Mapping VRA Core 4.0 to the CIDOC CRM ontology*

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Abstract. In this paper, we present an effort to semantically map VRA Core 4.0, a cultural heritage metadata schema describing visual resources, to CIDOC CRM. This work is based on a semantic integration scenario, where CIDOC CRM acts as a mediation schema. More specifically, each element of the schema (along with its subelements and attributes) is mapped to the equivalent CRM path (represented as a sequence of classes and properties). The mapping is formally described using a Mapping Description Language (MDL), which explicitly defines semantic rules from the source schema to the target schema.

1 Introduction

Managing cultural heritage resources is a rather complex process, in which a range of sciences and scientists (computer scientists, information scientists, archives scientists, museologists, historians, etc.) are involved. Cultural heritage institutions are challenged to handle the information and knowledge dissemination in such a way that the needs and demands of various user groups are efficiently met. Within this framework, cultural heritage institutions (otherwise called “memory institutions”) use various metadata schemas for the documentation of cultural collections, that facilitate access and retrieval to cultural information via the web. The complexity of the cultural information imposes the development of several different metadata standards (such as DCMI, VRA Core 4.0, EAD, Spectrum etc.), which exhibit significant diversity. This heterogeneity often results in data exchange failure, as the end user cannot access an integrated information system and retrieve the desired information. In order to address all the aforementioned issues and achieve a unified and standard-independent access to the relative information, it is necessary to integrate all these schemas. One

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of the most important and continuously evolving methods implemented in the interoperability domain is the ontology-based integration [7]. Ontologies provide the means for defining common vocabularies, representing the domain knowledge, while at the same time facilitating knowledge sharing and reuse among heterogeneous and distributed application systems.

The basic component of an information integration system is the mapping of the various metadata schemas to a schema or a core ontology, acting as a mediation schema, so that (meta)data integration is successfully accomplished. In the integration scenario proposed by our research group [9], the CIDOC CRM ontology is used as a mediation schema, to which different metadata schemas (such as MODS, DC, MARC, EAD etc.) are mapped.

In this paper, we present a mapping methodology of the VRA Core 4.0 schema to the CIDOC CRM ontology. This methodology, which is based on a path-oriented approach, is formally defined using a Mapping Description Language (MDL), which defines semantic rules from the source schema to the target schema. In the proposed methodology, each element of the schema (with its subelements) is represented as a VRA path (expressed in XPath form) and is then semantically translated to an equivalent path of classes and properties of CIDOC CRM. It is important to note that the mapping procedure focuses on the restricted version of the VRA Core 4.0, which imposes controlled vocabularies and type lists. Thus, each attribute assigned to an element/subelement of the metadata schema may generate different semantic paths on the ontology, depending on the value it takes each time, and produces a plethora of conceptual expressions for the same element/subelement. The use of several global attributes provided by the VRA Core 4.0 schema makes the mapping procedure even more complicated, by generating additional semantic paths on the ontology.

2 Mapping VRA Core 4.0 to CIDOC CRM

2.1 Brief description of the VRA Core 4.0

VRA Core 4.0 [10] is a metadata schema for the cultural heritage community, initially developed by the Visual Resources Association’s Data Standards Committee. Currently, it is hosted by the Network Development and MARC Standards Office of the Library of Congress (LC) [5] in partnership with the Visual Resources Association. VRA Core 4.0 provides guidance on describing works of visual culture, collections, as well as images that document them. Therefore, it allows for three broad groups of entities, which are works, images, and collections. A work may represent a painting, sculpture or other artistic product. An image is a visual representation of a work that can come in a wide range of formats, and include various image formats (such as JPEG, GIF, TIFF) or could include physical photographs, slides, etc. Finally, a collection represents a group of works or images.

