OSTIS Glossary — the Tool to Ensure Consistent and Compatible Activity for the Development of the New Generation Intelligent Systems

Nikita Zotov, Tikhon Khodosov, Mikhail Ostrov, Anna Poznyak, Ivan Romanchuk,
Kate Rublevskaya, Bogdan Semchenko, Daria Sergievich, Artsiom Titov, Filip Sharou
Belarusian State University of
Informatics and Radioelectronics
Minsk, Belarus
Email: n.zotov@bsuir.by

***Abstract*—This paper includes a detailed analysis of the problems of organising various types of collective activities, a comparative analysis of current solutions to ensure the consistency and compatibility of information from different knowledge areas, as well as an analysis of methods and technologies for creating unified information spaces to ensure consistent and compatible storage, processing, accumulation and dissemination of knowledge. The paper proposes one of the options for realising a unified information resource to ensure consistent and compatible activities in the development of new generation intelligent computer systems — the *OSTIS Glossary*. It describes its structure, rules of structuring, placement and identification of knowledge in it, as well as its operating principles.**

Keywords*—problem of mutual understanding, knowledge unification, knowledge convergence and integration, knowledge consistency, semantic knowledge compatibility, knowledge standardisation, interdisciplinary synthesis, consistency and compatibility of activities, Artificial Intelligence, semantic knowledge representation, semantic web, knowledge base, intelligent system, scientific knowledge portals, *OSTIS Glossary*, *OSTIS Standard

I. Introduction

In the era of information society, the problem of mutual understanding between people is becoming more and more acute. Due to the existing inconsistency in the definition of terms of concepts, people not only do not understand each other, but (!) also do not have the necessary means to communicate with computer systems and create collectives of computer systems that understand each other [1], [2].

First of all, the reason for this problem lies in the form of information representation and the means by which this information is presented, accumulated, processed, distributed and visualised [1], [3], [4]. As the amount of information increases, not only the number of different forms of representing this information [5] grows, but also the number of different tools and methods to support them.

In addition, due to the rapid development of information technology and the emergence of new fields, knowledge can quickly become outdated or may not correspond to reality and current needs. Therefore, it is important to constantly update and clarify terminology, establish common standards and rules for the use of terms to reduce the likelihood of inconsistency of concepts.

At the current stage of information technology development, the problem of information inconsistency is solved with the help of integrated repositories in the form of reference books, encyclopaedias, standards and online resources. However, even with the use of these tools, the problem of conceptual inconsistency remains relevant for several [1] reasons:

- In different fields of knowledge, terms of concepts often have different meanings, leading to misunderstandings between the people using these terms [5].
- The understanding of the terms of concepts may vary from person to person depending on their experience, education and culture.
- With the development of the internet and digital technology, information has become more accessible. Among the variety of information available, it is often difficult to understand which term is used in which context, what its exact meaning is, and to which field it belongs.
- There are many sources of information, some of which may be inaccurate, distorted or misinforming [6].
- Modern natural languages are constantly evolving, the terms of concepts in them are rapidly changing their meanings or acquiring new ones depending on context and usage, which complicates the task of creating information resources, such as encyclopaedias or reference books, which could fully reflect the unified meaning of terms [1].

- There is a problem of translating terms of concepts from one language to another, which also leads to misunderstanding and misuse of these terms.
- Concepts are described and represented in different ways, which makes it difficult for both humans and computer systems to use them in problem solving [7], [3].

Most often the main problem is not the concepts themselves, but (!) the terms of the concepts with which we name these concepts. All the above problems are related not so much to the current capabilities of the technology as to the current state of modern information technologies and the means realised by them. To solve these problems, it is necessary to switch to methods and technologies of a new level [3], namely:

- to develop standards for the unified interpretation of concepts and their terms in different fields of knowledge;
- to create and implement accessible, unified, integrated information resources that are continuously updated and adaptable to changing meanings and contexts of the terms of concepts;
- to develop the conditions and capabilities to build collectives of people and computer systems and to enable them to enhance their understanding, agreement and coordination capabilities;
- to create and implement human-centred systems that reduce the requirements and improve the conditions for their adaptation and knowledge acquisition.

In simple words, to solve these problems it is necessary to comprehensively standardise the existing terminologies [3], [4] used in various fields of knowledge and to create a unified information space for quick access to information in it, as well as the possibility of using and processing this information not only by a human but also by computer systems [4], [8].

The objective of this paper is to address these issues by creating a single ***integrated glossary*** that can be used to:

- to provide a single source for the interpretation of concepts from different fields of knowledge;
- to provide a single source for obtaining relevant and reliable information;
- to integrate knowledge from different information sources;
- to systematise concepts and the links between them in the form of hierarchies of these concepts;
- to unify the representation form of concepts and their terms, i.e. to describe concepts in the same language understandable both to a human and a computer system;
- to standardise the descriptions of these concepts and their terms by introduction and consistent use of common rules for their identification, specification and placement;
- to provide collective consistency and supplement of existing concepts and introduction of new ones;
- to provide open access to all knowledge and facilitate its exchange;
- and, finally, to develop semantically compatible intelligent systems of various kinds.

Such an integrated glossary needs to be developed as an intelligent system, which will provide:

- usability of this glossary, for example, will allow to explain the difference between terms, to give advice, to automate (!) the search for synonyms and homonyms on the basis of some secondary features, and so on;
- convenience of this glossary development, which will allow not only to collectively develop such a glossary, but (!) also will help the system to improve itself.

In the next section we will consider in detail the main problems associated with the organisation of various types of collective activity and the problems associated with the representation, processing, accumulation and transmission of information, since these are the problems that are the object of study in this paper.

II. Analysis of modern solutions to the problems of consistency and compatibility of different types of activities

A. History of the development of the problem of consistency and compatibility of different activities

To understand modern problems of consistency and compatibility of different types of activities it is necessary to consider the problems associated with the presentation, processing and application of different kinds of information, namely, it is necessary to study the history of the development of society in the direction of improving the ways of interaction between people, organisation of their activities and ways of transferring and accumulating knowledge from the older generation of people to the new generation.

As far back as in ancient times, people began to face the problem of understanding each other. First of all, the need to understand each other was the need for self-preservation (survival) in the environment of similar people. The only way of communication between people for a long time remained communication by means of gestures, pictures and other similar means. For a long time people exchanged knowledge with the help of these means. And not all gestures came only from the man himself. Man also perceived the gestures of nature and made strategically important decisions based on them.

With the development of mental capabilities and the increasing needs of each individual, people began to look for more flexible forms to realise their self-preservation (survival) in nature. People began to realise that it is possible to negotiate with each other to achieve a certain goal through mutual benefit. People co-operated and coordinated their actions on the basis of common interests, traditions and customs, which helped to coordinate actions and establish rules of interaction between people. The first languages appeared, in which people could express their thoughts and transmit these thoughts to other people. People began to organise themselves into groups, thanks to which they became stronger among other groups of people and nature in general. In each group, so-called leaders were formed, usually distinguished among other people by their physical and mental abilities. Thus a form of people management appeared — power, with the help of which one person could organise the work of other people. This form of people management has evolved a lot since then.

Today, people manage not just people, but the environment in which they exist: resources, relationships, knowledge, etc. Whereas in ancient times the question of survival was of primary importance to humans, today the main question is how to properly accumulate, organise, use and transfer knowledge from one person to another and from one generation to another generation of people. This question is also related to the question of human survival. If we, people, do not or cannot develop, i.e. accumulate and multiply the knowledge that we have, how will we be able to solve those constantly emerging problems that any person or society faces, how will we be able to build a future in which every person will be happy and will be able to get what he or she wants. Even today, questions about the future of humanity remain a priority and open for discussion.

B. Organisation and consistency of collective activities through standardisation and legal regulations

For a long time of human and social existence, people have invented and realised quite a large number of forms by means of which they can communicate with each other, achieve goals by reaching common understanding and agreement, solve problems, relying on common sources of knowledge that have passed through time. The issue of organising common activities between people remains the most important. It is the coordinated collective activity of people that contributes to the rapid flow of the creative process, which allows to solve problems faster.

Compared to primitive society, the level of organisation is much higher nowadays. Nowadays, people use a great variety of methods and tools to organise and coordinate their activities:

- organisational structures are established within businesses, organisations and public institutions that define the hierarchy, roles and functions of employees;
- information technologies such as e-mail, messengers, video conferencing, project management systems and others are used to exchange information, coordinate actions between people;
- all rules of behaviour and processes within communities are standardised to improve efficiency and ensure the quality of their products or services.

It can be seen that the degree of the consistency of actions is also much higher compared to earlier stages of human development.

Regulations and standards were the first to address the problem of collecting and systematising knowledge, as they represent formalised norms and rules that regulate the behaviour of people and organisations in society. The introduction of regulations and standards helps to create a unified and ordered approach to knowledge organisation and provides a common basis for information exchange.

Regulations and standards enable:

- to ensure unity, accuracy and reliability of information;
- to organise knowledge, i.e. classify and structure information;
- to protect people's rights and interests.

Regulations and standards are documents that establish rules, norms and requirements in a particular area (e.g. product quality standards, building codes, safety regulations, etc.). They are aimed at ensuring uniformity, quality and safety in different areas of activity. The task of any standard in general is to describe a consistent system of concepts (and corresponding terms), business processes, rules and other regularities, ways of solving certain classes of tasks etc.

