Data Engineering

LTAT.02.007

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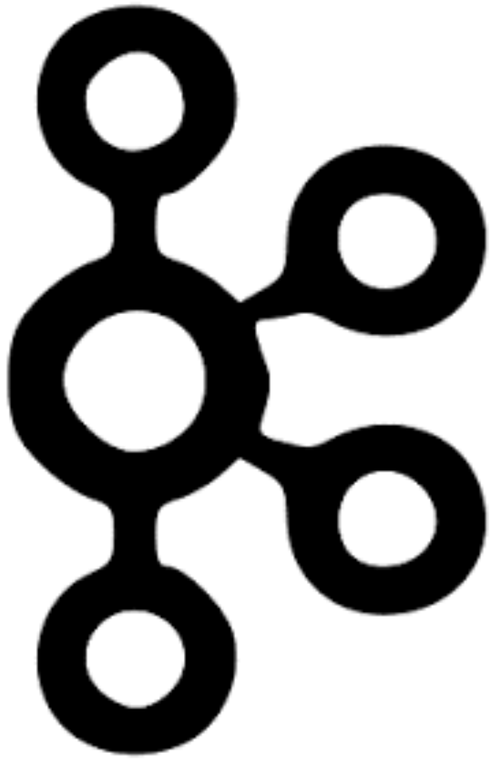
https://courses.cs.ut.ee/2020/dataeng

Forum

Moodle

Apache Kafka[^1]



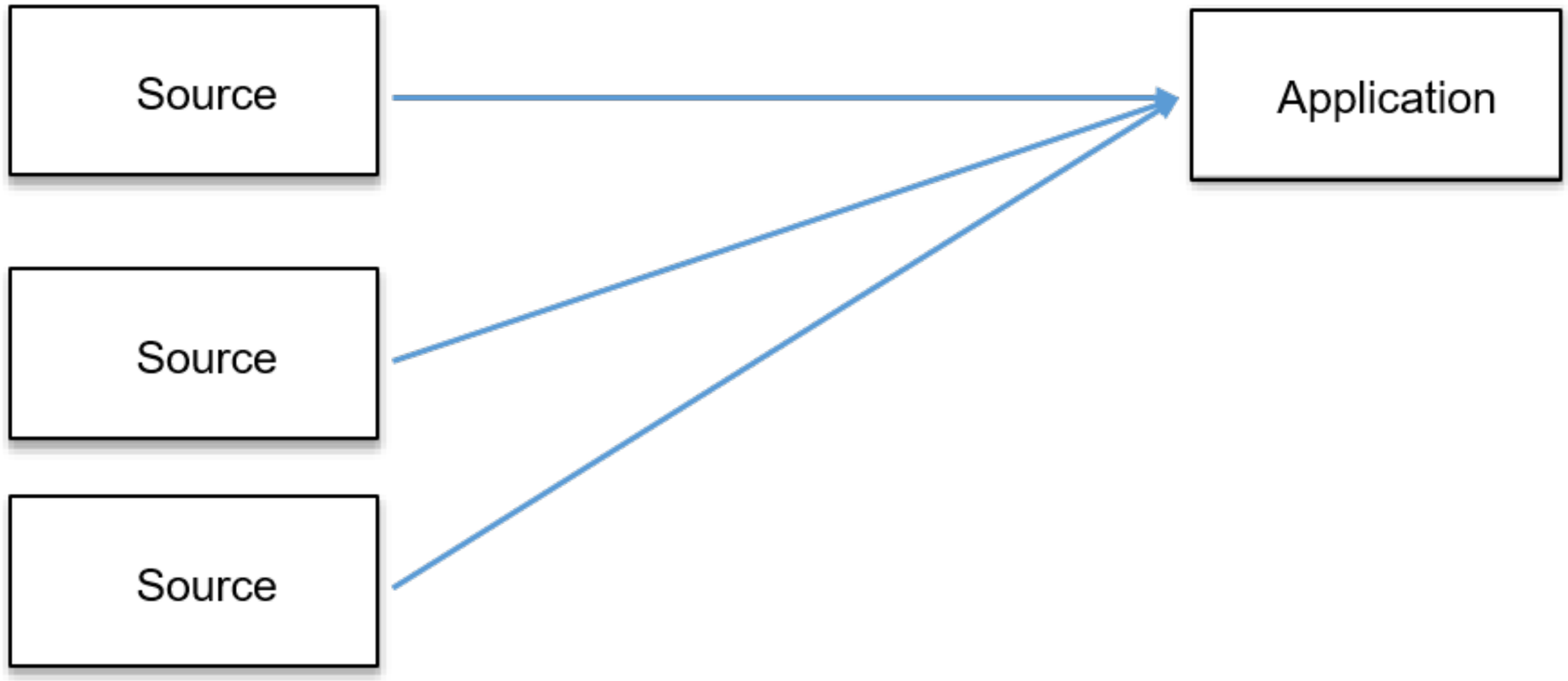
An overview

Motivation

Data pipelines start with a small number of systems to integrates. A single ETL (extract, transform, load) process move data from the source to the interested applications.

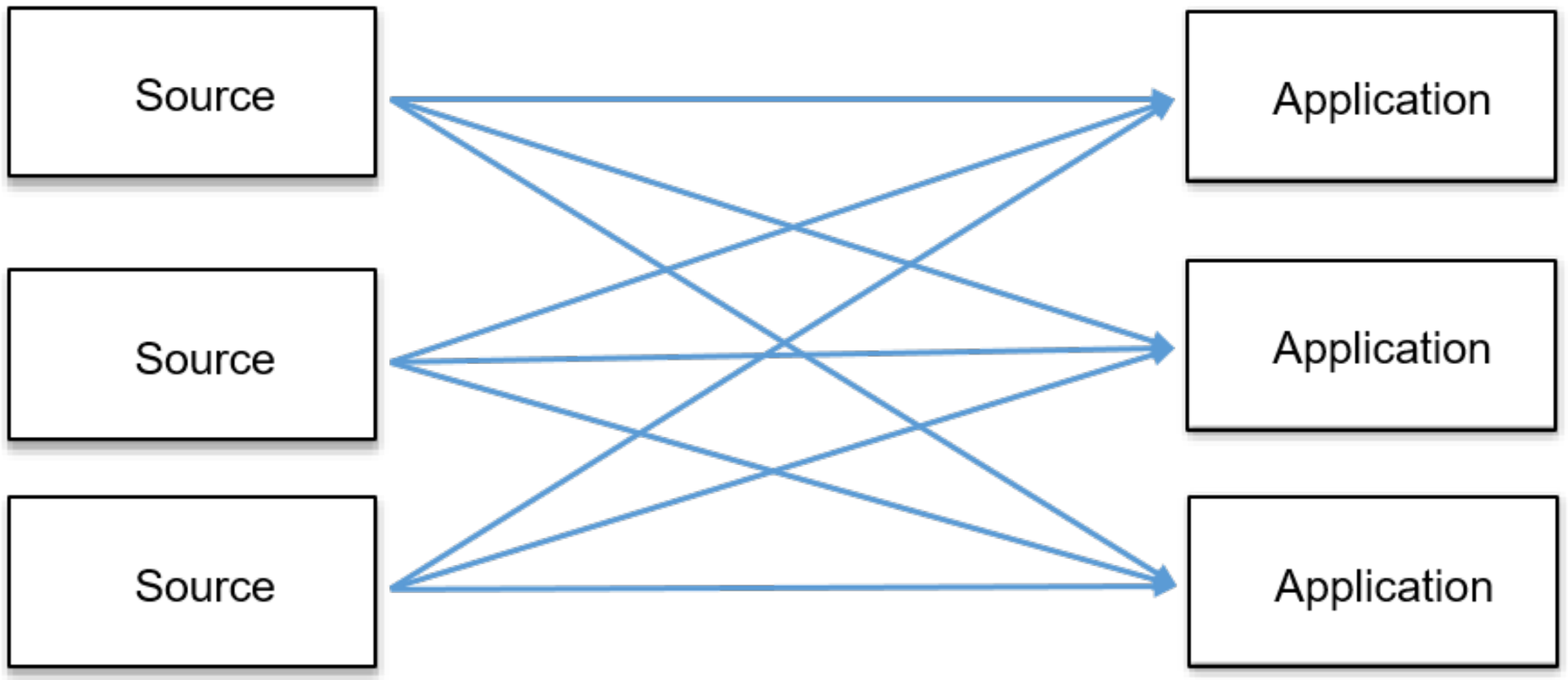
Motivation

But data pipeline grow over time. Adding new system causes the need of new ETL process. The code-base grows together with data formats and services.



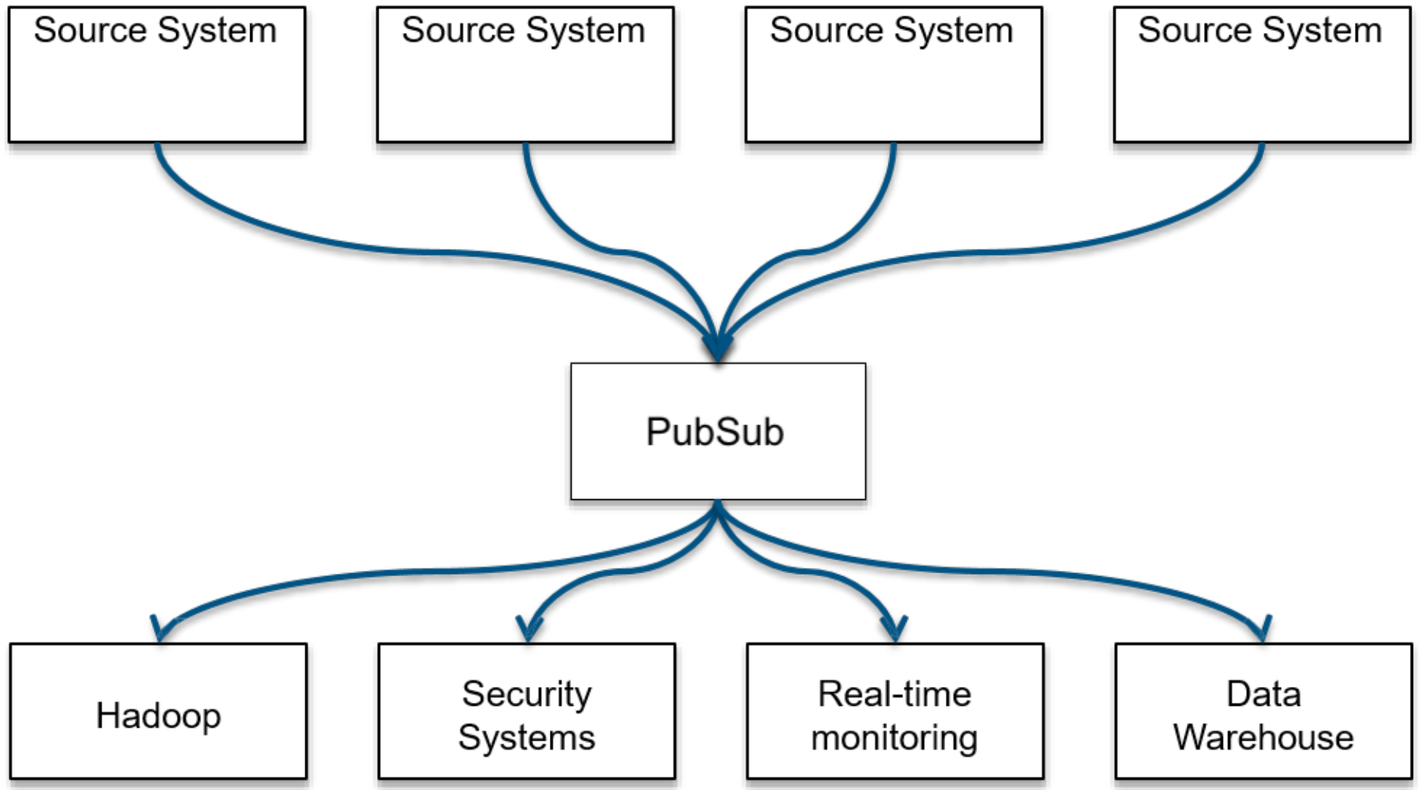
Motivation

Things end up messy when sources and sinks are coupled!



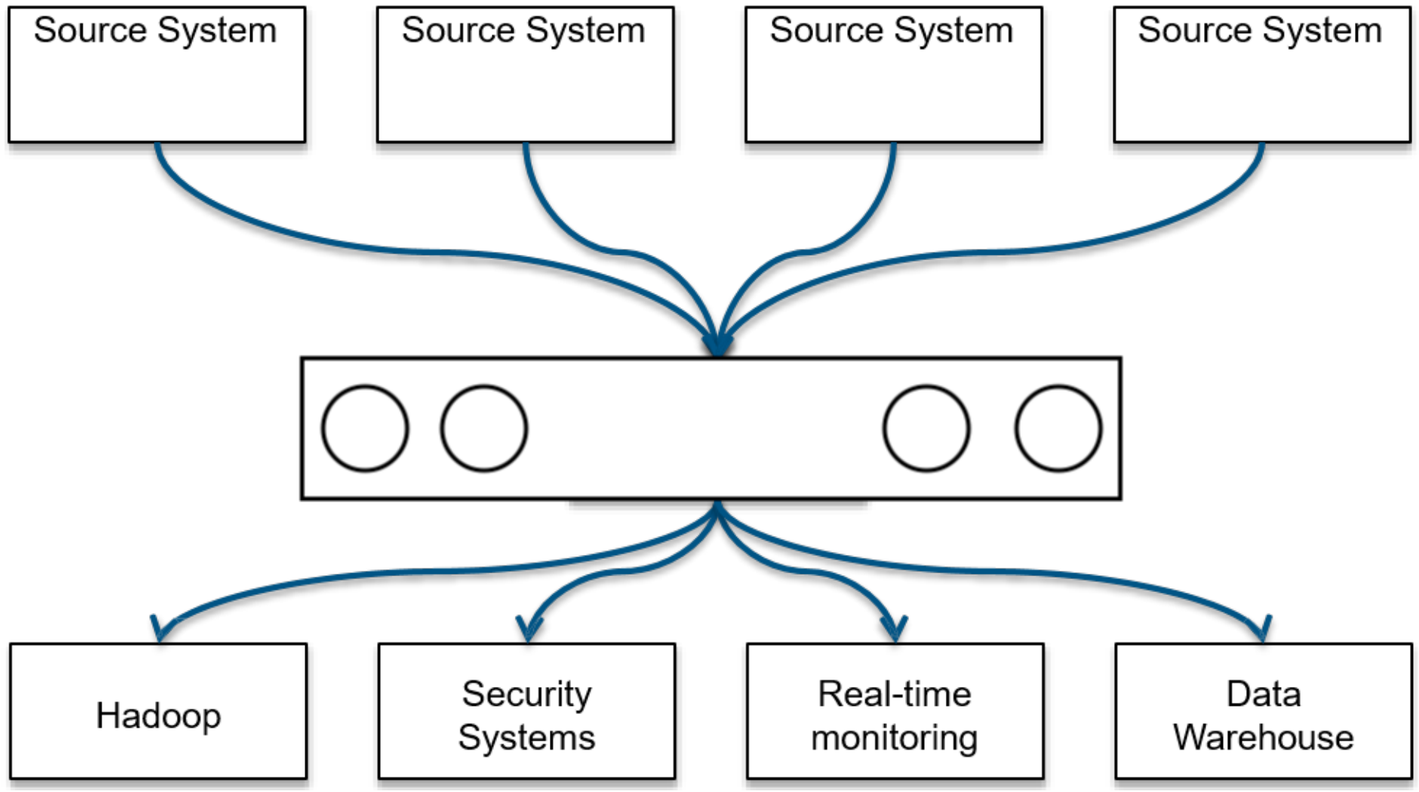
An alternative: Publish/Subscribe

PubSubs decouple data sources and their consumers making communication asynchronous and processing scalable.



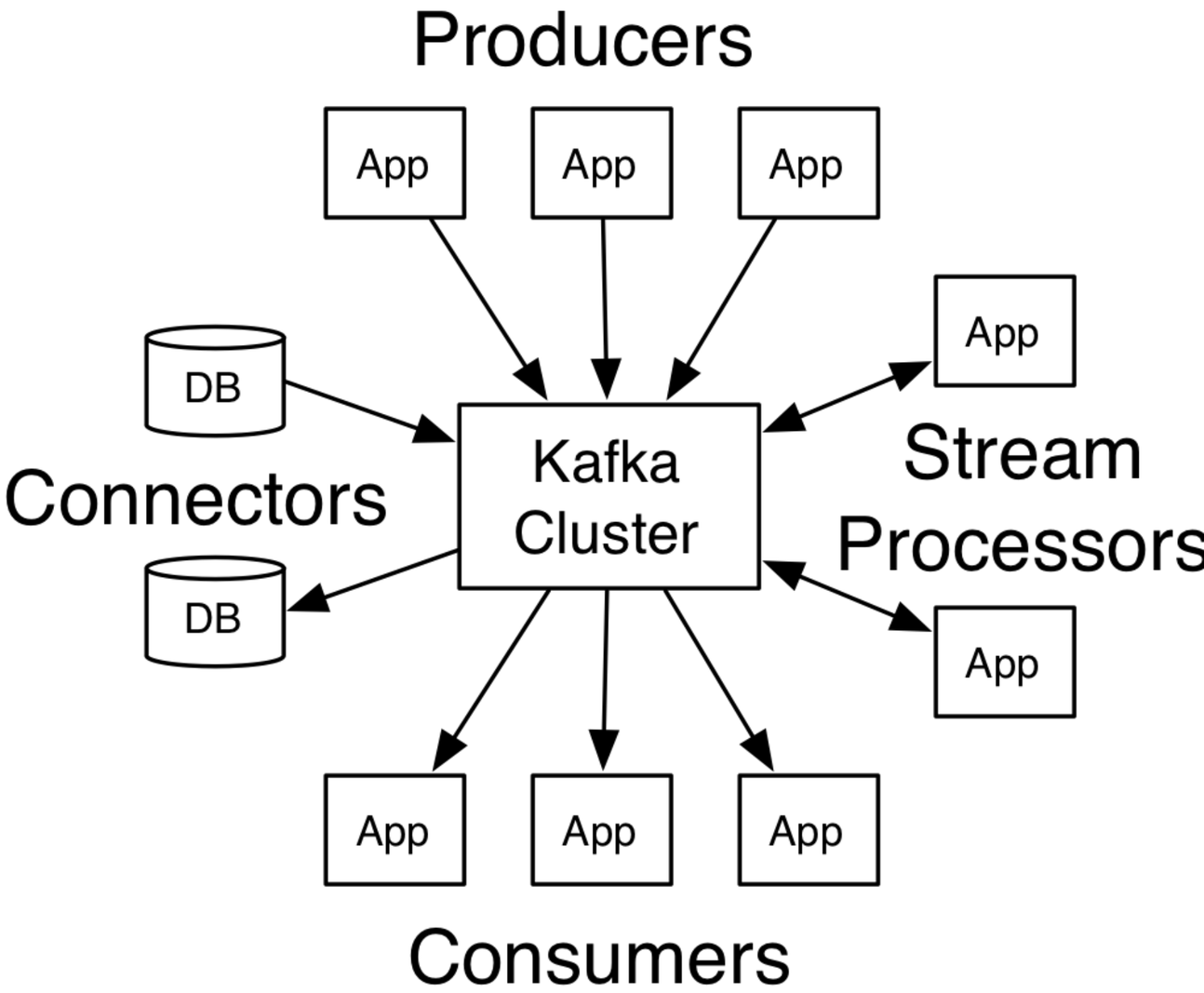
An alternative: Publish/Subscribe

PubSubs organize messages logically so that it is easier for the interested consumers to access.

