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## QUALITATIVE MODELS OF ANALYSIS OF THE EFFECTIVENESS OF MANAGEMENT DECISIONS TO ENSURE SOCIO-ECONOMIC SECURITY

©*Shvaiba D.*, ORCID: 0000-0001-6783-9765, Ph.D., Belarusian Trade Union of workers  
of chemical, mining and oil industries, Belarusian national technical University,  
Minsk, Belarus, [shvabia@tut.by](mailto:shvabia@tut.by)

## КАЧЕСТВЕННЫЕ МОДЕЛИ АНАЛИЗА ЭФФЕКТИВНОСТИ УПРАВЛЕНЧЕСКИХ РЕШЕНИЙ ПО ОБЕСПЕЧЕНИЮ СОЦИАЛЬНО- ЭКОНОМИЧЕСКОЙ БЕЗОПАСНОСТИ

©*Швайба Д. Н.*, ORCID: 0000-0001-6783-9765, канд. экон. наук,  
Белорусский профсоюз работников химической, горной и нефтяной отраслей  
промышленности, Белорусский национальный технический университет,  
г. Минск, Беларусь, [shvabia@tut.by](mailto:shvabia@tut.by)

*Abstract.* For the analysis of dynamic processes in the system while ensuring its safety and for the adoption of appropriate management conclusions, it is likely to introduce the apparatus of sign-oriented graphs–digraphs. This installation has a conditional mathematical simplicity that allows overcoming the known obstacle of significant computational effort that occurs due to the need to take into account a large number of important points. At the same time, this setting is slightly sensitive to the accuracy of the initial data. As a result, it allows forming adequate models on the dependencies of the quality level. All this determines the need and prospects of using the apparatus of digraphs in the presented subject area.

*Аннотация.* Для анализа динамических процессов в системе при обеспечивании ее безопасности и для принятия надлежащих управленческих заключений вполне вероятно внедрение аппарата знаковых ориентированных графов–орграфов. Данная установка обладает условной математической простотой, что разрешает преодолеть известное препятствие существенной вычислительной трудозатратности, возникающее по причине надобности учета большого количества важных моментов. При этом, данная установка слабо чувствительна к точности начальных данных. Вследствие этого она разрешает формировать адекватные модели на зависимостях качественного уровня. Все это определяет необходимость и перспективность применения аппарата орграфов в представленной предметной области.

*Keywords:* socio-economic security, government, society, enterprise, employee, threat, security, interests, economics, analysis, system.

*Ключевые слова:* социально-экономическая защищенность, государство, общество, предприятие, работник, угроза, защищенность, интересы, экономика, анализ, система.

For the analysis of dynamic processes in the system while ensuring its safety and for the adoption of appropriate management conclusions, it is quite possible to introduce the apparatus of sign-oriented graphs–digraphs. This installation has a conditional mathematical simplicity that

allows you to overcome the known obstacle of significant computational effort that occurs due to the need to take into account a large number of important points. At the same time, this setting is weakly sensitive to the accuracy of the initial data. As a result, it allows to form adequate models on the dependencies of the quality level. All this determines the necessity and prospects of application of the apparatus of digraphs in the presented subject area [1, c. 25].

The mathematical model of sign, weighted sign, functional sign digraphs is considered an extension of the mathematical model of digraphs. It includes a directed graph, a large number of vertex characteristics, and a list of arc rearrangement possibilities [2, c. 14].

Oriented graph, or digraph,  $G(X, E)$  it consists of a finite non-empty set  $X$  of vertices and an existing set  $E$  of ordered pairs of various vertices. The components of  $E$  are referred to as oriented edges, or arcs. According to the theory there are no loops and multiple arcs in the digraph.

Many of the parameters of the peaks  $V = \{v_i, i \leq N||X||\}$  consists of features  $v_i \in V$ , in this case, each is determined in accordance with each of the vertices  $x_i$ .

The functionality of the transformation arcs  $F(V, E)$  each arc specifies in the compliance of any sign, either the weight or function.

