XML

7.1 Introduction

- **eXtensible Markup Language**
- **Developed from SGML**
- **A *meta-markup* language**
- **Deficiencies of HTML and SGML**
  - **Lax syntactical rules**
  - **Many complex features that are rarely used**
- **HTML is a markup language, XML is used to define markup languages**
- **Markup languages defined in XML are known as *applications***
- **XML can be written by hand or generated by computer**
  - **Useful for data exchange**

What is XML

- **XML is a *markup* language much like HTML**
- **XML is used to describe *structured data***
- **XML data is stored in plain-text format i.e software and hardware-independent**
- **XML tags are not predifined. One *must define its own tags.***
- **XML may use a Document Type Definition (DTD) or an XML Schema to describe the data**

XML Vs HTML

- **XML and HTML were designed with different goals:**
  - ***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. HTML tags are predifined**

How can XML be used

- **XML can be used to:**
  - **Separate data from its presentation**
  - **Exchange data between incompatible systems**
  - **Share data between different applications**
  - **Store data**
- **In fact, currently XML is the de-facto standard in many software application areas such as Web content description, Web-Services and Communication Protocols (e.g SOAP) among many others.**

XML Syntax (1)

- **XML Declaration contains:**
  - **Version of the XML specification**
  - **Character encoding of the document**
- **XML Tags must:**
  - **Be case sensitive**
  - **Start with letter or underscore**
  - **Not contain whitespaces**
  - **Have an end Tag**

XML Syntax (2)

- **Element Declaration**
  - **Elements must be properly nested**
  - **All XML documents must have a root element**
- **Attribute Declaration**
  - **Atributes provide metadata for the element**
  - **Atributes must be enclosed in “” with no commas between**
  - **Same naming conventions as elements**

An XML example

The following is a very simple example of an XML document representing data of pets:

```
<?xml version="1.0" encoding="iso-8859-1"?>
<pets>
<pet type="dog" color="brown">Max</pet>
<pet type="cat" color="white">Toula</pet>
</pets>
```

7.2 The Syntax of XML

- **Levels of syntax**
  - ***Well-formed documents* conform to basic XML rules**
  - ***Valid documents* are well-formed and also conform to a *schema* which defines details of the allowed content**
- **Well-formed XML documents**
  - **All begin tags have a matching end tag**
    - **Empty tags**
  - **If a begin tag is inside an element, the matching end tag is also**
  - **There is one *root* tag that contains all the other tags in a document**
  - **Attributes must have a value assigned, the value must be quoted**
  - **The characters <, >, & can only appear with their special meaning**
- **Validity is tested against a schema**

7.3 XML Document Structure

- **Auxiliary files**
  - **Schema file**
    - **DTD or XML Schema**
  - **Style file**
    - **Cascading Style Sheets**
    - **XSLT**
- **Breaking file up**
  - **Document entities**
  - **Entity syntax**
- **Character data**
  - **<![CDATA …..]]>**

7.4 Document Type Definitions

- **A set of *declarations***
- **Define tags, attributes, entities**
- **Specify the order and nesting of tags**
- **Specify which attributes can be used with which tags**
- **General syntax**
  - **<!keyword …. >**

7.4 Declaring Elements

- **General syntax**

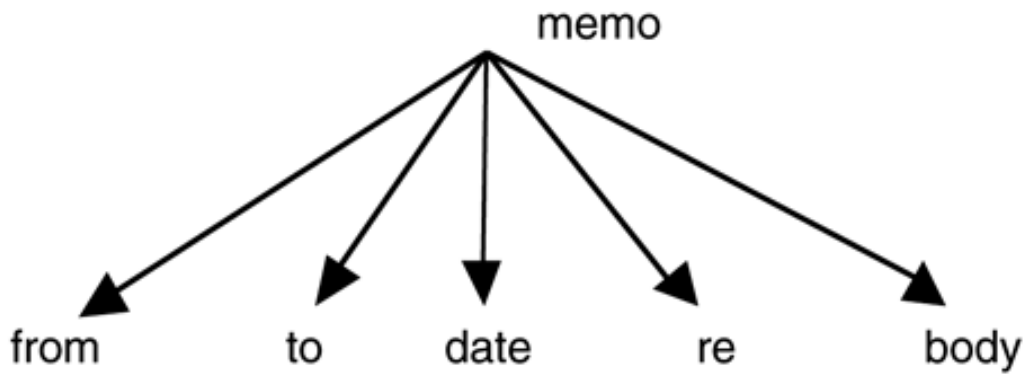
  <!ELEMENT *element-name content-description*>

