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Introduction to Apache Kafka

- Describe the evolution of event-driven architecture
- What is Apache Kafka?
- List some use cases for Kafka
- Describe basic Kafka concepts
- Work with the Kafka command-line interface

The event-driven evolution

87%
of companies are
transforming to be more
customer-centric

Source: A commissioned study conducted by Forrester Consulting on
behalf of IBM, September 2016
IBM Event Streams / WD107 / © 2019 IBM Corporation



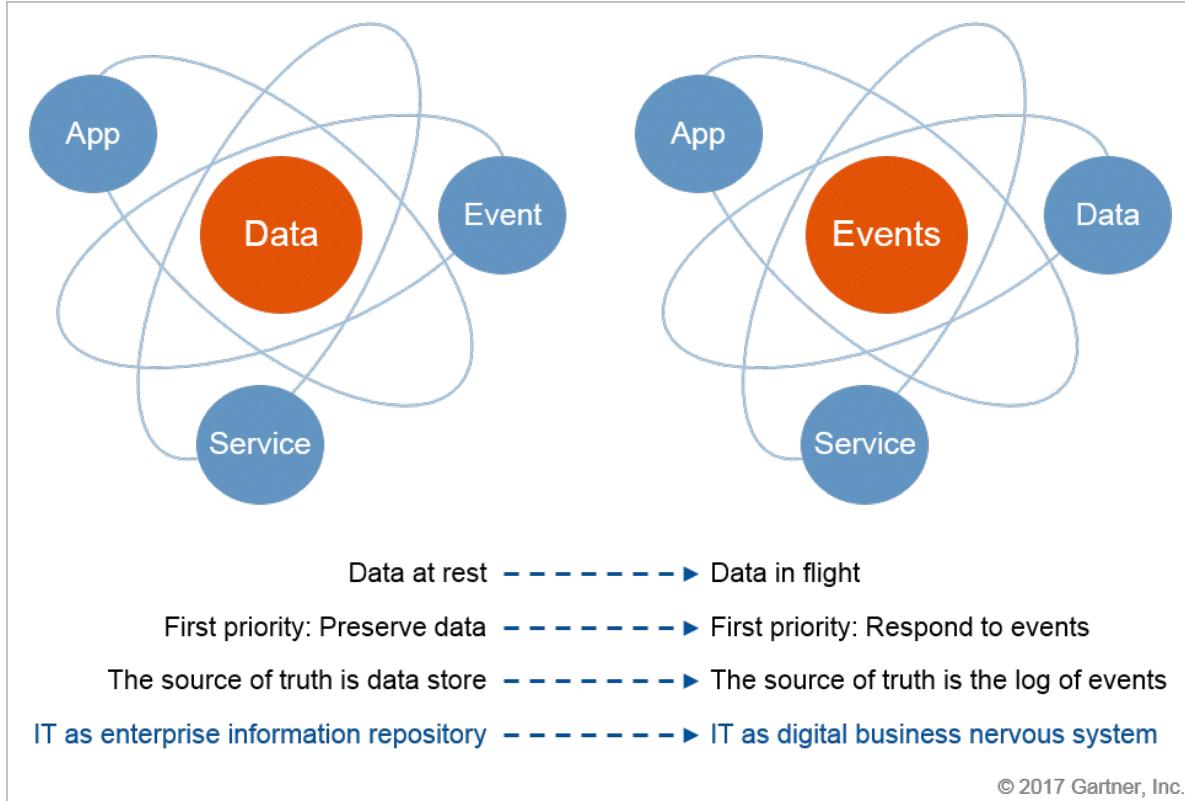
Typical Event-driven Use Case | Customer Satisfaction



‘Zoom Air’ is a commercial airline

Re-accommodate passengers
before they realize their journey
has been disrupted

Data-centric to event-centric



Source: Gartner May 2017, "CIO Challenge: Adopt Event-Centric IT for Digital Business Success"
IBM Event Streams / WD107 / © 2019 IBM Corporation

Event-Driven in Action

Getting data to where it's needed, before it's needed



**Respond to events before
the moment passes**

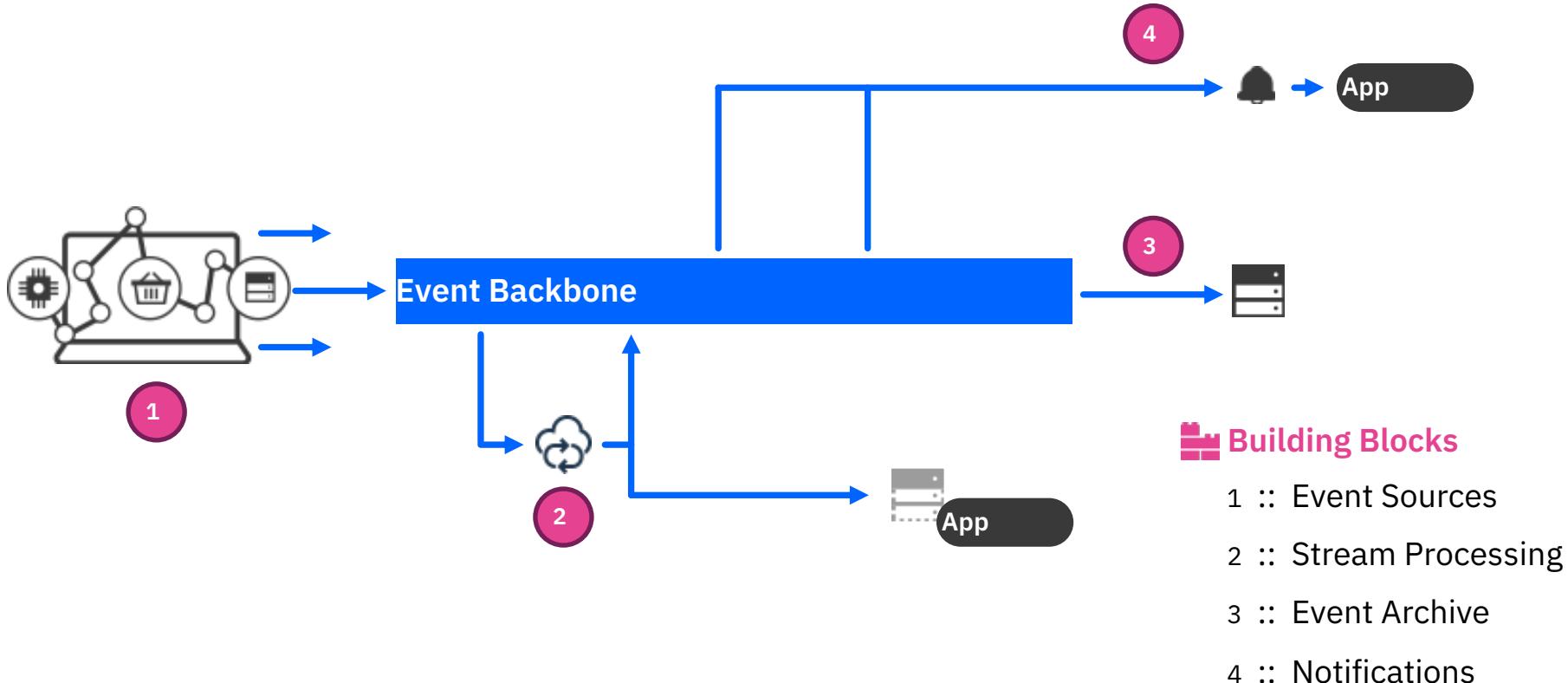


**Responsive & personalised
customer experiences**



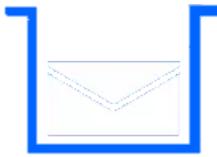
**Bring real time intelligence
to your apps**

Components of an event-streaming application

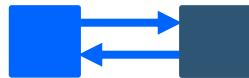


Two Styles of Messaging

MESSAGE QUEUING



Transient data persistence

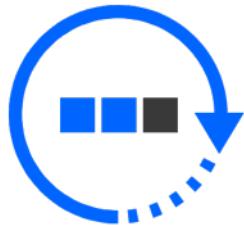


Request/reply

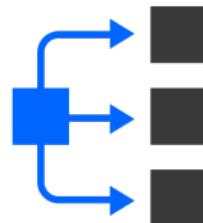


Targeted reliable delivery

EVENT STREAMING



Stream history

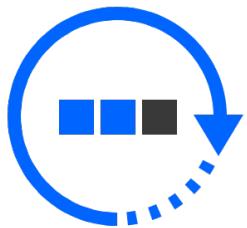


Scalable consumption

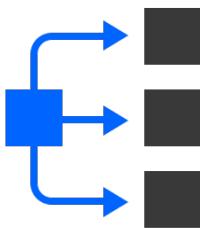


Immutable data

Properties of the Event Backbone



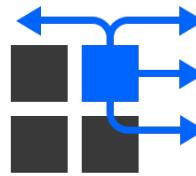
Stream history



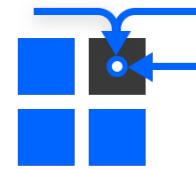
Scalable
consumption



Immutable data



Scalable



Highly available

What is Apache Kafka?

What is Apache Kafka?



An open-source project, originally created by LinkedIn

Designed for real-time activity streams

Can handle hundreds of reads/writes per second from many clients

Distributed and highly scalable: designed for partitioning over a cluster

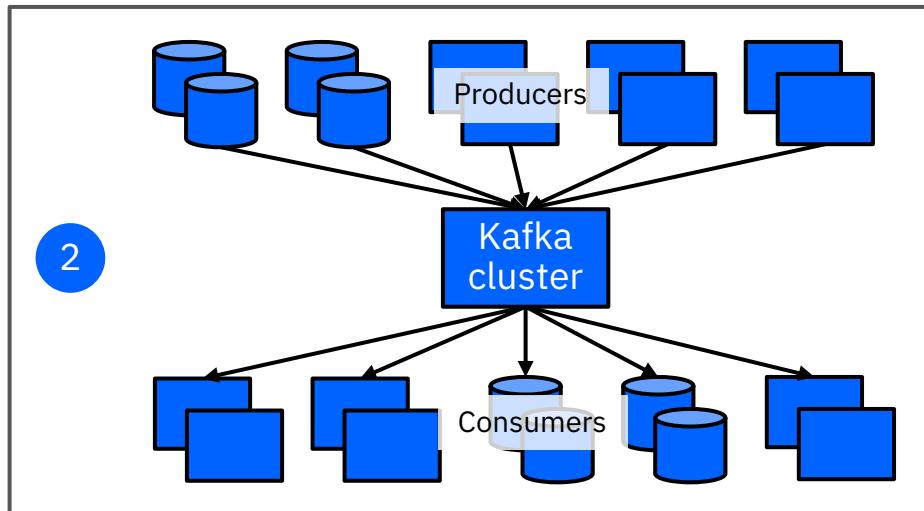
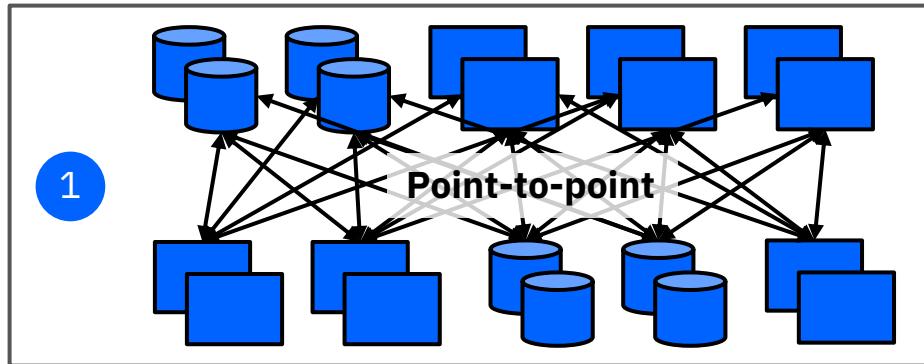
Can grow elastically and transparently with no downtime

Fault-tolerant: messages are persisted to disk and replicated within the cluster

Kafka decouples data pipeline

LinkedIn had dozens of data systems and repositories that connected in a geographically distributed point-to-point network.

Kafka was created as a centralized online data pipeline to decouple these systems.



