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APPLICATION OF ONTOLOGICAL MODELING IN THE PROBLEMS OF KNOWLEDGE MANAGEMENT IN A MODERN UNIVERSITY

ЗАМАНАУИ УНИВЕРСИТЕТТЕ БІЛІМДЕРДІ БАСҚАРУ МӘСЕЛЕЛЕРІНДЕ ОНТОЛОГИЯЛЫҚ ҮЛГІЛЕРДІ ҚОЛДАНУ

ПРИМЕНЕНИЕ ОНТОЛОГИЧЕСКОГО МОДЕЛИРОВАНИЯ В ЗАДАЧАХ УПРАВЛЕНИЯ ЗНАНИЯМИ СОВРЕМЕННОГО ВУЗА

Abstract*. The article provides a brief description of the stages of building an ontological model of the subject area. The results of building an ontological model of university knowledge, namely scientific knowledge, which allows integrating data on the results of scientific activity from scientometric databases, are presented. The proposed model is built by reengineering the SWRC and BiDO ontological model.*
Keywords: *ontological model; university knowledge management, Protégé, SWRC, BiDO.*

Аңдатпа*. Мақалада пәндік аймақтың онтологиялық моделін құру кезеңдерінің қысқаша сипаттамасы берілген. Жоғары оқу орны білімдерінің онтологиялық үлгісі, соның ішінде ғылыми білімдердің онтологиялық үлгісі ұсынылған. Бұл үлгі ғылымометриялық деректер қорынан қызметкерлердің ғылыми жұмыстарының нәтижелері туралы мәліметтерді интеграциялауға мүмкіндік береді. Ұсынылған үлгі SWRC және BiDO онтологиялық үлгілерін реинжиниринг жасау арқылы құрастырылған.*
Түйін сөздер*: онтологиялық үлгі; жоғары оқу орнының білімдерін басқару, Protégé, SWRC, BiDO.*

Аннотация. *В статье приводится краткое описание этапов построения онтологической модели предметной области. Представлены результаты построения онтологической модели знаний вуза, а именно научных знаний, которая позволяет интегрировать данные о результатах научной деятельности из наукометрических баз данных. Предложенная модель построена путем реинжиниринга онтологической модели SWRC и BiDO.*
Ключевые слова: онтологическая модель; управление знаниями вуза, Protégé, SWRC, BiDO.

Introduction. Today, knowledge, competencies and intangible assets are becoming the main factors of the organization's competitive advantages, in this regard, the idea of knowledge management (KM) is developing as a new management paradigm. KM provides an integrated

approach to the creation, collection, organization, use of enterprise information resources and access to them [1-2]. Information resources should cover all explicit and implicit knowledge describing the key descriptions of the organization.

Knowledge management is defined as the systematic process of identifying, using and transferring information, knowledge that people can create, improve and apply. This is a process during which an organization generates knowledge, accumulates it and uses it in the interests of obtaining competitive advantages [1]. Other authors [3] define KM as the practice of selectively applying knowledge from experience to decision-making in current and future decision-making activities with the explicit goal of improving organizational performance. The perception of KM and KMS is that they holistically combine organizational and technical solutions to achieve the goals of knowledge retention and reuse, which ultimately improves the process of organizational and individual decision making.

The creation of a knowledge management system will ensure the integration of heterogeneous sources of knowledge and the application of knowledge in the management of the organization. Ontologies in the knowledge management system serve as the basis for supporting management processes and providing these processes.

Materials and methods of research. Ontology development is an iterative process aimed at creating an efficient and well-formed ontology. According to best practices, the development of ontologies becomes simple and efficient by reusing existing ontologies. It is well known that when developing a semantics-based application, it is important to reuse and integrate existing ontologies to provide the necessary background knowledge of the domain [4]. The work [5-7] describes two different processes of ontology reuse: merging and composition/integration.

