Ontology-Based Knowledge Base Design

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Abstract—**The paper deals with the application of the ontological approach to the design of knowledge bases developed by group of developers. This approach is based on the representation of the knowledge base as a hierarchal structure of interconnected subject domains and their ontologies.**

Keywords—knowledge base, ontology, ontological design, component-based design, collective development

I. INTRODUCTION

A. Goal and relevance

Nowadays there is urgent problem of effective information support of various branches of human activity. Increasing of the amount of information has caused creating knowledge storages, providing structuring and systematization of stored knowledge, as well as their effective processing.

One of the most promising directions in this field is development of knowledge-based system [46]. A key component of such systems is the knowledge base. The quality of the developed system of such type is defined including by the quality of knowledge base and variety of types of knowledge, stored in it.

Developing of knowledge base is a time-consuming and lengthy process. Accordingly, there is urgent problem of reducing time of development and ensuring of effectiveness of life cycle support of knowledge bases.

There are following ways to reducing the time and decreasing the laboriousness of knowledge bases development:

- ensuring joint development of knowledge bases by distributed group of developers [12];
- automation of activity of knowledge bases developers;
- reusing of already developed knowledge bases fragments [30], [36], [1], [47], [33], [7].

However, full automation of the process of knowledge base development is impossible, because some steps, such as the formation of a concepts system, require the agreed efforts of a number of developers and experts and are subjective.

An important step of knowledge base development is structuring. Structuring of knowledge base, i.e. selection of various interconnected substructures in it is needed for a variety of reasons [3]. In particular, it is necessary for didactic purposes (for person, acquiring some knowledge, it is desirable to have a kind of contents of this knowledge, that allows to schedule its assimilation and consider it with varying degree of detail), as well as for organizing of the distribution of tasks of knowledge bases design (when various implementers are entrusted development of various fragments of knowledge bases, with enough clear boundaries).

The goal of this work is the development of a unified semantic models of knowledge bases and tools of their collective development, based on the ontological structuring of knowledge base, that allows to decrease laboriousness and time of their development and modernization.

B. Problems for achieving goal

Among problems in the field of knowledge bases development are following:

- Lack of tools of unification of all types of knowledge and models of knowledge representation in a single knowledge base.
- Lack of formal tools of structuring, enabling the knowledge base to be presented on different levels of detailing.
- Lack of a unified approach to the selection of reusable components of knowledge bases and formation of components libraries, which leads to the large number of incompatible already developed components of knowledge bases. [33]
- Laboriousness of modernization of knowledge bases and their support is high (some changes, made in knowledge base can cause the necessity of substantial changes in knowledge base structure).
- Despite there are a lot of well-developed tools for design of knowledge bases, still there are no tools to ensure complex support for the development team on the all stages of knowledge base design, which are, in its turn, enough flexible and extensible. Besides, all existing tools are generally oriented at any specific knowledge storage format, which makes complicated the transfer of already developed knowledge base on another interpretation platform.

C. The analysis of modern approaches to achieving the goal

Nowadays, there are several models of knowledge representation, however most of them can be reduced to four basic: semantic networks, frames, productional and logical model [2].

However, each of said knowledge representation models is adapted to specific kinds of knowledge representation, while creating of intelligent systems often requires representation of various kinds of knowledge in a single base, which can not be provided by any of the models above, taken individually. [15], [13] Hence there is a necessity of creation a universal model of knowledge representation, which would allow to represent any kinds of knowledge in a unified manner.

The key moment in the process of knowledge structuring is formation of system of basic concepts of subject domain. [3].

Nowadays, during the process of development of knowledge-based system, widespread use of the W3C consortium standards [43]. Its mission is the development of standards in the field of Semantic Web [43], [25]. In particular language for ontologies description OWL [39] and knowledge representation language in the form of semantic networks RDF [40] were developed by consortium. Also effective knowledge base storages based on RDF were developed ensure storage and access to data by means of the query language SPARQL [42]. To edit ontologies a large number of editors was created, which have a fairly broad functionality [38].

However, despite the development of the Semantic Web project and related means, a significant part of the resources of Web still contains no semantic markup and metadata. Semantic resources that are developed on the base of Wiki-Technologies [44] are exceptions and are becoming increasingly popular.

Wiki-technology allows to accumulate knowledge, which are presented in interoperable form, providing knowledge navigation. Using Wiki-technology is possible for projects of any scale and thematic focus (from open electronic encyclopedias, to reference systems of different companies and educational institutions) [21].

Wiki-technology provides its users tools for storage, structuring text, hypertext, files and multimedia. Wiki-technology uses MediaWiki platform as a tool [37], which allows to perform information interaction, provides access to information resources of all participants in the system development process, organize, manage and oversee the development process. [6] Among advantages of this technology can be distinguished simplicity of wiki-marking, communication capabilities, which are implemented through co-authoring pages editing as well as by electronic discussions on the wiki or other environments, such as chat or forum, project nature of the work, cooperation, formation of a single product of joint activity provide a meaningful engagement, knowledge sharing, evaluation and continuous improvement of work [21].

Influence of Semantic Web for such projects is constantly increasing, so that the engines of Wiki-sites were created, which support the ontological knowledge representation and semantic markup resources, by Semantic MediaWiki tools [41]. These tools allow to include semantic annotation to Wiki-markup in the form of OWL and RDF and to separate explicitly structured and unstructured information. [21].

Besides these advantages, Wiki, as technology, has several disadvantages: duplication of information on different pages, the impossibility of knowledge structuring due to lack of hyperlinks hierarchy and lack of unification of data representation, lack of possibility of automatic verification.

In this paper, the idea of Wiki technology has been used, but has been attempted to eliminate these problems.

To the problem of development and structuring knowledge bases the following research were focused on:

- Knowledge Base and Knowledge Management [2], [3]
- Fractal model of knowledge structuring, based on the representation of different forms (species) of knowledge as objects layered (stratified) space [19]
- Technology of development engineering knowledge source providing performance of complex engineering calculations [8]
- AT-Technology [23]
- Technology of development of intelligent cloud services based on IACPaaS platform - Intelligent Application, Control and Platform as a Service [9]
- Technology of sources development of scientific knowledge [13], [14]

Nowadays, a large number of knowledge bases on a variety of subject domains was developed [29]. However, most of them are not well-structured, consistent and compatible with each other.

D. The principles underlying the proposed approach to achieve this goal

At the proposed models are following basic principles of open semantic technology of intelligent systems design OSTIS (Open Semantic Technology for Intelligent Systems) [34]:

- using of the ontological approach to the knowledge bases design, which involves structuring of knowledge bases, based on ontologies;
- phased evolutionary knowledge bases design;
- focus on team-oriented knowledge base design in the project;
- focus on semantic knowledge base representation;
- unification of knowledge bases models of intelligent systems;
- modular design based on libraries of typical reusable components.

OSTIS technology is focused on the development of ***knowledge-driven computer systems*** - systems, each of which is based on knowledge base, presented in a unified way, which contains all the information, used by the system, in a systematic way [4]. As part of paper, knowledge-based system developed using OSTIS Technology, is called ***ostis-systems***.

E. The tasks that must be solved for implementation of the proposed approach to achieve the goal

To solve the above problems is required to solve the following tasks:

- develop a unified semantic models of representation of different types of knowledge, based on ontologies;
- develop ontological models of knowledge bases structuring;

- develop ontological models of team knowledge base design;
- develop support subsystem of team knowledge bases design, including automation of developers' activities, tools for editing of knowledge bases, tools for automation of verification of knowledge bases.

