SOFTWARE PACKAGE TRANSP IN THE FUNCTION OF AUTOMATISATION OF TRANSPORT MANAGEMENT SYSTEM

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Abstract:

This paper analyses the possibility of Transp software package for practical application in transport management. Thus, the solution for classic transport problem has been demonstrated, which can be defined from the aspect of operational research as follows: Transport problem is a type of problem that requires determining the number of homogenous units, which should be allocated from multiple starting points to multiple destinations in order to reduce transport costs and increase the overall income. The main goal of this research is to demonstrate the usability of applications in companies where it is necessary to pay special attention to the reduction of transport costs.

Key words:

transport problems,
resource optimization,
software modeling.

INTRODUCTION

Transport management is one of the most dominant logistics processes in business today. That is mostly the case because these kinds of services are often recommended, while their costs are significant and notable. Transport costs are included in logistics costs in most systems. Transport management includes planning, application and control of transport services in order to achieve organizational goals (Regodić, 2011).

Changes in global business have forced many organizations to strategically manage their business processes. One of such processes is, of course, transport management process. In order to survive in the market and do business successfully, an organization has to find the way to offer products of higher value, or services at lower price than the competi-

tion. One solution could be to improve business processes related to delivering goods or services. At the same time, fast IT development enables implementation of business strategy.

The aim of this paper is to use software package to solve minor theoretical transport problems, thus presenting the advantages of computer data processing in transport management. The model includes all the factors that affect processes and performances and that will be used to respond to the demands of users and enable the modern transport manager to make functional decisions related to transport management system.

Transport problems are the part of every economy, especially if we bear in mind the importance of market in modern economy. As the transport connects production and consumption, transport costs represent a significant part of product price.

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Transport task is a special case of a general task related to linear programming. Nowadays, this field of IT belongs to operational research, and it has been developing rapidly in the last five decades. Development trends and application of transport methods will continue in future decades with more applications related to computer programs with algorithms of the most efficient methods, which emerged in the above mentioned period.

If there is a linear relationship between transport costs and transported quantities, we can talk about linear transport tasks. Transport methods used for solving these tasks represent a special case of linear programming method. Furthermore, the development of nonlinear, network and dynamic programming has led to development of various nonlinear transport methods.

The subject of this paper is the application of Transp software package, which is used for presenting the automatization of calculation processes used for the model of transport problem. Theoretical example (a minor problem that can easily be solved by iterative handy of software data processing) has also been shown.

Things are slightly different in the real world. There are usually a lot of parameters, which affect the task and its solution due to their complexity

The given optimal solution is not always the best one in practical application. Psychological, social, environmental and other issues are not usually taken into consideration, which can affect the variations of the outcome of the problem.

Based on the defined research goals, and in accordance with the problem, subject and the object of the research, we can emphasize the following assumptions:

- 1) Profitability and economic efficiency of a company greatly depends on the transport management methods.
- 2) IT model used for managing transport system enables clear and precise generating vehicle trajectories.
- 3) Application of such model enables saving resources and improving benefits.

This kind of problem requires a lot of calculations as well expertise and a relatively long period of time required for all necessary iterations in order to reach optimal solution. Software package Transp has a wide range of functions used for manipulations. Thus, depending on the applied method, the

starting solution will approximate the final solution in a better or worse way.

MATHEMATICAL MODEL OF TRANSPORT PROBLEM

The most frequent issue of transport problem is minimization of overall transport costs: resources, passengers, energy, information, *etc.* In real conditions, these issues may represent a huge expenditure for a certain economic system. Transport task can be defined as a problem related to defining an optimal transport plan from m starting points (dispatch station) $A_i, i=1,2,...,m$ to n destinations (receiving stations) $B_j, j=1,2,...,n$. Starting points could include production plants, warehouses from which goods are transported, *etc.*, while destinations could include warehouses to which goods are transported, consumer centres, *etc.* The optimal criteria defined by the function of the goal is usually minimization of transport costs.

Mathematical model of transport task includes the following data:

- Number of starting points m and quantity of goods available at each starting point $A_i, i=1,2,...,m$;
- Number of destinations n and quantity of goods required at each destination point $B_j, j=1,2,...,n$;

Transport costs per commodity unit from starting point $A_i, i=1,2,...,m$ to destination $B_j, j=1,2,...,n$, which are marked as follows $c_{ij}, i=1,2,...,m, j=1,2,...,n$.

These values can not be negative, i.e:

$$a_i > 0, \quad b_j > 0, \quad c_{ij} \geq 0$$

$$i=1,2,...,m$$

$$j=1,2,...,n$$

Upon the assumption that it is the transport of homogenous goods all available and necessary quantities are related to one kind of commodity.

Transport problem could be formulated as follows:

It is necessary to define the quantities of commodity $x_{ij}, i=1,2,...,m, j=1,2,...,n$ that should be transported from starting points $A_i, i=1,2,...,m$ to destinations $B_j, j=1,2,...,n$ in such a way so that available quantities of goods $a_i, i=1,2,...,m$ are transported from starting points while required

quantities of goods $b_j, j = 1, 2, \dots, n$ are transported to destinations. The total transport costs should be minimal.

