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

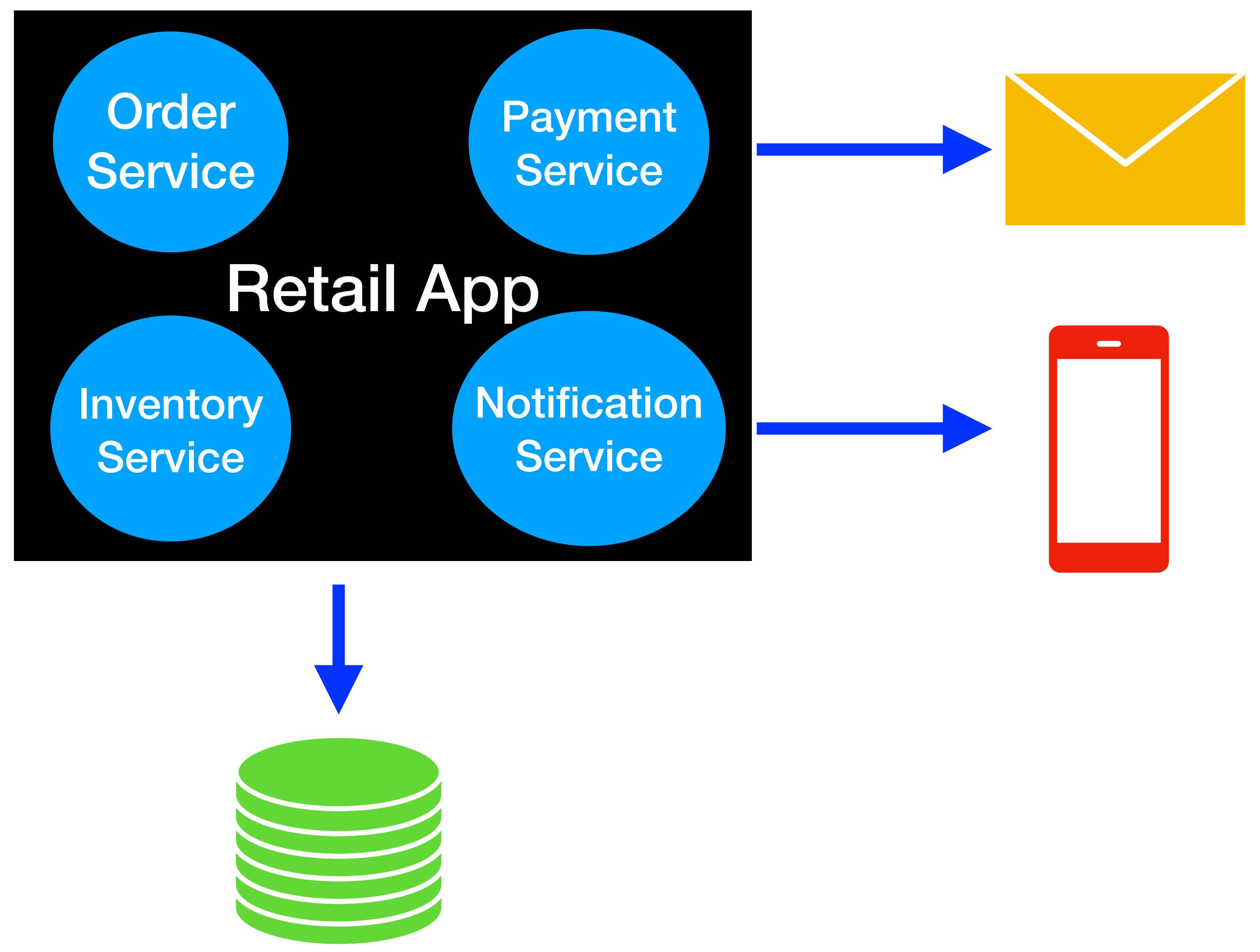
Prerequisites

Course Prerequisites

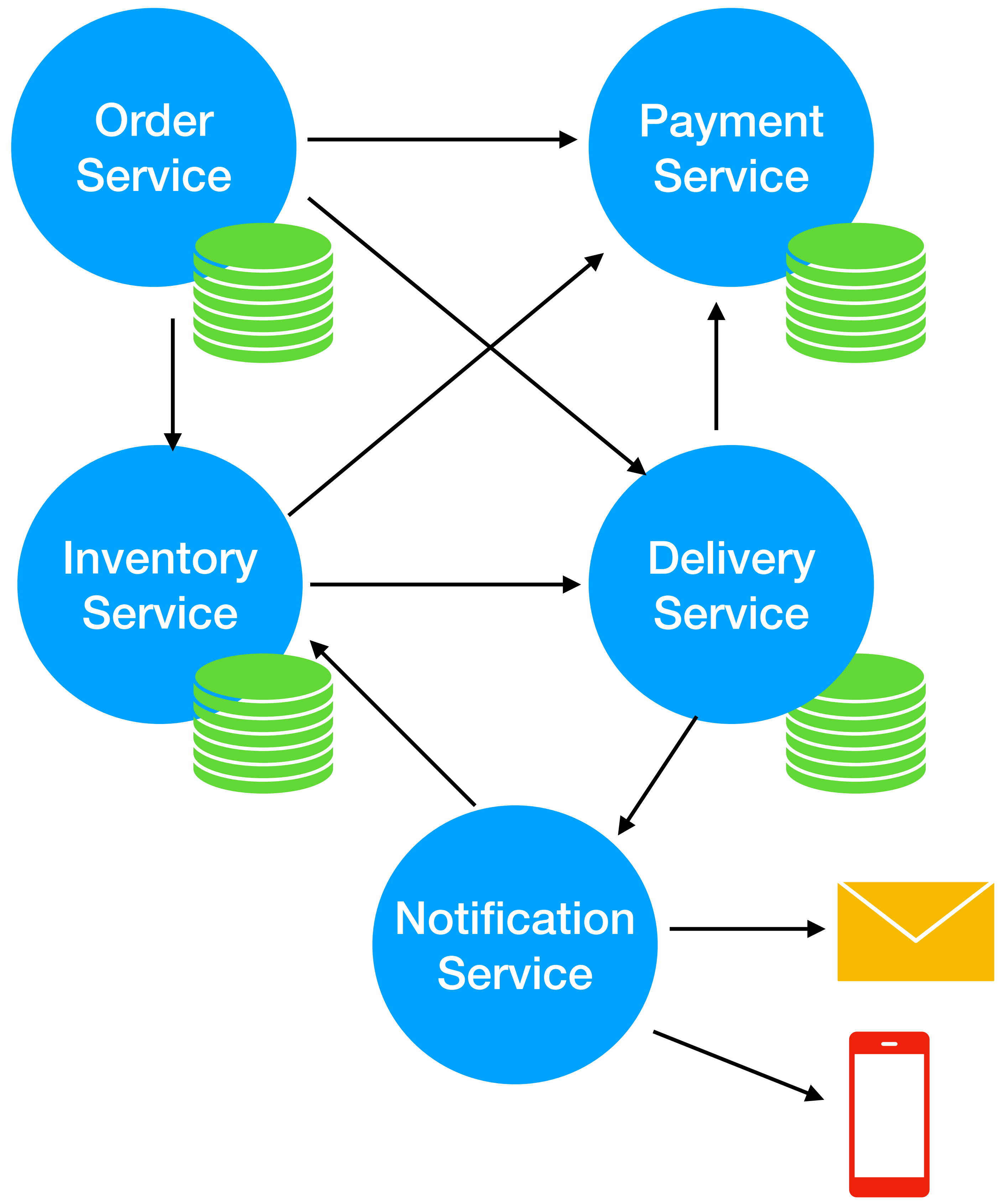
- Prior Knowledge or Working Experience with **Spring Boot/Framework**
- Knowledge about building **Kafka Clients** using Producer and Consumer API
- Knowledge about building **RESTFUL APIs** using Spring Boot
- Experience working with **Spring Data JPA**
- Automated tests using **JUnit**
- Experience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

Software Development

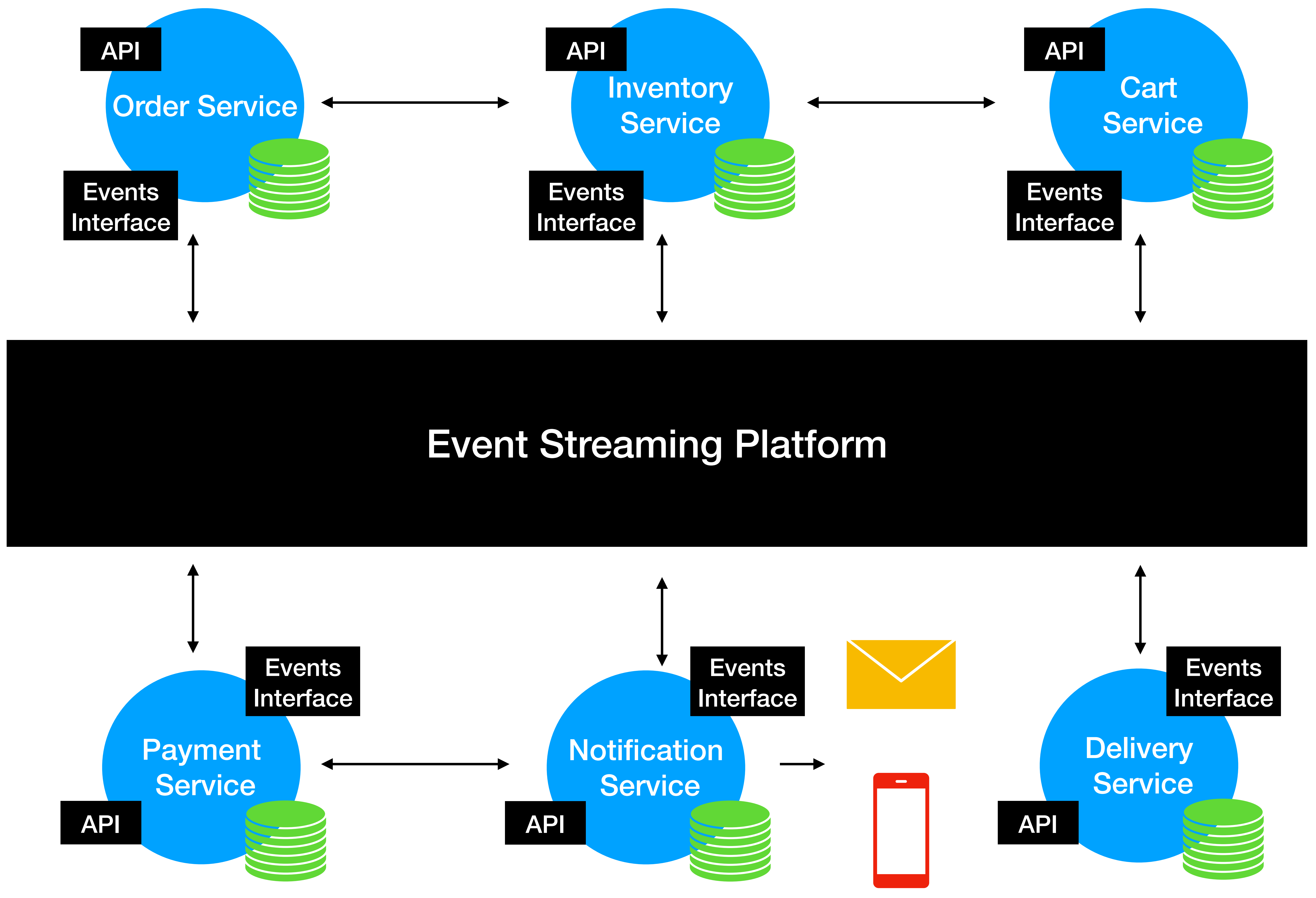
Past



Current

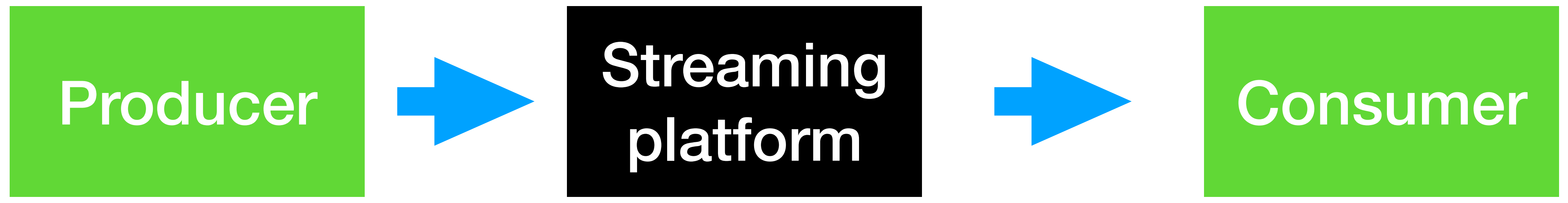


MicroServices Architecture

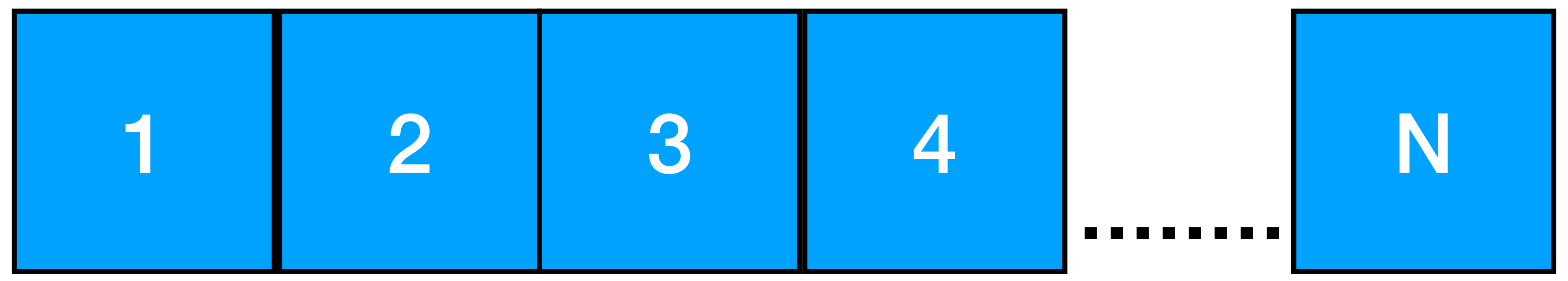


What is an Event Streaming Platform?

- Producers and Consumers subscribe to a stream of records

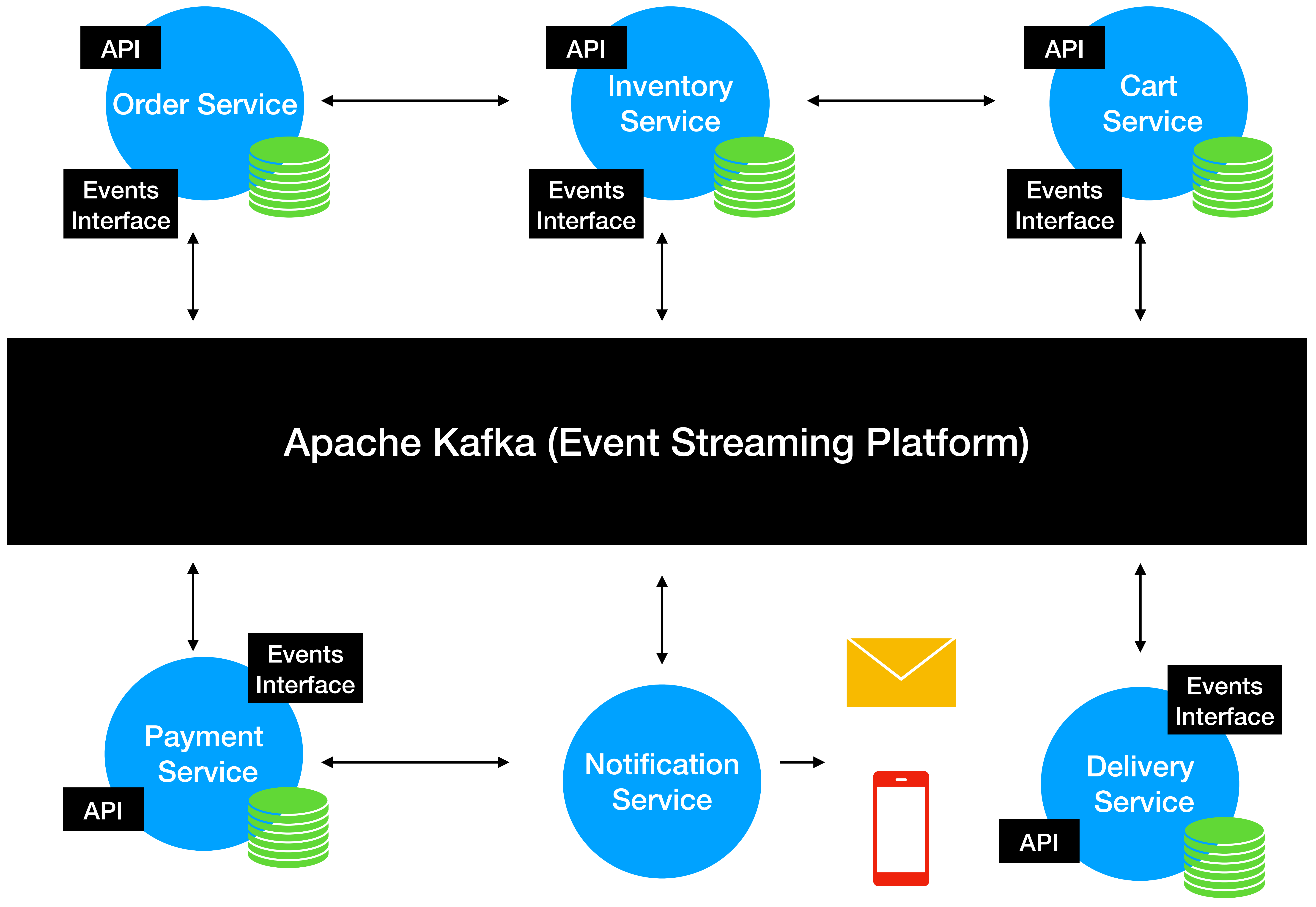


- Store stream of Events



- Analyze and Process Events as they occur

Apache Kafka (Event Streaming Platform)



Traditional Messaging System	Kafka Streaming Platform
• Transient Message Persistance	• Stores events based on a retention time. Events are Immutable
• Brokers responsibility to keep track of consumed messages	• Consumers Responsibility to keep track of consumed messages
• Target a specific Consumer	• Any Consumer can access a message from the broker
• Not a distributed system	• It’s a distributed streaming system

Kafka Use Cases

Transportation

Driver-Rider Notifications

Food Delivery Notifications

Retail

Sale Notifications

RealTime Purchase recommendations

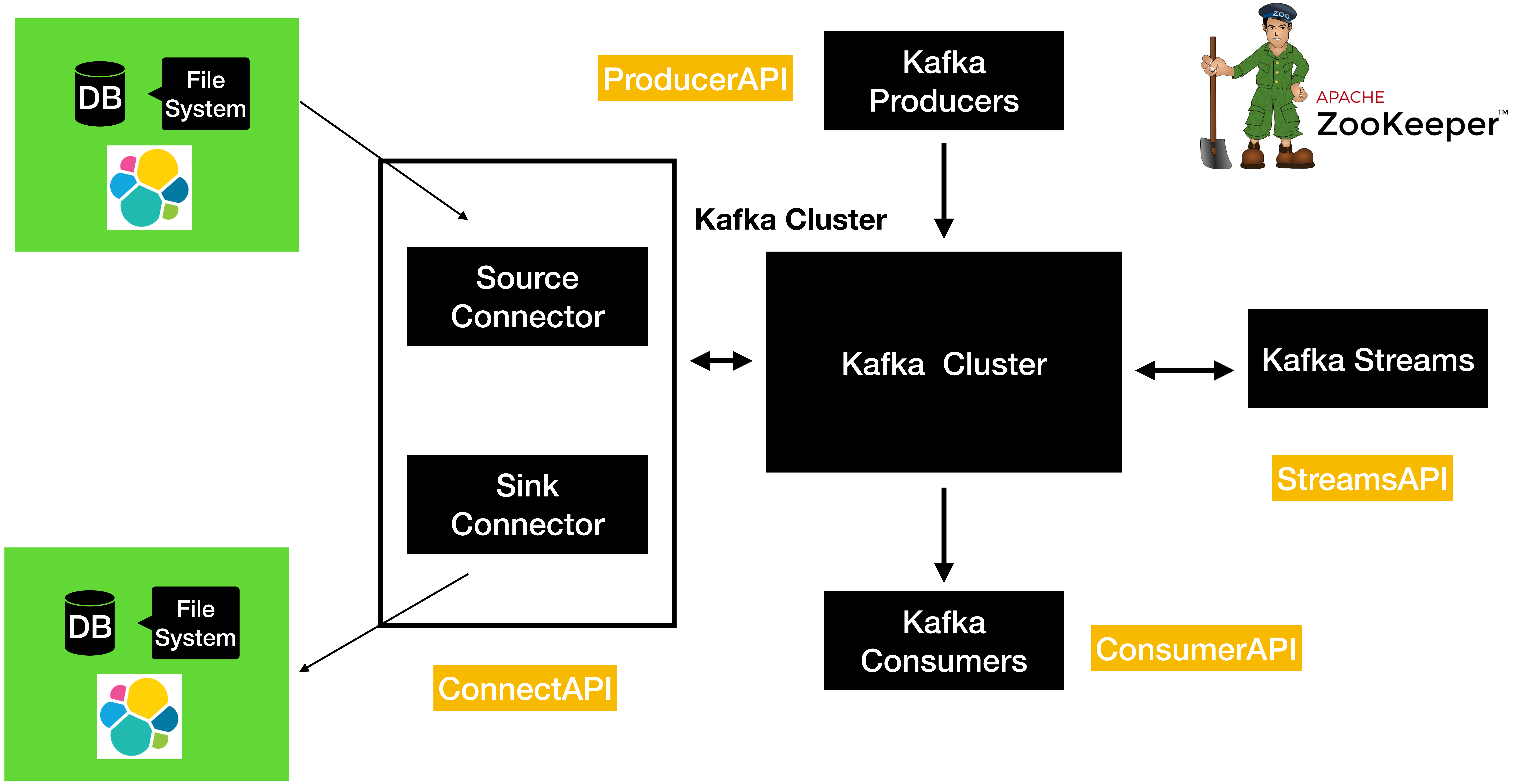
Tracking Online Order Deliveries

Banking

Fraud Transactions

New Feature/Product notifications

Kafka Terminology & Client APIs



Download Kafka

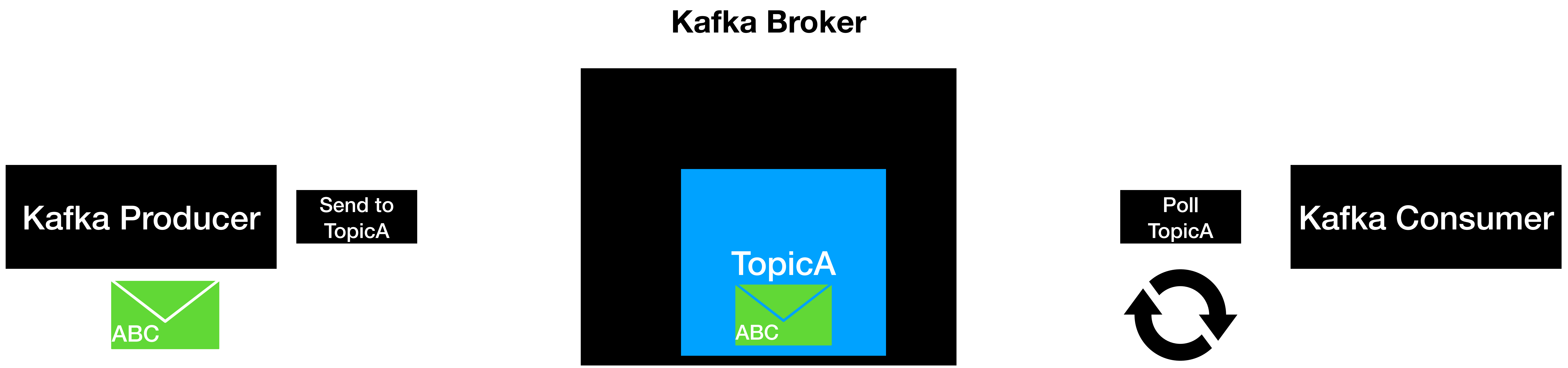
Kafka Topics
&
Partitions

Kafka Topics

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

Kafka Topics

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

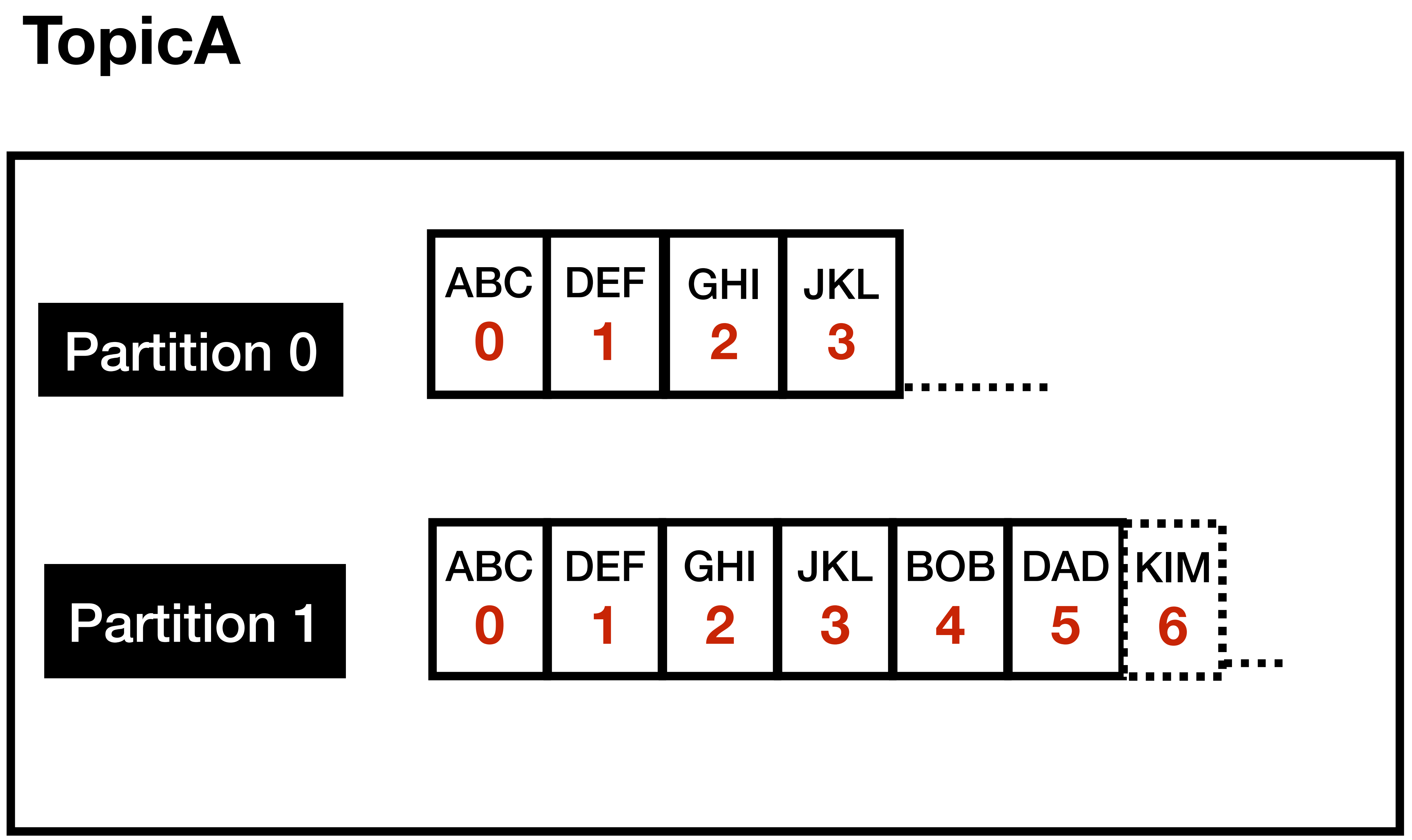


Topic and Partitions

- 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***

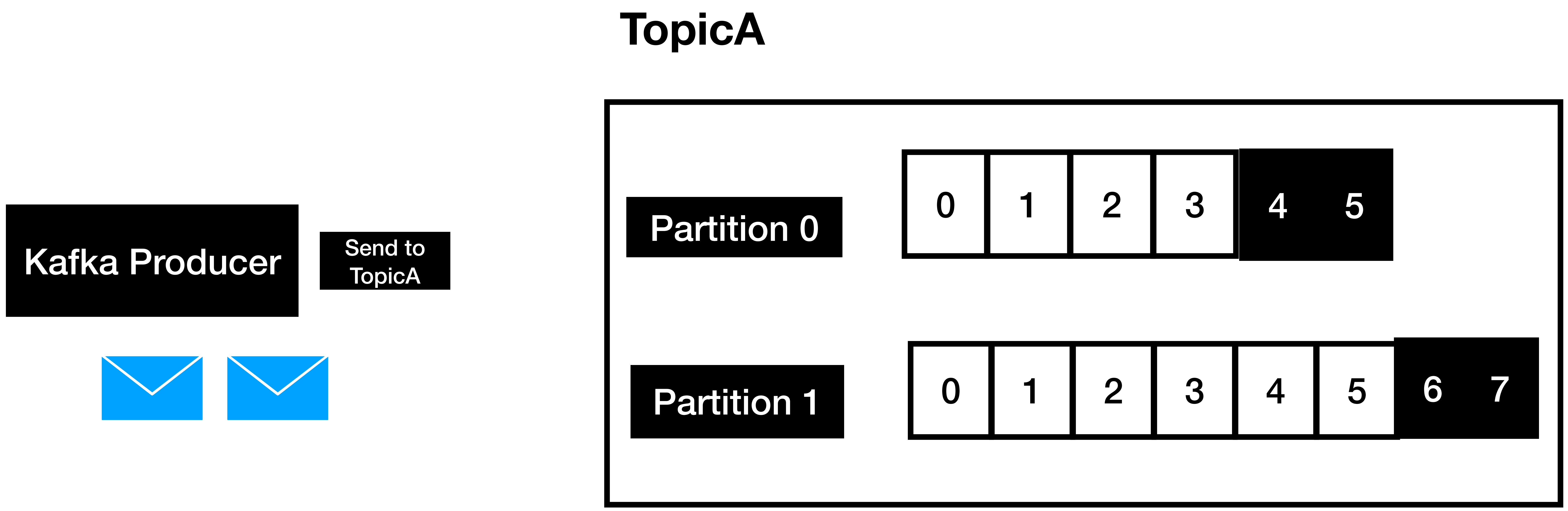
- Each partition is independent of each other

- Ordering is guaranteed only at the partition level

- Partition continuously grows as new records are produced

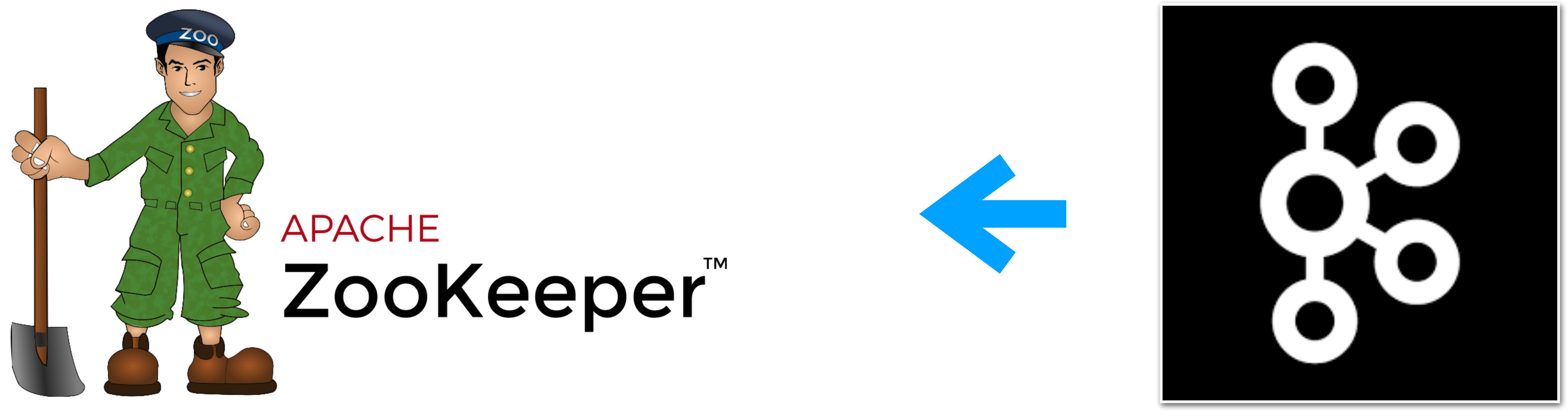
- All the records are persisted in a commit log in the file system where Kafka is installed

