IOT DATA STREAMING WITH APACHE KAFKA

From the data to the wisdom

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WHO AM I ?

@ppatierno

- Principal Software Engineer @ Red Hat
  - Messaging & IoT team
- Lead/Committer @ Eclipse Foundation
  - Hono, Paho and Vert.x projects
- Microsoft MVP Azure/IoT
- Dad of two
- VR46's fan (I don't like MM93)
- Try to be a runner ...

IOT USE CASES

- Smart city
- Healthcare
- Connected cars
- Logistics
- Home automation
- Airlines
- Farmers
- You!

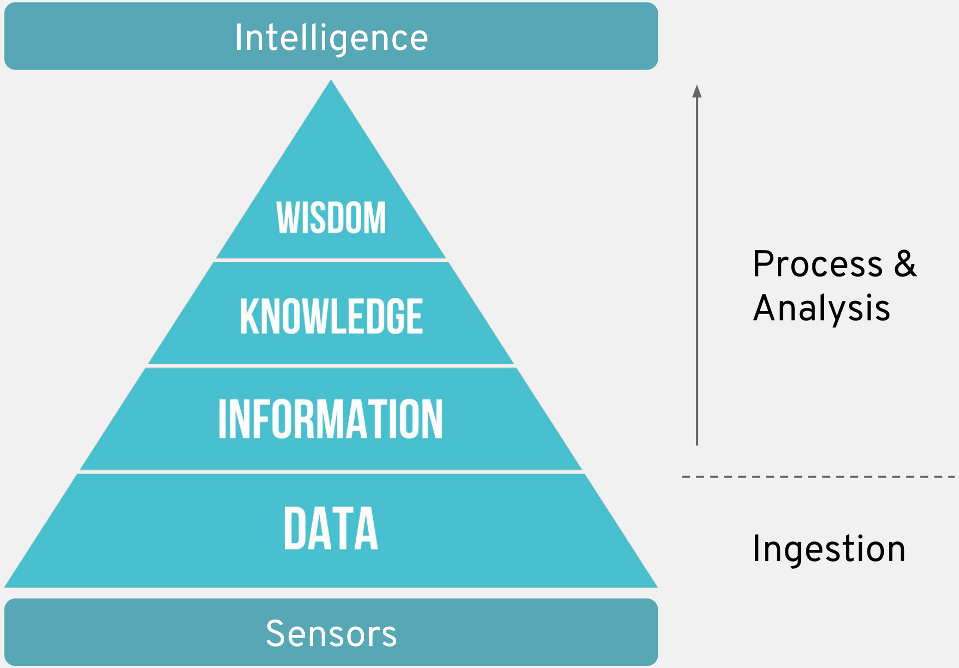
WHAT THEY HAVE IN COMMON?

IOT WORKLOAD

- Huge amount of data to ingest
- Unbounded dataset
- Need for real time analytics
- Need for real time reactions
- Sometimes the need to join :
  - with static data
  - with historical data

IOT WORKLOAD

From raw data to the intelligence



THE NEED FOR A PARADIGM DIFFERENT FROM BATCH PROCESSING

STREAM PROCESSING

- A type of data processing engine that is designed with infinite datasets in mind
- Working with data as they arrive
- Working with an infinite stream of data
    - Moving boundaries with data in “windows”
- Tradeoffs between latency/cost/correctness

STREAM PROCESSING

Versus batch processing

Compared to batch based flows, streaming flows ...

- ... are often more time-sensitive
- ... could be larger in volume
- ... may or may not be of long-term value after processing

So that you can ...

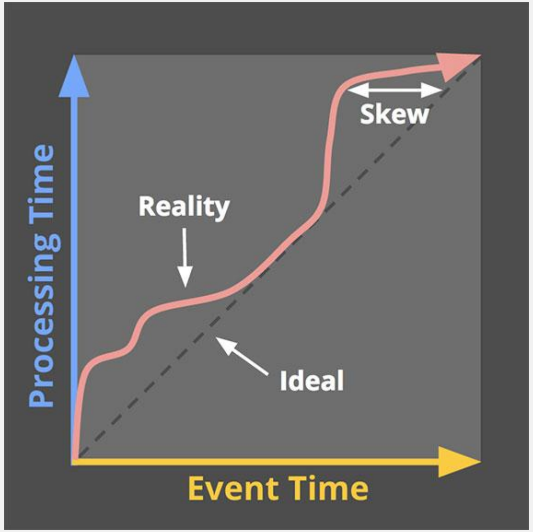
- ... capture and aggregate millions of events per second
- ... instantly take action
- ... respond to changing conditions

STREAM PROCESSING

Because time matters

Time

- Event time, which is the time at which events actually occurred
- Processing time, which is the time at which events are observed in the system



STREAM PROCESSING & IOT

What are the good parts for IoT?

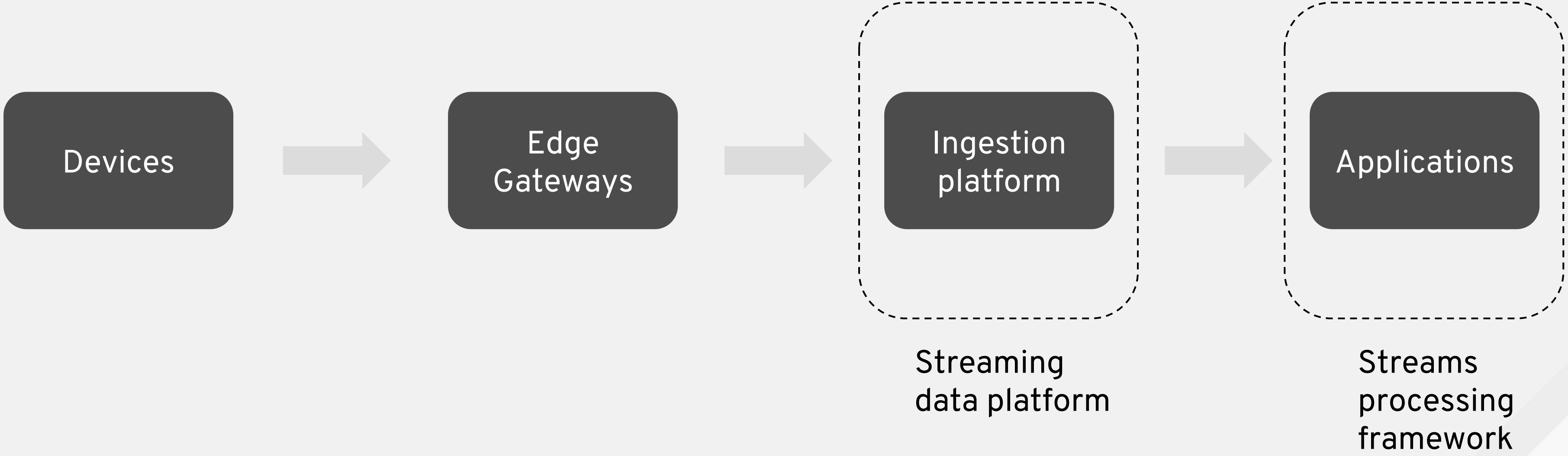
- Ordering
  - Handling devices data in the order they are sent
  - Handling “out of order” data when the device is not able to guarantee order
- Timing
  - Allowing “event time” which makes much sense in IoT scenarios
  - Supporting “windowing” for getting analytics in a specific time window
- State management
  - Be fast on joining real time data with metadata to enrich information content
  - Be fast on data aggregation
  - Be able to join different streams of data, from different devices

