combined decentralization; vehicle routing problem

Biljana GRGUROVIC*, Slavica STRBAC, Jelena MILUTINOVIC, Mirjana POPOVIC
ICT College of Vocational Studies
Zdravka Celara 16, 11000 Belgrade, Serbia
**Corresponding author*. E-mail: biljana.grgurovic@ict.edu.rs

SOLVING A PROBLEM OF ESTABLISHING A CONNECTION BETWEEN POST OFFICES IN THE AREA OF A CITY

Summary. According to The General Plan of Post Network and in accordance with the criteria for opening branches of postal services for customers numerous postal offices which perform delivery services are located on the territory of every large city area. In case of using the system for combined decentralization one of the offices is assigned the role of the central deliverance post office. If the central office cannot be connected to some other unit directly, their connection is realized through one or more other units which are located in between them. Aside from the idea of the most economical management, the organization of postal offices is limited by some other actors, from the number of available vehicles, their capacity, to the question of the place and time of realizing a transaction.

This paper provides information about how the money-saving algorithm for solving the problem of time interval routing can be used in a suitable way in these situations as well.

РЕШЕНИЕ ПРОБЛЕМЫ РАЗРАБОТКИ СЕТИ ПОЧТОВЫХ ОТДЕЛЕНИЙ ДЛЯ ДОСТАВКИ НА ТЕРРИТОРИИ ГОРОДА

Аннотация. Согласно Общему плану почтовой сети и в соответствии с критериями для открытия отделений связи, для оказания почтовых услуг клиентам на территории любого города, как правило, располагается несколько почтовых отделений, осуществляющих, в том числе, и операции доставки. В случае применения системы комбинированной децентрализации, одному из них присваивается роль центрального почтового отделения доставки (городского узла доставки). При отсутствии возможности прямого соединения центрального и любого другого пункта, их связь осуществляется через одно или несколько других отделений, находящихся на пути между ними. Наряду с идеей о высокоэффективном и экономичном для хозяйственной деятельности решении, Почту (как организацию) ограничивают и другие факторы, в т.ч. количество имеющихся в распоряжении транспортных средств, их вместимость, а также намеченные сроки выполнения определенных операций.

В статье освещается применение в соответствующем порядке и в подобных ситуациях алгоритма экономики для решения вопроса применения транспорта, курсирующего по заранее разработанным маршрутам с указанием промежутков времени при доставке.

1. INTRODUCTION

Making a connection between two cities is not always done in the same manner. According to urban plans, two places can be interconnected by roads of different significance to traffic, and the possibility that a direct connection between them does not exist is even more presumable. If the two cities cannot be directly connected, their connection is formed through a city which is connected to both of them. A similar method is used in organizing postal traffic, adding that a connection via third city is also acceptable when the amount of packages justifies it, and the required quality allows it. That is the reason why the transport connections, which include all units of postal web in the country, are divided to major and minor, and the transportation of packages is organized based on routes. [1, p. 144-149].

This angle of viewing the problem of connecting two places can be reduced to a lower level, i.e. connecting two or more locations in one city in case of using the system of consignments delivery known as combined decentralization.

Decentralized system of consignments delivery is distinctive in a way that in one city area which includes multiple postal units all or some of them are given the duty of doing business concerning consignments delivery. In case of combined decentralization there is a main delivery post office and a certain number of decentralized delivery post offices.

The main post office prepares the shipping and the delivery for the whole city area, i.e. it divides the consignments according to delivery areas of decentralized delivery post offices (Fig. 1). The duty of postmen of decentralized delivery post offices is to divide the consignments according to the itinerary, i.e. to put every consignment in a matching compartment.

In this system, the unproductive working hours of postmen is reduced to minimal, there is an option of organizing repeated delivery by one postman, resources for transporting postmen and consignments to a delivery area are not needed, it is possible to use auxiliary transport means when it comes to big packages (carts etc.) or organize special deliveries and an opposite delivery system and hiring postmen on side job places.

Downsides of this system are, above all, the complicity of addressing consignments, as well as and increased use of motor vehicles in a traffic which is already loaded as it is.

2. ESTABLISHING A CONNECTION BETWEEN DECENTRALIZED DELIVERY POST OFFICES

Main delivery post office can be connected to decentralized delivery post offices through a direct connection but, in case that is impossible or unprofitable, a connection which enables physical distribution of items (consignments) can be realized through one or more other units which are located between them (Fig. 1).

