Federated Stream Processing Support for Real-Time Business Intelligence Applications

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Introduction

- Business Intelligence (BI) enables better decision-making for businesses.
- In **operational BI**, real-time response to business events is critical, which requires:
  - reducing latency
  - providing rich contextual information

➢ We propose **MaxStream federated stream processing system** as a platform to meet these needs.

Talk Outline

- Example Use Cases & Motivation
- MaxStream System
  - Architecture
  - Usage
  - Feasibility
- Conclusions & Open Challenges

Example Use Cases

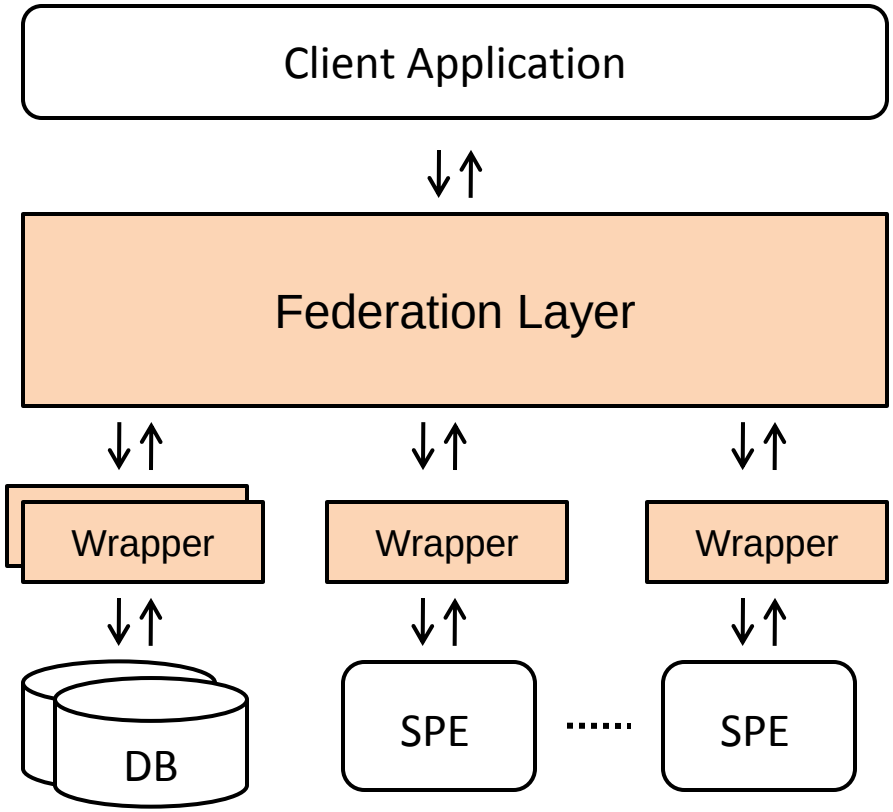
- Supply-Chain Optimization
- Call Center Management
- Quality Management in Manufacturing
- SLA Monitoring and Maintenance
- Global Shipment & Delivery Monitoring
- Fraud Detection in Financial Companies
- Real-time Marketing
- …

➢ Different levels of latency and data persistence requirements

e.g., Call Center Management

- Multiple centers across the globe
- Every incoming call is captured with arrival time, service start and end times
- Main BI tasks:
  - Run statistics on wait time, service duration, etc. for different regions
  - Generate reports, analyzing problems and proposing strategic improvements

