Lecture 7. System and Control

The purpose of the lecture: introduction to the main problem (attribute) of system analysis - system management (in the system).

Lecture plan:
Introduction
1 Management in the system
2 System management functions and tasks
3 Cognitology
Conclusion
Control questions

Keywords: information, stability, parity control, software, word, system control, system control, function, external function, transmission rate, bandwidth, control, system, information flow, control cycle, information organization rule, output information, control , input, reliability, measure, control system, value, queue, inequality, Ashby's principle, manager, Seller, LLC, weight, function and task of system management, function and task, behavior strategy, cost management, quality manager, resource management, risk management, e-procurement, functioning algorithm, self-organization, self-organizing, internal connections, asymptotic stability, variable, connected stability, height, length, tools, cognitology, informatics, mathematics, communication, cognitive scheme, weighted graph, cognitive, scheme, cognitive grid , Layout.

Contents of the lecture:

Introduction

Due to the constant flows of information (from the system to the environment and vice versa), the system carries out a reasonable interaction with the environment, i.e. controls or is controlled. Information has become a means not only of production, but also of management.

Timely and operational information can help stabilize the system, adapt and (or) adapt, recover from violations of the structure and (or) subsystems. The development and stability of the system depends on the degree of awareness of the system, on the richness of experience of interaction between the system and the environment.

Information also has a certain redundancy: the more messages about the system, the more completely and more accurately it is controlled.

Example. When transmitting messages, the method of double (redundant) sequential transmission of each symbol is often used (which allows you to get rid of interference, "noise" during transmission and to carry out, for example, the parity of signals, the results of which reveal the number of failures). Suppose that as a result of a failure in transmission, the receiver received a word of the form "ппраосснтоо". Let us determine which meaningful (having semantic meaning) word of the Russian language was transmitted by the transmitter. It is easy to see that "candidates for the word" are the words "праспо", "проспо", "рроспо", "рраспо", "прасто", "рросто", "просто" and "рраспо". Of all these words, only the word "просто" is meaningful.

The essence of the system management task is to separate valuable information from "noise" (useless, sometimes even harmful to the system of information disturbance) and to extract information that allows this system to exist and develop. Management is purposeful updating of knowledge. Management and a special form – self-government – is the highest form of knowledge actualization.

1 Management in the system

Management in the system is an internal function of the system, carried out regardless of how, by what elements of the system it should be performed.

System control – the performance of external control functions that provide the necessary conditions for the functioning of the system (see Fig. 7.1).

Figure 7.1. General scheme of system control

System management (in the system) is used for various purposes:

1. *increasing the speed of message transmission;*
2. *increasing the volume of transmitted messages;*
3. *reducing the processing time of messages;*
4. *increasing the compression ratio of messages;*
5. *increase (modification) of system connections;*
6. *increasing information (awareness).*

Typically, these goals are integrated.

In general, the information is used for two main global purposes: maintaining the stable functioning of the system and transferring the system to a given target state.

Example. The emergence of the ability to control electrical and magnetic oscillations made radio and television widely available, while the speed of information transmission reached the speed of light; the bandwidth of the TV channel in comparison with the bandwidth of the telephone channel has grown by about 2000 times, the speedup of processing – by a million times. Both the conciseness of information and the information content of messages have increased.

Management of any system (in any system) must be supported by the necessary resources – material, energy, informational, human and organizational (administrative, economic, legal, humanitarian, socio-psychological type). At the same time, the nature and degree of activation of these resources can affect (sometimes only indirectly) and the system in which the information is used. Moreover, the information itself may be system dependent.

Example. In the media, the government is more often criticized, actors are more often praised, athletes are usually mentioned in connection with sports results, weather forecasts are usually brief, and political news is official.

Management is a continuous process that cannot be stopped, because the movement, the flow of information in the system does not stop.

The control cycle for any system (in any system) is as follows:

{collecting information about the system →
information processing and analysis →
getting information about the trajectory →
identification of control parameters →
defining resources for management →
system trajectory control}

Basic rules for organizing information for managing the system:

1. *clarification of the form and structure of the initial (input) information;*
2. *clarification of means, forms of transmission and sources of information;*
3. *clarification of the form and structure of the output information;*
4. *clarification of the reliability of information and control of reliability;*
5. *finding out the forms of using information for decision-making.*

Example. When controlling the flight of a rocket, the ground control station generates and, in a certain form, by certain structures, sends input information to the onboard computer of the rocket; in this case, the signals are eliminated from possible "noise", the input information is monitored for reliability, and only then the on-board computer makes a decision to refine the trajectory and correct it.

