Towards Online Relational Schema Transformations

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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.

Source: http://yellowstone.cs.ucla.edu/schema-evolution/index.php/Schema_Evolution_Benchmark

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:

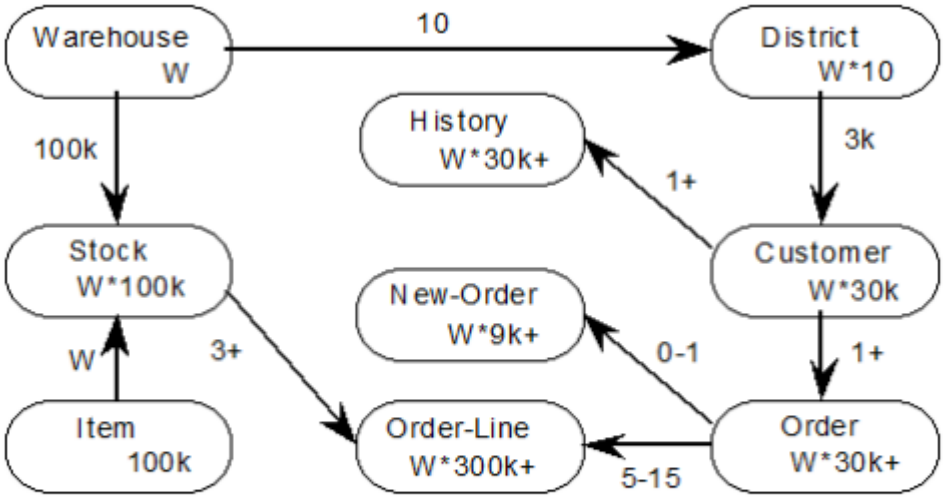
- Blocking
- Aborts
- Slowdown

Performance of schema transformations:

