Team *SimpleMind*

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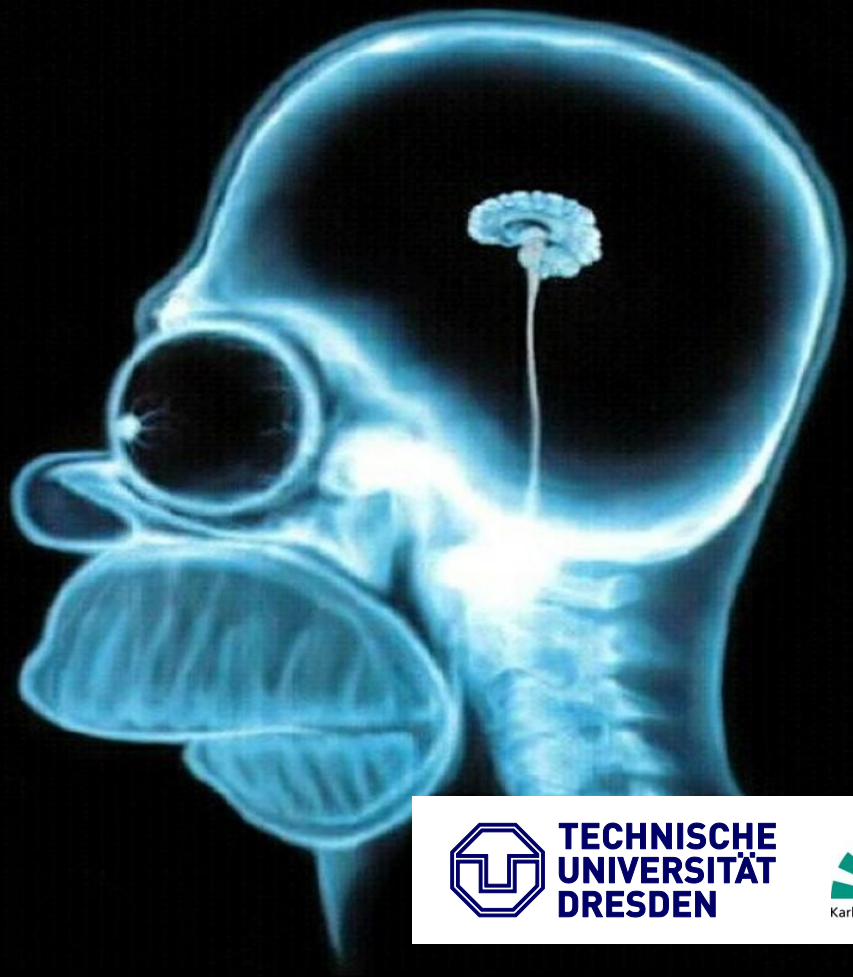
ACM SIGMOD 2015 Programming Contest @ SIGMOD 2015 (June 2)

Public



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Agenda

- Programming Contest Overview
- Transaction Processing
- Data Structures for Validation
- Validation Processing
- Parallelization: Bulk-Synchronous
- Implementation Details
- Runtime Break-Down

