Chapter 2
Structured Web Documents in XML

Adapted from slides from Grigoris Antoniou and Frank van Harmelen

Outline

(1) Introduction

(2) XML details

(3) Structuring

- DTDs
- XML Schema

(4) Namespaces

(5) Accessing, querying XML documents: XPath

(6) Transformations: XSLT

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) based on XML standards
- So XML is (1) the source for many key SW concepts technology bits; (2) a potential alternative the SW must improve on; and (3) a common serialization for SW data

To paraphrase Jamie Zawinski

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

Now they have two problems.

“Some people, when confronted with a problem, think "I know, I'll use regular expressions." Now they have two problems.”
-- Wikiquote

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*"?

```
<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
```

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., **<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:
  - 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)
  - …

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(2) Detailed Description of XML

(3) Structuring

- DTDs
- XML Schema

(4) Namespaces

(5) Accessing, querying XML documents: XPath

(6) Transformations: XSLT

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 is what's between the tags
- It can 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/>  =  <lecturer></lecturer>
```

XML Attributes

- An empty element is not necessarily meaningless
  - It may have properties expressed as *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 (except self-closing tags like <foo/>)
- 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

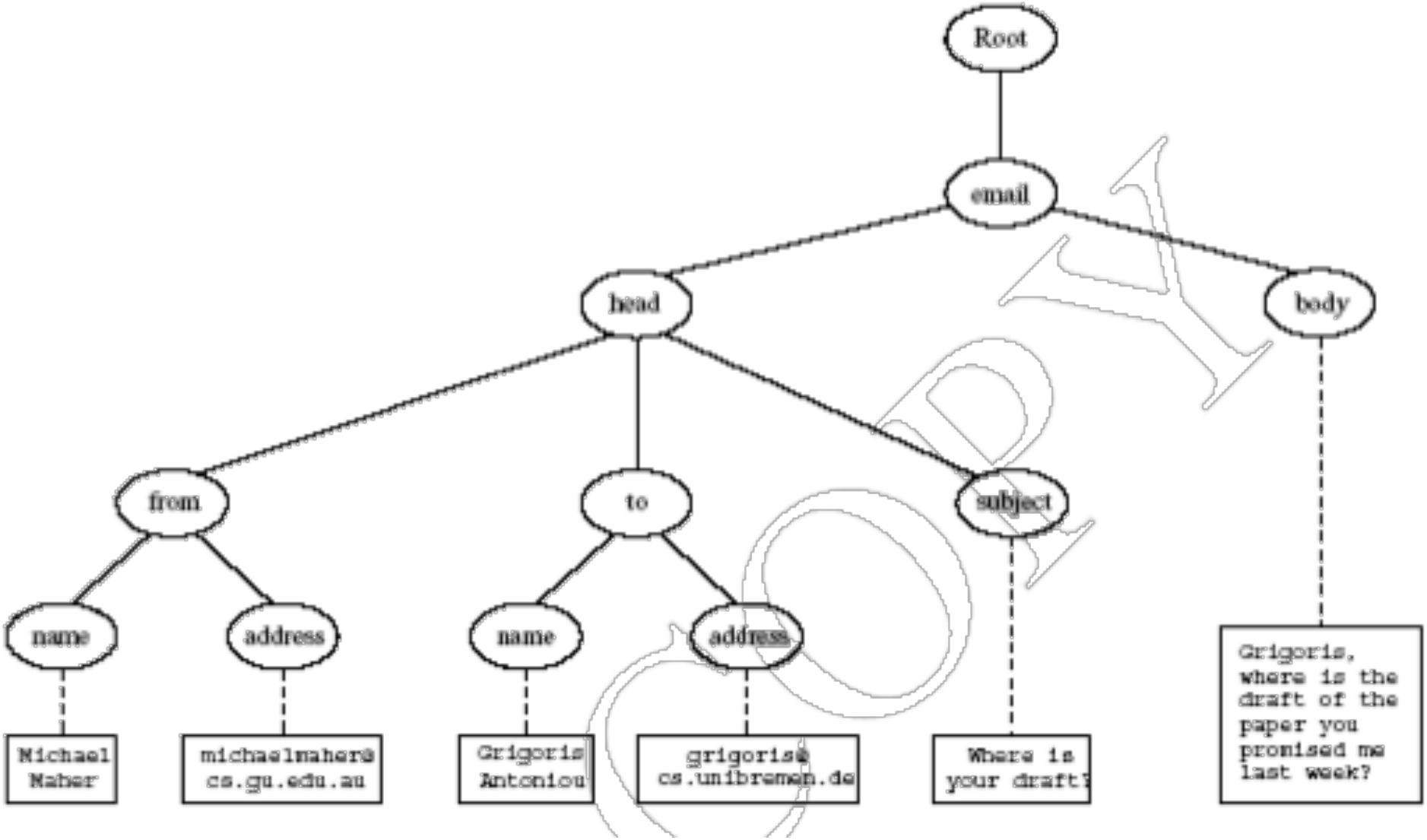
The tree representation of an XML document is an **ordered** labeled tree:

- 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

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



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Structuring XML Documents

- Some XML documents must follow constraints defined in a “template” that 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
- Ways to define the structure of XML documents:
  - **DTDs** (*Document Type Definition*) came first, was based on SGML's approach.
  - **XML Schema** (aka *XML Schema Definition*, XSD) is more recent and expressive
  - 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 element type and stands for "*parsed character data*"

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

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

