Principles for implementing the ecosystem of next-generation intelligent computer systems

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***Abstract*—In the article, the architecture of the ecosystem of intelligent computer systems based on the OSTIS Technology is considered. The formal interpretation of such concepts as ostis-system, ostis-community has been clarified, the typology of ostis-systems has been identified, which together makes it possible to determine the structure of the OSTIS Ecosystem. The results obtained can be applied in the implementation of such projects as "Society 5.0", "Industry 4.0", "Smart Home", "Smart City", "Knowledge Market".**

***Keywords*—Digital Ecosystem, OSTIS Ecosystem, Society 5.0, Smart City**

I. Introduction

To increase the level of automation of more and more broad types of human activity, a qualitative transition to the development of entire complexes of independently interacting intelligent computer systems is necessary.

The central problem of the next stage in the development of information technologies is the problem of ensuring the semantic compatibility of computer systems and their components [1]. To solve this problem, it is necessary to move from traditional computer systems and modern intelligent systems to semantically compatible computer systems [2], [3].

Semantic computer systems are next-generation computer systems that eliminate many of the shortcomings of modern computer systems. *However, for the mass development of such systems, an appropriate technology is required*, which should include:

- methods and tools for designing semantic computer systems;
- methods and tools for permanent improvement of the technology itself.

As the subject of engineering activity in the field of artificial intelligence, not a set of intelligent computer systems should be considered but the whole complex of intelligent computer systems interacting with each other.

The purpose of this work is to designate the architecture of the ecosystem, within which the most comfortable conditions would be created for the implementation of next-generation intelligent computer systems, capable of organizing collectives of systems due to the high level of interoperability of these systems. It is necessary to focus not on creating an ideal information ecosystem but on creating an effective technology aimed at the permanent evolution of this ecosystem.

II. Analysis of existing approaches to solving the problem

To create any complex things, humanity draws on the concepts of nature. The process of studying elementary, natural systems and processes in order to inspire and try to replicate the learned behaviour in their designs is called biomimicry. Biomimicry is not a direct imitation of processes – it is the study of basic natural principles and their application in various areas of human society [4].

The idea of a network, a community, complex adaptive systems has also been realized by nature. The concept of such an archetype is reduced to the combination of many autonomous objects with each other. These objects are strongly connected to each other and at the same time do not have any center. Thus, they form a decentralized network, where there is the lack of a single control center [5]. The following characteristics of such a system can be distinguished:

- absence or lack of centralized control;
- autonomous nature of participants, objects of such a network;
- strong connectivity of the participants of such a network with each other;
- the influence of the participants of such a network on each other is non-linear and rather complicated.

Such distributed artificial systems have both advantages (high level of adaptability, stability, connectivity) and disadvantages (non-optimality, uncontrollability, unpredictability of behaviour). The most appropriate example of an implemented technology based on the concept of a network is the Internet.

It is convenient to use the network archetype to display complex processes, the interdependence of components, economic, social, environmental processes, and communication processes. In such processes, there is no beginning or ending, everything is the center. The network is the only topology capable of limitless expansion or self-learning;

other topologies have their own limitations. “The Atom is the icon of 20th century science. The symbol of science for the next century is the dynamical Net” [6].

The idea of a digital ecosystem is also borrowed from nature, where biological ecosystems are the main source of inspiration. The concept of an ecosystem has become a popular way of describing collaboration outside an organization [7]. It can be defined as a multi-stakeholder structure of organizations that materializes a shared value proposition. Ecosystems have two distinct characteristics compared to other collaborative concepts: complementarity and interdependence exist at the same time, and the system is not fully hierarchically controlled [8].

Implementation options for the ontology of the digital ecosystem have been proposed [9]. There are such types of ecosystems as Business, Innovation, Knowledge, Entrepreneurial. Each of these ecosystems has its own characteristics, structure, purposes [10].

The ecosystem serves as a value multiplier for a product. The coefficient value depends on the quality of each member of the given community [11], [12]. Approaches to the integration of the digital ecosystem into various spheres of human activity [13], [14], [15], [16], approaches to expanding an existing ecosystem with new objects [17] are considered. There were also attempts to recreate the ecosystem model based on traditional information technologies [18], [19].

