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INFORMATION TECHNOLOGY OF PROBLEMS SOLUTIONS SUPPORT IN A COMPLEX SYSTEM MANAGEMENT

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Abstract

The study of the problems arising in the management of complex multi-factor systems allows to conclude that the latter should be considered as integrated organizational and technical. The basis of such management is a crisis – an exciting phenomenon, an incentive – unfulfilled needs, a defect, a deficiency or a threat that causes a targeted crisis through technical intervention or to avoid interaction or a change in the state of an object, a change in oneself or one's attitude to what is happening. An information technology for overcoming crises is proposed, which consists in the construction of each crisis into a group of elementary ones with the subsequent transformation of each elementary crisis into an elementary solution using the proposed information technology. The aim of research is to increase the efficiency of managing the development of complex organizational and technical systems through the development and implementation of new dynamic models and methods for finding optimal ways to overcome management crises at the level of elementary representations. The analysis and classification of the negative circumstances that arise in the management of complex dynamic organizational and technical systems, and the crises arising from these circumstances are carried out. The life cycle of an elementary crisis in managing the development of complex organizational and technical systems is shown – from the emergence of elementary negative circumstances to the receipt of elementary solutions to overcome them. An informational method has been developed to support decision making on the choice of means to overcome crises, based on the use of multidimensional percolation models. The structure is proposed and a description of the main steps that are carried out at one iteration of managing a complex organizational and technical system is provided.

Keywords: complex object, elementary crisis, crisis management, information technology, elementary solutions.

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1. Introduction

Cognitive management of the development of complex organizational and technical systems is one of the oldest types of human activity. At the dawn of civilization, people did not know what a complex system was in general, and even more so did not know that it controls this system. In fact, almost everything in this direction – whether it is the construction of unique structures, the creation of modern computer systems, the implementation of flights into space, etc. – all these processes have the basic properties of creative activity. These include multi-parametricity, uniqueness, limited time and resources, the presence of a special team, and much more.

Subsequently, when creative management of the development of complex organizational and technical systems was recognized by science, modern methods, in particular, mathematics, namely, new models of processes occurring and mathematical methods for optimizing these processes, began to be attracted to the formulation and solution of scientific problems arising from this.

This allowed to expand the concept of "problem", to distinguish two main types of problems: problems of the development of directly organizational and technical systems (crisis) and problems of scientific research (ignorance), which allow this development to be supported as efficiently as possible.

This approach, which allowed to move from one type of problem to another and vice versa, and to enrich the methodology and methods of their solution at every step, ensured the achievement of an effective practical result when working with specific complex organizational and technical systems.

2. Literature review and problem statement

As indicated above, the concept of "problem" in the management of a complex organizational and technical system has an ambiguous meaning.

According to existing definitions, a problem is a complex theoretical or practical question requiring solution, study, research [1]. It follows that the problem is an exciting phenomenon, the stimulus is unfulfilled needs, a defect, a deficiency or a threat that causes a targeted crisis through technical intervention or to avoid interaction or a change in the state of an object, a change in itself or its attitude to what is happening.

In general, the problem is a situation requiring active action and is an exciting factor for the purposeful activity of a person (scientific research, technical design and management) in order to eliminate the consequences of negative circumstances or to prevent their occurrence.

So what is the problem at the time of its formulation? First of all, the problem is the opinion or idea of the need, additionally, due to some negative circumstances that have just been determined, to obtain, for example, some resources through some actions. But the problem is not just an opinion, it is a mathematical formulation of how it is effective, that is, at the lowest cost, to obtain the desired resources in a significantly anisotropic environment [2]. So, the problem is the question of the most effective (optimal) method for achieving a local or common goal in the current circumstances.

How to formulate the problem? In order, for example, to choose an effective method of obtaining resources, it is necessary to understand what resource is actually needed. Let's consider an example. Let one freight tractor with a relatively high load get stuck under a bridge over the road along which construction equipment is transported. This is only a circumstance. The problem in these circumstances may be the lack of a high load item required by the plan at the construction site, which may cause the construction to stop altogether. But the problem in this case may be the complex relationship between builders and representatives of the city government. Another type of problem is ignorance of the properties of the cargo material, which can reduce its height with subsequent restoration.

Let's also note that often one of the most important resources needed is time. If the problem is a question about the most effective method of obtaining the resource, then in the example the problem is formulated as follows: "How to get the necessary cargo within a certain time"?

The analysis of literature data allowed to identify individual conceptual groups of the very concept of "problem":

– technical problems (technical crisis) [3–7];
– organizational problems (organizational crisis) [8–13];
– scientific problems (scientific ignorance) [14–19].

For convenience of generalization, the first two groups of problems hereinafter will be called simply crises, because in any management process it may be a crisis of purely technical or organizational origin. The latter also include crises generated by a turbulent environment (exchange rates, natural phenomena, etc.), or by the human factor (competence, erroneous decisions in management, etc.).

