A Framework for Generic Integration of XML Sources

Wolfgang May
Institut für Informatik
Universität Freiburg
Germany
may@informatik.uni-freiburg.de

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OVERVIEW

- Integration operations (Warehouse strategy)
- Integration strategies
- Language: XPathLog
- Implementation: LoPiX
- Conclusion

Topics Overview

- Considerations on a Data Model for XML with updates/integration:
  FMLDO/FMII’01
  independent from the programming language
- XPathLog as an XML Database Programming Language:
  DBPL’01
- Implementation: LoPiX
  VLDB Demonstration Track

Application for Data Integration

- objects of different sources represent the same real-world object

⇒ Fusing objects, merging their properties

- different names and structure

⇒ Result views as projections

- Strategies for “intelligent” data-driven integration
  KRDB’01

Document vs. Database

- integration of documents: tree, ordered
  "integration follows structure"
- integration of databases: graph, non-ordered
  semantics-driven integration process

Database Integration

- objects of different sources represent the same real-world object

⇒ Fusing objects, merging their properties

- synonyms, ontologies
- not compatible with XML Data Model (DOM, XML Query Data Model)
- requires a powerful language
- experiences with F-Logic for semi-structured data and data integration

SCENARIO

- Different autonomous sources, describing the same application area
  e.g., catalogs of Digital Photography
- overlapping, but potentially incomplete and inconsistent
- No fixed integration mapping known

⇒ Data-Driven integration strategies

- stepwise generation of an integrated database
- Warehouse vs. virtual approach

```
<producer name=“Nikon”>
    <product type=“digital camera” name=“Coolpix880”
                mpix=“3.34” price=“1799.00”>
        <zoom> <external focallength=“8 20”>
               <digital factor=“4”>      </zoom>
        <accessory type=“lens” name=“WC-E24”/>
        <accessory type=“lens” name=“TC-E2”/>
        <accessory type=“lens” name=“TC-E3”/>
    </product>
    <product   type=“wide angle adapter” name=“WC-E24”
               factor=“0.66” price=“219.00”>    </product>
    <product   type=“teleconverter” name=“TC-E2”
               factor=“2” price=“259.00”>    </product>
    <product   type=“teleconverter” name=“TC-E3”
               factor=“3” price=“589.00”>    </product>
      ⋮
</producer>
```

```
<store name="shop1">
    <digitalcamera    producer="Nikon"
                      type="Coolpix880" price="1699.00"/>
    <digitalcamera    producer="Nikon"
                      type="Coolpix990" price="2399.00"/>
    <digitalaccessory    producer="Nikon"
                         type="WC-E24" price="199.00"/>
    <digitalaccessory    producer="Nikon"
                         type="TC-E2" price="269.00"/>
    <digitalcamera    producer="Olympus"
                      type="C3000" price="1599.00"/>
        ⋮
</store>
```

- other resellers pages
- test reports etc

INTEGRATION: "THREE-LEVEL" MODEL

access multiple sources

- "basic" layer: source(s) provide tree structures,
- optionally with namespaces
  - nikon: producer's tree
  - shop1, shop2 etc: resellers trees

merge data from different sources

Abstract Operations

- fuse elements/merge subtrees
- introduce synonyms for properties
- connect elements and tree fragments from several sources by links
- generate elements

"internal" data model: XTreeGraph

- overlapping trees
- multiple parents
- references

"export" layer: result trees views defined as projections

Integration: Fusing Elements and Subtrees

Situation

- elements represent the same real-world entity in different sources
- fuse elements into a unified element: $e_1 = e_2$

Resulting element

1. globally replace e_2 in all properties by e_1.
2. e_1 is then an element of *both* source trees, i.e., positive queries against the original tree using the original namespace still yield at least the original answers,
3. e_1 collects the attributes of both original elements.
4. e_1 collects the subelements of both original elements.

