2009 Third International Conference on Digital Society

Music Ontology for Mood and Situation Reasoning to Support Music Retrieval and Recommendation

Seheon Song and Minkoo Kim
Graduate School of Information and Communication, Ajou University
Suwon, Korea
{lego, minkoo}@ajou.ac.kr

Seungmin Rho
School of Computer Science,
Carnegie Mellon University
Pittsburgh, PA, USA
smrho@andrew.cmu.edu

Eenjun Hwang
School of Electrical Engineering,
Korea University
Seoul, Korea
ehwang04@korea.ac.kr

Abstract— **In this paper, we discuss the use of knowledge for analyzing and retrieving music contents semantically. First, we present Context-based Music Recommendation (COMUS) ontology to reason desired user emotion state from context and user preference information in the ontology. COMUS is a music dedicated ontology in OWL constructed by incorporating domain specific classes for music recommendation into the Music Ontology, which include situation, mood and musical features. More specifically, we describe the ontologies of mood and situation in music using low-level features like pitch or duration and musical factors like tempo or rhythm. Our proposed ontology defines generic as well as domain-specific concepts whose detection is important for the analysis and description of music in a specific domain. As a novelty, our ontology can express detailed and complicated relations among the music, moods and situations, enabling users to find appropriate music for the music retrieval and recommendation application. We present some of the experiments we performed as a case-study for music recommendation.**

Keywords - Music ontology, situation reasoning, music recommendation

I. INTRODUCTION

Recently, with advances in network bandwidth, hardware technology, and signal processing techniques, diverse issues related to the content-based music retrieval, classification and recommendation are getting tremendous attention. Most traditional content-based music retrieval (CBMR) techniques [1, 2] have focused on low-level features such as energy, zero crossing rate, audio spectrum, etc. However, these features were not enough to give semantic information of music contents and gave serious limitation in retrieving and recommending appropriate music. For example, a person is very sad for some reason. Depending on his/her personality, he/she may want to listen to some music that may cheer him/her up, or easy music that can make him/her calm down.

Due to the aforementioned limitations of feature-based music retrieval, some researchers have tried to bridge the semantic difference, which is also known as semantic gap, between the low-level features and high-level concepts such as human emotion and mood [3, 4]. With low-level feature analysis only, we will experience many difficulties in identifying the semantics of music contents. Similarly, it is difficult to correlate high-level features and the semantics of music. For instance, user's profile which includes education background, age, gender and musical taste is one possible high-level feature. Due to this semantic gap, semantic web technology is considered as one of promising methods to bridge it.

Therefore, in this paper, we try to tackle the abovementioned problem in the domain of music recommendation by combining content-based music retrieval, music ontology and domain specific ontologies such as Mood and Situation. More specifically, based on the basic concepts from the upper ontologies which can be found in the previous ontology-related projects such as Music Ontology [5, 6], Kanzaki taxonomy [7] and MusicBrainz [8], we define more specific domain-oriented ontologies.

In our scenario for music recommendation, we noted musical terms as concepts. The relations consist of several types, including formal ontological relations such as 'is-a' and 'has-a.' We deal with these two formal relations to indicate the specialization of concepts and required parts. For example, mood, genre and music features are part-of music and MFCC, tempo, onset, loudness and chroma is-a music feature. The other important relation is 'like-song/singer/genre/mood'. This relation is used to describe user's musical and emotional preference.

In this paper, we develop extended music ontologies to enable mood and situation reasoning in a music recommendation system. Those ontologies are described in OWL language using Protégé editor [9]. For the retrieval and recommendation, the Jena SPARQL engine is used to express and process necessary queries to our ontologies. For example, when a user creates a profile containing his/her musical preference, it is not reasonable to expect him/her to specify all the required details into the profile. In that case, missing valuable information could be inferred from the partial information in the profile.