If the number of possible states of the system S is equal to N, then the total amount of diversity of the system (the measure of choice in the system - see above "information measures") is

$$V(N) = \log_2 N.$$

Let the controlled system have the variety $V(N_1)$, and the controlling system – $V(N_2)$. The purpose of the control system is to reduce the value of $V(N_1)$ by changing $V(N_2)$. In turn, a change in $V(N_1)$, as a rule, entails a change in $V(N_2)$, namely, the control system can effectively perform its inherent control functions only if the inequality is true

$$V(N_2) \geq V(N_1).$$

This inequality expresses Ashby's principle (the required variety of a controlled system): the controlling subsystem of the system must have a higher level of organization (or greater variety, more choice) than the controlled subsystem, i.e. diversity can be controlled (destroyed) only by diversity.

Example. The manager of the company should be more prepared, more literate, more organized, and more free in his decisions than, for example, the salesman of the company. Small and medium-sized companies, LLC, JSC are a necessary factor of diversity, successful business development, as they are more dynamic, flexible, and adaptable to the market. In developed market systems, they have a greater weight, for example, in the United States, the share of large corporations is no more than 10%.

2 System management functions and tasks

System management functions and tasks:

1. *System organization - a complete, high-quality selection of subsystems, a description of their interactions and the structure of the system (both linear and hierarchical, network or matrix).*
2. *Predicting system behavior, i.e. investigation of the future of the system.*
3. *Planning (coordination in time, space, according to information) of resources and elements, subsystems and system structure necessary (sufficient - in the case of optimal planning) to achieve the goal of the system.*
4. *Accounting and control of resources leading to certain desired system states.*
5. *Regulation - adaptation and adaptation of the system to changes in the external environment.*
6. *Implementation of certain planned states, decisions.*

The functions and tasks of system management are interrelated and also interdependent.

Example. It is impossible, for example, to carry out complete planning in the economic system without forecasting, accounting and control of resources, without analyzing supply and demand - the main regulators of the market. The economy of any state is always a controlled system, although control subsystems can be organized in different ways, have different elements, goals, structure, and relationships.

By the nature of management, coverage of subsystems and sub-goals (system goals), management can be:

1. *strategic, aimed at developing, adjusting the strategy of the system's behavior;*
2. *tactical, aimed at developing, adjusting the tactics of the system's behavior.*

By the time of the control action, the systems can be: long-term and short-term controllable.

Sometimes strategic and long-term, tactical and short-term management are equated, but this is not always true.

Example. Any serious economic system of strategic management should include a control (information) subsystem that processes, updates strategic information about innovative activities, investment conditions, opportunities and conditions of markets for goods, services, securities, available resources, financial conditions and criteria, principles and methods of management, etc. Such systems usually have the following goals and, often, corresponding structures:

1. *coordination management (Project Integration Management);*
2. *goal management (Project Scope Management);*

3. *time management (Project Time Management);*
4. *cost management (Project Cost Management);*
5. *quality management (Project Quality Management);*
6. *human resource management (Project Human Resource Management);*
7. *communication management (Project Communication Management);*
8. *risk management (Project Risk Management);*
9. *supply management (Project Procurement Management).*

All of these functions are closely intertwined.

Identifying control parameters and using them to control the system can also help reduce system complexity. In turn, reducing the complexity of the system can make the system manageable.

A system is called structurally stable (dynamically; computationally; algorithmic; informational; evolutionary or self-organizing) if it maintains a tendency to strive for the state that is most consistent with the goals of the system, the goals of maintaining quality without changing the structure or not leading to strong changes in the structure (dynamics of behavior; computing facilities; algorithms for the functioning of the system; information flows; evolution or self-organization - see below) of a system on a given set of resources (for example, on a time interval). The vague concept of "strong change" each time should be concretized, determined.

Example. Consider a pendulum suspended at some point and deflected from the equilibrium position by an angle $0 \leq \varphi \leq \pi$. The pendulum will be structurally, computationally, algorithmically and informationally stable at any point, and at $\phi = 0$ (the state of rest of the pendulum) it will be stable both dynamically and evolutionarily (we do not take into account self-organizing processes in the pendulum at the micro level). When deviating from a stable state of equilibrium, the pendulum, self-organizing, tends to equilibrium. At $\varphi = p$, the pendulum passes into a dynamically unstable state. If we consider ice (as a system), then at the melting temperature this system is structurally unstable. A market with unstable supply-demand is structurally unstable.

The more diverse the input signals (parameters) of the system, the number of different states of the system, the more diverse the usually output signals, the more complex the system, the more urgent is the problem of finding control invariants.

Complexity is detailed in different subject areas in different ways. To concretize this concept, it is necessary to take into account the background, the internal structure (complexity) of the system and the controls that lead the system to a stable state. However, in practice, all internal connections are difficult not only to describe, but also to detect. In these cases, it helps to clarify and describe the connectedness of the system, its connected and asymptotic stability.

