R-Store: A Scalable Distributed System for Supporting Real-time Analytics

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Outline

- Background & Motivation
- System Overview
- System Design
- RTOLAP in R-Store
- Evaluation
- Conclusion
- Q & A

Background & Motivation

- Situation for large scale data processing
  - Systems classified into 2 categories: OLTP, OLAP
  - Data periodically transport to OLAP through ETL
- Demand
  - Time critical decision making (RTOLAP)
    - the freshness of OLAP results
    - Fully RTOLAP entail executing query directly on OLTP data
  - OLAP & OLTP processed by one integrated system

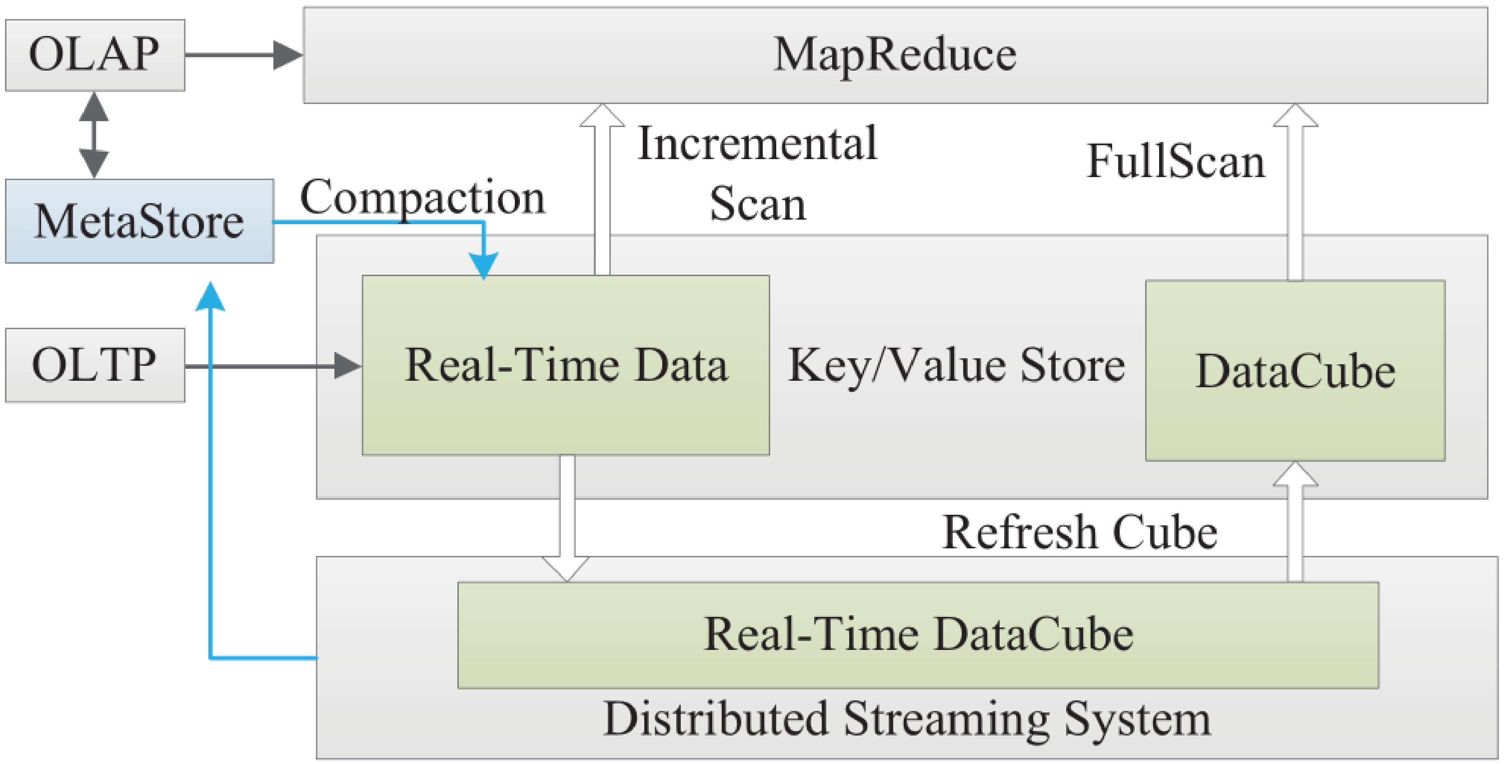
Background & Motivation

- Problem on simple combination
  - Resource contention
    - OLTP query blocked by OLAP
  - Inconsistency
    - Long running OLAP may access same data sets several times, updates by OLTP could lead to incorrect OLAP results
- Solution – R-Store
  - Resource contention
    - Computation resource isolation
  - Inconsistency
    - Multi-versioning storage system