Kafka use cases

- Messaging: publish/subscribe
- Real-time website user activity tracking
- Collecting operations metrics
- Collecting log data
- Processing data streams
- And more



Kafka basic concepts

Kafka basic concepts

Broker: a server in a Kafka cluster

Topic: a user-defined category to which messages are published

Partition: a topic is made up of one or more partitions

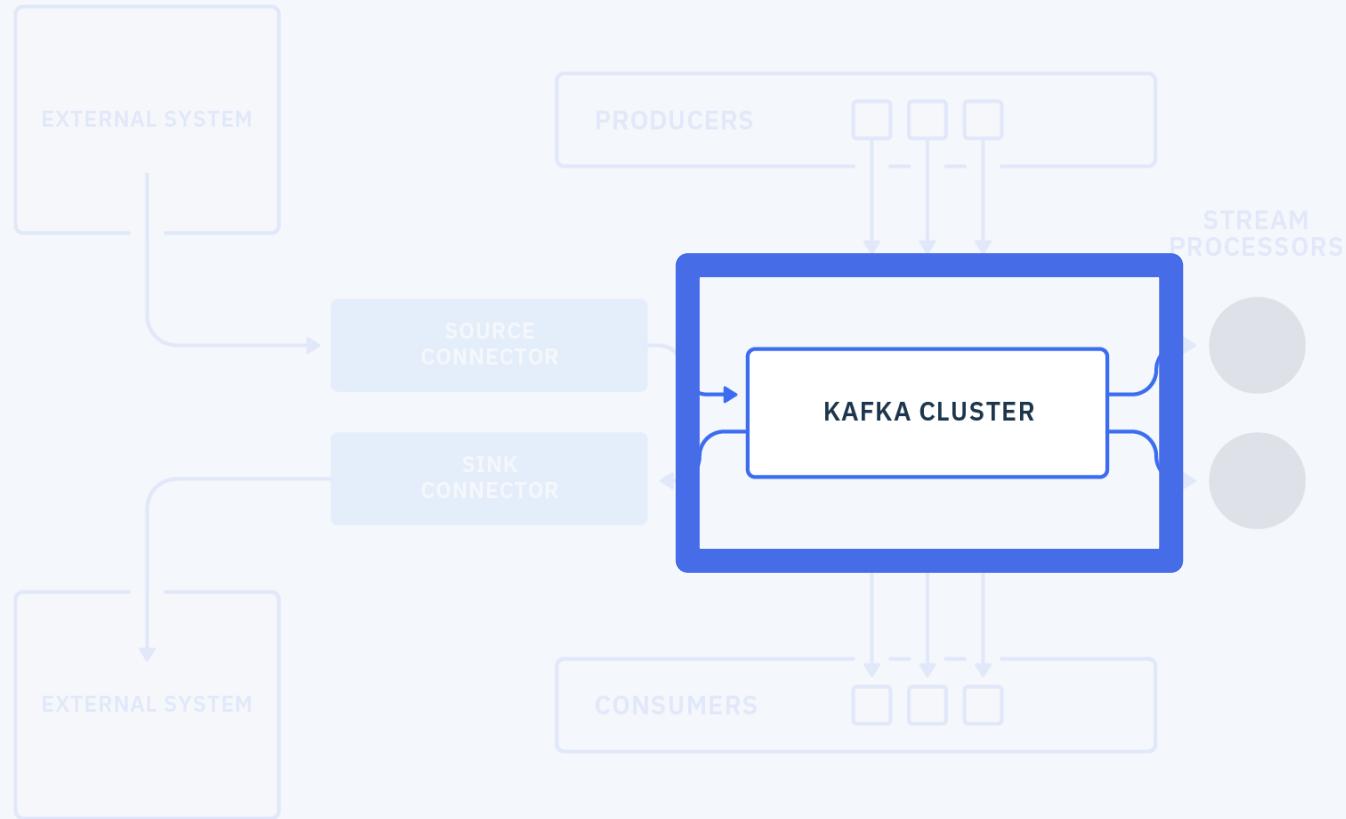
Replication: each topic can be replicated to multiple brokers

Consumers: read topics and consume messages from topic partitions

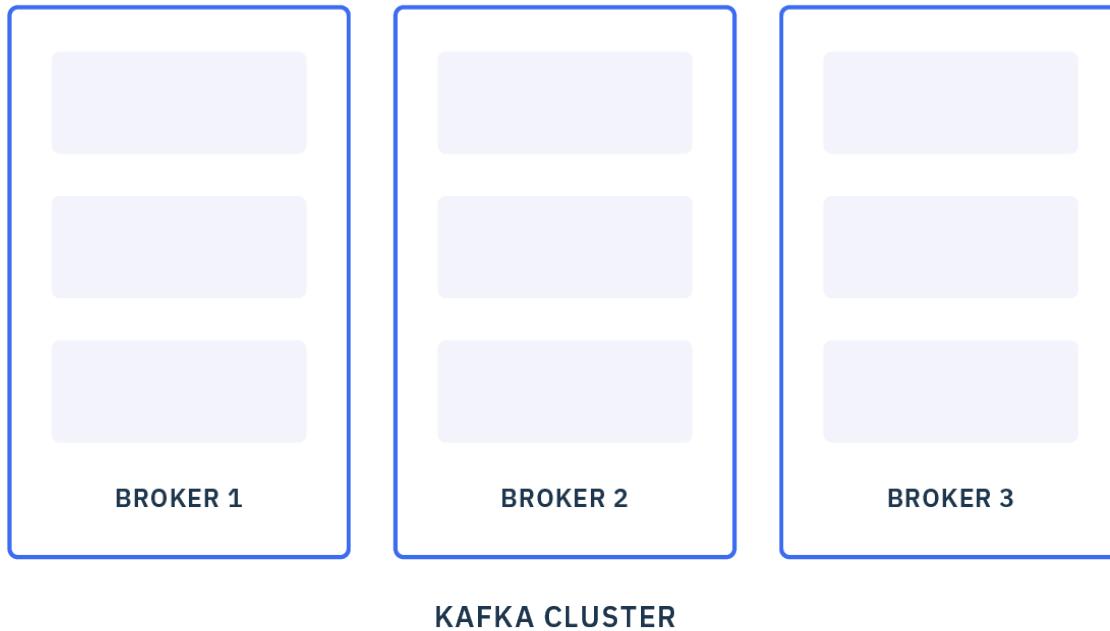
Producers: publish messages to a topic

Stream: an unbounded flow of data





Brokers



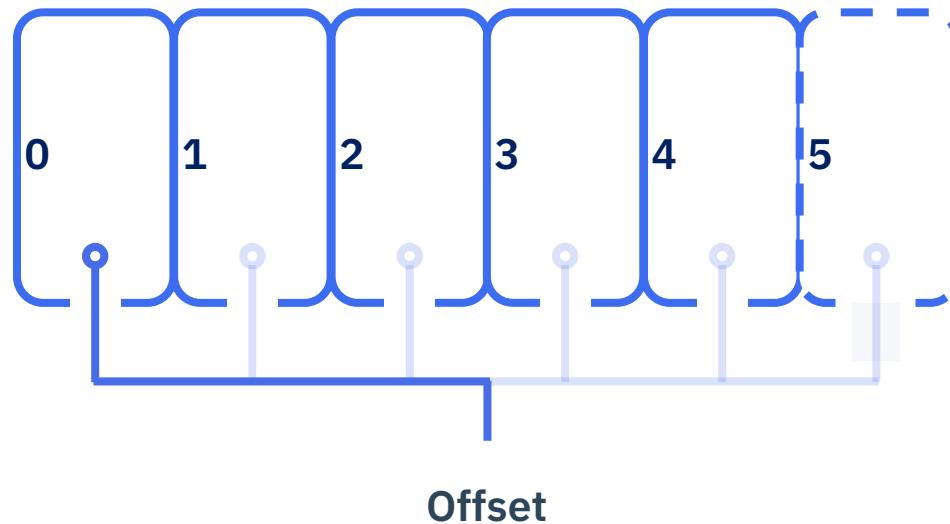
Topics

Topics are an immutable sequence of records

An individual record is made up of a key and a value

Messages are assigned a sequential ID number called an **offset**

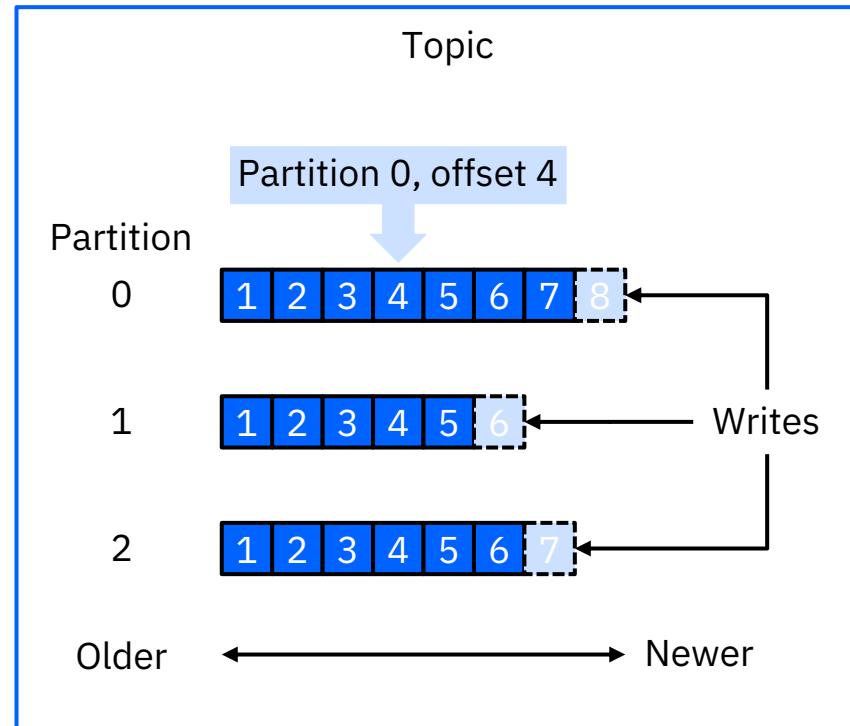
Messages are appended to the end; offset number increases



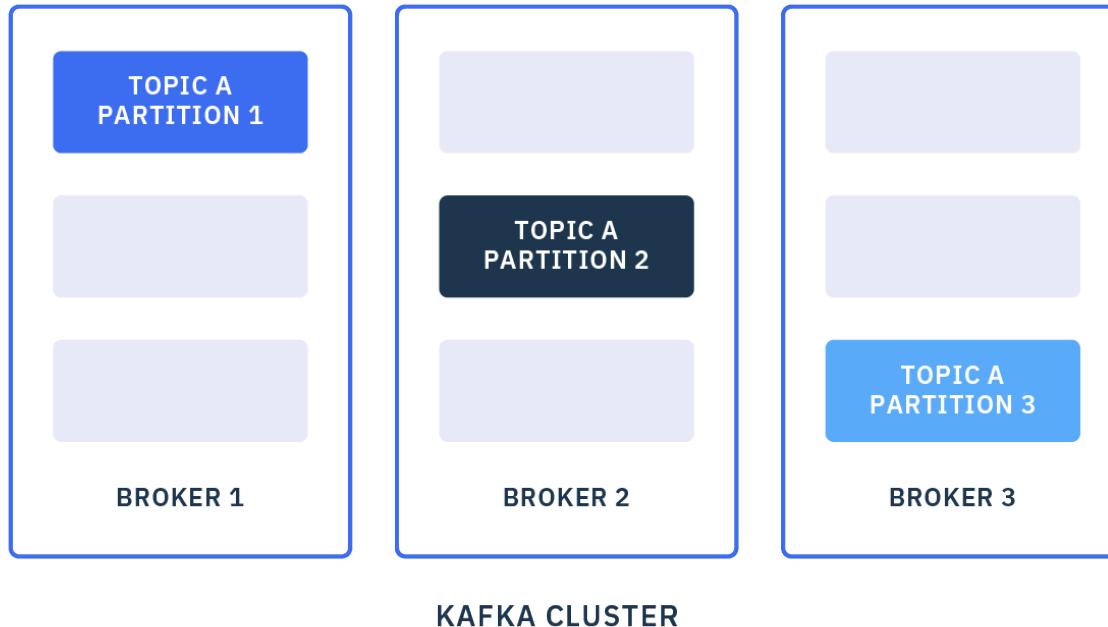
Partitions

A topic is made up of one or more partitions

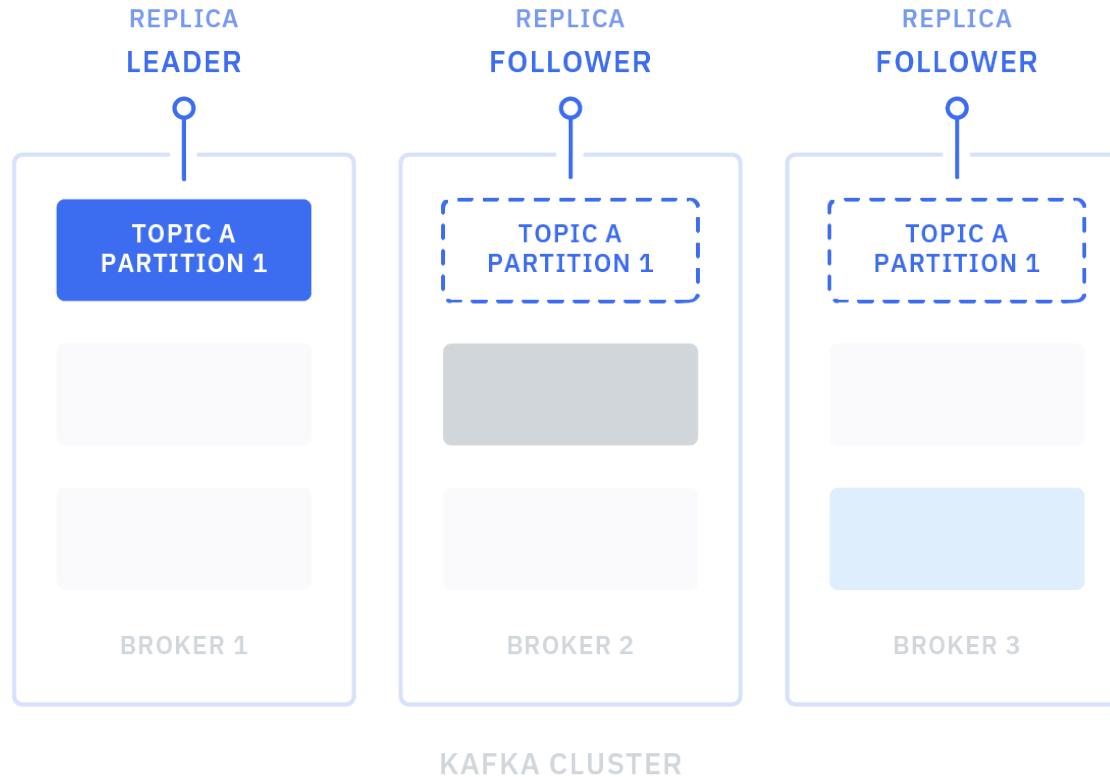
A partition is an ordered, immutable sequence of messages that is continually appended to



