Information Technologies of Formation of Intellectual Decision-Making Strategies under Conditions of Cognitive Failures

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Abstract. The article considers methods of construction of information technologies formation and decision-making in terms of risk, to control technogenic systems by using a cognitive model of operator performance as the basis of intellectualization of decision-making processes. Was Substantiated on the basis of on system analysis, decomposition of problem management, for tasks the solution of which is necessary for decision-making. Was built the structural scheme of interaction of intellectual automatic control system with the face of the management (team) and developed by information technology dialogue in the governance structure of the technological system. Was Developed and substantiated the scheme of interaction between the conflict-active systems in terms of redistribution of resources. Was developed and proved the structural system information model management tasks of Glushkov – Rabinovich as the basis of the synthesis strategies of conflict resolution. Was conducted the classification of managerial tasks with the use of system analysis and information technology to assess the situation in the system. Was developed the structure of the cognitive-logic formation of management objectives in terms of risk based on the model of an intelligent agent and generator procedures of their solving situational tasks. Were justified logical – cognitive procedure and models of decision-making in hierarchical structures when exposed to threats and the cognitive failures of the operator in process control.

Keywords: system, information, situation, knowledge, risks, decisions, cognitive procedures, conflicts, logical, rules, management

1 Introduction

An integrated man-machine system, a control structure of an automated system of personnel training are hierarchical systems that are characterized by the uncertainty of the structure and dynamics of control objects. Therefore, decision making in such systems with incomplete data about the problem and the structure of the operation processes and the effects on them of disturbances with unknown statistical properties is a complex intellectual procedure, which includes the choice of adequate models of objects, algorithms for the selection and processing of data and, accordingly, the formation of approaches to the synthesis procedures of decision-making using possibility theory and fuzzy set theory in the evaluation of situations based on the recognition of the state of objects [1, 2, 9].

Justification of methods of information technologies, system analysis, logical and cognitive models to create a systems management man-made structures in terms of threats. Information technology in the formation and adoption of targets for liquidation emergencies of technogenic systems.

2 Related works

The fundamental work [1] covers the basics of creating automated human – machine systems complex management structures and the development of large systems.

In [2, 3] are considered methods of construction of hierarchical systems using cognitive models of operator manager.

In the monographs [4, 5] is considered the problem of operator activity control in automatic control systems and operational thinking when making decisions.

In works [6, 8, 9] are considered the problems of management in the conditions of the situation changes under the effect of disturbances on the decision-making process.

In the monographs [7, 10, 11] is considered the logical problem of artificial intelligence for use in management systems.

In [12, 13, 15] are considered object – oriented methods of constructing control programs and the basics of logic decision-making.

In [14, 16, 17] are substantiated methods of the system analysis decision-making process in social, organizational, and technological structures.

In [18-20] are justified decision-making methods based on logical – cognitive models for the system of the principles of creating governance structures.

In [21-24] were conducted, the analysis of models of risks that arise in hierarchical industrial systems.

3 Formalation of the problem

Decision-making under the action of active threats in hierarchical organizational systems is a complex problem characterized as a game component, and clear decision-making procedures in the management mode of operation of technological processes

(TP) and organizational-administrative structures (OAS), both in normal and in extreme conditions attacks by type of information and cognitive failures managers.

Decomposition of the problem of managerial decision-making under conditions of risk validity threats can be divided into a set of tasks:

- the creation of new intellectual systems of management of processes of functioning of Autonomous control systems (ACS) TP and OAS;
- diagnostic modes of operation an existing automated control systems, optimization and adaptation under the action of disturbances and threats, and change their aim orientation;
- synthesis of non-conflict games strategies decision making on the markets of resources and products when choosing coordination methods of resolving problem situations and adapt the structure;
- reconstruction and modernization of corporate management systems which are used in the coordinating of strategic and local problem solving.

To build appropriate strategies and synthesis architecture of ACS it is necessary to conduct a conceptual analysis design tool and evaluate the cognitive characteristics of operators [7, 9, 13].

Classification of intelligent information management systems

Let's give a classification of the intelligent information systems (IIS) [2, 3], which are components of automated control systems (man – machine complexes):

- expert systems "decision maker ↔ intelligent agent control ↔ expert system with artificial intelligence" (IAC ↔ IA ↔ ESAI) that interact;
- problem-oriented expert system using artificial intelligence for data processing and data classification;
- intelligent information system of situational management of technological and organizational structures that operate in conditions of threats and attacks on the changing strategies and goals;
- design-logical modeling of system dynamics of potentially dangerous objects (PDO) object design;
- CAD systems – intelligent systems of automated control of the process of design man-made structures;
- intelligent robots for automated production;
- intelligent training system in the structure of universities;
- intelligent equipment for special training of personnel working in conditions of threats and cognitive disruption;
- intelligent agents as whole oriented structures in the hierarchical control systems of technological systems;
- intelligent consultants in integrated corporations;
- intelligent enterprise network for hierarchical systems.

Let's consider the classes of problems, the solution of which ensures the reliable operation of man-made systems under active threats.

The problem and the types of tasks that can perform information and intelligent system (IIS) [4, 5] when developing management strategies and sustainability inactive threats and information attacks on the process control system and man-made structures:

- fault diagnosis of complex systems and software products;
- design systems with desired properties, given limitations on resources and information flows and data structure;
- planning a purposeful sequence of actions to implement the strategies;
- observing situations and the recognition and classification of images;
- management of the facility in accordance with set strategies and objectives.

We give a structural scheme of interaction of intelligent systems (*IS*) (Fig. 1).

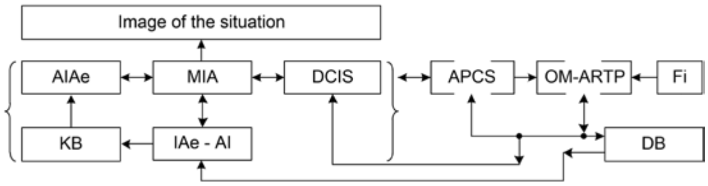

Fig. 1. Block *diagram of the interaction of intelligent systems (ACS-PMD):* ACS — automated control system; PMD — the person who makes the decision; AIAe — active intellectual agent as a person-expert in the subject-oriented field of decision-making on object management; MIA — managing intellectual agent – a person who coordinates the strategy of behavior of APCS in accordance with the specified mode; DCIS — data collection information system about the state of the object; APCS – automated process control system; OM — object of management (SR – source of resources, ARTP — active reactor of the technological process, IMS – information measuring system); F_i — source of disturbances acting on the object of control; KB — knowledge base on the subject area of technological processes; IAe-AI — intelligent expert agent with artificial intelligence and control system structure; DB — database (TP), which characterizes the course of technological processes and their controllability

Such a complex of intellectual structure performs the function of managing an object with a certain type of technological process $\{TPj \leftarrow Fi\}$, which is affected by disturbing factors from the external environment and the dynamics of changes in the parameters of the market environment. The task of the system is the main tenance of the object in the target area of functioning failures and the cavity resource type. For the effective decision of tasks of management it is required that the structure of the decision-making procedures and the data structure must have formalized, logical-mathematical and information representation and the corresponding meaning in the perception of the content of the situation cognitive system operator – manager.

