Introduction to XSLT

Processing the XML data

- Huge amount of XML information, and growing
- We need to "*manage*" it, and then "*process*" it
  - *Store it efficiently*
  - Verify the correctness
  - *Filter, search, select, join, aggregate*
  - *Create new pieces of information*
  - Clean, normalize the data
  - *Update it*
  - Take actions based on the existing data
  - *Write complex execution flows*
- No conceptual organization like for relational databases (applications are too heterogeneous)

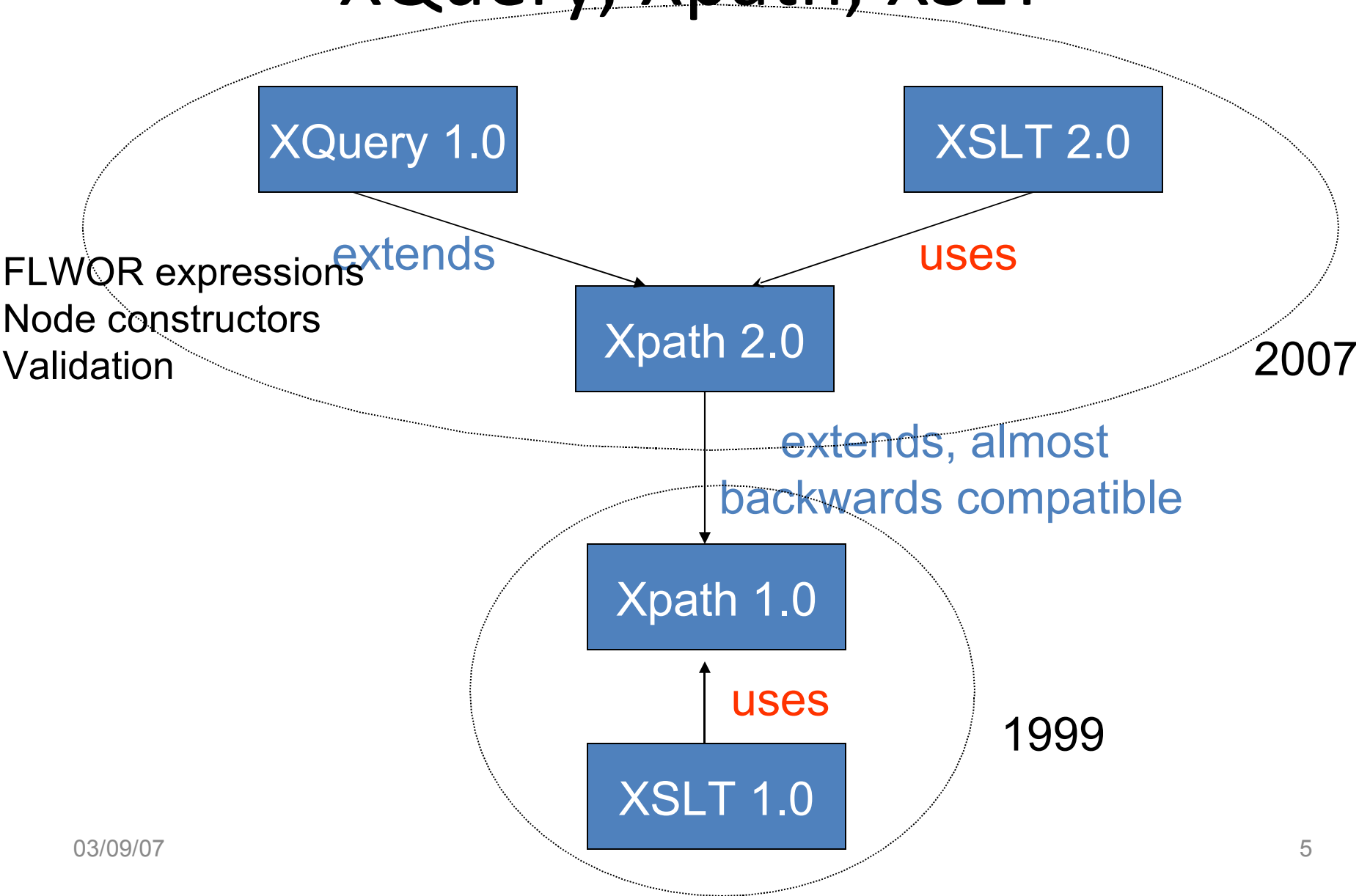
Frequent solutions to XML data management

