Lesson 12

STREAM BASED ARCHITECTURE

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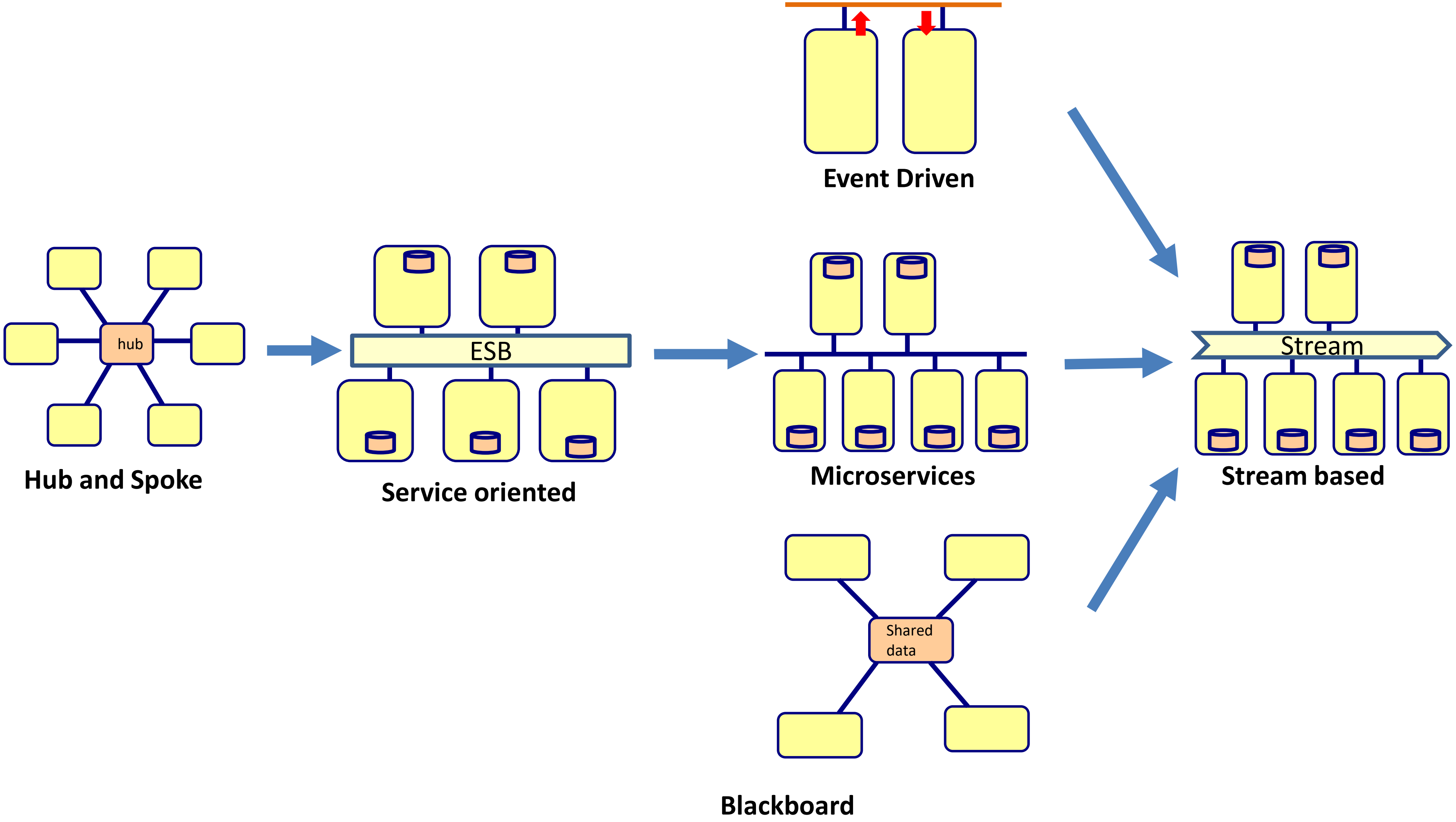
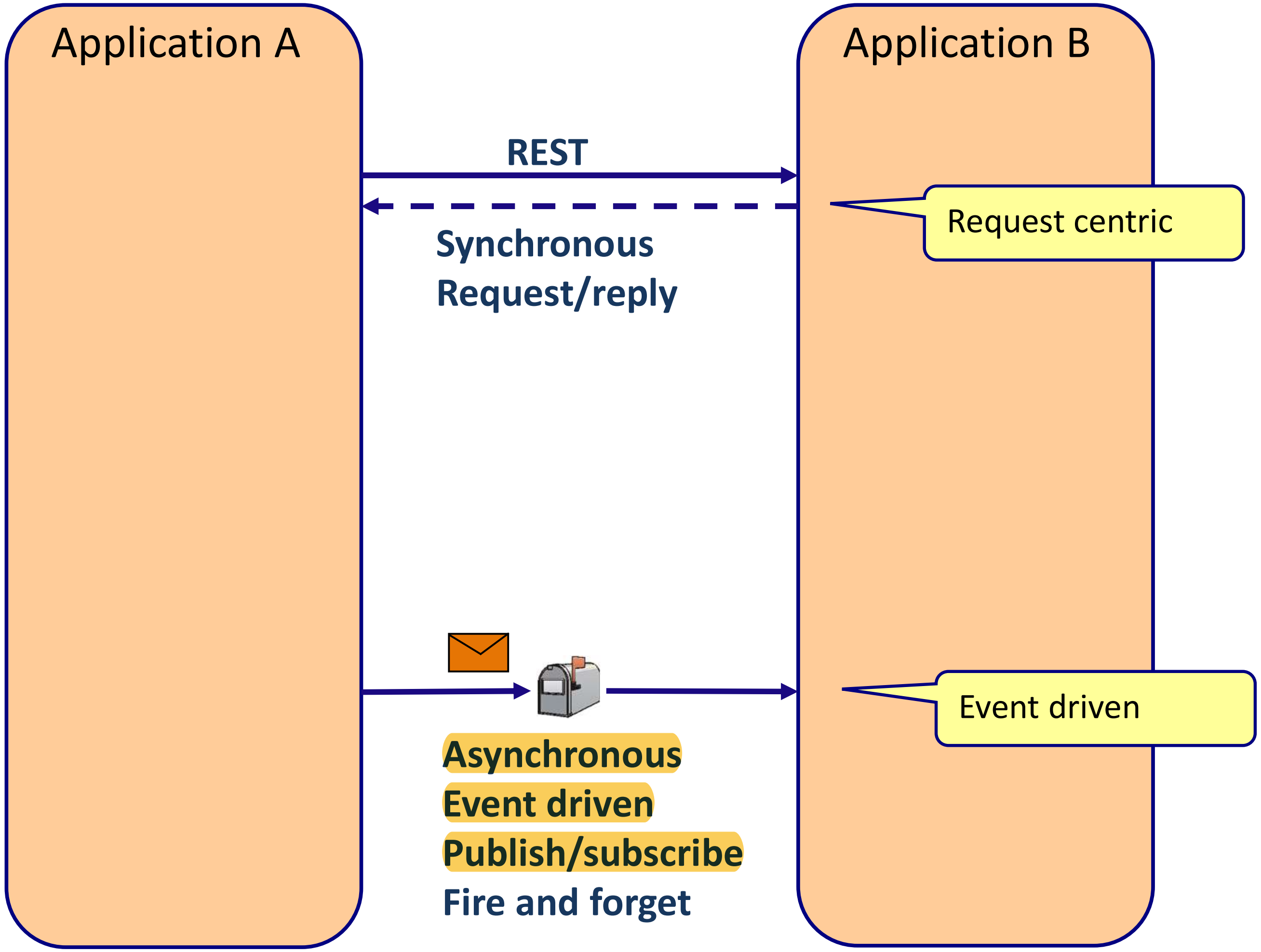
Architecture evolution



EVENT DRIVEN ARCHITECTURE

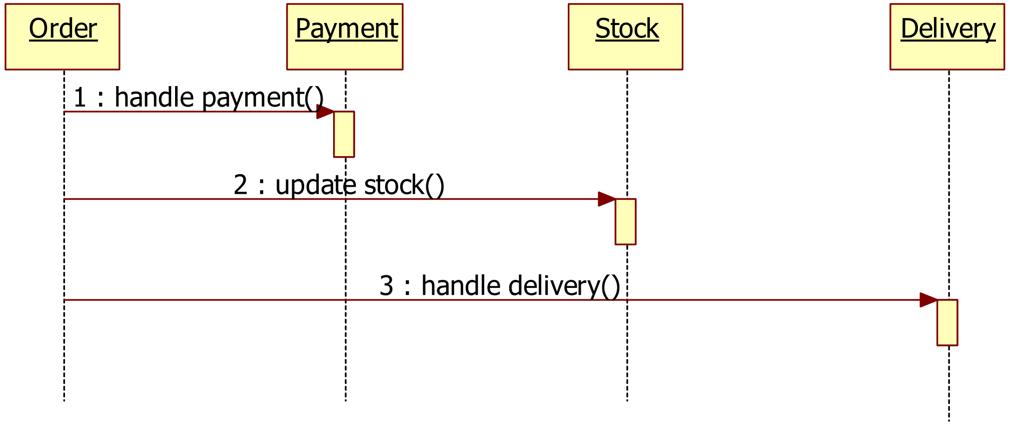
2 ways to communicate



Request centric (REST) calls

Tight coupling

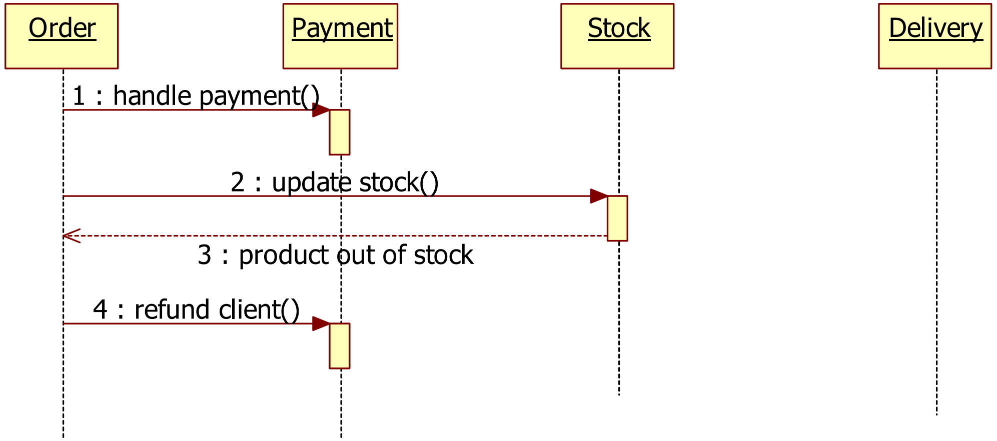
Orchestration



What if a service is not available?

What if a service changes its interface?

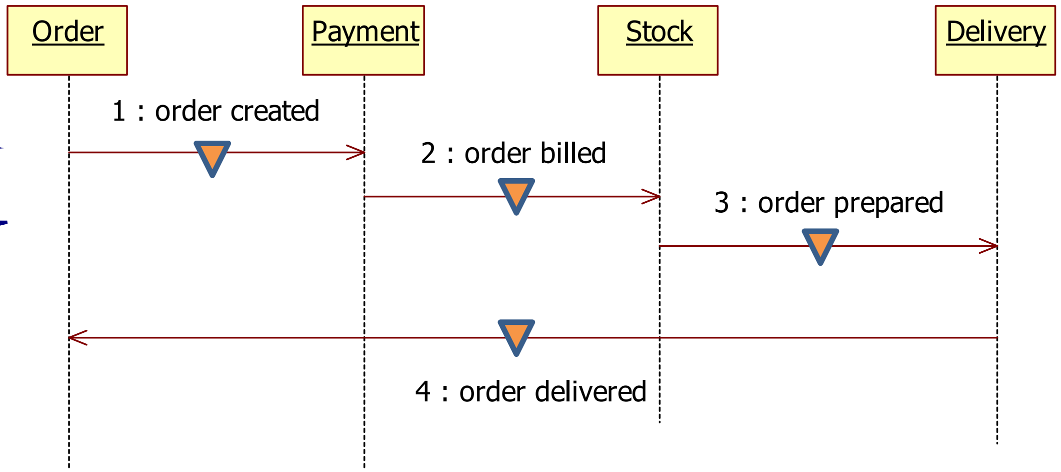
What if a service becomes slow?

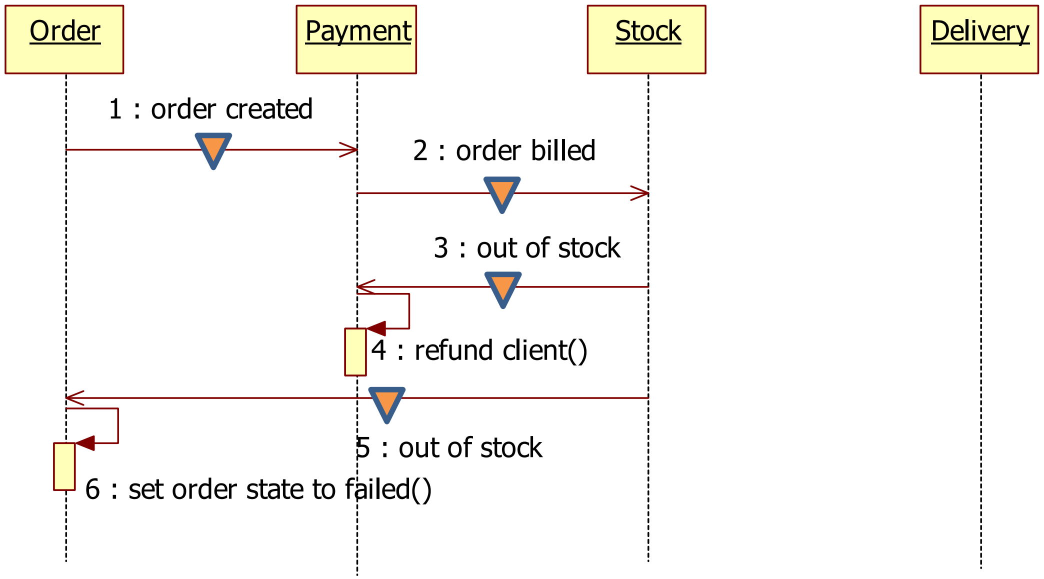


Event driven(messaging)

Loose coupling

Choreography





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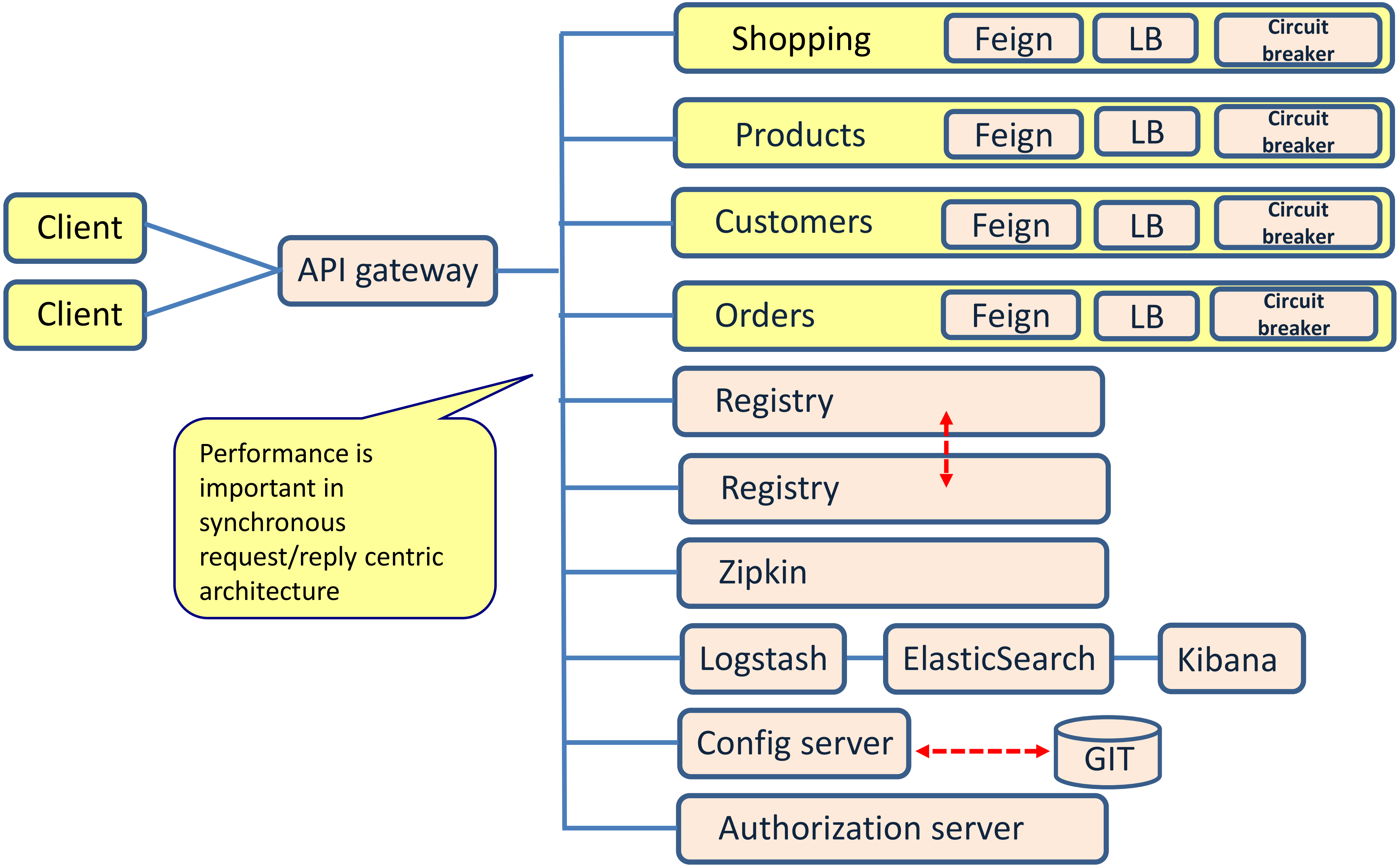
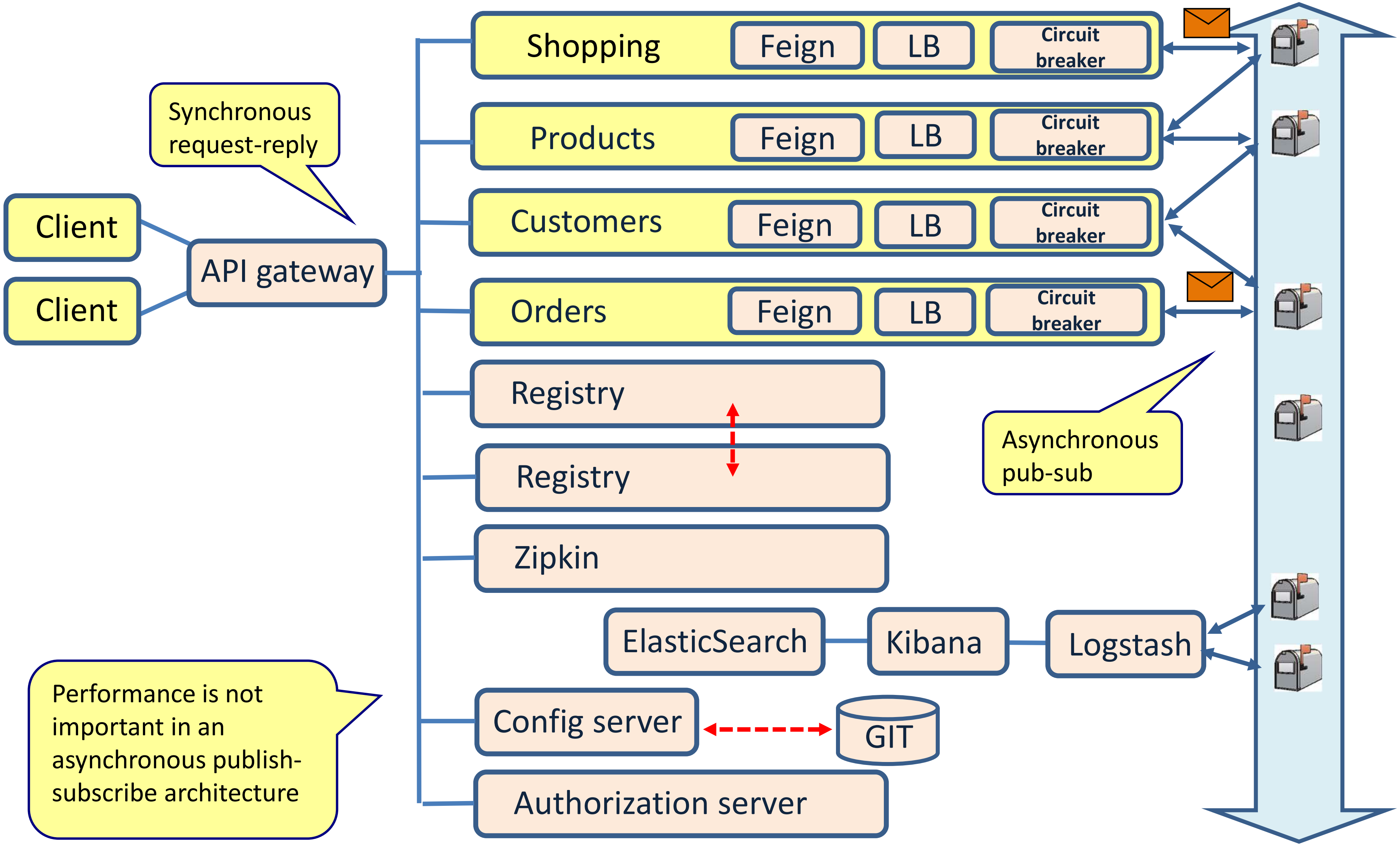
Implementing microservices



