ΕΛΛΗΝΙΚΗ ΔΗΜΟΚΡΑΤΙΑ
ΠΑΝΕΠΙΣΤΗΜΙΟ ΚΡΗΤΗΣ

Εισαγωγή στην Επιστήμη και Τεχνολογία των Υπηρεσιών

Ενότητα 5: Schema - 1

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Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

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ΕΥΡΩΠΑΪΚΟ ΚΟΙΝΩΝΙΚΟ ΤΑΜΕΙΟ

Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

XML Schema
605.444 / 635.444

David Silberberg

Lecture 5

Problems with Document Type Definitions (DTDs)

- XML came out of the SGML world
  - So, too, DTDs came out of the SGML world
  - DTDs are very useful for document definitions
  - However, XML has become more than a document language
    - General data exchange mechanism
      - Across applications
      - Across platforms
      - Wireless
      - Multimedia
      - Binary files
    - SGML and specifically DTDs were not created to handle all these data types
  - DTDs are still somewhat useful for general XML definitions

Limitations of DTDs

- Only one DTD can be associated with an XML document
  - SGML intended for there to be one central document definition
  - In the world of XML, documents can employ elements from multiple domains
    - Parts - Suppliers - Customers
    - Students - Faculty - Administration
  - In this environment, a centralized definition of elements and attributes is not practical, desirable, or reasonable
    - Cannot easily incorporate legacy systems
    - Cannot implement B2B or Enterprise systems
    - Need inter-corporation and inter-agency cooperation to achieve (not likely)
  - A mechanism is needed to enable the definition of an XML document from different sources

Limitations of DTDs (2)

- DTDs are not extensible
  - Unlike eXtensible Markup Language documents, which DTDs describe
    - XML syntax is not required to define XML documents
    - However, there is an elegant symmetry if the definition language of XML is defined using the XML syntax
  - Would like some way to add to the definition of a document
    - Parent banking institution uses a standards XML definition
    - Fred's bank, which has giveaways (like toasters), needs to augment the XML syntax a little
      - DTDs allow this to be done within a specific document
      - However, if multiple banks decide to give away toasters, these banks also need to augment their DTDs
      - It is poor practice to define the data in the data document itself

Limitations of DTDs (3)

- DTDs do not support Namespaces in a reasonable manner
  - In fact, Namespaces do not make sense in the context of DTDs
    - Namespaces resolve conflicts between named elements (and maybe attributes)
    - DTDs specify definitions in a single document
    - Thus, unique names can be defined to circumvent conflicts
  - Namespaces assume that there are multiple definitions
    - Each definition is associated with a unique namespace
    - There is not a pressing need to define multiple namespaces within a single document
  - If namespaces are defined with respect to DTDs, they must be specified in a single document
    - Defeats the purpose of namespaces
    - DTDs become unwieldy

Limitations of DTDs (4)

- DTDs hardly define datatypes
  - SGML was meant to work with document text
    - XML, however, has rapidly evolved to work with many datatypes
    - Thus, DTDs, which were meant for text documents, are limiting to general XML documents
  - Types of data used now
    - Integer
    - Float
    - Decimal
    - Date/time
    - Duration
    - Byte, hexadecimal, etc.
    - Binary
    - String templates
    - Etc., etc., etc.

Limitations of DTDs (5)

- No inheritance
  - Cannot derive data types from other data types
  - Cannot construct complex types from
    - Simple types
    - Other complex types
  - (Schema enables data type inheritance, not conceptual inheritance.)
- Internal DTDs are a bad idea
  - Internal DTDs can augment external DTDs (OK)
  - Internal DTDs can also override external DTDs (bad)
    - Standard exchange structures (and protocols) may be ignored
    - Defeats the whole purpose of standardization

Limitations of DTDs (6)

- DTDs do not represent all the elements of XML documents
  - Processing Instructions (PIs) are not represented
  - DTDs represent only the information in the data portion of a document
  - However, one would like to specify that PIs are necessary, if they are indeed necessary
    - Perhaps, one needs to specify that a specific type of stylesheet is necessary
    - Perhaps, certain classes of parsers are necessary
    - PIs are necessary to identify such specifications
    - Thus, PIs may need to be defined

