8th INTERNATIONAL CONFERENCE
''TOWARDS A HUMANE CITY''
New Mobility Challenges
Novi Sad 11th and 12th November 2021

Dragana Šarac, PhD[1]
E-mail: dsarac@uns.ac.rs
Bojan Jovanović, PhD[1]
E-mail: bojanjov@uns.ac.rs
Nataša Čačić, MSc[1]
E-mail: ncacic@uns.ac.rs

[1] Faculty of Technical Sciences, University of Novi Sad, Trg Dositeja Obradvića 6, Novi Sad, Serbia

SOLVING THE PROBLEM OF VEHICLE PARKING DURING POSTAL DELIVERY

Key Words
Postal delivery
Parking spots
Focal point zone

Abstract

An increase in the number of packages and express mails generated based on electronic trade, as well as user requests for the delivery of those mails, have additionally made the delivery vehicle parking problems more complex in urban areas. Some studies point to the fact that the delivery vehicle spends 15% to 74% of the total transportation time on parking [1]. In the paper, a proposal is made for solving the problem of the illegal parking of delivery vehicles using reserved parking spots and a methodology was proposed for determining the optimal location for delivery vehicle stopping and parking.

1. INTRODUCTION

The postal operators' delivery vehicle parking problem is one of the burning issues in today's cities. When speaking about postal operators, there is an increase in fuel consumption, paying illegal parking fees, an increased stress in the deliverer that may also result in a lower quality of the service rendered. On the other hand, social communities also suffer due to the mentioned problems, which reflects in the additional greenhouse gas emission and an irrational use of the existing infrastructure and available resources.

This paper is aimed at perceiving the number of delivery vehicle stops and reducing the number of stops based on the developed methodology, and also at increasing the probability of finding a free parking spot. By perceiving the problem, it is noticed

that there are significant optimization resources (the deliverer spends even more than one whole hour during the working time on moving a vehicle along the itinerary so as to evade parking recording and tolling systems). Pursuant to that, a methodology is developed after defining the issue and an example of the application of the methodology and finding out a solution is given for one delivery region on the territory of the City of Novi Sad. The leading idea is to provide the optimal number of reserved parking spots on public parking lots for postal delivery vehicles to park, because those vehicles participate in public traffic transportation.

2. PROBLEM DEFINING

With respect to postal mail deliveries, there is a special challenge connected with central city zones and high-level gravitational regions (focal points) as well. It can be said that there is ever more pronounced incompatibility between the increase in the number of cars and the needed parking areas. It can also be noticed that the competition among postal operators has become ever more pronounced, too, in urban areas, which leads to the even greater complexity of this issue.

The need for parking most frequently goes beyond available capacities with respect to the traffic infrastructure. According to some authors, the cause for that lies in free-of-charge parking, so that an adequate toll parking system can achieve a balance between parking demand and the offer [2]. Different parking management systems have been developed. Most frequently, that requires the use of different sensors as the integral parts of the available infrastructure. Some solutions propose installing a sensor on each parking spot, which is quite expensive [3]. On the other hand, a possible solution implies that citizens should be included in the identification of available parking spots [4, 5].

Parking management encompasses different policies and programs aimed at the more rational use of parking resources, in which manner significant economic and social results can be ensured and negative influences on the environment can be reduced. Problems related to parking in cities and urban areas are becoming ever more important and are one of the topics being paid the most attention to [6]. In the era of the Internet of Things and smart cities and smart parking, there is a necessity for appropriate innovative solutions towards the implementation of sustainable cities [7]. The elements considered with the aim of achieving an optimal solution to parking are vehicles, the available road infrastructure and users as well [8]. Contemporary technologies have ever increasingly been present in solving the parking problem [9, 10].

In order to reach a balance with respect to the needs for parking spots and their availability, there is the need for gaining control of parking demands and managing available parking spots. From the point of view of postal traffic, an optimal parking spot needs to be found so as to properly make a delivery in the observed area. Therefore, parking demands are, on the one hand, defined by postal service users (as postal mail destination places), and by postal operators on the other, defining delivery regions. From the point of view of deliverers, a limited parking space can be

said to be one of the key factors whose consequence reflects in the deliverer's longer mileage, which on its part reflects on the service quality, even financial penalties such as parking fines [11]. On the other hand, deficient parking spots for making a delivery has as consequences an irrational dissipation of resources, a negative influence on the environment, and the influence of stress on the deliverer as well if the deliverer is making a delivery in the case of illegal parking.

