

Metasystem of the OSTIS Technology and the Standard of the OSTIS Technology

Kseniya Bantsevich
*Belarusian State University of
Informatics and Radioelectronics*
Minsk, Belarus
Email: ksusha.bantsevich@gmail.com

Abstract—In the article, an approach to automating the processes of creation, development, and application of standards based on the OSTIS Technology is proposed. The general problems related to the development and usage of modern standards in various fields are considered. Standardization of intelligent computer systems is proposed, as well as standardization of methods and means of their design within the proposed approach.

Keywords—Standard, standard of intelligent computer systems, Metasystem of the OSTIS Technology, Standard of the OSTIS Technology.

I. INTRODUCTION

Each developed sphere of human activity is based on a number of standards that formally describe its various aspects — a concepts system (including terminology), typology, sequence of actions performed in the process of applying appropriate methods and tools, and much more [1].

Standards in a wide variety of fields are the most important knowledge type, the main purpose of which is to ensure the compatibility of various activities. Despite the development of information technologies, currently, the vast majority of standards are represented either in the form of traditional linear documents or in the form of web resources containing a set of static pages connected by hyperlinks. In order for standards to fulfill their main function, they must be constantly improved. Due to the need for their permanent development, the current design of standards does not meet modern requirements.

II. ANALYSIS OF EXISTING PROBLEMS AND APPROACHES TO THEIR SOLUTIONS

The current design of standards has a number of disadvantages that prevent the effective and competent usage of standards in various fields [2], [3]:

- duplication of information within the document describing the standard;
- the complexity of maintaining the standard itself due, among other things, to the duplication of information, in particular, the complexity of changing terminology;
- the problem of internationalization of the standard — in fact, the translation of the standard into several

languages leads to the need to support and coordinate independent versions of the standard in different languages;

- the complexity of studying and applying standards;
- and others.

The listed problems are mainly related to the form of representation of standards. To solve these problems, standards should be designed in the form of intelligent reference systems that are able to answer a variety of questions. Thus, it is advisable to design standards in the form of knowledge bases, corresponding to intelligent reference systems. This approach makes it possible to significantly automate the processes of developing the standard and its application [4], [5].

Another urgent problem in the field of creating and applying standards for comprehensive technologies is the problem of their incompatibility, since different aspects of technology can be standardized by different standards that are incompatible with each other due to the inconsistency of the system of concepts and terms.

III. PROPOSED APPROACH

Currently, *Informatics* is overcoming the most important stage of its development – the transition from data informatics (data science) to knowledge informatics (knowledge science), where attention is focused on semantic aspects of the representation and processing of *knowledge*.

Without a fundamental analysis of such a transition, it is impossible to solve many problems related to the management of *knowledge*, the economy of *knowledge*, *semantic compatibility of intelligent computer systems*.

To solve the above problems, it is proposed to use the *OSTIS Technology*, the main feature of which is the focus on the usage of next-generation computers specifically designed for the implementation of semantically compatible hybrid *intelligent computer systems* [6].

From a semantic point of view, each standard is a hierarchical ontology that clarifies the structure and systems of concepts of their corresponding subject domains, which describes the structure and functioning of either a certain class of technical or other artificial systems, or a

certain class of organizations, or a certain type of activity. This approach provides obvious advantages in terms of automating the processes of harmonization and usage of standards [7], [8].

As part of this work, the experience of using this *technology* when designing the *Standard of the OSTIS Technology* will be considered. The suggested *Standard of the OSTIS Technology* is designed in the form of a *family of knowledge base sections* of a special intelligent computer *OSTIS Metasystem* (Intelligent MetaSystem for ostis-systems) [9], which is built based on the *OSTIS Technology* and represents a constantly improving intelligent *portal of scientific and technical knowledge*, which supports the permanent evolution of the *OSTIS Standard*, as well as the development of various *ostis-systems* (intelligent computer systems built based on the *OSTIS Technology*).

The *OSTIS Technology* is a complex of models, techniques, automated methods, and tools permanently developed within an open project, focused on ontological design, production, operation, and reengineering of semantically compatible hybrid *intelligent computer systems* capable of interacting independently with each other.

The represented *technology* is a technology of a fundamentally new level, which is conditioned by:

- the high quality of intelligent computer systems (*ostis-systems*) developed on its basis – their *semantic compatibility*, the ability to interact independently, the ability to adapt to users, and the ability to adapt (train) users themselves to interact with intelligent computer systems more effectively;
- the high quality of the *technology* itself – the ability to integrate the most diverse *knowledge types* and the most diverse *problem-solving models*, the inextricable connection between the processes of development of *intelligent computer systems* and professional training of developers.

The *OSTIS Technology* is based on the usage of unified semantic networks with a basic set-theoretic interpretation of their elements as a method of knowledge representation. This way of knowledge representation is called an *SC-code*, and the semantic networks, represented in the *SC-code*, are called *sc-graphs* (*sc-texts*, or *texts of the SC-code*). The elements of such semantic networks are called *sc-elements* (*sc-nodes* and *sc-connectors*, which, in turn, can be *sc-arcs* or *sc-edges* depending on their orientation). The *Alphabet of the SC-code* consists of five basic elements, on the basis of which *SC-code* constructions of any complexity are built, including the introduction of more particular kinds of *sc-elements* (e.g., new concepts). The memory storing *SC-code* constructions is called semantic memory, or *sc-memory*.

The key feature of the *SC-code* is the joint usage of the mathematical apparatus of a graph theory and a set theory. This allows, on the one hand, ensuring the strictness and

universality of formalization tools and, on the other hand, ensuring the convenience of storing and processing information represented in this form.

