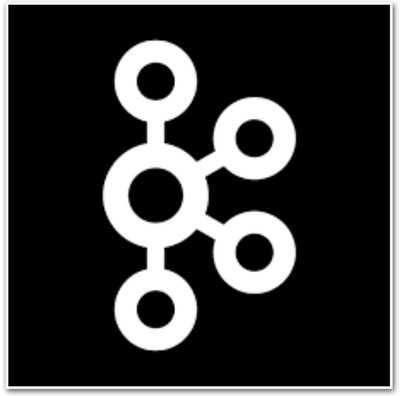


Kafka For Developers Using Spring Boot

Dilip Sundarraj

About Me

- Dilip
- Building Software’s since 2008
- Teaching in **UDEMY** Since 2016

Whats Covered?

- Introduction to Kafka and internals of Kafka
- Building Enterprise standard Kafka Clients using **Spring-Kafka/ SpringBoot**
- Resilient Kafka Client applications using **Error-Handling/Retry/Recovery**
- Writing Unit/Integration tests using **JUnit**

Targeted Audience

- Focused for developers
- Interested in learning the internals of Kafka
- Interested in building Kafka Clients using Spring Boot
- Interested in building Enterprise standard Kafka client applications using Spring boot

Source Code

Thank You !

Introduction to Apache Kafka

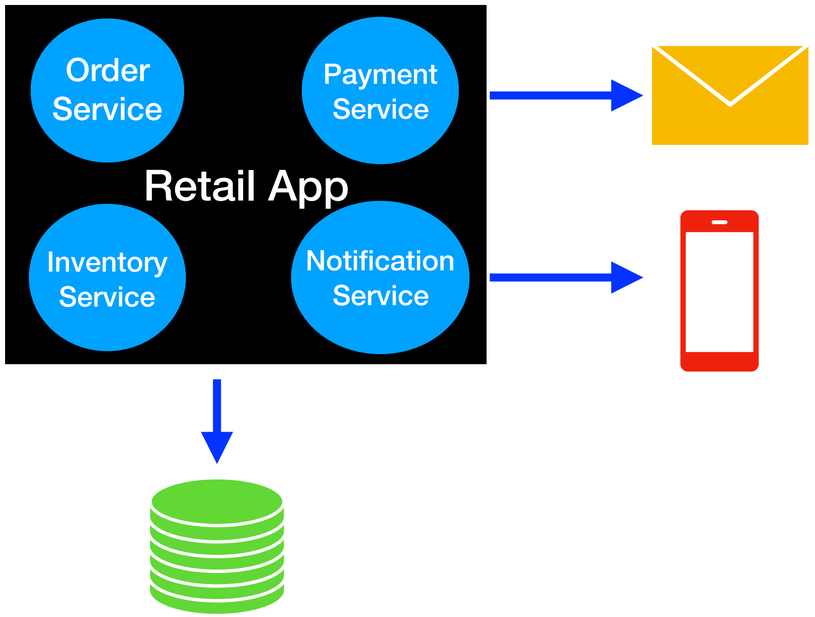
Prerequisites

Course Prerequisites

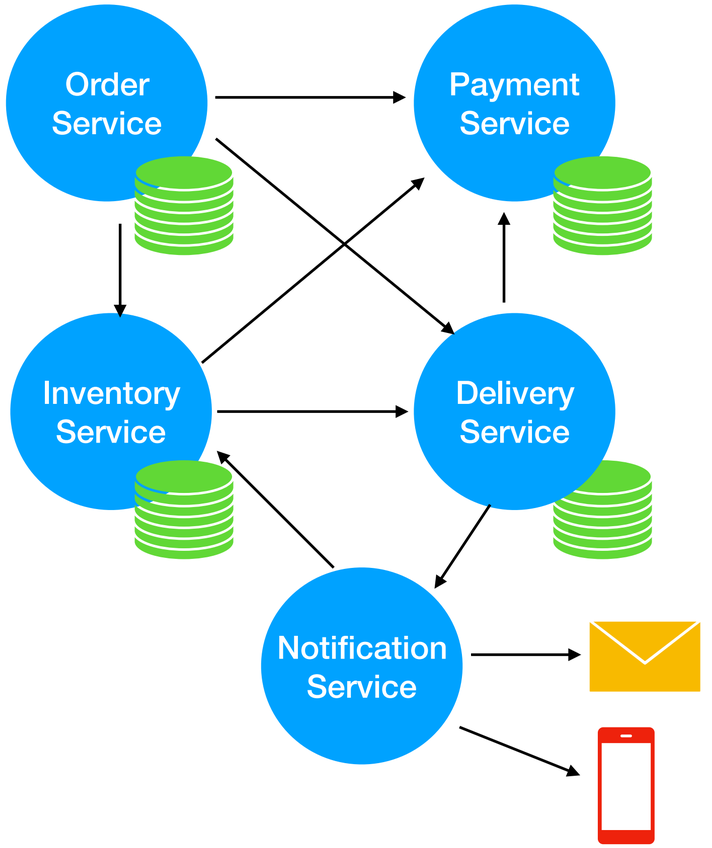
- Prior Knowledge or Working Experience with **Spring Boot/Framework**
- Knowledge about building **Kafka Clients** using Producer and Consumer API
- Knowledge about building **RESTFUL APIs** using Spring Boot
- Experience working with **Spring Data JPA**
- Automated tests using **JUnit**
- Experience Working with **Mockito**
- **Java 11 or Higher** is needed
- **Intellij** , **Eclipse** or any other IDE is needed

Software Development

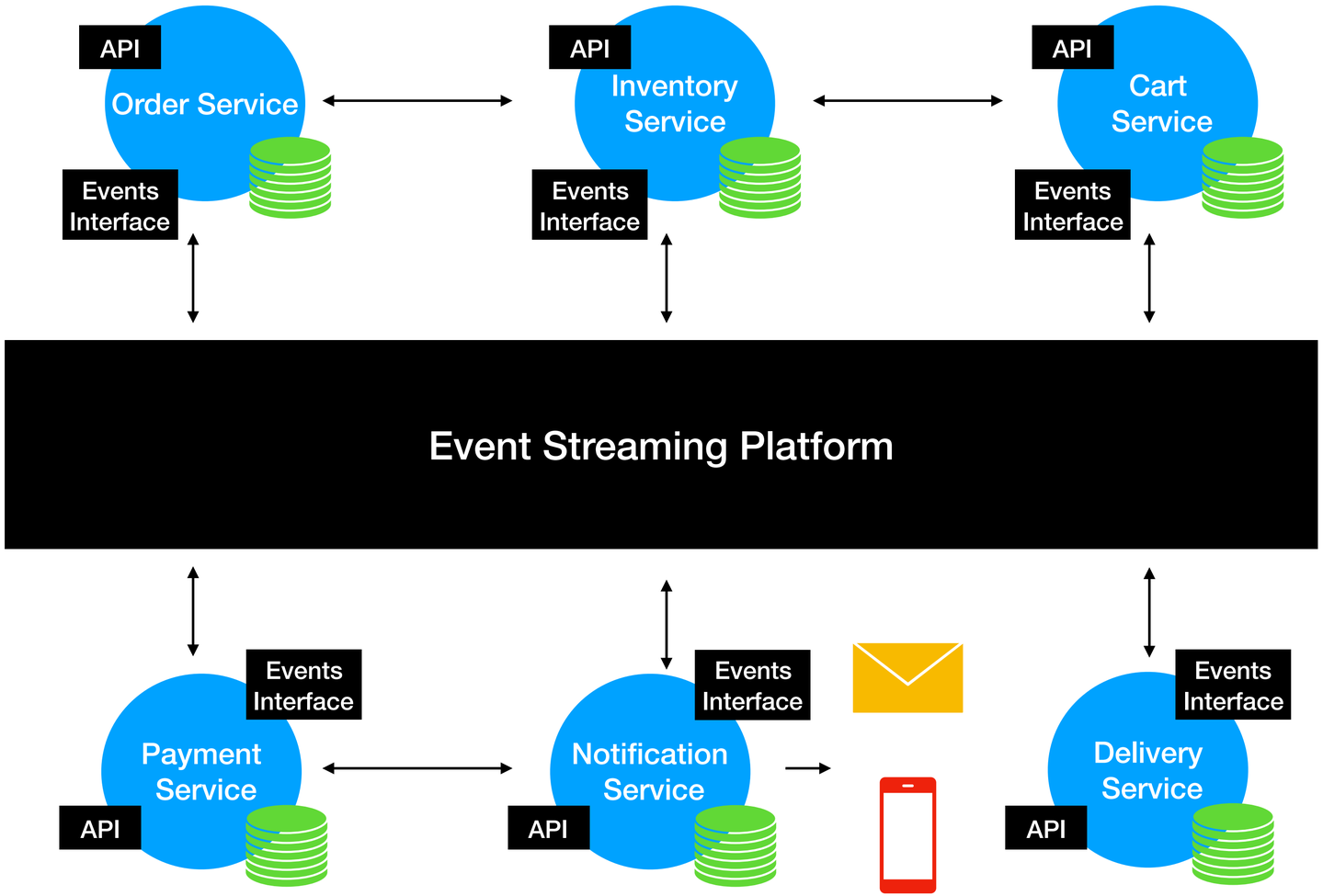
Past



Current



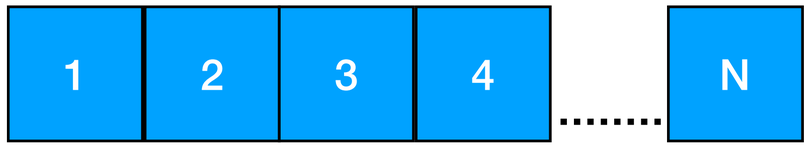
MicroServices Architecture



What is an Event Streaming Platform?

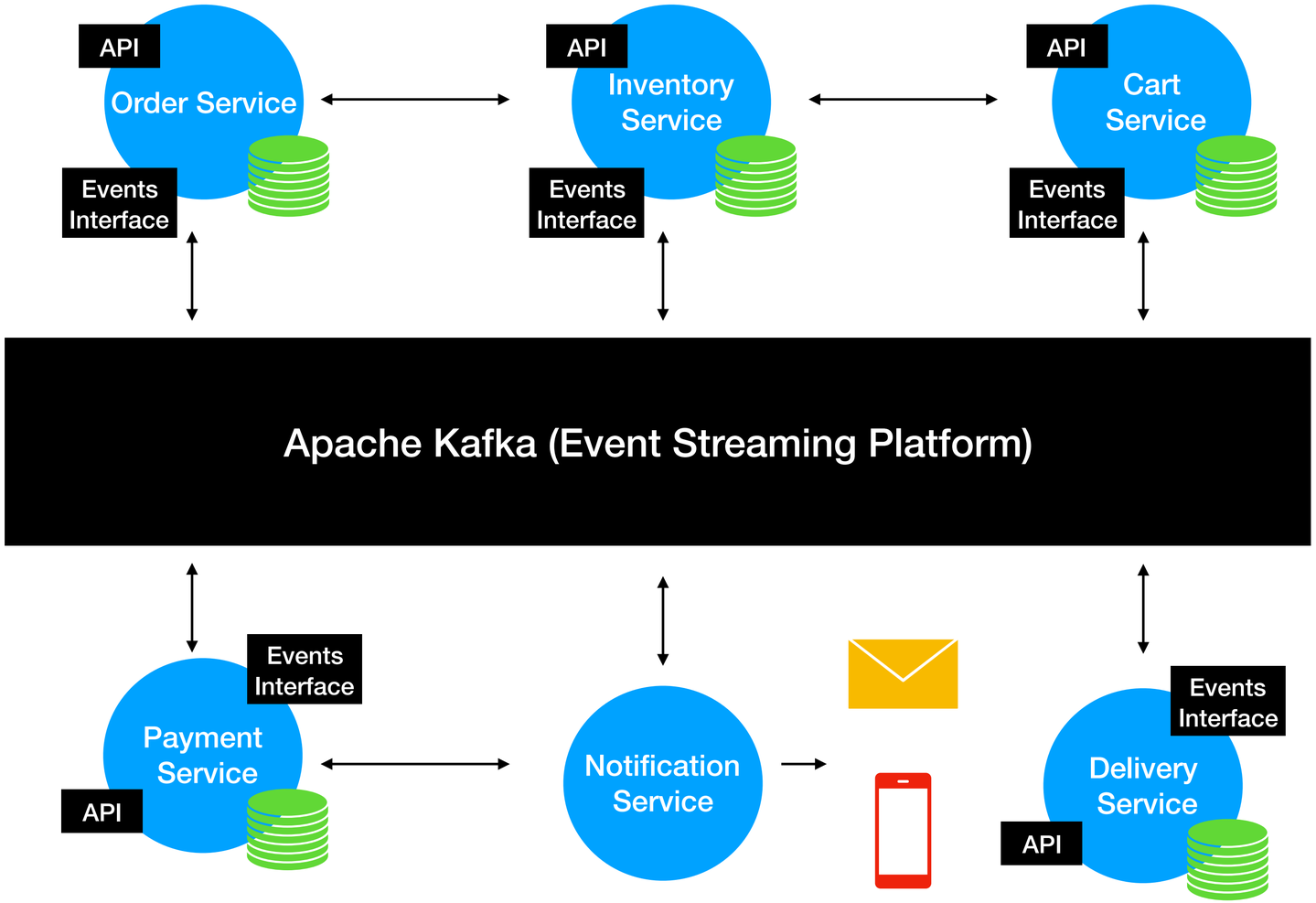
- Producers and Consumers subscribe to a stream of records

- Store stream of Events



- Analyze and Process Events as they occur

Apache Kafka (Event Streaming Platform)



Traditional Messaging System

- Transient Message Persistance
- Brokers responsibility to keep track of consumed messages
- Target a specific Consumer
- Not a distributed system

Kafka Streaming Platform

- Stores events based on a retention time. Events are Immutable
- Consumers Responsibility to keep track of consumed messages
- Any Consumer can access a message from the broker
- It’s a distributed streaming system

Kafka Use Cases

Transportation

Driver-Rider Notifications

Food Delivery Notifications

Retail

Sale Notifications

RealTime Purchase recommendations

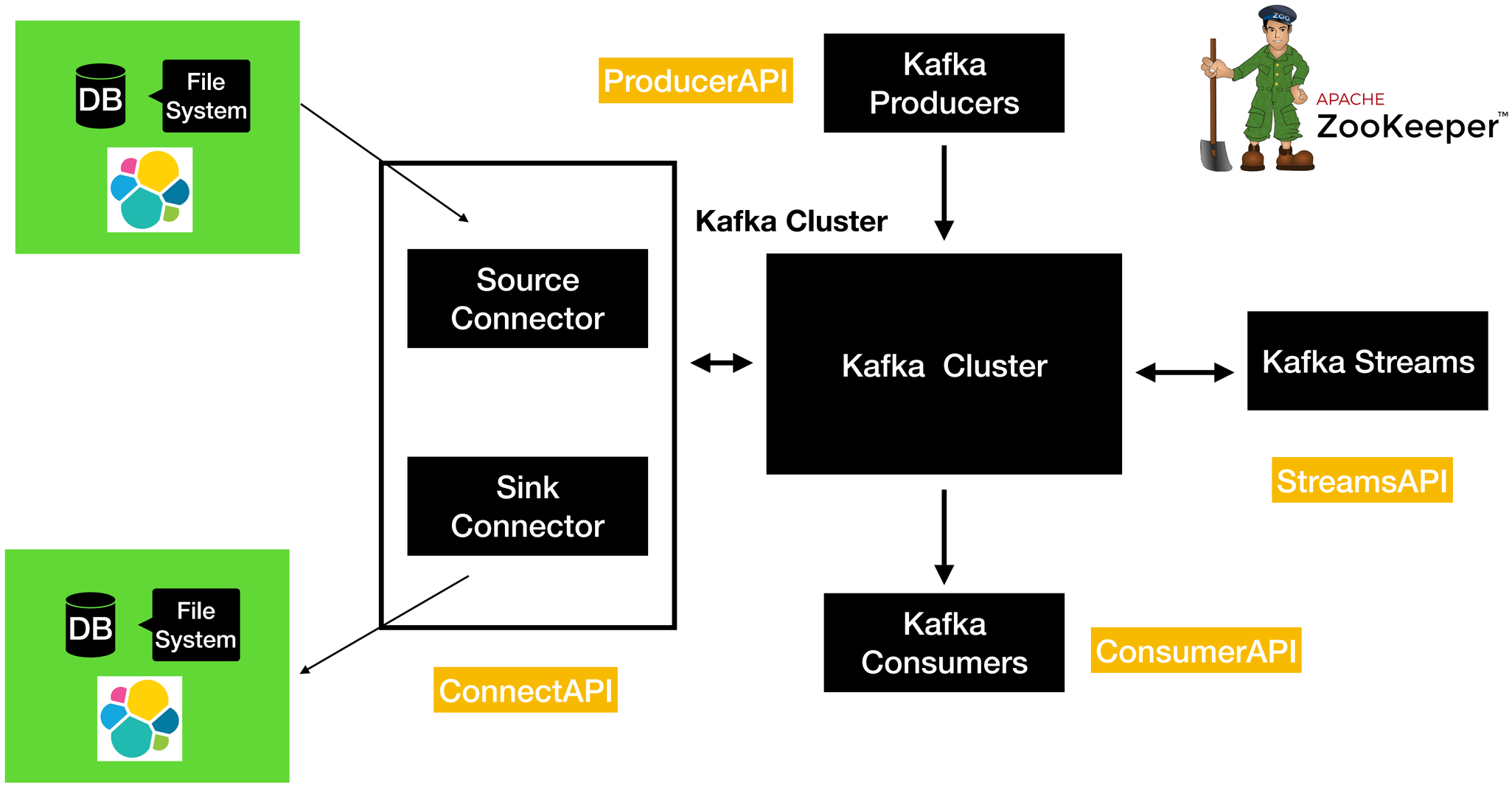
Tracking Online Order Deliveries

Banking

Fraud Transactions

New Feature/Product notifications

Kafka Terminology & Client APIs



Download Kafka

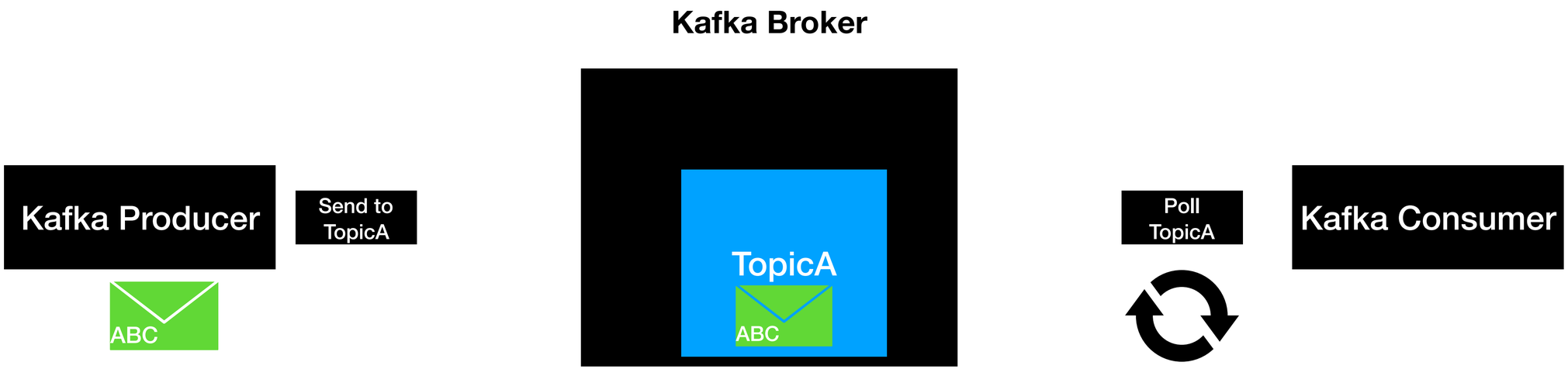
Kafka Topics
&
Partitions

Kafka Topics

- Topic is an **Entity** in Kafka with a name

Kafka Topics

- Topic is an **Entity** in Kafka with a name

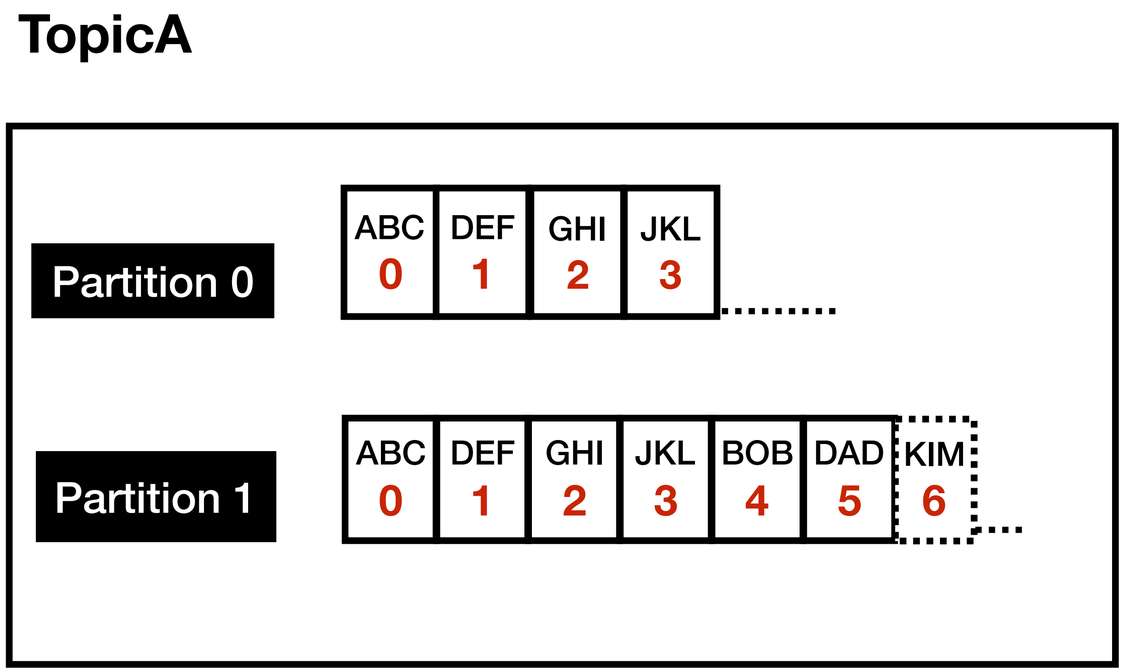


Topic and Partitions

- Partition is where the message lives inside the topic

- Each Topic will be create with one or more partitions

Topic and Partitions



- Each Partition is an ordered , immutable sequence of records

- Each record is assigned a sequential number called ***offset***

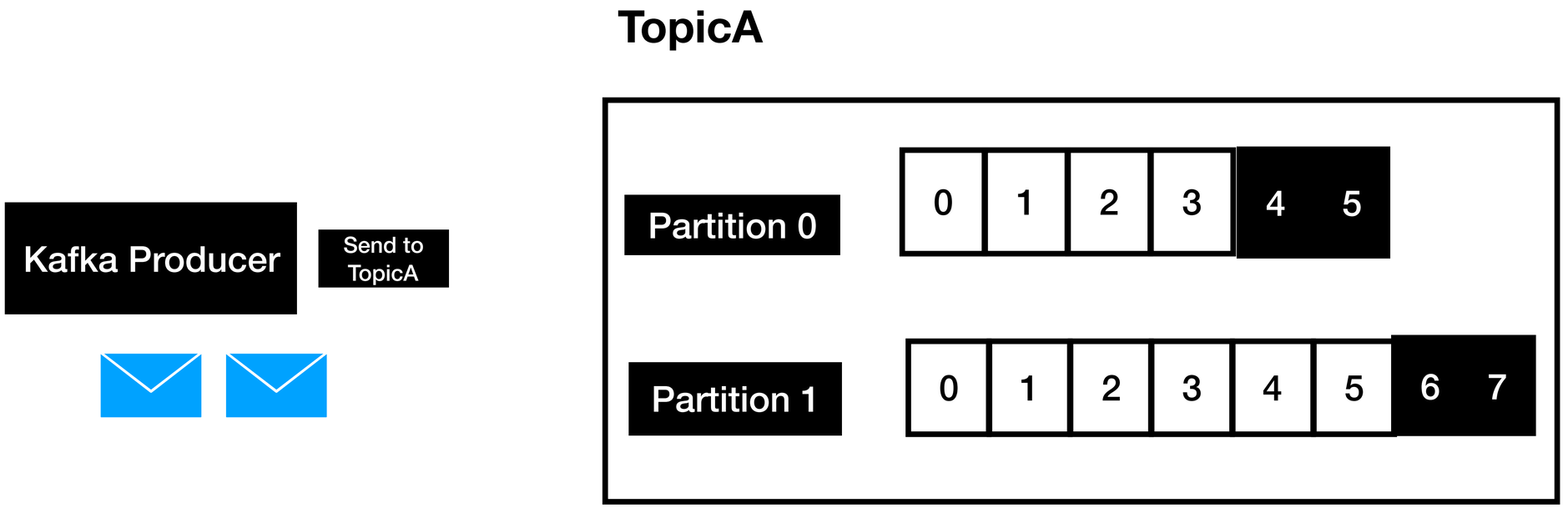
- Each partition is independent of each other

- Ordering is guaranteed only at the partition level

- Partition continuously grows as new records are produced

- All the records are persisted in a commit log in the file system where Kafka is installed

