# Computer Science E-259

## XML with Java, Java Servlet, and JSP

### Lecture 10: XML Schema, Continued

3 December 2007

David J. Malan

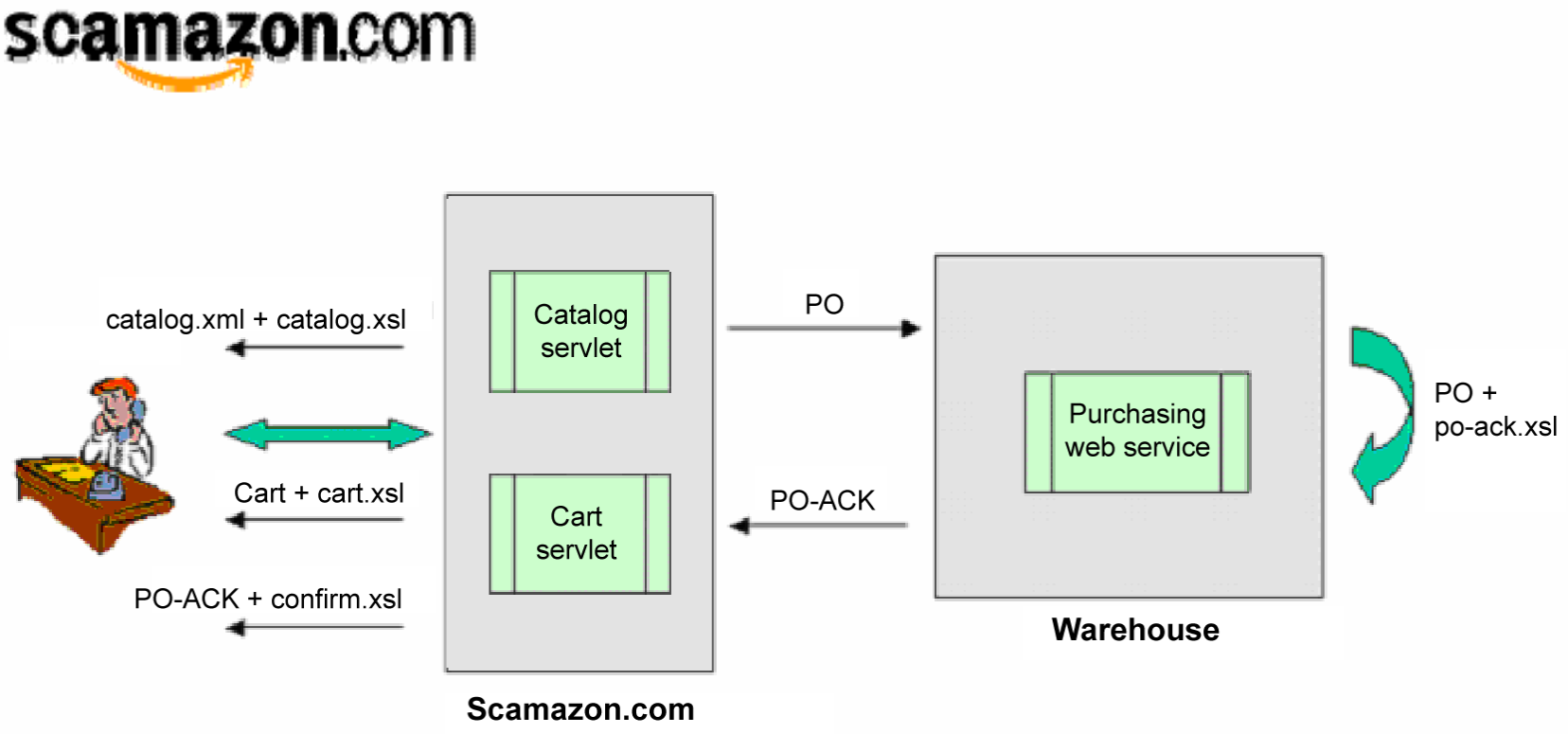
malan@post.harvard.edu

# Last Time

## XML Schema (Second Edition)

- XML Schema (Second Edition)
- Project 4

# Last Time



# Last Time

## XML Schema (Second Edition)

- Declarations v. Definitions
- Global v. Local Components
- Element and Attribute Declarations
- Simple v. Complex Types
- Named v. Anonymous Types
- Type Definition Hierarchy
- Simple Types
- Complex Types
- Namespaces
  - Multiple
  - Default
  - Target
- Relating Instances to Schemas

