Mobile alternative delivery points

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Abstract

The rapid development of e-commerce directly affects the growth of delivery demands for goods and documents. As per our research, customers prefer home delivery. Research in the U.K. reported that the rate of failed first deliveries of home delivery was 12%. This result is caused by the fact that half of homes are empty from 9 a.m. to 4 p.m. on weekdays largely due to changes in the lifestyle. Redelivery is an important source of delivery costs. Additional trips also cause more environmental pollution. Developing alternative delivery points, to enable customers to participate in last-mile delivery is a promising solution. The most popular solution for alternative delivery points is fixed parcel locker, which supports unattended delivery. Fixed parcel lockers, however, have some inherent limitations. First, their location and configuration are fixed in place, which brings poor accessibility and ability to respond to change of demands. Moreover, the fixed parcel lockers have high requirements for information and communication technology (ICT) and can't be set up in old residential areas. In addition, high construction costs are required. This paper proposes an alternative delivery model. The model implies the use of existing resources. The aim is to minimize the operating cost for the home delivery and to offer customers more mobile alternative delivery points near their homes.

Keywords*: optimization, model, delivery points, postal network*

1 Introduction

The market of postal services is a place where offering and demand for services meet. This market requires constant monitoring of customers, their needs, and the degree of satisfaction with the services provided to them. The rapid development of e-commerce directly affects the growth of demand for the delivery of goods and documents. Postal operators create their services based on market needs. Postal service providers are modernizing their ways of doing business as a result of new development trends. They create location tracking systems, and GPS systems, where each vehicle is equipped with a GPS receiver to allow the vehicle to be positioned at any time. In this way, postal operator base stations can receive current information both on the location of the delivery vehicle and the current location of the postal items being transported in the vehicle. The application of software tools in modern business has great importance.

A plan, on how the routing of postal items should work in the postal system was presented in the paper [1]. In the papers [2]-[3]-[4] the need for monitoring and control of shipments during transport was emphasized, where the role and possibility of RFID and GPS technology in the organization and rationalization of the transport of postal shipments were shown. The paper [5], also talk about the importance of applying new forms of delivery and tracking postal items. Research on the mutual coexistence of active and passive RFID technology in the field of postal and logistics network optimization and transport processes was analyzed in the work [6]. The paper [7] discussed the application of ICT technology in courier services. The authors gave the algorithm of dynamic routing which is of the heuristic kind and is based on principles different from those already used, for solving transportation problems. The paper [8] also talks about the importance of tracking postal items.

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Tracking of postal items is a process that enables customers to receive timely information about the status of their item, from the moment when an item enters the system i.e. where the item is currently in the technological process phase. With this paper, an alternative delivery model was proposed. When the postal item is in the delivery vehicle, the customer can check where the item is currently located in the delivery area Algorithm 1. With this method of information, the customer has an insight into when exactly he can expect his item at the address or pick it up personally in the area from the deliverer. Having information about where the postal item is at any given moment improves the quality of the service and fulfills the company's strategic goals and customer satisfaction.

Postal operators in the world, to reduce costs and meet the needs of customers, have included parcel lockers as a modern way of the service point. A large number of scientific works deal with the analysis of the efficiency and functionality of the parcel locker. According to the analysis of the efficiency and usability of parcel lockers in the example of the Polish InPost company [9], it was established that it is the right choice for shaping future delivery systems in cities. The paper [10] investigates the impact of parcel lockers concerning traveled distances as well as CO_2 emissions. The choice of parcel locker location is also very important. Correct positioning of the parcel lockers means being able to reach a greater number of potential customers and make the delivery service competitive regarding home delivery [11]. The authors of the paper [12] bilevel programming (BLP) model is established to identify the optimal location for parcel lockers by considering the benefits to consumers and logistics planning departments. Bearing in mind that last-mile delivery is associated with a negative impact on the environment and high costs, in the paper [13] the design of a stationary parcel locker (SPL) was considered. The authors of the paper [14] dealt with the comparison of traditional delivery and delivery through parcel lockers. The authors developed a quantitative activity-based model for estimating kgCO2e and the operational costs. A comparison of the effects of classic delivery and delivery via parcel locker in urban and rural areas was also analyzed in the paper [15]. It was concluded that, based on the observed parameters, parcel lockers are a better solution in both urban and rural areas. In the working paper [16] a new concept for last-mile distribution was developed. The new concept describes mobile parcel lockers that can change their location during the day, whether autonomously or moved by a driver. The results show that mobile lockers are a better solution than stationary lockers. The work that also deals with the optimization of the mobile parcel locker location is presented in [17] and aims to develop an optimization model to locate movable parcel locker units and determine the number of units under stochastic demands. In the cities of Polan, research was carried out on the usability of the parcel lockers from the customer's perspective [18]. It has been established that the popularity of parcel lockers will continue to grow in the future.