System Overview – A glimpse of R-Store

- OLAP query data based on timestamp of query submission from multi-versioning storage system
  - – Modified HBase as storage
  - – Mapreduce job for query execution
- Periodically materialize real-time data into data cube
  - – Fully HBaseScan every time is time-consuming
    - Entire table is scanned & shuffled during MR
  - – Streaming Mapreduce to maintain data cube

System Overview – R-Store Architecture



OLTP submitted to KV Store

OLAP query processed by

MapReduce – Scan on HBase

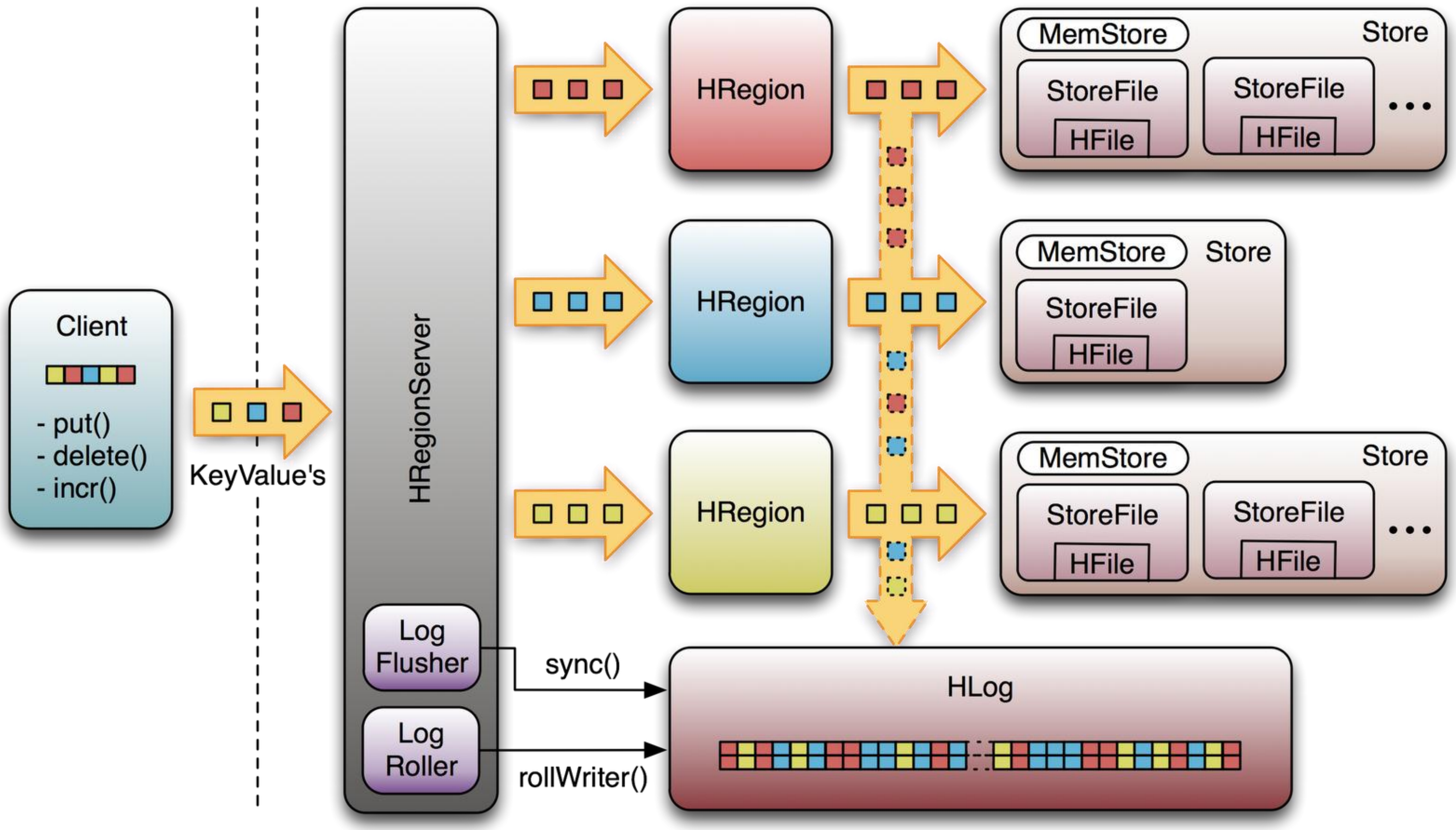
Refresh data cube through

streaming MapReduce

MetaStore to generate query

timestamp T Q & metadata

System Design – A Glimpse of HBase



System Design – Storage Design based on HBase

- Extend Scan to 2 versions
  - FullScan for querying data cube
  - IncrementalScan for querying real-time data
- Infinite versions of data to maintain query consistency
  - Compaction to remove stale versions