# Computer Science E-259

## This Time

- XML Schema 1.0, Continued

# Datatypes

## Built-In

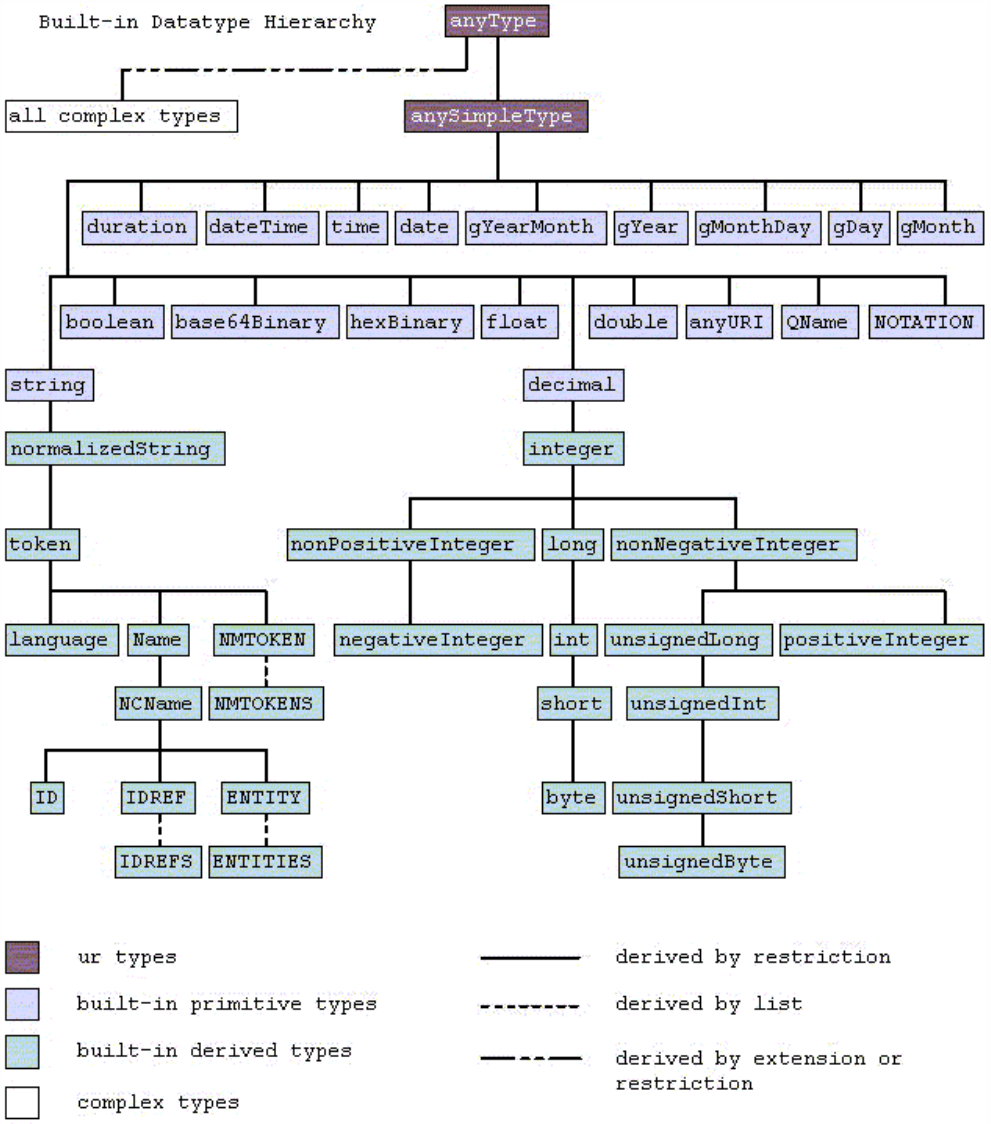



Image from http://www.w3.org/TR/xmlschema-2/.

