SamzaSQL

Scalable Fast Data Management with *Streaming SQL*

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Fast Data

Data has to be processed as it arrives, so that we can react immediately to changing conditions.

Big data isn't just big; it's also fast.

Big data is often data that is generated at incredible speeds, such as click-stream data, financial ticker data, log aggregation, and sensor data.

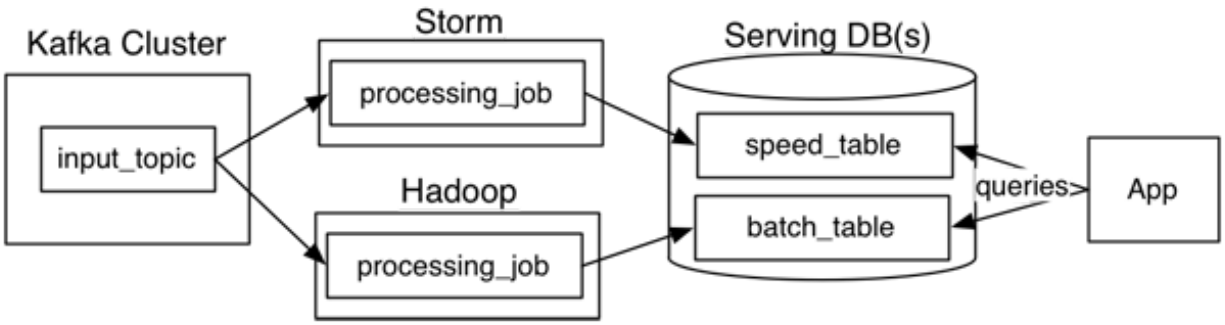
*John Hugg, **"Fast data: The next step after big data"***

Applications

- Real-time distributed tracing for website performance and efficiency optimizations
- Calculating click-through rates
- Data stream enrichment
  - Count page views by group key where group key is retrieved from a key/value storage
  - Enriching data streams related to use activities with user's information such as location and company
- **At the time of writing LinkedIn uses 90 Kafka clusters deployed across 1500 nodes to process 150TB of input data daily**

Lambda Architecture (LA)

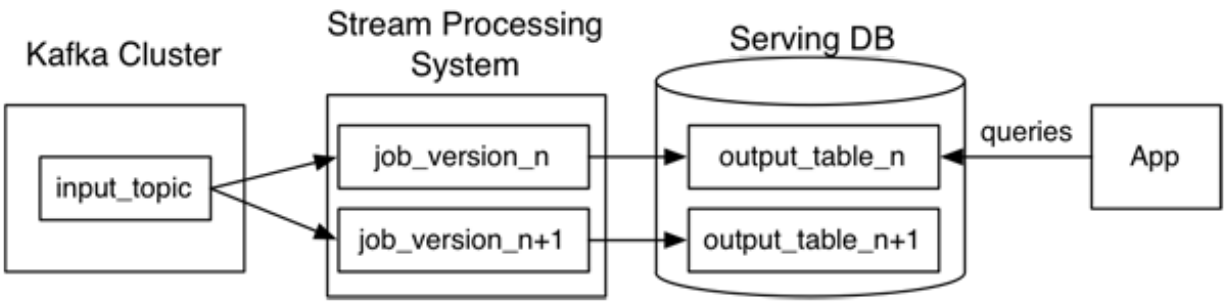
LA is a technology agnostic data processing architecture that attempts to balance latency, accuracy, throughput and fault-tolerance by providing a unified serving layer on top of batch and stream processing sub-systems.



From: `https://www.oreilly.com/ideas/questioning-the-lambda-architecture`

Kappa Architecture (KA)

Simplification of *Lambda Architecture* is KA that uses append-only immutable log as the canonical data store; batch processing is replaced by stream replay.



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Motivation

Programming APIs for LA and KA

Summingbird is a well known abstraction for writing *LA* style applications. *KA* style applications are mainly written in a **stateful stream processing APIs** provided by frameworks such as Apache Samza.

Limitations

- Need to maintain two complex distributed systems
- Users need to understand complex programming abstractions
- Long turnaround times

Summingbird

Word Count

```
def wordCount[P <: Platform[P]]
    (source: Producer[P, String], store: P#Store[String, Long]) =
      source.flatMap { sentence =>
        toWords(sentence).map(_ -> 1L)
      }.sumByKey(store)
```

More examples at https://github.com/twitter/summingbird

Samza API

Window Aggregation

```
public class WikipediaStatsStreamTask implements StreamTask, InitableTask, WindowableTask {
  ...
  private KeyValueStore<String, Integer> store;
  public void init(Config config, TaskContext context) {
    this.store = (KeyValueStore<String, Integer>) context.getStore("wikipedia-stats");
  }
  @Override
  public void process(IncomingMessageEnvelope envelope, MessageCollector collector,
                      TaskCoordinator coordinator) {
    Map<String, Object> edit = (Map<String, Object>) envelope.getMessage();
    ...
  }
  @Override
  public void window(MessageCollector collector, TaskCoordinator coordinator) {
    ...
    collector.send(new OutgoingMessageEnvelope(new SystemStream("kafka", "wikipedia-stats"), counts));
    ...
  }
```

SQL for Big Data

There are several well known SQL-on-Hadoop solutions and most organizations that use Hadoop use one or more SQL-on-Hadoop solutions.