Definition. Model  $\{G(X, E), V, F(V, E)\}$  it's called a sign digraph  $F(v_i, v_j, e_{ij}) = 1$ , if the rise (fall)  $v_i$ , provokes growth (fall)  $v_j$ , and  $F(v_i, v_j, e_{ij}) = -1$ , if the rise (fall)  $v_i$ , provokes a fall (increase)  $v_j$ .

Definition. Model  $\{G(X, E), V, F(V, E)\}$  it is called a weighted sign digraph  $F(v_i, v_j, e_{ij}) = w_{ij}$ , if the rise (fall)  $v_i$ , provokes growth (fall)  $v_j$ , and  $F(v_i, v_j, e_{ij}) = -w_{ij}$ , if the rise (fall)  $v_i$ , provoking a fall (growth)  $v_j$ . Here  $w_{ij}$  protrudes the weight of the corresponding arc.

Definition. Model  $\{G(X, E), V, F(V, E)\}$  referred to as the functional sign digraph  $F(v_i, v_j, e_{ij}) = f_{ij}(v_i, v_j)$ .

The concept of a pulse process in a discrete time space is formed on the digraphs extended in this way [3, c. 336].

Definition. Pulse  $P_i(n)$  in the vertex  $x_i$  at time  $n \in N$  the parameter is fixed at the given vertex at the moment of time  $n$ :

$$P_i(n) = v_i(n) - v_i(n - 1), \quad (1)$$

The index of the parameter in the top  $x_i$  determined by the ratio:

$$v_i(n) = v_i(n - 1) + \sum_{\substack{j=1 \\ j \neq i}}^N F(v_i, v_j, e_{ij})P_j(n - 1) + P_i^0(n), \quad (2)$$

where  $P_i^0(n)$  — external pulse input to the top  $x_i$  at time  $n$ . The equation for momentum in the analyzed process can be distinguished from the finish-difference equations:

$$P_i(n) = \sum_{\substack{j=1 \\ j \neq i}}^N F(v_i, v_j, e_{ij})P_j(n - 1) + P_i^0(n), \quad (3)$$

Definition. The pulse process can be called Autonomous, if

$$P_k^0(m) = 0 \quad \forall m \geq 1, \forall x_k \in X, \quad (4)$$

Definition. The pulse process can be called simple, if

$$\left(\sum_{k=1}^N P_{\lambda}^0(0) = 1\right) \& (P_k^0(m) = 0 \quad \forall m \geq 1, \forall x_k \in X), \quad (5)$$

In earlier studies of graphs by route in a graph  $G(X, E)$  a variable is a sequence of vertices and edges. The route is closed, if  $x_0 = x_k$ , *open in the opposite case*. A route is called a chain, if all its edges are different and a simple chain, if all the vertices (and as a consequence of the edges) are different. A closed circuit is called a cycle. The mathematical model of sign, weighted sign, functional sign digraphs uses the definitions of even and odd cycles. An even cycle has a positive product of the signs of all its arcs, an odd one — a negative one. An essential fact for the study of ring structures in the system is that an even cycle is an elementary model of structural instability. In fact, any of the initial changes of a parameter in any of the vertices of the even cycle leads to an infinite growth of the module parameters of the vertices of the cycle in the period as any of the initial changes when any of the vertices of an odd cycle can only lead to oscillations of the parameters of the vertices.

*Definition.* Top  $x_i \in X$  sign, suspended sign, symbolic functional digraph stands impulse-ustoichivy for a given pulse of the process sequence of the absolute values of pulses in the vertex  $\{|P_i(n)|, n = 0, 1, \dots\}$  limited.

*Definition.* Top  $x_i$  sign (and other) digraph is absolutely stable for a given pulse process sequence of absolute values of the parameters at a given vertex  $\{|v_i(n)|, n = 0, 1, \dots\}$  limited.

*Definition.* The iconic (and other) acts impulse count (absolute) sustainable pulse for this process, each vertex acts as a pulse (absolutely) stable in this switching process.

As a result of interaction of cycles of the sign digraph the resonance can arise. Resonance analysis is the basis for the analysis of dynamic processes in complex systems.