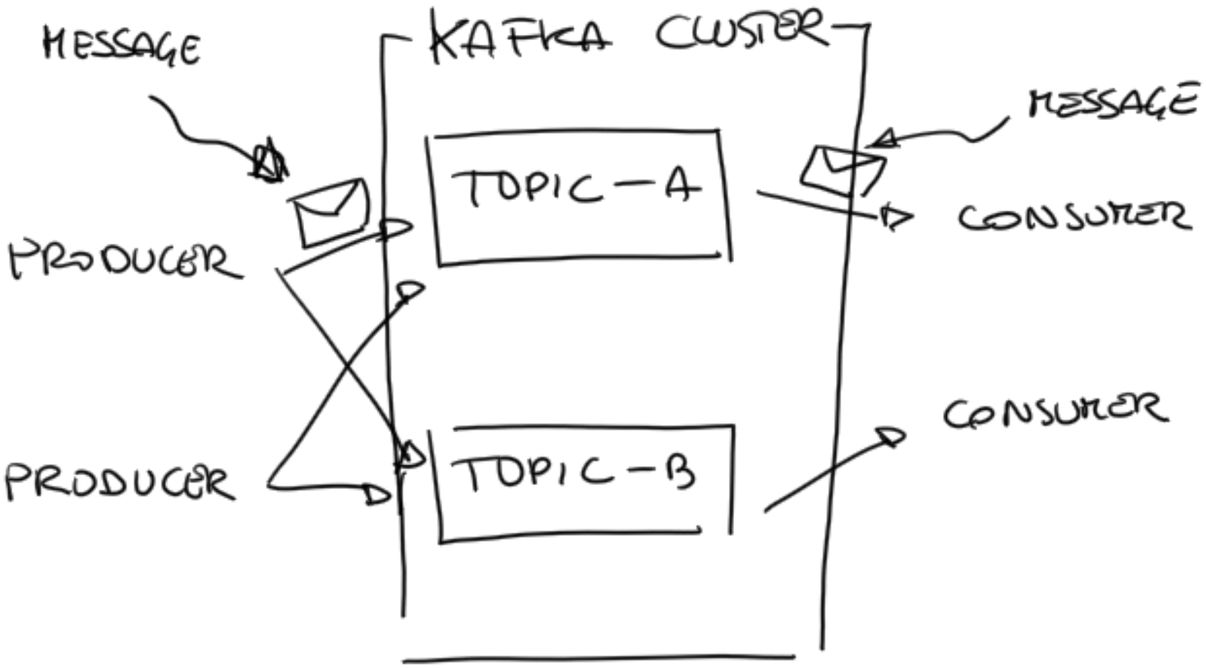


Apache Kafka

Apache Kafka is an horizontally scalable, fault-tolerant, publish-subscribe system. It can process over 1 trillion messages without neglecting durability, i.e., it persists data on disk.

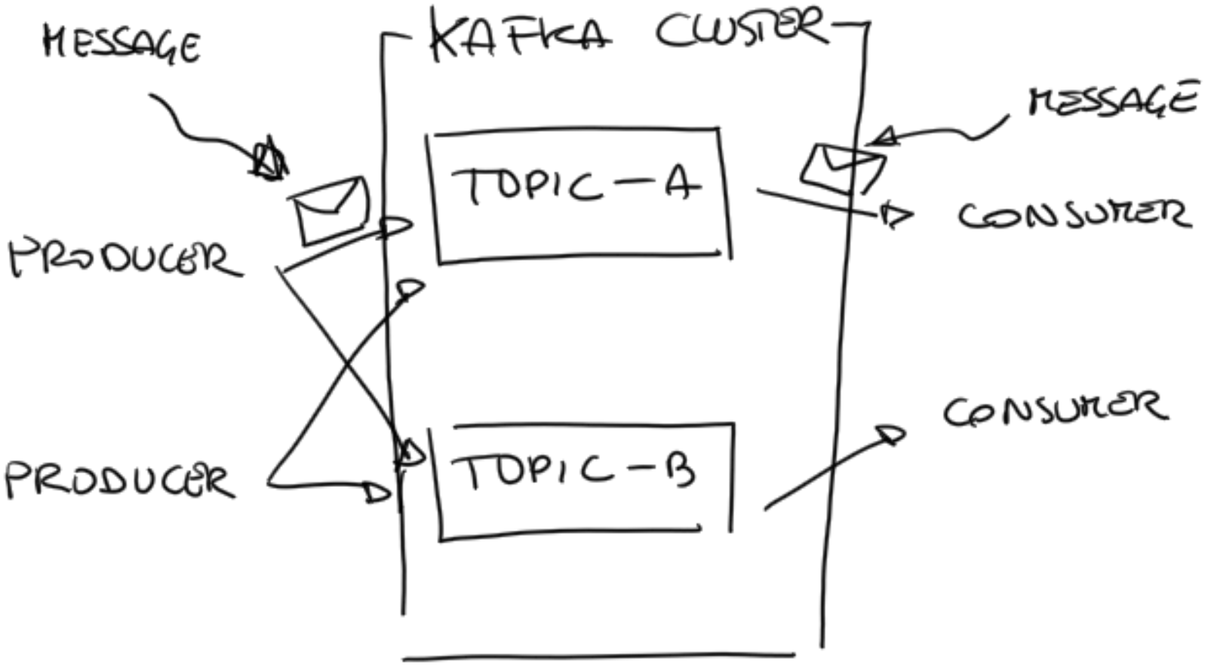


Kafka Conceptual View



Kafka Conceptual View

- **Messages**, the basic unit in Kafka, are organized in **Topics**



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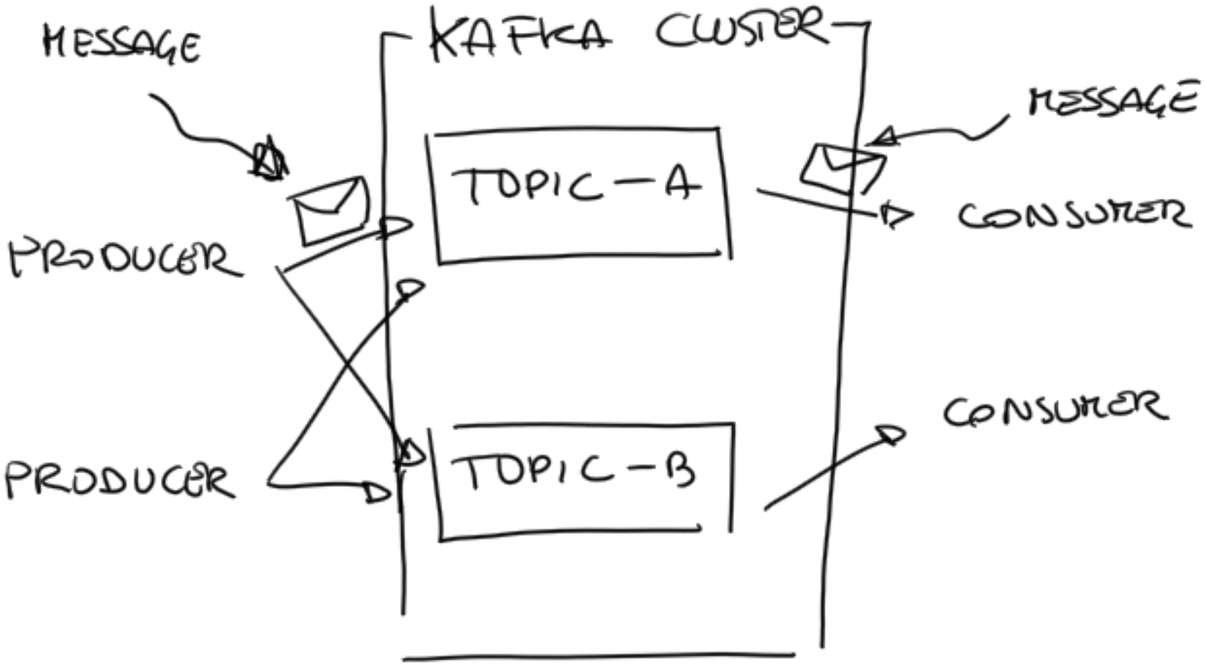

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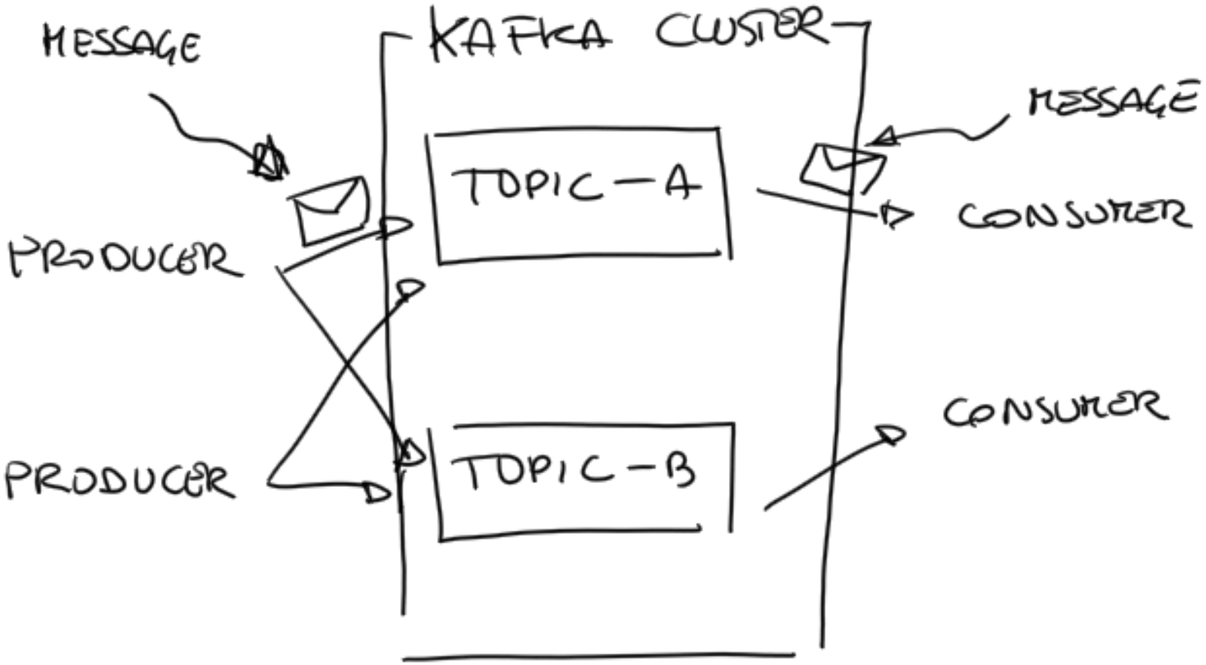
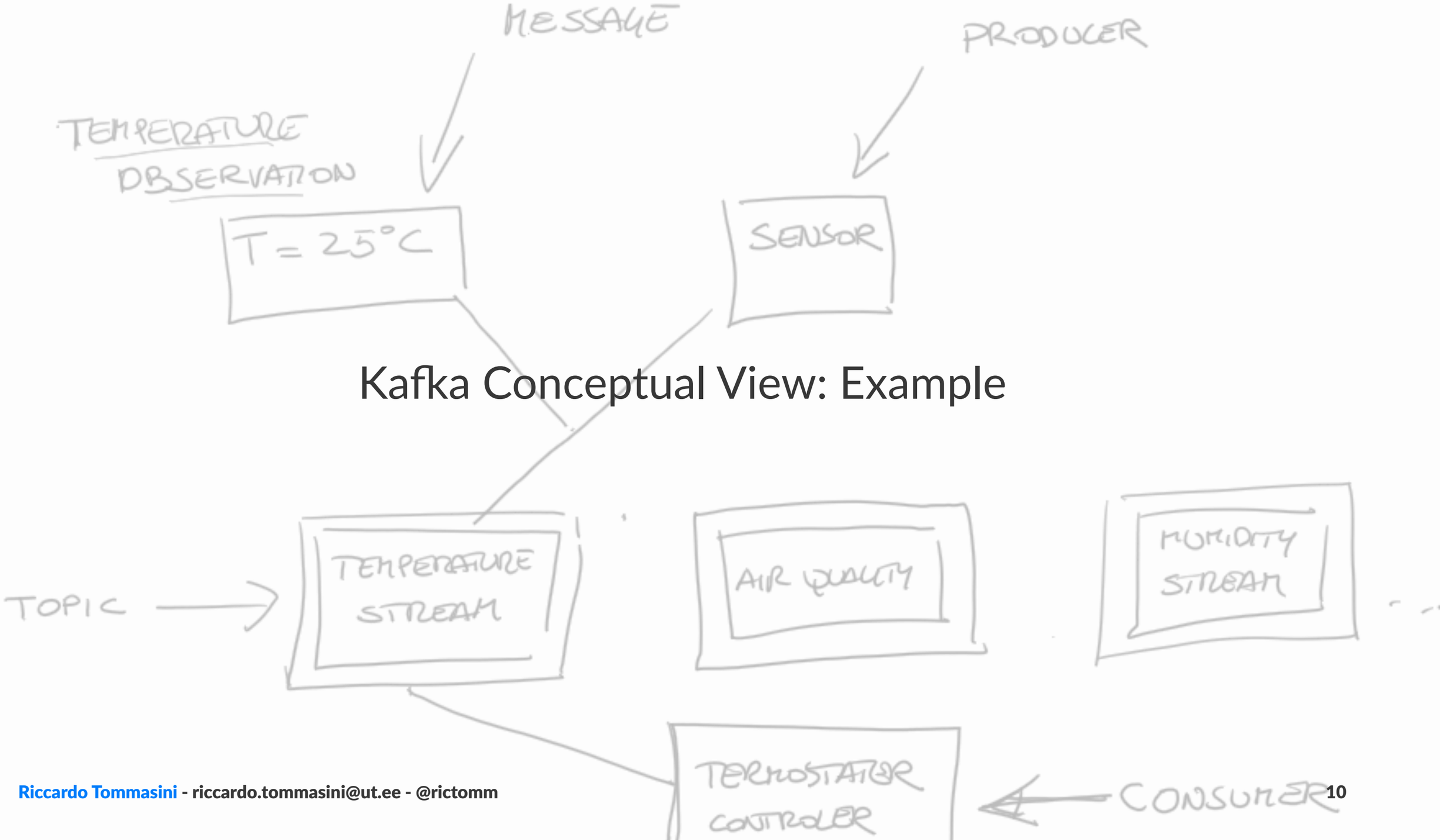
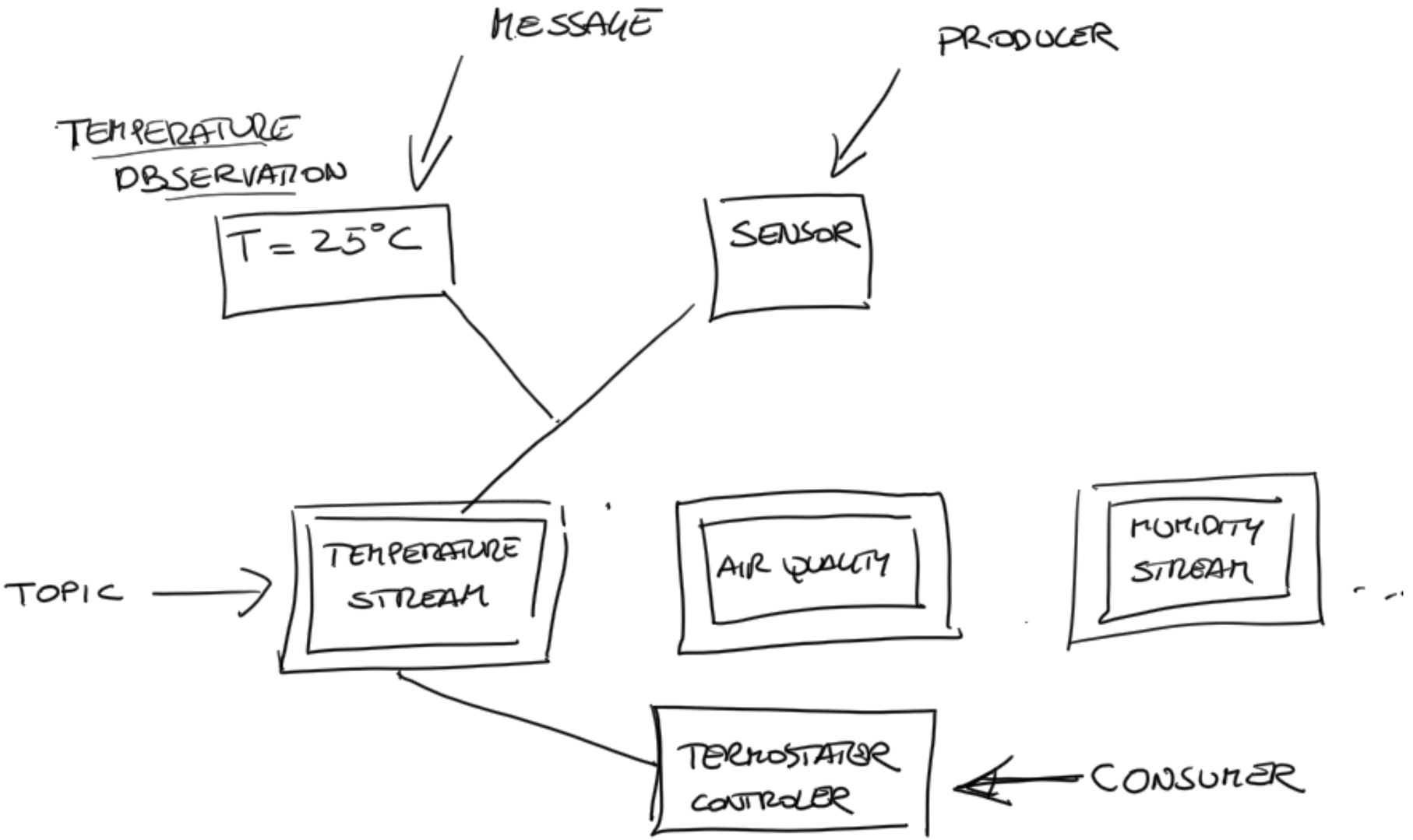
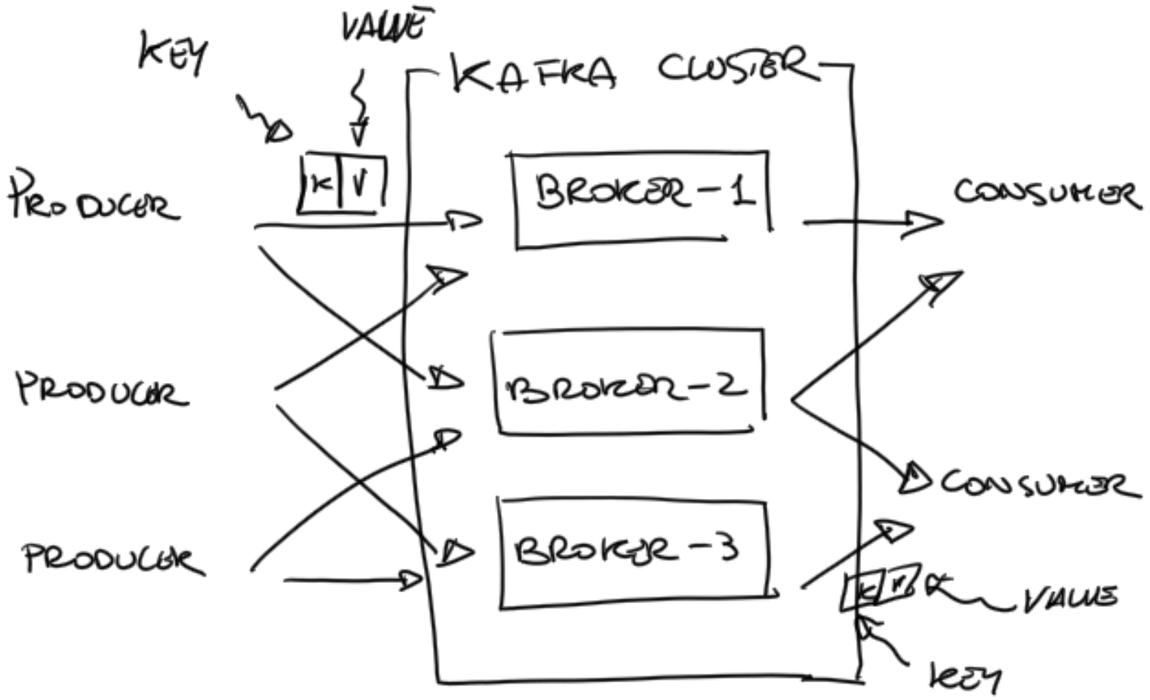