Performance is important in synchronous request/reply centric architecture

Implementing microservices



Synchronous request-reply

Asynchronous pub-sub

Performance is not important in an asynchronous publish-subscribe architecture

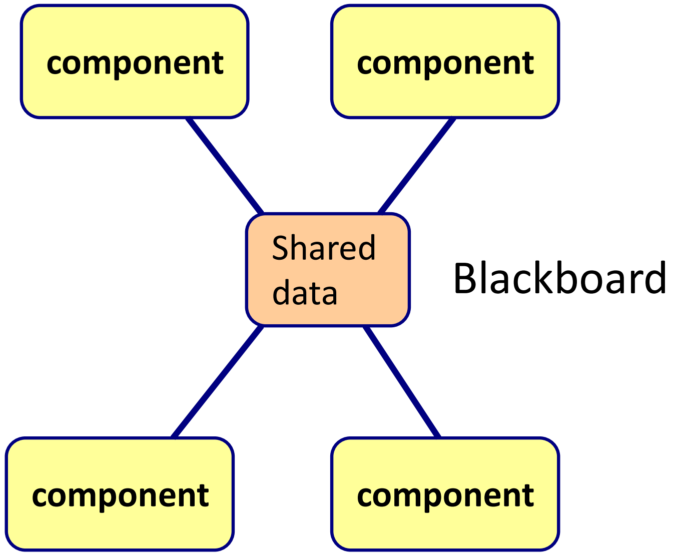
Challenges of a microservice architecture

Challenge	Solution
Complex communication	Feign Registry API gateway
Performance	Event Driven Architecture (EDA)
Resilience	Registry replicas Load balancing between multiple service instances Circuit breaker
Security	Token based security (OAuth2) Digitally signed (JWT) tokens
Transactions	Compensating transactions Eventual consistency
Keep data in sync	Publish-subscribe data change event
Keep interfaces in sync	Spring cloud contract
Keep configuration in sync	Config server
Monitor health of microservices	ELK + beats
Follow/monitor business processes	Zipkin ELK

BLACKBOARD

Blackboard

- Used for non deterministic problems
  - There is no fixed straight-line solution to a problem
- Every component adds her information on the blackboard



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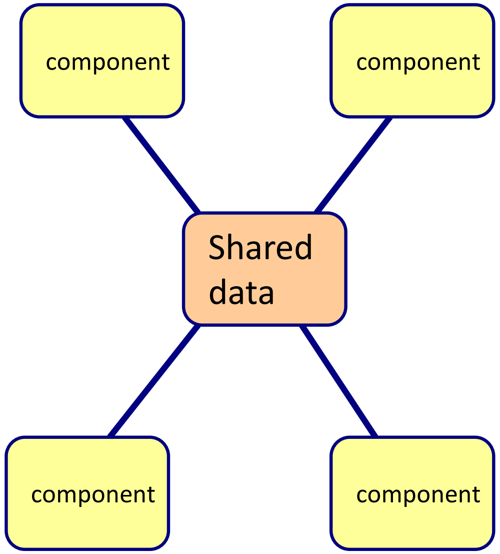
Blackboard

- Common data structure
  - Extension is no problem
  - Change is difficult
- Easy to add new components
- Tight coupling for data structure
- Loose coupling for
  - Location
  - Time
  - Technology(?)
- Synchronisation issues



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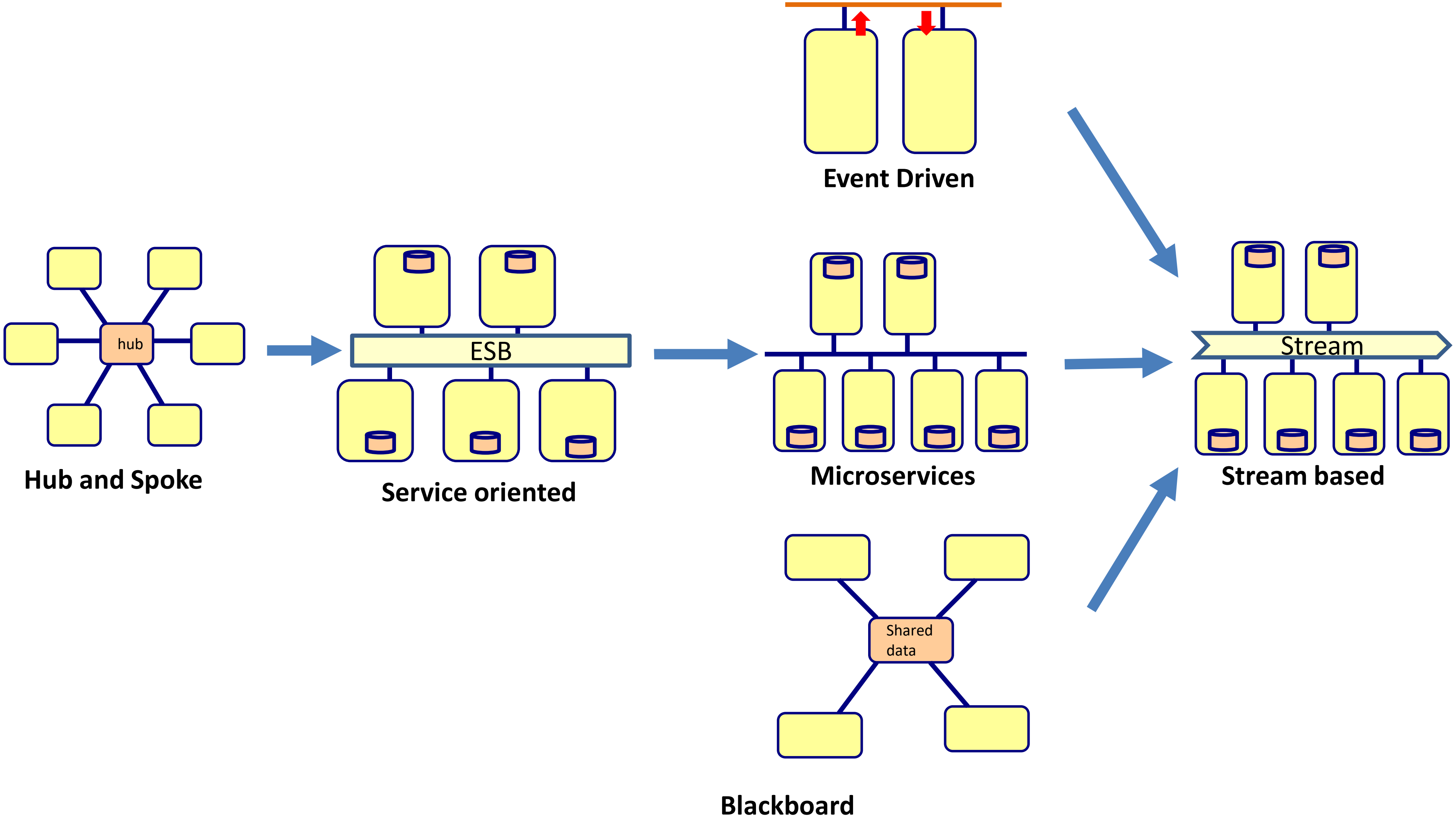
Blackboard

- Benefits
  - Easy to add new components
  - Components are independent of each other
  - Components can work in parallel

- Drawbacks
  - Data structure is hard to change
    - All components share the same data structure
  - Synchronization issues

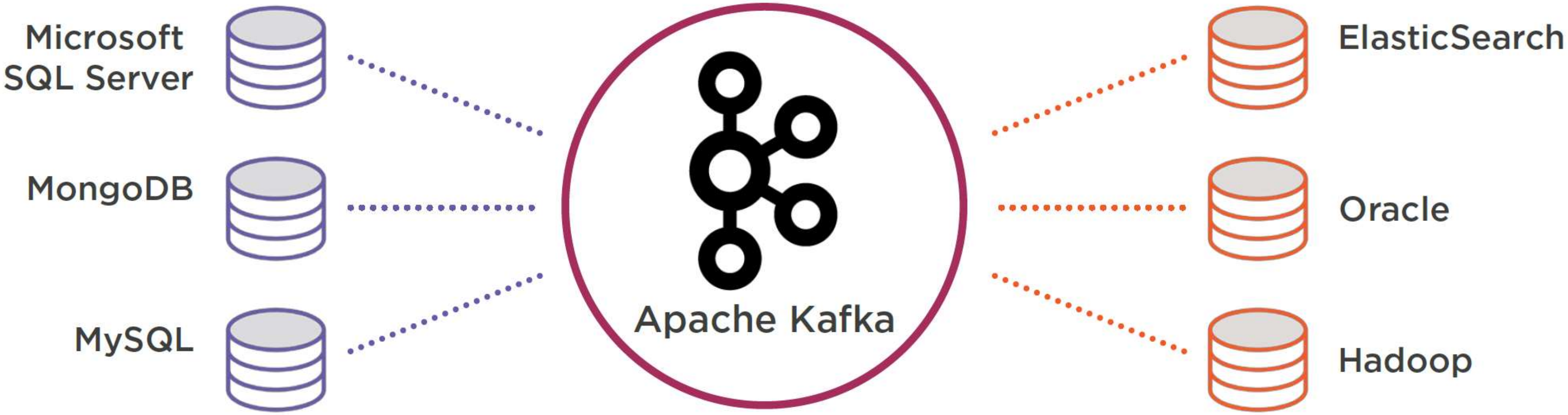
Architecture evolution



KAFKA OVERVIEW

What is Kafka?

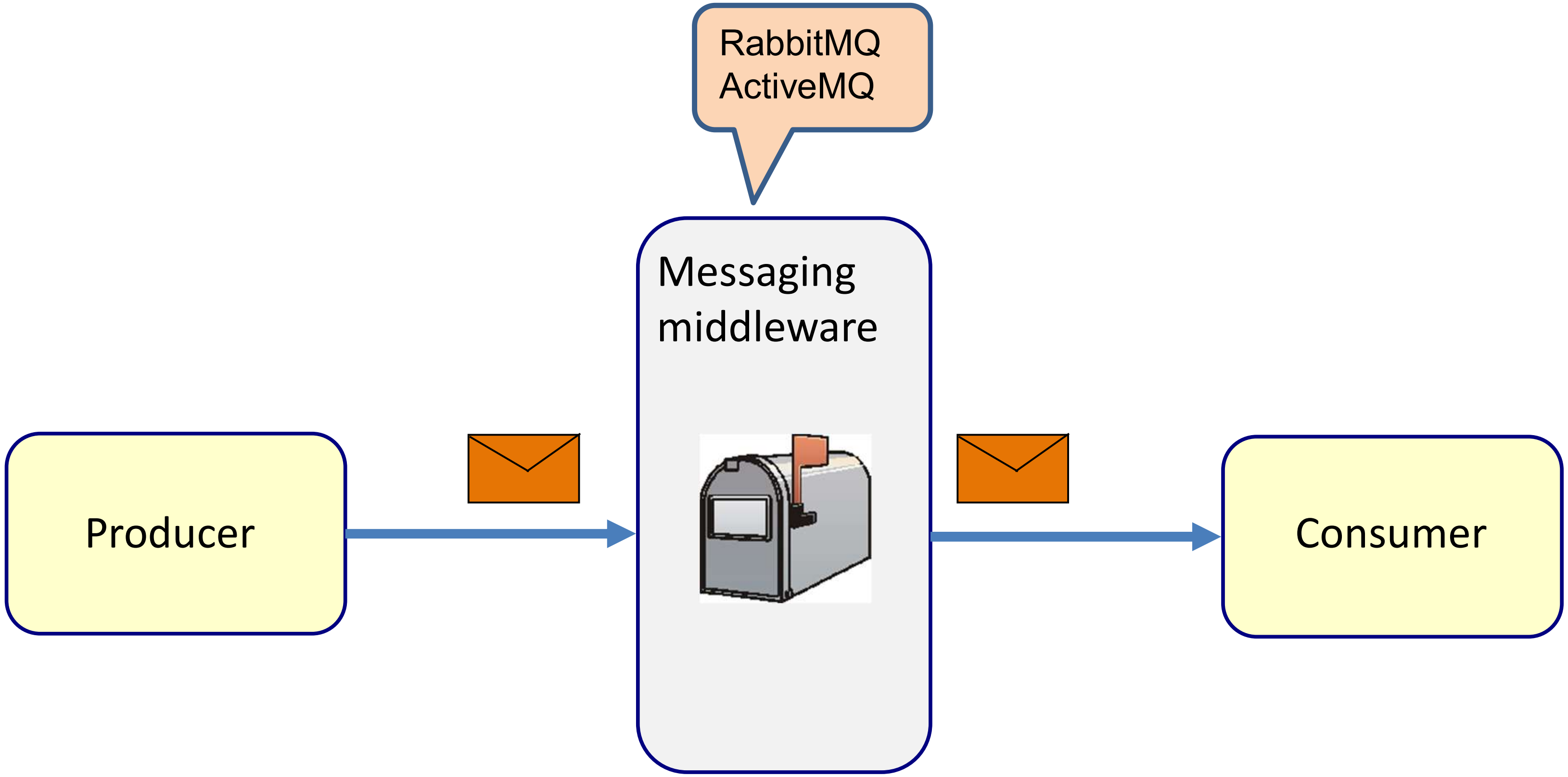
- High-throughput distributed messaging system



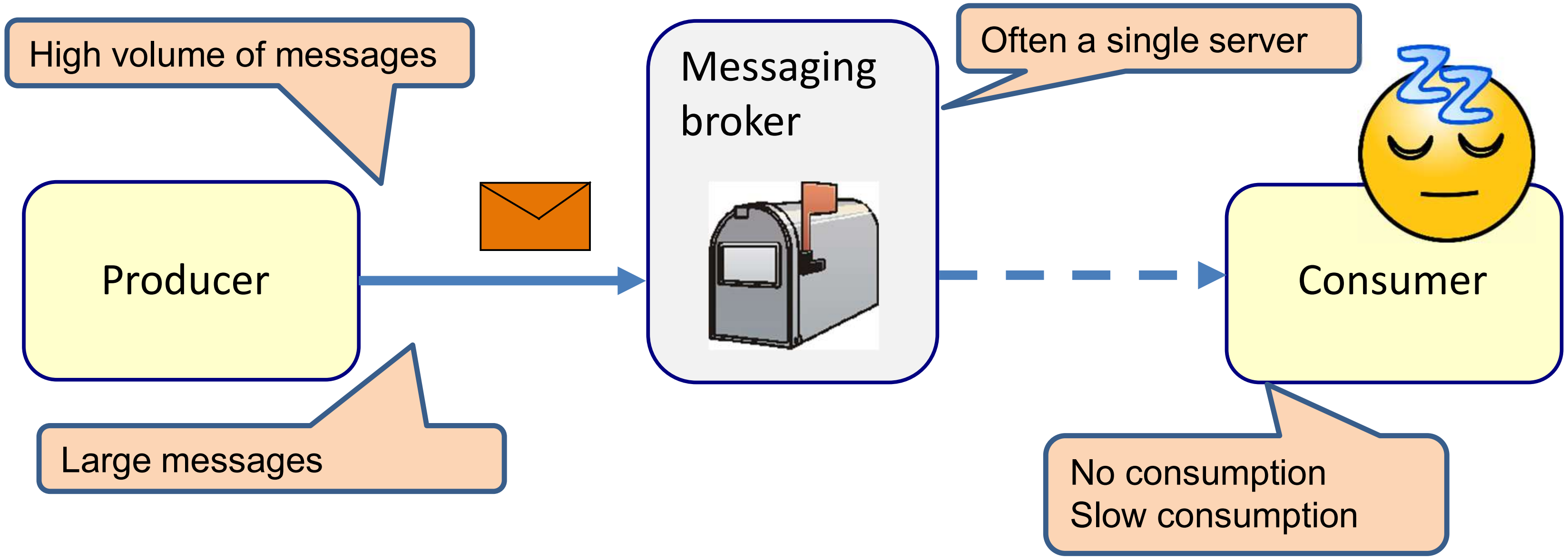
REST vs. Messaging

- REST
  - Synchronous
  - Tight coupling
- Messaging
  - Asynchronous
    - Fire and forget
  - Loose coupling
  - Buffer
  - Middleware needs to be maintained

Traditional Messaging Systems



Problems with traditional messaging middleware



- If the consumer is temporally not available (or very slow) the message middleware has to store the messages
  - This restricts the volume of messages and the size of the messages
  - Eventually the message broker will fail