Given that transportation is one of the key elements to be rationalized, and because improving speed, regularity and safety leads to increase of service quality, providers who work in the area of post traffic tend to continually improve in this segment as well. Innovations are primarily aimed at protecting environment, increasing traffic safety, lowering transport costs by forming an optimal structure of transportation network.

If we start from defining the transportation network as a group of units and connections which the traffic-transport activity is taking place on, [2, p. 1-38], then obviously the problem with connecting the decentralized delivery post offices can be viewed on a graph. The basis of the graph, where it all begins and ends, is the main delivery post office, while other delivery post offices represent nodes of the graph, and streets – a branch which connects two nodes.

The rule says that the basis of the graph should be connected to other nodes through the shortest possible way, i.e. forming a minimal belonging "tree" is required. Bibliography provides various effective algorithms which can successfully solve the problem of finding the shortest belonging tree [3, p. 7-22]. They are all based on the fact that the shortest connections leaving a node should belong to the shortest belonging tree.
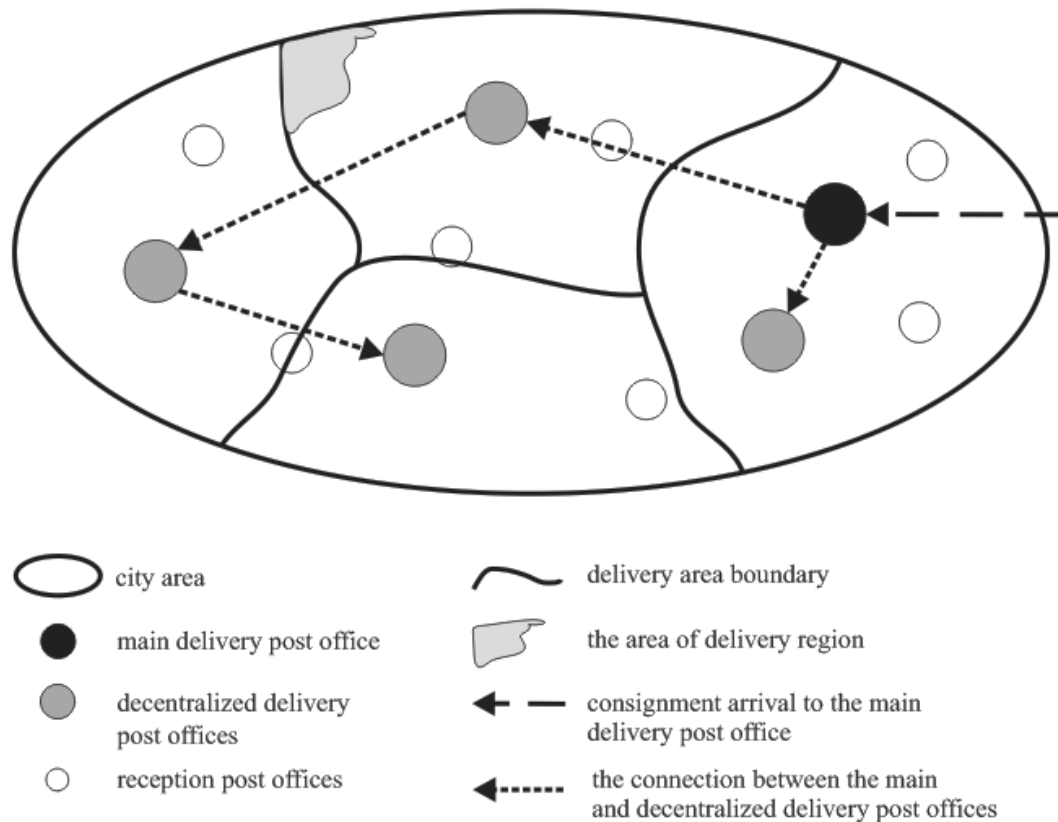
Fig. 1. Combined decentralization
Рис. 1. Комбинированная децентрализация

Most commonly used Kruskal's and Prim's algorithm are almost useless when it comes to defining a way to establish a connection between decentralized delivery post offices. The reason is the fact that each node has certain requirements, as well as that transient resources aren't always the same.

