Lecture 10
XML

Monday, Oct. 21, 2001

Outline

- Finish Datalog (4.2-4.4)
- XML:
  - Syntax, DTDs (*Data on the Web*, 3.1)
  - Semistructured data in XML (3.2)
  - Exporting Relational Data in XML (8.3.1)

Multiple Datalog Rules

Product (pid, name, price, category, maker-cid)
Purchase (buyer-ssn, seller-ssn, store, pid)
Company (cid, name, stock price, country)
Person(ssn, name, phone number, city)

- Find names of buyers and sellers:

  A(n) ← Person(s,n,_,_), Purchase(s,_,_,_)
  A(n) ← Person(s,n,_,_), Purchase(_,s,_,_)

- Multiple rules correspond to union

Multiple Datalog Rules

Product (pid, name, price, category, maker-cid)
Purchase (buyer-ssn, seller-ssn, store, pid)
Company (cid, name, stock price, country)
Person(ssn, name, phone number, city)

- Find Seattle residents who bought products over $100:

  E(s) ← Product(i,_,p,_,_) AND Purchase(s,_,_,i) AND p>100
  A(n) ← Person(s,n,_,"Seattle") AND E(s)

- Multiple rules correspond to sequential computation
- Same as substituting E's body in the second rule

Negation in Datalog

Product (pid, name, price, category, maker-cid)
Purchase (buyer-ssn, seller-ssn, store, pid)
Company (cid, name, stock price, country)
Person(ssn, name, phone number, city)

- Find all "bad pid's" in Purchase (I.e. which don't occur in Product)

  P(p) ← Product(p,_,_,_,_)
  BadP(p) ← Purchase(_,_,_,p) AND NOT P(p)

- Wrong solution why ?

  BadPWrong(p) ← Purchase(_,_,_,p) AND NOT Product(p,_,_,_)

Negation in Datalog (continued)

Product (pid, name, price, category, maker-cid)
Purchase (buyer-ssn, seller-ssn, store, pid)
Company (cid, name, stock price, country)
Person(ssn, name, phone number, city)

- Find products that were never sold:

  Sold(p) ← Purchase(_,_,_,p) AND Product(p,_,_,_,_)
  NeverSold(p)← Product(p,_,_,_) AND NOT Sold(p)

Relational Algebra and Datalog

- Datalog:
  - Friendly
  - Says nothing about how to evaluate
- Relational Algebra
  - Unfriendly
  - Can say in which order to evaluate
- Good news: relational algebra is equivalent to (non-recursive) datalog !

From Relational Algebra to Datalog

- Union R1 U R2:
  S(x,y,z) ← R1(x,y,z)
  S(x,y,z) ← R2(x,y,z)
- Difference R1 - R2
  S(x,y,z) ← R1(x,y,z) AND NOT R2(x,y,z)
- Cartesian product R1 x R2
  S(x,y,z,u,w) ← R1(x,y,z) AND R2(u,w)

From RA to Datalog (cont'd)

- Selection $\sigma_{z > 35}(R)$

  S(x,y,z,u) ← R(x,y,z,u) AND z > 35

- Projection $\Pi_{x,z}(R)$

  S(x,z) ← R(x,y,z,u)

From (non-recursive) Datalog to RA

- Let's take an example: R(A,B,C), S(D,E,F,G), T(H,I)
  S(x,y) ← R(x,y,z) AND S(y,y,w,x) AND T(z,55)
- First make all variables distinct, add arithmetic atoms:
  S(x,y) ← R(x,y,z) AND S(y1,y2,w,x3) AND T(z4,c5)
  AND y=y1 AND y1=y2 AND x=x3
  AND z=z4 AND c5=55
- In RA: a select-project-join expression:
  $\Pi_{A, B}(\sigma_{B=D \text{ AND } D=E \text{ AND } A=G \text{ AND } C=H \text{ AND } I=55}(R \times S \times T))$

From (non-recursive) Datalog to RA

- Exercises:
  - Translate a rule with negation to RA (hint: use difference)
  - Translated multiple rules to RA (hint: use union and/or substitutions; remember that rules are non-recursive)

Recursive Datalog Programs

- Recall:
  - Find Fred's relatives

Name1	Name2	Relation ship
Fred	Mary	Father
Mary	Joe	Cousin
Mary	Bill	Spouse
Nancy	Lou	Sister

Relative(x) ← R("Fred",x,_)
Relative(y) ← Relative(x) AND R(x,y,_)

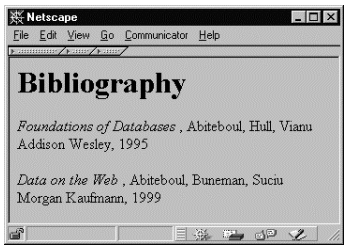
Recommended reading: 4.4

XML

Facts About XML

- 254 books at Amazon
- 6,344,313 pages at www.altavista.com
- Every database vendor has an XML page:
  - www.oracle.com/xml
  - www.microsoft.com/xml
  - www.ibm.com/xml
- Many applications are just fancier Websites
- But, most importantly, XML enables data sharing on the Web – hence our interest

