XML Data Management

XML

- e**X**tensible **M**arkup **L**anguage

- Data representation format proposed by W3C (WWW Consortium) for Web documents, such as:
  - books,
  - product catalogs,
  - order forms,
  - messages

The Origin of XML

- **Original idea:** a meta-language used to specify markup languages
- **As in HTML** (or in WML, ...)
  - XML data are contained in documents
  - data properties are expressed with mark-ups
- **XML was designed to describe data and to focus on what data is**
- **HTML was designed to display data and to focus on how data looks like**

XML

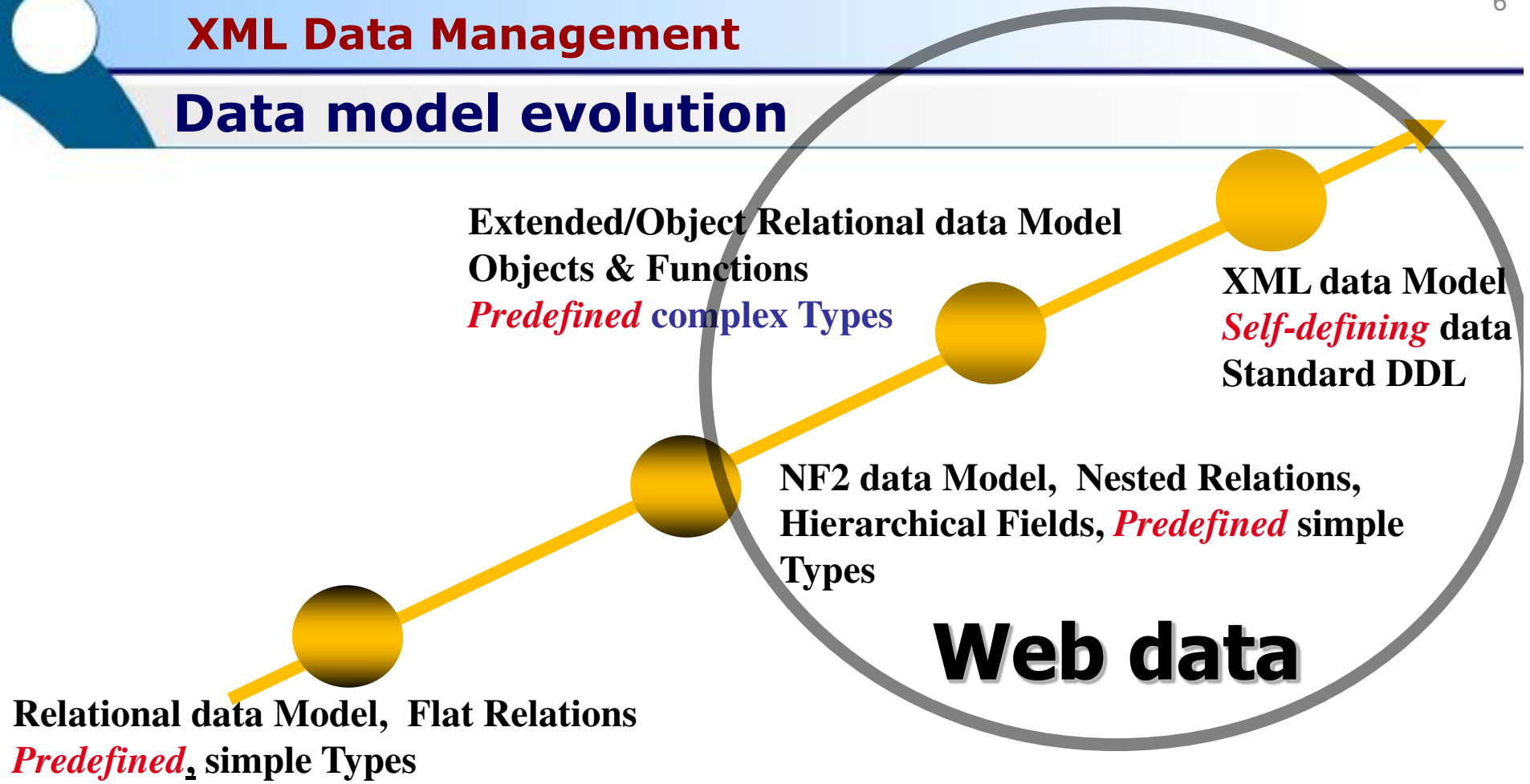
- 1986: Standard Generalized Markup Language (SGML) ISO 8879-1986
- Nov. 1995: HTML 2.0
- Gen. 1997: HTML 3.2
- Aug. 1997: XML W3C Working Draft
- Feb 10, 1998: XML 1.0 Recommendation
- Dec. 13, 2001: XML 1.1 W3C Working Draft
- Oct. 15, 2002 : XML 1.1 W3C Candidate Recommendation
- Aug 16, 2006 Extensible Markup Language (XML) 1.0 (Fourth Edition) W3C Recommendation

HTML vs XML

```
<h1>The Idea
    Methodology</h1><br>
<ul>
 <li>by S. Ceri,
     P. Fraternali  </li>
 <li> Addison-Wesley</li>
 <li> US$ 49 </li>
</ul>
```

```
<bib>
 <book>
  <title>The Idea
       Methodology </title>
  <author> S. Ceri </author>
  <author> P. Fraternali
                  </author>
  <pub>Addison-Wesley</pub>
  <price> US$ 49 </price>
 </book>
</bib>
```

Data model evolution



XML is used to exchange data

- **With XML, data can be exchanged between incompatible systems**
- In the real world, computer systems and databases contain data in incompatible formats. One of the most time-consuming challenges for developers has been to exchange data between such systems over the Internet.
- Converting the data to XML can greatly reduce this complexity and create data that can be read by many different types of applications.
- XML is the main language for exchanging financial information between businesses over the Internet.