In order to successfully manage transportation activity, we should be well acquainted with characteristics of each limitation and all types of requirements.

2.1. Limitations and requirements

In case of using the combined decentralization system it is sometimes hard to distinguish limitations from requirements. They can all be viewed and defined from the main delivery post office, decentralized post offices or customers' point of view, so they will only be mentioned in this text, but not placed in a certain group.

Most frequently set limitations/requirements are:
- Time interval required for taking consignments from the main delivery post office,
- Time interval required for taking consignments from a decentralized delivery post office,
- The number of available vehicles for consignments transport from the main to one of the decentralized delivery post offices,
- The capacity of available vehicles.

Taking into consideration the above requirements and existing limitations, providers are to find a way to realize the basic goal – achieving the best possible effects using as little resources as possible. Although the savings on transport charges reflect on lowering overall expenses of physical

distribution, as well as lowering the overall goods costs, posts sometimes require deviation from this economic principle. The tendency for optimal organization when it comes to expenses should be replaced with the tendency for rational organization which leads to realizing the service of a certain quality.

The organization which should be established and managed is based on using the routing and timetable algorithms.

3. USING THE VECHILE ROUTING PROBLEM AND TIMETABLE ALGORITHMS IN POSTAL TRAFFIC

The basic operation practice in case of using the combined decentralization system is distributing. That means that a vehicle starts its route from the base filled with a certain amount of consignments, and returns empty.

Postal service providers have access to their own vehicles. The number of vehicles is mainly connected to the main delivery post office (base) where the vehicles start their route and return after the delivery. A connection between the problem of a traveling salesman who should visit n towns and keep the expenses on the minimal level, so that he could return to the starting point is obvious. The question is how to use the vehicles so that each one has a defined route and the amount of consignments is as close to their capacity as possible.

However, the number of decentralized post offices (junctions in which the requests for service occur), the distance between them, the amount of consignments, number of deliveries during a day, defined time intervals etc. define how many and which means of transport should be used. Solving such a problem requires setting new limits, such as: each vehicle should visit a certain number of post offices or exceed a certain distance or perform the deliveries until a certain hour or deliver a certain amount of consignments. This problem can be transmitted to the problem of k travelling salesmen [4]. Instead of simultaneously viewing k vehicles, the problem can be solved just like a problem of one travelling salesman who can't transport all the goods to all the stores in one take, but has to return to the warehouse k times, always using different routes.

For the vehicle routing problem, i.e. the problem where all travelling salesmen start their routes from the same town and return to it, while visiting a certain number of towns, routes and vehicle sorting are planned.

The problem of k travelling salesmen is used in planning vehicle routes when there are limitations when it comes to the number of vehicles or capacity limits.

In order to function normally in every delivery post office it is important to estimate in advance the time intervals which are required for picking up consignments in the main delivery post office. The pickup should be done in early morning hours, according to the fixed chart links. The exception is possible only in case when multiple pickups are scheduled during a day or when it comes to disorder in regular postal-traffic connections. In this moment, the problem can be divided into two variations:

− The pickup is performed in a certain time interval or,
− The pickup should at least begin during a certain time interval.

For the demands of this text, the authors will pay attention solely on the first case.

All these consignments are addressed to their final receivers living in that area. The exact time of the delivery, or the time interval in which it is possible to begin the process, is a consequence of the organization of work in that particular post office and it depends on various factors. The time needed for mailmen to sort the consignments according to their meant route which is directly influenced by the amount and the sort of consignments; the distance between the post office and the final points of delivery area which necessarily influences defining the time of the mailmen departure, the manner and the type of the delivery; in which time the customers request their consignments… these are just some of those factors.

The time taking for the consignment pickup, for which, when it comes to transport organization, the time it takes to unload the consignments from a vehicle and deliver it according to a certain form is

crucial, is also not a random number. It primarily depends on the amount and the type of consignments addressed to a certain post office. It is clear that this time interval should match the provided point in time when the vehicle needs to arrive to the post office or depart from it to another post office.