  Content description specifies what tags may appear inside the named element and whether there may be any plain text in the content

  <!ELEMENT *element-name* (*List of names of child elements*)>

  Example

  <!ELEMENT memo *(from, to, date, re, body)*>



Document tree structure

Declaring Elements……

- **Multiplicity**

Modifier	Meaning
+	One or more occurrences
*	Zero or more occurrences
?	Zero or one occurrence

Example:

<!ELEMENT person (parent+, age, spouse?, siblings*)>

- **Sequence of tags**
- **Alternate tags**
- **#PCDATA**

•<!ELEMENT *element-name (#PCDATA*)>

7.4 Declaring Attributes

- **General syntax**
  - **<!ATTLIST *element-name***

    (*attribute-name attribute-type default-value*) >

- **Default values**

Value	Meaning
A value	The quoted value, which is used if none is specified in an element
`#FIXED` value	The quoted value, which every element will have and which cannot be changed.
`#REQUIRED`	No default value is given; every instance of the element must specify a value
`#IMPLIED`	No default value is given (the browser chooses the default value); the value may or may not be specified in an element

7.4 Declaring Entities

- **General Syntax**
  - **<!ENTITY [%] *entity-name “entity-value”*>**
  - **With %: a parameter entity**
  - **Without %: a general entity**
- **Parameter entities may only be referenced in the DTD**
- **Remote form**
  - **<!ENTITY *entity-name* SYSTEM *“file-location”*>**
  - **The replacement for the entity is the content of the file**

Sample DTD

```
<?xml version = "1.0" encoding = "utf-8"?>

<!-- planes.dtd - a document type definition for
                  the planes.xml document, which specifies
                  a list of used airplanes for sale  -->

<!ELEMENT planes_for_sale (ad+)>
<!ELEMENT ad (year, make, model, color, description,
              price?, seller, location)>
 <!ELEMENT year (#PCDATA)>
 <!ELEMENT make (#PCDATA)>
 <!ELEMENT model (#PCDATA)>
 <!ELEMENT color (#PCDATA)>
 <!ELEMENT description (#PCDATA)>
 <!ELEMENT price (#PCDATA)>
 <!ELEMENT seller (#PCDATA)>
 <!ELEMENT location (city, state)>
 <!ELEMENT city (#PCDATA)>
 <!ELEMENT state (#PCDATA)>

 <!ATTLIST seller phone CDATA #REQUIRED>
 <!ATTLIST seller email CDATA #IMPLIED>

 <!ENTITY c "Cessna">
 <!ENTITY p "Piper">
 <!ENTITY b "Beechcraft">
```

XML Document

This XML file does not appear to have any style information associated with it. The document tree is shown below.

```
- <!--
    planes.xml - A document that lists ads for
          used airplanes
  -->
- <!--
    <?xml-stylesheet  type = "text/css"  href = "planes.css" ?>
  -->
- <planes_for_sale>
  - <ad>
      <year> 1977 </year>
      <make> cessna </make>
      <model> Skyhawk </model>
      <color> Light blue and white </color>
    - <description>
        New paint, nearly new interior, 685 hours SMOH, full IFR King avionics
      </description>
      <seller phone="555-222-3333"> Skyway Aircraft </seller>
    - <location>
        <city> Rapid City, </city>
        <state> South Dakota </state>
      </location>
    </ad>
  - <ad>
      <year> 1965 </year>
      <make> Piper </make>
      <model> Cherokee </model>
      <color> Gold </color>
    - <description>
        240 hours SMOH, dual NAVCOMs, DME, new Cleveland brakes, great shape
      </description>
      <seller phone="555-333-2222"> John Seller </seller>
    - <location>
        <city> St. Joseph, </city>
        <state> Missouri </state>
      </location>
    </ad>
  </planes_for_sale>
```

