ARCHITECTURE OF AN INTELLIGENT TOURIST GUIDE

Mariya Miteva, Asya Stoyanova-Doycheva, Vanya Ivanova
University of Plovdiv „Paisii Hilendarski”
mkmariq@gmail.com, astoyanova@uni-plovdiv.net, vantod@abv.bg

Abstract: *The article presents a part of the architecture of an intelligent tourist guide. It is intended for users, who are interested in the cultural and historical heritage of Bulgaria. It consists of two intelligent agents and a knowledge base in the form of ontologies that are described in the article.*

1. INTRODUCTION

The region of the Balkans and more specifically Bulgaria are an interesting tourist destination. For the digital presentation of our cultural and historical heritage more than ten years ago we developed the BECC environment (Bulgarian Electronic Cataloging Culture) [1] that is based on the Cataloging Cultural Objects standard (CCO) [2]. The project was updated in connection with building an e-learning environment known as the Virtual Education Space [3, 4, 5]. The space provides e-learning services and learning content for blended, self-paced, and lifelong learning. In the part related to lifelong learning, educational content for cultural and historical heritage has been created, where the intelligent tourist guide is a main application [6].

The article presents a part of the architecture of the intelligent tourist guide – the main components of the back-end of this architecture. The complete architecture of the intelligent guide is presented in [7].

2. RELATED WORKS

The topic of the cultural and historical heritage of a country is quite common. There are a number of works associated with it and they all have particular goals, for example to promote some objects or events, give an opportunity to learn something new or just to improve people’s knowledge. Various approaches are implemented to accomplish these goals such as 3D projects presenting specific places and objects, mobile applications and so on, and each one of them uses different technologies.

The 3D visualization model, presented in [8], is an interesting way of showing information about the cultural and historical heritage, and it provides user interaction. In the project that the authors are describing in the above-mentioned paper, ontologies are used as a knowledge base. However, except for the 3D visualization, there are two main differences between that project and our tourist guide. The first one is that through the question-answer approach we have the ability to show the user most suitable information for their search. This helps us to prevent situations where we could provide redundant and unwanted information. In addition, we use intelligent agents to communicate with the user and to process the knowledge base, which also contributes to obtaining more intelligent results.

The mobile application, presented in [9], determines the location of the user and shows cultural and historical objects as well as information about them. Also, it uses ontologies to represent the knowledge of this domain. Our approach to delivering knowledge to a particular user/learner is different. We use specific questions, which are different depending

on what the learner is searching for, in order to find out what exactly he/she is interested in. Another difference between our application and the mobile one is that we have intelligent agents.

Nowadays, the topic of question generation based on ontologies is very interesting and there is a lot of scientific research and works related to it. One commonly used solution to this problem is a multiple choice question generation, presented in [10]. The procedure we use is specific because instead of giving multiple choice answers to the learner we want to allow him or her to enter their own texts, which we subsequently compare to the knowledge base.

Another work related with question generation is presented in [11]. The main idea of this work is to use ontology and question generation for student testing. One of the differences between the testing environment and the TG is that in the guide we benefit from multiple ontologies. Another big difference is related with the answers: our goal is to generate a readable text that will provide the knowledge searched by the learner.

3. ARCHITECTURE OF THE TOURIST GUIDE

The architecture of the Tourist Guide (TG) consists of two main parts: a back-end and a front-end part. One of the main components of the back-end part, that will be presented in this article, are two operational assistants and a knowledge base. The operational assistants are responsible for processing the knowledge base and each of them has specific responsibilities. The work of the two assistants provides one of the important features of the tourist guide – the ability to supply the user with appropriate knowledge and objects, depending on what they want to learn/ study.

The assistants are developed as Jade [12] agents. The Question Generator Agent (QGA) is mainly related to understanding what the user wants. This is achieved by generating coherent, meaning-related questions in the form of a quest. The knowledge of ontologies is used to create the questions. Once the wishes and preferences of the user are known, the QGA transmits this information to the other Knowledge Generator Agent (KGA) assistant. Its task is, depending on the specific search, to find appropriate information from the knowledge base and to convert it into a meaningful text. To contact the user, both agents communicate with another Tourist Guide Agent (TGA), which is in the front-end of the architecture (Figure 1).

