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Operative Planning of the Production Program with the Help of MKO-2 Software System

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Abstract: *The paper describes an application of MKO-2 software system in the operative planning of photo camera production line. Brief analysis of the software systems for multicriteria optimization recently developed is presented. The main features of the general purpose software system MKO-2, which is intended to aid the solution of linear and linear integer problems of multicriteria optimization, are discussed. The criteria, the variables and the constraints groups of the multicriteria optimization problem, to which one basic problem for operative planning in a photo camera enterprise is reduced, are described.*

Keywords: *multicriteria optimization, operative planning, decision support systems.*

1. Introduction

The software systems, developed to support the solution of multicriteria optimization problems, find various applications (Ehrgott and Wiecek (2004), Alves and Climaco (2000), Miettinen and Makela (2000), Wiestroffer and Narula (1997)). These systems could be divided in the following two groups: software systems of general purpose and problem-oriented software systems.

The first group of program systems usually includes more than one method for solving wide gamma of multicriteria problems and is most often used for research and education or to aid the solution of different problems of multicriteria optimization by different Decision Makers (DMs). Some well-known software systems of general purpose supporting the solution of multicriteria optimization problems are the following systems: NLPJOB (Schittkowski (2003)), MOMILP (Alves and Climaco (2000)), NIMBUS (Miettinen and Makela (2000)), SOMMIX (Climaco et al. (1997)), LBS (Jaszkiewicz and Slowinski (1994)), MOLP-16 (Vassilev et al. (1993)), DIDAS (Lewandowski and Wierzbicki (1989)), VIG (Korhonen (1987)) and NBI package for Matlab (**http://www.owlnet.rice.edu/~indra/-NBIhomepage.html**).

The problem-oriented software systems for multicriteria optimization are most often included in other information-control systems. They serve to solve one or several types of multicriteria optimization problems and a problem-oriented users' interface is usually developed for them.

Usually one method that solves multicriteria problems is realized in them. This is due to the following reasons:

- the different methods are designed to solve different types of multicriteria optimization problems (linear, nonlinear, discrete, continuous, network, etc.);
- different types of procedures are used in the different methods to derive and transfer information from and to the DM, which causes considerable difficulties in the realization of the modules for user-friendly interface
- different strategies are used in the different methods to educate the DM in the specifics of the problem being solved, as well as different approaches are implemented to decrease the time of the scalarizing problem solving;
- the developers of the software systems are usually interested in the implementation of their own methods.

In some of these systems more than one method is realized to solve multicriteria optimization problems. Special attention deserves the following systems: Multicriteria DSS for planning the quality of the river water (Lotov et al. (1997)) and ADELAIS system for portfolio selection (Zopounidis et al. (1998)).

The software systems, using different multicriteria evolution methods (algorithms), are also included in the group of the multicriteria optimization software systems. In spite of the fact that they do not guarantee the obtaining of exact solutions, they can successfully find approximations of the sets of Pareto optimal solutions in discrete, combinatorial and non-convex nonlinear multicriteria problems. Many program systems of this type have been developed, four of them being the following systems: PAES (Knowles and Corne (2000)), NSGM system (Srinivas and Deb (1994)), MOSES system (Coello and Christiansen (1999)) and MOEA Toolbox for MATLAB (**http://vlab.ee.nus.edu.sg/~kctan/moea.htm**).

The systems aiding the solution of multicriteria optimization problems are a part of the systems supporting decision making. The quality of such a system depends on the possibilities which it provides to the DM for:

- input data entering and editing;
- description of DM's local and global preferences;
- generation of new Pareto optimal solutions for evaluation;

- visualization of different types of information that is necessary for DM's education concerning the multicriteria problem being solved;
- control of the multicriteria problem solution process, alteration of separate parameters, storing of the current Pareto optimal solutions found, interrupt of the computing process, multifold starting of the computing process from different current Pareto-optimal solutions, etc.

The new programming languages and operating environments enable the significant improvement of the control programs and of the interface modules of these systems, so that the possibilities above described are realized. The description of DM's preferences and the generation of new solutions for evaluation depend strongly on the type of the multicriteria and single-criterion optimization methods included. In their larger part, the systems aiding the solution of multicriteria optimization problems, developed up to now, comprise interactive multicriteria methods of the reference point designed to solve continuous problems. This has influenced the design of these systems with respect to the input data entry, the solution of the multicriteria problems and the visualization of the current and final results.

The present paper describes the application of the general purpose software system MKO-2 in solving the operative planning problem of the production program of a production line for digital cameras. The problem for operative planning is reduced to a linear integer multicriteria optimization problem.