II. The ontological model of the knowledge base

In this paper it's proposed to use as a formal basis for knowledge representation method of knowledge representation in the form of semantic networks with the basic set-theoretic interpretation, allowing to describe as knowledge relating to the subject domain (including meta-knowledge and a simple transformation from knowledge to meta-knowledge), so as processing procedure. This method is the base on Open semantic technologies of intelligent systems (OSTIS). Thus it was developed a method of such semantic networks encoding - SC-code (Semantic Code). Elements of such a semantic network are called sc-nodes and sc-connectors (sc-arcs, sc-edges). Using this approach to knowledge representation due to its versatility and possibility of unlimited transformation from knowledge to meta-knowledge and number of other advantages [4], [5].

As mentioned above, one of the key principles in the design of knowledge bases using OSTIS Technology is using of the ontological approach.

Nowadays ontologies are the most effective tools of formalizing and structuring various fields of knowledge [32]. This approach is used in most modern solutions of problem of intelligent systems development and their components development. [32], [31], [35], [36], [45], [3], [7], [8], [12], [16], [18], [20], [22], [24]. The purpose of the ontology - to form the conceptual basis of the subject domain, therefore, ontologies are backbone of any knowledge base and are used for the integration of different knowledge bases and their parts.

The ontological approach to the design knowledge base includes development of:

- ontological model of developed artifact, ie, ***ontological model of the knowledge base***
- ***ontology project activities, aimed at knowledge bases development***, ie, formal description of the method of knowledge bases design.
- ***ontological model of tools for support of knowledge bases design***, ie, formal description of model of the support subsystem of knowledge bases design.

Knowledge base *of ostis-system* is finite information structure, which is a formal representation of all knowledge, sufficient for the functioning of a computer system and stored in the memory of the system. [4].

Precise separation of the design process of the formal description of the semantic model of developed knowledge base from the implementation process (interpretation) of the model on one or another platform is a basic of knowledge base development using OSTIS technology [4]. The advantage of this approach to the design of knowledge bases is independence of such an implementation from the platform, ie, developing only semantic model of knowledge base, it is possible to implement this model on different platforms without changing the model itself. Formal model of knowledge bases, presented in ***SC-code*** will be called ***sc-models of knowledge bases***.

Knowledge base of intelligent system, presented in the form of well-constructed semantic network of the specified form, eliminates duplication of information in such knowledge base.

As mentioned earlier, one of the ways to reduce labor costs in the development of knowledge bases is to organize their team design. An important task is to ensure coordinated work of the development team. In this paper, this task is also solved with use of ontological approach.

The essence of the ontological approach in knowledge base design is to consider structure of knowledge base as a hierarchical system of selected subject domains and their respective ontologies, such as ontology classes of solving tasks that allows to reduce search area of ways to a particular problem, limiting it by specific subject domain. This is true both in the case of solving tasks by system automatically, and in the case of performing design tasks by developers. In the second case, this approach helps to minimize the dependence of development process of some knowledge base components from others. In those cases, where the process of solving a problem involves concepts from different subject domains, is required coordination of these concepts. One of the problems in the formation of the structure of the specific knowledge base and set of subject domains is to minimize these kinds of cases. Besides, a significant advantage of using ontologies in knowledge bases design is the ability to reuse already developed knowledge base components, which also reduces the time of development of knowledge bases.

Thus, **the main problem of knowledge base design using the proposed approach** is to identify subject domains so that they minimally depend on each other and allow relatively independent evolution of each fragment of knowledge base that describes the relevant subject domain and its ontology.

During the development of a formal model of a subject domain it's necessary to remember that despite the fact that it is always possible to find a connection between any two entities, it is necessary to abstract from some of the connections considered the subject domain, which are not essential in the task. It is necessary to take into account the sufficiency of the conditions for solution of certain problems, without breach of integrity of knowledge base.

An explicit denotation of fragments of knowledge base for agreement with the development team, greatly reduces the effort required during the development of knowledge bases, as developer knows which it's necessary to coordinate with the others, and which parts of the knowledge base is area of responsibility of developer.

One of the distinguishing features of knowledge bases design within ***OSTIS Technology*** is the development of a knowledge base is reduced to development of its model presented in ***SC-code*** (***sc-model of knowledge base***).

Further, the model is interpreted on one of the platforms of sc-models interpretation, additional adaptation of the developed model to the features of a particular platform is not required.

Consider the structure of *sc-model of knowledge base of ostis-system*, which is researching in the ***Subject domain of sc-models of knowledge bases***:

sc-model of knowledge base
= *unified semantic model of knowledge base*
∈ *section of knowledge base*
<= *basic decomposition*:*
{
- *the subject part of the knowledge base*
- *context of subject of knowledge base of the Global Knowledge Base*
- *documentation of the computer system*
- *history and current processes of computer system operation*
- *history, current processes and computer systems development plan*

}

subject part of the knowledge base contains all the information about *subject domain* (or several related domains within the same knowledge base) [11], for which is this or that knowledge-based system (eg - Help System). Examples of such sections are *Documentation OSTIS* or *Documentation. Euclidean Geometry*

context of subject of knowledge base of the Global Knowledge Base contains a specification of the objects, which are not studied directly in the subject part of the knowledge base of the system, but have the attitude to it, that is, referred to in the description of any of concepts researching in the subject part of the knowledge base. For example, for IMS system it can be such concepts as *artificial intelligence* or *intelligent system*, for Euclidean Geometry system - historical reference of the life of Euclid, mathematics, etc.

Section ***documentation of the computer system*** contains documentation of *ostis-system*, at least, specification of its knowledge base, knowledge processing machine [26] and interface, as well as all the necessary guidance to ensure the opportunity to learn how to use the system.

history and current processes of computer system operation
<= *basic decomposition*:*
{
- *history of operating computer system*
- *current processes of computer system operation*

}

Section ***history of operating computer system*** stores the history of the system dialogue with its users, ie the specification of all the actions carried out (already become past entities) by system in order to satisfy the information needs of users, including answers to questions and the implementation of the transformation in the knowledge base including sequence of the actions and result. If necessary, a part of such descriptions can be removed, for example, after timing expiration.

There are specifications of all actions executed by ostis-system at the moment (included in the set of real entities) in ***current processes of computer system operation*** section, as well as all temporary structures generated by sc-agents during the process and has not yet been deleted. After performing the actions of their marks and specifications are transferred to the section of the ***history of operation of the computer system***.

history, current processes and computer systems development plan
<= *basic decomposition*:*
{
- *structure and organization of computer system project*
- *history of computer system development*
- *current processes of computer system development*
- *plan of computer system development*

}

Structure of the project, aimed at developing ostis-system, including its sub-projects and specified the role of developers responsible for each project describes in section ***Structure and organization of computer system project***.

Specification of project activities carried out during the development of the system (the last entity), with the obligatory indication of the performers, consistency and performance results are stored in section *of* ***history of computer system development***.

There are specifications of approved and initiated project *actions* executed by developers of the system at the moment (*real entities*), with the obligatory indication of the performers, the sequence and target of performance, as well as all the information that describes suggestions for *subject part of the knowledge base* and *history of operating computer system* editing and its discussion by administrators, managers and experts in section of ***current processes of computer system development***.

There are specifications of the project actions which have been approved to execution, but not yet executed for any reason, as well as all theinformation that describes the proposals for editing of *history, current processes and computer systems development plan* section and its discussion by administrators, managers and experts in ***plan of computer system development*** section.