The scheme for transport problem is given in Figure 1.

Thus, total transport costs represent the function of the goal and can be expressed as:

$$f(X) = \sum_{i=1}^m \sum_{j=1}^n c_{ij} x_{ij} \quad (1)$$

Limitation system can be expressed as:

1. The total amount of goods transported from one starting point $A_i, i = 1, 2, \dots, m$ to all destinations has to be equal to the available amount of goods at that starting point $a_i, i = 1, 2, \dots, m$.

$$\sum_{j=1}^n x_{ij} = a_i, \quad i = 1, 2, \dots, m \quad (2)$$

2. The total amount of goods delivered at one destination point $B_j, j = 1, 2, \dots, n$ from all starting points has to be equal to the amount of goods necessary for that destination point $b_j, j = 1, 2, \dots, n$.

$$\sum_{i=1}^m x_{ij} = b_j, \quad j = 1, 2, \dots, n \quad (3)$$

3. The quantities of transported goods have to be non-negative:

$$x_{ij} \geq 0, \quad i = 1, 2, \dots, m, \quad j = 1, 2, \dots, n \quad (4)$$

Figure 1: Transport problem

Thus, mathematical model of transport task is:

Find:

$$\min f(X) = \min \sum_{i=1}^m \sum_{j=1}^n c_{ij} x_{ij}$$

at limitations:

$$\sum_{j=1}^n x_{ij} = a_i, \quad i = 1, 2, \dots, m$$

$$\sum_{i=1}^m x_{ij} = b_j, \quad j = 1, 2, \dots, n$$

$$x_{ij} \geq 0, \quad i = 1, 2, \dots, m \quad j = 1, 2, \dots, n$$

By comparing the total scope of offer in all starting points $A_i, i = 1, 2, \dots, m$ to the scope of demand in all destination points $B_j, j = 1, 2, \dots, n$, two cases can be mentioned:

- a) If the total supply equals to total demand and if:

$$\sum_{i=1}^m a_i = \sum_{j=1}^n b_j \quad (5)$$

Then, we can talk about a closed transport model (described in this paper). This model is also known as standard or balanced model.

- b) If the total supply and demand are different and if:

$$\sum_{i=1}^m a_i \neq \sum_{j=1}^n b_j \quad (6)$$

Then, we can talk about an open transport model, also known as nonstandard or unbalanced model.

Transport costs per commodity unit are usually defined by price matrix, also known as standard transport matrix:

$$C = \begin{bmatrix} c_{11} & c_{12} & \dots & c_{1n} \\ c_{21} & c_{22} & \dots & c_{2n} \\ \dots & \dots & \dots & \dots \\ c_{m1} & c_{m2} & \dots & c_{mn} \end{bmatrix} \quad (7)$$

Price matrix can also be marked as follows:

$$C = [c_{ij}] \quad (7.1)$$

Variables x_{ij} , which form the solution, can also be expressed by matrix:

$$X = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix} \quad (8)$$

This matrix can also be marked as follows:

$$X = [x_{ij}] \quad (8.1)$$

The data used in the model of the transport task can be presented in the table:

Table 1: Data used in the model of transport task

	I	II	III	
A_1	c_{11} x_{11}	c_{12} x_{12}	c_{1n} x_{1n}	a_1
A_2	c_{21} x_{21}	c_{22} x_{22}	c_{2n} x_{2n}	a_2
...	...	...	...	...
A_m	c_{m1} x_{m1}	c_{m2} x_{m2}	c_{mn} x_{mn}	a_m
	b_1	b_2	b_n	

Limitation system includes mutually dependent linear equations. The system matrix range is $m+n-1$.

Every possible solution to transport problem has mn components

$$x_{ij}, i = 1, 2, \dots, m, j = 1, 2, \dots, n.$$

In that case, the solution is called non-degenerated solution, if the number of positive components x_{ij} equals to $m+n-1$. If the number of positive components x_{ij} is less than $m+n-1$, the solution is called *degenerated*.

The data given in the transport task are shown in the table. The process of task solving is carried out using series of tables. Each table represents a solution for one task. Every following table represents a new and improved solution. This procedure stops when we come to the table showing the best, optimal solution.

THE SOLUTION OF TRANSPORT PROBLEM USING TRANSP SOFTWARE

This example illustrates the usage of Transp software tool in solving transport problem to minimize transport costs, relying on parameters given beforehand. TRANSP software has emerged as a result of the project at the Laboratory of Operations Research at the Faculty of Organizational Sciences, University

of Belgrade in 1997. The project was led by Assistant Professor Milan Stanojevic. This freeware software is awarded to the students of the Technical Faculty "Mihajlo Pupin" in Zrenjanin as a teaching tool in the Operations Research.

Example:

Find an optimal transport plan of goods from the storehouses A_1, A_2, A_3 i A_4 to stores B_1, B_2, B_3 i B_4 .