STREAM PROCESSING & IOT

What are the good parts for IoT?

- Re-processing
    - Supporting the possibility to re-read the stream of data
- Fault tolerance
    - Allowing to get data from devices continuously even in case of consumers crash
- Scalability/Partitioning
    - Being able to handle bursts of traffic
    - Being able to handle more and more devices data

STREAM PROCESSING & IOT



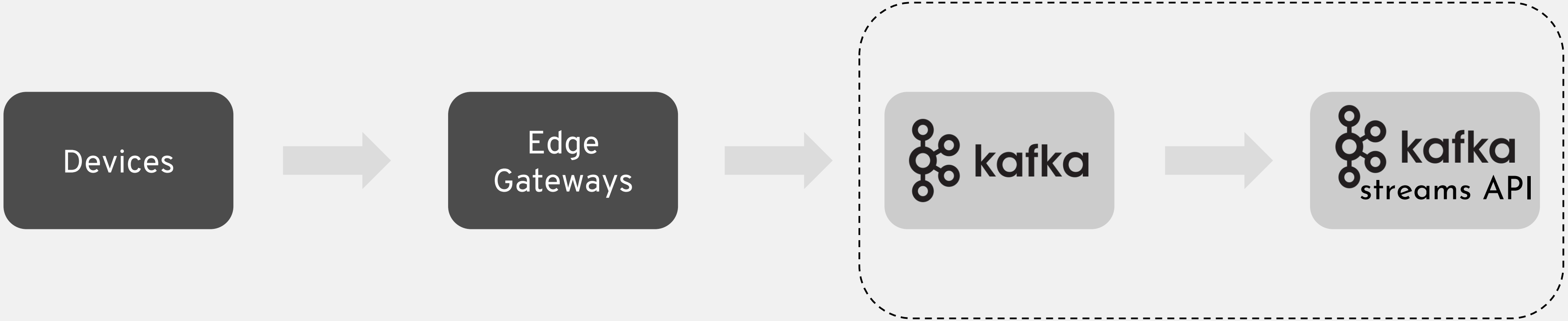
STREAM PROCESSING & IOT

It’s a wild west out there

- Streaming data platform
  - Apache Kafka
- Streams processing framework
  - Apache Spark (streaming)
  - Apache Samza
  - Apache Flink
  - ...

DO WE REALLY NEED MORE THAN ONE PLATFORMS IN PLACE?

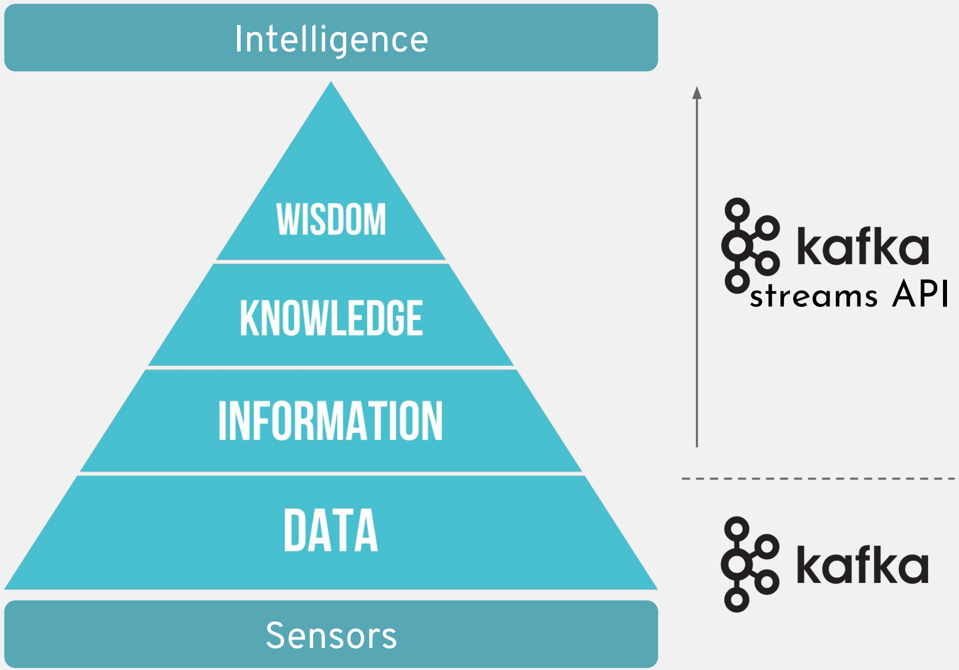
STREAM PROCESSING & IOT



Apache Kafka + Kafka Streams API

IOT WORKLOAD

From raw data to the intelligence



APACHE KAFKA

WHAT IS APACHE KAFKA

A publish/subscribe messaging system?

