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VIRTUAL CENTER FOR THE PARADIGMATIC STUDIES

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Abstract: The Virtual Center for Paradigmatic Studies is a serious profession and, at the same time, a beneficial offer addressed to people who treat the process of their education and professional development both at home and in the academic environment as a unique life opportunity. This article presents material constituting the program and the basis for conducting theoretical and practical work at the Virtual Center for Paradigmatic Studies. The published material covers such issues as: the description of the Gorbatov's characterization principle, the theoretical correctness of the model of functioning, an example of the Semantic Model of 5 Projects, effective search for forbidden graph figures, the essence of functions that integrate semantic graphs, multi-object semantic sequences of events, the structure and purpose of Hasse diagrams.

Keywords: Gorbatov's characterization principle, model of functioning Ψ_a , model of structure Ψ_b , Hasse diagram, forbidden graph figures (FGF), sentence variable (SV), sequences of sentence variables (SSV).

JEL Classification: C58, E27, G11, G17, O22.

1 Introduction

The aim is for the prepared publication to have theoretical and practical values, essential for the development of the future monograph, and for its direct practical applications at the Virtual Center for Paradigmatic Studies, prepared for the needs of the Faculty of Management Warsaw University of Technology. In order to achieve academic and civic goals – our intention is an open formula of work for the benefit of people studying or significantly interested in the research areas specified in the article.

Table 1 defines three key research areas (A, B, and C) for the Virtual Center for Paradigmatic Studies, which each covers five operational programs, the implementation of which will be based on the processing of paradigmatic data¹.

A team of seven leading editors was invited to implement individual programs. Some of them (T. Krupa, E. Kulińska, T. Ostrowska, J. Patalas-Maliszewska, M. Wiśniewski) were the authors of the monograph published in 2019: *Strategic Risk Management*

Against Hazards for Safety of Processes in Critical Infrastructures, developed under Management Sciences Series Vol. VIII, published by the Faculty of Management of the Warsaw University of Technology.

The team of leading editors of the planned monograph entitled: *The Virtual Paradigmatic Studies of Characterization Theory* will be (in alphabetical order): Tadeusz Krupa, Ewa Kulińska, Krzysztof Maj, Teresa Ostrowska, Justyna Patalas-Maliszewska, Tomasz Prokopowicz, Michał Wiśniewski.

The article presents V.A. Gorbatov's characterization theory – the most significant cyberneticist in the last 100 years, a member of the Russian Academy of Sciences, a specialist in solving seemingly unrecognizable problems. Life and modern technologies impose similar challenges on us almost every day, and responsibly, we cannot leave them unanswered.

Gorbatov's characterization principle² will form the basis of research conducted in the research areas proposed in Table 1.

¹ Paradigmatic data – data intended to work with semantic models and the characterization principle.

² The concept of the characterization principle was born in the 1980s in work on the synthesis of logical structures.

Table 1. Research areas of *The Virtual Center for Paradigmatic Studies* and their programs
(Source: Own elaboration)

<p>Research area A</p> <p>A.1 – Formal notation and application of characterization theory</p> <p>A.2 – Structure and purpose of Hasse diagrams</p> <p>A.3 – The essence of functions that unite semantic graphs</p> <p>A.4 – Multi-entity semantic sequences of events</p> <p>A.5 – Effective searching for forbidden graph figures (FGF)</p> <p>... ..</p>
<p>Research area B</p> <p>B.1 – Building a semantic model of the functioning of objects</p> <p>B.2 – Theoretical correctness of the model of functioning Ψ_a</p> <p>B.3 – Elimination of multi-body forbidden graphs figures</p> <p>B.4 – Functions that integrate semantic graphs</p> <p>B.5 – Conjunctive and concurrent object sequences</p> <p>... ..</p>
<p>Research area C</p> <p>C.1 – Sequences of events, objects, and potentials as paradigms?</p> <p>C.2 – Graph semantic models – how to build them?</p> <p>C.3 – Application of the Semantic Model of 5 Projects</p> <p>C.4 – Simulation calculus for the elimination of forbidden graph figures (FGF)</p> <p>C.5 – Why is the theoretical correctness of Ψ_a not always theoretically correct?</p> <p>... ..</p>

The essence of the characterization principle is the flawless adequacy of the functioning of logical calculations and the structure of connections of the logical computational elements that implement them – in situations where their correctness is proven by the theory of the characterization principle and not by simulation.

The characterization principle, the formal description of which is contained in Section 3, takes into account the model of functioning Ψ_a , the model of structure Ψ_b , and forbidden graph figures $(Q^A)^3$ and $(Q^B)^4$.

The essence of the characterization principle is illustrated by an example expressed by the formula of the sequence of sentence variables (SSV)⁵.

The sequence of sentence variables consists of sentence variables (SVs) and is treated as an evaluation tool (used to determine the available evaluation events): increasing or decreasing the available potential. This may relate to issues such as prioritization of insurance decisions, construction of a communication network, or the specific example of Model of 5 Projects, presented in Section 3.

The conducted research shows that the theoretical correctness of the model of functioning Ψ_a is not always absolute, which is presented in Section 4.

³ Q^A – Forbidden graph figures of type Q^A (Fig. 3).

⁴ Q^B – Forbidden graph figures of type Q^B (Fig. 4).

⁵ SSV – sequence of sentence variables, can be built from symbols of evaluating events $X_i, X_j, X_k \dots$ or letter evaluation events a, b,

c, ... connected by symbols of serial sequences (&) and connected by symbols of concurrent sequences (#), for example, $X_i \& X_j \& X_k \dots$ or a # (b & c) # - respectively.