# Structures

## Elements

```
<element
  abstract = boolean : false
  block = (#all | List of (extension | restriction | substitution))
  default = string
  final = (#all | List of (extension | restriction))
  fixed = string
  form = (qualified | unqualified)
  id = ID
  maxOccurs = (nonNegativeInteger | unbounded)  : 1
  minOccurs = nonNegativeInteger : 1
  name = NCName
  nillable = boolean : false
  ref = QName
  substitutionGroup = QName
  type = QName
  {any attributes with non-schema namespace . . .}>
  Content: (annotation?, ((simpleType | complexType)?, (unique | key |
   keyref)*))
</element>
```

Excerpted from http://www.w3.org/TR/xmlschema-1/.

# Structures

## Attributes

```
<attribute
  default = string
  fixed = string
  form = (qualified | unqualified)
  id = ID
  name = NCName
  ref = QName
  type = QName
  use = (optional | prohibited | required) : optional
  {any attributes with non-schema namespace . . .}>
  Content: (annotation?, (simpleType?))
</attribute>
```

Excerpted from http://www.w3.org/TR/xmlschema-1/.

# Simple Types

## Elements of Unrestricted, Simple Types

- Canonical Declaration

```
<xsd:element name="..." type="..."/>
```

- Examples of Instances

```
<name>John Harvard</name>
<year>1636</year>
```

- Examples of Declarations

```
<xsd:element name="lastname" type="xsd:string"/>
<xsd:element name="age" type="xsd:integer"/>
```

# Simple Types

## Attributes of Unrestricted, Simple Types

- Canonical Declaration

```
<xsd:attribute name="..." type="..."/>
```

- Example of an Instance

```
<student gender="male">John Harvard</student>
```

- Example of a Declaration

```
<xsd:attribute name="gender" type="xsd:string"/>
```

# Simple Types

## Attributes with Default or Fixed Values

- In the absence of a value, a default can be assigned

```
<xsd:attribute name="country" type="xsd:string" default="US"/>
```

- A value, if present and declared fixed, must appear as declared; in the absence of a value, the declared will be assigned

```
<xsd:attribute name="country" type="xsd:string" fixed="US"/>
```

# Simple Types

## Optional and Required Attributes

- By default, attributes are optional

```
<xsd:attribute name="country" type="xsd:string" use="optional"/>
```

- If declared required, attribute must be present

```
<xsd:attribute name="country" type="xsd:string" use="required"/>
```

# Simple Types

## Restrictions through Facets

| Facet | Description |
|---|---|
| enumeration | Defines a list of acceptable values |
| fractionDigits | Specifies the maximum number of decimal places allowed. Must be equal to or greater than zero |
| length | Specifies the exact number of characters or list items allowed. Must be equal to or greater than zero |
| maxExclusive | Specifies the upper bounds for numeric values (the value must be less than this value) |
| maxInclusive | Specifies the upper bounds for numeric values (the value must be less than or equal to this value) |
| maxLength | Specifies the maximum number of characters or list items allowed. Must be equal to or greater than zero |
| minExclusive | Specifies the lower bounds for numeric values (the value must be greater than this value) |
| minInclusive | Specifies the lower bounds for numeric values (the value must be greater than or equal to this value) |
| minLength | Specifies the minimum number of characters or list items allowed. Must be equal to or greater than zero |
| pattern | Defines the exact sequence of characters that are acceptable |
| totalDigits | Specifies the exact number of digits allowed. Must be greater than zero |
| whiteSpace | Specifies how white space (line feeds, tabs, spaces, and carriage returns) are handled |



Adapted from http://www.w3schools.com/schema/schema_facets.asp.

