A User Preference Model and a Query Language that allow Semantic Retrieval and Filtering of Multimedia Content

Chrisa Tsinaraki, Stavros Christodoulakis
Lab. of Distributed Multimedia Information Systems & Applications (MUSIC)
Technical University of Crete (TUC)
{chrisa, stavros}@ced.tuc.gr

Abstract[1]

We present in this paper MP7QL, a powerful query language that we are developing for querying MPEG-7 descriptions, and a user preference model that allows for expressing preferences about every aspect of an MPEG-7 multimedia content description. The MP7QL queries may utilize the user preferences as context, thus allowing for personalized multimedia content retrieval. The user preference model supports multimedia Filtering and Search Preferences (FASP) that allow for expressing semantic preferences, preferences regarding the low-level visual features and preferences regarding media-related aspects (creation, classification, source etc). The proposed FASPs essentially are MP7QL queries, allow for the systematic integration of domain knowledge in the semantic preferences of the users and have the standard MPEG-7 FASPs as a special case. The MP7QL and the FASP model have been expressed using both XML Schema and OWL syntax. An implementation on top of an XML Repository is currently under way.

1. Introduction

The development of digital multimedia content services that offer high content quality, advanced interaction capabilities, media personalization and adaptation according to the user preferences and access conditions, together with the emergence of advanced network infrastructures that allow for the fast, efficient and reliable transmission of multimedia content have formed an open multimedia consumption environment. Such an open environment will become popular only if it is based on standards that allow the services provided by different vendors to interoperate.

The dominant standard in multimedia content description is the MPEG-7 [13]. MPEG-7 allows the description of (segments of) multimedia objects in terms of *media information* (including media format, quality etc.), *creation information* (including title, creators, subject, related material etc.), *structure*, *usage information* (including rights, availability etc.), *textual annotations*, *media semantics*, *matching hints* for associating the media with audio and visual descriptors, the importance of the multimedia content from specific *points of view* and the *relations* of the multimedia content with other media or metadata items.

In addition to the syntactic interoperation, which is achieved through the usage of well-accepted standards, semantic interoperation is also needed for providing efficient retrieval and filtering services. The semantic interoperation is typically achieved through the integration of domain knowledge, which is usually expressed in the form of domain ontologies. The domain knowledge is subsequently utilized for supporting semantic retrieval and filtering, as well as for providing semantically personalized services [15][17]. The semantic personalization is built on top of semantic user preference descriptions, which are used as content-related context during both retrieval (where the user preferences will be used in order to expand and/or disambiguate the user queries) and filtering (where the user preferences will be used as continuous queries that select the content to be returned to the user).

We have shown, in our previous research [16], that domain knowledge, in the form of domain ontologies, can be expressed using MPEG-7 constructs and integrated in the MPEG-7 semantic descriptions.

Powerful retrieval and filtering capabilities can be built on top of the rich information captured in the MPEG-7 descriptions. Several research groups have been working on MPEG-7 based multimedia content retrieval and filtering. The VizIR [3] framework fully exploits the *Visual* MPEG-7 Descriptors [8] for low-level feature based multimedia content retrieval. Sev-

eral groups utilize the textual annotations and/or the media-related elements of the MPEG-7 descriptors [5][12][14][18] for retrieval and filtering support. Finally, the semantic metadata descriptions formed according to the *Semantic DS* of the MPEG-7 *Multimedia Description Schemes (MDS)* [9] are utilized in other retrieval and filtering approaches [1][7][15][16].

The major limitation of the above approaches is that they treat some aspects of the MPEG-7 based retrieval and filtering, but they do not provide a uniform and transparent MPEG-7 retrieval and filtering framework.

A first approach towards this end was the proposal to use plain XQuery [2] on top of an XML repository for MPEG-7 based multimedia content retrieval [11], without taking into account the peculiarities of the MPEG-7 description elements. The major limitation of this approach is that, using XQuery only, the different MPEG-7 metadata description elements cannot be fully exploited. This happens because both the MPEG-7 semantic model and the domain knowledge integrated in the semantic MPEG-7 descriptions are expressed in an involved way and cannot be successfully exploited if they are accessed in the same way with the textual and the media-related elements of the MPEG-7 metadata descriptions. Special treatment is also needed for the low-level visual features. It is difficult for the average user to express, using plain XQuery, queries on the semantics and the low-level features and even more difficult to combine such query conditions with textual and media-related query conditions.