- No aborts
- Time to commit

Experimental Setup

TPC-C



New order

Payment

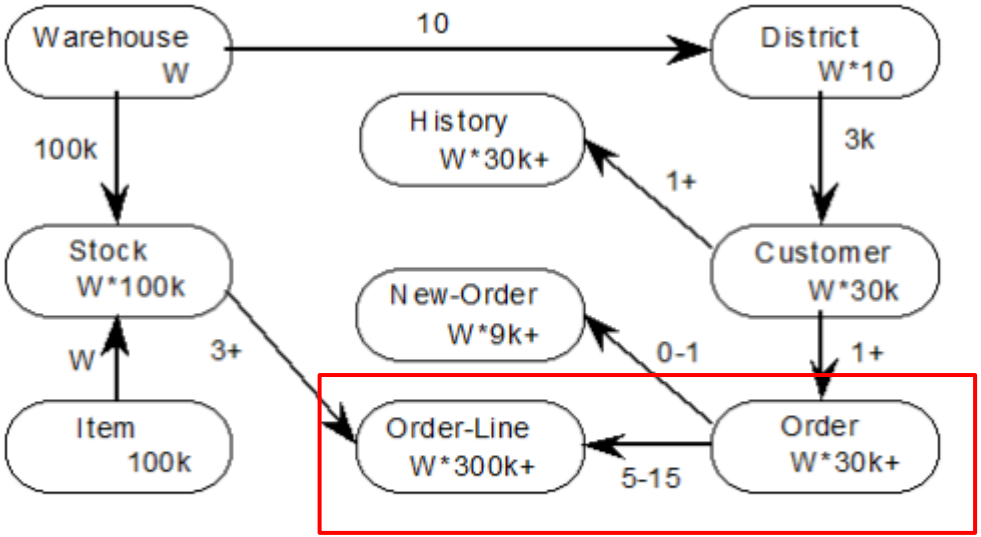
Order status

Delivery

Stock level

Experimental Setup

TPC-C



New order

Payment

Order status

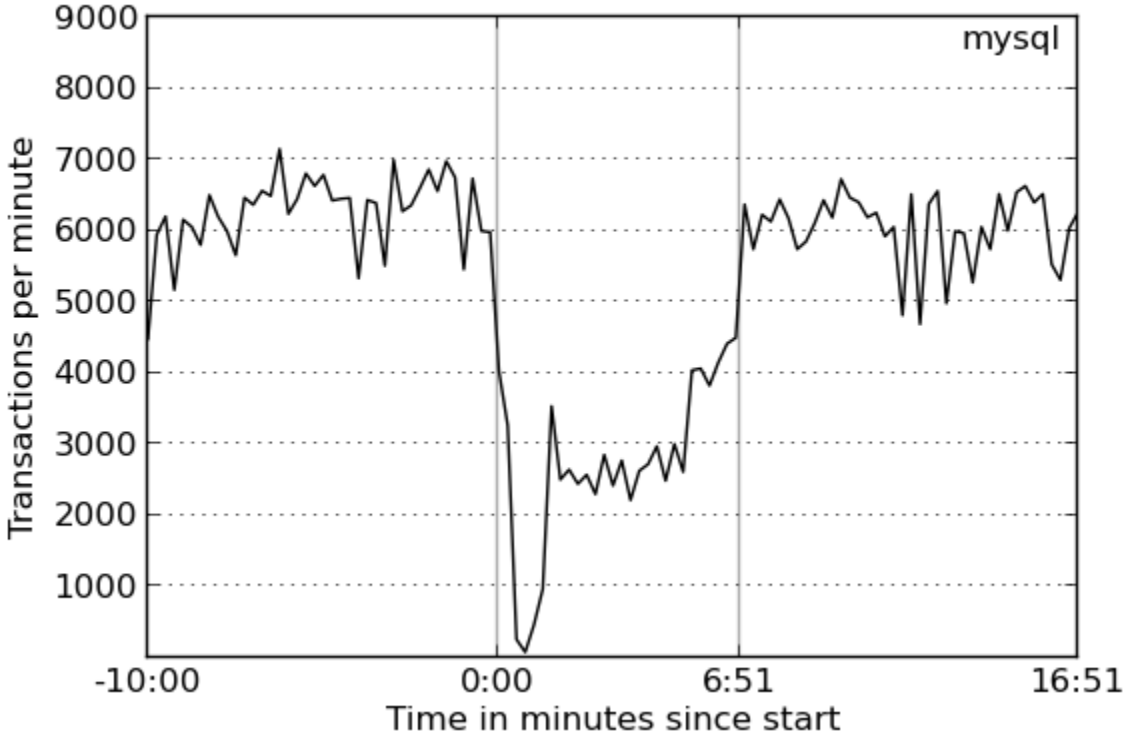
Delivery

Stock level

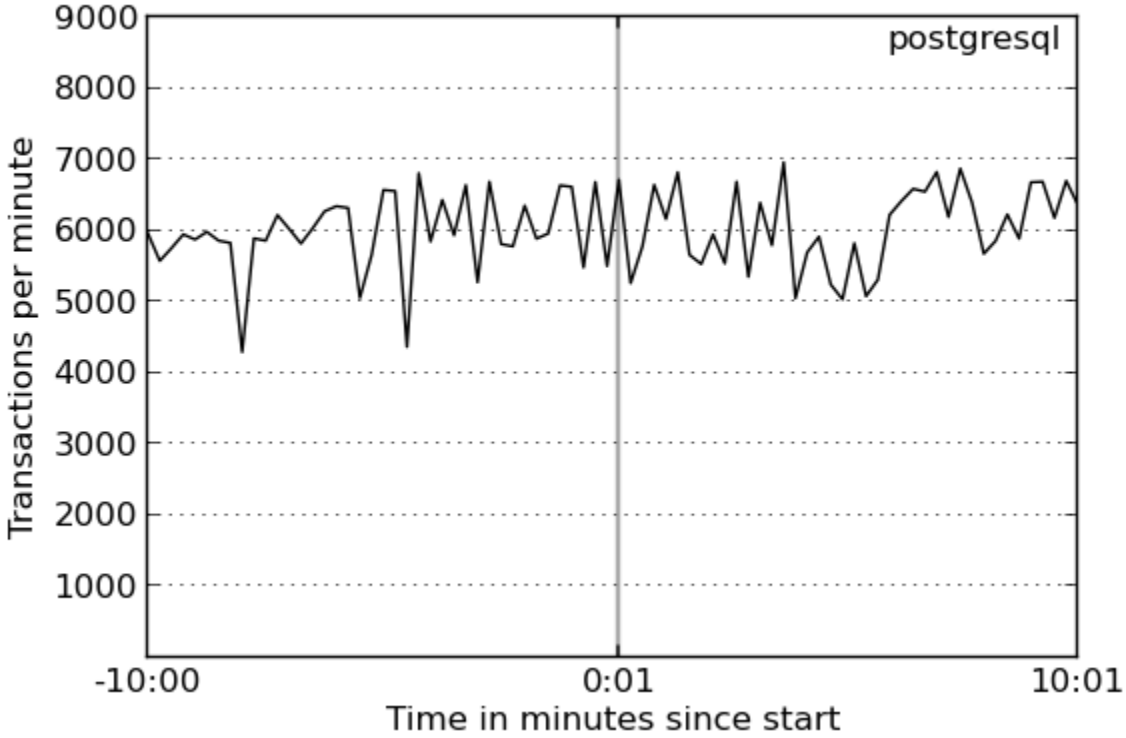
Experiment 1

Add a column to an existing table.