XML is used to share data

- **With XML, plain text files can be used to share data**
- Since XML data is stored in plain text format, XML provides a *software- and hardware-independent* way of sharing data.
- This makes it much easier to create data that different applications can work with. It also makes it easier to expand or upgrade a system to new operating systems, servers, applications, and new browsers.

XML separates data from representation

- **With XML, data is stored outside HTML**
- When HTML is used to display data, the data is stored inside the HTML document. With XML, data can be stored in separate XML files. This way you can concentrate on using HTML for data layout and display, and be sure that changes in the underlying data will not require any changes to your HTML.
- XML data can also be stored inside HTML pages as "data Islands". You can still concentrate on using HTML only for formatting and displaying the data.

XML is used to store data

- **With XML, plain text files can be used to store data**
- XML data are also stored in files or in databases. Applications can be written to store and retrieve information from the store, and generic applications can be used to display the data.
- Data management extensions include data models (DTD,XSD), query languages (XQuery, XSLT)
- Data management occurs
  - Within native systems (eXists,Galax,ISI-XQ,BaseX,...)
  - Within relational systems (Oracle, DB2, SQLServer)

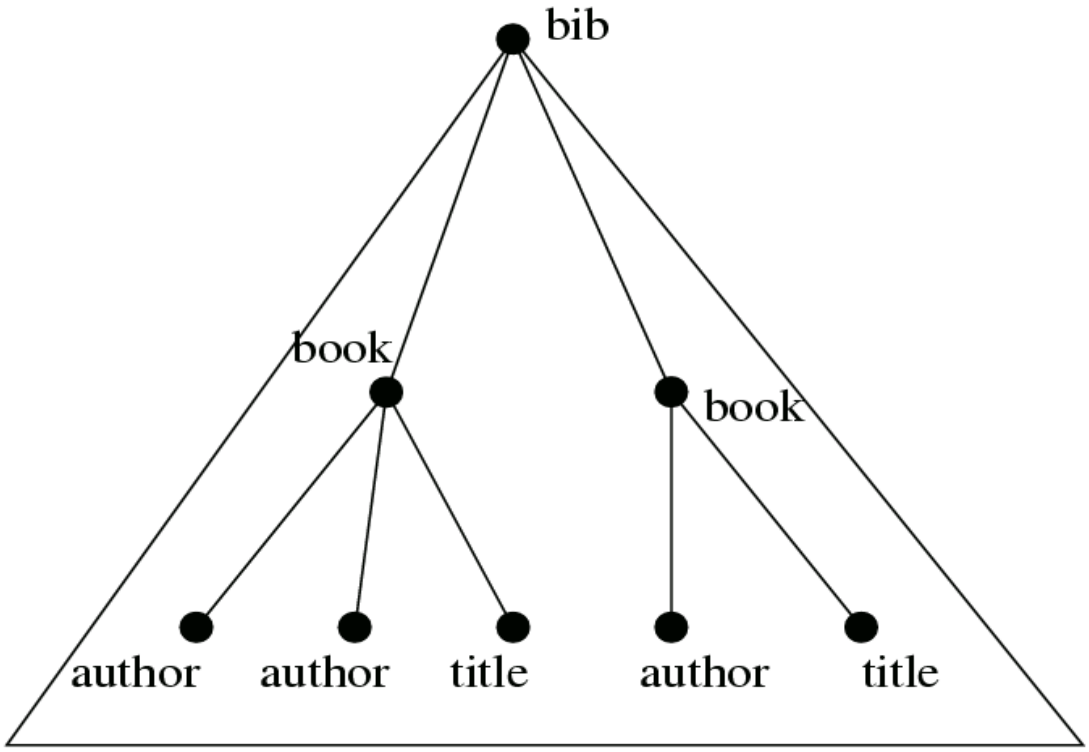
XML can make your data more useful

- **With XML, data is available to more users**
- Since XML is independent of hardware, software and applications, you can make your data available to other than only standard HTML browsers
- Other clients and applications can access your XML files as data sources, like they are accessing databases. Your data can be made available to all kinds of "reading machines" (agents)
- XML is the mother of new special-purpose languages.
  - E.g. the Wireless Markup Language (WML), used to markup Internet applications for handheld devices like mobile phones, is written in XML

Syntax

- The syntax rules of XML are very simple and very strict. The rules are very easy to learn, and very easy to use.
- Because of this, creating software that can read and manipulate XML is very easy.
- XML documents use a self-describing and simple syntax.

