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THE PRINCIPLE OF CHARACTERIZATION AS A SYSTEMIC PARADIGM OF SAFETY: EXPERIMENTS AND APPLICATIONS

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Abstract: This work is devoted to promoting the principle of characterization, treated as a systemic paradigm binding in an integral whole the functional and structural aspects of any organization, understood as a deliberate relationship of related resources. The principle of characterization and the specific characterization theories built on its basis belong to the methodology of systemic research. Its essence is the axioms contained in model Ψ_a of the proper functioning, which are assigned to the relationships contained in model Ψ_b of the structure of this organization. The functional–structural paradigm considered is characteristic primarily of project activity in which an efficient structural response to a certain problem of the correct (safe) functioning of the organization as a whole or its considered part is sought after.

Keywords: principle of characterization, security paradigm, graphical axiomatic of the proper functioning, semantic graph model, prohibited graph figure.

JEL: C4, C5.

1 Introduction[1]

From the analysis of examples of the rapidly growing literature of management sciences, one can assume that their development results from the emergence of new paradigms as an attempt to answer the need and sometimes necessity, explain, and generalize new socio-economic phenomena, civilization changes, and technological progress (Krupa, 2010; Kulińska, 2011; Prokopowicz and Krupa, 2008), which escape the simple judgment of industry observers. An example of such paradigms in the world of socio-economic phenomena is the idea of corporate social responsibility or the concept of sustainable (responsible) development. The world of technology and engineering looks radically different, the ideas of which take the shape of structured products. Social ideas have been dying for centuries, leaving behind traces of papyrus, clay tablets, handmade paper, and, recently, optical media or various kinds of e-books and iPhones. It is a linguistic trace, a trace of graphic symbols understandable to philosophers and, in part, less-sophisticated witnesses of passing eras.

2 The model of the characterization principle

The relationship between the functioning of any object and its structure is considered natural (obvious) for work in the field of decomposition and solving any task of designing organizational and technical systems, particularly tasks of designing intelligent decision support systems in various areas of applications.

The first theoretical solutions regarding structural and functional relationships were presented by V.A. Gorbatov in the work on the theory of partially ordered systems used in the synthesis of logical structures that perform the functions of logic algebra, under the name "principle of characterization" (Gorbatov, 1979; Kieżun, 1998; Krupa, 1976). The continuation of this research has led to the formulation and development of the characterization principle for the

[1] The article was prepared on the basis of the chapter *Zasada charakteryzacji jako systemowy paradygmat w naukach o zarządzaniu: eksperymenty i zastosowania* (Principle of characterization as a systemic paradigm in management sciences: Experiments and applications), contained in the monograph *Stan i perspektywy rozwoju nauk o zarządzaniu* (*State and prospects of development of management sciences*) by A. Zakrzewska-Bielawska (ed.) (Toruń: Organizer's House, 2016). The permission to print the chapter in the journal *Foundations of Management* was given by Aneta Sylvia Szóstek, PhD, President of TNOiK, Branch in Toruń.

design of complex organizational and technical systems.

The prototype of the characterization principle was proposed by V.A. Gorbatov as a basic model of characterization theory, expressed in the following statement:

$$< \Psi_a, \Psi_b, P_0(\Psi_a, \Psi_b) > \qquad (1)$$

where:

Ψ_a - is a model of functioning of the object under consideration,

Ψ_b - is the structure model of this object,

$P_0(\Psi_a, \Psi_b)$ - is an atomic predicate characterizing the possibility of model Ψ_a interpretation and in terms of model Ψ_b and vice versa, model Ψ_b in terms of model Ψ_a.

The value of 1 of the predicate $P_0(\Psi_a,\Psi_b)$ means that we have achieved a state of mutually unambiguous interpretation of the models Ψ_a and Ψ_b. The value 0 of the predicate $P_0(\Psi_a, \Psi_b)$ means that such a state could not be obtained.

We consider the relationship of functioning and structure to be necessary for the whole analytical and synthetic work in the field of decomposition and solving tasks related to the object under consideration (e.g. design tasks).

The first theoretical solutions regarding structural and functional relationships were carried out by V.A. Gorbatov in research on systems partially ordered during the synthesis of large and especially complex logical structures of the microprocessor type of calculating machines. The continuation of this research led to the formulation and subsequent development of the characterization principle for the tasks of analysis and design of broadly understood organizational and technical systems (Krupa, 2002; Krupa and Prokopowicz, 2010).

Mutual interpretation of models Ψ_a and Ψ_b is obtained by the selection of universal rules for the "correct" functioning of the Ψ_a model, expressed in the structure of the Ψ_b model. An illustration of different possible mutual interpretations of models Ψ_a and Ψ_b is shown in Fig. 1. Ambiguities of mappings indicate the ambiguity of interpretation, which corresponds to the situation of $P_0(\Psi_a, \Psi_b) = 0$.

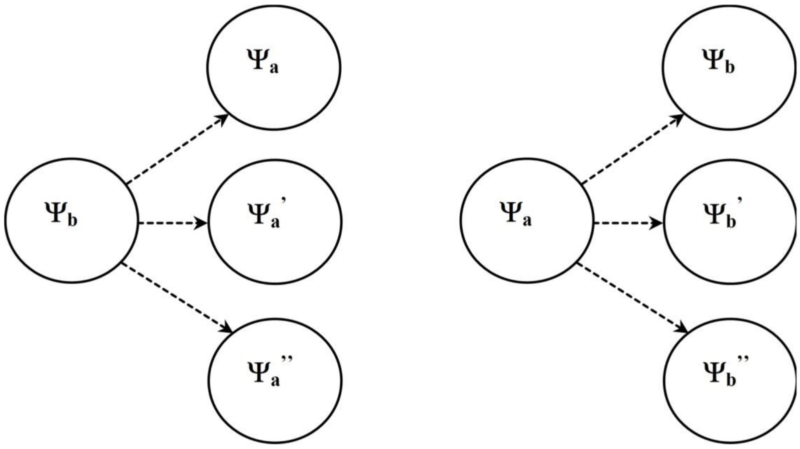

Figure 1. Ambiguous interpretations of the Ψ_a and Ψ_b models
(*Source:* own elaboration)

The rules for the proper functioning of logic algebra functions for logical structures are formulated using the so-called prohibited figures class Q^A and Q^B of the model Ψ_a (Fig. 2 and Fig. 3). These figures are often called graph figures due to the graphic form of their structure.

The elements of the construction of "carousel" graph figures Q^A and graph figures such as "snowflake" Q^B are symbols of events X_i. The symbols are accompanied by the sequence numbers in brackets in which these events occur.

