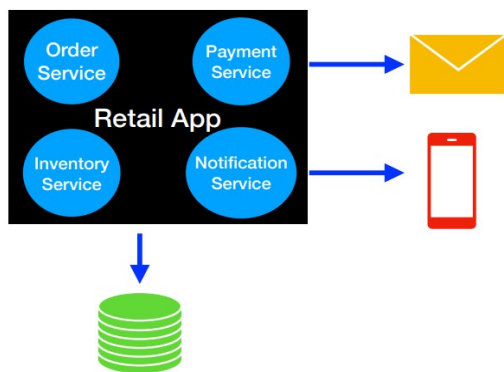
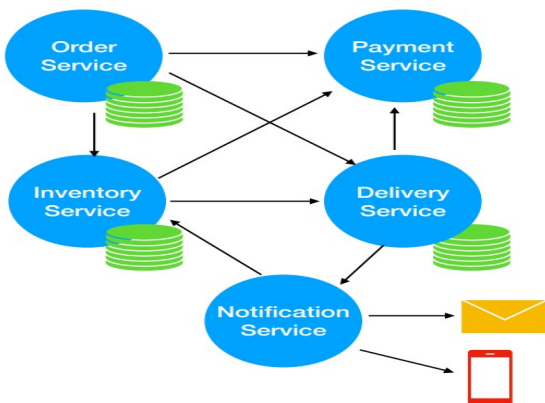


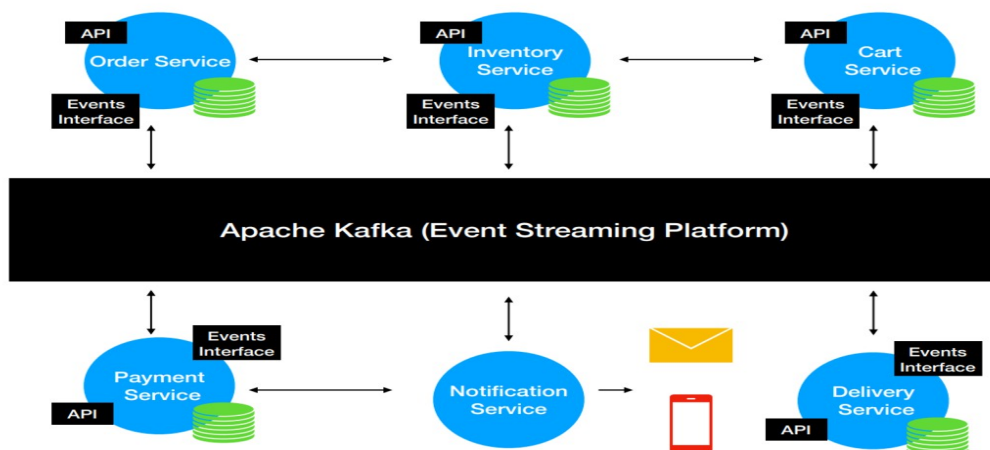
Why Event Streaming in case of Microservices



In monolith architecture, all the functionality will reside in one single application and share the same database. **This monolith architecture is proven to fail under heavy load.**



Modern architecture now-a-days is microservice architecture. The application is decomposed into multiple micro services. In order to deliver value, multiple micro services need to interact with each other. **It will look spaghetti if each microservice talk to each other.**



Having a middleware (event streaming platform like kafka) is necessary to communicate instead of each microservices directly talking to each other. In a nutshell, **every microservice will provide API, be a event producer and a event consumer. Producer and Consumer are independent of each other.** The event streaming platform store the stream of events which can replayed if needed. These events are stored in multiple servers for fault-tolerance and availability.

Traditional Messaging System vs Kafka

Traditional Messaging System

Transient Message Persistence

Brokers keep track of consumed message

Not a distributed system

Kafka

Store events based on retention time. Events are immutable.

Consumer's responsibility to keep track of the consumed messages

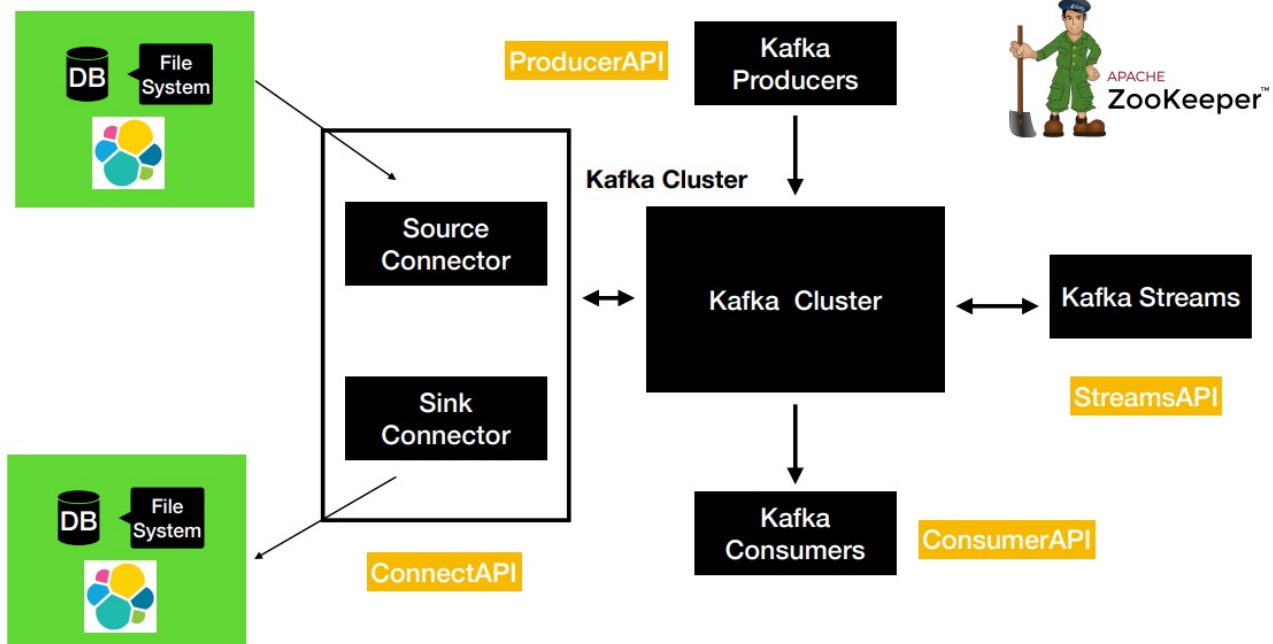
Distributed stream system

Transient Message Persistence means once the message is consumed, the message is removed from the Message Broker

Kafka is not just a messaging system. It is also a distributed streaming system too.

Kafka Terminology

- Kafka Cluster – Multiple Brokers
- Zookeeper – To manage multiple brokers and keeps track the health of the brokers
- Kafka Producers – Uses the client producer API to write/produce new data in kafka
- Kafka Consumers – Consume the message using the Client consumer API
- Kafka Connect – Client API (Source Connector and Sink Connector). Source Connector is used to pull the data from external sources like Database, files etc., into a Kafka Topic. With Kafka connect, we can do the data movement (in and out of Kafka) without writing a single line of code.
- Kafka Streams API – Used to take data from Kafka and perform simple to complex transformations on it and put it back to kafka
- 4 Client API Types – Producer API, Consumer API, Kafka Connect, Kafka Streams API using which you can interact with Kafka

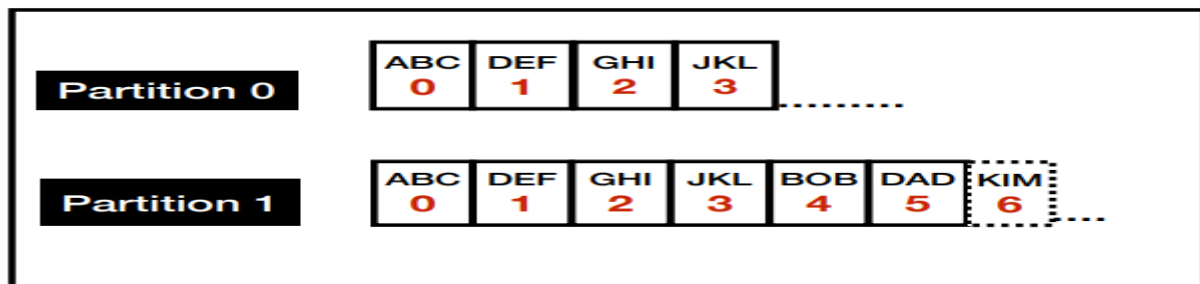


Understanding Kafka Components

Kafka Topic: Kafka Topic live inside the broker. Kafka clients use the Topic name to produce and consume messages.

Topic Partitions: Partitions are where the message exactly lives. Each topic can have one or more partitions. Partitions has significant effect on scalable message consumption. Each partition is an ordered, immutable sequence of records. Each record is assigned a sequential number called offset. This offset is generated when the record is placed in a Topic Partition. Each Partition is independent of each other and so ordering is guaranteed only at the Partition level. Partiion continue grow as new records are added and the offsets get incremented one by one. All records in the partition is persisted in a distributed commit log in the file system where kakfa is installed.

TopicA



Setup of Zookeeper and Kafka Broker

Zookeeper maintains the metadata of the Kafka Broker and also the kafka client information. Anytime the kafka broker starts it registers itself with the Zookeeper. T

he Zookeeper will keep track of the health of the kafka broker. It acts as a centrlaized service for maintaining the configuration information, health of the broker and provide synchronization when we have multiple brokers.