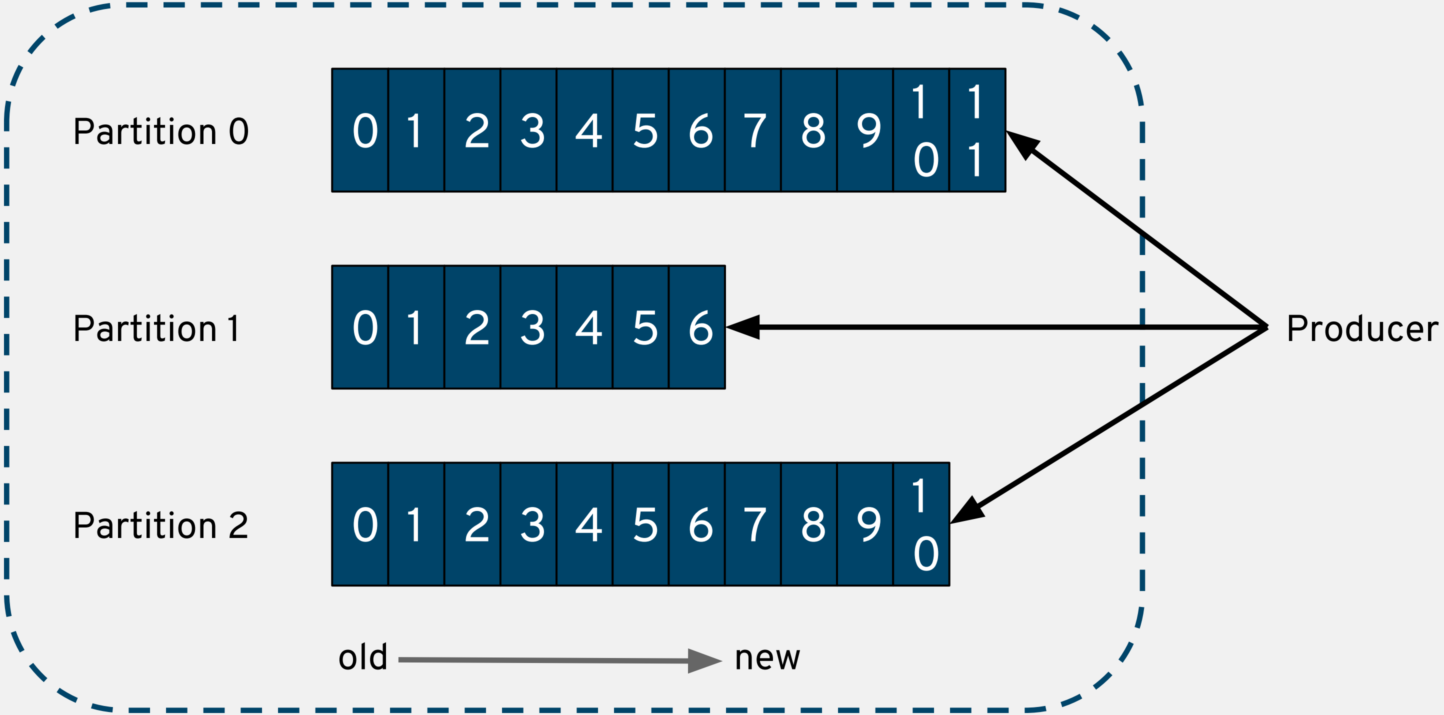
A streaming data platform?

A distributed, horizontally-scalable, fault-tolerant, commit log?

APACHE KAFKA CONCEPTS

- Messages are sent to and received from a topic
  - Topics are split into one or more partitions (aka shards)
  - All actual work is done on partition level, topic is just a virtual object
- Each message is written only into a one selected partition
  - Partitioning is usually done based on the message key
  - Message ordering within the partition is fixed
- Retention
  - Based on size / message age
  - Compacted based on message key
- Replication
  - Each partition can exist in one or more copies to achieve high availability