Topics and Partitions



Setting up Zookeeper & Kafka Broker

Setting up Kafka in Local



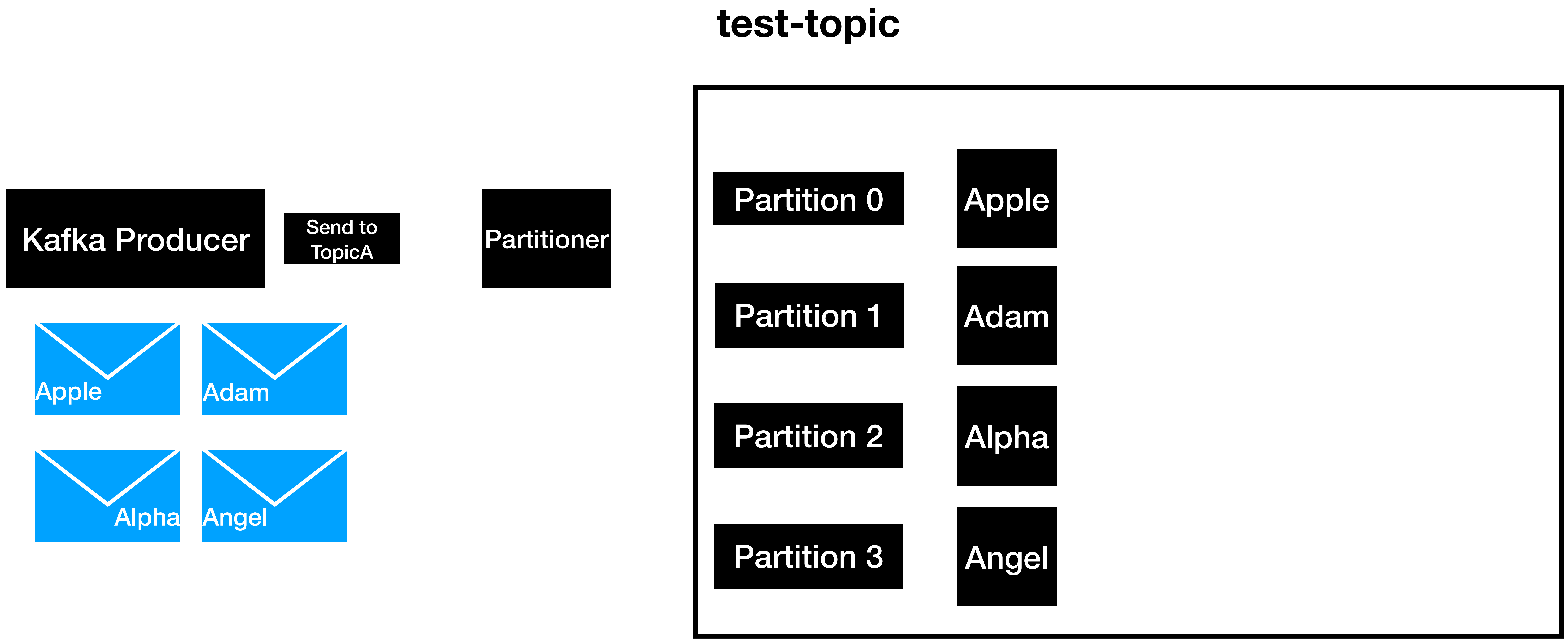
Broker registered with zookeeper

Sending Kafka Messages With Key and Value

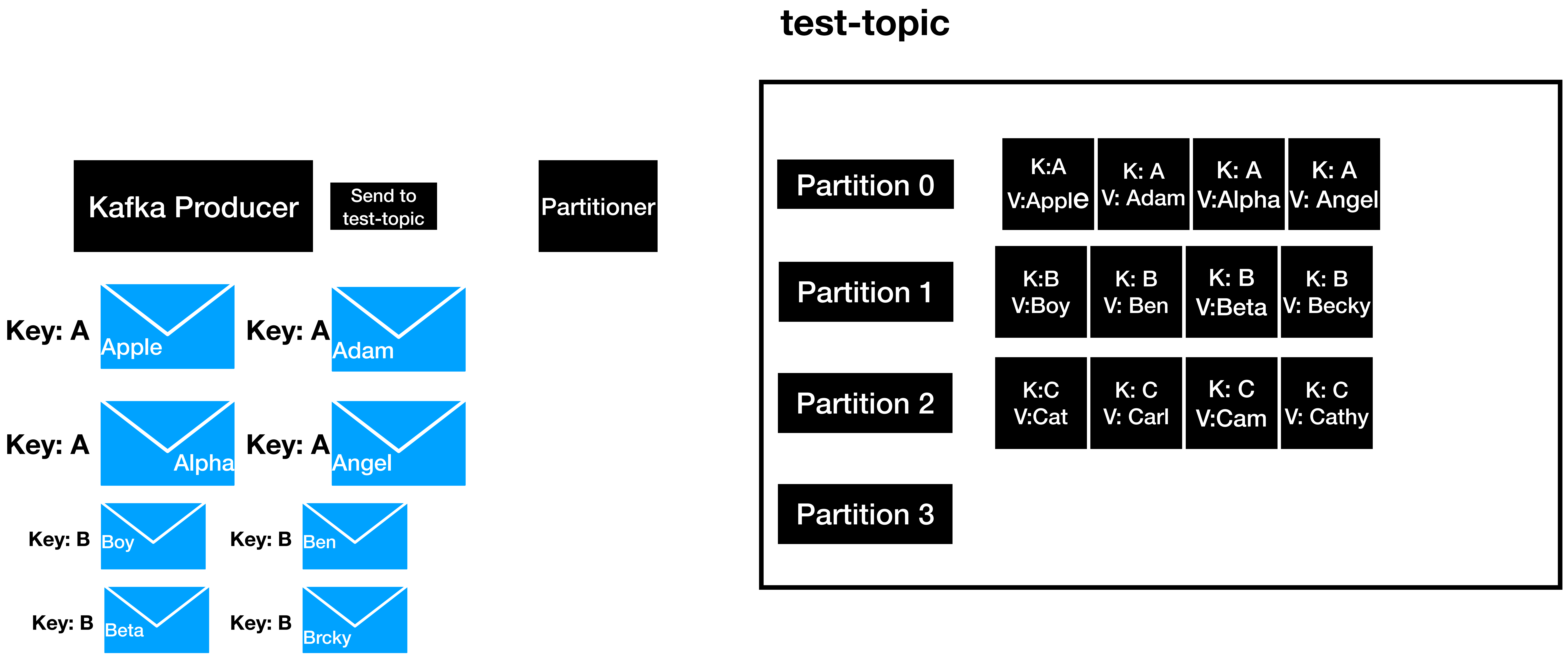
Kafka Message

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

Sending Message Without Key



Sending Message With Key

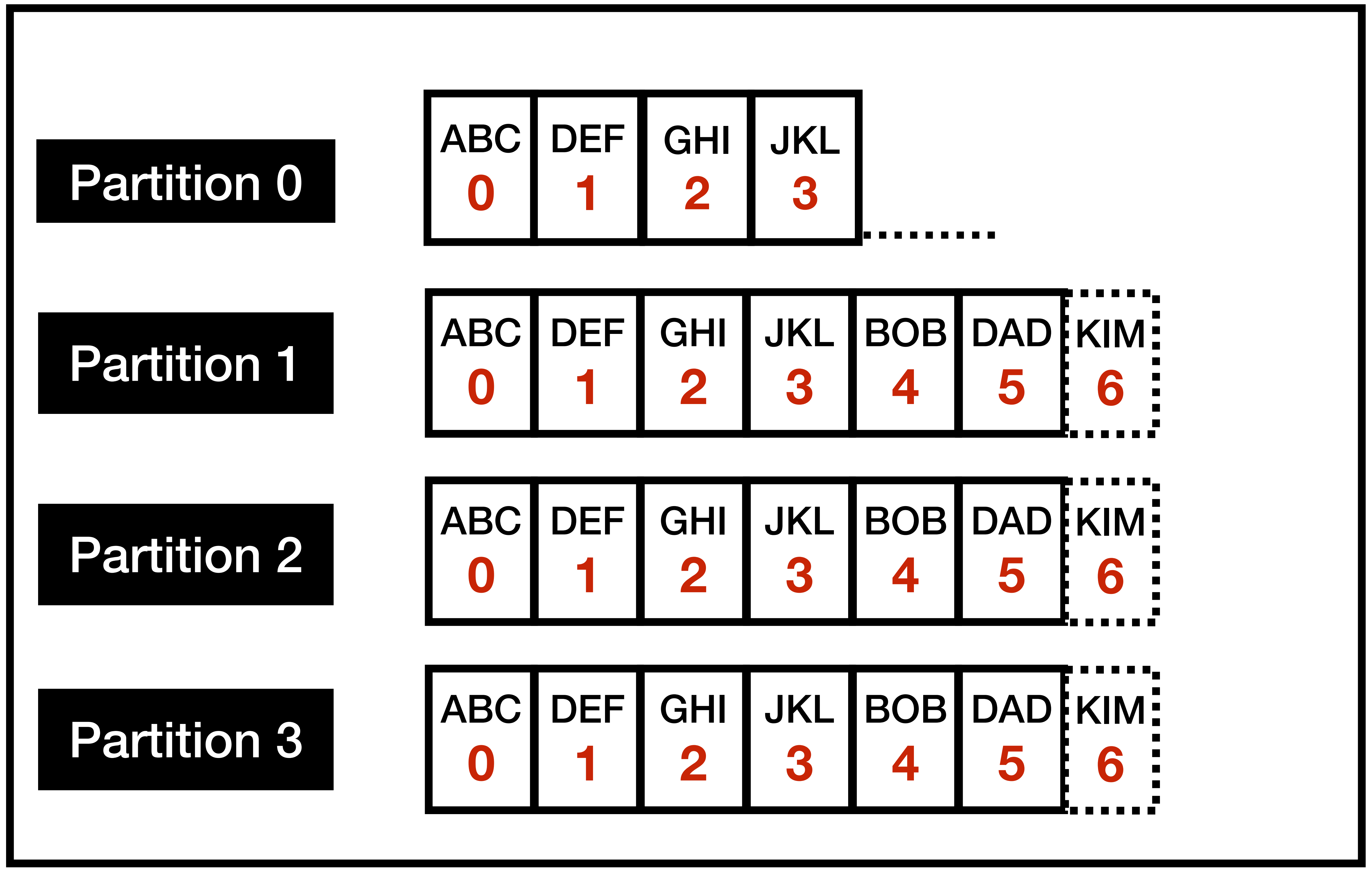


Consumer Offsets

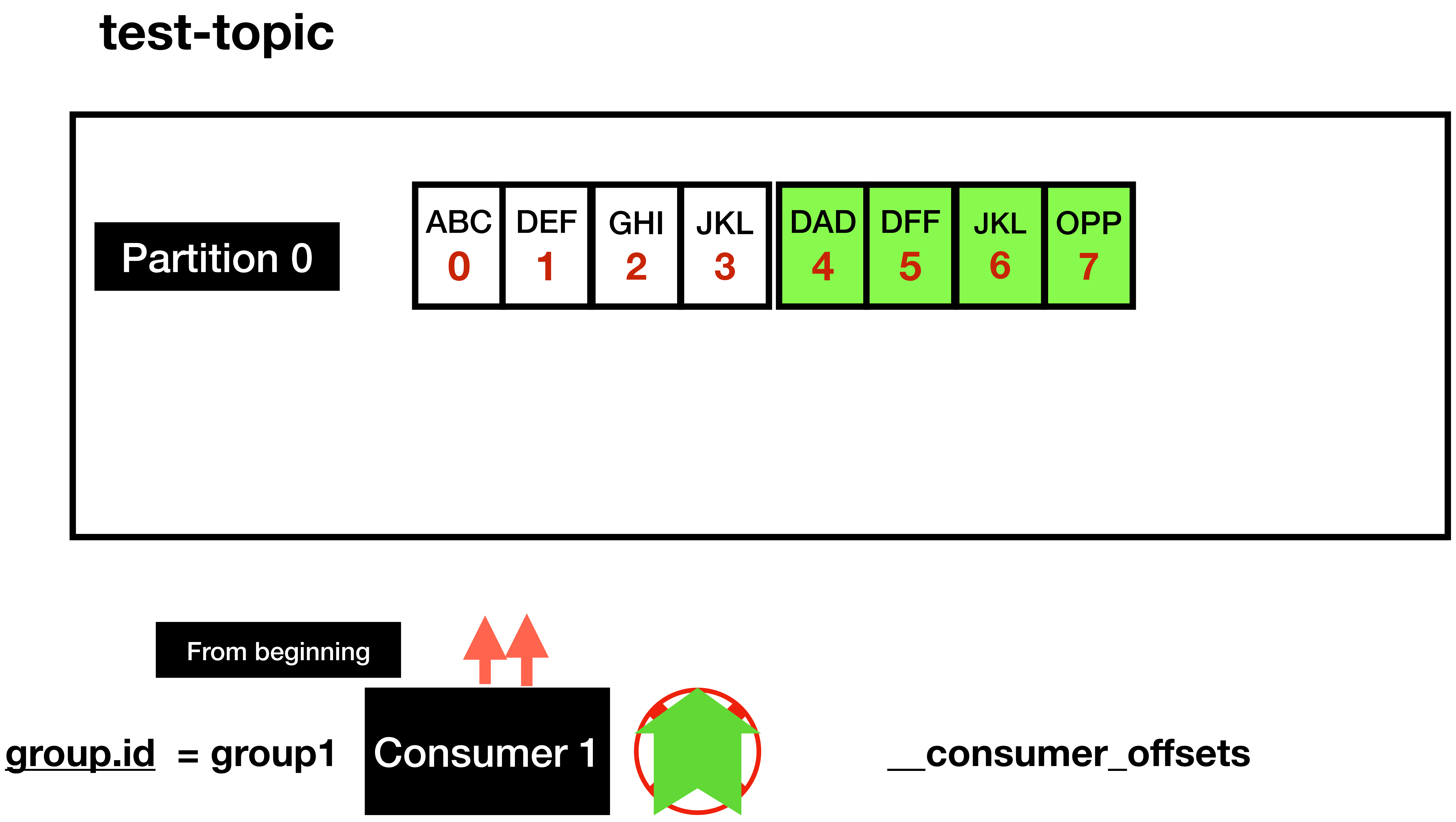
Consumer Offsets

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

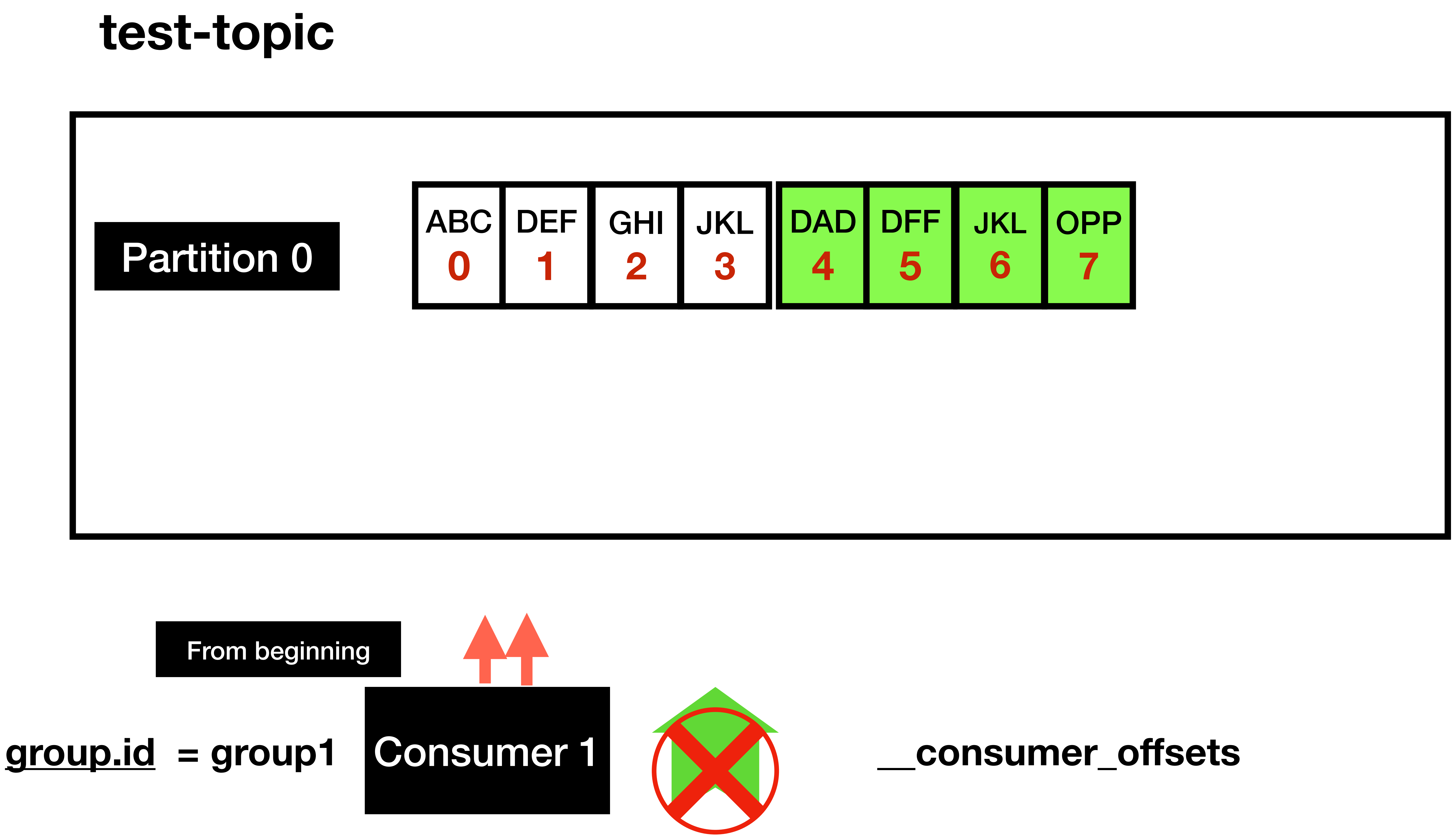
test-topic



Consumer Offsets



Consumer Offsets



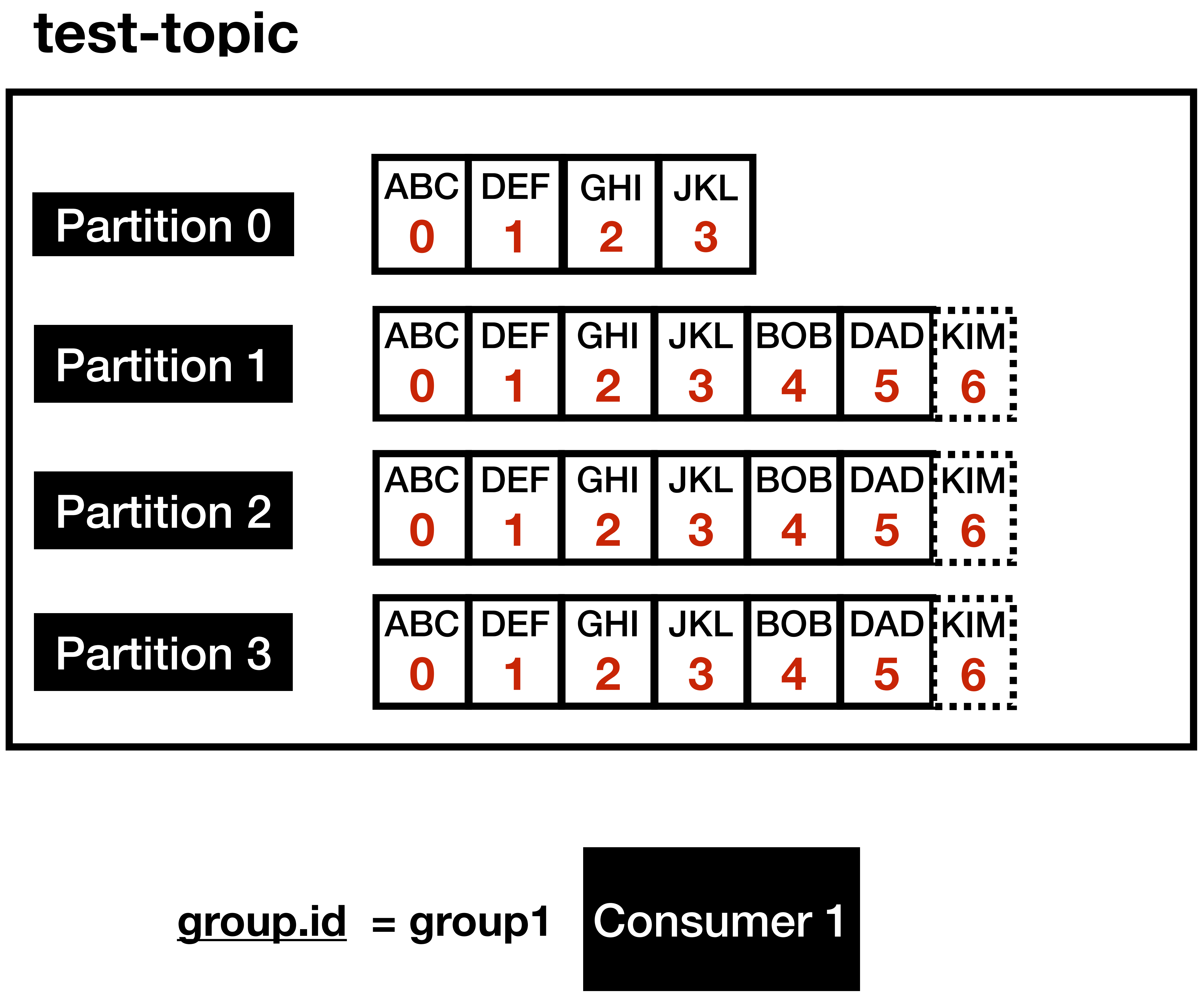
Consumer Offset

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

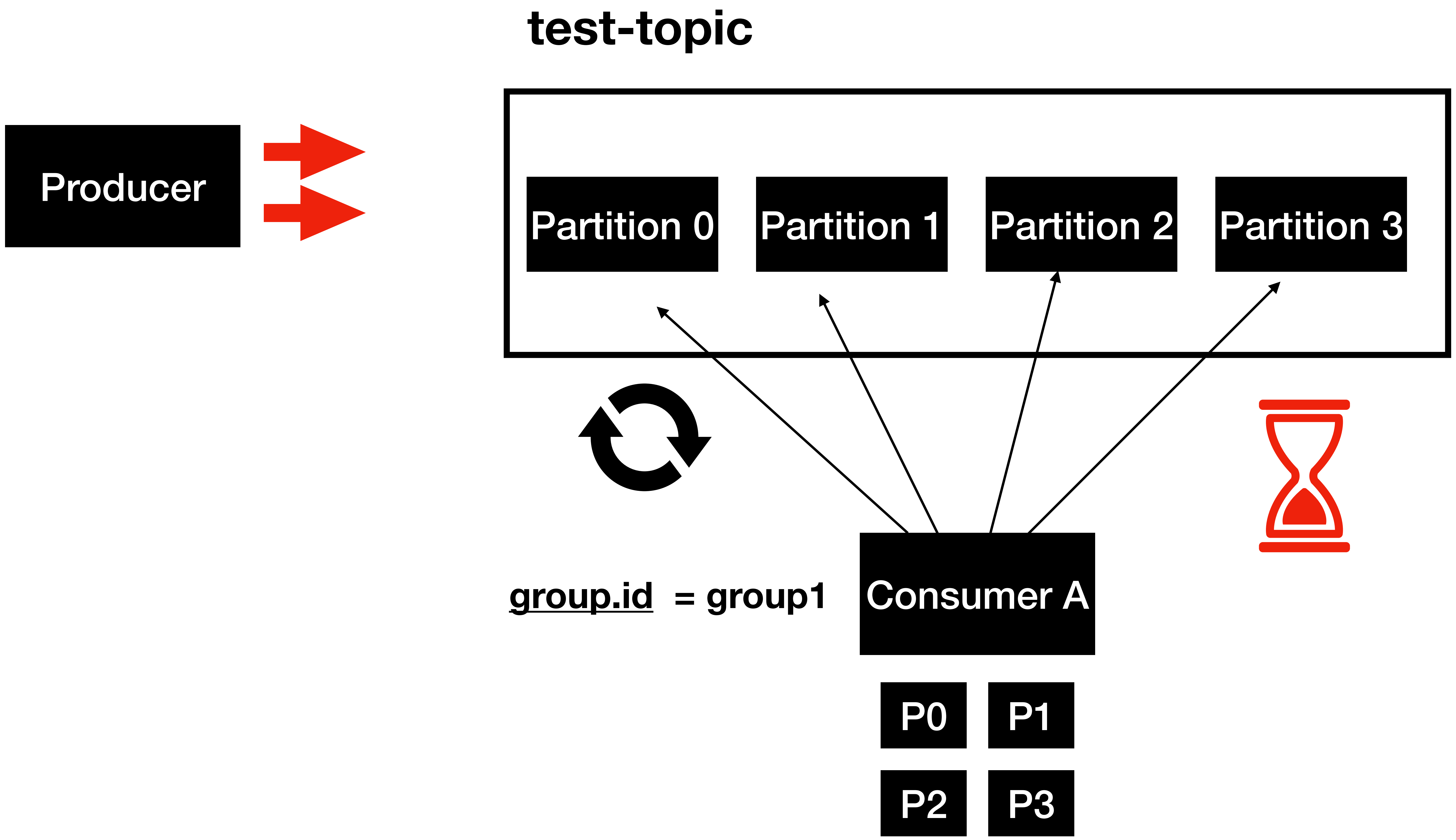
Consumer Groups

Consumer Groups

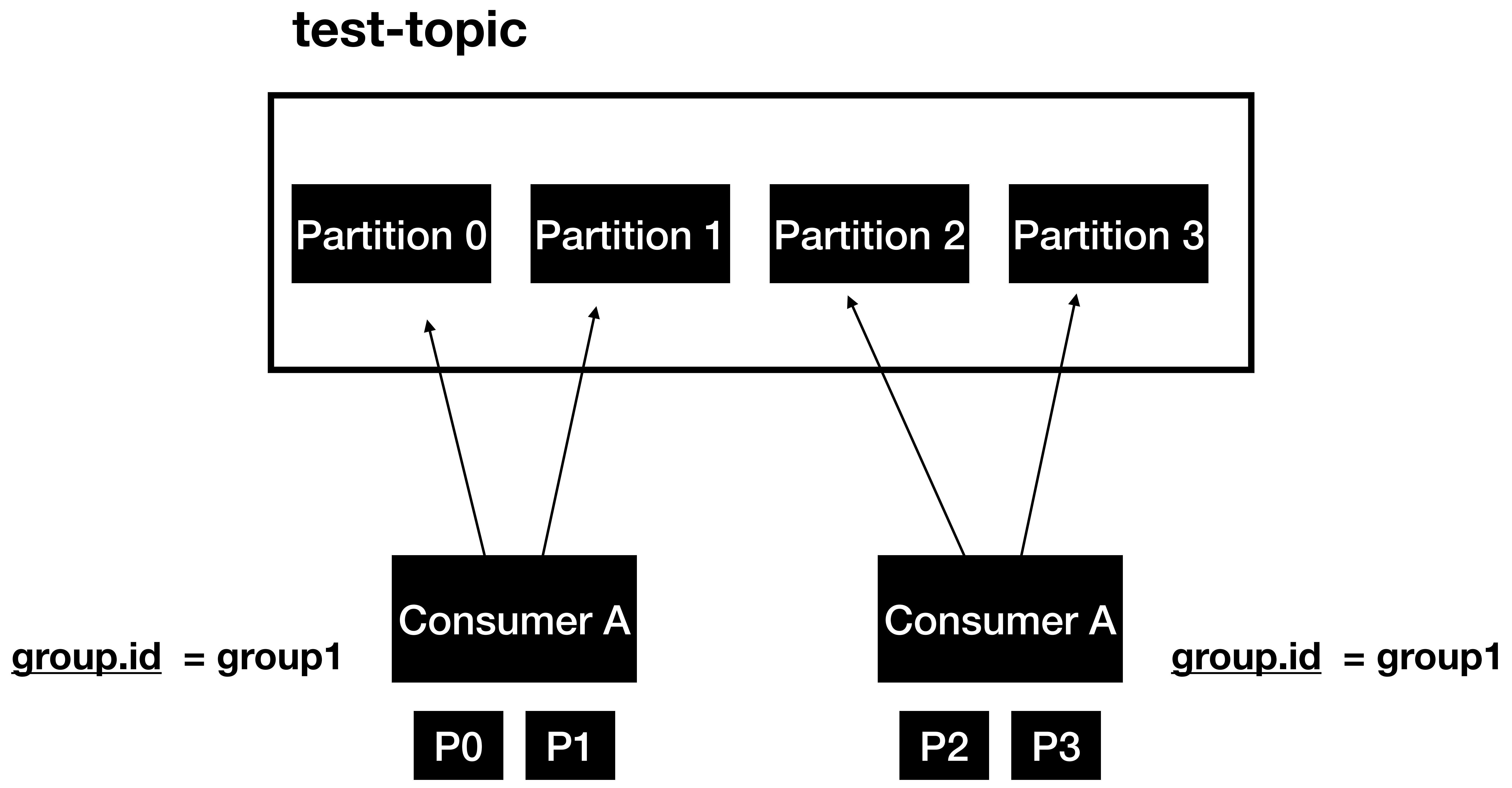
- **group.id** is mandatory
- **group.id** plays a major role when it comes to scalable message consumption.