Within the technology, several universal variants of visualization of the *SC-code* constructions are also proposed, such as *SCg-code* (graphic version), *SCn-code* (non-linear hypertextual version), *SCs-code* (linear string version).

Within this article, fragments of structured texts in the *SCn-code* [9] will often be used, which are simultaneously fragments of source texts of the knowledge base, which are understandable both to a human and to a machine. This allows making the text more structured and formalized while maintaining its readability. The symbol “:=” in such texts indicates alternative (synonymous) names of the described entity, which reveal in more detail some of its features.

The key features of the represented *technology* are:

- Complex nature, consisting in:
 - supporting the design of not only separate components of *intelligent computer systems* but also *intelligent computer systems* as a whole;
 - supporting not only the design but also the entire *life cycle* of intelligent computer systems.
- Ensuring *semantic compatibility* of both components of *intelligent computer systems* and intelligent computer systems as a whole throughout their *life cycle*.
- Implementation of the *OSTIS Technology* in the form of a *next-generation intelligent computer system*, which is also built based on the *OSTIS Technology*.

OSTIS Technology

⇒ *class of products**:

ostis-system

:= [next-generation intelligent computer systems built using the *OSTIS Technology*]

⊂ *next-generation intelligent computer system*

⊃ *OSTIS Metasystem*

IV. OSTIS METASYSTEM

The *OSTIS Metasystem* [9] is an intelligent computer system that provides:

- comprehensive information support for all stages of the *life cycle* of next-generation intelligent computer systems;
- automation of the design for all components of *next-generation intelligent computer systems*;
- comprehensive automation of all stages in the *life cycle* of *next-generation intelligent computer systems*.

The implementation form of the represented *OSTIS Metasystem* is the *OSTIS Technology*.

The *OSTIS Metasystem* is:

- a system of information and instrumental support for all stages of the life cycle of next-generation intelligent computer systems (*ostis-systems*) for various purposes;
- OSTIS Technology Knowledge Portal, providing:
 - □ coordination of work on the development of the OSTIS Technology;
 - □ automation of quality analysis of the OSTIS Standard.

That is, the OSTIS Metasystem is a project management system for the creation and development of the *OSTIS Standard*.

V. OSTIS STANDARD

The *Standard of the OSTIS Technology* [10] is a documentation of the OSTIS Technology, which is represented as the main part of the knowledge base of a special intelligent computer system designed to comprehensively support the life cycle of semantically compatible next-generation intelligent computer systems (the OSTIS Metasystem).

OSTIS Standard

- := [documentation of the *OSTIS Technology*]
- := [documentation of the Open Technology for ontological design, production, and operation of semantically compatible hybrid *intelligent computer systems*]
- := [description of the *OSTIS Technology* (Open Semantic Technology for Intelligent Systems), represented in the form of a family of sections in the *knowledge base of a special ostis-system* (system built based on the *OSTIS Technology*) in the internal language of *ostis-systems* and possessing sufficient completeness for the usage of this *technology* by developers of *intelligent computer systems*]
- := [complete description of the current state of the *OSTIS Technology*, represented in the form of a family of sections in the *knowledge base* built based on the *OSTIS Technology*]
- := [family of sections in the *knowledge base* of the *OSTIS Metasystem*, which is designed to provide comprehensive support for the ontological design of semantically compatible *hybrid intelligent computer systems*]
- ∈ *family of knowledge base sections*
 - := [family of sections of the internal representation of the *ostis-system knowledge base* – an intelligent computer system built using the *OSTIS Technology*]
- := [fairly complete formal documentation of the current version of the *OSTIS Technology*, represented either as the main part of the knowledge base of

- the *OSTIS Metasystem* or as an external formal representation of this *knowledge base*]
- := [main part of the *OSTIS Metasystem* knowledge base describing the current version of the *OSTIS Technology*]
- := [formal text, the object of which is the *OSTIS Technology*, i.e. a text that is a fairly complete description of the current state of the *OSTIS Technology*]
- := [documentation of the *OSTIS Technology*, fully reflecting the current state of the *OSTIS Technology* and represented by the corresponding *family of knowledge base sections* of the *ostis-system*, which is focused on supporting the design, production, operation, and evolution (reengineering) of *ostis-systems*, as well as supporting the evolution of the *OSTIS Technology* itself and named the *OSTIS Metasystem*]
- := [family of sections that includes all sections of the *OSTIS Standard*]
- ⇒ *main sc-identifier**:
[OSTIS Standard]
- ⇐ *reduction**:
[Standard of the *OSTIS Technology*]
- ⇐ *reduction**:
[Standard of an Open *technology* for integrated support of the *life cycle* of semantically compatible *next-generation intelligent computer systems*]

It should be emphasized that the *OSTIS Standard* is not a description of a certain state of the *OSTIS Technology* but a dynamic information model of the evolution of this *technology*.

VI. TABLE OF CONTENTS OF THE OSTIS STANDARD

One of the components of the *OSTIS Standard* is the *Table of contents of the OSTIS Standard*.

The *Table of contents of the OSTIS Standard* is a hierarchical list of sections included in the *OSTIS Standard*, with an additional specification of some sections indicating their alternative names. It is essential to emphasize that the hierarchy of sections of the *OSTIS Standard* does not mean that *sections* of a lower level of the hierarchy are part of the corresponding sections of a higher level. The relation between *sections* at different levels of the hierarchy means that a *section* at a lower level of the hierarchy is a *child* section in relation to the corresponding *section* at a higher level, i.e. a section that inherits the properties of the specified *section* at a higher level.

In contrast, each *part of the OSTIS Standard*, as well as the *OSTIS Standard* itself, is a *family of sections* (a set of sections) that are part of it.

