Computer Science E-259

XML with J2EE

Lecture 8: XQuery 1.0 and DTD

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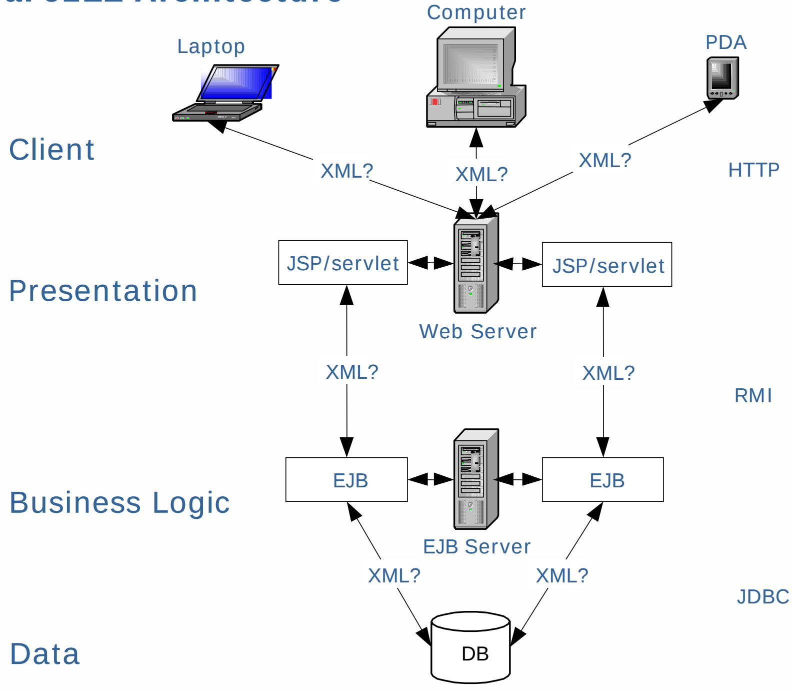
Last Time

HTTP 1.1, JavaServer Pages 2.0, and Java Servlet 2.4

- HTTP 1.1
- *n*-Tier Enterprise Applications
- JavaServer Pages 2.0
- Java Servlet 2.4
- Project 3

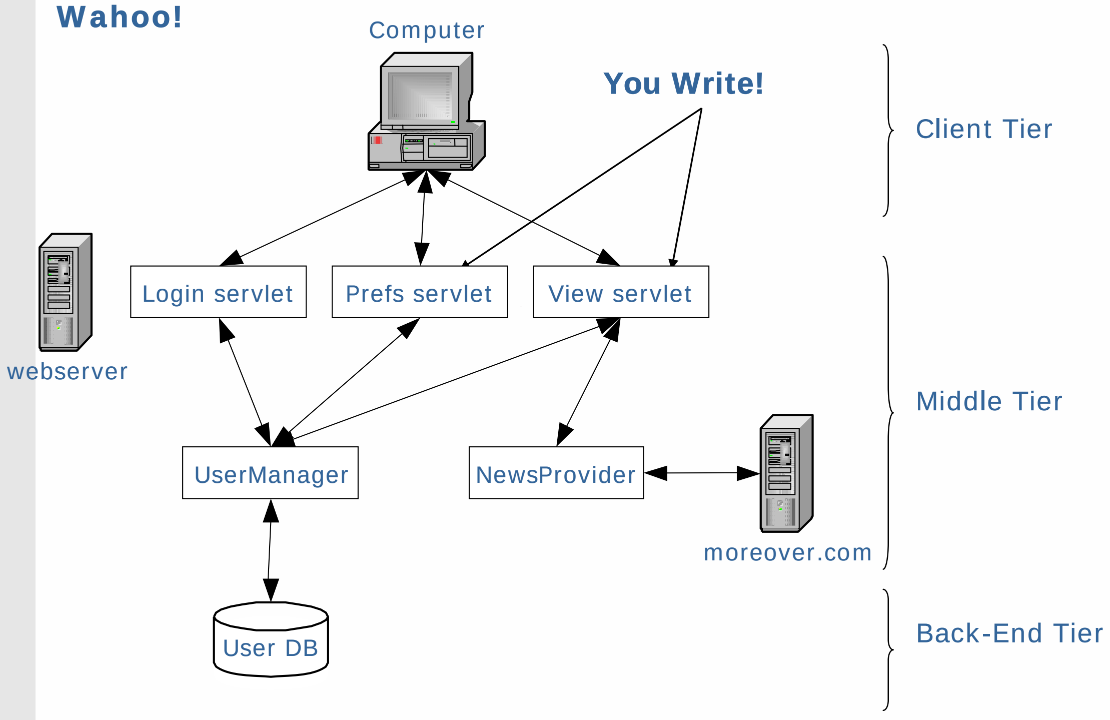
Last Time

Typical J2EE Architecture



Last Time

Wahoo!