Schema Addresses the Limitations of DTDs

- Like all other World Wide Web Consortium (W3C) specifications, the Schema specification and other supporting documents can be found at:
  - http://www.w3c.org/
  - Can easily find Schema documents from the home page
- Syntax is XML
  - Makes Schema specifications easy to parse
  - DOM tools support reading Schema documents
  - Can use other tools like XPath and Namespaces, etc.
  - Easy to interpret and understand

Schema Benefits (1)

- Multiple Schema definitions can be associated with an XML document
  - Documents can employ elements from multiple domains
    - Parts - Suppliers - Customers
    - Students - Faculty - Administration
  - Supports distributed environments
    - Can incorporate legacy systems
    - Can be used to implement B2B or Enterprise systems
    - Does not need inter-corporation and inter-agency cooperation
    - Can use multiple standards

Schema Benefits (2)

- Schema definitions are extensible
  - Enables more detailed definitions of Schemas
    - Enables more robust definitions within a sub-schema
    - Often, general standards are developed by a company or agency
    - Schema enables corporate subdivisions to define comprehensive standards for sub-areas
      - Spacecraft design
      - Mechanical design
  - Enables the extension of certain types
    - Integer -> Positive Integer
    - Date -> Valid Date
  - Enables complex type definitions
    - From primitive types
    - From other complex types

Schema Benefits (3)

- Support for namespaces
  - Can incorporate definitions from different domains
  - Can resolve identical element names from different definitions
- Support for datatypes
  - Support for general datatypes such as integer, decimal, date, time, binary, hex, string, etc.
  - Support for XML-specific datatypes such as URIs, URLs, IDREFs, NMTOKENs, etc.
- Eliminates internal definitions
  - Separates data and definition
  - Allows others to access special (or overriding) definitions

Example

```
<?xml version="1.0"?>
<store xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:noNamespaceSchemaLocation="store.xsd">
      <cust_list>
          <customer cid="C-1" >
              <name title="Mr.">
                  <first>Sam</first>
                  <middle>Ta</middle>
                  <middle>Chuan</middle>
                  <last>Chu</last>
              </name>
              <address>
                  <street>123-A Kensington Circle</street>
                  <city>London</city><country>England</country>
              </address>
              <purchase date="2002-01-12" items="I-34 I-62 I-15" qty="3 1 1" />
              <purchase date="2002-01-13" items="I-15" qty="2" />
          </customer>
```

Example (2)

```
        <customer cid="C-2" ctype="bad">
            <name title="Dr.">
                <first>Darsana</first>
                <last>Sudarsen</last>
            </name>
            <address>
                <street>11100 Johns Hopkins</street>
                <city>Baltimore</city><state>MD</state>
                <zip>21207</zip>
            </address>
            <purchase date="2002-02-02" items="I-62 I-5" qty="2 1" />
        </customer>
    </cust_list>
    <inventory_list>
        <item item_no="I-5" supplier_id="S-1">
            <description>Ivory Soap</description>
            <in_stock>50</in_stock>
            <price>1.09</price>
            <cost>.28</cost>
        </item>
```

