Creating Virtual Exhibition Rooms from Emigration Digital Archives

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Abstract. In the context of a research and development project, the authors are cooperating with a municipal Archive aiming at supporting the preservation of physical documents, and at facilitating the information extraction and dissemination. Saving individual records, such as emigration documentation, it is important for end-users, and History or Social Sciences Researchers as they can know more about each individual and they can learn about society. Using the Internet resources, the information stored in digital format may be brought forward on Web pages displaying it to the end-users and enabling them to learn and interact with the available information, creating knowledge. The long-term goal is to automatize the creation of these web-sites, so-called Learning Spaces, from high-level descriptions. This paper discusses the creation of Virtual Exhibition Rooms (VER) from ontological descriptions of the Emigration Digital Archives. It presents the data retrieved from documents and stored in a digital repository, and then proposes the use of the CIDOC Conceptual Reference Model (CIDOC-CRM) ontology (a standard in the area of Museums knowledge representation). That ontology will provide a higher level of description, where concepts are enhanced (instead of data items and low-level relationships holding among them). SPARQL Protocol and RDF Query Language (SPARQL) is then used to query the Resource Description Framework (RDF) triple-storage; eXtensible Stylesheet Language Transformations (XSLT) and Cascading Style Sheets (CSS) allow to create templates that are used to automatically build the VER that is a conceptual navigator over the repository.

Keywords: Virtual Emigration Museum, Web-based Learning Spaces, Exhibition Rooms, Ontology

1 Introduction

Virtual Exhibitions Rooms, such as virtual classrooms, virtual seminars, virtual museums, improve learning experience by supporting learning at flexible locations and time, for instance at leisure time, and so on [1].

Traditional Learning Spaces are physical locations, usually within schools and universities. These spaces generally contain groups of people (usually students) debating about a specific subject and someone (usually a professor) who leads the debate, organizing behaviors through formal methods of education, to impart knowledge to the group. Also at cultural institutions, physical rooms exposing objects with information (material or immaterial things [2]), arranging them in order to convey a message to the visitor or the attendants [3][4], are traditional Learning Spaces. So it can be argued that any physical space that features knowledge sharing can be considered a learning space (LS); exhibition rooms are a kind of LS.

However, an important part of people's knowledge is not acquired through formal methods of education in a classroom. Learning also occurs during leisure time outside the classroom, using the laptop, smartphone or any device to socialize with other people, as well as in snack bars at breakfast or lunch time, travelling on a train, in family moments, in a simple walk and also in visits to museums, libraries and the like [5]. So, these new electronic devices and computer-based systems shall also be considered Learning Spaces, because a large range of people (not only students) are using these new media as virtual spaces to generate and acquire knowledge.

Notice that, following the definition above, the term e-Learning should not be applied in this context to avoid misunderstandings, because it is usually used to describe LS just for students enrolled in distance education, which is not within the scope of this paper [6].

According to this approach, Virtual Exhibition Room is considered as a website where the information is arranged in such a way that the visitor learns with it. This perspective differs from the traditional concept of virtual museums that are similar to real museums offering a 3D virtual tour [7][8]. To achieve these virtual Exhibition Rooms, data about the target domain should be stored in a way that it can later be processed and displayed to the learner in the best possible way.

The domain covered in this paper is about Emigration documents. The purpose is to use the information stored in an emigration relational database[4] to create Virtual Exhibition Rooms.

This paper presents the authors' contribution in terms of describing in an ontology the emigration domain and creating a VER that is a conceptual navigator over the emigration repository. Subsection 1.1 presents the contextualization of this work under CaVa project. Section 2 outlines how emigration data is stored

[4] Described in the paper entitled "Storing Archival Emigration Documents to create virtual Exhibition Rooms" accessible in http://link.springer.com/chapter/10.1007/978-3-319-16486-1_40

and conceptually organized. Section 3 discusses the automatic generation of a VER with the aid of templates in eXtensible Stylesheet Language Transformation (XSLT) and Cascading Style Sheets (CSS). Finally, Section 4 summarizes what was developed and describes the future work to create VER with the assistance of a Domain Specific Language.