Let's call the third group of problems "ignorance", since each of them hides a certain phenomenon that exists or existed before, but the person did not know anything about it. Ignorance, as a rule, ends with a discovery (an example is the tenth planet of the solar system or the piezoelectric effect), which, in turn, gave an impetus to a significant number of methods for solving technical and organizational crises.

Technical crisis (lack and therefore failure of equipment, tools, instruments, etc.). To overcome technical crises at a creative scientific level, they create models of process and equipment elements that allow predicting the development of events in these objects, so that they can be created so that they do not develop crises.

Automatic control of technical processes is also based on mathematical models of the latter [3, 4]. These models, as a rule, are quite complex, but their main sign is that these models are most often based on only one variable: temperature, flow rate, electric current, etc. [5, 6]. This greatly simplifies the calculation and execution of control actions.

The methods and models used to control and design multi-parameter objects are much more complicated and can't function in conditions of exact data values that are used in them. Moreover, such data can't be measured or otherwise obtained.

In particular, for multi-parameter objects, a method for searching for optimal control of technological processes based on the analysis of solving a system of differential equations (SDE), which is a mathematical model of a controlled process, is proposed. It is shown that the solutions obtained in this case are consistent with the Pontryagin's maximum principle for the performance problem, but additional possibilities are opened in controlling the final state. A method is proposed for a multi-alternative parametric description of the final state [7].

Multi-parameter crises cease to be purely technical – involving a person in the assessment of an object and making anti-crisis decisions transfers them to a group of organizational and technical, in which all signs of organizational crises appear.

Organizational crises (lack of planning, financing, making ineffective management decisions on these issues, etc.).

If the management process follows the previously adopted strategic plan [11], then the difference between the planned parameter values (at the end of each iteration, if the time in the process model is discrete) and their actual value obtained by measurement or quantitative modeling can be considered an organizational crisis.

Unfortunately, today complexes of mathematical models do not exist or are not sufficiently developed to optimize all aspects of the evolution of complex organizational systems [10]. In particular, dynamic morphological models of problems arising in the management of organizational systems have not been proposed. No methods have been developed to optimize the structure and control of management parameters; it is carried out in a dynamic environment that expands over time and attracts more and more environmental aspects.

A negative conclusion follows from this: it is impossible to build a more or less accurate and adequate model of a complex organizational system, since in any case it contains, at best, dozens of such parameters [8]. Therefore, in the future, it is necessary to try to distribute the general model into local groups. Thus, accompanied by organizational systems, elementary events first appear (for example, lack of components or supplies) – as a result of decomposition of an event space, then elementary crises (for example, a financial crisis) – as a result of decompositions of a common crisis space, and, finally, decomposition decision space (for example, bank credit) – as an option to exit the decision support system [9].

Such an algorithm of organizational activity requires the determination of properties, characteristics, type of crisis to parameterize the next stage – its solution. For most managers, especially managers of large systems, it is this stage that is crucial for the formulation of a strategic task [12, 13].

Most researchers and project managers confuse organizational crisis with circumstances, considering obstacles (or negative, in their own assessment, circumstances) crisis. But if it is about resolving crises, then circumstances can't be resolved – they either exist or they do not exist. Circumstances can't be negative or positive.

Summing up, it can be argued that in the organizational crisis they understand the discrepancy between "Need" and "Is", between the circumstances in which the managed object is now and those in which it will be in the future, between the desired and the actual. The decision on actions to bring "Need" and "Is" closer together is the first step in overcoming the organizational crisis. Actions themselves are the second step.

In complex multi-parameter crisis systems, technical and organizational crisis are rarely encountered separately. Both the cause and the consequences of both types of crises are most often both technical and organizational factors, so it is possible to talk about combined organizational and technical risks and combined methods to overcome them. Therefore, the research is based on organizational and technical systems with all their inherent properties, in particular, stochasticity and multi-factorial nature.

To solve organizational and technical crises, specialists in complex cases involve scientific research and solve new scientific problems (ignorance).

Indeed, recently in the theory of control of complex systems, universal developments have appeared that made it possible to create models and methods for structural and parametric analysis of organizational and technical control systems based on modeling phase trajectories of their development. It became clear that not only the technological level of a complex system can be described using known methods [14, 15]. Indeed, the creative level also shows similarities with mathematical models of the basic laws of nature, which allows to use these models in planning and, as a result, in the quality of systems and products of their functioning [16, 17].

All the definitions given sound differently, but, despite this, they all have a common meaning: scientific ignorance is such a question, the answer to which is not contained in the accumulated knowledge.

A generalization of the results of the above works devoted to the creation of information technology to support crisis resolution in the management of complex systems implies the need to develop models in the face of uncertainty due to the inability to control many parameters in real time, the inability to accurately assess the state of the system, the process factor and the lack of sufficient information for implementation management. The solution to this problem can be used in the development of information-control models and methods for managing complex objects in industrial production and project management.

