Towards Online Relational Schema Transformations

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DBDBD 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
Result: Add Column
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
Experiment 3

Instead of a single carrier per ORDER, make every ORDER-LINE have a different carrier.
Results: Move Attribute
Results: Move Attribute
## Experimental Results

<table>
<thead>
<tr>
<th></th>
<th>PostgreSQL</th>
<th>MySQL</th>
<th>pt-osc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple Changes</td>
<td>Mixed results</td>
<td>Mixed results</td>
<td>Good*</td>
</tr>
<tr>
<td>Complex Changes</td>
<td>Correct but blocking</td>
<td>Online but incorrect</td>
<td>No support</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.