# Simple Types

## Restricting by Value

```
<xsd:element name="year">
  <xsd:simpleType>
    <xsd:restriction base="xsd:integer">
      <xsd:minInclusive value="2007"/>
      <xsd:maxInclusive value="2010"/>
    </xsd:restriction>
  </xsd:simpleType>
</xsd:element>

<xsd:element name="year">
  <xsd:simpleType>
    <xsd:restriction base="xsd:integer">
      <xsd:minExclusive value="2006"/>
      <xsd:maxExclusive value="2011"/>
    </xsd:restriction>
  </xsd:simpleType>
</xsd:element>
```

# Simple Types

## Restricting by Value

```
<xsd:element name="major">
  <xsd:simpleType>
    <xsd:restriction base="xsd:string">
      <xsd:enumeration value="English"/>
      <xsd:enumeration value="Math"/>
      <xsd:enumeration value="Physics"/>
    </xsd:restriction>
  </xsd:simpleType>
</xsd:element>
```

# Simple Types

## Restricting by Value

```
<xsd:element name="major" type="majors"/>

<xsd:simpleType name="majors">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="English"/>
    <xsd:enumeration value="Math"/>
    <xsd:enumeration value="Physics"/>
  </xsd:restriction>
</xsd:simpleType>
```

# Simple Types

## Restricting by Pattern

```
<xsd:element name="choice">
  <xsd:simpleType>
    <xsd:restriction base="xsd:string">
      <xsd:pattern value="[abcd]"/>
    </xsd:restriction>
  </xsd:simpleType>
</xsd:element>

<xsd:element name="initials">
  <xsd:simpleType>
    <xsd:restriction base="xsd:string">
      <xsd:pattern value="[A-Z][A-Z][A-Z]?"/>
    </xsd:restriction>
  </xsd:simpleType>
</xsd:element>
```

Adapted from http://www.w3schools.com/schema/schema_facets.asp.

# Simple Types

## Restricting by Pattern

```
<xsd:element name="gender">
  <xsd:simpleType>
    <xsd:restriction base="xsd:string">
      <xsd:pattern value="male|female"/>
    </xsd:restriction>
  </xsd:simpleType>
</xsd:element>

<xsd:element name="password">
  <xsd:simpleType>
    <xsd:restriction base="xsd:string">
      <xsd:pattern value="[a-zA-Z0-9]{8}"/>
    </xsd:restriction>
  </xsd:simpleType>
</xsd:element>
```

Adapted from http://www.w3schools.com/schema/schema_facets.asp.