Computer Science E-259

This Time

- XQuery 1.0
- DTD
- Project 3

XQuery 1.0

History

- Candidate Recommendation as of 11/05.
  - "XML is a versatile markup language, capable of labeling the information content of diverse data sources including structured and semi-structured documents, relational databases, and object repositories. A query language that uses the structure of XML intelligently can express queries across all these kinds of data, whether physically stored in XML or viewed as XML via middleware. This specification describes a query language called XQuery, which is designed to be broadly applicable across many types of XML data sources."

XQuery 1.0

XPath 2.0

- Sequences
- Data types
- Enhanced function set
- Multiple sources

XQuery 1.0

Path Expressions

- `doc("books.xml")`
- `doc("books.xml")/bib/book/title`
- `doc("books.xml")//title`
- `doc("books.xml")/bib/book[price<50]`

Adapted from `http://www.w3schools.com/xquery/xquery_example.asp`.

XQuery 1.0

FLWOR Expressions

```
FLWORExpr ::=
 (ForClause | LetClause)+ WhereClause? OrderByClause? "return" ExprSingle
```

Excerpted from http://www.w3.org/TR/xquery/.

XQuery 1.0

FLWOR Expressions

```
for $x in doc("books.xml")/bib/book
where $x/price>50
order by $x/title
return $x/title
```

Adapted from http://www.w3schools.com/xquery/xquery_example.asp.

XQuery 1.0

FLWOR Expressions

```
<bib>
  <book>
    <title>TCP/IP Illustrated</title>
    <author>Stevens</author>
    <publisher>Addison-Wesley</publisher>
  </book>
  <book>
    <title>Advanced Unix Programming</title>
    <author>Stevens</author>
    <publisher>Addison-Wesley</publisher>
  </book>
  <book>
    <title>Data on the Web</title>
    <author>Abiteboul</author>
    <author>Buneman</author>
    <author>Suciu</author>
  </book>
</bib>
```

Excerpted from http://www.w3.org/TR/xquery/.

XQuery 1.0

FLWOR Expressions

```
<authlist>
 {
   for $a in fn:distinct-values($books//author)
   order by $a
   return
     <author>
        <name>
          { $a/text() }
        </name>
        <books>
          {
            for $b in $books//book[author = $a]
            order by $b/title
            return $b/title
          }
        </books>
     </author>
 }
</authlist>
```

Adapted from http://www.w3.org/TR/xquery/.

XQuery 1.0

FLWOR Expressions

```
<authlist>
   <author>
      <name>Abiteboul</name>
      <books>
         <title>Data on the Web</title>
      </books>
   </author>
   <author>
      <name>Buneman</name>
      <books>
         <title>Data on the Web</title>
      </books>
   </author>
   <author>
      <name>Stevens</name>
      <books>
         <title>TCP/IP Illustrated</title>
         <title>Advanced Unix Programming</title>
      </books>
   </author>
   <author>
      <name>Suciu</name>
      <books>
         <title>Data on the Web</title>
      </books>
   </author>
</authlist>
```

Excerpted from http://www.w3.org/TR/xquery/.

XQuery 1.0

Sequence Expressions

```
for $d in doc("depts.xml")//deptno
let $e := doc("emps.xml")//emp[deptno = $d]
where count($e) >= 10
order by avg($e/salary) descending
return
   <big-dept>
      {
      $d,
      <headcount>{count($e)}</headcount>,
      <avgsal>{avg($e/salary)}</avgsal>
      }
   </big-dept>
```

Example excerpted from http://www.w3.org/TR/xquery/.

XQuery 1.0

Conditional Expressions

```
FOR $h IN doc("library.xml")//holding
RETURN
  <holding>
    { $h/title,
      IF ($h/@type = "Journal")
      THEN $h/editor
      ELSE $h/author
    }
  </holding>
```

Example adapted from http://www.brics.dk/~amoeller/XML/querying/condexp.html.

