Ontology-Driven Interoperability for MPEG-7

Chrisa Tsinaraki
TUC/MUSIC, Technical University of Crete Campus, 73100 Kounoupidiana, Crete, Greece
chrisa @ced.tuc.gr

Abstract

Research efforts for interoperability support in the multimedia domain are presented here. Interoperability, both at the syntactic and the semantic level, is necessary in the open multimedia consumption environment formed in the Internet today, so that the multimedia content services offered by different vendors may interoperate. Syntactic interoperability support is achieved in the multimedia domain through the adoption of the dominant MPEG-7 standard for multimedia content and service description. Domain knowledge is then integrated, in the form of domain ontologies, in the MPEG-7 constructs, in order to achieve semantic interoperability. Finally, the utilization of the interoperability support in real world applications is discussed.

1 Introduction

Multimedia content services are becoming increasingly popular in the open multimedia consumption environment formed in the Internet today due to the advanced network infrastructures that allow for the fast and efficient multimedia content delivery and the availability of cheap consumer electronic devices that allow the consumption and management of multimedia content. Interoperability, both at the syntactic and the semantic level, is necessary in this open multimedia consumption environment, so that the multimedia content services offered by different vendors may interoperate.

The syntactic interoperability is usually achieved through the adoption of standards, while the semantic interoperability is achieved through the integration of domain knowledge that is expressed in domain ontologies.

The dominant standard in multimedia content and service description is the MPEG-7 (Chang, Sikora and Puri 2001). The adoption of the MPEG-7 in the multimedia domain guarantees syntactic interoperability and the integration of domain knowledge in the MPEG-7 constructs achieves semantic interoperability.

In this paper the ontology-driven interoperability support for MPEG-7 is discussed. The rest of the paper is structured as follows: Domain knowledge representation using pure MPEG-7 constructs is presented in section 2, OWL ontology driven interoperability for MPEG-7 is discussed in section 3, interoperable multimedia application support is described in section 4 and the paper concludes in section 5.

2 Domain Knowledge Representation using pure MPEG-7 Constructs

We present here how domain knowledge, in the form of domain ontologies, can be expressed using MPEG-7 constructs and can then be integrated in the MPEG-7 semantic descriptions. This is achieved through the methodology described in (Tsinaraki et al 2005).

According to this methodology, the domain ontology classes are represented as abstract semantic entities and the domain ontology individuals are represented as concrete semantic entities. The *AbstractionLevel* element of the *SemanticBaseType* (which represents the semantic entities) specifies if a semantic entity is abstract or concrete. If the *Dimension* attribute of *AbstractionLevel* has the value 0, the semantic entity is concrete and if it has a non-zero value, the semantic entity is abstract.

An abstract semantic entity that represents a domain-specific class is related with each of the semantic entities representing its subclasses through: *(a)* A relationship of type *generalizes*, which has as source the semantic entity that represents the class and as target the semantic entity that represents the subclass; and *(b)* A relationship of type *specializes*, which has as source the semantic entity that represents the subclass and as target the semantic entity that represents the class. In addition, an abstract semantic entity that represents a class is related with the concrete semantic entities representing the class individuals through pairs of *exemplifies*/*exemplifiedBy* relationships.

The properties of the domain-specific classes are represented as *Property* elements (if they are of simple type) or as pairs of *property*/*propertyOf* relationships that associate semantic entities (if they are of complex type).

3 OWL Ontology Driven Interoperability for MPEG-7

It was shown in the previous section that the MPEG-7 allows for the representation of domain ontologies using pure MPEG-7 constructs. The domain ontologies are usually expressed in OWL (McGuinness and F. van Harmelen 2004) syntax, as OWL is the dominant standardization effort in ontology description. It is therefore very important for the multimedia community to have a methodology for the interoperability of OWL with MPEG-7 and for the integration of domain knowledge expressed in OWL within MPEG-7. This way, the Semantic Web tools (such as reasoners) and methodologies may be used with MPEG-7.