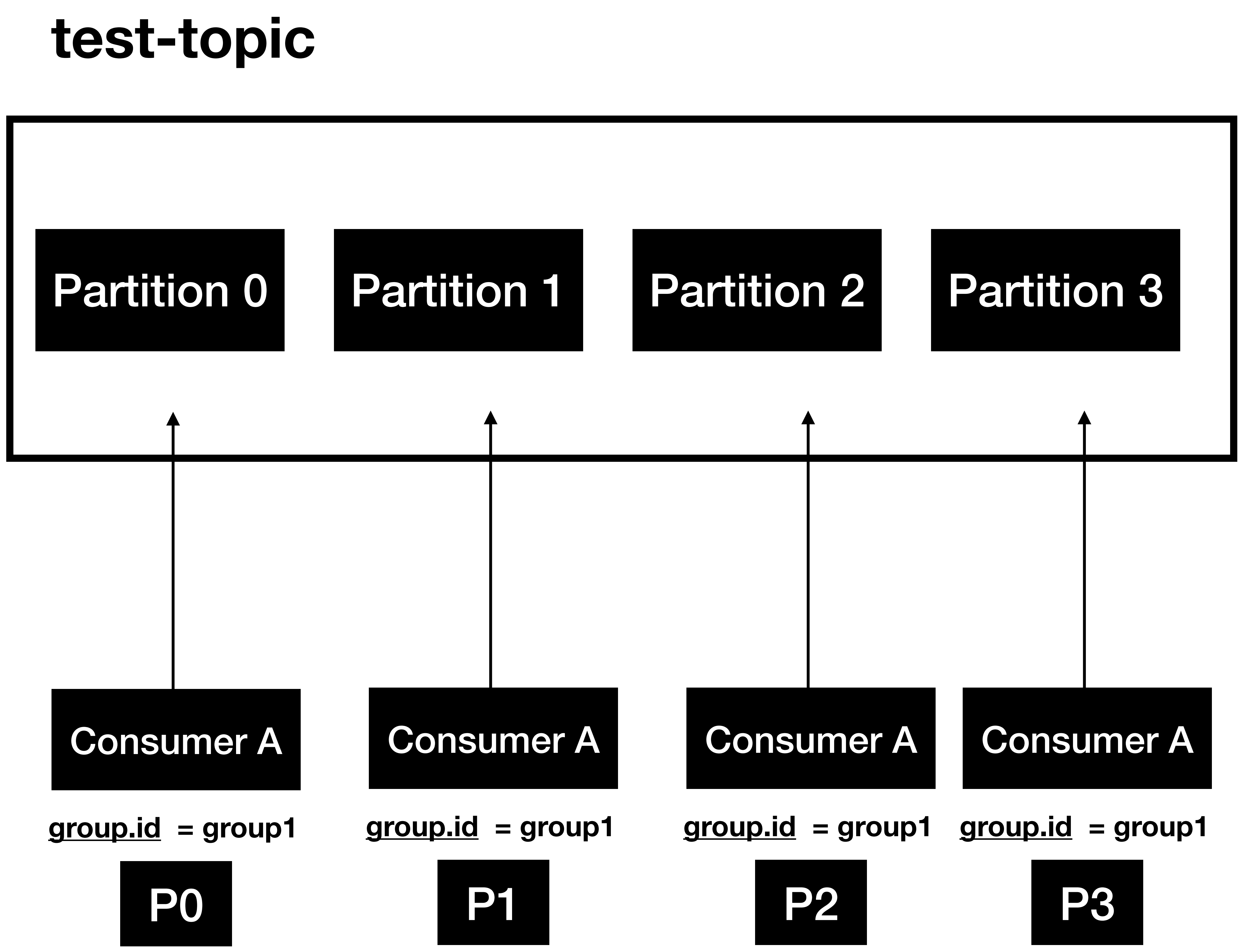
Consumer Groups



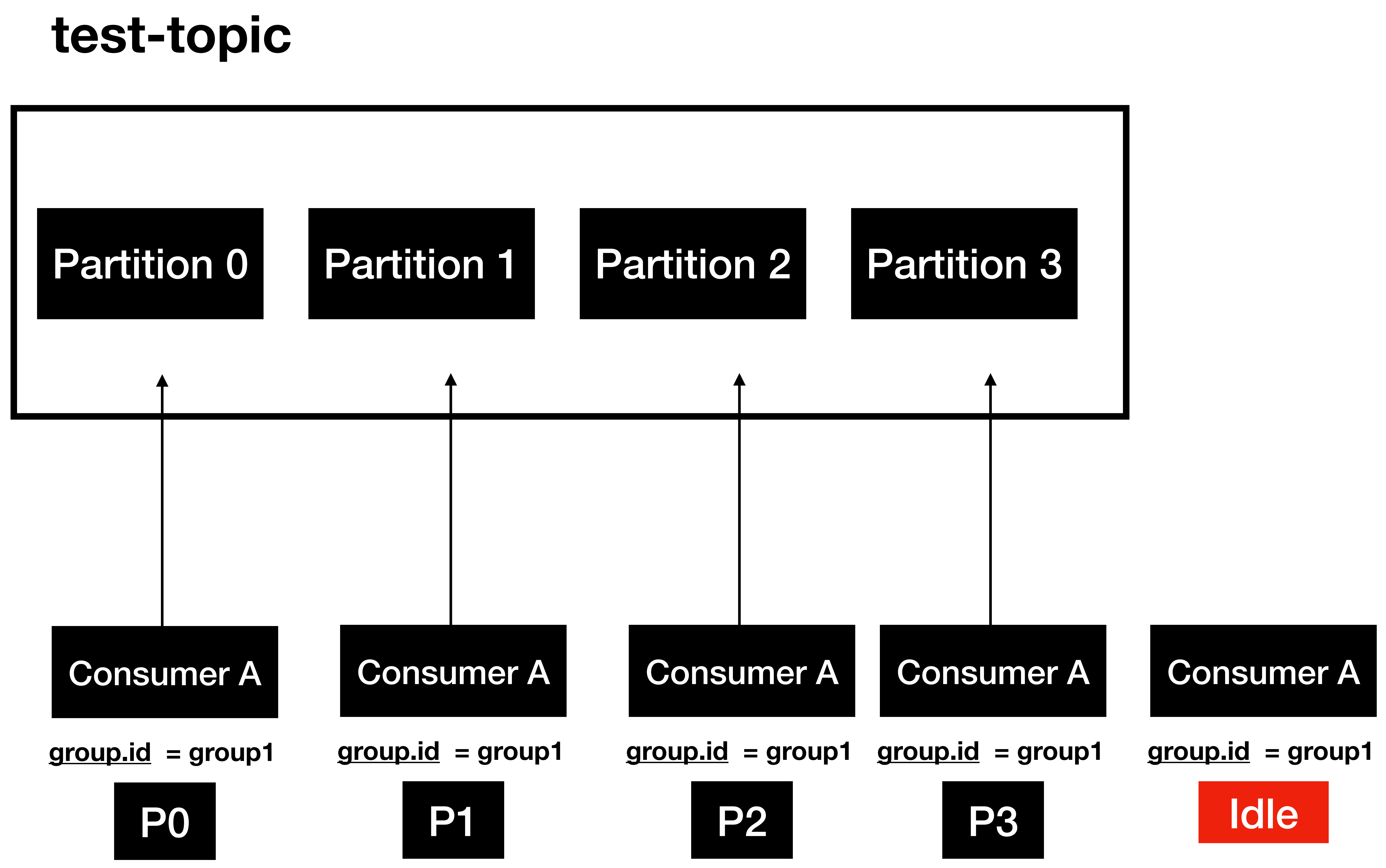
Consumer Groups



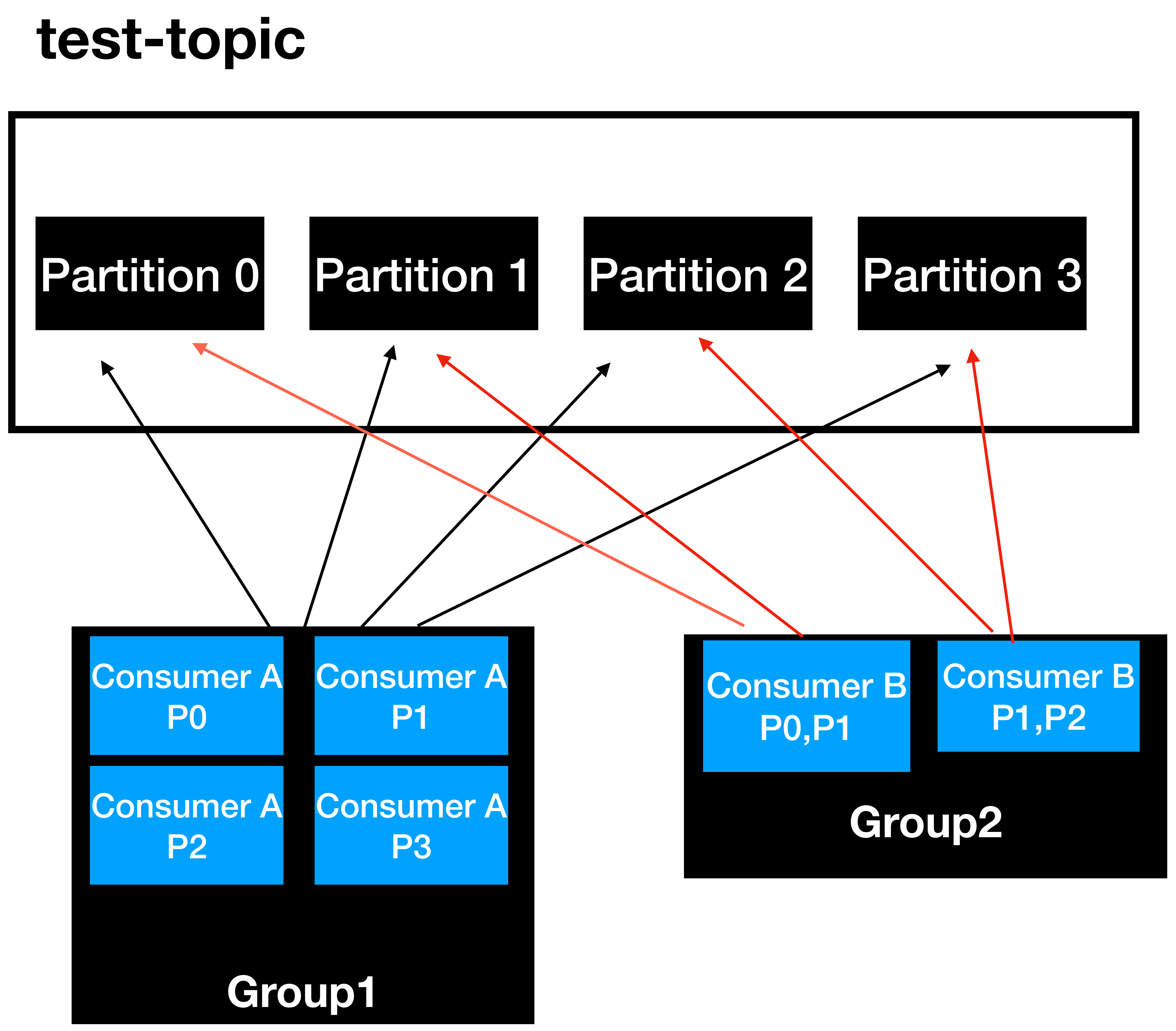
Consumer Groups



Consumer Groups



Consumer Groups

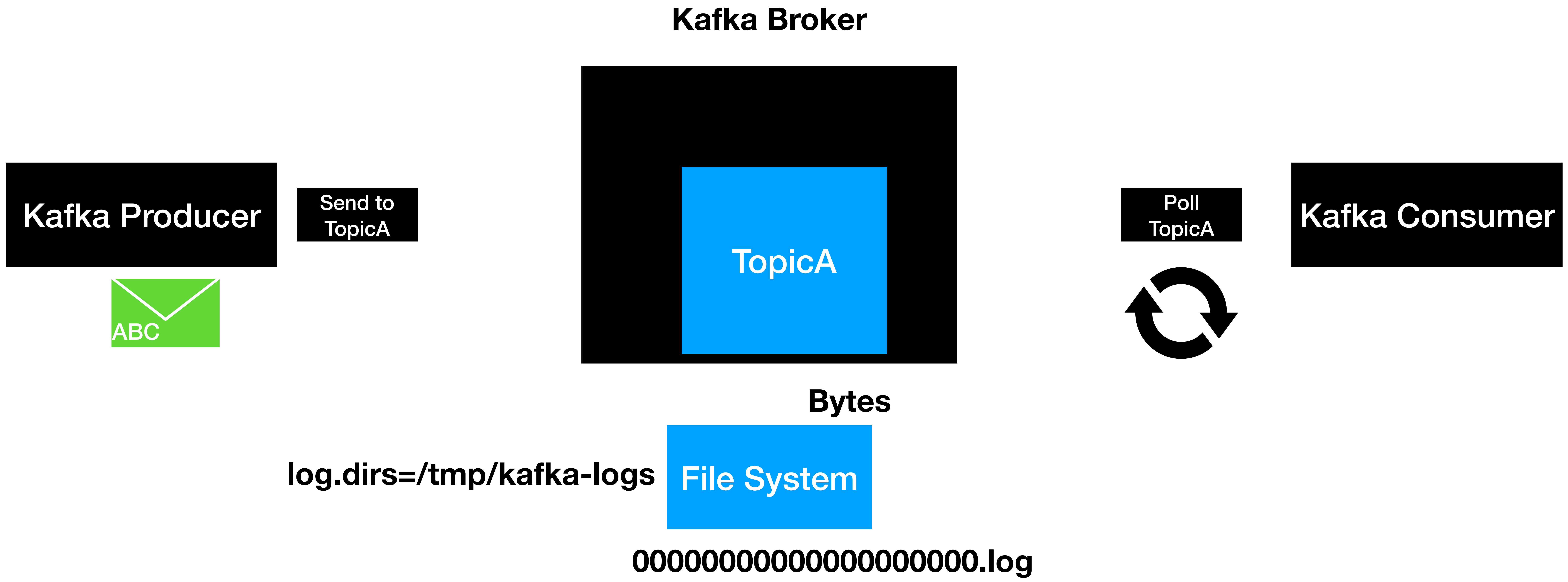


Consumer Groups : Summary

- 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

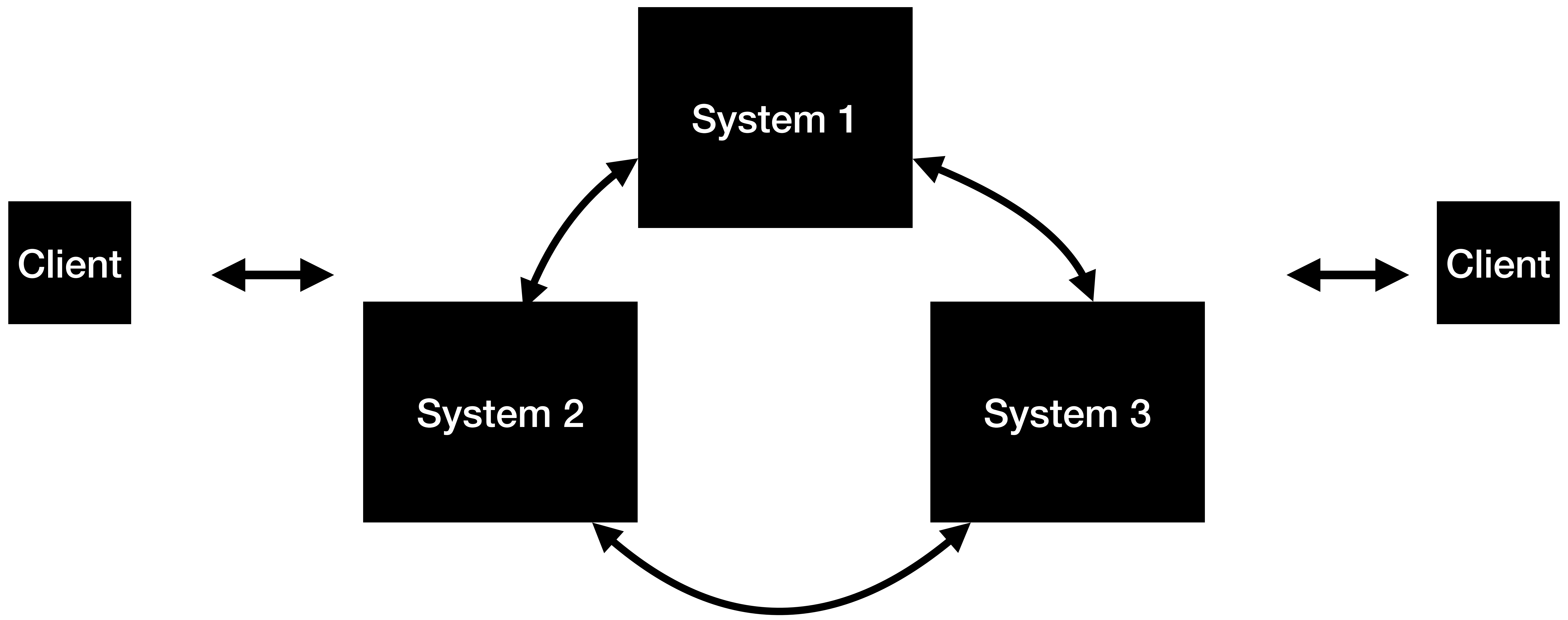
- Determines how long the message is retained ?
- Configured using the property **log.retention.hours** in **server.properties** file
- Default retention period is **168 hours** (7 days)

Kafka
as a
Distributed Streaming
System

Apache Kafka® is *a distributed streaming platform*

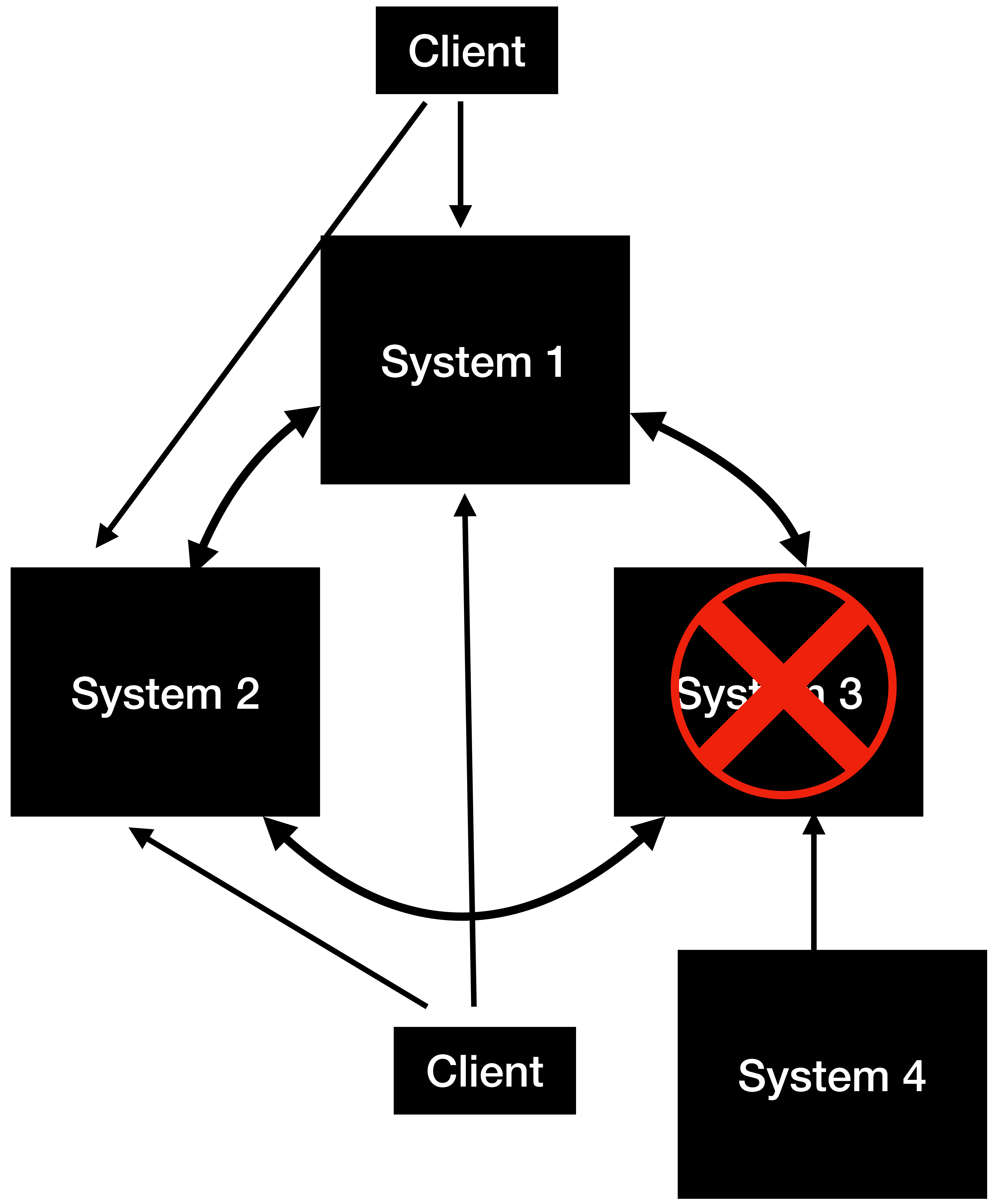
What is a Distributed System?

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

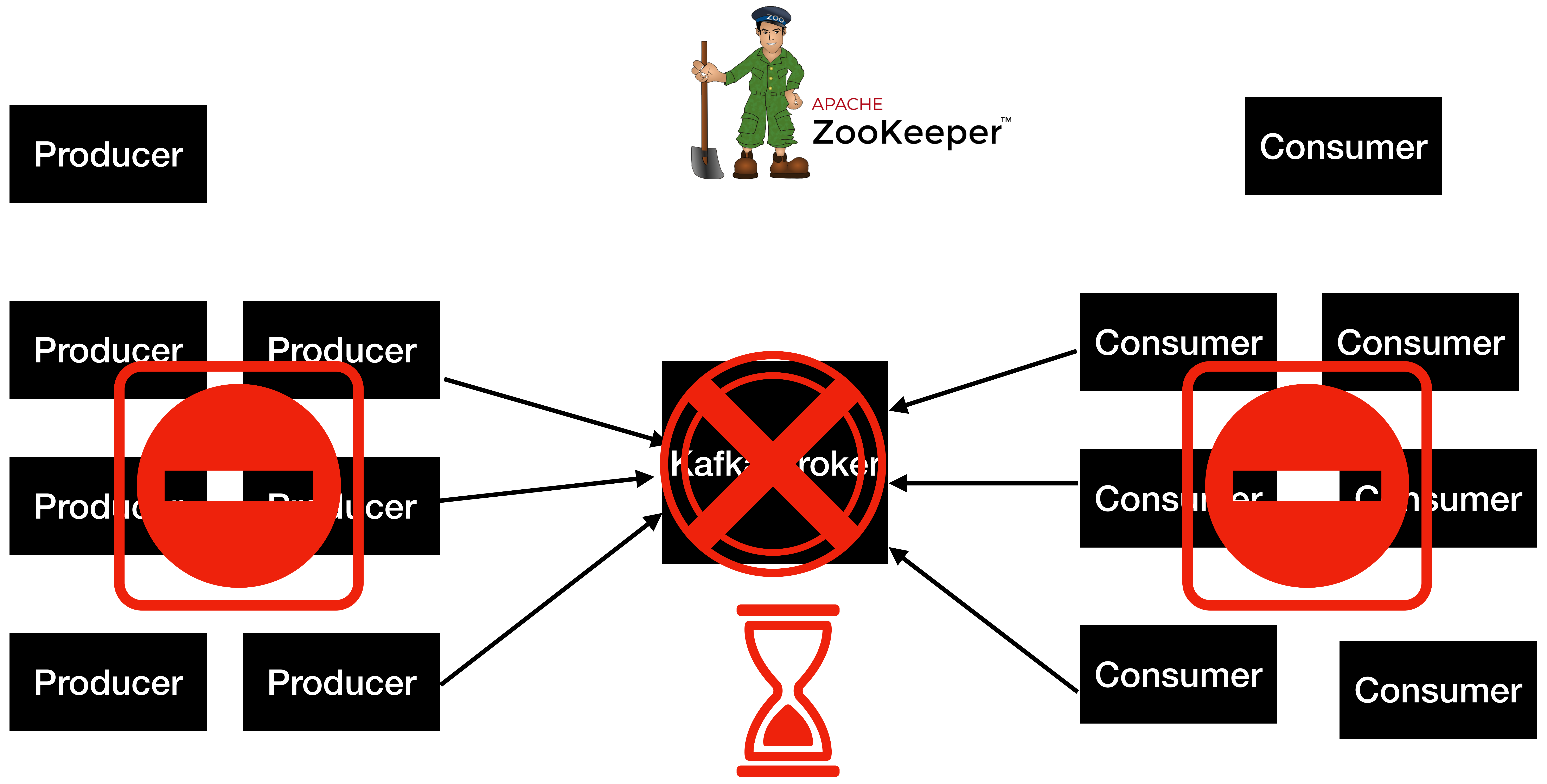


Characteristics of Distributed System

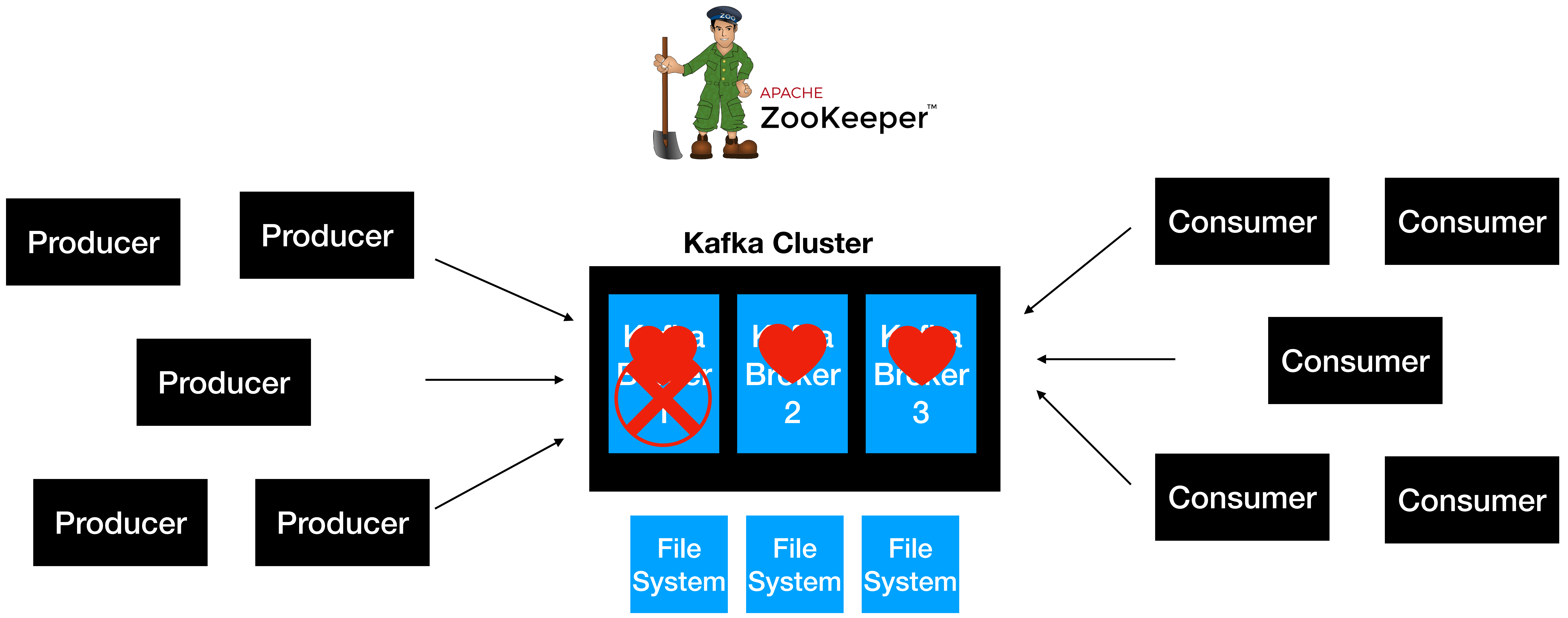
- Availability and Fault Tolerance
- Reliable Work Distribution
- Easily Scalable
- Handling Concurrency is fairly easy