VII. GENERAL STRUCTURE OF THE OSTIS STANDARD

Consider the structure of the top-level *OSTIS Standard*:

- Part 1 of the OSTIS Standard.
Introduction to next-generation intelligent computer systems
 - := [Analysis of the current state of *technologies of Artificial Intelligence* and setting the objective for creating a *complex* of compatible *Artificial Intelligence technologies* that provides support for the entire *life cycle of next-generation intelligent computer systems* and named an *OSTIS Technology*]
- Actual documentation of the *OSTIS Technology*
 - Part 2 of the OSTIS Standard.
Semantic representation and ontological systematization of knowledge of the next-generation intelligent computer systems
 - := [Standard for information representation in ostis-systems]
 - := [Models of representation of knowledge and knowledge bases in ostis-systems]
 - Part 3 of the OSTIS Standard.
Multi-agent problem solvers of next-generation intelligent computer systems
 - := [Standard of processes and methods of information processing in ostis-systems]
 - := [Knowledge processing models in ostis-systems (logical, production, functional, neural network, procedural and non-procedural, clear and fuzzy)]
 - Part 4 of the OSTIS Standard.
Ontological interfaces models of next-generation intelligent computer systems
 - := [Standard of information resources and models for solving interface problems in ostis-systems]
- Standard of methods and means of life cycle support for ostis-systems
 - := [Standard of business processes and techniques, automatically implemented processes and methods, information tools and tools used to support the life cycle of ostis-systems]
- Part 5 of the OSTIS Standard.
Methods and means of designing next-generation intelligent computer systems
 - := [Techniques, methods, and tools for designing knowledge bases, problem solvers, and interfaces of ostis-systems]
- Part 6 of the OSTIS Standard.
Implementation platforms for next-generation intelligent computer systems

:= [Methods and means of implementing ostis-systems (based on software platforms and specially designed computers for this purpose)]

- Part 7 of the OSTIS Standard.
Methods and means of reengineering and operation of next-generation intelligent computer systems
 - := [Methods and means of ostis-systems operating by end users, as well as their maintenance (maintenance of operability) and reengineering (updates, upgrades)]
- Part 8 of the OSTIS Standard.
Ecosystem of next-generation intelligent computer systems and their users
 - := [Description of products created using the OSTIS Technology, the main of which is the *OSTIS Ecosystem*, semantically compatible and actively interacting ostis-systems and their users]
 - := [Theory of the OSTIS Ecosystem and its evolution]
- OSTIS Bibliography
 - := [Specification of *bibliographic sources* semantically close to the *OSTIS Technology*, in the context of their comparative analysis with the *OSTIS Standard*]

VIII. KEY SIGNS OF THE OSTIS STANDARD

The system of key signs of the OSTIS Standard is ordered in exact accordance with the Table of contents of the OSTIS Standard and is a clarification of the specified Table of contents by listing and explaining the key entities described in the sections of the Standard, and, first of all, those entities that are specified in the identifiers (names) of the sections of the OSTIS Standard.

The *System of key signs of the OSTIS Standard* is a complete addition to the Table of contents of the OSTIS Standard, since:

- the hierarchy and sequence of key characters clearly correspond to the hierarchy and sequence of sections of the standard;
- the system of key signs of the OSTIS Standard, as well as its Table of contents, is perceived (read) as a complete understandable text.

IX. PURPOSE OF THE OSTIS STANDARD

Since the *OSTIS Standard* is an integral part of the *OSTIS Metasystem* (the main part of its knowledge base), the main purpose of the *OSTIS Standard* is to ensure the most effective implementation of what the *OSTIS Metasystem* is designed for.

In addition, the most important direction of the *OSTIS Metasystem* and, accordingly, the most important direction of the application of the *OSTIS Standard* is their usage

as a comprehensive integrated computer textbook in the specialty “Artificial Intelligence”. For this purpose, a connection is established between the sections of the *OSTIS Standard* and the programs of various academic disciplines of the specified specialty. It is important to emphasize at the same time: the *OSTIS Standard* contains a fairly complete comparative analysis with various alternative approaches, i.e. in no case is limited to considering only the *OSTIS Technology*.

The *OSTIS Standard* is considered as a result of convergence and integration of various directions of *Artificial Intelligence*, which allows students and undergraduates to form a holistic view of the subject of *Artificial Intelligence*, rather than a mosaic representation in the form of a variety of disciplines (directions), the connections between which are not considered in detail and even more formally.

The *OSTIS Standard* is permanently and rapidly evolving. During the training of students and undergraduates, there are very significant changes in the current version of the *OSTIS Standard*.

Students and undergraduates are actively involved in the process of evolution of the *OSTIS Standard*, which ensures:

- formation of the necessary level of their qualifications in conditions of rapid moral aging of what they have already been taught;
- formation of the necessary skills that allow them to quickly adapt to the new conditions of this activity and, in particular, to new versions of relevant technologies in the process of real professional activity.

X. ANALOGUES OF THE OSTIS STANDARD

Analogues of the *OSTIS Standard* include:

- any serious attempt to systematize the results obtained in the field of Artificial Intelligence to the current moment:
 - a textbook that fully reflects the current state of *Artificial Intelligence*;
 - a reference book containing fairly complete information about the current state of *Artificial Intelligence*.
- any attempt to move from particular formal models of various components from the intelligent computer systems of the general (combined, integrated) formal model of intelligent computer systems as a whole to the general theory of intelligent computer systems;
- any unification of technical solutions, elimination of the variety of forms of technical solutions in the development of intelligent computer systems;
- the first attempts to develop standards for *intelligent computer systems*, as well as *Artificial Intelligence technologies*, which, most often, are limited to the building of systems of corresponding concepts.