The rest of the paper is organized as follows. Section 2 gives the basic characteristics of MKO-2 system. The problem for operative planning is described in Section 3, and Section 4 shows the use of MKO-2 system in the solution process of this applied problem. The conclusions are given in the last section.

2. MKO-2 software system

MKO-2 software system is designed to aid the solution of linear and linear integer problems of multicriteria optimization and it is oriented towards operation under the control of MS Windows operating system. It has been developed (V a s s i l e v et al. (2005), V a s s i l e v et al. (2004), V a s s i l e v et al. (2004)), on the basis of generalized scalarizing problem for multiobjective optimization and consists of three main groups of modules: Control program, optimization modules and interface modules.

The control program is integrated software environment for creation, processing and storing of files associated with MKO-2 system, as well as for linking and execution of different types of software modules. The basic functional possibilities of the control program may be separated in three groups. The first group includes the possibilities to use the applications, menus and system functions being standard for MS Windows – "File", "Edit", "View", "Window", "Help", in the environment of MKO-2 system. The second group of functional possibilities encloses the control of the interactions between the modules realizing:

- creation, modification and storing of files associated with MKO-2 system, which contain input data and data connected with the process of solution of linear and linear integer problems of multicriteria optimization;
- interactive solution of the linear and linear integer multicriteria optimization problems entered;
- localization and identification of the errors occurring during the process of operation with MKO-2 system.

The third group of functional possibilities of the control program includes the possibilities for visualization of essential information about the DM and information of the system operation as a whole.

The control program is built on the principle of the Multi-Document Interface (MDI) in MS Visual Basic software environment. In the main form there is a menu with the standard for MS Windows applications, drop down menus for files control, for edition, for windows control and Help. The basic functions of the system are realized with the help of several daughter forms and context menus.

The optimization modules realize one generalized interactive scalarizing problem for multiobjective optimization (V a s s i l e v a (2006)), two simplex methods solving continuous single-criterion problems (Linear Programming Software Survey [9], V a n d e r b e i (1996)), a method of "branches and bounds" type for exact solution of linear integer single-criterion problems (W o l s e y (1998)) and a method (V a s s i l e v and G e n o v a (1991)) for approximate solution of linear integer single-criterion problems.

The interface modules provide the dialogue between the DM and the system during the entry and correction of the input data of the multicriteria problems solved, during the interactive process of these problems solution and for dynamic numerical and graphical visualization of the main parameters of this process. With the help of an editing module the descriptions of the criteria and constraints are input, altered and stored, and also the type and limits of the variables alteration. Another interface module serves to supply two types of graphic presentation of the information about the values of the criteria at the different steps, as well as the possibilities for their comparison. Dynamic Help is provided, which gives specific information about the denotation and way of use of each one of the fields and radio buttons. MKO-2 software system is developed at the Institute of Information Technologies of the Bulgarian Academy of Sciences and it is a modern professional system with user-friendly interface, with efficient single-criterion methods and with interactive multicriteria methods providing wide possibilities to the DM in setting his/her preferences. MKO-2 software system is designed both for education and also for solving real-life problems. It is applied for the entry and solution of different problems for operative planning such as the one being described in Section 3 and Section 4, which follow below.

3. Description of the operative planning problem

The operative planning of the production program of photo camera manufacturing department is a complex and slow process. The company produces two models of photo cameras – simple and luxury model. Each of these models can be sold in the internal market or exported abroad.

The requirements concerning the manpower and machine time limitations are described in the Table 1.

Table 1

Parameter	Personal working, hours	Machine time, hours	Selling price for internal market, $	Selling price for export, $
Simple model	22	1	1000	800
Luxury model	35	1/2	1740	1020
Available resources (hours)	1620	81	–	–
Resource price (expenses)	30	20	–	–

Goal: The manufacturing process must be optimized in a way considering that the company starts promotional campaign for imposition of its name on the international market.

Building the mathematical model of the problem:

Variables of the model:

x_1 – number of sample model photo cameras manufactured for the internal market;

x_2 – number of sample model photo cameras manufactured for export;

x_3 – number of luxury model photo cameras manufactured for the internal market;

x_4 – number of luxury model photo cameras manufactured for export.

Goal functions:

1. Maximization of the profit (manufacturing price – expenses)

$$\max Z_1 = 320x_1 + 120x_2 + 650x_3 - 70x_4,$$

where the coefficients for each x variable represent the difference between the selling price and the production expense and are obtained with the following formula:

for x_1: $1000x_1 - (30\times 22 + 20\times 1)x_1 = 320x_1$.

