*Обґрунтовано потребу в інструментальних засобах зіставлення та порівняння Європейської та національних рамок кваліфікацій. Досліджено потенціал Semantic Web у рішенні цієї проблеми. Розроблена модель рамки кваліфікацій, яка базується на еталонній онтології компетентностей, та метод її застосування на основі Semantic MediaWiki. Створено програмну реалізацію семантичного пошуку на базі цієї онтології для поповнення Wiki-ресурсу*

*Ключові слова: рамка кваліфікацій, онтологія рамки кваліфікацій, Wiki, семантична розмітка, семантичний пошук*

*Обоснована потребность в инструментальных средствах сопоставления и сравнения Европейской и национальных рамок квалификаций. Исследован потенциал Semantic Web в решении этой проблемы. Разработана модель рамки квалификаций, которая базируется на эталонной онтологии компетентностей, и метод ее реализации на основе Semantic MediaWiki. Создана программная реализация семантического поиска на основе этой онтологии для пополнения Wiki-ресурса*

*Ключевые слова: рамка квалификаций, онтология рамки квалификаций, Wiki, семантическая разметка, семантический поиск*

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# USE OF ONTOLOGIES AND THE SEMANTIC WEB FOR QUALIFICATIONS FRAMEWORK TRANSPARENCY

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## 1. Introduction

Aspirations in Ukraine for the European integration, an urgent need for balancing the national market of educational services with the globalized labor market, workforce mobility and increasing requirements to quality and efficiency of training specialists determine a need for the development and implementation of national qualifications system. National qualifications system will contribute to transparency in matchingand comparison of educational documents; it will provide international recognition of qualifications and will become a catalyst for reforming Ukrainian education system. A key factor in effectiveness of the qualifications system is the national qualifications framework (NQF), a systematic description of qualifications levels, structured by competences. Approved back in 2011, the NQF was supposed to contribute to the establishment of effective cooperation in the sphere of educational services and labor market, providing harmonization of national legislation in the field of education and socio-labor relations and, as a result, international recognition of qualifications that were obtained in Ukraine. At the legislative level, the basic positions of the NQF, which must comply with the European qualifications framework (EQF), were defined, and the strategy of development of the national qualifications system was declared. However, the mechanism for establishing the correlation between levels of the NQF and the EQF and comparison of learning outcomes has not been developed. Today there are no tools that would allow juxtaposing and comparing the level of national and European qualifications frameworks, contributing to transparency of the national qualifications system. Therefore, development of a tool of juxtaposing and comparison of the national qualifications framework of Ukraine with the European framework is a relevant and timely scientific challenge.

## 2. Literature review and problem statement

Theoretical aspects of the NQF implementation became the subject of active debates among scientists. Researchers analyze the experience of correlating the levels of the European and national qualifications framework, outcomes of development and implementation of new educational standards of specialist training [2, 3]. Considerable attention is paid to the role of national qualifications in modernization of vocational education [4] and interaction at the global and local levels in the course of development of the national qualifications framework [5]. Developers of the national frameworks seek to take into account the experience of other countries [6]. A comprehensive review of the national framework of qualifications in EU countries, which is presented in [7], allows evaluating the trends of their development and their impact on the national education system.

In practice, theoretical ideas of matching and comparing the levels of qualifications frameworks are partly implemented in several tools. In particular, the interactive table of the European Commission portal [8] makes it possible to match the levels of the national qualifications framework of European countries and get acquainted with the description of the specified levels through the descriptors of learning outcomes.

The tool, developed within the framework of The European Dictionary of Skills and Competences (DISCO II) of the European Commission [9] provides a comparison of learning outcomes, terminological support for the process of translation and juxtaposing of documents on education in the context of the European transparency of documents. Project DISCO II uses such national collection of learning outcomes as AMS-Qualifikationsklassifikation (Austria), Kompetenzenkatalog (Germany), ROME (France), Taxonomy DB (Sweden) and O*NET (United States), and the tool allows their juxtaposition in such documents as the Europass CV, the Europass Mobility, Europass Certificate Supplement, Profile of Occupation and a Profile of Qualification. Despite the practical significance and ease of use, the tools of the project DISCO II have certain drawbacks. Firstly, it is a limited list of subject domains (SD), for which learning outcomes were defined and described. They include health care, the sphere of social services, environmental protection, and information technology. Secondly, the process of supplementing the content of learning outcomes and their further use is limited due to the closed code of the tool.

