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Cost Management in Designing Public Transportation in Metropolitans

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Abstract:
With the increasing demand in metropolitan cities, the need for more traffic and transportation are felt more than before. One of the major problems of urban unit management is to promote and regulate the movement of citizens. Among serious challenges in this area is the lack of proper servicing of public transport systems in cities and metropolitans. In this paper, one method of optimizing cost management in design of public transport feeder network based on artificial intelligence is introduced. For showing results, a real example is used that is public transportation network of Mashhad metropolitan. The results show that improving mass transit rail feeder network structure will reduce %15.4 of overall costs for system users and operators.

Keywords: management, transportation, systems, feeder network, optimization, ACO

1. INTRODUCTION

In recent years a greater tendency of urban management is seen toward creation of new methods of minimizing the cost related to urban transportation systems user and operator. Given that transport is always considered a key element as blood flow of urban fabric, therefore it is necessary to be enough careful in optimization and implementation of designs and conducing acceptable systems. One of the most important sub-systems of transport is its public sector whose benefits of performing are no secret for everyone. In this paper, feeder network design optimization model of public transport in metropolitan transportation network is considered. Given that costs management is always among successful ways to improve the system, thus this paper presents an appropriate and scientific approach for using in this context. The public transport feeder networks are a part of overall transportation network that service with some modes like urban bus, taxi and Jitney. Due to the fact that demand for public transportation is high in large cities, so it is necessary to use massive services such as rail speed lines (Metro) and other semi-massive modes such as bus rapid transit. Because of high start-up costs of such services it is not optimal to expand them to all parts of the city. Thus by down handed modes and by lower operating costs and capacity, a design can be done to maintain the integrity of the network, and also to meet rail lines requested demand. It is noteworthy that launching mass transportation lines are optimal when its required demand exists. Since there is no such high demand in any city corridor so one way to meet required demand is to use feeder network. Due to the inherent complexity of transportation problems, mathematical methods are usually unable to solve such problems. Hence, in this paper, a suitable meta-heuristic method, ant colony optimization is used for solving problem. As meta-heuristic methods are inspired by the natural structure so they can easily search an acceptable reply in multi-dimensional space of problem solving.

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2. LITERATURE REVIEW

Many studies have been done in the previous literature in the field of urban transportation management. Due to breadth of issues related to public transport, those works only focused in design of feeder network are reviewed in this area.

Feeder network design was introduced for the first time in 1987 by Perl and Kuah. In their paper, they presented a method to design feeder network and determine the frequency of lines and article objective is minimizing passengers and operator costs. Perl and Kual (1989) improved their previous paper about feeder and they design a feeder network complete by using mathematics model. Design variable of problem was routes frequency.

The problem posed by Kuah and Perl (1989) was solved by two other articles and a new approach. Kuah and Ong (2006) have presented a paper in which the design and analysis of two meta-heuristic methods ACO and GA[2] were introduced for solving feeder network. Also Martin and Pato (1998) have solved expressed problem about feeder network with three innovative methods constructive heuristic, local search heuristic and tabu search.

Feeder network design using innovative and meta-heuristic methods has been done by different people.

Dhingra and Shrivastava (2001) presented a model for the design of feeder network in Mumbai city, India that demand reach destination through feeder network of suburban railway of this city. Presented model is an innovative type.

Dhingran and Shrivastava (2006) studied timing of integration between city bus and suburban rail network. In this paper, feeder route and its timing of integration for public feeder network with suburban train has been studied. An innovative routing algorithm is used to build the network. Then integrated and optimization scheduling is performed for feeder network while railway timing is preset and fixed. Problem solving is performed using a genetic algorithm.

O`Mahony and Shrivastava (2006) studied feeder network design and its integrated scheduling using the Genetic Algorithm. They implement their model for rapid railway stations in Ireland. Results show improved response compared to the previous essays of these writers.

