Lab 9. Building Streaming Applications Using Kafka Streams

In this lab, we will cover Kafka Streams in detail.

Understanding tables and Streams together

Before we start discussing tables and Streams, let's understand the following simple code of a word count program written in Java using a Kafka Stream API, and then we will look into the concepts of `KStream` and `KTable`. We have been discussing the concepts of Kafka Stream; in this section, we will discuss `KStream`, `KTable`, and their internals.

Lab Solution

Complete solution for this lab is available in the following directory:

`~/kafka-advanced/labs/Lab09`

Maven dependency

The Kafka Stream application can be run from anywhere. You just need to add library dependency and start developing your program. We are using Maven to build our application. Add the following dependency into your project:

```
<dependency>
    <groupId>org.apache.Kafka</groupId>
    <artifactId>Kafka-Streams</artifactId>
    <version>0.10.0.0</version>
</dependency>
```

Kafka Stream word count

The following code is a simple word count program built using a Stream API. We will go through the important APIs used in this program, and will talk about their uses:

```
package com.fenago.Kafka;

import org.apache.Kafka.common.serialization.Serde;
import org.apache.Kafka.common.serialization.Serdes;
import org.apache.Kafka.Streams.KafkaStreams;
import org.apache.Kafka.Streams.KeyValue;
import org.apache.Kafka.Streams.StreamsConfig;
import org.apache.Kafka.Streams.kStream.KStream;
import org.apache.Kafka.Streams.kStream.KStreamBuilder;

import java.util.Arrays;
import java.util.Properties;

public class KafkaStreamWordCount {
    public static void main(String[] args) throws Exception {
        Properties KafkaStreamProperties = new Properties();
// Stream configuration
```

```
        KafkaStreamProperties.put(StreamsConfig.APPLICATION_ID_CONFIG, "Kafka-Stream-
wordCount");
        KafkaStreamProperties.put(StreamsConfig.BOOTSTRAP_SERVERS_CONFIG,
"localhost:9092");
        KafkaStreamProperties.put(StreamsConfig.ZOOKEEPER_CONNECT_CONFIG,
"localhost:2181");
        KafkaStreamProperties.put(StreamsConfig.KEY_SERDE_CLASS_CONFIG,
Serdes.String().getClass().getName());
        KafkaStreamProperties.put(StreamsConfig.VALUE_SERDE_CLASS_CONFIG,
Serdes.String().getClass().getName());

        Serde<String> stringSerde = Serdes.String();
        Serde<Long> longSerde = Serdes.Long();

        KStreamBuilder StreamTopology = new KStreamBuilder();

//Kstream to read input data from input topic
        KStream<String, String> topicRecords = StreamTopology.Stream(stringSerde,
stringSerde, "input");
        KStream<String, Long> wordCounts = topicRecords
                .flatMapValues(value ->
Arrays.asList(value.toLowerCase().split("\\W+")))
                .map((key, word) -> new KeyValue<>(word, word))
                .countByKey("Count")
                .toStream();

//Store wordcount result in wordcount topic
        wordCounts.to(stringSerde, longSerde, "wordCount");

        KafkaStreams StreamManager = new KafkaStreams(StreamTopology,
KafkaStreamProperties);
//Running Stream job
        StreamManager.start();

        Runtime.getRuntime().addShutdownHook(new Thread(StreamManager::close));
    }

}
```

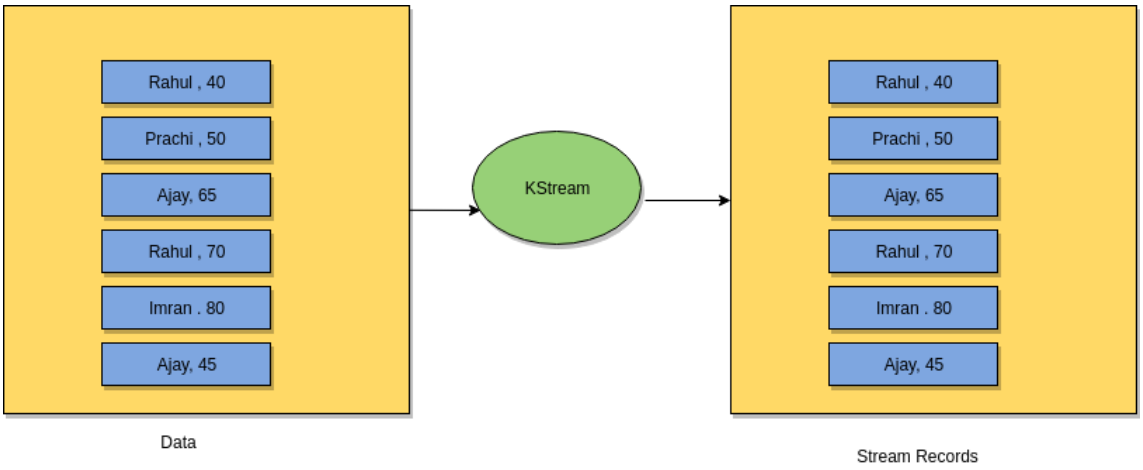
The application starts with a configuration where we define the set, Kafka Stream provides two important abstractions: one is `KStream`, and the other is `KTable`.