7.4 Internal and External DTDs

- **A document type declaration can either contain declarations directly or can refer to another file**
- **Internal**
  - **<!DOCTYPE *root-element* [**

    declarations

    ]>
- **External file**
  - **<!DOCTYPE *root-name* SYSTEM *“file-name”*>**
- **A public identifier can also be specified, that would be mapped to a system identifier by the processing system**

7.5 Namespaces

- **“XML namespaces provide a simple method for qualifying element and attribute names used in Extensible Markup Language documents by associating them with namespaces identified by URI references.”**
  - **From the specification**

    http://www.w3.org/TR/2006/REC-xml-names-20060816/
- **A namespace can be declared for an element and its descendants by**
  - ***<element xmlns[:prefix]=“URI”>***
  - **The prefix is used to qualify elements that belong to the namespace**
  - **Multiple namespaces can be used in a single document**
  - **Default namespace**
- **DTDs do not support namespaces very well**

7.6 XML Schemas

- **Schema is a generic term for any description of an XML content model**
- **DTDs have several deficits**
  - **They do not use XML syntax**
  - **They do not support namespaces**
  - **Data types cannot be strictly specified**
    - **Example date vs. string**

7.6 Schema Fundamentals

- **Documents that conform to a schema's rules are considered *instances* of that schema**
- **Schema purposes**
  - **Structure of instances**
  - **Data types of elements and attributes**
- **XML Schemas support namespaces**
  - **The XML Schema language itself is a set of XML tags**
  - **The application being described is another set of tags**

7.6 Defining a Schema

- **The root of an XML Schema document is the schema tag**
- **Attributes**
  - **`xmlns` attributes for the schema namespace and for the namespace being defined**
  - **A `targetNamespace` attribute declaring the namespace being defined**
  - **An `elementFormDefault` attribute with the value qualified to indicate that all elements defined in the target namespace must be namespace qualified (either with a prefix or default) when used**

7.6 Defining a Schema Instance

- **The xmlns attribute declares a namespace for an element and its descendants**
  - **<element xmlns[:prefix]="URI">**
  - **The element itself may not be in the namespace**
  - **Multiple elements may be defined**
- **The http://www.w3.org/2001/XMLSchema-instance namespace includes one attribute, schemaLocation**
  - **That attribute value is pairs, separated by spaces**
  - **Each pair consists of a namespace and the location of a file that defines that namespace**

7.6 An Overview of Data Types

- **Data types are of two kinds**
  - **Simple data types with string content**
  - **Complex data types with elements, attributes and string content**
- **Predefined types**
  - **Primitive**
  - **Derived**
- **Restrictions**
  - **Facets**
- **Anonymous and named types**

7.6 Simple Types

- **Named types can be used to give the type of**
  - **an attribute (which must be simple) or**
  - **an element (which may be simple or complex)**
- **Elements or attributes with simple type may have default values specified**
- **New simple types can be defined by restriction of base types**
  - **Facet maxLength**
  - **Facet precision**

7.6 Complex Types

- **Definition of a complex type can specify**
  - **Elements in content (either sequence or choice)**
    - **Individual elements may specify a multiplicity**
  - **Attributes that can appear for an element of that type**
  - **Whether plain text is allowed in the content, a *mixed* type**
- **An element definition can be associated with a type by**
  - **Referring to a named type directly in the type attribute**
  - **Including an anonymous type definition**

7.6 Validating Instances of Schemas

- **Various systems for validating instances against schemas**
  - **Online http://www.w3.org/2001/03/webdata/xsv**
  - **XML support libraries include validation: Xerces from Apache, Saxon, Altova XML tools**
  - **Some IDE's have automatic validation: Altova Spy, Eclipse with Oxygen, Eclipse with XML Buddy Pro**
- **Certain IDE's will use schemas to provide support for XML file creation**