XQuery 1.0

Quantified Expressions

```
FOR $b IN doc("bib.xml")//book
WHERE SOME $p IN $b//paragraph SATISFIES
  (contains($p,"sailing") AND
   contains($p,"windsurfing"))
RETURN $b/title
```

```
FOR $b IN doc("bib.xml")//book
WHERE EVERY $p IN $b//paragraph SATISFIES
  contains($p,"sailing")
RETURN $b/title
```

Examples adapted from http://www.brics.dk/~amoeller/XML/querying/quantexp.html.

XQuery 1.0

Data Types

- String-related
  - **ENTITIES, ENTITY, ID, IDREF, IDREFS, language, Name, NCName, NMTOKEN, NMTOKENS, normalizedString, QName, string, token**
- Date-related
  - **date, dateTime, duration, gDay, gMonth, gMonthDay, gYear, gYearMonth, time**
- Number-related
  - **base64Binary, byte, decimal, double, float, hexBinary, int, integer, long, negativeInteger, nonPositiveInteger, positiveInteger, short, unsignedLong, unsignedInt, unsignedShort, unsignedByte**
- Err, unrelated
  - **anyURI, boolean, NOTATION, ...**
- User-Defined

XQuery 1.0

Expressions on Sequence Types

- Instance of
```
<a>{5}</a> instance of xs:integer
```
- Typeswitch
```
typeswitch($customer/billing-address)
  case $a as element(*, USAddress) return $a/state
  case $a as element(*, CanadaAddress) return $a/province
  case $a as element(*, JapanAddress) return $a/prefecture
  default return "unknown"
```
- Cast and Castable
```
if ($x castable as hatsize)
then $x cast as hatsize
else if ($x castable as IQ)
then $x cast as IQ
else $x cast as xs:string
```

Examples excerpted from `http://www.w3.org/TR/xquery/`.

DTD

Well-Formedness

```
<moreovernews>
  [...]
  <article id="_479411492">
    <url>http://c.moreover.com/click/here.pl?x479411492</url>
    <headline_text>Biometrics look ready for prime time
   </headline_text>
    <source>Government Computer News</source>
    <media_type>text</media_type>
    <cluster>moreover...</cluster>
    <tagline></tagline>
    <document_url>http://www-gcn3.iproduction.com</document_url>
    <harvest_time>Mar 4 2006 10:54PM</harvest_time>
    <access_registration></access_registration>
    <access_status></access_status>
  </article>
  [...]
</moreovernews>
```

Excerpted from http://www.fas.harvard.edu/~cscie259/distribution/projects/project3-6.0/ROOT/xml/cache/Biotech%2520news.xml.

DTD

Validity

```
<!ELEMENT moreovernews (article*)>
<!ELEMENT article (url, headline_text, source, media_type, cluster,
tagline, document_url, harvest_time, access_registration,
access_status)>
<!ATTLIST article id ID #IMPLIED>
<!ELEMENT url (#PCDATA)>
<!ELEMENT headline_text (#PCDATA)>
<!ELEMENT source (#PCDATA)>
<!ELEMENT media_type (#PCDATA)>
<!ELEMENT cluster (#PCDATA)>
<!ELEMENT tagline (#PCDATA)>
<!ELEMENT document_url (#PCDATA)>
<!ELEMENT harvest_time (#PCDATA)>
<!ELEMENT access_registration (#PCDATA)>
<!ELEMENT access_status (#PCDATA)>
```

Available at http://www.fas.harvard.edu/~cscie259/distribution/projects/project3-6.0/ROOT/dtd/moreovernews.dtd.

DTD

XHTML 1.0 Transitional

```
<?xml version="1.0" encoding="iso-8859-1"?>

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
   "http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">

<html xmlns="http://www.w3.org/1999/xhtml" lang="en" xml:lang="en">
    <head>
        <title/>
    </head>
    <body/>
</html>
```

Available at http://www.fas.harvard.edu/~cscie259/distribution/lectures/8/examples8/xhtml.html.

