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ALTERNATIVE POSSIBILITIES OF LATTICE MODEL RESEARCH IN THE DEVELOPMENT OF SOCIO-ECONOMIC SYSTEMS

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Abstract:

The state-of-the-art. The necessity and possibility of developing models to analyze alternatives to managerial decisions is indispensible for the adequacy of understanding and relevance in actions to regulate the processes occurring in the socio-economic system. However, currently used models of managerial decision-making are complex, not always simple and easy to use, consider many indicators, factors and conditions and insufficiently reflect the processes. In this regard, it is relevant to expand the possibilities of using discrete lattice models in managerial systems, which play an increasingly important role in various branches of science and economics. The proposed approach is based on a two-dimensional lattice model with a constant calculation step.

Results: *The lattice model of the organizational activities and options of its development is considered. It is found that the lattice model gives adequate option indicators, allowing to make a reasonable choice. The experiment shows that the lattice model is relatively simple, convenient for computer implementation, modeling and analysis of managerial decisions. The lattice model can be used to solve transportation problems (in optimizing passenger and cargo transportation), medical problems (for example, in modeling diseases attack rate), etc.*

Keywords: *lattice model, modeling, analysis, managerial decisions, alternatives, cluster, indicators.*

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INTRODUCTION:

The most important characteristic of the modern manager, being at any level of hierarchy in an organization is to possess an arsenal of methods and tools that ensure timely and reasonable effective managerial decision-making.

The object of the managerial decision is a problem, in the form of a complex theoretical question or the current practical situation that impede its solving due to specific conditions. The managerial problem is characterized by the following main features: it always has alternative solutions; has quantitative parameters and a certain solution algorithm. The task of the managerial decision is to choose the best options optimal for external and internal conditions to achieve the aim (the desired activity result).

The aim of the research given in this article is to develop a lattice model that facilitates the selection of the best options from the available alternatives.

Lattice models in general are methodologically based on the mathematical lattice theory, which uses partially ordered data sets in the absence of a clear hierarchy of objects [1].

Lattice models are widely used in various sciences (mathematics, physics, mechanics, chemistry, medicine, biology, economics, etc.) when analyzing objects with connected fields, boundaries passing that contribute to changes in structures, configurations, system elements, relationships between stages in processes.

So, for example, the percolation theory (S. Broadbent and J. Hammersley) [2] developed in the works of other researchers [3; 4; 5; 6], uses the lattice as a tool that reflects regularities in dynamics of phase passing between cells that interprete elements of the research object.

The lattice form is the basis of a discrete model of cellular automaton used to solve algorithmic decision problems that are reflected in the works of J. von Neumann [7], J.H. Conway [8], M.L. Tsetlin [9], S. Wolfram [10], etc.

Graph theory (L. Euler, D. Kőnig, R. Distel, etc.) [11; 12; 13] studies the graph features that visually represent a number of edge-connected vertices. At a certain transformation, the lattice can be displayed as a graph and vice versa.

In recent years, lattice theory has been developed in modeling data of complex information systems [14].

Lattice model: contents:

The main elements of the lattice model: DM (decision maker); lattice; aim (result); alternative aims (results); criteria (indicators, conditions).

DM refers to an agent of management, implementing a set of creative and volitional activities to solve the problem and achieve the aim. Implementing interrelated and logically consistent actions, he manages resources (human, financial, material, etc.) in accordance with specified criteria (for example, minimizing costs and maximizing efficiency).

A lattice (or grid) contains a set of cells that can be in many different states, not necessarily linked together. The lattice is graphically represented as a two-dimensional plane (planar lattice) consisting of any number of cells (n*n) characterizing its dimension (L). The lattice has entries – cells, through which DM begins to solve the problem, and exits – cells, after accounting for which in the calculations, the solution of the problem is considered complete.

The primitive unit of the lattice is a cell, conditionally reflecting the object of research or impact (for example, an organization, a division, a specific type of work, activity, etc.).

The cell sides represent the boundaries between them, as well as between them and the environment. Discrete variables (Pi), characterizing the relevant indicators involved in achieving the aim, are reflected on the cell sides. The composition and values of these variables and indicators can be changed at DM request, depending on the influence of various factors (for example, time), or according to the regulations.

For example, cell №1 contains parameters (indicators) P1-P4 that determine the alternative values of the choice, the acceptability of further actions to pass to the next cell, which means the next activity, stage, focusing the direction to solve the problem (figure 1).