VRA Core 4.0 contains 19 elements (work, agent, culturalContext, date, description, inscription, location, material, measurements, relation,
rights, source, stateEdition, stylePeriod, subject, technique, textref, title and worktype) and several optional global attributes (dataDate, extent, href, pref, refid, rules, source, vocab, xml:lang), which are applied additionally to any element or subelement, when necessary. Two XML Schema versions have been proposed for the VRA Core 4.0. An unrestricted version, which specifies the basic structure of the schema and imposes no restrictions on the values entered into any of the elements, sub-elements, or attributes, and a restricted version, which extends the unrestricted one by imposing controlled type lists and date formats.

Example 1. In this example we present a fragment of a simplified VRA document, describing a textual manuscript of the 18th century, taken from http://www.vraweb.org/projects/vracore4/example017.html.

```xml
<?xml version="1.0" encoding="UTF-8" ?>
<vra>
  <work id="w_4" source="Core 4 Sample Database (VCat)" refid="4">
    <agentSet>
      <agent>
        <name vocab="ULAN" refid="500017255" type="personal">Jefferson, Thomas</name>
        <dates type="life">
          <earliestDate>1743</earliestDate>
          <latestDate>1826</latestDate>
        </dates>
        <culture>American</culture>
        <role>author</role>
      </agent>
    </agentSet>
    <measurementsSet>
      <measurements type="height" unit="cm">75.56</measurements>
      <measurements type="width" unit="cm">62.23</measurements>
    </measurementsSet>
    <stylePeriodSet>
      <stylePeriod vocab="LCSAF" refid="85041401">Eighteenth century</stylePeriod>
    </stylePeriodSet>
    <techniqueSet>
      <technique vocab="AAT" refid="300053162">calligraphy(process)</technique>
      <technique vocab="AAT" refid="300054698">writing(process)</technique>
    </techniqueSet>
    <titleSet>
      <title type="popular" xml:lang="en">Declaration of Independence</title>
    </titleSet>
    <worktypeSet>
      <worktype>manuscript (document genre)</worktype>
    </worktypeSet>
  </work>
</vra>
```
2.2 The CIDOC CRM ontology

The *CIDOC Conceptual Reference Model* (CIDOC CRM) [3], which emerged from the CIDOC Documentation Standards Group in 1999, is a formal extensible ontology, which aims at providing a conceptual representation of cultural heritage domain, promoting semantic interoperability and integration. It is an object-oriented model comprised of a class hierarchy of 86 named classes interlinked by 137 named properties. CIDOC CRM defines the complex interrelationships between objects, actors, events, places, and other concepts used in the cultural heritage domain [2].

A class (also called entity), identified by a number preceded by the letter “E” (e.g. E1 CRM Entity, E2 Temporal Entity), groups items (called class instances) that share common characteristics. A class may be the domain or the range of properties, which are binary relations between classes. Properties are identified by numbers preceded by the letter “P” (e.g. P2 has type (is type of) with domain the class E1 CRM Entity and range the class E55 Type). A property can be interpreted in both directions (active and passive voice), with two distinct but related interpretations. A subclass is a class that specializes another class (its superclass). A class may have one or more immediate superclasses. When a class A is a subclass of a class B then all instances of A are also instances of B. A subclass inherits the properties of its superclasses without exception (strict inheritance) in addition to having none, one or more properties of its own. A subproperty is a property that specializes another property. A sample of CIDOC CRM properties is shown in Fig. 1.

```
<table>
<thead>
<tr>
<th>Property Id &amp; Name</th>
<th>Entity - Domain</th>
<th>Entity - Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1 is identified by (identifies)</td>
<td>E1 CRM Entity</td>
<td>E41 Appellation</td>
</tr>
<tr>
<td>P2 has type (is type of)</td>
<td>E1 CRM Entity</td>
<td>E55 Type</td>
</tr>
<tr>
<td>P4 has time-span (is time-span of)</td>
<td>E2 Temporal Entity</td>
<td>E52 Time-Span</td>
</tr>
<tr>
<td>P14 carried out by (performed)</td>
<td>E7 Activity</td>
<td>E39 Actor</td>
</tr>
<tr>
<td>P58 has section definition (defines section)</td>
<td>E18 Physical Thing</td>
<td>E46 Section Definition</td>
</tr>
<tr>
<td>P108 has produced (was produced by)</td>
<td>E12 Production</td>
<td>E24 Physical Man-Made Thing</td>
</tr>
</tbody>
</table>
```

Fig. 1. A sample of CIDOC CRM properties.

