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MULTILEVEL HIERARCHICAL MODELS AS A METHOD OF CONSERVATION OF INTEGRATED REPRESENTATION IN THE STUDYING OR ENGINEERING THE SYSTEM

VOLKOVA VIOLETTA (ORCID 0000-0001-9658-5135)[1],
LOGINOVA ALEKSANDRA (ORCID 0000-0002-7783-7795)[1]

[1]Peter the Great St.Petersburg Polytechnic University

Abstract. The problem of preserving the integrity of a complex system during the procedure of decomposition, dividing into more observable components that can be better understood and modeled, is considered. The concept of preserving the integrity of the system when dividing it into components is one of the basic principles of the system analysis. The implementation of this fundamental allows to work at different levels of models of complex systems, while maintaining a connection with the overall objectives of the system through the application of system theory methods. Traditionally the group of methods for the construction of a tree-visible hierarchical structure reflecting the connections between the elements of the system is used. However, the lack of a hierarchical structure is that the horizontal links in it are "broken", since the components of the same level are in a state of "rivalry". Therefore, it is proposed to apply stratified models.

Keywords: system, system analysis, stratum, structure, systems theory, integrity.

The one of the basic principles of system analysis, that helps to investigate problems with great initial uncertainty, is the fundamental nature of division of a complex system into more visible components that are more convenient to comprehension and modeling. The difficulty of such division lies in the fact that a researcher can lose the whole idea of a system.

Figuratively, this idea can be illustrated by a quotation from I.V. Goethe, cited in [1]: "Wishing to study a living object, so that a clear knowledge of it was obtained, the scientist first seizes the soul, then dissects the subject, and sees them. Yes, it's a pity, their spiritual connection has disappeared meanwhile, has been carried away".

In the first method of system analysis PATTERN (pattern – template, target; abbreviation PATTERN means Planning Assistance through Technical Evaluation from the Relevance Number), this "dismembering" of the general problem was proposed to be done by constructing tree-like hierarchical structure – a "tree of goals", and by distributing the obtained sub-goals and problems between scientific collectives that are able to investigate these problems.

Already in the first examples of application of systems theory and system analysis methods to managing the design of complex products the research and design processes were presented in a form of related stages. It helps to maintain the integrity of processes at the stages of research, design and product development.

This experience was transferred to the study of systems in the field of organizational management, as well as to the field of information systems management. However, for such objects the stages of project works most often cannot be described by a simple linear sequence of events, i.e. cannot be represented as a directed graph. Such structures could be well described using arbitrary graphs with breaks and feedbacks, in which the stages were located either horizontally or vertically, in analogy with the formats adopted in the theory of algorithmization and programming, but without strictly observing the rules for the design of algorithms [e.g., 2, 3].

As technical complexes and organizational systems became more complex the new forms of structures for representation of the project task organization were offered. For example, it was suggested to present the structure in the form of a two-dimensional matrix [2].

In the theory of hierarchical systems developed by M. Mezarovich structures like "strata", "layers", "echelons" were described. The stratified representation of a system assumes that the system is specified by a series ("family") of models. Each of these models describes the behavior of the system from the point of view of the corresponding level of abstraction (which is called a "strata"). This approach allows to solve a problem of finding a compromise between preserving a holistic view of a complex system and detailing the description of its components [4].

The simplest example of a stratified description of the system, given in [4], was a map of a computer device in a form of two strata: strata of physical operations (at the lower level) and strata of mathematical and logical operations (at the upper level).

In a stratified form, one can also imagine the problem of text modeling: letters → words → sentences → paragraphs →x text. In this case, the rules for converting elements of one level to another (synthesis or, conversely, "disassembly" of the text) can be introduced. Such rules are used in the development of analytical-synthetic text processing systems and artificial languages, they are also used in automation systems design.

Another example of a stratified description of a system proposed in the period of the theory of systems formation in our country was given by Yu.I. Chernyak [5], who singled out the levels of abstraction on which the designers of the system consistently work: from the philosophical (theoretic-cognitive) description, i.e. concept of the system, to its material embodiment. Such a representation helps to understand that the same system at different stages of cognition and design should be described by different means, in different "languages": philosophical or theoretical-cognitive language is used for verbal description of the concept; research language in a form of models of all kinds helps to understand better and reveal the design of the system; project language is used for technical project, for the development and presentation of which mathematical calculations and schematic diagrams may be required; engineering language (language of constructors) is utilized at the stage of making design drawings and accompanying documentation; technological language is a language for technological maps, standards and other technological documentation; material implementation (system implementation) is the stage at which the language describes parts, blocks, assembled product or a whole system created, the principles of functioning of which are reflected in the relevant normative and technical and regulatory documents (operating instructions, regulations, etc.).

