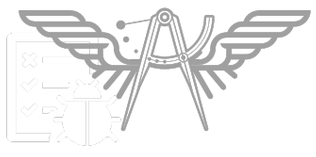
สยามชำนาญกิจ
SIAM CHAMNAN KIT

Apache Kafka with Java



Apache Kafka

- Why Apache Kafka ?
- What is Apache Kafka ?
- Architecture
- Topologies and Tools

Working with Java

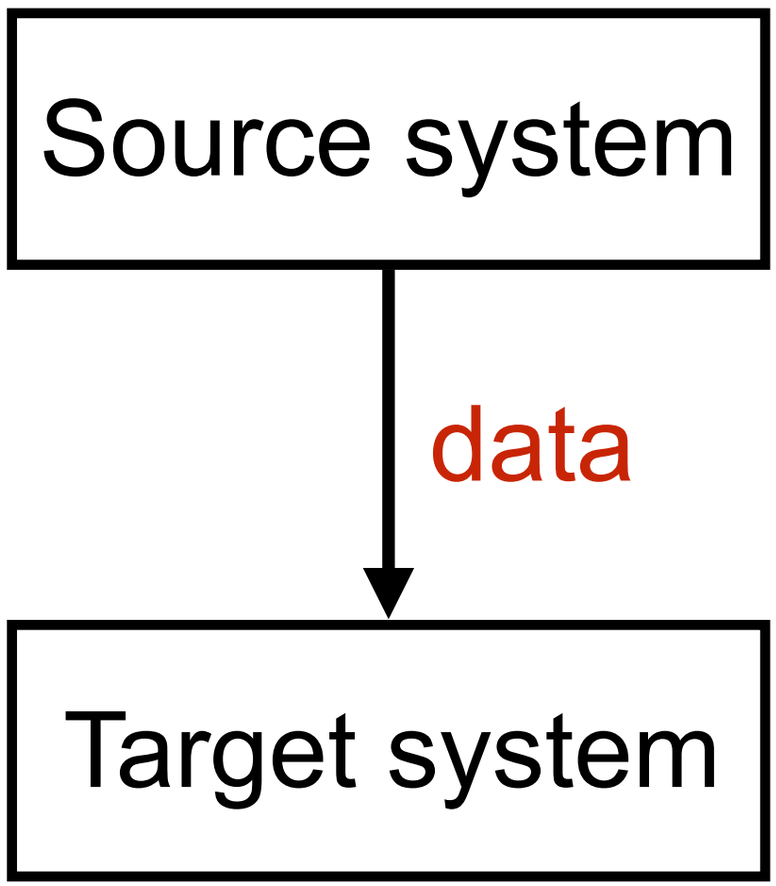
- Working with Spring Kafka
- Producer
- Consumer
- Consumer group
- Message key
- Serialization and deserialization
- Testing

Apache Kafka

https://kafka.apache.org/

Why

Starting with simple

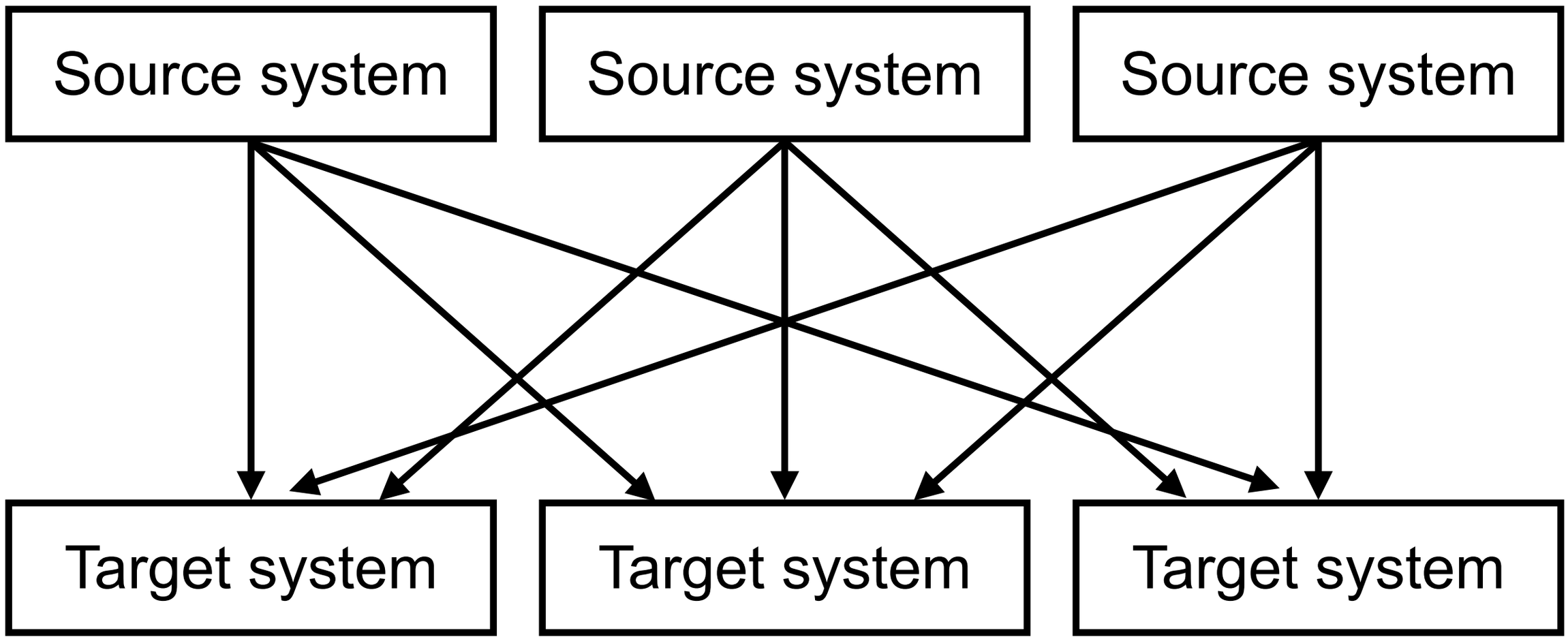


Why

More source systems
More target systems
More protocols
More data formats and schemas
More loads/traffics

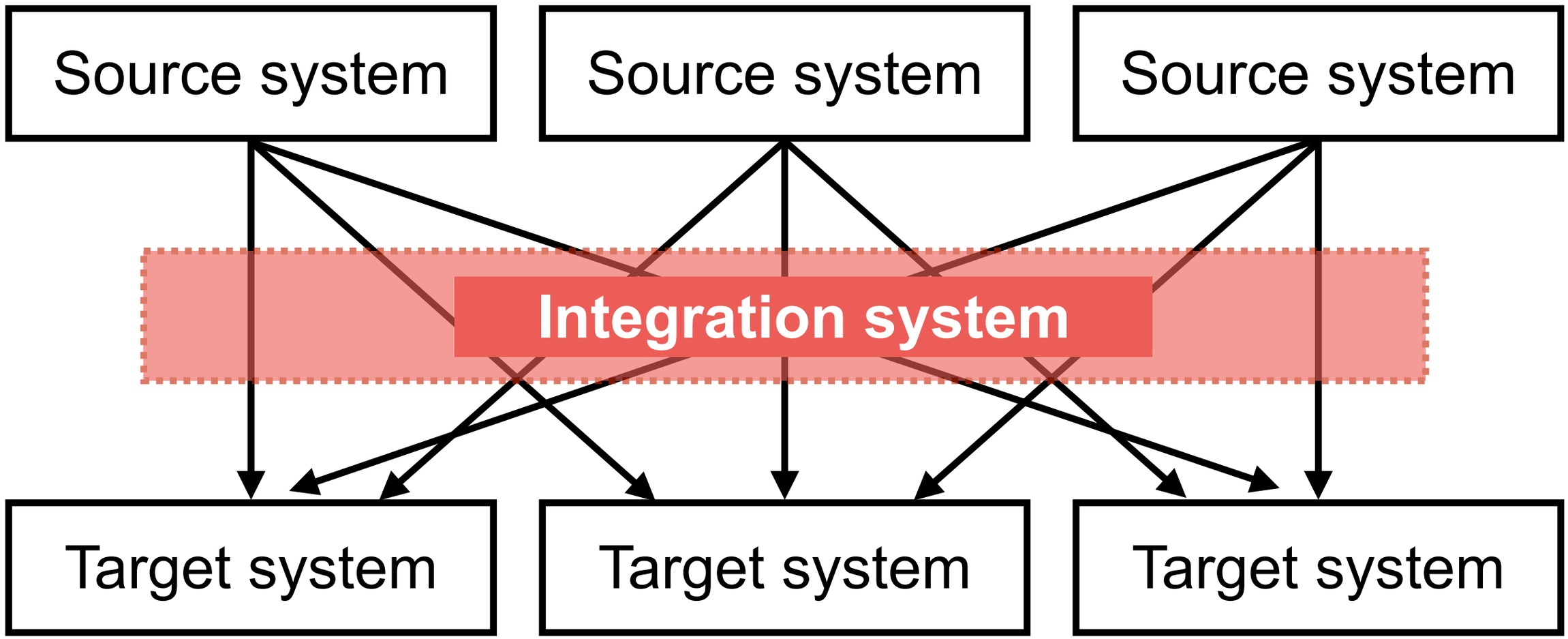
Why

Complex system !!

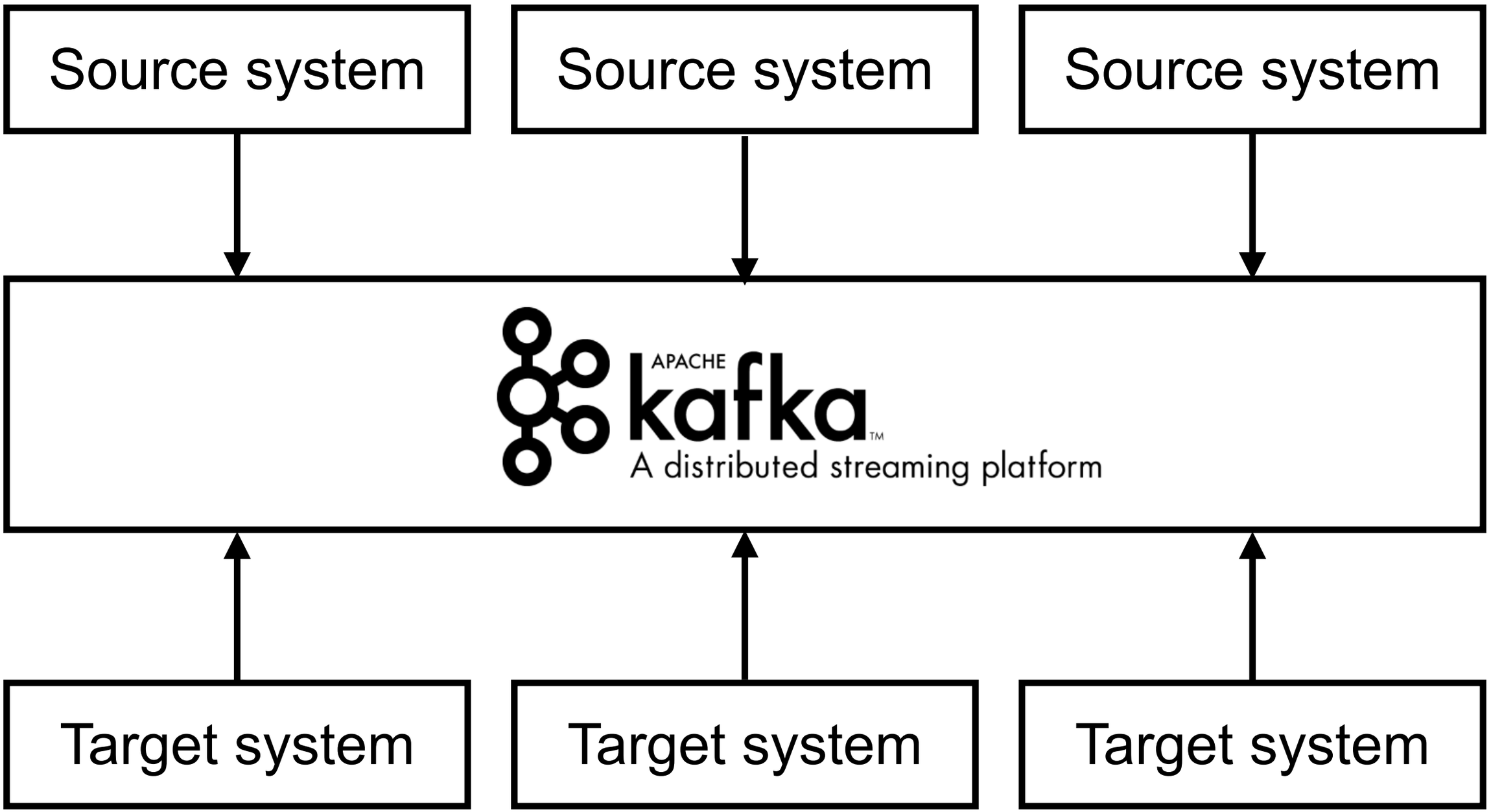


Why

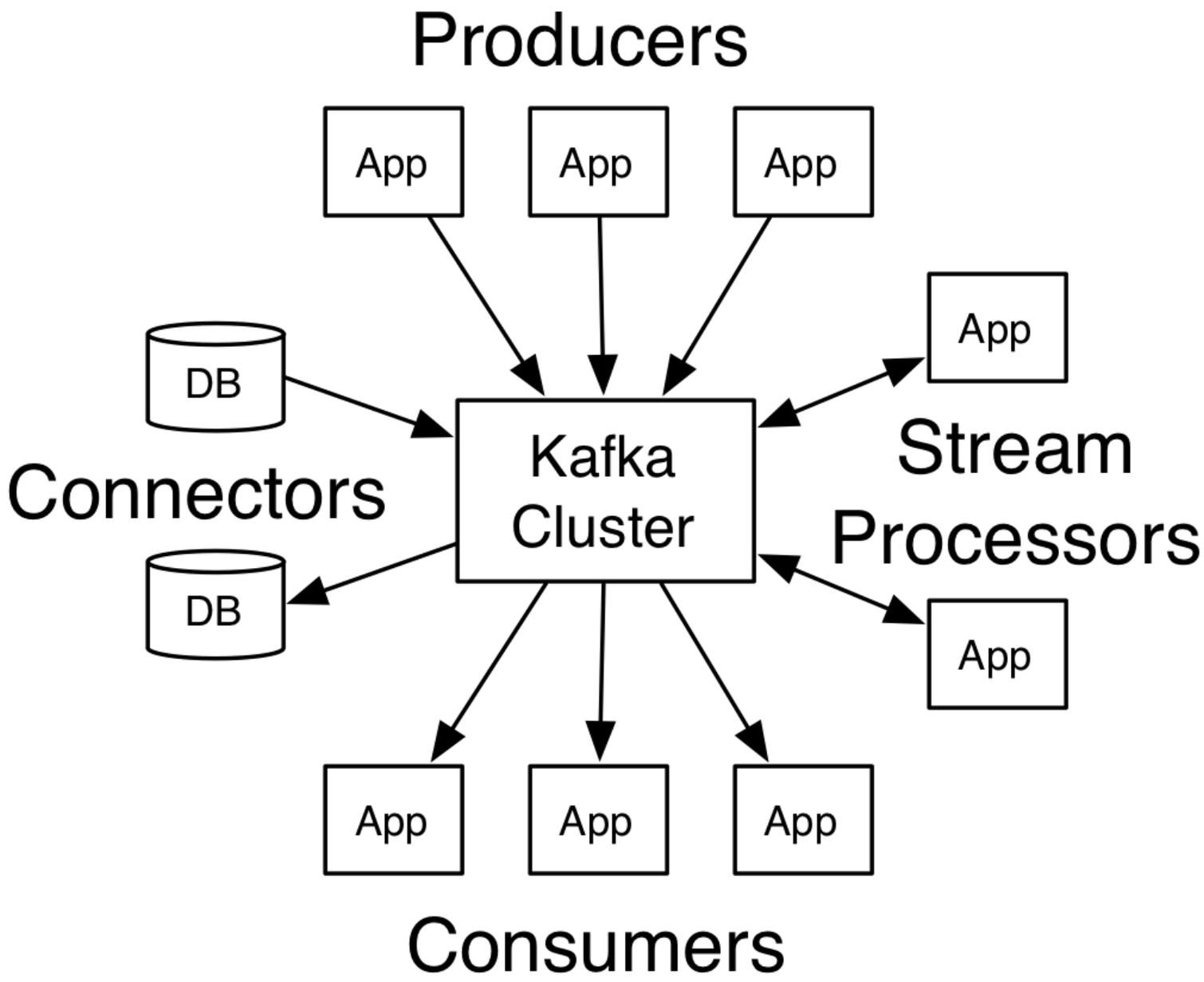
Need integration system



Apache Kafka



Apache Kafka



https://kafka.apache.org/intro.html

Why Apache Kafka ?