Kafka Conceptual View: Example




MESSAGE
PRODUCER
TEMPERATURE OBSERVATION
T = 25°C
SENSOR
TOPIC
TEMPERATURE STREAM
AIR QUALITY
HUMIDITY STREAM
TERMOSTATIC CONTROLLER
CONSUMER

Kafka Logical View



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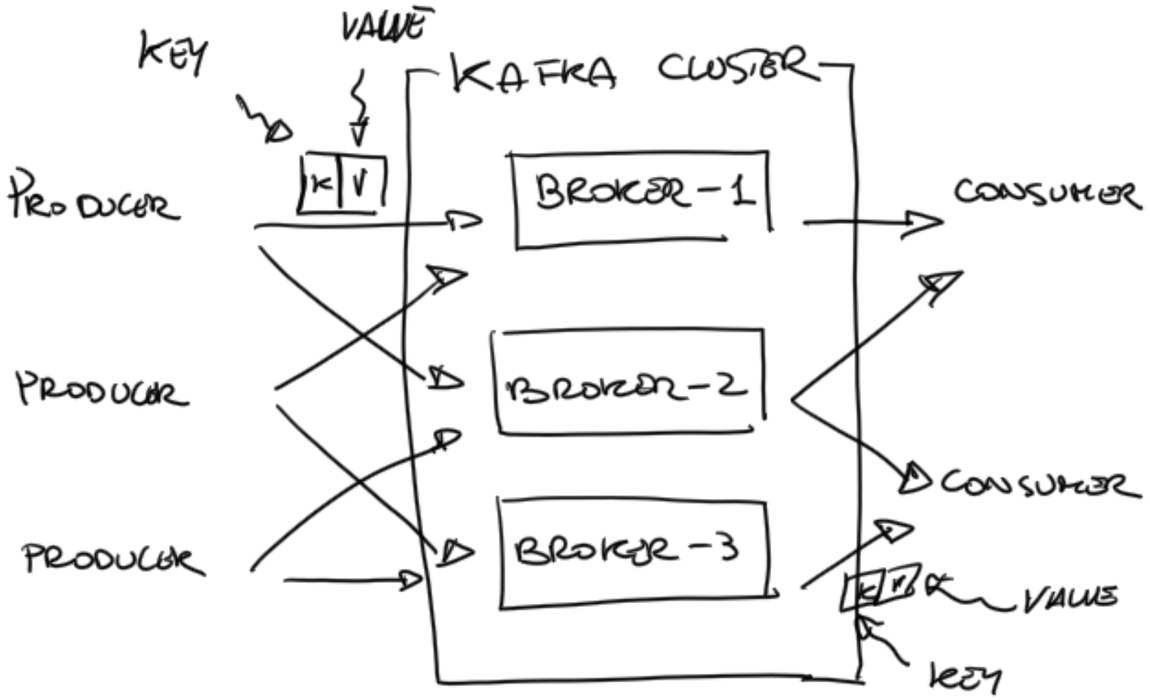

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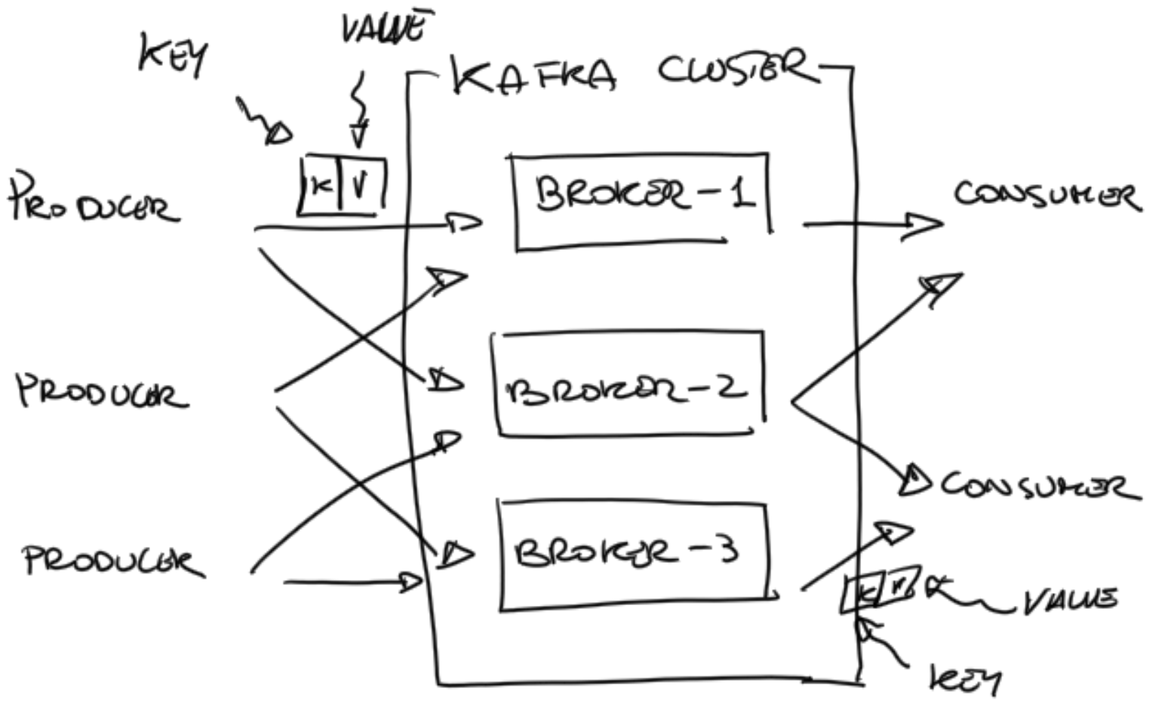

- **Messages** are key-value pairs
- **Brokers** are the main component inside the Kafka Cluster.

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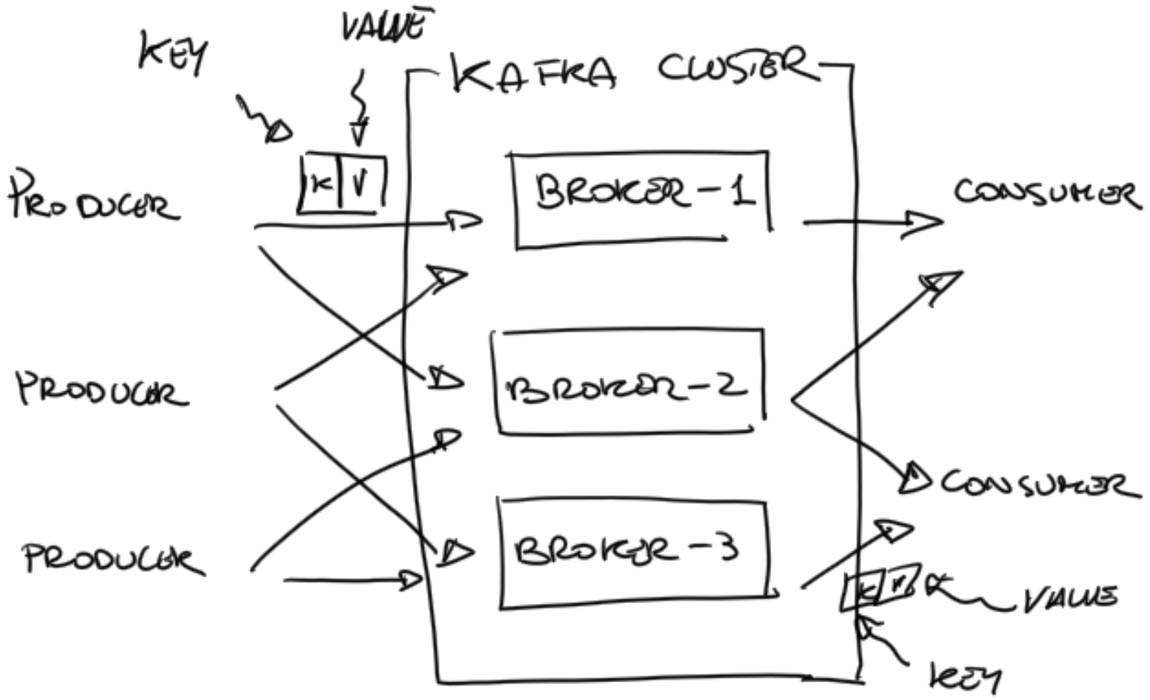

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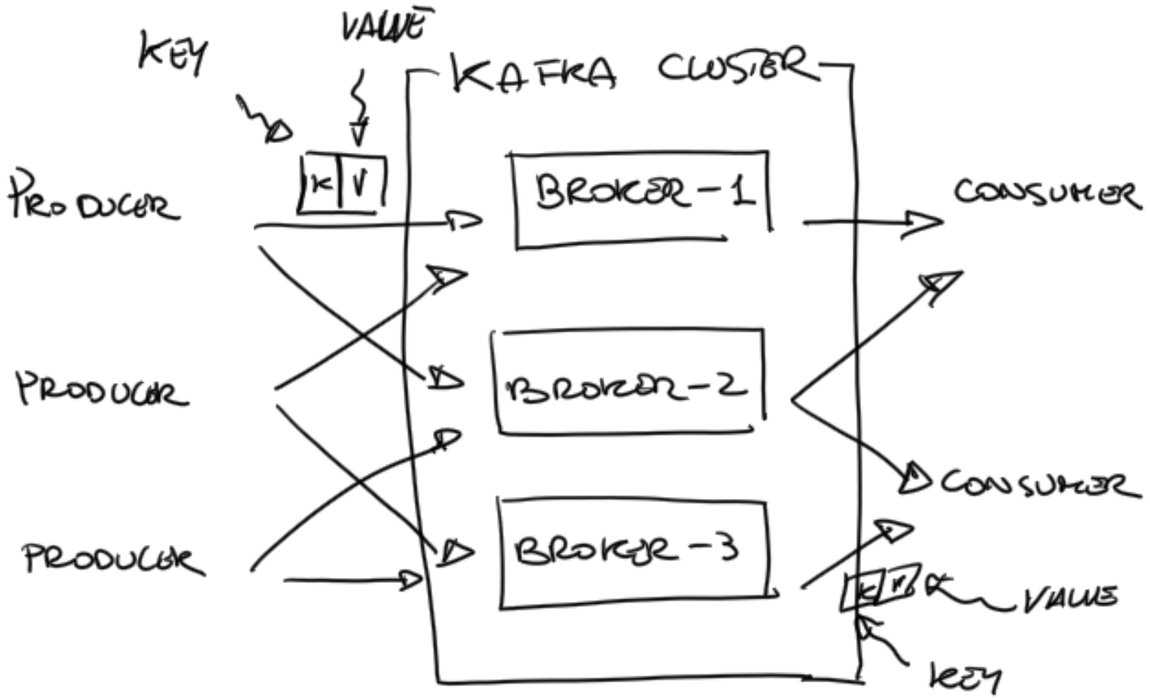

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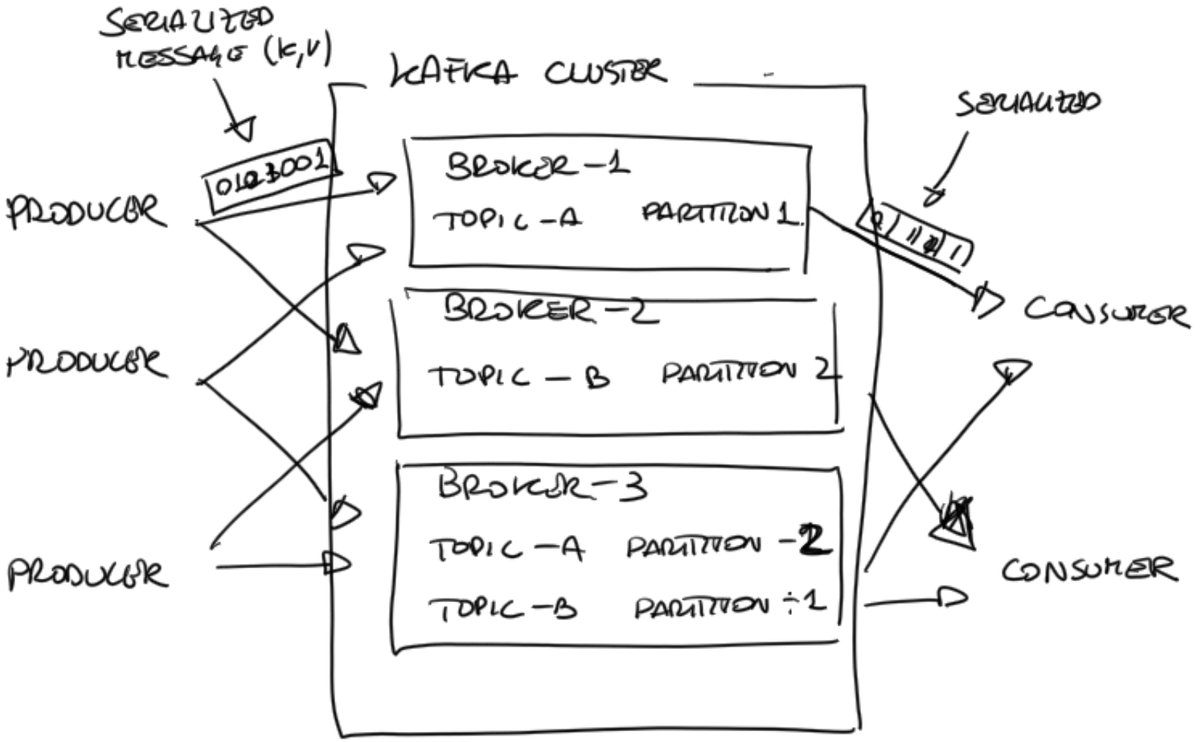
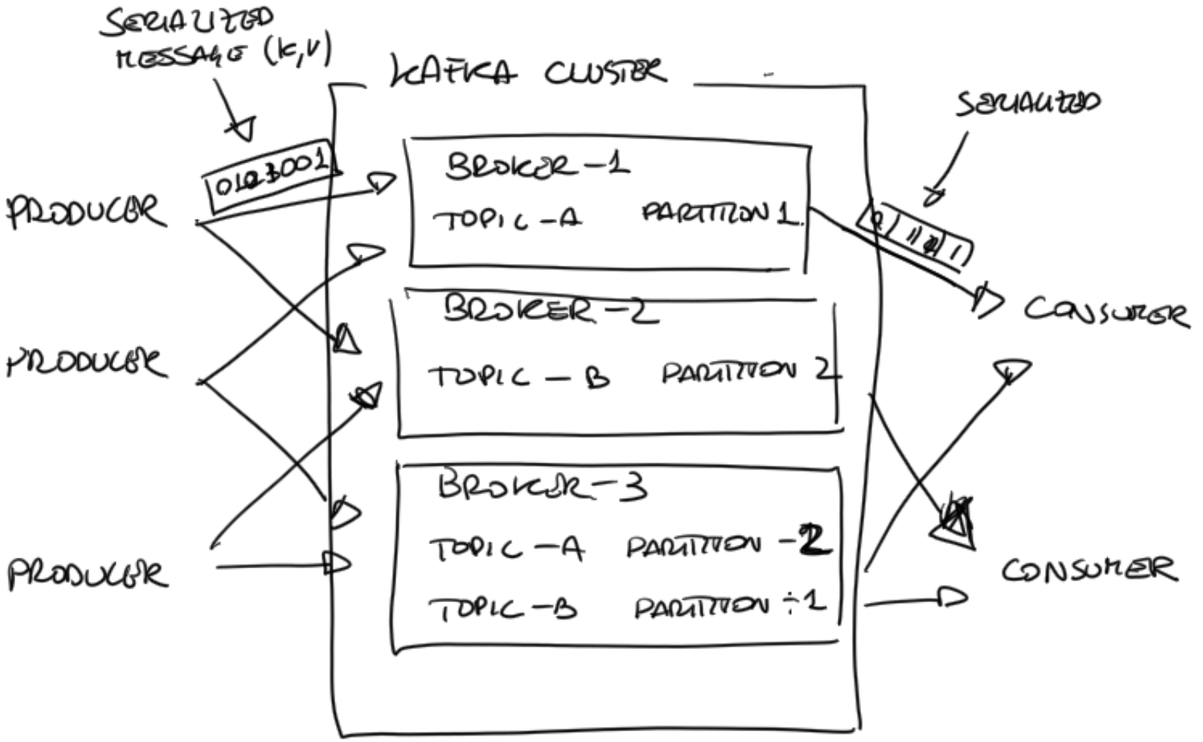


Kafka Physical View

- **Topics** are partitioned across brokers using the message **Key**.