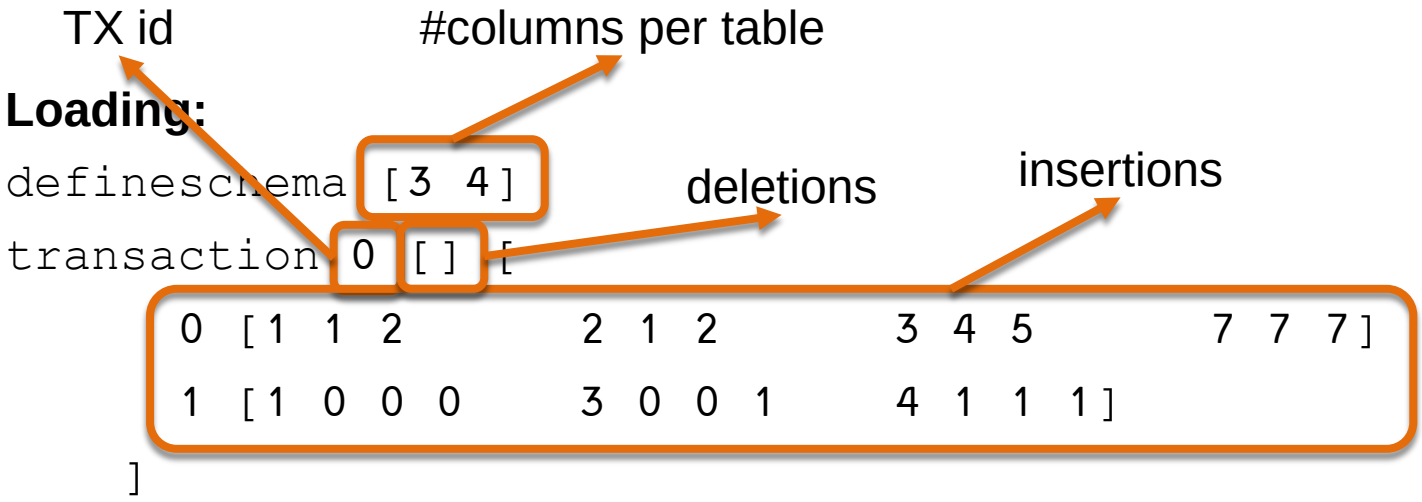
Programming Contest: Task Overview + Data Loading

Context: “Optimistic Concurrency Control”

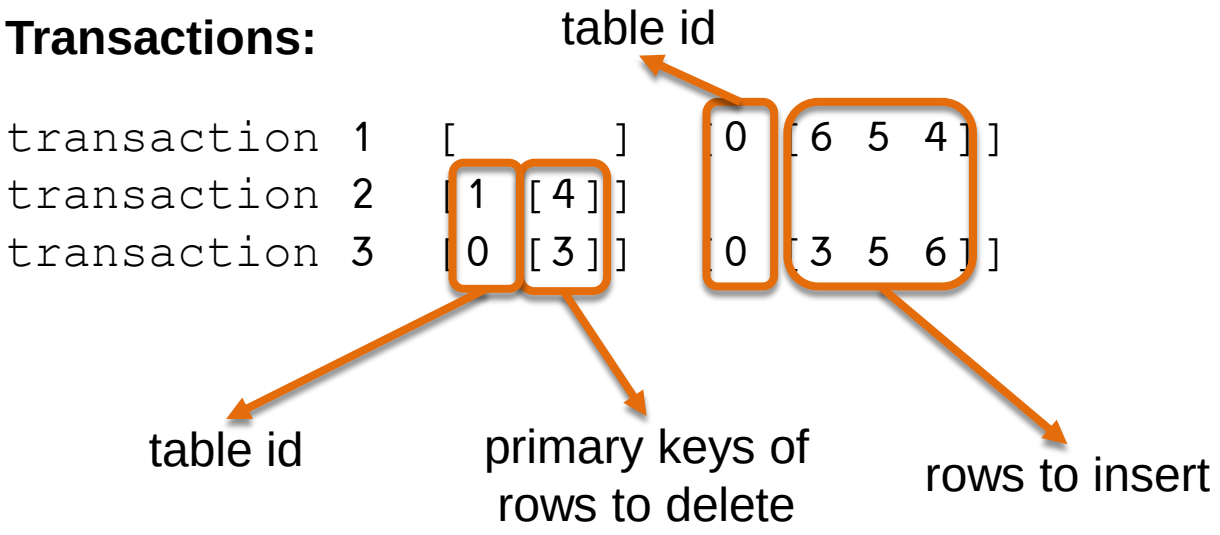
- Given a sequence of **transactions,**
  - i.e., insert or delete statements
- A sequence of **validation queries,**
  - i.e., select statements on data modified by a range of transaction
- Detect for each validation whether it **conflicted** or not,
  - i.e., non-empty result set