1.1 CaVa, an overview

The work presented in this paper is part of a PhD project called CaVa (Criação de Ambientes Virtuais de Aprendizagem) to automatically create virtual Learning Spaces. Figure 1 illustrates the proposed architecture to achieve the final goal.

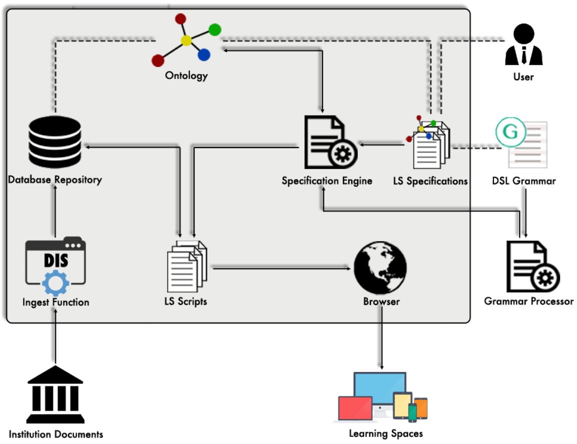


Fig. 1. Proposed Architecture of CaVa Project

The *ingest function* with the aid of a *Document Ingestion System* (DIS) to upload and manage the document's data is essential as the initial layer of CaVa, because this component is responsible for the electronic storage of the emigration documents that are later used to generate the virtual learning spaces. A web-based application called SGPE (Sistema Gerenciador de Processos de Emigração), an implementation of DIS for a concrete case study (the Emigration Museum) was developed and already described in [9].

As can be seen in Figure 1, the ontology, the specification engine and the browser are the necessary components besides SGPE to achieve the objective. The ontology serves to describe and to relate semantic concepts of a specific domain, in addition to connecting these concepts with the digital objects stored in the database. The specification processor transforms the formal description of the learning spaces into scripts. Finally, the generated scripts are processed by the web browser to render the final learning spaces.

2 Emigration Data

In order to define the principles for the protection of the emigrant, the Portuguese Decree-Law 36 558 of October, 28th, 1947 created *Junta da Emigração*, a department to treat of "all due diligence and preparatory formalities of boarding of any emigrant and of their application forms"[5] [10], although later, this department was unable to deal with all the applications of the emigration in Portugal. Then its tasks were reduced to the appreciation of passport applications that started to be processed and archived locally at the Municipal Departments [11].

Therefore, the emigration documents characterized in this paper are restricted to those that describe the emigrants' data needed to apply for a passport. These files contain information such as general data of the document itself (document identification), general data about the emigrant, list of attached documents, family members accompanying the emigrant, desired type of transportation, qualifications (academic and professional) and criminal records, family members in charge of the emigrant who remain in the country, previous travel abroad, details of the person calling the emigrant, employment contract, aid in the destination country, among other information. All these data items (more than 80) must be provided to get a passport; some fields are atomic (strings, numbers, or dates); some fields are lists; some of them are compulsory while others are optional.

The fond of Emigration documents is dated from 1960s to 1970s and belongs to Fafe city Archive. As previously said, this large set of data items has a big potential to describe each individual integrated in the society of his/her epoch, also providing knowledge about the society in a precise context of the country or world history.

2.1 Data Representation as Relational Repository

To store these passport application data, a relational database was created. The database implemented covers the data items described above, which are necessary to obtain an emigration passport. The model designed with sixteen tables is the result of the normalization of the high-level conceptual schema firstly drawn, centered on tables *Processo* – that details the general data about the emigration documents – and *IdentificacaoEmigrante* – that details the general data about the emigrant.

The construction of this database was of great importance for this project, because storing the emigration documents in a database is a good way to preserve them and to later create Exhibition Rooms, disseminating the emigrations data in an easier way to handle than the physical documents.

[5] See also: `https://dre.pt/application/file/635905`

2.2 Data Representation as an Ontology

Already mentioned, to generate the virtual Exhibition Rooms, which have the objective of transmit knowledge about a specific domain to the end-users, it is necessary to describe the knowledge implicit in the information contained in the sources, that are emigration documents in the present case study.