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)
```

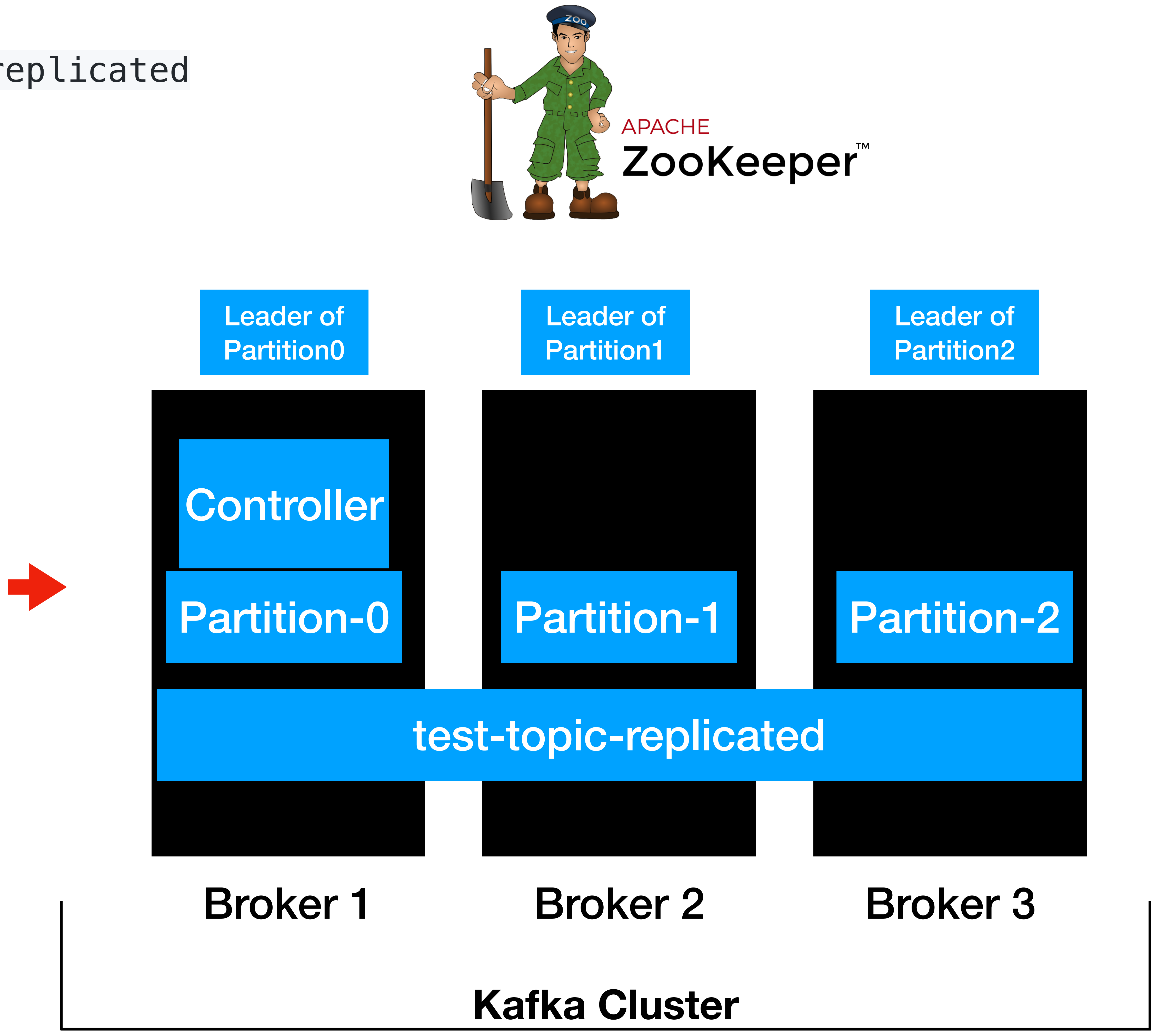
Example: **server-1.properties**

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

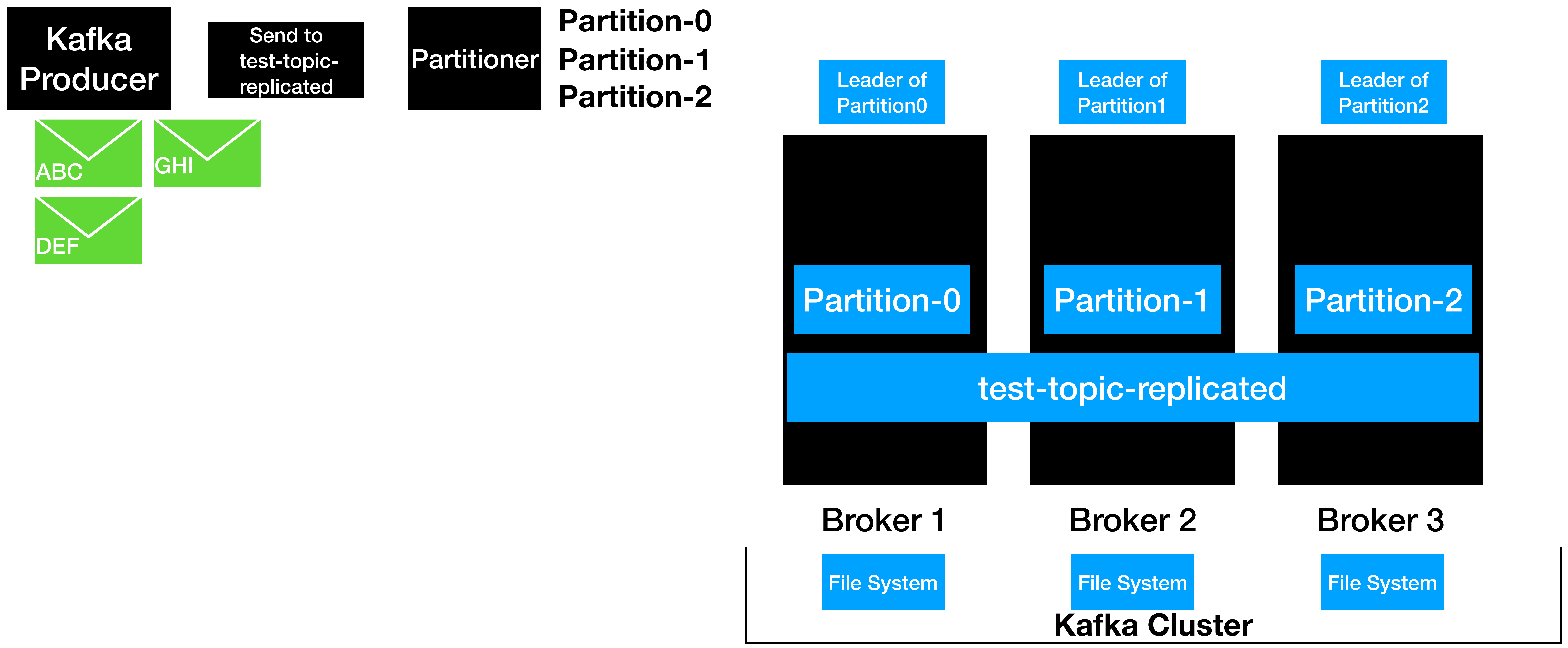
How Kafka Distributes the Client Requests?

How Topics are distributed?

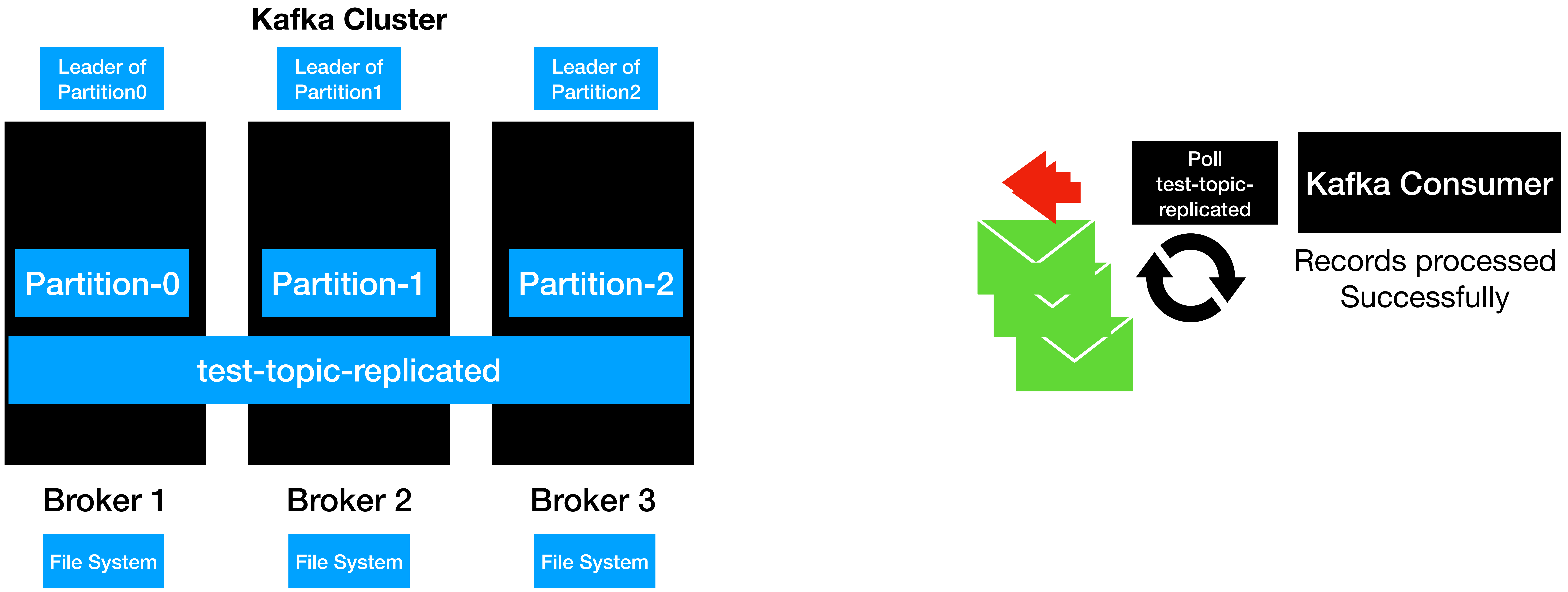
```
./kafka-topics.sh -
-create --topic test-topic-replicated
-zookeeper localhost:2181
--replication-factor 3
 --partitions 3
```



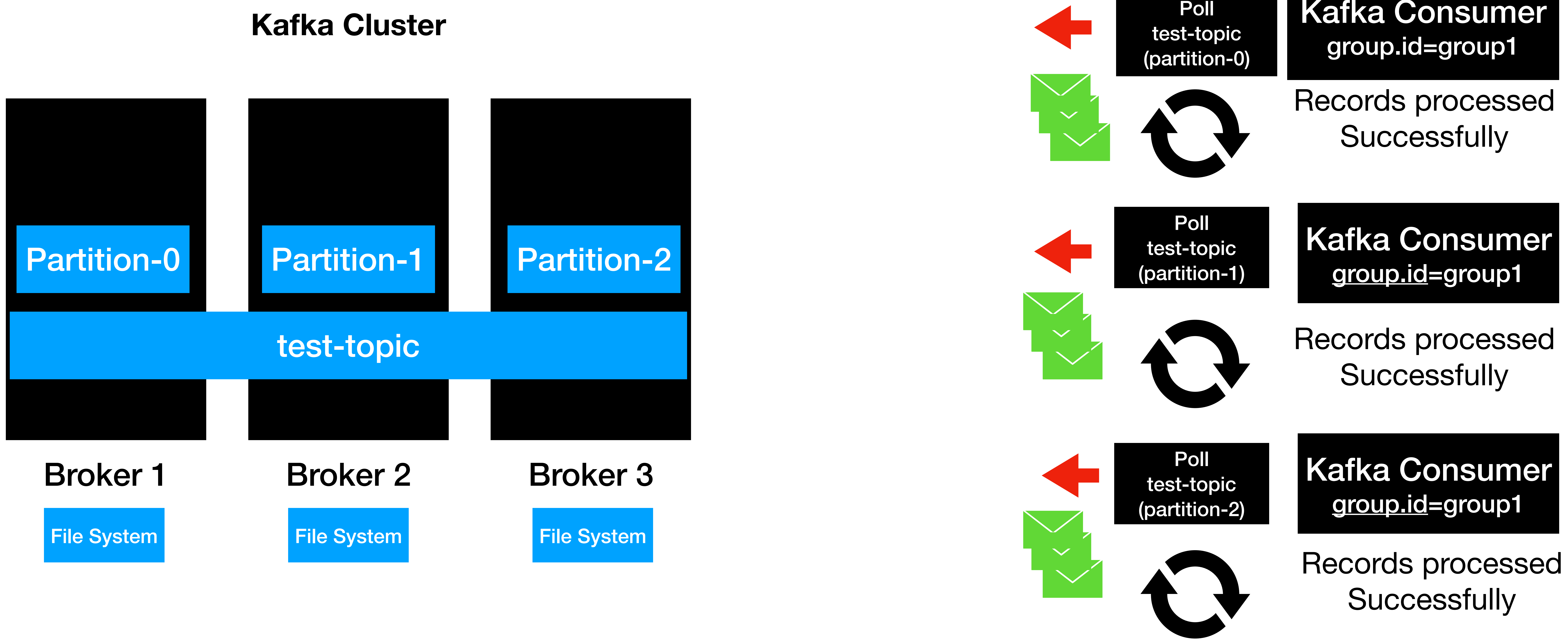
How Kafka Distributes Client Requests?
Kafka Producer



How Kafka Distributes Client Requests? Kafka Consumer



How Kafka Distributes Client Requests? Kafka Consumer Groups

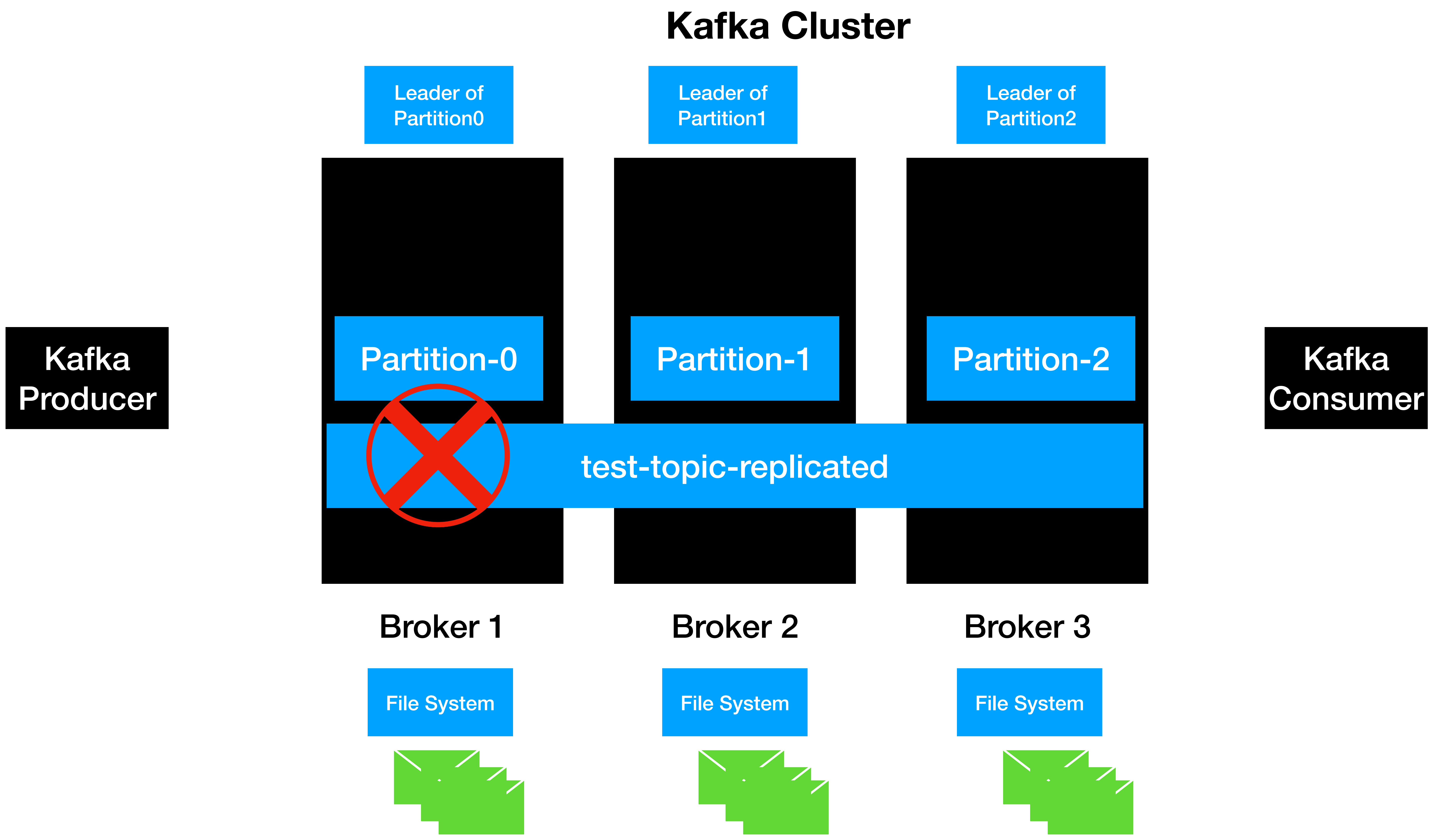

Kafka Cluster
Partition-0
Partition-1
Partition-2
test-topic
Broker 1
Broker 2
Broker 3
File System
File System
File System
Poll test-topic (partition-0)
Kafka Consumer group.id=group1
Records processed Successfully
Poll test-topic (partition-1)
Kafka Consumer group.id=group1
Records processed Successfully
Poll test-topic (partition-2)
Kafka Consumer group.id=group1
Records processed Successfully

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 ?

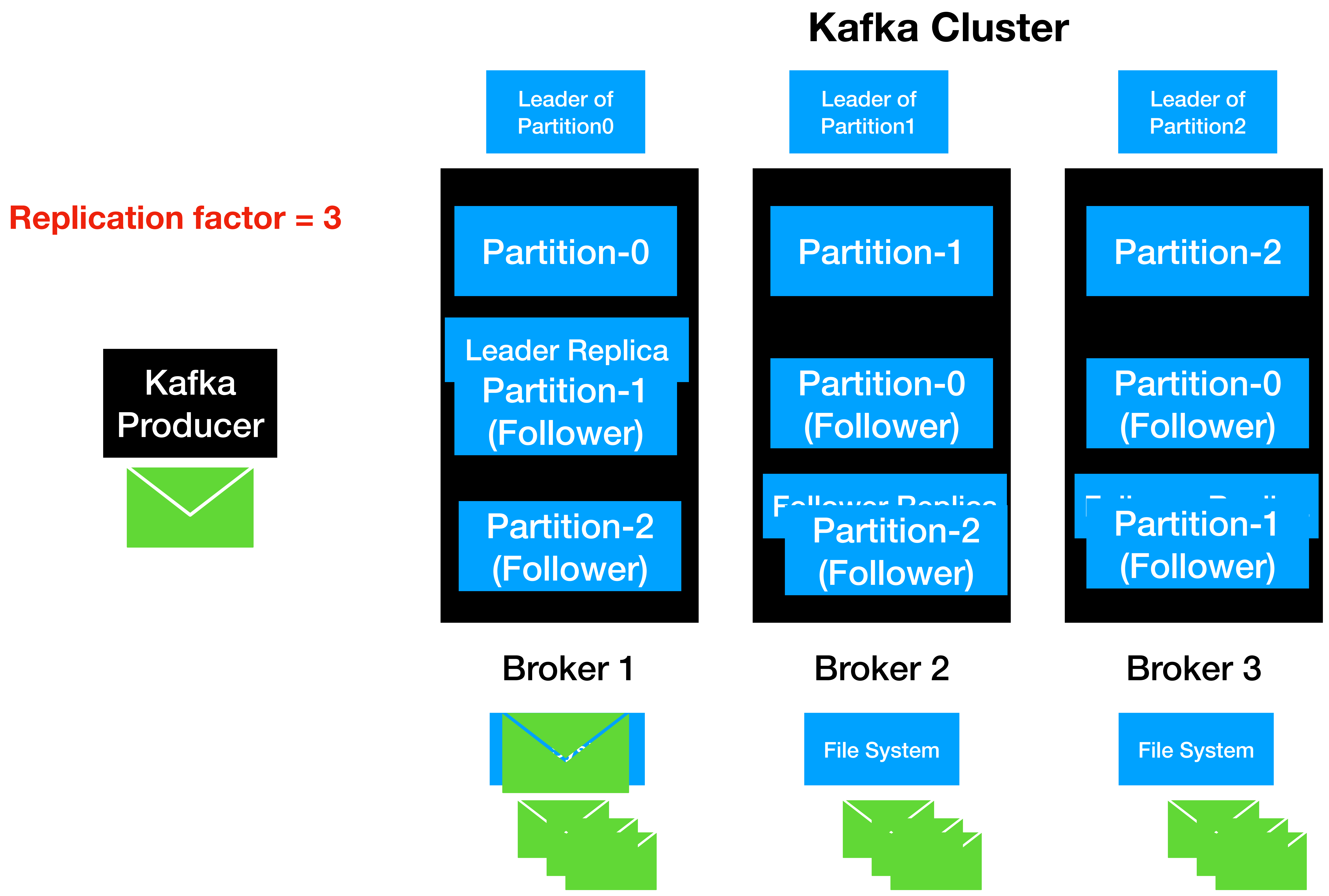
How Kafka handles Data loss?



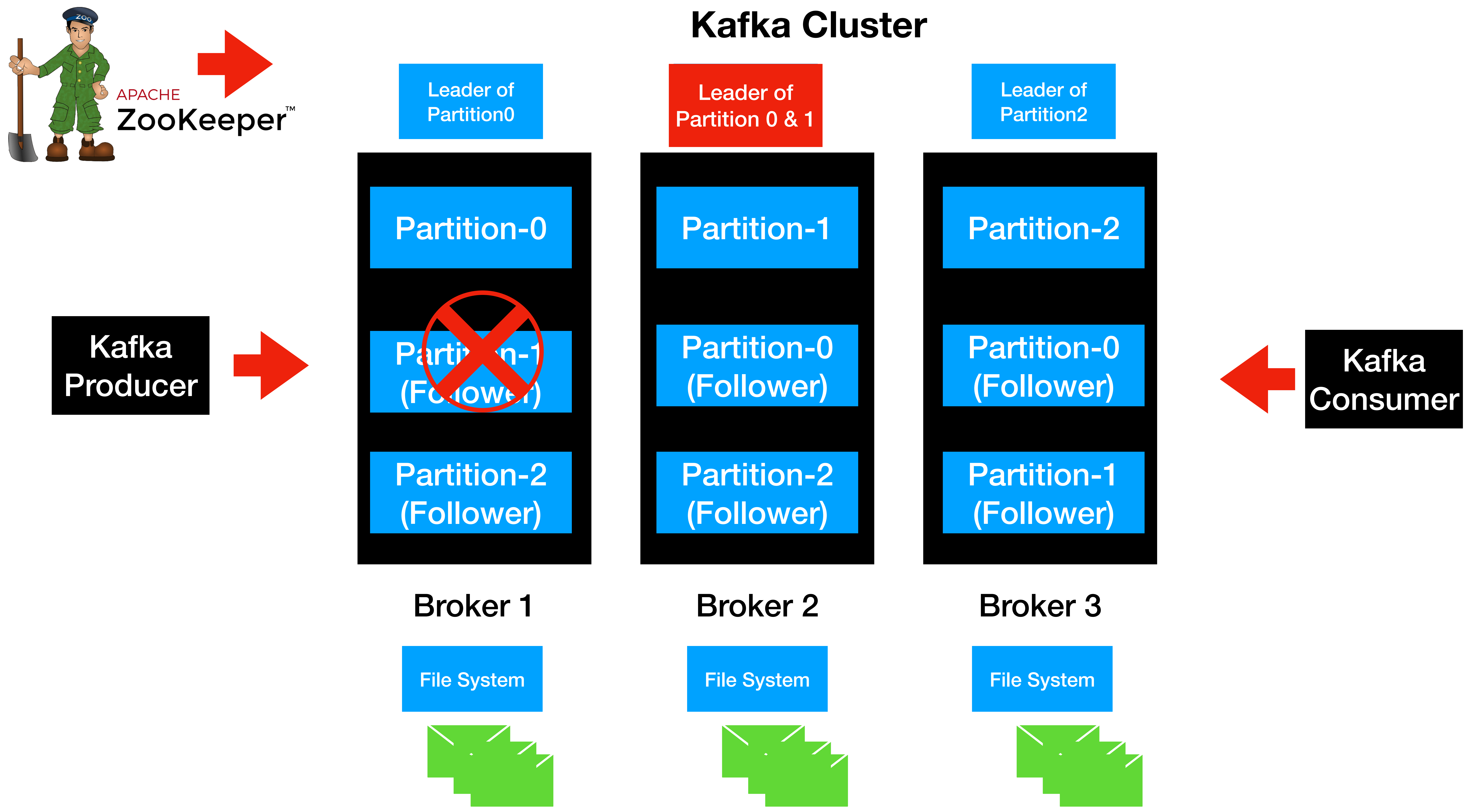
Replication

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

Replication



Replication



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

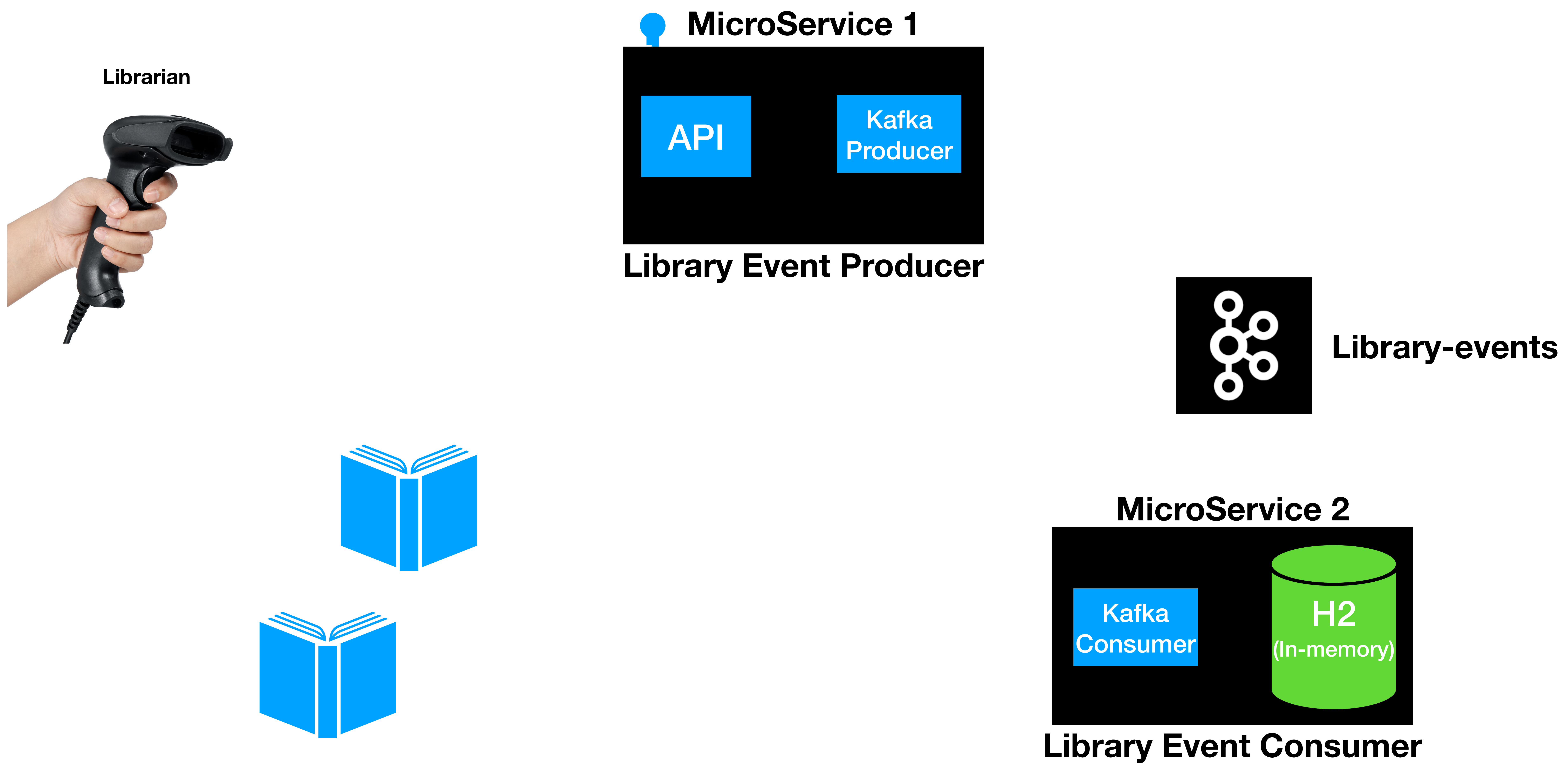
Library Inventory

Library Inventory Flow

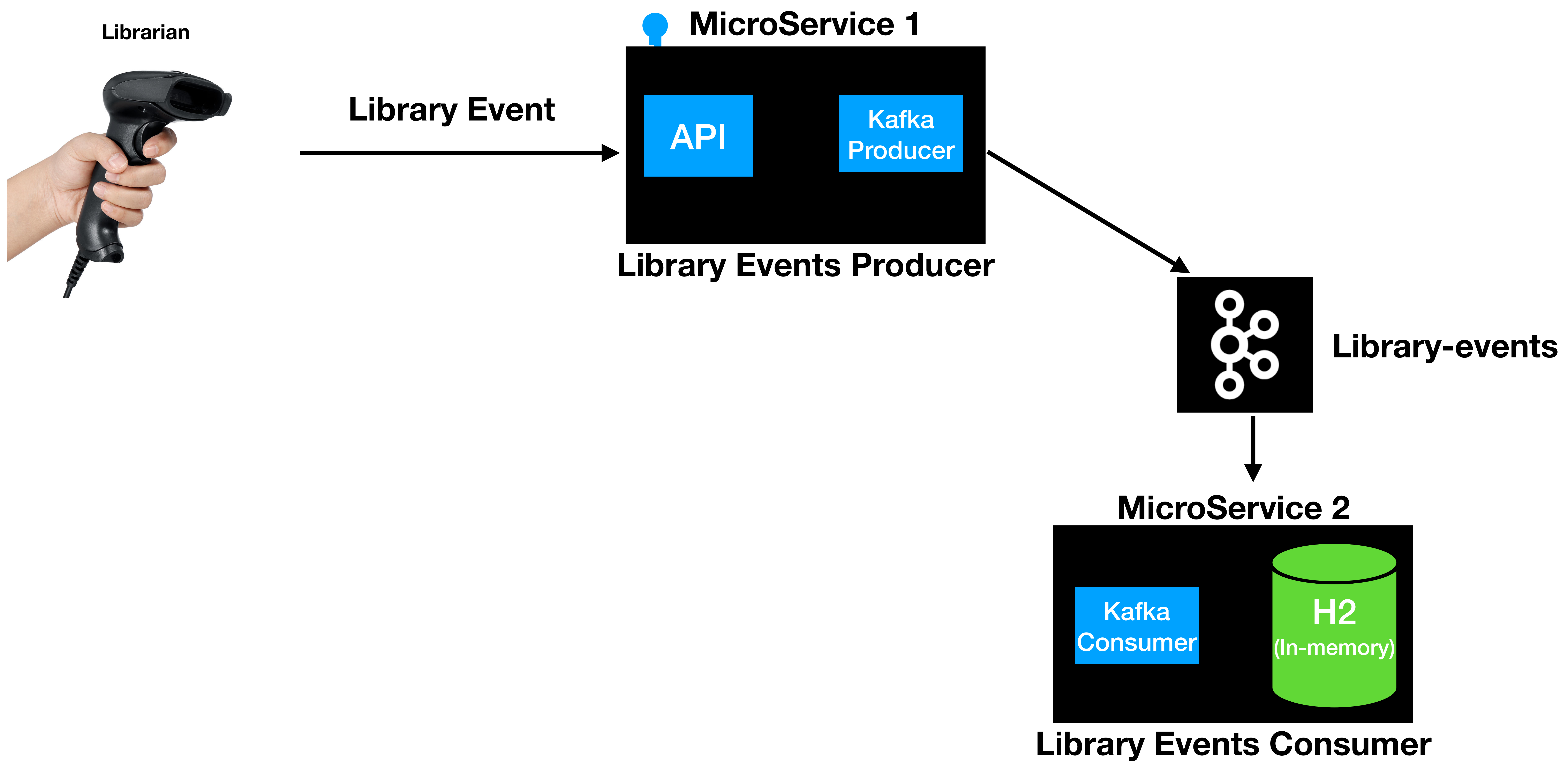
Librarian

Library Inventory

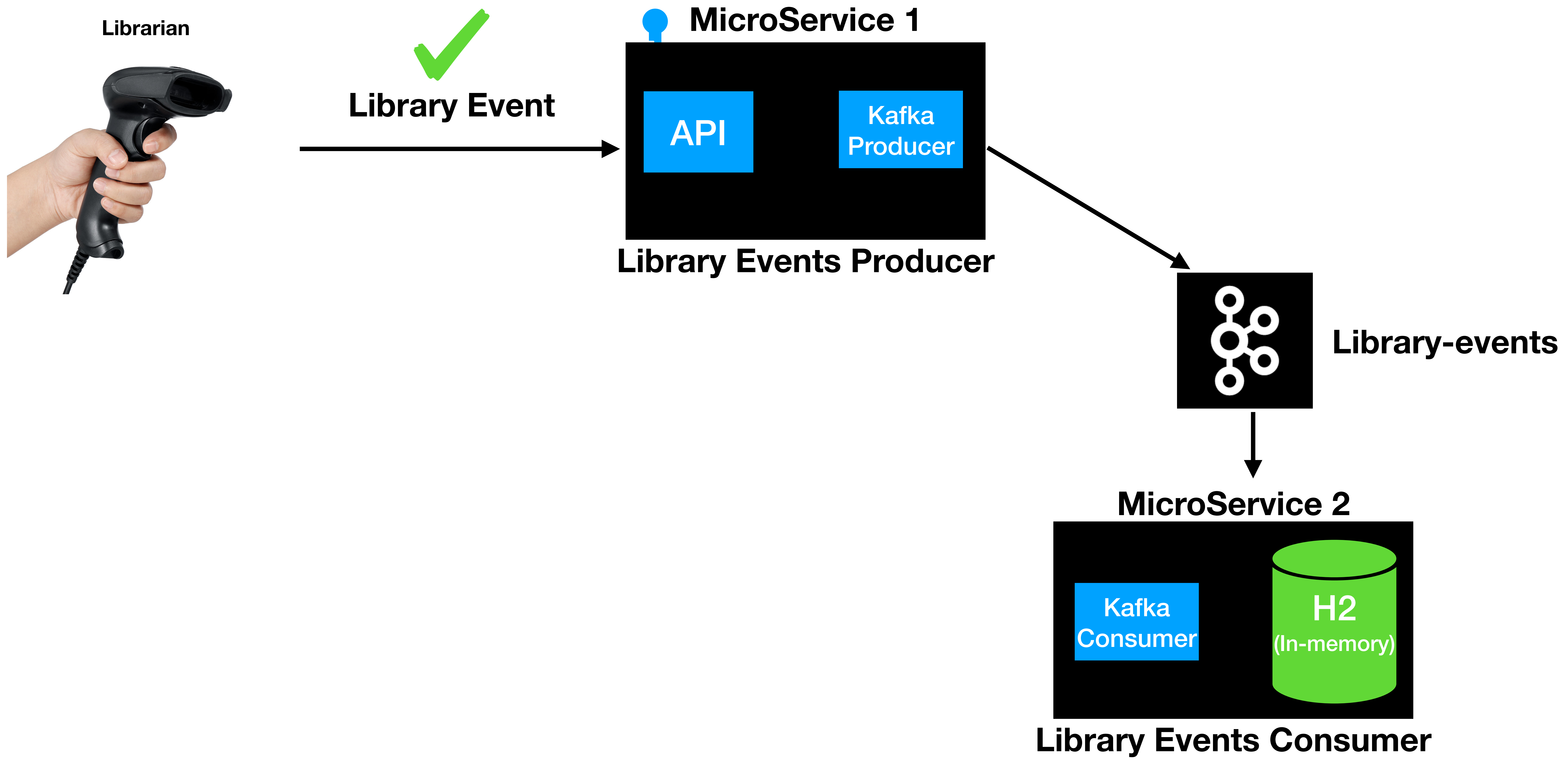
Library Inventory Architecture



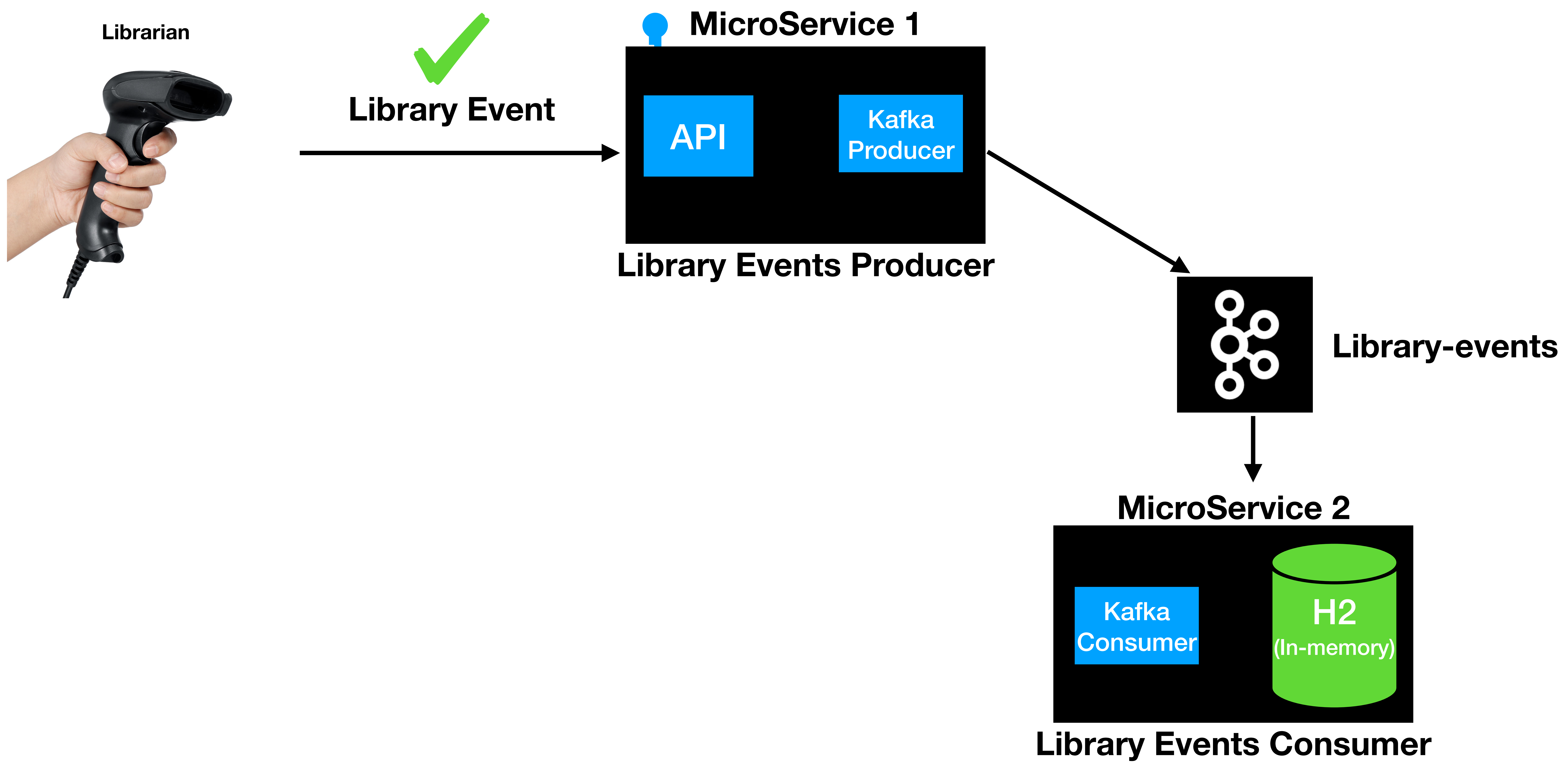
Library Inventory Domain



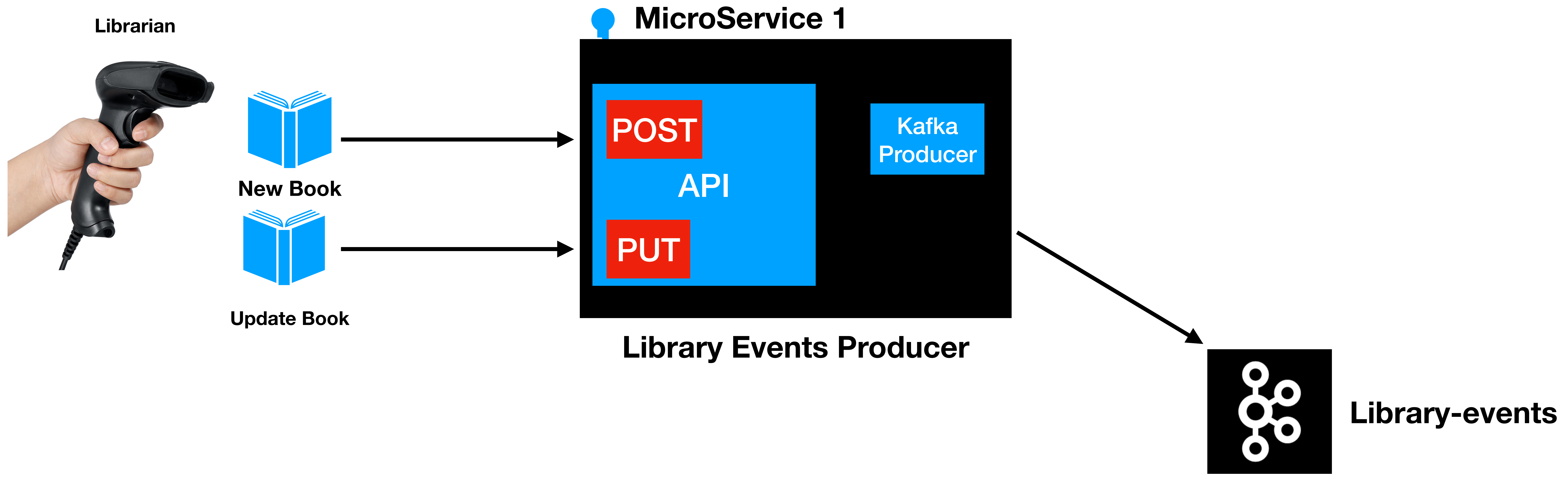
Library Event Domain



Library Event Domain



Library Events Producer API



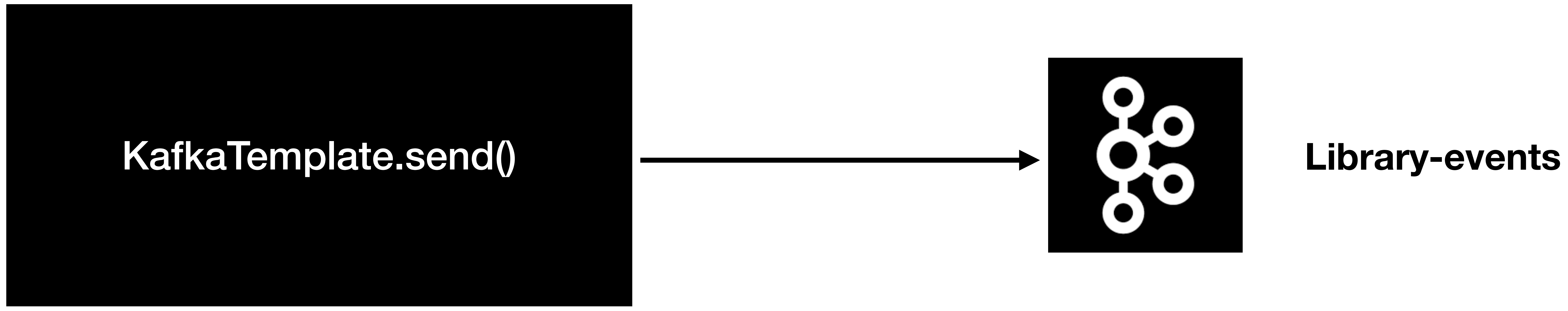