Created by LinkedIn
Open source project (maintain by Confluent)
Distributed system
Resilient architecture, fault tolerant
Horizontal scalability
High performance/ low latency

Used by

https://cwiki.apache.org/confluence/display/KAFKA/Powered+By

Use cases

Messaging system
Activity tracking
Gather metric from different locations
Gather application logs
Stream processing
Decoupling of system dependencies
Integration with others system/technologies

Kafka terminologies

Producers
Consumers
Topics
Partitions
Broker
Consumer groups
Cluster/Replicate
Offset

Learning paths

Part 1

- Kafka theory
- Starting Kafka
- Kafka CLI
- Kafka with Java

Part 2

- Configuration
- Producers
- Consumers
- Monitoring

Kafka theory

Topics, partitions and offsets

Topics

Stream of data

Similar to a table in database

You can have many topics as you want

A topic is identified by **name**

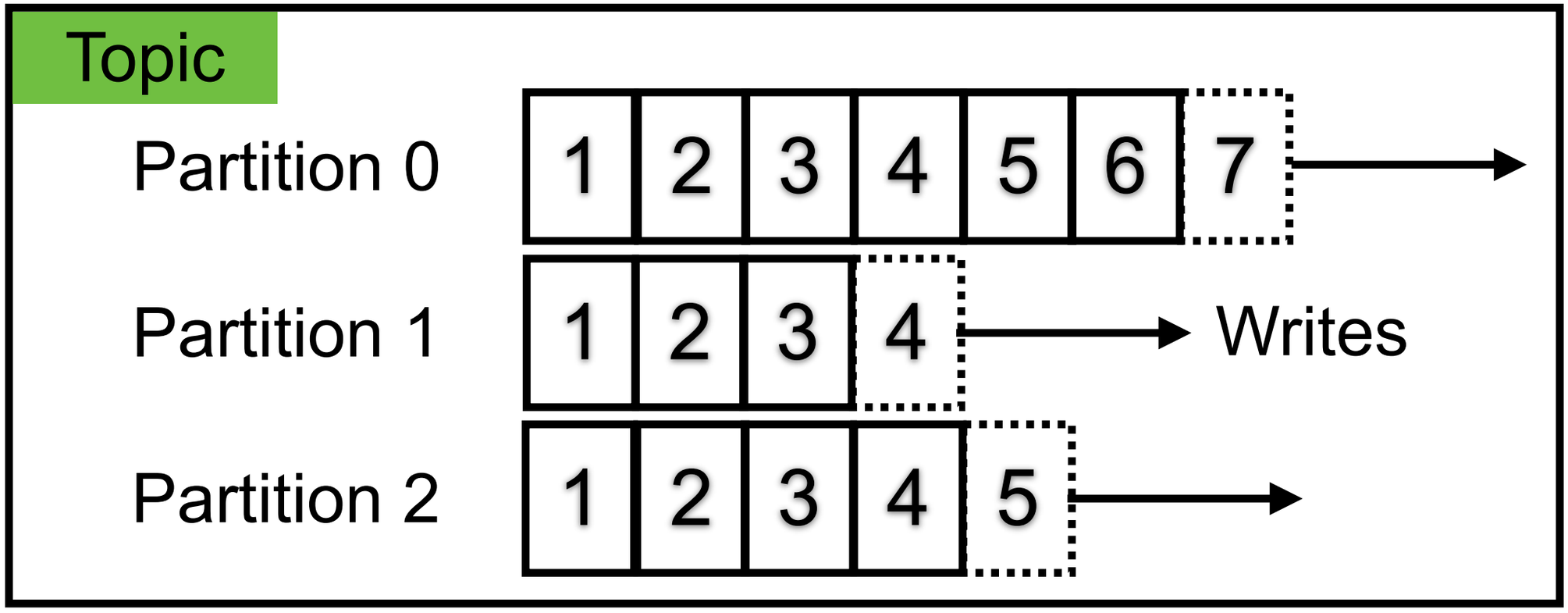
Topics, partitions and offsets

Partitions

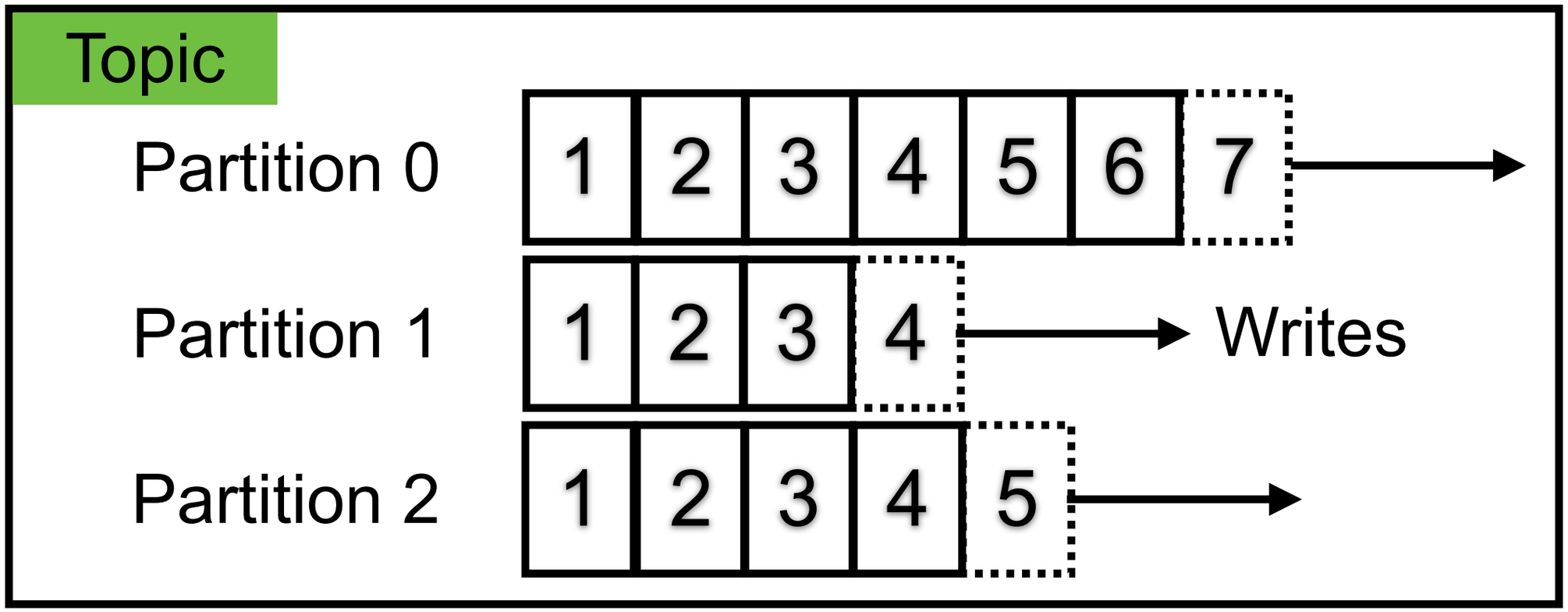
Topics are split in partitions

Each partition is **ordered**

Each message in partition get incremental id (**offset**)



Topics, partitions and offsets



Order is guaranteed only within partition

Data is keep in limited time (**Default = 1 week**)

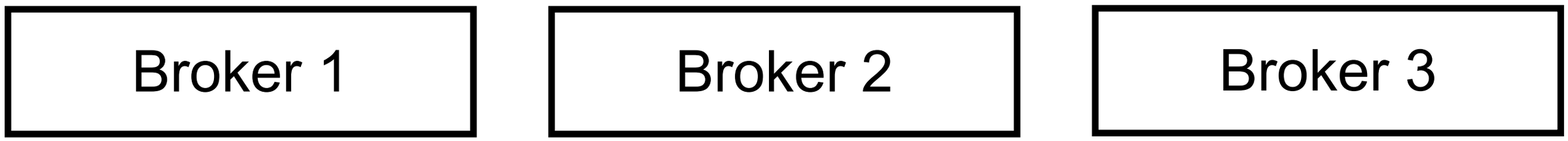
Data is **immutable** (can't be changed)

Data is assigned **randomly** to a partition

Brokers and topics

Brokers

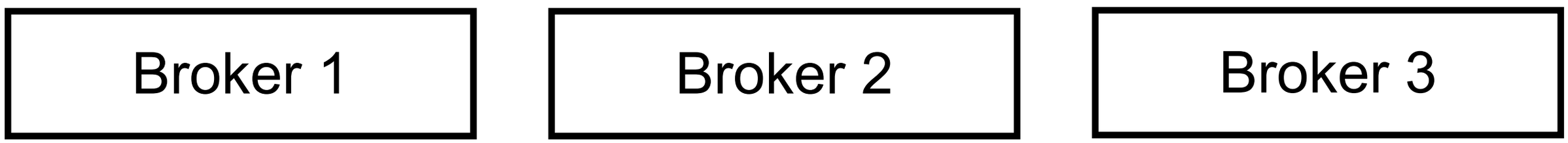
Kafka cluster is composed of multiple brokers (servers)
Each broker is identified by ID (integer)
Each broker contains certain topic partitions
After connecting any broker (bootstrap broker), you will connected to the entire cluster



Brokers and topics

Brokers

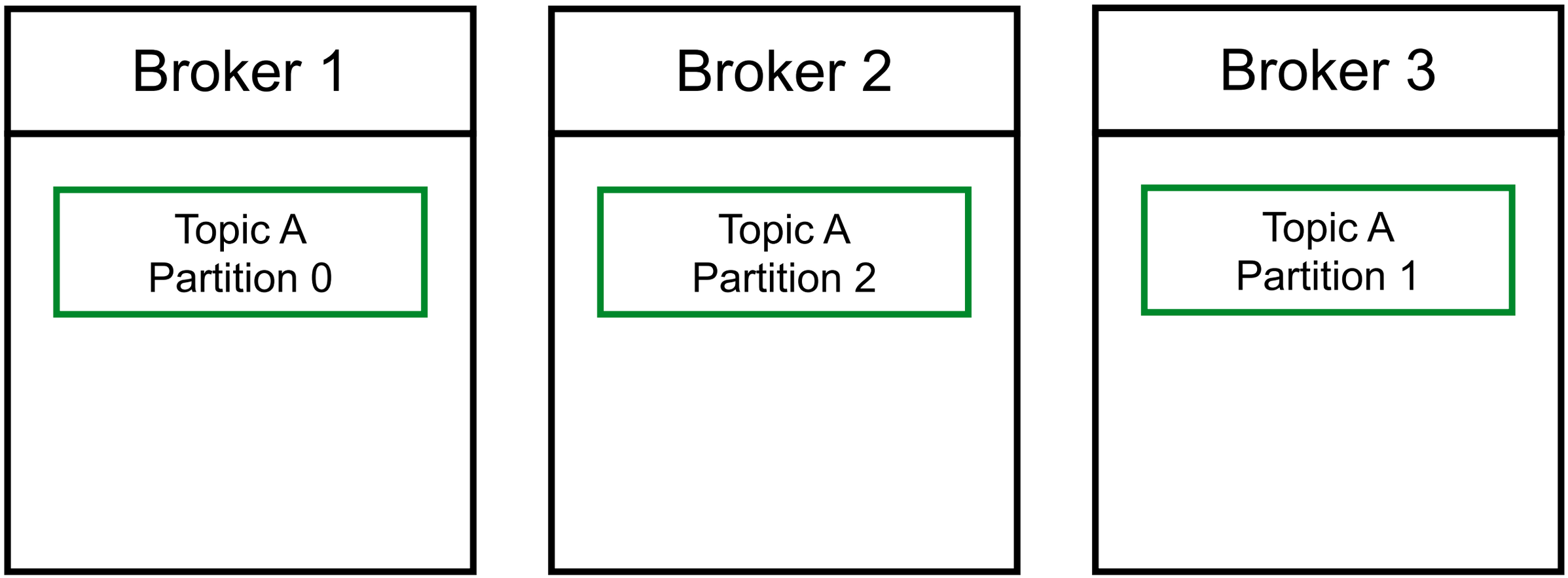
Good number to start id **3 brokers**



Brokers and topics

Example

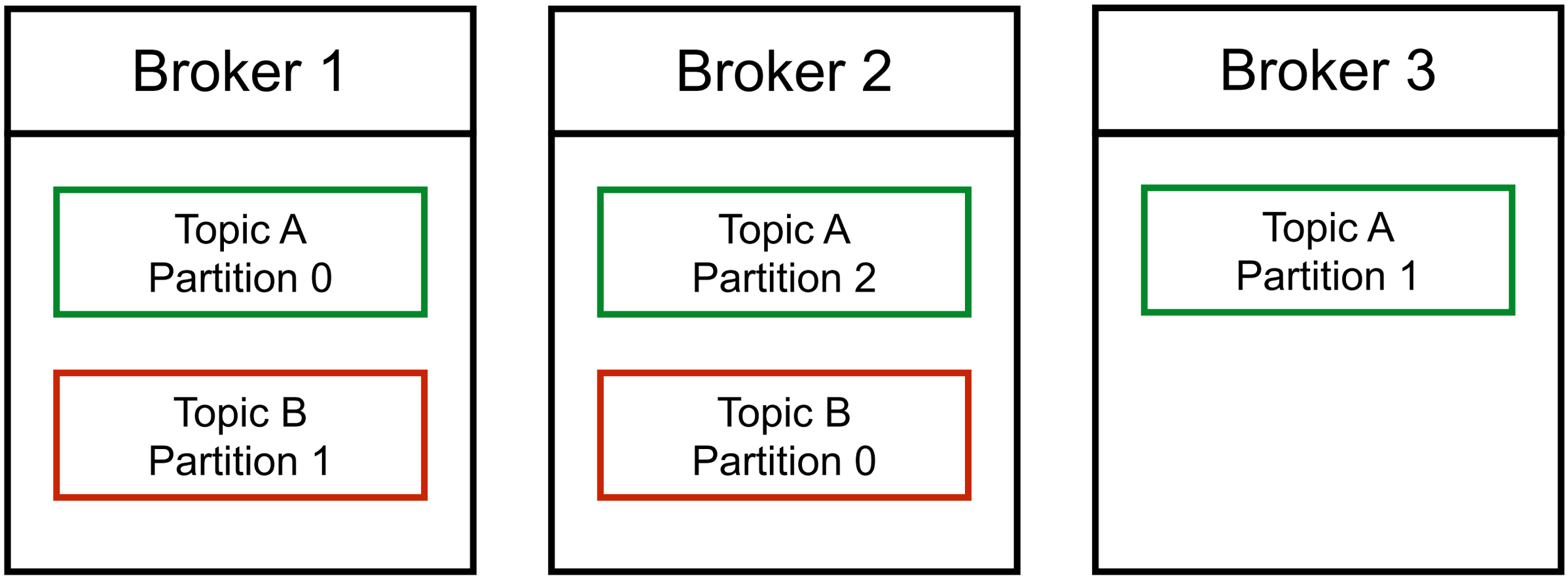
Topic A with 3 partitions



Brokers and topics

Example

Topic B with 2 partitions



Topic with replication factor

Topic should have a replica factor > 1 (2-3)