TOPIC & PARTITIONS



Partition 0 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11

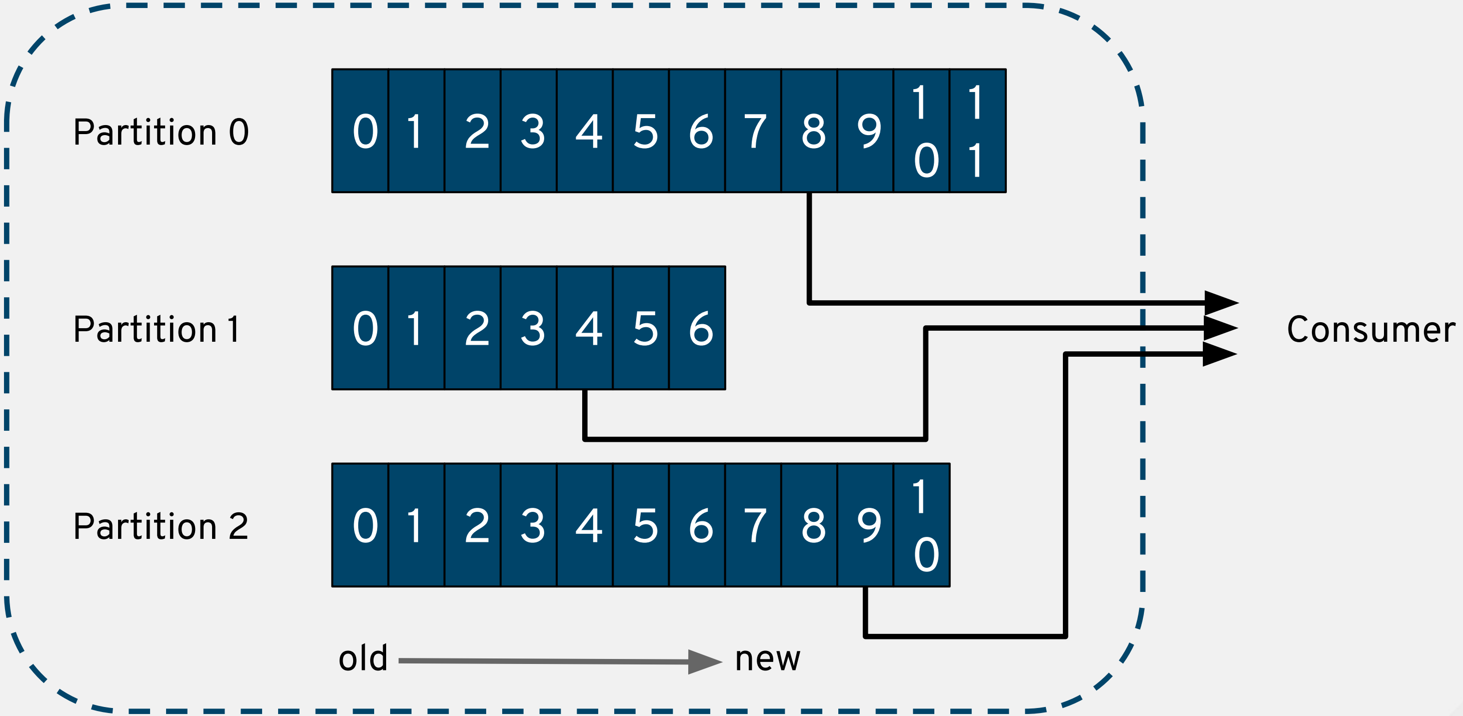
Partition 1 | 0 | 1 | 2 | 3 | 4 | 5 | 6

Partition 2 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10

Producer

old → new

TOPICS & PARTITIONS



Partition 0

0 1 2 3 4 5 6 7 8 9 10 11

Partition 1

0 1 2 3 4 5 6

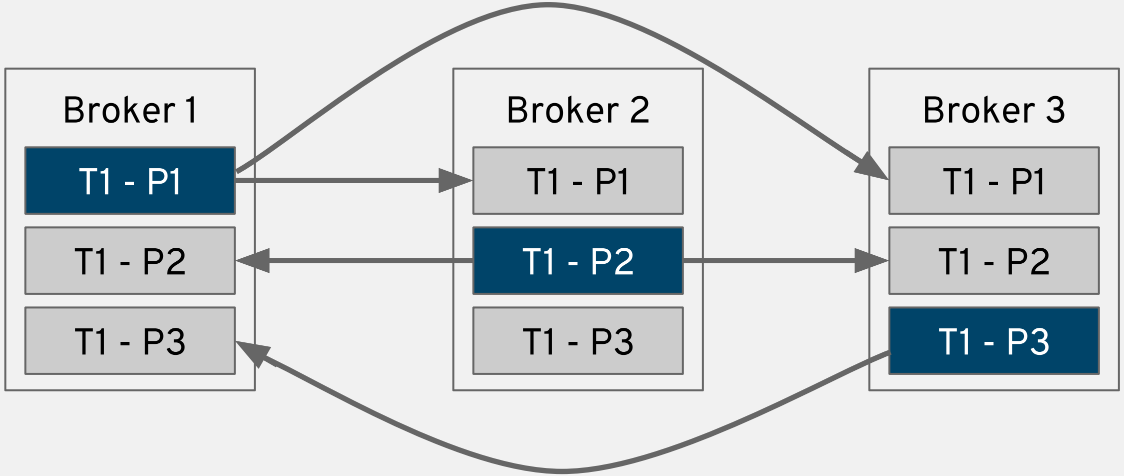
Partition 2

0 1 2 3 4 5 6 7 8 9 10

old → new

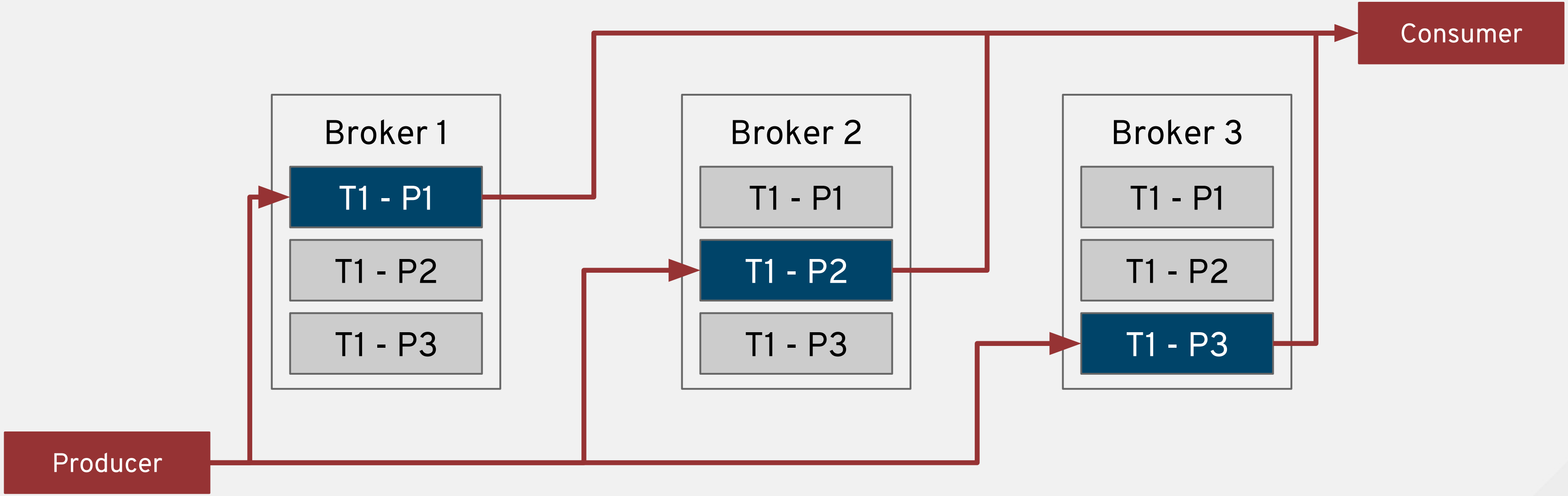
Consumer

HIGH AVAILABILITY



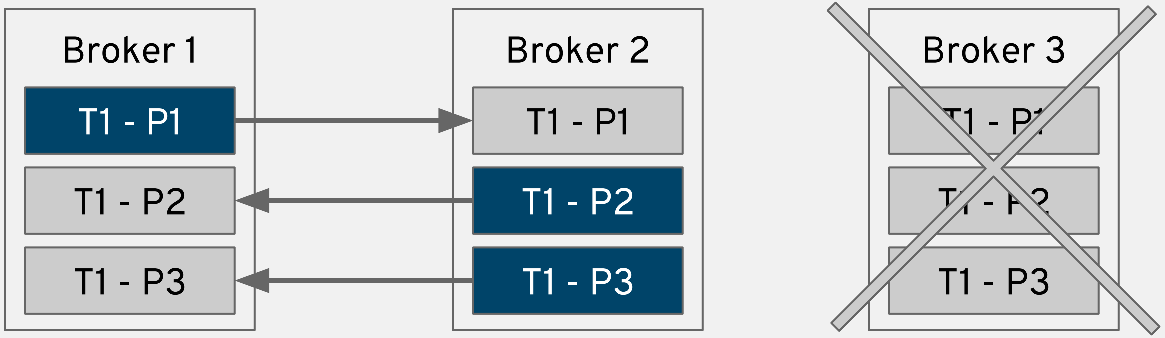
Leaders and followers spread across the cluster.

