OntoMedia* - Creating an Ontology for Marking Up the Contents of Heterogeneous Media

Faith Lawrence[1], Mischa M. Tuffield[1], Mike O. Jewell[2], Adam Prügel-Bennett[2], David E. Millard[1], Mark S. Nixon[2], monica schraefel[1], & Nigel R. Shadbolt[1]

[1] Intelligence, Agents, Multimedia (IAM) Group
School of Electronics and Computer Science
University of Southampton
[2] Image, Speech and Intelligent Systems (ISIS) Group
School of Electronics and Computer Science
University of Southampton

Abstract. This paper describes the OntoMedia ontology, an ontology for describing the semantic content of hetrogeneous media. We present our motivation for creating this ontology and consider how it relates to similar ontologies in the bibliographic and multimedia domains.

1 Introduction

Ontologies are paving the foundations for the realisation of the Semantic Web (SW) vision [1] by capturing knowledge in a machine understandable language, such as the Web Ontology Language (OWL) [2]. These conceptualisations of different domains are being harnessed to annotate documents for a variety of tasks. The OntoMedia ontology aims to provide a meaningful set of classes and relationships to facilitate the annotation of the semantic content of heterogeneous multimedia items[3] (see section 2.1).

Given the widely adopted Stuber *et al* definition of an ontology: "An ontology is a formal, explicit specification of a shared conceptualisation" [3], this paper will present the phenomenon that OntoMedia aims to model highlighting how this differs from existing models.

There are currently many overlapping ontologies on the Semantic Web. A Swoogle[4] search for the term "character", you would get approximately 95 matches from their repository. This is because people tend to represent the same phenomenon from different view points and not always for differing domains. To help justify the creation and deployment of an ontology, the abstract model needs to present a novel view point of a given phenomenon or even a representation of an altogether new domain, for otherwise an exiting ontology should be employed or refactored. The remainder of this paper will present the novel view that OntoMedia takes to the annotation of multimedia items with respect to existing models.

* Project Website: http://ontomedia.ecs.soton.ac.uk

[3] The term multimedia items is used to refer to text documents, video and audio streams, pictures, etc.

[4] MindSwap's Semantic Web search engine, http://swoogle.umbc.edu

1.1 Scope

The scope of this ontology is the representation of heterogeneous media through description of the semantic content of that media item. The representation may be limited to the description of some or all of the elements contained within the source or may include information regarding the narrative (see section 2.1) relationship that these elements have both to the media and to each other.

OntoMedia is presented as a General/Common ontology [4] [5], allowing for re-use across domains. This ontology aims to describe a media item by making explicit the narrative elements and their relationships.

2 Problem and Context

2.1 The Problem

Narrative in the Context of OntoMedia The term narrative is used to describe the story that an item of rendered media is presenting. The Semantic Web vision is challenging the manner in which we are publishing content, from a manner suitable for solely human consumption, to the publishing of items of raw knowledge in the form of annotated multimedia items, linked together by a common model, in a machine processable manner. The availability of such semantically enriched artifacts would allow for narratives to be generated in a manner targeted to the user preferences [6]. A discussion of the relevance of the application of narrative theory to Semantic Web enabling technologies is presented in [7].

Motivation Bibliographic data is necessary for accurate attribution and to categorise works. Since the creation of the Internet the way we interacted with media, especially text, has changed. It is now possible to have easy access to all kinds of information that would have been impractical to search, collect, and correlate upon. There are two main reasons to wish to have this information. Firstly to improve searching [8] and secondly to improve filtering.

In a number of recent talks on his vision for the semantic web, Jim Hendler has used the example of the type of query that is commonly used between people and which the semantic web might also be able to understand. The question is "what was that movie with the short henchman who decapitates a statue with his bowler hat?" A person reading that sentence having familiarity with the movie in question will immediately think of the famous scene in the Bond movie Goldfinger. However, it is not the type of query that one can enter into a system like the Internet Movie Database[5], despite its vast array of bibliographic data stored on films and television series. While this example relates to video it can equally apply to text or images e.g. "what is that story where the hero has a portrait of himself that changes?" or "what is that book with a lamp-post in the middle of a wood and it is always winter?". The questions could deliberately be

[5] Internet Movie DataBase or IMDB can be found on www.imdb.com

more vague such as "which books have the main character making a deal with the devil?" or "which myths contain the world being created from body parts". The former examples are more useful to track down a particular story while the later are useful for comparative studies of literature, fictional, historical or mythological. The OntoMedia ontology is a step towards answering these sorts of questions by going beyond bibliographic data, into the discussion of the relationships that exist within and between elements of heterogeneous media.