III. Structuring of knowledge base

One of the most common (in terms of semantics specification) concepts for describing of properties of any object is the concept of ***structure***, considered in ***Subject domain of structures***.

Each ***structure*** is a set of *sc-elements*, removing one of which leads to breach of integrity of the set.

Concepts that describe roles of the elements in the structure have been introduced for formal representation of structures:

element of structure'
<= *partitioning*:*
{
- *non-represented set'*
- *fully represented set'*
- *partially represented set'*

• *structure element, which is not set'*
}
<= *partitioning**
{
• *maximal set'*
• *non-maximal set'*
}

A series of *correspondences** such as *homomorphism*, polymorphism*, automorphism*, isomorphism**, *structures analogy*,* etc. can be defined on the structures.

More detailed *Subject domain of structures* is considered in paper [11].

Within knowledge base will be selected semantically meaningful *structure,* which have a semantic integrity. These structures will be called ***knowledge***.

Within ***Subject domain of knowledge*** were identified following types of ***knowledge***, which are considered in [11]:

knowledge
= *sc-knowledge*
= *Set of all possible knowledge*
= *sc-knowledge or holistic fragment sc-knowledge*
$\subset$ *structure*
$\supset$ *semantic neighborhood*
$\supset$ *comparison*
$\supset$ *factual knowledge*
$\supset$ *section*
$\supset$ *subject domain*
$\supset$ *ontology*
$\supset$ *task*
$\supset$ *program*
$\supset$ *plan*
$\supset$ *solution*
$\supset$ *statement*
$\supset$ *definition*

Important relation, defined on the set of knowledge, is the relation to be *meta-knowledge** that describes transformation from knowledge to meta-knowledge describing their [2].

For specification of individual *entities* within knowledge base we introduce the concept of ***semantic neighborhood***, which is considered in ***Subject domain of semantic neighborhoods***.

semantic neighborhood - is *knowledge*, which is a specification (description) of *an entity* which sign is a *key element* of the knowledge. Note that each *semantic neighborhood* as opposed to other kinds of knowledge has the only one key element (the key sign, sign of described entity). Also note that a variety of types of semantic neighborhoods shows the variety of semantic kinds of descriptions of the various entities. Typology of semantic neighborhoods discussed more detail in paper [11].

As mentioned above, one of the key concepts in determining the structure of knowledge base is a ***subject domain***.

Subject domain - is the most important kind of knowledge that is part of semantic space [4]. Each subject domain focuses on the description of connections the relevant class of research objects. Each sign, which is part of the knowledge base, should belong to (be part of) at least one subject domain, performing a role in it. Each subject domain can be associated with:

- set of semantic neighborhoods, describing researching objects of this subject domain;
- family of various types of ontologies that describe properties of the concepts of this subject domain.

Subject domains are the basis for structuring of the semantic space, localization tool, focusing on the properties of the most important classes of described entities, which are classes of objects of research *in subject domains*.

Consideration of the structure of the knowledge base in relation to the subject domain allows to consider objects of research on different levels of detail. Detail of consideration of researched objects can be carried out as within original subject domain, to the independent system, but related between each other subject domains.

Following conditions are fulfilled, during the transition from subject domain to its model, presented in the form of a semantic network:

- each element of subject domain one-to-one correspondence denoting its element of semantic network;
- each signature-based element of subject domain one-to-one corresponds either indicating its key node of semantic network or indicating element of alphabet of semantic network.

For a description of the formal model of subject domain in knowledge base, let's consider the ***Subject domain of subject domains and its ontology***. The composition of ***Subject domain of subject domains*** include structural specification of the *subject domains*, included in knowledge base of *ostis-system*, including ***Subject domain of subject domains*** itself. Thus, ***Subject domain of subject domains***, at first, is a reflexive set, secondly, reflexive subject domain, that is, *subject domain*, one of the objects of research is itself.

In terms of representation in the knowledge base, there is any ***subject domain*** is a result of integration (association) partial semantic neighborhoods, describing all the investigated entity of a given class and have the same (common) subject of research (ie the same set of relations, which should include connectors, included in *integrable semantic neighborhoods*).

The concept of ***subject domain*** is the most important methodological techniques to select from the World only a certain class of the researching entities, and only a certain family of relations defined on the specified class. That is done localization, focusing only on that, abstracting from the rest of researching world [4].

Any ***subject domain*** from the formal point of view is a structure.

More detailed relations that define the role of elements in subject domain considered in papers [4], [11].

On Figure 1, the example of fragments of structural specifications of ***Subject domain of triangles*, *Subject domain of rounds and circles*** and ***Subject domain of inscribed planar***

figure shows the principle of correlating concepts with subject domains. The figure shows that the concept of a *triangle, right-angled triangle, equilateral triangle, obtuse triangle, an isosceles triangle, the median ratio*, congruence*, bisector*, side** and the concept of the *area* are the key to the ***Subject domain of the triangles***. However, the concept of the triangle and areas are studied in other subject domains (***Subject domain inscribed planar figures*** and ***Subject domain of rounds and circles***) and performing other roles in them. Accordingly, during knowledge base process developers have to take into account the requirement of coordination concepts ***triangle*** and ***area***.

Following set-theoretic relations can be defined on the set of subject domains: *inclusion * union*, intersection*, decomposition*, homomorphism*, isomorphism **, as well as the special relations, which domain is set of *subject domains*.

particular subject domain* - binary oriented attitude, used to specify a hierarchy of domains by transforming from less detailed to more detailed consideration of the researching concepts. An example of a hierarchical structure of subject domains is shown on Figure 2 by the example of the structure of ***Subject domain of Euclidean geometry***.

Particular subject domain can be selected according by two criteria:

- ***particular subject domain by primary elements class**** - restriction of the subject domain in the class of primary elements;
- ***particular subject domain by researching relations**** - restriction of subject domain by the subject of research.

Connections of relations ***unrelated subject domains**** connects two subject domains that have common elements, but are not related by relation *particular subject domain**.

Considered above relations are special case of the relation ***meta-knowledge****.

Each ontology is a specification of subject domain, ie, specification of a system of concepts used in this subject domain. The concept of ontologies discussed in the ***Subject domain of ontologies***.

The relation between subject domain and its ontology is defined by relation *ontology**, which is a special kind of *meta-knowledge** relation.

Depending on the considered properties of concepts of subject domain, that are described in the ontology, distinguish the following types of ontologies:

- ***structural specification*** - is ontology, which describes the role of concepts included in the subject domain, as well as connections of specifiable subject domains to other subject domains
- ***set-theoretical ontology*** - is ontology that describes the set-theoretic relations between the concepts of subject domain (inclusion, partition, union, intersection, set difference, domain, domain name, function)
- ***logical ontology*** - is ontology, which is a description of the system of statements of given subject domain
- ***logical hierarchy of concepts*** - is ontology is built on the logical ontology, including the description of system of definitions of concepts for a given subject domain, indicating a set of concepts, through which is determined each defined concept of subject domain
- ***logical hierarchy of statements*** - is ontology is built on logical ontology includes description of system of the subject domain, indicating a set of statements, through which can be proved every statement
- ***terminological ontology*** - is ontology that describes the system of major and minor terms (names, external symbols) corresponding absolute concepts and relations of a given subject domain, as well as description of the rules of terms construction for entities that are members (instances) of these concepts and relations
- ***ontology of tasks and solutions*** - is ontology that describes the problem and their classes solved in the subject domain
- ***ontology of task classes and solution methods*** - is an ontology that describes ways to solve problems and their classes within the subject domain. It is built on the ontology of problems and classes of problems
- ***integrated ontology*** - is ontology, combining all ontologies of different kinds of a certain subject domain

To provide formal representation in the knowledge base of different kinds of knowledge has been selected a number of subject domains and their ontologies. Data of ontology refers to the ***top-level ontologies*** [45], because they are basics for structuring and description of all kinds of knowledge.