XML data model



First Example (1)

- An example XML document:

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<note>
    <to>Tove</to>
    <from>Jani</from>
    <heading>Reminder</heading>
    <body>Don't forget me this weekend!</body>
</note>
```

First Example (2)

- The first line in the document - the XML declaration - defines the XML version and the character encoding used in the document. In this case the document conforms to the 1.0 specification of XML and uses the ISO-8859-1 (Latin-1/West European) character set.

- The next line describes the root element of the document (like it was saying: "this document is a note"):

- <note>

First Example (3)

- The next 4 lines describe 4 child elements of the root (to, from, heading, and body):

```
<to>Tove</to>
<from>Jani</from>
<heading>Reminder</heading>
<body>Don't forget me this weekend!</body>
```

- And finally the last line defines the end of the root element:

```
</note>
```

- It’s easy to detect that the XML document contains a Note to Tove from Jani. XML is indeed quite self-descriptive

XML Syntax (1)

- **All XML elements must have a closing tag**
  - **Note**: You might have noticed from the previous example that the XML declaration did not have a closing tag. This is not an error. The declaration is not a part of the XML document itself. It is not an XML element, and it should not have a closing tag.
- **XML tags are case sensitive (unlike HTML)**
  - The tag <Letter> is different from the tag <letter>.
  - Opening and closing tags must therefore be written with the same case:

    <Message>This is incorrect</message>

    <message>This is correct</message>
- The syntax for comments in XML is the same as that of HTML

  <!-- This is a comment -->

XML Syntax (2)

- **All XML elements must be properly nested**
- **All XML documents must have a root element**
- **All XML documents must contain a single root element**
  - All other elements must be within this root element.
  - All elements can have sub elements (child elements). Sub elements must be correctly nested within their parent element:

    <root> <child> <subchild>.....</subchild> </child> </root>

Elements

- **Elements can have different content types**
- An **XML element** is everything from (including) the element's start tag to (including) the element's end tag.
- An element can have **element** content, **mixed** content, **simple** content, or **empty** content. An element can also have **attributes**.

Second Example (1)

```
<book>
    <title>My First XML</title>
    <prod id="33-657" media="paper"></prod>
    <chapter>Introduction to XML
        <para>What is HTML</para>
        <para>What is XML</para>
    </chapter>
    <chapter numberOfPages=“23”>XML Syntax
        <para>Elements must have a closing tag</para>
        <para>Elements must be properly nested</para>
    </chapter>
</book>
```

Second Example (2)

- Book is the **root element**. Title, prod, and chapter are **child elements** of book. Book is the **parent element** of title, prod, and chapter. Title, prod, and chapter are **siblings** because they have the same parent.
- Book has **element content**, because it contains other elements. Chapter has **mixed content** because it contains both text and other elements. Para has **simple content** (or **text content**) because it contains only text. Prod has **empty content**, because it carries no information.
- Only the prod element has **attributes**. The **attribute** named id has the **value** "33-657". The **attribute** named media has the **value** "paper".

Element naming

- **XML elements must follow these naming rules:**
  - Names can contain letters, numbers, and other characters
  - Names must not start with a number or punctuation character
  - Names must not start with the xml (or XML or Xml ...)
  - Names cannot contain spaces

Element naming

- Take care when "inventing" element names and follow these simple rules:
  - Any name can be used, no words are reserved, but the idea is to make names descriptive. Names with an underscore separator are nice.
    - Examples: <first_name>, <last_name>.
  - Avoid "-" and "." in names. For example, if you name something "first-name", it could be a mess if your software tries to subtract name from first.
  - Element names can be as long as you like, but don't exaggerate. Names should be short and simple, like this: <book_title> not like this: <the_title_of_the_book>.

Element naming

- Take care when "inventing" element names and follow these simple rules:
  - XML documents often have a corresponding database, in which fields exist corresponding to elements in the XML document. A good practice is to use the naming rules of your database for the elements in the XML documents.
  - Non-English letters like éòá are perfectly legal in XML element names, but watch out for problems if your software vendor doesn't support them.
  - The ":" should not be used in element names because it is reserved to be used for something called namespaces (more later).

Attributes

- **XML elements can have attributes.**
- From HTML you will remember this: <IMG SRC="computer.gif">. The SRC attribute provides additional information about the IMG element.
- In HTML (and in XML) attributes provide additional information about elements:

```
<img src="computer.gif"> <a href="demo.asp">
```

- Attributes often provide information that is not a part of the data. In the example below, the file type is irrelevant to the data, but important to the software that wants to manipulate the element:

```
<file type="gif">computer.gif</file>
```

Attributes

- **Attribute values must always be quoted (it is illegal to omit quotation marks around attribute values)**

  <incorrectNote date=12/11/2002>

  <note date="12/11/2002">

- **Quote Styles, "female" or 'female'?**
- Attribute values must always be enclosed in quotes, either single or double. For a person's sex, the person tag can be:

  <person sex="female"> or <person sex='female'>

- **Note:** If the attribute value itself contains double quotes, it is necessary to use single quotes, like in this example:

  <gangster name='George "Shotgun" Ziegler'>

  If instead the attribute value itself contains single quotes, it is necessary to use double quotes, like in this example:

  <gangster name="George 'Shotgun' Ziegler">

Elements vs Attributes

- Try to use **elements** to describe data.
- Use attributes only to provide information that is not relevant to the data or for metadata.
  - Example: ID references can be used to access XML elements
  - Example: creation user and date of a document, date of last document's update
- **Should you avoid using attributes?**
- Some of the problems with using attributes are:
  - attributes cannot contain multiple values (child elements can)
  - attributes are not easily expandable (for future changes)
  - attributes cannot describe structures (child elements can)
  - attributes are more difficult to manipulate by program code
  - attribute values are not easy to test against a Document Type Definition (DTD) - which is used to define the legal elements of an XML document

Name conflicts

- Since element names in XML are not predefined, a name conflict will occur when two different documents use the same element names.
  - This XML document carries information in a table:
    - <table> <tr> <td>Apples</td> <td>Bananas</td> </tr> </table>
  - This XML document carries information about a table (a piece of furniture):
    - <table> <name>African Coffee Table</name> <width>80</width> <length>120</length> </table>
- If these two XML documents were added together, there would be an element name conflict because both documents contain a <table> element with different content and definition.

Namespaces

- **Name conflicts are solved by using a prefix**
- This XML document carries information in a table:
  - <h:table> <h:tr> <h:td>Apples</h:td> <h:td>Bananas</h:td> </h:tr> </h:table>
- This XML document carries information about a piece of furniture:
  - <f:table> <f:name>African Coffee Table</f:name> <f:width>80</f:width> <f:length>120</f:length> </f:table>
- Now there will be no name conflict because the two documents use a different name for their <table> element (<h:table> and <f:table>).
- The prefix helped us create two different types of <table> elements

The XML Namespace (xmlns) Attribute

- A **Uniform Resource Identifier** (URI) is a string of characters which identifies an Internet Resource. The most common URI is the **Uniform Resource Locator** (URL) which identifies an Internet domain address. Another, not so common type of URI is the **Universal Resource Name** (URN). Usually URLs are used.
- The XML namespace attribute is placed in the start tag of an element and has the following syntax:

  xmlns:*namespace-prefix*="*namespaceURI*"
- When a namespace is defined in the start tag of an element, all child elements with the same prefix are associated with the same namespace.
- Note that the address used to identify the namespace is not used by the parser to look up information. The only purpose is to give the namespace a unique name. However, very often companies use the namespace as a pointer to a real Web page containing information about the namespace.

Namespace References

- This XML document carries information in a table:
  - <h:table xmlns:h="http://www.w3.org/TR/html4/"> <h:tr> <h:td>Apples</h:td> <h:td>Bananas</h:td> </h:tr> </h:table>
- This XML document carries information about a piece of furniture:
  - <f:table xmlns:f="http://www.w3schools.com/furniture"> <f:name>African Coffee Table</f:name> <f:width>80</f:width> <f:length>120</f:length> </f:table>

XML

- **A "Well Formed" XML document has correct XML syntax**
  - A "Well Formed" XML document is a document that conforms to the XML syntax rules that were described
- **A "Valid" XML document also conforms to a DTD**
  - A "Valid" XML document is a "Well Formed" XML document, which also conforms to the rules of a Document Type Definition (DTD)

DTD

- The purpose of a Document Type Definition is to define the legal building blocks of an XML document. It defines the document structure with a list of legal elements.
- A DTD can be declared inline in the XML document, or as an external reference.
- If the DTD is included in the XML source file, it should be wrapped in a DOCTYPE definition with the following syntax:

```
<!DOCTYPE root-element [element-declarations]>
```

Why use a DTD?

- With DTD, each of your XML files can carry a description of its own format with it.
- With a DTD, independent groups of people can agree to use a common DTD for interchanging data.
- Your application can use a standard DTD to verify that the data you receive from the outside world is valid.
- You can also use a DTD to verify your own data.

Internal DTD

```
<?xml version="1.0"?>
<!DOCTYPE note
        [ <!ELEMENT note (to,from,heading,body)>
          <!ELEMENT to (#PCdata)>
          <!ELEMENT from (#PCdata)>
          <!ELEMENT heading (#PCdata)>
          <!ELEMENT body (#PCdata)> ]>
<note>
        <to>Tove</to>
        <from>Jani</from>
        <heading>Reminder</heading>
        <body>Don't forget me this weekend</body>
</note>
```

DTD

- The DTD above is interpreted like this:
  - **!DOCTYPE note** (in line 2) defines that this is a document of the type **note.**
  - **!ELEMENT note** (in line 3) defines the **note** element as having four elements: "to,from,heading,body".
  - **!ELEMENT to** (in line 4) defines the **to** element to be of the type "#PCdata".
  - **!ELEMENT from** (in line 5) defines the **from** element to be of the type "#PCdata".
  - and so on.....

External DTD

- If the DTD is external to the XML file, it should be wrapped in a DOCTYPE definition with the following syntax:

```
<!DOCTYPE root-element SYSTEM "filename">
<?xml version="1.0"?>
<!DOCTYPE note SYSTEM "note.dtd">
<note> <to>Tove</to> <from>Jani</from> <heading>Reminder</heading>
<body>Don't forget me this weekend!</body> </note>
```

- This is a copy of the file "note.dtd" containing the DTD:

```
<!ELEMENT note (to,from,heading,body)>
<!ELEMENT to (#PCdata)>
<!ELEMENT from (#PCdata)>
<!ELEMENT heading (#PCdata)>
<!ELEMENT body (#PCdata)>
```

Declaring an element

- In the DTD, XML elements are declared with an element declaration. An element declaration has the following syntax:

<!ELEMENT element-name category>

or

<!ELEMENT element-name (element-content)>

Declaring elements

Empty elements

- Empty elements are declared with the category keyword EMPTY:

  <!ELEMENT element-name EMPTY>

  example: <!ELEMENT br EMPTY>

Elements with only character data

- Elements with only character data are declared with #PCdata inside parentheses:

  <!ELEMENT element-name (#PCdata)>

Elements with any contents

- Elements declared with the category keyword ANY, can contain any combination of parsable data:

  <!ELEMENT element-name ANY>

Elements with children

- Elements with one or more children are defined with the name of the children elements inside parentheses:

  <!ELEMENT element-name (child-element-name)>

  <!ELEMENT element-name (child-element-name,child-element-name,.....)>

  example: <!ELEMENT note (to,from,heading,body)>

- When children are declared in a sequence separated by commas, the children must appear in the same sequence in the document. In a full declaration, the children must also be declared, and the children can also have children.

One, min one

- **Declaring only one occurrence of the same element**

  <!ELEMENT element-name (child-name)>

  <!ELEMENT note (message)>

- The example declaration above declares that the child element message must occur once, and only once inside the "note" element.

- **Declaring minimum one occurrence of the same element**

  <!ELEMENT element-name (child-name+)>

  <!ELEMENT note (message+)>

- The + sign in the example above declares that the child element message must occur one or more times inside the "note" element.

Zero or more, zero or one

- **Declaring zero or more occurrences of the same element**

  <!ELEMENT element-name (child-name*)>

  <!ELEMENT note (message*)>

- The * sign in the example above declares that the child element message can occur zero or more times inside the "note" element.

- **Declaring zero or one occurrences of the same element**

  <!ELEMENT element-name (child-name?)>

  <!ELEMENT note (message?)>

- The ? sign in the example above declares that the child element message can occur zero or one times inside the "note" element.

Alternative and mixed content

- **Declaring either/or content**

  example:<!ELEMENT note (to,from,header,(message|body))>

- The example above declares that the "note" element must contain a "to" element, a "from" element, a "header" element, and either a "message" or a "body" element.

- **Declaring mixed content**

  example:<!ELEMENT note (#PCdata|to|from|header|message)*>

- The example above declares that the "note" element can contain zero or more occurrences of parsed character, "to", "from", "header", or "message" elements.

Declaring attributes

- An attribute declaration has the following syntax:

<!ATTLIST element-name attribute-name attribute-type default-value>

- Example:

  <!ATTLIST payment type Cdata "check">

  Corresponding XML

  <payment type="check" />

Attribute type

The attribute-type can have the following values:

Cdata	The value is character data
(en1|en2|..)	The value must be one from an enumerated list
ID	The value is a unique id
IDREF	The value is the id of another element
IDREFS	The value is a list of other ids
NMTOKEN	The value is a valid XML name
NMTOKENS	The value is a list of valid XML names
ENTITY	The value is an entity
ENTITIES	The value is a list of entities
NOTATION	The value is a name of a notation
xml:	The value is a predefined xml value

Default values

The default-value can have the following values:

Value	The default value of the attribute
#REQUIRED	The attribute value must be included in the element
#IMPLIED	The attribute does not have to be included
#FIXED value	The attribute value is fixed

Example of attribute declarations

```
<!ELEMENT PRODUCT ( ..... )

<!ATTLIST PRODUCT
    code                    ID                  #REQUIRED
    label                   CDATA               #IMPLIED
    status      (available|unavailable)  'available'
    sconto                  CDATA               FIXED  '15%'  >
```

A simple DTD

```
<!DOCTYPE NEWSPAPER [
   <!ELEMENT NEWSPAPER (ARTICLE+)>
   <!ELEMENT ARTICLE (HEADLINE,BYLINE,LEAD,BODY,NOTES)>
   <!ELEMENT HEADLINE (#PCDATA)>
   <!ELEMENT BYLINE (#PCDATA)>
   <!ELEMENT LEAD (#PCDATA)>
   <!ELEMENT BODY (#PCDATA)>
   <!ELEMENT NOTES (#PCDATA)>
   <!ATTLIST ARTICLE AUTHOR CDATA #REQUIRED
                     EDITOR CDATA #IMPLIED
                     DATE CDATA #IMPLIED
                     EDITION CDATA #IMPLIED >
 ]>
```

XML Schema

- XML Schema is a richer, XML based alternative to DTD
- An XML schema describes the structure of an XML document
- The XML Schema language is also referred to as XML Schema Definition (XSD)

Why XML Schemas?

- The purpose of an XML Schema is to define the legal building blocks of an XML document, just like a DTD.
- An XML Schema:
  - defines elements that can appear in a document
  - defines attributes that can appear in a document
  - defines which elements are child elements
  - defines the order of child elements
  - defines the number of child elements
  - defines whether an element is empty or can include text
  - defines data types for elements and attributes
  - defines default and fixed values for elements and attributes

An example of XSD

```
<?xml version="1.0"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" …>
<xs:element name="note">
    <xs:complexType>
      <xs:sequence>
            <xs:element name="to" type="xs:string"/>
            <xs:element name="from" type="xs:string"/>
            <xs:element name="heading" type="xs:string"/>
            <xs:element name="body" type="xs:string"/>
      </xs:sequence>
    </xs:complexType>
</xs:element>
</xs:schema>
```

Simple and complex types

- The **note** element is said to be of a **complex type** because it contains other elements

- The other elements (to, from, heading, body) are said to be **simple types** because they do not contain other elements

Simple elements

- A simple element is an XML element that can contain only text. It cannot contain any other elements or attributes.
- However, the "only text" restriction is quite misleading. The text can be of many different types. It can be one of the types that are included in the XML Schema definition (boolean, string, date, etc.), or it can be a custom type that you can define yourself.
- You can also add restrictions (facets) to a data type in order to limit its content, and you can require the data to match a defined pattern.

Simple elements

- The syntax for defining a simple element is:

```
<xs:element name="xxx" type="yyy"/>
```

- where xxx is the name of the element and yyy is the data type of the element. Here are some XML elements:

```
<lastname>Refsnes</lastname>
<age>34</age>
<dateborn>1968-03-27</dateborn>
```

and here are the corresponding simple element definitions:

```
<xs:element name="lastname" type="xs:string"/>
<xs:element name="age" type="xs:integer"/>
<xs:element name="dateborn" type="xs:date"/>
```

XML Schema data types

- XML Schema has a lot of built-in data types. Here is a list of the most common of them:
  - xs:string
  - xs:decimal
  - xs:integer
  - xs:boolean
  - xs:date
  - xs:time

Default and Fixed values for simple elements

- Simple elements can have a default value OR a fixed value set.
- A default value is automatically assigned to the element when no other value is specified. In the following example the default value is "red":

```
<xs:element name="color" type="xs:string" default="red"/>
```

- A fixed value is also automatically assigned to the element. You cannot specify another value. In the following example the fixed value is "red":

```
<xs:element name="color" type="xs:string" fixed="red"/>
```

Attribute definition

- The syntax for defining an attribute is:

```
<xs:attribute name="xxx" type="yyy"/>
```

where xxx is the name of the attribute and yyy is the data type of the attribute.

- Here is an XML element with an attribute:

```
<lastname lang="EN">Smith</lastname>
```

and the corresponding simple attribute definition:

```
<xs:attribute name="lang" type="xs:string"/>
```

Value restrictions

- This example defines an element called "age" with a restriction. The value of age cannot be lower than 0 or greater than 100:

```
<xs:element name="age">
        <xs:simpleType>
                <xs:restriction base="xs:integer">
                        <xs:minInclusive value="0"/>
                        <xs:maxInclusive value="100"/>
                </xs:restriction>
        </xs:simpleType>
</xs:element>
```

Enumeration constraint

- To limit the content of an XML element to a set of acceptable values, we would use the enumeration constraint.
- This example defines an element called "car":

```
<xs:element name="car">
        <xs:simpleType>
                <xs:restriction base="xs:string">
                        <xs:enumeration value="Audi"/>
                        <xs:enumeration value="Golf"/>
                        <xs:enumeration value="BMW"/>
                </xs:restriction>
        </xs:simpleType>
</xs:element>
```

- The "car" element is a simple type with a restriction. The acceptable values are: Audi, Golf, BMW.

Separate type definition

- The previous example could also have been written like this:
- <xs:element name="car" type="carType"/>
- <xs:simpleType name="carType">
  <xs:restriction base="xs:string">
  <xs:enumeration value="Audi"/>
  <xs:enumeration value="Golf"/>
  <xs:enumeration value="BMW"/>
  </xs:restriction>
  </xs:simpleType>

- In this case the type "carType" can be used by other elements because it is not a part of the "car" element.

Pattern constraints

- To limit the content of an XML element to define a series of numbers or letters, we would use the pattern constraint.
- This example defines an element called "letter":
-
```
<xs:element name="letter">
    <xs:simpleType>
        <xs:restriction base="xs:string">
            <xs:pattern value="[a-z]"/>
        </xs:restriction>
    </xs:simpleType>
</xs:element>
```
- The "letter" element is a simple type with a restriction. The acceptable value is one of the lowercase letters from a to z.

Complex elements

- A complex element is an XML element that contains other elements and/or attributes.
- There are four kinds of complex elements:
  - empty elements
  - elements that contain only other elements
  - elements that contain only text
  - elements that contain both other elements and text

- **Note:** Each of these elements may contain attributes as well!

Example of complex element

- The "employee" element can be declared directly by naming the element, like this:
- <xs:element name="employee">

```
<xs:complexType>
    <xs:sequence>
        <xs:element name="firstname" type="xs:string"/>
        <xs:element name="lastname" type="xs:string"/>
    </xs:sequence>
</xs:complexType>
</xs:element>
```

Use of externally defined complex types

- The "employee" element can have a type attribute that refers to the name of the complex type to use:

```
<xs:element name="employee" type="personinfo"/>
<xs:element name="student" type="personinfo"/>
<xs:complexType name="personinfo">
    <xs:sequence>
        <xs:element name="firstname" type="xs:string"/>
        <xs:element name="lastname" type="xs:string"/>
    </xs:sequence>
</xs:complexType>
```

Example: Complex type for empty element

- <xs:element name="product">
  <xs:complexType>
  <xs:attribute name="prodid" type="xs:positiveInteger"/>
  </xs:complexType>
  </xs:element>

Sequence vs Mixed

-
```
<xs:element name="person">
  <xs:complexType>
    <xs:sequence>
        <xs:element name="firstname" type="xs:string"/>
        <xs:element name="lastname" type="xs:string"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>
```

-
```
<xs:element name="letter">
  <xs:complexType mixed="true">
    <xs:sequence>
      <xs:element name="name" type="xs:string"/>
      <xs:element name="orderid" type="xs:positiveInteger"/>
      <xs:element name="shipdate" type="xs:date"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>
```

Legal XML document:
<letter> Dear Mr.<name>John Smith</name>. Your order <orderid>1032</orderid> will be shipped on <shipdate>2001-07-13</shipdate>. </letter>

All

- The <all> indicator specifies by default that the child elements can appear in any order and that each child element must occur once and only once:

```
<xs:element name="person">
  <xs:complexType>
    <xs:all>
      <xs:element name="firstname" type="xs:string"/>
      <xs:element name="lastname" type="xs:string"/>
    </xs:all>
  </xs:complexType>
</xs:element>
```

Choice

- The <choice> indicator specifies that either one child element or another can occur:
- <xs:element name="person">

```
<xs:complexType>
  <xs:choice>
    <xs:element name="employee" type="employee"/>
    <xs:element name="member" type="member"/>
  </xs:choice>
</xs:complexType>
</xs:element>
```

MaxOccurs and minOccurs

- The <**maxOccurs**> indicator specifies the maximum number of times an element can occur. The <**minOccurs**> indicator specifies the minimum number of times an element can occur:
- <xs:element name="person"> <xs:complexType> <xs:sequence>
  <xs:element name="full_name" type="xs:string"/>
  <xs:element name="child" type="xs:string"
  maxOccurs="10" minOccurs="0"/>
  </xs:sequence> </xs:complexType> </xs:element>
- The example indicates that the "child" element can miss or can occur a maximum of ten times in a "person" element.
- The default value for minOccurs and maxOccurs is 1
- To allow an element to appear an unlimited number of times, use the maxOccurs="unbounded" statement.

Any

- The <any> element enables us to extend the XML document with elements not specified by the schema.
- The following example is a fragment from an XML schema called "family.xsd". It shows a declaration for the "person" element. By using the <any> element we can extend (after <lastname>) the content of "person" with any element:

```
<xs:element name="person">  <xs:complexType> <xs:sequence>
    <xs:element name="firstname" type="xs:string"/>
    <xs:any minOccurs="0"/>
</xs:sequence>  </xs:complexType> </xs:element>
```

AnyAttribute

- The <anyAttribute> element enables us to extend the XML document with attributes not specified by the schema.

```
<xs:element name="person">  <xs:complexType>
    <xs:sequence>
      <xs:element name="firstname" type="xs:string"/>
      <xs:any minOccurs="0"/>
    </xs:sequence>
    <xs:anyAttribute/>
</xs:complexType> </xs:element>
```

Query Languages for XML

(XPath, XQuery)

Query languages for XML

- XML can be considered as a semi-structured data model
- A set of XML documents (or a single one, e.g. Divina Commedia) can be considered as a large data collection
- Query languages are needed for extracting relevant information from such documents
- The languages are:
  - XPath a simple document selection language
  - XQuery a rich query language
  - XSLT expecially used for document transformations (e.g. Producing HTML from XML) – not discussed in this course

XPath

- XPath uses path expressions to select nodes in an XML document. The node is selected by following a path or steps. The most useful path expressions are listed below:

Expression	Description
Nodename	Selects all child nodes of the node
/	Selects from the root node
//	Selects nodes in the document from the current node that match the selection no matter where they are
.	Selects the current node
..	Selects the parent of the current node
@	Selects attributes

Path expressions

- A path expression starts from the root of the document, e.g. doc("books.xml") returns the root element and all its content.

- Starting from the root it is possible to express path expressions in order to extract the desired content

  doc("books.xml")/bookstore/book

  Return **the sequence** of all book elements in the document

Path expressions

```
<?xml version="1.0"?>
<bookstore>
      <book available='Y'>
            <title>Il Signore degli Anelli</title>
            <author>J.R.R. Tolkien</author>
            <date>2002</date>
            <ISBN>88-452-9005-0</ISBN>
            <publisher>Bompiani</publisher>
      </book>
     <book available='N'>
            <title>Il nome della rosa</title>
            <author>Umberto Eco</author>
            <date>1987</date>
            <ISBN>55-344-2345-1</ISBN>
            <publisher>Bompiani</publisher>
      </book>
      <book available='Y'>
            <title>Il sospetto</title>
            <author>F. Dürrenmatt</author>
            <date>1990</date>
            <ISBN>88-07-81133-2</ISBN>
            <publisher>Feltrinelli</publisher>
      </book>
</bookstore>
```

doc("books.xml")/bookstore/book

```
<book available='Y'>
      <title>Il Signore degli Anelli</title>
      <author>J.R.R. Tolkien</author>
      <date>2002</date>
      <ISBN>88-452-9005-0</ISBN>
      <publisher>Bompiani</publisher>
</book>
<book available='N'>
      <title>Il nome della rosa</title>
      <author>Umberto Eco</author>
      <date>1987</date>
      <ISBN>55-344-2345-1</ISBN>
      <publisher>Bompiani</publisher>
</book>
<book available='Y'>
      <title>Il sospetto</title>
      <author>F. Dürrenmatt</author>
      <date>1990</date>
      <ISBN>88-07-81133-2</ISBN>
      <publisher>Feltrinelli</publisher>
</book>
```

Conditions

- doc ("books.xml")/bookstore/book[publisher='Bompiani']/title

  Return the sequence of all titles of books edited by Bompiani

```
<title>Il Signore degli Anelli</title>
<title>Il nome della rosa</title>
```

Subelements

- doc("books.xml")//author

  Return the sequence of all authors in the document, independently of their nesting level

