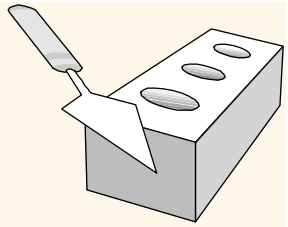
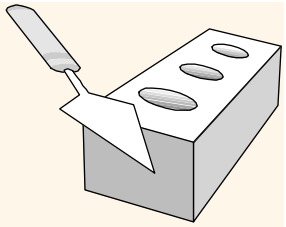


# *Introduction to XML (Extensible Markup Language)*

# *History and References*

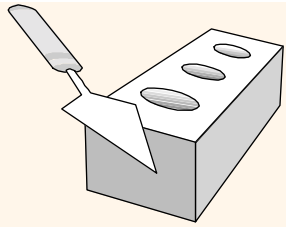


- XML is a meta-language, a simplified form of SGML (Standard Generalized Markup Language)
- XML was initiated in large parts by Jon Bosak of Sun Microsystems, Inc., through a W3C working group

- References:

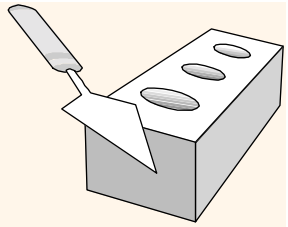

1. "*XML Pocket Reference,"* Robert Eckstein, O'Reilly & Associates, Inc., 1999
2. "*Describing and Manipulating XML Data,"* Sudarshan S. Chawathe, Bulletin of Data Engineering, v22, n3, Sept. 99
3. "*XML Schema Tutorial,"* Roger L. Costello http://www.xfront.com/
4. XML namespaces: http://www.w3.org/TR/1999/REC-xml-names-19990114/
5. XML specifications: http://www.w3.org/TR/REC-xml/
6. XML Schema Part 0: Primer http://www.w3.org/TR/xmlschema-0/
7. XML Schema Part 1: Structures http://www.w3.org/TR/xmlschema-1/
8. XML Schema Part 2: Datatypes http://www.w3.org/TR/xmlschema-2/
9. WWW Consortium XML Site: http://www.w3.org/XML/
10. XML Namespaces Tutorial: http://zvon.org/xxl/NamespaceTutorial/Output/index.html
11. XML Tutorials: http://www.zvon.org/index.php?nav_id=tutorials&mime=html
12. XSL: http://www.w3.org/TR/xsl and http://www.w3.org/TR/xslt

# *Overview*



- An XML compliant application generally needs three files to display XML content:
  - The XML document
    - Contains the data tagged with meaningful XML elements
  - A document type definition – DTD or Schema
    - Specifies the rules how elements and attributes are logically related
  - A stylesheet
    - Dictates the formatting when the XML document is displayed. Examples: CSS - cascading style sheets, XSL - extensible stylesheet language

# *Terminology*



- Element, e.g.,:

```
<Body>
This is text formatted according to the body element
</Body>
```

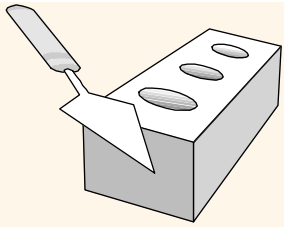
  - An element consists always of two tags:
    - An opening tag, e.g., <Body>
    - A closing tag, e.g., </Body>

- An element can have attributes, e.g.,:

```
<Price currency="Euro">25.43</Price>
```

  - Attribute values must always be in quotes (unlike HTML)

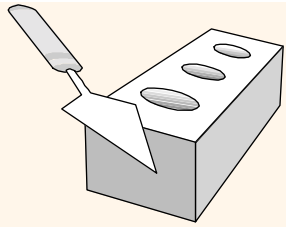
# *A Simple XML Document*



- Example: Book description

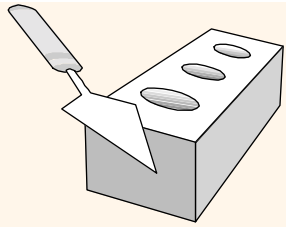
```
<?xml version="1.0" standalone="no"?>
<!DOCTYPE BOOKCATALOG SYSTEM "http://tt.com/bookcatalog.dtd">
<!-- Here begins the XML data -->
<book>
  <title>The spy who came in from the cold</title>
  <author>John <lastname>Le Carre</lastname></author>
  <price currency="USD">5.59</price>
  <review><author>Ben</author>Perhaps one of the
  finest...</review>
  <review><author>Jerry</author>An intriguing tale
  of...</review>
  <bestseller authority="NY Times"/>
</book>
```