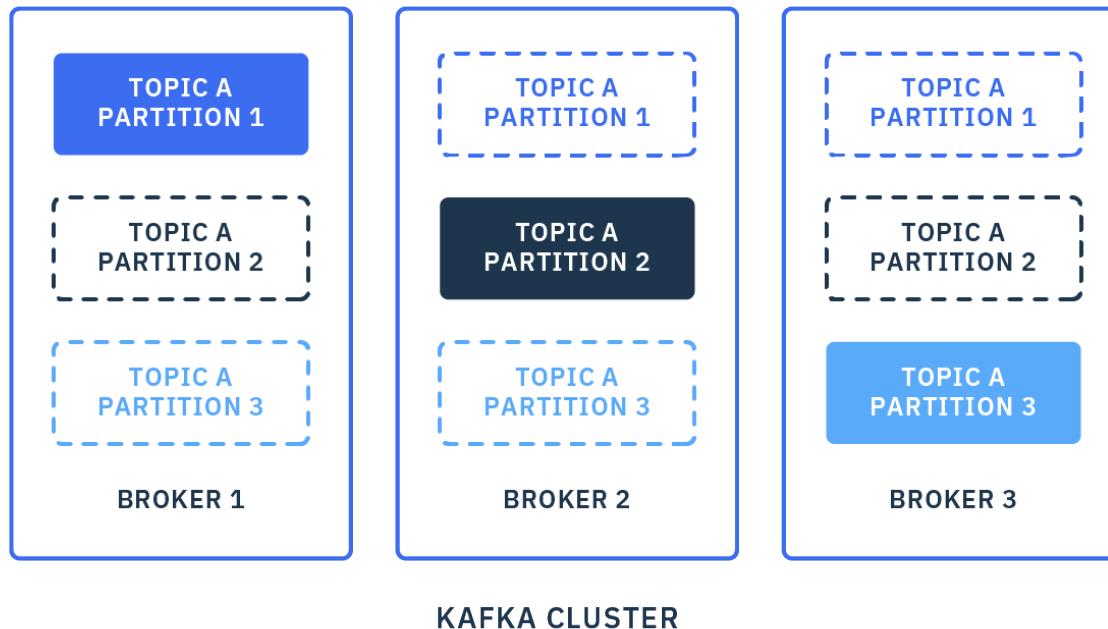
Partitions



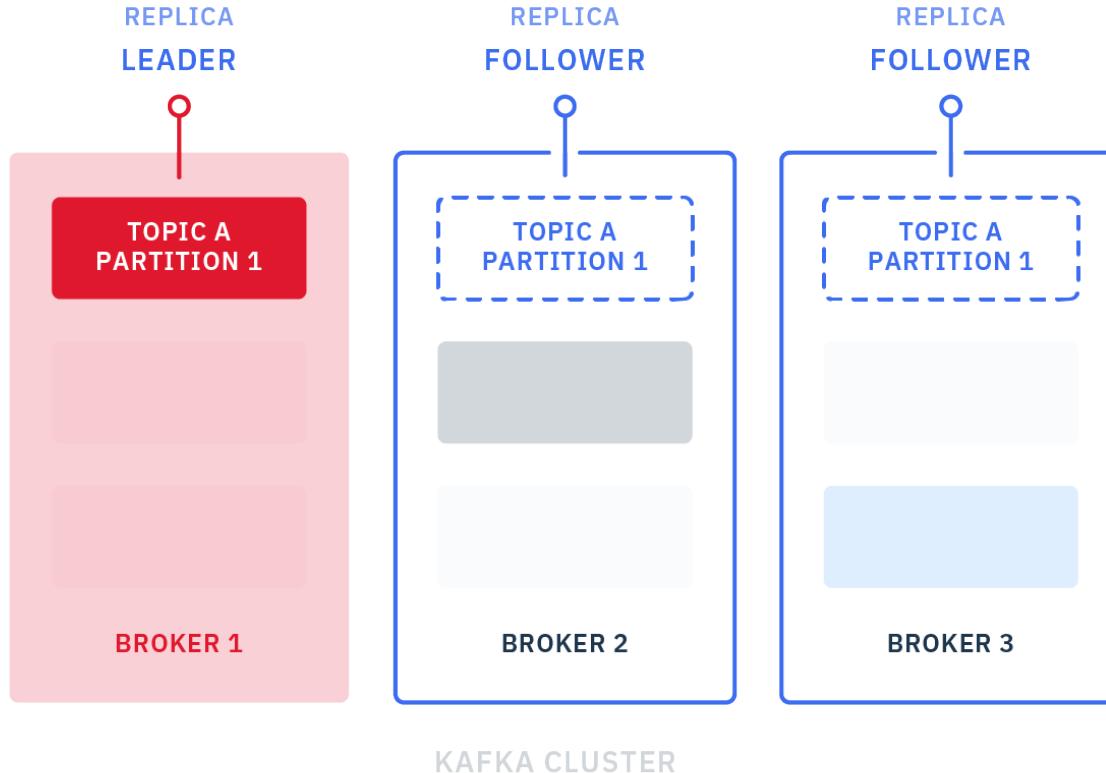
Replication



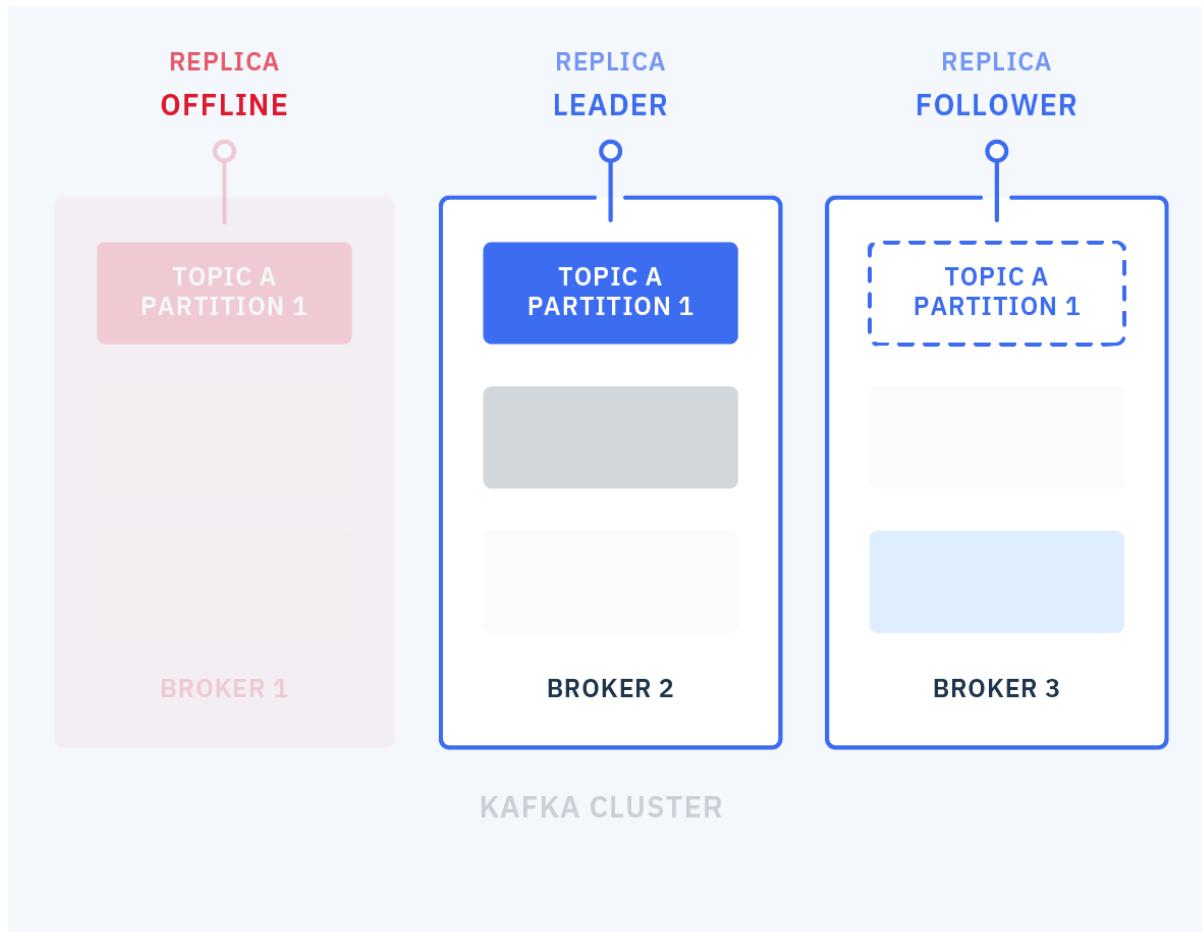
Replication



Replication



Replication



Retention period and compaction

Retention set in time or size

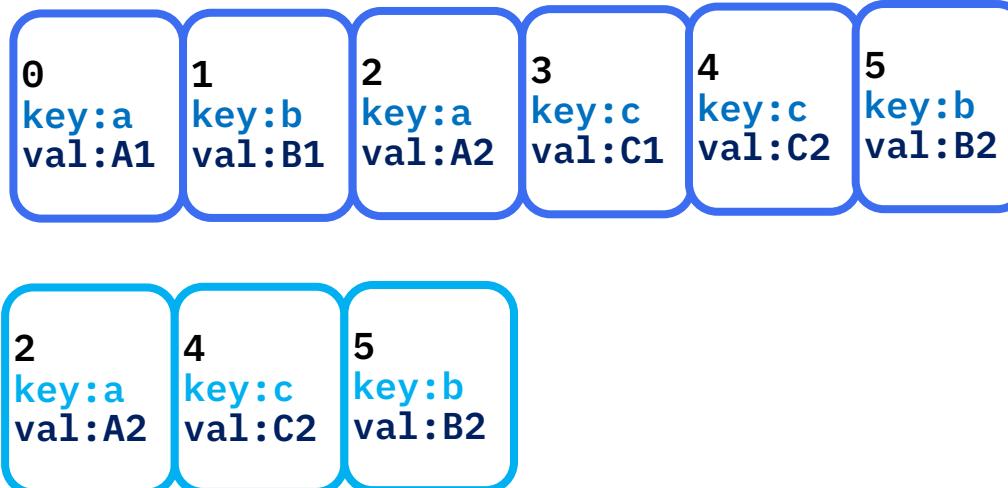
Compacted topics are evolving data stores

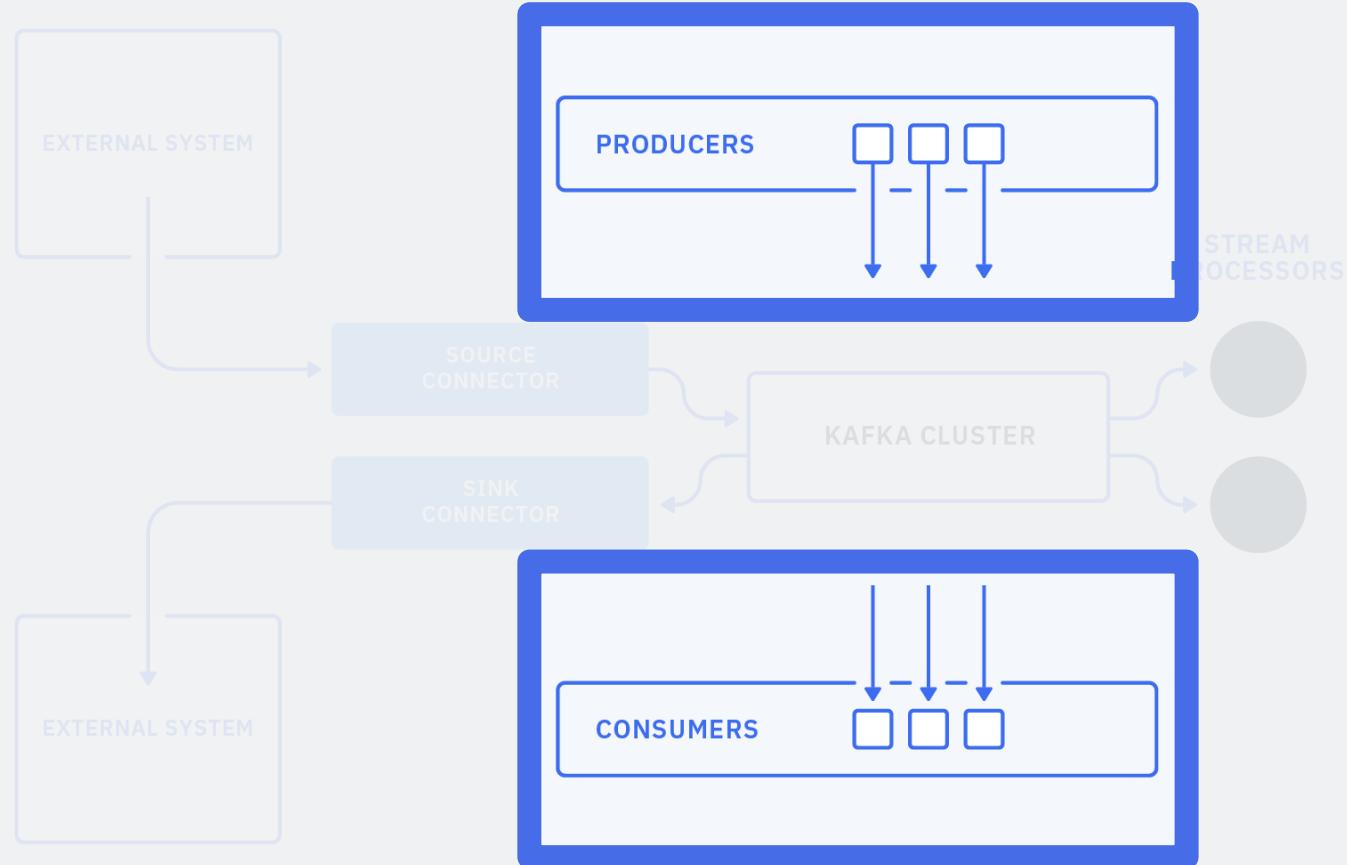
```
log.retention.minutes = 3000  
log.retention.bytes    = 1048
```

