REVIEW

By Prof. Asya Georgieva Stoyanova-Doycheva, PhD

Faculty of Mathematics and Informatics at the University of Plovdiv "Paisii Hilendarski"

of a dissertation for awarding the educational and scientific degree "**doctor**"

in field of higher education

4. Natural sciences, Mathematics, and Informatics,

professional field

4.6. Informatics and Computer Science

doctoral program

Informatics

Author of the dissertation: ***Sebiha Ahmedova Madanska***

Topic: **Semantic modelling of the Bulgarian cultural and historical heritage**

Scientific supervisor: ***Prof. Stanimir Nedyalkov Stoyanov, PhD, Faculty of Mathematics and Informatics at the University of Plovdiv "Paisii Hilendarski"***

1. General presentation of the submitted materials

By order № RD 21-200 of 26 January 2023 of the Rector of the University of Plovdiv "Paisii Hilendarski" (PU), I have been appointed as a member of the scientific jury to participate in a procedure for the defense of a dissertation on the topic of **Semantic modelling of the Bulgarian cultural and historical heritage** for acquiring the educational and scientific degree "doctor" in field of higher education 4. Natural sciences, Mathematics, and Informatics, professional field 4.6. Informatics and Computer science, doctoral program Informatics. The author of the dissertation is **Sebiha Ahmedova Madanska** – a full-time doctoral student at the Department of Computer Systems, with scientific supervisor Prof. Stanimir Nedyalkov Stoyanov, PhD, from FMI at the University of Plovdiv "Paisii Hilendarski".

The set of materials presented to me by Sebiha Ahmedova Madanska on electronic media is in accordance with Article 36 (1) of the Law on the Development of the Academic Staff of the University of Plovdiv and includes the following documents:

- an application form to the Rector of PU for initiating a procedure for the defense of a dissertation work;
- CV in European format;
- minutes from the department council related to reporting the readiness to open the procedure and preliminary discussion of the dissertation;
- a dissertation;

– an abstract in Bulgarian and in English;
– a list of scientific publications on the topic of the dissertation;
– copies of the scientific publications;
– a declaration of originality and authenticity of the attached documents;
– a certificate of compliance with the minimum national requirements;
– a certificate for participation in projects from the Department for Scientific Research.

The doctoral student has submitted 4 publications.

2. Brief biographical data for the doctoral student

Sebiha Madanska graduated in 2017 with a Bachelor's degree from the University of Plovdiv "Paisii Hilendarski", Branch – Smolyan, majoring in "Information Technology, Mathematics, and Educational Management" and she obtained the educational qualification degree of Master from FMI at the University of Plovdiv in 2018 majoring in "Software technology with a specialization in artificial intelligence systems". Sebiha Madanska has been a part-time assistant at the Department of Computer Systems since 2019, and since 2022 she has been a full-time assistant in the department. She conducts seminars in the disciplines "Databases", "Ontological Engineering", and "Practical Projects 1 and 2" in Bachelor's and Master's programs at FMI of PU.

In 2021 Sebiha Madanska worked for a short time as an "Expert System Software for Databases" at the Educational Research Center of the University of Plovdiv "Paisii Hilendarski".

3. Relevance of the topic and appropriateness of the set goals and tasks

The topic of the dissertation work is related to the development of semantic models in the field of the cultural and historical heritage of Bulgaria. Semantic modelling is becoming an increasingly topical issue, especially in the current boom in the advancement of artificial intelligence. The representation of common-sense knowledge in any field is of utmost importance for developing ever more intelligent and environmentally aware systems.

The goal of the dissertation given to me for review, as defined on page 8, is "building a unified ontological model with standardized data based on semantic representation for its subsequent integration into a network of ontologies for CHH under the name of Cultural and Historical Heritage Ontology Network (CHH-OntoNet) and use for the purposes of an intelligent tourist guide". The doctoral student focused on creating a semantic model of the Revival houses in Bulgaria and for this purpose, she consulted architects and used multiple sources (electronic and paper), with the help of which she defined a real semantic model of this type of cultural and historical objects. All the information is structured according to an international standard for cultural and historical ob-

jects (CCO) with the aim of its integration into a network of ontologies created to represent these cultural and historical objects.