This paper proposes an alternative delivery model. The model implies the use of existing resources. The aim is to minimize the operating cost for home delivery and to offer customers more mobile alternative delivery points near their homes. Also, in support of the analysis of mobile alternative delivery points a survey was conducted among customers of postal services in the form of a questionnaire. The analysis of the obtained results indicates that the new alternative delivery model would be a good solution that would meet the needs of customers.

2 Research results

2.1 Respondents` answers to the survey questionnaire

For this paper, a survey questionnaire of the postal services market was conducted. As part of the survey questionnaire, customers were asked questions of interest to observe customers' attitudes related to the methods of delivery of postal items. The analysis included 409 respondents in the territory of the Republic of Serbia. The results are presented in Fig. 1-3.

Processing the questionnaire leads to the conclusion that for the largest number of customers, as many as 331 are the first choice of delivering parcels to their home address, while 9 customers opted for delivery via parcel lockers (Fig. 1). This situation indicates that the majority of customers still prefer to have their package delivered to their home address.

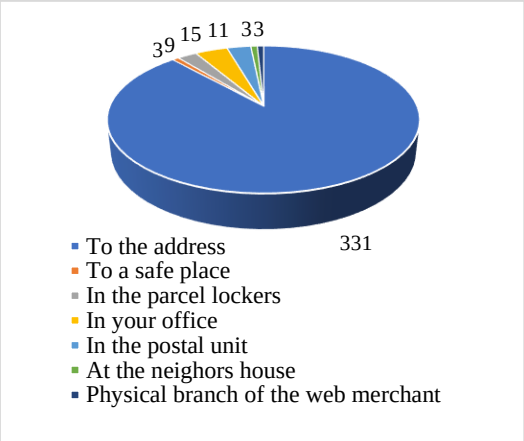


Fig. 1. What is your first choice of postal item delivery?

As for the frequency of using parcel lockers, 259 customers never use them, while only 3 surveyed customers always use them (Fig. 2).

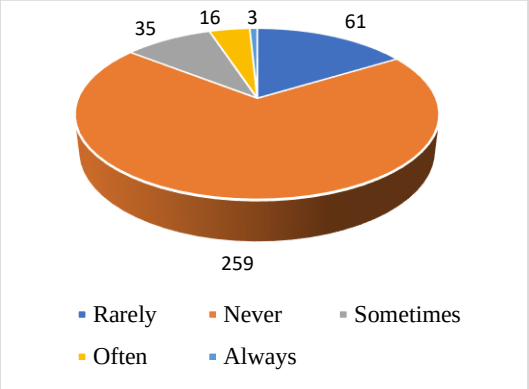


Fig. 2. How often do you use parcel lockers as a delivery service?

As a reason for non-using parcel lockers, 134 customers state that they do not exist in their place of residence, while 36 surveyed customers are dissatisfied with the location of existing parcel lockers (Fig. 3).

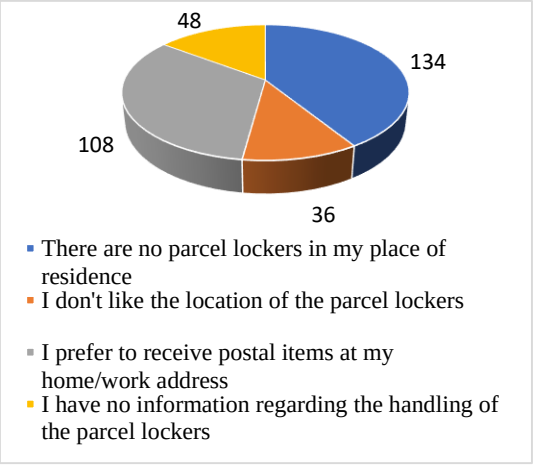


Fig. 3. If you have not used a parcel locker before, state the reason

These results indicate that in the process of making decisions about the location of parcel lockers, a larger number of factors should be included for analysis. Also the needs of customers and the possibilities of other alternative delivery solutions should be explored in more detail.