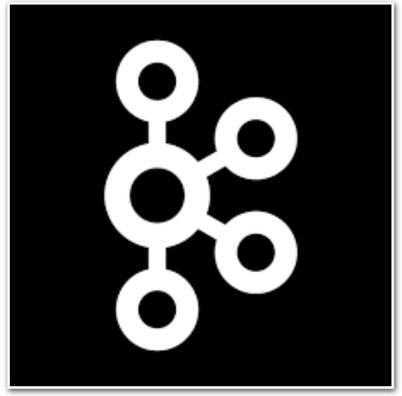
Topics and Partitions



Setting up Zookeeper & Kafka Broker

Setting up Kafka in Local

APACHE
ZooKeeper™



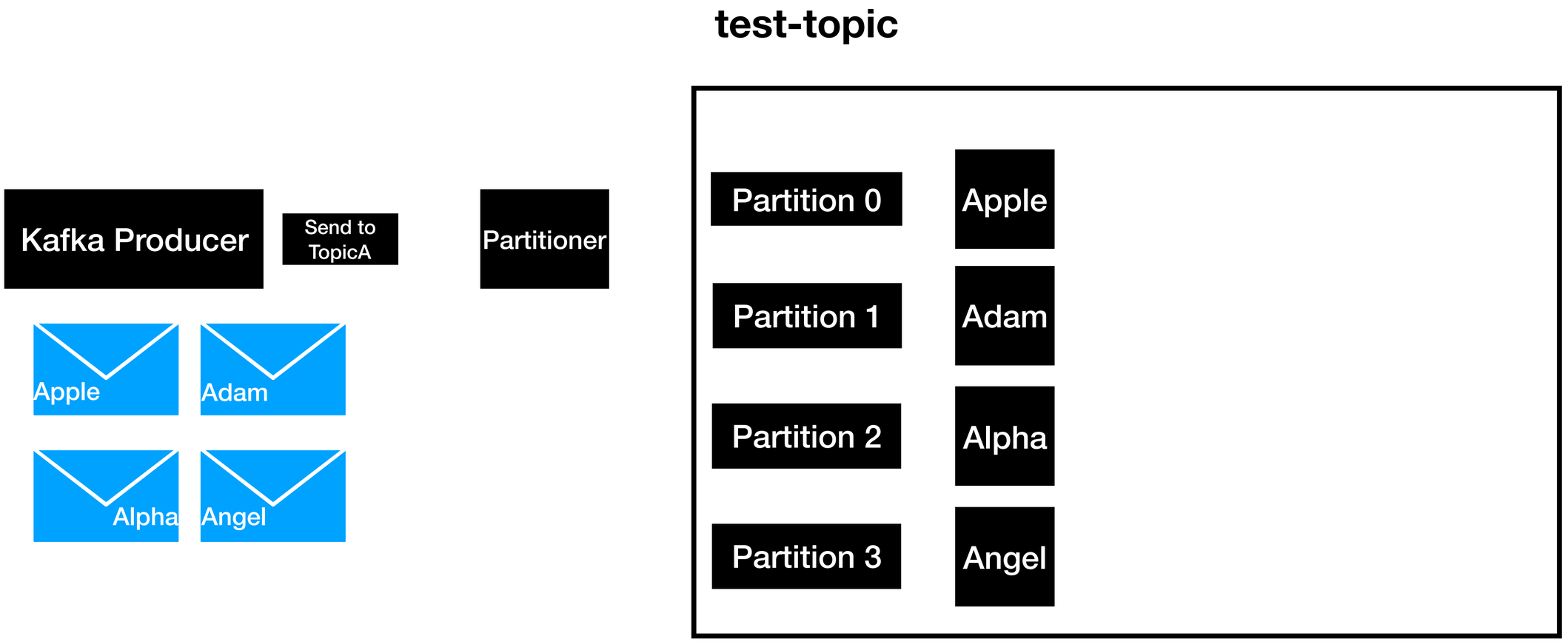
Broker registered with zookeeper

Sending Kafka Messages With Key and Value

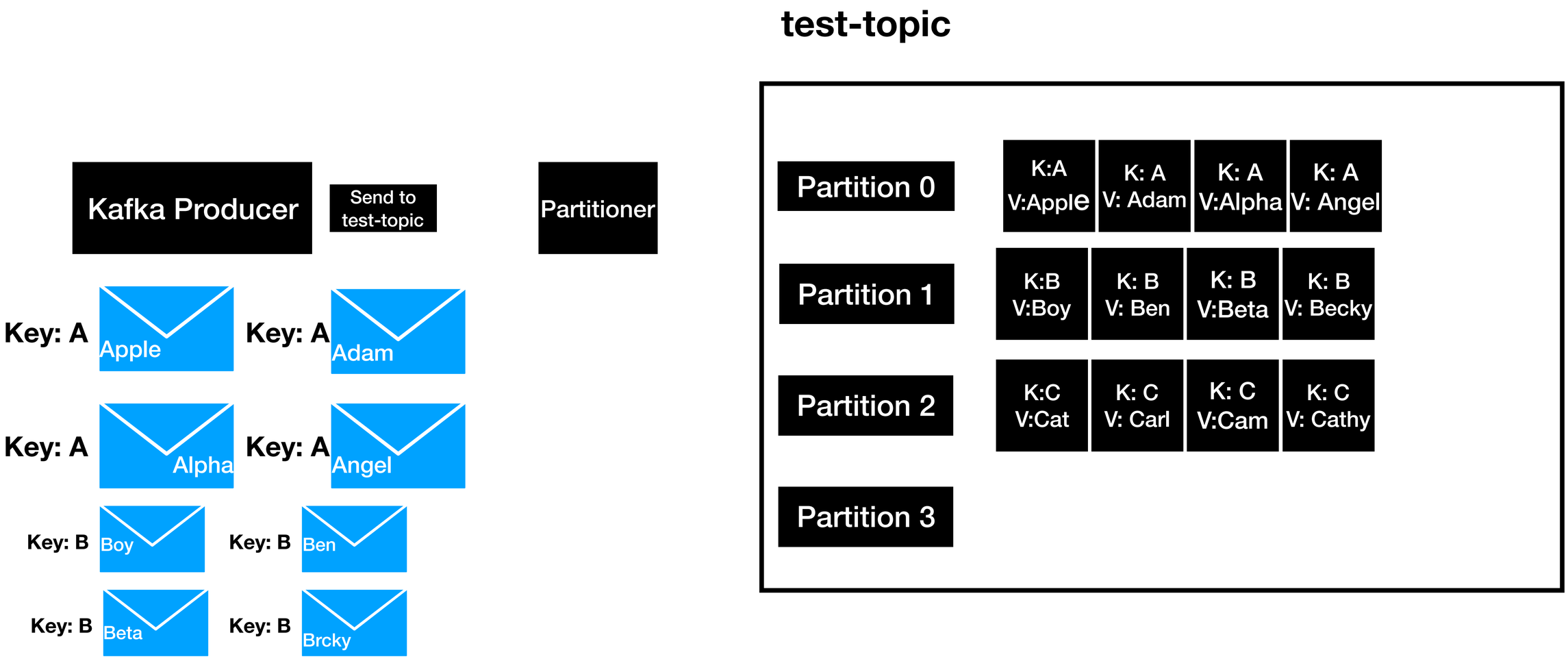
Kafka Message

- Kafka Message these sent from producer has two properties
  - Key (optional)
  - Value

Sending Message Without Key



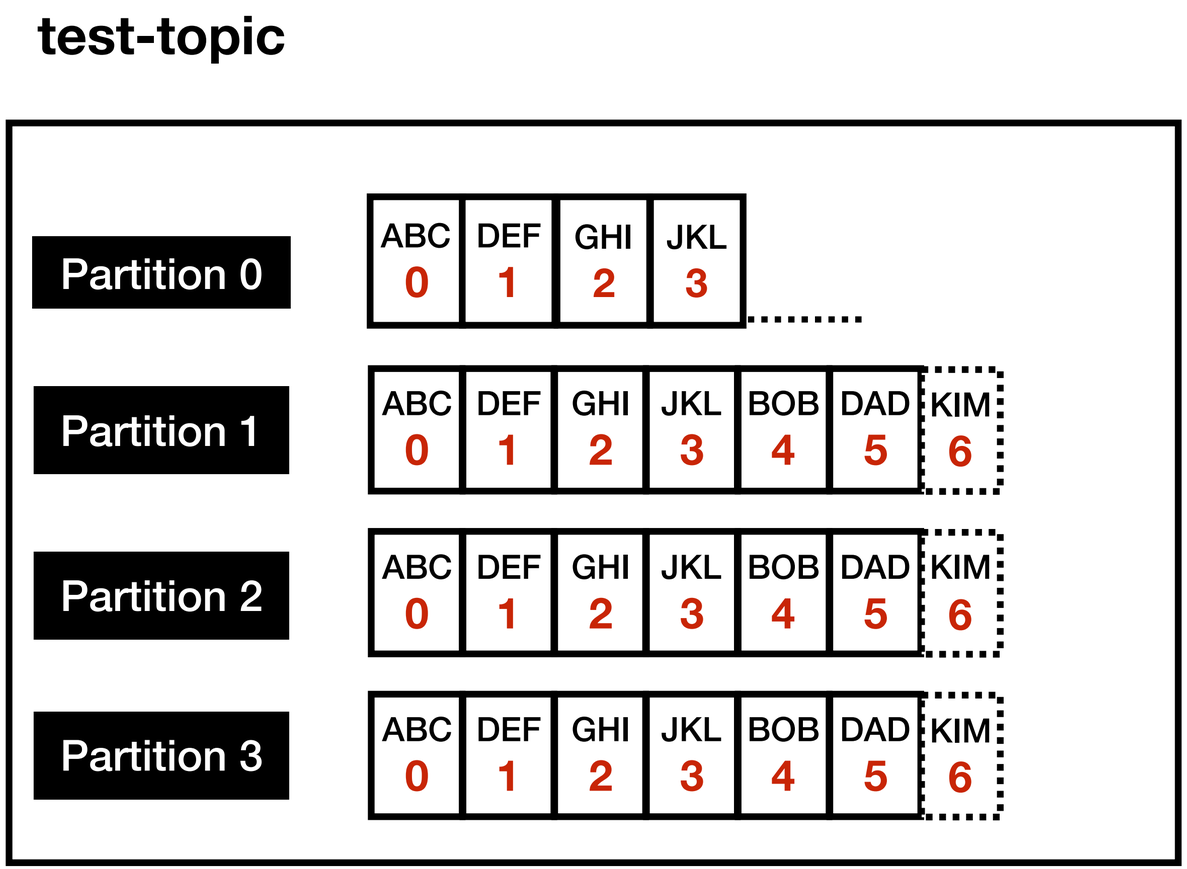
Sending Message With Key



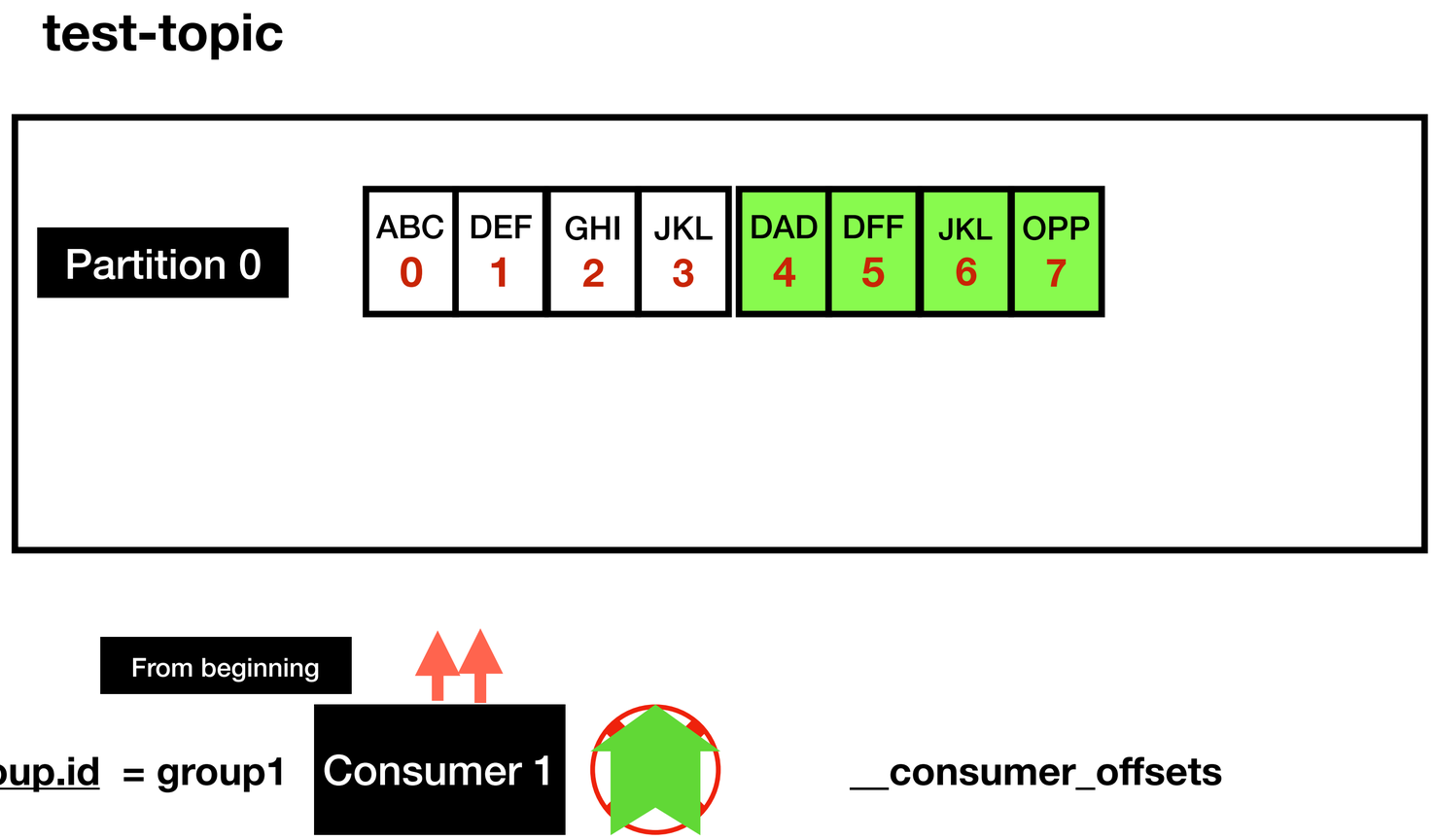
Consumer Offsets

Consumer Offsets

- Consumer have three options to read
  - from-beginning
  - latest
  - specific offset

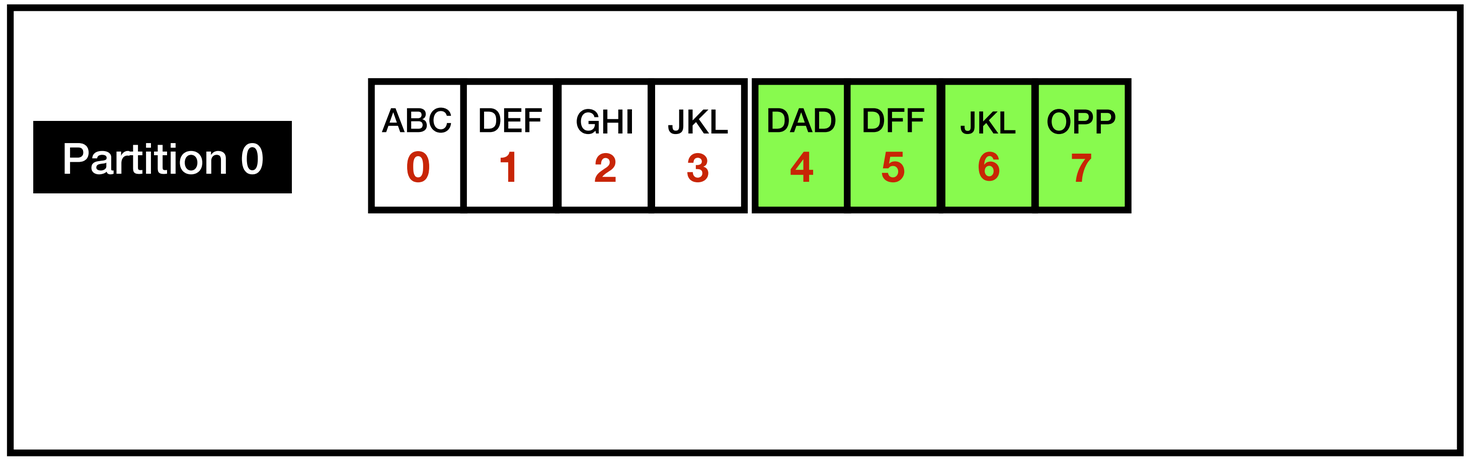


Consumer Offsets



Consumer Offsets

test-topic



From beginning

group.id = group1

Consumer 1

__consumer_offsets

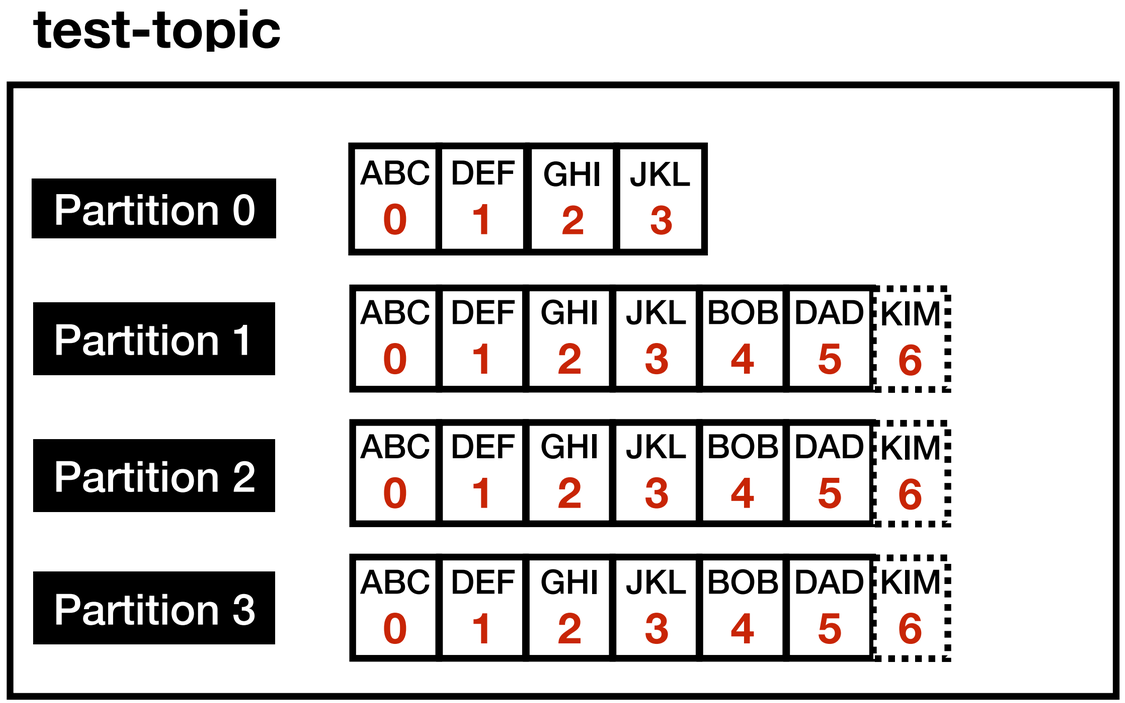
Consumer Offset

- Consumer offsets behaves like a bookmark for the consumer to start reading the messages from the point it left off.

Consumer Groups

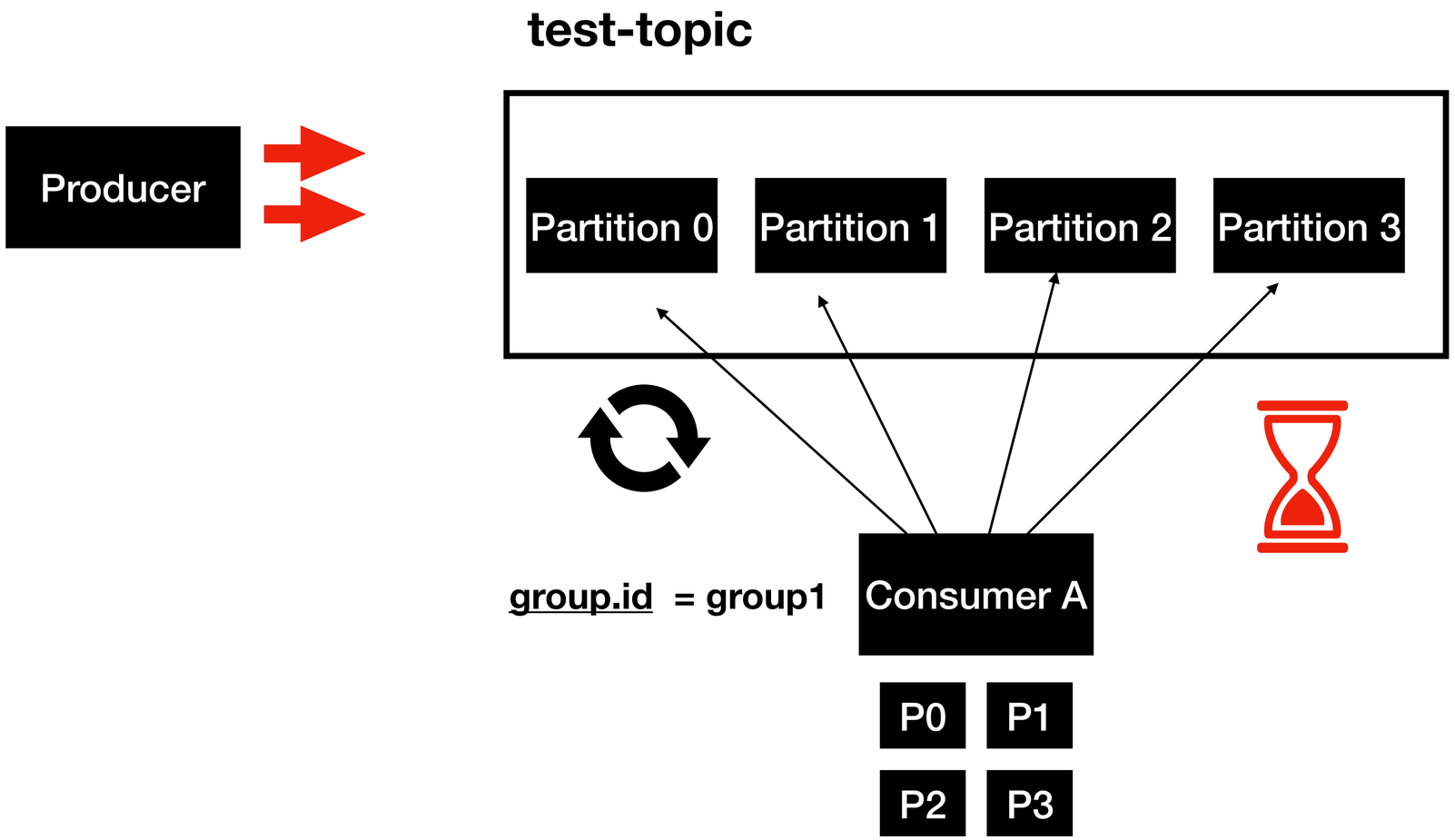
Consumer Groups

- **group.id** is mandatory
- **group.id** plays a major role when it comes to scalable message consumption.