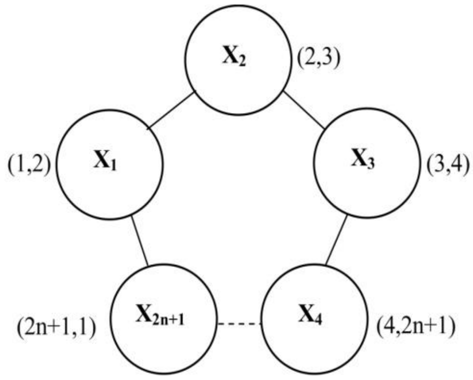

Figure 2. Prohibited graph figure class Q^A (*Source:* V.A. Gorbatov elaboration)

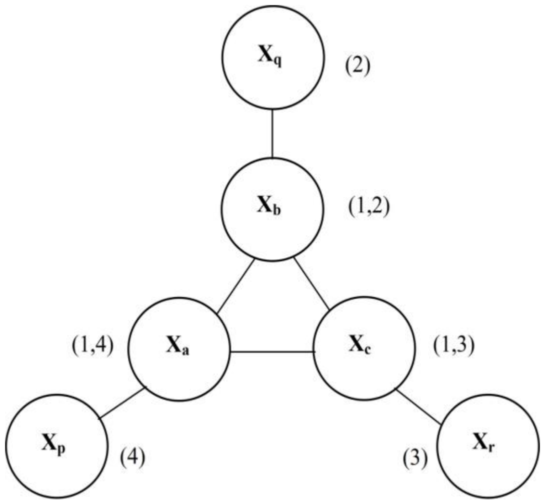

Figure 3. Prohibited graph figure class Q^B (*Source:* V.A. Gorbatov elaboration)

The idea of the proper functioning of a specific object can be asked through the mutual interpretation of the Ψ_a and Ψ_b models as follows:

- the object functions adequately to its structure described by model Ψ_b,
- the structure of the object is adequate to the desired function described by model Ψ_a.

A satisfactory interpretation is obtained when the model of functioning Ψ_a (e.g. model of solving a specific problem (Krupa and Ostrowska, 1990) is recorded in the form of axioms of proper functioning expressed in the form of illicit graphic forms.

Thanks to this approach, one can create flawless (and also optimal in terms of meeting certain criteria) project solutions avoiding the time-consuming and unreliable process of building and direct (physical) testing of the prototypes of the structures of these solutions. For example, when designing an information and decision system (management system) for a large enterprise, the principle of characterization comes down to an interpretation of the model Ψ_a of decision-making processes of this enterprise (with complex logical, time, and priority relationships) in terms of a structural model Ψ_b of its organizational and technical resources. Interpretation is achieved through the axiom of proper functioning expressed by the absence of prohibited graphical figures of model Ψ_a.

A necessary condition for the correctness of the project is the absence of homeomorphic graphical figures for the prohibited graphical figures of the characterization principles developed for this purpose. Search and disintegration of such figures are fundamental theoretical difficulties in applying the characterization principle in design. As a result of establishing the unambiguous equivalence of the models Ψ_a and Ψ_b, it is possible to effectively differentiate the solutions in the designed system (information, technology, or infrastructure) without the need for time-consuming and costly testing. The key result of such a procedure is the theoretically proven faultlessness of the solution written in the form of the atomic predicate $P_0(\Psi_a, \Psi_b)$.

3 Experiment I - The model of functioning Ψ_a of concurrent processes described by event sequences

As part of experiment I, we will consider an example of the application of the characterization principle to the design of the logical structure of processes given by sequences of coincident events (Krupa, 2009a; Krupa, 2009c). For this purpose, we will express n alternative sequences of permissible concurrent events, described by the expression:

$$(X_1 \# X_2 \# \ldots \# X_m)_1 \text{ V } \ldots \text{ V } (X_1 \# X_2 \# \ldots \# X_m)_n \quad (2)$$

where:

Xi - represents any event in one of the alternative sequences;

V - symbol of sequence alternative;

\# - symbol of concurrency of events in alternative sequences.

An example sequence of alternative sequences of concurrent events has the form:

$$\begin{aligned}&(X_1\#X_7\#X_9)_1 \text{ V } (X_1\#X_4)_2 \text{ V } (X_2\#X_3)_3 \text{ V}\\&(X_6\#X_3\#X_9)_4 \text{ V } (X_3\#X_8\#X_5)_5 \text{ V}\\&(X_2\#X_4\#X_5)_6 \text{ V } (X_1\#X_3\#X_8)_7\end{aligned} \quad (3)$$

The next step to build a model of functioning Ψ_a (Fig. 3) is Table 1 based on the expression (3), in which each event of X_i is assigned sequence numbers containing this event. On this basis, a graphical model of Ψ_a operation will be created, whose vertices are assigned X_i events. At the edges, these vertices are joined, the events of which occur in common sequences.

Table 1. Events and their sequence numbers (*Source:* own elaboration)

X_1	X_6	X_2	X_3	X_7	X_4	X_8	X_5	X_9
(1,2,7)	(4)	(3,6)	(3,4,5,7)	(1)	(2,6)	(5,7)	(5,6)	(1,4)

The condition of functional correctness of alternative sequences of concurrent events is, according to the Gorbatov characterization principle, the absence of graph figures of the Q^A class (Fig. 2) and graph figures of the Q^B class (Fig. 3).

In the graphical model of functioning Ψ_a, shown in Fig. 4, four prohibited figures of class Q^A and seven prohibited figures of class Q^B, corresponding to the graph figures shown in Fig. 2 and Fig. 3, are found below.

Prohibited graph figures class Q^A:

$$\begin{aligned}Q_1^A &= \{X_1(1,2)\ \ X_4(2,6)\ \ X_2(6,3)\\&\qquad X_3(3,4)\ \ X_9(4,1)\}\\Q_2^A &= \{X_1(1,2)\ \ X_4(2,6)\ \ X_5(6,5)\\&\qquad X_3(5,4)\ \ X_9(4,1)\}\\Q_3^A &= \{X_2(6,3)\ \ X_3(3,5)\ \ X_5(5,6)\}\\Q_4^A &= \{X_1(1,7)\ X_3(7,4)\ \ X_9(4,1)\}\end{aligned} \quad (4)$$

Prohibited graph figures class Q^B:

$$\begin{aligned}Q_5^B &= \{\ X_2(3,6)\ \ X_4(2,6)\ \ X_5(5,6)\ \}\\Q_6^B &= \{\ X_1(1,7)\ \ X_8(5,7)\ \ X_3(3,7)\ \}\\Q_7^B &= \{\ X_1(2,7)\ \ X_8(5,7)\ \ X_3(3,7)\ \}\\Q_8^B &= \{\ X_1(1,7)\ \ X_8(5,7)\ \ X_3(4,7)\ \}\\Q_9^B &= \{\ X_1(2,7)\ \ X_8(5,7)\ \ X_3(4,7)\ \}\\Q_{10}^B &= \{\ X_3(3,5)\ \ X_8(7,5)\ X_5(6,5)\ \}\\Q_{11}^B &= \{\ X_3(4,5)\ \ X_8(7,5)\ X_5(6,5)\ \}\end{aligned} \quad (5)$$

The condition for obtaining a flawless structure model Ψ_b is to remove from the functioning model Ψ_a all of its prohibited graph figures. The removal of prohibited graph figures takes place through "galvanic" splitting of X_i events selected for this purpose.

