Master's Thesis

Configurable Schema-Aware RDF Data Input Forms

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Abstract

Abstract in English

Kurzfassung

Kurzfassung auf Deutsch

Contents

List of Figures

List of Tables

Chapter 1

Introduction

Introduction.
You can reference the only entry in the .bib file like this: [1]

1.1 Initial goal and contributions

1.2 Thesis outline

Chapter 2

Preliminaries

2.1 Web applications

2.1.1 Introduction

Usually web applications do not consist of one single page, but of several different pages. In order to navigate between the pages of the application, the HTML document contains links that trigger further HTTP requests. Links in HTML can be defined by means of the <a/> tag. The most important parameter of this tag is href, whose value contains the URL of the HTTP request. Let assume that an application's main page is accessible through the URL http://newsPortal.com. Common practice that subpages of the application can be called through various url-mappings, which means the main URL is extended with a keyword that denotes the page to be requested.

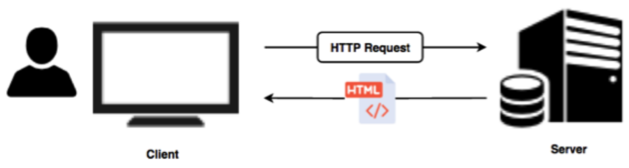
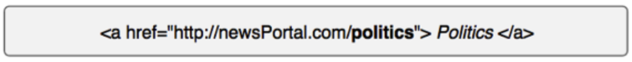


Figure 2.1: Client server communication

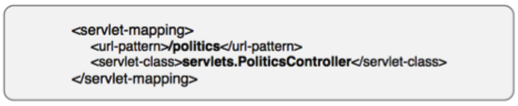
Usually web applications do not consist of one single page, but of several different pages. In order to navigate between the pages of the application, the HTML document contains links that trigger further HTTP requests. Links in HTML can be defined by means of the <a/> tag. The most important parameter of this tag is href, whose value contains the URL of the HTTP request. Let assume that an application's main page is accessible through the URL http://newsPortal.com. Common practice that subpages of the application can be called through various url-mappings, which means the main URL is extended with a keyword that denotes the page to be requested.



```
<a href="http://newsPortal.com/politics"> Politics </a>
```

Figure 2.2: HTML Link

The link in Figure 2 shows the link for the subpage. Programming the server incorporates the task of assignment of the url-mappings to particular classes, which are responsible for the response preparation. In Java web application these responder classes are called servlets an the definition of the mapping-class assignment looks as follows:

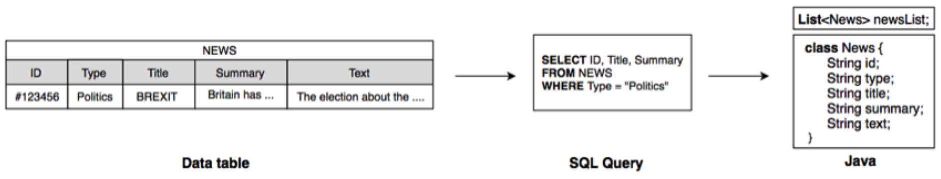


```
<servlet-mapping>
    <url-pattern>/politics</url-pattern>
    <servlet-class>servlets.PoliticsController</servlet-class>
</servlet-mapping>
```

Figure 2.3: Servlet mapping definition in web.xml

A modern web application do not just send static web pages to the client, that contains in this case the political articles, but the articles are stored in a database, and the pages are generated dynamically by substituting the retrieved data into so-called template files. First of all the task of responding requires a query that retrieves that data from the database. By applications using relational data model, the tables and attributes are always modeled by classes of the used object oriented programming (OOP) language. So the data retrieval is the instantiation of the classes in scope.

In our example the news are stored in the NEWS table and the application has a class named News with the same attributes that the table has. Consequently one single row of the table can be stored in an instance of the News class. As the database returns a table with multiple news, thus the resulting Java data will have the type List<News>. Then this in this simple case the list is passed to the template engine together with the template file.



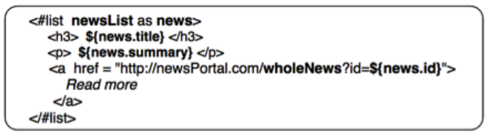
NEWS				
ID	Type	Title	Summary	Text
#123456	Politics	BREXIT	Britain has ...	The election about the ....

```
SELECT ID, Title, Summary
FROM NEWS
WHERE Type = "Politics"
```

```
List<News> newsList;

class News {
    String id;
    String type;
    String title;
    String summary;
    String text;
}
```

Figure 2.4: Data flow



```
<#list  newsList as news>
   <h3> ${news.title} </h3>
   <p> ${news.summary} </p>
   <a  href = "http://newsPortal.com/wholeNews?id=${news.id}">
      Read more
    </a>
</#list>
```

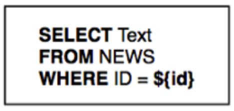
Figure 2.5: Template file

The template file is a description of how the data has to be converted into HTML document. It can be seen that it is possible for instance to declare a list on the input variable newsList. Then the template engine iterates through the News objects and by accessing its fields (title, summary, id) and generates the HTML for each element.

The template file contains the following link

<a href="http://newsPortal.com/wholeNews?id=$news.id" >Read more <a>

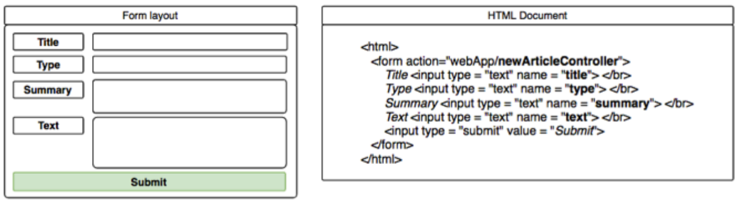
which redirects to the page where the whole article can be seen. To achieve this it is necessary to equip each link with the parameter id that holds the ID of NEWS item, order to inform the server about which article's whole text has to be displayed. Then the servlet class of the mapping /wholeNews has to perform the following query where the id is the input.



```
SELECT Text
FROM NEWS
WHERE ID = ${id}
```

Figure 2.6: SQL query with parameter

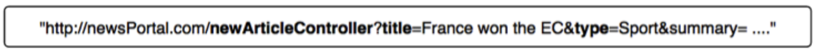
Web applications do not only just display existing data, but they allow the users to enter their new data. In HTML the element used for data input is called form. Form is a container, and it consists of particular form elements according to the data to be added.



```
<html>
  <form action="webApp/newArticleController">
     Title <input type = "text" name = "title"> </br>
     Type <input type = "text" name = "type"> </br>
     Summary <input type = "text" name = "summary"> </br>
     Text <input type = "text" name = "text"> </br>
     <input type = "submit" value = "Submit">
  </form>
</html>
```

Figure 2.7: Form layout and HTML document

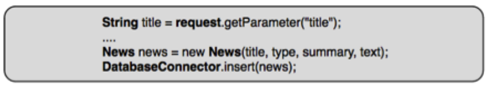
Submitting the form to the server send an HTTP request with multiple parameters, where they are divided through the & character.



```
"http://newsPortal.com/newArticleController?title=France won the EC&type=Sport&summary= ...."
```

Figure 2.8: Request with parameters

By the data entry creation the task of the controller is to get the values from the request an instantiate the class representing the data to be created. Then initialized class instance is passed to the database where the entered data will be persistently stored.