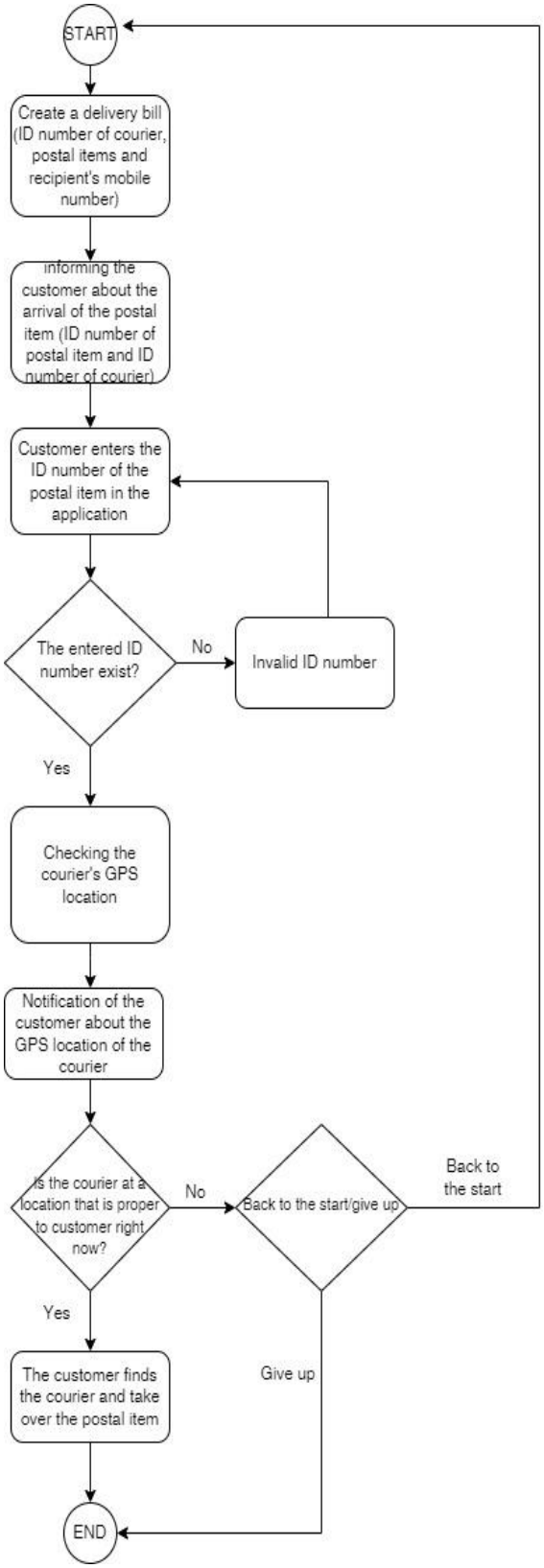
2.2 Algorithm for mobile alternative delivery points

Existing alternative delivery models in the form of mobile and stationary parcel lockers have their advantages and disadvantages. This paper presents a new mobile alternative delivery points model. The model implies the use of available resources, does not require additional financial investments, and minimizes the existing costs of home delivery.

The model for mobile alternative delivery points is shown by Algorithm 1. This algorithm describes in detail the procedure from the creation of a delivery bill by the postal operator to take over the postal items by the customer at the delivery area of the courier. With this mode of operation, customers can check the current location of their postal items in the region at any time through the created application. If the customer believes that he will not be at his home during the scheduled delivery time, he can personally go to the courier located in the area and take over the postal item. This model brings benefits to both customers and postal operators.

Research in the U.K. reported that the rate of failed first deliveries of home delivery was 12%. This result is caused by the fact that half of the homes are empty from 9 a.m. to 4 p.m. [19]. Most customers in the period from 9 a.m. to 4 p.m. are at their workplaces and are unable to receive their postal items. The result of absence of the customers at the residential address leads to the return of the postal item and a retry of delivery the next day. For postal operators, this situation creates additional costs (fuel consumption, depreciation, etc.) as well as unproductive time due to failed deliveries. With the proposed model for mobile alternative delivery points, by entering the postal item number in the application, customers could have insight into where the courier is currently located, when he will arrive at their address, or if they cannot wait for the courier, they can personally go to him and take over their postal item.

Algorithm 1. Algorithm for mobile alternative delivery point model



3 Analysis of the observed area of the city of Novi Sad

About 15 postal operators provide postal services in the area of the city of Novi Sad. Among them, only three operators: Public Enterprise Post of Serbia, Ananas e-commerce, and YU-PD Express, have their stationary parcel lockers installed in several locations on the territory of Novi Sad.