For the presentation of the above-mentioned evaluation events, which are also the model of structure Ψ_b , the graphic form is used in the form of Hasse diagrams, the use of which is presented in Section 5.

Section 6 is a summary of the existing and further activities in the research areas defined at the beginning.

2 A formal record of the principle of characterization

The formal record of Gorbatov's characterization principle (predicate) is as follows:

$$\langle \Psi_a, \Psi_b, P_0(\Psi_a, \Psi_b) \rangle \tag{1}$$

where:

Ψ_a – model of functioning,

Ψ_b – model of structure,

$P_0(\Psi_a, \Psi_b)$ – atomic predicate combining the models Ψ_a and Ψ_b , which resolves truth or falsehood: if $P_0(\Psi_a, \Psi_b) = 1$ – it is true, if $P_0(\Psi_a, \Psi_b) = 0$ – it is false (intermediate values are not recognized).

The essence of the P_0 predicate is to show the mutual unambiguous (bilateral) mapping of both models.

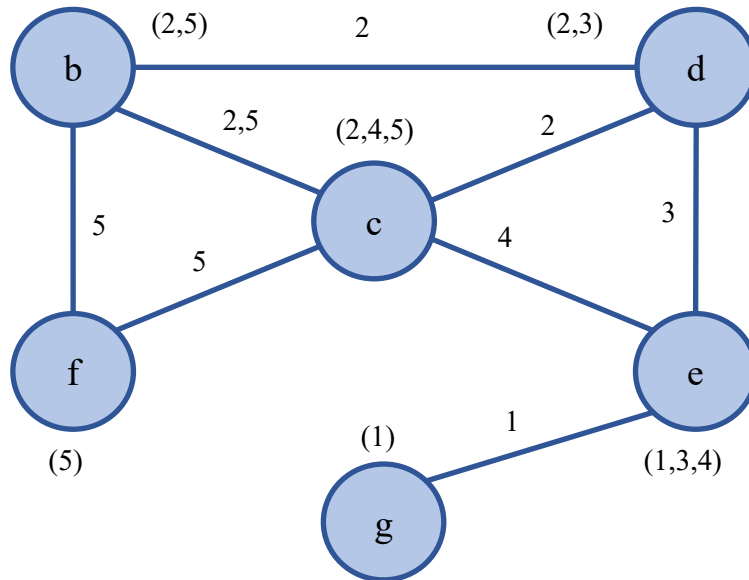


Figure 1. An example of a semantic graph compliant with the formal record of characterization principle (Source: Own elaboration)

Comment: In the presented graph, its edges do not require orientation. The common numbers on the edges indicate which pair of letter symbols will be assigned to the SSV. In this case, the SSV will be given to a pair of letter symbols <g, e>.

The model of functioning Ψ_a written in the form of an sequence of sentence variables (SSV) is expressed by the formula:

$$\begin{aligned} & [X_{11} \& X_{21} \& \dots \& X_{m1}]_1 \# \\ & [X_{12} \& X_{22} \& \dots \& X_{m2}]_2 \# \dots \# \\ & [X_{1n} \& X_{2n} \& \dots \& X_{mn}]_n \end{aligned} \tag{2}$$

or its equivalent semantic graph (Fig. 1)

The model of functioning Ψ_a :⁶

- was written in the form of a sequence of sentence variables (SSV),
- was expressed by formula (2),

⁶ Model of functioning Ψ_a – a key model of Gorbatov's characterization principle, showing how the model of functioning is created, expressed using letter symbols and connecting symbols, for

example, linking sentence variables or letter symbols with symbols connecting #, &, V, and others, which were given appropriate linking interpretation.

- was illustrated with an analogous to it semantic graph (Fig. 1), whose vertices are assigned sentence variables, and the edges of the graph are numbers of sequences in which there are sentence variables assigned to the edge vertices.

The formal description of the characterization principle will be determined using the model of structure Ψ_b presented in the form of Hasse diagrams⁷ (also called Hasse twigs⁸ in the case of individual diagrams). The model of structure Ψ_b is usually considered in the following areas: the characterization principle – model of functioning and model of structure.

Universal SSVs are linked together by operations that perform actions: conjunction serial (&), concurrent serial (#) operations, and extremely complicated strong alternative operations⁹ (V), which allow for multiple grouping and spreading of extremely effective cyclical actions (symbol *).

Symbol X_{ij} – which means the occurrence of the sentence variable X_i inside the j -th sequence with the possibility of repetition in different SSVs. SSV concurrency also allows for alternation or parallelism.

The value of the variable X_i can be homogeneous objects of the modeled problem (e.g., events, logical variables, identifiers of specific resources, etc.). The & symbol denotes serial linking of sentence variables within each SSV.

The sequence of symbols $[X_{1j} \& X_{2j} \& \dots \& X_{mj}]$ – is usually taken as the j -th homogeneous of m -element sequence SSV.

– is a symbol of concurrency separating homogeneous SSV; additional restrictions may be imposed on the serial ordering of the SSV in the functioning models, only in terms of positioning in the SSV (any or a priori position, for example: "only in the first place in each sequence" or in some other predetermined random, descriptive, or deterministically determined).

A particularly important limitation is the inadmissibility of a situation in which an SSV is identical to another

SSV or is included in another SSV, regardless of the ordering of the sentence variables in the SSV and regardless of the arrangement of individual SSV among themselves.

