Efficient Transaction Processing in SAP HANA Database

Presented by Henggang Cui
15-799b Talk

Motivation

- OLTP
  - large number of concurrent users and transactions
  - high update load
  - very selective point queries
- OLAP
  - aggregation queries over a huge volume of data
  - compute statistical models from the data

Motivation

- Zoo of different systems with different capabilities for different application scenarios
  - OLTP: row-stores
  - OLAP: column-stores
- However, workloads usually contain both
  - transactional database needs statistical information to make on-the-fly business decisions
  - data-warehouses are required to capture transactions feeds for real-time analytics

SAP HANA

- SAP HANA
  - efficient processing for both OLTP and OLAP
  - achieved through a sophisticated multi-step record life cycle management approach

Outline

- Lifecycle management of records
- Merge details & optimization
- Summary & discussion

Lifecycle Management of Records

- Three stages of physical representation
  - L1-delta
  - L2-delta
  - Main
- Records are propagated through different stages in their lifetime

L1-delta Storage

- L1-delta
  - accepts all incoming data requests
  - stores records in row format (write-optimized)
    - fast insert and delete
    - fast field update
    - fast record projection
  - no data compression
  - holds 10,000 to 100,000 rows per single-node

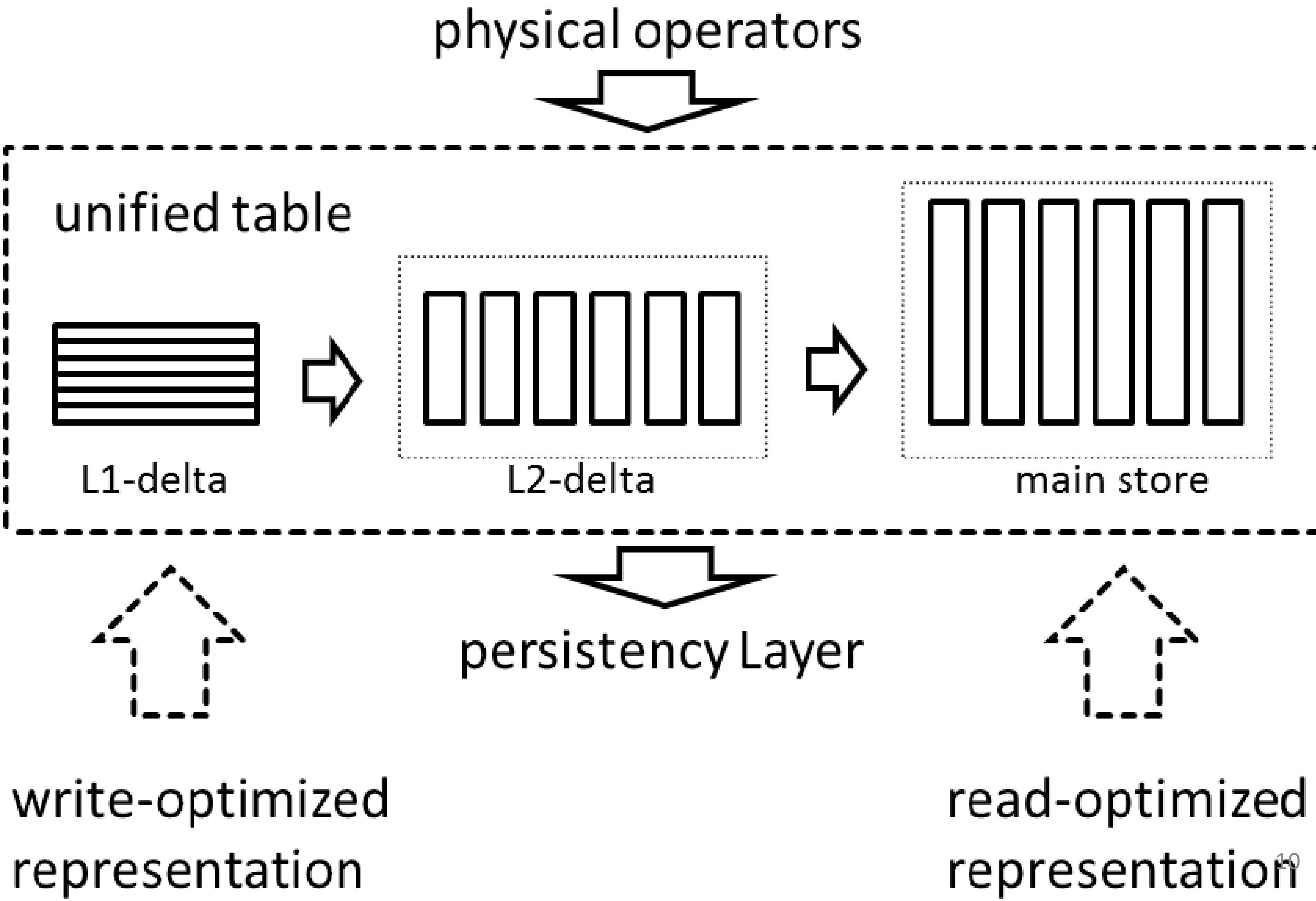
L2-delta Storage

- L2-delta
  - the second stage of the record life cycle
