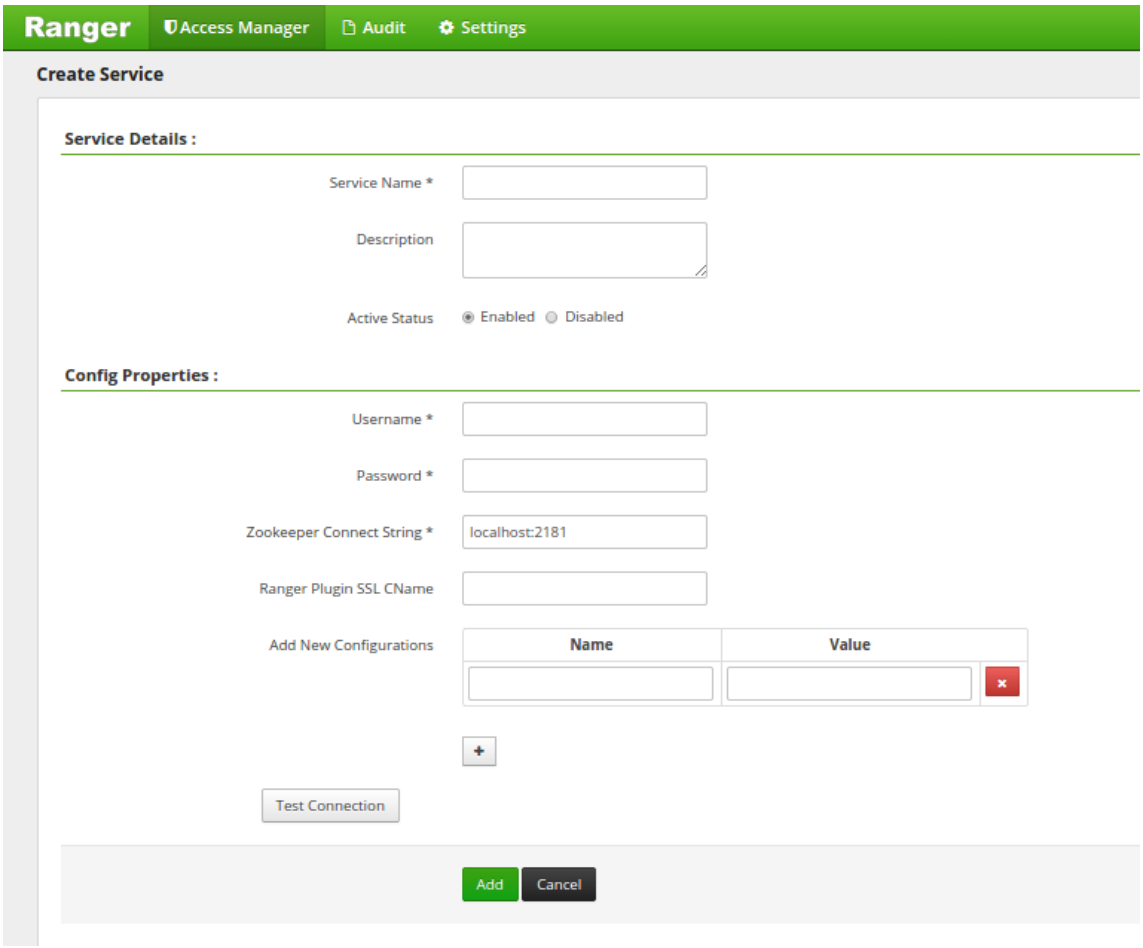
```
Client {
  com.sun.security.auth.module.Krb5LoginModule required
  useKeyTab=false
  useTicketCache=true
  principal="client@REALM.COM";
  doNotPrompt=true
};
```

Apache Ranger for authorization

Ranger is a used to monitor and manage security across the Hadoop ecosystem. It provides a centralized platform from which to create and manage security policies across the cluster. We will look at how we can use Ranger to create policies for the Kafka cluster.

Adding Kafka Service to Ranger

The following screenshot shows the user interface in Ranger which is used to add services. We will add Kafka service here to configure policies for it later:



Let's look into the `Service Details` :

- `Service name` : The service name needs to be set up in agent config. For example, in this case, it can be Kafka

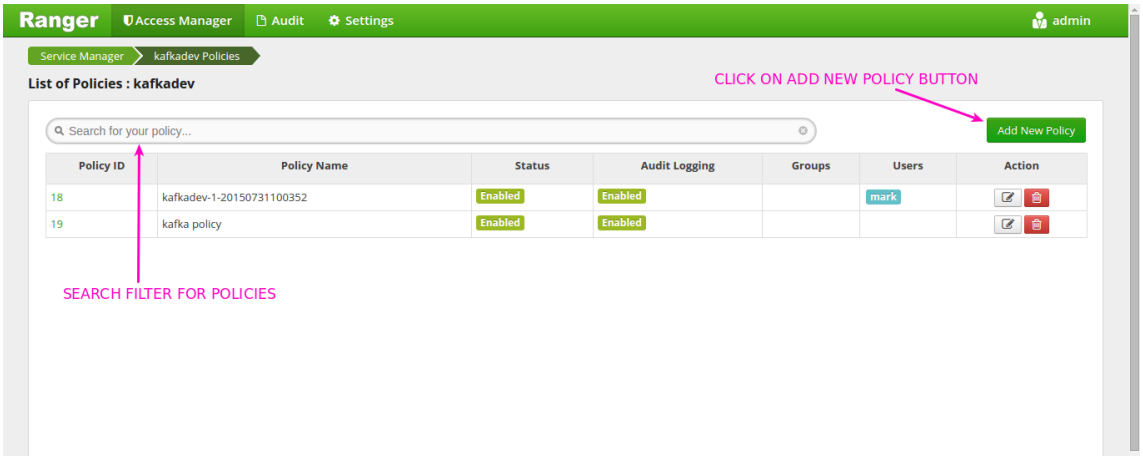
- `Description` : This represents what this service will do
- `Active Status` : This refers to enabling or disabling this service

