COMPSCI 732: Software Tools and Techniques
Assignment 2: XSLT-based Mapping Generator

Worth 16.6% of your final grade
This assignment is due on 14th May 2007
This assignment must be done individually

Aims

The aim of this project is to give you some experience in the use of a simple mapping language. This language will be used to describe a series of basic mappings between XML-based representations of publications. You will use the mapping specification to generate XSLT capable of performing mappings in either direction for XML documents based on the specified DTD.

Overview

Your system must be capable of generating XSLT to perform the mappings specified in a XML document based specification of a mapping. Several example mappings are provided to help you develop your system. A separate set of mappings will be used to mark your system. For a particular mapping your system must load the XML file describing the mapping and generate XSLT files which will perform the specified mapping in both directions. The marker will use these generated XSLT files to test the mapping against XML documents containing data in the structure described in the mapping file.

The mapping language

In order to specify a mapping we need a formalism to describe it. As we wish to generate XSLT for both directions from one mapping specification we aim for a high-level, declarative approach to the formalism. Below I describe the components of a basic mapping language. In this formalism I use the symbol ↔ to represent an equivalence between information on one side of the symbol and that on the other side of the symbol.

Top level specification

We need to capture which schemas a mapping is being specified for. Therefore at the top level in the formalism we specify the DTDs:

interSchema(*DTD_URI* ↔ *DTD_URI*, …)

Element level specification

After listing the schemas (DTDs) we need to describe which elements are mapped between. We do this by listing the elements, with the first coming from the initial DTD in the interSchema and the second from the second DTD in the interSchema:

interElement(*ElementName*+ ↔ *ElementName*+, …)

Invariant specification

Following this we describe the invariants which control whether this mapping should be used for a particular instance of a class. These invariants will be simple equalities between an element value and a constant. Invariants can be specified for elements from the schema on either side of the mapping. Remember that an invariant which

restricts a mapping in one direction is used as an initialiser when the mapping is run in the reverse direction.

Data level mapping specification
Within the element level association we then describe all mappings between individual element values in the schema. This takes the form of:

Equation ↔ *Equation*

The *Equation* on the left-hand side of the equivalence symbol refers to data in the left-hand side *ElementName* from this interElement, and similarly for the right-hand side *Equation*. An equation can be of the following form:

- An element name, or path following element references (as in XPath)
- A default value
- A function applied to a combination of elements or values. The allowable functions are the XPath functions (note that concat/n will not be tested with more than 3 elements):
  - concat/n
  - substring-before/2
  - substring-after/2
- A mathematical equation involving a single arithmetic operator and one element name. The allowable operators are the XPath operators of:
  - +
  - –
  - *
  - div

Assumptions for this assignment
In order to reduce some of the other complexities that can occur when processing XML documents and DTDs we make the following assumptions about the types of mapping and structure of DTDs we will be handling:

- The order of elements is equivalent in both DTDs. Here we assume that we can generate the resultant XML file by processing the data level mappings in the order specified. Without this assumption we would have to load the DTD for each schema and determine the correct order to write out element values.
- The elements described as part of the invariants are the first elements in the DTD, occurring in the same order as they are listed in the mapping specification.
- The equations are very simple, so rewriting the equations to perform an inverse mapping is greatly simplified. A mathematical equation will only have one element on each side of the equivalence and an equation will only map to an element (i.e., no equation to equation mappings to solve).
- The invariant specification is very simple with the assumption that all invariants describe a simple equality between a constant value and an element.
- A catalogue element wraps all data being mapped between (so there is a root element for the XML file). You should generate XSLT to handle this top level element (not shown in mappings).

