UMBRA

Relation-Based In-Database Stream Processing

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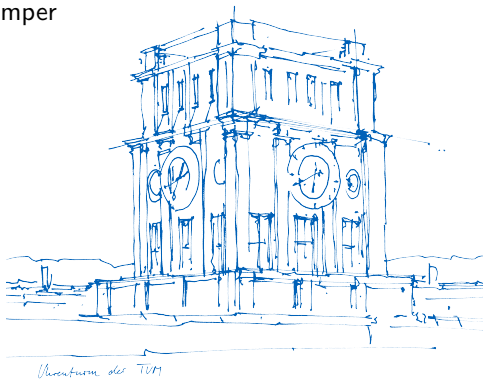
Technical University of Munich

CDMS @ VLDB 2023



Motivation

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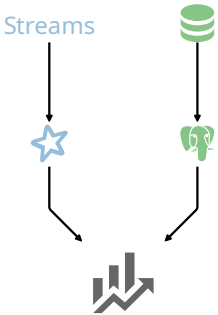
  - Business reporting
  - Log monitoring
  - Logistics



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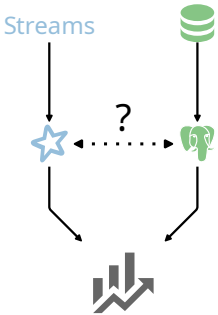

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- Stream data analytics is growing increasingly complex
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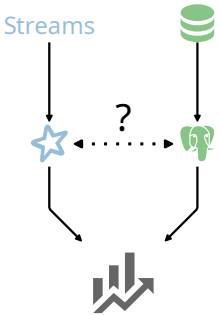
- Stream processing engines inefficient for historic data
- Database systems not built for ephemeral data



Complex stream analytics in a single system is hard

Current Solutions

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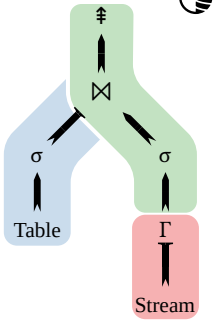
- Historic data in stream processing engines
  - Read-only
  - Optimized for filter-and-aggregate queries



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- Historic data in stream processing engines
  - ⚠ Read-only
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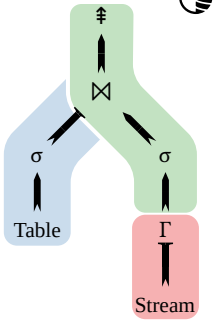
- View-based stream processing
  - ✓ Highly performant
  - ⚠ Requires fine-tuned and invasive integration



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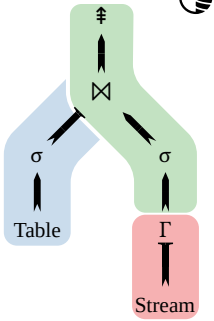

Current solutions are complex to implement and integrate

Relation-Based Integration

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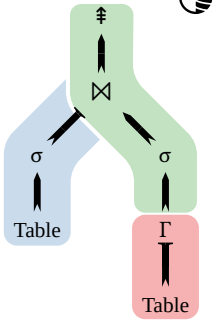
- Relations are entry point for all data in a DBMS



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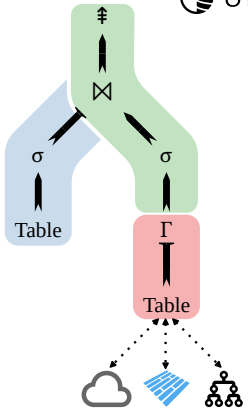
- Relations are entry point for all data in a DBMS
- Database systems utilize physical data independence
  - Masks remote data access
  - Independence of storage formats, e.g., Parquet
  - Optimized access paths for OLTP or OLAP



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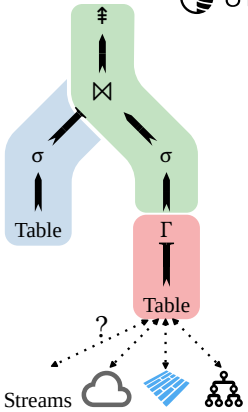