In the following section, we present a brief overview on the current state-of-the-art music ontologies. In Section 3, we describe our extended music ontologies and demonstrate their usage using a few typical scenarios. Experimental result is given in Section 4. In the last section, we conclude the paper with some observations and future work.

978-0-7695-3526-5/09 $25.00 © 2009 IEEE
DOI 10.1109/ICDS.2009.50

II. RELATED WORK

Many researches have been done in the area of music recommendation in the past few years. In this section, we review some of recently developed music ontologies and discuss their practical usage.

A. The Music Ontology

The Music Ontology[5, 6] is an effort led by ZitGist LLC and the Centre for Digital Music to express music-related information on the Semantic Web. The Music Ontology is an attempt to link all the information about musical Artists, Albums and Tracks together: from MusicBrainz to MySpace. The goal is to express all the relations between musical information to help people to find anything about music and musicians. It is based around the use of machine readable information provided by any web site or web service on the Web.

The Music Ontology is mainly influenced by several ontologies such as The FRBR (Functional Requirements for Bibliographic Records), Event ontology, Timeline ontology, ABC ontology, and FOAF ontology. Some part of this specification is stable, but others are still unstable.

The Music Ontology can be divided into three levels of expressiveness – from the simplest one to more complex ones. Level 1 aims at providing a vocabulary for simple editorial information (tracks/artists/releases, etc). Level 2 aims at providing a vocabulary for expressing the music creation workflow (composition, arrangement, performance, recording, etc). Level 3 aims at providing a vocabulary for complex event decomposition, to express, for example, what happened during a particular performance, what is the melody line of a particular work, etc.

B. Kanzaki Vocabulary

Kanzaki[7] is a music vocabulary which describes classical music and performances. It defines classes for musical works, events, instruments and performers, as well as related properties. It distinguishes musical works from performance events. The current version of this vocabulary is tested using a model to describe a musical work and its representations (performances, scores, etc) and a musical event to present a representation like concert. This ontology consists of 112 classes and 34 properties definitions, and 30 individuals.

C. The Friend of a friend (FOAF)

FOAF project[15] aims at creating a machine-readable ontology describing persons, their activities and their relations to other people and objects. Anyone can use FOAF to describe him/her. FOAF allows groups of people to describe social networks without the need for a centralized database. FOAF is an extension to the RDF (Resource Description Framework) and can be defined using OWL Web Ontology Language. For example, computers may use these FOAF profiles to find all people living in a certain area, or to list persons of interest. This is accomplished by defining relationships between people. Each profile has a unique identifier such as person's e-mail address, Jabber ID, or URI of the homepage or weblog of the person to define these relationships.

III. ONTOLOGY MODEL

As we mentioned above, in order to provide music recommendation service intelligently, we need a set of common ontologies for knowledge sharing and reasoning. We have developed music and its related ontologies in the music recommendation domain. We use the W3C recommendation ontology language OWL (Web Ontology Language) to represent ontology. The OWL helps developers to represent a domain by defining classes and properties of those classes, to define individuals and asserting properties about them, and to reason about these classes and individuals.

The OWL language is derived from the DAML+OIL language and both are layered on top of the standard RDF(S) triple data model (i.e., subject, predicate, and object). We adopt basic concepts and relations from previous work - the Music Ontology[5, 6]; we expand it to include additional features such as musical feature, genre, instrument taxonomy, mood, and situation. We serialize these ontologies by OWL so that we can retrieve some information using SPARQL query language.

A. COMUS ontology

COMUS (Context-based Music Recommendation) ontology consists of 18 classes and 32 properties. Figure 2 shows a graph representation of some of key COMUS ontology definition. This ontology describes music related information about relationships and attributes that are associated with people, genre, mood (e.g., angry, happy), location (e.g., office, street), time (e.g., morning, winter), and events (e.g., driving, working) in a daily life.

Figure 1 shows a part of the COMUS ontology in XML syntax. The key top-level elements of the ontology consist of classes and properties that describe Person, Situation, Mood, Genre and Music classes. In the following, we will briefly describe each of the classes and show a few SPARQL query examples for the scenario which we will discuss in the next section.