`KStream` is an abstraction of a key-value pair record Stream of Kafka's topic record. In `KStream`, each record is independent, meaning that a record with a key does not replace an old record with the same key. `KStream` can be created in two ways:

- [**Using the Kafka topic**]: Any Kafka Stream application starts with `KStream`, which consumes data from the Kafka topic. If you look into the earlier program, the following lines create `KStream topicRecords`, which will consume data from the topic input:

```
KStream<String, String> topicRecords = StreamTopology.Stream(stringSerde, stringSerde,
"input");
```

- [**Using transformation**]: `KStream` can be created by doing transformation on the existing `KStream`. If you look at the previous program, you will see that there are transformations such as `flatMapValues` and `map` that are used on `KStream topicRecords`. `KStream` can also be created by converting `KTable` into `KStream`. In the same example, `countByKey` will create `KTable Count`, and then we convert it to `KStream` using `toStream()`:

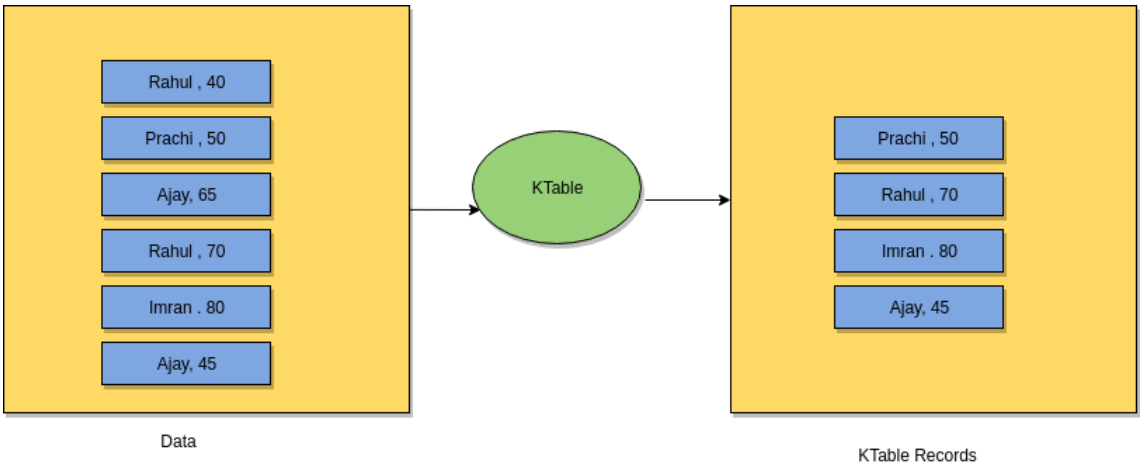


KStream record representation

KTable

`KTable` is a representation of `Changelog`, which does not contain a record with the same key twice. This means that if `KTable` encounters a record with the same key in the table, it will simply replace the old record with the current record.

If the same record represented in the previous diagram for `KStream` is converted to `KTable`, it will look like this:



KTable record representation

In the previous figure, you can see that the records of `Rahul` and `Ajay` have been updated and the old entries have been removed. `KTable` is similar to the update operation in Map. Whenever a duplicate key is inserted, the

old value gets replaced by a new value. We can perform various operations on `KTable` and join it to other `KStream` or `KTable` instances.

Use case example of Kafka Streams

Maven dependency of Kafka Streams

The best part of Kafka Stream is that it does not require any extra dependency apart from Stream libraries. Add the dependency to your `pom.xml` :

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://Maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://Maven.apache.org/POM/4.0.0
http://Maven.apache.org/xsd/Maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>

    <groupId>com.fenago</groupId>
    <artifactId>KafkaStream</artifactId>
    <version>1.0-SNAPSHOT</version>
    <build>
        <plugins>
            <plugin>
                <groupId>org.apache.Maven.plugins</groupId>
                <artifactId>Maven-compiler-plugin</artifactId>
                <configuration>
                    <source>1.8</source>
                    <target>1.8</target>
                </configuration>
            </plugin>
        </plugins>
    </build>
    <dependencies>
        <!-- https://mvnrepository.com/artifact/org.apache.Kafka/Kafka-Streams -->
        <dependency>
            <groupId>org.apache.Kafka</groupId>
            <artifactId>Kafka-Streams</artifactId>
            <version>0.10.0.1</version>
        </dependency>