The other coefficients are calculated in the same way.

2. Minimization of the lack of work load for the personal:

$-\min Z_2 = \max(-Z_2) = 1620 + 22x_1 + 22x_2 + 35x_3 + 35x_4$.

In this function there is one free coefficient 1620. Because of some syntax restrictions of MKO-2 system this is not allowed and one addition variable must be provided and in this case named a. In order to keep the mathematical meaning of the whole function, an additional constraint must be provided which bounds this variable to 1: $a = 1$.

3. Maximization of the number of the photo cameras for export:

$-\max Z_3 = x_2 + x_4$.

Constraints:

1. A constraint that describes manpower requirements is

$$22x_1 + 22x_2 + 35x_3 + 35x_4 <= 1620.$$

2. A constraint that describes machine power requirements is

$$x_1 + x_2 + 2x_3 + 2x_4 <= 81.$$

3. A constraint concerning the type of the variables is

x_1, x_2, x_3, x_4 – positive integer numbers.

4. Solving the problem with the help of MKO-2 system

1. Entering the goal functions and the constraints (Fig. 1).

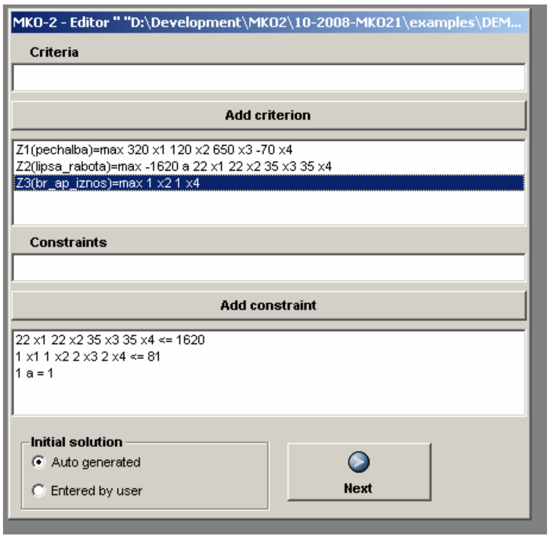

Fig. 1

2. Describing the variables (real/integer) and the upper/lower bounds of each variable (Fig. 2).

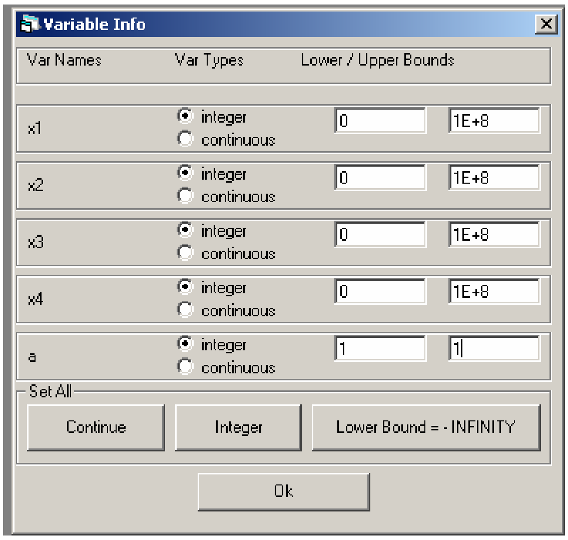

Fig. 2

On the next step the MKO-2 system provides the possibility for the DM to choose in which way to provide the preferences concerning the current problem. This procedure is connected directly to the generalized interactive scalarizing problem in the optimization modules and makes possible to generate and use 12 of the most known multicriteria optimization algorithms (Figs. 3-5).

