PROFINIT

B0M33BDT – Apache Kafka, Architecture patterns

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30. Října 2024

Apache Kafka

Motivation for message broker

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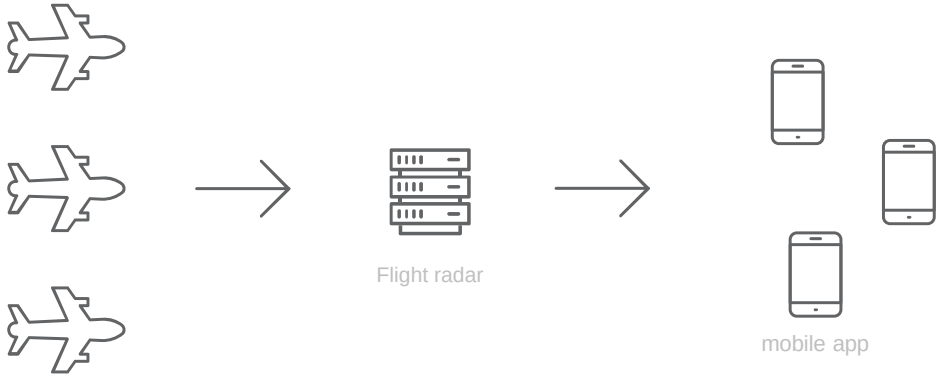
- It is a vacation day, your flight is scheduled for 14:00
- Is my flight on time?



Getting rid of peer-to-peer data transfer

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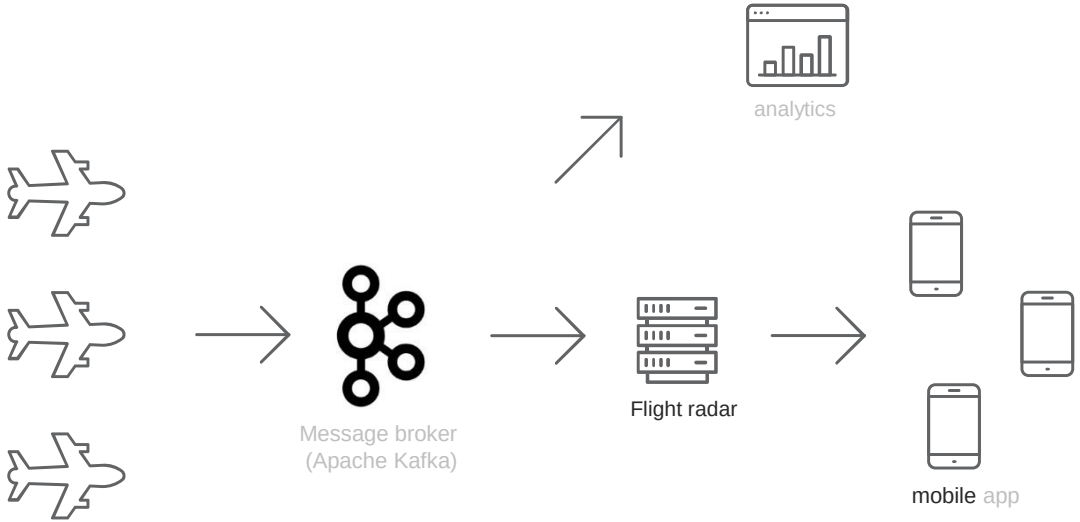

Apache Kafka

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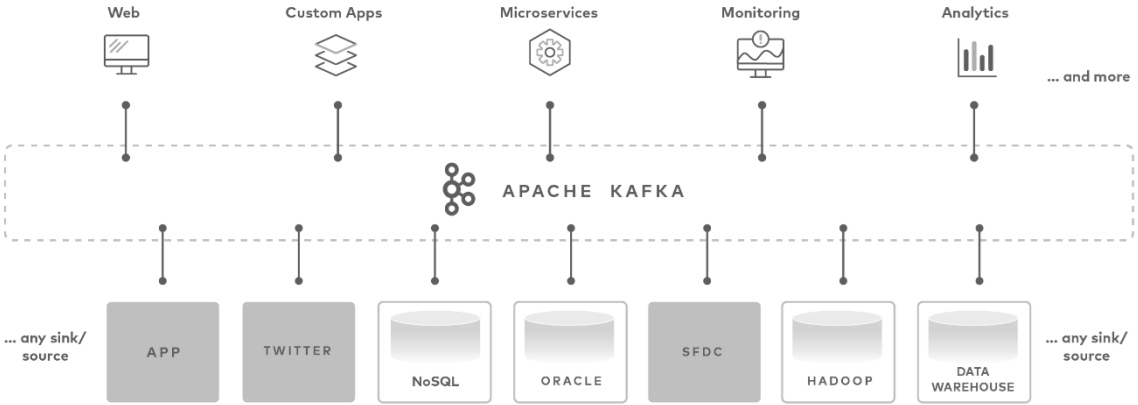
- Started as message broker at Linkedin, now it's a data processing ecosystem
- Key characteristics
  - High-throughput
  - Distributed
  - Scalable



https://engineering.linkedin.com/kafka/benchmarking-apache-kafka-2-million-writes-second-three-cheap-machines

Kafka 101 – naming convention

PROFINIT

- Consumer
  - An application that is reading data from Kafka
- Consumer Group
  - A group of an application processes that read data from Kafka
- Producer
  - An application that is writing data to Kafka
- Broker
  - Kafka process (single server) that is receiving data from producers, storing data on disk and provide them to consumers

Kafka 101 – naming convention

PROFINIT

- Topic
  - Named „message queue“
- Partition
  - Topics are broken down into partitions
- Offset
  - The position of a last committed message of a consumer in a topic/partition

Kafka cluster

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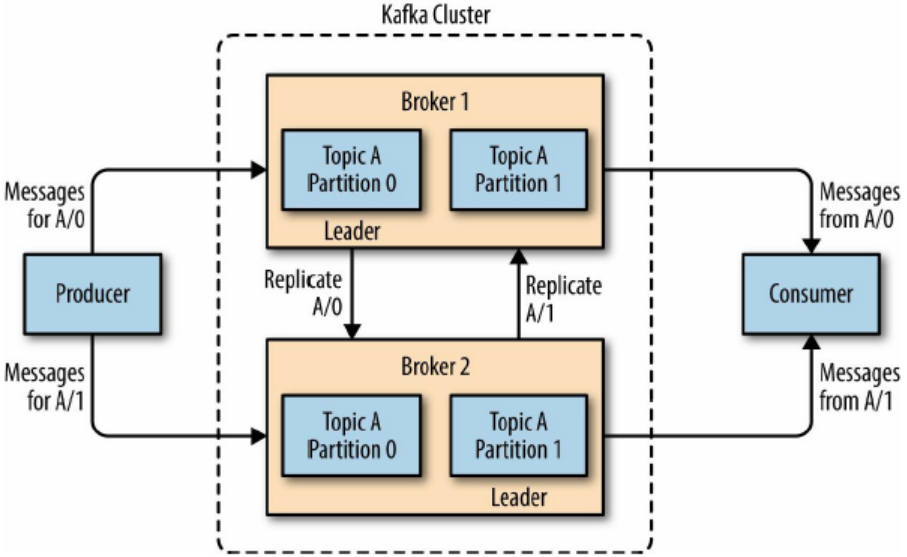
- Broker – a single Kafka server
- Kafka cluster – collection of brokers that work together



