The Main Directions, Problems and Prospects of the Development of the Next-Generation Intelligent Computer Systems and the Corresponding Technology

Vladimir Golenkov, Natalia Gulyakina
Belarusian State University of Informatics and Radioelectronics
Minsk, Belarus
Email: golen@bsuir.by, guliakina@bsuir.by

***Abstract*—The paper considers the main directions, problems, and prospects for the development of next- generation intelligent computer systems and corresponding technologies, with a focus on the current state of work in the field of Artificial Intelligence. It highlights the problems and methodological challenges of the current stage of development, as well as the prerequisites for transitioning to intelligent computer systems of the new generation. The text also provides background and history of OSTIS Technology development, and outlines its features, advantages, and novelty. Additionally, it mentions current projects related to the development of OSTIS Technology in the current stage of work.**

***Keywords*—Next-generation intelligent computer system, self-learning intelligent computer system, interoperable intelligent computer system, individual subject, collective of subjects, hierarchical subject, social responsibility^, interoperability^, individual activity, collective activity, intelligence of a collective of subjects^, strategic problem of the subject∗, subproblem∗, Society, OSTIS Ecosystem .**

I. The feature of the current state of work in the field of Artificial intelligence—is the transition to the next-generation intelligent computer systems.

The epicenter of the modern stage of automation of human activity is a low level of automation and high overhead costs

- for the system integration of various computer systems, in other words, for the creation of complicated hierarchical computer complexes;
- for the modernization of computer systems during their operation [1].

Modern computer systems clearly lack the *intelligence* and *autonomy* to automate these aspects of human activity.

The necessity to move from modern *computer systems* (including modern *intelligent computer systems*) to next-generation *intelligent computer systems* is due to the necessity to move to automate more and more complex types and areas of *human activity* requiring the creation of whole complexes of *intelligent computer systems* that can independently evolve and interact effectively with each other in the *collective solution of complex problems.* Computer systems with these abilities are the *new generation computer systems.* Since these *computer systems* cannot but have a high level of *intelligence*, they should also be referred to as *next-generation intelligent computer systems.* A high level of *intelligence* is necessary for next-generation computer systems:

- to adequately assessment their own competence and the competence of their partners;
- to ensure mutual understanding, contractual capacity and coordination (consistency) of their actions with the actions of partners in the course of *collective solution of complex problems* in the conditions of possible occurrence of unpredictable (non-standard) circumstances.

next-generation intelligent computer system
= *(self-learning intelligent computer system* ∩ *interoperable intelligent computer system)* [2]
self-learning intelligent computer system
:= [*an intelligent computer system* that has a high rate of self-realized evolution, which results in a significant reduction in the complexity (costs, overhead) of its modernization]

self-learning of an intelligent computer system
⇒ *suggests∗*:

- ability to monitor the state and dynamics of the environment and adjust their actions with appropriate environmental changes (adaptability);
- ability to analyze and improve the quality of your own knowledge base (structuring and analysis of contradictions, information holes, information garbage);
- ability to extract knowledge from external sources of information;
- ability to analyze and improve the quality of their own activities (including the ability to learn from their own mistakes);
- ability to analyze the quality of the activities of other subjects and benefit from it for yourself (learn from the mistakes of others).

high level of self-learning of an intelligent computer system
⇒ *is provided by*∗:

- high level of flexibility of an intelligent computer system
- high level of stratification of an intelligent computer system
- high level of reflexivity of an intelligent computer system
- high level of cognitive activity

interoperable intelligent computer system
:= [computer system capable of independent effective interaction with other systems]

interoperability of an intelligent computer system
⇒ *suggests*∗:

- ability to understand other systems and its users
  ⇒ *suggests*∗:

  semantic compatibility with interacting systems and users
- negotiability
- ability to coordinate their actions with the actions of partners

Our proposed approach to the construction of the next-generation intelligent computer systems is based on the following principles:

- semantic representation of knowledge stored in the memory of *next-generation intelligent computer systems*;
- ontological structuring and systematization of knowledge stored in memory;
- decentralized situational agent-oriented organization of *problem solving processes*;
- convergence and deep (diffuse) integration of various problem solving models and, as a consequence, the hybrid nature of *problem solvers*;
- semantic integration of input information entering an individual intelligent computer system from the outside through different sensory channels and in different languages by translating input information into a common universal *language of internal semantic representation of knowledge.*.

it should be distinguished∗
∋ {

- *individual next-generation intelligent computer system*
- *collective next-generation intelligent computer system*

