The use of CRM Core in Multimedia Annotation

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Abstract. Cultural heritage institutions are fantastic resources of multimedia content. Rich metadata structures, able to capture the diversity of the media, the subject matter and the context around each information asset, are required to make this content accessible. This paper describes how the CIDOC CRM Core format can be used to structure cultural heritage metadata for multimedia by making the appropriate abstractions to reconstruct and exploit relevant parts of the historical context for rich associative resource retrieval.

1 Introduction

Research, presentation and education in cultural heritage and history in the widest sense is based on the interpretation of primary materials proving witness of the past. These materials can be as diverse as sites and monuments, objects and relics found in excavations, objects and historical records preserved as heirlooms or rediscovered. Cultural heritage and memory institutions, such as museums, archives and libraries preserve an immense amount of such treasures, far more than any exhibition can show. A typical museum may keep between 10.000 and a million objects. Memory institutions and researchers systematically create detailed documentation about these items that justify their value for our society by revealing their particular features within their historical context. Any documentation is already an interpretation of the past. Other interpretations may be more free in associating values with things in the past or make assumptions about the intellectual and spiritual processes behind the material witnesses we perceive. The interpretations themselves become historical documents that have to be taken into account by further work.

Recently the ambition is to make this wealth of information available to the public in digital form, and more and more primary material is created in digital form. This adds even another dimension of complexity. Unique physical objects appear now in a multitude of digital representations, commentaries may be in audiovisual form etc. Therefore memory institutions become fantastic resources of multimedia content,

with a variety of uses and applications, serving publication, research, education and preservation.

The information technology challenge is how to make this material accessible so that the users can make sense out of it. This requires sufficiently rich metadata. The particular problems are the diversity of the material and media, the heterogeneity of the representation, and the fact that virtually nothing can be understood or interpreted without its relation to a context of thousands of other directly or indirectly related information assets. Each institution holds its own formats and often various different systems operate within the same institution. Even the multimedia objects themselves can be composed in a highly complex manner.

Under these difficulties, current metadata paradigms mainly serve as "finding aids" to retrieve a set of equivalent assets that match a number of search criteria, such as "who, when, where, what". Hypertext links may point to a related asset without any hint on which facts justify the relation. From this point on, the user is left alone to interpret each asset, to reconstruct the context manually by a multitude of queries and finally to reveal the deeper relationships. There is no way to systematically retrieve complementary information, such as friends of friends, ancestors, matching art objects with works of friends, treaties and political interests etc. The ideal metadata format should support a way of relating this information in a standardized manner that allows for automatically aggregating objects by various contextual criteria. Further, since historical sources (once they are out of the news) are very scarce and incomplete, it should provide sufficient recall and precision to pick out every single reference. Finally, it should accommodate the different levels of detail or abstraction in which the same things may be documented, and help aggregating even contradictory information about known things from the past.

In this paper we present a very simple metadata format, which we believe fulfils the above criteria, at least more than current competitive formats. It is based on the CIDOC Conceptual Reference Model (CRM) [1], a core ontology describing the semantics of schema and data structure elements used for museum object documentation. The central idea of the CIDOC CRM is that the notion of historical context can be abstracted as things, people and ideas meeting in space–time. By adding to this the fundamental properties of classification, part decomposition, aboutness and similarity, one can capture in metadata elements a surprising wealth of contextual and structural information, that can be integrated into large knowledge networks, completely independent from the nature and format of the described items. The simplicity and genericity of this proposal makes it in our opinion attractive far beyond cultural applications.

2 Background

Multimedia information has been managed historically via the associated key terms or metadata added to the media and used for indexing, browsing and retrieval. In the cultural heritage domain there have been several approaches to specifying metadata standards for modelling information about cultural objects and events.

The Dublin Core [11] metadata standard is widely used in the digital library world, and has been applied in the cultural heritage domain as finding aids. Dublin Core specifies a small and commonly used set of elements to describe general online resources. Dublin Core however fails to capture a very important part of the complexity of cultural and other resources. Among others, it cannot describe the place of creation of an item; it cannot capture a creation process of more than one phase; it cannot characterize the finding of an archaeological object.

