"Markup Sprachen und semi-strukturierte Daten"

http://www.pms.informatik.uni-muenchen.de/lehre/markupsemistrukt/02ss

XSLT 1.0 Tutorial

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What means XSLT?

XSL (e**X**tensible **S**tylesheet **L**anguage) consists of

- XSL-T (**T**ransformation)
  - primarily designed for transforming the structure of an XML document
  - W3C Specification: `http://www.w3c.org/TR/xslt`
- XSL-FO (**F**ormating **O**bjects)
  - designed for formatting XML documents
  - W3C Specification: `http://www.w3c.org/TR/xsl`

XSLT origin: **D**ocument **S**tyle **S**emantics and **S**pecification **L**anguage (DSSSL, pron. Dissel).

Why Transform XML?

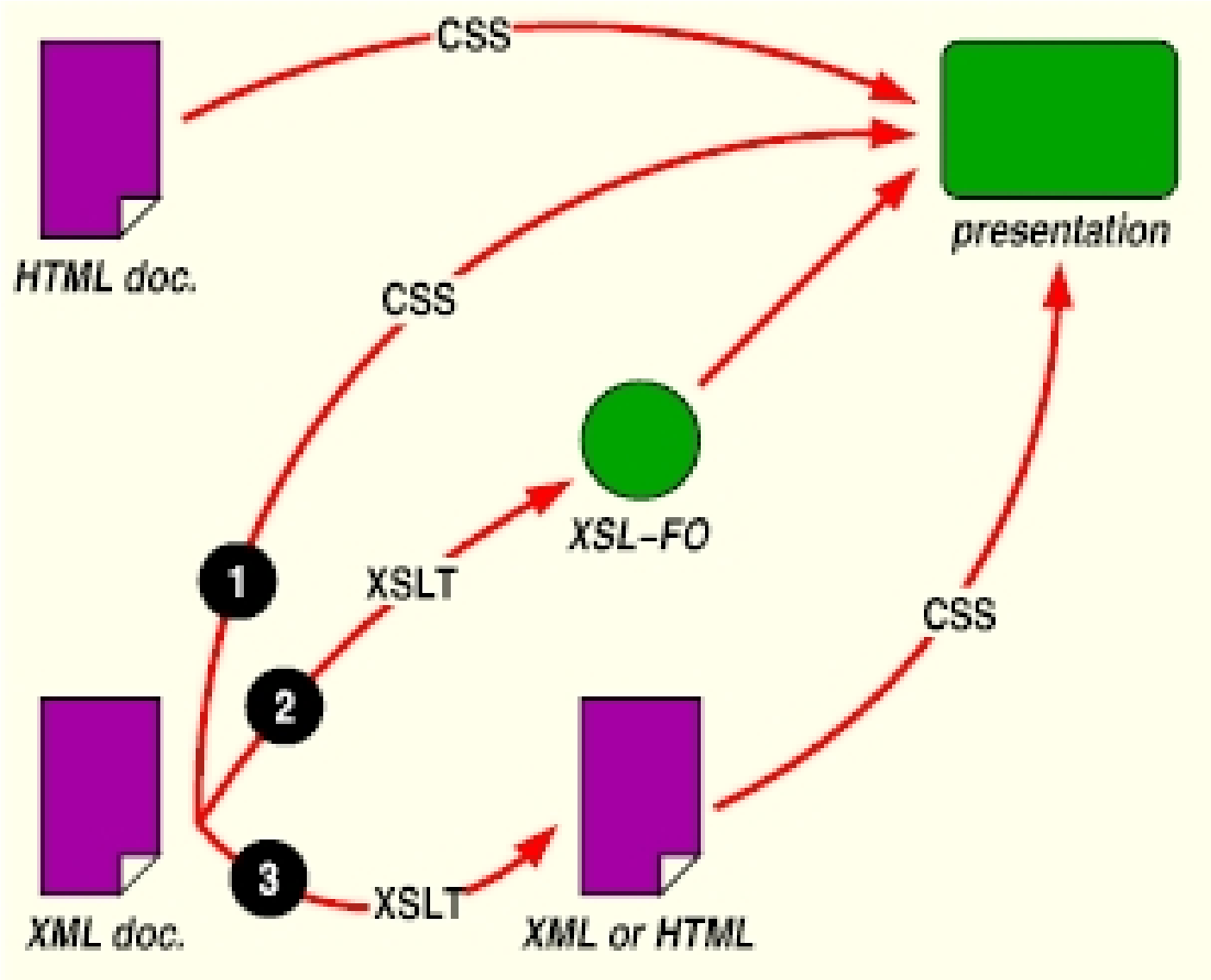
XML is a success because it is designed:

- for separation between content and presentation
  (XML is a generic markup language)
- as a format for electronical data interchange(EDI) between computer programs
- as human readable/writable format

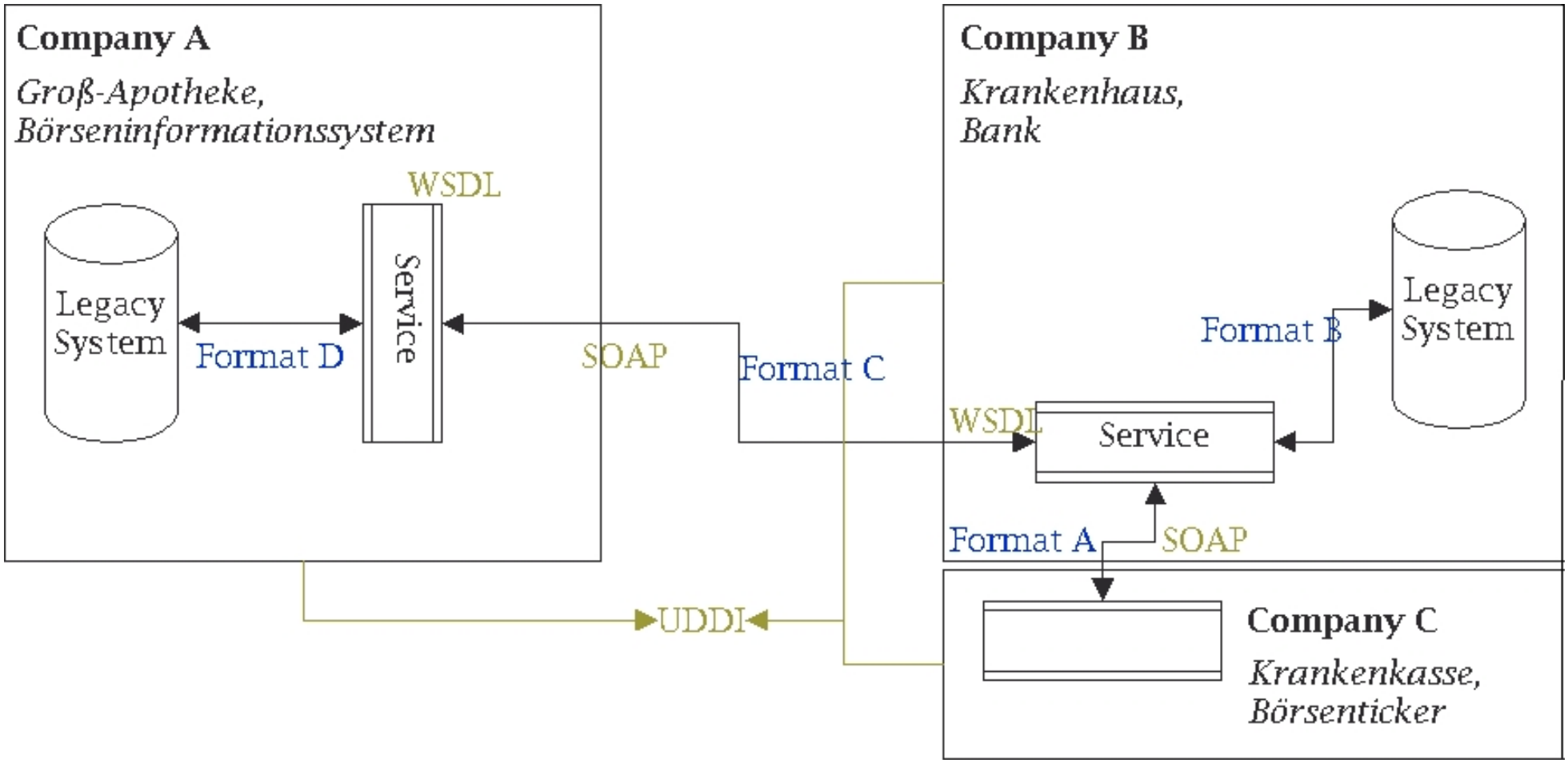
Transforming XML is not only desirable, but necessary.
XSLT is an attempt to fulfill this need, by supporting

- publishing data (not necessarily XML).
- conversion between two proprietary formats (not necessarily XML).