```
<!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

- 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 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)>

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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 and version 1.1 in 2012

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 can't use elements or attributes
  - **complex data types**, which can use these

Complex Data Types

Complex data types are defined from 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

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

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Namespaces

- XML namespaces provide uniquely named elements and attributes in an XML document
- An XML document may use more than one DTD or schema
- Since each was developed independently, name clashes may appear
- The solution is to use a different prefix for each DTD or schema

  prefix:name

- Namespaces are even more important in RDF

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 as the *default* prefix

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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

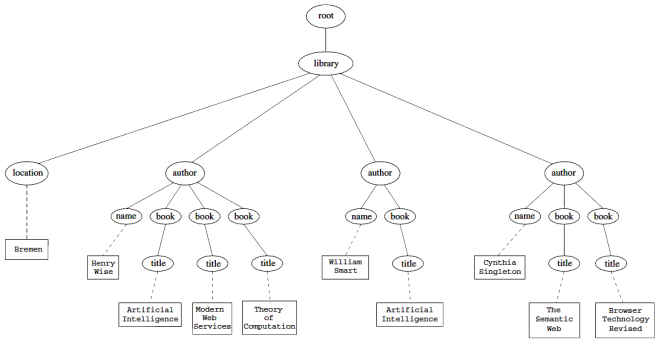
- XPath is core for XML query languages
- Language for addressing XML document parts
  - It operates on the tree data model of XML
  - It has a non-XML syntax
- Versions
  - XPath 1.0 (1999) is widely supported
  - XPath 2.0 (2007) is a more expressive subset of Xquery
  - XPath 3.0 became a candidate recommendation in 2013