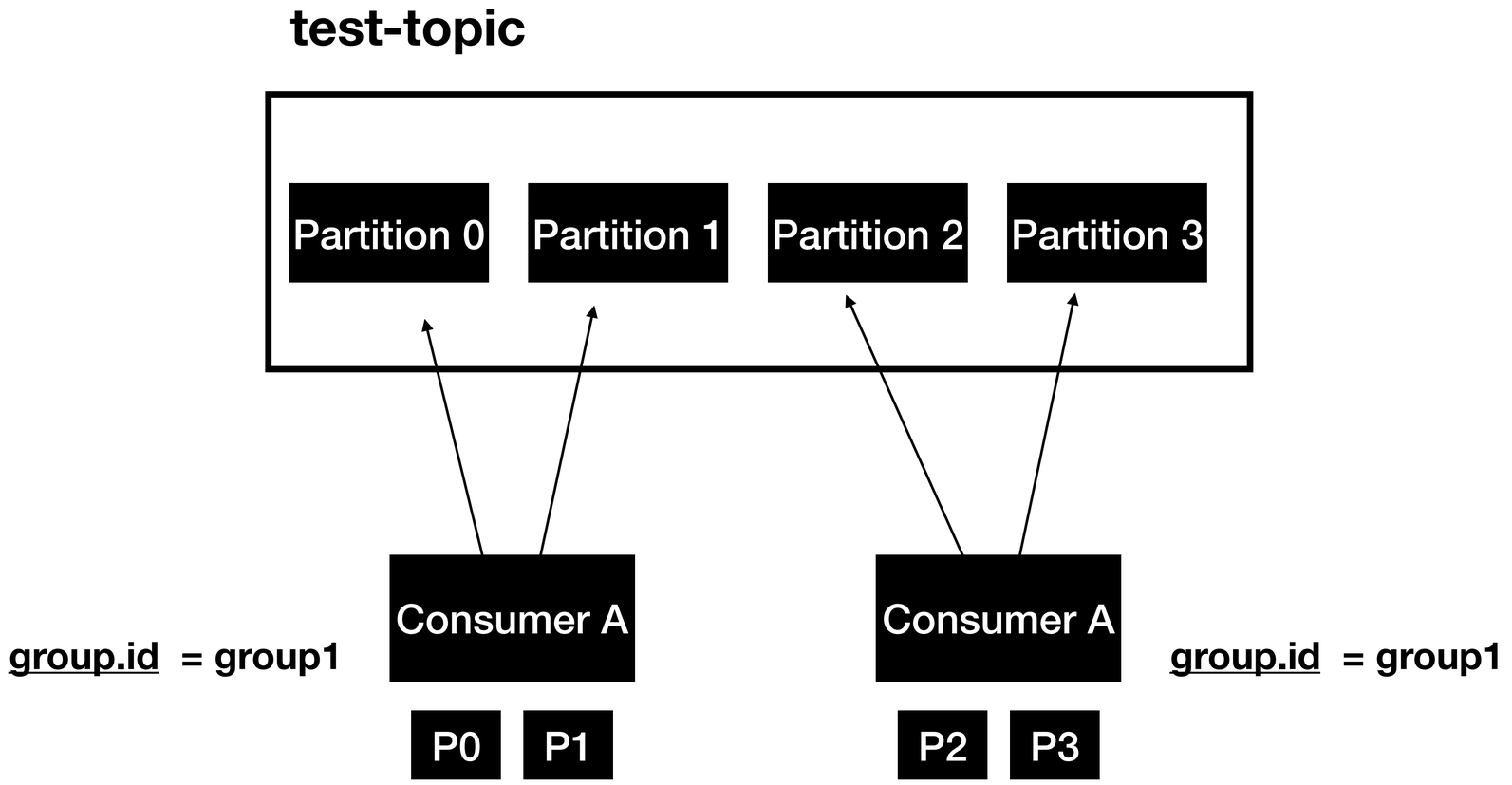


group.id = group1 Consumer 1

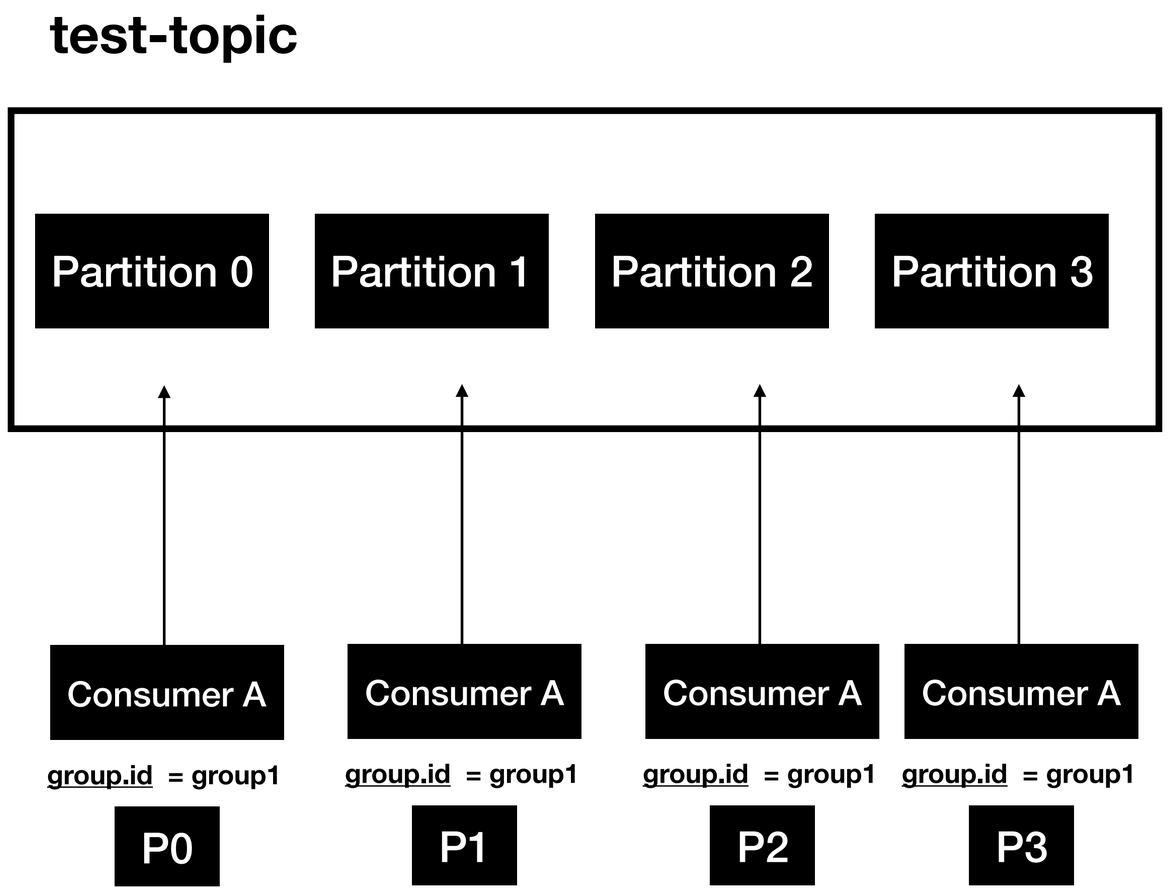
Consumer Groups



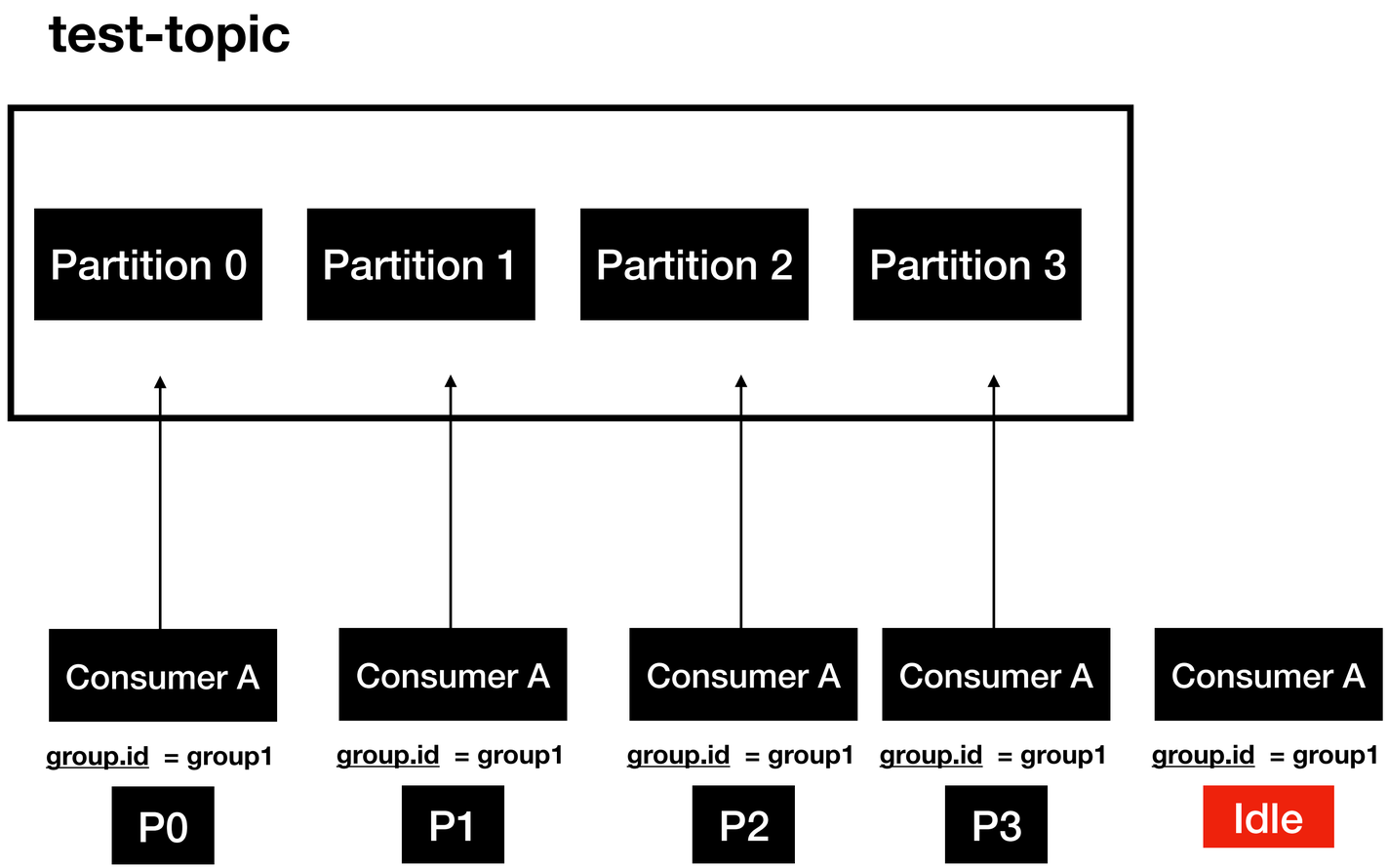
Consumer Groups



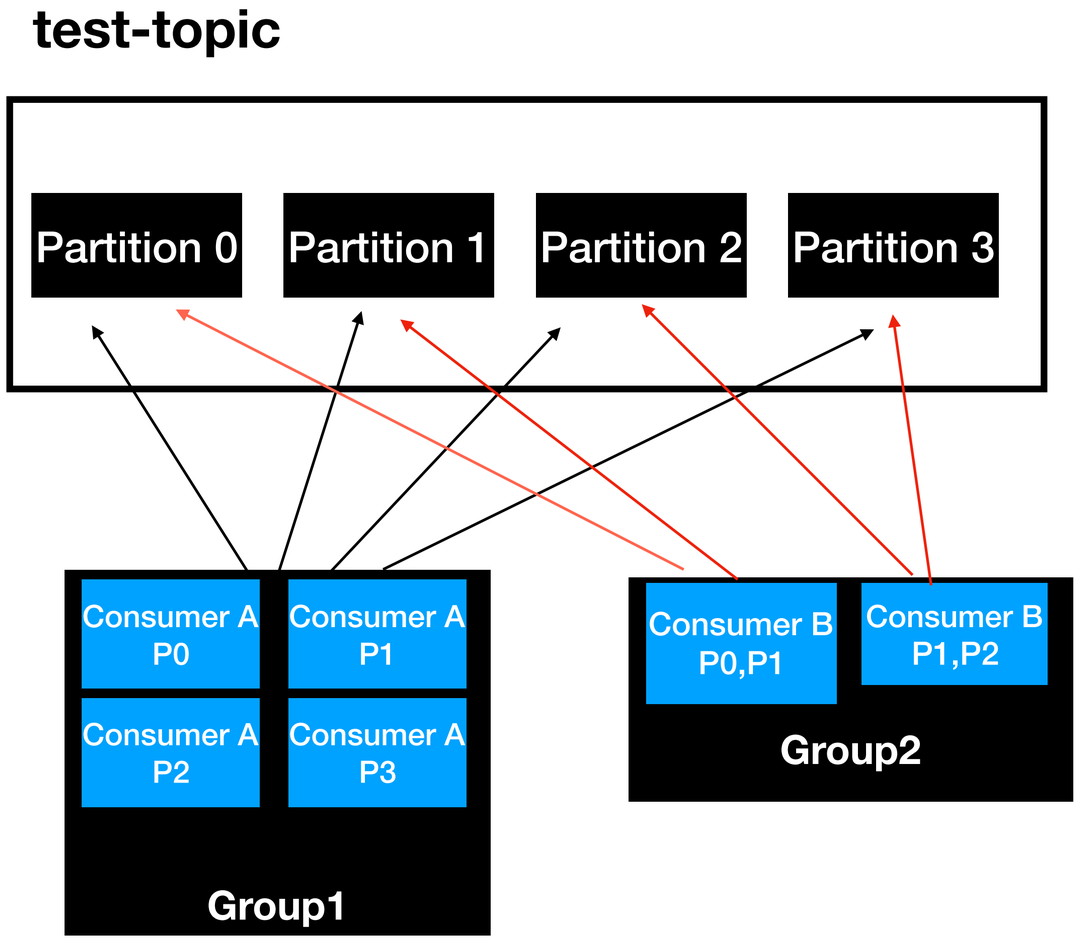
Consumer Groups



Consumer Groups



Consumer Groups

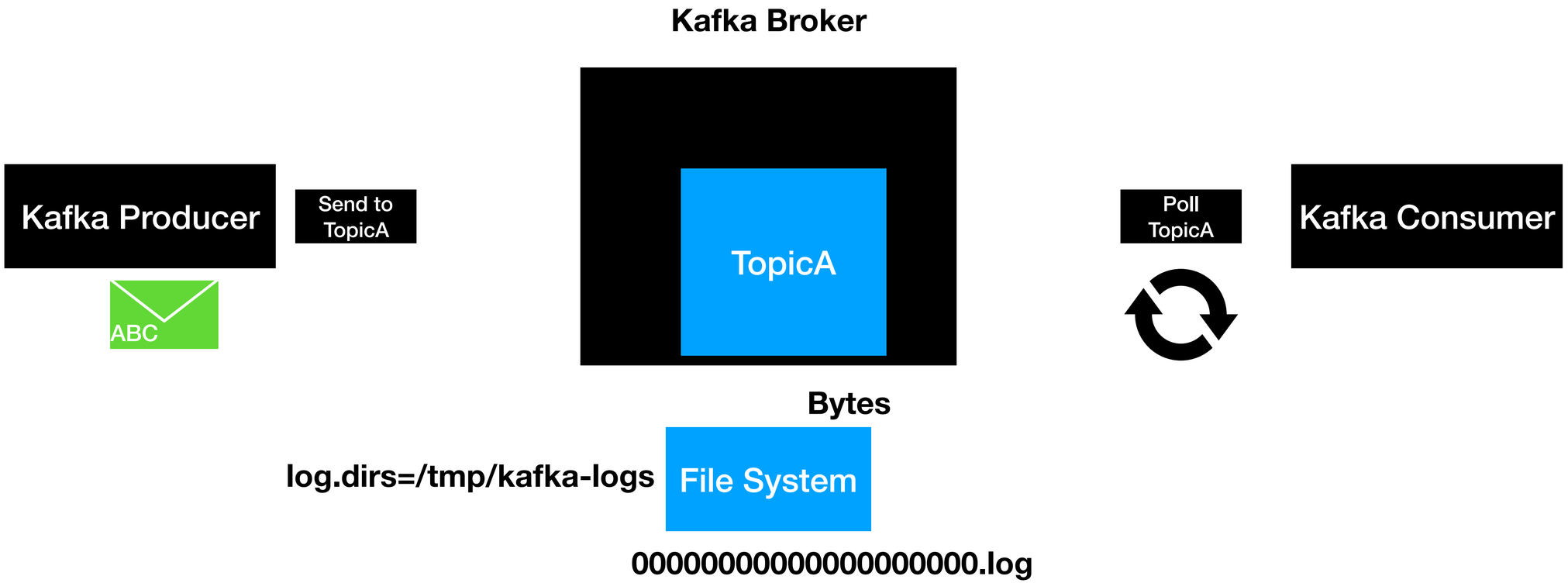


Consumer Groups : Summary

- Consumer Groups are used for scalable message consumption
- Each different application will have a unique consumer group
- Who manages the consumer group?
  - Kafka Broker manages the consumer-groups
  - Kafka Broker acts as a Group Co-ordinator

Commit Log
&
Retention Policy

Commit Log


Kafka Broker
Kafka Producer
Send to TopicA
ABC
TopicA
Poll TopicA
Kafka Consumer
Bytes
log.dirs=/tmp/kafka-logs
File System
00000000000000000000.log

Retention Policy

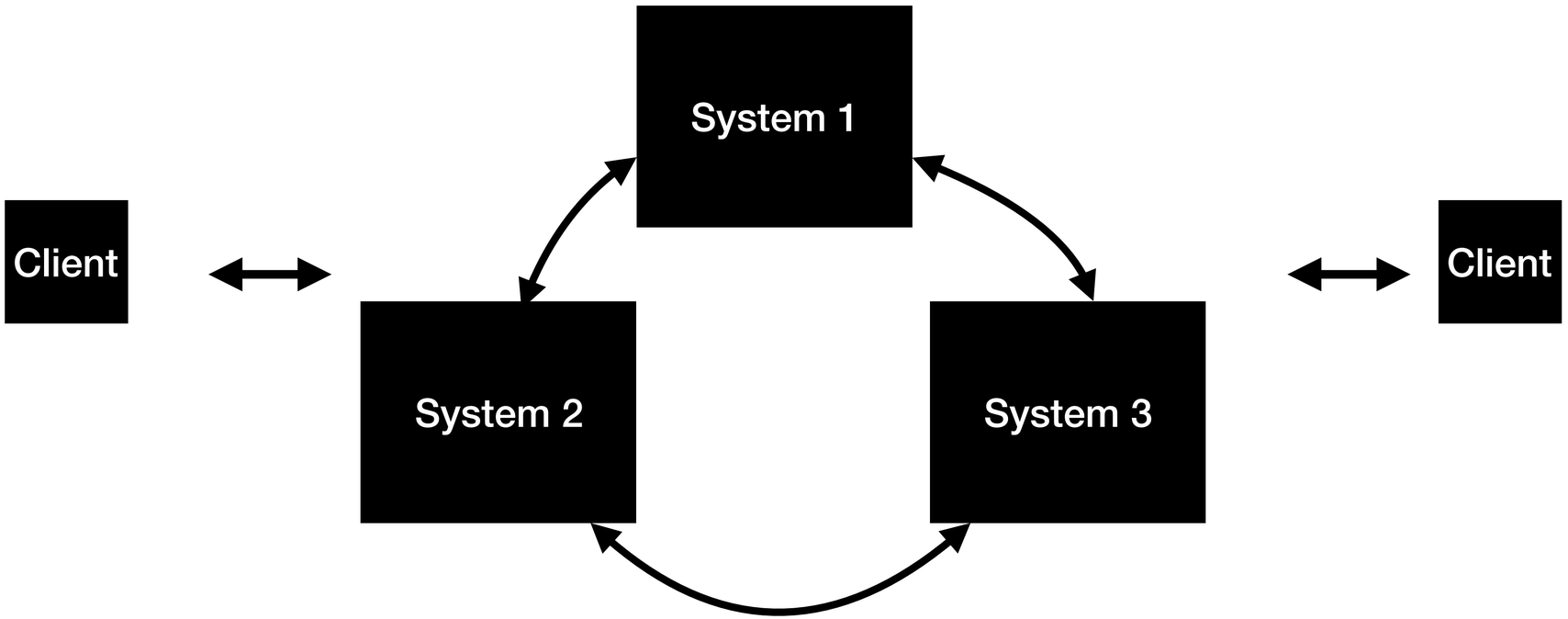
- Determines how long the message is retained ?
- Configured using the property **log.retention.hours** in **server.properties** file
- Default retention period is **168 hours** (7 days)

Kafka
as a
Distributed Streaming System

Apache Kafka® is *a distributed streaming platform*

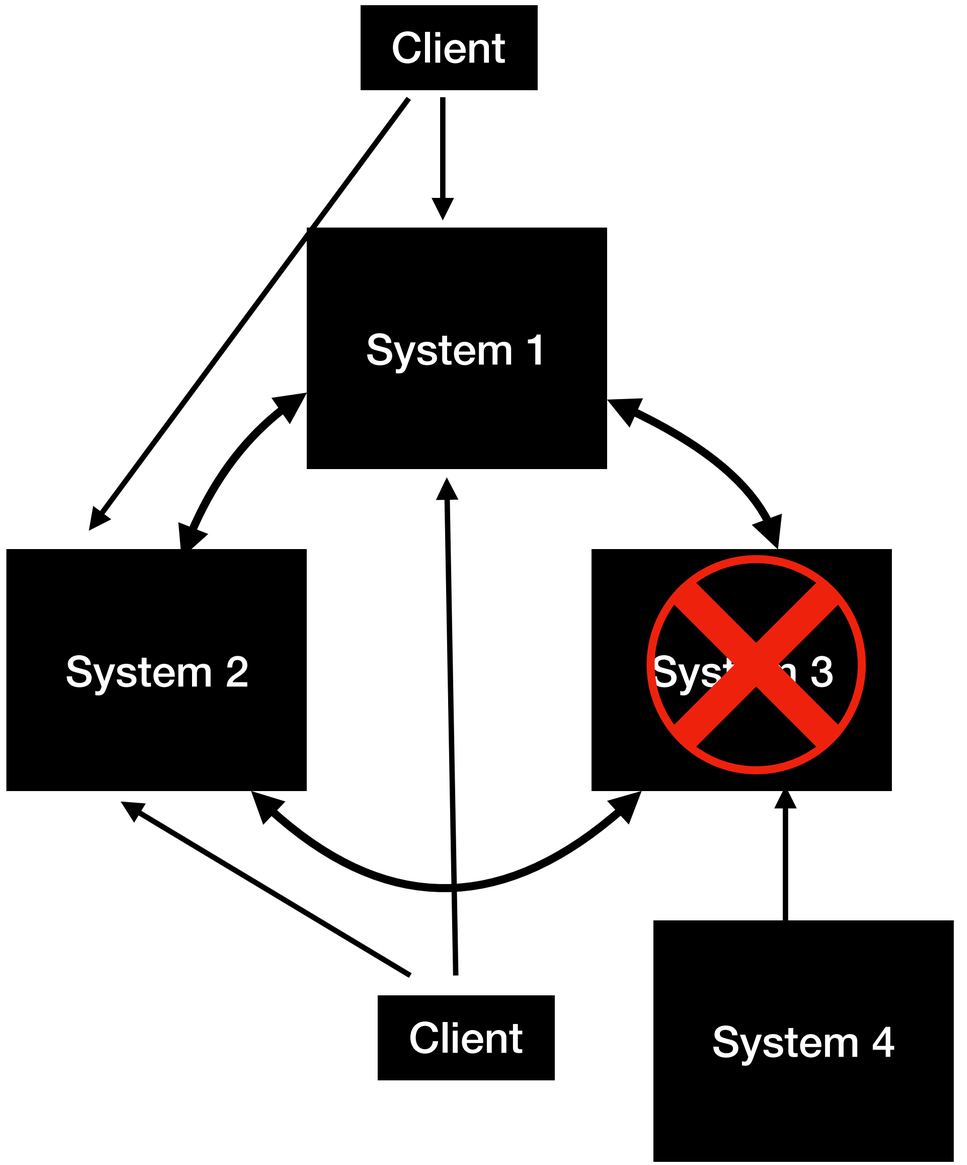
What is a Distributed System?