Reference: <https://github.com/dilipsundarraaj1/kafka-for-developers-using-spring-boot-v2/blob/main/docker-compose.yml>

docker-compose.yml

version: '2.1'

services:

zoo1:

image: confluentinc/cp-zookeeper:7.3.2

hostname: zoo1

container_name: zoo1

ports:

- "2181:2181"

environment:

ZOOKEEPER_CLIENT_PORT: 2181

ZOOKEEPER_SERVER_ID: 1

ZOOKEEPER_SERVERS: zoo1:2888:3888

kafka1:

image: confluentinc/cp-kafka:7.3.2

hostname: kafka1

container_name: kafka1

ports:

- "9092:9092"
- "29092:29092"

environment:

```
KAFKA_ADVERTISED_LISTENERS: INTERNAL://kafka1:19092,EXTERNAL://$
{DOCKER_HOST_IP:-127.0.0.1}:9092,DOCKER://host.docker.internal:29092
KAFKA_LISTENER_SECURITY_PROTOCOL_MAP:
INTERNAL:PLAINTEXT,EXTERNAL:PLAINTEXT,DOCKER:PLAINTEXT
KAFKA_INTER_BROKER_LISTENER_NAME: INTERNAL
KAFKA_ZOOKEEPER_CONNECT: "zoo1:2181"
KAFKA_BROKER_ID: 1
KAFKA_OFFSETS_TOPIC_REPLICATION_FACTOR: 1
KAFKA_TRANSACTION_STATE_LOG_MIN_ISR: 1
KAFKA_TRANSACTION_STATE_LOG_REPLICATION_FACTOR: 1
```

depends_on:

- zoo1

Explanation:

depends_on:

- zoo1

This means the kafka broker will wait for the zookeeper to start

\$ docker-compose -f docker-compose.yml up

PS C:\Users\rames> docker ps							
CONTAINER ID	IMAGE	COMMAND	CREATED	STATUS	PORTS	NAMES	
6036c7ca1c14	confluentinc/cp-kafka:7.3.2	"/etc/confluent/dock_"	2 hours ago	Up 2 hours	0.0.0.0:9092->9092/tcp, 0.0.0.0:29092->29092/tcp	kafka1	
8265981cd341	confluentinc/cp-zookeeper:7.3.2	"/etc/confluent/dock_"	2 hours ago	Up 2 hours	2888/tcp, 0.0.0.0:2181->2181/tcp, 3888/tcp	zoo1	

Produce and Consume messages using CLI

Create the topic

First, login to the docker container that is running kafka.

\$ docker exec -it kafka1 bash

kafka1:19092 refers to the KAFKA_ADVERTISED_LISTENERS in the docker-compose.yml file

```
$ kafka-topics --bootstrap-server kafka1:19092 \
--create \
--topic test-topic \
--replication-factor 1 --partitions 1
```

```
[appuser@kafka1 ~]$ kafka-topics --bootstrap-server kafka1:19092 \
> --create \
> --topic test-topic \
> --replication-factor 1 --partitions 1
Created topic test-topic.
[appuser@kafka1 ~]$
```

Produce messages to the Topic

We will use the kafka console producer to produce messages to the topic.

```
$ docker exec --interactive --tty kafka1 \
kafka-console-producer --bootstrap-server kafka1:19092 \
--topic test-topic
```

```
PS C:\Users\rames> docker exec --interactive --tty kafka1 kafka-console-producer --bootstrap-server kafka1:19092 --topic test-topic
>First Message - Helloworld from Kafka
>Second Message - How are you?
>
```

Consume messages from the Topic

We will use the kafka console consumer to consume messages from the topic

```
$ docker exec --interactive --tty kafka1 \
kafka-console-consumer --bootstrap-server kafka1:19092 \
--topic test-topic \
--from-beginning
```

```
PS C:\Users\rames> docker exec --interactive --tty kafka1 kafka-console-consumer --bootstrap-server kafka1:19092 --topic test-topic --from-beginning
First Message - Helloworld from Kafka
Second Message - How are you?
```

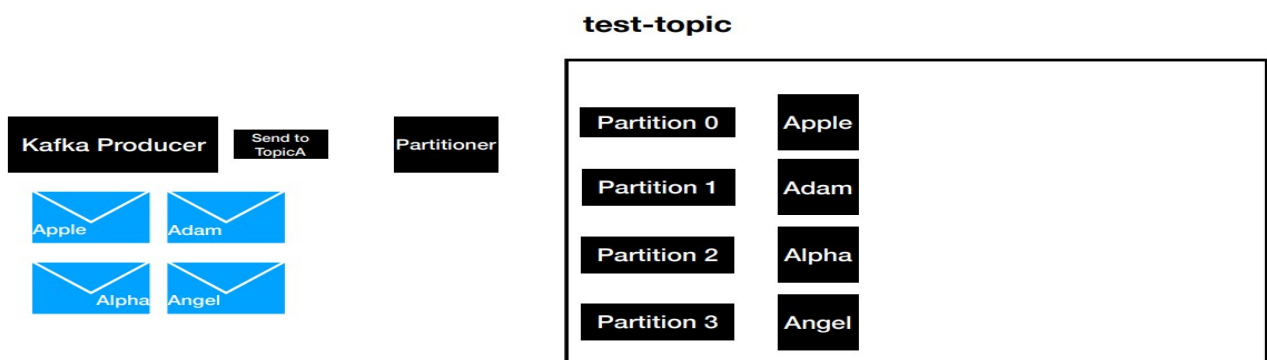
Produce and Consume messages with a Key

Before the message is sent to the kafka, it passes through multiple layers beneath the Kafka Producer. One such layer is called the Partitioner.

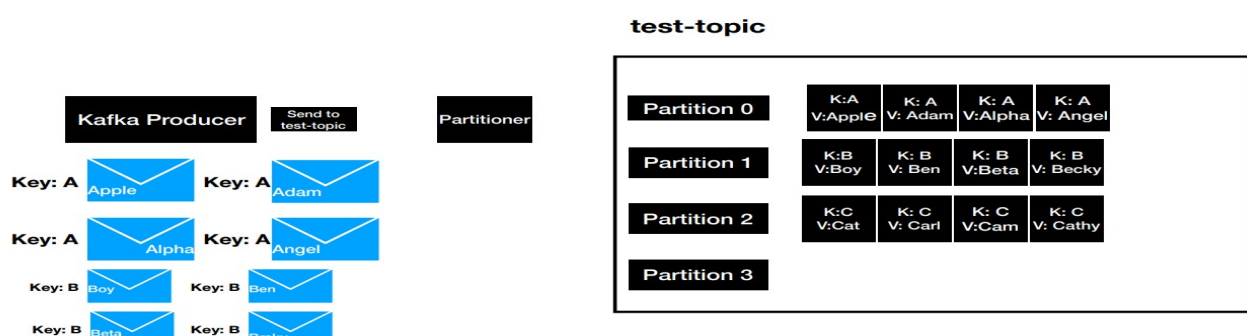
If no key is sent and only the value is sent. Then, the Partitioner will use the round-robin approach to choose the partition to place the messages.

If key is sent along with the value. Then, the Partitioner will do hashing of the key to determine the partition. The same key will always resolve to the same partition.

Message without Key



Message with Key



Console Producer to Create Message with key and value

```
$ docker exec --interactive --tty kafka1 \
kafka-console-producer --bootstrap-server kafka1:19092 \
--topic test-topic \
--property "key.separator=-" --property "parse.key=true"
```

Note: we are sending messages like “A-Apple”, “B-Bob” because we are using the property `key.separator` as “-”

```
PS C:\Users\rames> docker exec --interactive --tty kafka1 kafka-console-producer --bootstrap-server kafka1:19092 --topic test-topic --property "key.separator=-" --property "parse.key=true"
>A-Apple
>B-Bob
>C-Cat
>NoKey
org.apache.kafka.common.KafkaException: No key separator found on line number 4: 'NoKey'
    at kafka.tools.ConsoleProducer$LineMessageReader.parse(ConsoleProducer.scala:374)
    at kafka.tools.ConsoleProducer$LineMessageReader.readMessage(ConsoleProducer.scala:349)
    at kafka.tools.ConsoleProducer$.main(ConsoleProducer.scala:59)
    at kafka.tools.ConsoleProducer.main(ConsoleProducer.scala)
PS C:\Users\rames>
```

Console Consumer to Read Message with key and value

```
$ docker exec --interactive --tty kafka1 \
kafka-console-consumer --bootstrap-server kafka1:19092 \
--topic test-topic \
--property "key.separator=-" --property "print.key=true"
```

```
PS C:\Users\rames> docker exec --interactive --tty kafka1 kafka-console-consumer --bootstrap-server kafka1:19092 --topic test-topic --property "key.separator=-" --property "print.key=true"
A - Apple
B - Bob
C - Cat
```

Consumer Offset

Any message that is produced into the topic will have a unique id called offset.

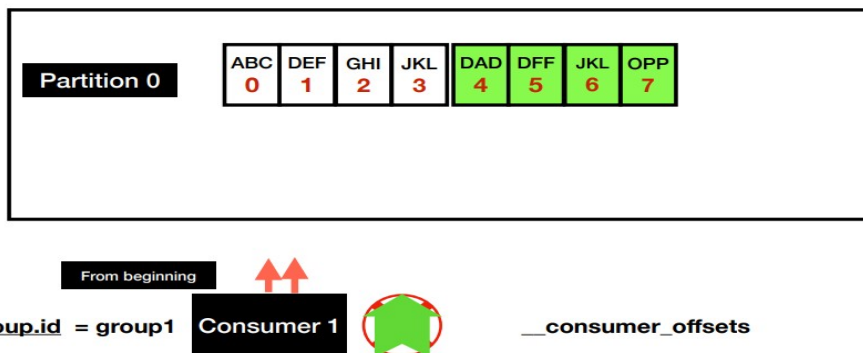
Consumer has three positions to read

- from-beginning
- latest – Read messages from the instance the consumer is spun-up
- from a specific offset – This can be done only programmatically

Every consumer is required to provide a group id

How does the consumer know from which offset to start (let's say for example the consumer has crashed and restarted. Also, the producer has created more messages meanwhile)

test-topic



The consumer offsets are stored in an internal topic called `__consumer_offsets`. Consumer offsets

behaves like a bookmark for the consumer to start reading the messages from the point it left of.