Types of Path Expressions

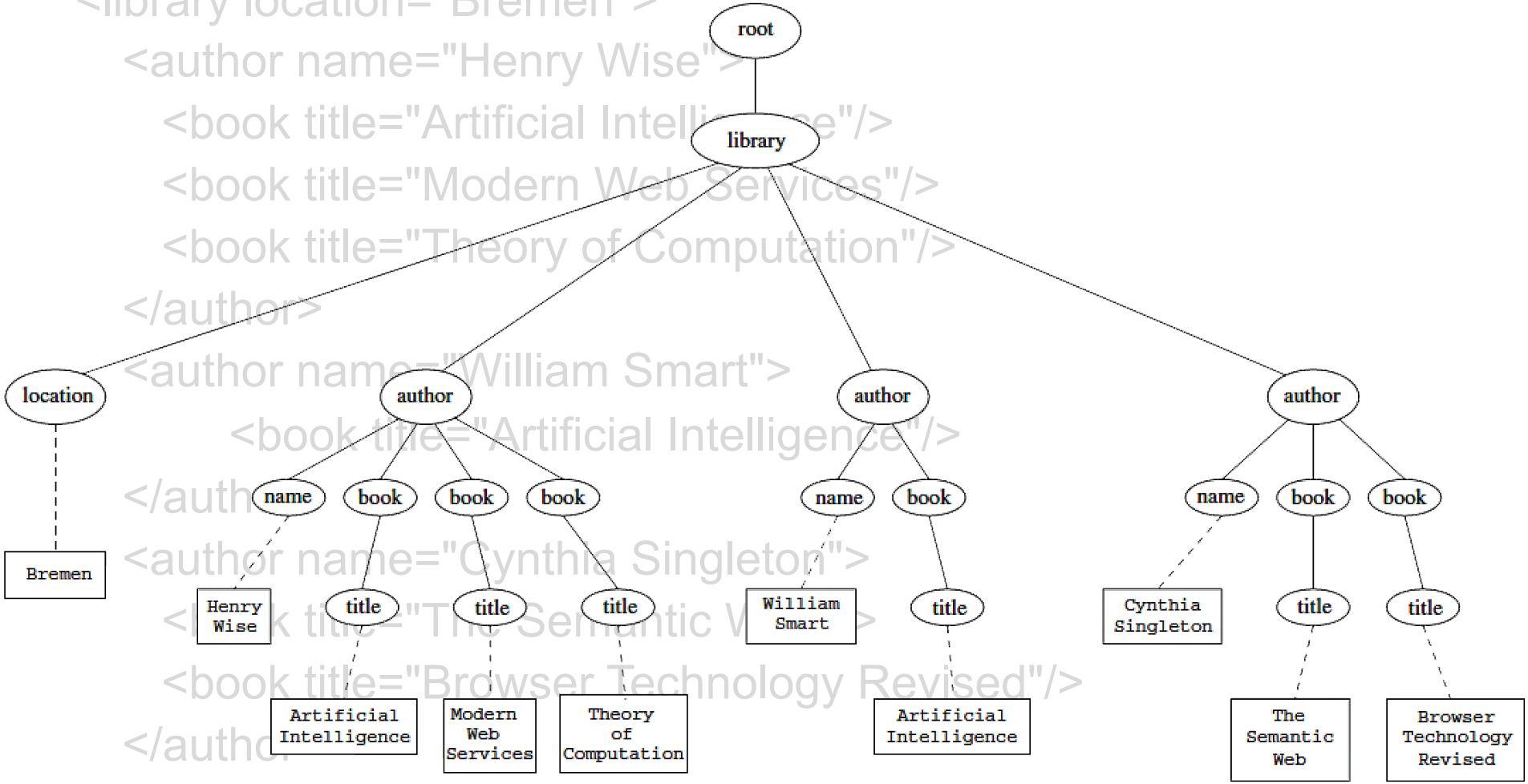
- **Absolute** (starting at the root of the tree)
  - Syntactically they begin with the symbol */*
  - It refers to the root of the document (situated one level above the root element of the document)
- **Relative** to a context node