3 Example of the Semantic Model of 5 Projects (alternatively: Objects)

At this point, we will consider an example of the SSV called the "Example of the Semantic Model of 5 Projects", which in the first step is presented in Fig. 1 in the form of a semantic graph.

The terms "project" and "object" are used interchangeably – rather with an indication of the term "project", because the term "object" allows for a more flexible formulation of the interpretation of the terms used.

The Semantic Model of 5 Projects is used to indicate routine activities used for a relatively simple procedure to build a graph semantic model that unambiguously defines the connections between vertices and edges of the semantic graph model.

Based on the preliminary preparations made, we will try, using a graphic notation, to present a semantic model consisting of five vertices and eight edges in order to fully formalize the graphic form of the constructed semantic model, presented in Fig. 1.

In the example of the Semantic Model of 5 Projects, the carrier M of the SSV model is a fixed set of sentence variables:

$$M = \{ b, c, d, e, f, g \} \quad (3)$$

On the set M , five SSVs of the model Ψ_a were defined, corresponding to five concurrent projects (objects):

$$\begin{aligned} \text{Projekt 1.:} & [X_1 \& \dots \& X_m]_1 = [e, g] \\ \text{Projekt 2.:} & [X_1 \& \dots \& X_m]_2 = [b, c, d] \\ \text{Projekt 3.:} & [X_1 \& \dots \& X_m]_3 = [d, e] \\ \text{Projekt 4.:} & [X_1 \& \dots \& X_m]_4 = [c, e] \\ \text{Projekt 5.:} & [X_1 \& \dots \& X_m]_5 = [b, c, f] \end{aligned}$$

⁷ Hasse diagram – is a graph model of the SSV built from vertices and connecting them directed (oriented) edges of evaluating events.

⁸ Hasse twig – this is a Hasse diagram of a single SSV.

⁹ The concept of "strong alternative" refers to a phenomenon established in the form of a contract concluded between partners

for which the SSV can be composed of symbols of evaluation events $X_i, X_j, X_k \dots$ or letter evaluation events a, b, c, \dots , which can be used to control serial sequences (&) and symbol-connected concurrent sequences (#), for example, $X_i \& X_j \& X_k \dots$ or a # ($b \& c$) # - respectively.

Ultimately, we get five Hasse twigs examples for a set of concurrent SSV designs.

Semantic Model of 5 Projects has been correctly defined, which means that:

- none of the five projects is repeated, and none is part of another project,
- sentence variables are not repeated in any project,
- any order of the sentence variables is allowed, which will actually be projects – vertices of five SSV,

- any sequence of SSV is allowed.

In Fig. 2, we consider the sequence of the initially available evaluation events belonging to Hasse twigs for a set of concurrent SSV.

The essence of individual projects has not changed – while the form of some Hasse twigs makes it impossible to build a uniform Hasse diagram due to unexpected obstacles – some of the twigs have become fragments of the model of functioning Ψ_a , called forbidden graph figures (FGF).

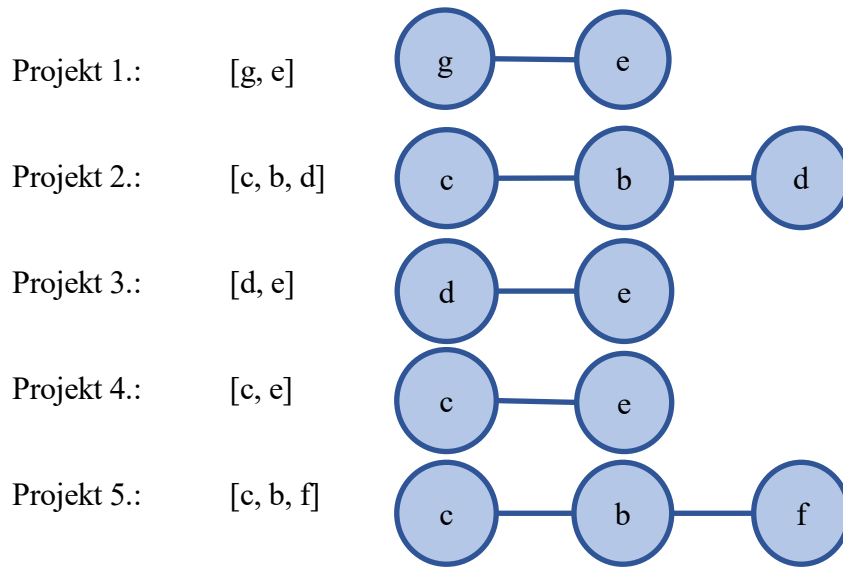


Figure 2. An example of a semantic graph of the model Ψ_a five concurrently implemented projects (Source: Own elaboration)