- **Person** The "Person" class defines generic properties of a person such as name, age, gender, hobby, socioeconomic background (e.g., job, final education) and music related properties for music recommendation such as musical education, favorite music, genre and singer.

- **Situation** The "Situation" class defines person's situation in terms of conditions and circumstances, which are very important clues for effective music recommendation. Hence, this class describes user's situational contexts such as whereabouts of the user (Location), what happens to the user (Event), and so on.

The following questions describe how this ontology might be used for reasoning about the user's situational contexts and recommending appropriate music.

- Q1: What kinds of music does he/she listen to when he/she feels gloomy in her bed at night?
- Q2: What kinds of music does he/she listen to when he/she takes a walk for enjoying a peaceful afternoon?
- Q3: What kinds of music does he/she listen to when he/she wake up late in the morning?
- Q4: What kinds of music does he/she listen to when he/she drive into the office in the morning?

```
   <owl:Class rdf:about="#Feature">
   <rdfs:comment rdf:datatype="http://www.w3.org/
2001/XMLSchema#string"> MFCC, Chroma, Average
Energy, … </rdfs:comment>
   <rdfs:subClassOf
rdf:resource="#MusicExtension"/>
  </owl:Class>
  <owl:Class rdf:about="#MFCC"><rdfs:subClassOf
rdf:resource="#Feature"/></owl:Class>
  <owl:Class rdf:ID="Mood">
     <rdfs:subClassOf
rdf:resource="#MusicExtension"/></owl:Class>
 <owl:ObjectProperty rdf:ID="hasLocation">
   <rdfs:domain rdf:resource="#Situation"/>
   <rdfs:range rdf:resource="#Location"/>
  </owl:ObjectProperty>
  <owl:ObjectProperty rdf:ID="hasUserMood">
   <rdfs:domain rdf:resource="#Situation"/>
   <rdfs:range rdf:resource="#Mood"/>
  </owl:ObjectProperty>
  <owl:ObjectProperty rdf:ID="like_mood">
   <rdfs:range rdf:resource="#Mood"/>
   <rdfs:domain rdf:resource="#Person"/>
  </owl:ObjectProperty>
  <owl:ObjectProperty rdf:ID="like_genre">
   <rdfs:domain rdf:resource="#Person"/>
   <rdfs:range rdf:resource="#Genre"/>
  </owl:ObjectProperty>
```

Figure 1 This is a part of our proposed ontology represented in XML syntax.

- **Mood** The "Mood" class defines the state of one's mind or emotion. Each mood has a set of similar moods. For example, "aggressive" has similar moods like "hostile, angry, energetic, fiery, rebellious, reckless, menacing, provocative, outrageous, and volatile."

- **Genre** The "Genre" class defines the category of music. There have been many researches for the music genre classification. In the music industry, music taxonomies are usually made up of four levels [13]: (i) Top level consists of global musical categories such as Classical, Jazz, and Rock; (ii) Second level consists of specific sub categories (e.g., "Hard Rock" within "Rock"); (iii) Third level usually gives an alphabetical ordering of artists (e.g., "Queen"); (iv) Fourth level consists of tracks in the artist album. There exist several popular online systems such as All Music Guide [11], MusicBrainz [8] and Moodlogic for annotating popular music genre and emotion. We create our own genre taxonomy based on All Music Guide along with second level of industry taxonomy.

- **Music** The "Music" class defines general properties of music such as title, released year, artists, genre, and musical features (e.g., MFCC, Tempo, Onset, Chroma, Segment, Spectra Centroid, Spectra Flux, Spectra Spread, and Zero Crossing Rate). Using music class we can express information ranging from this example to: This song was performed by Queen in 1988. "Keep The Faith" by Bon Jovi was released on the "Keep The Faith" album in 1992. Also, music has moods such as gloomy, angry, exciting, and etc for guessing related music which has same mood.