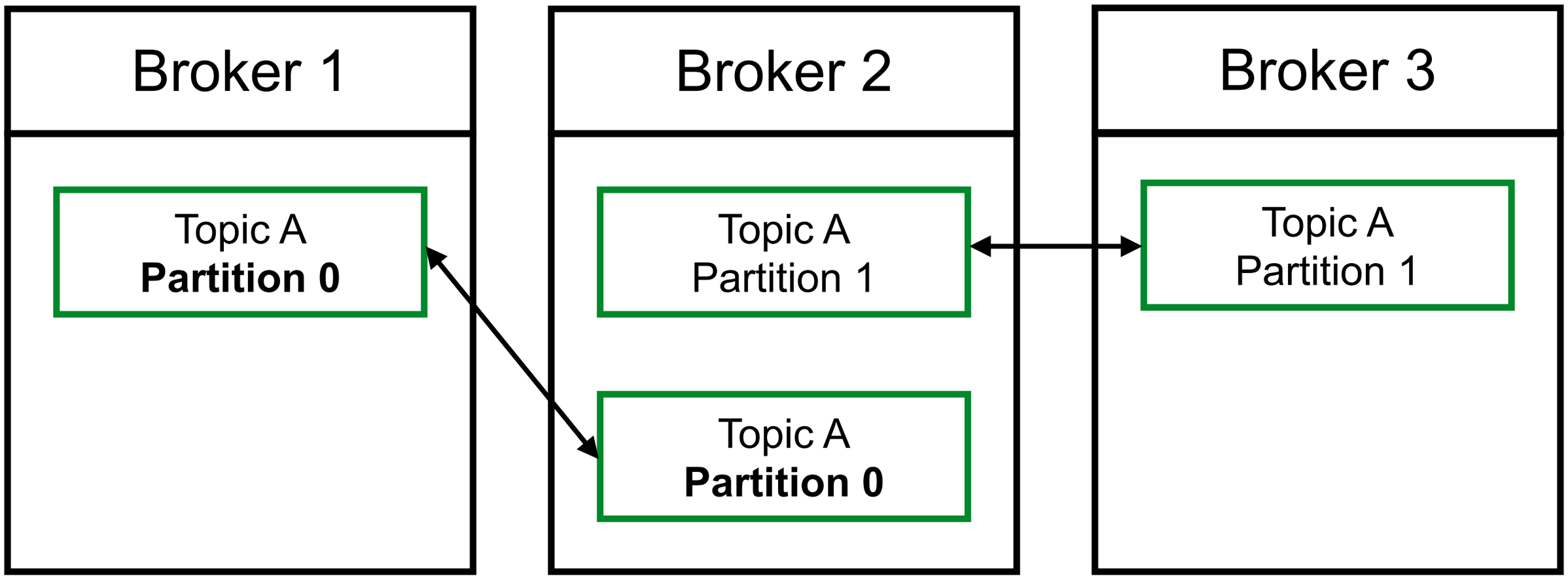
replica factor < no. of brokers

This way if a broker down, another broker can serve the data

Topic with replication factor

Example

Topic A with 2 partitions and replication factor = 2



Leader for a partition

At any time only **one Broker** can be leader for partition

Only leader partition can receive and serve data for a partition

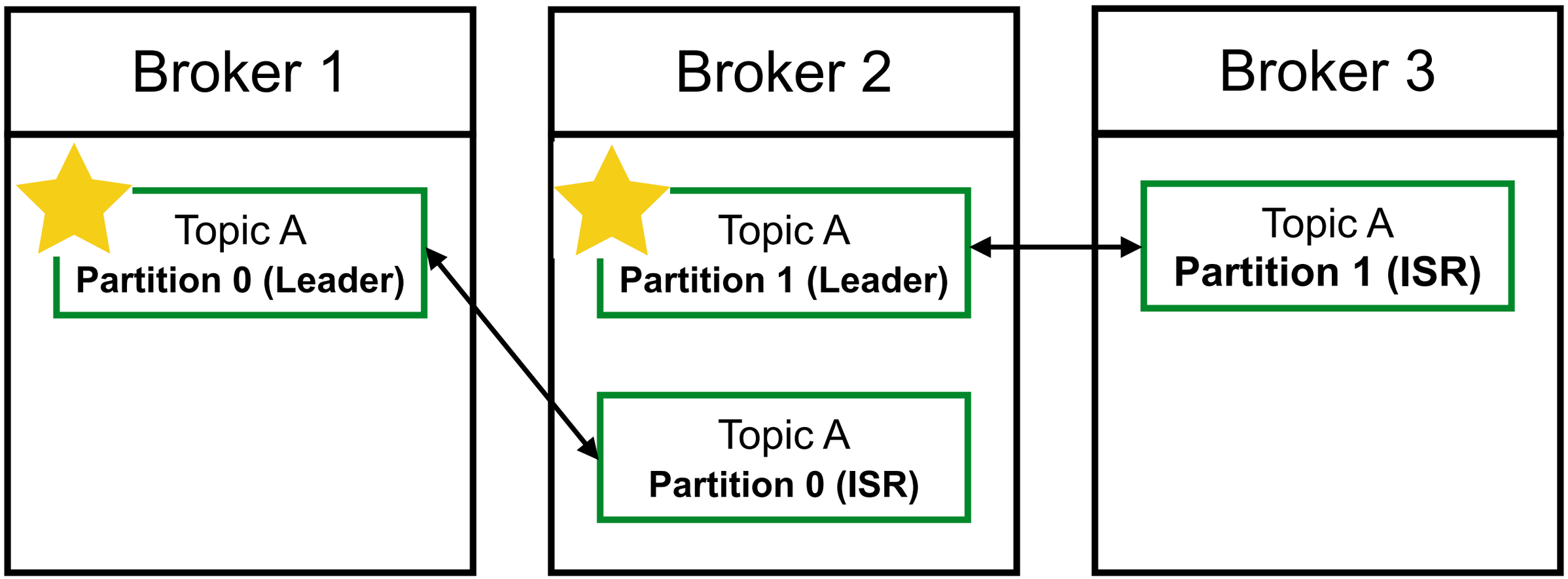
Other brokers will synchronize the data

Other partition called **in-sync replica (ISR)**

Leader for a partition

Example

Topic A with 2 partitions and replication factor = 2



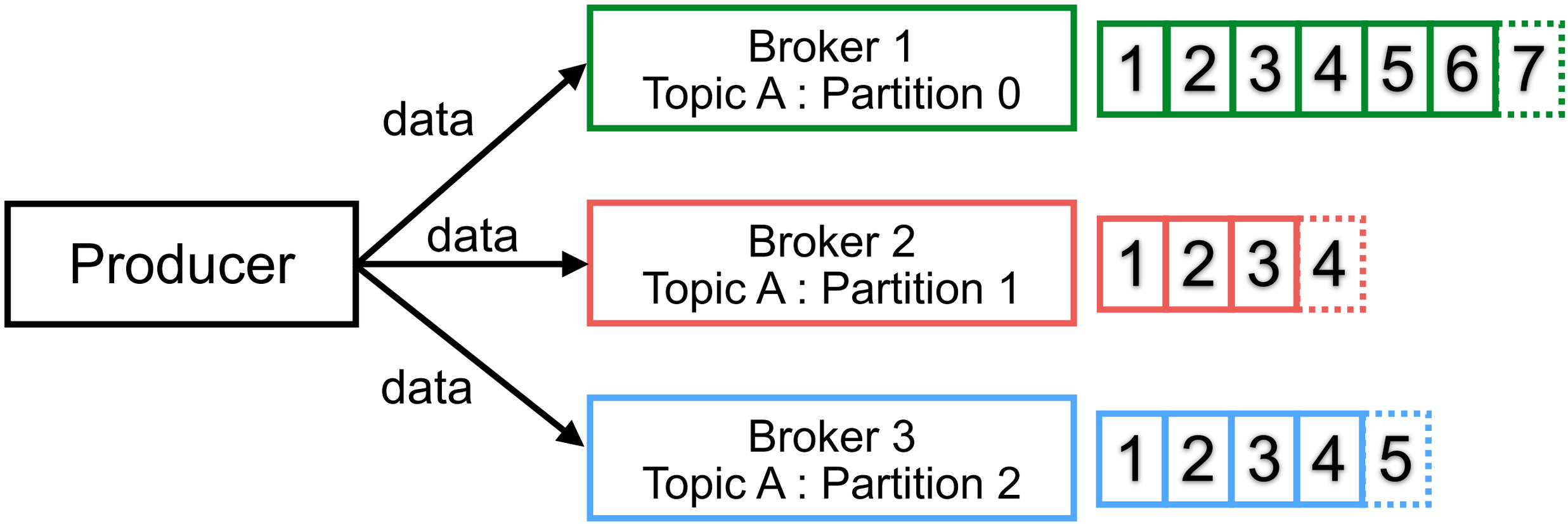
Producers

Producers write data to topics

Producers automatically know to broker and partition to write

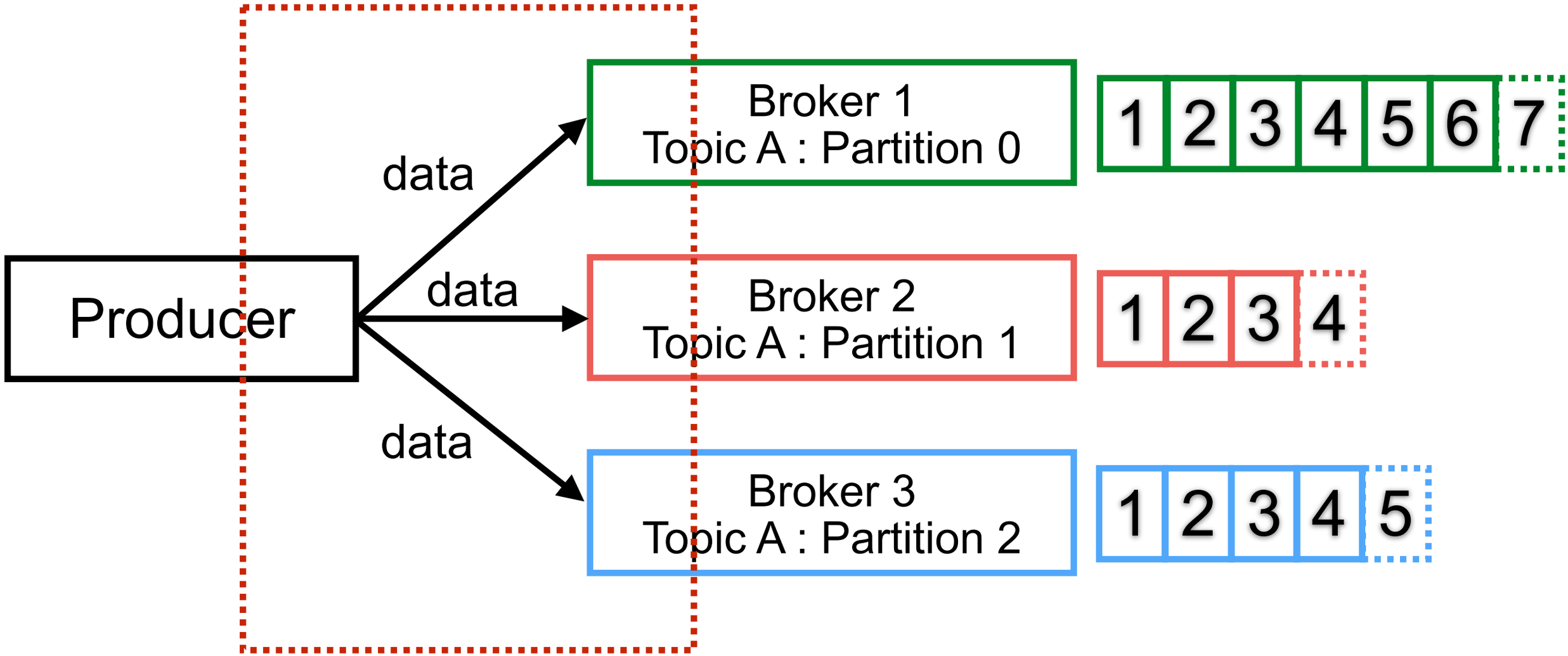
When broker failures, producers will automatically recover

Producers



*** The load is balance to many brokers (no. of partitions) ***

Producers issue to write data !!



Producers with acknowledgment

acks=0

Producer not wait for acknowledgment

Possible data loss

acks=1

Producer will wait for **leader** acknowledgment

Limited data loss

acks=all

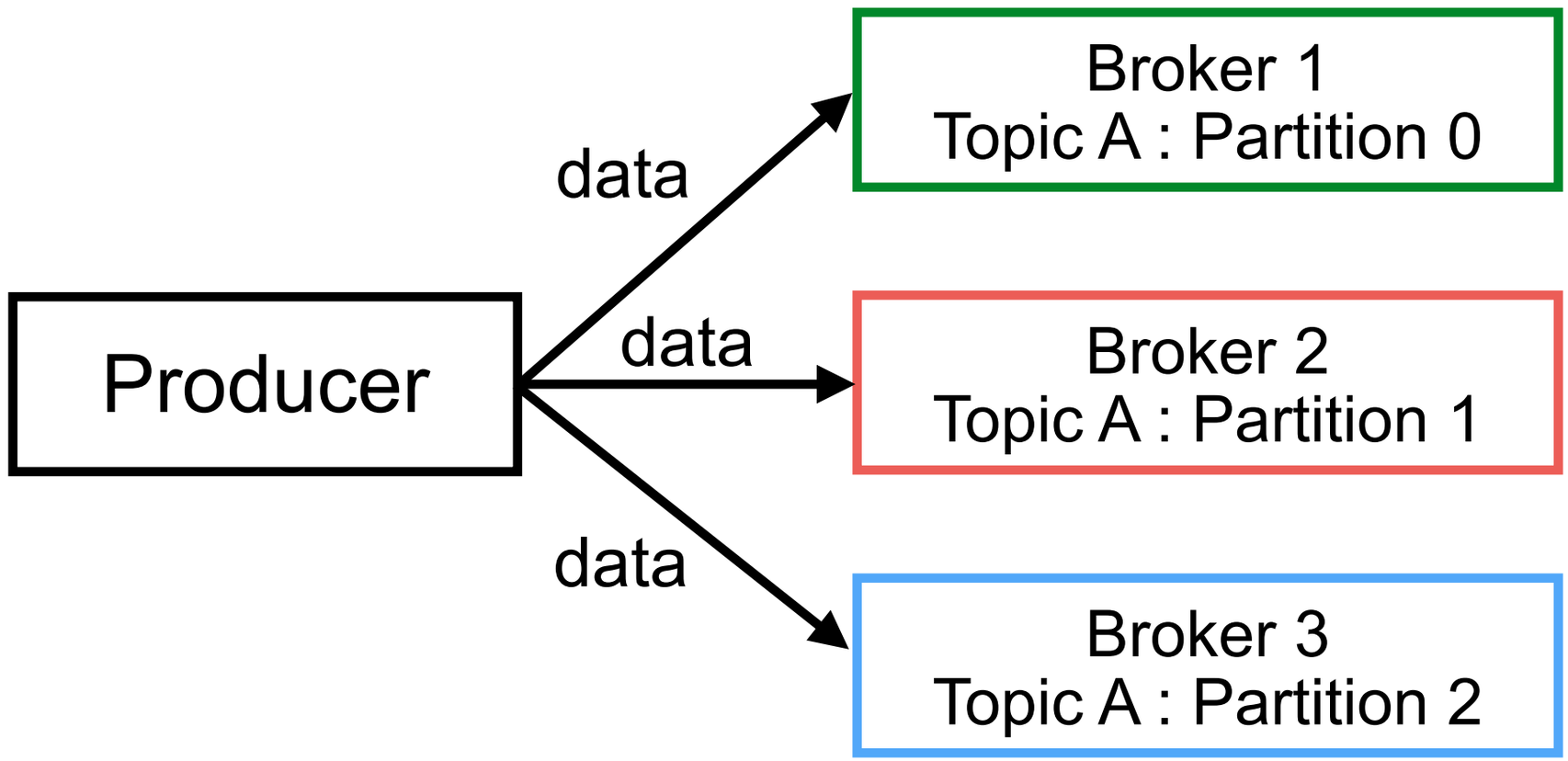
Producer will wait for **leader + ISR** acknowledgment

No data loss

Producers with message keys

Producers can choose to sent a **key** with data

Key = null, data is sent **round-robin**



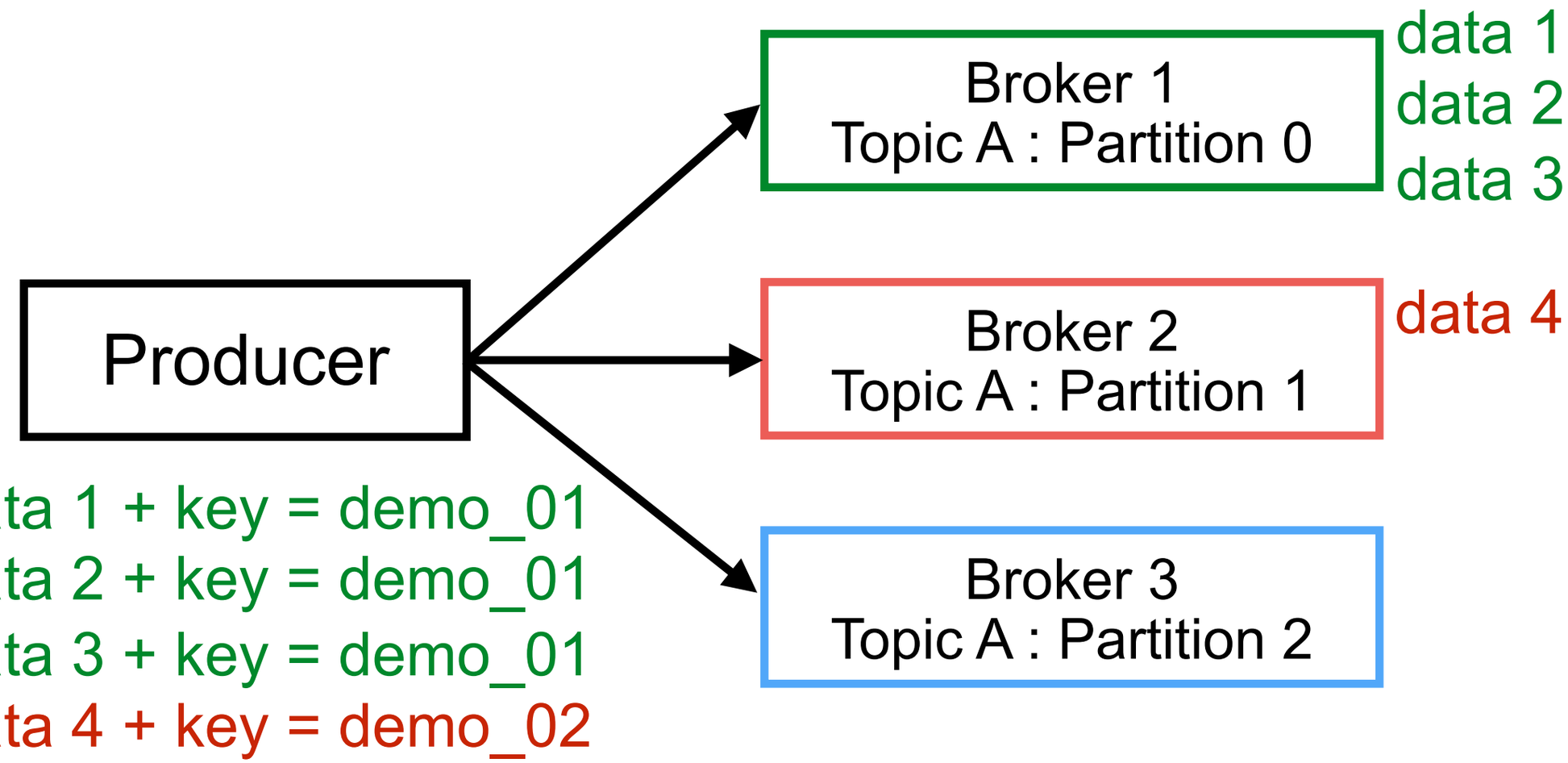
Producers with message keys

```
public int partition(String topic, Object key, byte[] keyBytes, Object value, byte[]
    if (keyBytes == null) {
        return stickyPartitionCache.partition(topic, cluster);
    }
    List<PartitionInfo> partitions = cluster.partitionsForTopic(topic);
    int numPartitions = partitions.size();
    // hash the keyBytes to choose a partition
    return Utils.toPositive(Utils.murmur2(keyBytes)) % numPartitions;
}
```

https://github.com/apache/kafka/blob/trunk/clients/src/main/java/org/apache/kafka/clients/producer/internals/DefaultPartitioner.java

Why use message keys ?