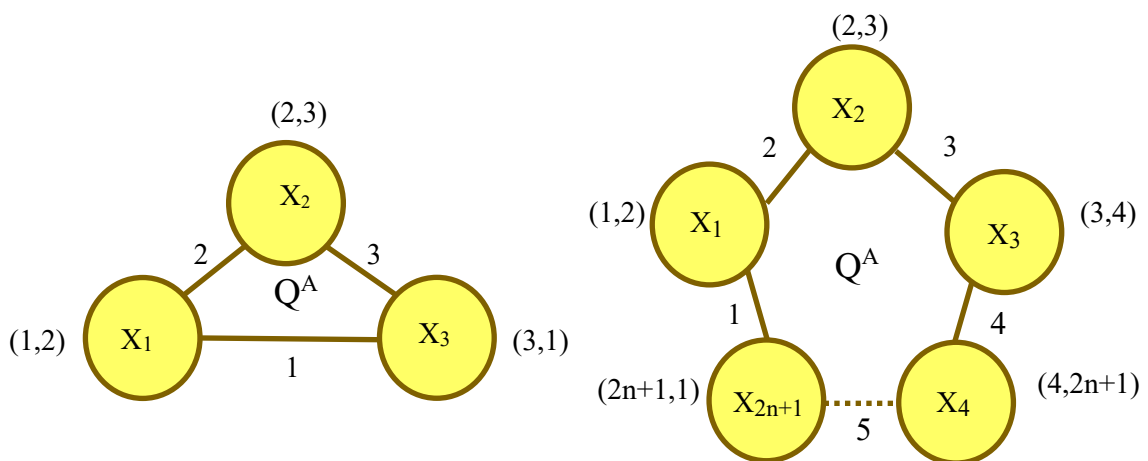


Figure 3. Examples semantic graphs of model Ψ_a of type Q^A (Source: Own elaboration)

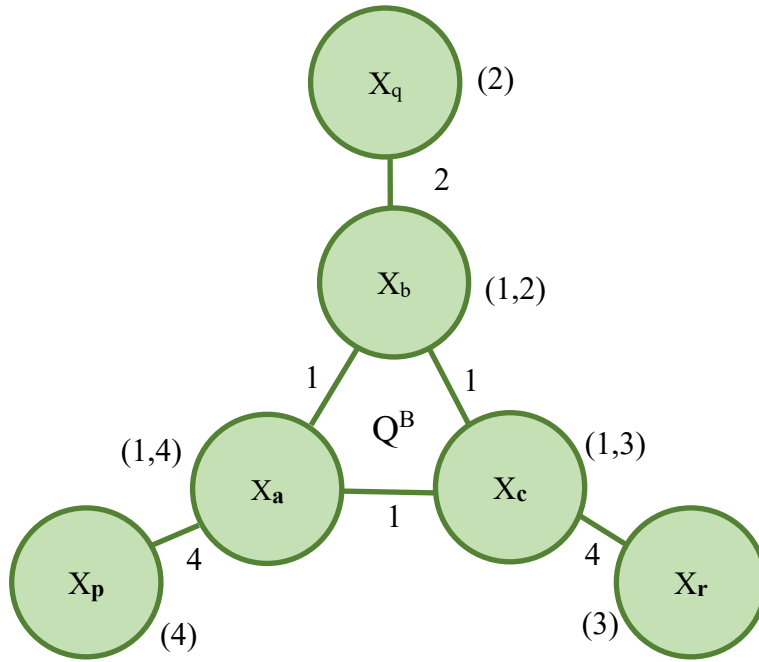


Figure 4. An example of forbidden graph figure of type Q^B (so-called snowflake)
 (Source: Own elaboration)

The vertices of forbidden graph figures FGF of type Q^A (Fig. 3) and type Q^B (Fig. 4) correspond to the sentence variables X_i .

In the case of Q^A graph figures, the sequences of sentence variables SSV should be of odd lengths: 3, 5, 7, $2n + 1$; in the case of a Q^B graph figure, it appears only in the form of the so-called "snowflake."

4 The theoretical correctness of the model of functioning Ψ_a

It turns out, however, that the theoretical correctness of the model of functioning Ψ_a is not always sufficient for the correctness of the semantic model and, consequently, for the construction of a model of structure, as illustrated in Fig. 5.

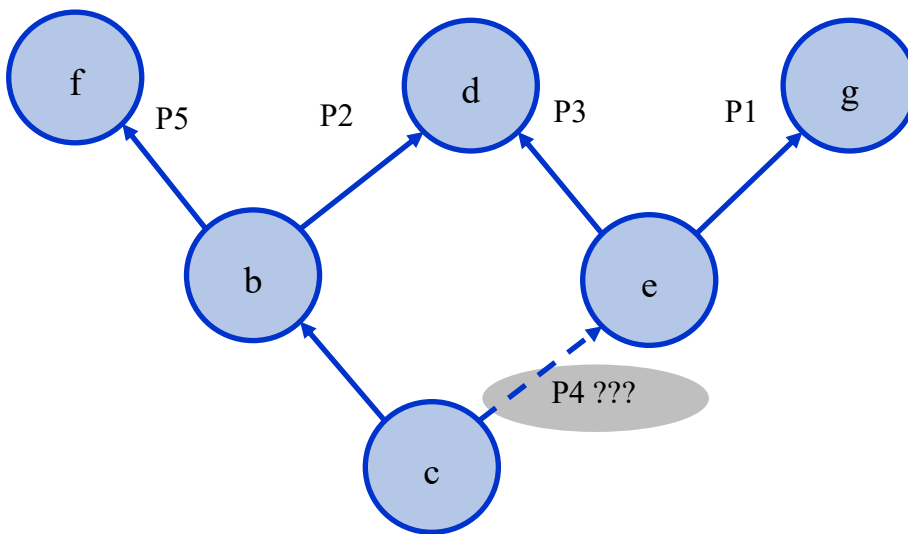


Figure 5. An example of a failed attempt to build a Hasse diagram for 5 Projects - the P4 project is part of the P1 project, which indicates the presence of FGF of type Q^B (Source: Own elaboration)

Often, it becomes necessary to correct the model of functioning Ψ_a in accordance with the Gorbatov predicate P_0 (Ψ_a, Ψ_b), consisting in the search for and liquidation of FGF Q^A and Q^B classes.