HIGH AVAILABILITY



Clients always connect only to the leaders.

HIGH AVAILABILITY

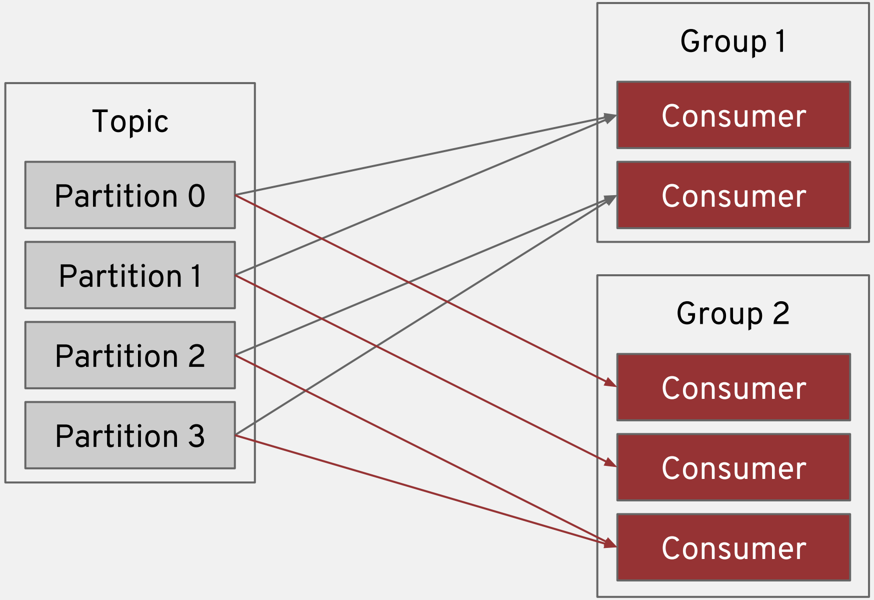


If a broker with leader partition goes down, a new leader partition is elected on different node

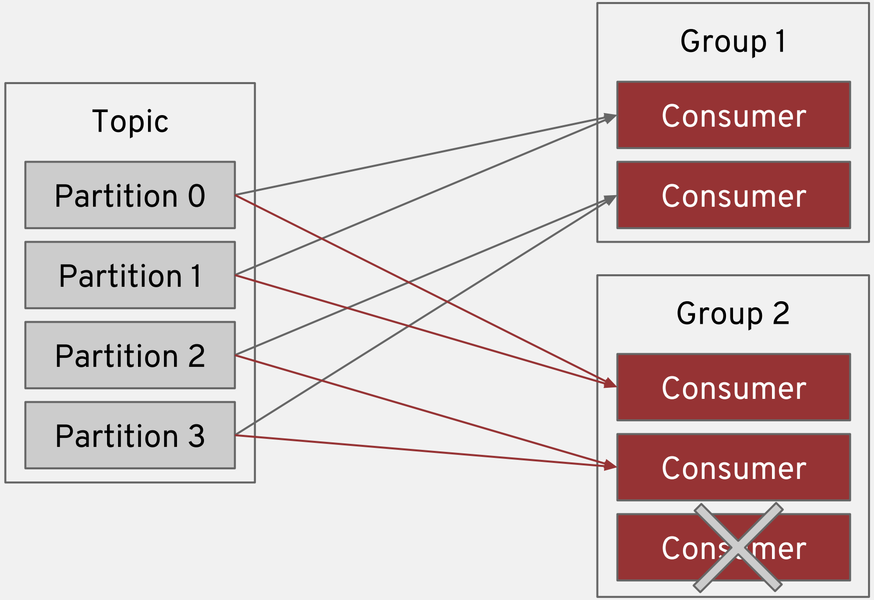
CONSUMER GROUPS

- Consumer Group
    - Grouping multiple consumers
    - Each consumer reads from a “unique” subset of partition → max consumers = num partitions
    - They are “competing” consumers on the topic, each message delivered to one consumer
    - Messages with same “key” delivered to same consumer
- More consumer groups
    - Allows publish/subscribe
    - Same messages delivered to different consumers in different consumer groups

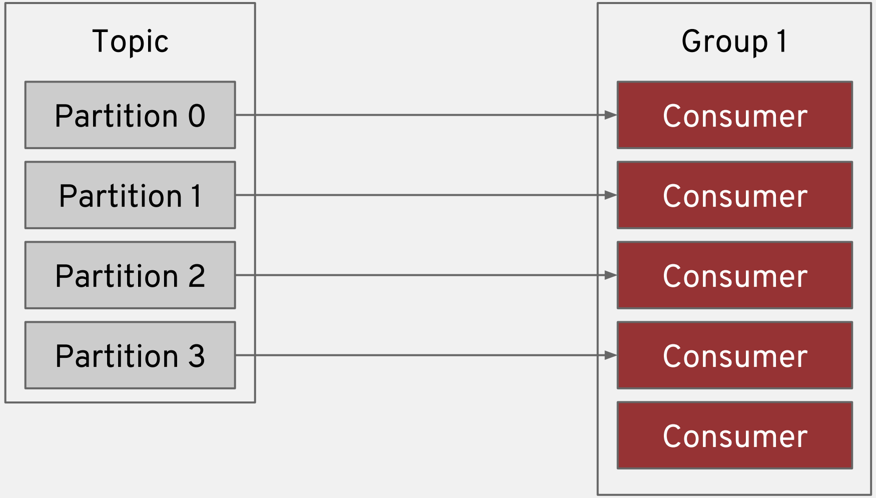
CONSUMER GROUPS



CONSUMER GROUPS



CONSUMER GROUPS



APACHE KAFKA FOR IOT

Pros & Cons

Pros

- “Big” buffer for handling back pressure
- High throughput
- High availability
- Long term storage
- Reprocessing devices data