These subject domains include:

- *Subject domain of entities*
- *Subject domain of sets*
- *Subject domain of connections and relations*
- *Subject domain of parameters and values*
- *Subject domain of numbers and numerical structures*
- *Subject domain of logical formulas and logical ontologies*
- *etc.*

IV. The ontological model of team of knowledge bases design

In this section, we consider ***Subject domain of activities aimed at the development and evolution of the knowledge base*** and its *ontology*. Objects of research of this subject domain are the processes of *sc-models design of knowledge bases of ostis-systems*. It is important to build it in such a way as to minimize the complexity of the design process, at the same time, ensuring the high quality of the developed knowledge bases.

The process of development of *sc-model of knowledge base of ostis-system* is the formation *of* ***proposals for editing*** of a knowledge base section by *developers* and the review of these proposals by *administrators*, if necessary - by experts, as well as in individual cases by *managers* of corresponding projects.

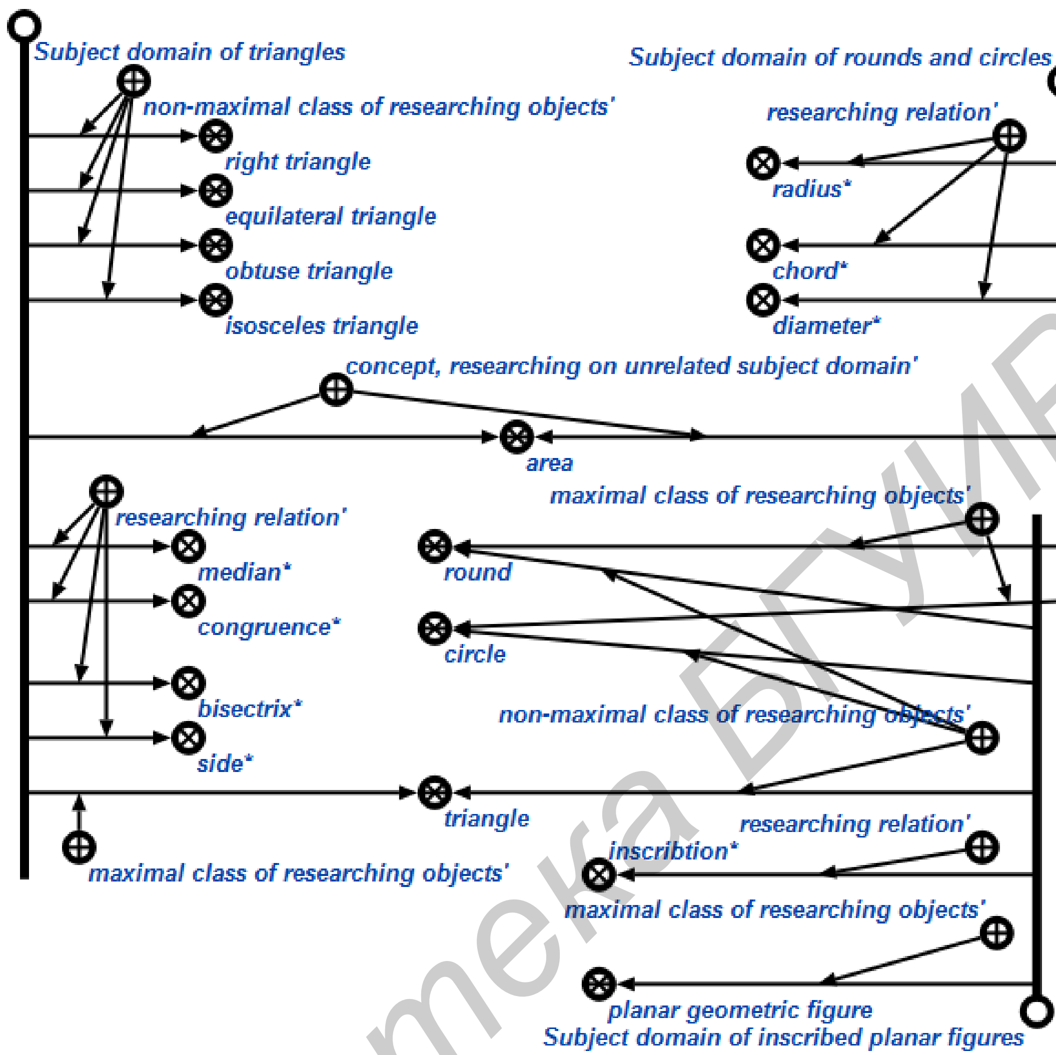

Figure 1. Specification of subject domains

A. Typology of developer of ostis-systems

Consider typology of users of ***ostis-system***.

All users of any ostis-systems are divided into ***registered users**** and ***unregistered users****.

user*
= *user of ostis-system**
∈ *binary relation*
∈ *non-role relation*
<= *partitioning*:*
{
- *unregistered user**
- *registered user**

}

unregistered user* - a *binary relation* which connects *ostis-system* and *sc-element* denoting *a person* who does not pass the registration process in the system.

Unregistered user has read access to the subject part of the knowledge base of *ostis-system*. This type of user can work with *ostis-system* in operation mode, ie, can only ask questions, addressed *the subject part of the knowledge base (ie the subject tasks)*.

registered user* - *a binary relation* which connects *ostis-system* and *sc-element* denoting a person that has passed the registration process in the system.

Registered user has read access to the whole knowledge base and making suggestions to the whole knowledge base, can perform the role of the finite user of *ostis-system*, ie work in the mode of operation and the role of its developer. At the same time independent of the role performed by a particular user, it may make an offer to edit any part of the knowledge base, which, depending on its level will either be accepted automatically, or will be considered separately.

Other user type is selected among the registered users - ***developer*.***

developer* - a *binary relation* that relates a *knowledge base section of ostis-system* (in the limit - the whole knowledge base) and *sc-element* denoting *a person*, which may be a