In the project TRAnsparent Competence in Europe (TRACE) [10], main attention is paid to providing transparency of the European and national qualifications frameworks in EU countries. The use of computer ontologies for description of educational and professional qualifications is believed to be progressive in the project TRACE. However, educational programs and industry educational standards, which are not presented in the form of semantic meaning of the subject area, are lying in the basis of the specified qualifications.

Multilingual classifier European Skills, Competences, Qualifications and Occupations (ESCO) [11] defines and categorizes skills, competences, qualifications and professions. In this case, the first version of the classifier was published back in October 2013 and today there is no available sample for the "industrial" use.

One of the promising trends in development and use of tools of providing transparency of the European and National qualifications frameworks include the standards of Reasable Competency Definition (RCD) and Simple Reasable Competency Mapping (SRCM) [12]. RCD was developed as the standard of consistent and structured description of competences. The standard contains both a description of competences and the mechanism of exchange of information about them between different automated systems. In this case, competences are characterized using natural language and are free from semantic load. This leads to the fact that often two almost identical competences are recognized by the system as totally different. Unlike the RCD, in the SRCM standard, objects are connected by logical relationships. Without doubt, it has improved the level of understanding competences and their identification. However, even with this significant addition, the SRCM standard could not guarantee their effective recognition.

These tools are specific examples of the EQF and NQF processing. However, focusing on and orientation to the specific needs of the majority of them make it impossible to use them as a universal means of juxtaposing and comparing the levels of European and national qualifications frameworks. The main problem is that natural language descriptions of qualifications and learning outcomes in information resources (IR) are not suitable for automated processing, even within a single qualifications framework. If they belong to different frames, their comparison is complicated even more because of the differences in terminology base and in principles of classification. This causes the need for the search of such a model of data representation, which would make it possible to formalize semantics of these categories for their automated analysis and search in intelligent information systems.

## 3. The aim and tasks of the study

The aim of this study is to create a model of intelligent system for matching of learning outcomes in different frameworks of qualifications based on ontologies.

To achieve this purpose, the following tasks have to be solved:

– to develop a reference ontological model of national and European qualifications frameworks by formalizing the knowledge about basic information objects (IO) and relations between them;

– to propose a theoretical apparatus for IO matching and comparing related to learning outcomes;

– to develop an ontology-controlled tools of semantic search support for actualization of information on these IO.

To substantiate the proposed approach, we have to develop and to validate program implementation of these methods and models.

## 4. Materials and methods of examining qualifications frameworks

The task of establishing a correlation between qualifications levels of the European and national frameworks can be seen as a special case of the problem of semantic search for complex IO, for the solution of which a large number of different methods and approaches have been proposed. Most of them are oriented to using and automated processing the knowledge on relevant SD. In this semantic search, it is possible to use both natural language IP and knowledge bases that were obtained from the Web with the help of Data Mining.

Despite significant differences in the descriptions of levels of qualifications framework, their characteristic feature is in that underlying both the NQF and the EQF are the descriptions of person's knowledge, understanding and abilities, that is, "learning outcomes". In the Ukrainian NQF, learning outcomes are described in four categories: knowledge, skills, communication, autonomy and responsibility, which are divided into 10 levels. Each of the 10 levels is characterized by a description of the so-called "integrated competence", which combines all four categories of learning outcomes, and describes the level of the ability to act in working or training situations. Descriptions of levels serve as a common reference framework for describing, comparing, classifying, recognizing and developing qualifications. In the context of the qualifications framework, qualifications themselves act not only as standards (norms) of what a person must know/understand and be able to do at the end of educational process, but also as official confirmation that a person meets certain expectations.