  - Global compaction
    - Immediately following data cube refresh
  - Local compaction
    - Compact old versions not accessed by any scan process

System Design – IncrementalScan in detail

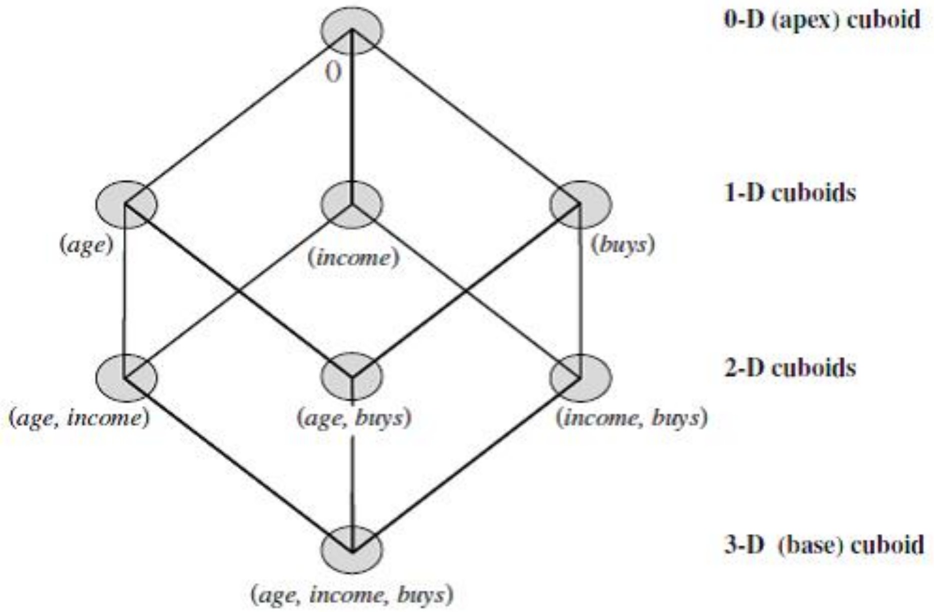
- Target: Find out changes since last data cube materialization
- Method
  - – Take 2 timestamps as input T_{DC} & T_Q, return the values with largest timestamp before T_{DC} & T_Q
- Implementations
  - – Naïve: Accessing *memstore* & *storefile* in parallel
  - – Adaptive: Maintain key modified since last materialization, first scan *memstore*, scan or random access keys based on cost

System Design – Compaction in detail

- Global compaction
  - Similar to Hbase's default, retain only one version of each key
  - Triggered by data cube's refresh completion
- Local compaction
  - Compacted data stored in different file in case block scan process
  - Files can be removed when not accessed by any scan
  - Triggered when #tuple/#key exceeds threshold

