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The Need for Formalizing Media Semantics in the Games and Entertainment Industry

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Abstract: The digital media and games industry is one of the biggest IT based industries worldwide. Recent observations therein showed that current production workflows may be potentially improved as multimedia objects are mostly created from scratch due to insufficient reusability capacities of existing tools. In this paper we provide reasons for that, provide a potential solution based on semantic technologies, show the potential of ontologies, and provide scenarios for the application of semantic technologies in the digital media and games industry.
Key Words: multimedia semantics, digital entertainment, ontologies, semantic search
Category: H.5.1

1 Introduction

The overall goal of the integrated project SALERO[1], as introduced e.g. in [Haas et al. 2006], is to define and develop "intelligent content" with context-aware behaviours for self-adaptive use and delivery across different platforms, building on and extending research in media technologies and web semantics to reverse the trend towards ever-increasing cost of creating media.

Today's businesses are overwhelmed with the need to create more content, more quickly, customized for more customers and for more media than ever before. Supporting the reuse of content can provide significant improvements in the way how content is created and used, including increased quality and consistency, long-term reduced time and costs for development, maintenance, or adaptation to changing needs [Rockley 2002]. It could be observed, that also in the media industry there is a great demand for the reuse of content. However, as initial investigations in the SALERO project showed, most multimedia objects are created from scratch due to insufficient reusability capabilities of existing tools. One reason for that is their poor self-description-ability and the lack of formal representations of the properties of multimedia objects, their context and intended meaning. In most cases, content reuse is also hindered by the lack of search interfaces on especially 3D based multimedia content that allows retrieval of content that was previously produced and that could potentially be reused.

In order to reach a sufficient solution for that problem, several steps need to be solved: Besides the need for algorithms and frameworks to automatically

[1] http://www.salero.eu

extract high-level semantics from low-level features[2] which is well known as the "Semantic Gap" [Smeulders et al. 2000], annotation support for users, a solution for metadata interoperability across the content lifecycle, and cross-media adaptation is needed.

In this paper, we first introduce the intention of (multimedia) ontologies, their purpose and potential benefits for media production, sketch scenarios in which they can be applied, and finally conclude with an outlook on future work in SALERO with respect to the development of a semantic framework for media production.

2 Using Ontologies for Semantic Representation of Media Items

The term ontology has been in use for many centuries mainly in philosophy. However, it got much attention in the last years in the course of the research towards a new version of the Web: the Semantic Web. The Semantic Web in contrast to the "existing" Web allows the representation and exchange of information in a meaningful way, facilitating automated processing of descriptions of published information on the Web, whereas annotations establish the needed links between resources and formal ontologies. Formal ontologies can be seen as the backbone of the Semantic Web, establishing a shared understanding of concepts and facts as being a formal structure supporting knowledge sharing and reuse. Ontologies are widely used in applications related to information integration, information retrieval, knowledge management or in the Semantic Web [Fensel 2003] and they are usually used to establish a common understanding of a domain and to capture the domain knowledge. This is usually done by modeling basic terms and relations which hold between terms, and by providing rules stating restrictions on the usage of both terms and relations.

There are many definitions for the term "ontology" around, the most popular is by Gruber [Gruber 1993] who defines an ontology as follows: *"An ontology is an explicit specification of a (shared) conceptualization." "Conceptualization"* refers to an abstract model of some part of the world which identifies the relevant concepts and relations between that concepts (the "facts"). *"Explicit"* means that the type of concepts, the relations between the concepts and the constraints on their usage are explicitly defined. *"Formal"* refers to the fact that the ontology should be machine readable. However, different degrees of formality can be observed ranging from thesauri to richly axiomated structures [McGuiness 2003]. Finally, *"shared"* means that the ontology should reflect the understanding of multiple people and not be restricted to some individuals. By that, it captures

[2] e.g. "this picture depicts a scene in a football game" is inferred from the low level features "white circle AND green background color"

consensual knowledge [Fensel 2003].