Search for a free parking spot and an optimal parking location is one of the basic problems in research studies dedicated to delivery vehicle parking. While looking for a parking spot, there is the unnecessary blocking of the traffic infrastructure by the vehicle, additional fuel consumption, a greater emission of greenhouse gases and an increase in the deliverer's nonproductive work, which is a consequence of passing the additional distance on foot in order to come to the ultimate destination. If there is no parking spot in the vicinity, the deliverer may illegally park the vehicle (double-park), which may significantly reflect on the amount of parking fees [12]. A lack of parking spots is especially present in rush hours along urban arteries [13]. Postal mail delivery is one of the main challenges postal operators are faced with, where failure to make it is one of the basic problems.

3. METHODOLOGY

As the first step in developing the methodology, available parking spots on the area of observation where a mail delivery is made need to be perceived. After that, the area which the deliverer can cover by occupying a certain parking spot needs to be defined. In that direction, the significant input variables are the deliverer's working time measured in norm-minutes for service performance, as well as the average number of the mails delivered by the deliverer during the day. With respect to the norm-minutes available to the deliverer, for example 400 norm minutes available to the deliverer for an eight-hour working time. This number of the norm minutes is obtained when the time the deliverer spends on preparing the workplace and daily rest during the day is subtracted from 480 minutes of such eight-hour working time.

Perceiving different postal operators, the conclusion is that on average the deliverer delivers mails at 60 destinations (stops) per day. Given the fact that 3.5 mails on average should be delivered at 60 stops within the available 400 norm minutes, the conclusion is that one stop requires the delivery time (the distance travelled and mail deliveries) of around 6 minutes. In Figure 1, the places where one delivery vehicle has stopped or is parked in the Center – Novi Sad City region. The number of the stoppings is either equal to or greater than the number of the stops. This is for the reason of avoiding paying for parking or illegal stopping. The implementation of the delivery process can be said to consist of the mileage (the distance travelled) and the mail delivery. The distance travelled contains driving the transportation vehicle to the car parking place and a walk from the vehicle to the mail delivery destination. The envisaged mail delivery time (according to the operator's statistical norms) is 2 minutes, so that that walk takes the deliverer up to 4 minutes. Taking into account the fact that the speed the deliverer moves at is 1.5 m/s in the open and inside a

building, he can deliver mails at the address (stop) 180 m away from the vehicle in 4 minutes (2 minutes to go to the address and 2 minutes to return to the vehicle).

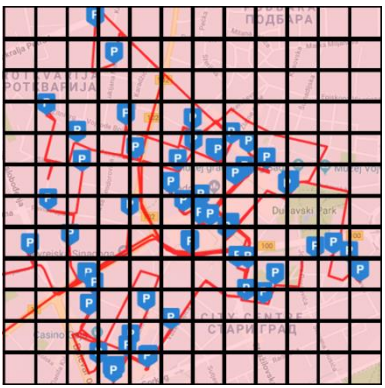

Figure 1. Vehicle parking in the delivery area Center Novi Sad–the use of over 100 parking spots

The input variables having been defined, the set covering location problem (SCLP) method for finding optimal parking spots will be applied while making a delivery. The applied method has the task to find the minimum number of the parking spots that the deliverer will use, thus including the maximum delivery points with a defined cover radius. Taking into consideration the potential parking spots and demands for mail delivery, an appropriate cover matrix is developed. The cover matrix$[p(i,j)]$ is obtained upon the following condition [14]:

$$p(i,j) = \begin{cases} 1 \; for \; d_{i,j} < d_{i,j}^{*} \\ 0 \; for \; other \end{cases} \tag{1}$$

where $p(i,j)$ is the element of the cover matrix $[p(i,j)]$, $d(i,j)$ is the given distance, and $d_{i,j}^{*}$ is the maximum acceptable distance. The aim is to reduce the number of the rows in the cover matrix to as few as possible in a way that each column of the reduced matrix contains at least one element equal to 1.