According to the World Wide Web Consortium (W3C), “the ultimate goal of the Web of data is to enable computers to do more useful work and to develop systems that can support trusted interactions over the network”[6]. Thus, it can be inferred that one of the most important things in the virtual world is to give semantics to the classic “Web of documents”. To the present domain it is not different. Giving semantics to the data stored in the relational database makes simple data become valuable information about the emigration movement, and opens the chance to reach the knowledge, which is the main goal in this work.

To get this, the emigration repository is represented in a standard ontology known as Comité International pour la Documentation Conceptual Reference Model[7] (CIDOC-CRM), which describes the Cultural Heritage domain. As it was decided to reuse an existent ontology for the museums domain, it was not necessary to choose a methodology — as described in [12][13][14][15] — for the creation of a new ontology.

In the present project, CIDOC-CRM[8] is used to provide an abstraction of the emigration content stored in a relational database. CIDOC-CRM is an event-based ontology and its core can be seen in Figure 2.

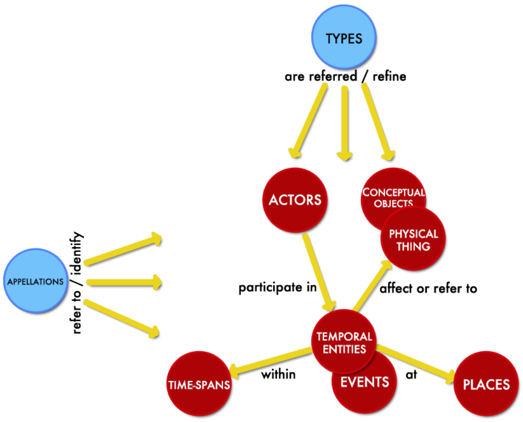


Fig. 2. The core structure of the standard ontology CIDOC-CRM (adaptated from [16])

[6] http://www.w3.org/standards/semanticweb/

[7] http://www.cidoc-crm.org/

[8] The use of CIDOC-CRM in this work is considered a *reduced CRM-compatible form*.

To demonstrate the use of CIDOC-CRM within the scope of the present work, an example of its application to the emigration domain (schematized in Figure 3) will be presented in the following.

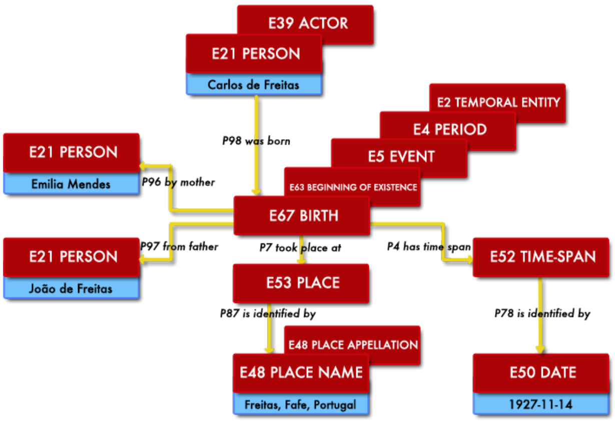


Fig. 3. Example of an instantiation of CIDOC-CRM ontology

This example demonstrates the representation of an event describing the birth of the emigrant (Carlos de Freitas) and the other actors (people related: parents), time-span (birthdate), and place.

The main classes (concepts) are denoted in red with the capital letter *E* (related to the *Entities*) followed by an identification number and the literals (atomic values) are denoted in blue, below the entities that have a final value (related to the *Appellations*). The relations are denoted with arrows between the entities and have names starting with the capital letter *P* followed by an identification number. The overlapping classes in Figure 3 denote the specialization (sub and super classes). For example, the class *E2 Temporal Entity* is super class of *E4 Period*, which in turn is super class of *E5 Event*, and so on.

To connect the source to the ontology, a mapping that describes which data (table, column, row) in the database corresponds to the abstract definition (concept, object property, etc.) on the ontology is necessary. Building this map between the relational database and the ontology is currently work in progress. For that purpose, a suitable representation language – Resource Description Framework (RDF) – was used to describe the emigration ontology triples.