However, they cannot completely solve all existing problems because:

- Knowledge is constantly evolving and changing, making regulations and standards quickly outdated or unable to adequately reflect new knowledge.
- The process of adding new knowledge is too resource-intensive because adding new knowledge requires searching for similar existing knowledge and manually integrating that knowledge with existing knowledge.
- Modern normative legal acts and standards describe only rather narrowly specialised knowledge, when the rest of knowledge is not standardised in any way. That is, the question of interdisciplinary organisation of knowledge remains open.
- The most urgent problem remains the problem related not to the form, but to the essence (semantics) of standards - the problem of inconsistency of systems of concepts and terms between different standards, which is relevant even for standards within the same field of activity.

C. Use of common encyclopaedias in organising and coordinating collective activities

In addition to regulations and standards, there are encyclopaedias [9] and dictionaries that cover knowledge from different subject domains and are interdisciplinary

[10]. Encyclopaedias and dictionaries are designed to integrate information related to a common topic.

Encyclopaedias are reference publications that contain information on a wide range of topics and subjects. They are intended for general familiarisation with different fields of knowledge and may contain general information, historical facts, descriptions of phenomena, etc. The purpose of any encyclopaedia is to collect knowledge scattered across disciplines and bring it into a system understandable to the individual.

While regulations and standards cannot always provide complete information or cover all aspects of a particular topic, encyclopaedias can be useful to provide a broader context or additional information on a given topic. Today, regulations, standards and encyclopaedias complement each other, but are also used for different purposes.

D. Digitalisation of information for simplifying and accelerating the organisation and consistency of collective action

With the development of technology, it has become much easier to describe and popularise knowledge by creating topic-based websites. One of the representatives of this kind of knowledge repository is mathprofi — a site that is a resource describing all topics of school and higher mathematics. There is a large number of such online resources on any topic and subject. In them, information is presented and described in an understandable and accessible form for any untrained reader.

In parallel with the development of sites like mathprofi, there occurred an idea of creating a common repository that brings together all the knowledge of mankind, categorised by topic, and to which any person can add new information.

The most widely used computer encyclopaedia at present is Wikipedia — a publicly available multilingual universal Internet encyclopaedia with free content. Its main advantages are its multilingualism and the possibility for users to add and adjust its content.

Traditional wikis based on this approach have a number of disadvantages, including a lack of content consistency, that is, the lack of uniformity in the presentation and formalisation of this content. In wikis, due to frequent duplication of data, the same information may be contained on several different pages. When this information is changed on one wiki page, users must ensure that the data is also updated on all other pages.

Another disadvantage is the difficulty of accessing the knowledge available on wikis. Large wikis contain thousands of pages. Performing complex search queries and comparing information from different pages in traditional wiki systems is a time-consuming task. Traditional wikis use flat classification systems (tags), or classifiers organised into taxonomies. The inability to use typified properties generates a huge number of tags or categories [9].

Open databases and knowledge bases are promising tools for building and retrieving knowledge. Semantic Web-based open databases and knowledge bases [11] are resources that use Semantic Web principles and technologies to represent and organise data and knowledge in a structured and semantic form [12]. The Semantic Web is an extension of the World Wide Web in which information has semantic meaning that allows computers to understand and process data efficiently and accurately. Examples of such Semantic Web-based databases and knowledge bases are:

- DBpedia — one of the best known Semantic Web projects. It extracts structured data from Wikipedia and presents it in RDF format. DBpedia contains an extensive set of knowledge, including information about people, places, organisations, scientific articles and more.
- Linked Open Data (LOD) is an initiative that aggregates and provides access to open data in RDF format from a variety of sources. LOD brings together data from fields such as geography, biology, culture, economics and others, and makes it possible to share and analyse these data.
- Wikidata is an open knowledge base developed by the Wikimedia Foundation. It contains structured data about various entities, including people, places, books, films, scientific terms, and more. Wikidata uses the RDF language to represent the data and provides an API to access this data.
- Cyc — a project to create an ontological knowledge base that allows computer systems to solve complex Artificial Intelligence problems based on logical inference.
- GeoNames — a geographic database that contains information about places from all over the world. It provides data on geographic coordinates, population, administrative units, geographic objects, and other information. GeoNames uses Semantic Web standards such as RDF and OWL to represent and organise data.
- MusicBrainz — an open source music database that contains information about music artists, albums, tracks and other music-related entities. It uses Semantic Web technologies to organise and represent data, and provides an API to access this data.

The listed databases and knowledge bases also do not solve all the problems that modern Wikipedia has.

Unfortunately, modern traditions of presentation of various kinds of documentation, standards, reports, scientific and technical articles and monographs are not only not oriented to their adequate understanding by intelligent computer systems, but also do not contribute to their quick understanding by those people to whom these texts are addressed. The latter circumstance requires the development (writing) of textbooks and teaching aids specially designed for those people who are beginning to master the relevant field of knowledge, who have not yet acquired the necessary qualifications. But it is obvious that this implies a significant duplication of the information presented.

E. Shortcomings of current solutions to ensure consistency and compatibility of different activities

All the tools considered for representing, structuring and accumulating information make it possible to simplify the organisation and coordination of collective activities, but do not allow to solve these tasks in a comprehensive way, because:

- The increase in the number of reference materials presenting and describing the same information in different forms leads to an increase in duplication and, consequently, inconsistency of this information.
- There is quite a lot of information in existing information resources that is characterised by inaccuracy, unstructured, incomplete, incoherent and unreliable information.
- Information becomes obsolete rather quickly, i.e. becomes irrelevant and unclaimed due to finding new methods of solving existing problems. All irrelevant information is quickly accumulated in the Internet space. That is why there is a lot of so-called "junk information" in Internet resources, which is this irrelevant and unclaimed information.
- The input of information in information resources is done by intermediaries - people who do not have the necessary competence to modernise and disseminate this information, which directly affects the quality of all information. This is also due to the fact that a person who receives information from one source interprets and transmits it to another source in his or her own way. Different people describe concepts from different sources by synonymous terms, which leads to the loss of the original meaning of these concepts. Thus, new contradictions in information appear.
- Working with huge amounts of information implies working with several sources of this information. In such sources it is difficult to search for necessary (relevant) information, as there is a huge number of different categories, which implies the use of complex search operations.
- This, in turn, is related to the language of knowledge representation. The format of knowledge representation and description in reference materials is understandable only to a human being and cannot be processed by a computer system, and as a consequence, cannot be used for solving problems by a computer.
- Knowledge is most often structured in the form of books, encyclopaedias, dictionaries and reference books on specific subject domains, which allows one to learn a particular subject domain quickly. However, this makes it difficult to understand information at the "junctions" of subject domains, so that a person is not well-versed in interdisciplinary knowledge. The so-called "mosaicism" of perception is formed in a human being, as a human being during training and work gets used to artificial division of knowledge areas and has difficulties in solving problems at "junctions".
- To integrate information from different sources, algorithms for matching and merging data, identifying and resolving duplicates, and algorithms for converting to common presentation formats are used, but even these algorithms do not completely eliminate inconsistencies and duplication of existing information.
- The existing information resources do not standardise and do not apply general principles of presenting information for a wide range of readers. Each reader perceives information in his/her own way, and consequently, there are differences in the understanding of the same information.
- The popularisation of knowledge is carried out with the help of specialised Internet resources that not only simplify but also distort the presentation of information for professionally untrained readers. The increase in the number of such Internet resources contributes to the duplication of information and the development of contradictions in it.

To solve these problems, methods and technologies must be utilised which can:

- present any information in the same form;
- integrate information from different information sources;
- describe and structure information both from one subject domain and information at "junctions" between subject domains;
- standardise the description and visualisation of various types of information;
- re-use existing knowledge and accumulate new knowledge;
- present information in a form that is understandable to both (!) humans and computers;
- develop tools to quickly find the information you need;
- create a personalised experience for any user;
- develop methods and tools to improve these methods and technologies.

In other words, it is necessary to create such unified integrated information resources, with the help of which it is possible to quickly obtain existing information and to integrate new information and it would be easy to coordinate various activities, including activities on the development of intelligent systems. It is also necessary to develop methods and tools by which such information resources can be continually modernised and updated.

F. Methods and technologies for solving the problem of collective activity organisation and consistency

Today, some information is combined, structured and used in the form of common information repositories — Internet resources with their own databases or knowledge bases [13]. Databases and knowledge bases allow storing and processing information in the same place and automating the solution of information tasks of various kinds. That is, unlike non-digital analogues, information in databases or knowledge bases can be interpreted not only by a human but also by a computer.

This approach is the most promising in comparison with other existing approaches, as it allows solving some of the above mentioned problems. However, it is necessary to approach the solution of these problems in a methodologically correct way, in other words, to use, integrate and develop methods and technologies with the help of which it is possible to develop tools that allow solving all the problems listed above.

In order to create unified information resources with the help of which specific activities could be easily made consistent, it is necessary to apply modern technologies and methods that enable effective data and knowledge management [14].

Knowledge-Based Engineering.

A popular area of research is ***knowledge-based engineering***. Knowledge-based engineering (KBE) [15] is a research area that explores methodologies and technologies for capturing and reusing knowledge in product development. The goal of KBE is to reduce product development time and costs, which is primarily achieved by automating repetitive design tasks while getting, storing, and reusing knowledge about already designed products.

One of the hallmarks of the KBE approach is the automation of repetitive, non-creative design tasks. Automation not only provides significant time and cost savings, but also frees up time for creativity, allowing more of the design domain to be explored. This is facilitated by another advantage of KBE: it allows knowledge to be reused. As the researchers note, "about 20% of a designer's time is spent searching for and assimilating information." This means that development information and knowledge is not represented in a common and easily accessible knowledge base. Obviously, in such cases, reusing knowledge according to the established KBE framework can save considerable time and effort.