From the set goal and tasks (pages 8-9) of the dissertation, it is clear that the doctoral student Sebiha Madanska is working on current problems related to semantic modelling, especially in relation to cultural and historical objects associated with the Bulgarian cultural and historical heritage. Semantic modelling, which is also a main pillar of the Semantic Web that is developing in full force nowadays, as well as the possibilities of combining these semantic models with artificial intelligence, give me a reason to believe that the problem under consideration in the dissertation given to me for review is current.

4. Knowledge of the research problem

Sebiha Madanska has extensive knowledge in the field of the studied problem, which is evident from the large number of literary sources cited in the bibliography of the dissertation – 277 sources in total. Also, in Chapter 2 “Problem Domain Overview” of the dissertation, the doctoral student successively examines various semantic models, ontologies, and ontology-building languages. In this chapter, ontologies are examined as part of the Semantic Web and also the application of ontologies in various fields, with special attention paid to their use in the field of cultural and historical heritage. In addition, the doctoral student has focused on the specifics of Revival residential architecture, since the semantic model created is mainly for Revival houses in Bulgaria. Particular attention is given to sources related to this architecture by famous architects and to Revival houses registered as objects of cultural value in the public register of the National Institute for Immovable Cultural Heritage. To check the credibility of the facts, the doctoral student also visited many of the sites described in the semantic model of the dissertation. The information about the Revival houses is coordinated with architects and specialists in the field of Revival architecture and presented in great detail. In addition, Sebiha Madanska attached great importance to the architecture of ViPS, which is used to develop various projects, including ones related to the cultural and historical heritage of Bulgaria. All this gives me a reason to believe that the doctoral student knows the area of the studied problem well.

5. Research methodology

The chosen methodology for developing the dissertation work follows the set goal. First of all, the main characteristics of Revival houses in Bulgaria are examined. In the second place, the CCO standard is presented, with which the developed semantic model conforms. The elements of the standard are presented as well as the way of describing Revival houses by means of this standard. A hierarchical data model compliant with the CCO standard is structured and the ontologies

from which the model will be developed are presented. As a third step in the dissertation, the architecture and realization of a prototype ontology for Revival houses are presented.

6. Characteristics and evaluation of the dissertation work

The dissertation is in a volume of 158 pages including the bibliography. The literary sources used are a total of 277, of which 66 are in Bulgarian and 211 in English.

The dissertation is structured as follows: an Introduction, four Chapters, a Conclusion, and Bibliography.

The introduction presents the problem that is being solved in the dissertation and gives a clear vision of the set goal and tasks.

It is followed by Chapter 2 – "Overview of the Problem Area"; this chapter presents basic theoretical foundations in the field of semantic modelling. Ontologies as an approach to creating semantic models are discussed in detail. The application of ontologies in various fields is considered too, with special attention paid to their use in the field of cultural and historical heritage. The analysis of the domain in which the doctoral student develops her semantic models makes a significant impression, which is the specifics of the Revival residential architecture. Particular attention is devoted to sources related to this architecture from famous architects and objects (Revival houses) registered as objects of cultural value in the public register of the National Institute for Immovable Cultural Heritage. The information about the Revival houses is coordinated with architects and specialists in the field of Revival architecture and presented in great detail. The architecture of ViPS is examined, which is a reference architecture used for the development of applications in various fields, including projects related to the cultural and historical heritage of Bulgaria.

Chapter 3 of the dissertation is "Semantic Modelling of Domain Ontologies". It is organized into four parts (Sections 3.1 to 3.4). Section 3.1 describes the main approach to creating the semantic model of Revival houses. This includes the use of the CCO standard. The elements of the standard, and more specifically the individual authorities, which are the main part of the standard, are presented in detail. Descriptions of a Revival house, person, and organization are given as examples according to the requirements of the standard and some features of this standard are discussed, which were taken into account in the implementation of the semantic model. Section 3.1.2 shows the hierarchy of ontologies that represent the semantic model of the Revival House and are compliant with the CCO standard. In section 3.2., different technologies for representing formal models are provided such as predicate logic and descriptive logic. Some of the concepts of the semantic model of the Revival House are also rendered as predicate expressions.