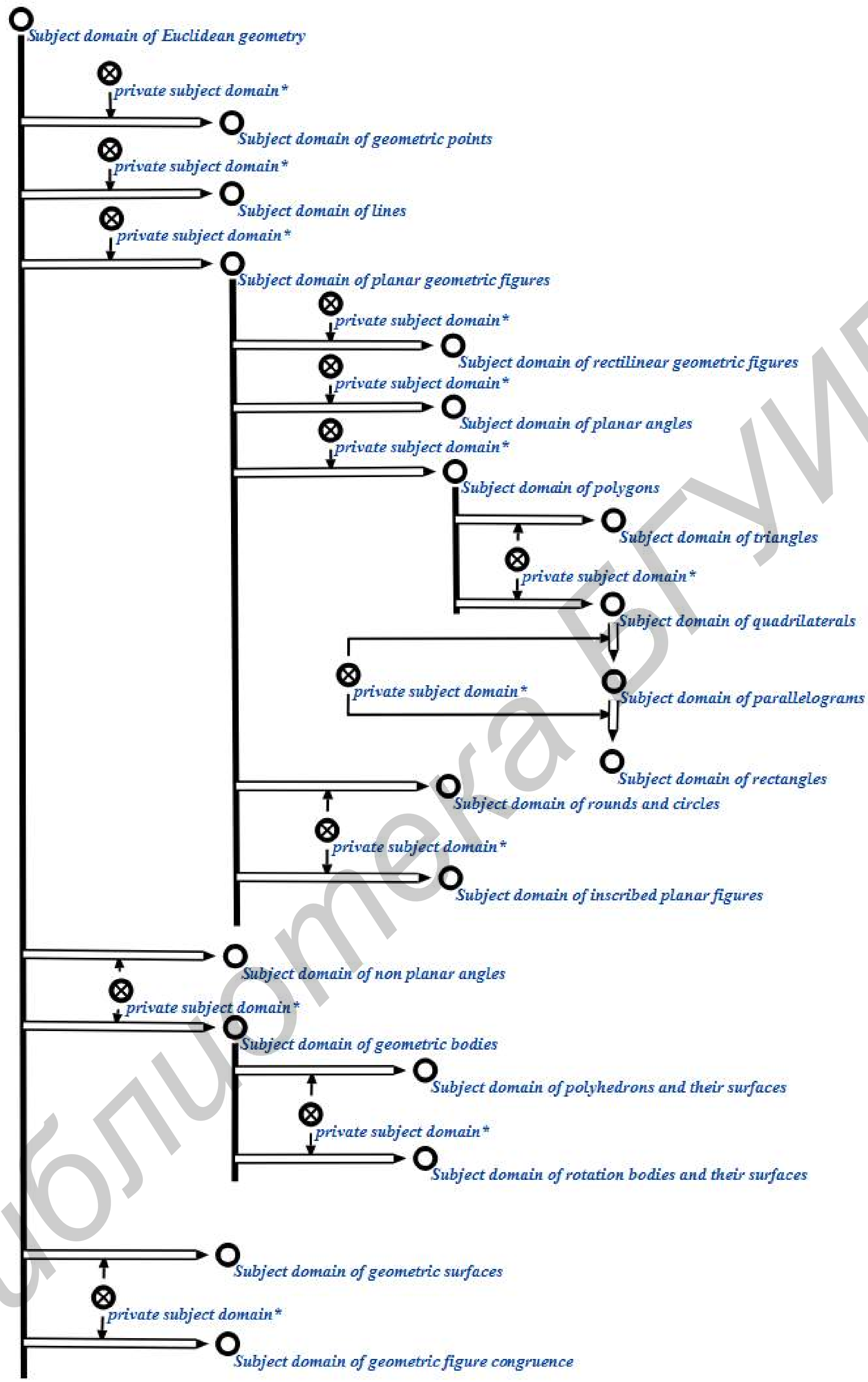

Figure 2. Hierarchical structure of Subject domain of Euclidean geometry

developer of the knowledge base section, i.e. perform design tasks under this section.

Besides *ostis-system* operation ***developer**** can make proposals for editing of any part of the knowledge base, adding comments to the proposals for editing of knowledge base. Among developers selected such roles as ***administrator****, ***manager**** and ***expert*.***

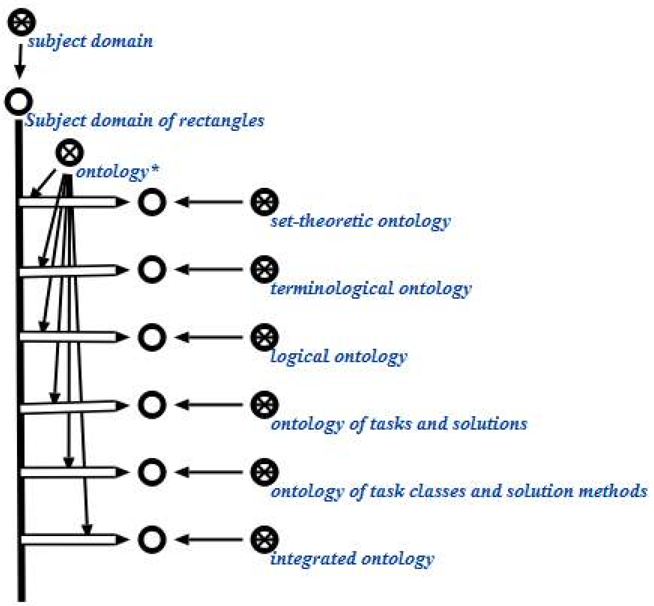

Figure 3. Ontologies of Subject domain of rectangles

developer*
=> *inclusion**:*
- *administrator**
- *manager**
- *expert**

administrator* - a *binary relation* that relates a *section of knowledge base of ostis-system* (in general case - the whole knowledge base) and *sc-element* denoting the *person* who is an administrator *of the knowledge base section*.

There are tasks of ***administrator****:

- control of the integrity and consistency of the whole knowledge base;
- definition of access levels of other users;
- decision making the acceptance or rejection of proposals in different parts of the knowledge base, including, if necessary, send them for examination;
- independent making changes in different parts of the knowledge base through using editing command (in this case the changes are automatically made out as suggestions and are recorded in *history of ostis-system development*).

manager* - a *binary relation* that connects a knowledge base section of *ostis-system* (in general case - the whole knowledge base) and sc-element denoting *the person* who is the manager of *the knowledge base section*.

Tasks of ***manager**** are:

- planning of capacity of work on knowledge base design;
- detailed division of tasks into subtasks, directly formulation of project objectives, setting performers of project objectives;
- setting priorities and timing of work on design of knowledge base;
- control the timing of performing of project objectives.

manager* makes changes to the part of the section describing the project tasks, using the appropriate editing command (in this case the changes are automatically made out as suggestions and are recorded in section *project of ostis-system. History, current processes and development plan ostis-system*). Thus, the ***manager**** is *administrator** of section *history, current processes and plan of computer system development*.

expert* - a *binary relation* that relates *knowledge base section of ostis-system* (in general case - the whole knowledge base) and *sc-element* denoting *the person* who is an expert of *the knowledge base section*.

Tasks of ***expert**** are:

- verification and testing results of the implementation of project tasks;
- if necessary, an expert can add comments to any fragment of knowledge base regarding to its correctness. All comments fall into *plan of computer system development*.

B. Typology of actions of knowledge base developers

During the development process of *sc-model of knowledge base of ostis-system*, each of the users participated in design uses a specific set of commands. Each command corresponds to a certain class of *actions in sc-memory* [28]. All these actions are combined into a common *class* ***action of developer of unified semantic models of knowledge bases***, which are considered in Subject domain of activities aimed at the development and evolution of knowledge base [10].

Consider the typology of such actions:

action of developer of unified semantic models of knowledge bases
<= *inclusion**:*
action in sc-memory
=> *inclusion**:*
- *action of expert of knowledge base*
- *action of administrator of knowledge base*
- *action of manager of knowledge base*
- *action of developer of knowledge base*

action of developer of knowledge base
=> *inclusion**:*
- *action form project task proposal*
- *action.form new fragment for inclusion in knowledge base*

action of developer of knowledge base* can be performed by any *registered user** of ostis-system*, including, if necessary, administrator or manager.

action. form knowledge base editing proposal
=> *inclusion**:*
- *action. form project task proposal*
- *action. form project task executor proposal*

<= *inclusion*:*
action of developer of knowledge base

It is supposed that in the case of approval of the proposal, this structure will be integrated into the appropriate section of knowledge base, and, if necessary, *action* will be initiated, which signs are included in its composition. The process of formation of the *structure* can be automated using appropriate commands.

