Software package WinQSB in the function of automatisation of transport management system

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Abstract— **This paper deals with the possibilities of WinQSB software package for application in transport management. In this way, it has been demonstrated the solution for classic problem, which from the aspect of operational research, can be defined as follows: Transport problem needs defining the number of homogenous units, which should be arranged from many starting points to many destinations in order to decrease transport charges and increase the income. The main goal of the research is to demonstrate the usability of applications in companies where is necessary to take care about reduction of transport charges.**

Index Terms—**resource optimization, software modeling, transport proble**

I. Introduction

Transport management is one of the most dominant logistics processes in business today. That is why these kinds of services are necessary, while costs are significant and notable. Transport charges are always included in logistics costs in most systems. Transport management includes planning, application and control of transport services in order to achieve organizational aims [10].

Changes in global business have forced many organizations to use strategic managing in their business, and one of these processes is, of course, transport managing. 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 competition. One of the solutions could be the improving business processes related to delivering goods and services. At the same time, fast developing of IT enables carrying out of business strategy.

The aim of this paper is to use software package for solving minor theoretical transport problems and to present the advantages of computer data processing in transport managing. The model includes all the factors that affect processes and performances and which will be used to respond to user demands and enables modern manager to make functional decisions related to transport managing system.

Transport problems are the part of each economy, especially if we have in mind the importance of market in modern economy. As the transport connects production and consumption, transport charges are significant part of product price. 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 last five decades. Development trends and applications of transport methods would be continued in future decades with more applications related to computer programs with algorithms of most efficient methods, which have been used in abovementioned period.

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

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

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

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

On the basis of defined research goals, and in accordance to the problem, subject and the object of the research, we can note following assumptions:

1) *Profitability and efficiency of a company mostly depend on transport management methods*
2) *IT model used for managing transport system enables clear and precise generating vehicle trajectories.*
3) *Application of this model enables saving resources and improving benefits.*

This kind of problems requires a lot of calculations as well expertise and a very long period of time needed for all necessary iterations in order to reach optimal solution. Software package WinQSB has a vide range of functions used for manipulations. Thus, depending on applied method, starting solution will approximate the final solution in a better or worse way.

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II. MATHEMATICAL MODEL OF TRANSPORT PROBLEM

The most frequent issue of transport problems is minimization of total transport charges: resources, passengers, energy, information, etc. These issues may be, in real world, a large expenditure for some economic system. Transport task can be defined as a problem related to defining 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, etc.while destintions could include warehouses, consumer centres, etc. The optimal cryteria defined by the function of the aim is usually minimization of transport charges.

Mathematical model of transport task includes 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 charges 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:

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

$$i = 1,2,\ldots,m$$

$$j = 1,2,\ldots,n$$

Upon the assumption that it is the transport of homogenous goods i.e. all available and required 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 that available quantities of goods a_i, $i = 1,2,...,m$ should be transported from starting points while required quantities of goods b_j, $j = 1,2,...,n$ are transported to destinations. Total transport charges should be minimal.

Scheme for transport problem is given in figure 1.

Thus, total transport charges are the function of the goal and can be expressed as:

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

Limitation system can be expressed as:

1. Total quantity of goods transported from one starting point A_i, $i=1,2,...,m$ to all destinations have to be equal to availabe quantity of goods at that starting point a_i, $i = 1,2,...,m$.

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

2. Total quantity of goods delivered at one destination point B_j, $j=1,2,...,n$ from all starting points have to be equal to the quantity of goods required for that destination point b_j, $j=1,2,...,n$.

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

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

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

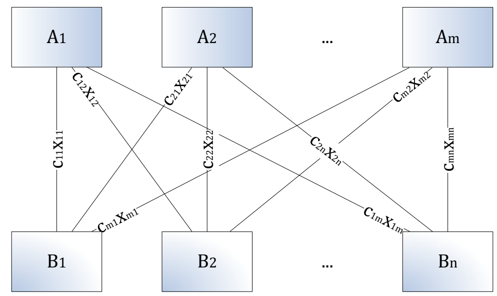


Figure 1: Transport problem

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:

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

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

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

Comparing the scope of offer in all starting points A_i, $i = 1,2,...,m$ and the scope of demand in all destination points B_j, $j = 1,2,...,n$, two cases can be noticed:

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

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

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

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

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

Then, it is an open transport model, also known as nonstandard or unbalanced model.