- Apache Hive
- Presto
- Apache Drill
- Apache Impala
- Apache Kylin
- Apache Tajo
- Apache Phoenix

Motivating Research Questions

- Can the same low barrier and the clear semantics of SQL be extended to queries that execute simultaneously over data **`streams`** (in movement) and **`tables`** (at rest)?
- Can this be done with minimal and well-founded extensions to SQL?
- And with minimal overhead over a non-SQL-based LA/KA?

SamzaSQL

Streaming SQL - Data Model

- **Stream:** A stream S is a possibly indefinite partitioned sequence of temporally-defined elements where an element is a tuple belonging to the schema of S.
- **Partition:** A partition is a time-ordered, immutable sequence of elements existing within a single stream.
- **Relation:** Analogous to a relation/table in relational databases, a relation R is a bag of tuples belonging to the schema of R.

Streaming SQL - Continuous Queries

SamzaSQL

```
SELECT STREAM rowtime, productId, units FROM Orders
  WHERE units > 25
```

CQL

```
SELECT ISTREAM rowtime, productId, units FROM Orders
  WHERE units > 25;
```

Streaming SQL - Window Aggregations

SamzaSQL

```
SELECT STREAM TUMBLE_END(rowtime, INTERVAL '1' HOUR) AS rowtime,
  productId,
  COUNT(*) AS c,
  SUM(units) AS units
FROM Orders
GROUP BY TUMBLE(rowtime, INTERVAL '1' HOUR), productId
```

CQL

```
SELECT ISTREAM ... AS rowtime, productId, COUNT(*) AS c,
  SUM(units) AS units
FROM Orders[Range '1' HOUR, Slide '1' HOUR]
GROUP BY  productId;
```

Streaming SQL - Sliding Windows

SamzaSQL

```
SELECT STREAM rowtime, productId, units,
  SUM(units) OVER (ORDER BY rowtime PARTITION BY productId RANGE
    INTERVAL '1' HOUR PRECEDING) unitsLastHour
FROM Orders;
```

CQL

```
SELECT ISTREAM rowtime, productId, units,
  SUM(units) AS unitsLastHour
FROM Orders[Range '1' HOUR]
GROUP BY  productId;
```

Streaming SQL - Window Joins

SamzaSQL

```
SELECT STREAM
  GREATEST(PacketsR1.rowtime, PacketsR2.rowtime) AS rowtime,
  PacketsR1.sourcetime,
  PacketsR1.packetId,
  PacketsR2.rowtime - PacketsR1.rowtime AS timeToTravel
FROM PacketsR1 JOIN PacketsR2 ON
  PacketsR1.rowtime BETWEEN
  PacketsR2.rowtime - INTERVAL '2' SECOND
  AND PacketsR2.rowtime + INTERVAL '2' SECOND
  AND PacketsR1.packetId = PacketsR2.packetId
```