Publishing XML data

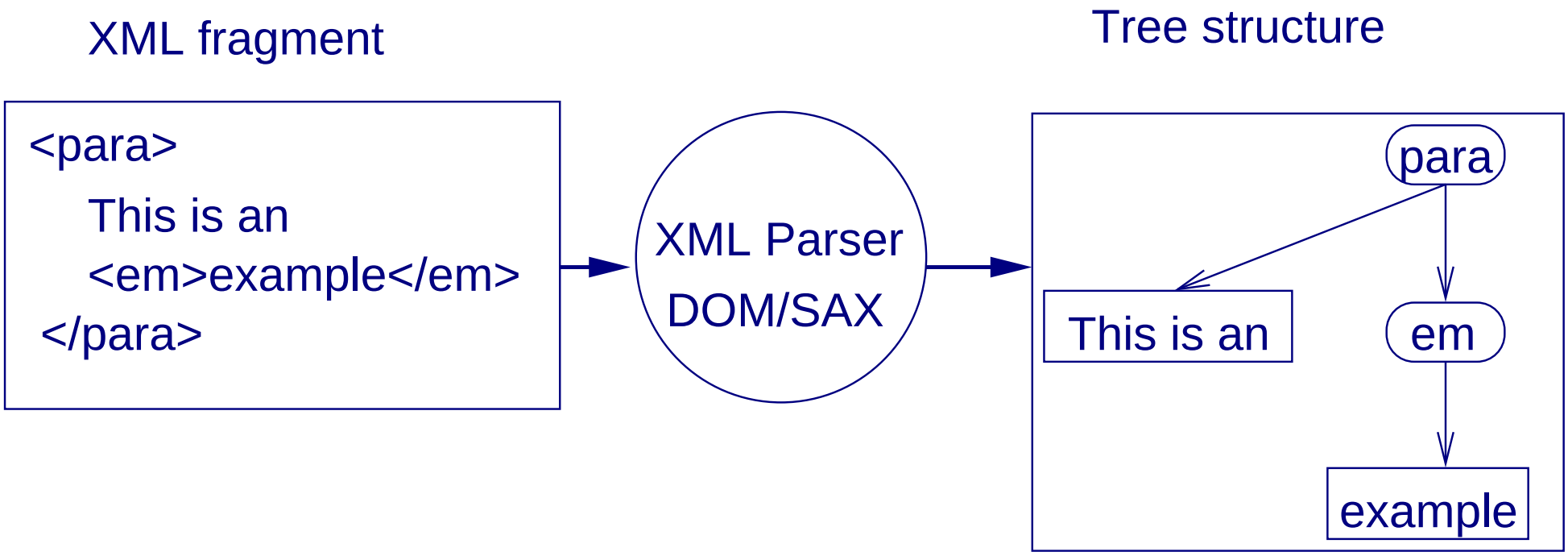


Data Conversion



How XML data can be transformed using XSLT? (1/3)

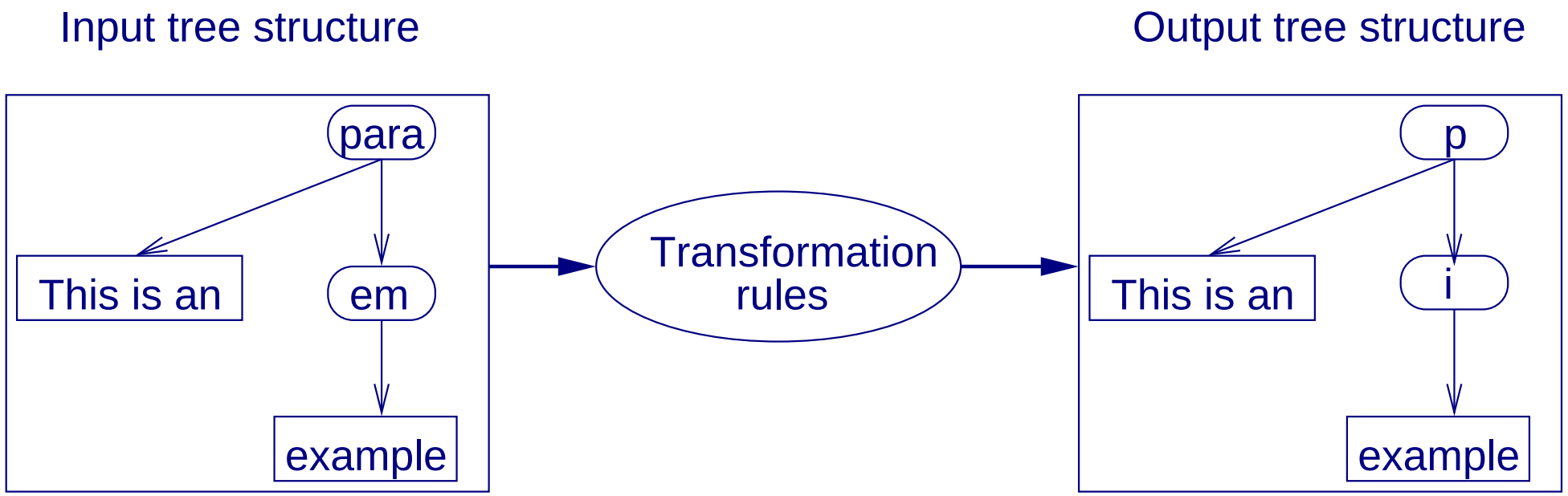
1 a **conversion** of XML data into a tree structure, e.g. using an XML parser conformant to
   - Document Object Model (DOM) http://www.w3.org/DOM/
   - Simple Api for XML (SAX) http://www.megginson.com/SAX/sax.html



How XML data can be transformed using XSLT? (2/3)