It is worth noting that when assessing the computational complexity – the number of different combinations of the SSV of the Model of 5 Projects is 288 and may increase exponentially, especially in the case of similarity or overlapping between FGF:

$$\begin{aligned} & |[e,g]|! \times |[b,c,d]|! \times |[d,e]|! \times |[c,e]|! \times |[b,c,f]|! \\ & = 2! \times 3! \times 2! \times 2! \times 3! = 288 \end{aligned}$$

In the case of the Model of 5 Projects, containing five sentence variable SVs, the computational complexity increases to the value of 1,205 = approximately 250 million variants. It is obvious that the number of SSV variants of this size can be troublesome even for terahertz processors.

Based on the example of Model of 5 Projects (SSV) included in Fig. 1, a semantic graph was presented, which will be used to analyze the correctness of the model Ψ_a by identifying forbidden graph figures (FGF) presented in Figs 3 and 4.

The analysis of the graph figures presented in Figs 3 and 4 allows us to check whether the individual FGF does not coincide by way of coincidence. This, in turn, enables, by splitting a single sentence variable (SV), to split the FGF multiple times. The correctness of the model Ψ_a guarantees obtaining the correct Hasse diagram (without FGF).

Unfortunately, among the 288 possible combinations of s, if we do not identify all FGFs and do not split them (i.e., we do not eliminate them), we can – with sweat on the forehead – find out that we will not find a complete Hasse diagram, which will be similar to the diagram in Fig. 6.

5 Solving sample projects – Hasse diagram

The last stage of building the Model of 5 Projects is to present the solution in the form of an SSV diagram and Hasse diagram, similar to Fig. 5 – but correct, thanks to the application of the characterization principle (by liquidation of the FGF).

The SSV set for the Model of 5 Project example, as a result of dividing one sentence variable d into d'' and d', will obtain the form:

$$\begin{aligned} & [g \& e]_1 \# [c \& b \& d'']_2 \# [d' \& e]_3 \# \\ & [c \& e]_4 \# [c \# b \# f]_5 \end{aligned} \quad (5)$$

Thanks to the application of the characterization principle, the necessity to generate about 300 possible solutions was avoided in order to find out that there is no possibility of obtaining SSV without splitting at least one sentence variable, presented in Fig. 6.

Comparing with the example of Hasse diagram construction shown in Fig. 5 for the Model of 5 Projects - you can see different positions of the vertices and their connections. Hasse twigs are clearly visible.

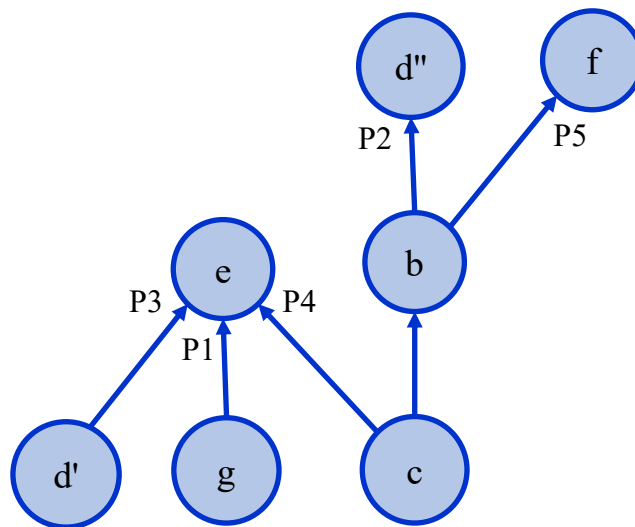


Figure 6. An example of a Hasse diagram for the Model of 5 Projects after removing the FGF of the type Q^B (Source: Own elaboration)

6 Construction of a semantic model and its transformation into a Hasse diagram

The Hasse diagram proposal will move from the model of functioning Ψ_a to the model of structure Ψ_b according to Gorbatov's characterization principle.

The building of the model of functioning will follow a plan that includes the following activities:

- 1) Specifying the five-letter carrier $M = \{a, b, c, d, e\}$.
The carrier M , which is small in number, is a condition for the effective implementation of the model of structure Ψ_b , as we will see during the implementation of the semantic model and the following stages.