Triples are expressed facts with three-part statements. Each triple is like a sentence stating a fact. The three parts of a triple are called of *subject*, *predicate*, and *object* [17].

RDF Triplestore. As said above, RDF is used to describe the data of the emigration repository. However, to have access to these data and make some queries over them, RDF triples must be stored. To store the triples in a dataset, an RDF database (Apache TDB[9] with Fuseki[10]) is used.

After storing the RDF file on Apache TDB, the triples are created in Turtle syntax. The code snippet in Listing 2-1 is an example of some triples written in Turtle.

Listing 2-1. Turtle triples

```
@prefix : <http://erlangen-crm.org/140617/>
:Emigrante_1 a :E21_Person ;
          :P107i_is_current_or_former_member_of :G1 ;
          :P11i_participated_in :M1 ;
          :P131_is_identified_by :Manuel_Vaz ;
          :P74_has_current_or_former_residence :PL4 ;
          :P98i_was_born :B1 .

:Manuel_Vaz a :E82_Actor_Appellation ;
          :P3_has_note ``Manuel Vaz''^^xsd:string .

:B1 a :E67_Birth ;
          :P98i_was_born :Emigrante_1 ;
          :P97_from_father Pai_Emigrante_1 ;
          :P96_by_mother Mae_Emigrante_1 ;
          :P4_has_time-span TS1 ;
          :P7_took_place_at PL1 .

:PL1 a :E53_Place ;
          :P87_is_identified_by Monte ;
          :P89_falls_within PL2 .

:PL2 a :E53_Place ;
          :P87_is_identified_by Fafe ;
          :P89_falls_within PL3 .

:PL3 a :E53_Place ;
          :P87_is_identified_by Braga .

                                   ...
```

Listing 2-1 shows six individuals of the CIDOC-CRM ontology that will be used to explain SPARQL queries in Section 3.1. The classes and relations (object properties) are described in `http://erlangen-crm.org/140617/`[11]. The individuals are explained below.

[9] `https://jena.apache.org/documentation/tdb/index.html`

[10] `https://jena.apache.org/documentation/fuseki2/`

[11] The Erlangen CRM / OWL is an OWL-DL 1.0 implementation of the CIDOC Conceptual Reference Model (CIDOC CRM)

From line 2 to 7, the individual *Emigrante_1* is described, which is an instance of *E21 Person* class (real persons who live or are assumed to have lived) and has object properties that relate the individual with other individuals as follows:

- *P107i is current or former member of* group named *G1*;
- *P11i participated in* event *M1*;
- *P131 is identified by* the individual named *Manuel_Vaz*;
- *P74 has current or former residence*at place named *PL4*;
- *P98i was born*: involved in birth named *B1*.

From line 9 to 10 the individual *Manuel_Vaz* is described, which is an instance of *E82 Actor Appellation* class (any sort of name, number, code or symbol used to identify an E39 Actor that is superclass of E21 Person) and has the object property:

- *P3 has note*: that relates the individual with the literal value (string) *"Manuel Vaz"*.

From line 12 to 17, the individual *B1* is described, which is an instance of *E67 Birth* class (the births of human beings) and has these object properties:

- *P98i was born* the individual named *Emigrante_1*;
- *P97 from father* named *Pai_Emigrante_1*;
- *P96 by mother* named *Mae_Emigrante_1*;
- *P4 has time-span* defined by *TS1*;
- *P7 took place at PL1*.

From line 19 to 21, the place described by the individual *PL1* is described, which is an instance of *E53 Place* class (extents in space, in particular on the surface of the earth, in the pure sense of physics: independent from temporal phenomena and matter) and has these object properties:

- *P87 is identified by* the individual named *Monte*;
- *P89 falls within* the place named *PL2*;

From line 23 to 25, the place represented by the individual *PL2* is described, which is an instance of *E53 Place* class and has these object properties:

- *P87 is identified by* the individual named *Fafe*;
- *P89 falls within* the place named *PL3*;

From line 27 to 28, the place represented by the individual *PL3* is described, which is an instance of *E53 Place* class and has the object property:

- *P87 is identified by* the individual named *Braga*;

Note that each individual of *E53 Place* class has two relations. The relation *P87 is identified by* identifies the name of the location and the relation *P89 falls within* identifies a location that falls within the area covered by another place. This means that *Monte* falls within *Fafe*, which in turn, falls within *Braga*.