Streaming SQL - Stream-to-Relation Joins

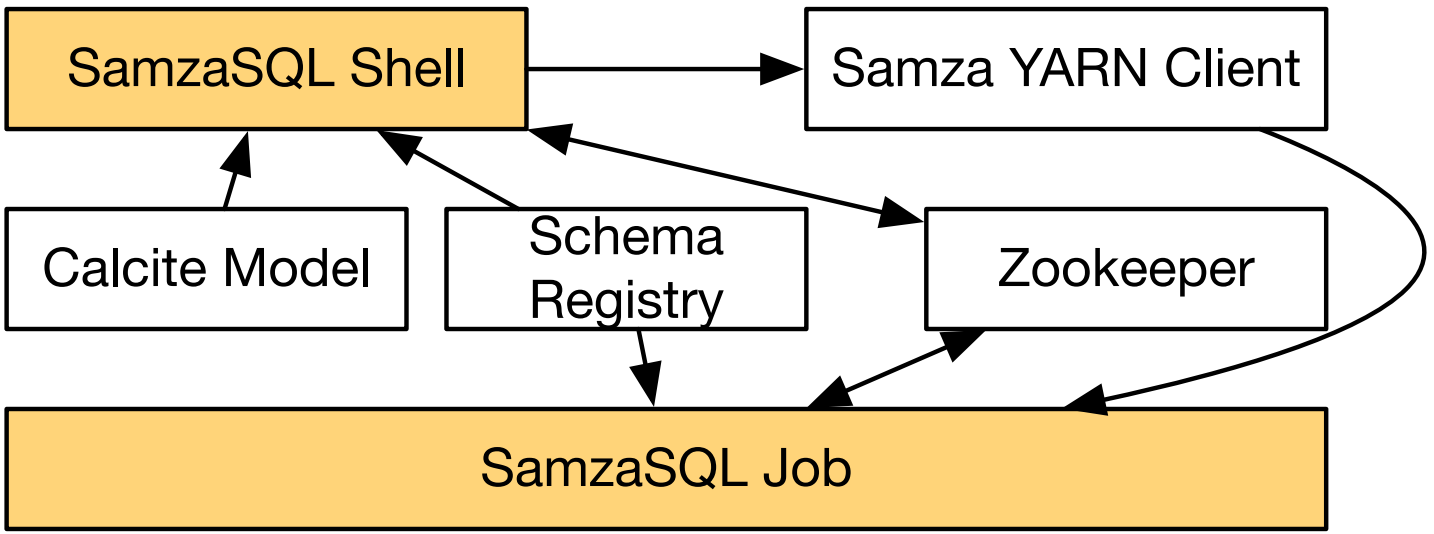
SamzaSQL

```
SELECT STREAM *
FROM Orders as o
JOIN Products as p
  on o.productId = p.productId
```