2.3 The Mapping Description Language (MDL)

The proposed mapping method between the metadata schemas and CIDOC CRM is based on a path-oriented approach. A mapping from a source schema to a target schema transforms each instance of the source schema into a valid instance of the target schema. Hence, we interpret the metadata paths to semantically equivalent CIDOC CRM paths. As we are interested in metadata schemas, which are based on XML, the paths in the source schemas are based on XPath [11], 

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in fact they extend the XPath location paths with variables and stars (meaning data transfer). The syntax of the MDL mapping rules is given below in EBNF:

(R1) \( R ::= \text{Left} '−−\text{Right}' \)

(R2) \( \text{Left} ::= A_{\text{Path}} | V_{\text{Path}} \)

(R3) \( A_{\text{Path}} ::= \epsilon | \text{'} / \text{'} R_{\text{Path}} \)

(R4) \( R_{\text{Path}} ::= L | L \text{'}* | L \{ \{ \text{'} V_{j} \text{'} \} | L \text{'}* \{ \{ \text{'} V_{j} \text{'} \} \} \)

(R5) \( V_{\text{Path}} ::= \text{'$'} V_{c} \text{''} | \text{'$'} V_{p} \text{''} \)

(R6) \( \text{Right} ::= E_{t} | E_{e} \text{''} \rightarrow \text{'} O | \text{'$'} V_{c} \text{''} \rightarrow \text{'} O | \text{'$'} V_{p} \text{''} \rightarrow \text{'} P_{p} \text{''} \rightarrow \text{'} E_{55} \)

(R7) \( O ::= P_{e} \text{''} \rightarrow \text{'} E_{t} | P_{e} \text{''} \rightarrow \text{'} E_{e} \text{''} \rightarrow \text{'} O \)

(R8) \( E_{x} ::= E | E \text{''} \{ \{ \text{'} V_{c} \text{'} \} \}

(R9) \( E_{t} ::= E | E \text{''} \{ \{ \text{'} V_{c} \text{'} \} \} \text{''} | E \text{''} \{ \{ \text{'} String \} \}

(R10) \( E_{55} ::= E_{55} | E_{55} \text{''} \{ \{ \text{'} V_{c} \text{'} \} \} | E_{55} \text{''} \{ \{ \text{'} String \} \}

(R11) \( P_{e} ::= P | P \text{''} \{ \{ \text{'} V_{p} \text{'} \} \}

The terminals used in these rules have the following semantics:

- \( L \): it represents an XPath location path.
- \( V_{j} \): it represents the location variables, which are used to declare the “branches” of the XML trees (XPath paths).
- \( V_{c} \): it represents the class variables. The class variables are used to declare that a class can be the starting point of one or more CIDOC CRM paths.
- \( V_{p} \): it represents the property variables. The property variables are used to declare that a property can be the starting point of a new CIDOC CRM path, which - in this case - it is a property of a property linking the property that the variable represents to an instance of the class.
- \( E \): it represents the identifier of the class.
- \( E_{55} \): it represents the identifier of the class.
- \( P_{p} \): it represents the identifier of the property of a property.
- \( \text{String} \): it represents a string.