In the area of the city of Novi Sad, the delivery area of the settlement Grbavica, Limani (1-4) was observed. Currently, in the Republic of Serbia, one postal operator can only use his parcel lockers. There is no collaboration between operators in terms of sharing lockers. The analysis was performed based on data obtained from one private postal operator. Based on the data, it was determined that the observed operator has 51 stop points in the delivery area. According to the data on stop points, demand nodes were determined. Demands nodes and parcel lockers of observed operators were also viewed as potential nodes of service provision. Fig. 4 shows the location of the observed operators' parcel lockers and the places where the postal operator stops to provide service to customers. The red line represents the boundaries of the area within which the courier moves in the observed delivery area.

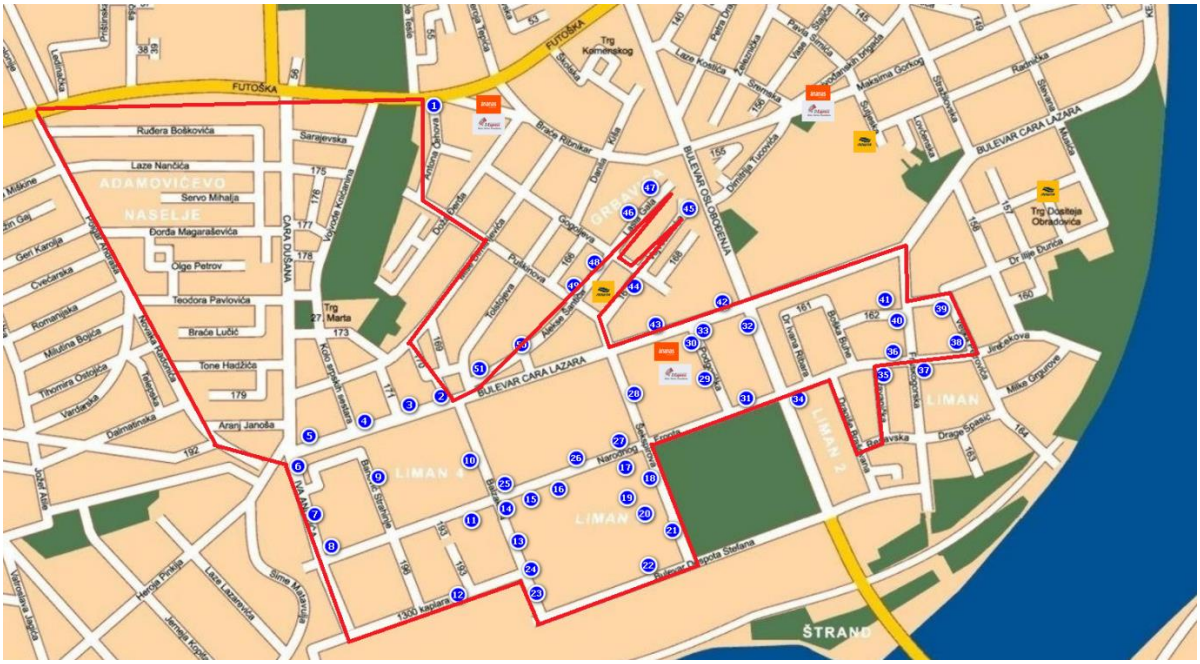


Fig. 4. Map of the observed delivery area

The numerical calculation of the distance was realized in the Matlab programming language. The obtained matrix '**A**' of dimensions 51x51, represents the determined distances (expressed in meters) between the service demand nodes and mobile alternative delivery points. Matrix '**B**' of dimensions 51x9, represents the determined distances (expressed in meters) between the service demand nodes and the parcel lockers.

$$A = \begin{bmatrix} 0 & 775 & 880 & 900 & 1000 & \dots \\ 775 & 0 & 134 & 250 & 260 & \dots \\ 880 & 110 & 0 & 130 & 296 & \dots \\ 900 & 210 & 130 & 0 & 150 & \dots \\ 1000 & 260 & 296 & 150 & 0 & \dots \\ \vdots & \vdots & \vdots & \vdots & \vdots & \ddots \end{bmatrix}$$

$$B = \begin{bmatrix} 150 & 150 & 1000 & 1000 & 1200 & 2100 & 1200 & 1200 & 1000 \\ 830 & 830 & 1250 & 1250 & 1380 & 1600 & 690 & 690 & 607 \\ 897 & 897 & 1400 & 1400 & 1550 & 1800 & 800 & 800 & 750 \\ 970 & 970 & 1580 & 1580 & 1620 & 1920 & 950 & 950 & 820 \\ 1150 & 1150 & 1700 & 1700 & 1800 & 2100 & 1100 & 1100 & 950 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \end{bmatrix}$$

