Design of Public Urban Transport Network through Software Evolver in Pristina

Bashkim Çerkini
Cost Management – Project Control
Kellogg and Brown & Root
Ferizaj, KOSOVË
bashkimqerkini@gmail.com

Thoma Mitre
Applied Mathematics - Faculty of Natural Sciences
University of Tirana
Tirana, ALBANIA
thoma.mitre@unitir.edu.al

Abstract—**Efficiency of any public urban transport system can be enhanced by making the optimization of the transport bus network, and determining the appropriate node in terms of minimizing operator costs as well as meeting the requirements of passengers. With the intensive advances in computer software and hardware, there arise multiple methods to solve this problem, which is present in many of the world metropolitan. In this study we have presented mathematical constrains and design new model of the urban bus network in Pristina through evolver. Than we compare actual urban bus transportation network with the one solved by evolver.**

Keywords— Public Urban Transport; Evolver; Mathematic Constrains; Optimization and Nodes.

I. INTRODUCTION

Evolver is an optimization tool which is used through Microsoft Excel and uses Genetic Algorithms and the technology of linear programming to rapidly solve problems in finance, distribution, allocation of resources, manufacturing, engineering, etc. Actually, every type of problem that can be modeled in Excel can be solved with evolver including those impossible and complex nonlinear problems.

Evolver presents optimization through genetic algorithms faster and advanced ever used. Evolver is mostly used in the add-in in MS Excel that provides all the formulas and graphs that most users need to create realistic models of their problems. It provides the interface to describe the uncertainty in your model and what you are looking for, and provides the right engines that will find it. Evolver can find optimal solutions to any practical problem that can be modeled.

Evolver uses a customizable set of genetic algorithms to search an optimal solution to a problem. Genetic algorithms are used in Evolver to find the best solution to a model. Genetic algorithms mimic the principles of natural selection by creating an environment where hundreds of possible solutions to a problem can compete with one another, and only the "strongest" survive [6]. Just as in biological evolution, each solution can pass through the "genes" of its best through a 'successor' solution so that the entire population of solutions will continue to develop the best solution.

Optimization is a process to find the best solution for a problem that may have many possible solutions [6].

II. USING EVOLVER TO DESIGN URBAN BUS TRANSPORTATION NETWORK IN PRISTINA

Urban transport network is presented through a graph G (V, E) that contains a set of nodes in a set of streets and roads [4]. Notice the number of joints with $|V| = n$ and the number of roads $|E| = m$. The distance between node i and node j is l_{ij}. We will define the variables 0 and 1 for X_{ij}:

$$x_{ij} = \begin{cases} 1, If\ there\ is\ a\ path\ between\ nodes\ i\ and\ j \\ 0, others \end{cases}$$

If there is a path between nodes v_i and v_j then applies:

$$x_{ij} + x_{ji} = 1$$

However, in practical problem, since you are given the starting node and terminal node, the eventual solution of the shortest path is a direct path between them [1].

So nodes x_i and x_j may be limited as follows:

$$x_{ij} + x_{ji} \leq 1$$

In the graph network every possible starting node has only one "line in" and end node has only one "line out". Joints in between have both "line in", and "line out" and off-road nodes have neither the "line in" nor "line out". So, we define "net flow" as "line out" minus "line in". It is clear that the net flow of the starting node is 1 and the last node is -1 while others are zero [4]. Because the nodes in the path of applicable there is a "line out" and nodes outside the applicable road there is no "line in", so we have:

$$\sum_j x_{ij} \leq 1, \qquad \forall i \in V$$

We can calculate the distance of each applicable road. We need to find the shortest path, so:

$$Min\,S = \sum_{i}^{n} \sum_{j}^{n} l_{ij}\, x_{ij}$$

To summarize, we can pose the problem of shortest road model as follows:

$$Min\,S = \sum_{i}^{n} \sum_{j}^{n} l_{ij}\, x_{ij}$$

$$s.t. \sum_{j} x_{ij} - \sum_{j} x_{ji} = \begin{cases} 1, & i\ is\ starting\ node \\ -1, & i\ is\ \text{last node} \\ 0, & others \end{cases}$$

$$x_{ij} \in \{0,1\}, \qquad \forall(i,j) \in E,$$

$$\sum_{j} x_{ij} \le 1, \qquad \forall i \in V.$$

$$X_{ij} + X_{ji} \le 1$$

$$i,j \in V$$

In column A titled "From" we set start of the road and in column B, entitled "To" we set end of the road between any two nodes. In column C, entitled "Cost" we have put the price of road between these two nodes. In column D, entitled "Path Chosen by Evolver " we don't set any formula except in cell D164 we set formula SUMPRODUCT (C2: C163, D2: D163) through which to calculate the total cost. But this column is treated here as "Adjust Table Cell Range" where Evolver is determined by the value 0 or 1 for the objective of minimizing total costs (see Table 1).