Another approach is to use the existing MPEG-7 *Filtering and Search Preferences (FASP)* as query specifications that allow multimedia content filtering and retrieval. The major limitations of this approach are the following: *(a)* The MPEG-7 description elements that represent the semantic descriptions and the low-level features of the multimedia content are not present in the current MPEG-7 FASPs; *(b)* Not all the media-related MPEG-7 elements are present in the MPEG-7 FASPs; and *(c)* The boolean operators AND/OR/NOT cannot be explicitly specified in the MPEG-7 FASPs.

The limitations of the existing approaches make apparent the need for a query language that provides retrieval and filtering support for all the aspects of an MPEG-7 description in a transparent and uniform way. As a response to this need, the International Organization for Standardization (ISO) has recently issued the *MPEG-7 Query Format Requirements* [10], in order to guide the MPEG-7 query format standardization.

We present in this paper the MP7QL MPEG-7 Query Language and a compatible FASP model (expressed according to the MP7QL model) that allow for

the uniform and transparent MPEG-7 based retrieval and filtering of multimedia content that combine conditions on semantics, conditions on the low-level visual features and conditions on the media aspects (creation, classification, source etc). The design of the MP7QL allows querying every aspect of an MPEG-7 multimedia object description and satisfies the ISO MPEG-7 Query Format Requirements [10]. The MP7QL queries may utilize the user preferences as context, thus allowing for personalized multimedia content retrieval. The proposed FASP model has the standard MPEG-7 FASPs as a special case, and, at the same time, extends our previous research for supporting semantic user preferences for multimedia content consumption [15].

The rest of the paper is structured as follows: In section 2 we present the MP7QL query language, in section 3 we present our proposed FASP model and we conclude in section 4.

2. The MP7QL Query Language

We present in this section the MP7QL query language, a language for querying MPEG-7 descriptions that we are developing, which allows querying every aspect of an MPEG-7 multimedia object description. The design of the MP7QL query language has taken into account the MPEG-7 Query Format Requirements. The MP7QL queries may utilize the user preferences as context, thus allowing for personalized multimedia content retrieval.

The fundamental MP7QL element is the MP7QL query, which is represented by the instances of the subtypes of the *MPEG7QueryType* abstract type shown in Figure 1.
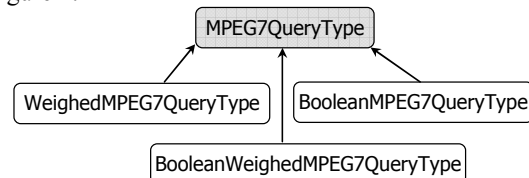

Figure 1: The MP7QL query type hierarchy

The MP7QL allows the specification of queries that refer to: *(a)* multimedia content that satisfies specific criteria (for example, "give me the multimedia objects where a goal is scored"); *(b)* semantic entities that satisfy specific criteria and can be used for the semantic descriptions of multimedia content (for example, "give me the players affiliated to the soccer team Barcelona"); and *(c)* constructs of domain ontologies expressed using MPEG-7 syntax (for example, "give me the subclasses of the *Player* class"). This is specified in the *From* attribute of an MP7QL query, which corresponds to the FROM part of the SELECT-FROM-WHERE languages like XQuery.

MP7QL allows the explicit specification of boolean operators and preference values for the MP7QL query elements. Three subtypes of MPEG7QueryType have been defined for the representation of all the possible types of queries, as shown in Figure 1:

1. The *WeighedMPEG7QueryType*, which represents queries with explicit preference values (WQ) that are formally described using the regular expression syntax of (1).

$$WQ=(WQS\,pv)* \qquad (1)$$

pv is an explicit preference value and *WQS* is a query specification with explicit preference values. The preference values are integers in the range [-100, 100], with default value 10^2. The query specification represents the user's search and filtering criteria, corresponds to the WHERE part of the SELECT-FROM-WHERE languages and is formally described in (4).

2. The *BooleanMPEG7QueryType*, which represents queries with explicit boolean operators (BQ) that are formally described using the regular expression syntax of (2).

$$BQ=WQS[NOT]\,((AND|OR)\,WQS\,[NOT])* \quad (2)$$

BQS is a query specification with explicit boolean operators (formally described in (7)).

3. The *BooleanWeighedMPEG7QueryType*, which represents queries with explicit preference values and boolean operators (BWQ) that are formally described using the regular expression syntax of (3).

$$BWQ=WQS\,pv\,((AND|OR)\,WQS\,pv)* \qquad (3)$$

BWQS is a query specification with explicitly specified preference values and boolean operators (formally described in (11)).

The MP7QL query specifications are represented by the *MPEG7QuerySpecificationType* abstract type, which is specialized according to the presence/absence of explicit boolean operators and/or preference values as shown in Figure 2: The *WeighedQuerySpecificationType* represents query specifications with explicit preference values, the *BooleanQuerySpecificationType* represents query specifications with explicit boolean operators and the *BooleanWeighedQuerySpecificationType* represents query specifications with explicit boolean operators and preference values.