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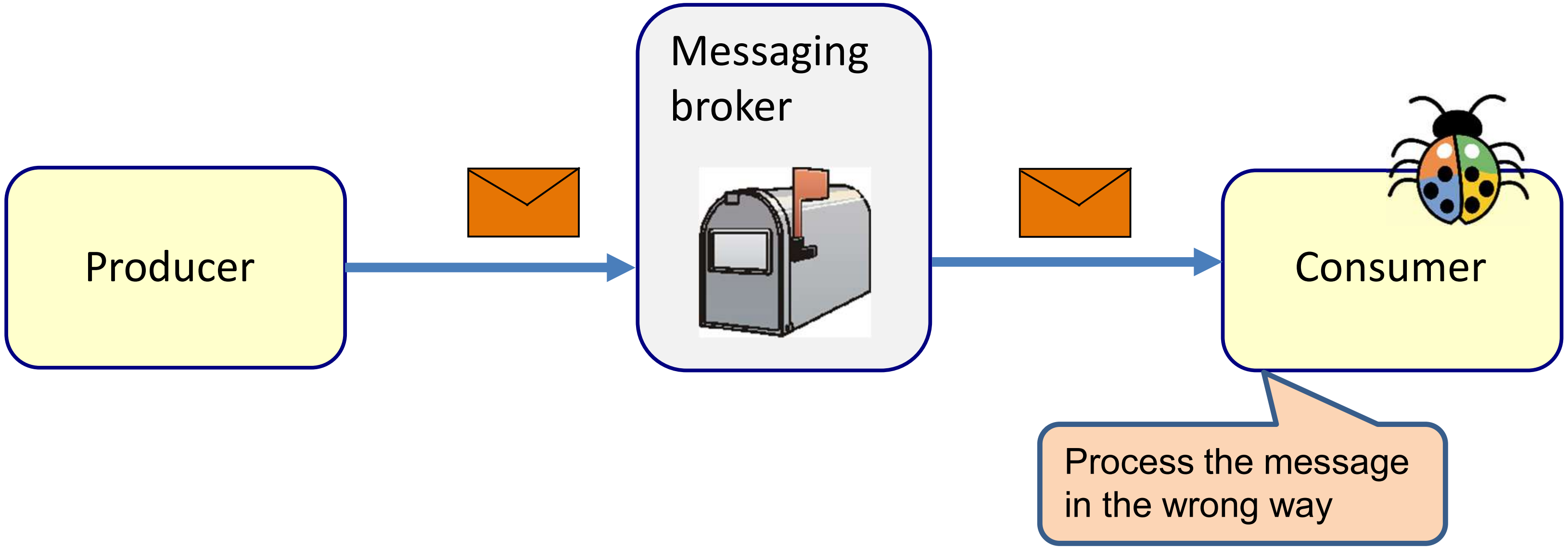
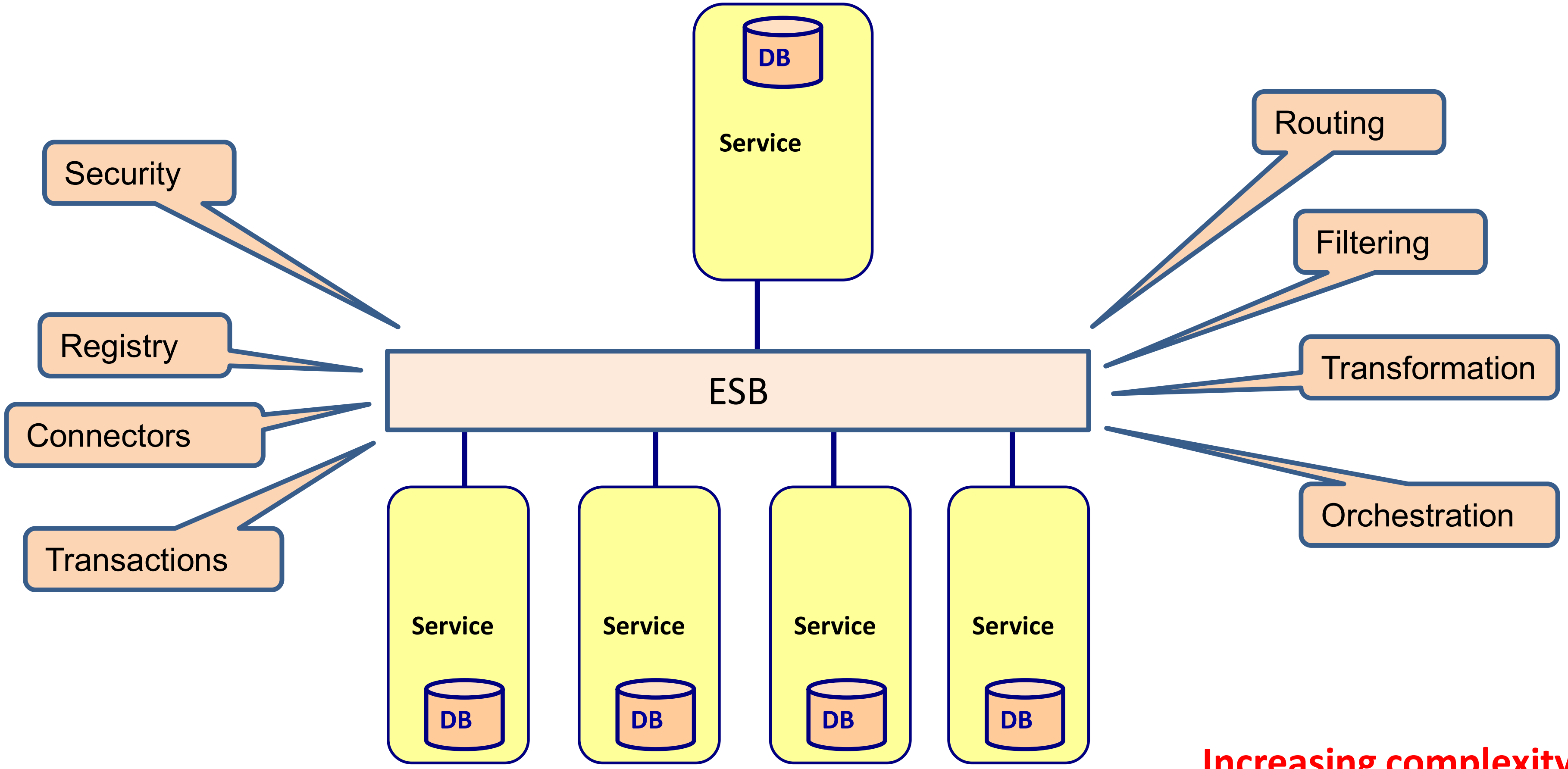
Problems with traditional messaging middleware



Process the message in the wrong way

- If the consumer has a bug, and handles the messages incorrectly, then the messages are gone.
    - Not fault-tolerant

Enterprise Service Bus



Increasing complexity
Deceiving
Potentially expensive

What we need?

- Move data around
  - Cleanly
  - Reliably
  - Quickly
  - Autonomously

Kafka

Apache Kafka

- Created by Linked In
- Characteristics
  - High throughput
  - Distributed
  - Unlimited scalable
  - Fault-tolerant
    - Reliable and durable
  - Loosely coupled Producers and Consumers
  - Flexible publish-subscribe semantics

High Volume:

- Over 1.4 trillion messages per day
- 175 terabytes per day

High Velocity:

- Peak 13 million messages per second
- 2.75 gigabytes per second

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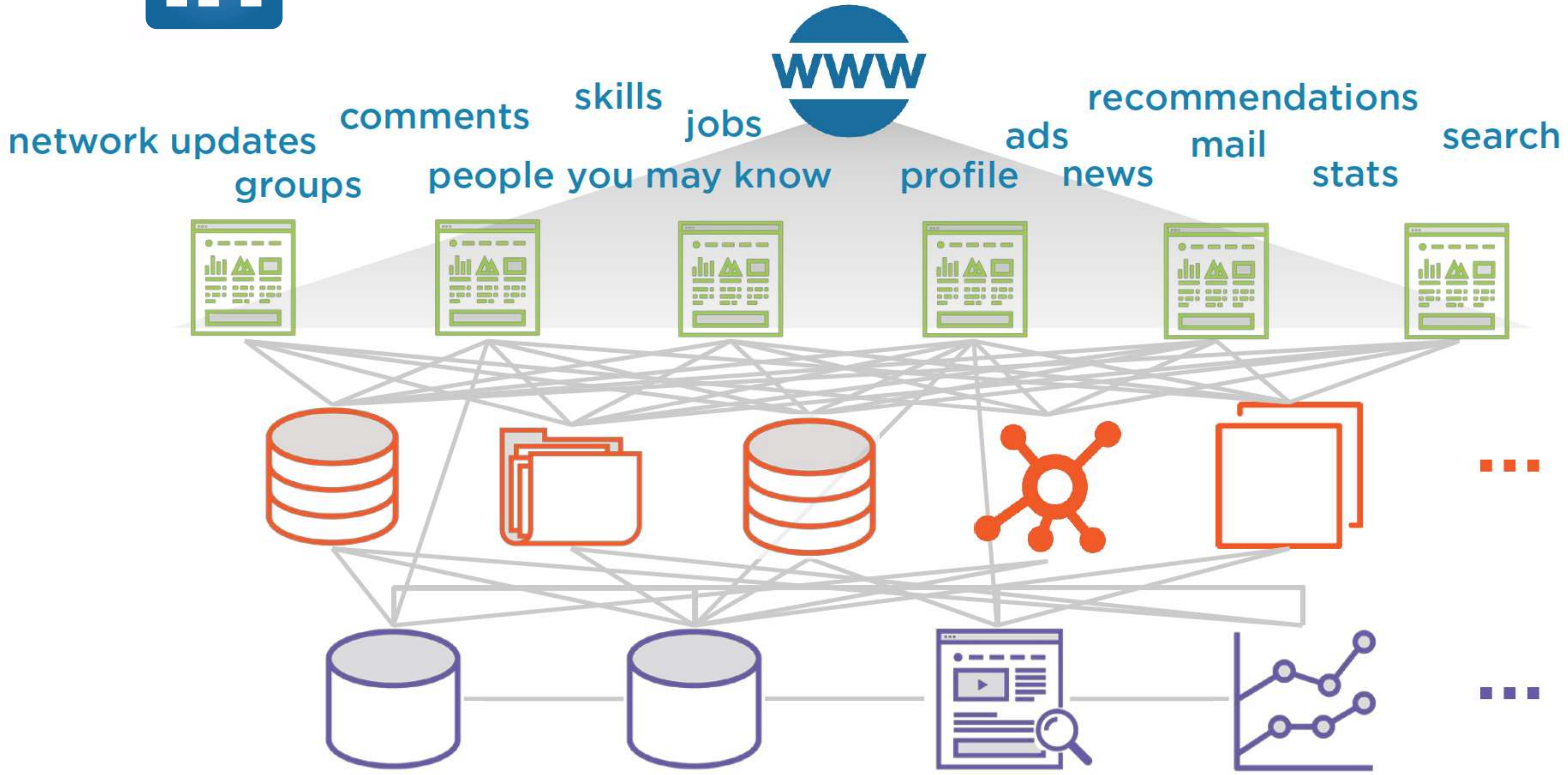
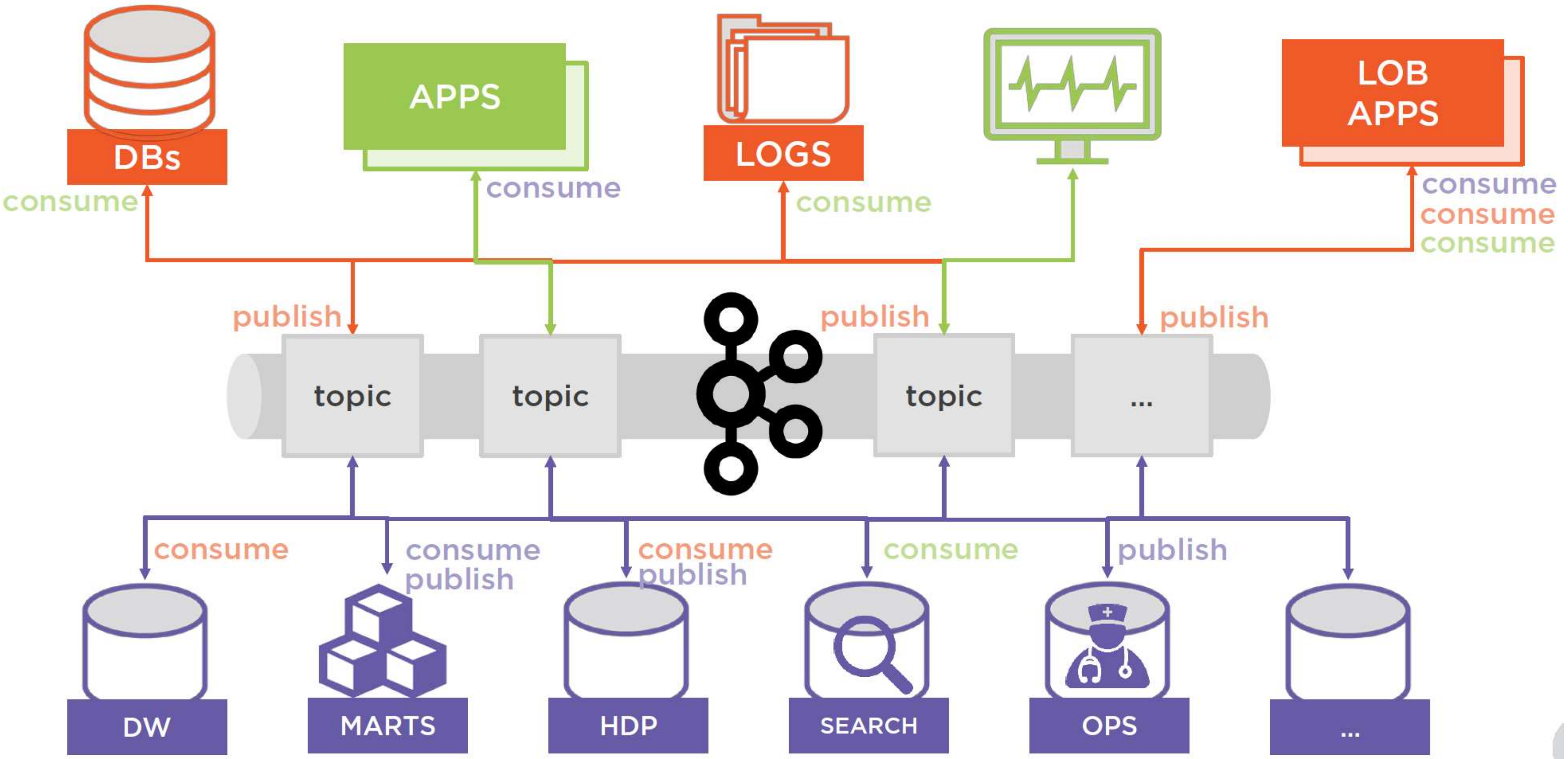
Pre 2010 LinkedIn data architecture