So, the paper proposes a method of information transition (information transition 1) from negative circumstances to management crises, consists in stratification of the space and time of occurrence of circumstances, the choice of elementary events within this space, and then to elementary management crises. The article proposes a method of information transition (information transition 2) from elementary management crises to elementary decisions to overcome these crises and then to general decisions in management, as well as the general structure of information technology for decision support, which is used in one time management iteration of complex organizational technical system.

3. The aim of research

The aim of research is to increase the efficiency of managing the development of complex organizational and technical systems through the development and implementation of new dynamic models and methods for finding optimal ways to overcome organizational and technical management crises at the level of elementary representations.

4. Management of the development of complex organizational and technical systems

4. 1. Method of information transition from negative circumstances to crises in managing the development of complex systems (information transition 1)

The decision support system for managing the development of complex organizational and technical systems should contain subsystems of stratification of all parametric spaces – from the space of crisis parameters to the space of competencies of development performers [16].

The paper suggests strategies for stratification of the general space of circumstances/crises/decisions into elementary ones:

– determination of a subset of the parameters of elementary circumstances/crises/decisions by the total set of corresponding parameters of the latter;

– preliminary stratification of the parameter spaces of circumstances/crises/decisions according to the selected ones (known or new) with the formation of unit cells of the common space, which do not change with appropriate identification, but are only selected as a stable element.

Let's show an example of how crisis stratification can be carried out according to the second strategy. The crises that arise when managing the development of complex organizational and technical systems are distinguished by the importance of their influence on the latter, and therefore by the attention that must be brought to them by the management team. In absolute terms, these global crises are difficult to classify, and to have some mathematical and computer models of the entire development process is a natural desire, but impossible because of the lack of capacity of even the most modern computers.

Therefore, let's turn to the method of achieving organizational effectiveness through decentralization [17]. Indeed, fortunately, large multi-parametric objects will encounter local crises relatively rarely, their "location" (in the space of crisis parameters of the control object as a whole) within the development process resembles strongly sparse matrices:

$$\mathbf{M} = \begin{pmatrix} 0 & 0 & ... & 1 & 0 \\ 0 & 1 & ... & 0 & 0 \\ ... & ... & ... & ... & ... \\ 0 & 0 & ... & 0 & 1 \end{pmatrix}. \quad (1)$$

In real multidimensional control, events are also relatively rare (**Fig. 1**).

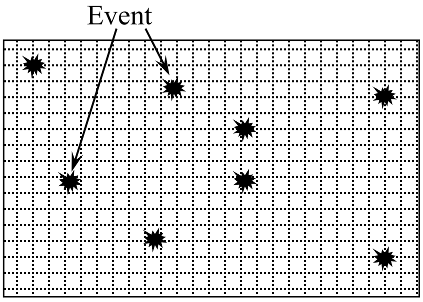


Fig. 1. Sparse two-dimensional iterative structure of event spaces

Let's define a local crisis as elementary in the sense that breaking it up into even smaller ones does not make sense or capabilities in one or another object and for one or another modeling goal. Thus, any elementary model with the dimension of its space $\mathbf{R}_{el}$ and the composition of its parameters $\mathbf{\Pi}_{el}$ is completely in the space of crises of the development process:

$$\forall \mathbf{R}_{el} \in \mathbf{R}; \quad (2)$$

$$\forall \mathbf{\Pi}_{el} \in \mathbf{\Pi}. \quad (3)$$

The work of creating and determining the properties of elementary crises begins with the stratification of such a space.

Like any stratification, the stratification of crises has a multilevel character. The number of levels is determined by the specific content of the control, as well as internal and external conditions, that is, the internal capabilities of the process manager and the turbulent environment [20].

The first level of crisis stratification contains four sublevels: a crisis is planned; unplanned but predictable crises, unplanned unpredictable crises and, finally, crises arising from the expansion of the spacious development of the facility as a whole as a result of the Big Bang [16].

The planned crises include difficulties in the planned activities: logistics crisis, weather accounting crisis, staff competence crisis, technical equipment crisis, and the like. According to the general plan for the creation and operation of a complex system, the manager should have "at hand" all the means to overcome most of these crises (the analogue is spare parts in maintenance of technical systems).

Let's refer to unplanned and predictable crises of which it was possible and was known during the planning and operation of a complex system, but the probability of their occurrence was so small that no means of overcoming such crises were provided for by this plan. An example of such crises can be a sharp change in the terms of fulfillment of agreements by stable reliable partners, a sharp and unexpected change in the exchange rate, unexpected penetration of new materials, energy carriers and the like.

Unplanned and unpredictable crises included completely unexpected events that were not mentioned or discussed during the planning of managerial activities. An example of such crises can be relatively rare natural disasters.

The second level of crisis stratification is associated with the functional areas of the development process (**Fig. 2**).

The corresponding environment of features (events), crises and decisions is multidimensional.