The VRA Core Categories [10] standard provides a more specialized set of elements to cover works of visual culture as well as the images that document them. VRA also defines how standard vocabularies should be used to annotate material. However, like Dublin Core, VRA fails to capture composite contexts of creation, use, find etc., since information about dates, places and agents is disassociated from the event context.

The <indecs> project [6,4] was aimed at the massive integration of multimedia metadata for tracing intellectual property rights in the music industry. Being supported by experts on legal issues, they came up with an event-centric core ontology that was later developed into the ABC model in the ABC Harmony project [7]. This was an international collaboration funded by DSTC, JISC and NSF from 1999 until 2002 to investigate a number of the key issues in describing complex multimedia resources in digital form. It tested applications of the ABC model in general digital library projects and in more specific cultural heritage applications. Being very compact, the ABC model had a distinct theoretical impact on several research projects. It comes closest to the CIDOC CRM, and both models have been harmonized [3]. In practical applications, such as an RDF metadata schema, the decision of ABC to model both events and the states between the events however turned out to be rather unwieldy, creating far more complex instances than what we propose here.

The MPEG-7 metadata standard [8] provides a set of elements for describing the semantic content of audiovisual material. It can be used to describe what (e.g. people, objects) exists in a multimedia content, their relationships (e.g. friends, family members), when they appear in the content and where they appear on the video image (or in the real world). Jane Hunter has worked on a harmonization of MPEG 7 and the CIDOC CRM [5].

3 The Conceptual Reference Model

The CIDOC CRM is a core ontology for the semantic integration of cultural information, including library, archive and other information. Since 1996 it has been developed and supported by the International Committee for Documentation (CIDOC) of the International Council of Museums (ICOM). More recently, it has been accepted as an ISO standard and is available as a Final Draft ISO standard (ISO/FDIS 21127).

The CIDOC CRM concentrates on the definition of relationships, rather than classes, to capture the underlying semantics of multiple data and metadata structures. This has led to a compact and easy to comprehend model of 80 classes and 130 relationships, comprised of the most characteristic concepts required for museum, archive and library documentation.

The CIDOC CRM enjoys a rapidly increasing take up by information systems designers all around the world. An on-going collaboration of the ICOM and IFLA committees has resulted in the harmonization of CIDOC CRM with the FRBR model, a standard for conceptualizing bibliographic information. This process has demonstrated that CIDOC CRM subsumes all of the relevant FRBR concepts. Jane Hunter describes a consolidation of MPEG7 concepts with the CIDOC CRM to provide an ontology for describing museum multimedia content [5]. In the Sculpteur project, the CIDOC CRM was used as the common model for providing search and retrieve facilities over different museum multimedia collections [9].

The model is available as an XML DTD, and it has also been formulated as RDFS and OWL ontologies.

We believe that the model can serve as a basis for the mediation of cultural and library information, thereby providing the semantic 'glue' needed to transform today's disparate, localised information sources into a coherent and valuable global resource.

3.1 CRM Core

The CRM Core is a recent proposal from CIDOC for a highly condensed set of metadata elements, designed for resource discovery, i.e. it aims at summarizing the most relevant associations about a resource that may help a user to select the information she is looking for on an information system. It captures the basic functions of identification, classification, participation, part decomposition, references and similarity. In other words, it describes the most fundamental relationships that connect things, concepts, people, time and place. CRM Core is not only a metadata format for resource discovery, but also a simple schema for summarization of historical facts. It allows for exploiting the fact that metadata about the creation, use and discovery constitute historical facts comparable to the information found in documents themselves.

The explicit modelling of events is the central idea behind the CIDOC CRM and CRM Core, both for the representation of metadata, such as creation, publication, and use, as well as for content summarization and the creation of integrated knowledge bases. The normal human way to analyse the past is to split up evolution into discrete events. Therefore, all such information about the past can be formulated as events involving “Persistent Items” (continuants or endurants). The involvement can be of quite different nature, but it implies in any case presence of the respective things. Even immaterial items can be present in events through their carriers. This abstraction creates a view of history as lifelines of Persistent Items meeting in discrete events, an example of which is shown in Fig. 1.