- Distributed systems are a collection of systems working together to deliver a value

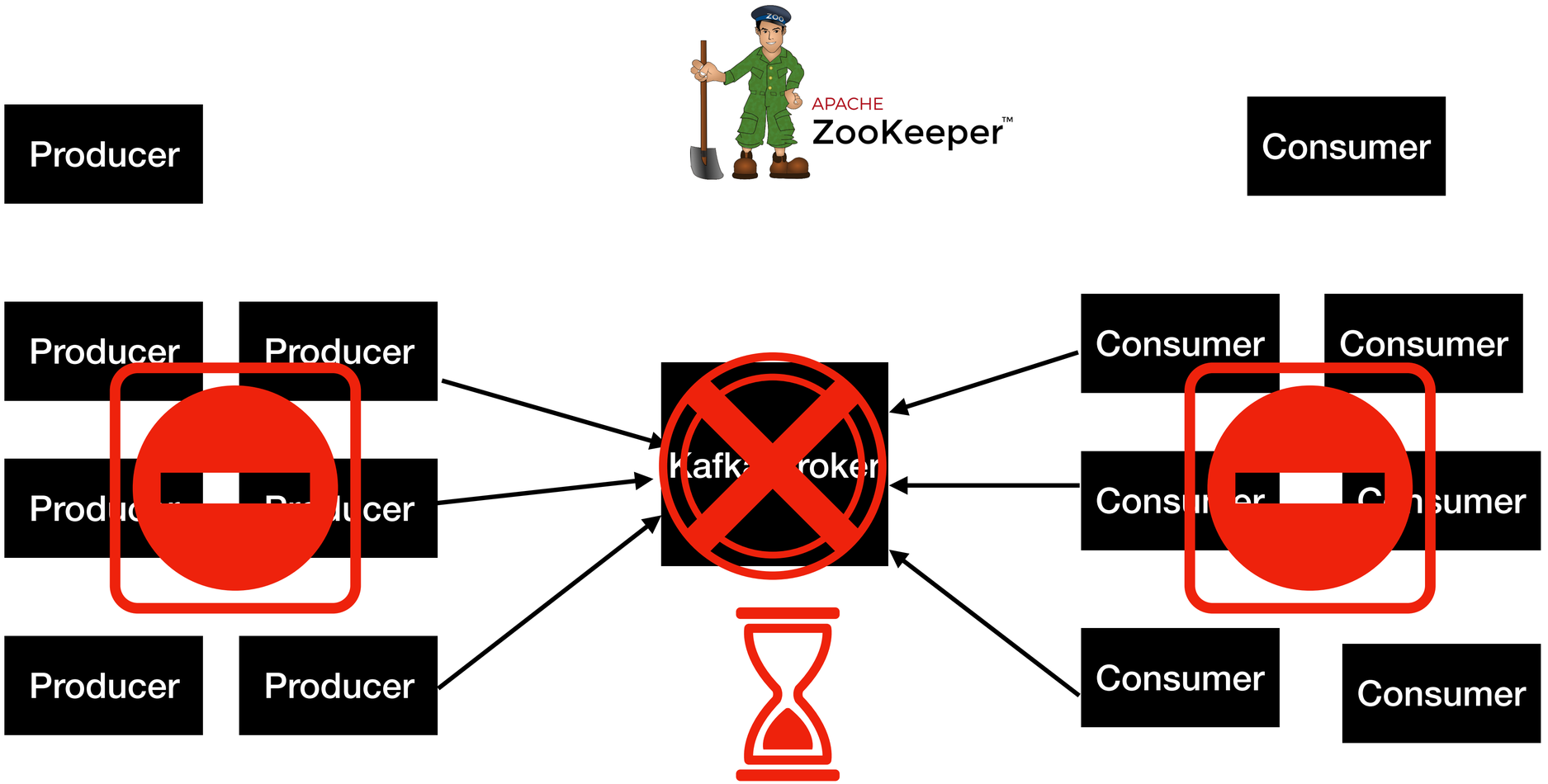


Characteristics of Distributed System

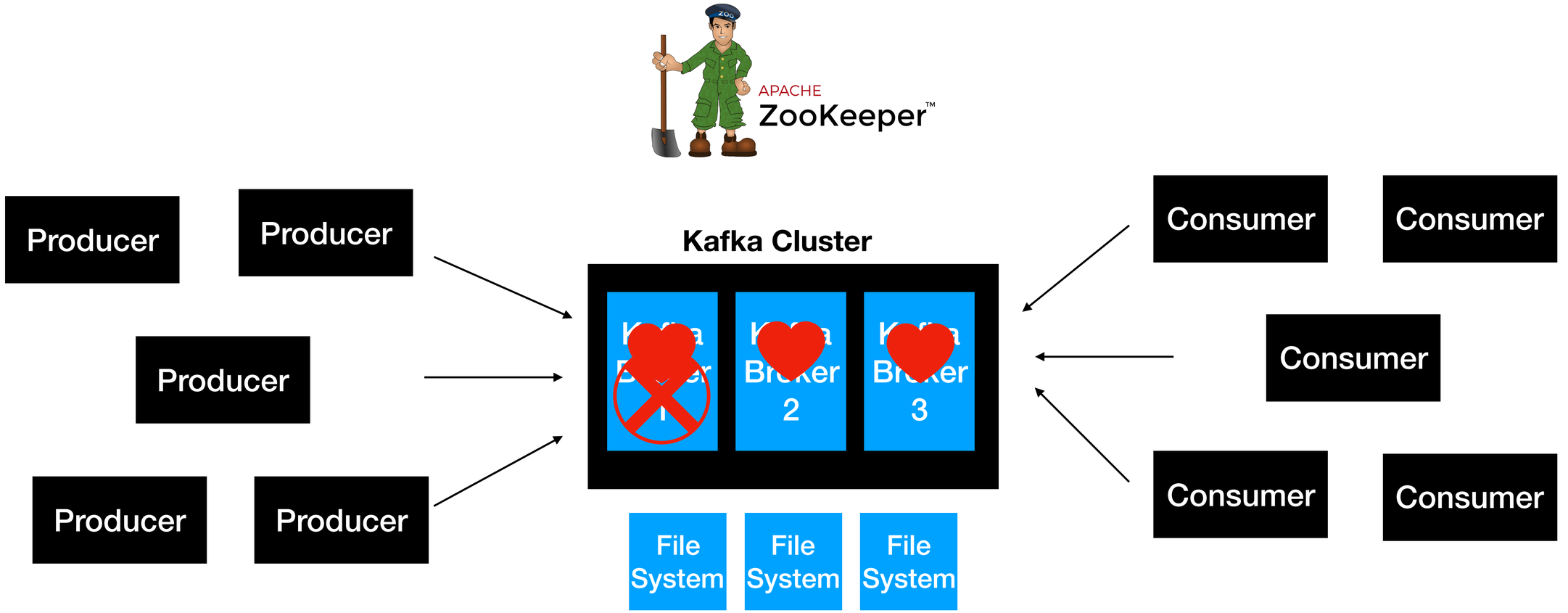
- Availability and Fault Tolerance
- Reliable Work Distribution
- Easily Scalable
- Handling Concurrency is fairly easy



Kafka as a Distributed System



Kafka as a Distributed System



- Client requests are distributed between brokers
- Easy to scale by adding more brokers based on the need
- Handles data loss using Replication

SetUp
Kafka Cluster
Using
Three Brokers

Start Kafka Broker

```
./kafka-server-start.sh ../config/server.properties
```

Setting up Kafka Cluster

- New **server.properties** files with the new broker details.

```
broker.id=<unique-broker-d>
listeners=PLAINTEXT://localhost:<unique-port>
log.dirs=/tmp/<unique-kafka-folder>
auto.create.topics.enable=false(optional)
```

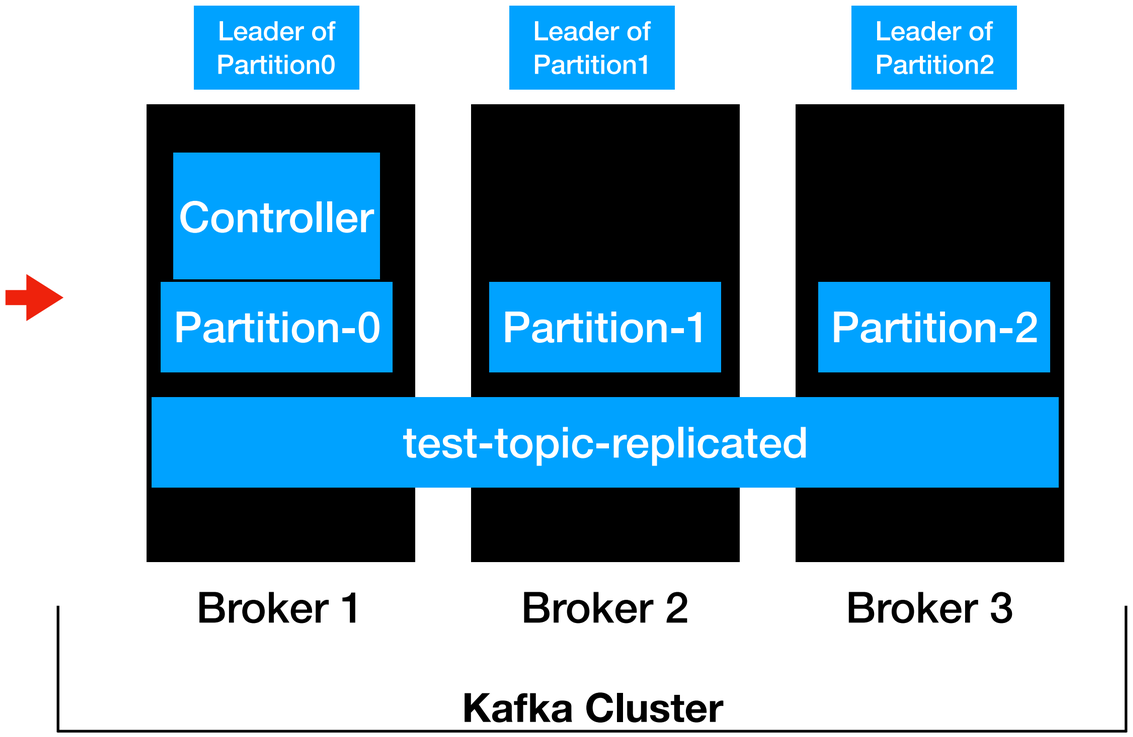
Example: **server-1.properties**

```
broker.id=1
listeners=PLAINTEXT://localhost:9093
log.dirs=/tmp/kafka-logs-1
auto.create.topics.enable=false(optional)
```

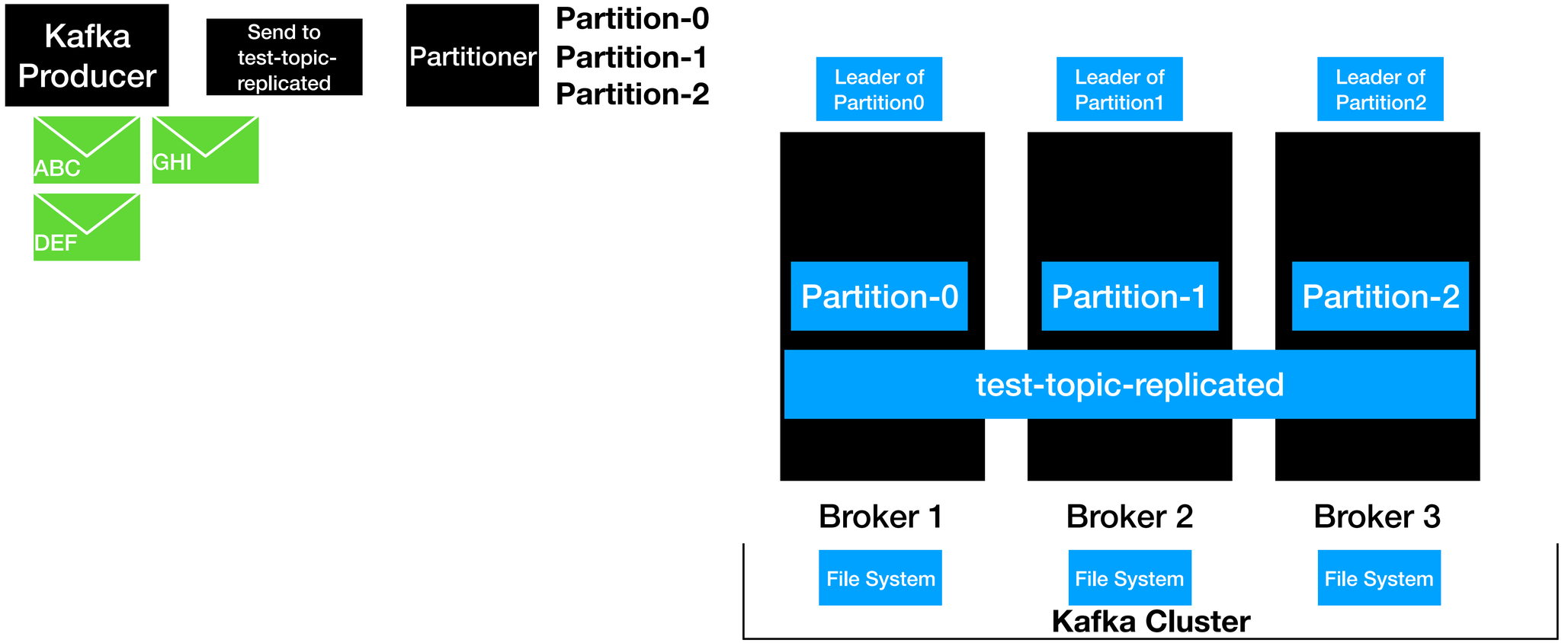
How Kafka Distributes the Client Requests?

How Topics are distributed?

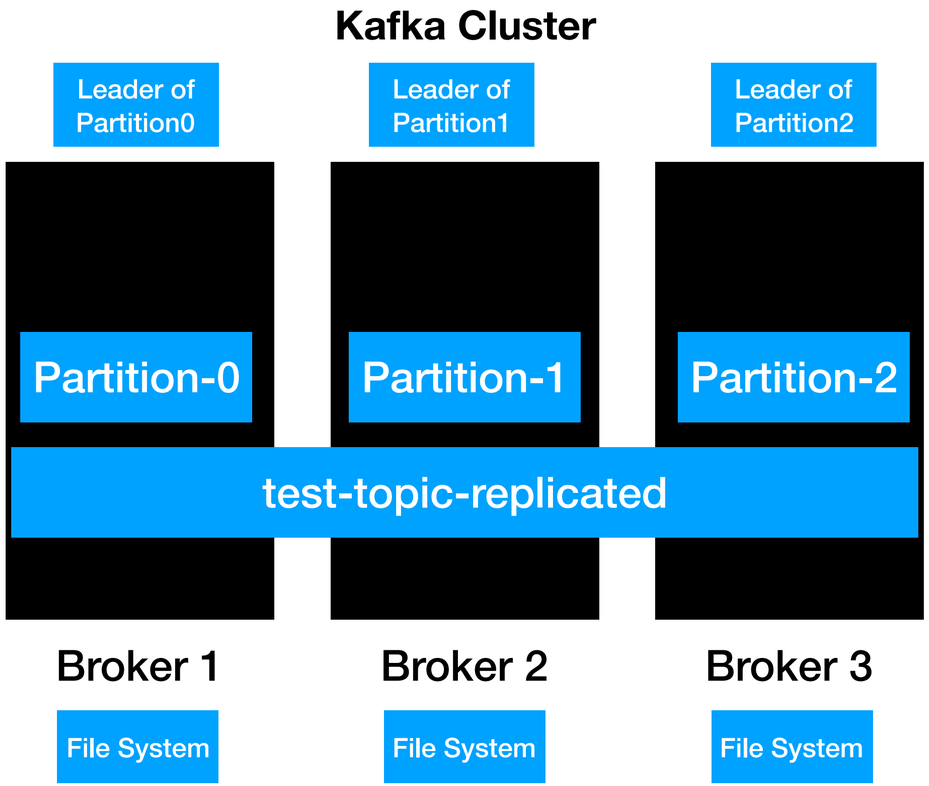
```
./kafka-topics.sh -
-create --topic test-topic-replicated
-zookeeper localhost:2181
--replication-factor 3
 --partitions 3
```

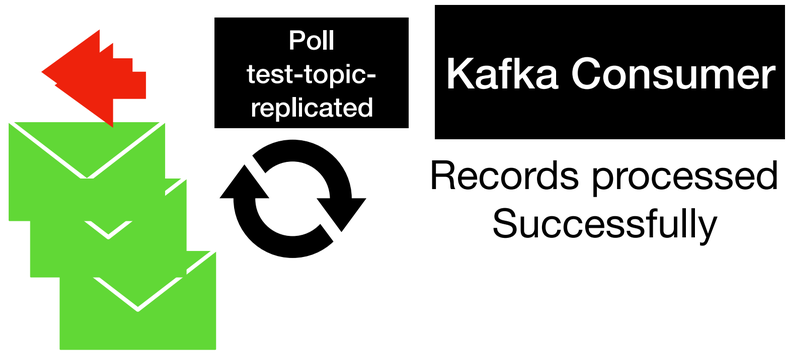


How Kafka Distributes Client Requests?
Kafka Producer

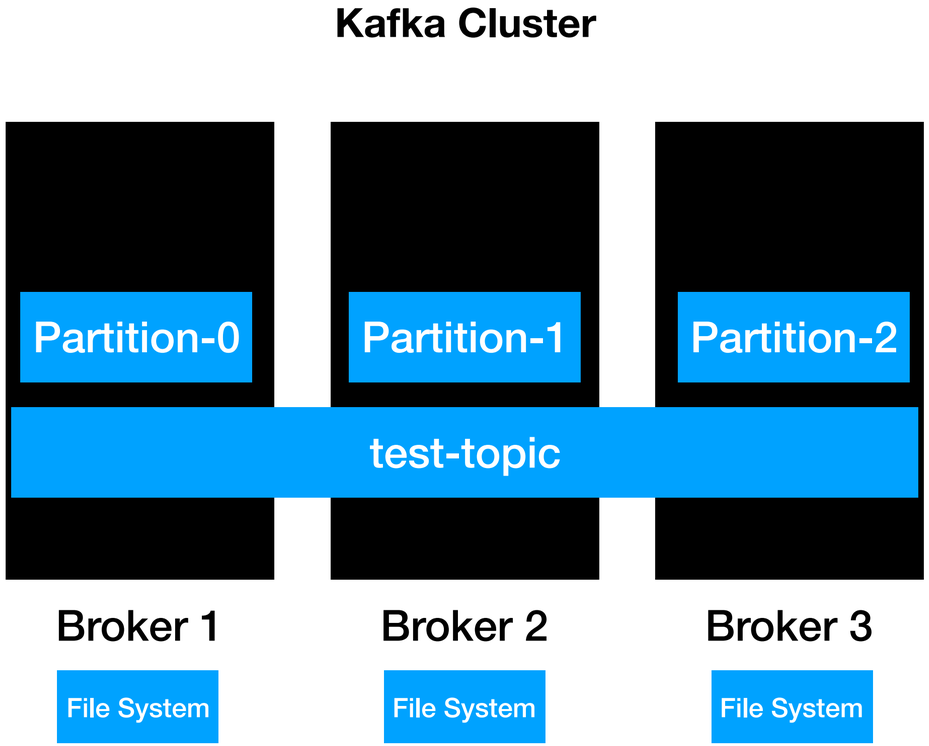


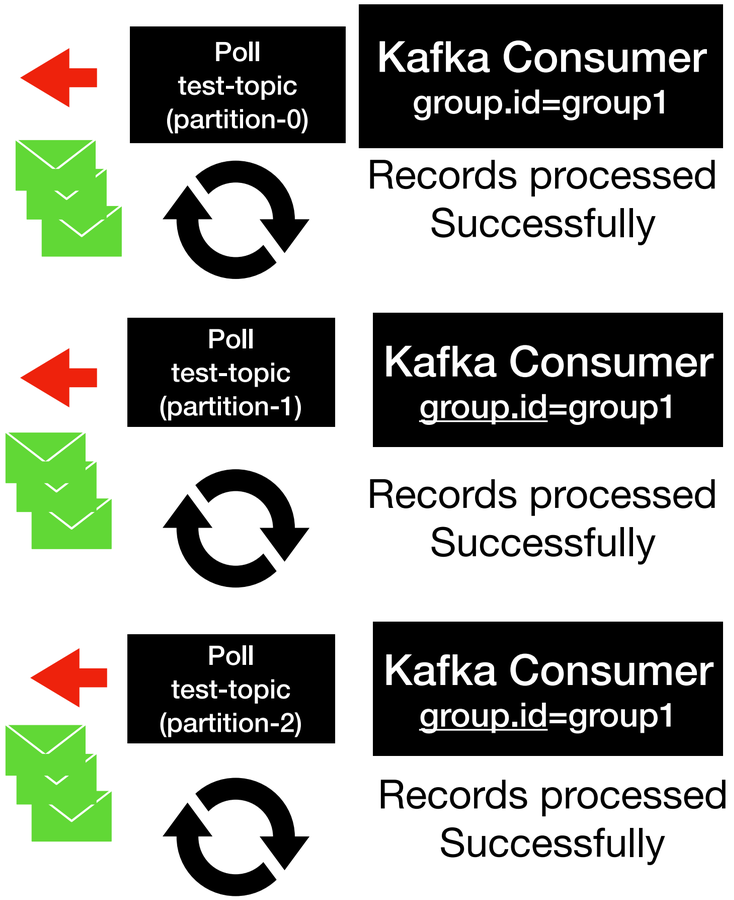
How Kafka Distributes Client Requests?
Kafka Consumer





How Kafka Distributes Client Requests?
Kafka Consumer Groups



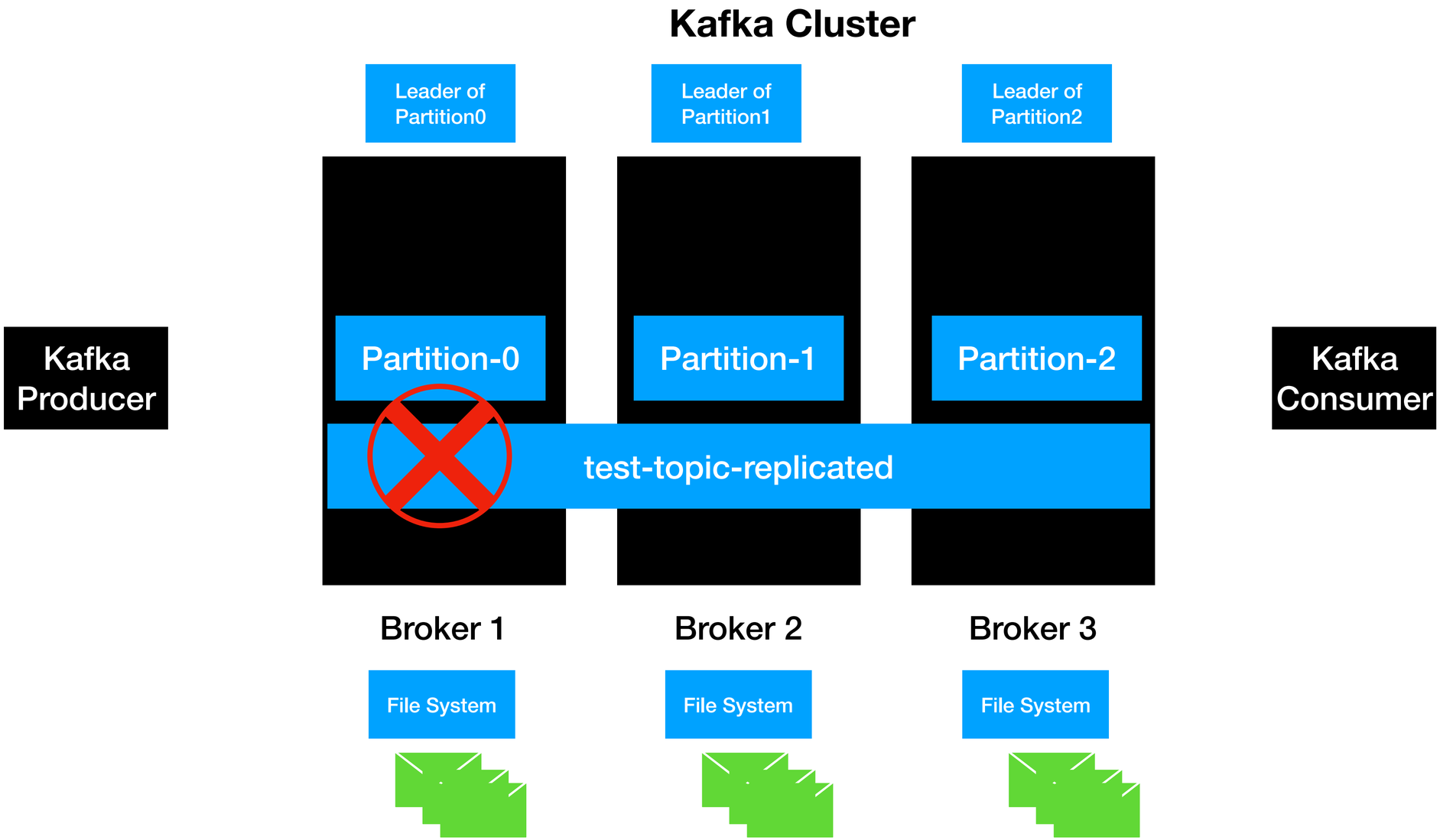


Summary : How Kafka Distributes the Client Requests?

- Partition leaders are assigned during topic Creation
- Clients will only invoke leader of the partition to produce and consume data
    - Load is evenly distributed between the brokers

How Kafka handles Data Loss ?

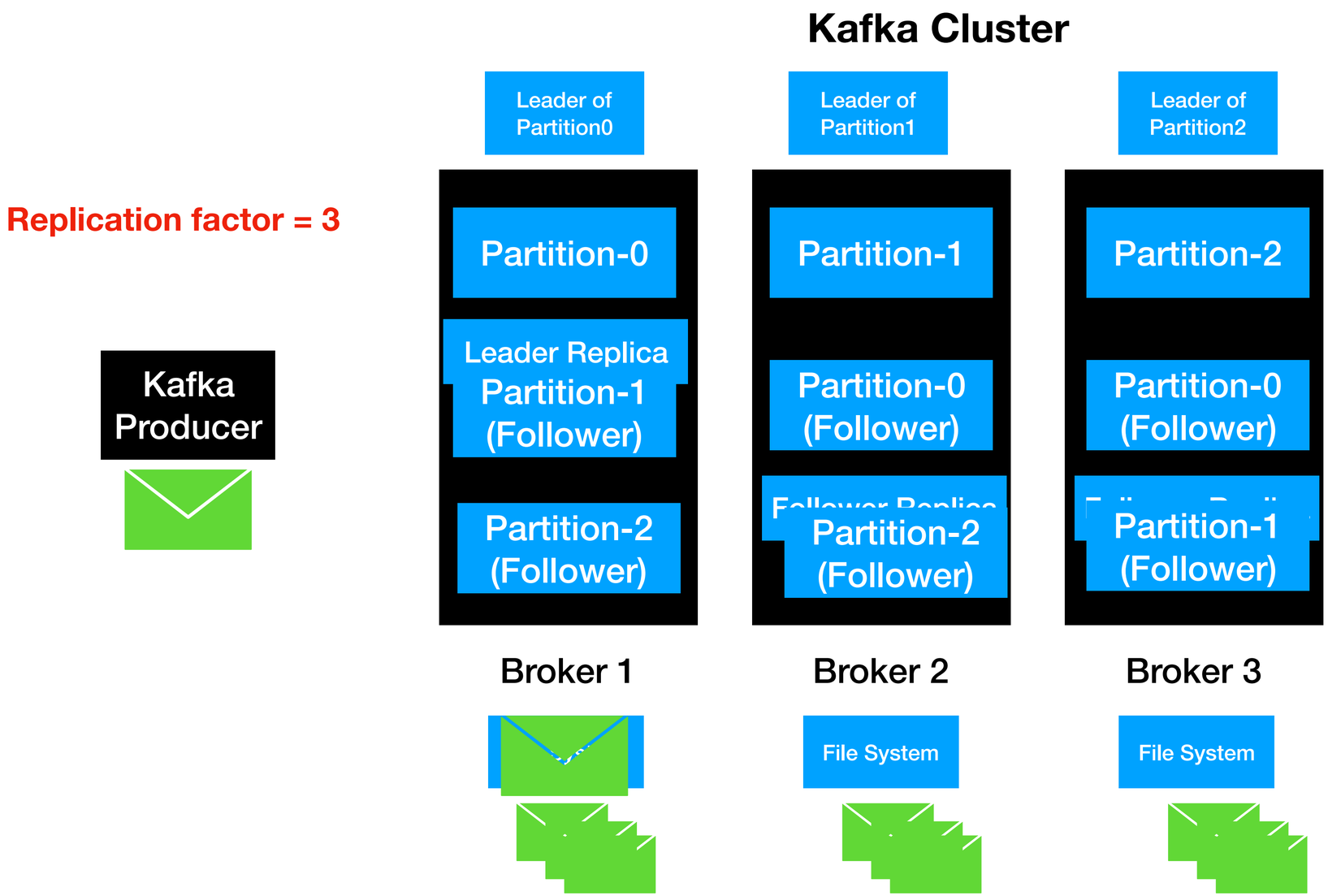
How Kafka handles Data loss?