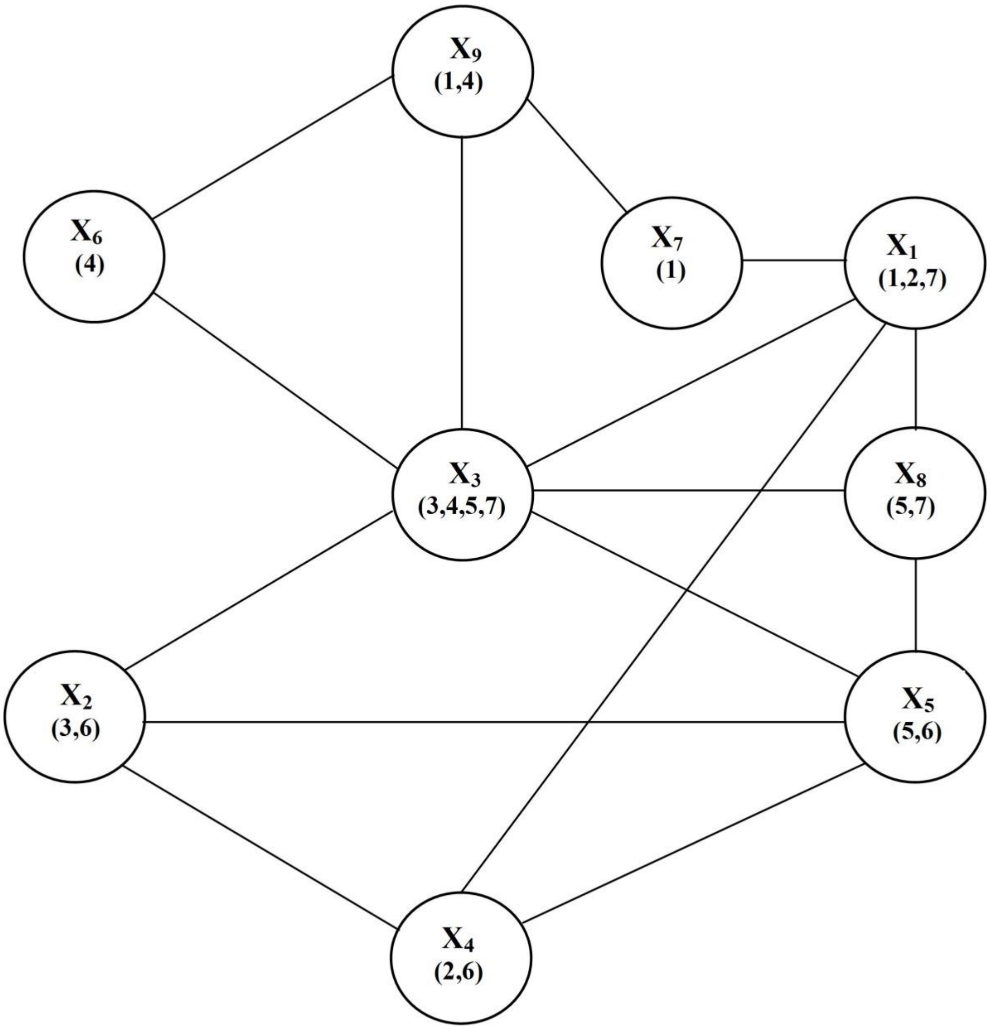

Figure 4. Graph model of functioning Ψ_a (experiment I)
(*Source:* own elaboration)

As a result of splitting, an event is exchanged for two or more "galvanic replicas," the feature of which is that despite different names they simultaneously carry out the same event in different places[2].

The cleavage should be carried out in such a way that the number of replicas created additionally is as small as possible. For this purpose, a semantic table is created (Table 2), the columns of which are described by events and pairs of corresponding sequence numbers, and the rows by the corresponding identifiers of prohibited graphical figures of the Q^A class and the Q^B class.

Obtained as a result of removing prohibited graphical figures from the functioning model Ψ_a, we mark it as Ψ_a*. Such a model meets the conditions of Gorbatov's characterization principle (1) and can be directly used to build the structure model Ψ_b in the form of so-called Hasse diagrams[3].

In the semantic table (Table 2), the symbol 1 is placed at the intersection of columns and rows, if the event and the corresponding pair of sequence numbers appear in the given forbidden graphic figure. Then, from all the columns corresponding to the events, their minimal set is selected so that the corresponding symbols 1 cover all the figures, which means that each line should contain at least one symbol 1.

[2] On different object channels.

[3] Hasse diagram - a graphical form of expressing the partial ordering of binary relation on the set of elements, when it is a reverse, anti-symmetric and transitive relation; the name comes from the name of the German mathematician Helmut Hasse.

Table 2. Semantic table indicating the connections of prohibited events and figures
(*Source:* own elaboration)

	Process events mapped in the operating model												
	X_1	**X_1**	**X_1**	**X_2^***	**X_3**	**X_3**	**X_3**	**X_3**	**X_3**	**X_4**	**X_8^***	**X_5**	**X_9^***
	Sequence numbers of the occurrence of events												
	1,2	1,7	2,7	3,6	3,4	3,5	3,7	4,5	4,7	2,6	5,7	5,6	1,4
Prohibited graph figures of the Q^A class													
Q_1	1			1	1					1			1
Q_2	1							1		1		1	1
Q_3				1		1						1	
Q_4		1							1				1
Prohibited graph figures of the Q^B class													
Q_5				1						1		1	
Q_6		1					1				1		
Q_7			1				1				1		
Q_8		1							1		1		
Q_9			1						1		1		
Q_{10}						1					1	1	
Q_{11}								1			1	1	

As a result of splitting events[4] $X_2(3,6)$, $X_8(5,7)$ and $X_9(1,4)$ (Fig. 5), next to the originals, replicas of events were also marked with the symbol "*": $X_2^*(6)$, $X_8^*(7)$ and $X_9^*(4)$. These replicas were introduced (by replacing the originals) directly to the sequence of alternative sequences of concurrent events. The result is a functional and structural correct sequence of alternative sequences of concurrent events:

$$(X_1\#X_7\#X_9)_1 \ \mathrm{V}\ (X_1\#X_4)_2 \ \mathrm{V}\ (X_2\#X_3)_3 \ \mathrm{V}$$
$$(X_9^*\#X_6\#X_3)_4 \ \mathrm{V}\ (X_3\#X_8\#X_5)_5 \ \mathrm{V} \qquad (6)$$
$$(X_2^*\#X_4\#X_5)_6 \ \mathrm{V}\ (X_1\#X_3\#X_8^*)_7$$

From the obtained form of the Ψ_a^* model, one can start to build Hasse diagrams (twigs) (Fig. 6), which already directly represent the model of the structure Ψ_b. The structure model Ψ_b obtained in the form of the Hasse diagram is isomorphic to the model of the functioning of Ψ_a^* written in the form of sequences of alternative sequences of concurrent events (taking into account the events already split).