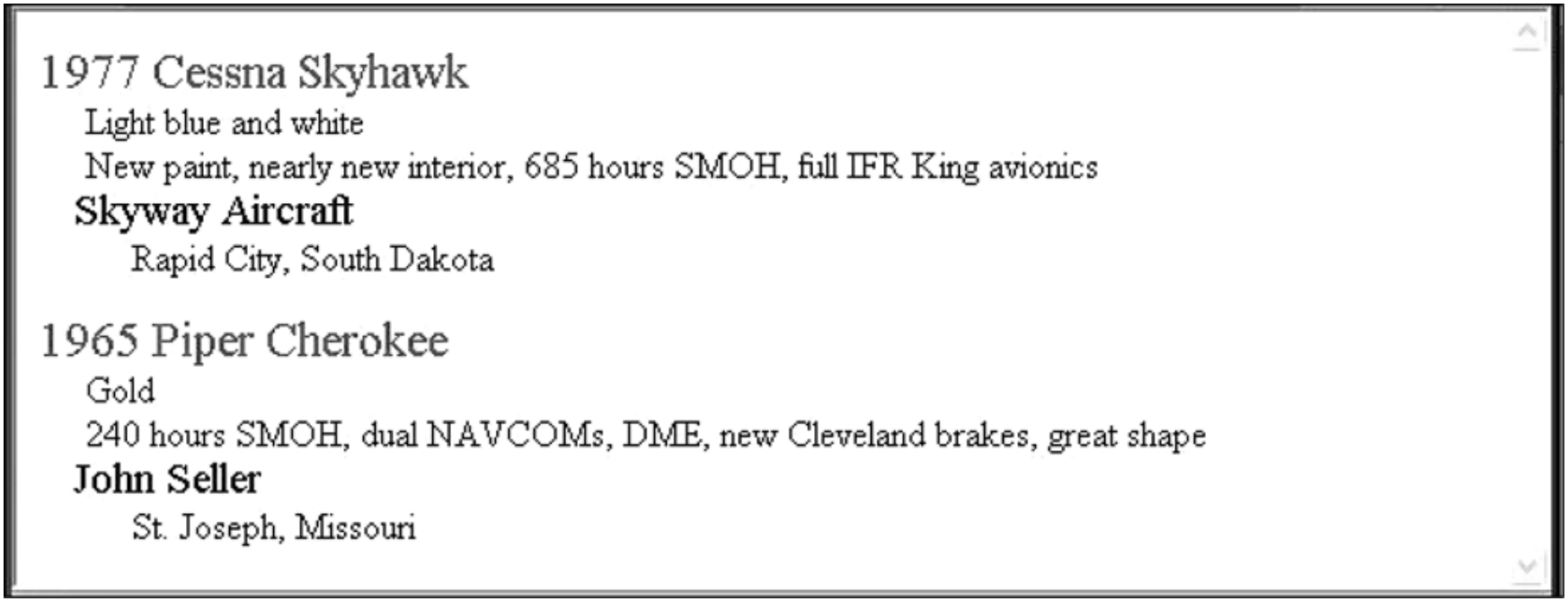
7.7 Displaying Raw XML Documents

- **Plain XML documents are generally displayed literally by browsers**
  - **Firefox notes that there is no style information**

7.8 Displaying XML Documents with CSS

- **An xml-stylesheet processing instruction can be used to associate a general XML document with a style sheet**
  - **`<?xml-stylesheet type="text/css" href="planes.css">`**
- **The style sheet selectors will specify tags that appear in a particular document**