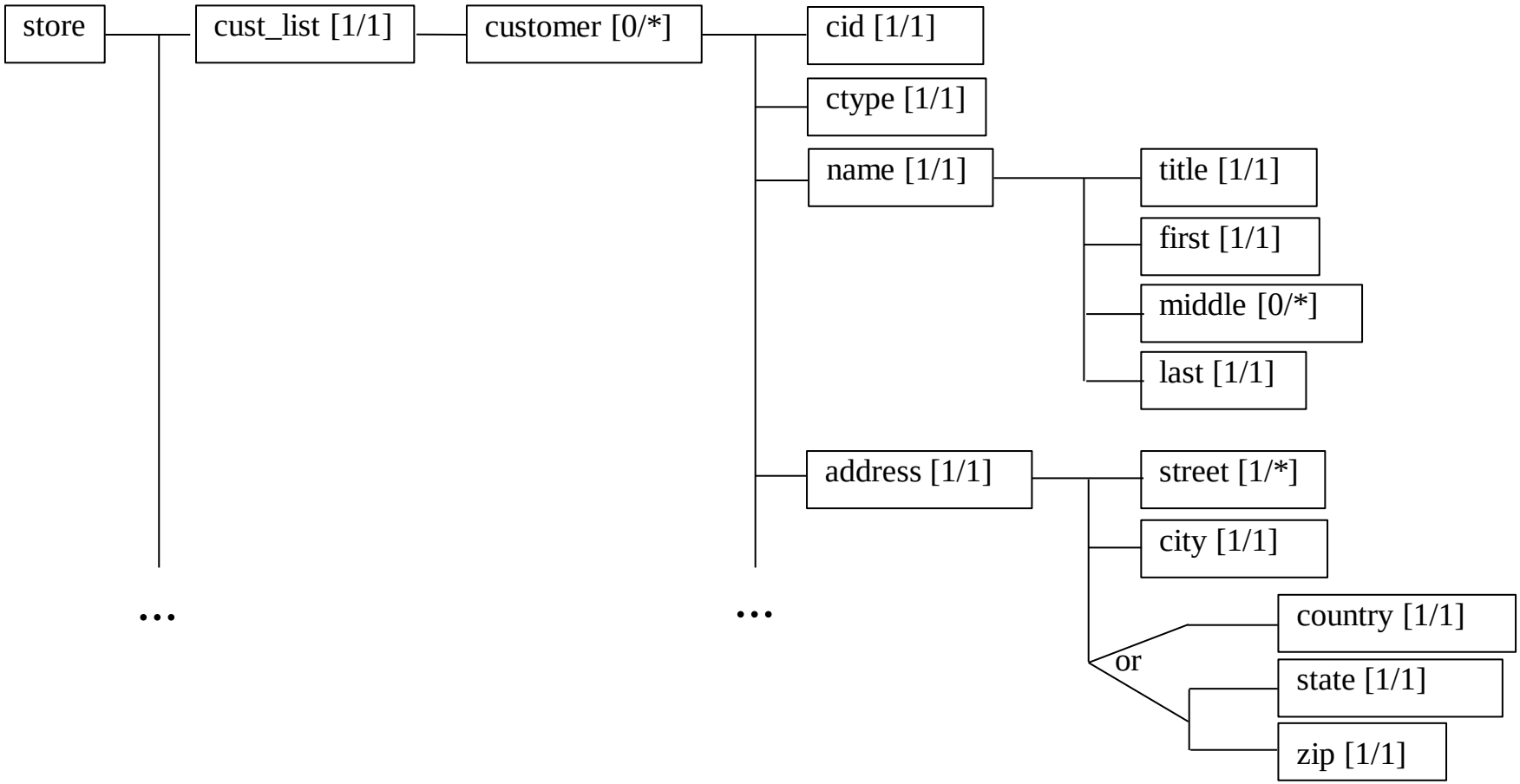
Example (3)

```
<item item_no="I-15" supplier_id="S-1">
        <description>Cheer Detergent</description>
        <in_stock>37</in_stock>
        <price>5.98</price>
        <cost>2.10</cost>
</item>
<item item_no="I-34" supplier_id="S-1">
        <description>Bounty Paper Towels</description>
        <in_stock>112</in_stock>
        <price>1.48</price>
        <cost>.57</cost>
</item>
<item item_no="I-62" supplier_id="S-2">
        <description>Sunshine Tissues</description>
        <in_stock>320</in_stock>
        <price>1.65</price>
        <cost>.98</cost>
</item>
</inventory_list>
```