The task, in the general case, is the uncertainty that motivates the purposeful action of an intelligent system to achieve a particular goal at the moment time interval and its effective solution based on proven strategies, methods, algorithms and procedures, and cognitive methods.

The goal in this system is encoded in decoupling system (ISP – intelligent solver of problems). Then it acts as a description of the requirements for the state of the system in which the generated target is focmed. Intelligent system (IRZ) is characterized by the algorithm of functioning and the procedure of search strategies for solving problems, tasks and situations based on the given integer orientation.

The important role of information technologies for creating methods and procedures for solving problems arising in the design of systems in their research and publishing technological and organizational systems, were pointed out in writings, written by V. M. Glushkov [8].

Justifying their automation based on the use of informational models of dialogue mode, logical inference, methods of generating hypotheses, and making decisions, he first defined the role of the intellectualization of the management schemes procedures for the synthesis of algorithms for the solution of design problems. It does not take account of cognitive, but only the energy aspects of the behavior of the operator in assessing the situation the operator, which is stored in the system under action of interference and threats of the active type (Fig. 2).

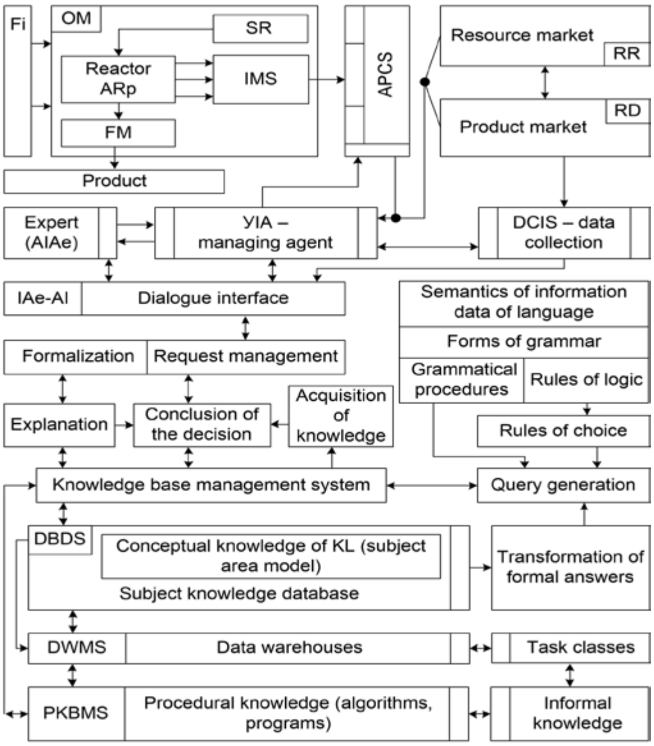

Fig. 2. Information technology and the interaction of the agent with artificial intelligence with an expert coordinating and managing agent management system: Fi — perturbation factors; OM — object of management; SR — source of resources; IMS — information measuring system; FM — forming mechanism; APCS — automated process control system; DCIS — data collection information system about the state of the object; IAe-AI — intelligent expert agent with artificial intelligence; DBDS — database management system; DWMS — data warehouse management system; PKBMS — procedural knowledge base management system

Glushkov V. M. introduced the concept of forming and decoupling system, which can be interpreted as the IA for the solution of problem situations [1]. At the same time accordingly are allocated functional purposes (Fig. 3):

- task-forming system as a goal-oriented intelligent system;
- decoupling system as a purposeful intelligent system of synthesis strategies to achieve the objectives of the functioning of the APCS system;
- PS – purposeful system that implements the strategy of target management;
- the interaction of active systems $(AS_1 \otimes AS_2)$ as a generator of problematic tasks and situations that arise in the allocation of resources;
- information system as the shaper of the way situations $(Icon\ Sit(t_i \in Tm))$;
- intelligent agent of influence – IAv, which generates control actions on the change strategies of behavior systems AS_1, AS_2.

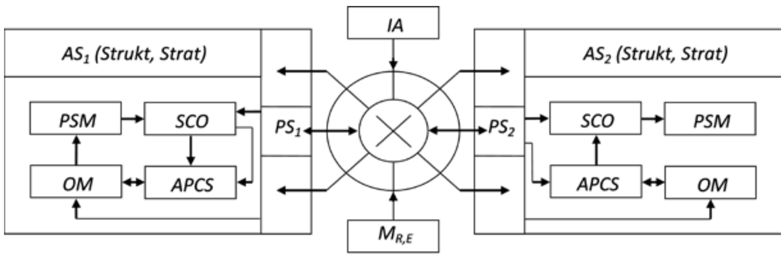

Fig. 3. Interaction *of conflict – active technogenic systems in the conditions of redistribution of energy active resources:* PSM — purposeful system management; SCO — the state of the control object*;* OM — object of management; APCS — automated process control system; M — resource

In Fig. 4 we give a simplified model of task management based on the concept of Glushkov-Rabinovich, which reflects the process of implementing strategies to achieve the objectives of the operation of the ACS.

Let’s consider the informative and intellectual characteristics of situational tasks and ways of their classification in the relation to the formation of strategies:

- $Sit[M_{Ai}] \rightarrow [\exists \mathrm{Alg}\, A_j(RZ_j)]$ – the situation for which there is a reference algorithm for solving the problem ES_i, full information support;
- $Sit[IAL_{Aj}] \rightarrow [\exists \mathrm{Alg}\, A_{ij}(RZ_i)]$ – a situation where the person acting *IA* is interested in solving the problem RZ_i and has a procedure, a set of algorithms A_{ij} for its solution and the corresponding resource;
- $Sit\left[\bar{M}_{Aj}, I\bar{AL}_{Aj}\right]$ – when neither the *ES* expert system nor the *IA* has algorithms for solving problems that arise in the process of information and resource conflicts or cognitive overload of the operator in decision-making.

Accordingly, were selected classes of tasks, which developed algorithms and strategies for solving problem situations in an integrated control system:

1. $KLZj\left(IALj \otimes M_{Aj}\right)$ – tasks that a person solves with the help of an expert solving system, using $\left(\exists A\lg RZj\left(\Pi\kappa\right)\right)$ – based programs Π_K;
2. $KLZj\left(IALj \otimes \bar{M}_{Aj}\right)$ – tasks for which it is necessary to create strategies, algorithms, programs, that is their generation with an incomplete information database and knowledge;
3. $KLZj\left(IA\bar{L}j \otimes M_{Aj}\right)$ – tasks of search of the algorithm in the base of programs of the intellectual expert for the decision of situational problems;
4. $KLZj\left(IA\bar{L}j \otimes M_{Ak}\Big|_{k=1}^{m}\right)$ – task synthesis algorithm for solving problems and synthesis procedure program for solving problem situations in PDO;
5. $KLZi\left(\neg\exists A\lg RZi\right)$ – a class of tasks for which there are currently no solution algorithms, which, accordingly, determines the problem situation of strategic management, taking into account threats and cognitive disruptions.