With traditional approaches to solving the problem of ecosystem formation, there are problems associated with the low level of interoperability of such systems [20]. Often, each of the systems will have its own specialized programming interface and data format for communicating with it, which leads to additional costs for eliminating the shortcomings of such problems. Moreover, life cycle support, modification of existing systems can impose additional time and resource costs.

III. Proposed approach

Within this article, it is proposed to take an OSTIS Technology [21] as a basis. The OSTIS Technology is a set of technologies that provide the design, production, operation, and reengineering of intelligent computer systems designed to automate a wide variety of human activities. The Technology is based on semantic representation and ontological systematization of knowledge, as well as agent-oriented knowledge processing.

The principles underlying the OSTIS Technology are:

- Orientation towards the development of intelligent computer systems with a high level of intelligence and, in particular, a high level of socialization. These systems, developed using the OSTIS Technology, will be called ostis-systems.
- Orientation towards complex automation of all types and areas of human activity by creating a network of interacting and coordinating their activities ostis-systems. This network of ostis-systems, together with their users, is called the OSTIS Ecosystem.
- The OSTIS Technology is implemented as a network of ostis-systems, which is part of the OSTIS Ecosystem. The key ostis-system of this network is the OSTIS Metasystem (Intelligent MetaSystem for ostis-systems), which implements the OSTIS Technology Core, which includes basic (subject-independent) methods and tools for designing and producing ostis-systems with integration into their structure of typical built-in support subsystems for operation and reengineering of ostis-systems. The remaining ostis-systems that are part of the network under consideration implement various specialized ostis-technologies for designing various classes of ostis-systems that automate any areas and types of human activity.
- Convergence and integration based on the semantic representation of knowledge of various scientific directions of Artificial Intelligence (in particular, various basic knowledge and skills for solving intelligent problems) within the General formal semantic theory of ostis-systems.
- Orientation towards the development of next-generation computers that provide efficient (including productive) interpretation of the logical-semantic models of ostis-systems, which are represented by knowledge bases of these systems with semantic representation.

Within the technology, several universal variants of visualization of *SC-code* constructions are proposed, such as *SCg-code* (graphic variant), *SCn-code* (nonlinear hypertext variant), *SCs-code* (linear string variant).

Within this article, fragments of structured texts in the SCn code [22] will often be used, which are simultaneously fragments of the source texts of the knowledge base, 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, revealing in more detail certain of its features.

The basis of the knowledge base within the OSTIS Technology is a hierarchical system of subject domains and ontologies. Based on this, in order to solve the problems set within this article, it is proposed to develop the following system of subject domains and ontologies:

IV. Formal model of the ecosystem of next-generation intelligent computer systems

An OSTIS Ecosystem is a sociotechnical ecosystem, which is a collective of interacting semantic computer systems, which provides permanent support for the evolution and semantic compatibility of all its member systems throughout their entire life cycle.

Subject domain and ontology of the OSTIS Ecosystem

⇒ *private subject domain**:

- *Logical-semantic model of integration of heterogeneous information resources and services in the OSTIS Ecosystem in the process of its extension*
- *Subject domain and ontology of semantically compatible intelligent ostis-portals of scientific knowledge*
- *Subject domain and ontology of semantically compatible intelligent corporate ostis-systems for various purposes*
- *Subject domain and ontology of ostis-systems, which are personal assistants of users, ensuring the organization of effective interaction of each user with other ostis-systems and users that are part of the OSTIS Ecosystem*

An intelligent computer system that is built in accordance with the requirements and standards of the OSTIS Technology is defined as an ostis-system. This provides a significant development of a number of properties for this computer system, which can significantly increase the level of intelligence of this system (and, above all, its level of learning and the level of socialization).

The OSTIS Ecosystem is a collective of interacting:

- ostis-systems themselves;
- users of the specified ostis-systems (both end users and developers);
- some computer systems that are not ostis-systems but are considered by them as additional information resources or services.

Members of the OSTIS Ecosystem collective are characterized as:

- semantically compatible;
- constantly evolving individually;
- constantly maintaining their compatibility with other members in the course of their individual evolution;
- capable of decentralized coordination of their activities.

The purpose of the OSTIS Ecosystem is to provide continuous support for the compatibility of computer systems included in the Ecosystem both at the stage of their development and during their operation. The problem lies in the fact that during the operation of the systems included in the OSTIS Ecosystem, they may change, due to which compatibility may be violated. The objectives of the OSTIS Ecosystem are:

- prompt implementation of all agreed changes in the ostis-systems standard (including changes in the concepts systems used and their corresponding terms);
- permanent support of a high level of mutual understanding of all systems included in the OSTIS Ecosystem, as well as all their users;
- corporate solution for various complex problems that require the coordination of several ostis-systems and possibly also particular users.