Figure 7.4 The result of using a CSS style sheet to format `planes.xml`



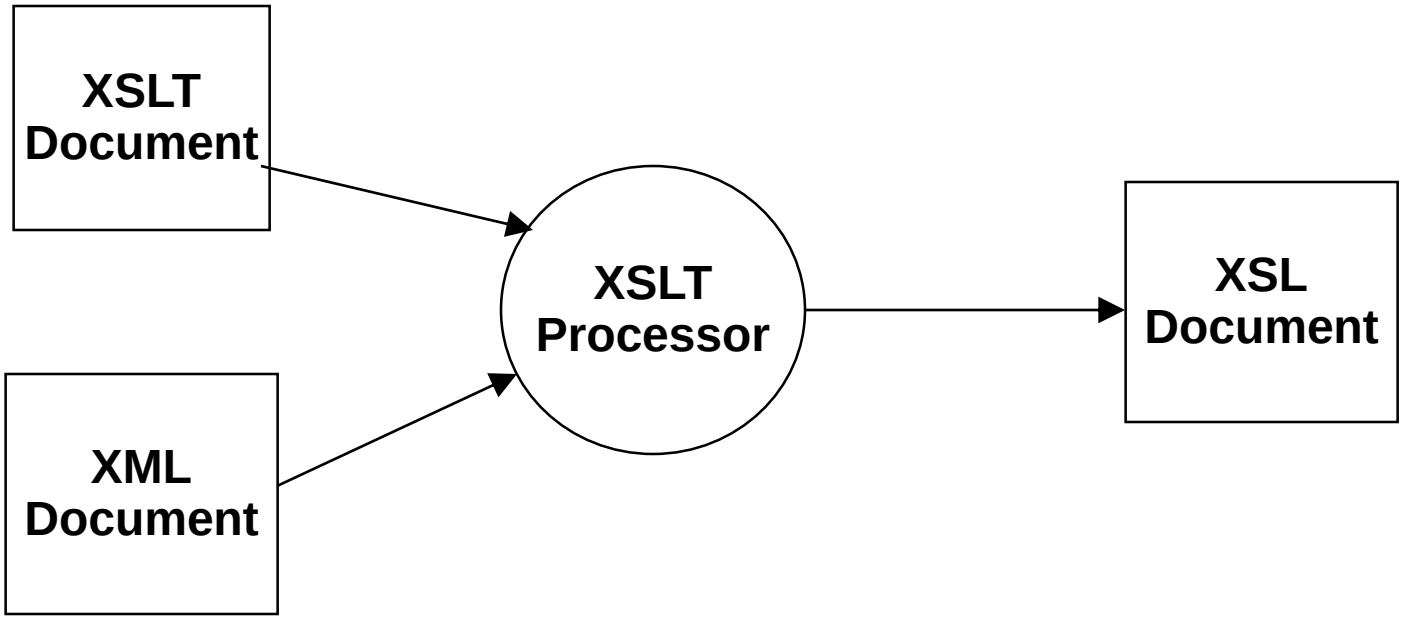
7.9 XSLT Style Sheets

- **A family of specifications for transforming XML documents**
  - **XSLT: specifies how to transform documents**
  - **XPath: specifies how to select parts of a document and compute values**
  - **XSL-FO: specifies a target XML language describing the printed page**
- **XSLT describes how to transform XML documents into other XML documents such as XHTML**
  - **XSLT can be used to transform to non-XML documents as well**

7.9 Overview of XSLT

- **A functional style programming language**
- **Basic syntax is XML**
  - **There is some similarity to LISP and Scheme**
- **An XSLT processor takes an XML document as input and produces output based on the specifications of an XSLT document**

7.9 XSLT Processing



7.9 XSLT Structure

- **An XSLT document contains templates**
- **XPath is used to specify patterns of elements to which the templates should apply**
- **The content of a template specifies how the matched element should be processed**
- **The XSLT processor will look for parts of the input document that match a template and apply the content of the template when a match is found**
- **Two models**
  - **Template-driven works with highly regular data**
  - **Data-driven works with more loosely structured data with a recursive structure (like XHTML documents)**

7.9 XSL Transformations for Presentation

- **One of the most common applications of XSLT is to transform an XML document into an XHTML document for display**
- **A XSLT style sheet can be associated with an XML document by using a processor instruction**
- **<?xml-stylesheet type="text/xsl" href="*stylesheet-ref*"?>**
- **The example xslplane.xml is an xml file with data about a single plane**
  - **The file is linkded to the stylesheet xslplane.xsl**