4. SOLUTION PROPOSAL

Depending on the requirements in terms of the gravitational areas and the allowed maximum distance of the service nodes from the demand nodes (180m), the parking spot locations and the total minimum number of parking spots as well are determined. The settlement areas are divided into the 180m-diagonal N zone squares, whereas the radius of the circumscribed circle encompasses the four square-shaped zones (Figure 2). The Euclidean distance formula is used. In Figure 2, the lattice structure is shown.

STEP 1. The lattice structure of the settlement is organized as follows–the vertical and horizontal lines are swiped through the focal point, which generates the most gatherings; then, the grid is “stretched” to left/right and up/down from the focal point (in Figure 2, the focal point is 18), so that it covers the entire settlement area. According to the previously defined pattern, the place with the most content is taken as the starting point if the focal point cannot be in the settlement. This is how the network G (N, A) is obtained, where N is the number of the nodes, A is the number of the square zones for which d=180m, covering the surface of the settlement. In the concrete case in the nodes 15, 16, 20, 21 and 25, there is no demand for the service, nor is there any possibility whatsoever to park a vehicle, because the deliverer would have to cross the communication with several lanes.

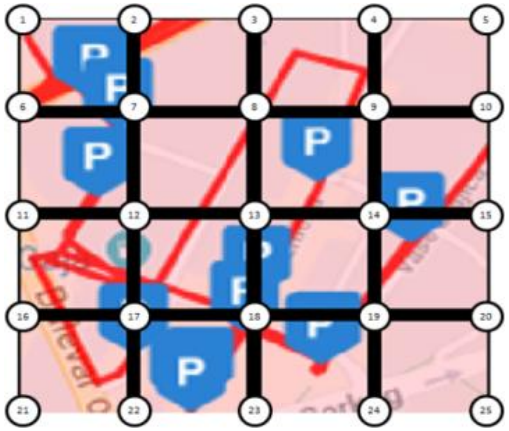

Figure 2. Part of the Center Novi Sad zone

STEP 2. The values “0” or “1” are assigned to the obtained square zones, depending on the urban attributes of the observed zones and the requirements for a coverage radius, i.e. the maximum acceptable distance between the parking spot and the point where demand is generated (stop delivery)(“0” for the maximum distance up to 180 m and “1” for the maximum distance up to 360m). the zones without housing buildings or those whose percentage of the already constructed housing buildings does not exceed 20% of the total area are not taken into consideration for setting up the demand and service nodes. The requirement to determine the gravitational area radius is based on the truth of the following statements: A: The shape of the settlement/zone is an axial shape; B: In the settlement/zone, there is a well-maintained infrastructure (bicycle and pedestrian paths); C: The construction in the settlement/zone is indented; D: The settlement/zone is predominantly single-family residential, and E: The settlement/zone has a high housing density. By establishing the logical structure between the pieces of evidence, more complex evidence is obtained. Based on this, the conclusion is made about the value of the gravitational radius of the zone. The truth value of this complex expression will indicate the need

to define the GP radius as a value 360m;otherwise, the value of the radius will be 180m.

STEP 3. The zones are compressed into the mega-zones of a 360m radius and a radius 180m <r <360m.

STEP 4. In each node in the network G` (N´, A´), anode is set which generates a service request. There are N´ nodes. When the nodes requiring a service level and the nodes candidates for the allocation of parking spots were defined, the task was further solved as alocational problem with requirements.

The application of the proposed methodology determined the position and number of the parking spots with a complete service level (Figure 3).