The query specifications have been designed to allow expressing constraints on every aspect of a multimedia object that has been described using MPEG-7, so that MP7QL may be used for querying any MPEG-7 multimedia object description. Thus, every element of an MPEG-7 multimedia object description has a corresponding query specification element in the MP7QL

query specifications. The corresponding query specification element is used to impose constraints on the values of the MPEG-7 element, which constraints should be satisfied by the segments retrieved. In order to satisfy the requirement of the MPEG-7 Query Format Requirements [10] stating that the existing MPEG-7 FASPs should be valid query specifications, we decided to use the same naming and typing scheme with the MPEG-7 FASPs for all the elements that exist in the MPEG-7 FASPs. The rest of the MP7QL query specification elements follow the naming and typing scheme of the MPEG-7 multimedia object descriptions.
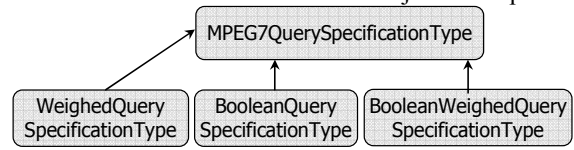

Figure 2: The type hierarchy of the MP7QL query specifications

The MP7QL query specifications include the following (optional) elements:

- The *MediaIdentification (MI)* element (which corresponds to the *MediaIdentification* element of the MPEG-7 multimedia object descriptions), where the users specify criteria about the identification of the query results.
- The *MediaProfile (MP)* element (which corresponds to the *MediaProfile* element of the MPEG-7 multimedia object descriptions), where the users specify criteria about the media features (i.e. media format, quality etc.) of the query results.
- The *MediaLocator (ML)* element (which corresponds to the *MediaLocator* element of the MPEG-7 multimedia object descriptions), where the users specify criteria about the actual media comprising the query results.
- The *StructuralUnit (SU)* element (which corresponds to the *StructuralUnit* element of the MPEG-7 multimedia object descriptions), where the users specify criteria about the structure of the requested items.
- The *CreationPreferences (CrP)* element (which corresponds to the *CreationPreferences* element of the MPEG-7 filtering and search preferences), where the users specify criteria about the creation details of the requested items (i.e. title, creators, related material etc.). An example of the usage of the creation preferences is shown in the FASP of Figure 8.
- The *ClassificationPreferences (ClP)* element (which corresponds to the *ClassificationPreferences* element of the MPEG-7 filtering and search preferences), where the users specify criteria about the classification of the requested items (i.e. language, genre, etc.).

---

[2] The type, the range and the default value of *pv* are compatible with the preference values used in the MPEG-7 FASPs.

- The *SourcePreferences (SoP)* element (which corresponds to the *SourcePreferences* element of the MPEG-7 filtering and search preferences), where the users specify criteria about the dissemination of the requested items (i.e. dissemination source, format etc.).
- The *SemanticPreferences (SeP)* element (which corresponds to the *Semantic* element of the MPEG-7 filtering and search preferences), where the users specify criteria about the semantics of the content of the requested items. The semantic preferences are very important in event-based environments (like sports). Examples of the usage of the semantic preferences are shown in the queries of Figure 5 and Figure 7 and the FASP of Figure 8.
- The *PreferenceCondition (PC)* element (which corresponds to the *PreferenceCondition* element of the MPEG-7 filtering and search preferences), where the users state which conditions should hold, in terms of place and time, for the query specification to be taken into account.
- The *UsageInformation (UI)* element (which corresponds to the *UsageInformation* element of the MPEG-7 multimedia object descriptions), where the users specify criteria about the usage of the requested items (i.e. rights, availability etc.).
- The *MatchingHint (MH)* element (which corresponds to the *MatchingHint* element of the MPEG-7 multimedia object descriptions), where the users specify criteria about the matching of low-level descriptor features with the media element features.
- The *PointOfView (PoV)* element (which corresponds to the *PointOfView* element of the MPEG-7 multimedia object descriptions), where the users specify criteria about the importance of the multimedia content from specific points of view.
- The *RelatedMaterial (RM)* element (which corresponds to the *RelatedMaterial* element of the MPEG-7 multimedia object descriptions), where the users specify criteria about the related material of the requested items.
- The *Relation (R)* element (which corresponds to the *Relation* element of the MPEG-7 multimedia object descriptions), where the users specify the relationships of the requested items with other media or metadata items.