}
collective next-generation intelligent computer system
⇒ *subdividing*∗:
{

- *collective of next-generation individual intelligent computer systems*
- *hierarchical collective of next-generation intelligent computer systems*

  := [collective of next-generation intel- ligent computer systems, whose members can be both collective and individual *next-generation intelligent computer systems*]

}
individual next-generation intelligent computer system
⇒ *features*∗:

- *individual next-generation computer system cannot be decomposed into subsystems that can be developed absolutely independently of each other and coordinated only by inputs and outputs, implementing the "black box" principle.*
- In an *individual next-generation intelligent computer system*, convergence, compatibility and "meaningful" interaction of various types of knowledge and models of problem solving are necessary. That is, an *individual next-generation intelligent computer system* should be a *hybrid system.*

OSTIS Technology
:= [Our proposed Technology for developing and maintaining *next-generation intelligent computer systems*]

:= [Open Semantic Technology for Intelligent Systems [3]]

⇒ *requirements*∗:

- complexity — *OSTIS Technology* ensures the compatibility of all private *Artificial intelligence* technologies; compatibility, self-learning and interoperability of *intelligent computer systems* being developed, as well as support not only for the design of *intelligent computer systems*, but also for their entire life cycle
- universality — *OSTIS Technology* is focused on the development and maintenance of *next-generation intelligent computer systems* for any purpose
- self-learning — *OSTIS Technology* ensures the permanent evolution of the *OSTIS Technology* itself (itself) due to the fact that it is implemented in the form of the *next-generation intelligent computer system* that "knows" the *OSTIS Technology* and "knows" how to use it

ostis-system
:= [*intelligent computer system* based on OSTIS Technology]

OSTIS Ecosyste
:= [The main product of *OSTIS Technology*, which is a global network of *ostis-systems*]
∈ *hierarchical collective of intelligent computer systems of the new generation*

The main components of *OSTIS Technology* are:

- ***OSTIS Standard***
  := [The standard of next-generation intelligent computer systems as well as methods, methods and means of supporting their life cycle]
  := [*OSTIS Technology Standard*]
- ***OSTIS metasystem***
  := [The core of the *ostis-systems* lifecycle support automation system]
- ***OSTIS Library***
  := [Distributed library of typical (reusable) components of *ostis-systems*]

II. Problems of the current stage of development of the theory and technology of next-generation intelligent computer systems.

The creation of *next-generation intelligent computer systems* requires answers to the following questions:

- What are the requirements for *intelligent computer systems* that provide the above complex automation of *human activities*;
- Why modern intelligent computer systems do not meet these requirements and, accordingly, why the transition to a fundamentally *next-generation intelligent computer systems is necessary*;
- What fundamental principles should underlie the *next-generation intelligent computer systems*;
- What principles should underlie the most automated technology for designing and supporting the entire life cycle of *next-generation intelligent computer systems*;
- What principles should underlie the structure and organization of various types and areas of *human activity* to ensure its comprehensive and maximum possible automation with the help of *next-generation intelligent computer systems* (as you know, before automating any *human activity*, it is necessary to put it in order — automating disorder leads to even greater disorder).

The current fundamental problems of creating the theory and technology of *next-generation intelligent computer systems* include:

- Development of a theory of hierarchical *multi-agent systems* in which agents are individual or collective *intelligent computer systems that are interoperable.*
- Unification and standardization of various models of knowledge representation and processing. The effect of this unification will not be visible immediately. But if this does not happen, we will never come to an effective comprehensive automation of *human activity.* The eclectic variety of automation methods and tools leads not only to unjustified duplication of the systems being developed, but also to an increase in the complexity of their use and maintenance.
- Convergence and integration of different areas of *Artificial Intelligence.* Currently, various areas of *Artificial Intelligence* have a fairly high level of development (signal processing, natural language processing, logical models, artificial neural networks, ontological models, multi-agent models, and many others). Integration of all these directions is a rather time-consuming problem, but it is quite a solvable one, which is based on the harmonization of related notions.
- Convergence of such activities in the field of *Artificial Intelligence* as:

– training of specialists in the field of *Artificial Intelligence*;
– engineering activities for the development of applied *next-generation intelligent computer systems*;
– development of *technology* for designing and supporting the life cycle of *next-generation intelligent computer systems*;
– research activities in the field of *Artificial intelligence.*

- In order to develop the Technology of *next- generation intelligent computer systems*, it is also necessary to converge this Technology with all