The authors of the paper [15] highlight the challenges of using knowledge-based engineering and, first and foremost, emphasise the need to bridge the "technology gap" — lack of tools and technologies to support cost-effective KBE development and its application in the development of information systems for various purposes. According to the authors of the paper, such tools and technologies should provide search and reuse of knowledge, allow standardisation of this knowledge, describe the meaning of information and ensure transparency of information systems developed according to KBE principles.

Ontology-based approach.

Among the methodologies and technology of knowledge engineering, the description and structuring of knowledge by means of ontologies is most often given more attention [16]. The **ontology-based approach** is a methodology based on the use of ontologies to organise and represent knowledge about a particular subject domain [17]. In this context, "ontology" refers to the formal description of concepts, relationships, and attributes in a subject domain.

The widespread use of the ontological approach is explained by the fact that [18], [19], [20]:

- Ontologies make it possible to provide consistency of concept systems between participants in some process.
- Ontologies allow to organise and classify knowledge from different disciplines, establishing links between them, thus making knowledge more structured and usable [21].
- Ontologies allow knowledge integration by combining information from different sources and with different representations, which helps to eliminate semantic incompatibilities between different systems and facilitates information sharing [22].
- Ontologies allow knowledge to be represented in a form that computers can understand. Thus systems can automatically analyse and make decisions based on the knowledge in ontologies.
- Ontologies provide a formal basis for developing expert systems that can provide recommendations and advice in complex and multidimensional problems [23].

The use of ontologies for interdisciplinary knowledge synthesis and integration helps in gathering and analysing information from different domains and ensuring that it is properly understood and used in practice, thus contributing to better knowledge utilisation and more informed decision making.

A series of works [24] emphasises the importance of using ontologies to structure engineering knowledge. According to the authors, ontologies reveal the semantics of the information presented, eliminate heterogeneity in the representation of multiple information sources, provide a common knowledge base for multi-agent systems, provide semantics and structure for trust and reputation systems, privacy-based systems, and codify common knowledge across business and scientific domains. The authors believe that the use of semantics as a central mechanism will revolutionise the development and consumption of software and lead to the development of software as a service — Software engineering 2.0.

According to the authors, an important challenge remains the problem of ensuring that knowledge bases are consistent and coherent with each other, one solution to which may be to develop a hierarchy of ontologies for all systems in the form of a common knowledge base. Knowledge bases help to simplify the storage of different types of knowledge [23], and the ontology approach helps to structure knowledge and the relationships between them [19]. This provides a deeper understanding of the information context and improves data availability and integrity.

The authors also highlight the importance of multi-agent systems in ontology processing. A set of agents in a multi-agent system can use this ontology as a common knowledge base. This will greatly facilitate communication and coordination between agents when solving tasks together. The [24] describes the problem that methodologies for developing ontologies and methodologies for developing multi-agent systems are completely separate and have no connection with each other. The authors believe that combining multi-agent systems and ontologies for mutual use could revolutionise information technology.

Knowledge graph.

Another popular method for describing complex structured knowledge and knowledge from different subject domains is the ***knowledge graph*** [25], [26]. A knowledge graph is a semantic network that stores information about different entities and the relationships between them. An entity or "node" of a graph can be anything: any material object or abstract concept. Predicates or "edges" reflect the relationships between different entities in the graph. For example, Albert Einstein and the city of Ulm in Germany are two separate entities, and the fact that Einstein was born in Ulm is a predicate.

The use of graph models has the following advantages [12], [27], [11], [13]:

- Graph data models have tremendous expressive power. Graph databases offer a flexible model of data and a way to represent it. Graphs are additive, providing the flexibility to add new data relationships, new nodes and new subgraphs to an existing graph structure without compromising its integrity and coherence.
- The diversity of data representation is minimised by reducing the number of syntactic aspects, as graph data models allow different types of knowledge to be written in the same way.
- To understand the meaning of knowledge, it is necessary to represent this knowledge in an understandable form for everyone: both for a person and for the system. Speaking about unification of representation of all kinds of knowledge, it is considered important to use graph models not just as means for storing structured data, but for storing semantically coherent and interconnected knowledge.
- Performance of data processing is improved by one or more orders of magnitude when representing data in the form of graphs, which is explained by the properties of the graph itself. Unlike relational databases, where query performance degrades with increasing query intensity as the dataset grows, the performance of the graph data model remains constant even as the dataset grows. This is because data processing is localised in some part of the graph. As a result, the execution time of each query is only proportional to the size of the part of the graph traversed to satisfy that query, not the size of the entire graph.
- Graph models enable efficient semantic search, i.e. finding data and information based on the relationships between them, which helps to improve the quality and accuracy of search queries, as well as provides a deeper understanding of these relationships and dependencies between data.

Knowledge graphs, like ontologies, help to link large amounts of data from different sources into one common knowledge collection. They can be general, i.e. storing information about different types of data, and specialised, focusing on a single subject domain.

Today, one of the largest knowledge graphs that stores information from different subject domains is Wikidata. Another good example of a knowledge graph is BioPortal – the largest specialised graph with over 140 billion facts about biotechnology and medicine. These graphs are publicly available and accessible to all Internet users.

Systems that use knowledge graphs to represent and process information are widespread. Google Knowledge Graph — is a system used by the Google search engine to provide structured data about user queries. Google Knowledge Graph combines data from various sources such as Wikipedia, Freebase and others to provide information about objects in various fields such as history, culture, science and technology.

Collaborative design.

Obviously, to ensure consistent and compatible activities, only technologies and tools for representing, structuring, accumulating different kinds of knowledge used in these activities are not enough. In addition, it is necessary to create conditions and means to improve the activity itself and its integration with other activities to solve more problems.

One of such approaches that promotes the convergence of activities of specialists from different fields is the methodology of ***collaborative design***. Collaborative design implies collective decision-making, open communication and active participation of all stakeholders throughout the design process. By utilizing the power of collaboration, this approach aims to create innovative and effective solutions that meet the needs and desires of end users.

IEEE researchers in their paper [28] examine the problems of knowledge management and sharing, which are of considerable interest in the field of organisational management. The authors note that much of the knowledge within organisations exists in the minds of individuals and is difficult to document or transfer.

American researchers Stephanie E. Hampton and John N. Parker in their paper [29] consider the importance of co-operation between scientists in the process of research and solving scientific problems. They use and describe the concept of scientific synthesis. Scientific synthesis is the process of combining knowledge from different fields to create new knowledge and develop innovative solutions. With the increasing amount of information and complexity of scientific problems, the role of collaboration is becoming more and more relevant for successful scientific synthesis. The paper also emphasises that collaboration involves not only sharing knowledge from different fields, but also joint research, discussion, synthesis, analysis and interpretation of results. Highly organised collaboration improves the quality of scientific synthesis by providing a broader overview of the problem [30].

The authors offer a number of recommendations for successful collaboration and increased productivity. One of them is to create resources and platforms for sharing knowledge and ideas that are accessible to all scientific researchers. This would reduce the information formats used and facilitate the sharing of information and discussion of results [31].

One way of creating centralised access to information is through ***knowledge portals***. Such portals can contain information related to processes, documentation, procedures, tutorials, and answers to frequently asked questions [32], [33].

One of the key advantages of knowledge portals is their ability to collect and store information from various sources, such as databases, document management systems, project management systems and so on, allowing users to obtain complete and up-to-date information in one place. Based on the knowledge portal, the ability for users to interact with each other by creating forums, discussions and collective editing of documents is provided. This facilitates the sharing of knowledge and experience among the staff of the organisation and enhances their work efficiency.

G. Conclusions

If we consider society as a multi-agent system consisting of independent intellectual agents, it is obvious that the important factors determining the improvement of the quality (level of development) of society are:

- increasing the efficiency of utilisation of the experience accumulated by society, the efficiency of mankind's use of knowledge and skills;
- increasing of the rate of acquisition, accumulation and systematization of knowledge and skills effectively used by mankind.

The solution of the above problems becomes quite possible if for this purpose intelligent computer systems of new generation are used, with the help of which the knowledge and skills accumulated by mankind will be organised as a systematized distributed library of reusable information resources (knowledge and skills).

Consequently, systematisation and automation of reusable information resources accumulated by mankind requires their convergence, deep integration and formalisation. A special place in this process is occupied by mathematics as a basis for systematisation and formalisation of knowledge and skills at the level of formal ontologies.

III. Proposed approach. Semantic electronic glossary based on the *OSTIS Technology* — the *OSTIS Glossary*

A. About the relation between the OSTIS Standard and the OSTIS Glossary. Basic requirements for the OSTIS Glossary

In the analytical part of this paper, the current state of the solution of the problem of ensuring consistency and interoperability of different types of activities was demonstrated, shortcomings and ways to solve them were highlighted. The authors of this paper do not deny all the accumulated experience in solving this problem, but they see significant shortcomings of existing technologies and means by which knowledge is presented, processed, accumulated and disseminated, and which significantly slows down the pace of development of various areas of activity in society.

The intention of the authors and the purpose of this paper is to create a unified information resource that allows:

- to present information of various kinds in a comprehensible and accessible form both for a human being, including untrained professionals, and for a computer;
- to reuse existing information to solve problems of any information complexity;
- to accumulate information from various sources,

that is:

- to contribute to the consistency of different points of view and different activities of society;
- and to promote integration and convergence (interoperability) of one activity between its parts ("horizontally") and between different activities ("vertically").