PARTITION 0

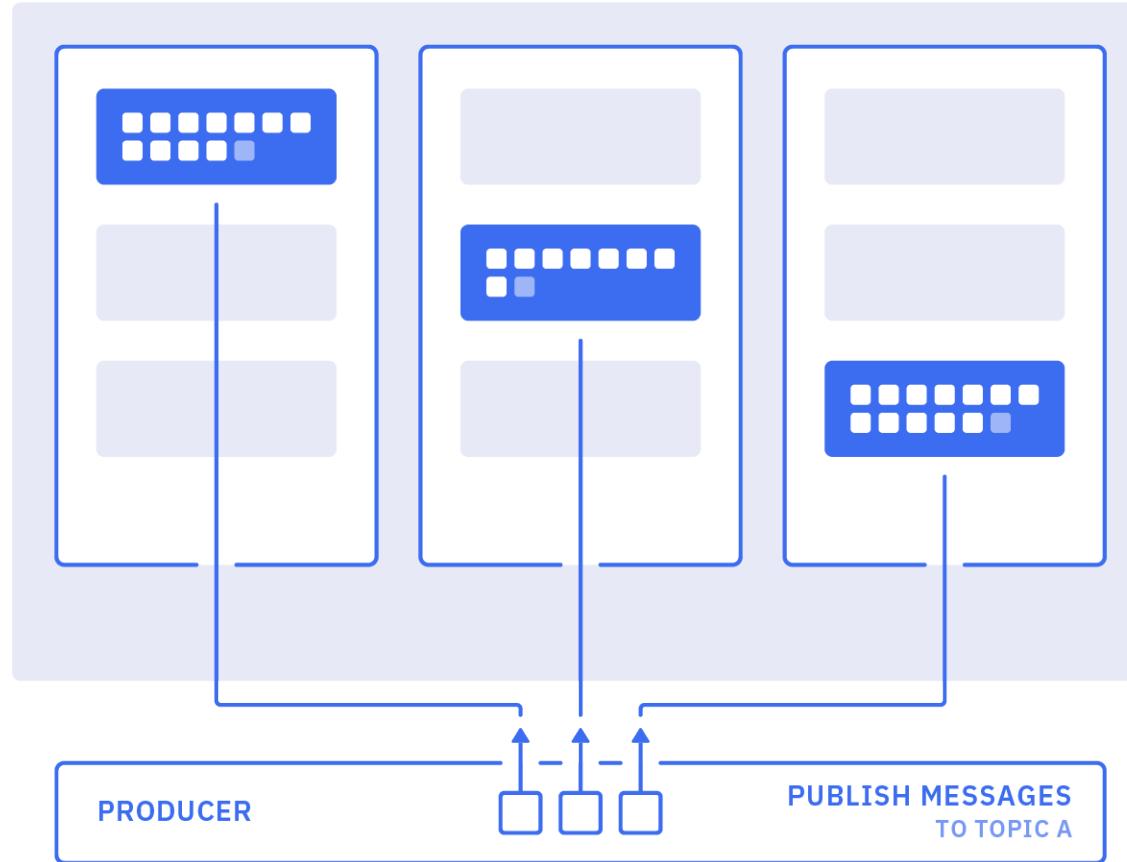


PARTITION 0
(REWRITTEN)

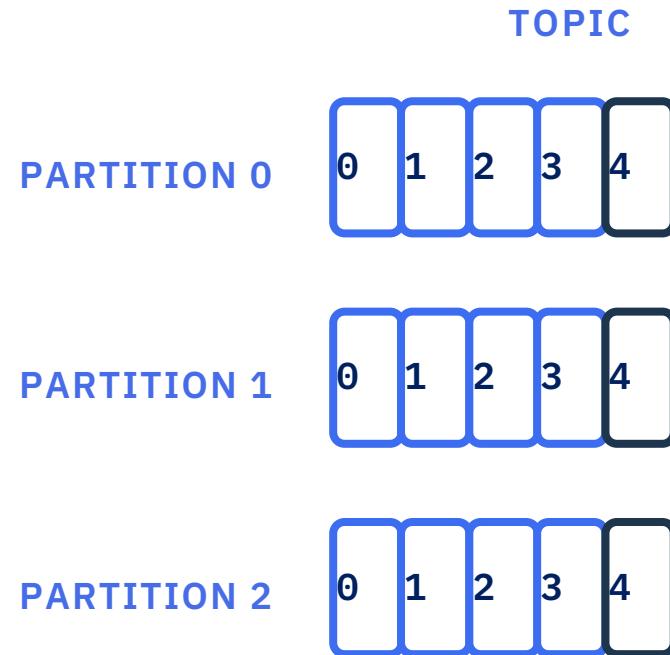




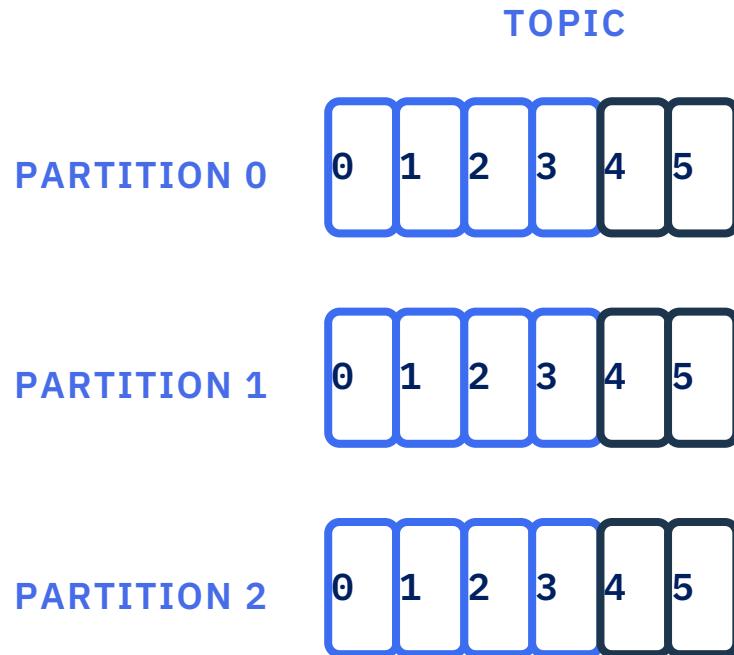
Producers



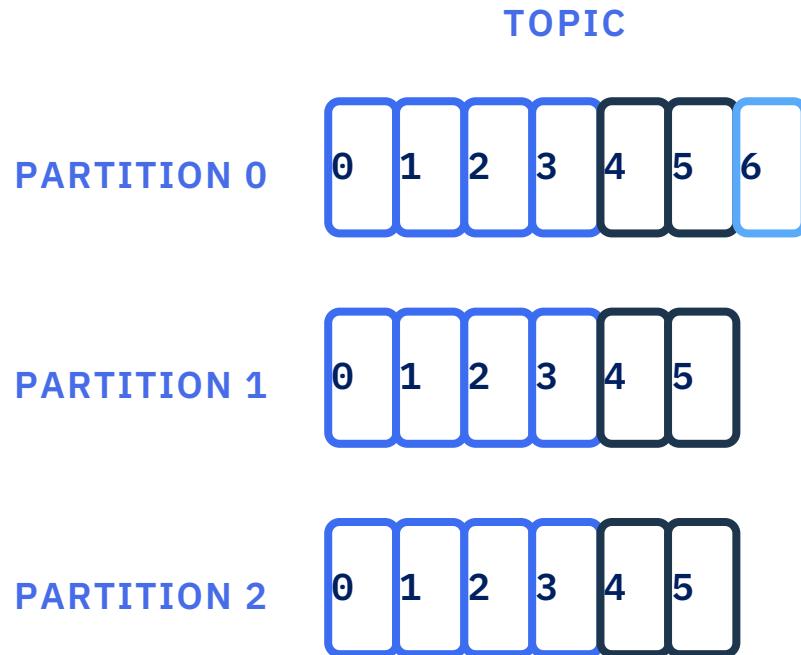
Producers and Keys



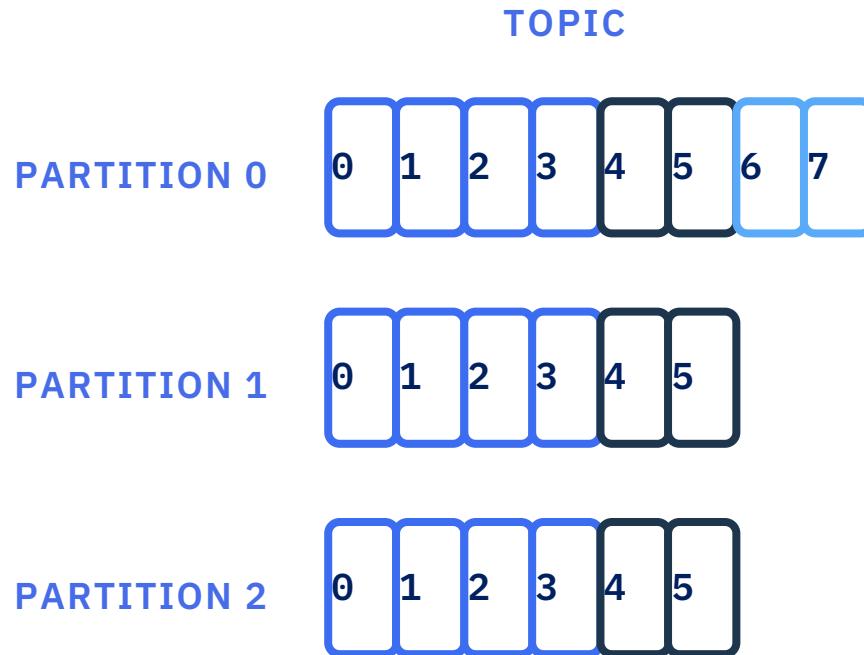
Producers and Keys



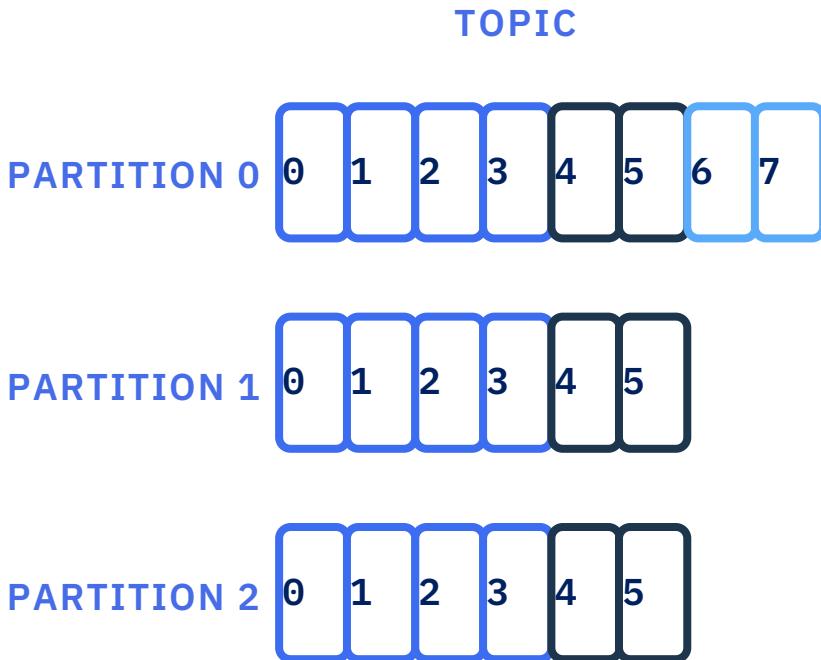
Producers and Keys



Producers and Keys



Producers



Producer can choose acknowledgement level:

- 0** Fire-and-forget
Fast, but risky
- 1** Waits for 1 broker to acknowledge
- ALL** Waits for all replica brokers to acknowledge

