Chapter 2
Structured Web Documents in XML

Adapted from slides from Grigoris Antoniou and Frank van Harmelen

Outline

Role of XML in the Semantic Web

- Most of the Semantic Web involves ideas and languages at a fairly abstract level
  - e.g., for defining ontologies, publishing data using them
- But we also need a practical way of encoding the abstract languages
- Today's Web technology is (still) heavily based on XML standards
- So XML is (1) a potential alternative that the SW must improve on and (2) the most common encoding for SW data on the Web

To paraphrase Jamie Zawinski

Some people, when confronted with a problem, think, "I know, I'll use XML."

Now they have two problems.

History

- XML's roots are in SGML
  - Standard Generalized Markup Language
  - A metalanguage for defining document markup languages
  - Very extensible, but very complicated
- HTML was defines using SGML
  - It's a markup language, not a *markup metalanguage*
- XML proposal to W3C in July 1996
  - Idea: a simplified SGML could greatly expand the power and flexibility of the Web
  - First XML Meeting, August 1996, Seattle
- Evolving series of W3C recommendations

An HTML Example

```
<h2>Nonmonotonic Reasoning: Context-
  Dependent Reasoning</h2>
<i>by <b>V. Marek</b> and
  <b>M. Truszczynski</b></i><br>
Springer 1993<br>
ISBN 0387976892
```


The Same Example in XML

```
<book>
  <title>Nonmonotonic Reasoning: Context-Dependent
  Reasoning</title>
  <author>V. Marek</author>
  <author>M. Truszczynski</author>
  <publisher>Springer</publisher>
  <year>1993</year>
  <ISBN>0387976892</ISBN>
</book>
```


HTML versus XML: Similarities

- Both use **tags** (e.g. <h2> and </year>)
- Tags may be nested (tags within tags)
- Human users can read and interpret both HTML and XML representations quite easily

… **But how about machines?**

Problems Interpreting HTML Documents

An intelligent agent trying to retrieve the names of the authors of the book

- Authors' names could appear immediately after the title
- or immediately after the word "*by*" or *"van"* if it's in Dutch
- Are there two authors?
- Or just one, called "*V. Marek and M. Truszczynski*"?

HTML vs XML: Structural Information

- HTML documents do not contain **structural information**: pieces of the document and their relationships.
- XML more easily accessible to machines because
  - Every piece of information is described.
  - Relations are also defined through the nesting structure.
  - E.g., the **<author>** tags appear within the **<book>** tags, so they describe properties of the particular book.

HTML vs XML: Structural Information

- A machine processing the XML document would be able to deduce that
  - the **author** element refers to the enclosing **book** element
  - rather than by proximity considerations or other heuristics
- XML allows the definition of constraints on values
  - E.g. a year must be a number of four digits

HTML vs. XML: Formatting

- The HTML representation provides more than the XML representation:
  - The formatting of the document is also described
- The main use of an HTML document is to display information: it must define formatting
- **XML: separation of content from display**
  - same information can be displayed in different ways
  - Presentation specified by documents using other XML standards (CSS, XSL)

HTML vs. XML: Another Example

In HTML

```
<h2>Relationship matter-energy</h2>
<i> E = M × c2 </i>
```

In XML

```
<equation>
   <gloss>Relationship matter energy </gloss>
   <leftside> E </leftside>
   <rightside> M × c2 </rightside>
</equation>
```


HTML vs. XML: Different Use of Tags

- Both HTML documents use the same tags
- The XML documents use completely different tags
- HTML tags come from and finite, pre-defined collection
- They define properties for display: font, color, lists …
- XML tags not fixed: user definable tags
- XML meta markup language: language for defining markup languages

XML Vocabularies

- Web applications must agree on common vocabularies to communicate and collaborate
- Communities and business sectors define their specialized vocabularies
  - mathematics (MathML)
  - bioinformatics (BSML)
  - human resources (HRML)
  - Syndication (RSS)
  - Vector graphics (SVG)
  - …

Outline

The XML Language

An XML document consists of

- a **prolog**
- a number of **elements**
- an optional **epilog** (not discussed, not used much)

Prolog of an XML Document

The prolog consists of

- an XML declaration and
- an optional reference to external structuring documents

```
<?xml version="1.0" encoding="UTF-16"?>

<!DOCTYPE book SYSTEM "book.dtd">
```


XML Elements

- Elements are the “things” the XML document talks about
  - E.g. books, authors, publishers
- An element consists of:
  - an opening tag
  - the content
  - a closing tag

```
<lecturer>David Billington</lecturer>
```