Kafka basics – Topic and partitioning

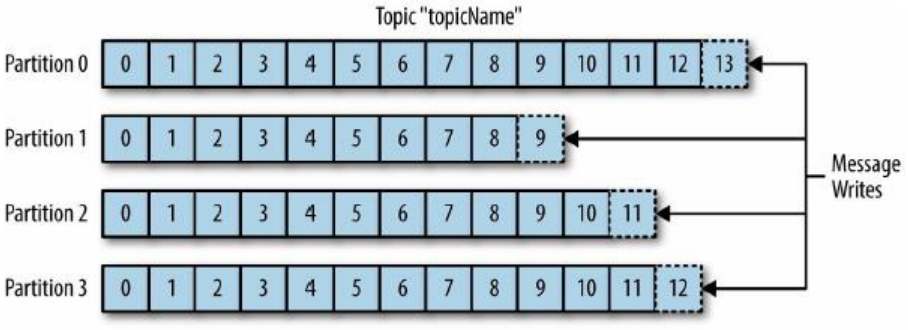
PROFINIT

- Topic
  - Named container for similar events
    - Usually there are many topics in a system
    - Data in one topic can be duplicated with data in another topic
  - Durable logs of events
    - New message always on the end
    - Can be read by seaking arbitrary offset
    - Are immutable - once something has happened, it is exceedingly difficult to make it un-happen
    - Are durable – stored on filesystem

Kafka basics – Topic and partitioning

PROFINIT

- Partitioning
  - Breaked single topic log to multiple logs that can live independently
  - Are spread out across a cluster



Kafka basics - Offset

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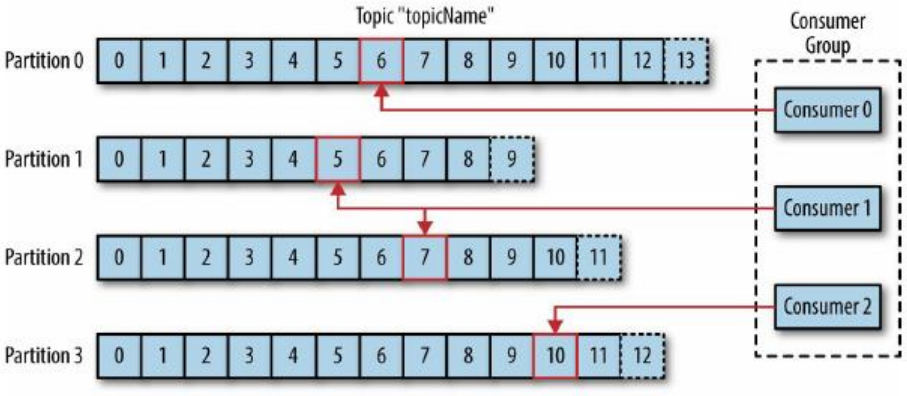
- The consumer offset is a way of tracking the sequential order in which messages are received by Kafka topics.
- Consumer offsets are persisted



Message structure

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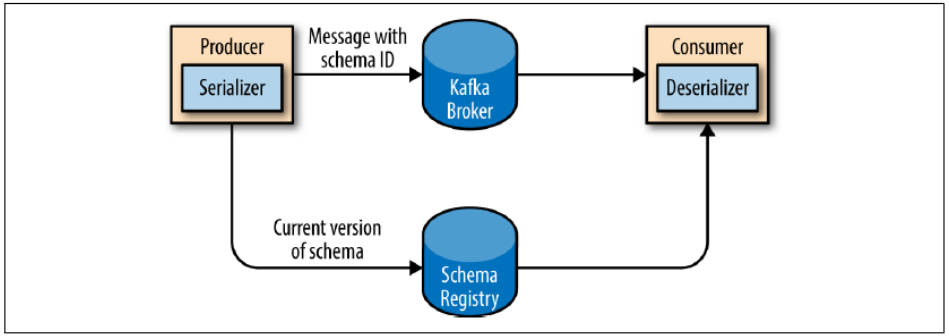
- Key
- Value
- Header
- Key and Value can be any type (as long as we can serialize/deserialize them to bytes)
  - We can easily send json records as Values
  - Another very popular format to serialize data is Avro, but it requires Schema Registry



Message ordering in Kafka

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- Message order
  - Kafka guarantees to maintain a message order **per partition**
  - That doesn’t guarantee an order of messages **per topic**
- Messages with the same key are guaranteed to be send to the same partition
  - By default a hash partitioned is used
  - Messages without a key will be uniformly distributed between partitions

Kafka basic - Producer

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- Client application
- Write data to appropriate kafka topic and broker
  - Serialize data
  - Define partition
  - Compress data
  - Handle errors

Acks	Throughput	Latency	Durability
0	High	Low	No Guarantee. The producer does not wait for acknowledgment from the server.
1	Medium	Medium	Leader writes the record to its local log, and responds without awaiting full acknowledgment from all followers.
-1	Low	High	Leader waits for the full set of in-sync replicas (ISRs) to acknowledge the record. This guarantees that the record is not lost as long as at least one IRS is active.