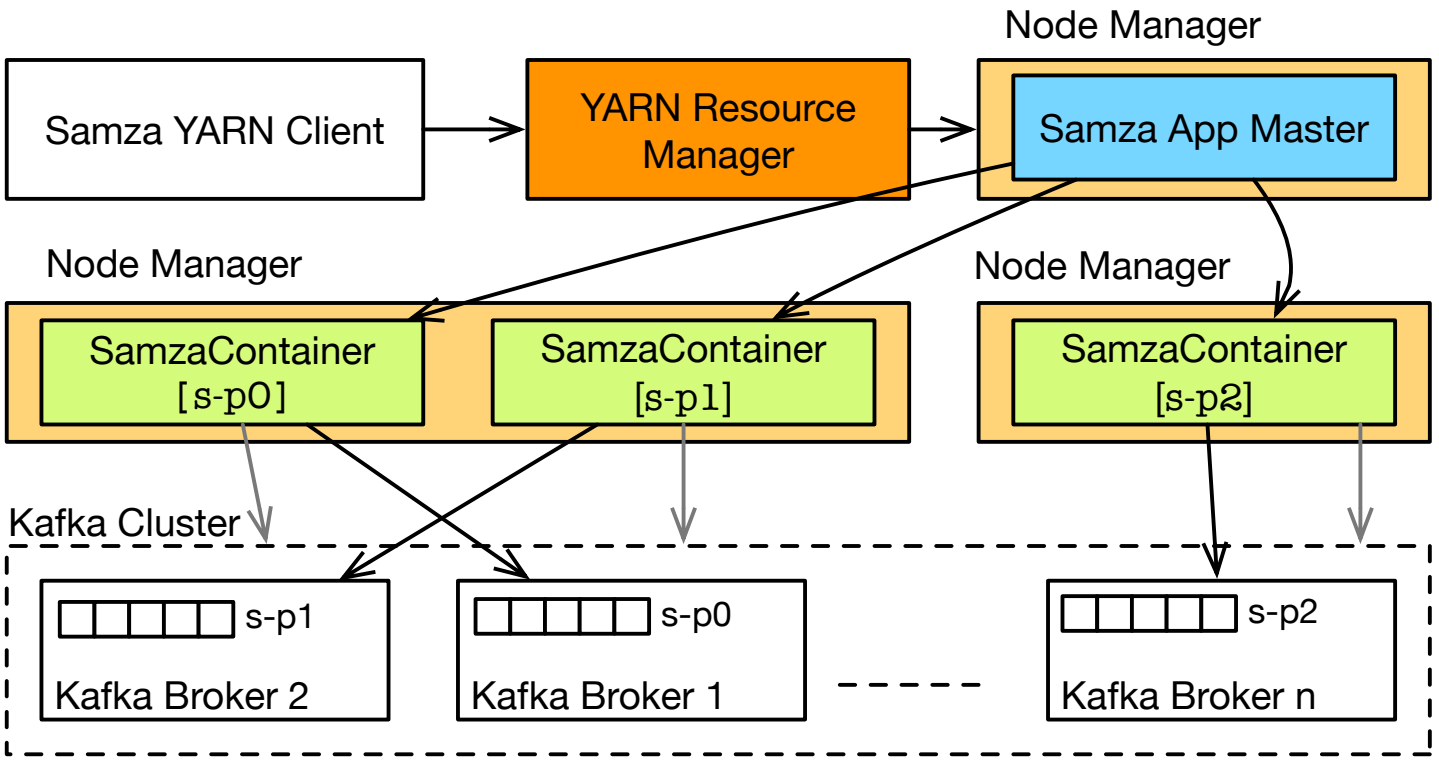
SamzaSQL - Implementation

- Uses Apache Calcite query planning framework
- Utilizes Calcite's code generation framework
- Generates Samza jobs for streaming SQL queries
- Uses Samza's local storage to implement fault-tolerant window aggregations
- Uses Samza's bootstrap stream feature to cache the relation to perform stream-to-relation join queries
- Uses Janino to compile operators generated during stream task initialization