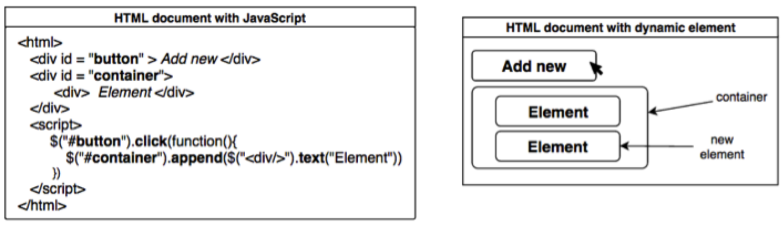
```
String title = request.getParameter("title");
....
News news = new News(title, type, summary, text);
DatabaseConnector.insert(news);
```

Figure 2.9: Example Java routine for data storage

2.1.2 JavaScript bacics

JavaScript (JS) is the programming language of the web browser. A JS code can be embedded into any HTML document between <script></script> tags. The most fundament capability of JS, is that it is capable of manipulating the elements of the web page. The following example illustrates a simple case, where clicking a button can change the page by adding a new div to an other div.

The HTML page contains with two divs with the id-s button and container. JavaScript handles each element on the page as objects. These objects can be referenced by $(“#id”) where the id is the id parameter of


HTML document with JavaScript
HTML document with dynamic element
Add new
Element
Element
container
new element

```
<html>
  <div id = "button" > Add new </div>
  <div id = "container">
     <div>  Element </div>
  </div>
  <script>
     $("#button").click(function(){
        $("#container").append($("<div/>").text("Element"))
     })
  </script>
</html>
```

Figure 2.10: Simple JavaScript example

the html tag. Thus the definition of a click event to the first div is done by writing the following code:

$("#button").click(. . . the handler function . . .)

to the script. The added function defines only one single operation, which uses the append function on the $("#container") div object. The input parameter is a new div object, created by JS with the text value Element.

2.1.3 Data in JS

In JavaScript there are not typed variable, each type variable is defined by the keyword var. In the simplest case a JavaScript variable holds a single value of a primitive type like boolean, string or number (a). Or it be an array (b) or an object (c), which is a set of key-value pairs. The following figure shows the definition of three main JavaScript variable types.

```
var a = "someText"       //Data field
var b = ["element", 3.45, false]  //Array
var c = {        //JSON Object
  name : "Bob",
  friends : ["Jack", "John"],
  studies : {
    university : "University of Freiburg",
    course : "Computer Science"
  }
}
```

Listing 2.1: JavaScript data types

Important to note the values of JavaScript object (c) can be single values, arrays or even further objects. The access of these variables are quite simple.

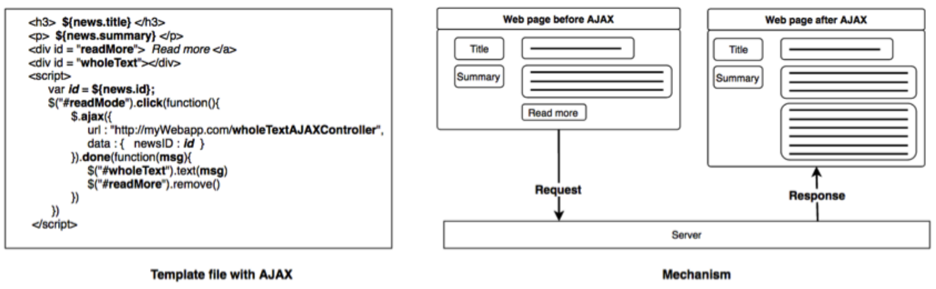
```
b[2]  —>   3.45
c.studies.course —> "Computer Science"
```

Listing 2.2: JavaScript data access

These variables can be set either through the template variables like any value in the HTML document. Or the event handler routines can assign values to the variables based on user actions.

2.1.4 AJAX

AJAX is an abbreviation for Asynchronous JavaScript And XML. This is a technology that allows the web browser to exchange data with the server without reloading the whole page. AJAX calls are initiated from JavaScript and of course JS itself is responsible for handling the response. This mechanism is where the JavaScript data plays a really important role. The following example shows and AJAX based solution for loading the whole text of an article.



```
<h3> ${news.title} </h3>
<p> ${news.summary} </p>
<div id = "readMore"> Read more </a>
<div id = "wholeText"></div>
<script>
    var id = ${news.id};
    $("#readMode").click(function(){
        $.ajax({
            url : "http://myWebapp.com/wholeTextAJAXController",
            data : {  newsID : id  }
        }).done(function(msg){
            $("#wholeText").text(msg)
            $("#readMore").remove()
        })
    })
</script>
```

Figure 2.11: Loading new element through AJAX

The example from the image illustrates extends the previous case so that the click function contains the AJAX call. This call is practically the same as basic request from the <a/> tag in HTML. It has a URL and a data object. The data object in this example consists of only one key-value pair, with the key newsID. The value is the JavaScript variable id, whose own value was set at the beginning of the script part by $news.id template variable. This is the way that Java variables can be passed the JavaScript variables. The done function of the AJAX routine defines what has to be done with the data that arrives. The response data coming from the server is accessible in the msg variable. In the example we assume the server return only the string of the whole text, which will be set as the text of the new div.

2.2 Semantic Web

2.2.1 RDF

In RDF, abbreviation for Resource Description Framework, the information of the web is represented by means of triples. Each triple consists of a subject, predicate and object. The set of triples constitute to an RDF graph, where the subject and object of the triples are the nodes, the predicates are the edges of the graph. An RDF triple is called as well statement, which asserts that there is a relationship defined by the predicate, between subject and the object. The subjects and the objects are RDF resources. A resource can be either an IRI (Internationalized Resource Identifier) or a literal or a blank node (discussed later). A resource represents any physical or abstract entity, while literals hold data values like string, integer or datum. Basically there are two types of triples, the one that links two entities to each other, and the other that links a literal to an entity. The former expresses a relationship between two entities, and the latter in turn assign an attribute to the entity. Common practice is to represent IRI with the notation prefix:suffix, where the prefix represents the namespace, and the expression means the concatenation of the namespace denoted by the prefix, with the suffix. This convention makes the RDF document more readable. The namespace of RDF is the http://www.w3.org/1999/02/22-rdf-syntax-ns#, whose prefix is in most cases "rdf". This is defined on the following way:

@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>.