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

- **Q2: //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

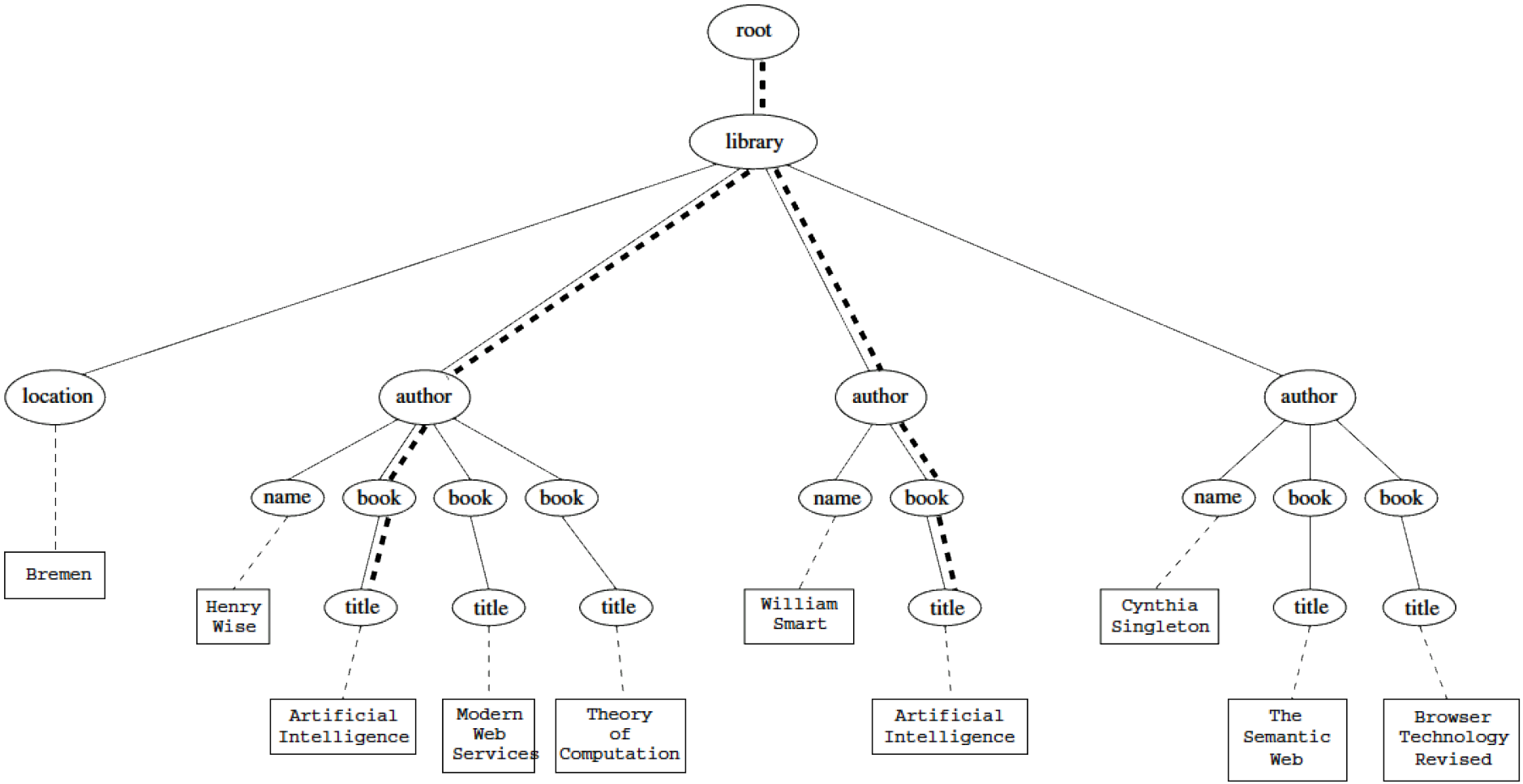
Examples of Path Expressions in XPath

- **Q3: /library/@location**
  - Addresses the location attribute nodes within library element nodes
  - The symbol @ is used to denote attribute nodes

- **Q4: //book/@title="Artificial Intelligence”**
  - Adresses all title attribute nodes within book elements anywhere in the document, which have the value “Artificial Intelligence”

Tree Representation of Query 4

//book/@title="Artificial Intelligence”