  - stores records in column format
  - dictionary encoding for better memory usage
  - unsorted dictionary
    - requiring secondary index structures to optimally support point query access patterns
  - well suited to store up to 10 million rows

Main Storage

- Main
  - final data format
  - stores records in column format
  - highest compression rate
    - sorted dictionary
    - positions in dictionary stored in a bit-packed manner
    - the dictionary is also compressed

Lifecycle Management of Records



Unified Table Access

- A common abstract interface to access different stores
- Records are propagated asynchronously
  - without interfering with running operations
- Two transformations (or merge steps)
  - L1-deta to L2-delta
  - L2-delta to main

Merge from L1-delta to L2-delta

- Row format to column format conversion
  - rows are split into corresponding columnar values
  - column-by-column inserted into the L2-delta

L1-delta to L2-delta Merge Steps

- Step 1 (parallel)
  - appends new entries to the dictionary
- Step 2 (parallel)
  - column values are added using the dictionary encodings
- Step 3
  - propagated entries removed from the L1-delta

L1-to-L2-delta Merge is Cheap

- Step 1 and Step 2 can be performed in parallel
  - # tuples to be moved is known in advance
- Needs no reconstruction of L2-delta structures
  - just appends entries to the unsorted dictionary
- This merge can be incremental

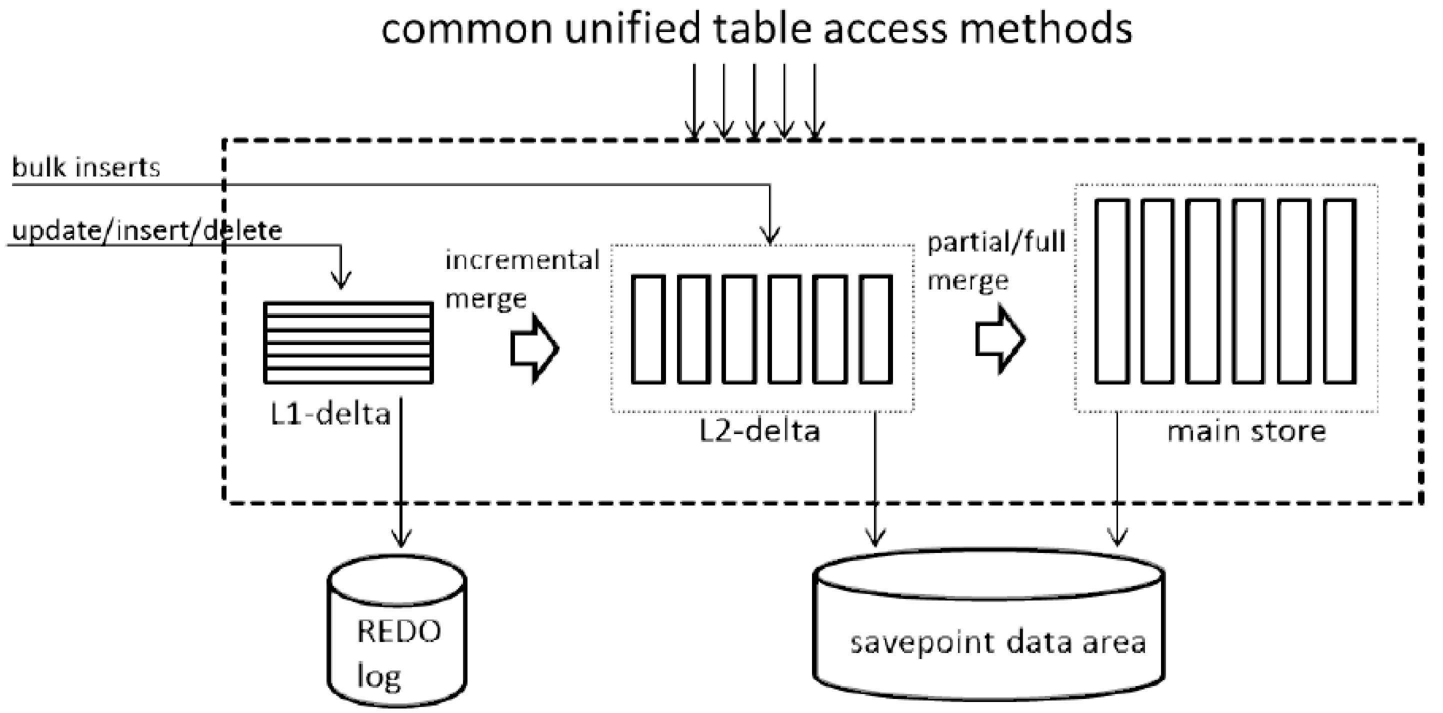
- Minimal influence to the running transactions