F column titled "Node" settle all possible nodes, in this specific case we have 61 knots. In column G "Flow Net" set formula for quantity and deduction of the cells in column D based in column I entitled "The paths between nodes". For example cell G6 = D8 + D55 - D9 - D54 and cell I6 have ways 05-04, 05-25. 05-04 and vice versa way we find on line 8 and 9 and 05-25 and vice versa way we find in row 54 and 55. In column H titled "1 – Starting Node and -1 End Node" set manually "1" if it is the start of the path, and "-1" if the end of the path (see table below). In column C is located cost for each route using the same formula as above [3].

Table 1. EVOLVER IMPLEMENTATION IN EXCEL

The objective in this case is to minimize total cost and it is placed in cell D164, called "Optimization Goal" and in drop down list we have chosen option "Minimum". Then we set values for "Adjustable Cell Ranges" in cells D2:D163. The value of these cells may be less or equal to 1 and greater than or equal to 0, also the type of value must be an integer. In this model of Evolver's also we have set the condition for cells F2:F62 = G2:G62 (see fig. 1).
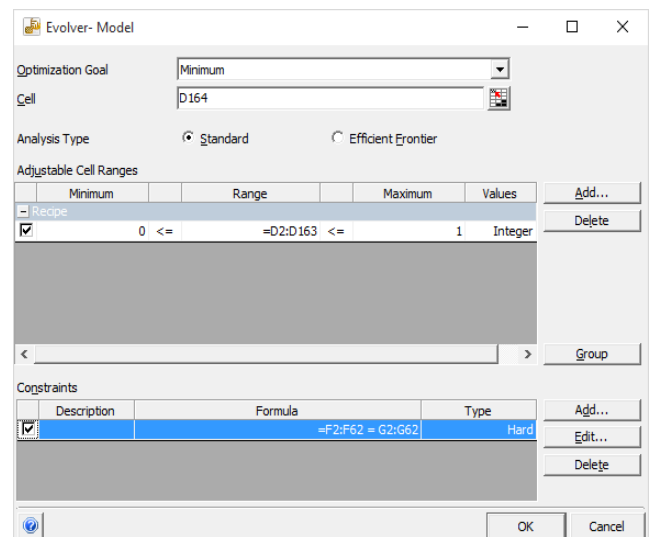

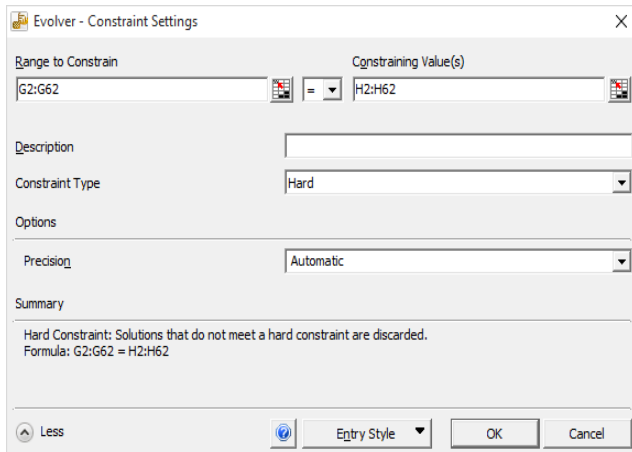Fig. 1. *Optimization Goal and Adjustable Cell Ranges in Evolver*

Fig. 2. *Evolver Constrains*

In the table below is shown definition, cells and description of the formulas in excel program used for finding shortest path in urban bust transportation network with evolver.

TABLE 2. FORMULA DESCRIPTION IN EXCEL

Definition	Cells	Descriptions or Formulas in Excel	Remarks
Variables	D2:D163	its Integer and value from 0 to 1	Path Choosen bay Evolver
Constraints	G:G	G2:G62=H2:H62	Type of formula "Hard"
Net Flow	G2:G163	= Dij - Dji	fill datas to cell D
Objective	D164	= SUMPRODUCT(C2:C163,D2:D163)	Shortest Path