Storehouses dispose of the following quantities of goods:

A_1 disposes of 200 commodity units,

A_2 disposes of 150 commodity units,

A_3 disposes of 280 commodity units,

A_4 disposes of 120 commodity units,

The stores demand the following quantities of goods:

B_1 demands 300 commodity units,

B_2 demands 170 commodity units,

B_3 demands 50 commodity units,

B_4 demands 230 commodity units,

Transport costs per commodity unit, given in monetary units, are expressed by the following matrix:

$$C = \begin{bmatrix} 2 & 3 & 1 & 7 \\ 5 & 5 & 2 & 3 \\ 2 & 1 & 2 & 6 \\ 3 & 1 & 3 & 9 \end{bmatrix}$$

The optimality criterion includes minimal transport costs.

The data given in the task are written in the table:

Table 2. Data given in the task

	B_1	B_2	B_3	B_4	
A_1	2	3	1	7	200
A_2	5	5	2	3	150
A_3	2	1	2	6	280
A_4	3	1	3	9	120
	300	170	50	230

Transp software package enables us to enter the data given in the table in the starting application in the same way as shown in Figures 2 and 3.

Figure 2. Screen display while starting Transp.exe program

Figure 3. Initial entering of number of sources and number of gaps

Figure 4. Initial entering of price matrix parameters and available resources

As mentioned before, this tool offers numerous possibilities. Thus, before starting, it gives us the opportunity to calculate the starting or optimal transport solution, iterative methods and goal functions.

Figure 5. Choosing an option for calculating the optimal solution

Figure 6. Choosing a method for defining the starting solution

Figure 7. Choosing iterative method

Figure 8. Choosing goal function

Figure 9. Starting program

Sledeci korak	P2	P3	P4	Ponuda
S1	2	3	1	7
S2	5	5	2	3
S3	2	1	2	6
S4	3	1	3	9
Traznja	300	170	50	230

Figure 10. Table after first iteration

	P1	P2	P3	P4	Vi
S1	2 (200)	3 / 1.00	1 / -2.00	7 / 0.00	2.00
S2	5 (100.00)	5 (50.00)	2 / -4.00	3 / -7.00	5.00
S3	2 / 1.00	1 (120.00)	2 (50)	6 (110.00)	1.00
S4	3 / -1.00	1 / -3.00	3 / -2.00	9 (120.00)	4.00
Uj	0	0.00	1.00	5.00	

Figure 11. Table after second iteration

	P1	P2	P3	P4	Vi
S1	2 (200)	3 / 8.00	1 / 5.00	7 / 7.00	2.00
S2	5 (100.00)	5 / 7.00	2 / 3.00	3 (50.00)	5.00
S3	2 / -6.00	1 (170.00)	2 (50)	6 (60.00)	8.00
S4	3 / -8.00	1 / -3.00	3 / -2.00	9 (120.00)	11.00
Uj	0	-7.00	-6.00	-2.00	

Figure 12. Optimal solution and arrangement that realizes minimization of transport costs

	P1	P2	P3	P4	Vi
S1	2 (150.00)	3 / 2.00	1 (50.00)	7 / 1.00	2.00
S2	5 / 6.00	5 / 7.00	2 / 4.00	3 (150.00)	-1.00
S3	2 (150.00)	1 (50.00)	2 / 1.00	6 (80.00)	2.00
S4	3 / 1.00	1 (120.00)	3 / 2.00	9 / 3.00	2.00
Uj	0	-1.00	-1.00	4.00	

CONCLUSION

The basic request in economizing on transport costs is to achieve an optimal relationship in transportation between storehouses and end users, which can cause financial problems and lead to undesirable effects regarding the stability of the process itself. Thus, optimal transport policy includes cost minimization with the continuous work of business systems and meeting market demands. The optimal solution (the most ideal calculation) represents a compromise between the desired goal and given limitations that affect the opportunities for achieving extreme solutions. There are numerous cases used for solving the given problem as it is a time consuming process that demands considerable practical knowledge and skills. With the development of computer technology, the methods for problem solving have become software oriented and extremely efficient, thus contributing to the development of optimization.

This paper provides an overview of software solution used for the optimization of transport process. Application of IT in this field makes the planning process much easier, and contributes significantly to achieving the primary goals of the company: increasing benefits and minimizing costs.

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SOFTVERSKI PAKET TRANSP U FUNKCIJI AUTOMATIZACIJE SISTEMA MENADZMENTA TRANSPORTOM

Rezime:

Ovaj rad ispituje mogućnost praktične primene softverskog paketa Transp u menadžmentu transportom. On prikazuje rešenje klasičnog transportnog problema koji je sa aspekta operacionih istraživanja definisan na sledeći način: Transportni problem je takva vrsta problema za koji je potrebno odrediti broj homogenih jedinica koje treba rasporediti iz više ishodišta na više odredišta s ciljem da se umanje troškovi prevoza odnosno da se poveća ukupan prihod. Istraživanje ima za cilj da pokaže primenljivost aplikacija u preduzećima gde je neophodno voditi računa o smanjenju troškova transporta.

Ključne reči:

transportni problem,
optimizacija resursa,
softversko modelovanje.

Received: February 18th, 2013

Correction: March 29th, 2013

Accepted: April 7th, 2013