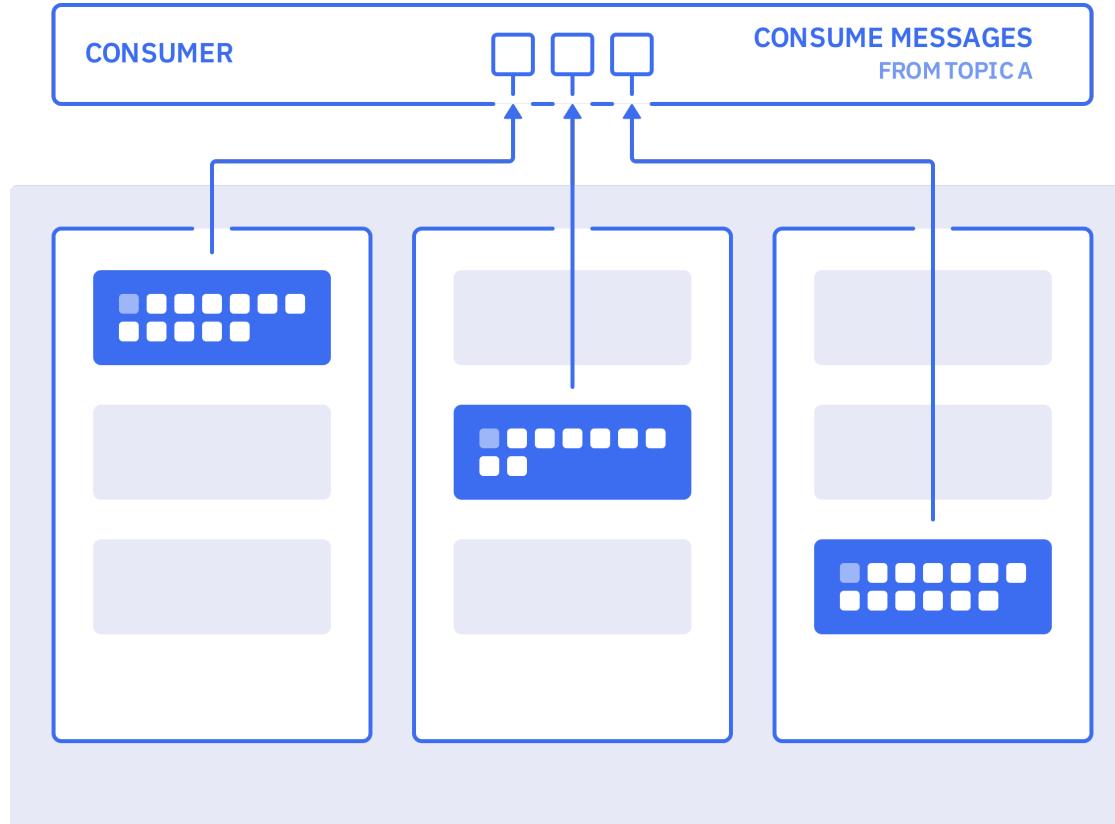
Producer can choose whether to retry:

- 0** Do not retry
Loses messages on error
- >0** Retry
Retry, might result in duplicates on error

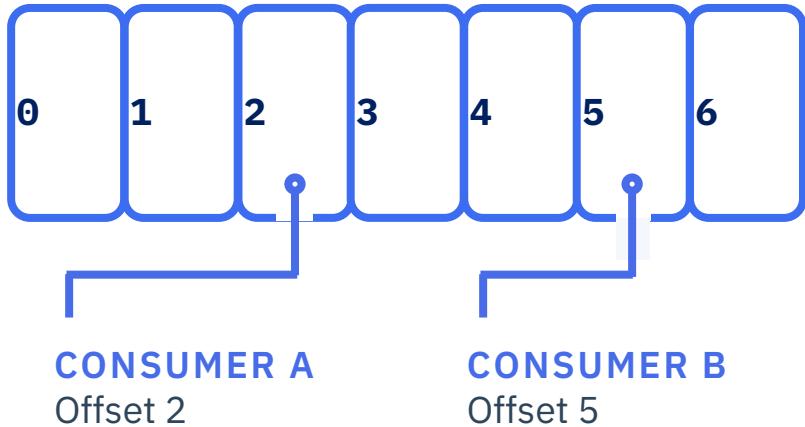
Producer can also choose idempotence

Can retry without risking duplicates

Consumers



Consumers



Consumer can choose how to commit offsets:

Automatic

Commits might go faster than processing

Manual, asynchronous

Fairly safe, but could re-process messages

Manual, synchronous

Safe, but slows down processing

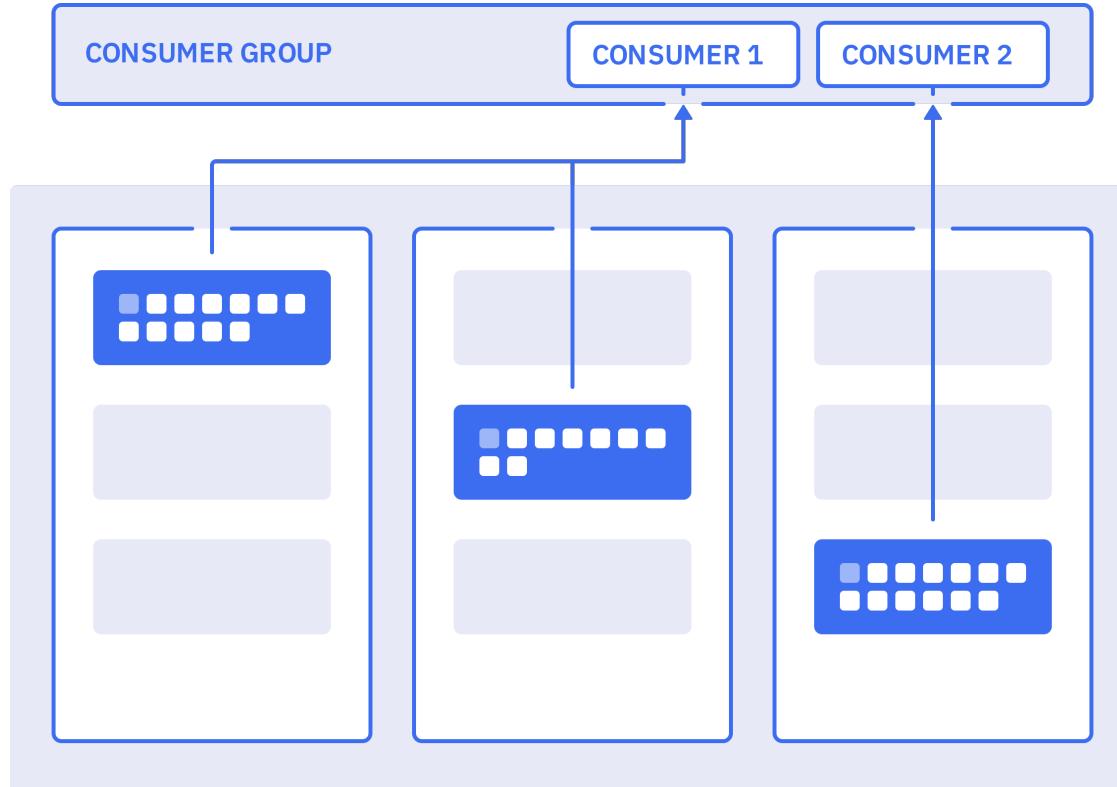
A common pattern is to commit offsets on a timer

Exactly once semantics

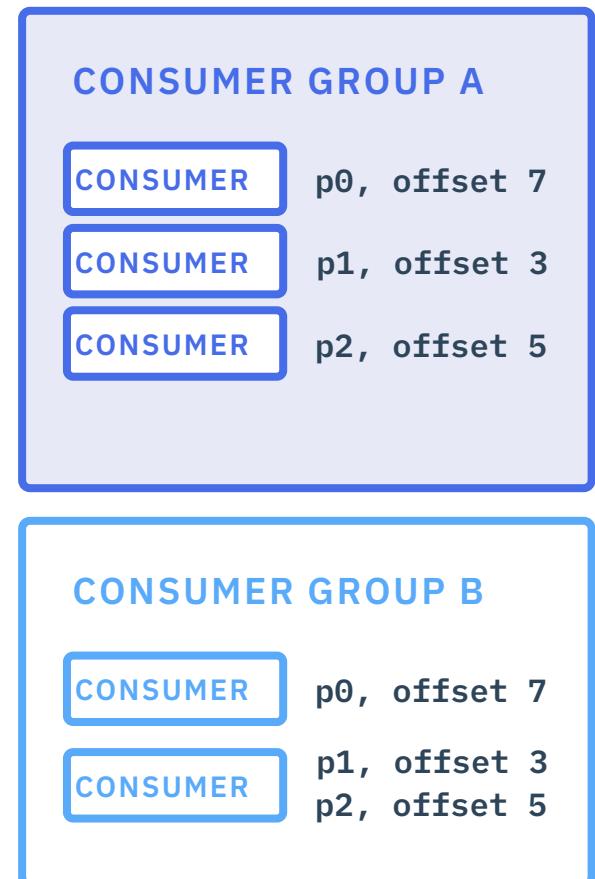
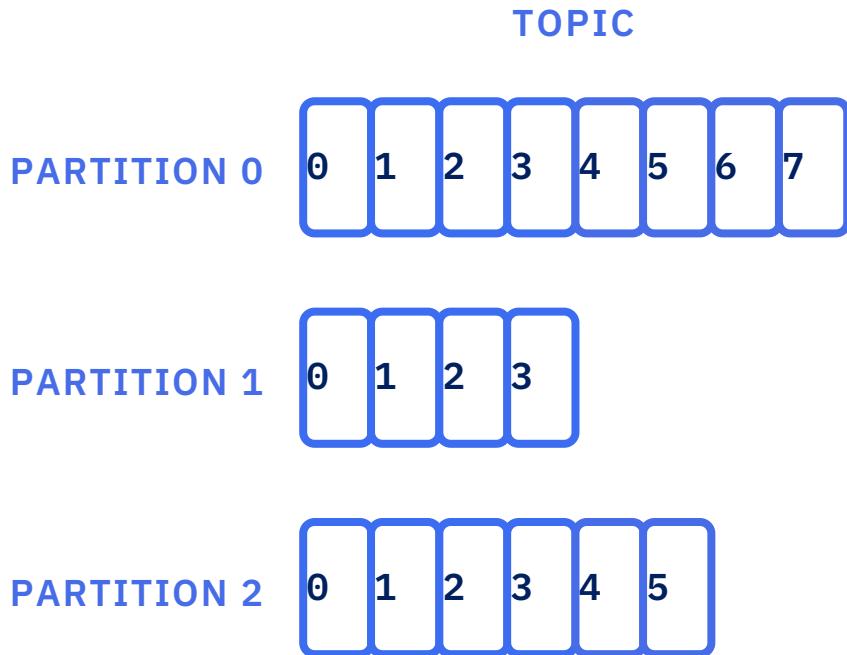
Can group sending messages and committing offsets into transactions

