Introduction to Database Systems
CSE 414

Lecture 14: XQuery, JSON

Announcements

- Midterm: Monday in class
  - Review Sunday 2 pm, SAV 264
  - Includes everything up to, but not including, XML
  - Closed book, no notes; we'll provide needed reference information on the test, but you should know basics of, e.g., SQL.
- Today's lecture: sec. 12.2

Querying XML Data (Review)

- XPath = simple navigation
- XQuery = the SQL of XML
- XSLT = recursive traversal
  - will not discuss in class

- Think of XML/Xquery as one of several data exchange solutions.
  - Another solution: JSON/JSONiq http://www.jsoniq.org/

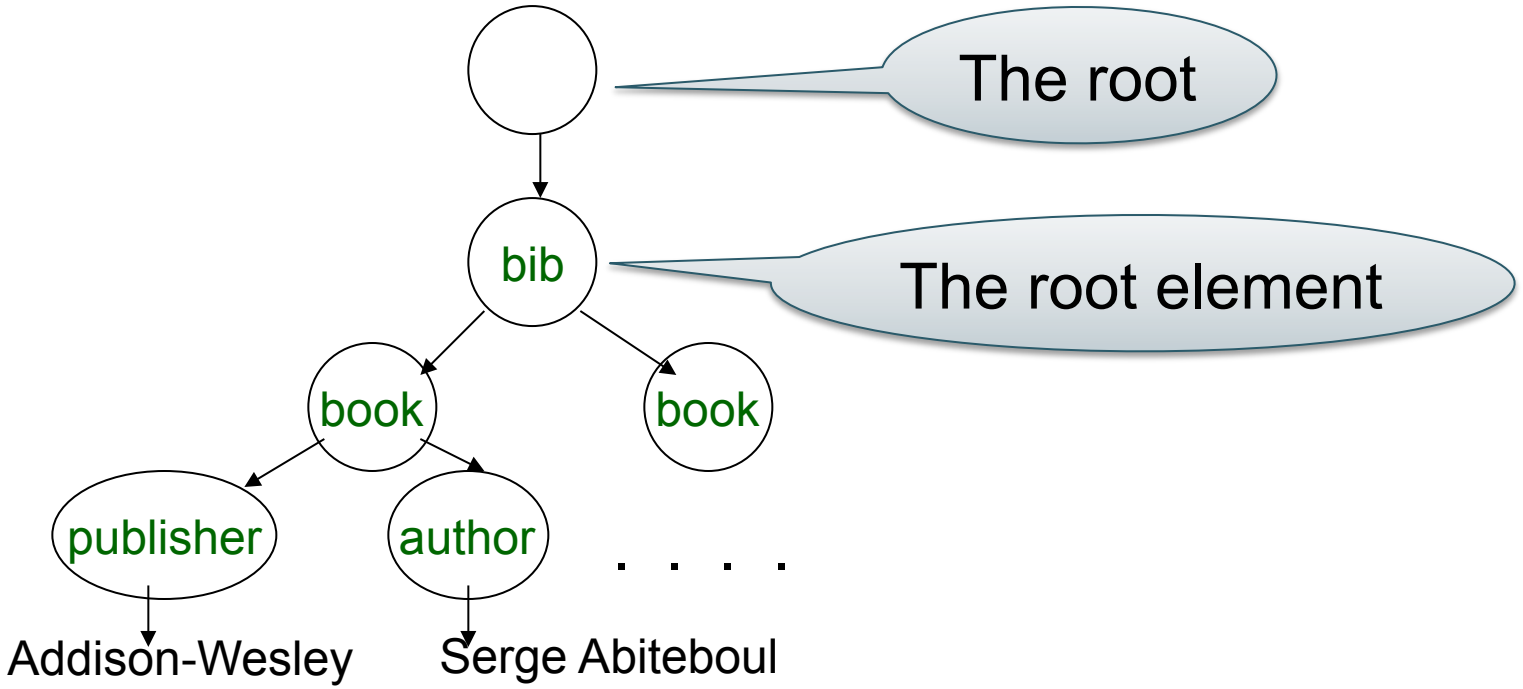
Sample XML Data for Queries

```
<bib>
    <book>  <publisher> Addison-Wesley </publisher>
            <author> Serge Abiteboul </author>
            <author> <first-name> Rick </first-name>
                     <last-name> Hull </last-name>
            </author>
            <author> Victor Vianu </author>
            <title> Foundations of Databases </title>
            <year> 1995 </year>
    </book>
    <book price="55">
            <publisher> Freeman </publisher>
            <author> Jeffrey D. Ullman </author>
            <title> Principles of Database and Knowledge Base Systems </title>
            <year> 1998 </year>
    </book>
</bib>
```

Data Model for Xpath (Review)