XML Elements

- Tag names can be chosen almost freely.
- The first character must be a letter, an underscore, or a colon
- No name may begin with the string “xml” in any combination of cases
  - E.g. “Xml”, “xML”

Content of XML Elements

- Content may be text, or other elements, or nothing

```
<lecturer>
  <name>David Billington</name>
  <phone> +61 − 7 − 3875 507 </phone>
</lecturer>
```

- If there is no content, then the element is called empty; it can be abbreviated as follows:

<lecturer/> for <lecturer></lecturer>

XML Attributes

- An empty element is not necessarily meaningless
  - It may have some properties in terms of attributes
- An **attribute** is a name-value pair inside the opening tag of an element

```
<lecturer
  name="David Billington"
  phone="+61 − 7 − 3875 507“ />
```


XML Attributes: An Example

```
<order orderNo="23456“
       customer="John Smith"
  date="October 15, 2002” >
  <item itemNo="a528" quantity="1“ />
  <item itemNo="c817" quantity="3“ />
</order>
```


The Same Example without Attributes

```
<order>
  <orderNo>23456</orderNo>
  <customer>John Smith</customer>
  <date>October 15, 2002</date>
  <item>
    <itemNo>a528</itemNo>
    <quantity>1</quantity>
  </item>
  <item>
    <itemNo>c817</itemNo>
    <quantity>3</quantity>
    </item>
</order>
```

XML Elements vs. Attributes

- Attributes can be replaced by elements
- When to use elements and when attributes is a matter of taste
- **But attributes cannot be nested**

Further Components of XML Docs

- **Comments**
  - A piece of text that is to be ignored by parser

  <!-- This is a comment -->
- **Processing Instructions (PIs)**
  - Define procedural attachments

  <?stylesheet type="text/css“ href="mystyle.css"?>

Well-Formed XML Documents

Syntactically correct documents must adhere to many rules

- Only one outermost element (the **root element**)
- Each element contains an opening and a corresponding closing tag
- Tags may not overlap

  <author><name>Lee Hong</author></name>
- Attributes within an element have unique names
- Element and tag names must be permissible

The Tree Model of XML Docs

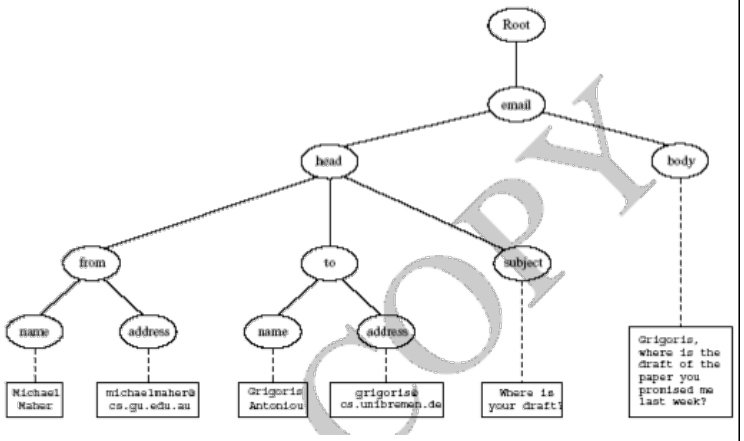
The tree representation of an XML document is an **ordered** labeled tree:

- There is exactly one root
- There are no cycles
- Each non-root node has exactly one parent
- Each node has a label.
- The order of elements is important
- … but the order of attributes is not important

Tree Model of XML Documents

```
<email>
  <head>
    <from name="Michael Maher"
          address="michaelmaher@cs.gu.edu.au"/>
    <to name="Grigoris Antoniou"
          address="grigoris@cs.unibremen.de"/>
    <subject>Where is your draft?</subject>
  </head>
  <body>
    Grigoris, where is the draft of the paper you promised
  me last week?
  </body>
</email>
```


Tree Model of XML Documents



Outline

Structuring XML Documents

- Some XML documents are required to follow constraints defined in a “template” which can…
- Define all the element and attribute names that may be used
- Define the structure
  - what values an attribute may take
  - which elements may or must occur within other elements, etc.
- If such structuring information exists, the document can be **validated**

Structuring XML Documents

- An XML document is **valid** if
  - it is well-formed
  - respects the structuring information it uses
- There are several ways of defining the structure of XML documents:
  - **DTDs** (*Document Type Definition*) came first, was based on SGML's approach.
  - **XML Schema** (aka *XML Schema Definition* or XSD) is a more recent W3C recommendation and offers extended possibilities
  - RELAX NG and DSDs are two alternatives