Transport cost per commodity unit is 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:

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

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

TABLE I
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 $x_{ij}, i=1,2,\ldots,m, j=1,2,\ldots,n$. 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 smaller than $m+n-1$, the solution is called *degenerated.*

Data given in transport task are shown in table. The solution is carried out by series of tables. Each table is a solution for one task. Every following table is a new, improved solution. The procedure stops when we come to the table including the best, i.e. *optimal solution.*

III. THE SOLUTION OF TRANSPORT PROBLEM USING WINQSB SOFTWARE

This example shows the usage of WinQSB software tool in solving transport problem in order to minimize transport charges, according to prior given parameters.

Example:

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

Storehouses have following quantities of goods:

A_1 have 200 commodity units,
A_2 have 150 commodity units,
A_3 have 280 commodity units,
A_4 have 120 commodity units,

The stores demand following quantities:

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 charges per commodity unit, given in money units, are expressed by following matrix:

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

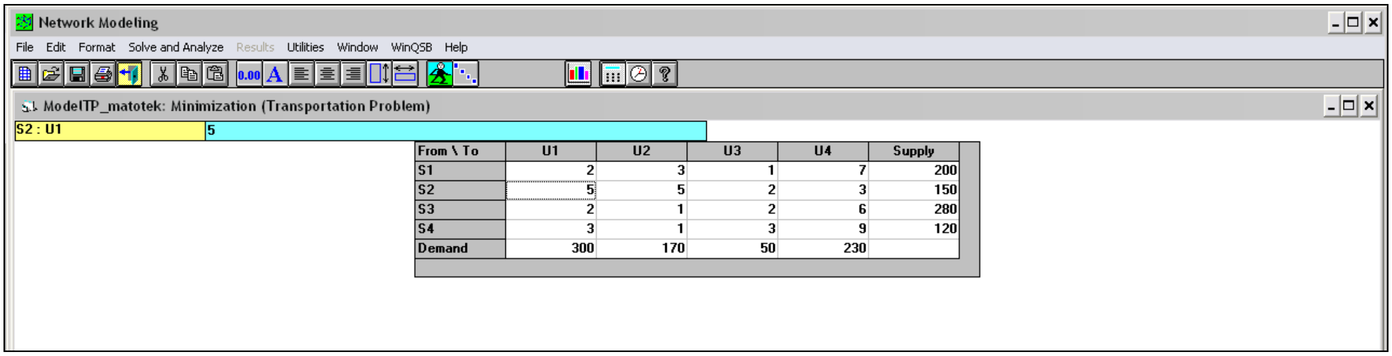
Optimum criterions are minimal transport charges.

Data given in the task is written in the table:

TABLE II
DATA GIVEN IN THE TASK

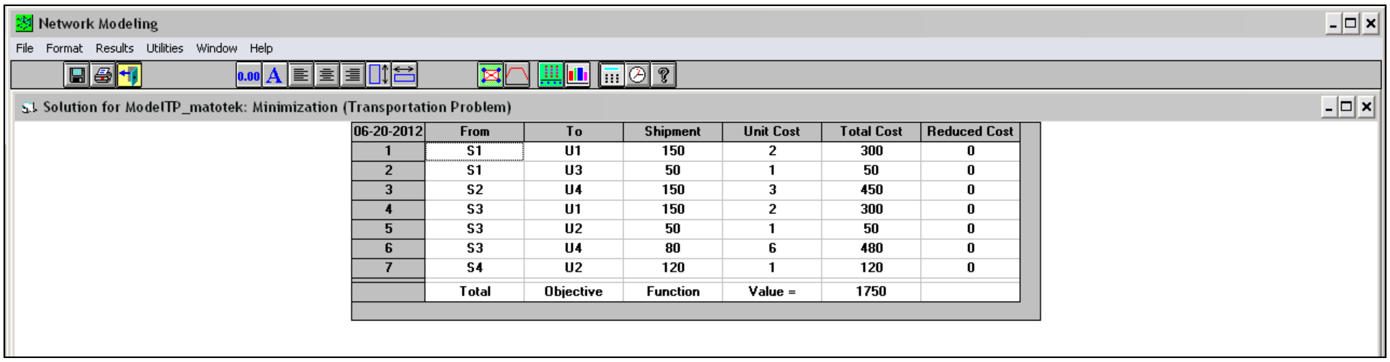
	B_1	**B_2**	**B_3**	**B_4**	
A_1	2	3	1	7	200
A_2	5	5	2	3	150
A_3	2	1	2	6	280
A_4	3	1	3	9	120
	300	170	50	230	

