Problems and prospects of automating various types and fields of human activity with the help of next-generation intelligent computer systems

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***Abstract*—In the article, the principles for automating various fields of human activity using next-generation intelligent computer systems are considered. An ontology of various types of activities and related technologies is proposed. The specification of these principles is carried out on the example of human activity in the field of Artificial Intelligence.**

***Keywords*—OSTIS, ostis-system, activity, ontological approach, intelligent computer system, interoperability, knowledge base, SC-code**

I. Introduction

The key problem of the modern level of complex automation of *human activity* is as follows. Currently, either full automation of some classes of actions initiated by the corresponding teams is being carried out, or partial automation of some types of *human activity*, within which a person controls the appropriate automation tools. At the same time, automation of complex problems solving, which are reduced to several partially automated subproblemss, requires "manual" (non-automated) control of several automation tools simultaneously.

The principles underlying the transition to a higher level of automation of *human activity* are as follows. All automation tools (all services) currently managed by people are being "managed" by ***interoperable intelligent computer systems*** that are able to effectively interact with each other and, accordingly, are able to fully automate the solution of complex problems requiring the use of several automation tools (services) [1], [2], [3], [4], [5], [6].

In this paper, we will first clarify the basic concepts we use to consider the structure of *human activity*, then we will consider in detail the structure of the current state and the problems of *Human activity development in the field of Artificial Intelligence*. Next, we will generalize the principles of organization and automation of *Human activity in the field of Artificial Intelligence* to all the variety of types and directions of *human activity*.

II. Basic concepts underlying the formal description of the structure of human activity

activity
:= [process of situational impact on some dynamic system, aimed either at creating this system, or maintaining certain characteristics of this system, or its destruction, or its development (improvement)]
:= [system of all actions performed by some individual or collective entity or an integral subsystem of such actions corresponding to the purpose (duties) of this entity]
⊂ *process*

should be distinguished*
∋ {• *activity*
• *action*
}
⇒ *comparison**:
[Each *action* necessarily corresponds to the formulation of the problem that is solved as a result of performing this action. In this case, the *action* can be complex (non-atomic), i.e. it can be a hierarchical system of sub-actions, providing the solution of *sub-problemss* of the initial *problem*.

In contrast, each *activity* can correspond to several initial problems that are not sub-problems of other problems within this *activity*.

An example of an activity that is not an action is an activity carried out by some subject within some *field* (meaning the *activity* to solve all kinds of problems of the most different kinds that can be formulated within the specified *field*).]
⇒ *note**:
[Each activity and, accordingly, each action uniquely corresponds to a subject performing that activity.]

human activity
:= [a system of actions performed by people or human communities either "manually" or with "passive" tools (sticks, ropes, shovels, axes and e.t.c.) or with "active" tools (vehicles, excavators, chainsaws and e.t.c.)]

action
:= [process of changing the state of some dynamic system (from a given state to a desired target state), initiated and possibly directly carried out by some subject with the possible use of some tools, additional materials and information resources (in particular methods)]
:= [a purposeful (conscious) process of some subject acting on some object]
⇒ *note**:
[The subject of the action can be either individual or collective. The object of impact may have any complex structure and consist of any number of components that are impacted. The initiation and execution of an action can be carried out by different subjects using various auxiliary tools]
. ⊃ *information action*
:= [information process performed by some subject (including a computer processor)]
:= [process of changing the state of some information resource]

should be distinguished*
∋ {• *action*
• ***problem***
:= [specification of some action that contains enough information to perform that action]
:= [problem formulation]
⊃ *declarative problem formulation*
⊃ *procedural problem statement*
}

relationship defined on the action set
∋ *action**
:= [be an action performed to solve a given problem]
⇔ *inverse relation**:
*problem**
:= [to be a problem performed as a result of this action]

relationship defined on the set of activities
∋ *activity object**
:= [being an object over which a given activity is performed*]
∋ *product of activity**
:= [to be the product of a given activity*]
∋ *part of the time of existence**
:= [to be a segment of time of existence of a given temporal entity*]
∋ *activities whose object classes coincide**
∋ *activities performed simultaneously**

activity type
:= [class of activities]
:= [class of similar activities, which can be matched with a common technology that ensures the performance of all activities of this class]
:= [a class whose instances (elements) are equivalent (similar) activities performed in general by different cybernetic systems]
∋ *example′*:
design
:= [design activity]
:= [human activity whose product is the design documentation of some created entity]
:= [building a complete specification (design documentation) of some entity to be created]
⇒ *note**:
[The products of this activity are the specifications of any socially significant created entities]
⇒ *particular activity over a subclass of activity objects**:
• *ostis-systems design*
• *circuit design*
• *building design*
∋ *example′*:
life cycle support
⇒ *particular activity over a subclass of activity objects**:
• *chip life cycle support*
• *buildings life cycle support*
• *support of life cycle of ostis-systems*
⇒ *particular activity over a subclass of activity objects**:
• *support of the ostis-systems knowledge base life cycle*
• *support for the life cycle of ostis-systems problem solvers*
• *support life cycle of ostis-systems interfaces*
∋ *human resources training*
:= [educational activity]
∋ *production*
∋ *environmental activity*
∋ *construction activity*
∋ *health care activity*
∋ *administrative activity*
∋ *research activity*

should be distinguished*
∋ {• *type of activity*
• *class of actions*
}

should be distinguished*
∋ {• *class of actions*
• *class of problems*
:= [a set of similar (similar) formulations of specific problems that can easily be generalized by replacing some constants going into those formulations with variables]
• *problem class formulation*
:= [a generalized problem class formulation (specification) that "turns" into a specific problem formulation when specific values are assigned to all the free variables included in this generalized problem class formulation]
}

relationship defined on the action set
∋ *method**
:= [to be a method that provides all actions of a given class of actions, or solving all problems of a given class of problems, or performing a particular given action, or solving a particular given problem*]
∋ *maximal action class**
:= [to be the maximum class of actions performed by a given method*]

method
:= [information construct whose interpretation by any subject belonging to the corresponding class of subjects ensures that any action belonging to the corresponding class of actions]
⊃ *methodology*
:= [method implemented by a person or group of people]

a relation defined on a set of activities
∋ *technology**
:= [be a technology that ensures the performance of each activity belonging to a given type of activity*]
∋ *class of objects of activity**
:= [be a class of activity objects for a given type of activity*]
∋ *activity product class**
:= [be a class of activity products for a given type of activity*]
∋ *a particular type of activity over a subclass of objects of activity**
:= [a particular type of activity, the class of objects of which is a subclass of objects of activity of a given type of activity*]
∋ *a particular type of activity over a class of components of objects of activity**
:= [a particular type of activity, the class of objects of which is the class of components of the objects of activity of a given type of activity*]
∋ *a particular type of simultaneously performed activity**
:= [a particular type of activity, each of which is performed simultaneously (in parallel) with activities belonging to a given type of activity*]
∋ *a particular type of activity performed at some stage**
:= [a particular type of activity, each of which is performed as one of the stages of the activity, belonging to a given type of activity*]
∋ *types of activities whose object classes coincide**
∋ *types of activities performed by the same entities**

technology
:= [a system of knowledge, skills and tools that ensure the performance of each activity of the appropriate type by the relevant subjects]
⇒ *note**:
[The basis of any *technology* is multiplicity - either the multiplicity of creating similar (analogous) entities, or the multiplicity of performing similar actions, the multiplicity of using similar methods (techniques). Obviously, the higher the degree of similarity (proximity, convergence) of repeatedly created entities and repeatedly used methods, the higher their unification, the simpler the corresponding *technology* will be.]

scope of execution*
:= [be a subject domain and a corresponding ontology (possibly with some child subject domains and corresponding ontologies) containing knowledge sufficient to perform a given action, or a given class of actions, or a given activity, or a given type of activity*]
⊃ *scope of the action**
⊃ *scope of the action class execution**
⊃ *scope of activity**
⊃ *scope of the type of activity**

subject*
:= [be a subject performing a given action or a given activity*]
⇒ *note**:
[The initiation of an action or activity performed by a subject can be carried out either independently (on its own initiative), or on the initiative (command, task) of another subject.]

information resource
:= [a socially significant information structure that is a product of relevant human activity, which requires not only its creation, but also maintenance (updating, updating)]
⊃ *project documentation*
⊃ *scientific theory*
:= [the product of scientific research activity, which is a strict description of the properties and patterns of a certain class of entities]
⊃ *standard*
⊃ *specification of a set of techniques of the corresponding technology*
⊃ *specification of tools of the corresponding technology*

project documentation
:= [full specification of the entity being created]
:= [product of project activity]
:= ["digital" copy of some entity]
:= [an information model (description) of an entity that has sufficient completeness (detail) to reproduce (reproduce) this entity]

III. Problems and prospects of human activity development in the field of Artificial intelligence

Earlier in the work [7] we clarified:

- architecture of *next-generation intelligent computer systems*
- how the activity (functioning) of *next-generation intelligent computer system* is carried out
- the way *applied engineering human activity for designing new-generation intelligent computer systems* is automated and supporting all subsequent stages of their life cycle.

Let's clarify how the whole complex of *human activity in the field of Artificial Intelligence* is carried out and automated.