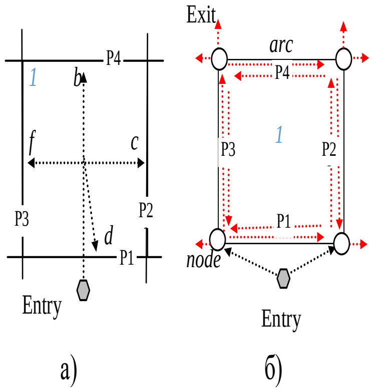

Figure 1 Cell content and directions of the possible option for DM to solve the problem

The choice of a cell and direction of conditional motion within it is set by specification of the solvable tasks and parameters (indicators) fixed on the boundaries for passing to the adjacent cell. So, if the task to minimize the parameter is set, then on condition P3>P4<P2, the path b of the problem is chosen (figure 1, a).

The cell sides can be formed by arcs, reflecting the paths, directions, measures, activities, works, actions and other elements of the solvable task. The cell sides can also begin and end with nodes, meaning the activity numbers, the sequence of works, processes, etc. (figure 1, b).

There can be 3 exits from the sides and nodes of a given cell: to adjacent cells, beyond the lattice (which means the end of the analysis), or return to the original position. At this, passage to other adjacent cells on the diagonal is not allowed.

Quantitative indicators characterizing the cell sides (or arcs) can have natural and cost values, as well as be reflected in conditional value (for example, points).

For each cell, a set of adjacent cells is defined, creating its neighborhood. Thus, the neighborhood of a given cell can be a set of other adjacent cells at a distance of not more than 1, which, according to the provisions of the cellular automaton theory, refers to John von Neumann neighborhood, domain or region of range 1 (figure 2).

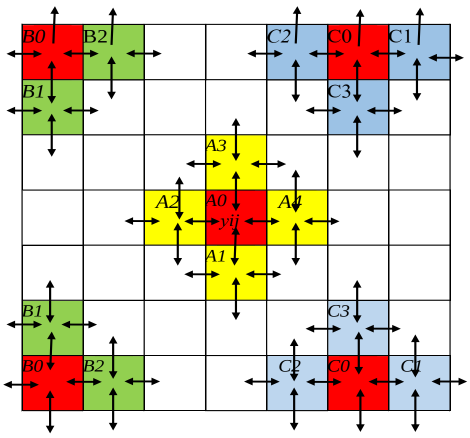

Figure 2 Cell neighborhood of range 1 and possible directions of its interaction with adjacent cells

In a two-dimensional lattice, each cell can be denoted by indices – yij. The nearest adjacent cells belonging to the neighborhood of cell A0 yij are upper-lower located cells (A1; A3) and to the left-right of it (A2; A4), forming the von Neumann neighborhood:

$$Vn(y_{i,j}) = (y_{i-1,j}, y_{i,j-1}, y_{i,j}, y_{i,j+1}, y_{i+1,j}).$$

As can be seen, cell A0 has 4 adjacent cells in the center of the lattice; cell C0 has 3 adjacent cells at the beginning or end of the lattice; cell B0 in the corner of the lattice has 2 neighborhood adjacent cells.

The aim is the desired result of the subject impact on the object of management using a lattice model. Alternative aims reflect other possible options to solve the problem.

Criteria (indicators, conditions) – quantitative values (for example, costs, factors, etc.) that characterize the conditions to solve the problem.

To work with the lattice, it is necessary to specify the initial state of all cells and the rules for passing the boundaries between them. The set of cell parameters or its separate sets determines the state of the entire lattice, which can be changed according to a certain rule established by the researcher depending on a number of circumstances (for example, based on the influence of various factors).

An example of lattices with set quantitative parameters of cells prepared for DM analysis is presented in figure 3.

