KAPITEL 4 / *CHAPTER 4* [4]
THE BASIC ASPECTS OF THE DEVELOPMENT OF SITUATIONAL CONTROL SYSTEMS

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Introduction

Management of modern enterprises under growing competition, increasing complexity of tasks, a priori uncertainty and high dynamics of changes in demand and supply, require daily solution of interrelated and mutually agreed upon tasks for organizing work, planning, monitoring and control of used resources. This state of affairs gradually leads to the abandonment of the classical principles of management, represented by "program-target management" and the transition to a more flexible and effective "situational management". The basis of such management is teamwork, built on mutual understanding and agreement (consensus) of decision makers in real time.

Situational management at the same time denies the formal mechanical adherence to previously created "repetitive" rules without any analysis of the essence of the situation and, on the contrary, offers a detailed analysis of all the features of the situation and the collective generation of solutions in the format of a dialogue of all interested parties [10, 13, 15].

Situational management, to one degree or another, exists at different levels of the hierarchical management ladder, starting with state management and ending with the management of individual sectors of the national economy, enterprises and technological cycles [16].

Such management is implemented through the creation of situational centers (SCs), the development and implementation of which is actively carried out in many developed countries of the world. SCs become the basis for managing large systems such as government, industry, defense, environmental facilities, objects with a high degree of danger, etc. [11]. In recent years, SCs have begun to be developed and implemented in Ukraine.

It is important to note that in order to resolve a problem situation, teams of different specialists are dynamically created, who must first fully understand the situation, develop solution options and, in a coordinated manner, make a decision that will be the most valuable for the enterprise.

A simplified decision-making cycle in a situational control system is shown in Fig. 1.

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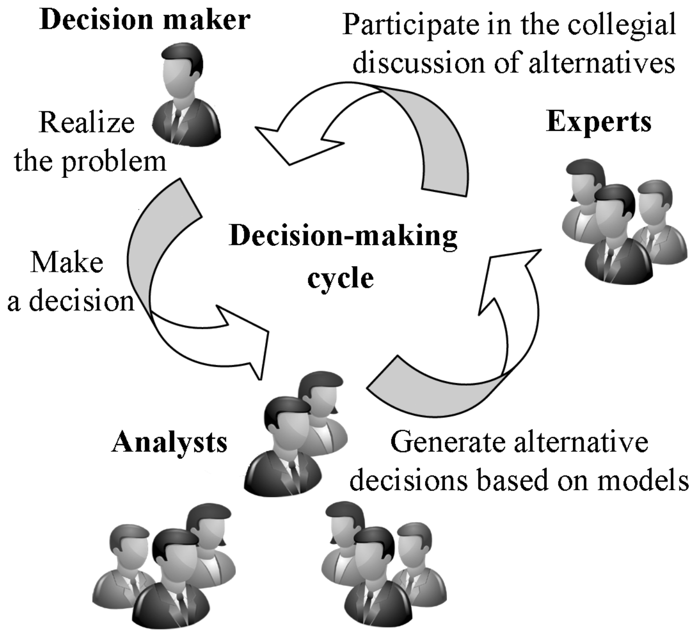

Figure 1 – A simplified decision-making cycle in a situational control systems

The following roles of specialists participating in the decision-making process can be distinguished [11].

Decision maker is a specialist in the subject area, discussed in situational control systems, who has realized the need for a collegial solution to some management problem. He takes part in collective decision-making and is responsible for the decision made.

Analyst is a specialist in the subject area discussed in situational control systems who has the experience and skills to model possible alternative solutions to a management problem and is not responsible for the decision made.

Expert is an experienced specialist in the subject area discussed in situational control systems, who participates in a collegial discussion of possible alternative solutions to a management problem and is not responsible for the decision made.

4.1. Basic aspects of situational management

The basic concepts of situational management can be presented as follows. The current situation C is a set of the current state of objects (vector of states X) and its external environment (vector of disturbances F). Then $C = <X, F>$.

The concept of a complete situation is introduced as $S = <C, G>$, where C is a current situation and G is a control goal.

In turn, a control goal G can be represented by the target function Gg, to which the current situation should be reduced.

Then S = <C, Gg>. Provided that the current situation C belongs to a certain class Q', and the target (given) situation Gg belongs to the class Q'', a control (vector of control actions U) is sought that belongs to a set of admissible controls Ω_U and ensures the necessary transformation of one class of situations into another : $C \in Q' \xrightarrow{U \in \Omega_U} Gg \in Q''$.

Thus, situational control acts as a reflection $(Q', Q'') \to U \in \Omega_U$ that compares with the pair “current situation – target situation”, the required result is control U.

A general idea of situational management is given in Fig. 2 [6].

