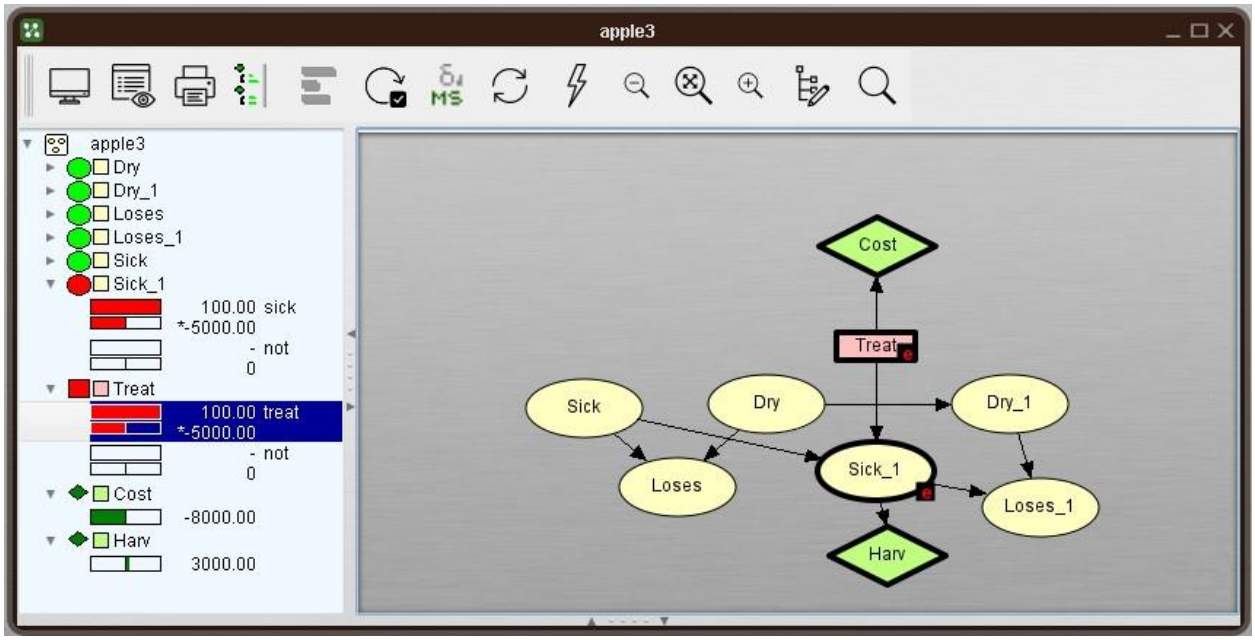
Brief information about the project

Name of the project	AP19679142 «Search for optimal solutions in Bayesian networks in models with linear constraints and linear functionals. Development of algorithms and programs»
Relevance	There is an extensive class of practical problems containing various types of uncertainties. The results in solving such problems are usually probabilistic in nature, indicating the degree of reliability of the result obtained. In many such tasks, various causal relationships between the objects under study are often found. To solve this class of problems, the apparatus of Bayesian networks is usually used. The use of Bayesian networks is quite transparent and, as a rule, gives good results. Difficulties arise when it is necessary to find an optimal solution in some sense, to quantify the results. To solve such problems, Bayesian networks have been further developed – influence diagrams. Influence diagrams allow you to search for the most appropriate solution from the various solutions under consideration and obtain some kind of quantitative assessment of the solutions under consideration. However, it is not necessary to talk about the optimality of the resulting solution in some sense. Only the best solution is chosen from several considered ones. For example, when solving linear programming problems, the extremum of some linear functional is found under given linear constraints. The idea arises whether it is possible to use the linear programming apparatus for problems with various types of uncertainties that are probabilistic in nature. At the same time, some of the variables of the task may be limited by cause-and-effect relationships. Otherwise, is it possible to supplement linear constraints in linear programming with constraints on some variables (not all) that arise in a Bayesian network containing these variables. The presence of such restrictions is causal in nature and such restrictions are difficult or simply impossible to describe by linear inequalities. In this project, it is planned to develop a mathematical apparatus that allows using the ideas of Bayesian networks in conjunction with the capabilities of linear programming.
Purpose	Development of the theory of constructing optimal solutions in Bayesian networks under linear constraints and for linear functionals. Development of algorithms that implement this theory. Implementation of the constructed algorithms in the program code.
Objectives	1. The theory being developed in this project is at the junction of the theory of Bayesian networks and the theory of linear programming. The implementation of this theory in a software product is supposed to be carried out in an environment (WINDOWS10 + Visual Studio19(C#)).