WinQSB software package enables us to enter the data given in the table in the starting application in the same way, as it is shown in figure 2.



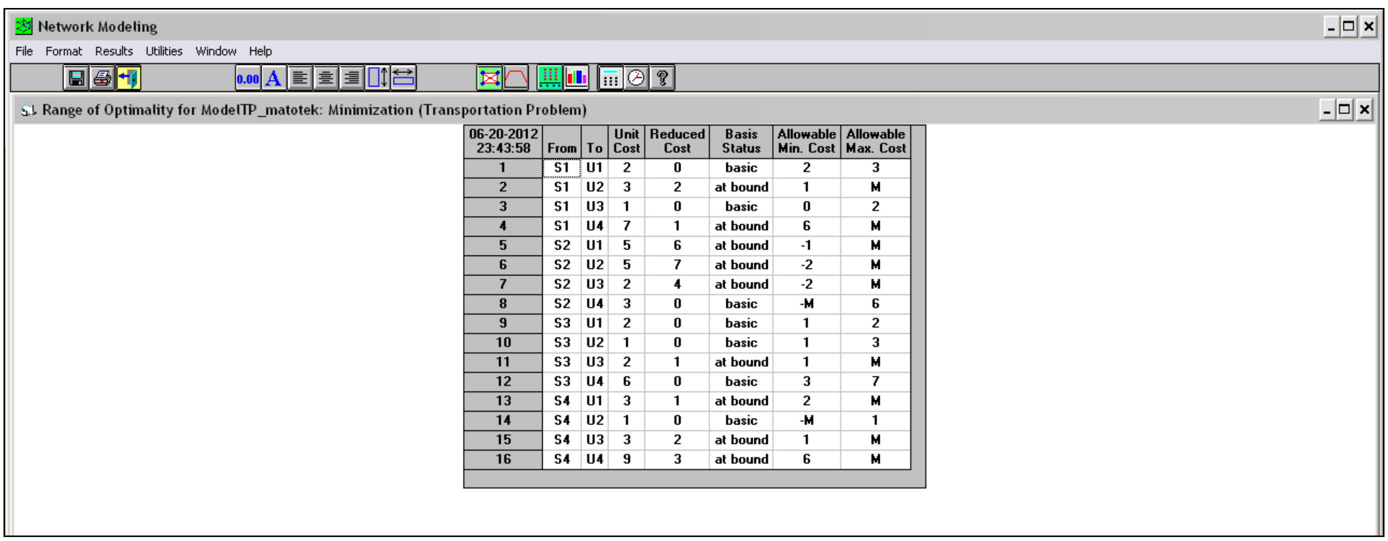
From \ To	U1	U2	U3	U4	Supply
S1	2	3	1	7	200
S2	5	5	2	3	150
S3	2	1	2	6	280
S4	3	1	3	9	120
Demand	300	170	50	230	

Figure 2. Display of the initial input parameters matrix of prices and available resources