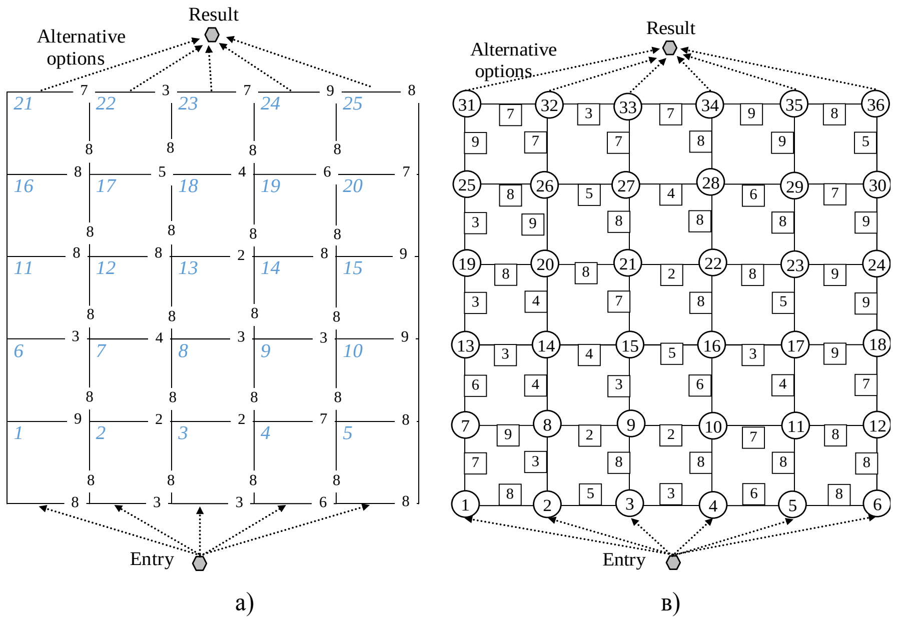

Figure 3 Example of lattices with specified quantitative parameters of the cells

For each iteration of actions, rules for passing are used based on the state of adjacent cells at the time of this passage. The rules for passing the boundaries between cells may differ significantly for each cell, but general rules applied to the entire lattice or its certain part can be set.

Alternative solutions of the conditional managerial task to minimize the costs plan (resources, time, etc.) are shown in figure 4.

It is clear that the minimum costs (14 points) are provided by the activities implementing under option 3, reflected on the cell sides 3, 9, 14, 13. At this the costs range is set from 1 to 9 points.

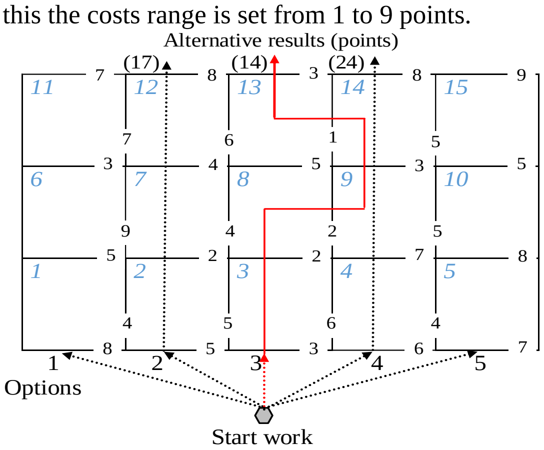

Figure 4 Example of identifying alternative solutions of conditional managerial tasks to minimize costs

To work with the lattice, it is necessary to specify the parameters of the initial state of all cells and set the rules for passing between them. The rules for passing are often the same for all lattice cells, which simplifies the calculations. Sometimes after each iteration, specification of the new state of the cell parameters is required.

The total number of cells and set parameters (indicators, values) shows the lattice volume reflecting the possible number of alternative solutions to the management problem.

A set of interconnected lattice cells with a single algorithm for solving the problem is a cluster, which can be denoted by:

$$\text{KL} = \sum k\, i,$$

where KL is a cluster; k are sequentially connected cells.

For example, in figure 4, the cluster is formed by cells 3, 8, 9, 14, 13, which ensure the aim achievement – cost minimization. The cluster shows that there is an oriented path from the lattice entry cell 3 to exit cell 13, which ensures the aim achievement with a specified cost minimization condition.

The number of cluster cells must be less than their total set in the lattice.

The lattice model of the alternative analysis in managerial decisions was tested in 2015 in PLC "Vladikavkaz Railroad Car Repair Plant" in the city of Vladikavkaz, Republic of North Ossetia-Alania while developing strategy under the conditions of unstable environment and a long-existing decline in activities since 2011.

The aim was to provide the following indicators by 2020:

- to increase revenue in 2020 by 1,7 times to level for 2015;
- to increase the return on investment per employee from 0,7 mln rub per year in 2015 to

1,4 mln rub in 2020;

- to increase the competitiveness;
- to contribute to the formation of a long-time order portfolio with a high level of investment projects implementation.

The indicators used in the model had alternative values reflecting many options of combinations in the search for the optimal way to solve the problems of the organization.

Modeling on the lattice consisted of the following main stages:

- development of the activities set with their quantitative values, ensuring the aim achievement;
- systematization of activities in accordance with the logical sequence of their implementation, interrelation between them and quantitative characteristics;
- lattice model development, computer modeling;
- analysis and verification of results, verification of results compliance with the specified conditions.

