UNIVERSITY OF PISA – DEPARTMENT OF COMPUTER SCIENCE

XQuake as a Constraint-Based Mining Language

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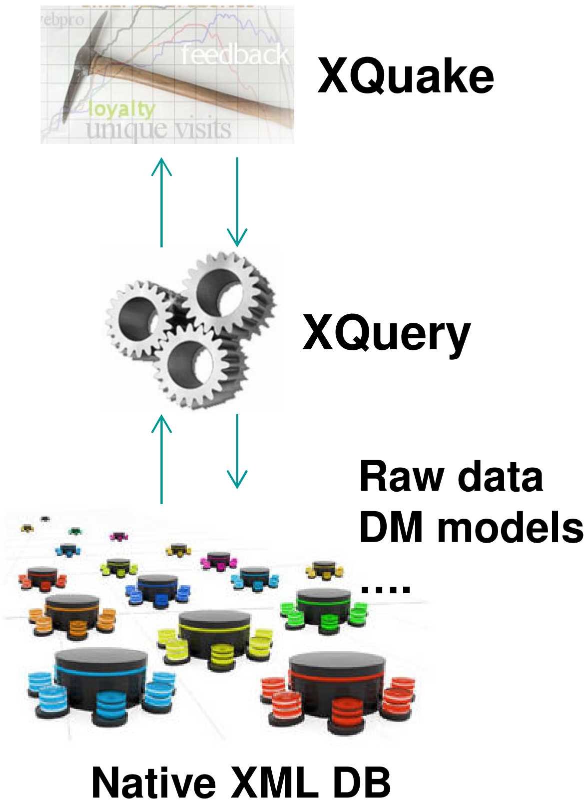
Motivation and objective

- The amount of information coding XML data is growing
  - Systems for storing and querying XML data exist
  - Systems supporting DM features out of XML data are still missing

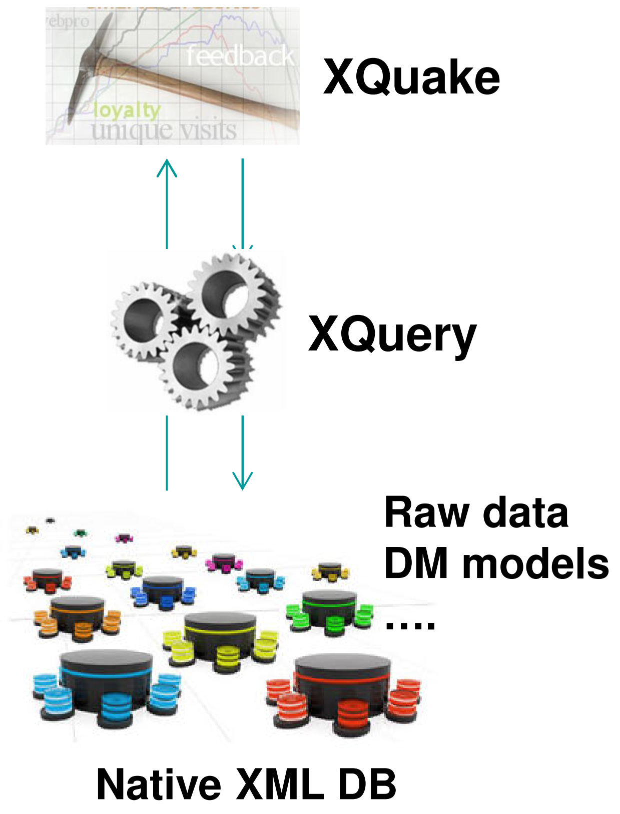
- Our goal is to mine XML data according to the principles of the inductive databases theory (IDBs)
  - We give the main intuition that is behind a constraint-based mining language out of XML data