The first research effort in this direction was presented in (Hunter 2001), where the DAML+OIL (McGuinness, Fikes, Hendler and Stein. 2002) ontology definition language has been used to partially describe the MPEG-7 MDS and Visual metadata structures. The ontology has been recently translated in OWL. An important shortcoming of this ontology is the limited coverage of the MPEG-7 constructs.

An Upper OWL-DL ontology that fully captures the MPEG-7 MDS and the parts of the MPEG-7 Visual and Audio that are necessary for the complete representation of the MPEG-7 MDS has been presented in (Tsinaraki, Polydoros and Christodoulakis 2007). The ontology was manually developed, according to a methodology that allows the transformation of the XML Schema constructs of MPEG-7 in OWL-DL.

A methodology for the definition of OWL domain ontologies integrated in the MPEG-7 semantic model has been described in (Tsinaraki, Polydoros and Christodoulakis 2007). In this methodology, the domain-specific entities are represented as domain ontology classes. These classes are (direct or indirect) subclasses of the OWL classes that represent the subtypes of *SemanticBaseType* (*EventType*, *ObjectType*, *AgentObjectType*, *SemanticPlaceType*, *SemanticTimeType*, *SemanticStateType* and *ConceptType*) in the OWL Upper ontology defined in (Tsinaraki, Polydoros and Christodoulakis 2007).

Interoperation of the multimedia content descriptions with applications using pure MPEG-7 is achieved through a set of transformation rules (Tsinaraki, Polydoros and Christodoulakis 2007) that allow the transformation of domain ontologies and semantic content descriptions to valid MPEG-7 descriptions. They allow the transformation of domain ontologies defined according to the methodology described in section 2 into abstract MPEG-7 semantic descriptions as well as the transformation of OWL individuals that belong to the domain ontology classes into MPEG-7 semantic descriptions. The produced descriptions are valid MPEG-7 (parts of) documents.

During the metadata transformation from OWL to MPEG-7, the individuals representing MPEG-7 constructs are transformed into XML elements. The object properties are transformed into elements and the datatype properties are transformed into the constructs they represent in the original MPEG-7 schemas (attributes, elements or simple values). In order to produce valid MPEG-7 descriptions, information regarding the MPEG-7 XML element order, the default values and the original MPEG-7 representation of the datatype properties is needed. This information is kept in a transformation rule ontology and is utilized during both ontology and metadata transformations.

The generalization and the automation of the methodology for ontology-driven interoperability for MPEG-7 described in (Tsinaraki, Polydoros and Christodoulakis 2007) has led to the development of a generic methodology and its software implementation that allow the expression of the XML Schema (Fallside 2001) semantics in OWL-DL, as described in (Tsinaraki and Christodoulakis 2007).

4 Application Support

We show in this section how the semantic information integrated with MPEG-7 can be utilized in specific applications.

A challenging issue is the consistent description of multimedia content that depicts cultural heritage artifacts. It can be achieved through the alignment of the MPEG-7 semantics with the semantics of the CIDOC/CRM (ISO/IEC 2004), which is a model that subsumes the semantics of the different cultural heritage standards. The alignment of the CIDOC/CRM with MPEG-7 is under way using both the standards expressed using OWL syntax (Doussias 2007).

Important multimedia content services that are useful in several different domains and form the basis for complex semantic based services are the semantic multimedia content retrieval and filtering. These services rely on the existence of semantic knowledge integrated with the multimedia content descriptions and the capability of the users to express their preferences on the multimedia content semantics. In order to allow the expression of the user preferences regarding multimedia retrieval and filtering on every aspect of the MPEG-7 descriptions, the MP7QL query language and its compatible filtering and search preference model have been developed (Tsinaraki and Christodoulakis 2006).

5 Conclusions – Future Work

We have presented in this paper research efforts in ontology-driven interoperability support for MPEG-7 and we have outlined some important applications that will benefit from the infrastructures developed in this context.

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