XI. FEATURES OF THE OSTIS STANDARD

The *OSTIS Standard* is not just a systematization of the current state of results in the field of *Artificial Intelligence* – it is a systematization represented in the form of a general complex formal model of *intelligent computer systems* and a complex formal model to support their life cycle. Moreover, the text of the *OSTIS Standard* is the *main part of the knowledge base* of a special *intelligent metasystem*, which is focused on:

- support for the development of *intelligent computer systems* for various purposes;
- support for the evolution of the *OSTIS Standard*;
- support for the *training of specialists in the field of Artificial Intelligence*.

The *OSTIS Standard* is a dynamic text that permanently reflects new scientific and technical results obtained in the field of *Artificial Intelligence* within a *General theory of intelligent computer systems* and *General comprehensive technology for the development of intelligent computer systems*. It is important that new scientific and technical results are recorded promptly, i.e. minimizing the time interval between the moment of obtaining new results and the moment of integrating the description of these results into the *OSTIS Standard*. In the future, the authors of new scientific and technical results in the field of *Artificial Intelligence* will be interested in personally publishing (integrating) their results into the *OSTIS Standard*, i.e. becoming co-authors of the *OSTIS Standard* to ensure the necessary efficiency of such publication and the absence of distortion of its results. Dynamism of the *OSTIS Standard* and efficiency of integration into its structure of new scientific and technical results in the field of *Artificial Intelligence* does the *OSTIS Standard* always relevant and never obsolete.

Within the *OSTIS Standard*, there is no opposition between scientific and technical information, obtained in the field of Artificial Intelligence, and educational and methodological information, used for the training and self-training of specialists in the field of Artificial Intelligence. Information about what to learn should be “intertwined”, integrated with information about how to learn.

It is important to note that the *OSTIS Standard*, unlike other standards, is a structured formal text that can be directly used not only by developers of *intelligent computer systems* but also by intelligent computer systems that automate the design of developed *intelligent computer systems* and support subsequent stages of their life cycle. Thus, the development of the *OSTIS Standard* is an integral part in the development of a set of information and instrumental support tools for the entire life cycle of *intelligent computer systems*, and these support tools of *life cycle of intelligent computer systems* become equal partners in the process of creating, operating, and maintaining *intelligent computer systems* due to their

awareness (understanding) in *intelligent computer systems* and their *life cycle*.

Comprehensive, the *OSTIS Standard* covers not only the description of models of intelligent computer systems being developed but also the description of techniques, automated methods, and tools for supporting (automating) all stages of the life cycle of intelligent computer systems being developed.

The *OSTIS Standard* development project is focused on high rates of evolution of the *OSTIS Standard* thanks to automating the management of this project using the *OSTIS Metasystem*, which is a full participant in this project.

Building and structuring of text of the *OSTIS Standard* are focused on the maximum possible reduction of the language and cognitive barrier for its novice users. For this purpose, (1) various kinds of natural language notes and comments are used that have appropriate semantic connections with the entities being explained, as well as (2) various kinds of didactic knowledge indicating various analogies, differences, examples, principles underlying the described entities, etc.

XII. USER OF THE OSTIS STANDARD

Consider the target audience of the *OSTIS Standard*.

OSTIS Standard

⇒ *users class**:

user of the OSTIS Standard

:= [target audience of the *OSTIS Standard*]

⇒ *subdividing**:

- {• *developer of the ostis-system*
 - ⊃ *developer of the OSTIS Metasystem*
 - ⊃ *developer of the ostis-system knowledge base*
 - ⊃ *developer of the OSTIS Standard*
 - ⊃ *developer of the ostis-system problem solver*
 - ⊃ *developer of the OSTIS Metasystem problem solver*
 - ⊃ *developer of the ostis-system interface*
 - ⊃ *developer of the OSTIS Metasystem interface*
 - ⊃ *developer of ostis-systems implementation platforms*
- *potential developer of the ostis-system*
- *specialist in the field of Artificial Intelligence who wants to*

integrate their results into the general theory of next-generation intelligent computer systems and the corresponding comprehensive technology

- *student or master student of the “Artificial Intelligence” specialty or another related specialty who wants to gain practical experience in the development of applied next-generation intelligent computer systems or in the development of an appropriate comprehensive technology*

}

developer of the OSTIS Metasystem

⇒ *subdividing**:

- {• *developer of the OSTIS Standard*
- *developer of the OSTIS Metasystem problem solver*
- *developer of the OSTIS Metasystem interface*

}

XIII. WRITING TEAM OF THE OSTIS STANDARD

To ensure permanent evolution, there are a number of requirements focused on the authors of the *OSTIS Standard*.

Authors of the *OSTIS Standard* should:

- Track and study new publications on the topics covered in the *OSTIS Standard*. Close sources for this are:
 - magazine issues;
 - conference materials:
 - * organized by the 3WC Consortium;
 - * on the integration of various AI directions;
 - standards in the field of AI;
 - publications, considering:
 - * formal ontologies;
 - * top-level ontologies;
 - * semantic networks;
 - * knowledge graphs;
 - * graph databases;
 - * semantic representation of knowledge;
 - * convergence of different AI directions.
- To record the results of the study of new publications on topics close to the *OSTIS Standard* in the *OSTIS Bibliography*, as well as in the main text of the *OSTIS Standard* in the form of appropriate references, citations, comparative analysis.
- Track the current state of the total text of the *OSTIS Standard*, form proposals aimed at the development of the *OSTIS Standard* and at increasing the pace

of this development; actively participate in the discussion of the problems of OSTIS Technology development.