A description of the object’s state is entered into the control object state identification block using a set of feature values characterizing the current situation C_i. To identify the current situation in control systems there is a set of reference (typical) situations $C^{TS} = \{C_i^{TS} \mid i = \overline{1,n}\}$ on a set of which a search is carried out for the one most similar C_i^{TS} to the current situation C_i. Such a search can be carried out, for example, using the nearest neighbor method, for which a special measure of similarity of situations is introduced. The decision-making process can then develop in two ways. The first of them consists of directly determining decisions based on the results of identifying incoming situations (Fig. 2, connection 1). It corresponds to a one-step algorithm of the “situation-decision” type. Where, in each reference situation, a specific standard solution (or set of solutions) is matched, which is issued to the executive bodies.

Algorithms of the "situation-solution" type are used in operational control in static environments with monotonous (linear) behavior of the object. Another way is a targeted search for solutions based on building a strategy (Fig. 2, connection 2). A strategy is a sequence of situations through which it is necessary to lead an object to achieve a target situation. In this case, each reference situation is associated with a specific target situation. This algorithm for generating management decisions is multi-step in nature and is called a “situation-strategy-decisions” algorithm.

Algorithms of this type are relevant when managing in uncertain changing environments with non-monotonic (nonlinear) behavior of control objects (works, technological processes, enterprises, economic regions, ecological systems, etc.) [6].

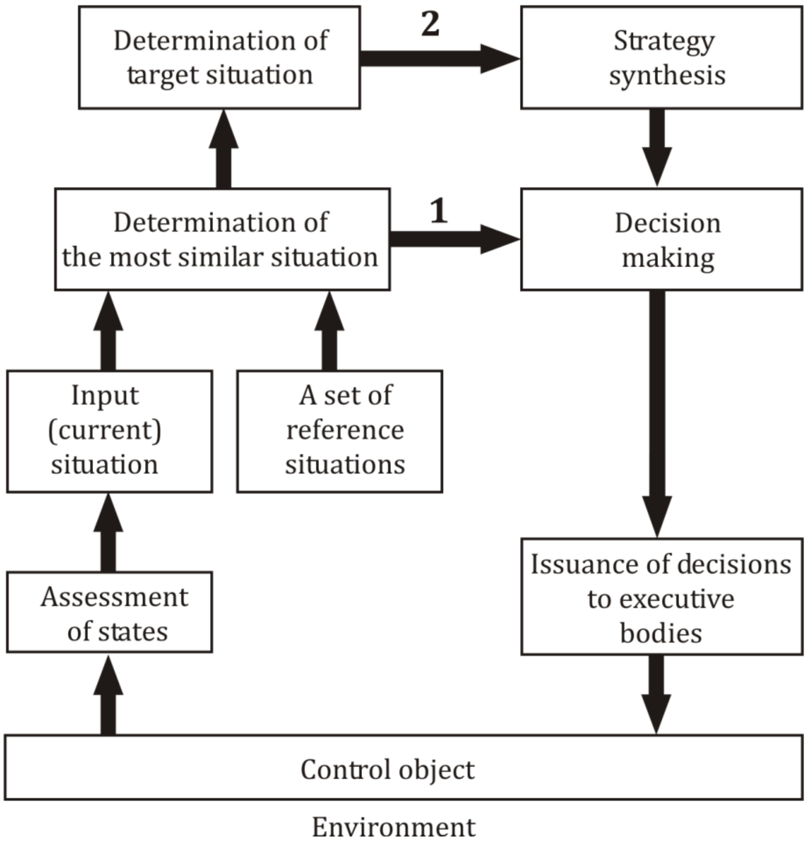

Figure 2 – General scheme of situational management

4.2. An ontological approach to modeling problem situations

Intelligent real-time decision support systems, an integral part of which are knowledge bases, are used as tools for implementing situational management. The creation of a knowledge base is based on a model of knowledge about the subject areas of situations regarding which decisions need to be made quickly.

Recently, to model knowledge about subject areas of various problem situations, the *ontological approach* has become increasingly developed and used [14].

The concept of “ontology” (from the Latin *ontologia*) in the philosophical sense is interpreted as the doctrine of being and its properties and conditions (space, time, movement, form, origin from another, and transition to another, etc.).

In information technology, *ontology* is understood as a way of representing knowledge about a fragment of the surrounding world, or knowledge “*as it is*”.

The ontological approach allows for continuous improvement of the model based on basic ontologies through their completion and development

To build ontologies, the most widely used models are frames, production rules, and semantic networks [3-5, 7, 9, 15].

The first, simplest form of representing ontologies were different types of ***frame***

models [3, 5, 7, 9]. Frames are intended to denote the structure of knowledge for the perception of spatial scenes or display of images. As an example of framing, consider the image of a room: “a room with four walls on the third floor, with windows and doors.” Nothing can be removed from this description (for example, by removing the windows, we will get a lumber-room). But in this image there are “slots” – these are unfilled values of some attributes, for example, the number of windows, ceiling height, wall color, presence of furniture, room area, etc.