2.2 Context

FicNet FicNet is an ongoing human-computer interaction research project, which examines the presentation of the semantic web to end users, in this case the amateur writing online community [9]. Community Studies involving observation and a questionnaire were employed to determine what records were used and desired by members of the community. This interaction with the user group showed that there was a perceived need among many of the respondents for a greater level of detail to be optionally available to them. This worked to replace the cues they would normally get from a professionally printed novel. This was because in some cases the stories were about already known and loved characters, with whom the readers had a more involved relationship than they would otherwise expect to have. Between these two reasons and the great deal of material easily available to chose from many readers expressed their preference for this extra information. It was stressed by the users who were involved in the study that the metadata they were provided with was used to find stories that involved specific story lines and/or concepts, to avoid those that they disliked, found upsetting or simply were not in the mood for. A noticeable tension was discovered between the desire for this information and the concern that it would spoil the story.

From the study above a number of requirements were drawn up that fed directly into the early development of the OntoMedia ontology. The first of these was the need to describe the media objects that were created by this community in terms of both bibliographic detail and content. While the majority of these media objects were textual works of fiction others included images, video and occasionally music. The bibliographic data could be described by any one of the many vocabularies that already exist such as the Dublin Core or the Functional Requirements for Bibliographic Records (see 3.2) but none of these were designed with the intent of describing the internal content of the media. While it is possible to use these models to include information concerning the contents of the media item it produces a less than ideal situation since this was not the primary purpose for which they were designed. The second of these requirements was for the ontology to acknowledge that some of the metadata records could be considered sensitive information in that they would give away important plot information. This information is now included in the Fiction extension of OntoMedia.

State-Based Sequencer Concentrating on video-related annotation, SBS[10] (State-Based Sequencer) is a project for the automatic composition of film soundtracks. The composition process is parameterised using a marked video and a 'composer representation' which denotes how aspects of a film should be represented in the music. For example, it can be specified that a certain colour should signify the introduction of a different instrument into the resultant music. OntoMedia is being utilised for the annotation process, and this is then mapped using SerQL queries into the final parameter file for input into a set of composing algorithms.

Cultural Heritage OntoMedia is also being directed as a result of both current and prior cultural heritage projects. This area is a significant driver of ontologies and annotation techniques, and the Sculpteur[11] and eChase projects have both been influential towards the design of the OntoMedia classes. The Sculpteur project, itself extending the Artiste[12] project, provided metadata for museum collections (specifically 3D items, such as a sculpture) and hence enabled access through a semantic layer. More recently, the eChase project is one project considering OntoMedia and its aim to provide access to cultural heritage materials provides an apt opportunity. Working with the eChase team has resulted in a number of additions to the ontology through extension classes, such as flexible means for denoting regions of media and additional attributes to provide details of ownership and creator. OntoMedia further augments the cultural heritage representation with the availability of a timeline which allows for the placing of events and items within a temporal context - and hence allowing for the generation of historical narratives. A similar of using annotated multimedia is the Story Fountain system [13] that produces story paths from the historical archives of Bletchley Park.

Memories for Life Memories for Life has been selected as a grand challenge for UK computing[6], and aims to address the applicability of storing a lifetimes worth of autobiographical memories in the form of digital multimedia. Given the task of storing such a collection of memories, methods of storing, and annotating are currently being investigated. A system of annotating personal pictures using as much information from readily available sources as possible (zero cost, low overhead annotation) is currently under development. This system aims to generate autobiographical narratives in the form of multimedia presentations from digital memories. OntoMedia's ability to model events occurring in different mediums on a time-line, will allow for events and entities to be used to construct autobiographical narratives.

[6] Memories for Life website: www.memoriesforlife.org, describes the ambitions and directions of the network

3 Existing Resources and Past Work

3.1 CIDOC Conceptual Reference Model

The summarised scope of the CIDOC Conceptual Reference Model (CRM) is "the curated knowledge of museums" [14]. In their most recent documentation this is expanded to describe the intended scope of the CRM "as all information required for the exchange and integration of heterogeneous scientific documentation of museum collections". The practical scope must include duplicating all information stored in the currently used documentation standards without any loss of meaning. The CRM works with an entity & event model that in many ways resembles the OntoMedia ontology. The similarity between cultural heritage and fictional content is one of underling significance.

Despite their initial similarities the CIDOC CRM is still primarily concerned with the physical object equivalent of bibliographic data. It can describe in detail the condition, provenance, and attributes of an object, such as a red-figure vase. As part of this description it will include information on the decorative scenes, without placing the depictions with a narrative context.