The string and number comparison operators of the elements of the MP7QL query specifications may be explicitly specified. For the string comparison operator, the default value is *"contains"*, which succeds if the value of the Query Specification Element (QSE) is contained in the value of the corresponding metadata description element (MDE). The string comparison op-

erator may also take one of the following values: *(a) "equals"*, which succeeds if the value of the QSE equals to the value of the corresponding MDE; *(b) "startsWith"*, which succeeds if the value of QSE equals to the start of the value of the corresponding MDE; *(c) "endsWith"*, which succeeds if the value of the QSE equals to the end of the value of the corresponding MDE; and *(d) "keywords"*, which succeeds if each of the words contained in the QSE is contained in the value of the corresponding MDE. For the number comparison operator, the default value is *"equals"*, which succeeds if the value of the QSE is equal to the value of the corresponding MDE. The number comparison operator may also take one of the following values: *(a) "greaterThan"*, which succeeds if the value of the QSE is greater than the value of the corresponding MDE; *(b) "greaterThanOrEqual"*, which succeeds if the value of the QSE is greater than or equal to the value of the corresponding MDE; *(c) "lessThan"*, which succeeds if the value of the QSE is less than the value of the corresponding MDE; and *(d) "lessThanOrEqual"*, which succeeds if the value of the QSE is less than or equal to the value of the corresponding MDE.

Variables are provided in MP7QL, so as to support joins on the criteria about the features of semantic entities that are interrelated through MPEG-7 relationships. From a syntactic point of view, a variable is a semantic entity identifier that begins with the "$" character.

The MP7QL has been expressed using both XML Schema [4] syntax and OWL [6] syntax (available at http://elikonas.ced.tuc.gr/Queries/MP7QL_XS.zip and http://elikonas.ced.tuc.gr/Queries/MP7QL_OWL.zip respectively). An implementation of the MP7QL, using the XML Schema syntax is under way on top of an XML repository that is accessed by XQuery.

In the rest of this section we present the different types of MP7QL query specifications. In particular, we present query specifications with explicit preference values in subsection 2.1, query specifications with explicit boolean operators in subsection 2.2 and query specifications with explicit boolean operators and preference values in subsection 2.3.

2.1 Query Specifications with Explicit Preference Values

We present in this subsection the query specifications with explicit preference values, where a preference value may be explicitly specified for each query specification element. The query specifications with explicit preference values are represented by the subtypes of the *WeighedQuerySpecificationType*, as shown

in Figure 3. The *WeighedContextQuerySpecification-Type* type represents queries for which a query context may be specified in the *FilteringAndSearchPreferences* element. The context is either the FASP of the user or a set of ad-hoc specified queries that represent the user preferences for this query. The *WeighedFilteringAnd-SearchPreferencesType* type represents user FASPs with explicit preference values, which also have FASP elements that allow forming FASP hierarchies (details on the FASP model are provided in section 3).
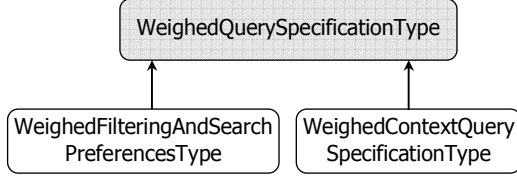

Figure 3: Type hierarchy of the MP7QL query specifications with explicit preference values

The WeighedContextQuerySpecificationType and the WeighedFilteringAndSearchPreferencesType query specifications *(WQS)* are formally described using the regular expression syntax of (4).

$$WQS=((WMI|WMP|WML|WSU|WCrP|$$
$$WClP|WSoP|WSeP|WPC|WUI|WMH| \qquad (4)$$
$$WPoV|WRM|WR|WFASP) pv)*$$

WMI is a media identification element, *WMP* is a media profile element, *WML* is a media locator element, *WSU* is a structural unit element, *WCrP* is a creation preferences element, *ClP* is a classification preferences element, *WSoP* is a source preferences element, *WSeP* is a semantic preferences element, *WPC* is a preference condition element, *WUI* is a usage information element, *WMH* is a matching hint element, *WPoV* is a point of view element, *WRM* is a related material element, *WR* is a relation element and *WFASP* is a filtering and search preferences element. All the WQS elements may also have explicit preference values. This way, the users may specify their search and filtering criteria as well as the importance of each of the criteria.