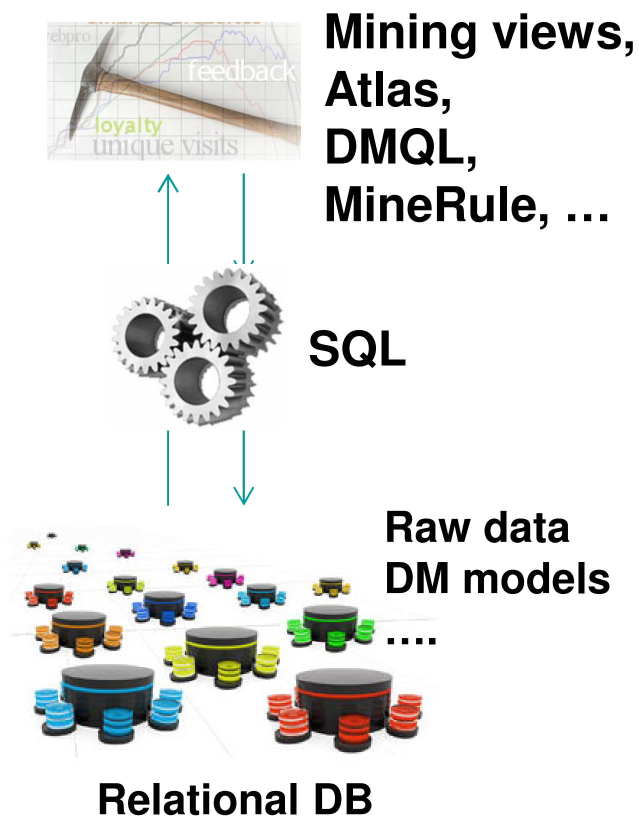
XQuake at a glance



- XQuake is a language/system that extends XQuery with data mining features
- Applications can use XQuery for simple data manipulation/querying or for control structures
- According to the IDB, data and mining models are stored in a native XML DB
- Data mining is performed where the data is stored (i.e. no data transformation/manipulation)

XML-based vs. Relational-based





Mining constructs (1)

- XQuake admits several operators for pre-processing, mining and post-processing
- Each mining operator is made up of a combination of base constructs.
  - The syntax is an adaptation of the XQuery syntax
  - The output result is always an XML sequence
- Base constructs include:
  - Data and models iterators
  - Data/model binder
  - Constraints specification
  - Output constructor

Mining constructs (2)

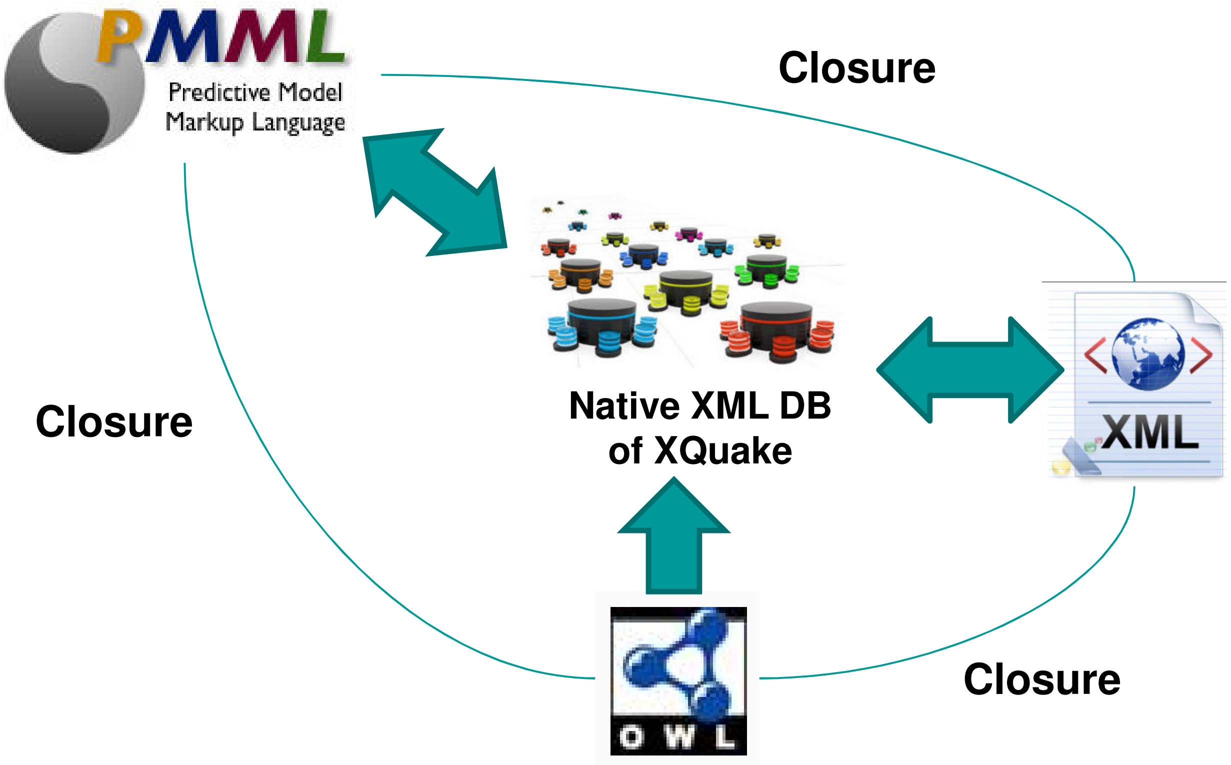
	Data Iterator	Model Iterator	Data/model binder	Constraints	Output
Preproc.	X				X
Mining	X			X	
Model application	X	X	X		X
Model evaluation	X	X	X		X
Filtering		X		X	