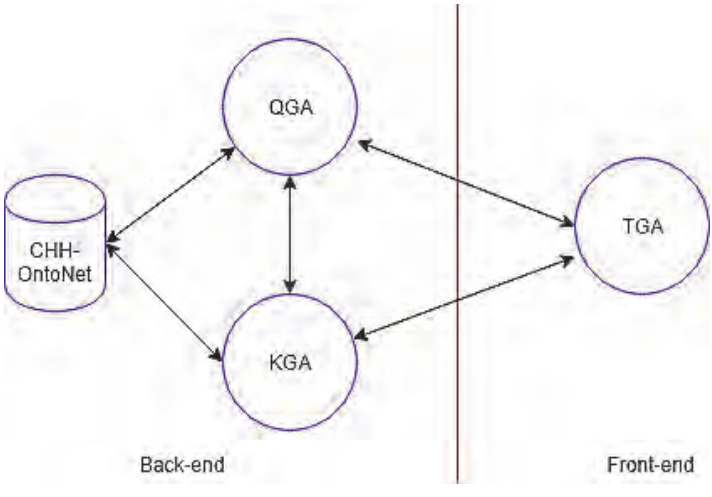

Fig. 1: Part of TG architecture

3.1. QGA

The QGA starts with some regular questions to figure out the basic information that is searched for. Next, it defines questions for the specific user and search. There are two main things the QGA needs to know at the beginning: the location and type of the object (museum, costume, etc.). The user's location is where he or she is at that moment. This information is obtained from the GPS of the mobile device, or it can be a location where the user wants to go. So when the QGA knows the location it asks the user what kind of object he/she wants to learn about. When the user answers this question the QGA has the basic information and it is ready to ask more detailed and specific questions. To determine what exactly to ask, the QGA uses CHH-OntoNet. First, it looks for proper knowledge related to the searched object and location. Then, it constructs the question in a human-readable format and the result is a brand new question. When the user replies, a new question is generated depending on the received answer.

Let us assume that the user is in Burgas, and the QGA already knows that. An example of a question that the QGA can generate is something like „What kind of cultural and historical object would you like to see?". The user may wish to say they want to see a traditional Bulgarian costume. Then the QGA can ask a question about costumes, for instance „What kind of costume do you want to see?". This question is checked against the location the user wants to visit. In case the user says he/she wants to see a costume that cannot be found in a certain museum in Burgas, the TG will declare it and will wait for a new answer. A subsequent question could be „A costume from which Bulgarian region would you like to see?", and so on. After the QGA has sufficient knowledge about the users' preferences, it can pass this information to the KGA.

3.2. KGA

The main responsibility of the KGA is to return knowledge. This could be information about locations and objects but one of the most interesting features is that it can generate a human-readable text. Based on the information gathered by the QGA, the KGA searches for proper knowledge in the ontologies, which means that it looks into the axioms of the ontologies. When the KGA finds the necessary information it has to convert all the axioms into a human-readable text and this is its next important responsibility. The last step is to return this text to the other agents so that it can be shown to the user.

3.3. CHH-OntoNet

The knowledge base of the TG consists of ten ontologies that are developed in Protégé [13]. They present the cultural and historical heritage of Bulgaria and so far there have been created ontologies describing the Bulgarian traditional costumes. Most ontologies characterize a subdomain or knowledge needed for a subdomain of the Bulgarian cultural and historical heritage domain. Ontologies are developed on the basis of the CCO standard, which contributes to easy and convenient sharing of data between different systems, communities, institutes, and more.

There are nine ontologies describing a certain part of the cultural and historical heritage of Bulgaria: *Subjects*, *FolkloreRegions*, *Costumes*, *Agents*, *Objects*, *Locations*, *Materials*, *Museums* и *Expositions* These ontologies, as well as their knowledge, are structured in a way that meets the requirements of the CCO standard. There are ontologies corresponding to the dictionaries defined in the standard, and others to the specific objects that are described.

The distribution of knowledge in particular ontologies is very important, as on the one hand it is easy and convenient to compare the knowledge to the requirements of a standard. On the other hand, the partition of the domain of the cultural and historical heritage of Bulgaria into separate sub-domains allows effective, distributed maintenance and editing of the ontologies and knowledge in them. Separate ontologies can be upgraded and changed without influencing the others. Also, the addition of knowledge and new ontologies related to new objects is simple and it does not require to make changes to the structure of the other ones.

The objects of the cultural and historical heritage such as traditional Bulgarian costumes are usually placed in different expositions. At the same time, these expositions are located in specialized museums. This is a precondition for the development of additional ontologies containing knowledge about expositions and museums.

In Fig. 2 can be seen all the ontologies that have been created so far, as well as the relations between the knowledge in them. Each of the presented ontologies uses knowledge from other ontologies to describe some of the concepts. In this way a network of interconnected concepts is created in separate ontologies. For example, *Costumes* in the *Costume Ontology* uses *Objects* (includes concepts such as types of clothing and their basic features), *Materials* (materials used in the manufacture of traditional costumes), and others.