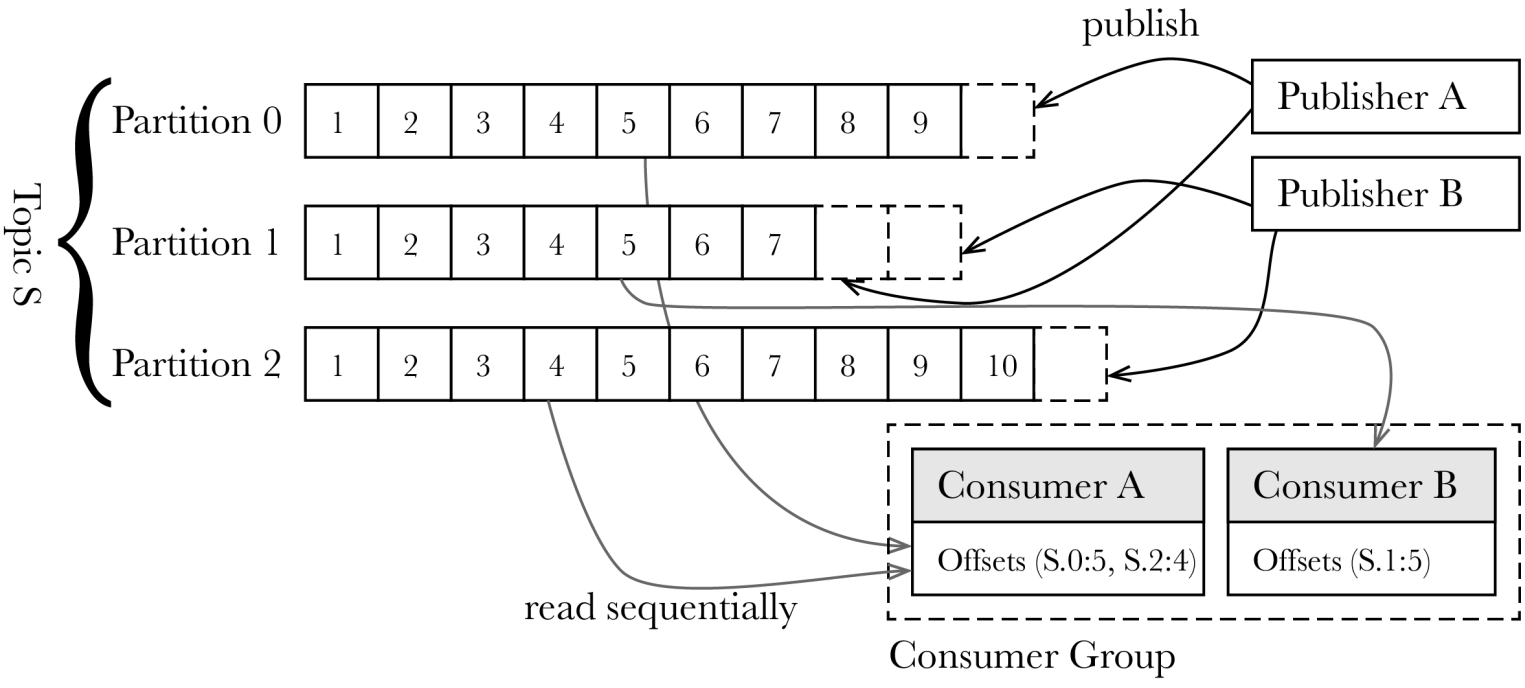
SamzaSQL - Architecture



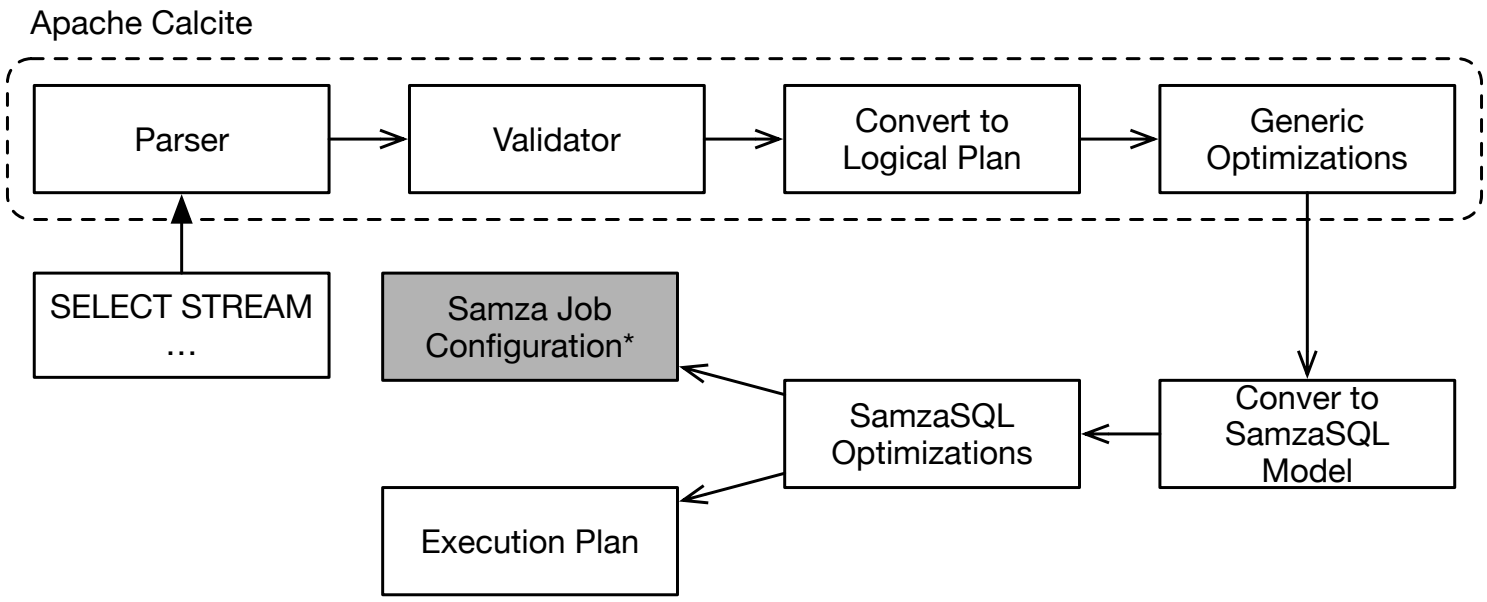
SamzaSQL - Samza Job



SamzaSQL - Kafka



SamzaSQL - Query Planner



Evaluation

Evaluation - Environment

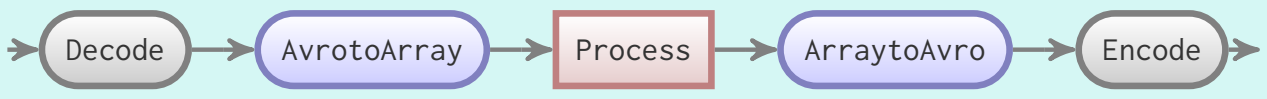
- 100 byte messages (based on previous Kafka benchmarks)
- 3 node (EC2 r3.2xlarge) Kafka cluster
- 3 node (EC2 r3.2xlarge) YARN cluster
- Each r3.2xlarge instance has 8 vCPUs, 61GB of RAM and 160 GB SSD backed storage
- Data model
  - Stream - `Orders (rowtime, productId, orderId, units)`
  - Table - `Products (productId, name, supplierId)`