KafkaTemplate

Kafka Producer in Spring

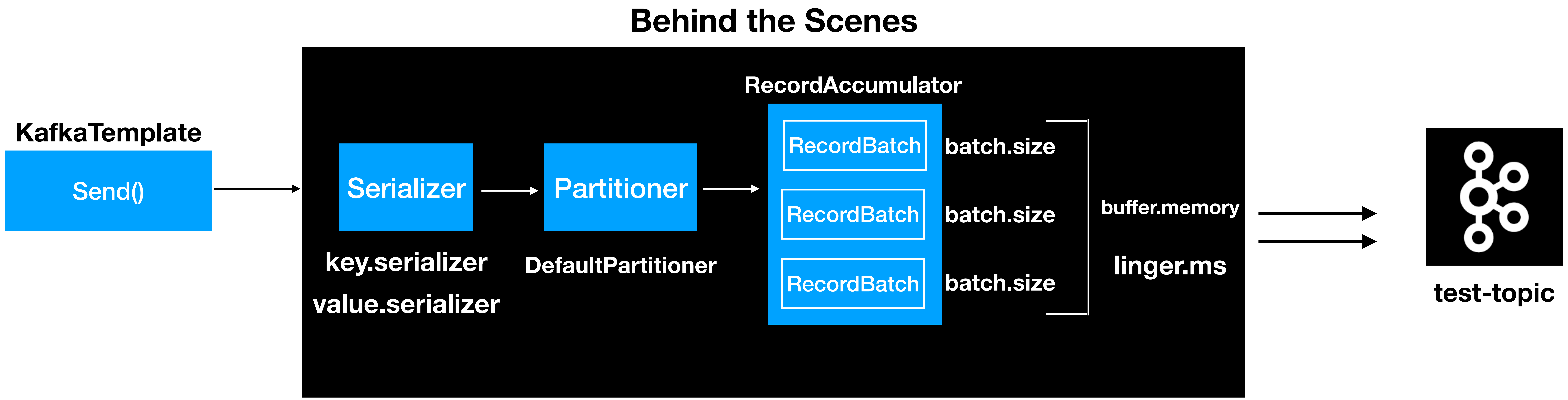
KafkaTemplate

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

How KafkaTemplate Works ?



KafkaTemplate.send()



Configuring KafkaTemplate

Mandatory Values:

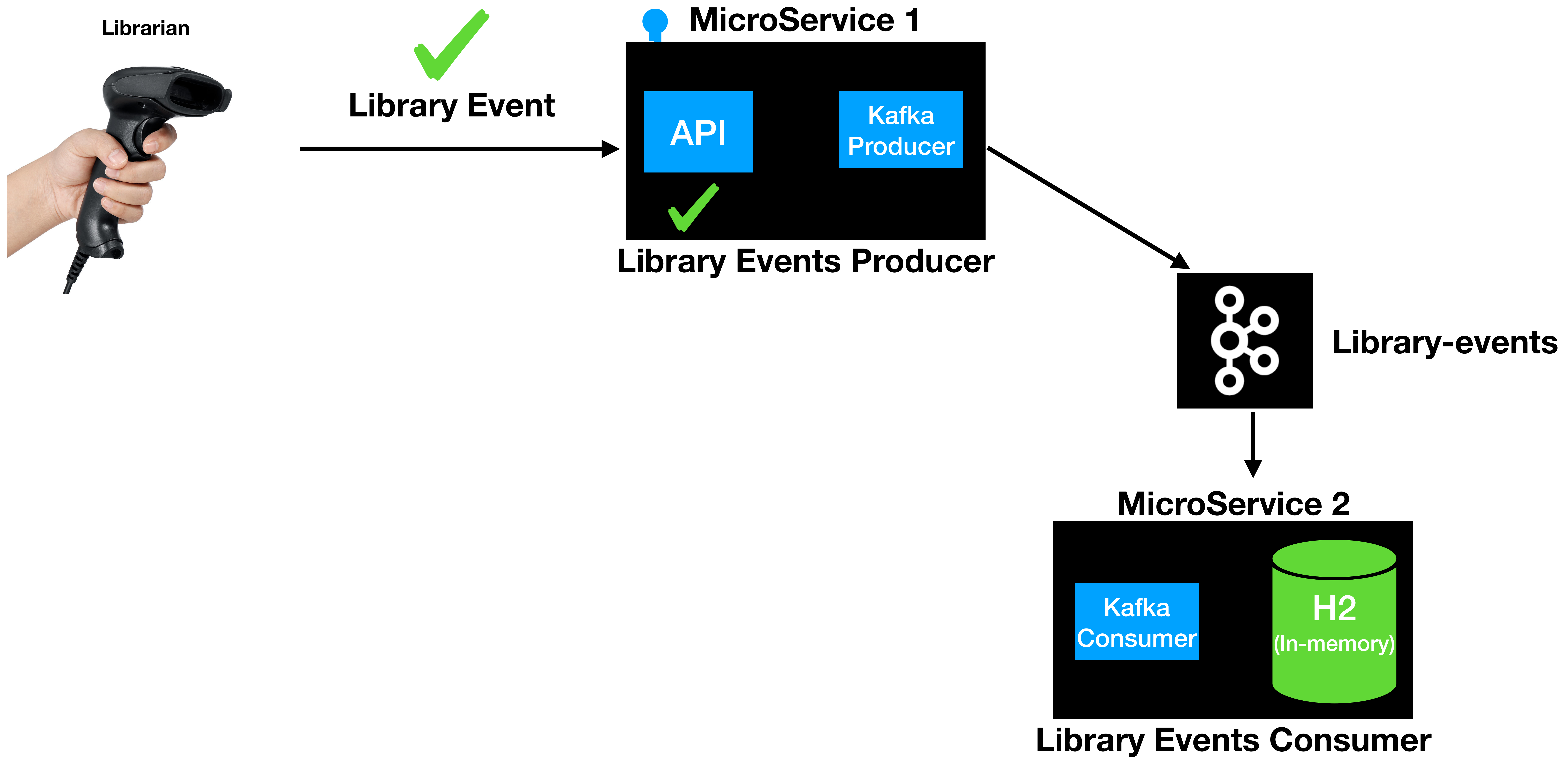
```
bootstrap-servers: localhost:9092,localhost:9093,localhost:9094
key-serializer: org.apache.kafka.common.serialization.IntegerSerializer
value-serializer: org.apache.kafka.common.serialization.StringSerializer
```

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

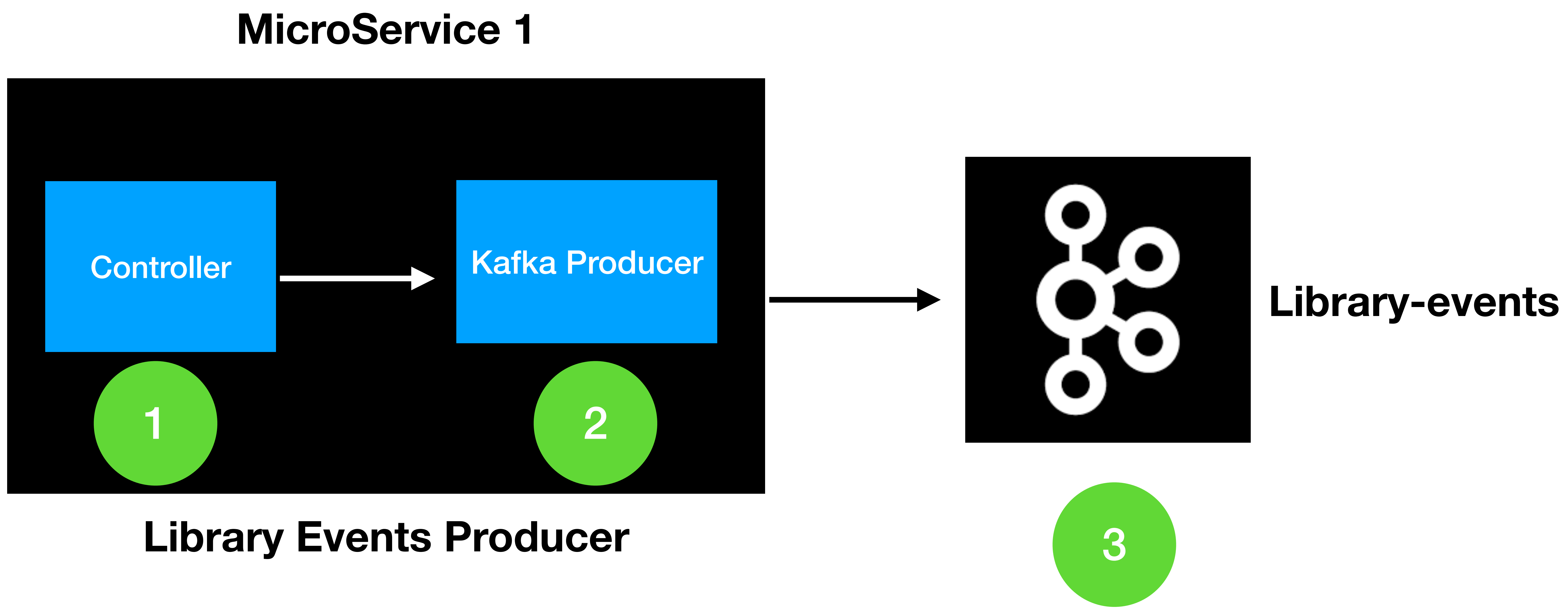
- JUnit

- Spock

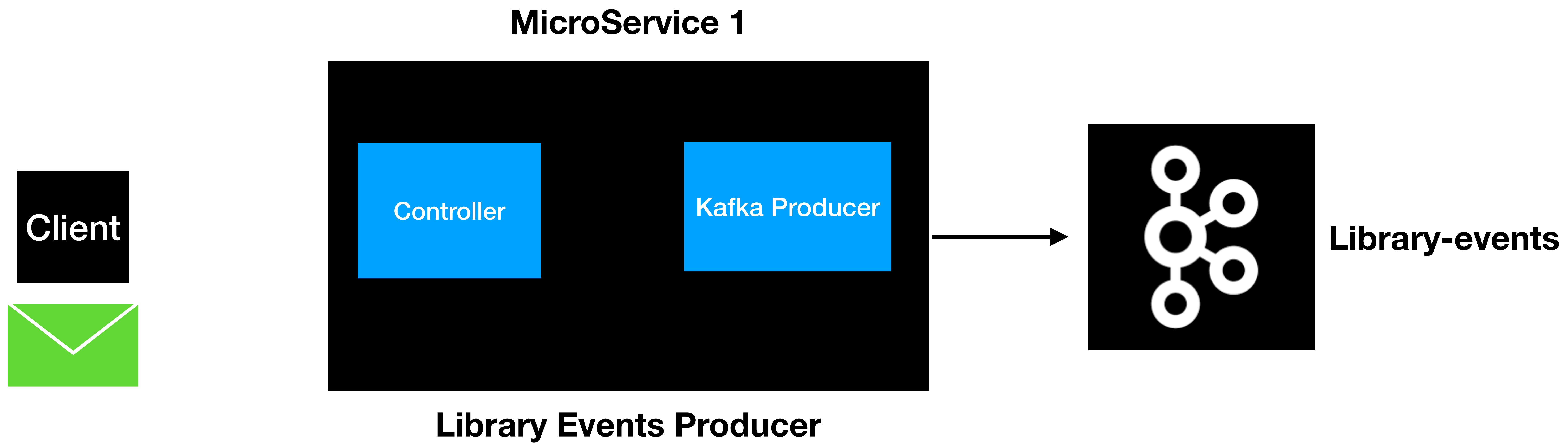
Integration Tests
Using
JUnit5

What is Integration Test?

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



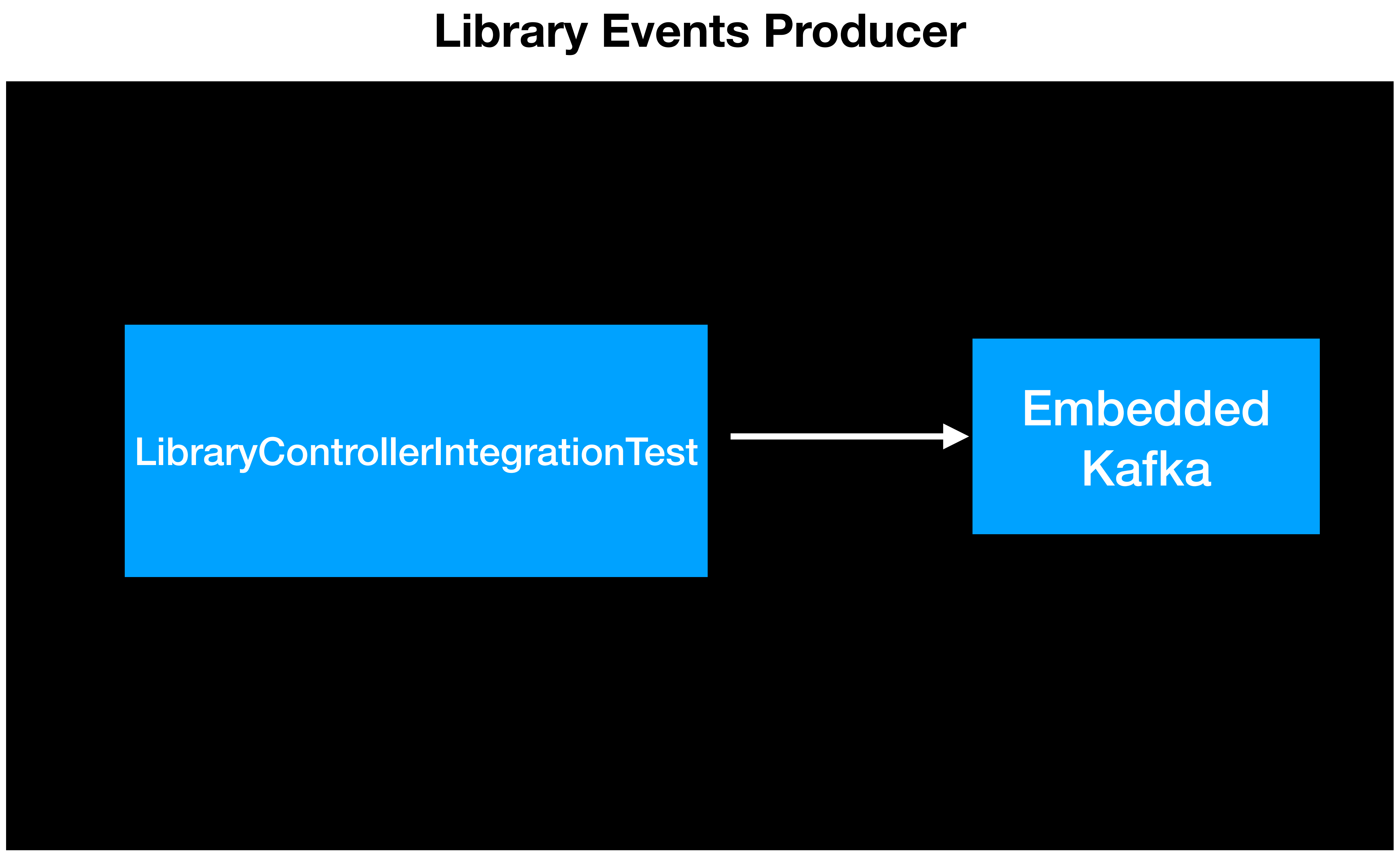
Integration Test



Embedded Kafka

What is EmbeddedKafka?

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

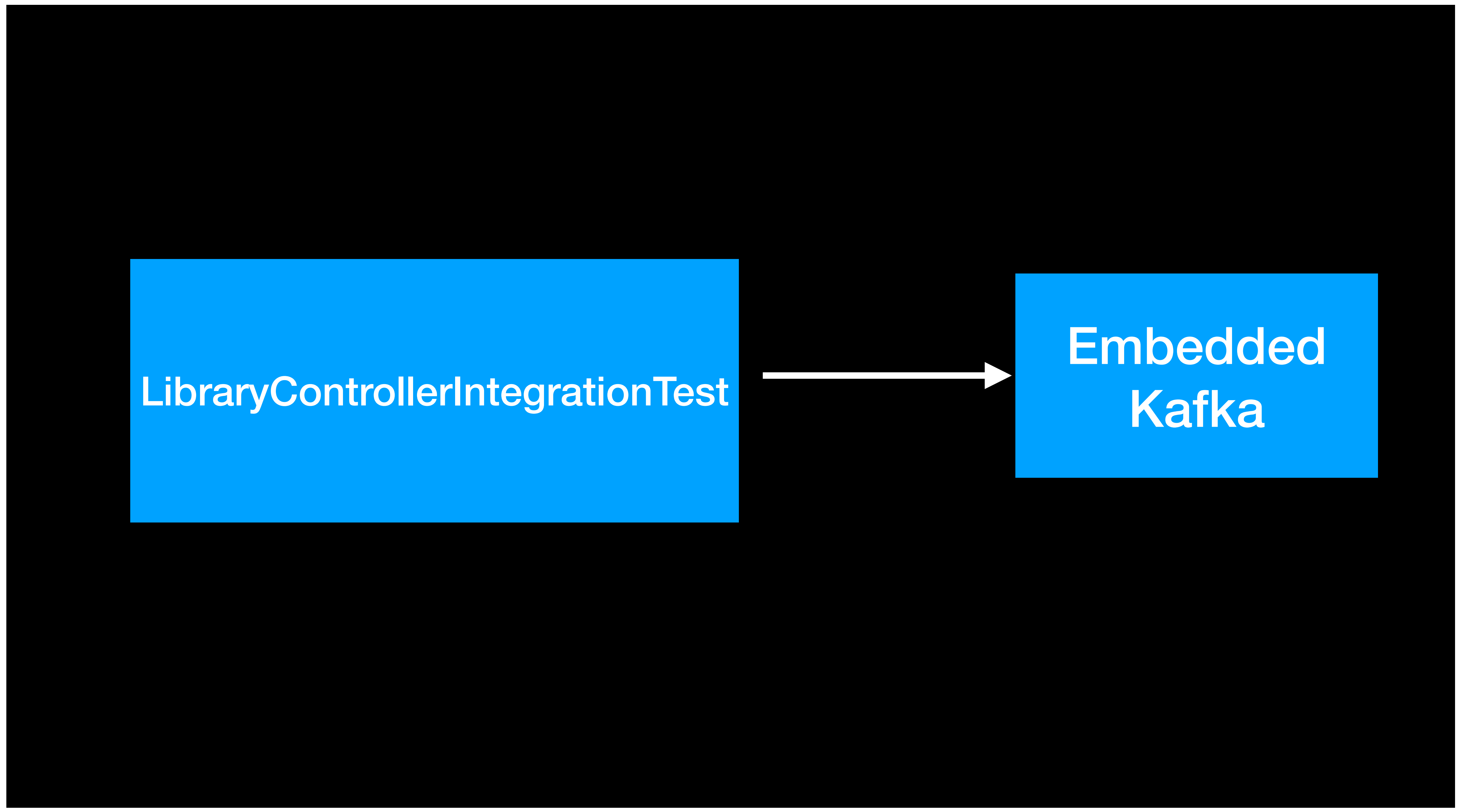


Why Embedded Kafka ?

- Easy to write Integration Tests

- Test all the code as like you interact with Kafka

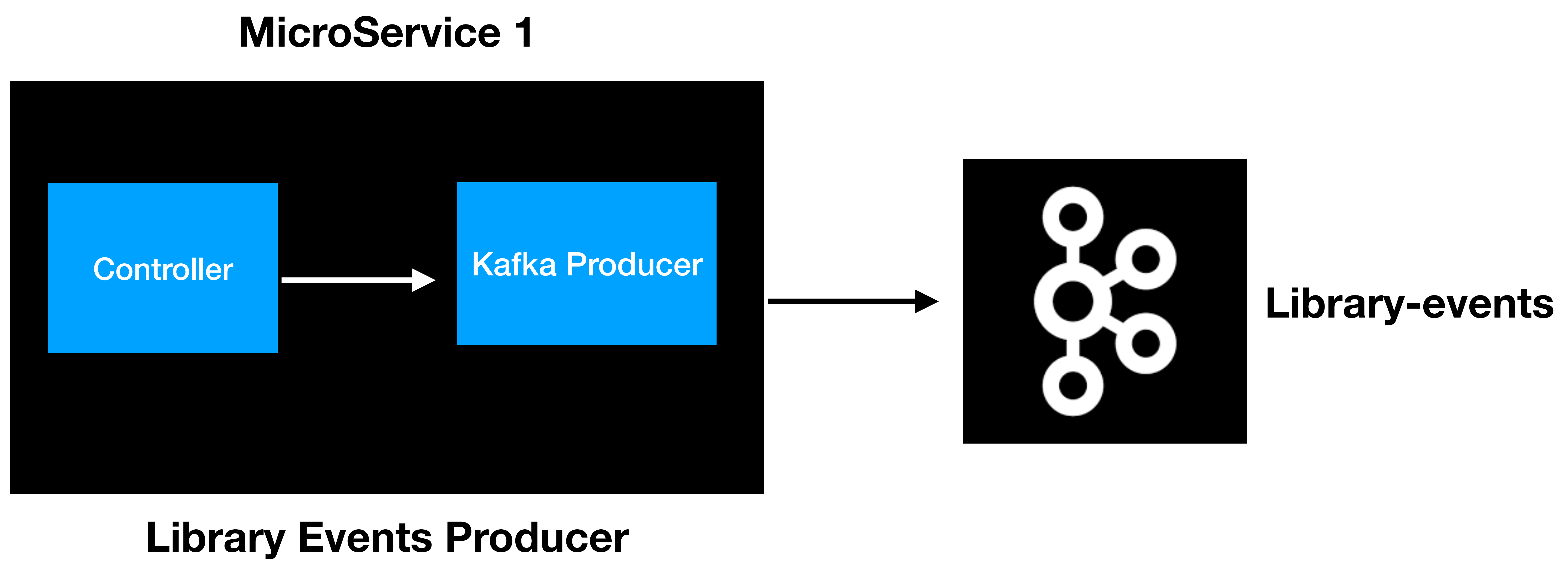
Library Events Producer



Unit Tests
Using
JUnit5

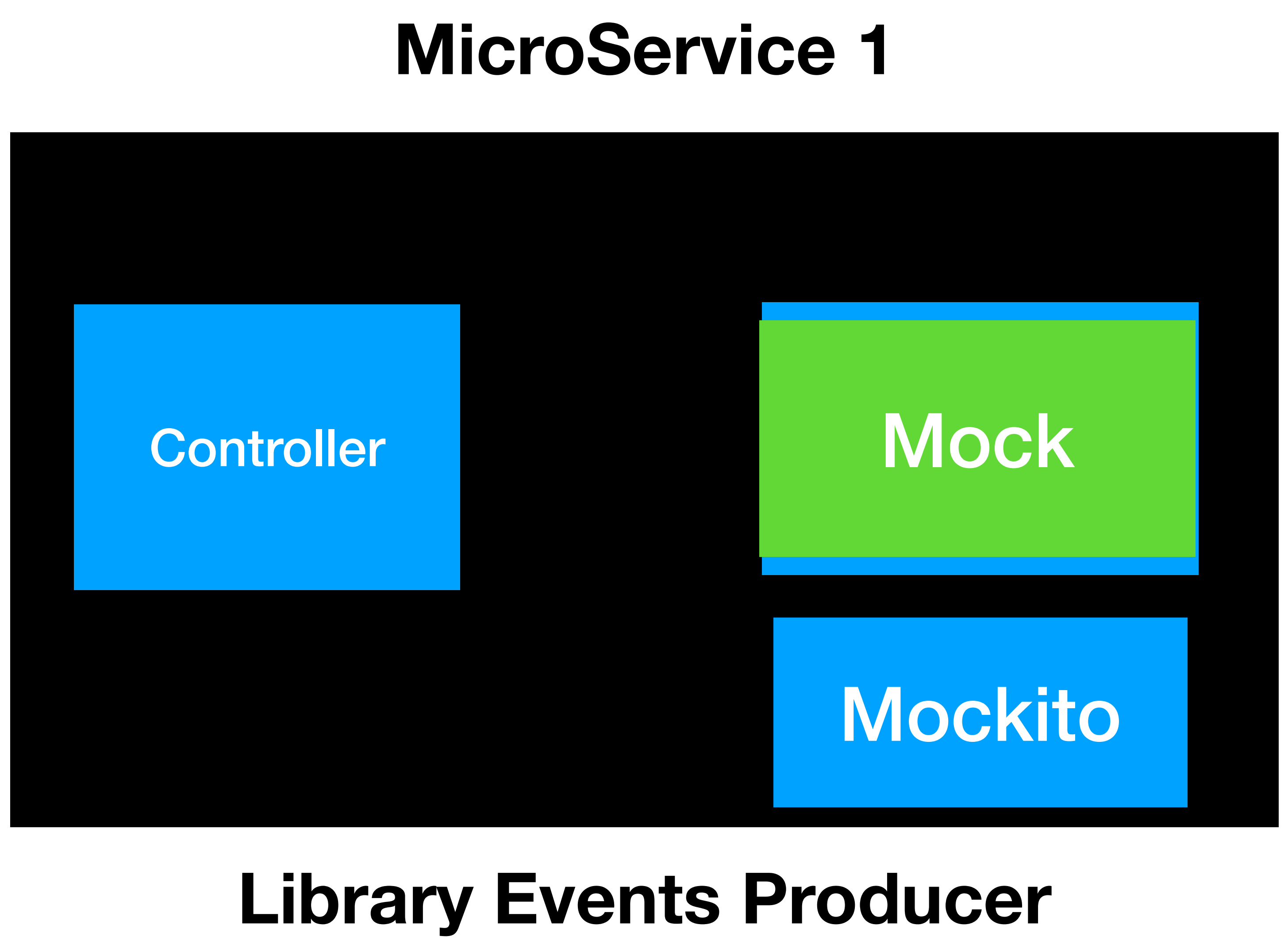
What is Unit Test?

- 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



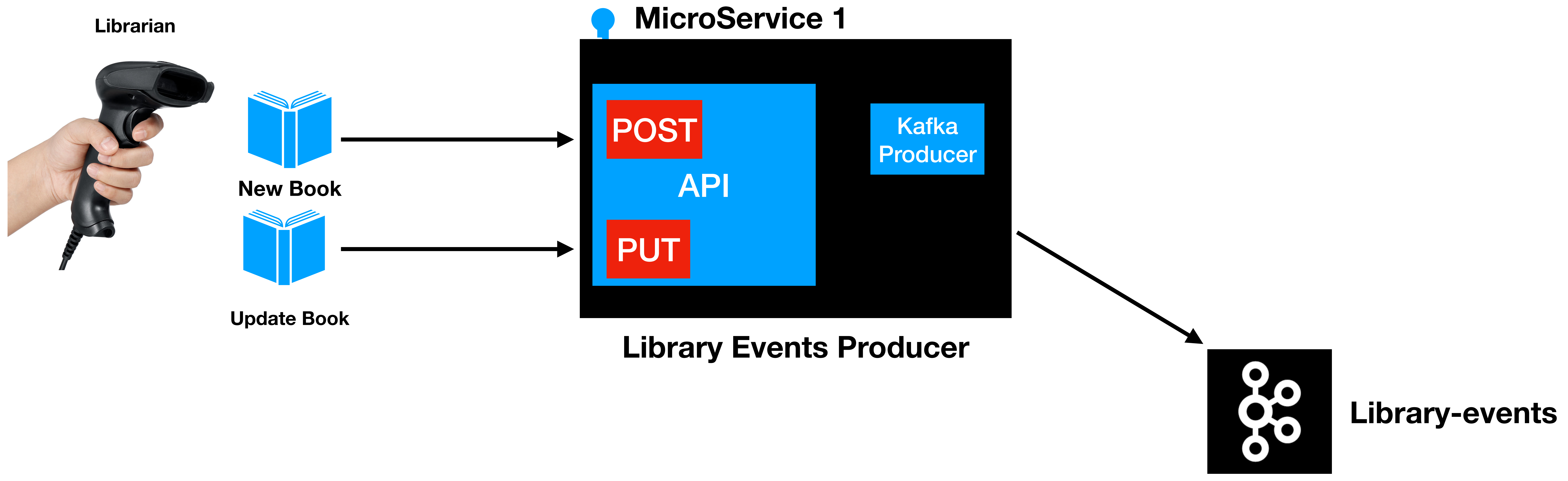
Why Unit Test?

- 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

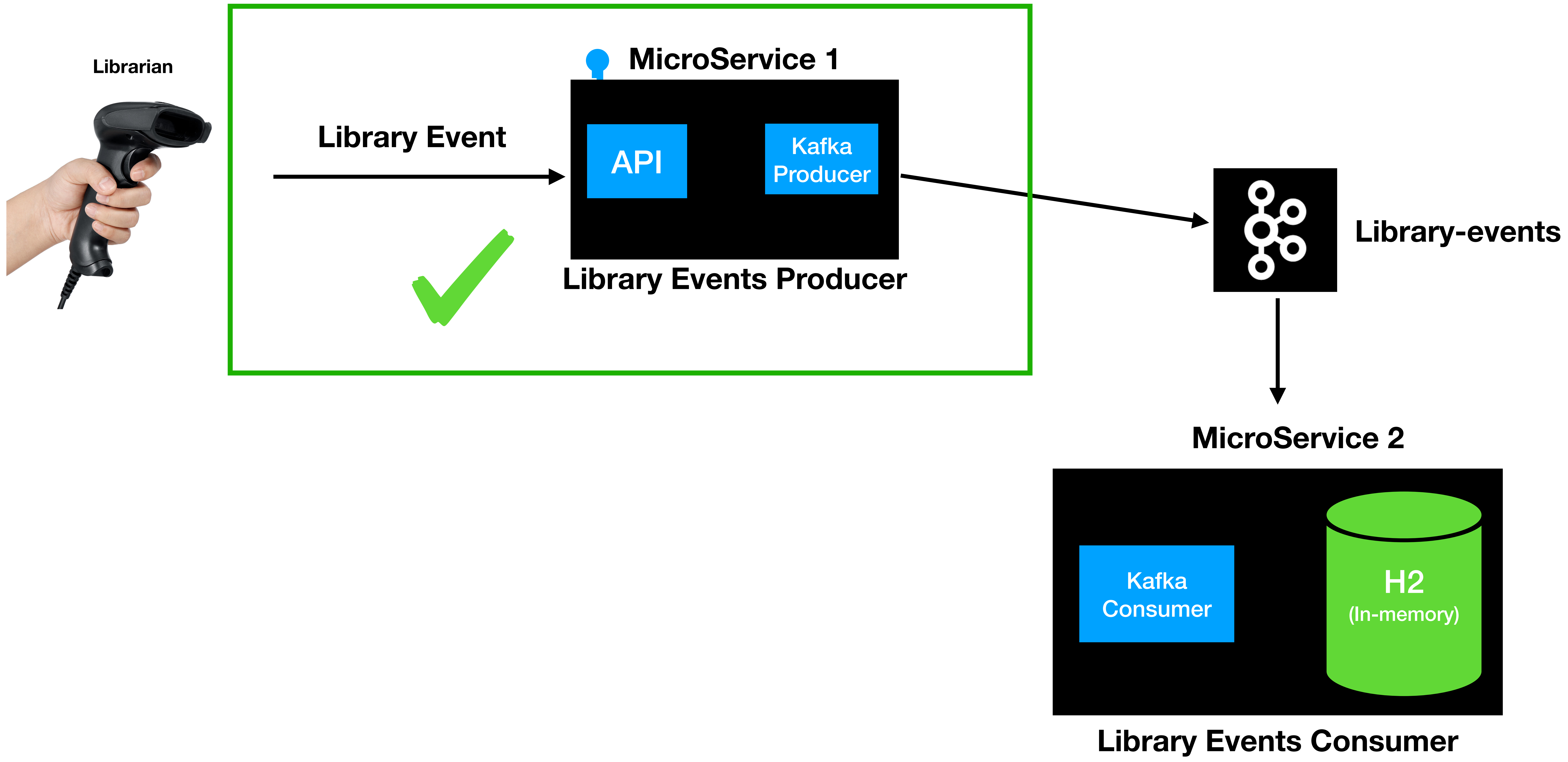
Kafka Producer Configurations

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

Kafka Producer Configurations

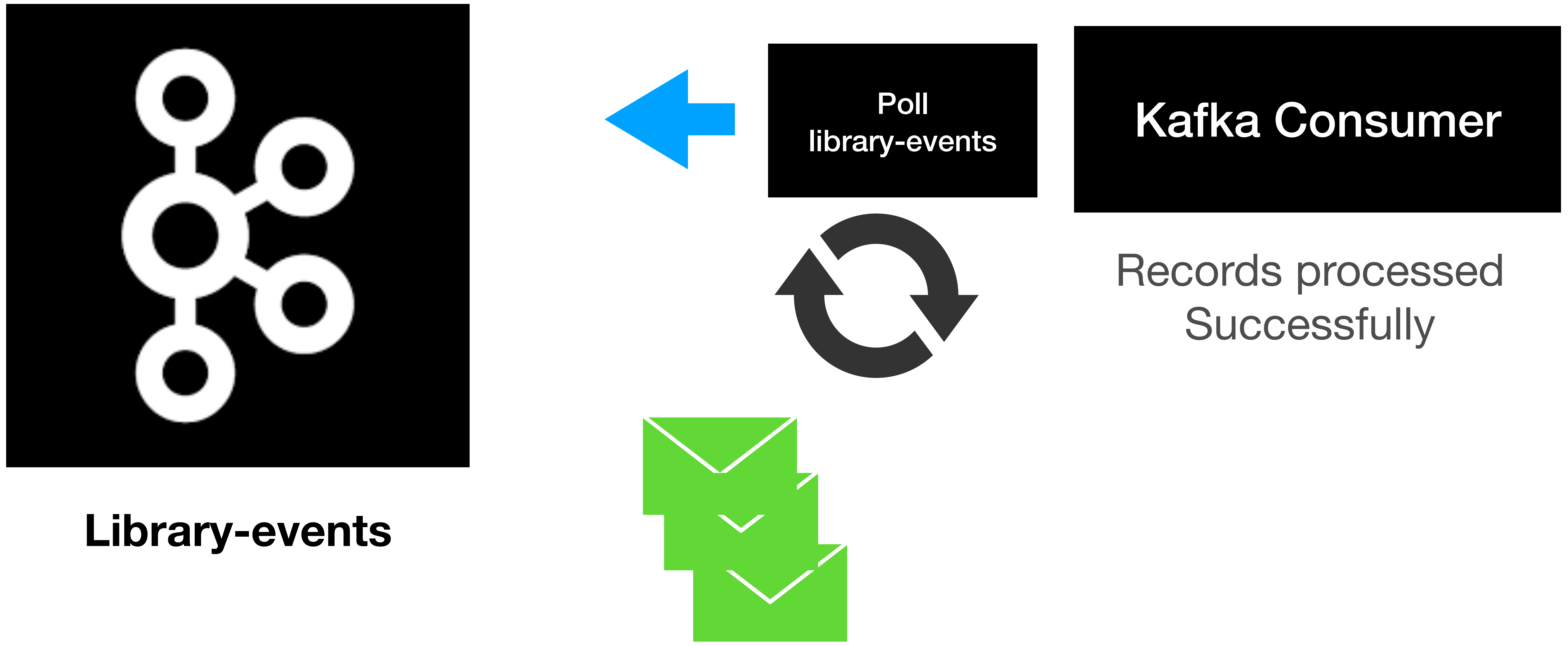
- retries
    - Integer value = [0 - 2147483647]
    - In Spring Kafka, the default value is **-> 2147483647**
- retry.backoff.ms
    - Integer value represented in milliseconds
    - Default value is 100ms

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
```