Primarily aimed at stream processing applications

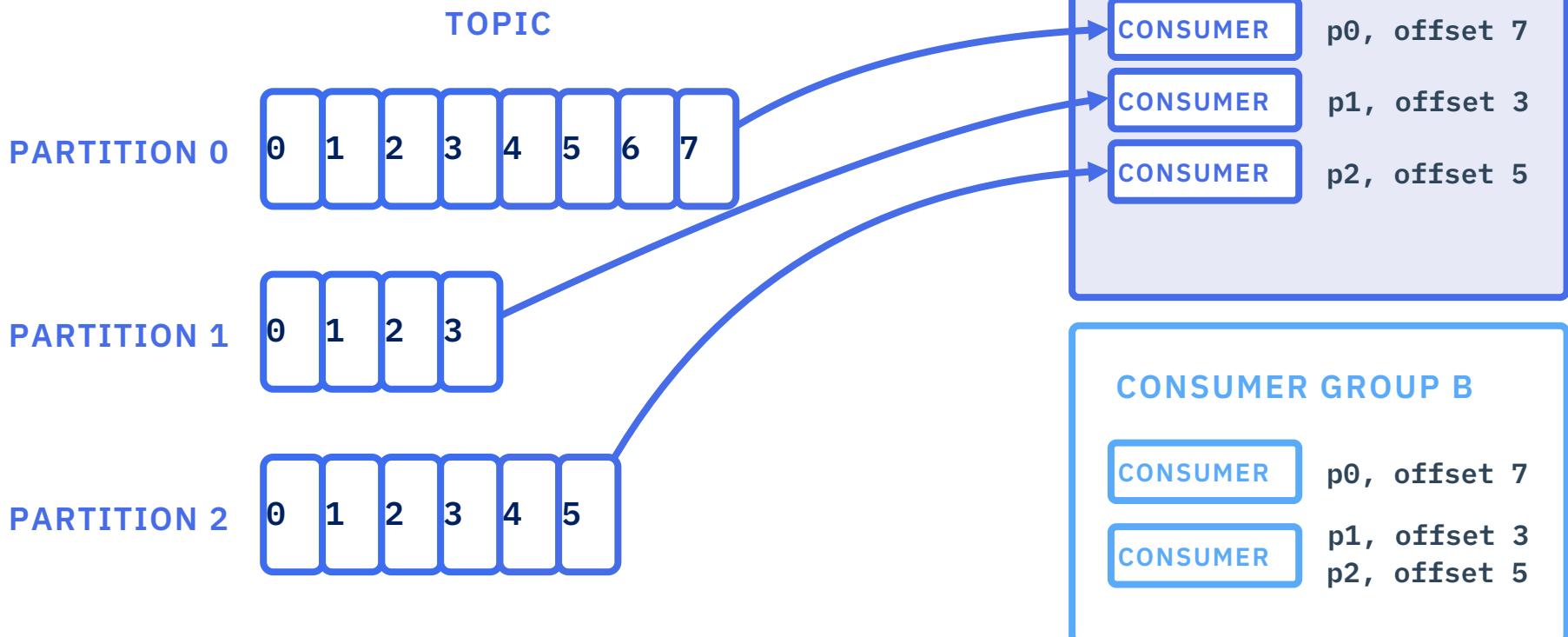
Consumer Groups



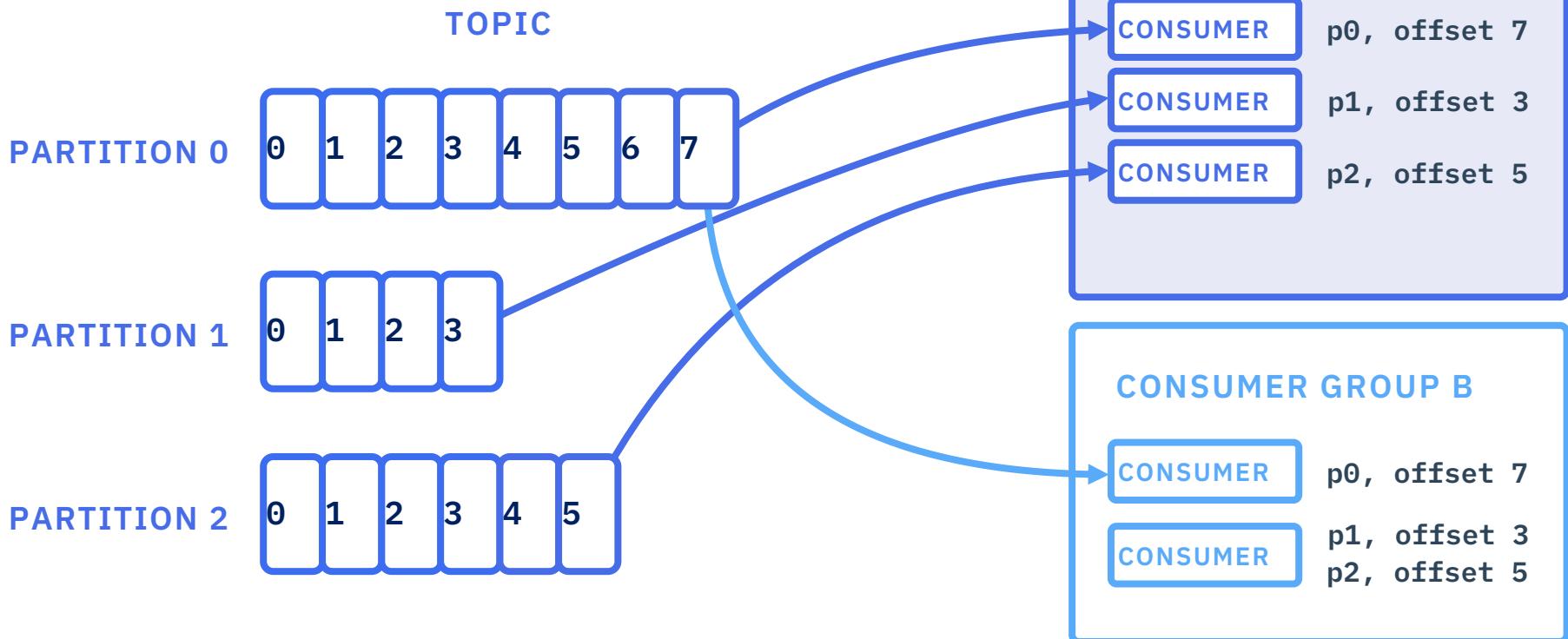
Consumer Groups



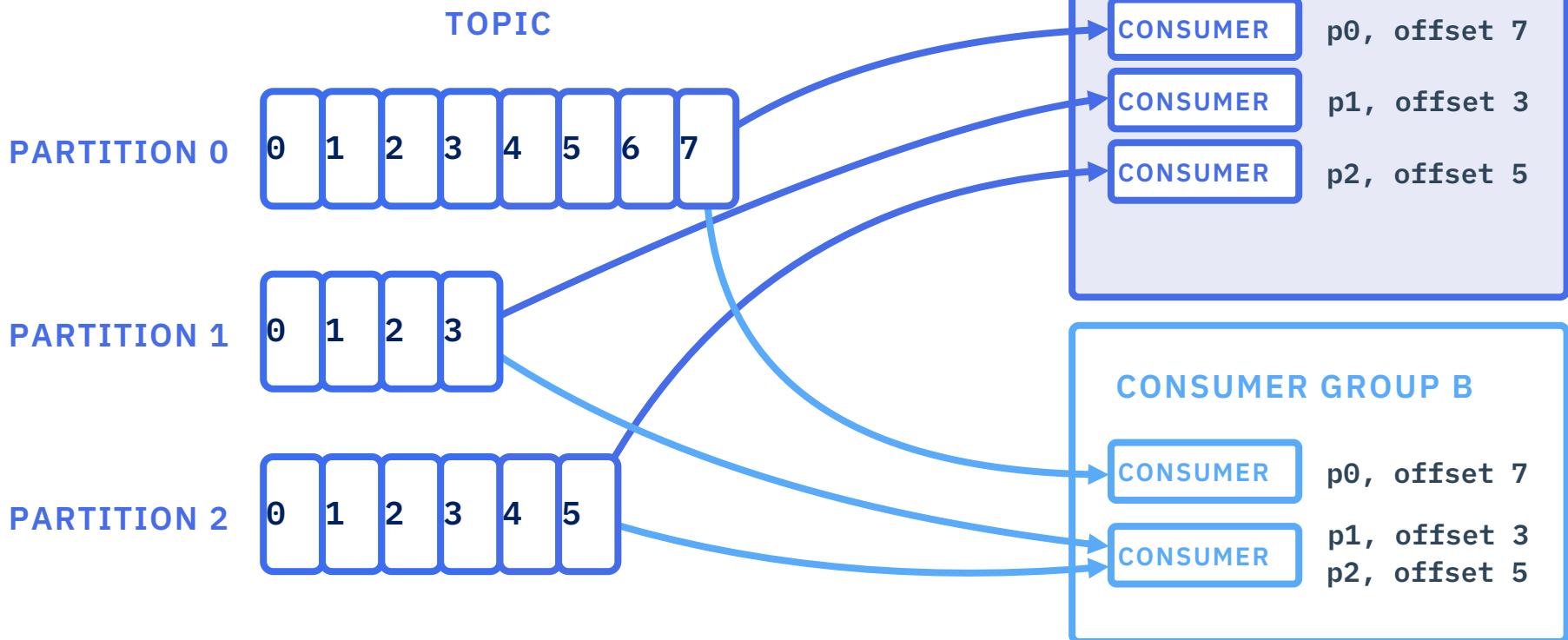
Consumer Groups



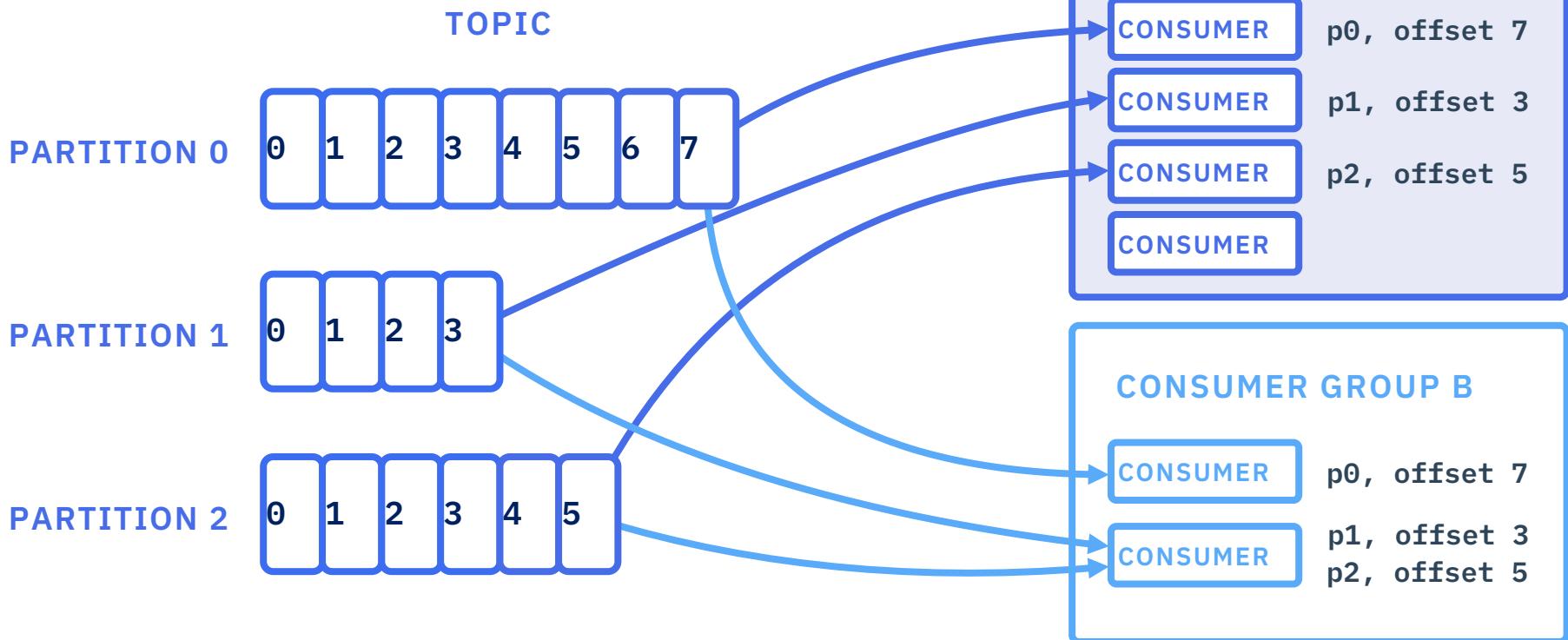
Consumer Groups

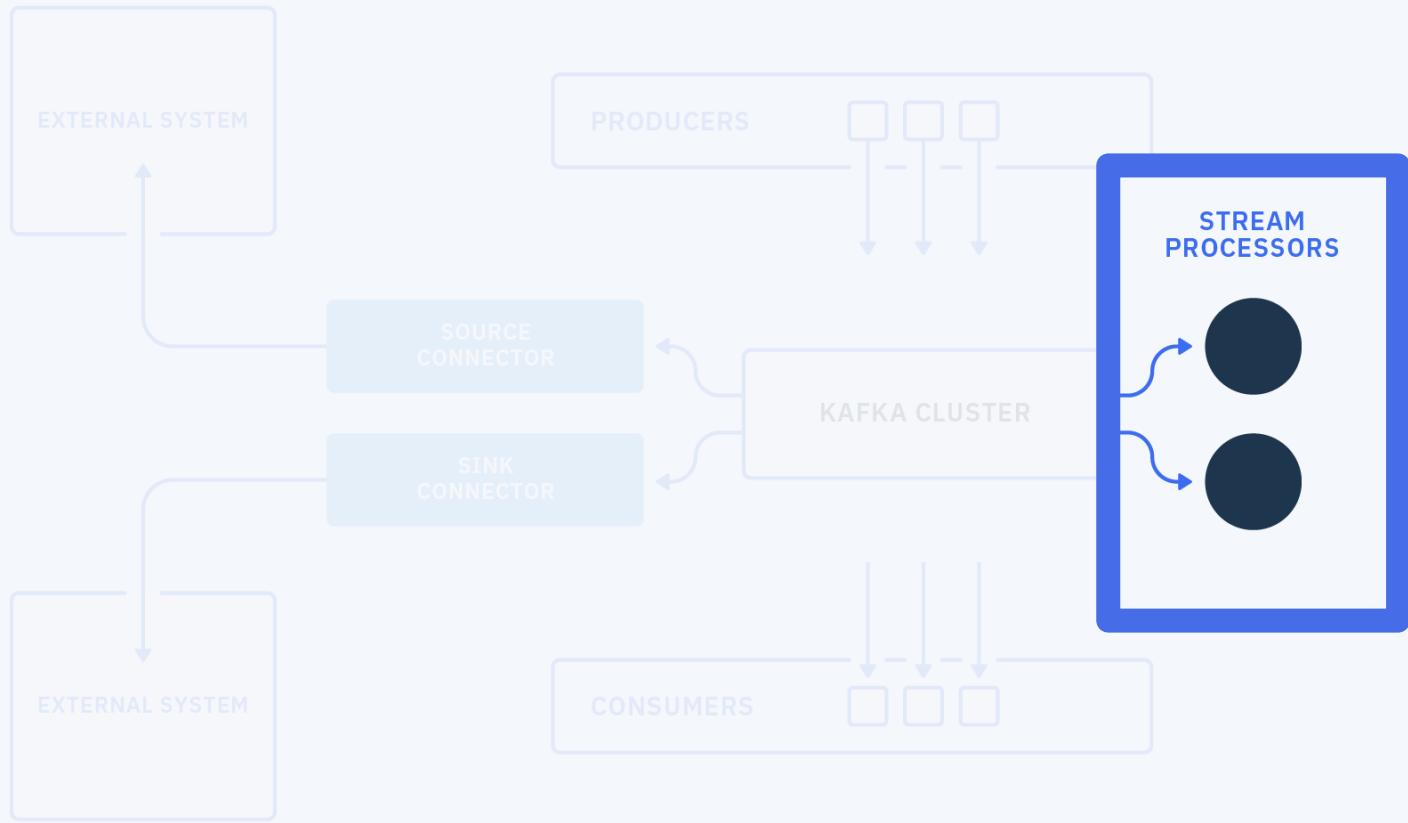


Consumer Groups



Consumer Groups



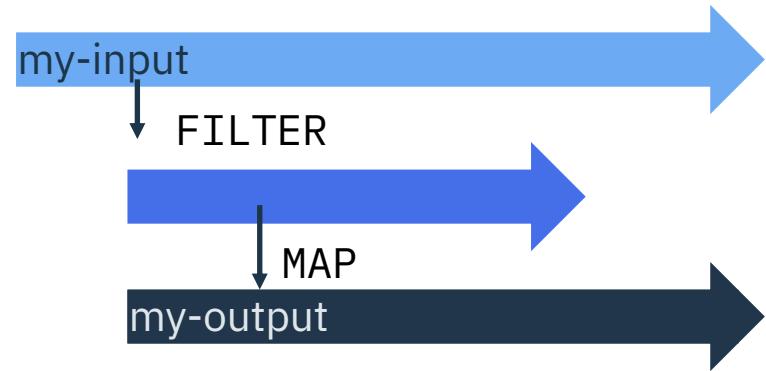


Kafka Streams

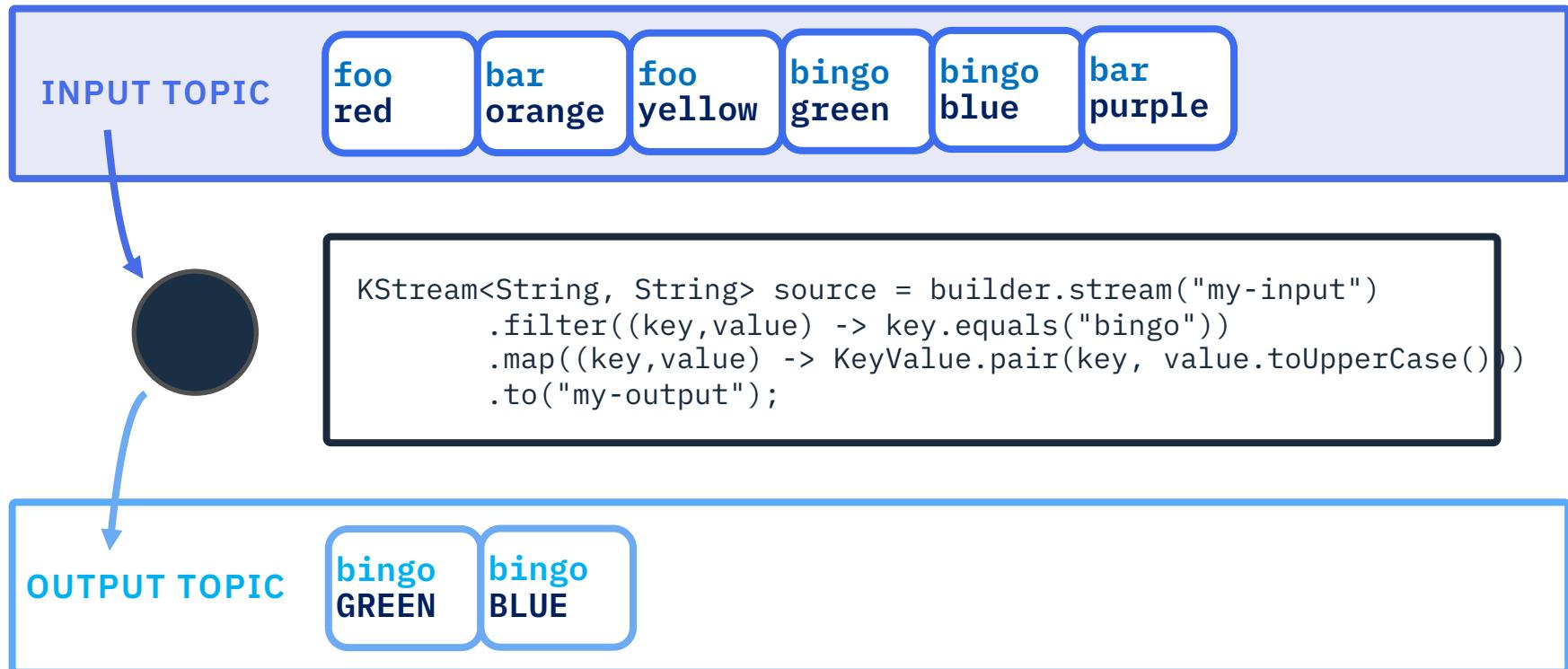
Client library for processing and analyzing data stored in Kafka