At this point, it is worth paying attention to the computational complexity of even small Ψ_a^* models stored in sequences of alternative sequences of concurrent events (6). In the example under consideration, the computational complexity (7) of searching for Hasse diagrams in seven alternative event sequences can be determined by the expression:

$$\Sigma\, |X_i|_j! = |X_i|_1! + |X_i|_2! + |X_i|_3! + |X_i|_4! + |X_i|_5! + |X_i|_6! + |X_i|_7! \qquad (7)$$

where: $|X_i|_j!$ - the strong number of X_i events included in the j-th order.

[4] The fission operation and its products are marked with the symbol "*".

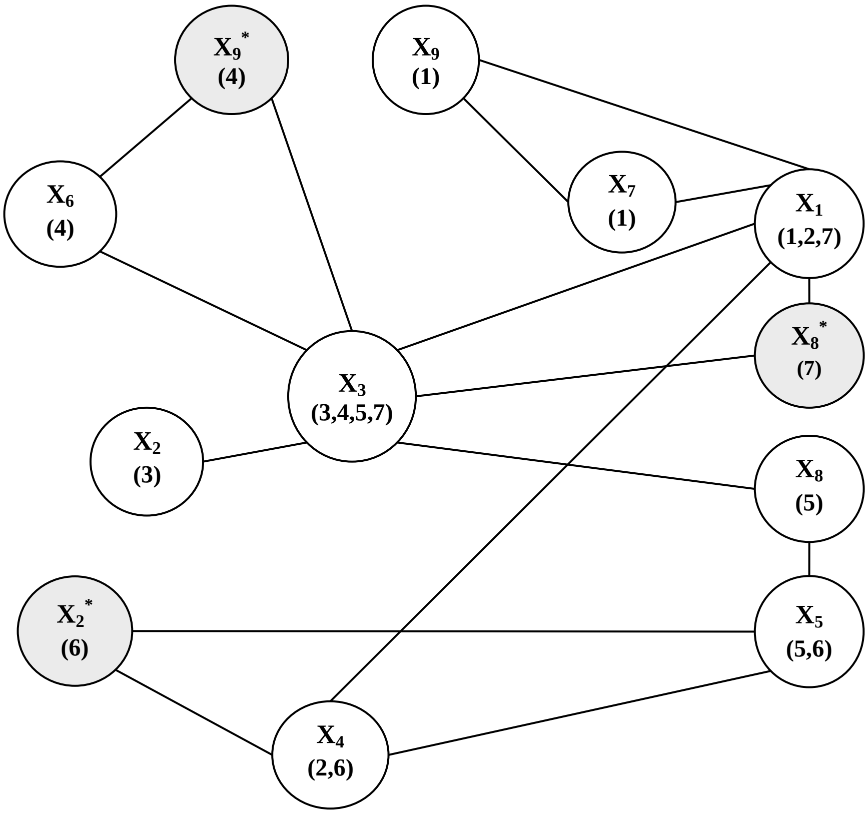

Figure 5. Graphical model of functioning Ψ_a^* after splitting (*) of events X_2, X_8, and X_9 (experiment I) (*Source:* own elaboration)

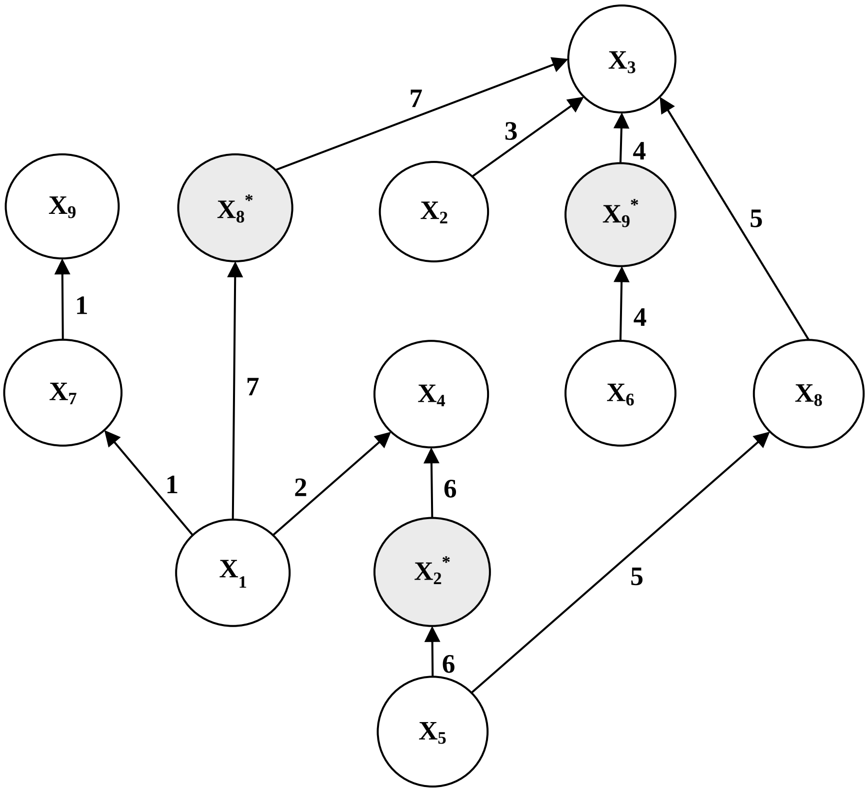

Figure 6. Hasse diagram as a structure model Ψ_b (experiment I); the numbers on the graph arcs connecting the pairs of events are the sequence numbers in which the given events occur (*Source:* own elaboration)

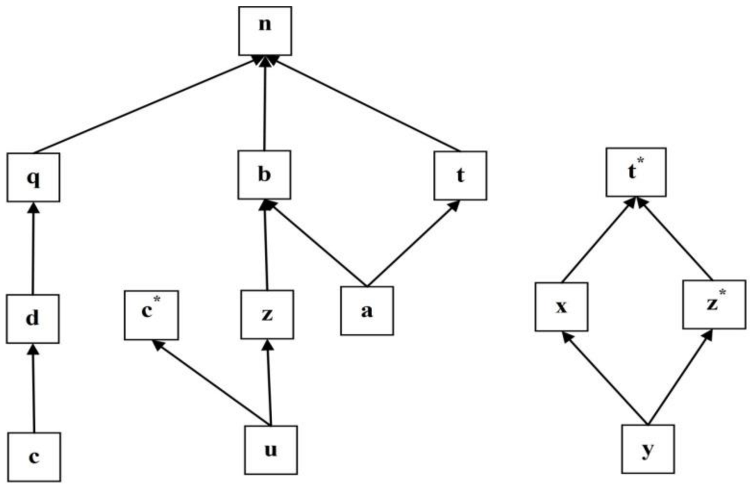

Figure 7. Example of linking tasks in the Hasse diagram structure (experiment II)
(*Source:* own elaboration)

In the case at hand, it will be over 40,000 event distribution combinations in all alternative sequences of concurrent events for which it would turn out that it is impossible to build a single valid operating model Ψ_a^* in the form of the expected Hasse diagram.