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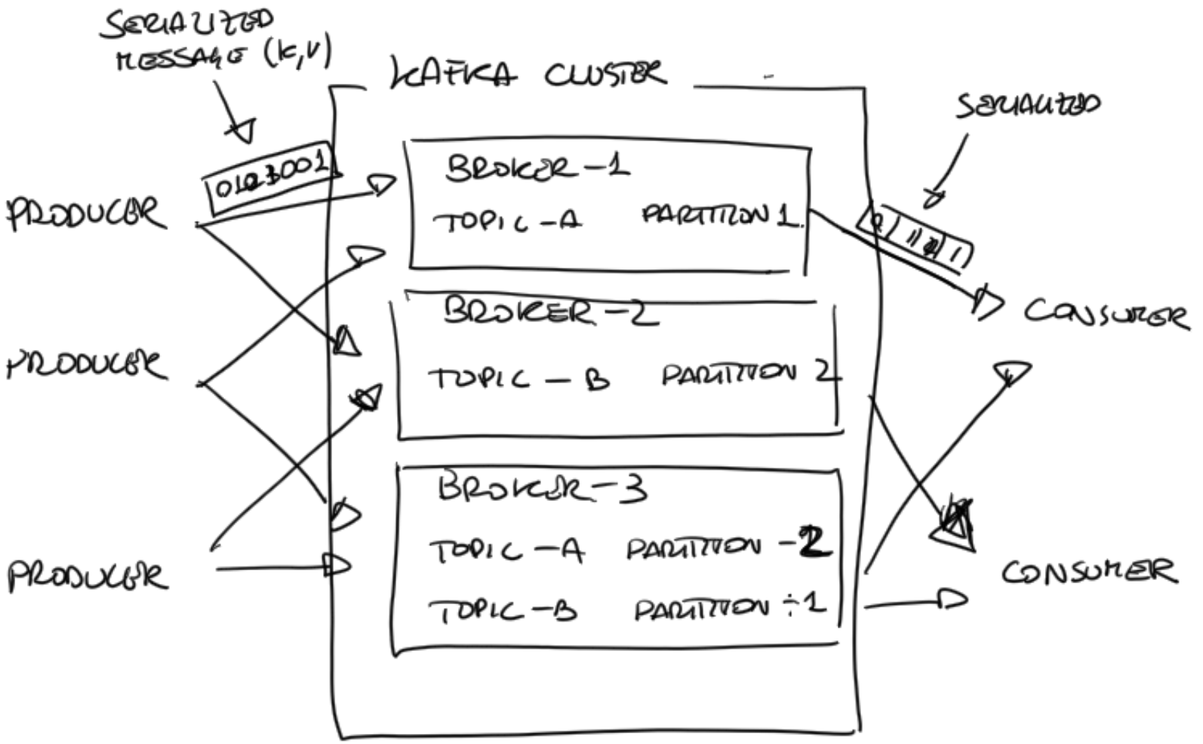

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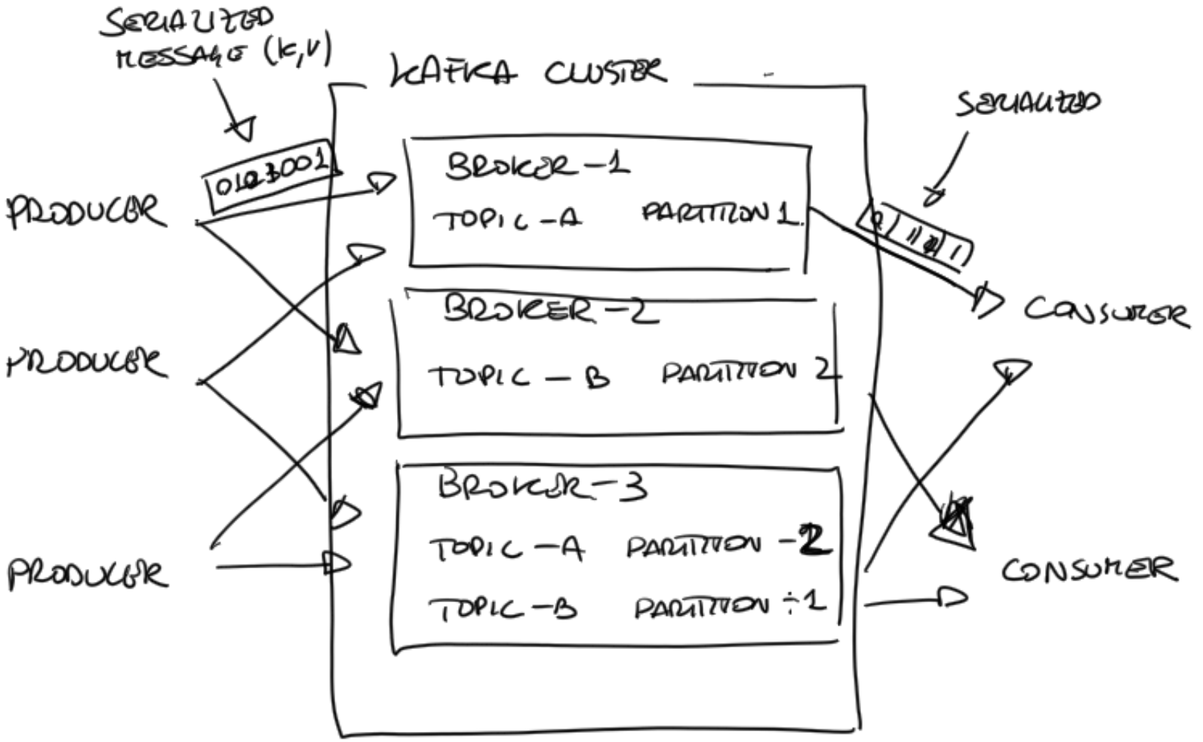
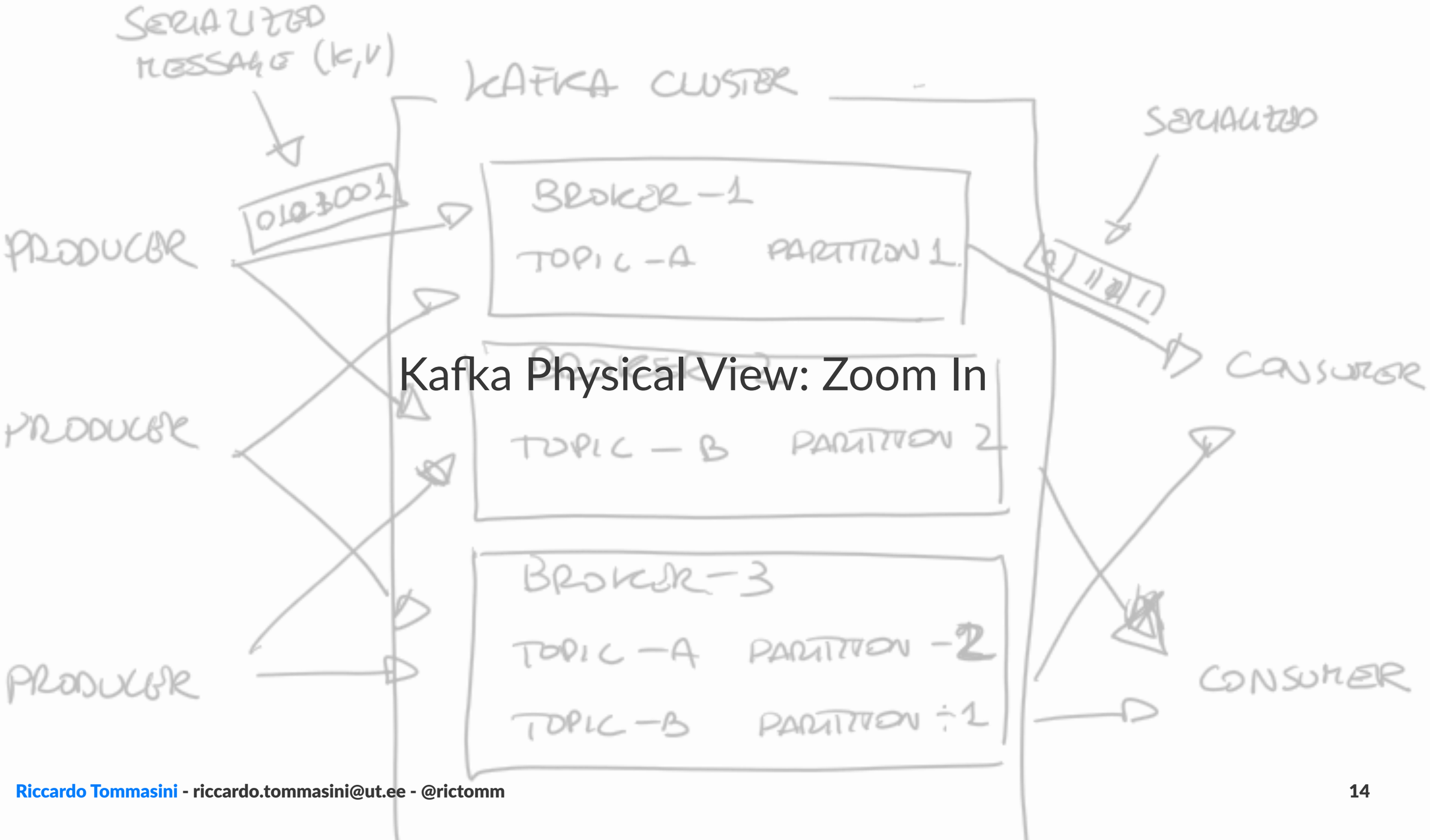
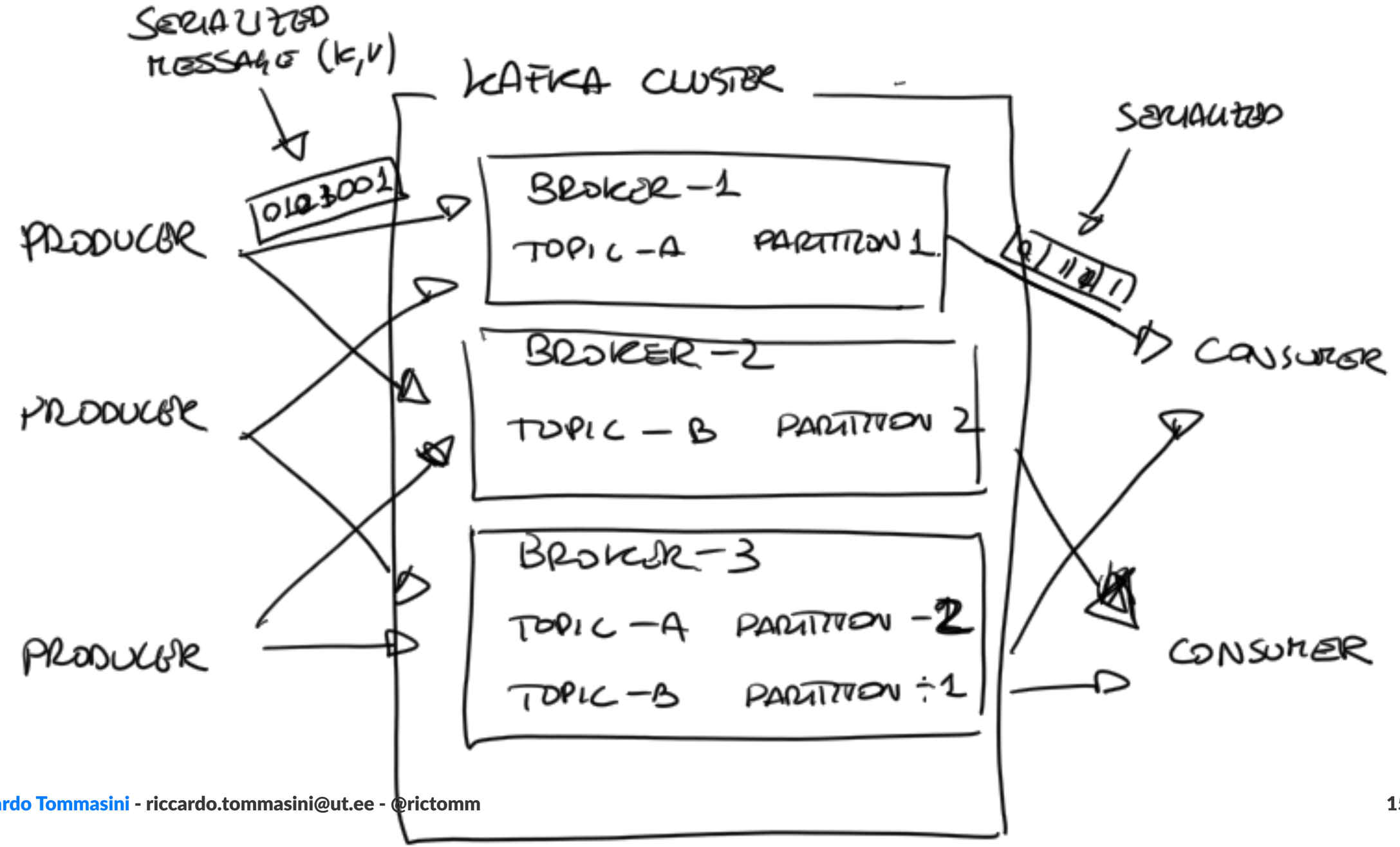




Kafka Physical View: Zoom In


SERIALIZED MESSAGE (K,V)
KAFKA CLUSTER
SERIALIZED
PRODUCER
PRODUCER
PRODUCER
BROKER-1
TOPIC-A
PARTITION 1
BROKER-2
TOPIC-B
PARTITION 2
BROKER-3
TOPIC-A
PARTITION -2
TOPIC-B
PARTITION ÷1
CONSUMER
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Topics Partitions

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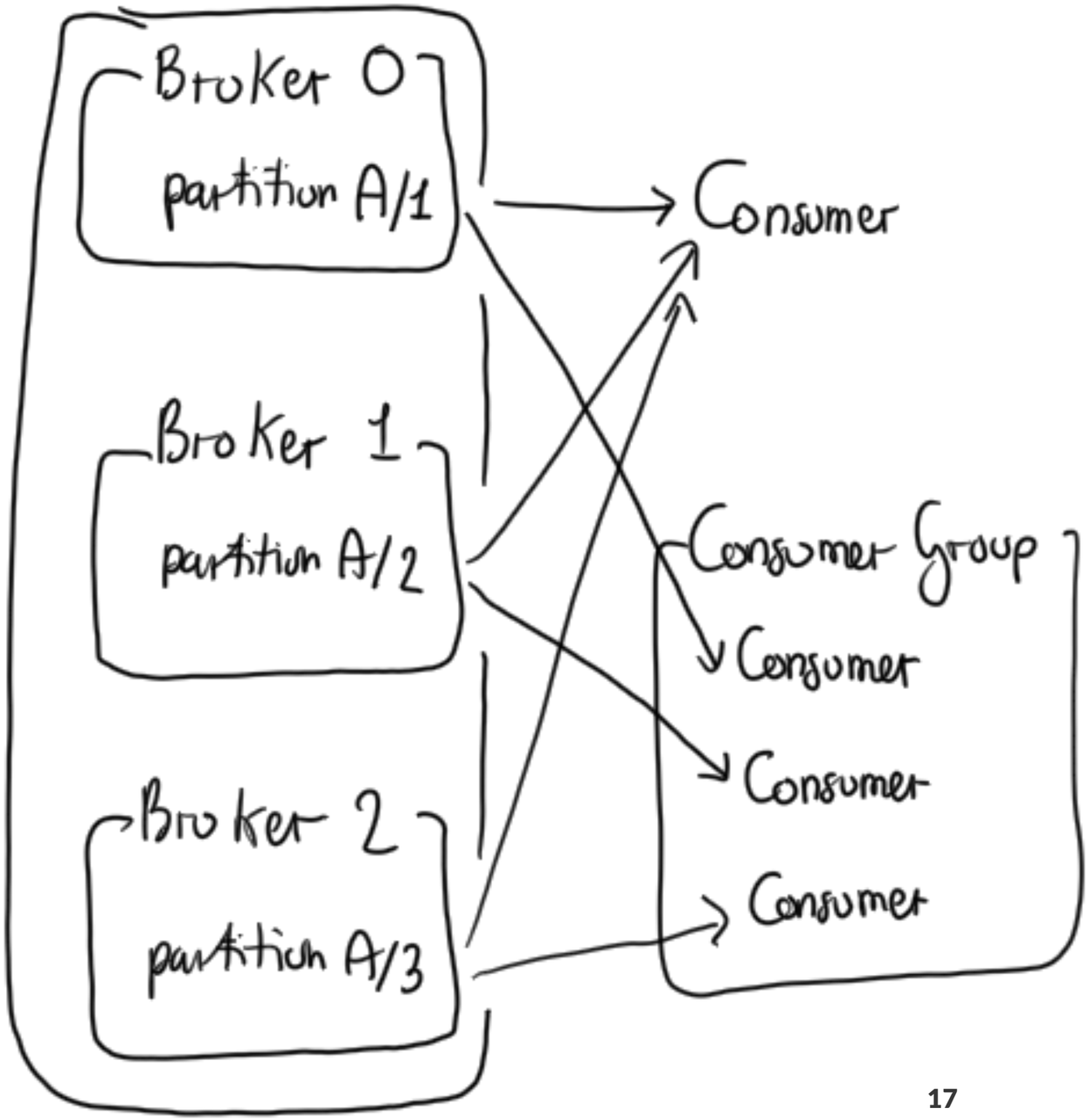
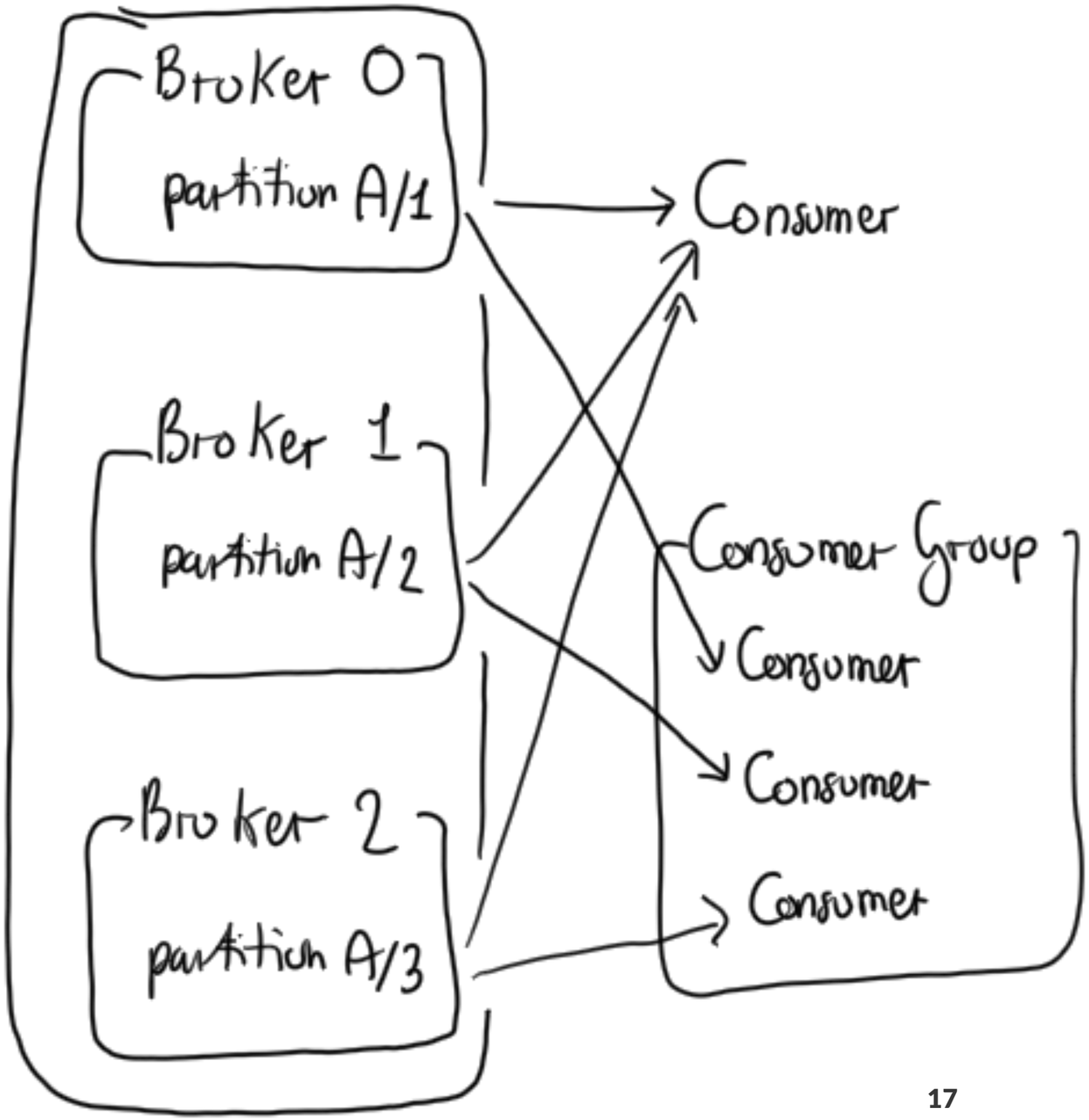
- Each Partition is an ordered, immutable log of messages

