Modelling Data Warehouses with Multiversion and Temporal Functionality

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Outline

1. Introduction
2. Related Work
3. Goal
4. Challenges
5. The Approach
6. Conclusions
Data Warehouse Architecture
Type of Changes in External Data Sources

External data sources (EDSs) change in their:

1. **Content**
   - Daily operations

2. **Structure**
   - Changes in the business requirements
   - Changes in the modeled reality
   - Adaptation of the new technologies
   - Changes in legislation
Propagating Changes in EDS into Data Warehouses

- As a result of changes in EDSs, DWs also change in their:
  1. **Content**
     - changes in the product prices
  2. **Structure**
     - changes in the geographical hierarchies
- The user may be interested in keeping the history of changes in the content and structure
  - to reconstruct the state of the business world in the past
  - to simulate the effect of the future changes
  - for the audit and accountability purposes
What if the user wants to keep the history of changes in the content and structure of the data warehouse?
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6. Conclusions
Available Approaches

1. Slowly Changing Dimensions
2. Temporal Data Warehouses
3. Multiversion Data Warehouses
Slowly Changing Dimensions (SCDs)

- **Idea**
  - Three basic and four hybrid responses to changes in the contents
  - Basic types are supported by commercial tools such as SSIS, SSAS

- **Drawbacks**
  - Not suitable for temporal data – performance issues
  - Unable to handle structural changes

- **References**
**Temporal Data Warehouses**

- **Idea**
  - Systems which provide built in support for *storing* and *querying* time varying data
  - Temporal features are supported by commercial and open source systems such as Teradata, PostgreSQL

- **Drawbacks**
  - Limited support for temporal operations such as coalescing
  - Unable to handle the structural changes

- **References**
Temporal Data Warehouses

- Capture the evolution of attribute values by associating independent time dimensions
  - Valid time – Time when a fact is valid in the modeled reality
  - Transaction time – Time when a fact is registered in the system

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Table before change

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Temporal Data Warehouses

- Capture the evolution of attribute values by associating independent time dimensions
  - Valid time – Time when a fact is valid in the modeled reality
  - Transaction time – Time when a fact is registered in the system
- Temporal DWs cannot handle the structural changes

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Multiversion Data Warehouses (MVDW)

- Idea
  - Consists of the sequence of DW versions
  - Each DW version is composed of schema version and data version

- Drawbacks
  - Inter and intra-version querying is complex
  - Storage and performance issues
  - No support for creating temporal data versions in a schema version

- References
Something More about Cross-Version Queries

Figure: Schema versions in the example MVDW
Something More about Cross-Version Queries

Figure: Three versions of a DW and possible cases for a query computing the value of a schema element present in the current version only
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Design, implement, and evaluate a multiversion data warehouse that can:

- Store temporal data versions in each schema version
- Efficiently query the data stored within a schema version (intra-version)
- Efficiently query the data stored across multiple schema versions (inter-version)
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Challenges

• Modelling
  • Schema modification operators (SMOs) to derive schema versions
  • A meta-model to store the details of the multiple schema versions
  • Integrity constraints to ensure inter-schema and intra-schema data consistency

• Performance
  • No comprehensive study of temporal algebraic operators for multidimensional model with temporal and multiversion functionality

• Storage
  • Time varying aggregates are complex e.g. coalescing
  • Data redundancy overhead in case of multiple versions
  • An efficient storage model for temporal and multiversion data
Challenges (Cont.)

- **Querying**
  - The temporal data stored in multiple schema versions is not trivial
  - Missing data and data with different structure across multiple schema versions

- **Technological challenge**
  - Limited support for the temporal features in the SQL-Standards and thus in commercial systems
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Our Approach

1 Model that supports
   - Temporal data in schema versions

2 Query mechanism that supports
   - Inter-schema and intra-schema querying of data

3 Performance
   - Benchmark

4 Prototype
   - System as a proof of concept
Our Approach

Model that supports

1. Temporal data in schema versions

Query mechanism that supports

2. Inter-schema and intra-schema querying of data

Performance

3. Benchmark

Prototype

4. System as a proof of concept
Ongoing Work

- Extension of the multiversion DW model with SMOs and temporal features
- Extension of TPC-DS to use it as the benchmark
- Query rewriting algorithm for the cross-version queries
- Prototype
Planned Publications

1. **A Query Mechanism for Multiversion Datawarehouse**
   The paper will present a system capable of storing multiple schema versions of a DW and querying these versions.
   **Outlet:** Bulletin of the Polish Academy of Science. The proposal has already been accepted by the committee.

2. **A Data Warehouse with Multiversion and Temporal Functionality: A Prototype Implementation**
   The paper will present the details of prototype system implementation and empirical results obtained from running this application on the reference data set.
   **Outlet:** ACM SIGMOD (SIGMOD 2016).
   **Expected Submission Deadline:** December 2015.
Modelling Data Warehouses with Multiversion and Temporal Functionality

The paper, with an aim to be published in a journal, will detail all aspects of the doctoral project.

1. **Outlet**: Information Systems Journal (IS).
2. **Outlet**: Information and Software Technology (IST).

**Expected Submission Deadline**: March 2016.
## Plan for Fall 2015 - Spring 2016

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<td>September 2015</td>
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<td>2</td>
<td>Paper presentation in ADBIS 2015</td>
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<td>Submission of the first journal paper</td>
<td>October 2015</td>
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<td>3</td>
<td>Preparation and submission of conference paper</td>
<td>December 2015</td>
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<td>Preparation and submission of the second journal paper</td>
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<td>6</td>
<td>Thesis defense</td>
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Conclusions

• Maintaining the history of changes in the content and structure is an important, yet a challenging issue in the field of data management.

• The temporal and multiversion features allow the user to re-create the state of the business retrospectively or prospectively.

• A natural solution to the challenge of the evolution of content and structure is to combine the both, temporal and multiversion features as a single solution.

• For this, a model, efficient data storage, retrieval and querying mechanism are needed.

• This project aims to address the challenges and present its outcome as a proof of the concept application.