Kafka basic - Producing data

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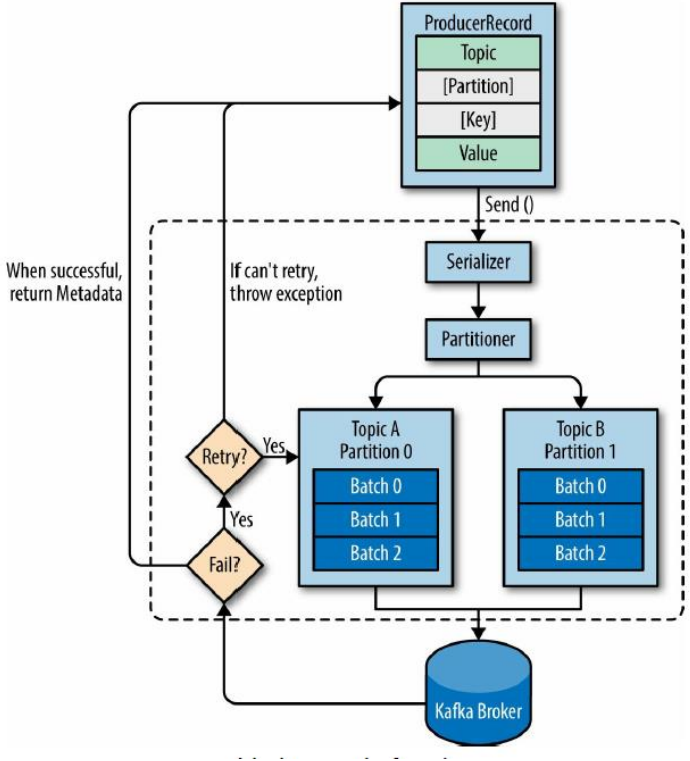

Kafka basic - Consumer

PROFINIT

- Client application
- Read data from Kafka topic
- Scallable – organized to consumer groups
- Keep up to date metadata (offset)

Kafka basics – Consumer Group

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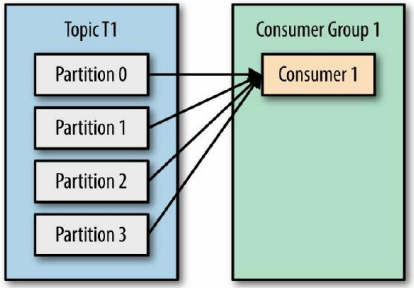

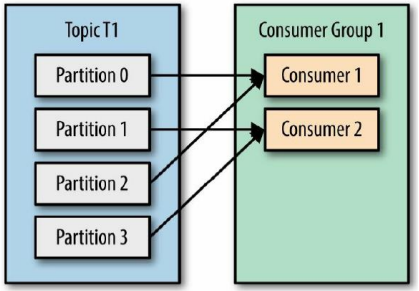

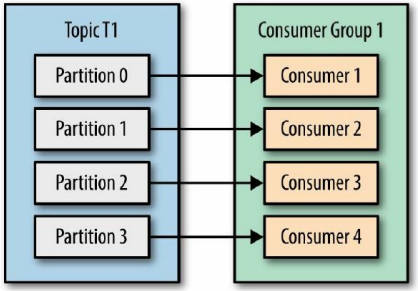

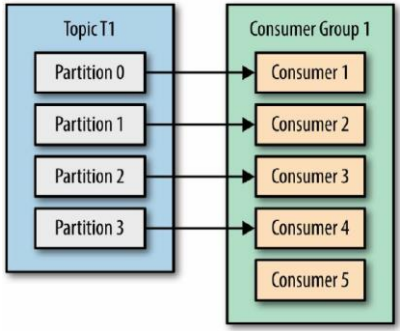

Kafka basics – Consumer Groups

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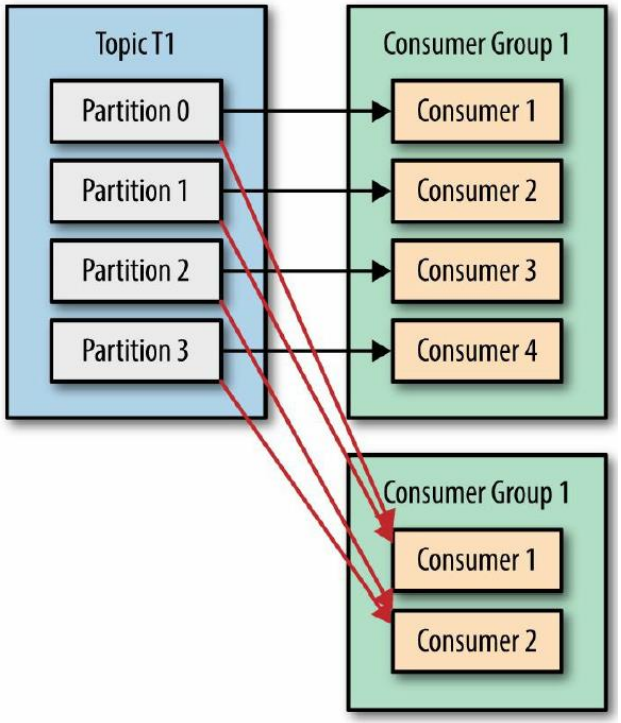

Log compaction

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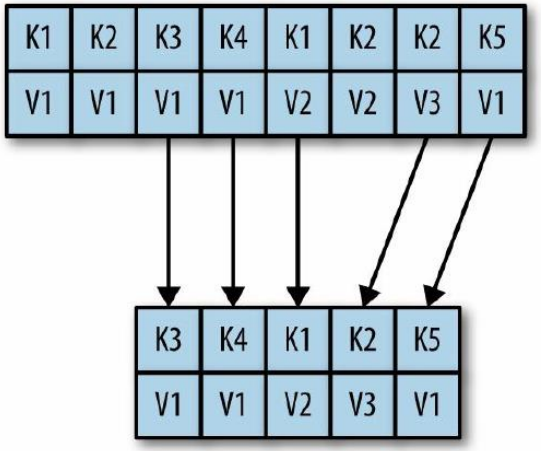
- When the data is no longer needed (after retention period) the default action is to delete the message
- Kafka has special retention policy called “compaction” in case we want to store most recent message for each key



Schema registry

PROFINIT

- Centralized repository for managing schemas of kafka messages
- Key component for data governance
  - Schema management including validation
  - Compatibility check
  - Versioning
- Supported schema types
  - AVRO
  - JSON
  - Protobuff

Message delivery

Message delivery semantics

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- Exactly once
  - Every message is delivered only once
  - We need to keep track which messages were delivered and processed
- At least once
  - A message might be delivered more than once
  - Might be OK given pragmatic consideration
- At most once
  - The system will never try to deliver a message again once it was sent
  - Good option for non-critical data, that quickly become irrelevant

Exactly once – Kafka support

PROFINIT

- Idempotence: Exactly-once in order semantics per partition
  - Safeguard against duplicates in retry logic, that might be caused by broker or producer failure
  - The message will be written to the Kafka topic once
  - Enable enable.idempotence=true in producer configuration
- Transactions: Atomic writes across multiple partitions
  - New transation API - atomic writes across multiple partitions
  - Consumer side - configuration
    - isolation.level (read_committed, read_uncommitted)
- Kafka streams
    - processing.guarantee=exactly_once