A. General assessment of the current state of human activity in the field of Artificial intelligence

Let's consider the need to move the organization of *human activity* of ***Artificial intelligence*** to a fundamentally new level, ensuring the formation of a market for **semantically compatible *new-generation intelligent computer systems***, developed on the basis of a fundamentally new complex of *semantically compatible* ***Artificial intelligence technologies***.

Now it is important to investigate not only *models for solving intelligent problems* in intelligent computer systems of various types, but also methodological problems of the current state of *Artificial intelligence* in general and ways to solve these problems.

An analysis of the current state of work in the field of *Artificial intelligence* shows that this scientific and technical discipline is in a serious methodological crisis. Therefore, it is necessary:

- Identification of the main causes of this crisis;
- Clarification of the main measures aimed at its elimination.

The solution of the crisis problems under consideration requires:

- An essential fundamental system-wide rethinking of *everything* we do in the field of *Artificial intelligence* and *how* we do it, i.e. requires clarification of the characteristics of *intelligent computer systems*, clarification of the concept of a community consisting of *intelligent computer systems* and users interacting with them, clarification of the requirements for *intelligent computer systems*, as well as clarification of methods and means of their creation and use.
- The realization that *Cybernetics, Computer Science* and *Artificial intelligence* are a common fundamental science that requires an integrated approach to the construction of general formal models of systems based on information processing (*cybernetic systems*) by *convergence* and *integration* of formal models of various components of these systems [8]. Thus, the current stage of the development of *Artificial intelligence* is a transition from the accumulated to the current moment variety of models for solving various types of problems to the transformation of this variety into a coherent system of *semantically compatible* models;
- The realization that now it is necessary not to expand the diversity of points of view, but to learn to coordinate them, to ensure their *semantic compatibility*, improving the appropriate methods.

Discussing the modern problems of *convergence* of various models in the field of *Artificial intelligence* and the construction of integrated *hybrid models*, it is appropriate to recall «the fantastic story of D.A. Pospelov "Contact", dedicated to the contact of different worlds. In it, the main character popularly expounds his theory of *conceptual faults* <...>. This theory resembles the history of a long period of differentiation of sciences, when various scientific disciplines developed independently, like parallel worlds, only occasionally touching each other, and individual scientists, receiving an increasingly narrow specialization, knew little about the achievements of even their "close brethren". Fortunately, in recent years, new directions of contact between individual disciplines have been emerging more and more often, ideas are interpenetrating, analogies are being established between the results obtained and development trends. This is largely due to the emergence and widespread introduction of advanced information and communication technologies into all spheres of society <...>. Modern technologies rely on the achievements of many scientific and technical disciplines, among which new-generation synthetic sciences - the sciences of artificial» come to the fore.

⇐ *quote**:

Tarasov V.B. fMStIO – 2002bk/p.13 [9]

Analyzing the current state of work in the field of *Artificial intelligence (AI)*, it should be stated that the *conceptual gap* between the various directions of *Artificial intelligence* is an obvious fact. This is confirmed by the following quote from the book by V.B. Tarasov [9] «again, as at the dawn of AI, the formation of unified methodological foundations of AI, the development of theoretical problems of creating intelligent systems of new generations, the development of unconventional hardware and software are becoming relevant. Here, great prospects are associated with the use of ideas and principles of synergetics in AI. The term "synergetics" itself comes from the word "synergy", meaning joint action, cooperation. According to the "father of synergetics" G. Haken, such a name is quite suitable for the modern theory of complex self-organizing systems for two reasons: a) the joint actions of many elements of a developing system are being investigated; b) to find common principles of self-organization, it requires the combined efforts of representatives of various disciplines».

⇐ *quote**:

Tarasov V.B. fMStIO – 2002bk/p.14 [9]

In order to make sure that there is a *conceptual rift* between different directions of *Artificial intelligence*, it is enough to simply list the main directions of work of conferences on the subject of *Artificial intelligence*, paying attention to the fact that many of them are developing independently of others:

- synergetic models of self-organization of intelligent computer systems;
- hybrid intelligent computer systems;
- collaborative intelligent computer systems;
- soft computing, intelligent computing;
- modeling of non-factors;
- non-classical, multivalued, modal, pseudophysical, inductive, fuzzy logic and approximate reasoning, logic programs;
- fuzzy sets, relations, graphs, algorithms;
- functional programs, fuzzy algorithms, genetic algorithms, production models;
- neural network models;
- parallel asynchronous models of decentralized problem solving;
- signal processing;
- multisensory convergence, sensorimotor coordination;
- situational management models.

Overcoming the *conceptual rift* between different directions of research in the field of *Artificial intelligence* is a kind of "leap" across the "conceptual abyss", which requires special concentration of efforts. You can't jump over the abyss in two jumps.

If we briefly characterize the **current state** of all work in the field of ***Artificial Intelligence***, it is an **illusion of well-being**. There is an active local development of various directions of *Artificial Intelligence* (*non-classical logics*, *formal ontologies*, *artificial neural*

networks, *machine learning*, *soft computing*, *multi-agent systems*, etc.), but there is no comprehensive increase in the level of *intelligence* of modern *intelligent computer systems*. This first of all requires the convergence and *integration* of all directions of *Artificial intelligence* and the corresponding building of a ***general formal theory of intelligent computer systems***, and also the transformation of the modern variety of *development tools* (frameworks) of various components of *intelligent computer systems* into a single ***Technology of integrated design and support the whole life cycle of intelligent computer systems***, which guarantees the compatibility of all developed components of *intelligent computer systems*, as well as the compatibility of *intelligent computer systems* themselves as independent entities (agents, actors) interacting with each other within complex systems of automation of complex collective *human activity* (smart houses, smart hospitals, smart schools, smart manufacturing enterprises, smart cities, etc.). Thus the epigraph of the current state of work in the field of Artificial Intelligence is the well-known statement from Ecclesiastes: "A time to scatter stones and a time to gather stones - to all in good time".

«Unfortunately, in today's discussions on AI (Artificial Intelligence) scientific debates are often substituted by exaggerated expectations from the rapid introduction of AI and a significant narrowing of the topic of AI, which has been reduced only to *machine learning* based on *artificial neural networks*. <...> Meanwhile *ontologies*, *knowledge bases*, *methods of reasoning* and *decision making*, *methods of synthesis and analysis of complex structures*, intelligent cyber-physical systems, *digital twins*, *autonomous systems*, systems of analysis of both "big" and "small" data were left out of the National Strategy. <...>

Recognizing the importance of *machine learning* based on *artificial neural networks*, world-class scientific and practical results should be sought at the intersection of different disciplines in the ***convergence*** of different AI technologies and ***integration*** of multidisciplinary *knowledge*. In this regard, *knowledge* formalization in the form of *ontologies* and *knowledge bases* within *Semantic Web* is seen as one of the fundamental directions for the creation of AI. Indeed, what kind of *intelligence* can there be without using the *knowledge* of modern textbooks, on the basis of which AI will understand the *context of the situation*, draw *conclusions* and *make decisions*? <...>

Another key direction of AI that is not reflected in the Russian AI strategy is *distributed decision-making*, which is increasingly becoming collective for the rapidly developing smart Internet of Things and autonomous control systems, starting with unmanned cars, aircraft, ships, etc.

Gartner has declared 2020 the year of "autonomous things" which, according to the company, have already evolved from "digital" to "smart". In the next phase, autonomous things with their own AI are expected to "talk" to each other and the scientific agenda will include ***semantic interoperability*** of AI systems that will not only exchange data, but also negotiate to agree on solutions. The U.S. AI research roadmap highlights such direction as the *connectivity* of *Artificial intelligence* systems (Integrated Intelligence) and their *meaningful interaction*, along with various types of *Self-Aware Learning* in systems, as key.»

⇐ *quote*:*

Barinov I.I.. DevelSFoftheConAI- 2021art/pp. 264-265 [10]

The **key reason** for the **methodological problems** of the current state of *Artificial intelligence* and a serious challenge for specialists in this field is the curse of the ***Babylonian Pillar*** of [11], which haunts us at all levels:

- at the level of internal organization of *problem solving* in *intelligent computer systems*;
- at the level of interaction of *intelligent computer systems*, both among themselves and with users;
- at the level of interaction of scientists working in the field of *Artificial intelligence*, which prevents the creation of a *general formal theory and standard of intelligent computer systems*, as well as the *Technology of integrated design and support of the entire life cycle of intelligent computer systems*
- at the level of interaction between scientists, engineers who develop applied *intelligent computer systems*, university professors who train specialists in the field of *Artificial intelligence*, as well as students, undergraduates and graduate students.

The complexity of currently developed *intelligent computer systems* and Artificial Intelligence technologies has reached such a level that their development requires not just large creative teams, but also a significant increase in the qualifications and quality of these teams. It is well known that the qualification of a team of developers is determined not only by the qualification of its members, but also by the efficiency and atmosphere of their interaction. It is also known that the quality of any technical system is a reflection of the quality of the team that developed the system. Can a team of sufficiently qualified specialists, many of whom are not highly interoperable, develop an intelligent computer system with a high level of interoperability, much less a technology for integrated support of the entire life cycle of intelligent computer systems of this level? The obvious answer to this question and the obvious complexity of creating workable creative teams indicate the main challenge addressed to Artificial Intelligence specialists at the present time. Thus, the requirements for the new-generation intelligent computer systems, determining their ability to individually and collectively solve complex problems, should also be imposed on the developers of these systems, as well as the developers of any other

complex objects, since all complex types and directions of human activity are collective and creative.

