CMSC 724: XML

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XML

- eXtensible Markup Language
  - Came out of document community
  - Simplified subset of: Standard Generalized Markup Language (SGML)
- De facto data exchange format
  - Self-describing (although beware of Semantic Heterogeneity)
  - Text (passes through firewalls, compresses well)

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  - Text (passes through firewalls, compresses well)
- NOTE:
  - Somewhat older paper
    - Different languages popular today
    - XPath, XQuery etc..
- Much work since then on this topic

XML: Example

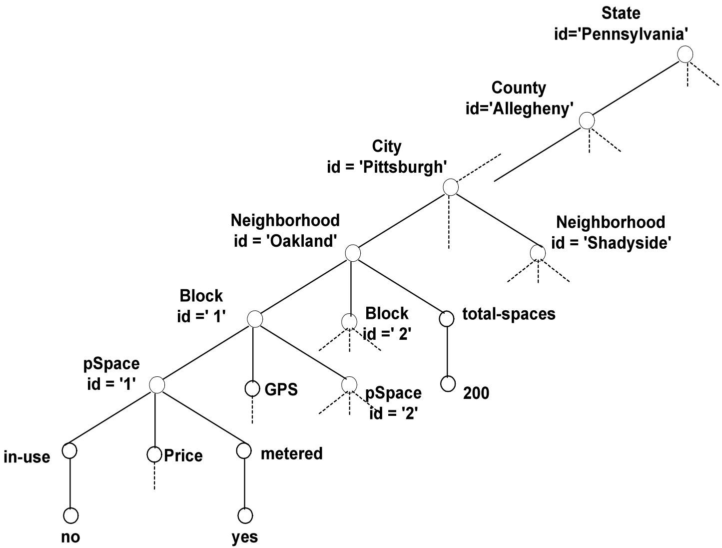
- From the Irisnet project...

Example XML: Parking Space Information

```
<State id="Pennysylvinia">
  <County id="Allegheny">
    <City id="Pittsburgh">
      <Neighborhood id="Oakland">
        <total-spaces>200</total-spaces>
        <Block id="1">
          <GPS>…</GPS>
          <pSpace id="1">
            <in-use>no</in-use>
            <metered>yes</metered>
          </pSpace>
          <pSpace id="2">
            …
          </pSpace>
        </Block>
      </Neighborhood>
      <Neighborhood id="Shadyside">
```

[[pSpace == parking space]]

Example XML Fragment for PSF



XML Standardization

- XML may allow arbitrary structures, but need **schemas** and **namespaces** to exchange data
- Schema languages
  - Initially DTD (Document Type Definition)
  - XMLSchema is more standard now
  - However XMLSchema is considered too complex, and there are many alternatives
    - RELAX NG
    - Schematron, Examplotron etc...
    - See for a comparison
- Purpose of namespaces is to mainly avoid duplicate attribute/element names
  - But also commonly used to define attributes or elements
  - See here for more information

XML DTDs

```xml
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<!DOCTYPE people_list [
  <!ELEMENT people_list (person)*>
  <!ELEMENT person (name, birthdate?, gender?, socialsecuritynumber?)>
  <!ELEMENT name (#PCDATA)>
  <!ELEMENT birthdate (#PCDATA)>
  <!ELEMENT gender (#PCDATA)>
  <!ELEMENT socialsecuritynumber (#PCDATA)>
]>
<people_list>
  <person>
    <name>Fred Bloggs</name>
    <birthdate>2008-11-27</birthdate>
    <gender>Male</gender>
  </person>
</people_list>
```