The *Meta-ontology* is the only ontology that does not contain knowledge about the cultural and historical heritage of Bulgaria. It describes additional knowledge related to the other ontologies. This knowledge is used as a distributor by the operational agents to determine where and what to look for when they are creating a survey.

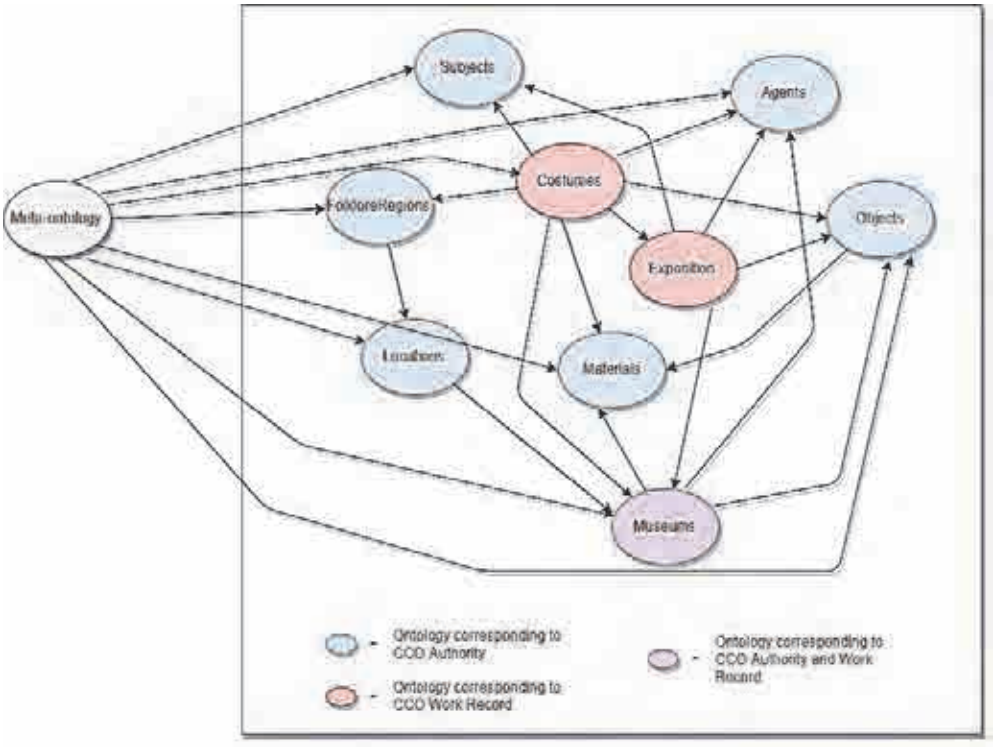

Fig. 2. Linked ontologies in the domain of the cultural and historical heritage of Bulgaria

CCO Representation. The structure of the ontologies and knowledge described therein is developed in accordance with the requirements of the CCO standard. By defining the standard, it is necessary to create and use authoritative dictionaries (autoritis) that serve as repositories for the most commonly used terms in describing objects. Together with the dictionaries, the standard defines the ways to describe the objects of interest – a work record.

CCO Authorities. The Standard defines four such dictionaries in which terms are grouped together: Concepts, Personal and Corporate Names, Subjects, and Georaphy Places. In the field of the cultural and historical heritage of Bulgaria, such dictionaries can present the knowledge related to the materials, the types of cultural and historical objects, the folklore regions of Bulgaria, museums and others. In Fig. 3 „CCO Authorities and Corresponding Ontologies“ are shown authorities that the standard defines and their corresponding ontologies.

In addition to the way the data is distributed, the standard also defines a rich set of elements that specific data must hold. Each dictionary defines individual elements necessary for a complete description of the terms. The standard offers mandatory and free elements, both of which are presented in the ontologies mainly through *properties*. In Fig. 3 can be seen some of the mandatory elements and their corresponding properties for each ontology. For example, costumes as a type of object are defined in the Objects ontology, and are used in the Costumes ontology by setting additional characteristics defining traditional Bulgarian costumes. According to the standard, each term must have a name that may be preferred or the most commonly used one, alternative (eg in a different language), etc. In our case, we can say that the added annotations, and in particular the labels to the class, as well as the specified languages (Bulgarian and English) fulfill the requirement of the standard for a description of the different existing names of the terms.

By definition, the Concept Authority states that there must be a mandatory field of the term, which has to be a Note, i.e. a description of additional characterizing information about the term is required. To achieve this is used a set of other defined properties of the classes involved in different axioms. Similarly, the recommendations and requirements of the standard for dictionaries are followed in the presentation of knowledge in other relevant ontologies.