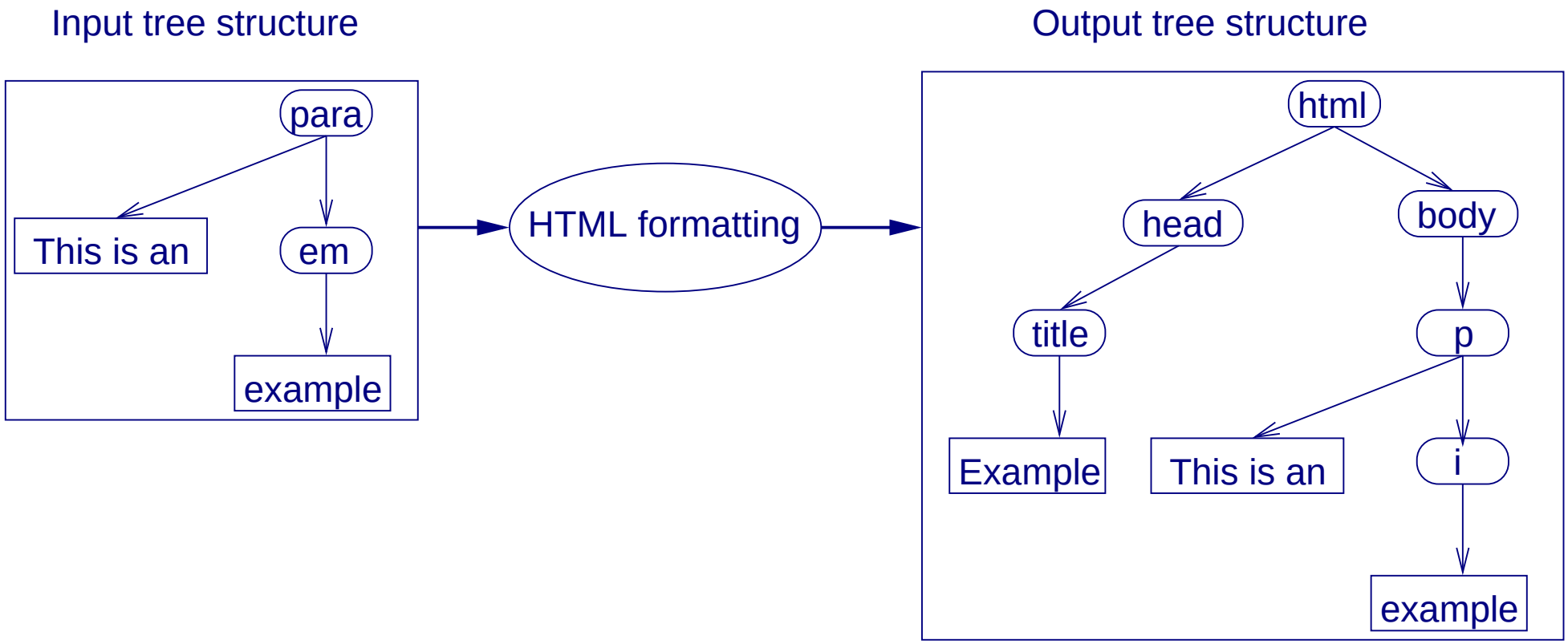
2 a **structural transformation** of the data: from the input to the desired output structure

- involves selecting-projecting-joining, aggregating, grouping, sorting data.
- XSLT vs. custom applications: factoring out common subtasks and present them as transformation rules in a high-level declarative language

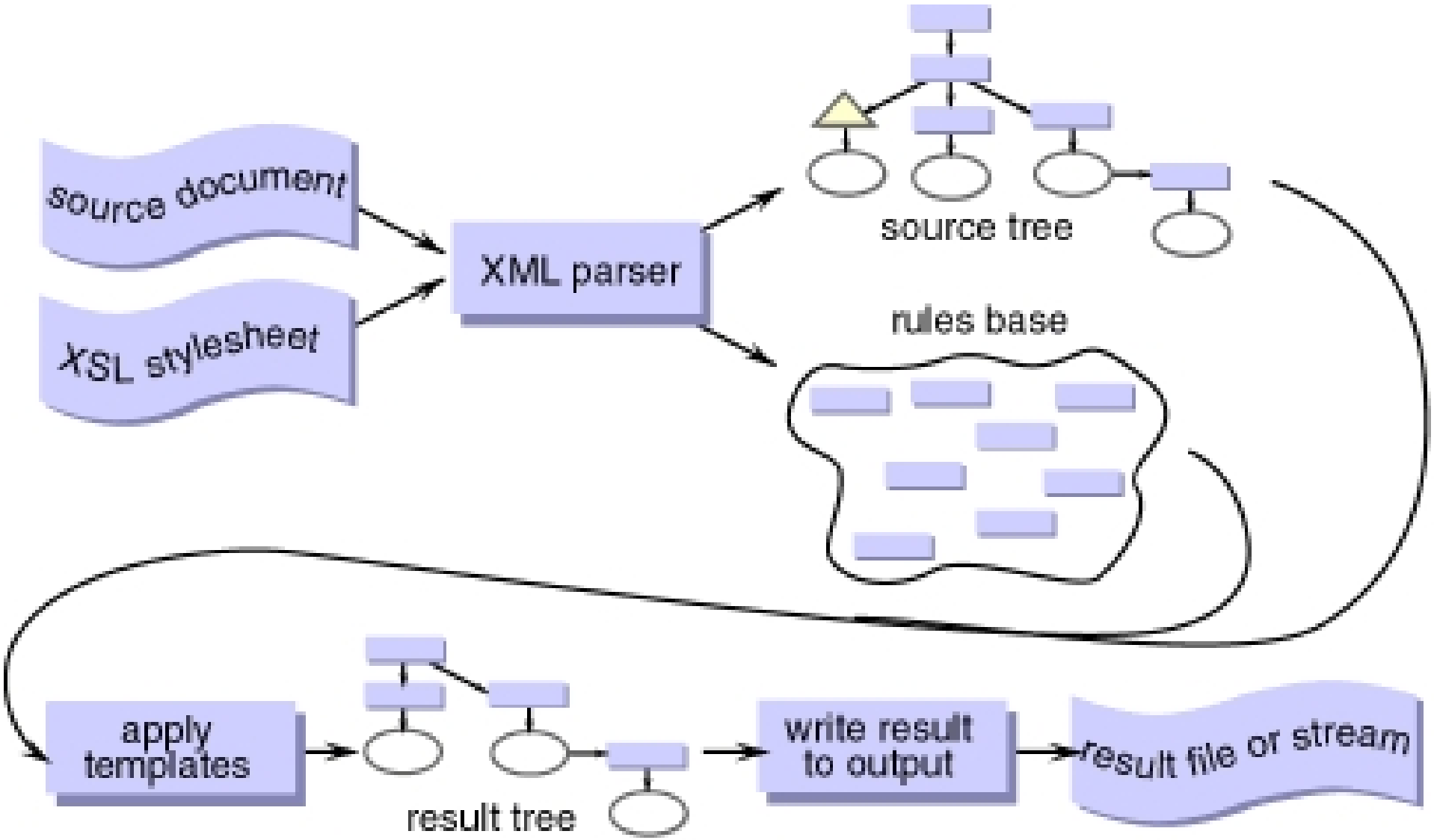


How XML data can be transformed using XSLT? (3/3)

3 **formatting** of the data: data in the desired output structure is enriched with target-format constructs, e.g. from
PDF (paper-print), VoiceXML (aural presentations), SVG (graphics), HTML (browsing)



