Ontological Model to Represent Information About Songs

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Abstract. The purpose of this article is to carry out the design of an ontological model for the domain of songs, that is, its purpose is to cover the relevant information corresponding to the characteristic data currently sought to be known in the songs from different music genres, such as title, performer, album which it belongs, duration, release date, among many others. It is wanted for this model to answer queries made by users when they are facing the need to know a specific data. For this work realization, the Grüninger and Fox's methodology design phases, proper for the ontologies design, are followed, along with this, this document includes the proposal of a scenario, competition questions, definition of classes, properties, formalization and evaluation through the responses obtained through the SPARQL query language. Furthermore, the implementation of the presented ontological model was carried out using the software known as Protégé.

Keywords: Ontological model · Ontology design methodology · Songs · Query information

1 Introduction

Now days there are information sources on the web with search engines that respond to what the user requests, however, these engines work syntactically, that is, they reply results containing lexical elements related exactly to the query terms, so this is why the semantic web is used with the objective to overcome the current web limitations [3].

Gruber defines an ontology as an explicit formal specification of a shared conceptualization [12]. An ontology defines a hierarchy of concepts, relationships, restrictions, axioms and instances to describe a domain, which will serve for information exchange [3]. On the other hand, the use of ontologies has become a common interest area for some research groups, such as: the artificial intelligence line, knowledge engineering, natural language processing and knowledge representation, among others [1].

The ontology creation is a process made up from series of activities carried out in a certain order for a specific purpose. However, not all possible ontologies are already created, which is why it is necessary to develop and implement them in some way so that they can be used by the general community [2].

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This is why, with the realization of this work, it is intended to carry out an ontology implementation that shows the information related to songs, which we can find today in our daily life, since, we all have a like, either for a specific genre or a song and many times we would like to know relevant data such as the artist, the album to which it belongs, the date of release, the duration, etc.

With the development of this ontology, the objective to be covered is to provide a songs library to the general public, that is, to make inference in the information corresponding to the songs according to their musical likes and thus make inquiries about the songs data, which becomes this tool, a very useful system for users who several times, in their daily lives, need to know this kind of information.

Following each of the steps specified in the used methodology, it is possible to develop an ontological model capable of handling the most important information regarding the domain of songs, the data being worked on is very extensive, so the use of a ontology is the most feasible solution to work with this type of context, this model allows queries to be made on the data, thus enabling the user to gather the information they require depending on their need, in addition to implementing the design of the ontology using the tool known as Protégé [6], therefore, a ready-to-use model is obtained.

The article is structured as follows: in Sect. 2 the related works are mentioned; Sect. 3 shows the design methodology used; Sect. 4 shows the ontology design; Sect. 5 shows the competence questions formalization and queries in SPARQL. Finally, the conclusions and references are presented.

2 Related Works

Some similar articles have been found in the literature and related to the use of methodologies for the ontology's construction, as well as proposed solutions focused on the domain of songs. Guzmán L. et al. [1] present a comparative analysis of methodologies and some existing methods mainly oriented to the design and implementation of ontologies, in addition, the specification of implementation tools typical of ontological models is included, for their application they use the domain oriented to the area of plastic arts; on the other hand, Bravo Contreras et al. [7] present a methodology for the design and construction of ontologies incorporating the most prominent design principles as well as a comprehensive evaluation process.

Flores et al. [3] present an ontological model design for the search of information within an institution of higher education and seeks to answer questions about the student's enrollment procedures and their respective release of professional practices, in addition they give a clear example of one Grüninger and Fox's methodology application for the ontologies design. In the same way, López R. et al. [2] present some methods and approaches published for the evaluation of ontologies, seeking to take up good practices from other existing methods and consider internal aspects of ontologies.