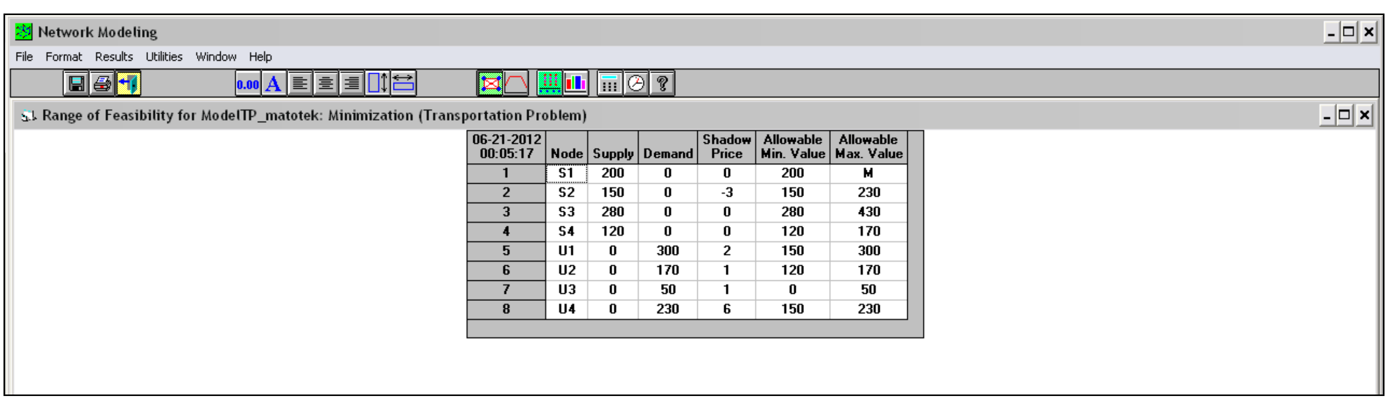
06-20-2012	From	To	Shipment	Unit Cost	Total Cost	Reduced Cost
1	S1	U1	150	2	300	0
2	S1	U3	50	1	50	0
3	S2	U4	150	3	450	0
4	S3	U1	150	2	300	0
5	S3	U2	50	1	50	0
6	S3	U4	80	6	480	0
7	S4	U2	120	1	120	0
	Total	Objective	Function	Value =	1750	

Figure 3. Solution of the problem presented nonzero fields



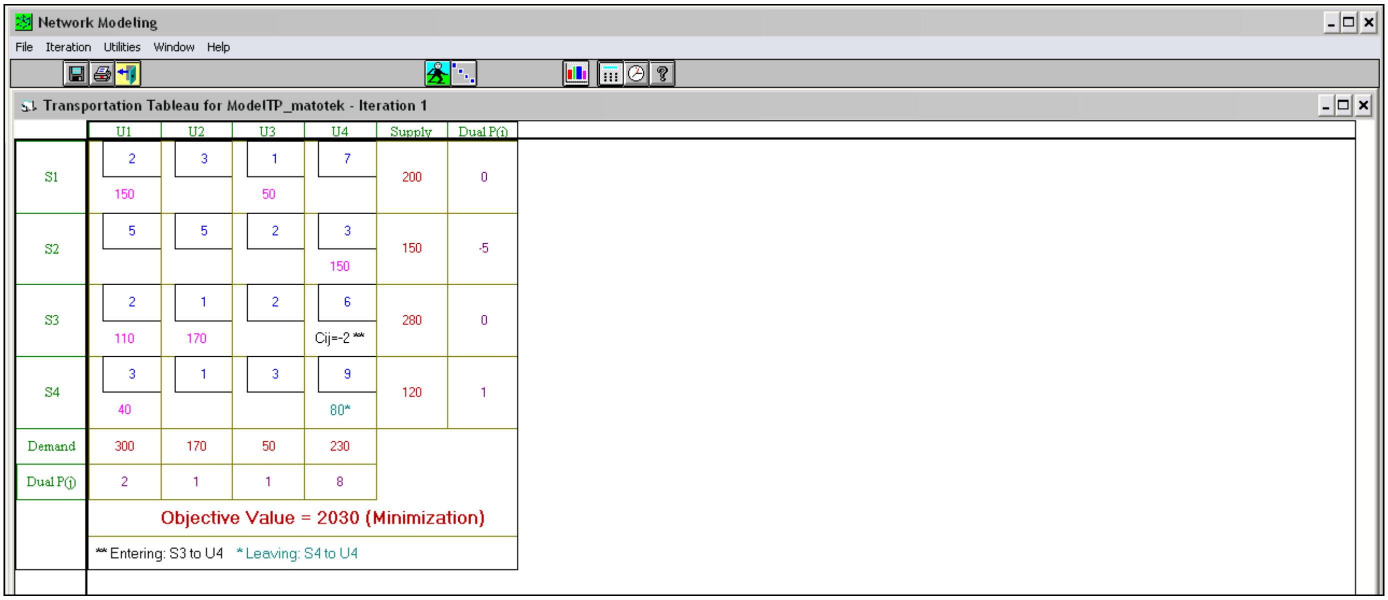
06-20-2012 23:43:58	From	To	Unit Cost	Reduced Cost	Basis Status	Allowable Min. Cost	Allowable Max. Cost
1	S1	U1	2	0	basic	2	3
2	S1	U2	3	2	at bound	1	M
3	S1	U3	1	0	basic	0	2
4	S1	U4	7	1	at bound	6	M
5	S2	U1	5	6	at bound	-1	M
6	S2	U2	5	7	at bound	-2	M
7	S2	U3	2	4	at bound	-2	M
8	S2	U4	3	0	basic	-M	6
9	S3	U1	2	0	basic	1	2
10	S3	U2	1	0	basic	1	3
11	S3	U3	2	1	at bound	1	M
12	S3	U4	6	0	basic	3	7
13	S4	U1	3	1	at bound	2	M
14	S4	U2	1	0	basic	-M	1
15	S4	U3	3	2	at bound	1	M
16	S4	U4	9	3	at bound	6	M