DTD

Overview

- A DTD is a definition of an XML document's schema
  - Codifies what the structure of a document must be
  - The relationships between the components of the document
  - What data is allowed where
- The DTD language was released as part of the official XML specification
- XML Schema is a more modern, powerful way to accomplish the same goals
- However, DTDs are still widely in use, and are supported as the primary method of validating XML

DTD

Motivation

- DTDs, or schemas in general, are a contracts for what make a certain type of XML document
- DTDs allow you to check whether a document "instance" is "valid" with respect to its schema (in contrast with its simply being well-formed)
- DTDs provide a place to specify what belongs in elements, attributes, and what individual elements represent, *etc*.
- Particularly useful in B2B transactions where agreeing on a data format is important
- DTDs encapsulate good document design so you can benefit from it
  - Why reinvent a document standard when there is DocBook? **`http://www.oasis-open.org/specs/index.php#dbv4.1`**
  - Why reinvent a financial exchange standard when there is OFX? **`http://www.ofx.net/ofx/specview/SpecView.html`**
  - Why reinvent a voice standard when there is VoiceXML? **`http://www.w3.org/TR/voicexml20/vxml.dtd`**

DTD

To DTD or not to DTD

- It depends on the application
- DTDs (or schemas in general) are crucial when a common understanding of data is important
  - XML makes data interchange easier from a technical standpoint, but it still doesn't eliminate human misunderstandings
  - I say **`<price>`**, you say **`<cost>`**
- Writing a DTD can help you design a good data model
  - All the principles of proper data modeling apply to XML as well
- However, DTDs constrain XML flexibility
  - As soon as you have a DTD, your data model is less extensible
  - At least, changes require distribution of a new DTD

DTD

A SONG Element

```
<SONG>
  <TITLE>Everyday</TITLE>
  <COMPOSER>Dave</COMPOSER>
  <COMPOSER>Boyd Tinsley</COMPOSER>
  <PRODUCER>Dave Matthews</PRODUCER>
  <PUBLISHER>BMG</PUBLISHER>
  <LENGTH>12:20</LENGTH>
  <YEAR>2001</YEAR>
  <ARTIST>Dave Matthews Band</ARTIST>
</SONG>
```

Excerpted from http://www.fas.harvard.edu/~cscie259/distribution/lectures/8/examples8/song{1,2}.xml.

DTD

A DTD for SONG Elements

```
<!ELEMENT SONG (TITLE, COMPOSER+, PRODUCER*,
 PUBLISHER*, LENGTH?, YEAR?, ARTIST+)>
<!ELEMENT TITLE (#PCDATA)>
<!ELEMENT COMPOSER (#PCDATA)>
<!ELEMENT PRODUCER (#PCDATA)>
<!ELEMENT PUBLISHER (#PCDATA)>
<!ELEMENT LENGTH (#PCDATA)>
<!ELEMENT YEAR (#PCDATA)>
<!ELEMENT ARTIST (#PCDATA)>
```

Available at http://www.fas.harvard.edu/~cscie259/distribution/lectures/8/examples8/song.dtd.

DTD

The <!ELEMENT> Declaration

```
<!ELEMENT    element_name    (content_model)>
```

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DTD

The <!ELEMENT> Declaration

- Gives the name and content model of an element
- The name must be unique
- The content model specifies what the valid child content can be
  - **#PCDATA** `<!ELEMENT TITLE (#PCDATA)>`
  - **EMPTY** `<!ELEMENT course EMPTY>`
  - Elements
  - Mixed
  - **ANY** `<!ELEMENT comment ANY>`

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DTD

Element Content

- The most sophisticated of content types
- Allows you to specify a regular expression for the allowed child elements
  - **`<!ELEMENT SONG (TITLE, COMPOSER+, PRODUCER*, PUBLISHER*, LENGTH?, YEAR?, ARTIST+)>`**
  - **`<!ELEMENT spec (front, body, back?)>`**
  - **`<!ELEMENT div1 (head, (p | list | note)*, div2*)>`**

DTD

Building Blocks of Regular Expressions

- **`foo?`**
  - The **`foo`** element must occur 0 times or exactly 1 time.
- **`foo*`**
  - The **`foo`** element may occur 0 or more times.
- **`foo+`**
  - The **`foo`** element must occur 1 or more times.
- **`(foo|bar|baz)`**
  - Either **`foo`** or **`bar`** or **`baz`** must appear exactly 1 time.
- **`(foo,bar,baz)`**
  - 1 instance of **`foo`** must occur, followed by 1 instance of **`bar`**, followed by 1 instance of **`baz`**.