Evaluation - Results

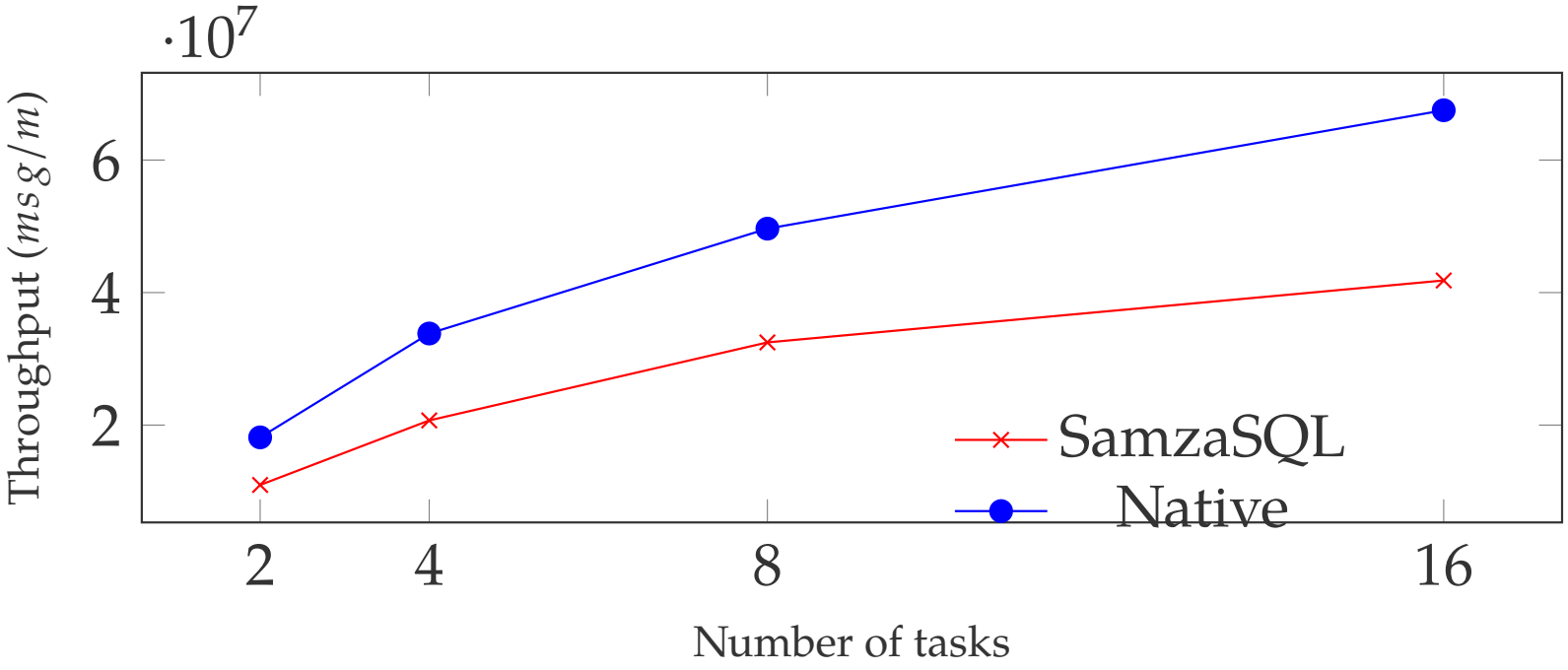
- Per task throughput is around 550MB/m for simple queries (100 byte messages)
- Throughput is around 200MB/m when local storage is used (100 byte messages)
- 30-40% overhead for simple queries when compared with Samza jobs written in Java
- Overheads are mainly due to message format transformations required in streaming SQL runtime
- Overheads increase when local storage is used due to message serialization/deserialization