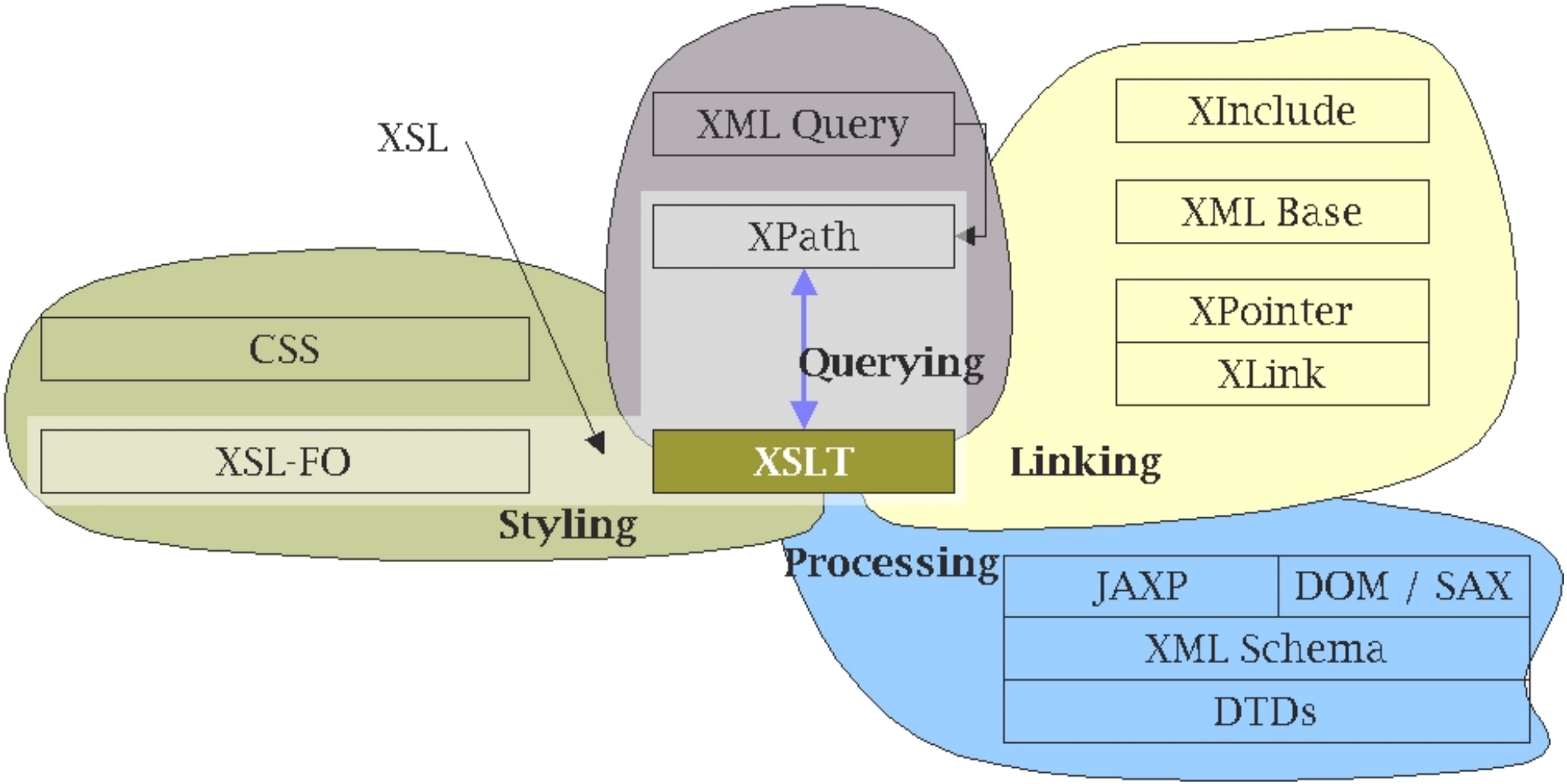
How XML data can be transformed using XSLT?



The place of XSLT in the XML family (1/2)

- based on XML InfoSet and Namespaces Specs.
- Styling: XSLT vs. CSS
  CSS can not
  - reorder elements from the XML document.
  - add new elements.
  - decide which elements should be displayed/omitted.
  - provide functions for handling numbers/strings/booleans.
- Processing: XSLT vs. XML Query
  - Long debate on XML development list: *XQuery: Reinventing the Wheel?* at `http://lists.xml.org/archives/xml-dev/200102/msg00483.html`
  - the same pattern language, i.e. XPath, and the same expressive power.
  - different processing models.
- Linking: XSLT vs. XPointer
  they share XPath as language for localizing fragments of XML documents.

The place of XSLT in the XML family (2/2)



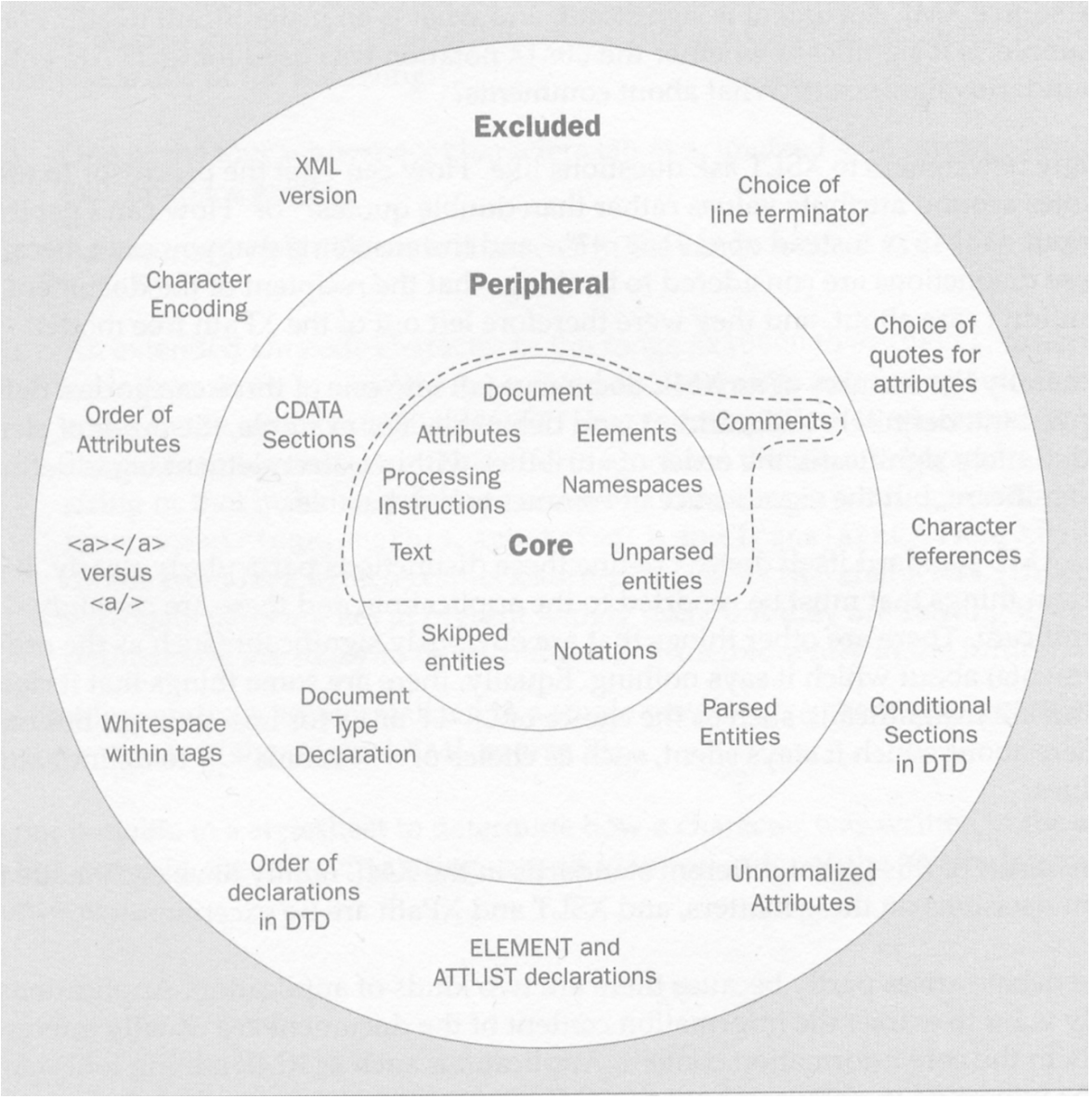
Simple Transformation Examples with XSLT

- XSLTrace from IBM AlphaWorks
  available at `http://www.alphaworks.ibm.com/aw.nsf/download/xsltrace`
- allows a user to visually "step through" an XSL transformation,
  highlighting the transformation rules as they are fired.
- Add the `XSLTrace.jar`, `xml4j.jar`, `lotusxsl.jar` Java archives $CLASSPATH.
- command line: `java com.ibm.xsl.xsltrace.XSLTrace <input> <style>`
- input: xml and xslt documents from Chapters 1 and 2 from
  XSLT Programmer's Reference, M. Kay. `http://www.wrox.com`

The XSLT Processing Model

- usually input, output and XSLT program - well-balanced XML documents, represented internally as XPath data model/DOM-like trees.
- different output formats: xml, html, text.
- multiple inputs via `document()` XSLT function.
- multiple outputs via `<xsl:document>` XSLT element.
- multiple programs via `<<xsl:include>` and `<xsl:import>` XSLT elements.