3 Mapping VRA Core 4.0 elements to equivalent CIDOC CRM paths

VRA Core 4.0 is an XML-based standard, therefore we use the XPath to locate VRA elements/attributes. A VRA path is a sequence of VRA elements and subelements, starting from the schema root element \( \text{vra} \) separated by the slash symbol (\(/\)). For instance, the path \(/\text{vra/work/titleSet/title} \) denotes the title of a work being described. A CRM path is defined as a chain in the form entity-property-entity, such that the entities associated with a property correspond to the property’s domain and range. VRA Core defines three basic top elements: work, collection and image. In the context of a VRA Core 4.0 record, a work is defined as a physical entity that exists, existed in the past, or may exist in the future. It might be an artistic creation, such as a painting or a sculpture, a performance, a building or other construction, etc. Therefore, we associate each work element in a VRA document with an instance of the class E24 Physical Man-Made Thing, which comprises all persistent physical items that are purposely created by human activity.
In the following paragraphs, we present the mapping of the agent element of the VRA Core 4.0 schema to CIDOC CRM. The agent (including its sub-elements and attributes) is a representative element of VRA Core 4.0 and its mapping presents significant diversity and complexity. The methodology applied to this mapping can be used to map the other elements of the VRA Core 4.0 as well.

3.1 Mapping the agent element and its subelements

The agent element denotes a person, group or corporate body that has contributed to the production or creation of the work being described. It contains the following five subelements: name, culture, dates, role and attribution. Each one of them provides a part of the agent element:

- The name subelement specifies the names and appellations, assigned to an individual, group or corporate body. A type attribute is assigned to this subelement, with possible values personal, corporate, family, or other.
- The culture subelement refers to the nationality or culture of the person, group, or corporate body that participated to the work being described.
- The dates subelement, which contains two additional subelements, namely the earliestDate and the latestDate, refers to the dates associated with the agent. A type attribute is also assigned to this subelement (with possible values activity, life and other).
- The role subelement denotes the specific role of the individual, group or corporate.
- The attribution subelement defines a characteristic or a specific attribute related to the agent.

Mapping the agent element: It is easy to see, by examining the semantics of the CIDOC CRM classes, that the appropriate class of CIDOC CRM to map the agent element of VRA is the class E39 Actor. The instances of E39 Actor corresponding to each specific agent need to be related to the instance of E24 Physical Man-Made Thing representing the work being described, in order to express that an agent “contributed to the production or creation of the work being described”. However, as CIDOC CRM is event-centric, it does not provide properties to directly relate the instances of these two classes. Instead, these instances can be related indirectly, though an event (instance of the class E12 Production) during which the object was created. In this way, the work being described (i.e. the instance of the class E24 Physical Man-Made Thing) is related through the property P108B was produced by to this event. Additionaly, this event should then be related to the instances of the class E39 Actor (representing the agent), through the property P14 carried out by. In this way, a CIDOC CRM path of the following form is created:

E24 Physical Man-Made Thing → P108B was produced by →
E12 Production → P14 carried out by → E39 Actor

which semantically corresponds to a VRA path of the form:
We should note that, in case there are more than one agents (i.e. more than one agent subelements of the element agentSet), different subpaths of the form:

→ P14 carried out by → E39 Actor
will be rooted to the (same) instance of E12 Production to relate it with the different agents (instances of E39 Actor) that took part in this production event.

**Mapping the name subelement of agent element:** The name subelement, which identifies the name of an agent, is mapped to an instance of the class E82 Actor Appellation and is linked to the corresponding instance of the class E39 Actor through the property P131 is identified by. In this way, the CIDOC CRM path, which semantically corresponds to the VRA path:

/vra/work/agentSet/agent/name

becomes:

E24 Physical Man-Made Thing → P108B was produced by → E12 Production → P14 carried out by → E39 Actor → P131 is identified by → E82 Actor Appellation

**Mapping the type attribute of the name subelement:** In VRA an attribute named type is assigned to the name element. This attribute is quite remarkable given that it determines if an agent is a person (when the value of type is personal), a corporate or an organization (when the value of type is corporate), a family (when the value of type is family), or none of the above (when the value of type is other). To map the attribute type in CIDOC CRM, we have investigated two different approaches:

**First approach:** A first approach to map the type attribute in CIDOC CRM is to employ the class E55 Type and link instances of this class (of the values personal, corporate, family or other respectively) to the corresponding instances of the class E39 Actor through the property P2 has type. In this case, the following CIDOC CRM path will be created:

E24 Physical Man-Made Thing → P108B was produced by → E12 Production → P14 carried out by → E39 Actor [→ P2 has type → E55 Type] → P131 is identified by → E82 Actor Appellation

which semantically corresponds to the VRA path:

/vra/work/agentSet/agent/name[@type]

Notice that in this approach the value of the type attribute is given as value of the instance E55 Type.