# *Characteristics*



- Markup: Text delimited by angle brackets (<…>)
- Character Data: the rest
- Element names are not unique
  - (e.g., two `<review>`)
- Attribute names are unique within an element
  - (e.g., one “currency” attribute in price)
- Elements can be empty and hence presented concisely
  - (e.g., `<bestseller></bestseller>` = `<bestseller/>`)
- An XML document is *well-formed* if it satisfies simple syntactic constraints

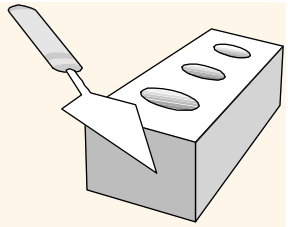
# *A Simple Document Type Definition*



- Example DTD

```
<!ELEMENT book (title, author+, price, review*,
  bestseller?)>
<!ELEMENT title (#PCDATA)>
<!ELEMENT author
  (#PCDATA|lastname|firstname|fullname)*>
<!ELEMENT price (#PCDATA)>
<!ATTLIST price currency CDATA "USD"
source (list|regular|sale) list
taxed CDATA #FIXED "yes">
<!ELEMENT bestseller EMPTY>
<!ATTLIST bestseller authority CDATA #REQUIRED>
```

# *The DTD Language: Required Elements*

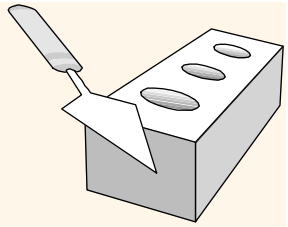


- Example DTD

```
<!ELEMENT book (title, author+, price, review*,
  bestseller?)>
<!ELEMENT title (#PCDATA)>
<!ELEMENT author
  (#PCDATA|lastname|firstname|fullname)*>
<!ELEMENT price (#PCDATA)>
```

  - Required child elements for the *book* element: *title, author, price*
  - #PCDATA: Parsed Character Data

# *The DTD Language: Element*



- An XML compliant document is composed of elements:
  - Simple elements

    ```
    <!ELEMENT title ANY>
    ```

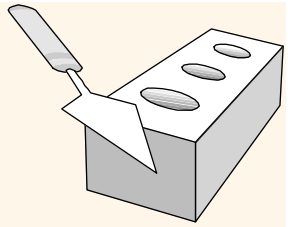
    - The element can contain valid tags and character data

    ```
    <!ELEMENT title (#PCDATA)>
    ```

    - The element cannot contain tags, only character data
  - Nested elements

    ```
    <!ELEMENT book (title)>
    <!ELEMENT title (#PCDATA)>
    ```

# *The DTD Language: Element (cont'd)*



- Nested and ordered elements:

```
<!ELEMENT books (title,author)>
<!ELEMENT title (#PCDATA)>
<!ELEMENT author (#PCDATA)>
```

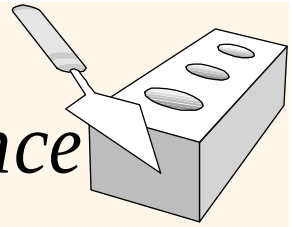
  - The order of the elements must be title, then author

- Nested either-or elements

```
<!ELEMENT books (title|author)>
<!ELEMENT title (#PCDATA)>
<!ELEMENT authors (#PCDATA)>
```

  - There must be either a title or an author element, but not both.

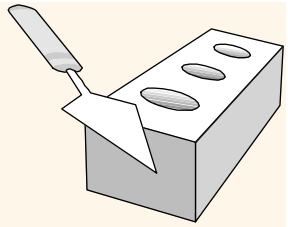
# *The DTD Language: Grouping and Recurrence*



```
<!ELEMENT book (title, author+, price, review*,
  bestseller?)>
<!ELEMENT title (#PCDATA)>
<!ELEMENT author (#PCDATA|lastname|firstname|fullname)*>
```

- Wild cards
  - ?: 0 or 1 time
  - +: 1 or more times
  - *: 0 or more times
- Declaration requires every book element to have a price sub-element
- The use of some element names (e.g., review, lastname) without a corresponding declaration is not an error; such elements are simply not constrained by this DTD

