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Application of Multicriteria System MKA-2 for Multicriteria Choice of the Most Preferred Insurance "Motor Third Party Liability"[1]

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1. Introduction

Different problems in planning, control, analysis and monitoring in economy, transport, industrial production, education, ecology and other spheres can be reduced to multicriteria decision making problems [7]. Multicriteria decision making problems can be divided into two separate classes [17, 20], depending on their formal statement. In the first class a finite number of explicitly set constraints in the form of functions define an infinite number of feasible alternatives [9]. These problems are called continuous multicriteria decision making problems or multicriteria optimization problems. In the second class of problems a finite number of alternatives are explicitly given in a tabular form [20]. These problems are called discrete multicriteria decision making problems or multicriteria analysis problems.

The decision making problems are non-formalized or weak formalized problems, the solution of which requires the participation of the so-called decision maker (DM) [4, 16]. The solutions obtained are to a great extent subjective and depend on the DM's preferences. In multicriteria analysis problems several criteria are simultaneously optimized in the feasible set of alternatives. In the general case there does not exist one alternative, which optimizes all the criteria. There is a set of alternatives however, characterized by the following: each improvement in the value of one criterion leads to deterioration in the value of at least one other criterion. This set of alternatives is called a set of the non-dominating alternatives.

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Each alternative in this set could be a solution of the multicriteria problem. In order to select one alternative, it is necessary to have additional information, set by the DM. The information that the DM provides reflects his/her global preferences with respect to the quality of the alternative sought.

MA problem may be described by a decision matrix $A(n \times k)$, which can be defined in two ways (Table 1 and 2), where: a_i denotes an alternative with an index i, $i = 1, \ldots, n$; K_j or $f_j(.)$ denote a criterion with an index j, $j = 1, \ldots, k$.

Table 1. Decision matrix (variant 1)

$A_i \backslash K_j$	K_1	K_2	K_3	. . .	K_k
A_1	a_{11}	a_{12}	a_{13}	. . .	a_{1k}
A_2	a_{21}	a_{22}	a_{23}	. . .	a_{2k}
A_3	a_{31}	a_{32}	a_{33}	. . .	a_{3k}
. . .	. . .	. . .	. . .	. . .	. . .
A_n	a_{n1}	a_{n2}	a_{n3}	. . .	a_{nk}

Table 2. Decision matrix (variant 2)

$A_i \backslash f_j$	$f_1(.)$	$f_2(.)$	$f_3(.)$	. . .	$f_k(.)$
A_1	$f_1(a_1)$	$f_2(a_1)$	$f_3(a_1)$	. . .	$f_k(a_1)$
A_2	$f_1(a_2)$	$f_2(a_2)$	$f_2(a_2)$	. . .	$f_k(a_2)$
A_3	$f_1(a_3)$	$f_2(a_3)$	$f_3(a_3)$	. . .	$f_k(a_3)$
. . .	. . .	. . .	. . .	. . .	. . .
A_n	$f_1(a_n)$	$f_2(a_n)$	$f_3(a_n)$	. . .	$f_k(a_n)$

The set of indices set of alternatives is denoted by I, and the indices set of the criteria – by J. The evaluation of i-th alternative with respect to all the criteria is given by the following row-vector: $(a_{i1}, a_{i2}, \ldots, a_{ik})$ or $(f_1(a_1), \ldots, f_k(a_i))$. The evaluation of all the alternatives with respect to j-th criterion is given by the following column-vector $(a_{1j}, a_{2j}, \ldots, a_{nj})^T$ or $(f_1(a_1), \ldots, f_k(a_n))^T$.

MA problems can be classified into three main groups, as follows:

1. In the first group of problems, called discrete multicriteria choice problems, the main goal is to search for the most preferred non-dominated alternative.

2. In the second group of problems, called ranking problems, the non-dominated alternatives are ranked in a descending order (i.e., starting from the best toward the worst alternative).

3. In the third group of problems, called sorting problems, the set of alternatives is partitioned into several separated groups.