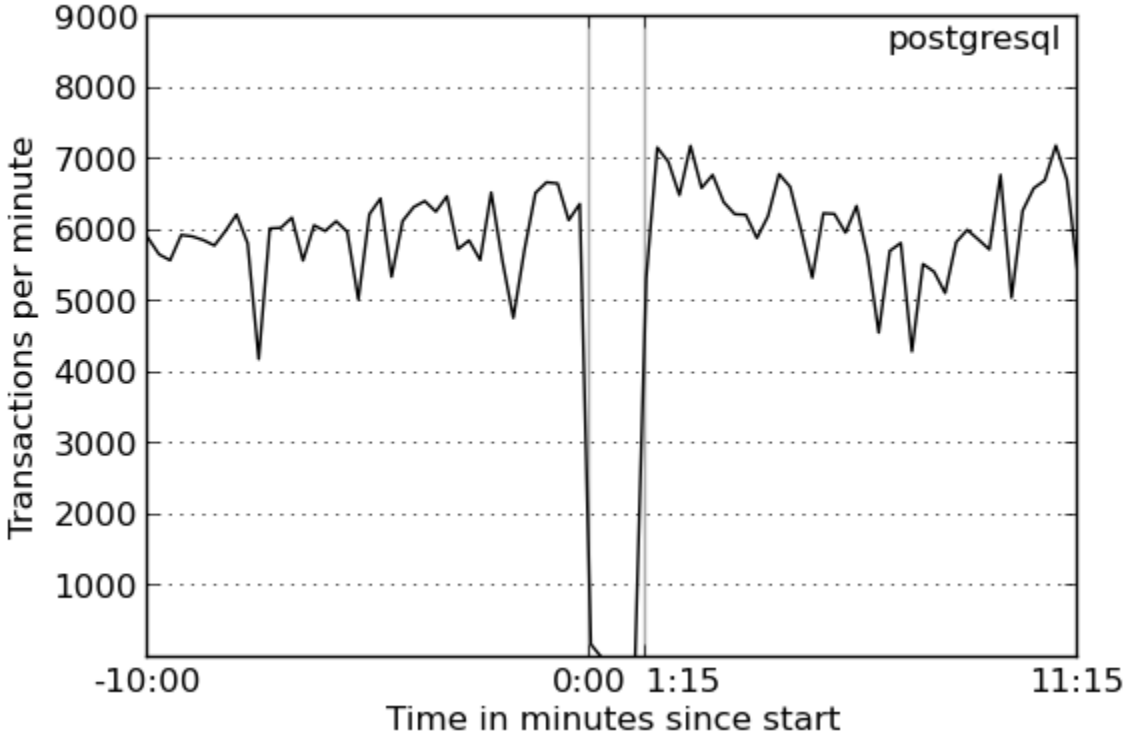
Results: Add Column



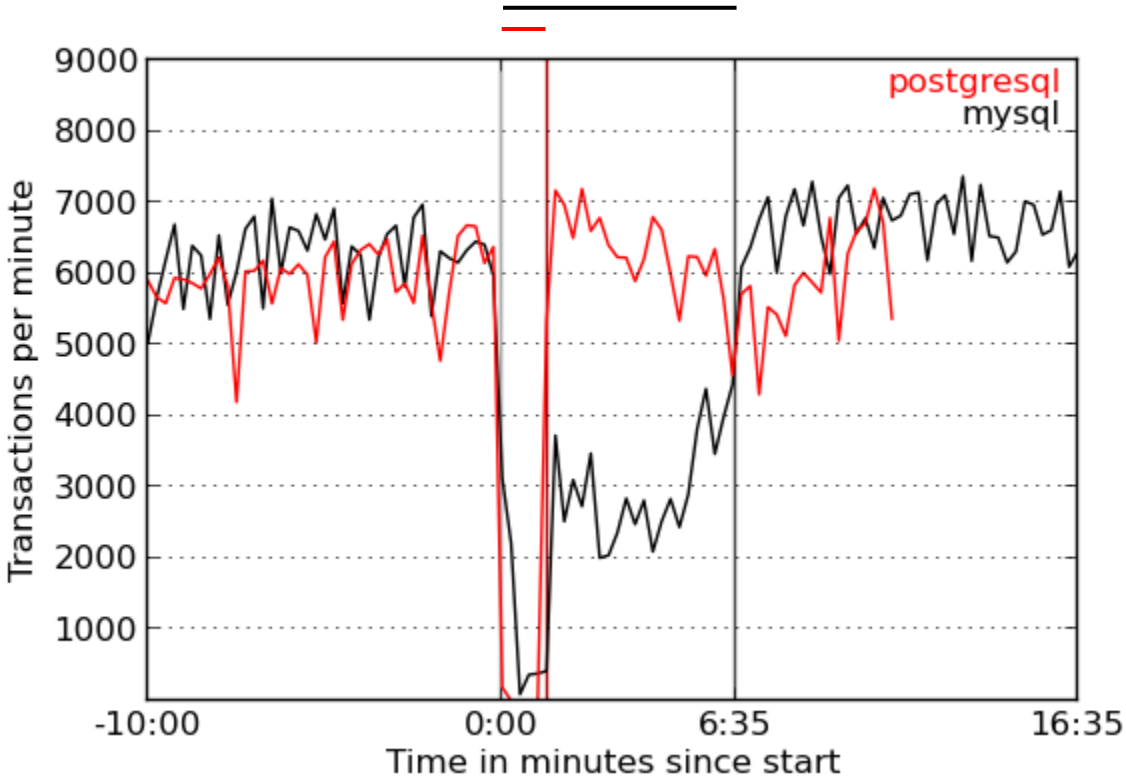
Results: Add Column