Get the List of topics

```
docker exec --interactive --tty kafka1 \
  kafka-topics --bootstrap-server kafka1:19092 --list
```

```
PS C:\Users\rames> docker exec --interactive --tty kafka1 kafka-topics --bootstrap-server kafka1:19092 --list
__consumer_offsets
test-topic
PS C:\Users\rames>
```

`__consumer_offsets` topic is local and internal to Kafka

Consumer Groups

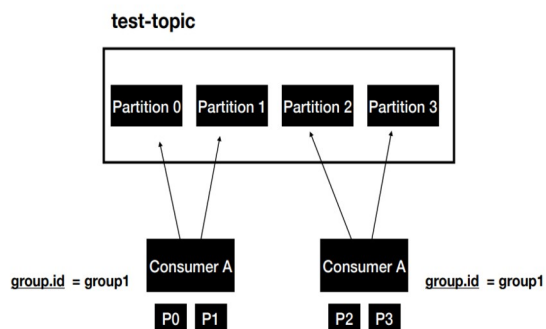
Group id plays a major role in scalable message consumption.

If we have a consumer with group id 1 and have 4 partitions. The consumer is single threaded and will pool all the four partitions. If the producer is producing messages at a higher rate. Then, it will create a lag at the consumption side. So, the messages might not be processed in real time.

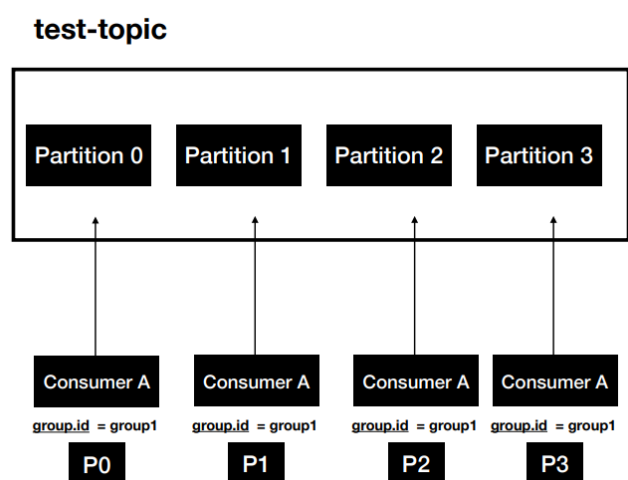
If more consumers with the same group id are started. Now, the partitions are split between the two consumers. This way we can scale our message consumption.

As we add more consumers with the same group id. Then, the consumption of the messages by the consumer is split between the partitions.

2 consumers in a group and 4 partitions

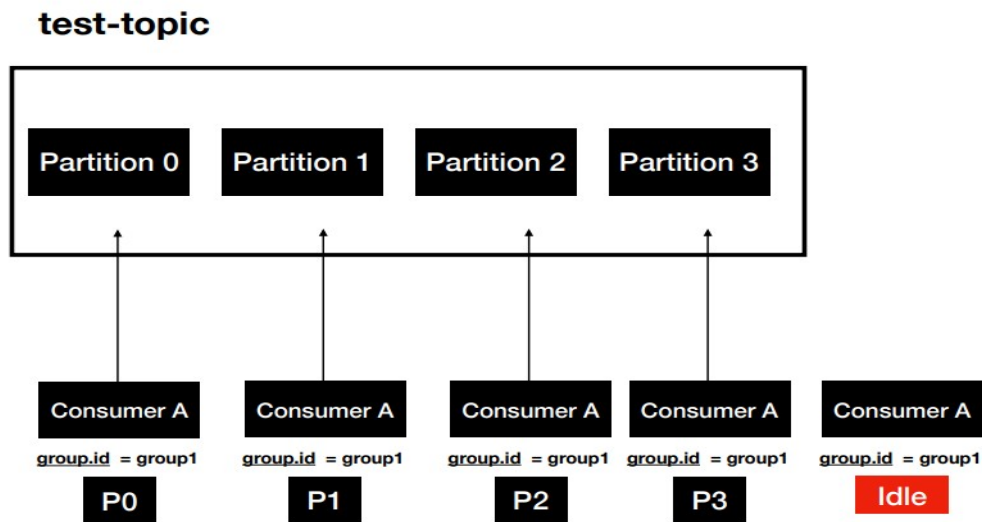


4 consumers in a group and 4 partitions



5 consumers in a group and 4 partitions

Note: One of the Consumers in the group will remain idle



Each Consumer Group is like an application Concept

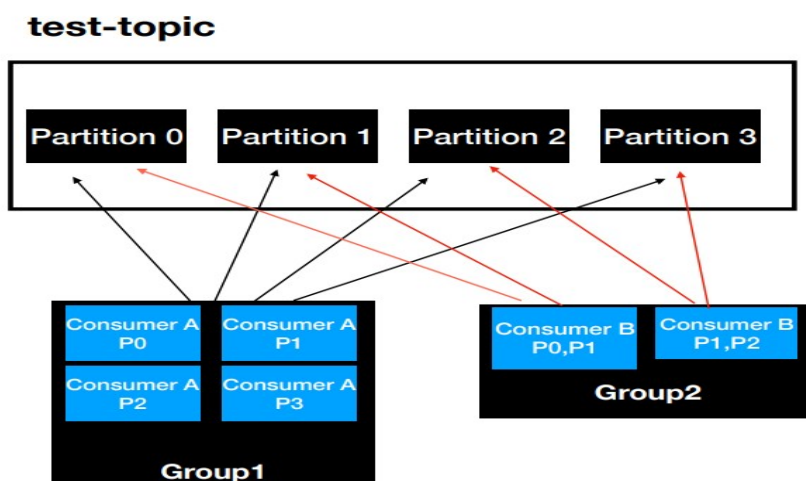
Two different application for the same topic.

Here, every/same message will be read by two different consumers of different consumer groups.

Each application will have their own processing logic and hence each application that consume will have their own group id. Also, each application has different number of instances based on the requirement.

Here, the application (consuming group id of group1) has four consumers to read the messages from the topic whereas a different applicaiton (consuming group id of group2) has two consumers to read the messages from the same topic. It is upto the individual application team to decide how many consumers they want.

You have make sure each applicaiton uses a unique group id for themselves



Summary

- Consumer Groups are used for scalable message consumption
- Each different application will have a unique consumer group

Hands-on Consumer Groups

View Consumer Groups

```
docker exec --interactive --tty kafka1 \
kafka-consumer-groups --bootstrap-server kafka1:19092 --list
```

```
PS C:\Users\rames> docker exec --interactive --tty kafka1 kafka-consumer-groups --bootstrap-server kafka1:19092 --list
console-consumer-96243
PS C:\Users\rames>
```

Describe All topics

```
docker exec --interactive --tty kafka1 \
kafka-topics --bootstrap-server kafka1:19092 --describe
```

```
PS C:\Users\rames> docker exec --interactive --tty kafka1 kafka-topics --bootstrap-server kafka1:19092 --describe
Topic: test-topic      TopicId: ed0IUqzaRQ0n-mSJPjUK7Q PartitionCount: 1      ReplicationFactor: 1      Configs:
    Topic: test-topic      Partition: 0      Leader: 1      Replicas: 1      Isr: 1
PS C:\Users\rames>
```

Describe a specific Topic (test-topic here)

```
docker exec --interactive --tty kafka1 \
kafka-topics --bootstrap-server kafka1:19092 --describe \
--topic test-topic
```

```
PS C:\Users\rames> docker exec --interactive --tty kafka1 kafka-topics --bootstrap-server kafka1:19092 --describe --topic test-topic
Topic: test-topic      TopicId: ed0IUqzaRQ0n-mSJPjUK7Q PartitionCount: 1      ReplicationFactor: 1      Configs:
    Topic: test-topic      Partition: 0      Leader: 1      Replicas: 1      Isr: 1
PS C:\Users\rames>
```

Alter the number of partitions to 4 in order to test Consumer Topics

```
docker exec --interactive --tty kafka1 \
kafka-topics --bootstrap-server kafka1:19092 \
--alter --topic test-topic --partitions 4
```

```
PS C:\Users\rames> docker exec --interactive --tty kafka1 kafka-topics --bootstrap-server kafka1:19092 --alter --topic test-topic --partitions 4
PS C:\Users\rames> docker exec --interactive --tty kafka1 kafka-topics --bootstrap-server kafka1:19092 --describe --topic test-topic
Topic: test-topic      TopicId: ed0IUqzaRQ0n-mSJPjUK7Q PartitionCount: 4      ReplicationFactor: 1      Configs:
    Topic: test-topic      Partition: 0      Leader: 1      Replicas: 1      Isr: 1
    Topic: test-topic      Partition: 1      Leader: 1      Replicas: 1      Isr: 1
    Topic: test-topic      Partition: 2      Leader: 1      Replicas: 1      Isr: 1
    Topic: test-topic      Partition: 3      Leader: 1      Replicas: 1      Isr: 1
PS C:\Users\rames>
```

Start the Producer

```
docker exec --interactive --tty kafka1 \
kafka-console-producer --bootstrap-server kafka1:19092 \
--topic test-topic \
--property "key.separator=-" --property "parse.key=true"
```

Start one consumer

```
docker exec --interactive --tty kafka1 \
kafka-console-consumer --bootstrap-server kafka1:19092 \
--topic test-topic --group console-consumer-41911 \
--property "key.separator= - " --property "print.key=true"
```