DTD

Mixed Content

- When both character and element content can be interspersed, the names of the elements can be constrained, but not their order or number; and **#PCDATA** must be declared first!
  - **`<!ELEMENT p (#PCDATA|a|u|b|i|em)*>`**
    - **`<p>I am <b>bold</b> and <i>italic</i>.</p>`**
  - **`<!ELEMENT PO (#PCDATA|item|shipdate|qty)*>`**
    - **`<PO><qty>1</qty> <item>Flowbee</item> was shipped to you on <shipdate>29 March 2003</shipdate>.</PO>`**

The Flowbee Precision Home Haircut System is available for purchase at http://www.flowbee.com/.

DTD

The <!ATTLIST> Declaration

```
<!ATTLIST element_name
  attribute_name    attribute_type    default_declaration
  attribute_name    attribute_type    default_declaration
  ...
>
```

DTD

<!ATTLIST> Examples

-
  ```
  <!ATTLIST termdef
    id       ID      #REQUIRED
    type     CDATA   #REQUIRED
    name     CDATA   #IMPLIED>
  ```

-
  ```
  <!ATTLIST list
    type     (bullets|ordered|glossary)  "ordered">
  ```

-
  ```
  <!ATTLIST form
    method    CDATA   #FIXED “post">
  ```

-
  ```
  <!ATTLIST paper
    language CDATA   "English">
  ```

DTD

Attribute Types

- **CDATA**
  - Character data, including entities.
- **ID**
  - Must be unique within document (and must start with a letter ☹).
- **IDREF**
  - Must refer to an **ID** in document.
- **IDREFS**
  - References one or more **ID**s, separated by spaces.
- **ENTITY**
  - Must refer to an entity.
- **ENTITIES**
  - References one or more entities, separated by spaces.
- **NMTOKEN**
  - Name token devoid of whitespace.
- **NMTOKENS**
  - Series of one or more **NMTOKEN**s, separated by spaces.

DTD

Default Declarations

- **#FIXED**
  - Attribute's value is fixed and must be that specified in DTD.
- **#REQUIRED**
  - The element is required to have the attribute, and the the attribute is required to have a value.
- **#IMPLIED**
  - Attribute is optional.

DTD

Where do DTDs go?

- DTDs can be
  - placed in a standalone file known as an "external subset"
  - part of the **<!DOCTYPE>** declaration in the XML document as an "internal subset" (which overrides any declarations in an external subset)
- Examples

  -
    ```
    <!DOCTYPE SONG [
      <!ELEMENT SONG (TITLE, COMPOSER+, PRODUCER*,
      PUBLISHER*, LENGTH?, YEAR?, ARTIST+)>
    ]>
    ```

  -
    ```
    <!DOCTYPE SONG SYSTEM "song.dtd">
    ```

  -
    ```
    <!DOCTYPE SONG SYSTEM "song.dtd" [
      <!ELEMENT ARTIST (FIRST,LAST)>
      <!ELEMENT FIRST (#PCDATA)>
      <!ELEMENT LAST (#PCDATA)>
    ]>
    ```

DTD

Validation

```
javax.xml.parsers.SAXParserFactory
     org.xml.sax.ErrorHandler
```

DTD

Whitespace

```
<foo>
  <bar/>
  <baz/>
</foo>
```

DTD

Similar XML Constructs

- Entities
  - `<!ENTITY nbsp "&#160;">`
  - `<!ENTITY copyright "Copyright (c) David Malan. All rights reserved.">`
- Notations (`http://msxml.com/intro_xml/notation_decl.html`)

  -
    ```
    <!NOTATION GIF SYSTEM "GIF Notation">
    <!ENTITY watAGE_Logo SYSTEM "watage.gif" NDATA GIF>
    ```

DTD

Shortcomings

- Not well-formed XML (though still derived from SGML)
- No built-in data types (*e.g.*, bool, int, float, string, *etc.*)
- No support for custom data types (*e.g.*, phone numbers)
  - No pattern-matching
  - No inheritance
- No support for ranges (*e.g.*, "**year** must be an integer between 0 and 99", "**review** can appear as a child of **book** no more than 10 times", *etc.*)
- Not namespace-aware
- Content models must be deterministic; cannot allow arbitrary ordering of children, as with:

  -
    ```
    <!ELEMENT foo ((bar,baz,qux) | (bar,qux,baz) |
                   (baz,bar,qux) | (baz,qux,bar) |
                   (qux,bar,baz) | (qux,baz,bar))>
    ```
- …

Next Time

XML Schema (Second Edition)

- XML Schema (Second Edition)

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