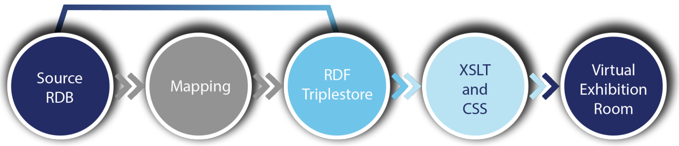


Fig. 4. The entire workflow to achieve the automatic generation of Virtual Exhibition Rooms

Having the data source (the ontology instances) described in Turtle syntax and stored in an RDF Triplestore, it is possible to process the queries over the dataset and with the creation of VER. Figure 4 shows the steps to create the virtual Exhibition Room from the data repository of CaVa project.

Because the *mapping* step in Figure 4 is an ongoing task (not discussed in this paper), it was considered that the source (Relational Database - RDB) is described directly in RDF Triplestores.

Starting from the dataset finished with the RDF triples described, the Turtle triples can be queried. To accomplish this task, a language that is able to query this kind of file is needed. The language used is SPARQL Protocol and RDF Query Language[12] (SPARQL), which will be described in Section 3.

3 Automatic Generation of Virtual Exhibition Rooms

As aforementioned, a virtual Learning Space is basically a web environment where the information available about a specific domain is disposed for the users to learn the content displayed in a friendly and interesting way.

As an entry to the conceptual navigator, the virtual exhibition room, a web page was created letting the end-user perform some queries and then, navigate over the concepts found. This web page executes some SPARQL queries and shows the results to the end-user in a new web page, automatically generated.

The entry HTML page that allows the end-user to query the dataset on Emigration movement described in Section 2.2 can be seen in Figure 5.

The three queries shown in Figure 5 are related to:

1. people who were born on a certain place;
2. people who were born on a particular date;
3. emigrants who emigrated to a particular location.

To get the results of these three queries, a SPARQL statement should be executed in the background. Section 3.1 will detail how the SPARQL query (1) is made; for the sake of space only the first example is discussed (the others are similar).

[12] `http://www.w3.org/TR/rdf-sparql-query/`

3.1 SPARQL Queries

As already mentioned, SPARQL is the language used to query RDF knowledge models, i.e., a set of RDF triples. To run SPARQL queries, a SPARQL end-point, which is a protocol service that receives, parses and interprets statements in SPARQL language over an RDF dataset, is needed. In this work, Apache Fuseki is used, that exchanges data using Hypertext Transfer Protocol (HTTP).

Thus, to execute the queries described above and get their results, a Common Gateway Interface (CGI) script was written in Python programming language. That script defines and executes SPARQL queries, as well as generates the HTML user interface (conceptual navigator) to display the query results.

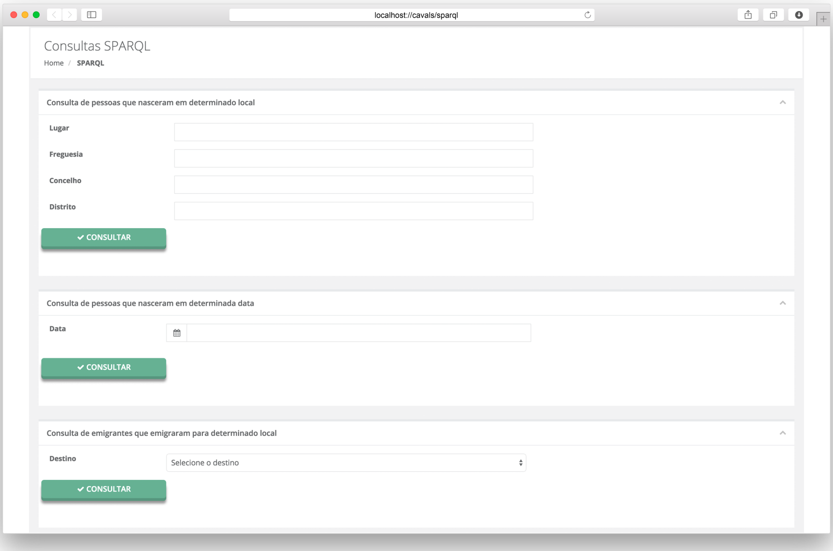
So, to answer query 1 above, *people who were born on a certain place*, the CGI includes the SPARQL code described in Listing 3-2.