The following methods and technologies are also considered appropriate for the creation of such a unified information resource:

- As a basis for structuring information of different types and different subject domains, as well as

for ensuring the consistency and interoperability of this information and different types of activities that use this information, it is proposed to use an ontological approach based on the representation of information in the form of semantic networks (knowledge graphs);
- An agent-based approach is proposed as tools for retrieving already existing information, reusing it for problem solving and accumulating it from various information sources;
- Semantic user interfaces using ontological, graphodynamic and agent-based approaches are proposed as means to realise personalised representation and transfer of information.

Such an information resource can be realised in the form of an ***Electronic glossary*** for all available spheres of human activity in society. In the traditional sense, such a glossary can be a dictionary of highly specialised concepts and their terms in various subject domains, the text of which will be clear to the end user. In a broader sense, such a glossary will be understood as a system or subsystem with the help of which:

- you can quickly find already existing information: concepts, their terms, definitions, connections with other concepts, and so on;
- reuse information by both humans and computer systems that know how to communicate with this glossary;
- accumulate information, i.e. new information from various sources can be entered both manually and automatically;
- information can be visualised depending on the user's learning level.

The ***OSTIS Technology*** is proposed to be used as a technology that allows to realise such systems and has all the necessary methods and means for their implementation. The *OSTIS Technology* is an open semantic technology of complex life cycle support of semantically interoperable intelligent computer systems of new generation. The purposefulness of using this technology is determined by the tasks that can be solved with the help of this technology, and the high level of scientific problem, which is aimed at solving this technology.

The *OSTIS Technology* is known for its basic principles [34], [35], [36]:

- all knowledge is described by means of a unified knowledge representation language — *SC-code*, which ensures syntactic and semantic interoperability of this knowledge and makes it possible to interpret knowledge not only by humans but also by computer systems;
- All knowledge is structured by means of a hierarchy of subject domains and their corresponding ontologies, through which the consistency of this knowledge is ensured;
- knowledge processing of various kinds is based on the principles of graphodynamic models, with the help of which it is possible to understand the meaning of this knowledge efficiently and flexibly;
- all knowledge is accumulated in the form of semantically powerful libraries of reusable components, with the help of which the reuse of already existing knowledge in problem solving is realised;
- all knowledge is open and transparent in use and modification by both humans and systems.

SC-code is the main internal formal universal abstract language for representing information constructs in ostis-systems. *SC-code* supports various data types, including numbers, strings, lists and other data structures. It also provides facilities for working with knowledge bases and performing logical operations. There are 3 main external languages of ostis-systems: SCs-code, SCn-code and SCg-code [37]. They provide a way for ostis-systems to communicate with their users and other ostis-systems.

This technology is considered to be a new generation technology. And in the context of the *OSTIS Technology*, all computer systems, in particular intelligent systems, developed on the basis of this technology are called new generation intelligent systems or ostis-systems. The *OSTIS Technology* is realised in the form of a special ostis-system, which is called the *OSTIS Metasystem* [38] and the knowledge base, which this system contains:

- The formal theory of ostis-systems;
- The standard of ostis-systems (standard of ostis-systems knowledge bases, ostis-systems problem solvers, ostis-systems interfaces);
- The standard of methods and tools for ostis-systems life cycle support (the core of the Library of reusable ostis-system components (the OSTIS Library), methods for supporting the life cycle of ostis-systems and their components, tools for supporting the life cycle of ostis-systems).

The *OSTIS Standard* defines general principles and rules for the development and use of knowledge bases and intelligent systems based on the *OSTIS Technology*. It defines the structure of knowledge bases, data formats, ways of knowledge organisation and other aspects that should be taken into account when developing intelligent systems based on the *OSTIS Technology*. In addition, the *OSTIS Standard* defines the rules of organisation and representation of knowledge in knowledge bases. The *OSTIS Standard* helps to ensure interoperability and uniformity within the projects using the *OSTIS Technology* and provides convenience for developers and researchers to work together.

In the context of this paper, the *OSTIS Metasystem* [38], [39] attracts attention because it is some computer version of the *OSTIS Standard*, additionally implementing tools for processing, visualising and using this standard, the aim of which is to provide a consistent and compatible activity both for the development of intelligent systems and for the improvement of methods, models and tools for their development, which is a sub-objective of the Electronic glossary conceived by this work.

In addition, all ostis-systems are combined to form an integrated ecosystem — the *OSTIS Ecosystem* [40], containing knowledge from all subject domains of society in a consistent, semantically interoperable and understandable form. If we compare the Electronic glossary and the *OSTIS Ecosystem*, it is obvious that the Electronic glossary is a variant of the *OSTIS Ecosystem* knowledge base. However, in the context of this work, it is more appropriate to specify the Electronic glossary to the glossary, which is a variant of displaying the *OSTIS Standard*, because if we consider the Electronic glossary as a variant of displaying the knowledge base of the *OSTIS Ecosystem*, it is necessary in this work to focus in more detail not on the principles of structuring information in this glossary, but on the principles of coordination of information from different subject domains, which are united in the form of a single knowledge base of the *OSTIS Ecosystem* and which is the subject of the *OSTIS Standard*.

Also due to the identified dependence of the Electronic glossary on the *OSTIS Standard* and the *OSTIS Technology* as a whole, we will refer to this Electronic glossary as the ***OSTIS Glossary***. And also it is important to understand that in this case the *OSTIS Glossary* is not some separate ostis-system, but is a form of display of the *OSTIS Standard*, its part, visualised according to certain formalised rules, and by virtue of this it is also a part of the knowledge base of the *OSTIS Metasystem*, to which it is possible to ask various questions.

Therefore, in the following sections, besides the content of the conceived the *OSTIS Glossary*, the rules of its development, visualisation and tools for working with it will be described in detail. That is, in this paper it is important to fulfil the following tasks:

- describe and fix the principles and rules of development and consistency of the *OSTIS Glossary* fragments both with itself and with the *OSTIS Standard*;
- describe and fix the rules of placement, structuring, identification of concepts and fragments of concepts in the *OSTIS Glossary*;
- describe and fix the principles of interaction of users and systems with the *OSTIS Glossary* and the rules of visualisation of concepts and fragments of concepts in it;
- describe the current structure of the *OSTIS Glossary*.

Further on we will consider in detail the principles of consistency of the *OSTIS Glossary* and the *OSTIS Standard*, the rules of structuring and specification of *OSTIS Glossary* objects, as well as the rules of identification of these objects within the *OSTIS Glossary*.

B. Principles of consistency of the OSTIS Glossary and the OSTIS Standard

As stated earlier, the *OSTIS Glossary* is closely related to the *OSTIS Standard*. This is due to the following reasons, which at the same time are the ***basic principles for the development of the OSTIS Glossary***, consistency of its text with itself and the text of the *OSTIS Standard*:

- The *OSTIS Glossary* is not a separate knowledge base or ostis-system. On the contrary, the *OSTIS Glossary* is a semantically compatible and ordered fragment of the *OSTIS Standard*, some variant of its display, which describes with sufficient detail the entities and concepts used in Artificial Intelligence and, in particular, OSTIS Technologies, as well as the relations between them, references to bibliographic sources and authors of these entities and concepts. The *OSTIS Glossary* is the result of a collective consistency of terms both within the *OSTIS Technology* and across Artificial Intelligence.
- In addition to the *OSTIS Glossary*, an important component of the *OSTIS Standard* is the OSTIS Bibliography. The OSTIS Bibliography is a list of the literature used in the *OSTIS Standard*. The OSTIS Bibliography is the result of the analysis of other works and analogues studied during the development of the *OSTIS Technology* and includes brief bibliographic descriptions of both other technologies similar to the *OSTIS Technology* and the technologies, models and tools on which the *OSTIS Technology* itself is based.
- Consequently, the key objects of description in the Glossary may be:
  - concepts (absolute and relative);
  - specific entities that are not concepts, e.g. specific systems, projects, technologies, languages, etc. (the *OSTIS Ecosystem* [40], the *OSTIS Metasystem*, Neo4j Project, RDF Language);
  - specific individuals;
  - specific bibliographic sources (books, articles, electronic resources).
- The *OSTIS Glossary* is not a static structure stored in the knowledge base of the *OSTIS Metasystem*. It is the result of the work of some collective of agents transforming the hierarchy of sections of the *OSTIS Standard* into some simplified from the reader's point of view hierarchy of sections, in which concepts are ordered lexicographically rather than logically, i.e. the *OSTIS Glossary* can be formed by means of explicit or indirect start of a non-atomic agent consisting of agents: forming a particular section of this glossary, concatenation

of glossary sections, filtering of concepts and their specifications according to given criteria, and so on.
- Since the *OSTIS Glossary* is some fragment of the knowledge base of the *OSTIS Metasystem*, it is more appropriate to develop it by the same means that are used to develop any knowledge base of the ostis-system. From this point of view, the development of the *OSTIS Glossary* is reduced to the development of the knowledge base of the *OSTIS Metasystem*, including the *OSTIS Standard*, already loaded in this knowledge base. Thus, manual transformation of the *OSTIS Standard* into the *OSTIS Glossary* is not required and is automated by existing ostis-system knowledge base development tools.
- For visualisation of the *OSTIS Glossary* the existing tools for development of ostis-systems knowledge bases are sufficient. Viewing of the *OSTIS Glossary* from the whole knowledge base of the *OSTIS Metasystem* should be done with the help of a specialised agent. Such an agent should allow to display it in one of the external sc-languages (SCn-code, or SCg-code).