Number of classes of actions that are executed only by developers who have additional levels of responsibility, ie *administrator**, *manager** and *expert** of knowledge base is highlighted among actions of ordinary developers. It includes: ***action. approve knowledge base editing proposal*** and ***action. to reject the proposal for editing knowledge base*** that can be performed by ***expert, manager and administrator*** of the knowledge base, depending on the additional conditions.

action of administrator of knowledge base
=> *inclusion*:*
- *action. consider knowledge base editing proposal*
  => *inclusion*:*
  - *action. consider new project task*
  - *action. consider proposal verification result*
- *action. form task of proposal verification*
- *action. approve proposal verification result*
- *action. reject proposal verification result*

action of manager of knowledge base
=> *inclusion*:*
- *action. form project task proposal*
- *action. consider project task proposed executor*
  => *inclusion*:*
  action. consider new project task

action of expert of knowledge base
=> *inclusion*:*
- *action. verify given structure*
- *action. reject verifying proposal*
- *action. approve verifying proposal*
- *action. form task of proposal verification result considering*

C. Means of proposals specification for editing of knowledge base

Consider the number of relations that are used for specification of *actions of developers of sc-models of knowledge bases and structures* that describe the proposal for editing the knowledge base and researching in ***Subject domain of activities aimed at the development and evolution of the knowledge base***.

proposal* - a *binary relation* that connects the sign of *action. consider knowledge base editing proposal* and the sign of the *structure*, which describes the proposal of editing, for example, contains a fragment for inclusion in the current state of knowledge base.

approved* - a *binary relation* that connects the sign of action for consideration of any proposal for editing knowledge base and sign of user of *ostis-system*, which approved (endorsed) this action. Typically, this *administrator** or *expert** of corresponding project.

rejected* - a *binary relation* that connects the sign of action for consideration of any proposal for editing the knowledge base and sign of user of *ostis-system*, which dismissed the action. Typically, this *administrator** or *expert** of corresponding project.

new version* - *a binary relation* that connects sign of *structure* that describes a proposal for editing the knowledge base and the sign of *structure* denoting the version of the proposal after its completion by performer. The presence of such a connection simplifies and speed up the re-testing of proposals for editing the knowledge base.

D. Tools of the specifications of transients in the knowledge base

During the process of its evolution, the knowledge base is undergoing significant changes. There are the most problematic following changes among these types of are:

1) The knowledge base is required to override already entered and used the concept.
   Consider the situation in the following example. There is concept *square* in geometry knowledge base in the *Subject domain of quadrilaterals*. This concept has been defined through the concept of *rectangle*.
   After some time, the domain expert considered that the concept of the *square* must be defined through the concept of *a rhombus*. The problem is that other fragments of knowledge base and concepts related to the concept of the *square*, should be brought into line with the new concept defined by other concepts.
   In this situation it is necessary to fix the status of changing concept during the transition time of knowledge base - the time when the full knowledge base will be made all the necessary changes related to the overridden concept.
2) There is an alternative concept in knowledge base, which eliminates using of another associated with it.
   Example of this is the following.
   Two sections of geometry knowledge base. *Section. Triangles* and *Section. Quadrilaterals* developed by different developers.
   Concept *side of triangle** was introduced in the *Subject domain of triangles*, connecting a triangle with segment, which is its side.
   In *Subject domain of quadrilaterals*, in its turn, the concept of *side of quadrilateral** introduced connecting rectangle with its side.
   Subsequently, administrator of the section, describing *the polygons* based on the principle of minimizing of the key nodes of knowledge base has decided to introduce a generalized notion of *side of the polygon**. e.g. the developers figure out the conclusion that two previously introduced concepts are redundant, and carry methodological character to define the concepts described.

Following concepts are introduced to solve problems in the situations described above:

concept
<= partitioning:*
{
• *basic concept*
• *non-basic concept*
• *concept, turning from basic to non-basic*
• *concept, turning from non-basic to basic*
}

Basic concepts are concepts which are widely used in the system and can be key elements *of sc-agents*. The ***basic concepts*** are also all undefined concepts.

Each ***non-basic concept*** must be strictly defined by the basic concepts. Such ***non-basic concepts*** are used only for the understanding and appreciation of input information, including, for aligning ontologies. A key element of the sc-agents may not be ***non-basic concepts***.

In the case where a concept completely turned from *the basic concepts* to *non-basic*, that is, become non-basic concept, and the corresponding *basic concept* (through which it is defined) within ab external language there is the same basic identifier with it, then it is added # sign in the front of non-basic concept identifier. If these basic concepts have different identifiers in this external language, no additional means of identification is used.

In the case where the current *basic concept* and the corresponding concept, turning from non-basic to basic the same basic identifier in external language with non-basic concept, then $ sign is added the to the basic. If these basic concepts have different identifiers in this external language, no additional means of identification is used.

V. The ontological model of subsystem of support of team knowledge bases design

OSTIS technology embodied in the form of Intelligent ***Metasystem IMS*** (Intelligent MetaSystem) [34], which is also built on OSTIS Technologies. At each time point metasystem includes accrued and formalized models by this moment, tools and techniques for design of intelligent systems using *OSTIS Technologies*.

In general, the *IMS* system as the parent system interacts with all its *subsidiaries sc-systems* (with systems built using *OSTIS Technology*), ensuring the system will automatically update subsidiaries versions of reusable components of OSTIS [27]. Any subsidiary system based *on OSTIS Technology* acts as an intermediary between the developer of the system and *IMS* system. The developer can choose component based on interest or set of components in one of the libraries and include them in the developed subsidiary system.

Each ***reusable component of sc-model of knowledge bases*** is a *structure* or explicitly represented in the current state of *sc-memory*, or not fully formed *structure*, which if necessary can be completely formed by combining its parts, indicated by *decomposition relations*, such as a *partitioning** or *inclusion** relations.

Integration of ***reusable component of sc-model of knowledge bases*** into the subsidiary system is reduced to gluing key nodes by identifiers and elimination of possible duplications and contradictions that could arise if the developer of subsidiary system manually made any changes in its knowledge base.

The main types of reusable components of knowledge bases stored in the library components of knowledge bases, include:

- ontologies of various subject domains that can be different in content, but must be semantically compatible;
- basic fragments of theories, corresponding to different levels of user's knowledge: from basic school level to the professional;
- semantic neighborhood of different entities;
- specifications of formal languages descripting various subject domains.

To ensure semantic compatibility of knowledge bases components, which are unified semantic models, it's required:

- to approve semantics of all used key nodes;
- to approve basic identifiers of the key nodes used in different components. After that, the integration of all the components that are part of the library, and in any combination is carried out automatically, without the intervention of the developer.

Another aspect of support of knowledge base design is support of activities of developers of knowledge bases already in the process of developing the knowledge base of *subsidiary ostis-system*. For this purpose the ***support subsystem of knowledge bases design team*** is used, tasked with information and technical support of activities of the team of knowledge base developers, including - ensuring the correct and effective implementation of all stages of the envisaged method of designing knowledge bases.

Ontological model of support subsystem of knowledge bases design team includes:

- ***ontological model of knowledge base of support subsystem of knowledge bases design team***;
- ***ontological model of the machine processing of knowledge of support subsystem of knowledge bases design team***;
- ***ontological model of the user interface of support subsystem of knowledge bases design team***.

Ontological model of knowledge base of support subsystem of knowledge bases design team includes sections covering:

- set of top-level ontologies needed for the operation of the subsystem itself and are the basis for the construction of sc-model knowledge bases of *subsidiaries ostis-systems* [27];
- typology of system developers, typology of actions of developers, as well as the formal tools of specification of proposals for knowledge base editing.

