Integration of Cultural and Historical Heritage Ontologies into an Ontological Network

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Abstract. Ontology creation poses integration and interoperability challenges. Ontology integration is a hot topic in artificial intelligence. The article considers variants for integrating ontologies in Bulgarian cultural and historical heritage, which can be used as an Intelligent Tourist Guide's knowledge base. Cataloguing standard and ontology integration mechanisms using Protégé are discussed.

Keywords: Ontology Integration, Protégé, Ontological Network, Cultural and Historical Heritage, Tourism Domain of Interest.

1 Introduction

The Department of Computer Systems at the Faculty of Mathematics and Informatics, *Paisii Hilendarski* University of Plovdiv, together with an expanded group of scientists, is working on a project focused on Bulgarian cultural and historical heritage and its application in an *Intelligent Tourist Guide*.

The knowledge base is an important part of that project. It is also a long-term module. Since ontology engineering is widely used in artificial intelligence systems in collaboration with intelligent agents, we continue to model and enhance the ontology network *Bulgarian Cultural and Historical Heritage-Ontology Network (CHH-OntoNet)*, which forms the core of the application as the main advantage of the project. However, the integration of the CHH-OntoNet's subdomains is a key step in fulfilling the user's needs with optimal domain knowledge.

The paper's aim is to discuss the ontology integration. The main objectives are to outline the applied *Cataloguing Cultural Objects (CCO)* standard and some mechanisms to connect the CHH-OntoNet's subdomain ontologies.

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2 Cataloguing Cultural Objects Standard & Bulgarian Cultural and Historical Heritage-Ontology Network

The CCO standard (Baca, et al., 2006, p. 29) defines the term thesaurus as: "*a semantic network of unique concepts, including relationships between synonyms, broader and narrower contexts, and other related concepts."* The CCO standard also points that it could be modelled as monolingual or with more than one language – multilingual, and it may have relationships, such as: *Equivalence, Associative, Hierarchical.*

The standard includes ten key principles, and the fifth of them is: *"Create local authorities that are populated with terminology from standard published controlled vocabularies as well as with local terms and names. Structure local authorities as thesauri whenever possible. Record and document decisions about local authorities."* There are four authorities, but also "*some institutions may wish to create separate authorities for various elements, such as Work Type and Materials"* (Baca, et al., 2006):

- *A.1 Personal and Corporate Name Authority;*
- *A.2 Geographic Place Authority*;
- *A.3 Concept Authority;*
- *A.4 Subject Authority.*

The CCO standard also "*recommends creating separate Work Records for each part and for the whole when the information for the whole varies significantly from the information for the part.* (Baca, et al., 2006)*"* The entity relationship diagram from the CCO document is included (Fig. 1).

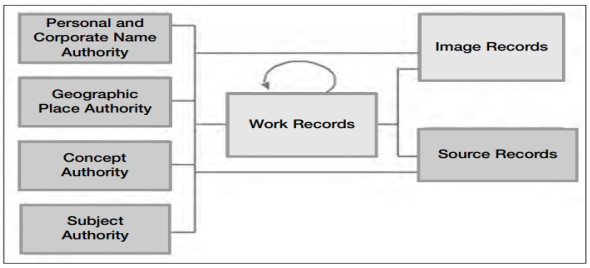

Fig. 1. E-R Diagram for CCO.
Source: (Baca, et al., 2006)

The ontologies are more advanced semantic models that surpass the thesaurus. They offer the possibility to present these relationships formally and semantically in a way that is comprehensible to machines and humans. One of their key advantages is the reasoning process, which could deduce new knowledge on the basis of the asserted axioms. The CCO standard does not mention ontology descriptions as a structure for modelling in its document, but the requirements imply that they are an appropriate technology for fulfilling the purpose of cataloguing.

Our approach is to have ontologies that correspond to the authorities and others that correspond to the work records. The approach is used for two domains of interest –

Bulgarian national costumes (Glushkova, et al., 2018) and Bulgarian National Revival houses (Madanska, 2023).

The ontologies are modelled with Protégé desktop (Musen, 2015). The *Sources Records* and *Image Records,* as mentioned in CCO (Fig. 1), are modelled using annotation property assertions applied to some ontology elements. The *Views ontology*, which was initially included in (Madanska, 2023), is still under development. Its *OWLGrEd* view (Institute of Mathematics and Computer Science, University of Latvia, 2020) is shown in Fig. 2.