XPath returns a sequence of items. An item is either:

- A value of primitive type, or
- A node (doc, element, or attribute)



XPath: Summary (Review)

bib	matches a bib element
*	matches any element
/	matches the root element
/bib	matches a bib element under root
bib/paper	matches a paper in bib
bib//paper	matches a paper in bib, at any depth
//paper	matches a paper at any depth
paper|book	matches a paper or a book
@price	matches a price attribute
bib/book/@price	matches price attribute in book, in bib

bib/book[@price<“55”]/author/last-name matches…

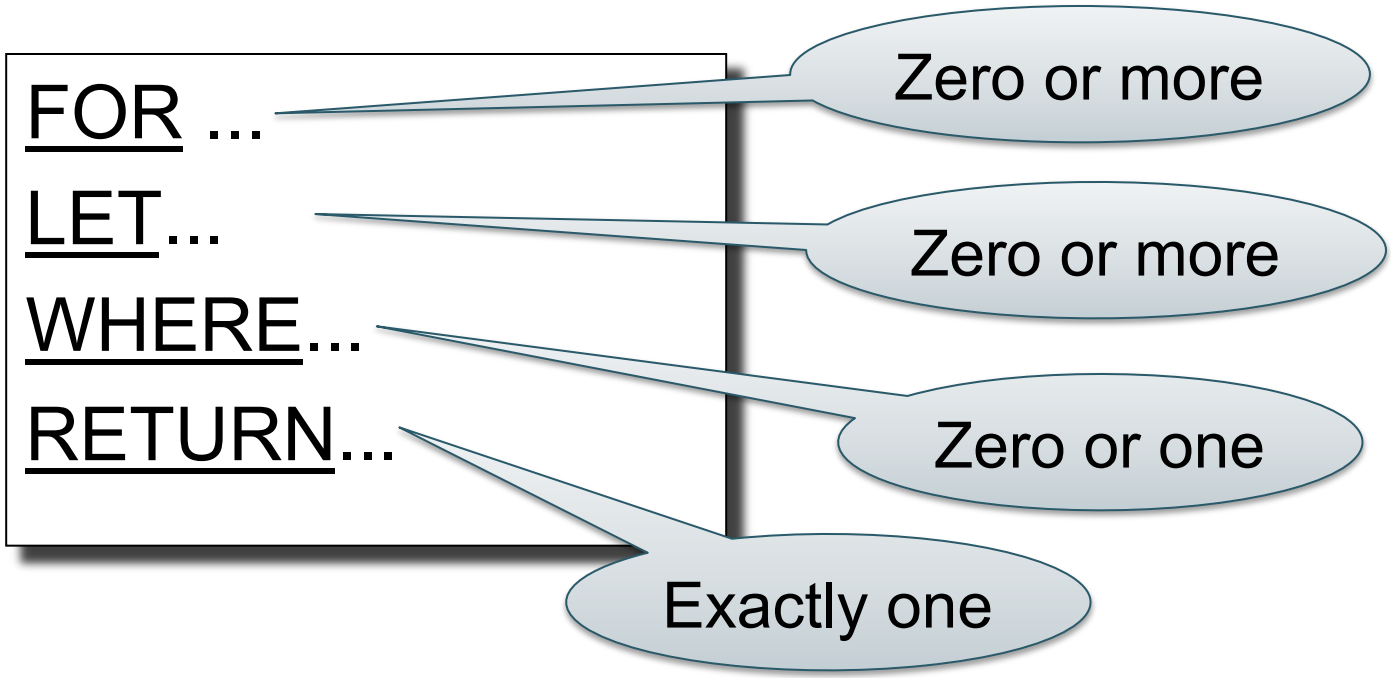
bib/book[@price<“55” or @price>”99”]/author/last-name matches…

XQuery

- Standard for high-level querying of databases containing data in XML form
- Based on Quilt, which is based on XML-QL
- Uses XPath to express more complex queries
  - Every XPath expression is itself a (simple) XQuery or can be part of a more complex query

- Reference: sec. 12.2

FLWR ("Flower") Expressions



FOR-WHERE-RETURN

Find all book titles published after 1995:

```
FOR $x IN doc("bib.xml")/bib/book
WHERE $x/year/text() > 1995
RETURN $x/title
```

Result:

```
<title> abc </title>
<title> def </title>
<title> ghi </title>
```

FOR-WHERE-RETURN

Equivalently (perhaps more geekish)

```
FOR $x IN doc("bib.xml")/bib/book[year/text() > 1995] /title
RETURN $x
```

And even shorter:

```
doc("bib.xml")/bib/book[year/text() > 1995] /title
```

COERCION

The query:

```
FOR $x IN doc("bib.xml")/bib/book[year > 1995] /title
RETURN $x
```

