XML schemas, Java Annotations, JAXB & Dozer

Introduction to Service Design and Engineering 2013/2014.

Lab session #4

University of Trento

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Some slides from LabSDE-2012/2013

Outline

- XML schema definition (XSD) overview
- Java Annotation minimal example
- Introduction to JAXB
- JAXB Annotations
- Example: XML from/to Object Model
- Exercise
- Dozer
- Assignment

The goal of the session

How can we map xml documents to java objects (and viceversa) so that our program deals only with objects?

XSD: XML Schema Definition (1)

- An XML schema describes the structure of an XML document
- An XML Schema is written in XML
- It is an XML-based alternative to DTD (document type definition - which is yet another set of markups to learn)
- XML Schema is a W3C Recommendation: http://www.w3.org/2001/XMLSchema

XSD: XML Schema Definition (1)

- An XML Schema defines:
  - **elements** that can appear in a document
  - **attributes** that can appear in a document
  - **data types** for elements and attributes
  - which elements are **child** elements
  - the **order** of child elements
  - whether an element is **empty** or can include **text**
  - **default and fixed values** for elements and attributes

Example 1: XSD

```
<xsd:schema
    xmlns:xsd="http://www.w3.org/2001/XMLSchema">
    <xsd:complexType name="personType">
        <xsd:sequence>
            <xsd:element name="firstName" type="xsd:string"/>
            <xsd:element name="lastName"  type="xsd:string"/>
            <xsd:element name="birthDate" type="xsd:date"/>
            <xsd:element name="age"       type="xsd:integer"
                minOccurs="0" maxOccurs="1"/>
            <xsd:element name="healthProfile" type="healthProfileType"
                minOccurs="0" maxOccurs="1"/>
        </xsd:sequence>
    <xsd:attribute name="id" type="xsd:integer"/>
    </xsd:complexType>
    <xsd:complexType name="healthProfileType">
        <xsd:sequence>
            <xsd:element name="weight" type="xsd:decimal"/>
            <xsd:element name="height"  type="xsd:decimal"/>
         </xsd:sequence>
    </xsd:complexType>
    <xsd:element name="person" type="personType"/>
</xsd:schema>
```

Example 1: Validate XML against XSD (1)

- Open and XML/XSD validation tool online: http://www.utilities-online.info/xsdvalidation/#.Ul0rkGRvj40
- Copy the content Example 1 XML Schema and Example 1 XML instance
- Validate XML againsts XSD

Example 1: XSD (2)

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

- **xmlns:xsd="…"** indicates that the elements and data types used in this schema
  - come from the *http://www.w3.org/2001/XMLSchema* namespace
  - should be prefixed with xsd:

XML Schema built-in data types

- The most common built-in data types are:
  - xsd:string
  - xsd:decimal
  - xsd:integer
  - xsd:boolean
  - xsd:date
  - xsd:time
- The complete built-in data type hierarchy
  - http://www.w3.org/TR/xmlschema-2/#built-in-datatypes

Example 1: XSD (3)

- XML Elements

```
<firstName>George R. R.</firstName>
<lastName>Martin</lastName>
<birthDate>1970-06-21</birthDate>
```

- Corresponding XSD definitions

```
<xsd:element name="firstName" type="xsd:string" />
<xsd:element name="lastName"  type="xsd:string" />
  <xsd:element name="birthDate" type="xsd:date"   />
```

Complex Data Types

- 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 (and attributes)
  - elements that contain both other elements and text
- For each kind, there are many ways to write it in a XSD document. We see only one way, that is compatible with JAXB

Example 1: XSD (4)

Empty Elements

- XML Elements

```
<person id="12345">
…
</person>
```

- Corresponding XSD definitions

```
…
<xsd:element name="person" type="personType"/>
  <xsd:complexType name="personType">c
  </xsd:complexType>
```

Example 1: XSD (5)

Elements that contain only Elements

- XML Elements

```
<person>
  <firstName>George R. R.</firstName>
  <lastName>Martin</lastName>
  <birthDate>1970-06-21</birthDate>
</person>
```