In SALERO, we try to establish a **multimedia ontology framework** that combines declarative descriptions of

1. *Low-level physical and semantic features* through the use of multimedia description standards like MPEG-7 [Martinez et al. 2002] or essence internal formats

2. Domain specific *high-level semantic features* through the use of ontology languages like WSML [de Bruijn et al. 2005] or OWL [Dean et al. 2006]

3. *context information and rules* using WSML or RIF [Boley and Kifer 2007]

By using multimedia ontologies, recent research initiatives in the multimedia domain try to overcome the commonly known drawbacks of existing multimedia metadata standards for the descriptions of the semantics of multimedia content (see e.g. [Bloehdorn et al. 2005, Troncy et al. 2006, Benitez et al. 2002, Tsinaraki et al. 2007, Arndt et al. 2007]). Furthermore, others try to establish a framework for the representation of multimedia assets for use on the Semantic Web [Hausenblas et al. 2007a].

Multimedia ontologies are mostly designed to serve one or more of the following purposes [Eleftherohorinou et al. 2006]:

– *Annotation*, which is in most cases motivated by the need to have high-level summarizations of the content of multimedia items, using commonly accepted concepts and terms

– *Automated semantic analysis*, i.e. to support the analysis of the semantics and syntax of the structure and content of multimedia items

– *Retrieval*, i.e. to use rich formal descriptions to enable context-based retrieval and recommendations to users. The use of semantics enables automatic matching of content properties with user properties

– *Reasoning*, i.e. the application of reasoning techniques to discover previously unknown facts of multimedia content or to enable question answering about properties of the content.

– *Personalized filtering*, i.e. the delivery of multimedia content according to user-, network- or device-preferences.

– *Meta-Modeling*, i.e. to use ontologies or rules to model multimedia items and associated processes.

A comprehensive overview of existing efforts and multimedia vocabularies can be found in [Hausenblas et al. 2007b].

3 The Purpose of Multimedia Ontologies in the digital games and entertainment industries

The potential benefits of formalizing media semantics were summarized and highlighted already before [van Ossenbruggen et al. 2004, Nack et al. 2005]. In order to highlight the benefits for the digital games and entertainment industries, we especially try to summarize the purpose of the ontology framework that will be built in SALERO, sketch expected benefits for traditional media production and point out to important problems that we see in each point.

3.1 Semantic Search

To enable semantic search is the prime advantage of using ontologies in media production. Semantic Search aims to improve recall and precision of search results for multimedia objects. A prime pre-requisite for this is a way to attach hidden or contextual features to media items which are not visually embedded in them. By encoding such information using ontologies, the ontologies can then be used for the retrieval process and to present the results. This helps to clearer present contextual information, and helps to find more accurate results.

The *most important problems* that we intend to solve with this facility are

1. The *Semantic Gap*, i.e. how to assign meta-data (semi-)automatically to multimedia data?
2. Low Precision/Recall for search in large multimedia collections or how to increase the amount of true positives for multimedia information retrieval?
3. How to match context of data with context of users?

3.2 Annotation Support

Metadata[3] has an important role in the multimedia lifecycle which was already highlighted by many others [Smith and Schirling 2006]. A recurring problem in industrial settings is however the task of creating metadata and keeping it up to date. Therefore one of the biggest issues we see is how to support creative people in creating annotations and how in turn existing workflows are only minimally disturbed by the implementation of new annotation facilities. We aim to develop ontology-based ways of supporting the user with these important tasks by developing a suite of ontology tools which can be used in daily work. An important point – as already emphasized above – is the integration of the

[3] metadata is data about data

ontology-enhancements into the work process with a minimum amount of disturbing the workflow. We intend to solve this by providing APIs that allow to include the functionality into existing multimedia authoring tools.