Recap

Kafka ecosystem

Kafka Connect

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- Common framework for building connectors to integrate various data stores with Kafka
- Allows both getting data into and from Kafka
- If you find yourself trying to get data into or from Kafka, there is probably a connector for that
- The ingest process can be speeded up by running multiple connector instances in distributed fashion
- Aside from plain piping the data from system a to Kafka, also supports simple transformations of data records in transition

https://docs.confluent.io/cloud/current/connectors/index.html

https://docs.confluent.io/kafka-connectors/self-managed/supported.html#supported-self-managed-connectors

Kafka Connect- Example

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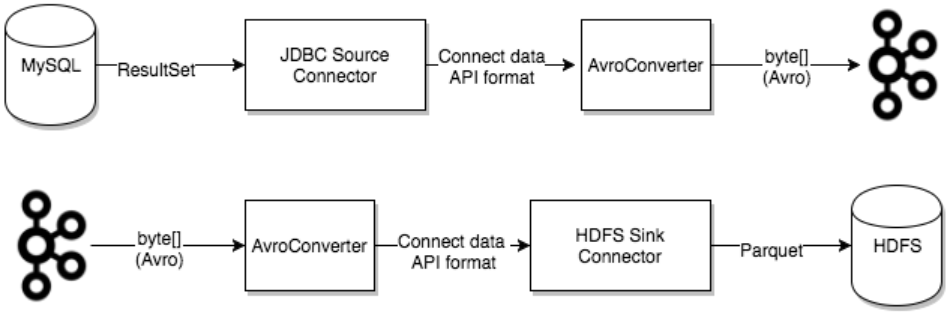



```
{
 "name": "gcs-sink-01",
 "config": {
  "connector.class": "io.confluent.connect.gcs.GcsSinkConnector",
  "tasks.max": "1",
  "topics": "gcs_topic",
  "gcs.bucket.name": "<my-gcs-bucket>",
  "storage.class": "io.confluent.connect.gcs.storage.GcsStorage",
  "format.class": "io.confluent.connect.gcs.format.avro.AvroFormat",
  "partitioner.class": "io.confluent.connect.storage.partitioner.DefaultPartitioner",
  "value.converter": "io.confluent.connect.avro.AvroConverter",
  "value.converter.schema.registry.url": "http://localhost:8081",
  "schema.compatibility": "NONE",
  "confluent.topic.bootstrap.servers": "localhost:9092",
   "errors.tolerance": "all",
  "errors.deadletterqueue.topic.name": "dlq-gcs-sink-01"
 }
}
```

Kafka Streams

PROFINIT

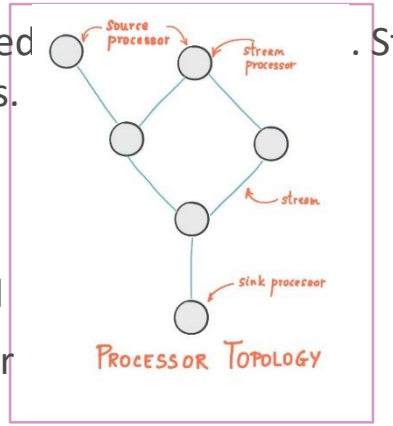
- Library build on-top of Kafka Producer/Consumer API for real-time stream processing
- It’s best suited for reading data from Kafka topic, doing some work and then writing data to another Kafka topic
- Application instance is a JVM process
- The parallelism of a Kafka Streams application is primarily determined by how many partitions the input topics have
- StafeFull support (RockDB)

Kafka Streams naming convention

PROFINIT

- Source processor
  - produces an input stream to its topology from one or multiple Kafka topics by consuming records from these topics.
- Sink processor
  - sends any received records from its up-stream processors to a specified Kafka topic.
- Stream processor
  - represents a processing step in a topology - it is used . Standard operations are map or filter, joins, and aggregations.
- Stream task
  - smallest unit of work within a Kafka Streams

application instance. The number of tasks is determined by an application's source topic with the highest number of partitions.



Stream task

Kafka Streams Architecture

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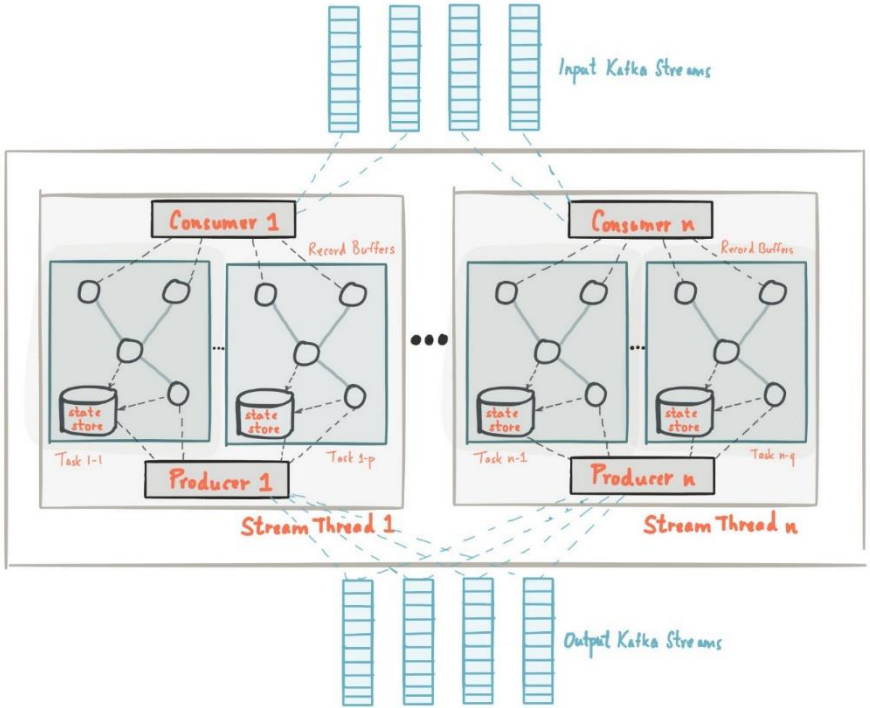
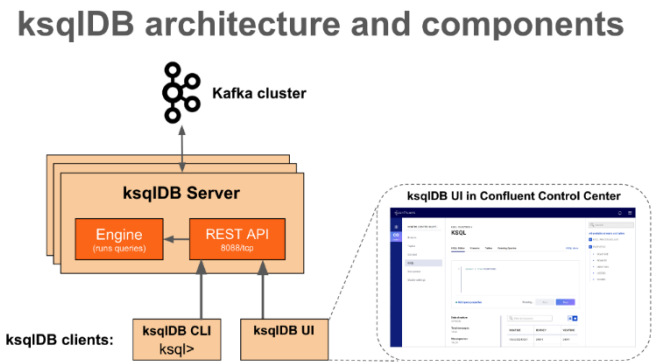


ksqlDB

PROFINIT

- DB-like abstraction on top of Kafka Streams
- Provides table-like interface over Kafka topic (using extended SQL syntax)
- Main components
  - KSQL Server – processes SQL statements and queries
  - KSQL CLI – CLI program to i