Due to the top-level similarity, mapping between the CIDOC CRM and OntoMedia can be undertaken comparatively easily. It is expected that the two ontologies will work together each within their intended scope. For example, the CIDOC CRM would describe the physical attributes of our ceramic item, while the OntoMedia ontology would be used to describe the conceptual content of the decoration. The concepts of narrative, character, and context imbued within this object can then be compared to cultural heritage sources just as the make, material, and style of the vase can be. This additional layer of metadata allows for the integration of abstract myths, traditions, and concepts (both written and oral) with the material evidence, allowing for any additional relationships to be explored.

3.2 The Functional Requirements for Bibliographic Records Model

The existence of textual evidence in cultural heritage had lead to work on mapping the CIDOC CRM to the Functional Requirements for Bibliographic Records (FRBR) model. FRBR was created by the International Federation of Library Associations and Institutions to "produce a conceptual model that would serve as the basis for relating specific attributes and relationships (reflected in the record as discrete data elements) to the various tasks that users perform when consulting bibliographic records" [15].

FictionFinder[7] is a prototype system, which applied the FRBR model to the Online Computer Library Center (OCLC) WorldCat database. This system is notable for allowing search on fictional characters and imaginary places as well as the more common author, setting, genre, summary, title, and subject. The Columbus Metropolitan Library Fiction Finder[8] has a similar although less

[7] Project url: http://www.oclc.org/research/projects/frbr/fictionfinder.htm
[8] Project url: http://www.columbuslibrary.org/cmlradv/browse2.cfm

developed system, in so far that only some of their records have metadata about characters associated with them. This information on what might be seen as content rather than bibliography is taken, in the case of the OCLC system, from the section of the FRBR model referred to as the Group 3 Entities. These are `Concept`, `Object`, `Event` and `Place` and relate to the FRBR object Work through the `has-as-subject` relationship. A work may also have as a 'subject' entities from Group 1 (other media objects) and Group 2 (people and corporations). The Group 3 entities defined in the FRBR can be considered equivalent to the top level of the OntoMedia Ontology using the following mapping:

FRBR Group 3 Entities	**OntoMedia Core Classes**
Concept	Abstract-Item
Object	Physical-Item
Event	Event
Place	Space

Expending this mapping, if we consider the FRBR Groups 1 and 2 as if they appeared as subjects in a narrative the mapping could be made as below:

Group 1 Entities As Subject	**OntoMedia Core Classes**
Work	Context
Expression	Abstract-Item
Manifestation	Collection/Physical Item
Item	Physical-Item
Group 2 Entities As Subject	**OntoMedia Being Classes**
Person	Being/Character
Corporate Body	Organization

Where the FRBR approach differs from OntoMedia is the meaning with which these 'subjects' are imbued. The FRBR has no model of time or narrative flow. For example, the attribute for an event is simply the term used for that event, i.e. 'the Second World War'. It is an identifying label rather than an object with its own meaning. OntoMedia expands on this metadata as it does with the CIDOC CRM to allow exploration of the events and entities which the media object contains within in conceptual framework. From this, the subject as defined by its FRBR can be directly drawn or inferred. Future research may even allow such bibliographic categorisations such as genre and summary to be suggested if not generated by querying of the OntoMedia data.

The CIDOC CRM, FRBR, and OntoMedia models work as complementary vocabularies. They overlap enough to be mappable between each other, and the differences in their scopes and strengths implies that they best be applied for different purposes and subsequently linked through mapping.

3.3 The ABC Ontology

In designing the OntoMedia ontology a variety of existing techniques for media annotation were taken into consideration. Of particular note is the ABC Ontology by Lagoze and Hunter[16]. This was developed as part of the Harmony

international digital library project with an aim to provide a level of interoperability between existing metadata ontologies, primarily for the cataloguing community. The OntoMedia Core is based on similar principles, particularly the separation of spatial and temporal classes. OntoMedia further adds the capability for trait and motivation representation, which ease the annotation of attributes and intent to provide specializing classes for application to fiction. Furthermore, Hunter proposes a technique to represent MPEG-7 using a DAML+OIL representation, whereas we make use of a VLit adaptation combined with a geometry ontology to reference sections of source media.

3.4 Action

A further related ontology is that of Action[17], a taxonomy focusing on the representation of events. As such, it highlights the physical effects of events, the activities involved, and more abstract characteristics such as style. OntoMedia carries several of these ideas into the Event class, which may have preconditions and postconditions to describe the causes and effects. Furthermore, this has the capability of being combined with the motivation attributes that are assignable to participants to infer more information regarding the intent of those involved.