Uschold M. et al. [8] present a description of the emerging field related to the design and use of ontologies, aspects such as the benefits of using this kind of tools as ontological models are discussed, also in addition to mentioning how the methodologies are analyzed and then carrying out the ontology evaluation. Meanwhile, in another related work, Uschold M. together with King M. [9] present a work focused on modeling and

emphasized in the process of capturing ontologies, describe ways to handle ambiguous terms so as not to fall into the problem that shared understanding is not adequate, since ontology must be understandable for its application.

In the same way, Banu A. et al. [10] propose an approach to reuse existing ontologies for the implementation of new ontological models that cover different domains, mainly based on retrieving ontologies based on important domain terms from online repositories using semantic web search engines.

Lachtar N. [11] presents a proposal for a musical repository based on the use of an ontology to index a collection of songs and the use of semantic links to allow the inference of all the relevant songs, in addition a refinement algorithm is proposed of queries to find songs, the development of a web application is carried out to index the songs by concepts, carry out conceptual searches for songs and exploit the semantic relationships that structure the ontology. Finally, Raimond Y. et al. [13] present and ontology development based on the domain of music production, including editorial, cultural and acoustic information regarding music, in the work presented by reusing "The Timeline Ontology" and "The Event Ontology" they are in charge of sound analysis which are involved in recording a piece of music, in addition to obtaining the different editorial information provided for the music.

Unlike the two works mentioned above, in Lachtar N. [11] they only make use of song titles to index or perform conceptual searches and Raimond Y. et al. [13] focus more on the field of music production, handling detailed information on music including acoustic aspects, in addition to making a more complex analysis to obtain the results they present; it is worth mentioning the contribution of this work is that, the presented ontology covers more information regarding a song, not mixing aspects of musical production or sound, that is the domain covered is broad in terms of information from a single song, since more data is worked in addition to the title, so the queries could be more complex to gather information, corresponding not only to a song but also to albums, interpreters, record labels, genres of music, composers and producers.

3 Ontology Design Methodology

It is proposed to use the Grüninger and Fox's methodology to carry out this work, which is inspired by the development of knowledge based on first-order logic [4]. Said methodology proposes an optimal design for the field of ontologies, since it presents different phases that can be followed step by step to carry out its development.

Mainly, it was decided to use this methodology since the domain of songs is very extensive, it is necessary to have the description of the stage to know all the data that will be used regarding the songs, in addition to the fact that using questions that solve the needs of users when they want to know specific data is an optimal way to evaluate and keep in mind if the ontology fulfills its purpose, which is to provide more detailed information in the musical field, a reengineering is not used since other related works present similarity only in providing information about the songs, in this work the contribution is to provide a way to query information regarding albums, interpreters, record labels, composers and producers, that is, more detailed information and attributes related to songs are being handled.

As a first step, this methodology proposes to identify the main scenarios, that is, the possible applications in which the ontology will be used. As a second step it is proposed to ask a series of questions called "competence", which are used to determine the scope of the ontology. These questions and their answers are used to extract the main concepts and their properties, relationships and formal axioms of ontology [5]. Next, Sect. 3.1 shows the scenario approach; in Sect. 3.2 the proposed competence questions are shown and finally in Sect. 3.3 the classes description and their properties are presented.

3.1 Scenario Presentation

The ontological model will provide answers about the most relevant information you need to know about a song, in this case data such as the title, artist, album to which it belongs, song genre, language, release date, duration, recording year, related record label, composer and producer, this set of attributes of a song may be consulted depending on the data you want to know, the ontology will be able to provide the required information.

In the same way, specific information about the performers can be gathered, which can be a singer, a composer or a musical group, and information about the album related to the song, the recorded music genres, the musical instruments used by the performers mentioned above, related record labels, composers and producers, since all these attributes are related to each other because they are part of the data of a song, that is, why each of these terms are defined as classes, which will contain their own attributes (data) that depict them.

3.2 Competition Questions

Following the methodology used to carry out this ontological model, a series of questions were prepared, which are called "competition", this in order to have an idea of what a user could do as a search, that is, queries within the ontological model, in addition to being useful to identify classes, relationships, properties and axioms for the realization of this ontology of songs. Here are some elaborate competence questions:

1. What are the characteristics of a song?
2. What are the songs lasting more than four minutes?
3. What are the registered music genres?
4. What are the registered singers or songwriters' names with Mexican nationality?
5. Who are the members from the rock band called Queen?