DTD: Element Type Definition

```
<lecturer>
  <name>David Billington</name>
  <phone> +61 − 7 − 3875 507 </phone>
</lecturer>
```

DTD for above element (and all **lecturer** elements):

```
<!ELEMENT lecturer (name, phone) >
<!ELEMENT name (#PCDATA) >
<!ELEMENT phone (#PCDATA) >
```


The Meaning of the DTD

- The element types **lecturer**, **name**, and **phone** may be used in the document
- A **lecturer** element contains a **name** element and a **phone** element, in that order (*sequence*)
- A **name** element and a **phone** element may have any content
  - In DTDs, **#PCDATA** is the only atomic type for elements
  - PCDATA = "*parsed character data*"

Disjunction in Element Type Definitions

- We express that a **lecturer** element contains *either* a **name** element *or* a **phone** element as follows:

  ```
  <!ELEMENT lecturer ( name | phone )>
  ```

- A **lecturer** element contains a **name** element and a **phone** element in *any order*.

  ```
  <!ELEMENT lecturer((name,phone)|
    (phone,name))>
  ```

- Do you see a problem with this approach?

Example of an XML Element

```
<order orderNo="23456"
        customer="John Smith"
        date="October 15, 2002">
    <item itemNo="a528" quantity="1"/>
    <item itemNo="c817" quantity="3"/>
</order>
```


The Corresponding DTD

```
<!ELEMENT order (item+)>
<!ATTLIST order
      orderNo     ID          #REQUIRED
      customer    CDATA       #REQUIRED
      date        CDATA       #REQUIRED >

<!ELEMENT item EMPTY>
<!ATTLIST item
   itemNo     ID          #REQUIRED
   quantity   CDATA       #REQUIRED
   comments   CDATA       #IMPLIED >
```


Comments on the DTD

- The **item** element type is defined to be empty
  - i.e., it can contain no elements
- **+** (after **item)** is a **cardinality operator**:
  - Specifies how many item elements can be in an order
  - **?**: appears zero times or once
  - ***:** appears zero or more times
  - **+**: appears one or more times
  - No cardinality operator means exactly once

Comments on the DTD

- In addition to defining elements, we define attributes
- This is done in an **attribute list** containing:
  - Name of the element type to which the list applies
  - A list of triplets of attribute name, attribute type, and value type
- *Attribute name*: A name that may be used in an XML document using a DTD

DTD: Attribute Types

- Similar to predefined data types, but limited selection
- The most important types are
  - **CDATA**, a string (sequence of characters)
  - **ID**, a name that is *unique* across the entire XML document (~ DB key)
  - **IDREF**, a reference to another element with an ID attribute carrying the same value as the IDREF attribute (~ DB foreign key)
  - **IDREFS**, a series of IDREFs
  - **(v1| . . . |vn)**, an enumeration of all possible values
- Limitations: no dates, number ranges etc.

DTD: Attribute Value Types

- **#REQUIRED**
  - Attribute must appear in every occurrence of the element type in the XML document
- **#IMPLIED**
  - The appearance of the attribute is optional
- **#FIXED "value"**
  - Every element must have this attribute
- **"value"**
  - This specifies the default value for the attribute

Referencing with IDREF and IDREFS

```
<!ELEMENT family (person*)>
<!ELEMENT person (name)>
<!ELEMENT name (#PCDATA)>
<!ATTLIST person
    id          ID      #REQUIRED
    mother      IDREF   #IMPLIED
    father      IDREF   #IMPLIED
    children    IDREFS  #IMPLIED >
```


An XML Document Respecting the DTD

```
<family>
      <person id="bob" mother="mary" father="peter">
       <name>Bob Marley</name>
      </person>
      <person id="bridget" mother="mary">
       <name>Bridget Jones</name>
      </person>
      <person id="mary" children="bob bridget">
       <name>Mary Poppins</name>
      </person>
      <person id="peter" children="bob">
       <name>Peter Marley</name>
      </person>
</family>
```

A DTD for an Email Element

```
<!ELEMENT email (head,body)>
<!ELEMENT head (from,to+,cc*,subject)>
<!ELEMENT from EMPTY>
<!ATTLIST from
   name        CDATA   #IMPLIED
   address     CDATA   #REQUIRED>
<!ELEMENT to EMPTY>
<!ATTLIST to
   name      CDATA  #IMPLIED
   address  CDATA  #REQUIRED>
```