Merging means building ontologies by combining knowledge from source ontologies in the same domain as the target ontology. Composition involves the construction of ontologies by combining two or more ontologies that may come from subject areas that are different from the subject area of the target ontology [11]. In this process, the original ontologies are aggregated, combined, brought together to form the resulting ontology, after the reused ontologies have undergone some modification, such as extension, specialization, or adaptation.

While merging usually has a lot of overlapping knowledge in different source ontologies, composition usually has few overlapping concepts. The main difference between these processes is that after composition in the resulting ontology, it is possible to select areas taken from the source ontologies where knowledge has remained more or less unchanged, while after merging it is usually difficult to identify areas in the resulting ontology taken from the source ontologies and left more or less unchanged.

When constructing an ontological model for the formation of the knowledge base of the university, the methods of system analysis were applied, which make it possible to analyze the functioning and development of a complex system, taking into account the requirements of the authorized bodies [9], along with the reengineering of existing ontologies. The METEOR methodology (MEthodology and TEchnology of formation of Ontologies based on integRation) [10] integrates heterogeneous data into an ontology, taking into account the semantics of the subject area.

Figure 1 shows a general scheme for developing ontologies, and a detailed description of each step of the proposed scheme is given below.

The first step in any ontology is the collection of all information about the order of work of the subject area, in this case, the university. The identification and definition of all super- and subclasses of the target research area is the second step. The third step is to identify and define the properties (such as object, data, and annotation) that exist among certain classes. Identifying and applying appropriate constraint constraints to classes to bind them to work together and aid

in reasoning is the fourth step. Combining all of the above steps together to obtain a single view of the ontology design in order to detect any design inconsistencies is the fifth step. The sixth step is the practical implementation of the developed ontology using Protégé. Next, consistency and reliability are checked by reasoning (generation of the approved and assumed model) using FaCT++ reasoning. If the result of the reasoning does not correspond to the desired result, then it is necessary to rethink the collection of relevant information to build the ontology anew, after which all the above steps should be repeated.

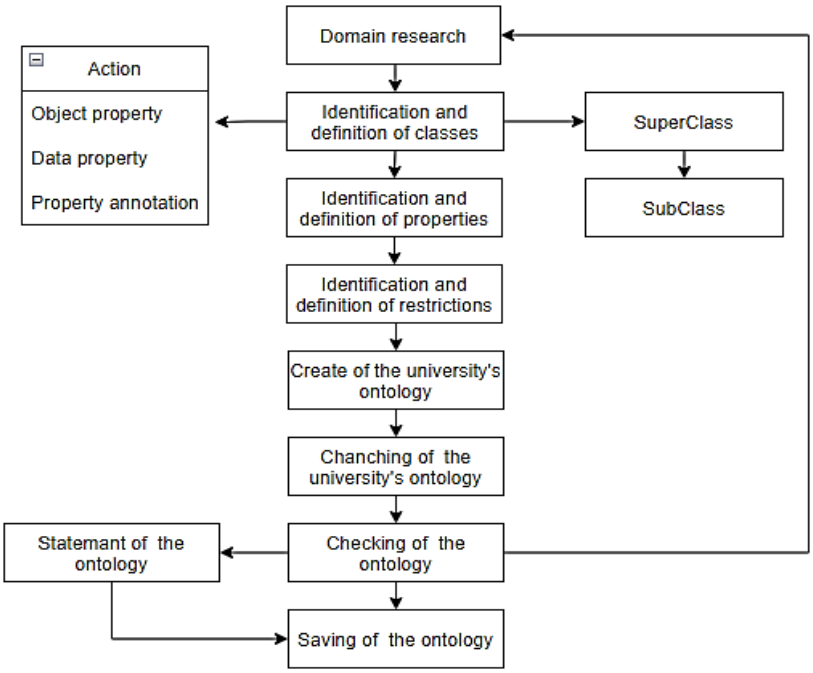

Figure 1. Stages of ontology creation

The last step is to save or export the created ontology.