Topics Partitions and Distributed Consumption



Topics Partitions and Distributed Consumption

- Different Consumers can read data from the same Topic



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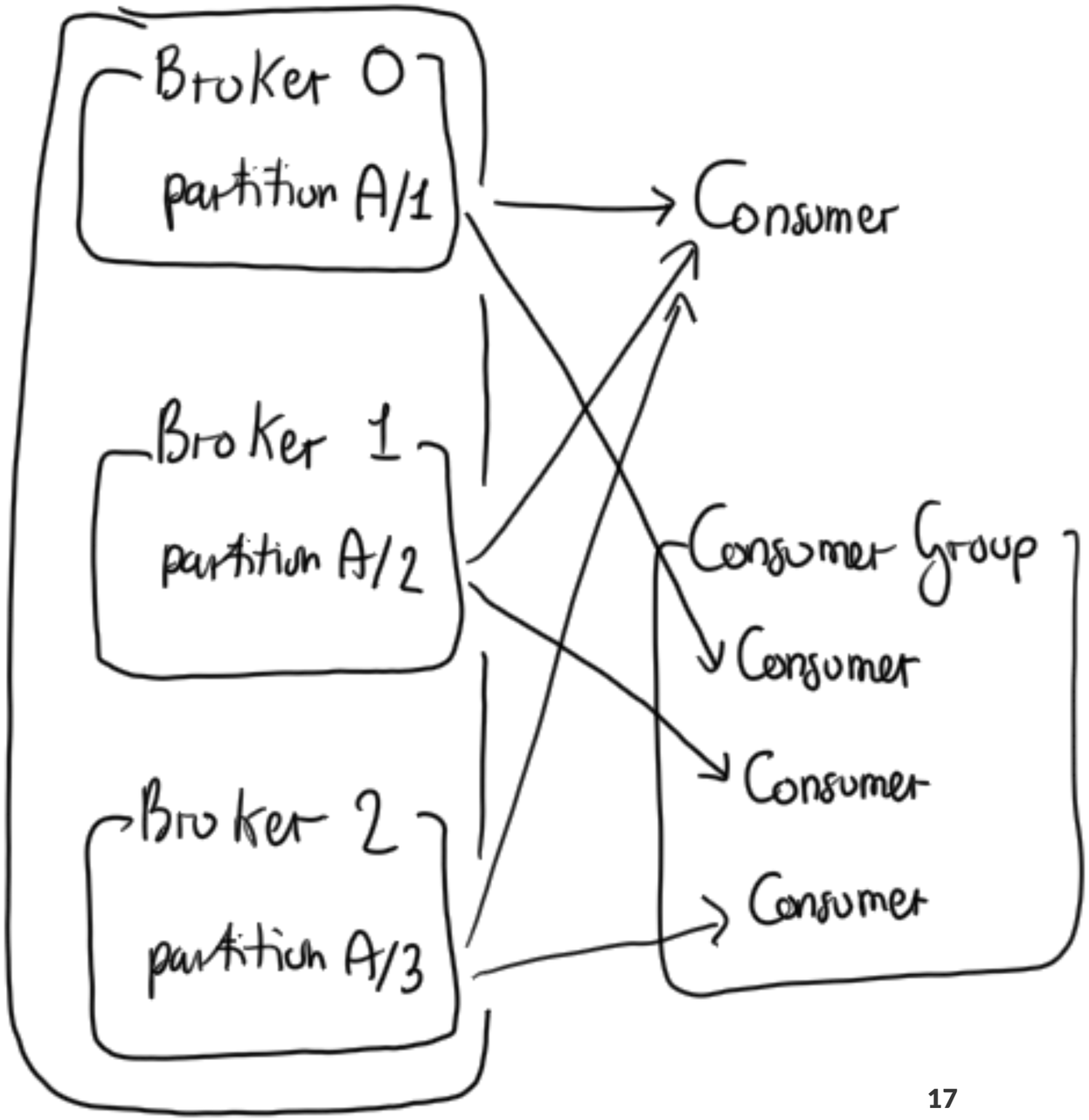

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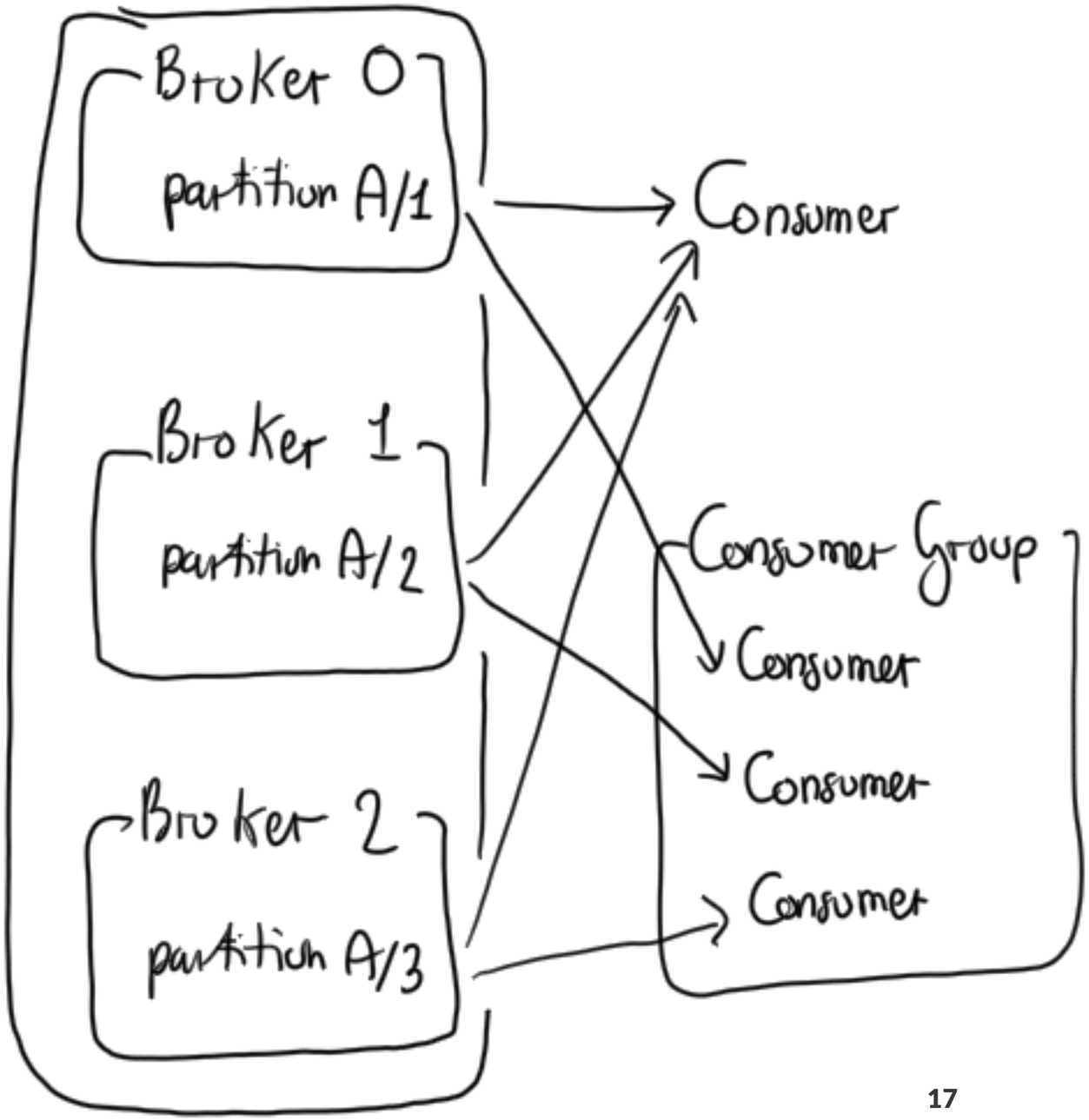

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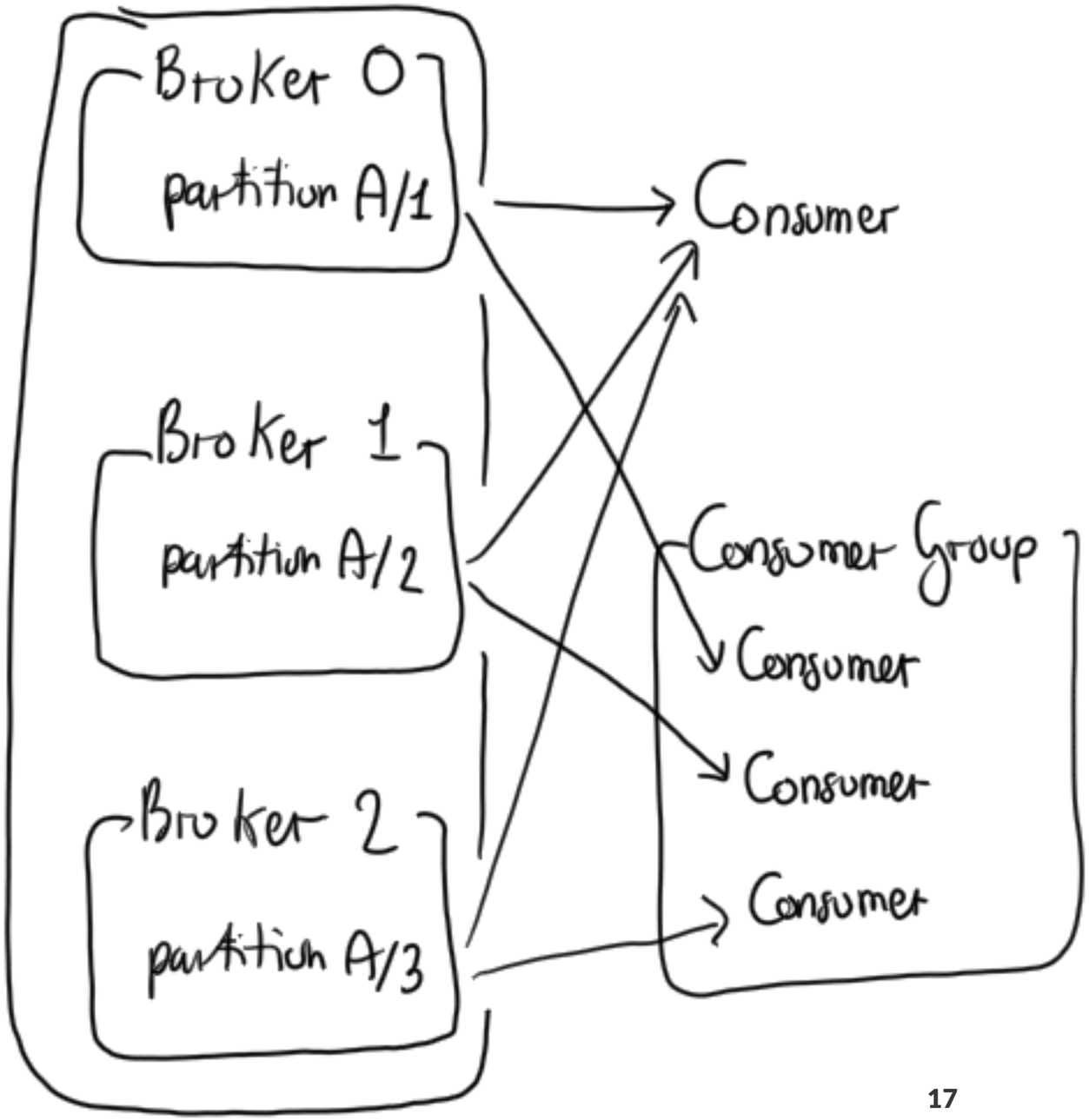

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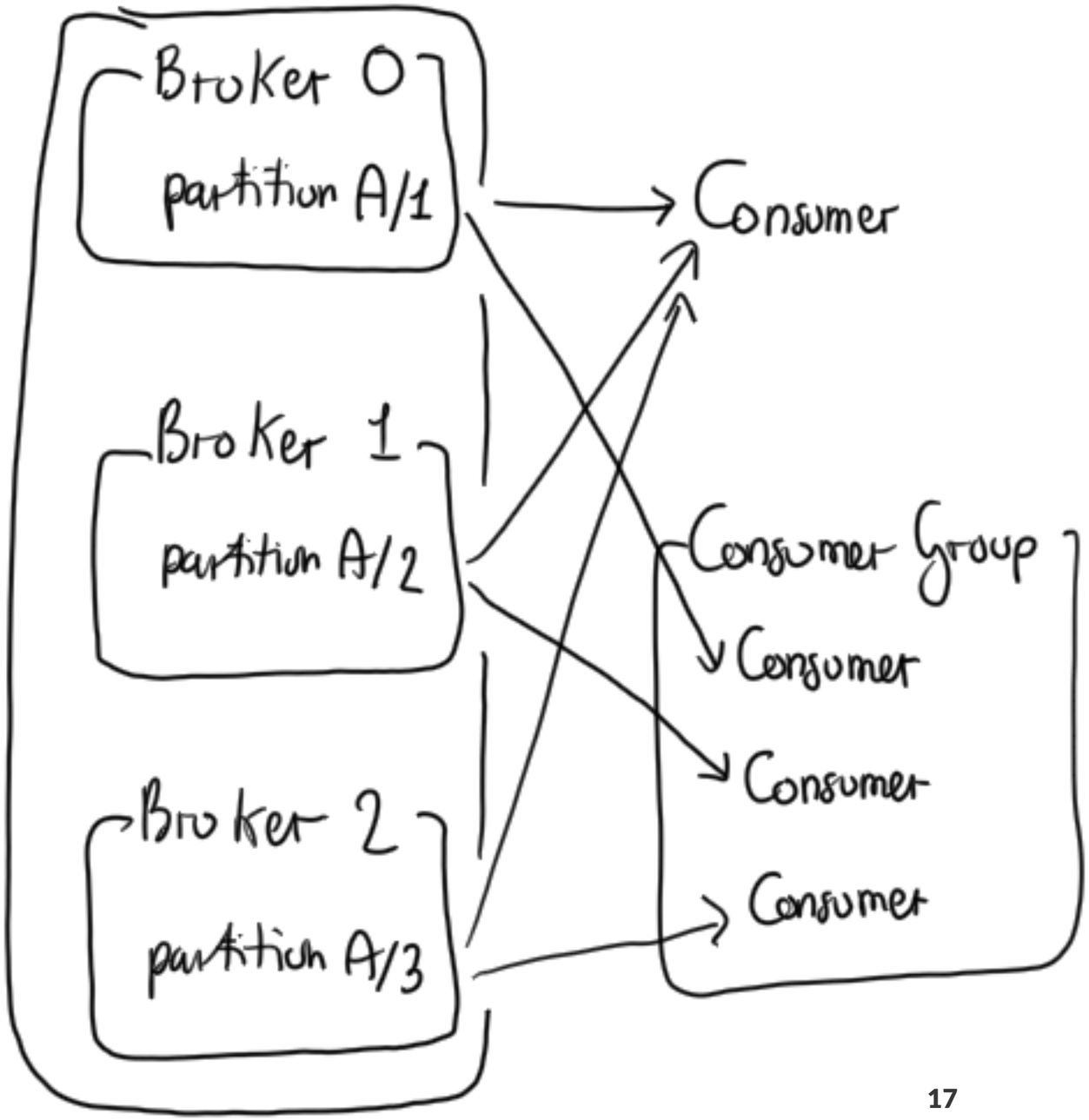
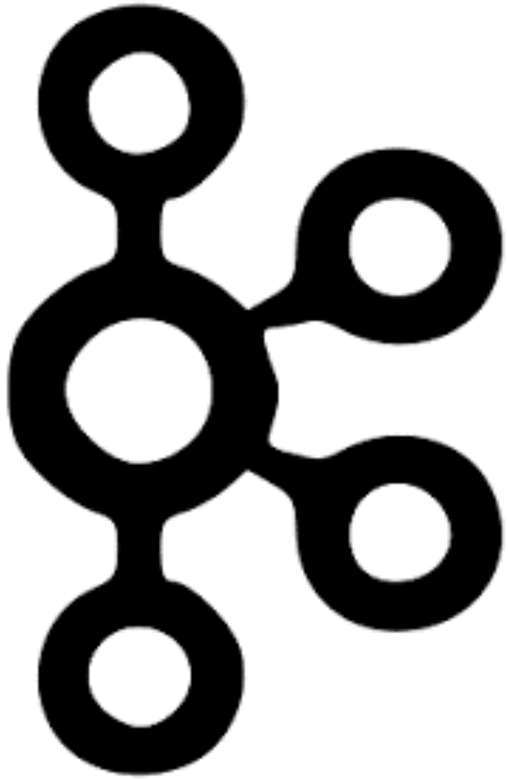
  - Each Consumer is assigned a subset of Partitions for consumption



Apache Kafka[^2]

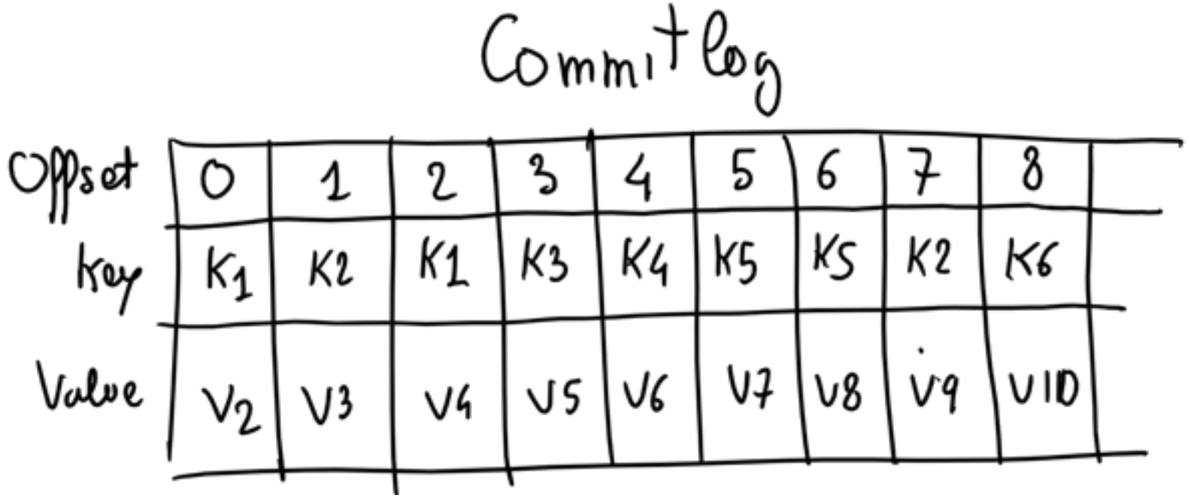


Internals

Messages and Metadata

Messages are Key-Value pairs and there is not restriction on what each of them can be.