Creating a rapidly growing market of semantically compatible *intelligent computer systems* is the main goal addressed to the experts in the field of Artificial Intelligence, requiring overcoming the ***Babylonian pandemonium*** in all its manifestations, forming a high culture of agreement and a unified, coordinated form of representation of collectively accumulated, improved and used knowledge. Scientists, working in the field of *Artificial Intelligence*, should ensure the ***convergence*** of the results of different directions of *Artificial intelligence* and build a *general formal theory of intelligent computer systems*, as well as the *Integrated Design Technology for semantically compatible intelligent computer systems*, including appropriate standards for *intelligent computer systems* and their components. Engineers *who develop applied intelligent computer systems* should collaborate with scientists and participate in the development of the *Comprehensive technology for fesign of semantically interoperable intelligent computer systems*, and support all subsequent stages of the life cycle of these systems.

The isolation of various research directions in the field of *Artificial Inteiligence* is the main obstacle to the creation of a *comprehensive technology for the design of semantically compatible intelligent computer systems*, as well as the *Technology of integrated support* for all subsequent stages of the life cycle of *intelligent computer systems*.

B. Structure of activity in the field of Artificial Intelligence

In order to consider the problems of further development of *activity* in the field of *Artificial Intelligence* and, in particular, the problems of complex automation of this *activity*, it is necessary to specify the structure of the mentioned *activity*.

Human activity in the field of *Artificial Intelligence* are aimed at research and creation of *intelligent computer systems* of various kinds and different purposes. The objects of research in *Artificial Intelligence* are:

- *individual intelligent computer systems* (in particular, cognitive agents);
- *multiagent intelligent computer systems* (in particular, communities consisting of *individual intelligent computer systems*);
- Human-machine communities consisting of *intelligent computer systems* and their users.

The main goals of human activity in *Artificial Intelligence* are:

- building a formal theory of *intelligent computer systems* (artificial *intelligent systems*);
- creation of technologies (techniques and tools) that provide *design, implementation, maintenance and operation of intelligent computer systems*;
- transition to a fundamentally new level of complex automation of all types of human activity, which is based on mass application of *intelligent computer systems* and which implies:
  - not only the presence of *intelligent computer systems* capable of understanding each other and coordinating their activities,
  - but also consideration of the general structure of *human activity* carried out under the conditions of its new level of automation (smart-society activity), which should be "understandable" to the used *intelligent computer systems* and which will require a substantial rethinking of the modern organization of *human activity*.

Artificial Intelligence as a *field* of *human activity* includes the following *activities*:

- ***Research activity in the field of Artificial Intelligence***, in the process of which there is a competition of different points of view and approaches to the construction of formal models of various components of *intelligent computer systems*. The ultimate goal of such activity is the constantly evolving *General theory of intelligent computer systems*. The objects of research of this theory are *intelligent computer systems* and their formal *logical-semantic models*. These models include formal models of various types of *knowledge*, which are part of *knowledge bases* of intelligent computer systems, as well as various *problem-solving models* (logical models of various types, neural network models, genetic models, productive models, functional models, etc.).
- ***The development of the Intelligent Computer Systems Standard***, which includes the permanent evolution of this standard and maintains the integrity of each version of it. The current version of the *Standard for Intelligent Computer Systems* is the consensus (generally accepted) currently part of the *General Theory of Intelligent Computer Systems*.
- ***Development of technology for designing intelligent computer systems***, which includes a family of design methodologies, as well as methods and tools for automating *design* of various *components* of *intelligent computer systems* and *intelligent computer systems* in general. The result of designing *intelligent computer systems* is a complete formal logical-semantic model of this system.
- ***The development of technology for the implementation of designed intelligent computer systems***, as well as technologies for the operation and maintenance of *intelligent computer systems*. In the basis of the technology of implementation (production) of the designed *intelligent computer systems* lies the *universal interpreter of formal logical-semantic models of intelligent computer systems*, which are the result of the design of the specified systems. The

specified universal interpreter can be implemented either as a *software system* on modern computers, or as a *universal new-generation computer*, oriented to the interpretation of formal *logical-semantic models of intelligent computer systems*.

- ***Applied engineering activity in the field of Artificial Intelligence***, i.e., the direct design, implementation and maintenance, which includes updating (re-engineering) performed during operation, of specific *intelligent computer systems.*
- ***Training activity in the field of Artificial Intelligence*** are aimed at training specialists in the field of *Artificial Intelligence* and at continuous professional development of existing specialists in this field. Without effective organization of training activities in the field of *Artificial Intelligence*, rapid progress in this field is impossible. Direct inclusion of learning activity in the general structure of human activity in the field of *Artificial Intelligence* is caused by the following circumstances:
  - the necessity of deep convergence between different fields and types of activities in the field of Artificial Intelligence and the corresponding specificity of requirements to specialists in this field – each such specialist must be competent enough both in research activities in the field of Artificial Intelligence, and in the development of technologies (methods and means) of designing intelligent computer systems, and in the development of technologies of reproduction (realization) of the designed *Artificial Intelligence*;
  - high rate of evolution of results in the field of *Artificial Intelligence*, which makes it necessary to organize the training of relevant specialists by connecting them directly not to training (simplified) projects, but to real projects, implemented at the moment. Otherwise, trained specialists will have the qualification of "yesterday's day";
  - the significant expansion of the volume of work in the field of *Artificial Intelligence* and the urgent need for mass training of relevant specialists.

  The difficulty of ***Training of young professionals in the field of Artificial Intelligence*** lies not only in the high degree of scientific intensity of this field, but also in the fact that the formation of relevant knowledge and skills in them is carried out in conditions of rapid moral aging of the current state of *Artificial Intelligence* technology, significant changes in which occur during the education of students and undergraduates. Therefore, it is necessary to teach not the current level of development of *Artificial Intelligence*, but the level of development that will be achieved in five years or more.

  When training young professionals in the field of *Artificial Intelligence*, it is necessary to form in them:
  - formalization culture (mathematical culture);
  - systemic culture (in particular, the ability to perform qualitative stratification of complex dynamic systems);
  - technological culture (in particular, the ability to distinguish between what should be unified and what unification limits the direction of evolution of a given class of complex systems);
  - technological discipline;
  - culture of collective creativity (in particular, initial *interoperability*);
  - high *cognitive activity* and motivation;
  - ability to combine individual creative freedom and independence with ensuring compatibility of one's results with the results of one's colleagues, i.e. to combine freedom in creating (generating) new meanings with the coherence (compatibility) of forms of their representation – notions, terms and syntax are not argued about, but agreed upon.
- ***Organizational activity in the field of Artificial Intelligence***, aimed at creating an infrastructure for the quality performance of all other activities in the field of *Artificial Intelligence*, namely:
  - to ensure a deep *convergence* between the different fields and activities in the field of *Artificial Intelligence* and, in particular, between theory, technology and engineering practice in this field;
  - to balance tactics and strategy in the development of *Artificial Intelligence* activities as a key basis for significantly increasing the level of automation of all types of *human activities* and the transition to *smart society*.

The considered decomposition of *human activity* in the field of *Artificial Intelligence* by *types of activities* is not a traditional feature of *scientific-technical disciplines* decomposition. Usually, the decomposition of *scientific-technical disciplines* is carried out according to the content directions which correspond to the decomposition of *technical systems* studied and developed within these *scientific-technical disciplines*, i.e. correspond to the allocation of various kinds of components in these *technical systems*. For *Artificial Intelligence* such directions are:

- Research and development of formal models and knowledge representation languages;
- research and development of knowledge bases;
- research and development of logical models of knowledge processing;
- research and development of artificial neural networks;
- research and development of computer vision subsystems;
- research and development of subsystems for processing natural language texts (syntactic analysis, comprehension, synthesis);
- and many others.

The importance of decomposition of *Artificial Intelligence* by *types of activities* is determined by the fact that the allocation of different *types of activities* allows to clearly set a problem for the development of automation tools for these *types of activities*.

Here is the general structure of *human activities in the field of Artificial Intelligence*.