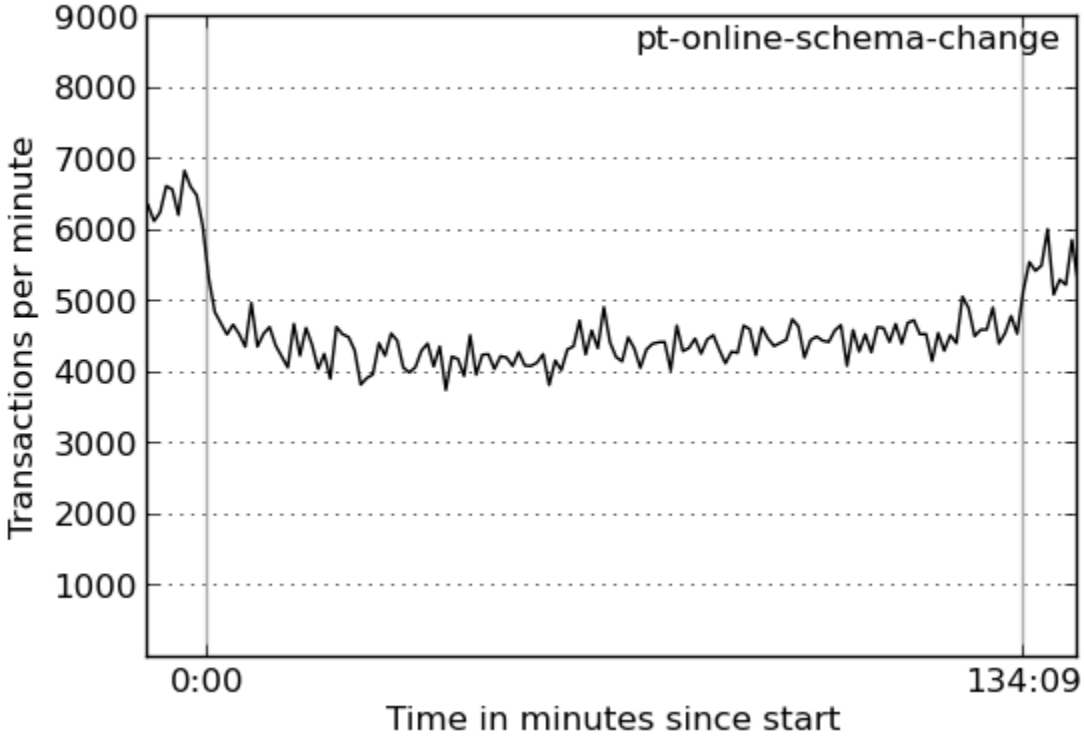
Results: Add Column with Default



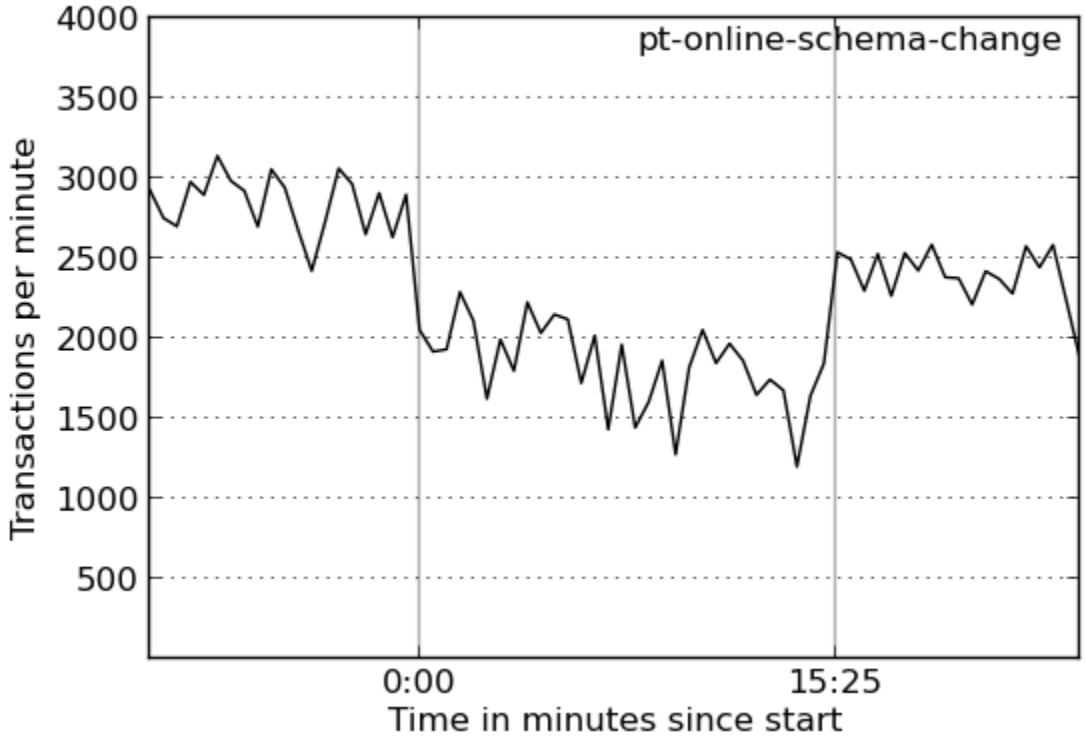
Result: Add Column