Listing 3-2. Getting the people who were born on a certain place

```
 1  PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
 2  PREFIX    : <http://erlangen-crm.org/140617/>
 3
 4  SELECT DISTINCT ?personName
 5  WHERE {
 6     ?person     a :E21_Person ;
 7                 :P131_is_identified_by ?ap .
 8     ?ap         a :E82_Actor_Appellation ;
 9                 :P3_has_note ?personName .
10     ?person     :P98i_was_born ?birth .
11     ?birth      :P7_took_place_at ?place0 .
12     ?place0     :P87_is_identified_by ?lugar ;
13                 :P89_falls_within ?place .
14     ?lugar      :P3_has_note ‘‘LUGAR’’^^xsd:string .
15     ?place      :P87_is_identified_by ?freguesia ;
16                 :P89_falls_within ?place2 .
17     ?freguesia  :P3_has_note ‘‘FREGUESIA’’^^xsd:string .
18     ?place2     :P87_is_identified_by ?concelho ;
19                 :P89_falls_within ?place3 .
20     ?concelho   :P3_has_note ‘‘CONCELHO’’^^xsd:string .
21     ?place3     :P87_is_identified_by ?distrito .
22     ?distrito   :P3_has_note ‘‘DISTRITO’’^^xsd:string .
23  }
```

Lines 6-9 of the query in Listing 3-2, are used to look for a person (*E21 Person*) identified by an appellation (*E82 Actor Appellation*) that has a note(P3 Note) defining the person's name (a value with string datatype). According to line 4, *personName* is actually the *answer*, this is, the output value for this query. The SPARQL end-point will return a list with all the *personName* values found. To restrict the output list only to those names that belong to people born in a given place, it is necessary to constraint the search to those persons whose birth took place there. This is precisely the objective of lines 10-22.

To allow for a dynamic and interactive querying process, it was necessary to create the input form shown in Figure 5. So, to start a search, the user needs to enter four values that correspond to an address (street (can be empty), parish, county, and district) of Portugal. After reading these four values the CGI replaces the placeholders *LUGAR*, *FREGUESIA*, *CONCELHO*, and *DISTRITO* in the SPARQL query of Listing 3-2 before submit it to the end-point for execution.



localhost://cavals/sparql

Consultas SPARQL

Home / SPARQL

Consulta de pessoas que nasceram em determinado local

Lugar

Freguesia

Concelho

Distrito

Consulta de pessoas que nasceram em determinada data

Data

Consulta de emigrantes que emigraram para determinado local

Destino: Selecione o destino

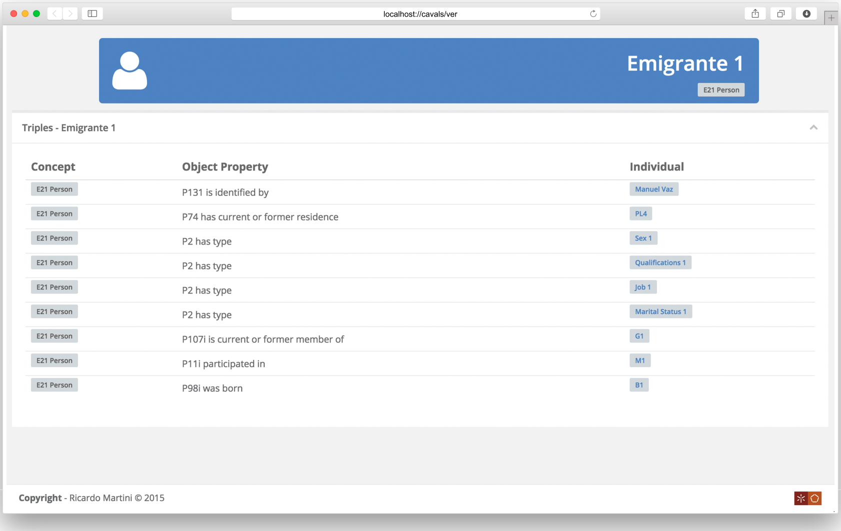
Fig. 5. Entry page for CaVa Learning Space on the Web

Then, the returned results are displayed in a new Web page (automatically created) where the user can navigate over the information of the individuals of Emigration Museum repository according to concepts and the knowledge organization defined by CIDOC-CRM.