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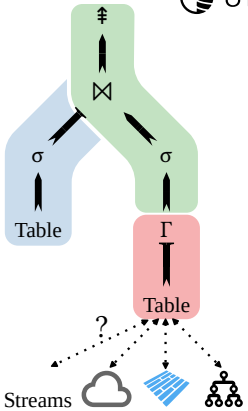
- New relation types transparent to other operators
- Streams are ephemeral in nature
- Scanned data is unknown at query start



Masking Unknown Scan Boundaries

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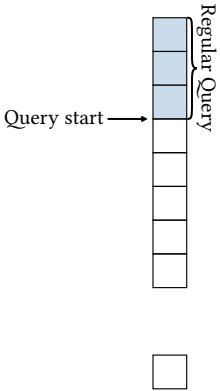
- Scans rely on fixed set of accessed data, i.e. TIDs



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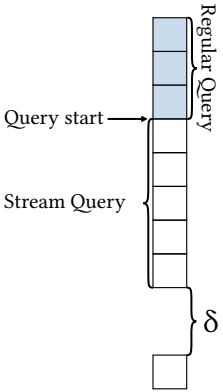
- ⚠ Stream data arrives during query processing



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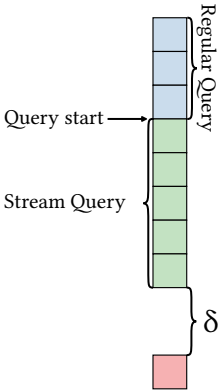
- ⚠ Stream data arrives during query processing
- Scan has to detect stream depletion
  - ⚠ Control messages would break SQL interface
  - ✔ Detect stream depletion from metadata



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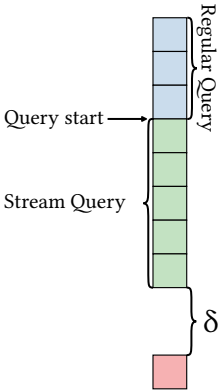

Queries with session-window semantics

Masking Data Ephemerality

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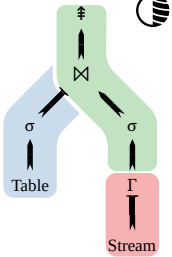
- Scans rely on data to be fully and durably materialized



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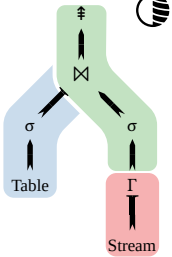

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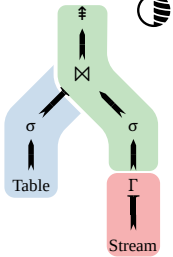
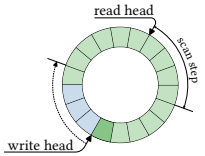
- ⚠ Streams are too voluminous be materialized fully
- Scans have to deal with short-lived data
  - ✓ Ring buffer provides required abstraction
  - ⚠ Requires careful overflow checks for variable-sized data





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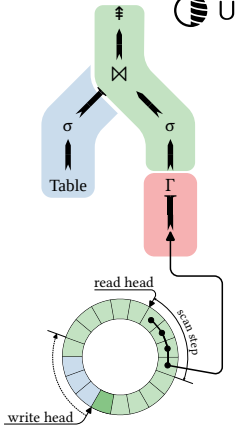

Ring-buffered cache with overflow handling

Experimental Analysis - Analytical Performance

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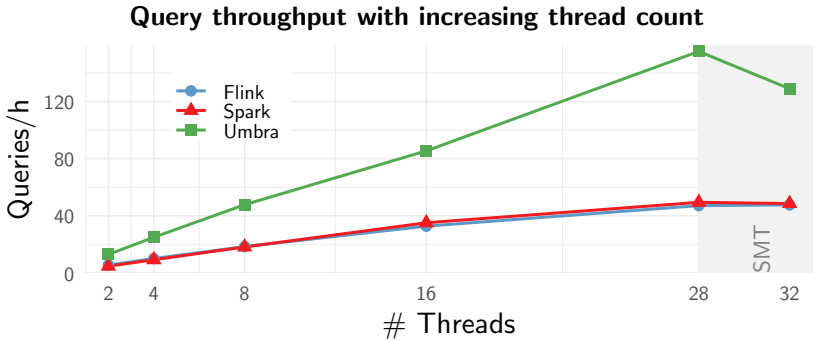