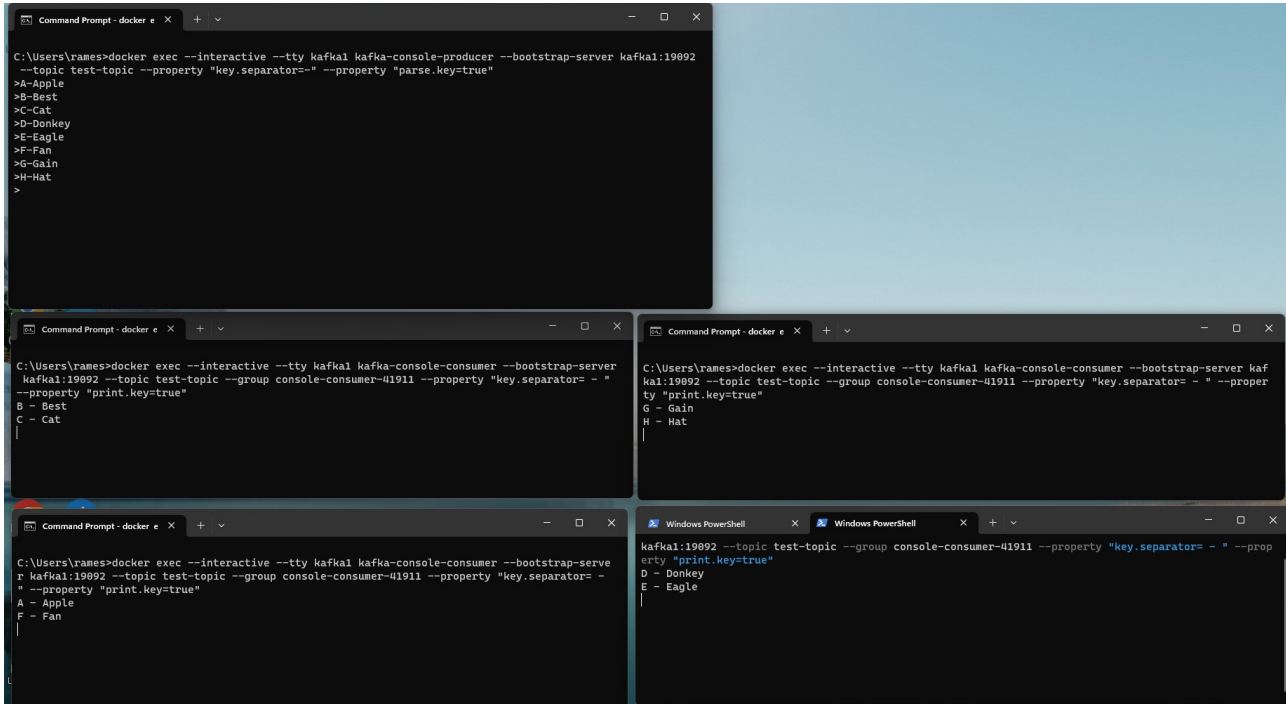
Get the consumer group of the started consumer

```
docker exec --interactive --tty kafka1 kafka-consumer-groups --bootstrap-server kafka1:19092 --list
```

```
C:\Users\rames>docker exec --interactive --tty kafka1 kafka-consumer-groups --bootstrap-server kafka1:19092 --list  
console-consumer-41911
```

Start the Other three consumers using the same consumer group

```
docker exec --interactive --tty kafka1 \  
kafka-console-consumer --bootstrap-server kafka1:19092 \  
--topic test-topic --group console-consumer-41911\  
--property "key.separator= - " --property "print.key=true"
```



The screenshot displays four terminal windows. The top-left window shows the command to start a Kafka console producer and a list of messages: A-Apple, B-Best, C-Cat, D-Donkey, E-Eagle, F-Fan, G-Gain, H-Hat. The bottom-left window shows the command to start a Kafka console consumer and the first two messages received: B - Best, C - Cat. The middle-right window shows the command to start another Kafka console consumer and the next two messages received: G - Gain, H - Hat. The bottom-right window shows the command to start a third Kafka console consumer and the next two messages received: D - Donkey, E - Eagle.

Each Consumer receiving the messages from its corresponding partition

Let's start the 5th Consumer in the same consumer group (**Number of Consumers > Number of Partitions**)

You will notice one of the consumer will remain idle

Commit Log and Retention Policy

Commit Log

Whenever a message is produced to a topic, It is written to a file with extension of .log in the filesystem called commit log. Each partition will have its own log file. The filesystem location for the commit log is configured in server.properties in a property called **log.dirs**.

The message is written to the filesystem as bytes. It is when the message is written to the file, the message produced by the producer is considered committed. Consumers can see only the records that are committed.

Retention Policy

Kakfa retains the messages for a prefined period of time called retention policy. It determines how long the message is going to be retained. Configured using the property **log.retention.hours** in server.properties

The default retention period is 168 hours (7 days)

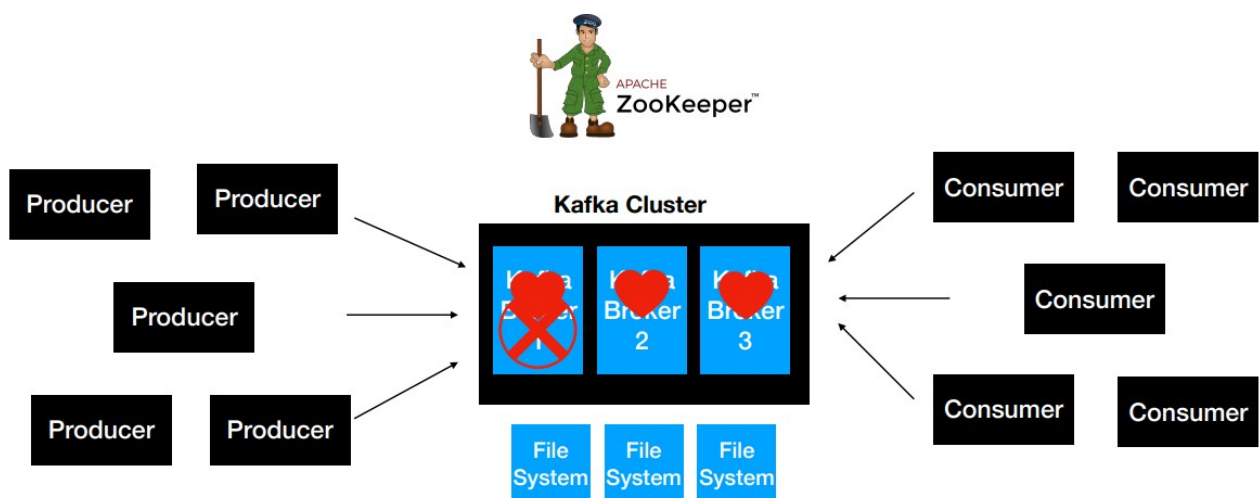
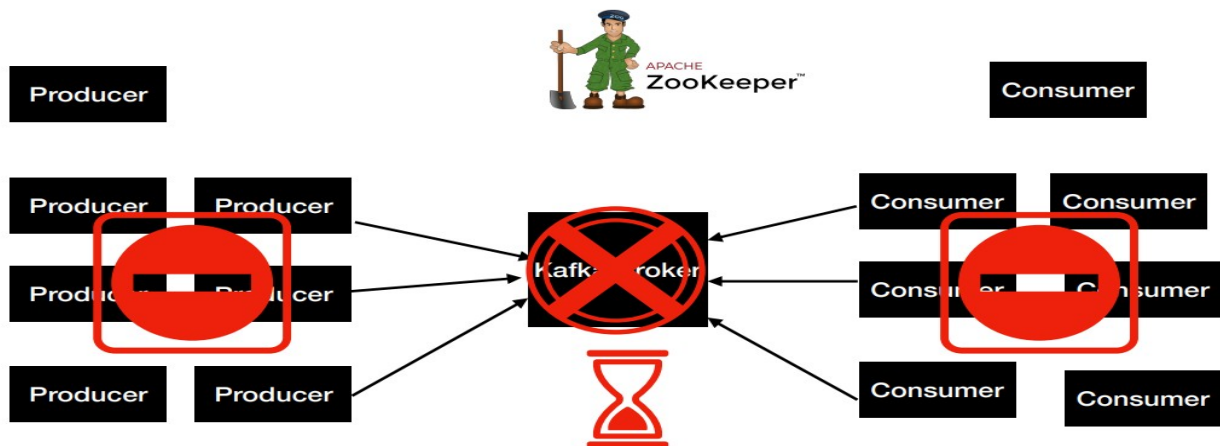
Kakfa – As a Distribute System

Kafka is a distributed streaming platform. Distributed systems are a collection of systems working together to deliver a value

Characteristics of Distributed System

- Availability and Fault Tolerance – Even if one of the system is down, Still it won't impact the overall availability of the system.
- Reliable Work distribution – The work load is distributed and shared by the different systems.
- Easily scalable – Adding another system to the existing setup can be done easily

Single point of failure



With a Kafka Cluster. Kafka Cluster is nothing but 1 or more brokers. It is common to have more than 1 broker.

- Client requests are distributed between brokers
- Easy to scale by adding more brokers based on the need
- Handles data loss using Replication
- If one of the broker goes down. Then, cluster manager (namely the Zookeeper) is notified and all the client requests are routed to the available brokers.