Figure 4. The range of optimal solutions



06-21-2012 00:05:17	Node	Supply	Demand	Shadow Price	Allowable Min. Value	Allowable Max. Value
1	S1	200	0	0	200	M
2	S2	150	0	-3	150	230
3	S3	280	0	0	280	430
4	S4	120	0	0	120	170
5	U1	0	300	2	150	300
6	U2	0	170	1	120	170
7	U3	0	50	1	0	50
8	U4	0	230	6	150	230

Figure 5. The range of possible solutions

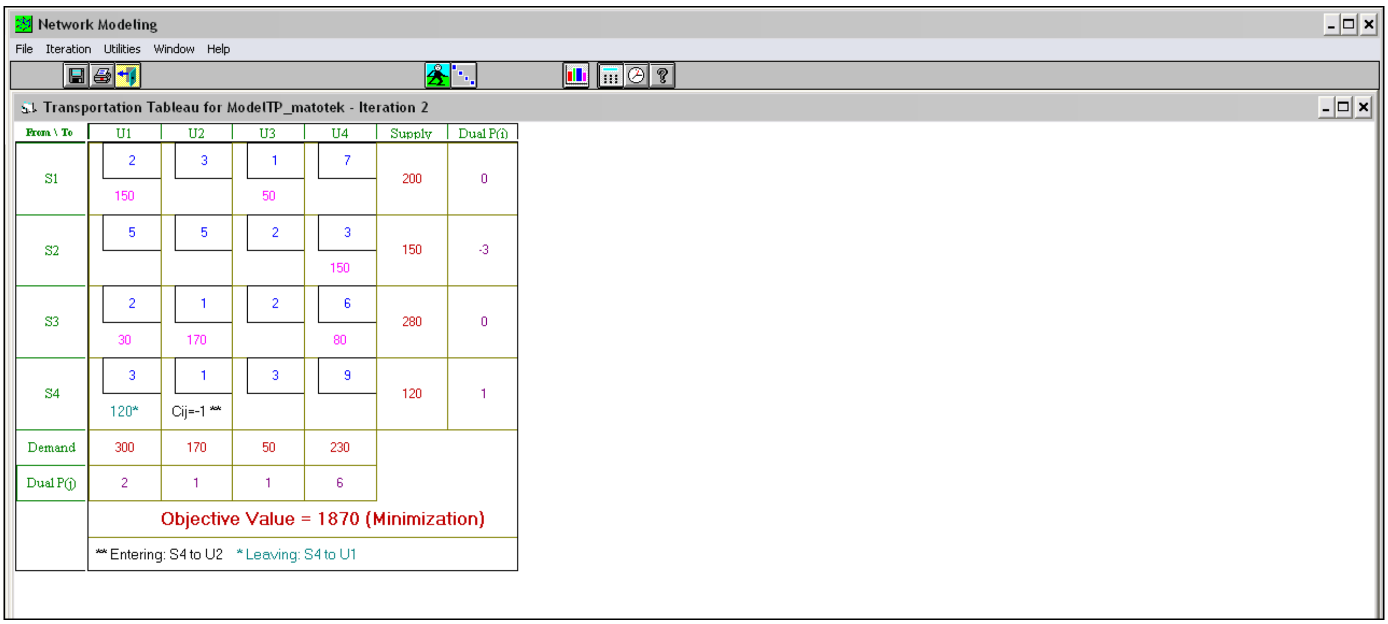


	U1	U2	U3	U4	Supply	Dual P(i)
S1	2 150	3	1 50	7	200	0
S2	5	5	2	3 150	150	-5
