An XML-to-Relational User-Driven Mapping Strategy Based on Similarity and Adaptivity

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Introduction

- **XML = a standard for data representation and manipulation**
  - **Growing demand for efficient managing and processing of XML data**

⇒ **A natural alternative: To exploit tools and functions of (object-)relational database management systems ((O)RDBMS)**

(–) XML trees vs. flat relations ⇒ inefficiency

(+) Long theoretical and practical history, mature technology

⇒ **The techniques should be further enhanced**

Goals of This Presentation

Proposal of improvement of XML processing based on (O)RDBMS

- **Overview and classification of existing approaches**
- **Motivation for improvements**
- **Proposal of improvement of user-driven methods**
- **Related open issues**
- **Conclusion**

Content

1. **Overview of existing approaches**
2. Motivation for improvements
3. Proposed improvement
4. Related open issues
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Managing XML Data

- File system
  - (–) Inability of querying without additional pre-processing of data
- Pure object-oriented approach
  - (–) No efficient and comprehensive tool
- Native methods
  - (+) No need to adapt structures to a new purpose
- (O)RDBMS ⇐
  - (+) Most practically used

Database-Based XML Processing Methods (1)

Key concern: Choice of the most efficient XML-to-relational mapping strategy

- **Fixed** – predefined set of mapping rules and heuristics
  - Generic vs. schema-driven
- **Adaptive** – adapt the target schema to intended usage
  - Cost-driven
- **User-involving** – storage decisions in hands of users
  - User-defined vs. user-driven

Database-Based XML Processing Methods (2)

- **Generic** vs. **schema-driven** – omitting / exploiting XML schema
  - Straightforward mapping
- **Cost-driven** – search a space of possible mappings and choose the one which conforms the target application most = the least "expensive"
  - Application: sample XML data, XML queries
- **User-defined** vs. **user-driven** – the amount of user involvement
  - User-driven = a type of adaptivity
    - Schema is adapted to the annotations

User-Driven Methods: Shortcomings and Improvements

- **Default mapping strategy is always fixed**
  - **Systems are able to store schema fragments in various ways ⇒ adaptive enhancing is natural**
- **Weak exploitation of user-given information**
  - **Annotations are just directly applied**
  - **Idea: Annotations = "hints" how a user wants to store particular XML patterns ⇒**
    - **We search for similar fragments**
    - **We use the knowledge in adaptive enhancing**

⇒ General idea: Emphasis on user-given information

Mlynkova, Pokorny: Adaptability of Methods for Processing XML Data using Relational Databases - the State of the Art and Open Problems. RCIS 2007. Ecole Marocaine des Sciences de l'Ingénieur, 2007.

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Why User-Given Information? (Example 1)

- Situation: Documents with XHTML fragments
- Problem: Shredding into tables = inefficient fragment reconstructions
  - XHTML DTD contains complete graphs on up to 10 nodes
- What if the real complexity is much simpler?
  - Statistical analysis: Yes, it is <u>much</u> simpler!

$\Rightarrow$ Simpler storage strategy (CLOB)

Mlynkova, Toman, Pokorny: Statistical Analysis of Real XML Data Collections. COMAD 2006. Tata McGraw-Hill Publishing Company Limited, 2006.

Why User-Given Information? (Example 2)

- Situation: Updatability of data vs. fast query evaluation
- Problem: Amount of mutual relationships information
  - Fast querying $\Rightarrow$ additional indices, numbering schemes
  - Fast updates $\Rightarrow$ the simplest information of mutual relationships
  - Fast querying, fast updates $\Rightarrow$ compromise

Why User-Given Information? (Example 3)

- Situation: Data redundancy
- Question: Is it always necessary to strictly follow the rules of normal forms?
  - No, it is not.
  - Optimal XML-to-relational storage strategy = 4NF
    - No null values, no redundancy

⇒ In all the cases we need additional information given by a user
  - XML data, XML queries, annotations…

