PB138 — XML databases, NoSQL databases

NoSQL databases

- non relational databases, **flexible schema**
- often used for big data applications, clusters
- different storage structure than SQL databases
- **give up constraints**/transactions to improve performance
- low-level interface

NoSQL types

- **key-value**
  - Redis, Memcached, Amazon SimpleDB…
- **document** (JSON, XML…)
  - CouchDB, Elasticsearch, MongoDB…
- **graph / RDF triple**
  - Virtuoso, Neo4j…
- **object**
  - Caché, GemStone…

RDF databases / triple store

- standard data model (RDF)
- standardized interchange format (N-Triples, N-Quads, XML,…)
- query language (SPARQL), Linked Data
- native
  - Apache Jena, Sesame/RDF4J…
- RDF layer to relational database
  - Virtuoso, IBM DB2…

SPARQL

- SPARQL Protocol and RDF Query Language
- W3C Recommendation SPARQL 1.1, March 2013

- *SELECT* - values as table
- *CONSTRUCT* - extract RDF
- *ASK* - true/false
- *DESCRIBE* - extract RDF graph
- inferencing

SPARQL example

Ontology

```
ex1:FullProfessor  rdf:subClassOf  ex1:Professor.
ex1:AssistantProfessor  rdf:subClassOf  ex1:Professor.
ex1:Professor  owl:equivalentClass  ex2:Teacher
```

Data

```
ex1:Bob  rdf:type  ex1:FullProfessor .
ex1:Alice  rdf:type  ex1:AssistantProfessor .
ex2:Mary  rdf:type  ex2:Teacher
```

SPARQL example

Data

```
ex1:Bob  rdf:type  ex1:FullProfessor .
ex1:Alice  rdf:type  ex1:AssistantProfessor .
ex2:Mary  rdf:type  ex2:Teacher
```

SPARQL query

```
SELECT ?x
 WHERE {
 ?x rdf:type ex1:Professor
 }
```

- noone is *Professor*, but inferencing will find Bob, Alice, Mary

XML databases, when to use

- **working with documents** or metadata in XML format
- data format/**schema changes** over time
- complex and variable schema

- structure queries

XML database concepts

- basic element = *document*
- documents gathered in *collections* ("tables")
- query on document structure
- output is document, document fragment, or constructed XML

XML database types

- **XML-enabled** databases
  - mapping XML data to own data model (relational, object…)
    - character large object
    - fragmented to series of tables/objects
    - stored in XML Type
  - **ISO SQL/XML** - element construction, data mapping, enhanced SQL with XQuery
  - Oracle, IBM DB2, MS SQL, PostgreSQL

XML database types

- **native** XML databases
  - using XML data model directly
- open-source
  - eXist, Sedna, BaseX, MonetDB, Oracle/Berkeley DB XML
- commercial
  - MarkLogic, Virtuoso, Qizx

Interface

XQuery

```
<titles>{
for $book in collection("books")/book where $book/year="1990"
return $book/title
}</titles>
```

Interface

XQuery Update

```
update delete collection("books")/book/isbn
```

```
update insert <title>XQuery Guide</title>
 into collection("books")/book[isbn="42"]
```

Interface

SQL/XML (result-table)

```
SELECT
   id, vol,
   xmlquery('$j/name', passing journal as "j") as name
FROM
   journals
WHERE
   xmlexists('$j[licence="CreativeCommons"]',
     passing journal as "j")
```

Interface

SQL/XML (result-XML)

```
SELECT XMLELEMENT (NAME "saleProducts",
     XMLNAMESPACES (DEFAULT 'http://posample.org'),
     XMLAGG (XMLELEMENT (NAME "prod",
        XMLATTRIBUTES (p.Pid AS "id"),
        XMLFOREST (p.name AS "name",
        i.quantity AS "numInStock"))))
FROM PRODUCT p, INVENTORY i
WHERE p.Pid = i.Pid
```

- *XSLT* - output transformation
- *XML Schema* - input validation

Interface

- *XQJ* - XQuery API for Java
  - unified query layer between application and XML Datasource