O`Mahonny and Shrivastava (2007) in their paper, studied feeder network design using a combination of genetic algorithm and a secondary heuristic method. In this paper, at first genetic algorithm are designed feeder network routes, then a special innovative algorithm to cover demand of all stations. The main objective of optimum design of the feeder network is to meet existing demand due to travel time constraints and minimizing mode change between railway and feeder network lines according to co-ordination of timing between two modes of transportation. Problem decision making variables are also included routes and buses frequencies.

Dhingra and Verma (2005) have presented a model that coordinate feeder network optimal routing with related railway. Paths are made in two stages: the first stage is to build a set of shortest routes (potential feeder routes) and in the second stage, a search is performed by algorithm of the shortest route for each pair of rail station to terminal and using genetic algorithm.

Dhingra and Verma (2006) have presented a model that provides an optimal and integrated scheduling for two modes of rail and feeder bus network. The model presented consists of two sectors of rail way scheduling and integrating this scheduling. Railway scheduling objective function is to minimize total costs of operator and total costs of passengers` waiting time.
Feeder network design is also expressed by Parti and Marwah (2004) using optimal functions. They have presented a logity model to analyze the choice between bus and mass public transportation line for the city of New Delhi. Model presented aims to determine transferred demand share from bus to mass public transportation system.
Gholami and Shariat (2010) for the first time have provided a model by which feeder network is designed as multi-modes. Problem objective function is to minimize the cost of passengers, operator and economic- social costs. They used ants' community meta-heuristic algorithm to solve the problem. To compare the results, at first problem is solved for basis state that only cover network bus mode and then results were analyzed by compiled entering. Decision variables include a set of network paths, frequency related to each path and stations under cover of each mode. Thus the solution is in this way that at first it is performed by routing ant algorithm for all network stations. Then, for each route it is reviewed that whether servicing by bus mode is better or van mode. The measure of this evaluation is the cost of the network, each of which gives a lower cost, is chosen.
Efficiency of transit-taxi modes with a capacity of 4 persons, compared with bus in feeder network is investigated in study of Gholami and Shariat. In this study, single-mode bus network is compared with multiple modes network that is designed by 4 seating car and bus. In this paper, the effects of capacity, demand and unit costs are shown on performance indicators of feeder network.
Tahoorinia and Shariat (2011 a & b) investigated the application of ant colony algorithm in designing public transportation community and reviewing the effect of demand changes in feeder network design in two articles.
As it can be seen, most of works done in the area of network design is to provide superior methods while management subject and implementation of these methods are less dealt with. In this paper by using a real example, implementation of a new method in terms of reducing the cost of transportation network design will be shown.

Problem Model:
For designing optimal multi-modes feeder network, a six-part model similar to what is referred in the reference (Shariat et al, 2011) has been used, equation (1). First two terms are objective function represents the costs associated with the user and third to sixth terms are related to operation cost of system, social, repair and maintenance and fixed of transportation system, respectively

$$C_k^m = C_{w,k}^m + C_{r,k}^m + C_{o,k}^m + C_{s,k}^m + C_{f,k}^m + C_{m,k}^m \quad (1)$$

Where:
C_k^m : Total cost of network for mode m and route k; $C_{w,k}^m$: The cost of waiting time for mode m and route k; $C_{r,k}^m$: The cost of riding time for mode m and route k; $C_{o,k}^m$: Operating costs for mode m and route k; $C_{s,k}^m$: social cost for mode m and route k; $C_{f,k}^m$: system fixed cost for mode m and route k; $C_{m,k}^m$: maintenance cost for mode m and route k.

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More details of problem objective function in Equation (2) are given.

$$C_k^m = \sum_{m=1}^{M}\left(\frac{\lambda_w^m}{2}\sum_{k=1}^{K^m}\frac{P_k^m}{F_k^m}\right)+\sum_{m=1}^{M}\left(\lambda_r^m\sum_{k=1}^{k^m}\frac{1}{V_{o,k}^m}\sum_{s=1}^{S_k^m}\left(l_{s,d}.P_s^m\right)\right)$$
$$+\sum_{m=1}^{M}\left(2\left(\lambda_o^m+\lambda_s^m\right)\sum_{k=1}^{K^m}F_k^m l_k^m\right)+\sum_{m=1}^{M}\left(2\left(\lambda_f^m+\lambda_m^m\right)\sum_{k=1}^{K^m}\left[\frac{F_k^m l_k^m}{V_{c,k}^m}\right]^+\right) \qquad (٢)$$