The Supported Information Items



The Transformation Process

- based on template rules.
- a template rule = template pattern + template body.
  `<xsl:template match=''pattern''> body </xsl:template>`
  the pattern matches nodes in the source tree.
  for the matched nodes, the template body is instantiated.
- template pattern = XPath expression.
- template body = literal result elements + XSLT instructions.
- find templates that apply to nodes in the source tree.
- more templates for the same nodes $\rightarrow$ processing modes or conflict resolution policy.
- no template for nodes $\rightarrow$ built-in templates.
- after processing a node, start to process its children:
  `<xsl:apply-templates>`

Push Processing

How is working?

- a template rule for each kind of node.
- apply templates for children.
- use built-in templates if needed.

Application: similar structure for input and output.

Example

- Chapter 2 from *XSLT Programmer's Reference*, M. Kay. `http://www.wrox.com`
- XML Source: `books.xml`
- XSLT StyleSheet: `books.xsl`

Pull Processing

How is working?

- explicitly select and process the required nodes.

  ```
  <xsl:value-of  select=''pattern''/>
  <xsl:apply-templates  select=''pattern''/>
  <xsl:for-each  select=''pattern''/>
  ```

- greater control over which nodes are to be processed.

Application: very different structure for input and output.

Example (Chapter 1)

- XML Source: `books.xml`
- XSLT StyleSheet: `books_pull.xsl`

Processing Modes

- for processing the same node in the source tree more than once, but in different ways.
- another (not general) possibility: push and pull processing for the same node.
- example: handling the section headings of a book in two different ways

  – for the table of contents (mode toc).

  ```
  <xsl:apply-templates  select=''heading''  mode=''toc''/>
  <xsl:template  match=''heading''  mode=''toc''/>
  ```

  – inside the body of the document (mode body).

  ```
  <xsl:apply-templates  select=''heading''  mode=''body''/>
  <xsl:template  match=''heading''  mode=''body''/>
  ```

Example

- Formatting the XML Specification
- Chapter 10 from *XSLT Programmer's Reference*, M. Kay. http://www.wrox.com
- XML Source: `REC-xml-19980210.xml` XSLT StyleSheets: `xmlspec.xsl`, `xpath.xsl`, `xslt.xsl`

Conflict Resolution Policy

- more templates with patterns matching the same node in the source tree.
- no processing modes are used.
- appears when several stylesheets are imported, or included.

Solution: each template has a priority

- set by an XSLT instruction.
  `<xsl:template match=''pattern'' priority=''1''/>`.
- given by the selectivity of its pattern.

Patterns	Default priority
`node()`, `text()`, `*`	-0.5
`abc:*`	(-0.5 , 0.0)
`title`, `@id`	0.0
`book[@isbn]`, `para[1]`	> 0.0

A numerically higher value indicates a higher priority.

Built-in Templates

- `<xsl:apply-templates>` is invoked to process a node,
  and there is no template rule in the stylesheet that matches that node.
- built-in template rule for each type of node.

Node type	Built-in template rule
root	call `<xsl:apply-templates>` to process its children.
element	call `<xsl:apply-templates>` to process its children.
attribute	copy the attribute value to the result tree.
text	copy the text to the result tree.
commment	do nothing.
pi	do nothing.
namespace	do nothing.

The XSLT Language

- XML syntax.

  Benefits reuse of XML tools for processing XSLT programs (or stylesheets).

  In practice Visual development tools needed to avoid typing angle brackets.

- free of side-effects, i.e. obtain the same result regardless of the order/number of execution of the statements.

  Benefits Useful for progressive rendering of large XML documents.

  In practice a value of a variable can not be updated.

- processing described as a set of independent pattern matching rules.

  Benefits XSLT - a declarative language.

  similar to CSS, but much more powerful.

  In practice a rule specifies what output should be produced

  when particular patterns occur in the input.

- dynamically-typed language.
  types are associated with values rather than with variables, like JavaScript.

Data Types in XSLT

- five data types available: boolean, number, string, node-set, external object.
- addition with XSLT 1.1: result tree fragment (RTF).
- implicit conversion is generally carried out when the context requires it.
- explicit conversion with functions `boolean`, `number`, `string`.

From/To	boolean	number	string	node-set	external object
boolean	n.app.	false → 0 true → 1	false → 'false' true → 'true'	n.a.	n.a.
number	0 → false other → true	n.app.	decimal	n.a.	n.a.
string	null → false other → true	decimal	n.app.	n.a.	n.a.
node-set	empty → false other → true	string() function	string value of first node	n.app.	n.a.
external object	n.a.	n.a.	n.a.	n.a.	n.app.

XSLT variables & parameters

Variables

- global variables - accesible throughout the whole stylesheet.
- local variables - available only within a particular template body.
- variable name and value defined with XSLT element `<xsl:variable>`, e.g. `<xsl:variable name=''sum'' value=''0''/>`
- can be referenced in XPath expressions as `$sum`.

Parameters

- global parameters - set from outside the stylesheet, e.g. command line, API.
  defined with XSLT element `<xsl:param>`.
- local parameters - available only within a template.
  defined with XSLT element `<xsl:with-param>`.

XPath Expressions

- evaluated in a context, consisting of a static and dynamic context.
- static context - depends on where the expression appears.
  - set of namespace declarations in force at the point where the expression is written.
  - set of variable declarations in scope at the point where the expression is written.
  - set of functions available to be called.
  - base URI of the stylesheet element containing the expression.
    for `document()` function.
- dynamic context - depends on the processing state at the time of expression evaluation.
  - current values of the variables in scope.
  - current location in the source tree, i.e.
  - current node - the node currently being processed.
  - context node - different from previous only for qualifiers inside expressions.
  - context position - position in the current node list.
  - context size - size of the current node list.

Stylesheet Structure

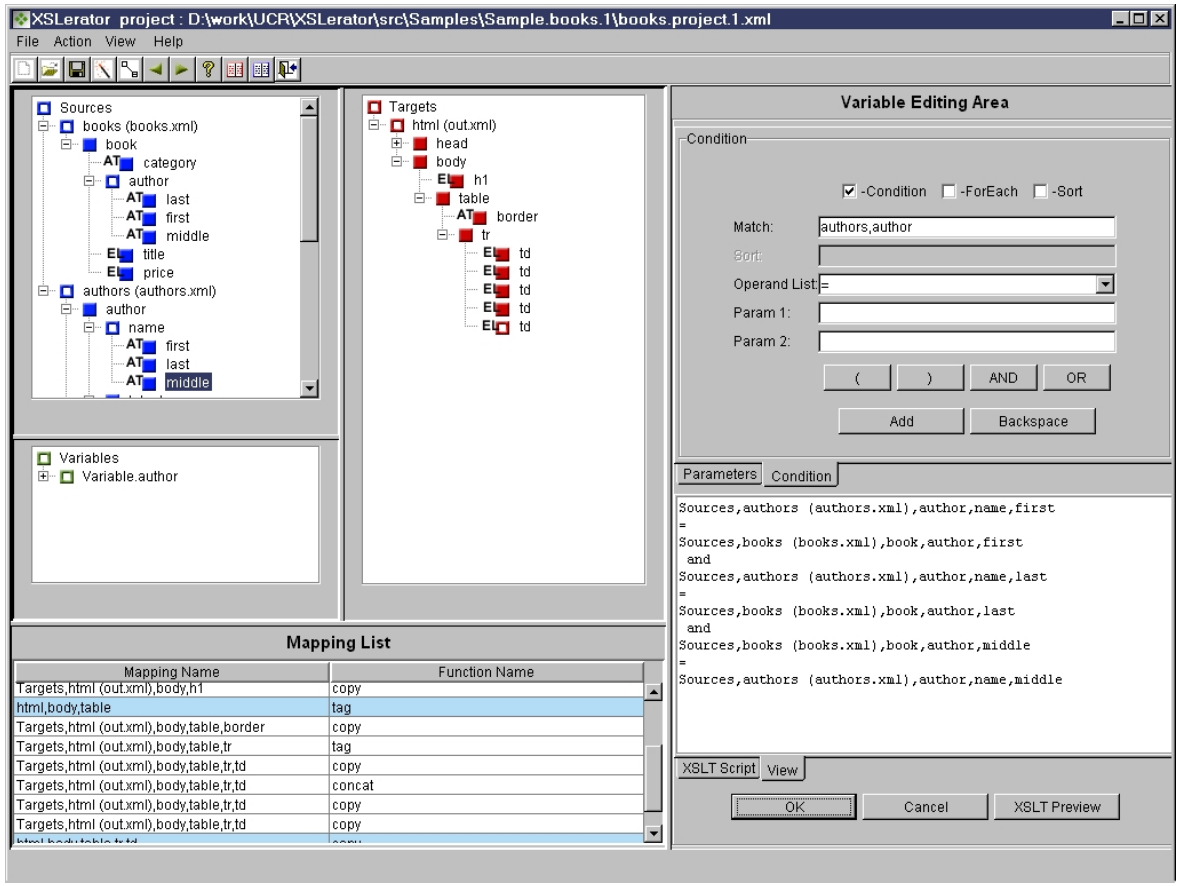
- `<xsl:stylesheet>` and `<xsl:transform>` elements.
  the outermost elements of any stylesheet.
- `<?xsl:stylesheet?>` processing instruction.
  used within an XML source to identify the stylesheet that should be used to process it.
- stylesheet modules, using
  - `<xsl:include>` - textual inclusion of the referenced stylesheet module.
    Example(Chapter 03): `sample.xml`, `principal.xsl`, `date.xsl`, `copyright.xsl`
  - `<xsl:import>` - the definitions in the imported module have lower import precedence.
- embedded stylesheets - inluded within another XML document,
  typically the document whose style it is defining.