- prepared statements
- binding variables

Interface

```
XQDataSource xqs = new ExistXQDataSource();
XQDataSource xqs = new SednaXQDataSource();
xqs.setProperty("serverName", "localhost");
XQConnection conn = xqs.getConnection();
XQExpression xqe = conn.createExpression();
String xqueryString =  "for $x in doc('books.xml')//book
   return $x/title/text()";
XQResultSequence rs = xqe.executeQuery(xqueryString);
while(rs.next())
  System.out.println(rs.getItemAsString(null));
conn.close();
```

Interface

- *XML:DB*
- similar concept to JDBC, abstract interface to XML database
  - *Driver* - access to given database
  - *Collection* - document collection in database
  - *Services* - support database features, e.g. XPathQueryService, XUpdateQueryService
  - *Resource* - data stored in database
  - *ResourceSet* - data as result of query

Storage

- **intact document storage**
  - unique identifier for document
  - preferably **parse and index** on storage
  - on query: fast, if application need **access to whole document** and index can select the right document
  - slow, if additional parsing needed

Storage

- **parsing documents**
  - document parsed on save and **stored in own data model** (eg. DOM)

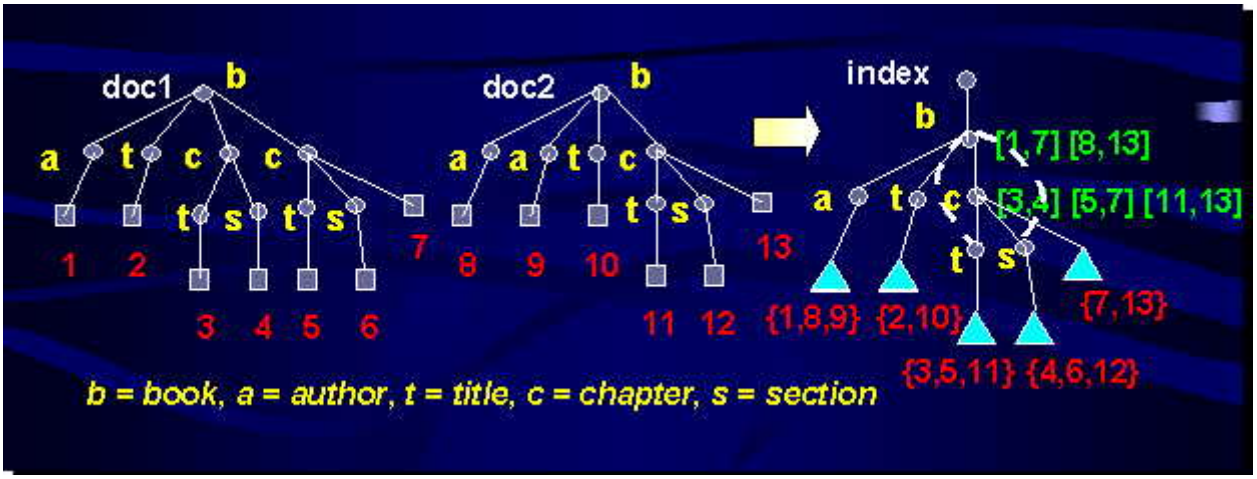
- addressable **numbered nodes** - some operations faster based on numbers
- no need for parsing on query, more efficient
- retrieved document **not 100% same**
- fine granularity for addressing
- **partial modifications**

Indexing

- index scope - collection, database, document
- index target - document, node
- **value** index
  - store all combinations of element/attribute values
- **substring** index
  - for contains() etc., store n-grams

Indexing

- **structural** index
  - track existing paths, enriched tree, trie, DataGuide etc.



Benchmark

- compare database performance
- mostly XQuery speed, less often Update
- data generator (up to GBs) and a set of XQueries
- *XMark*, *XBench*, *XMach-1*
- *TPoX* - complex database testing, XQuery and SQL/XML, indexing, XML Schema, XQuery Update