4 Ontology Formalization

Below is an extract of the OntoMedia's formalisation. OntoMedia is split into three parts the core ontology of which the main section is below, extensions e.g. Fiction, and finally stand alone additions. The ontology can be viewed in its entirety on the project website (http://ontomedia.ecs.soton.ac.uk/ontologies/).

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

<!DOCTYPE owl [
...
  <!ENTITY base "http://ontomedia.ecs.soton.ac.uk/ontologies/core/expression">
...
]>

<rdf:RDF xmlns:rdf="&rdf;"
...
 xmlns:dct="&dct;">

  <owl:Ontology rdf:about="&base;">
    <rdfs:label>OntoMedia Core</rdfs:label>
    <dc:title xml:lang="en">OntoMedia Core</dc:title>
    <dc:description xml:lang="en">OntoMedia (Ontology for Media) has been designed to describe
     the interactions occurring in multimedia.</dc:description>
    <dc:creator>Michael O. Jewell (mailto:moj@ecs.soton.ac.uk)</dc:creator>
    <dc:creator>K Faith Lawrence (mailto:kf03r@ecs.soton.ac.uk)</dc:creator>
    <dc:creator>Mischa M Tuffield (mailto:mmt04r@ecs.soton.ac.uk)</dc:creator>
    <dct:created>2005-05-03</dct:created>
    <owl:versionInfo>0.3</owl:versionInfo>
    <owl:imports rdf:resource="http://signage.ecs.soton.ac.uk/ontologies/location" />
  </owl:Ontology>

<!-- Core -->
```

```
<owl:Class rdf:ID="Expression">
  <rdfs:label>Expression</rdfs:label>
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string">This class
   represents a piece of information conveyed through a media</rdfs:comment>
</owl:Class>

<owl:ObjectProperty rdf:ID="inspired-by">
  <rdfs:label>inspired by</rdfs:label>
  <rdfs:comment rdf:datatype="&xsd;string">This property indicates that the
   expression was inspired by another</rdfs:comment>
  <rdfs:domain rdf:resource="#Expression"/>
  <owl:inverseOf>
    <owl:ObjectProperty rdf:ID="inspired"/>
  </owl:inverseOf>
  <rdfs:range rdf:resource="#Expression"/>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="has-shadow">
  <rdfs:label>has shadow</rdfs:label>
  <rdfs:comment rdf:datatype="&xsd;string">This property indicates that the
   expression is a variation on another, typically darker in nature</rdfs:comment>
  <owl:inverseOf>
    <owl:ObjectProperty rdf:ID="is-shadow_of"/>
  </owl:inverseOf>
  <rdfs:range rdf:resource="#Expression"/>
  <rdfs:domain rdf:resource="#Expression"/>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="has-spin-off">
  <rdfs:label>has spin off</rdfs:label>
  <rdfs:comment rdf:datatype="&xsd;string">This property indicates that the
   expression has developed from another</rdfs:comment>
  <rdfs:domain rdf:resource="#Expression"/>
  <owl:inverseOf>
    <owl:ObjectProperty rdf:ID="is-spin-off-of"/>
  </owl:inverseOf>
  <rdfs:range rdf:resource="#Expression"/>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="is-potentially">
  <rdfs:label>is potentially</rdfs:label>
  <rdfs:range rdf:resource="#Expression"/>
  <rdfs:domain rdf:resource="#Expression"/>
  <rdfs:comment rdf:datatype="&xsd;string">This property indicates that the
   expression is potentially another. For example, it may be a possible future
   version</rdfs:comment>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="is">
  <rdfs:label>is</rdfs:label>
  <owl:inverseOf>
    <owl:ObjectProperty rdf:ID="is-not">
      <rdfs:comment rdf:datatype="&xsd;string">This property indicates that
       the expression is entirely different to another</rdfs:comment>
    </owl:ObjectProperty>
  </owl:inverseOf>
  <rdfs:domain rdf:resource="#Expression"/>
  <rdfs:range rdf:resource="#Expression"/>
  <rdfs:comment rdf:datatype="&xsd;string">This property indicates that the
   expression is exactly the same as another</rdfs:comment>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="in-context">
  <rdfs:label>in context</rdfs:label>
```

```
    <rdfs:comment rdf:datatype="&xsd;string">This property specifies the context
     in which this expression lies.</rdfs:comment>
    <owl:inverseOf>
      <owl:ObjectProperty rdf:ID="includes-expression"/>
    </owl:inverseOf>
    <rdfs:range rdf:resource="#Context"/>
    <rdfs:domain rdf:resource="#Expression"/>
  </owl:ObjectProperty>