System Design – Data cube

- Define a data cube for "Customer Profiles"
- Dimensions: age, income, buys



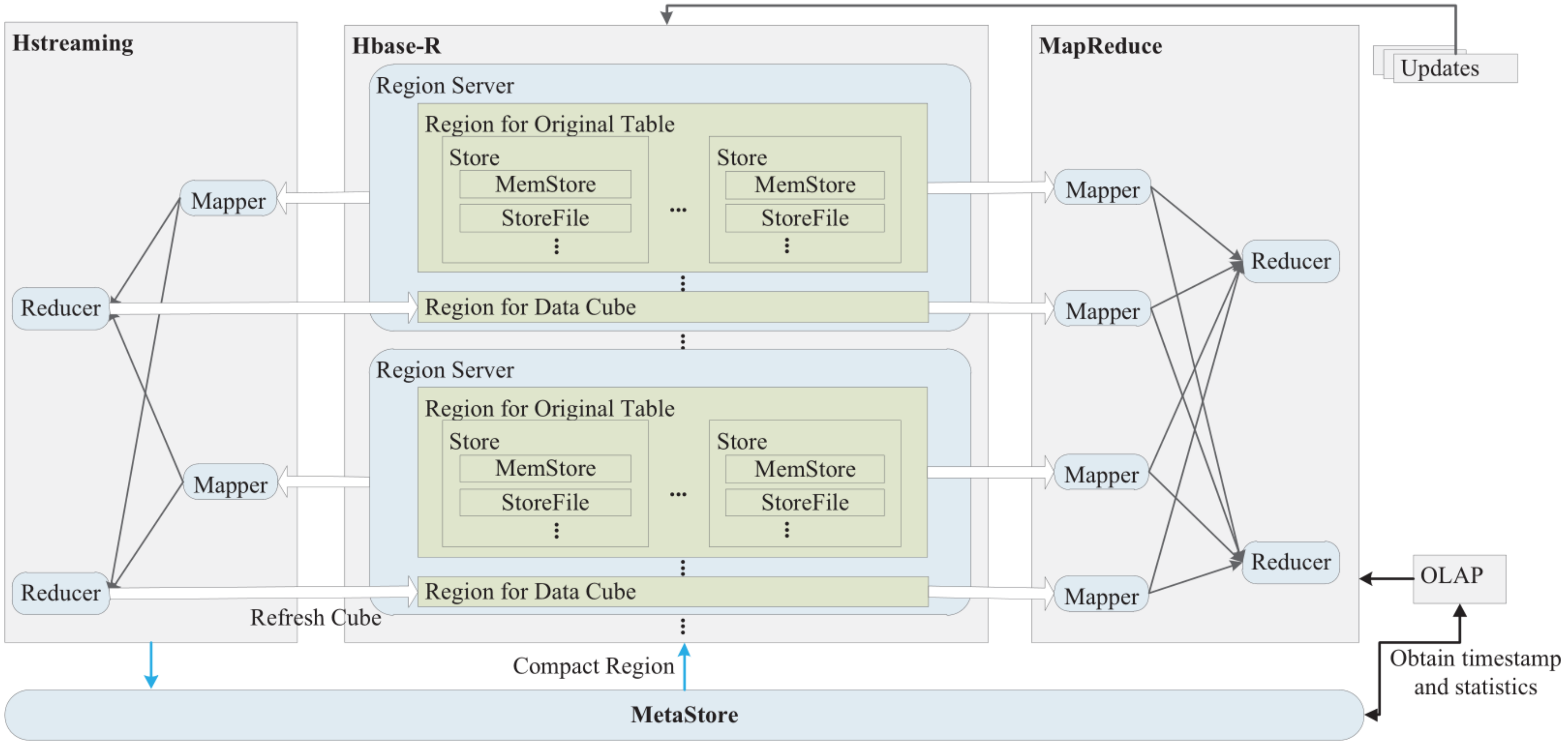
System Design – Data cube maintenance

- Re-computation
  - – First run
  - – FullScan on one region, generate a KV pair for each cuboid in mapper, aggregate & output in reducer
- Incremental Update
  - – Consequent runs
  - – Propagation step to computes change & update step to update cube
  - – Streaming system updates cube inside & periodically materialize it into storage

System Design – HStreaming for cube maintenance

- Each mapper responsible for processing update within a key range
  - – Maintain KVs locally, cache hot keys in memory
  - – For updates, emit 2 KV pair for each cubiod(+, -)
- Reducer cache the output KV of mapper and invoke reduce every W_r , refresh cube every W_{cube}