SYNONYMS

- identify properties with the same semantics

$$\textit{name}_1 = \textit{name}_2$$

- take properties from the (namespaced) sources are completely added to the result – with another name

$$\textit{namespace:name}_1 = \textit{name}_2$$

- does *not* introduce new children or attribute nodes,
- “only” defines an alternative navigation path,
- does not change order of children

Result Views

Projection by Signatures

Given:

- Database with (overlapping) trees
- signature specification (derivable from DTD or XML Schema),
- a root node r.

Tree view rooted in r:

- the root node r,
- attributes and subelements (recursively) filtered according to the signature

Integrity Constraints:

- result may contain dangling references.
- result may be cyclic/infinite.

Strategies

- use a reference tree
- describe keys (names, codes, titles etc.)
- Identify corresponding concepts and elements in different trees
  (element types, attribute names etc.)
- candidate sets of corresponding elements
  products in the nikon tree and in the reseller's trees
- verify correspondence and fuse elements
- identify corresponding properties by values based on "known" identical elements
  - properties which have to be identified
  - properties which correspond, but have to be compared
  - technical data vs. prices of different resellers
- generalize to all elements of a given type
  from nikon products to olympus products in the reseller tree
- analogies: semantics of related element types
- detect mappings between properties (price in DM, Dollars; lengths in cm, inch)
- generalize relationships between sources

Strategies, Details, Extensions

- Well-founded semantics for detecting sets of corresponding elements in “graph” databases
  interfering, negative dependencies between candidate sets, deep-equality etc.
- Statistical methods/Data Mining for handling inconsistencies
  property coincides for 95% of all identified objects
- perhaps consider another input database for these data
  confidence measures
- include meta-knowledge
  - ontologies
  - domain-dependent knowledge (units, currencies, taxes, languages)

⇒ requires a powerful language

WAREHOUSE VS. VIRTUAL REVISITED

- Apply strategies to an excerpt of the database in the warehouse approach
- derive a mapping
- apply mapping to complete databases in a virtual integration strategy

LANGUAGE PROPOSAL: XPATHLOG

Design Decisions

- experiences with F-Logic for semi-structured data and data integration
- declarative rule-based language with bottom-up semantics
- extend XPath with variable-bindings
- XTreeGraph data model
- support for 3-level integration approach

XPathLog by Examples

Pure XPath expressions

?- //producer[@name = “Nikon”]
//product[@name=“Coolpix 880”]/@mpix.

true

Output Result Set

?- //producer[...]//product[...]/@mpix→M.

M/3.34

Additional Variables

?- //producer[...]//product[@name=N]/@price→P.

N/“Coolpix 880”	P/1799.00
N/“WC-E24”	P/219.00
⋮	

Dereferencing

?- //producer[...]//product/accessory/@name/@price→P.

Schema Querying

?- //product[@type=“camera”]/@Prop.

Prop/name

Prop/mpix

Prop/price

XPATHLOG RULES

head(V_1,...,V_n) :- body(V_1,...,V_n)

Constructive semantics of XPath expressions

- Definite XPathLog atoms:
  - use only the child, sibling, and attribute axes
  - no negation, function applications, aggregation, and *proximity position predicates*