- To connect personal work on the OSTIS Standard with other forms of activity – scientific, educational, applied – in the maximum possible way.
- Indicate the authorship of their proposals to supplement and/or correct the current text of the OSTIS Standard.
- Participate in reviewing and approving proposals submitted by other authors of the OSTIS Standard.

The large volume of work on the creation and development of the *OSTIS Standard* and, accordingly, the *OSTIS Technology*, the complex nature of these works, which require deep convergence and integration of various directions of *Artificial Intelligence*, place high demands on the *Writing Team of the OSTIS Standard* in terms of motivation, the quality of the creative atmosphere, the level of *interoperability* of all team members, i.e. the level of ability to quickly and efficiently coordinate personal points of view.

Since the Project for the creation and development of the *OSTIS Standard* is open, anyone who follows the Rules for organizing the interaction of members of the OSTIS Standard Writing Team, sharing the purposes and objectives of developing such a Standard can become a member of the OSTIS Standard Writing Team.

The following key points of the *Rules for organizing the interaction of members of the OSTIS Standard Writing Team of the OSTIS Standard* are highlighted:

- collectively form tactical and strategic directions for the development of the OSTIS Standard and, accordingly, OSTIS Technology;
- collectively distribute tasks for the implementation of the approved directions for the development of the OSTIS Standard, taking into account (1) the scientific interests, qualifications and capabilities of each member of the Writing Team, (2) the priority of tasks and a sufficiently complete coverage of all priority tasks.

XIV. EDITORIAL BOARD OF THE OSTIS STANDARD

Within the *Writing Team of the OSTIS Standard*, the *Editorial Board of the OSTIS Standard* is also distinguished.

The *Editorial Board of the OSTIS Standard* is a part of the *Writing Team of the OSTIS Standard*, which is the center of collegial decision-making on the main directions of the development of the OSTIS Standard and, accordingly, the OSTIS Technology, in order to clarify the relevant priorities and terms. The *Editorial Board of the OSTIS Standard* is also responsible for the formation and implementation of strategic directions for the development of the OSTIS Standard and, in particular,

for the selection and appointment of *responsible executors for sections of the OSTIS Standard*.

The main activities of the *Editorial Board of the OSTIS Standard* are:

- ensuring the integrity and improving the quality of the constantly developing OSTIS Technology, as well as a fairly accurate description (documentation) of each current version of this technology;
- ensuring clear control of compatibility of OSTIS Technology versions as a whole, as well as versions of various components of this technology;
- constantly clarifying the degree of importance for various directions of OSTIS Technology development for each current moment;
- formation and constant refinement of the plan for tactical and strategic development of the *OSTIS Technology* itself, as well as complete documentation of this Technology in the form of the *OSTIS Standard*. At the same time, we emphasize that this documentation is an integral part of the *OSTIS Technology*.

XV. REQUIREMENTS FOR THE OSTIS STANDARD

The *OSTIS Standard* must meet the following requirements:

- the concepts introduced (including didactic relations) should be clearly explained and/or defined in the relevant section of the OSTIS Standard;
- providing the possibility of step-by-step formalization of information, starting from nl-texts, which can later be written in a formal language;
- a clear logical and semantic specification of each subject domain considered in the OSTIS Standard. The named specification should reflect both the internal structure of the subject domain (the roles of its key elements) and the connections with other subject domains;
- convergence, (“seamless”) integration of various *knowledge* types describing a variety of entities, which, in particular, include knowledge of all kinds;
- integrity, completeness, connectivity:
 - lack of information holes;
 - a fairly complete specification of all entities;
 - consistency of basic identifiers (terms), absence of synonyms and homonyms.
- absence of information excesses and information garbage;
- clear semantic stratification – each fragment of the knowledge base should have its own semantic “shelf” (no duplication);
- strict logical sequence of the text (all entities used must be introduced either in a given subject domain or in a higher-level subject domain);
- unification of stylistics – the text should not cause difficulties for its understanding;

- extended bibliography and comparative analysis;
- strict compliance with and improvement of the rules for identification and specification of the described entities;
- a sufficiently detailed specification of each introduced concept in the relevant subject domain.

XVI. RULES FOR THE CONSTRUCTION OF THE OSTIS STANDARD

As part of the development of the *OSTIS Standard*, the *General rules for the construction of the OSTIS Standard* and the *Particular rules for the construction of the OSTIS Standard* are distinguished.

General rules for the construction of the OSTIS Standard

:= [principles underlying the structuring and design of the OSTIS Standard]

Let us consider the main conditions:

- The main form of representation of the *OSTIS Standard* as a complete documentation for the current state of the *OSTIS Technology* is the *internal representation* of the main part from the *knowledge base* of the special intelligent computer *OSTIS Metasystem*, which ensures the usage and evolution (permanent improvement) of the *OSTIS Technology*. This representation of the *OSTIS Standard* provides effective semantic navigation through the contents of the *OSTIS Standard* and the ability to ask the *OSTIS Metasystem* a wide range of non-trivial questions about the most diverse details and subtleties of the *OSTIS Technology*.
- In addition to the representation of the *OSTIS Standard* in the *internal language of knowledge representation*, the external form of the representation of the *OSTIS Standard* in the *external language of knowledge representation* is also used. At the same time, the specified external representation of the *OSTIS Standard* should be structured and designed so that the reader can easily “manually” find almost any *information* of interest in this text. The *SC-code* is used as the formal language of the external representation of the *OSTIS Standard*.
- The *OSTIS Standard* has an ontological structuring, i.e. it is a hierarchical system of related *formal subject domains* and their corresponding *formal ontologies*. This ensures a high level of stratification of the *OSTIS Standard*.
- 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 considered (investigated) in detail, where all the basic information about this *concept*, about its various properties, is concentrated.
- The *OSTIS Standard* also includes files of information constructions that are not *SC-code* constructions (including *sc-texts* belonging to various natural languages). Such files allow formally describing the syntax and semantics of various external languages in the knowledge base, as well as also allow including in the knowledge base various kinds of explanations and 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 hierarchical system of formal models of *subject domains* and their corresponding *formal ontologies*.
- From a semantic point of view, the *OSTIS Standard* is a large *refined semantic network*, which, accordingly, has a non-linear character and which includes signs of any types of entities described (material entities, abstract entities, concepts, connections, structures), as well as, accordingly, contains connections between all these types of entities (in particular, connections between connections, connections 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 determined by a set of *relations* and *parameters* indicated on the classes of *research objects*. On a set of *subject domains*, the *private subject domain** relation is set, which indicates the direction of inheritance of properties for research objects considered in different *subject domains*.
- Each *section of the OSTIS Standard* may contain the *knowledge* that is part of the *subject domain and ontology*, which is either fully represented by the specified *section* or partially represented in the form of a specification of one or more specific research objects.
- Synonymy and homonymy of the main *sc-identifiers* within each family is not allowed.
- 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 it should be specified for each subject domain.
- The *OSTIS Standard* itself is an internal *semantic representation* of the main part from the knowledge base of the *OSTIS Metasystem* in the internal semantic language of *ostis-systems* (this language is called an *SC-code* – Semantic Computer Code).

In addition to the *General Rules for the construction of the OSTIS Standard*, in the *OSTIS Standard*, descriptions of various particular (specialized) rules for constructing (formatting) various types of fragments of the *OSTIS Standard* are provided. These types of fragments include

the following ones:

- *sc-identifier*
 - := [external identifier of the internal sign (*sc-element*) included in the *ostis-system knowledge base*]
 - := [*information construction* (most often, a string of characters) that provides unambiguous identification of the corresponding entity described in the *ostis-systems of knowledge bases* and is, most often, a name (term) corresponding to the entity being described, a name denoting this entity in the external texts of *ostis-systems*]
- *sc-specification*
 - := [semantic neighborhood]
 - := [semantic neighborhood of the corresponding *sc-element* (an internal sign stored in the memory of the *ostis-system* as part of its *knowledge base*, represented in the internal language of the *ostis-systems*)]
 - := [semantic neighborhood of some *sc-element* stored in *sc-memory* within the current state of this *sc-memory*]
- *sc-construction \ sc-specification*
 - := [*sc-construction* (construction of the *SC-code* – the internal language of *ostis-systems*), which is not an *sc-specification*]
- *ostis-system file \ sc-identifier*
 - := [*ostis-system file*, which is not an *sc-identifier*]

It is also important to note that among the particular rules for building *sc-constructions* there are *Rules for building ostis-systems knowledge bases*. These rules are aimed at ensuring the integrity of the ostis-systems knowledge bases, (1) the relevance (necessity) of the knowledge included in each knowledge base, and (2) integrity of the knowledge base itself, i.e. the sufficiency of the knowledge included in each knowledge base for the effective functioning of the corresponding ostis-system.

XVII. DIRECTIONS OF DEVELOPMENT OF THE OSTIS STANDARD

OSTIS Standard

- ⇒ *general directions of development**:
- {• [To include in the OSTIS Standard sufficiently detailed rules for the construction (design) of *sc-identifiers* and *sc-specifications* of various types of entities, as well as various types of files of *ostis-systems*]
 - [At each stage, clearly distribute the work on the development of various sections of the OSTIS Standard]

- [All the tools that are part of the OSTIS Technology should be described (specified) in sufficient detail in the form of appropriate ontological models that have a clear semantic connection with the corresponding ontologies and related subject domains that are part of the OSTIS Standard]
- [To ensure sufficient completeness of the *sc-specification* of all entities under consideration]
- [Significantly expand the OSTIS Bibliography]
- [Constantly monitor the synonymy/homonymy of *sc-identifiers*]
- [Constantly improve quality control of work on the development of the OSTIS Standard]
- [It is necessary to constantly analyze the publications of other authors on issues close to the subject of the OSTIS Standard and to record in the OSTIS Standard the results of a comparative analysis of the point of view, represented in the OSTIS Standard, with the points of view of other authors by including specifications of relevant bibliographic sources with useful quotes in the OSTIS Standard]

}

XVIII. ADVANTAGES OF THE OSTIS STANDARD

The *OSTIS Standard* is an example of the transition to a fundamentally new form of representation and publication of *scientific and technical information*, research results – not just to the form of an electronic document but to the form of a semantically structured electronic document that is part of the *knowledge base* for the relevant *scientific and technical discipline*. This significantly increases the efficiency of using *scientific and technical information* accumulated by a human, since the user of this information can not only view (read) it but also interact with the intelligent computer system, which becomes a partner in using the information they need.

The *Project of creation and development of the OSTIS Standard* is a prototype of a fundamentally new approach to the organization of *scientific and technical activity* within each *scientific discipline*. This activity is implemented in the form of an open project aimed at developing the *knowledge base* of the intelligent knowledge portal in the relevant scientific and technical discipline. Such a level of formalization of *scientific and technical information*, which is understandable not only to specialists but also to *intelligent computer systems*, significantly increases the efficiency and expands the application areas for this information in *intelligent computer systems*. For example,

Knowledge base IMS

⇒ main identifier*:

Knowledge base IMS ...