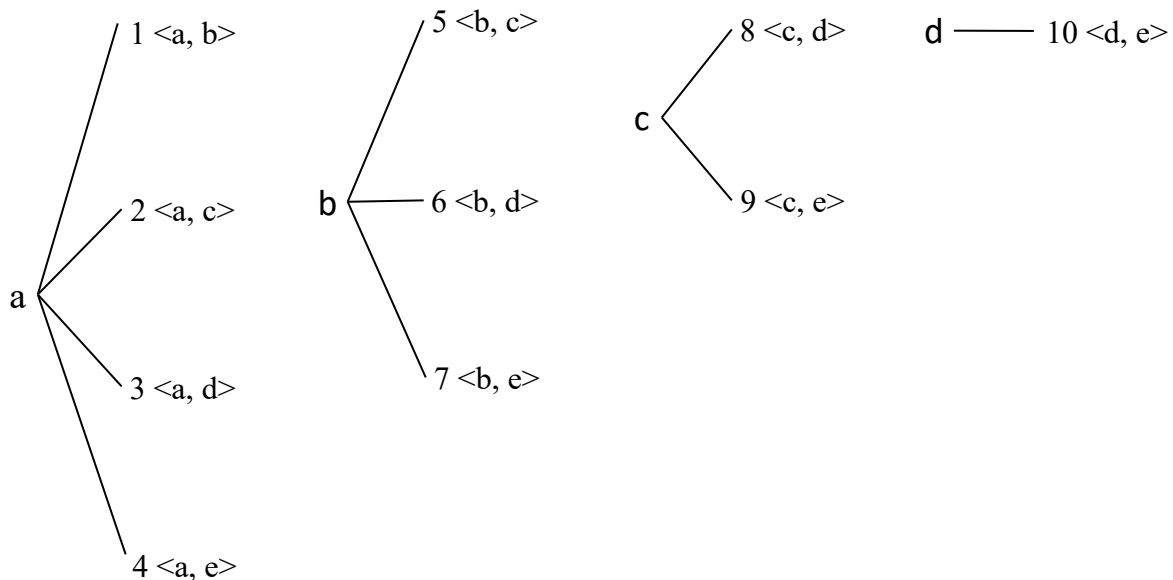


Figure 7. Letters sequences downloaded from M_5
(Source: Own elaboration)

- 4) In the semantic graph, the vertices of carrier of the M_5 are marked with letter values. Without losing universality, we will assume the orientation in letter pairs, which will turn out to be very beneficial for the construction of a semantic graph imitating the four sets of sequences from Fig. 8.

- 2) Specification on carrier M of the 10 two-letter different sequences and 10 pairs of unique sequences as shown below. The order of letters in the sequences is free and can be changed without restrictions.
- 3) It should be remembered that both in the carrier M and in two-letter sequences, their order is arbitrary and can be changed. An illustration of the sequence is shown in Fig. 7.
 - a) $M_5 = \{a, b, c, d, e\}$ – carrier of the model of functioning Ψ_a according to the characterization principle,
 - b) four sets sequences of the letters, taken from M_5 (Fig. 7).

Fig. 9 illustrated the dynamics of "spinning" graph forbidden figures of Q^A type.

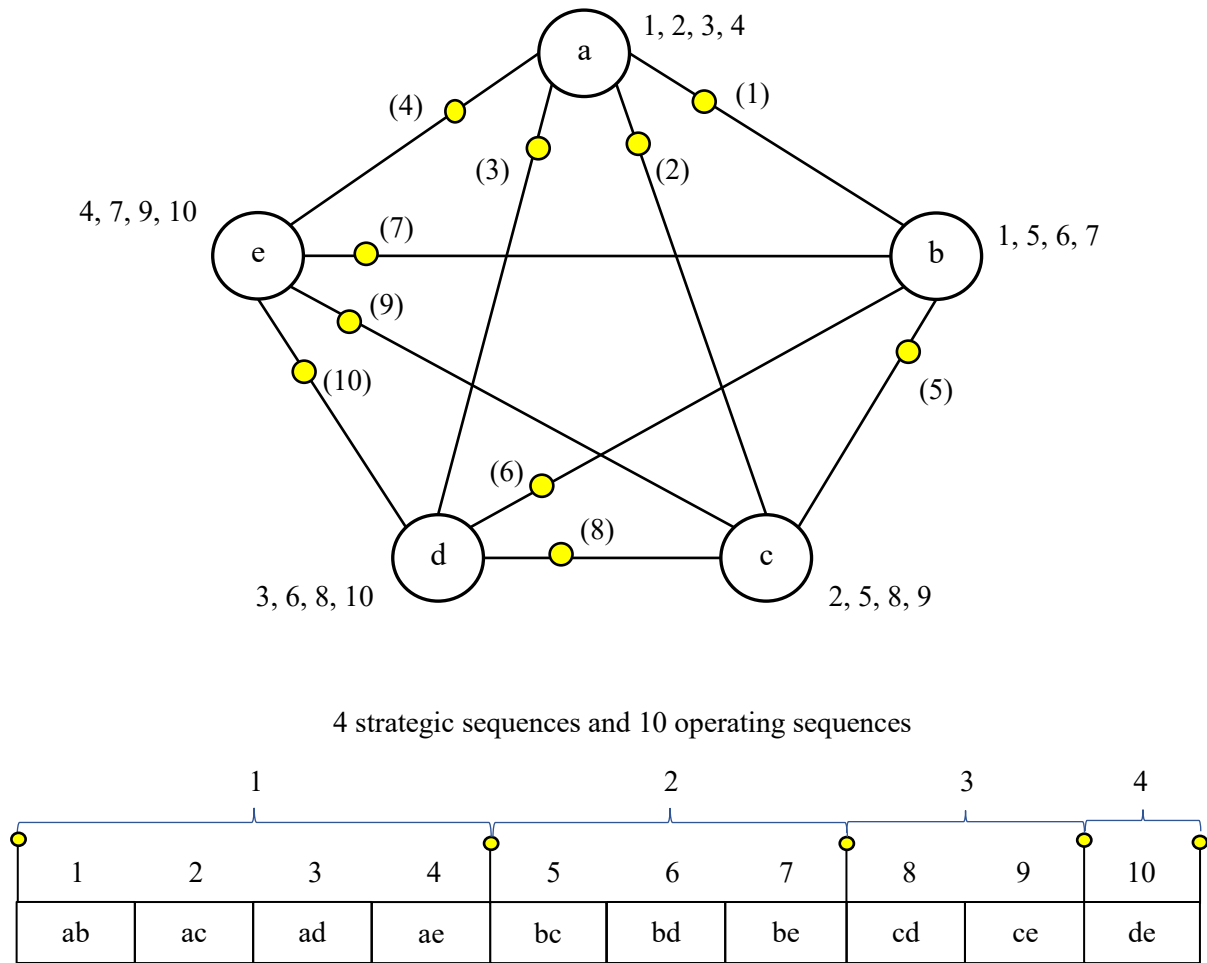


Figure 8. Semantic model in the form of the graph in terms of 4 strategic sequences and 10 operating sequences (Source: Own elaboration)

7 Summary

The aim of the article *The Virtual Center for Paradigmatic Studies* was to present the principle of Gorbato's characterization theory and its development as a paradigm for many applications. The basic concept was developed in the 1980s in the work on the synthesis of logical structures.