S3	2 110	1 170	2	6 Cij=-2 **	280	0
S4	3 40	1	3	9 80*	120	1
Demand	300	170	50	230		
Dual P(j)	2	1	1	8		

Objective Value = 2030 (Minimization)

** Entering: S3 to U4 * Leaving: S4 to U4

Figure 6. First iteration

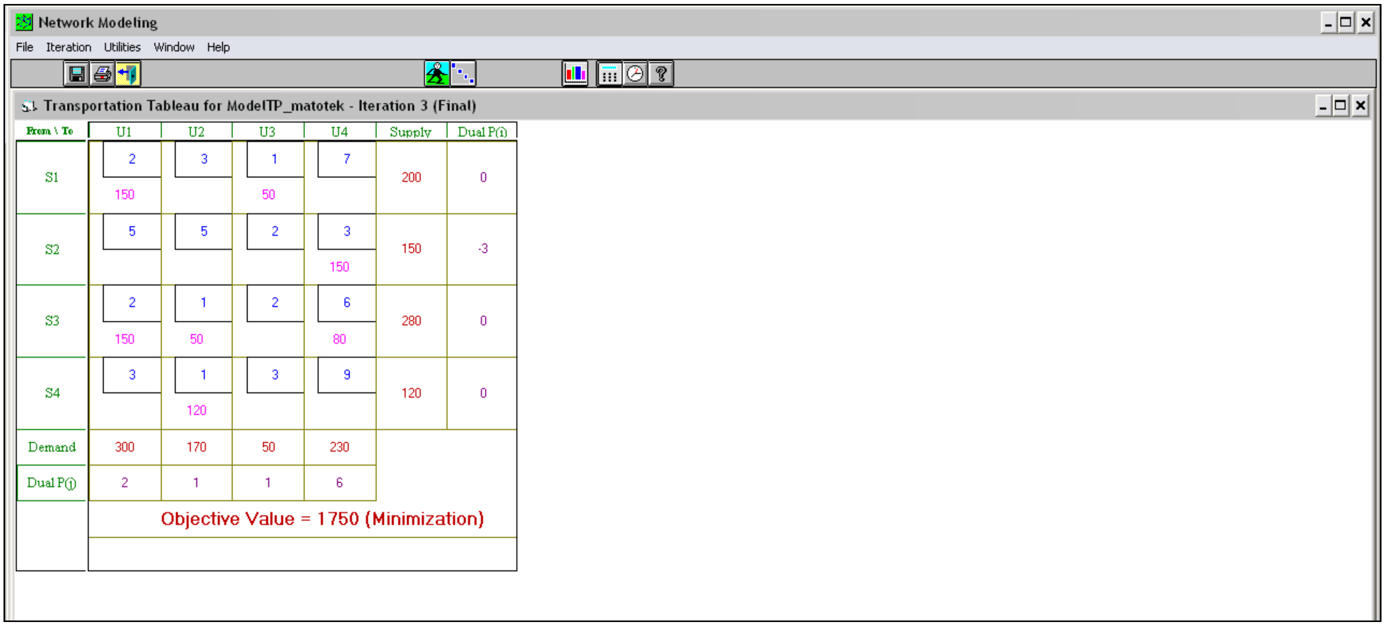


From \ To	U1	U2	U3	U4	Supply	Dual P(i)
S1	2 150	3	1 50	7	200	0
S2	5	5	2	3 150	150	-3
S3	2 30	1 170	2	6 80	280	0
S4	3 120*	1 Cij=-1 **	3	9	120	1
Demand	300	170	50	230		
Dual P(j)	2	1	1	6		

