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The Simplex Method in Modelling of Information Systems

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Annotation: *The scientific article is devoted to modelling of information systems. The mathematical model of corporate information system is developed. The mathematical model of corporate information system allows to lower financial expenses at designing information systems.*

Development of information technologies is a priority direction. Increase of efficiency of designing of information systems is an actual problem. The methods of the mathematical programming are used for the decision of a problem. Methods of optimization allow to choose the best variant from set alternative. The ordinary Jordan elimination method can be applied to modelling information systems.

The mathematical model is formulated as follows: from among the firms, rendering services satellite Internet in territory of the Russian Federation, it is required to choose the provider satellite Internet with the maximal size net present value and satisfying to financial restrictions (1).

It is necessary to develop mathematical model of corporate information system and to define the optimum decision by the simplex method.

The method of expert estimations and linear programming are used for the decision of a problem. The mathematical model includes two stages:

1. The method of expert estimations is used for a choice of the firms giving satellite Internet in territory of the Russian Federation.

2. The method of linear programming is used for definition of an optimum variant from among the satellite providers chosen at the first stage (1).

The first stage is a choice of firms by a method of expert estimations.

Let i – number of the investment project satellite Internet, $i=\overline{1,n}$; q – number of the expert estimating variants of projects satellite Internet, $q=\overline{1,t}$; k – number of the factor, $k=\overline{1,p}$; β_{qk} – the weight appropriated q by the expert k to the factor, Z_{qk}^{i} – the estimation given q by the expert k to the factor. The average estimation i variant of the project satellite Internet is defined under the formula

$$\overline{Z_i}=\frac{1}{q}\sum_{q=1}^{t}\sum_{k=1}^{p}\beta_{qk}*Z_{qk}^{i}$$

The second stage is definition of an optimum variant.
The mathematical model of a choice of the optimum investment project satellite Internet looks like

$$\overline{Z_i} = \frac{1}{q} \sum_{q=1}^{t} \sum_{k=1}^{p} \beta_{qk} * Z_{qk}^{i}$$

$$\max \leftarrow Z = \sum_{i=1}^{n} A_i * X_i = A_1 * X_1 + \ldots + A_n * X_n$$

subject to

$$\begin{cases} B_1^0 * X_1 + B_2^0 * X_2 + \ldots + B_n^0 * X_n \le I^0 \\ B_1^1 * X_1 + B_2^1 * X_2 + \ldots + B_n^1 * X_n \le I^1 \\ \vdots \\ B_1^m * X_1 + B_2^m * X_2 + \ldots + B_n^m * X_n \le I^m \\ \mathrm{X_i} \ge 0, i = \overline{1,n},\ j = \overline{1,m} \end{cases}$$

where A_i – net present value of i project, million roubles;

B_i^j – investment expenses i of the project in j the period of time, million roubles;

I_j – available means of financing in j the period of time, million roubles;

X_i – share of financing i of the investment project;

$i = \overline{1,n}$ – number of the investment project;

$j = \overline{1,m}$ – number of the period of time, year.

Using the mathematical model, let us select the optimal project of information system for the Compulsory Medical Insurance Fund of Kurgan region.
At the first stage we shall choose variants of satellite Internet projects by means of a method of expert estimations. After ranging of satellite Internet projects for the Compulsory Medical Insurance Fund of Kurgan region in a portfolio of investments are included NTV-plus (199 points), Europe Online Networks (177 points), Astra Networks (157 points), Satpro (152 points) and Network Service (137 points).
The optimum variant is defined at the second stage.
Let X_1 – share NTV-plus project financing, X_2 – share of Europe Online Networks project financing, X_3 – share of Astra Network project financing, X_4 – share of Satpro project financing, X_5 – share of Network Service project financing.
The mathematical model looks like

$$\max \leftarrow Z = 1.527270 * X_1 + 0.741239 * X_2 + 1.374394 * X_3 + 0.145110 * X_4 + 0.530312 * X_5$$

subject to

$$\begin{cases} 5{,}4*X_1+3.2*X_2+2.931*X_3+6.286*X_4+5.9*X_5\le 6{,}5\\ 2.006437*X_1+1.5*X_2+3.000547*X_3+3.000575*X_4+3.2*X_5\le 3{,}0\\ 2.5*X_2+2.0*X_3+1.6*X_5\le 3{,}0\\ 0.881832*X_2+1.186*X_5\le 1{,}5\\ X_1,X_2,X_3,X_4,X_5\ge 0 \end{cases}$$

The optimum decision of mathematical model is defined by the ordinary Jordan elimination method.