Evaluation - SamzaSQL Message Processing Flow

Message processing flow

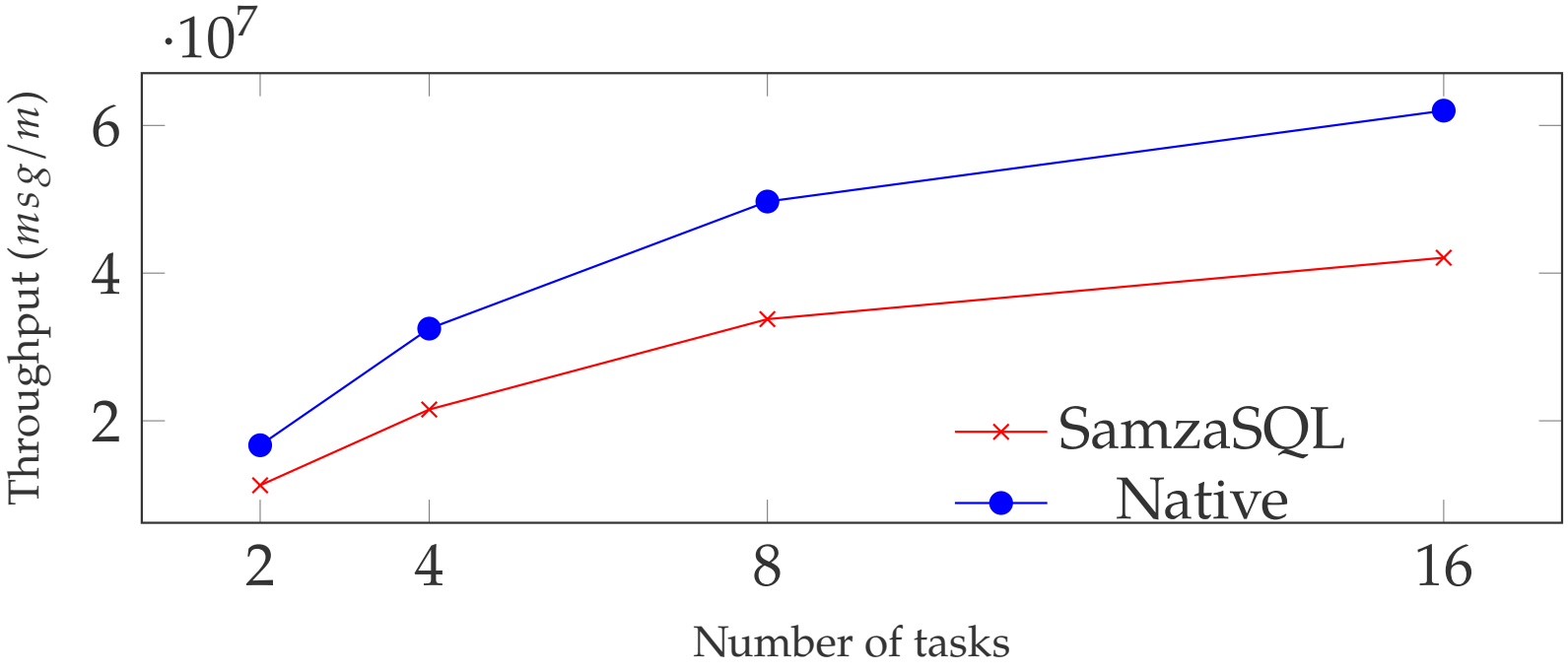


Evaluation - Filter Throughput



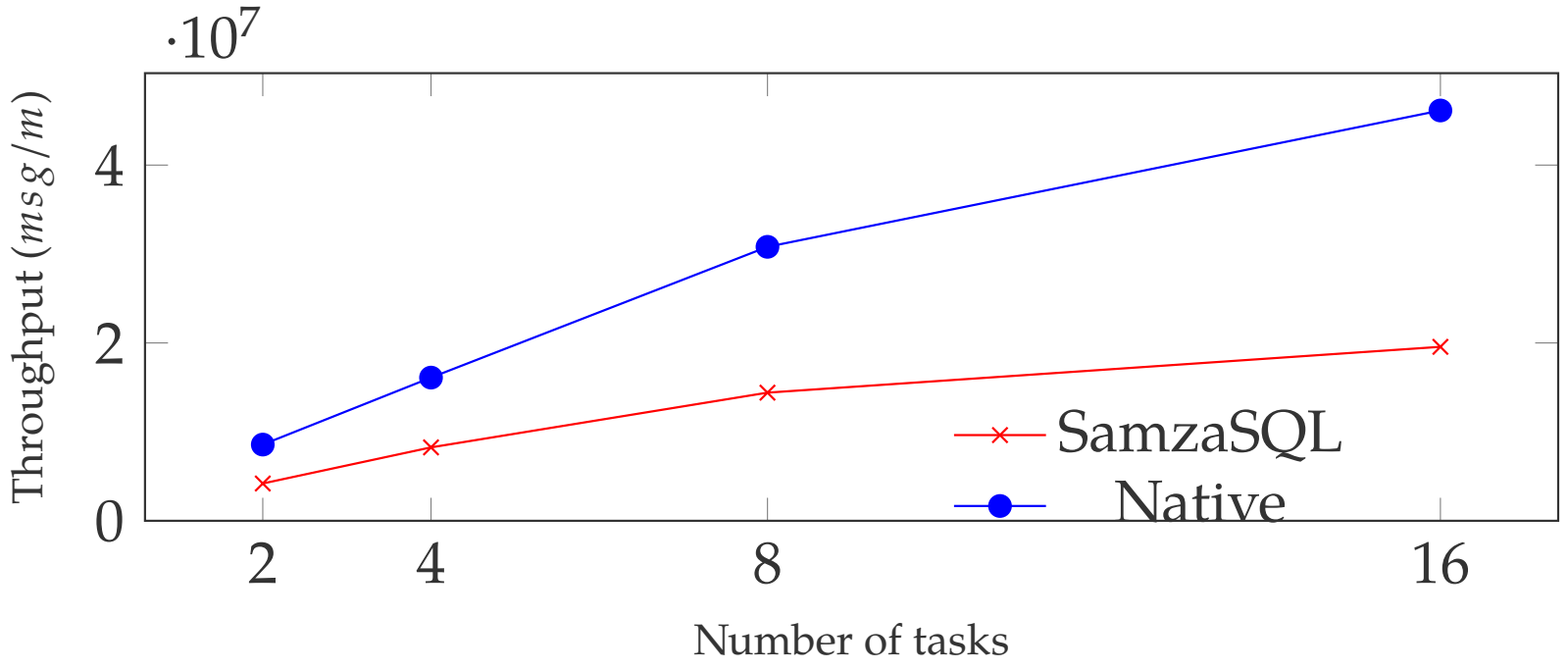

```
SELECT STREAM * FROM Orders WHERE units > 50
```