Asymptotic stability of the system consists in returning the system to an equilibrium state at $t \to \infty$ from any nonequilibrium state.

Example. The famous toy "Vanka-vstanka" is an example of such a system.

Let the system S depend on the vector of factors, variables $x = (x_1, x_2, ..., x_n)$.

By the matrix of the system we mean the matrix $E = ||e_{ij}||$ from 1 and 0: $e_{ij} = 1$ only when the variable x_i affects x_j.

Connected stability consists in the asymptotic stability of the system for any matrices E.

Example. Consider a set of friends X = {Ivanov, Petrov, Sidorov} and cities Y = {Moscow, Paris, Nalchik}. Then you can build a 3D structure in R_3 (in the space of three dimensions - height, width, length), formed by linking elements X and Y, for example, according to the principle "who was where" (Fig. 7.2). In this structure, X, Y network 2D structures were used (which, in turn, used 1D structures). In this case, elements X and Y can be taken as points, elements of the space of zero dimension R_0.

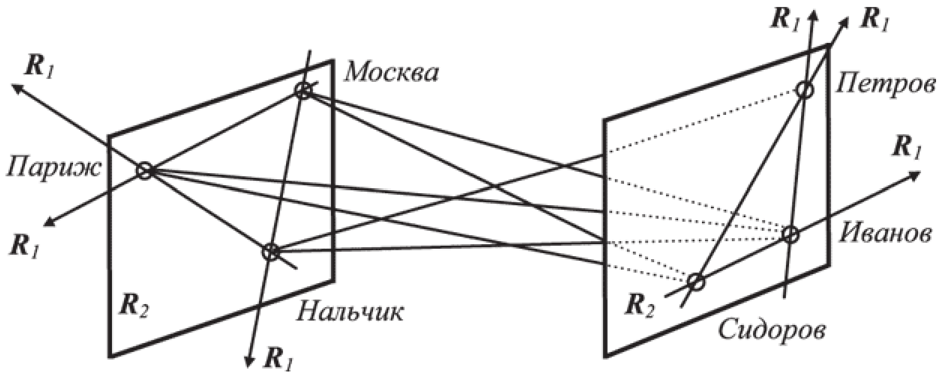

Figure 7.2. Geometric illustration of complex connected structures

3 Cognitology

In a systematic analysis of various systems, especially socio-economic ones, a convenient tool for their depiction and study is the cognitive structuring toolkit and the system-cognitive concept.

Cognitology is an interdisciplinary (philosophy, neuropsychology, psychology, linguistics, computer science, mathematics, physics, etc.) scientific direction that studies methods and models of the formation of knowledge, cognition, universal structural schemes of thinking.

The goal of cognitive structuring is to form and refine a hypothesis about the functioning of the system under study, i.e. structural diagrams of cause-and-effect relationships, their qualitative and (or) quantitative assessment.

A causal relationship between systems (subsystems) A and B is positive (negative) if an increase or increase in A leads to an increase or increase (decrease or decrease) in B.

The cognitive scheme (map) of the situation is a directed weighted graph, which is built according to the rules:

1. *vertices in one-to-one correspondence with the selected factors of the situation, in terms of which the processes in the situation are described;*
2. *the cause-and-effect relationships of the selected factors on each other are identified and assessed (positive influence, negative influence).*

Example. The cognitive block diagram for analyzing the energy consumption problem can be as follows (Fig. 7.3):

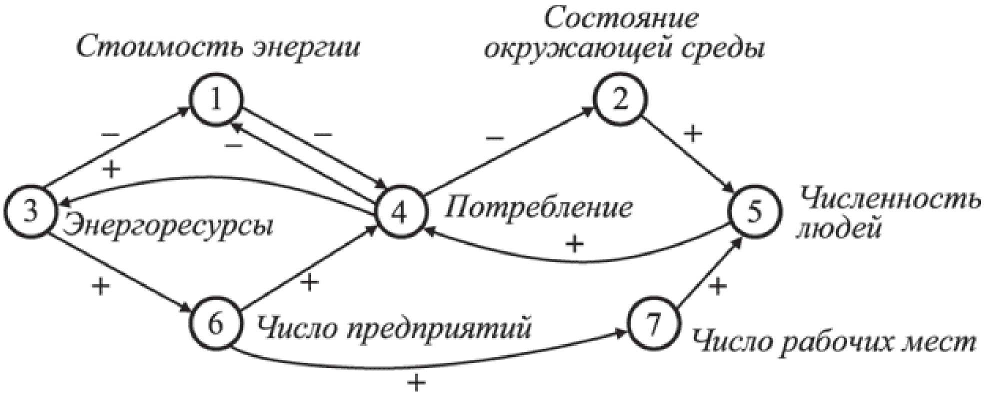

Figure 7.3. An example of a cognitive map

In addition to cognitive schemes (schemes of situations), cognitive grids (scales, matrices) can be used, which allow defining behavior strategies (for example, a manufacturer in the market). The lattice is formed using a system of factor coordinates, where each coordinate corresponds to one factor, indicator (for example, financial), or some interval of variation of this factor. Each region of the lattice corresponds to a particular behavior. Indicators can be relative (for example, from 0 to 1), absolute (for example, from minimum to maximum), bipolar ("high or large" - "low or small").