In order to build a correct model Ψ_a^*, for some events occurring in sequences, one needs to create their "galvanic replicas" by distinguishing their names and possibly places (channels[5]) in which these events can occur. In particular:

- event X_2 should start sequence No. 3, and the galvanic event X_2^* should go inside sequence No. 6,
- event X_8 should be inside sequence No. 5, and the galvanic event X_8^* should be inside sequence No. 7,
- event X_9 should end sequence No. 1, and the galvanic event X_9^* should be inside sequence 4.

4 Experiment II - The characterization principle applied to concurrent implementation of projects defined as task sequences

In experiment II, concurrent implementation of projects consisting of a sequence of tasks belonging to the set {a, b, c, d, n, q, t, u, x, y, z} is considered, which may be implemented with different limitations of their order of initiation. Let's assume that the list of projects has the form:

$$\begin{aligned} &P1 = \{a, b, n\},\\ &P2 = \{a, n, t\},\\ &P3 = \{b, n, u, z\},\\ &P4 = \{t, x, y\},\\ &P5 = \{c, d, n, q\},\\ &P6 = \{t, y, z\},\\ &P7 = \{c, u\} \end{aligned} \tag{8}$$

The task can be started if all the resources necessary for its implementation are gathered, and it is possible to terminate it in such a way that all resulting resources of this task become input resources for other waiting tasks. Tasks with the same name (Fig. 7) can be, with splitting accuracy, carried out in different projects (8) (e.g. c and c^* in P5 and P7 projects or in shared parts of these projects, such as t^* task in projects P4 and P6).

In the first part of this experiment, we assume for simplicity that the order of tasks in the project is arbitrary. The structure of projects shows that some tasks occurring in them are repeated many times. For the sake of simplifying the experiment, we assume that repeats occurred no more than three times.

For the considered projects, bypassing Gorbatov's characterization rule for a while, we will build an intuitive (arbitrary) structure of Hasse diagrams shown in Fig. 7. Each of the diagrams in the struc-

[5] Channel - auxiliary concept; the channel acts as a memory for events, states and their effects.

ture in Fig. 7 represents a sequence of tasks initiated sequentially from the lower level up.

All repetitive tasks are marked with the "*" fission symbol used in the characterization rule (Fig. 5), although in this case they did not arise as a result of fission within the meaning of this principle. The diagram shown in Fig. 7 has the main disadvantage resulting from the necessity of synchronizing projects P1, P2, P3, and P5 as well as projects P4 and P6 in order to eliminate the multiple initiation of the top-level tasks n in the first and tasks t^* in the second collection of projects.

For the list of projects (8), presented in Fig. 7 in the form of the Hasse diagram, we get the following task sequences:

$$\begin{aligned} &\langle a, b, n\rangle_1, \langle a, t, n\rangle_2, \\ &\langle u, z, b, n\rangle_3, \langle y, x, t^*\rangle_4, \\ &\langle c, d, q, n\rangle_5, \langle y, z^*, t^*\rangle_6, \\ &\langle u, c^*\rangle_7 \end{aligned} \tag{9}$$

The above result was obtained as a result of an intuitive (natural) approach to solving the considered example of the list of projects (8). We easily find three tasks for which replicas c^*, t^* and z^* should be created in projects P4, P6 and P7. A new set of projects with tasks ordered in accordance with the Hasse diagrams (Fig. 7) will have the form:

$$\begin{aligned} P1 &= \{a, b, n\}, \\ P2 &= \{a, t, n\}, \\ P3 &= \{u, z, b, n\}, \\ P4^* &= \{y, x, t^*\}, \\ P5 &= \{c, d, q, n\}, \\ P6^* &= \{y, z^*, t^*\}, \\ P7^* &= \{u, c^*\} \end{aligned} \tag{10}$$

The order of tasks in project task sets (8) does not match their order in the diagrams shown in Fig. 7.

The following working hypothesis can be formulated on the basis of the first part of experiment II:

For a given set of Z tasks implemented in the set of projects P in such a way that each P_i project is a subset of arbitrarily ordered tasks from the set $Z / P_i \subset Z$, one can build – using Gorbatov's characterization principle – the model of functioning Ψ_a and the structure model Ψ_b in the form of Hasse diagrams. The number of replicas of these tasks is not less than a certain number of γ sufficient to fully cover all prohibited figures in the semantic table, appearing in the model of functioning Ψ_a. The number of γ cannot be determined in advance by omitting the characterization principle – see analogous example of a semantic table contained in Table 2 (experiment I).

The proof for the correctness of the above hypothesis results directly from Gorbatov's characterization principle described by the model and its forbidden figures, Q^A class and Q^B class.

In the second part of experiment II in Fig. 8, we present the model of functioning of Ψ_a describing the dynamics of the set of projects from the list (8). It is easy to see in it, among other things, "carousel" figures of the Q^A class (e.g. cycles: [z↔t↔n↔z], [z↔y↔t↔a↔n↔z], [c↔u↔z↔t↔n↔c], [u↔n↔c↔u]) and Q^B class (e.g. flakes: [u∴z∴n], [n∴a∴b], [z∴y∴t], [n∴a∴t] of snowflake figures). This is not a full list of prohibited figures; finding them all has, in a general case, a combinatorial character and can only be effectively carried out using heuristic algorithms.

The seven projects we consider can theoretically be implemented as 1,492,992 scenarios, among which we are looking for projects that will minimize the number of split tasks (minimizing the replication of tasks). Changing the order of tasks within the project obviously has no effect on model Ψ_a, and it can happen that the tasks we split will prove insufficient to obtain a satisfactory sequence of tasks in individual projects (Hasse diagrams). The characterization principle allows us to find Hasse diagrams of the structure model Ψ_b, but to check in all projects, it remains whether the acquired task sequences meet the imposed order of their deployment.