A DTD for an Email Element

```
<!ELEMENT cc EMPTY>
<!ATTLIST cc
      name       CDATA     #IMPLIED
      address    CDATA     #REQUIRED>
<!ELEMENT subject (#PCDATA) >
<!ELEMENT body (text,attachment*) >
<!ELEMENT text (#PCDATA) >
<!ELEMENT attachment EMPTY >
<!ATTLIST attachment
    encoding      (mime|binhex)   "mime"
    file  CDATA   #REQUIRED>
```


Interesting Parts of the DTD

- A **head** element contains (in that order):
  - a **from** element
  - at least one **to** element
  - zero or more **cc** elements
  - a **subject** element
- In **from**, **to**, and **cc** elements
  - the **name** attribute is not required
  - the **address** attribute is always required

Interesting Parts of the DTD

- A **body** element contains
  - a **text** element
  - possibly followed by a number of **attachment** elements
- The **encoding** attribute of an **attachment** element must have either the value "**mime**" or "**binhex**"
  - "**mime**" is the default value

Remarks on DTDs

- A DTD can be interpreted as an Extended Backus-Naur Form (EBNF)
  - **<!ELEMENT email (head,body)>**
  - is equivalent to **email ::= head body**
- Recursive definitions possible in DTDs
  - **<!ELEMENT bintree**
    ((bintree root bintree)|emptytree)>

Outline

XML Schema

- XML Schema is a significantly richer language for defining the structure of XML documents
- Syntax is based on XML itself
  separate tools to handle them not needed
- Reuse and refinement of schemas
  can expand or delete existing schemas
- Sophisticated set of **data types**, compared to DTDs (which only supports strings)
- W3C published the XML Schema recommendation in 2001

XML Schema

- An XML schema is an element with an opening tag like

  <schema "http://www.w3.org/2000/10/
  XMLSchema"
  version="1.0">
- Structure of schema elements
  - Element and attribute types using data types

Element Types

```
<element name="email"/>
<element name="head“
   minOccurs="1“
   maxOccurs="1"/>
<element name="to" minOccurs="1"/>
```

Cardinality constraints:

- **minOccurs="x"** (default value 1)
- **maxOccurs="x"** (default value 1)
- Generalizations of *,?,+ offered by DTDs

Attribute Types

```
<attribute name="id" type="ID“ use="required"/
   >
< attribute name="speaks" type="Language"
   use="default" value="en"/>
```

- Existence: **use="x",** where **x** may be **optional** or **required**
- Default value: **use="x" value="..."**, where **x** may be **default** or **fixed**

Data Types

- There are many **built-in data types**
  - Numerical data types: **integer**, **Short** etc.
  - String types: **string**, **ID**, **IDREF**, **CDATA** etc.
  - Date and time data types: **time**, **Month** etc.
- There are also **user-defined data types**
  - **simple data types**, which cannot use elements or attributes
  - **complex data types**, which can use these

Complex Data Types

Complex data types are defined from already existing data types by defining some attributes (if any) and using:

- **sequence**, a sequence of existing data type elements (order is important)
- **all**, a collection of elements that must appear (order is not important)
- **choice**, a collection of elements, of which one will be chosen

A Data Type Example

```
<complexType name="lecturerType">
    <sequence>
        <element name="firstname" type="string"
            minOccurs="0“ maxOccurs="unbounded"/>
        <element name="lastname" type="string"/>
    </sequence>
    <attribute name="title" type="string"
        use="optional"/>
</complexType>
```


Data Type Extension

Already existing data types can be extended by new elements or attributes. Example:

```
<complexType name="extendedLecturerType">
    <extension base="lecturerType">
        <sequence>
            <element name="email" type="string"
                minOccurs="0" maxOccurs="1"/>
        </sequence>
        <attribute name="rank" type="string“
            use="required"/>
    </extension>
</complexType>
```


Resulting Data Type

```
<complexType name="extendedLecturerType">
    <sequence>
        <element name="firstname" type="string"
            minOccurs="0" maxOccurs="unbounded"/>
        <element name="lastname" type="string"/>
        <element name="email" type="string"
            minOccurs="0" maxOccurs="1"/>
    </sequence>
    <attribute name="title" type="string" use="optional"/>
    <attribute name="rank" type="string" use="required"/>
</complexType>
```


Data Type Extension

A **hierarchical relationship** exists between the original and the extended type

- Instances of the extended type are also instances of the original type
- They may contain additional information, but neither less information, nor information of the wrong type