  <owl:Class rdf:ID="Entity">
    <rdfs:label>Entity</rdfs:label>
    <rdfs:subClassOf rdf:resource="#Expression" />
  </owl:Class>

  <!-- Entity Subclasses -->
  <!-- Items -->

  <owl:Class rdf:ID="Item">
    <rdfs:comment rdf:datatype="&xsd;string">This class represents an entity which
     may participate in an event within the media. An Item may be abstract or
     physical</rdfs:comment>
    <rdfs:label>Item</rdfs:label>
    <rdfs:subClassOf rdf:resource="#Entity" />
  </owl:Class>

  <owl:Class rdf:ID="Physical-Item">
    <rdfs:comment rdf:datatype="&xsd;string">This class represents a physical entity
     which may participate in an event within the media</rdfs:comment>
    <rdfs:label>Physical Item</rdfs:label>
    <rdfs:subClassOf rdf:resource="#Item" />
  </owl:Class>

  <owl:Class rdf:ID="Abstract-Item">
    <rdfs:comment rdf:datatype="&xsd;string">This class represents an abstract entity
     which may participate in an event within the media</rdfs:comment>
    <rdfs:label>Abstract Item</rdfs:label>
    <rdfs:subClassOf rdf:resource="#Item" />
  </owl:Class>

  <!-- Abstract-Item Subclases -->

  <owl:Class rdf:ID="Context">
    <rdfs:comment rdf:datatype="&xsd;string">This class represents the context in
     which an event or entity exists</rdfs:comment>
    <rdfs:label>Context</rdfs:label>
    <rdfs:subClassOf rdf:resource="#Abstract-Item" />
  </owl:Class>

  <owl:Class rdf:ID="Collection">
    <rdfs:comment rdf:datatype="&xsd;string">This class represents a collection of
     entities</rdfs:comment>
    <rdfs:label>Collection</rdfs:label>
    <rdfs:subClassOf rdf:resource="#Abstract-Item" />
  </owl:Class>

  <!-- Temporal -->

  <owl:Class rdf:ID="Timeline">
    <rdfs:comment rdf:datatype="&xsd;string">This class contains a sequence of occurring
     events</rdfs:comment>
    <rdfs:label>Timeline</rdfs:label>
    <rdfs:subClassOf rdf:resource="#Entity" />
  </owl:Class>

  <owl:Class rdf:ID="Occurrence">
```

```
  <rdfs:comment rdf:datatype="&xsd;string">This class represents a single occurrence
   of an event, placing it at a position in a timeline</rdfs:comment>
  <rdfs:label>Occurrence</rdfs:label>
  <rdfs:subClassOf rdf:resource="#Entity" />
</owl:Class>

<owl:ObjectProperty rdf:ID="final-event">
  <rdfs:domain rdf:resource="#Event"/>
  <rdfs:range rdf:resource="http://www.w3.org/2002/07/owl#Class"/>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="initial-event">
  <rdfs:domain rdf:resource="#Event"/>
  <rdfs:range rdf:resource="http://www.w3.org/2002/07/owl#Class"/>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="precedes">
  <rdfs:label>precedes</rdfs:label>
  <rdfs:comment rdf:datatype="&xsd;string">This property defines the occurrence which
   immediately follows this occurrence</rdfs:comment>
  <rdfs:range rdf:resource="#Occurence"/>
  <rdfs:domain rdf:resource="#Occurence"/>
  <owl:inverseOf>
    <owl:ObjectProperty rdf:ID="follows"/>
  </owl:inverseOf>
</owl:ObjectProperty>

<!-- Events -->

<owl:Class rdf:ID="Event">
  <rdfs:label>Event</rdfs:label>
  <rdfs:subClassOf rdf:resource="#Expression" />
</owl:Class>

<owl:ObjectProperty rdf:ID="has-subject-entity">
  <rdfs:label>has subject entity</rdfs:label>
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string">This property
   specifies the entity which carries out the aim of the event</rdfs:comment>
  <rdfs:domain rdf:resource="#Event"/>
  <rdfs:range rdf:resource="#Entity"/>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="has-object-entity">
  <rdfs:label>has object entity</rdfs:label>
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string">This property
   specifies the entity which is the target of the event</rdfs:comment>
  <rdfs:range rdf:resource="#Entity"/>
  <rdfs:domain rdf:resource="#Event"/>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="has-occurrence">
  <rdfs:label>has occurrence</rdfs:label>
  <rdfs:comment rdf:datatype="&xsd;string">This property defines any occurrences
   of this event</rdfs:comment>
  <rdfs:range rdf:resource="#Occurrence"/>
  <rdfs:domain rdf:resource="#Event" />
  <owl:inverseOf>
    <owl:FunctionalProperty rdf:ID="occurrence-of"/>
  </owl:inverseOf>
</owl:ObjectProperty>