The *most important problems* that we intend to solve with this facility are

1. How can creative – and sometimes non-technical – people create ontological annotations?

2. How to maximize support and simultaneously minimize disturbance of current production workflows?

3.3 Unifying Disparate Metadata Formats

At present, different metadata standards are used to annotate in- and output of different steps in the multimedia production lifecycle. This fact is highlighted for the broadcasting domain in [Smith and Schirling 2006]. One result of SALERO will be to show the feasibility of using ontologies to unify these partially disparate metadata formats and the vocabularies used in them. Using ontologies is promising because of their modeling power, their formal background and their strong semantics compared to ad-hoc and informally specified data models. We try to use the arising multimedia ontology in order to enhance metadata integration and as a further step to improve the reusability of multimedia items.

The *most important problems* that we intend to solve with this facility are

1. How to process and re-use assets in different production tools?

2. How to integrate different standards that are used to describe different asset types? (e.g. to provide a unifying search infrastructure on top of asset repositories)

3. How to create a scalable mapping/mediation layer between each of the standards? (i.e. a bidirectional mapping between each of the standards does not scale!)

3.4 Support for Cross Media Adaptation

Another cost driver of today's media productions is the huge manual effort necessary for the adaptation of media to different target platforms and output formats (e.g. cinema, games, print or Internet). Ontologies offer the possibility to model and capture a rich set of metadata including the context of images or other assets. Therefore they can be used to cross purpose multimedia assets as automatically as possible. A wide range of multimedia objects is used by different parties in different media productions. This has to be considered when choosing or developing applications to create, manage or use ontologies for description of multimedia data like image sequences (TV recordings, computer generated content, film sequences), audio objects (recorded sound as well as synthesized speech), 3D Objects (Animated 3D objects in the application domains of interactive games, special effects for film), or any combination of the mentioned types.

The *most important problems* that we intend to solve with this facility are

1. How to ensure a common technological basis for (originally diverse) production tools?
2. How to establish declarative descriptions of workflows in order to match process- with content-descriptions for cross media production?

4 Scenarios - Using Multimedia Ontologies in Media Production

In this section we briefly sketch examples how a multimedia ontology framework may be applied in media production environments.

4.1 Ontologies to Support the Re-Use of Assets

One big problem that media production companies are facing is the lack of possibilities to re-use material across productions. This is mainly due to the lack of definitions of methods and rules how assets can be reused and how certain assets can adapt themselves to new environments, e.g. it needs to be considered how characters are able to interact with the re-used elements or how the elements can be adjusted to fit in a particular scene. In order to recognize if assets are re-useable their properties have to be stored explicitly (i.e. the usage context of the asset, the rights to re-use, or rules about how to extract specific parts of an asset in order to be transferable to other animations. Using ontologies to describe the (usage) context of assets could help to clearly identify which methods are needed to transfer assets between different productions and to automatically identify the parts of the animations that one wants to re-use. This demands for advanced asset management systems that are able to store rich metadata together with the assets, perform fast and reliable searches and to access assets across productions.

4.2 Integrated Production and Cross-Media Delivery of Assets

In the increasingly fragmented media distribution marketplace there is a great need to be able to produce different delivery formats in parallel. One example for that is the sharing of datasets between film asset creation and tie in-game production. There are different problems attached to that wish: First of all there is the problem of reusing media objects in new functions: e.g. media objects in films and games have different roles and functions: in films they are actors, in games they are avatars: in films, they can be seen and heard, in games they are used in various interactive ways. This change of function affects the design of media objects. This demands for explicit descriptions of the story, storytelling, style and medium of a production. There ontologies could help. In turn, rules apply on how to convert between different genres. This rules could be modelled using ontology languages in order to turn them into actionable knowledge that makes an automatic conversion possible.

4.3 Ontologies to Aid Multimedia Information Retrieval

A major research problem in multimedia information retrieval is the "Semantic Gap" [Smeulders et al. 2000], the large gulf between the low level image features which can typically be processed in a multimedia document, and the high level concepts which a user is typically interested in. For example, a user may want to search for a video showing "Bing and Bong on a trip to planet XY"[4]. The high level concepts implicit in this query may be stated as the characters "Bing" and "Bong", plus the abstract action "traveling". The action "traveling" in this case is almost impossible to recognize and could be derived from other recognizable features like "sitting on a couch"[5] or "galaxy"[6] which has to be explicitly modeled in an ontology capturing the knowledge of this special application domain. Automatic annotation of videos and images is currently an active research topic, and allows data-driven techniques to be used together with large training sets. However, automatic processing is not sufficient to annotate multimedia documents with the features like the ones used in the example above. Therefore annotation tools need to be developed that allow designers to annotate the material during the production to ease a latter retrieval-task.