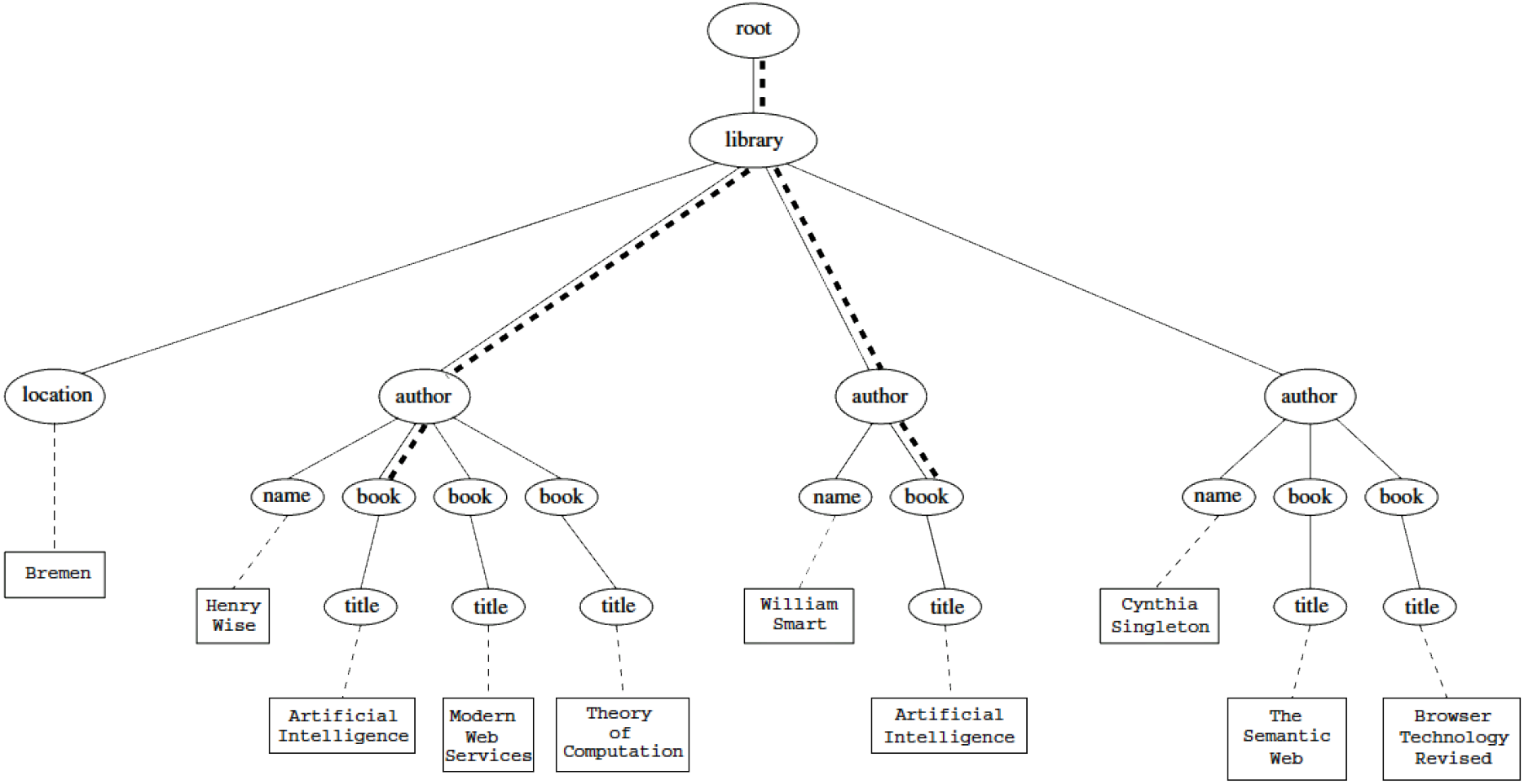


Examples of Path Expressions in XPath

- **Q5: /book[@title="Artificial Intelligence"]**
  - Addresses all books with 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 5

/book[@title="Artificial Intelligence"]