7.9 XSLT Organization

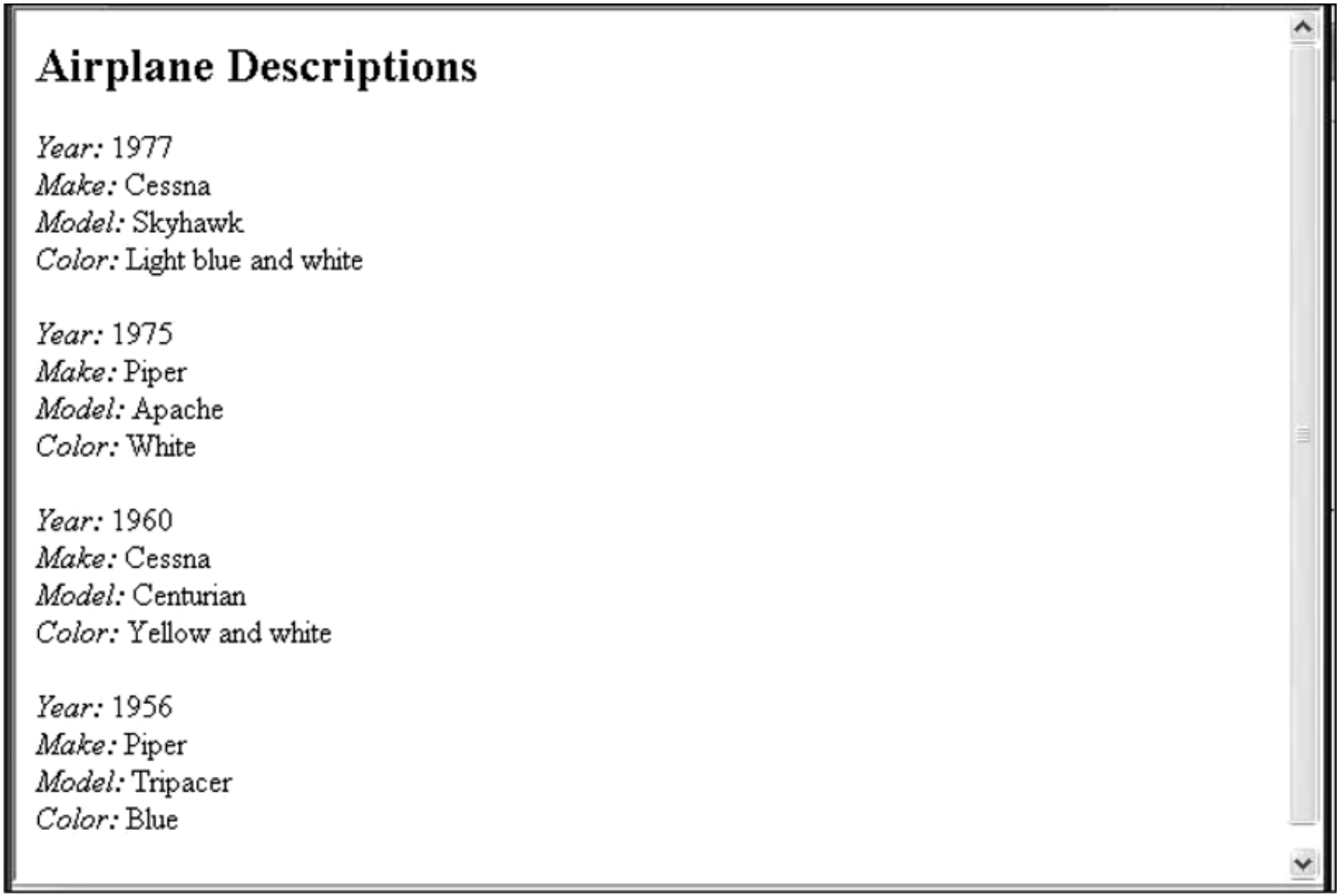
- **Root element stylesheet**
  - **Specifies namespaces for XSL and for non-XSLT elements included in the stylesheet**

```
<xsl:stylesheet xmlns:xsl =
    "http://www.w3.org/1999/XSL/Format"
    xmlns = "http://www.w3.org/1999/xhtml">
```