Example Sequence: Loading + Transactions

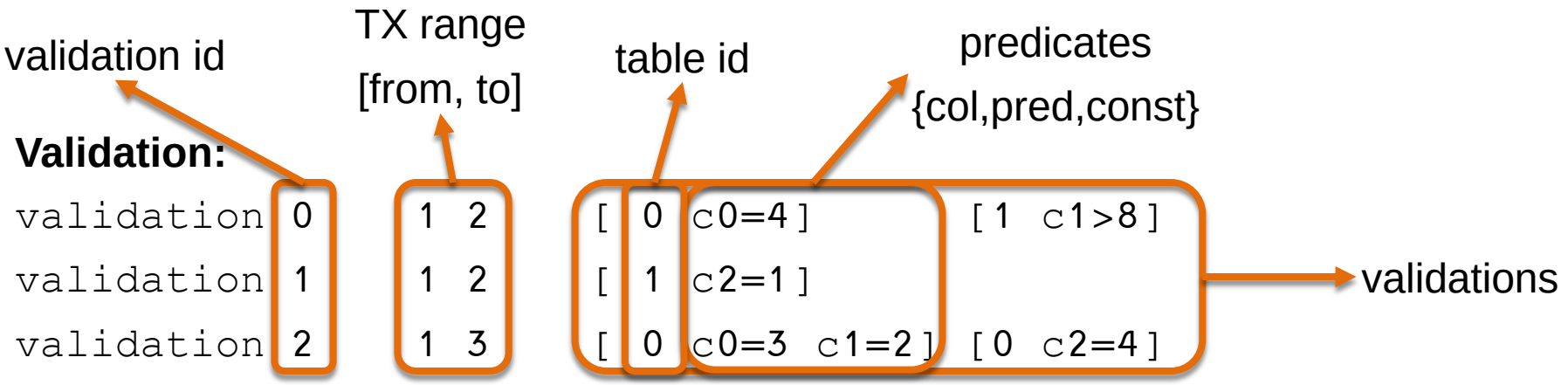
(copied from http://db.in.tum.de/sigmod15contest/task.html)



Transactions:



Example Sequence (cont'd): Validations



Task:

For every validation, check for conflict, i.e., check whether a transaction from the given range modified data that matches the predicates of the validation.

Example Output: 0 1 1

Workflow:

Validations only need to answered when a „Flush" is triggered.

Programming Contest: Data Sets + Statistics

Data Sets:

- Three sizes: “small” (90MB), “medium” (900MB), “large” (9GB?)
- “Small” and “medium” available for testing,
- “Large” used to determine 5 finalists in online submission system
- Winner announced on SIGMOD with an “extra-large” data set

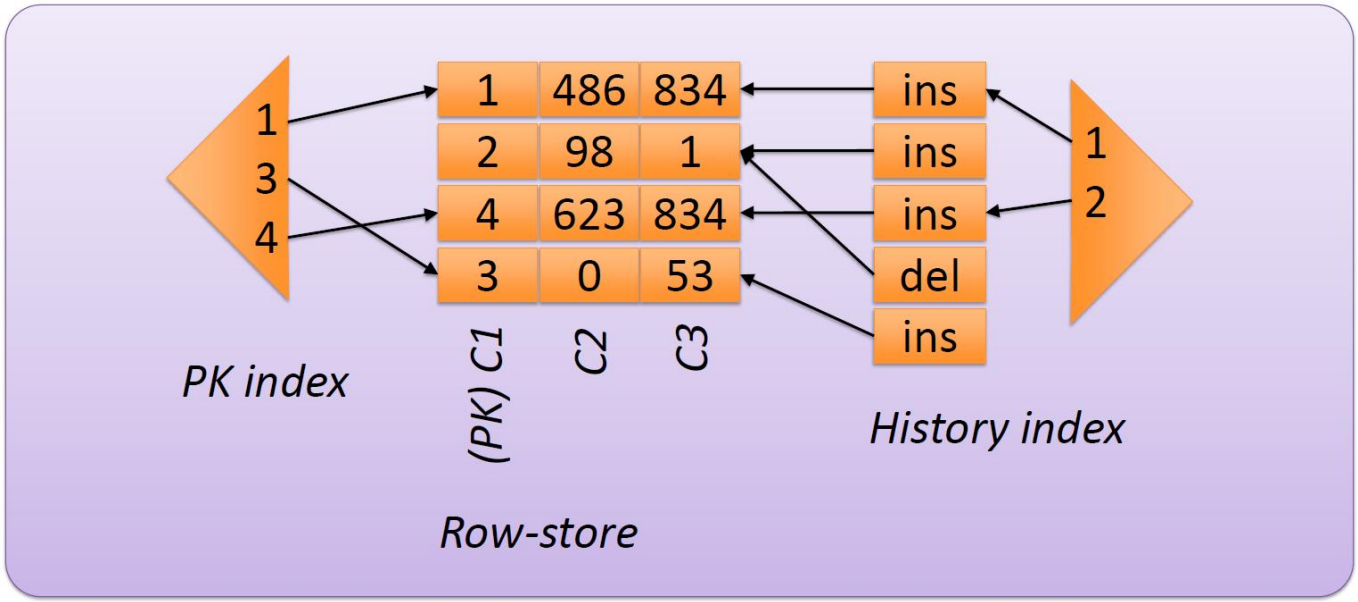
Statistics (approximate):