XML Schema

```xml
<?xml version="1.0" encoding="utf-8"?>
<xs:schema elementFormDefault="qualified" xmlns:xs="http://www.w3.org/2001/XMLSchema">
  <xs:element name="Address">
    <xs:complexType>
      <xs:sequence>
        <xs:element name="Recipient" type="xs:string" />
        <xs:element name="House" type="xs:string" />
        <xs:element name="Street" type="xs:string" />
        <xs:element name="Town" type="xs:string" />
        <xs:element name="County" type="xs:string" minOccurs="0" />
        <xs:element name="PostCode" type="xs:string" />
        <xs:element name="Country">
          <xs:simpleType>
            <xs:restriction base="xs:string">
              <xs:enumeration value="FR" />
              <xs:enumeration value="DE" />
              <xs:enumeration value="ES" />
              <xs:enumeration value="UK" />
              <xs:enumeration value="US" />
            </xs:restriction>
          </xs:simpleType>
        </xs:element>
      </xs:sequence>
    </xs:complexType>
  </xs:element>
</xs:schema>
```

XML Schema

```
<?xml version="1.0" encoding="utf-8"?>
<Address xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:noNamespaceSchemaLocation="SimpleAddress.xsd">
  <Recipient>Mr. Walter C. Brown</Recipient>
  <House>49</House>
  <Street>Featherstone Street</Street>
  <Town>LONDON</Town>
  <PostCode>EC1Y 8SY</PostCode>
  <Country>UK</Country>
</Address>
```

XML Query Languages

- XPath: Identify a set of nodes in the document
  - Used by both XSLT and XQuery to enumerate/identify nodes
- XSLT: Transformation language
  - Fairly verbose... essentially a program that traverses the document
  - "... whose primary goal was to render XML for the human reader on screen"
- XQuery: The current standard
  - Personally, I think it is too complicated
  - Likely only a subset will be used/implemented in practice

Example Queries

- Users issue queries against the document as a whole
  - Find all available parking spots in Oakland

    /State[@id="Pennsylvania"]/County[@id="Allegheny"]/City[@id="Pittsburgh"]
    /Neighborhood[@id="Oakland"]/Block/pSpace[in-use = "no"]

  - Find all blocks in in Allegheny have more than 20 metered parking spots

    /State[@id="Pennsylvania"]/County[@id="Allegheny"]
    //Block[**count**(./pSpace[metered = "yes"]) > 20]

  - Find the cheapest parking spot in Oakland Block 1 /

    State[@id="Pennsylvania"]/County[@id="Allegheny"]/City[@id="Pittsburgh"]
    /Neighborhood[@id="Oakland"]/Block[@id='1']
    /pSpace[**not**(../pSpace/price > ./price)]

XQuery

The sample XQuery code below lists the unique speakers in each act of Shakespeare's play Hamlet, encoded in hamlet.xml

```
<html><head/><body>
{
  for $act in doc("hamlet.xml")//ACT
  let $speakers := distinct-values($act//SPEAKER)
  return
    <div>
      <h1>{ string($act/TITLE) }</h1>
      <ul>
      {
        for $speaker in $speakers
        return <li>{ $speaker }</li>
      }
      </ul>
    </div>
}
</body></html>
```

XML Storage

- Option 1: Using a *native XML database*
  - Special purpose data stores
  - Going back to hierarchical/network models?
  - Many developed over the years, some by big names: see e.g., PureXML by IBM
  - Disadvantages: performance; need to re-build transaction/concurrency support etc
    - Often XML constructed from relational for data exchange
    - Often need support to do relational query processing (e.g., OLAP) on XML data

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  - Disadvantages: performance; need to re-build transaction/concurrency support etc
    - Often XML constructed from relational for data exchange
    - Often need support to do relational query processing (e.g., OLAP) on XML data
- Option 2: Using relational databases
  - May lose structure in the XML document
  - Need to develop schemes to convert back and forth
  - XML queries naturally hierarchical $\rightarrow$ need many joins

XML in RDBMS

- NOTE: Somewhat older paper... much work since then
- Key issues
  - Converting an XML document to relational
    - Called “shredding”
    - Uses the DTD Information
  - Processing queries
  - Converting the relational data back to XML
    - Essentially a query + some post-processing (maybe as a UDF)

XML in RDBMS

1. Simplify the DTD
   - The conversion can be a one-way process
   - No need to preserve exact structure in the relational schema
   - Order is important in XML
     - See a later paper Handling order when converting

