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Statement and Solution of Multicriteria Tasks of Database Modular Block-Schemes Development

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***Abstract*—The paper considers developed and offered an effective algorithm for solving the block-symmetrical tasks of polynomial computational complexity of data processing modular block-schemes designing.**

Currently, there are a large number of technologies and tools that allow you to create information systems of any class and purpose. To solve the problems of designing effective information systems, various models and methods are used, in particular, mathematical discrete programming methods. At the same time, it is known that such tasks have exponential computational complexity and can not always be used to solve practical problems. In this regard, there is a need to develop models and methods of the new class, which provide the solution of applied problems of discrete programming, aimed at solving problems of large dimensions. The work has developed and proposed block-symmetric models and methods as a new class of discrete programming problems that allow us to set and solve applied problems from various spheres of human activity.

The issues of using the developed models are considered. and methods for computer-aided design of information systems (IS).

***Keywords*—models and methods, discrete programming, data processing system, multicriteria problem**

I. Introduction

THE as the experience of the data processing designing systems has shown, in a number of cases, they are applied different technological requirements, often contradictory, which shall be taken into account. At that, some requirements have the important significance as performance criteria, and others – specify technological constraints within the data processing designing systems.

During the analysis and synthesis of data processing systems there appears the necessity of several efficiency indicators simultaneous account, which define the being elaborated system's quality in the set constraints domain. Then the task is reduced to the necessity of using several criteria in order to show their demanded statement most adequately. In such case it is indispensable to formulate and solve multicriteria block-symmetrical problems. The general statement of the multicriteria task is formulated as follow [1-3,15,19,20].

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It is necessary to find the functions vector extremum, representing the efficiency of being developed data processing systems indicators in the prescribed technological constraints field.

II. Designing Modular Block-Charts for Data Processing Systems

Let's deduce the mathematical statement of the general multicriteria task.

Let us assume, that X is a double index variable, reflecting one type elements distribution per groups, and Y is a variable, representing another type elements per the corresponding groups. There is prescribed a matrix W of various types elements inter-linkages between them.

There were defined the efficiency criteria $F_i(X,Y)$, $i=\overline{1,I}$, depending on the variables X and Y, providing the function extreme of the form $F_i(X,Y)$, $i=\overline{1,I}$.

Multicriteria block-symmetrical task of the discreet programming is formulated as follows:

$$F_i(X,Y) \to extr\,, \tag{1}$$

at constraints:

$$\varphi_m(X) \geq \varphi_0\,,\ m=\overline{1,M}\,, \tag{2}$$

$$\psi_n(Y) \geq \psi_0\,,\ n=\overline{1,N}\,. \tag{3}$$

To solve a single criteria block-symmetrical task $(i=1)$ there has been elaborated and offered an effective algorithm, which allows specifying the optimal solutions under definite conditions. Using the developed algorithm, it is possible to propose the following scheme of the multicriteria task solution.

1. There is solved a single criteria task $F_i(X,Y) \to extr$ at the constraints (2) - (3) using the preset algorithm. Determined the variables X and Y.
2. Defined the functions $F_i(X,Y)$, $i=\overline{2,I}$ values.
3. Solved a single criteria task $F_i(X,Y) \to extr$ at the constraints (2) - (3) using the prescribed algorithm. Specified the variables X and Y.
4. Defined the values of the functions $F_i(X,Y)$, $i=\overline{3,I}$
5. Solved a single criteria task $F_i(X,Y) \to extr$ at the constraints of the types (2) - (3) using the preset algorithm. Determined the variables X and Y.
6. Extreme values of the function $F_i(X,Y)$ define the determining solution domain.

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Thus, proceeding from the multicriteria task solution there is defined the solution domain, in which there determined the solution satisfying all criteria and appropriate conditions [15].

Let's consider the statement and solution of the double criteria task of the data processing modular block-scheme system development.

In the statement thereof it is needed to distribute per program modules the data processing procedures set $P = \{p_r; r = \overline{1,R}\}$, and informational elements multitude $D = \{d_l; l = \overline{1,L}\}$, necessary for the prescribed procedures implementation, to distribute per database massifs in the way to minimize connections of the program modules.

As a performance criterion let's use the minimum inter-linkages between block-schemes modules and database massifs. The criterion thereof allows representing the block-scheme structure as loosely bound modules components and linked with them database massifs, minimizing the number of modules inversion to the massifs during their processing. At the prescribed numerical characteristics: informational elements processing procedure time, modules inversion to the database massifs time, procedures and informational elements volumes, there formed the criteria of the block-schemes processing minimum time, memory minimum upon the block-schemes treatment, etc.