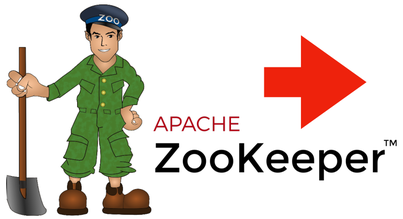
Replication

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

Replication



Replication



Kafka Cluster

Leader of Partition0

Leader of Partition 0 & 1

Leader of Partition2

Kafka Producer

Partition-0

Partition-1 (Follower)

Partition-2 (Follower)

Partition-1

Partition-0 (Follower)

Partition-2 (Follower)

Partition-2

Partition-0 (Follower)

Partition-1 (Follower)

Kafka Consumer

Broker 1

Broker 2

Broker 3

File System

File System

File System

In-Sync Replica(ISR)

- Represents the number of replica in sync with each other in the cluster
    - Includes both **leader** and **follower** replica
- Recommended value is always greater than 1
- Ideal value is **ISR == Replication Factor**
- This can be controlled by **min.insync.replicas** property
        - It can be set at the **broker** or **topic** level

Fault Tolerance
&
Robustness

Application Overview

Library Inventory

Library Inventory Flow

Librarian

Library Inventory

Library Inventory Architecture

Librarian

MicroService 1

API

Kafka Producer

Library Event Producer

Library-events

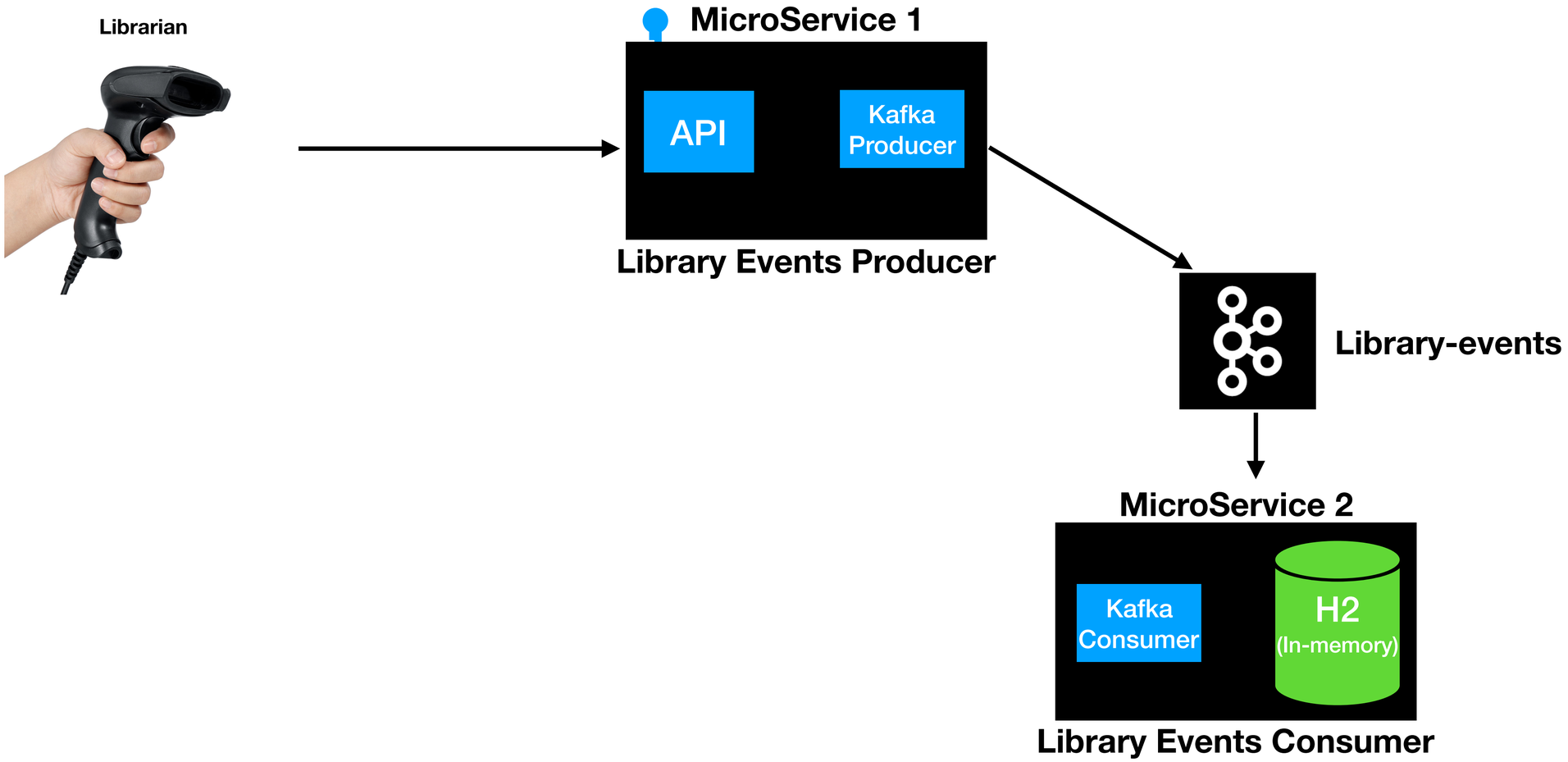
MicroService 2

Kafka Consumer

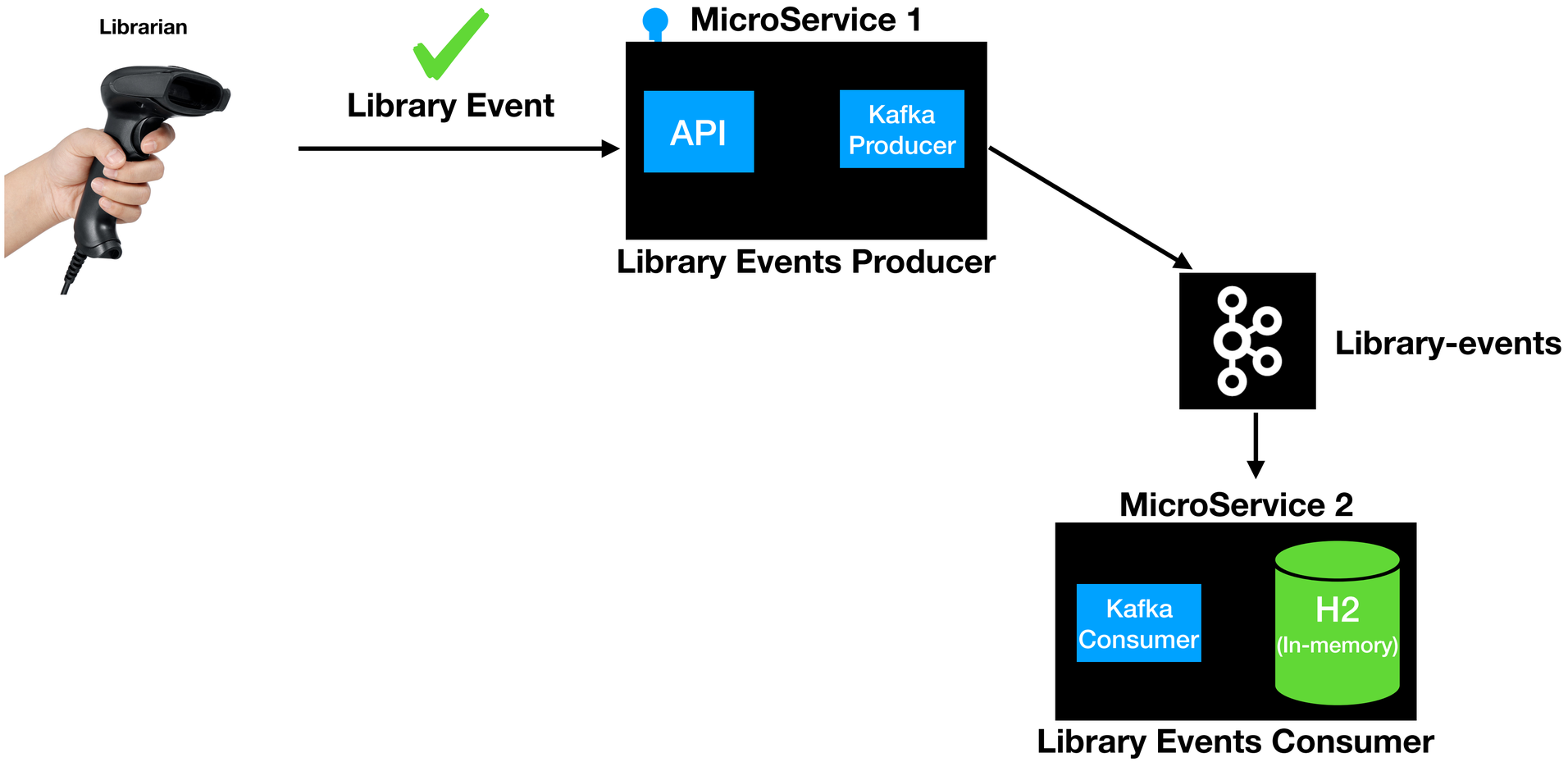
H2 (In-memory)

Library Event Consumer

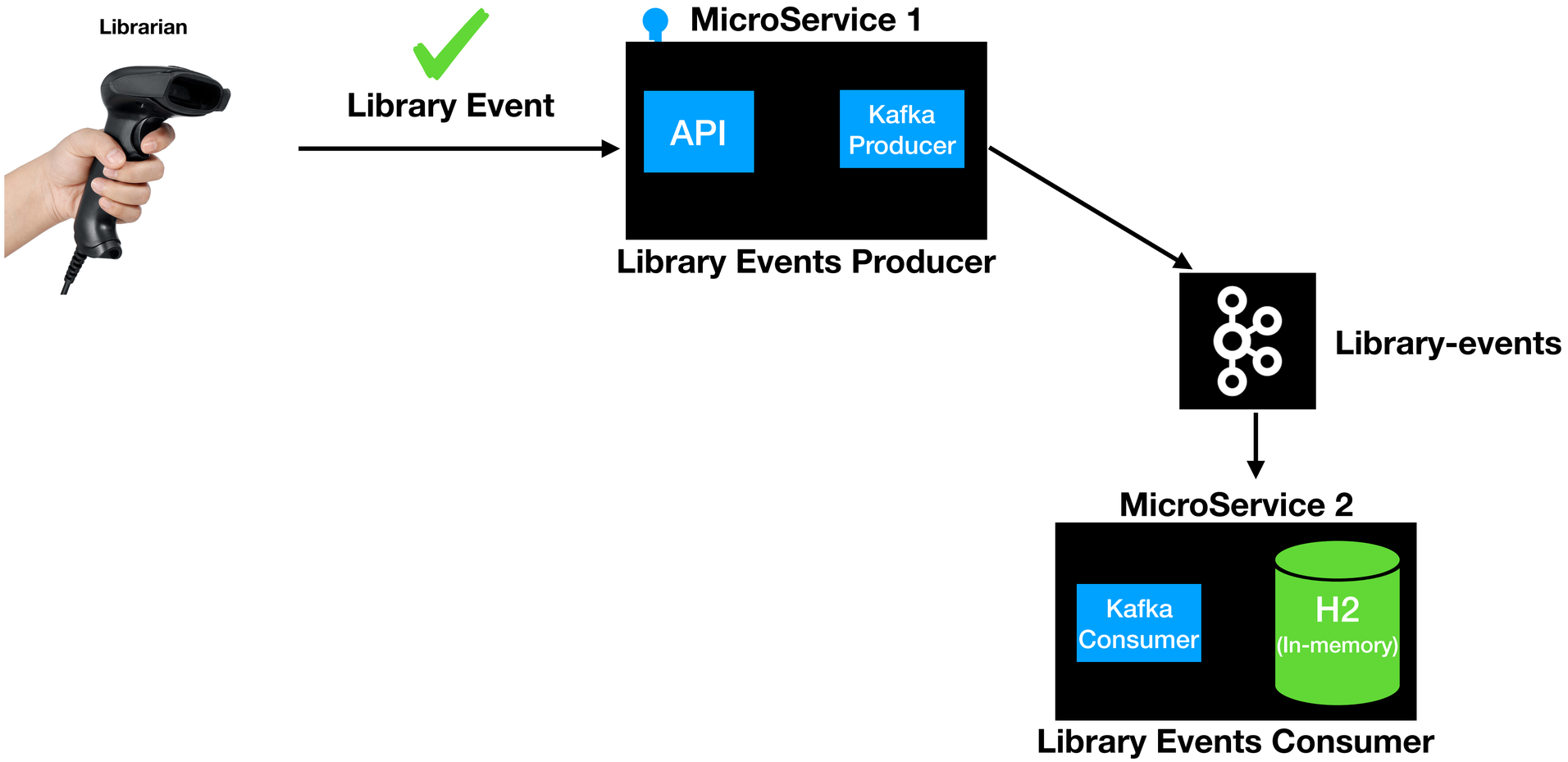
Library Inventory Architecture



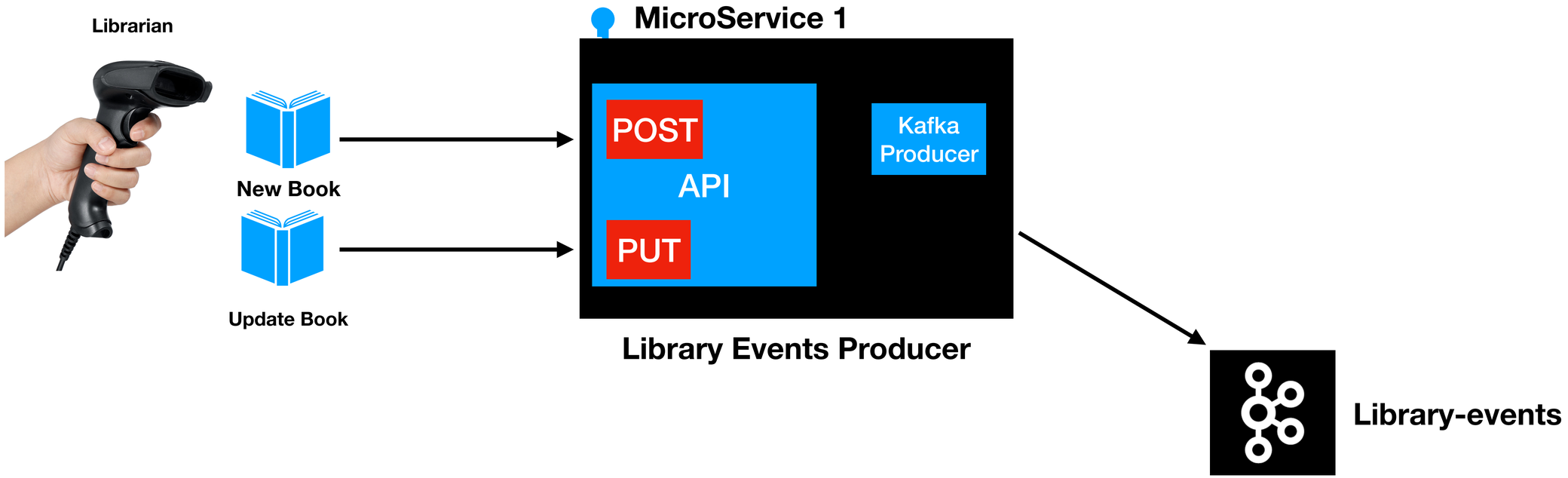
Library Event Domain



Library Event Domain



Library Events Producer API



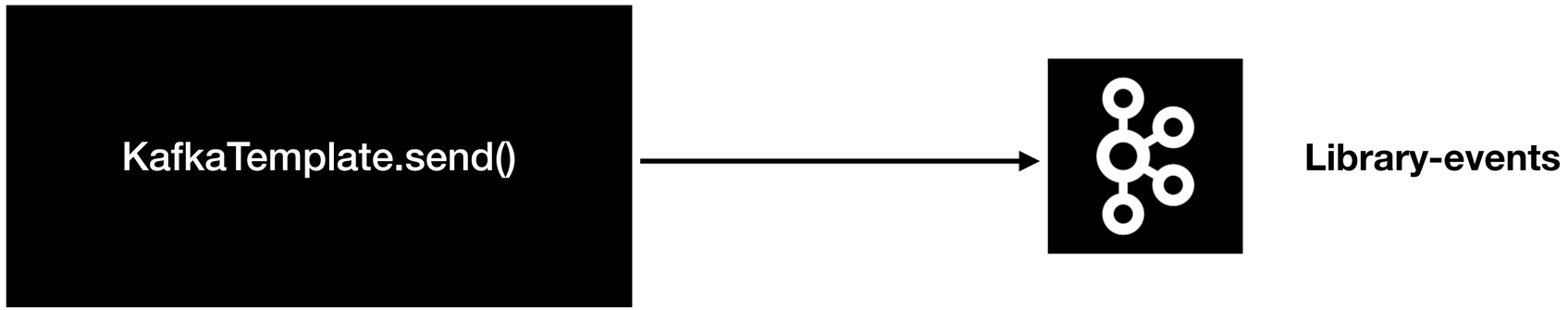
KafkaTemplate

Kafka Producer in Spring

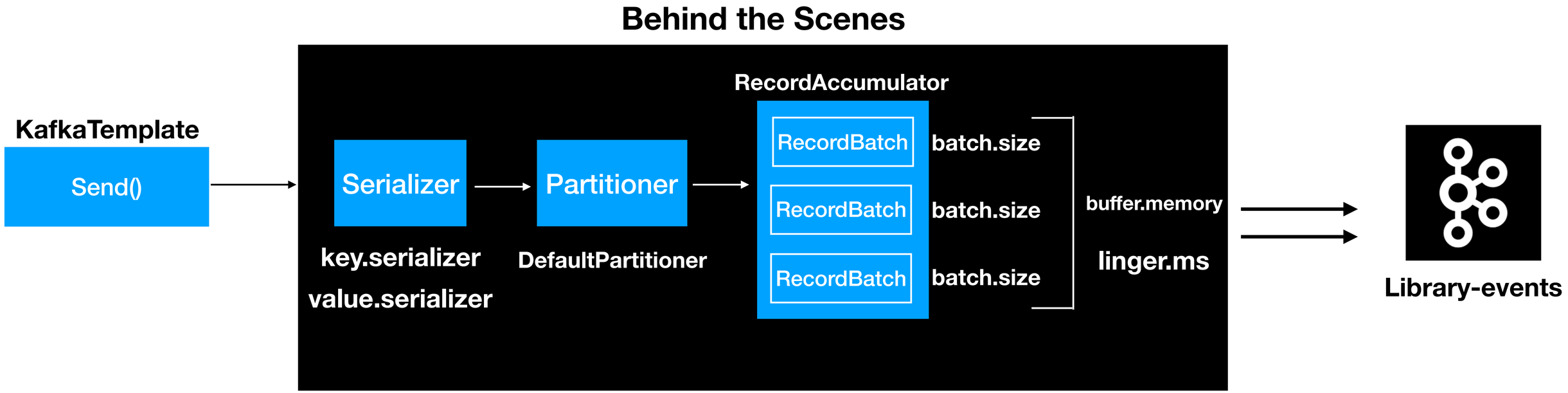
KafkaTemplate

- Produce records in to Kafka Topic
    - Similar to JDBCTemplate for DB

How KafkaTemplate Works ?



KafkaTemplate.send()



Configuring KafkaTemplate

Mandatory Values:

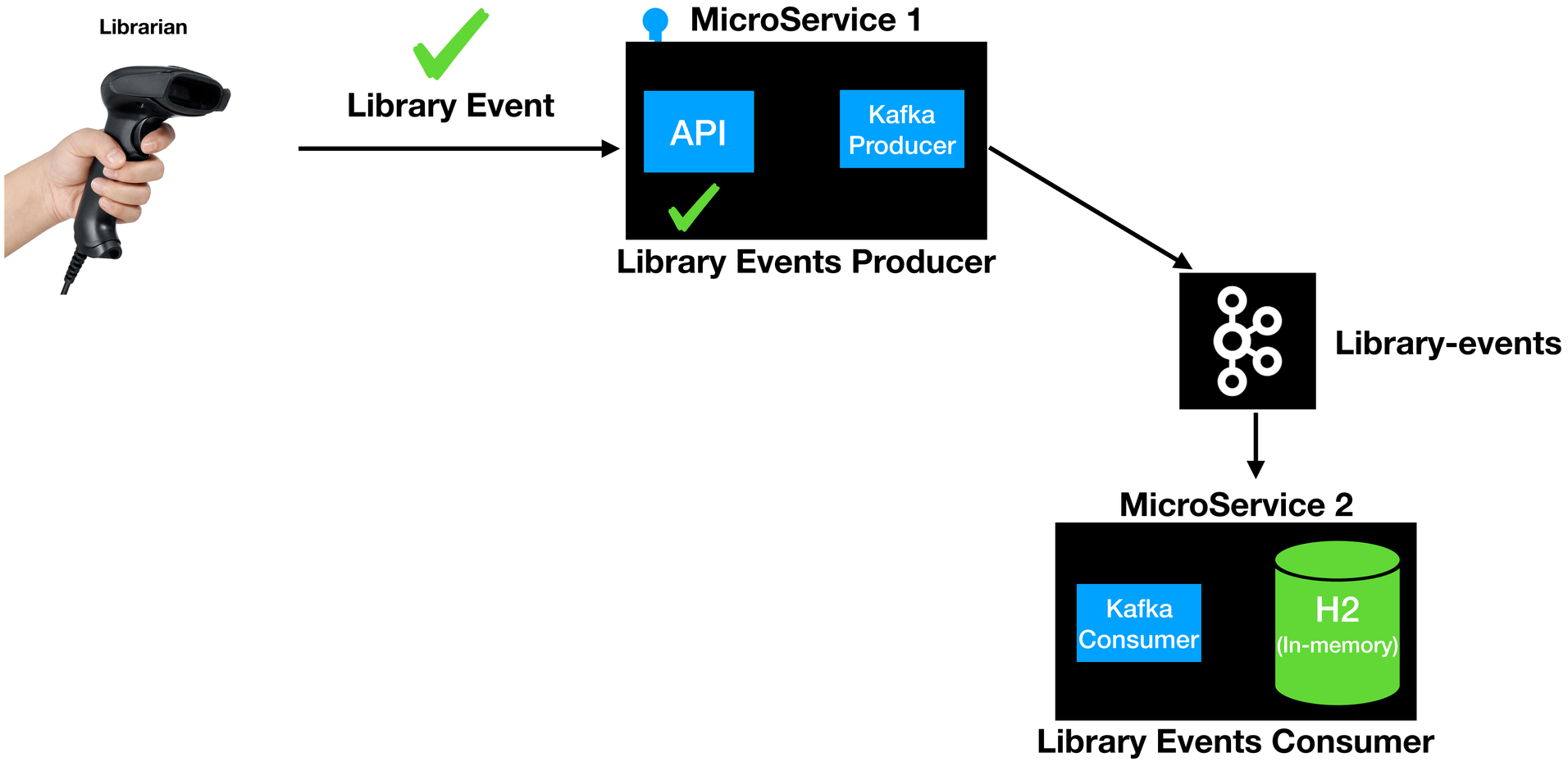
```
bootstrap-servers: localhost:9092,localhost:9093,localhost:9094
key-serializer: org.apache.kafka.common.serialization.IntegerSerializer
value-serializer: org.apache.kafka.common.serialization.StringSerializer
```

KafkaTemplate AutoConfiguration

application.yml

```yaml
spring:
  profiles: local
  kafka:
    producer:
      bootstrap-servers: localhost:9092,localhost:9093,localhost:9094
      key-serializer: org.apache.kafka.common.serialization.IntegerSerializer
      value-serializer: org.apache.kafka.common.serialization.StringSerializer
```

Library Inventory Architecture



KafkaAdmin

- Create topics Programmatically
- Part of the **SpringKafka**
- How to Create a topic from Code?
    - Create a Bean of type **KafkaAdmin** in SpringConfiguration
    - Create a Bean of type **NewTopic** in SpringConfiguration

Introduction
To
Automated Tests

Why Automated Tests ?

- Manual testing is time consuming
- Manual testing slows down the development
- Adding new changes are error prone

What are Automated Tests?