- Map it to *generic* programming APIs (e.g. DOM, SAX, StaX)
- *Manually* map it to *non-generic* APIs
- *Automatically* map it to *non-generic* structures
- Use *XML extensions* of existing languages
- Shredding for relational stores
- *Native* XML processing through XSLT and XQuery

History of XSLT

- Much older then XQuery
  - XSLT 1.0 and XSLT 2.0
- Was designed a re-formatting language for the browsers
  - Still primarily used in this way (e.g Ebay has more 10.000 XSLT stylesheets)
  - Most browsers have an embedded XSLT processor
  - Now has broader applications for XML management
- XSLT 2.0 and XQuery 1.0 are designed jointly
- Same data model, same type system, same Xpath 2.0
- Different programming paradigm
  - XQuery is compositional and functional, XSLT is based on recursive templates

XQuery, Xpath, XSLT



Your first XSLT stylesheet

```
<xsl:stylesheet version="1.0"
   xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
          xmlns="http://www.w3.org/TR/xhtml1/strict">
<xsl:template match="/">
<html>
   <head>
       <title>Expense Report Summary</title>
   </head>
   <body>
       <p>Total Amount: <xsl:value-of   select="expense-
   report/total"/>
       </p>
   </body>
</html>
</xsl:template>
</xsl:stylesheet>
```

The anatomy of a stylesheet

- An XSLT program is an XML document
- The root element of the document is called `xsl:stylesheet` and is composed of a set of "templates" (I.e elements called `xsl:template`)
- The `xsl` namespace is bound to the "official" XSLT URI (e.g. `http://www.w3.org/1999/XSL/Transform)`
- The XML elements composing the XSLT program: a blend of "*user*" names and "*XSLT*" names (QNames in the `xsl` namespace)
- The "simple" `xsl` elements are "interpreted" and replaced by the result of their evaluation
  - `xsl:for-each, xsl:if, xsl:choose, xsl:value-of`

An XSLT program

```
<xsl:stylesheet version="1.0"
  xmlns:xsl=
  http://www.w3.org/1999/XSL/Transform>

  <xsl:template …..>
  ……
  </xsl:template>

  <xsl:template …..>
  ……
  </xsl:template>

</xsl:stylesheet>
```

Each template rule specifies how certain nodes from the input XML doc have to be reformatted in the output

XSLT templates

- Rules that describe how certain input XML nodes have to be transformed in the output nodes
- Represented by elements in the `xsl` namespace called `<xsl:template>`
- Can have patterns that describe to what kind of nodes is the template rule applicable
  - `<xsl:template match="author | editor">`
- Can have names (later)
- Have a body -- an XML fragment that described the output
  - `<xsl:template match="*"> <foobar/> <xsl:template>`

Template patterns

- Describe to what kind of nodes is a template applicable to
- Represented as an optional `match` attribute on the `xsl:template` elements
- The value of the match attribute is a string representing a pattern
- The pattern language is a subset of the XPath language
- A node *matches* a pattern if it is a member of the result list of nodes of the pattern expression (almost normal XQuery evaluation)

Template patterns: examples

- `para` matches any `para` element
- `*` matches any element
- `chapter|appendix` matches any `chapter` element and any `appendix` element
- `olist/item` matches any `item` element with an `olist` parent
- `appendix//para` matches any `para` element with an `appendix` ancestor element
- `/` matches the root node
- `text()` matches any text node
- `processing-instruction()` matches any processing instruction
- `node()` matches any node other than an attribute node and the root node
- `id("W11")` matches the element with unique ID `W11`
- `para[1]` matches any `para` element that is the first `para` child element of its parent
- `@class` matches any `class` attribute (*not* any element that has a `class` attribute)•
- `@*` matches any attribute

Applying a template to a single node

- Input
  - <foo>beam</foo>
- Two example templates

```
<xsl:template match="foo">
    <bar>baz</bar>
</xsl:template>
<xsl:template match="foo">
    <bar><xsl:-value-of select="."></xsl:value-of></bar>
</xsl:template>
```

<bar>baz</bar>

<bar>beam</bar>

- Applying a template to a single node
  - Return the body of the template
  - All the xsl elements in the body are "interpreted" and replaced by their result
  - The other elements remain unchanged
  - The current node is set to the input node while evaluating Xpath expressions (remember "."?)