The space of crises is determined by both physical and non-physical elements that create or contribute before the crisis. The solution leaves the "space of solutions" of resources and alternatives. To obtain an adequate solution, it is desirable that the space of decisions be wider than the space of crises. For example, if a two-dimensional crisis sounds like this: there is no way to overcome the obstacle to moving an object from zone A to zone B within two-dimensional space, then a three-dimensional solution to this crisis can easily cope (**Fig. 3**).

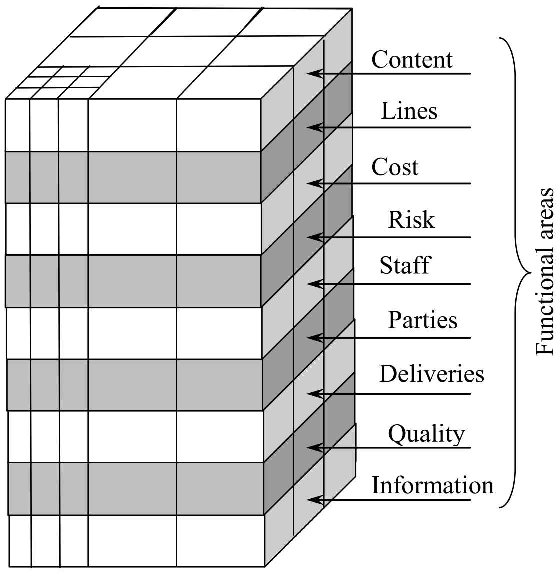


Fig. 2. Discretization of the process of managing a complex object by functional areas

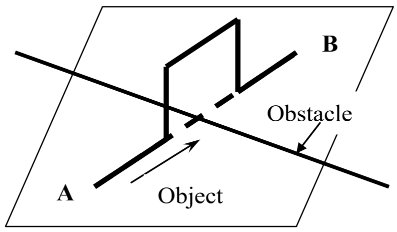


Fig. 3. Overcoming the obstacle due to the fact that $\mathbf{R}_p \geq \mathbf{R}_p$

As a rule, certain troubles when managing complex systems begin with some circumstances (events), either previously known and taken into account in terms of management, or unexpected, arising as risks for one or another probability [21]. Such circumstances or events are objective – they simply are and the fact of their existence (and not the reason!) are independent of the person (**Fig. 4**). An example of this circumstance is the destruction of the pipeline section through which the process fluid is supplied.

Let, in order to describe such a circumstance at the information level, in the general case, it is necessary to apply q of its parameters: $o_1, o_2, \ldots, o_q$. Let's note immediately that the dimension of such a description R_o is equal to the number of parameters in the circumstances vector

$$\mathbf{O}=\{o_1, o_2, \ldots, o_q\}. \quad (4)$$

Among them, for sure, there will be parameters of different "cost" in terms of future transformations of this data. They can be immediately ranked at this cost, some can be neglected, while reducing the dimension of the problem as a whole.

For example, if it was a circumstance (event) that some cargo was stuck on a wheeled platform under the bridge truss, then its most important parameters could be the clearance between the bridge and the road and the cargo height, and secondary – the amount of fuel in the tank truck's tanks.

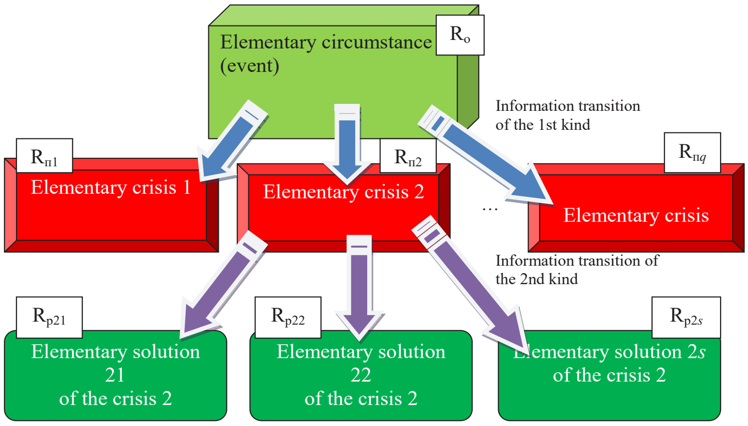


Fig. 4. The structure of the life cycle of an elementary crisis in managing the development of complex organizational

Such a circumstance is not in itself an invariant, that is, it is not some absolute crisis of governance. Indeed, the personnel of an organization or enterprise may perceive this event ambiguously, because it can now cause a number of various crises: from the slowdown of a separate technological process to the cessation of production in general.

After all, the struggle is, as was said above, not for the elimination of negative circumstances (events), but with the consequences of these events – the crises that the latter cause. Indeed, in a philosophical understanding, between a circumstance (event), for example, a destroyed pipeline, and methods to overcome its consequences, for example, switching to another pipeline or adjusting the old one, is one more stage. It depends on the person, that is, purely subjective, stage of identification of the crisis or crises [22], for example, the lack of fluid in the technological capacity.

This means that one more step is added to the information hierarchy "Negative circumstance"→"Decision to eliminate": "Negative circumstance"→"Crises"→"Decision to eliminate".