Example. Such grids can be useful, in particular, when optimizing the share distribution of the main group of taxes between the federal and regional budgets, when developing a strategy for increasing budgetary self-sufficiency, etc. 7.4 shows the lattice in bipolar metrics; zone D is the most, zone A is the least favorable.

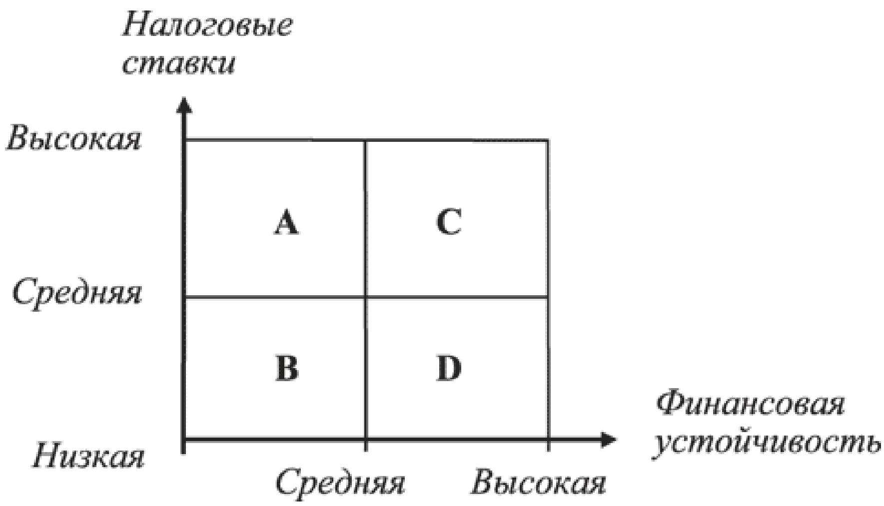

Figure 7.4. The cognitive grid of a firm's financial strength

Cognitive tools can reduce the complexity of research, formalization, structuring, and modeling of the system.

The cognitive map does not reflect the detailed nature or dynamics of changes in influences depending on the changing situation. To do this, it is necessary to build an appropriate procedure for cognitive system analysis, according to the scheme below.

The procedure for the cognitive analysis of the system, situation.

1. *Allocation of the main factors of the system.*
2. *Determination of target factors in the selected factors.*
3. *Identification of factors that can influence target factors.*
4. *Determination of factors that can explain the development of the system, and their grouping into clusters of factors (as a rule, this is a hierarchical system, at the lower level of which the most elementary ones are located, at the next level, integral ones, etc.).*
5. *Allocation in the cluster of a group of integral factors and indicators characterizing them, which can be informative (explaining the development trends of the system), and their detailing, formalization, mathematization.*
6. *Determination of links between clusters.*
7. *Determination of connections and character (for example, positive, negative) and the strength of mutual influences within the clusters.*
8. *Checking the adequacy of the cognitive schema, i.e. comparison of the results obtained with the logical and historical manifestations of the system.*
9. *Correction, clarification of the scheme.*

This procedure underlies the system-cognitive concept, on the basis of which they try to adequately, in a structured manner, using simple basic cognitive operations and, if possible, formally, mathematically reflect and automate the essence of the process of human cognition, for example, the processes of verbalization, syntactic synthesis, semantic analysis. , prototyping, virtualization, etc.

The basic cognitive operations (procedures) include (see also the system procedures mentioned in "History, subject, goals of system analysis"):

- ✓ *perception, registration of a property, relationship, object, process, system;*
- ✓ *assignment of a unique name to a property, relation, object, process, system;*
- ✓ *scaling and clustering, classification;*
- ✓ *generalization;*
- ✓ *comparison;*
- ✓ *identification, recognition of an object by its manifestations;*
- ✓ *morphological analysis (for example, relationships between elements);*
- ✓ *parsing (for example, attributes of elements and classes);*
- ✓ *semantic analysis (for example, class relationships);*
- ✓ *verification, comparison with experience and conclusion about training;*
- ✓ *planning an experiment;*
- ✓ *decision-making.*

Conclusion

The problems of system control (in the system), the scheme, goals, functions and tasks of system control, the concept and types of system stability, elements of cognitive analysis are considered.

Control questions

See the manual on the organization of students' independent work.