You need message ordering



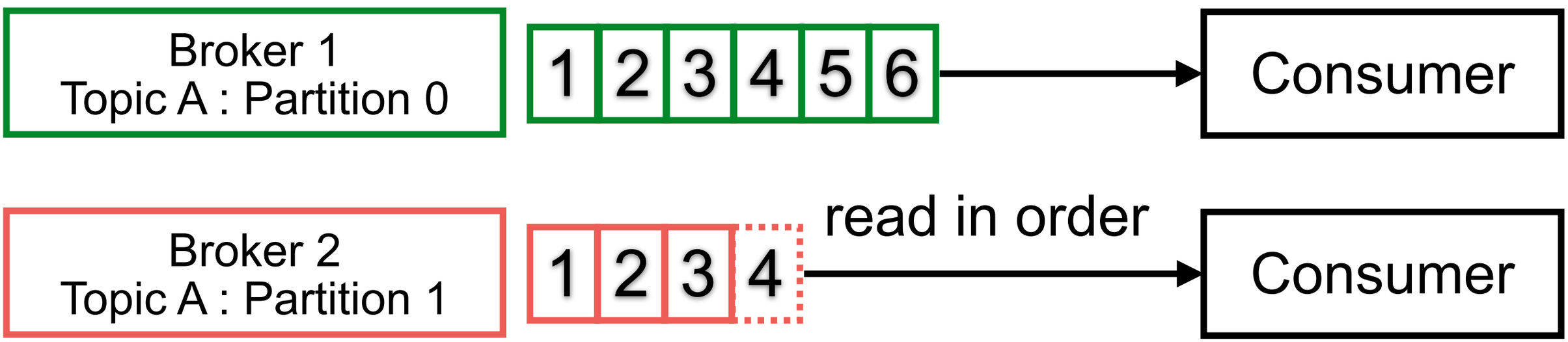
Consumers

Consumers read data from topic

Consumers know which broker to read from

Data will read in order **within each partition**

When broker failures, consumer know how to recover

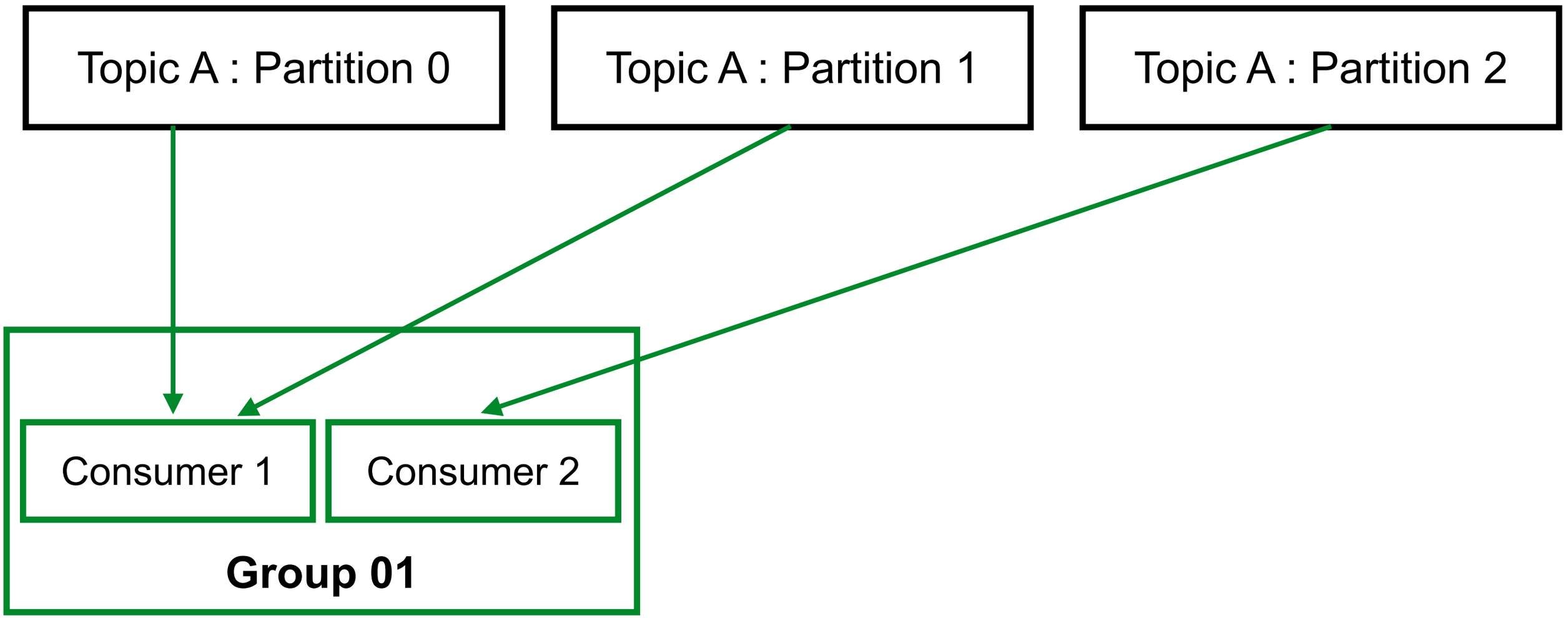


Consumer groups

Consumers read data in consumer groups

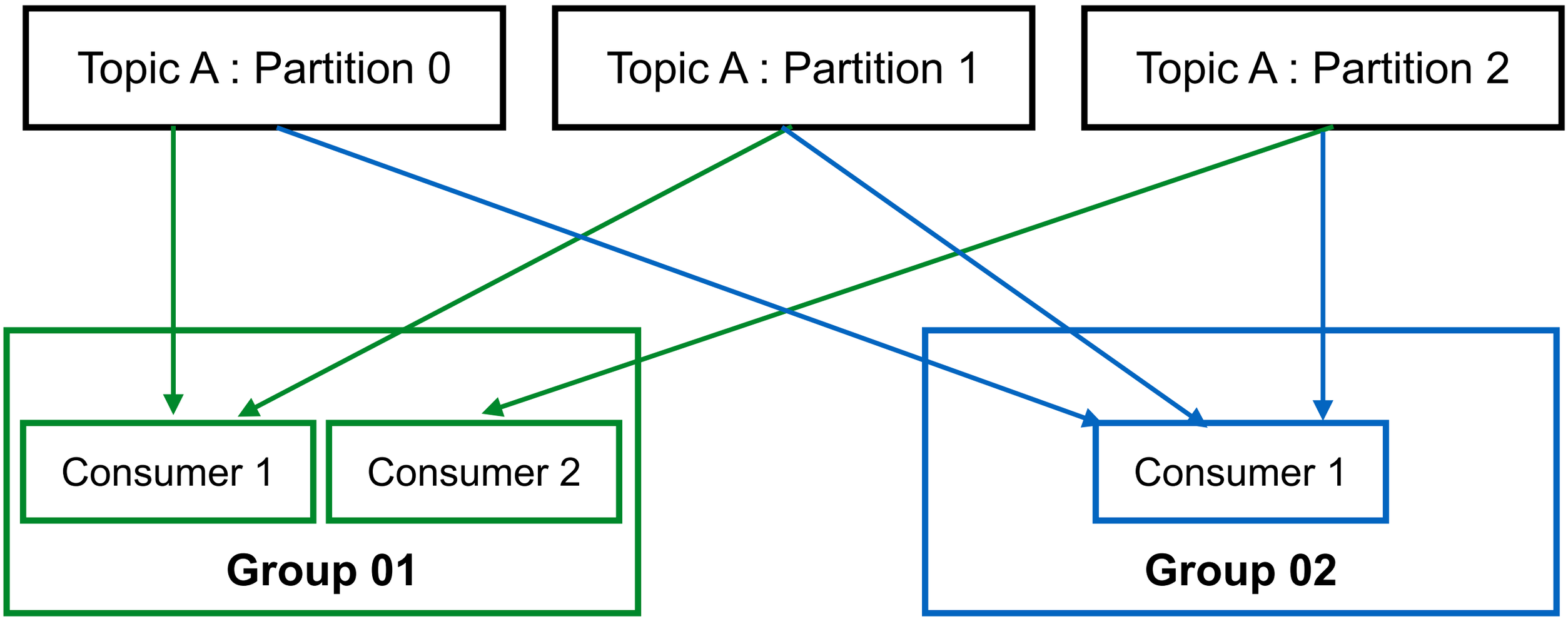
Each consumer in a group read from exclusive partitions

Consumer groups



Consumer will automatically use a GroupCoordinator and ConsumerCoordinator to assign a consumer to a partition.

Consumer groups



Partition assignment strategies

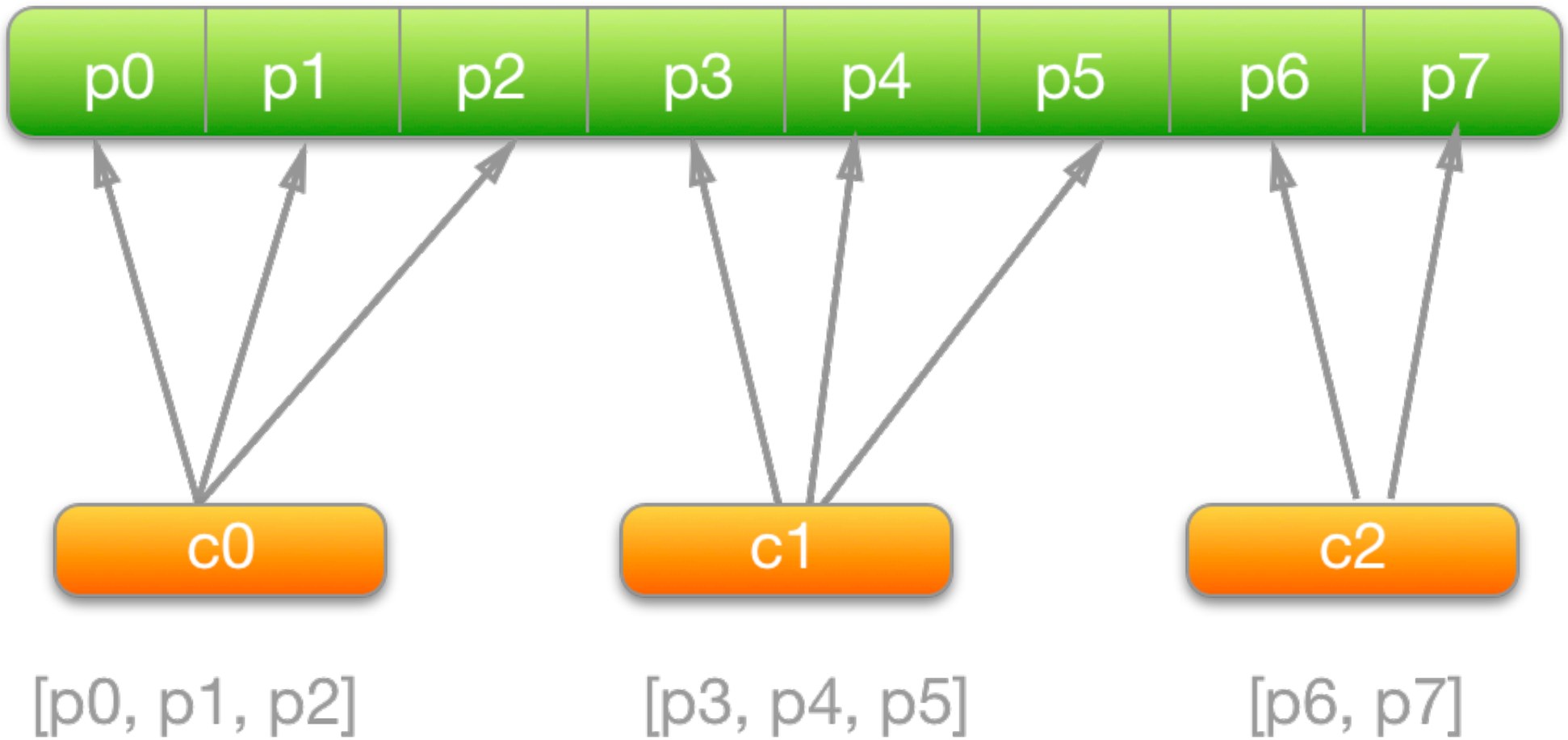
Range (default)

Round Robin

Sticky

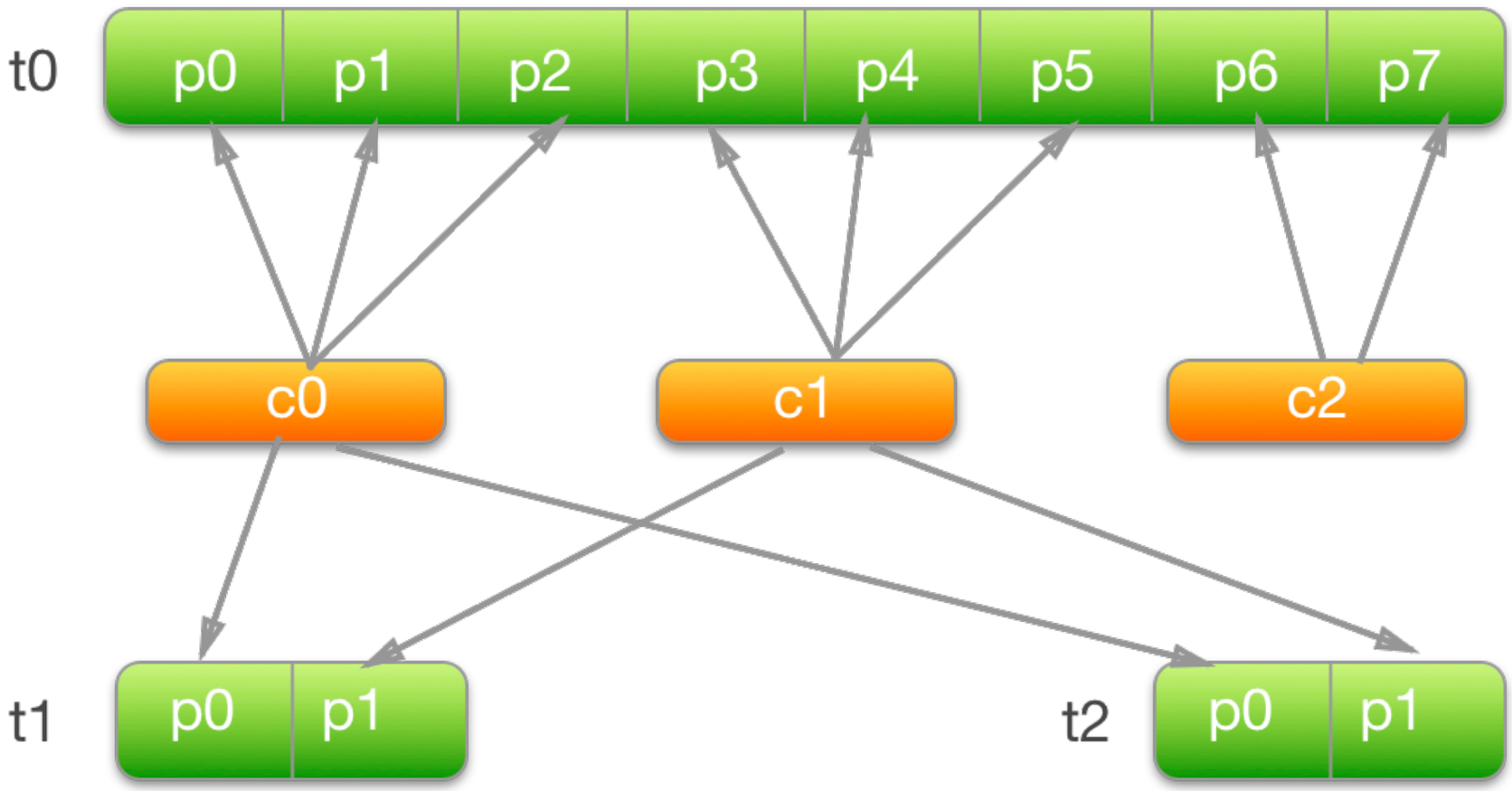
Customize (AbstractPartitionAssignor)

Range assignor



org.apache.kafka.clients.consumer.RangeAssignor

Range assignor

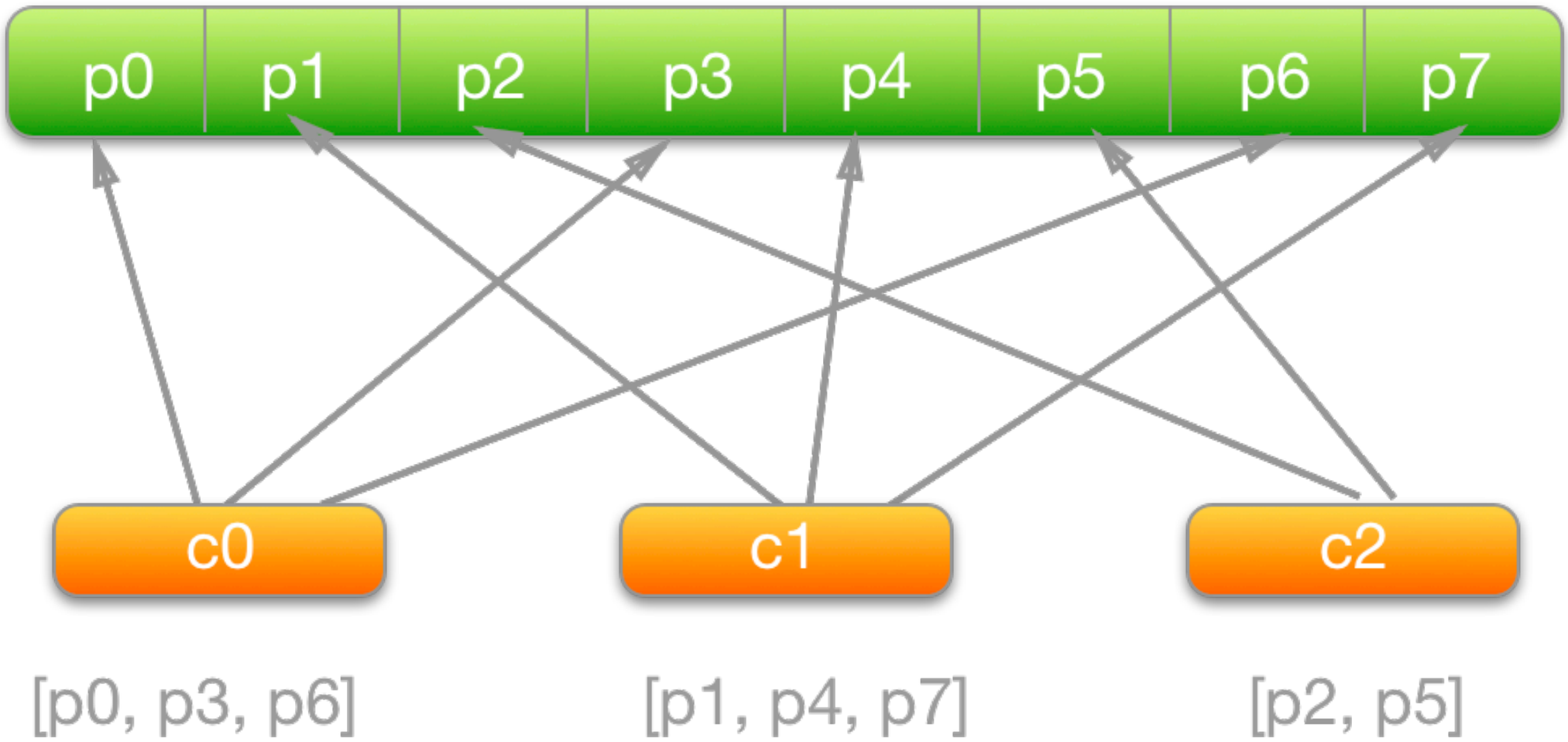


c0 -> [t0p0, t0p1, t0p2, t1p0, t2p0]

c1 -> [t0p3, t0p4, t0p5, t1p1, t2p1]

c2 -> [t0p6, t0p7]