In order to build the operating model Ψ_a for the list of projects (8), Table 3 was created containing the table of tasks and their occurrence in projects, including the frequency of occurrence (analogically to the case of Table 1). The functioning model Ψ_a based on it is presented in Fig. 8 and is the starting point for constructing Hasse diagrams with a minimized number of replicas.

Table 3. Tasks (a...n) and their occurrence in projects (1...7)
(*Source:* own elaboration)

a	b	c	d	n	q	t	u	x	y	z
(1,2)	(1,3)	(5,7)	(5)	(1,2,3,5)	(5)	(2,4,6)	(3,7)	(4)	(4,6)	(3,6)
2	2	2	1	4	1	3	2	1	2	2

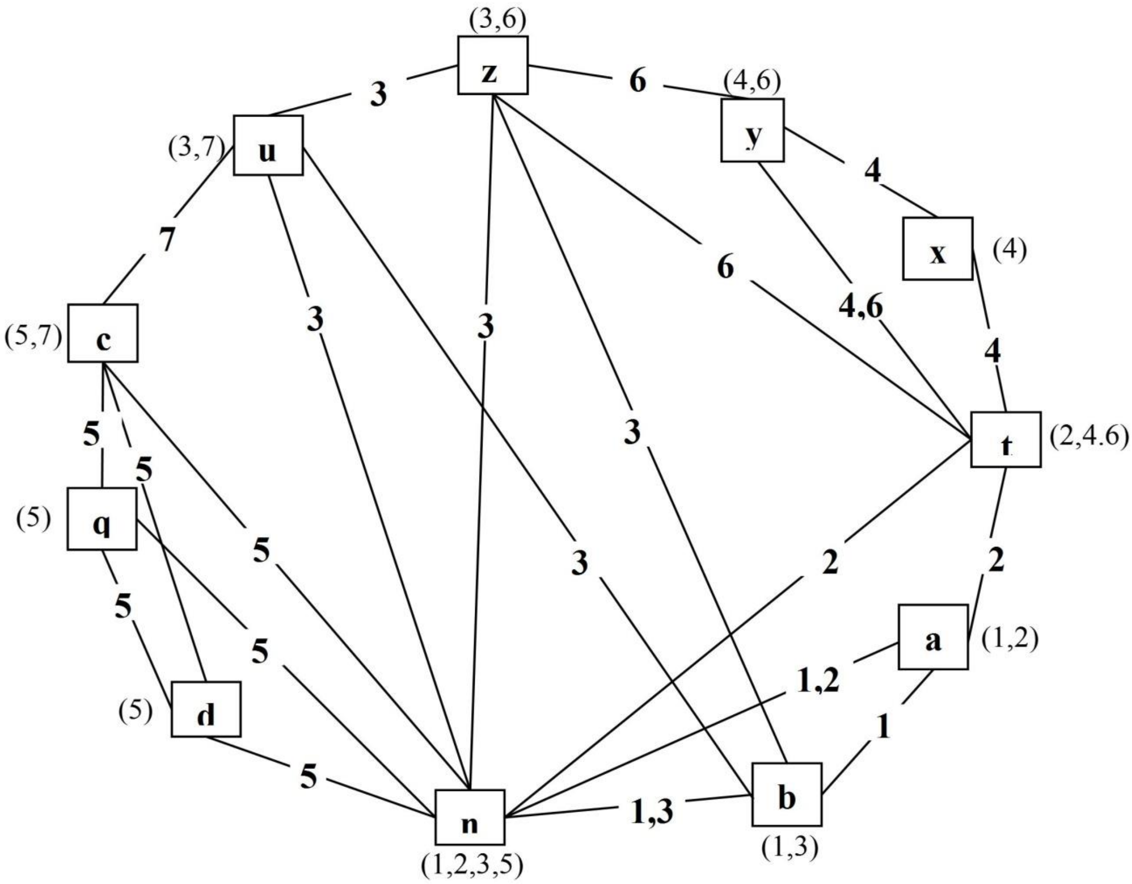

Figure 8. Semantic graph model of the functioning Ψ_a (experiment II)
(*Source:* own elaboration)

In case of limitations imposed on the order of tasks, it may be necessary to increase the number of replicas obtained as a result of applying the characterization principle. This situation is illustrated by the example of the formation of project scenarios (Table 4) in which the limitation is to perform tasks that are more often repeated in the set (portfolio) of projects.

For the proposed "first-order" scenario $ we get the structure of Hasse diagrams shown in Fig. 9. The number of required replicas has increased slightly compared to the situation shown in Fig. 7. Because the examples we consider are very small in relation to real projects and their tasks components whose number can be estimated within 1,000 – 10,000, we should take into account the necessity to specify the number of additional replicas of tasks in Hasse diagrams on the possibly minimum level, and additional replicas (forced by limitations of task execution scenarios) can be entered as a result of necessary corrections.

Table 4. Projects and tasks in the "first-order" scenarios \$
(*Source:* own elaboration)

projects	“first-order” scenario \$
P1 = {a, b, n}	P1\$ = {n, a, b}
P2 = {a, n, t}	P2\$ = {n, a, t}
P3 = {b, n, u, z}	P3\$ = {n, u, z, b}
P4 = {t, x, y}	P4\$ = {t, y, x}
P5 = {c, d, n, q}	P5\$ = {n, c, d, q}
P6 = {t, y, z}	P6\$ = {t, y, z}
P7 = {c, u}	P7\$ = {u, c}