- 80% of the messages are validations
- <10% of the validations conflict
- 80% of the transactions go to one table
- 90% of the predicates are equality (=)
- 50% of the queries use the primary key columns

Transaction Processing

Each relation consists of:

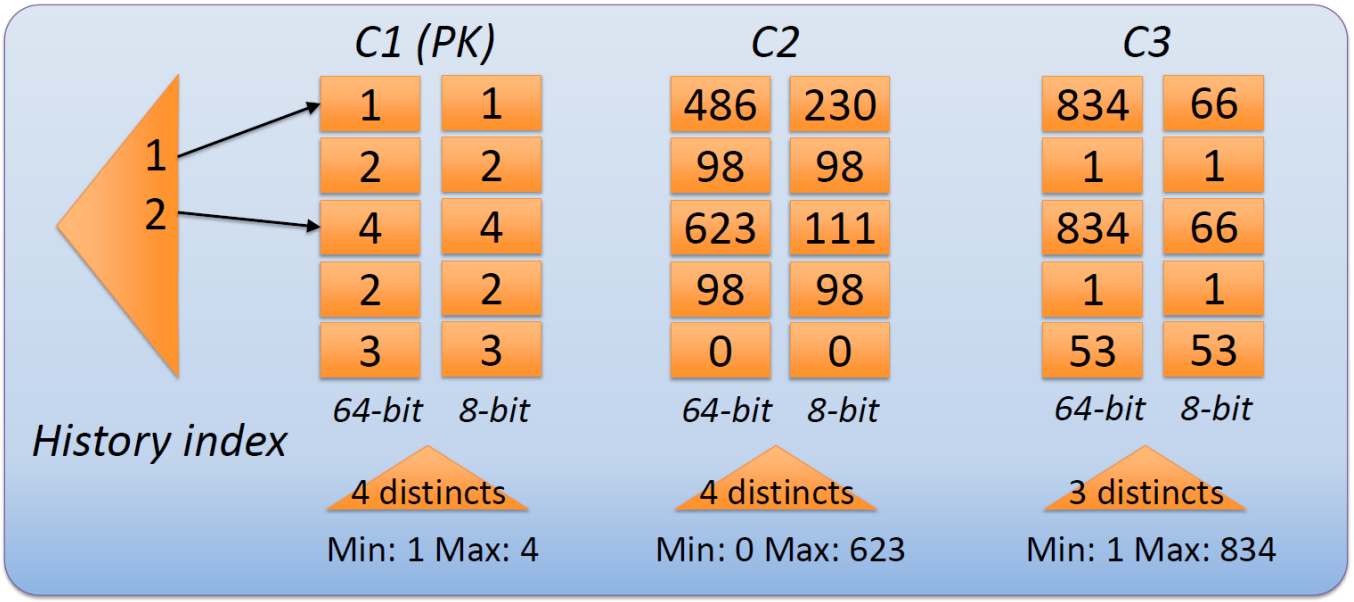
- A **row-store** of valid and deleted rows
- A **primary key** (PK) **index** (PK → valid rows) for fast updates
- A two-level "**history index**" for fast validation of single rows:
  Transaction ID (TX ID) → list of ptrs to modified rows → row