Literals are strings consisting of two elements. The first is the lexical form, which is the actual value, and the second is the data type IRI. RDF uses the data types from XML schema. The prefix (commonly xsd) is the following :

@prefix xsd: <http://www.w3.org/2001/XMLSchema#>.

So a literal value in RDF looks as follows:

"Some literal value"^^xsd:string

The RDF vocabulary provides some built-in IRIs. The two most important are, the rdf:type property, and the rdf:Property class. The meaning of the triples, where the predicate is the property rdf:type is that the subject IRI is the instance of the class denoted by the object. Therefore the following statement holds in the RDF vocabulary:

rdf:type rdf:type rdf:Property.

It is maybe confusing that an IRI appears in a triple as subject and predicate as well, but we will see by the RDFS vocabulary that it is inevitable to express rules of the language. To be able to represent information about a certain domain, it is necessary to extend the RDF vocabulary with properties and classes. The classes will be discussed in the next section, but here it is explained how custom properties can be defined. The namespace of the example is the following:

@prefix eg: <http://example.org#>.

The example dataset intends to express information about people, which university they attend and how old are them. To achieve this two properties are needed:

eq:attends rdf:type rdf:Property .
eq:age rdf:type rdf:Property .

The actual data about a person:

eg:JanKlein eq:attends eq:UniversityOfFreiburg .
eg:JanKlein eq:age "21"^^xsd:integer .

2.2.2 RDF Schema

The previous section gave an insight into RDF world by showing how can information stored by means of triples. However the explanation did not mention that each RDF dataset has to have scheme, which is also called ontology. The ontology describes the set of properties and classes and how

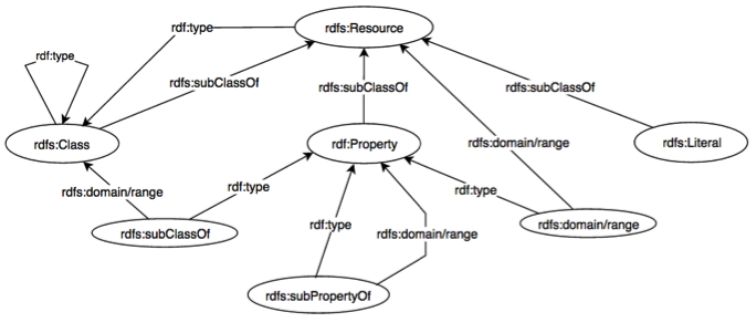


Figure 2.12: Main structure of the RDFS vocabulary

are they are related to each other. RDFS provides a mechanism to define such ontologies using RDF triples. The most important elements of the RDFS vocabulary can be seen on the following image.

The two most important classes in the RDFS vocabulary is the rdfs:Class and the rdfs:Resource. The rdfs:Class is class, because it is the instance of itself, and the same way the rdfs:Resource is a class. The rdf:Propery and the rdfs:Literal are both classes as well. The rdfs:domain, rdfs:range, rdfs:subPropertyOf and rdfs:subClassOf are properties. Important to note that these properties are subjects and predicates in the same time in the RDFS vocabulary graph. Also they describe themselves like rdf:type. The properties rdfs:domain and rdfs:range describe for the property the type of the subject and object respectively, which with it can build a triple as predicate. The following image illustrates their meaning:

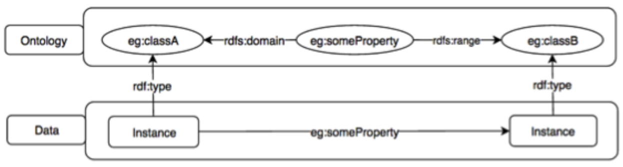


Figure 2.13: RDFS domain and range definition

Since both the rdfs:domain and rdfs:range are properties themselves, they have as well their domain and range, which is the class rdfs:Resource. The property rdfs:subClassOf expresses subclass relationship between classes. It means if a class B is a subclass of class A, and resource R is the instance of class B, then resource R is the instance of class A as well. Since it describes the relationship between two classes its both domain and range is the class rdfs:Class. The property rdf:subPropertyOf expresses the relationship between two properties. If property P2 is sub property of P1 and two instances are related by P2 then they are related by P1 as well. Its domain and range is the class rdf:Property. Now everything is given to define the ontology for the example of the previous section.

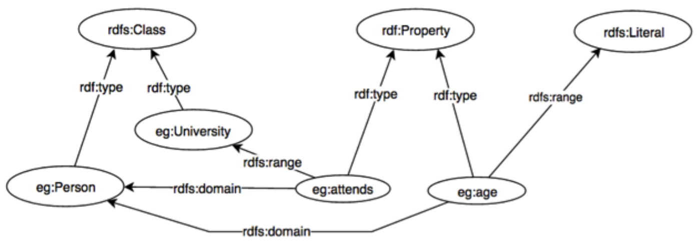


Figure 2.14: RDFS domain and range definition

2.2.3 OWL

OWL, abbreviation for Ontology Web Language is an extension of the RDFS vocabulary. OWL allows expressing additional constraints on the data, above the range and domain definitions. These constraints are called restrictions. Restrictions are conventionally expressed by blank nodes. Blank nodes do not have IRIs, but it is defined through the triples in which they participate as a subject. For example a restriction stating that the instances of the class eg:FootballTeam can build a triple through the eg:hasPlayer property only with the instances of eg:FootballPlayer class can be expressed the following way:

```
eg:FootballTeam  rdfs:subClassOf   [
  rdf:type       owl:Restriction  ;
  owl:onProperty      eg:hasPlayer  ;
  owl:allValuesFrom  eg:FootballPlayer  ]  .
}
```

Listing 2.3: OWL restriction in N3 format

owl:Restriction is class and owl:onProperty and owl:allValuesFrom are properties. It can be seen that class, on which the restriction applies is the subclass of the restriction blank node. Furthermore OWL is capable of expressing qualified cardinality restriction. For example the statement that a basketball team has to have exactly five players, look as follows in OWL:

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX eg: <http://example.org>

eg:BasketballTeam rdfs:subClassOf [
  rdf:type  owl:Restriction ;
  owl:onProperty  eg:hasPlayer ;
  owl:onClass   eg:Player ;
  owl:qualifiedCardinality "5"^^xsd:nonnegativeInteger ] .
```

Listing 2.4: OWL restriction in N3 format

These two examples cover the thesis related features of OWL. The next image depicts the OWL vocabulary.

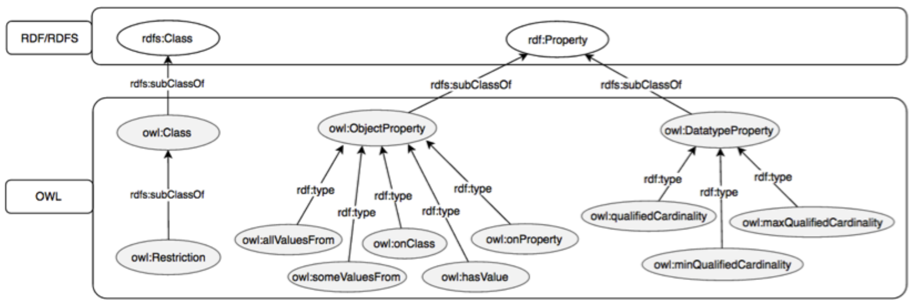


Figure 2.15: A subset of OWL vocabulary

There are two new class types are the owl:Class and the owl:Restriction. The rdf:Property has two subclasses, the owl:ObjectProperty and owl:DataTypeProperty. owl:ObjectProperty represent the properties that links instances to instances, and the owl:DataTypeProperty is those that link instances to literals. The following two images shows the domain and range definitions of the OWL properties used to describe restrictions.

2.2.4 SPARQL

SPARQL is a query language for querying data in RDF graphs. A SPARQL query is a definition of a graph pattern through variables and constants. The following example query returns all IRIs that represent a football player:

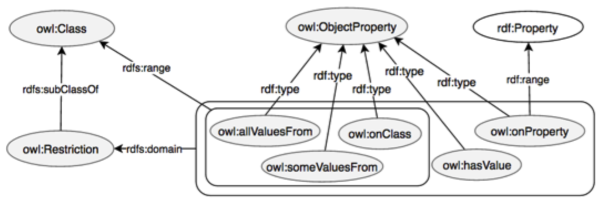


Figure 2.16: OWL object properties

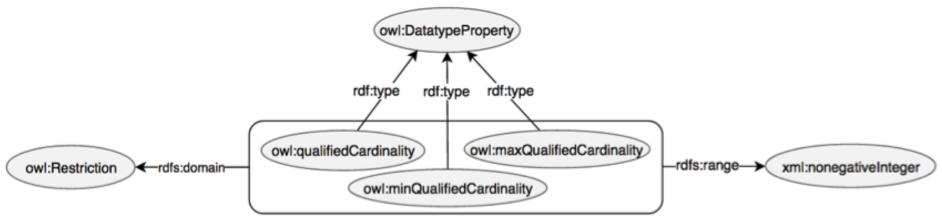


Figure 2.17: Properties for qualified cardinalities

```
SELECT ?player
WHERE {
  ?player   rdf:type   eg:FootballPlayer .
}
```

Listing 2.5: SPARQL Query I.

In the example the query consist of only one triple. The subject is a variable and the predicate and the object are constant. Therefore the triple store looks all the triples and checks the predicate is rdf:type and the object is eg:FootballPlayer. It is well possible to not just ask the IRI of the players but further information by adding additional triples to the query in order to ask the name for example of the player:

```
SELECT ?player ?name
WHERE {
  ?player   rdf:type   eg:FootballPlayer .
  ?player   eg:name    ?name .
}
```

Listing 2.6: SPARQL Query II.

The result table in this case will contain two columns, one with the IRI of the person and one with their name. Important that it is as well possible to query blank nodes by introducing a variable for it. So if we want to list all the instances that are coming into question as player to a football team we can formulate the following query:

```
SELECT ?person ?name
WHERE {
  eg:FootballTeam rdfs:subClassOf   ?restriction .
  ?restriction  rdf:type    owl:Restriction .
  ?restriction  owl:onProperty    eg:hasPlayer .
  ?restriction  owl:allValuesFrom ?playerType .
  ?player   rdf:type    ?playerType .
  ?player eg:name ?name .
}
```

Listing 2.7: SPARQL Query III.

2.3 VIVO Framework

VIVO is an open source web application framework, developed particularly for browsing and editing RDF data. VIVO utilizes that the data scheme in RDF is stored by means of triples as well, and it can adopt its pages to the ontology. It offers an ontology editor and there are particular features of the application that can be customized through a specific configuration dataset. This dataset is in RDF too, and describes the way in which the data is displayed and can be edited on the web pages. VIVO allows to manipulate this configuration triples via the web interface, which enables the extension of the application to some extent conveniently without any coding. Finally there is a possibility to import any RDF file to VIVO's triple store.

2.3.1 Class groups

One important feature of the VIVO framework is the possibility to order the classes of the ontology into so-called class groups. If a class is assigned to a class group then it appears in the list of the admin panel, which is used to select the type of the new instance.

Further possibility of class groups that it is possible to create links on the main menu (can be seen on the top of Figure 2.19), which redirects to a page where all the instances are listed that belong to one of the classes of

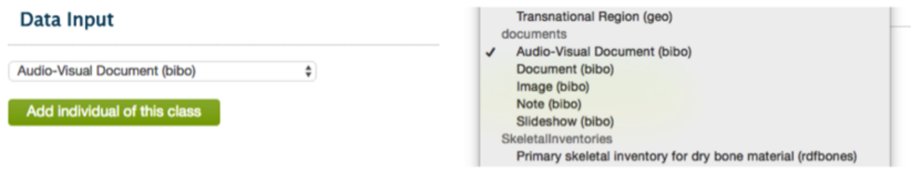

Data Input
Audio-Visual Document (bibo)
Add individual of this class
Transnational Region (geo)
documents
✓ Audio-Visual Document (bibo)
Document (bibo)
Image (bibo)
Note (bibo)
Slideshow (bibo)
SkeletalInventories
Primary skeletal inventory for dry bone material (rdfbones)

Figure 2.18: Document class group on the admin panel

the class group.

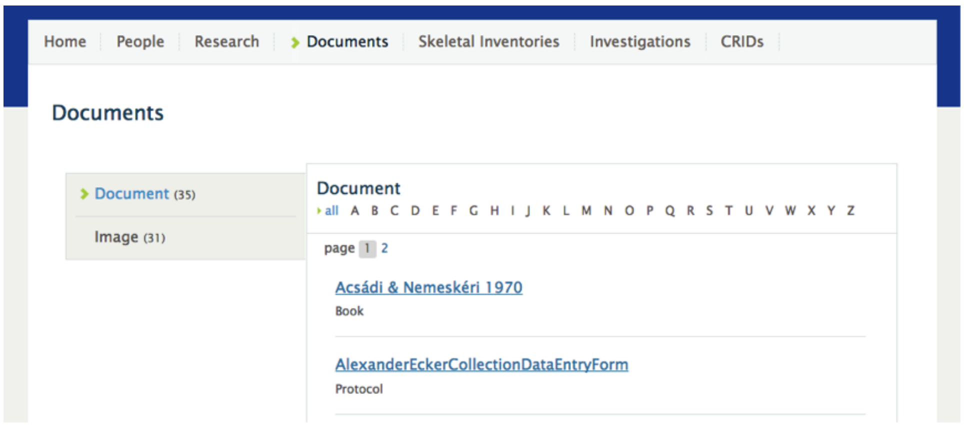


Figure 2.19: VIVO class group page for documents

The application configuration showed in the last two images is defined by the set of configuration triples on Figure 2.20.

There are three instances of the classes display:NavigationElement, display:ClassGroupPage and for vitro:ClassGroup. The triples itself are self-explanatory, but important to note that property vitro:inClassGroup is the one that connects the configuration dataset to the domain ontology.

2.3.2 Profile Pages

A profile pages in VIVO displays information about a particular RDF instance. These pages can be reached by clicking one of the entries of the list on the class group pages. The profile page organizes data connected to the individual into tabs. Each tab displays the properties of a specific property group. Figure 2.21 shows a screenshot from the profile page under the Overview tab.

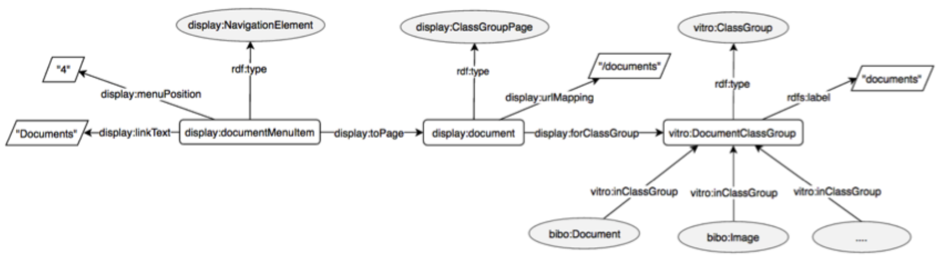
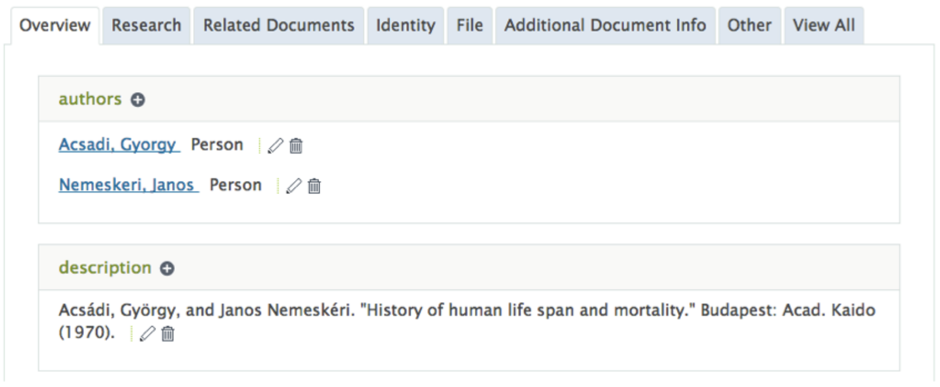


Figure 2.20: RDF configuration data in VIVO



Acsádi, György, and Janos Nemeskéri. "History of human life span and mortality." Budapest: Acad. Kaido (1970).

Figure 2.21: VIVO profile page layout

As it was already addressed this page adopts to the ontology by querying the properties whose domain or range is the type of the instance to display. The properties bibo:author and vivo:description are assigned to the property group overview, and they appear on the page only because the both have the domain bibo:Document class.

An additional important feature of VIVO is the definition of so-called faux properties. They are really similar to the rdfs:subProperty, but they are considered by the profile pages.

2.3.3 Default Data Entry Forms

On Figure 2.22, next to the predicate labels (authors, description) there are plus image elements, which are a links. These links redirect the user to data entry forms where new triple can be added.

They initiate the HTTP request depicted on Figure 2.23. The server gets with which subject and predicate the triple has to be created.

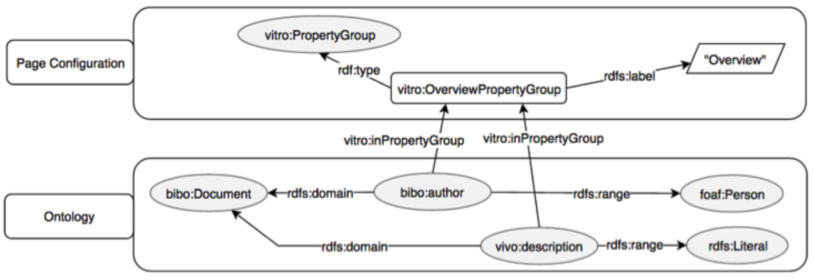
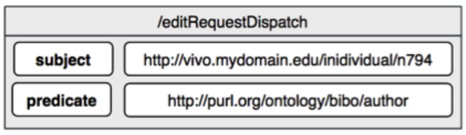


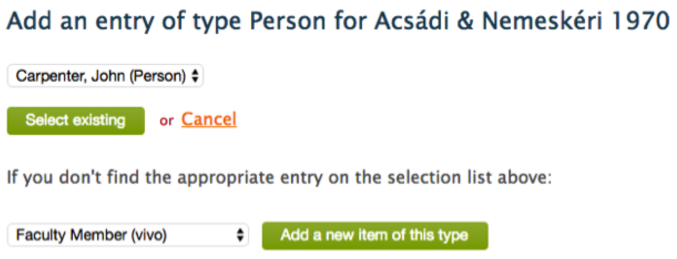
Figure 2.22: Triples contributing to the displayed profile page layout



/editRequestDispatch	
subject	http://vivo.mydomain.edu/inidividual/n794
predicate	http://purl.org/ontology/bibo/author

Figure 2.23: HTTP request for data entry form

The subject of the triple is the instance; from whose the profile page the request has been initiated. The predicate is the property to which the link belongs. The data entry forms allows the user to set the object of this triple. By the property bibo:author the domain is the class foaf:Person, thus application offers each existing instance of this class to select, or allows to add a new instance as an object.



Add an entry of type Person for Acsádi & Nemeskéri 1970

Carpenter, John (Person)

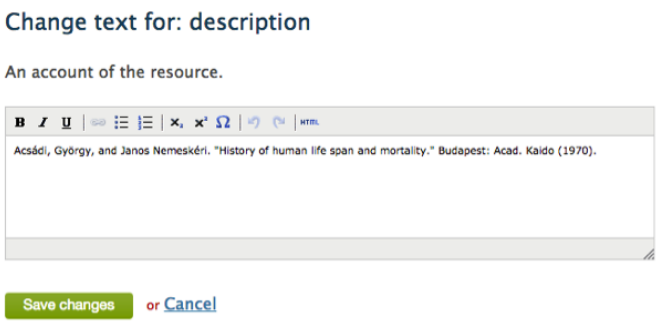
Select existing or Cancel

If you don't find the appropriate entry on the selection list above:

Faculty Member (vivo) Add a new item of this type

Figure 2.24: Object property entry form for bibo:author

In the case of the property vivo:description, the domain is the class rdfs:Literal thus the entry form displays a text input field.



Change text for: description

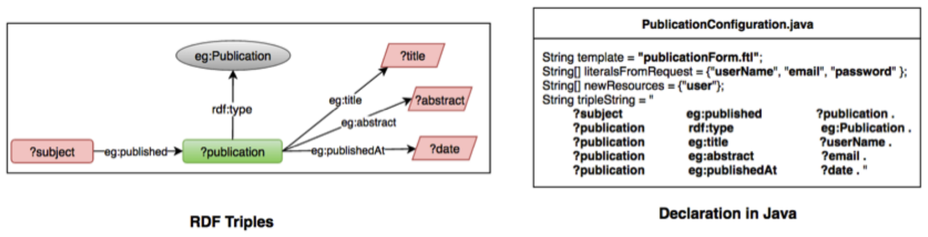
An account of the resource.

Acsádi, György, and Janos Nemeskéri. "History of human life span and mortality." Budapest: Acad. Kaido (1970).

Figure 2.25: Data property entry form

2.3.4 Custom Entry Forms

VIVO allows the editing of the triples through default entry forms only one by one. However it is often the case that it desired to add multiple triples, thus larger dataset by one entry form. This is as well possible in VIVO through custom entry form definition. Let assume an entry form, which let the user add new publications to person instance. About the publication its title, abstract and the date of publishing can be stored. The left part of following image shows dataset of the example. The red nodes denote the variables that are coming as input from the entry form; the green means that its value has to be an unused IRI, and the grey stands for constants.



