Bojan Jovanović[1]
E-mail: bojanjov@uns.ac.rs
Dragana Šarac[1]
E-mail: dsarac@uns.ac.rs
Nataša Čačić[1]
E-mail: ncacic@uns.ac.rs
Estera Rakić[2]
E-mail: estera_rakic@hotmail.com
[1] Faculty of Technical Sciences, University of Novi Sad
Trg Dositeja Obradovića 6, 21102 Novi Sad, Serbia
[2] Faculty of Transport, Communications and Logistics Budva, Adriatic University
Žrtavafašizma 56, 85310 Budva, Montenegro

URBAN LAST-MILE DELIVERY SOLUTIONS

Keywords
Urban area
E-commerce
Last-mile delivery

Abstract
Trend in population growth at urban areas, and also intensive development e-commerce present a significant challenge for last mile delivery systems. Requirements placed on development last mile delivery systems are more complex, both from the customers' point of view and as well as racional exploitation available resources and reduce destructive impact on environment. E-commerce is defined by a large number of small individual packages, which besides increase complexity of situation in urban areas from the last mile delivery, also lead to significant increase costs. According that, solutions in last mile delivery domain must be efficient in terms of speed, price, service and quality. The aim of the paper is to enable solutions review in last mile delivery domain, as well as to compare their advantages and disadvantages in function of sustainable urban development.

1. INTRODUCTION

The urbanization process is progressing rapidly. More than half of the world's population lives in urban areas, and the forecast is that the urban population will reach 6 billion by 2045 [1]. Current trends lead to a situation where urban areas

demand more and more quantities of goods and services. In the urbanization process, it comes an increasing number of inhabitants move away from necessary resources, so expectations of last-mile delivery are to solve it. Those systems need to find efficient ways for the proper functioning of urban areas. The consequence of that is greater pressure on the urban infrastructure, so it is necessary to find innovative approaches that enable sustainable and effective exploitation. Also, the goal that is set for participants in urban life is to achieve sustainable development.

2. LAST-MILE DELIVERY

Digitalization is the dominant cause of changes in all spheres of human activity. Digital technology development crucially reshapes relations in the e-commerce field. Electronic commerce, or e-commerce, is defined as the production, distribution, marketing, sale, or delivery of goods and services by electronic means [2]. With technological development, the e-commerce environment becomes more dynamic. Under the influence of digitalization in the retail domain, customers are buying more and more products online. During 2022, 91% of the EU population aged from 16 to 74 used the internet, and of them, 75% had e-commerce experience [3].

Last-mile delivery is the final phase in the e-commerce value chain. It can be said that last-mile delivery includes all activity from the final sorting center to end-customer delivery. Last-mile delivery is observed as one of the most expensive, inefficient, and most polluted parts of the supply chain [4].

E-commerce growth generates an increasing number of parcels, so last-mile delivery operators (postal or logistics) face significant challenges. Last-mile delivery problems are caused, first of all, by customer expectations according to delivery, and secondly, there is urban infrastructure with limited capacity to support increasing parcel flows.

The B2C segment has the fastest development. An essential characteristic of the B2C segment is the many small deliveries. To develop a successful business model, value chain members need to be effective and must reduce costs.

The initial conditions of last-mile delivery are set up by an e-retailer that defines services, and it is transferred to other value chain members by defining conditions for efficiency and cost optimization. Providing different delivery options to customers becomes an important factor in the selection process of e-retailer. In that way, customers expect a range of delivery options, so they can choose what they need. Thus, last-mile delivery solutions belong to critical factors.

Different strategies in the field of last-mile delivery must take into account certain elements specific to the observed urban area [5]: demand characteristics, customer preferences, and environmental regulations. Better approaches to resource management and innovations present basic elements for last-mile delivery optimization.

3. DEVELOPED SOLUTIONS

Execution of delivery is key to customer satisfactionwith e-commerce. The vast majority of deliveries from e-commerce are directed to urban areas. Considering the intensive growth of e-commerce, it has negative impact on last-mile delivery activities. Urban areas make demands on delivery systems in terms of higher speed, higher reliability and lower negative impact on safety and the environment. Space in cities is limited, and attempts to increase transport infrastructure cannot follow the demands generated by the last-mile. Customer decision to cooperate with e-retailer is defined according to the spectrum of services offered by e-commerce [6].

Ordering products in small quantities, urbanization and the evolution of customer behaviour, make restrictions on the investments in developing concepts of last-mile delivery. Technological development and innovations strive to improve current solutions, as well as to develop new ones. Last-mile delivery in the B2C segment is based on: service promise, cost optimization and sustainable impact on the environment. Thus, the quality of developed solutions is necessary to evaluate through the prism of these dimensions.

E-customers, when making decisions about buying, give an important place to attributes of particular delivery options such as delivery cost, delivery speed and delivery place. E-commerce development leads to situation where delivery options are adjusted to end customers. Mutual connections as well as information sharing between customers, trace the path to a wider range and adaptable delivery options.