Data Structures for Validation

The **modified rows** are converted periodically to **column-wise format**. Additional metadata include:

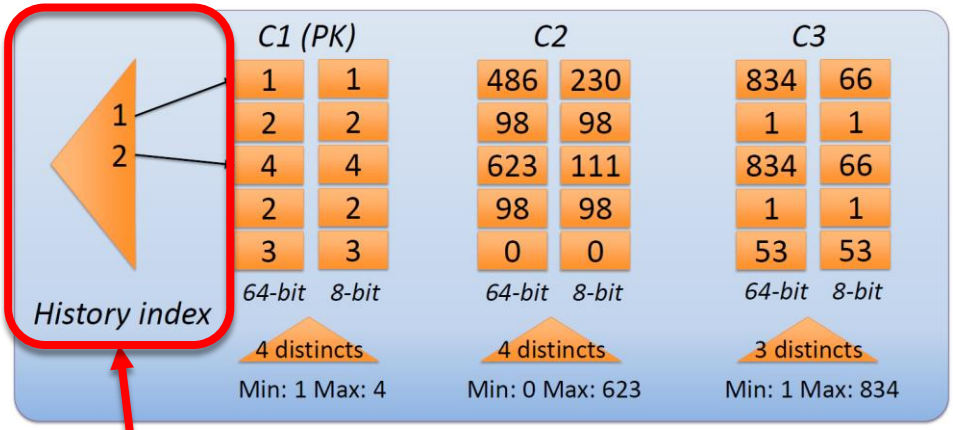
- A single level "**history index**" (TX ID → offset of first modified row)
- 8-bit **fingerprint columns** (for superfast approximate scans)
- A sample of distinct values per column (to **estimate selectivity**)

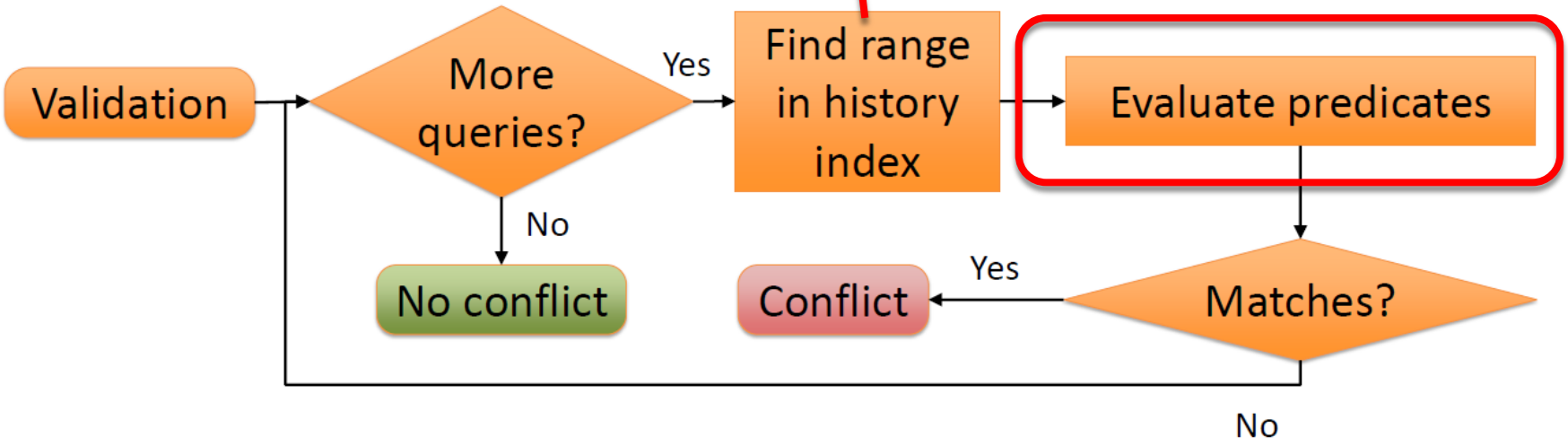


Validation Processing (1/2)