Additionally, messages are enriched with metadata:



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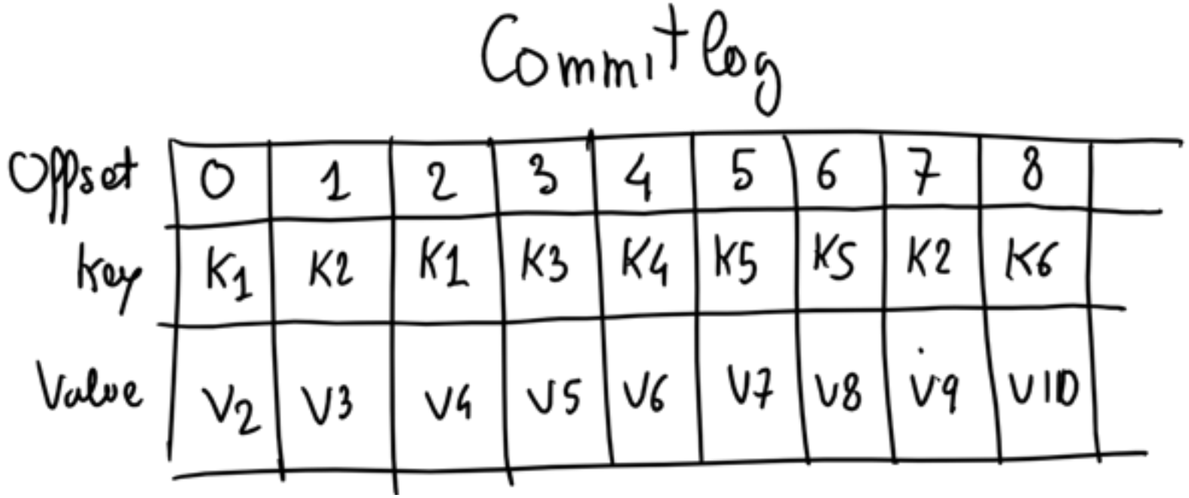

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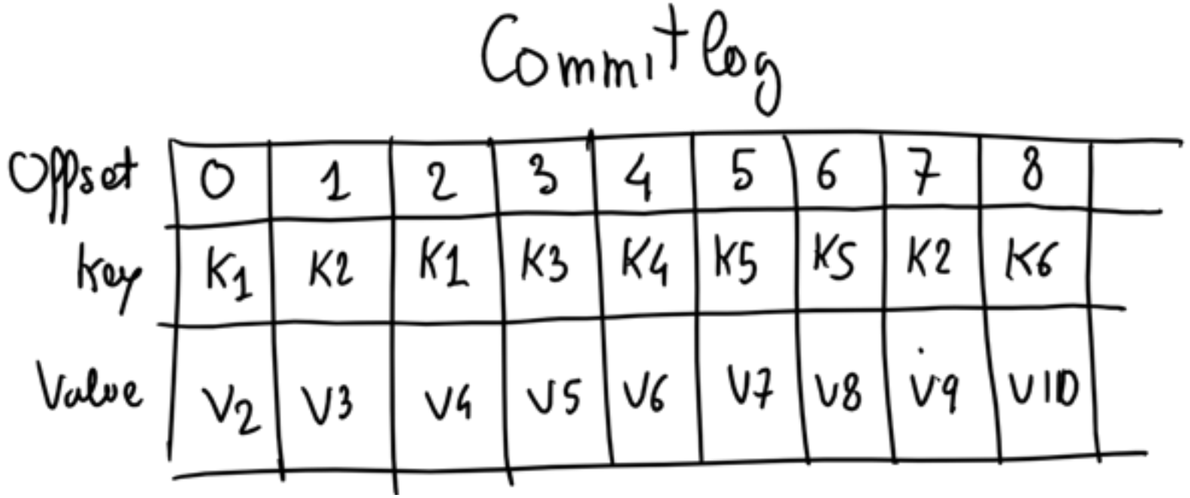

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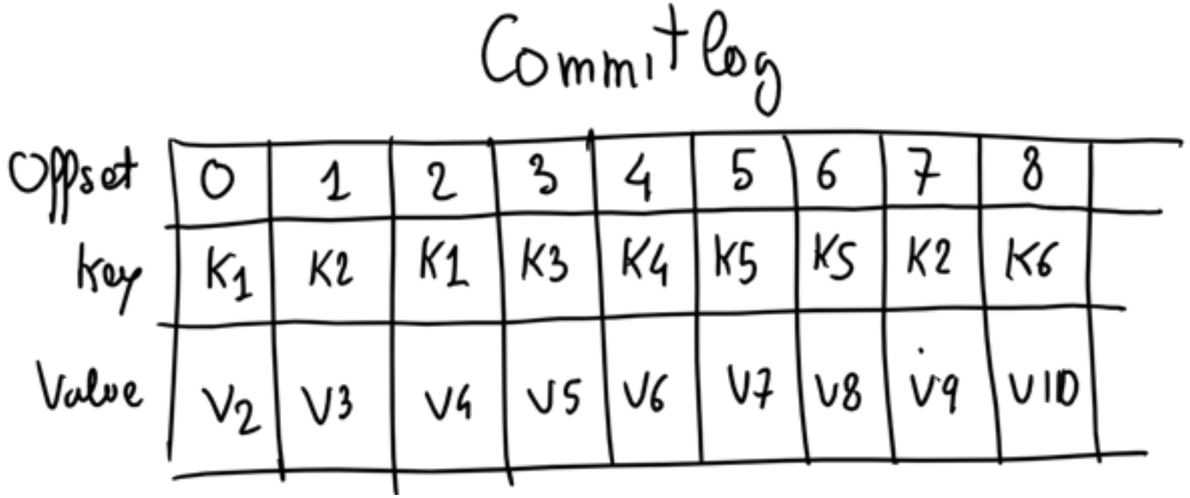

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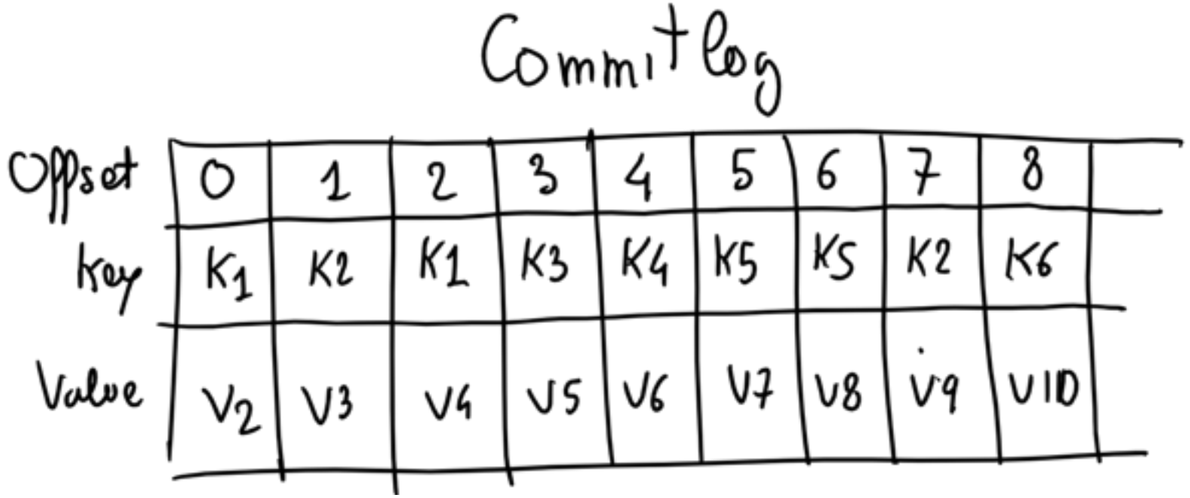

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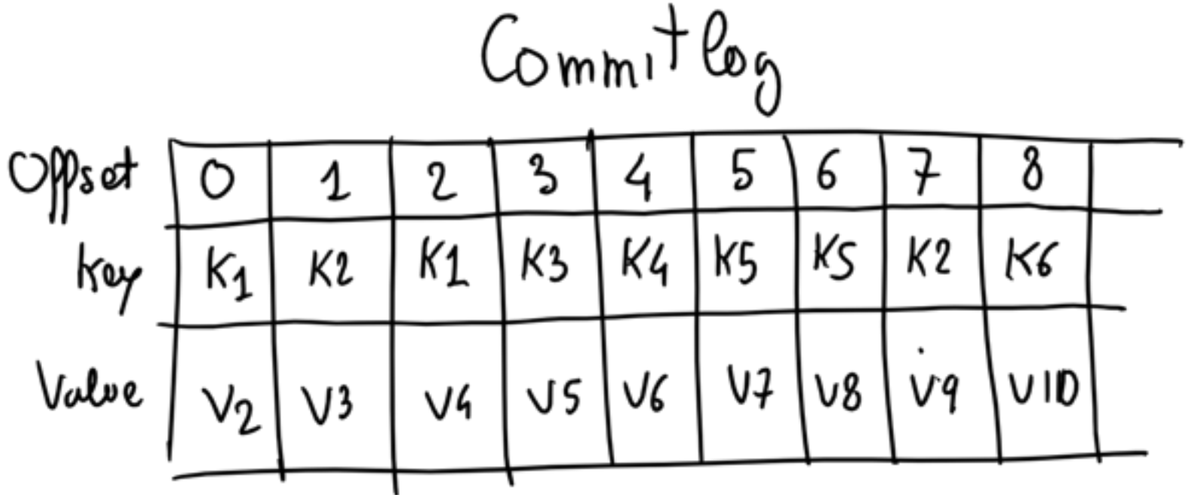

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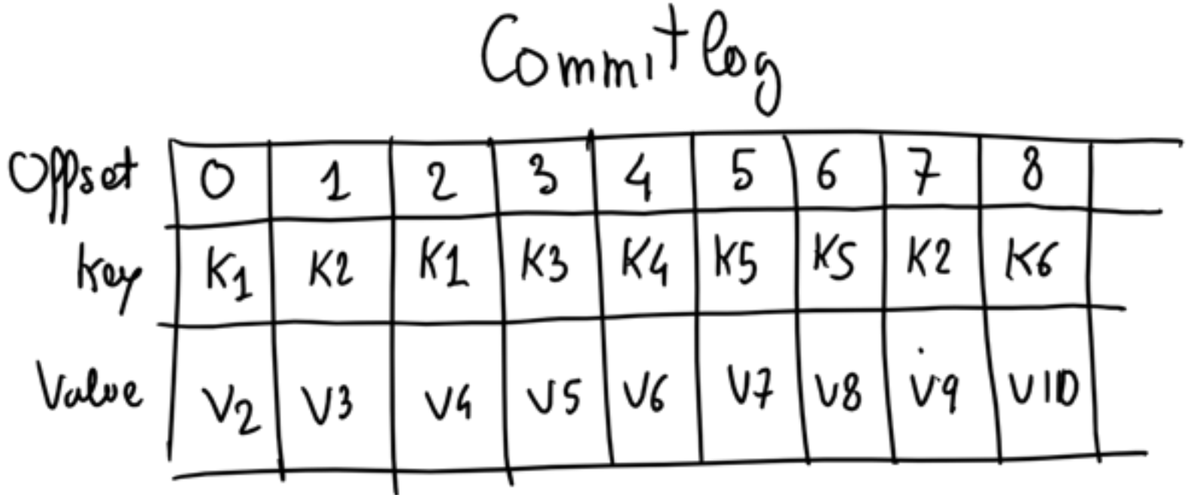

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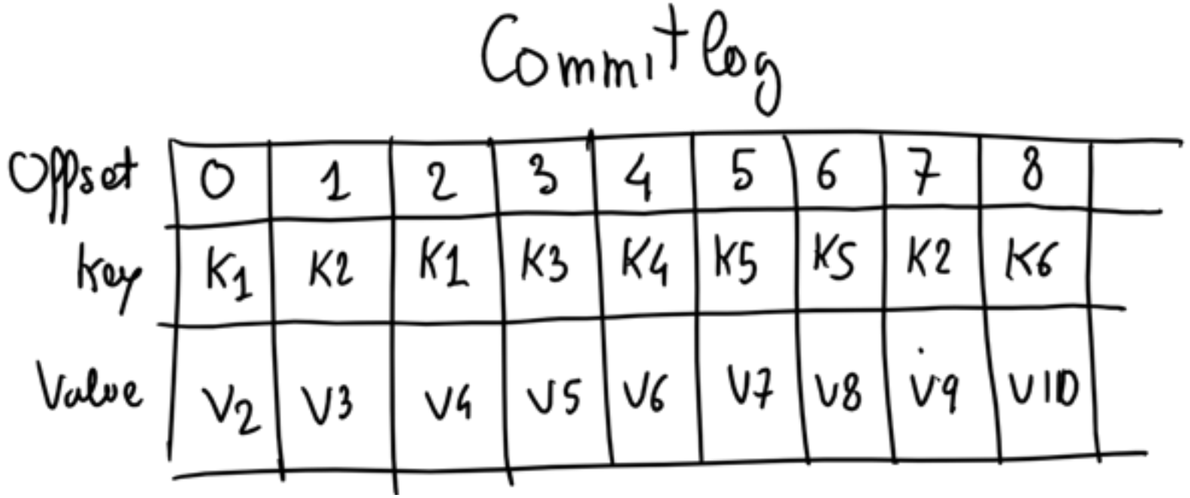
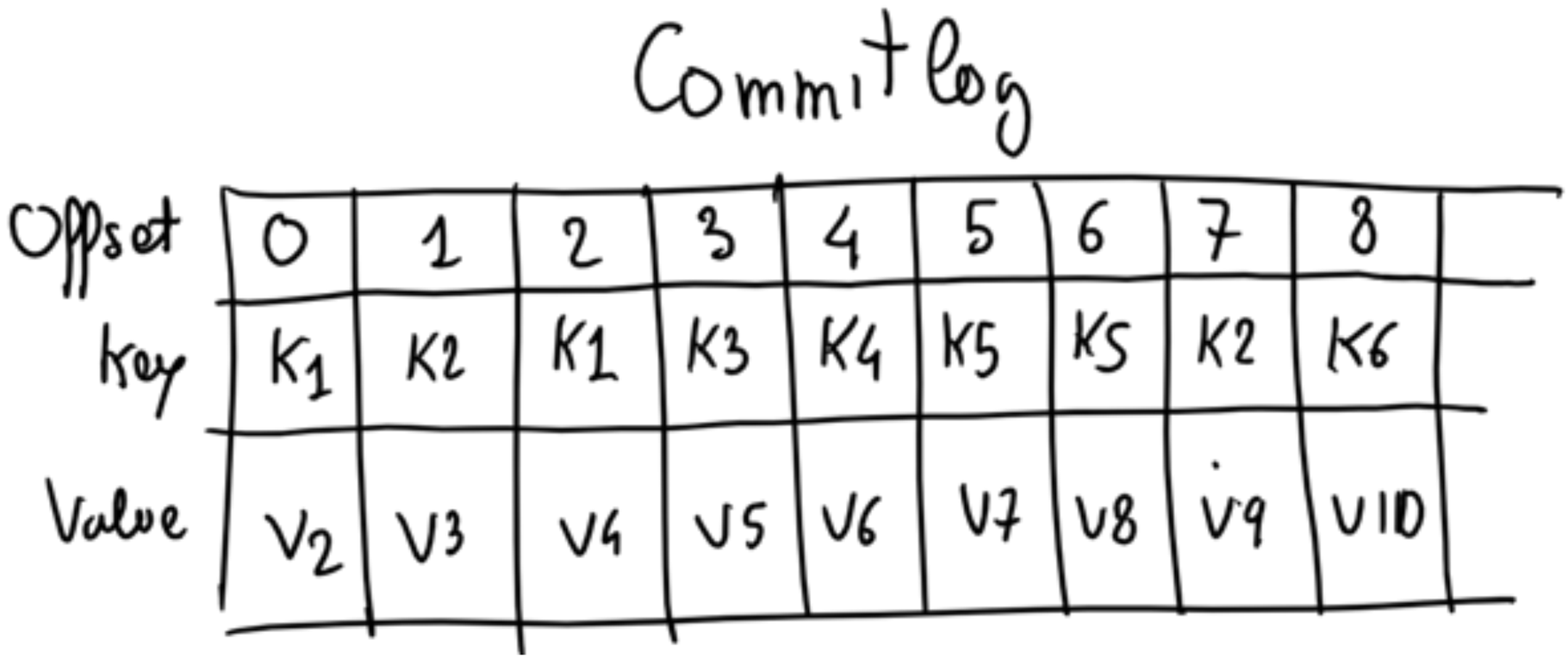
- Additional fields to support batching, exactly once semantics, replication protocol



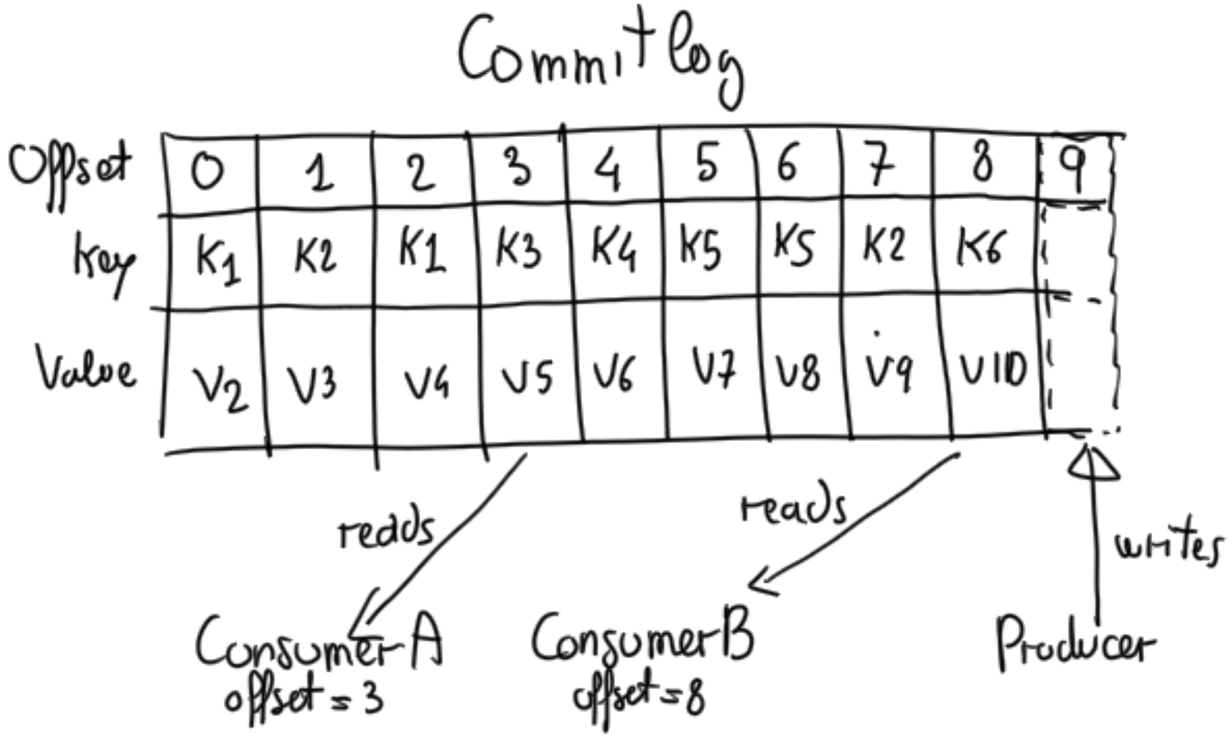
Topics Partitions: Physical View

Each Partition is stored on the Broker's disk as one or more log files Each message in the log is identified by its offset number



Topics Partitions: Physical View

Messages are always appended. Consumers can consume from different offset. Brokers are single thread to guarantee consistency



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You can customize the partition strategy, but!