Human activities in Artificial Intelligence
:= [Artificial Intelligence (as a scientific and technical discipline]
∈ *scientific-technical discipline*
:= [human activity in the *Subject domain of intelligent computer systems*]
∈ *activity*
⇒ *decomposition**:
{• *Integral activity of support the life cycle of all types of intelligent computer systems*
⇒ *decomposition**:
support the life cycle of intelligent computer systems
• *Support the life cycle of the General Theory of Intelligent Computer Systems*
∈ *research activity*
• *Smart computer systems standard life cycle support*
∈ *standardization*
⇒ *part**:
Support the life cycle of the ostis-systems Standard
• *life cycle Support for Integrated Life Cycle Support Technologies for Intelligent Computer Systems*
∈ *support technology life cycle*
:= [technology creation and maintenance]
⇒ *part**:
OSTIS Technology life cycle Support
• *Support of the human resources life cycle for Human Activity in the field of Artificial Intelligence*
• *Support the life cycle of the system of complex organization of interaction between all directions of Human Activity in the field of Artificial Intelligence*
∈ *supporting the life cycle of meta-systems of complex management support and providing life cycle support for entities of the respective class*
}

support the life cycle of intelligent computer systems
∈ *type of activity*
⇒ *generalized decomposition**:
{• *designing intelligent computer systems*
• *production of intelligent computer systems*
• *initial training of intelligent computer systems*
• *quality monitoring of intelligent computer systems*
• *recovery of the required quality level of intelligent computer systems*
• *reengineering intelligent computer systems*
• *security assurance of intelligent computer systems*
• *operation of intelligent computer systems by end users*
}

Technology of intelligent computer systems life cycle support technology
⇒ *type of activity**:
smart computer systems life cycle support
⇒ *decomposition**:
{• *Technology of intelligent computer system design*
⇒ *type of activity**:
designing intelligent computer systems
• *Technology of production intelligent computer systems*
⇒ *type of activity**:
intelligent computer system production
• *Technology for initial training of intelligent computer systems (activity-specific adaptation)*
⇒ *type of activity**:
initial training of intelligent computer systems
• *Technology of Quality monitoring for intelligent computer systems*
⇒ *type of activity**:
quality monitoring of intelligent computer systems
:= [planned testing and diagnosis of intelligent computer systems]
• *Technology of restoring the required level of quality of intelligent computer systems during their operation*
:= [Technology for detecting and correcting potentially dangerous situations and events in the operation of intelligent computer systems (errors, inconsistencies, etc.)]
⇒ *type of activity**:
restoring the required level of quality of intelligent computer systems
• *Technology of reengineering intelligent computer systems*
:= [Technology of improving, modernizing, updating intelligent computer systems]
⇒ *type of activity**:
reengineering intelligent computer systems
• *Technology of intelligent computer systems security*
⇒ *type of activity**:
securing intelligent computer systems
• *Technology of operation of intelligent computer systems by end users*
⇒ *type of activity**:
exploitation of intelligent computer systems by end users
}

C. Current state and current problems of Artificial Intelligence

Let's consider in which directions the evolution (quality improvement) of *Artificial Intelligence* activities should take place, as well as the evolution of the products of these activities.

1) Current state and current problems of ***research activities in the field Artificial Intelligence****:* Currently, research in *Artificial Intelligence* is actively developing in a wide range of different directions (*knowledge representation models*, different kinds of *logics* – deductive, inductive, abductive, clear, fuzzy, various kinds of *artificial neural networks*, machine learning, decision making, goal setting, behavior planning, situational behavior, multi-agent systems, computer vision, recognition, data mining, soft computing, and more). However:

- There is no consistency of *definitions* systems in different directions of *Artificial Intelligence* and, as a consequence, there is no *semantic compatibility* and *convergence* of these directions, resulting in significant difficulties in the direction of building

General theory of intelligent systems with a high level of formalization. The existence and continuing increase in the "height of barriers" between different research directions in the field of *Artificial Intelligence* is manifested in the fact that a specialist working within a particular direction of *Artificial Intelligence*, attending meetings of "not his" section at a conference on *Artificial Intelligence*, can understand little there and, accordingly, learn something useful for himself;

- There is a lack of motivation and awareness of the urgent need for mentioned *convergence* between different directions of *Artificial Intelligence*;
- There is no real movement in the direction of building *General theory of intelligent systems*, because there is no appropriate motivation and awareness of the acute practical need for it;
- There is no rigorous and consistent specification of the concept of *intelligent computer system*. So far, the Turing Test has been used for this purpose. A superficial interpretation of the Turing Test has given rise to various imitations of intelligence in the style of "small talk". In fact, a meaningful, goal-oriented dialogue should be taken into account, in which the intelligence of *intelligent computer system* is defined as its non-trivial contribution to the collective solution of some intelligent (creative) problem.

2) Current status of ***intelligent computer systems Standard****:* Currently, the need for unification and standardization of *intelligent computer systems* is not realized, which significantly hinders the creation of *complex technology of Artificial Intelligence*.

3) Current state and current problems of ***development: technologies of intelligent computer system design***

Modern *technology of Artificial Intelligence* is a whole family of all sorts of private technologies focused on development various kinds of *intelligent computer systems* components that implement a wide variety of information representation and processing models, as well as focused on development different classes of *intelligent computer systems*. However:

- high complexity of development of *intelligent computer systems*;
- high qualification of developers is required;
- modern *technologies of Artificial Intelligence* do not fundamentally ensure the development of such *intelligent computer systems*, which eliminate the drawbacks of modern *intelligent computer systems* and, in particular, provide a sufficiently high level of interoperability;
- compatibility of *design technologies of different classes of AI intelligent computer systems* is practically absent and, as a consequence, there is no *semantic compatibility* and interaction of the developed *intelligent computer systems*, so the system integration of *intelligent computer systems* is done manually;
- there is no *complex technology of intelligent computer systems design*;
- there is no compatibility between existing *particular design technologies for various components of intelligent computer systems* (knowledge bases, problem solvers, intelligent interfaces). There are tools for component development, but it is necessary to "glue" (connect, integrate) developed components manually, because there are no comprehensive tools to develop *intelligent computer systems* as a whole.

4) The current state and current problems of ***development technologies for the implementation of designed intelligent computer systems*** *as well as their operation and maintenance:* There have been a number of attempts to develop *new-generation computers* focused on the use of *in intelligent computer systems*. But all of them were unsuccessful because they were not oriented towards the whole variety of *problem-solving models* in *intelligent computer systems*. In this sense, they were not *universal computers* for *intelligent computer systems*.

Developed *intelligent computer systems* can use a variety of combinations of *intelligent problem-solving models* (logic models corresponding to various kinds of logics, neural network models of various kinds, goal-setting models, plan synthesis, complex object control models, natural language text understanding and synthesis models, etc.). However, modern traditional (von Neumann's) *computers* are not able to interpret all the variety of these *problem-solving models* in a sufficiently productive way. At the same time, the development of specialized *computers* focused on the interpretation of any one *problem-solving model* (neural network model or any logical model) does not solve the problem, because in *intelligent computer system* several different *problem-solving models* must be used at once, and in various combinations.

Currently, there is no comprehensive approach to the technological support of all stages of the *intelligent computer systems* life cycle – not only to support the design and implementation (assembly, production) of *intelligent computer systems*, but also to the technological support of maintenance, re-engineering and operation of *intelligent computer systems*.

The semantic unfriendliness of the *user interface* and the lack of built-in intelligent help systems that allow you to query information about interface elements and system features leads to low operational efficiency of all *intelligent computer system* features.

5) Current state and current problems of ***applied engineering in the field of Artificial Intelligence****:* We have accumulated quite a lot of experience in the development of *intelligent computer systems* for various purposes - systems of medical diagnostics automation,

as well as diagnostics of complex technical systems, intelligent learning, information and help systems, systems of natural language communication, intelligent computer personal assistants, intelligent corporate systems, intelligent systems of situational management of various kinds of complex objects, systems of intelligent analysis of big data. However:

- The level of efficiency of practical use of scientific results in the field of *Artificial Intelligence* clearly does not correspond to the current level of development of these scientific results themselves. In order to improve the level of effectiveness of the practical use of the mentioned scientific results, collaborative efforts of scientists creating new models of intelligent problem solving, developers of design and implementation technologies, and developers of applied *intelligent computer systems* are required.
- There is no clear systematization of the variety of *intelligent computer systems*, corresponding to the systematization of automated *types of human activity*;
- There is no *convergence of* ***intelligent computer systems*** that provide automation of *fields of human activity* belonging to the same *type of human activity*;
- There is a lack of *semantic compatibility* (semantic unification, mutual understanding) between *intelligent computer systems*, the main reason being the absence of a concerted system of common *concepts* used;
- Analysis of the problems of complex automation of all *types of human activity* convinces us that further *automation of human activity* requires not only increasing the level of *intelligence* of the corresponding *intelligent computer* systems, but also to substantially increase their ability level:
  - build its *semantic compatibility* (understanding) both with other *computer systems* and with its users;
  - maintain this *semantic compatibility* in its own evolution, as well as the evolution of users and other *computer systems*;
  - coordinate with users and other *computer systems* in the collective solution of various problems;
  - participate in the distribution of work (subproblems) in the collective solution of various problemss.

It is important to emphasize that the implementation of the above capabilities will create the possibility for substantial and even complete automation of *system integration of computer systems* into complexes of interacting *intelligent computer systems* and automation of reengineering of such complexes. Such automation of system integration and its reengineering:

- will give the complexes of computer systems the opportunity to adapt independently to the solution of new problems;
- will significantly increase the efficiency of operation of such complexes of computer systems, as the reengineering of system integration of computer systems included in such a complex is often in demand (for example, in the reconstruction of enterprises);
- significantly reduces the number of errors compared to "manual" (non-automated) execution of *system integration* and its *reengineering*, which, in addition, require high skills.

Thus, the next stage of increasing automation of *human activity* urgently requires the creation of such *intelligent computer systems*, which could by themselves (without a system integrator) combine to solve complex problems together.