Kafka Cluster Setup

Reference: <https://github.com/dilipsundarraaj1/kafka-for-developers-using-spring-boot-v2/blob/main/docker-compose-multi-broker.yml>

Cluster with three brokers

version: '2.1'

services:

zoo1:

image: confluentinc/cp-zookeeper:7.3.2

platform: linux/amd64

hostname: zoo1

container_name: zoo1

ports:

- "2181:2181"

environment:

ZOOKEEPER_CLIENT_PORT: 2181

ZOOKEEPER_SERVER_ID: 1

ZOOKEEPER_SERVERS: zoo1:2888:3888

kafka1:

image: confluentinc/cp-kafka:7.3.2

platform: linux/amd64

hostname: kafka1

container_name: kafka1

ports:

- "9092:9092"

- "29092:29092"

environment:

KAFKA_ADVERTISED_LISTENERS: INTERNAL://kafka1:19092,EXTERNAL://\${DOCKER_HOST_IP:-127.0.0.1}:9092,DOCKER://host.docker.internal:29092

KAFKA_LISTENER_SECURITY_PROTOCOL_MAP:

INTERNAL:PLAINTEXT,EXTERNAL:PLAINTEXT,DOCKER:PLAINTEXT

KAFKA_INTER_BROKER_LISTENER_NAME: INTERNAL

KAFKA_ZOOKEEPER_CONNECT: "zoo1:2181"

KAFKA_BROKER_ID: 1

KAFKA_LOG4J_LOGGERS:

"kafka.controller=INFO,kafka.producer.async.DefaultEventHandler=INFO,state.change.logger=INFO"

depends_on:

- zoo1

kafka2:

image: confluentinc/cp-kafka:7.3.2

platform: linux/amd64

hostname: kafka2

container_name: kafka2

ports:

- "9093:9093"

- "29093:29093"

environment:

KAFKA_ADVERTISED_LISTENERS: INTERNAL://kafka2:19093,EXTERNAL://\$

```
{DOCKER_HOST_IP:-127.0.0.1}:9093,DOCKER://host.docker.internal:29093
  KAFKA_LISTENER_SECURITY_PROTOCOL_MAP:
INTERNAL:PLAINTEXT,EXTERNAL:PLAINTEXT,DOCKER:PLAINTEXT
  KAFKA_INTER_BROKER_LISTENER_NAME: INTERNAL
  KAFKA_ZOOKEEPER_CONNECT: "zoo1:2181"
  KAFKA_BROKER_ID: 2
  KAFKA_LOG4J_LOGGERS:
" kafka.controller=INFO,kafka.producer.async.DefaultEventHandler=INFO,state.change.logger=INFO"
  depends_on:
    - zoo1
```

kafka3:

```
  image: confluentinc/cp-kafka:7.3.2
  platform: linux/amd64
  hostname: kafka3
  container_name: kafka3
  ports:
    - "9094:9094"
    - "29094:29094"
  environment:
    KAFKA_ADVERTISED_LISTENERS: INTERNAL://kafka3:19094,EXTERNAL://$
{DOCKER_HOST_IP:-127.0.0.1}:9094,DOCKER://host.docker.internal:29094
    KAFKA_LISTENER_SECURITY_PROTOCOL_MAP:
INTERNAL:PLAINTEXT,EXTERNAL:PLAINTEXT,DOCKER:PLAINTEXT
    KAFKA_INTER_BROKER_LISTENER_NAME: INTERNAL
    KAFKA_ZOOKEEPER_CONNECT: "zoo1:2181"
    KAFKA_BROKER_ID: 3
    KAFKA_LOG4J_LOGGERS:
" kafka.controller=INFO,kafka.producer.async.DefaultEventHandler=INFO,state.change.logger=INFO"
  depends_on:
    - zoo1
```

\$ docker-compose -f docker-compose-multi-broker.yml up

```
PS C:\Users\rames> docker ps
CONTAINER ID   IMAGE                                COMMAND                  CREATED        STATUS        PORTS                                NAMES
f79eb0a59a6c   confluentinc/cp-kafka:7.3.2        "/etc/confluent/dock..." 20 seconds ago Up 18 seconds 0.0.0.0:9092->9092/tcp, 0.0.0.0:29092->29092/tcp   kafka1
e81e667fa083   confluentinc/cp-kafka:7.3.2        "/etc/confluent/dock..." 20 seconds ago Up 18 seconds 0.0.0.0:9093->9093/tcp, 9092/tcp, 0.0.0.0:29093->29093/tcp   kafka2
4a3ac6c94d6e   confluentinc/cp-kafka:7.3.2        "/etc/confluent/dock..." 20 seconds ago Up 18 seconds 0.0.0.0:9094->9094/tcp, 9092/tcp, 0.0.0.0:29094->29094/tcp   kafka3
33e26078c3a0   confluentinc/cp-zookeeper:7.3.2    "/etc/confluent/dock..." 20 seconds ago Up 19 seconds 2888/tcp, 0.0.0.0:2181->2181/tcp, 3888/tcp               zoo1
```

Create a topic with replication factor of 3

```
docker exec --interactive --tty kafka1 \
kafka-topics --bootstrap-server kafka1:19092 \
--create \
--topic test-topic \
--replication-factor 3 --partitions 3
```

Note: Though, we connect to one broker to create the topic. Still , the topic gets created in all the brokers.

```
PS C:\Users\rames> docker exec --interactive --tty kafka1 kafka-topics --bootstrap-server kafka1:19092 --create --topic test-topic --replication-factor 3 --partitions 3
Created topic test-topic.
PS C:\Users\rames>
```

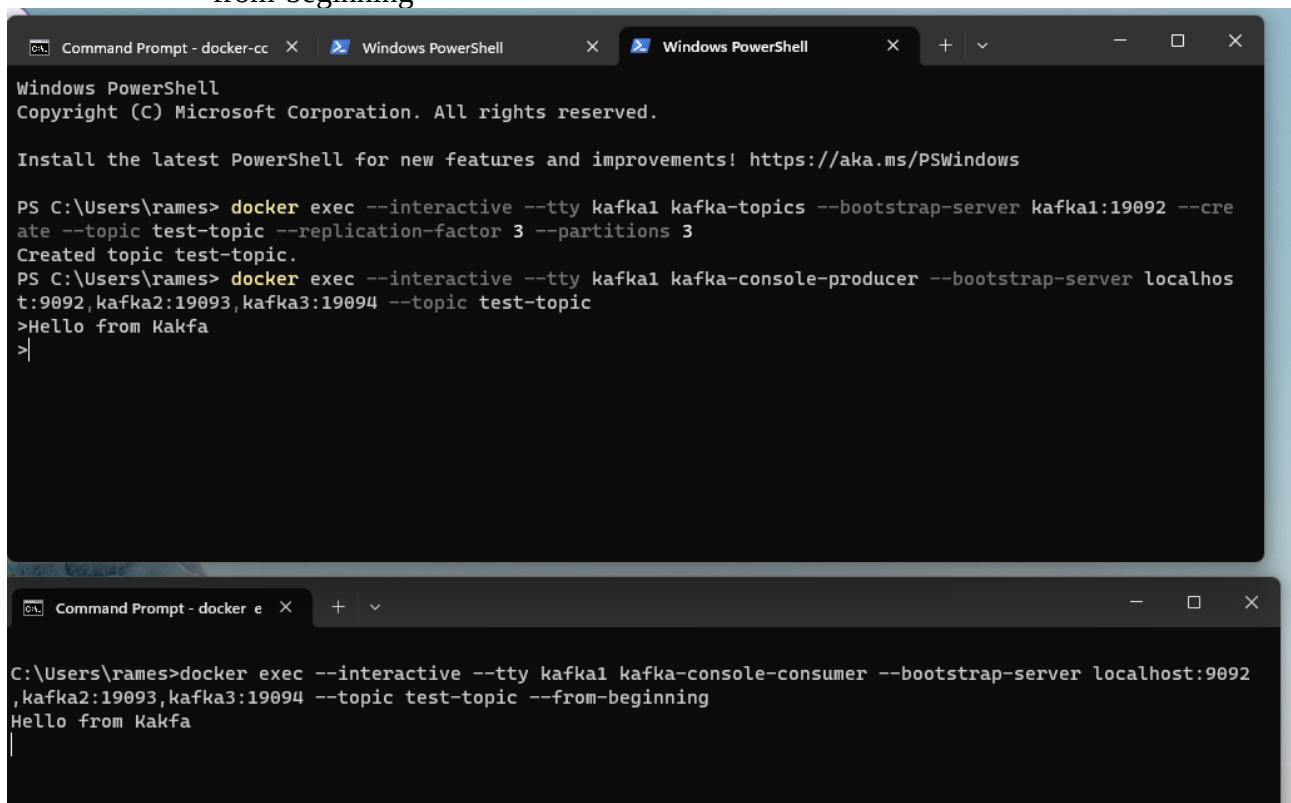
Produce Messages to the Topic

```
docker exec --interactive --tty kafka1 \
kafka-console-producer --bootstrap-server localhost:9092,kafka2:19093,kafka3:19094 \
--topic test-topic
```

Note: We give all the broker address in the bootstrap-server when producing the topic. Since, we login to kafka1 to issue the command, we use localhost for kafka1

Consume Messages from the Topic

```
docker exec --interactive --tty kafka1 \
kafka-console-consumer --bootstrap-server localhost:9092,kafka2:19093,kafka3:19094 \
--topic test-topic \
--from-beginning
```



```
Windows PowerShell
Copyright (C) Microsoft Corporation. All rights reserved.

Install the latest PowerShell for new features and improvements! https://aka.ms/PSWindows

PS C:\Users\rames> docker exec --interactive --tty kafka1 kafka-topics --bootstrap-server kafka1:19092 --create --topic test-topic --replication-factor 3 --partitions 3
Created topic test-topic.
PS C:\Users\rames> docker exec --interactive --tty kafka1 kafka-console-producer --bootstrap-server localhost:9092,kafka2:19093,kafka3:19094 --topic test-topic
>Hello from Kakfa
>|

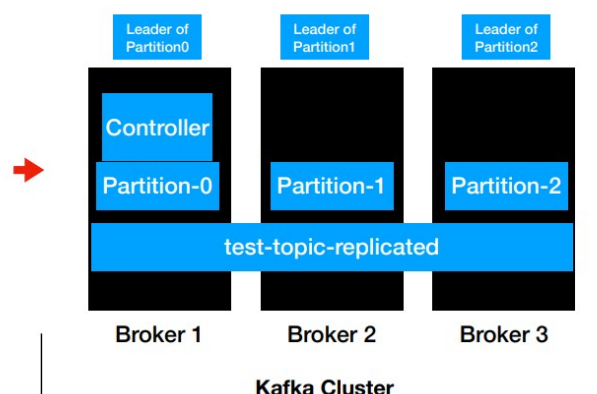
C:\Users\rames>docker exec --interactive --tty kafka1 kafka-console-consumer --bootstrap-server localhost:9092,kafka2:19093,kafka3:19094 --topic test-topic --from-beginning
Hello from Kakfa
|
```

Distribution of Client Requests – Leader and Follower

How Kafka cluster distributes the client requests between the brokers.