Therefore, the management team, based on the circumstances (events) and the complex system in which this event occurred, must first formulate an n-dimensional matrix of crises that arise as a consequence of this circumstance (**Fig. 1**). The length of the rows in the matrix is not constant, because it reflects a different number of parameters in different crises. An example of a 2-dimensional crisis matrix is as follows:

$$C=\begin{pmatrix} C_{11} & C_{12} & \ldots & C_{1n} & \ldots \\ C_{21} & C_{22} & \ldots & \ldots & C_{2(n+1)} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ C_{m1} & C_{m2} & \ldots & C_{mn} & \ldots \end{pmatrix}. \quad (5)$$

Each crisis with (5) also has its own dimension $\mathbf{R}_c$ and is described by the corresponding parameter vectors.

Information transition of the 1st kind. To compile a list of crises and determine the values of the parameters of each, having the values of the components of the vector (1), there are three ways:

– using expert assessments of specialists in the field of the operation of the control object;
– using a database of information on the progress of such events;
– using a thorough examination of the scene.

As follows from (4), there can be several such crises for each circumstance, and each of them must somehow be decided, which, as a rule, can also be implemented by various methods or methods, for example, not paying attention to it, or organizing a temporary or overhaul of the pipeline, to supply the process fluid in another way, and the like.

There is no direct causal connection between the event and the way to overcome its consequences. This means that, even with a carefully compiled vector of the parameters of the circumstance $\mathbf{O}=\{o_1, o_2,\ldots, o_q\}$, it is impossible to immediately decide on a method to eliminate its consequences, that is, "direct" to obtain the values of the tensor parameters:

$$\mathbf{P}=\left\{\begin{matrix} \mathbf{P}_1=\begin{pmatrix} p_{111} & p_{112} & \cdots & p_{11n} & \cdots \\ p_{211} & p_{212} & \cdots & p_{21n} & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ p_{m11} & p_{m12} & \cdots & & p_{m1(n+1)} \end{pmatrix}, \\ \mathbf{P}_2=\begin{pmatrix} p_{121} & p_{122} & \cdots & p_{12n} & \cdots \\ p_{221} & p_{222} & \cdots & p_{22n} & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ p_{m21} & p_{m22} & \cdots & & p_{m2(n+1)} \end{pmatrix}, \ldots \end{matrix}\right\}. \quad (6)$$

Thus, the reaction of management personnel to the event should occur in a tree-like pattern (**Fig. 1**). After the circumstance (event) has taken place and will be identified, the management team needs to identify the matrix of crises (5) that are caused by this circumstance.

Next, for each crisis, a tensor of measures to overcome it is created (6), each of which is ranked according to one of the parameters, for example, cost, environmental hazard, and the like.

The ranked event tensors are transferred to the manager of the management as support for its further actions to eliminate crises. It is with these suggestions that the manager works further from the decision-making system, choosing the necessary tool and implementing it either with a stop of the process, or parallel to it.

Such an approach puts at the level of the main information and incentive characteristics of management precisely the crisis, and not the circumstance that gave rise to it. If the circumstance, for example, is the inability to transport responsible cargo under a relatively low bridge, then the crisis will be a threat to the completion of work on time or the destruction of the cargo. Such crises are studied in systemology. It is the systemology at the first stage of the system-organizational activity algorithm (SOA algorithm) that gives the main definition of a crisis: the presence, excess, absence or lack of which [1].

4. 2. The method of the information transition from elementary management crises to elementary decisions (information transition 2)

An informational transition of the second kind, that is, from the crisis space to the solution space can also be carried out in various ways – from completely brainstorming the management of the development of a complex system to automatically searching for a single solution by transferring it directly to the executors of crisis compensation measures.

The “man/computer” ratio in such a transition largely depends on the dimension of the space of the circumstances/crisis/decision parameters. It is clear that for large values of these dimensions (that is, when try to control the entire object at the same time), the proportion of the computer in this ratio will be insignificant. In managing elementary circumstances/crisis/decision, this proportion increases to the decision support function during the transition. In this case, multidimensional matrix mathematics is widely used: multidimensional matrix transposition, symmetry, antisymmetries, determinants and inversions [23], mathematical methods for selecting minimally contradictory messages [24], etc.

An example of such automation of transition 2 is the use of percolation models or an information model of the processes [4] to calculate optimal solutions to the problem of finding solutions with respect to some parameter (time, cost, etc.) (**Fig. 5**).

In the three-dimensional figure, the n-dimensional hypercube is conventionally marked, which also has the input and output matrices. Let’s recall that at the input of transformation 2 is the vector of parameters of the elementary crisis, and at the output is the vector of parameters of the elementary solution.

There are various methods for converting multidimensional vectors: intelligent with memory (neural networks, Markov models, etc.). In the work let’s use the method of the flow (percolation) of information, it is not necessary to pre-prepare on training sets, but it is necessary to have a data bank on the finite sets “What do we have?” and “What do we want?”.