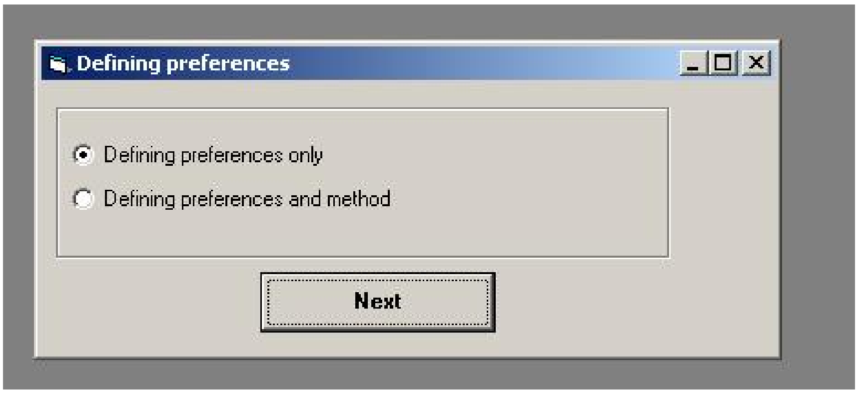

Fig. 3

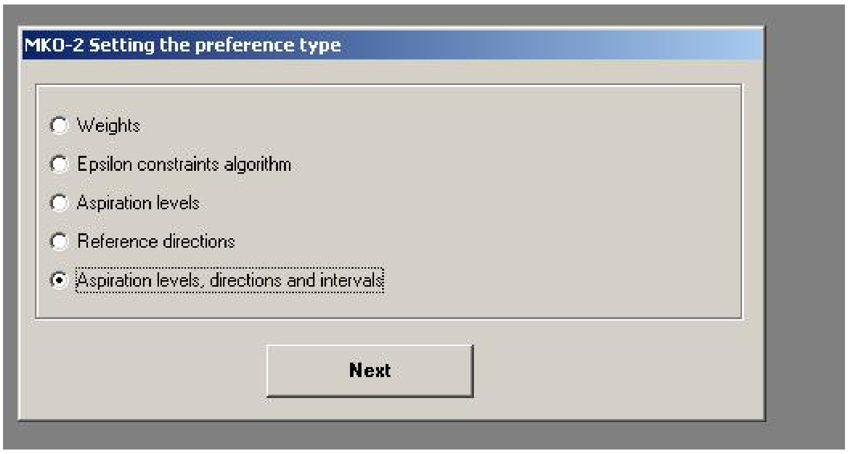

Fig. 4

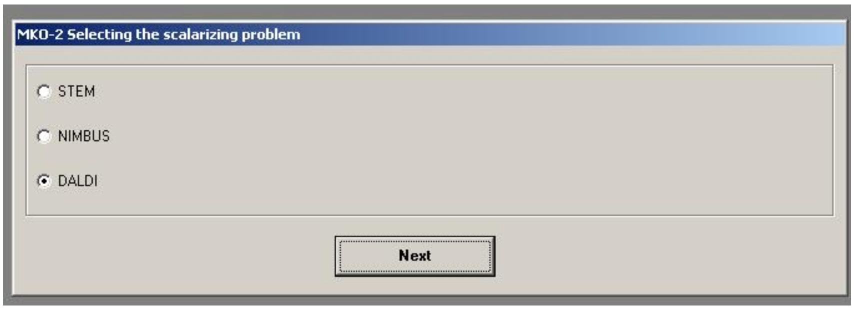

Fig. 5

3. Starting the solver and visualizing the solution (Fig. 6).

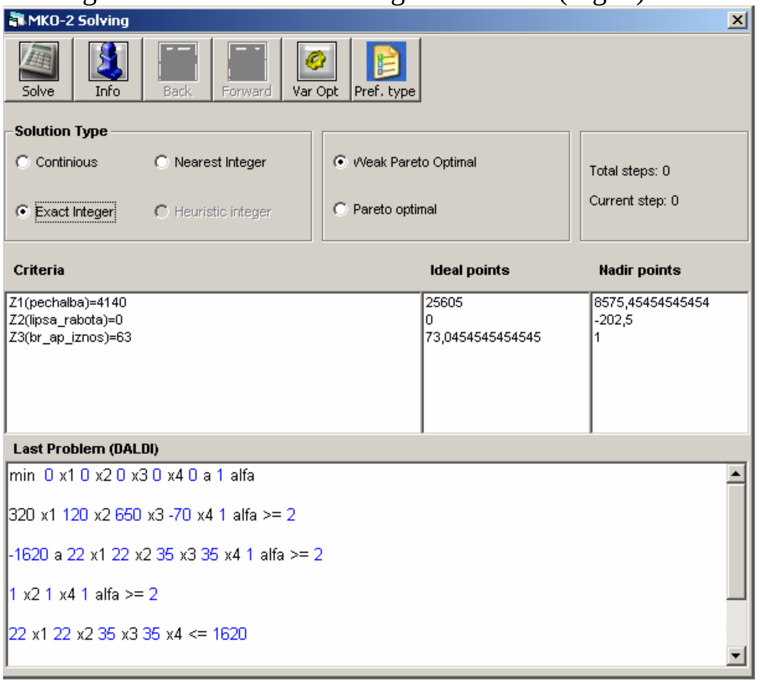

Fig. 6

4. Information about variable values for the current solution (Fig. 7).

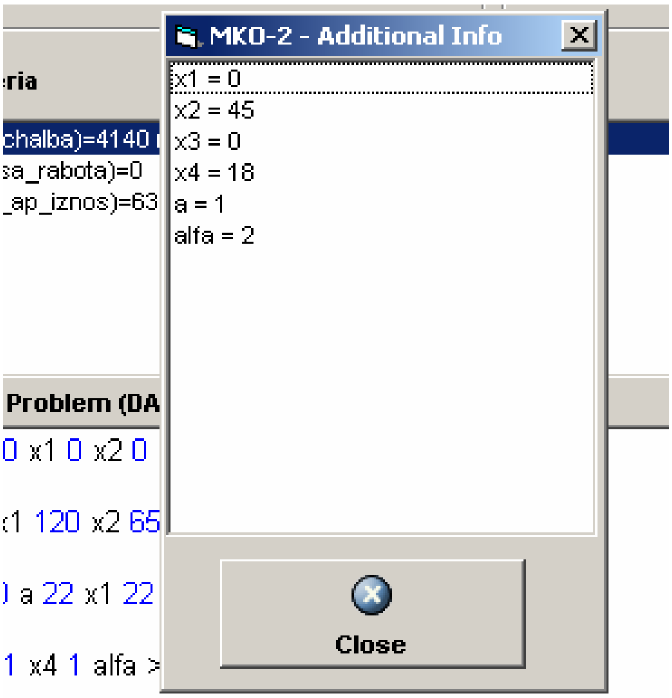

Fig. 7

The solution shows that if the company wants to maximize the profit and to manufacture as many photo camera for export as possible, the production line should be programmed as follows:

x_1 = 0 means that no simple model photo cameras should be made for the internal market;

x_2 = 45 means that 45 of simple model photo cameras should me made for export;

x_3 = 0 means that no luxury model photo cameras should be made for the internal market;

x_4 = 18 means that 45 of simple model photo cameras should me made for export.