<owl:DatatypeProperty rdf:ID="summary">
  <rdfs:label>summary</rdfs:label>
  <rdfs:domain rdf:resource="#Event"/>
  <rdfs:range rdf:resource="&xsd;string"/>
```

```
  <rdfs:comment rdf:datatype="&xsd;string">This property is a plain-text description
   of what occurs in the event</rdfs:comment>
</owl:DatatypeProperty>

<owl:ObjectProperty rdf:ID="precondition">
  <rdfs:label>precondition</rdfs:label>
  <rdfs:range>
    <owl:Class>
      <owl:unionOf rdf:parseType="Collection">
        <owl:Class rdf:about="#Entity"/>
        <owl:Class rdf:about="#Event"/>
      </owl:unionOf>
    </owl:Class>
  </rdfs:range>
  <rdfs:domain rdf:resource="#Event"/>
  <rdfs:comment rdf:datatype="&xsd;string">This property is a state that must exist
   before the event can occur</rdfs:comment>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="postcondition">
  <rdfs:label>postcondition</rdfs:label>
  <rdfs:range>
    <owl:Class>
      <owl:unionOf rdf:parseType="Collection">
        <owl:Class rdf:about="#Entity"/>
        <owl:Class rdf:about="#Event"/>
      </owl:unionOf>
    </owl:Class>
  </rdfs:range>
  <rdfs:comment rdf:datatype="&xsd;string">This property contains the state which
   should occur as a consequence of this event</rdfs:comment>
  <rdfs:domain rdf:resource="#Event"/>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="involves">
  <rdfs:label>involves</rdfs:label>
  <rdfs:comment rdf:datatype="&xsd;string">This property specifies the entities involved
   in this event. Note that this includes the subject and object.</rdfs:comment>
  <rdfs:range rdf:resource="#ontomedia_Entity"/>
  <rdfs:domain rdf:resource="#ontomedia_Event"/>
  <owl:inverseOf>
    <owl:ObjectProperty rdf:ID="involved-in" />
  </owl:inverseOf>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="causes">
  <rdfs:label>causes</rdfs:label>
  <rdfs:comment rdf:datatype="&xsd;string">This property indicates the instigating
   factor of an event, whether it be an item, event, or collection.</rdfs:comment>
  <rdfs:range>
    <owl:Class>
      <owl:unionOf rdf:parseType="Collection">
        <owl:Class rdf:about="#Event"/>
        <owl:Class rdf:about="#Entity"/>
      </owl:unionOf>
    </owl:Class>
  </rdfs:range>
  <rdfs:domain>
    <owl:Class>
      <owl:unionOf rdf:parseType="Collection">
        <owl:Class rdf:about="#Event"/>
        <owl:Class rdf:about="#Entity"/>
      </owl:unionOf>
    </owl:Class>
  </rdfs:domain>
```

```
    <owl:inverseOf>
      <owl:ObjectProperty rdf:ID="caused_by"/>
    </owl:inverseOf>
  </owl:ObjectProperty>

<!-- Events Subclasses -->

  <owl:Class rdf:ID="Gain">
    <rdfs:label>Gain</rdfs:label>
    <rdfs:subClassOf rdf:resource="#Event" />
    <rdfs:comment rdf:datatype="&xsd;string">This event class results in an overall
     increase of the entities related to the primary subject or subjects of the
     event</rdfs:comment>
  </owl:Class>

  <owl:Class rdf:ID="Introduction">
    <rdfs:label>Introduction</rdfs:label>
    <rdfs:comment rdf:datatype="&xsd;string">This event class denotes the introduction
     of an entity to the media</rdfs:comment>
    <rdfs:subClassOf rdf:resource="#Event" />
  </owl:Class>

  <owl:Class rdf:ID="Loss">
    <rdfs:label>Loss</rdfs:label>
    <rdfs:comment rdf:datatype="&xsd;string">This event class results in an overall
     reduction of the entities related to the primary subject or subjects of the
     event</rdfs:comment>
    <rdfs:subClassOf rdf:resource="#Event" />
  </owl:Class>

  <owl:Class rdf:ID="Transformation">
    <rdfs:comment rdf:datatype="&xsd;string">This event class results in no gain or loss
     of attributes or entities, merely alteration</rdfs:comment>
    <rdfs:label>Transformation</rdfs:label>
    <rdfs:subClassOf rdf:resource="#Event" />
  </owl:Class>