Ontological model of knowledge processing machine support subsystem of team knowledge bases design includes a *sc-agents* of the following types:

Knowledge processing machine of support subsystem of team knowledge bases design
∈ non-atomic abstract sc-agent
<= abstract sc-agent decomposition:*
{
- *Abstract sc-agent of knowledge bases verification*
- *Abstract sc-agent of knowledge bases editing*
- *Abstract sc-agent of automation of activity of sc-model of knowledge bases developer*
- *Abstract sc-agent of automation of activity of knowledge base administrator*
- *Abstract sc-agent of automation of activity of knowledge base manager*
- *Abstract sc-agent of automation of activity of knowledge base expert*
- *Abstract sc-agent of calculations of knowledge base characteristics*

}

Abstract sc-agent of knowledge bases verification - the group of agents responsible for verifying the correctness and completeness of the knowledge base.

Abstract sc-agent of knowledge bases editing - a group of agents that provide automation knowledge base editing.

Abstract sc-agent of automation of activity of sc-model of knowledge bases developer - the agents that implement the mechanisms of interaction between the developer knowledge base and design support subsystem.

Abstract sc-agent of automation of activity of knowledge base administrator - agents that implement the mechanisms of interaction between administrator of knowledge base and design support subsystem.

Abstract sc-agent of automation of activity of knowledge base manager - agents that implement the mechanisms of interaction between manager of knowledge and design subsystem design support.

Abstract sc-agent of automation of activity of knowledge base expert - agents that implement the mechanisms of interaction between an expert of knowledge base and design support subsystem.

Abstract sc-agent of calculations of knowledge base characteristics - group of agents that implement the calculation of quantitative and qualitative characteristics of knowledge bases.

User interface of system of support of knowledge base design represented by a set of interface commands that allow developers to initiate activities of required agent, which is a part of this system. [17] This set of fully corresponds to set of agents of knowledge processing machine considered above.

VI. Conclusion

In this paper we consider the ontological approach to the design of knowledge bases based on knowledge representation as a hierarchical structure of interconnected domains and ontologies. Using this approach allows to:

- provide an opportunity for representation of all kinds of knowledge within a unified platform-independent knowledge base;
- reduce the complexity and development time of knowledge base design by:
  - enable possibility of team development of knowledge bases;
  - minimize the number of agreements during the process of team development;
  - using of reusable components of knowledge bases;
  - using of unificated methods of design of knowledge bases and their components;
- increase the clarity and learning level due to their structuring.

The developed support system of knowledge bases design team allows to automate the design, verification and optimization of the knowledge base design process, reduce the number of errors that occur and their elimination time.

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ОНТОЛОГИЧЕСКОЕ ПРОЕКТИРОВАНИЕ БАЗ ЗНАНИЙ

Давыденко И.Т.

В настоящее время актуальной является задача эффективного информационного обеспечения различных отраслей человеческой деятельности. Увеличение объемов информации привело к необходимости создания хранилищ знаний, обеспечивающих структуризацию и систематизацию хранимых знаний, а также их эффективную обработку.

Одним из наиболее перспективных направлений в данной области является разработка систем, основанных на знаниях [46]. Ключевым компонентом таких систем является база знаний. Качество разрабатываемой системы такого класса определяется, в том числе, качеством базы знаний и разнообразием видов знаний, хранимых в ней.

Разработка базы знаний является трудоемким и продолжительным процессом. Соответственно, актуальной является задача сокращения сроков разработки и обеспечения эффективности поддержки жизненного цикла баз знаний.

Можно выделить следующие пути сокращения сроков и снижения трудоемкости разработки баз знаний:

- обеспечение совместной разработки баз знаний распределенным коллективом разработчиков [12];
- автоматизация деятельности разработчиков баз знаний;
- повторное использование уже разработанных фрагментов баз знаний [30], [36], [1], [47], [33], [7].

Однако, полностью автоматизировать процесс разработки базы знаний невозможно, поскольку некоторые этапы, такие, например, как формирование системы понятий, требуют согласованных усилий некоторого числа разработчиков и экспертов и носят субъективный характер.

Важным этапом разработки базы знаний является ее структуризация. Структуризация базы знаний, т.е. выделение в ней различных связанных между собой подструктур необходимы по целому ряду причин [3]. В частности, это необходимо для дидактических целей (человеку, усваивающему некоторые знания, желательно иметь, своего рода оглавление этих знаний, что позволяет планировать их усвоение и рассматривать их с различной степенью детализации), а также для организации распределения работ по проектированию баз знаний (когда разным исполнителям поручается разработка разных фрагментов базы знаний, имеющих достаточно четкие границы).

Целью данной работы является разработка унифицированных семантических моделей баз знаний и средств их коллективной разработки, основанных на онтологической структуризации баз знаний, что позволяет снизить трудоемкость и сроки их разработки и модернизации.

Среди проблем в области разработки баз знаний выделяются следующие:

- Отсутствие средств унификации любых видов знаний и моделей представления знаний в рамках одной базы знаний
- Отсутствие формальных средств структуризации, позволяющих представить базу знаний на различных уровнях детализации
- Отсутствие единого подхода к выделению повторно используемых компонентов баз знаний и формированию библиотек таких компонентов, что приводит к наличию большого числа несовместимых уже разработанных компонентов баз знаний; [33]
- Высока трудоемкость модернизации баз знаний и их сопровождения (некоторые изменения, вносимые в базу знаний, могут повлечь необходимость внесения существенных изменений в саму структуру базы знаний)
- Несмотря на наличие достаточно развитых средств проектирования баз знаний, все еще отсутствуют средства, обеспечивающие комплексную поддержку коллектива разработчиков на всех стадиях проектирования базы знаний, обладающие, в свою очередь, достаточной гибкостью и расширяемостью. Кроме того, все существующие средства ориентированы, как правило, на какой-либо конкретный формат хранения знаний, что затрудняет перенос уже разработанной базы знаний на другую платформу интерпретации.

На сегодняшний день существуют десятки моделей представления знаний, однако большинство из них можно свести к основным четырем: семантические сети, фреймы, продукционные и логические модели [2]. Однако, каждая из указанных моделей представления знаний адаптирована для представления знаний определенного вида, в то время как при создании интеллектуальных систем часто возникает необходимость представить различные виды знаний в рамках одной базы, чего не может обеспечить ни одна из вышеперечисленных моделей, взятых в отдельности. [15] [13] В связи с этим возникает необходимость в создании универсальной модели представления знаний, которая позволила бы представлять любые виды знаний в унифицированном виде.

Ключевым моментом в процессе структуризации знаний является формирование системы основных понятий предметной области [3]. В настоящее время при разработке систем, основанных на знаниях, широко распространено использование стандартов консорциума W3C [43]. Его задачей является разработка стандартов в области Semantic Web [43], [25]. В частности, данным консорциумом был разработан язык описания онтологий OWL [39] и язык представления знаний в виде семантических сетей RDF [40]. Также разработаны эффективные хранилища баз знаний на основе RDF, обеспечивающих хранение и доступ к данным средствами языка запросов SPARQL [42]. Для редактирования онтологий создано большое число редакторов, обладающих довольно широким функционалом. [38]

Однако, несмотря на развитие проекта Semantic Web и связанных с ним средств, значительная часть ресурсов Web все еще не содержит семантической разметки и метаданных. Исключением являются семантические ресурсы, которые разрабатываются на основе Wiki-Технологии [44] и становятся все более популярными.