Simple nested loops:

1. Validations in request stream
2. Queries in validation
3. Predicates in query
4. Rows in transaction range

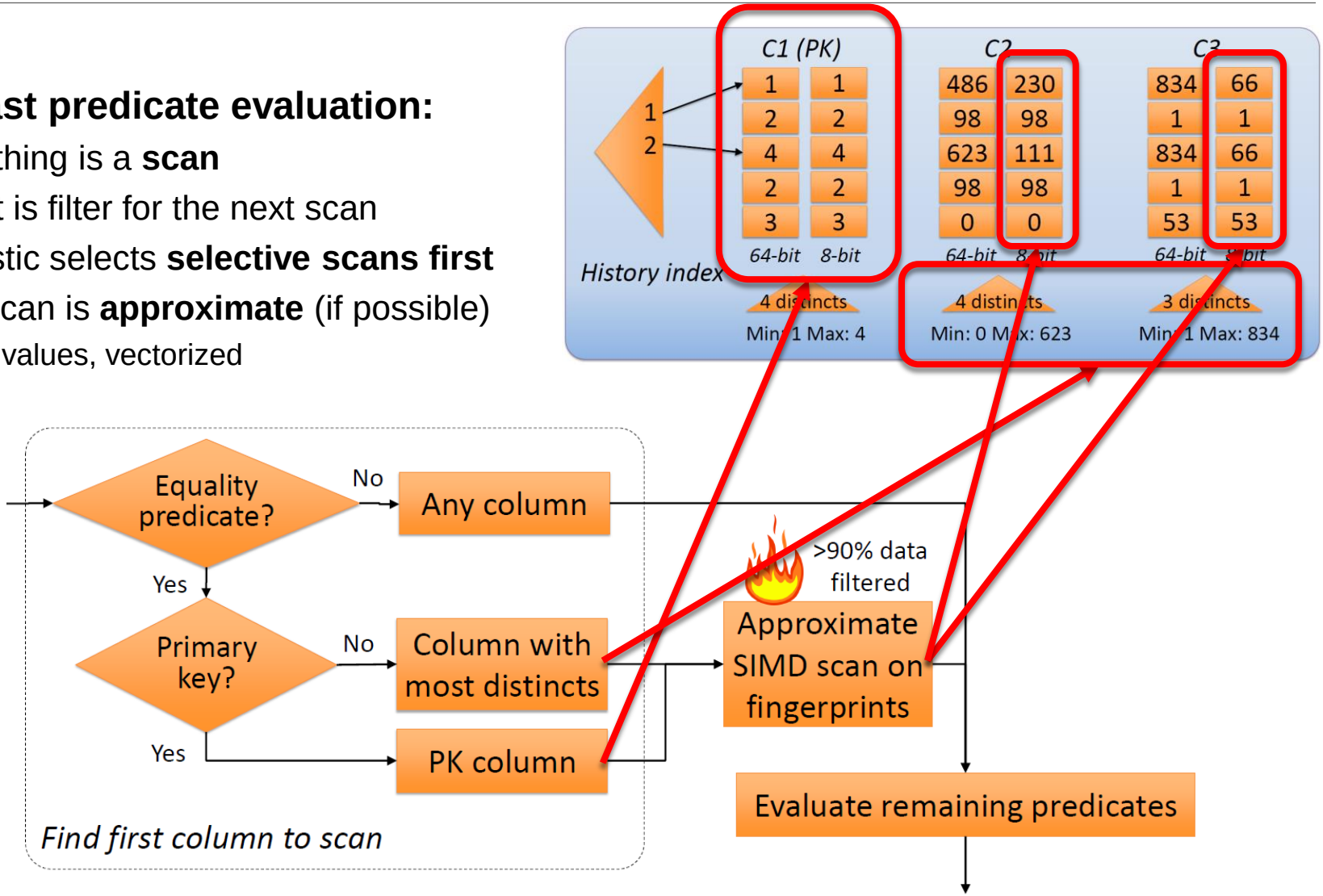




Validation Processing (2/2)