MaxStream Architecture: From 30,000 ft

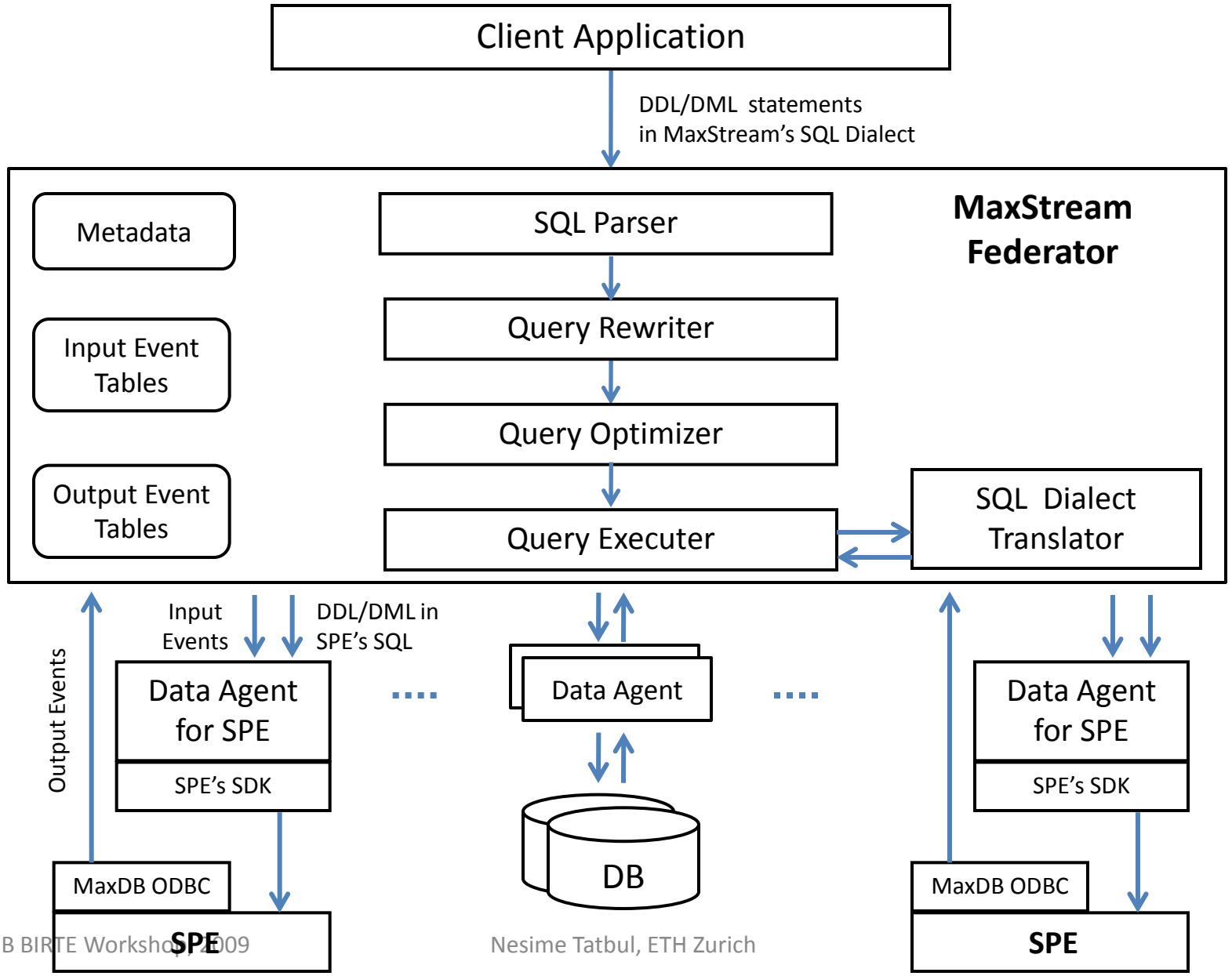


- Key ideas:
  - Uniform query language and API
  - Relational database infrastructure as the basis for the federation layer (in our case: SAP MaxDB and SAP MaxDB Federator)
  - "Just enough" streaming capability inside the federation layer

Putting MaxStream into Context

- vs. Federated Databases
  - Less focus on data locality, more focus on functional heterogeneity
- vs. Stream Processing Engines (SPEs)
  - Unlike distributed SPEs, there may be heterogeneity
  - Unlike stream-relational SPEs, MaxStream federator is not a full-fledged SPE
- vs. Business Intelligence Software
  - Tighter integration between (possibly heterogeneous) SPEs and databases

MaxStream Architecture: A Closer Look



MaxStream Architecture
Two Key Building Blocks

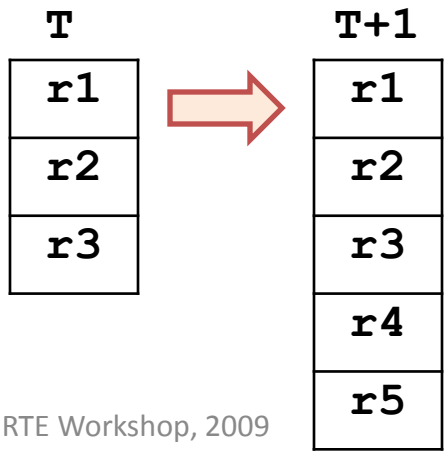
- Streaming Inputs through MaxStream
  - **ISTREAM** Operator for Persistent input events
  - Tuple Queues for Transient input events

- Streaming Outputs through MaxStream
  - **Monitoring Select** over Event Tables
    - Persistent Event Tables for Persistent output events
    - In-Memory Event Tables for Transient output events

Streaming Persistent Input Events

- The ISTREAM ("Insert STREAM") Operator
  - Relation-to-Stream operator first proposed by Widom et al. [STREAM Project], that streams new tuples being inserted into a given relation.
  - Example:

```
INSERT INTO STREAM CallStream
       SELECT OpCode, ArrivalTime, StartTime, EndTime
         FROM ISTREAM(CallTable);
```



`ISTREAM(CallTable)` at `T+1` returns:

`<r4, T+1>, <r5, T+1>`

Streaming Output Events

- Opposite of streaming input events, but…
  - Unlike the SPE interface, the client application interface is not push-based.
- Alternative solutions:
  - Each client monitors its own alerts on a given table.
    - cumbersome and error-prone
  - A monitoring program does so for all registered clients using periodic select queries (i.e., polling) or triggers.
    - Not event-driven, inefficient, not scalable