In this particular case the given solution is optimal regarding the constraints, but if the decision maker is not satisfied, he can continue by setting new preferences on the goal functions and look for another solution (Fig. 8).

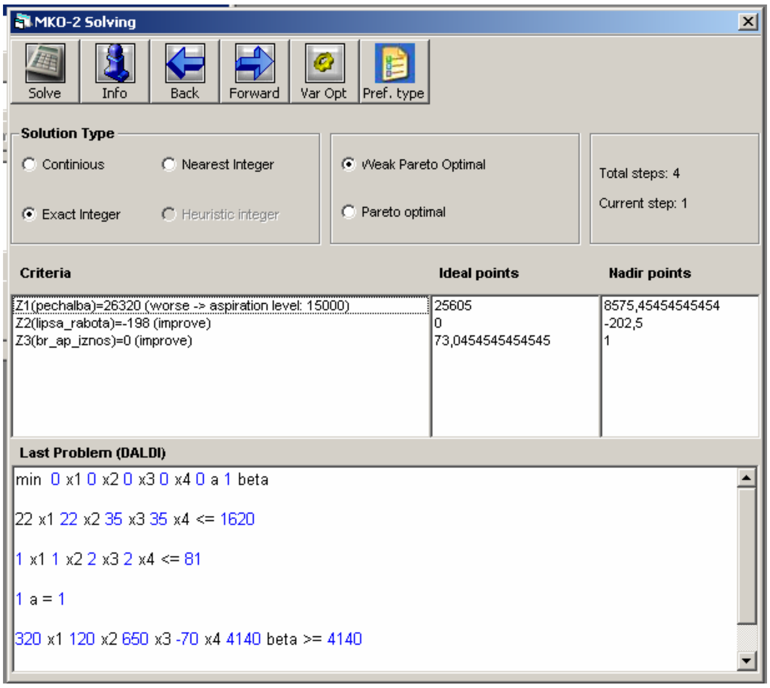

Fig. 8

The solving process of multicriteria problems is interactive and step-by-step which means that the decision maker participates all the time in the process and gives his preferences on each step until he finds a solution that satisfies him.

5. Conclusion

The software system MKO-2 supporting the solution of multicriteria optimization problems may find various applications in solving real-life problems. The user-friendly interface, the efficient single-criterion and multicriteria methods assure wide possibilities for the DM in setting his/her preferences and in searching for new solutions. This enables the solution of real-life production problems with the help of MKO-2 system such as the problem, described in the paper.

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