- Corresponding XSD definitions

```
<xsd:element name="person" type="personType"/>
  <xsd:complexType name="personType">
      <xsd:sequence>
          <xsd:element name="firstName" type="xsd:string"/>
          <xsd:element name="lastName"  type="xsd:string"/>
          <xsd:element name="birthDate" type="xsd:date"/>
       </xsd:sequence>
  </xsd:complexType>
```

Example 2: XSD (6)

Elements that contain only Text and Attributes

- XML Elements

```
<shoesize country="france">35</shoesize>
```

- Corresponding XSD definitions

```
<xsd:element name="shoesize" type="shoesizeType"/>
  <xsd:complexType name="shoesizeType">
      <xsd:simpleContent>
        <xsd:extension base="xsd:integer">
          <xsd:attribute name="country" type="xsd:string"/>
        </xsd:extension>
       </xsd:simpleContent>
  </xsd:complexType>
```

Example 3: XSD (7)

Elements that contain both elements and text

- XML Elements

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

- Corresponding XSD definitions

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

- **What was new here?**

XSD Indicators

- **Order indicators** are used to define the order of the elements
  - all, choice, sequence
- **Occurrence indicators** are used to define how often an element can occur
  - maxOccurs, minOccurs
- **Group indicators** are used to define related sets of elements.
  - group name, attributeGroup name

Example 4: XSD (8)

Group names

```
<xsd:group name="persongroup">
    <xsd:sequence>
        <xsd:element name="firstName" type="xsd:string"/>
        <xsd:element name="lastName"  type="xsd:string"/>
        <xsd:element name="birthDate" 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>
```

Example 5: XSD (9)

AttributeGroup name

```
<xsd:attributeGroup name="elementAttrGroup">
    <xsd:attribute name="refURI" type="xsd:anyURI" use="optional">
    </xsd:attribute>
    <xsd:attribute name="id" type="xsd:integer">
    </xsd:attribute>
</xsd:attributeGroup>
<xsd:complexType name="SomeEntity" >
    <xsd:simpleContent>
        <xsd:extension base="xsd:string">
            <xsd:attributeGroup ref="elementAttrGroup"/>
        </xsd:extension>
     </xsd:simpleContent>
</xsd:complexType>
<xsd:element name="root" type="SomeEntity"/>
```

Exercise 0

- Add a HealthProfile to the Example1.xml and make sure this is valid with respect to the Example1.xsd

Exercise 1

- Go to the online validator: http://www.utilities-online.info/xsdvalidation/#.Ul0rkGRvj40
- Copy Example 5 in the XSD Schema.
- Create an XML instance of this schema that is **valid**

Example 6: XSD (10)

Sustitution

```
<xs:element name="name" type="xs:string"/>
<xs:element name="navn" substitutionGroup="name"/>
```

```
<xs:element name="name" type="xs:string"/>
<xs:element name="navn" substitutionGroup="name"/>
<xs:complexType name="custinfo">
  <xs:sequence>
    <xs:element ref="name"/>
  </xs:sequence>
</xs:complexType>
<xs:element name="customer" type="custinfo"/>
<xs:element name="kunde" substitutionGroup="customer"/>
```

- Valid XMLs

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

or

```
<kunde>
  <navn>John Smith</navn>
</kunde>
```

Java Annotations

- Annotations provide data about a program that is not part of the program itself.
- They have no direct effect on the operation of the code they annotate.
- Annotations can be applied to a program's declarations of classes, fields, methods, and other program elements.

```
@XmlRootElement // this is a java annotation
@XmlType(name = "", propOrder = { "publisher", "edition", "title", "author" })
public class Catalog {
  private String publisher;
  private String edition;
  private String title;
  private String author;
  ...
  @XmlAttribute
  public String journal;
```