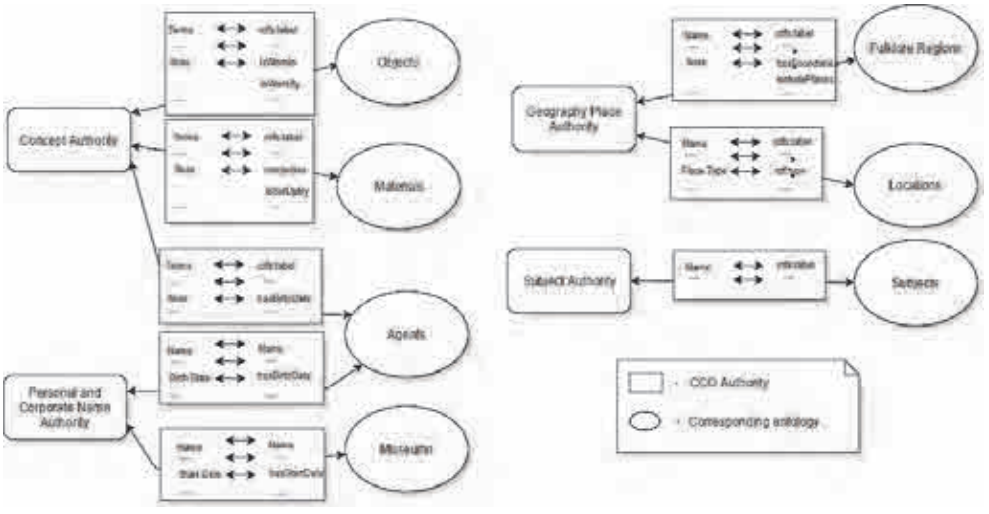

Fig. 3. CCO Authorities and Corresponding Ontologies

CCO Work Records. As mentioned, the standard distinguishes two separate components in the presentation of data: dictionaries and work records. Both the structure of the dictionaries and the objects comply with the requirements for mandatory elements. The ontologies that have been implemented up to now describe three types of work records. One is Bulgarian traditional costumes, typical of the respective regions of Bulgaria. The other kind of objects are museums. They are treated as separate and standalone work records, possessing the distinctive features of the objects, and as separate public units whose data, according to the standard, is a part of the Personal and Corporate Name Authority. The third one are the expositions in which the individual costumes are placed. Figure 4 shows the correspondence of the described objects in the ontologies and the objects of the CCO standard. As a mandatory field, each object must have a description of what type of objects, already listed in the Objects Authority, it belongs to. We have achieved this in our ontologies extremely easily since the classes describing costumes and museums in the *Costumes* and *Museums* ontologies are subclasses of the defined parent in *Objects.*

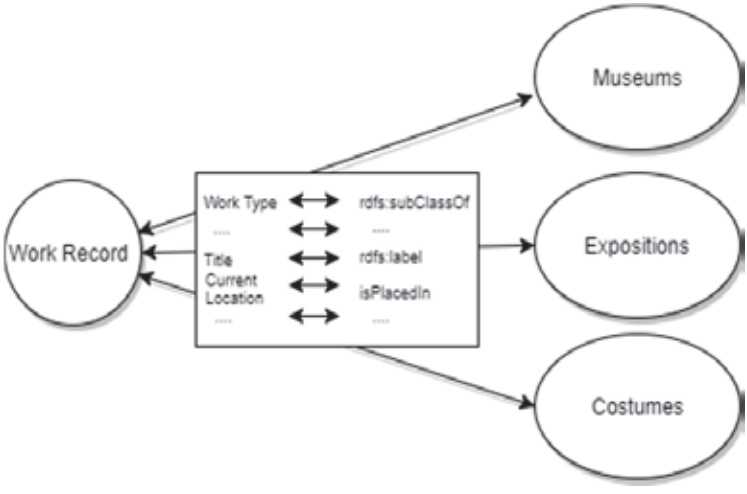

Fig. 4. CCO Work Record and the Corresponding Ontologies

4. CONCLUSIONS

The architecture of the TG has been created so that it can be extended and adapted to different cultural and historical objects. The main purpose of the TG is to provide a variety of cultural and historical routes and knowledge to users in an interesting and intuitive way. For this reason, its architecture will expand with additional features such as generating virtual 3D routes, suggesting different tourist routes in one area according to the location, and others. The proposed tourist guide is a major part of the Lifelong learning project in the Virtual Education Space in the section of the non-formal learning.

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