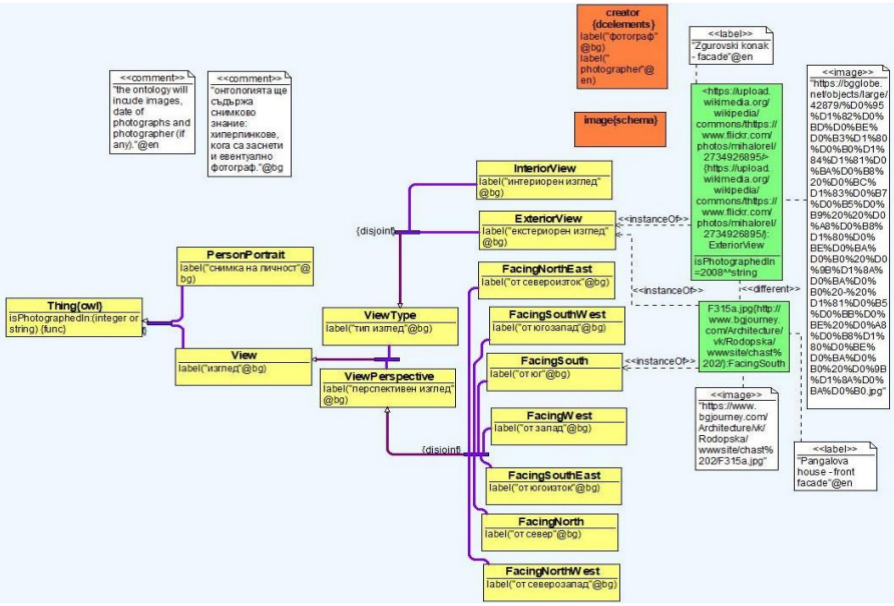

Fig. 2. Views ontology design iteration (not included in the CHH-OntoNet).
Source: Semantic modelling of the Bulgarian cultural and historical heritage (Madanska, 2023)

3 Integration Planning

The integration of several ontologies into one file is possible with the Protégé import mechanism. Protégé also supports ontology merging. But if *the IRIs (Internationalized Resource Identifiers)* of the elements /even if they are exact thing/ are different it can be challenging to identify inconsistencies. For example, if an entity x in the first ontology has an ontology-specific *IRI* and a different name from the corresponding entity in the second ontology, even though they represent the same concept, they will be treated as distinct by the Reasoner. You could use ontology mapping with the usage of explicit axioms with `owl:equivalentClass` or `owl:equivalentProperty` on semantic level for integration of the elements. There are also other mechanisms for ontology integration.

The ontologies, the object of our scientific-practical research, are related to each other at the level of the field of interest, but we plan to strengthen their overall integration based on various technological solutions in ontological engineering. The paper (Madanska, et al., 2024) reflects the discussion on the topic of ontology integration in CHH-OntoNet. As a variant of the scheme (Fig. 3), it is presented there as well (Madanska, et al., 2024), and here we will additionally focus on the future conceptual development of the project.

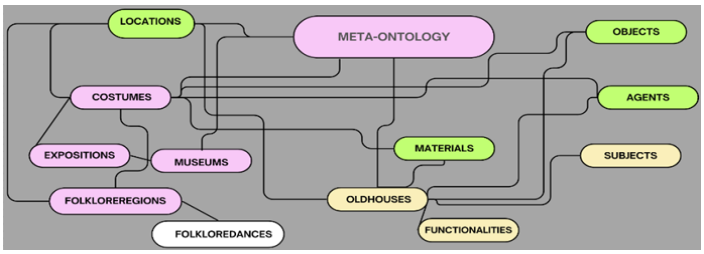

Fig. 3. Integration variant in CHH-OntoNet.
Adapted from a template design by Freya Saad (@freyasocialcreative), via Canva.com

Figure 3 presents a schematic conceptual integration of different ontologies under the general CHH's umbrella. The ontologies that are modelled based on the CCO standard (Baca, et al., 2006) as authorities (for example, Agents, Objects, Materials, Locations) can be included in a single owl file – this is only one ontology.