Merge from L2-delta to Main

- Resource intensive task
  - a new main structure is created out of the L2-delta and the existing main
  - should be carefully scheduled and highly optimized
- Must be a complete merge
  - the old L2-delta is closed and a new one is created
  - retries the merge on failure

Persistency Mapping

- HANA provides Full ACID guarantees
  - using REDO logs and save pointing
  - merging makes it quite complicated



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Merge Optimization

- The classic merge needs optimization because
  - L2-delta to main merge is resource intensive
  - Main store needs high compression rate

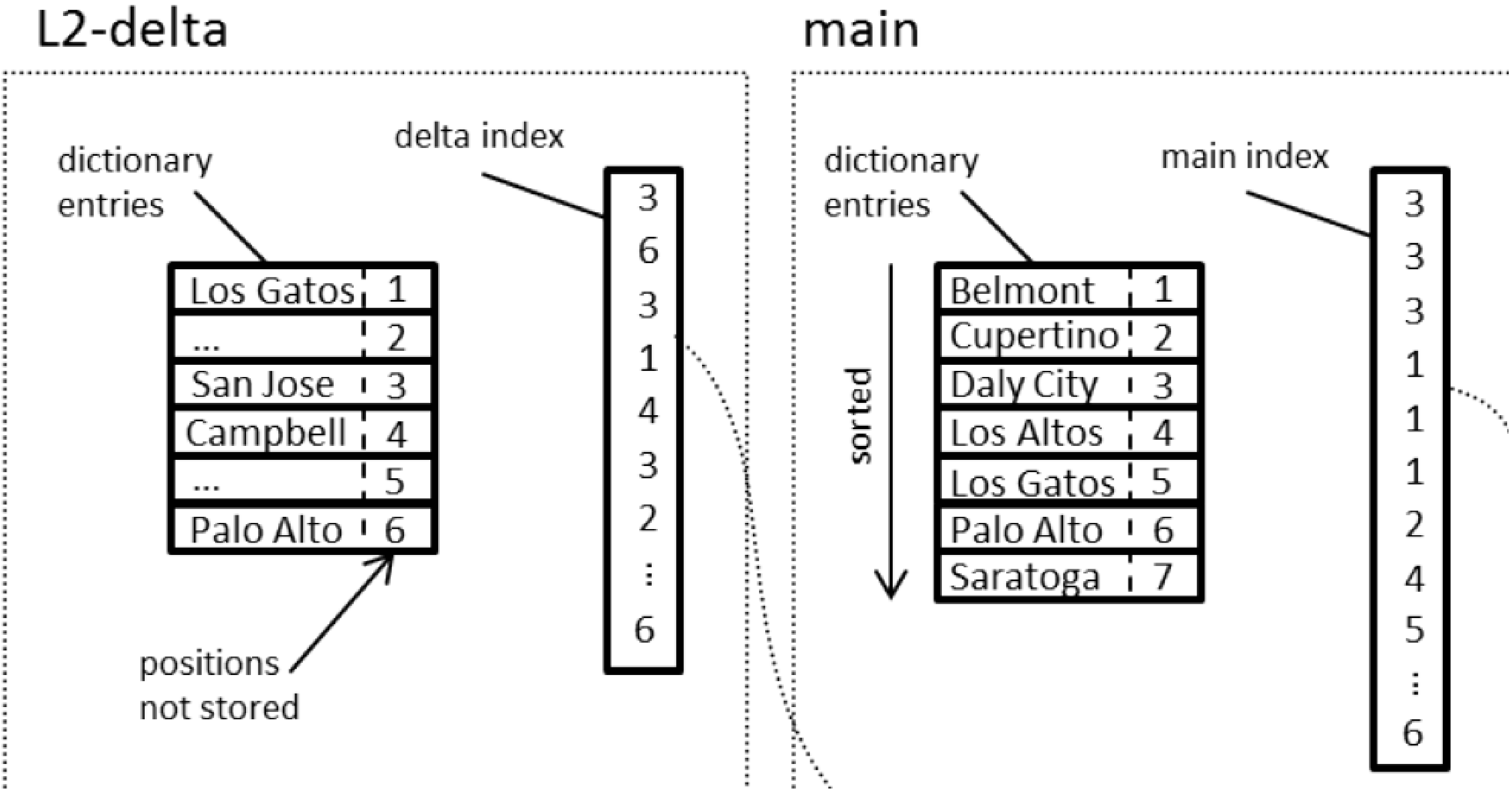
- Optimization: Re-sorting merge
- Optimization: Partial merge