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

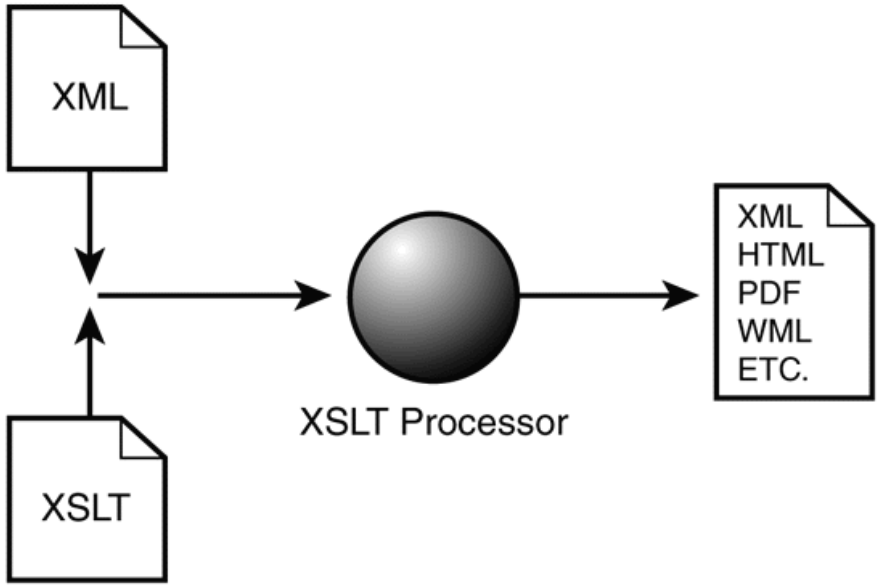
Idea: use an external style sheet to transform an XML tree into an HTML or XML tree

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 to transform a XML document 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 Use Cases

- 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="author"/>
      <!-- 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 current template applies to **/**, then element **xsl:apply-templates** applies to root element
- i.e., the **authors** element (**/** is located above root)
- 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:

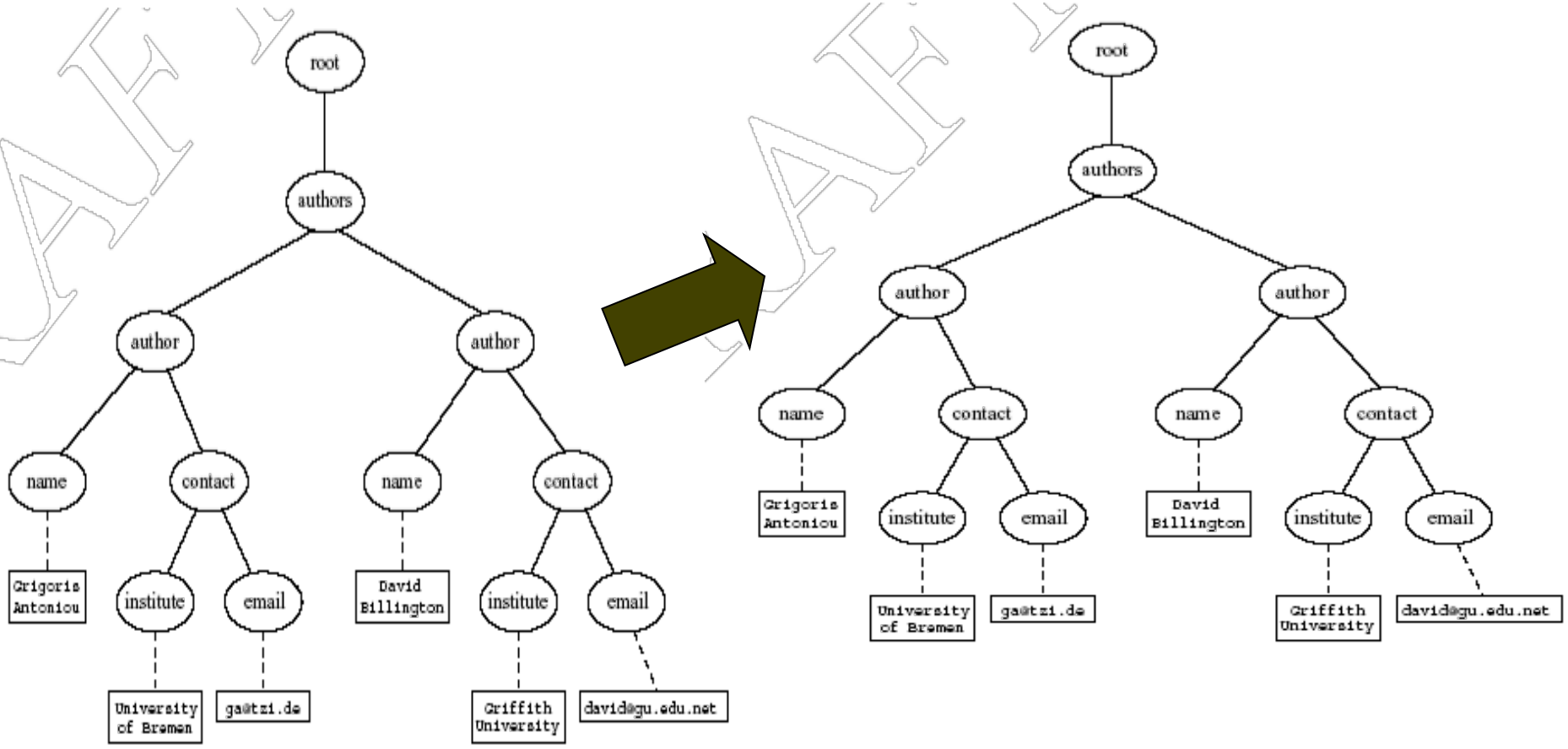
```
<xsl:template match="person">
  <person firstname="<xsl:value-of select="@firstname">"
          lastname="<xsl:value-of select="@lastname">"/>
</xsl:template>
```