# *The DTD Language: Entity*



- Inside a DTD we can declare an entity which allows us to use an entity reference in XML document to substitute a series of characters, similar to macros.
  - Format:

    ```
    <!ENTITY name "replacement_characters">
    ```

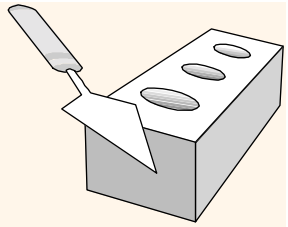
    - Example for the © symbol:

      ```
      <!ENTITY copyright "&#xA9;">
      ```

  - Usage: entities must be prefixed with '&' and followed by ';':

    ```
    <copyright>
    &copyright; 2000 MyCompany, Inc.
    </copyright>
    ```

# *The DTD Language: Parameter Entity*



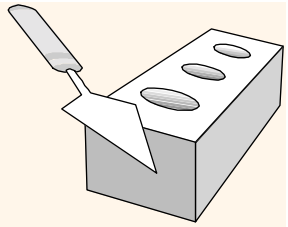
- Parameter entity references appear only within a DTD and cannot be used in an XML document. They are prefixed with a %.
  - Format and usage:

    ```
    <!ENTITY % name “replacement_characters”>
    ```

    - Example:

      ```
      <!ENTITY % pcdata “(#PCDATA)”>
      <!ENTITY authortitle %pcdata;>
      ```

# *The DTD Language: External Entity*



- External entities allow us to include data from another XML document (think of it as #include<...> statement in C):
  - Format and usage:

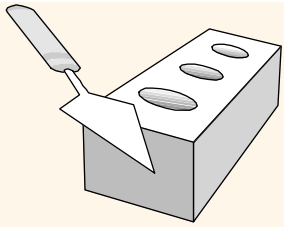
```
<!ENTITY quotes SYSTEM
  “http://www.stocks.com/quotes.xml”>
```

    - Example:

```
<document>
  <heading>Current stock quotes</heading>
  &quotes; <!-- data from quotes.xml -->
</document>
```

  - Works well for the inclusion of dynamic data.

# *The DTD Language: Attribute*



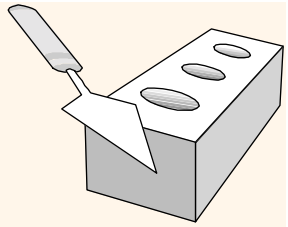
- Attributes for XML elements are declared in DTD
  - Format and usage:

```
<!ATTLIST target_element attr_name
  attr_type default>
```

  - Examples:

```
<!ATTLIST box length CDATA “0”>
<!ATTLIST box width CDATA “0”>
<!ATTLIST frame visible (true|false) “true”>
<!ATTLIST person marital (single | married | divorced
  | widowed) #IMPLIED>
```

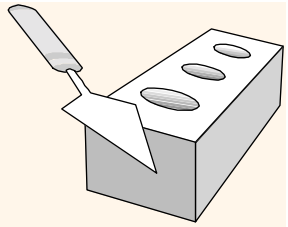
# *The DTD Language: Attribute Example*



```
<!ELEMENT price (#PCDATA)>
<!ATTLIST price currency CDATA "USD"
source (list|regular|sale) “list”
taxed CDATA #FIXED "yes">
<!ELEMENT bestseller EMPTY>
<!ATTLIST bestseller authority CDATA #REQUIRED>
```

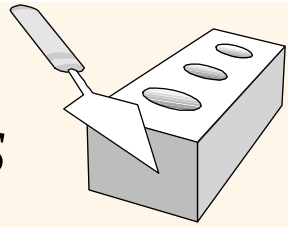
- *Currency*, of type character data, default “USD”
- *Source*, of one of the three enumerated types, default “list”
- *Taxed*, with the fixed value “yes”
  - Fixed attribute type is a special case of default
  - It determines that the default value cannot be changed by an XML document conforming to the DTD
  - E.g., a book in our XML example must be taxed

# *The DTD Language: Attribute Modifiers*



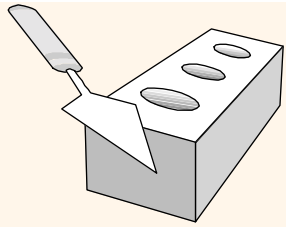
| Modifier | Description |
|---|---|
| #REQUIRED | The attributes value must be specified with the element. |
| #IMPLIED | The attribute value can remain unspecified. |
| #FIXED | The attribute value is fixed and cannot be changed by the user. |