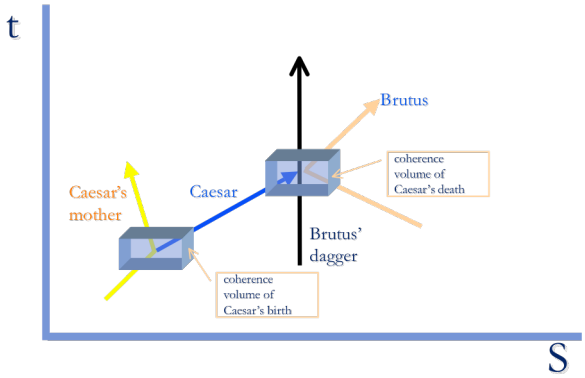

Fig. 1. History as meetings of things and people. This example models the life of Julius Caesar. His birth can be regarded as his first meeting with is mother, which also begins his existence. The coherence volume of his birth can be estimated by both the room and the whole day of his birth. Caesar's murder can be described as a meting of Caesar, Brutus, Brutus's dagger and others. Whereas Caesar's existence finishes, Brutus, his dagger and others continue to exist after the event.

In the CIDOC CRM, this abstraction is represented by the superproperty *P12 occurred in the presence of*, which generalizes over dozens of more specific roles something can have in an event. In CRM Core, this property is implicit in the fields "participants" and "things_present", which can be material or immaterial. In the case of immaterial items, they "participate" through their carriers, be it a human mind, a piece of paper or whatever. CRM Core is *designed so* that, once the identifiers of referred items are resolved, multiple CRM Core records can be integrated into a CIDOC CRM compatible semantic network, which allows then for deductions from deeper data paths expressing various contextual properties, such as friends of friends etc.

This approach to event modelling is generic enough to describe not only cultural materials but also the basic documentation of experiments and observations carried out in the sciences.

CRM Core can be expressed in a Dublin Core compatible format that is expressive enough to describe large meaningful networks of knowledge. CRM Core is more general than Dublin Core, and more precise as it allows different kinds of events to be specified.

CRM Core is currently available as an XML DTD, although an OWL ontology is under development. CRM Core represents a subset of CIDOC CRM concepts and links, so we are able to transform CRM Core records into CIDOC CRM networks.

4 Modelling multimedia annotations with CRM Core

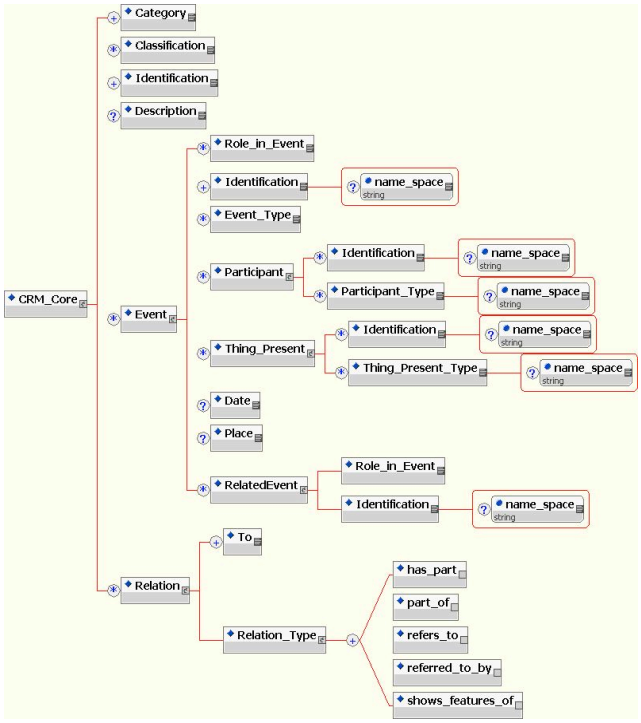

Fig. 2. A graphical representation of the CRM Core DTD

A graphical representation of the CRM Core model is presented in Fig. 2. CRM Core reduces the CIDOC CRM to four fundamental principles: participation in events, part whole relation, reference and classification. Each entity, including people, objects, places, institutions and so on, is modelled as a separate CRM Core record.