The measured distances of 51 service demand nodes to mobile alternative delivery points and to stationary parcel lockers are given in Table 1-2. According to the calculations, the average distance of all service demand nodes to potential mobile alternative delivery points is **714.8m**, while the average distance of all demand nodes to stationary parcel lockers is **1070m.** It can be concluded that, on average, customers would cross **355m** less if they take over postal items using mobile alternative delivery points.

Table 1. Average distance of each demand nodes to mobile alternative delivery points

Nodes	Distance	Nodes	Distance
1	**1225**	27	**515,3**
2	**639**	28	**542,6**
3	**725**	29	**551,43**
4	**788,8**	30	**578,2**
5	**908**	31	**592**
6	**960**	32	**624**
7	**951,5**	33	**558**
8	**1001**	34	**695,9**
9	**877,13**	35	**808,5**
10	**721,3**	36	**876,8**
11	**529,5**	37	**963,5**
12	**894**	38	**963**
13	**686,8**	39	**1054**
14	**784**	40	**895**
15	**621,5**	41	**901,8**
16	**497,7**	42	**619**
17	**541,9**	43	**529,13**
18	**581,8**	44	**612**
19	**614**	45	**738**
20	**598**	46	**703**
21	**710**	47	**824**
22	**702**	48	**627**
23	**692**	49	**566**
24	**650**	50	**494,2**
25	**598**	51	**489,6**
26	**529**		

Table 2. Average distance of each demand nodes to the stationary parcel lockers

Nodes	Distance	Nodes	Distance
1	**1000**	27	**960**
2	**1014**	28	**821**
3	**1143**	29	**722**
4	**1262**	30	**661**
5	**1416**	31	**768**
6	**1511**	32	**650**
7	**1602**	33	**645**
8	**1728**	34	**917**
9	**1522**	35	**915**
10	**1335**	36	**913**
11	**1540**	37	**969**
12	**1800**	38	**1016**
13	**1688**	39	**914**
14	**1500**	40	**860**
15	**1400**	41	**859**
16	**1375**	42	**594**
17	**1244**	43	**620**
18	**1208**	44	**578**
19	**1300**	45	**537,7**
20	**1327**	46	**542**
21	**1424**	47	**499**
22	**1600**	48	**595**
23	**1405**	49	**641**
24	**1318**	50	**750**
25	**1080**	51	**864**
26	**1015**		

Based on the available data of the postal operator, it was determined that the postal operator delivered **3,497** packages in the delivery area in one month. From that number of packages, daily, at least 10% of packages are not delivered to customers (about 367 packages per month). Taking into account this fact, potential savings in kilometers traveled by customers can be determined if they use a mobile alternative delivery point to take over postal items instead of parcel lockers. The calculation of savings in kilometers driven by customers was performed only for packages that were not delivered to customers within the estimated frame time monthly. They represent potential customers of parcel lockers and mobile alternative delivery points.

367 x 1070m =**392.690m**

367 x 714,8m=**262.331m**

By comparing the obtained results, it can be concluded that customers, on average, monthly, if they use a mobile alternative delivery point to take over postal items, travel **130km** less than if they take over the postal items via the nearest parcel lockers. Seen on an annual basis, it is **1560 km** less.

4 Conclusion

This paper proposes a new alternative delivery model that does not create additional costs for postal operators but implies the use of existing resources. The advantages of applying the proposed delivery model are numerous for both customers and postal operators. Some of the advantages of mobile alternative delivery points for postal operators are:

- Existing infrastructure and equipment (resources) are used
- There are no additional investment costs
- More productive work of couriers in the delivery area
- Saving time
- It is not necessary to rent a space as with parcel lockers
- There are no charging costs as with parcel lockers
- Less CO_2 emission

The benefits for customers are:

- Better information about the delivery time
- Personal take over postal items from the courier at the delivery area
- Saving time
- Less travel to the courier than to the parcel locker
- Saves on fuel consumption

The proposed model represents a universal approach that can be further applied to other delivery areas. Future research should be focused on the time and financial aspects of this model. An analysis of customer satisfaction with the proposed model is also suggested.

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