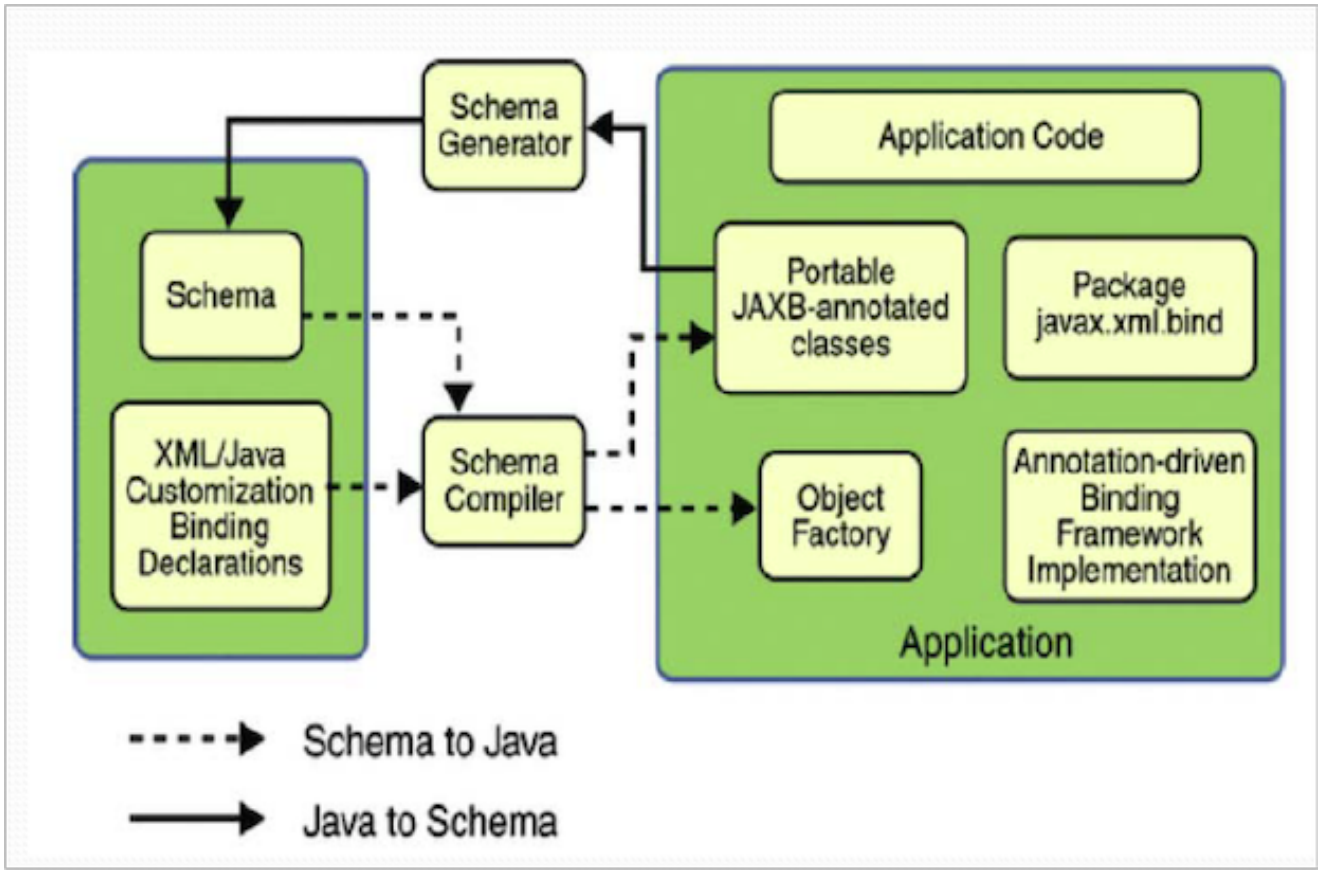
Java Annotations: Uses

- **Information for the compiler:** Annotations can be used by the compiler to detect errors or suppress warnings.
- **Compile-time and deployment-time processing:** Software tools can process annotation information to generate code, XML files, and so forth.
- **Runtime processing:** Some annotations are available to be examined at runtime