The algorithm of the ordinary Jordan elimination method includes stages:

Stage 1. Resolving element of Jordan table is replaced with return size.

Stage 2. Other elements of a resolving line share on resolving element and change signs on opposite.

Stage 3. Other elements of a resolving column share on resolving element. Signs do not vary.

Stage 4. The remained elements new Jordan tables pay off by a rule of a rectangular.

Let's transform mathematical model in Jordan table (table 1).

Table 1

Basis	1	X_1	X_2	X_3	X_4	X_5
$X_6 =$	6,500000	-5,40000	-3,20000	-2,93100	-6,28600	-5,90000
$X_7 =$	3,000000	-2,00643	-1,50000	-3,00054	-3,00057	-3,20000
$X_8 =$	3,000000	0,000000	-2,50000	-2,00000	0,00000	-1,60000
$X_9 =$	1,500000	0,00000	-0,88183	0,00000	0,00000	-1,18600
$Z =$	0,00000	-1,52727	-0,74123	-1,37439	-0,14511	-0,53031

The initial admissible basic decision is equaled to $X = \{0; 0; 0; 0; 0\}$. The value of criterion function Z is equaled to zero. We define resolving column on the greatest absolute value of negative elements of a Z-line equal -1,527270. Included variable is X_1. Excluded variable is X_6. The resolving element is equaled to -5,4. We carry out step of Jordan elimination. We receive new Jordan table (table 2). We check the new plan for an optimality. In Z-line of Jordan table there is a negative value -0,545426, hence, the decision admissible and can be improved it. We carry out the second iteration. We define resolving column of Jordan table (table 2):-0,545426.

Table 2

Basis	1	X_6	X_2	X_3	X_4	X_5
$X_1 =$	1,203704	-0,18518	-0,59259	-0,54277	-1,16407	-1,09259
$X_7 =$	0,584844	0,371562	-0,31100	-1,91149	-0,66493	-1,00778
$X_8 =$	3,000000	0,000000	-2,50000	-2,00000	0,000000	-1,60000
$X_9 =$	1,500000	0,000000	0,881832	0,000000	0,000000	-1,18600
$Z =$	-1,83838	0,282828	0,163810	-0,54542	1,632745	1,138372

Included variable is X_3. Excluded variable is X_7. A resolving element is equaled to -1,911498. We carry out step of Jordan elimination. We receive new Jordan table (table 3). We check the new plan for an optimality. In Z-line of Jordan table does not have negative values, hence, the decision optimum and it to improve it is impossible at the given restrictions.

Optimum plan is equaled $X^* = \{1,037635; 0,0; 0,305961; 0,0; 0,0\}$. The maximal value of the net present value is equaled 2,00526 million roubles. The optimum project is the project of NTV-plus.

Table 3

Basis	1	X_6	X_2	X_7	X_4	X_5
$X_1 =$	1,037635	- 0,29069	- 0,50428	0,283954	- 0,97526	- 0,80642
$X_3 =$	0,305961	0,194383	- 0,16270	- 0,52315	- 0,34786	- 0,52722
$X_8 =$	2,388077	- 0,38876	- 2,17460	1,046300	0,695720	- 0,54555
$X_9 =$	1,500000	0,000000	0,881832	0,000000	0,000000	- 1,18600

Z =	-2,00526	0,176806	0,252551	0,285340	1,822477	1,425932

The C++ program, formalizing the ordinary Jordan elimination method is developed. Calculations were spent on personal computer in the integrated environment of programming Microsoft Visual Studio 2010 Professional.

Results of the lead researches have allowed to draw following conclusions.

1. The mathematical model of a choice of an optimum variant of information system is developed.

2. Definition of the optimum plan is made by the ordinary Jordan elimination method.

3. The C++ program, formalizing the ordinary Jordan elimination method is developed on personal computer.

5. The developed technique allows to reduce expenses and terms of designing of information systems and to raise validity of accepted decisions.

Results of modelling can be used in the further research information systems.

References:

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