XML form of the mapping language

So that you do not need to consider parsing the mapping formalism the mapping examples for this assignment have been coded in a XML format. The DTD for this XML format, which reflects the mapping language above, is as follows:

```
<!ELEMENT interSchema (dtdURI, dtdURI, interElement+) >
<!ELEMENT dtdURI (#PCDATA) >
<!ELEMENT interElement (elementNameSet, elementNameSet, invariant*, mapping+) >
<!ELEMENT elementNameSet (elementName+) >
<!ELEMENT elementName (#PCDATA) >
<!ELEMENT mapping (equation, equation) >
<!ELEMENT equation (elementName | value | function | arithmetic) >
<!ELEMENT value (#PCDATA) >
<!ELEMENT function (equation+) >
<!ATTLIST function name (concat | substring-before | substring-after) #REQUIRED>
<!ELEMENT arithmetic (elementName, value) >
<!ATTLIST arithmetic op (plus | minus | times | div) #REQUIRED>
<!ELEMENT invariant (expression, expression) >
<!ELEMENT expression (elementName | value) >
```

Task One (70%)

In the first part of this project you will need to handle a one-to-one mapping between single elements in a XML file using basic equations and functions. For the simplest mapping between single elements the only change which occurs is to modify the name of elements in the XML documents. For a mapping with equations the only equation which will be present is an equivalence between two elements. Two example DTDs are as follows:

publication1.dtd

```
<!ELEMENT catalogue (publication+) >
<!ELEMENT publication (title, creator, isbn,
subject?, description?, tableOfContents?, cost) >
<!ELEMENT title (#PCDATA) >
<!ELEMENT creator (#PCDATA) >
<!ELEMENT isbn (#PCDATA) >
<!ELEMENT subject (#PCDATA) >
<!ELEMENT description (#PCDATA) >
<!ELEMENT tableOfContents (#PCDATA) >
<!ELEMENT cost (#PCDATA) >
```

publication2.dtd

```
<!ELEMENT catalogue (publication+) >
<!ELEMENT publication (title, author, isbn,
classification?, description?, contents?, price,
country?) >
<!ELEMENT title (#PCDATA) >
<!ELEMENT author (#PCDATA) >
<!ELEMENT isbn (#PCDATA) >
<!ELEMENT classification (#PCDATA) >
<!ELEMENT description (#PCDATA) >
<!ELEMENT contents (#PCDATA) >
<!ELEMENT price (#PCDATA) >
<!ELEMENT country (#PCDATA) >
```

The mapping which is required for this transformation can be found in the file ‘one2one.xml’ and has the following specification:

```
interSchema(publication1.dtd ↔ publication2.dtd,
        interElement(publication ↔ publication,
                title ↔ title,
                creator ↔ author,
                isbn ↔ isbn,
                subject ↔ classification,
                description ↔ description,
                tableOfContents ↔ contents,
                cost ↔ price
        )
)
```

You need only handle equations with a single operator (i.e., +, -, *, div) between an element and a constant value (you don't have to worry about type checking) or a single function (i.e., concat/n, substring-before/2, substring-after/2).

A first test for equations is to use the DTDs and XML files above but with the mapping in the file 'equation.xml'. In this mapping the cost is defined as price * 0.5855 (US$ conversion).

A second test is to use the following DTDs for publisher information which requires a concatenation as part of the mapping.

publisher1.dtd	**publisher2.dtd**
<!ELEMENT catalogue (publisherDetails +) >	<!ELEMENT catalogue (publisher+) >
<!ELEMENT publisherDetails (publisherName, address, phone?, fax?, email?) >	<!ELEMENT publisher (name, addr1, addr2, addr3, email?) >
<!ELEMENT publisherName (#PCDATA) >	<!ELEMENT name (#PCDATA) >
<!ELEMENT address (#PCDATA) >	<!ELEMENT addr1 (#PCDATA) >
<!ELEMENT phone (#PCDATA) >	<!ELEMENT addr2 (#PCDATA) >
<!ELEMENT fax (#PCDATA) >	<!ELEMENT addr3 (#PCDATA) >
<!ELEMENT email (#PCDATA) >	<!ELEMENT email (#PCDATA) >

The mapping which is required for this transformation can be found in the file 'function.xml' and has the following specification:

```
interSchema(publisher1.dtd ↔ publisher2.dtd,
        interElement(publisherDetails ↔ publisher,
                publisherName ↔ name,
                address ↔ concat(addr1, “, “, addr2, “, “, addr3),
                phone ↔ “”,
                fax ↔ “”,
                email ↔ email
        )
)
```

There is example data in the files publisher1.xml and publisher2.xml to use for testing.