3.3 Classes Description and Properties

For this phase, an analysis was carried out, in which, starting from the scenario and the competition questions, the different classes that the ontological model would contain were identified, in the same way the properties for each class were obtained together with their relationships. Table 1 describes some classes that were included in the ontological model, such as: song, musical group, singer-songwriter, composer, producer and music genre, but there are also classes such as album, singer, record label, person and musical instrument within the ontology.

Table 1. Ontological model classes.

Class	Description
Song	Main class containing the different data to be provided about a song
Band	Class corresponding to the song interpreters, in this case a group of singers
Singer_Songwriter	Subclass of Person, corresponds to the song interpreter, in this case it is the responsible person for composing and interpreting the song
Composer	Subclass of Person, corresponds to the song or songs composer. A composer can be a singer-songwriter too
Producer	Subclass of Person, refers to the song or the album producer. In the same way, it can be a singer or a singer-songwriter
Music_Genre	Class to list the different genres of music that exist and relate them to each song

Tables 2 and 3 describe the properties for each class, which are highly important, since they help to store the information to answer the competence questions above described.

Table 2. Data type properties.

Data type property	Domain	Range
has_title	Song	String
has_language	Song	String
has_publication_date	Song	String
has_duration	Song	Decimal
has_recording_year	Song	Int
has_name	Band	String
has_origin_place	Band	String
has_activity_status	Band	String
has_emergence_year	Band	Int
has_activity_period	Band	String
has_stage_name	Singer_Songwriter	String
has_occupation	Singer_Songwriter	String
has_activity_period	Singer_Songwriter	String
has_award	Singer_Songwriter	String
has_occupation	Composer	String

(*continued*)

Table 2. (*continued*)

Data type property	Domain	Range
has_activity_period	Composer	String
has_stage_name	Producer	String
has_award	Producer	String
has_name	Music_Genre	String

Table 3. Object type properties or relationships between classes.

Object property	Domain	Range
belongs_to	Song	Music_Genre
is_included_in	Song	Album
is_interpreted_by	Song	Singer Singer_Songwriter Band
is_composed_by	Song	Singer_Songwriter Composer
is_recorded_by	Song	Record_Label
is_produced_by	Song	Producer Singer Singer_Songwriter
has_member	Band	Singer Singer_Songwriter
interprets	Band	Music_Genre
works_with	Band	Record_Label
is_member_of	Singer_Songwriter	Band
uses	Singer_Songwriter	Musical_Instrument
interprets	Singer_Songwriter	Music_Genre
works_with	Singer_Songwriter	Record_Label
uses	Composer	Musical_Instrument
composes	Composer	Music_Genre
works_with	Producer	Record_Label
produces	Producer	Music_Genre

Table 2 shows the ontological model data type properties and Table 3, shows the object type properties, which are the relationships between classes.

4 Design

This section presents the design for the proposed ontology developed with the help of the Protégé tool, an open source software for building ontologies through its interface that helps the developer in the process [6]. In Fig. 1 the ontological model classes are depicted, the classes have relations between them, therefore, in Fig. 2 the object type properties diagram (relations between classes) is shown, which were described in Table 3.

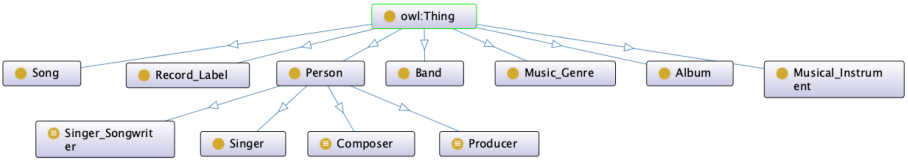

Fig. 1. Ontological model classes.