	2. Research of the modern market of algorithms and software products for working with Bayesian networks, as well as for solving linear programming problems. 3. Development of an extended Bayesian network structure focused on the use of linear programming methods. 4. Development of the theory of working with Bayesian networks containing extended types of evidence. 5. Development of algorithms for working with Bayesian networks containing extended types of evidence. Implementation of algorithms in the program code. 6. Development of the theory of working with Bayesian networks containing elements of linear programming. 7. Development of the theory of solving linear programming problems in environments containing Bayesian networks. 8. Development of algorithms for working with Bayesian networks containing elements of linear programming. 9. Development of algorithms for solving linear programming problems in environments containing Bayesian networks. 10. Development of the structure and appearance of the software package. 11. Development of methods for storing Bayesian networks containing elements of linear programming. 12. Development of software modules for working with Bayesian networks containing elements of linear programming. 13. Development of software modules for solving linear programming problems in environments containing Bayesian networks. 14. Development of software modules that create images of Bayesian networks containing elements of linear programming. 15. Development of software modules for working with images of Bayesian networks containing elements of linear programming. 16. Debugging software modules. 17. Checking the operability of software modules on test examples. 18. Adjustment based on the results of testing software modules. 19. Development of technical documentation.
Expected and achieved results	In this project, the following will be developed: • The theory of using evidence of various types in Bayesian networks. • The extended structure of the Bayesian network, focused on the use of linear programming methods. • Theory of working with Bayesian networks containing extended types of evidence, algorithms have been developed and implemented in software code.

	• Theory of working with Bayesian networks containing elements of linear programming, algorithms have been developed and implemented in software code. • Theory of solving linear programming problems in environments containing Bayesian networks, algorithms have been developed and implemented in software code. • The general structure and appearance of the software package. • Ways to store Bayesian networks containing linear programming elements. • Software modules for working with Bayesian networks containing linear programming elements. • Software modules for solving linear programming problems in environments containing Bayesian networks. • Software modules that create images of Bayesian networks containing elements of linear programming. • Software modules for working with images of Bayesian networks containing elements of linear programming
Research team members with their identifiers (Scopus Author ID, Researcher ID, ORCID, if available) and links to relevant profiles	Shayakhmetova Asem Serikbayevna, PhD, associate Professor, Hirsch Index – 4, Researcher ID ABA-1440-2020, ORCID: 0000-0002-4072-3671, Scopus author ID: 56151793500. Abdildayeva Assel Asylbekovna, PhD, associate professor, Hirsch Index – 3; Researcher ID O-4374-2017, ORCID: 0000-0002-6381-9350, Scopus Author ID: 56367145800. Gennady G. Litvinenko, Senior Researcher, programmer. Litvinenko Natalya Gennadievna, Master's degree, Hirsch Index – 1, ORCID: 0000-0002-0576-8305, Scopus author ID: 57209263290. Akhmetova Ardak Mergenbaevna PhD, Hirsch Index – 4, ORCID: 0000-0003-2678-3296, Scopus author ID: 57191727441. Kunelbaev Murat Merkebekovich Master's degree, Hirsch Index – 7, ORCID: 0000-0002-5648-4476, Scopus author ID: 56203480200
List of publications with links to them	1. Assem SHAYAKHMETOVA, Murat KUNELBAYEV, Assel ABDILDAYEVA, Ardak AKHMETOVA Research of the modern market of algorithms and software products for working with Bayesian networks \\ 3. Interdisciplinary Conference on Mechanics, Computers and Electrics ICMECE 21-22 October 2023, ISTANBUL / TÜRKİYE 2. A. Shayakhmetova, M.Kunelbayev, A. Akhmetova, A. Abdildayeva, N. Litvinenko Linear constraints on variables in influence diagrams for causal models \\ International Journal of Innovative Research and Scientific Studies, 2023 3. Akhmetova A.M., Abdildayeva A.A., Litvinenko N. G., Litvinenko A. G. Markovskiye idei v bayyesovskikh setyakh // ADVANCED TECHNOLOGIES AND COMPUTER SCIENCE, 2023. - № 3. – S. 9-16.