Wiki-Технология позволяет накапливать знания, которые представляются в интероперабельной форме, обеспечивая навигацию по знаниям. Использовать Wiki-Технологию возможно для проектов любого масштаба и тематической направленности (от открытых электронных энциклопедий, до справочных систем различных предприятий и учебных заведений). [21]

Wiki-Технология предоставляет своим пользователям средства хранения, структуризации текста, гипертекста, файлов и мультимедиа. Wiki-технология использует в качестве инструмента платформу MediaWiki [37], которая позволяет осуществлять информационное взаимодействие, обеспечивать доступ к информационным ресурсам всем участникам процесса разработки системы, организовывать управление и наблюдение за разработкой. [6] Среди достоинств данной технологии можно выделить простоту wiki-разметки, коммуникативные возможности, которые реализуются через совместное редактирование страниц, а также посредством электронных обсуждений в wiki или дополнительных средах, таких как чат или форум, проектный характер работы, сотрудничество, формирование единого продукта совместной деятельности обеспечивают содержательное взаимодействие, обмен знаниями, оценку и постоянное совершенствование работ. [21]

Влияние Semantic Web на подобные проекты постоянно возрастает, вследствие чего были созданы движки Wiki-сайтов, которые поддерживают онтологическое представление знаний и семантическую разметку ресурсов при помощи средств Semantic MediaWiki [41]. Данные средства позволяют включать семантические аннотации в Wiki-разметку в виде OWL и RDF и явно разделять структурированную и неструктурированную информацию. [21]

Кроме указанных достоинств, Wiki как технология имеет ряд недостатков: дублирование информации на различных страницах, невозможность структурирования знаний ввиду отсутствия иерархии гиперссылок и отсутствия унификации представления информации, отсутствие возможности автоматической верификации.

В данной работе идеи Технологии Wiki получили свое развитие, однако предпринята попытка устранить указанные проблемы. Вопросам разработки и структуризации баз знаний также посвящены следующие исследования:

- Базы знаний и управление знаниями [2], [3]
- Фрактальная модель структурирования знаний, основанная на представлении разных форм (видов) знаний как объектов расслоенного (стратифицированного) пространства [19]
- Технология разработки порталов инженерных знаний, обеспечивающих выполнение сложных инженерных расчетов [8]
- АТ-Технология [23]
- Технология разработки облачных интеллектуальных сервисов на базе платформы IACPaaS – Intelligent Application, Control and Platform as a Service [9]
- Технология разработки порталов научных знаний [13], [14]

На сегодняшний день разработано большое число баз знаний по самым различным предметным областям [29]. Однако большинство из них не являются хорошо структурированными, согласованными и совместимыми между собой.

В основе предлагаемых моделей лежат следующие основные принципы открытой семантической технологии проектирования интеллектуальных систем OSTIS (Open Semantic Technology for Intelligent Systems) [34]:

- использование онтологического подхода к проектированию баз знаний, что предполагает структуризацию базы знаний на основе онтологий;
- поэтапное эволюционное проектирование баз знаний;
- ориентация на коллективное проектирование баз знаний в рамках проекта;
- ориентация на семантическое представление знаний;
- унификация моделей баз знаний интеллектуальных систем;
- модульное проектирование на основе библиотек типовых многократно используемых компонентов.

Технология OSTIS ориентирована на разработку компьютерных систем, управляемых знаниями – систем, в основе каждой из которых лежит представленная унифицированным образом база знаний, содержащая в систематизированном виде всю информацию, используемую этой системой [4]. В рамках данной работы системы, управляемые знаниями, построенные по Технологии OSTIS, будем называть ostis-системами.

Для решения указанных выше проблем необходимо решить следующие задачи:

- разработать унифицированные семантические модели представления различных видов знаний, основанные на онтологиях
- разработать онтологические модели структуризации баз знаний
- разработать онтологические модели коллективного проектирования баз знаний,
- разработать подсистему поддержки коллективного проектирования баз знаний, включающую средства автоматизации деятельности разработчиков, средства редактирования баз знаний, средства автоматизации верификации баз знаний.

В данной работе предлагается использовать в качестве формальной основы для представления знаний способ представления знаний в виде семантических сетей с базовой теоретико-множественной интерпретацией, позволяющих описывать как знания, относящиеся к предметной области (включая и метазнания, и простой переход от знаний к метазнаниям), так и процедуры их переработки. Указанный способ является базовым в рамках Открытой семантической технологии проектирования интеллектуальных систем (OSTIS). Соответственно был разработан способ кодирования таких семантических сетей – SC-код (Semantic Code). Использование данного подхода к представлению знаний обусловлено его универсальностью, а также возможностью неограниченного перехода от знаний к метазнаниям и рядом других достоинств [4], [5].

Онтологический подход к проектированию баз знаний подразумевает разработку:

- онтологической модели разрабатываемого артефакта, т.е. онтологической модели базы знаний
- онтологии проектной деятельности, направленной на разработку баз знаний, т.е. формального описание методики проектирования баз знаний
- онтологическую модель инструментальных средств поддержки проектирования баз знаний, т.е. формальное описание модели подсистемы поддержки проектирования баз знаний.

Под базой знаний ostis-системы будем понимать конечную информационную конструкцию, являющуюся формальным представлением всех знаний, достаточных для функционирования некоторой компьютерной системы и хранимых в памяти этой системы [4].

В основе разработки баз знаний с помощью технологии OSTIS лежит четкое разделение процесса проектирования формального описания семантической модели, разрабатываемой базы знаний от процесса реализации (интерпретации) этой модели на той или иной платформе [4]. Достоинством такого подхода к проектированию баз знаний является независимость такой реализации от платформы, т.е., разработав только лишь семантическую модель базы знаний, появляется возможность реализовывать эту модель на различных платформах, не изменяя при этом саму модель. Формальные модели баз знаний, представленные в SC-коде будем называть sc-моделями баз знаний.

Суть онтологического подхода при проектировании базы знаний заключается в рассмотрении структуры базы знаний как иерархической системы выделенных предметных областей и соответствующих им онтологий, в частности, онтологий классов решаемых задач, что позволяет сузить область поиска путей решения конкретной задачи, ограничивая ее рамками конкретной предметной области. Это справедливо как в случае автоматического решения задач системой, так и в случае выполнения разработчиками проектных задач. Во втором случае такой подход позволяет минимизировать зависимость процесса разработки одних компонентов базы знаний от других. В тех случаях, когда в процессе решения некоторой задачи задействованы понятия из разных предметных областей, требуется согласование указанных понятий. Одной из задач при формировании структуры конкретной базы знаний и набора предметных областей является минимизация ситуаций такого рода. Кроме того, существенным достоинством использования онтологий при разработке баз знаний является возможность повторного использования уже разработанных компонентов баз знаний, что также сокращает время разработки баз знаний.

Рассмотренный в работе онтологический подход к проектированию баз знаний, базирующийся на представлении базы знаний как иерархической структуры взаимосвязанных между собой предметных областей и их онтологий, позволяет:

- обеспечить возможность представления любых видов знаний в рамках одной базы знаний унифицированным не зависящим от платформы образом;
- снизить трудоемкость и сократить сроки разработки баз знаний за счет:
  - обеспечения возможности согласованной коллективной разработки баз знаний;
  - минимизации числа согласований в процессе такой коллективной разработки;
  - использования многократно используемых компонентов баз знаний;
  - использования унифицированной методики проектирования баз знаний и их компонентов
- повысить уровень понятности и усвоения знаний за счет их структуризации.

Разработанная система поддержки разработчиков баз знаний позволит автоматизировать процесс разработки, верификации и оптимизации базы знаний, уменьшить количество возникающих ошибок и времени на их устранение.

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