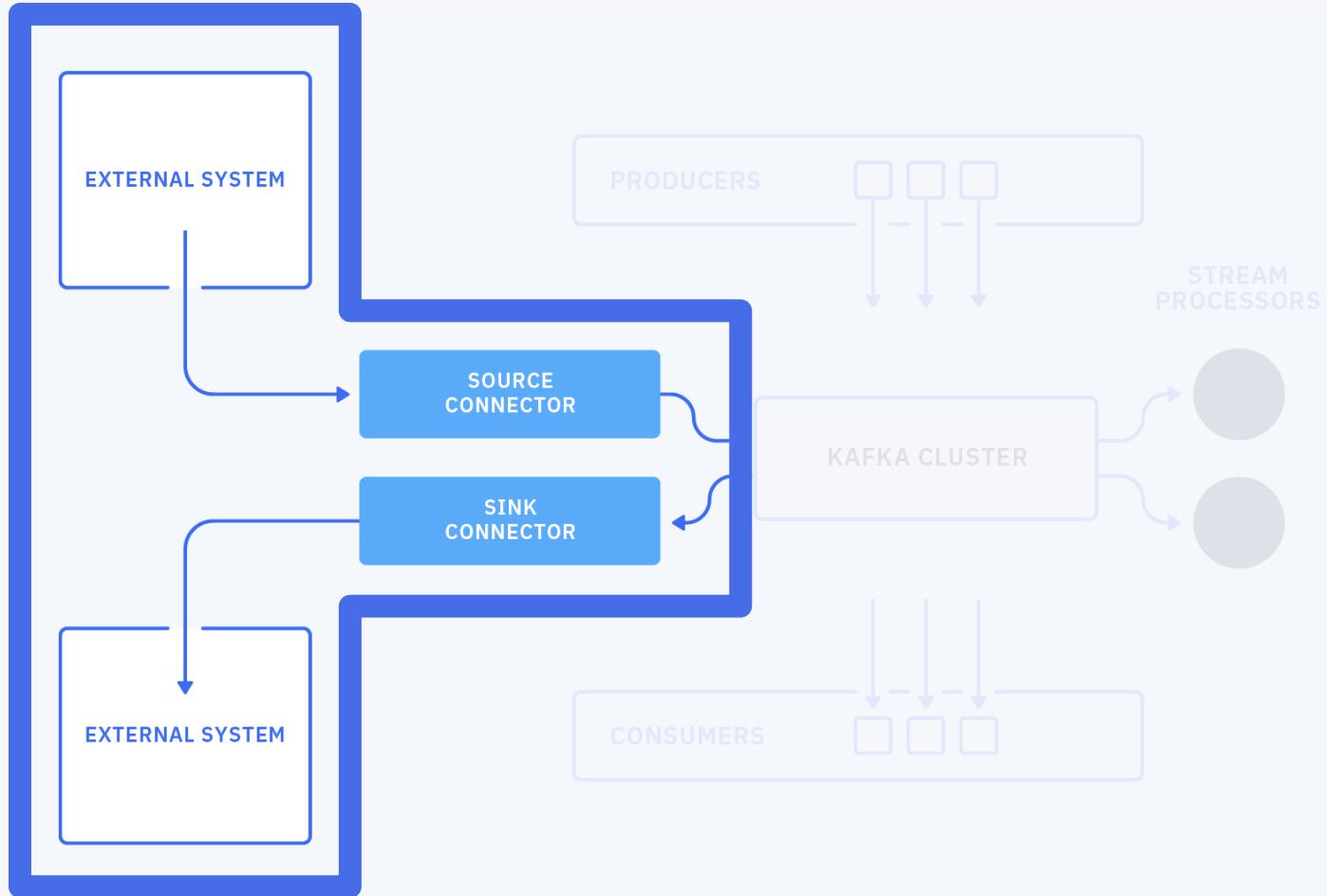
Processing happens in the app

Supports per-record processing – no batching

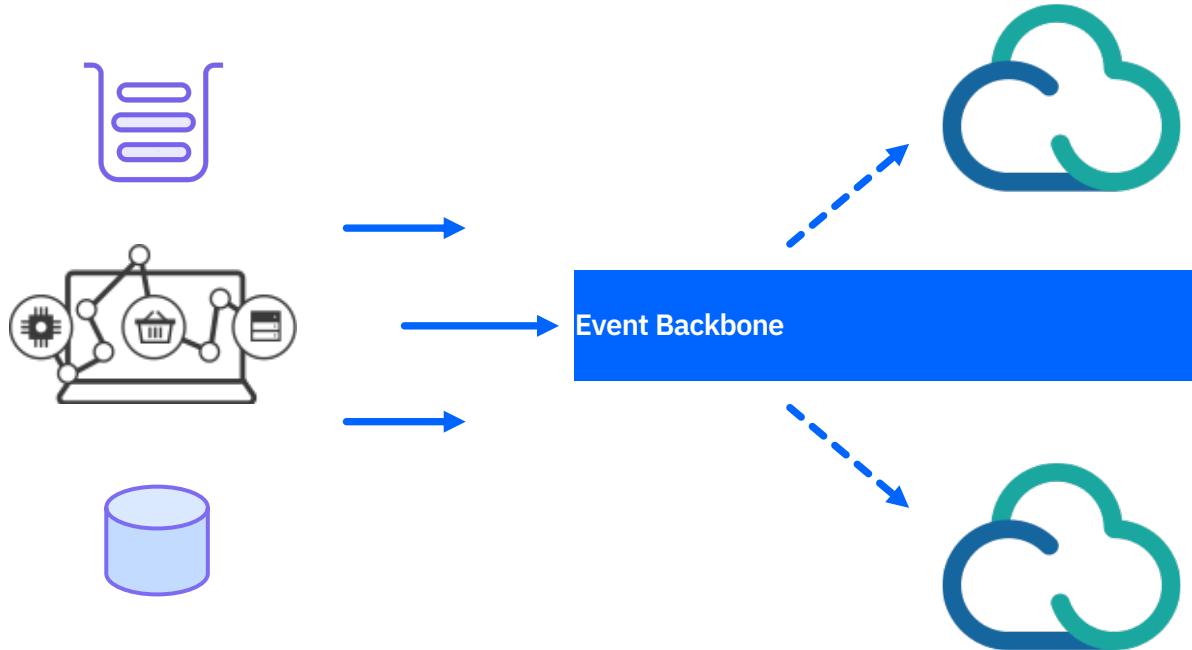


Kafka Streams

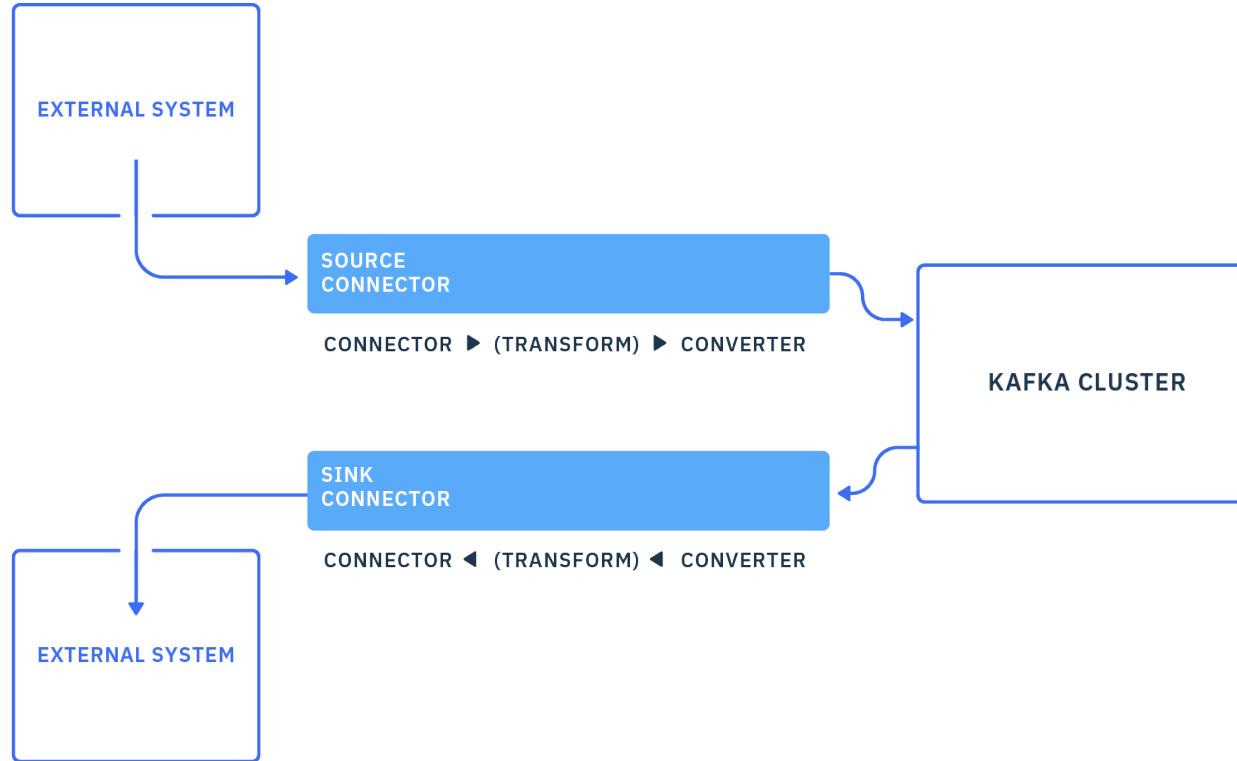




Kafka Connect – bridge to cloud-native apps



Kafka Connect



Over 80 connectors

HDFS

Elasticsearch

MySQL

JDBC

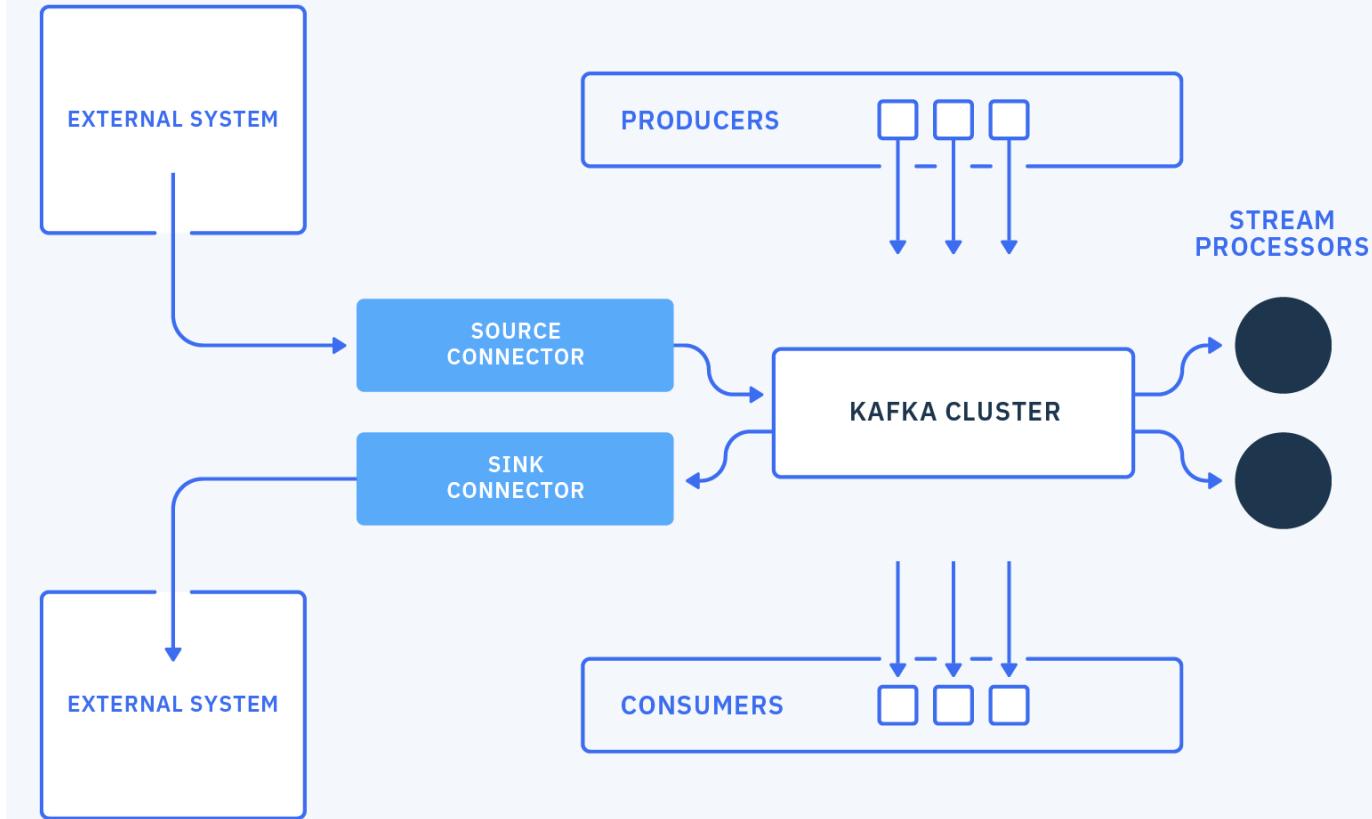
IBM MQ

MQTT

CoAP

+ many others

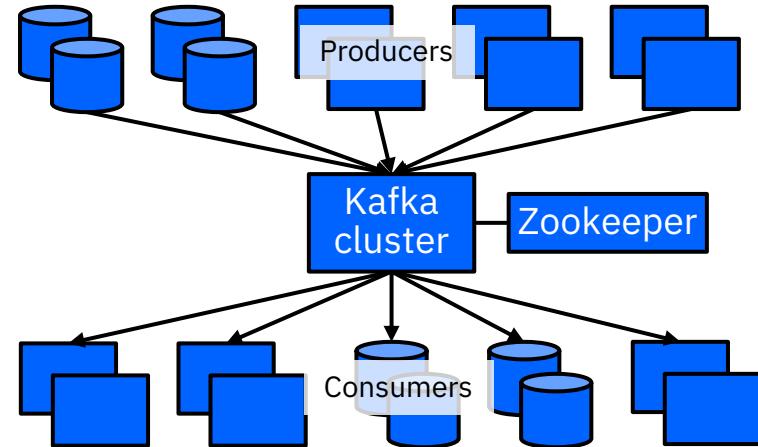
Kafka cluster architecture



Zookeeper

Kafka requires Apache Zookeeper

Manages cluster membership, electing leaders, topic configuration, and more



Kafka guarantees

Messages are appended to partitions in the order they are sent

Consumers see messages in the order they are stored in the log

Committed messages are not lost as long as at least one ISR exists at all times

For a topic with a replication factor of N , Kafka tolerates up to $N-1$ server failures without losing any messages that are committed to the log

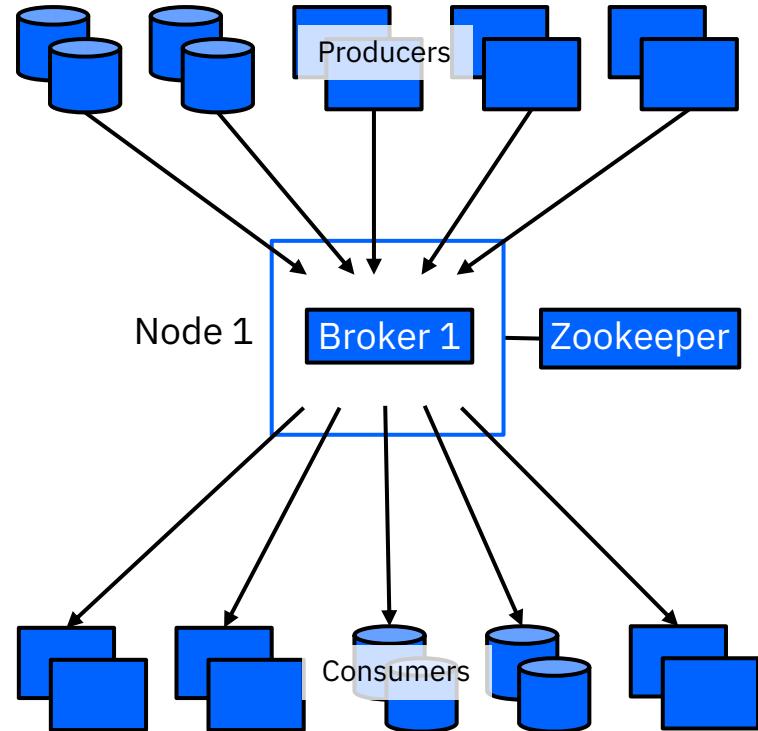
At-least-once message delivery guaranteed by default

You can implement at-most-once by disabling producer retries and committing offset prior to processing a batch of messages

Exactly-once requires cooperation with the destination storage system

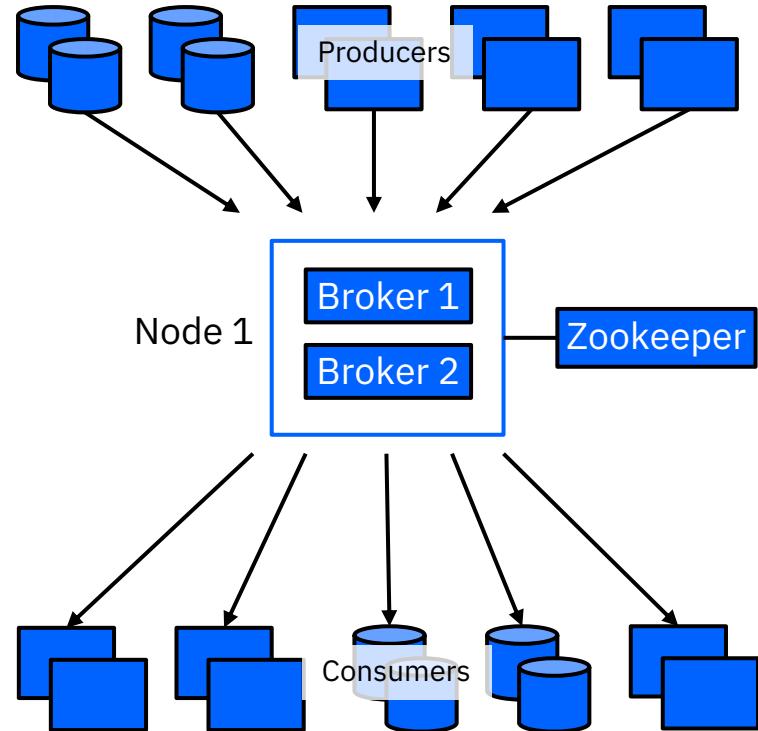
Kafka cluster configurations

Single node, single broker



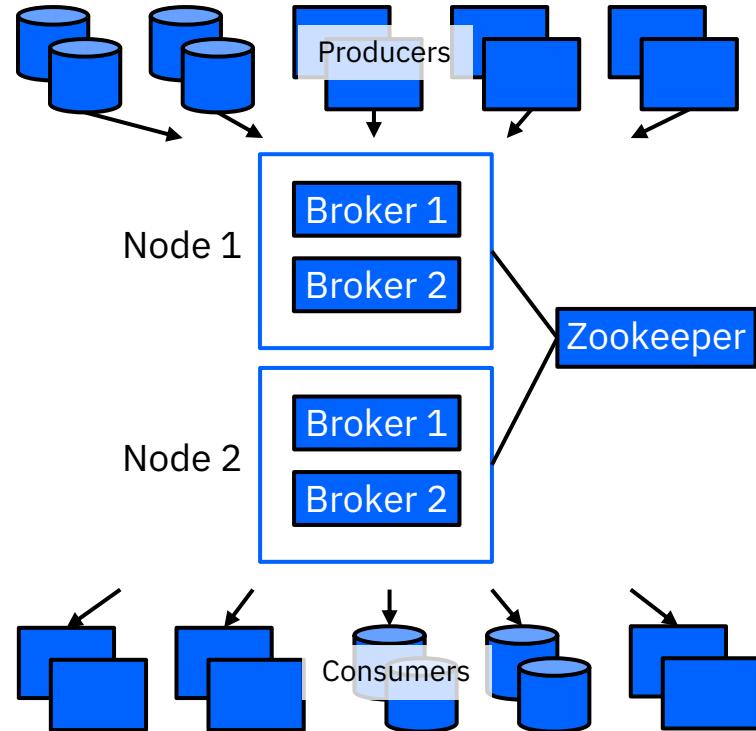
Kafka cluster configurations

Single node, multiple brokers



Kafka cluster configurations

Multiple nodes,
multiple brokers



Kafka commands

Commands in the Kafka `/bin` directory

Start and stop a Kafka broker server

Pass in a `server.properties` file

Kafka `/config` directory contains a default `server.properties` file

You can also use Kafka commands to create and manage topics

```
student@master:~/Downloads/kafka_2.12-2.2.0/bin$ ls
connect-distributed.sh
connect-standalone.sh
kafka-acls.sh
kafka-broker-api-versions.sh
kafka-configs.sh
kafka-console-consumer.sh
kafka-console-producer.sh
kafka-consumer-groups.sh
kafka-consumer-perf-test.sh
kafka-delegation-tokens.sh
kafka-delete-records.sh
kafka-dump-log.sh
kafka-log-dir.sh
kafka-mirror-maker.sh
kafka-preferred-replica-election.sh
kafka-producer-perf-test.sh
kafka-reassign-partitions.sh
kafka-replica-validation.sh
kafka-run-class.sh
kafka-server-start.sh
kafka-server-stop.sh
kafka-streams-application-reset.sh
kafka-topics.sh
kafka-verifiable-consumer.sh
kafka-verifiable-producer.sh
trogdor.sh
windows
zookeeper-security-migration.sh
zookeeper-server-start.sh
zookeeper-server-stop.sh
zookeeper-shell.sh
```

Kafka server.properties file