  <owl:Class rdf:ID="Action">
    <rdfs:comment rdf:datatype="&xsd;string">This event class describes an action sequence
     (ie no plot)</rdfs:comment>
    <rdfs:label>Action</rdfs:label>
    <rdfs:subClassOf rdf:resource="#Event" />
  </owl:Class>

  <owl:ObjectProperty rdf:ID="from">
    <rdfs:label>from</rdfs:label>
    <rdfs:comment rdf:datatype="&xsd;string">This property specifies the entity which
     is being transformed</rdfs:comment>
    <rdfs:range rdf:resource="#Entity"/>
    <rdfs:domain rdf:resource="#Transformation"/>
  </owl:ObjectProperty>

  <owl:ObjectProperty rdf:ID="to">
    <rdfs:label>to</rdfs:label>
    <rdfs:comment rdf:datatype="&xsd;string">This property specifies the resultant
     entity</rdfs:comment>
    <rdfs:range rdf:resource="#Entity"/>
    <rdfs:domain rdf:resource="#Transformation"/>
  </owl:ObjectProperty>

  <!-- Unsorted -->

  <owl:ObjectProperty rdf:ID="has_parody">
    <rdfs:domain rdf:resource="#Expression"/>
    <rdfs:range rdf:resource="#Expression"/>
```

```
  <owl:inverseOf>
    <owl:ObjectProperty rdf:ID="is_parody_of"/>
  </owl:inverseOf>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="occurs">
  <rdfs:range rdf:resource="#locspec_Location_Specifier"/>
  <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#FunctionalProperty"/>
  <rdfs:domain rdf:resource="#Instant_Occurence"/>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:about="#allows_existance_of">
  <rdfs:domain rdf:resource="#Context"/>
  <owl:inverseOf rdf:resource="#exists_in"/>
  <rdfs:range rdf:resource="#Expression"/>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="start_point">
  <rdfs:domain rdf:resource="#Period_Occurence"/>
  <rdfs:range rdf:resource="#locspec_Location_Specifier"/>
  <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#FunctionalProperty"/>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="duration">
  <rdfs:domain rdf:resource="#Period_Occurence"/>
  <rdfs:range>
    <owl:Class>
      <owl:unionOf rdf:parseType="Collection">
        <owl:Class rdf:about="#locspec_Location_Specifier"/>
        <owl:Class rdf:about="#Dimension"/>
      </owl:unionOf>
    </owl:Class>
  </rdfs:range>
  <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#FunctionalProperty"/>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:about="#contains">
  <owl:inverseOf rdf:resource="#contained_by"/>
  <rdfs:range rdf:resource="#Expression"/>
  <rdfs:domain>
    <owl:Class>
      <owl:unionOf rdf:parseType="Collection">
        <owl:Class rdf:about="#Expression"/>
        <owl:Class rdf:about="#Expression"/>
      </owl:unionOf>
    </owl:Class>
  </rdfs:domain>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:about="#follows">
  <rdfs:range rdf:resource="#Occurence"/>
  <rdfs:domain rdf:resource="#Occurence"/>
  <owl:inverseOf rdf:resource="#precedes"/>
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Follows should
   specify both timeline and event IDs where there is more than one timeline or over
   two events</rdfs:comment>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="timeline_ref">
  <rdfs:range rdf:resource="#Timeline"/>
  <rdfs:domain rdf:resource="#Occurence"/>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:about="#is_parody_of">
  <rdfs:range rdf:resource="#Expression"/>
```

```
    <owl:inverseOf rdf:resource="#has_parody"/>
    <rdfs:domain rdf:resource="#Expression"/>
  </owl:ObjectProperty>

  <owl:ObjectProperty rdf:ID="end_point">
    <rdfs:range rdf:resource="#locspec_Location_Specifier"/>
    <rdfs:domain rdf:resource="#Period_Occurence"/>
    <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#ObjectProperty"/>
  </owl:ObjectProperty>

  <owl:FunctionalProperty rdf:ID="TPQ">
    <rdfs:range rdf:resource="#locspec_Location_Specifier"/>
    <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >Terminus Post Quem</rdfs:comment>
    <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#ObjectProperty"/>
    <rdfs:domain rdf:resource="#Occurence"/>
  </owl:FunctionalProperty>

  <owl:FunctionalProperty rdf:ID="type">
    <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
    <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#DatatypeProperty"/>
    <rdfs:domain rdf:resource="#Item"/>
  </owl:FunctionalProperty>

  <owl:FunctionalProperty rdf:about="#occurence_of">
    <rdfs:domain rdf:resource="#Occurence"/>
    <rdfs:range rdf:resource="#Expression"/>
    <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#ObjectProperty"/>
    <owl:inverseOf rdf:resource="#has_occurence"/>
  </owl:FunctionalProperty>