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>
```

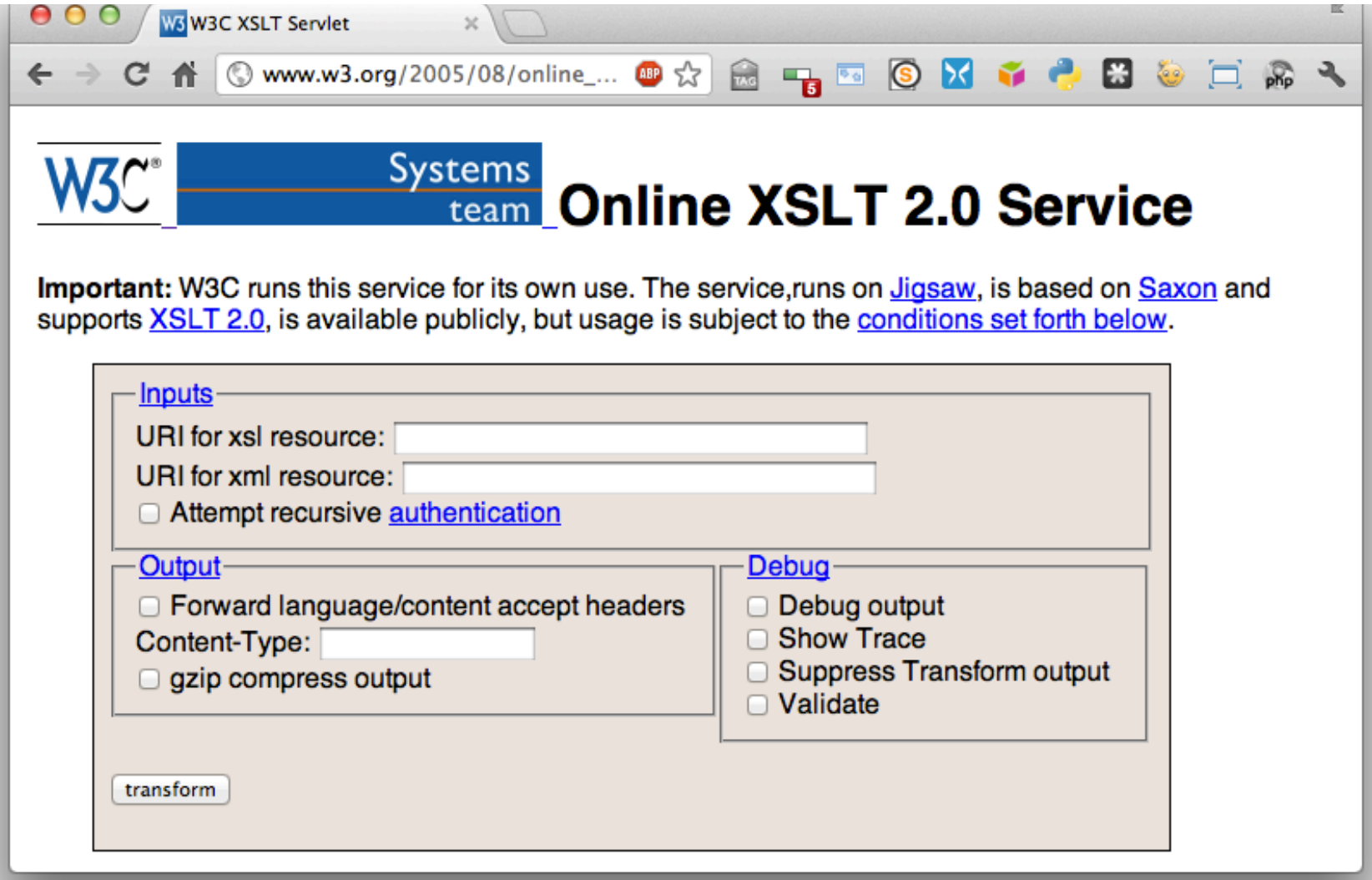
Transforming an XML Document to Another