For comparison of the NQF levels it is necessary to link qualifications to one of its levels. In turn, this requires the matching of qualifications with the descriptors of learning outcomes of the NQF. Descriptors of NQF are built by the principle of inclusiveness, i.e. the learning outcomes of higher levels include learning outcomes of lower levels without indicating, except cases when you add certain items. In the case of adding certain characteristics, it is again indicated in descriptors. The qualification level is determined by using the principle of closest correspondence to descriptors of learning outcomes of the NQF.

However, in practice such processing of information objects is a nontrivial task. Different levels of qualifications and learning outcomes, which are characterized by natural language use, do not carry any semantic load and may not be recognized by information systems. This justifies the application of Semantic Web technologies, based on computer ontologies.

In knowledge engineering, ontology is understood as a detailed description of a problem area, which is used for formal and declarative definition of its conceptualization [13]. Ontologies are effective tools for simulation of ideas of various SA, making possible to formally show their semantics. Formal models of ontologies [14] contain the notions that are divided into classes and instances, relationships between them and functions of interpretation of these concepts and relationships. Semantic Web develop a large number of standards, methods and program tools of managing ontological knowledge [15] in the Web, providing their interoperable representation [16].

One of the promising technologies of the Semantic Web is Semantic Wiki. It is based on the known Wiki-technology which provides distributed processing of information in the Web and allows users to freely edit content of pages [17]. Information in the Wiki has a non-linear navigation structure and contains hyperlinks to other resources. There are many different platforms for creating and supporting Wiki-resources that provide *semantization* of information. For example, there is a semantic extension Semantic MediaWiki (SMW) for MediaWiki. It allows users to add semantic annotations to Wiki-pages that transform MediaWiki into semantic resource and use such markup elements as semantic properties (for data creation) and semantic queries (for data usage). Semantic Wiki-resources are quite easily to integrate with relevant ontology of SD: ontology can be used as the basis for a hierarchy of categories in Wiki, and by the set of Wiki pages it is possible to generate ontology that obtains knowledge from semantic markup of these pages.

## 5. Results of examining the qualifications framework

For the development of a *reference model of qualifications framework* (EMQF), natural language descriptions of the national and European frameworks were analyzed. Based on this analysis, the data model of qualifications framework that contains IO and their properties, characteristic for the majority of the examined approaches is constructed.

The EMQF defines the IO semantic properties and relationships deal with learning outcomes. The EMQF classes correspond to the IO classes of given SD. The EMQF formalizes the relationships between IO and sets their hierarchy (Fig. 1). This model is described in the language OWL Lite and can be visualized by means of ontology editor Protégé. OWL Lite (as well as OWL DL and OWL 2.0) is based on descriptive logic ALC (Attributive Language with Complements) that guarantees finite logical inference on this ontology.

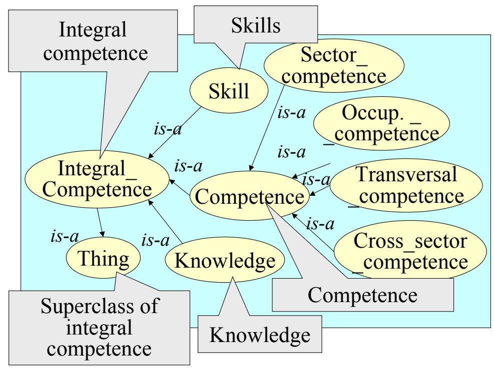


Fig. 1. Hierarchy of competences of EMQF (fragment)

The EMQF describes properties of these classes (both object properties and data properties) and relationships between these basic terms and their subclasses. Classes in the data model are combined into groups and subgroups of different levels depending on the specific subject domain.

Each IO instance $x \in X$ can be presented as

$$\left\langle \left( r_{obj_i}, \{x_k\} \right), \left( r_{data_j}, \{d_m\} \right) \right\rangle,$$

where $r_{obj_i}$ are the object properties of SD ontology, $r_{data_j}$ are the properties of ontology data of SD, $x_k$ are arbitrary instances of different IO classes, and $d_m$ are the constants of different types. Each $r_{obj_i}$ may be seen as

$$r_{obj_i} : \left\{ X_{in_{i_1}}, ..., X_{in_{i_k}} \right\} \rightarrow \left\{ X_{out_{i_1}}, ..., X_{out_{i_m}} \right\},$$

that is, for every object property, the domain of meanings and the domain of definition from IO subsets are determined.