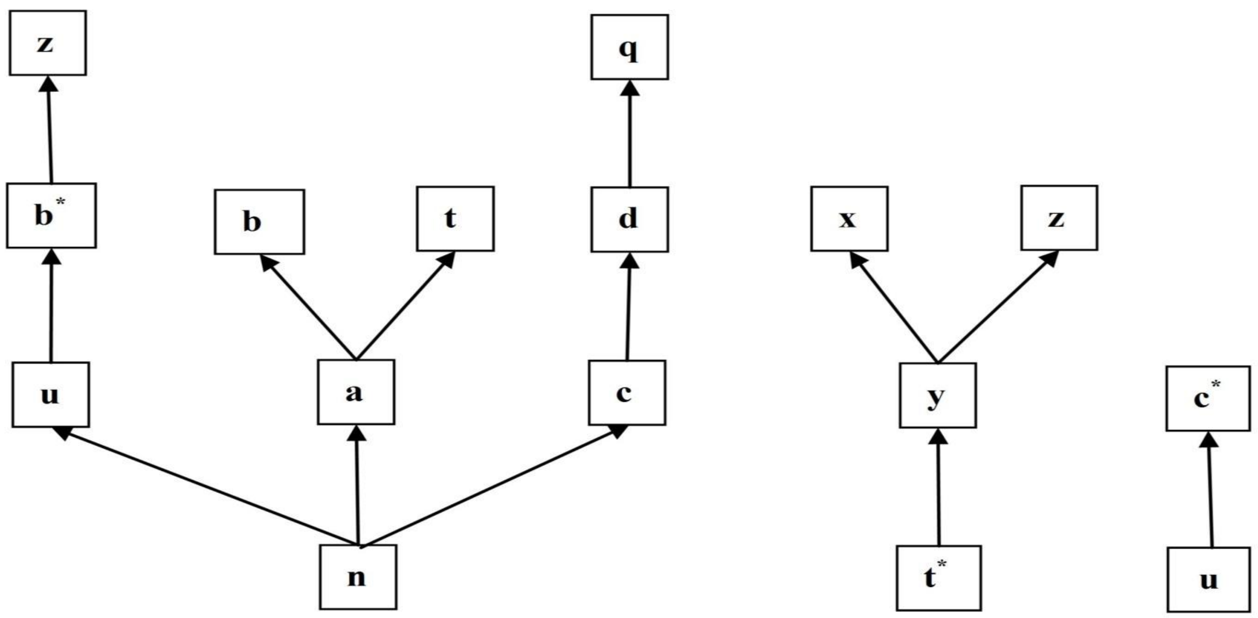

Figure 9. Hasse diagram of the Ψ_b structure model obtained for the "first-order" scenario (experiment II)
(*Source:* own elaboration)

As in experiment I, task clearing should be carried out in such a way that the number of replicas created additionally is as small as possible. For this purpose, a semantic table is created (Table 5), the columns of which are described by project tasks and pairs of corresponding project numbers, and the rows by the corresponding identifiers of prohibited graph figures Q^A and Q^B.

Task sequence pairs located in Table 5 indicate projects in which tasks assigned to them can be split (in the case under consideration, they are tasks z, b, and n). In Table 5, tasks in gray are marked with “*”, b^*, and n^*, whose symbol "1" covers all the figures of class Q^A and class Q^B in the semantic table.

For the previously considered set of projects (8), we will split tasks b, n, and z as shown in Fig. 10. All replicas of tasks were located in project P3.

Table 5. Semantic table indicating the connections of prohibited tasks and figures in model Ψ_a
(*Source:* own elaboration)

	Project tasks mapped in the operating model														
	c	**u**	**z***	**y**	**t**	**t**	**t**	**a**	**b***	**n**	**n**	**n**	**n**	**n**	**n***
	Sequence numbers of the occurrence of events														
	5,7	3,7	3,6	4,6	2,4	2,6	4,6	1,2	1,3	1,2	1,3	1,5	2,3	2,5	3,5
Prohibited graphical figures of the Q^A class															
$Q^A_{1/3}$	1	1													1
$Q^A_{2/3}$								1	1				1		
$Q^A_{3/3}$			1			1							1		
$Q^A_{4/5}$	1	1	1			1								1	
$Q^A_{5/5}$			1		1		1	1	1						
$Q^A_{6/7}$	1	1	1	1	1			1				1			
Prohibited graphical figures of the Q^B class															
Q^B_1			1	1		1									
Q^B_2			1						1						1
Q^B_3		1							1		1				
Q^B_4		1	1												1
Q^B_5		1	1						1						

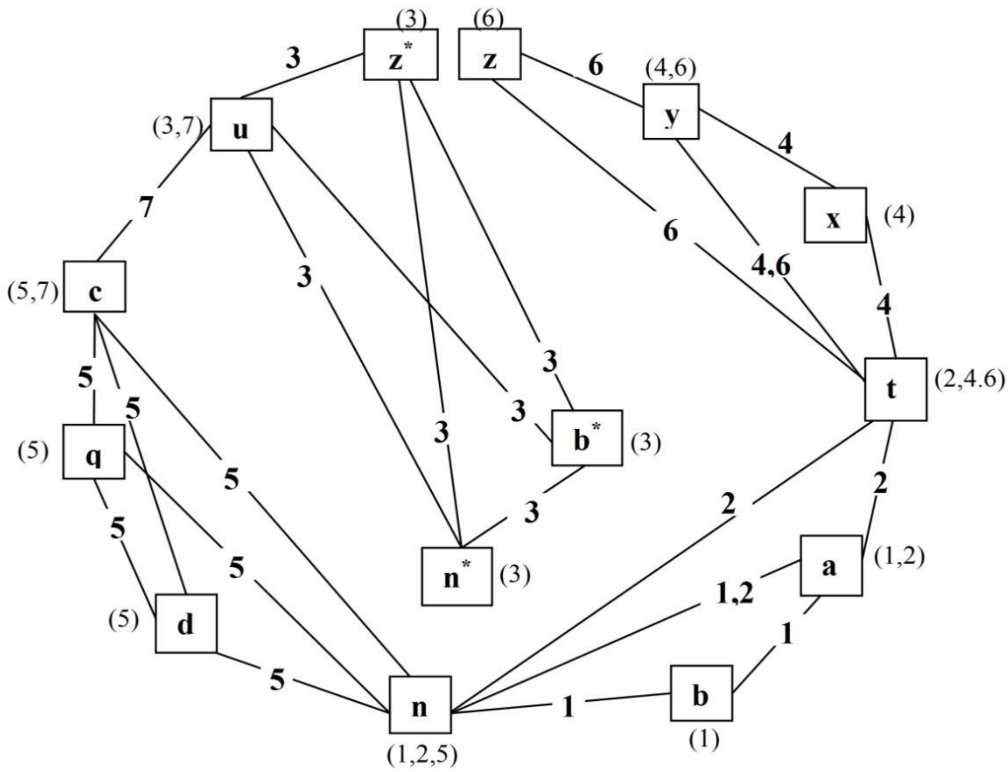

Figure 10. Graph operating model Ψ_a (experiment II) with split tasks (*Source:* own elaboration)

Focusing split tasks in one project reduces the need for interference in the processes of coordination of split tasks performed in other projects:

$$\begin{array}{ll} P1 = \{a, b, n\}, & P2 = \{a, n, t\}, \\ P3 = \{b^*, n^*, u, z^*\}, & \\ P4 = \{t, x, y\}, & P5 = \{c, d, n, q\}, \\ P6 = \{t, y, z\}, & P7 = \{c, u\} \end{array} \quad (11)$$

On the basis of the sets (11) with split tasks b^*, n^*, and z^*, we obtain the structure model Ψ_b in the form of Hasse diagrams presented in Fig. 11.