In a matrix form the criterion thereof is recorded as:

$$\sum (XWY) \to \min \tag{4}$$

In the process of block-schemes designing there is often necessary to define the intermodule interface, which represents the composition and quantity of informational elements between the data processing systems modules. The criterion thereof allows determining the intermodule interface's content and an optimal structure of the whole modular block-scheme.

The criterion of information element minimum, used by the data processing block-scheme program modules (intermodule interface) in a matrix form is recorded as follows:

$$\sum Y^T\ Y \to \min \tag{5}$$

In a general way the criteria thereof are contradictory, for which it is difficult to define an exact solution.

In a matrix form a double criteria block-symmetrical task is stored as follows:

$$\sum (XWY) \to \min \tag{6}$$

$$\sum Y^T\ Y \to \min \tag{7}$$

at constraints (2) – (3).

$\sum$ - the sum of the resulting Boolean matrixes identity elements (6) and (3);

$X = \|x_{vr}\|$, $r = \overline{1,R}$, $v = \overline{1,V}$ - a variable of data processing procedures allocation per block-scheme modules;

$Y = \|y_{lf}\|$, $l = \overline{1,L}$, $f = \overline{1,F}$ - a variable of information elements distribution per the database massifs;

$W = \|w_{rl}\|$ - inter-linkage between informational elements and the data processing procedures;

Y^T - transposed matrix.

For solving the set task there was developed and offered an algorithm, based on the general multicriteria task solution scheme.

Let's consider numerical example of double criteria task solution. Table 1 shows a parent matrix. Applying an offered algorithm of solving a single-criterion task, we find a double-criterion task solution. Figures 2 and 3 demonstrate a numerical example of double-criteria task solution. Goal function values are on the Figure 3. The obtained solution defines the domain, limited with a triangle ABC (Figure 4).

There was developed the software for a double-criteria task solution (1) – (3) and (4) – (5) at any size of a parent matrix W (parent matrix size is generated at random) in the medium Delphi 7.0. The software is described in section 2.

TABLE I
PARENT MATRIX W WITH A MARKED BASIS B

r/l	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1	1	0	1	0	1	0	1	1	0	0	0	0	1
2	0	1	0	0	1	1	0	1	1	0	1	0	0
3	1	0	1	0	1	0	1	1	1	0	0	1	1
4	1	0	1	0	1	1	1	0	0	1	1	0	0
5	1	1	0	1	0	1	0	1	0	1	0	1	1
6	0	1	0	0	1	1	1	0	1	1	0	1	1
7	1	1	1	0	1	0	0	0	1	0	1	0	1
8	0	1	0	1	1	1	0	0	1	1	0	0	1

