AN APPROACH TO THE SOLUTION OF THE HANOI TRAFFIC PROBLEM

Pham Xuan Hinh

Hanoi Metropolitan University

Abstract: *The construction and management of the transport system are one of the key issues for a developing country like our country in general and for Hanoi city in particular. Besides the investment in infrastructure development, the problem of organizing and managing the transport system is urgently raised. In this paper, we present a model for traffic schedule setting with multiple control centers and approaches to the solution as well as the applicability for Hanoi bus network.*

Keywords: *Traffic schedule setting.*

Received 2.1.2021; accepted for publication 25.1.2021

Email: pxhinh@daihocthudo.edu.vn

1. INTRODUCTION

The construction and management of the transport system are one of the key issues for a developing country like our country in general and for Hanoi city in particular. Besides the investment in infrastructure development, the problem of organizing and managing the transport system is urgently raised. The reality of our country in the past few years has shown that no matter how much investment has been focused on infrastructure development, if we do not know how to manage the traffic system properly, this investment is also not effective and the problem of traffic congestion is still not resolved. Of course, this is not only a problem of our country but also other countries, so problems related to organizing and managing the transport network always receive special attention from the Mathematics community all around the world. The characteristic of traffic organization and management problems is that they often have mathematical models which are integer, nonlinear programming problems and have a very large number of variables, so they are often in the

NP-*hard*class and there is no way to find the solution.

Solving these problems often relies on exploiting the unique characteristics of each city, so the solution is only applicable to each specific case. We know that why the traffic problems have been posed for a long time, have been studied by many interested people and have obtained a lot of results, but the problem always draw attention of many people in mathematics community. Recent results of this type can be viewed, for example, in the works of Gabor and Salhib (2005) (see [3]), by Lim and Wang (2005) (see [7]), by Hadjar , Marcotte and Soumis (2006) (see [4]), by Hoa, Hob, Jib and Laub (2008) (see [5]). The problems related to the traffic network are extremely diverse which beyond the framework of any research program, so each group of authors and "school" of research often refer to some specific issues. In this paper, we only mention the problem related to the scheduling problem in the traffic network and the applications of practical significance to the reality of our country and Hanoi city today.

2. CONTENT

2.1. Model of the problem

One of the most "prominent" issues of our country's transport industry today is the organization and management of urban transport networks in big cities. The highest goal of a public transport network in the city is that it is responsive to the travel requirements of city residents. This requirement is usually expressed in the form of a set of itineraries intersecting major intersections in the city (with a defined frequency and at certain times, based on survey results thoroughly by the city traffic management agency).

In the process of making these journeys, the vehicle usually has to take some auxiliary itinerary that is not required (for example, the distance from the center of the convey to the beginning of the restraining journey first, or the segment of the road from the end of one journey that has just been executed to the beginning of another journey to be executed next). This is the non-lucrative cost part, but one of the major goals of the transport industry is to minimize these costs. This is done by streamlining entry trips into a number of routes (each is assigned to a vehicle that takes a day, called a ride schedule), and that means we optimize the set of driving schedules under the management of a number of operator centers (predetermined in the city traffic network). This problem is called the problem of setting the optimal schedule system for public transport network. Well-solving this problem will be the basis for solving a series of other problems related to the public transport network (such as optimal assignment of crews, optimal use of the number of drivers). So, even though it is a very difficult problem (of the NP-*hard*class, as will be seen later), we have to focus on solving it.

In fact, the bus network of a Hanoi city was formed and developed in many stages besides the other developments of that city. Although it can be designed "optimally" from the outset, in the course of its operation, with the expansion of the city and the constant growth of forces involved in traffic, the network will cannot keep the original "optimal" structure due to the addition of new itineraries (which comes from the actual requirement). Then, it is a natural requirement to restructure the schedule (and then redistribute the service quotas of the operating centers) to continue to get the optimum at a reasonable level. Thus, besides proposing a solution to systematically set up optimal schedules for the network at a certain time, we must also pay attention to the issue of "network restructuring" after a certain period of time. In fact, an optimization for a new phase is often very different from the previous one, and will require significant changes in operations and management of the network, and this change often entails small costs.