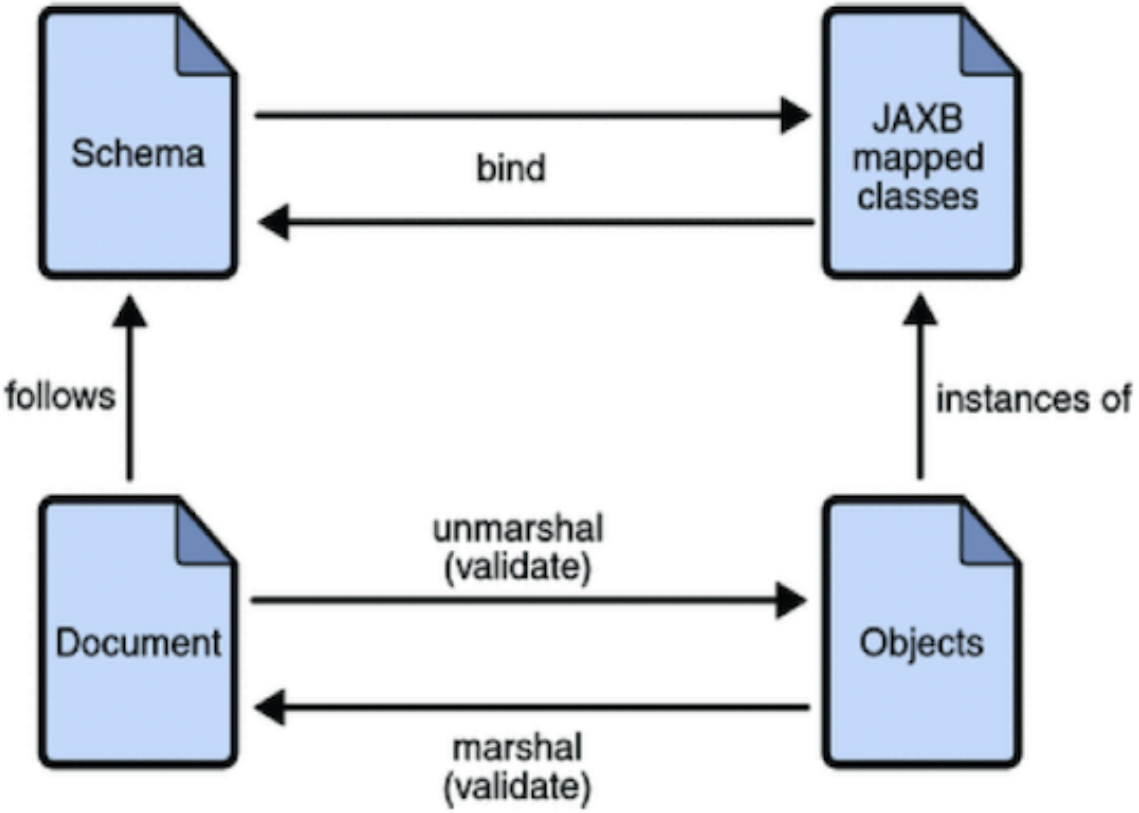
Introduction to JAXB

- JAXB = **J**ava **A**rchitecture for **X**ML **B**inding
- Java standard that defines how Java objects are converted **from** and **to** XML.
- As opposed to XPATH, now we can map XML to a set of Java Classes and restrict our Java program to java objects (not a document tree)
- JAXB Provides two main features:
  - the ability to **marshal** (i.e., convert) Java objects into XML
  - the ability to **un-marshal** XML back into Java objects
- Download from https://jaxb.java.net/2.2.7/