The notation [..] in the CIDOC CRM path is used to denote that a new branch is rooted on the E39 Actor class node.

**Second approach:** A second approach to map the type attribute in CIDOC CRM is to refine the mapping of the specific agent by replacing the class E39 Actor with an appropriate subclass of this class determined by the value of the type attribute. More specifically, if the value of the type attribute is personal, then the corresponding agent can be considered to be an instance of the class E21 Person. In this case, the CIDOC CRM path becomes:

E24 Physical Man-Made Thing → P108B was produced by →
E12 Production → P14 carried out by → E21 Person → P131 is identified by → E82 Actor Appellation which semantically corresponds to the VRA path:

/vra/work/agentSet/agent/name[@type="personal"]

If the value of the type is corporate, the corresponding agent will be denoted as an instance of the class E40 Legal Body, while if the value is family then the corresponding agent will be considered as an instance of the class E74 Group.

Fig. 2 depicts the mapping of the agent element and its subelements when the type attribute has the value personal, while applying the second approach. In this figure, the upper part of each box indicates the VRA path mapped to the CIDOC CRM class shown in the lower part. The boxes are linked with arrows that represent CIDOC CRM properties, which appear as labels to these arrows. In case a property is used according to its inverse property name, it is characterized by the letter “B” as part of its name (e.g. P108B was produced by). The mapping of other subelements of the element agent, appearing also in Fig. 2 (that is the subelements culture, role and dates), will be presented in the following paragraphs. At this point, we should mention that the type attribute assigned to the name subelement exhibits a rather weak point of the VRA Core Schema, as it actually refers to the agent element to which we believe that is should have been assigned and not to the name subelement.

Fig. 2. The mapping of the value personal of the type attribute of the element agent.
Mapping the role subelement of agent: The role subelement, which identifies the role of an agent, is expressed in CIDOC CRM through the subproperty P14.1 in the role of, which actually links the property P14 carried out by to an instance of the class E55 Type. In this way, the CIDOC CRM path becomes:

E24 Physical Man-Made Thing → P108B was produced by → E12 Production → P14 carried out by [→ P14.1 in the role of → E55 Type] → E39 Actor

which semantically corresponds to the VRA path:
/vra/work/agentSet/agent/role

Mapping the culture subelement of agent: The culture subelement, which identifies the nationality or culture of an agent, can be modelled as a membership of the agent to a group. This group is modelled in CIDOC CRM as an instance of the class E74 Group, which is related to the corresponding instance of the class E39 Actor, through the property P107B is current or former member of, resulting in the CIDOC CRM path of the form:

E24 Physical Man-Made Thing → P108B was produced by → E12 Production → P14 carried out by → E39 Actor → P107B is current or former member of → E74 Group

which semantically corresponds to the VRA path:
/vra/work/agentSet/agent/culture

Mapping the dates subelement of agent: The dates subelement is one of the most complex subelements to map, for three specific reasons: a) it contains a type attribute, with possible values life, activity, and other. Thus, it can define either the dates that span the known activity of an individual, group or corporate body, or the birth and death dates of a person (or even none of the above, by implementing the other attribute), b) it is strongly related to the name subelement, and more specifically to the value of the type attribute of the name subelement. For instance, if the type attribute of the subelement name is defined as corporate, then the value of the type attribute of the dates subelement can be either activity or other, denoting eg. the foundation dates of a corporate body, c) it contains two additional subelements, earliestDate and latestDate, which also define different semantic mappings. The following mapping of the dates refers to the case where the type attribute of the name subelement has the value personal, while the type attribute of the dates subelement gets the value life. The basic idea behind the mapping of the element dates (and its subelements) in this case is that the earliestDate subelement presents the birth date of an agent, while the latestDate subelement represents the date of his/her death.