The OSTIS Ecosystem is a transition from independent ostis-systems to collectives of independent ostis-systems, i.e. to distributed ostis-systems.

ostis-system

⇒ *subdividing**:

{•
- *stand-alone ostis-system*
- *built-in ostis-system*
- *ostis-systems collective*

}

A. Compatibility support between ostis-systems that are part of the OSTIS Ecosystem

Each system that is part of the OSTIS Ecosystem have to:

- study intensively, actively, and purposefully, both with the help of teachers-developers and independently;
- inform all other systems about proposed or finally approved changes in ontologies and, in particular, in the set of concepts used;
- accept proposals from other ostis-systems about changes in ontologies, including the set of concepts used, to agree or approve these proposals;
- implement approved changes to ontologies stored in its knowledge base;
- help in maintaining of a high level of semantic compatibility not only with other ostis-systems included in the OSTIS Ecosystem but also with its users (train them, inform them about changes in ontologies).

Special requirements are imposed on independent ostis-systems that are part of the OSTIS Ecosystem:

- they must have all the necessary knowledge and skills for messaging and purposeful organization of interaction with other ostis-systems that are part of the OSTIS Ecosystem;
- in the context of constant change and evolution of ostis-systems included in the OSTIS Ecosystem, each of them must itself monitor the state of its compatibility (consistency) with all other ostis-systems, i.e. must independently maintain this compatibility, coordinating with other ostis-systems all changes that require coordination, occurring in itself and in other systems.

According to the purpose, the ostis-system, included in the OSTIS Ecosystem, can be:

- assistants of specific users or specific user collectives;
- typical built-in subsystems of ostis-systems;
- systems of information and instrumental support for designing various components and various classes of ostis-systems;
- systems of information and instrumental support for designing production of various classes of technical and other artificially created systems;
- portals of knowledge in various scientific disciplines;
- control automation systems for various complex objects (manufacturing enterprises, educational institutions, university departments, certain students);
- intelligent reference and help-systems;
- intelligent robotic systems.

To ensure high operational efficiency and high rates of evolution of the OSTIS Ecosystem, it is necessary to constantly increase the level of information compatibility (the level of mutual understanding) not only between the computer systems that are part of the OSTIS Ecosystem but also between these systems and their users. One of the ways to ensure such compatibility is the desire to ensure that the knowledge base (picture of the world) of each user becomes a part (fragment) of the Unified knowledge base of the OSTIS Ecosystem. This means that each user must know how the structure of each scientific and technical discipline is arranged (objects of research, subjects of research, definitions, regularities, etc.), how different disciplines can be interconnected.

Maintaining the compatibility of the OSTIS Ecosystem with its users is carried out as follows:

- each ostis-system includes built-in ostis-systems oriented
  - for permanent monitoring of the activities of end users and developers of this ostis-system,
  - for analyzing the quality and, first of all, the correctness of this activity,
  - for advanced training of users (personalized training);
- The OSTIS Ecosystem includes ostis-systems specially designed to train users of the OSTIS Ecosystem with basic generally recognized knowledge and skills for solving the corresponding classes of problems.

The OSTIS ecosystem is associated with its unified knowledge base, which is a virtual combination of the knowledge bases of all ostis-systems that are part of the OSTIS Ecosystem. The quality of this knowledge base (completeness, consistency, compliance) is a constant concern of all independent ostis-systems that are part of the OSTIS Ecosystem.

B. Structure of the OSTIS Ecosystem

A subject that is part of the OSTIS Ecosystem is an agent of the OSTIS Ecosystem.

OSTIS Ecosystem agent
⇒ *subdividing**:
{•
individual ostis-system of the OSTIS Ecosystem
⇒ *subdividing**:
{•
stand-alone ostis-system of the OSTIS Ecosystem
•
build-in ostis-system of the OSTIS Ecosystem
}
•
ostis-community
⇒ *subdividing**:
{•
simple ostis-community
•
hierarchical ostis-community
}
•
OSTIS Ecosystem user
}

The concept of an ostis-community is not only a collective of ostis-systems but also a certain collective of humans (users and developers of the corresponding ostis-systems). The ostis-community is a stable fragment of the OSTIS Ecosystem, which provides comprehensive automation of a certain part of the collective human activity and a permanent increase in its efficiency. A hierarchical ostis-community is an ostis-community, at least one of whose members is some other ostis-community.