The use of ontologies of scientific knowledge will allow:

– integrate information distributed across various document repositories, databases and knowledge bases;

– generalize and systematize the available information, acting as a metamodel;

– use automated inference to improve search results, gain new knowledge and analyze information;

– use more effective mechanisms for obtaining, visualizing and searching for knowledge.

Following the recommendations for the development of ontologies proposed by the authors [5-6], which are used by many researchers, within the framework of the work, the ontology of knowledge of the university is structured around the following basic concepts:

– participant – the central link connecting all scientific information, is a scientific support staff, teaching staff, students;

– organization – a resource that describes the main structural units;

– project – a resource describing the process of scientific activity, information about the results of projects, patents, etc. [eleven];

– publication – articles, reports, scientific papers and accompanying bibliographic metadata, including authors, titles, keywords and annotations;

– event – describes the types of events, specializing in a wide range of concepts, including events such as lectures, conferences and competitions;

– direction – a resource that describes the main areas of activity in accordance with the classifier;

– goal – describes the strategic goals of the organization;

– indicators – a resource that describes the structure of the calculated indicators of the rating and internal monitoring;

– measurements – describes the units and values of measurements used to calculate internal monitoring indicators and ratings.

The developed ontological model of the knowledge base of the university is described by a combination of several ontologies, represented by formula (1):

$$O_u = \langle O_m, O_s \rangle \quad (1)$$

where, O_m is the ontology of university management, O_s is the ontology of scientific knowledge of the university (ontology of the university's activities).

Based on the analysis of ontological models related to the scientific activities of the university, SWRC with the COIN extension is most suitable for monitoring the development of the university as an ontological model of the scientific knowledge of the university. The study attempts to build an ontology by reengineering the ontological model of SWRC and Bibliometric Data Ontology (BiDO). BiDO allows you to describe numerical and categorical bibliometric data, such as h-index, the number of citations of authors, the impact factor of the journal, and also considers time space, since these indicators change over time [12]. These indicators can be used to evaluate the scientific output of researchers.

The merging of these ontologies will make it possible to most fully describe the important activities of the university, such as scientific and publishing activities, which takes into account all time-dependent indicators. To describe academic activity, it is necessary to supplement the ontological model of the knowledge base with new objects and properties.

To describe the university system, first of all, it is necessary to determine its purpose and structure. This definition has the following formalized notation (2):

$$\begin{gathered} S =< E, P, R, G > \\ S =< E, D, R, A > \end{gathered} \quad (2)$$

where E is a set of elements, D is a set of properties of elements, P – is a set of properties of elements; $R = R_T \cup R_p \cup R_A$ – set of connections (relations), connections can be R_T – asymmetric, transitive; R_p – binary transitive; R_A – associative relations; G – goals, A – set of axioms of the subject area.

The ontological model of university management allows to achieve the conceptualization of business processes, aligned with the strategy of the university, which must be covered, presented, distributed and processed by personnel and software systems.

The rationale for choosing the approach to describe the components of the university system is described below. Recent studies [7-10] show that the ontological approach is considered as a well-established technology for representing knowledge of a particular subject area. The use of ontologies to represent domain knowledge allows for improved information retrieval and knowledge sharing, which is one of the main motivations for this research. The second aspect of using the ontological approach is the ease of understanding the model Ontology is used to represent consistent knowledge in a particular subject area, and this aspect makes it easier to understand. The third reason for using the ontological approach is the possibility of reusing existing components of ontological models. The ontology design process takes into account the possibility of reusing some parts of other ontologies.

The ontological model of university management allows to achieve the conceptualization of business processes aligned with the strategy of the university, indicating information about indicators in order to facilitate a better understanding and comparison:

the subject interested in the indicator;

the variables with which the indicator is associated;

description, meaning and importance of indicators;

what criteria are used in the field to evaluate the indicator;

what formula or mathematical calculation is performed to calculate the value of the indicator;

what other attributes make up the value of the indicator;

what point in time the indicator refers to;

what relationships between other indicators you need to know.