What is XML ?
From HTML to XML



HTML describes the presentation: easy for humans

HTML

```
<h1> Bibliography </h1>
<p> <i> Foundations of Databases </i>
      Abiteboul, Hull, Vianu
      <br> Addison Wesley, 1995
<p> <i> Data on the Web </i>
      Abiteboul, Buneman, Suciu
      <br> Morgan Kaufmann, 1999
```

HTML is hard for applications

XML

```
<bibliography>
    <book>   <title> Foundations… </title>
             <author> Abiteboul </author>
             <author> Hull </author>
             <author> Vianu </author>
             <publisher> Addison Wesley </publisher>
             <year> 1995 </year>
    </book>
    …
</bibliography>
```

XML describes the content: easy for applications

XML

- eXtensible Markup Language
- Roots: comes from SGML
  - A very nasty language
- After the roots: a format for sharing *data*
- Emerging format for data exchange on the Web and between applications

XML Applications

- Sharing data between different components of an application.
- Archive data in text files.
- EDI: electronic data exchange:
  - Transactions between banks
  - Producers and suppliers sharing product data (auctions)
  - Extranets: building relationships between companies
- Scientists sharing data about experiments.
- Sending data by email -- see project

XML Syntax

- Very simple:

```
<db>
 <book>
    <title>Complete Guide to DB2</title>
    <author>Chamberlin</author>
 </book>
 <book>
    <title>Transaction Processing</title>
    <author>Bernstein</author>
    <author>Newcomer</author>
 </book>
 <publisher>
   <name>Morgan Kaufman</name>
   <state>CA</state>
 </publisher>
</db>
```

XML Terminology

- tags: book, title, author, …
- start tag: <book>, end tag: </book>
- start tags must correspond to end tags, and conversely

XML Terminology

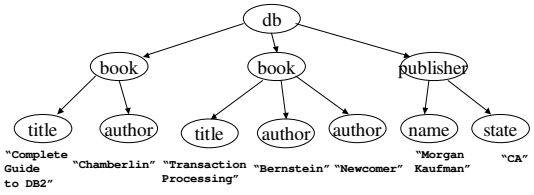
- an element: everything between tags
  - example element:
    <title>Complete Guide to DB2</title>
  - example element:

```
<book> <title> Complete Guide to DB2 </title>
       <author>Chamberlin</author>
</book>
```

- elements may be nested
- empty element: <red></red> abbreviated <red/>
- an XML document has a unique root element

well formed XML document: if it has matching tags

The XML Tree



Tags on nodes
Data values on leaves

More XML Syntax: Attributes

```
<book price = "55" currency = "USD">
  <title>    Complete Guide to DB2 </title>
  <author> Chamberlin </author>
  <year>   1998 </year>
</book>
```

price, currency are called *attributes*

Replacing Attributes with Elements

```
<book>
  <title>    Complete Guide to DB2 </title>
  <author> Chamberlin </author>
  <year>   1998 </year>
  <price>  55 </price>
  <currency> USD </currency>
</book>
```

attributes are alternative ways to represent data

"Types" (or "Schemas") for XML

- Document Type Definition – DTD
- Define a *grammar* for the XML document, but we use it as substitute for types/schemas
- Will be replaced by XML-Schema (will extend DTDs)

An Example DTD

```
<!DOCTYPE db [
  <!ELEMENT db   ((book|publisher)*)>
  <!ELEMENT book (title,author*,year?)>
  <!ELEMENT title      (#PCDATA)>
  <!ELEMENT author  (#PCDATA)>
  <!ELEMENT year  (#PCDATA)>
  <!ELEMENT publisher  (#PCDATA)>
]>
```

- PCDATA means *Parsed Character Data* (a mouthful for *string*)

More on DTDs: Attributes

```
<!DOCTYPE db [
  <!ELEMENT db   ((book|publisher)*)>
  <!ELEMENT book (title,author*,year?)>
  . . .
  <!ATTLIS book   price      CDATA  #REQURED
                  language CDATA #IMPLIED>
  <!ATTLIS author phone    CDATA #IMPLIED>
]>
```

Default declaration:
#REQUIRED=required
#IMPLIED=optional
#FIXED=fixed (rarely used)

The type:
CDATA = string
ID = a key
IDREF = a foreign key
others=rarely used

```
<db>
  <book price="55" language="English">
    <title>    Complete Guide to DB2 </title>
    <author> Chamberlin </author>
  </book>
…
</db>
```

DTDs as Grammars

Same thing as:

```
db          ::=  (book|publisher)*
book        ::=  (title,author*,year?)
title       ::=  string
author      ::= string
year        ::= string
publisher   ::= string
```