Section 3.2 outlines how the Virtual Exhibition Room (VER) is built, i.e., resorting to eXtensible Stylesheet Language Transformation (XSLT).

3.2 Rendering VER with XSLT

As already mentioned, a Web page is created from SPARQL query results displaying the information returned, and providing the capability of a conceptual navigation. Figure 6 shows the virtual Exhibition Room created after choosing an individual (in the example, the Person instance *Emigrante 1*) from the list of results returned after the query execution. The page displays all the properties that characterize the Person *Emigrante 1*; for each property (or relation) the respective value is also displayed. As the property values are also concepts, it is possible to select anyone and immediately jump to a new page similar to the present one, with the selected concept as the page header.



Emigrante 1

E21 Person

Triples - Emigrante 1

Concept	Object Property	Individual
E21 Person	P131 is identified by	Manuel Vaz
E21 Person	P74 has current or former residence	PL4
E21 Person	P2 has type	Sex 1
E21 Person	P2 has type	Qualifications 1
E21 Person	P2 has type	Job 1
E21 Person	P2 has type	Marital Status 1
E21 Person	P107i is current or former member of	G1
E21 Person	P11i participated in	M1
E21 Person	P98i was born	B1

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Fig. 6. Virtual Exhibition Room showing the instance *Emigrante 1*

The table shown in Figure 6 depicts the object properties (nine in this case) identified in the CIDOC-CRM ontology that relate *Emigrante 1*, individual of *E21 Person* class, with their values, also *Individuals* of some concepts. The first relation is about the identification of *Emigrante 1*, which in this case is *Manuel Vaz* an instance of *E82 Actor Appellation* class.

To keep navigating on the individuals of Emigration Museum, it is enough to pick one of the values. As explained above, a new page is presented, showing the properties of the chosen individual. For instance, if the user selects the instance *B1* of *E67 Birth*, related with *Emigrante 1* through the object property *P98i was born*, a new page for it is displayed following precisely the same organization (the same template) illustrated in Figure 6.

In *B1* page the relations (properties) about a birth instantiated for *Emigrante 1* are shown. These properties are:

- *P96 by mother*: defines the mother of *Emigrante 1*;
- *P97 from father*: defines the father of *Emigrante 1*;
- *P4 has time-span*: represents the birthdate of *Emigrante 1*;
- *P7 took place at*: represents the birth place of *Emigrante 1*.

If the user picks the birth place instance *PL1*, a new page is presented with the relations about it. The relations are *P87 is identified by* and *P89 falls within* as already mentioned above. So, navigating over the *P89 falls within* relations (until reaching a place that does not has a *P89* relation), the user can see the place where the birth event of *Emigrante 1* identified by *Manuel Vaz* has occurred.

To automatically create these Web pages designated by VER, the page template (elements' position and content) must be specified. The language used for that purpose was eXtensible Stylesheet Language Transformation (XSLT), which is a language used to transform XML documents into something new. A XSLT specification (or program) can take an XML document and output that document's information as another XML document with a different structure, or translate it into an HTML document to be displayed on a Web browser [18].

Listing 3-3 shows a fragment of the triples that describe an individual (*Emigrante 1* in that case) written in XML/RDF format for ontologies description. The processor takes an input description like the one shown and, using an XSLT program, creates the VER HTML pages.

