COS 597A:
Principles of
Database and Information Systems

XML and Information Exchange

XML
eXtensible Markup Language

History

1988 SGML: Standard Generalized Markup Language
- Annotate text with structure

1992 HTML: Hypertext Mark-up Language
- Documents that are linked pieces
- Simple structure of language

1996 XML
- General-purpose description of content of a *document*
- Includes namespaces → linking across the Web
- Designed by working group of W3C (World Wide Web Consortium)
  - Define standard

Outline

- XML document structure
- XML querying with XQuery
- XML name spaces
- XML Schema definition

XML

On surface looks much like HTML:

- Tags: <title> *title of document*</title>
- Structure: tags within tags
  <body><table> …</table> … </body>
  - Must be nested → hierarchy
- Tags have attributes <body bgcolor="#ffffff">

But **Tags are User-defined**
- General *metadata*

XML

- Originally tags generalized description of document display– allow flexibility in markup
- Now tags can have *any* meaning
  - parties using *agree in advance* as to meaning
- Can use as data specification

XML has become major vehicle of exchanging data among unrelated, heterogeneous parties
- Internet major vehicle of distribution

Example XML

```
<students>
   <student>
        <startyear>2008</startyear>
        <name><fn>Joe </fn><ln>Jones</ln></name>
        <address>…</address>
        <course type="dept">cos 597A</course>
        <course type="dept">cos 402</course>
        <course type="elective">wri 503</course>
        etc.
   </student>
   <student> ……</student>
        ….
</students>
```

Important XML concepts

- Information/data contained in a document
  - Document = Database
- Tags contain text and other tags
- Tags can be repeated arbitrary number of times
- Tags may or may not appear
  - Example for <student>: …<generals>April 2008</generals>…
- Attributes of tags (strings) may or may not appear
- Tags need not appear in rigid order

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Benefits of XML representation

- Self documenting by tag names
- Flexible formatting
  - Can introduce new tags or values
- Format can evolve without invalidating old
- Can have multi-valued components
  - e.g. courses of student, authors of book
- Wide variety of tools can process
  - Browsers
  - DB tools

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Undesirable properties of XML representation

- Verbose representation:
  repetition of tag names
  - Inefficient
- Redundant representation
  - Document contains all info, even if much does not change
    - e.g. document containing employee info:
      basic name, address, etc. repeated even if only assignment changes
    - Compare one table in relational DB

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Board Example

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Specification

Need exchange syntax (semantics?) as well as XML document:

- XSL – eXtensible Style Language
  - How display information
- DTD = Document Type Declaration
  - User specifies own tags and attributes
  - User-defined grammar for syntax

➢ XML Schema – similar to but more general than DTD

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Semistructured Data Model

- XML gives structure, but not fully or rigidly specified
- Tag <> … </> defines XML element
  - Elements may contain sub-elements
  - Elements may contain values
  - Elements may have attributes
- Use labeled tree model
  - Element → node: atomic or compound object
  - Leaves: values and attributes

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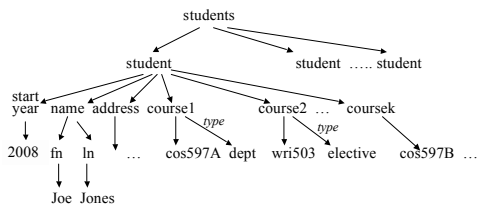
Example

```
<students>
   <student>
        <startyear>2008</startyear>
        <name><fn>Joe </fn><ln>Jones</ln></name>
        <address>…</address>
        <course type="dept">cos 597A</course>
        <course type="elective">wri 503 </course>
        etc.
   </student>
   <student> ……</student>
        ….
</students>
```

XML Tools

- Display
  - Very flexible what and how display
- Convert to different representation
  - Example: put in relational database?
- Extract information from XML document
  - ➢Querying

Querying XML

- Storing data in XML; want to query
- Could map to relational model, but then must restructure data
- Several querying languages
  - XPath : now building block
  - Quilt : historic
  - XQuery
  - XSLT : designed for style sheets but general

XQUERY

- Specified by W3C working group
  - Circa 2000
- Derived from older languages
- Modeled after SQL

Brief look at XQUERY

FLWOR (flower) expression:

- FOR *path expression* – anal. to SQL "FROM"
- LET *variable name = path expression* – anal. To SQL "AS"
- WHERE *condition* – anal. to SQL "WHERE"
- ORDER BY – anal. to SQL "ORDER BY"
- RETURN – constructs XML result – anal to SQL "SELECT"

XQUERY returns XML fragment

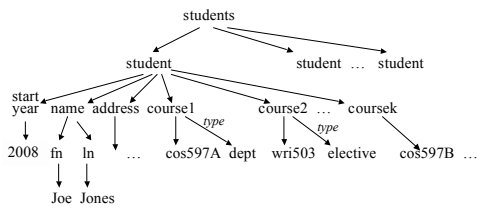
- XML $\xrightarrow{\text{XQuery}}$ XML
  - Compare: relations $\xrightarrow{\text{SQL}}$ relation

Path expression

- Traverse paths of tree
  - Use element names to name path
- Take ***all*** matching branches
- Returns sequence of nodes of tree
  - Node = XML elements

Doc. Identifier	//	element name	/
e.g. URL root of tree	indicates element nested anywhere- jump down tree at this point in path		indicates immed. child of path so far

e.g. /students/student/course



Path expressions – *some* details

- Returns sequence of matching elements
  - Includes tags of those elements
  - Sequence ordered by appearance in document
- Attributes can be accessed: @attribute_name
- … /* denotes *all children* of elements …/
- Predicates at any point in path
  - Prunes out paths
  - e.g. /students/student/course[@type='dept']
- Doc(*document name*) returns root of a named document
  - File name
  - URL (URI)

XQuery FOR …

For $x in *path expression 1,*
$y *in path expression 2,*
...

- $ precedes variable name
- Each variable ranges over sequence of elements returned by its path expression
- Multiple variables => Cartesian product

XQuery Let …

Let $z := *path expression1*
Let $q := *path expression2*
...

Value of variable (e.g. $z) is entire sequence if path expression returns sequence

XQuery WHERE …

WHERE *predicate*

- Predicate on set defined in FOR
  FOR $b IN /students/student
  WHERE $b/startyear='2009'
- Rich set of functions, comparison operations

XQuery RETURN …

- Constructs XML result
- Give explicit tags for result
- Give expressions to be evaluated
  {*expression*}
- Example

```
FOR $b IN doc_id/students/student
WHERE $b/startyear='2009'
RETURN <Result>{$b/name/fn $b/name/ln} </Result>
```

Gives: <Result><fn>Joe</fn><ln><Jones></ln></Result>
<Result> …
etc.

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Example

```
FOR $x IN doc_id//name/ln
RETURN <LastName>{$x}</LastName>
```

Gives: ?
For :
```
<students>
  <student>
    <startyear>2009</startyear>
    <name><fn>Joe </fn><ln>Jones</ln></name>
    …
  </student>
  <student>
    <startyear>2008</startyear>
    <name><fn>Jane </fn><ln>Smith</ln></name>
    …
  </student>

</students>
```

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Examples

```
FOR $x IN doc_id//name/ln
RETURN < LastName >{$x}</LastName >
```

Gives: <LastName><ln>Jones</ln></LastName>
< LastName ><ln>Smith</ln></LastName >

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Examples

```
FOR $x IN doc_id//name/ln
RETURN < LastName >{$x/text()}</LastName >
```

Gives: <LastName>Jones</LastName>
< LastName >Smith</LastName >

- Many functions

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XQuery: A *very* incomplete list of features

- Are aggregation operations
- Can nest XQuery expressions in RETURN clause
  - Can get nested elements in result not nested in original
- Get joins: conditions in WHERE coordinate paths expressions over variables in FOR
- Can have if…then ...else within RETURN clause
- Can have quantification within WHERE clause
  - SOME $e IN *path expression* SATISFIES *predicate with $e free*
  - EVERY $e IN …

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Outline

- ✓ XML document structure
- ✓ XML querying with XQuery
- XML name spaces
- XML Schema definition

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Namespaces

- Exchanging XML documents with unrelated sites, unrelated applications requires unambiguous identifiers across sources of documents
- XML allows each source to specify a globally unique name: universal resource identifiers (URIs)
  - URLs
- Names within one source expect source to keep unambiguous

Namespace specification

- Prepend URI to each tag or attribute name
  http://www.princeton.edu:student
- Verbose – have abbreviation mechanism
  Attribute within *roo*t tag: xmlns:*abbrev*="*URI*"