The Classic Merge

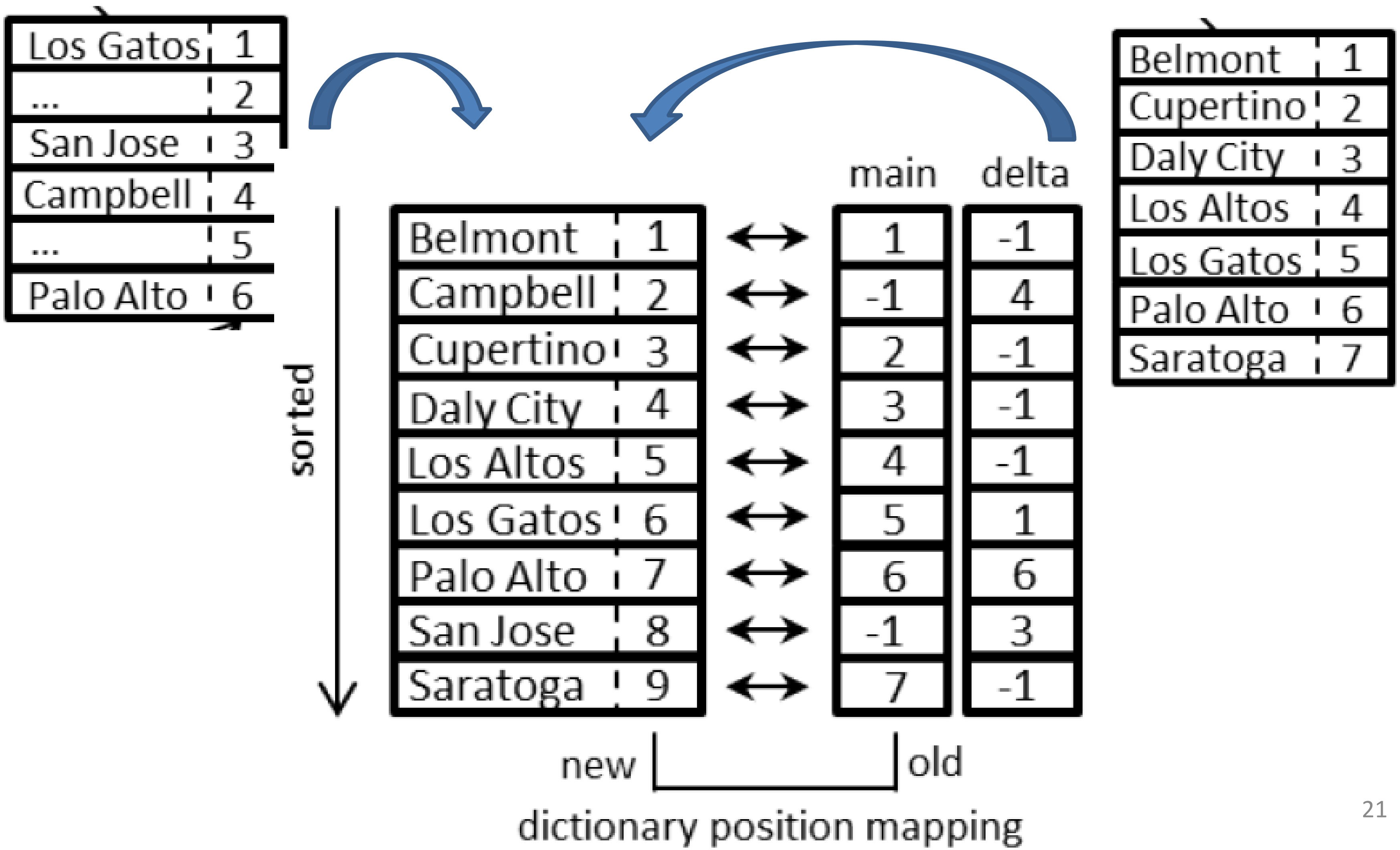
- Step1:
  - generate new dictionary

- Step2:
  - generate new indices based on the new dictionary

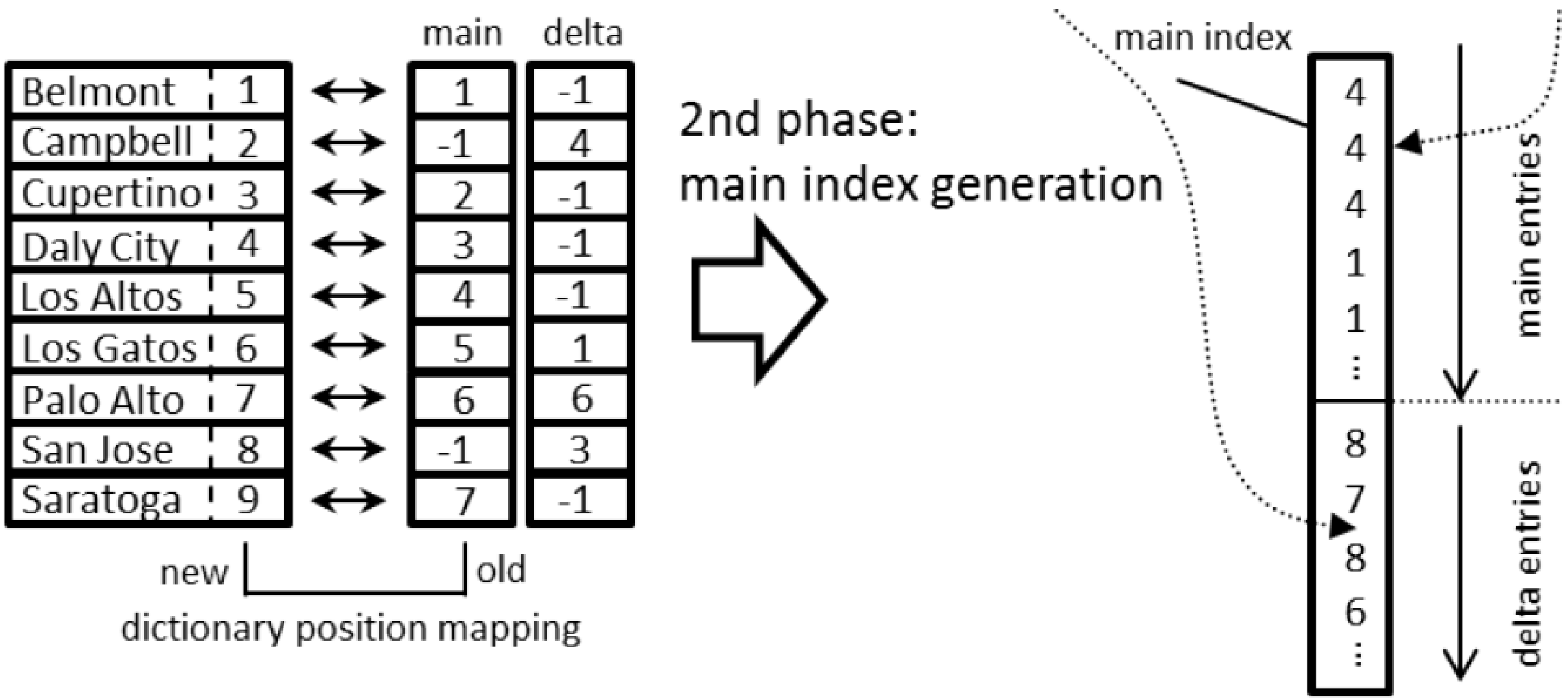
The Classic Merge



The Classic Merge



The Classic Merge



Re-Sorting Merge