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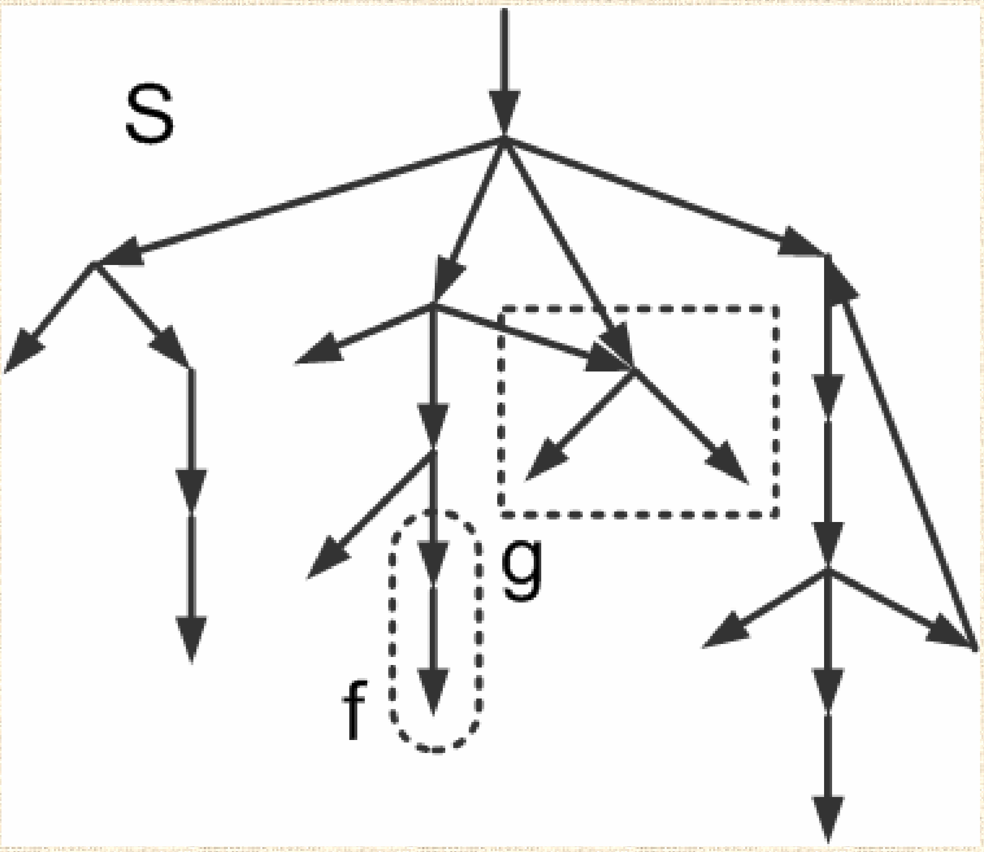
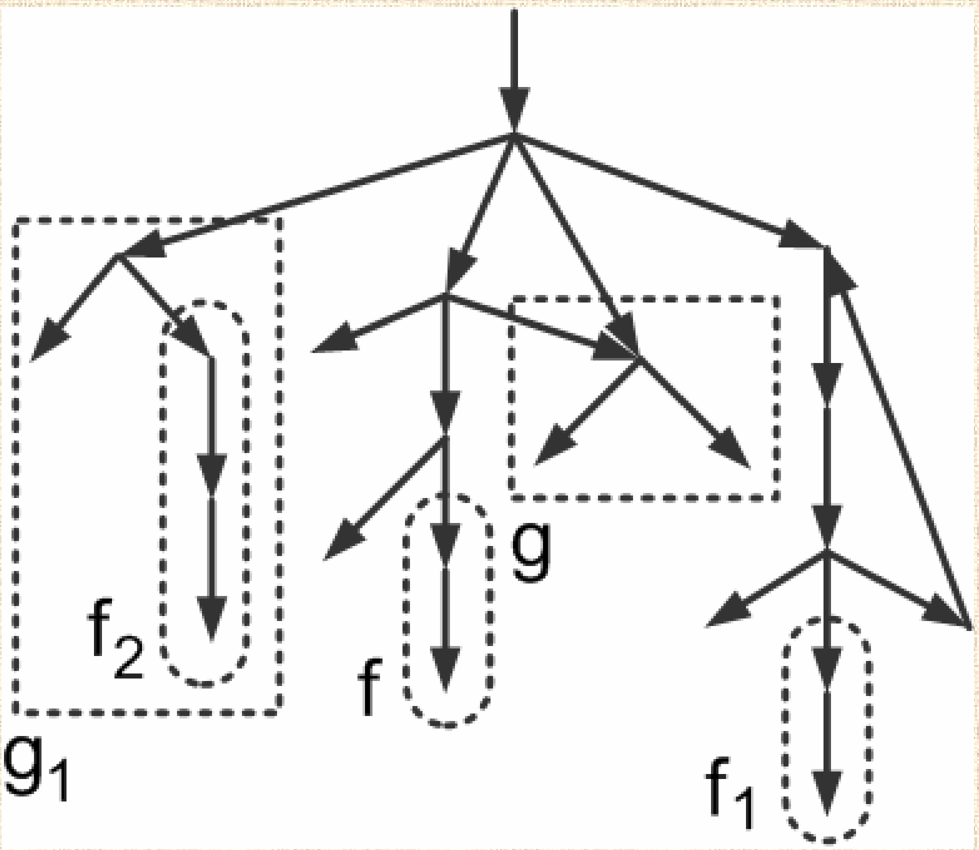
Basic Ideas

