# Introduction to Database Systems CSE 444

## Lecture 11 Xpath/XQuery

October 19, 2007

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## Outline

- XPath
- XQuery

- See recommend readings in previous lecture

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## Querying XML Data

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

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## Sample 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>
```

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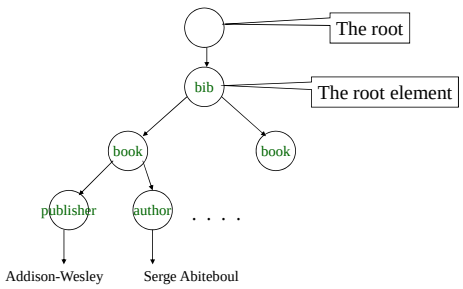
## Data Model for XPath

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## XPath: Simple Expressions

/bib/book/year

Result: <year> 1995 </year>
<year> 1998 </year>

/bib/paper/year

Result: empty (there were no papers)

/bib — What's the difference ? — /

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## XPath: Restricted Kleene Closure

//author

Result: <author> Serge Abiteboul </author>
<author> <first-name> Rick </first-name>
<last-name> Hull </last-name>
</author>
<author> Victor Vianu </author>
<author> Jeffrey D. Ullman </author>

/bib//first-name

Result: <first-name> Rick </first-name>

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## Xpath: Attribute Nodes

/bib/book/@price

Result: "55"

@price means that price is has to be an attribute

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## Xpath: Wildcard

//author/*

Result: <first-name> Rick </first-name>
<last-name> Hull </last-name>

* Matches any element
@* Matches any attribute

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## Xpath: Text Nodes

/bib/book/author/text()

Result: Serge Abiteboul
Victor Vianu
Jeffrey D. Ullman

Rick Hull doesn't appear because he has firstname, lastname

Functions in XPath:
- text() = matches the text value
- node() = matches any node (= * or @* or text())
- name() = returns the name of the current tag

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## Xpath: Predicates

/bib/book/author[firstname]

Result: <author> <first-name> Rick </first-name>
<last-name> Hull </last-name>
</author>

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## Xpath: More Predicates

/bib/book/author[firstname][address[.//zip][city]]/lastname

Result: <lastname> … </lastname>
<lastname> … </lastname>

How do we read this ?
First remove all qualifiers (predicates):

/bib/book/author /lastname

Then add them one by one:

/bib/book/author[firstname][address]/lastname etc

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## Xpath: More Predicates

/bib/book[@price < 60]

/bib/book[author/@age < 25]

/bib/book[author/text()]

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## Xpath: Position Predicates

/bib/book[2] — The 2nd book

/bib/book[last()] — The last book

/bib/book[@year = 1998] [2] — The 2nd of all books in 1998

/bib/book[2][@year = 1998] — 2nd book IF it is in 1998

## Xpath: More Axes

. means *current node* /bib/book[.//review]

/bib/book[./review] Same as /bib/book[review]

/bib/author/. /firstname Same as /bib/author/firstname

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## Xpath: More Axes

.. means *parent node*

/bib/author/.. /author/zip Same as /bib/author/zip

/bib/book[.//review/../comments]

Same as

/bib/book[.//*[comments][review]]

Hint: don't use ..

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## Xpath: Summary

| | |
|---|---|
| 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/lastname | matches… |

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## XQuery

- Based on Quilt, which is based on XML-QL
- Uses XPath to express more complex queries

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## FLWR ("Flower") Expressions

```
FOR ...
LET...
WHERE...
RETURN...
```

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## FOR-WHERE-RETURN

Find all book titles published after 1995:

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

Result:

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

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## FOR-WHERE-RETURN

Equivalently (perhaps more geekish)

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

And even shorter:

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

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## COERCION

The query:

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

Is rewritten by the system into:

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

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## FOR-WHERE-RETURN

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

```
FOR $x IN document("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>
```

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## FOR-WHERE-RETURN

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

```
FOR $x IN document("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>
```

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## Nesting

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

```
FOR $b IN document("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

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## Result

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

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## Aggregates

Find all books with more than 3 authors:

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

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

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## Aggregates

Same thing:

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

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## 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

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## The LET Clause

Find books whose price is larger than average:

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

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## Flattening

- Compute a list of (author, title) pairs

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

Input:

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

Output:

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



## Re-grouping

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

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

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## 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 !

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## 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 document("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>
. . . .
```

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## 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 document("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 document("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>
```

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