A semantic preference element with explicit preference values *(WSeP)* is formally described in (5).

$$WSeP=(WSE pv)* \qquad (5)$$

WSE is a set of search and filtering criteria for a semantic entity with explicit preference values, and is formally described in (6).

$$WSE=[SID] \, SType \, pv \, ((AName \, AValue \, pv) \, |$$
$$(EName \, EValue \, pv \, (EAName \, EAValue \, pv)* \, (E$$
$$pv)*) \, | \, (RType \, RTarget \, RSource \, RStrength \, pv))* \quad (6)$$
$$maxOccurs \, minOccurs$$

A WSE may be identified by *SID*, which plays the role of a variable name. The desired type *(SType)* of the semantic entity may also be specified, as well as: *(a)* The name *(AName)* and the desired value *(AValue)* re-

spectively of the attributes of the semantic entity; *(b)* Descriptions of the desired values of the semantic entity elements, including the element name *(EName)*, the element value *(EValue)* the list of the desired element attribute values represented by attribute name *(EAName)* – desired attribute value *(EAValue)* pairs and the list of the desired values of its sub-elements *(E)*; *(c)* Relationship description information, consisting of the type *(RType)*, the target *(RTarget)*, the source *(RSource)* and the strength *(RStrength)* of the relationship. The minimum and maximum number of occurrences of a semantic entity that satisfies a set of criteria is specified in the values of *minOccurs* (with default value 1) and *maxOccurs* (with default value unbounded) respectively.

2.2 Query Specifications with Explicit Boolean Operators

We present in this subsection the query specifications with explicit boolean operators, where the *AND/OR operator* and the *NOT operator* that should be applied in the element contents may be explicitly specified for each query specification element. The default value of the AND/OR operator is "OR" and the default value of the NOT operator is "false" (meaning that the users by default would like the media elements that satisfy the specific criteria to be returned to them). The query specifications with explicit boolean operators are represented by the subtypes of the *BooleanQuerySpecificationType*, as shown in Figure 4. The *BooleanContextQuerySpecificationType* type represents queries for which a query context may be specified, comprised of the FASP of the user or a set of ad-hoc specified queries that represent the user preferences for this query. The *BooleanFilteringAndSearchPreferencesType* type represents user FASPs with explicit boolean operators, which also have FASP elements that allow forming FASP hierarchies (details on the FASP model are provided in section 3).

The BooleanContextQuerySpecificationType and the BooleanFilteringAndSearchPreferencesType query specifications *(BQS)* are formally described using the regular expression syntax of (7).

$$BQS=(BMI|BMP|BML|BSU|BCrP|BClP|BSoP|$$
$$BSeP|BPC|BUI|BMH|BPoV|BRM|BR|BFASP)$$
$$[NOT] \, ((AND|OR)(BMI|BMP|BML|BSU|BCrP \quad (7)$$
$$|BClP|BSoP|BSeP|BPC|BUI|BMH|BPoV|$$
$$BRM|BR|BFASP)[NOT])*$$

BMI is a media identification element, *BMP* is a media profile element, *BML* is a media locator element, *BSU* is a structural unit element, *BCrP* is a creation preferences element, *BClP* is a classification prefer-

ences element, *BSoP* is a source preferences element, *BSeP* is a semantic preferences element, *BPC* is a preference condition element, *BUI* is a usage information element, *BMH* is a matching hint element, *BPoV* is a point of view element, *BRM* is a related material element, *BR* is a relation element and *BFASP* is a filtering and search preferences element. All the BQS elements may have explicit boolean operators.
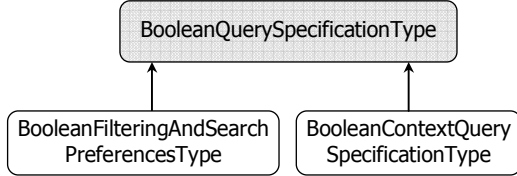

Figure 4: Type hierarchy of the MP7QL query specifications with explicit boolean operators

A semantic preference element with explicit boolean operators *(BSeP)* is formally described in (8).

$$BSeP=[NOT]\ BSE\ ((AND/OR)\ [NOT]\ BSE)^*\quad(8)$$

BSE is a set of search and filtering criteria for a semantic entity with explicit boolean operators, and is formally described in (9).

$$\begin{aligned}BSE=[SID]\ SType\ ((AND/OR)[NOT]\ (AName\\ AValue)\ |\ (EName\ EValue\ (EAName\ EAValue)^*\\ (E)^*)\ |\ (RType\ RTarget\ RSource\ RStrength))^*\\ maxOccurs\ minOccurs\end{aligned}\quad(9)$$

An example of an MP7QL query specification with explicit boolean operators, which states "I want the multimedia objects where a goal is scored by *Zidane*" is shown, expressed in formal syntax, in (10).

$$\begin{aligned}BQS1 = (EventType\ AND\ (exemplifies,\ Goal)\\ AND\ (agent,\ \$zid))\ AND\ ((\$zid,\ AgentOb\text{-}\\ jectType)\ AND\ (exemplifies,\ PlayerObject,\ \$zid)\\ AND\ (Agent(Name(FamilyName\ 'Zidane'))))\end{aligned}\quad(10)$$