Recursive application of templates

- The templates are not (normally) invoked by hand (see later)
- XSLT semantics is based on a built-in, recursive application of templates
- *Apply-templates(list of XML nodes) -> list of XML nodes*
  - For each input node (in order, see later)
    - Find the “best” template that applies (see conflicting templates later…)
    - Note: choice of template is on a node basis
    - Apply the template, returns back a sequence of nodes
  - Concatenate all partial results, return
- The evaluation of the XSLT main program starts by invoking this recursive procedure on the input document node

Invoking the recursive application of templates

- Why is this procedure “recursive” ?
  - While evaluating a template one can trigger the re-evaluation of this procedure
  - `<xsl:apply-template>`
- Example:
  - Input
    - `This is an <emph>important</emph> point.`
  - Template

```
<xsl:template match="emph">
    <fo:inline-sequence font-weight="bold">
        <xsl:apply-templates select=“./text()”/>
    </fo:inline-sequence>
</xsl:template>
```

xsl:apply-templates

- Re-enter the built-in recursive application of templates
- Has a *select* attribute that specifies on what set of nodes to apply the procedure (using Xpath)
  - <xsl:apply-templates select="author"/>
  - <xsl:apply-templates select="author/name"/>
  - <xsl:apply-templates select=".//heading"/>
  - <xsl:apply-templates select="ancestors::department/group"/>
  - <xsl:apply-templates select="."/>
- The order of those nodes can be changed using a xsl:sort (see later); default is document order
- If no *select* attribute, then implicitly trigger the recursive application of templates on the list of children of the current node

Default templates

- What happens if there is no template that matches a node ? Default templates..
- Elements and document nodes

```
<xsl:template match="*|/">  <xsl:apply-templates/>
</xsl:template>
```

- Attributes and text nodes

```
<xsl:template match="text()|@*">  <xsl:value-of
   select="."/></xsl:template>
```

- The other nodes

```
<xsl:template match="processing-instruction()|
   comment()"/>
```

Named templates

- Sometimes one can invoke a particular template -- by name

  `<xsl:template name="authorsTemplate">`
- Instead of <xsl:apply-templates>
  - <xsl:call-template name="`authorsTemplate`">
- Semantics is the same
- Small semantic difference
  - xsl:call-templates does not change the current node
  - xsl:apply-templates does

xsl:value-of

- You have seen it already
- <xsl:value-of select="path expression"/>
- Evaluates the path expression => nodes
- Apply the fn:string(..) function to each node (remember it ?)
- Concatenate the strings
- Create (and return) a new text node with this value

xsl:for-each

```
<xsl:for-each
  select = node-set-expression>
  <!-- Content: (xsl:sort*, template-body) -->
</xsl:for-each>
```

- The node-set expression evaluates to a list of nodes
- For each one of them return the template body, evaluated normally
- Each application returns a list of nodes, concatenate them all
- The input list is processed in document order in case of no sort, otherwise in the sorting specified by the xsl:for-each

Xsl:for-each example

- Data

```
<customers>
  <customer>
    <name>...</name>
    <order>...</order>
    <order>...</order>
  </customer>
  <customer>
    <name>...</name>
    <order>...</order>
    <order>...</order>
  </customer>
</customers>
```

- Program

```
<xsl:template match="/">
  <html>
    <head>
      <title>Customers</title>
    </head>
    <body>
      <table>
        <tbody>
          <xsl:for-each select="customers/customer">
            <tr>
              <th>
                <xsl:apply-templates select="name"/>
              </th>
              <xsl:for-each select="order">
                <td>
                  <xsl:apply-templates/>
                </td>
              </xsl:for-each>
            </tr>
          </xsl:for-each>
        </tbody>
      </table>
    </body>
  </html>
</xsl:template>
```