Is rewritten by the system into:

```
FOR $x IN doc("bib.xml")/bib/book[year/text() > 1995] /title
RETURN $x
```

FOR-WHERE-RETURN

- Find all book titles and the year when they were published:

```
FOR $x IN doc("bib.xml")/ bib/book
RETURN <answer>
                <title>{ $x/title/text() } </title>
                <year>{ $x/year/text() } </year>
            </answer>
```

Result:

```
<answer> <title> abc </title>  <year> 1995 </ year > </answer>
<answer> <title> def </title>  < year > 2002 </ year > </answer>
<answer> <title> ghk </title>  < year > 1980 </ year > </answer>
```

FOR-WHERE-RETURN

- Notice the use of “{“ and “}”
- What is the result without them ?

```
FOR $x IN doc("bib.xml")/ bib/book
RETURN <answer>
                <title>  $x/title/text() </title>
                <year> $x/year/text() </year>
              </answer>
```

<answer> <title> $x/title/text() </title> <year> $x/year/text() </year> </answer>

<answer> <title> $x/title/text() </title> <year> $x/year/text() </year> </answer>

<answer> <title> $x/title/text() </title> <year> $x/year/text() </year> </answer>

Nesting

- For each author of a book by Morgan Kaufmann, list all books he/she published:

```
FOR $b IN doc("bib.xml")/bib,
        $a IN $b/book[publisher /text()="Morgan Kaufmann"]/author
RETURN <result>
                  { $a,
                     FOR $t IN $b/book[author/text()=$a/text()]/title
                     RETURN $t
                  }
              </result>
```

In the RETURN clause comma concatenates XML fragments

Result

```
<result>
        <author>Jones</author>
        <title> abc </title>
        <title> def </title>
  </result>
  <result>
        <author> Smith </author>
        <title> ghi </title>
  </result>
```

Aggregates

Find all books with more than 3 authors:

```
FOR $x IN doc("bib.xml")/bib/book
WHERE count($x/author)>3
RETURN $x
```

count = a function that counts
avg = computes the average
sum = computes the sum
distinct-values = eliminates duplicates

Aggregates

Same thing:

```
FOR $x IN doc("bib.xml")/bib/book[count(author)>3]
RETURN  $x
```

Eliminating Duplicates

Print all authors:

```
FOR $a IN distinct-values($b/book/author/text())
RETURN <author> { $a } </author>
```

Note: distinct-values applies ONLY to values, NOT elements

The LET Clause

Find books whose price is larger than average:

```
FOR $b in doc("bib.xml")/bib
LET $a:=avg($b/book/price/text())
FOR $x in $b/book
WHERE $x/price/text() > $a
RETURN $x
```

LET enables us to declare variables

Flattening

Compute a list of (author, title) pairs

Input:

```
<book>
   <title> Databases </title>
   <author> Widom </author>
   <author> Ullman </author>
</book>
```

Output:

```
<answer>
   <title> Databases </title>
   <author> Widom </author>
</answer>
<answer>
   <title> Databases </title>
   <author> Ullman </author>
</answer>
```

```
FOR $b IN doc("bib.xml")/bib/book,
        $x IN $b/title/text(),
        $y IN $b/author/text()
RETURN <answer>
                  <title> { $x } </title>
                  <author> { $y } </author>
               </answer>
```

Re-grouping

For each author, return all titles of her/his books

```
FOR $b IN doc("bib.xml")/bib,
        $x IN $b/book/author/text()
RETURN
  <answer>
    <author> { $x } </author>
    { FOR $y IN $b/book[author/text()=$x]/title
      RETURN $y }
  </answer>
```

Result:

```
<answer>
   <author> efg </author>
    <title> abc </title>
    <title> klm </title>
    . . . .
</answer>
```

What about duplicate authors ?

Re-grouping

Same, but eliminate duplicate authors:

```
FOR $b IN doc("bib.xml")/bib
LET $a := distinct-values($b/book/author/text())
FOR $x IN $a
RETURN
  <answer>
    <author> $x </author>
    { FOR $y IN $b/book[author/text()=$x]/title
      RETURN $y }
  </answer>
```

Re-grouping

Same thing:

```
FOR $b IN doc("bib.xml")/bib,
        $x IN distinct-values($b/book/author/text())
RETURN
  <answer>
     <author> $x </author>
     { FOR $y IN $b/book[author/text()=$x]/title
       RETURN $y }
  </answer>
```

SQL and XQuery Side-by-side

Product(pid, name, maker, price) Find all product names, prices, sort by price

```
SELECT x.name,
       x.price
FROM Product x
ORDER BY x.price
```

SQL

```
FOR $x in doc("db.xml")/db/Product/row
ORDER BY $x/price/text()
RETURN <answer>
          { $x/name,  $x/price }
       </answer>
```

XQuery

XQuery's Answer

```
<answer>
      <name>  abc  </name>
      <price>  7 </price>
</answer>
<answer>
      <name>  def  </name>
      <price>  23 </price>
</answer>
  . . . .
```

Notice: this is NOT a well-formed document ! (WHY ???)