In other words, the *OSTIS Glossary* should not be some other text describing the current state of the *OSTIS Technology*, on the contrary, the Glossary should be consistent and semantically interoperable with the *OSTIS Standard* and should be only some form of its presentation, simplified for the reader, reducing the threshold for new people to enter the *OSTIS Technology*, allowing to quickly find concepts and agree new ones.

C. Rules for structuring and specification of the OSTIS Glossary objects

The main purpose of the *OSTIS Glossary* is to present concise specifications of the *OSTIS Standard* concepts in an organised form, simplified for the reader. The text of the *OSTIS Standard* is presented in the form of a sequence of ordered and organised sections of subject domains and ontologies containing a logical statement of the specifications of the objects considered within the *OSTIS Technology*. The *OSTIS Standard* is based on the ***following principles of text structuring***:

- The *OSTIS Standard* is the main part of the knowledge base of the *OSTIS Metasystem* and is a description of the current state of the *OSTIS Technology*.
- As a formal language for the external representation of the *OSTIS Standard*, SCn-code, which is an external form of *SC-code* representation, is used.
- The *OSTIS Standard* is ontologically structured, i.e. it is a hierarchical system of related formal subject domains and their corresponding formal ontologies, thus ensuring a high level of stratification of the *OSTIS Standard*.
- Each subject domain can be matched:
  - a family of corresponding ontologies of different kinds;
  - a set of semantic neighbourhoods describing the research objects of this subject domain.

  subject domains are the basis for structuring the sense space, a means of localisation, focusing attention on the properties of the most important classes of described entities, which become classes of objects of research in subject domains.
- Each concept used in the *OSTIS Standard* has its own place within this standard, its own subject domain and its corresponding ontology, where this concept is investigated in detail, where all the basic information about this concept and its various properties is concentrated.
- The *OSTIS Standard* also includes files of information constructs that are not *SC-code* constructs (including sc-texts belonging to different natural languages). Such files allow to formally describe in the knowledge base the syntax and semantics of various external languages, and also allow to include in the knowledge base various explanations, notes addressed directly to users and helping them to understand the formal text of the knowledge base.
- From a semantic point of view, the *OSTIS Standard* is a large refined semantic network, which is non-linear in nature and which includes signs of all kinds of described entities (material entities, abstract entities, concepts, relations, structures) and, accordingly, contains links between all these kinds of entities (in particular, links between links, links between structures).
- The *OSTIS Standard* is a hierarchical system of subject domains and their corresponding ontologies specifying these subject domains. Each of the subject domains describes the corresponding classes of research objects with the maximum possible degree of detail defined by a set of relations and parameters defined on the classes of research objects.
- Each section of the *OSTIS Standard* contains the knowledge that is part of the subject domain and ontology that is either fully represented by the specified section or partially represented by the specification of one or more specific objects of study.
- The specification of each subject domain and each section should have a sufficient degree of completeness. At a minimum, the role of each concept used in each subject domain should be specified.

Since the *OSTIS Glossary* is nothing but a part of the *OSTIS Standard*, the structuring principles of the *OSTIS Glossary* are the same as the structuring principles of the *OSTIS Standard*. The exception is that the structuring of the *OSTIS Glossary* should happen automatically, by some agent generating a structure corresponding to this glossary. Hence, it is important to consider the structure to be formed by this agent, i.e. the principles and rules by which this agent should form the structure of the *OSTIS Glossary*.

In this section, the authors of this paper also want to focus only on why it is important and how to structure and stratify information in general. That is, the purpose of this section is to review the principles of structuring and stratification of knowledge in knowledge bases on *SC-code*, because as it was clarified earlier, the *OSTIS Glossary* is part of one common knowledge base of one ostis-system. If necessary, a detailed description of the syntax and denotational semantics of the knowledge representation language can be found in the works of [34], [41], and a detailed description of what knowledge is and how to structure knowledge in knowledge bases can be found in the works of the following authors [42].

So, let us consider in detail the listed structuring principles of the *OSTIS Standard* and describe the structuring principles of the *OSTIS Glossary*.

In the context of the *OSTIS Standard*, an object is usually defined as either a concept, i.e. an abstract entity that combines other abstract or concrete entities, or an instance of a concept, i.e. a concrete entity. Concepts can be absolute or relative. Absolute concepts denote the same attributes of some group of concepts or entities, relative concepts — connections and relations between other concepts or entities. Generally speaking, there are quite a lot of types of knowledge that can be represented on the *SC-code*. Absolute and relative concepts are basic characteristics of other concepts.

The specification of an object is commonly used to denote a set of information describing this object. Depending on the quality of the knowledge base, primarily determined by the quality of its development, concepts and entities can be specified or unspecified.

Suitably specified entities have the following requirements:

- if the entity is not a concept, the following must be specified for it:
  - different variants of the external signs denoting it;
  - the classes to which it belongs;
  - the links by which it is connected to other entities (indicating the relevant relationship);
  - values of the parameters it possesses;
  - those sections of the knowledge base in which the specified entity is key;
  - the subject domains in which the entity is included;
- if the specified entity is a concept, the following must be specified for it:
  - different variants of external labelling of this concept;
  - The subject domains in which this concept is explored;
  - definition of the concept;
  - explanation;
  - sections of the knowledge base in which this concept is key;
  - example description - an example of an instance of a concept.

These requirements can be formulated in another way. For each object in the knowledge base it is possible to fix their specifications by means of structures denoting sets of all relations of these objects with other objects in the knowledge base. For these structures it is possible to introduce classification, i.e. to set classes for these structures, with the help of which it is possible to understand the degree of detail of specification of a particular object of the knowledge base.

Within the framework of the *OSTIS Technology* for each entity it is done so, such structures describing the specification of entities in the knowledge base are commonly called semantic neighbourhood. Semantic neighbourhood is a specification of a given entity, the sign of which is specified as a key element of this specification.

The set of features by which entities can be specified varies. In addition, it may be necessary to specify the same entity in different aspects and to explicitly capture these aspects in the knowledge base (Fig. 1).

For example, the same person can be described from professional, medical, civil and other perspectives, as presented in the figure.

Consider a specific example of the concept of "cybernetic system" and its specification from the *OSTIS Standard*.

cybernetic system
:= [adaptive system]
:= [targeted system]
:= [active subject of independent activity]
:= [a material entity capable of purposefully (in its own interests) influencing its environment as a minimum to preserve its integrity, viability, and safety]
:= [a natural or artificially created system capable of monitoring and analysing its own state and the state of the environment, as well as capable of sufficiently active influence on its own state and the state of the environment]
:= [a system capable of interacting with its environment sufficiently independently to perform various tasks]
:= [information processing based system]
⇒ *note**:
[The level of adaptability, purposefulness, activity in systems based on information processing can be very different.]

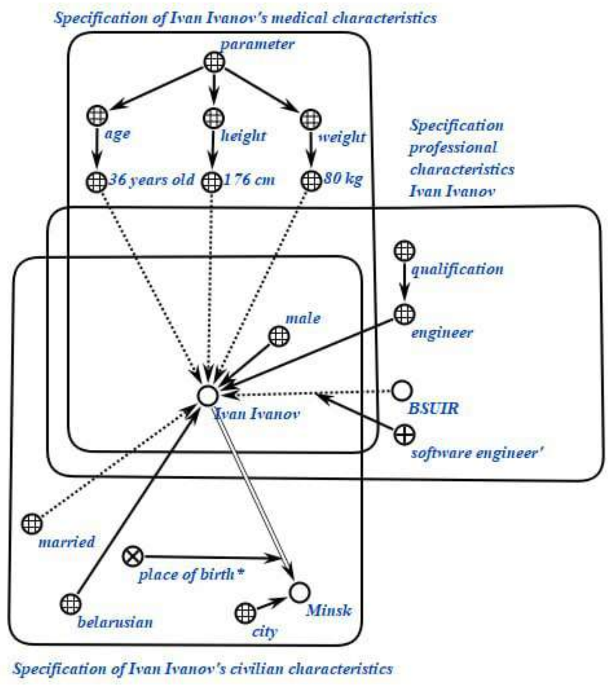

Figure 1. Examples of entity specifications for different sets of attributes of this entity

⇒ *partition**:
A sign of naturalness or artificiality of cybernetic systems
= {• *natural cybernetic system*
⊃ *human*
• *computer system*
• *symbiosis of natural and artificial cybernetic systems*
⊃ *community of computer systems and people*
}
⇒ *partition**:
Structural classification of cybernetic systems
= {• *simple cybernetic system*
• *individual cybernetic system*
• *multi-agent system*
}
⇒ *partition**:
Classification of cybernetic systems on the basis of the presence of a supersystem and the role within that supersystem
= {• *a cybernetic system that is not part of any other cybernetic system*
• *a cybernetic system embedded in an individual cybernetic system*
• *multi-agent agent*
}
⇒ *generalised decomposition**:
{• *information stored in the memory of the cybernetic system*
• *abstract memory of a cybernetic system*
• *cybernetic system problem solver*
• *physical shell of the cybernetic system*
}
⇒ *author**:
Glushkov V.M.
⇒ *Bibliographic source**:
Glushkov V.M.Cyber-1979st.
⇒ *standard bibliographic description**:
[V. Glushkov, "Cybernetics", 1979, pp. 850-856]

Whole presented example is a semantic neighbourhood of the concept "cybernetic system". As we can see, this example illustrates several types of knowledge described within the semantic neighbourhood of a given concept. Thus, for example, within the semantic neighbourhood of a given entity the theoretical-multiple relations of this entity with other entities, didactic relations linking the given entity with the information due to which the content of this entity is revealed and explained, and so on, are specified.