Post 2010 LinkedIn data architecture



KAFKA’S ARCHITECTURE

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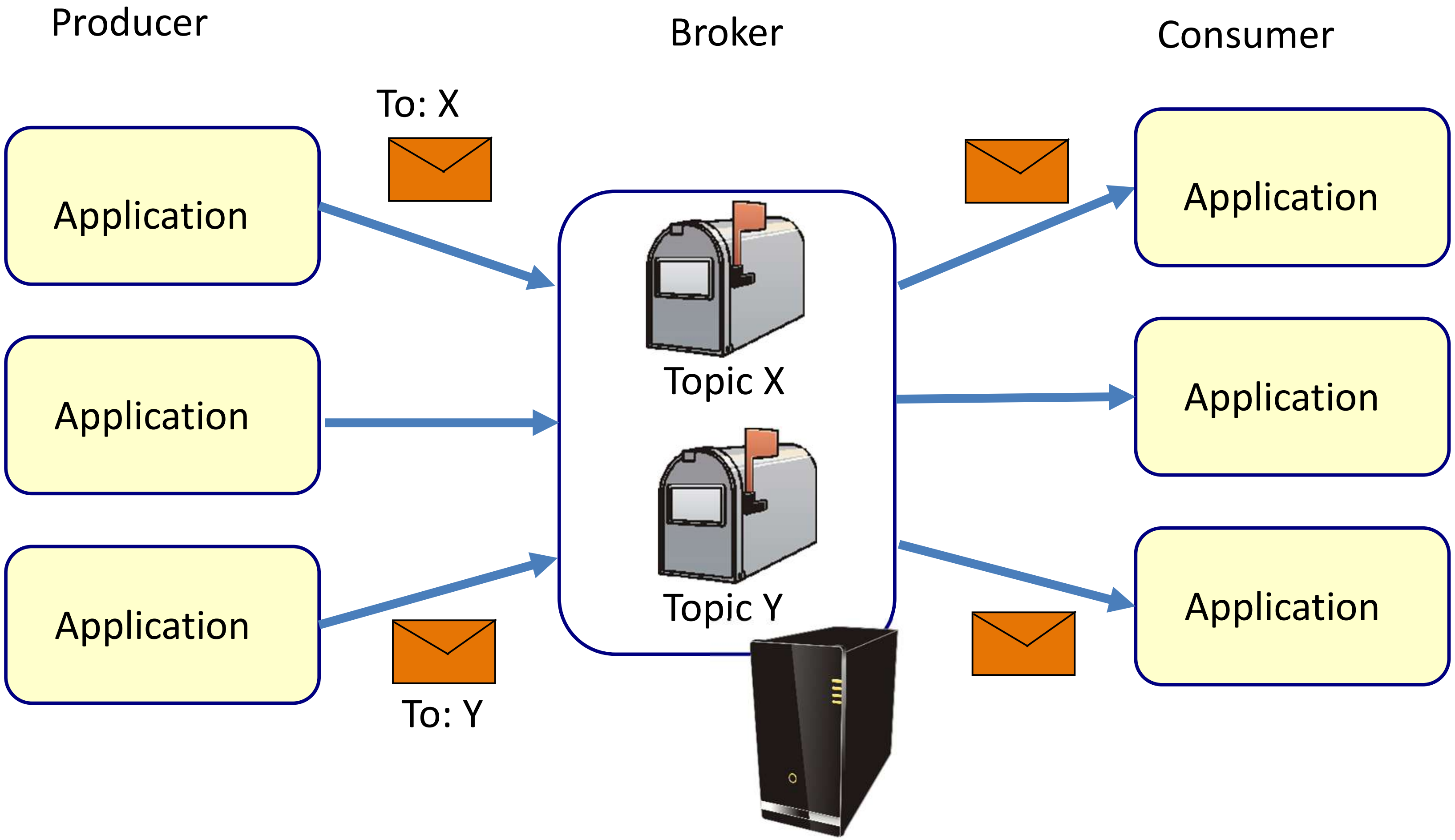
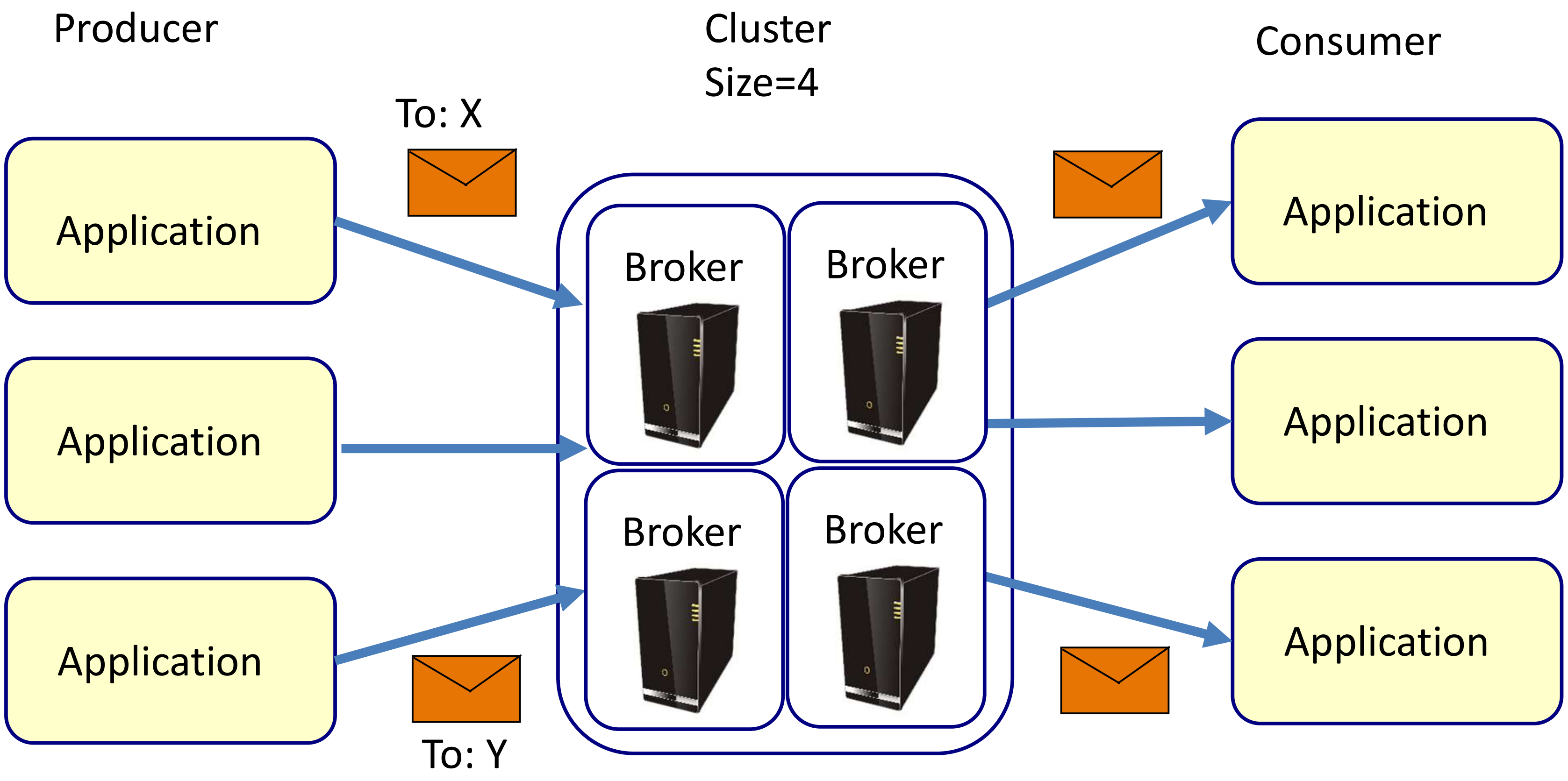
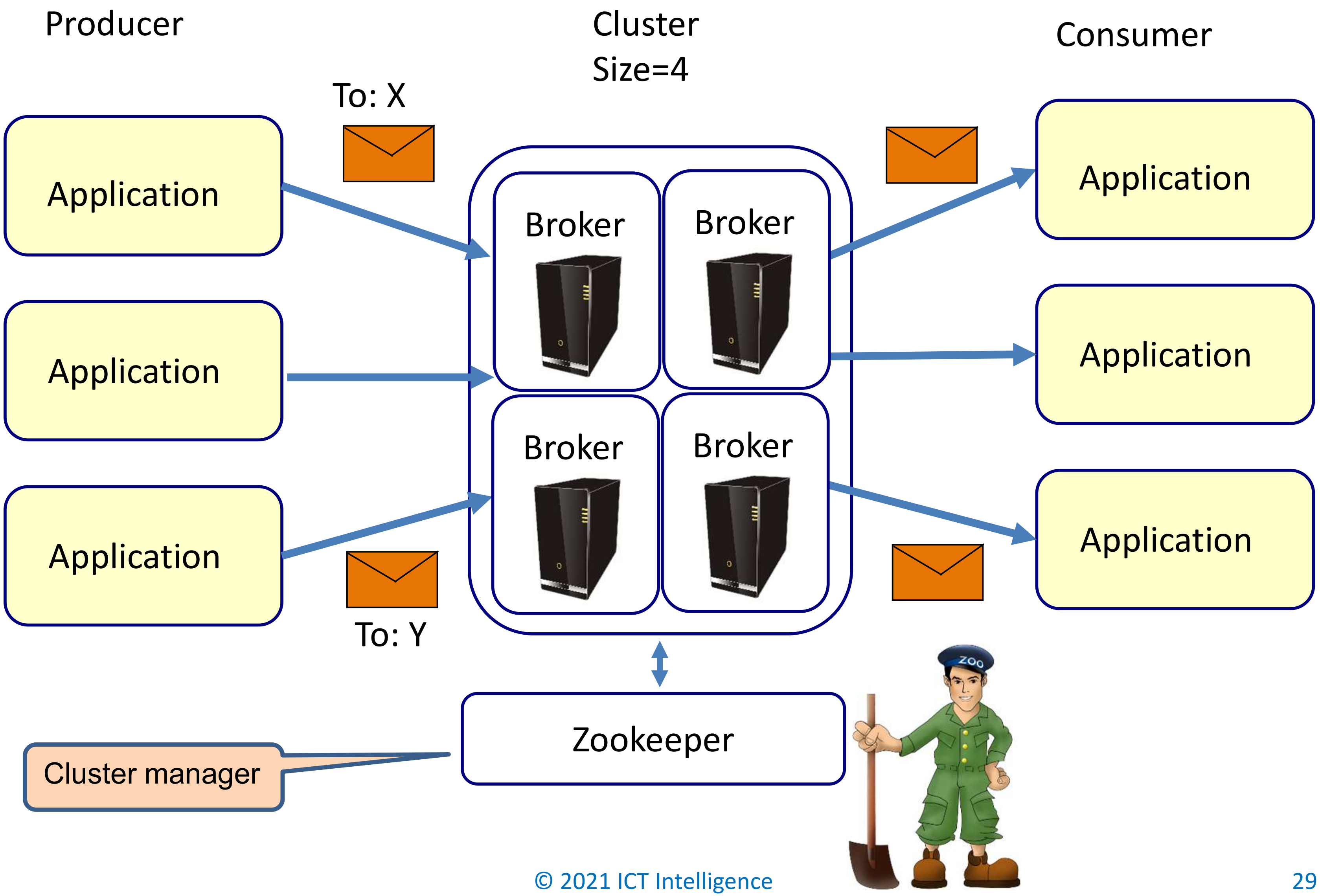
Kafka


Producer
Broker
Consumer
To: X
Application
Application
Application
Topic X
Topic Y
To: Y
Application
Application
Application

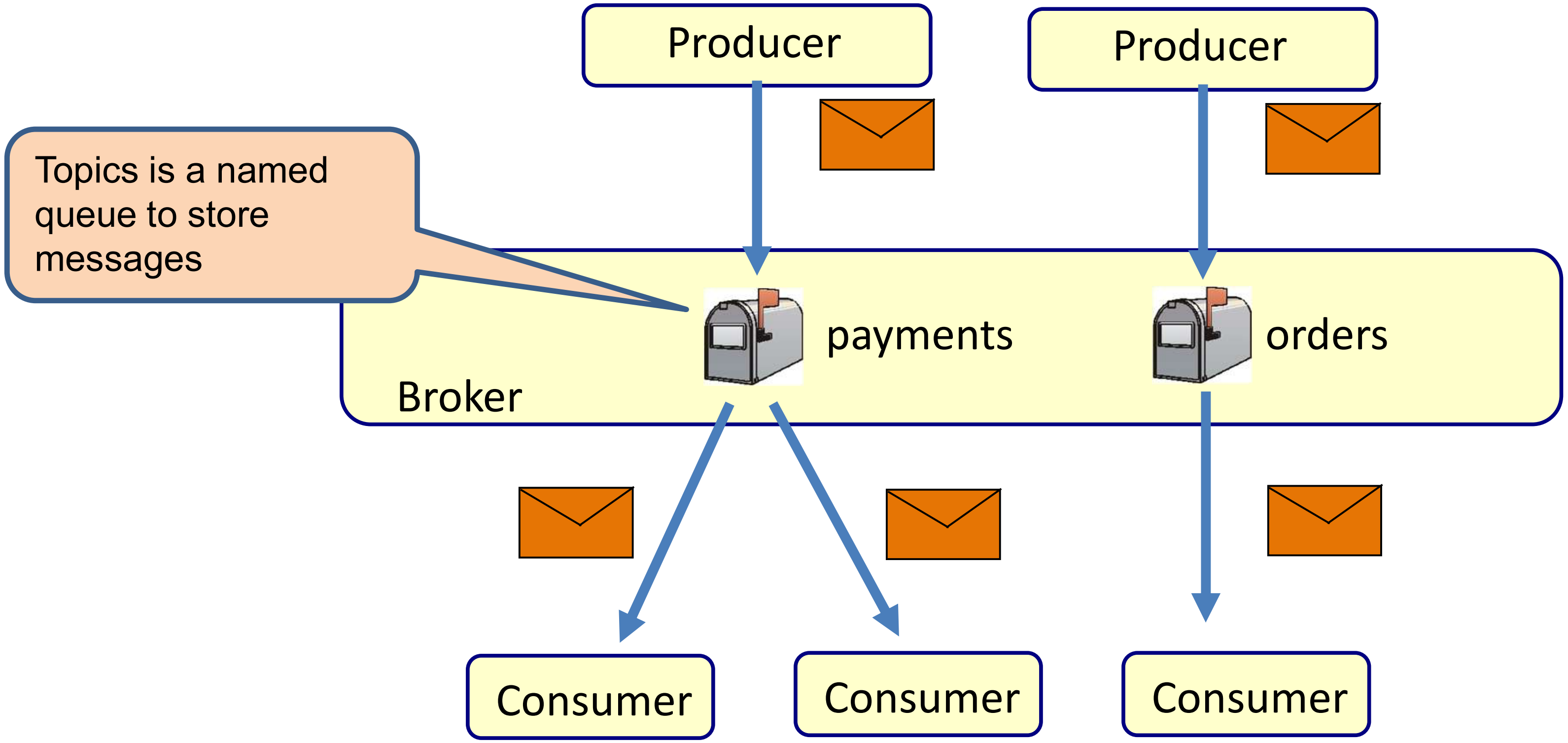
Cluster of Brokers



Apache Zookeeper

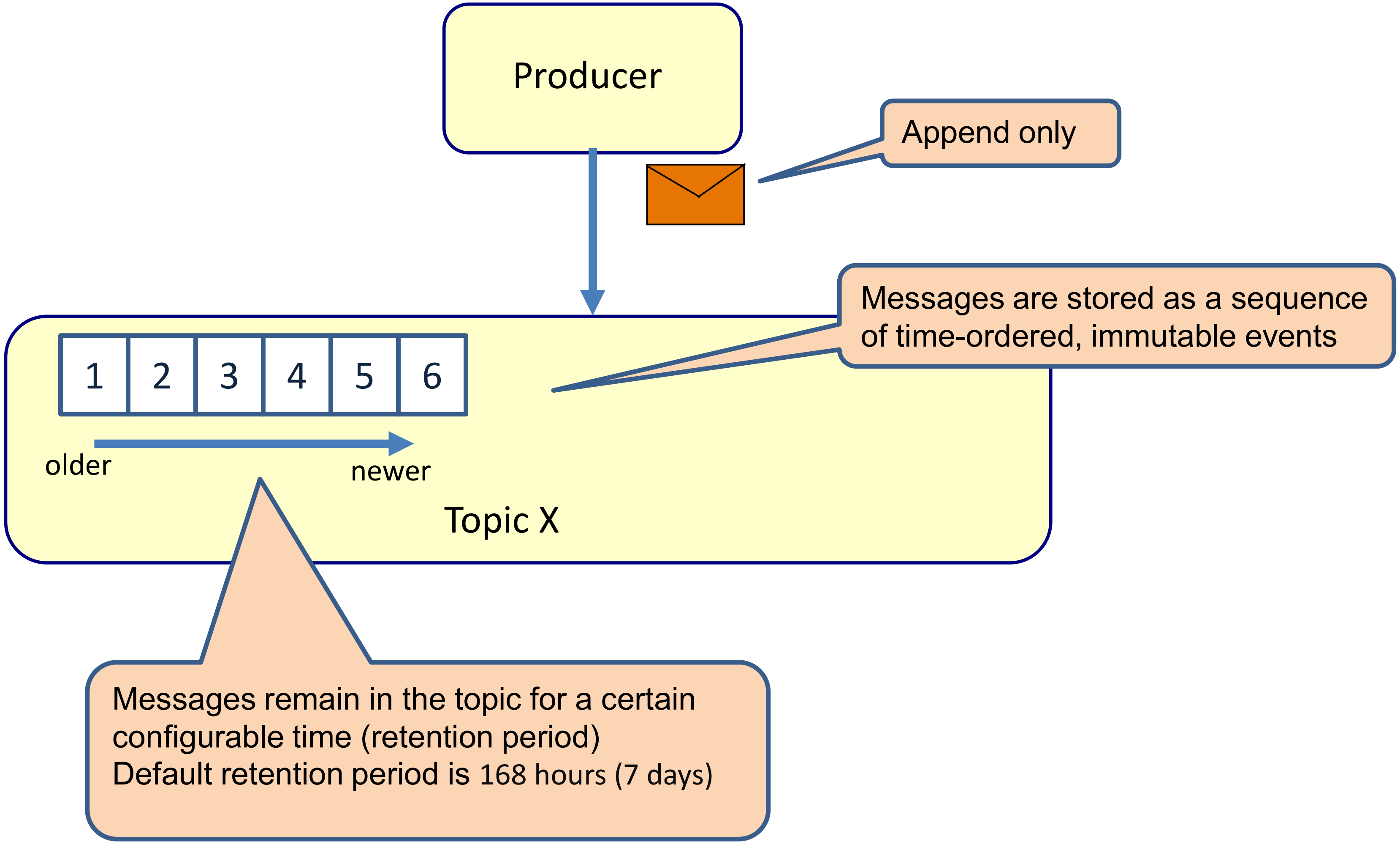


Topics



Topics is a named queue to store messages

Event sourcing

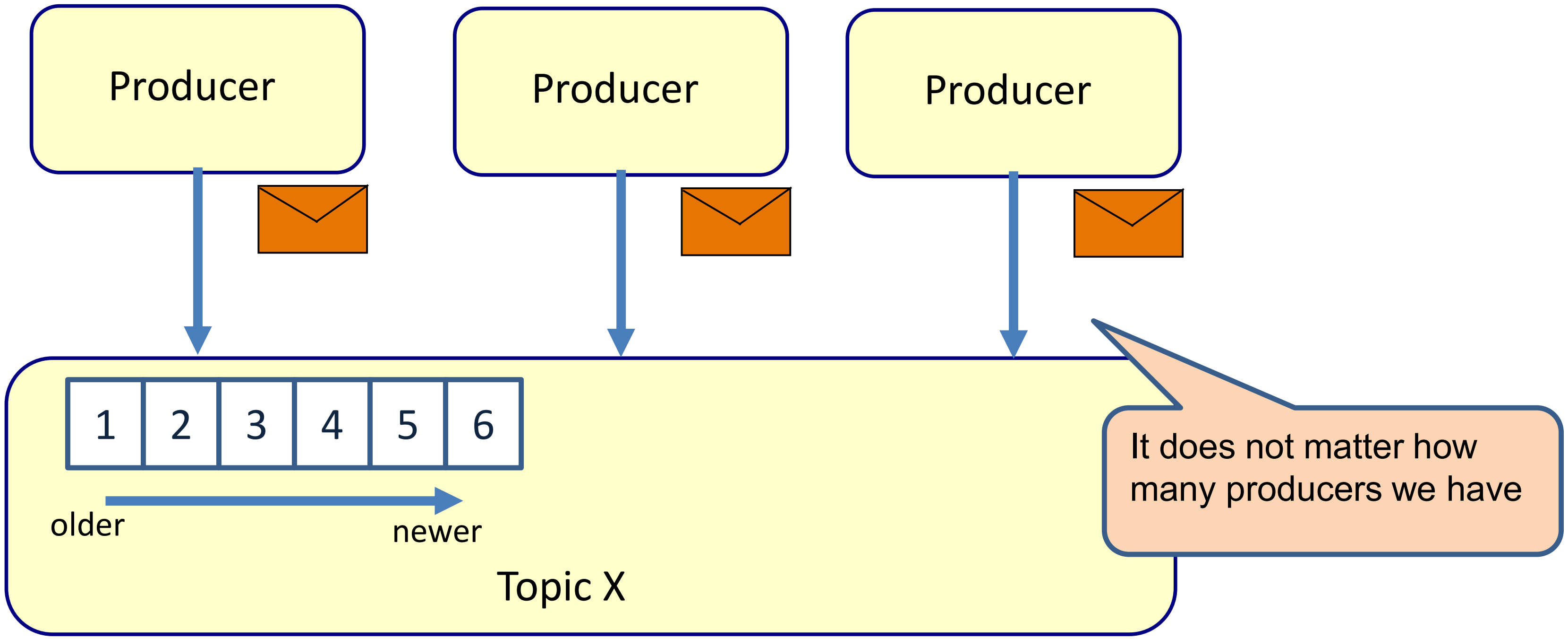


Append only

Messages are stored as a sequence of time-ordered, immutable events

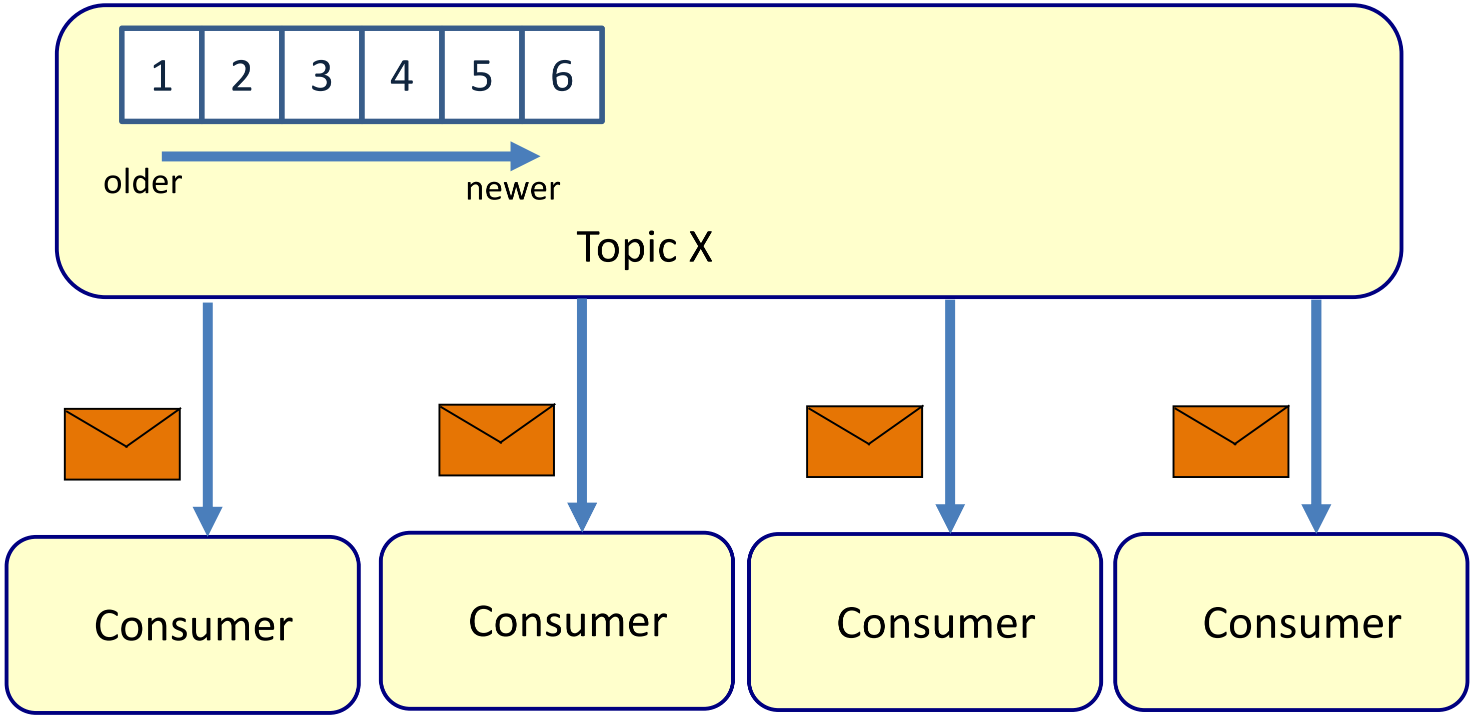
Messages remain in the topic for a certain configurable time (retention period)
Default retention period is 168 hours (7 days)

Why event sourcing?