4.4 Ontologies as an Aid to Personalising Search

Search tasks, such as those supported by Multimedia Information Retrieval (MIR) systems, are typically subtasks of some main work task, which may be the creation of a new cartoon character, or some other aspect of the user's work. As such there are many contextual factors which may be captured about users, encoded in an ontology, with the aim of providing better retrieval results for

[4] Bing and Bong virtual characters and part of Tinyplanets (see http://www.tinyplanets.com) which is a UK television show aimed at pre-schoolers
[5] This is Bing and Bong's favorite vehicle
[6] Bing and Bong usually travel in the galaxy

the user in that particular situation. For example, the role of a user within an organisation may imply different search preferences: managers and administration staff may be less technical minded than engineering staff, and therefore an information retrieval engine should attempt to find documents of a less technical difficulty than may be presented to an engineer or scientist. Likewise, the immediate work context of the user engaged on the creation of characters for a particular film, may be used to condition searches, with the aim of interpreting queries relative to this topic.

5 An ontology Management Framework and Multimedia Ontologies for Media Production in SALERO

SALERO aims to pave the way for the use of ontologies and semantic technologies in media production. This is why SALERO develops a management framework for multimedia ontologies, tools to annotate existing media data, a set of ontologies that can be used to annotate the media data, and a semantic search facility to retrieve content based on the semantic annotations.

In the remainder of this section we will introduce the multimedia ontology management suite and ontology engineering process to be applied for the development of the first ontologies in SALERO.

5.1 Multimedia Ontology Management

There are already many ontology workbenches and tool suites around: Protege [Noy et al. 2001], KAON [Maedche et al. 2003], TopBraid Composer[7] or OilEd [Bechofer et al. 2001] to name just a few.

According to [Gomez-Perez et al. 2004] these ontology tools can be categorised into the following groups:

1. *Ontology development tools* (i.e. to build ontologies from scratch, to import/export ontologies using different formats)
2. *Ontology evaluation tools* (i.e. to evaluate the contents of the ontologies and their related technologies)
3. *Ontology merge and alignment tools* (i.e. to merge and align ontologies in the same domain)
4. *Ontology-based annotation tools* (i.e. to insert ontological annotations in documents)
5. *Ontology querying tools and inference engines*

[7] http://www.topbraidcomposer.com/

6. *Ontology learning tools* (i.e. to semi-automatically derive ontologies from natural-language texts)

We particularly believe that for an ontology workbench to be useful for the building and application of ontologies it has to combine aspects of groups (1)-(3) from the list above. To fulfil the requirements of the SALERO project, the SALERO workbench has to combine functionalities from (1)-(3), (4), and (5). Ontology learning features (6) which are currently mainly researched based on texts [Buitelaar et al. 2005, Cimiano et al. 2006] are beyond the scope of the project.