Data Type Restriction

- An existing data type may be restricted by adding constraints on certain values
- Restriction is not the opposite from extension
  - Restriction is not achieved by deleting elements or attributes
- The following **hierarchical relationship** still holds:
  - Instances of the restricted type are also instances of the original type
  - They satisfy at least the constraints of the original type

Example of Data Type Restriction

```
<complexType name="restrictedLecturerType">
    <restriction base="lecturerType">
        <sequence>
            <element name="firstname" type="string"
              minOccurs="1" maxOccurs="2"/>
        </sequence>
        <attribute name="title" type="string"
         use="required"/>
    </restriction>
</complexType>
```


Restriction of Simple Data Types

```
<simpleType name="dayOfMonth">
      <restriction base="integer">
        <minInclusive value="1"/>
        <maxInclusive value="31"/>
      </restriction>
</simpleType>
```


Data Type Restriction: Enumeration

```
<simpleType name="dayOfWeek">
      <restriction base="string">
        <enumeration value="Mon"/>
        <enumeration value="Tue"/>
        <enumeration value="Wed"/>
        <enumeration value="Thu"/>
        <enumeration value="Fri"/>
        <enumeration value="Sat"/>
        <enumeration value="Sun"/>
      </restriction>
</simpleType>
```

XML Schema: The Email Example

```
<element name="email" type="emailType"/>

<complexType name="emailType">
    <sequence>
        <element name="head" type="headType"/>
        <element name="body" type="bodyType"/>
    </sequence>
</complexType>
```


XML Schema: The Email Example

```
<complexType name="headType">
    <sequence>
        <element name="from" type="nameAddress"/>
        <element name="to" type="nameAddress"
            minOccurs="1" maxOccurs="unbounded"/>
        <element name="cc" type="nameAddress"
            minOccurs="0" maxOccurs="unbounded"/>
        <element name="subject" type="string"/>
    </sequence>
</complexType>
```


XML Schema: The Email Example

```
<complexType name="nameAddress">
        <attribute name="name" type="string"
        use="optional"/>
        <attribute name="address"
        type="string" use="required"/>
</complexType>
```

- Similar for bodyType

Outline

Namespaces

- An XML document may use more than one DTD or schema
- Since each structuring document was developed independently, name clashes may appear
- The solution is to use a different prefix for each DTD or schema
  - **prefix:name**

An Example

```
<vu:instructors   xmlns:vu="http://www.vu.com/empDTD"
                  xmlns:gu="http://www.gu.au/empDTD"
                  xmlns:uky=http://www.uky.edu/empDTD >

    <uky:faculty  uky:title="assistant professor"
                  uky:name="John Smith"
                  uky:department="Computer Science"/>

<gu:academicStaff     gu:title="lecturer"
                      gu:name="Mate Jones"
                      gu:school="Information Technology"/>
</vu:instructors>
```


Namespace Declarations

- Namespaces are declared within an element and can be used in that element and any of its children (elements and attributes)
- A namespace declaration has the form:
  - **xmlns:prefix="location"**
  - **location** is the address of the DTD or schema
- If a prefix is not specified: **xmlns="location"** then the **location** is used by default

Outline

Addressing & Querying XML Documents

- In relational databases, parts of a database can be selected and retrieved using SQL
  - Also very useful for XML documents
  - **Query languages**: XQuery, XQL, XML-QL
- The central concept of XML query languages is a **path expression**
  - Specifies how a node or a set of nodes, in the tree representation of the XML document can be reached

XPath

- XPath is core for XML query languages
- Language for addressing parts of an XML document.
  - It operates on the tree data model of XML
  - It has a non-XML syntax

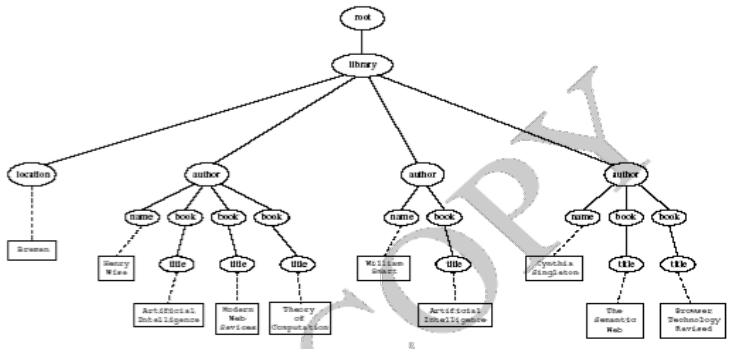
Types of Path Expressions

- **Absolute** (starting at the root of the tree)
  - Syntactically they begin with the symbol **/**
  - It refers to the root of the document (situated one level above the root element of the document)
- **Relative** to a context node