These entities can participate in events, using the *Participant* and *Thing_Present* elements. This information is used to model a wide variety of relationships, such as creator, contributor, publisher, birth date, birth place, creation date, place of find, designer, project leader and so on.

CRM records can refer to other records through the relation element, which can be typed as: *has part*/*part of*, *refers to*/*referred to* by and *shows features of*. As mentioned above, events can define participants and things that were present, events can relate to one another using the full range of CRM properties.

Being able to specify part-whole relations is a crucial element of CRM Core. In addition to model these using the *has part*/*part of* relationships, (e.g. an item belongs to a particular collection), events can also be broken down into a set of sub events. While this is sufficient to model part-whole relations, it does not cover all non-hierarchical structures, such as logically ordered sequences or the relative position of elements within an item. We are considering extending CRM Core to cover these kinds of relations, which are commonly encountered in multimedia.

Each CRM record can be assigned to a set of CRM concepts to define the type of record using the *Category* element. In addition to this, records can be classified using standard controlled vocabularies and thesauri using the *Classification* element.

4.1 Example: Yalta Agreement

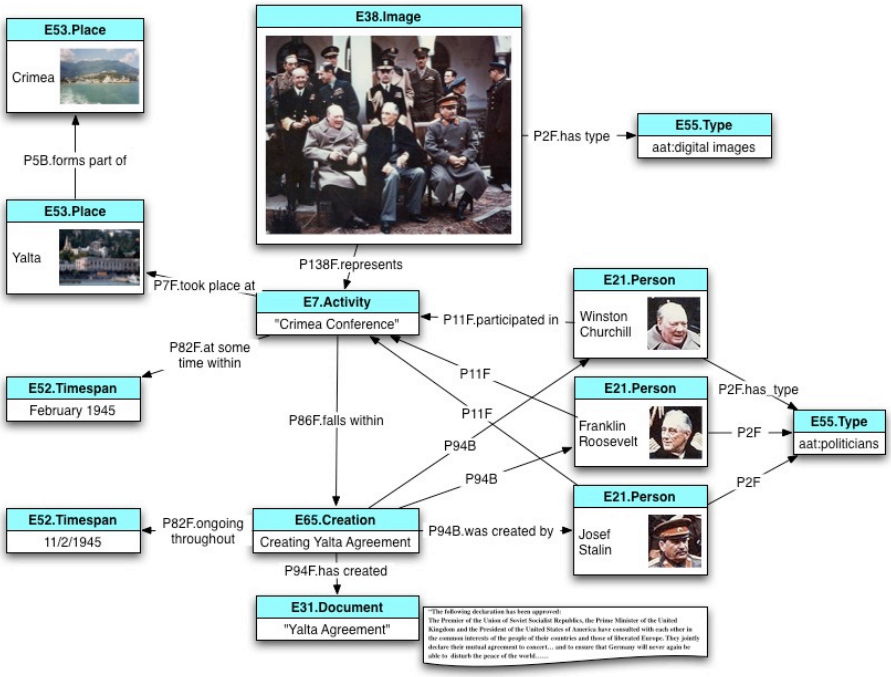

Fig. 3. A typical cultural heritage scenario modelled using CIDOC CRM

Fig. 3 illustrates how a typical cultural heritage scenario is modelled using a CIDOC CRM structure. The photo was taken at the Crimea Conference summit in 1945 at Yalta where the three Allied leaders, Winston Churchill, Franklin Roosevelt and Josef Stalin, signed the Yalta agreement.