Instances of different classes in the EMQF are related to various object properties $r_{obj_i}$. Object property *associations* does not have any additional restrictions (such as transitivity, symmetry, etc) and therefore does not represent the additional semantics that allows their representation using the language OWL Lite. In addition, EMQF uses semantically meaningful object properties, such as "requires prior examination", "is based on the level of education", etc., which may have additional restrictions.

To complement the IO, traditional for qualifications frameworks, we propose to use an additional IO class – atomic competence [18], which is meant for correlating instances of different IO classes by assessing their semantic proximity. *Atomic competence* a possesses the following properties:

– $a \in C$, where K is the set of IO class «Competence» and $C_{atomic}$ is the set of atomic competences, i. e. $C_{atom} \subseteq C$;

– every competence can be represented by a sum of atomic competences

$$\forall c \in C \exists a_i \in C_{atomic}, \quad i = \overline{1, n}, k = \bigcup_{i=1}^{n} a_i;$$

– no atomic competence is a subset of another atomic competence $\forall a, b \in C, a \subseteq b \Rightarrow b \notin C_{atomic}$.

From these properties, it follows that for each competence $c \in C$ there is one and only one set of atomic competences.

We propose a simple algorithm for construction of atomic competences: if two competences $a \in C$ and $b \in C$ are intersected $a \cap b \neq \varnothing$, then three potentially atomic competences are constructed by them. This operation is repeated iteratively to all pairs of competences, until a set of atomic competences, which do not intersect, is constructed for each competence.

The main problem in this algorithm is related to the fact that at every step you need to analyze the semantics of competences that are described by the natural language, using SD knowledge, so this process cannot be performed automatically without the participation of experts.

Such formalization allows supplementing an ontological model with the class "Atomic competence", with the help of which one can formally define the semantics of other IO. This is a subclass of the class "competence", which has the following object properties:

– "provide" for classes "discipline", "qualification", "specialty" and "occupation";

– "include" for the class "competence";

– "match the level" for the class "level of qualification framework".

One and the same atomic competence may be used by various instances of different classes. From the standpoint of providing of qualifications framework transparency, it is important that the basic classes of EMQF should have object properties with meanings from the class "Atomic competence" that allows to analyze and compare these IO at the knowledge level, that is, for each instance of IO $x \in \underline{X}$, there are such object properties of the SD ontology $r_{obj_i}, i = \overline{1,l}$, that

$$C_{atomic} \subseteq \left\{ X_{out_{i_1}}, \ldots, X_{out_{i_m}} \right\}.$$

Other IO can have object properties of the class "atomic competence". It is important that several different object properties of the class "atomic competence" can exist for one IO. For example, IO "speciality" has object properties "necessary skills" and "additional skills" of the class "atomic competence".

Thus, one of the basic classes of IO in EMQF is "Competence" $c \in C$. Competences are divided into two sets, which do not intersect – atomic competences $c \in C$. and complex competences $C_{complex}$, $C = C_{atomic} \cup C_{complex}$, $C_{atomic} \subseteq C$, $C_{complex} \subseteq C$. Every instance of the class "Complex competence" is defined as a non-empty set of instances of the class "Atomic competence".

Basic EMQF classes are the IO, which describe learning outcomes, people who receive them, and those institutions that provide them. IO are determined through their properties. They have subclasses, in which specific properties that define the semantics of these subclasses and their relationship with other IO are added to the properties of the basic classes. For example, all instances of the "Person" class have such data properties as "First name" and "Year of birth", and instances of the "Student" class, which is a subclass of the "Person" class, has also object properties "Place of studying" of the class "Educational organization", "Studies" of the "Speciality" class and the data property of "Year of study". Eight levels of qualifications of the EQF may be represented as subclasses of the "Qualification" class with data properties "Qualification level" from 1 to 8 and with meanings of properties of the data of "Qualifications system", which equals to the text constant "EQF".