XSLT Elements

- define template rules and control the way they are invoked:
  `<xsl:template>`, `<xsl:apply-templates>`, `<xsl:call-template>`
- define the structure of a stylesheet: `<xsl:stylesheet>`, `<xsl:include>`, `<xsl:import>`
- generate output: `<xsl:value-of>`, `<xsl:element>`, `<xsl:attribute>`, `<xsl:text>`, `<xsl:comment>`, `<xsl:processing-instruction>`
- define variables and parameters: `<xsl:variable>`, `<xsl:param>`, `<xsl:with-param>`
- copy information from the source to the result: `<xsl:copy>`, `<xsl:copy-of>`
- conditional processing and iteration:
  `<xsl:if>`, `<xsl:choose>`, `<xsl:when>`, `<xsl:otherwise>`, `<xsl:for-each>`
- sort and number: `<xsl:sort>`, `<xsl:number>`
- control the final output format: `<xsl:output>`, `<xsl:document>`

Finally an Example Break :-)

- XSLerator at IBM AlphaWorks http://www.alphaworks.ibm.com/tech/xslerator
- generate XSLT transformations from mappings defined using a visual interface.
- Input examples from Chapter 4.



XSLT Design Patterns

repertoire of programming techniques in XSLT which were found useful.

- Fill-in-the blanks stylesheets.
- Navigational stylesheets.
- Rule-based stylesheets.
- Computational stylesheets.

Fill-in-the-blanks Stylesheets

- the template looks like a standard HTML file.
- addition of extra tags used to retrieve variable data.
- useful for non-programmers with HTML authoring skills.
- useful when the stylesheet has the same structure as the desired output.
- fixed content included as text or literal result elements.
- variable content included by means of `<value-of>` instructions, that extract the relevant data from the source.
- similar to a wide variety of proprietary templating languages.
- Example: `orgchart.xml`, `orgchart.xsl` (Chapter 9).
  table with one row per person, with three columns for person's name, title, and the name of the boss.

Navigational Stylesheets

- still essentially output-oriented.
- use named templates as subroutines to perform commonly-needed tasks.
- use variables to calculate values needed in more than one place.
- looks very like a conventional procedural program with variables, conditional statements, loops, and subroutine calls.
- often used to produce reports on data-oriented XML, where the structure is regular and predictable.
- Example: `booklist.xml`, `booksales.xsl` (Chapter 9).
  report on the total number of sales for each publisher.

Rule-based Stylesheets

- primarily consists of template rules, describing how different informations from the source should be processed.
- represents the principal way that it is intended to be used.
- is not structured according to the desired output layout.
- like an inventory of components that might be encountered in the source, in arbitrary order.
- good for sources with flexible or unpredictable structure.
- natural evolution of CSS, with reacher pattern language and actions.
- Example: `scene2.xml`, `scene.xsl` (Chapter 9).
  HTML format for Scene 2 from Shakespeare's *Othello*.

Computational Stylesheets

- for generating nodes in the result tree that do not correspond directly to nodes in the source, e.g.
  - there is structure in the source document that is not explicit in markup.
  - complex aggregation of data.
- based heavily on functional programming paradigma
  - no side-effects, i.e. no assignment instructions
  - recursion instead of iteration
- Example: `number-list.xml`, `number-total.xsl` (Chapter 9).
  totaling a list of numbers.

More XSLT Examples

- Finding the type of a node.
- Finding the namespaces of elements and attributes.
- Differentiate with XSLT.
- Computation of $n!$.
- The Sieve of Erastothenes.
- XML to SVG.

Example: Finding the Type of a Node

```
<xsl:template name="node:type">
  <xsl:param name="node" select="."/>
  <xsl:choose>
    <xsl:when test="$node/self::*">
      <xsl:text> element </xsl:text>
    </xsl:when>
    <xsl:when test="$node/self::text()">
      <xsl:text> text </xsl:text>
    </xsl:when>
    <xsl:when test="$node/self::comment()">
      <xsl:text> comment </xsl:text>
    </xsl:when>
    <xsl:otherwise>
      <xsl:text> processing instruction </xsl:text>
    </xsl:otherwise>
  </xsl:choose>
</xsl:template>
```

Example: Finding the Namespaces of Elements and Attributes

```
<xsl:template match="*" mode="namespace">
  <xsl:for-each select="namespace::*">
    <xsl:variable name="uri" select="."/>
    <xsl:if test="namespace-uri(..)  = $uri">
      <p> <span style="text-width:bold;color:blue;">
        <xsl:value-of select="name(..)"/>
      <span/> is in namespace
      <code> <a href="$uri"> <xsl:value-of select="$uri"/> </a> </code>
      <xsl:if test="name()">
        with prefix <code> <xsl:value-of select="name()"/> </code>
      </xsl:if> </p>
    </xsl:if>
  </xsl:for-each>
</xsl:template>
```

Example: Differentiate with XSLT (1/2)

$$f(x) = (1 \cdot x^3) + (2 \cdot x^2) + (3 \cdot x^1) + (4 \cdot x^0)$$
$$f'(x) = (3 \cdot x^2) + (4 \cdot x^1) + (3 \cdot x^0) + (0 \cdot x^{-1})$$

DTD:

```
<!ELEMENT function-of-x (term+)>
  <!ELEMENT term (coeff, x, power)>
    <!ELEMENT coeff (#PCDATA)>
    <!ELEMENT x EMPTY>
    <!ELEMENT power (#PCDATA)>
```

Instance:

```
<function-of-x>
  <term> <coeff> 1 </coeff> <x/> <power> 3 </power> </term>
  <term> <coeff> 2 </coeff> <x/> <power> 2 </power> </term>
  <term> <coeff> 3 </coeff> <x/> <power> 1 </power> </term>
  <term> <coeff> 4 </coeff> <x/> <power> 0 </power> </term>
</function-of-x>
```

Example: Differentiate with XSLT (2/2)

```
<xsl:stylesheet version='1.0' xmlns:xsl='http://.../Transform'>
  <xsl:strip-space elements='*'/>
  <xsl:output method='xml' indent='yes'/>
  <xsl:template match='/function-of-x'>
    <xsl:element name='function-of-x'>
      <xsl:apply-templates select='term'/>
    </xsl:element>
  </xsl:template>

  <xsl:template match='term'>
    <term>
      <coeff> <xsl:value-of select='coeff * power'/> </coeff>
      <x/>
      <power> <xsl:value-of select='power - 1'/> </power>
    </term>
  </xsl:template>
</xsl:stylesheet>
```