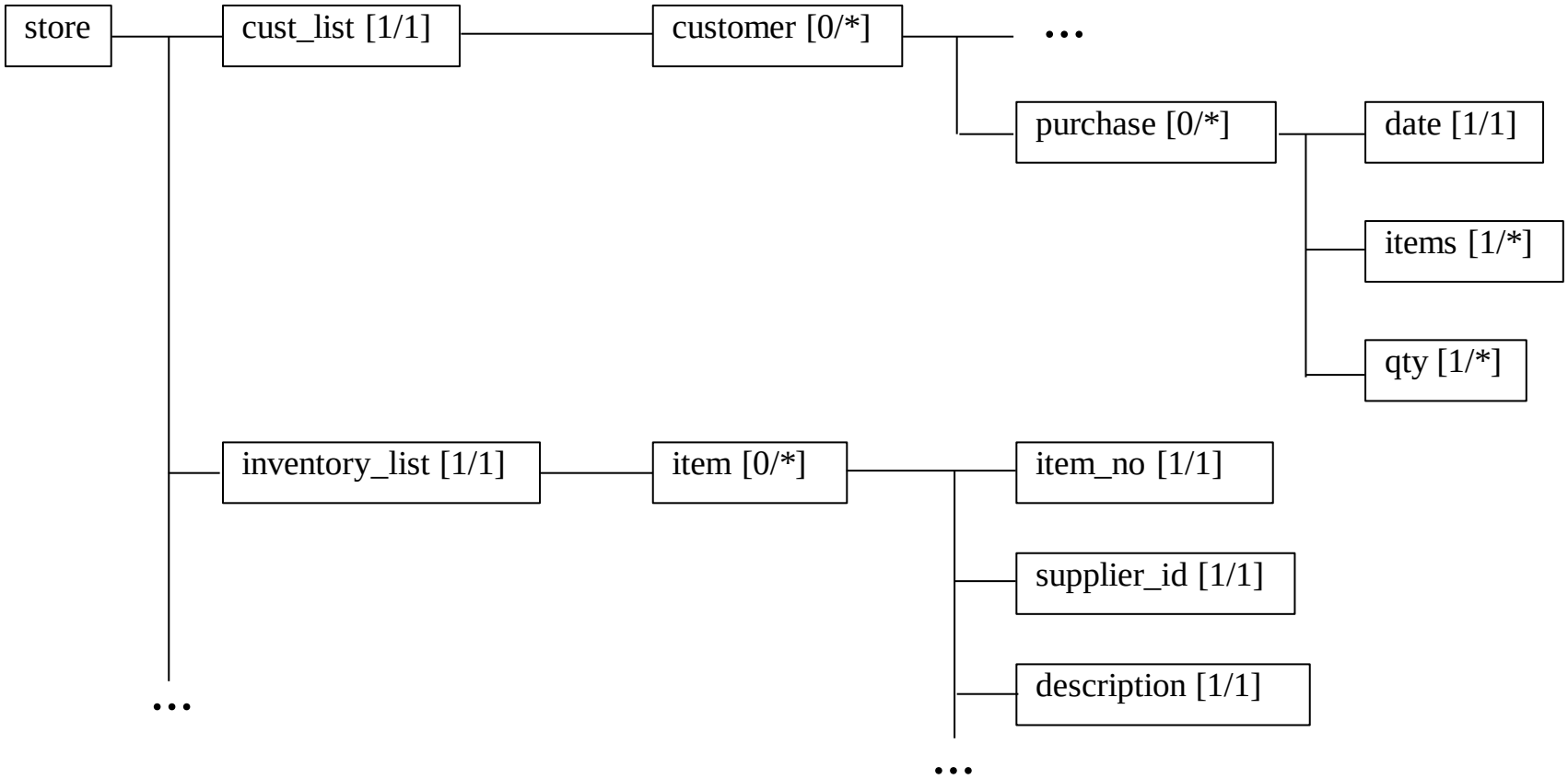
Example (4)

```
    <supplier_list>
        <supplier sid =“S-1”>
            <company>Proctor and Gamble</company>
            <telephone>1-800-PAMPERS</telephone>
        </supplier>
        <supplier sid =“S-2”>
            <company>Sunshine Products</company>
            <telephone>1-888-344-9881</telephone>
        </supplier>
    </supplier_list>
</store>
```