When the broker starts up and connect to the zookeeper, one of the broker acts as a controller.

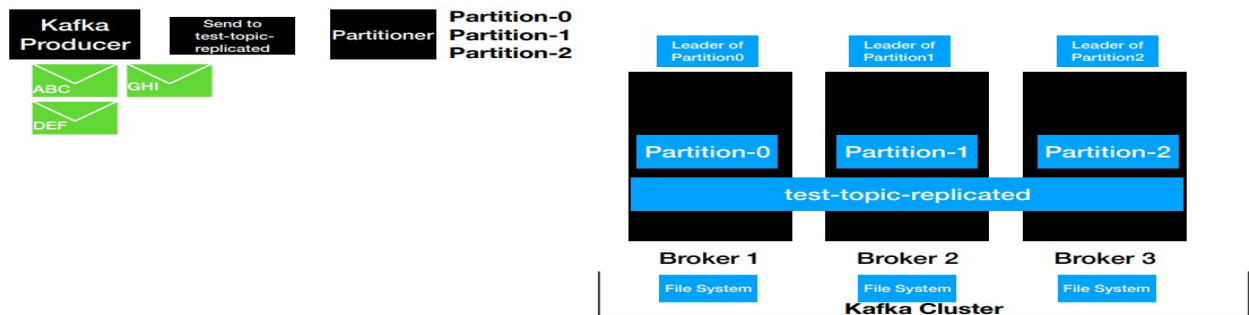
```
./kafka-topics.sh -
-create --topic test-topic-replicated
-zookeeper localhost:2181
--replication-factor 3
--partitions 3
```



When the create topic command is issued to the cluster, the zookeeper takes care of re-directing the request to the controller. The role of the controller is to distribute the partitions to the available broker. This process is called leader assignment.

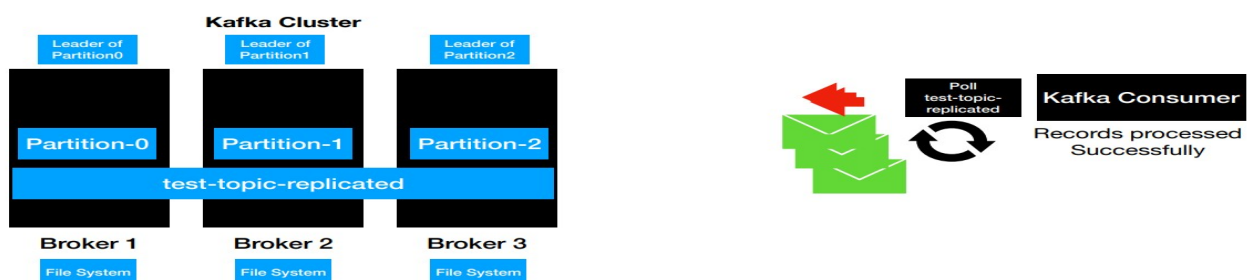
How Producer distributes the client requests?

The partitioner finds out which partition the message should be delivered. For example, the partitioner decides to send the message to Partition-0. In this case, the leader of Partition-0 is Broker1. Therefore, the message is sent to Broker1. **The client will always invoke the leader of the partition.** The client requests from the producer end is distributed between the brokers based on the partition which means indirectly it is distributed among the brokers.

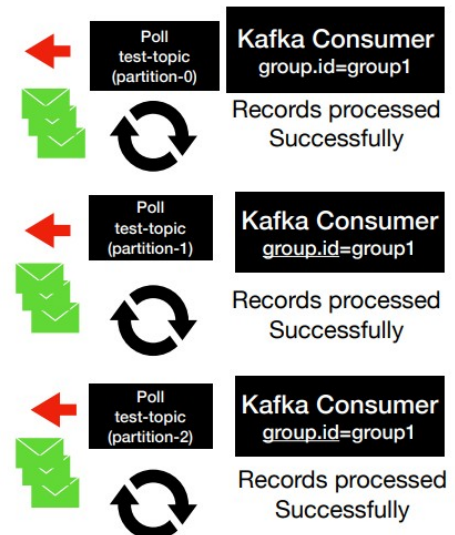
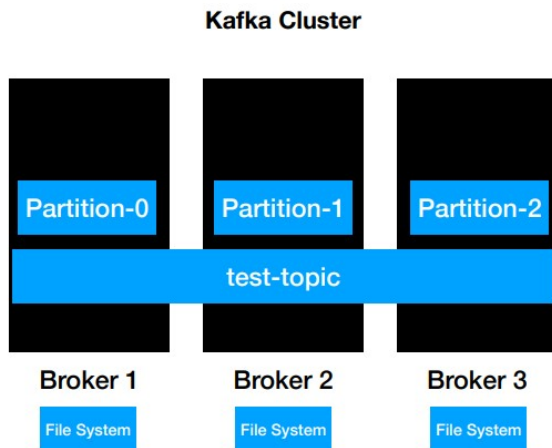


How Kafka distributes the client request – Kafka Consumer

Requests go to all the partitions/brokers to retrieve the records to process.



With consumer groups, it is a common practise to run multiple instances of a consumer in a consumer group and process the records in parallel. If one or more consumers are started with the same groupid. Then, the partitions are distributed for scalable consumption. Each consumer gets one partition assigned. Also, the call goes to the broker which leader of the respective partition.

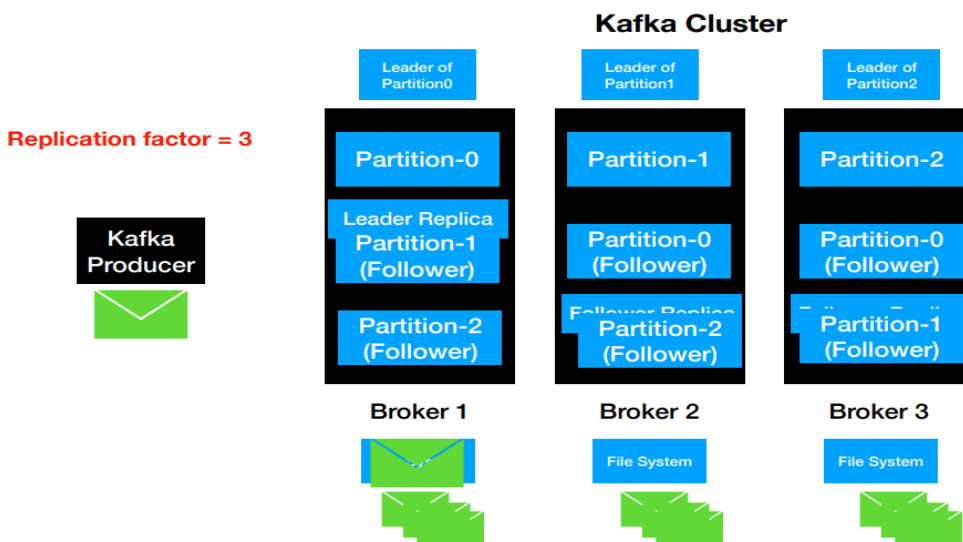


How Kafka handles data loss?

Kafka handles data loss via replication. The producer and consumer will always talk to the leader of the partition.

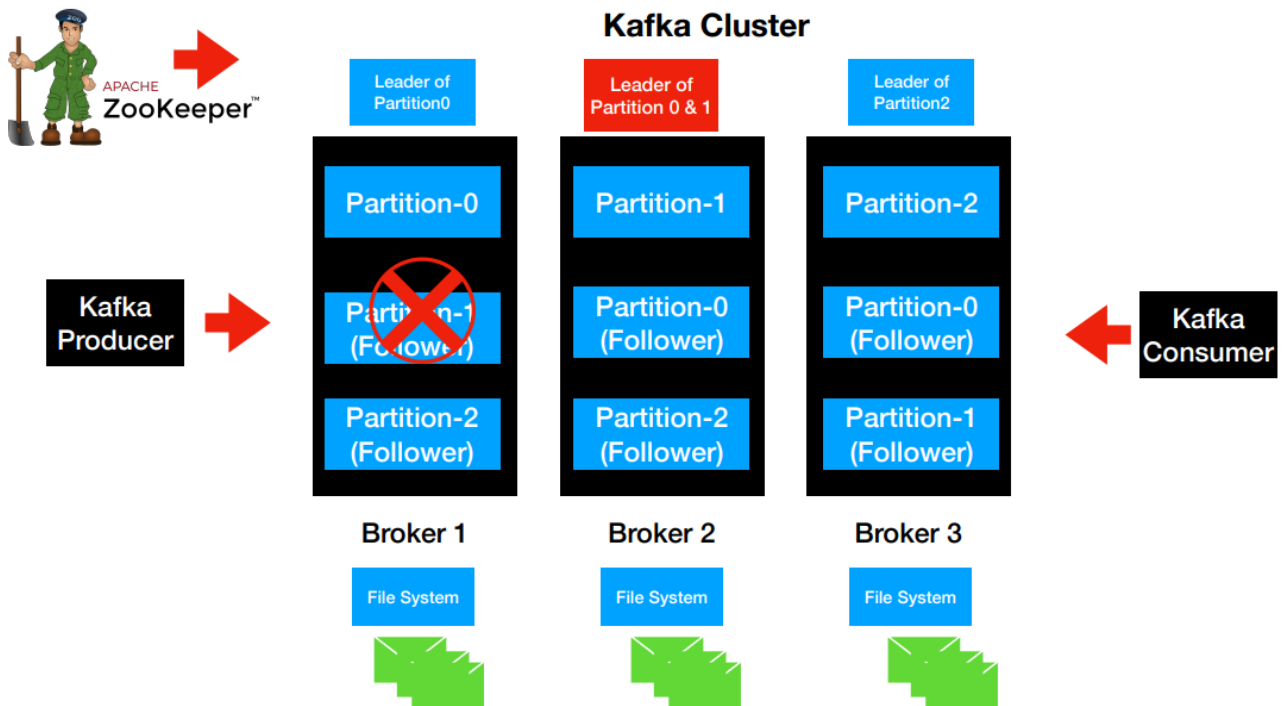
When the data is produced it will be written to the leader of the partition and ultimately to the file system of the leader of the partition.