<students xmlns:PUstu="http://www.princeton.edu">
  <PUstu:student>
  <PUstu:year>2005</PUstu:year>
  …

Becomes part of tag name

Multiple namespaces

- One document can have several namespaces defined and used
  - Different sources
  - Sources need not be sites
- Namespace can denote specific XML standard
  - Extend types
  - Extend functions

xmlns:xs="http://www.w3.org/2001/XMLSchema"
Get types "xs:string", "xs:decimal"

Leads us to …

Outline

- ✓ XML document structure
- ✓ XML querying with XQuery
- ✓ XML name spaces
- **XML Schema definition**

Language *XML Schema*

Standard for specifying schema of a document:

- Specify tag names, attribute names
- Declare leaf types (contents)
  - Built-in types
  - User-defined types
- Declare tag structure
  - tree model
- Specify constraints:
  - key
  - foreign key

XML Schema specification

The schema for a document is
an XML document

Says using specific w3c standard from namespace

<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema">

. . . *specification of document*

</xs:schema>

XScheme Basics

- Declare elements (nodes of tree)

<xs:element name="…" type="…" > … </xs:element

name of element declaring type of element content: nested elements attributes

– if no nested elements and element has no attributes, can abbreviate to <xs:element name="…" type="…" />

example

<xs:element name="isbn" type="xs:string" />

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Nested elements

- Choice 1:

<xs:element name="…" > no type declared
  <xs:complexType>
    <xs:sequence>
      <xs: element name="…" …>
      </xs:element>
      …
      <xs: element name="…" …>
      </xs:element>
    </xs:sequence>
  </xs:complexType>
</xs:element>

declaration for nested elements

could be nesting within nesting

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Define named complex type

- Choice 2:

<xs:complexType name="*typename*">
  <xs:sequence>
    <xs: element name="…" …>
    </xs:element>
    …
    <xs: element name="…" …>
    </xs:element>
  </xs:sequence>
</xs:complexType>

sequence as for choice 1

<xs:element name="…" type= "*typename*"/>

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Other parts specification

- attribute declaration: in content part:
  <xs:attribute name="…" type="…" />
- refer to previously defined element:
  <xs:element ref="*name of prev. defined element*" />
- multiple occurrences of element in a sequence
  – specify and quantify

<xs:sequence>
  <xs:element … minOccurs="…" maxOccurs="…" >
</xs:sequence>

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Putting example all together

```
< xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema">
    <xs:element name="books" type="ListBooksType"/>
    <xs:element name="book" type="BookType"/>
    <xs:complexType name="BookType">
        <xs:attribute name="in_print"/>
        <xs:sequence>
            <xs:element name="title" type="xs:string"/>
            <xs:element name="isbn" type="xs:string"/>
            <xs:element name="edition" type="xs:string"/>
            <xs:element name="date" type="xs:string"/>
        </xs:sequence>
    </xs:complexType>
    <xs:complexType name="ListBooksType">
        <xs:sequence>
            <xs:element ref="book" minOccurs="1" maxOccurs="unbounded"/>
        </xs:sequence>
    </xs:complexType>
</xs:schema>
```

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Primary keys and Foreign keys

- defining a candidate key:

<xs:key name="*name you give*" >
  <xs:selector xpath=" *a path specification* " /> path to key
  <xs:field xpath = "*names of fields*" />
</xs:key> elements and attributes that make up key

- defining a foreign key constraint:

<xs:keyref name="*name you give*"
    refer="name of candidate key referencing">
  <xs:selector xpath=" *a path specification* " />
  <xs:field xpath = "*names of fields*" />
</xs:keyref>

- These top-level definitions within scheme

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XML uses for information exchange

- Many and wide range of applications use XML to exchange information (data)
- Some examples:
  - PADS tool here (Prof. Walker) converts “ad hoc" (nonstandard) data file into an XML file
    - XML one of choices
  - XML standards for specifying 3D models
    - Acrobat (U3D)
    - Google (Collada)
  - describe security vulnerabilities
  - W3C specify XML standards

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SUMMARY

- XML is language for representing information (data) in semi-structured way
  - Self documenting by tag names
  - Flexible formatting
  - Began as language for generalizing specification of document display
- Generality allows XML to be important information exchange format for internet
- ***XML Schema*** provides formal specification of document schema
- ***XQuery*** provides SQL-like query language for extracting information from an XML document

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