Cons

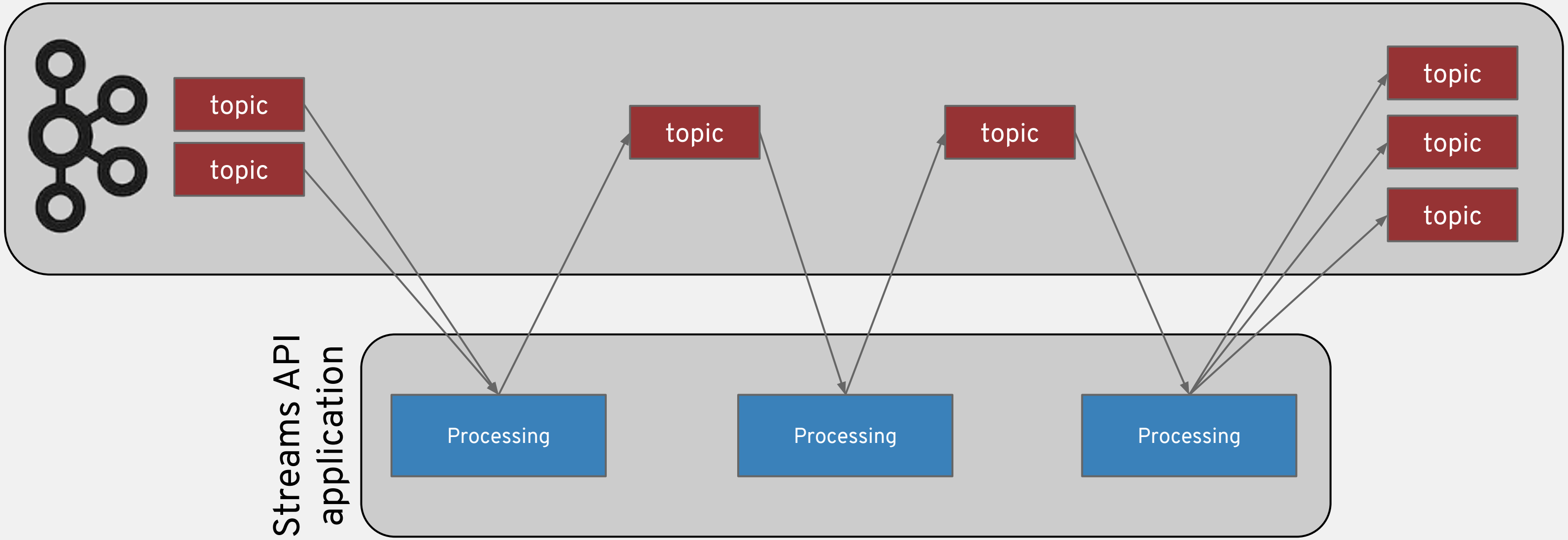
- Cannot handle a huge number of device connections
- No standard IoT devices oriented protocol
- Network needs to be stable