5.1.1 High level architecture and requirements

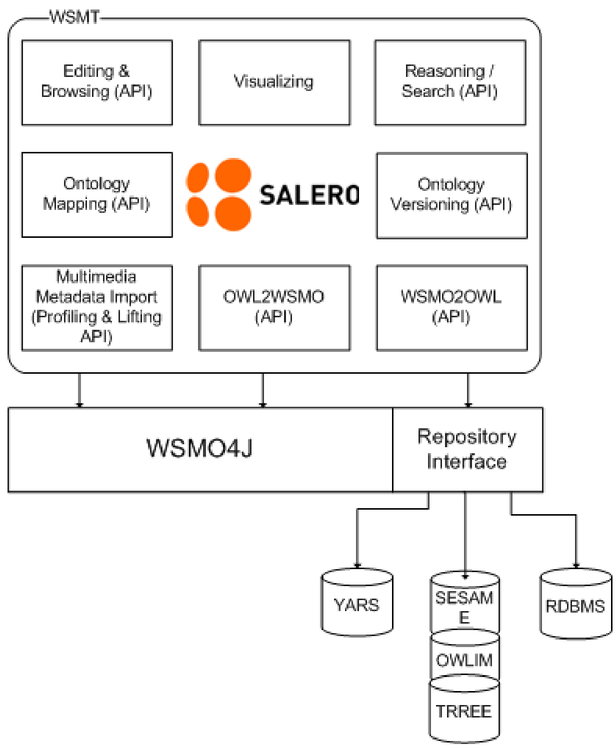

Figure 1: Ontology Workbench High Level Architecture

The ontology workbench to be built for SALERO – as depicted in figure 1 – needs to support the creation, modification and management of domain ontologies which includes the following main functionalities:

1. **Ontology Management:** Central aspects of ontology management include how to align different domain descriptions, how to translate ontologies, how to build ontologies from components, how to maintain versions of ontologies or how to store ontologies.

2. **Annotation Support:** Central aspects here include the support of non-technological users with the annotation of media items. The media object annotator shall allow easy annotation of multimedia objects. This shall be integrated into existing tools, but may also be a standalone tool. The use of ontologies during the annotation process further supports the user in choosing the proper term (from a controlled vocabulary).

3. **Semantic Search Support:** This functionality needs to have access to the ontologies, provide full text search on concepts and attributes and reasoning in ontologies and annotations of media objects.

The architecture of the ontology workbench follows a service-oriented design where separable and core functionalities will be available as Web Services to guarantee their usability in the tools of the partners. In Figure 1, a high level architecture of the ontology workbench including functional components that were deduced from the requirements gathering phase is shown. The functional requirements analysis led to the following functional groups of components:

1. **Storage:** The main prerequisite of storage is a persistency backend / database. Therefore (i) a repository to store ontologies and (ii) an interface to access this repository are needed

2. **Editing & Browsing:** Facilities to edit the ontologies are necessary

3. **Search and Retrieval / Inferences:** The ontologies need to be searchable and inferencing must be applicable

4. **Im- and Export:** To guarantee compatibility with other ontology suites and allow re-use of ontologies written in different languages import and export facilities must be present.

5. **Versioning:** Due to the dynamic nature of most ontologies versioning support is essential.

6. **Metadata re-use and Interoperability:** Due to the availability of existing annotation in traditional multimedia metadata formats (e.g. MPEG-7), components are needed to help to ensure re-use of their annotations.

5.1.2 Workbench API

The ontology workbench provides an API to access its functionalities. The intention of the API is to provide means for the integration of the workbench functionality into existing tools from SALERO partners. The API consists of two parts: The workbench API and the Semantic Search API: The workbench API provides foundational methods for the creation, modification and storage of ontologies and their integral parts (e.g. concepts, properties, axioms). The Semantic Search API provides an additional abstraction level to especially access functionality for supporting semantic search in SALERO. Most parts of the workbench API are based on WSMO4J[8] and ORDI[9], however also advanced functionality like mapping from WSML to OWL[10] or WSML Rule Reasoning and Query Answering[11] are offered via Web Service interfaces. The Semantic Search API is currently being built. It will comprise of methods for query construction and query support, query processing and result presentation.

5.1.3 First prototype

The first prototype of the SALERO workbench builds on the Web Service Modelling Toolkit (WSMT)[12]. WSMT is a collection of tools for Semantic Web Services and ontologies implemented in the Eclipse framework[13]. The WSMT is made up of a number of Eclipse editors, used for editing documents, and Eclipse views, used to provide added-value views over the document content. A number of Eclipse perspectives are used in the WSMT to group, position and arrange these editors and views. WSMT supports three different perspectives: the WSML perspective, the Mapping Perspective and the Semantic Execution Environment Perspective. The most interesting perspectives of WSMT for SALERO are the WSML Perspective for engineering WSMO ontologies in WSML (see figure 2) and the Mapping Perspective to map ontologies. Furthermore WSMT supports

[8] WSMO4J is an API and a reference implementation of the Web Service Modelling Ontology (WSMO) which is expressed in the Java programming language. The library, which has been developed by DERI in cooperation with Ontotext Lab2, is completely available under LGPL3.