- Automated Tests run against your code base
- Automated Tests run as part of the build
- This is a requirement for todays software development
- Easy to capture bugs
- Types of Automated Tests:
    - UnitTest
    - Integration Tests
    - End to End Tests

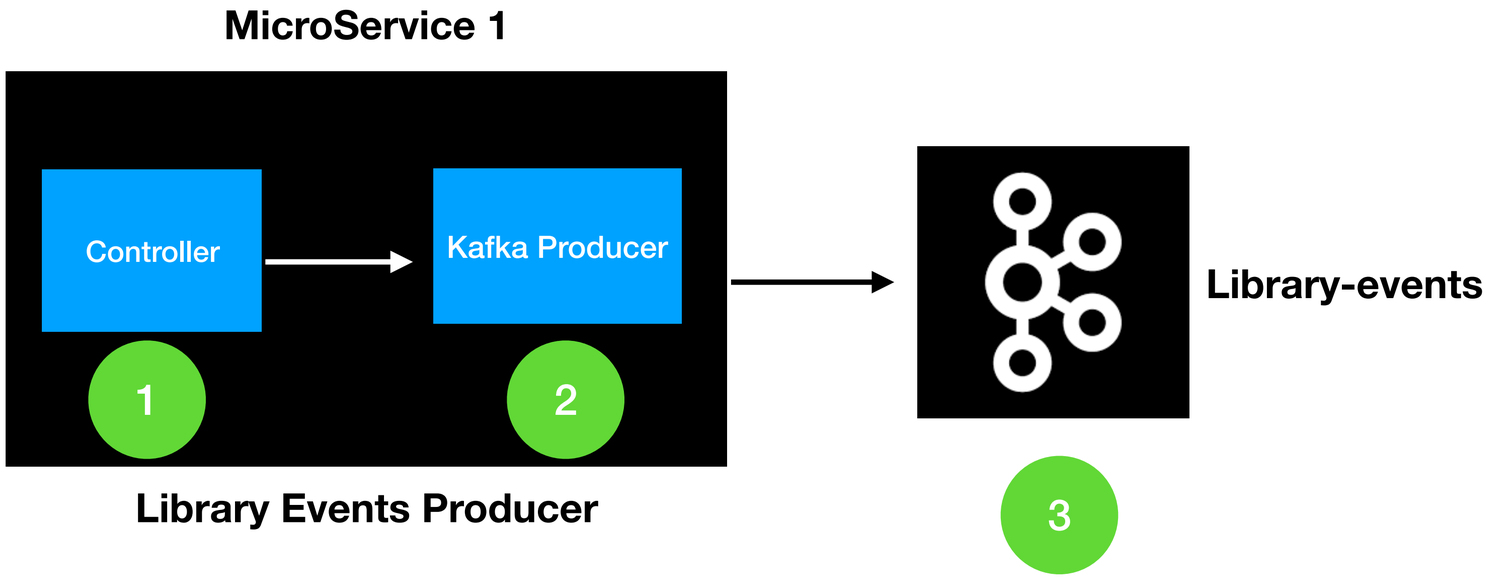
Tools for Automated

- JUnit
- Spock

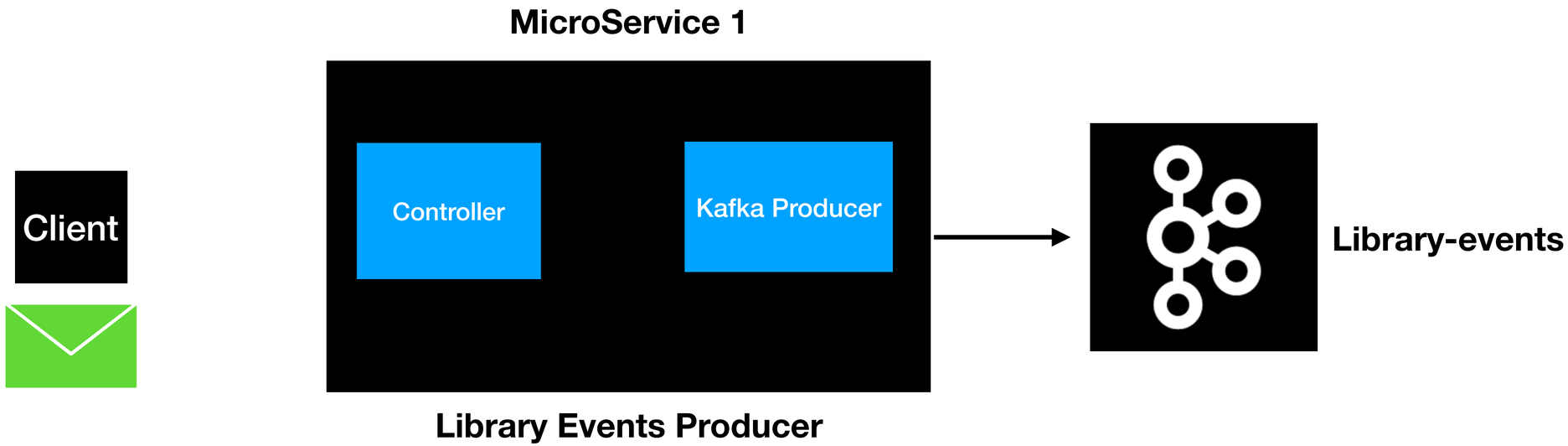
Integration Tests Using JUnit5

What is Integration Test?

- Test combines the different layers of the code and verify the behavior is working as expected.



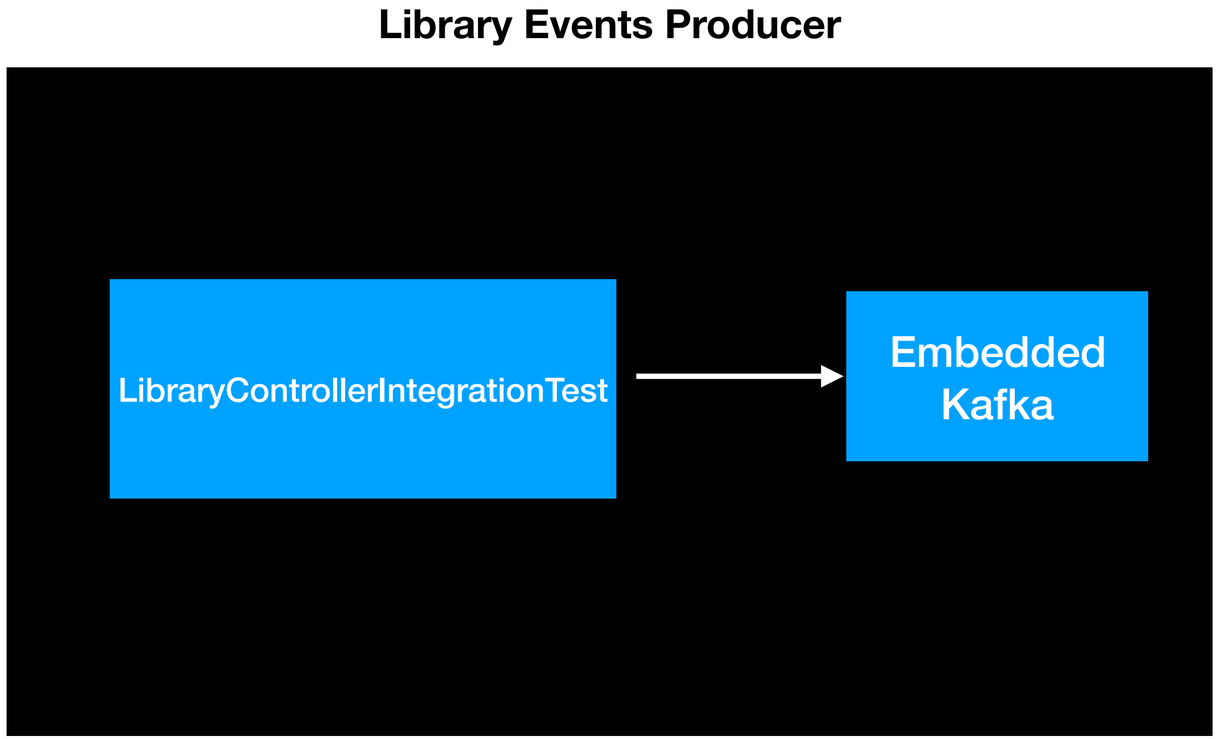
Integration Test



Embedded Kafka

What is EmbeddedKafka?

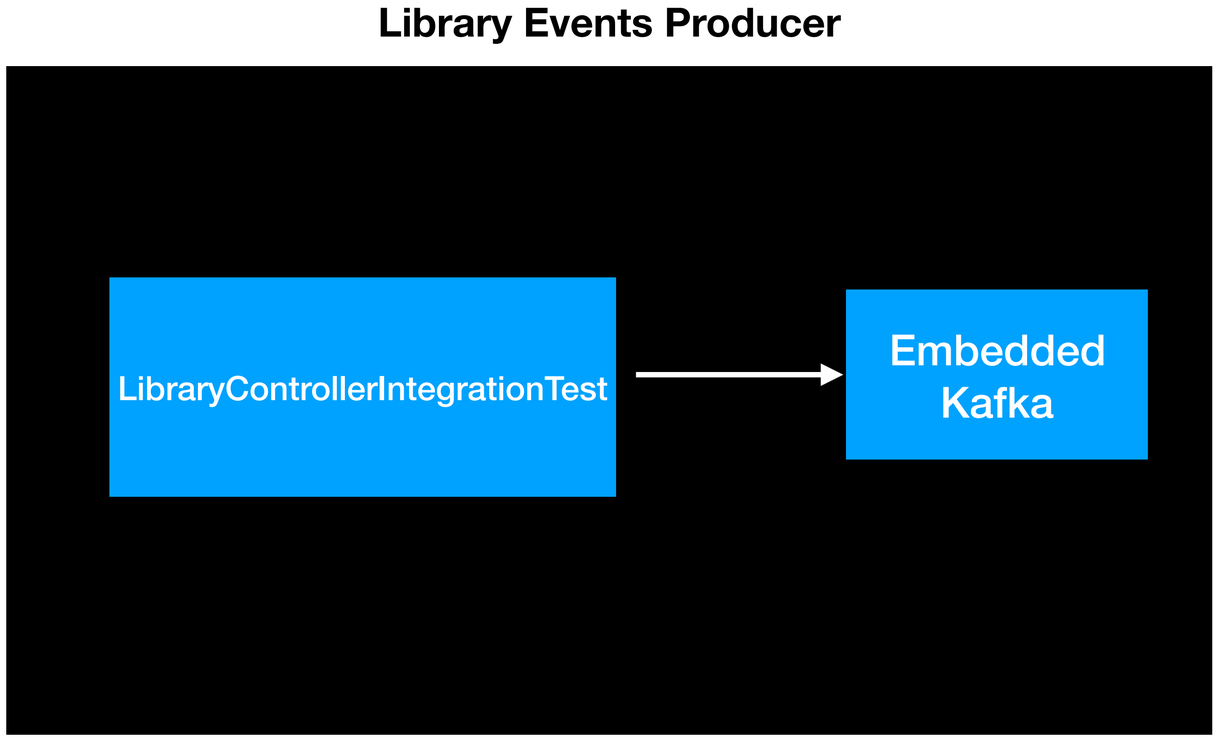
- In-Memory Kafka
- Integration Tests can interact with EmbeddedKafka



Why Embedded Kafka ?

- Easy to write Integration Tests

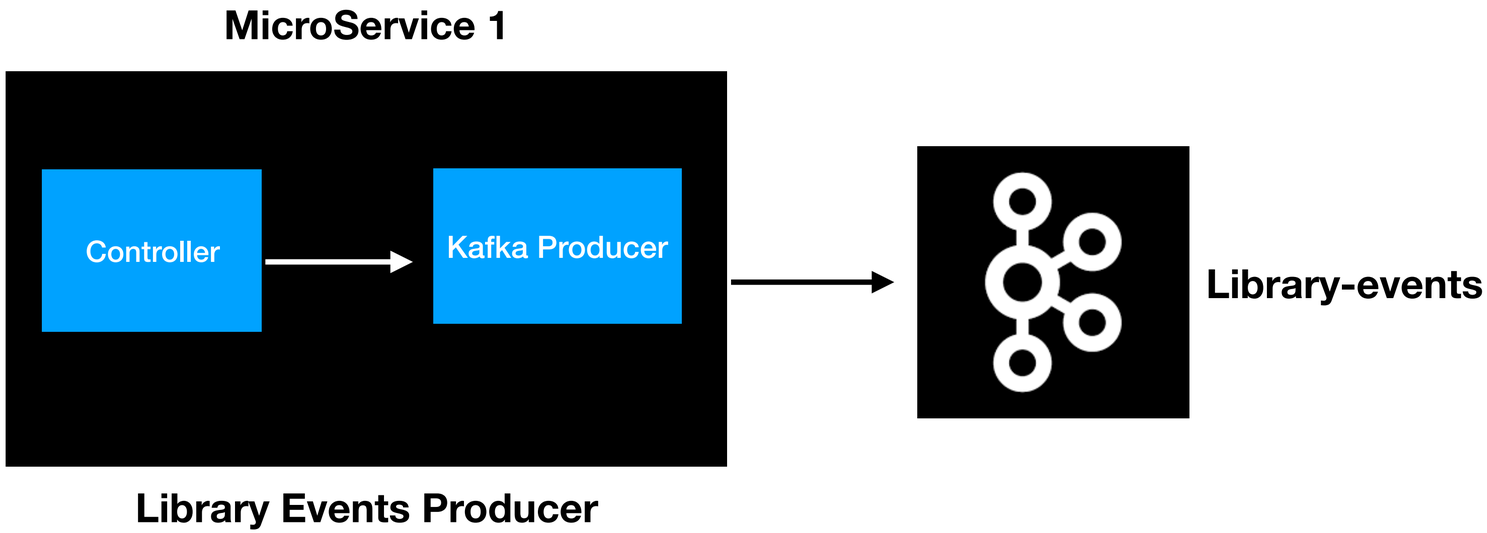
- Test all the code as like you interact with Kafka



Unit Tests Using JUnit5

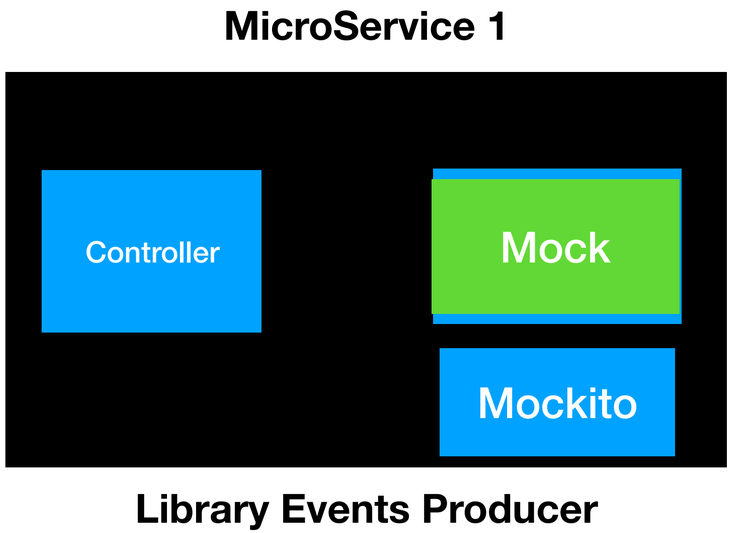
What is Unit Test?

- Test the just focuses on a single unit (method)
- Mocks the external dependecies



What is Unit Test?

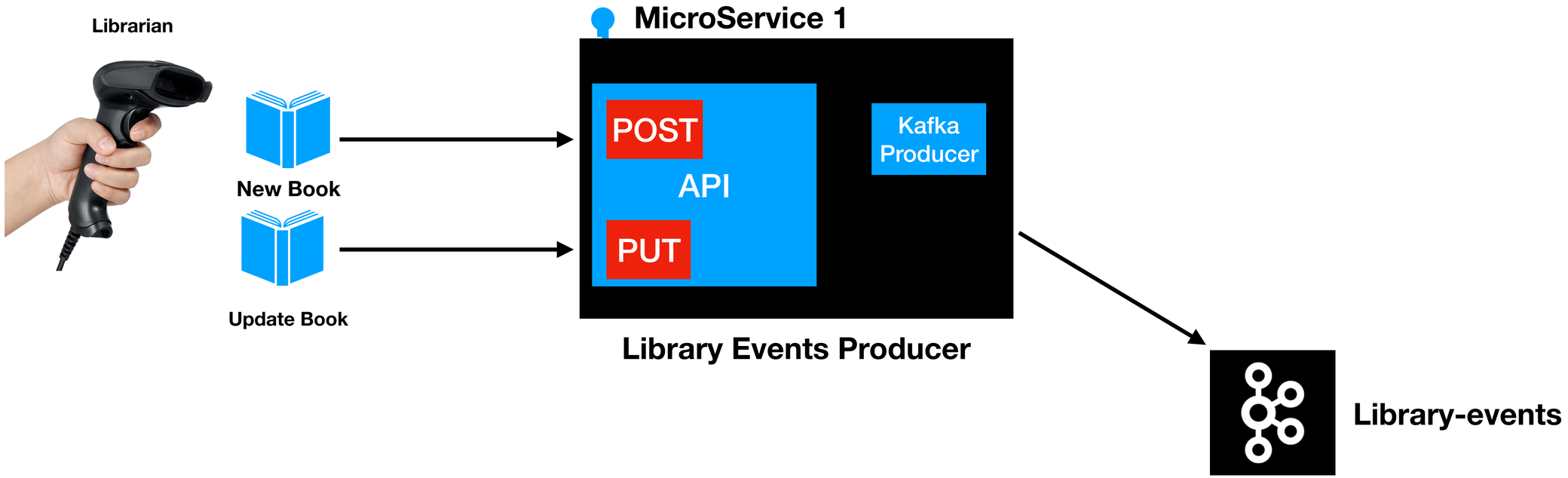
- Test the just focuses on a single unit (method)
- Mocks the external dependencies



Why Unit Test?

- Unit Tests are handy to mock external dependencies
- Unit Tests are faster compared to Integration tests
- Unit Tests cover scenarios that’s not possible with Integration tests

Library Events Producer API



PUT - “/v1/libraryevent”

- libraryEventId is a mandatory field

```
{
   "libraryEventId": 123,
  "eventStatus": null,
  "book": {
    "bookId": 456,
    "bookName": "Kafka Using Spring Boot",
    "bookAuthor": "Dilip"
  }
}
```

Kafka Producer Configurations

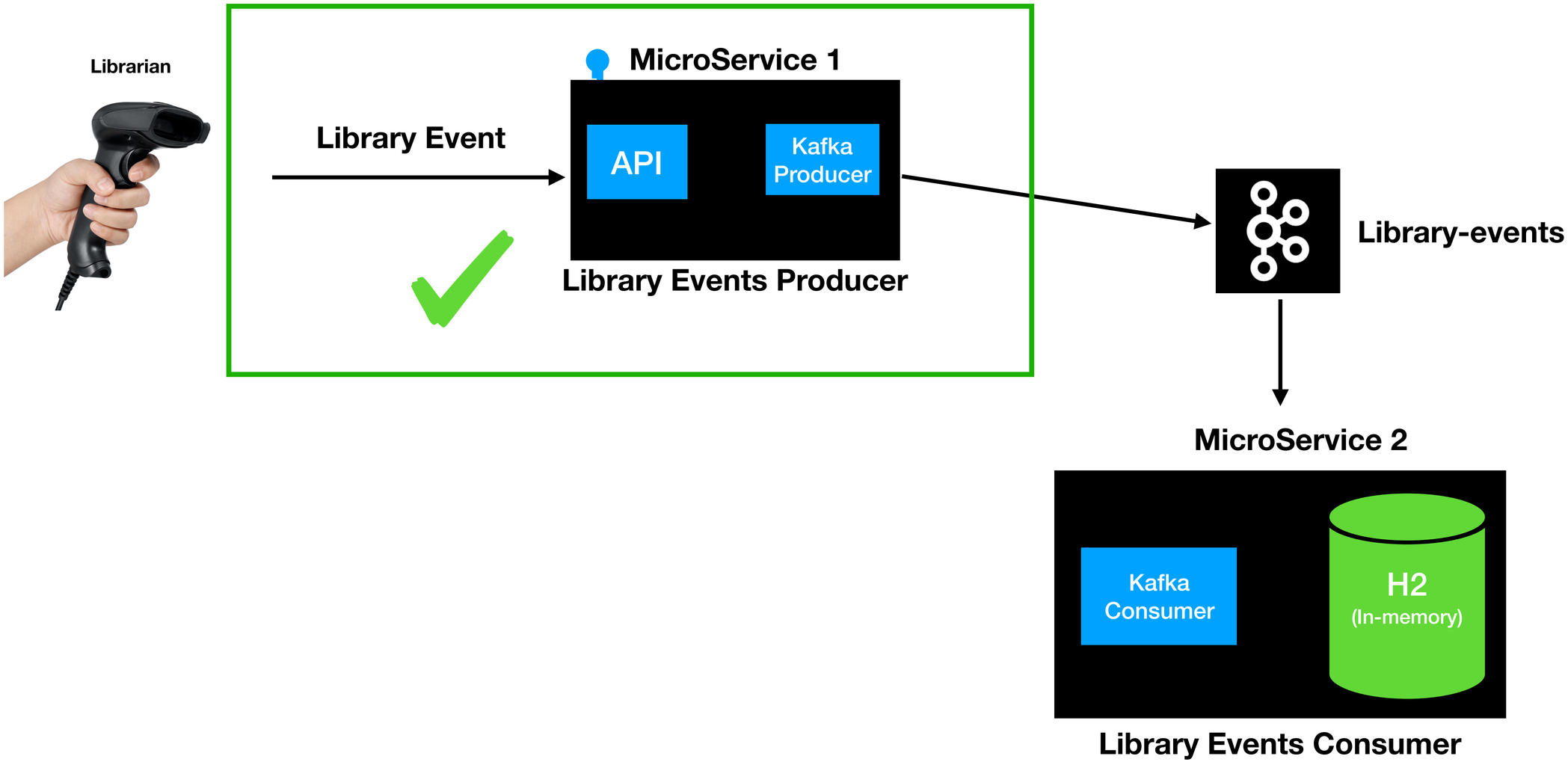
Kafka Producer Configurations

- acks
  - acks = 0, 1 and all
    - acks = 1 -> guarantees message is written to a leader (Default)
    - acks = all -> guarantees message is written to a leader and to all the replicas
    - acks=0 -> no guarantee (Not Recommended)

Kafka Producer Configurations

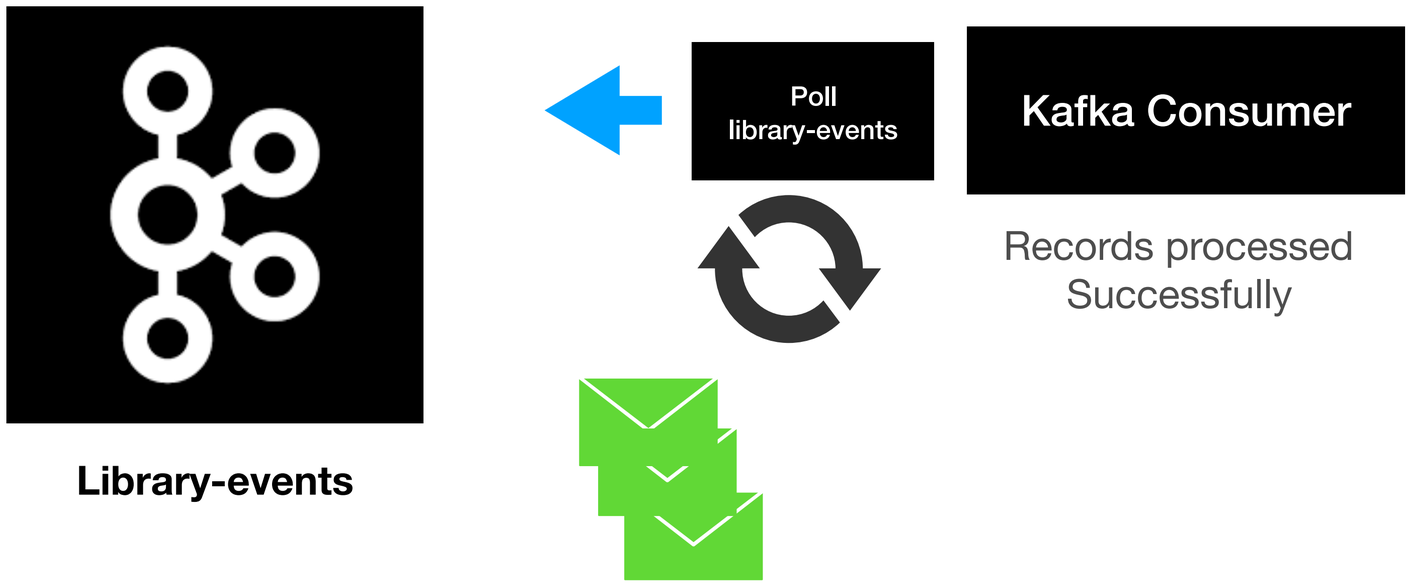
- retries
  - Integer value = [0 - 2147483647]
  - In Spring Kafka, the default value is **-> 2147483647**
- retry.backoff.ms
  - Integer value represented in milliseconds
  - Default value is 100ms

Library Events Consumer



Spring Kafka Consumer

Kafka Consumer



Spring Kafka Consumer

- MessageListenerContainer
    - KafkaMessageListenerContainer
    - ConcurrentMessageListenerContainer
- **@KafkaLisener** Annotation
    - Uses ConcurrentMessageListenerContainer behind the scenes

KafkaMessageListenerContainer

- Implementation of MessageListenerContainer
- Polls the records
- Commits the Offsets
- Single Threaded

ConcurrentMessageListenerContainer

Represents multiple **KafkaMessageListenerContainer**

@KafkaListener

- This is the easiest way to build Kafka Consumer

- KafkaListener Sample Code

```
@KafkaListener(topics = {"${spring.kafka.topic}"})
public void onMessage(ConsumerRecord<Integer, String> consumerRecord) {
    log.info("OnMessage Record : {} “, consumerRecord);
}
```

- Configuration Sample Code

```
@Configuration
@EnableKafka
@Slf4j
public class LibraryEventsConsumerConfig {
```

KafkaConsumer Config

```
key-deserializer: org.apache.kafka.common.serialization.IntegerDeserializer

value-deserializer: org.apache.kafka.common.serialization.StringDeserializer

group-id: library-events-listener-group
```

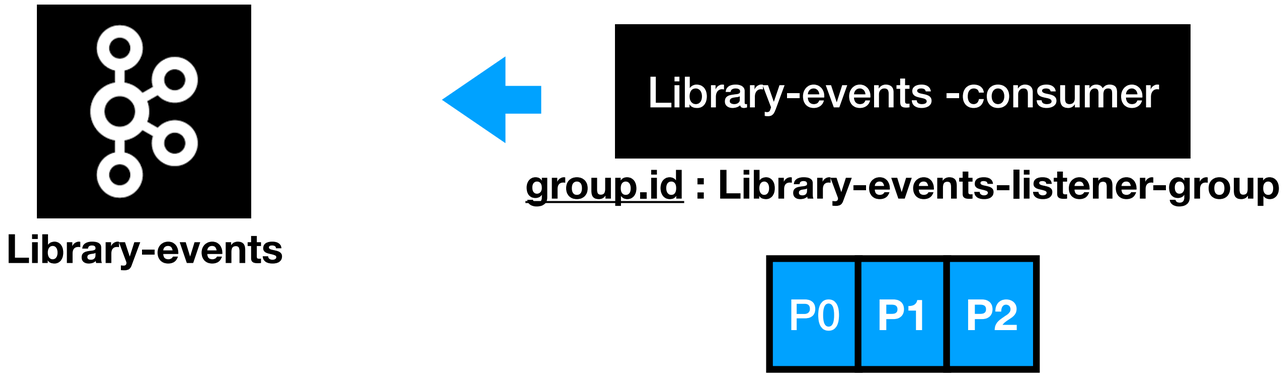
Consumer Groups
&
Rebalance

Consumer Groups

Multiple instances of the same application with the same group id.