- **Elements in XSLT itself will have the prefix `xsl:`**
- **Elements from XHTML will have no prefix (default namespace)**

Figure 7.8 An output document from the XSLT processor

Figure 7.7 Using the `for each` element for lists of elements



8.9 XSLT Templates

- There must be at least one template element in an style sheet
- The value of the `match` attribute is an XPath expression which specifies to which nodes the template applies
- Two standard choices for the `match` expression of the first template
  - '/' to match the root node of the entire document structure
  - '*root-tag*' to match the root element of the document
- The first template is applied automatically
- All other templates are applied only in response to `apply-template` elements

7.9 XPath Basics and Node Selection

- **An XPath expression beginning with a / specifies nodes in an absolute position relative to the document root node**
- **Otherwise, the expression specifies nodes relative to the *current node*, that is the node being processed before the matched node**
- **The expression '.' refers to the current node**
- **The apply-templates tag uses the select attribute to choose which nodes should be matched to templates**
- **There is a default template applied if one is not provided that matches a selected node**

7.9 Producing Transformation Output

- **Elements not belonging to XSLT and other text will be copied to the output when the containing template is applied**
- **The value-of tag causes the select attribute value to be evaluated and the result is put into the output**
  - **The value of an element is the text contained in it and in sub-elements**
  - **The value of an attribute is the value**
- **Example xslplane1.xsl transforms the xslplane.xml file into XHTML for display purposes**
  - **If the style sheet is in the same directory as the XML file, some browsers will pick up the transformation and apply it**
  - **This works with Firefox and Internet Explorer but not Opera**

7.9 Processing Repeated Elements

- File xslplanes.xml contains data about multiple airplanes
- The style sheet xslplanes.xsl uses a for-each element to process each plane element in the source document
- A sort element could be included to sort output
  - The element

    ```
    <xsl:sort select="year" data-type="number"/>
    ```

  - Specifies sorting by year

7.10 XML Processors

- **XML processors provide tools in programming languages to read in XML documents, manipulate them and to write them out**

7.10 Purposes of XML Processors

- **Four purposes**
  - **Check the basic syntax of the input document**
  - **Replace entities**
  - **Insert default values specified by schemas or DTD's**
  - **If the parser is able and it is requested, validate the input document against the specified schemas or DTD's**
- **The basic structure of XML is simple and repetitive, so providing library support is reasonable**
- **Examples**
  - **Xerces-J from the Apache foundation provides library support for Java**
  - **Command line utilities are provided for checking well-formedness and validity**
- **Two different standards/models for processing**
  - **SAX**
  - **DOM**

7.10 Parsing

- **The process of reading in a document and analyzing its structure is called *parsing***
- **The parser provides as output a structured view of the input document**

7.10 The SAX Approach

- **In the SAX approach, an XML document is read in serially**
- **As certain conditions, called events, are recognized, event handlers are called**
- **The program using this approach only sees part of the document at a time**

7.10 The DOM Approach

- **In the DOM approach, the parser produces an in-memory representation of the input document**
  - **Because of the well-formedness rules of XML, the structure is a tree**
- **Advantages over SAX**
  - **Parts of the document can be accessed more than once**
  - **The document can be restructured**
  - **Access can be made to any part of the document at any time**
  - **Processing is delayed until the entire document is checked for proper structure and, perhaps, validity**
- **One major disadvantage is that a very large document may not fit in memory entirely**

7.11 Web Services

- **Allow interoperation of software components on different systems written in different languages**
- **Servers that provide software services rather than documents**
- **Remote Procedure Call**
  - **DCOM and CORBA provide impllementations**
  - **DCOM is Microsoft specific**
  - **CORBA is cross-platrom**

7.11 Web Service Protocols

- **Three roles in web services**
  - **Service providers**
  - **Service requestors**
  - **Service registry**
- **The Web Services Definition Language provides a standard way to describe services**
- **The Universal Description, Discovery and Integration service provides a standard way to provide information about services in response to a query**
- **SOAP is used to specify requests and responses**