# *The DTD Language: Attribute Data Types*



| Type | Description |
|---|---|
| CDATA | Character data |
| enumerated | A series of values of which only 1 can be chosen |
| ENTITY | An entity declared in the DTD |
| ENTITIES | Multiple whitespace separated entities declared in the DTD |
| ID | A unique element identifier |
| IDREF | The value of a unique ID type attribute |
| IDREFS | Multiple whitespace separated IDREFs of elements |
| NMTOKEN | An XML name token |
| NMTOKENS | Multiple whitespace separated XML name tokens |
| NOTATION | A notation declared in the DTD |

# *The DTD Language: Example*

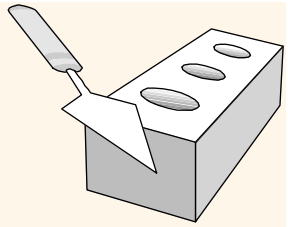


- Sales Order Document

  “An order document is comprised of several sales orders. Each individual order has a number and it contains the customer information, the date when the order was received, and the items ordered. Each customer has a number, a name, street, city, state, and ZIP code. Each item has an item number, parts information and a quantity. The parts information contains a number, a description of the product and its unit price.

  The numbers should be treated as attributes.”

# *The DTD Language: Example (cont'd)*

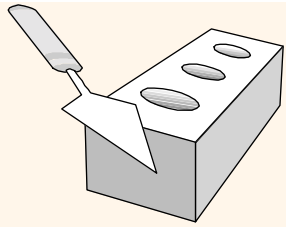


- Sales Order DTD Document

```
<!-- DTD for example sales order document -->
<!ELEMENT Orders (SalesOrder+)>
<!ELEMENT SalesOrder (Customer,OrderDate,Item+)>
<!ELEMENT Customer (CustName,Street,City,State,ZIP)>

<!ELEMENT OrderDate (#PCDATA)>
<!ELEMENT Item (Part,Quantity)>
<!ELEMENT Part (Description,Price)>
<!ELEMENT CustName (#PCDATA)>
<!ELEMENT Street (#PCDATA)>
<!ELEMENT ... (#PCDATA)>
<!ATTLIST SalesOrder SONumber CDATA #REQUIRED>
<!ATTLIST Customer CustNumber CDATA #REQUIRED>
<!ATTLIST Part PartNumber CDATA #REQUIRED>
<!ATTLIST Item ItemNumber CDATA #REQUIRED>
```

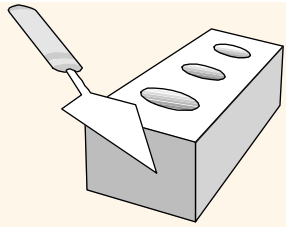
# *The DTD Language: Example (cont'd)*



- Sales Order XML Document

```
<Orders>
 <SalesOrder SONumber="12345">
  <Customer CustNumber="543">
   <CustName>ABC Industries</CustName>
   <Street>123 Main St.</Street>
   <City>Chicago</City>
   <State>IL</State>     <ZIP>60609</ZIP>
  </Customer>
  <OrderDate>10222000</OrderDate>
  <Item ItemNumber="1">
   <Part PartNumber="234">
    <Description>Turkey wrench</Description>
    <Price>9.95</Price>
   </Part>
   <Quantity>10</Quantity>
  </Item>
 </SalesOrder>
</Orders>
```

# *The DTD Language: DOCTYPE*

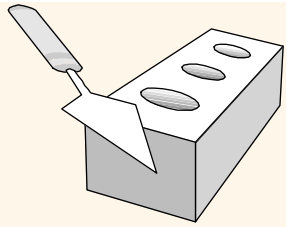


- An XML document that satisfies the constraints of a DTD is said to be *valid* with respect to that DTD.
- *document type declaration* (at the “prolog” of an XML document):

  <!DOCTYPE BOOKCATALOG SYSTEM "http://tt.com/bookcatalog.dtd">

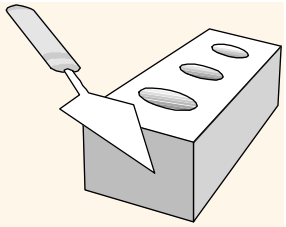
- XML document claims validity with respect to the BOOKCATALOG DTD