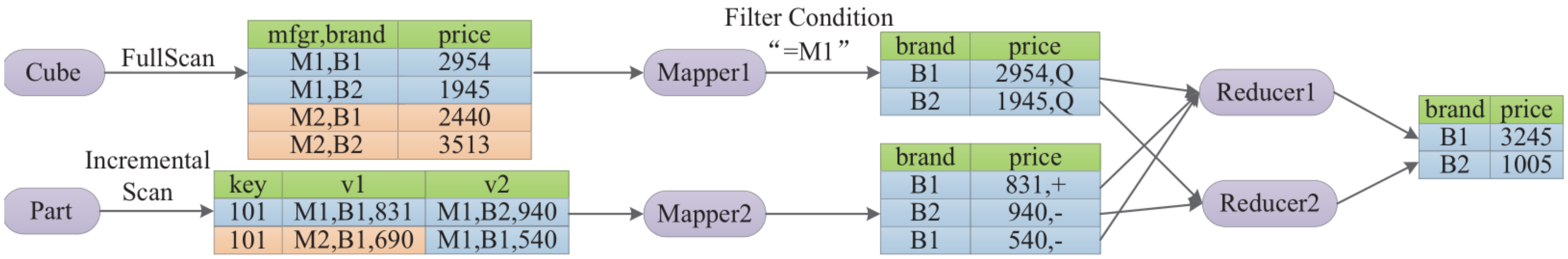
System Design – Data Flow of R-Store



1. Updates arrives Hbase-R 2. stream updates to a Hstreaming mapper

3. Reducer periodically materialize local data cube to Hbase-R & notifies Metastore

RTOLAP in R-Store – Query Processing



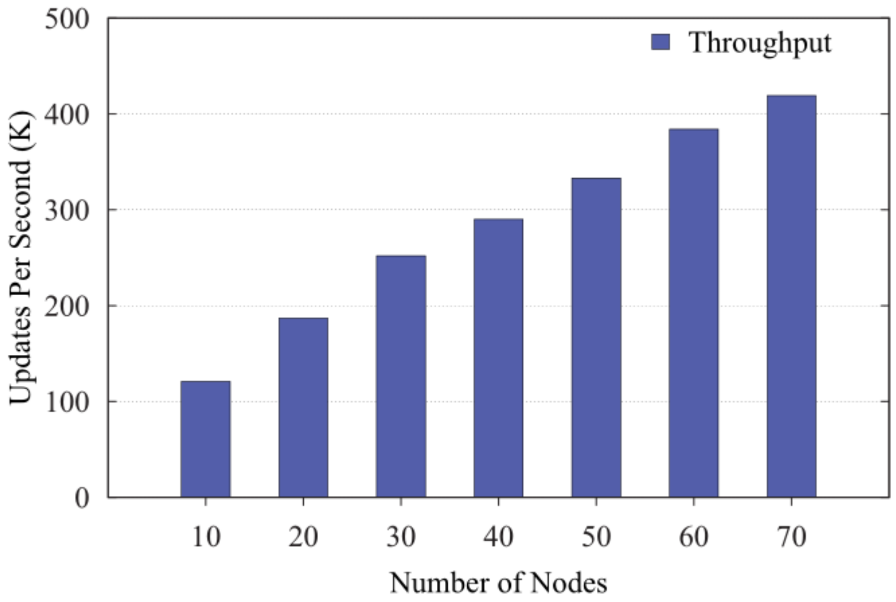
- Map
- Tag the values with 'Q' '+', '-'

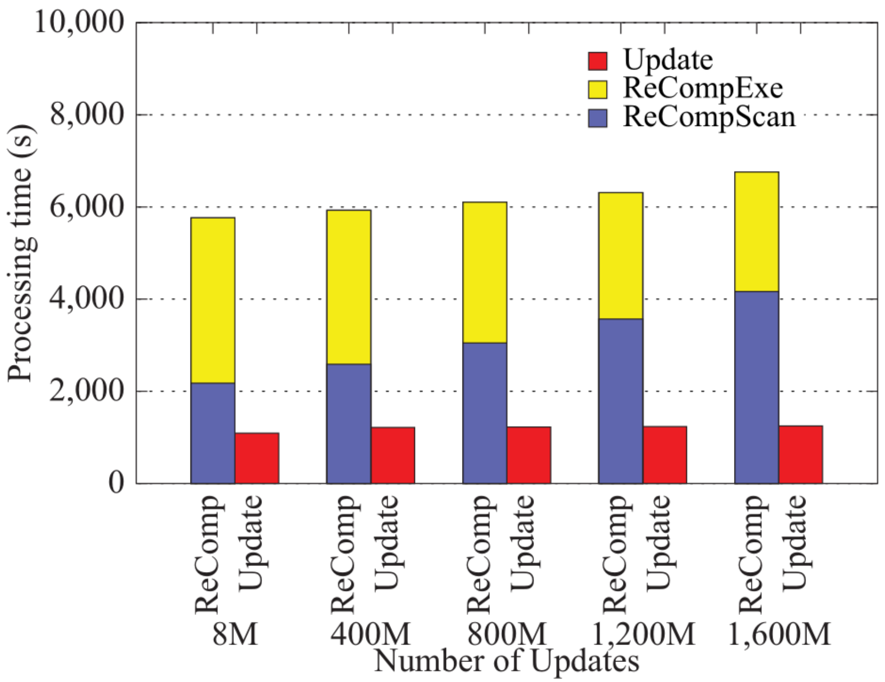
- Reduce
- Do calculation based on aggregation function & three values