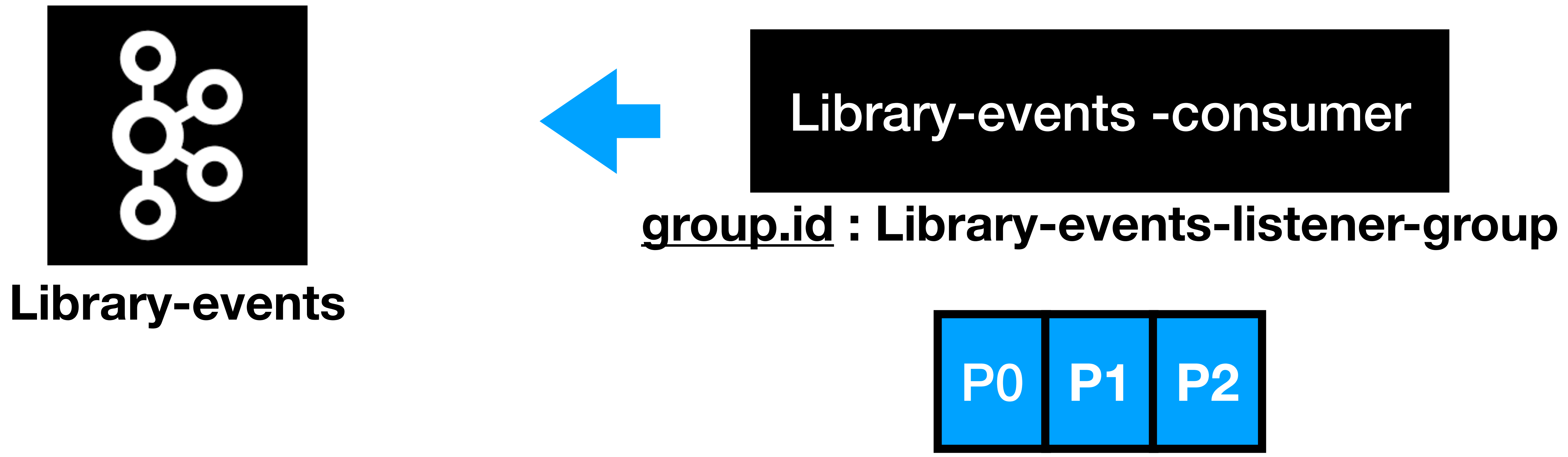
Consumer Groups
&
Rebalance

Consumer Groups

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

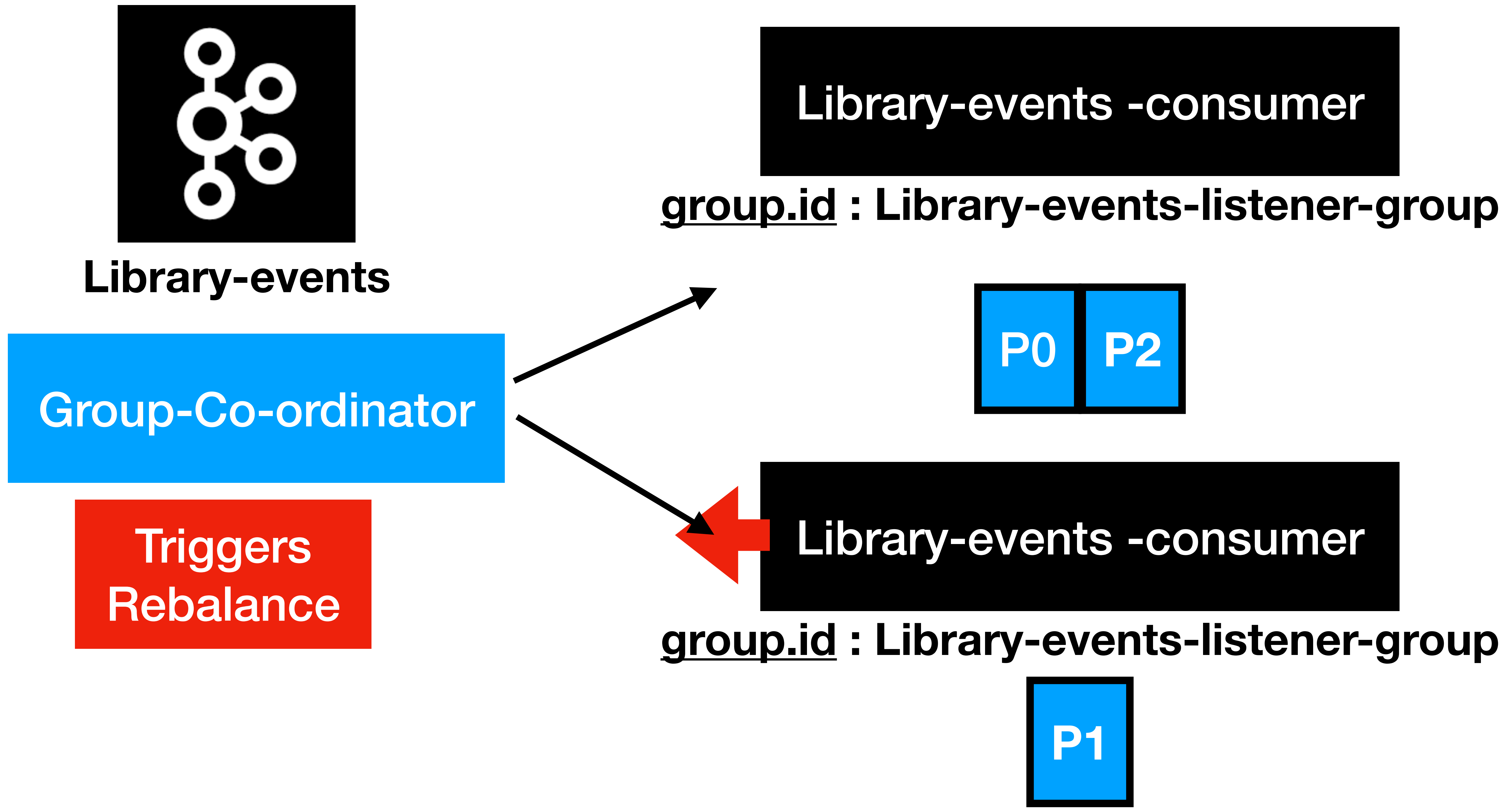
Rebalance

- Changing the partition ownership from one consumer to another

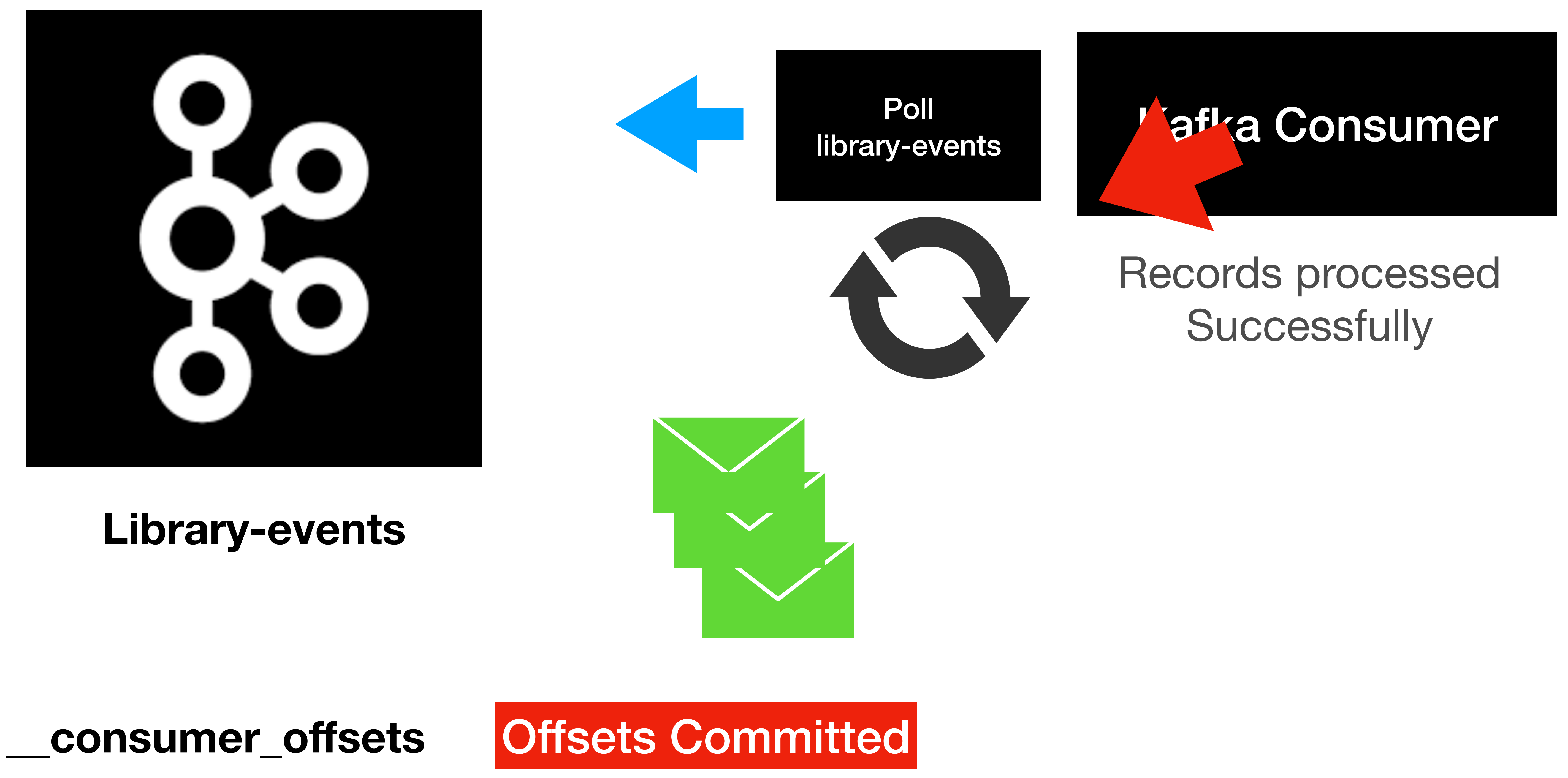


Rebalance

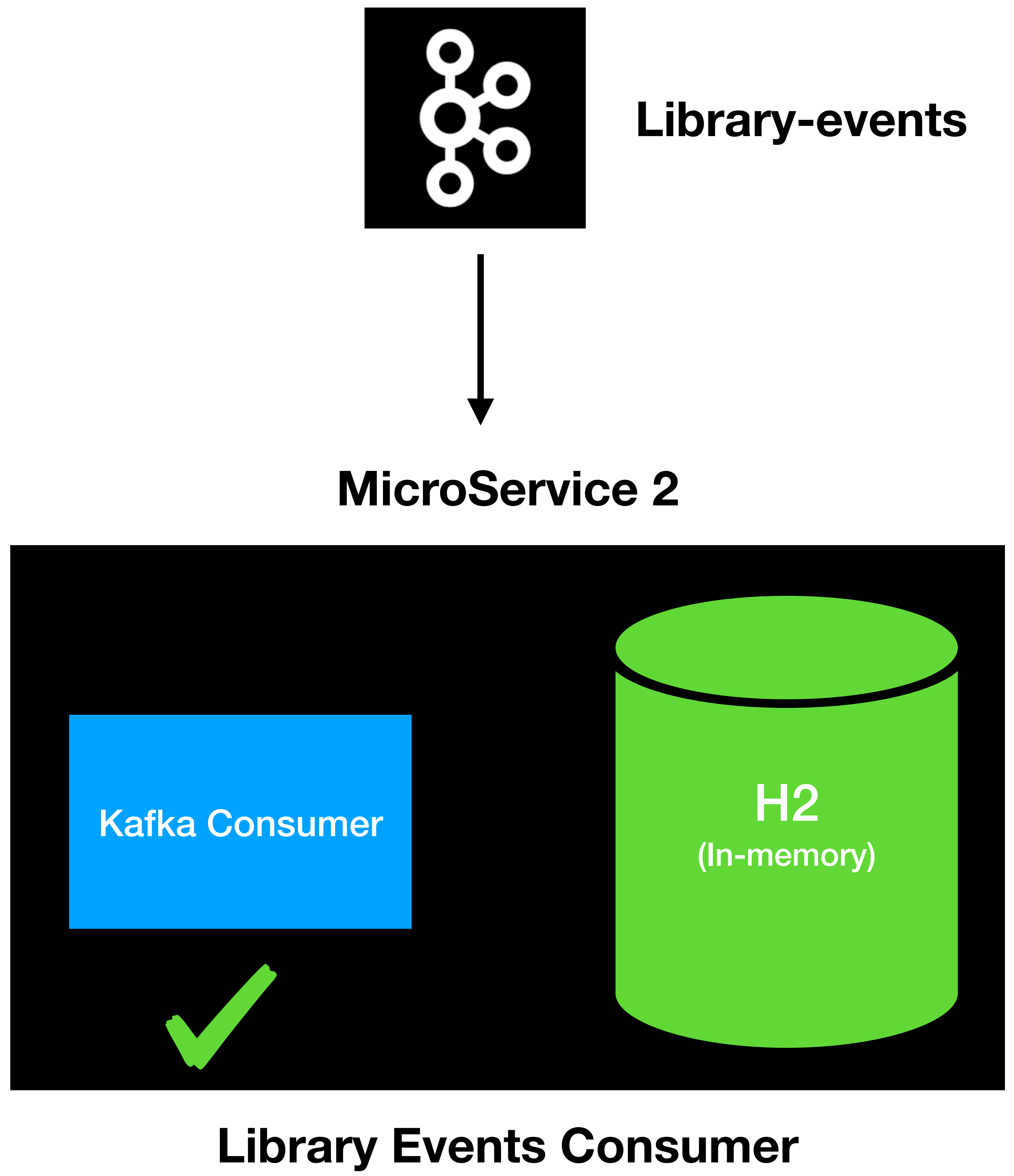
- Changing the partition ownership from one consumer to another



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**

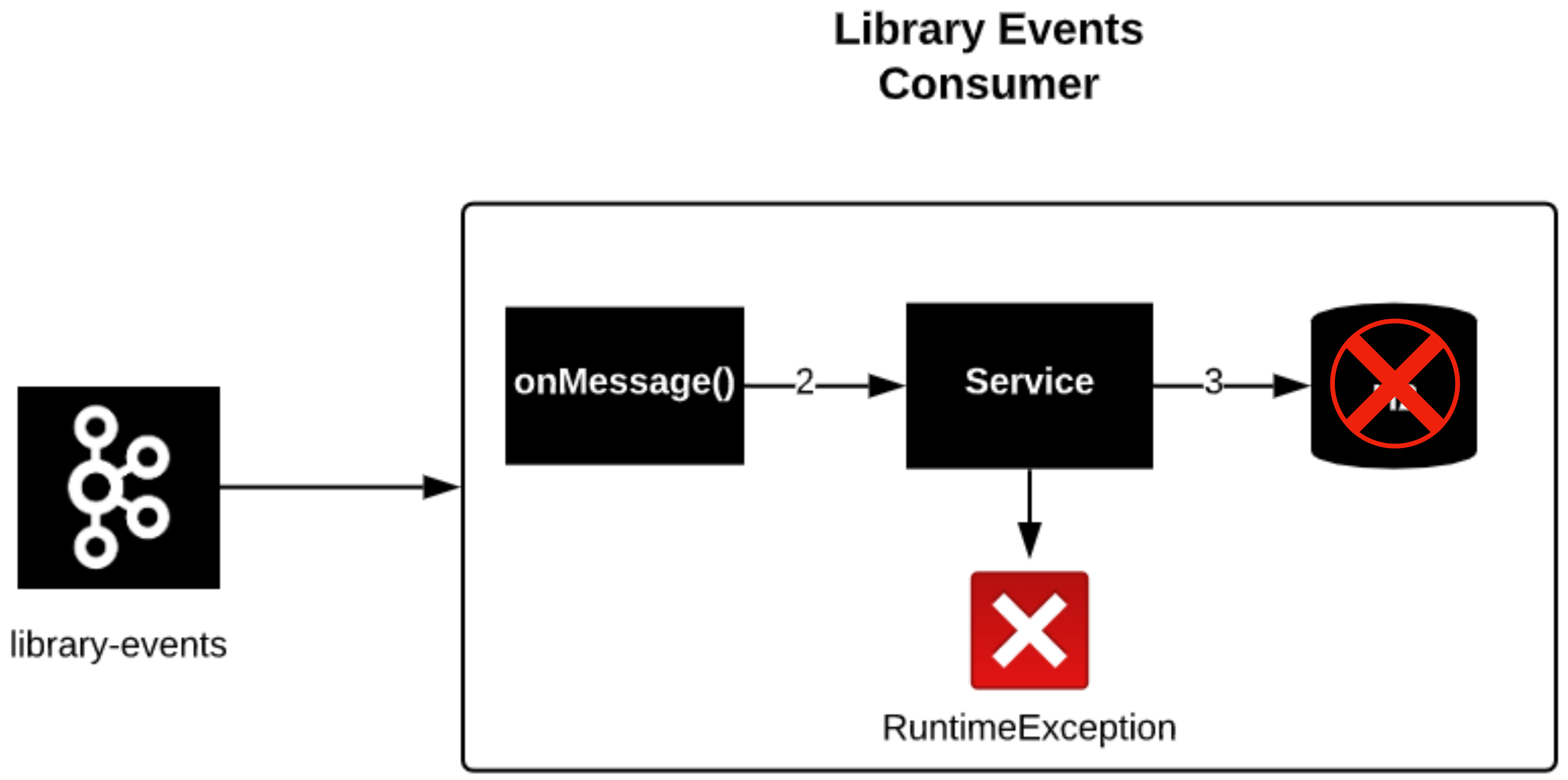
SpringOne Platform by Pivotal
Testing Spring Boot Applications
Andy Wilkinson
@ankinson
SpringOne Platform by Pivotal
October 7–10 / Austin, TX

TestContainers

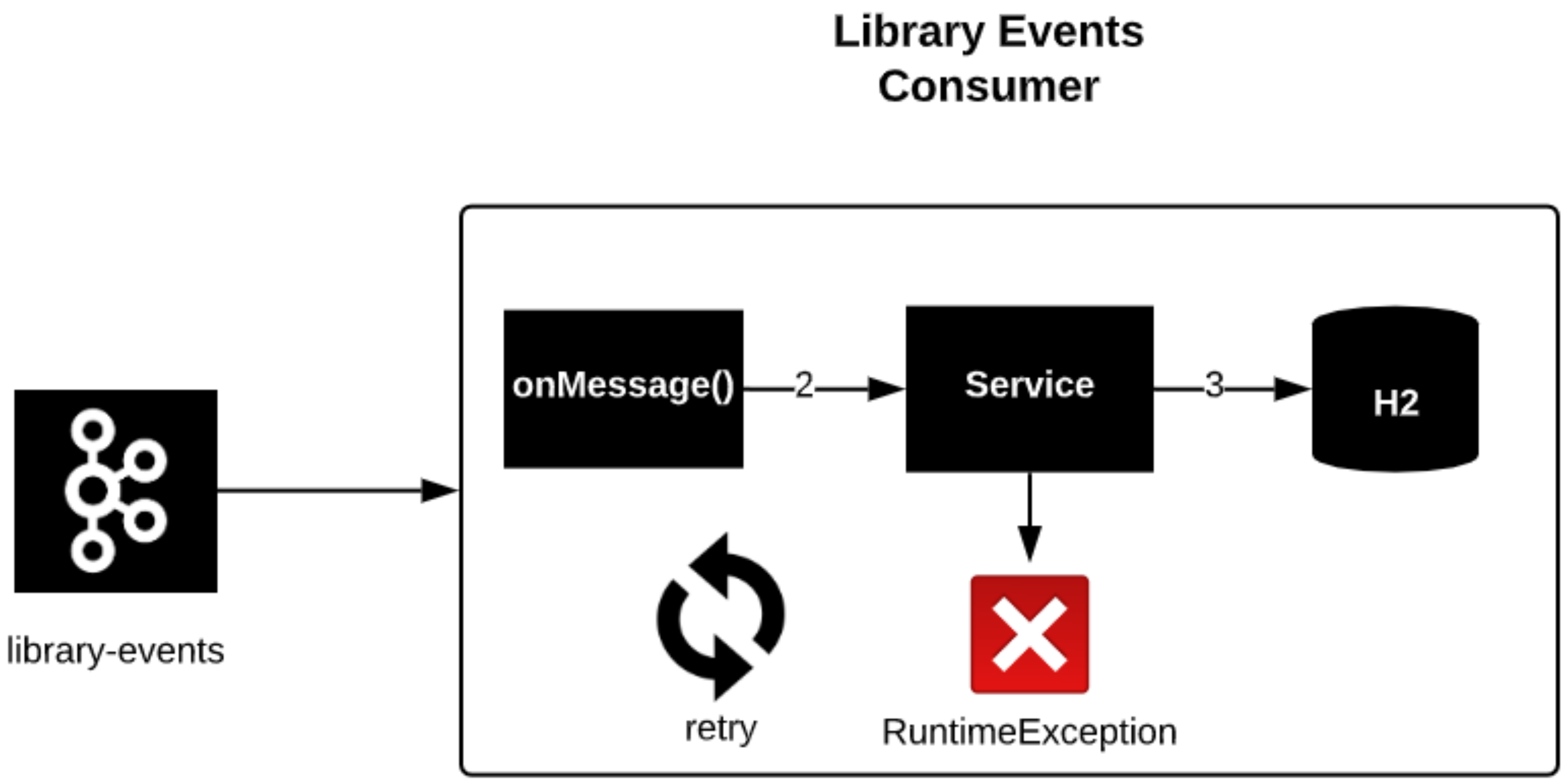
- What are TestContainers?
    - Testcontainers is a Java library that supports JUnit tests, providing lightweight, throwaway instances of common databases, Selenium web browsers, or anything else that can run in a **Docker** container.
- More Info about TestContainers - **https://www.testcontainers.org/**