Evaluation - Project Throughput



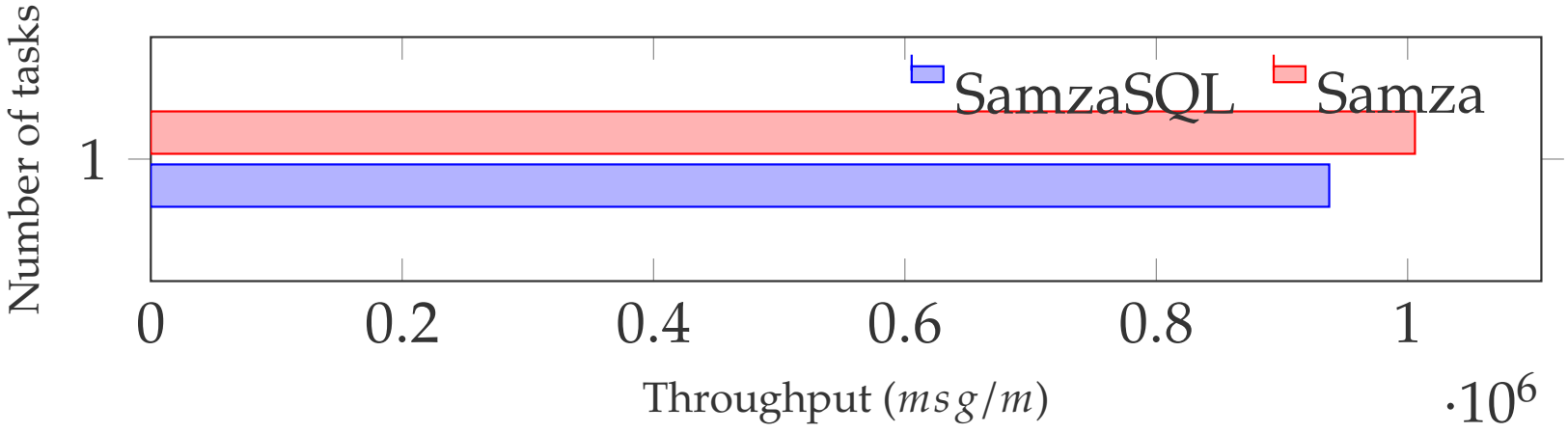

```
SELECT STREAM rowtime, productId, units FROM Orders
```

Evaluation - Stream-to-Relation Join Throughput




```
SELECT STREAM Orders.rowtime, Orders.orderId, Orders,productId, Orders.units,
Products.supplierId FROM Orders JOIN ON Orders.productId = Products.productId
```

Evaluation - Sliding Window Throughput




```
SELECT STREAM rowtime, productId, units, SUM(units) OVER (PARTITION BY
productId ORDER BY rowtime RANGE INTERVAL '5' MINUTE PRECEDING)
unitsLastFiveMinutes FROM Orders
```

Sliding window query throughput was measured in a iMac due to limitations in EC2 IO rates.

Related Work

Related Work

- Eerly work on streaming SQL - TelegraphCQ, Tribecca, GSQL
- CQL
- Streaming SQL for Apache Flink and Apache Storm based on our work in Apache Calcite

Future Work and Conclusion

Future Work

- Code generation to bring SamzaSQL generated physical plans closer to Samza Java API based queries
- Local storage related improvements to reduce serialization/deserialization overheads
- Streaming query optimizations for fast data management systems
- Ordering guarantees in the presence of stream repartitioning
- Stream-to-relation queries
- Intra-query optimizations
- Handling out-of-order arrivals

Summary and Conclusion

- We proposed a novel set of extensions to standard SQL for expressing streaming queries.
- SamzaSQL is an implementation of proposed streaming SQL variant on top of Apache Samza.
- We demonstrate that we can achieve decent amount of performance by utilizing existing libraries.
- Our evaluation results shows that further improvements such as code generation is needed to bring streaming SQL runtime closer in performance to streaming queries written in languages such as Java and Scala.

References

- Apache Samza
- Apache Calcite
- High-Level Language for Samza
- Calcite Streaming SQL
- Stream Processing for Everyone with SQL and Apache Flink

Acknowledgments

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