Information Technology for Forecasting and Guaranteeing of Software-Hardware Complexes Information Security Indicators

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Abstract

The information technology of polyergatic organizations for forecasting and guaranteeing information security of software and hardware complexes is developed. The dependence of the final report document on changes in the processes of information activity forms knowledge with the active use of innovative technical and technological decisions is proved. The structural and functional support of each system intellectual agent computer integration efforts is proposed to ensure synergistic multicriteria efficiency and safety of the software and hardware complexes functioning in conditions of increased risk of cyber-attacks. The goal of this article is to develop the methodological and theoretical principles of system integration of heterogeneous technological processes based on the awareness of the future state of improving information security through the innovative development of the software-hardware complexes nowadays. Methods of analysis and synthesis of complex dynamic systems with fixation of role participation of each intellectual agent are described in accordance with the principles of Agile for development and construction and the fundamental contribution of procedures for measuring, predicting, testing and making step-by-step solutions. The result is displayed in the form of tables and a block diagram of hierarchical cyclic interactions for the purpose. Fundamental metrization of key concepts and system-forming processes provides the functional stability of future technological and technological solutions to the predicted interval of global awareness of space-time phenomena in the universe. Our proposed technology in the distributed hierarchical information analytical complex team in advance raises public awareness of certain trends in the external environment.

Keywords

information security, engineering knowledge, measurement, testing forecasting, innovations, security technology.

1. Introduction

Ensuring the development of machinery and technology to improve information security depends on the development of science and engineering knowledge aimed on the future [1-3]. Aspects of the relationship between probable prediction and reliable existence of the predicted change in the processes information activities forms with cognition with the use of innovative technical and technological solutions [4-6]. Polyergatic production organizations of scientific and critical direction, for software and hardware complexes in open information systems implement acts of action. These acts record the transitions from known to unknown, from safe operation to volatile situations in non-stationary conditions of numerous environmental influences with significant changes in information and analytical parameters [7].

The purpose of the work is to develop methodological and theoretical principles of heterogeneous technological processes system integration based on awareness of the future information security improvement state through nowadays software and hardware innovative development.

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The set scientific task is achieved by solving partial goals.

1. Formalization of the terminological basis for predicting and forecasting the software and hardware complexes safety indicators.
2. Determining the conditions for the technical and technological solutions integration of modern intelligent technologies and methodologies for the functional stability management on the basis of innovative information analytical complex tools.
3. Guaranteeing the quality and efficiency of polyergatic means for the measurement processes controlling, forecasting, testing, generalization of thus formed technical and technological solutions.

2. Problem statement

At the same time, the real global problems of the state information security have a complex socio-natural character. Therefore, futurological (futurum + logos) research for information-analytical complex is performed in cooperation with experts of many countries and leading IT companies in order to obtain plausible forecasts for 20-30 years ahead to future epochs. Scientific regional or local predictions are aimed at basic knowledge of current situations, direct review trends, short (up to 5 years) intervals. The main thing is to have the available resources to carry out alternate self-adjustment of the plan, project and programs of management and acts of action implementation in accordance with the agreed tasks of the information analytical complex in the face of cyber-attacks and uncertainty. Such scientific and engineering forecasting of integrated technical and technological solutions allows to reveal possible variants according to situations with definition of space-time continuum. Then to answer the question "where, when, what awaits us (object) in the future?" it is necessary to implement step by step rational management according to sound strategies, tactics and operations to ensure the functional stability of a complex dynamic system [8].

3. Review of the literature

Current state of research in the area of information system security is quite wide and is developing from year to year. Modern researchers concentrate their attention on ongoing security problems, defending information and intellectual systems from external attacks and internal issues. Fundamental challenges and vulnerabilities of computing systems are described and determined [1-3]. Security mechanisms, indicators and techniques of control and monitor security of each type of distributed information analytical complexes are described [4-5]. Approaches for monitoring, intrusion detections, encrypting, distributing accesses and interfaces, authentication and authorization and more others give opportunity to have a sufficient level of security and functional stability of nowadays existing informational and intellectual systems [6-7]. On another hand, scientific literature from all over the world gives researchers strong understanding that fast development and growing amount of information technologies and systems requires from architectures, designers, and developers of such systems to overtake this grow with the new approaches of new approaches to ensure the safety and stability of both new and existing technical and technological solutions implementation [8]. All modern scientists agree that scientific knowledge in the field of information systems security requires constant research and expansion of scientific and technical approaches to ensure stability. Methodology of improving functional stability of various distributed information systems should include all past experience in models, methods and tools for automating the process for controlling ergatic innovative systems and investigate new approaches such as agile methodology, function distribution and microservice architecture to make system more robust and resistant to new vulnerabilities not known yet.