```
<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>
```

How to apply XSLT transforms

- When a modern browsers loads an XML file, it will will apply a linked XSLT and display the results (hopefully HTML!)
- Use an external Web service
- Use an XML editor
- Use a module or library for your favorite programming language

An XSLT Web Service



http://www.w3.org/2005/08/online_xslt/

CD Catalog example

```
<?xml-stylesheet type="text/xsl"
href="cdcatalog.xsl"?>
<catalog>
<cd>
 <title>Empire Burlesque</title>
 <artist>Bob Dylan</artist>
 <country>USA</country>
 <company>Columbia</company>
 <price>10.90</price>
 <year>1985</year>
</cd>
<cd>
 <title>Hide your heart</title>
 <artist>Bonnie Tyler</artist>
 <country>UK</country>
 <company>CBS Records</company>
…
</cd> …
```

```
<xsl:template match="/">
 <html> <body>
 <h2>My CD Collection</h2>
  <table border="1">
   <tr bgcolor="#9acd32">
    <th align="left">Title</th>
    <th align="left">Artist</th>
   </tr>
   <xsl:for-each select="catalog/cd">
    <tr>
     <td><xsl:value-of select="title"/></td>
     <td><xsl:value-of select="artist"/></td>
    </tr>
   </xsl:for-each>
  </table>
 </body> </html>
</xsl:template>
</xsl:stylesheet>
```

See http://bit.ly/VQfLVV

Viewing an XML file in a Browser

~> curl http://www.csee.umbc.edu/courses/graduate/691/spring12/03/examples/xml/cdcatalog/cdcatalog.xml

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<?xml-stylesheet type="text/xsl" href="cdcatalog.xsl"?>
<catalog>
<cd>
 <title>Empire Burlesque</title>
 <artist>Bob Dylan</artist>
 <country>USA</country>
 <company>Columbia</company>
 <price>10.90</price>
 <year>1985</year>
</cd>
<cd>
 <title>Hide your heart</title>
 <artist>Bonnie Tyler</artist>
 <country>UK</country>
 <company>CBS Records</company>
 <price>9.90</price>
 <year>1988</year>
</cd>
...
```

Title	Artist
Empire Burlesque	Bob Dylan
Hide your heart	Bonnie Tyler
Greatest Hits	Dolly Parton
Still got the blues	Gary Moore
Eros	Eros Ramazzotti
One night only	Bee Gees
Sylvias Mother	Dr.Hook
Maggie May	Rod Stewart
Romanza	Andrea Bocelli
When a man loves a woman	Percy Sledge
Black angel	Savage Rose
1999 Grammy Nominees	Many
For the good times	Kenny Rogers
Big Willie style	Will Smith
Tupelo Honey	Van Morrison
Soulsville	Jorn Hoel
The very best of	Cat Stevens
Stop	Sam Brown

Summary

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

Comments for Discussion

- The nesting of tags doesn’t 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 and less so for global communication
- Databases went from tree structures (60s) to relations (80s) and graphs (10s)