Where:

M: Number of modes existed on the network, λ_w^m: unit cost of waiting time for mode m, K^m: number of route mode m, P_k^m: demand route k for mode m, F_k^m: frequency route k for mode m, λ_r^m: unit cost of riding time for mode m, $V_{o,k}^m$: operating speed of mode m in route k, S_k^m: a set of route stations k and mode m, $l_{s,d}$: distance between station s and destination d, P_s^m: station demand s for mode m, λ_o^m: unit cost of operator for mode m, λ_s^m: social unit cost for mode m, l_k^m: route length k for mode m, λ_f^m: fixed unit cost of system for mode m, λ_m^m: unit cost for system maintenance for mode m, $V_{c.k}^m$: cycle speed for route k and mode m

Running program:

As it was outlined in the previous section, the model presented in this paper has six sections that involve costs related to the user, operator and the community. To run the program and show results of a real example, public transportation network of Mashhad city was used. Mashhad city has textured lines in terms of transportation and city building and its semi-massive railway network whose no. 1 line is opened currently is expanded west to east and it divides city in two parts of north and south; figure (1). Given that the western part of the city of Mashhad has dense and different applications, and also its closeness to urban countryside is another feature of this city, and since travel demand of this part of the city is such a way that most of public transportation travels using railway or bus city are performed that is moving parallel to it, we are about to implement delivered model for feeder network in west side of Mashhad, figure 1. To run problem algorithm program in MATLAB environment software is scripted and scenario applied to the program is like table (1). As it is seen in this table, costs related to model parameters are entering at the beginning of the program and as fixed to the model. In next section, results obtained from model implementing and analyzes are presented. Program model capacity is to use different modes in designing network, but here we have used two usual urban modes, bus and van.

Table 1 –Cost Parameters related to program model

$Bus(Ca=40,V_o=20)$						$Van(Ca=10,V_o=20)$					
λ_w^b (rial/prs-h)	λ_w^b (rial/prs-h)	λ_w^b (rial/prs-h)	λ_w^b (rial/prs-h)	λ_w^b (rial/prs-h)	λ_w^b (rial/prs-h)	λ_w^b (rial/prs-h)	λ_w^b (rial/prs-h)	λ_w^b (rial/prs-h)	λ_w^b (rial/prs-h)	λ_w^b (rial/prs-h)	λ_w^b (rial/prs-h)
18000	12000	11496	22992	129143	3472	18000	12000	2796	2796	23763	1778

Ca: Capacity of vehicles (passenger); V0: vehicle operating speed (km/h)