- it must ensure load balancing across the Brokers too, i.e., hash(key) % number_of_partitions

Topics Partitions: Load Balancing

Producers use a partition strategy to assign each message a partition

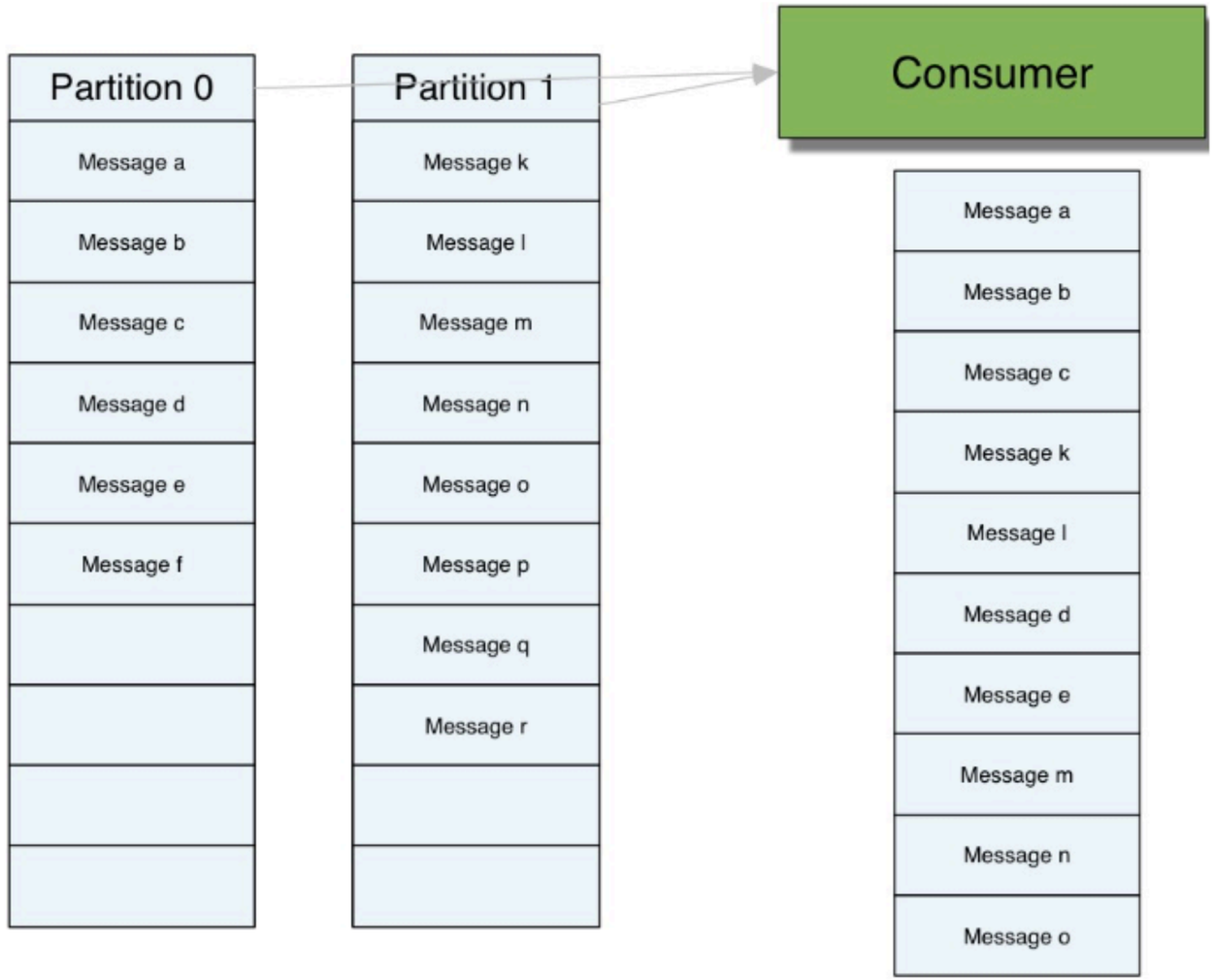
- To ensure load balancing across the Brokers
- To allow user-specified key

You can customize the partition strategy, but!

- it must ensure load balancing across the Brokers too, i.e., hash(key) % number_of_partitions
- if key is not specified, messages are sent to Partitions on a round-robin basis

Important: About Ordering

If there are multiple Partitions, you will not get total ordering across all messages when reading data



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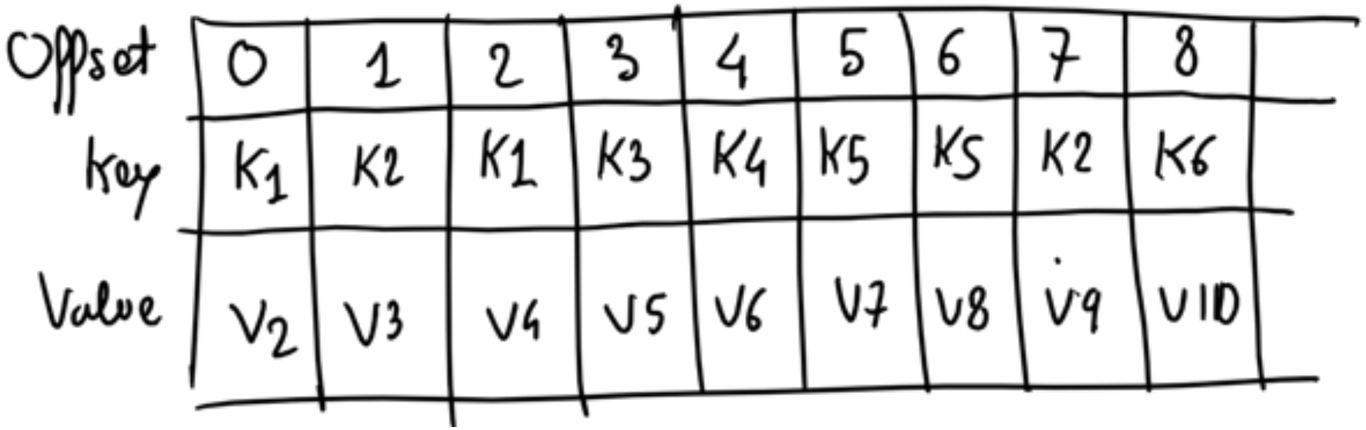
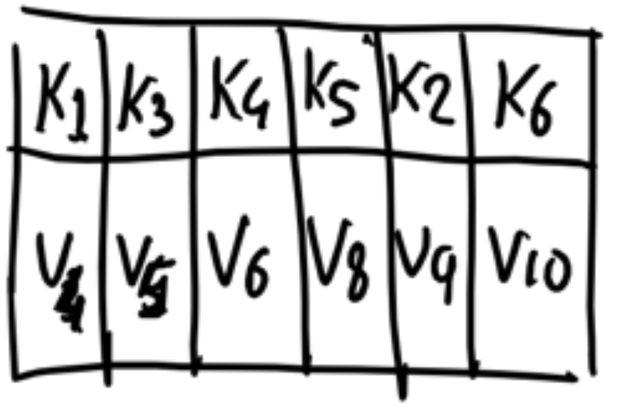
  - An alternate policy is compact

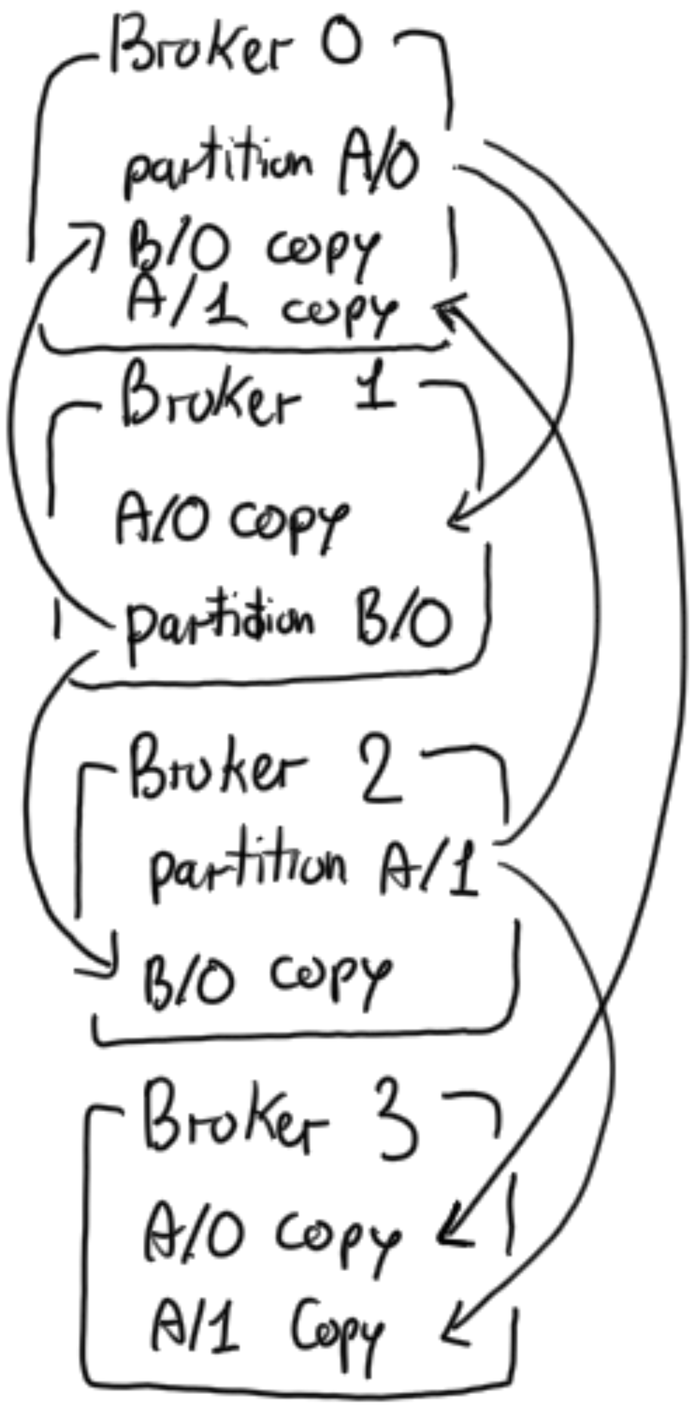
Log Compaction

A compacted log retains at least the last known message value for each key within the Partition
Before After





Fault Tolerance via a Replicated Log



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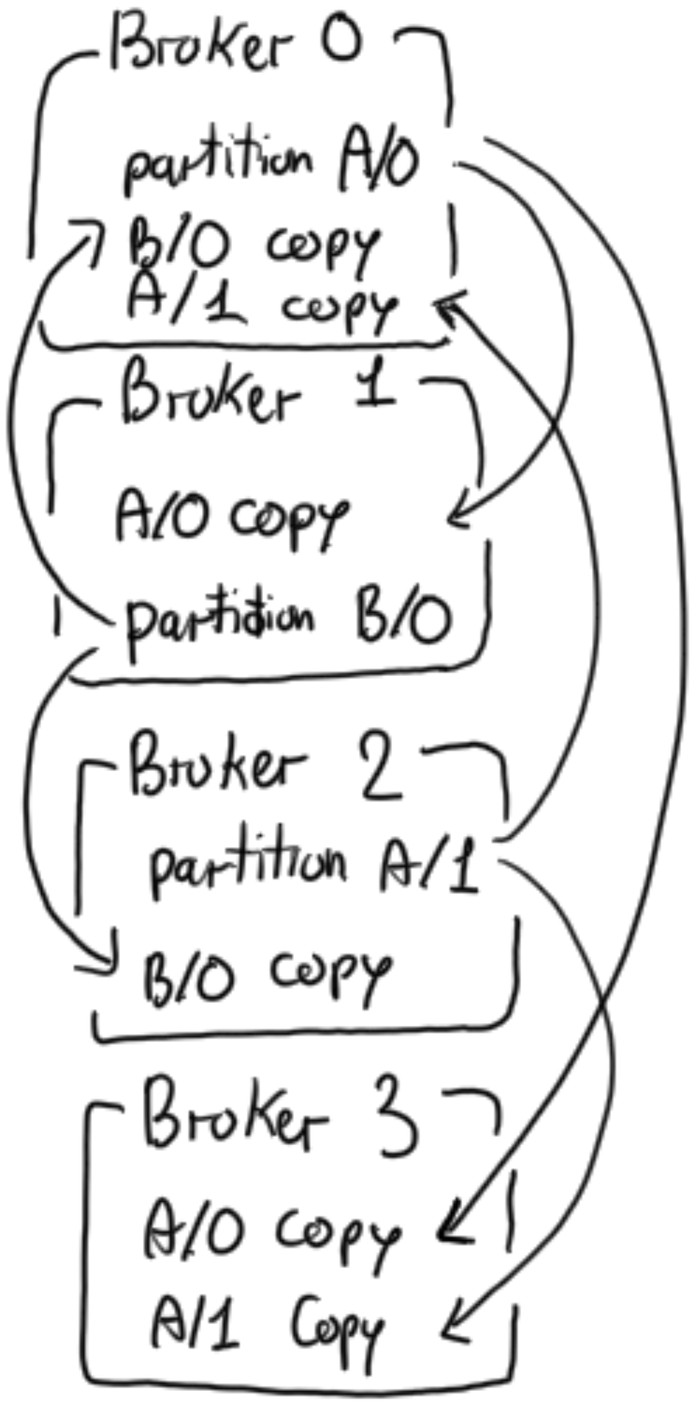

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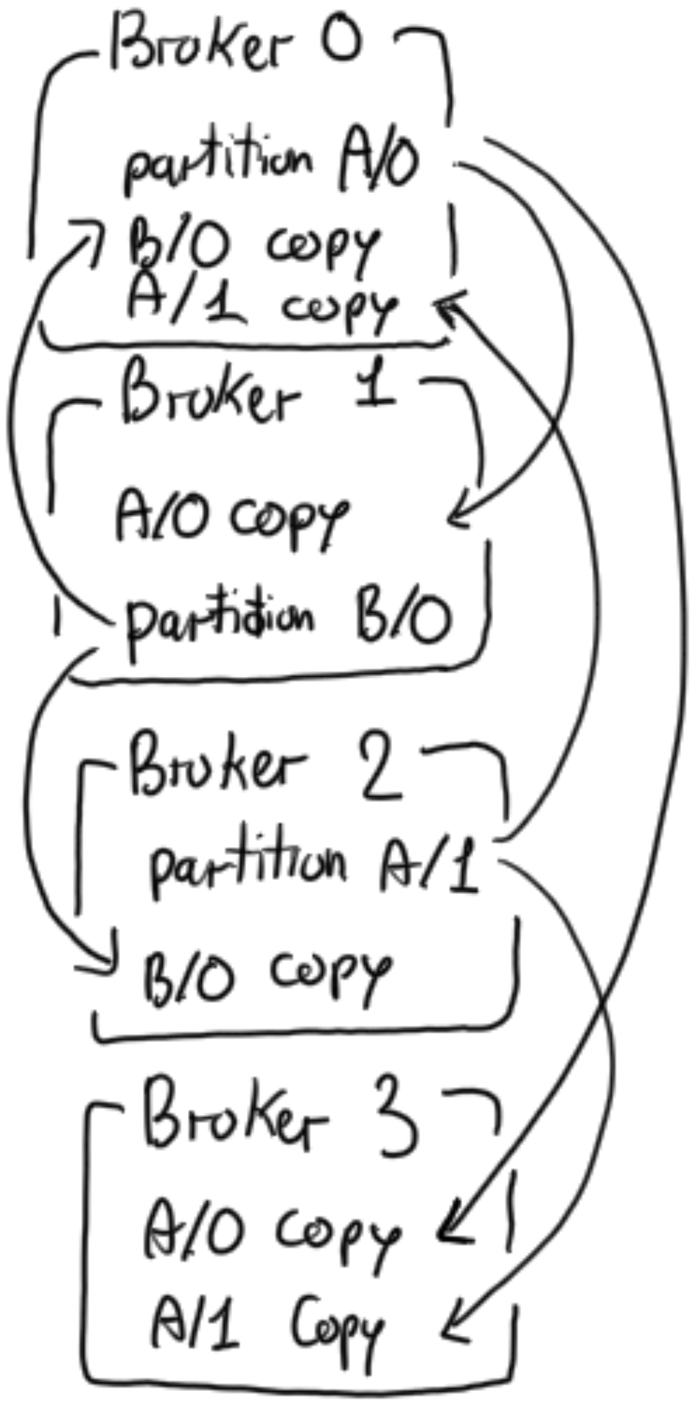