In frame theory, this image of a room is called a room frame.

Another popular way of representing ontology is ***production models*** based on rules and allowing knowledge to be represented in the form of rules: “IF (*condition*), THEN (*action*)” [3, 5, 7, 9]. By “condition” we mean a certain sentence – a pattern by which a search in the knowledge base takes place, and by “action” – the action that occurs when the search is successful. More often, the conclusion from such a knowledge base is direct (from data to searching for a goal) or reverse (from a goal – to data).

An example of a production rule: “IF (*a person has a high temperature*), THEN (*he is sick*).”

The production model of knowledge is most developed in industrial expert systems due to its clarity and simplicity of logical conclusion.

As noted earlier, ontologies contain the basic concepts of a subject area and the relationships between them, which can be represented in the form of a ***semantic network*** [3-5, 7, 15]. The term "semantic" means “meaningful”; “semantics” is a science that establishes relationships (connections) between symbols and the objects that they designate, that is, a science that determines the content of signs.

A semantic network is a directed graph, the vertices of which are a *concepts*, and the arcs are the *relationship* between them.

Concepts are usually abstract or concrete objects, and relations are connections of the form: (“*is*”, “*kind-of*”, *has part*, belongs, etc.

A characteristic feature of a semantic network is the mandatory presence of three types of relationships [4, 13, 15]:

1. class – class element (vehicles – passenger vehicles);
2. property – value (shape – rectangular);
3. example of an elementary class (bus, trolleybus).

There are several classifications of semantic networks related to the types of relationships between concepts.

By number of relationship types:

1. homogeneous (with a single type of relationship);

2. heterogeneous (with different types of relationships).

By type of relationship:

1. binary (a relationship connects two objects);

2. *n*-ary (relations connect more than two objects).

The following relations are most often used in semantic networks [4, 13, 15]:

1. connection of the “part – whole” type; “class – subclass”, “element – set”, etc.;

2. functional connections, usually denoted by the verbs “produces”, “influences”, etc.;

3. quantitative connections (more, less, equal, etc.);

4. spatial connections (far from, close to, under, above, etc.);

5. temporary connections (earlier, later, flow, etc.);

6. attributive connections (to have a property, to have a value);

7. logical connections (AND, OR, NO);

8. linguistic connections, etc.

The problem of finding solutions in a knowledge base such as a semantic network comes down to the problem of finding a fragment of the network corresponding to a certain subnet that maps the query to the database.

4.3. General characteristics of situational control systems

Decision-making in situational management must be carried out in real time as problem situations arise. In view of this, situational control systems are implemented in the form of intelligent real-time decision support systems (DSS) [1, 2, 8, 12]. Systems operating in real time are subject to certain restrictions on temporal (dynamic) characteristics. .

Formally, such a limitation can be written as follows: $T_{\min} < T < T_{\max}$, where T is some time characteristic (for example, reaction time to an external event, the duration of a certain operation, the moment of occurrence of a certain event, etc.). $T_{\min}$ and $T_{\max}$ are the maximum permissible limits of this characteristic. Exceeding these limits is considered a system failure.

In the process of construction of such systems, it is necessary to take into account their specifics:

1. obtain a solution under time constraints determined by the real controlled process;

2. take into account the time factor when describing a problem situation in the process of finding solutions;

3. impossibility of obtaining all the objective information necessary for a decision, and in connection with this, the use of subjective expert information;

4. multivariate search for solutions;

5. input of additional information into the system knowledge base when searching for a solution.

Let us briefly consider the main blocks and elements of the basic DSS architecture [1, 8, 12]. General structure of the DSS is shown in Fig. 3 [16].