Xsl:if

- General form

```
<xsl:if
  test = boolean-expression>
  <!-- Content: template-body -->
</xsl:if>
```

- Example 1:

```
<xsl:template match="namelist/name">
  <xsl:apply-templates/>
  <xsl:if test="not(position()=last())">, </xsl:if>
</xsl:template>
```

- Example 2:

```
<xsl:template match="item">
  <tr>
    <xsl:if test="position() mod 2 = 0">
      <xsl:attribute name="bgcolor">yellow</xsl:attribute>
    </xsl:if>
    <xsl:apply-templates/>
  </tr>
</xsl:template>
```

Xsl:choose

- General form:

```
<xsl:choose>
  <!-- Content: (xsl:when+, xsl:otherwise?) -->
</xsl:choose>

<xsl:when
  test = boolean-expression>
  <!-- Content: template-body -->
</xsl:when>

<xsl:otherwise>
  <!-- Content: template-body -->
</xsl:otherwise>
```

xsl:choose: example

```
<xsl:template match="orderedlist/listitem">
  <fo:list-item indent-start='2pi'>
    <fo:list-item-label>
      <xsl:variable name="level"
                    select="count(ancestor::orderedlist) mod 3"/>
      <xsl:choose>
        <xsl:when test='$level=1'>
          <xsl:number format="i"/>
        </xsl:when>
        <xsl:when test='$level=2'>
          <xsl:number format="a"/>
        </xsl:when>
        <xsl:otherwise>
          <xsl:number format="1"/>
        </xsl:otherwise>
      </xsl:choose>
      <xsl:text>. </xsl:text>
    </fo:list-item-label>
    <fo:list-item-body>
      <xsl:apply-templates/>
    </fo:list-item-body>
  </fo:list-item>
</xsl:template>
```

xsl:sort

- Can be a child of xsl:apply-templates or xsl:for-each elements; multiple xsl:sort possible
- General form:

```
<xsl:sort
  select = string-expression
  lang = { nmtoken }
  data-type = { "text" | "number" | qname-but-not-ncname }
  order = { "ascending" | "descending" }
  case-order = { "upper-first" | "lower-first" } />
```

- Example:

```
<xsl:template match="employees">
  <ul>
    <xsl:apply-templates select="employee">
      <xsl:sort select="name/family"/>
      <xsl:sort select="name/given"/>
    </xsl:apply-templates>
  </ul>
</xsl:template>
```

```
<xsl:template match="employee">
  <li>
    <xsl:value-of select="name/given"/>
    <xsl:text> </xsl:text>
    <xsl:value-of select="name/family"/>
  </li>
</xsl:template>
```

Xsl:key

- Xsl:key allows to declare “keys” (unique identifiers for elements belonging to a certain domain)
- A key is composed of:
  - the name of the key (an expanded-name)
  - the set of nodes which has the key (the domain)
  - the value of the key (a string)
- General form:

```
<xsl:key
  name = qname
  match = pattern
  use = expression />
```

- Can appear at the root of a stylesheet
- Use later using the key(Qname, expression) function
- Can be used to create cross-references between elements (e.g. bibliographical references, HTML links, etc)

xsl:key: example

- One bib.xml document containing bibliographical entries:

  <entry name="Java">...</entry>

- One document containing references:

  <bibref>Java</bibref>

- The stylesheet formatting the bibrefs

```
<xsl:key name="bib" match="entry" use="@name"/>

<xsl:template match="bibref">
  <xsl:variable name="name" select="."/>
  <xsl:for-each select="document('bib.xml')">
    <xsl:apply-templates select="key('bib',$name)"/>
  </xsl:for-each>
</xsl:template>
```

Creating output: elements

- Constant elements (similar to the direct element constructors in Xquery)

```
<xsl:if test="a mod 2 = 0">
    <foobar>baz</foobar>
</xsl:if>
```

- Computed element generation (similar to the computed element constructors in Xquery)
- General form:

```
<xsl:element
  name = { qname }
  namespace = { uri-reference }
  use-attribute-sets = qnames>
  <!-- Content: template-body -->
</xsl:element>
```