2. Multicriteria system MKA-2 – basic characteristics

Among the well known multicriteria analysis decision support systems are the following systems [21]: Expert Choice [14], VIMDA [10], ELECTRE III-IV [13], PROMCALC [2], HIVIEW [12], McView [19], WINPRE [15], Decision Lab [3], VIP Analysis [6], HIPRE-3 [8], and Web-HIPRE [11]. There is one method that is implemented in each of these systems. The main reasons for this are the big difference between the methods in describing the DM's preferences and probably the fact that the developers give preference to their own methods only.

MKA-2 software system is designed to support the solution of problems for multicriteria choice and for multicriteria ranking. The system includes three types of methods: weighting method – AHP [14], outranking method – PROMETHEE II [1, 2] and interactive method CBIM [18]. In other words, the solving modules of the system realize four methods – one representative from the three main groups of MA methods – weighting, outranking and interactive methods.

AHP method [14] is one of the most widely spread weighting method. Pair-wise criteria comparison is used in this method to set DM's preferences. On this basis a pair-wise comparison matrix is constructed. The estimates of the weights can be found by normalizing the eigen vectors corresponding to the largest eigen value of this matrix.

PROMETHEE II method [1] is one of the most often used outranking methods. In this method the intensity of the preference of one alternative over another alternative regarding each criterion is measured in terms of the so-called preference function. Six types of preference functions are used in the method. The method provides a complete preordering of the alternatives through a pair-wise dominance comparison of net positive and net negative outranking flows.

CBIM method [18] is a representative of the interactive methods and is appropriate for solving MA problems with a large number of alternatives and a small number of criteria. The DM is able to provide desired or acceptable levels, directions and intervals of changes in the values of the criteria at every iteration. On the basis of this information, the method enables the use of discrete optimization scalarizing problems, with the help of which the DM has the possibility for a more systematic and successful screening of the set of alternatives.

MKA-2 system enables:

- the entry, correction and storing of data for different problems of multicriteria choice and of multicriteria ranking;
- the solution of these type of MA problems with the help of three methods: AHP (Analytic-Hierarchy Process), PROMETHEE II method and CBIM (Classification-Based Interactive Method);
- the presentation of the final solution of the digitally and graphically;
- the saving of the input data for the problems solved and of the results obtained in a file and on a paper carrier.

The MKA-2 system is built on the principle of Multidocument interface [5].

3. Multicriteria choice of the most preferred insurance "Motor Third Party Liability" – formulation and solution of the problem using MKA-2 system

The aim of the problem for multicriteria choice of the most preferred insurance "Motor Third Party Liability" is to choose, according to certain preferences of the DM, the best of MTPL insurance offered for a motor vehicle. Let us consider [22] a motor vehicle with the following characteristics: engine capacity 1581 sm3, region of use – Sofia and years of driving 30. Let us consider that the multicriteria analysis problem we solve contains the following criteria and alternatives (Table 3).

Table 3. The initial multicriteria analysis problem to be solved

BANK	Bulgarian Property Insurance Company Ltd.	Victoria Insurance Co.	Telecommunications Act Bul Ins Co.
General information about the product			
Cost of MTPL insurance	139.00 BGN	134.00 BGN	139.00 BGN
Cost of insurance on Payment	**First installment**:69.50 BGN; **Next installments**:69.50 BGN; **Total**:139.00 BGN	**First installment**:75.50 BGN; **Next installments**:65.50 BGN; **Total**:141.00 BGN	**First installment**:79.00 BGN; **Next installments**:69.00 BGN; **Total**:148.00 BGN
Bonus in Casco in the same insurance company	no	no	In concluded insurance civil liability in the same company, you may get a discount at a rate of 10% of the cost of insurance Auto Casco "the same vehicles.

Let the criteria to be evaluated are the following:
1. Cost of MTPL insurance;
2. Cost of First installment;
3. Cost of Next installments;
4. Total cost of Payment
5. Bonus in Casco in the same insurance company.

Let the possible alternatives are as follows:
1. Bulgarian Property;
2. Victoria Insurance;
3. Bul Ins.

The formulated problem is a problem of multicriteria choice and will be solved with the help of MKA-2 system. The main steps of the solving process will be demonstrated in what follows. First, the DM should enter the initial data to the task in the following way – first by entering (Fig. 1) the objective of the task ("Choosing the best insurance "Motor Third Party Liability"), and then, by entering the values of the quantitative criteria "Cost of MTPL insurance" and "Cost of the First installment" (Fig. 2).