Listing 3-3. RDF file describing the emigration documents

```
<?xml version="1.0"?>

<?xml-stylesheet type=``text/xsl'' href=``ver.xsl''?>

<!DOCTYPE rdf:RDF [
   <!ENTITY owl ``http://www.w3.org/2002/07/owl#''>
   <!ENTITY ecrm ``http://erlangen-crm.org/140617/''>
   <!ENTITY xsd ``http://www.w3.org/2001/XMLSchema#''>
   <!ENTITY rdf ``http://www.w3.org/1999/02/22-rdf-
        syntax-ns#''>
]>

<rdf:RDF xmlns=``http://erlangen-crm.org/140617/''
      xml:base=``http://erlangen-crm.org/140617/''
      xmlns:owl=``http://www.w3.org/2002/07/owl#''
      xmlns:rdf=``http://www.w3.org/1999/02/22-rdf-
          syntax-ns#''>

<owl:NamedIndividual rdf:about=``&ecrm;Emigrante_1''>
        <rdf:type rdf:resource=``&ecrm;E21_Person''/>
        <P131_is_identified_by rdf:resource=``&ecrm;
            Manuel_Vaz''/>
        <P74_has_current_or_former_residence
            rdf:resource=``&ecrm;PL4''/>
        <P2_has_type rdf:resource=``&ecrm;Sex_1''/>
        <P2_has_type rdf:resource=``&ecrm;
            Qualifications_1''/>
```

```
23          <P2_has_type rdf:resource=‘‘&ecrm;Job_1’’/>
24          <P2_has_type rdf:resource=‘‘&ecrm;
                Marital_Status_1’’/>
25          <P107i_is_current_or_former_member_of
                rdf:resource=‘‘&ecrm;G1’’/>
26          <P11i_participated_in rdf:resource=‘‘&ecrm;M1’
                ’/>
27          <P98i_was_born rdf:resource=‘‘&ecrm;B1’’/>
28      </owl:NamedIndividual>
29  </rdf:RDF>
```

Notice that the information specified in Listing 3-3 in XML/RDF is the same that is presented in the final VER shown in Figure 6.

An important declaration of this snippet can be seen in line 3 (<?xml-stylesheet type="text/xsl" href="ver.xsl"?>), which allows style sheets to be associated with an XML document by including one or more processing instructions with a target of xml-stylesheet in the document's prolog[13]. In this case, the ver.xsl stylesheet is associated.

This XSL file is the template that rules how the XML/RDF input file will be rendered in new HTML files. For each individual on the RDF file, an associated HTML file is created. To generate each HTML file, it is necessary to specify an XSL template (<xsl:template match="rdf:RDF">) that matches the rdf:RDF root element of RDF associated file. The creation of each HTML file is given with the command <xsl:result-document href="@rdf:about.html">), which, in this case, creates the HTML name files with the value of the rdf:about attribute. So, each HTML page has a file name associated to the name of the individual of RDF file. For instance, for the individual *Emigrante 1*, the associated HTML file created has the name *Emigrante_1.html*.

Now that the root element has been associated, the input file can be transformed into a new HTML page with the CSS style (position, color, links, etc.). The creation of the tables entitled "Triples - *individual name*" that can be seen in VER of Figure 6 is built by matching the concept, object property, and individual names of emigration documents described in the RDF file and then an HTML table element with these data is created.

The XSLT works with any change of the input RDF file, so any adjustment in the ontology reflects in VER appearance. XSLT allows the automatic creation of web pages, which are the virtual Learning Spaces about the emigration movement in Portugal.

4 Conclusion

The main goal of this paper is to propose a method and a technological architecture to generate, in an automatic way, virtual Learning Spaces from the

[13] http://www.w3.org/TR/xml-stylesheet/

knowledge described in an ontology. However, that ontology content must be described in a structured format, so that it can be processed. In the project here reported it has been represented as RDF triples, which allows to query the information repository systematically with the aid of SPARQL. From each SPARQL query, the result is returned in a structured format, namely JSON notation is used.

Thus, templates to generate the virtual Exhibition Rooms (in the paper, a case study – the *emigration social phenomena* – was discussed) have been created.

This paper has proved that it is possible to automatically build virtual Learning Spaces due to the structured information, retrieved from the repository using an ontology, transformed by a XSLT program.

As future work, the authors plan to enhance the transformations (creation of VER) allowing the curator to specify the transformation schema through a Domain Specific Language.

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