TOWARDS SCALABLE REAL-TIME ANALYTICS:
AN ARCHITECTURE FOR SCALE-OUT OF OLXP WORKLOADS

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Motivation

• Real-time analytics
  – Business value through data scientists
  – Transactions (OLTP) + Analytics (OLAP)

• Hardware trends
  – Low-latency network interconnect
  – Storage class memory
Motivation

• Elastic scale
  – Large load fluctuation
  – Dynamic resource provisioning

• Rapid code-shipping
  – Separating functional components
  – Decouple development and release cycles
Key Question

How can we scale-out OLTP and OLAP workloads independently in a cluster?
HANA-SOE Architecture

- **Transaction Broker**
- **Shared Log**

Que Engine
# Three Components

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<th>COMPONENTS</th>
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<td>Transaction Broker</td>
<td>Shared state for concurrency control</td>
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<td>Shared Log</td>
<td>Durability mechanism on top of storage units</td>
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<td>Query Engine</td>
<td>Slice-oriented in-memory SQL engine</td>
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Interplay of components

• Transaction Broker
  – *Issues timestamps and does validation*

• Shared Log
  – *Persists updates and supports versioning*

• Query Engine
  – *Performs local changes*
1. Transaction Broker

- Decouple txn from query processing
  - *MVCC layer on top of the slice abstraction*
- Strong snapshot isolation
  - *Asynchronous update propagation to slices*
- Independent OLAP scale-out
  - *No distributed commit protocol*
1. Transaction Broker

• Efficient cross-partition transactions
  – Separate partition-level updates to the log
  – Shared log takes care of ordering

• Epoch-based versioning scheme
  – All current transactions aborted on broker failure
  – No “split-brain” scenario
1. Transaction Broker

• Query engine contract
  – Answer query at requested logical timestamp
  – In-memory snapshots kept in-sync using log

• Scheduling analytics transactions
  – Run at same read timestamp based on SLA
2. Shared Log

- Distributed shared log
  - Key-metadata-value store
  - Total order over all writes for linearizability

- Scan operation
  - Bulk-read log entries based on predicate
  - Metadata can be slice identifier
2. Shared Log

• Each transaction corresponds to a LSN
  – LSN acquired by transaction broker

• Implementation
  – Partitioned and replicated entries over a cluster
  – Distributed hash table for partitioning
  – Chain replication protocol
2. Shared Log

- **Storage units**
  - Asynchronous I/O operations on SSDs
  - NVM-optimized design
  - RDMA support to allow scatter-gather reads

- **Log compaction**
  - Entries corresponding to same key
3. Query Engine

• Distributed query processor
  – Distributed execution plan
  – Mapping from slices to compute nodes

• Data manager
  – Read log and apply updates to build versions
  – Main-memory column store
3. Query Engine

- SQL-to-C code generator
  - Physical query plan to C code
  - LLVM to transform C to native code

- Late materialization
  - Intermediate operators generate only row-ids
  - Result printer materializes the result
3. Query Engine

• Update processing
  – Perform locally cached updates
  – Write validated updates to log

• Checkpoint
  – Per-slice per-version by the engine to cold storage
## Summary

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Conclusions

• Decouple OLTP and OLAP processing
  – *Distinguish three types of services*

• Scale-out of mixed OLTP/OLAP workloads
  – *Strict SLA on data freshness for analytics*