A new option will only be feasible when its "theoretical optimization" yields economic efficiency outweighs the cost of disturbing the management and operation practices (due to the change cause). Perhaps this is one of the main reasons why "theoretical optimal options" are not always implemented in practice, even though finding such an optimal solution is extremely hard. With cities in the process of changes like in our country, especially when the ability of traffic forecast is still very limited, finding a solution to apply for stable network operation in the long term (as in developed countries) may not be feasible, but a more practical problem is probably to find plans to operate the network in a reasonable time, then continue to make new changes. Obviously, the proposed options, in addition to reducing unproductive costs in the process of network operation, must also cause as little disturbance as possible in the management and operation of the system (so that there is less pay for this disturbance).

The main goal of the research direction is to propose a possible solution for finding a solution that is able to reconcile those two goals. Modeling problems related to traffic network scheduling, studying solutions to approaching the problem of setting up transport scheduling systems for traffic networks with multiple control centers and application possibilities for bus networks Hanoi City. Firstly, we study the following problem.

2.2. The problem of setting up a scheduling system for traffic networks with multiple control centers

In a big city (like Hanoi nowadays), maintaining only one control center (CC) to let all vehicles cover all the city's routes will be inadequate, because the number of vehicles having to serve at the CC will be too crowded, most vehicles have to travel too far to reach the service point of the first journey of the day, and at the end of the day's service, they also have to go it's a long way to get back to the CC). Therefore, in this case, people often use several CC instead of just one (each bus network like Hanoi now has four digital centers).

The change from one CC to multiple CC has made the problem of setting up the schedule system for the traffic qualitative changes, even though the appearance still has similar features. Suppose that the set of CC is$K$and at the$k$ -the CC, we have v^k vehicles, $k \in K$. Each vehicle of CC is used to run a number of roads and then eventually return to the same CC after each working day.

Now, we consider a graph of n vertices, each vertex denotes an destinations/routes and I is the set of compatible trip pairs.

For $k \in K$, we consider the graph $G^k = (V^k, A^k)$, with

$$A^k = I \cup (\{n+k\} \times N) \cup (N \times \{n+k\})$$

$V^k = N \cup \{n+k\}$,

That the vertex $n+k$ presents k -th CC.

For X_{ij}^k is indicator variable w.r.t the side$(i,j) \in A^k$; the cost on this side (this cost does not depend on $k$if$(i,j) \in I$, and the costs $c_{n+k,j}$for$j \in N$and $c_{i,n+k}$;$i \in N$ can depend on$k$).

The mathematical model of this problem is as follows:

$$\textit{Minimize} \sum_{k\in K} \sum_{(i,j)\in A} c_{ij} X_{ij}^k \tag{1}$$

with the following binding conditions:

$$\sum_{k\in K} \sum_{j\in V^K} X_{ij}^k = 1, \quad \forall i \in N, \tag{2}$$

$$\sum_{j\in N} X_{n+1,j}^k \leq v^k, \qquad \forall k \in K, \tag{3}$$

$$\sum_{i\in V^K} X_{ij}^k - \sum_{i\in V^K} X_{ji}^k = 0, \ \forall k \in K, \forall j \in V^K, \tag{4}$$

$$X_{ij}^k \geq 0, \qquad\qquad , \tag{5}$$

$$X_{ij} \in \{0,1\}, \forall k \in K, \forall (i,j) \in A^k. \tag{6}$$

The objective function (1) is the total cost. Constraint (2) is a condition that ensures that each route is executed exactly once, while constraints (3) and (4) are, respectively, a constraint on the number of vehicles and the condition of flow balance.

If$|k| = 1$then this is the problem of setting up a scheduling system for traffic networks with the only CC (see [1]).

If $|k| \geq 2$ then this problem is in the class *NP-hard* (as shown in [5]). Then, the problem of finding the approximately optimal solution εhas also been *NP-hard*. In addition, it was also pointed out that the problem of finding an acceptable solution for this problem when there was a constraint on the capacity of the centers was also a NP-complete problem. This is the reason why although this problem has been studied by many people (see [2], [6]), but so far there has not been a satisfactory solution.