XML in RDBMS

1. Simplify the DTD
   - The conversion can be a one-way process
   - No need to preserve exact structure in the relational schema
   - Order is important in XML
     - See a later paper Handling order when converting
2. Create a set of tables
   - Simple option: Create a table for each element
     - Too many tables; a lot of joins needed later
     - Can think of that as denormalizing
   - Should try *inlining* as much as possible

XML in RDBMS: Example

```
<book>
   <booktitle> The Selfish Gene </booktitle>
   <author id = “dawkins”>
         <name>
            <firstname> Richard </firstname>
            <lastname> Dawkins </lastname>
         </name>
         <address>
            <city> Timbuktu </city>
            <zip> 99999 </zip>
         </address>
   </author>
</book>
```

Figure 1

```
<!ELEMENT book (booktitle, author)
<!ELEMENT article (title, author*, contactauthor)>
<!ELEMENT contactauthor EMPTY>
<!ATTLIST contactauthor authorID IDREF IMPLIED>
<!ELEMENT monograph (title, author, editor)>
<!ELEMENT editor (monograph*)>
<!ATTLIST editor name CDATA #REQUIRED>
<!ELEMENT author (name, address)>
<!ATTLIST author id ID #REQUIRED>
<!ELEMENT name (firstname?, lastname)>
<!ELEMENT firstname (#PCDATA)>
<!ELEMENT lastname (#PCDATA)>
<!ELEMENT address ANY>
```

Figure 2

XML in RDBMS: DTD Graph

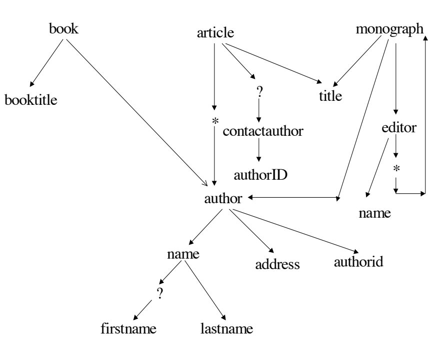
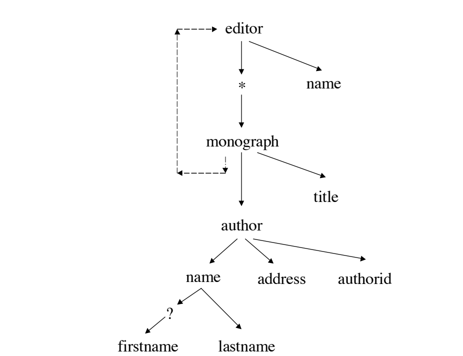


Figure 8



XML in RDBMS: Schema without inlining

book (bookID: integer, book.booktitle : string, book.author.name.firstname: string, book.author.name.lastname: string, book.author.address: string, author.authorid: string)

booktitle (booktitleID: integer, booktitle: string)

article (articleID: integer, article.contactauthor.authorid: string, article.title: string)

article.author (article.authorID: integer, article.author.parentID: integer, article.author.name.firstname: string, article.author.name.lastname: string, article.author.address: string, article.author.authorid: string)

contactauthor (contactauthorID: integer, contactauthor.authorid: string)

title (titleID: integer, title: string)

monograph (monographID: integer, monograph.parentID: integer, monograph.title: string, monograph.editor.name: string, monograph.author.name.firstname: string, monograph.author.name.lastname: string, monograph.author.address: string, monograph.author.authorid: string)

editor (editorID: integer, editor.parentID: integer, editor.name: string)

editor.monograph (editor.monographID: integer, editor.monograph.parentID: integer, editor.monograph.title: string, editor.monograph.author.name.firstname: string, editor.monograph.author.name.lastname: string, editor.monograph.author.address: string, editor.monograph.author.authorid: string)

author (authorID: integer, author.name.firstname: string, author.name.lastname: string, author.address: string, author.authorid: string)

name (nameID: integer, name.firstname: string, name.lastname: string)

firstname (firstnameID: integer, firstname: string)

lastname (lastnameID: integer, lastname: string)

address (addressID: integer, address: string)