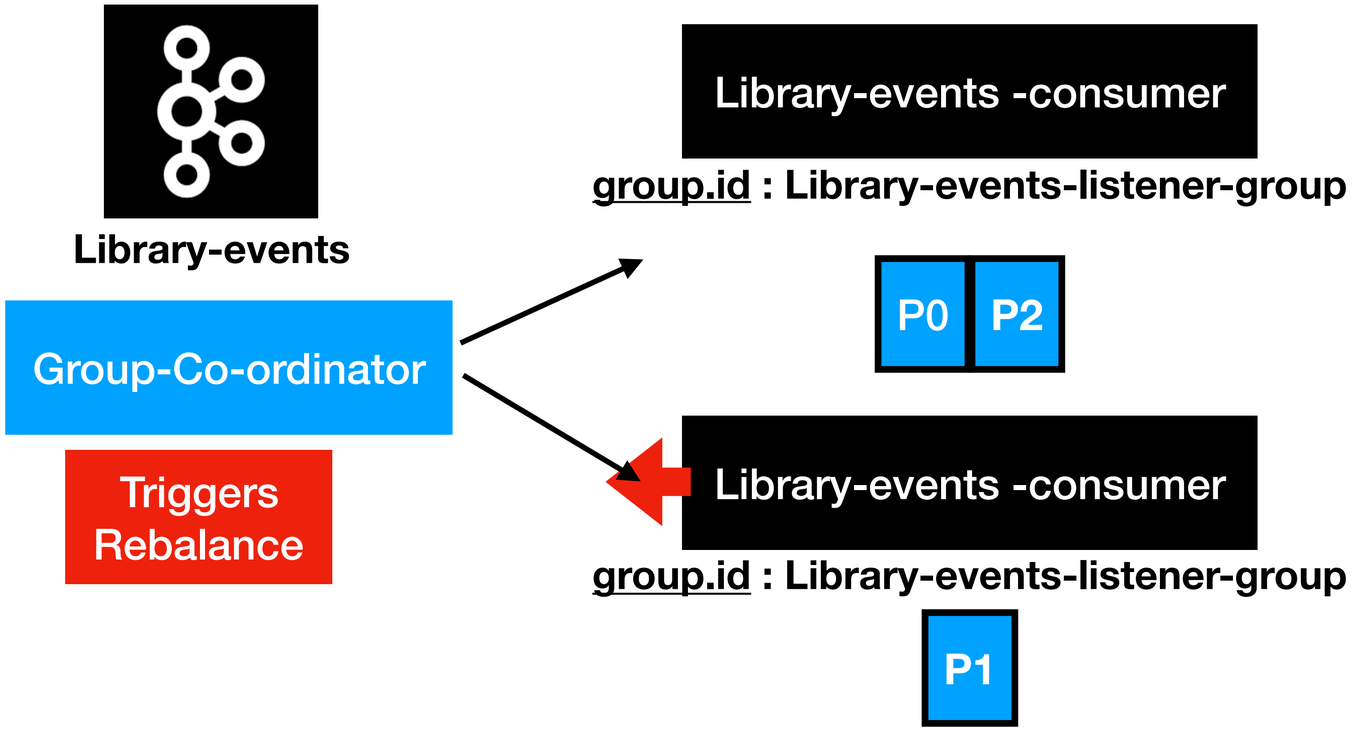
Rebalance

- Changing the partition ownership from one consumer to another

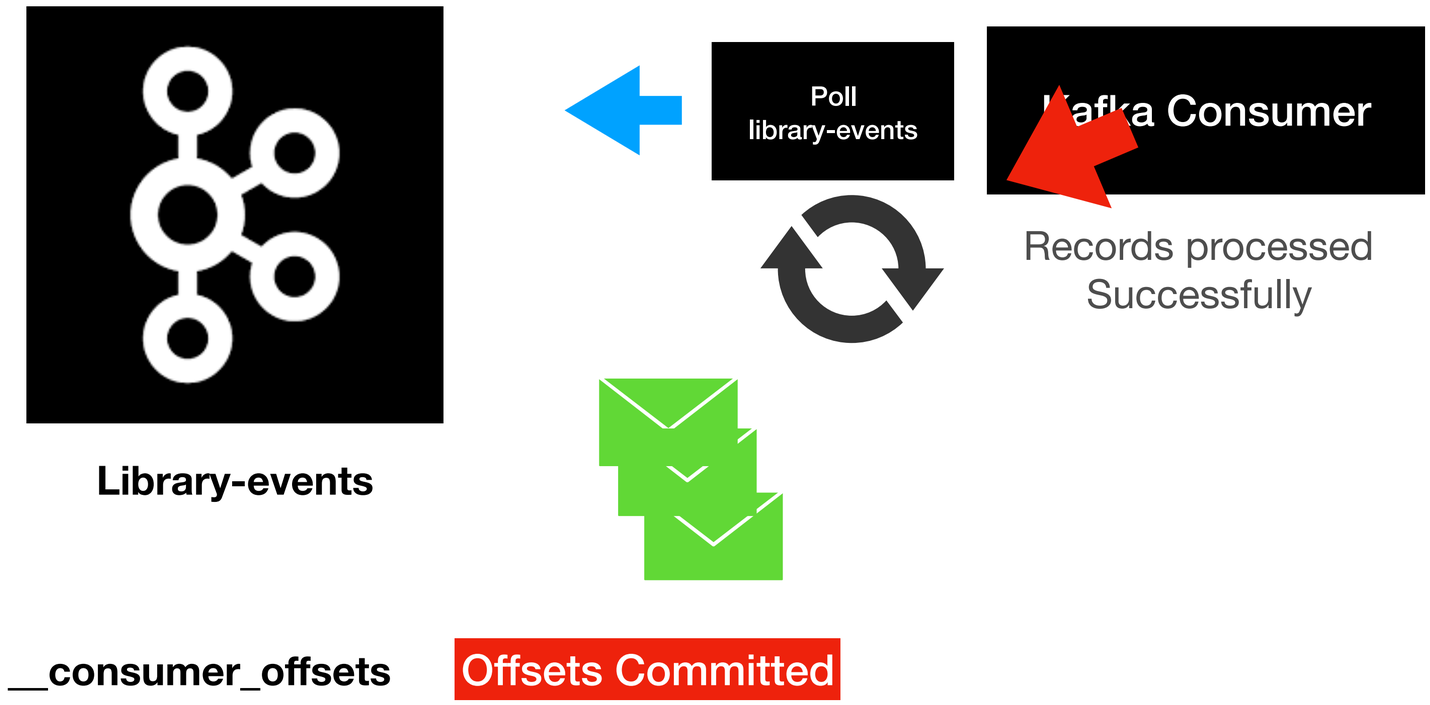


Rebalance

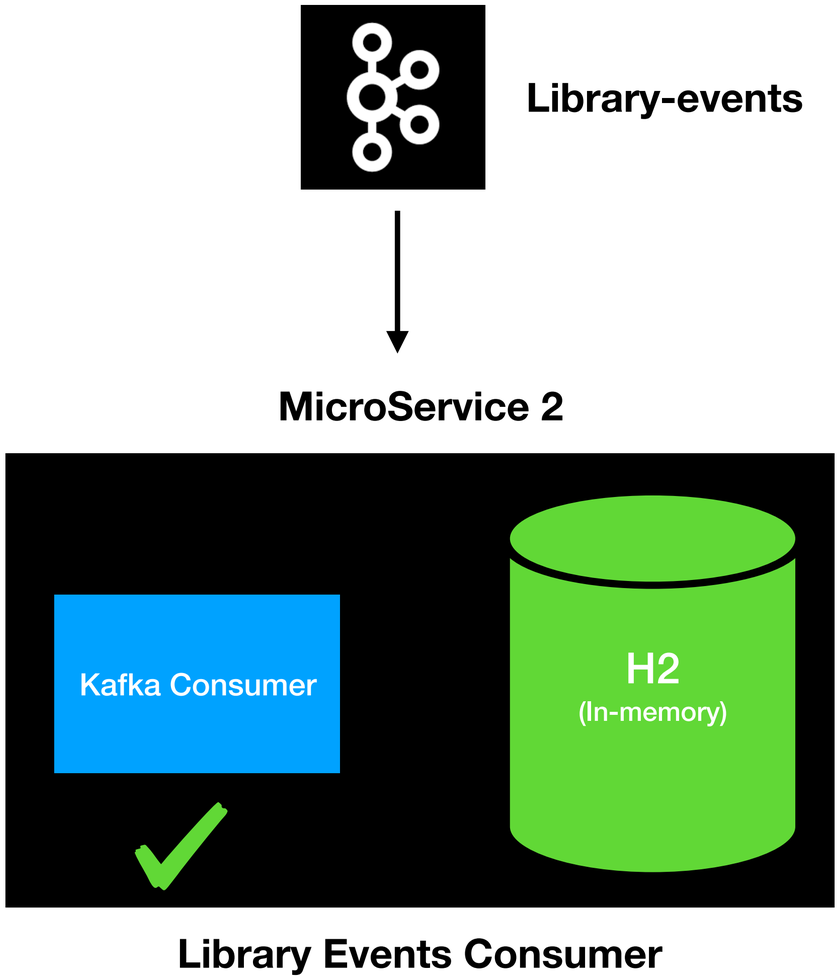
- Changing the partition ownership from one consumer to another



Committing Offsets



Library Events Consumer



Integration Testing
For
Real DataBases

Integration Testing using Real Databases

- Different aspects of writing unit and integration testing

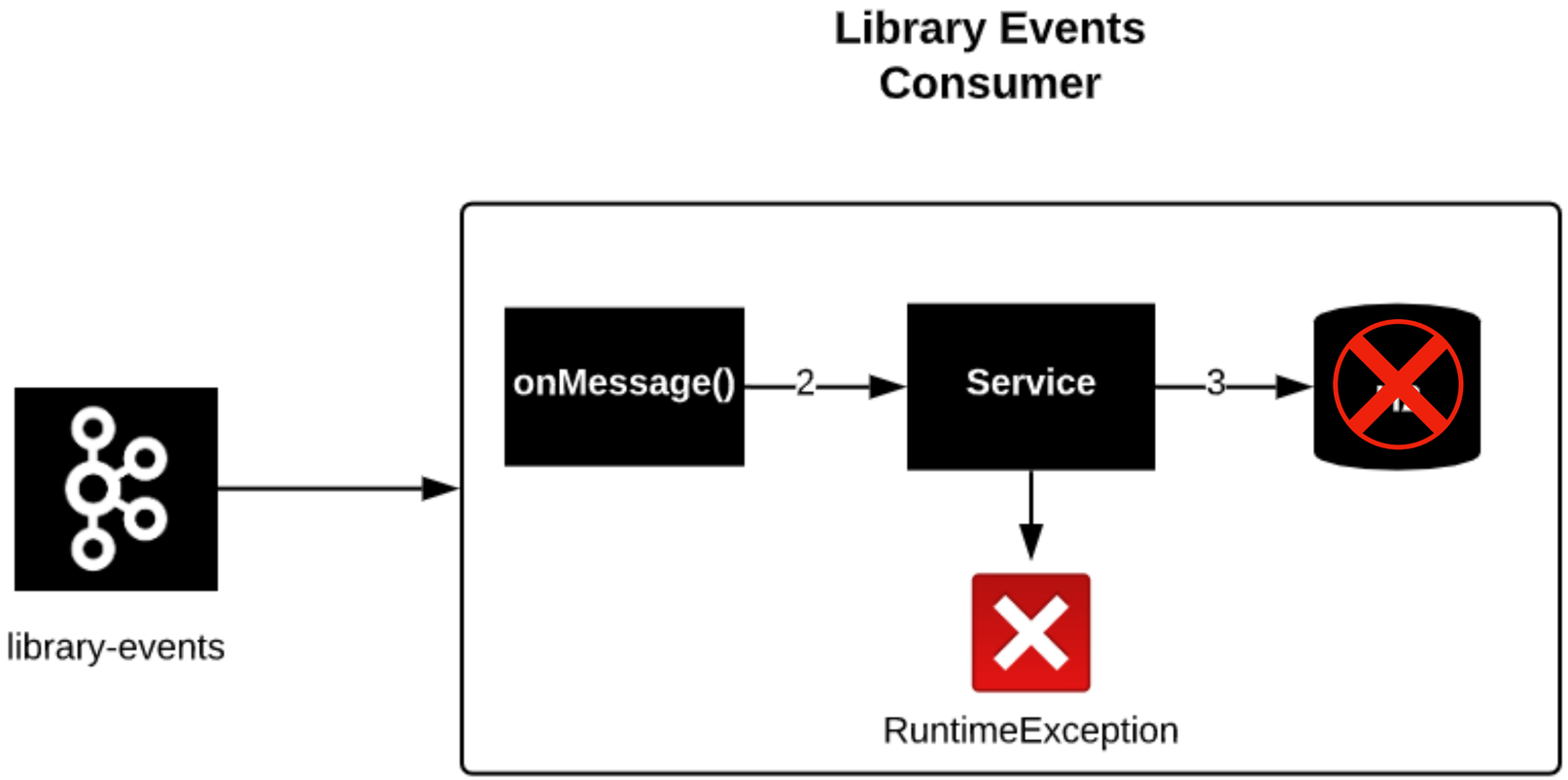
- Integration testing using **TestContainers**

TestContainers

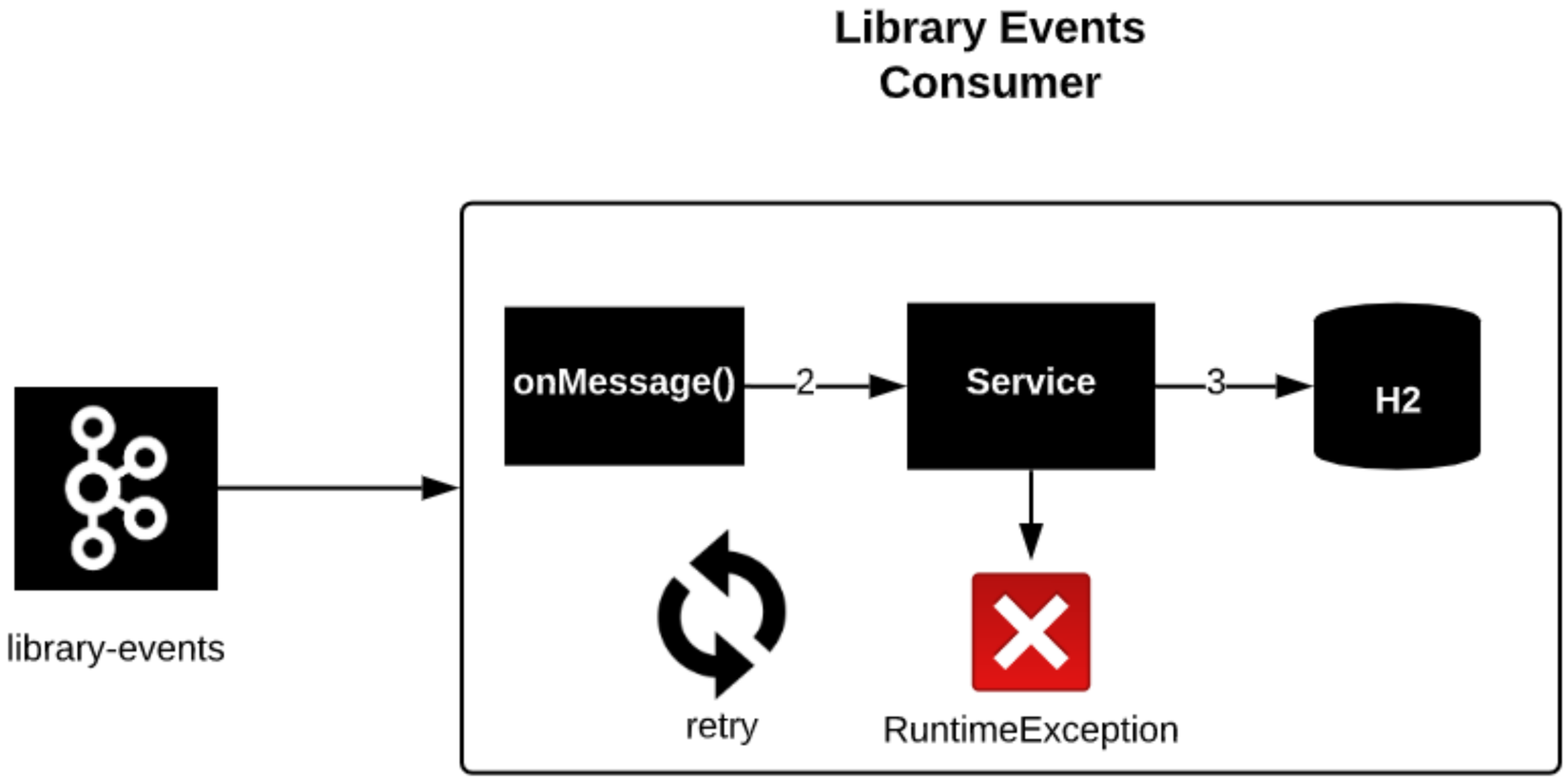
- What are TestContainers?
    - Testcontainers is a Java library that supports JUnit tests, providing lightweight, throwaway instances of common databases, Selenium web browsers, or anything else that can run in a **Docker** container.
- More Info about TestContainers - **https://www.testcontainers.org/**