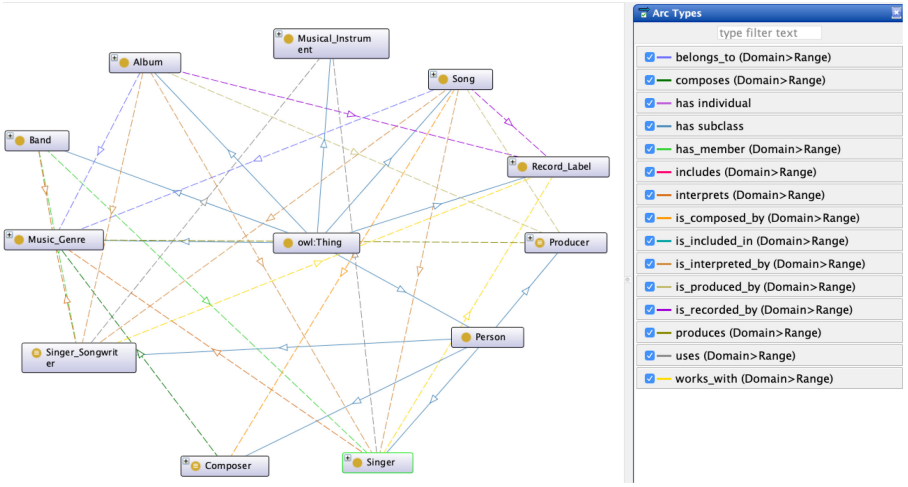

Fig. 2. Relations between the ontological model classes.

The same way, some rules were created for the classes as a singer-songwriter, who can be a singer and a composer at the same time, so it must be defined in the ontological model (see Fig. 3). The composer also, as being part of the singer-songwriter restriction, can be of both types, using Protégé the restriction is defined in the composer class as well. The producer can be a singer or a songwriter at the same time, since several times the same performers are in charge of being producers of their songs (see Fig. 4).

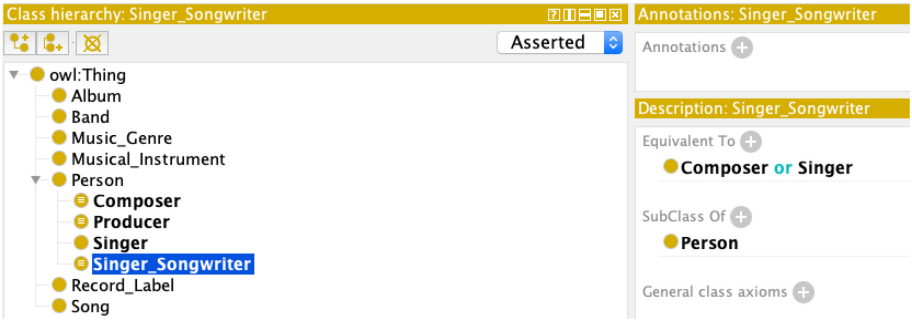

Fig. 3. Class restriction singer-songwriter.

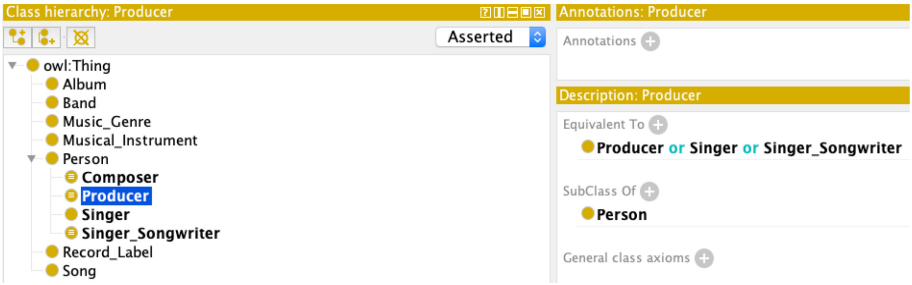

Fig. 4. Producer class restriction.