B. Scenario: Situation-based music recommendation

In this subsection, we will introduce a typical scenario that demonstrates how COMUS ontology can be used to support ontology reasoning for recommending appropriate music to users.

Example Scenario

Tom is a technical consultant and he is 30 years old. His favorite singer is "Chicago," and he likes Pop and Hard Rock style music. His hobby is baseball. He is a very positive person and likes bright, soft and sweet music. When he feels sad or gloomy, he usually listens to the music that might help cheer him up. The date is 7 July, 2008. Tom woke up late in the Monday morning and he is still very tired due to working late last night. He has to come into work early to prepare for a presentation at Monday morning meeting. Therefore, he asks the music recommendation system to look up some hard and fast beat music then he listens to the music like "Welcome to the jungle (Guns N' Roses)," "Heartbreaker (Nirvana)" and "I remember you (Skid Row)." These kinds of music help him to hurry up to go to work in time.After a while, he was stuck in a traffic jam which started making him nervous on his way to work. In order to calm down that situation, he asks again the system to recommend some calm-down music such as The Carpenters, Air Supply and Simon & Garfunkel.

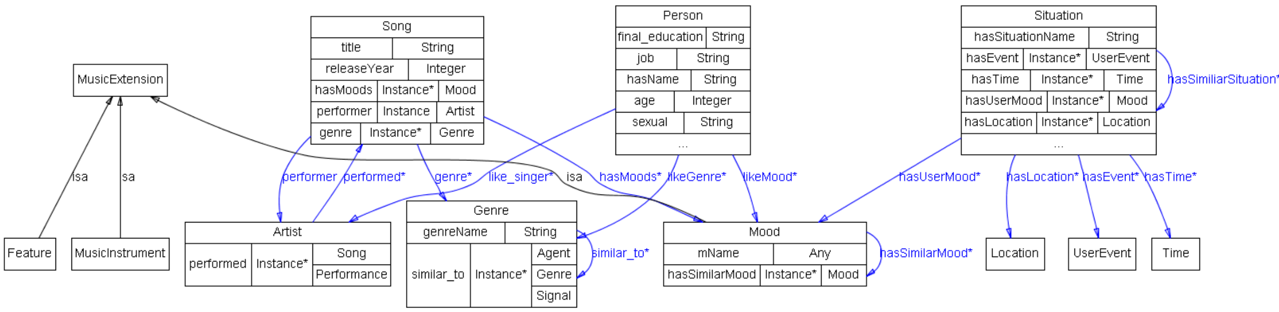


Figure 2 (a) This is a abstract and partial graph representation of the COMUS ontology