Contains several configuration properties for the broker, such as the broker ID, port, and socket that the broker listens on

You can copy and modify this file for each broker

```
# see kafka.server.KafkaConfig for additional details and defaults
#####
# The id of the broker. This must be set to a unique integer for each broker.
broker.id=0
#####
# Socket Server Settings #####
# The address the socket server listens on. It will get the value returned from
# java.net.InetAddress.getCanonicalHostName() if not configured.
# FORMAT:
#   listeners = listener_name://host_name:port
# EXAMPLE:
#   listeners = PLAINTEXT://your.host.name:9092
#listeners=PLAINTEXT://:9092

# Hostname and port the broker will advertise to producers and consumers. If not set,
# it uses the value for "listeners" if configured. Otherwise, it will use the value
# returned from java.net.InetAddress.getCanonicalHostName().
#advertised.listeners=PLAINTEXT://your.host.name:9092

# Maps listener names to security protocols, the default is for them to be the same. See the config
# documentation for more details
#listener.security.protocol.map=PLAINTEXT:PLAINTEXT,SSL:SSL,SASL_PLAINTEXT:SASL_PLAINTEXT,SASL_SSL:SA

# The number of threads that the server uses for receiving requests from the network and sending
# responses to the network
num.network.threads=3

# The number of threads that the server uses for processing requests, which may include disk I/O
num.io.threads=8

# The send buffer (SO_SNDBUF) used by the socket server
socket.send.buffer.bytes=102400

# The receive buffer (SO_RCVBUF) used by the socket server
socket.receive.buffer.bytes=102400

# The maximum size of a request that the socket server will accept (protection against OOM)
socket.request.max.bytes=104857600
```

Kafka console producer

Can be used for development and testing

Takes input from a file or the console and sends messages to the Kafka cluster

Each line is sent as a separate message

After entering the command, in the console, type a message and press Enter

Example:

```
# bin/kafka-console-producer.sh  
--broker-list localhost:9092 --topic  
mytopic
```

Kafka console consumer

Can be used for development and testing

Prints messages from topics to standard output

Each message is printed on a new line

Use `--from-beginning` to consume messages published before consumer start

Example:

```
# bin/kafka-console-consumer.sh  
--zookeeper localhost:2181 --topic  
mytopic -from-beginning
```

This is message one.

This is message two.

More resources

Apache Kafka documentation

<https://kafka.apache.org/documentation/>

Event Driven Reference Architecture

<https://ibm-cloud-architecture.github.io/refarch-edu/>