Evaluation

- Cluster of 144 nodes
  - – Intel X3430 2.4 GHz processor
  - – 8 GB of memory
  - – 2x500 GB SATA disks
  - – gigabit Ethernet
- TPC-H data

Evaluation - Performance of Maintaining Data cube



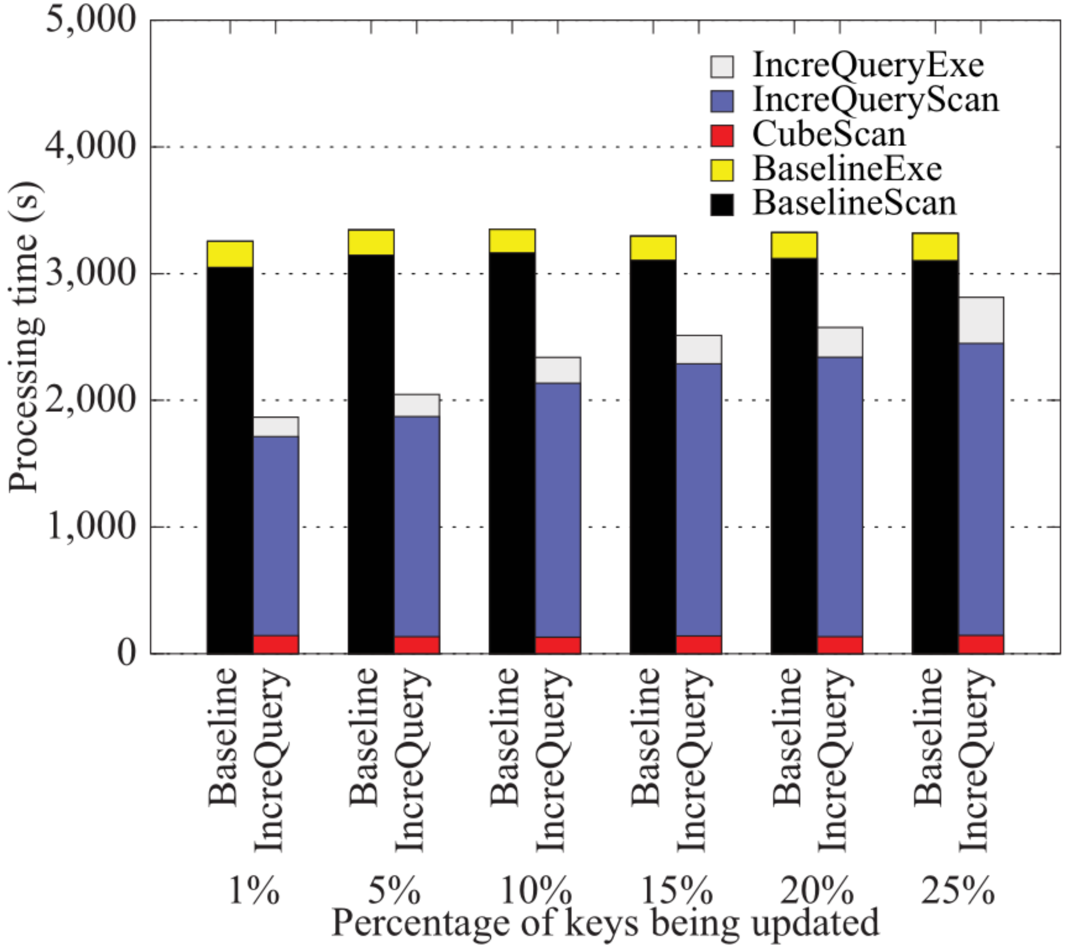


- Hstreaming with 10 nodes have higher

throughput than 40 Hbase-R nodes

- 1.6 billion keys, 1% updated, update algorithm fast enough,
- latency equals to Hbase-R input speed