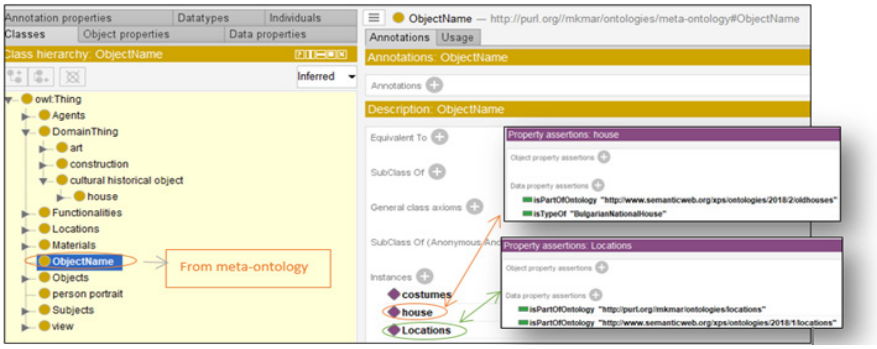

Fig. 4. Meta-ontology imported into Protégé, along with other CHH-OntoNet ontologies, modified for the domain of Bulgarian National Revival houses.

The initial version of the *Meta-Ontology* was created by M. Miteva under the guidance of Prof. Stoyanova-Doycheva (Glushkova, et al., 2018). There is modification in the *Meta-Ontology* for the Bulgarian National Revival houses domain of interest (Fig. 4). This is the *Meta-Ontology* added an instance with a new *IRI* – house, to link it via `isPartOfOntology` (data property) to the value `<IRI of OldHouses.owl>`. `ObjectName` already included an individuality Locations, linked via `isPartOfOntology` to `<IRI of Locations.owl (costumes subdomain)>`, in

the same individuality we added another link to the value <IRI of Locations.owl (old houses subdomain)>. The *Meta-Ontology* is a higher level of hierarchy above the ontologies in the ontology model, as in (Glushkova, et al., 2018) it is argued that its conceptual design is not related to the storage of knowledge about CHH, but to facilitating the work of intelligent agents with other ontologies in the network and searching this so-called catalogue. It has a direct connection with *Locations, Costumes, OldHouses* and *Museums.* And with a specific interest in some of the characteristics of these areas described in their related ontologies, the corresponding information could be extracted.

Figure 3 also shows the inclusion of the *FolkloreDances ontology*, which is essential for describing traditional Bulgarian folk dances. This is the new area of interest planned for short-term implementation in CHH-OntoNet. Folk dances belong to certain ethnographic areas, that is, an already existing ontology in the network. Ethnographic or folklore areas: Rhodope, Shopska, Pirin, Northern, Dobrudzha and Thracian, are defined in many works, for example (Vaglarov, 1976). In the future, adding an ontology for folk songs, to which specific dances and traditional musical instruments are performed, would be a good extension for dance cultural heritage as a sub-area of interest in the ontological network. The ontology for Bulgarian folk costumes could easily be linked to folk dances. Connections could also be created with the ontology for Agents. Frequently, the stage dance manifestation is telling a story, is associated with certain emotions or rituals, such subjective, religious or mythological beliefs related to an event can be described in the ontology Subjects, etc.

An ontology that describes some characteristics of works of art by Prof. Kiril Dzhenev is presented in (Ivanova, et al., 2023) and (Kazashka, et al., 2024). It is this ontology that we intend to use, correcting, developing and expanding it for the purposes of the ontological network. The ontology describes several performances from different ethnographic areas and various purposes (case in which the dance is built and performed), as well as other characteristics, such as the type of dancers (men, women, or both). There is a possibility of classifying dances according to given conditions, thanks to the defined classes and axioms that correspond to their necessary and sufficient conditions.

With already existing basic ontologies, further developments on the topic of CHH can easily be simply building on/expanding them and, as the standard itself (Baca, et al., 2006) determines that the objects should be documented without redundant effort.

4 Conclusions and Future Plans

The paper presents integration planning of ontologies in CHH-OntoNet using the CCO standard and Protégé's technical mechanisms. At the next stage, we intend to further describe the existing ontologies and enrich them with additional individuals for a better user experience. We will also continue the integration of the ontologies into the network and plan its expansion with new areas of interest.

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