Producing a Well-Formed Answer

```
<myQuery>
  {  FOR $x in doc("db.xml")/db/Product/row
     ORDER BY $x/price/text()
     RETURN <answer>
                  { $x/name,  $x/price }
            </answer>
   }
</myQuery>
```

XQuery's Answer

```
<myQuery>
  <answer>
        <name>  abc  </name>
        <price>  7 </price>
  </answer>
  <answer>
        <name>  def  </name>
        <price>  23 </price>
  </answer>
    . . . .
</myQuery>
```

Now it is well-formed !

SQL and XQuery Side-by-side

Product(pid, name, maker, price)
Company(cid, name, city, revenues)

Find all products made in Seattle

```
SELECT x.name
FROM Product x, Company y
WHERE x.maker=y.cid
      and y.city="Seattle"
```

SQL

```
FOR $r in doc("db.xml")/db,
      $x in $r/Product/row,
      $y in $r/Company/row
WHERE
   $x/maker/text()=$y/cid/text()
   and  $y/city/text() = "Seattle"
RETURN { $x/name }
```

XQuery

Cool XQuery

```
FOR $y in /db/Company/row[city/text()="Seattle"],
      $x in /db/Product/row[maker/text()=$y/cid/text()]
RETURN { $x/name }
```

```
<product>
        <row> <pid> 123 </pid>
                <name> abc </name>
                <maker> efg </maker>
         </row>
         <row> …. </row>
         …
</product>
<product>
   . . .
</product>
. . . .
```

SQL and XQuery Side-by-side

For each company with revenues < 1M count the products over $100

```
SELECT y.name, count(*)
FROM Product x, Company y
WHERE x.price > 100 and x.maker=y.cid and y.revenue < 1000000
GROUP BY y.cid, y.name
```

```
FOR $r in doc("db.xml")/db,
        $y in $r/Company/row[revenue/text()<1000000]
RETURN
    <proudCompany>
        <companyName> { $y/name/text()  }  </companyName>
        <numberOfExpensiveProducts>
         { count($r/Product/row[maker/text()=$y/cid/text()][price/text()>100])}
        </numberOfExpensiveProducts>
    </proudCompany>
```

SQL and XQuery Side-by-side

Find companies with at least 30 products, and their average price

```
SELECT y.name, avg(x.price)
FROM Product x, Company y
WHERE x.maker=y.cid
GROUP BY y.cid, y.name
HAVING count(*) > 30
```

An element

A collection

```
FOR $r in doc("db.xml")/db,
    $y in $r/Company/row
LET $p := $r/Product/row[maker/text()=$y/cid/text()]
WHERE count($p) > 30
RETURN
  <theCompany>
    <companyName> { $y/name/text()  }
    </companyName>
    <avgPrice> avg($p/price/text()) </avgPrice>
  </theCompany>
```

XML Summary

- Stands for eXtensible Markup Language
  1. Advanced, **self-describing file format**
  2. Based on a flexible, **semi-structured data model**

- Query languages for XML
  - XPath
  - XQuery

Beyond XML: JSON

- JSON stands for “**J**ava**S**cript **O**bject **N**otation”
  - Lightweight text-data interchange format
  - Language independent
  - “Self-describing" and easy to understand

- JSON is quickly replacing XML for
  - Data interchange
  - Representing and storing semi-structure data

JSON

```
Example from: http://www.jsonexample.com/
myObject = {
    "first": "John",
    "last": "Doe",
    "salary": 70000,
    "registered": true,
    "interests": [ "Reading", “Biking”, "Hacking" ]
}
```

Query language: JSONiq http://www.jsoniq.org/

Google Protocol Buffers

- Extensible way of serializing structured data
  - Language-neutral
  - Platform-neutral
- Used in communications protocols, data storage, etc.
- How it works
  - Developer specifies the schema in .proto file
  - Proto file gets compiled to classes that read/write the data
    - Compiler is language specific

https://developers.google.com/protocol-buffers/docs/overview

Google Protocol Buffers Example

```
From: https://developers.google.com/protocol-buffers/
message Person {
  required string name = 1;
  required int32 id = 2;
  optional string email = 3;
  enum PhoneType { MOBILE = 0; HOME = 1; WORK = 2; }
  message PhoneNumber {
    required string number = 1;
    optional PhoneType type = 2 [default = HOME];
  }
  repeated PhoneNumber phone = 4;
}
```