- Searching for similar fragments in the not annotated schema parts
  - The user is not forced to annotate all schema fragments
  - The system can reveal new structural similarities
- Searching for optimal mapping strategy for the remaining schema fragments
  - Adaptive strategy

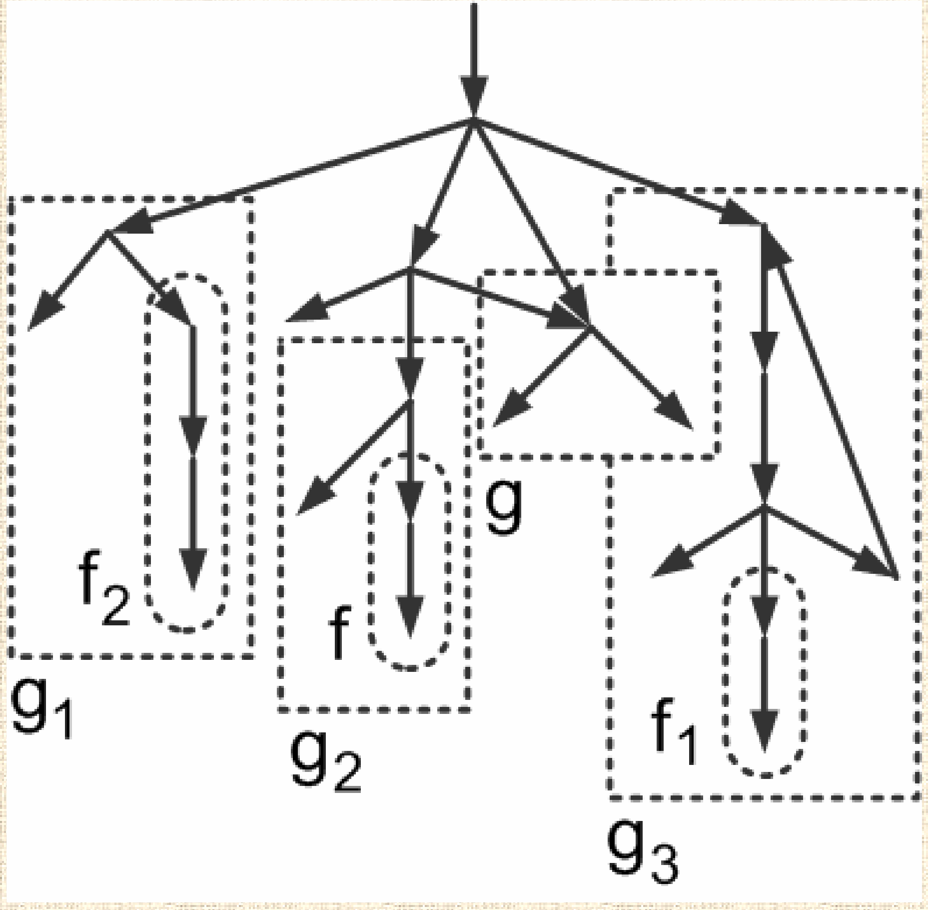
Step 1. Annotated Schema



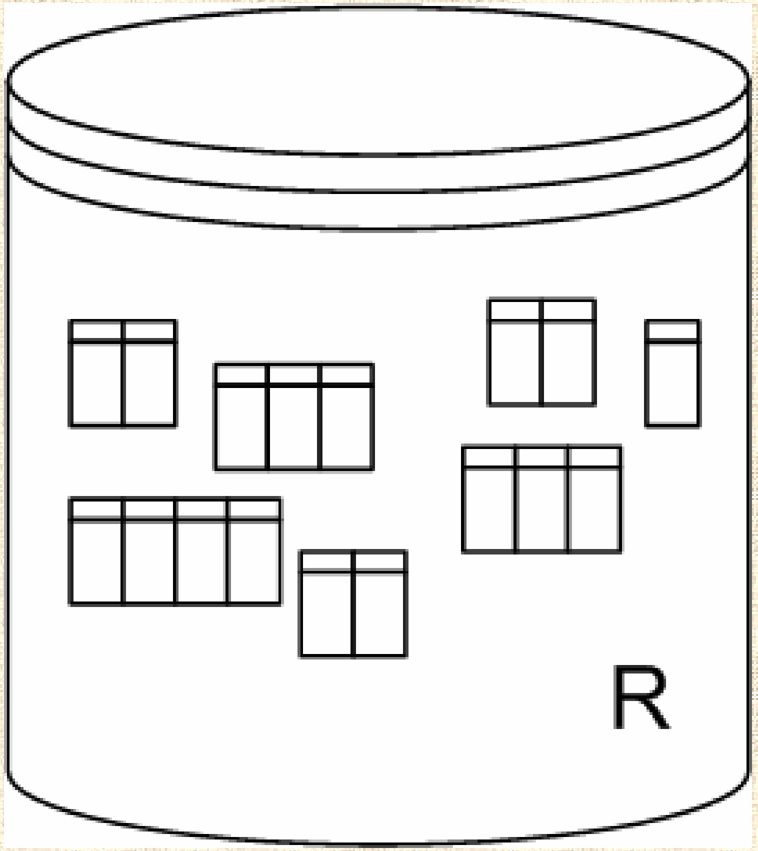
Step 2. Searching for Similar Fragments



Step 3. Adaptive Strategy



Step 4. Mapping to Relations



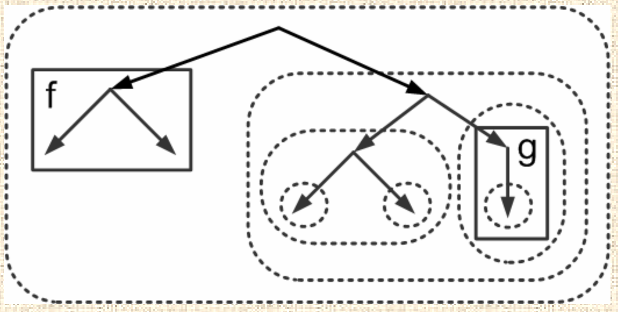
Open Issues

- What **types of annotations**, i.e. fixed mapping strategies, are supported? How are they combined?
- What **similarity measure** is used? Can we optimize the exhaustive search for similar fragments?
- Should we use a classical **adaptive strategy**?