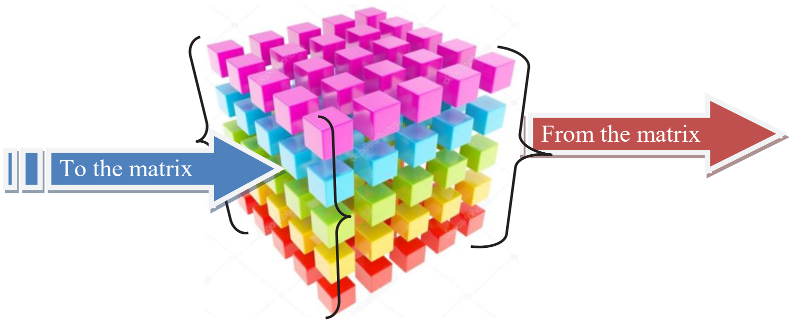


Fig. 5. Example of automation of transition 2 using percolation models (the basis of the figure is borrowed from the site https://ru.depositphotos.com/12071605/stock-photo-rainbow-colored-cube-composition-broken.html)

The use of such a model for solving elementary problems is confirmed by the modern capabilities of the method, because percolation problems are now known, posed and solved on two-dimensional [4], three-dimensional [5] and even seven-world lattices [6].

The threshold and power of percolation clusters on orthogonal lattices are estimated at the same time on percolation-fractal models [25].

The method involves “sketching” small n-dimensional cubes into the space of a large n-dimensional hypercube or replacing existing cubes with similar ones, but with different parameter values. At the same time, the properties of the clusters of such cubes that are formed during the sketching or replacement are calculated, and the moment is recorded when the so-called “endless cluster” (EC) is formed in the sense that both matrices reach its “end”.

In the latter case, a tunnel appears between the crisis and its solution, that is, this path (sometimes far from direct) will allow finding the necessary solution. The components of the solution are the essence of the cubes in the path of the cluster.

In parallel, the program calculates the cost of paths, which is additively accumulated during the experiment. After the completion of the EC construction, all dead-end branches are discarded and only an effective path remains with a minimum cost of passing it.

Possible paths are ranked by cost (or time) and transferred to the manager for a final decision.

4. 3. General structure of information technology for decision support

A diagram of the general structure of information technology for decision support to overcome crises, which is used today to manage complex organizational and technical systems of various types, is presented in **Fig. 6, *a***. The main drawback of the existing approach is the attempt to find solutions to overcome crises at the macro level of circumstances, crises and solutions "in general" [26], which makes it extremely difficult to create appropriate models and makes computer work with them unrealistic due to temporary overloads.

The scheme of the proposed general structure of information technology for supporting decision-making on crisis management, which is used to manage a complex organizational and technical system, is presented in **Fig. 6, *b***.

The scheme of the general structure of information technology for decision support on overcoming crises, which is used in *one iteration of managing* a complex organizational and technical system, is presented in **Fig. 7**.

The iteration begins with the fact that information on negative circumstances (events) is collected for all functional areas of the management process. The source of such information is difficulties in fulfilling planned tasks, predictable and unpredictable management risks, and new challenges that arise from the natural expansion of the structure of the control system of a complex object.

Information about the accumulated circumstances (events) in the form of a vector $\mathbf{O}=\{o_1, o_2,\ldots, o_q\}$, using informational transitions of the first kind, goes to the crisis environment where, with their help, the corresponding elementary crises or groups of elementary crises are formed in the form of a matrix

$$C=\begin{pmatrix} \mathrm{C}_{11} & \mathrm{C}_{12} & \ldots & \mathrm{C}_{1n} & \ldots \\ \mathrm{C}_{21} & \mathrm{C}_{22} & \ldots & \ldots & \mathrm{C}_{2(n+1)} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ \mathrm{C}_{m1} & \mathrm{C}_{m2} & \ldots & \mathrm{C}_{mn} & \ldots \end{pmatrix}.$$