TABLE II
GOAL FUNCTIONS VALUES

min	logic addition	logic miltiplication
σ(Z)	33	11
σ(F)	14	3

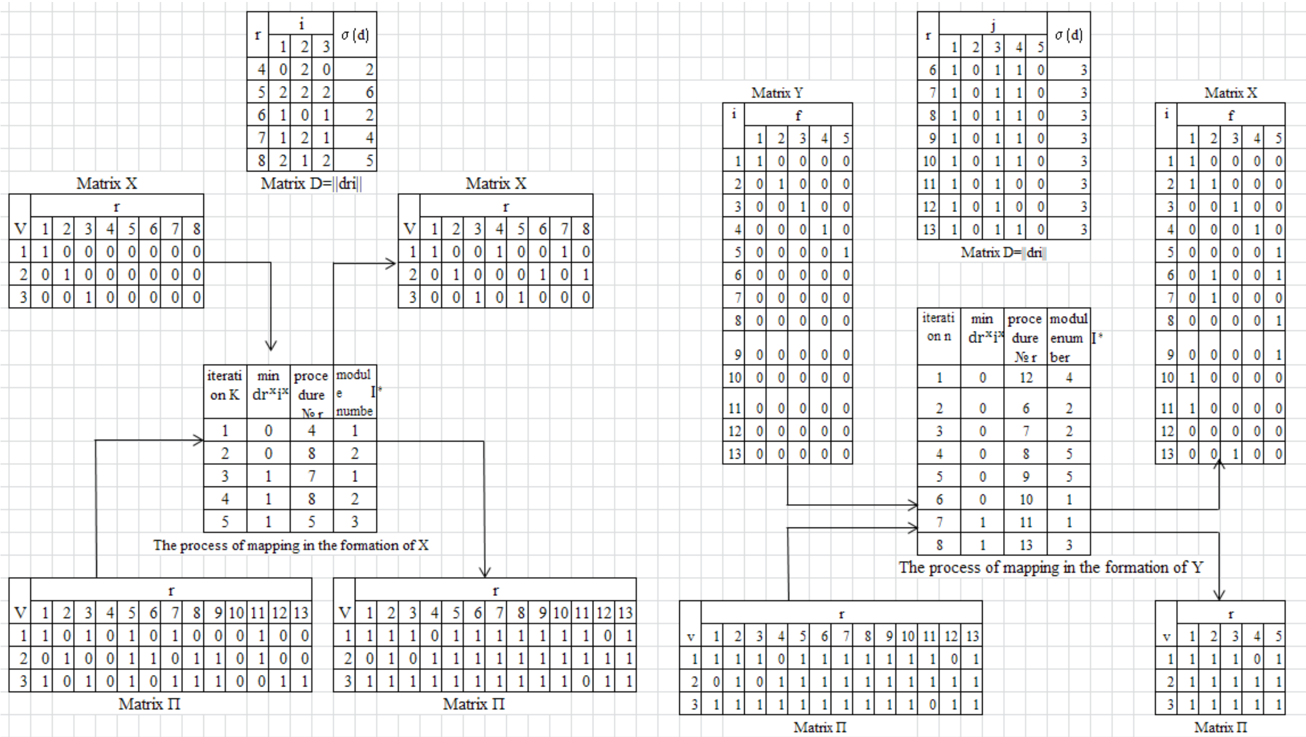

Fig. 2. Task solution with a criterion

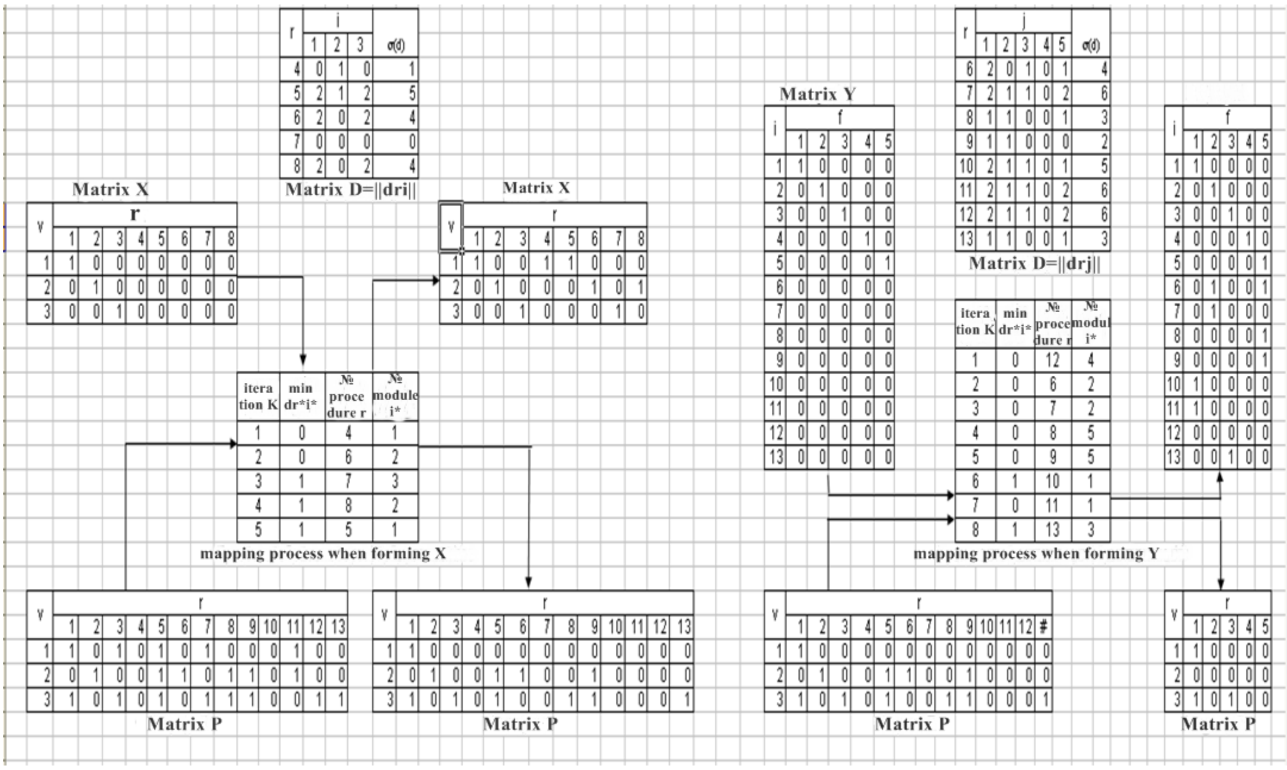

Fig. 3. Task solution with a criterion

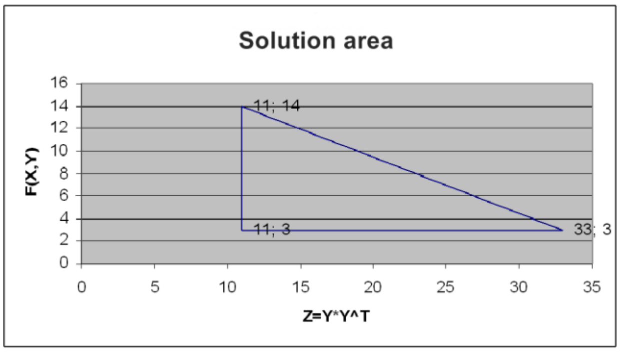

Fig. 4. Solution domain per criteria (6) and (7)

III. Software for solving the double-criteria block-symmetrical task of data processing modular systems designing

Describing the software for the solving the tasks of data processing modular block-scheme designing.

The developed program is designated for the solving the double-criteria task of designing the data modular block-schemes processing [16-18,20,21].

The program allows data processing circuits developers promptly and effectively find the decision and find the task solution for designing the modular block-schemes meeting the prescribed criteria.

The main criteria for selecting the software environment to create the program thereof are:

1. Maintaining the work simplicity in the system, for that purpose there has been developed the interface comfortable for a user.
2. Securing the maximum program operation speed.
3. Accessibility of program’s all fonts.

On the basis of sequential criteria and modern software environment analysis there has been chosen a visual software environment Borland Delphi 7.0. The program has been elaborated in the medium Borland Delphi 7 [16].