JAXB Architecture



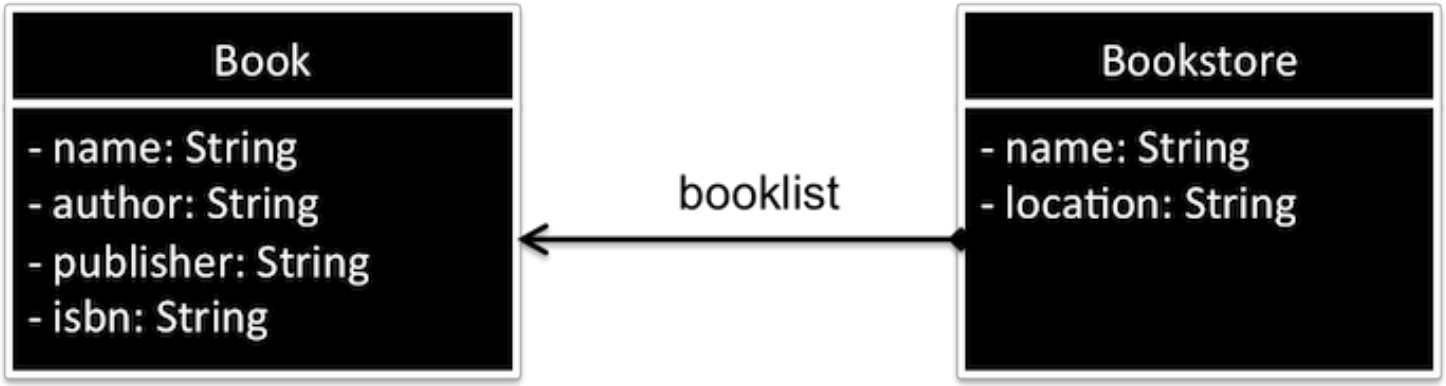
JAXB Binding Process



Source: http://java.sun.com/javaee/5/docs/tutorial/doc/bnazg.html

XML From/to Object Model

- Think about the following simple object model



JAXB Annotations

- **@XmlRootElement(namespace = "namespace"):** defines the root element for an XML tree
- **@XmlType(propOrder = { "field2", "field1",.. }):** allows to define the order in which the fields are written in the XML file
- **@XmlElement(name = "neuName"):** defines the XML element which will be used. Only need to be used if the neuNeu is different then the JavaBeans Name

Example 6: JAXB Annotations

- Open Example6-JAXB/src/model/Book.java

```java
@XmlRootElement(name = "book")
// If you want you can define the order in which the fields are written
// Optional
@XmlType(propOrder = { "author", "name", "publisher", "isbn" })
public class Book {
//
private String name;
private String author;
private String publisher;
private String isbn;
//
// If you like the variable name, e.g. "name", you can easily change this
// name for your XML-Output:
@XmlElement(name = "title")
public String getName() {
  return name;
}
```

Example 6: JAXB Annotations

- Open Example6-JAXB/src/model/Book.java

```
//This statement means that class "Bookstore.java" is the root-element of our example
@XmlRootElement(namespace = "de.vogella.xml.jaxb.model")
public class Bookstore {
//
// XmLElementWrapper generates a wrapper element around XML representation
@XmlElementWrapper(name = "bookList")
// XmlElement sets the name of the entities
@XmlElement(name = "book")
private ArrayList<Book> bookList;
private String name;
private String location;
```

Example 6: XML from/to Object Model

- Open Example6-JAXB/src/model/Book.java

```
public class BookMain {
// let's put the final result somewhere
private static final String BOOKSTORE_XML = "./bookstore-jaxb.xml";
public static void main(String[] args) throws JAXBException, IOException {
  ArrayList<Book> bookList = new ArrayList<Book>();
  // create books
  Book book1 = new Book();
  book1.setIsbn("978-0060554736");
  book1.setName("The Game");
  book1.setAuthor("Neil Strauss");
  book1.setPublisher("Harpercollins");
  bookList.add(book1);
  //
  Book book2 = new Book();
  book2.setIsbn("978-3832180577");
  book2.setName("Feuchtgebiete");
  book2.setAuthor("Charlotte Roche");
  book2.setPublisher("Dumont Buchverlag");
  bookList.add(book2);
  //
  // create bookstore, assigning book
  Bookstore bookstore = new Bookstore();
  bookstore.setName("Fraport Bookstore");
  bookstore.setLocation("Frankfurt Airport");
  bookstore.setBookList(bookList);
…
```

Example 6: XML from Object Model

```
...
  // create JAXB context and instantiate marshaller
  JAXBContext context = JAXBContext.newInstance(Bookstore.class);
  Marshaller m = context.createMarshaller();
  m.setProperty(Marshaller.JAXB_FORMATTED_OUTPUT, Boolean.TRUE);
//
  // Write to System.out
  m.marshal(bookstore, System.out);
//
  // Write to File
  m.marshal(bookstore, new File(BOOKSTORE_XML));
//
  // get variables from our xml file, created before
  System.out.println();
  System.out.println("Output from our XML File: ");
  …
```