[9] ORDI is an extension of wsmo4j. The major functionality of ORDI (as added value on top of wsmo4j) is: (i) a more scalable repository implementation through TRREE (http://www.ontotext.com/trree/), a fast and scalable reasoning and rule entailment engine (ii) a WSMO-RDF parser, serializer and query facility. The main intention of the Ontology Representation and Data Integration Framework (ORDI) is the integration of databases and other structured data-sources and to support heterogeneous reasoners and data-sources.

[10] see http://tools.deri.org/wsml/wsml2owl-translator/v0.1/services/wsml2owlTranslation?wsdl

[11] see http://tools.deri.org/wsml/rule-reasoner/v0.1/

[12] http://wsmt.sourceforge.net

[13] http://www.eclipse.org/jdt/

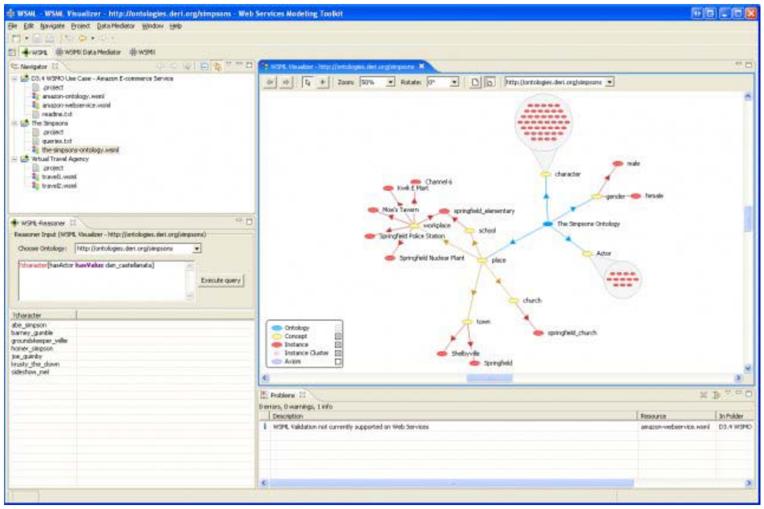

Figure 2: The Web Service Modeling Toolkit (WSML perspective)

a broad range of additional ontology management functionalities like mapping or versioning.

5.2 Ontology Engineering in SALERO

Ontologies are built in SALERO to support the advanced scenarios that we outlined in this paper. The process of building these ontologies which is commonly referred to as ontology engineering is done in a collaborative manner, involving domain experts, ontology engineering experts, i.e. people who design and implement the ontologies, and the end users who are using the ontologies to annotate, search or to browse repositories, etc. Typically, ontologies are built according to ontology engineering methodologies. These methodologies usually reflect the ontology lifecycle as depicted in figure 3. There are actually many ontology engineering methodologies around as summarized e.g. in [Gomez-Perez et al. 2004, Tempich et al. 2005]. What made the first ontology engineering tasks difficult in SALERO was the fact that simultaneously the requirements from different user partners had to be gathered in order to be fed into a common ontology framework. This fact is acknowledged by different distributed and collaborative ontology engineering approaches which recently were proposed in [Pinto et al. 2005], [Braun et al. 2007], or [Siorpaes and Hepp 2007].