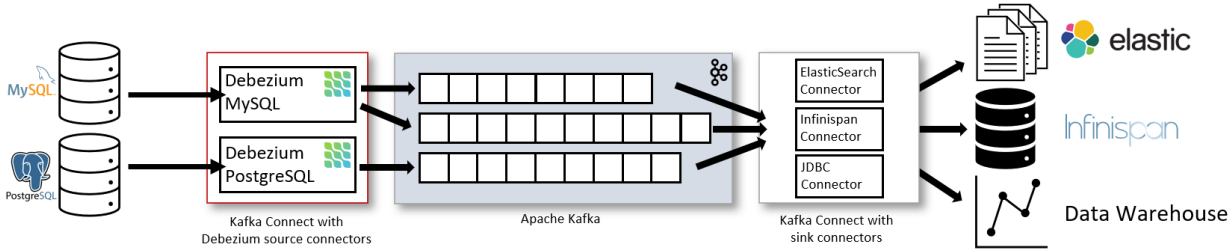


Kafka Connect - Debezium

Debezium

PROFINIT

- Debezium is a set of distributed services that capture row-level changes in your databases (CDC – change data capture)



Debezium - sources

PROFINIT

- MySQL
- MariaDB
- MongoDB
- Oracle
- MSSQL server
- Cassandra
- …

Debezium – connector operations

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- CDC – debezium send changes
- Full snapshot – debezium send full mirror of table
- Incremental snapshot - debezium send records based on provided filter (request)

Use Cases

UseCases

PROFINIT

- Messaging - replacement of messages brokers (RabitMQ,Active MQ)
- Log Aggregation – stream of log events with applied business logic
- Web Tracking - user aktivity tracking pipeline with publish subsribe model
- Stream Processing – RSS Feed
- Event sourcing – Application style (current (at every a point of time) state can be reconstruct based on past events)
- CommitLog – support for distributed systém
- Reportin – operational monitoring data

Cloudification

Confluent cloud

PROFINIT

- Cloud streaming platform build on Apache Kafka
  - Available on AWS, Azure, Google Cloud
- Streaming data accross different cloud providers
- Integration with Apache Flink (streaming platform)
- New Kora Engine (better performance – latency)
- Pricing
  - Basic – Limited storage
  - Standard – HA 99,99
  - Enterprise - Private networking

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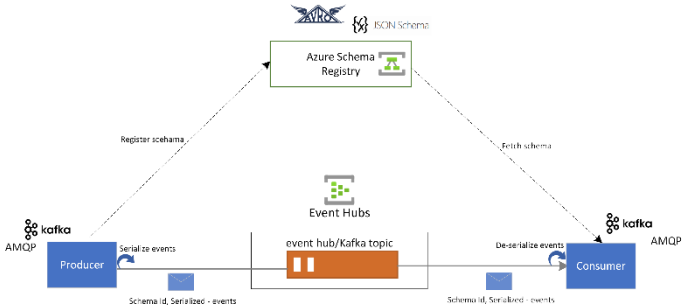
Source: https://developer.confluent.io/

Azure Event Hubs

PROFINIT

- Streaming platform with native Apache Kafka support
  - Advanced Message Queuing Protocol (AMQP)
  - Apache Kafka
  - HTTPS protocols

- Pricing
  - Basic – without Kafka
  - Standard – Kafka support, pay per event
  - Premium – 90 days retetion
  - Dedicated – 10 TB retention



Source: https://learn.microsoft.com/en-us/azure/event-hubs/event-hubs-about

Amazon Managed Streaming for Apache Kafka (MSK)

PROFINIT

- Fully managed Kafka service
  - MSK Cluster
  - MSK Connect
  - MSK Replicator
- MSK serverless
  - Serverless cluster
- Pricing
  - Cluster instances (cluster size per hour)
  - Serverless (price per hour - cluster, partition, storage, data in, data out)
  - Connect (MCU per hour)

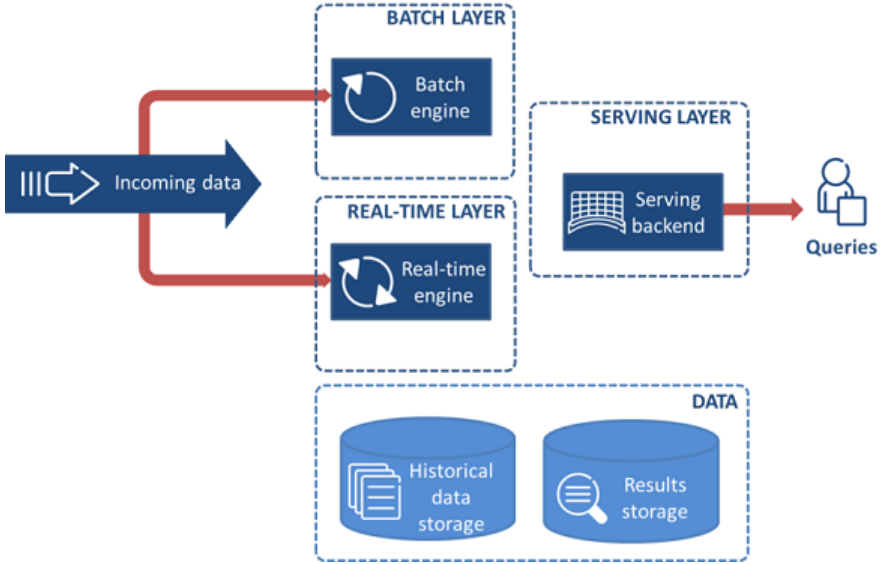
Source: https://docs.aws.amazon.com/msk/latest/developerguide/what-is-msk.html