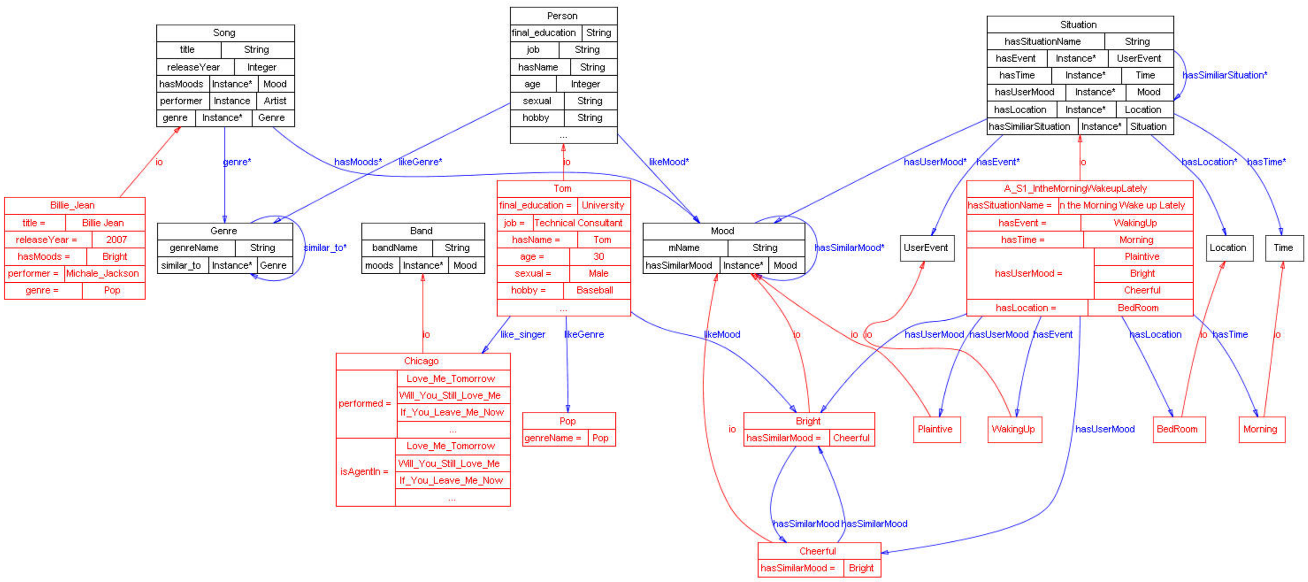


Figure 2 (b) This is a graph representation of the COMUS ontology in case of instantiation.

The scenario above assumes that Tom has set his musical preferences such as singer, genre and mood to filter out the query result automatically. For example, considering the wake-up-late situation abovementioned scenario, the situation information described in Figure 3(b) is analyzed and sent to the recommendation system. Using this information, the system will reason about Tom's situational context and his favorite mood from the user profile information. From this information, the system recommends a bunch of music which best fits Tom's interest and current situation.

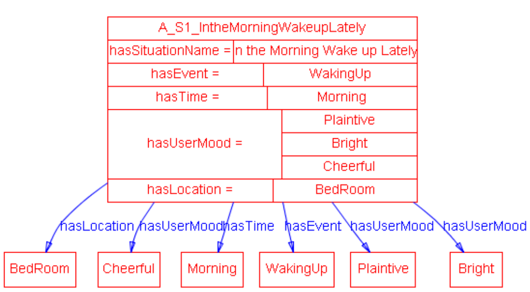


Figure 3 (a) This is a sample situation ontology represented in XML syntax.

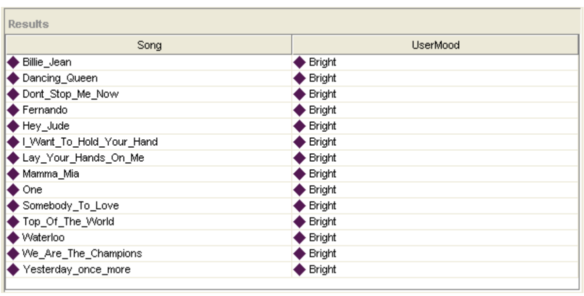
```
  <Situation
rdf:ID="S1_IntheMorningWakeupLately">
      <hasEvent>
      <UserEvent rdf:ID="WakingUp"/>
</hasEvent>
      <hasTime> <Time rdf:ID="Morning"/>
</hasTime>
      <hasSituationName
rdf:datatype="http://www.w3.org/2001/XMLSche
ma#string">
          Wake Up Late</hasSituationName>
      <hasUserMood rdf:resource="#Plaintive"/>
      <hasUserMood rdf:resource="#Bright"/>
      <hasUserMood rdf:resource="#Cheerful"/>
      <hasUserMood rdf:resource="#Gloomy"/>
      <hasLocation>
      <Location rdf:ID="BedRoom"/>
</hasLocation>
 </Situation>
```

Figure 3 (b) This is a sample situation ontology represented in XML syntax.