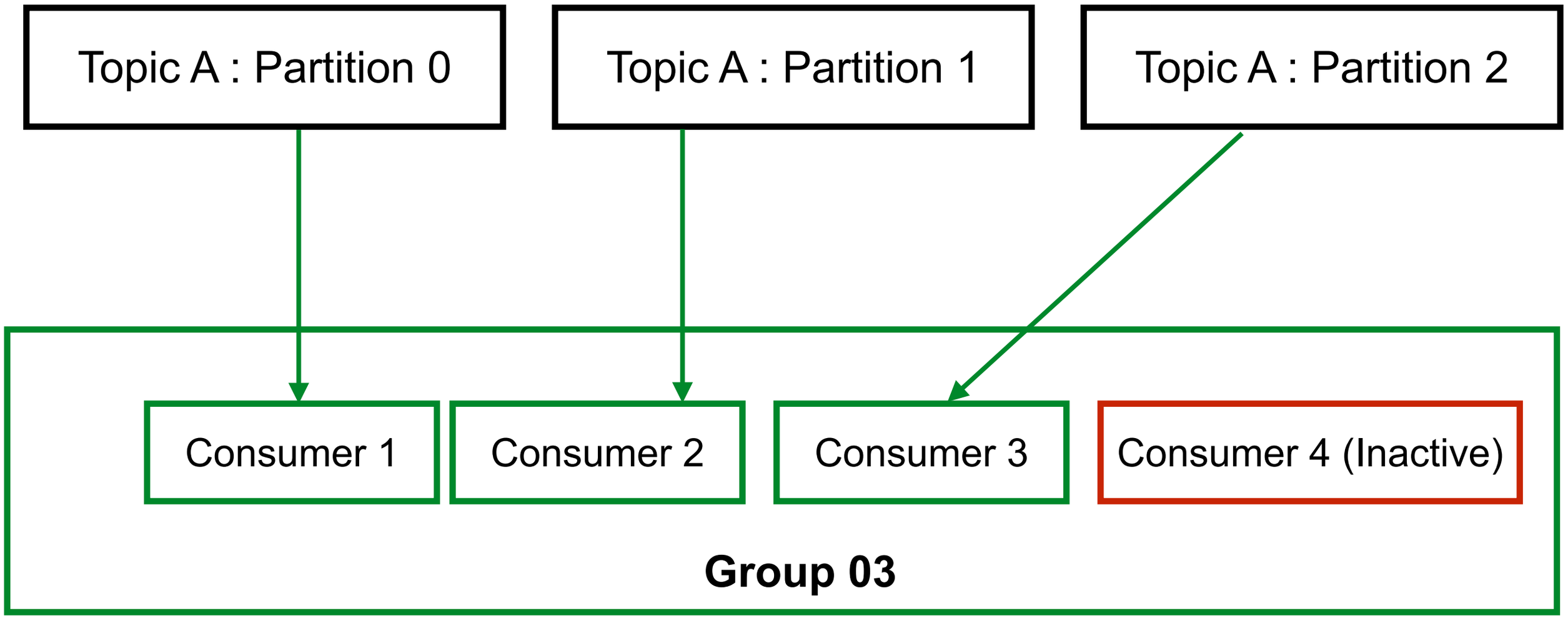
Round Robin assignor



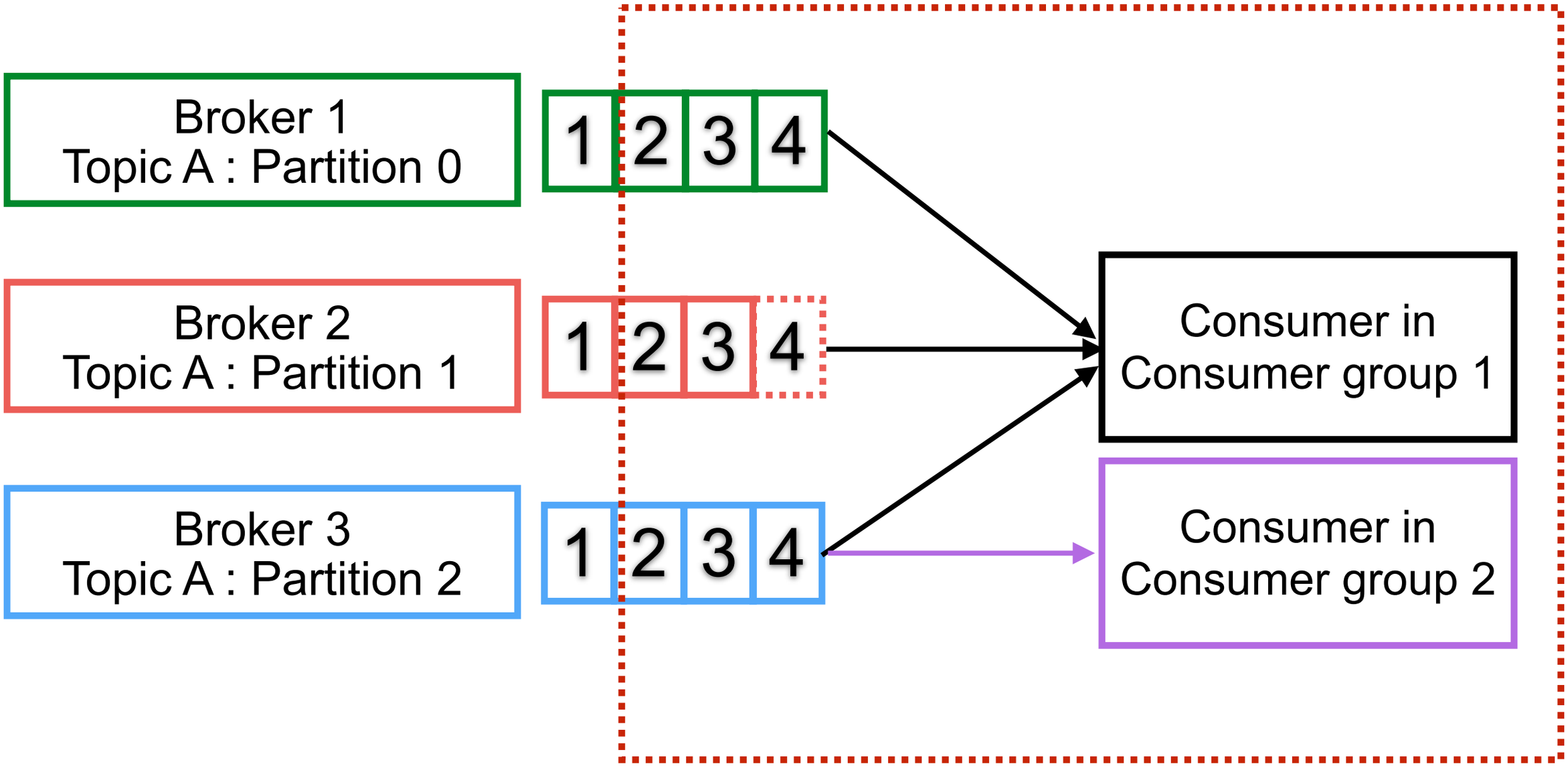
org.apache.kafka.clients.consumer.RoundRobinAssignor

Consumers > partitions ?

Some consumers will inactive



Consumers offsets



Consumers offsets

Kafka store the offset at which a consumer group has been reading

The offsets committed live in **topic** named "**__consumer_offsets**"

When consumer in a group has processed data received from Kafka,
it should be **committing the offsets**

When to commit the offset ?

Delivery semantics for consumer

At most once
At lease once (preferred)
Exactly once

1. At most once

Offsets are committed as soon as the message is received

If processing go wrong, the message will be **loss**!!

2. At lease once

Offsets are committed after the message is processed

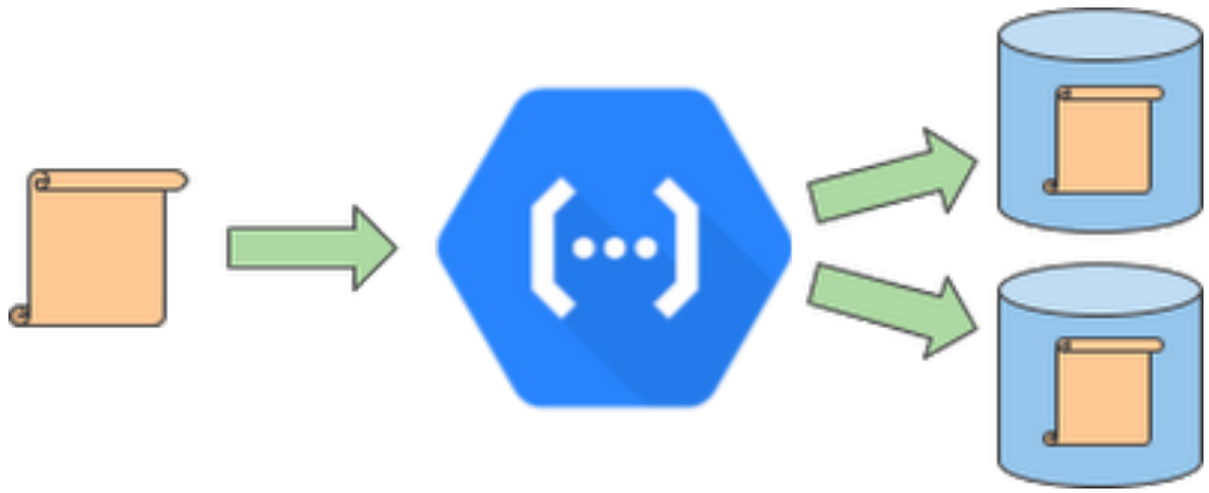
Messages are never lost but may be **redelivered**

If processing go wrong, the message will be **read again**

2. At lease once

Make sure your processing is **idempotent**

Processing again the message not impact to your system !!



3. Exactly once

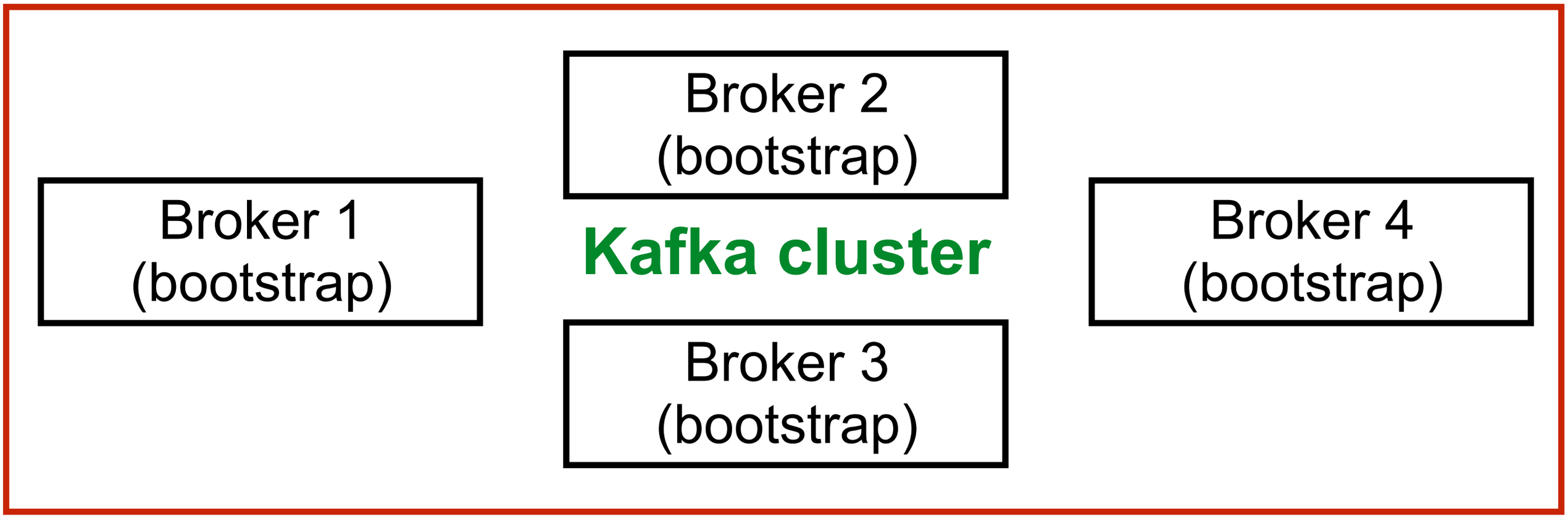
Each message is delivered once and only once

Can be achieved for Kafka (Workflow, Stream API)

Kafka broker discovery

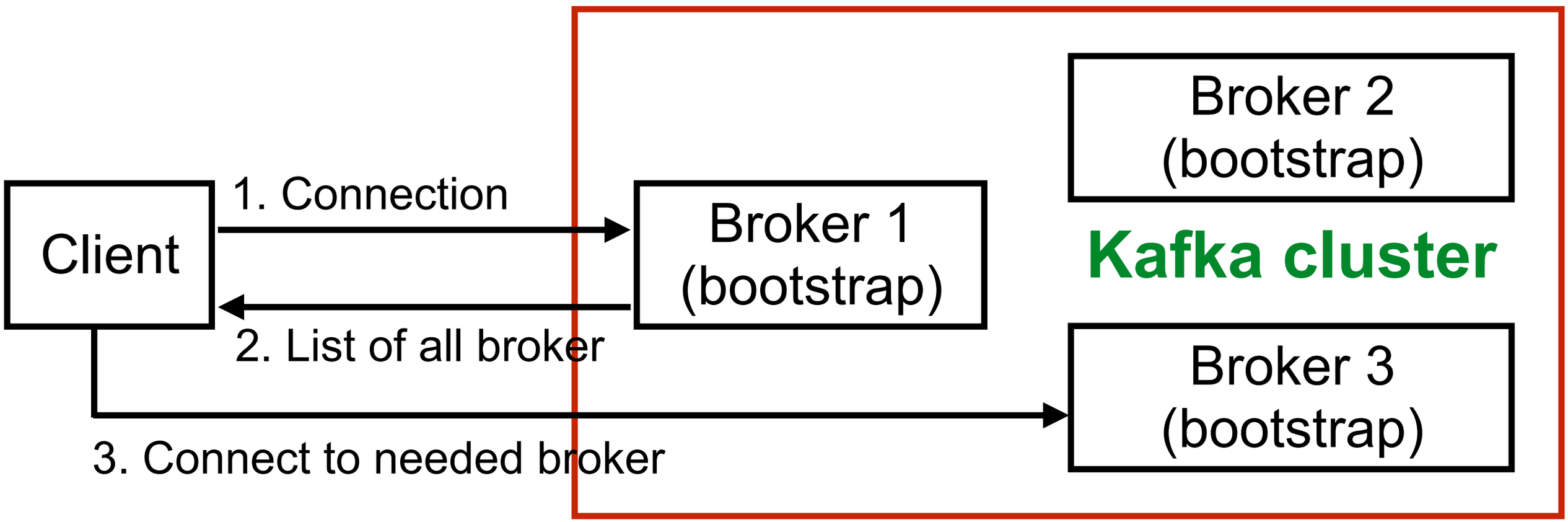
Every Kafka broker is called **“bootstrap server”**

You only need to connect to one broker, and you will connected to the entire cluster



Kafka broker discovery

Each broker knows about all brokers, topics and partitions (**metadata**)



Apache Zookeeper

Kafka can not work without Zookeeper !!

APACHE ZooKeeper™

https://zookeeper.apache.org/

Apache Zookeeper

Zookeeper **manages** brokers

Zookeeper help in performing **leading election** for partitions

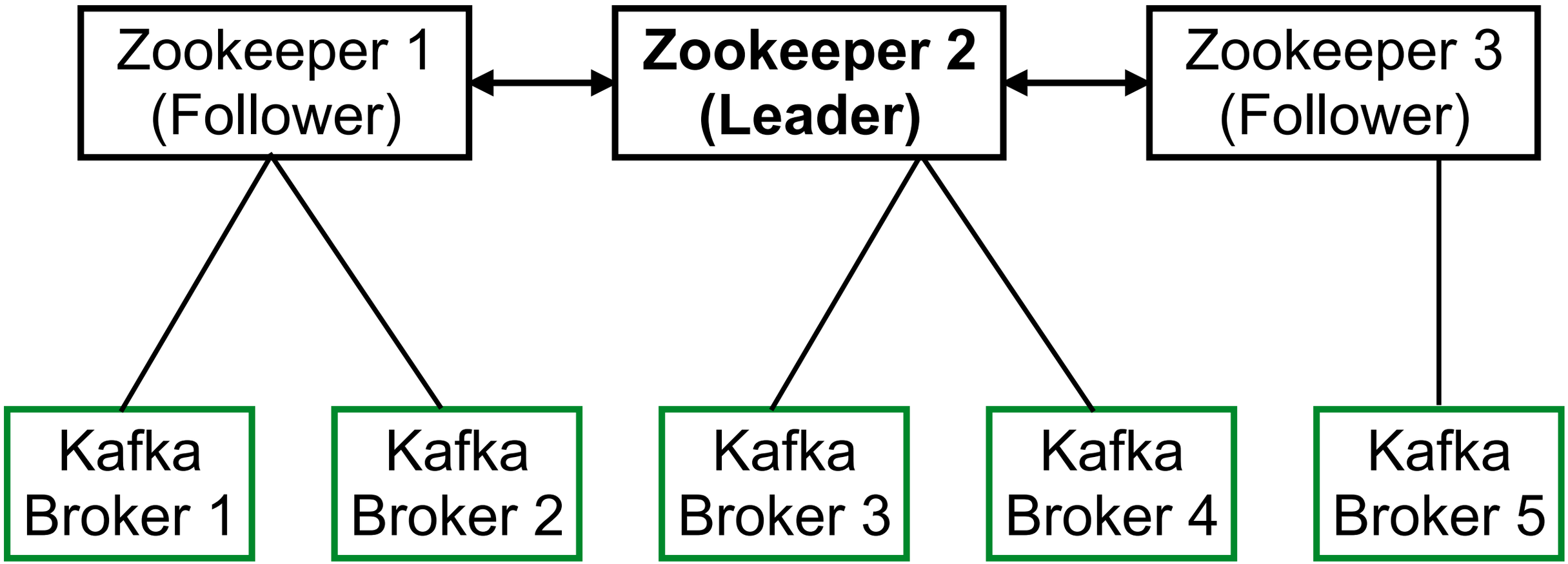
Zookeeper sends **notifications** to Kafka in case of changes (new topic, broker die)