    </dependencies>

</project>
```

Property reader

We are going to use the same property file and property reader that we used in Lab 6 with a few changes. Kafka Stream will read the record from the `iprecord` topic and will produce the output to the `fraudIp` topic:

```
topic=iprecord
broker.list=localhost:9092
output_topic=fraudIp
```

Here is the property reader class:

```
package com.fenago.Kafka.utils;


import java.io.FileNotFoundException;
import java.io.IOException;
import java.io.InputStream;
import java.util.Properties;

public class PropertyReader {

    private Properties prop = null;

    public PropertyReader() {

        InputStream is = null;
        try {
            this.prop = new Properties();
            is = this.getClass().getResourceAsStream("/Streaming.properties");
            prop.load(is);
        } catch (FileNotFoundException e) {
            e.printStackTrace();
        } catch (IOException e) {
            e.printStackTrace();
        }
    }

    public String getPropertyValue(String key) {
        return this.prop.getProperty(key);
    }
}
```

IP record producer

Again, the producer is the same as we used in Lab 5 and Lab 6 which generates records with random IPs. The producer will auto-create the topic if it does not exist. Here is how the code goes:

```
package com.fenago.Kafka.producer;

import com.fenago.Kafka.utils.PropertyReader;
import org.apache.Kafka.clients.producer.KafkaProducer;
import org.apache.Kafka.clients.producer.ProducerRecord;
import org.apache.Kafka.clients.producer.RecordMetadata;

import java.io.BufferedReader;
import java.io.IOException;
import java.io.InputStreamReader;
import java.util.*;
import java.util.concurrent.Future;


public class IPLogProducer extends TimerTask {
```

```
    public BufferedReader readFile() {
        BufferedReader BufferedReader = new BufferedReader(new InputStreamReader(
                this.getClass().getResourceAsStream("/IP_LOG.log")));
        return BufferedReader;

    }

    public static void main(final String[] args) {
        Timer timer = new Timer();
        timer.schedule(new IPLogProducer(), 3000, 3000);
    }

    private String getNewRecordWithRandomIP(String line) {
        Random r = new Random();
        String ip = r.nextInt(256) + "." + r.nextInt(256) + "." + r.nextInt(256) + "."
+ r.nextInt(256);
        String[] columns = line.split(" ");
        columns[0] = ip;
        return Arrays.toString(columns);
    }

    @Override
    public void run() {
        PropertyReader propertyReader = new PropertyReader();

        Properties producerProps = new Properties();
        producerProps.put("bootstrap.servers",
propertyReader.getPropertyValue("broker.list"));
        producerProps.put("key.serializer",
"org.apache.Kafka.common.serialization.StringSerializer");
        producerProps.put("value.serializer",
"org.apache.Kafka.common.serialization.StringSerializer");
        producerProps.put("auto.create.topics.enable", "true");

        KafkaProducer<String, String> ipProducer = new KafkaProducer<String, String>
(producerProps);

        BufferedReader br = readFile();
        String oldLine = "";
        try {
            while ((oldLine = br.readLine()) != null) {
                String line = getNewRecordWithRandomIP(oldLine).replace("[",
"").replace("]", "");
                ProducerRecord ipData = new ProducerRecord<String, String>
(propertyReader.getPropertyValue("topic"), line);
                Future<RecordMetadata> recordMetadata = ipProducer.send(ipData);
            }
        } catch (IOException e) {
            e.printStackTrace();
        }
        ipProducer.close();
```

```
    }
}
```

Verify the producer record using the console producer. Run the following command on the Kafka cluster:

```
cd ~/kafka-advanced

kafka/bin/kafka-console-consumer.sh \
    --bootstrap-server localhost:9092 \
    --topic iprecord \
    --from-beginning
```

Remember that we are producing multiple records by changing the IP address randomly. You'll be able to see the records as shown in the following figure:

IP lookup service

As mentioned earlier, the lookup service is reused from Lab 5 and Lab 6, [*Building Storm Application with Kafka*]. Note that this is in the memory lookup created over the interface, so you can add your own lookup service by simply providing implementation for `isFraud()`, and you are done.

The [**IP scanner interface**] looks like this:

```
package com.fenago.Kafka.lookup;

public interface IIPScanner {

    boolean isFraudIP(String ipAddresses);