Architectures

Lambda

PROFINIT

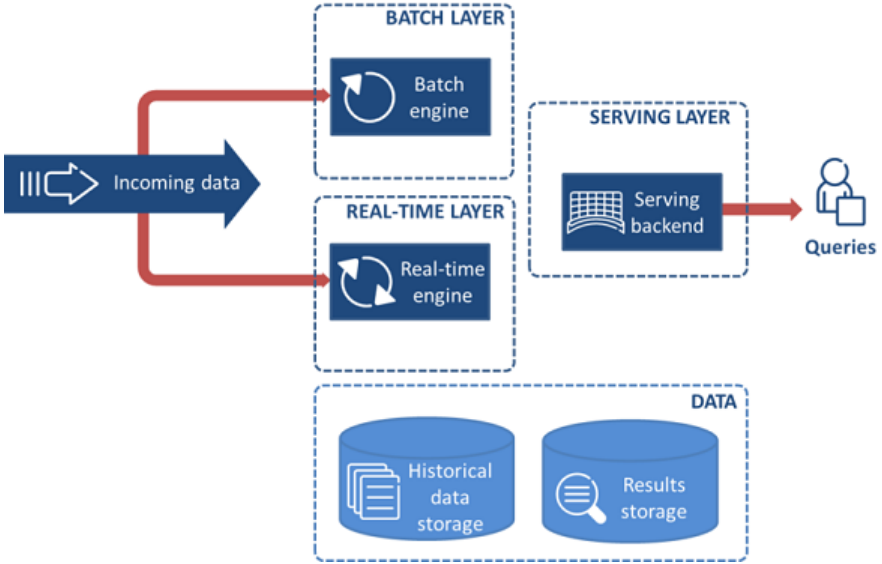
- From Apache Storm
- Nathan Marz, 2011
- http://nathanmarz.com/blog/how-to-beat-the-cap-theorem.html
- Yahoo, Netflix



Lambda

PROFINIT

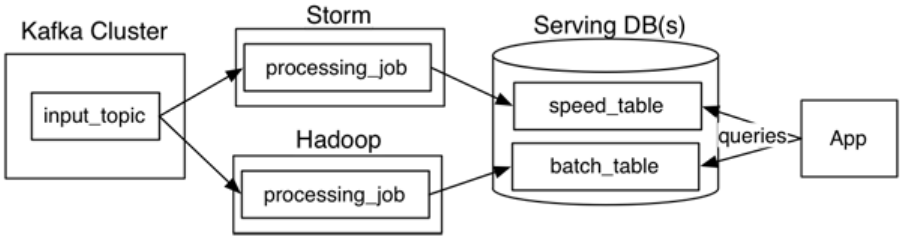
- 4 layers

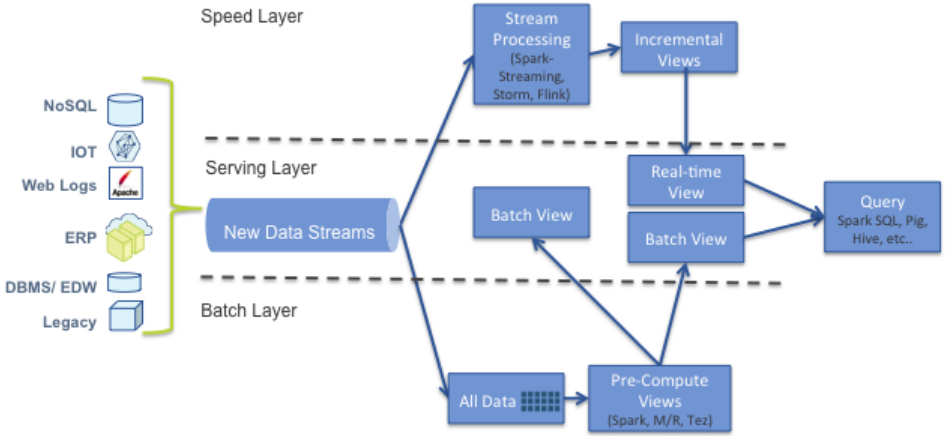


Lambda

PROFINIT

- Mapping to the technologies

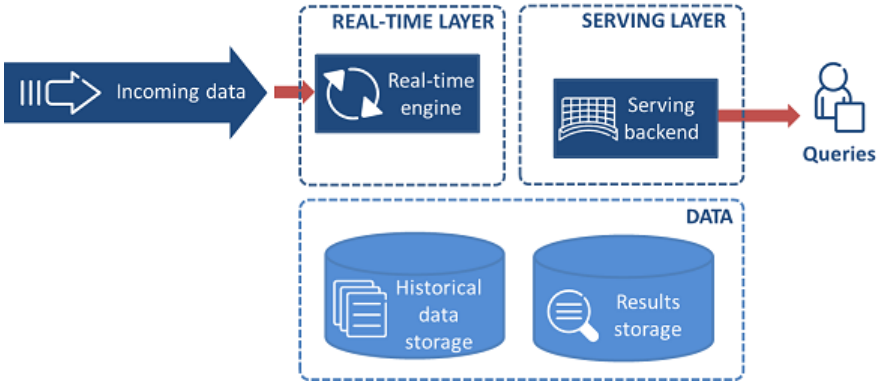




Kappa

PROFINIT

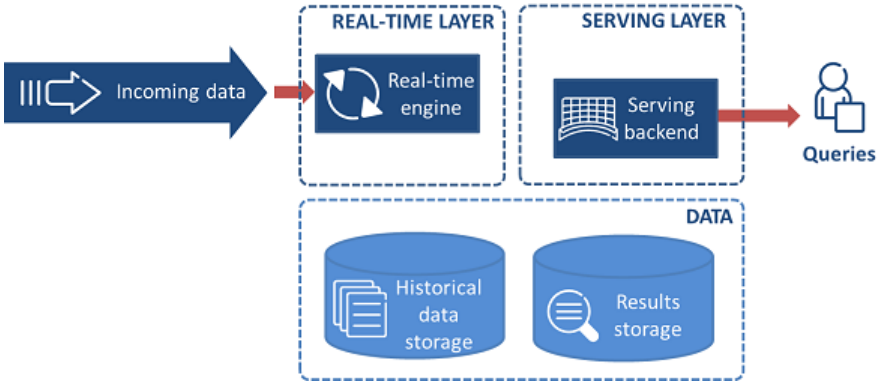
- 2014 Jay Kreps – Linkedin
- https://www.oreilly.com/ideas/questioning-the-lambda-architecture



Kappa

PROFINIT

- 3 layers – batch layer removed
- Long retention can be used
- How to work with state – microbatches?