*Definition.* Assume that the cycles do not match  $L_1$  и  $L_2$  sign digraph  $G(X, E)$  interact if at least one of the proposed 2 conditions is implemented:

–arc available  $e \in E$ , relating to  $L_1$  and to  $L_2$ ;

–there is a bridge between  $L_1$  and  $L_2$  or between  $L_2$  and  $L_1$  (a bridge is an arc of a digraph whose removal causes an increase in the number of components in the digraph).

*Definition.* The appearance of the pulse instability of the sign digraph in simple pulse processes, formed as a result of the interaction of feedback cycles, called resonance.

There is an Association between the presence of cycles in the sign digraph and its impulse stability. For starters, the signed digraph that has no cycles, pulse resistant for all simple pulse processes. At the same time, for any pulse process there is the last moment of time, after which the pulses in all vertices at any further moment are equal to 0. In-2, signed digraph, which has only one cycle, pulse resistant for all simple pulse processes. In-3, signed digraph, which has only just interacting cycles, pulse is steady in all simple pulse processes. It follows from all this that resonance is the only root cause of impulse instability in Autonomous impulse processes.

Ordinary resonant topological structures are considered to be roses–digraphs, consisting of one Central vertex and intersecting only in it cycles, which are called petals (Figure 1.).

When resonances in the roses module of the pulse is increasing exponentially. However, there are such topological structures; in which the pulse modulus increases linearly at resonance. This phenomenon may be called linear resonance.

A simple case of linear resonance is considered to be a digraph consisting of 2 even cycles of equal length, United by a bridge of a single arc (Figure 2.). The applied value of this phenomenon lies in the fact that the linear resonance is the least unsafe than the exponential one, due to the fact that it can be extinguished by external pulses unchanged in magnitude. Hence, the rebuilding of the structure, changing the essence of the resonance, has the ability to be useful in practice [3, p. 254].

The axioms of eigenvalues give the possibility to implement the analysis on stability, but do not represent the way of finding a rational management strategy for avoiding resonance [4, p. 163;

5, p. 135; 6, p.19]. Axioms that connect the stability and topology of the digraph, is confirmed only for certain structures, such as rose [3, p. 152; 4, p. 95]. As a consequence of this, we certainly approximate the random digraph by some rose and conduct a subsequent study on the given rose. The applied value of the approximation by roses is as follows. Replacement of the initial digraph approximating the rose allows to modify the topology of the rose, firstly, length and character of the petals, with the goal of eliminating resonance. The configurations introduced into the rose topology can later be interpreted in the configuration of the initial digraph topology.

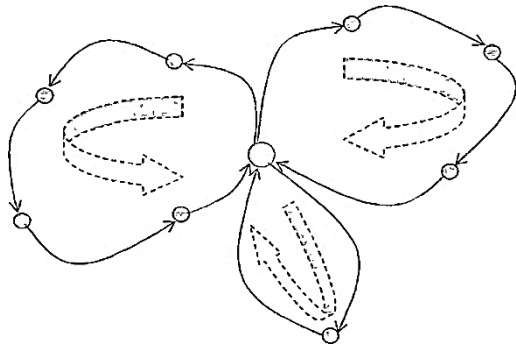


Figure 1. Three-petaled rose. Source: elaboration of author.

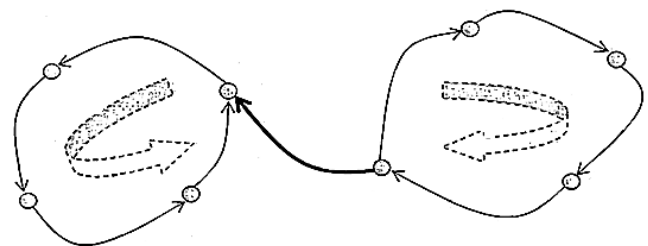


Figure 2. Topological structure with linear resonance. Source: elaboration of author.