Class "Qualification" in the EMQF can be formally represented as threesome

$$Q = \left\langle Iq, Lq, Compet = Kn \cup Sk \cup Com \cup \ldots \cup Compet_p \right\rangle,$$

$$p = \overline{0,r},$$

where $iq_j \in Iq, j = \overline{1,n}$ is the identifier of the qualification system;

$$Lq = \bigcup_{j=1}^{n} \left\{ lq_{i_1}, \ldots, lq_{i_{s_j}} \right\},$$

where $lq_{i_{s_j}}$ is the number of levels in the classification system $iq_j$; $Kn \subseteq C_{atomic}$ is the set of atomic competences, which characterizes knowledge of this qualifications; $Sk \subseteq C_{atomic}$ is the set of atomic competences, which characterizes skills of this qualification; $Com \subseteq C_{atomic}$ is the set of atomic competences, which characterizes communications of these qualifications; $Compet_p \subseteq C_{atomic}$ is the set of atomic competences, that characterizes pth set of competences of this qualification (for other arbitrary qualification systems).

Each instance $q \in Q$ has a corresponding set

$$C(q) = \{c_i\}, \quad i = \overline{1,n}, \quad c_i \in Compet \subseteq C_{atomic}.$$

Regardless of what qualification systems were used for the description of qualifications, we shall consider two qualifications $q_1 \in Q$ and $q_2 \in Q$ equivalent, if $c(q_1) \equiv c(q_2)$.

Specialities, disciplines and other IO are modeled similarly. In those cases, when some object properties with the meaning domain from $C_{atomic}$, are used to describe one IO, their set of competences is defined as merging of sets of competences of individual object properties:

$$C(x) = \{c_i\} = \bigcup_{p=1}^{q} C\left(r_{obj_p}, x\right), c_i \in C_{atomic}.$$

In general, the user describes his information need, indicating IO class X, to which the required IO instance belongs (for example, a person, educational establishment, speciality) refers, and conditions, imposed on the meaning of its properties.

To provide transparency of qualifications framework, we propose to use conditions regarding the competences that characterize the properties of IO instances. The user can explicitly specify which exactly object properties he is interested in.

Then the function of semantic proximity between IO is calculated as follows:

$$S\left(x, y, r_{obj_i}\right) = \sum_{j=1}^{n} s_j\left(x, y, r_{obj_i}\right), \tag{1}$$

where

$$s_j\left(x, y, r_{obj_i}\right) = \begin{cases} 1, c_j \in C\left(r_{obj_i}, x\right) \wedge c_j \in C\left(r_{obj_i}, x\right), \\ 0, c_j \notin C\left(r_{obj_i}, x\right) \vee c_j \notin C\left(r_{obj_i}, x\right). \end{cases}$$

If a user does not specify them, those sets of atomic competences that are related to IO with the same object properties are compared first of all, that is, the total of assessments of their semantic proximity is calculated (1):

$$S(x,y)=\sum_{i=1}^{m}S\left(x,y,r_{obj_i}\right). \qquad (2)$$

However, there are some situations where various object properties have different weights for a user (for example, ability to teach a specific competence is more important than the ability to use it. Then the function of semantic proximity (2) needs to be supplemented by weight coefficients for individual object properties:

$$S_w(x,y)=\sum_{i=1}^{m}w_i * S\left(x,y,r_{obj_i}\right), \qquad (3)$$

where $w_i$ is the weight of the ith object property.

An important advantage of the proposed model of search is that with such description, semantics of the information need is clearly indicated. As a result, you can run the search, which distinguishes different relationships between a required IO and a set of competences. For example, with the same instance of the class "person" some different subsets of atomic information can be linked to relationships "possesses", "has a certificate", "can teach", "has experience of using". Such differentiation makes it possible to meet more accurately the information needs of a user, identifying the IO that meets his requirements. The problems, arising in the process of solving such tasks, are related to the formation of a set of atomic competences and supplementing the base of knowledge about IO instances.