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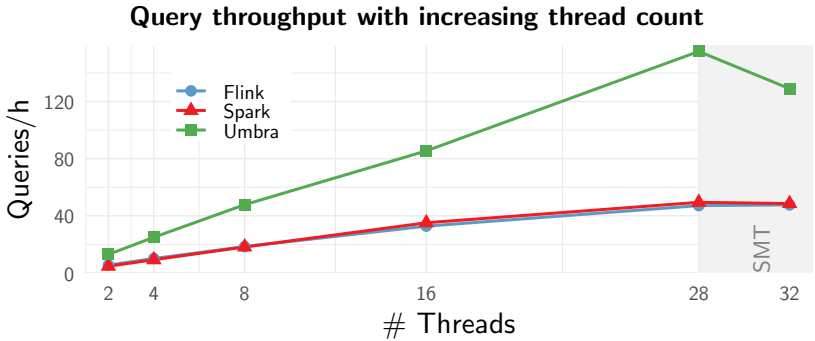

- TPC-H SF 100 where `lineitem` is treated as a stream
- Near-linear scaling to all physical cores
- **3**× speedup over established stream processing engines

Experimental Analysis - Query Overhead

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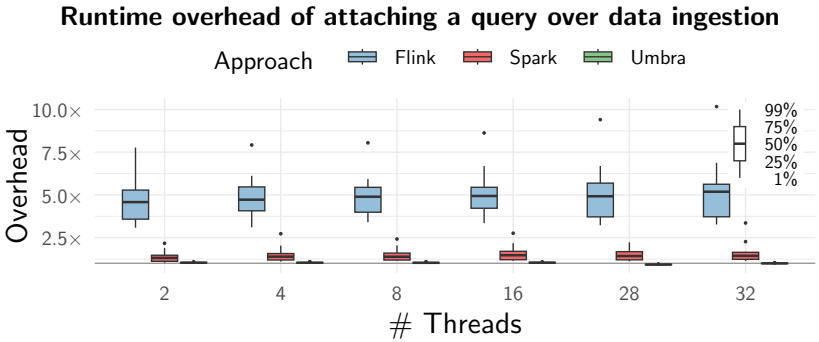

➔ Runtime difference of evaluating a query to parsing the data in each system

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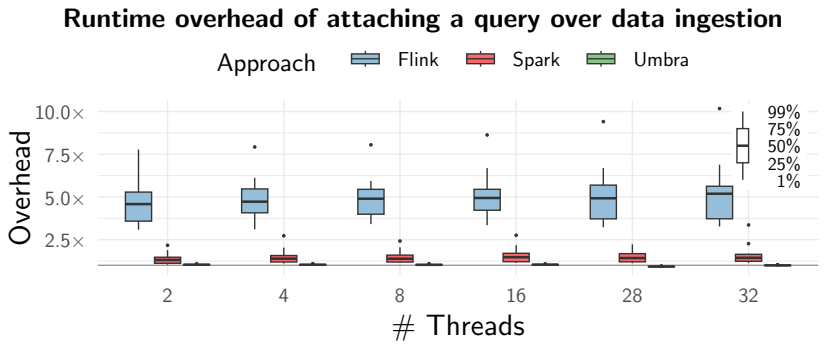

- Runtime difference of evaluating a query to parsing the data in each system
- ✓ Next to no overhead over insert processing
- ✓ Attaching multiple queries has no additional cost

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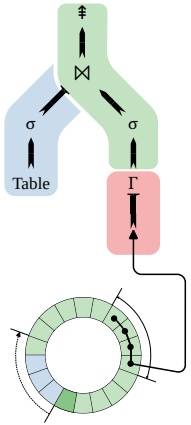
  - Session-windowed semantics masks unknown stream bounds
  - Minimally invasive, fully SQL-based integration
  - Full functionality for historic data



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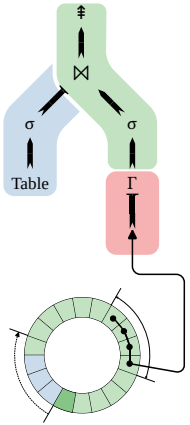

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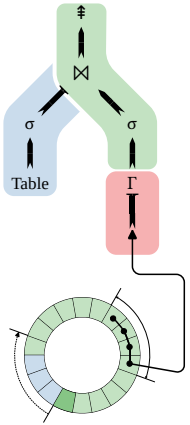

Thank you for your attention!