Based on the situation described in Figure 3 and Tom's favorite mood from his profile information, we might formulate a user query as in Figure 4(a) and its result is shown in Figure 4(b).

```
PREFIX mol:
<http://ceai.ajou.ac.kr/ontology/0.1/
musicontology.owl#>
SELECT DISTINCT ?Song ?UserMood
FROM
<http://ceai.ajou.ac.kr/ontology/0.1/musicontology.
owl>
WHERE {
?Person mol:hasName "Tom";
mol:likeMood ?UserMood.
?Situation mol:hasSituationName "Wake Up
Late";
mol:hasUserMood ?UserMood.
?UserMood
mol:hasSimilarMood ?SimiliarMood.
{?Song mol:hasMoods ?UserMood} UNION
{?Song mol:hasMoods ?SimiliarMood}
} ORDER BY ?Song
```

Figure 4 (a) A sample SPARQL query in the "Wake up late" situation


Results

Song	UserMood
Billie_Jean	Bright
Dancing_Queen	Bright
Dont_Stop_Me_Now	Bright
Fernando	Bright
Hey_Jude	Bright
I_Want_To_Hold_Your_Hand	Bright
Lay_Your_Hands_On_Me	Bright
Mamma_Mia	Bright
One	Bright
Somebody_To_Love	Bright
Top_Of_The_World	Bright
Waterloo	Bright
We_Are_The_Champions	Bright
Yesterday_once_more	Bright

Figure 4 (b) The result of the query above.

IV. EXPERIMENT

In this section, we describe experiments that we have performed to measure the performance of our system and show some of the results.

According to [10], the development of ontology is motivated by scenarios that arise in the application. A motivating scenario provides a set of intuitively possible solutions to the problems in the scenario. The COMUS ontology is a collection of terms and definitions relevant to the motivating scenario of music recommendation that we described above. Thus, to build ontology, it is important to start with describing the basic concepts and one or more scenarios in the specific domain of interest.

After building the ontology, the next step is to formulate competency questions. These are also based on the scenarios and can be considered as expressiveness requirements that are in form of questions. Ontology must be able to represent these questions using its domain-related terminology and characterize their answers using the axioms and definitions. Therefore, we asked participants to answer the competency questions through the online questionnaire system.

In the experiment, we had about 30 participants. Some of them had been musically trained and others are not. Participants were asked to fill out the questionnaire to collect suitable terms and definitions about the situation and mood. They were also requested to describe their own emotional state transition like current and desired emotions in the specific scenario. The description was based on one or more emotional adjectives such as happy, sad, angry, nervous, and excited those were collected from All Music Guide taxonomy [11]. Finally, the most frequently described adjectives were chosen to define the instances in the COMUS ontology.

After building the ontology, we performed an experiment to measure the level of user satisfaction using either our proposed COMUS ontology or AMG Taxonomy in our system. The procedure for the experiment is as follows.

1) *The experimenter explained the procedure and the purpose of the experiment and demonstrated how to run our music recommendation system.*

2) *The participant should describe his/her profile (e.g., musical preferences) using web form interfaces such as buttons, textbox, checkbox and selection list.*

3) *All the participants were told to describe the situation, current emotion and their desired emotion or just select the predefined scenario using the query interfaces.*

4) *Then, the system returned recommended songs based on the ontology reasoning and the participant's profile. Then the participant judged which one was appropriate for their current emotion. Participants chose one of the 5 point rating scales (from 1 – strongly unsatisfied to 5 – strongly satisfied).*

5) *Finally, all the participants were asked to fill out a questionnaire.*

As shown in Table 1, over 80% of the participants responded positively to the overall satisfaction of the system using ontology instead of AMG taxonomy. The result of the satisfaction ratings shows most of the users were satisfied with the query results recommended by the system.

TABLE 1. PARTICIPANTS' OPINION WITH REGARD TO THE SYSTEM USING EITHER COMUS ONTOLOGY OR AMG TAXONOMY.