## 6. Discussion of results of using EMQF

The use of EMQF allows the automation of processing information regarding learning outcomes, integrating the knowledge that meets the needs of a user [19]. Having built this ontology, you can run SPARQL queries in it in order to obtain required knowledge. But the problems, related to supplementing ontology with information as for new IO instances arise: for this purpose, specific skills of ontological analysis are necessary. Therefore, there is a need of using technological platforms, oriented to users who do not specialize in knowledge engineering. A platform is the Wiki environment that allows users to individually supplement and edit content pages. Wiki significantly expands the scope of using such a system compared to traditional databases and content management systems. Wiki technology provides the relevance of the obtained results – content pages are automatically updated after changes on the pages that are information sources for them. In the process of application of the ontological model of competences for semantic markup based on Semantic MediaWiki, a user semantically marks up by IO elements of this ontology. A user can define a category (or set of categories) for each document and identify individual elements of the content. For example, it is possible to define a specific page as the description of speciality and specify its level, name, key competences, etc. This allows running complex semantic queries, for example, to find all educational institutions in a specific city, which teaches the disciplines, which contain a user-defined set of competences.

The elements of the semantic markup in Semantic MediaWiki, based on the described above data model and reference ontology of competences, is the basis for obtaining information from these pages. The structure of this ontology defines what knowledge can be obtained in the automated way from Wiki-pages.

In Semantic MediaWiki, a simple but powerful query language SMW-QL is implemented. It opens wide opportunities for semantic search in the Wiki-resources. Semantic properties and categories allow organizing data in Wiki, and one needs queries to use this information.

SMW-QL makes it possible to filter pages by specified criteria and to retrieve as query results only the information interesting for a user, but not the entire text of a Wiki-page. Queries can be inserted into Wiki-pages with relevant explanations and combined, their results can be imported to other intelligent systems. The information on these pages will be updated automatically every time you change the content of those Wiki-pages, from which information is obtained by queries.

User can retrieve the results of already built information queries as for specialities, levels of qualifications framework, etc., which are integrated into Wiki-pages (Fig. 2). He can also create such requests independently, having mastered a relevant formal language.

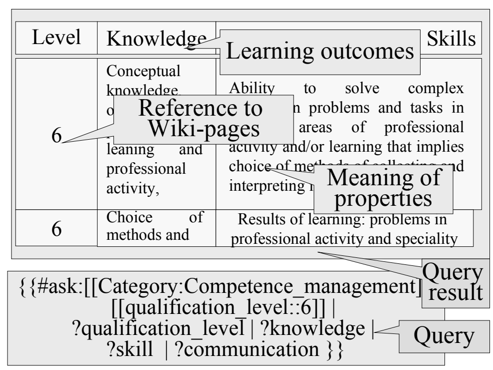


Fig. 2. Results of running semantic query in Semantic MediaWiki

Semantic MediaWiki allows running queries not only for retrieval of IO with certain properties but also retrieval of semantically similar IO instances. For example, it is possible to run a query that finds all professions, in which competences of a particular speciality are used, and organizes them according to criterion (1) from the nearest to the farthest.

In those cases, where expressive abilities of Semantic MediaWiki are not sufficient to calculate the measure of semantic proximity, for example, using (3), it is necessary to develop additional software that analyzes a query result and organizes it according to the obtained meanings.

It is necessary to take into account the dynamics of open information environment of Web, as well as constantly update information and analyze, for example, the new state and international standards and norms, related to the description of learning outcomes. To do this, it is advisable to apply a *semantic search engine*s (SSE) that use knowledge about users and a subject domain of search for finding IO of the assigned types. In this case, the role of knowledge base about a search SD is performed by EMQF. It is proposed to use for this search the SSE "MAIPS" [20], which supports the application of ontologies to rearrange the search results in accordance with the interests of users and their tasks, which are determined with the help of thesaurus (Fig. 3).