Streaming Output Events

- Our Solution: Monitoring Select
  - Select operation blocks until there is at least one row to return.
  - For continuous monitoring, the client program re-issues Monitoring Select in a loop.
  - Monitoring Select operates on “Event Tables”.
- Example: Detect calls with unusually long waiting times.

```
SELECT *
  FROM /*+ EVENT */ CallAnalysis
 WHERE AvgWait > 10;
```

Hybrid Queries in MaxStream

- Hybrid queries are continuous queries that join Streams with Tables
  - Similar to joining Fact tables with Dimension tables in data warehouses
- One can conveniently use hybrid queries in MaxStream in two ways:
  - To enrich the input stream before it is passed to the SPE
  - To enrich the output stream after it is received from the SPE

Hybrid Queries: Call Center Example

```
CREATE TABLE CallTable (Opcode, ArrivalTime, StartTime, EndTime);
```

Enriching the input in MaxStream:

```
INSERT INTO STREAM CallStream
  SELECT o.RegionNm AS Region, c.StartTime-c.ArrivalTime AS WaitTime,
         c.EndTime-c.StartTime AS Duration
   FROM  ISTREAM(CallTable) c, OperatorsbyRegion o
  WHERE c.Opcode = o.Operator;
```

Continuous Query in SPE:

```
INSERT INTO TABLE CallAnalysis
  SELECT Region, COUNT(*) AS Cnt, AVG(WaitTime) AS AvgWait,
         AVG(Duration) AS CallLength
   FROM  CallStream
  GROUP BY Region
  KEEP 1 HOUR;
```

Enriching the output in MaxStream:

```
SELECT   a.Region, a.AvgWait, a.AvgDuration, r.NOps, r.Training
 FROM    /* +Event */ CallAnalysis a, Regions r
WHERE    AvgWait > 10
   AND   a.Region = r.RegName;
```

Initial Feasibility Study

- Goal: to show
  - if MaxStream is useful in supporting real-time BI applications
  - whether MaxStream's performance overhead is acceptable
- Setup: SAP Sales and Distribution Benchmark
  - Persistent events, Throughput critical
  - Original benchmark: No streaming
  - We add streaming and compare the following two setups:
    - SD vs. SD with MaxStream/ISTREAM + SPE "X"
    - SD vs. SD with MaxStream/Monitoring-Select

SAP Sales and Distribution (SD) Benchmark

- It is a business benchmark that models a sell-from-stock scenario that consists of 6 transactions, each with 1-4 dialog steps and around 10 seconds of think-time for each.
  - Example transactions: Create customer order document, Create order delivery document, Create invoice, etc.
- Measure: throughput in the number of processed dialog steps per minute (SAPs).

Use of MaxStream in SAP SD Benchmark

MaxStream/ISTREAM + SPE "X"

- Stream incoming orders.
- Forward sales orders to SPE "X" via MaxStream in order to continuously compute the daily sum of sales orders for each product and region.

```
INSERT INTO STREAM SalesOrderStream
    SELECT   A.MANDT, A.VBELN, A.NETWR,
             B.POSNR, B.MATNR, B.ZMENG
    FROM     ISTREAM(VBAK) A, VBAP B
    WHERE    A.MANDT = B.MANDT
      AND    A.VBELN = B.VBELN;
```

MaxStream/Monitoring-Select

- Monitor big sales.
- Continuously monitor big sales orders (i.e., with amount > 95) by storing purchase orders in an event table and running Monitoring Select over it.

```
SELECT    A.MANDT, A.VBELN, B.KWMENG
FROM      /*+ EVENT */ VBAK A, VBAP B
WHERE     A.NETWR > 95
  AND     A.MANDT = B.MANDT
  AND     A.VBELN = B.VBELN;
```

MaxStream SAP SD Benchmark Performance

	SD	SD with ISTREAM	SD with Monitoring-Select
# of SD Users	16,000	16,000	16,000
Throughput (SAPs)	95,910	95,910	95,846
Dialog Response Time (msec)	13	13	13
DB Server CPU Utilization (%)	49.8%	50.6%	50.1%

- SD with streaming features achieves similar performance as the standard one.

Conclusions

- Real-time BI requires new platforms which offer
  - low latencies of stream processing
  - support for analytics of data warehouses
  - flexible, dynamic access to data of data federation engines
- MaxStream stream federation engine provides
  - access to heterogeneous SPEs and DBs
  - flexible persistence and data federation capabilities
- MaxStream is low-overhead and useful in various operational BI scenarios.

Open Challenges

- Unified continuous query execution model and semantics
- Cost- and Capability-based query optimization and dispatching over multiple SPEs
- Transactional aspects of federated stream processing
- Distributed operation aspects (e.g., load balancing, high availability)

Thanks!

- You ☺
- MaxStream team
- Chan Young Kwon (SAP Labs, Korea)
- ETH Zurich Enterprise Computing Center (ECC)

- More information:

  http://www.systems.ethz.ch/research/projects/maxstream/