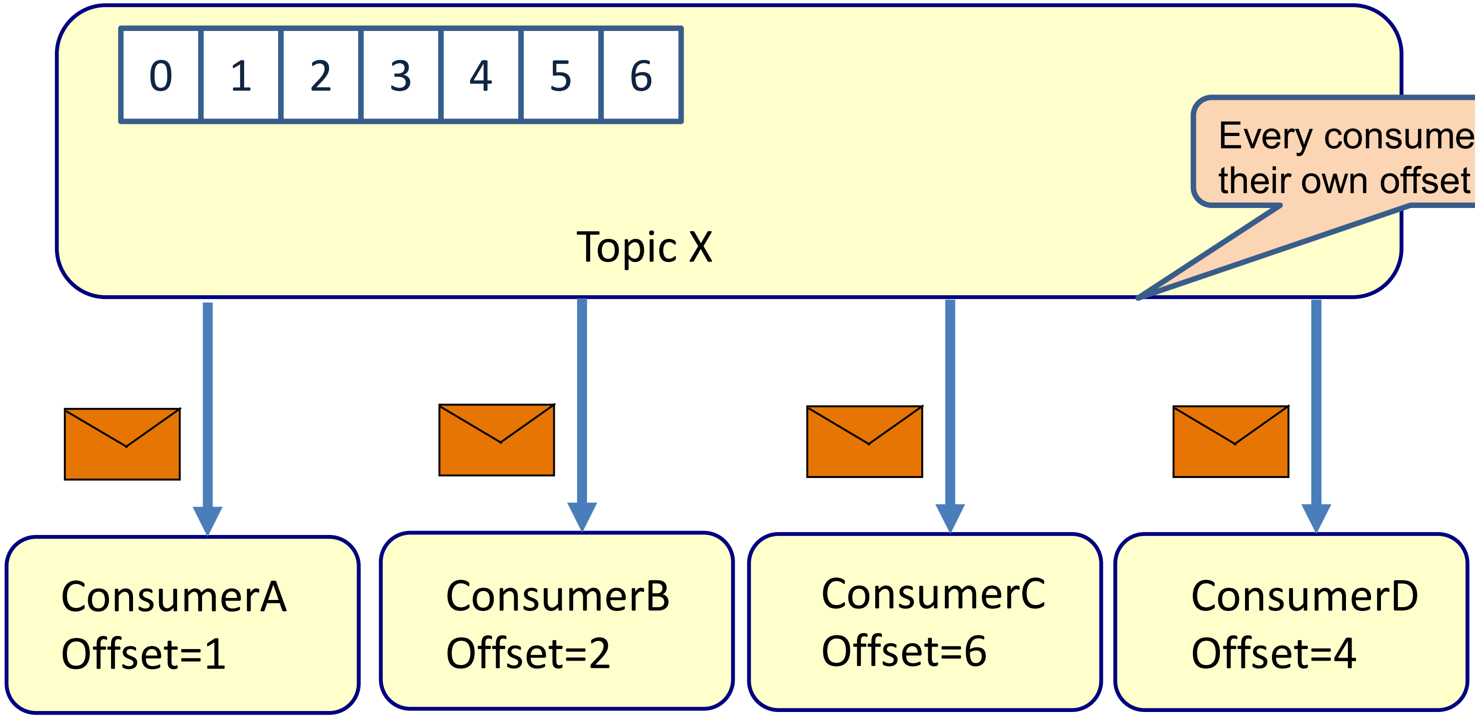
It does not matter how many producers we have

Why event sourcing?



It does not matter how many consumers we have

Offset



Every consumer manages their own offset in the topic

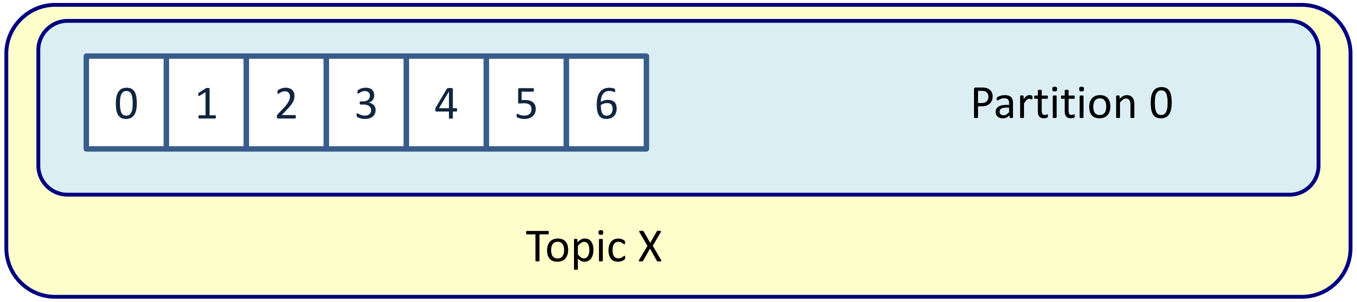
It does not matter how many consumers we have

It does not matter if a consumer is slow

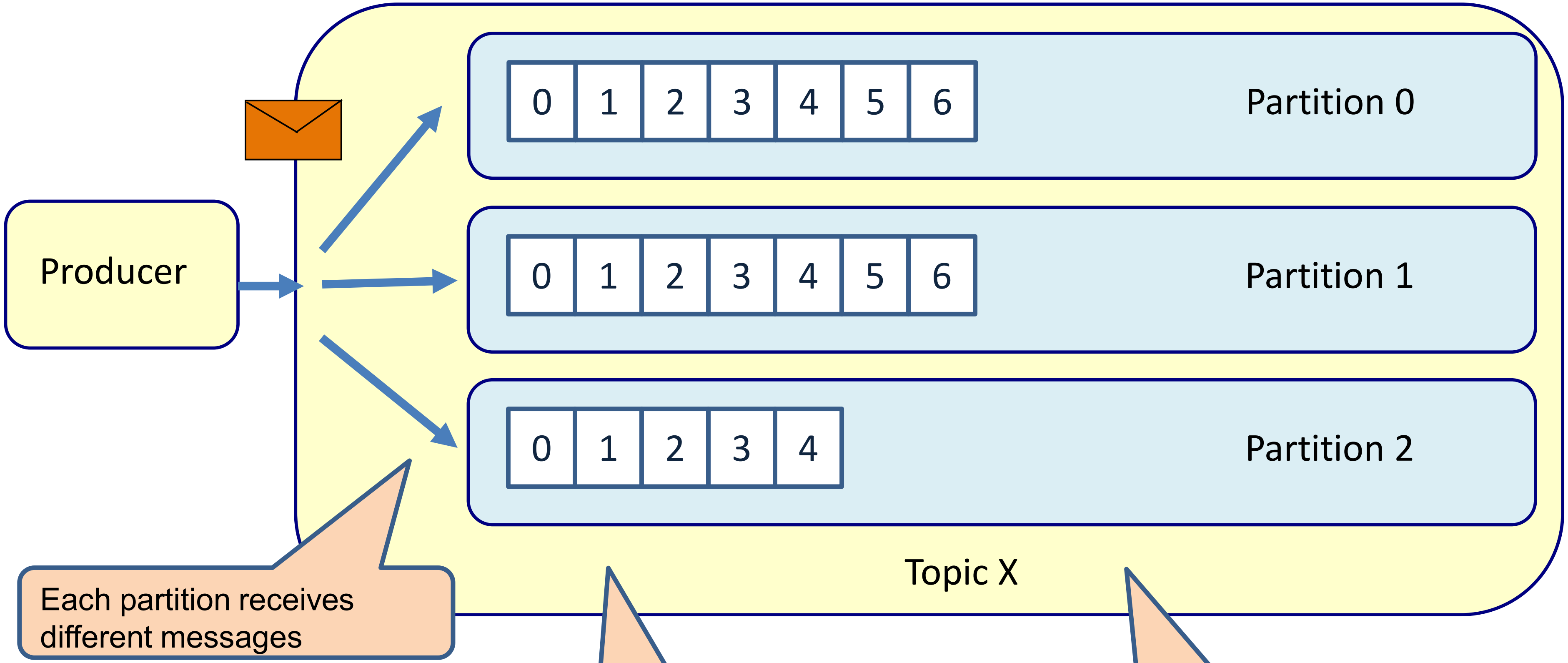
It does not matter if a consumer is offline for a while

Partition

- Each topic has one or more partitions
  - This is configurable
- Each partition must fit on 1 broker



3 partitions

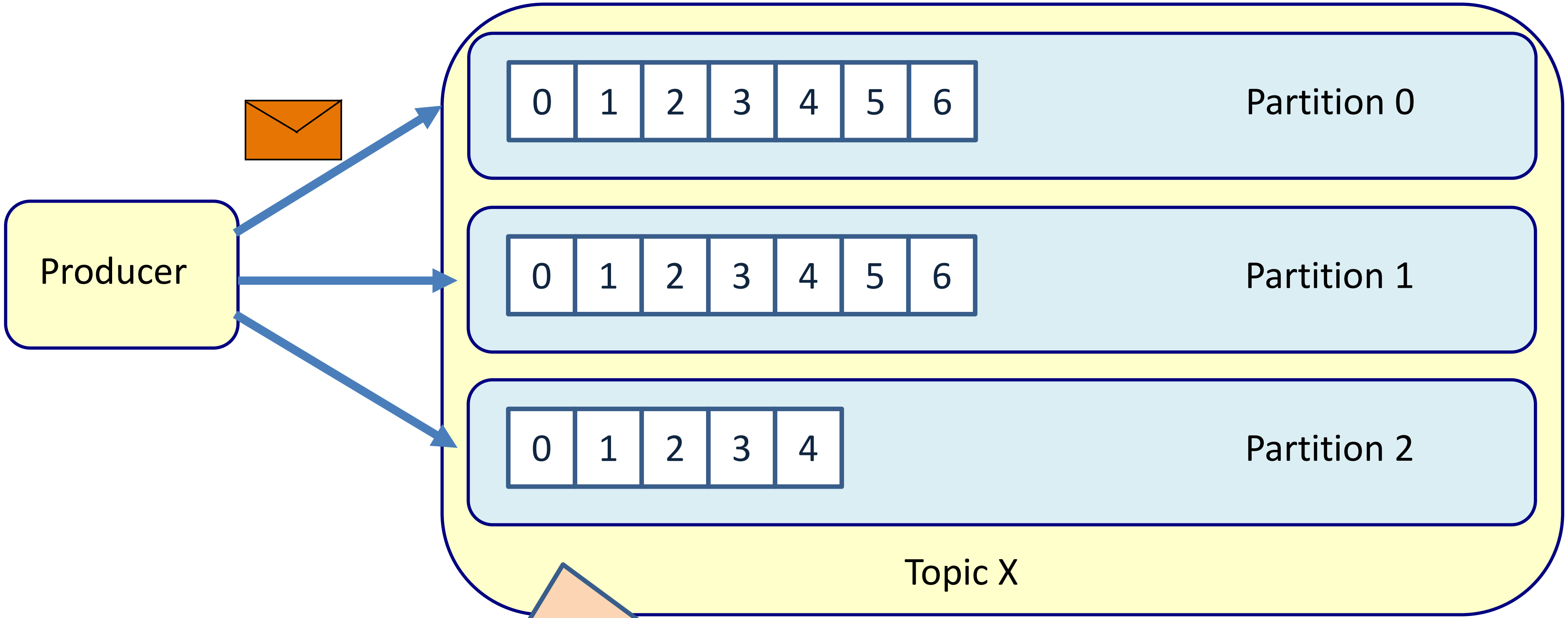


Each partition receives different messages

If the message contains a key, kafka will compute the partition based on the key

If the message does not contain a key, kafka will use round robin to divide the messages over the topics

3 partitions



There is no message order between partitions
If this is important

- Use a single partition
- Let the consumer manage the order using a key

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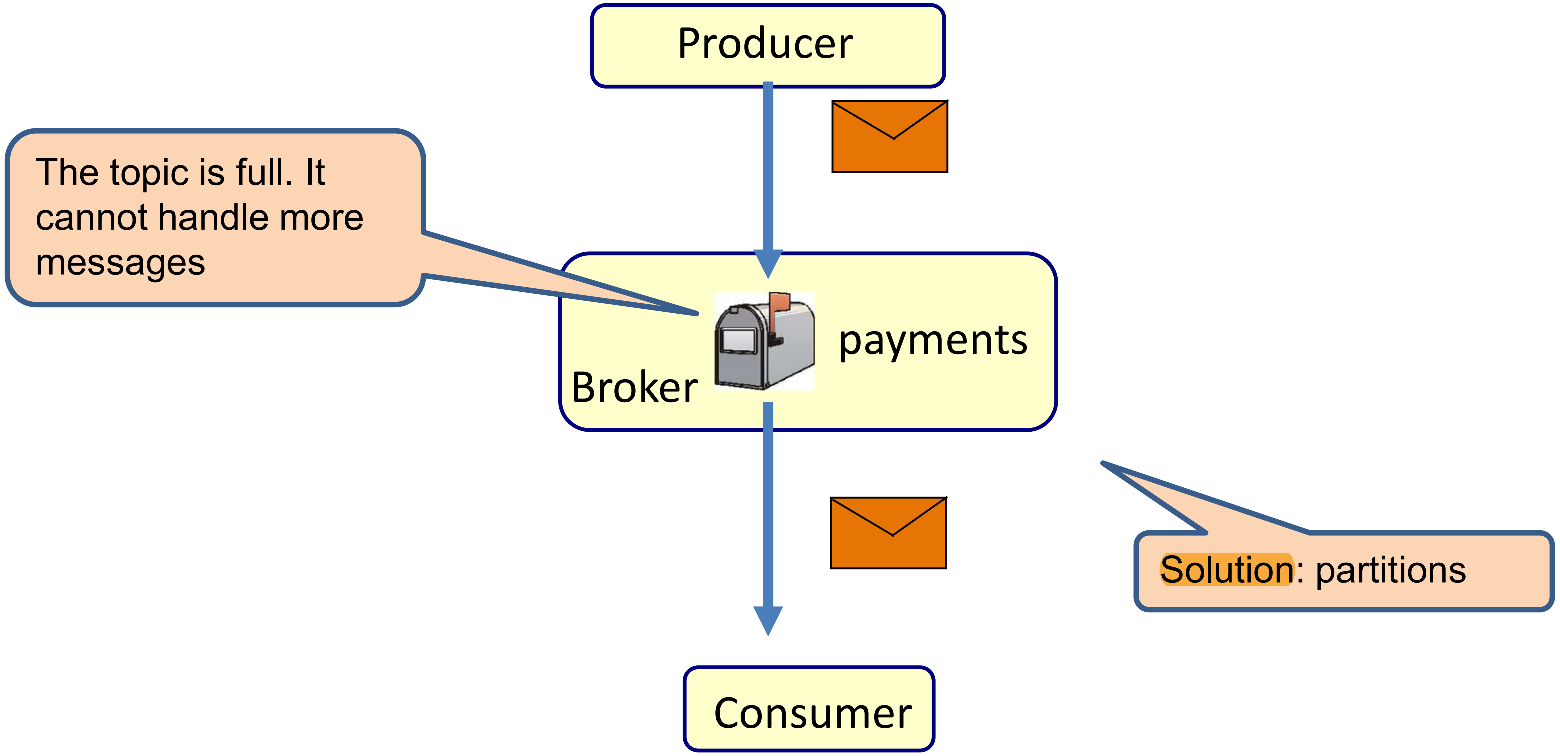
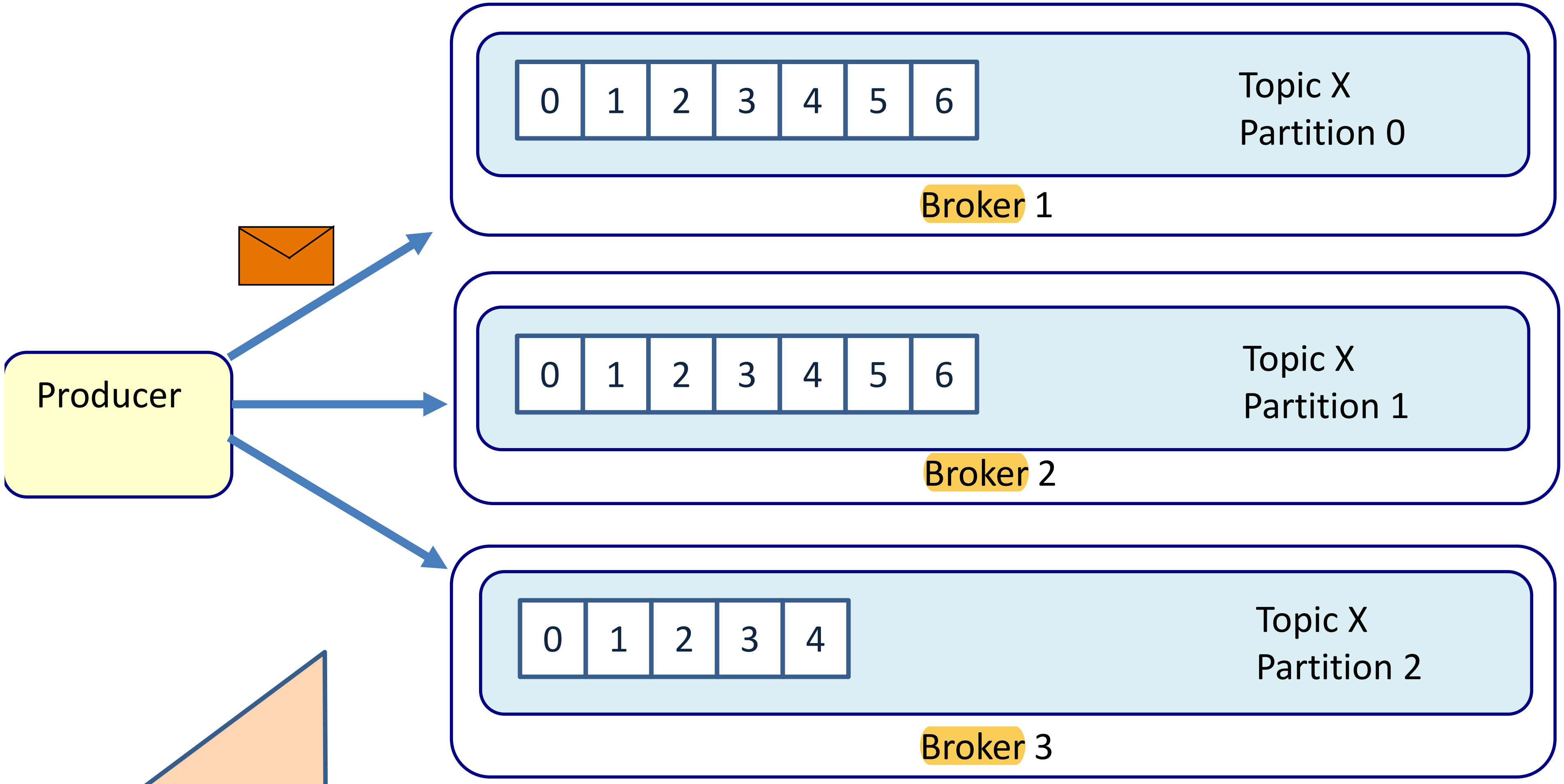
What if the topic gets too full?