- Goal: higher compression rate

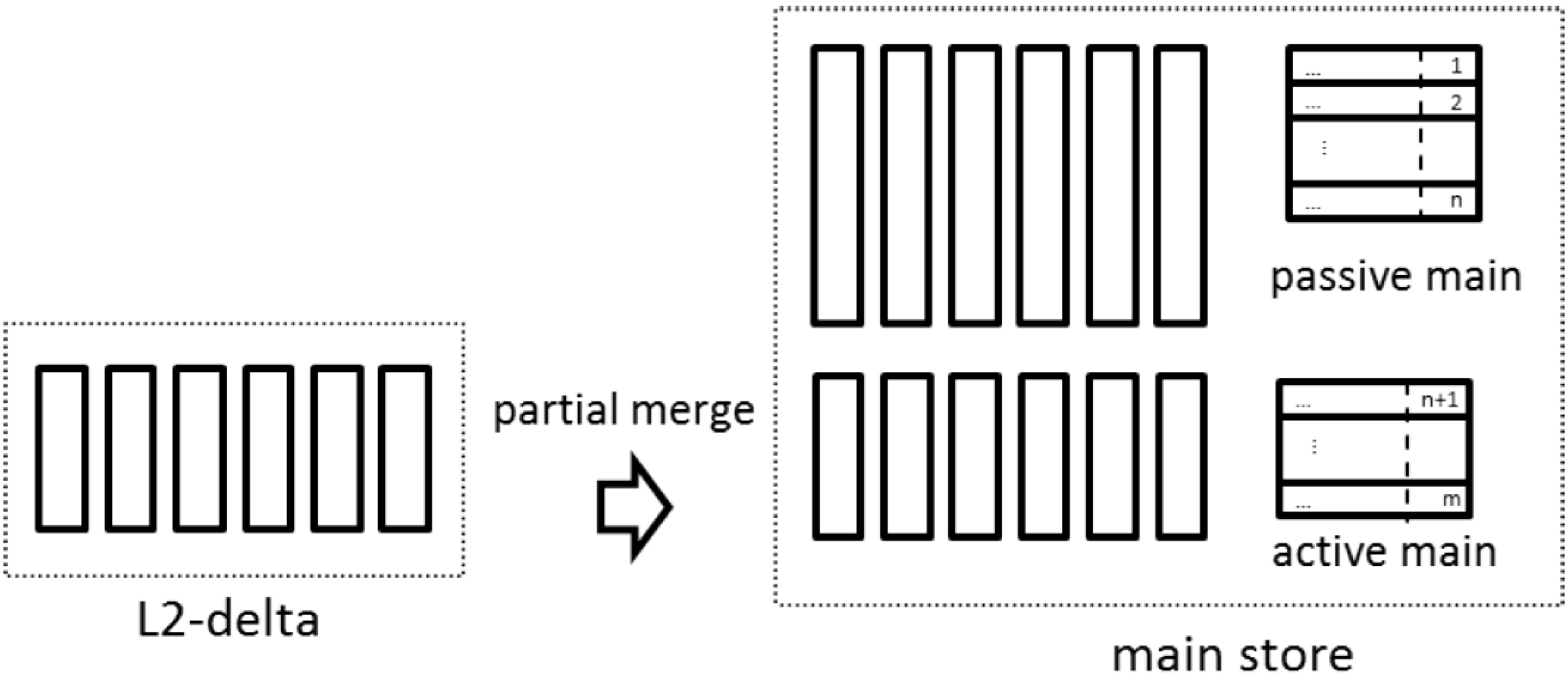
- Re-Sorting Merge
  - reorganizes the content of the full table to yield a data layout which provides higher compression potential
  - not easy because all records should have the same order in all columns
  - uses a scheme discussed in another paper

Partial Merge

- Goal: reduce merge overhead
- Partial Merge
  - splits the main into two independent structures

- Passive main
  - not part of the merge process
- Active main
  - takes part in the merge process with the L2-delta

