Computer Science E-259

XML with Java

Lecture 8: XQuery 1.0 and DTD

21 March 2007

David J. Malan

malan@post.harvard.edu

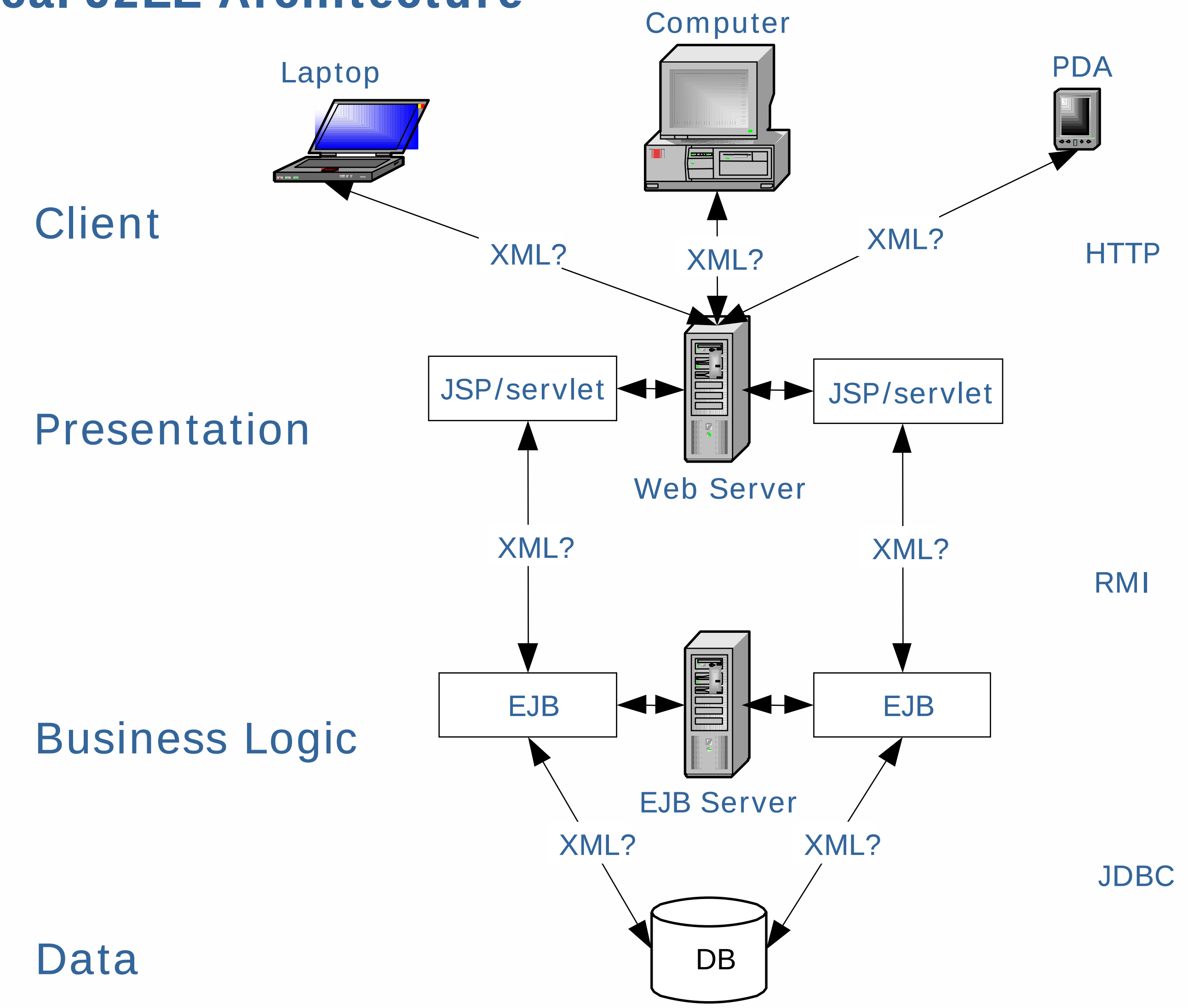
Last Time

HTTP 1.1, JavaServer Pages 2.1, and Java Servlet 2.5

- HTTP 1.1
- *n*-Tier Enterprise Applications
- JavaServer Pages 2.1
- Java Servlet 2.5
- Project 3