For the sake of simplicity we decided to guide the users according to the design criteria that were proposed by [Uschold and Gruninger 1996] and the main ontology engineering steps proposed in [Noy and McGuiness 2001]: The design

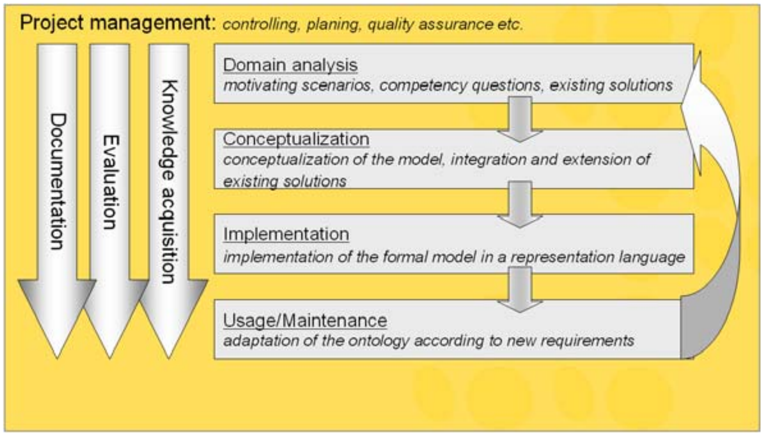

Figure 3: The Ontology Lifecycle [Paslaru-Bontas-Simperl et al. 2006]

criteria should guarantee the objectivity of the ontology. They include (1) clarity, i.e. the definition of terms should be clear without any ambiguity, (2) coherence, i.e. the ontology must not have any contradictory statement, (3) extensibility, the model and underlying classes should allow its extension and customization and (4) minimal ontological commitment, which means the balance between a simple ontology and an over-axiomatized structure.

To develop the initial versions of the ontologies together with the user partners we decided to adopt the main ontology building steps proposed by Noy et. al in [Noy and McGuiness 2001]:

1. **Determine the domain and scope of the ontology:** We asked the partners to specify the domain: What do we want to describe? Together with the partners we defined the usage of the ontology: For what are we going to use the ontology (e.g. retrieval, integration, knowledge representation)? Finally, we asked the partner to provide so-called competency questions, i.e. for what types of questions the ontology should provide answers?

2. **Consider re-using existing ontologies:** The ontology development experts then looked for possible ontologies to re-use. More information about methodologies for ontology re-use and integration steps in general can be found in [Pinto and Martins 2001, Paslaru-Bontas and Mochol 2005].

3. **Enumerate the terms of the ontology:** We asked the partners to enumerate the most important terms in the domain that the ontology should cover. The users provided a set of terms independently and the terms were then consolidated together with the ontology development experts.

4. **Class definition and Class hierarchy:** This step was carried out by the ontology development experts. This step is due to identification of classes and to arrange the classes hierarchically. We applied the middle-out approach as proposed in [Uschold and King 1995]: In the middle-out approach you first identify the core of basic terms and then specify and generalize them as needed.

5. **Determine the data type and the object properties of classes:** This step was carried out by the ontology development experts. The terms not identified as classes are most probably object properties which have a data type.

6. **Determine the restrictions of the data type and the object properties:** This step was carried out by the ontology development experts. The intention of this step is to identify and specify restrictions describing the possible value types, the allowed values, etc.

7. **Creation of individuals:** The last step is about entering individuals. This step was not carried out so far.

Currently the SALERO ontology engineering team builds an ontology for the description of virtual 3D characters which will be used for search and retrieval. The ontology will extend the AIM@SHAPE[14] ontology for the description of virtual humans [Gutierrez at al. 2007].

6 Conclusions

In general, formal semantics can support the annotation, analysis, retrieval or reasoning about multimedia assets. With this paper we aimed to stress the importance of the use of formal semantics in the digital games and entertainment industry by pointing out to expected benefits and by sketching scenarios illustrating their intended application in media production in general and the SALERO project in particular.

A first version of the ontology management tools has already been developed. Currently, the media semantics team in SALERO is building the ontologies for the description of virtual 3D characters. One of our next steps in SALERO is to develop a method for the evaluation of the economics of multimedia ontologies which will be based on Ontocom [Paslaru-Bontas-Simperl et al. 2006].

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[14] http://www.aimatshape.net

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