```
String template = "publicationForm.ftl";
String[] literalsFromRequest = {"userName", "email", "password" };
String[] newResources = {"user"};
String tripleString = "
      ?subject            eg:published         ?publication .
      ?publication        rdf:type             eg:Publication .
      ?publication        eg:title             ?userName .
      ?publication        eg:abstract          ?email .
      ?publication        eg:publishedAt       ?date . "
```

Figure 2.26: Data definition graphical (left) and lexical (right)

dataDef

The variable ?subject is the instance from whose profile page entry form was called. To declare the information held by the graphical representation of the triples from Figure ??, three static Java variables are needed. Two arrays of string for the inputs and new resources (literalsFromRequest, newResources) and a string for the triples (tripleString). Moreover the configuration class has an additional variable for defining the template file for the form layout (VIVO uses Freemarker template engine, and the .ftl extension stands for Freemarker Template File). The last step towards the definition of the custom entry form is to connect the property eg:Published with the predicate vitro:customEntryFormAnnotation to the literal value that holds the name of the entry form configuration class.

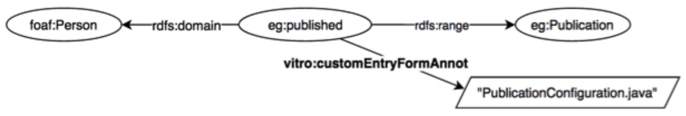


Figure 2.27: Definition of custom entry form configuration class

Chapter 3

Problem Statement

3.1 Challanges of the RDFBones project

3.1.1 Human skeleton

The subject of the anthropological investigations is primarily human skeletal remains. To be able to create data about these remains, first of all an ontology is required. As the human skeleton is complex, the ontology is not developed by us, but an existing have been taken. The used ontology is the subset of FMA (Foundation Model of Anatomy) ontology. For us the two most important classes are the following:

- Subdivision of skeletal system - fma:85544
- Bone Organ – fma:5018

The class *Bone Organ* is the superclass of all bones in the human skeleton. Each bone belongs to a skeletal subdivision and a skeletal subdivision can be a part of another skeletal subdivision. This relationship in both cases is expressed by the property *fma:systemic_part_of*. To define which bone organ belongs to which skeletal subdivision FMA uses OWL restrictions.

In our project the most important element is the skull. Figure 3.3

To implement an entry form that allows the user to create such triple set takes considerably more effort then the cases explained in the previous sections, because not only key value pairs has to be sent from the client to the server, but a multi dimensional dataset. Like this:

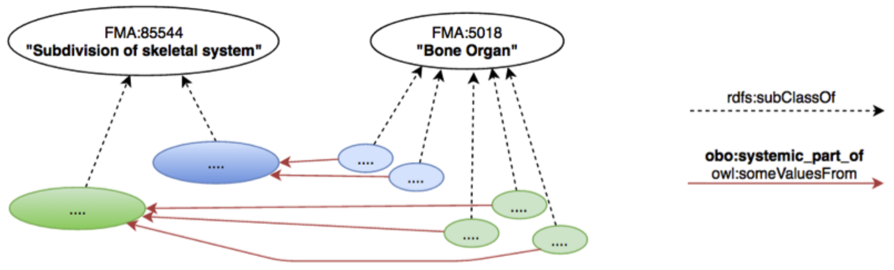


Figure 3.1: Ontology structure for skeleton

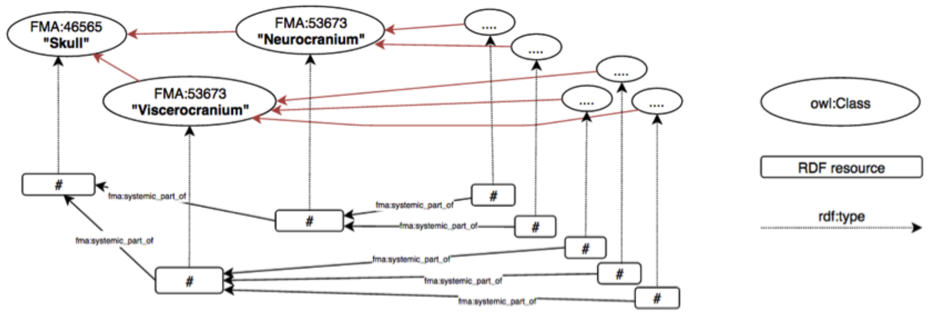


Figure 3.2: RDF Triple representation of a skull