It is important to understand that the variety of types of semantic neighbourhoods indicates the variety of semantic types of descriptions of different entities. In the context of the *OSTIS Standard* we distinguish between full, basic and specialised semantic neighbourhoods, each of which is some kind of description of a particular entity.

For example, the structure of a complete semantic neighbourhood is determined primarily by the semantic typology of the entity being described. Thus, for example, for an absolute concept (class) the following information should be included in the full semantic neighbourhood if available:

- identification options in different external languages (sc-identifiers);
- membership in some subject domain, with an indication of the role performed within that subject domain;
- theoretical-multiple relations of a given concept with other objects;
- definition or explanation;
- statements describing the properties of the specified concept;
- problems and their classes in which this concept is key;
- a description of a typical example of the use of the specified concept;
- instances of the concept being described;
- authors and bibliographic sources of the specified concept;
- and others.

For a relative concept, i.e. a concept that is a relation, the semantic neighbourhood additionally specifies:

- domains;
- area of definition;
- relationship diagram;
- classes of relations to which the described relation belongs.

Obviously, there can be a large number of types of such specifications, since there can be a lot of information describing a particular object, and the need to obtain and visualise this information can be different. For the *OSTIS Glossary*, too, it is possible to specify a kind of semantic neighbourhood, with the help of which it will be possible to specify only what is important from the point of view of the *OSTIS Glossary* itself.

Drawing an analogy with the *OSTIS Standard*, all information in the *OSTIS Glossary* can be presented in the form of ordered and organized sections of the subject domains and ontologies that make up the *OSTIS Standard*. Each section can be presented as a sequence of objects and their specifications arranged alphabetically by the terms of these objects, i.e. in lexicographic order.

In the context of the *OSTIS Glossary*, the specification of each object should specify:

- identification options in various external languages (sc-identifiers);
- object membership in some subject domain with indication of the role performed within this subject domain;
- theoretical-multiple relations of a given object with other objects;
- definition or explanation of a given object;
- description of a typical example of the use of the specified object;
- instances of the described object, if the given object is a concept;
- authors of the given object;
- authors of the specification of the given object;
- analogs of the given object;
- bibliographic sources of the object.

In other words, in the context of the *OSTIS Glossary*, the semantic neighborhood of each specifiable object should include not just information defining and explaining the specified object, but also the information that determines the level of significance of this object in comparison with other objects. In this case, the *OSTIS Glossary* acts not only as a tool for consistency of some kind of activity, but also plays an important role in search and comparison of similar objects, i.e. it acts as a tool for convergence of different, but having common features, objects.

Thus, with the help of semantic neighborhoods it is possible to structure ("horizontally") knowledge about other knowledge. In order to stratify ("vertically") this knowledge about other knowledge among themselves, other kinds of structures have to be used. Therefore, all the *OSTIS Standard* objects are grouped by subject domains and their corresponding ontologies, which are used to stratify knowledge in knowledge bases.

The concept of the subject domain is the most important methodological technique, which allows to single out from the whole variety of the investigated World only a certain class of investigated entities and only a certain family of relations defined on the specified class. That is, localization, focusing attention only on it, abstracting from the rest of the World under study, is carried out.

The subject domains and their corresponding ontologies identified within the knowledge base of an intelligent system are semantic strata, clusters, which allow to "decompose" all the knowledge stored in the memory into "semantic shelves" in the presence of clear criteria that allow to unambiguously determine on which "shelf" certain knowledge should be located.

From the point of view of the *OSTIS Standard*, a subject domain is the result of integration (union) of partial semantic neighborhoods describing all investigated entities of a given class and having the same (common) subject of investigation (i.e. the same set of relations to which the mappings belonging to the integrated semantic neighborhoods should belong). That is, the subject domain is a structure that includes:

- the main studied (described) objects — primary and secondary;
- different classes of studied objects;
- different links, the components of which are the studied objects;
- different classes of the above-mentioned links (i.e. relations);
- different classes of objects that are neither the studied objects nor the above-mentioned links, but are components of these links.

Each concept corresponds to at least one subject domain in which the concept is a studied concept and in which the main characteristics of the concept are dealt with. When describing any subject domain, it is important that all classes declared by the studied concepts should be fully represented within the given subject domain together with their elements, elements of elements, etc. up to terminal elements.

For effective collective development and operation of the knowledge base of the ostis-system not just structuring is important, but such structuring, which is as objective as possible, having a clear semantic interpretation and allowing, on the basis of semantic links between structurally selected fragments of the knowledge base, to easily determine (localise) the "location" of either the knowledge being sought or new knowledge being introduced into the knowledge base. Such semantic structuring of the knowledge base, the formation of a system of semantically related "semantic shelves" on which specific knowledge satisfying clearly defined requirements is placed, significantly simplifies navigation through the knowledge base and clearly localises the evolution of knowledge located on each "semantic shelf". From a meaningful point of view, the subject domain is a set of factual statements describing all elements of a given set of objects of research with the help of a given set of relations and parameters (characteristics).

A section — is a sign of a set of all possible sections included in different knowledge bases. Each section represents a conditionally didactically distinguished fragment of the knowledge base, possessing logical integrity and completeness. In the limit, the whole knowledge base of a particular ostis-system is also one large non-atomic section.

For each partition it is necessary to explicitly specify the belonging to a set of atomic or non-atomic partitions. Atomic partition — a sign of the set of all possible atomic partitions included in various documentation, i.e., partitions not decomposable into more private partitions. Non-atomic section — the sign of the set of all possible non-atomic sections that make up the various documentations, that is, sections that are decomposed into more private sections.

In the context of the *OSTIS Glossary*, it may be appropriate to identify sections that will describe some portion of that information described in the relevant sections of the *OSTIS Standard*. But nobody forbids to consider the *OSTIS Glossary* as some atomic section in which all objects are listed according to the external natural language alphabet together with their specifications. As for subject domains, it is more expedient to use them not as a means for knowledge stratification, but as a means for searching already existing information to form sections with this information.

So, let's list the ***basic rules of structuring and specification of the OSTIS Glossary objects***:

- All information about the *OSTIS Glossary* objects should be represented in the form of semantic neighbourhoods of these objects, in which will be listed:
  - identification variants (variants of terms) of a given object in various external (natural) languages;
  - membership of the object in some subject domain with indication of the role performed within this subject domain, including membership of this object in the corresponding section of the knowledge base or the *OSTIS Standard*;
  - theoretical-multiple relations of the given object with other objects, including:
    - partition and decomposition of a given object into other objects;
    - including a given object into other objects;
    - and other possible unions, intersections that form a given object;
  - definition of the given object;
  - explanation of the given object;
  - description of a typical example of using the specified object;
  - instances of the described object, if the given object is a concept;
  - authors of the given object;
  - authors of the specification, i.e. the authors who described the given object in the knowledge base;
  - analogues of this object, including:
    - close analogues of the given object;
    - differences and similarities with other objects, including listed analogues;
  - bibliographic sources of the object;
  - possible quotations, aphorisms, metaphors and epigraphs related to the given object; This variant of specification will be called dictionary specification.
- In this case, all objects and their specifications within the *OSTIS Glossary* can be ordered:
  - as an enumeration of these objects in the lexigraphic order of their terms, forming one single atomic section, respectively being the *OSTIS Glossary*;
  - and the enumeration of sections corresponding to the sections of the *OSTIS Standard*, uniting objects by common features, considered within a particular section, and representing sequences of these objects in the lexigraphic order of their terms.

  For the second case, it is important that the sections do not overlap with each other, i.e., do not duplicate descriptions of the same entity. From this point of view, the first option is easier to implement, because it does not require taking into account the possibility of occurrence of the found object in the already formed sections of the *OSTIS Glossary*.
- Structuring of objects of the *OSTIS Glossary* should be reduced to the formation of text from the already structured text of the *OSTIS Standard*.

D. Rules for identification of the OSTIS Glossary objects

In the previous section the rules of structuring and specifying (standardisation) of the *OSTIS Glossary* objects were fixed. However, it is necessary to standardise not only those texts that are written directly in *SC-code*, but also those texts that are written in external, e.g. natural languages. One of the features of the *SC-code* is that with it it is also possible to record some natural language files, by means of which the comprehension of the text by any human being is improved. Such a possibility is realised with the help of ostis-system files, with the help of which external information constructions which are not text in *SC-code* [43] are denoted. With their help it is possible to specify information in an external natural language for all objects in the knowledge base. A special case of ostis-system files are files denoting identifiers of objects in the knowledge base.

Identifier is a structured sign representing an entity denoted by a string of symbols. An identifier is an information construct (most often a string of symbols) providing unambiguous identification of the corresponding object described in knowledge bases of ostis-systems, and is, most often, a name (term) corresponding to the described object, a name denoting this object in external texts of ostis-systems.

In formal texts, identifiers must be unique to uniquely match an object. Each pair of identical identifiers must denote the same object.

