Chapter 2
Structured Web Documents in XML

Grigoris Antoniou
Frank van Harmelen

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 with Automated Interpretation of 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
- 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 (2)

- 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
- 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

HTML vs XML: Another Example

- In HTML

```
<h2>Relationship force-mass</h2>
<i> F = M × a </i>
```

- In XML

```
<equation>
      <meaning>Relationship force-mass</meaning>
      <leftside> F </leftside>
      <rightside> M × a </rightside>
</equation>
```

HTML vs XML: Different Use of Tags

- In both HTML docs same tags
- In XML completely different

- HTML tags define display: 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 are defining their specialized vocabularies
  - mathematics (MathML)
  - bioinformatics (BSML)
  - human resources (HRML)
  - …

Lecture Outline

1. Introduction
2. Detailed Description of XML
3. Structuring
   a) DTDs
   b) 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)

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

- 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 (2)

- 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 is 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"?>**

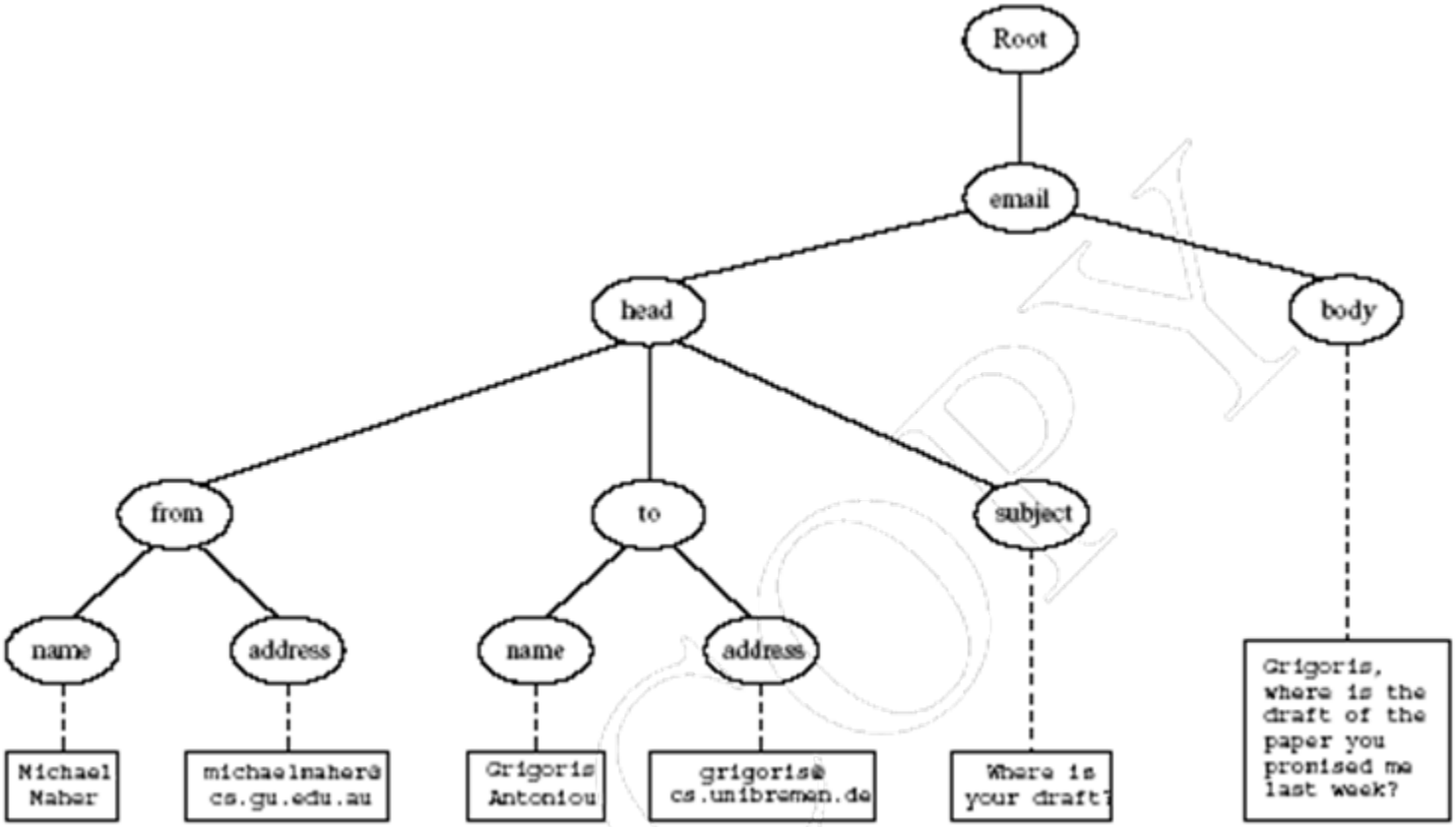
Well-Formed XML Documents

- Syntactically correct documents
- Some syntactic rules:
  - Only one outermost element (called 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 Documents: An Example

```
<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>
```

The Tree Model of XML Documents: An Example (2)



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

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Structuring XML Documents

- 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 Dcuments (2)

- An XML document is valid if
  - it is well-formed
  - respects the structuring information it uses
- There are two ways of defining the structure of XML documents:
  - DTDs (the older and more restricted way)
  - XML Schema (offers extended possibilities)

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XML Schema

- Significantly richer language for defining the structure of XML documents
- Tts syntax is based on XML itself
  - not necessary to write separate tools
- Reuse and refinement of schemas
  - Expand or delete already existent schemas
- Sophisticated set of data types, compared to DTDs (which only supports strings)

XML Schema (2)

- 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 is a variety of 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

Data Types (2)

- 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 (2)

- 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 (2)

```
<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 (3)

```
<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

- 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