}
```

We have kept the in-memory IP lookup very simple for an interactive execution of the application. The lookup service will scan the IP address and detect whether the record is a fraud or not by comparing the first 8 bits of the IP address:

```
package com.fenago.Kafka.lookup;

import java.io.Serializable;
import java.util.HashSet;
import java.util.Set;
```

```
public class CacheIPLookup implements IIPScanner, Serializable {

    private Set<String> fraudIPList = new HashSet<>();

    public CacheIPLookup() {
        fraudIPList.add("212");
        fraudIPList.add("163");
        fraudIPList.add("15");
        fraudIPList.add("224");
        fraudIPList.add("126");
        fraudIPList.add("92");
        fraudIPList.add("91");
        fraudIPList.add("10");
        fraudIPList.add("112");
        fraudIPList.add("194");
        fraudIPList.add("198");
        fraudIPList.add("11");
        fraudIPList.add("12");
        fraudIPList.add("13");
        fraudIPList.add("14");
        fraudIPList.add("15");
        fraudIPList.add("16");
    }


    @Override
    public boolean isFraudIP(String ipAddresses) {
        return fraudIPList.contains(ipAddresses);
    }
}
```

Fraud detection application

The fraud detection application will be running continuously, and you can run as many instances as you want; Kafka will do the load balancing for you. Let's look at the following code that reads the input from the `iprecord` topic and then filters out records that are fraud using the lookup service:

```
package com.fenago.Kafka;


import com.fenago.Kafka.lookup.CacheIPLookup;
import com.fenago.Kafka.utils.PropertyReader;
import org.apache.Kafka.common.serialization.Serde;
import org.apache.Kafka.common.serialization.Serdes;
import org.apache.Kafka.Streams.KafkaStreams;
import org.apache.Kafka.Streams.StreamsConfig;
import org.apache.Kafka.Streams.kStream.KStream;
import org.apache.Kafka.Streams.kStream.KStreamBuilder;

import java.util.Properties;
```

```
public class IPFraudKafkaStreamApp {
    private static CacheIPLookup cacheIPLookup = new CacheIPLookup();
    private static PropertyReader propertyReader = new PropertyReader();

    public static void main(String[] args) throws Exception {
        Properties KafkaStreamProperties = new Properties();
        KafkaStreamProperties.put(StreamsConfig.APPLICATION_ID_CONFIG, "IP-Fraud-
Detection");
        KafkaStreamProperties.put(StreamsConfig.BOOTSTRAP_SERVERS_CONFIG,
"localhost:9092");
        KafkaStreamProperties.put(StreamsConfig.ZOOKEEPER_CONNECT_CONFIG,
"localhost:2181");
        KafkaStreamProperties.put(StreamsConfig.KEY_SERDE_CLASS_CONFIG,
Serdes.String().getClass().getName());
        KafkaStreamProperties.put(StreamsConfig.VALUE_SERDE_CLASS_CONFIG,
Serdes.String().getClass().getName());

        Serde<String> stringSerde = Serdes.String();

        KStreamBuilder fraudDetectionTopology = new KStreamBuilder();
//Reading fraud record from topic configured in configuration file

        KStream<String, String> ipRecords = fraudDetectionTopology.Stream(stringSerde,
stringSerde, propertyReader.getPropertyValue("topic"));
//Checking if record is fraud using in memory lookup service

        KStream<String, String> fraudIpRecords = ipRecords
                .filter((k, v) -> isFraud(v));
//Storing fraud IP's to topic
        fraudIpRecords.to(propertyReader.getPropertyValue("output_topic"));

        KafkaStreams StreamManager = new KafkaStreams(fraudDetectionTopology,
KafkaStreamProperties);
        StreamManager.start();

        Runtime.getRuntime().addShutdownHook(new Thread(StreamManager::close));
    }

//Fraud ip lookup method
    private static boolean isFraud(String record) {
        String IP = record.split(" ")[0];
        String[] ranges = IP.split("\\.");
        String range = null;
        try {
            range = ranges[0] + "." + ranges[1];
        } catch (ArrayIndexOutOfBoundsException ex) {
                 //handling here
        }
        return cacheIPLookup.isFraudIP(range);
    }
}
```

Summary

In this lab, you learned about Kafka Stream and how it makes sense to use Kafka Stream to do transformation when we have Kafka in our pipeline. We also went through the architecture, internal working, and integrated framework advantages of Kafka Streams. We covered `KStream` and `KTable` in brief and understood how they are different from each other. A detailed explanation of the Kafka Stream API is out of the scope of this course.

In the next lab, we will cover the internals of Kafka clusters, capacity planning, single-cluster and multi-cluster deployment, and adding and removing brokers.