The image is represented as an instance of the CIDOC CRM concept *E38.Image*. The image represents, through the CIDOC CRM property *P138F.represents,* the "Crimea Conference", which is modelled as an *E7.Activity*. The conference took place (*P7F.took place at*) at Yalta (*E53.Place*) in (*P82F.at some time within*) February 1945 (*E52.Timespan*). Winston Churchill, Franklin Roosevelt and Josef Stalin are modelled as instances of *E21.Person* that were present (*P11F.participated in*) the Crimea Conference.

At the conference, the Yalta Agreement was signed. The creation (*E65.Creation*) of the agreement, an instance of *E31.Document*, is defined as a subevent (*P86F.falls within*) of the Crimea conference, which occurred (*P82F.ongoing throughout*) the 11th of February 1945.

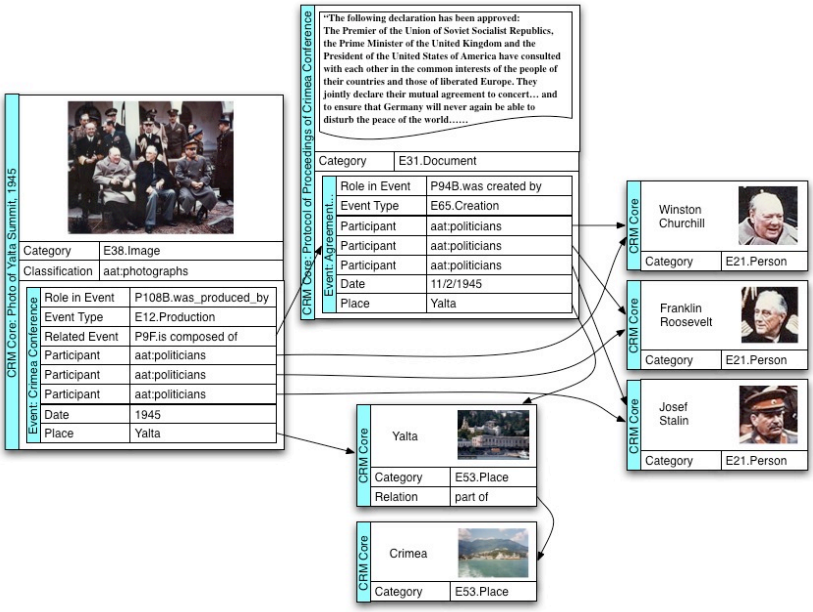

Fig. 4. The same example structured using CRM Core

Fig. 4 shows the same example but structured as CRM Core records. Sample CRM Core XML records for some of these elements are presented in the Appendix. More examples, illustrating other aspects of modelling cultural heritage information, can be found on the CIDOC CRM web site [1].

The CIDOC CRM defines the underlying semantics of cultural heritage information in terms of a formal ontology, and thus it does not specify any of the terminology appearing typically as data in the respective data structures. CRM Core defines characteristic relationships for the use of controlled terminology by allowing CRM Core records to be classified according to entries in controlled thesauri.

In the example above, the Getty Art and Architecture Thesaurus (AAT) has been used to classify each record. The image on Wikipedia is classified with the "digital images" term, and each person has been classified with the term "politicians". It is important that associations to domain vocabularies are handled through the identifiers in the vocabulary, as opposed to simply using free text labels.

In the cultural heritage domain several domain vocabularies are widely used, including AAT, English Heritage, HEREIN, ICONCLASS and SHIC. Outside of the cultural heritage domain there are a wide variety of vocabularies that can be used, such as IPTC news codes.

Location information should be handled through a gazetteer, such as the Getty Thesaurus of Geographical Names. References to people and institutions should also be performed using a controlled list. In the cultural heritage domain, the Union List of Artist Names is available for artist information.