TABLE 3. COST FOR EVERY PATH IN PUBLIC URBAN TRANSPORT NETWORK WITH EVOLVER SOFTWARE

| Path	Path with Nodes	Cost
	Public Urban Transport Network with Evolver Software	
1	15,20,21,34,42,45,52,54,60,61	10.54
2	15,20,21,34,42,45,52,58,57,56	13.25
3	12,19,18,21,22,23,24,29,28,36,27,37,38,48	8.23
3A	2,14,30,20,21,22,23,24,29,28,36,27,37,38,26	11.16
3B	14,30,20,21,22,23,24,29,28,36,27,37,38,48,49	11.76
4	16,21,22,23,17,7	7.58
5	12,19,18,21,22,23,17	4.05
6	55,58,52,44,43,32,13	5.23
6A	50,37,27,36,39,40,46,52,54,59	8.67
7	53,54,52,46,40,41,35,24,29,11,10,6	9.29
7A	32,33,34,21,22,23,17,11,10,9	7.43
7B	60,54,52,46,40,39,27,25,5	16.00
8	14,30,20,21,22,23,24,29,28,36,27,25,5,4	21.75
9	3,8,22,23,17,7	10.51
10	1,31,32,33,34,41,35	12.74
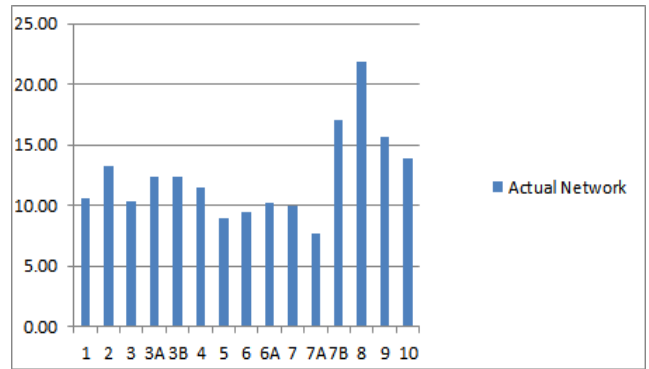
Fig. 3. *Cost for Every Path in Public Urban Bus Transport Network with Evolver Software*

Results obtained from all bus lines through evolver are presented in the table and figure above.

Table below shows all bus lines of the current network of urban buses in Pristina with switching nodes and costs in euros for every road [2].

TABLE 4. COST FOR EVERY PATH IN ACTUAL PUBLIC URBAN TRANSPORT NETWORK

| Path	Path with Nodes	Cost
	Actual Public Urban Transport Network	
1	15,20,21,34,42,45,52,54,60,61	10.54
2	15,20,21,34,42,45,52,58,57,56	13.25
3	12,19,20,30,33,34,41,35,24,29,28,36,37,38,48	10.31
3A	2,14,30,33,34,21,22,23,24,29,28,36,37,38,26	12.36
3B	14,30,33,34,41,35,24,29,28,36,37,38,48,49	12.36
4	16,21,20,30,33,34,41,35,24,23,17,7	11.43
5	12,19,20,30,33,34,21,22,23,17	8.93
6	55,47,39,36,28,29,24,23,22,21,34,33,30,14,13	9.42
6A	50,37,36,28,29,24,35,41,40,46,52,54,59	10.23
7	53,54,52,45,42,34,21,22,23,17,11,10,6	9.89
7A	32,33,30,20,21,22,23,24,29,11,10,9	7.18
7B	60,54,52,45,42,34,21,22,23,24,29,28,36,27,25,5	17.08
8	14,30,33,34,41,35,24,29,28,36,27,25,5,4	21.86
9	3,8,16,22,21,20,30,33,34,41,35,24,23,17,7	15.63
10	1,31,32,33,30,20,21,22,23,24,35	12.51
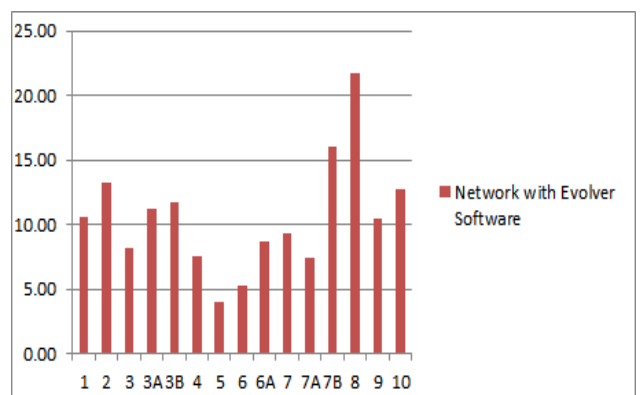
Fig. 4. *Cost for Every Path in Actual Public Urban Bus Transport Network*

III. CONCLUSION

Public urban transport can play an important role in developing countries and provide different benefits, including direct benefits to the passengers and indirect benefits to society. In this paper we have proposed urban bus transportation network based on evolver and compared with actual transportation network. The result of this comparison is shown in the diagram below. Based on this diagram, cost for bus lines 1 and 2 are equal for both designs and in the rest of transportation bus lines actual public urban transport network model has higher cost than actual urban bus network that is in use currently.
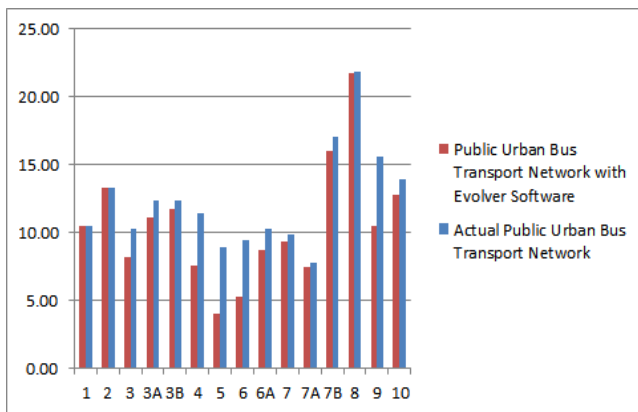

Fig. 5. *Comparison between Bus Transportation Network designed by Evolver and Actual Bus Transportation Network*

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