⇐ section decomposition:

- {
- Table of contents of the OSTIS Standard
- Context and OSTIS Technology within the global knowledge base
- Section. OSTIS Project. History, current state and perspectives of evolution and use of OSTIS Technology
- Documentation. IMS
- History and current processes of use IMS
- Section. IMS Project. History, current processes and development program for IMS
- }

⇐ result*:

Project IMS Knowledge Base

∈ start sc-element

∈ not enough formed structure

∈ sc-model of knowledge base

∈ ...

⇒ sc-model decomposition*:
IMS

Figure 1. A home page of the *OSTIS Metasystem* knowledge base

Table of contents of the OSTIS Standard

⇒ section base order:

Context and OSTIS Technology within the global knowledge base

⇒ main identifier*:

Table of contents of the OSTIS Standard ...

⇐ section decomposition:

- {
- Part 1 of the OSTIS Standard. Introduction to next-generation intelligent computer systems
- Part 2 of the OSTIS Standard. Semantic representation and ontological systematization of knowledge of the next-generation intelligent computer systems
- Part 3 of the OSTIS Standard. Multi-agent problem solvers of next-generation intelligent computer systems
- Part 4 of the OSTIS Standard. Ontological interfaces models of next-generation intelligent computer systems
- Part 5 of the OSTIS Standard. Methods and means of designing next-generation intelligent computer systems
- Part 6 of the OSTIS Standard. Implementation platforms for next-generation intelligent computer systems
- Part 7 of the OSTIS Standard. Methods and means of reengineering and operation of next-generation intelligent computer systems
- Part 8 of the OSTIS Standard. Ecosystem of next-generation intelligent computer systems and their users
- OSTIS Bibliography
- }

∈ key sc-element:

Structure. Knowledge base IMS

∈ ...

⇒ section decomposition:
Knowledge base IMS

∈ substantive part of the knowledge base

Figure 2. A Table of contents of the OSTIS Standard

an intelligent knowledge portal on a technical discipline naturally becomes an *intelligent system for automating the design* of technical systems of the appropriate class.

Another important advantage is the fact that the *OSTIS Standard* is a prototype of next-generation textbooks that have a clear logical-semantic structuring and stratification of educational material, as well as a set-theoretic and logical classification of all concepts used. Therefore, the

usage of the *OSTIS Standard* not only as the basis of an intelligent automation system for integrated support of the *next-generation intelligent computer systems life cycle* but also as a comprehensive textbook for the training of young specialists in the field of *Artificial Intelligence* is a prototype of the widespread usage of various intelligent portals of scientific and technical knowledge as comprehensive textbooks for the training of young specialists in

relevant specialties. This will significantly improve the quality of education, which should not lag behind the development of relevant scientific and technical areas but should become an integral part of this development.

XIX. OSTIS STANDARD AS THE MAIN PART OF THE KNOWLEDGE BASE OF THE OSTIS METASYSTEM

As mentioned above, the *OSTIS Standard* is the main part of the *OSTIS Metasystem* knowledge base describing the current version of the *OSTIS Technology*, as shown in Figure 1.

The proposed representation of the *OSTIS Standard* provides effective semantic navigation through the contents of the *OSTIS Standard*, since by going to the corresponding section of the *OSTIS Metasystem*, as shown in Figure 2, it is possible to see the current version of the *OSTIS Standard*.

The user is given the opportunity to go to any topic of interest to them (Figure 3) and ask the *OSTIS Metasystem* a wide range of non-trivial questions about the most diverse details and subtleties of the *OSTIS Technology*, as shown in Figure 4, and get answers to the questions asked, as shown in Figure 5.

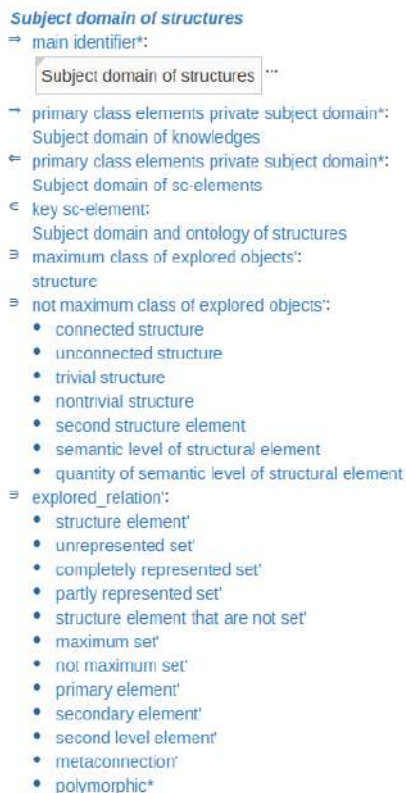


Figure 3. Navigation through the OSTIS Standard Table of contents

By default, the system responses to the user are displayed in the *SCn-code*, which is a hypertext version of the external display of *SC-code* texts and can be read as linear text.