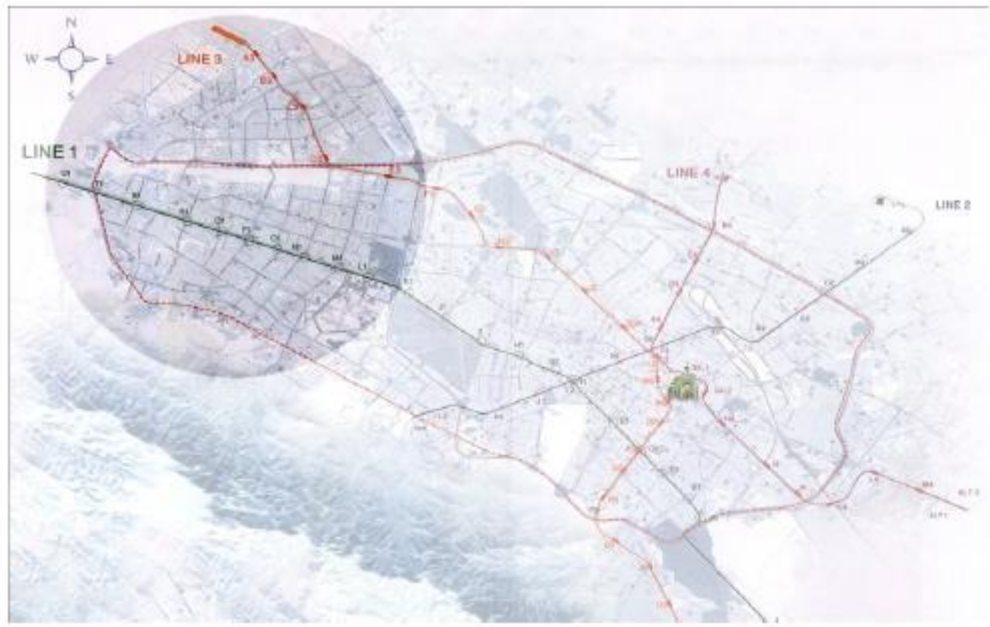

Figure 1 – Mashhad city transportation network and under design area

Analysis of results and conclusions:

In this paper, to better understand before and after situation, at first program model is implemented for design state only with one mode and then we entered two modes. Given that the approach presented in this paper is a step forward compared to previous works in the field of urban management, it is found from scenarios overall cost comparison that network design with method of this article is always optimal. As comparing costs of two designs shows mean 15.4% reduction in costs. Its reason is greater flexibility of network with model of this article and suitable coverage of modes towards each other and less empty space in a vehicle and also cost of less waiting time of passengers in stations. Network designed using program model is shown in Figure (2).

It is noteworthy that two main factors to select the type of mode by passengers are network stations, time in a vehicle and waiting time, and given services by van and bus is provided in a network by an operator consequently program work trend is to maximize operator profit. On the other hand, a program for reducing passengers' costs is planned so that it minimizes total travel time. So for a passenger, selecting bus or van is no different in shared stations, because selecting each one of them will provide minimized travel time for him/her. So here it is assumed that waiting passenger at the station will use first service, whether bus or van. Given that making cities transportation network structure and distribution demand and in urban areas, public transportation design should be done so that required modes of integration maintain in a network.