The program’s overall block-scheme is given on the Figure 5.

By the procedure Create_Mat we create the matrix W at random according to the prescribed quantities of the matrix rows and columns and record it into the file. The procedure Rotate transposes the preset matrix and it is used for computing the matrix Y. The procedure Mat_D creates the matrix D (basis), which at every iteration defines the elements’ values. Procedure New matrix. The mid-stage matrix is created according to the matrix D elements values and forms the solutions X and Y using the algorithm of a single-criterion block-symmetrical task. The program uses the functions SUM and SUM_UM, which compute the mid-stage matrix’s elements per criteria (logic addition and multiplication). The values of the goal functions on two criteria are accordingly recorded in two files and there is constructed their solution domain.

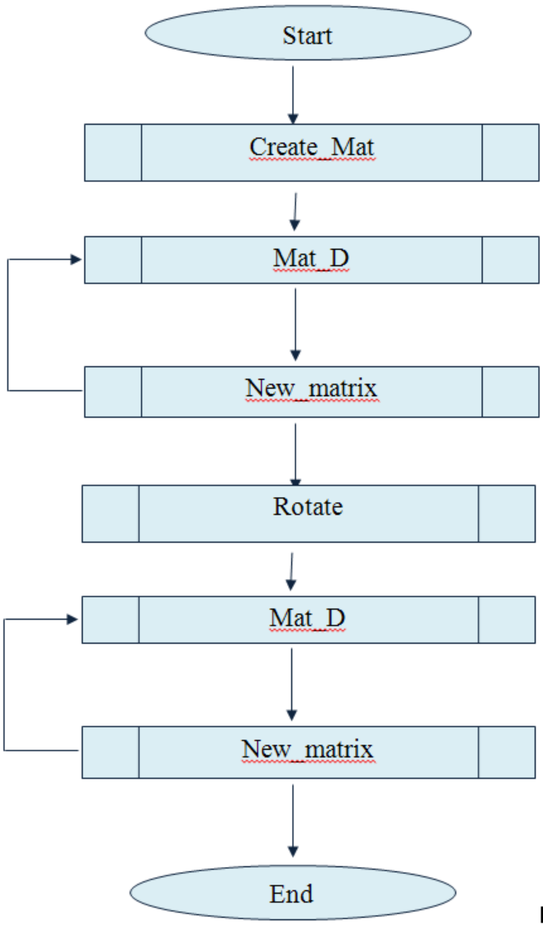

Fig. 5. Program’s general block-scheme

Describing the logic structure of the developed program, designated for solving a double-criteria task of data processing modular block-scheme designing. *Input data.* Input data are represented on the Figure 6.

Output data. By means of various procedures and functions we obtain the data, presented on the Figures 7, 8, 9.