Zookeeper by design operates with a odd number of servers (3, 5, 7)

Zookeeper architecture

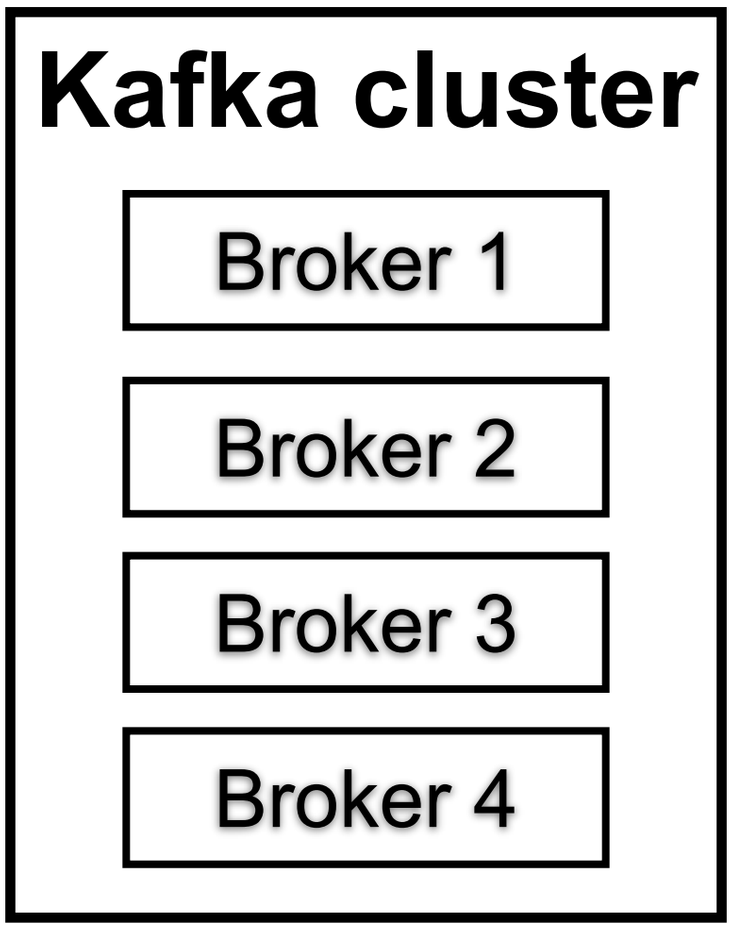
Leader for write
Follows for read

Zookeeper architecture



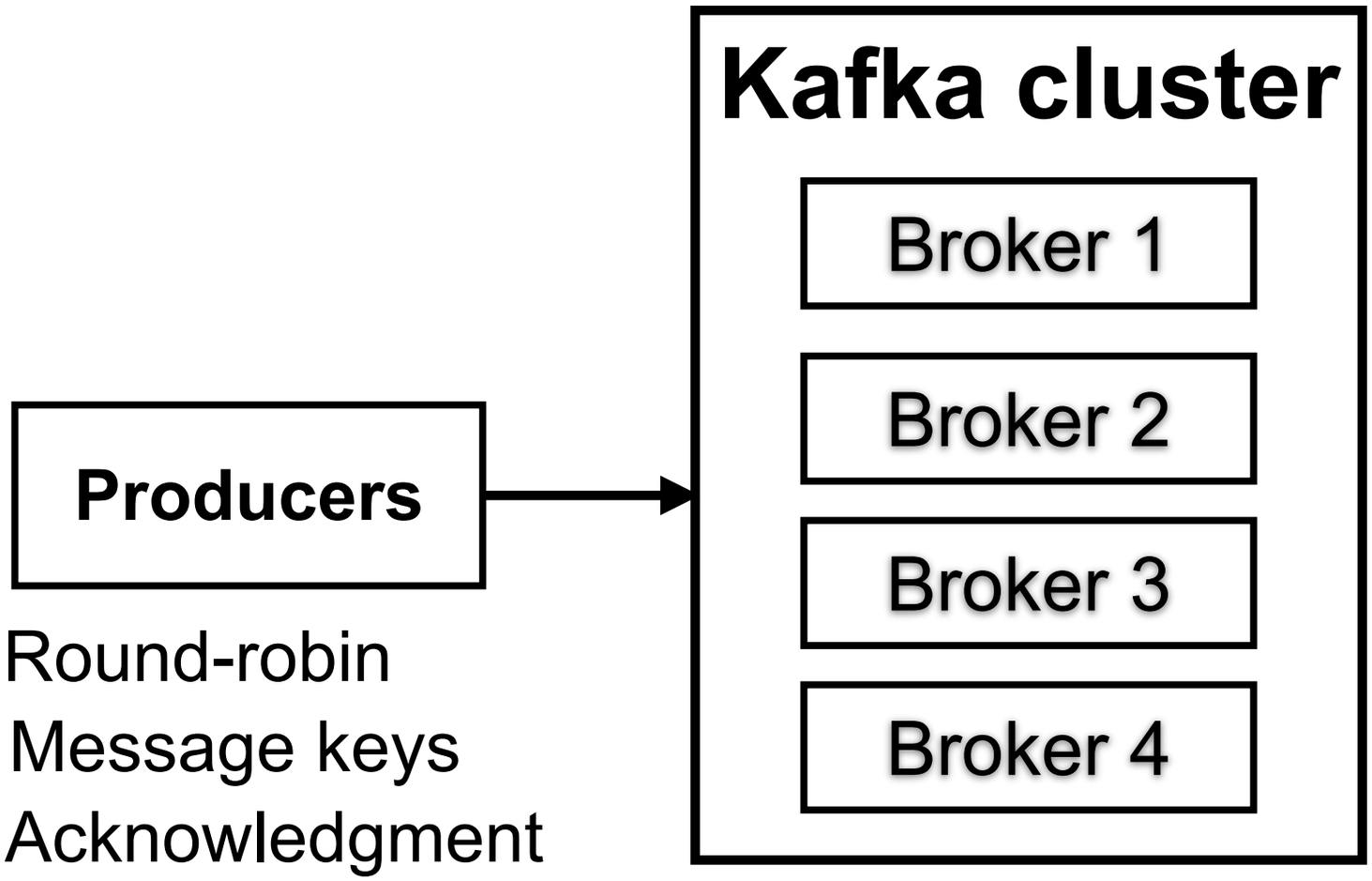
Summary of Kafka

Kafka concepts



1. Topics
2. Partition
3. Replication factor
4. Partition leader/ISR
5. Topic offset

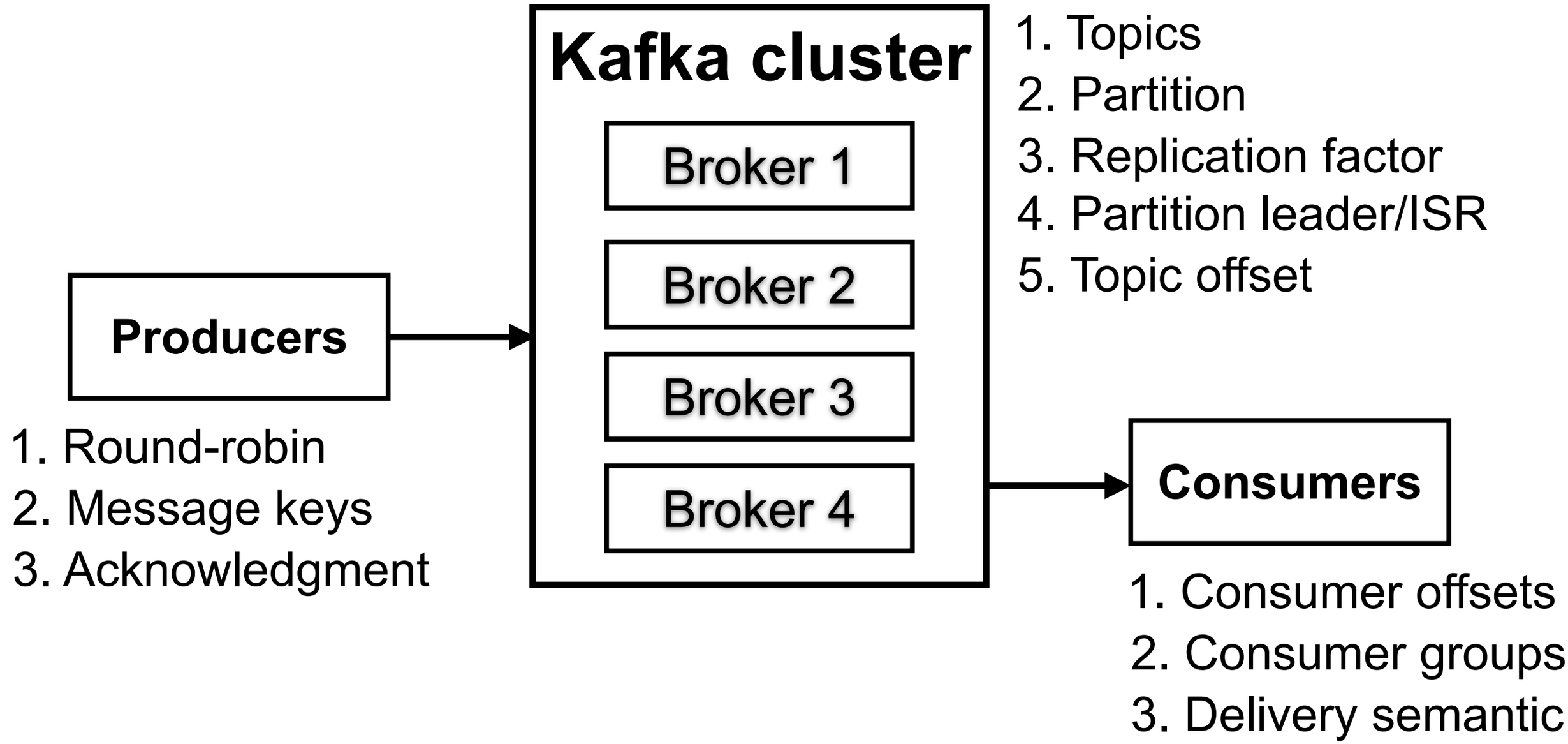
Kafka concepts



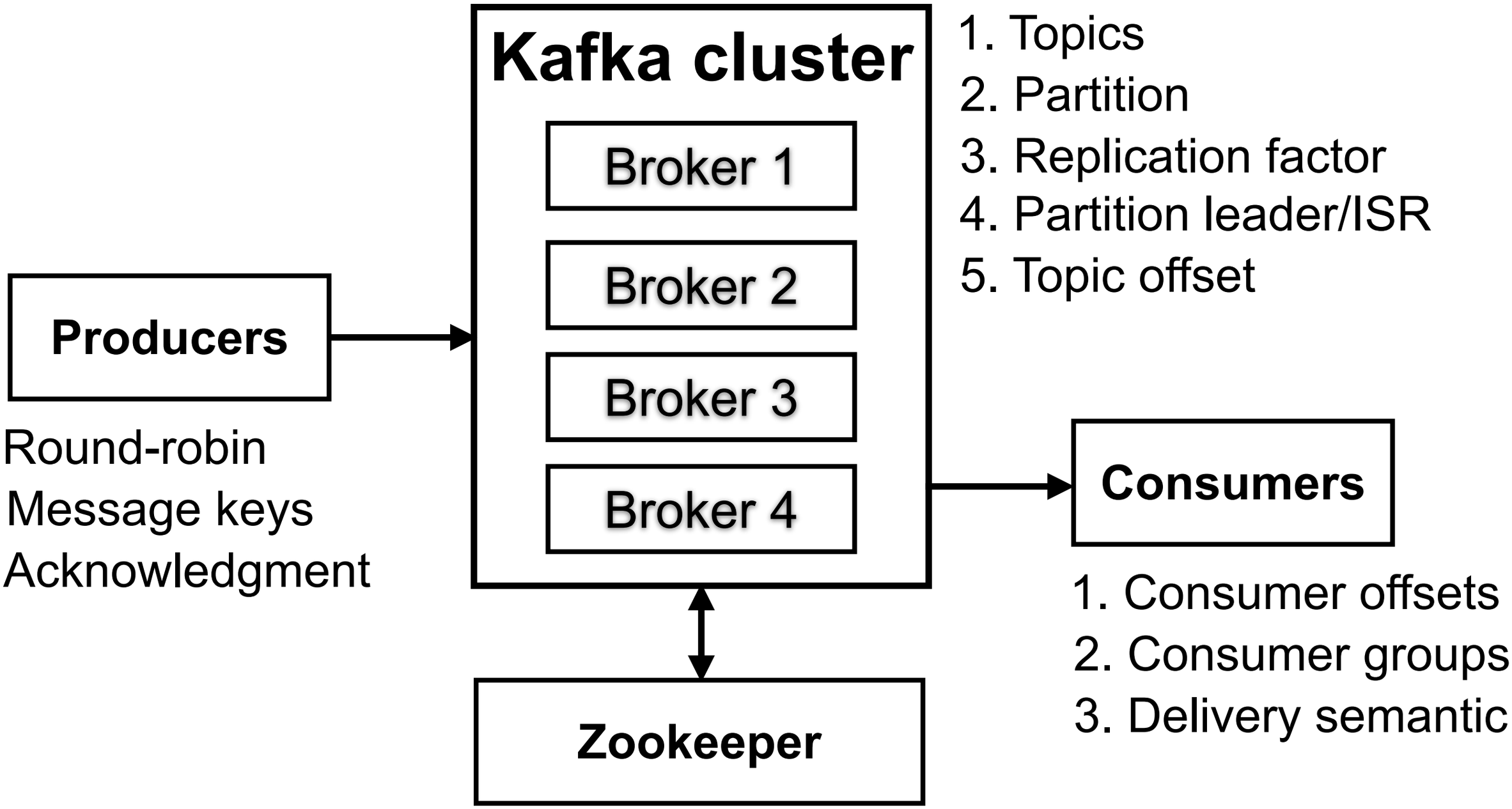
1. Topics
2. Partition
3. Replication factor
4. Partition leader/ISR
5. Topic offset

1. Round-robin
2. Message keys
3. Acknowledgment

Kafka concepts



Kafka concepts



1. Topics
2. Partition
3. Replication factor
4. Partition leader/ISR
5. Topic offset

1. Round-robin
2. Message keys
3. Acknowledgment

1. Consumer offsets
2. Consumer groups
3. Delivery semantic

Kafka workshop

Steps

Start Zookeeper
Start Kafka broker
Create topic
Produce message to topic
Consume message from topic

Kafka + Java

Workshop

Steps

Create project
Message for publish and read from Topic
Configuration
Create producer
Create consumer
Create REST controller

Create project

spring initializr

Project
- Maven Project
- Gradle Project

Language
- Java
- Kotlin
- Groovy

Spring Boot
- 3.0.0 (SNAPSHOT)
- 3.0.0 (M4)
- 2.7.3 (SNAPSHOT)
- 2.7.2
- 2.6.11 (SNAPSHOT)
- 2.6.10

Project Metadata

Group	com.example
Artifact	kafka
Name	kafka
Description	Demo project for Spring Boot
Package name	com.example.kafka
Packaging	Jar / War
Java	18 / 17 / 11 / 8

Dependencies ADD DEPENDENCIES... ⌘ + B

Spring for Apache Kafka MESSAGING
Publish, subscribe, store, and process streams of records.