The essence of the principle of characterization theory is flawless isomorphic operation and the structure of adequacy in situations where the correctness of the research is confirmed by theory, not simulation.

The article gives an example of the cyclic mechanism of the characterization principle – this phenomenon requires further research due to its unexpected effects and risks.

The included educational examples mainly cover design issues, educating the academic staff to prepare doctoral and postdoctoral dissertations.

These examples are an attempt to synthesize Hasse diagrams at the Center for Paradigmatic Studies, organized at the Faculty of Management Warsaw University of Technology by Prof. Tadeusz Krupa and his successors.

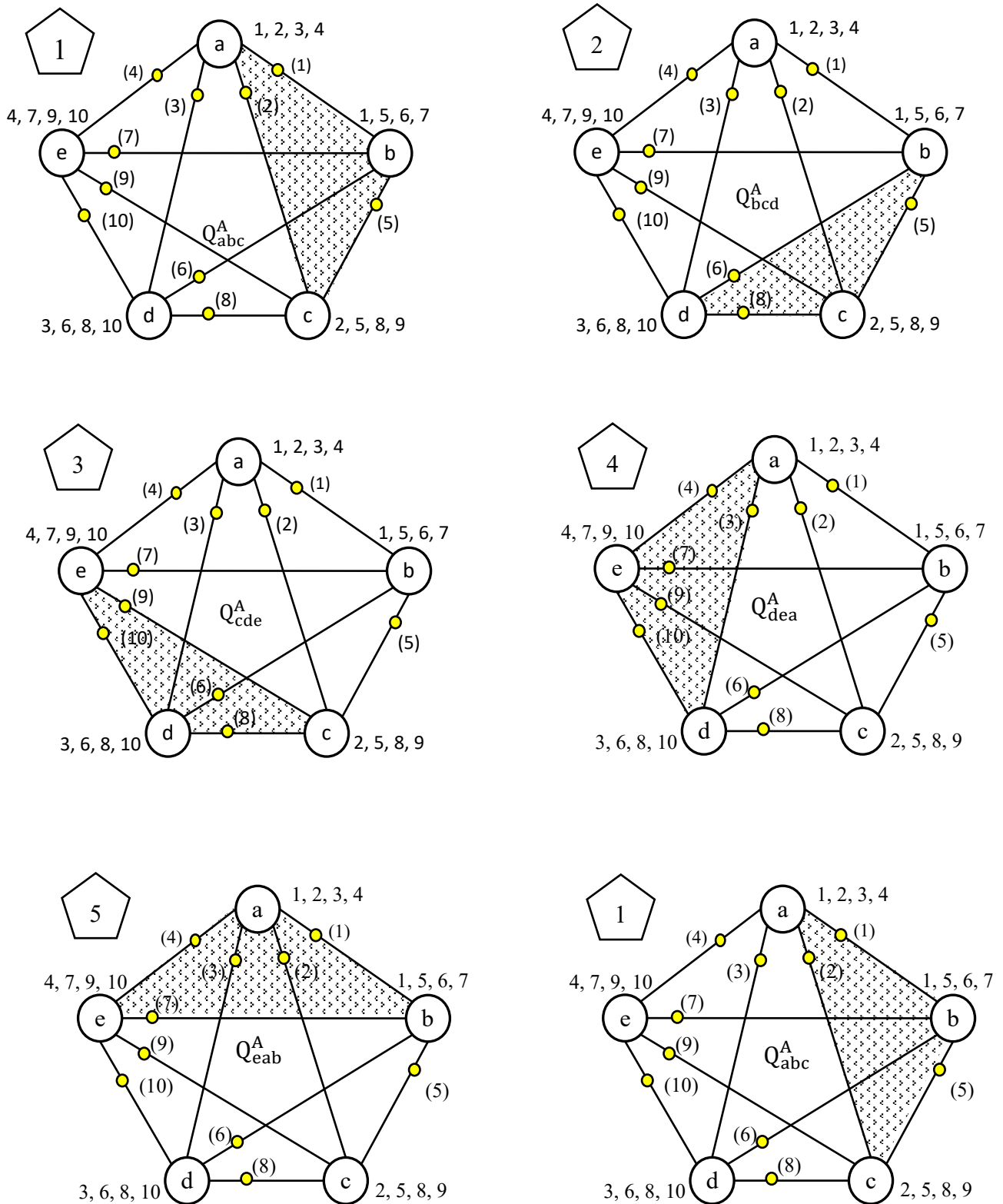


Figure 9. Distribution of the five original forbidden figures of Q^A type
 (Source: Own elaboration)

This subject is also popularized by the international journal *Foundations of Management* (run by the Faculty of Management Warsaw University of Technology) and a group of leading chairs, habilitated doctors and doctors engaged in independent and advanced research on practical applications, largely inspired by the Faculty of Management at the University of Warsaw.

The author would like to thank the Deans and Employees of the Faculty of Management at the University of Warsaw for many years of support and cooperation.