Fig. 1. Initial data entering

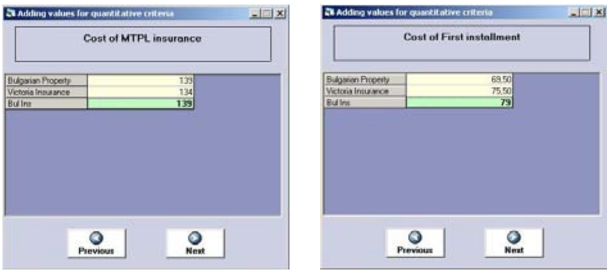


Fig. 2. Entering the values of the first and second criterion

The criterion “Cost of Next installments” is arranging criterion. This means that alternatives must rank in importance to the size of the next installment. When entering the initial data of this criterion, the most preferred alternative occupies first place (Fig. 3).

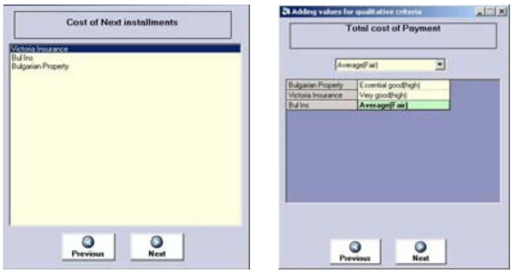


Fig. 3. Entering the values of the third criterion

The criterion “Total cost of Payment” is a qualitative criterion for qualitative assessments of each alternative to total cost of payment. The criterion “Bonus in Casco” in the same insurance company is a weighting criterion. On Fig. 4 the alternatives are compared in pairs in order to enter the values of alternatives for this criterion.

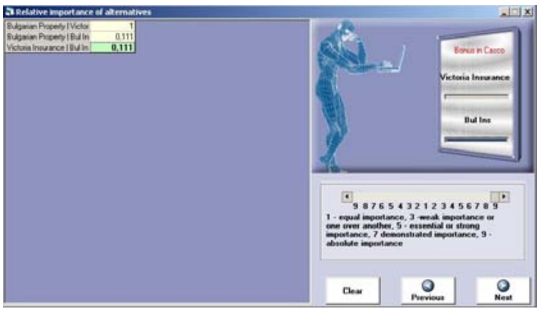


Fig. 4. Comparison of the alternatives in pairs

Following the entries, the system determines whether there are dominated alternatives (Fig. 5, left). After that the DM has to choose the method for solving the initial problem (Fig. 5, right).

In what follows, we shall describe one solving scenario of the initial problem discussed, which includes using of all the methods, developed in the MKA-2 system, in order to demonstrate the main characteristics of each method. In other words, we shall consider that the DM wants to solve the initial problem at four iterations and at each iteration the DM wants to use different method. Of course, the solving scenario for every multicriteria analysis problem depends entirely on the DM.

Let us first consider that the DM chooses to use the Analytic Hierarchy Process (AHP method) for finding one solution of the initial problem. In this method at the first step alternatives are compared in pairs by the DM in order to determine preferences (Fig. 6).

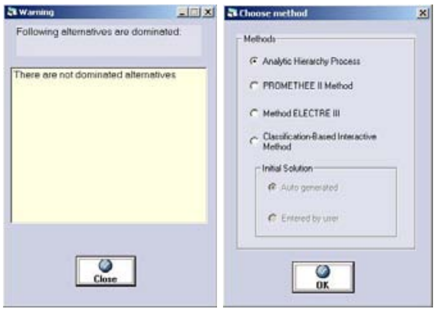


Fig. 5. Determination of dominated alternatives (on the left) and choosing the method for solving the problem (on the right)

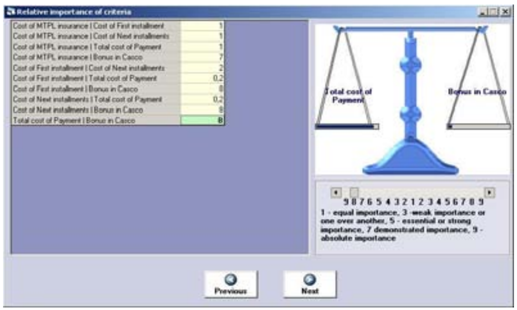


Fig. 6. Comparison of alternatives in pairs in AHP method

On the basis of this preference information, set by the DM, the AHP algorithm, implemented in MKA-2 system, finds the weight of each criterion (Fig. 7).