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

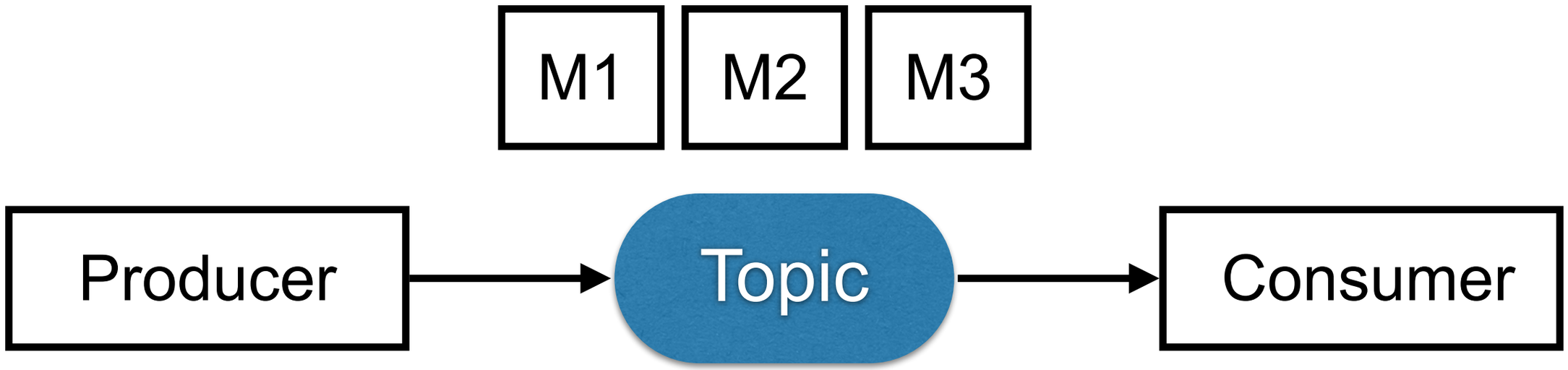
https://start.spring.io/

Spring for Apache Kafka

KafkaTemplate
KafkaMessageListnerContainer
@KafkaListener
KafkaTransactionManager
spring-kafka-test (embedded Kafka server)

https://spring.io/projects/spring-kafka

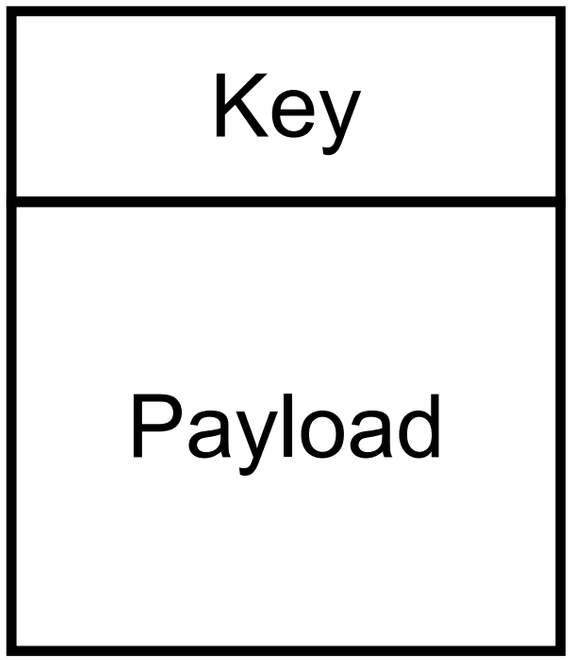
Message



Message format

Text

Binary



Working with JSON

```
{
    "id": 1,
    "name": "User 01",
    "age": 30
}
```

```
public class NewUser{

  private String name;
  private int id;
  private int age;

    ...

}
```

Configuration

Application.properties or YAML
Java configuration

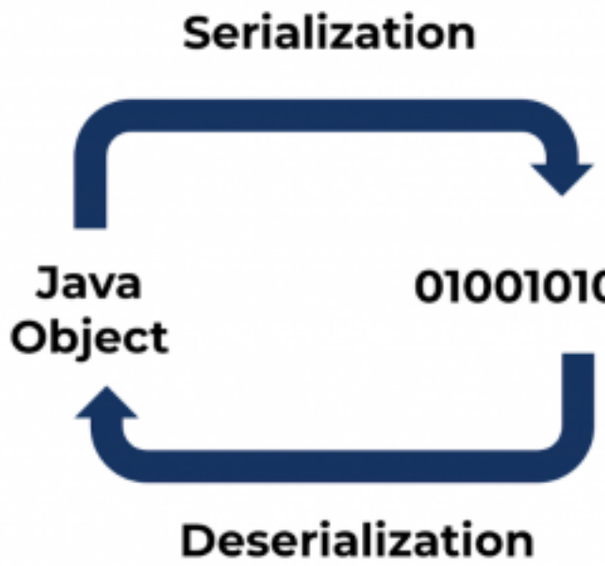
https://docs.spring.io/spring-kafka/docs/current/reference/html/

Application.yml

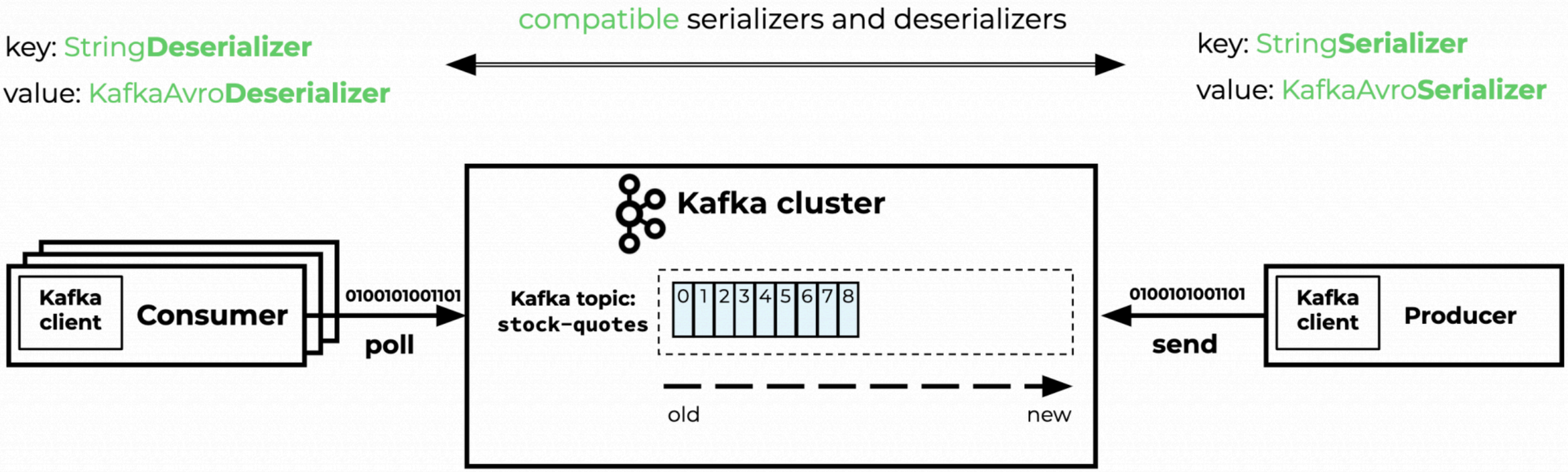
```yaml
spring:
  kafka:
    consumer:
      bootstrap-servers: localhost:9092
      auto-offset-reset: earliest
      key-deserializer: org.apache.kafka.common.serialization.StringDeserializer
      value-deserializer: org.apache.kafka.common.serialization.StringDeserializer
    producer:
      bootstrap-servers: localhost:9092
      key-serializer: org.apache.kafka.common.serialization.StringSerializer
      value-serializer: org.apache.kafka.common.serialization.StringSerializer
```

https://kafka.apache.org/documentation/#configuration

Serialization and Deserialization

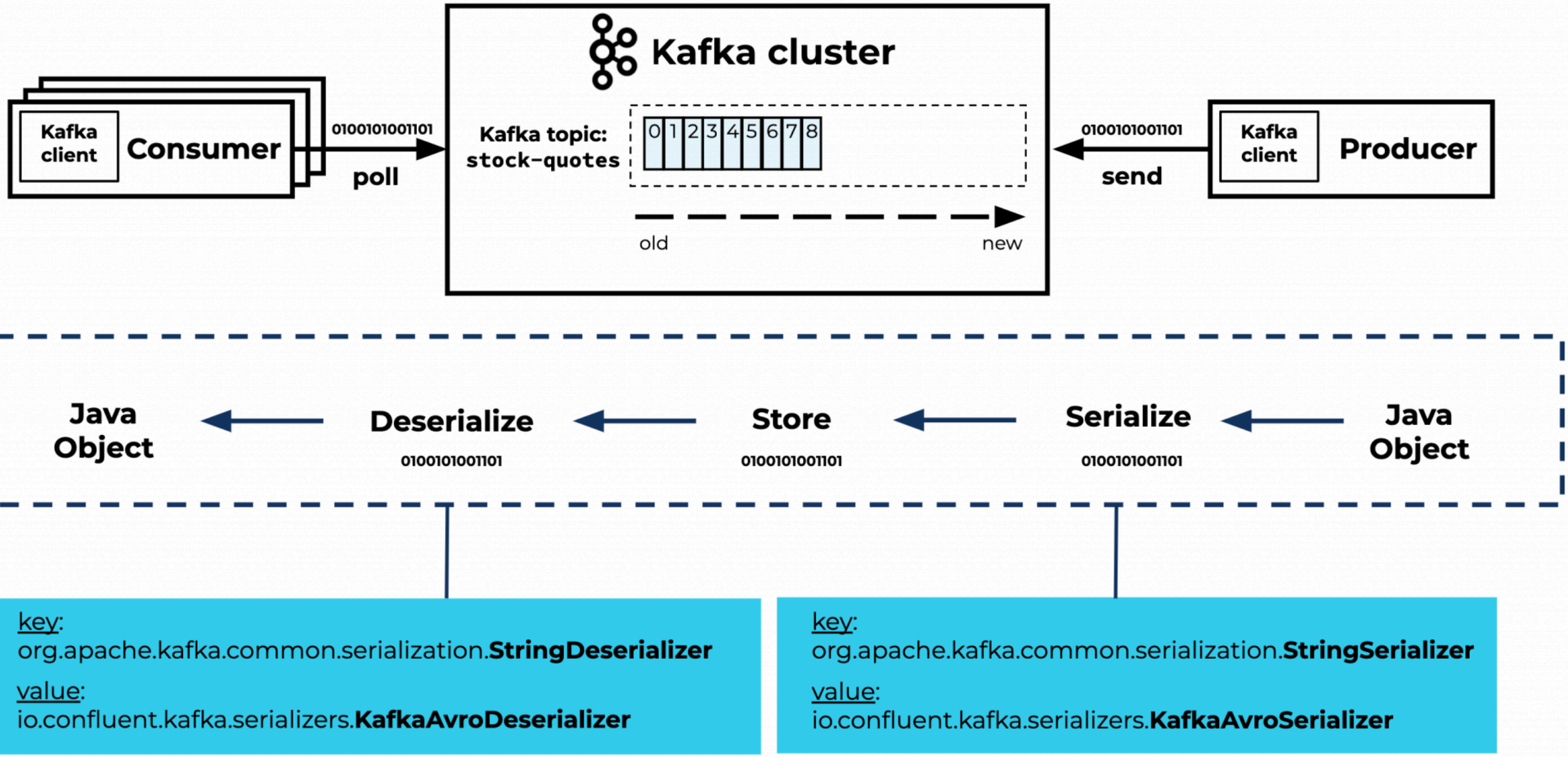


Serialization and Deserialization



https://www.confluent.io/blog/spring-kafka-can-your-kafka-consumers-handle-a-poison-pill/

Serialization and Deserialization



https://www.confluent.io/blog/spring-kafka-can-your-kafka-consumers-handle-a-poison-pill/

Problem !!

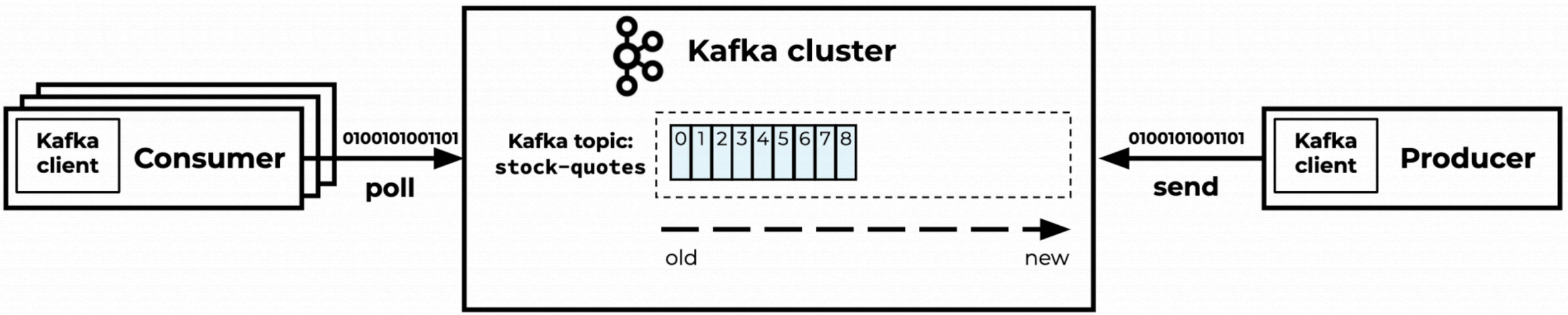
key: String**Deserializer**

value: String**Deserializer**

incompatible serializers and deserializers

key: String**Serializer**

value: KafkaAvro**Serializer**



Auto-offset-reset

earliest

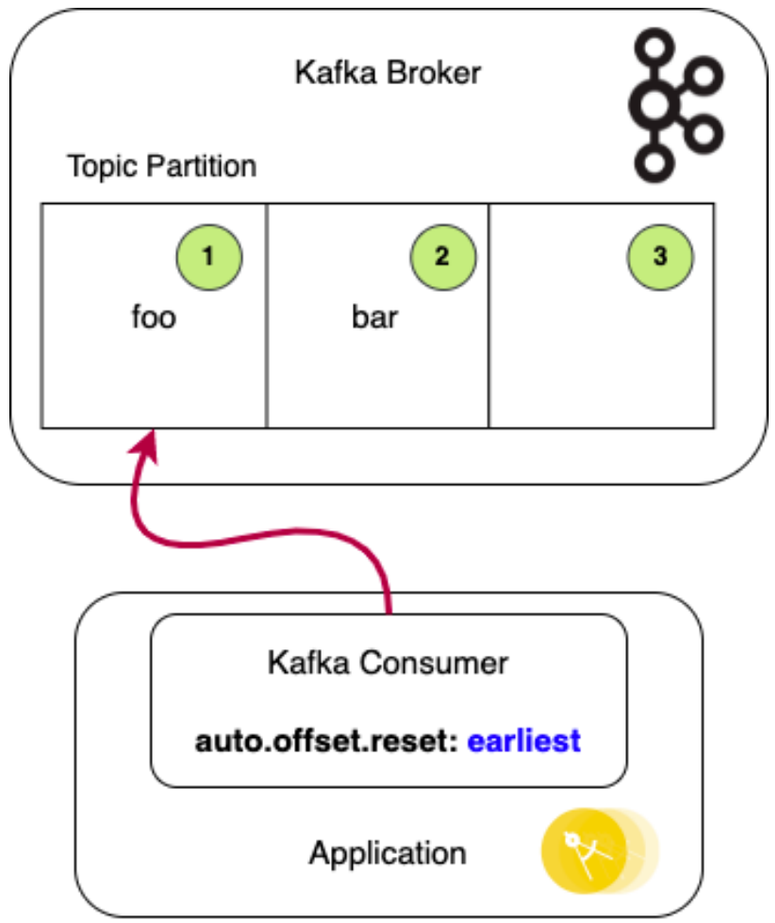
latest (default)

none

https://kafka.apache.org/documentation/#consumerconfigs_auto.offset.reset

Earliest

Consume from the beginning of topic partition



Earliest

of messages are depend on **retention.ms**

retention.ms

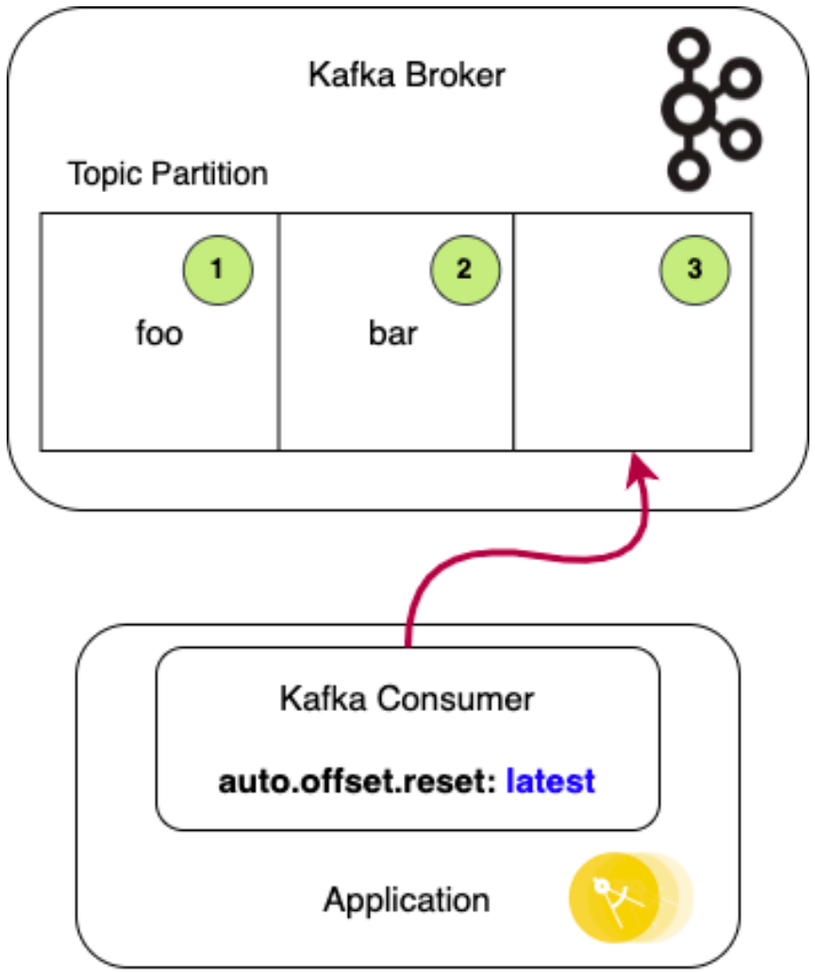
This configuration controls the maximum time we will retain a log before we will discard old log segments to free up space if we are using the "delete" retention policy. This represents an SLA on how soon consumers must read their data. If set to -1, no time limit is applied.