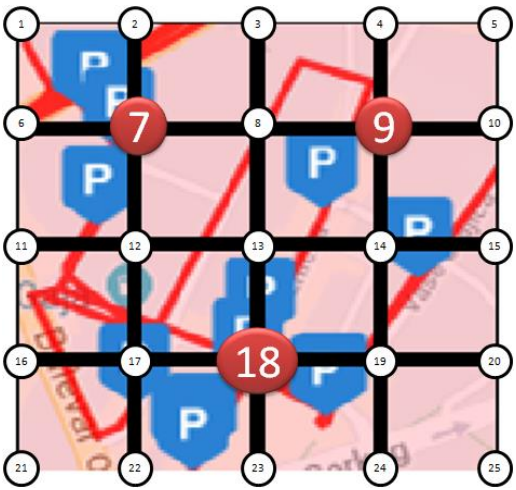

Figure 3. The permanent parking spot location

5. CONCLUSION

When considering the implementation of the proposed model for determining the minimum number of parking spots an example of the Novi Sad –Center settlement was subjected to consideration. Currently, there are seven parking spots for postal couriers to use them in the settlement. The application of the proposed methodology determined the position and number of the permanent parking spots (Figure 4). The example shows that the determination of the minimum number of the parking spots has not decreased the service quality level. On the contrary, this example is a demonstration of an increase in the postal service rendering level. Significant progress was made, given the fact that it was realized that only 3 out of 10 stoppings were needed in the places that would be reserved for postal operators, where the mentioned aggravating circumstances during the delivery of postal mails would be avoided in that way.

ACKNOWLEDGMENT

This work has been partially supported by the Ministry of Education and Science of the Republic of Serbia within the Project " Development and application of modern tools and research methods in the field of traffic and transport", University of Novi Sad, Faculty of Technical Sciences.

REFERENCES

[1] R.C. Hampshire and D. Shoup, What share of traffic is cruising for parking?. Journal of Transport Economics and Policy (JTEP), 52(3), 184-201,2018.

[2] D. C. Shoup, “The high cost of free parking,” Journal of Planning Education and Research, vol. 17, no. 1, pp. 3–20, 1997.

[3] W.J. Park, B.S. Kim, D.S. Kim and K.H. Lee, Parking space detection using ultrasonic sensor in parking assistance system. In: proc. of the IEEE Intelligent Vehicles Symposium, IEEE (2008) 1039-1044.

[4] J. Hildenbrand, Google releases open spot for android find and share parking (July 10 2010), 2010.

[5] L. Stenneth, O. Wolfson, B. Xu and P.S. Yu, Phone Park, Street parking using mobile phones. In: Proceedings of the 13th IEEE International Conference on Mobile Data Management (MDM '12), IEEE (2012) 278-279.

[6] I.Hossam El-Din, Car Parking Problem in Urban Areas, Causes and Solutions (November 25, 2017). 1st International Conference on Towards a Better Quality of Life, 2017.

[7] Al-Turjman and A. Malekloo, Smart parking in IoT-enabled cities: A survey. Sustainable Cities and Society, 49, 101608, 2019.

[8] M. Gohar, M. Muzammal and A. U. Rahman, SMART TSS: Defining transportation system behavior using big data analytics in smart cities. Sustainable cities and society, 41, 114-119, 2018.

[9] M. Abujubbeh, F. Al-Turjman and M. Fahrioglu, Software-defined wireless sensor networks in smart grids: An overview. Sustainable Cities and Society, 51, 101754, 2019.

[10] T. Lin, H. Rivano and F. Le Mouël, A survey of smart parking solutions. IEEE Transactions on Intelligent Transportation Systems, 18(12), 3229-3253., 2017.

[11] J. Allen, M. Piecyk and M. Piotrowska, An Analysis of Online Shopping and Home Delivery in the UK, 2017.

[12] M. Figliozzi and C. Tipagornwong, Impact of last mile parking availability on commercial vehicle costs and operations. In Supply Chain Forum: An International Journal (Vol. 18, No. 2, pp. 60-68). Taylor & Francis, 2017.

[13] A. Wenneman, K. Habib and M. Roorda, “Disaggregate Analysis of Relationships between Commercial Vehicle Parking Citations, Parking

Supply, and Parking Demand.”Transportation Research Record: Journal of the Transportation Research Board 2478: 28–34, 2015.

[14] D. Šarac, M. Kopić, K. Mostarac, M. Kujačić and B. Jovanović, Application of set covering location problem for organizing the public postal network. PROMET-Traffic & Transportation, 28(4), 403-413., 2016.