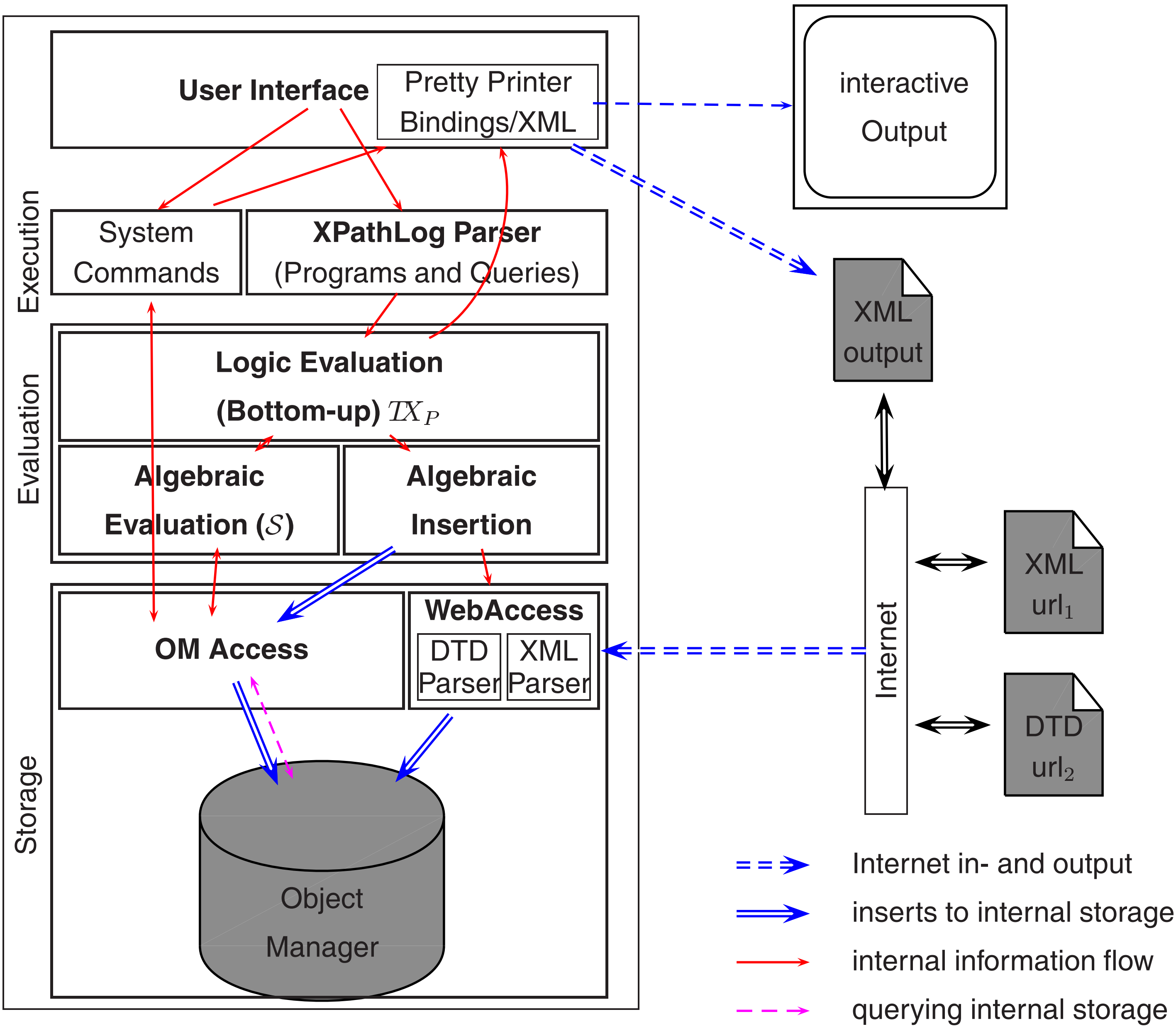
"/" and "[...]" act as constructors:

- $host[property \rightarrow value]$ modifies $host$
- $property$ of the form
  - child::$name$
  - child(i)::$name$
  - preceding/following-sibling::$name$
  - preceding/following-sibling(i)::$name$
  - attribute::$name$

$\Rightarrow$ unambiguous insertions

IMPLEMENTATION: LOPIX

- developed using major components from FLORID



Conclusion

- specialized integration operations for XML data:
  fusing, linking, synonyms
- not compatible with DOM/XML Query Data Model:
  unique-parent
- graph data model suitable & necessary for updates and integration
- 3-level integration process
- manually written integration programs vs. high-level, generic, heuristics-based strategies

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