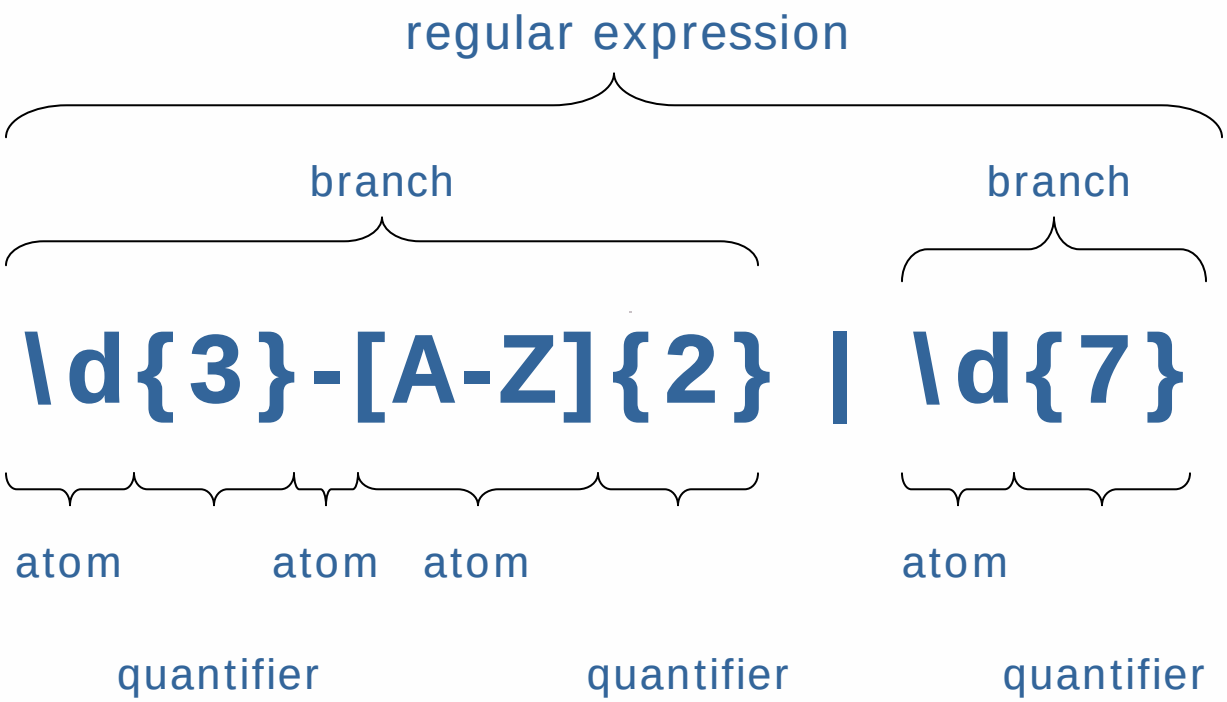
# Simple Types

## Restricting by Pattern

```
<xsd:simpleType name="ProdNumType">
  <xsd:restriction base="xsd:string">
    <xsd:pattern value="\d{3}-[A-Z]{2} | \d{7}"/>
  </xsd:restriction>
</xsd:simpleType>
```

# Simple Types

## Regular Expressions



# Simple Types

## Regular Expressions

- An atom describes one or more character through
  - a single normal character (*e.g.*, `a` or `c`)
  - a parenthesized regular expression (*e.g.*, `(a|c)`)
  - an escape, such as

    `\n` for newline, `\?` for `?`, `.` for any character but `\n` and `\r`

    `\d` for any digit, `\D` for any character but a digit

    `\s` for any whitespace character
  - a character class expression

    `[abc]` matches any of a list of characters

    `[0-9]` or `[a-z]` matched any character from a range
- A quantifier indicates how many times an atom should repeat (*e.g.*, `?`, `*`, `+`, `{n}`, `{n,}`, `{n,m}`)

# Simple Types

## Restricting Whitespace

```
<xsd:element name="name">
  <xsd:simpleType>
    <xsd:restriction base="xsd:string">
      <xsd:whiteSpace value="preserve"/>
    </xsd:restriction>
  </xsd:simpleType>
</xsd:element>

<xsd:element name="name">
  <xsd:simpleType>
    <xsd:restriction base="xsd:string">
      <xsd:whiteSpace value="replace"/>
    </xsd:restriction>
  </xsd:simpleType>
</xsd:element>

<xsd:element name="name">
  <xsd:simpleType>
    <xsd:restriction base="xsd:string">
      <xsd:whiteSpace value="collapse"/>
    </xsd:restriction>
  </xsd:simpleType>
</xsd:element>
```

Adapted from http://www.w3schools.com/schema/schema_facets.asp.

# Simple Types

## Restricting by Length

```
<xsd:element name="password">
  <xsd:simpleType>
    <xsd:restriction base="xsd:string">
      <xsd:length value="8"/>
    </xsd:restriction>
  </xsd:simpleType>
</xsd:element>

<xsd:element name="password">
  <xsd:simpleType>
    <xsd:restriction base="xsd:string">
      <xsd:minLength value="5"/>
      <xsd:maxLength value="8"/>
    </xsd:restriction>
  </xsd:simpleType>
</xsd:element>
```

Adapted from http://www.w3schools.com/schema/schema_facets.asp.