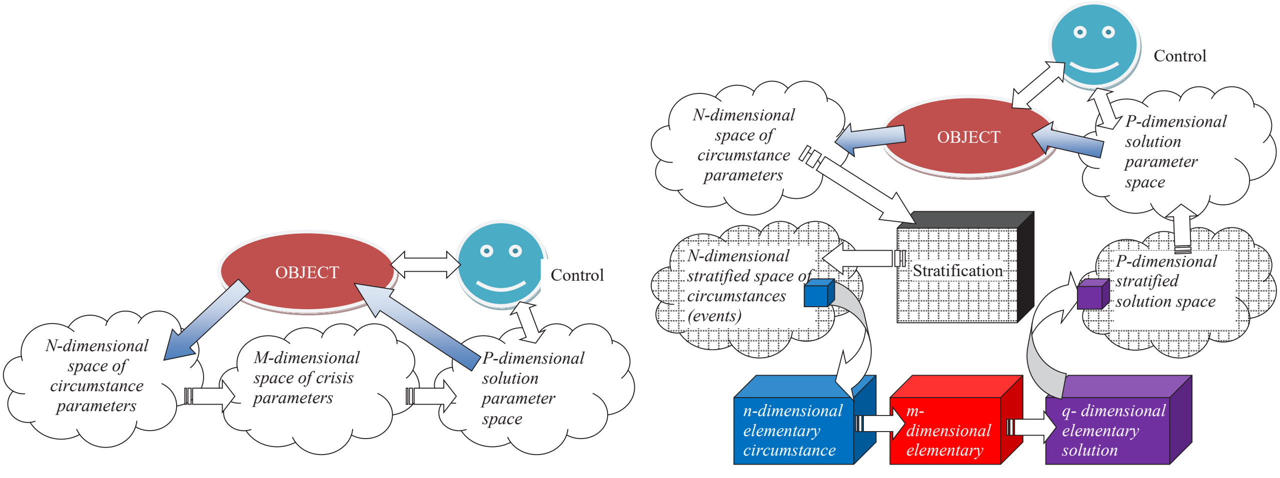
Each matrix **C** goes to the information block of transformation of the matrix of elementary crisis into the tensor of elementary solution

$$\mathbf{P}=\left\{\begin{matrix} \mathbf{P}_1=\begin{pmatrix} \mathrm{p}_{111} & \mathrm{p}_{112} & \cdots & \mathrm{p}_{11n} & \cdots \\ \mathrm{p}_{211} & \mathrm{p}_{212} & \cdots & \mathrm{p}_{21n} & \cdots \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ \mathrm{p}_{m11} & \mathrm{p}_{m12} & \cdots & & \mathrm{p}_{m1(n+1)} \end{pmatrix}, \\ \mathbf{P}_2=\begin{pmatrix} \mathrm{p}_{121} & \mathrm{p}_{122} & \cdots & \mathrm{p}_{12n} & \cdots \\ \mathrm{p}_{221} & \mathrm{p}_{222} & \cdots & \mathrm{p}_{22n} & \cdots \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ \mathrm{p}_{m21} & \mathrm{p}_{m22} & \cdots & & \mathrm{p}_{m2(n+1)} \end{pmatrix}, \ldots \end{matrix}\right\}$$

using percolation flow models and the corresponding data bank.

The elementary solutions thus formed give the space of general solutions, where they are ranked and offered to the manager to select and organize a vector of influence on the organizational and technical system. An additional unit evaluates the results of such an impact.

According to the results of the analysis of the obtained solutions, the current iteration ends and the next information on expanding the space of existence of the control object, new properties and resource restrictions, etc. are added to the system databank.



a *b*

Fig. 6. Scheme of the general structure of information technology for decision support on overcoming crises, which is used to manage a complex organizational and technical system: *a* – existing; *b* – proposed

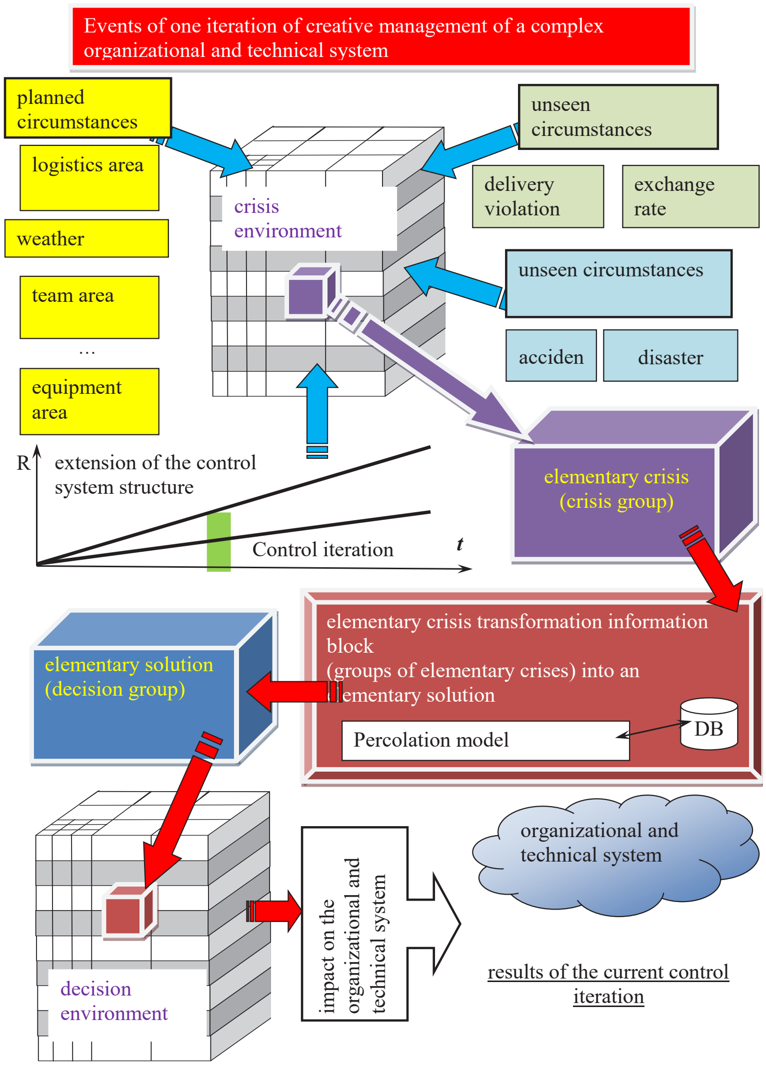


Fig. 7. Structure of information technology for decision support on overcoming crises, which is used in one iteration of creative management of a complex organizational and technical system