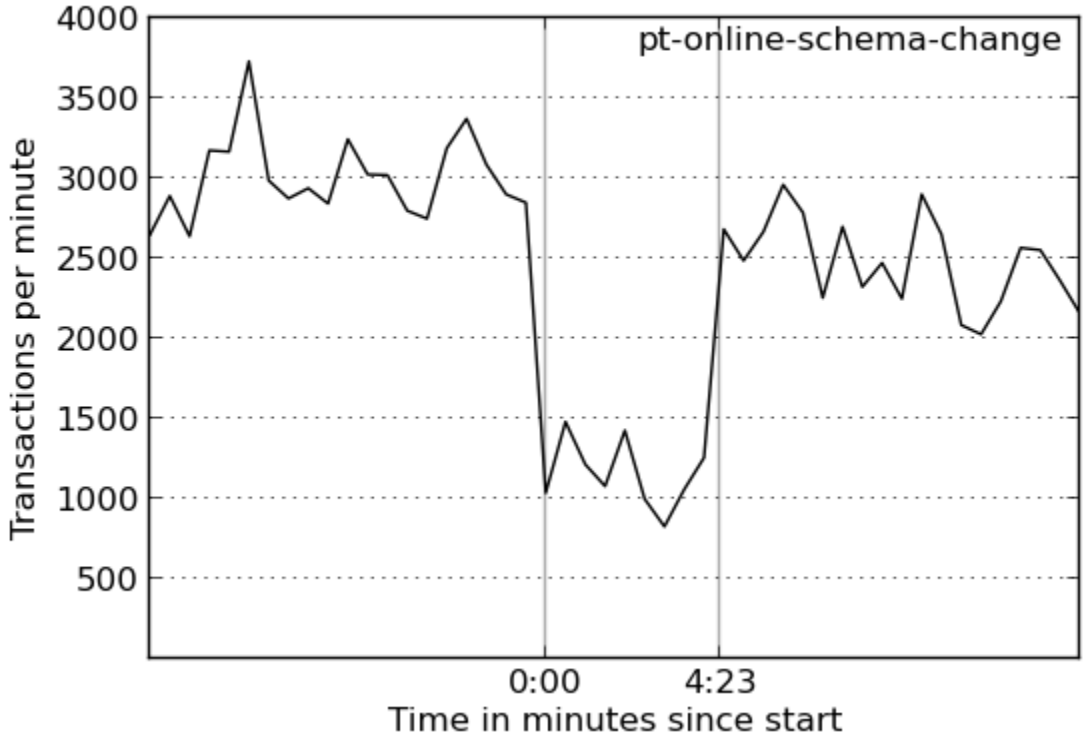
Result: Add Column with Default



Result: Add Column with Default