4. Presentation of the main research material

The paradigm of key concepts fundamental metrization is designed to ensure the functional stability of the target resulting technical and technological solutions implementation in the yet unpredictable, undescribed, unreasonable future.

Intelligent system agent (IAS) [7,8] is a part of polyergatic production organizations' information analytical complex. Intelligent system agent competence - knowledge of technical sciences in the field of informatization, engineering, technology, physics, dynamics, economic and intellectual security for information analytical complex by means of guaranteeing system resilience to failures and cyberattacks. Information spatial-situational awareness a set of security knowledge necessary and reliable for the further development and management of the formation processes according to continuous successive acts of action to transform the past-present into the future of information system software and hardware complex under the influence of environment.

Collective awareness within polyergatic production organizations' information analytical complex presupposes the level of information spatial-situational awareness competence of each specialist (as intelligent system agent, which has the ability according to its available resources and stocks) to perform professional acts in current situations. Separation of functions and hierarchy of subordination within polyergatic production organizations' information analytical complex is clearly formalized and structured in work regulations depending on operational situations. An example of architectural construction (Table 1) is provided for future polyergatic production organizations' information analytical complex. Each of the system unit provides concrete actions and tasks to provide stability for the whole system or for the system units separately. For example, ASSA keeps each intellectual agent of the system informed about global cybersecurity and monitors possible vulnerabilities. Depending on situation provides suggestion for system stabilization based on previous practical and theoretical knowledge.

Table 1
Classification subsystems of information security indicators in the conditions of space-time continuum risks from independent effects of EI in the future

Rand	Defining subsystems of the future information analytical complex	Symbol	Purpose
1	Competent knowledge of information security (Space Situational Awareness)	ASSA	Global information situation of geo-relations for cybersecurity
2	Secure response tools (Shared Early Warning)	ASEW	Early warning of attacks and threats
3	Navigation in the space-time continuum (Positioning Navigation Timing)	PNT	Local and global positioning of the complex dynamic system and environment region
4	space-time continuum sounding reconnaissance (Intelligence Surveillance and Reconnaissance)	ISR	Observations and express analysis of the sounding field
5	Situational support in space-time continuum (Spare Situational Support)	SSS	Distribution of functions, resources tasks
6	Telecommunications in networks (Internet Communications Transponder Tracking)	ICTT	Network channels of hierarchical data exchange on request
7	Comprehensive special solutions (Space Control and domain Enhancement)	SCDE	Scope of Application Coordination Control for information analytical complex

The basic concept of functional stability of information intellectual system (characterizes the synergistic property of a single complex dynamic system to guarantee a full range of operating modes normalized, invariant level of the resulting efficiency of technological processes, due to a specialized subsystem of intelligent agents, which are capable to accelerate procedures for recovery (compensation) of partially lost functions in accidental extreme conditions. The traditional block-modular principle of building an autonomous system involves the rigid consolidation of material, energy and information resources between autonomous components. They interact with each other on a limited number of

inputs and outputs of each multipole. If for any reason there is and there is a failure of a particular component, then its resources do not work in such a system. Restoration is achieved by including backup components that have so far only waited for the load.

The functions of each IAS within the life cycle of solving practical problems of professional activity include the following stages:

- Formation of internal motivation and interest in active actions, according to the idea announced in the received request.
- Collection, accumulation and specification of any data necessary to overcome the existing uncertainty.
- Solving the current problem using specially organized and existing or borrowed software and hardware complexes.
- Control and evaluation of the obtained results of intellectual activity (natural and artificial) according to the agreed plans.
- Decision-making with the help of expert systems and tools to support optimal decision-making.
- Activation of external communication with other IASs that evaluate the results obtained in order to initiate further targeted actions within the joint program.

The spatio-temporal continuum - space-time continuum always determines the specified limited share of ASSA. The future as a result of controlled and uncontrolled various processes, phenomena, transformations is formed in the space-time continuum, where variables are determined on the basis of two-parameter parameterization. They characterize the dimensions of the units and the similarity of the corresponding distances between objects [8]. The actual geometric dimensions of the objects embedded in the space-time continuum can correspond to nano (10-9), micro (10-6), macro (101-103), mega (106) and tera (1012) units of scale of the phenomenon in the equivalent multidimensional space.