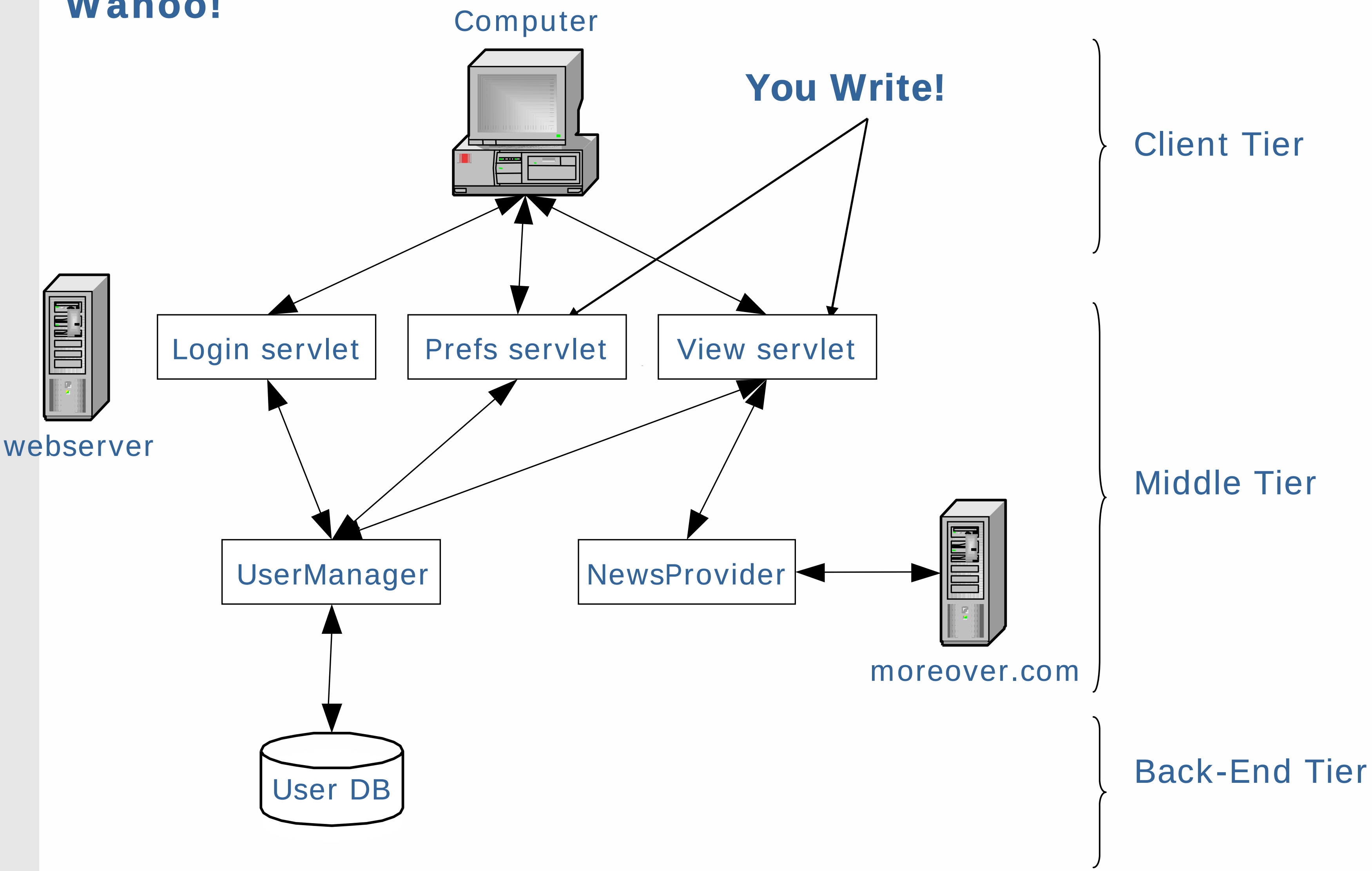
Last Time

Typical J2EE Architecture



Last Time

Wahoo!



Computer Science E-259

This Time

- XQuery 1.0
- DTD
- Project 3

XQuery 1.0

History

- Recommendation as of 1/07.
  - “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.”

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="_840925179">
    <url>http://c.moreover.com/click/here.pl?x840925179</url>
    <headline_text>Whose Genome Is It, Anyway?</headline_text>
    <source>Discover</source>
    <media_type>text</media_type>
    <cluster>moreover...</cluster>
    <tagline></tagline>
    <document_url>http://discovermagazine.com</document_url>
    <harvest_time>Mar 11 2007 8:46AM</harvest_time>
    <access_registration></access_registration>
    <access_status></access_status>
  </article>
  [...]
</moreovernews>
```

Excerpted from http://www.fas.harvard.edu/~cscie259/distribution/projects/project3-7.0/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/project3-7.0/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)>
```

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>`

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)

Computer Science E-259

XML with Java

Lecture 8: XQuery 1.0 and DTD

21 March 2007

David J. Malan

`malan@post.harvard.edu`