Various solutions for last-mile delivery can be observed by the level of interaction between the delivery operator and the end customer. Widely adopted and promising solutions are: attended home delivery, attended collection-and-delivery points, parcel lockers, mobile parcel lockers, crowd-shipping services, drones and autonomous delivery vehicles.

3.1. Attended home delivery

Attended home delivery is the dominant solution for last-mile delivery. This solution demands the customer's presence at home, and the customer confirms the delivery. Failed delivery occurs in cases when a customer is absent. The delivery failure rate can reach up to 25% [7]. Last-mile delivery activities in attended home delivery are under the influence of different factors[8]:increasing demands for services, sustainability questions (increasing number of delivery vehicles), attended home delivery being the most expensive option, time pressure generated by e-retailer (delivery same or next day) and labor shortage.

Traditional home delivery is very expensive. Factors that contribute to high costs, in this case are: failed delivery – the recipient is not available, traffic jams, parking problems and negative influence on the environment. Operators tend to optimize delivery routesin function of reducing delivery stops and increasing the number of deliveries per stop.

Considering that source of customer satisfaction is in customer-employee contact during the service [9], delivery man skills (like competency, training and courtesy) have a crucial impact on customer perception of the entire e-commerce process. In particular, customers appreciate it when the delivery man is flexible if they have special requests. Beside that, the situation of failed delivery causes additional costs, which is also a potential source of customer dissatisfaction.

The absence of adequate parking space can lead to delivery vehicles spending one hour a day cruising for parking [10]. Also, parking problems lead to many parcel operators having a significant financial allocation for fines as a result of illegal parking.

Implementing alternative solutions, that do not demand customer attendance at home, can achieve cost reductions of up to 70% [11].Even though attended home delivery is the most time-consuming and expensive solution for last-mile delivery from any point of view, it is still the dominant option for customers. Customers recognize this option as one of the main e-commerce advantages. In an aim to improve this delivery solution, efforts are to achieve intensive implementation of electric vehicles.

3.2. Attended collection-and-delivery points

Solving last-mile delivery in this way is based on the utilization of different locations (post offices, local shops, gas stations, parcel shops or other locations) the customers select as an alternative delivery address. Atattended collection-and-delivery points, we have personnel that havecontact with end customers. Compared to traditional delivery, operators avoid failed deliveries and route optimizations, but on the other hand, active participation is expected from customers.

3.3. Parcel lockers

In contrast to previous solutions, parcel lockers present an approach there are no human interactions. Parcel lockers are available 24/7. Compared to traditional delivery, parcel lockers bring certain advantages [12]:decrease inefficiency caused by failed deliveries, consolidate parcels at a certain location (that leads to better utilization of delivery vehicles), reduce the number of delivery trips, avoid customers waiting, reduce traffic congestionand reduce negative impacts on the environment.

In the conceptdevelopment of parcel lockers, it is most important to determine their adequate location. Optimal parcel locker location is defined by [13]: customers' income, fixed installation costs, operating costs, and potential loss of customers if the location is outside of their acceptable distance.

There is a strong investment trend in the development of parcel locker networks by postal operators. Some examples are Deutsche Post DHL and InPost. Deutsche Post DHL started with this concept in 2003. The tempo of development was 7,000 parcel lockers by 2021 and 11,500 parcel lockers by 2022, with a plan to achieve 15,000 parcel lockers in Germany during 2023[14].InPost had 16,445 parcel lockers

in Poland by 2021, and that number increased to 19,306 by 2022[15].The estimated market value of parcel lockers in 2021 was 722.1 billion USD, and the forecast is 1883.9 USD by 2029 [16].

One variation of this approach is mobile parcel lockers. Mobile parcel lockers can change their location during the day. They can be managed by humans or they can be autonomous. This solution improves accessibility for customers who are not tied to one place [17]. The tasks, in this case are: route optimization and waiting time estimation at proper locations.

3.4. Crowd-shipping services

The basic idea for crowd-shipping services is that the parcelis delivered from a person who needs to travel, so the delivery process does not cause new kilometers [18]. In this case, the delivery process is realized by privately owned vehicles. The development of crowdsourced services is based on digital technologies, which is necessary to ensure a digital platform for communication between participants. Apart from bringing benefits, crowd-shipping opens the questions of parcel safety and data privacy concerns.

3.5. Drones

Drones are a very popular option for resolving problems in last-mile delivery. In comparison to attended home delivery, drone delivery has advantages in: speed, costs and environmental impacts. This approach is not limited to traffic conditions and existing urban infrastructure. Drones' ability to take off and land vertically, give them a chance to operate in various environments. In terms of using drones, their energy demands define their performances (flight distance, costs etc.) [19].One parcel per delivery is also a significant limitation.

Taking all into account, drones are a promising solution in urban areas, because they move activities from the ground to the air.

3.6. Autonomous delivery vehicles

Autonomous delivery vehicles are driverless electric vehicles, equipped with sensors, cameras and navigation system [20].Considering urban conditions, autonomous delivery vehicles optimize their delivery routes. The elementary advantage of autonomous delivery vehicles is reflected in their profitability when we have labor shortages and wage growth[21].