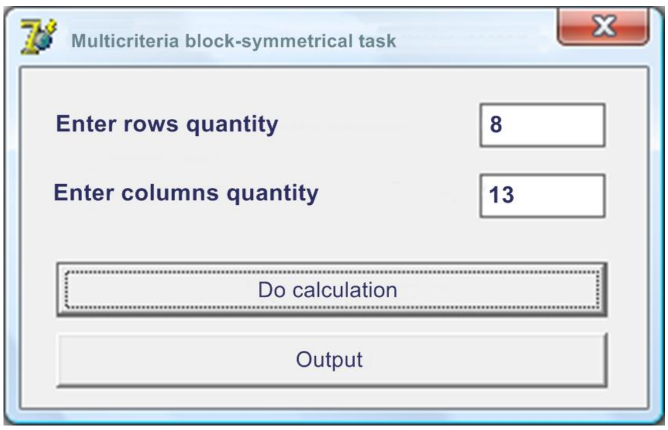

Fig. 6. Input of matrix size parameters

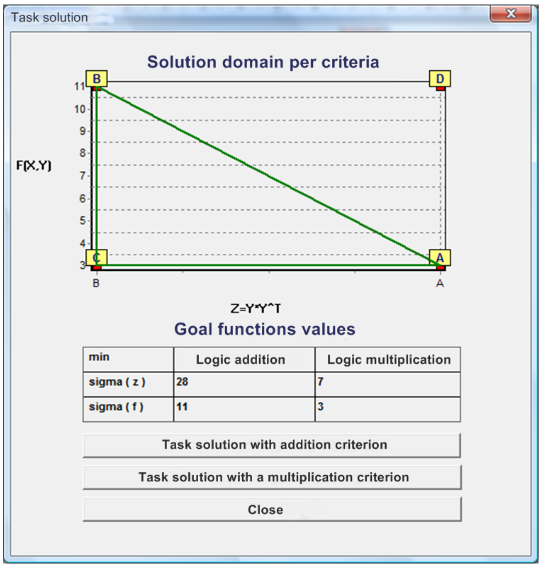

Fig. 7. Goal function and schedule

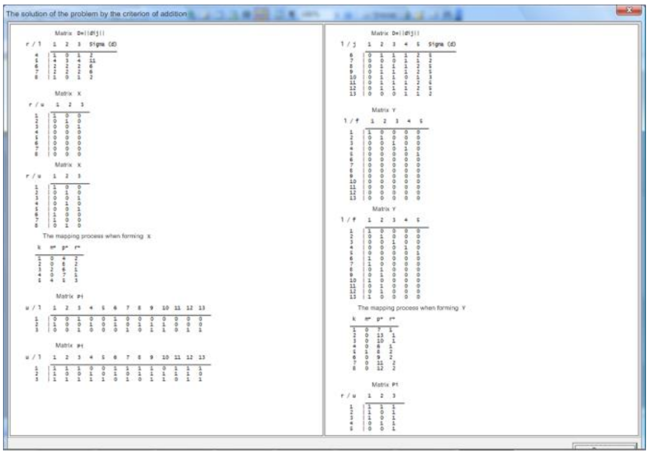

Fig. 8. Solving the task on the addition criterion

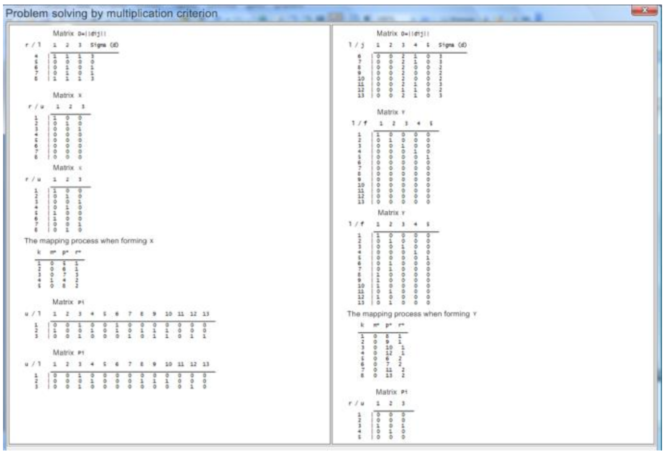

Fig. 9. Task solution per multiplication criterion

CONCLUSION

Developed and offered an effective algorithm for solving the block-symmetrical tasks of polynomial computational complexity of data processing modular block-schemes designing.

Stated and solved a multicriteria task of data processing modular block-schemes synthesis, using performance indicators: minimum inter-linkages between the modules and database massifs, minimum of intermodule interface in the systems being designed.

Developed the software of data processing systems designing.

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