The topic is full. It cannot handle more messages

Solution: partitions

Scale out partitions



Increases

- Scalability (number of messages and their size)
- Higher levels of throughput (parallelism)

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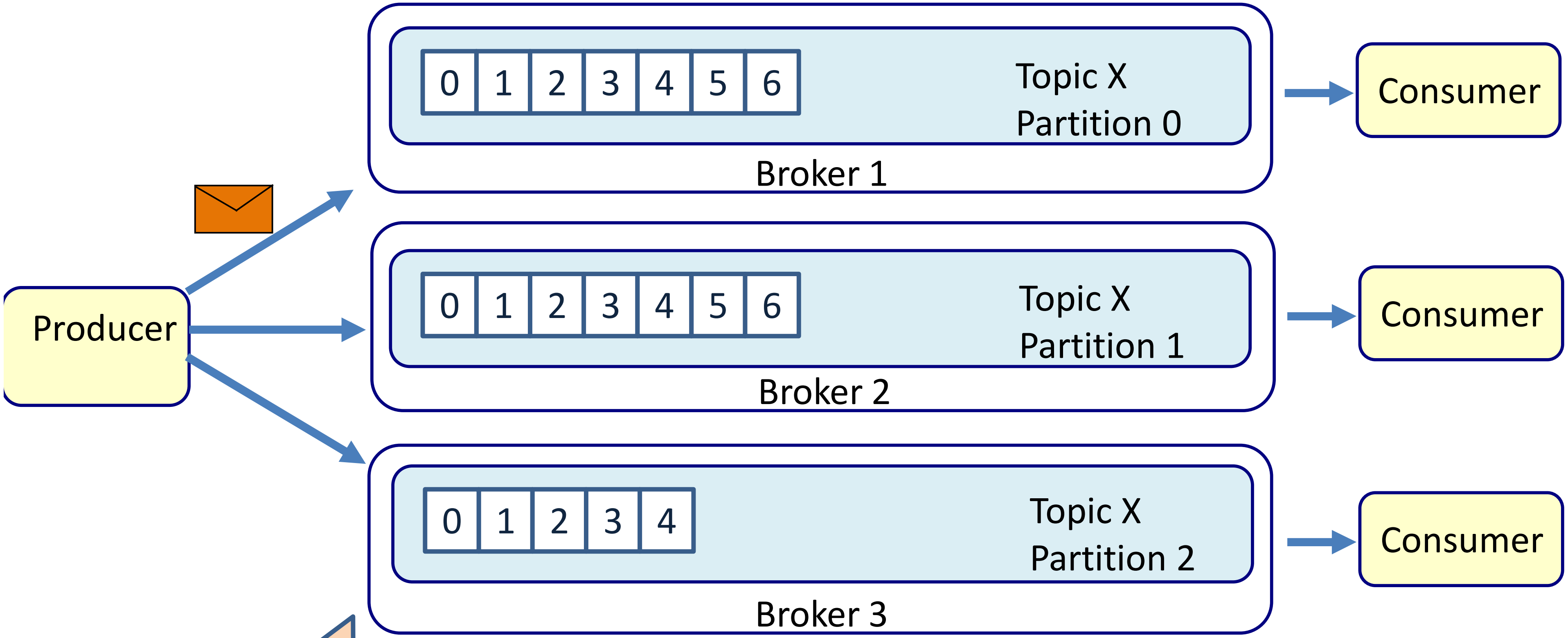
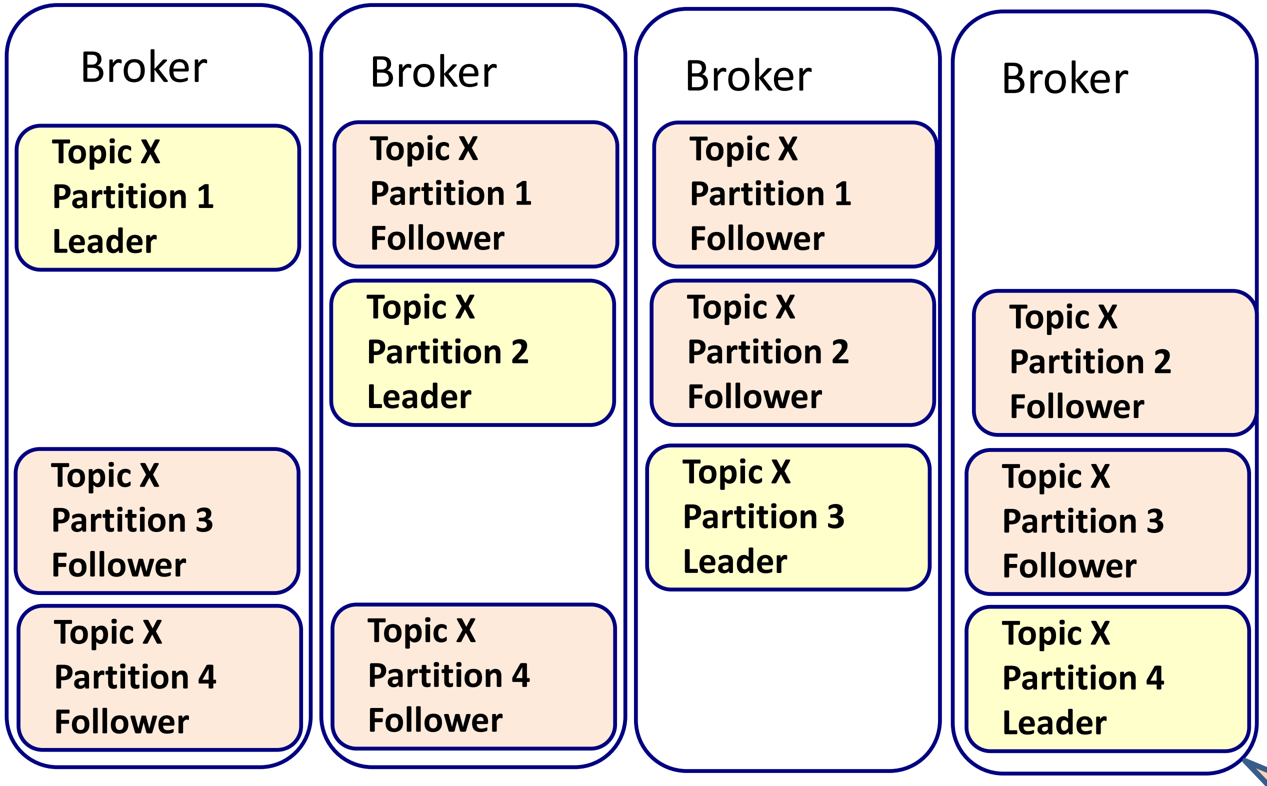
Scale out partitions



Increases

- Scalability (number of messages and their size)
- Higher levels of throughput (parallelism)

Replication



Broker

Topic X Partition 1 Leader

Topic X Partition 3 Follower

Topic X Partition 4 Follower

Broker

Topic X Partition 1 Follower

Topic X Partition 2 Leader

Topic X Partition 4 Follower

Broker

Topic X Partition 1 Follower

Topic X Partition 2 Follower

Topic X Partition 3 Leader

Broker

Topic X Partition 2 Follower

Topic X Partition 3 Follower

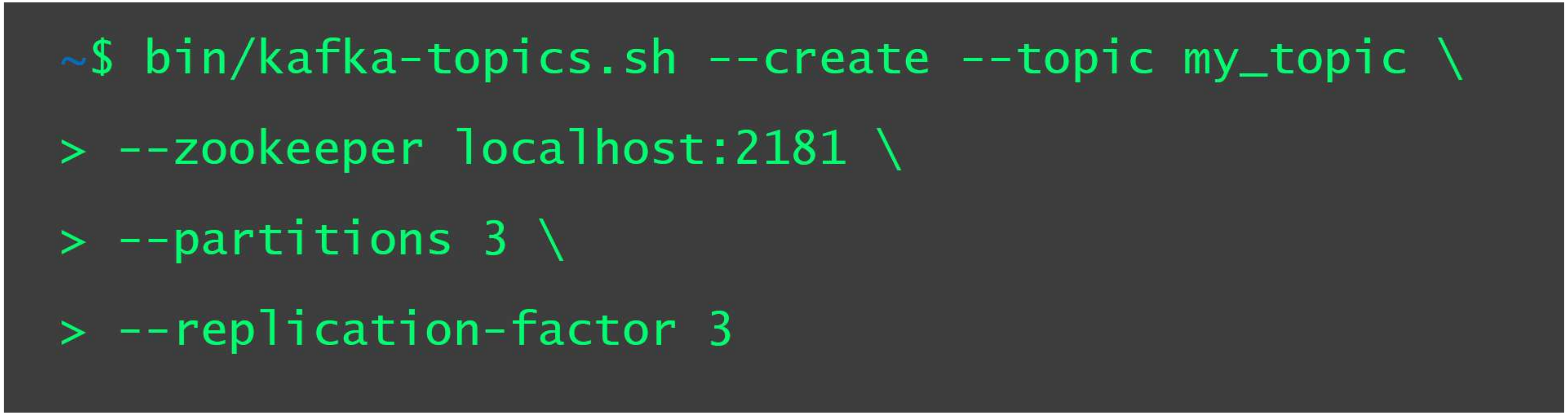
Topic X Partition 4 Leader

Replication gives fault tolerance

Every topic has a replication factor

Leaders replicate messages to the followers

Creating a topic



```
~$ bin/kafka-topics.sh --create --topic my_topic \
> --zookeeper localhost:2181 \
> --partitions 3 \
> --replication-factor 3
```

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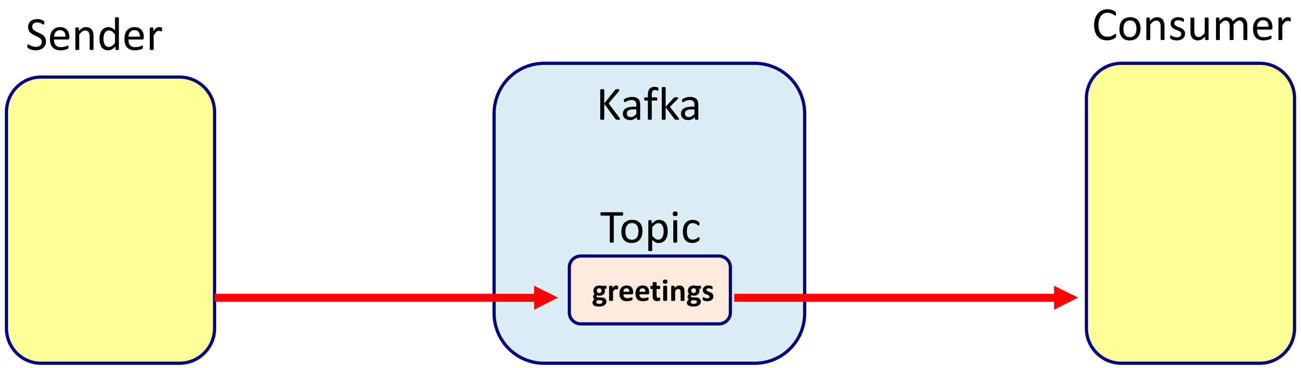
SPRING BOOT AND KAFKA

Example



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SenderApplication

```java
@SpringBootApplication
@EnableKafka
public class SenderApplication implements CommandLineRunner {
   @Autowired
   Sender sender;

   public static void main(String[] args) {
      SpringApplication.run(SenderApplication.class, args);
   }

   @Override
   public void run(String... args) throws Exception {
      sender.send("topicA", "Hello World");
      System.out.println("Message has been sent");
   }
}
```

Sender

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

   public void send(String topic, String message){
      kafkaTemplate.send(topic, message);
   }
}
```

application.properties

```properties
spring.kafka.bootstrap-servers=localhost:9092
spring.kafka.consumer.group-id= gid
spring.kafka.consumer.auto-offset-reset= earliest
spring.kafka.consumer.key-deserializer= org.apache.kafka.common.serialization.StringDeserializer
spring.kafka.consumer.value-deserializer= org.springframework.kafka.support.serializer.JsonDeserializer
spring.kafka.producer.key-serializer= org.apache.kafka.common.serialization.StringSerializer
spring.kafka.producer.value-serializer= org.springframework.kafka.support.serializer.JsonSerializer
spring.kafka.consumer.properties.spring.json.trusted.packages=kafka


logging.level.root= ERROR
org.springframework= ERROR
```

ReceiverApplication

```
@SpringBootApplication
@EnableKafka
public class ReceiverApplication implements CommandLineRunner {


   public static void main(String[] args) {
      SpringApplication.run(ReceiverApplication.class, args);
   }

   @Override
   public void run(String... args) throws Exception {
      System.out.println("Receiver is running and waiting for messages");
   }
}
```

Receiver

```java
@Service
public class Receiver {

   @KafkaListener(topics = {"topicA"})
   public void receive(@Payload String message) {
      System.out.println("Receiver received message= "+ message);
   }
}
```

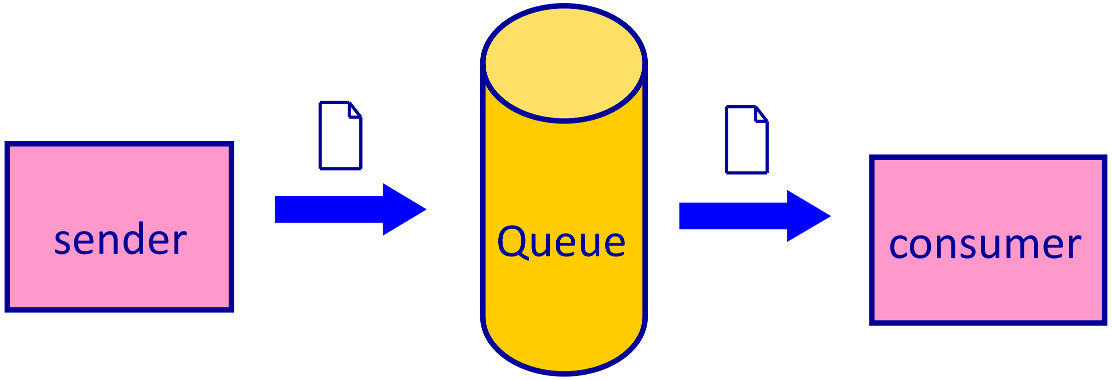
application.properties

```
spring.kafka.bootstrap-servers=localhost:9092
spring.kafka.consumer.group-id= gid
spring.kafka.consumer.auto-offset-reset= earliest
spring.kafka.consumer.key-deserializer= org.apache.kafka.common.serialization.StringDeserializer
spring.kafka.consumer.value-deserializer= org.springframework.kafka.support.serializer.JsonDeserializer
spring.kafka.producer.key-serializer= org.apache.kafka.common.serialization.StringSerializer
spring.kafka.producer.value-serializer= org.springframework.kafka.support.serializer.JsonSerializer
spring.kafka.consumer.properties.spring.json.trusted.packages=kafka