Since the time intervals defined in decentralized delivery post offices are of great importance, the distance between two post offices should be defined according to the time it takes for a vehicle to transport consignments from office A to office B, the latter being the next one in its route. The additional limitation is introduced in case of the transportation vehicle arriving to the next post office before the arranged point in time, when the service of this junction should not be performed earlier. [2, p. 211-226]

4. USING CONTEMPORARY TECHNOLOGY AS A SUPPORT IN MAKING A DECISION

When all the requirements and limitations are taken into account, it is obvious that this is not a case of the standard time interval routing problem. Postal service providers do not have the access to only one type of means of transport, and the decentralized post offices do not have a precisely defined demand (the amount of consignments being delivered) every day.

The amount of consignments delivered to the destination post office is a number which directly influences the choice of the type and the number of vehicles, as well as the number and the type of delivery post offices that one route includes, which mean of transport can deliver consignments to them, if a vehicle can be used multiple times during a day.

The problem which is a result of the unknown demand data could be solved by using the advantages of new information technologies.

As a consequence of technological achievements and new communicational patterns, postal services have drastically changed during the last decade. The improved post operators, in order to increase the efficiency of the process, are already abandoning old concepts of investing in new technologies, which meant the increase in productivity and the decrease in costs, and embracing the new concept, which means achieving a certain level of adaptability. [5, p. 56-65]

It is known that a great number of events and information emerged as a result of everyday functioning of postal traffic has a space component which means the ability to include coordinates and, at the same time, view them clearly on a map, diagram or a table. [6, p. 205-211].

The use of the Geographical Information System (GIS), aside from enabling gathering, processing, managing, analysis and viewing spatially oriented data [7, p. 87-100], also contributes to faster and better decision making.

By combining the system for consignment tracking and GIS in the main delivery post office it is possible to gather data about the quantity and the type of consignments sorted by decentralized post offices long before the decision about routing and timetabling means of transport in a certain area is made. This problem exceeds the topic of this text.

5. CONCLUSION

Transportation profession is the profession of today, and even more, one of tomorrow. Transformation waves demand setting up fast, trusting, safe and high-quality traffic systems on all levels and in all areas.

Postal transportation, as a part of transportation system of every country, constantly demands bettering the service quality, better organization and technology of work, better economy, profitability and efficiency, the development of work culture, planning, following ecological standards…

Rapid and uncontrolled development of motorized delivery shown mainly in the intense rise of road traffic needs to be ended.

A well projected timetable can lead to lowering transportation charges, as well as heightening the quality of the provided transportation service, for the customers, as well as the providers. Also, the results of using routing algorithms show that there can be a conflict between defined quality of

transportation deadlines and what the provider of post service can really offer in the final phase of the technological transportation process.

This leads us to the fact that the vehicle routing problem is of great importance in the area of physical consignment distribution, but it cannot be viewed independent of the problems which occur especially before public post operators.

The problem can also be transmitted from basic transport operations to the transport operations in case of the main delivery post office having the similar role in consignment concentration.

References

1. Grgurovic, B. & Strbac, S. & Popovic, M. & Milovanovic-Brakovic, G. Setting up transport services in postal traffic. In: *Proceedings of International Conference "V International Scientific Conference Transport Problems"*. Katowice: Silesian University of Technology. Faculty of Transport. 2013. P. 144-149.
2. Todorovic, D. *Transport Networks, Algorithmic Approach.* Belgrade: University of Belgrade. 1996.
3. Kalic, M. *Transport Networks Practicum.* Belgrade: University of Belgrade. 2004.
4. Cvetkovic, D. & Cangalovic, M. & DugoSija, D. & Kovacevic-Vujcic, V. & Simic, S. & Vuleta, J. *Combinatorial Optimization.* Belgrade: DOPIS. 1996.
5. Grgurović, B. The Influence of Technology on Post Traffic. *FBIM Transactions*. 2013. Vol. 1. No. 1. P. 56-65.
6. Grgurovic, B. & Strbac, S. & Popovic, M. Using the Geographical Information System in Making New Sources of Income in the Area of Post Traffic. *XVIII Festival of informatics achievements INFOFEST*. Budva. 2011. P. 205-211.
7. Grgurović, B. & Marković, D. & Štrbac, S. The Use of Spatial Data for Segmentation of the Postal Service Market. *Technological and Economic Development of Economy*. 2011. Vol. 17(1). P. 87-100. DOI: 10.3846/13928619.2011.554016.