```
{
  skeletalSubdivisionUri : "FMA:46565",
  sytemic_parts : [{
    uri : "FMA:53672",
    systemic_parts : [{
      uri : "FMA:52788",  //Right parietal bone
    } , { ... }]
  } , { ... }
  ]
}
```

Listing 3.1: Form data representing skull

Here the really important point the not only values are added like the simple form of the previous examples, but some elements can be added or just or just leaved. This leads to more dynamic interfaces.

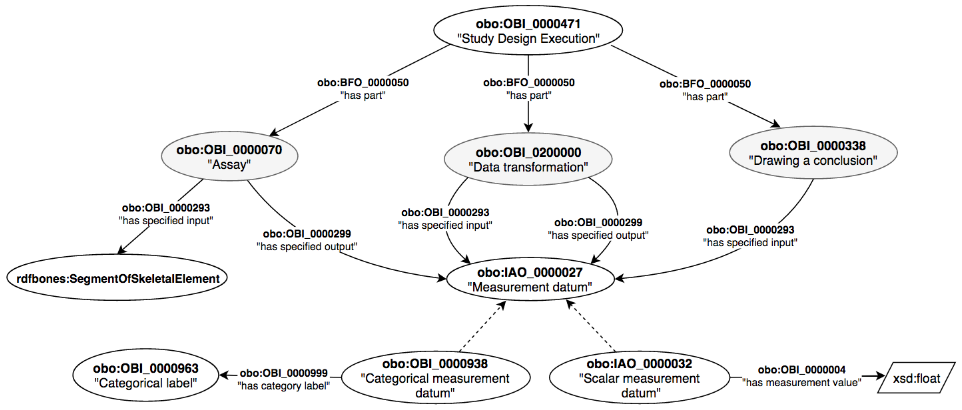


Figure 3.3: RDF Triple representation of a skull

3.1.2 Study Design Execution

In most investigations the researcher take a set of bones belong to one individual and examine different tokens. Tokens refer to specific features of parts or regions of bones. These token have particular expressions.

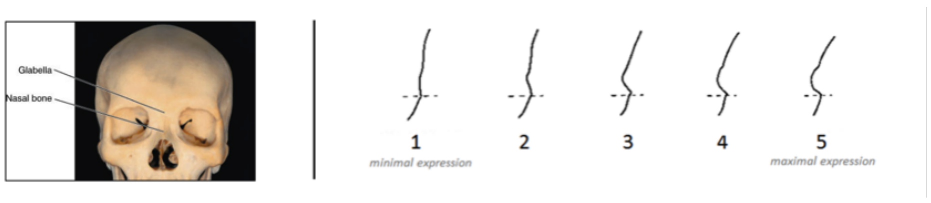


Figure 3.4: Glabella and its expressions

The previous images show the token called glabella, and its expressions. The task of the web application is let the researcher select one of the already added Nasal Bones (because on that bone is the glabella token), and set the expression of it. The following data structure models the process.

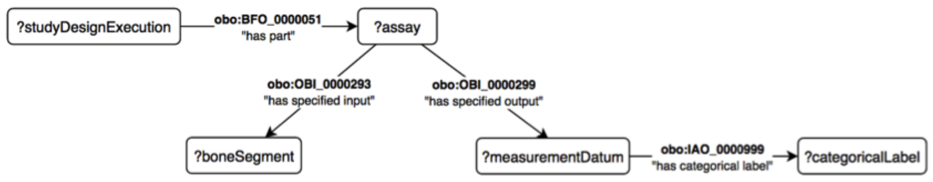


Figure 3.5: Study Design Execution Data Structure

Where the variable ?categoricalLabel represents the expression of the token. The values this variable can take are defined in the ontology extension. The variable ?boneSegment is the bone on which the glabella can be found. This instance won't be as well newly created, but an already added bone has to be selected on the interface. The ?assay and the ?meausurementDatum variables are new instances. To be able to generate an entry form for the problem, the following ontology extension has to be defined.

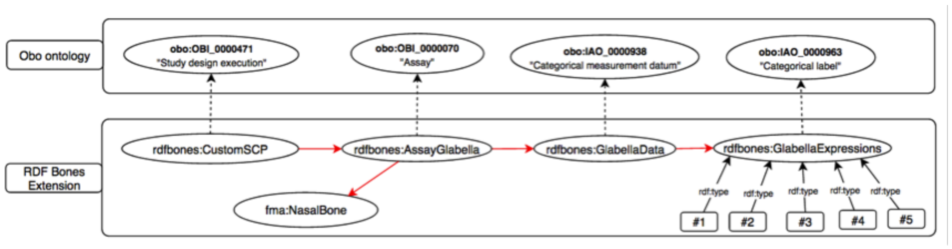


Figure 3.6: Ontology extension for Glabella

Mention that the task of the user is to add some elements if they exists or not.

3.1.3 Ontology Extensions

It is often the case that in an investigation not only the bone itself, but also particular segments has to be addressed. However the bone segments of the bones are not standard, and they can differ according to researcher or research project. Therefore FMA do not contain any bone segment of the bone organs, and consequently we have to define it on our own. Important that the skeletal subdivision instances do not appear on the dataset on their own, but they are connected to Skeletal Inventories. Skeletal inventories are used to gather information about particular skeletal remains. The following image show the triple structure of skeletal inventories.

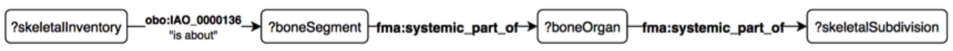


Figure 3.7: Skeletal Inventory Data Structure

The variable ?skeletalInventory is the instance of the class rdfbones:SkeletalInventory, while the ?boneSegment is from the class rdfbones:SegmentOfSkeletalElement.

The core ontology of the project contains a subclass of the rdfbones:SkeletalInventory, the rdf:PrimarySkeletalInventory. This skeletal inventory type is for skeletal remain collections where only the whole bone organs have to be addressed. The way to define custom bone segments is always through a custom skeletal inventories, which contains restrictions on the property obo:isAbout and on the class of custom bone segments. Of course the custom bone segments has to be assigned to the bone organ class they belong to, via restrictions on property obo:systemic_part_of. The following image illustrates the extension definition.

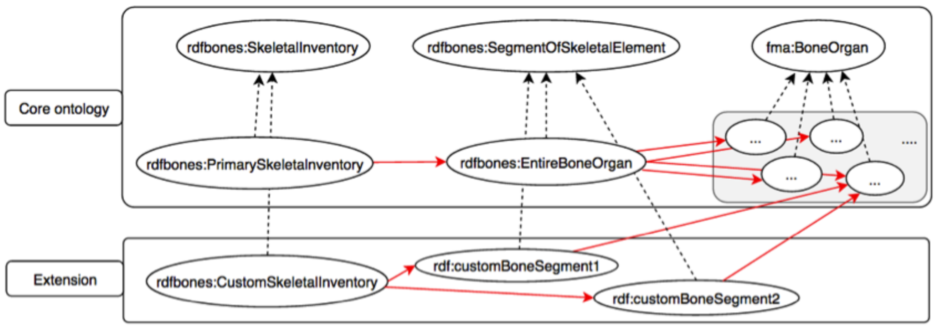

Core ontology
Extension
rdfbones:SkeletalInventory
rdfbones:SegmentOfSkeletalElement
fma:BoneOrgan
rdfbones:PrimarySkeletalInventory
rdfbones:EntireBoneOrgan
rdfbones:CustomSkeletalInventory
rdf:customBoneSegment1
rdf:customBoneSegment2

Figure 3.8: Ontology extension scheme

As these extensions are expressed by OWL restriction the application can query the definitions. Consequently if the custom entry form is called from the profile of a skeletal inventory instance, then the entry form processor routine can ask, what bone segment are defined to the type of the subject variable coming as input, and can offer them on the interface.

3.2 RDF Data input

3.2.1 Multi dimensional form

As it was addressed in the previous section each data input process of the application can be modeled by means of a tree style data structure. This means in terms of the data of the form, that just single key-value pairs like by the static HTML form is not sufficient for the problem. Therefore the task is provide such an interface that allows the user to add dynamically subforms, whose data object will be stored in arrays. Figure 3.10 illustrates the idea of the structure.

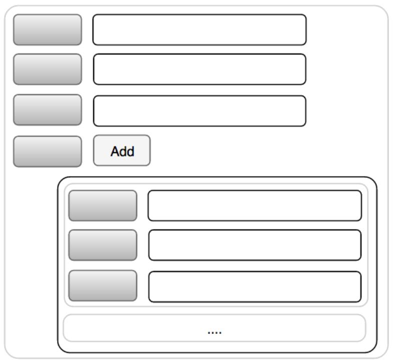


Figure 3.9: Multi dimensional form layout

So the forms consist of the selectors, and literalfield explained in the Chapter 1., but with an additional element that add further subforms. To achieve this JavaScript routine is required that adds the elements automatically and fills the form object with the data. The produced data of the form is looks as follows.