logging.level.root= ERROR
org.springframework= ERROR
```

Point-To-Point (PTP)

- A dedicated consumer per Queue message



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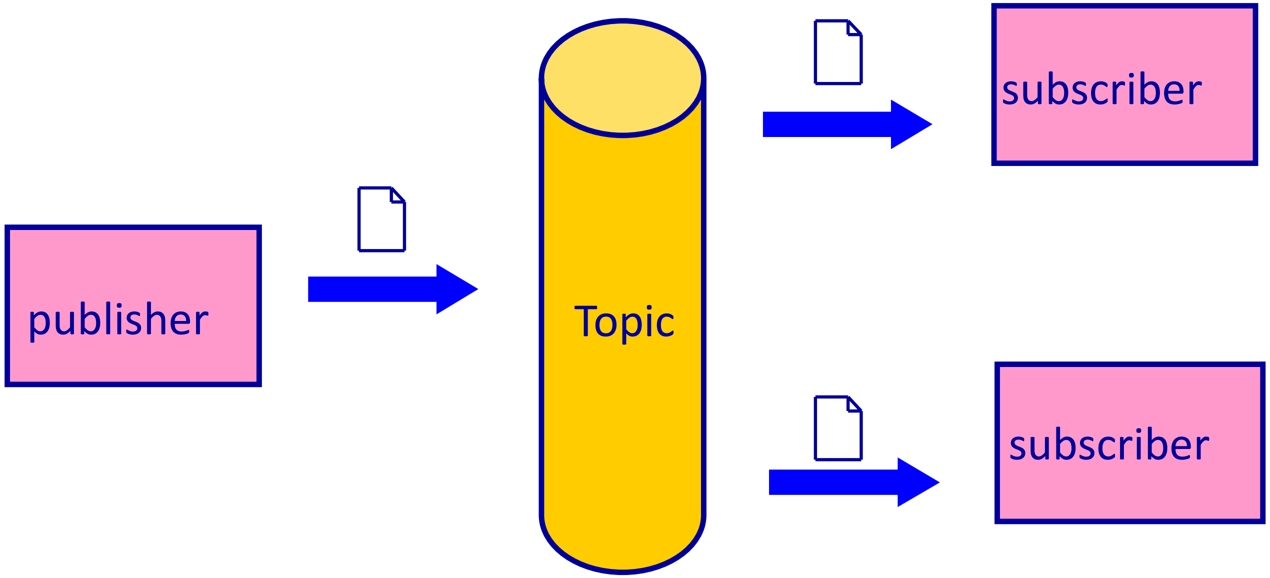
Publish-Subscribe (Pub-Sub)

- A message channel can have more than one ‘*consumer*’
  - Ideal for broadcasting



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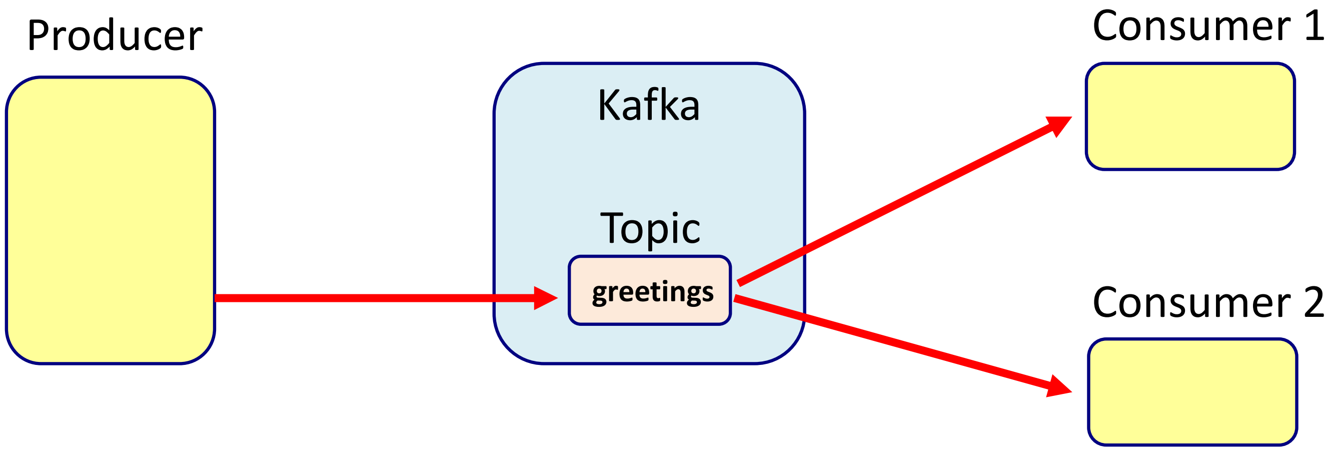
What if we have 2 consumers

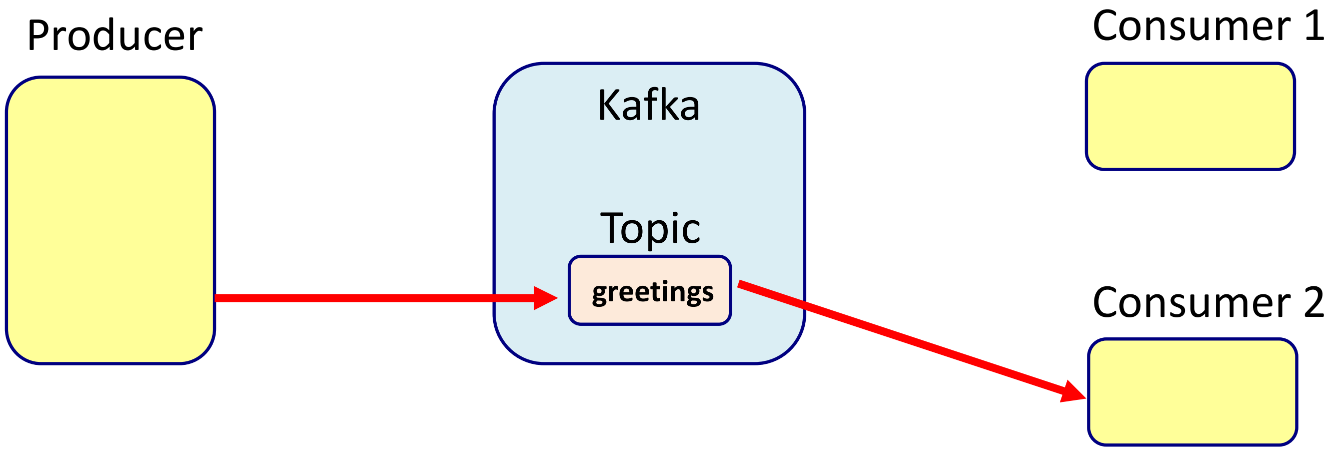
- The default behavior is pub/sub
  - Instead op point to point



- Both consumers receive the message

What if we want point to point

- Competing consumers



- Only one consumers receives the message

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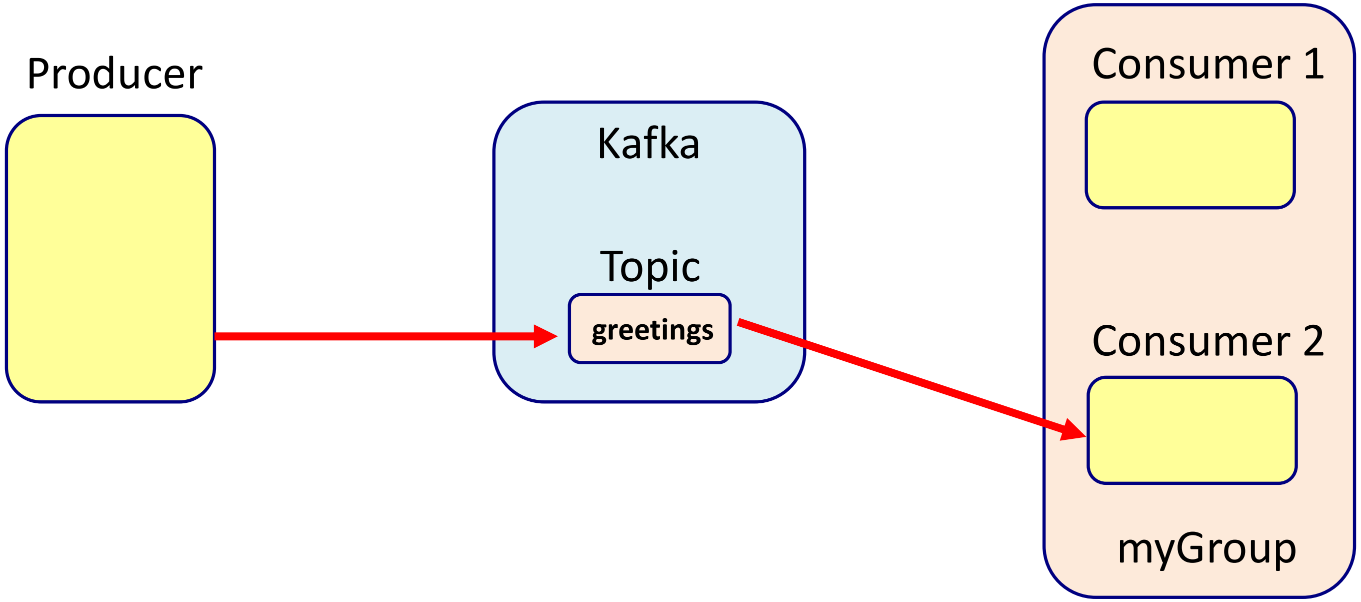
Consumer groups



application.properties

```
spring.kafka.bootstrap-servers=localhost:9092
spring.kafka.consumer.group-id= gid
…
```

Give both consumers the same group-id

Send an object: Sender

```
@SpringBootApplication
@EnableKafka
public class OrderApplication implements CommandLineRunner {
   @Autowired
   Sender sender;

   public static void main(String[] args) {
      SpringApplication.run(OrderApplication.class, args);
   }

   @Override
   public void run(String... args) throws Exception {
      sender.send("ordertopic", new Order("A1276", LocalDate.now()+"", 1200.0));
      System.out.println("Order has been sent");
   }
}
```

```
public class Order {
   private String orderNumber;
   private String date;
   private double amount;
```

Sender

```java
@Service
public class Sender {
   @Autowired
   private KafkaTemplate<String, Order> kafkaTemplate;

   public void send(String topic, Order order){
      kafkaTemplate.send(topic, order);
   }
}
```

application.properties

```properties
spring.kafka.bootstrap-servers=localhost:9092
spring.kafka.consumer.group-id= gid
spring.kafka.consumer.auto-offset-reset= earliest
spring.kafka.consumer.key-deserializer= org.apache.kafka.common.serialization.StringDeserializer
spring.kafka.consumer.value-deserializer= org.springframework.kafka.support.serializer.JsonDeserializer
spring.kafka.producer.key-serializer= org.apache.kafka.common.serialization.StringSerializer
spring.kafka.producer.value-serializer= org.springframework.kafka.support.serializer.JsonSerializer
spring.kafka.consumer.properties.spring.json.trusted.packages=kafka


logging.level.root= ERROR
org.springframework= ERROR
```

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Receiver Application

```
@SpringBootApplication
@EnableKafka
public class OrderApplication  {


   public static void main(String[] args) {
      SpringApplication.run(OrderApplication.class, args);
   }

}
```

```
public class Order {
   private String orderNumber;
   private String date;
   private double amount;
```

Receiver

```
@Service
public class Receiver {

    @KafkaListener(topics = {"ordertopic"})
    public void receive(@Payload Order order) {
        System.out.println("OrderReceiver 1 received order="+ order);
    }
}
```

application.properties

```
spring.kafka.bootstrap-servers=localhost:9092
spring.kafka.consumer.group-id= gid
spring.kafka.consumer.auto-offset-reset= earliest
spring.kafka.consumer.key-deserializer= org.apache.kafka.common.serialization.StringDeserializer
spring.kafka.consumer.value-deserializer= org.springframework.kafka.support.serializer.JsonDeserializer
spring.kafka.producer.key-serializer= org.apache.kafka.common.serialization.StringSerializer
spring.kafka.producer.value-serializer= org.springframework.kafka.support.serializer.JsonSerializer
spring.kafka.consumer.properties.spring.json.trusted.packages=kafka