6) Current state and current problems of ***academic activities in the field of Artificial Intelligence****:* Many leading universities are training specialists in *Artificial Intelligence*. At the same time it is necessary to note the following features and problems of the current state of this activity:

- Since *activities in the field of Artificial Intelligence* combines both a high degree of science-intensive and a high degree of engineering complexity, training specialists in this field requires simultaneous formation of both research skills and knowledge and engineering-practical skills and knowledge, as well as system and technological culture and style of thinking. From the point of view of teaching methodology and psychology, the combination of fundamental scientific and engineering-practical training of specialists is a rather complex pedagogical problem;
- There is no *semantic compatibility* between different academic disciplines, which leads to "mosaic" perception of information;
- There is no systematic approach to the training of young professionals in the field of *Artificial Intelligence*;
- There is no personalization of learning, as well as an attitude to the identification, discovery and development of individual abilities;
- There is no purposeful formation of motivation for creativity;
- No formation of skills to work in real teams of developers. There is no adaptation to the real practical work;
- Any modern technology (including *Artificial Intelligence* technology) must have a high rate of development, because without it it is impossible to maintain a high level of its competitiveness. But a rapidly developing technology requires:
  - not just highly qualified personnel using and developing the technology;

– but also a high rate of improvement of this qualification, because without this it is impossible to effectively use and develop rapidly changing technology.

It follows that *learning activity in Artificial Intelligence field* and its corresponding technology should not just be an important part of *activities* in the field of *Artificial Intelligence*, but a part that is deeply integrated into all other *types of activities* in the field of *Artificial Intelligence*. Thus, for example, every *intelligent computer system* must be oriented not only to serving its end users, not only to organizing purposeful interaction with its developers who are constantly improving the system, and not only to providing a minimum "threshold of entry" for new end users and developers, but also to organize continuous and personalized professional development for each of its end users and developers in the face of constant changes made to mentioned *intelligent computer system*. To do this, the operated *intelligent computer system* must "know" what has changed in it, what it is capable of, and how to initiate these abilities (the content and form, of the corresponding user commands).

When we talk about *convergence* and *integration* in the field of *Artificial Intelligence*, we are talking not only about convergence between *intelligent computer systems*, but also between different types and fields of *human activities*. Thus, *learning activities* aimed at training specialists in *Artificial Intelligence* are organically part of *activities in Artificial Intelligence field*, and the most important way to increase the efficiency of this activity is its *convergence* and *integration* with other types of *activities in the field of Artificial Intelligence*.

7) Current state and current problems of ***organizational activities in the field of Artificial Intelligence****:* The urgent need to significantly increase the level of automation in various fields of *human activities* (industry, medicine, transportation, education, construction and many others), as well as the current results in the development of *Artificial Intelligence technology* have led to a significant increase in the creation of *applied intelligent computer systems* and the appearance of a large number of commercial organizations focused on the development of such applications. However:

- It is not easy to balance the tactical and strategic directions of development of all types of activities in the field of *Artificial Intelligence* (research activities, development of design technology and production of intelligent computer systems, development of application systems, educational activities), as well as the balance between all the above *types of activities*;
- Currently, there is no deep *convergence* of different *types of ctivities* in the field of *Artificial Intelligence* (primarily, the convergence of development of *Artificial Intelligence* technologies and development of various applied *intelligent computer systems*), which makes the development of each of these activities very difficult and in particular makes the integration of different problem-solving models (e.g., logic models, neural network models, natural language text processing models, signal processing models – audio signals, images).
- The high level of science-intensive work in the field of *Artificial Intelligence* makes special requiremnts on the qualifications of employees and their ability to work as part of *creative teams*.

D. Key tasks and methodological problems of the current stage of development of ***Artificial intelligence***

Among the **key tasks** of the current stage of development of *Artificial intelligence* should be included:

- Construction of a ***general formal theory of intelligent computer systems***, which would provide compatibility of all directions of *Artificial intelligence*, all models of knowledge representation, all models of problem solving, all components of *intelligent computer systems*. This implies:
  - Clarification of the requirements for a *new-generation intelligent computer systems* – clarifying the properties of *intelligent computer systems* that determine a high level of *intelligence*;
  - ***Convergence*** and *integration* of all kinds of *knowledge* and all kinds of *problem-solving models* within each *intelligent computer system*.
- Creating an ***infrastructure*** that ensures intensive permanent development of the *General Formal Theory of Intelligent Computer Systems* in a variety of directions, guaranteeing the preservation of logical and semantic integrity of this *theory* and compatibility of all directions of its development;
- Based on the *General Formal Theory of Intelligent Computer Systems*, constructing the ***Technology of Integrated Life Cycle Support for Next Generation Intelligent Computer Systems*** with a High Level of Interoperability and Compatibility;
- Creation of ***infrastructure*** to ensure intensive permanent development of the *Integrated technology for the development and operation of new-generation intelligent computer systems* in a variety of directions, guaranteeing the preservation of the integrity of this *technology* and compatibility of all directions of its development;
- Development of ***new-generation computers*** focused on high-performance interpretation of *logical-semantic models of next-generation intelligent computer system*;
- Creation of a ***global ecosystem of new-generation intelligent computer systems***, focused on comprehensive automation of various human activities.

The epicenter of modern methodological problems of development of *human activity* in the field of *Artificial Intelligence* is the ***convergence*** and *deep integration* of all types, directions and results of this *activity*. The level of interconnection, interaction and ***convergence*** between different types and directions of activities in the field of *Artificial Intelligence* is currently clearly insufficient. This leads to the fact that each of them develops in isolation, independent of the others. It is a question of ***convergence*** between such directions of *Artificial Intelligence* as knowledge representation, solution of intelligent problems, intelligent behavior, understanding etc., and between such types of *human activity in the field of Artificial Intelligence* as scientific research, technologies development, applications development, education, business. Why the market of *intelligent computer systems* and complex technology of *Artificial Intelligence*, providing the development of a wide range of *intelligent computer systems* for various purposes and accessible to a wide contingent of engineers, has not yet been created on the background of already long intensive development of scientific research in the field of *Artificial Intelligence*. Because the combination of high level of science intensity and pragmatism of this problem requires for its solution a fundamentally new approach to the organization of interaction between the scientists working in the field of *Artificial Intelligence*, developers of design automation tools of *intelligent computer systems*, developers of means for the realization of *intelligent computer systems*, including hardware support tools of *intelligent computer systems*, developers of applied *intelligent computer systems*. This purposeful interaction should be carried out within each of these forms of activity in the field of *Artificial Intelligence*, as well as between them. Thus, the ***convergence*** of both different types (forms and directions) of *human activities* in the field of *Artificial Intelligence* and different products (outcomes) of these activities is the main tendency of further development of theoretical and practical works in the field of *Artificial Intelligence*. It is necessary to eliminate the barriers between different types and products of activities in the field of Artificial Intelligence in order to ensure their compatibility and integrability.

Convergence of *intelligent computer systems* under development transforms a set of individual (autonomous) *intelligent computer systems* of different purposes into a collective of actively interacting *intelligent computer systems* for joint (collective) solution of complex (complex) problems and for the permanent support of compatibility between all the *intelligent computer systems* included in the collective, in the process of individual evolution of each of these systems.

The ***convergence*** of specific artificial entities (e.g., technical systems) is an aspiration to their unification (in particular, to standardization), i.e., an aspiration to minimize the diversity of forms of solving similar practical problems - an aspiration to ensure that everything that can be done equally, is done equally, but without compromising the required quality. The latter is very important, since illiterate standardization can lead to a significant brake on progress. Limiting the diversity of forms should not lead to a limitation of content, opportunities. Figuratively speaking, "words should be crowded, but thoughts - free" .

Methodologically ***convergence*** of artificially created entities (artifacts) is reduced (1) to revealing (discovering) principal similarities between these entities, which are often quite camouflaged and difficult to "see" and (2) to implementing the discovered similarities in the same way (in the same form, in the same "syntax"). Figuratively speaking, from "semantic" (semantic) equivalence we have to go to "syntactic" equivalence as well. By the way, this is exactly the point of *semantic representation of information*, the aim of which is to create such a linguistic environment (semantic space) within the limits of which (1) semantically equivalent information constructions would completely coincide, and (2) ***convergence*** of information constructions would be reduced to revealing isomorphic fragments of these constructions.