Main idea (1)

- XQuake supports only simple constraints
  - E.g. «extract association rules having two items in the antecedent and the item ‘bread’ in the consequent»
- We aim at integrating domain-specific constraints
  - How to represent the background knowledge?
  - How to express the constraint?
  - How to maintain the closure principle?
- Our solution consists in
  - Representing the background knowledge with the aid of an ontology (RDF/OWL)
  - Expressing constraints directly via XQuery predicates
    - A built-in function library is used to query the ontology

Main idea (2)

- The result is in an integrated environment in which all mining entities are represented via XML

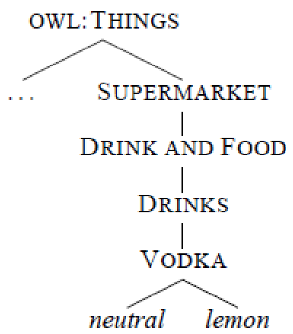


A simple example of use (1)

- A domain expert investigates for a future promotional campaign during the holidays (MBA)
  - The goal is to study the relation between the most frequent drinks promoted at Easter, and the most frequent cakes promoted at Christmas in the past

```
<MBA>
  <store @id="id00193">
    <purchase @date="05/01/2012">
      <item @qty="2" @price="3.5">vodka lemon</item>...
    </purchase>...
  </store>...
</MBA>
```

Input data: XML transactions



attribute	value
hasColour	*neutral*
hasAlcoholic	*high*
hasFlavour	*lemon*
hasBrand	*Best*
hasSize	*70 cl*
hasPrice	*EUR 7.56*
hasPromotion	*Christmas*

Domain knowledge: OWL document

A simple example of use (2)

- We aim at extracting association rules having the following form:

$$(i_1 \in \text{EasterDrink}) \text{ and } (i_2 \in \text{AnyItem}) \text{ and ... and } (i_n \in \text{AnyItem}) \Rightarrow (i_{n+1} \in \text{ChristmasCake}) \text{ [supp] [conf]}$$

- Where:
  - EasterDrink (resp. ChristmasCake) is the class of items that are drinks (resp. cakes) having an Easter (resp. Christmas) promotion
  - AnyItem is the entire set of distinct items

A possible implementation (1)

- XQuery is employed for querying and reasoning with OWL and RDF ontologies
- A built-in function library is used to navigate and to query the ontology

```
declare function local:hasRec($class, $prop)
as xs:boolean {
  let $owl := owldoc("items.owl")
  return sw:hasSuperclass($owl, mfn:item(), $class)
         and sw:hasProperty($owl, mfn:item(),
                            $prop, "hasRecurrency")]
};
```

A possible implementation (2)

- An XQuake construct can be defined to extract association rules satisfying the given constraint
  - The local:hasRec(…) function is directly used inside the mining operator

```
(: Transactions, items and data constraints specif. :)
1.  for data $trans in doc("MBA")/store/purchase
        [@date > "01/01/2012" and @date < "01/05/2012"]
2.  let group $item := $trans/item[@price * @qty > 5.0]

(: Domain knowledge specification :)
3.  let supplementary $hasRec :=
      (<drink>{local:hasRec("Drink","Easter")}</drink>,
       <cake>{local:hasRec("Cake","Christmas")}</cake>)

(: Output constraints specification :)
4.  having (some $v in mfn:supplementary-body()
              satisfies $v/drink) and
5.    count(mfn:supplementary-head()) = 1 and
6.    mfn:supplementary-head[1]/cake and
7.    mfn:support() > 0.50 and mfn:confidence() > 0.70

8. return pmml
```

Final Remarks (1)

- Flexibility
  - As far as the modification of the domain knowledge
    - A built-in library is employed to traverse the ontology
  - As far as the introduction of different kinds of constraints
    - An XQuery predicate is employed to express constraints

- Closure principle
  - Data, mining models and the background knowledge are XML documents
  - XQuery (extended) is used to represent the KDD process

Final Remarks (2)

- Future work
  - Finalizing the implementation of the built-in XQuery library used to navigate the ontology
  - Exploiting domain-specific constraints for different kinds of models
    - E.g. clusters and sequential patterns

[1] J. M. Almendros-Jiménez, 'Querying and reasoning with RDF(S)/OWL in XQuery', in *Proceedings of the* 13^{th} *Web Technologies and Applications Conference (APWeb)*, pp. 450–459, (2011).

[5] A. Romei and F. Turini, 'XML data mining', *Softw., Pract. Exper.*, **40**(2), 101–130, (2010).

[6] A. Romei and F. Turini, 'Programming the KDD process using XQuery', in *Proceedings of the* 4^{th} *International Conference on Knowledge Discovery and Information Retrieval (KDIR)*, pp. 131–139, (2011).