Example 6: XML to Object Model

```
  ...
    Unmarshaller um = context.createUnmarshaller();
    Bookstore bookstore2 = (Bookstore) um.unmarshal(new FileReader(BOOKSTORE_XML));
    ArrayList<Book> list = bookstore2.getBooksList();
    for (Book book : list) {
      System.out.println("Book: " + book.getName() + " from "
          + book.getAuthor());
    }
  }
}
```

Example 6: XML from/to Object Model

- Enter Example6-JAXB
- Explore the content of BookMain.java, Book.java and Bookstore.java
- Compile and run the code

```
ant init
ant compile
ant execute
```

- What's new in the folder?

Exercise 2: XML from Object Model

- Create a simple Program that creates an xml from a Person model in the following format

```
<person name="Thomas">
  <age>35</age>
  <address>Via Malpensada 140</address>
</person>
```

Example 7: more JAXB

- Enter the directory Example7-JAXB
- Edit the build.xml to update the JAXB home (e.g., /opt/jaxb-ri-2.2.6)
- Compile the code and then run

```
ant init
ant compile
ant execute.JavaToXML
```

Example 7: generating classes from XML Schema

- JAXB comes with an XML Schema binding compile

```
ant generate
```

- Explore the classes under the newly created "generated folder"
- Now, Marshal these classes into an XML

```
ant execute.JAXBUnMarshaller
```

- Explore catalog.xml
- UnMarshal them into Java objects

```
ant execute.JAXBUnMarshaller
```

Exercise 3

- What should you change in Example7-JAXB to add an **element year** within each article of a journal?

Domain Objects vs Transfer Objects

- **You have a domain model** (i.e., the model that is mapped to your database)

```
public class PersonDB {
    private String firstName;
    private String lastName;
    private String address;
    private String dbID;
```

- **What if your client is waiting this, and it does not care about ids?**

```
<person>
  <fName>Cristhian</fName>
  <lName>Parra</lName>
  <address>Povo Trento</address>
</person>
```

- In other words, we want to keep domain objects separate from the logics that manage the transformation into XML/JSON representations of the resources in our model
- To do se, we need **Transfer Objects** in the middle

Dozer basics

- Dozer is a Java Bean to Java Bean mapper that recursively copies data from one object to another
- Dozer supports mapping between attribute names and between types.
- Standard conversions are provided automatically
- You are allowed to specify custom conversions via XML
- With Dozer, your internal domain objects are not exposed to external presentation layers or to external consumers.
- Dozer maps your domain objects to external APIs calls and vice-versa.
- Dozer can works both with XML and JSON

Dozer Installation

- Download Dozer and extract the archive: https://github.com/DozerMapper/dozer/archive/v5.4.0.zip
- Add ${dozer.home}/dist/dozer.jar to your classpath.
- Add required thirdparty runtime jars to your classpath http://dozer.sourceforge.net/dependencies.html

Dozer Example (1)

- Open Example8-Dozer
- The basic idea is that you have two set of classes in different packages:
  - **entity classes**: here we put pure domain objects
  - **transfer classes**: here we put objects as they are going to be mapped to the presentation layer (xml, json)
- Dozer maps domain objects into jaxb objects, that can later be marshalled to xml

Dozer Example (2)

```
package dozerproject.entity;
public class PersonDB {
    private String firstName;
    private String lastName;
    private String address;
    private String dbID;
```

```
package dozerproject.transfer;
@XmlRootElement(name="person")
public class PersonUI {
    private String fName;
    private String lName;
    private String address;
    // getters and setters
```