Among the general methodological problems of the current stage of development of *Artificial Intelligence* are:

- Lack of mass awareness that the creation of a market of *new-generation intelligent computer systems*, with *semantic compatibility* and a high level of *interoperability*, as well as the creation of complexes (ecosystems) consisting of such *intelligent computer systems* and providing automation of *various human activities*, is impossible unless the development teams of such systems and complexes significantly increase the level of *socialization* of **all** their employees. The level of quality of the team of developers, i.e. the level of qualification of employees and the level of coordination of their activities, should exceed the level of quality of the systems developed by this team. The considered problem of specialists' activity coherence in the field of *Artificial Intelligence* has a special meaning for the construction of *General formal theory of new-generation intelligent computer systems*, as well as the *Complex technology of development and Exploitation of new-generation intelligent computer systems*;
- Not all scientists working in the field of *Artificial Intelligence* accept the pragmatic, practical orientation of *Artificial Intelligence*;
- Not everyone accepts the need to ***converge*** the various directions of *Artificial Intelligence* and the need to integrate them in order to build a *general formal theory of intelligent computer systems*;
- Not everyone accepts the need for the ***convergence*** of different activities in the field of *Artificial Intelli-*

gence;

- An important obstacle to the ***convergence*** of scientific and technological results is the emphasis formed in science and technology on identifying differences rather than similarities. To be convinced of this, it is enough to pay attention to the fact that the level of scientific results is evaluated by scientific novelty, which can be imitated by novelty not in substance, but in form of presentation (for example, by means of new concepts or even new terms). Results in engineering, for example, in patents are also evaluated by differences from previous technical solutions. But ***convergence*** requires a different emphasis – not the search for differences, but the identification of non-obvious similarities and their transformation into obvious similarities presented in the same form;
- There is no movement to build a *comprehensive technology for the design, implementation, maintenance, re-engineering and operation of intelligent computer systems*. It is a comprehensive approach to the technological support of all stages of the life cycle of *intelligent computer systems*;
- There is no active development of work on the creation of a *global ecosystem of next-generation intelligent computer system*;
- At the heart of the modern organization and automation of *human activity* is the "*Babylonian Pillar*" of an ever-expanding variety of *languages*. This refers not only to *natural languages*, but also to *formal languages* aimed at precise representation of various kinds of *knowledge*. The variety of different *specialized languages* permeates all *human activities* – in many fields of *human activity*, *specialized languages* are created to solve different kinds of *problems*, to develop different *models for solving problems*. An example of this is the diversity of *programming languages*. *Specialized languages* can and must appear, but only as *sub-languages* of more general *languages*, the syntax of each of which coincides with the *syntax* of all the corresponding *sub-languages*. In this case within the framework of *General Formal Theory of Intelligent Computer Systems* one *universal formal language* – kernel language, with respect to which all other used *formal languages* are *sublanguages*, should be defined. *Denotational semantics* of the mentioned *universal formal language* should be set by an appropriate *formal ontology* of the highest possible level. Otherwise what ***convergence*** and *integration* of *knowledge* and *semantic compatibility* of computer systems can be talked about.

The proposed organization of *human activity* in the field of *Artificial Intelligence* is based on the following provisions:

- ***complex convergence*** - both "vertical" *convergence* between different *types of activities* in the field of *Artificial Intelligence* and "horizontal" *convergence* within each of these *activities*, corresponding to different components or different classes of *intelligent computer systems* - knowledge bases, problem solvers, different types of problem-solving models, different types of interfaces (visual, audio, natural-language), robotic intelligent computer systems, intelligent learning systems, intelligent automated control systems, intelligent design automation systems, etc.);
- ***"horizontal" convergence*** within each *human activity* in the field of *Artificial Intelligence* includes:
  - *convergence* in the *research activities in the field of Artificial Intelligence*, which means the transition from the independent development of different directions of *Artificial Intelligence* to the general theory of *intelligent computer systems*;
  - *convergence* in the development of *Artificial Intelligence technologies*, meaning the transition from the independent development of private technologies to the creation of a single set of semantically compatible private technologies;
  - *convergence* within *Artificial Intelligence engineering*, meaning the transition from the practice of independent development of various applied *intelligent computer systems* to the development of a set (ecosystem) of interoperable *intelligent computer systems*;
  - *convergence* in the framework of *educational activities in the field of Artificial Intelligence*, denoting the transition from the study of individual disciplines to the formation of young professionals a comprehensive picture of the current state of *Artificial Intelligence* and the problem directions for further development;
  - *convergence* within the *general organizational activities in the field of Artificial Intelligence*, the transition from the individual activities listed above in the field of *Artificial Intelligence* to a single set of all these activities and providing convergence and integration of these activities in the field of *Artificial Intelligence*, which will significantly improve their quality, as each of these activities is highly dependent on all others;
- organization of the design and permanent development of the proposed *technology* in the form of an ***open international project*** that provides:
  - free access to the use of the current version of the *technology* under development;
  - the opportunity for everyone to join the team of developers of this *technology*;
- ***phased*** process of forming the market of *semantically compatible* and *actively interacting* with each

other *next-generation intelligent computer systems*, the initial stages of which are:

- development of *logical-semantic models* (knowledge bases) of several *applied next-generation intelligent computer systems*;
- software implementation on modern computers *platform interpretation of logical-semantic models of next-generation intelligent computer systems*;
- installation of each developed *logical-semantic model of the applied intelligent computer system* on the developed software platform of interpretation of such models with subsequent *testing* and *re-engineering* of each such model;
- development and permanent improvement of the logical-semantic model (knowledge base) of *intelligent computer metasystem*, which contains (1) a description of the *standard of new-generation intelligent computer systems* [12], (2) a *library* of reusable (in different *intelligent computer systems*) knowledge of different types and, in particular, different *methods of solving problems*, (3) *design methods* and *design support tools* of *different types of components of intelligent computer systems* (components of knowledge bases),
- development of an *associative semantic computer* as a hardware implementation *platform for interpreting logical-semantic models of next-generation intelligent computer systems*;
- transfer of the developed *logical-semantic models of next-generation intelligent computer systems* to new, more effective variants of the implementation platform of interpretation of these models;
- development of a *new-generation intelligent computer systems market* in the form of a global ecosystem consisting of actively interacting such systems and focused on comprehensive automation of all *human activities*;
- creation of a ***knowledge market*** based on a *global ecosystem* of *next-generation intelligent computer systems*;
- automating the *re-engineering* of operating *next-generation intelligent computer systems* in the direction of bringing them into compliance with new versions of the *intelligent computer systems standard* by automatically replacing obsolete *components* in these systems with current versions of these .

It should be emphasized that the **key factor in solving the considered methodological problems** in the field of *Artificial Intelligence* are various directions of ***convergence*** and ***integration***, providing the transition to a ***new-generation intelligent computer systems***, the corresponding technology for the integrated support of their life cycle and a significant increase in the level of automation of the entire complex of human activities:

- *convergence* and *integration* of different models of *information* representation and processing in *new-generation intelligent computer systems*
  - *convergence* and *integration* of different *types* of *knowledge* in *knowledge bases* of *new-generation intelligent computer systems*
  - *convergence* and *integration* of different *problem-solving models*
  - *convergence* and *integration* of different *types of interfaces* of *new-generation intelligent computer systems*
- *convergence* and *integration* of different directions of *Artificial Intelligence* for the purpose of building a *general formal theory of new-generation intelligent computer systems*
- *convergence* and *integration* of *design* technologies for various *components of next-generation intelligent computer systems* in order to build integrated *Design Technologies for next-generation intelligent computer systems*
- *convergence* and *integration* of technologies to support various *stages of the life cycle* of *next-generation intelligent computer systems* in order to build *technologies of comprehensive support for all stages of the life cycle of next-generation intelligent computer systems*
- *convergence* and *integration* of various *types of human activities in the field of Artificial intelligence* (*research activities*, *development of technological complex*, *applied engineering*, *educational activities*) to increase the level of coherence and coordination of these *activities*, as well as to increase the level of their complex automation with the help of ***semantically compatible*** *new-generation intelligent computer systems*
- *convergence* and *integration* of various *types and fields of human activity*, as well as means of complex automation of this activity with the help of *new-generation intelligent computer systems*

The final practical result of human activity in the field of Artificial Intelligence is:

- Reorganization and complex automation of *human activity in the field of Artificial intelligence* with the help of *new-generation intelligent computer systems*;
- Step-by-step creation of a global network of effectively interacting ***new-generation intelligent computer systems***, providing comprehensive automation of various types and fields of *human activity*.

The transition from modern intelligent computer systems to *new-generation intelligent computer systems* and to the corresponding integrated technology does not require specialists in the field of Artificial intelligence to change the scope of their scientific interests. They are only required to overcome the ***Babel*** syndrome, formalizing

their scientific results as part of a common collective product.

The problems of the current stage of *Artificial Intelligence* development aimed at creating a general theory and technology of *new-generation intelligent computer systems* require a fundamental integrated interdisciplinary approach and a fundamentally new organization of scientific and technical activities.

E. Comprehensive automation of human activities in the field of Artificial Intelligence with the help of new-generation intelligent computer systems

Within the framework of *OSTIS technology*, the life cycle support of new-generation intelligent computer systems (*ostis-systems*) is carried out on the basis of *OSTIS Metasystem*, which belongs to the class of *ostis-systems* and is actually a form of implementation of the specified Technology. Automation of life cycle support of *ostis-systems* is carried out both in the form of instrumental maintenance of engineering activities (in particular, OSTIS Metasystem is a system of design automation of ostis-systems), and in the form of information maintenance of the specified activities. For this purpose, the knowledge base *OSTIS Metasystem* contains:

- The current state of the full text *Standard of ostis-systems*;
- The current state of the reusable components library of ostis-systems;
- The current status of the ostis-systems life cycle support methodologies used and implemented by engineers;
- Documentation of tools used by engineers to support the life cycle of ostis-systems.

In addition to all of this, *OSTIS Metasystem*:

- Provides automation of *the support of the life cycle of the ostis-systems Standard*, i.e. provides the organization of interaction between the authors of this Standard, aimed at its permanent development
- Provides automation of *OSTIS Technology life cycle Support*, which boils down to supporting the life cycle of the main part of the *OSTIS Metasystem* knowledge base, which is the complete documentation of the current state of *OSTIS Technology*.