We assume in this example that the abstract semantic entities "PlayerObject" and "Goal" exist, which represent the classes of all the players and all the goals respectively. We also assume that the soccer player Zidane is bound to the "$zid" variable. The same query is shown in Figure 5, expressed using XML syntax.

```
<Mpeg7Query xsi:type="BooleanMpeg7QueryType">
 <QuerySpecification ANDOROperator="AND"
xsi:type="BooleanContextQuerySpecificationType">
   <SemanticPreferences ANDOROperator="AND">
    <SemanticBase xsi:type="BooleanEventType"
ANDOROperator="AND" NOTOperator="false">
     <Relation ANDOROperator="AND"
type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:
exemplifies" target="soccerevents#Goal"/>
     <Relation ANDOROperator="AND"
type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001
:agent" target="$zid"/>
    </SemanticBase>
    <SemanticBase ANDOROperator="AND"
xsi:type="BooleanAgentObjectType" id="$zid"
NOTOperator="false">
```

```
     <Relation ANDOROperator="AND" tar-
get="socceragents#PlayerObject" type="urn:mpeg:
mpeg7:cs:SemanticRelationCS:2001:exemplifies"/>
     <Agent xsi:type="BooleanPersonType">
      <Name>
       <FamilyName>Zidane</FamilyName>
      </Name>
     </Agent>
    </SemanticBase>
   </SemanticPreferences>
 </QuerySpecification>
</Mpeg7Query>
```

Figure 5: MP7QL query stating "I want the multimedia objects where a goal is scored by Zidane", using XML syntax

2.3 Query Specifications with Explicit Boolean Operators and Preference Values

We present in this subsection the query specifications with explicit boolean operators and preference values, where the boolean operator and the preference value that should be applied in the element contents may be explicitly specified for each query specification element. The query specifications with explicit boolean operators and preference values are represented by the subtypes of the *BooleanWeighedQuerySpecificationType*, as shown in Figure 6. The *BooleanWeighedContextQuerySpecificationType* type represents queries for which a query context may be specified, comprised of the FASP of the user or a set of ad-hoc specified queries that represent the user preferences for this query. The *BooleanWeighedFilteringAndSearchPreferencesType* type represents user FASPs with explicit boolean operators and preference values, which also have FASP elements that allow forming FASP hierarchies (details on the FASP model are provided in section 3).
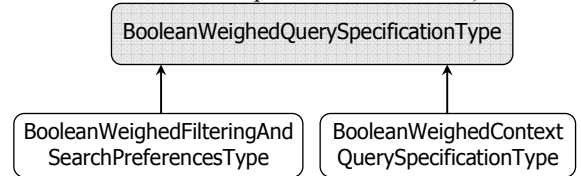

Figure 6: Type hierarchy of the MP7QL query specifications with explicit boolean operators and explicit preference values

The BooleanWeighedContextQuerySpecificationType and the BooleanWeighedFilteringAndSearchPreferencesType query specifications (BWQS) are formally described using the regular expression syntax of (11).

$$\begin{aligned}BWQS=(BWMI|BWMP|BWML|BWSU|BWCrP|\\ BWClP|BWSoP|BWSeP|BWPC|BWUI|BWMH|\\ BWPoV|BWRM|BWR|BWFASP)\ pv\ ((AND|OR)\\ (BWMI|BWMP|BWML|BWSU|BWCrP|BWClP|\\ BWSoP|BWSeP|BWPC|BWUI|BWMH|BWPoV|\\ BWRM|BWR|BWFASP)\ pv)^*\end{aligned}\quad(11)$$

BWMI is a media identification element, *BWMP* is a media profile element, *BWML* is a media locator element, *BWSU* is a structural unit element, *BWCrP* is a creation preferences element, *BWClP* is a classification preferences element, *BWSoP* is a source preferences element, *BWSeP* is a semantic preferences element, *BWPC* is a preference condition element, *BWUI* is a usage information element, *BWMH* is a matching hint element, *BWPoV* is a point of view element, *BWRM* is a related material element, *BWR* is a relation element and *BWFASP* is a filtering and search preferences element. All the BWQS elements may have explicit boolean operators and preference values.