Retry in Kafka Consumer

Error in Kafka Consumer

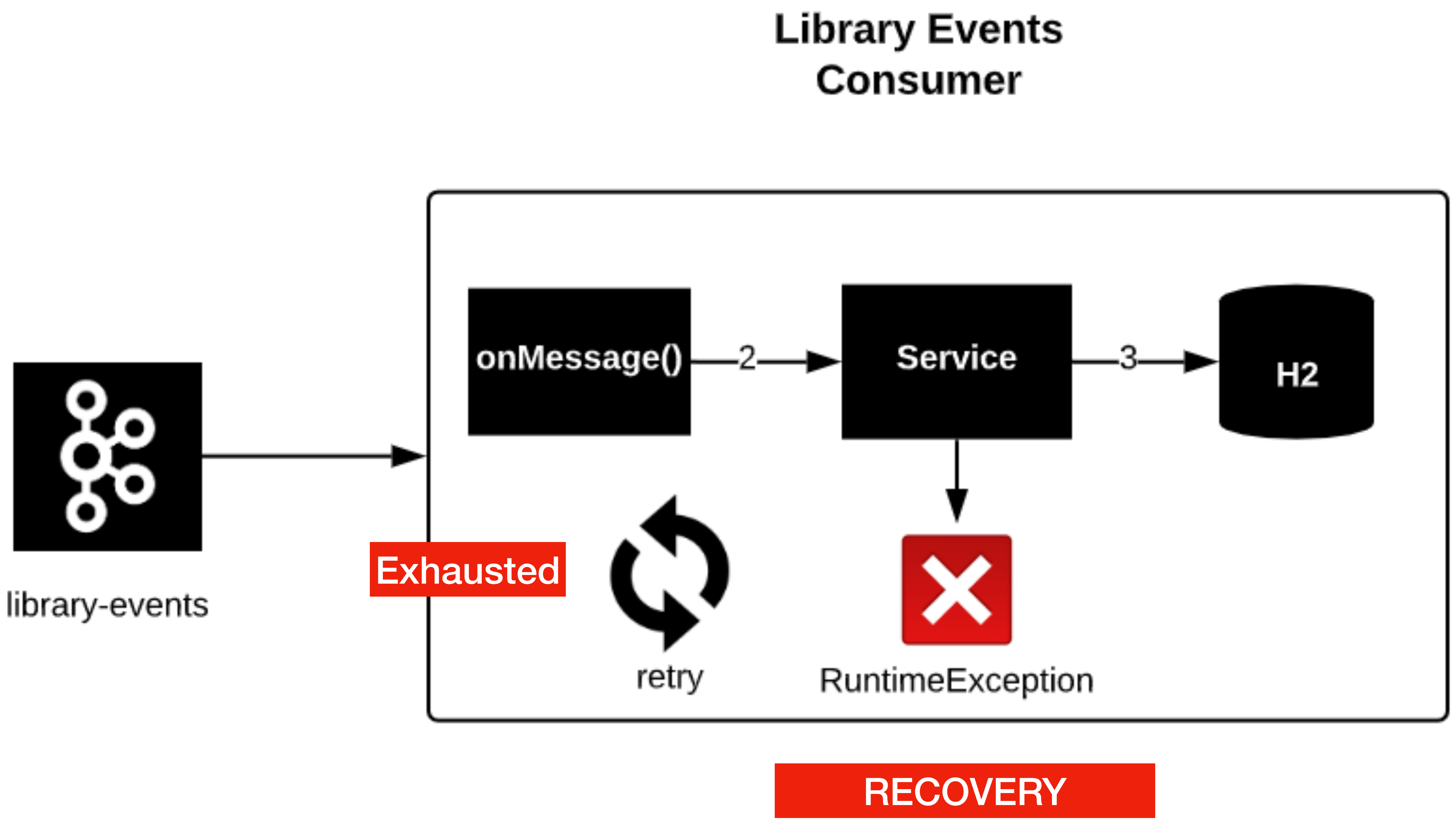


Retry in Kafka Consumer

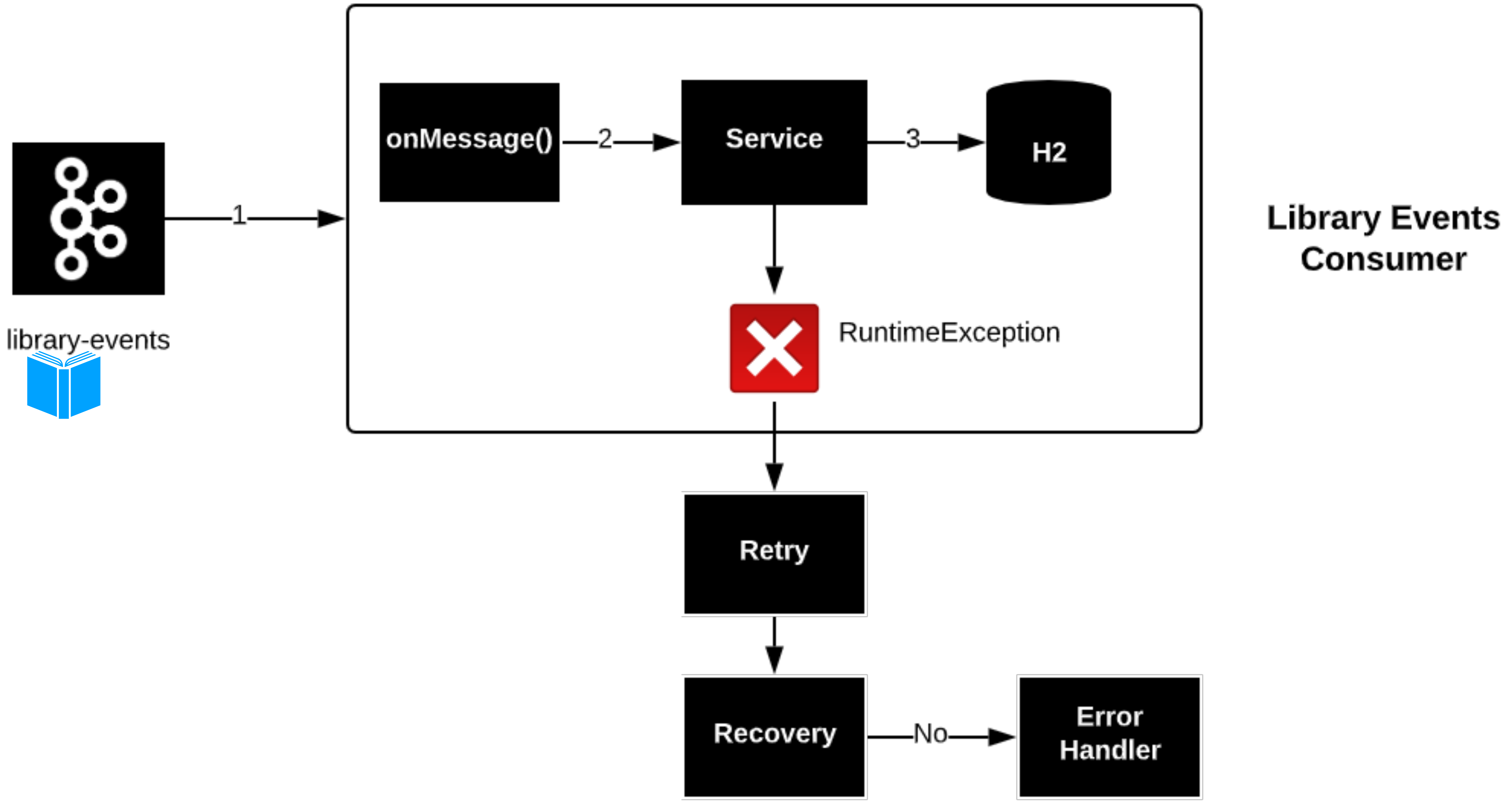


Recovery in Kafka Consumer

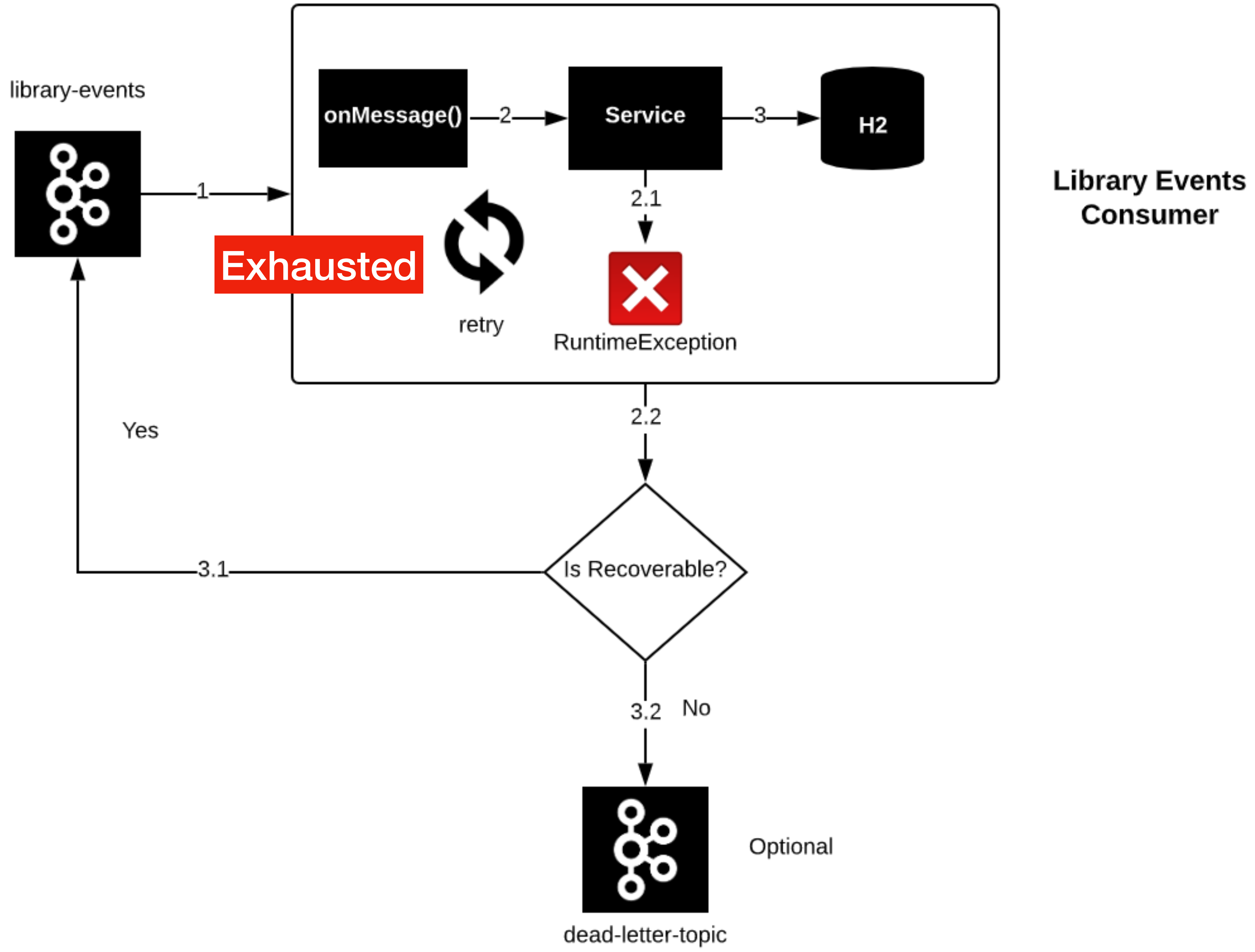
Recovery in Kafka Consumer



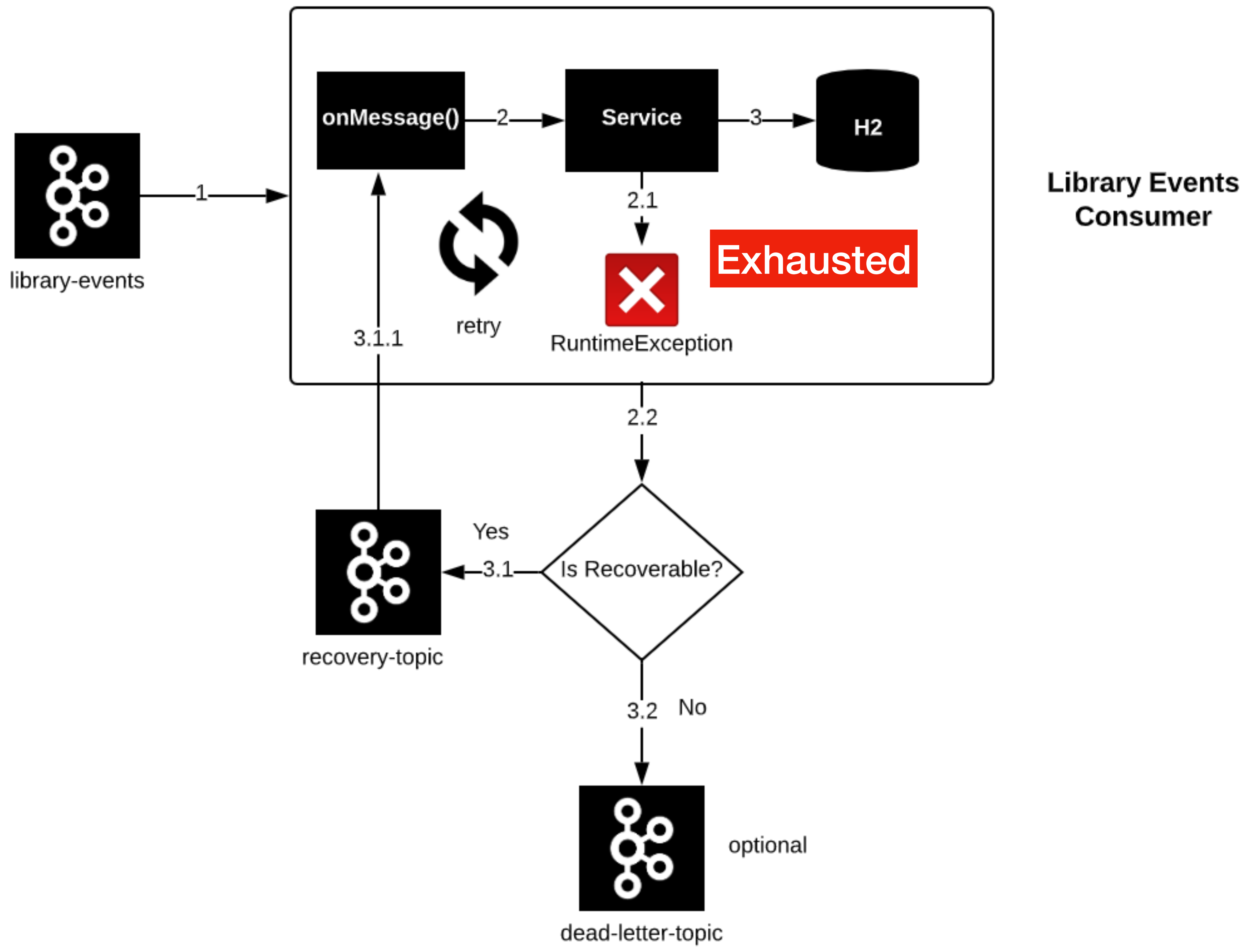
Retry and Recovery



Recovery - Type 1



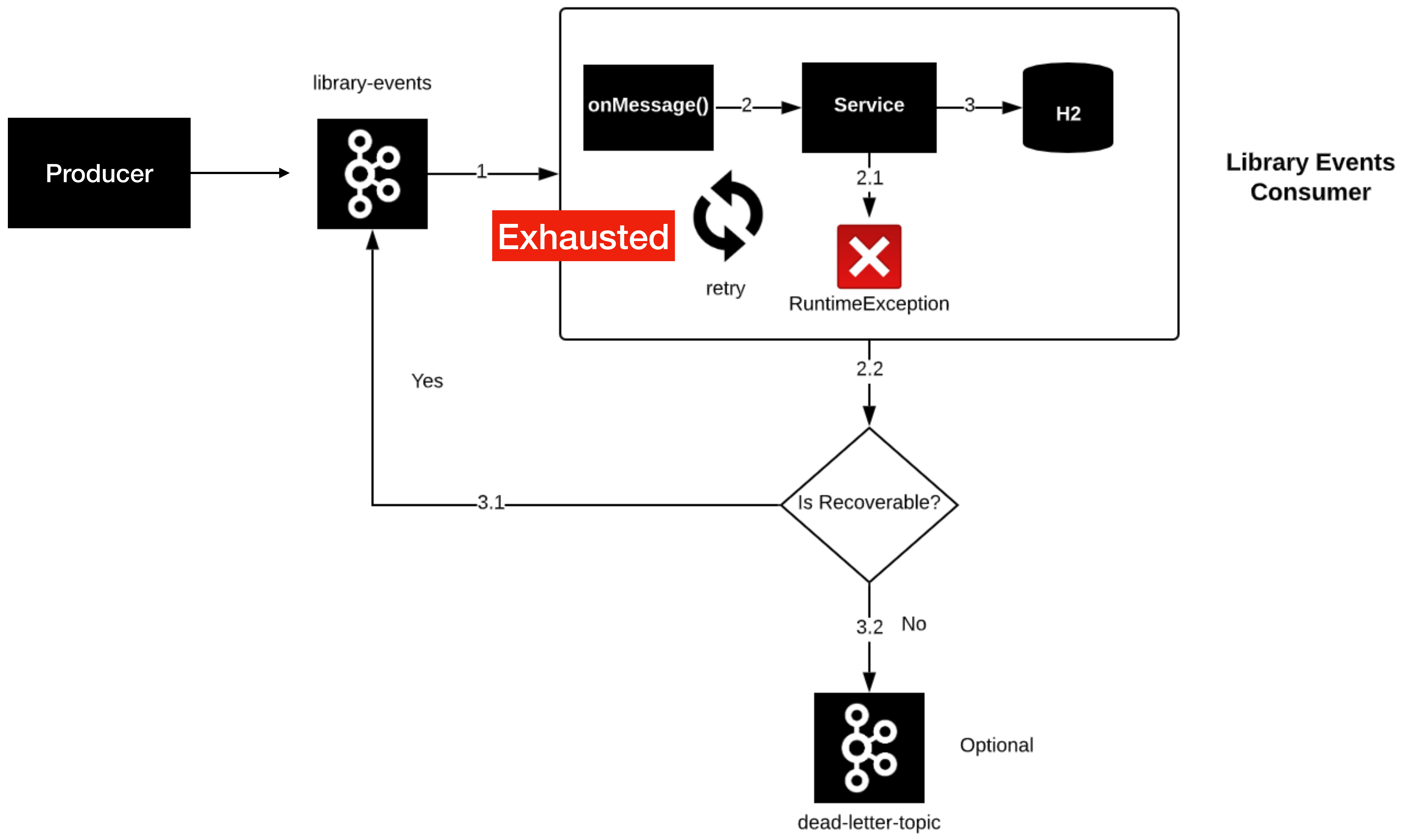
Recovery - Type 2



Issues with Recovery ?

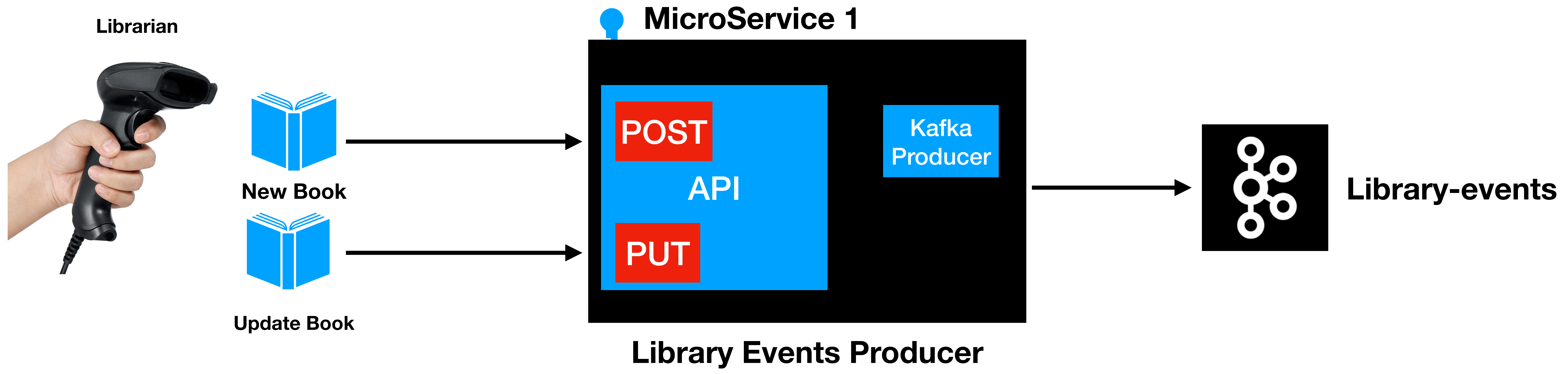
- Recovery can alter the order of events

Recovery - Type 1



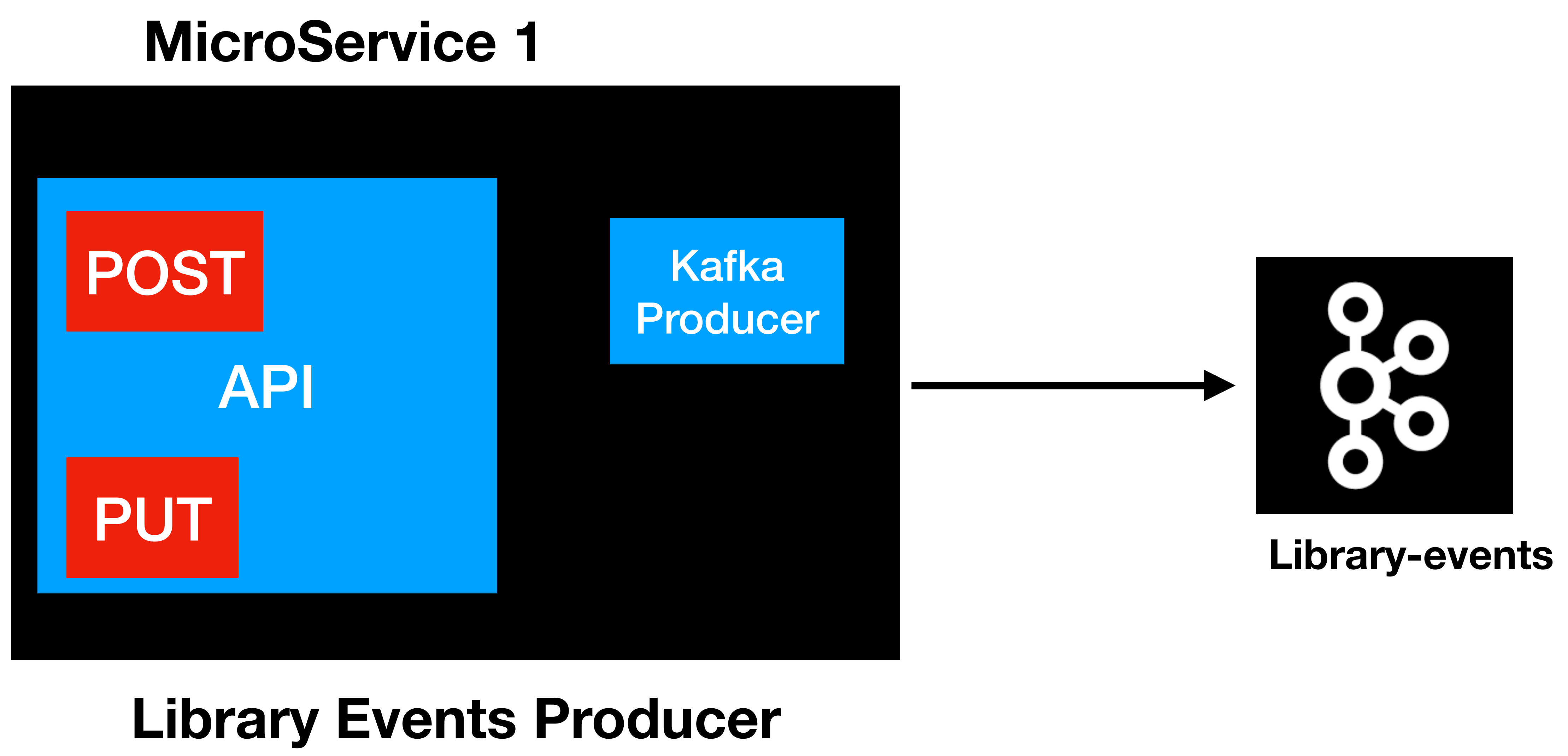
Error Handling in Kafka Producer

Library Events Producer API

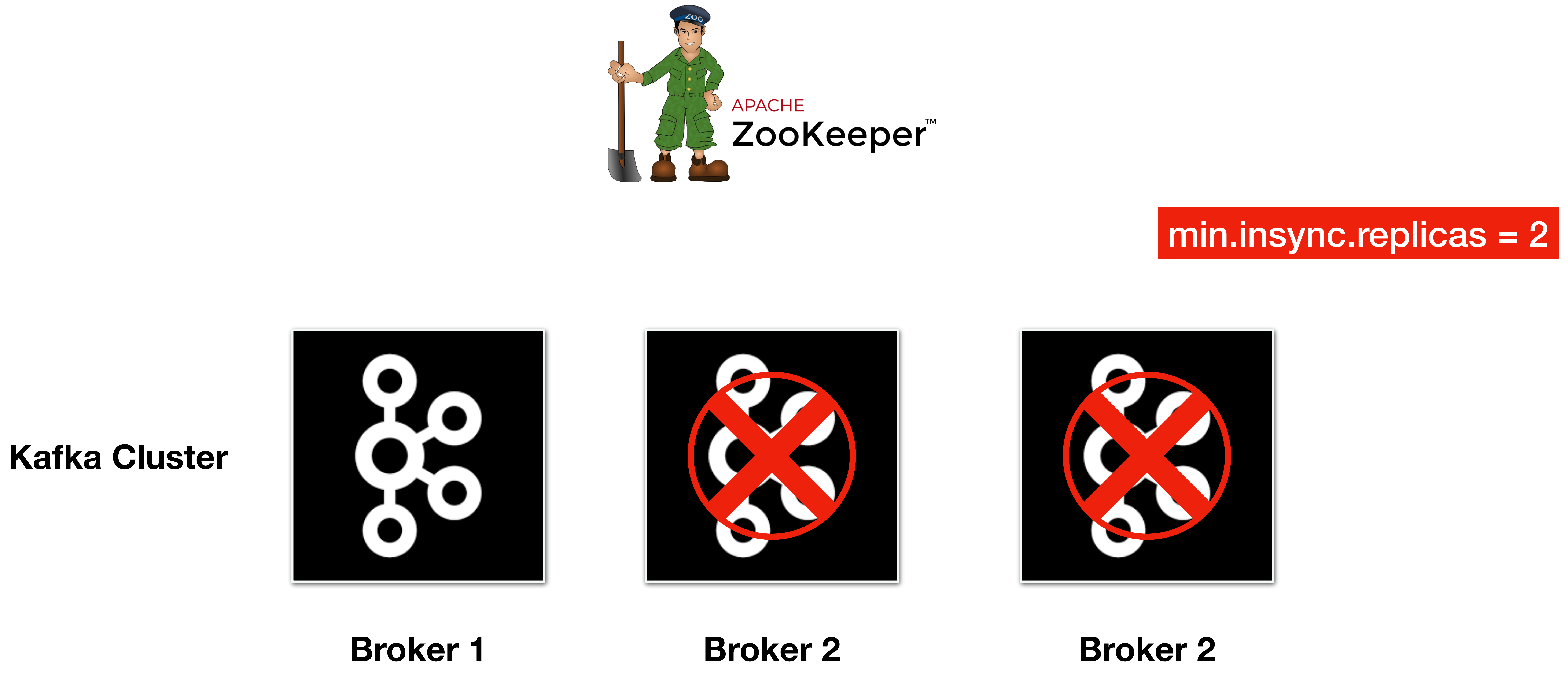


Kafka Producer Errors

- 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

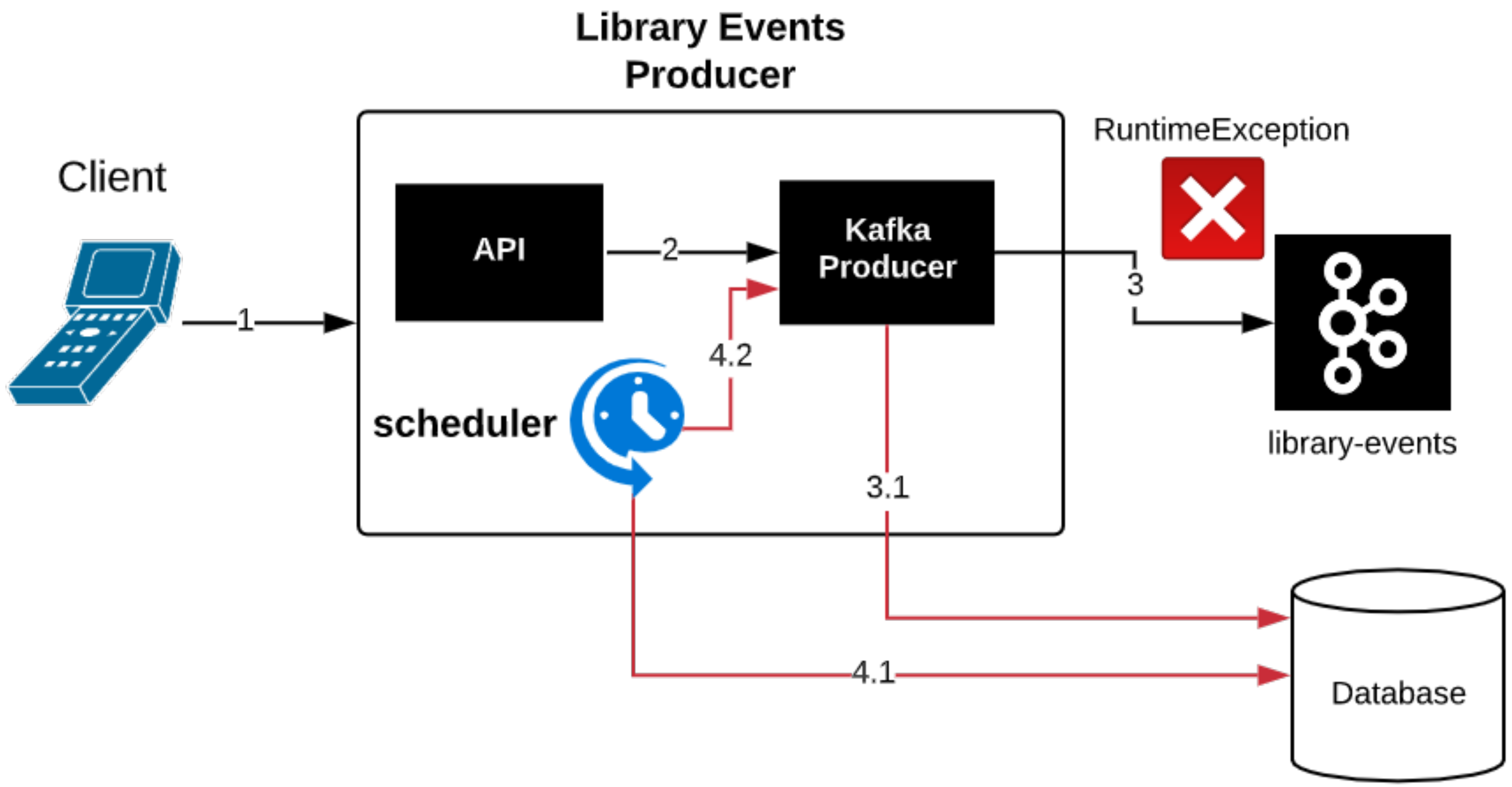


min.insync.replicas

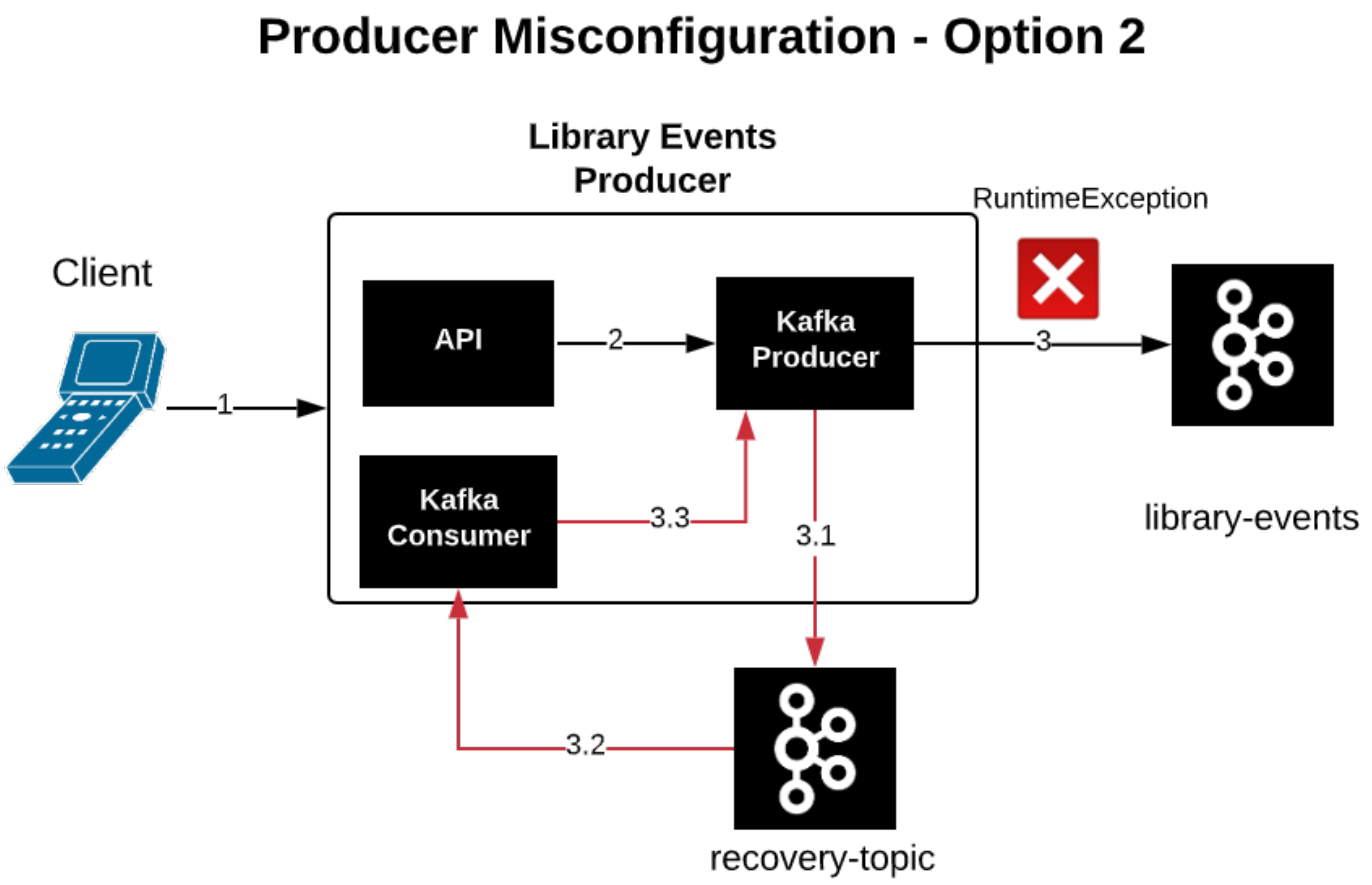


Retain/Recover Failed Records

Retain/Recover Failed Records



Retain/Recover Failed Records



Kafka Security

Kafka Security

- Kafka is used in variety of business:
  - Banking
  - Retail
  - Insurance
- Confidential Information:
  - Credit Card Details
  - Customer Information and etc.,