5 Results

The following section shows the competence questions formalization (see Table 4), which were presented in Sect. 3.2. The ontology evaluation was carried out at the application level, that is, through the answers provided by the ontological system, in the same way these answers are provided when formalizing the competency questions, it is worth mentioning that the ontology meets the consistency criteria and the HermiT reasoner was used to test the ontological model from the Protégé tool.

Table 4. Competition questions formalization and answers in SPARQL.

Nº	Question and formalization	**Query SPARQL**
1	**What are the characteristics of a song?** ∃xmnpqrtuvw$y (Song($x) ∧ has_title($x, $m) ∧ belongs_to ($x, $n) ∧ is_included_in ($x, $p) ∧ is_interpreted_by ($x, $q) ∧ has_language($x, $r) ∧ has_publication_date($x, $t) ∧ has duration($x, $u) ∧ is_composed_by ($x, $v) ∧ is_recorded_by ($x, $w) ∧ is_produced_by ($x, $y))?	Figure 5

(*continued*)

Table 4. (*continued*)

Nº	Question and formalization	**Query SPARQL**
2	**What are the songs lasting more than four minutes?** ∃xy$z (Song($x) ∧ has_title ($x, $y) ∧ (has_duration ($x, $z) > 4))?	Figure 6
3	**What are the registered music genres?** ∃xy (Music_Genre ($x) ∧ has_name ($x, $y))?	Figure 7
4	**What are the registered singers or songwriters' names with Mexican nationality?** ∃xpqwyzkmno ((Singer_Songwriter($x) ∧ has_stage_name ($x,$p) ∧ has_age ($x,$q) ∧ has_occupation ($x, $w) ∧ (has_nationality ($x, $y) = "Mexican")) ∨ ((Singer ($z) ∧ has_stage_name ($x,$k) ∧ has_age ($x,$m) ∧ has_occupation ($x, $n) ∧ (has_nationality ($x, $o) = "Mexican"))?	Figure 8
5	**Who are the members from the rock band called Queen?** ∃xpqwyzkmnort ((Singer_Songwriter ($x) ∧ has_stage_name ($x,$p) ∧ has_activity_period ($x,$q) ∧ has_nationality ($x, $w) ∧ has_occupation ($x,$y) ∧ (is_member_of ($x, $z) = "Queen")) ∨ ((Singer($k) ∧ has_stage_name ($k,$m) ∧ has_activity_period ($k,$n) ∧ has_nationality ($k, $o) ∧ has_occupation ($k, $r) ∧ (is_member_of ($k, $t) = "Queen"))?	Figure 9

For the realization of the queries, the proper language is used for the use of ontologies which is SPARQL and the answers to the competence questions are presented in Figs. 5–9 (see column 3 of Table 4).

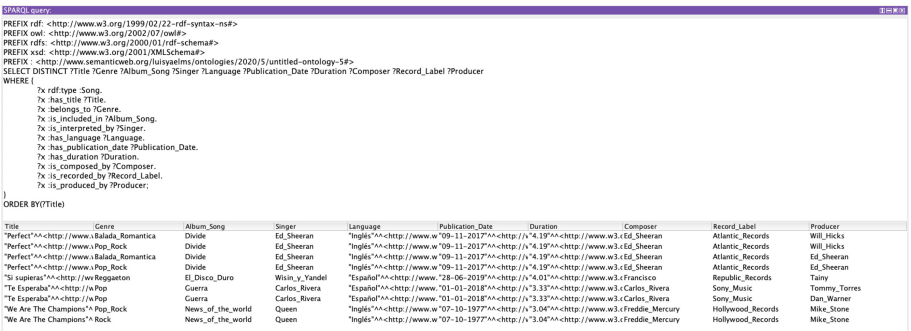

Fig. 5. Answer to question 1.