8 References

- [1] Bocewicz, G., Banaszak, Z., et al., 2020. *Simulation Versus an Ordered-Fuzzy-Numbers-Driven Approach to the Multi-depot Vehicle Cyclic Routing and Scheduling Problem*. In: International Conference on Computational Science - ICCS 2020. Lecture Notes in Computer Science, Vol. 12138, pp.251-266. Amsterdam, the Netherlands.
- [2] Gorbатов, V.A., 1979. *Semanticeskaja teorija projektirovanija avtomatov (Semantic Theory of Design Automation)*. Moskva: Izd. Energia.
- [3] Gorbатов, V.A., Krupa, T., 1984. *Zasada charakteryzacji w logistyce systemu produkcyjnego (The Principle of Characterization in the Logistics of the Production System)*. Międz. Konf. SYPRO'84 Systemy Produkcyjne - Teoretyczne i Praktyczne Problemy Projektowania (International. Conf. SYPRO'84 Production Systems Theoretical and Practical Design Problems), Warsaw, pp.213-218.
- [4] Kasprzak, T., (ed.), 2005. *Modele referencyjne w zarządzaniu procesami biznesu (Reference Models in Business Process Management)*. Warszawa: Difin S.A.
- [5] Krupa, T., 2013. V.A. Gorbатов Theory of Characterization – Principles and Examples. *Foundations of Management*, Vol. 5, No. 3, pp.89-102, DOI: 10.2478/fman-2014-0022.
- [6] Krupa, T., 2016. Zasada charakteryzacji jako systemowy paradygmat w naukach o zarządzaniu – eksperymenty i zastosowania (The characterization principle as a systemic paradigm in Management Science - Experiments and Applications). In: A., Zakrzewska-Bielawska (ed.). *Stan i perspektywy rozwoju nauk o zarządzaniu – Wybrane problemy (The State and Development Prospects of Management Sciences – Selected Problems)*. Toruń: Wyd. TNOiK, pp.180-217.
- [7] Krupa, T., 2018. The Principle of Characterization as a Systemic Paradigm of Safety: Experiments and Applications. *Foundations of Management*, Vol. 10, pp.303-318, DOI: 10.2478/fman-2018-0024.
- [8] Krupa, T., Kulińska, E., Ostrowska T., Patalas-Maliszewska J., Wiśniewski, M., Zawila-Niedźwiecki, J., 2019. *Strategic Risk Management Against Hazards for Safety of processes in Critical Infrastructures*. Management Sciences Series Vol. VIII. Warszawa: Wydział Zarządzania, Politechnika Warszawska.
- [9] Krupa, T., Ostrowska, T., 2018. Security in Topological, Functional and Semiotic Terms. *Foundations of Management*, Vol. 10, pp.177-194, DOI: 10.2478/fman-2018-0014.
- [10] Krupa, T., Prokopowicz, T., 2018. Paradygmat teorii charakteryzacji w procesach podejmowania decyzji (The Characterization Theory Paradigm in Decision-Making Processes). In: M., Budzianowska-Drzewiecka, K., Czernek (eds.) *Kierunki ewolucji nauk o zarządzaniu (Directions of the Evolution of Management Sciences)*. Kraków: Wydawnictwo Uniwersytetu Jagiellońskiego, pp.51-72.
- [11] Maj, K., Krupa, T., 2010. The Management Method Preventing a Crisis Situation in an Electrical Energy Utility. *Foundations of Management*, Vol. 2, No. 2, pp.37-50.
- [12] Nasierowski, W., 2018. *Formułowanie Strategii Przedsiębiorstwa. Klasyka*. (Formulating the Enterprise Strategy. Classic.) Warsaw: Difin SA.
- [13] Nowak, A.Z., 2009. Zamiast wstępu (Instead of an Introduction). In: W., Chmielarz, J., Turyna (eds.), 2009. *Komputerowe Systemy Zarządzania (Computer Management Systems)*. Księga jubileuszowa z okazji siedemdziesięciolecia urodzin prof. zw. dr. hab. Jerzego Kisielnickiego (Jubilee Book on the Occasion of the 70th Birthday of prof. dr. hab. Jerzy Kisielnicki).

- [14] Pogorzelski, W., 1999. *Inżynieria badań systemowych. Prolegomena (Systems Research Engineering. Prolegomena)*. Warsaw: Publishing House of the Warsaw University of Technology.
- [15] Prokopowicz, T., Krupa, T., 2010. Modeling of Polish Enterprises Insolvency Processes with Use of Gorbатов Characterization Principle – Research Results. *Foundations of Management*, Vol. 2, No. 1, pp.71-98, DOI: 10.2478/v10238-012-0022-y.
- [16] Siudak, M., 1998. Wskaźniki zarządzania wartością – nowy aspekt analizy finansowej przedsiębiorstwa (Value Management Indicators - a new Aspect of the Company's Financial Analysis). In: T., Krupa, M., Siudak, (eds.). *Nowe trendy i rozwiązania w organizacji produkcji i zarządzaniu przedsiębiorstwem (New Trends and Solutions in the Organization of Production and Enterprise Management)*. Warsaw: Institute of Production Systems Organization of the Warsaw University of Technology.
- [17] Skrzypek, E., 2016. *Procesy logistyczne w społeczeństwie sieciowym (Logistic Processes in a Network Society)*. Lublin: Department of Quality and Knowledge Management, Faculty of Economics, Maria Curie-Skłodowska University.
- [18] Yourdon, E., 2007. *Marsz ku klęsce. Poradnik dla projektanta systemów (March to defeat. A Guide for a System Designer)*. Warsaw: WNT.