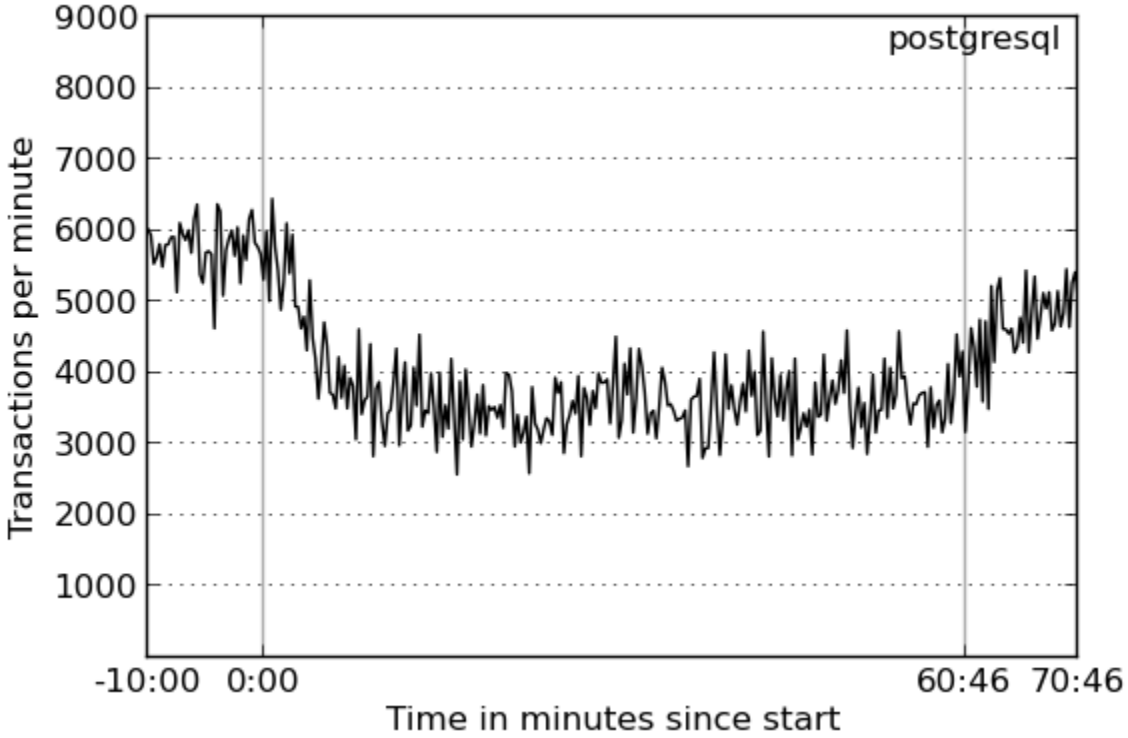
Result: Add Column with Default



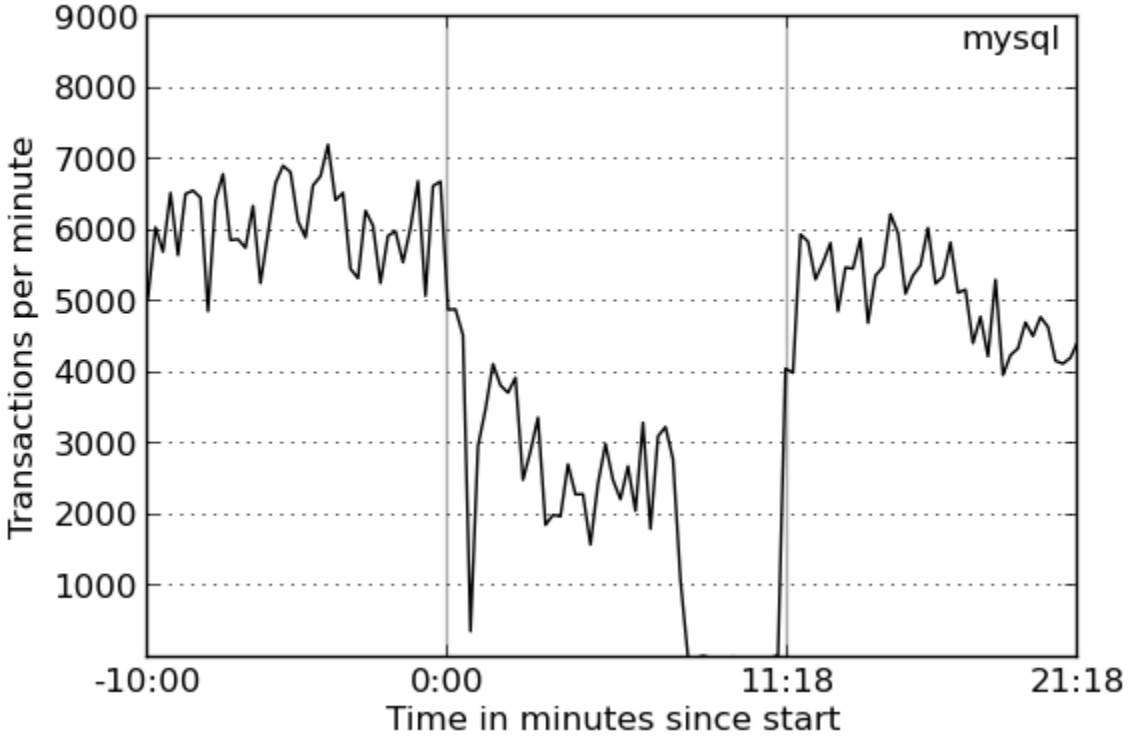
Experiment 2

Create an index.