A semantic preference element with explicit preference values and boolean operators *(BWSeP)* is formally described in (12).

$$BWSeP=BWSE \; pv \; ((AND/OR) \; BWSE \; pv)^* \quad (12)$$

BWSE is a set of search and filtering criteria for a semantic entity with explicit preference values and boolean operators, formally described in (13).

$$BWSE=[SID] \; SType \; pv \; ((AND/OR) \; (AName \; AValue \; pv) \; | \; (EName \; EValue \; pv \; (EAName \; EAValue \; pv)^* \; (E \; pv)^*) \; | \; (RType \; RTarget \; RSource \; RStrength \; pv))^* \; maxOccurs \; minOccurs \quad (13)$$

An example of an MP7QL query specification with explicit boolean operators and preference values, which states "I want the multimedia objects where a goal is scored (preference 100) or a penalty kick takes place (preference 50)", is shown, expressed in formal syntax, in (14).

$$BWQS1 = (EventType \; AND \; (exemplifies, \; Goal)) \; OR \; (EventType \; AND \; (exemplifies, \; Pe-naltyKick)) \quad (14)$$

We assume in this example that the abstract semantic entity "PenaltyKick" exists, which represents the class of all the penalty kicks. The same query, expressed using XML syntax, is shown in Figure 7.

```
<Mpeg7Query
xsi:type="BooleanWeighedMpeg7QueryType">
  <QuerySpecification ANDOROperator="OR"
xsi:type="BooleanWeighedContextQuerySpecificatio
nType">
    <SemanticPreferences ANDOROperator="OR">
     <SemanticBase preferenceValue="100"
xsi:type="BooleanWeighedEventType">
       <Relation ANDOROperator="AND"
type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:
exemplifies" target="soccerevents#Goal" />
     </SemanticBase>
     <SemanticBase preferenceValue="50"
xsi:type="BooleanWeighedEventType">
       <Relation ANDOROperator="AND"
type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:
exemplifies" target="soccerevents#PenaltyKick"/>
     </SemanticBase>
    </SemanticPreferences>
  </QuerySpecification>
</Mpeg7Query>
```

Figure 7: MP7QL query stating "I want the multimedia objects where a goal is scored (preference 100) or a penalty kick takes place (preference 50)", using XML syntax

3. Filtering and Search Preference Model

We present in this section our proposed *Filtering and Search Preference (FASP)* model. As already mentioned, the FASPs we propose in this paper essentially are MP7QL query specifications. Thus, a FASP may have all the elements of a query specification.

According to the above presentation, the FASPs are distinguished into FASPs with explicit preference values, represented by the *WeighedFilteringAndSearchPreferencesType* (see Figure 2), FASPs with explicit boolean operators, represented by the *BooleanFilteringAndSearchPreferencesType* (see Figure 3) and FASPs with explicit boolean operators and explicit preference values, represented by the *BooleanWeighedFilteringAndSearchPreferencesType* (see Figure 4). These types extend the abstract query specification types (*WeighedQuerySpecificationType*, *BooleanQuerySpecificationType* and *BooleanWeighedQuerySpecificationType* respectively) with *FilteringAndSearchPreferences* elements that allow forming FASP hierarchies. Notice that the NOT operator and the negative preference values allow the users to express their negative preferences (dislikes) in the FASPs.

The FASP model proposed here enhances the FASP model we proposed in [15] for the extension of the MPEG-7 FASPs with semantic user preferences. The model of [15] has extended the MPEG-7 FASPs with semantic user preferences only, while the FASP model proposed here allows one to express preferences for every aspect of the MPEG-7 multimedia object descriptions. In addition, the usage of boolean operators is more flexible in the FASP model proposed here. The discussion shows that the FASP model we proposed in [15] is a special case of the FASP model proposed here.

The MPEG-7 FASPs are also a special case of the FASP model proposed here. In particular, an MPEG-7 FASP is also a FASP of type WeighedFilteringAndSearchPreferencesType, which has only the *CreationPreferences*, *ClassificationPreferences*, *SourcePreferences* and *PreferenceCondition* elements.

An example of a FASP with explicit preference values, which states "I want the multimedia objects where a goal is scored (preference 100) and their title contains the keyword 'soccer' (preference 90)", is shown, expressed in formal syntax, in (15).

$$FASP1 = ((EventType \; AND \; (exemplifies, \quad (15)$$

Goal)) 100 (Title 'soccer') 90)

The same query, expressed using XML syntax, is shown in Figure 8.

```
<Mpeg7Query xsi:type="WeighedMpeg7QueryType">
 <QuerySpecification xsi:type=
"WeighedFilteringAndSearchPreferencesType">
   <SemanticPreferences preferenceValue="100">
     <SemanticBase xsi:type="WeighedEventType">
       <Relation target="soccerevents#Goal"
type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:
exemplifies"/>
     </SemanticBase>
   </SemanticPreferences>
   <CreationPreferences>
     <Title preferenceValue="90"
stringComparisonOperator="keywords">
       soccer
     </Title>
   </CreationPreferences>
 </QuerySpecification>
</Mpeg7Query>
```