The use of a lattice model (cells 83x63) to calculate the necessary increase in the volume of activity in the involved organization PLC "Vladikavkaz Railroad Car Repair Plant" allowed to identify 3 main directions (clusters) from the initially considered 12 options that have favourable prospects for further optimization of indicators (figure 5).

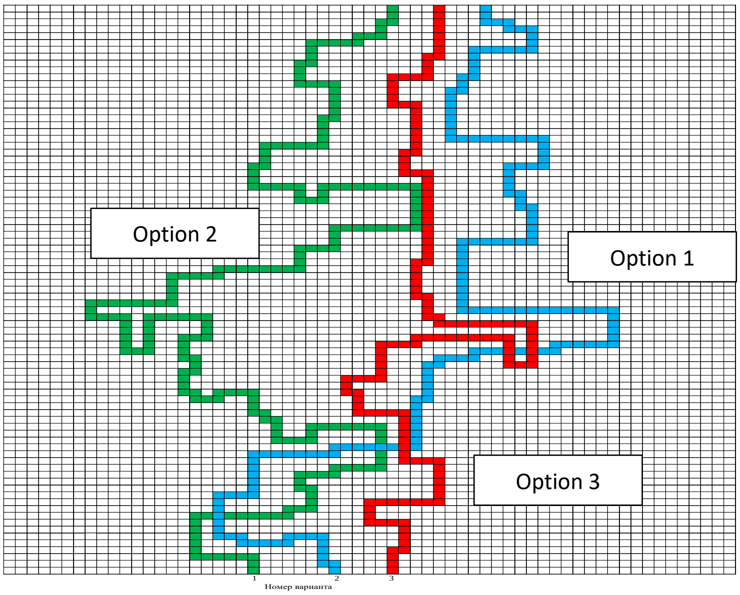

Figure 5 Screenshot of modeling results

The required results of the organizational development were provided by option 3, which was later adopted as the basis for the medium-term prediction until 2020 (figure 6).

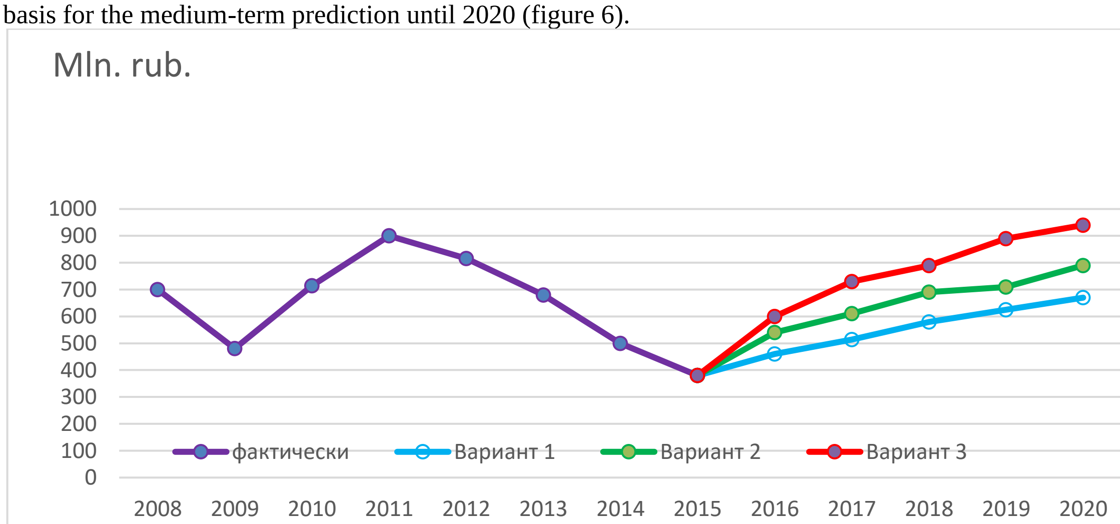

Figure 6 Dynamics in the organizational activity level and options of its development

As can be seen, option 3 shows the maximization in the activity level of PLC “Vladikavkaz Railroad Car Repair Plant” in 2020 by 2,5 times to level for 2015, which allows not only to reach the level of 2011 (900 million rubles), but also to exceed it (940 million rubles).

CONCLUSIONS:

1. The study showed the possibility of using lattice models in the problems of modeling and analysis of managerial decisions in the development of socio-economic systems. The lattice model uses partially ordered data sets in the absence of a clear hierarchy of objects.
2. The use of lattices requires specifying the initial state of all cells and rules for passing the boundaries between them. The state of the lattice changes according to a certain rule depending on the influence of various factors.
3. The study showed that the lattice model is relatively simple and convenient. This allows recommending it to use in modeling and analysis processes.

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