logging.level.root= ERROR
org.springframework= ERROR
```

STREAM BASED ARCHITECTURE

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Stream based systems

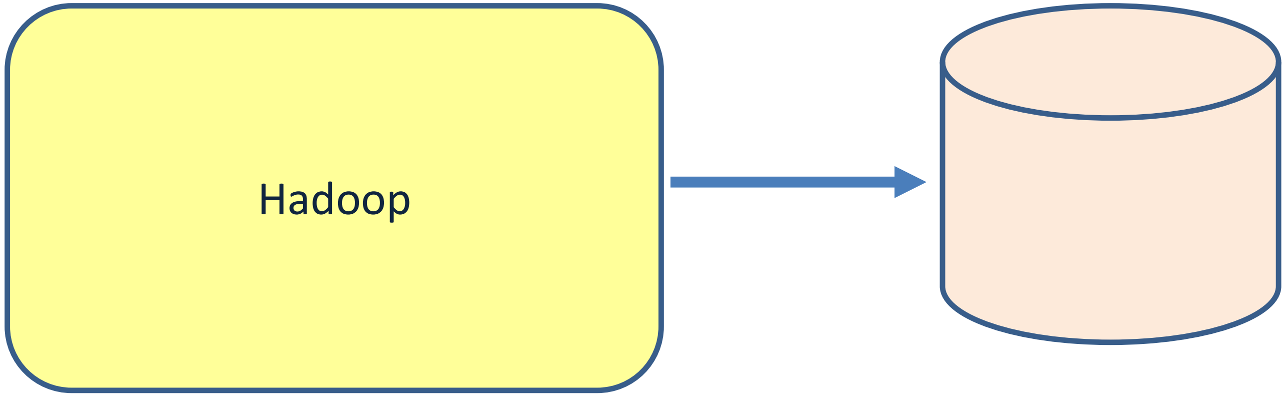
- Continuous stream of data
  - Stock market systems
  - Social networking systems
  - Internet of Things (IoT)systems
  - Systems that handle sensor data
  - System that handle logfiles
  - Systems that monitor user clicks
  - Car navigator software

But also

- Stream of purchases in web shop
- Stream of transactions in a bank
- Stream of actions in a multi user game
- Stream of bookings in a hotel booking system
- Stream of user actions on a web application
- …

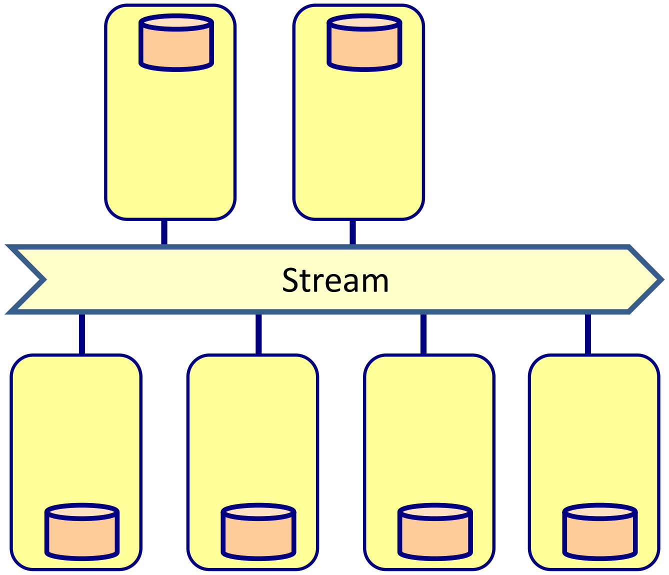
Batch processing

- First store the data in the database
- Then do queries (map-reduce) on the data
- Queries over all or most of the data in the dataset.
- Latencies in minutes to hours



Stream processing

- Handle the data when it arrives
- Handle event (small data) by event
- Latencies in seconds or milliseconds



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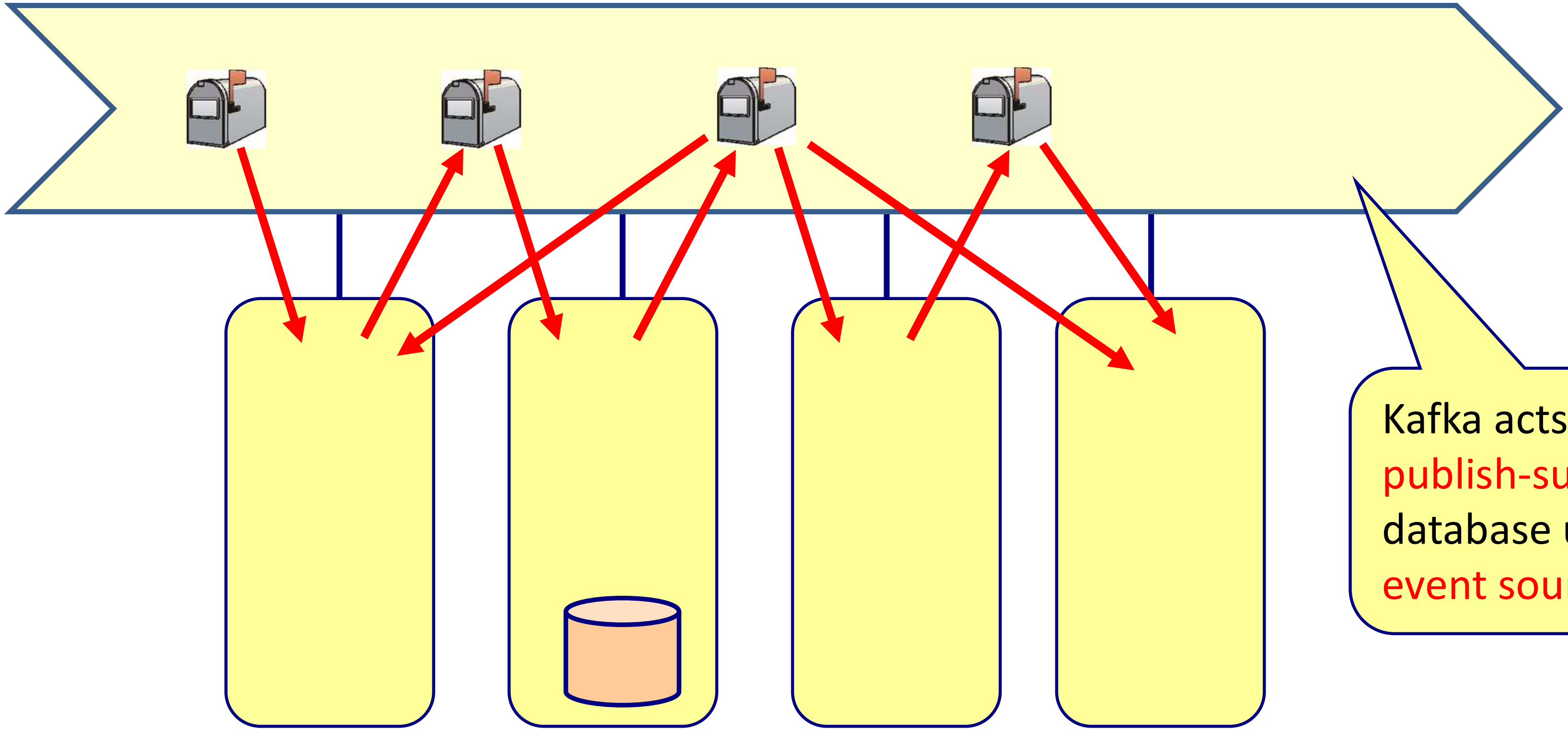
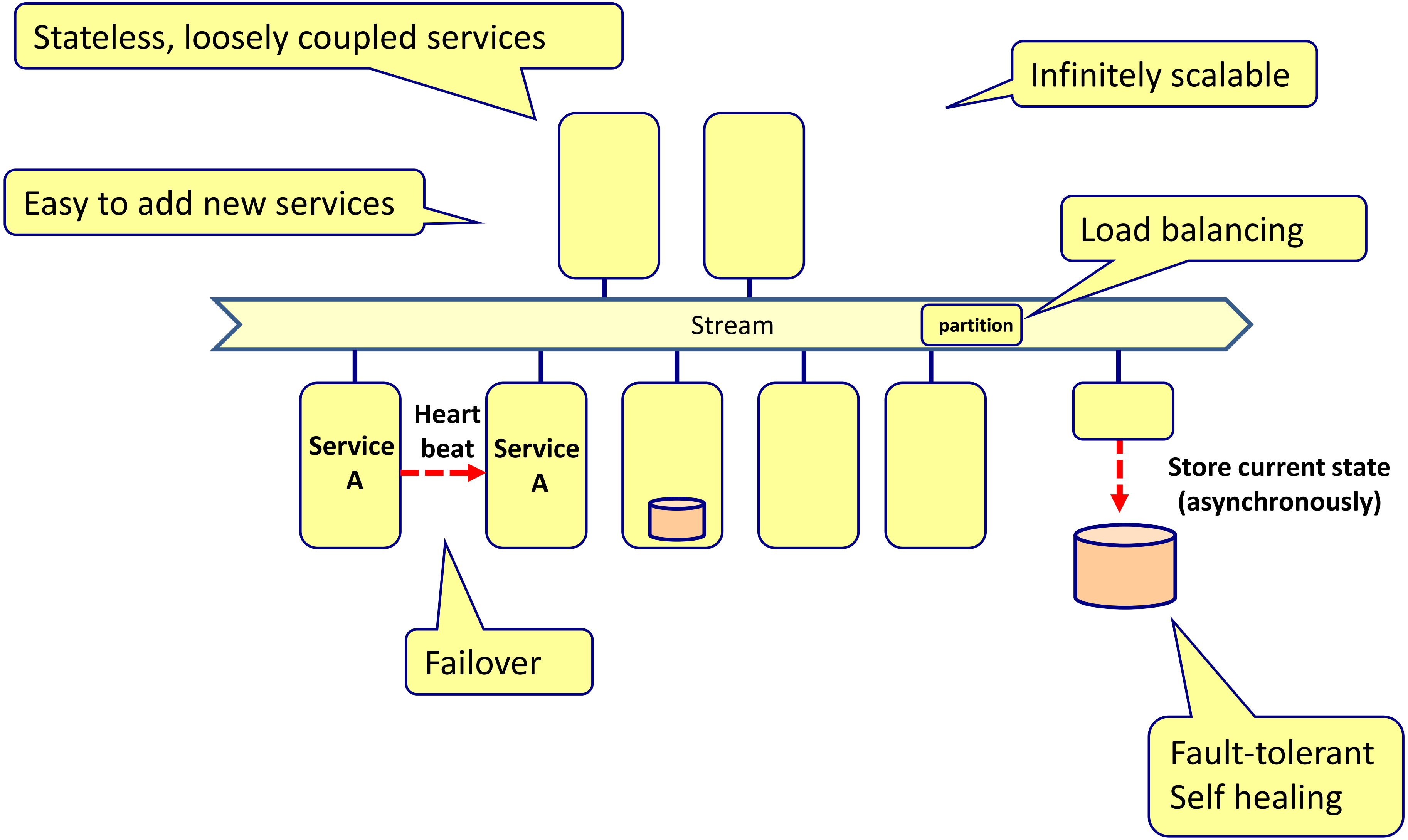
Publish-subscribe and event sourcing



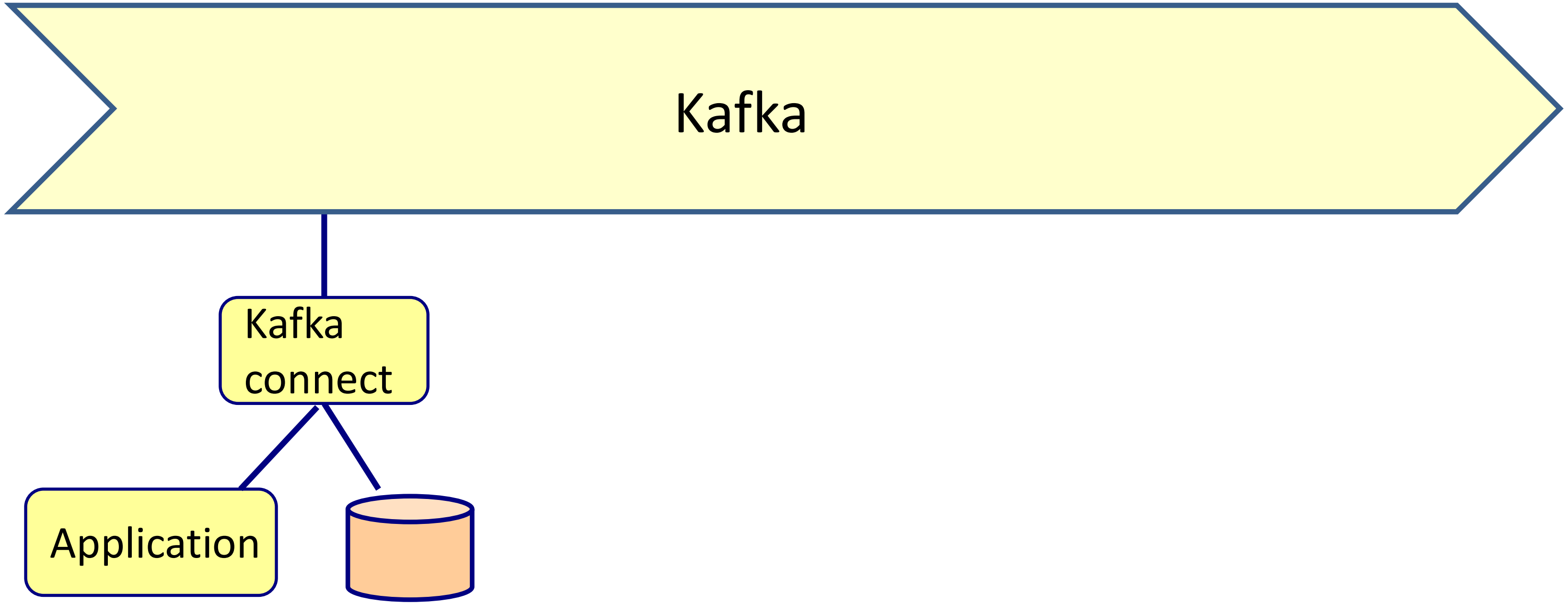
Kafka acts as a publish-subscribe database using event sourcing

Stream based architecture

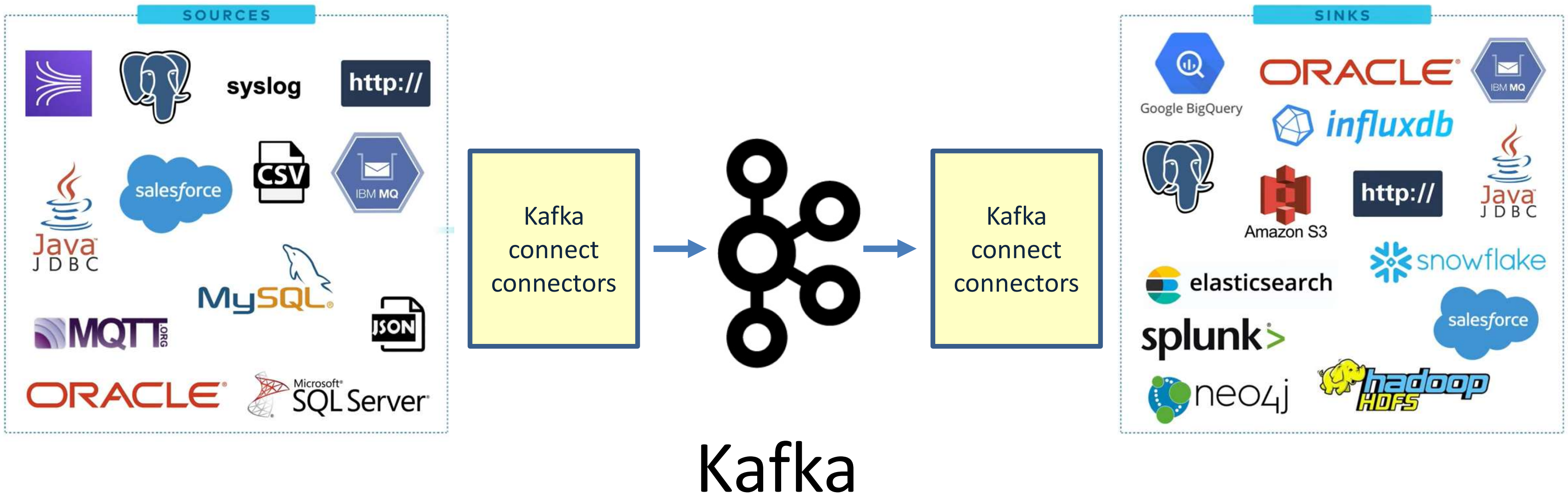


KAFKA ECOSYSTEM

Kafka ecosystem: Kafka connect



Kafka connect

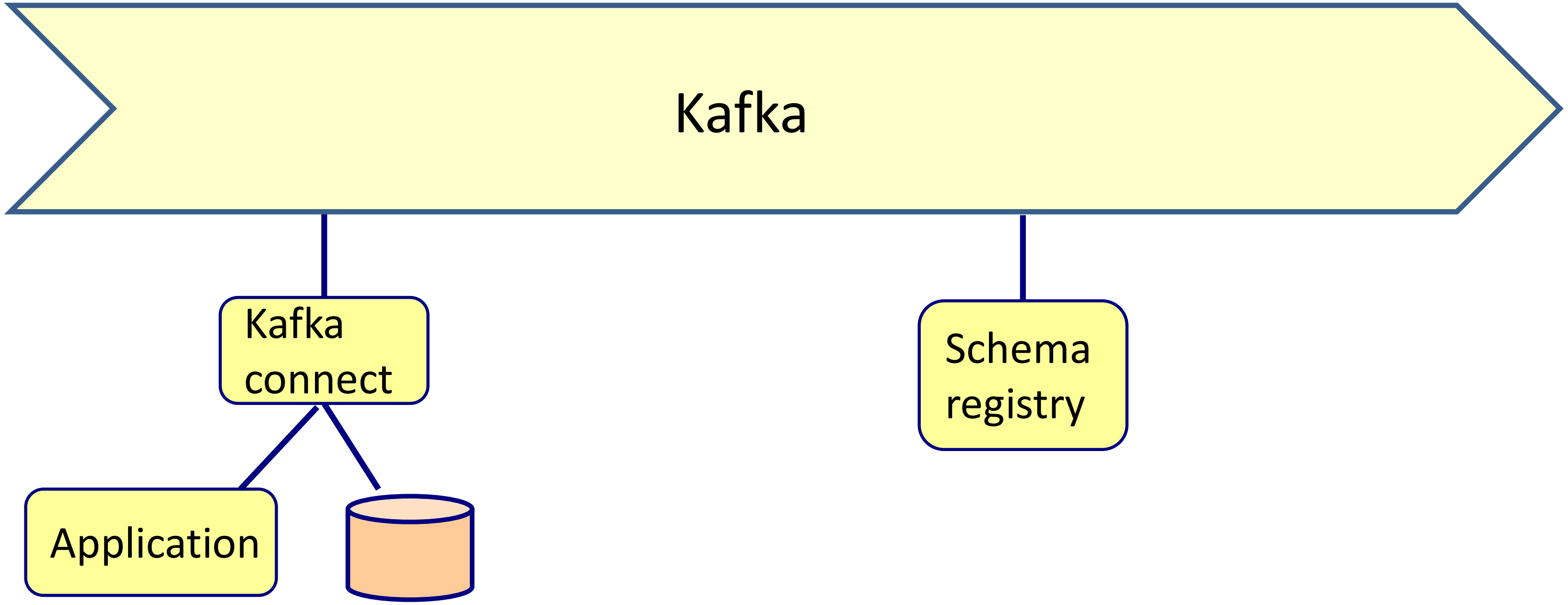


Kafka connect connectors

Kafka connect connectors

Kafka

Kafka ecosystem: Schema registry



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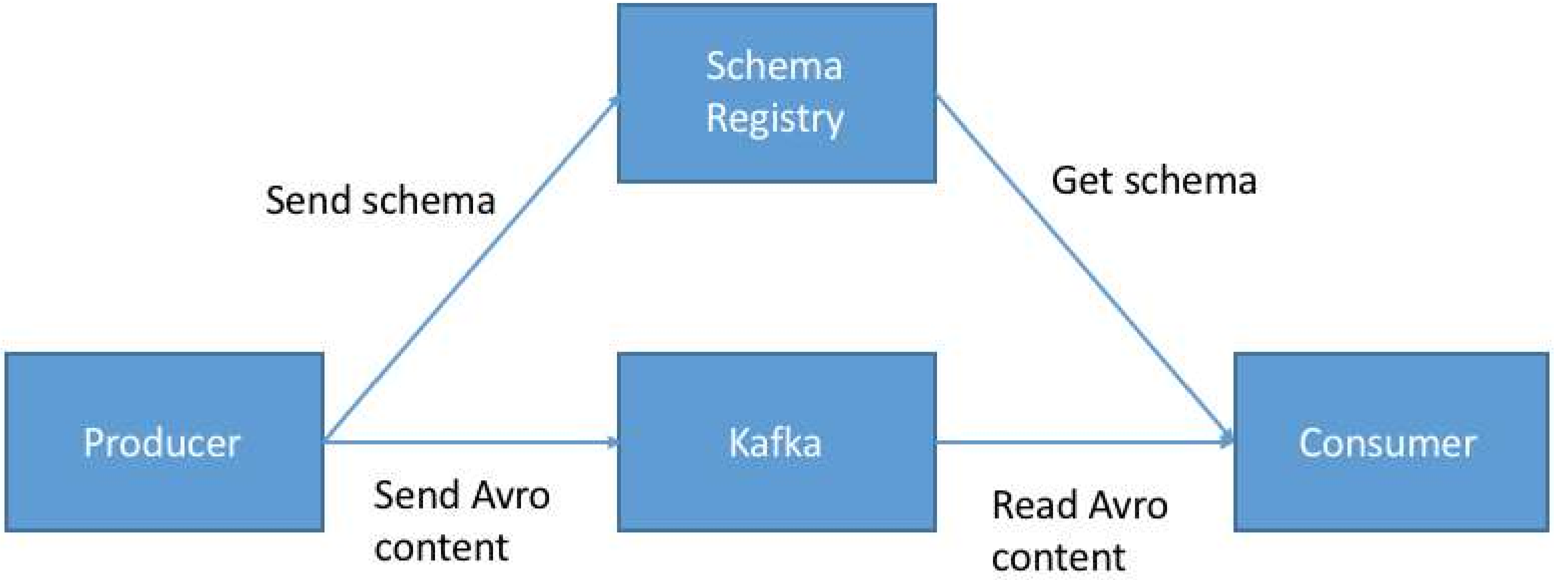
Need for a schema registry

- What if the producer sends bad data?
- What if a field gets renamed?
- What if the data format changes ?

- The consumer breaks

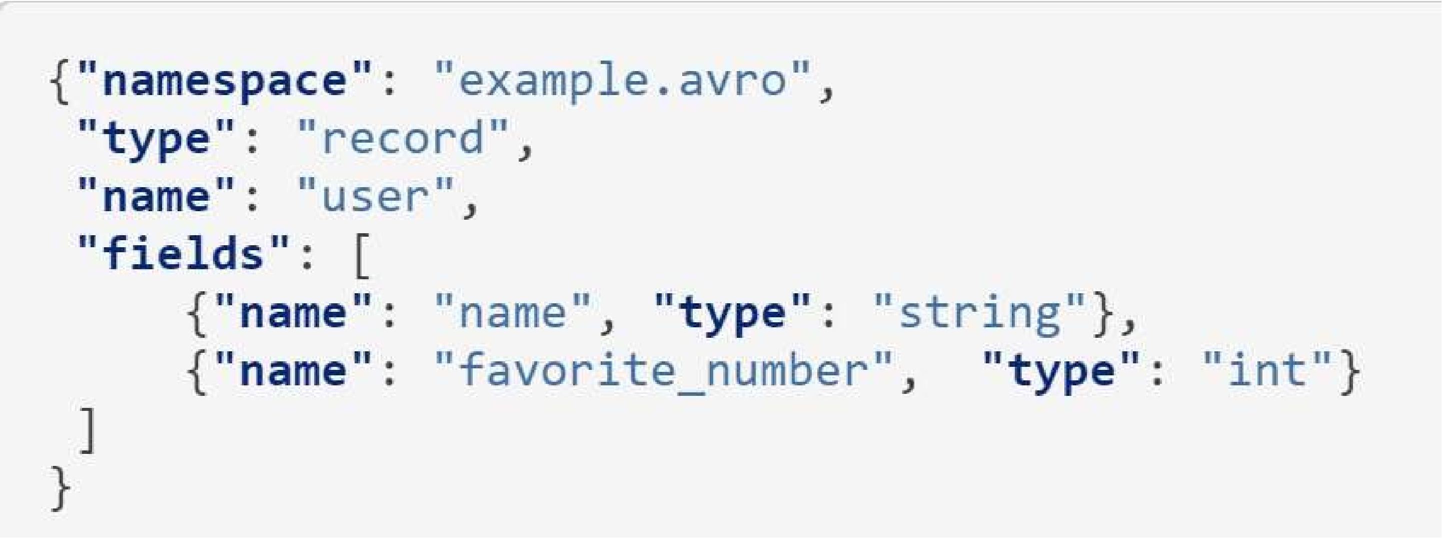
Kafka does not verify the message

- Schema registry is a separate component (server)
- Maintains a database of schema’s



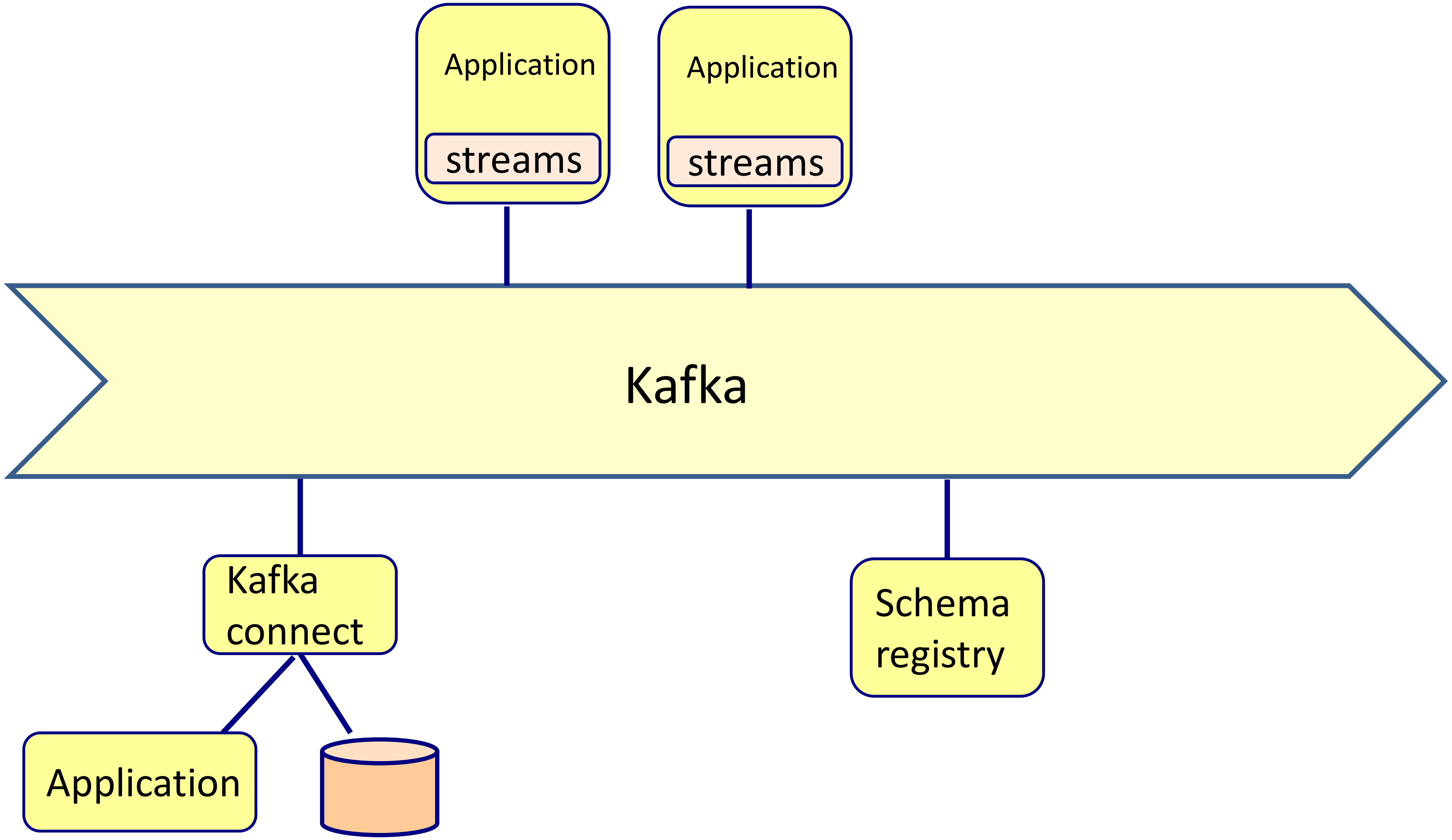
Avro

- JSON + schema
  - Data is fully typed
  - Schema is in the data
  - Schema can evolve over time



```
{"namespace": "example.avro",
 "type": "record",
 "name": "user",
 "fields": [
     {"name": "name", "type": "string"},
     {"name": "favorite_number",  "type": "int"}
 ]
}
```

Kafka ecosystem: Kafka streams



Kafka streams

- Java library for making stream processing simpler
  - Simple concise code
  - Threading and parallelism
  - Stream DSL (map, filter, aggregations, joins,…)

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Kafka security

- Authentication
  - Are you allowed to access kafka?
  - SSL & SASL
    - Using certificates
- Authorization
  - Who is allowed to publish or consume which topic?
  - Access Control Lists (ACL)
- Encryption
  - Data sent is not readable by others
  - SSL
    - Only inflight security