`Config properties :`

- `Username` : This will be used to connect to this service. In case of Kafka, this is a principal who has access to defined resources to configure security.
- `Password` : This refers to the password of the user for authentication.
- `Zookeeper Connect String` : This refers to the IP address and port of Zookeeper running on cluster. The default value is `localhost:2181` .
- `Ranger Plugin SSL CName` : You need to install Ranger Kafka plugin for integrating Kafka with Ranger and provide a common name for the certificate, which is then registered.

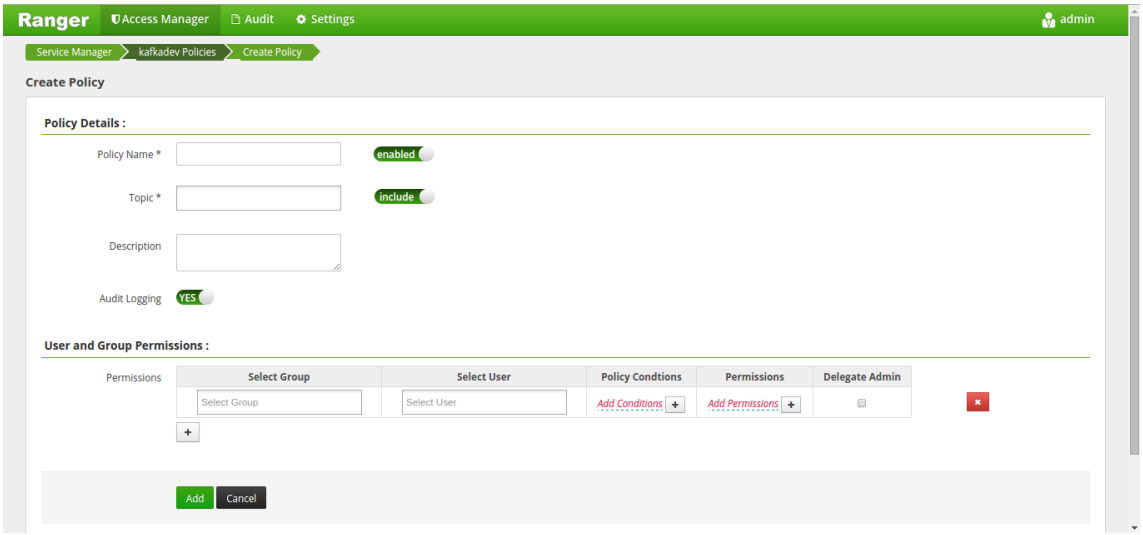
Adding policies

Once the service is configured and enabled, you can start adding policies by going into the Kafka policy listing page, which looks like the following screenshot. On the left side, you can see the `Add New Policy` tab:



Kafka policy listing page

Once you click on the `Add New Policy` tab, you will be redirected to the following page, where you need to specify permission and policy detail:



Kafka add policy page

Let's discuss the parameters available in the preceding screenshot and see their meaning:

`Policy Detail:`

- `Policy Name:` This defines what this policy is meant for. The policy name should match the objective of the policy.
- `Enable Policy:` You can enable or disable this policy.
- `Topic:` This refers to the Kafka Topic name for which the policy is being created.
- `Description:` This refers to a detailed description of why you are creating this policy.
- `Audit Logging:` This needs to be enabled or disabled for auditing this policy.

`User and Group Permission :`

- `Select Group:` This refers to the user group name from the list of user groups configured in the cluster. You can assign permissions to the group as well.
- `Select User:` This refers to the username (Principal) from the group for which permission has to be given.
- `Permission:` This defines the type of permission you want to grant to this user:
  - [**Publish**]: If a given user can produce data to Kafka topic
  - [**Consume**]: If a given user can consume data from topic partitions
  - [**Configure**]: If a given user can configure brokers/clusters
  - [**Describe**]: Permission to fetch metadata on the topic
  - [**Kafka Admin**]: If checked, the user will have the permissions of an admin

Ranger is easy to configure and provides a nice user interface. You can install Ranger and try using this policy creation. All the diagram reference for Ranger is taken from https://cwiki.apache.org/confluence/display/RANGER.

Summary

In this lab, we covered different Kafka security paradigms. Our goal with this lab is to ensure that you understand different paradigms of securing Kafka. We wanted you to first understand what are different areas you should evaluate while securing Kafka. After that, we wanted to address how parts of securing Kafka. One thing to note here is that Authentication and Authorization is something you have to always implement in a secure Kafka cluster.

Without these two, your Kafka cluster is not secure. SSL can be optional but is strongly recommended for highly sensitive data. Please keep not of best practices of securing Kafka as these are more gathered from practical industry implementation experiences of securing Kafka.