# Simple Types

## Lists

```
<grades>90 85 77 100 99 45</grades>

<xsd:element name="grades">
  <xsd:simpleType>
    <xsd:list itemType="xsd:nonNegativeInteger"/>
  </xsd:simpleType>
</xsd:element>
```

# Simple Types

## Unions

```
<xsd:element name="jeans_size">
  <xsd:simpleType>
    <xsd:union memberTypes="sizebyno sizebystring"/>
  </xsd:simpleType>
</xsd:element>

<xsd:simpleType name="sizebyno">
  <xsd:restriction base="xsd:positiveInteger">
    <xsd:maxInclusive="42"/>
  </xsd:restriction>
</xsd:simpleType>
<xsd:simpleType name="sizebystring">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="small"/>
    <xsd:enumeration value="medium"/>
    <xsd:enumeration value="large"/>
  </xsd:restriction>
</xsd:simpleType>
```

Adapted from http://www.w3schools.com/schema/el_union.asp.

# Complex Types

## Content Types for Elements

- Simple (*i.e.*, children include text only)

```
<name>Jerry Seinfeld</name>
```

- Element-Only (*i.e.*, children include elements only)

```
<name><first>Jerry</first><last>Seinfeld</last></name>
```

- Mixed (*i.e.*, children contain text and/or elements)

```
<p><name>Jerry Seinfeld</name> is a <title>comedian</title>.</p>
```

- Empty (*i.e.*, no children)

```
<comedian name="Jerry Seinfeld"/>
```

# Complex Types

## Simple Content

```
<xsd:element name="...">
  <xsd:complexType>
    <xsd:simpleContent>
      <xsd:restriction base="...">
        ....
      </xsd:restriction>
    </xsd:simpleContent>
  </xsd:complexType>
</xsd:element>

<xsd:element name="...">
  <xsd:complexType>
    <xsd:simpleContent>
      <xsd:extension base="...">
        ....
      </xsd:extension>
    </xsd:simpleContent>
  </xsd:complexType>
</xsd:element>
```

# Complex Types

## Element-Only Content

```
<student>
  <name>John Harvard</name>
  <year>1636</year>
</student>

<xsd:element name="student">
  <xsd:complexType>
    <xsd:sequence>
      <xsd:element name="name" type="xsd:string"/>
      <xsd:element name="year" type="xsd:integer"/>
    </xsd:sequence>
  </xsd:complexType>
</xsd:element>
```

# Complex Types

## Element-Only Content

```
<name>
  <first>John</first>
  <last>Harvard</last>
</name>

<xsd:element name="name">
  <xsd:complexType>
    <xsd:sequence>
      <xsd:element name="first" type="xsd:string"/>
      <xsd:element name="last" type="xsd:string"/>
    </xsd:sequence>
  </xsd:complexType>
</xsd:element>
```

# Complex Types

## Mixed Content

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

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

Adapted from http://www.w3schools.com/schema/schema_complex_mixed.asp.

# Complex Types

## Empty Content

```
<foo bar="baz" />
```

```
<xsd:element name="foo">
  <xsd:complexType>
    <xsd:attribute name="bar" type="xsd:string"/>
  </xsd:complexType>
</xsd:element>
```

# Complex Types

## Model Groups

- A `sequence` group of element declarations is used to indicate the order in which the elements should appear
- A `choice` group of element declarations is used to indicate that only one of the elements should appear
- An `all` group is used to indicate that all elements should appear, in any order, but no more than once each

# Complex Types

## The `sequence` Model

```
<xsd:element name="name">
  <xsd:complexType>
    <xsd:sequence minOccurs="0">
      <xsd:element name="first" type="xsd:string"/>
      <xsd:element name="last" type="xsd:string"/>
    </xsd:sequence>
  </xsd:complexType>
</xsd:element>
```

# Complex Types

## The `sequence` Model

```
<xsd:element name="name">
  <xsd:complexType>
    <xsd:sequence>
      <xsd:element name="first" type="xsd:string"/>
      <xsd:element name="last" type="xsd:string"/>
      <xsd:element name="nick" type="xsd:string"
      maxOccurs="unbounded" minOccurs="0"/>
    </xsd:sequence>
  </xsd:complexType>
</xsd:element>
```

