Scalable Data Ingestion for Stream Processing and Beyond

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From Big Data to Fast Data

Volume

Data at rest

Stationary
Static

Velocity

Data in motion

Fluid
Dynamic
| Correctness | Batch | Exact results |
| Latency | High-latency |
| Cost | Stateless |

| Correcness | Streaming | Approximate results |
| Latency | Low-latency |
| Cost | Stateful |
State of the art until recently: Lambda Architectures

- Historical events
- Periodic queries
- Exact historical model
- Batch processing
- Spark

- Real-time events
- Continuous queries
- Approximate real-time model
- Stream processing
- Flink

Results & Actions

What?

Why?
The streaming pipeline: latency happens

Unified batch and stream processing

Ingest delay (write latency)
Throughput (read latency)
Network delay or unavailable
Backlog
Poor storage design
Starved resources
Hardware failure

DATA TRANSFER

Edge Cloud

Unified batch and stream processing
What is ingestion?

- **Collect** data from various sources → *producers*

- **Deliver** them for processing / storage → *consumers*

- Optionally: buffer, log, pre-process

Ingestion determines the processing performance
State of the art: Apache Kafka

Limitations

• Scalability
• Data duplication
The KerA approach to ingestion

• **Scalability** → *Dynamic partitioning*
  • Enables seamless elasticity

• **Data duplication** → *Unified ingestion and storage*
  • Support for both
    • Streams (unbounded data)
    • Objects (bounded data)
Each partition is statically associated with one consumer: limited scalability
KerA: dynamic partitioning

- **Streamlets**: logical stream containers; \#streamlets > \#brokers
- **Groups**: created and processed dynamically; maximum \#active groups per broker
Increased network and storage overheads
KerA: unified ingestion and storage

- Streams
- Acquire
- Objects

**INGESTION Brokers**

**STORAGE Backups**

KerA

Move less data, process them faster

**Common data model** for streams and objects
Evaluating scalability

Vertical

4 brokers, 32 partitions, 128KB request size, 100B records

Horizontal

64 clients, 32 partitions, 1MB request size, 100B records

2x better throughput with 75% less resources
Our vision: hybrid analytics architecture
Hybrid analytics: processing architecture

**In situ** pre-processing of simulation data

**DATA from the Hypothetical World**

**Computation**

**In situ stream** pre-processing of sensor data

**Sensor**

**DATA from the Real World**

**Learning**

**Better Decision**

**Hybrid (stream + batch) in transit** processing (data in-motion + data at-rest)

**Historical data**

**Simulation (e.g., digital twin)**

**Data processing**
Hybrid analytics architecture

**Postdoc (ANR OverFlow project)**
- Investigating Edge vs. Cloud computing trade-offs for stream processing
- Methodology for benchmarking Edge processing frameworks

**Ph.D. (to hire)**
- Uniform Cloud and Edge stream processing for Fast Data analytics

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Pedro Silva

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Better Decision

In situ pre-processing of simulation data

Learning

Hybrid (stream + batch)

... 

Research Engineer (Inria ADT project)
- Enable support for in situ Big Data analytics
- Elastic allocation of dedicated resources (cores/nodes)

Ovidiu Marcu

Historical data
Hybrid analytics architecture

**Startup (ZettaFlow)**
- Low and consistent latency (lightweight offset indexing, independent memory management)
- Model applications not partitioning/stream storage

**Ph.D. (Inria IPL project)**
- HPC – Big Data processing convergence
- Bridge in situ/in transit and stream/batch processing

**H2020 project in preparation**

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**Sensor**

**KerA++**
+seamless integration with in situ/in transit +large state management

**DATA from the Real World**

**Ovidiu Marcu**

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Thank You!