The above components are subsystems of a single integrated information technology based on computer networks and telecommunications. They interact with each other at different levels of the information analytical complex's hierarchy. Each participant in the adaptation processes in the single information space provides an active focus of collegial joint efforts through its own adaptive role (the roles of each participant in the agile process). Such components development requires a clear and formalized integration process, where each of its components is a separate discipline. Ignoring the interaction between them sometimes leads to a fatal outcome. To a greater extent, this applies to the process of coordinating the architecture of the system as a stable basis for the entire design solution.

Agile methodology [9-11] in the single information space provides (fast, situational, adaptive, early, efficient, ergatic) interaction through typical interface equipment. Under IASi, $\forall i = \overline{i,n}$ management the corresponding role software and hardware and information-analytical support of functioning quality indicators $Q_0 S$ (quality of security) in the joint polyergatic production organization are activated. Adaptive-collegial and simultaneously distributed in the single information space and space-time continuum system of situational response IASi to multiple changes in the effects of environment factors provides overcoming the great complexity of parallel events information analytical complex. Guaranteed adaptive control of complex dynamic system software and hardware processes due to the intelligent integration of heterogeneous technical and technological solutions according to the Agile concept [9-11].

The unique result of the guaranteed level of information security in the conditions of risky operation of open information systems arises as a result of large-scale combination of theoretical (scientific-analytical) and practical (ASSA) knowledge on the basis of rapid development of technologies of informatization of ergatic (human-computer) interaction. Each triangle generates a three-dimensional tetrahedron (quadrilateral). This states that the volume prediction arises due to the integration of various knowledge of specialists (experts Intelligent system agent). We are gaining experience in knowledge of technical and technological solutions (information and analytical software in the memory of distributed computers), as well as knowledge of the implementation of fast telecommunications messaging between all participants of information analytical complex at different hierarchical levels (Table 1), which is proposed. As a result of the Agile interaction methodology, the method of decomposition of complex distributed system into particles (single information space into specific space-time continuums) and synthesis of future product due to alternate (iterative, sequential, asymptotic) approximations from the

current state to achievable goals with guaranteed prevention of disasters, accidents, catastrophes risks of entire environment [8,9].

The success of Agile methodology [9-11] for the management of information analytical complex' processes is formed on the postulates of information security practice:

- Intelligent system agent collaboration has advantages over machines and tools.
- Crucial knowledge of technical and technological solutions is due to situational limitations;
- Continuous monitoring and diagnostics minimize unnecessary costs.
- a clear division of functions regulates the hierarchical priorities of polyergatic production organizations.
- Functional stability of the system due to adjustment, adaptation, coordination is maintained (stabilized) due to operational changes of tasks (plans, directives, guidelines). We adjust the current goals, criteria, standards, which no longer correspond to the processes, regimes and phenomena of entire environment interaction and complex dynamic systems for the expected end results of software and hardware.

Agile constructive engineering technology according to the needs of determining a rational future is formed situationally in the single information space. The description of implementation operations in each ergatic node IASi has the form of the following cyclic chain procedure (sprint). For a step we integrate the 5 phases of activity: Plan, Design, Build, Test, Review. Activation of the IAS node begins with the Plan procedure. The full cycle of a specific mode of solving an activated task is completed by the Review procedure. Based on the change of time (ASSA situation) during $\Delta\tau$ interval a collegial hierarchical decision "what to do next?" is made. If the data is received by telecommunication channels by other IASj, $\forall j \neq i$ whether to continue the next cycle (next + 1) to use the next step of interaction in the single information space of new additional information on entire environment and complex dynamic system. At each implementation of IASi ► IASj ► IASk messaging, interface tools implement their own interaction checks.

Regulatory procedures are mandatory: access-transparency; diagnostics-control; conditions-adaptation. Changing the needs of service markers (access, diagnostics, conditions-restrictions) accordingly affects the subsequent roles, procedures and forms of response of individual intelligent system agent. As seen from the Figure 1, besides the main functions of each IAS it's also worth to consider designing simple and stable interface for communication for each intellectual system agent.

This interface must ensure uninterrupted communication between agents to solve the general problem of ensuring the security of the system. To ensure IASi ► IASj communication process it is necessary to define structural and functional schemes of dialogues between communicators, as well as well-defined access protocols and message formats that each student of the security process can recognize [12-13].

