From XML Schema to Object-Relational Database – an XML Schema-Driven Mapping Algorithm

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Introduction

- **XML = a key format for representing and exchanging information**
  - **Growing usage of XML technologies**
  - **Growing demand for effective management of XML documents + querying XML data**

⇒ **Possibility: Storing and managing XML data using (O)RDBS**

⇒ **Advantage: To provide XML with missing database mechanisms (i.e. indexes, multi-user access, etc.)**

Goals of the Presentation

Proposal of an algorithm for mapping

- **XML Schema structures to object-relational database schema**

Content

1. Characterization and classification
2. Mapping rules
3. DOM graph
4. Mapping algorithm
5. Storage algorithm
6. Conclusion

Existing Methods

- Significant amount
- Main difference: Designed for data-centric vs. document-centric XML documents
- Basic classification:
  - Generic – do not use any XML schema
  - Schema-driven – based on the XML schema
    - Fixed vs. flexible
    - Source schema (DTD vs. XML Schema)
    - Target schema (relational vs. object-relational)
  - User-defined – based on user-defined mapping

Classification of the Proposed Algorithm

- Fixed schema-driven mapping algorithm
- Focuses on data-centric XML documents
  - Document-centric extensions
    - Preserving the sibling order
    - Preserving the mixed-content elements
- Source schema: XML Schema
- Target schema: object-relational

Contributions of the Proposed Algorithm

- Focus on complex XML Schema structures
  - Object-oriented features, semantic constraints
  - Not very common
- Exploitation of object-relational features of SQL:1999
  - UDTs, typed tables, references, nesting, etc.
- Modelling XML Schema structures by the auxiliary DOM graph

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Mapping Rules (1)

XML Schema item		OR mapping	
Built-in simple type		SQL simple type (eventually + IC)	
User-defined simple type		SQL simple + IC	
Complex type	Attributes	UDT	Attributes: simple type
	Content: • Simple • Complex (element-subelement relationship)		Content: • Attribute: simple type • Attribute: typed column / reference / array of references
Derived complex type		Inheritance of UDTs	
Element		Own typed table / typed column of parent typed table	

Mapping Rules (2)

- Established with respect to preserve the structure and semantic constraints of the source XML schema
- Document-centric extensions:
  - Preserving the order of sibling elements
    - Naturally – using arrays and their indexes
    - Unnaturally – using additional attribute(s)
  - Preserving the mixed content of elements
    - Like “other” elements + the text parts into a separate multi-valued property

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DOM Graph

- Idea: “XML schema expressed in XML Schema language is at the same time an XML document and thus can be processed using the DOM interface as well.”
- A modification of the DOM tree
  - Nodes: Nodes of the original DOM tree
  - Edges:

    - Directed edges of the original DOM tree
    - Additional edges expressing the "direction" of the usage of globally defined items or data types