Figure 8: FASP stating "I want the multimedia objects where a goal is scored (preference 100) and their title contains the keyword 'soccer' (preference 90)", using XML syntax

4. Conclusions – Future Work

We have presented in this paper MP7QL, a powerful query language that we are developing for querying MPEG-7 descriptions, and a user preference model that allows for expressing preferences about every aspect of an MPEG-7 multimedia content description. The MP7QL queries may utilize the user preferences as context, thus allowing for personalized multimedia content retrieval. The user preference model supports multimedia Filtering and Search Preferences (FASP) that allow for expressing semantic preferences, preferences regarding the low-level visual features and preferences regarding media-related aspects (creation, classification, source etc). The proposed FASPs essentially are MP7QL queries, allow for the systematic integration of domain knowledge in the semantic preferences of the users and have the standard MPEG-7 FASPs as a special case. The MP7QL and the FASP model have been expressed using XML Schema. An OWL syntax has also been developed. An implementation on top of an XML Repository is currently under way.

5. References

[1] H. Agius, M. Angelides, "Modelling and Filtering of MPEG-7-Compliant Meta-Data for Digital Video". In the Proc. of the ACM SAC, 2004, pp. 1248-1252.

[2] D. Chamberlin, A. Berglund, S. Boag, et. al., (Eds), "XQuery 1.0: An XML Query Language", W3C Recommendation, 3 Nov. 2005, http://www.w3.org/TR/xquery/.

[3] H. Eidenberger, C. Breiteneder, "VizIR: A Framework for Visual Information Retrieval", Journal of Visual Languages & Computing, 14, 5, 2003, 443-469.

[4] D. Fallside, "XML Schema Part 0: Primer", W3C Recommendation, 2001. (http://www.w3.org/TR/xmlschema-0/).

[5] A. Graves, M. Lalmas. "Video Retrieval using an MPEG-7 based Inference Network". In the proc. of the ACM SIGIR 2002, pp. 339-346.

[6] D. L. McGuinness and F. van Harmelen (eds.). OWL Web Ontology Language: Overview. W3C Recommendation, 10 Feb. 2004. (http://www.w3.org/TR/owl-features).

[7] S. Hammiche, B. Lopez, S. Benbernou, M.-S. Hacid, A. Vakali, "Domain Knowledge Based Queries for Multimedia Data Retrieval", In the proc. of the Workshop on Multimedia Semantics 2006 (WMS 2006), pp. 94-103, 19-21 June 2006, Chania, Crete.

[8] ISO/IEC: 15938-3:2001: Information Technology – Multimedia content description interface – Part 3 visual (2001) Version 1.

[9] ISO/IEC: 15938-5:2003: Information Technology – Multimedia content description interface – Part 5: Multimedia description schemes (2003) First Edition.

[10] ISO/IEC JTC1/SC29/WG11. MPEG-7 Query Format Requirements v.4, Montreux, CH, April 2006.

[11] M-H Lee, J-H Kang, S-H Myaeng, S-J Hyun, J-M Yoo, E-J Ko, J-W Jang, J-H Lim. A Multimedia Digital Library System based on MPEG-7 and XQuery. In the proc. of the ICADL 2003.

[12] D. Rogers, J. Hunter, Kosovic D.: The TV-Trawler Project. In Special Issue of the International Journal of Imaging Systems and Technology on Multimedia Content Description and Video Compression, March 2003.

[13] P. Salembier, "MPEG-7 Multimedia Description Schemes", IEEE TA on Circuits and Systems for Video Technology, 11, 6, 2001, 748-759.

[14] B. Tseng, C.-Y. Lin, J. Smith: Using MPEG-7 and MPEG-21 for personalizing video. IEEE Multimedia, 11(1):42-52, Jan.-Feb. 2004.

[15] C. Tsinaraki, S. Christodoulakis. "A Multimedia User Preference Model that Supports Semantics and its Application to MPEG 7/21". In the proc. of the Multimedia Modeling 2006 Conference (MMM 2006), pp. 35-42, January 2006, Beijing, China.

[16] C. Tsinaraki, E. Fatourou, S. Christodoulakis: An Ontology-Driven Framework for the Management of Semantic Metadata describing Audiovisual Information. In Proc. of the Conference of Advanced Information Systems Engineering (CaiSE), Velden, Austria, 2003, pp 340-356.

[17] D. Vallet., M. Fernandez, P. Castellis, P. Mylonas, Y. Avrithis. A contextual personalization approach based on ontological knowledge. In the proc. of the IJCAI 2006.

[18] Q. Wang, W.-T. Balke, W. Kiessling, A. Huhn: P-News: Deeply Personalized News Dissemination for MPEG-7 based Digital Libraries. In the Proc. of ECDL 2004.