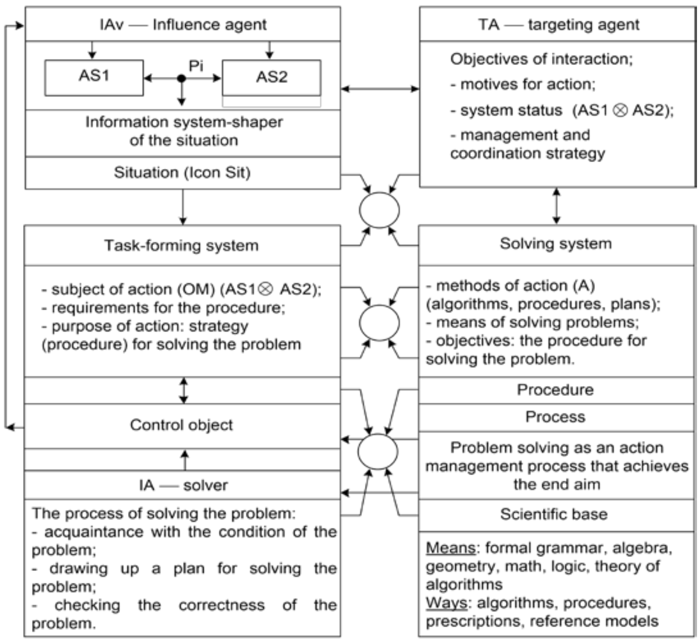

Fig. 4. System information model management tasks Glushkov-Rabinovich, as a synthesis of strategies to eliminate threats to man-made structures: *IA — intellectual agent; Icon Sit — image of the situation; OM — object of management; AS — active states*

Informative types of problems due to their content will be such procedural and informational signs of information character:

- tasks are well marked, if there are algorithms and tools to verify the solution in the corresponding problem-oriented knowledge database;
- the tasks are poorly represented, if at IA no means of checking the solutions;
- non-dialogue tasks – there is a finished algorithm of a sequence of actions that leads to goals-based action plans according to the chosen strategy;
- dialogue tasks – the algorithm of solution is formed in the process of solving problems based on the case data and expert support;
- non-search task, if the information is incorporated in the condition that the knowledge base of IA is sufficient to create the procedure, the solution algorithm (informational completeness);
- search task requires additional information from external intelligent systems that have structured information and the logical-cognitive basis.

Interaction intelligent systems (dialogue) in the process of problem solving is based on the following procedures and concepts and the game system (threats):

- are clarified the conditions of the problem-based search procedure additional properties of the object in the subject-oriented knowledge;
- are determined the presentation of data and results for the formation of the image of the situation in terms of actions of attacks and resource disturbances;
- accounting and analysis limitations that characterize the dynamics and structure of an object and software systems in the planning of action;
- systematization of existing data, their intellectual development and the formation of new knowledge in the formation of the expert decisions;
- conclusion about the possibility of solving the problem existing methods and tools based on the generation of scenarios in modeling system behavior, given the cognitive abilities of the operator;
- the synthesis of a plan of solving the problem and testing it from achieving the goal according to constructive policies.

Information and system technology to represent task control of man-made structures

Full representation problems in the actual and target state space for APCS (Fig. 5) includes:

- structure of $\left(R^n \times Tm\right)$ state space $(R,\ T)$ is the continuum of the object and aggregates;
- all possible states of the system in normal and limit modes;
- the initial state of the object relative to the target;
- tasks class of operators A_j of transitions from one state to another based on strategies $\left\{\exists Strat\left(DCi / Ui, Ai /_{i=1}^{m}\right) \vdots \left(AiUi\right) \vdots Zi \rightarrow Z_{i+1} / \tau_i \in Tm\right\}$ with $\{Uij\}$, and counts transitions $\{g_i / T_m\}$;
- • the target state of the control object with the marking lines limit state $\left(L_A^+, L_n^+ \middle| L_{\min}\right)$.

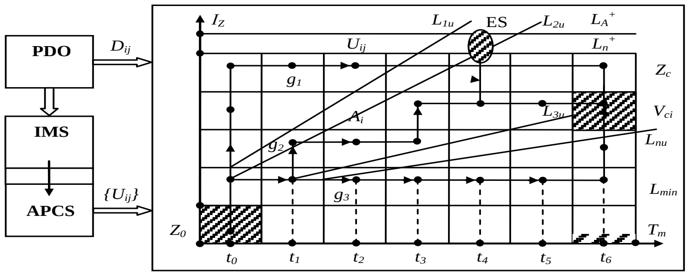

Fig. 5. Presenting *the tasks in state space using a graph of possible moves (*g_1, g_2, g_3*) of events in the PDO in the terminal time* T_m*:* PDO — potentially dangerous object*;* IMS — information measuring system; APCS — automated process control system; U — management; ES — emergency situation*;* t_i — time interval

The procedure of finding a solution in state space is to construct a sequence of action operators A_i running U_{ij} that transforms the initial state in the target (plan the route search algorithm) [2] based on enumeration strategies and coordination purposes in the state space and the target (Fig. 5).

The method of decomposition of the task. Such a representation is to split the problem into subtasks that have a solution. Based on the local decision is build the total solution in the form of combinations of logical rules over graphs of events $\exists\left\{\prod_i^R \left|T_m\right.\right\};\ \left\{\prod_i^R \left|C_{gi} : H_i Z_t \to V_{ci}\right.\right\}$.

Based on the structure of the split tasks (Fig. 6) is built a set of graph reduction tasks under the action of factors on the state of the system $F_A \equiv \left\{B, C, D \middle| E, F, G, H, I\right\}$.

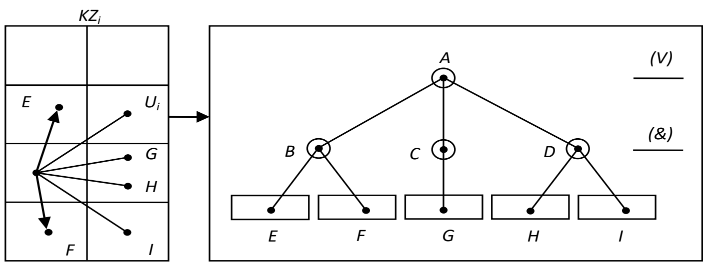

Fig. 6. Graph reduction task components $F_A \equiv \left\{B, C, D \middle| E, F, G, H, I\right\}$ by the action of factors of influence: KZ — transition matrix by state parameter; A — initial state; V — target area

Accordingly, to the action of in fluencing factors is selected a plan of operations according to the strategy of goal achievement and prevention of the perturbation taking into account indicators of the signs of the degree of influence (F_{Ai}).

At every step the count action according to the chosen strategy and plan of action, is evaluated the situation at the time $t_i \in \tau_m$, and are formed in the course of control actions on the object man-made system.