Mapping the earliestDate subelement (when @type="life"): In order to map the earliestDate subelement, an instance of the class E67 Birth is created and related to an instance of the class E21 Person, through the property P98B was born (denoting the birth event of a person). Then, an instance of the class E52 Time-Span is linked to an instance of E67 Birth, through the property P4 has
time-span, and finally in order to denote the specific date of the birth event, an instance of the class E50 Date is linked to an instance of E52 Time-Span through the property P78 is identified by. Thus, the following CIDOC CRM path:

- E24 Physical Man-Made Thing \(\rightarrow\) P108B was produced by \(\rightarrow\)
- E12 Production \(\rightarrow\) P14 carried out by \(\rightarrow\) E21 Person \(\rightarrow\)
- P98B was born \(\rightarrow\) E76 Birth \(\rightarrow\) P4 has time-span \(\rightarrow\)
- E52 Time-Span \(\rightarrow\) P78 is identified by \(\rightarrow\) E50 Date

semantically corresponds to:

\[
/vra/work/agentSet/agent/name[@type="personal"]
/dates[@type="life"]/earliestDate
\]

Mapping the latestDate subelement (when @type="life"): In order to map the latestDate subelement, an instance of the class E69 Death is created and related to an instance of the class E21 Person, through the property P100B died in (denoting the death event of a person). Then, adding as before the path \(\rightarrow\) P4 has time-span \(\rightarrow\) E52 Time-Span \(\rightarrow\) P78 is identified by \(\rightarrow\) E50 Date, we get the following CIDOC CRM path:

- E24 Physical Man-Made Thing \(\rightarrow\) P108B was produced by \(\rightarrow\)
- E12 Production \(\rightarrow\) P14 carried out by \(\rightarrow\) E21 Person \(\rightarrow\)
- P100B died in \(\rightarrow\) E69 Death \(\rightarrow\) P4 has time-span \(\rightarrow\)
- E52 Time-Span \(\rightarrow\) P78 is identified by \(\rightarrow\) E50 Date

which semantically corresponds to the VRA path:

\[
/vra/work/agentSet/agent/name[@type="personal"]
/dates[@type=":life"]/latestDate
\]

The mappings presented in this section are also shown in Fig. 2.

3.2 The mapping of the agent element expressed in MDL

MDL can be used to formally describe the mapping rules of the elements/attributes of a source schema to equivalent paths of the target schema. Part of the mapping, containing the rules that map the VRA element agent and its subelements/attributes, is shown in Table 1, expressed in MDL. In this section, a brief analysis of the rules' semantics is presented. For example, Rule R1 states that the /vra/work is mapped to an instance of the class E24. R2 states that the agentSet corresponds to an instance of the class E12, which is linked to E24 through the binary relation P108B. Rules R3, R4, R5 describe the three different versions of the agent element, according to the three possible values of the type attribute of the name subelement, which correspond to the three different sub-classes (E21, E40, E74), respectively. It is also important to note here that the variables Y5, Y10 and Y15 on the left part of the rules, as well as the variables J5, J10 and J15 on the right part, denote branching points, that indicate that more than one paths may extend the previous paths (see also Fig. 2). Rules R6, R7, R8, R9 and R10 can be appended to the Rule R3.
Table 1. Mapping the VRA element agent to the CIDOC CRM using MDL.