Section 3.3 presents a visualization of an OWL model with the UML language and more precisely with a modification of the UML language to achieve the open-world concept in ontologies. Section 3.4 defines the next stages of the dissertation work.

In Chapter 4 of the dissertation, the architecture and a prototype of the ontology representing the semantic model of the Revival House are examined. The chapter is divided into 9 sections (from 4.1 to 4.9). Section 4.1 introduces the work's main additional development, CHH-OntoNet. Sections 4.2 to 4.8 demonstrate the implementation of the ontologies presented in the hierarchical model. The first elaboration described is the Objects ontology; it defines the objects that are generally needed to describe a standard house, without details about the Revival style. The purpose of the Materials ontology is to logically separate building materials and their constituent parts (including chemical compounds) in one structure; to specify the techniques in combination with which these materials are used, and also for what building structures. The Subjects ontology aims to logically separate in one structure periods (for example the Renaissance) and historical events important for the houses and the concept as a whole. The Agents ontology embodies the concept of describing individuals and organizations associated with the houses.

The Locations ontology conforms to the authority of the CCO standard for geographic locations. The Functionalities ontology is an additional and non-composite element of the cataloging standard, but it adds detail from the point of view of dialectics in a regional aspect and specifics of individual rooms, how they relate to modern ones in terms of function, as well as an example arrangement of rooms in the floor plan of a house. The OldHouses ontology represents house types including the Revival House. The ontology can be expanded with the other types of houses. The description of all ontologies is sufficiently detailed with a large number of screenshots from Protégé of classes, properties, annotations, axioms, and identities. In addition, the doctoral student suggests developing another Views ontology to contain images of the houses, which I welcome.

Chapter 5 of the dissertation presents the results and applications of the work. It provides validation of the ontologies with a reasoner and extraction of additional information (inferences) based on the conclusions made by the reasoner. Section 5.2 compares house types. The SPARQL language for ontology queries is reviewed and several examples of such are presented. It is also shown how the created ontology can be used by the Test Generation Environment to automatically generate ontology questions in English. It should be emphasized here that the developed ontology of the Revival Houses was created in two languages – Bulgarian and English. A prototype web application for presenting the ontology information is enclosed.

The conclusion of the dissertation includes a summary of the results and related elaborations and publications recorded in a table and it provides a vision for the future expansion of the work.

7. Contributions and significance of the work for science and practice

The main contributions of the dissertation have a scientific-applied and applied nature.

Four main results are defined in the dissertation that correspond to the tasks set in the Introduction (p. 138):

1. Study the problem area CHH (Revival residential architecture) and create a concept.
2. Model prototype ontologies for the domain against defined criteria.
3. Implementation of ontologies for the domain of interest.
4. Integration and application. Comparative analysis of Revival houses in Bulgaria.

Each of the four tasks corresponds to the work described in Chapters 2 to 5, respectively, so I accept the claims of the doctoral student to have achieved the set goal of the dissertation work.

I believe that the reached results correspond to the normative requirement that they represent an "original contribution to science" (Art. 27(1) of the Rules for the Implementation of the Act for the Development of the Academic Staff in the Republic of Bulgaria).

8. Evaluation of the dissertation publications

The author has presented a list of 4 works, of which 1 is in a journal and 3 in proceedings of international conferences; one of the publications is in Bulgarian and three are in English. Three of the articles numbered 1, 2, and 4 from the list of publications presented on pages 137 and 138 are referenced in Scopus and/or Web of Sciences. This satisfies the minimum national requirements of the Rules for the Implementation of the Act for the Development of the Academic Staff in the Republic of Bulgaria for a minimum of 30 points under group D indicators, where the doctoral student has 54 points. From table 3 on page 138, it is clear that all the tasks and respective results of the dissertation were reflected in two or more of these publications, which I am convinced of. The author has 2 independent publications (listed on pages 137 and 138, publications numbered 3 and 4), and 2 publications are co-authored (listed on pages 137 and 138, publications numbered 1 and 2).

A list of noted citations is attached, in which one citation is indicated.

The doctoral student participated in a project financed by the "Scientific Research" Fund at the Ministry of Education and Culture, for which a certificate from the Department for Scientific Research is attached.