Task Two (15%)

Extend your system to allow invariants to control which mapping specification is used for a class in a schema. For example, if one schema uses a publication class to represent all types of publications (e.g., books, magazines, CDs, DVDs, etc) and another schema has individual classes for each type of publication then we need to use an invariant to define when the general publication can be mapped to each of these individual classes.

publications.dtd	**catalogue.dtd**
<!ELEMENT catalogue (publication+) > <!ELEMENT publication (type, title, creator, subject?, description?, tableOfContents?, cost) > <!ELEMENT type (#PCDATA) > <!ELEMENT title (#PCDATA) > <!ELEMENT creator (#PCDATA) > <!ELEMENT subject (#PCDATA) > <!ELEMENT description (#PCDATA) > <!ELEMENT tableOfContents (#PCDATA) > <!ELEMENT cost (#PCDATA) >	<!ELEMENT catalogue (book*, cd*, dvd*) > <!ELEMENT book (title, author, classification?, description?, tableOfContents?, price) > <!ELEMENT title (#PCDATA) > <!ELEMENT author (#PCDATA) > <!ELEMENT classification (#PCDATA) > <!ELEMENT description (#PCDATA) > <!ELEMENT tableOfContents (#PCDATA) > <!ELEMENT price (#PCDATA) > <!ELEMENT cd (title, band, musicType?, description?, songList?, price) > <!ELEMENT band (#PCDATA) > <!ELEMENT musicType (#PCDATA) > <!ELEMENT songList (#PCDATA) > <!ELEMENT dvd (title, producer, movieType?, description?, price) > <!ELEMENT producer (#PCDATA) > <!ELEMENT movieType (#PCDATA) >

The mapping which is required for this transformation can be found in the file 'invariant.xml' (there is example data in the files publications.xml and catalogue.xml) and has the following specification:

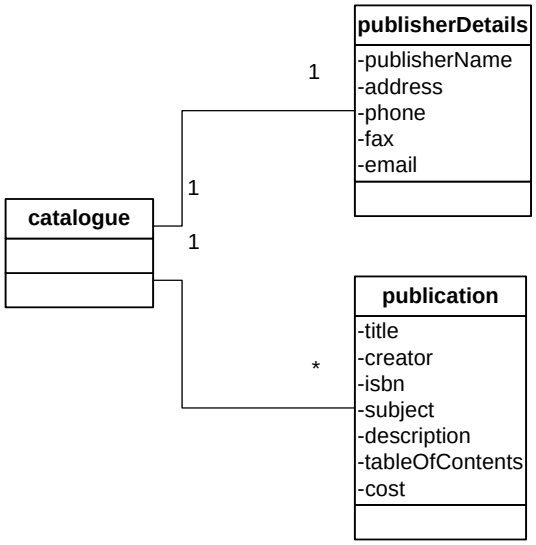
```
interSchema(publications.dtd ↔ catalogue.dtd,
        interElement(publication ↔ book,
                invariants(type = "BOOK"),
                title ↔ title,
                creator ↔ author,
                subject ↔ classification,
                description ↔ description,
                tableOfContents ↔ tableOfContents,
                cost ↔ price * 0.5855
        )
        interElement(publication ↔ cd,
                invariants(type = "CD"),
                title ↔ title,
                creator ↔ band,
                subject ↔ musicType,
                description ↔ description,
                tableOfContents ↔ songList,
                cost ↔ price * 0.5855
        )
```

```
        interElement(publication ↔ dvd,
                invariants(type = "DVD"),
                title ↔ title,
                creator ↔ producer,
                subject ↔ movieType,
                description ↔ description,
                cost ↔ price * 0.5855
        )
)
```

Remember that invariants (e.g., *type = "BOOK"*) restrict which object will be mapped when going from the publications DTD to the catalogue DTD. In the reverse direction the invariant will initialise the value of *type* in the publications DTD to the value *"BOOK"*. There will only ever be one invariant to determine which mapping to apply for a particular element.