Kappa

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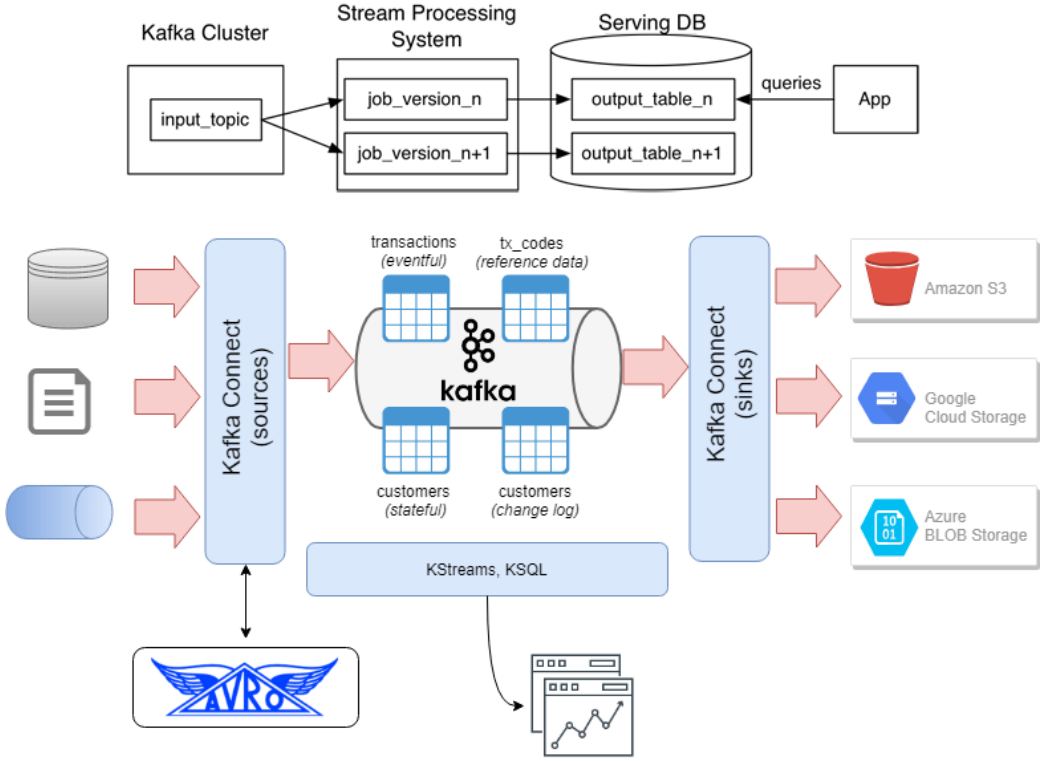

Apache Nifi

NIFI (Niagara Files, Hortonworks Data Flow (HDF))

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- NiFi is a processing engine designed to manage a continuous flow of information as a series of events in an ecosystem
- Visual creation and management of directed graphs of processors
- Highly concurrent model without a developer having to worry about the typical complexities of concurrency
- Natural error handling
- Cohesive and loosely coupled components which can then be reused

Naming Convention

PROFINIT

- **Flowfiles** - Information Packet. Represents each object moving through the system and for each one. Map object (key, value pair)
- **Processors** - Perform the work - data routing, transformation, or mediation between systems.
- **Connections** - Connections provide the actual linkage between processors. These act as queues and allow various processes to interact at differing rates.
- **Flow Controller** – Scheduler. The Flow Controller maintains the knowledge of how processes connect and manages the threads and allocations thereof which all processes use

APACHE nifi

Hello World - Example

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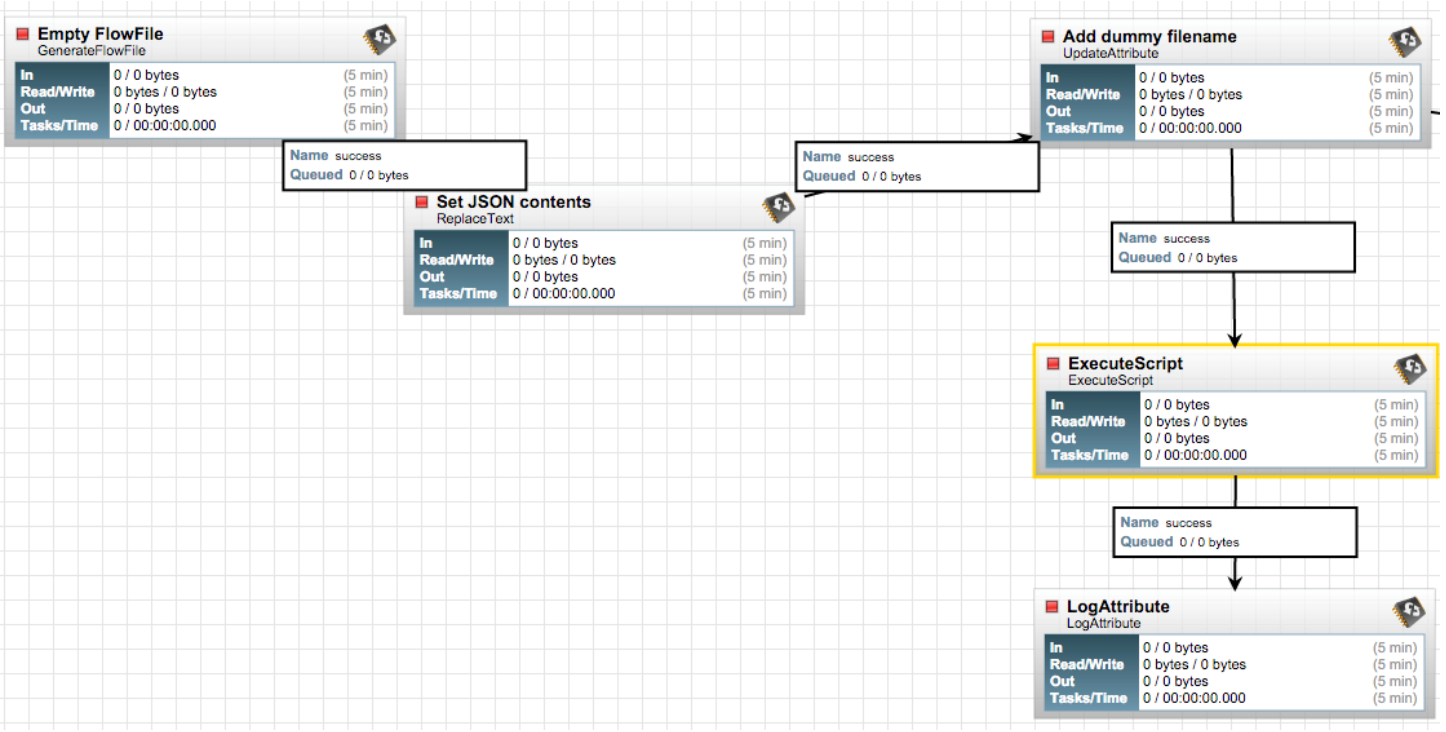