To ensure the integration and systematization of knowledge, the ontology of scientific knowledge of the university supports the following functions:

– ensuring meaningful access to information resources and knowledge of the scientific and pedagogical activities of the university;

– providing navigation through the ontology of knowledge of the university;

– organization of search queries on the concepts and relations of the ontology;

– classification of knowledge objects.

The ontology is described using the OWL DL (Web Ontology Language) [14].

The ability to define the cardinality and hierarchy of roles, as well as inverse and transitive roles, is possible due to the expressive ability of DL (Description Logics). To formalize the representation of domain knowledge, the description logic language DL ALC (Descriprion Logic Attributive Language with Complement) will be used. A full description is given in [115-116]. DL ALC tools for representing knowledge of the subject area are the concepts of "concept", "role", the language is used to describe intensional knowledge, extensional knowledge about individuals, their properties and relationships with other objects. In accordance with this division, the knowledge fixed using the DL ALC language is divided into [13]: a set of statements (facts) about individuals - ABox (A); a set of terminological axioms - TBox (T).

Research results. This study describes the process of building an ontological model of scientific knowledge of the university.

SWRC is an ontological model used to manage and share research data. SWRC provides a data model that can be used to describe a subject area, including the relationships between its constituent parts.

The scientific activity of the university is based on such principles as the development of scientific schools of the university, the integration of scientific research and the academic process, and the promotion of international cooperation. Research activity has a close relationship with the academic process. It includes the implementation of educational programs, research activities of students.

The ontological model of scientific knowledge of the university includes the main classes and relations of objects of scientific activity, provides a description of the scientific profile of information resources and allows for the analysis of scientific research. But, this model does not reflect the factors associated with academic activities and bibliometric data that affect the final result of research activities. According to the results of the study [14], the SWRC model will be supplemented with new classes and relationships that describe academic activities and the established roles between them cover the main elements of managing the scientific and pedagogical activities of the teaching staff of the university and merging with BiDO.

The addition of the model will make it possible to develop a software architecture for a

specialized information system for analyzing scientific and educational activities, develop metadata and build a set of interrelated thesauri to describe and support end-user requests.

Figure 2 shows the main classes and properties that will be added to the SWRC model.