# Complex Types

## The `choice` Model

```
<xsd:complexType name="ProductType">
  <xsd:choice minOccurs="0" maxOccurs="3">
    <xsd:element name="size" type="SizeType"/>
    <xsd:element name="color" type="ColorType"/>
  </xsd:choice>
  <xsd:attribute name="effDate" type="xsd:date"/>
</xsd:complexType>
```

# Complex Types

## Nesting Models!

```
<xsd:complexType name="ProductType">
  <xsd:sequence>
    <xsd:element name="number" type="xsd:integer"/>
    <xsd:choice minOccurs="0" maxOccurs="3">
      <xsd:element name="size" type="SizeType"/>
      <xsd:element name="color" type="ColorType"/>
    </xsd:choice>
  </xsd:sequence>
  <xsd:attribute name="effDate" type="xsd:date"/>
</xsd:complexType>
```

# Complex Types

## The `all` Model

```
<xsd:element name="name">
  <xsd:complexType>
    <xsd:all>
      <xsd:element name="first" type="xsd:string"/>
      <xsd:element name="last" type="xsd:string"/>
    </xsd:all>
  </xsd:complexType>
</xsd:element>
```

# Complex Types

## Defining Model Groups

```
<xsd:group name="persongroup">
  <xsd:sequence>
    <xsd:element name="firstname" type="xsd:string"/>
    <xsd:element name="lastname" type="xsd:string"/>
    <xsd:element name="birthday" type="xsd:date"/>
  </xsd:sequence>
</xsd:group>

<xsd:element name="person" type="personinfo"/>
<xsd:complexType name="personinfo">
  <xsd:sequence>
    <xsd:group ref="persongroup"/>
    <xsd:element name="country" type="xsd:string"/>
  </xsd:sequence>
</xsd:complexType>
```

Adapted from http://www.w3schools.com/schema/schema_complex_indicators.asp.

# Complex Types

## Defining Attribute Groups

```
<xsd:attributeGroup name="personattrgroup">
  <xsd:attribute name="firstname" type="xsd:string"/>
  <xsd:attribute name="lastname" type="xsd:string"/>
  <xsd:attribute name="birthday" type="xsd:date"/>
</xsd:attributeGroup>

<xsd:element name="person">
  <xsd:complexType>
    <xsd:attributeGroup ref="personattrgroup"/>
  </xsd:complexType>
</xsd:element>
```

Adapted from http://www.w3schools.com/schema/schema_complex_indicators.asp.

# Complex Types

## Extending Simple Types

```
<xsd:simpleType name="size">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="small" />
    <xsd:enumeration value="medium" />
    <xsd:enumeration value="large" />
  </xsd:restriction>
</xsd:simpleType>

<xsd:complexType name="jeans">
  <xsd:simpleContent>
    <xsd:extension base="size">
      <xsd:attribute name="sex">
        <xsd:simpleType>
          <xsd:restriction base="xsd:string">
            <xsd:enumeration value="male" />
            <xsd:enumeration value="female" />
          </xsd:restriction>
        </xsd:simpleType>
      </xsd:attribute>
    </xsd:extension>
  </xsd:simpleContent>
</xsd:complexType>
```

Adapted from http://www.w3schools.com/schema/el_extension.asp.

# Complex Types

## Extending Complex Types

```
<xsd:complexType name="ProductType">
  <xsd:sequence>
    <xsd:element name="number" type="ProdNumType"/>
    <xsd:element name="name" type="xsd:string"/>
  </xsd:sequence>
</xsd:complexType>

<xsd:complexType name="ShirtType">
  <xsd:complexContent>
    <xsd:extension base="ProductType">
     <xsd:choice maxOccurs="unbounded">
       <xsd:element name="size" type="SizeType"/>
       <xsd:element name="color" type="ColorType"/>
     </xsd:choice>
   </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>
```