<table>
<thead>
<tr>
<th>RuleNo</th>
<th>VRA paths</th>
<th>CIDOC CRM paths</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1:</td>
<td>/vra/work{X1}</td>
<td>E24{C1}</td>
</tr>
<tr>
<td>R2:</td>
<td>${X1/agentSet}{Y1}</td>
<td>${C1}\rightarrow P108B\rightarrow E12{J1}</td>
</tr>
<tr>
<td>R3:</td>
<td>${Y1/agent{name/@type=&quot;personal&quot;}}{Y5}</td>
<td>${J1}\rightarrow P14{S2} \rightarrow E21{J5}</td>
</tr>
<tr>
<td>R4:</td>
<td>${Y1/agent{name/@type=&quot;corporate&quot;}}{Y10}</td>
<td>${J1}\rightarrow P14{S3} \rightarrow E40{J10}</td>
</tr>
<tr>
<td>R5:</td>
<td>${Y1/agent{name/@type=&quot;family&quot;}}{Y15}</td>
<td>${J1}\rightarrow P14{S4} \rightarrow E74{J15}</td>
</tr>
<tr>
<td>R6:</td>
<td>${Y5}</td>
<td>{Y10}</td>
</tr>
<tr>
<td>R7:</td>
<td>${Y5}</td>
<td>{Y10}</td>
</tr>
<tr>
<td>R8:</td>
<td>${Y5}</td>
<td>{Y10}</td>
</tr>
<tr>
<td>R9:</td>
<td>${Y5/dates[@type=&quot;life&quot;]}/earliestDate*</td>
<td>${J5} \rightarrow P98\rightarrow E67\rightarrow P4\rightarrow E52\rightarrow P78\rightarrow E50</td>
</tr>
<tr>
<td>R10:</td>
<td>${Y5/dates[@type=&quot;life&quot;]}/latestDate*</td>
<td>${J5} \rightarrow P100B\rightarrow E69\rightarrow P4\rightarrow E52\rightarrow P78\rightarrow E50</td>
</tr>
</tbody>
</table>

4 Related work

There is quite an amount of research dealing with ontology-based integration. Amann et al. [1] propose a mechanism for the integration of cultural information resources, by mapping XML fragments to domain specific ontologies, such as CIDOC CRM. In this way, they define a mapping language, which provides a set of rules that describe these resources, relating XPath location paths to the concepts and roles of an ontology. Furthermore, they define a query rewriting algorithm which translates queries executed by users into queries expressed in an XML language and are afterwards sent to XML resources for evaluation. This approach is worth mentioning as it describes a mapping language quite similar to ours and also focuses on the significance of offering mechanisms for representing the semantics of XML data. In [4] XML data are transformed to a global ontology (using the OWL syntax), defining mapping rules that are also based in OWL. In this way, issues of synonymy and structure hierarchy are faced. This work shares common ideas with ours, as it transforms data to a global ontology, although the mapping rules defined in our MDL are not based in OWL syntax.

In [6], an effort is described to integrate the CIDOC CRM ontology in the core model of the BRICKS project. This integration has been accomplished through a mapping scenario applied between the source schemas and the CRM ontology, although a number of issues had to be resolved. Some of them refer to inconsistencies, which mostly originate from the abstractness of some concepts definitions of the CRM [8]. This approach provides mappings that are implemented in spreadsheets, without defining a formal mapping methodology.

5 Conclusions

The mapping methodology presented in this paper is part of an ontology-based metadata integration scenario, where CIDOC CRM acts as a mediating schema among several metadata schemas. More specifically, a semantic mapping from the VRA Core 4.0 standard to the CIDOC CRM ontology is presented.
Mapping VRA elements to CIDOC CRM paths proved to be a rather difficult and time-consuming activity, which required a deep and conceptual work. CIDOC CRM provides very rich structuring mechanisms for metadata descriptions and an abstract but fine-grained conceptualization for events, objects, agents, things, etc. Thus, the combination of this wide range of CRM classes and properties generated a large number of conceptual expressions that should be studied very carefully in order to select the semantically closest one to map to the metadata schemas. Furthermore, the mapping procedure encountered significant obstacles due to the plethora of conceptual expressions that should be aligned. The type attribute assigned to several subelements defined different semantic mappings, making mapping even more complex. Finally, it is essential to note that the agent element and all the related information to the work's production, include the class E12 Production, which reveals one of the main characteristics of CIDOC CRM, which is the event-based approach adopted.

Currently, we are investigating the transformation of queries among various cultural heritage metadata schemas and the CIDOC CRM ontology. Our next research steps include the definition of the reverse semantic mappings from the ontology to the VRA Core schema, in order to enrich the mapping procedure proposed by our research group.

References