Rules of behaviour for OSTIS Ecosystem agents:

- Coordinate the denotational semantics of all used signs (primarily concepts);
- Coordinate terminology, eliminate contradictions and information holes;
- Constantly eliminate synonymy and homonymy both at the level of sc-elements (internal characters) and at the level of their corresponding terms, as well as other external identifiers (external designations);
- Each agent of the OSTIS Ecosystem, on its own initiative, can become a member of any ostis-community of the OSTIS Ecosystem after appropriate registration.

All rules of behaviour for OSTIS Ecosystem agents must be observed not only by ostis-systems that are agents of the OSTIS Ecosystem but also by human who are agents. The correct behaviour of ostis-systems as agents of the OSTIS Ecosystem is much easier to ensure than the correct behaviour of human as such agents. The behaviour of users (natural agents) of the OSTIS Ecosystem must be closely monitored and controlled, constantly contributing to the improvement of their qualifications as agents of

the OSTIS Ecosystem, as well as increasing their level of motivation, purposefulness, and self-realization.

The OSTIS Ecosystem is the maximum hierarchical ostis-community that provides comprehensive automation of all types of human activity. It cannot be part of any other ostis-community. The principles underlying the OSTIS Ecosystem are:

- the OSTIS ecosystem is a network of ostis-communities;
- each ostis-community corresponds one-to-one with the corporate ostis-system of this ostis-community;
- each ostis-community can be a part of any other ostis-community on its own initiative. Formally, this means that the corporate ostis-system of the first ostis-community is a member of another ostis-community;
- each specialist who is part of the OSTIS Ecosystem is assigned an one-to-one correspondence with their personal ostis-assistant, which is considered as a corporate ostis-system of a degenerate ostis-community consisting of one human.

In the OSTIS Ecosystem, the following levels of hierarchy can be distinguished:

- individual computer systems (individual ostis-systems and humans who are end users of ostis-systems);
- a hierarchical system of ostis-communities, each of which can have members of individual ostis-systems, humans, and other ostis-communities;
- the maximum ostis-community of the OSTIS Ecosystem that is not a member of any other ostis-community, which is part of the OSTIS Ecosystem.

The quality of the OSTIS Ecosystem is largely determined by the effectiveness of the interaction of each ostis-system (including each ostis-community), each human with their external environment, as well as the quality and compliance of the external environment itself. Therefore, the main purpose of the OSTIS Ecosystem is to improve the quality of the information environment for all entities that are part of the OSTIS Ecosystem. In other words, the OSTIS Ecosystem provides support for the Information Ecology of human society.

ostis-community
⇒ *subdividing**:
{• *minimal ostis-community*
• *ostis-systems collective*
}

Each human included in the OSTIS Ecosystem has an one-to-one correspondence with their personal assistant in the form of a personal ostis-assistant. Thus, the number of personal ostis-assistants included in the OSTIS Ecosystem coincides with the number of humans included in the OSTIS Ecosystem. An example of humans and their corresponding personal ostis-assistants is shown in Figure 1.

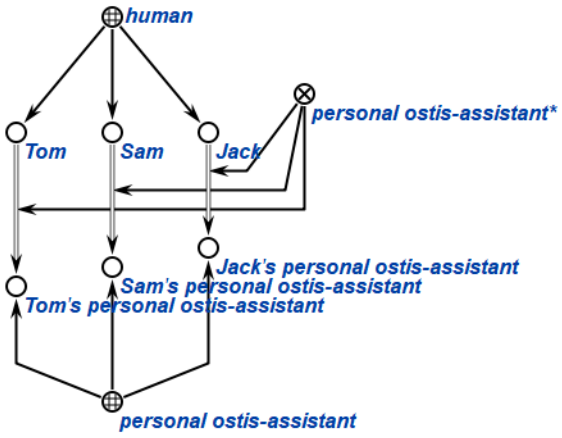

Figure 1. Jack, Tom, and Sam as humans and their corresponding personal ostis-assistants

A collective consisting of a human and a corresponding personal ostis-assistant is actually a minimal ostis-community. An example of minimal ostis-communities is shown in Figure 2.