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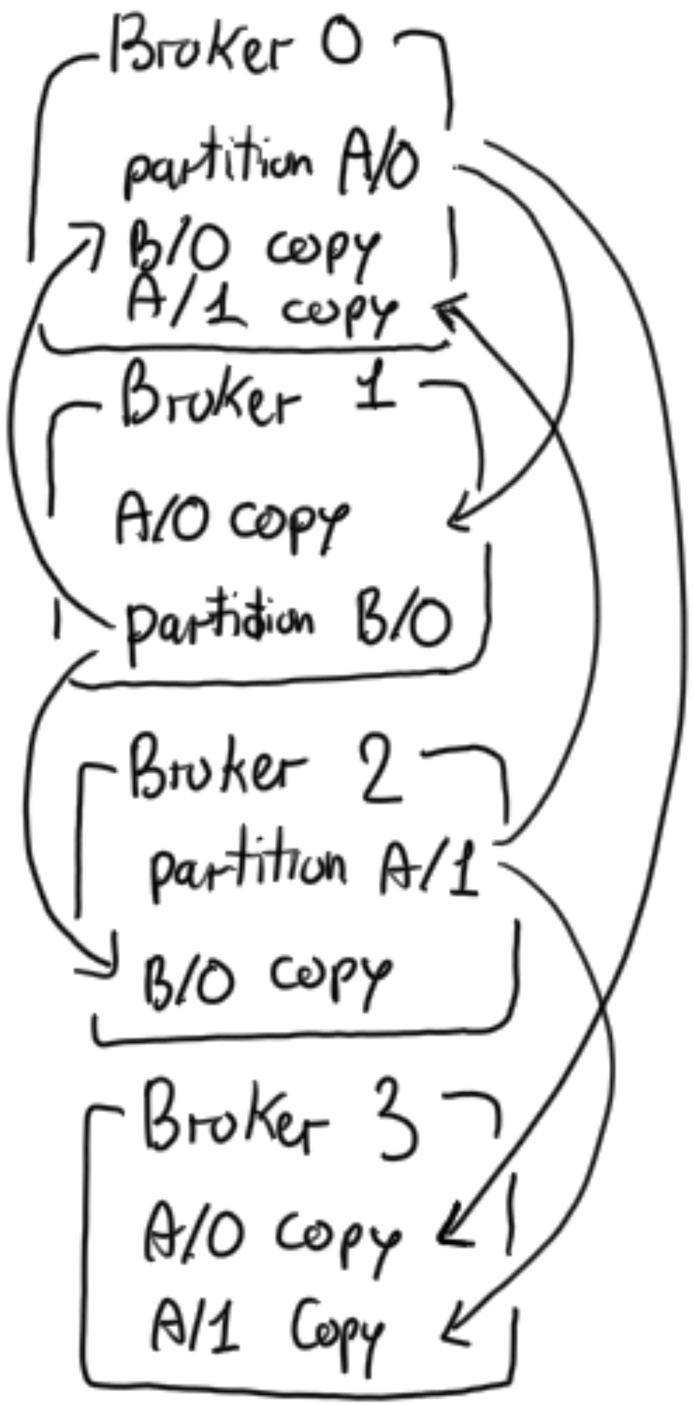

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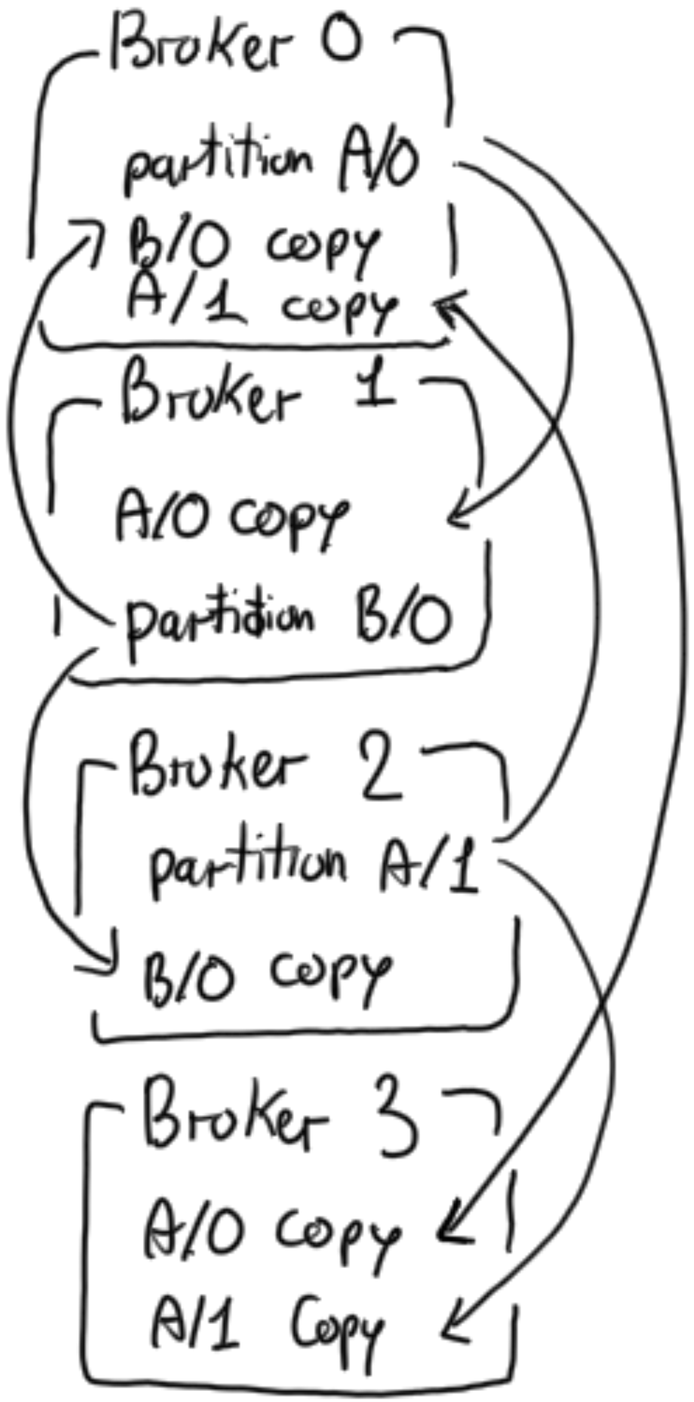

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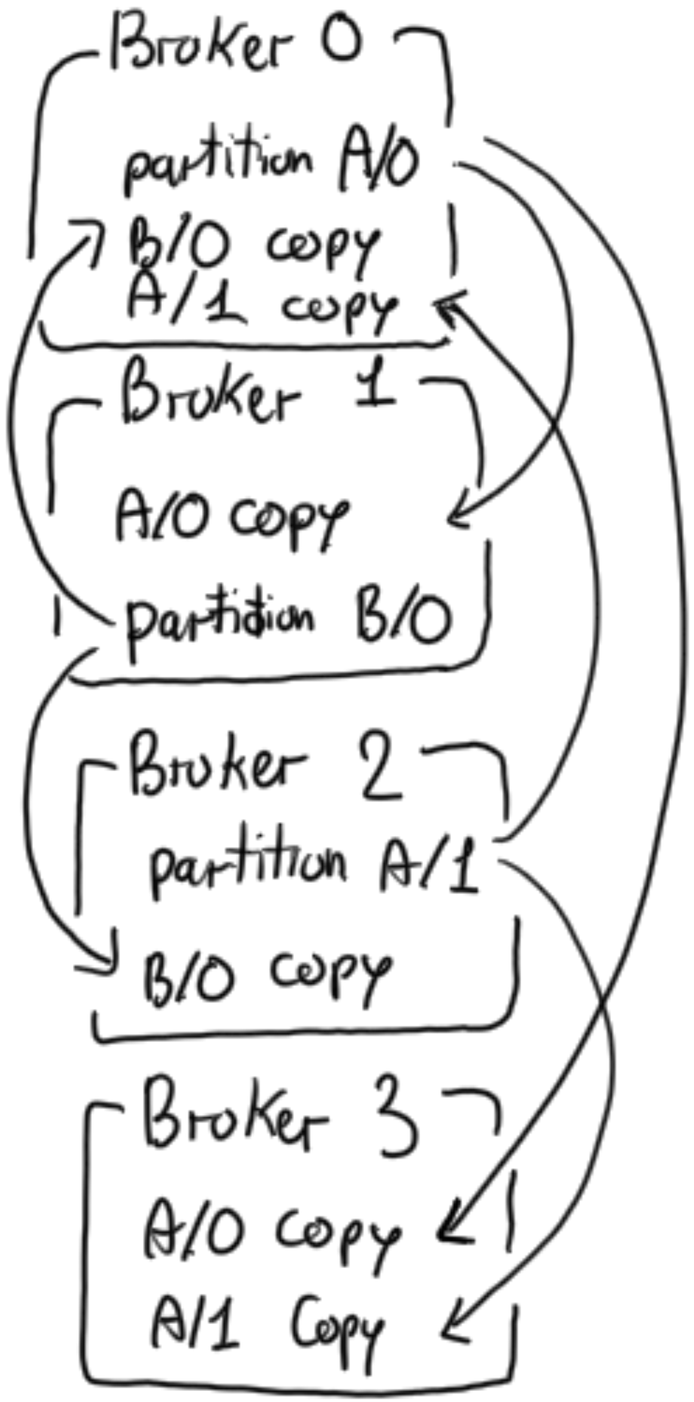

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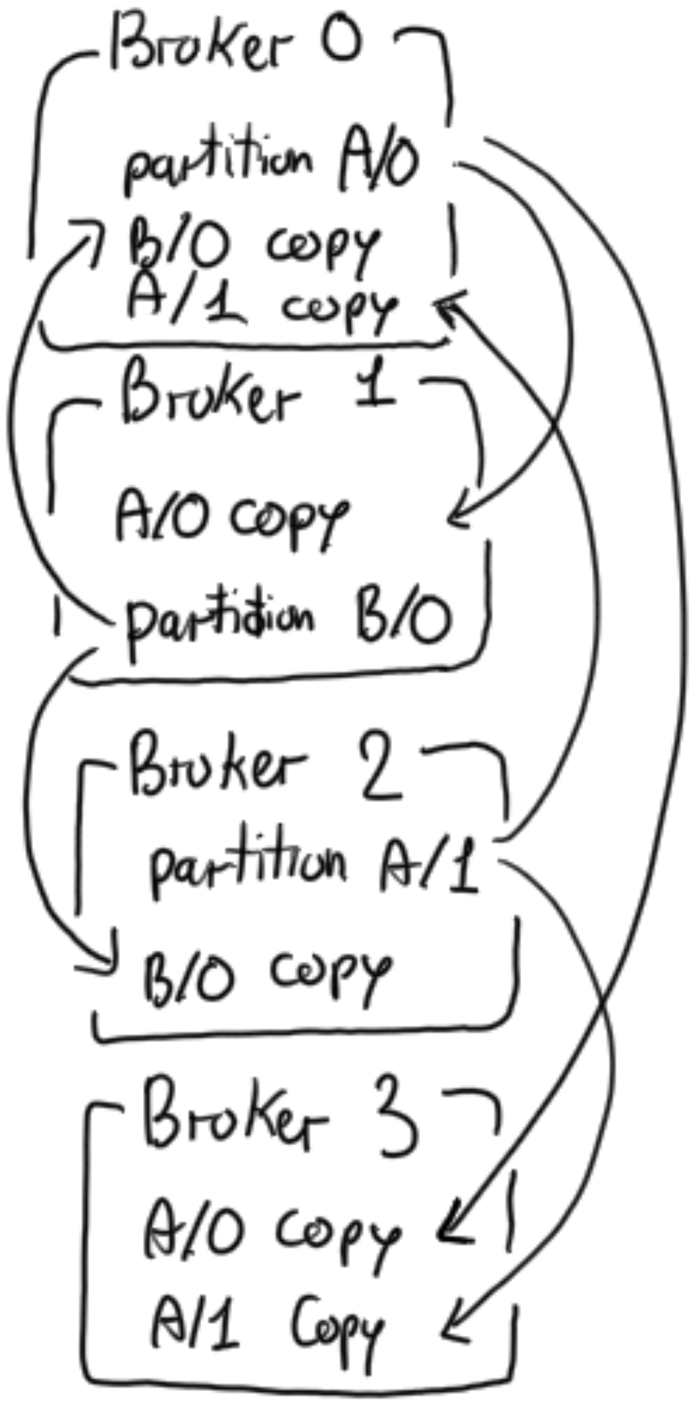

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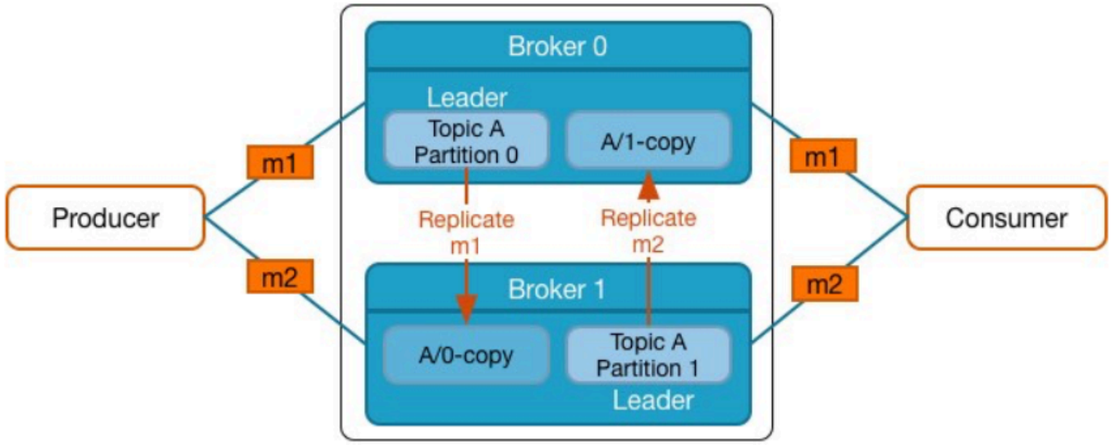

In the diagram, m1 hashes to Partition 0 and m2 hashes to Partition 1

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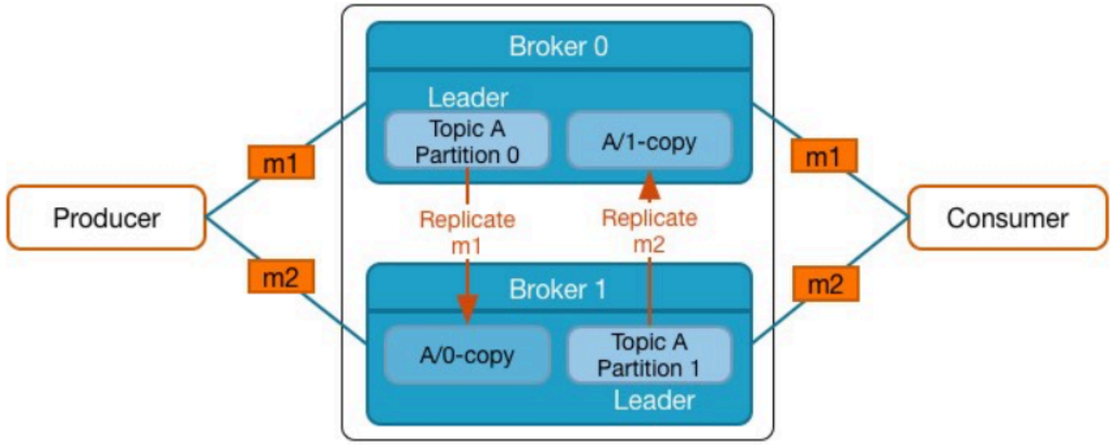

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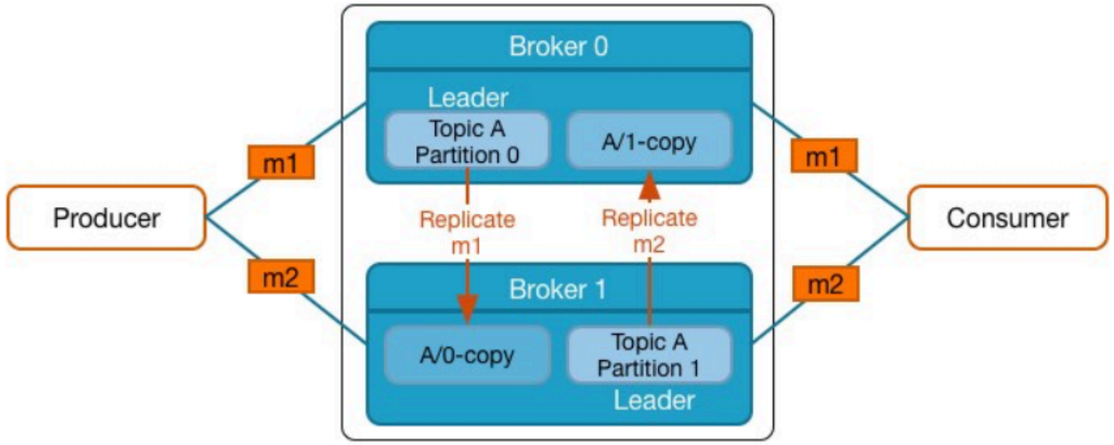

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Provide the correct relationship - 1:1, 1:N, N:1, or N:N -

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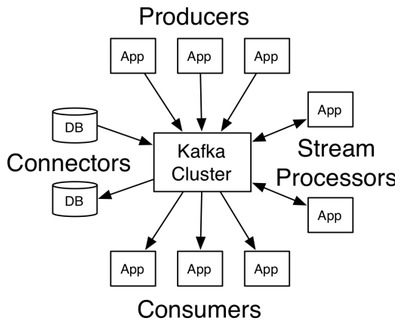
Systems Overview: [[Apache Kafka]]



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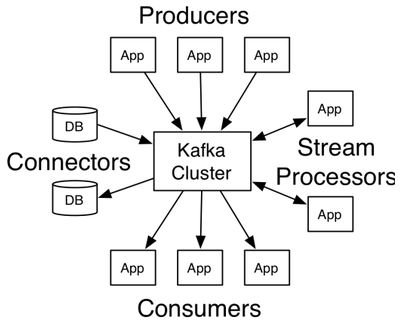

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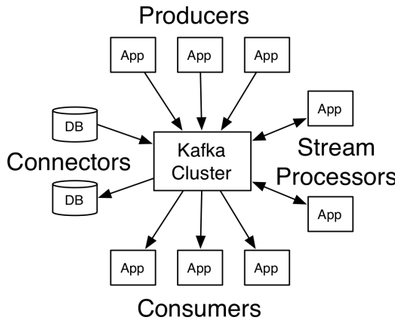

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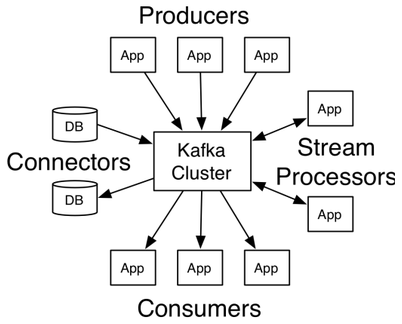

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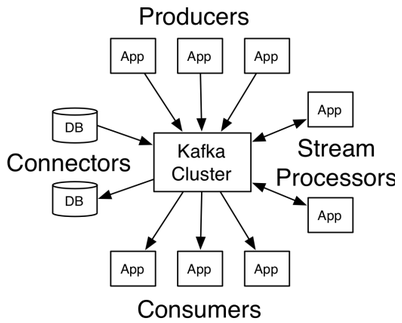

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