Replication factor represents the number of copies of the message. With a replication-factor of 3, two more brokers will be identified as follower replicas. The message is written to the leader replica and the same message is written to the follower replicas. **In total for replication-factor of 3, 3 copies of the message will be written.** Note: The replication factor should be greater than 1.



What happens when one of the broker fails.

We have a leader replica for each partition and follower replicas for them. Let's assume the Broker 1 is down. Still, the data of the partition-0 is available in its follower replicas namely Broker 2 and Broker 3. Zookeeper is informed about the failure of the broker and Zookeeper assigns a new leader. Now, Broker 2 becomes the leader of both partition 0 and partition 1.



In-Sync Replicas (ISR)

Represents the number of replicas which is in sync with each other in the cluster. The number includes both the leader and the follower replica.

Ideal value is **ISR == replication factor**

The value for ISR can be configured using the property **min.insync.replicas**. Can be set at the broker level or at the topic level.

Describe the topic

```
docker exec --interactive --tty kafka1 \
kafka-topics --bootstrap-server kafka1:19092 --describe \
--topic test-topic
```

```
PS C:\Users\rames> docker exec --interactive --tty kafka1 kafka-topics --bootstrap-server kafka1:19092 --describe --topic test-topic
Topic: test-topic      TopicId: nS4bpnfxR-KRWFE73gm02A PartitionCount: 3 ReplicationFactor: 3 Configs:
Topic: test-topic      Partition: 0 Leader: 2 Replicas: 2,3,1 Isr: 2,3,1
Topic: test-topic      Partition: 1 Leader: 3 Replicas: 3,1,2 Isr: 3,1,2
Topic: test-topic      Partition: 2 Leader: 1 Replicas: 1,2,3 Isr: 1,2,3
PS C:\Users\rames>
```

Here, you can see each partition which is the leader/follower and the Replica details.

Topic: test-topic TopicId: nS4bpnfxR-KRWFE73gm02A PartitionCount: 3

ReplicationFactor: 3 Configs:

Topic: test-topic	Partition: 0	Leader: 2	Replicas: 2,3,1	Isr: 2,3,1
Topic: test-topic	Partition: 1	Leader: 3	Replicas: 3,1,2	Isr: 3,1,2
Topic: test-topic	Partition: 2	Leader: 1	Replicas: 1,2,3	Isr: 1,2,3

If there are say 40 partitions and 3 brokers. Then, each broker will be leader replica for many partitions.

Isr: 2,3,1 – Means three replicas are in sync.

Let's remove one of the broker from the cluster

\$ docker stop <containerid_of_kafka3>

```
PS C:\Users\rames> docker ps
CONTAINER ID   IMAGE                                COMMAND                  CREATED        STATUS        PORTS                                                                                                     NAMES
f79eb0a59a6c   confluentinc/cp-kafka:7.3.2        "/etc/confluent/dock..." 3 hours ago    Up 3 hours    0.0.0.0:9092->9092/tcp, 0.0.0.0:29092->29092/tcp                kafka1
e81e607fa083   confluentinc/cp-kafka:7.3.2        "/etc/confluent/dock..." 3 hours ago    Up 3 hours    0.0.0.0:9093->9093/tcp, 9092/tcp, 0.0.0.0:29093->29093/tcp      kafka2
4a3ac6c94d6e   confluentinc/cp-kafka:7.3.2        "/etc/confluent/dock..." 3 hours ago    Up 3 hours    0.0.0.0:9094->9094/tcp, 9092/tcp, 0.0.0.0:29094->29094/tcp      kafka3
33e26070c3a0   confluentinc/cp-zookeeper:7.3.2    "/etc/confluent/dock..." 3 hours ago    Up 3 hours    2888/tcp, 0.0.0.0:2181->2181/tcp, 3888/tcp                    zool
```

```
PS C:\Users\rames> docker stop 33e26070c3a0
33e26070c3a0
PS C:\Users\rames>
```

Now, let's describe of the topic again now

```
PS C:\Users\rames> docker exec --interactive --tty kafka1 kafka-topics --bootstrap-server kafka1:19092 --describe --topic test-topic
Topic: test-topic      TopicId: D05Am97mRO2QGBub-WZQRw PartitionCount: 3      ReplicationFactor: 3      Configs:
  Topic: test-topic      Partition: 0      Leader: 2      Replicas: 3,2,1 Isr: 2,1
  Topic: test-topic      Partition: 1      Leader: 1      Replicas: 1,3,2 Isr: 1,2
  Topic: test-topic      Partition: 2      Leader: 2      Replicas: 2,1,3 Isr: 2,1
PS C:\Users\rames>
```

```
PS C:\Users\rames> docker exec --interactive --tty kafka1 kafka-topics --bootstrap-server kafka1:19092 --describe --topic test-topic
```

Topic: test-topic TopicId: D05Am97mRO2QGBub-WZQRw PartitionCount: 3

ReplicationFactor: 3 Configs:

Topic: test-topic Partition: 0 Leader: 2 Replicas: 3,2,1 Isr: 2,1

Topic: test-topic Partition: 1 Leader: 1 Replicas: 1,3,2 Isr: 1,2

Topic: test-topic Partition: 2 Leader: 2 Replicas: 2,1,3 Isr: 2,1

You will notice the Isr: 2,1 for partition-0 and all partitions has only 2 in-sync replicas

Note: Like the replication-factor, it is advisable to **keep the min.insync.replicas value to be greater than 1** so that there is atleast 1 backup of the messages.

Configuring min.insync.replicas

Setting min.insync.replicas at Topic Level

docker exec --interactive --tty kafka1 \

kafka-configs --bootstrap-server localhost:9092 --entity-type topics --entity-name test-topic \

--alter --add-config min.insync.replicas=2

```
PS C:\Users\rames> docker exec --interactive --tty kafka1 kafka-configs --bootstrap-server localhost:9092 --entity-type topics --entity-name test-topic --alter --add-config min.insync.replicas=2
[2023-09-09 10:51:47,885] WARN [AdminClient clientId=adminclient-1] Connection to node 3 (/127.0.0.1:9094) could not be established. Broker may not be available. (org.apache.kafka.clients.NetworkClient)
[2023-09-09 10:51:47,889] WARN [AdminClient clientId=adminclient-1] Connection to node 2 (/127.0.0.1:9093) could not be established. Broker may not be available. (org.apache.kafka.clients.NetworkClient)
Completed updating config for topic test-topic.
PS C:\Users\rames>
```

Let's instantiate the producer

docker exec --interactive --tty kafka1 \

kafka-console-producer --bootstrap-server localhost:9092,kafka2:19093,kafka3:19094 \

--topic test-topic

Let's instantiate a consumer

docker exec --interactive --tty kafka1 \

kafka-console-consumer --bootstrap-server localhost:9092,kafka2:19093,kafka3:19094 \

--topic test-topic \

--from-beginning

Message is flowing as expected.

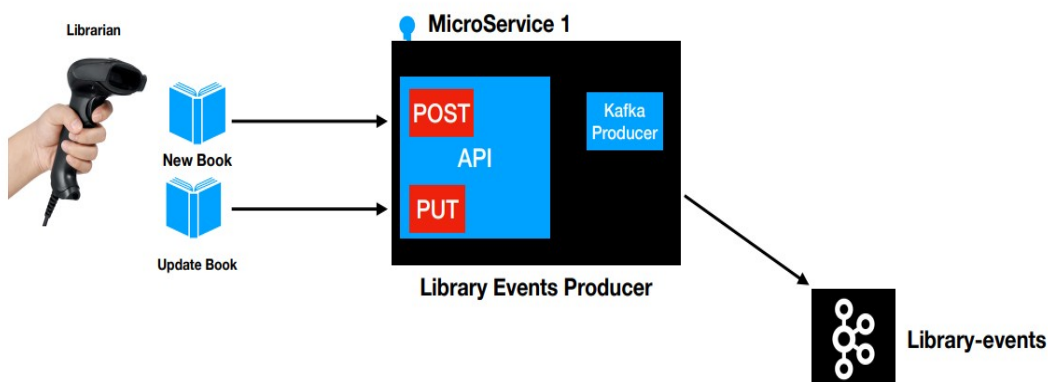
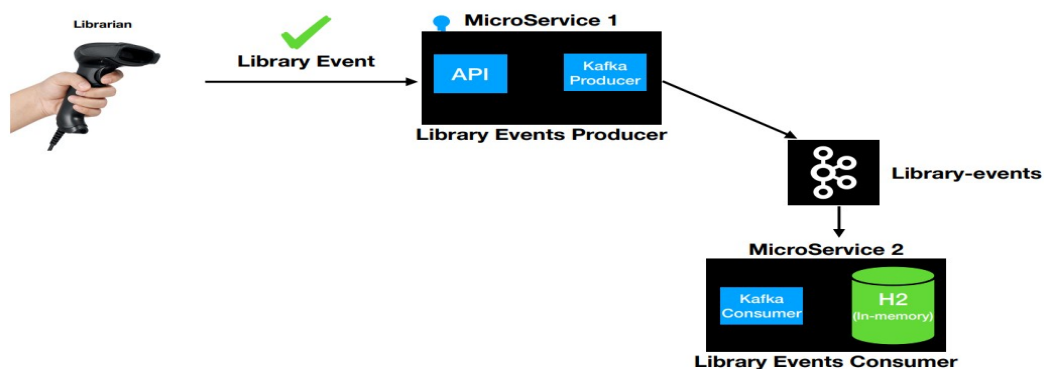
Now, Let's bring two out of the three brokers down. The setting for `min.insync.replicas = 2` and the number of brokers = 1

Now if you publish the message, you will get error saying `NOTENOUGH_REPLICAS`

If two out of the three brokers are up. Then, the requirements will be met and will be able to publish successfully.