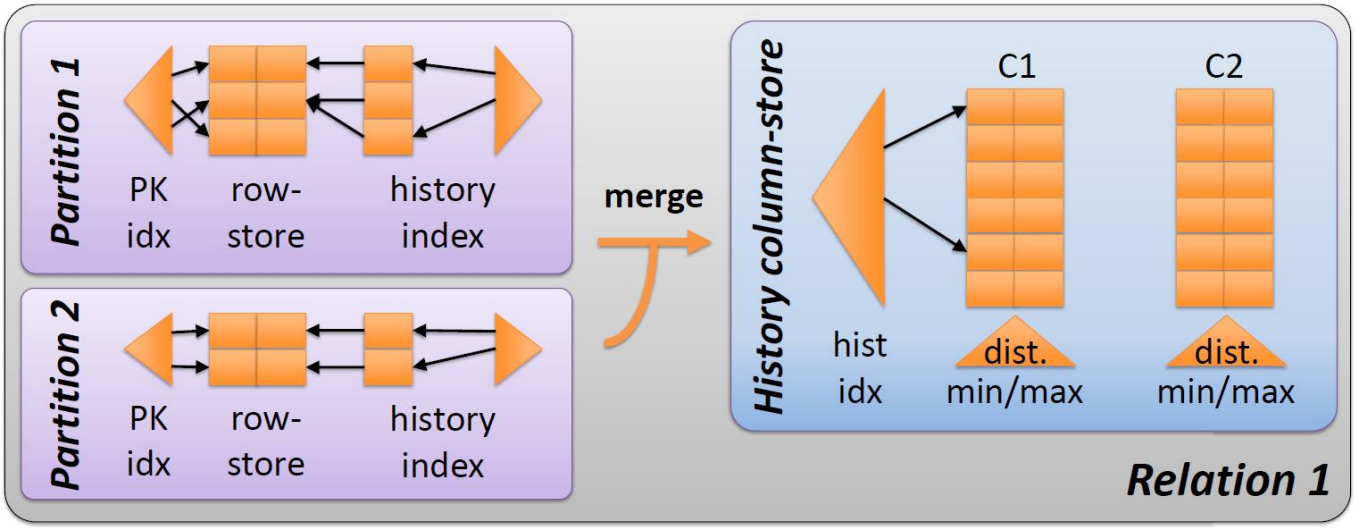
Very fast predicate evaluation:

- Everything is a **scan**
- Result is filter for the next scan
- Heuristic selects **selective scans first**
- First scan is **approximate** (if possible)
  - 8 bit values, vectorized



Parallelization: Bulk-Synchronous

- The row-store is **hash-partitioned**. Each thread only executes **transactions** of its partition. Validations are queued.
- On flush request, the **partitions are merged into the column-store**.



- Afterwards, threads process **validations from the queue**, now accessing **all data structures** in a **read-only** fashion.
- Additional flushes to overcome slow test driver.