An XML Example

```
<library location="Bremen">
  <author name="Henry Wise">
    <book title="Artificial Intelligence"/>
    <book title="Modern Web Services"/>
    <book title="Theory of Computation"/>
  </author>
  <author name="William Smart">
    <book title="Artificial Intelligence"/>
  </author>
  <author name="Cynthia Singleton">
    <book title="The Semantic Web"/>
    <book title="Browser Technology Revised"/>
  </author>
</library>
```

Tree Representation



Examples of Path Expressions in XPath

- **Q1: Address all author elements**

  /library/author

- Addresses all **author** elements that are children of the **library** element node, which resides immediately below the root
- **/t1/.../tn**, where each **ti+1** is a child node of **ti**, is a path through the tree representation

Examples of Path Expressions in XPath

- **Q2: Address all author elements**

  //author

  - Here // says that we should consider all elements in the document and check whether they are of type **author**
  - This path expression addresses all **author** elements anywhere in the document

Examples of Path Expressions in XPath

- **Q3: Address the location attribute nodes within library element nodes**

  /library/@location

  Note: The symbol **@** is used to denote attribute nodes

- **Q4: Address all title attribute nodes within book elements anywhere in the document, which have the value "Artificial Intelligence"**

  //book/@title="Artificial Intelligence"

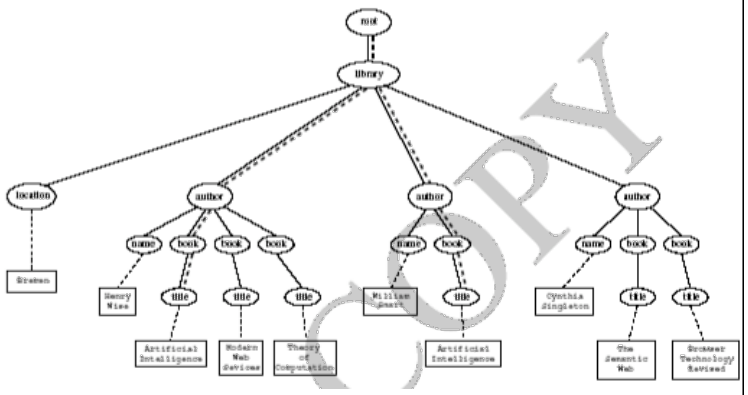
Examples of Path Expressions in XPath

- **Q5: Address all books with title "Artificial Intelligence"**

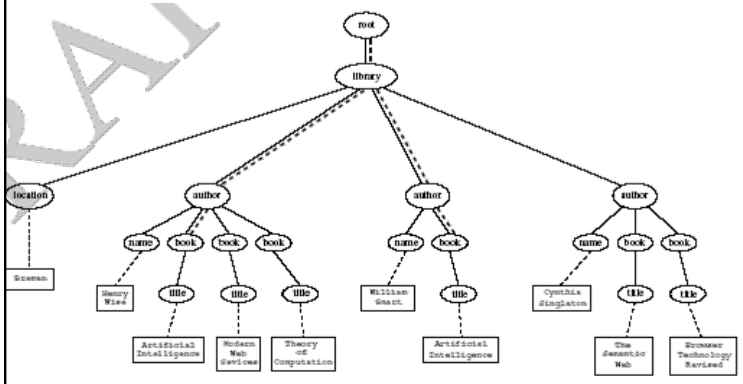
  /book[@title="Artificial Intelligence"]

  - A test in brackets is a **filter expression** that restricts the set of addressed nodes.
  - Note differences between Q4 and Q5:
    - Query 5 addresses **book** elements, the **title** of which satisfies a certain condition.
    - Query 4 collects **title** attribute nodes of **book** elements

Tree Representation of Query 4



Tree Representation of Query 5



Examples of Path Expressions in XPath

- **Q6: Address first author element node in the XML document**

  //author[1]

- **Q7: Address last book element within the first author element node in the document**

  //author[1]/book[last()]

- **Q8: Address all book element nodes without a title attribute**

  //book[not @title]

General Form of Path Expressions

- A **path expression** consists of a series of steps, separated by slashes
- A **step** consists of
  - An **axis specifier**,
  - A **node test**, and
  - An optional **predicate**

General Form of Path Expressions

- An **axis specifier** determines the tree relationship between the nodes to be addressed and the context node
  - E.g. parent, ancestor, child (the default), sibling, attribute node
  - // is such an axis specifier: descendant or self