Task Three (15%)

Finally, extend your system to perform mappings where the structuring of the XML data is quite different. For example, the following catalogue descriptions have very different structures (one is a flat structure, the other a nested structure). The nested structure is shown in the following UML diagram.



catalogues.dtd	**bookdata.dtd**
<!ELEMENT catalogue (publisherDetails, (publication)+) > <!ELEMENT publisherDetails (publisherName, address, phone?, fax?, email?) > <!ELEMENT publisherName (#PCDATA) > <!ELEMENT address (#PCDATA) > <!ELEMENT phone (#PCDATA) > <!ELEMENT fax (#PCDATA) > <!ELEMENT email (#PCDATA) > <!ELEMENT publication (title, creator, isbn, subject?, description?, tableOfContents?, cost) > <!ELEMENT title (#PCDATA) > <!ELEMENT creator (#PCDATA) > <!ELEMENT isbn (#PCDATA) > <!ELEMENT subject (#PCDATA) > <!ELEMENT description (#PCDATA) > <!ELEMENT tableOfContents (#PCDATA) > <!ELEMENT cost (#PCDATA) >	<!ELEMENT catalogue (bookdata+) > <!ELEMENT bookdata (publisher, title, isbn, bicClassification?, distributor?, availability?, format?, description?, tableOfContents?, price) > <!ELEMENT publisher (#PCDATA) > <!ELEMENT title (#PCDATA) > <!ELEMENT isbn (#PCDATA) > <!ELEMENT bicClassification (#PCDATA) > <!ELEMENT distributor (#PCDATA) > <!ELEMENT availability (#PCDATA) > <!ELEMENT format (#PCDATA) > <!ELEMENT description (#PCDATA) > <!ELEMENT tableOfContents (#PCDATA) > <!ELEMENT price (#PCDATA) >

For this structural mapping you can assume that there will be a maximum of two elements named on one side of the interElement specification and only one on the other side (so only handling cases like the example above). You can also assume that if there are two elements named that the first element will always only have one occurrence in the XML data file.

The mapping which is required for this transformation can be found in the file ‘structure.xml’ (there is example data in the files catalogues.xml and bookdata.xml) and has the following specification:

```
interSchema(catalogue.dtd ↔ bookdata.dtd,
        interElement(publisherDetails, publication ↔ bookdata,
                publisherDetails/publisherName ↔ publisher,
                publisherDetails/address ↔ “”,
                publisherDetails/phone ↔ “”,
                publisherDetails/fax ↔ “”,
                publisherDetails/email ↔ “”,
                publication/title ↔ title,
                publication/creator ↔ “”,
                publication/isbn ↔ isbn,
                publication/subject ↔ bicClassification,
                 “Amorzon” ↔ distributor,
                 “In Stock” ↔ availability,
                 “Paperback” ↔ format,
                publication/description ↔ description,
                publication/tableOfContents ↔ tableOfContents,
                publication/cost ↔ 0.5855 * price
        )
)
```

Deliverables

You should provide the following deliverables for this project (assuming you use Java for your development):

1. A single JAR file containing all of your code for tasks 1, 2 and 3. Name this file 'mapping.jar'. You do not need a separate program for each task, one program could work for all three tasks.
2. A Word document which states how far you got in your implementation and also contains instructions on how to run your mapping system for tasks 1, 2 and 3. Name this file 'instructions.doc'.

You should plan to spend no more than 25 hours on this assignment. This is an individual project, so make sure you develop your own solutions.

Hand in the electronic copy of your prototype through the web drop-box. You can make as many submissions as you like, only your last submission will be marked. If you make multiple submissions ensure that you send all files for each submission.

Online Sources

For general resources on XML, XSLT, and DOM look at:

- XML Tutorial: The XML Revolution: http://www.brics.dk/~amoeller/XML/
- The Java Web Services Tutorial: http://java.sun.com/webservices/tutorial.html
- XPath Language: http://www.w3.org/TR/xpath