XSLT

CPS 216

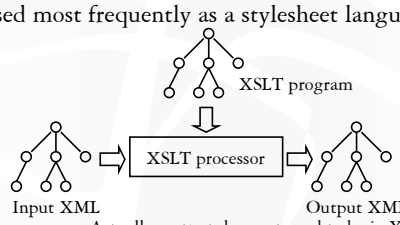
Advanced Database Systems

Announcements (March 16)

- Graded Midterm, sample solution, and graded Homework #2 will be handed out on Thursday
- Homework #3 out on Thursday
- Course project milestone 2 due in two weeks
- Reading assignment for next week
  - McHugh and Widom, *VLDB* 1999
  - Halverson et al., *VLDB* 2003
  - Both due next Monday
- Talk by Ashraf Aboulnaga
  - On-line Statistics for Database Query Optimization
  - Thursday 11:30am-12:30pm, D106

XSLT

- W3C recommendation
- XML-to-XML rule-based transformation language
- An XSLT program is an XML document itself
- Used most frequently as a stylesheet language



Actually, output does not need to be in XML in general

XSLT program

- An XSLT program is an XML document containing
  - Elements in the `<xsl:>` namespace
  - Elements in user namespace
- The result of evaluating an XSLT program on an input XML document = the XSLT document where each `<xsl:>` element has been replaced with the result of its evaluation
- Uses XPath as a sub-language

XSLT elements

- Element describing transformation rules
  - `<xsl:template>`
- Elements describing rule execution control
  - `<xsl:apply-templates>`
  - `<xsl:call-template>`
- Elements describing instructions
  - `<xsl:if>`, `<xsl:for-each>`, `<xsl:sort>`, etc.
- Elements generating output
  - `<xsl:value-of>`, `<xsl:attribute>`, `<xsl:copy-of>`, `<xsl:text>`, etc.

XSLT example

- Find titles of books authored by "Abiteboul"

Standard header of an XSLT document

```
<?xml version="1.0"?>
<xsl:stylesheet
  xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
  version="1.0">
<xsl:template match="book[author='Abiteboul']">
  <booktitle>
    <xsl:value-of select="title"/>
  </booktitle>
</xsl:template>
</xsl:stylesheet>
```

- Not quite; we will see why later

<xsl:template>


```
<xsl:template match="book[author='Abiteboul']">
  <booktitle>
    <xsl:value-of select="title"/>
  </booktitle>
</xsl:template>
```

- `<xsl:template match="`*match_expr*`">` is the basic XSLT construct describing a transformation rule
  - *match_expr* is an XPath-like expression specifying which nodes this rule applies to
- `<xsl:value-of select="`*xpath_expr*`"/>` evaluates *xpath_expr* within the context of the node matching the template, and converts the result node-set to a string
- `<booktitle>` and `</booktitle>` simply get copied to the output for each node match

Template in action


```
<xsl:template match="book[author='Abiteboul']">
  <booktitle>
    <xsl:value-of select="title"/>
  </booktitle>
</xsl:template>
```

- Example XML fragment

```
<book ISBN="ISBN-10" price="80.00">
  <title>Foundations of Databases</title>
  <author>Abiteboul</author>
  <author>Hull</author>
  <author>Vianu</author>
  <publisher>Addison Wesley</publisher>
  <year>1995</year>
  <section>…</section>…
</book>
<book ISBN="ISBN-20" price="40.00">
  <title>A First Course in Databases</title>
  <author>Ullman</author>
  <author>Widom</author>
  <publisher>Prentice-Hall</publisher>
  <year>2002</year>
  <section>…</section>…
</book>
```

Template applies

```
<booktitle>
  Foundations of Databases
</booktitle>
```

Template does not apply; default behavior is to process the node recursively and print out all text nodes

```
A First Course in Databases
Ullman
Widom
Prentice-Hall
2002
… …
```

Removing the extra output

- Add the following template:
  `<xsl:template match="text()|@*"/>`
- This template matches all text and attributes
- XPath features
  - `text()` is a node test that matches any text node
  - `@*` matches any attribute
  - `|` means "or" in XPath
- Body of the rule is empty, so all text and attributes become empty string
  - This rule effectively filters out things not matched by the other rule

<xsl:attribute>

- Again, find titles of books authored by "Abiteboul"; but make the output look like `<book title="`*booktitle*`"/>`

```
… …
<xsl:template match="book[author='Abiteboul']">
  <book title="{title}"/>
</xsl:template>
… …
```

- A more general method

```
… …
<xsl:template match="book[author='Abiteboul']">
  <book>
    <xsl:attribute name="title">
      <xsl:value-of select="title"/>
    </xsl:attribute>
  </book>
</xsl:template>
… …
```

`<xsl:attribute name="`*attr*`">`*body*`</xsl:attribute>` adds an attributed named *attr* with value *body* to the parent element in the output

<xsl:copy-of>

- Another slightly different example: return (entire) books authored by "Abiteboul"

```
<?xml version="1.0">
<xsl:stylesheet
  xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
  version="1.0">
<xsl:template match="text()|@*"/>
<xsl:template match="book[author='Abiteboul']">
  <xsl:copy-of select="."/>
</xsl:template>
</xsl:stylesheet>
```

- `<xsl:copy-of select="`*xpath_expr*`"/>` copies the entire contents (including tag structures) of the node-set returned by *xpath_expr* to the output