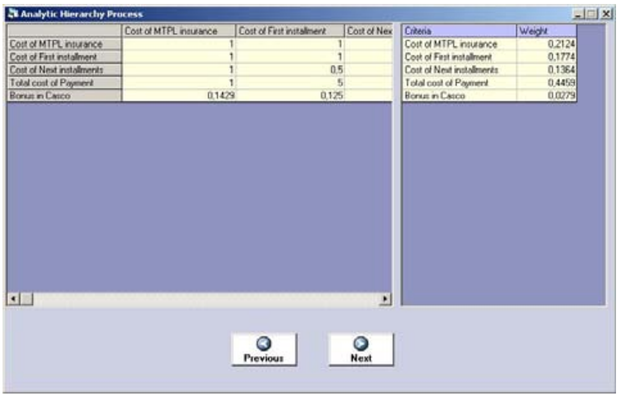
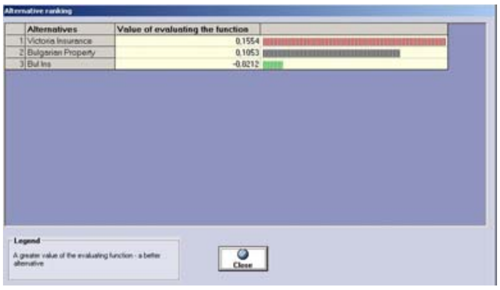


Fig. 7. The weights of the criteria

Finally, the MKA-2 system orders alternatives in order of importance and the first alternative in this order is the best solution of the problem for this iteration (Fig. 8). This solution might be the final solution of the problem if the DM decides that this solution satisfies his/her preferences to a greatest extent. Let us consider that the DM wants to solve the problem one more time using different method and compare the results.

Let us now consider that the DM chooses to use the PROMETHEE II Method. In this method, the following parameters for each criterion have to be set by the DM: Weight, Preference function and Unit. Depending on the Preference function, we can apply the Indifference threshold, Preference threshold, Gaussian threshold, Threshold unit and Unit.



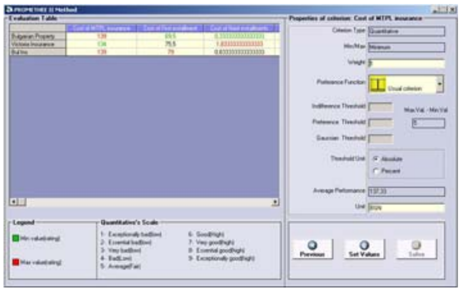


Fig. 8. The final solution of the problem when using AHP method

Fig. 9. Preference information set by the DM for PROMETHEE II method

In the specific task discussed in the paper, let us consider that the DM enters the following preference information (Fig. 9):

1. Cost of MTPL insurance: Weigh 1, Preference function – Usual criterion, Unit BGN;
2. Cost of First installment: Weigh 2, Preference function – Usual criterion, Unit BGN;
3. Cost of Next installments: Weigh 2, Preference function – Usual criterion, Unit BGN;
4. Total cost of payment: Weigh 3, Preference function – Usual criterion;
5. Bonus in Casko: Weigh 0, Preference function – Usual criterion.

On the basis of this preference information, set by the DM, the PROMETHEE II algorithm, implemented in MKA-2 system, orders alternatives in order of importance. The first alternative in this order is the best solution of the problem for this iteration (Fig. 10). This solution might be the final solution of the problem if the DM decides that this solution satisfies his/her preferences to a greatest extent. Let us again consider that the DM does not accept this solution to be the final solution of the initial multicriteria problem and he/she wants to solve the problem one more time using different method and compare the results.