Figure 10

XML in RDBMS: Schema with aggressive inlining

book (bookID: integer, book.booktitle.isroot: boolean, book.booktitle : string)

article (articleID: integer, article.contactauthor.isroot: boolean, article.contactauthor.authorid: string)

monograph (monographID: integer,monograph.parentID: integer, monograph.parentCODE: integer, monograph.editor.isroot: boolean, monograph.editor.name: string)

title (titleID: integer, title.parentID: integer, title.parentCODE: integer, title: string)

author (authorID: integer, author.parentID: integer, author.parentCODE: integer, author.name.isroot: boolean, author.name.firstname.isroot: :boolean, author.name.firstname: string, author.name.lastname.isroot: boolean, author.name.lastname: string, author.address.isroot: boolean, author.address: string, author.authorid: string)

Figure 11

XML in RDBMS: Query Conversion

- Left: Original Query (in XML-QL and Lorel syntax), Right: Converted query

```
WHERE <book>
        <booktitle> The Selfish Gene </booktitle>
        <author>
            <name>
                <firstname> $f </firstname>
                <lastname> $l </lastname>
            </name>
        </author>
      </book> IN * CONFORMING TO pubs.dtd
CONSTRUCT <result> $f $l </result>
```

```
Select Y.name.firstname,
       Y.name.lastname
From   book X, X.author Y
Where X.booktitle = “Databases”
```

```
Select A.”author.name.firstname”,
       A.”author.name.lastname”
From   author A, book B
Where B.bookID = A.parentID
        AND A.parentCODE = 0
        AND B.”book.booktitle” = “The Selfish Gene”
```

Figure 18

XML in RDBMS: Query Conversion

- Left: Original Query, Right: Converted query

```
WHERE <*.monograph>
            <editor.(monograph.editor)*>
                 <name> $n </name>
            </>
            <title> Subclass Cirripedia </title>
         </> IN * CONFORMING TO pubs.dtd
CONSTRUCT <result> $n </result>
```

```
Select Y.name
From   *.monograph X, X.editor.(monograph.editor)* Y
Where X.title = “Subclass Cirripedia”
```

```
With Q1 (monographID, name) AS
(Select X.monographID, X.”editor.name”
 From monograph X
 Where X.title = “Subclass Cirripedia”
UNION ALL
 Select Z.monographID, Z.”editor.name”
 From Q1 Y, monograph Z
 Where Y.monographID = Z.parentID AND
         Z.parentCODE = 0
)
Select A.name
From Q1 A
```

Figure 19

XML in RDBMS: Query Conversion

- Left: Original Query, Right: Converted query

```
WHERE <*.monograph>
               <editor.(monograph.editor)*>
                     <name> $n </name>
               </>
               <title> Subclass Cirripedia </title>
           </> IN * CONFORMING TO pubs.dtd
CONSTRUCT <result> $n </result>
```

```
Select Y.name
From   *.monograph X, X.editor.(monograph.editor)* Y
Where X.title = "Subclass Cirripedia"
```

```
With Q1 (monographID, name) AS
(Select X.monographID, X."editor.name"
 From monograph X
 Where X.title = "Subclass Cirripedia"
UNION ALL
 Select Z.monographID, Z."editor.name"
 From Q1 Y, monograph Z
 Where Y.monographID = Z.parentID AND
          Z.parentCODE = 0
)
Select A.name
From Q1 A
```

Figure 19

- Note: (right) is a recursive query
  - The query (WITH part) creates a table (Q1) and refers to it in the FROM clause

XML in RDBMS: Converting results to XML

- Some result construction can be done using SQL
- More complex ones require a post-processing step
  - Can be done using a user-defined function or embedded SQL or like
  - Can use "group by" etc to create the appropriates sets

Limitations of RDBMS

- Simple XML queries required too many joins or unions
- No support for sets
  - XML data usually set-valued
- No support for untyped references
  - IDREF is not typed, so storing it is problematic
- No text indices
- Need flexible comparison operators
  - XML treats everything as string
- More powerful recursion
  - SQL3 (latest version) allows recursion
  - Not very commonly used
    - Somewhat hard to reason about