All objects in a knowledge base have the following ***common identification rules***:

- The membership of the identified object in some object classes is explicitly specified in the external identifier of this object (in the sc-identifier) by means of appropriate conditional attributes:
  - if the last character of the sc-identifier is an "asterisk" character, then the identified object belongs to the Class of non-role relation designations;
  - if the last character of the sc-identifier is an apostrophe, then the identified object belongs to the Class of role relationship designations, each of which is a subset of Membership relation;
  - if the last character of the sc-identifier is "^", then the identified object belongs to the Parameter designation class.
- For each object, you can construct an sc-identifier, which is a proper name that always starts with a capital letter.
- If an object is a designation of some class of objects, then this object can be matched not only with a proper name, but also with a common name, which starts with a small (lowercase) letter. The specification of each class (each concept) includes a list of equivalent (synonymous) sc-identifiers, among which there are both proper and nominative names.
- Identification of partitions in knowledge bases is performed at the expense of identification of partition objects. Instances of partition classes within the Russian language are named according to the following rules:
  - at the beginning of the identifier the word Section is written and a dot is put;
  - followed by the name of the section with a capital letter, reflecting its content.

Obviously, the same rules apply to the *OSTIS Glossary* objects. Therefore, there is no need to describe any additional rules for identifying the *OSTIS Glossary* objects.

Besides identifiers of ostis-systems knowledge base objects, it is possible to standardise the form of presentation of information in the specification of these objects: both the style of writing the text itself and the information with the help of which it is possible to explain the basic information in the specification of these objects.

E. Key elements of didactic information in the OSTIS Glossary object specifications

The most important criterion of quality of created ostis-systems of any purpose is to create conditions so that insufficiently qualified users of each ostis-system (both end-users and those responsible for its effective operation and modernisation) could acquire the required qualification quickly enough with the help of the same ostis-system. This means that each ostis-system, irrespective of its direct purpose (automation of specific types of human activities in a particular field) should also be a training system, i.e. it should be able to train its users in the direction of improving their qualification. A qualified user of any category must understand the capabilities of the ostis-system with which he interacts, must understand what the system knows and can do, as well as how its activities can be managed. Lack of understanding between ostis-systems and their users — is a violation of the interoperability requirement [44] imposed on both ostis-systems and their users.

Therefore, the key stage in the development of any knowledge base, and, in general, any information resource is the stage of development and implementation of didactic information. Didactic information should be understood as a specification of the subject domain, which provides additional information designed to enable users and developers (knowledge engineers), who use or improve the specified subject domain and its ontology, to learn their features faster. Didactic information enables [45]:

- to quickly and adequately assimilate the denotational semantics of knowledge stored in the system;
- to provide a deeper understanding and assimilation of the meaning of various kinds of entities (including various knowledge);
- to establish mutual understanding between systems and their users;
- to accelerate the process of formation of the required qualification of users in various fields.

The "didactic" effect of didactic information is provided by:

- by sufficient detail of the studied entity (completeness of the semantic neighbourhood describing the relations of this entity with other entities)
  - decomposition of the entities under consideration;
  - by specifying analogues (similar entities in different senses);

- indicating metaphors (epigraphs);
- indicating antipodes (entities that differ in different senses);

- exercises — solutions to various problems using the entities studied;
- references to knowledge stored within the same knowledge base;
- references to bibliographic sources.

Following one of the goals of the *OSTIS Glossary*, namely to provide a quality and understandable text for the end user, it is necessary to describe and record the ***main elements of didactic information for the objects of the OSTIS Glossary***. Such elements should include:

- information by means of which the basic information in the *OSTIS Glossary* object specification is defined or explained, i.e.:
  - various types of definitions, explanations, and annotations for that object;
  - examples of how to use this object;
  - instances of this object, if it is a concept;
- information describing distinctive and similar characteristics between the *OSTIS Glossary* objects, including:
  - analogies, correspondences, corollaries between objects;
  - differences and similarities between objects;
- information that supports the significance, scientific novelty, and practical applicability of the *OSTIS Glossary* object, including:
  - of the authors of these objects, as well as the authors who specified this object;
  - bibliographic sources of these objects;
  - quotations, aphorisms, metaphors and epigraphs related to the given object;
  - other.

It should be noted that the quality of the information described in the knowledge base directly depends on the quality of the presentation of this information and the quality of the information with the help of which the basic information in the knowledge base is explained. The more qualitatively the information in the knowledge base is described, structured and stratified, the lower the requirements to the readers of this information and the higher the level of understanding of the information in the knowledge base by these readers [46].

Didactic information in the knowledge base determines the level of quality of the information described in the knowledge base. The key elements of didactic information are those elements that contribute to easier and deeper mastering of the basic information in the knowledge base. The authors believe that it is the information that reveals similarities between objects in the knowledge base that is the key to improving the quality of the entire knowledge base.

F. Conclusion

To summarize, it is important to note the following points:

- The *development of the OSTIS Glossary* is reduced to the development of the *OSTIS Standard* and a set of tools that allow to form and improve the *OSTIS Glossary* on the basis of the *OSTIS Standard*;
- When developing the *OSTIS Glossary* as part of the *OSTIS Standard*, it is important to fix and improve the principles and rules:
  - specification and formalisation of objects;
  - identification of objects and their specifications;
  - of structuring and stratification of object specifications;
  - development and consistency of objects and their specifications;
- The *quality of the OSTIS Glossary* is determined by:
  - quality of the *OSTIS Standard*, which is defined by:
    * the quality of the information it contains;
    * the quality of the means to improve this information, which is determined by:
      · the quality of the methods, principles and rules for developing this information;
      · the quality of didactic information explaining this information;
    * the competence and level of training of the developers of the *OSTIS Standard*.

In the final section the current state of the *OSTIS Glossary* within the *OSTIS Metasystem* will be considered, the principles of automatic formation of the *OSTIS Glossary*, information retrieval in it will be fixed, and also the current Author team of the *OSTIS Glossary* and requirements to its developers will be considered.

IV. Implementation of the *OSTIS Glossary* within the *OSTIS Metasystem*

A. Current specification and structure of the OSTIS Glossary

It is important to note that the *OSTIS Glossary* is not just a dynamically generated text from the text of the *OSTIS Standard*, which is a simplified representation of the *OSTIS Standard*. The *OSTIS Glossary* acts as a means to provide a consistent and interoperable activity for the development of new generation intelligent computer systems, and thus has documentation for its use and development. Therefore, first of all, the *OSTIS Glossary* is documentation on how to properly form a dictionary representation of the *OSTIS Standard*.

The OSTIS Glossary
:= [Semantic electronic dictionary of Artificial intelligence]

:= [Glossary of the *OSTIS Standard* terms and concepts]
:= [Semantically interoperable dictionary of concepts arranged in lexicographic order of their terms]
:= [A tool to ensure consistent and interoperable activities for the development of new generation intelligent computer systems]
:= [A variant of displaying the *OSTIS Standard* as a sequence of concepts and their dictionary specifications, presented in lexicographical order of the terms of these concepts]
:= [The result of different perspectives consistency in the field of information technology]
⇐ *form of presentation**:
OSTIS Standard
⊂ *OSTIS Standard*
∈ *knowledge base fragment*
∈ *semantic dictionary*
⇒ *generalised decomposition**:
{• *A sequence of concepts and their dictionary specifications, arranged in lexicographic order of the terms of these concepts*
  := [Dynamically formed atomic or non-atomic section of the *OSTIS Metasystem* knowledge base, representing a sequence of concepts and their dictionary specifications of the *OSTIS Standard*, arranged in lexicographic order of the terms of these concepts]
  ∈ *dynamic structure*
  ⊂ *OSTIS Standard*
    ⊂ *Knowledge base of the OSTIS Metasystem*
  ⊃ *Documentation on the development and use of the OSTIS Glossary*
• *OSTIS Glossary browsing and navigation subsystem*
  := [Collective of agents providing the *OSTIS Glossary* generation from the *OSTIS Standard* and its viewing in the system]
  ⊂ *Problem solver of the OSTIS Metasystem*
}

Documentation on the development and use of the OSTIS Glossary
∈ *knowledge base section*
∈ *ostis-documentation*
⇐ *section concatenation**:
⟨• *Principles and rules of the development and consistency of the OSTIS Glossary and the OSTIS Standard*
• *Rules of placement and specification of the OSTIS Glossary objects*
• *Rules of identification of the OSTIS Glossary objects*
• *Rules of visualisation of the OSTIS Glossary object specification*
• *Principles of interaction between users and computer systems with the OSTIS Glossary*
• *Structure of the OSTIS Glossary*
• *Features and advantages of the OSTIS Glossary*
• *Author team of the OSTIS Glossary*
• *Prospects for development of the OSTIS Glossary*
⟩

We will consider the specifications of the *OSTIS Glossary* generation agents from the *OSTIS Standard*, as well as the specifications of the *OSTIS Glossary* browsing agents.

B. Specification of the OSTIS Glossary Formation Agents from the OSTIS Standard

The *OSTIS Glossary* is nothing but a variant of the *OSTIS Standard* display. It is up to a specialised module to display the *OSTIS Glossary* to the end user.

Within the *OSTIS Technology*, the only kind of entities performing transformations in the memory of systems are agents — some entities capable of performing actions in the memory of these systems, belonging to some specific class of actions.

In order to map the *OSTIS Glossary*, the following tasks must be performed automatically:

- to find and transform information from the *OSTIS Standard* into some dictionary form, in which all information is represented as a lexicographic sequence of concepts and their specifications;
- to integrate several sections of the same dictionary among themselves;
- to be able to filter the dictionary depending on the characteristics of the end user.