5. Discussion of research results in the field of information technology for overcoming crises that arise during the creative management of complex systems

The main achievement of work in the field of information technology for overcoming crises that arise when managing multi-parameter complex systems is the application of a scientific approach to compensate for crises in technical and organizational-technical objects. First of all, let's talk about solving scientific problems (ignorance) that arise when a certain givenness or phenomenon exists, but it isn't known anything about it.

The obtained scientific results stem from the complexity and multi-factorial nature of the control object and its models and the ambiguity of interactions between the elements of these models.

The features of the proposed method are that the general process of information technology for management support is divided into separate stages, the boundaries between which are located exactly where new circumstances of the life cycle of the object arise, which give rise to new crises and ignorance.

But, unfortunately, it is the complexity of such objects that creates restrictions on the effective use of the method in various fields of human activity. Indeed, even with a slight increase in complexity, the adequacy of the models used and the accuracy of the results obtained with their help decrease. In addition, a large number of parameters of complex systems slow down the simulation, which, in turn, prevents the online use of most models.

The development of this study may consist in the further search for new integrated parameters of the systems involved in the management and those that allow to accelerate the receipt of results.

6. Conclusions

The study of the problems arising in the management of complex multi-factor systems allows to conclude that the latter should be considered as integrated organizational and technical. The basis of such management is a crisis – an exciting phenomenon, an incentive – unfulfilled needs, a defect, a deficiency or a threat that causes a targeted crisis through technical intervention or to avoid interaction or a change in the state of an object, a change in oneself or one's attitude to what is happening. Crisis is a situation requiring active actions and is an exciting factor for the purposeful activity of a person (scientific research, technical design and management) in order to eliminate the consequences of negative circumstances or to prevent their occurrence.

The adopted general structure of information technology for decision support, in which to reduce the dimension of general descriptions of circumstances/crises/decisions, a method of information transition (information transition 1) from elementary negative circumstances to elementary management crises is proposed. The method consists in the stratification of space and time of occurrence of general circumstances, the selection of elementary events within this space and then to elementary management crises. An option is also proposed when the initial space of circumstances is stratified into separate layers of the description of the object and interaction with it, and then all information transformations are performed at the level of individual elementary models.

A method of information transition (information transition 2) from elementary management crises to elementary solutions to overcome these crises and then to general management decisions using multidimensional dynamic percolation models with vector elements is proposed.

The general structure of information technology for decision support is proposed, which is used in one temporary iteration of managing a complex organizational and technical system. The iteration begins with the fact that information on negative circumstances (events) is collected for all functional areas of the management process. Information on accumulated events through informational transitions of the first kind comes to the environment of crises. Further, this information enters the block transforming the elementary crisis into an elementary solution using percolation flow models and the corresponding data bank. The elementary solutions thus formed give the space of elementary solutions they are ranked and offered to the manager for selecting and organizing the vector of influence on the organizational and technical system. An additional unit evaluates the results of such an impact.

This technology allows to quickly respond to negative events in the facility and the crises that these events generate. The speed, accuracy and effectiveness of the response are due to the widespread use of developed methods and computer models.

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METHOD OF CONSTRUCTING EXPLANATIONS FOR RECOMMENDER SYSTEMS BASED ON THE TEMPORAL DYNAMICS OF USER PREFERENCES

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Abstract

The problem of constructing explanations for recommendations in situations of cold start and shilling attacks is considered. The first situation is characterized by incomplete information about the user's preferences, and the second is characterized by a distortion of the ratings of items in the recommendation system. A method for constructing explanations for the recommended list of subjects is proposed. The method uses weighted temporal dependencies to form explanations. Each such dependence reflects a change in sales of goods for two non-contiguous time intervals. These intervals are set according to a given level of detail of time, for example, day, week, month. The input is presented by a sales journal with time stamps. The method includes the steps of forming temporal rules, calculating the weights of the rules, building explanations. The weights of the rules reflect the degree of change in sales for a pair of intervals. The result of the method is a recommendation in the form of a numerical estimate of the change in user preferences with respect to the subject in the recommendation. The proposed method allows to increase sales efficiency due to the active selection of items by the user based on the explanations received.

Keywords: recommendation system, explanation of recommendations, effectiveness of recommendations, credibility of recommendations.

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