Partial Merge



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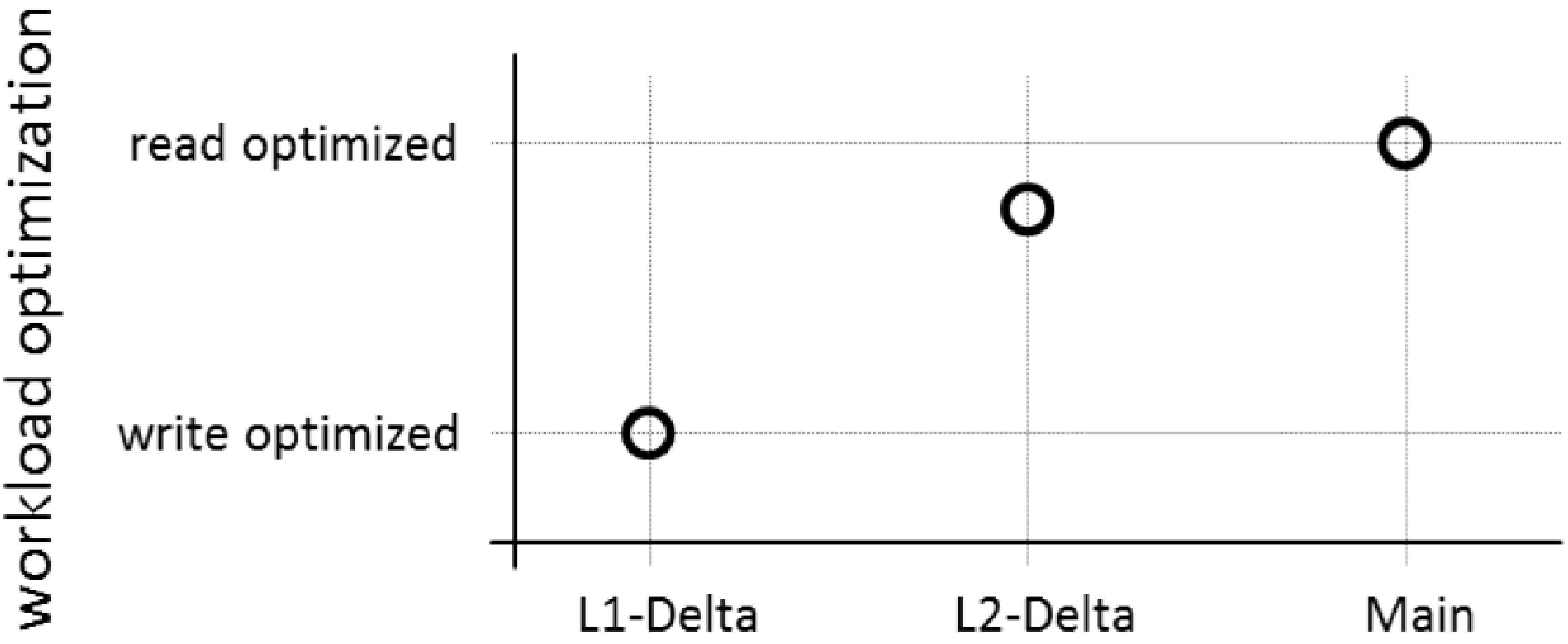
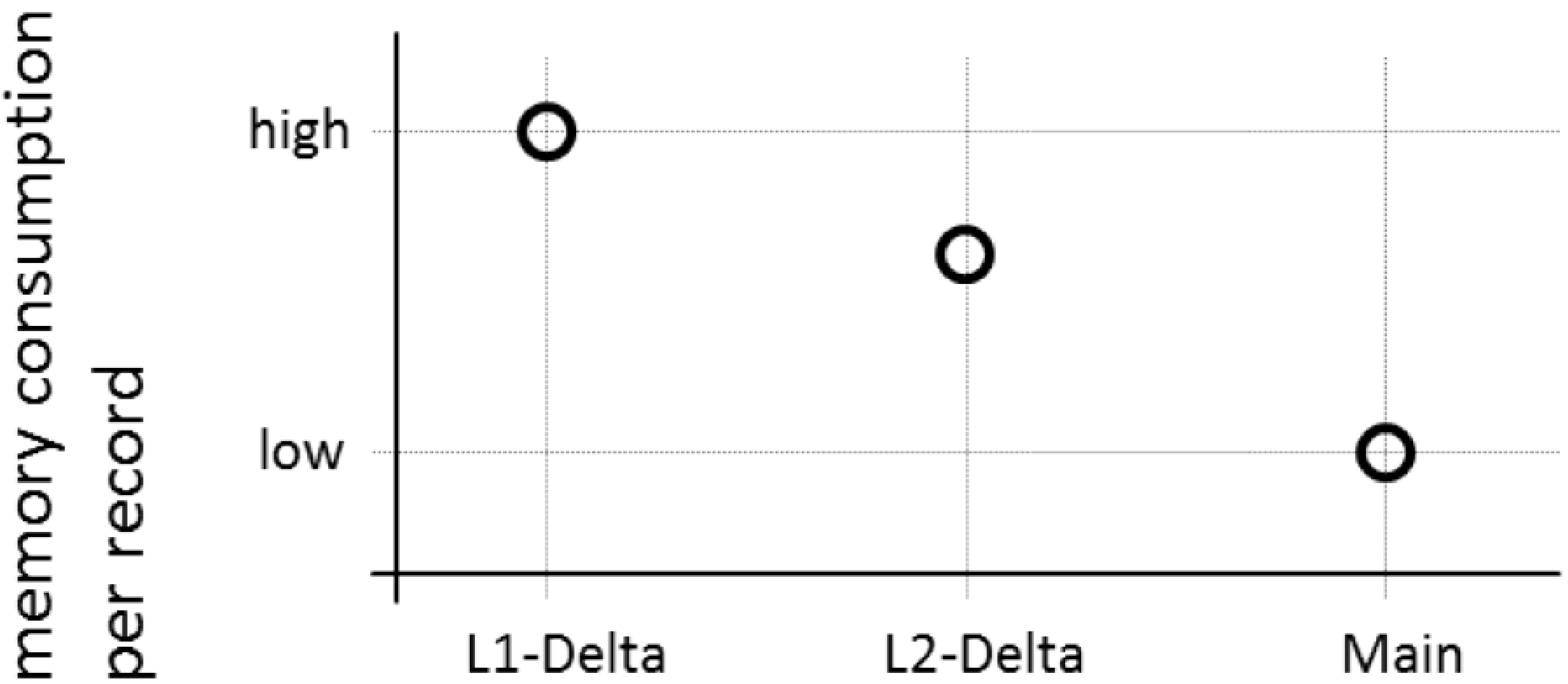
Characteristics of Record Stages



