

ABSTRACT

**thesis of Murzakhmetov Aslanek Nurbekovich
on the topic "Formation and optimization of the innovation system based on a
two-level dictionary and geometric interpretation"
submitted for the degree of Doctor of Philosophy (PhD) in the specialty
6D070300 - "Information Systems"**

Relevance of the research topic. Currently, the process of knowledge evolution leads to a new look at scientific and technological breakthroughs and a transition to a new level of development. One of the reasons for this breakthrough is the widespread use of innovative technologies in various fields. Although the mechanism of formation and dissemination of innovations has been partly known for a long time, research in this area is very relevant and requires further development due to the emergence of new concepts and new research tools in the field of innovation, since some issues have not been sufficiently resolved. The concept of innovation was first introduced by the American scientist J. Schumpeter in his "Theory of Economic Development" as the concept of "innovation" and "novelty". Then different scientists began to explain their own understanding of innovation. In particular, F.Valenta and L.Voldachek write that "innovation is a change", and E.Utkin considers innovation as a real "object". F.Nixon - "a set of measures", S.Valdaytsev gave the concept of "new product development". In general, innovations are a social phenomenon, that is, they determine people's behavior by changing the traditions of society, striving for innovation, and moving from one stage to another.

To date, a lot of experience has been accumulated in the study of the formation, dissemination and impact of innovations on society. Foreign scientists E.Rogers and F.Bass proposed mathematical models and concepts explaining the process of formation and the impact of innovations in the social environment. In the modern papers of such scientists as P.Deutschmann, V.Danielson, A.Baroncelli, A.M.Fedotov, F.A.Murzin, V.B.Barakhnin, the diffusion of innovations, the dictionary in the Naming Game are considered. In addition, the work of the dictionary is considered in the studies of domestic scientists A.E.Dyusembaev, Zh.A.Tusupov. However, these works do not mention the optimization of the innovation dictionary. In a global network, the practical size of such a dictionary can be very large. Such a problem is of great interest, especially if the dictionary is large. This is because the dictionary executes hundreds or more machine instructions in a few tens of microseconds. The loading time of dictionary pages takes several tens of milliseconds. Such situations can lead to an error of interconnected links on dictionary pages, i.e. to a page rejection. The presence of page failures can reduce system performance by up to 98% (D.Knuth, P.Denning, D.Ferrari, etc.). Therefore, one of the main problems of the page memory management system, including the innovation dictionary, is to minimize the number of page failures. Its solution is usually associated with the correct choice of the page replacement algorithm and the reorganization of the codes. One of such solutions is to use the WS (Working set) strategy by reorganizing the program codes for the problem of program segmentation (A.E.Dyusembayev). Undoubtedly, the concept of a working set plays

an important role in the theory of optimization of computational processes, so the WS strategy is of particular interest in solving the problem of reorganization.

The relevance of the chosen topic is due to:

- lack of optimization approaches and models for dictionary innovation systems;
- no final solutions, even for related problems (refactoring, restructuring);
- large dimension of the innovation dictionary (Big Data problem);
- poor alignment of concepts in the dictionary can cause a drop in the productivity of the innovation system;
- low system performance due to the excess number of page failures;
- the ability to build a multi-agent system optimization model to reduce the risk of an epidemic among agents;
- for the first time, the problem of optimization the work of the innovation dictionary is set and for the first time the possibility of optimization the model based on the geometric interpretation of the computational process is shown.

In this regard, the research carried out in the thesis is relevant.

The aim of the research is to formation and optimization of the innovation system, and the application of the optimized system to the problem of reorganizing groups of a multi-agent system.

Research objectives: the implementation of this aim involves the solution of the following problems:

- analysis of literature and technologies on the description of the innovation system and determination of the mechanism of innovation formation;
- formation of the innovation system;
- a model for optimization the innovation dictionary based on computational processes and geometric interpretation;
- application of the developed model to the problem of reorganizing groups of a multi-agent system.

The research object: innovation system, innovation system optimization, multi-agent system.

The subject of research: the formation of the innovation system, the optimization model of the innovation dictionary and the application of the optimization model.

The research method: The thesis uses the following methods to solve the formulated problems: discrete optimization methods, stochastic programming methods, methods of operations research, principles of geometric interpretation.

Scientific novelty:

1. Formation of the innovation system;
2. A model for optimization the innovation dictionary based on computational processes and geometric interpretation;
3. Application of the developed model to the reorganization of multi-agent system groups.