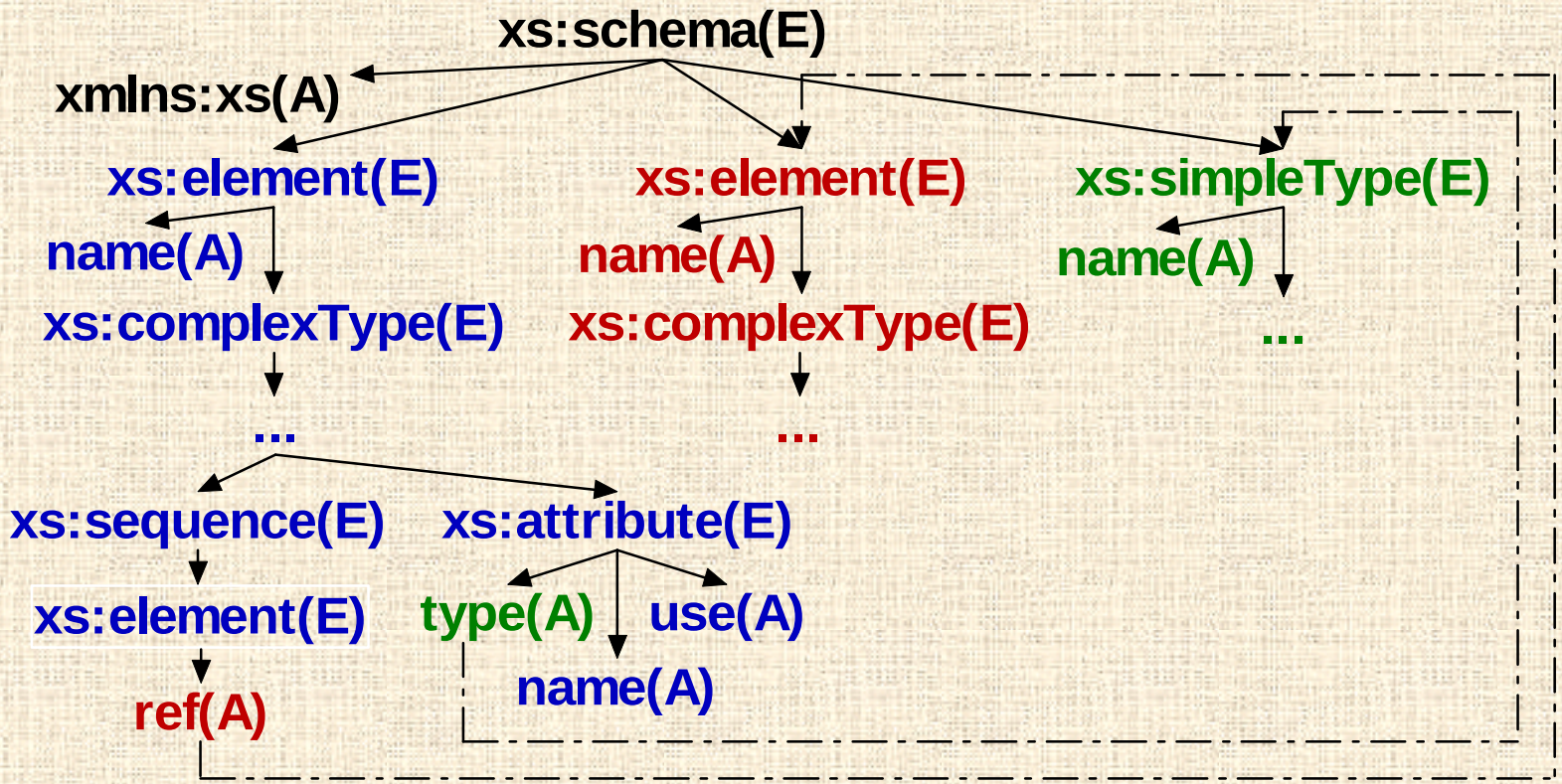
XML Schema Example

```
<xs:schema xmlns:xs="...">
  <xs:element name="Staff">
    <xs:complexType>
      ...
      <xs:sequence>
        <xs:element ref="Name"/>
      </xs:sequence>
      <xs:attribute name="OnHoliday"
                    type="YesNo"
                    use="required"/>
      ...
    </xs:complexType>
  </xs:element>

  <xs:element name="Name">
    <xs:complexType>
      ...
    </xs:complexType>
  </xs:element>

  <xs:simpleType name="YesNo">
    ...
  </xs:simpleType>
</xs:schema>
```

DOM Graph Example



Cycles in DOM Graph

- **Mutual usage of globally defined elements and/or complex types**
- **SQL:1999 allows no cyclic definitions among UDTs**
- **Existing (O)RDMS (e.g. Oracle9i) support *incomplete types***
  - **Forward declaration of a UDT declared without its content**
  - **Can be used instead of the corresponding complete type (except for inheritance ancestor)**

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Mapping Algorithm (1)

- Follows the established mapping rules
- Based on traversing the DOM graph
  - Edges determine the order in which the SQL items (i.e. UDTs, typed tables, references, etc.) should be created
- Two phases:
  1. DOM tree → DOM graph
  2. DOM graph → OR schema
- Resulting OR schema: Set of typed tables "interconnected" using references

Mapping Algorithm (2)

Phase 1. DOM tree → DOM graph

1. **Create a DOM tree of the given XML Schema file.**
2. **For each undirected edge create the corresponding directed one.**
3. **For each base, type, itemType or ref attribute create the corresponding (additional) directed edge.**

Mapping Algorithm (3)

Phase 2. DOM graph → OR schema

1. For each globally defined complex type / element create its incomplete UDT.
2. Starting in the root node process all nodes in the graph recursively:
   1. Process all child nodes of a current node (i.e. create corresponding SQL item / items).
   2. Process the current node.
3. For each incomplete UDT, create corresponding complete one.
4. Create corresponding typed tables.