Example: Computation of $n!$ Factorial

```
<xsl:template name="factorial">
  <xsl:param name="n" select="1"/>
  <xsl:variable name="sum">
    <xsl:if test="$n = 1"> 1 </xsl:if>
    <xsl:if test="$n != 1">
      <xsl:call-template name="factorial">
        <xsl:with-param name="n" select="$n - 1"/>
      </xsl:call-template>
    </xsl:if>
  </xsl:variable>
  <xsl:value-of select="$sum * $n"/>
</xsl:template>
```

Example: The Sieve of Erastothenes (1/2)

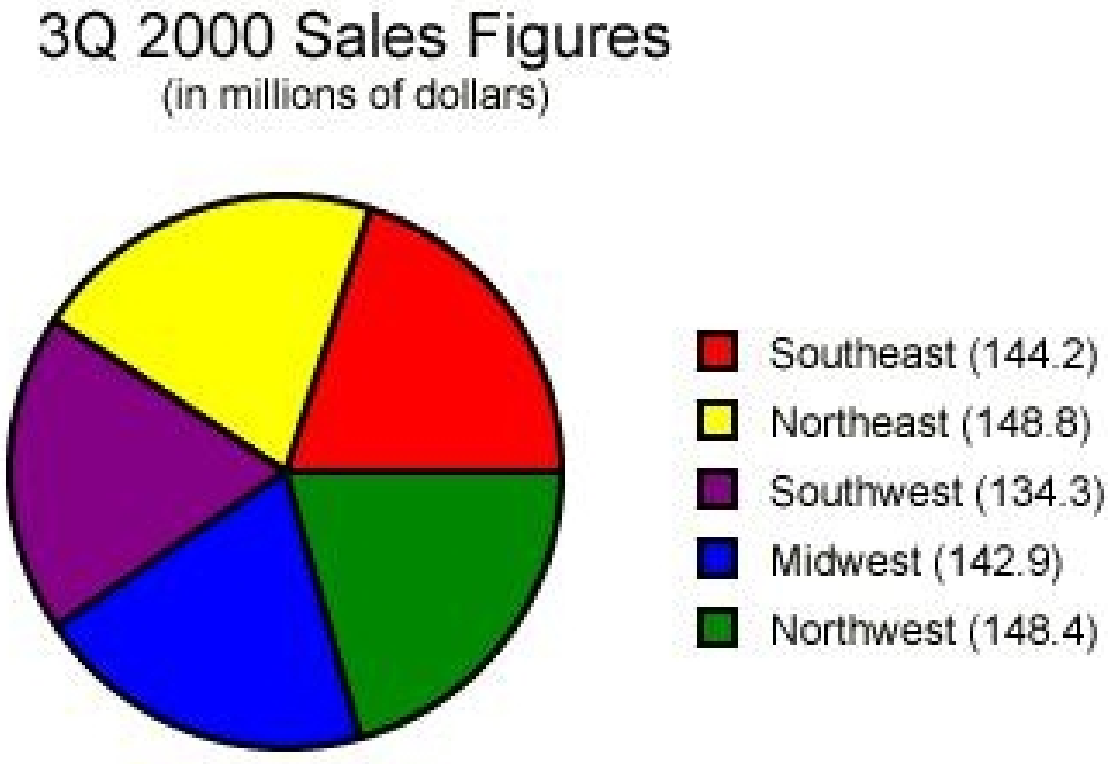
- Compute prime numbers
- 2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47, 53, 59, 61, 67, 71, 73, 79, 83, 89, 97, 101, 103, 107, 109, 113, 127, 131, 137, 139, 149, 151, 157, 163, 167, 173, 179, 181, 191, 193, 197, 199, 211, 223, 227, 229, 233, 239, 241, 251, 257, 263, 269, 271, 277, 281, ...

Example: The Sieve of Erastothenes (2/2)

```
<!-- Mark all multiples of $number in $array with '*' -->
<xsl:template name="mark">
  <xsl:param name="array"/>
  <xsl:param name="number"/>
  <xsl:choose>
    <xsl:when test="string-length($array) &gt; $number">
      <xsl:value-of select="substring($array, 1, $number - 1)"/>
      <xsl:text> * </xsl:text>
      <xsl:call-template name="mark">
        <xsl:with-param name="array" select="substring($array,$number+1)"/>
        <xsl:with-param name="number" select="$number"/>
      </xsl:call-template>
    </xsl:when>
    <xsl:otherwise>
      <xsl:value-of select="$array"/>
    </xsl:otherwise>
  </xsl:choose> </xsl:template>
```

Example: XML to SVG

```
<sales> <caption> 3Q 2000 Sales Figures </caption>
  <region> <name> Southeast </name>
    <product name="Heron"> 38.3 </product>
    <product name="Kingfisher"> 12.7 </product>
  </region> </sales>
```



XSLT Processors: Saxon

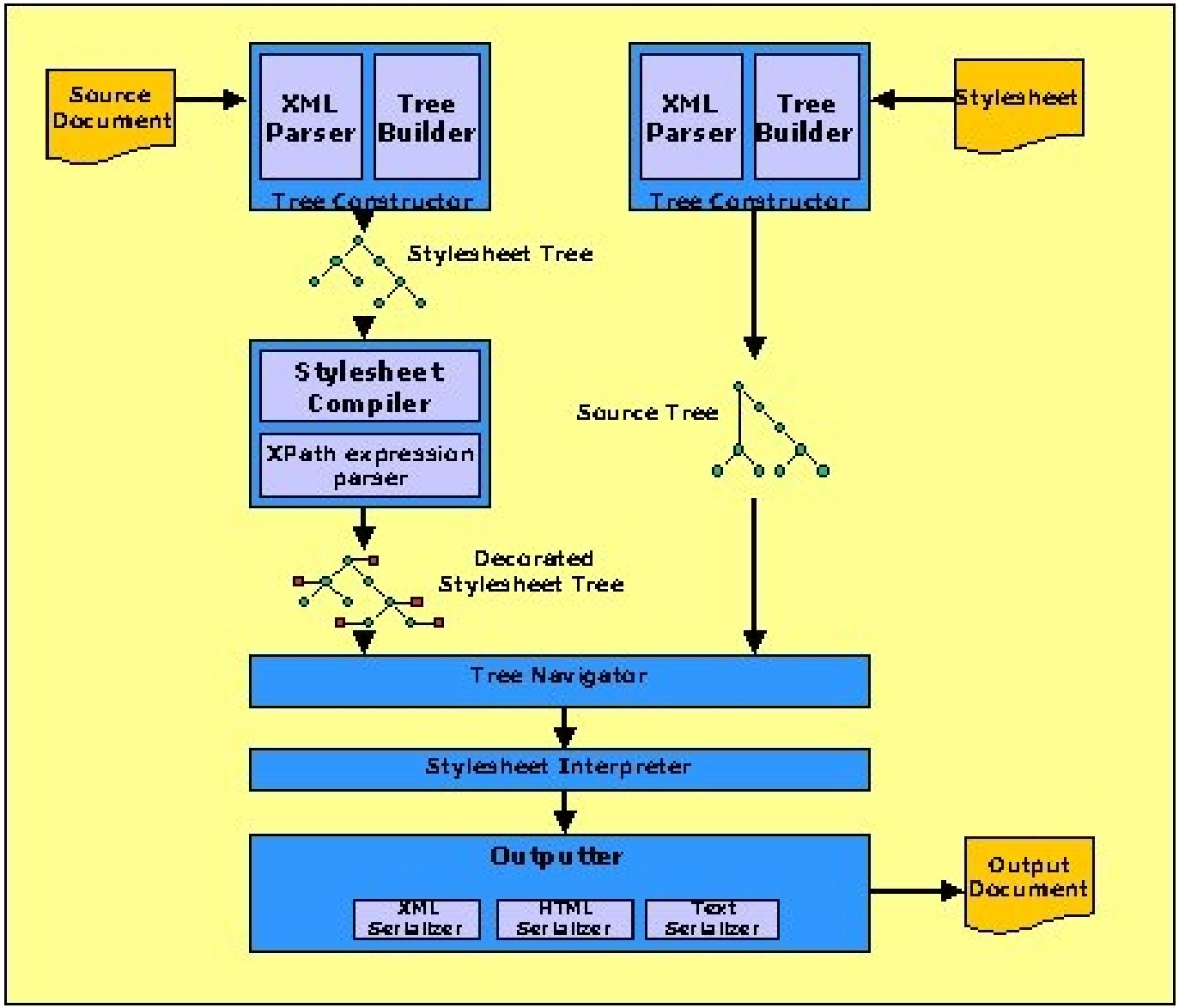
- open source, available at `http://users.iclway.co.uk/mhkay/saxon/`.
- runs on Java 1.1 or Java 2 platform.
- Instalation
  - fetch `instant-saxon.zip` or `saxon.zip`.
  - set CLASSPATH accordingly: CLASSPATH=saxon.jar:$CLASSPATH.
- Invokation
  - command line: `saxon source.xml style.xsl > output.html`
  - Java application: via the TrAX API defined in JAXP 1.1
    `java com.icl.saxon.StyleSheet source.xml style.xsl > output.html`
- built-in extension XPath functions:
  `after(ns1, ns2)`, `before(ns1, ns2)`, `difference(ns1, ns2)`,
  `intersection(ns1, ns2)`, `distinct(ns1)`, `evaluate(string)`.
- built-in extension XSLT elements:
  `<saxon:function>`, `<saxon:return>`, `<saxon:while>`.