2.3. Propose some solutions to the problem

We study a number of solutions to solve the above problem with specific traffic network in Hanoi city.

•Converting the general problem with high complexity to the problem with lower complexity, based on some assumptions about practical implementation conditions.

•Using a solution that combines repeating and decomposition processes. Each step in the iteration produces an improvement in the objective function.

•The decomposition process converts this problem into two other optimization problems that are easier to solve. Each problem is a step in reducing the value of the objective function. The result is an acceptable and feasible (does not require too much changes in the management and operation of the system, compared to the current plan).

•Studying the experimental algorithm, with a traffic network with the same structure and caliber as the Hanoi bus network, to find that the algorithm is capable of providing a plan where the objective function value decreases.

3. CONCLUSION

Currently, Hanoi city has been expanded and the city's traffic network has changed a lot, adding new routes and more control centers. Then the variable length of the problem will increase significantly and the data preparation will be very difficult which requires us to spend a lot of effort such as measuring the lengths of new roads, the number of people traveling at each station in each period of time. That helps us to research and propose a useful algorithm for the problem.

In this paper, we study the problem of setting up a scheduling system for a traffic network with many control centers. We propose a new approach to this problem based on the combination of iteration and decomposition processes. Deploying the calculation, we will build a traffic network model according to the structure of the Hanoi bus network, and a simulation data set with information capacity equivalent to the actual capacity. Besides the experimental calculations on this network we will confirm the feasibility of the algorithm for large traffic networks, and also show the effectiveness of the algorithm.

REFERENCES

1. Ahuja R.K, Magnanti T.L, Orlin J.B, (1993), "Network Flows: Theory, Algorithms and Applications", *Prentice-Hall, Inc., Englewood Cliffs, New Jersey*.
2. Branco I, Costa A, Paixão J, (1995), "Vehicle scheduling problem with multiple type of vehicles and a single depot", *Computer-Aided Transit Scheduling*, pp. 115-129.
3. Gabor N, Salhib S, (2005), "Heuristic algorithms for single and multiple depot vehicle routing problems with pickups and deliveries", *European Journal of Operational Research*, vol. 162(1): pp. 126-141.
4. Hadjar, A, O. Marcotte, and Soumis F, (2006), "A Branch-and-Cut Algorithm forthe Multiple Depot Vehicle Scheduling Problem", *Operations Research*, 54: pp. 130-149.
5. Hoa W, G. Hob T.S, Jib P, Laub H. C.W, (2008), "A hybrid genetic algorithm for the multi-depot vehicle routing problem", *Engineering Applications of Artificial Intelligence*, Vol. 21(4): pp. 548-557.
6. Kokott A, Loebel A, "Lagrangean relaxation and subgradient methods for multiple-depot vehicle scheduling problem", *Retrieved on http://www.zib.de*.
7. Lim A, Wang F, (2005), "Multi-depot vehicle routing problem: a one-stage approach", *IEEE Transactions on Automation Science and Engineering*, vol. 2(4): pp. 397-402.

MỘT HƯỚNG TIẾP CẬN TRONG VIỆC GIẢI BÀI TOÁN GIAO THÔNG THÀNH PHỐ HÀ NỘI

Tóm tắt: *Việc xây dựng và quản lý hệ thống giao thông là một trong những vấn đề then chốt đối với một quốc gia đang phát triển như nước ta hiện nay nói chung và của thành phố Hà Nội nói riêng. Song song với công tác đầu tư phát triển hạ tầng, bài toán quy hoạch và quản lý hệ thống giao thông đang được đặt ra một cách cấp bách. Trong bài báo này, chúng tôi đưa ra một mô hình bài toán Thiết lập lịch trình giao thông có nhiều trung tâm điều hành, nghiên cứu một hướng tiếp cận giải bài toán giao thông Hà Nội và khả năng ứng dụng cho mạng xe bus thành phố Hà Nội.*

Từ khóa: *Thiết lập lịch trình giao thông.*