Automation of other directions of *human activities in the field of Artificial Intelligence* can also be done with *ostis-systems* that are semantically compatible and interact with *Metasystem OSTIS* within the *Eco-system OSTIS*.

IV. Problems and prospects of comprehensive automation of all types and directions of human activity with the help of next-generation intelligent computer systems

Above it was considered how the whole complex of *Human activity in the field of Artificial Intelligence* is carried out and automated with the help of new-generation intelligent computer systems. Now we will summarize it and consider the principles of organization and complex automation of *human activity* as a whole, i.e. automation of the most various types and field of human activity.

A. General principles of systematization of human activity and its comprehensive automation with the help of new-generation intelligent computer systems

The experience of complex organization, structuring and automation of *human activities in the field of Artificial Intelligence* (in the creation and maintenance of intelligent computer systems) can be generalized to other fields of human activities. This is due to the following reasons:

- Firstly, because human activity aimed at supporting the whole *life cycle of new- generation intelligent computer systems* is a paricular direction of activity in relation to the type of human activity aimed at supporting the whole life cycle of any artificial (artificially created) entity (any artifact). Depending on the complexity of the artificially created entity, the level of complexity of human activities aimed at supporting the life cycle of this entity can be very different. But the overall structure of these activities corresponding to the different stages of the life cycle of artificially created entities. As well as the necessary directions of providing this engineering activity is the same for artificial entities of different classes. These directions of providing support for the life cycle of artificial entities include:
  - research activities aimed at the study of artificial entities of the relevant class;
  - development of the standard of artificial entities of the specified class;
  - development of life-cycle support technology for the specified class of artificial entities;
  - training personnel capable of supporting the life cycle of the specified class of artificial entities, i.e., capable of effectively using the above-mentioned technology;
  - training personnel capable of participating in the above-mentioned research and development activities;
  - training personnel capable of participating in the development of the standard of artificial entities of a given class;
  - training personnel capable of participating in the design and development of the above-mentioned technology;
  - organizational support of the whole set of works on the development and use of the above-mentioned technology.
- Second, because many complex technical systems are actually becoming *intelligent computer systems* (including distributed ones) with various sets of sensor and effector subsystems – intelligent cars

with autopilot and autosteer, intelligent automatic factories, smart houses, smart cities, etc.

- Thirdly, because the nature of the activities of *new-generation intelligent computer systems* and the nature of each *person* and each organization in fact there is little difference, because the *new-generation intelligent computer systems* become equal partners (subjects) of human activity, because the level of their independence, responsibility, interoperability and intelligence is close to the corresponding qualities of the *natural* subjects of human activity (individuals, legal persons, legal entities, etc.)

So, the structuring of *human activity* in the field of *Artificial Intelligence* based on the concepts of *type of activity*, *field of activity*, *product of activity* (object of activity) can be easily generalized for all *scientific and technical disciplines*, which makes it possible to consider automation of activity within all *scientific and technical disciplines* from the general position, as. because automation of different *type of activity* within different *scientific and technical disciplines* can look similar, and sometimes can be implemented using the same *intelligent computer system*. So, for example, any *intelligent computer system for design automation* of technical systems of a given types can be built on the basis of *intelligent computer system for design automation and knowledge base reengineering*, since the result of design of any *technical system* is a formal model (description, specification, documentation) of this *technical system*, which has enough completeness to reproduce (implement) this system.

At the current stage of development of *Artificial Intelligence* it is necessary to move from automation of separate *types of human activity* to integrated automation of the whole complex of *human activity*, to creation and constant evolution of the whole ***global ecosystem of intelligent computer systems***. That systems independently interact both among themselves and with people whose activities they automate, and also with modern computer systems, which are not intelligent systems. It should be remembered that the main "overheads", the main problems, arise at the "joints" when integrating different technical solutions. The developer of each subsystem should guarantee the absence of such "overhead" costs. It should be emphasized that one should focus not so much on creating an effective *global ecosystem of intelligent computer systems* as on creating effective techniques and tools aimed at the *permanent evolution* of such an *ecosystem*.

The methodology of complex automation *human activity* includes the following steps:

- Construction of a general ***structure of human activity***, based on the hierarchy of *human activity* by types of activity and products of activity with a clear fixation of different kinds of connections between the various components of this structure.
- Formalization of various *types of human activity*.
- Development of ***technology***, which ensures the maximum possible automation of this activity with the help of *new-generation intelligent computer systems*.
- Ensuring maximum possible ***convergence*** of various *types of activities*, which will reduce the variety of automation tools (i.e., appropriate *new-generation intelligent computer systems*).
- Ensuring maximum possible ***convergence*** of technologies for performing the same *type of activity* for different objects of activity (convergence of design technologies for objects of different classes, convergence of monitoring, prevention and diagnosis technologies for agents of different classes, etc.) and thereby ensure ***convergence*** of corresponding automation tools based on *new-generation intelligent computer systems*

B. Multiplicity of types of human activities and the connections between them

The basic type of human activity can be considered ***supporting the life cycle*** of various entities.

The class of objects of activity for this *type of activity* is the class of all kinds of socially significant objects, which it makes sense to influence, support the life cycle of which is advisable to implement.

life cycle support
:= [support of the life cycle of socially significant entities]
∈ *type of activity*
⇒ *particular type of activity performed at some point**:
- *design*
- *production*
- *initial training*
  := [setting up]
- *quality monitoring*
  := [scheduled examination and diagnosis]
- *restoring the required level of quality*
  := [repair, treatment]
- *reengineering*
  := [renewal, improvement]
- *security*
- *using*
  := [operation, usage]

⇒ *particular type of activity over a subclass of activity objects**:
- *research activities*
  := [support for the life cycle of scientific theories]
  ⇒ *class of activity objects**:
  scientific theory
- *standardization*
  := [standards life cycle support]
  ⇒ *class of activity objects**:
  standard
- *support for the technology life cycle*
  ⇒ *class of activities object**:
  technology
- *educational activities*

≔ [support for the human resource life cycle]
⇒ *class of activity objects**:
resource personnel

- *supporting the life cycle of comprehensive support management metasystems and providing support for the life cycle of the entities of the respective classes*
  ⇒ *class of activity objects**:
  meta-system for the integrated management of the support and provisioning of the life cycle of the entities of the respective classes

When the general structure of *human activity* was considered above by summarizing the structure of ***human activity in Artificial Intelligence***, we:

- introduced the concept of *type of activity*
- As a "starting point" generalization we chose such a *type of activity* as *support of life cycle of intelligent computer systems*
- further expand the class of *activity objects* of the selected *type of activity*,
  - moving from the class of *intelligent computer systems* to the class of all kinds of *artificial material entities*
  - combining the class of *artificial material entities* with the class of *natural material entities* (material entities of natural origin), as well as with the class of *natural-artificial material entities* (either *natural artificially modified material entities* or *hybrid natural-artificial material entities* with both natural and artificial components);
  - combining the class of *material entities* with the class of *information resources*, i.e., socially significant information constructions (documents) which are the products of corresponding actions or activities (*scientific theories*, *standards*, *bases of knowledge*, *methods*, *design documents* of corresponding created objects)
  - combining the class *material entities information resources* with the class *material-information-objects*, which, in particular, include various technologies.

Thus, *support of the life cycle* of various socially important objects is a special type of *human activity*. Firstly, the efficiency of *human activity* in general depends (1) on the duration of the socially useful (active) phase of the life cycle of the used objects and (2) on the amount of society's expenditure on maintaining the necessary socially useful properties of the used objects. Secondly, the nature and *technology* of life cycle support of different types of socially important objects can differ significantly from each other. For example, the organization of life cycle support for automobiles, traditional computer systems of various purposes, modern intelligent computer systems, interoperable intelligent computer systems, people, enterprises, houses, various legal entities, settlements, etc. differs significantly. At the same time, the typology of socially significant objects whose life cycle must be supported includes the most diverse classes of objects - artificially created material information products of human activity, all people, all kinds of social communities and enterprises. The diversity of types of socially significant objects generates a variety of technologies corresponding to them, which complicates the complex automation of human activity as a whole.