4.2 Example: Lawson Cabinet

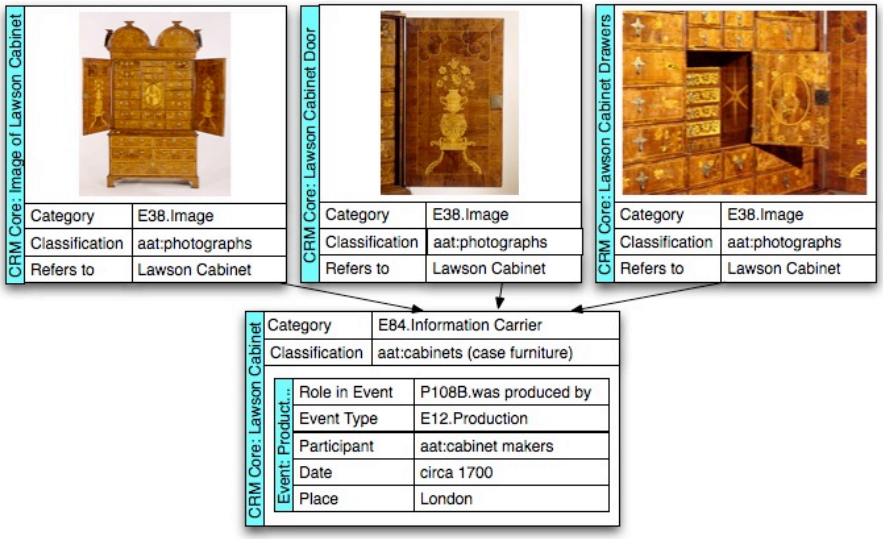

Fig. 5. Different views on the same physical object (V&A Museum)[1]

Figure 5 illustrates a CRM Core example where several multimedia items represent different views of the same physical object. A CRM Core *refers to* relation property is used as a simplification of the full CIDOC CRM *P138F.has representation*. The use of CRM Core relations allows the modeling of connections between different records that are not directly related to or involving an event.

5 Advanced Scenarios

There are many applications for multimedia in the cultural heritage domain, and very often cultural objects are surrounded by extraordinary circumstances. It is important that this information can be captured and structured adequately.

A common issue is that many multimedia items may be used to represent a single real world object. It may be that popular objects, such as the Mona Lisa, have been photographed or recorded many times by different people. There may be scientific reasons for photographing an item many times, such as determining its physical condition over time.

It is often not possible to capture a complex physical object using a single item of media, so it may be necessary to use a set of photographs representing multiple views of the same physical objects. Close-up shots may be used to capture specific details,

[1] http://www.vam.ac.uk/collections/furniture/object_stories/lawson/index.html

and three-dimensional objects need to be photographed from different perspectives. Even the reverse of paintings are sometimes photographed for conservation purposes.

With some objects different views are essential to provide a full representation, as an item's intended use may be unclear without multiple views. In the Lawson cabinet example, shown in Fig. 5, three views illustrate different aspects of a cabinet, including the detail on the inside of the cabinet door and a close up of a smaller door which was not apparent from the first photo.

The creation of one multimedia object may involve the processing of other multimedia objects, for example a series of 2D photographs can be used to make a set of 2D silhouettes, which in turn were used to create a 3D model and texture map. Multiple media objects are created using a particular process with both the starting point and end result describing a particular physical object.

Interesting scenarios arise where a particular artist creates several different works of art of the same subject, often located in different museums. There might also be preparatory paintings and sketches for certain paintings. Different multimedia objects might then represent each of these related items, and it may be useful to link between them. Art historians are interested in the social context behind the work. They would search for the sponsors, competitors, friends and their activities.

It is not uncommon for artists to create portraits of themselves or other artists, as was the case with Rubens and Brueghel[3]. In this scenario, a photograph represents a painting created by an artist that also depicts that artist and other people related to them. Frequently sponsors and other VIPs used to be portrayed in minor roles of religious sceneries, as accidental adorants or others. A Madonna may carry features of the sponsor's beloved.

Sometimes multimedia objects are the result of extraordinary situations. One example was the murder of photojournalist John Hoagland (1947-1984) by soldiers during the war in El Salvador. His last six frames, found in his camera, record his own death and show Hoagland a few yards from a pair of Salvadoran soldiers on an empty road. One turns towards him and apparently sees he is taking pictures. The next to last frame, shot as he was falling shows the tip of his shoe and the last picture is of the Salvadoran soil. This event has been modelled using CRM Core and details can be found on the CIDOC CRM website [1]. It demonstrates that metadata and contents basically belong to the same historical context.