MAIPS simplifies to the adding information to Wiki-resource: the results or retrieval in the Web, are semantically marked up by terms from the task thesaurus and user can selected those ones with a larger number of marked elements.

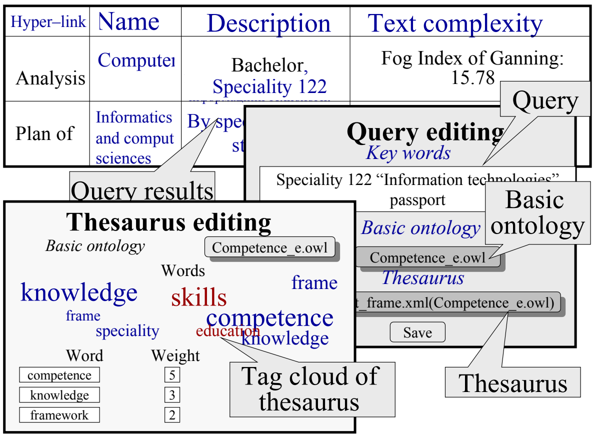


Fig. 3. Semantic search based on reference ontology of competences

## 7. Conclusions

Present work was performed within the project of the applied research "Development of intelligent system of information and cognitive support for functioning of the National qualifications framework", DR # 0115U00257.

As an outcome of the conducted studies, the following results were obtained:

– based on the analysis of the national and international qualifications frameworks, a reference ontology model, which formally defines basic concepts of the subject domain and relationships between them, was built;

– theoretical fundamentals were developed for substantiating the method of correlating IO that relate to learning outcomes and are associated with different sets of atomic competences using semantic properties that are formalized into the reference ontological model;

– a method is proposed for the integration of ontological models of qualifications framework with the technological platform Semantic MediaWiki, that makes it possible to process knowledge on learning outcomes, as well as tools of semantic Web search, based on the ontological model of qualifications frameworks for supplementing this Wiki-resource with actual information about relevant information objects.

Prospects of further research in the selected direction are related to the implementation of prototype of an intelligent system of information and cognitive support of functioning of the National qualifications framework to facilitate national and international recognition of qualifications, obtained in Ukraine, establishing effective cooperation in the sphere of educational services in the labor market, development of effective tool of representing qualifications and describing learning outcomes. This requires improving ontological basis of the system and supplementing its Wiki-resource.

We propose to develop in the future a user-oriented intelligent interface of the system that will allow all social partners to more effectively use computer ontologies of the European and national qualifications frameworks.

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# THE SCHEDULER FOR THE GRID-SYSTEM BASED ON THE PARAMETERS MONITORING OF THE COMPUTER COMPONENTS

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***Розроблено структуру планувальника розподіленої комп'ютерної системи, яка підтримує захищену обробку даних. Запропоновано структуру централізованого планувальника, який, взаємодіючи з локальними агентами даних обчислювальних вузлів, визначає параметри вузлів системи та підбирає ресурси для задачі з встановленими вимогами щодо захищеності. Подано результати досліджень застосування класичного та адаптивного механізмів управління захищеністю в РКС на прикладі Grid-системи***

***Ключові слова: розподілена комп'ютерна система, управління обчислювальними ресурсами, планування задач, моніторинг параметрів обчислювального вузла***

***Разработана структура планировщика распределенной компьютерной системы, поддерживающей защищенную обработку данных. Предложена структура централизованного планировщика, который, взаимодействуя с локальными агентами данных вычислительных узлов, определяет параметры узлов системы и подбирает ресурсы для задачи с заданными требованиями по защищенности. Проведены исследования по использованию классического и адаптивного механизмов управления защищенностью в распределенной компьютерной системе на примере Grid-системы***

***Ключевые слова: распределенная компьютерная система, управление вычислительными ресурсами, планирование задач, мониторинг параметров вычислительного узла***

## 1. Introduction

Since the emergence up to the present, distributed computer systems have undergone substantial changes. At the same time, resource allocation and management in such systems remain an important problem and researchers are working towards its solution. There are various DCS resource management approaches, most of which being focused on time parameters of task processing by the system and maintenance costs. However, in some cases during task