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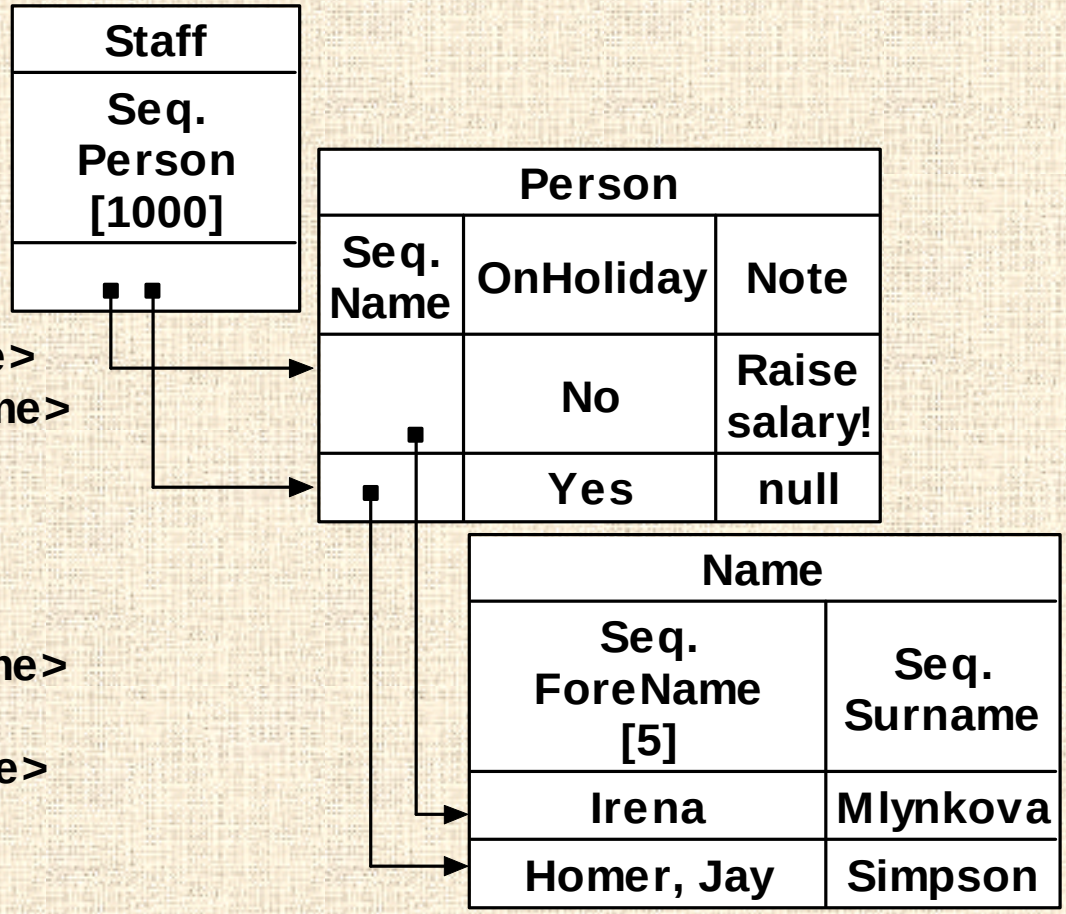
Storage Algorithm

- Storing the data from XML documents valid against the source XML schema into relations of the target OR schema
- Based on traversing the DOM tree of the XML document and creating SQL constructors of the data
- Driven by:
  - Structure of XML document
  - Auxiliary information about the current schema
    - Types of parent-child mapping, names of tables, etc.

Example

```
<Staff>
  <Person OnHoliday="No"
          Note="Raise salary!">
    <Name>
      <ForeName>Irena</ForeName>
      <Surname>Mlynkova</Surname>
    </Name>
  </Person>
  <Person OnHoliday="Yes">
    <Name>
      <ForeName>Homer</ForeName>
      <ForeName>Jay</ForeName>
      <Surname>Simpson</Surname>
    </Name>
  </Person>
</Staff>
```



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Conclusion

- Contributions
  - Focus on object-oriented features of XML Schema
  - Exploitation of object-relational features of SQL:1999
  - Definition of DOM graph
- Future work:
  - Optimalizations of the created schema
    - For a certain application – flexible methods
    - Generally – definition of a “good” XML schema (such as e.g. normal forms for relations) and ways how to establish it