Dozer Example (3)

```
<?xml version="1.0" encoding="UTF-8"?>
<mappings xmlns="http://dozer.sourceforge.net"
          xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
          xsi:schemaLocation="http://dozer.sourceforge.net
          http://dozer.sourceforge.net/schema/beanmapping.xsd">
  <mapping>
    <class-a>dozerproject.PersonDB</class-a>
    <class-b>lsde.lab4.presentation.PersonUI</class-b>
    <field>
      <a>firstName</a>
      <b>fName</b>
    </field>
    <field>
      <a>lastName</a>
      <b>lName</b>
    </field>
  </mapping>
</mappings>
```

Dozer Example (4)

```
public static void main (String argus[]){
    DozerMapper mapper = new DozerMapper();
    PersonDB pdb = getPersonFromDB();
    // load mapping files
    List myMappingFiles = new ArrayList();
    myMappingFiles.add("File:./dozerMappings.xml");
    // prepare DozerMapper
    DozerBeanMapper mapper = new DozerBeanMapper();
    mapper.setMappingFiles(myMappingFiles);
// do the mapping
    PersonUI destObject = (PersonUI) mapper.map(sourceObject, PersonUI.class);
    // serialize the mapped object to the final representation (e.g., xml)
    String xmlFile = "person.xml";
    File xmlDocument = newFile(xmlFile);
  try {
        JAXBContext jaxbContext = JAXBContext.newInstance(PersonUI.class);
        Marshaller marshaller = jaxbContext.createMarshaller();
        marshaller.setProperty("jaxb.formatted.output", new Boolean(true));
        marshaller.marshal(destObject, new FileOutputStream(xmlDocument));
    } catch (IOException e) {
     …
    }
```

Assignment #1

- Replace the HashMap db in the HealthProfile Reader with a xml file as follows

```
<people>
    <person>
        <firstname>George R. R.</firstname>
        <lastname>Martin</lastname>
        <healthprofile>
            <weitgh>120</weitgh>
            <height>1.65</height>
        </healthprofile>
    </person>
    <!-- add more people to the db -->
</people>
```

- **Part 1**
  - Extend the example above to include at least 20 people (maybe your friends with fake names, **extra points if you find a bigger datasource**)
  - Use xpath to implement methods like **getWeight** and **getHeight**
  - Make a function that prints all people in the list with detail (if >20, paginated)
  - A function that accepts **fullname as parameter** and prints that particular person **HealthProfile**
  - A function which accepts a **weight** and an **operator (=, > , <)** as parameters and prints people that fulfill that condition (i.e., >80Kg, =75Kg, etc.).

Assignment #1

- **Part 2**
  - Create the XML schema XSD file for the example XML document of people.
  - Write a java application that does the marshalling and un-marshalling using JAXB.

Assignment Rules

- Before submission make a zip file that includes only
  - All Java source files
  - All XML and XSD files
  - please, do not include .class or IDE generated project files
- Rename the Zip file to: your full name + assignment_no. for example: cristhian_parra_1.zip
- Submission link: www.dropitto.me/introsde2013
- Password will be given and class and sent to the group
- The assignment is due on 05-Nov (Mid-Night).
- On 06-Nov I'll copy your directory and I use that copy for the evaluation.

Assignment Evaluation

- The assignment will be evaluated in terms of:
  - **Completeness:** did you deliver all that was asked?
  - **Functioning:** does it work? Does it do what it was requested?
  - **Organization (for extra points):** the easier you make it for us to understand what you did and how to run it, the more chances for you to have a better mark (i.e., there is self-explained ant build file to automate things, files are structured in orderly manner, source code is readable, there is a maven project file taking care for dependencies - that would be awesome, etc.)

For next session

- Install Eclipse: http://www.eclipse.org/downloads/packages/eclipse-standard-431/keplersr1
- Install Maven (newly added requirement): http://maven.apache.org/download.cgi
- Prepare yourselves for a long session: we will go till 7pm.
- Stay tunned to the list, will send a list of plugins for eclipse to add later in the week.

References:

- XML Schemas
  - http://www.w3schools.com/schema/default.asp
  - http://www.xfront.com/files/xml-schema.html
  - Validators:
    - http://tools.decisionsoft.com/schemaValidate/
    - http://www.utilities-online.info/xsdvalidation/#.Ul0rkGRvj40
- JAXB
- Dozer