Patents	-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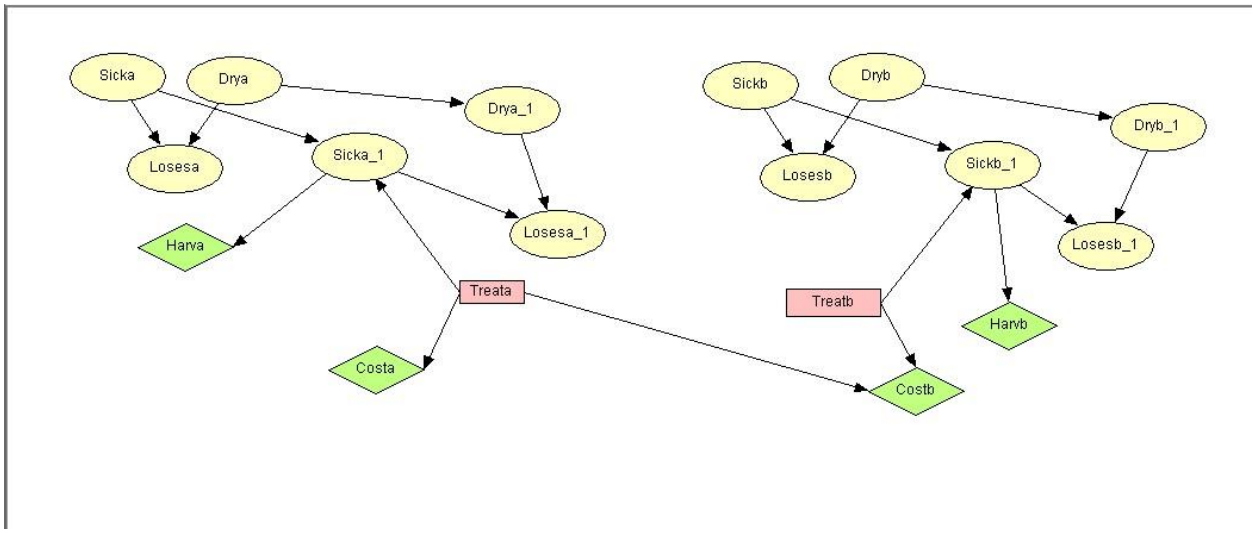
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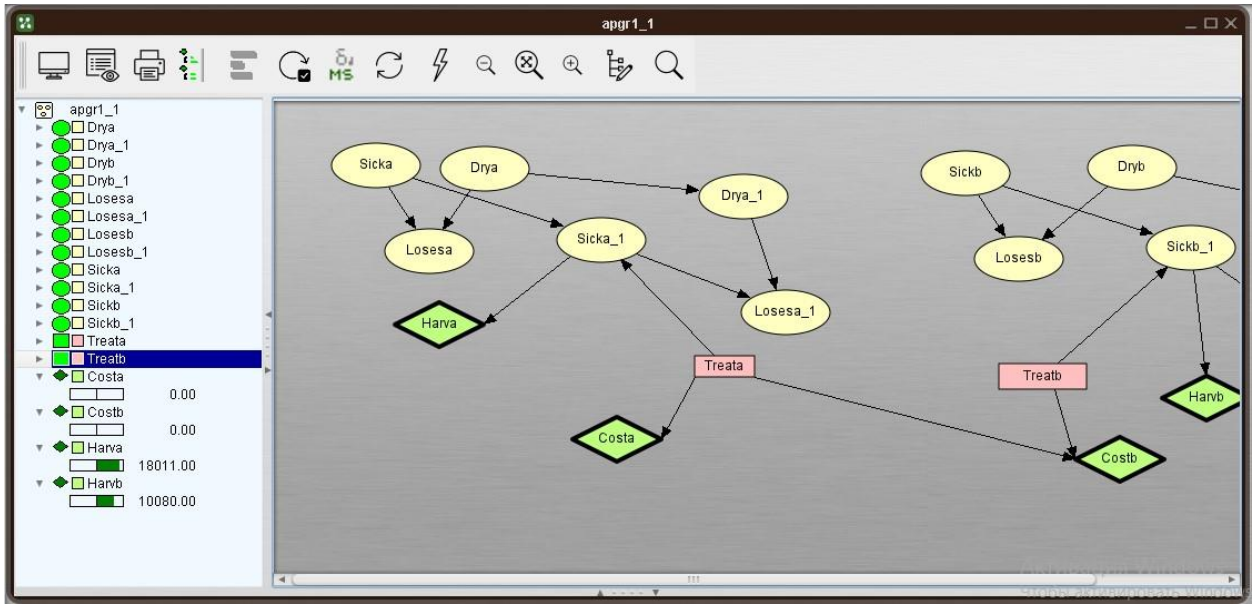
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Visit to Asia? (A)

Edit Functions View

yes	0.01
no	0.99

Table 1

Tuberculosis? (T)

Edit Functions View

Visit to Asia? (A)	yes	no
yes	0.05	0.01
no	0.95	0.99

Table 2

Smoker? (S)

Edit Functions View

yes	0.5
no	0.5

Table 3

Lung cancer? (L)

Edit Functions View

Smoker? (S)	yes	no
yes	0.1	0.01
no	0.9	0.99

Table 4

Bronchitis? (B)

Edit Functions View

Smoker? (S)	yes	no
yes	0.6	0.3
no	0.4	0.7

Table 5

Tuberculosis or cancer? (E)

Edit Functions View

Tuberculosi...	yes		no	
Lung cance...	yes	no	yes	no
yes	1	1	1	0
no	0	0	0	1

Table 6

Positive X-ray? (X)

Edit Functions View

Tuberculosis or cancer? (E)	yes	no
yes	0.98	0.05
no	0.02	0.95

Table 7

Dyspnoea? (D)

Edit Functions View

Bronchitis? (B)	yes		no	
Tuberculosis or cancer? (E)	yes	no	yes	no
yes	0.9	0.8	0.7	0.1
no	0.1	0.2	0.3	0.9

Table 8