The intensive development of artificial intelligence and sensor technologies creates an area for much more application of this approach. In that way, the last-mile delivery achieves cost reduction, energy savings, smaller negative environmental impact, reduction in traffic congestions and improvement of traffic safety. A major barrier to this approach is the adaptability of urban infrastructure for vehicle movement.

4. CONCLUSION

The increased demand for last-mile delivery services brings additional problems for inhabitants, parcel operators and urban planners. Optimization and innovations are the basis for solving problems in urban last-mile delivery. Anyway, it is necessary to include the limitations that the concept of sustainable development defines.

The success of individual solutions in last-mile delivery is caused by the level of customer acceptance. Thus, the impact on creating a proper customer experience by using different options becomes essential for a successful business.

ACKNOWLEDGMENT

This reserch has been supported by the project "Development and application of modern methods and technologies in education and research in traffic and transportation".

REFERENCES

[1] World Bank (2023) https://www.worldbank.org/en/topic/urbandevelopment/overview

[2] World Trade Organization(2017), Electronic commerce https://www.wto.org/english/thewto_e/minist_e/mc11_e/briefing_notes_e/bfecom_e.htm)

[3] eurostat (2023)E-commerce continues to grow in the EU https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20230228-2

[4] Gevaers, R., Vanelslander, T. & Van de Voorde, E. (2011), “Characteristics and typology of last-mile logistics from an innovation perspective in an urban context, city distribution and urban freight transport: multiple perspectives”, City Distribution and Urban Freight Transport: Multiple Perspectives, Edward Elgar Publishing, pp. 56-71, doi: 10.4337/9780857932754.00009.

[5] Janjevic, M., &Winkenbach, M. (2020). Characterizing urban last-mile distribution strategies in mature and emerging e-commerce markets. *Transportation Research Part A: Policy and Practice*, *133*, 164-196.

[6] Ma, B., Teo, C. C., & Wong, Y. D. (2022). Consumers’ preference for urban last-mile delivery: effects of value perception and long-term COVID-initiated contextual shifts. *International Journal of Logistics Research and Applications*, 1-22.

[7] Seghezzi, A., &Mangiaracina, R. (2023). Smart home devices and B2C e-commerce: a way to reduce failed deliveries. *Industrial Management & Data Systems*, *123*(5), 1624-1645.

[8] Boysen, N., Fedtke, S., &Schwerdfeger, S. (2021). Last-mile delivery concepts: a survey from an operational research perspective. *Or Spectrum*, *43*, 1-58.

[9] Mentzer, J. T., Flint, D. J., &Hult, G. T. M. (2001). Logistics service quality as a segment-customized process. *Journal of marketing*, *65*(4), 82-104.
[10] Dalla Chiara, G., & Goodchild, A. (2020). Do commercial vehicles cruise for parking? Empirical evidence from Seattle. *Transport Policy*, *97*, 26-36.
[11] Song, L., Mao, B., Wu, Z., & Wang, J. (2019). Investigation of home delivery models and logistics services in China. *Transportation Research Record*, *2673*(9), 11-22.
[12] Yuen, K. F., Wang, X., Ma, F., & Wong, Y. D. (2019). The determinants of customers' intention to use smart lockers for last-mile deliveries. *Journal of Retailing and Consumer Services*, *49*, 316-326.
[13] Deutsch, Y., &Golany, B. (2018). A parcel locker network as a solution to the logistics last mile problem. *International Journal of Production Research*, *56*(1-2), 251-261.
[14] Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen, (2023), Parcel market report 2022, Bonn, Germany
[15] InPost, https://inpost.eu/investors/financial-results
[16] Australian Government, Department of Infrastructure, Transport, Regional Development, Communications and the Arts, 2023, Postal Service Modernisation, Discussion Paper
[17] Schwerdfeger, S., & Boysen, N. (2020). Optimizing the changing locations of mobile parcel lockers in last-mile distribution. *European Journal of Operational Research*, *285*(3), 1077-1094.
[18] Tapia, R. J., Kourounioti, I., Thoen, S., de Bok, M., &Tavasszy, L. (2023). A disaggregate model of passenger-freight matching in crowdshipping services. *Transportation Research Part A: Policy and Practice*, *169*, 103587.
[19] Zhang, J., Campbell, J. F., Sweeney II, D. C., &Hupman, A. C. (2021). Energy consumption models for delivery drones: A comparison and assessment. *Transportation Research Part D: Transport and Environment*, *90*, 102668.
[20] Marsden, N., Bernecker, T., Zöllner, R., Sußmann, N., &Kapser, S. (2018). BUGA: log–A real-world laboratory approach to designing an automated transport system for goods in Urban Areas. In *2018 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC)* (pp. 1-9). IEEE.
[21] Ulmer, M. W., &Streng, S. (2019). Same-day delivery with pickup stations and autonomous vehicles. *Computers & Operations Research*, *108*, 1-19.