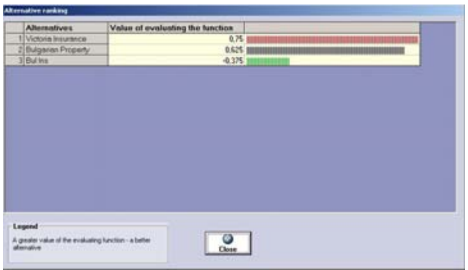


Fig. 10. The final solution of the problem when using PROMETHEE II method

Let us now consider that the DM chooses to use the ELECTRE III Method. In this method, the following parameters for each criterion have to be set by the DM: Weight, Veto threshold, Indifference threshold, Preference threshold, Threshold unit and Unit. In the specific problem we are solving, the DM enters the following preference information (Fig. 11):

1. Cost of MTPL insurance: Weigh 1, Veto threshold 4, Indifference threshold 0, Preference threshold 3, Unit BGN;
2. Cost of First installment: Weigh 2, Veto threshold 9, Indifference threshold 1, Preference threshold 2, Unit BGN;

3. Cost of Next installments: Weigh 2, Veto threshold 1, Indifference threshold 0, Preference threshold 1, Unit BGN;

4. Total cost of payment: Weigh 3, Veto threshold 3, Indifference threshold 0, Preference threshold 1;

5. Bonus in Casko: Weigh 0, Veto threshold 3, Indifference threshold 0, Preference threshold 0.

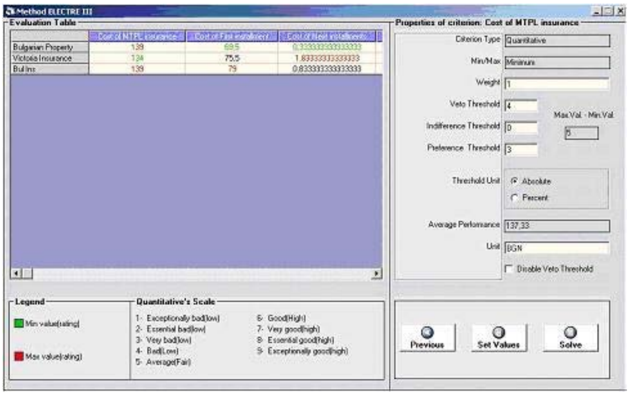


Fig. 11. Preference information set by the DM for ELECTRE III method

On the basis of this preference information, set by the DM, the ELECTRE III algorithm, implemented in MKA-2 system, orders alternatives in order of importance. The first alternative in this order is the best solution of the problem for the current iteration (Fig. 12). This solution might be the final solution of the problem if the DM decides that this solution satisfies his/her preferences to a greatest extent. Let us again consider that the DM does not accept this solution to be the final solution of the initial multicriteria problem and he/she wants to solve the problem one more time using the last method and compare the results.

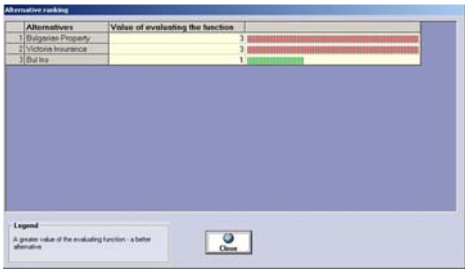


Fig. 12. The final solution of the problem when using ELECTRE III method

Let us now consider that the DM at this iteration chooses to use the Classification-Based Interactive Method (CBIM). At the beginning of the solving process at this iteration the DM has to choose whether the initial solution will be generated automatically or will be introduced by the user. This information is used in CBIM as a starting point. Let us consider that the DM chooses the option "Automatically generated" (Fig. 13).

In this method, the preference information, which has to be set by the DM, is connected to the changes the DM wishes to make in some or all of the criteria values in the current solution. So, the DM must improve at least one of the criteria (or set more changes in the criteria values compare to the criteria values in the current solution) in order to get one more Pareto optimal solution for evaluation. Let us consider that the DM enters the following preference information (Fig. 14):

1. Cost of MTPL insurance–Worse–Free;
2. Total cost of payment–Improve–Free;
3. Bonus in Casco–Indifferent.

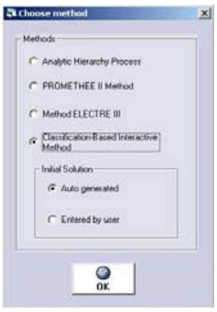


Fig. 13. Entering the initial information in CBIM

Fig. 14. Preference information set by the DM at current iteration

At the next step the MKA-2 system generates the current Pareto optimal (most preferred) alternative – Bulgarian Property. The other alternatives are inadmissible.