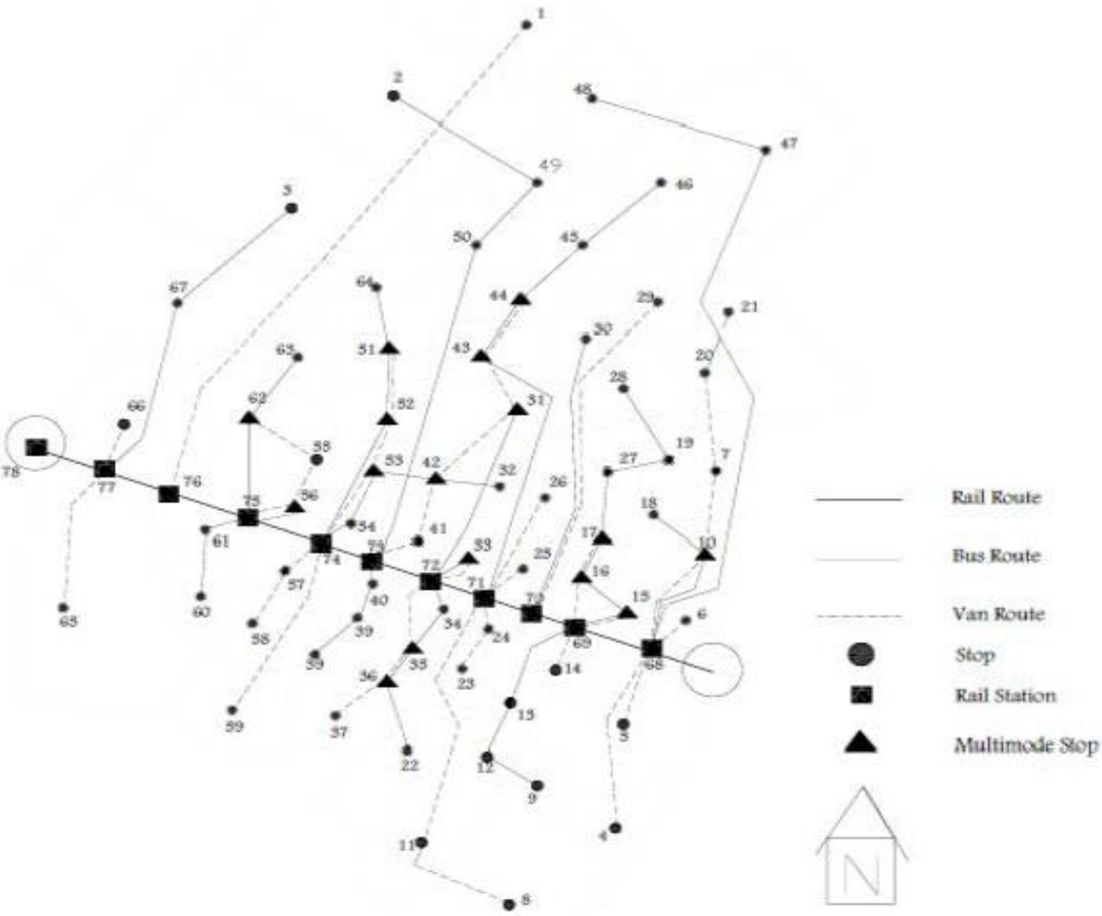

Figure 2- designed network of public transportation for two modes of bus and van

To achieve this, we need to offer services with modes by different capacities in order to have economic justifiability due to area demand. In this paper, a method for designing a multi-modes feeder network of public transportation line is presented that enable shared modes servicing in network stations. The method presented here has an improvement compared to previous works done in this area that provide multiple- modes feeder network design with modes servicing limitation separately in network stations. Offering this approach, furthermore, flexibility of network will increase because of service diversity. Also servicing empty capacity is reduced because of modes coverage with low and high capacities toward each other. Problem objective function is in direction of minimizing operator and passenger costs and economic-social costs. Variety of servicing modes in network stations causes to reduce operator and passenger costs, because by multi-modes services in stations, in addition to reduce services empty capacity using fleet variable capacity, also passenger waiting time is reduced because of more frequency in services. For urban management, it should be noted that costs optimization is among the most critical issues. Thus, scientific approaches that are provided in direction of optimal could always be helpful. In urban unit management, discussing appropriate transportation is used to meet needs of the community. An approach is offered in this paper that could be used in order to reach pre-set objectives to design an integrated network with an appropriate cost.

3. REFERENCES

1. Abul Alayi, B. (1995). Factors affecting labor productivity in the automotive industry, MSc thesis.Tehran, Allameh Tabatabai University, Department of Management and Accounting.
2. Prokopenko, J. (1993). Productivity management, translated by Abbas Ebrahimi Mehr, Institute of Labour and Social Security.
3. Taheri, Sh., (2003). Productivity analysis in organizations, Tehran, Havaye Tazehpublishing.
4. Khaki, Gh., (1997). Introduction to Productivity Management, Sayeh Nama Publishing Association Tehran.
5. Kotler, Ph., (2004). Marketing management, translation: Ali Parsaeian, cashmere publications.
6. Khaki, Gh., (1998). Productivity Management (in the analysis), the focus of publishers shadow cursor, Tehran, second edition.
7. Nazem, F., (2008). Productivity management (organizational atmosphere and productivity), Islamic Azad University of ROUDEHEN Research Publications.
8. Rastogi, P. N., (2009). "Productivity Innovation, Management and Development", London Sage.
9. Nowrziou, H., (2010). Productivity management, Bahavar publishing.
10. Tyler, T. R., (1998). "The Productivity of Procedural Justice: A Test of the 43-Group-Value Model." Journal of Personality and Social Psychology, vol 57 pp.830-838.
11. Fabricant, Sulomon., (1988). "A primer on Productivity", New York: Random Hones.
12. Shams, N.&Moballeq, M., (1999), Design and explanation of productivity of universities, Amirkabir University Publication Center.