# *XML vs. Databases*



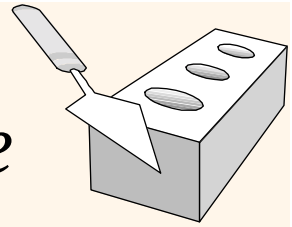
- "Is XML a database?"
  - In a strict sense, no; in a more liberal sense, yes:
    - XML has:
      - Storage (the XML document)
      - A schema (DTD)
      - Query languages (XQL, XML-QL, …)
      - Programming interfaces (SAX, DOM)
    - XML lacks:
      - Efficient storage, indexes, security, transactions, multi-user access, triggers, queries across multiple documents

# *XML Usage*



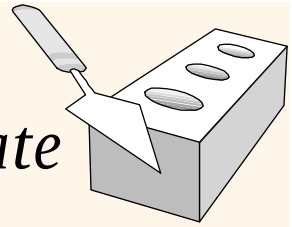
- There are two ways to use XML in a database environment:
  - Use XML for data exchange, i.e., to get data in and out of the database
    - Data is stored in a relational or object-oriented database
    - Middleware converts between the database and XML
  - Use a “native XML” database, i.e., store data in document form
    - Use a content management system

# *Data- vs. Document-Centric XML Storage*



- Data-centric storage and retrieval systems
  - Use a database
    - Add middleware to convert to/from XML
  - Use an XML server (specialized product for e-commerce)
  - Use an XML-enabled web server with a database backend
- Document-centric storage and retrieval systems
  - Content management system
  - Persistent DOM implementation

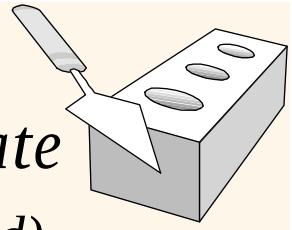
# *Mapping between Documents and Data: By Template*



- Mapping document structure to database structure
  1. Template-driven
     - No predefined mapping
     - Embedded commands process (retrieve) data
     - Currently only available from RDBMS to XML (unidirectional)
     - Example:

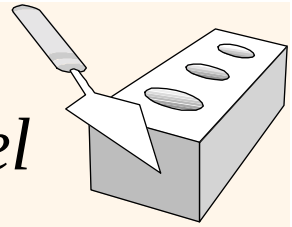
```
<?xml version="1.0">
<FlightInfo>
  <Intro>The following flights have
      available seats:</Intro>
  <SelectStmt>SELECT Airline, FltNumber,
   Depart, Arrive FROM Flights</SelectStmt>
  <Conclude>We hope one of these meets your
   needs</Conclude>
</FlightInfo>
```

# *Mapping between Documents and Data: By Template (cont'd)*



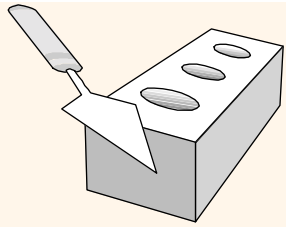
```
<?xml version="1.0">
<FlightInfo>
  <Intro>The following flights have
   available seats:</Intro>
  <Flights>
    <Row>
      <Airline>ACME</Airline>
      <FltNumber>123</FltNumber>
      <Depart>Dec 12, 2000, 13:43</Depart>
      <Arrive>Dec 13, 2000, 01:21</Arrive>
    </Row>
  </Flights>
  <Conclude>We hope one of these meets your
   needs</Conclude>
</FlightInfo>
```

# *Mapping between Documents and Data: By Model*



- Mapping document structure to database structure
  2. Model-driven
     - A data model is imposed on the structure of the XML document
     - This model is mapped to the structures in the database
     - There are two common models:
       - Model the XML document as a single table or a set of tables (***table-based mapping***; bi-directional)
       - Model the XML document as a tree of data-specific objects (***object-relational mapping***)

# *Mapping between Documents and Data: By Model (cont'd)*



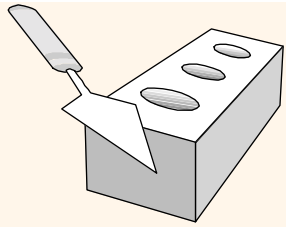
- Single table or set of tables:

```
<?xml version="1.0">
<database>
  <table>
   <row>
      <column1>...</column1>
      <column2>...</column2>
      ...
    </row>
    <row>
     ...
    </row>
  </table>
</database>
```

- Tree organization:

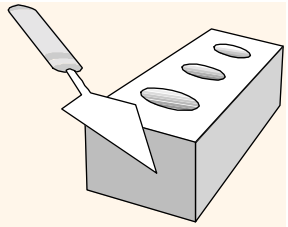
```
          Orders
            |
        SalesOrder
       /    |    \
Customer  Item  Item
            |     |
          Part  Part
```

# *Extensible Stylesheet Language (XSL)*



- XSL is a language for transforming and formatting XML
- Recently, the transformation and formatting parts of XSL were separated
- Here, we focus on the *XSL transformation language*, called *XSLT*
- An XSLT stylesheet is a collection of transformation rules that operate (non-destructively) on a source XML document (source tree) to produce a new XML document (result tree)
- Each rule consists of a *pattern* and a *template*
  - Patterns matched against nodes of source tree
  - Templates instantiated to produce part of result tree

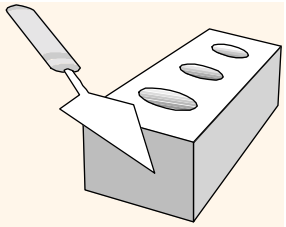
# *Example XSL*



```
<xsl:stylesheet version= “1.0”
  xmlns:xsl="http://w3.org/XSL/Transform/1.0"
xmlns="http://w3.org/1999/XSL/Transform"
indent-result="yes">
```

- Declare the XSL and XHTML namespaces used by the stylesheet
- The XHTML namespace is made the default namespace

# *Example XSL (cont'd)*

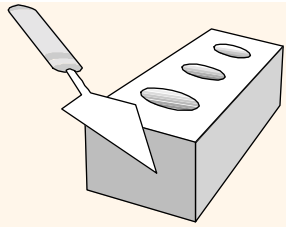


- Each template element describes one transformation rule
- The match attribute of a template element specifies the rule pattern while its content is the template used to produce the corresponding portion of the result tree

```
<!-- Rule 1 --> <xsl:template match="/">
     <html><head><title>Our New Catalog</title></head>
         <body>
            <xsl:apply-templates/>
         </body>
     </html>
 </xsl:template>
```

- The pattern "/" denotes the root of the source tree
- The template contains some standard XHTML header and trailer constructs
- The apply-templates element is a rule-processing instruction that denotes recursive processing of the contents of the matched element
- XSLT includes several other instructions which permit templates with constructs such as for-loops, conditional sections, and sorting

# *Example XSL (cont'd)*

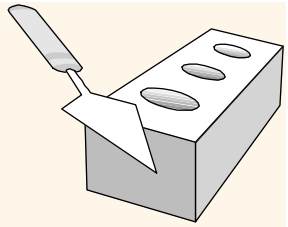


```
<!-- Rule 2 --> <xsl:template match="book/title">
    <h1><xsl:apply-templates/></h1>
</xsl:template>

<!-- Rule 3 --> <xsl:template match="book/author">
    <b><xsl:apply-templates/></b>
</xsl:template>
```

- Pattern, "book/title" matches a title element if its parent is a book element
- The template calls for recursive processing of the contents, enclosed in XHTML literals for bold display (...)
- XSL processing includes implicit rules that match elements, attributes, and character data (text) not matched by any explicit rules; these rules simply copy data from source to result tree
- In our example, all character data (such as the the text "The spy..." in the title) is copied to the result tree

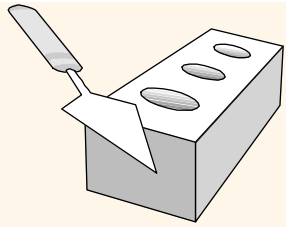
# *XSL Example (cont'd)*



```
<!-- Rule 4 --> <xsl:template match="book/price">
    <xsl:apply-templates/> <xsl:apply-templates select="@*">
</xsl:template>
```

- An additional apply-template instruction to extract the currency attribute using the syntax @*

# *XSL Example (cont'd)*



```
<!-- Rule 5 --> <xsl:template match="book/review[1]"
   priority="1.0">
     <xsl:apply-templates/>
</xsl:template>
```

- Matches only the first review element in each book element due to the "[1]" specification
- The template simply copies the contents to the result tree (using recursive processing with apply-templates combined with the default rules)

```
<!-- Rule 6 --> <xsl:template match="book/review"
   priority="0.5">
</xsl:template>
</xsl:stylesheet>
```

- Includes only the first review for each book:
- We ensure that the first review for each book is processed using Rule 5 instead of Rule 6 by assigning Rule 5 a higher priority