The `min.insync.replicas` will ensure that the required/stated number of copies of the data is available in more than 1 kafka broker.

Overview of the Application – Library inventory



Build SpringBoot Kafka Producer – Hands On

Project

☐ Gradle - Groovy
 ☐ Gradle - Kotlin
 ☒ Java
 ☐ Kotlin
 ☐ Groovy

☒ Maven

Language

☒ Java
 ☐ Kotlin
 ☐ Groovy

Spring Boot

☐ 3.2.0 (SNAPSHOT)
 ☐ 3.2.0 (M2)
 ☐ 3.1.4 (SNAPSHOT)
 ☒ 3.1.3
 ☐ 3.0.11 (SNAPSHOT)
 ☐ 3.0.10
 ☐ 2.7.16 (SNAPSHOT)
 ☐ 2.7.15

Project Metadata

Group

com.kakfa.example

Artifact

events-producer

Name

events-producer

Description

Demo project for Spring Boot

Package name

com.kakfa.example.events-producer

Packaging

☒ Jar
 ☐ War

Java

☐ 20
 ☒ 17
 ☐ 11
 ☐ 8

Dependencies

ADD DEPENDENCIES... CTRL + B

Spring Web

WEB

Build web, including RESTful, applications using Spring MVC. Uses Apache Tomcat as the default embedded container.

Spring for Apache Kafka

MESSAGING

Publish, subscribe, store, and process streams of records.

Validation

I/O

Bean Validation with Hibernate validator.

Lombok

DEVELOPER TOOLS

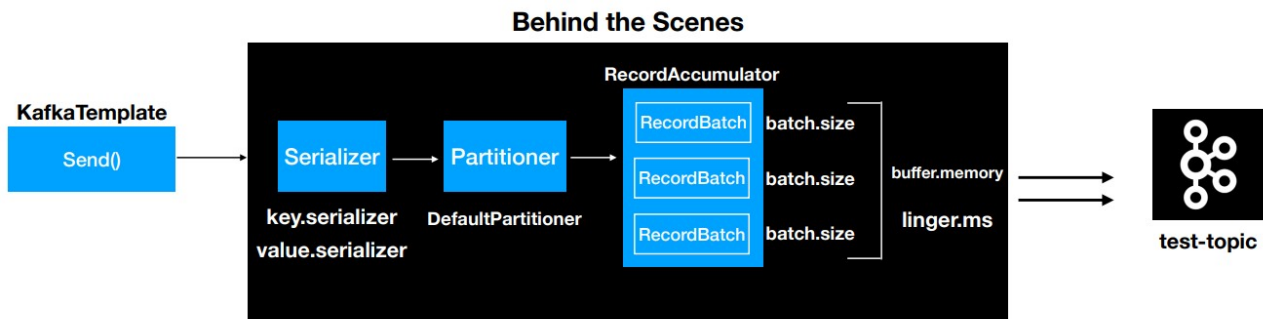
Java annotation library which helps to reduce boilerplate code.

Kafka Producer – KafkaTemplate (Spring)

Kafka Template is similar to the JdbcTemplate for DB interactions. It is used to produce records into Kafka Topic.

The KafkaTemplate wraps a producer and provides convenience methods to send data to Kafka topics. You will notice many variations of send and sendDefault methods.

The message goes through different layers before it reaches.



Serializer

The record needs to be serialized to bytes. There are two types of Serializer and is mandatory for the Producer and the client need to configure them by providing configuration values for the Serializer.

1. Key Serializer (**key.serializer**)
2. Value Serializer (**value.serializer**)

Partitioner

It determines which partition the message is going to go in the Topic. Configuring the Partitioner is not mandatory as the DefaultPartitioner comes into action if no Partitioner is configured. The DefaultPartitioner is more than enough most of the times

RecordAccumulator

Any record sent by the Producer/KafkaTemplate won't get sent immediately to the topic. This helps to increase the performance by limiting the number of trips to the Kafka Cluster. If the topic has

three partitions. Then, there will be three RecordBatches (one for each partition) to accumulate the records.

Every RecordBatch has a batch size (specified by batch.size)

Also, the RecordAccumulator has a overall buffer memory (specified by buffer.memory)

The record accumulator buffers the record. The records are sent to the topic once the buffer (**buffer.memory**) is full.

Once the batch is full, the records are sent to the topic. If the batch size doesn't fill up for a long time, the producer will not wait for long. Instead it will send after the threshold time configured (**linger.ms**) even if the batch does not fill.

Simple Configuration of KafkaTemplate

Mandatory Values:

bootstrap-servers: localhost:9092,localhost:9093,localhost:9094

key-serializer: org.apache.kafka.common.serialization.IntegerSerializer

value-serializer: org.apache.kafka.common.serialization.StringSerializer

Autocreate Topic using KafkaAdmin

This is not a recommended approach to create topic programmatically. KafkaAdmin is part of SpringKafka dependency.

To create a topic from code

Create a Bean of type **KafkaAdmin** in SpringConfiguration

Create a Bean of type **NewTopic** in SpringConfiguration

Kafka Template - Producer API

send(org.apache.kafka.clients.producer.ProducerRecord<K,V> record)

The send method which accepts ProducerRecord is helpful when **you want to send headers for the message.**

Reference:

<https://docs.spring.io/spring-kafka/reference/html/#sending-messages>

Integration Testing using JUnit5

Why we need Automated Tests? - Manual Testing is error-prone, time consuming and slows down delivery. Automated Tests can run as part of your build process which is a requirement for today's software development. Also, it is easy to catch bugs as it will fail the build.

Types of Automated Tests – Unit Test, Integration Test and End to End Tests.

Integration Test – It tests all the layers of the code and verify their behaviour is working as expected.

@SpringBootTest(webEnvironment = SpringBootTest.WebEnvironment.RANDOM_PORT)

We start the whole spring application using the @SpringBootTest

EmbeddedKafka – Configure and Integrate in Junit

EmbeddedKafka is needed if the integration test is running in a CI/CD pipeline as we cannot start a kafka instance locally and run the test.

```
@EmbeddedKafka(topics = {"library-events"}, partitions = 3)
@TestPropertySource(properties =
    {"spring.kafka.producer.bootstrap-servers=${spring.embedded.kafka.brokers}",
    "spring.kafka.admin.properties.bootstrap.servers=${spring.embedded.kafka.brokers}}")
```

The above starts an EmbeddedKafka instance and we provide the values for the properties spring.kafka.producer.bootstrap-servers and spring.kafka.admin.properties.bootstrap.servers with the values from the EmbeddedKafka instance namely the values of spring.embedded.kafka.brokers and spring.embedded.kafka.brokers

@Autowired

private EmbeddedKafkaBroker embeddedKafkaBroker;

We can access the EmbeddedKafka broker instance that was started as part of the test by Autowiring the EmbeddedKafkaBroker

Unit Testing using JUnit5

Unit Tests are faster compared to Integration Test because it doesn't need the whole environment to run the test.

All external dependencies need to be mocked out. For Example., If you are going to test the controller. Then, you mock the service layer, mock the writing of messages(Producer) and all external dependencies.

We are going to just test the web layer without starting the complete spring application and not the whole application context.

We just need a slice of the spring application context and test/load only the web layer using the @WebMvcTest

@SpringBootTest – Use it only for Integration Test

Whereas we use @WebMvcTest

1. **@WebMvcTest** – Unit Test the Web Layer
2. Autowire **MockMvc** bean to invoke the endpoints
3. **@MockBean** to mock the dependencies

Validation API

When we add the @Valid annotation to the controller method

```
public ResponseEntity<LibraryEvent> postLibraryEvent (@RequestBody @Valid LibraryEvent libraryEvent) { ... }
```

If the validation fails. Then, we get an exception (**MethodArgumentNotValidException**) and **HttpStatusCode of 400 (Client Error – Bad Request)**

We can customize this by using an Exception Handler for the Controller using ControllerAdvice.

Note: If you don't write an Exception Handler, Spring Framework will use the DefaultHandlerExceptionResolver (org.springframework.web.servlet.mvc.support) as part of the

framework. **DefaultHandlerExceptionResolver** is the default implementation of the **HandlerExceptionResolver** interface that resolves standard Spring exceptions and translates them to corresponding HTTP status codes.

Let's write an custom exception handler for the `MethodArgumentNotValidException`

@ControllerAdvice

```
public class LibraryEventControllerAdvice {
```

```
    @ExceptionHandler(MethodArgumentNotValidException.class)
```

```
    public ResponseEntity<?> handleRequestBody(MethodArgumentNotValidException ex) {
```

```
        List<FieldError> errorList = ex.getBindingResult().getFieldErrors();
```

```
        String errorMessage = errorList.stream()
```

```
            .map(fieldError -> fieldError.getField() + " - " + fieldError.getDefaultMessage())
```

```
            .sorted()
```

```
            .collect(Collectors.joining(", "));
```

```
        return new ResponseEntity<>(errorMessage, HttpStatus.BAD_REQUEST);
```

```
    }
```

```
}
```