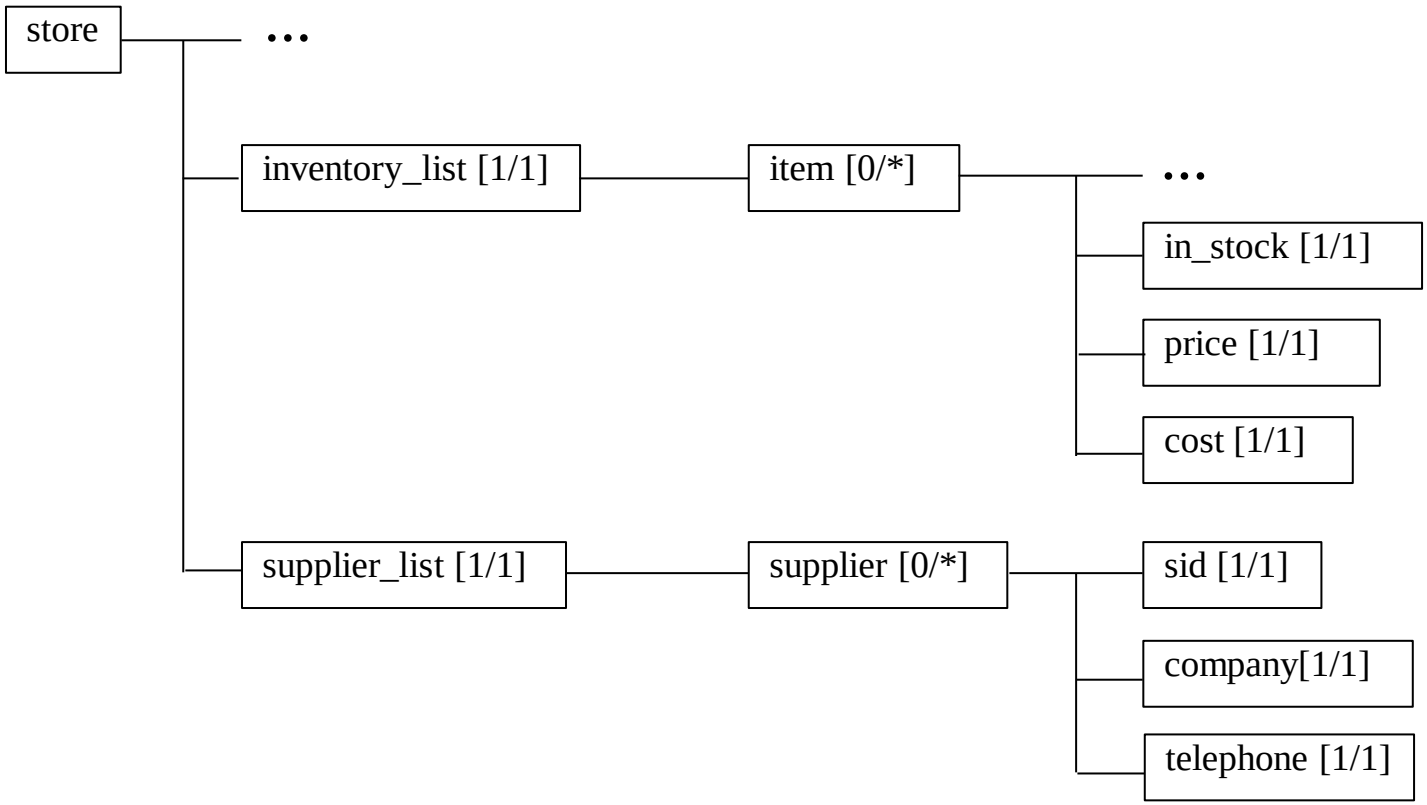
Data Model


store
cust_list [1/1]
customer [0/*]
cid [1/1]
ctype [1/1]
name [1/1]
title [1/1]
first [1/1]
middle [0/*]
last [1/1]
address [1/1]
street [1/*]
city [1/1]
country [1/1]
or
state [1/1]
zip [1/1]
...
...

Data Model (2)


store
cust_list [1/1]
customer [0/*]
...
purchase [0/*]
date [1/1]
items [1/*]
qty [1/*]
inventory_list [1/1]
item [0/*]
item_no [1/1]
supplier_id [1/1]
description [1/1]
...
...

Data Model (3)


store
...
inventory_list [1/1]
item [0/*]
...
in_stock [1/1]
price [1/1]
cost [1/1]
supplier_list [1/1]
supplier [0/*]
sid [1/1]
company[1/1]
telephone [1/1]

XML Schema Definition

- In Schema, everything is built from the bottom up
- High-level Schema declarations do not make sense without knowledge of the datatype declarations
- Thus, we start with datatypes
- Datatypes
  - Two flavors: simple and complex
  - Simple: Built-in types
  - Complex
    - Derived from simple and other complex types
    - Can define data structures

Simple Types

- string
- token
- byte
- integer
- positive Integer
- negative Integer
- unsignedInt
- long
- short
- decimal (1.33, 4.0, 4)
- float (12.3E-3, INF, NaN)
- double
- boolean (true, false, 1, 0)
- time (13:20:00.000)
- date (2001-10-24)
- Name
- QName (nmspc:element)
- anyURI
- language (en-US)
- ID
- IDREF
- NMTOKEN

Simple Schema Definition

- Standard XML Schema Definition (xsd) file header:

  <xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">

  …

  </xsd:schema>

  – All schema terms must be prefixed by xsd (standard abbreviation)
    - <xsd:element> … </xsd:element>
    - <xsd:attribute> … </xsd:attribute>