Let the problem have such limitations. To begin with, only digraphs with a finite number of vertices are subject to discussion. In-2, of all the vertices 1-on is noticeable, which is considered as the middle of the approximating rose. In-3, discussion of the subject only normal pulse processes allocated starting at the top.

Definition. We assume that the rose  $R$  with the center at the vertex  $U$  is an AP-proximation of the digraph  $G(X,E)$  with a designated top  $A$  and if the sequence  $\{v_A(t)\}$  and  $\{P_A(t)\}$ , formed by a simple impulse process on a digraph  $G(X,E)$ , originating in the top  $A$  match the traces sequences  $\{v_U(t)\}$  and  $\{P_U(t)\}$  as a consequence, formed by a simple pulse process on the rose  $R$ , originates in its center  $U$ .

*Algorithm for constructing an approximating rose [3, c. 152]*

Let the proposed digraph  $G(X,E)$  with a finite number of vertices and a designated vertex  $A$ . Let all the way from  $A$  to  $A^{nd}$  discovered (the algorithm of detecting them are known). These paths can intersect.

Step 1. A subset of intersection vertices is denoted. For each of the vertices of the given subset, fictitious but different vertices are introduced. Each vertex of intersection is identical with the number of dummy vertices, which is one less than the number of appearances of the vertices of intersection in the detected paths from  $A$  to  $A$ . the Indicated vertex  $A$  and, in fact, are not included in the subset of vertices of intersection.

Step 2. Redundant intersection vertices on these paths are replaced by dummy vertices. The totality of all paths forms a rose with the center at the top.

Step 3. Vertex  $A$  is re-designated as  $U$ .

Painted the conversion will be called  $R$ -transformation digraph  $G(X,E)$  centered at the vertex  $A$ .

It can be said that the result of the  $R$ -transformation is an approximating rose in essence of the above definition. To do this, first of all, it is necessary to understand the question of the final number of petals, because all the theorems on the stability of roses, applying eigenvalues, require finiteness of the number of petals [7; 8]. A number of statements are known that demonstrate that:

– To R — transform the digraph  $G(X, E)$ ,  $\|X\| < \infty$  with the center in the indicated vertex A having the final number of petals, it is necessary and sufficient that in digraph  $G(X, E)$  there is no local cycle that does not include A, reachable from A and such that A is reachable from it.

– R — the transformation of a digraph  $G(X, E)$  centered at vertex A with the final number of petals acts as an approximation of a digraph  $G(X, E)$ .

Often in the study of sign digraphs are formed approximating roses of only 2 petals. In addition, a two-petal rose is an elementary resonant structure, since a single petal is not able to give resonance. For a two-petal rose, an explicit form of the characteristic polynomial can be prescribed, in which the signs and lengths of the petals are dependent [3, p. 368]:

Let the length of the lobe of the petals of the rose are equal  $n_1$  and  $n_2-1$ . In this case, the characteristic polynomial will have the form:

$$\chi(\lambda) = \lambda^{n_1+n_2} - \lambda^{n_2} \text{sign}(l_1) - \lambda^{n_1-1} \text{sign}(l_2), \quad (6)$$

where  $\text{sign}(l_1)$ ,  $\text{sign}(l_2)$  — signs of petals.

We can see that statement 6 is generalized in the case of weighted sign digraphs. If  $w(l_1)$  and  $w(l_2)$  — this is the product of the weights of the lobe arcs, then the characteristic polynomial will have the form:

$$\chi(\lambda) = \lambda^{n_1+n_2} - \lambda^{n_2} w(l_1) - \lambda^{n_1-1} w(l_2), \quad (7)$$

In the situation of even petals of different lengths in a two-petal rose, resonance is inevitable.

If the lobe contains 2 rose less-than-zero amplitude, which is a multiple with an odd number ratio, the resonance is inevitable.

It should be noted that the presented tools undoubtedly have the opportunity to be useful in the analysis of the organizational and economic structure of the system in order to improve its socio-economic security. Generally speaking, in the literature (usually abroad) for a long period of time are examples of the use of models on the sign graphs and digraphs to solve problems in various fields of human activity.

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