Format of the communication packages as well as structure and form of the messages is not a part of this scientific work and will be investigated in in subsequent studies. For current study, at the moment, we propose to assume that the format of messages and protocols for their exchange is based on generally accepted data formats of Transmission Control Protocol (TCP) transport layer of the web systems OSI model, such as, XML, JSON, CSV etc. Choice of the message format and protocol depends on the IAS interfaces and access protocols for each subsystem of information security indicators in the conditions of space-time continuum risks from independent effects of EI. In general, Data is disseminated through the formation of a special service focused on messaging (MOM - message-oriented middleware). This message-oriented middleware service guarantees delivery of the message from the AIS sender to the AIS recipient. A simpler mechanism is to copy the necessary data ESj and send them through telecommunications channels to another place of distributed system.The structural scheme of the formalized communication between the AISj (data file ESj) and the AISi (data file ESi) is functioning thanks to the messaging service that works for each sender and recipient is as follows:

$$\mathrm{MOM(file)} = \mathrm{ES_j} \Leftrightarrow \mathrm{netDIS} \Leftrightarrow \mathrm{ES_i}(\mathrm{f}^*), \quad (1)$$

where f*- data file (which generates the ESj source and sends the distributed information system's network to the ESi recipient), the content of which depends on certain MOM (message-oriented middleware - special service focused on messaging) events.

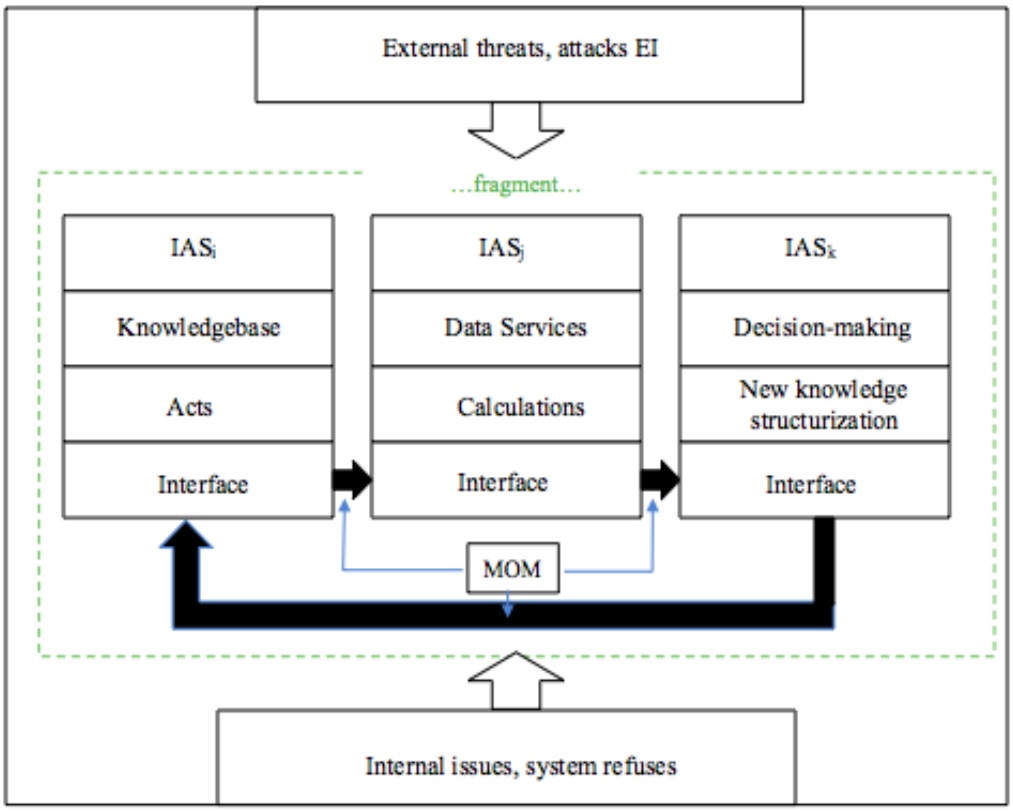

Figure 1. Fragment of Intellectual system's agents integration by means of message-oriented middleware in scope of finding solution in concrete situation that influence information system security and stability.