Types of Annotations

- Particular mapping methods influence versatility of implementation
  - CLOB, shredding to tables, indices, numbering schemes…
- Key aspect: Intersection of annotated fragments
  - Redundant - both methods are applied on intersection
    - XHTML fragments ⇒ shredding + CLOB
  - Overriding - only one of the methods is applied
    - Classical user-driven strategies
  - Influencing - both methods are combined into one storage strategy
    - Shredding + indices/numbering schemes

Similarity Measure and Search Algorithm (1)



- Closely related
  - No knowledge of measure

    ⇒ Few ways how to avoid exhaustive search
    - Clustering (expensive preprocessing)
- Idea: Exploit knowledge of the similarity measure
- Modification of a classical approach:
  - A set of matchers = partial similarity measures
    - Similarity of a particular feature
      - Depth, number of nodes, complexity of content…
  - A composite similarity measure = combines the results
    - Weighted sum

Similarity Measure and Search Algorithm (2)

- **Features of matchers $\Rightarrow$ a bottom-up strategy**
  - **Knowledge for child nodes $\Rightarrow$ knowledge for parent node**
    - **e.g. depth, number of nodes**
- **Heuristics: Searching can terminate if reasonable amount of matchers exceed their only optimum within the current root path**
  - **Not possible for the composite measure**
  - **e.g. similarity of depths**
    - **With growing number of nodes the depth grows until it reaches the depth of the searched schema fragment**
- **Note: Formally described in the paper**

Adaptive Strategy (1)

- Classical approach: Target DB schema is adapted to sample XML data and queries
  - + annotations = too much information
- Idea:
  - Queries = How the data are typically manipulated
  - Data = How complex are XML documents

$\Rightarrow$ How to store the data
  - Annotations = How particular schema fragments should be stored

$\Rightarrow$ Annotations can be reused $\Rightarrow$ no need for additional information

Adaptive Strategy (2)

- **Key operations:**
  - **Contraction = replaces each annotated fragment with an auxiliary node**
  - **Expansion = all auxiliary nodes are expanded to original schema fragments**
- **Algorithm:**
  1. **The searching for similar fragments and operation contraction repeats until there are no identified candidates for annotating**
  2. **The resulting schema is expanded**
- **Intersection of original and new annotations: Newly defined are overridden**

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Features of Implementation

- Determine the usability and versatility of system
  - The set of annotations and their intersection
  - Partial matchers
  - Composite similarity measure
    - Key problem: Tuning of parameters
  - Similarity threshold(s)
  - Side effects:
    - User intervention when more possibilities occur
    - Support for forbidden intersection of annotations
    - Support for fixed fragments
    - …

Behavior on Real-World Data

- We know typical characteristics of real-world data - where is the problem?

- The behavior of more complex similarity measure cannot be predicted
  - Tuning process
- The behavior of the search algorithm on contracted graph cannot be predicted
  - No research on contracted graphs
    - Of course…

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Currently Solved Issues

- Plenty of open issues = lots of work
- "Finished" research (under reviewing process)
  - Similarity measure focusing on structure of fragments
    - Tuning - based on statistical analysis of real-world data
  - Experimental evaluation of behavior of the adaptive strategy
    - Number of detected similar fragments, number of contractions, is the graph always contracted totally?
- Current research
  - Efficient querying over the resulting schema (query plans vs. intersecting annotations)
  - Combination with classical adaptive methods

Mlynkova: UserMap - an Enhancing of User-Driven XML-to-Relational Mapping Strategies. Technical report 2007/3. Charles University, Prague, Czech Republic, April 2007

Thank you