Then we have hypotheses about the existence of a procedure for solving the problem according to the strategy that generated the intelligent agent:

$$\left.\begin{array}{l} H_1 \vdots \exists PRZ_1(E,F) \Rightarrow PRZ(B) \\ H_2 \vdots \exists PRZ_2(G) \Rightarrow PRZ(C) \\ H_3 \vdots \exists PRZ_3(H,I) \Rightarrow PRZ(D) \end{array}\right\} \Rightarrow \left(\exists PRZ(PSitA) \Rightarrow (\exists StratRPSitA)\right),$$ where PRZ_i – the procedure of solving problem tasks selected in the current information base describing situations in time $t_i \in \tau_{mi}$.

Given the above we can write a system of conditions for the decomposition of the procedures in the rules and algorithms as inference schemes:

$$\left.\begin{array}{l} \left(PRZ(E) \wedge PRZ(F)\right) \Rightarrow PRZ(B) \\ PRZ(G) \Rightarrow PRZ(C) \\ PRZ(H) \wedge PRZ(I) \Rightarrow PRZ(D) \end{array}\right\} \Rightarrow \overset{3}{\underset{i=1}{V}} PRZ(B,C,D) \mapsto A .$$

System conditions determines the logical structure of the decision making process without regard to the cognitive organization of knowledge preteentranny face – IA_i.

Representation of a synthesis task of strategic management in the form of logical – lingua rules of inference

The logical-mathematical problem can be formulated as theorems that need to be proved (puzzles, games, tasks, decision-making, action planning, synthesis strategies).

Task structure is formed in the form of a block diagram (Fig. 7) cognitive logic of the shaper management tasks.

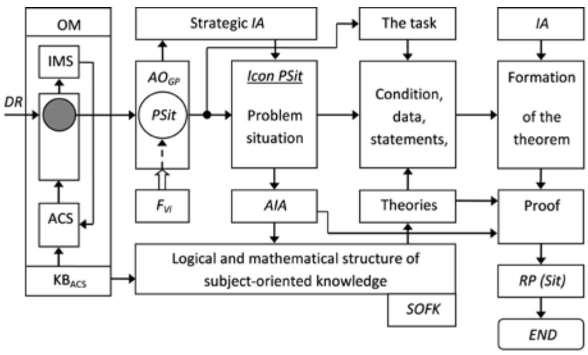

Fig. 7. The *structure of the cognitive logic of the driver tasks management in terms of risk solutions:* OM — object of management; AO_{GP} — active object generating problem situations in the form of an image (Icon PSit); PDO — potentially dangerous object; ACS — automated control system; AIA — active intellectual agent; KB — knowledge base; SOFK — subject oriented field of knowledge; RP (Sit) — decision of a problem situation

The strategy of solving problem tasks in the form of the theorem is based on the basis of the composition of the basic axioms (Fig. 8) in the structure of the subject-oriented field of knowledge (SOFK) then have the following logico – linguistic exercise: $\exists N\left\{LA_{i=1}^{n}\right\}$; $\exists N\left\{L\Pi_i\big|_{i=1}^{n}\right\}$; $\exists\left\{StratU_{ij}\big|C_i\right\}$, to assess the situation, and it is possible to build a logical – linguistic expressions relative to the whole rules-oriented conclusions: $\exists\left\{StratU_{ij}\left|C_i\right.\right\} \Rightarrow L\Pi_i\left\{\overset{R}{\underset{i=1}{\otimes}} A_i\right\}:\ \exists g\left(Z_0 \rightarrow Z_{gi}\right)_{T_m}$.

Accordingly, for the logical rules $L\Pi_i$ – composition axioms ensure the construction of the graph of the route of achieving the goal with a clear description of a problem situation.

The solution strategy

The scheme of the intelligent generator of the solver procedures in the DSS has a hierarchical structure that includes the following control levels (Fig. 8):

- PDO – potentially dangerous object man-made system;
- IMS – information-measuring system of the selection status data of the object;
- AIA – active intelligent agent staging situational problems of managerial decision-making in the context of threats to the management;
- SGPSP – system generation procedures for solving problems, which is a part of the strategic DSS intelligent agent;
- IGPR – the intelligent generator of procedures for solving an integer-oriented management tasks in the context of threats;
- PGAD – procedural generator active control actions in the action range of threats.

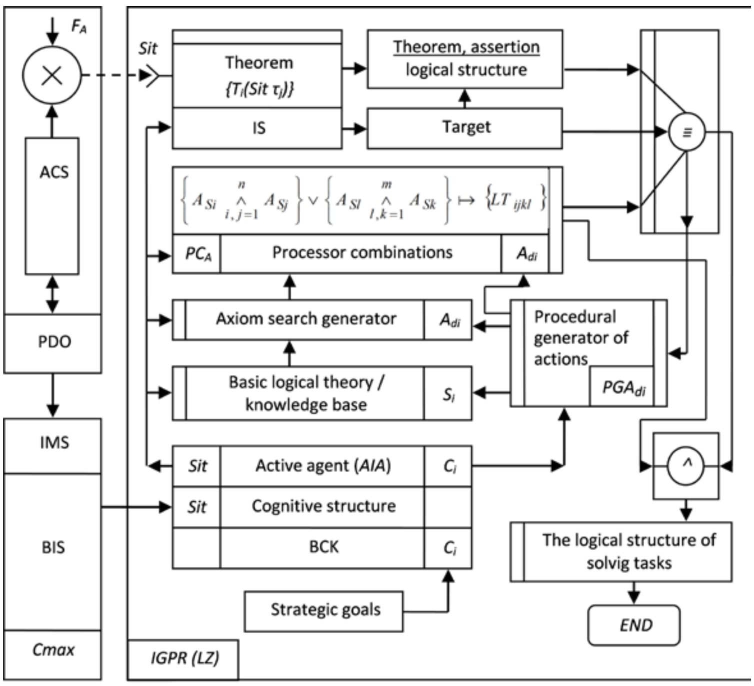

Fig. 8. The *scheme of intelligent generator management procedures for the solution of logical problems:* ACS — automated control system; Sit — operative situation; IS — the image of the situation; A_{di} — axioms; $\left\{Asi\left|_{i=1}^{n}\right.\right\}$ — the system of axioms; PC_A — processor combinations of axioms; BIS — base of images of situations; BCK — base of conscious knowledge

Heuristic methods of generating strategies to address managerial problems in technogenic systems in the conditions of active threats and the risks of cognitive failure.

For tasks with a hierarchical structure it is necessary to combine all of the above methods. The goal is set in the form: «to apply Ai to the situation Sit(tj | ΠCi)». It reflects some of the differences between the reference terms of the behavior and the situation in the studied system.

From this we can highlight the following problem of generating control strategies:

- problem transformation and believability of images of situations with the aim of obtaining deviation of the system from the target region;
- the problem of evaluating the images of situations in the state space and the target space of the control system in terms of the resource information threats;
- the problem of constructing the structure of the space of states of potentially hazardous facilities and spragan him a target structure;
- the problem of the classification of the situations and display it in the ACS;
- synthesis of criteria for selection of methods for solving problems of crisis of the state and selection of indicators of information and cognitive failure management process;
- normalization of classes of signs for construction status indicators;
- synthesis strategies for the construction of decision rules to achieve the goal;
- the content knowledge cognitive structures (IA – operator) and data and knowledge bases and operational control system.