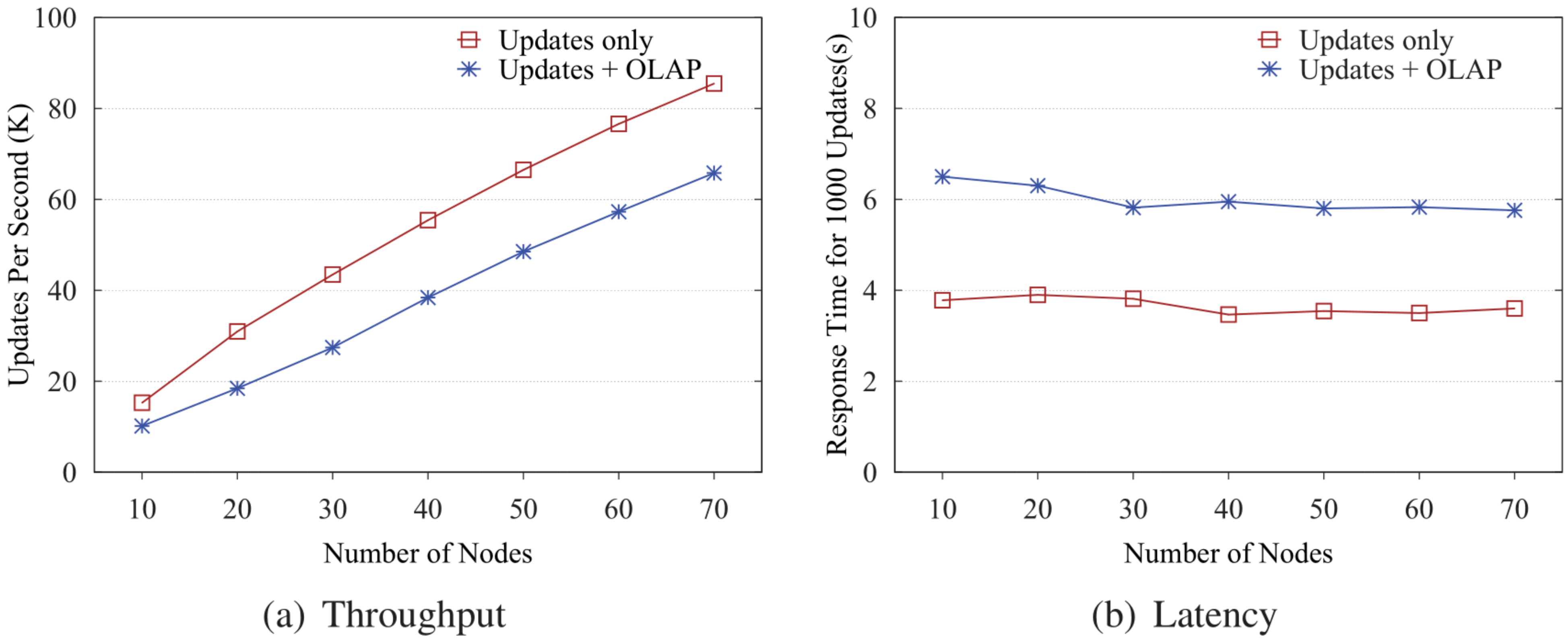
Evaluation - Performance of RT querying



- Small key range updates scans

fewer data in Hbase-R, process fewer data

Evaluation - Performance of OLTP



Related Work

- Database
  - C-Store(VLDB 05)
- Main-memory database
  - HyPer(ICDE 11), HYRISE(VLDB 10)
- Druid(SIGMOD 14)

Conclusion

- Multi-version concurrent control to support RTOLAP
- Data cube to reduce storage requirement & improve performance
- Streaming system to refresh data cube
- Available at https://github.com/lifeng5042/RStore

Q&A

Backup – OLAP Cube

- A multi-dimensional generalization of a two- or three-dimensional spreadsheet. Hypercube for dataset with more than three d's.
- Dimensions: Product, time, cities…
- Cells: each cell of the cube holds a number that represents some measure of the business, e.g. sales, profits…
- Slicer: the dimension held constant for all cells so that multi-dimensional information can be shown in a 2D physical space of a spreadsheet.

Backup – OLAP Cube

- Data cube can be viewed as a lattice of cuboids
- The bottom-most cuboid is the base cuboid
- The top-most cuboid (apex) contains only one cell
- How many cuboids in an n-dimensional cube with L levels?

$$T = \prod_{i=1}^{n} (L_i + 1)$$