XSLT Processors: Xalan

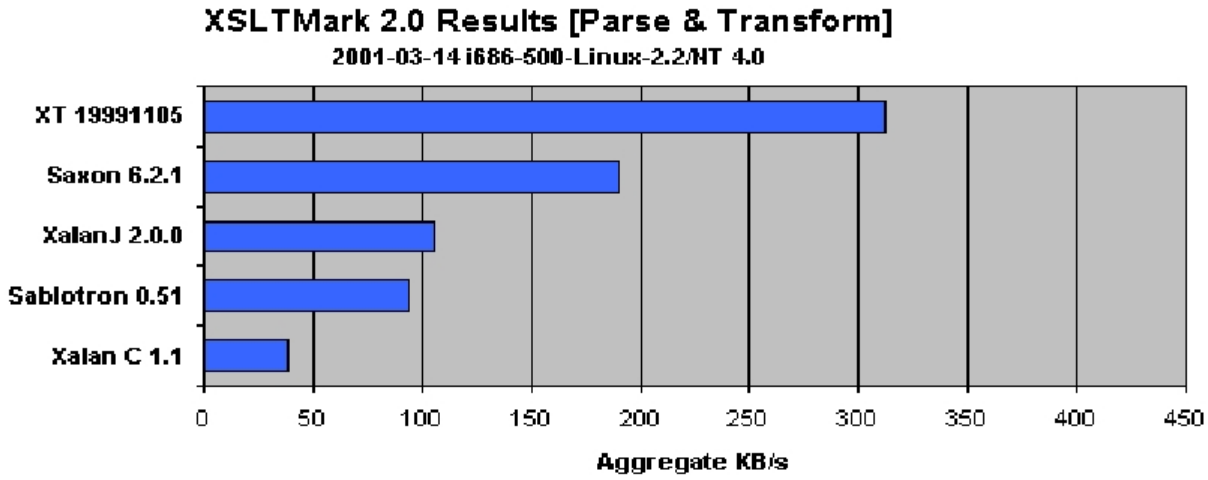
- open source, available at `http://www.apache.org/`.
- Java and C++ versions.
- Instalation
  - fetch `xalan.jar`, `xerces.jar`.
  - set CLASSPATH accordingly: CLASSPATH=xerces.jar:xalan.jar:$CLASSPATH.
- Invokation
  - command line:

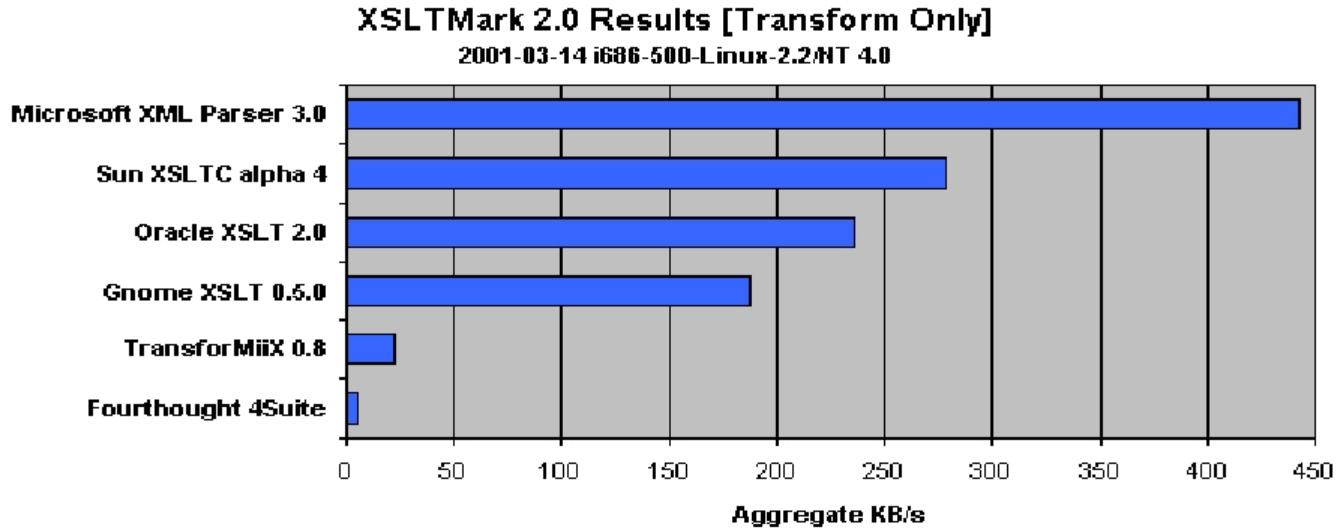
    ```
    java org.apache.xalan.xslt.Process -in a.xml -xsl b.xsl -out c.html
    ```
- user-defined and built-in extension functions and elements.
- built-in extension functions:
  `difference(ns1, ns2)`, `intersection(ns1, ns2)`, `distinct(ns1)`, `evaluate(string)`.
- SQL extension functions for JDBC connections.
- multiple output files.

XSLT Processors: Architecture



XSLT Processors: Comparison





What's coming? XSLT 2.0

XSLT 1.1 standardizes a small number of urgent features.

- multiple output documents via `<xsl:document>`.
- temporary trees via `nodeset()`.
- standard bindings to extension functions written in Java and ECMAScript.

XSLT 2.0 at `http://www.w3.org/TR/xslt20req`.

- simplify manipulation of XML Schema-typed content.
- support for reverse IDREF attributes, e.g. `key()` function.
- support sorting nodes based on XML Schema type.
- simplify grouping.

Tutorials: Useful links

- XSLT W3C Specification

  http://www.w3c.org/TR/xslt

- *XSLT Programmer's Reference*, Snd Edition. Michael Kay.

  www.wrox.com

- XSLT Tutorial at Zvon

  http://www.zvon.org/xxl/XSLTutorial/Output/index.html

- XSL Tutorial at W3Schools

  http://www.w3schools.com/xsl/

- Practical transformation using XSLT and XPath

  http://www-106.ibm.com/developerworks/education/xslt-xpath-tutorial.html

- The XML Cover Pages

  http://xml.coverpages.org/xsl.html