	1 (unsatisfied)	**2**	**3 (neutral)**	**4**	**5 (very satisfied)**
AMG Taxonomy	1	3	19	5	2
COMUS Ontology	0	2	4	16	8

With regard to the satisfaction of the participant's preferred emotional adjectives depicted in Table 2, positive adjectives (such as happy and excited) are found more satisfactory by about 78% of the participants whereas ambiguous adjectives like nervous by 43% of the participants (in the case of using COMUS ontology).

TABLE 2. PARTICIPANTS' PREFERRED EMOTIONAL ADJECTIVES.

	AMG Taxonomy					**COMUS Ontology**				
	1	*2*	*3*	*4*	*5*	*1*	*2*	*3*	*4*	*5*
angry	4	5	9	8	4	1	6	11	9	3
bored	9	12	6	2	1	1	3	6	11	9
calm	2	6	9	9	4	2	5	12	7	4
excited	3	4	6	8	9	0	3	6	8	13
happy	4	8	10	6	2	0	2	2	9	17
nervous	3	15	8	4	0	4	5	8	8	5
peaceful	3	7	8	6	6	0	3	5	14	8
pleased	6	7	13	3	1	0	1	5	9	15
relaxed	6	7	12	3	2	1	4	12	6	7
sad	4	8	16	2	0	0	1	14	11	4
sleepy	0	9	11	6	4	2	4	6	12	6

V. CONCLUSION

In this paper, we presented music-related ontologies for more customized and intelligent services such as music recommendation. We modeled musical domain and captured low-level musical features and several musical factors to describe music moods and music-related situations based on ontology. We have constructed musical ontology based on the current music ontology as part of ongoing project on building intelligent music recommendation system. To show its feasibility, we set up a usage scenario and presented several queries for reasoning useful information from the ontologies. Our next step is the refinement for this music ontology, many blind tests with more reliable people; also we hope to adapt this ontology to specific music recommendation system.

ACKNOWLEDGMENT

This research was supported by Defense Acquisition Program Administration and Agency for Defense Development under the contract.

REFERENCES

[1] Birmingham, W., Dannenberg, R., Pardo, B., "An Introduction to Query by Humming with the VocalSearch System," Communications of the ACM, Vol. 49 (8), pp. 49-52, 2006.

[2] Rho, S., Han, B., Hwang, E., and Kim, M., "MUSEMBLE: A Novel Music Retrieval System with Automatic Voice Query Transcription and Reformulation," Journal of Systems and Software (Elsevier), Vol. 81(7), pp. 1065-1080, July. 2008.

[3] Oscar, C., "Foafing the Music: Bridging the semantic gap in music recommendation," Proceedings of 5th International Semantic Web Conference (ISWC), 2006.

[4] Oscar, C., Perfecto, H., and Xavier, S., "A multimodal approach to bridge the Music Semantic Gap," Semantic and Digital Media Technologies (SAMT), 2006.

[5] Yves, R., and Frederick, G., "Music Ontology Specification," http://www.musicontology.com/

[6] Yves R, Samer A, Mark S, and Frederick G., "The Music Ontology," Proceedings of the International Conference on Music Information Retrieval, ISMIR 2007 : 417-422, 2007.

[7] Kanzaki Music Vocabulary. http://www.kanzaki.com/ns /music

[8] MusicBrainz. http://musicbrainz.org

[9] Protégé Editor. http://protege.stanford.edu

[10] Grüninger M, Fox MS., "The Role of Mariano Fernández López 4-12 Competency Questions in Enterprise Engineering," IFIP WG 5.7 Workshop on Benchmarking. Theory and Practice. Trondheim, Norway, 1994.

[11] All Music Guide. http://allmusic.com

[12] W3C. RDF Specification. http://www.w3c.org/RDF

[13] Francois, P., and Daniel, C., "A Taxonomy of Musical Genres," Content-Based Multimedia Information Access Conference (RIAO), 2000.

[14] Samer, A., Yves, R., and Mark, S., "An ontology-based approach to information management for music analysis systems," Proceedings of the 120th AES convention, 2006

[15] The Friend of a Friend (FOAF) project. http://www.foaf-project.org/