Announcements (October 19)

- Homework #3 assigned today
  - Due on October 31
- Project milestone #1 feedbacks available by the end of today, or tomorrow at the latest

---

XQuery

CPS 116
Introduction to Database Systems

---

XQuery

- XPath + full-fledged SQL-like query language
- XQuery expressions can be
  - XPath expressions
  - FLWOR (◊) expressions
  - Quantified expressions
  - Aggregation, sorting, and more…
- An XQuery expression in general can return a new result XML document
  - Compare with an XPath expression, which always returns a sequence of nodes from the input document or atomic values (boolean, number, string, etc.)

---

A simple XQuery based on XPath

Find all books with price lower than $50

```xml
<result>
  { doc("bib.xml")/bibliography/book[@price<50] }
</result>
```

- Things outside `{}`’s are copied to output verbatim
- Things inside `{}`’s are evaluated and replaced by the results

- `doc("bib.xml")` specifies the document to query
  - Can be omitted if there is a default context document
- The XPath expression returns a sequence of book elements
- These elements (including all their descendents) are copied to output

---

FLWOR expressions

- Retrieve the titles of books published before 2000, together with their publisher

```xml
<result>
  for $b in doc("bib.xml")/bibliography/book
  let $p := $b/publisher
  where $b/year < 2000
  return <book>
    { $b/title }
    { $p }
  </book>
</result>
```

- for: loop
  - $b ranges over the result sequence, getting one item at a time
- let: assignment
  - $p gets the entire result of $b/publisher (possibly many nodes)
- where: filter condition
- return: result structuring
  - Invoked in the 'innermost loop', i.e., once for each successful binding of all query variables that satisfies where

---

An equivalent formulation

- Retrieve the titles of books published before 2000, together with their publisher

```xml
<result>
  for $b in doc("bib.xml")/bibliography/book[year<2000]
  return <book>
    { $b/title }
    { $b/publisher }
  </book>
</result>
```
Another formulation

- Retrieve the titles of books published before 2000, together with their publisher

```xml
<result>
  for $b in doc("bib.xml")/bibliography/book,
  $p in $b/publisher
  where $b/year < 2000
  return
  <book>
    { $b/title }
    { $p }
  </book>
</result>
```

- Is this query equivalent to the previous two?
  - Yes, if there is one publisher per book
  - No, in general
    - Two result book elements will be created for a book with two publishers
    - No result book element will be created for a book with no publishers

Yet another formulation

- Retrieve the titles of books published before 2000, together with their publisher

```xml
<result>
  let $b := doc("bib.xml")/bibliography/book
  where $b/year < 2000
  return
  <book>
    { $b/title }
    { $b/publisher }
  </book>
</result>
```

- Is this query correct?
  - No!
  - It will produce only one output book element, with all titles clumped together and all publishers clumped together
  - All books will be processed (as long as one is published before 2000)

Subqueries in return

- Extract book titles and their authors; make title an attribute and rename author to writer

```xml
<bibliography>
  for $b in doc("bib.xml")/bibliography/book
  return
  <book title="normalize-space($b/title)">
    for $a in $b/author
    return <writer>{string($a)}</writer>
  </book>
</bibliography>
```

- `normalize-space(string)` removes leading and trailing spaces from string, and replaces all internal sequences of white spaces with one white space

An explicit join

- Find pairs of books that have common author(s)

```xml
<result>
  for $b1 in doc("bib.xml")//book
  for $b2 in doc("bib.xml")//book
  where $b1/author = $b2/author
    and $b1/title > $b2/title
  return
  <pair>
    {$b1/title}
    {$b2/title}
  </pair>
</result>
```

- These are string comparisons, not identity comparisons!

Existentially quantified expressions

(some $var in collection satisfies condition)

- Can be used in where as a condition

- Find titles of books in which XML is mentioned in some section

```xml
<result>
  for $b in doc("bib.xml")//book
  where (some $section in $b//section satisfies contains(string($section), "XML"))
  return $b/title
</result>
```

Universally quantified expressions

(every $var in collection satisfies condition)

- Can be used in where as a condition

- Find titles of books in which XML is mentioned in every section

```xml
<result>
  for $b in doc("bib.xml")//book
  where (every $section in $b//section satisfies contains(string($section), "XML"))
  return $b/title
</result>
```
Aggregation

List each publisher and the average prices of all its books

```xml
<result>
  for $pub in distinct-values(doc("bib.xml")//publisher)
  let $price := avg(doc("bib.xml")//book[publisher=$pub]/@price)
  return <publisherpricings>
    <publisher>{$pub}</publisher>
    <avgprice>{$price}</avgprice>
  </publisherpricings>
</result>
```

- distinct-values(collection) removes duplicates by value
  - If the collection consists of elements (with no explicitly declared types), they are first converted to strings representing their "normalized contents"
- avg(collection) computes the average of collection (assuming each item in collection can be converted to a numeric value)

Sorting (a brief history)

XPath always returns a sequence of nodes in original document order
- for loop will respect the ordering in the sequence
  - Introduce an operator sort by (sort-by-expression-list) to output results in a user-specified order
  - Example: list all books with price higher than $100, in order by first author; for books with the same first author, order by title
    ```xml
    <result>
      doc("bib.xml")//book[@price>100]
      sort by (author[1], title)
    </result>
    ```

Tricky semantics

List titles of all books, sorted by their prices

```xml
<result>
  doc("bib.xml")//book sort by (@price)/title
</result>
```

- What is wrong?
  - A path expression always returns a sequence of nodes in document order!
- Correct versions
  ```xml
  <result>
    for $b in doc("bib.xml")//book sort by (@price)
    return $b/title
  </result>
  <result>
    doc("bib.xml")//book/title sort by (../@price)
  </result>
  ```

Current version of sorting

As of June 2006
- sort by has been ditched
- Add a new order by clause in FLWR (which now becomes FLWOR)
- Example: list all books with price higher than $100, in order by first author; for books with the same first author, order by title
  ```xml
  <result>
    for $b in doc("bib.xml")//book[@price>100]
    stable order by $b/author[1], $b/title empty least
    return $b
  </result>
  ```

Summary

- Many, many more features not covered in class
- XPath is fairly mature and stable
  - 1.0 is already a W3C recommendation
  - Implemented in many systems
  - Used in many other standards
  - 2.0 is being developed jointly with XQuery
- XQuery is still evolving
  - Still a W3C "candidate" recommendation
  - Many vendors are coming out with implementations
  - Poised to become the SQL for XML

XQuery vs. SQL

- Where did the join go?
- Is navigational query going to destroy physical data independence?
- Strong ordering constraint
  - Can be overridden by unordered { for... }
- Why does that matter?