KAFKA STREAMS

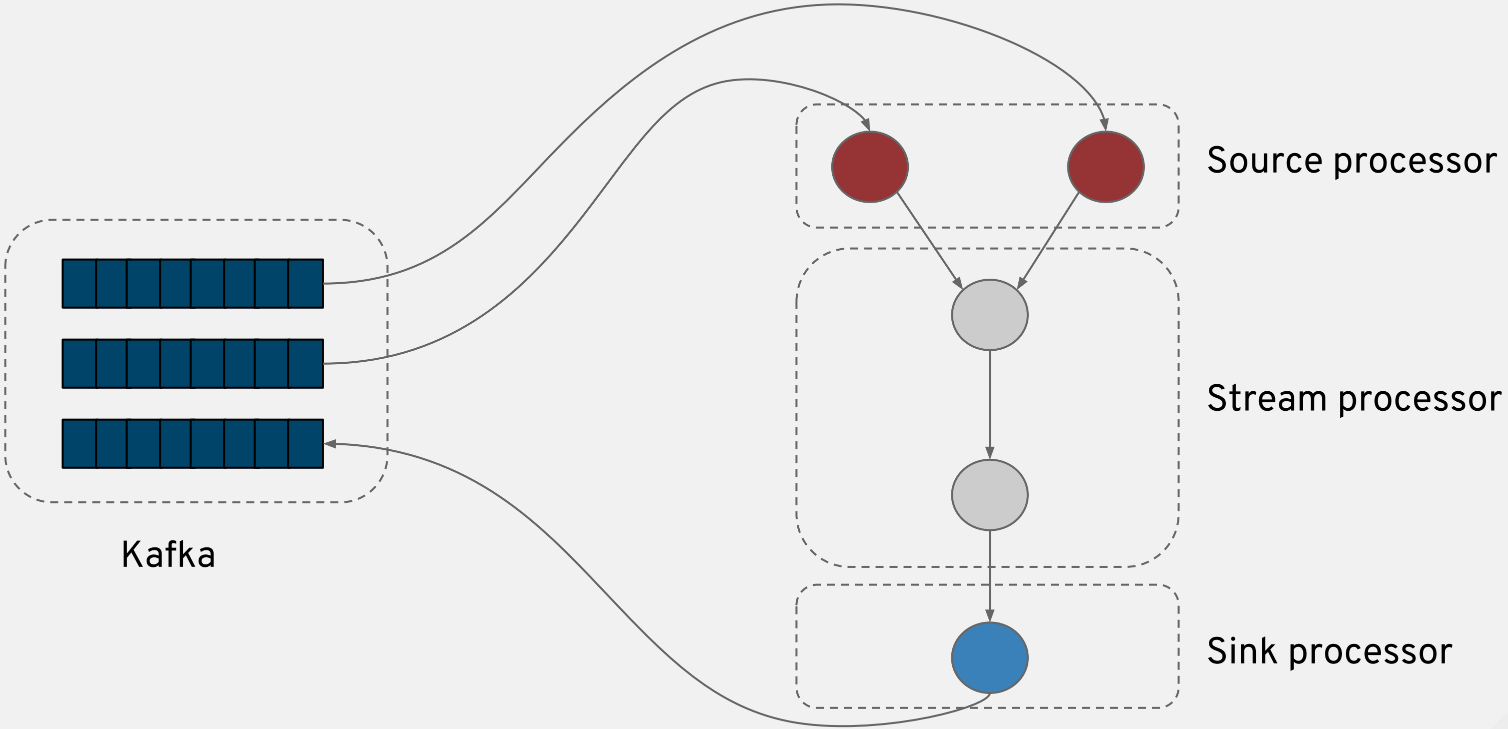
KAFKA STREAMS API

- Stream processing framework
- Streams are Kafka topics (as input and output)
- It’s really just a Java library to include in your application
- Scaling the stream application horizontally
- Creates a topology of processing nodes (filter, map, join etc) acting on a stream
    - Low level processor API
    - High level DSL
    - Using “internal” topics (when re-partitioning is needed or for “stateful” transformations)

KAFKA STREAMS API



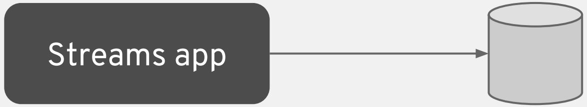
PROCESSORS TOPOLOGY



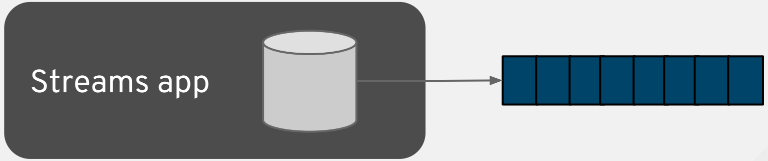
STATE MANAGEMENT

Stateless vs Stateful processing

- Stateless (filter, map) vs Stateful (join, aggregate)
- State handled locally
  - Faster
  - Better isolation
  - Flexible
- It’s based on RocksDB and backed by a Kafka topic as well
  - For rebuilding state on a different Streams node



Remote state



Local state

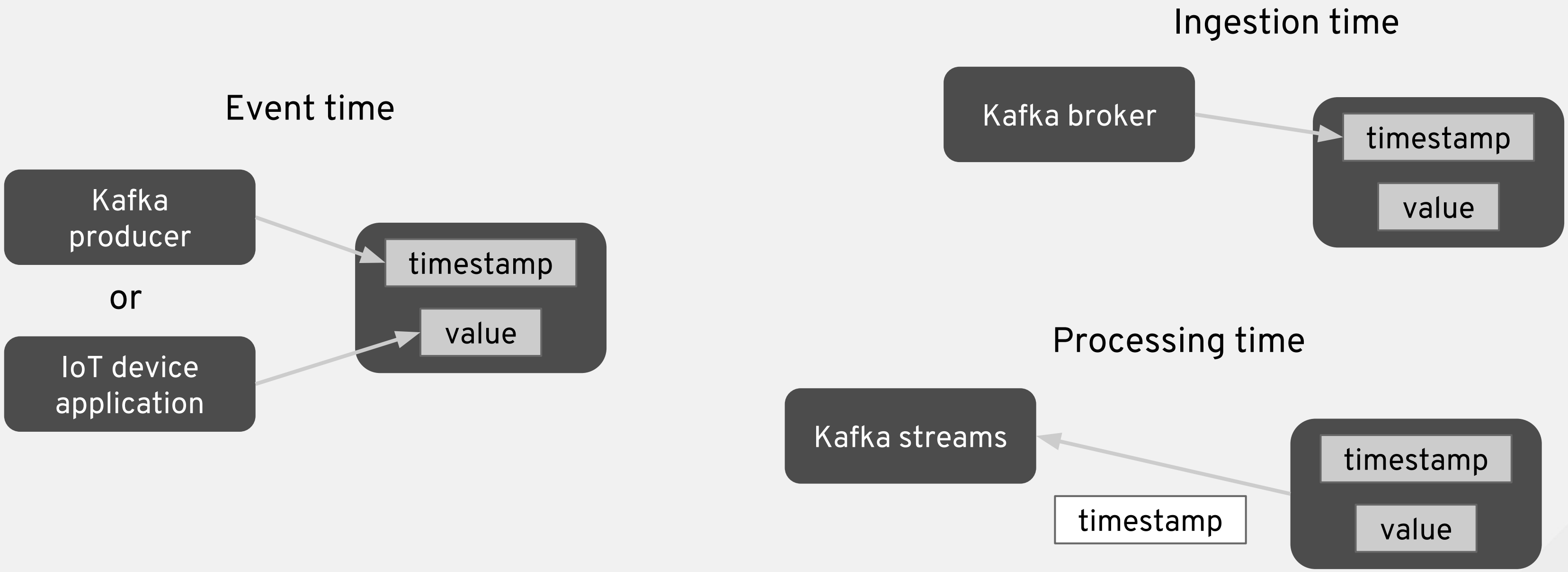
EVENTS TIMESTAMP

Always because time matters

Time

- Event time, which is the time at which events actually occurred
  - As part of the message payload
  - Timestamp on the message (set by the producer)
- Ingestion time, which is the time when the data enters the processing pipeline
  - The broker sets the timestamp on the message
- Processing time, which is the time at which events are observed in the system
  - It’s also called “wall-clock” time