- A DTD is a EBNF (Extended BNF) grammar
- An XML tree is precisely a derivation tree

XML Documents that have a DTD and conform to it are called valid

More on DTDs as Grammars

```
<!DOCTYPE paper [
  <!ELEMENT paper   (section*)>
  <!ELEMENT section ((title,section*) | text)>
  <!ELEMENT title      (#PCDATA)>
  <!ELEMENT text      (#PCDATA)>
]>
```

```
<paper> <section> <text> </text> </section>
        <section> <title> </title> <section> … </section>
                                   <section> … </section>
        </section>
</paper>
```

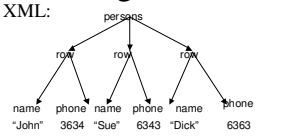
XML documents can be nested arbitrarily deep

XML for Representing Data

persons

name	phone
John	3634
Sue	6343
Dick	6363

XML:




```
<persons>
    <row> <name>John</name>
          <phone> 3634</phone></row>
    <row> <name>Sue</name>
          <phone> 6343</phone>
    <row> <name>Dick</name>
          <phone> 6363</phone></row>
</persons>
```

XML vs Data Models

- XML is self-describing
- Schema elements become part of the data
  - Reational schema: persons(name,phone)
  - In XML <persons>, <name>, <phone> are part of the data, and are repeated many times
- Consequence: XML is much more flexible
- XML = semistructured data

Semi-structured Data Explained

- Missing attributes:

```
<person>   <name> John</name>
           <phone>1234</phone>
 </person>

<person>  <name>Joe</name>
</person>
```

← no phone !

- Repeated attributes

```
<person> <name> Mary</name>
         <phone>2345</phone>
         <phone>3456</phone>
</person>
```

← two phones !

Semistructured Data Explained

- Attributes with different types in different objects

```
<person> <name>  <first> John </first>
                 <last> Smith </last>
         </name>
         <phone>1234</phone>
</person>
```

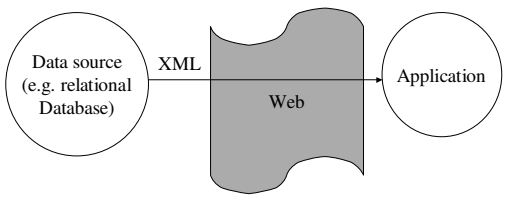
← structured name !

- Nested collections (no 1NF)
- Heterogeneous collections:
  - <db> contains both <book>s and <publisher>s

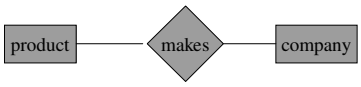
XML Data v.s. E/R, ODL, Relational

- Q: is XML better or worse ?
- A: serves different purposes
  - E/R, ODL, Relational models:
    - For centralized processing, when we control the data
  - XML:
    - Data sharing between different systems
    - we do not have control over the entire data
    - E.g. on the Web
- Do NOT use XML to model your data ! Use E/R, ODL, or relational instead.

Data Sharing with XML: Easy ☺



Exporting Relational Data to XML



- Product(pid, name, weight)
- Company(cid, name, address)
- Makes(pid, cid, price)

Export data grouped by companies

```
<db><company>  <name> GizmoWorks </name>
               <address> Tacoma </address>
               <product> <name> gizmo </name>
                         <price> 19.99 </price>
               </product>
               <product> …</product>
      …
   </company>
   <company>   <name> Bang </name>
               <address> Kirkland </address>
               <product> <name> gizmo </name>
                <price> 22.99 </price>
               </product>
               …
   </company>
   …
</db>
```

Redundant representation of products

The DTD

```
<!ELEMENT db (company*)>
<!ELEMENT company (name, address, product*)>
<!ELEMENT product (name,price)>
<!ELEMENT name    (#PCDATA)>
<!ELEMENT address (#PCDATA)>
<!ELEMENT price      (#PCDATA)>
```

Export Data by Products

```
<db> <product> <name> Gizmo </name>
               <manufacturer>
                     <name> GizmoWorks </name>
                     <price> 19.99 </price>
                     <address> Tacoma </address>
               </manufacturer>
               <manufacturer>
                     <name> Bang </name>
                     <price> 22.99 </price>
                     <address> Kirkland </address>
               </manufacturer>
               …
      </product>
      <product> <name> OneClick </name> …
</db>
```

Redundant Representation of companies

Which One Do We Choose ?

- The structure of the XML data is determined by agreement, with our partners, or dictated by committees
  - Many XML dialects (called *applications*)
- XML Data is often nested, irregular, etc
- No normal forms for XML ☺

Storing XML Data

- We got lots of XML data from the Web, how do we store it ?
- Ideally: convert to relational data, store in RDBMS
- Much harder than exporting relations to XML (why ?)
- DB Vendors currently work on tools for loading XML data into an RDBMS