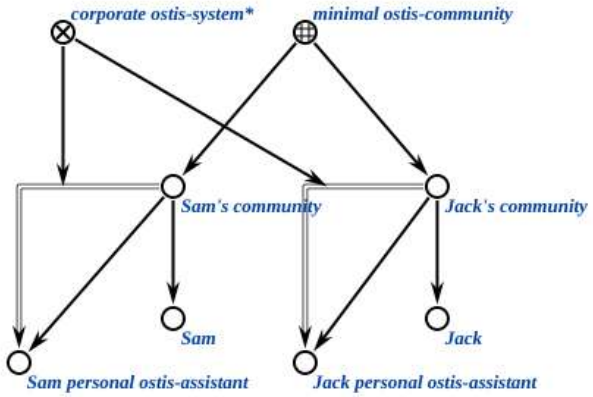

Figure 2. Samś and Jackś communities as objects of the *minimal ostis-community* class

Since, formally, non-minimal ostis-communities include not humans but personal ostis-assistants corresponding to them, all ostis-communities, except minimal ostis-communities, are collectives of ostis-systems.

The corporate ostis-system is the central ostis-system that coordinates, organizes, and supports the evolution of the activities of the members from the corresponding ostis-community. The corporate ostis-system is a representative of the corresponding ostis-community in other ostis-communities of which it is a member. An example of the ostis-system of the corporate community is shown in Figure 3.

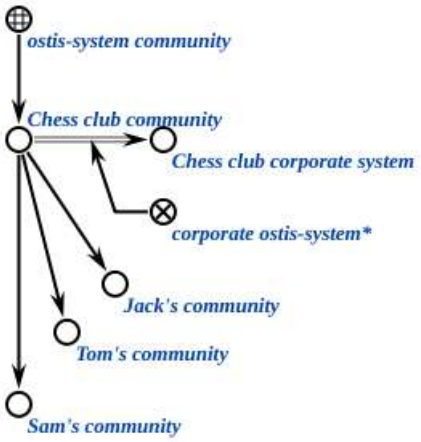

Figure 3. The chess club community with a corporate ostis-system

The main purpose of the OSTIS Ecosystem Corporate System is to organize common interaction in the performance of various types and areas of human activity, which can be either fully automated, or partially automated, or not automated at all. It follows from this that the knowledge base of the OSTIS Ecosystem Corporate System should contain the General formal theory of human activity, which includes a typology of types and areas of human activity, as well as a general methodology for this activity.

Activities in the field of Artificial Intelligence carried out on the basis of the OSTIS Technology

⇒ *core product**:
OSTIS Ecosystem

⇒ *subproject**:
- *OSTIS Metasystem Project*
- *Abstract sc-machine software implementation project*
- *Universal sc-computer development project*

The product of human activity in the field of Artificial Intelligence, carried out on the basis of OSTIS Technology, is not just a set of ostis-systems for various purposes but an Ecosystem consisting of interacting ostis-systems and their users. The typology of ostis-systems that are agents of the OSTIS Ecosystem is represented below.

C. Purpose of creating the OSTIS Ecosystem

The OSTIS Ecosystem is a self-developing network of ostis-systems that provides comprehensive automation of various types and areas of human activity. A special place among the ostis-systems that are part of the OSTIS Ecosystem is occupied by corporate ostis-systems, through which the coordination and evolution of the activities of some groups of ostis-systems and their users

ostis-system, which is an agent of the OSTIS Ecosystem

- ⊃ *personal ostis-assistant*
- ⊃ *corporate ostis-system*
- ⊃ *ostis-portal of scientific and technical knowledge*
- ⊃ *ostis-system of design automation*
- ⊃ *ostis-system of production automation*
- ⊃ *ostis-system of educational activities automation*
  - ⊃ *learning ostis-system*
  - ⊃ *corporate ostis-system of the virtual department*
- ⊃ *ostis-system of business automation*
- ⊃ *ostis-system of control automation*
  - ⊃ *ostis-system of project management of the appropriate type*
  - ⊃ *ostis-system of sensomotor coordination when performing a certain type of complex actions in the external environment*
    - ⊃ *ostis-system of self-driving control*

is carried out. The main purpose of corporate ostis-systems is to localize the knowledge bases of the indicated groups of ostis-systems, transfer them from virtual to real status, and automate their evolution.