Formatting XML into HTML

- Example templates to
  - Render a book title in italics in HTML
  - Render the authors as a comma-separated list

```
<xsl:template match="book/title">
  <i><xsl:value-of select="."/></i>
</xsl:template>
<xsl:template match="book/author[1]">
  <xsl:value-of select="."/>
</xsl:template>
<xsl:template match="book/author[position()>1]">
  <xsl:text>, </xsl:text><xsl:value-of select="."/>
</xsl:template>
```

- `<xsl:text>` allows precise control of white space in output

<xsl:apply-templates>

- Example: generate a table of contents
  - Display books in an HTML unordered list
  - For each book, first display its title, and then display its sections in an HTML ordered list
  - For each section, first display its title, and then display its subsections in an HTML ordered list

```
<xsl:template match="title">
  <xsl:value-of select="."/>
</xsl:template>
<xsl:template match="section">
  <li>
    <xsl:apply-templates select="title"/>
    <ol><xsl:apply-templates select="section"/></ol>
  </li>
</xsl:template>
```

(Continue on next slide)

`<xsl:apply-templates select="`*xpath_expr*`"/>` applies templates recursively to the node-set returned by *xpath_expr*

Example continued


```
<xsl:template match="book">
  <li>
    <xsl:apply-templates select="title"/>
    <ol><xsl:apply-templates select="section"/></ol>
  </li>
</xsl:template>
<xsl:template match="bibliography">
  <html>
    <head><title>Bibliography</title></head>
    <body>
      <ul><xsl:apply-templates select="book"/></ul>
    </body>
  </html>
</xsl:template>
```

- One problem remains
  - Even if a book or a section has no sections, we will still generate an empty `<ol></ol>` element

<xsl:if>

- A fix using `<xsl:if>`: replace

```
<ol><xsl:apply-templates select="section"/></ol>
```

with

```
<xsl:if test="section">
  <ol><xsl:apply-templates select="section"/></ol>
</xsl:if>
```

- The body of `<xsl:if test="`*xpath_cond*`">` is processed only if *xpath_cond* evaluates to true

White space control

- White space is everywhere in XML

```
… …
<book ISBN="ISBN-10" price="80.00">␤
␣␣<title>␤
␣␣␣␣Foundations of Databases.␤
␣␣</title>… …
```

  - "␤␣␣␣" goes into a text node
  - "␤␣␣␣␣Foundations of Databases.␤␣␣" goes into another text node
- Specify `<xsl:strip-space elements="*"/>` to remove text nodes (under any element) containing only white space
- To strip leading and trailing white space and replace any sequence of white space characters by a single space, specify

```
<xsl:template match="text()">
  <xsl:value-of select="normalize-space()"/>
</xsl:template>
```

<xsl:for-each>

- `<xsl:for-each select="`*xpath_expr*`">`
  body
  `</xsl:for-each>`
  - Process *body* for each node in the node-set returned by *xpath_expr*
  - Processing context changes to the node being processed
- Another way to render authors as a comma-separated list

```
<xsl:tempalte match="book">
  … …
  <xsl:for-each select="author">
    <xsl:if test="position()>1">, </xsl:if>
    <xsl:value-of select="."/>
  </xsl:for-each>
  … …
</xsl:template>
```

Named templates with parameters

- Define a generic template for rendering a list of things as a comma-separated list
  - Cannot use `match` because we do not know in advance the things to render

```
<xsl:template name="comma-separated-list">
  <xsl:param name="things-to-be-formatted"/>
  <xsl:for-each select="$things-to-be-formatted">
    <xsl:if test="position()>1">, </xsl:if>
    <xsl:value-of select="."/>
  </xsl:for-each>
</xsl:template>
```

Calling templates & passing parameters

- Use the generic template

```
<xsl:template match="book">
  <xsl:value-of select="title"/>
  <xsl:text>: </xsl:text>
  <xsl:call-template name="comma-separated-list">
    <xsl:with-param name="things-to-be-formatted"
                    select="author"/>
  </xsl:call-template>
  <br/>
</xsl:template>
```

- `<xsl:with-param name="`*para_name*`" select="`*xpath_expr*`">` evaluates *xpath_expr* and passes its result as the value of the parameter *para_name*
- `<xsl:call-template>` invokes the named template without changing the context

XSLT summary

- Used often as a stylesheet language, but can be considered a query language too
  - Very expressive, with full recursion
    - Cannot be replaced by XQuery
  - Easily non-terminating, difficult to optimize
    - Cannot replace XQuery
- So many features, so little time! ☺

Review

- XML: tree (or graph)-structured data
- DTD: simple schema for XML
  - Well-formed XML: syntactically correct
  - Valid XML: well-formed and conforms to a DTD
- XPath: path expression language for XML
  - An XPath expression selects a list of nodes in an XML document
  - Used in other languages
- XQuery: SQL-like query language for XML
  - FLWOR expression, quantified expression, aggregation, etc.
- XSLT: stylesheet language for XML, in XML
  - Transforms input XML by applying template rules recursively on the structure of input XML

XML API's

- SAX (Simple API for XML)
  - Started out as a Java API, but now exists for other languages too
  - Streaming input; callbacks for events (start/end of document and elements, chunk of characters, etc.)
- DOM (Document Object Model)
  - Language-neutral API with implementations in Java, C++, etc.
  - Converts input into a main-memory tree; supports tree traversal, construction, and in-place modification
- JAXB (Java Architecture for XML Binding)
  - XML Schema to Java objects
- ☞ Not covered further in lecture, but SAX and DOM will be covered in more detail in recitation