# Complex Types

## Allowing for Any Elements

```
<xsd:element name="name">
  <xsd:complexType>
    <xsd:sequence>
      <xsd:element name="first" type="xsd:string"/>
      <xsd:element name="last" type="xsd:string"/>
      <xsd:any minOccurs="0"/>
    </xsd:sequence>
  </xsd:complexType>
</xsd:element>
```

# Complex Types

## Allowing for Any Attributes

```
<xsd:element name="name">
  <xsd:complexType>
    <xsd:sequence>
      <xsd:element name="first" type="xsd:string"/>
      <xsd:element name="last" type="xsd:string"/>
    </xsd:sequence>
    <xsd:anyAttribute/>
  </xsd:complexType>
</xsd:element>
```

# Complex Types

## Allowing for Substitutes

```
<customer>
  <name>John Smith</name>
</customer>

<cliente>
  <nome>Giovanni Smith</nome>
</cliente>

<xsd:element name="name" type="xsd:string"/>
<xsd:element name="nome" substitutionGroup="name"/>
<xsd:complexType name="custinfo">
  <xsd:sequence>
    <xsd:element ref="name"/>
  </xsd:sequence>
</xsd:complexType>
<xsd:element name="customer" type="custinfo"/>
<xsd:element name="cliente" substitutionGroup="customer"/>
```

Adapted from http://www.w3schools.com/schema/schema_complex_subst.asp.

# XML Schema (Second Edition)

## Summary

| Element | Explanation |
|---|---|
| all | Specifies that the child elements can appear in any order. Each child element can occur 0 or 1 time |
| annotation | Specifies the top-level element for schema comments |
| any | Enables the author to extend the XML document with elements not specified by the schema |
| anyAttribute | Enables the author to extend the XML document with attributes not specified by the schema |
| appInfo | Specifies information to be used by the application (must go inside annotation) |
| attribute | Defines an attribute |
| attributeGroup | Defines an attribute group to be used in complex type definitions |
| choice | Allows only one of the elements contained in the <choice> declaration to be present within the containing element |
| complexContent | Defines extensions or restrictions on a complex type that contains mixed content or elements only |
| complexType | Defines a complex type element |
| documentation | Defines text comments in a schema (must go inside annotation) |
| element | Defines an element |
| extension | Extends an existing simpleType or complexType element |
| field | Specifies an XPath expression that specifies the value used to define an identity constraint |

Excerpted from http://www.w3schools.com/schema/schema_elements_ref.asp.

# XML Schema

## Summary

| | |
|---|---|
| group | Defines a group of elements to be used in complex type definitions |
| import | Adds multiple schemas with different target namespace to a document |
| include | Adds multiple schemas with the same target namespace to a document |
| key | Specifies an attribute or element value as a key (unique, non-nullable, and always present) within the containing element in an instance document |
| keyref | Specifies that an attribute or element value correspond to those of the specified key or unique element |
| list | Defines a simple type element as a list of values |
| notation | Describes the format of non-XML data within an XML document |
| redefine | Redefines simple and complex types, groups, and attribute groups from an external schema |
| restriction | Defines restrictions on a simpleType, simpleContent, or a complexContent |
| schema | Defines the root element of a schema |
| selector | Specifies an XPath expression that selects a set of elements for an identity constraint |
| sequence | Specifies that the child elements must appear in a sequence. Each child element can occur from 0 to any number of times |
| simpleContent | Contains extensions or restrictions on a text-only complex type or on a simple type as content and contains no elements |
| simpleType | Defines a simple type and specifies the constraints and information about the values of attributes or text-only elements |
| union | Defines a simple type as a collection (union) of values from specified simple data types |
| unique | Defines that an element or an attribute value must be unique within the scope |

Excerpted from http://www.w3schools.com/schema/schema_elements_ref.asp.

# Next Time

## Web Services, SOAP 1.2, and WSDL 1.1

# Computer Science E-259

## XML with Java, Java Servlet, and JSP

### Lecture 10: XML Schema, Continued

3 December 2007

David J. Malan

malan@post.harvard.edu