Theoretical and practical significance of the research: The problem set and solved in the thesis relate to the foundation direction of computer science. The practical significance of the work is determined by the fact that the constructed models can be

used in practice when optimizing the work of the innovation dictionary. Currently, issues and problems related to the problem of diffusion of innovation are of considerable interest both from a theoretical point of view and from the point of view of practice. A significant amount of the publication is devoted to the theoretical study of the phenomenon of diffusion of innovation, as well as applied aspects, while various authors used the concept of the innovation dictionary on the pages of which innovations themselves are located. Such a dictionary can have a large dimension and here the problem of optimization the work of the dictionary is natural. In our optimization model, the dictionary is two-level and divided into pages of various sizes. The first level of the dictionary is static memory, where the dictionary itself is located, divided into pages on which innovations or concepts are located. The second level of the dictionary is its dynamic memory, on the pages of which copies of pages of static memory are located. The thesis sets the problem of optimization the work of the dictionary, including a system of restrictions on acceptable solutions and functionality. The results obtained serve as the basis for the development of a practical optimization algorithm.

The results and conclusions of the study also make it possible to analyze the process of formation and dissemination of innovations in society, the emergence and dissemination of political views, ideas, and their impact on societies.

The main statements for the defense:

- For the first time, the problem of optimizing the work of the innovation dictionary based on the strategies of the working set is set;

- in the context of our research, the concept of innovation is introduced and the mechanism of innovation formation is described;

- a mathematical model of optimization of the innovation dictionary is constructed:

a) the functional (including the empirical functional for $h \geq 1$ experiments) of the optimization problem of the innovation dictionary and a system of constraints defining the set of acceptable solutions to the optimization problem are found;

b) a geometric interpretation of the computational process as a random walk along the vertices of a universal combinatorial space (Boolean) is found;

c) the possibility of reducing the dimension of the optimization problem of the innovation dictionary based on the geometric interpretation of the computational process is shown;

- the application of the developed model for the problem of reorganizing groups of a multi-agent system in order to reduce the risk of an epidemic is shown.

Approbation of the results: Discussion of the results was carried out in the framework of international conferences: ISIS 2017 «The 18th International Symposium on Advanced Intelligent Systems», Daegu, South Korea, 2017; «Integration of the scientific community to the global challenges of our time», Osaka, Japan, 2017; "Auezov readings", Shymkent, 2017; "Intellectual information and communication technologies - a tool for the implementation of the third industrial revolution in the framework of the strategy" Kazakhstan - 2050", Astana, 2016; "Science and Education", Astana, 2015. In addition, the results of the thesis were discussed at

scientific seminars of the Department of Information Systems, Faculty of Information Technologies of al-Farabi KazNU and in the Institute of Information and Computing Technologies.

Publications: The main results of the thesis were published in 20 publications: 4 publications in journals with a non-zero impact factor, entering the database of data Scopus and Web of Science (Clarivate Analytics); 5 publications in journals recommended by the Committee on Control in the field of education MES RK; 5 publications in materials and works of international conferences of foreign and RK; 1 publication in foreign journals; 5 copyright certificates.

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Volume and structure of the thesis: The thesis consists of an introduction, three chapters, a conclusion, a list of sources used and appendices. The work is made on 103 pages, including 22 drawings, a list of references from 159 sources and an appendix on 15 pages.

The introduction provides a general description of the work, a literary review of the research topic, a justification of relevance, the goals and objectives of the study, the main conclusions and the scientific novelty of the work are formulated.

The first chapter describes the features of the dissemination of innovations, general concepts and models of the dissemination of innovations, as well as some methods of exchange.

In the second chapter of the thesis presents research aimed at reorganizing the dictionary of innovations and their results. One of the reasons for the research in this direction is the lack of adequate models on the problem of reorganization of the dictionary of innovations (concepts). In our case, the problem of redistributing concepts across pages of a static memory dictionary in order to minimize the number of page failures is a well-known NP-hard problem and methods based on the cluster approach and other heuristic approaches can be used for it. In this chapter, a geometric interpretation of the computational process is also found, which simplifies the understanding of the details of the process and helps to build a mathematical model of reorganization, including functionality and constraints, the latter specifying a set of acceptable solutions. The model and its features provide the basis for further research on the construction of an algorithm to obtain an optimal or e-optimal solution of the constructed problem, and some properties of this kind of algorithm are discussed.

In the third chapter of the thesis, a multi-agent system is considered, in which agents are divided into groups and are at risk of infection when contacting each other. The problem of optimizing the functioning of a multi-agent system by redistributing agents into groups in order to reduce the possibility of an epidemic is formulated. As a combinatorial problem, this problem belongs to the class of NP complete problems, which reflects the fundamental aspect of this study. The concept of a working set is used here, which is an important concept in the theory of computational processes and can serve as a basis for the study of other processes. In addition, this section discusses the model of the spread of innovations in the social system.

In the conclusion, the main results and conclusions of the work were formulated.