- It is easier if this is the default namespace

  <schema xmlns="http://www.w3.org/2001/XMLSchema">

  …

  </schema>

Simple Type Definitions - Min and Max

- Min and max values:

```
<simpleType name="nonNegativeDecimal" >
    <restriction base="decimal">
        <minInclusive value="0" />
    </restriction>
</simpleType>
```

- Schema definition using simple type

```
<element name="price" type="nonNegativeDecimal" />
```

- XML document instance

```
<price>1.09</price>
```

Enumeration

- Enumeration

```
<simpleType name="USState" >
    <restriction base="string">
        <enumeration value="AK" />
        <enumeration value="AL" />
        <!-- etc. -->
    </restriction>
</simpleType>
```

- Schema definition using simple type

```
<element name="state" type="USState" />
```

- XML document instance

```
<state>MD</state>
```

Enumeration (2)

- Enumeration

```
<simpleType name="Title" >
    <restriction base="string">
        <enumeration value="Mr." />
        <enumeration value="Ms." />
        <enumeration value="Mrs." />
        <enumeration value="Miss" />
        <enumeration value="Dr." />
    </restriction>
</simpleType>
```

- Schema definition using simple type

```
<attribute name="title" type="Title" />
```

- XML document instance

```
<name title="Mr.">…</name>
```

Patterns

- Patterns:

```
<simpleType name="StdTelNum" >
    <restriction base="string">
        <pattern value="\d{1}\-\d{3}\-\d{3}\-\d{4}" />
    </restriction>
</simpleType>

<simpleType name="StringTelNum" >
    <restriction base="string">
        <pattern value="\d{1}\-\d{3}\-[A-Z0-9]{7}" />
    </restriction>
</simpleType>
```

Patterns (2)

- Schema definition using simple type

  <element name="telephone" type="StdTelNum" />
- XML document instance

  <telephone>1-888-344-9881</telephone>

- Schema definition using simple type

  <element name="telephone" type="StringTelNum" />
- XML document instance

  <telephone>1-800-PAMPERS</telephone>

More Patterns

- Chapter \d - Chapter 0, Chapter 1, …
- Chapter\s\d - Chapter followed by whitespace character (space, tab, newline, etc.) followed by a single digit
- Appendix\s\w - Appendix followed by whitespace character followed by a word character (letter or digit)
- a*x - x, ax, aax, aaax, …
- a?x - x, ax
- a+x - ax, aax, aaax, …
- (a|b)+x - ax, bx, aax, abx, bax, bbx, aaax, aabx, abax, abbx, etc.
- [aeiou]x - ax, ex, ix, ox, ux

More Patterns

- [d-f]x - dx, ex, fx
- [\-df]x - -x, dx, fx
- [^0-9]x - non-digit character followed by x
- \Dx - non-digit character followed by x
- .x - any character followed by x
- .*a.* - 0 or more characters followed by a followed by 0 or more characters
- ab{2}x - abbx
- ab(2,4)x - abbx, abbbx, abbbbx
- ab(2,)x - abbx, abbbx, abbbbx, abbbbbx, …
- (ab){2}x - ababx

Unions

- Union of types

```
<simpleType name="AllTelNum" >
    <union memberTypes="StdTelNum StringTelNum">
</simpleType>
```

- Schema definition using simple type

```
<element name="telephone" type="AllTelNum" />
```

- XML document instances

```
<telephone>1-888-344-9881</telephone>
<telephone>1-800-PAMPERS</telephone>
```

List Types

- Simple type - zipCode

```
<simpleType name="ZipCode" >
    <restriction base="string">
        <pattern value="[0-9]{5}" />
    </restriction>
</simpleType>
```

- Alternatively

```
<simpleType name="ZipCode" >
    <restriction base="integer">
        <minExclusive value="00000" />
        <maxInclusive value="99999" />
    </restriction>
</simpleType>
```

  - Actually, this will not work because it will accept '35' as a zip code

Simple Type Usage

- Schema definition using simple type

```
<element name="zip" type="ZipCode" />
```

- XML document instances

```
<zip>21207</zip>
<zip>20723</zip>
```

- Zip+4 definition

```
<simpleType name="ZipPlus4" >
    <restriction base="string">
        <pattern value="[0-9]{5}(\-[0-9]{4})?" />
    </restriction>
</simpleType>
```

List Type Creation

- List of Zip Codes

```
<simpleType name="ZipCodeList" >
    <list itemType="ZipCode" />
</simpleType>
```