Retry in Kafka Consumer

Error in Kafka Consumer

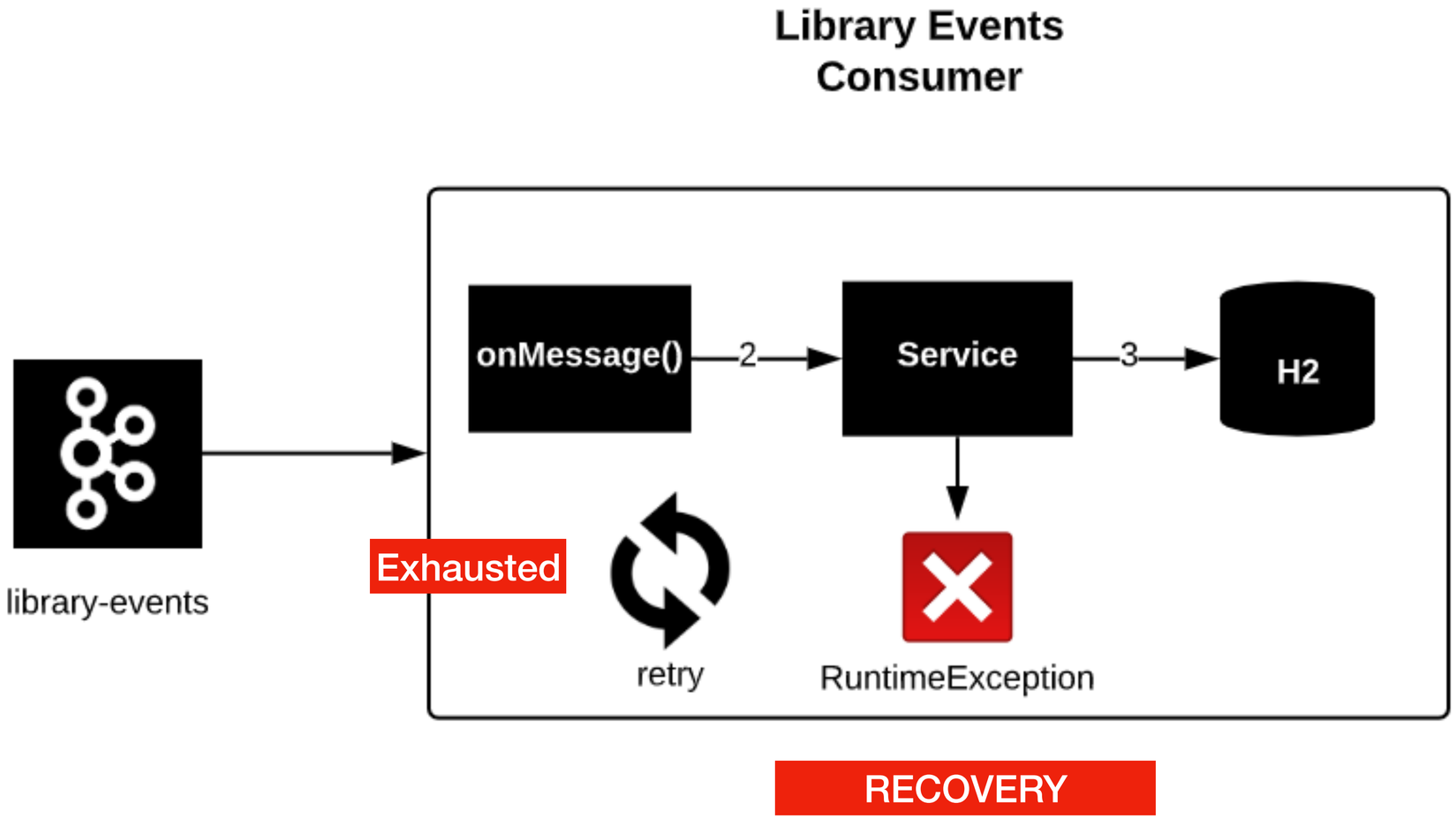


Retry in Kafka Consumer

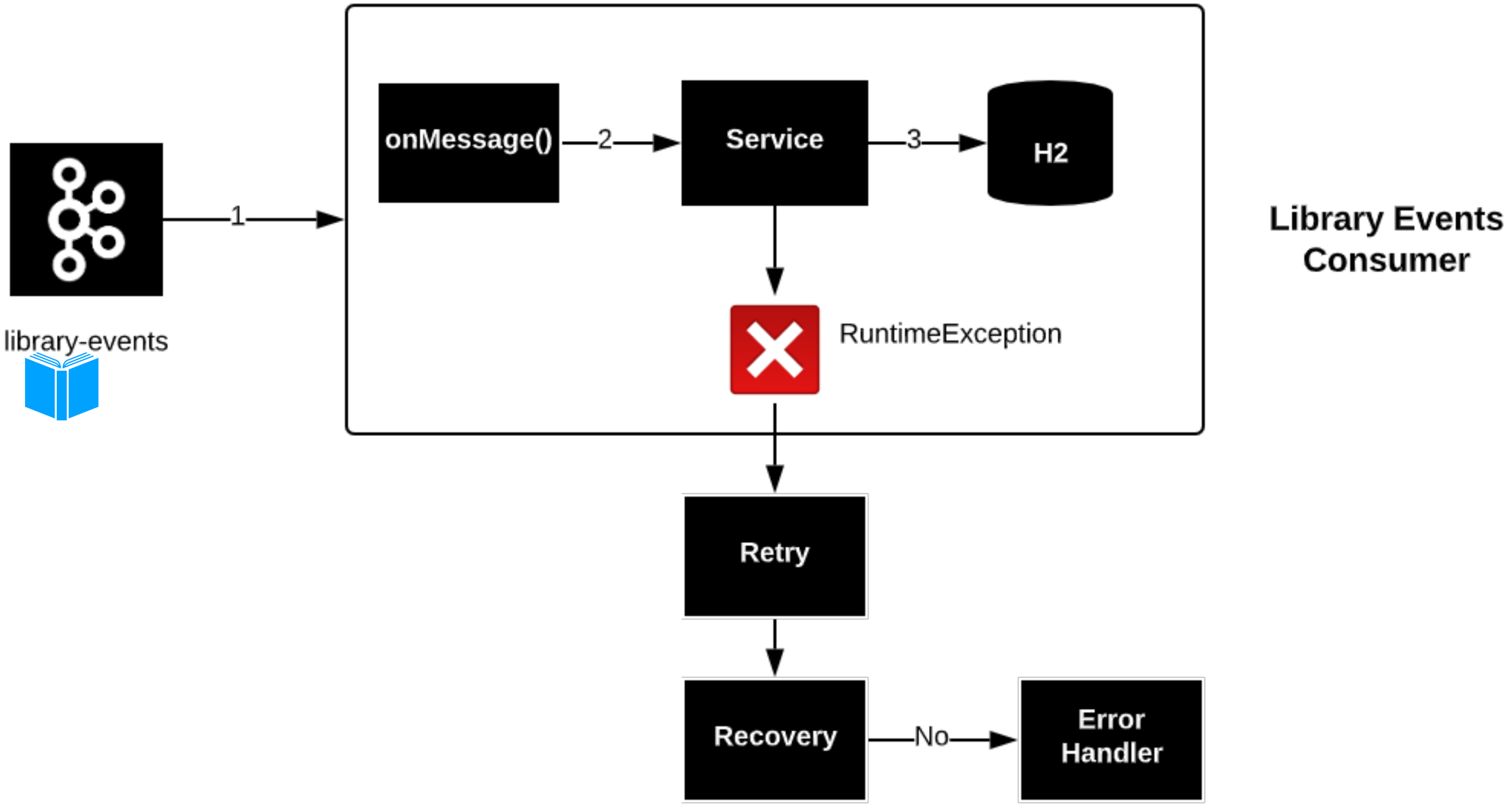


Recovery in Kafka Consumer

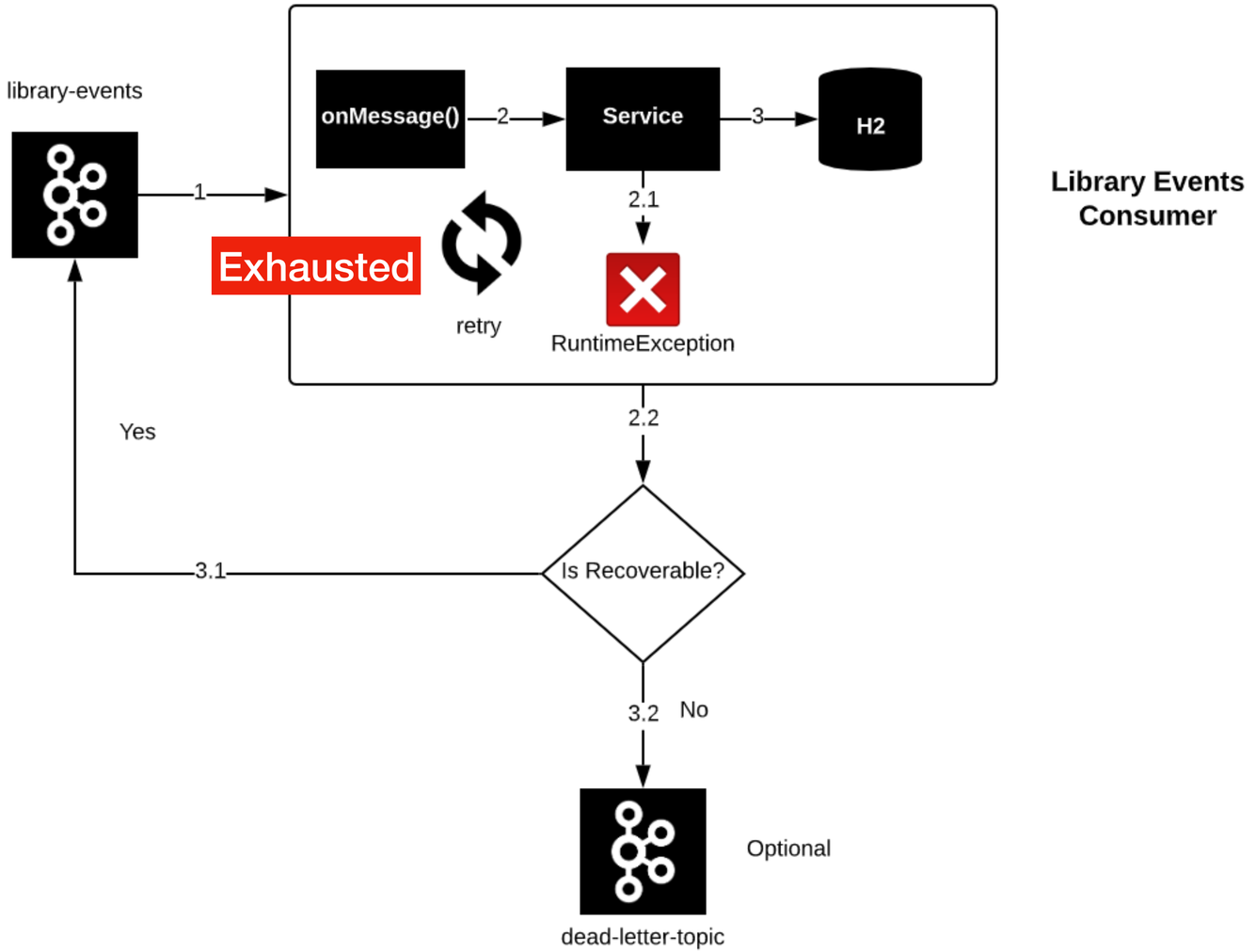
Recovery in Kafka Consumer



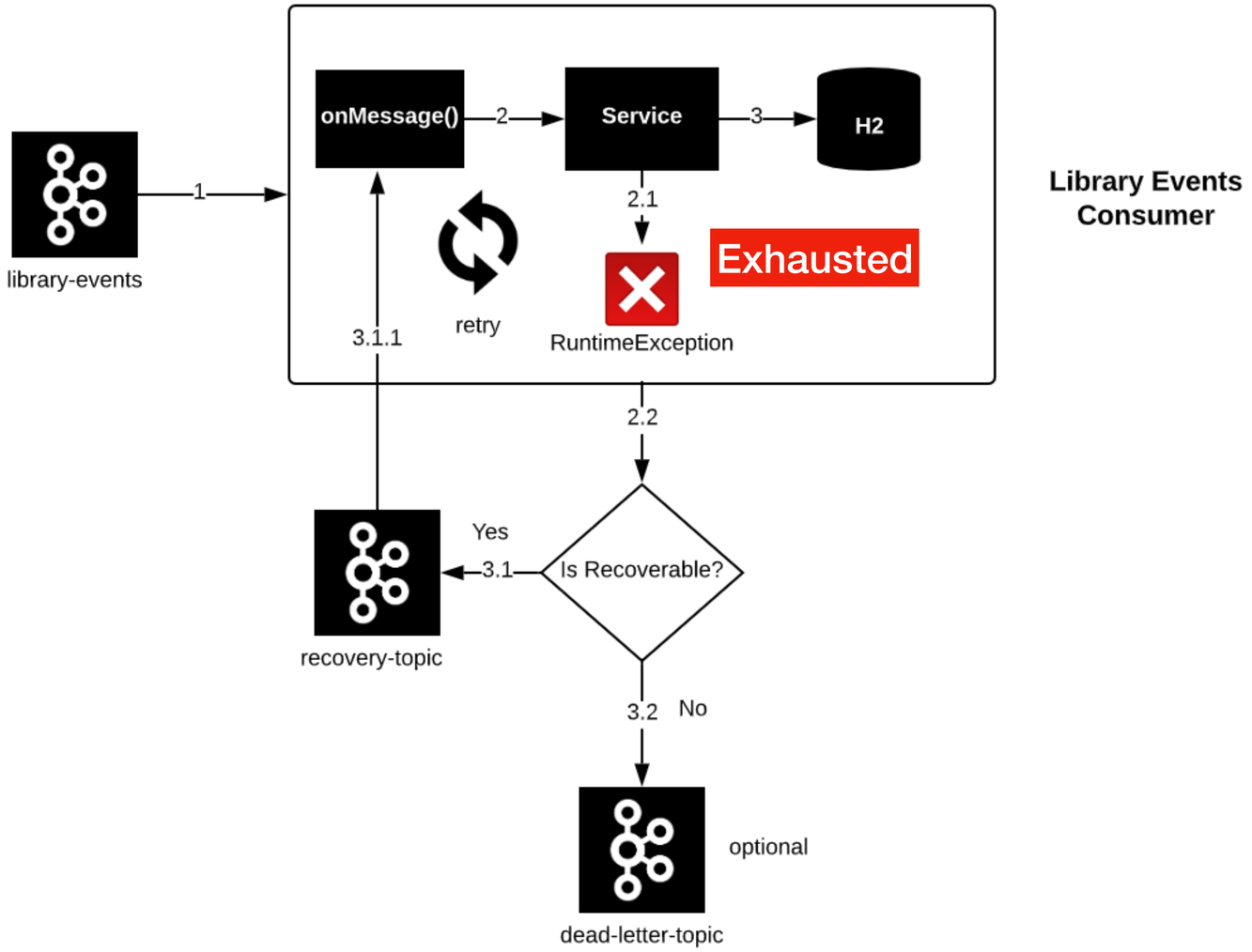
Retry and Recovery



Recovery - Type 1



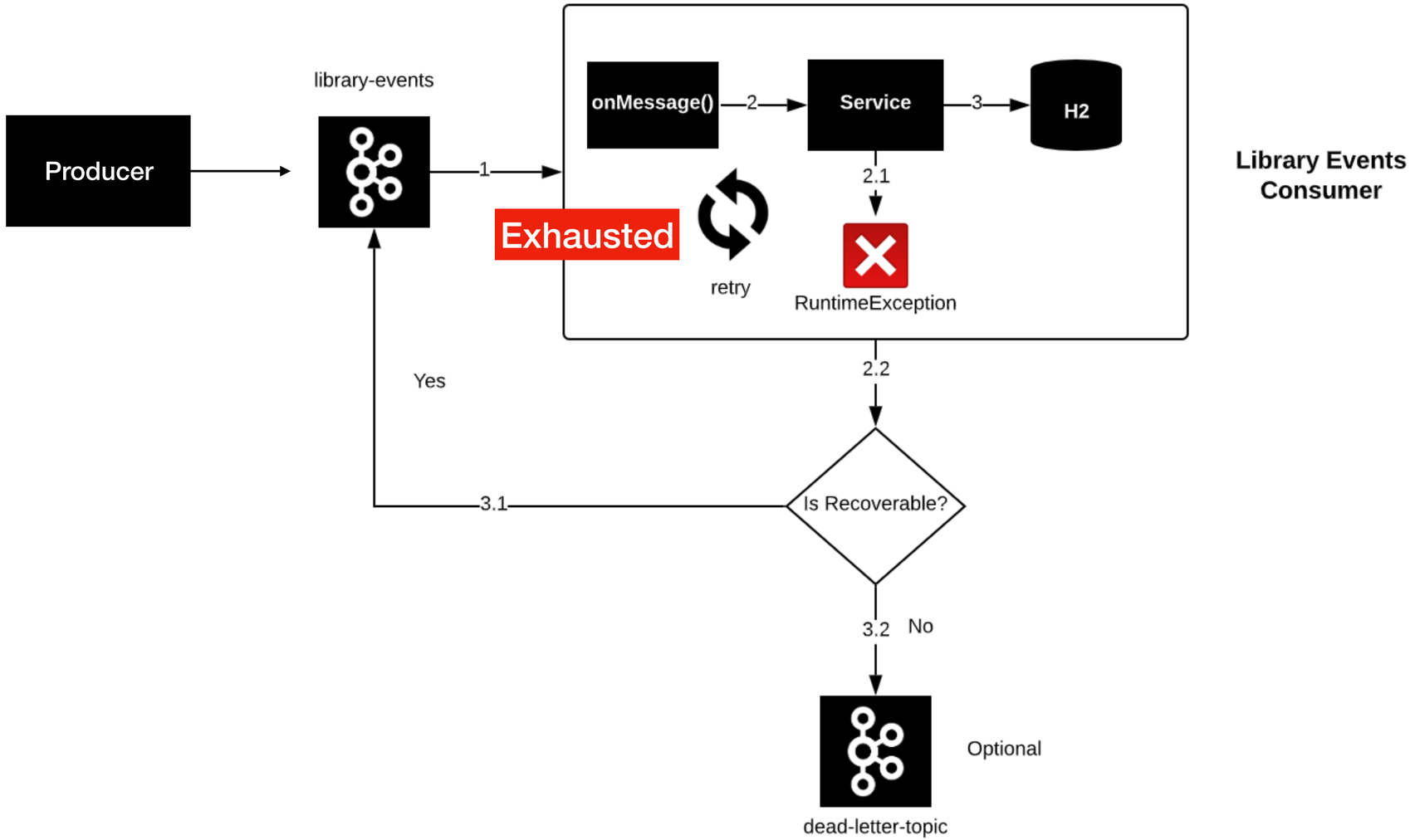
Recovery - Type 2



Issues with Recovery ?

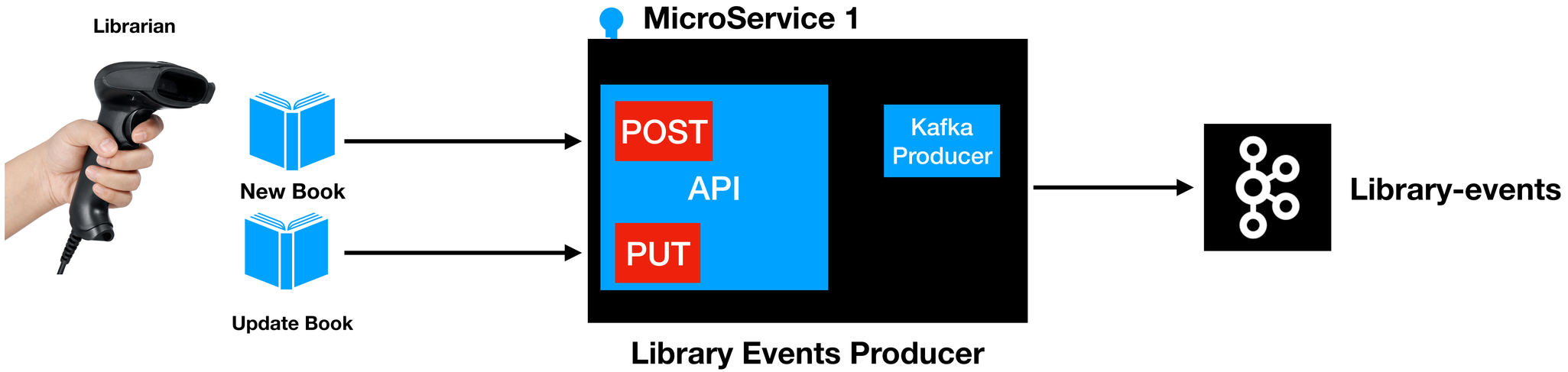
- Recovery can alter the order of events

Recovery - Type 1



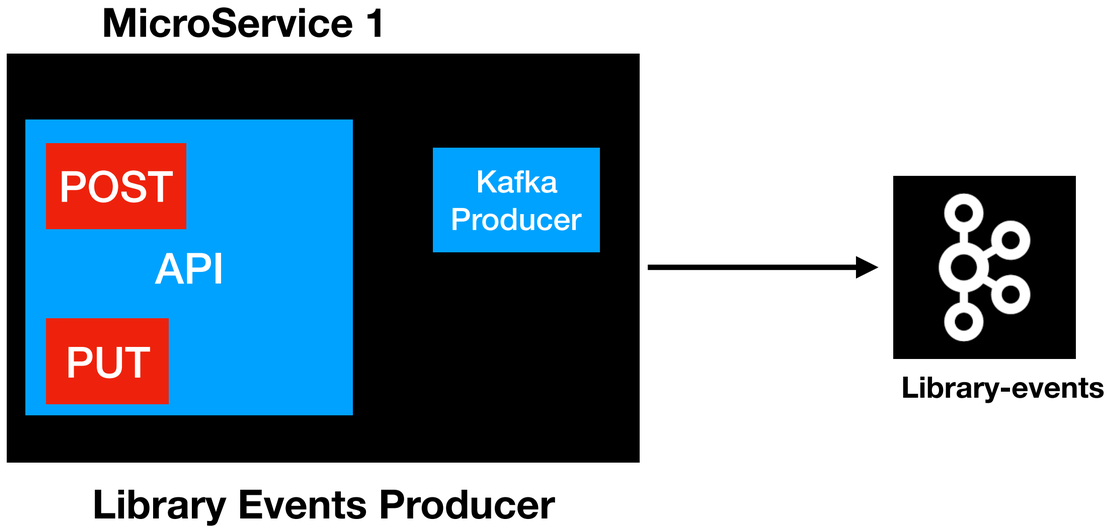
Error Handling
in
Kafka Producer

Library Events Producer API



Kafka Producer Errors

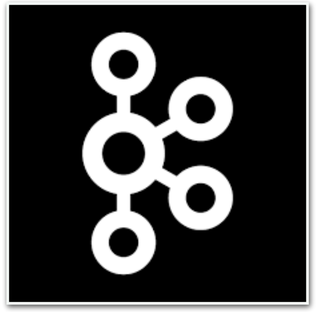
- Kafka Cluster is not available
- If **acks= all ,** some brokers are not available
- **min.insync.replicas** config
  - **Example : min.insync.replicas = 2**, But only one broker is available



min.insync.replicas

min.insync.replicas = 2

Kafka Cluster



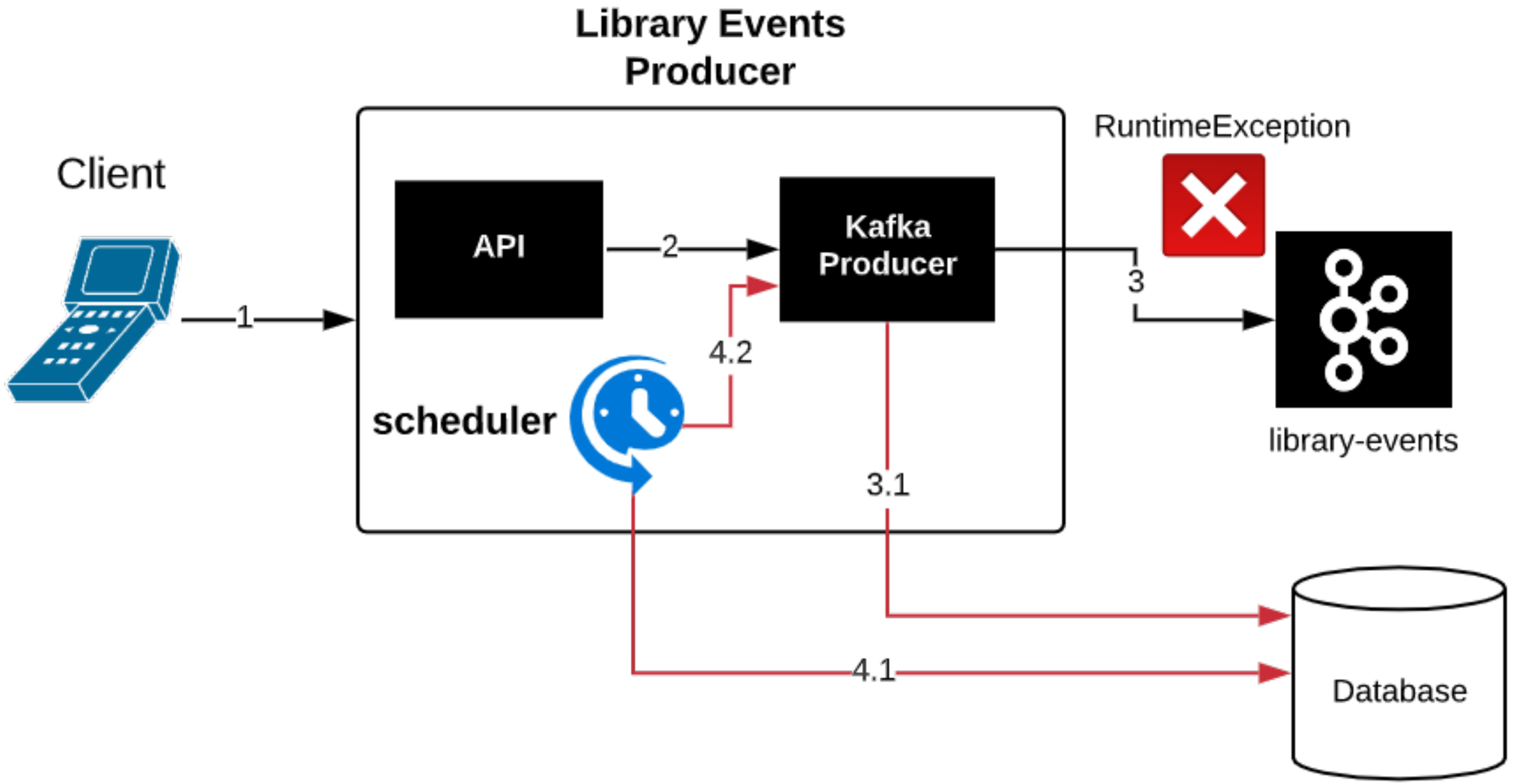
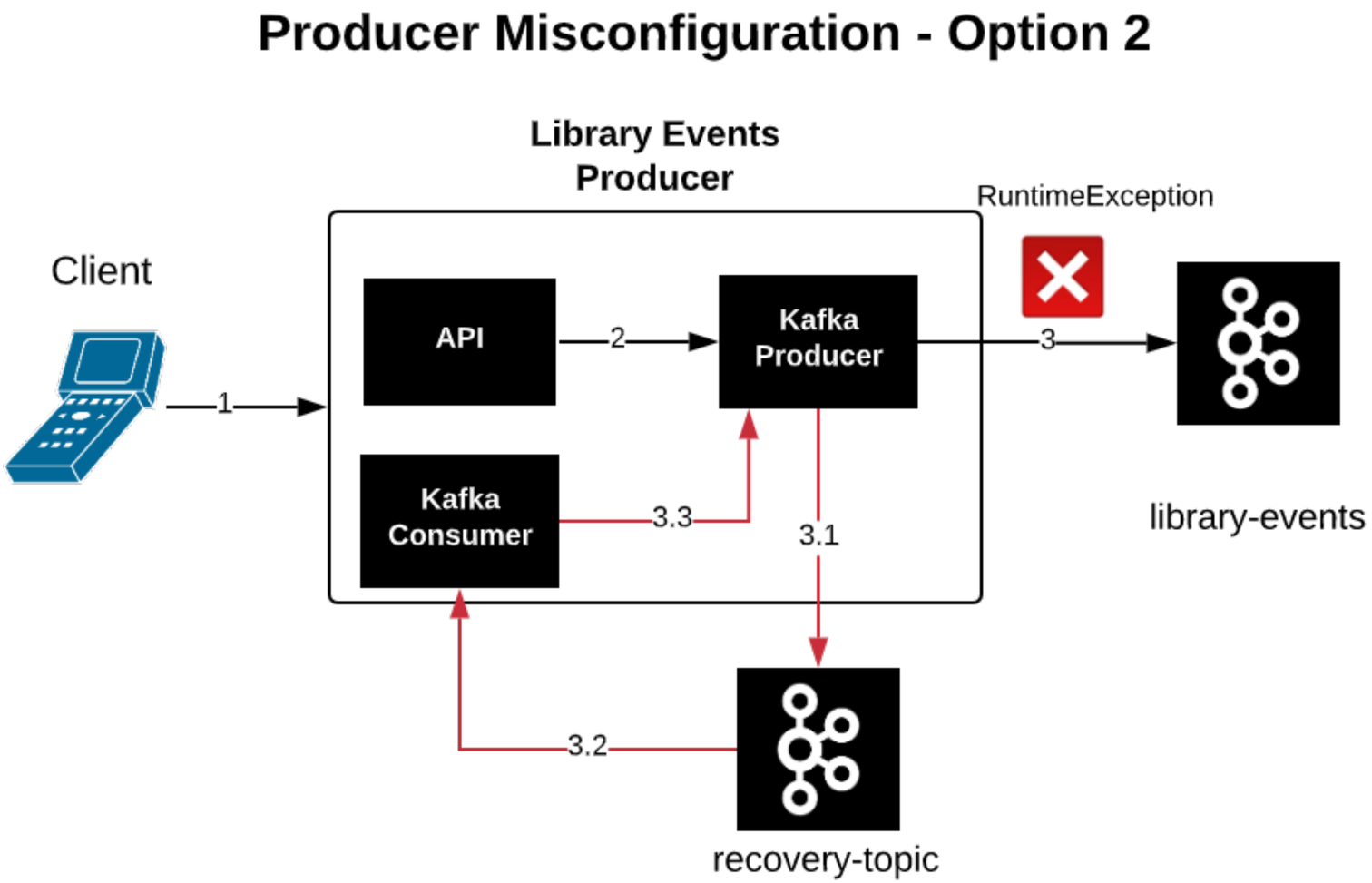
Broker 1

Broker 2

Broker 2

Retain/Recover Failed Records

Retain/Recover Failed Records



Retain/Recover Failed Records