The OSTIS Ecosystem is the next stage in the development of human society, providing a significant increase in the level of public (collective) intelligence by transforming human society into an ecosystem consisting of humans and semantically compatible intelligent systems. The OSTIS Ecosystem is a proposed approach to the implementation of a smart society, or Society 5.0, built on the basis of the OSTIS Technology.

The super-purpose of the OSTIS Ecosystem is not just a comprehensive automation of all types of human activity (of course, only those activities whose automation is appropriate) but also a significant increase in the level of intelligence of various human (more precisely, human-machine) communities and the entire human society as a whole.

V. Integration of heterogeneous information resources and services in the OSTIS Ecosystem

It is very important to design not only the OSTIS Ecosystem itself as a form of implementation of Society 5.0 but also the process of a phased transition from a modern global network of computer systems to a global network of ostis-systems (i.e. to the OSTIS Ecosystem).

Within such a transitional period, ostis-systems can play the role of system integrators for various resources and services implemented by modern computer systems, since the level of intelligence of ostis-systems allows them to specify the integrated computer systems with any level of

detail and, therefore, quite adequately "understand" what each of them knows and/or can. Also, ostis-systems are able to coordinate the activities of a third-party resource and service with sufficient quality and provide a "relevant" search for the desired resource and service. In addition, the systems can play the role of intelligent help systems – assistants and consultants on the effective operation of various computer systems with complex functionality, having a user interface with non-trivial semantics and used in complex subject domains. Such intelligent help systems can be made intelligent intermediaries between the respective computer systems of their users.

At the first stages of the transition to Society 5.0, there is no need to convert all modern automation systems into ostis-systems for certain types and areas of human activity. However, ostis-systems should take on a coordinating and connecting role due to the high level of their interoperability. The ostis-systems must learn to either fulfill the mission of an active interoperable superstructure over various modern automation tools or set problems that are feasible for modern automation tools, ensuring their direct participation in solving complex problems and organizing management of the interaction of various automation tools in the process of collectively solving complex complex problems.

The most important feature in the development of ostis-systems is that the development of an ostis-system is actually reduced to the development of its knowledge base. When developing the components of the problem solver and the interface, their features are taken into account, however, the general mechanism for making any changes to the ostis-system becomes a single one [23].

VI. Semantically compatible intelligent ostis-portals of scientific knowledge

Without the General formal theory of intelligent systems, it is impossible to build a set of methods and tools that provide comprehensive support for the development of intelligent computer systems for various purposes and with a different set of skills that intelligent computer systems may have but not necessarily each of them. At the same time, it is important not only to build a General theory of intelligent systems and bring it to a strict formal level but also to bring the representation of such a formal theory to the level of the knowledge base of the corresponding scientific knowledge portal.

The purposes of the intelligent portal of scientific knowledge are:

- accelerating the immersion of each human in new scientific areas while constantly maintaining a common holistic picture of the World (educational purpose);
- fixing new scientific results in a systematic way so that all the main connections between new results and known ones are clearly indicated;
- automating coordination of work on reviewing new results;
- automating the analysis of the current state of the knowledge base.

The creation of intelligent portals of scientific knowledge, providing an increase in the pace of integration and negotiation of different points of view, is a way to significantly increase the pace of evolution of scientific and technological activities. Compatible portals of scientific knowledge, implemented in the form of ostis-systems included in the OSTIS Ecosystem, are the basis of new principles for organizing scientific activity, in which the results of this activity are not articles, monographs, reports, and other scientific and technical documents but fragments of the global knowledge base, the developers of which are freely formed scientific collectives, consisting of specialists in the relevant scientific disciplines. With the help of scientific knowledge portals, both the process of reviewing new scientific and technical information coming from scientists to the knowledge bases of these portals is coordinated, and the process of coordinating different points of view of scientists (in particular, the introduction and semantic correction of concepts, as well as the introduction and correction of terms corresponding to different entities).

The implementation of a family of semantically compatible scientific knowledge portals in the form of compatible ostis-systems that are part of the OSTIS Ecosystem involves the development of a hierarchical system of semantically consistent formal ontologies corresponding to various scientific and technical disciplines, with a clearly defined inheritance of the properties of the described entities and with clearly defined interdisciplinary connections, which are described by connections between the corresponding formal ontologies and the subject domains specified by them.