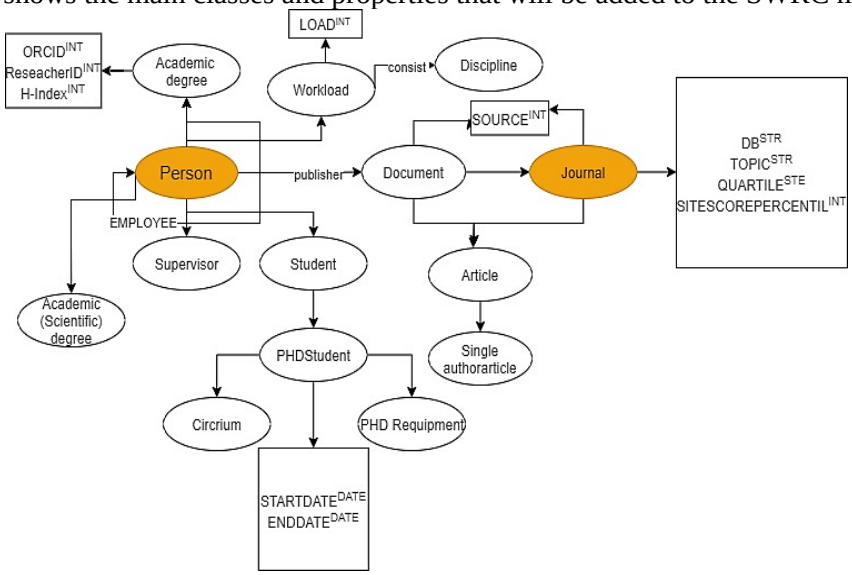

Figure 2. Main additions to the model

The "Person" class will be supplemented with the "Supervisor" and "Student" subclasses, as well as the H-Index, ResearcherID, ORCID properties for unique identification of scientific authors in scientometric databases. To describe the workload and the academic degree of an employee, the classes "Workload" and "AcademicDegree" are added. In turn, the class "Student" has a subclass "PhDStudent" and "Graduate" to describe students and individuals who have completed a doctoral program. "PhDStudent" has properties StartDate and Enddate, also has links with classes "Curriculum". The "Journal" class is supplemented with numerical and categorical bibliometric properties. Figure 3 shows a fragment of the developed ontological model. Basic entities represent the main subjects (Person and Organization) and their main activities (Project, Documentation, Event): collaboration between scientists, their participation in projects; cooperation with other organizations; holding various events; publication of articles, their relation to projects, if any; academic activities of employees.

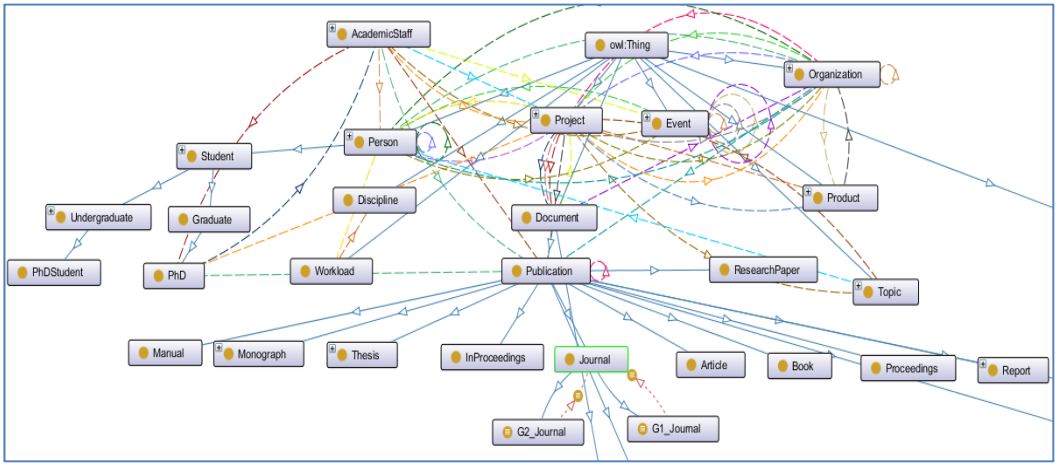

Figure 3. Fragment of the ontological model

The new classes and their properties and relationships are described in Table 1.

Table 1. Description of the main classes

Designation	Type	Purpose
Workload	Class	Teacher workload
Discipline	Class	Name of disciplines
Graduate	Subclass student	Graduates
PhD	Subclass student	Graduate who completed doctoral studies with the defense of a dissertation
G1_Journal	Subclass journal	Journals included in group Q1
G2_Journal	Subclass journal	Journals included in group Q2
G3_Journal	Subclass journal	Journals included in group Q3
G4_Journal	Subclass journal	Journals included in group Q4
ScientificDB	Subclass Topic	Scientometric databases
SuperVisor	Subclass Person	Employees who can supervise scientific work
EmployeesDegree	Subclass Employee	Scientific titles
DAssociateProfessor	Subclass Employee	Associate Professor
DfullProfessor	Subclass Employee	Professor
AssistantProfessor	Subclass Employee	Senior Lecturer Position
AssociateProfessor	Subclass Employee	Position of Acting Associate Professor
FullProfessor	Subclass Employee	Position of Acting Professor
SingleAuthor	Class	The sole author of the publication

The ontology of university knowledge consists of metaconcepts that determine the structure of the description of concepts in relation to the scientific and educational activities of the university.

Conclusions. As a result of the research, an ontological model of university knowledge has been developed, which allows integrating data on the results of scientific activity from scientometric databases. This model avoids the problem of semantic and structural conflicts, duplication of data, which most often arise during data integration. The ontological model is developed on the basis of the SWRC model, which is supplemented with new classes and properties to describe academic activities and the results of research work, taking into account the requirements of internal and external monitoring indicators.

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