Towards Online Relational Schema Transformations

Lesley Wevers
Menno Tammens
Marieke Huisman

Matthijs Hofstra
Maurice van Keulen

University of Twente
DBBD 2014, Oktober 17
Motivation

We often need to perform schema changes:

- Feature changes
- Improve performance

But, current database systems block concurrent transactions when transforming data!
Motivation

WikiMedia schema revisions:

- 90% require a write lock.
- Largest took 22 hours to complete for wikipedia.

Problem

Some systems can not go offline:
- Telecom, payment, airline reservation, online services

Ad-hoc solutions are insufficient:
- Fast hardware: Not scalable
- Splitting transformations: Non-transactional
- Lazy transformation: Difficult to get correct

The DBMS should solve this!
Goal

Drawing attention to the problem by investigating the extent of the problem in current database systems:

- **PostgreSQL**: no support for online schema changes.
- **MySQL**: claims to support online schema changes.
- **pt-online-schema-change**: representative for trigger based online schema transformation tools.
Contributions

● Criteria for online schema change mechanisms.

● Experimental investigation of existing systems.

● Proposal for a more fundamental solution.
Functional Criteria

Schema transformation mechanisms must:

● Allow simple and complex:
  ○ Logical transformations: e.g., adding columns, changing relationships
  ○ Physical transformations: e.g., column types, primary keys
  ○ Semantic data-only transformations: e.g., change currency

● Provide data in new schema upon commit

● Have transactional semantics:
  ○ Serializable
  ○ Failure atomic
  ○ Composable
  ○ Support for upgrading applications that use the database
Performance Criteria

Impact on concurrent transactions:
- Blocking
- Aborts
- Slowdown

Performance of schema transformations:
- No aborts
- Time to commit
Experimental Setup

TPC-C

New order
Payment
Order status
Delivery
Stock level
Experimental Setup

TPC-C

New order
Payment
Order status
Delivery
Stock level
Experiment 1

Add a column to an existing table.
Results: Add Column
Results: Add Column
Results: Add Column with Default

![Graph showing transactions per minute over time.](image-url)
Result: Add Column

The chart shows the transactions per minute over time, with a comparison between different databases. The chart tracks data from -10:00 to 16:35, with a peak at 0:00.
Result: Add Column with Default
Result: Add Column with Default
Result: Add Column with Default
Experiment 2

Create an index.
Results: Create Index
Results: Create Index
Results: Create Index

![Graph showing transactions per minute over time.}]
Experiment 3

Instead of a single carrier per ORDER, make every ORDER-LINE have a different carrier.
Results: Move Attribute
Results: Move Attribute
<table>
<thead>
<tr>
<th></th>
<th>PostgreSQL</th>
<th>MySQL</th>
<th>pt-osc</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Simple Changes</strong></td>
<td>Mixed results</td>
<td>Mixed results</td>
<td><strong>Good</strong>*</td>
</tr>
<tr>
<td><strong>Complex Changes</strong></td>
<td>Correct but blocking</td>
<td>Online but incorrect</td>
<td><strong>No support</strong></td>
</tr>
</tbody>
</table>
Solution Direction

Lazy schema transformations:

- A transformation is a view on the old schema.
- Transform data on demand when accessed.

How this better meets the requirements:

- Updates are immediately visible.
- Lazy schema changes are composable.
Lazy Schema Transformations

Literature shows promising results for:
- Object databases
- Simple relational transformations

Challenges:
- Complex relational transformations
- Index maintenance
A Real Fundamental Solution

Database based on functional core:

- Many opportunities for optimizing transactions:
  - Bottom up support for lazy evaluation.
  - Rewriting transactions.
  - Parallel execution.
- Not far from declarative queries:
  - XQuery is purely functional
Conclusion

● Requirements: A DBMS should allow complex **online** and **transactional** schema changes.
● Experimental evaluation of existing systems:  
  ○ Simple transformations sort-of work.  
  ○ Composed transformations either block or do not satisfy the ACID properties.
● Proposal: perform transformations lazily.