```
<author>J.R.R. Tolkien</author>
<author>Umberto Eco</author>
<author>F. Dürrenmatt</author>
```

Subelements

```
<a>
 bnnnn
    <b>mmm <a>primo</a> </b>  bnnnn
    <c><b>mmm <a>secondo</a>   </b></c>
</a>
```

doc("books.xml")//a

```
<a>
 bnnnn
    <b>mmm <a>primo</a> </b>  bnnnn
    <c><b>mmm <a>secondo</a>   </b></c>
</a>
<a>primo</a>
<a>secondo</a>
```

Ordered elements

- doc ("books.xml")/bookstore/book[2]
  Return the second book

```
<book>
  <title>Il nome della rosa</title>
  <author>Umberto Eco</author>
  <date>1987</date>
  <ISBN>55-344-2345-1</ISBN>
  <publisher>Bompiani</publisher>
</book>
```

Ordered elements

- doc (“books.xml”)/bookstore/book[2]/*

  Return all the elements (* = with any tagname) contained into the second book

```
<title>Il nome della rosa</title>
<author>Umberto Eco</author>
<date>1987</date>
<ISBN>55-344-2345-1</ISBN>
<publisher>Bompiani</publisher>
```

Path expressions

- Second order expression

  expr1 / expr2
- Semantics:
  1. Evaluate expr1 => sequence of nodes
  2. Bind . to each node in this sequence
  3. Evaluate expr2 with this binding => sequence of nodes
  4. Concatenate the partial sequences
  5. Eliminate duplicates
  6. Sort by document order
- A standalone step is an expression
  1. step = (axis, nodeTest) where
  2. nodeTest = (node kind, node name, node type)

XPath Axes

- An axis defines a node-set relative to the current node.
  - ancestor: selects all ancestors (parent, grandparent, etc.) of the current node
  - ancestor-or-self: selects all ancestors (parent, grandparent, etc.) of the current node and the current node itself
  - attribute: selects all attributes of the current node
  - child: selects all children of the current node
  - descendant: selects all descendants (children, grandchildren, etc.) of the current node
  - descendant-or-self: selects all descendants (children, grandchildren, etc.) of the current node and the current node itself
  - following: selects everything in the document after the closing tag of the current node
  - following-sibling: selects all siblings after the current node
  - parent: selects the parent of the current node
  - preceding: selects everything in the document that is before the start tag of the current node
  - preceding-sibling: selects all siblings before the current node
  - self: selects the current node

Abbreviated syntax

- Axis can be missing
  - By default the child axis
    - $x/child::person -> $x/person
- Short-hands for common axes
  - Descendent-or-self
    - $x/descendant-or-self::*/child::name-> $x//name
  - Parent
    - $x/parent::* -> $x/..
  - Attribute
    - $x/attribute::year -> $x/@year
  - Self
    - $x/self::* -> $x/.

XPATH EXAMPLES

/bookstore	Selects the root element bookstore (If the path starts with a slash (/) it always represents an absolute path to an element!
bookstore/book	Selects all book elements that are children of bookstore
//book	Selects all book elements no matter where they are in the document
bookstore//book	Selects all book elements that are descendant of the bookstore element, no matter where they are under the bookstore element
//@lang	Selects all attributes that are named lang

XPATH PREDICATES

Predicates are used to find a specific node or a node that contains a specific value. Predicates are always embedded in square brackets

/bookstore/book[1]	Selects the first book element that is the child of the bookstore element
/bookstore/book[=1]	Selects the …
/bookstore/book[last()]	Selects the last book element that is the child of the bookstore element
/bookstore/book[last()-1]	Selects the last but one book element that is the child of the bookstore element
/bookstore/book[position()<3]	Selects the first two book elements that are children of the bookstore element
/bookstore/book[<3]	Selects the …

XPATH PREDICATES

Predicates are used to find a specific node or a node that contains a specific value. Predicates are always embedded in square brackets

//title[@lang]	Selects all the title elements that have an attribute named lang
//title[@lang='eng']	Selects all the title elements that have an attribute named lang with a value of 'eng'
/bookstore/book[price>35.00]	Selects all the book elements of the bookstore element having a price element with a value greater than 35.00
/bookstore/book[price]	Selects all the book elements of the bookstore element having a price element

XPath filter predicates

- [ ] is an overloaded operator
- Filtering by position (if numeric value) :
  - /book[3]
  - /book[3]/author[1]
  - /book[3]/author[2 to 4]
- Filtering by predicate :
  - //book[author/firstname = “ronald”]
  - //book[@price <25]
  - //book[count(author[@gender=“female”])>0]
- Existential filtering:
  - //book[author]

Wildcards

XPath wildcards can be used to select unknown XML elements

Wildcard	Description
*	Matches any element node
@*	Matches any attribute node
node()	Matches any node of any kind

Path	ExpressionResult
/bookstore/*	Selects all the child nodes of the bookstore element
//*	Selects all elements in the document
//title[@*]	Selects all title elements which have any attribute

Alternative paths

The | operator in an XPath expression indicates several alternative paths that can be used to select results

- //book/title | //book/price
  Selects all the **title** and the **price** elements of all books
- //title | //price
  Selects all the **title** and the **price** elements in the document
- /bookstore/book/title | //price
  Selects all the title elements of the book element of the bookstore element AND all the price elements in the document