Model solver of problems in integrated intelligent control systems under the action of information attacks and disturbances.

Intellectual problem solver is a system that perceives a formalized description of the problem, from the subject area in which the problem situation arises, and based on this description in accordance with the rules develops a plan for its solution.

The scheme of stages of system analysis and procedures of formation of target decisions [2, 6] is based on:

P1) analysis of the current situation $\{Sit_0(\Pi S) \to Sit_j(\Pi S)\}$;

P2) comparison of the current situation with the reference target based on the decision-making procedure and rules and schemes of conclusions – Π_R in accordance with the target of the scenario:

$$\Pi_R : \begin{cases} Sit_j(\Pi \mathrm{S}) \Leftrightarrow \mathrm{Sit}_{\mathrm{E}}(\Pi S / Ci) \to End \\ Sit_j(\Pi S) \Leftrightarrow Sit_E(\Pi S / Ci) \Rightarrow Sit_K(\Pi S) \Rightarrow [\ldots] \Leftrightarrow [Sit_m(\Pi S) \neq Sit_E(\Pi S / Ci)], \end{cases}$$ where

$Sit(\Pi S / Ci)$ – the situation in the problem system relatively to the target state;

P3) the choice of rules Π_{Rj} which must be used by the operator to reduce the difference between the current and reference image;

P4) consistently apply a set of rules until the similarity of the current and target image;

P5) back to Π1 when reaching the target area due to the compensation information, resource, and cognitive failures in the course of the management process.

<u>Types of management tasks</u> that determine the strategies to achieve the goal of the man-made system in the face of threats and resource failures:

(1) $\Pi Z_1 : T(A,B), \exists \Pi_R(T) \vdots A \to B$ – transfer of a situation A to a situation B on the basis of the operator T in a rule $\Pi_R(T)$;

(2) $\Pi Z_2 : C(D,O,A,B), \exists \Pi_R(D,O) \vdots SitA \xrightarrow{di} SitB$ – transfer of a situation A to a situation B by means of the operator with the minimum difference $d_i \in D$;

(3) $\Pi Z_3 : R(O_I, A), \exists \Pi_R(O_I / A); O_I \vdots Sit\ A \to Icon\ X$ – apply the operator action O_I to the situation A and form a new image $Icon\ X$ of the situation.

These schemes can be applied to solving a class of problems irrespective of the subject area. At the preliminary stage it is necessary to fix the list of tasks as possible differences between the current and desired situation, to fix the list of operators that reconcile these differences.

The relationship of system and information tasks in the process of solving the problem of decision-making in general purposeful management of man-made structure.

Let us have: $S = Sit(t_0)$ – the initial situation; $Q = Sit(Q/Tm)$ – desirable (target), which are determined by the parameters in the state spaces and the target:

6. If $\exists d_T \in D, d_T < d\min \vdots T(S,Q) \vdots \Pi_R(T) \vdots \left(IconS \overset{d}{\equiv} IconQ \right)$, then the problem is solved.

7. If $\exists d_T \in D, (d_T > d\min) \vdots (IconS \neq IconQ)$, then move on to the next rule, which can reduce the difference images.

If the condition of the existence of strategies to of the goals is achieved then you can generate a rule: $\Pi_R\left[C(D,O,A,B)\right] : \exists O_i \subset O, O_i : \left(d \to d^*_{\min} \leq d_{\min}\right) \Rightarrow$ $\left\{\exists Strat(U|C_i), \exists\{\Pi_R\}\right\} \Rightarrow \begin{cases} \Pi_R(D,O_i) \vdots \left(IconS \overset{di}{\equiv} IconQ \right) \mapsto End \\ \Pi_R(D,O_i) \vdots (IconS \neq IconQ) \mapsto \left[\Pi_R(O,S)\right] \end{cases}$, is performed or not performed, then move on to the next rule. This rule establishes the conditions $\{Hi\} \subset H$ under which the operator $\{Oj\} \subset O$ can be applied to a situation S for which we have the following situation as: If $\begin{cases} 3.2.\ T(S^*,Q) \vdots \exists \Pi_R(T) \vdots (S \to S^* \to Q/H) \to [End] \\ 3.3.\ T(S^*,Q) \vdots \neg\exists \Pi_R(T/H) \vdots (S \to S^m \to \ldots Q) \Rightarrow \end{cases}$, (then there are two new tasks) – which can be represented as: $T(S,H), \exists \Pi_R(T_n) \vdots (S \to H)$; $T(H,Q), \exists \Pi_R(T_m) \vdots (H \to Q)$.

The intelligent system as a model solver task management

An intelligent system as a solution to problems must have common intelligent procedures suitable for solving a wide range of problems. Otherwise, it is necessary to move to the logical-cognitive models of IA and DSS.

These procedures in the process of their application should form new knowledge based on the existing knowledge base, new algorithms for solving specific problems based on the knowledge of analysis of algorithms and rules of goal-oriented decision-making and activation of cognitive structures of IA.

The problem of decision making in situations of threats

Models of predicate logic, as the basis for the formation of meaningful statements in making situational decisions to control the operator are basic in the construction of rules and procedures of executive actions.

The logical models determine the truth of the claims regardless of the variables, for each class of concepts dedicated on the grounds $\left(\theta\, F \to KL_A^F(\theta)\right)$.

We give basic structural logical laws which are the basis of the information schemes and structures to build decision-making rules when evaluating the content of the claims in the chains and scenarios in the cognitive structures of the person and are used in management procedures:

- affirmation of truth with the denial: $\forall x\left[F(x) \vee \sim F(x)\right]$;
- the law of the third exception in relation to $R: \forall x \forall y\left[R(x,y) \vee \sim R(x,y)\right]$;
- the law of neutrality statement: $\forall x\left[F(x) \to G(x)\right]$;
- the law of contradiction of the statement: $\exists x\left[F(x) \wedge \sim F(x)\right]$;
- the law of equivalence of statements for predicates:

$$\forall x \in A: \left(\left[F(x) \to G(x)\right] \leftrightarrow \left[\sim F(x) \vee G(x)\right]\right);$$

- the law of equivalence of relations for sets $x \in X$, $y \in Y$:

$$\forall (x,y) \in A: \left[R(x,y) \to S(x,y)\right] \leftrightarrow \left[\sim R(x,y) \vee S(x,y)\right];$$

$$\forall (x,y) \in A: \forall x \forall y \left\{\left[R(x,y) \to S(x,y)\right] \leftrightarrow \left[\sim R(x,y) \vee S(x,y)\right]\right\};$$