The following agents have been developed to solve these problems:

- The *OSTIS Glossary* section formation agent, which deals with the transformation of a logically stated the *OSTIS Standard* section into an the *OSTIS Glossary* section in which all objects are ordered lexicographically;
- The *OSTIS Glossary* section concatenation agent, designed to set the sequence between several generated the *OSTIS Glossary* sections;
- The *OSTIS Glossary* section filtering agents, forming:

– a simplified section of the *OSTIS Glossary* that contains objects without their specifications, but arranged in lexicographic order;
– simplified section of the *OSTIS Glossary*, which contains objects with their specifications without theoretical-multiplicity relations, arranged in lexicographic order;
– simplified section of the *OSTIS Glossary*, which contains objects with their specifications without didactic links, arranged in lexicographic order.

The purpose of the *OSTIS Glossary* section agent is to create a sequence of all objects belonging to the corresponding section of the *OSTIS Standard* in lexicographic order. This agent implements the following algorithm:

- Step 1: A section already existing in the knowledge base is specified as an argument.
- Step 2. A new section of the *OSTIS Glossary* is created and knowledge base objects and their corresponding dictionary specifications are added to it.
- Step 3. All objects are organised in alphabetical order.

The *OSTIS Glossary* section filtering agent allows you to simplify the display of the section for convenient use for specific purposes. The principle of operation is as follows:

- Step 1: The *OSTIS Glossary* section and the display option are specified as an argument.
- Step 2: Depending on the display option the agent changes the structure of the *OSTIS Glossary* section.

C. Specification of agents for navigating the OSTIS Glossary

One of the important tasks is the need to search for information in the *OSTIS Glossary* fast enough. To solve this problem, search agents have been developed, in particular:

- An agent for searching authors of a given object;
- An agent for searching analogues of a given object;
- An agent for searching for differences between a given object and its analogues;
- An agent for searching for objects developed by a given scientist;
- An agent for searching the definition of a given concept;
- Agent for searching relations defined on the concept;
- Agent for searching for concepts through which the given concept is defined;
- An agent for searching all entities that are specialized with respect to the given concept;
- An agent for searching authors of the specification of a given entity;
- An agent for searching identification rules for a given entity;
- and others.

D. Author team of the OSTIS Glossary

A key feature and also a key advantage of the *OSTIS Glossary* is its author team. Obviously, the authors of this paper are members of the author team of the *OSTIS Glossary*.

The ***highlight*** of the whole the *OSTIS Glossary* development activity lies in the authors themselves, the developers of the *OSTIS Glossary* — most of those involved in the development of the *OSTIS Glossary* and the writing of this paper are first-year students of the speciality "Artificial intelligence". The impetus for the creation of this creative team is as follows:

- First-year students have sufficient and, most importantly, "fresh" (!) learning experience: they understand and realise the problems related to the form of presentation and search of educational material, "gluing" information from different academic disciplines, application of the learned information in practice. Who but first-year students, who have gone through all the problems of pre-university education, are able to realise, understand and describe them in a form that will be understandable not only to highly qualified specialists, but also to the new generation of first-year students.
- Students are full of ambition and enthusiasm. The aspiration of a young person to learn new information, to create something unique contributes to the development of the whole society. From the school bench, students are the backbone of all activities for the development and improvement of all mankind. The *OSTIS Glossary* is a good starting point for the development of students.
- In addition to all this, students benefit greatly. Studying at such practice-oriented specialities as "Artificial intelligence", students not only study and get all the necessary information for developing themselves as professionals in this field, but also develop social qualities, i.e. become personalities, which is very important for their future work. Scientific-research activity, first of all, is not a creative activity, but a social one, and only effective social interaction will help to create solutions to existing problems in society.
- It should be recognised that the participation of students in such activities is also beneficial for the *OSTIS Technology* itself. Undoubtedly, the quality of any technology is determined by the level of preparedness of its developers. But every technology exists and develops as long as there is not only some need in it, but also when there is a constant replenishing and growing creative team of interoperable people.
- Yes, it should be noted that students are more interoperable than many other existing specialists in the world. It is easier to get in touch with them, it

is easier to communicate, to agree, to solve tasks together. The key problem of the current state of the whole society is that it is not capable of solving problems of a serious enough level.

Creating and organising such a team is not the easiest task. Let's reveal the secret of how to form such a team:

- First of all, it is important that the initiators of all these activities are not just teachers who are motivated by student learning and development, but also teachers who are engaged in both science and application development.
- And most importantly, such specialists should realise that nothing in the world is done by one person, that it is necessary not only to improve oneself, but also to contribute to the development and improvement of others, and only in this case society will be able to develop harmoniously in all its directions.

Students and teachers have the same requirements. They must possess:

- A high level of professional qualities, including:
  - a high level of system culture, i.e. the ability to think abstractly, argue a point of view, draw correct conclusions, etc.;
  - a high level of mathematical culture, i.e. the culture of formalisation;
  - a high level of technological and engineering culture, i.e. the ability to apply theoretical knowledge in practice, invent and implement ideas, etc;
- a high level of social qualities, including:
  - a high level of interoperability (!), as defined by:
    * a high level of social responsibility, i.e. responsibility for the tasks they have to perform;
    * a high level of social engagement, i.e. the ability to make decisions, to create ideas, to be the engine of the team;
    * a high level of agreement ability, i.e. the ability to create mutually beneficial conditions with other team members;
  - a high level of moral and ethical qualities.

The following directions of development of the current Author team of the *OSTIS Glossary* are worth mentioning:

- to create a favourable environment and conditions for the development and training of the members of this team;
- to create conditions for the rapid entry of new people;
- to create conditions for the accumulation and reuse of experience in the team.

E. Prospects for development of the OSTIS Glossary

The following directions can be set for the *OSTIS Glossary*:

- to improve the text of the *OSTIS Glossary*, which implies improving the text of the *OSTIS Standard*, including:
  - to provide a complete specification of the objects described within the *OSTIS Glossary*;
  - to provide sufficiently complete didactic information in the specifications of these objects, including:
    * full description of authors, bibliographic sources of these objects;
    * comparative description with similar objects within the *OSTIS Glossary*;
    * a sufficiently detailed description of the explanatory information to the basic information of these objects.
- translation of concept terms into other natural languages, including English;
- to improve the tools for browsing and navigating the *OSTIS Glossary*;
- improvement of tools to automate the process of updating the *OSTIS Ecosystem* knowledge base;
- development of the Author team of the *OSTIS Glossary* and attraction of new specialists and developers.

V. Conclusion

In summary, the result of this work is a comprehensive tool to ensure consistent and comatible activities both in the development of new generation intelligent systems and in any other field — the *OSTIS Glossary*, allowing:

- to represent any information in the same form which:
  - makes this information understandable and consistent not only for humans, but also for computers;
  - simplifies the processing of this information;
  - simplifies the convergence and integration of different types of knowledge;
  - makes it possible to integrate information from different information sources;
- to describe and structure information both from one subject domain and information at "junctions" between subject domains which:
  - makes it easier to provide consistency of existing information and addition of new information;
  - makes it easier to find this information and integrate new information;
  - makes it possible to build knowledge libraries, i.e. to reuse existing knowledge;
  - makes it possible to describe information in different external languages in a consistent form;
- to standardise the description and visualization of information of various kinds, which:

- simplifies the consistency of existing information and the addition of new information;
- standardizes support for methods and tools to enhance existing information;
- enables the creation of a personalized experience for any end-user.

It is also worth noting that the solution proposed within this paper — *OSTIS Glossary* — is:

- a part of the *OSTIS Metasystem* Knowledge base, as known the *OSTIS Standard*, which allows:
  - to develop the *OSTIS Glossary* by the same means by which any intelligent computer system based on the *OSTIS Technology* is developed;
  - use the same tools to view and navigate the text of the *OSTIS Glossary*;
  - automatic consistent development of the *OSTIS Glossary* and the *OSTIS Standard*;
- a simplified version of the *OSTIS Standard*, which allows:
  - to quickly search and reuse existing information;
  - to quickly provide consistency and integrate new information;
  - to reduce the circle of entry for new people to develop the *OSTIS Technology*;
- an environment for social and creative learning and development of new staff in the field of Artificial Intelligence.

The introduction of such information resources can significantly improve the quality and efficiency of various activities.

The authors believe that this paper will be useful not only for those who are researching innovative methods and technologies for more effective organisation of teamwork, but also for those who are just beginning research in this area.

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ГЛОССАРИЙ OSTIS — ИНСТРУМЕНТ ДЛЯ ОБЕСПЕЧЕНИЯ СОГЛАСОВАННОЙ И СОВМЕСТИМОЙ ДЕЯТЕЛЬНОСТИ ПО РАЗРАБОТКЕ ИНТЕЛЛЕКТУАЛЬНЫХ СИСТЕМ НОВОГО ПОКОЛЕНИЯ

Зотов Н. В., Ходосов Т. П., Остров М. А.,
Позняк А. В., Романчук И. М.,
Рублевская Е. А., Семченко Б. А.,
Сергиевич Д. П., Титов А. В., Шаров Ф. И.

Данная работа включает подробный анализ проблем организации различных видов коллективной деятельности, сравнительный анализ текущих решений по обеспечению согласованности и совместимости информации из различных областей знаний, а также анализ методов и технологий для создания единых информационных пространств для обеспечения согласованного и совместимого хранения, обработки, накопления и распространения знаний. В работе предлагается один из вариантов реализации единого информационного ресурса для обеспечения согласованной и совместимой деятельности по разработке интеллектуальных компьютерных систем нового поколения — Глоссарий OSTIS. Описывается его структура, правила структуризации, размещения и идентификации знаний в нём, а также принципы работы с ним.

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