But each ergatic node, which performs its own work sprint on the list <Plan, Design, Build, Test, Review>, implements messaging on a system-specific transport protocol at the end of such a cycle. Specialized knowledge bases, data and information and analytical software (Table 2), integrate a specific manipulations fund. Thanks to the thematic specialization and disclosure of the essence, features and specifics of each activation phase according to the Agile methodology we will get 5 * 3 = 15 variable possibilities for each cycle of functioning of this competent specialist. According to the communication plan each variable possibility is communicated to the proper recipient in considerable format respecting chosen transportation protocol. An example of a slave interaction for 4 intelligent system agents is shown in Figure 2. According to (Table 1,2), the origin of the future solution of the information analytical complex security problem begins with the ASSA subsystem. It is from the situational awareness of the fact of changes and threats in the factors of influence of entire environment and complex dynamic system that structures the primary leading given system. Further in the competitive software and hardware complex and information system the necessary decomposition and formation of concrete subtasks is realized. Hierarchical deployment on subtask graphs is performed quickly until typical trivial problems (TTPs) are obtained. In the opposite direction, situationally defined TTPijk determine plans for the implementation of specific results by synthesis. According to the Agile methodology, all available and designated IT resources have: the linguistic name of the object; syntax, semantics, ontology and grammar of the rules of description of the information and analytical software scope; acceptance criteria; quantitative and qualitative criteria for agreeing the deviation degree; requirements for components and security modes of information security. Symbolization of all components of IT allows the use of non-numerical methods of data processing. Various thematic, object-oriented tables provide tasks: recognition, translation, simulation, identification, analysis, synthesis, forecasting, planning, modeling, testing, evaluation, documentation in various forms of knowledge.

The useful result of the joint work of IASi forms the expected future product for implementation and safety and stability guaranteeing in information system's software and hardware complex. In this final parallel step, it receives the DoD (Definition of Done)[14, 15] ID of the officially completed

document. In electronic form, it provides all the necessary forms of scientific and technological progress of society for the next external steps to further improve the safety of today's software and hardware complex. In such way we accumulate knowledge from the design, development, security and stability of systems that already have proven effectiveness and create a container of knowledge base where data will be entered into observations of this system, to analyze the decision in the dynamics of life.

Table 2

Similarity of the 5 chain K cyclic functions of Sprint of each ergatic intelligent system agent in the integrated team of polyergatic production organizations' information analytical complex, which coordinates the measurement, prediction and testing of future technical and technological solutions in software and hardware complex

Rand	Defining subsystems of the future information analytical complex	The essence features of the 3-forms specifics of integral ASSA		
		Strategic possibility of the future	Tactical capacity of resource provision	Operational resonant synergy of performers
1	Plan	Tasks, design of the space-time continuum projection <Why, for what, profitability>	Project programming <what is running, what will happen>	Measuring modes of action <what, where, when, how, how>
2	Design	Composition, architecture <what's next>	Logical calculations <what, under what conditions>	Detailed expectation <what is different, how>
3	Build	Construction, system stages of construction <what where when>	Determination of stability <under what conditions, under what situations>	Functional realization of forms, acts of action ways
4	Test	Compliance control expert plans <why, by what criteria>	Determination of complex dynamic system functional stability <how>	Accumulation of experience and accurate measurement facts <paired processes>
5	Review	A varied review of the future usefulness	Critical analysis of operating modes	Periodic check for next sprint*

* Each Sprint IASi has a task to start (begin) implementation of 5 step iterations of those K cycles with 3 forms of completion (go end). Only then is it possible to address the report with the provision of IT product and start (next + 1) Sprint implementation of this competence of the next task, which is coordinated by polyergatic production organizations' information analytical complex.

5. Conclusions

1. Ensuring the continuity and integration efficiency of information technologies that accompany scientific and technological progress in the areas of forecasting, planning, design, development, testing, information security indicators of innovative models of future software and hardware complexes, requires the formation of an appropriate linguistic and terminological basis. This basis should be enshrined in the relevant directories, regulations, guidelines, ISO standards. Globalization of conceptual awareness of intellectual agents of polyergatic organizations of software and hardware complex guarantees rational multicriteria definition - how it is possible to reform and move away from the usual, traditional, unexpected threats and limitations in order to realistically and reliably overcome the problems of information security of software packages in open systems.

2. Necessary and sufficient conditions for highly effective integration of heterogeneous numerous technical and technological solutions with promising acts of action are preserved by telecommunication channels and Internet subnets. This means with the similarity of messaging functions form functional stability, coordinated controllability and rational development of future software and hardware complexes and information systems. Such approach can ensure informational and intellectual system's functional stability under influence of changing entire environments.