```
{
  key1 : "value1",
  key2 : "value2",
  ...
  subFormKey1 : [
  {
    key1_1 : "value1_1",
    ...
  }, { ... }]
}
```

Listing 3.2: JSON object of the form

3.2.2 Form dependencies

These dependencies can occur not only between subforms but as well by in form dependencies where the selector elements can change based on selections.

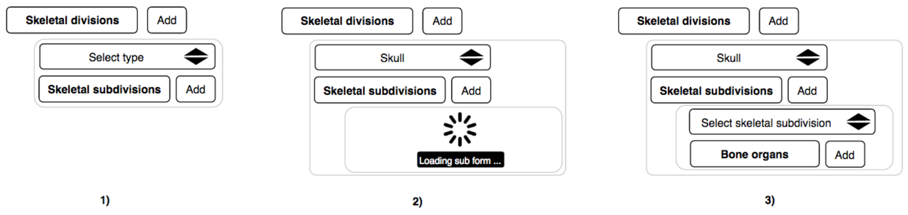


Figure 3.10: Subform dependencies

3.2.3 Instance browsing

- Figure 3.11 shows a further option for instance selection.

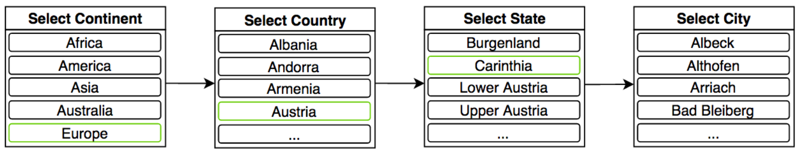


Figure 3.11: Navigator example

- The implementation requires on the server side query and the grouping of the result
- Client side - programming the navigator window

3.2.4 Validation

As by each form there is required field - required - restrictions The client has to get the information, about restrictions, and so

3.2.5 Editing form data

As it was already addressed in section 2.3.4, the dataset created by the forms have to be edited as well. By editing, the HTTP request calling the entry form contains an additional field, namely the *objectUri*. Based on the data model of the form, the server has to prepare the dataset, in our case a JSON object. The challenge of the server implementation is that in such multi dimensional dataset, it is not sufficient to perform only one query for the whole form data.

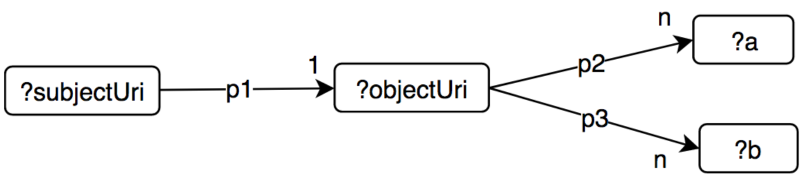


Figure 3.12: Example data model

?a	?b
a1	b1
a1	b2
a2	b1
a2	b2

Table 3.1: SPARQL Result

```
SELECT ?a ?b
WHERE {
  ?objectUri    p1    ?a .
  ?objectUri    p2    ?b .
  FILTER ( ?objectUri = <inputParameter>)
}
```

Listing 3.3: SPARQL query for the form data

The example data model from Figure 3.12 helps to understand the problem in more detail. If the SPARQL query on Listing 3.3 for variables ?a and ?b with incoming *objectUri* value were executed, then result table of the query is inconvenient to process. For example if there are two instances for both ?a and ?b present in the dataset, then the result table contains $2 \ x \ 2 = 4$ elements (Table 3.1).

Therefore the data object of the form has to be retrieved gradually, by dividing the data model graph by the predicates, whose cardinality is larger than one.

The next step after that the server has prepared the multi dimensional JSON object for the client, is to restore the state of the form, in which it was submitted by the user. This requires firstly the filling of the fields with the existing values, and adding the sub forms based on the arrays. Secondly the options of the selectors must be loaded, so that they conform to the dependencies explained in section 3.2.2.

Finally if a value of selector or literal field changes, or new sub forms has to be added or removed, the entry form data should not be completely sent again to the server, but only the data fields that are concerned by the modification. Thus it does not require a complete page reload, and these operation can be performed through AJAX calls. To achieve this the client has to be prepared to be able to send data modification requests to the server on change event of any form element or sub form.

3.2.6 Saving data

Appendix A

Glossary

Just comment `\input{AppendixA-Glossary.tex}` in Masterthesis.tex if you don't need it!

Symbols

$	US. dollars.

A

A	Meaning of A.

B

C

D

P

Q

R

S

T

U

V

W

X

Appendix B

Appendix

B.1 Something you need in the appendix

Just comment `\input{AppendixB.tex}` in Masterthesis.tex if you don't need it!

Erklaerung

Hiermit erkläre ich, dass ich diese Abschlussarbeit selbständig verfasst habe, keine anderen als die angegebenen Quellen/Hilfsmittel verwendet habe und alle Stellen, die wörtlich oder sinngemäß aus veröffentlichten Schriften entnommen wurden, als solche kenntlich gemacht habe. Darüber hinaus erkläre ich, dass diese Abschlussarbeit nicht, auch nicht auszugsweise, bereits für eine andere Prüfung angefertigt wurde.

Ort, Datum	Unterschrift

Bibliography

[1] Marcelo Arenas, Claudio Gutierrez, and Jorge Pérez. On the semantics of sparql. In *Semantic Web Information Management*, pages 281–307. 2009.