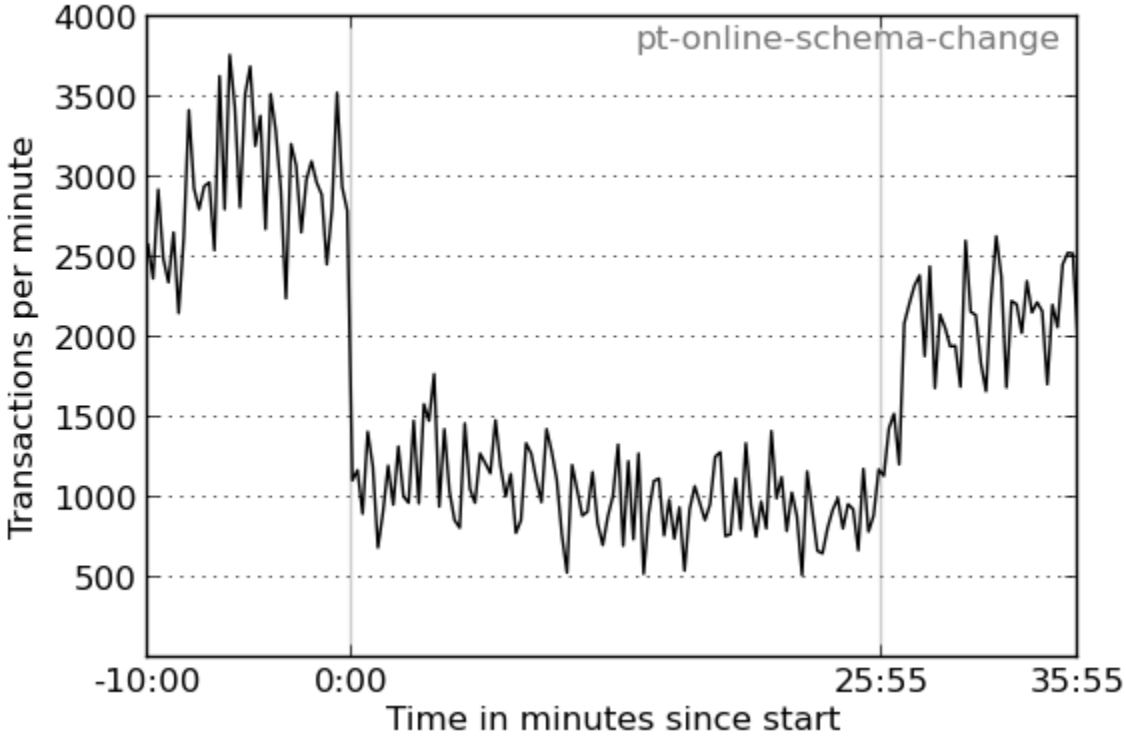
Results: Create Index



Results: Create Index



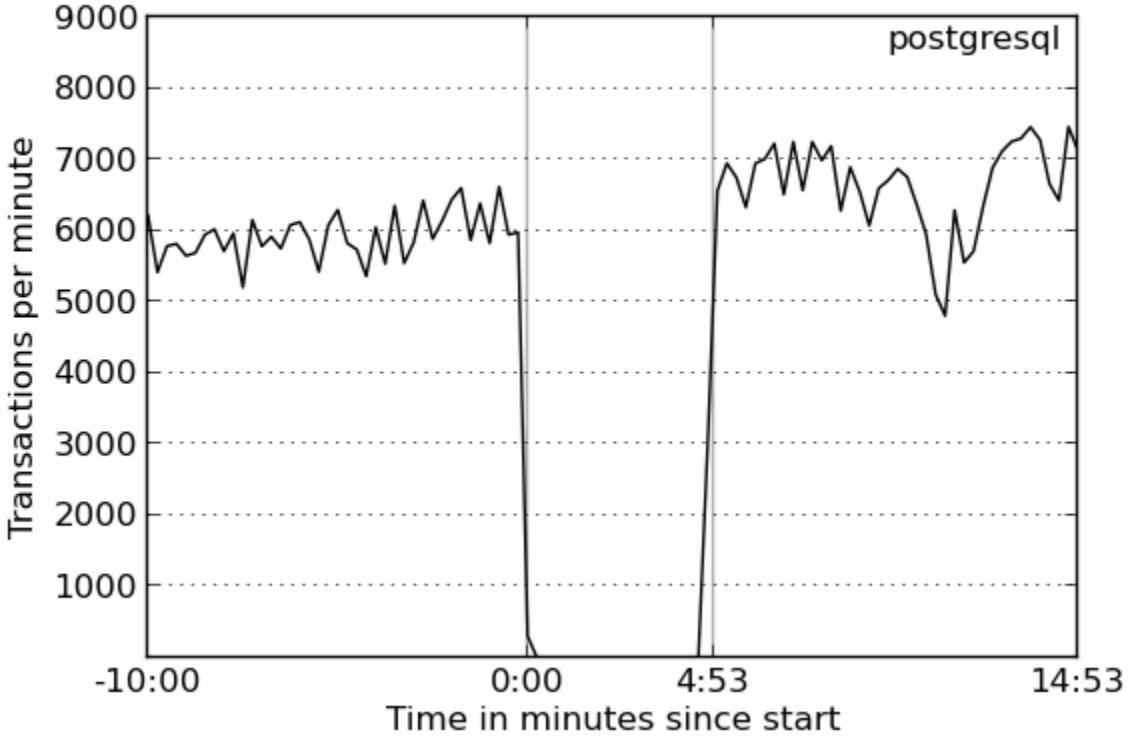
Results: Create Index



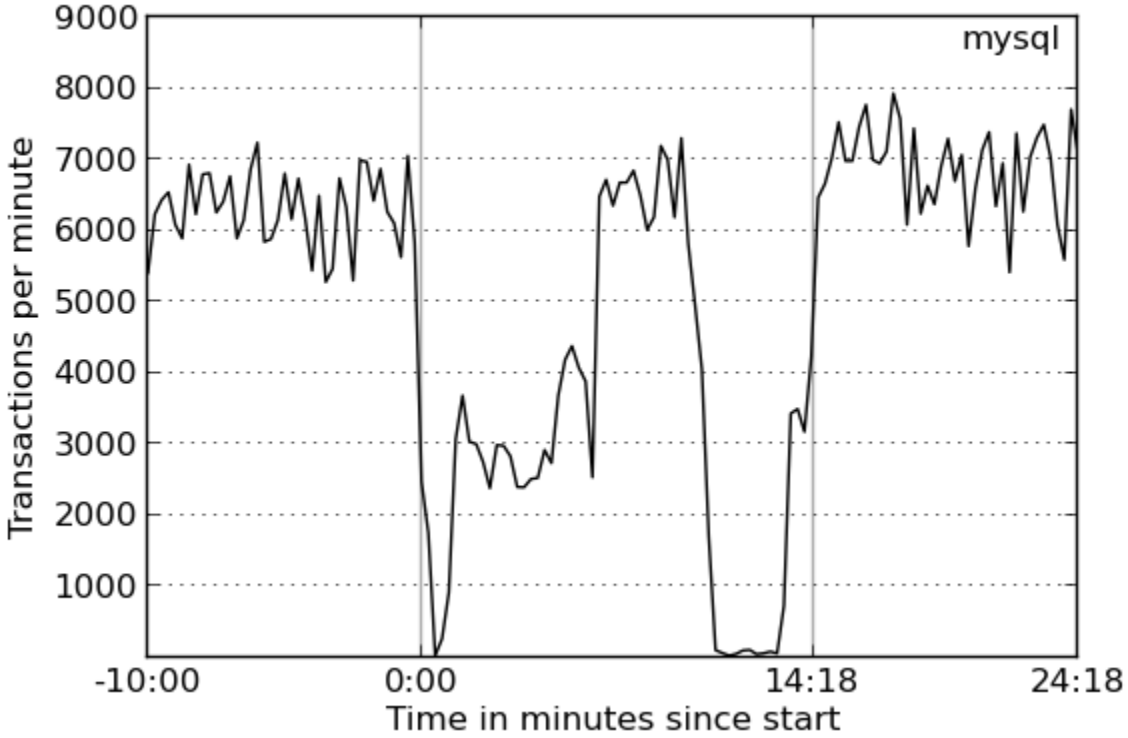
Experiment 3

Instead of a single carrier per ORDER, make every ORDER-LINE have a different carrier.

Results: Move Attribute



Results: Move Attribute



Experimental Results

	PostgreSQL	MySQL	pt-osc
Simple Changes	Mixed results	Mixed results	Good*
Complex Changes	Correct but blocking	Online but incorrect	No support

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.