https://nifi.apache.org/docs.html

Architecture

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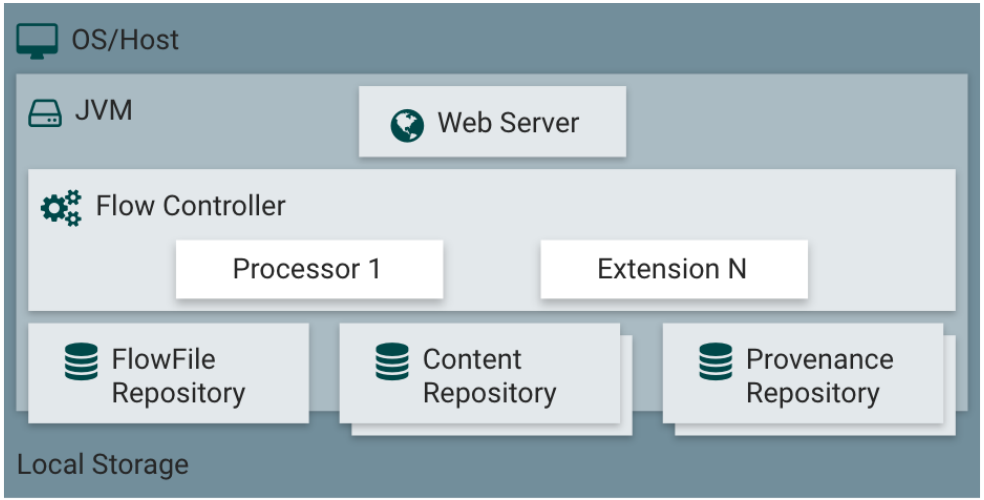
- **FlowFile Repository** - where NiFi keeps track of the state of what it knows about a given FlowFile that is presently active in the flow.
- **Content Repository** - where the actual content bytes of a given FlowFile live
- **Provenance Repository** - where all provenance event data is stored.



|Cluster

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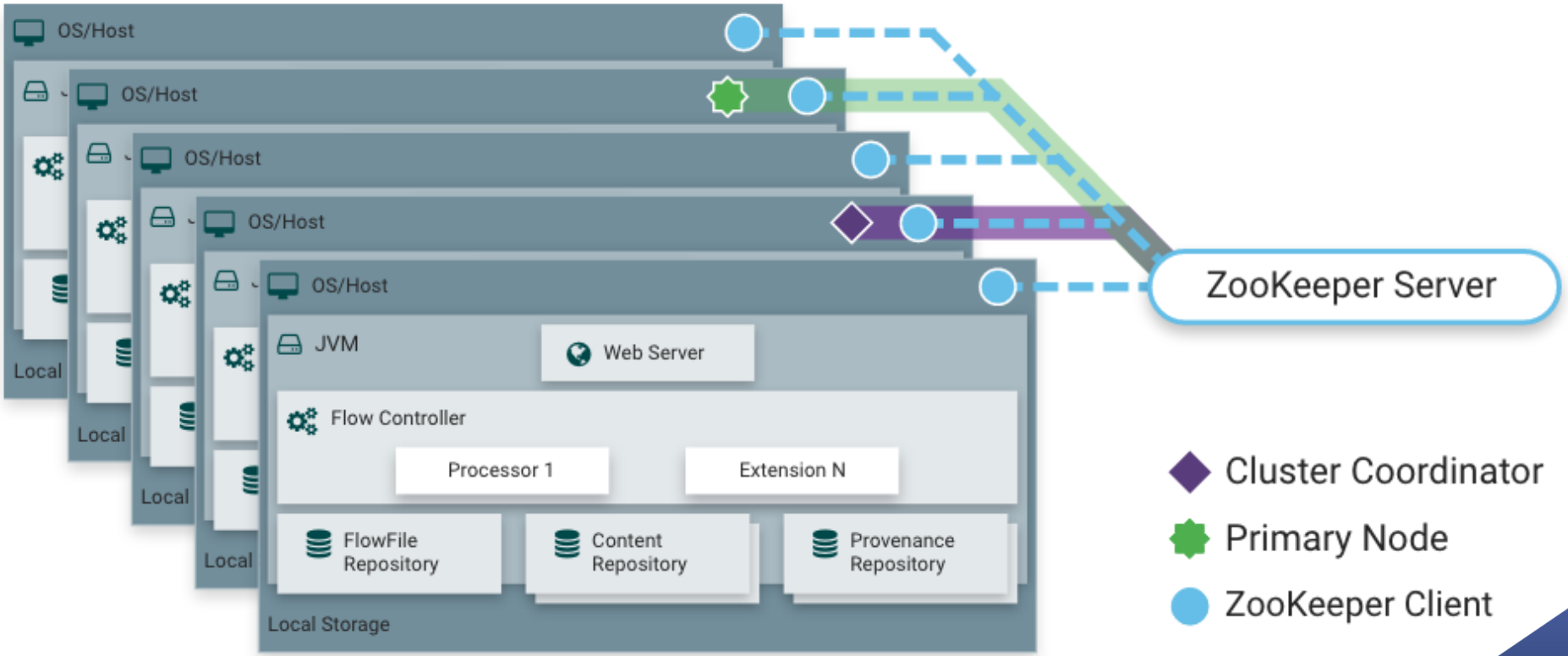

Minifi

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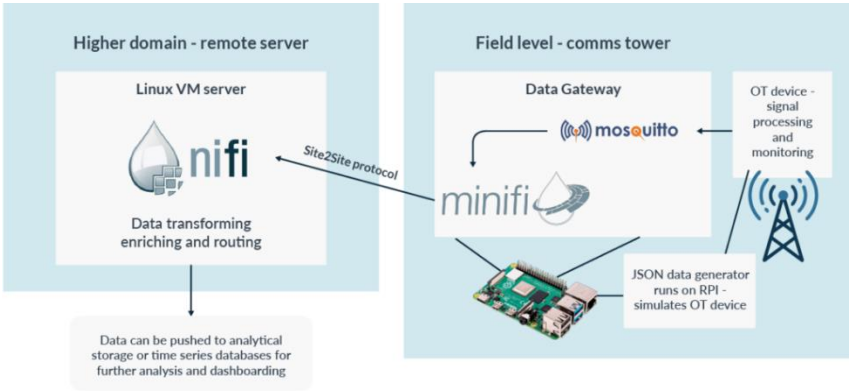
- A complementary data collection approach that supplements the core tenets of NiFi
- Small size and low resource consumption
  - binary (3.2MB)
  - Original Java agent (50MB)
- Integration with NiFi for follow-on dataflow management



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