Certain areas in cultural heritage are sources of very rich information. Explorers and geographers in the 18th and 19th centuries kept extremely detailed logs of their travels, including textual descriptions, paintings, sketches, animal and floral specimens and so on. These logs were also very well structured according to time and place, and richly interlinked across people and institutions. These artefacts are now scattered over archives, libraries and museums of various disciplines. Any scientific evaluation of these resources needs integration of information from multiple heterogeneous institutions.

Different scientific images, such as ultra-violet, infrared and x-ray, are often used for conservation. Sometimes these are presented alongside the original artwork in museums and galleries, along with explanations of how to interpret them and what

[3] http://www.artandarchitecture.org.uk/fourpaintings/rubens/index.html

they reveal, e.g. to show how conservation has been done on an oil painting, the under drawings, the paint layers, and the brush strokes. This scenario shows how different types of images can show different characteristics of the same physical object.

Conclusions

The examples presented here have illustrated the complex and intricate nature of the knowledge representation required to effectively capture historical and cultural heritage information. Essential to the sense-making process is the capability to represent the wider context from which we have witnessed by historical records, heirlooms and finds. Current standard metadata approaches are either too simplistic or they are not directly suited to reconstruct the knowledge about the historical context that could emerge from the integration of the various sources.

We have shown that the CIDOC CRM (ISO/FDIS21127) can provide an intellectual base to create meaningful contextual networks of facts based on participation of material and immaterial items in historical events and part-whole relations. We have further shown that the still considerable complexity of the CIDOC CRM, which aims at an adequate analysis of the conceptualizations behind quite elaborate data structure, can be further simplified into a very simple metadata element set we call CRM Core, still preserving the capability to become the basis for meaningful contextual networks.

Of course, in order to create such networks, as with any other metadata approach, a systematic approach to data cleaning and duplicate removal is required, so that the domain and range values of the created relations actually match.

The simplicity makes CRM Core an interesting candidate as a core metadata set for large-scale application. In conjunction with CIDOC-CRM-based metadata repositories, architectures integrating metadata of various degrees of complexity and detail can be imagined. The simplicity on the other side is the outcome of a very high level of abstraction, which entails applicability far beyond the cultural-historical domain. In particular in e-science, the access to and correlation of experimental data and measurements constitute the first level of information integration. Since experiments are historical events, they can appropriately be described by CRM Core. Other obvious applications are biodiversity data, epidemiological data and so on.

Acknowledgements

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Appendix: XML CRM Core Records

Example: Yalta Agreement

The image on Wikipedia:

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE CRM_Core SYSTEM "CRM_Core.dtd">
<CRM_Core>
 <Category>E38.Image</Category>
 <Classification
name_space="http://www.getty.edu/research/conducting_research/vocabularies/aat/">d
igital images</Classification>
 <Identification>
http://en.wikipedia.org/wiki/Image:Yalta_Conference.jpg</Identification>
 <Description>Yalta summit in 1945 with Winston Churchill, Franklin Roosevelt and
Josef Stalin</Description>
 <Event>
  <Role_in_Event>P138F.represents</Role_in_Event>
  <Identification name_space="http://cidoc.ics.forth.gr/crm_core/ demo">Crimea
Conference</Identification>
  <Event_Type name_space="http://cidoc.ics.forth.gr/rdfs/ci-
doc_v4.2.rdfs">E7.Activity</Event_Type>

  <Participant>
   <Identification>http://en.wikipedia.org/wiki/Churchill</Identification>
```