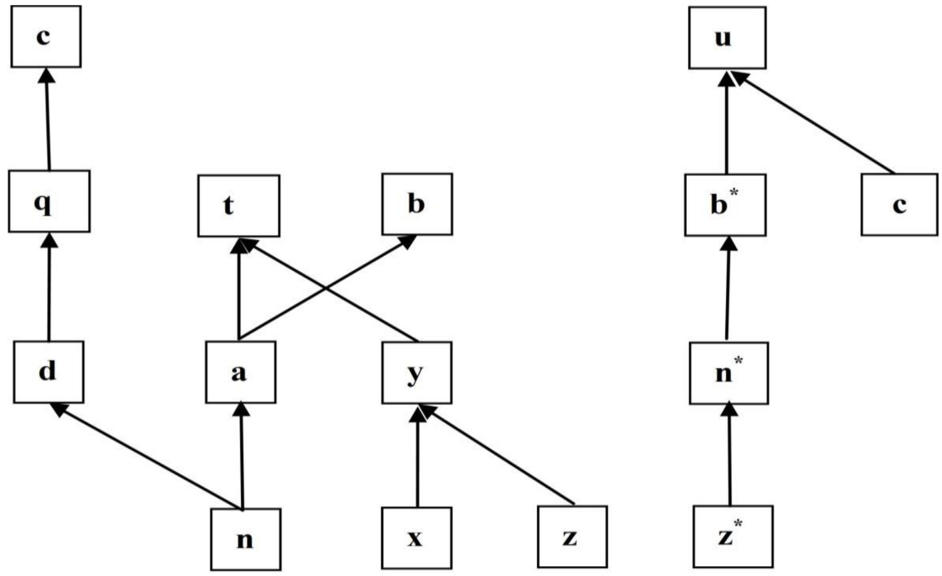

Figure 11. Hasse diagram of the structure model Ψ_b obtained on the basis of Table 5 and Fig. 10 with the minimum number of split tasks (experiment II) (*Source:* own elaboration)

5 Functional-structural relationships of the characterization principle as a systemic paradigm of management sciences

Functional-structural relationships are the basic scope of research on the systemic paradigm of management sciences. In research, first of presence all the so-called prohibited graph figures of type Q^A and Q^B make impossible unequivocally transforming the model of functioning Ψ_a to the form of a structure model Ψ_b.

Since obtaining the desired model of functioning is possible as a result of various graphs' splitting strategies, it is possible to obtain a number of functional models and corresponding structural models created as a result of the splitting of the functioning model variables.

In connection with the above, both strategies and methods of designing are the full range of the "industry" answer to questions as in the functional and structural approach:

- prepare organizational projects (e.g. investment banking and insurance products,
- information brochures),
- create architectural solutions,
- construct machines and devices,
- design processors and computer programs,
- . . .

There is no, and probably will not be, a universal method of designing any "industry" structures. Although industry structures become more and more similar to the system positions, analogies to the equations of physics are invariant to the phenomena of optics, laws of mechanics, or gravity.

In the above context, it is justifiable to formulate universal examples or functional-structural paradigms understood as special methods of designing organizational or organizational-technical solutions. On the other hand, the characterization theory, understood as a systemic paradigm of management sciences, may determine the general direction of methodological work on the search for the Ψ_a and Ψ_b models and binding figures (forbidden and neutral) adequate for specific classes of analytical and design tasks.

The neutral figures play the role of "systemic fillers" in this procedure, which can be removed or added without affecting the correct functioning of the whole object. The liquidation of neutral figures leads to an effective simplification of the object model and, consequently, to shortening the time of combinatorial calculations.

The functioning of any object, including, for example, any organization or engineering system, is determined by the correspondence between its structure (constructional properties – static) and functioning (dynamic properties). This appropriateness can be studied at various levels, in particular:

- at the level of models and abstract theories,
- at the level of program or physical simulation models,
- at the level of testing mockups and prototypes,
- during observation of working systems.

The practical significance of this kind of analytical work consists in indicating the directions of reducing the labor consumption of searching for functionally and structurally optimal systems. This property is particularly important in the case of computer-aided design works and in the use of computer systems supporting analytical and forecasting activities.

The paradigm of the characterization principle "gives hope" for combinatorial simplification of indirect solutions (system invariants) before final variants in the form of complete projects are generated (Krupa, 2006; Krupa and Ostrowska, 2007; Nogalski and Dworzecki, 2011; Szapiro, 2007).

6 The hypothesis of systemic correctness

A functional and structural paradigm gives rise to the hypothesis of constructive proof of the structural and functional unity of systems, with unity understood as the ability to design functionally correct and structurally economical (adequate) organizational and technological systems.

For the purposes of this hypothesis:

- functional correctness of a given class of systems should be understood as the possibility of defining a finite set of original rules (functional axioms) of the considered class of systems for which the organizational (or technological) possibility of their structural implementation will be created, ensuring that each system obtained in this class will implement only the original (canonical) functional rules written in the operating model,
- structural faultlessness of a given class of systems should be understood as the ability to perform a full recognition of mandatory, forbidden and neutral graphical figures based on the model of functioning of these systems, which will determine the structural correctness of these systems, which, in turn, means that the system projects created in such proceedings will not require testing of their performance.

The above postulates are possible if the axioms of the characterization principle are accompanied by the characterization theory expressed with the $P_0(\Psi_a,\Psi_b)$ predicate, which guarantees mutually unambiguous mappings of functional model Ψ_a and structure model Ψ_b.

All implemented functional model transformations should be reversible in such a way that there is always the possibility of full return to any of the previous forms of the model if the current form of this model does not guarantee a better result (with fewer replicas of variable carrier model) than all existing forms.

7 Summary

The principle of characterization and the specific characterization theories built on its basis belong to the methodology of systemic research. The essence and, at the same time, a special case of the characterization principle are Gorbatov's axioms formulated for the logical structures of logic algebra, which, in the language of the model of functioning Ψ_a, express structural relations and, in the language of structure model Ψ_b, express functional relationships of the designed object in the language of the so-called figurative prohibited figures.

In the analytical process, identifying and clearing the forbidden figures of the model of operation Ψ_a, by simple transformations of Hasse diagrams, leads to creation of the theoretically correct structure of the designed object (organization).

The functional-structural paradigm (leading from functioning to structure and vice versa) is characteristic of the project activity in which a structural response to a specific problem of functioning is sought. In balance with this paradigm, there is a reverse structural-functional paradigm (leading from the structure to functioning) in which interpretations in the functional sphere are derived from the original structure.

The structural and functional paradigm is common in the world of material and abstract realities around us; it rules mechanics, biology, and art on similar principles. In many practical situations, we cannot separate or indicate what is primary and what is secondary: functioning or structure?

From the functional-structural paradigm, a hypothesis is derived about constructive proof of the functional and structural unity of all systems, with unity understood as the ability to design functionally adequate and structurally flawless systems without the need for tedious and extremely costly testing of their correctness.

It should also be remembered that no test for the correct functioning of the structure can be proof of its theoretical – or the more correct – correctness. The principle of characterization and the special ("industry") theories of characterization built on its basis put this problem in a new light.

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