An example of a scientific knowledge portal built in the form of an ostis-system is the OSTIS Metasystem, which contains all currently known knowledge and skills that are part of the OSTIS Technology.

VII. Semantically compatible intelligent corporate ostis-systems for various purposes

The corporate ostis-system allows monitoring, analyzing, and gradually automating all data processing processes within the ostis-community. Such a system operates according to the following principles:

- intelligent subsystems (agents) organize the data structure in such a way that up-to-date information is always available and outdated information is automatically archived or deleted in accordance with data storage and protection laws;
- requests to the system are executed in the form of simple instructions, the system helps managers enter the necessary information, performs partial or complete automation of updating information from databases available via the Internet;

- intelligent subsystems perform structuring and classification of documents and information to make quick and correct decisions, automatically process documents and available databases to select key information needed now and in the future;
- the existing system environment in the enterprise can be easily connected to the system through open interfaces; all information remains available;
- all key data systems are synchronized with the main system; data is constantly compared with each other to avoid loss;
- all information is available in the knowledge base, which is the source of data for workflows, reporting, and comprehensive checks.

Thus, the proposed platform allows representing all information about the ostis-community in a single, holistic way. The advantages of introducing the proposed system are:

- help in collecting and evaluating information without intentional misrepresentations or human error;
- providing full control over own data;
- the system provides only high-quality, reliable, and up-to-date data;
- digital representation of all community processes provides integrated information processing within the community, which gives full transparency of management, facilitates access to all information and its analysis;
- thanks to the support of intelligent subsystems, all the necessary data from documents, processes, and external sources can be extracted, structured, and properly evaluated.

Corporate ostis-systems can be applied in various areas: medicine and healthcare, educational activities of a wide profile, insurance business, industrial activities, administrative activities, real estate, transport, etc.

VIII. Personal user assistants

Society must turn its "face" to each human, be responsible and really contribute to each human personally, adapting to their characteristics, to ensure:

- the maximum level of physical health, activity, and longevity;
- the maximum level of physical comfort, personal space, material consumption;
- the maximum level of social, administrative, and legal comfort.

For this, the following must be carried out:

- personal monitoring of each human in all directions;
- diagnostics and elimination of unwanted deviations;
- provision of timely personal assistance in clarifying the directions of further evolution of each personality.

It is necessary to move from the provision of services in solving various problems at the initiative of the humans who have encountered these problems to the timely detection of the possibility of these problems and to appropriate prevention. This is possible only if there is a clear system organization of personal monitoring.

The client is not required to know the set of services from which they must choose the functionality that suits them. For the client, a set of semantically compatible services should be located "behind the scenes". Therefore, all information resources and services used by the client must be semantically compatible. The choice of a resource or service suitable for the user should be made by their personal assistant.

The personal assistant must take into account that the roles of clients can change, expand, as well as their interests and purposes. At the same time, all personal assistants must be semantically compatible in order to understand each other and also have the ability to independently interact within various corporate systems, representing the interests of their clients.

Personal ostis-assistant is an ostis-system, which is a personal assistant of the user within the OSTIS Ecosystem. This system provides the opportunity to:

- analysis of user activity and the formation of recommendations for its optimization;
- adaptation to the user's mood, their personal qualities, the general environment, the problem that the user most often solves;
- permanent training of the assistant itself in the process of solving new problems, while learning is potentially unlimited;
- conduct a dialog with the user in natural language, including in speech form;
- answer questions of various classes, and if something is not clear to the system, then it can ask counter questions;
- autonomously receive information from the entire environment, and not just from the user (in text or speech form).

At the same time, the system can both analyze available information sources (for example, on the Internet) and analyze the physical world around it, for example, surrounding objects or the user's appearance.

Advantages of a personal ostis-assistant:

- the user does not need to store different information in different forms in different places – all information is stored in a single knowledge base compactly and without duplication;
- due to unlimited learning, assistants can potentially automate almost any activity, not just the most routine;
- thanks to the knowledge base, its structuring, and information search tools in the knowledge base, the user can get more accurate information more quickly.

Personal assistants have a variety of purposes and can be used for a variety of categories of users (patient, legal

service, administrative service, customer, consumer of various services).