- the law of contradiction of statements: $\exists x\left[F(x) \wedge \sim F(x)\right] \wedge \forall x G(x)$;
- the law of imitation of the properties of elements on the set $[X \to Y]$:

$$\forall x \quad F(x) \to F(y), (x,y) \in A; F(y) \to \exists x F(x); \forall x\, F(x) \to \exists x F(x).$$

On the basis of the transitivity of the implication, a procedure of quantified inference about the situation is built, which through the sensory system in the form of an imaginary information image, reflects in the operative conscious memory scenarios of the course of events: $\Pi R_v: \left\{ \begin{array}{c} \forall x \quad F(x) \to F(y) \\ F(y) \to \exists x F(x) \\ \hline \forall x \quad F(x) \to \exists x F(x) \end{array} \right| \forall x \in A; A \neq \varnothing.$

Analysis of the rules of making goal-oriented decisions

The rules in the separating procedures that distinguish the properties of F, G for the elements of the concept of the class $KL_A^{F,G}(\theta_i)$ are given in the form of [11, 15, 17] meaningful statements, the meaning of which differs at the cognitive level in order to identify failures in decision chains which is the basis for assessing the inconsistency of the links in the decision tree.

$$\left.\begin{array}{l} \Pi_1 : \forall x\left[F(x)\wedge G(x)\right]\leftrightarrow\left[\forall xF(x)\wedge\forall xG(x)\right]; \\ \Pi_2 : \exists x\left[F(x)\wedge G(x)\right]\rightarrow\left[\exists xF(x)\wedge\exists xG(x)\right]; \\ \Pi_3 : \left[\forall xF(x)\vee\forall xG(x)\right]\rightarrow\forall x\left[F(x)\vee G(x)\right]; \\ \Pi_4 : \exists x\left[F(x)\vee G(x)\right]\leftrightarrow\left[\exists xF(x)\vee\exists xG(x)\right]; \\ \Pi_5 : \forall x\left[F(x)\rightarrow G(x)\right]\rightarrow\left[\forall xF(x)\rightarrow\forall xG(x)\right]; \\ \Pi_6 : \forall x\forall y\left[R(x,y)\rightarrow S(x,y)\right]\rightarrow\left[\forall x\forall yR(x,y)\rightarrow\forall x\forall yS(x,y)\right]; \\ \Pi_7 : \exists x\exists y\left[R(x,y)\wedge S(x,y)\right]\rightarrow\left[\exists x\exists yR(x,y)\wedge\exists x\exists yS(x,y)\right]. \end{array}\right\}\rightarrow\overset{BS}{\overset{\downarrow}{\otimes}}\rightarrow \begin{array}{l}\text{Identification}\\ \text{of crisis}\\ \text{points in}\\ \text{the chains}\\ \text{of action plans}\end{array}$$

Situational rules for deriving the logic of predicates in the synthesis of decision-making procedures based on graphs and output trees

As from a general significant implications and as well as from the relationships of equivalence rules can be output. Let's consider the following rules that ensure the differentiation of situations [9, 10, 12]:

Π_{1V}: $\left|\forall x\, F(x)\rightarrow F(y)\right|\leftrightarrow\left|\dfrac{\forall x\, F(x)}{F(y)}\right|$ – the attribute for each element corresponds to the elements of the whole class;

Π_{2V}: $\left|F(y)\rightarrow\exists xF(x)\right|\leftrightarrow\left|\dfrac{F(y)}{\exists x\, F(x)}\right|$ – feature F, characteristic of y, indicates the existence of at least one element x with this feature.

Let's consider the relationship of general statements with statements related to the quantifiers of existence when comparing the reference and real images of situations in the conscious cognitive structure of the operator (intellectual agent – management), which is characterized by the ability to [8, 11]: 1) intelligent data processing; 2) the logic of thinking in decision making; 3) generation of ideas for solving situations in conditions of risk; 4) performing cognitive operations management; 5) search for non-standard methods of finding a way out of risk.

$$\Pi_{1R}: \left|\begin{array}{c}\forall x\, F(x)\\ \dfrac{\forall x\, F(x)}{\sim\exists x\sim F(x)}\end{array}\leftrightarrow\begin{array}{c}\sim\exists x\sim F(x)\\ \dfrac{\sim\exists x\sim F(x)}{\forall x\, F(x)}\end{array}\right|;\quad \Pi_{2R}: \left|\begin{array}{c}\sim\forall x\, F(x)\\ \dfrac{\sim\forall x\, F(x)}{\exists x\sim F(x)}\end{array}\leftrightarrow\begin{array}{c}\sim\exists x\sim F(x)\\ \dfrac{\sim\exists x\sim F(x)}{\sim\forall x\, F(x)}\end{array}\right|;$$

$$\Pi_{3R}: \left|\begin{array}{c}\exists x\, F(x)\\ \dfrac{\exists x\, F(x)}{\sim\forall x\sim F(x)}\end{array}\leftrightarrow\begin{array}{c}\sim\forall x\sim F(x)\\ \dfrac{\sim\forall x\sim F(x)}{\exists x\, F(x)}\end{array}\right|;\quad \Pi_{4R}: \left|\begin{array}{c}\sim\exists x\, F(x)\\ \dfrac{\sim\exists x\, F(x)}{\forall x\sim F(x)}\end{array}\leftrightarrow\begin{array}{c}\forall x\sim F(x)\\ \dfrac{\forall x\sim F(x)}{\sim\exists x\, F(x)}\end{array}\right|.$$

Synthesis of the structural scheme for construction of logical rules and procedures of formation of target decisions by the intelligent agent

According to these rules we will construct the structural scheme of models of a conclusion which are an information basis of process of acceptance of the purposeful decisions on the basis of construction of situational trees (fig. 9).

The block diagram includes the following intelligent structures [19-21]:

- model of the decision-making processor as an intelligent local agent that responds to influencing factors $\{F_i\}$;
- PMD model as a managing intelligent agent with a given management strategy and a base of inference rules.

The scheme has two structural blocks that reflect the model of interaction of the active agent with the object according to the target task in the appropriate sequence.

1. *Block formation of action* includes (informational aspect):

- selection of data about the state of the object;
- the classification of signs at the facility;
- rules of inference about the state of the object, based on the assessment of the situation in connection characteristics;
- making decisions to achieve goals based on the verification of the generated hypotheses about the way to achieve the goal.

8. *Block intelligent agent* (as an individual decision maker's conception of M. Zgurovskyi [14]), which includes the logical-informational components of a decision-making procedure and its intelligent services: data and knowledge bases, generators strategies and neural processors.