EVENTS TIMESTAMP



Event time

Kafka producer

or

IoT device application

timestamp

value

Ingestion time

Kafka broker

timestamp

value

Processing time

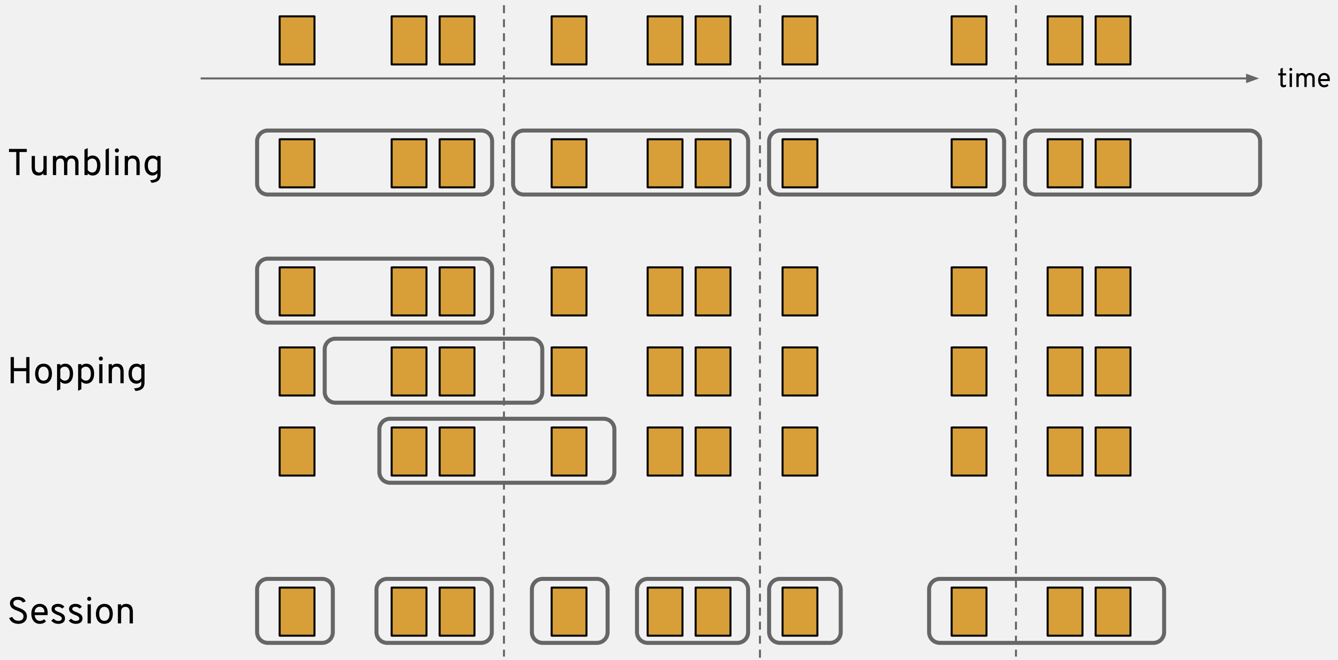
Kafka streams

timestamp

timestamp

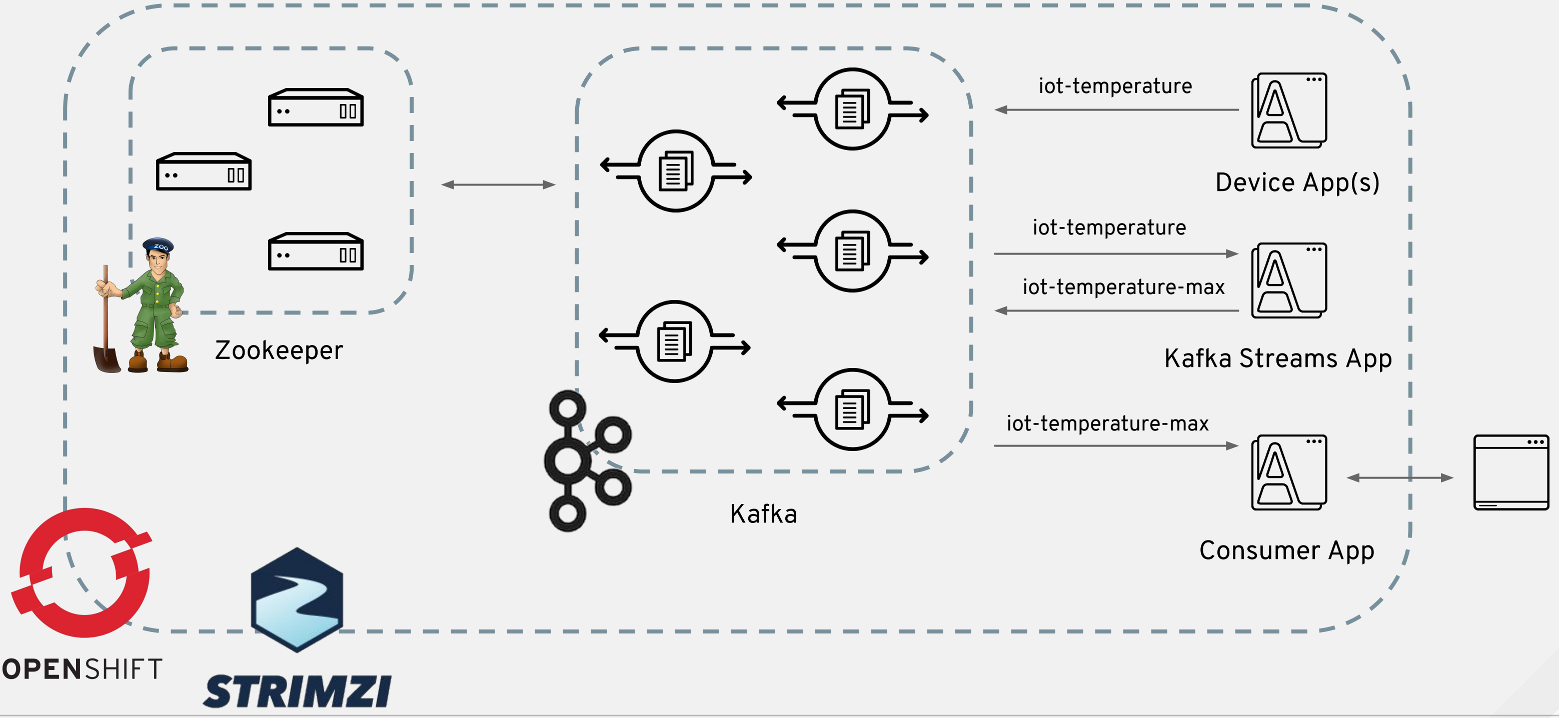
value

WINDOWING



DEMO

DEMO ARCHITECTURE



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