Objective Value = 1870 (Minimization)

** Entering: S4 to U2 * Leaving: S4 to U1

Figure 7. Second iteration



From \ To	U1	U2	U3	U4	Supply	Dual P(i)
S1	2 150	3	1 50	7	200	0
S2	5	5	2	3 150	150	-3
S3	2 150	1 50	2	6 80	280	0
S4	3	1 120	3	9	120	0
Demand	300	170	50	230		
Dual P(j)	2	1	1	6		

Objective Value = 1750 (Minimization)

Figure 8. Third iteration

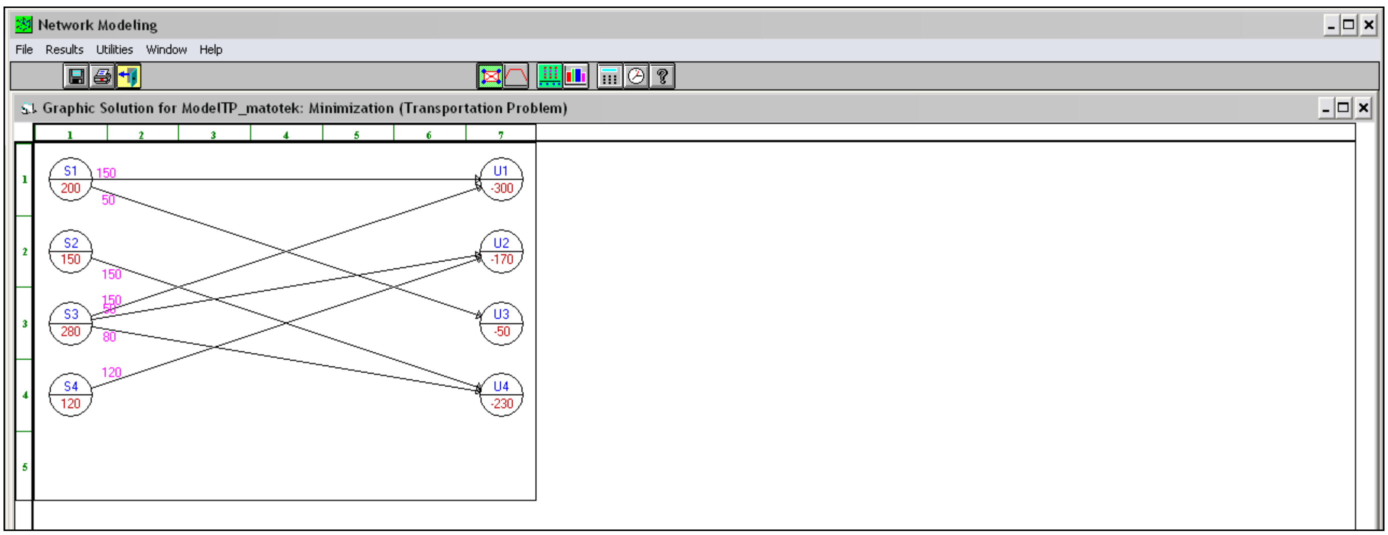


Figure 9. Graphic display of solution

IV. Conclusion

The main request in economizing transport charges is achieving an optimal relationship in transportation between storehouses and end users, which can cause financial problems and undesirable effects on the stability of the process itself. Thus, optimality in transport is added up to cost reduction as well as to continuous work of business systems and meeting market demands. Optimal solution (the most ideal calculation) is a compromise between required goal and given limitations that affect opportunities for achieving extreme solutions. There are many cases used for solving given problem. This problem requires great practical knowledge and time consuming processes. Not until computer technology has been developed, methods for solving problems became software oriented, extremely efficient contributing the development of optimization.

This paper gives a review of software solution used for optimization of transport process. Applying IT in this field, makes planning process much easier, and it helps achieving primary goals of the company, and that is: increasing benefits and reducing costs.

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