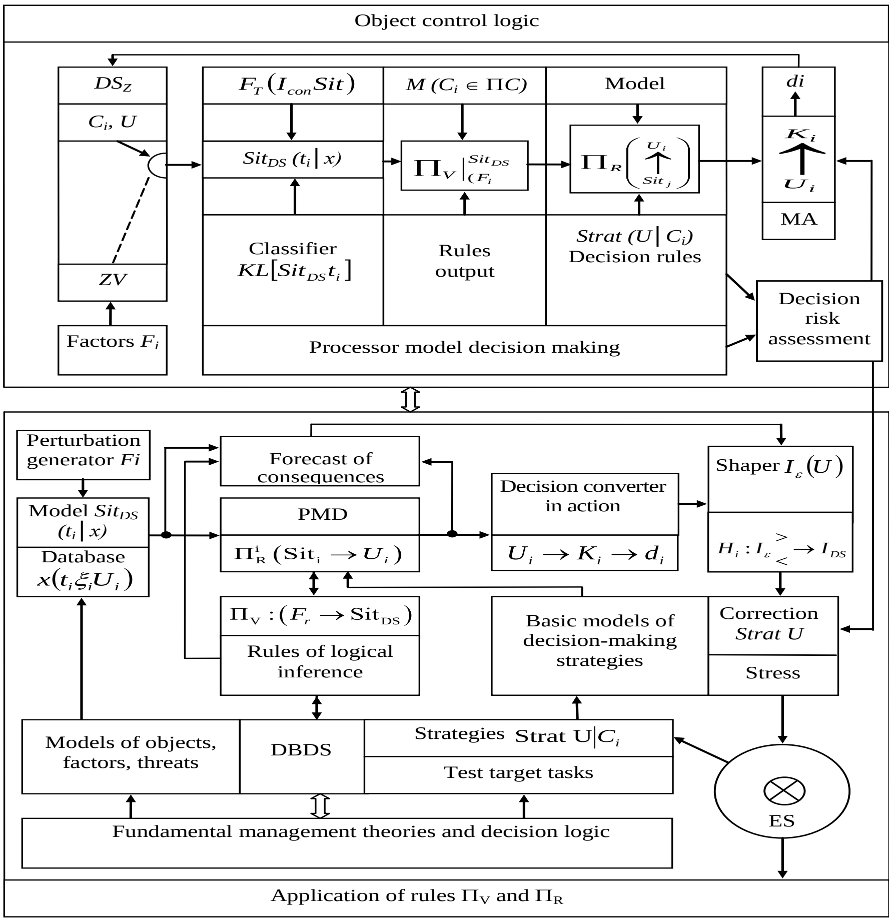

Fig. 9. The block diagram of the model rules of inference in the decision-making process an intelligent agent (IA): Sit — operative situation; Fi — factors of influence; MA — executive mechanism actuator; PMD – the person who makes the decision; DBDS — database management system; ES — executive system

Accordingly, the procedure of testing hypotheses, in making decisions and the assessment of the dynamic images of the situations are divided into two classes:

(i) $(KL - C_i)$ – about the degree of inclusion of the system in the target area:

(ii) $H_{1C} : Z(t,u_i,\xi_i) \in V(C_i / \Pi C_s) \Rightarrow [\mathrm{Re}\,al\,C_i]$,

$H_{2C} : Z(t,u_j,\xi_j) \notin V(C_i / \Pi C_s) \Rightarrow [\mathrm{Re}\,al\,C_i]$;

(iii) $(RL_\Delta(I_k))$ – on the dynamic difference of the trajectory to the target based on the metric $\Delta_r = [Z(t,u_i,\xi_i) - Z_l(t,T_{mer})] \geq 0$ as for Δ_c:

$H_{1i} : \Delta_{r_i} \geq \Delta C_T(\forall t \in T_{mer}) \Rightarrow$, $\Rightarrow (u_i > 0), u_i \in KLStratC_i$;

$H_{2j} : \Delta_{r_j} < \Delta C_T \left(\forall \tau \in T_j \subset T_{mer} \right) \Rightarrow \left(u_j = 0 \right)$. Accordingly, the effectiveness of management by cost functionals defined based on hypotheses of management strategies: $H_{1k} : \left(I_k > I_l \right) \Rightarrow opt\left[Strat\left(u_i / C_i \right) \right]$; $H_{2k} : \left(I_k < I_l \right) \Rightarrow \; \Rightarrow Koord\left[Strat\left(u_i / C_i \right) \right]$, where $\left(H_{1c}, H_{2c} \right)$– clearly the hypotheses regarding the status parameter – Z, control – u_i, of the perturbation ξ; $V\left(C_i / \Pi C_s \right)$ – the target area in the space of the system; $KLStratC_i$ – the class of target strategies; Δ_r – traktorne differences; $\left(I_k, I_l \right)$ – the functional quality; $opt[\;]$ – optimization strategies; $koord[\;]$ – coordination of local management strategies.

Synthesis strategies for the formation of the target strategies is based on the information procedures that describe the active interaction (*PI*↔*AI*) and operations are performed [13]:

- active sensing of the object and selection, identification of data, their estimation to rank the values of the status parameter;
- the download procedure of state space in the target description field the location of the target and its parameterization based on interval ranked breakdown which covers it;
- the procedure of forming the image of the dynamic situation and the operation of classification with the position of the target based on the rules of testing of hypotheses;
- the strategy to achieve the objective, which includes: building the trajectory of the object to the target through the block covering (coordinates); procedures for the selection of alternatives in relation goal orientation, coordinstion of the system of alternatives with a set of control commands;
- procedures for making decisions based on the classification of situations according to the procedure of testing hypotheses.

Then the scheme of formation of solutions has the form of logic – information of the chains and depends on the cognitive and intellectual level of the operating personnel.

4 Experiments, results & discussions

On the basis of system analysis of problems of management involving human subjects are considered the cognitive – informational factors that are important for decision-making [14, 17, 18]. The structure factors of the ability to make decisions includes the following component and system (Fig. 10) and tables.

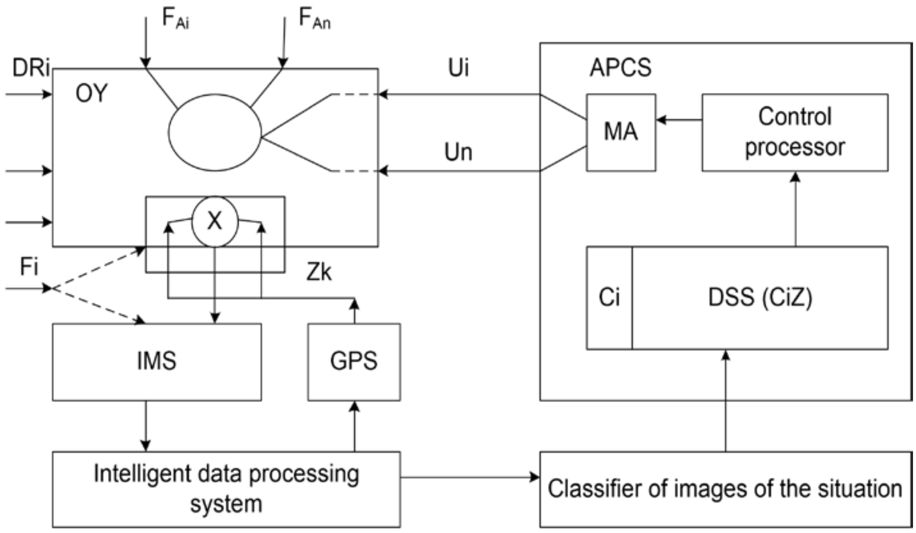

Fig. 10. Block diagram of the counter factors of influence on the SCADA system, which create a situation of risk: DRi — sources of resources; $\{F_{AI}\}$ — factors of active influence; Fi — information factors; Co — control object; Zk — area of control of object; IMS — information measuring system; GPS — generator of probing signals; $\{Ui\}$ — control actions; (Ciz) — target tas; EM — the executive mechanism

Accordingly we will construct tables (1, 2), which characterize the ability of the operator to the managerial decision-making. Expert evaluation of the cognitive component (CFi, PR_i) of decision-making by the manager.