- Schema definition of an element

```
<element name="zipList" type="ZipCodeList" />
```

- Usage in XML document

```
<zipList>20134  95123  78665</zipList>
```

More List Types

- List of three Zip Codes

```
<simpleType name="ThreeZipCodes">
    <restriction base="ZipCodeList" />
        <length value="3" />
    </restriction>
</simpleType>
```

- Schema definition of an element

```
<element name="limitedZipList" type="ThreeZipCodes" />
```

- Usage in XML document

```
<limitedZipList>20134  95123  78665</ limitedZipList >
```

Simple Elements and Attributes

- Elements and attributes with simple types:
  - <element name="first" type="string" />
  - <element name="in_stock" type="nonNegativeInteger" />
  - <attribute name="date" type="date" />
  - <attribute name="item_no" type="ID" />
  - <attribute name="items" type="IDREFS" />

Complex Types

- Define a complex Name type:

```
<complexType name="NameType">
    <sequence>
        <element name="first" type="string" />
        <element name="middle" type="string" />
        <element name="last" type="string" />
    </sequence>
    <attribute name="title" type="string" />
</complexType>
```

- Improvements to be made
  - Better data types
  - Cardinalities
  - IDs

Defining General Types

- Define a proper name and a mixed name

```
<simpleType name="ProperName">
    <restriction base="string">
        <pattern value="[A-Z][a-zA-Z]*" />
    </restriction>
</simpleType>
<simpleType name="MixedName">
    <restriction base="string">
        <pattern value ="[a-zA-Z0-9\-\s]*" />
    </restriction>
</simpleType>
```

- Define a title, as before

```
<simpleType name="Title" >
    <restriction base="string">
        <enumeration value="Mr." />
        <!-- etc. -->
    </restriction>
</simpleType>
```

A Better Name Definition

- Define a complex Name type:

```
<complexType name="NameType">
    <sequence>
        <element name="first" type="ProperName" />
        <element name="middle" type="ProperName" />
        <element name="last" type="ProperName" />
    </sequence>
    <attribute name="title" type="Title" />
</complexType>
```

- Still must represent cardinalities

Cardinality of Elements

- minOccurs
  - Can be any non-negative integer
  - If the value is 0, then the element is optional
  - If the value is 1 or more, then the element is required If
  - the value is 3, there must be at least three elements The
  - default value (when minOccurs is not declared) is 1
- maxOccurs
  - Can be any non-negative integer
  - The value must be greater than or equal to the minOccurs value
  - If the value is 5, there can be at most five elements
  - ‘unbounded’ is used to describe an unbounded number of occurrences

Attribute Cardinalities

- Attributes can only appear one time per element (at most)
- Attribute specification
  - ‘use’ attribute
  - Values
    - required - attribute must appear in element
    - optional - attribute may appear in element
    - prohibited - attribute may never appear in element

Default Attributes

- Used to set default value of attributes
- Only makes sense if attribute is optional
  - Proper use of default in Schema definition
    - <attribute name="…" use="optional" default="…">
  - Incorrect use of default in Schema definition
    - <attribute name="…" use="required" default="…">
    - <attribute name="…" use="prohibited" default="…">
- If the attribute's value appears in the XML document, the value specified in the document is used
- If the attribute's value does not appear in the XML document, the schema processor provides the default value

Default Elements

- Proper use of default in Schema Definition
  - <element name="city" default="Baltimore">
  - minOccurs and maxOccurs can be any value
- If element with value is present, the value is used
  - <city>Laurel</city>
- If element is present without the value, the default value is used
  - <city />
  - The value of city is Baltimore
- If element is not present, no value is assigned to the element

Fixed Values

- Applies to both attributes and elements
- It specifies value to be used
- If attribute or element is in document, the fixed value is used
- If attribute or element is not in document, the schema processor will supply the fixed value
  - <attribute name="country" use="optional" value="US" />
- Fixed and default attributes are mutually exclusive

A Better Name Definition

- Define a complex Name type:

```
<complexType name="NameType">
    <sequence>
        <element name="first" type="ProperName" />
        <element name="middle" type="ProperName"
            minOccurs="0" maxOccurs="unbounded"/>
        <element name="last" type="ProperName" />
    </sequence>
    <attribute name="title" type="Title"
        use="optional" default="Ms." />
</complexType>
```

Τέλος Ενότητας