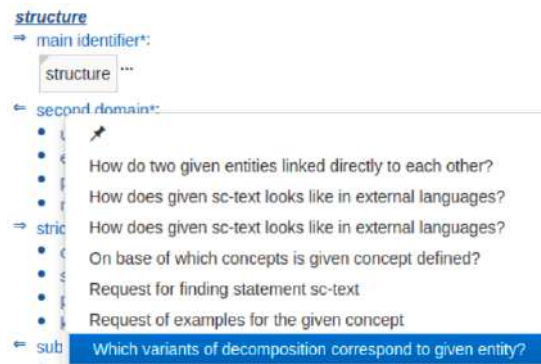


Figure 4. The function of questions of the OSTIS Metasystem

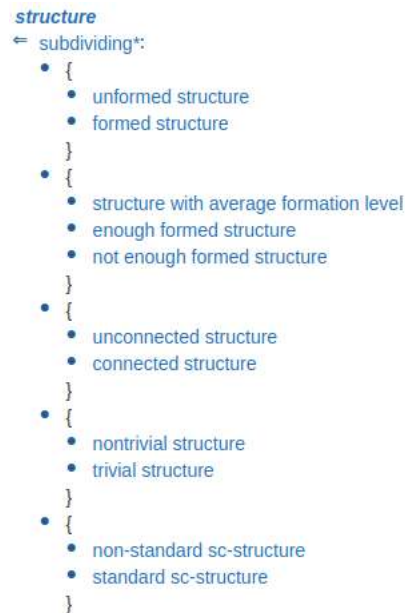


Figure 5. The function of responses of the OSTIS Metasystem

XX. CONCLUSION

Semantic compatibility of intelligent computer systems is necessary for the implementation of cooperative, purposeful, and adaptive interaction of intelligent computer systems within automatically formed collectives of intelligent computer systems, and this, in turn, requires the unification of intelligent computer systems. Unification of an intelligent computer system is possible only on the basis of a general formal theory of intelligent computer systems and the corresponding *standard of intelligent computer systems*, but for this a deep convergence of various research directions in the field of Artificial Intelligence is necessary.

Since the result of developing Artificial Intelligence as a scientific discipline is the permanent evolution of the general theory of intelligent computer systems and the corresponding standard of intelligent computer systems, in order to increase the pace of development of Artificial

Intelligence and, accordingly, technology for the development of intelligent computer systems, it is necessary to create a portal of scientific and technical knowledge on Artificial Intelligence, ensuring the coordination of the activities of specialists, as well as the coordination and integration of the results of this activity.

In the article, an approach to automating the processes of creation, development, and application of standards based on the *OSTIS Technology* is considered. Based on the *Standard of the OSTIS Technology*, the basic principles underlying the proposed approach to standardization are considered.

The approach proposed in the work allows providing not only the possibility of automating the processes of creating, approving, and developing standards but also significantly increasing the efficiency of the processes for applying the standard, both manually and automatically.

ACKNOWLEDGMENT

The author would like to thank the research group of the Departments of Intelligent Information Technologies of the Belarusian State University of Informatics and Radioelectronics for its help in the work and valuable comments.

REFERENCES

- [1] V. Golenkov, N. Gulyakina, I. Davydenko, and A. Ereemeev, "Methods and tools for ensuring compatibility of computer systems," *Otkrytye semanticheskie tekhnologii proektirovaniya intellektual'nykh sistem [Open semantic technologies for intelligent systems]*, pp. 25–52, 2019.
- [2] P. Serenkov, V. Solomahov, V. Nifagin, and A. Minova, "Konceptsiya infrastruktury standartizatsii kak bazy znaniy na osnove ontologii [the concept of a standardization infrastructure as an ontology-based knowledge base]," *Novosti. Standartizatsiya i sertifikatsiya. [News. Standardization and certification.]*, 2004.
- [3] V. Uglev, "Aktualizatsiya soderzhaniya standartov proektirovaniya slozhnykh tehnikeskikh ob'ektov: ontologicheskij podhod [updating the content of design standards for complex technical objects: ontologic approach]," *Ontologiya proektirovaniya. [Ontology of designing]*, 2012.
- [4] (2022, Nov) It/apkit professional standards. [Online]. Available: <http://www.apkit.webtm.ru/committees/education/meetings/standarts.php>
- [5] A. I. Volkov, L. A. Reingold, and E. A. Reingold, "Professional'nye standarty v oblasti it kak faktor tekhnologicheskogo i sotsial'nogo razvitiya [professional standards in the field of it as a factor of technological and social development]," *Prikladnaya informatika [Journal of applied informatics]*, pp. 80–86, 2015.
- [6] I. Davydenko, "Semantic models, method and tools of knowledge bases coordinated development based on reusable components," *Otkrytye semanticheskie tekhnologii proektirovaniya intellektual'nykh sistem [Open semantic technologies for intelligent systems]*, pp. 99–118, 2018.
- [7] S. El-Sappagh, F. Franda, F. Ali, and K.-S. Kwak, "Named ct standard ontology based on the ontology for general medical science," *BMC Medical Informatics and Decision Making*, vol. 18, no. 1, 2018. [Online]. Available: <https://doi.org/10.1186/s12911-018-0651-5>
- [8] B. R. Heravi, M. Lycett, and S. de Cesare, "Ontology- based standards development: Application of ontostand to ebxml business process specification schema," *International Journal of Accounting Information Systems*, vol. 15, no. 3, pp. 275–297, 2014. [Online]. Available: <https://doi.org/10.1016/j.accinf.2014.01.005>
- [9] (2022, Nov) IMS.ostis Metasystem. [Online]. Available: <https://ims.ostis.net>
- [10] V. Golenkov, N. Gulyakina, and D. Shunkevich, *Otkrytaja tekhnologija ontologicheskogo proektirovaniya, proizvodstva i jekspluatatsii semanticheski sovmestimyh gibridnyh intellektual'nyh komp'yuternyh sistem [Open technology of ontological design, production and operation of semantically compatible hybrid intelligent computer systems]*. Bestprint [Bestprint], 2021.

Метасистема Технологии OSTIS и Стандарт Технологии OSTIS

Банцевич К.А.

В данной работе предлагается подход к автоматизации процессов создания, развития и применения стандартов на основе Технологии OSTIS. Рассмотрены общие проблемы, связанные с развитием и применением современных стандартов в различных областях. Предложена стандартизация интеллектуальных компьютерных систем, а также стандартизация методов и средств их проектирования в рамках предлагаемого подхода.

Received 14.11.2022