Table 1. Cognitive operations to manage

factor	cognitive acts	Kd	Kr
		intervals	value
CF_1	the realization of the goal	0,8-10	0,6-0,9
CF_2	goal orientation	0,8-1,0	0,5-,8
CF_3	generation strategies	0,7-1,0	0,5-0,8
CF_4	the control logic	0,6-1,0	0,4-0,7
CF_5	evaluation of actions taken	0,5-1,0	0,5-0,7
PR_1	action planning	0,6-1,0	0,5-0,8
PR_2	alternatives	0,6-1,0	0,5-0,8
PR_3	wrong choice Ω_i	0,5-1,0	0,3-0,7
PR_4	creativity	0,7-1,0	0,6-0,9
PR_5	generation goals	0,8-1,0	0,6-0,8
PR_6	assessment situations	0,5-1,0	0,5-0,9
PR_7	procedure logic RZ	0,7-1,0	0,7-0,9
PR_8	coordination procedures	0,8-1,0	0,7-0,9

Table 2. Expert assessment (II) of the logic of thinking Cognitive components of IT – technology (KSi)

compon ents	information operations	intervals Kd, Kr	
KCm	information operations	0,6-0,95	0,50-0,95
KCd	a cognitive model of the whole based thinking	0,5-0,95	0,50-0,95
KCe	analytical data analysis	0,15-0,95	0,4-0,95
KCa	the logic of thinking, KIA	0,10-0,95	0,25-0,90
KCz	algorithmization of cognitive processes	0,15-0,85	0,40-0,55
KCp	cognitive analysis of the nature of the situational challenges	0,14-0,90	0,4-0,85
KCi	cognitive procedures for the formation of schemes for solution of tasks	0,25-0,90	0,60-0,95
KCr	identification of information entities to problems	0,30-0,90	0,60-0,95
KCdv	the use of information technology to solve problems	0,30-0,85	0,40-0,90
KCl	cognitive processing of data of KIA obtained from the object	0,4-0,90	0,40-0,90

Cognitive coefficients of expert assessment of intellectual abilities are determined on the basis of test data processing: $\left\{PRi\big|_{i=1}^{n}\right\}$, $\left\{\forall PR_i \in [0,5-1,0]\right\}$; $\left\{KCi\big|_{i=1}^{b}\right\}$, $\left\{\forall KCi \in [0,7-1,0]\right\}$ – accordingly determine the quality of decision-making operator in terms of threats.

Accordingly, we have assessments of the quality of decision-making for the management of an intelligent agent: $IA_n\begin{bmatrix} & \to [0,5-0,7] \to [Rick \to n] \\ \wedge_i \{PR_i \mid i=1,\mathrm{n}\} & \to [0,7-0,8] \to [Alarm] \\ & \to [0,8-1,0] \to [Norma] \end{bmatrix}$.

The assessment of the level of risk is based on the following models that characterize the management decision-making processes of the IA operator:

1. Probabilistic model of risk at the moment $(t \in T_{nk})$: $Risk(t_i \in T_{nk}) = L_{pi}\{P_i / C_i\}_{ti} \to$ $\to \{P_{i+1} / C_{in}\}_{ti+1} \to |Alarm|$ where Pi – the probability of wrong decisions that lead to consequences – failure of the target task in the emergency area.
9. Unprofitable risk assessment model when assessing an emergency situation [16, 21]: $Risk(P / Cui) \to \varnothing \to \begin{Bmatrix} H_{ij} : C_i \in C_V \to (\alpha_r \to 0) \\ H_{i2} : C_i \notin C_v \to (\alpha_r \to 1) \end{Bmatrix}$. Determines the maximum loss when leaving the target control area (*Cv*).
10. Risk assessment based on the decision tree in the management of threats to the maximum load of energy-intensive units of the man-made system.
11. Methods of payment of loss functions for structure, resources, products [22-24].
12. To assess the level of risks in the face of threats and management failures used hypothesis testing procedures in the form of: $H_1 : \forall x\left[P(x) \Rightarrow Q(x)\right]$, $P(x) \equiv Z_j \in B_i$; $H_2 : \forall x\left[Q(x) \Rightarrow R(x)\right], Q(x) \equiv Z_{j+1} \in B_{j+1}$. Then the condition for achieving the target state is set: $C_i : \forall x\left[P(x) \Rightarrow R(x)\right], traR(x) \equiv$ $\equiv (Z_j \to Z_{j+1} \to Z_{j+2}), R(x) \equiv Z_{j+2} \in B_c$. These chains can be locked in stress conditions, which leads to the failure of management actions and emergencies.

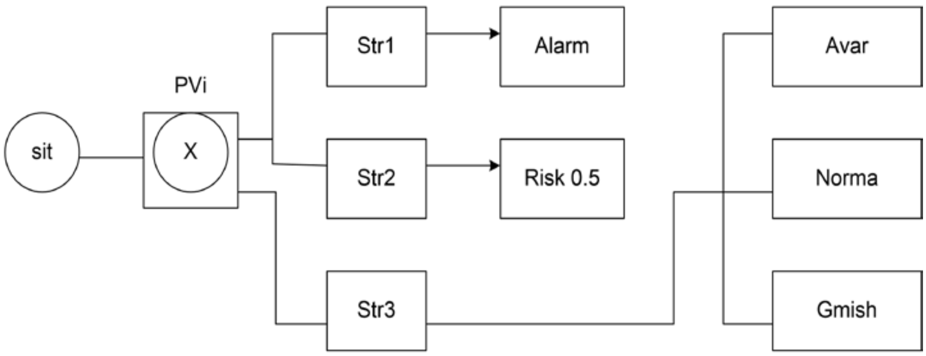

Fig. 11. Risk assessment based on the decision tree: PVi — procedure of choice, $\{Str_i\}$ — strategy selection and control of action

5 Conclusions

Was considered a problem of logical justification of the rules of decision-making in intelligent systems, reasonably scheme of dialogue and making situational decisions as to the basis of synthesis strategies for acceptable behavior of a person (active agent). It is shown that in a state of stupor chain deployment process clearer logical conclusion and evaluation of the scenario can be blocked, leading to loss of control SAI at a certain terminal time.

Were considered the problems of forming strategies for targeted solutions for the control of complex objects based on an active intellectual agent a purposeful system in the structure of integrated automated control systems. Were justified methods for constructing expert assessments to test the cognitive abilities of operators of intelligent agents.

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