Nevertheless, we note that *types of human activity* is much smaller than *fields of human activity*. This is, to some extent, due to the fact that the types of relations between entities (relative concepts) are much fewer than the classes of various entities. This circumstance indicates that the movement in the direction of global automation of *society* activities should be based on the orientation towards a competent systematization of *types of human activities*, and their deepest *convergence* (both within each type of activity and between different types). Thanks to this, the artificially introduced variety of automation means of *human activities* can be minimized.

should be distinguished* ∋ {
- *research activities*
  ≔ [support for the life cycle of scientific theories]
- *standardization*
  ≔ [standards design and development]
  ≔ [standards life cycle support]
- *support for the technology life cycle*

}

Research activity is aimed at studying the entities of a given class, at studying the principles underlying their structure and functioning. Within this type of activity, novelty and competition of ideas and approaches are important, the correlation between the structure (architecture) of the organization of functioning of the studied *entities* and the general characteristics (parameters) of the quality of these entities, the general requirements imposed on them is important. The product of the activity under consideration is the *General theory of entities of a given class*, which reflects the plurality and even contradiction of different points of view and whose most important direction of development (evolution) is to bring together (*convergence*) different points of view and ensure compatibility and inconsistency between them. At the heart of *research activity* is the competition of points of view, the principal novelty of ideas and verified results aimed at revealing and substantiating non-obvious properties and regularities of the corresponding *subject domain*, at developing methods of solving various *classes of problems* solved within this *subject domain*. The purpose of the *research activity* and the required detailing of the generated knowledge about the research objects of the corresponding *subject domain*

In contrast to *research activity*, the development of the *standard* of created entities and the development of the corresponding *technology* of support for their life cycle is based on agreement of different points of view

(consensus search) and their simplification as much as possible (observance of Occam's Razor principle). The necessity of such a methodological attitude is caused by the mass nature of *human activity* to create and *support* the life cycle of the corresponding class of entities and the need to involve people with *different* (including quite low) qualifications in this activity. In the process of *development of the standard of entities of a given class* it is not the competition of different points of view that is important, but their *convergence*, *semantic compatibility* and deep integration. Each *standard artificial entities of a given class* is an agreed currently point of view (consensus) about the structure, functioning, properties, and patterns of artificial entities of a given class, an agreed (generally accepted) part of the *General Theory of Artificial Entities of a Given Class*, which is understandable to the broad contingent of practitioners (engineers) who design, produce and maintain the entire life cycle of specific *artificial entities of a specified class*.

The creation and *support of the technology life cycle* must take into account a number of requirements for any *technology*:

- comprehensiveness - maximum possible coverage of all tasks that must be solved with *technology* (at least all stages of the life cycle)
- maximum ease of use of *technology* (required completeness of documentation, intelligent help-support, absence of unnecessary information that is not necessary for using *technology*, availability of rich and systematic library of typical reusable solutions)

Society is a hierarchical system of interacting individual and collective entities, each of which:

- Produces either part of the socially significant products produced by the collective entity, which includes this subject, or an integral socially significant product (produced goods) consumed by other external entities or provides some service to another entity, aimed at ensuring the livelihood and improvement of this other entity.
- It consumes products produced by other entities, necessary for the production of its own products (raw materials and equipment), as well as necessary to ensure its own livelihood.
- It consumes services provided by other entities necessary for the production of its own products or services, as well as those necessary to improve its activities.

The main directions of automation of the whole complex *human activity* are:

- automation of socially useful professional activities of all subjects of activity (both individual subjects - all individuals, and all kinds of collective - corporate entities, including legal entities)
- automation of providing (creating) comfortable conditions for all subjects of society based on the monitoring of activities and specific (adapted) facilitation of the evolution of each subject, taking into account its immediate needs and problems.

The organization of each subject's interactions with the external environment should be carried out both by this subject and by the mentioned external environment (i.e., by society). Society should turn "face" to each subject and not throw it to the mercy of fate. At present, creation (provision) of conditions of society's subjects' activity is given to each such subject. Society, represented by other subjects designated for this purpose, provides services and supplies goods on the initiative of the subject in need. Thus, the responsibility for the development of each subject of activity falls exclusively on the "shoulders" of this subject. The society's support is general and does not take into account in any way the peculiarities of the current situation of each subject.

The most important reason preventing further increase in the overall level of automation of human activity is the fact that automation of various fields of human activity is carried out local. At the current stage of application of intelligent computer systems the main problem is not the automation of local types and fields of human activity, but the automation of complex processes of human activity, requiring *integration* in a priori unpredictable combinations of a variety of information resources and a variety of automated services, implemented in the form of specialized intelligent computer systems.

Locality of automation of human activity leads to the fact that all human activity acquires the appearance of "archipelago" consisting of well-automated "islands" but interconnected "manually". This "manual" non-automated connection of these "islands" depends entirely on the human factor and qualification of corresponding executors.

The specified "manual" connection of some set of semantically close automated fields of human activity can be automated, but it should be done very competently at a high level of system culture and on the fundamental basis of the general theory of human activity.

Another important reason preventing further improvement of the overall level of automation in society is that automation of different fields of human activity is carried out without identifying and deeply analyzing the similarities of some activities in different fields and, accordingly, without converging, ***convergence*** and ***unifying*** these *types of activity*.

The most important direction to increase the level of automation of human activity is the transition to automation of more and more complex (large) types and fields of human activity, for example, from the automation of various enterprises, organizations, economic services to the automation of the city as a whole).

Automation of complex human activities requires the

creation of a set of actively interacting computer systems, each of which provides automation of the corresponding particular type of human activity that is part of the complex activity being automated. In this case the number of levels of hierarchy of automated human activities is not limited in any way. Obviously, the level of automation of complex human activities is determined by:

- level of convergence (convergence, compatibility) of the respective particular types of activities;
- quality of integration of these private activities;
- level of convergence of computer systems, providing automation of the specified particular types of activities;
- quality of interaction of these computer systems, i.e. the level of interoperability of these systems).

The level of evolution of society depends to a large extent on the level of automation of human activity, on the level of development of the corresponding technologies of such automation. But this dependence looks much more complicated than it seems at first glance, especially if we are talking about automation of not physical but intelligent human activity (both individual and collective). Illiterate and, all the more so, socially irresponsible or malicious automation of society's informational activity can cause enormous damage to its development. Such illiteracy and irresponsibility, for example, leads to such side factors as computer addiction, virtualization of the environment, superficiality of thinking, reduction of cognitive motivation and activity, and much more. Consequently:

- Needs to significantly increase the level of social responsibility of the developers of computer systems and related technologies.
- The danger from illiterate, socially irresponsible and, even more so, malicious implementation of the new-generation of intelligent computer systems can be fatal for humanity.

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

- increase the efficiency of humanity's *knowledge* and *skills* to use the experience accumulated by *society*, the efficiency of humanity's *knowledge* and *skills*;
- increase the rate of acquisition, accumulation and systematization of humanity's effective use of *knowledge* and *skills*.

The solution of the above problems becomes quite possible by using *new-generation intelligent computer systems*, by means of which humanity's accumulated the *knowledge* and *skills* will be organized as a systematized distributed library of reusable information resources (*knowledge* and *skills*). Consequently, the systematization and automation of the reusable information resources(that was acumaleted by humans) requires their convergence, deep integration and formalization. A special place in this process is occupied by mathematics as a basis for systematization and formalization of knowledge and skills at the level of formal *ontologies of the upper level*.

V. Conclusion

Due to the fact that *new-generation intelligent computer systems* become independent and active subjects of *human activity* sufficiently equal to humans(natural individual subjects of human activity), the nature and, respectively, the level of automation of *human activity* changes significantly – the need to control automation means is removed, since this "manual" management is replaced by the distribution of duties and responsibilities among people

If automation of any kind of automation in any types of *human activity* is carried out with the help of *new-generation intelligent computer systems* and if *new-generation intelligent computer systems* that provide automation of different types and fields of *human activity* will meaningfully interact with each other, the overall level of automation of *human activities* will significantly increase due to the fact that there will be no need to manually coordinate the use of various automation tools.

The efficiency and labor intensity of automation of different types and fields of *human activities* will be significantly determined by the degree of ***convergence*** between different types and fields of *human activities*. A hierarchical model of *human activity* must be built, within which a competent systematization and stratification of all types and fields of *human activity* must be carried out, aiming against an excessive eclectic diversity. Thus, before implementing comprehensive automation of *human activities* with the help of *new-generation intelligent computer systems*, it is necessary to rethink the organization of this activity from the perspective of general systems theory. Otherwise, automating clutter will lead to more clutter.

Let us emphasize the fact that many of the problems we have considered the current state and directions of further development of *human activity in the field of Artificial Intelligence* are similar to the problems and trends in many other scientific and technical disciplines.

Each person's time is the main irreplaceable resource of society, and it should be spent not on the routine support of the life cycle of all kinds of socially important objects, but on the integrated development of appropriate *technologies*. Automation of human activities with the help of a global system of interoperable semantically compatible and actively interacting *intelligent computer systems* in various fields of *human activities* will significantly reduce the time of each person to perform routine, easily automated activities. Human activity should become oriented to the maximum possible self-realization, opening creative potential of each person, aimed at

accelerating the rate of increasing the level of intelligence of the whole society.

The creation of *a Global ecosystem of next-generation intelligent computer systems*, involves:

- Building a formal model of *human activity*;
- The transition from eclectic construction of complex *intelligent computer systems* that use different types of *knowledge* and different types of *problem-solving models* to their deep *integration* and *unification*, when the same representation models and knowledge processing models are implemented equally in different systems and subsystems;
- Reducing the distance between the modern level of *the theory of intelligent computer systems* and the practice of their development;
- The development of a competent tactic and strategy for the transition period, in which modern *intelligent computer systems* should be gradually replaced by *new-generation intelligent computer systems*, which should effectively interact not only with each other, but also with well-proven modern information resources and services.

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Проблемы и перспективы автоматизации различных видов и областей человеческой деятельности с помощью интеллектуальных компьютерных систем нового поколения

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В работе рассмотрены принципы автоматизации различных областей человеческой деятельности с использованием интеллектуальных компьютерных систем нового поколения. Предлагается онтология различных видов деятельности и соответствующих технологий. Детализация указанных принципов осуществляется на примере человеческой деятельности в области Искусственного интеллекта.

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