IX. Knowledge Market

The evolution of ostis-systems and the OSTIS Ecosystem as a whole is a very complex creative, collective process, which in principle can only be partially automated. At the same time, high qualifications are required from humans participating in this process, the highest system culture at the level of deep knowledge of general systems theory, high mathematical culture – a culture of formalization, a high culture of convergence (discovering similarities, bringing them to formal analogies), a high culture of deep integration, high level of negotiation.

The evolution of ostis-systems and OSTIS Ecosystems as a whole comes down to the collective reengineering of knowledge bases of ostis-systems, which in turn comes down to:

- "manual" generation of proposed additional knowledge into the knowledge base of the specified ostis-system;
- "manual" generation of proposed changes to the current state of the knowledge base of the specified ostis-system;
- "manual" review of each submitted proposal;
- automatic appointment of competent and interested reviewers;
- automatic appointment of a sufficiently wide range of competent and interested specialists to approve the proposal received;
- automatic decision-making in relation to the received proposal based on the opinion of all involved experts and specialists.

In the knowledge base of each ostis-system, it is possible to record the entire process of discussing each proposal received, indicating the time points of all involved events, as well as the participants in each event (authors of proposals, authors of reviews, of polling participants). Each ostis-system, analyzing the process of using the knowledge stored by it during operation, can estimate the frequency of direct and indirect usage of this knowledge, i.e. can assess the degree of demand for this knowledge.

Therefore, in the future, the OSTIS Ecosystem with a sufficiently high degree of objectivity can assess the volume and significance of the contribution of each specialist to the development of the distributed knowledge base of the OSTIS Ecosystem. This is a fundamental basis for the formation of a fairly objective, honest knowledge market.

The knowledge proposed for review, approval, and publication, must be specified in the knowledge base of the corresponding ostis-system: ostis-system, atomic section of the knowledge base, date and time, author, type of publication. Copyright protection should not occur at the document level but at the content level of a knowledge base fragment.

Absolutely ideal solutions, including design ones, do not exist. Minimizing the degree of falsity can be ensured by:

- error-correction speed (other participants are less likely to use the erroneous fragment for their own purposes);
- improving the quality of analysis when making a decision (collective expertise, a larger number of experts involved, taking into account the level of expertise of an expert within a specific subject domain).

The implementation of the knowledge market will make it possible to make the transition from the classical representations of dictionaries and encyclopedias to a semantic network of specifications for all described entities. Such specifications will automatically determine the presence or absence of a synonymous sign within the technical state of the knowledge base for any new sign entered into the knowledge base.

X. Conclusion

The key direction in increasing the level of intelligence of individual intelligent cybernetic systems is the transition from individual intelligent cybernetic systems, absolutely independent of each other, to their universal communities, i.e. to multi-agent systems, independent agents of which are the indicated individual intelligent cybernetic systems. Within such systems, the possibility of communication of each agent with each one is provided, as well as the possibility of forming specialized collectives for the collective solution of complex collective problems. The implementation of the specified universal community of interoperable intelligent cybernetic systems is carried out in the form of the OSTIS Global Ecosystem.

The OSTIS Ecosystem is the basis for transferring the level of informatization of various areas of human activity to a fundamentally new level, as well as for integrating relevant projects: "Society 5.0", "Industry 4.0", "Smart House", "Smart City", "Knowledge market", and others. Without intelligent computer systems, all these projects are impossible.

The process of transition of the cybernetic systems community to next-generation intelligent cybernetic systems can take place gradually, where ostis-systems can play the role of coordinator of activities performed by other systems. Specified types of ostis-systems, such as semantically compatible intelligent ostis-portals of scientific knowledge, semantically compatible intelligent corporate ostis-systems, and personal user assistants, contribute to increasing the level of global community intelligence by increasing the level of interoperability.

The projects must be brought into a single coherent hierarchical system of interrelated projects covering the entire scope and diversity of human activity.

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Принципы реализации экосистемы интеллектуальных компьютерных систем нового поколения

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В работе рассмотрена архитектура экосистемы интеллектуальных компьютерных систем на основе Технологии OSTIS. Уточнена формальная трактовка таких понятий, как ostis-система, ostis-сообщество, выделена типология ostis-систем, что в совокупности позволяет определить структуру Экосистемы OSTIS. Полученные результаты могут быть применены при реализации таких проектов, как "Общество 5.0", "Industry 4.0", "Умный дом", "Умный город", "Рынок знаний".

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