- Example:
  - <xsl:element name="foobar">baz</xsl:element>
  - <xsl:element name="foobar"><xsl:value-of select="./text()"></xsl:value-of></xsl:element>

Creating output: attributes

- Computed attribute generation (similar to the computed attribute constructors in XQuery)
- General form:

```
<xsl:attribute
  name = { qname }
  namespace = { uri-reference } >
  <!-- Content: template-body -->
</xsl:attribute>
```

- Example:
  - <xsl:attribute name="foobar">baz</xsl:element>
  - <xsl:attribute name="foobar"><xsl:value-of select="./text()"></xsl:value-of></xsl:element>

Creating output: text

- <xsl:value-of select="expression">
- <xsl:text> XXXX </xsl:text>

Attribute value templates

- Similar to the dynamically computed content in the direct attribute constructor in XQuery

  <foo bar="baz{$x}"/>

- Unlike Xquery, only works for attributes (xsl:value-of does the job for the elements)
- Use "{" and "}" like Xquery (or vice-versa..)
- Example

```
<xsl:variable name="image-dir">/images</xsl:variable>

<xsl:template match="photograph">
<img src="{$image-dir}/{href}" width="{size/@width}"/>
</xsl:template>



<photograph>
  <href>headquarters.jpg</href>
  <size width="300"/>
</photograph>


<img src="/images/headquarters.jpg" width="300"/>
```

xsl:copy and xsl:copy-of

- xsl:copy
  - Creates a *shallow* copy of the current node -- copying the shell (name + NS) but not attributes and children

```
<xsl:copy
  use-attribute-sets = qnames>
  <!-- Content: template-body -->
</xsl:copy>
```

- Example -- the identity transformation

```
<xsl:template match="@*|node()">
  <xsl:copy>
    <xsl:apply-templates select="@*|node()"/>
  </xsl:copy>
</xsl:template>
```

- xsl:copy-of --- a way of copying *entire* XML tree fragments

Variables and parameters

- General form:

```
<xsl:variable
  name = qname
  select = expression>
  <!-- Content: template-body-->
</xsl:variable>
```

- Similar to the LET in Xquery
- Variables are not modifiable
- Scope is the body of the parent element
- Examples:

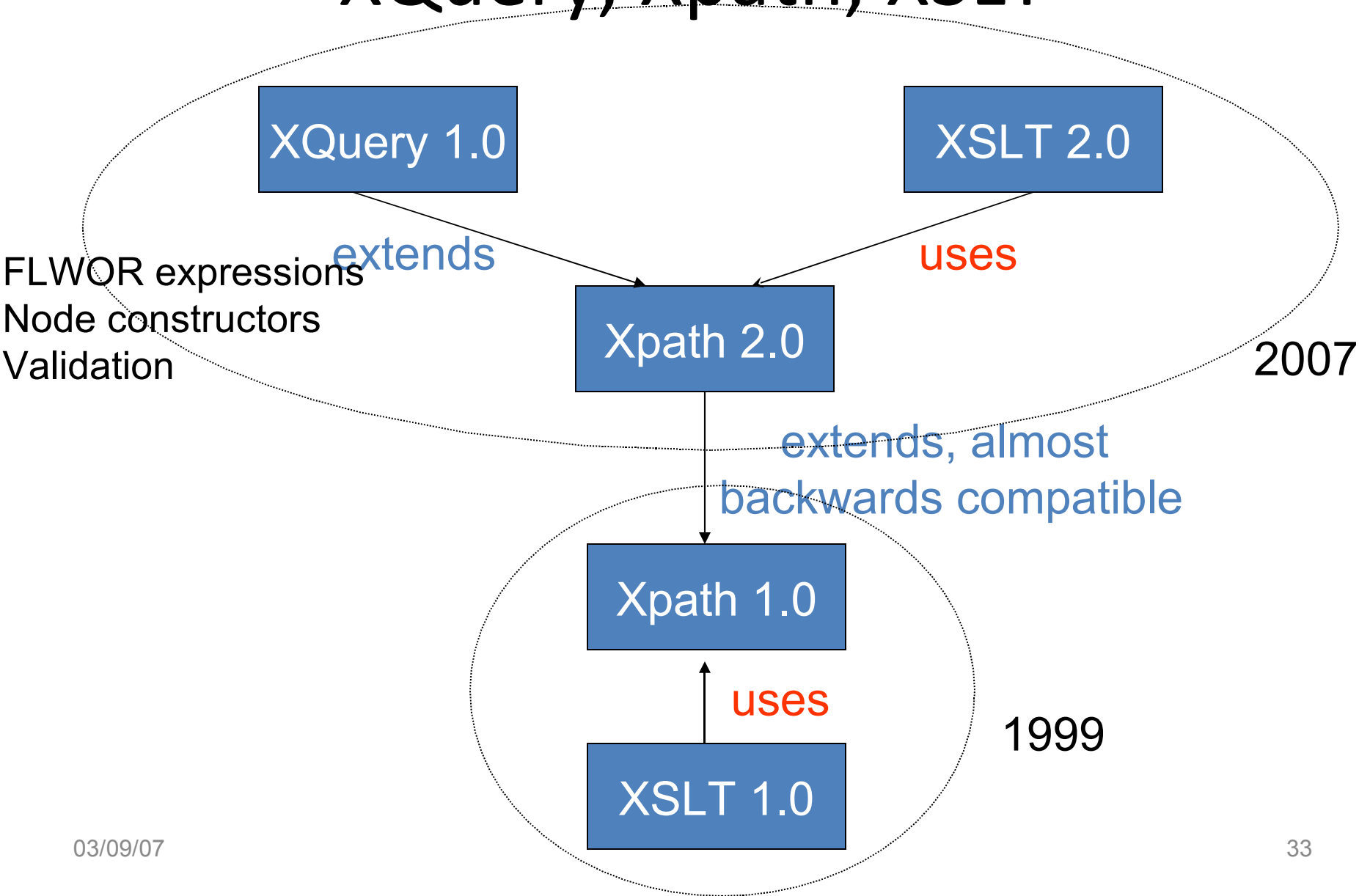
```
<xsl:variable name="n" select="2+2"/>
<foo bar="{$n}"/>

<xsl:variable name="n">2</xsl:variable>
<xsl:value-of select="item[position()=$n]"/>



<xsl:variable name="x"><xsl:apply-templates/></xsl:variable>
<xsl:copy-of select="$x"/>
```

XQuery, Xpath, XSLT



XSLT vs. XQuery

- XSLT has in addition to XQuery:
  - Dynamically generated ns (2.0)
  - Positional grouping (2.0)
  - Various output methods (HTML, XML, TEXT)
  - Built-in dynamic dispatch
- Xquery has lots of extra features
- *Both are Turing complete*
- Some implementations use the same runtime for both languages, and a simple different language layer (same data model, same Xpath, same libraries)
  - E.g. Oracle, Saxon
- No standard way to cross-call between the two languages (future work)
- Optimization:
  - *Much easier* in Xquery because dataflow is possible. Not possible in XSLT (plus iterations are cheaper then recursive calls)
  - Same reason why Xquery has a static typing and XSLT doesn't

When to use each one ?

- It depends on the application
- Mix and match (see Pipelining in W3C)
- Document formatting is better done in XSLT
- Data-style, query-style computations are better done in XQuery
- "*Depends on the degree of entropy in the data*"
  - Irregular data => XSLT
  - Regular data => XQuery
- Any side-effecting requirements imply XQuery (no updates and side-effects in XSLT)
- More then one document => almost implies XQuery
- Performance *will* certainly be better in XQuery
- XQuery will be a richer language in the future
- XQuery widely present in universities, XSLT no
- Automatic translators between the two languages

Frequent solutions to XML data management

- Map it to *generic* programming APIs (e.g. DOM, SAX, StaX)
- *Manually* map it to *non-generic* APIs
- *Automatically* map it to *non-generic* structures
- Use *XML extensions* of existing languages
- Shredding for relational stores
- *Native* XML processing through XSLT and XQuery