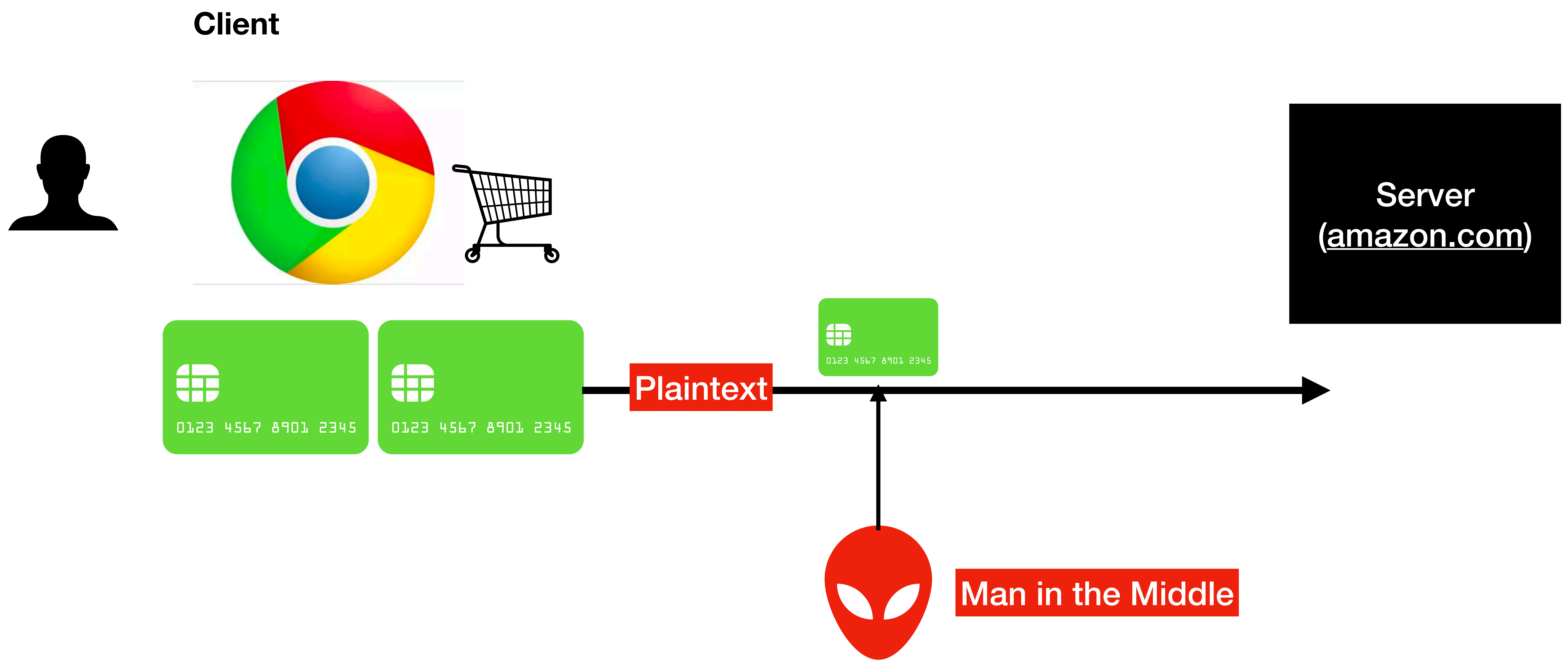
What Kafka Security Offers?

- Kafka supports two popular protocols:
    - **SSL** (Secured Sockets Layer), which is **TLS** (Transport Layer Security) now
    - **SASL** (Simple Authentication and Security Layer)

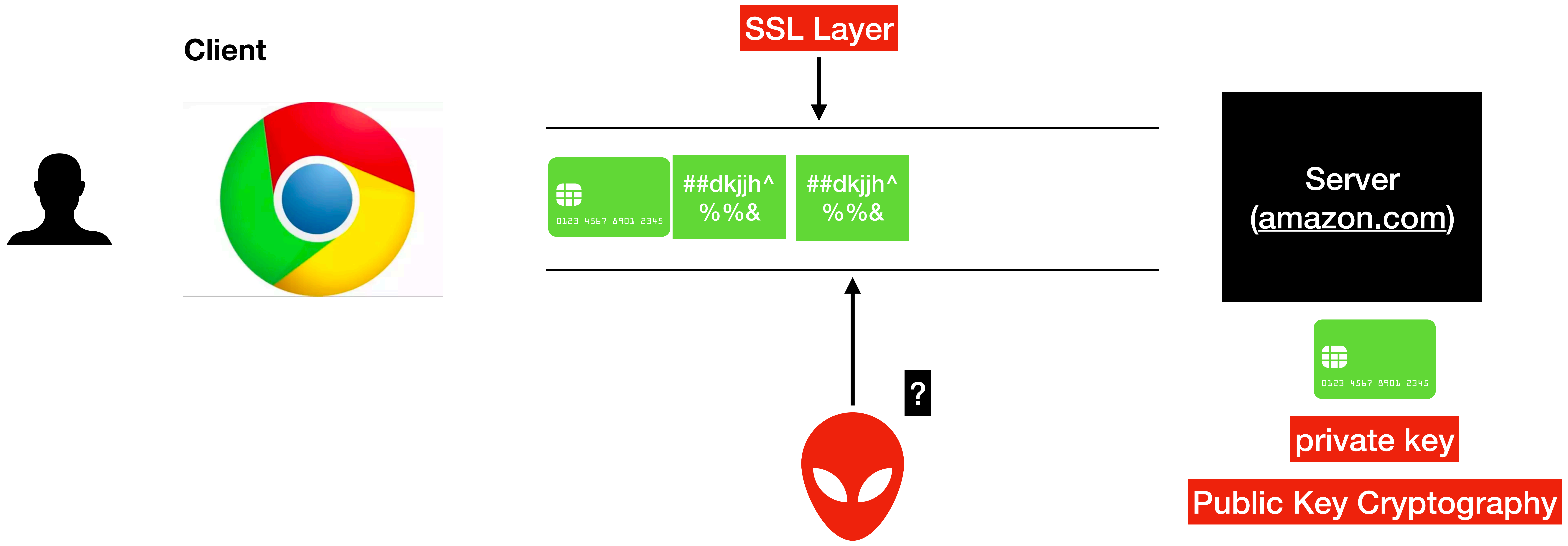
How SSL works?

- SSL used for two things:
    - Encryption
    - Authentication

Without SSL Encryption

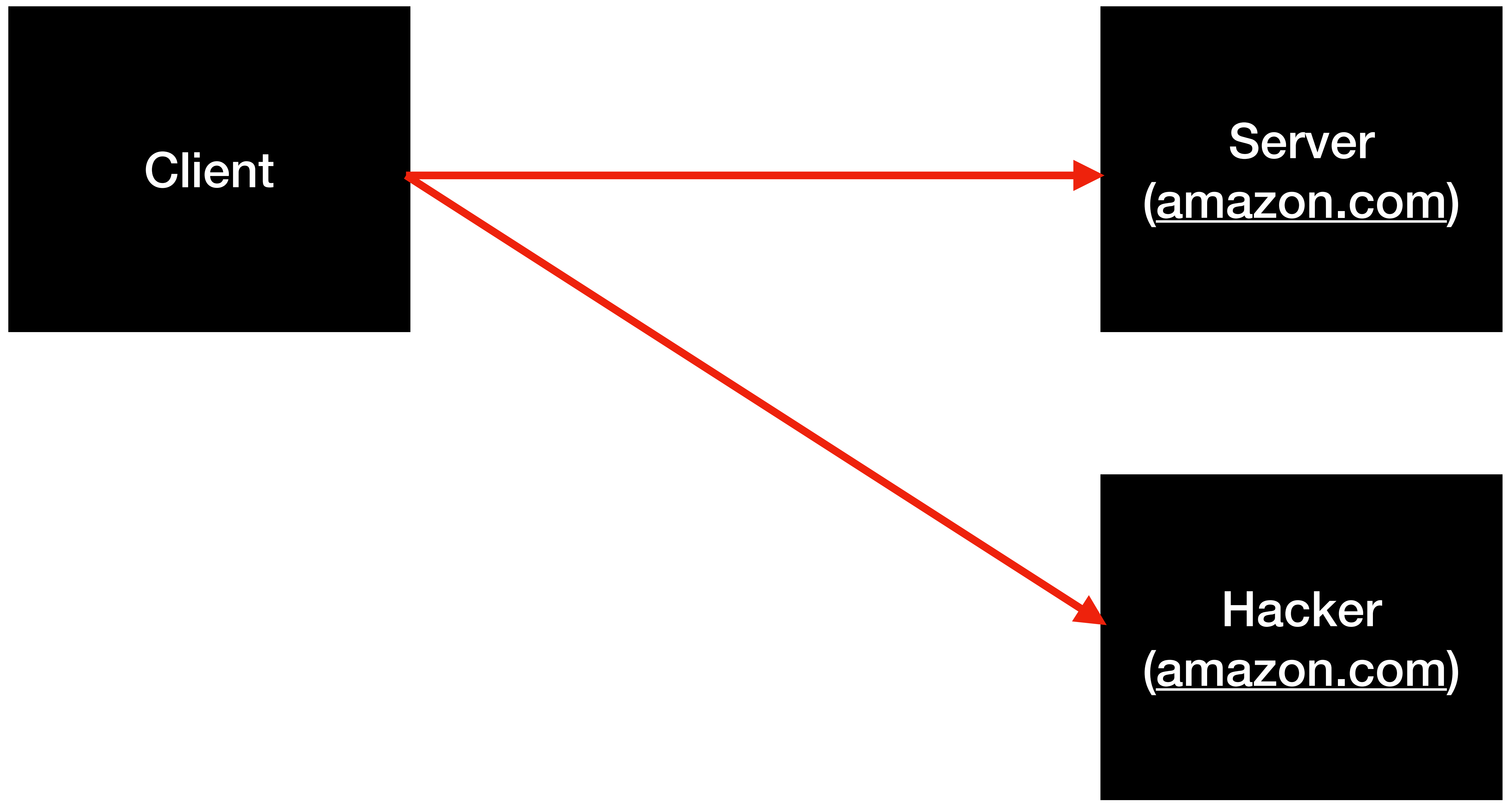


With SSL Encryption

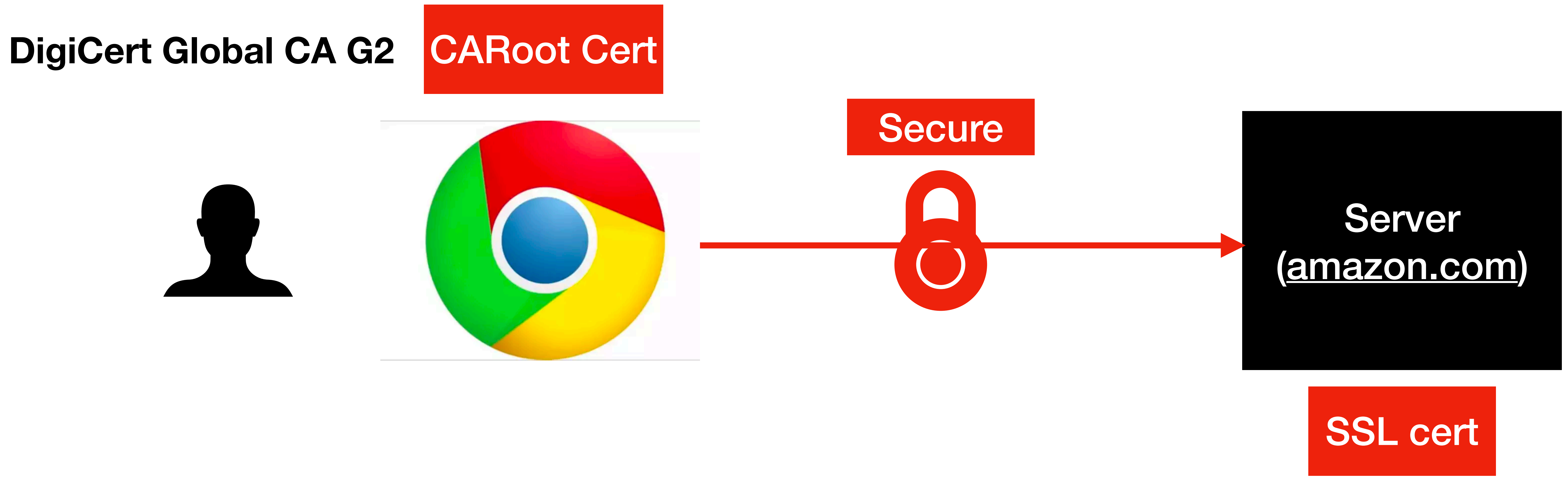


SSL Authentication

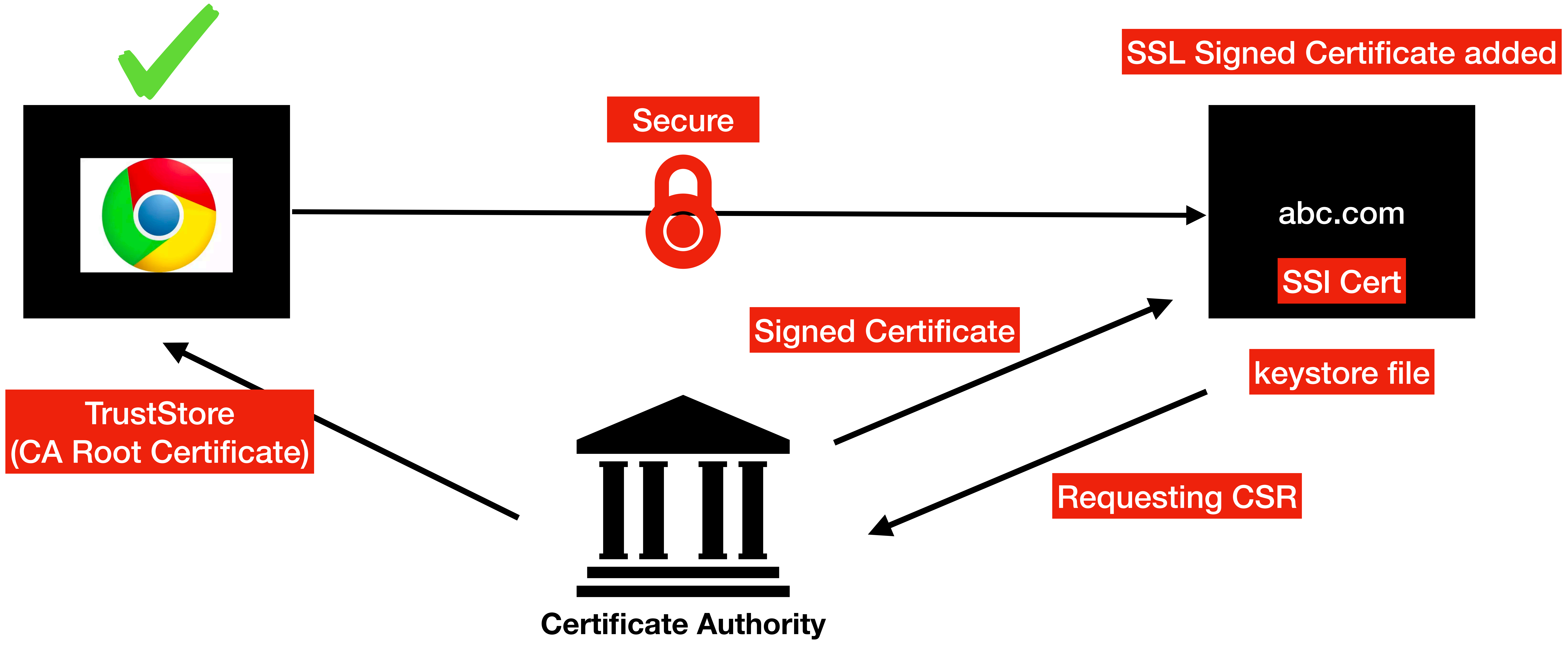
- SSL Authentication is to make sure you are talking to the correct server



How SSL Authentication works ?

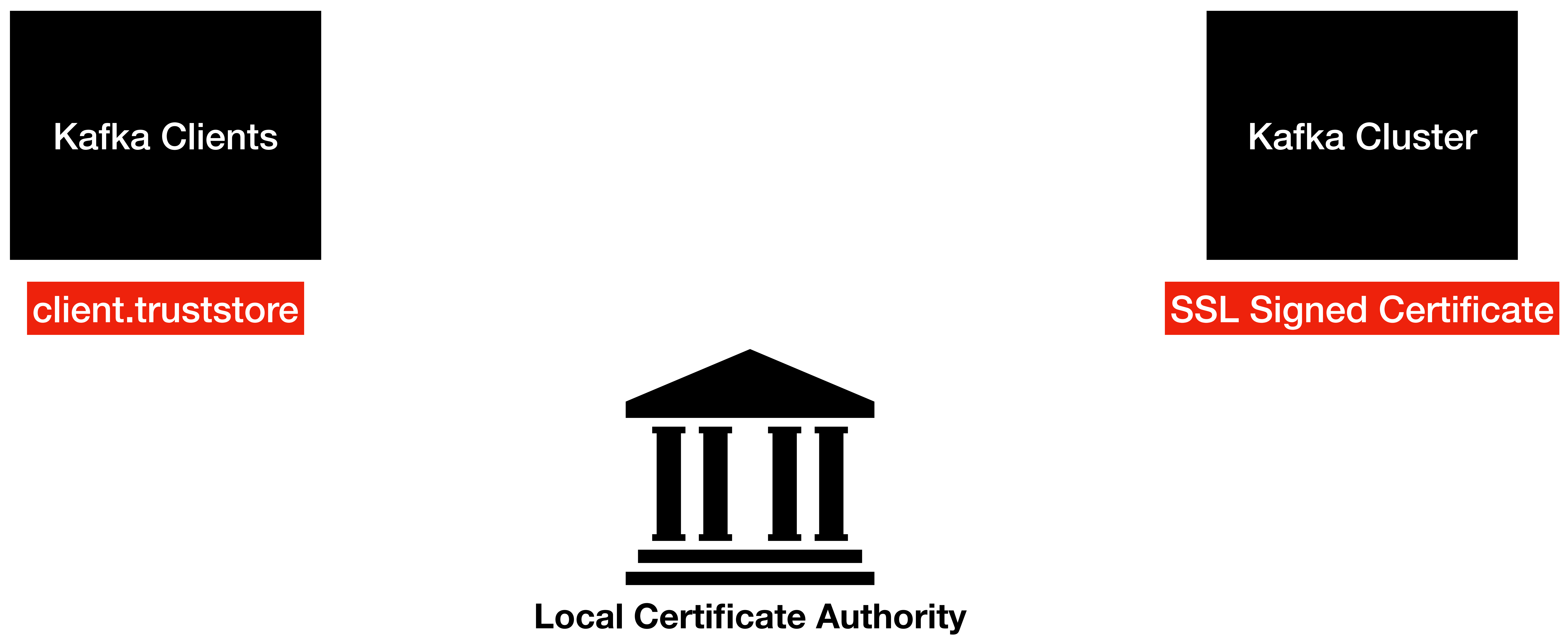


SSL Requests by Enterprise



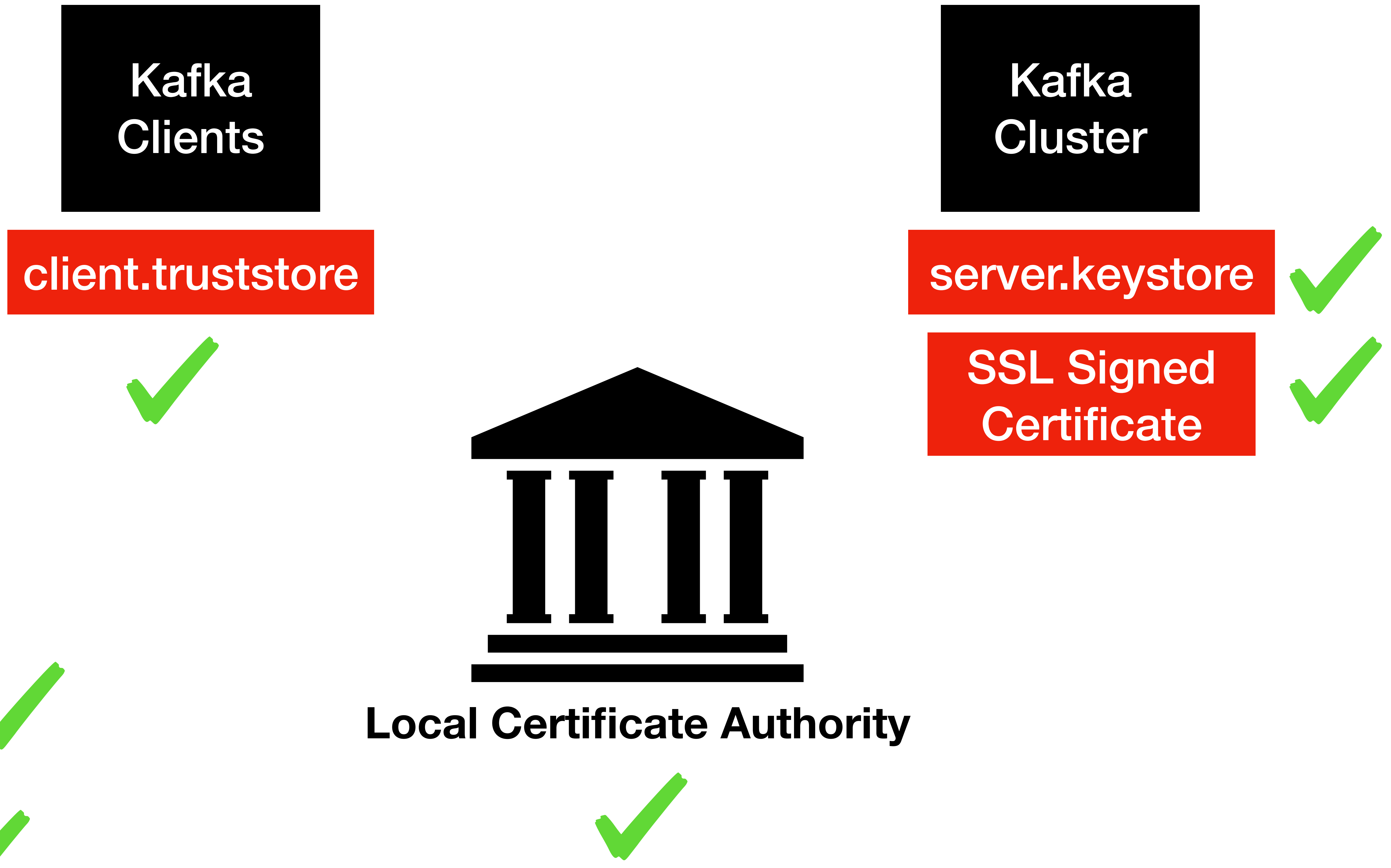
Kafka SSL SetUp

Kafka SSL SetUp



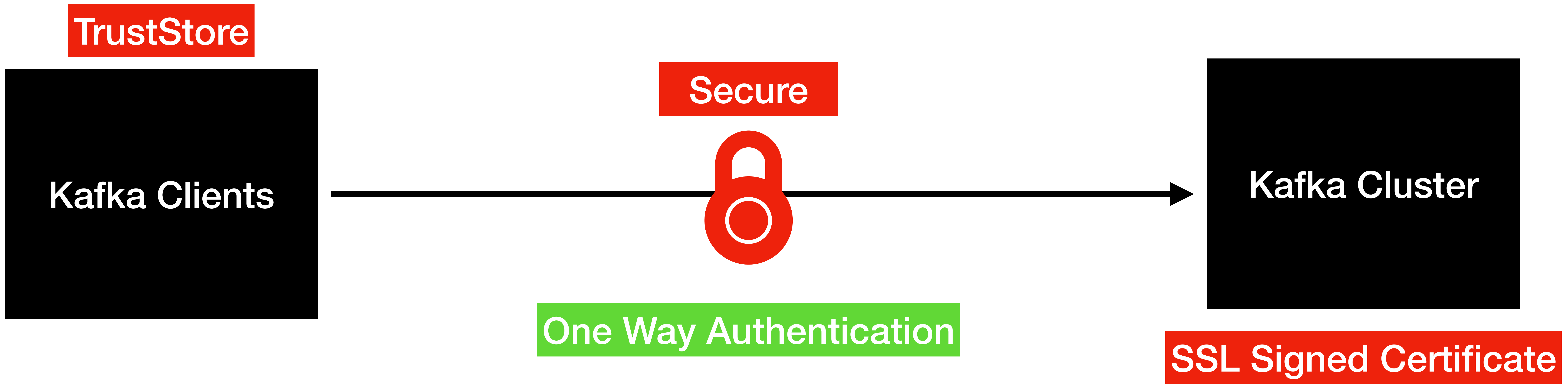
SSL Set Up Steps

1. Generate **server.keystore.jks** ✓
2. SetUp Local Certificate Authority ✓
3. Create CSR(Certificate Signing Request) ✓
4. Sign the SSL Certificate ✓
5. Add the Signed SSL Certificate to **server.keystore** file ✓
6. Configure the **SSL cert** in our Kafka Broker ✓
7. Create **client.truststore.jks** for the client ✓

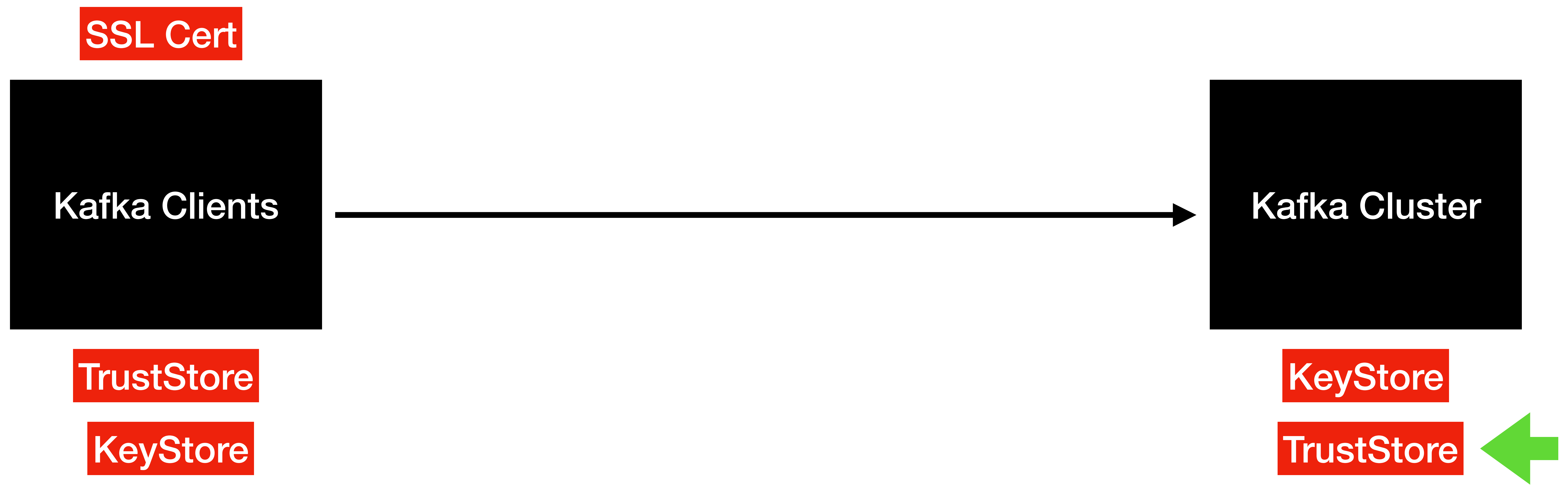


2 Way Authentication using **SSL**

SSL Authentication



2 Way SSL Authentication



2 Way SSL Authentication

- What's needed for 2 Way SSL Authentication?
    - Kafka Cluster
        - Server TrustStore(**server.truststore.jks**)
        - **server.properties**

```
ssl.truststore.location=<location>/server.truststore.jks
ssl.truststore.password=password
ssl.client.auth=required
```

- Client
    - Client KeyStore File(**client.keystore.jks**)
    - **client-ssl.properties**

```
ssl.keystore.type=JKS
ssl.keystore.location=<location>/server.keystore.jks
ssl.keystore.password=password
ssl.key.password=password
```

Accessing **SSL** secured Cluster using Spring Boot

Current State of Local Cluster

- **Non-Secured Cluster**
  - ✓ **PLAINTEXT**://localhost:9092,localhost:9093,localhost:9094
- **Secured Cluster**
  - ➡ **SSL**://localhost:9095,localhost:9096,localhost:9097