At this step the DM can continue to improve the current preferred alternative in order to achieve another Pareto optimal alternative at the next iteration or to accept this current preferred alternative for the most preferred or final alternative. Let us consider the case, in which the DM considers that the current preferred alternative satisfies his/her preferences to the greatest extent and accepts this alternative for the most preferred alternative. In this case this alternative will be the final solution of the initial multicriteria problem.

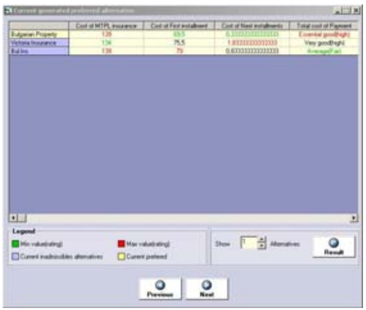


Fig. 15. The current preferred alternative

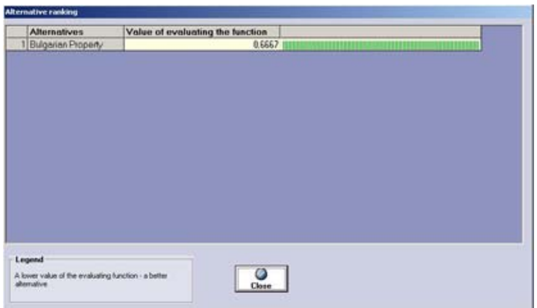


Fig. 16. The final solution of the problem

3. Conclusion

The problem for multicriteria choice of the most preferred MTPL, discussed in the paper, is an application multicriteria analysis problem. The decision support system MKA-2 is used for its solving and one solving scenario is demonstrated in the paper. In this scenario all four methods for solving multicriteria analysis problems, implemented in MKA-2 system, are used consecutively in order to achieve a Pareto optimal alternative that satisfies THE DM to the greatest extent. The solving scenario for each problem depends entirely on the DM. Different DMs may choose different solving scenarios for the same multicriteria problem and may choose different Pareto optimal alternatives as the final solution of the initial problem. The four methods, implemented in MKA-2 system, differ from one to another not only in the logic scheme of the algorithms, but also in the way of setting the preference information by the DM. This is the main criterion for the DM when choosing which method is the most suitable for solving of each for each specific task.

MKA-2 system is designed to support the DM in modeling and solving problems of multicriteria ranking and multicriteria choice. The user-friendly interface of MKA-2 system facilitates the operation of DMs with different qualification level relating to the multicriteria analysis and optimization methods and software tools. MKA-2 system can be used for education and for experimental and research problems solving as well. MKA-2 software system is a local multicriteria decision support system and operates in two languages – Bulgarian and English. A number of Bulgarian universities use the system for the purposes of education and for experimental and research problems solving as well. A number of official organizations and companies use the system for solving real multicriteria decision making problems. The future development of MKA-2 system will be realized in two directions. The first direction is connected with the addition of new methods. The second direction refers to web-based versions of the system, enabling distant decision making.

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Применение многокритериальной системы МКА-2 для многокритериального выбора самой подходящей страховки „Гражданской ответственности автомобилистов"

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(Р е з ю м е)

В работе описывается применение системы МКА-2, которая решает обобщенную задачу многокритериального выбора для самой подходящей страховки. Задача применения рассматривается как задача многокритериального анализа. Эти задачи решаются лицом, принимающим решение, (ЛПР) при помощи софтверных систем. В настоящей статье используется система, названная МКА-2, помогающая выбору ЛПР. Задача решена при помощи четырех методов многокритериального анализа, которые выполняются в системе МКА-2. В статье описан и граффический дружелюбный интерфейс системы. Систему МКА-2 можно применять как в образовательных, так и в реальных задачах.