9. Personal participation of the doctoral student

I have no doubts about the personal contribution of Sebiha Madanska in the conducted dissertation research and in obtaining the relevant scientific-applied and applied results.

10. Abstract

The abstract is provided in Bulgarian and English, according to the requirements, in the volume of 32 pages; in terms of size and content, it meets the requirements for accurate, complete, and concise coverage of the dissertation.

11. Critical remarks and recommendations

I have the following questions and remarks for the doctoral student:

1. Section 3.3 presents an OWL ontology in a UML model; the OWLGrEd tool was used. It is not clear what the purpose of this section is in the context of Chapter 3, "Semantic Modelling of Domain Ontologies". Could you clarify the reason for including this section that shows the transition from an OWL ontology to a UML knowledge representation?
2. The CCO standard, on the basis of which the semantic model of the Revival House in the dissertation was built, does not include the concept of ontology. It gives advantages to the presentation of information about cultural and historical objects in relational databases. However, one of its requirements is to show semantic connectivity between the various elements of authorities. This issue is addressed by the doctoral student in Chapter 3, Section 3.1.1, page 49. She draws some conclusions regarding the implementation of the standard for ontologies in Section 3.4 on page 59 "…which achieve better scalability, integrity, consistency, semantics, and also has the possibility to derive new knowledge." This can be noted as a result achieved in the dissertation work, which the doctoral student has not mentioned. I consider this part of the development to be an important contribution to the work.
3. CHH-OntoNet is built as a hierarchy of ontologies developed on the basis of the CCO standard. One of the ontologies in this hierarchy is Bulgarian folk costumes (developed by Maria Miteva). This ontology is created according to CCO and is included in CHH-OntoNet. My question is, have you used this work? Have you integrated the ontology for Revival houses in CHH-OntoNet (for the purpose of which the semantic model was created as mentioned on p.8)? If you attempted integration, my question is how did you integrate the Agents, Objects, Materials, and Locations ontologies into the hierarchy, given that they already exist there?
4. Are there characteristics of the Revival houses that are not part of the characteristics for cultural and historical sites of the CCO standard? If there are such characteristics, as I believe so, do they not expand the formal description of the cultural and historical sites in CCO with specific ones for the Revival House? I even think that the elaboration adds a

whole vocabulary of the functionality of the premises and the relation to modern premises and their functionality (in the form of an ontology), which further expands the formal model of the cultural and historical object in CCO. I consider this result a contribution to the work, but again it is not mentioned in the dissertation.

Despite the comments made, which do not affect the quality of the presented dissertation work, I must note that the topic of the dissertation is current and the achieved results deserve high praise. The doctoral student has shown in-depth knowledge of the field and the ability for independent scientific research in her work.

12. Personal impressions

I know Sebiha Madanska as a doctoral student and as a part-time assistant in the Department of Computer Systems; also, since the beginning of this academic year, as a full-time assistant. My personal impressions are that she is an extremely responsible teacher who does her job with great desire and diligence. As a doctoral student, she is exceptionally thorough and executive. I highly value her professional qualities, accountability, and capacity to work in a team.

CONCLUSION

The dissertation contains **scientific-applied and applied results**, which represent an original contribution to science and meet all the requirements of the Act for the Development of the Academic Staff in the Republic of Bulgaria, the Rules for the Implementation of the Act for the Development of the Academic Staff in the Republic of Bulgaria (ADASRB), and the relevant Rules of the University of Plovdiv "Paisii Hilendarski". The presented materials and dissertation results fully correspond to the minimum national requirements in the Rules for the implementation of the ADASRB.

Due to the above, I confidently give my **positive** assessment of the conducted research, presented by the above-reviewed dissertation work, abstract, achieved results, and contributions, and I propose to the honorable scientific jury to award the educational and scientific degree "doctor" to Sebiha Akhmedova Madanska in field of higher education: 4. Natural sciences, Mathematics, and Informatics, professional field: 4.6. Informatics and Computer Science, doctoral program: Informatics.

18.02.2023 Reviewer: .....

(signature)

Prof. Asya Stoyanova-Doycheva, PhD