General Form of Path Expressions

- A **node test** specifies which nodes to address
  - The most common node tests are element names
  - E.g., * addresses all element nodes
  - **comment()** addresses all comment nodes

General Form of Path Expressions

- **Predicates** (or *filter expressions*) are optional and are used to refine the set of addressed nodes
  - E.g., the expression **[1]** selects the first node
  - **[position()=last()]** selects the last node
  - **[position() mod 2 =0]** selects the even nodes
- XPath has a more complicated full syntax.
  - We have only presented the abbreviated syntax

Outline

(1) Introduction

(2) Detailed Description of XML

(3) Structuring

- DTDs
- XML Schema

(4) Namespaces

(5) Accessing, querying XML documents: XPath

(6) Transformations: XSLT

Displaying XML Documents

```
<author>
  <name>Grigoris Antoniou</name>
  <affiliation>University of Bremen</affiliation>
  <email>ga@tzi.de</email>
</author>
```

may be displayed in different ways:

Grigoris Antoniou
University of Bremen
ga@tzi.de

Grigoris Antoniou
University of Bremen
ga@tzi.de

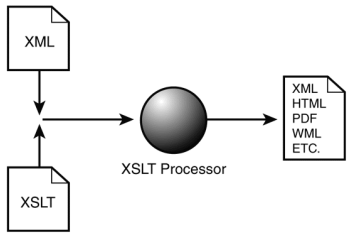
Idea: use an external style sheet to transform an XML tree into an HTML or XML tree

Style Sheets

- Style sheets can be written in various languages
  - E.g. CSS2 (cascading style sheets level 2)
  - XSL (extensible stylesheet language)
- XSL includes
  - a transformation language (XSLT)
  - a formatting language
  - Both are XML applications

XSL Transformations (XSLT)

- XSLT specifies rules with which an input XML document is transformed to
  - another XML document
  - an HTML document
  - plain text



- The output document may use the same DTD or schema, or a completely different vocabulary
- XSLT can be used independently of the formatting language

XSLT

- Move data and metadata from one XML representation to another
- XSLT is chosen when applications that use different DTDs or schemas need to communicate
- XSLT can be used for machine processing of content without any regard to displaying the information for people to read.
- In the following example we use XSLT only to display XML documents as HTML

XSLT Transformation into HTML

```
<author>
  <name>Grigoris Antoniou</name>
  <affiliation>University of Bremen</affiliation>
  <email>ga@tzi.de</email>
</author>
```

```
<xsl:template match="/author">
  <html>
    <head><title>An author</title></head>
    <body bgcolor="white">
        <b><xsl:value-of select="name"/></b><br>
        <xsl:value-of select="affiliation"/><br>
        <i><xsl:value-of select="email"/></i>
    </body>
  </html>
</xsl:template>
```


Style Sheet Output

```
<author>
  <name>Grigoris Antoniou</name>
  <affiliation>University of Bremen</affiliation>
  <email>ga@tzi.de</email>
</author>
```

```
<xsl:template match="/author"> <html>
    <head><title>An author</title></head>
    <body bgcolor="white">
      <b><xsl:value-of select="name"/></
b><br>
      <xsl:value-of select="affiliation"/><br>
      <i><xsl:value-of select="email"/></i>
    </body>
</html></xsl:template>
```

```
<html>
  <head><title>An author</title></head>
  <body bgcolor="white">
    <b>Grigoris Antoniou</b><br>
    University of Bremen<br>
    <i>ga@tzi.de</i>
  </body>
</html>
```


Observations About XSLT

- XSLT documents are XML documents
  - XSLT resides on top of XML
- The XSLT document defines a **template**
  - In this case an HTML document, with some placeholders for content to be inserted
- **xsl:value-of** retrieves the value of an element and copies it into the output document
  - It places some content into the template

A Template

```
<html>
  <head><title>An author</title></head>
  <body bgcolor="white">
   <b>...</b><br>
   ...<br>
   <i>...</i>
  </body>
</html>
```


Auxiliary Templates

- We have an XML document with details of several authors
- It is a waste of effort to treat each **author** element separately
- In such cases, a special template is defined for **author** elements, which is used by the main template

Example of an Auxiliary Template

```
<authors>
  <author>
    <name>Grigoris Antoniou</name>
    <affiliation>University of Bremen</affiliation>
    <email>ga@tzi.de</email>
  </author>
  <author>
    <name>David Billington</name>
    <affiliation>Griffith University</affiliation>
    <email>david@gu.edu.net</email>
  </author>
</authors>
```