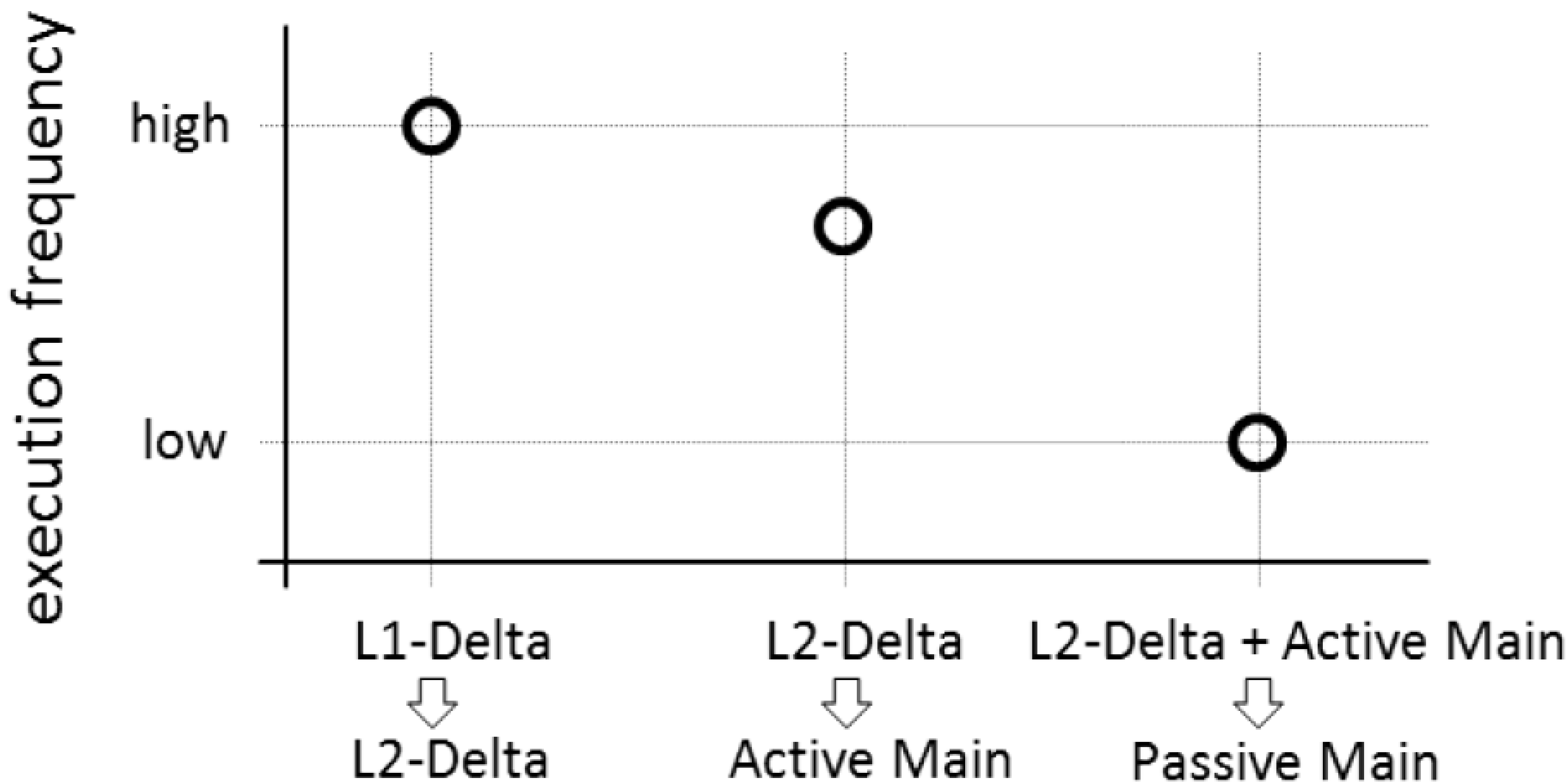
(a) workload optimization

Characteristics of Record Stages



(b) memory consumption

Characteristics of Record Stages



Discussion

- When to merge?
  – How do we know when the records are not likely to be updated anymore?

- Why it must be a complete merge?
  – Keep some in row-store, some in column-store?