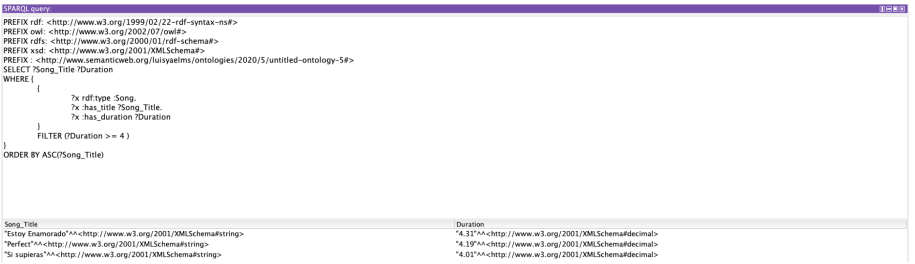

Fig. 6. Answer to question 2.

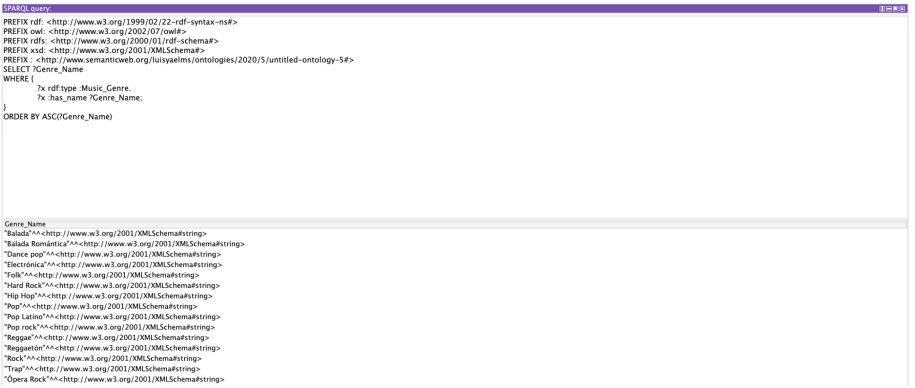

Fig. 7. Answer to question 3.

Fig. 8. Answer to question 4.

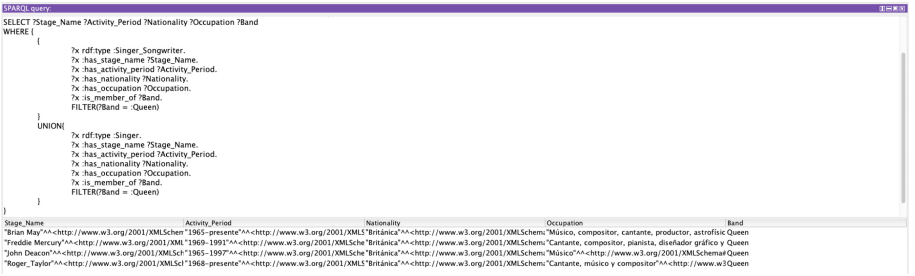

Fig. 9. Answer to question 5.

6 Conclusions

This document defines an ontology for the musical domain, created from the steps defined in the Grüninger and Fox's methodology. An ontological model has been obtained, which allows managing different relevant information data regarding songs, all this in order that different types of users can query these records when they have the need to know a song characteristic data, or his album, as well as its performers, related record labels, composers, producers, genres of music and musical instruments used by the performers.

The main contribution of this work is the application of a methodology for an ontology manual creation, applied to the songs domain for search information related to them, that is, songs specific data many times people want to know.

The methodology used has been of great help to solve the problems corresponding to structure, organization and information management through the use of semantic web tools such as ontologies. The Protégé tool in combination with the SPARQL query language has been used to answer the competence questions and to carry out the ontology design described in this work, since, by using this language the necessary queries are carried out within the ontological model designed in Protégé to gather the information you want to know; this makes the current ontology a practical method and as one option more for this area, with the aim of having an alternative to traditional databases.

Finally, as a proposal for future work, the creation of a web application that uses the ontology to make an automatic data population at the instance level of each class defined in the ontology is intended, query the registered songs information, delete desired records, as well as the presentation of the competition questions to an end user.

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