Type:	long
Default:	604800000 (7 days)
Valid Values:	[-1,...]
Server Default Property:	log.retention.ms
Importance:	medium

https://kafka.apache.org/documentation/#topicconfigs_retention.ms

Latest

Consume from the end of topic partition



None

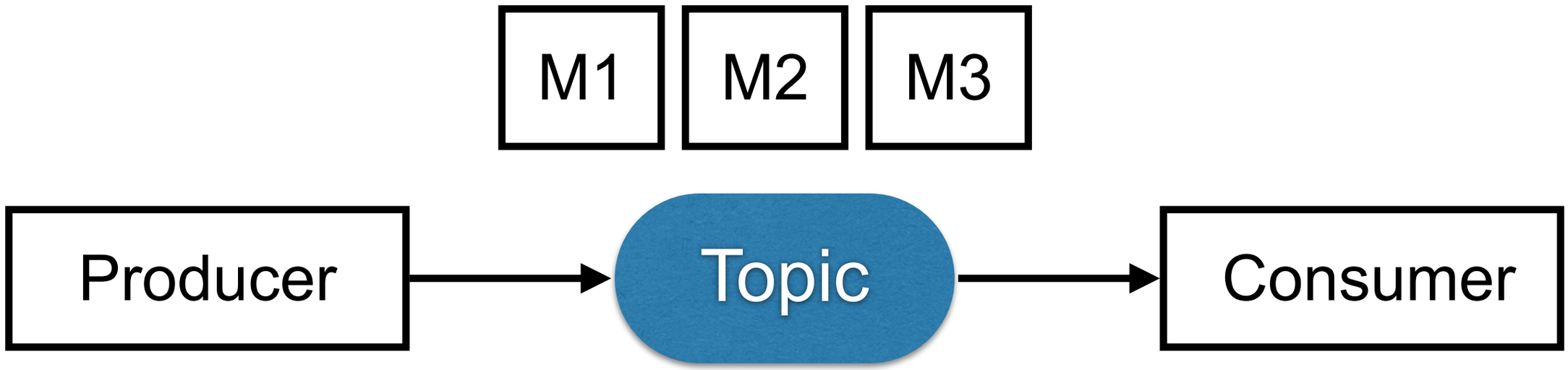
Throw an exception if no offset present for the consumer group

Create producer

Create a message
Send to topic in Kafka server

https://kafka.apache.org/documentation/#producerconfigs

Create producer



Working with KafkaTemplate

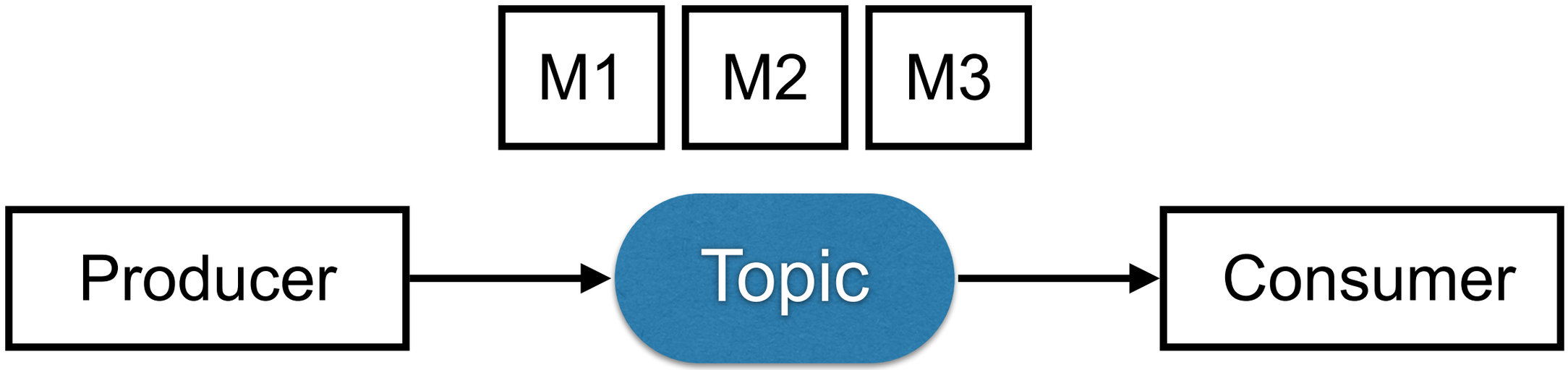
```
@Service
public class DemoProducer {
    @Autowired
    private KafkaTemplate<String, String> kafkaTemplate;

    public void sendMessage(String message) {
        this.kafkaTemplate.send("demo.topic", message);
    }
}
```

Create consumer

Read message from topic

https://kafka.apache.org/documentation/#consumerconfigs

Create consumer

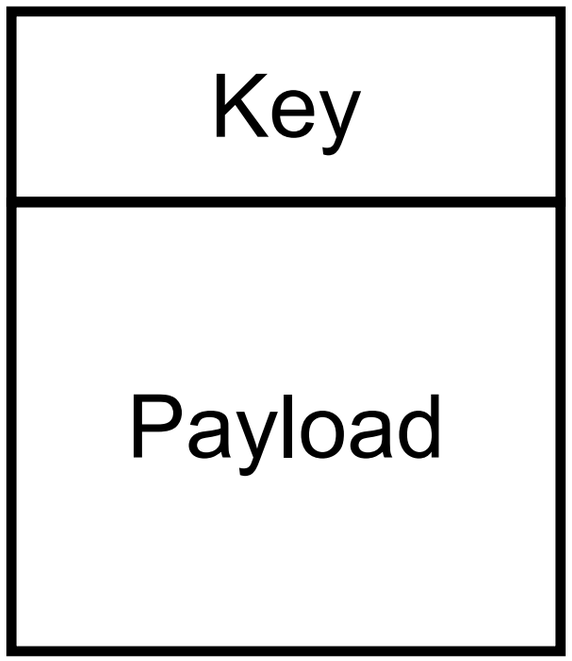


Working with KafkaListener

```
@Service
public class DemoConsumer {

    @KafkaListener(topics="demo.topic")
    public void receiveData(String message) {
        System.out.println("Receive data => " + message);
    }

}
```

Working with Message format

Message format

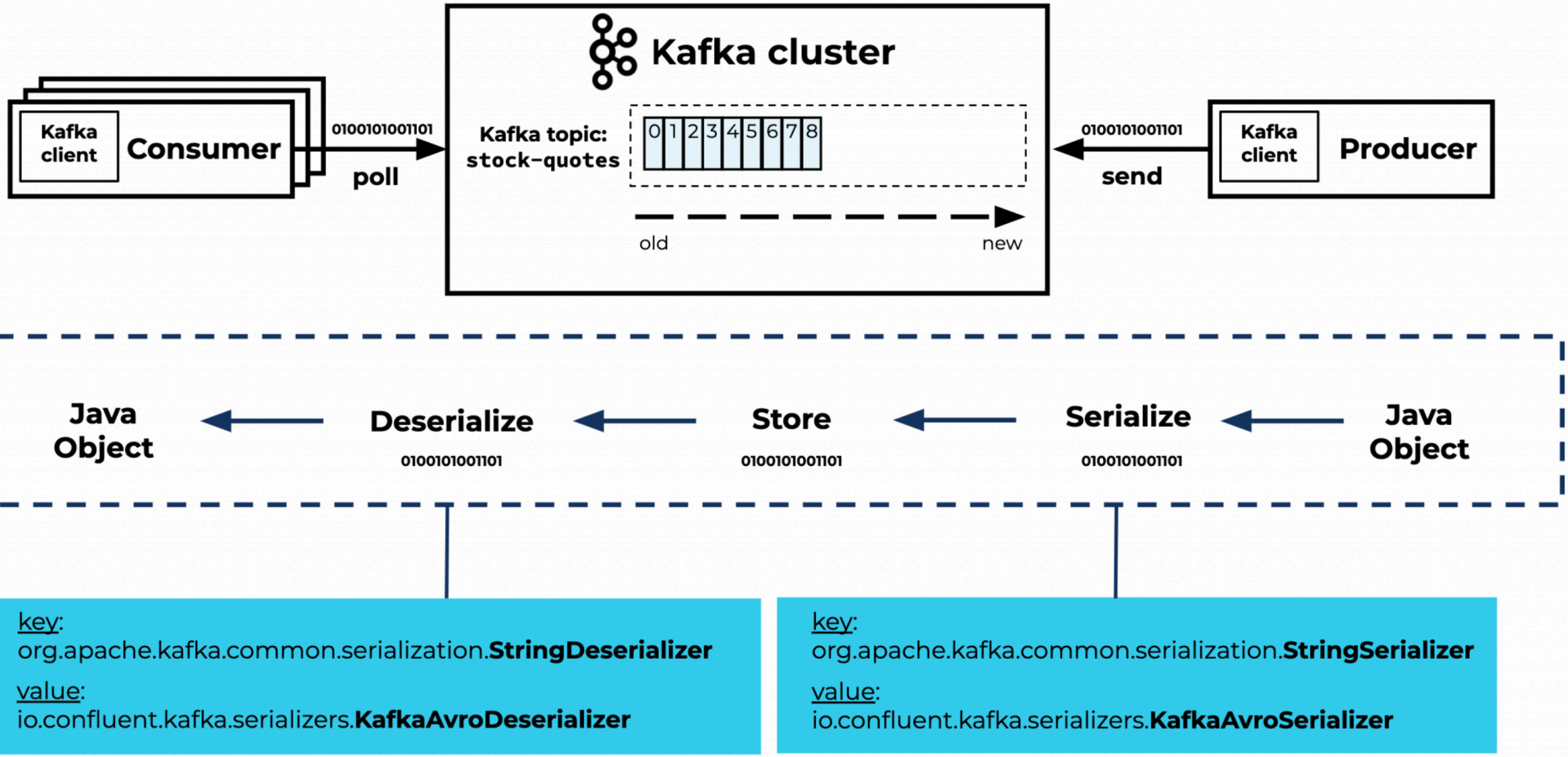


Use ProducerRecord

```
public SendResult<String, String> send(String key, String message) {

    // Create message with key and payload
    ProducerRecord<String, String> record
            = new ProducerRecord<>("topic", key, message);

    // Send message
    try {
        SendResult<String, String> result = template.send(record).get();
        return result;
    } catch (Exception e) {
        throw new RuntimeException(e);
    }
}
```

Serialization and Deserialization

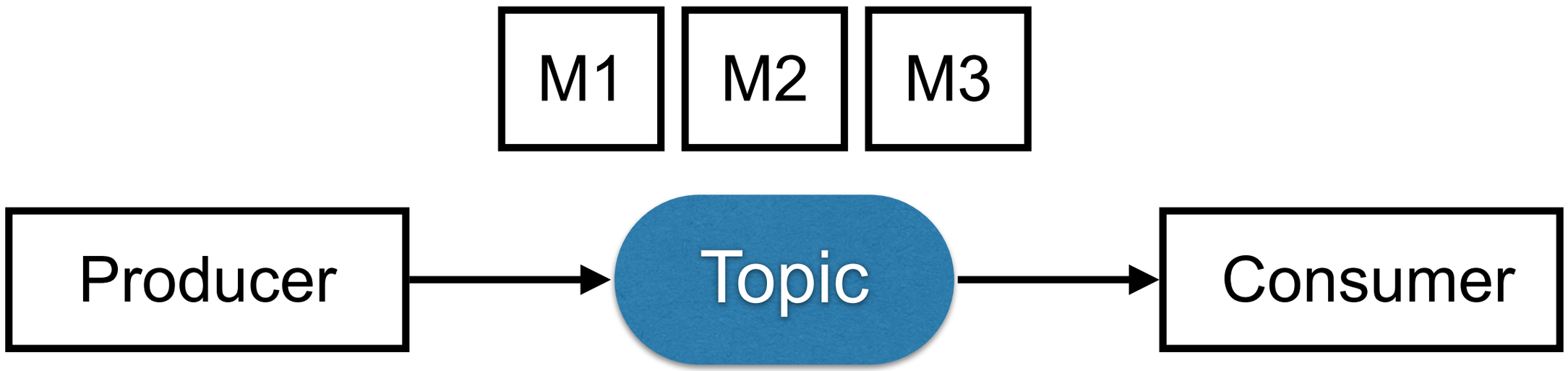
Serialization and Deserialization



https://www.confluent.io/blog/spring-kafka-can-your-kafka-consumers-handle-a-poison-pill/

JSON

Use JSON format in value



JsonSerializer

JsonDeserializer
Trusted package

JSON

Configuration in Spring project

```yaml
kafka:
  consumer:
    bootstrap-servers: localhost:9092
    group-id: ${spring.application.name}-group
    auto-offset-reset: latest   #earliest|latest|none
    value-deserializer: org.springframework.kafka.support.serializer.JsonDeserializer
    properties:
      spring:
        json:
          trusted:
            packages: com.example.kafka.models
  producer:
    bootstrap-servers: localhost:9092
    value-serializer: org.springframework.kafka.support.serializer.JsonSerializer
```

JSON

Configuration in Spring project

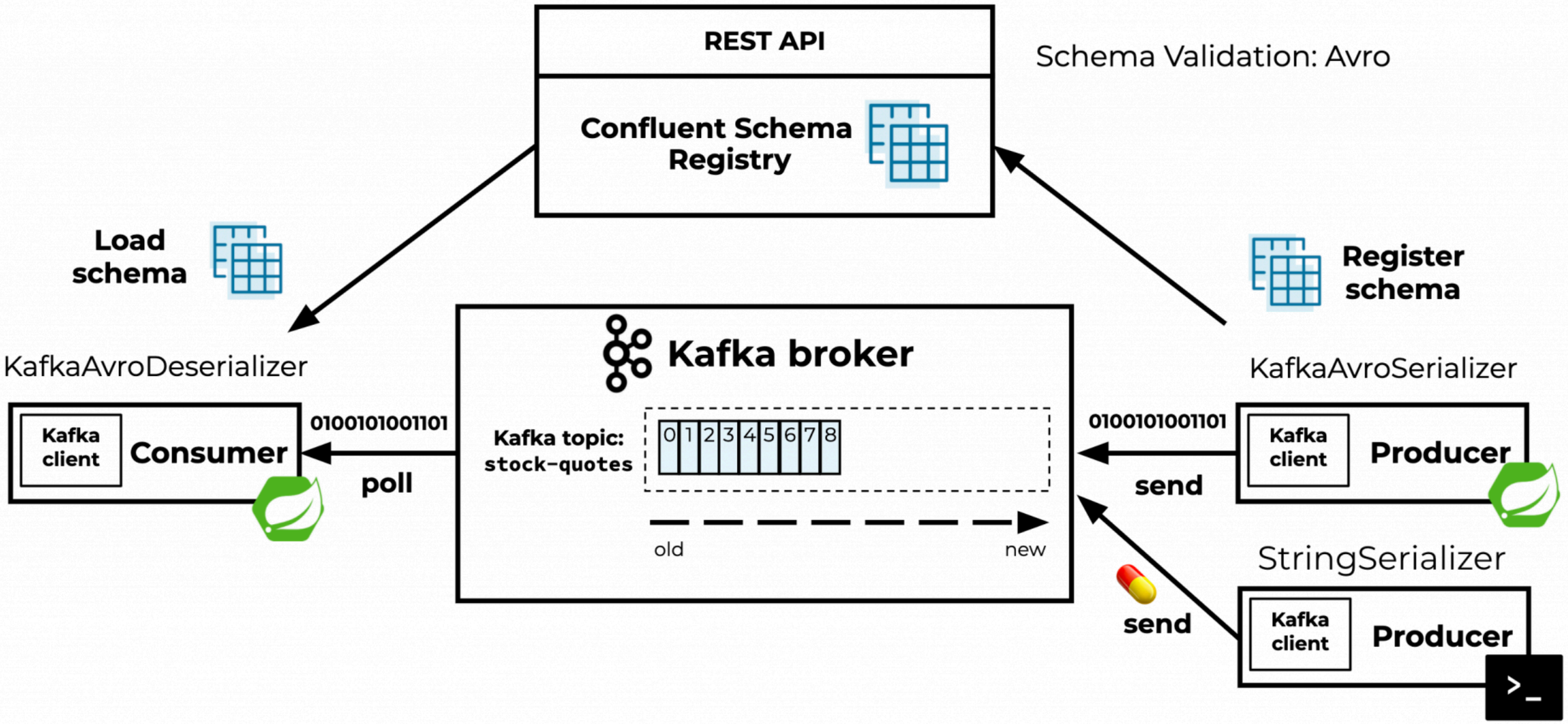
```yaml
kafka:
  consumer:
    bootstrap-servers: localhost:9092
    group-id: ${spring.application.name}-group
    auto-offset-reset: latest   #earliest|latest|none
    value-deserializer: org.springframework.kafka.support.serializer.JsonDeserializer
    properties:
      spring:
        json:
          trusted:
            packages: com.example.kafka.models
  producer:
    bootstrap-servers: localhost:9092
    value-serializer: org.springframework.kafka.support.serializer.JsonSerializer
```

Apache Avro

https://avro.apache.org/

Working Schema Registry

Schema validation with Apache Avro



https://github.com/confluentinc/schema-registry

Apache Avro with Kafka

Add dependency and repository

```
<dependency>
    <groupId>io.confluent</groupId>
    <artifactId>kafka-avro-serializer</artifactId>
    <version>5.5.0</version>
</dependency>
```

Apache Avro with Kafka

Add dependency and repository

```
<repositories>
    <!-- Confluent maven repo, required to Confluent Kafka Avro Dependencies -->
    <repository>
        <id>confluent</id>
        <url>https://packages.confluent.io/maven/</url>
    </repository>
</repositories>
```

Generate class from Avro

```
<plugin>
   <groupId>org.apache.avro</groupId>
   <artifactId>avro-maven-plugin</artifactId>
   <version>1.8.2</version>
   <executions>
      <execution>
         <id>schemas</id>
         <phase>generate-sources</phase>
         <goals>
            <goal>schema</goal>
            <goal>protocol</goal>
            <goal>idl-protocol</goal>
         </goals>
         <configuration>
            <sourceDirectory>${project.basedir}/src/main/resources/avro/</
sourceDirectory>
            <outputDirectory>${project.basedir}/src/main/java/</outputDirectory>
         </configuration>
      </execution>
   </executions>
</plugin>
```

Producer

Value serializer

```yaml
kafka:
  bootstrap-servers: localhost:9092
  producer:
    key-serializer: org.apache.kafka.common.serialization.StringSerializer
    value-serializer: io.confluent.kafka.serializers.KafkaAvroSerializer
    client-id: ${spring.application.name}
    properties:
      enable.idempotence: true
      schema.registry.url: http://localhost:8081
```

Producer

Connect to schema registry

```yaml
kafka:
  bootstrap-servers: localhost:9092
  producer:
    key-serializer: org.apache.kafka.common.serialization.StringSerializer
    value-serializer: io.confluent.kafka.serializers.KafkaAvroSerializer
    client-id: ${spring.application.name}
    properties:
      enable.idempotence: true
      schema.registry.url: http://localhost:8081
```

Consumer

Value deserializer

```yaml
consumer:
  key-deserializer: org.apache.kafka.common.serialization.StringDeserializer
  value-deserializer: io.confluent.kafka.serializers.KafkaAvroDeserializer
  client-id: ${spring.application.name}
  group-id: ${spring.application.name}-group
  auto-offset-reset: earliest
  properties:
    schema.registry.url: http://localhost:8081
    specific.avro.reader: true
```

Consumer

Connect to schema registry

```
consumer:
  key-deserializer: org.apache.kafka.common.serialization.StringDeserializer
  value-deserializer: io.confluent.kafka.serializers.KafkaAvroDeserializer
  client-id: ${spring.application.name}
  group-id: ${spring.application.name}-group
  auto-offset-reset: earliest
  properties:
    schema.registry.url: http://localhost:8081
    specific.avro.reader: true
```

Testing

Testing

Unit test

Integration test

Component test

End-to-end test