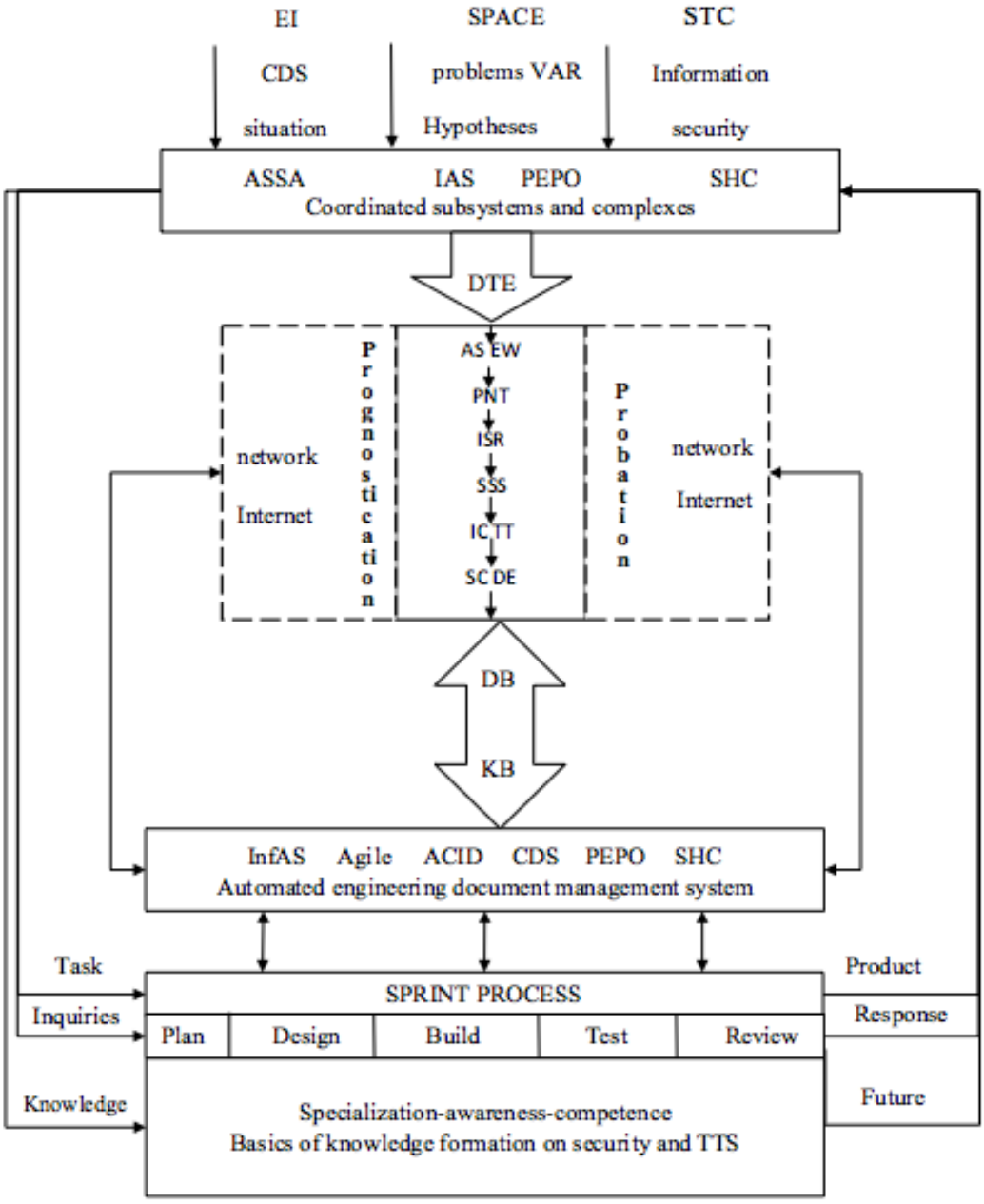

Figure 2: Conceptual scheme of team formation of synergistically adapted technical and technological solutions of the managed future software and hardware complex.

3. Natural and social randomness and variability of a single space-time system during the technological forecasting process of sequential and simultaneous cyclic iterative design, construction and testing of materials, parts, assemblies, units and complexes of future information analytical complex's tools can not realize the level of safety and uncertainty of future modes of operation. The proposed technology in the distributed hierarchical information analytical complex's team in advance raises public awareness ahead of knowledge of the patterns of certain trends in the external environment. As well as propose new approach for collecting empirical knowledge that were got after applying one or another solution.

4. Communication between each information analytical complex's team should be constructed according to the interfaces and access protocols for each subsystem of information security indicators in the conditions of space-time continuum risks from independent effects of entire environment. Format of the communication packages should take more consideration as it can influence not only the speed of response to the system but also its stability in general. This topic will be investigated in subsequent studies.

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