Implementation Details

Simple

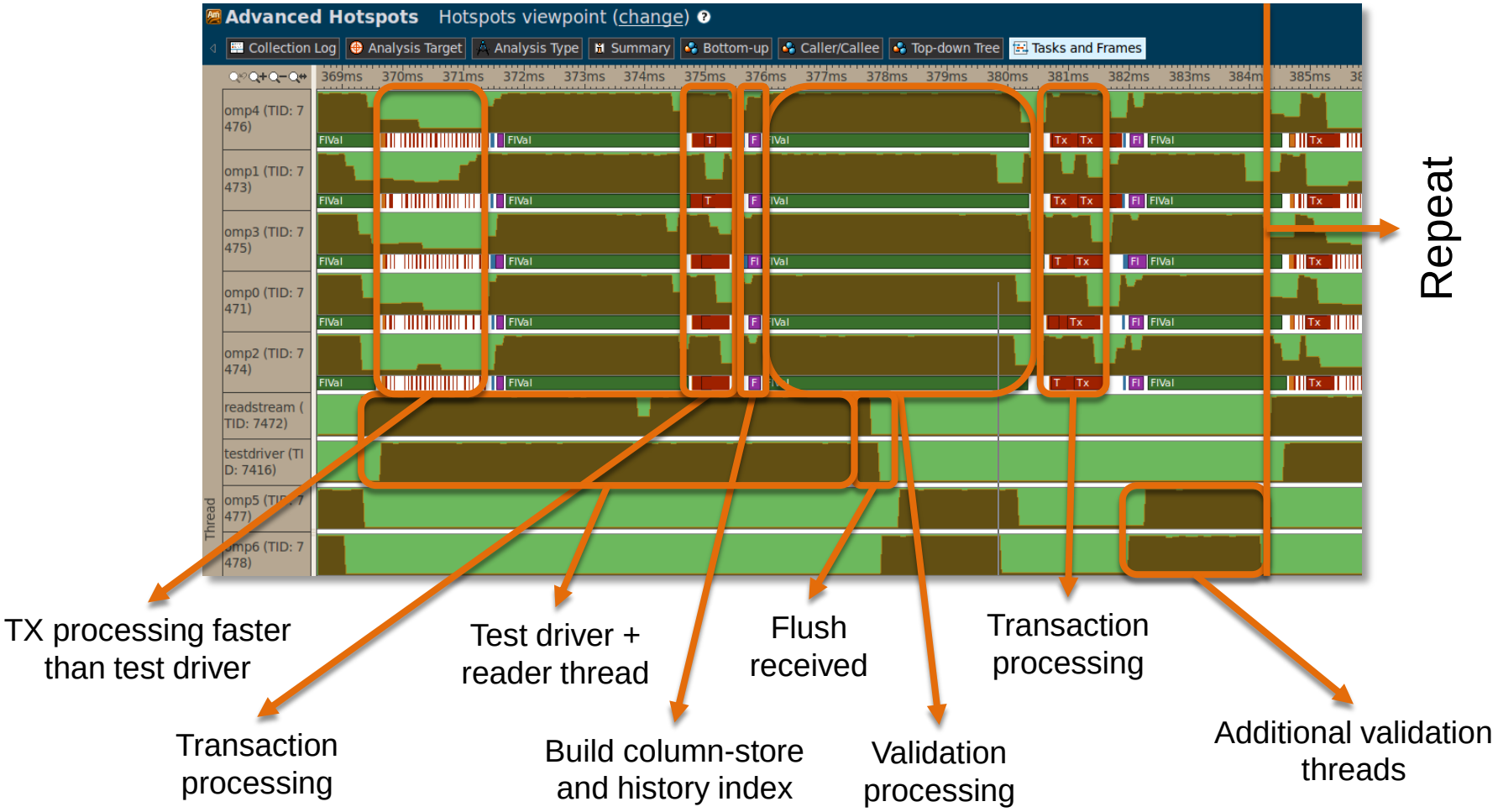
- **1268 lines of code** (according to `sloccount`)
  - vs. 165 of the reference implementation
- Simple parallel regions with **OpenMP**
  - plus a bit of last-minute mess with boost threads
- Extensive use of **STL** (and c++11 ☺), a bit of **boost**, nothing else
- Indented **4 spaces** ☺

A few noticeable tweaks (>10% gain)

- **„Infinite“ vectors** thanks to Linux‘ overallocation
  - `malloc(system_mem_size)`
- **Branch-free** scans
- History index is a `boost::flat_map`
- **Recycle memory** to avoid (serial!) mapping by OS
- **Simple** scan selection mechanism

Runtime Break-Down

This is a screenshot of the execution flow from Intel VTune Amplifier.



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