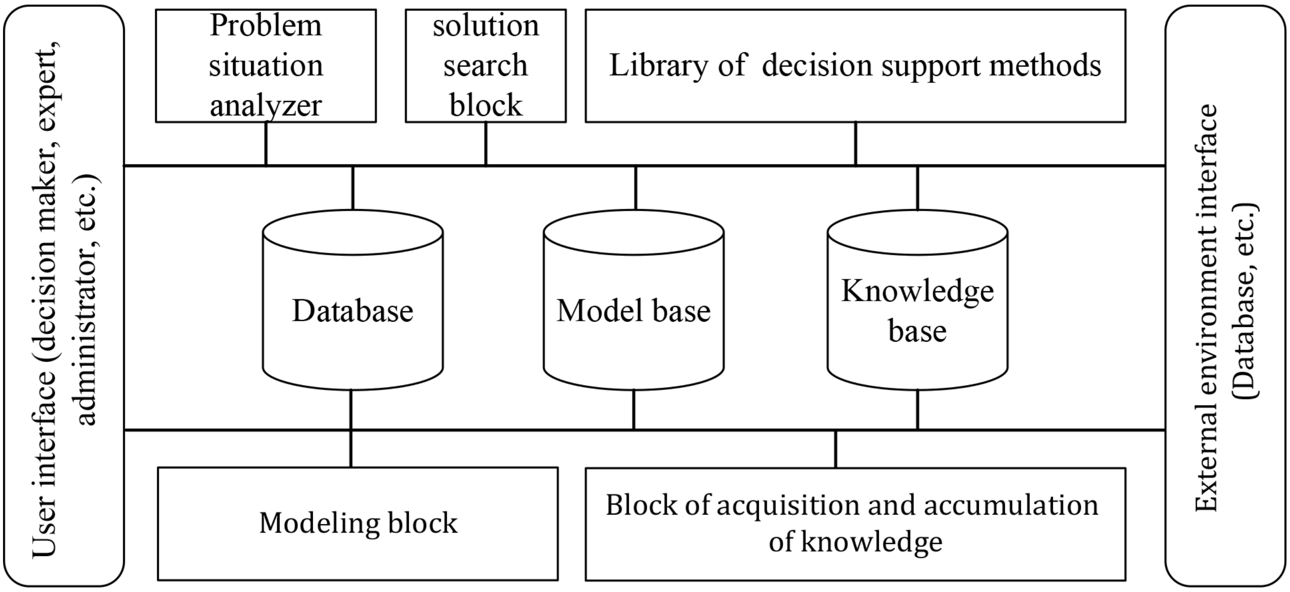

Figure 3 – General architecture of the DSS

The problem situation analyzer is one of the main blocks of DSS; it helps to study and structure the problem being solved. As part of this structuring, a list of factors and alternatives is formed, their properties (features, characteristics, attributes) are determined and described, limitations are identified, and evaluation criteria are set. This block interacts closely with the *model base*, which contains a set of possible models that can be led to by structuring the tasks of problem situations already under consideration. The models can include both traditional objective models, described by methods of traditional mathematics, and subjective models, built on the basis of subjective assessments of experts.

The solution search block is a key element of DSS and includes tools that help users find the best ways to solve pre-structured problems. The block input receives, on the one hand, a formalized idea of the problem, and on the other, requirements for the form of the final solution, which can be represented by three typical tasks [8]: ordering a set of objects; selecting one or more preferred or acceptable options from a plurality of objects; dividing a set of objects into groups (classes, clusters).

The formal presentation of the problem situation and the form of the final solution put forward certain requirements for the type of necessary models and data, form the need for subjective expert knowledge, and impose restrictions on the decision-making methods used. To fulfill the above conditions, the DSS includes a library containing various methods for solving multi-criteria problems based on objective and subjective models.

The *database* is a traditional component for all computer systems. In accordance with decision-making tasks, the database must contain factual information, expert assessments, text documents and other information. The knowledge base should contain objective knowledge about the user's subject area, subjective rules and criteria reflecting the experience of decision makers and experts.

In addition, the *knowledge base* should contain a so-called "archive of historical analogies", in which it would be possible to accumulate information about the results of using DSS in the past when solving specific problems. To model and represent knowledge, a number of methods are used, such as cognitive maps, the case based reasoning (CBR) method, rough set theory, etc.

The user-system interface, which provides user communication with DSS components, includes tools for managing databases, models and knowledge, managing and generating a user assistance dialog. Database, model and knowledge management tools are used to create, retrieve and modify the content of the corresponding databases. When solving problems, the user interacts with each of the databases through a control unit and dialogue generation. In difficult cases, the interface should provide assistance to the user in the form of instructions, tips, messages, etc. [8].

Conclusions

Situational management is operational management, which is a complement to strategic management. It consists in making management decisions in real time as problems arise in accordance with the current situation in unspecified planned periods of time. Situational management is envisaged as an additional method of solving problems, based on the subjective and heuristic knowledge of specialists.

The most practical form of implementation of the ideas of situational management is the development of intelligent real-time systems (real-time decision support systems) focused on open and dynamic subject areas.

Such systems are based on models capable of adapting, modifying and teaching knowledge representation and operation, focused on the specifics of the problem (subject) area.

The basic concepts and definitions of situational management, considers the ontological approach to modeling problem situations and the main models for representing ontologies have been considered in the paper. The main models for representing ontologies that are used for the formalized representation of knowledge in situational control systems are analyzed.

The features and general aspects of the construction of situational control systems implemented through real-time decision support systems have been studied. The main roles of specialists participating in the decision-making process in situational control of the analyzed object are considered.

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