Example of an Auxiliary Template (2)

```
<xsl:template match="/">
  <html>
    <head><title>Authors</title></head>
    <body bgcolor="white">
      <xsl:apply-templates select="authors"/>
      <!-- Apply templates for AUTHORS children -->
    </body>
  </html>
</xsl:template>
```

Example of an Auxiliary Template (3)

```
<xsl:template match="authors">
  <xsl:apply-templates select="author"/>
</xsl:template>

<xsl:template match="author">
  <h2><xsl:value-of select="name"/></h2>
  <p> Affiliation:<xsl:value-of select="affiliation"/><br/>
  Email: <xsl:value-of select="email"/> </p>
</xsl:template>
```


Multiple Authors Output

```
<html>
  <head><title>Authors</title></head>
  <body bgcolor="white">
    <h2>Grigoris Antoniou</h2>
    <p>Affiliation: University of Bremen<br/>
    Email: ga@tzi.de</p>
    <h2>David Billington</h2>
    <p>Affiliation: Griffith University<br/>
    Email: david@gu.edu.net</p>
  </body>
</html>
```


Explanation of the Example

xsl:apply-templates element causes all children of the context node to be matched against the selected path expression

- e.g., if the current template applies to */*, then element **xsl:apply-templates** applies to root element
- i.e. the **authors** element (*/* is located above the root element)
- If current context node is the **authors** element, then element **xsl:apply-templates select="author"** causes the template for the **author** elements to be applied to all **author** children of the **authors** element

Explanation of the Example

- It is good practice to define a template for each element type in the document
  - Even if no specific processing is applied to certain elements, the **xsl:apply-templates** element should be used
  - E.g. **authors**
- In this way, we work from the root to the leaves of the tree, and **all** templates are applied

Processing XML Attributes

Suppose we wish to transform to itself the element:

<person firstname="John" lastname="Woo"/>

Wrong solution:

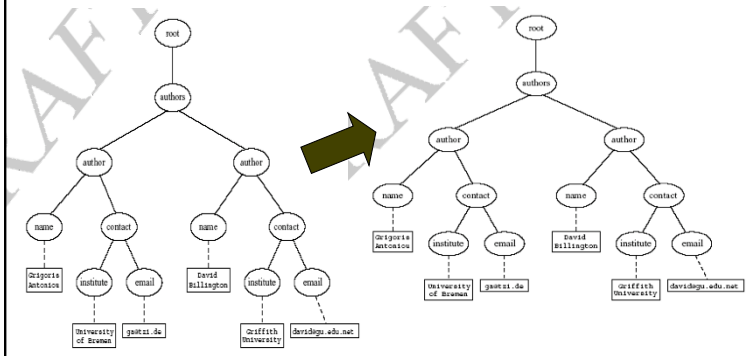
```
<xsl:template match="person">
  <person firstname="<xsl:value-of select="@firstname">"
          lastname="<xsl:value-of select="@lastname">"/>
</xsl:template>
```


Processing XML Attributes

- Not well-formed because tags are not allowed within the values of attributes
- We wish to add attribute values into template

```
<xsl:template match="person">
  <person
    firstname="{@firstname}"
    lastname="{@lastname}" />
</xsl:template>
```


Transforming an XML Document to Another



Transforming an XML Document to Another

```
<xsl:template match="/">
  <?xml version="1.0" encoding="UTF-16"?>
  <authors>
    <xsl:apply-templates select="authors"/>
  </authors>
</xsl:template>

<xsl:template match="authors">
  <author>
    <xsl:apply-templates select="author"/>
  </author>
</xsl:template>
```

Transforming an XML Document to Another

```
<xsl:template match="author">
  <name><xsl:value-of select="name"/></name>
  <contact>
    <institution>
      <xsl:value-of select="affiliation"/>
    </institution>
    <email><xsl:value-of select="email"/></email>
  </contact>
</xsl:template>
```


Summary

- XML is a metalanguage that allows users to define markup
- XML separates content and structure from formatting
- XML is the de facto standard to represent and exchange structured information on the Web
- XML is supported by query languages

For Discussion in Subsequent Chapters

- The nesting of tags does not have standard meaning
- The semantics of XML documents is not accessible to machines, only to people
- Collaboration and exchange are supported if there is underlying shared understanding of the vocabulary
- XML is well-suited for close collaboration, where domain- or community-based vocabularies are used
  - It is not so well-suited for global communication.