```
   <Participant_Type
name_space="http://www.getty.edu/research/conducting_research/vocabular-
ies/aat/">politicians</Participant_Type>
  </Participant>
  ...
  <Date>1945</Date>
  <Place name_space=
"http://www.getty.edu/research/conducting_research/vocabularies/tgn/">Yalta (in-
habited place)</Place>
  <RelatedEvent>
    <Role_in_Event> P9F.is_composed_of</Role_in_Event>
    <Identification name_space= "http://cidoc.ics.forth.gr/crm_core/demo">Creating
Yalta Agreement</Identification>
  </RelatedEvent>
 </Event>
</CRM_Core>
```

Record for the Protocol of Proceedings of Crimea Conference:

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE CRM_Core SYSTEM "CRM_Core.dtd">
<CRM_Core>
 <Category>E31.Document</Category>
 <Identification> http://www.taiwandocuments.org/yalta.htm</Identification>
 <Description>Protocol of Proceedings of Crimea Conference.</Description>
 <Event>
  <Role_in_Event>P94B.was_created_by</Role_in_Event>
  <Identification name_space="http://cidoc.ics.forth.gr/crm_core/demo">Creating
Yalta Agreement</Identification>
  <Event_Type name_space= "http://cidoc.ics.forth.gr/rdfs/cido c_v4.2.rdfs">
E65_Creation</Event_Type>
  <Participant>
   <Identification>http://en.wikipedia.org/wiki/Churchill</Identification>
   <Participant_Type
name_space="http://www.getty.edu/research/conducting_research/vocabular-
ies/aat/">politicians</Participant_Type>
   ...
  </Participant>
  <Date>1945</Date>
  <Place name_space=
"http://www.getty.edu/research/conducting_research/vocabularies/tgn/">Yalta (in-
habited place)</Place>
  <RelatedEvent>
   <Role_in_Event>P9B.forms_part_of</Role_in_Event>
   <Identification name_space="http://cidoc.ics.forth.gr/crm_core/demo">Crimea
Conference</Identification>
  </RelatedEvent>
 </Event>
</CRM_Core>
```

Example: Lawson Cabinet

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE CRM_Core SYSTEM "CRM_Core.dtd">
<CRM_Core>
 <Category>E84.Information_Carrier</Category>
 <Classification name_space=
"http://www.getty.edu/research/conducting_research/vocabularies/aat/">cabinets
(case furniture)</Classification>
 <Identification>
http://www.vam.ac.uk/collections/furniture/object_stories/lawson/index.html
 </Identification>
 <Description>The cabinet was made in about 1700 to commemorate the marriage of
Margaret Trotter to George Lawson. The couple's monograms can be seen on the outer
doors, while the arms of the two families can be found on the door of the inner
cupboard.</Description>
 <Event>
  <Role_in_Event>P108B.was_produced_by</Role_in_Event>
  <Identification name_space="http://cidoc.ics.forth.gr/crm_core/demo">  Mak-
ing_the_Lawson_Cabinet</Identification>
  <Event_Type name_space=
"http://cidoc.ics.forth.gr/rdfs/cidoc_v4.2.rdfs">E12_Production</Event_Type>
  <Participant>
   <Participant_Type name_space=
"http://www.getty.edu/research/conducting_research/vocabularies/aat/">cabinetmaker
s</Participant_Type>
  </Participant>
  <Date>Circa 1700</Date>
  <Place name_space=
"http://www.getty.edu/research/conducting_research/vocabularies/tgn/">City of
London (World, Europe, United Kingdom, England, Greater London, London)</Place>
 </Event>
</CRM_Core>

<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE CRM_Core SYSTEM "CRM_Core.dtd">
<CRM_Core>
 <Category>E38.Image</Category>
 <Classification name_space=
"http://www.getty.edu/research/conducting_research/vocabularies/aat/">photographs<
/Classification>
 <Identification>http://www.vam.ac.uk/images/image/3689-popup.html
 </Identification>
 <Description>Lawson Cabinet</Description>
 <Relation>
  <To>http://www.vam.ac.uk/collections/furniture/object_stories/lawson/index.html
  </To>
  <Relation_Type>
   <refers_to/>
  </Relation_Type>
 </Relation>
</CRM_Core>
```