The stratified view can be used as a tool for successively enhancing knowledge about the system: moving from top to bottom along the hierarchy of strata allows one to detail the properties of the components of the system; while moving along the strata from the bottom up one could obtain clearer the meaning and significance of the entire system. However, it is practically impossible in complex systems to explain the purpose of a system as a whole knowing only the properties of a lower strata elements. For example, as noted by R. Akoff and F. Emery in [6], the study of the structure and properties of separate organs of a human body will not allow us to understand how the organism is functioning as a whole, and especially such approach will not give an idea of what a person is like as a social -biological system. On the other hand, in order to properly understand and implement the overall design of the system, it is necessary to implement the underlying strata.

Russian scientist F.E. Temnikov illustrated the idea of the system specification on each level of the system as shown in Fig. 1, although the term "strata" was not used at that time.

The process of studying the system could be started from a stratum of any level. In the process of research new strata can be added, and the approach to stratification can change. It is possible to use a special description and modeling language at the level of each stratum, but the system exists until the representation on the upper stratum, that is the conception of the system, is not changed. This conception ("general plan" of a system) should not be destroyed when the system properties are uncovered on each subsequent stratum.

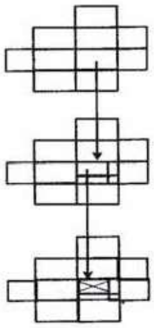

Fig. 1 The stratified representation of a system proposed by F. E. Temnikov
Source: [7, c. 53]

When presenting the enterprise management system, the strata can correspond to the existing levels: 1) management of technological processes (actual production process) or management of the production service; 2) the system of the enterprise organizational management. These spheres could be placed in the model in parallel, divided into sub-goals and tasks that will lead to the formation of a tree-like hierarchical structure of goals and functions. But in the hierarchical structure the connection between the components of the same level is practically lost, while it is possible not to lose the horizontal connections in the structures of the "strata" and "echelons" types suggested by M. Mesarovic.

The stratified representation was used to form the structure of the functional part of the Automated Control System of the Volzhsky Automobile Plant (AVTOVAZ), when the number of subsystems became too large to form the usual "tree" structures of the functional part of an information system [7].

Different principles could be used for determine strata. For example, the definition of a system implementing a system-target approach [8] could be taken into account. In this definition the object is not "broken up" into elements, that is, it does not break down, but is represented in the form of enlarged components:

S def = <Z, STR, TECH, COND, N>,

where Z = {z} means a set (structure) of goals; STR = {STRpr, STRorg, ...} means the set of structures that implement the goals (for example, for a socio-economic organization STR is an industrial structure and an organizational structure, etc.); TECH = {meth, means, alg, ...} means technologies (methods, tools, algorithms, etc.), implementing the system, ensuring its existence and functioning; COND = { CONDex, COND in} means conditions of the system existence, i.e., factors affecting its creation and functioning (CONDex are external conditions, CONDin are internal conditions); N means "observers", i.e., persons who make and execute decisions, structuring goals, adjusting structures, selecting methods and tools for modeling, etc. This definition can be supplemented with the components "environment" (SR) and "time interval" *Dt.*

The definition given above helps to start the exploration of a complex object, preserving its integrity. For example, the structure of the information and control complex of the organization was developed with the support on this definition (see Fig. 2).

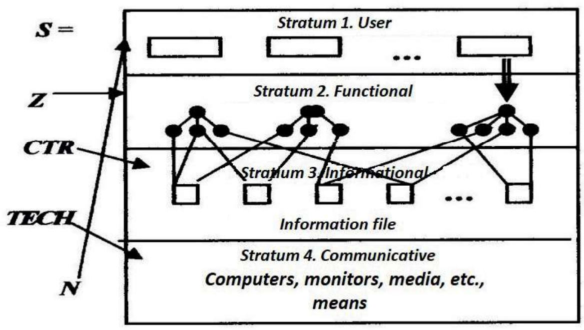

Fig. 2 The stratified structure of the information and control complex
Source:[8]

CONCLUSION

The article substantiates the usefulness of a stratified representation of complex systems for preserving a holistic view of them in the course of their decomposition in the process of research or design.

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