  <owl:FunctionalProperty rdf:ID="TAQ">
    <rdfs:domain rdf:resource="#Occurence"/>
    <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#ObjectProperty"/>
    <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >Terminus Ante Quem</rdfs:comment>
    <rdfs:range rdf:resource="#locspec_Location_Specifier"/>
  </owl:FunctionalProperty>

  <owl:FunctionalProperty rdf:ID="initial_event">
    <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >the first event which begins this sequence</rdfs:comment>
    <rdfs:range rdf:resource="#Event"/>
    <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#ObjectProperty"/>
    <rdfs:domain rdf:resource="#Event"/>
  </owl:FunctionalProperty>

</rdf:RDF>
```

5 Future Work and Conclusions

OntoMedia presents a novel way of representing the context of heterogeneous media items by making explicit previously disregarded knowledge. Work is currently being undertaken in the aforementioned projects to investigate the issues arising and posibilities presented by the availability of this new metadata.

6 Acknowledgments

This work is partially supported under the Advanced Knowledge Technologies (AKT) Interdisciplinary Research Collaboration (IRC), which is sponsored by the UK Engineering and Physical Sciences Research Council under grant number GR/N15764/01.

References

1. Berners-Lee, T.: Weaving the Web. Orion Business Books (1999)
2. McGuinness, D.L., v. Harmelen, F.: Owl web ontology language overview: W3c recommendation. http://www.w3.org/TR/owl-features/ (2004)
3. Stuber, R., Benjamins, V.R., Fensel, D.: Knowledge engineering: Principles and methods. Data and Knowledge Engineering **25** (1998) 161–197
4. Mizoguchi, R., Vanwelkenhuysen, J., Ikeda, M.: Task ontology for reuse of problem solving knowledge. Towards very Large Knowledge Bases: Knowledge Building and Knowledge Sharing (1995) 46–59
5. van Heist, G., Schreiber, T., Wielinga, B.: Using explicit ontologies in kbs. International Journal of Human-Computer Studies **46** (1997) 183–292
6. Bilasco, I.M., Gensel, J., Villanova-Oliver, M.: Stamp: A model for generating adaptable multimedia presentations. Int. Journal Multimedia and Applications **25** (2005) 361–375
7. Tuffield, M.M., Shadbolt, N.R., Millard, D.E.: Narrative as a form of knowledge transfer: Narrative theory and semantics. In: Proceedings of the 1st AKT Doctoral Colloquium, AKT (2005)
8. Jewell, M.O., Lawrence, F., Tuffield, M.M., Nixon, M.S., Prügel-Bennett, A., Shadbolt, N.R., Millard, D.E., m c schraefel: Ontomedia: An ontology for the representation of heterogeneous media. In: Proceedings of MultiMedia Information Retrieval (MMIR05) Workshop at SIGIR, SIGIR (2005)
9. Lawrence, K.F., m. c. schraefel: Amateur fiction online - the web of community trust. In: Proceedings of the 1st AKT Doctoral Colloquium, AKT (2005)
10. Jewell, M.O., Nixon, M.S., Prügel-Bennett, A.: State-based sequencing: Directing the evolution of music. In: International Computer Music Conference. (2005)
11. Addis, M., Boniface, M., Goodall, S., Grimwood, P., Kim, S., Lewis, P., Martinez, K., Stevenson, A.: Sculpteur: Towards a new paradigm for multimedia museum information handling. In: Proceedings of Semantic Web ISWC 2003. (2003) 582–596
12. Allen, P.J., Vaccaro, R., Presutti, G.: Artiste: An integrated art analysis and navigation environment. Cultivate Interactive **1** (2000)
13. Mulholland, P., Collins, T., Zdrahal, Z.: Story fountain: intelligent support for story research and exploration. In: In Proceedings of 9th international conference on Intelligence User Interfaces, International Conference on Intelligent User Interfaces (2004) 62–69
14. Crofts, N., Doerr, M., Gill, T., Stead, S., (eds), M.S.: Definition of the cidoc crm conceptual reference model. Reference document, International Council of Museums (2005)
15. Saur, K.G.: Functional requirements of bibliographic records: final report. Technical report, IFLA Study Group on the Functional Requirements of Bibliographic Records, München (1998)
16. Doerr, M., Hunter, J., Lagoze, C.: Towards a core ontology for information integration. Journal of Digital Information **4** (2003)
17. Feinberg, M., Shaw, R.: Action: An annotation framework for events in video. In: Proceedings of Semantic Web ISWC 2004. (2004)