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LOGISTICS AND LAST-MILE DELIVERY IN SMART CITIES

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Abstract: *Due to the constant growth of large cities and the rapid development of digital technologies, in recent years, many authors have discussed the concepts of Smart City, Logistics 4.0, digital supply chain management, blockchain, and the like, but what is meant by this has not yet been standardized. It is necessary to define which technologies fall under these general terms, how their development will proceed, and which management technics should emphasize their development. These are the main issues that need to be defined. Cyber-physical systems, networking, digitalization, internet communications, and cloud computing are in use to support the functioning of "Smart logistics." Via the Internet, cyber-physical systems communicate and collaborate in real-time, offer services and products, and provide the expected data and information for supply chain participants. Blockchain technology can support that sharing. Digital technologies of the Internet of Things and the subcategory Industrial Internet of Things, together with the Internet of Service, Big data and Data mining, and cyber-physical systems, are key elements of the logistics 4.0 concept and represent the common language of the future. This article pays special attention to the so-called "Last-mile delivery" because it is the last link in the supply chain, and, usually, in total costs, it accounts for more than 50% of the shipping costs. We expect the complete digitalization of logistics processes and the application of digital technologies soon.*

INTRODUCTION

The world we live in is changing extremely fast in its development. Projections show that by 2050, more than 60% of the world's population will live in cities [1]. People from rural areas, even smaller towns, migrate en masse to big cities. The bigger the city, the greater the influx of new residents, so one can say that big cities behave like black holes in the cosmos. They suck up everything around them and get bigger and bigger. This trend significantly affects the way of life. Every person's daily life relates to the intensive use of various services and resources. The bigger the city, the more problems related to its functioning require the implementation of the Smart City concept.

The increase in population in cities brings many problems in their management. It is anticipated that in 2050, cities will consume more than 70 percent of energy and emit the same amount of greenhouse gases. [2, p. VIII] With the increase in the influx of population,

all current problems of city management become more pronounced. Smart cities must be comfortable, economical, sustainable, and environmentally friendly. That implies the mass application of information technology in the infrastructure and services offered to the population improvement. All this must be in harmony with the environment. Information technologies for intelligent management and sustainable development goals achievements will aim at managing transportation, supply, and logistics in general, and at managing water supply, waste, and services of all kinds. In addition, smart-city management, combined with new technologies, must create new conditions for business and open new opportunities for living and work for the residents of these cities.

Here we will pay special attention to logistics in the smart cities and especially to the final part, called last-mile delivery. This term does not literally mean the last mile but the last link in the supply chain. It is even more significant when we know that last-mile delivery participates to the total price of transport costs by more than 50%.

SMART CITIES

The world's urban population increased rapidly from 751 million in 1950 to 4.2 billion in 2018. [3] Despite its relatively low level of urbanization, Asia is home to 54% of the world's urban population, followed by Europe and Africa with 13% each. Today, 55% of the world's population lives in urban areas. To predictions, this share will increase to 68% by 2050. Projections show that urbanization, the gradual shift in human habitation from rural to urban areas, combined with overall growth in the world's population, could add another 2.5 billion people to urban areas by 2050, with nearly 90% of this growth occurring in Asia and Africa, according to the UN [4].

The development of technologies must precede such significant changes and growing needs. And the needs are very diverse, starting from the basic ones, food, and drink, then through the movement of people and goods to what is considered superstructure and luxury. When they are not developed per the population's needs, cities are at risk of decay. If all services are not functioning, citizens' life can quickly turn from comfortable to unsustainable. The already seen situations related to the strikes of city cleaning workers speak of this, e.g., in Rome in 2018 [5] [6], Amsterdam [7], [8], etc. That tells us that it is not enough to improve technology but that the human factor is also very significant. For the city population to be satisfied, the part of the population that works in the city services must be satisfied also. Here we will not deal with issues such as employee salaries because city governments can resolve them quickly and satisfactorily. Technology and technological solutions are the more difficult problem because they require a lot of engagement in finding solutions and their implementation.

If a city wants to join the smart-cities group, it needs investments in the existing technologies improving. It must search for more suitable alternative solutions, the provision of relevant data and their processing, decision-making, and finally, most importantly, training and preparation of residents for life in such cities and the application of new technologies. In this paper, we look at smart cities from the aspect of logistics, and we will highlight some necessary components of the system:

- Organization of transportation,
- Roadways,
- Logistics centers,
- Global positioning systems (GPS) and their components from satellites to receivers,
- Sensors for monitoring and notifying about changes,
- Actuators that, based on observed changes, do physical actions through management actions,

- Microcontrollers, microcomputers, computers,
- High-speed computer networks (satellite and terrestrial),
- Public telecommunications networks,
- Databases, and
- Terminals by end-users.

CITY LOGISTICS

Due to its specificities, a city logistics category has crystallized within logistics. The term *city logistics* means ways and means that companies can use to distribute cargo in urban areas by applying strategies that can improve overall efficiency while reducing side effects, primarily harmful emissions, and traffic congestion.

Since it is about the distribution of goods within cities, the distribution process depends to a large extent on the environment in which it takes place. The environment dictates the requirements the carrier must meet to ensure urban cargo mobility and meet urban customer and business demands. In doing so, it very often must resort to innovative solutions. Retailers have had to be very imaginative and ready for change during the COVID-19 pandemic when customer habits have suddenly changed. What used to be infrequent, home delivery has now become a very significant, if not dominant, way of selling. Such a rapid change brought a whole series of new challenges, from how to transport goods to how to pay for delivered goods and billing for services performed.

Modern city logistics has introduced many changes in the operation of supply chains. Some authors, such as Rodrigue and Dablanc [9], see figure 1, began to separate supply chain management from urban logistics, insisting on their conceptual differences. The question is how justified it is because, in any case, city logistics is part of the supply chain, i.e., frequently the last link in the chain. As such, it has its specifics. But it is still part of the chain.

City logistics is increasingly focusing on just-in-time supply. Stocks in stores are getting smaller and adjusted to seasonal consumption. Customers increasingly want goods immediately, without waiting, so the need for courier and express services is increasing. That means that the frequency of distribution in cities has increased. Smaller loads are transported but more frequently. Based on estimates [9], the movements of urban goods account for 20 to 30% of the total vehicle kilometers traveled within the urban area.

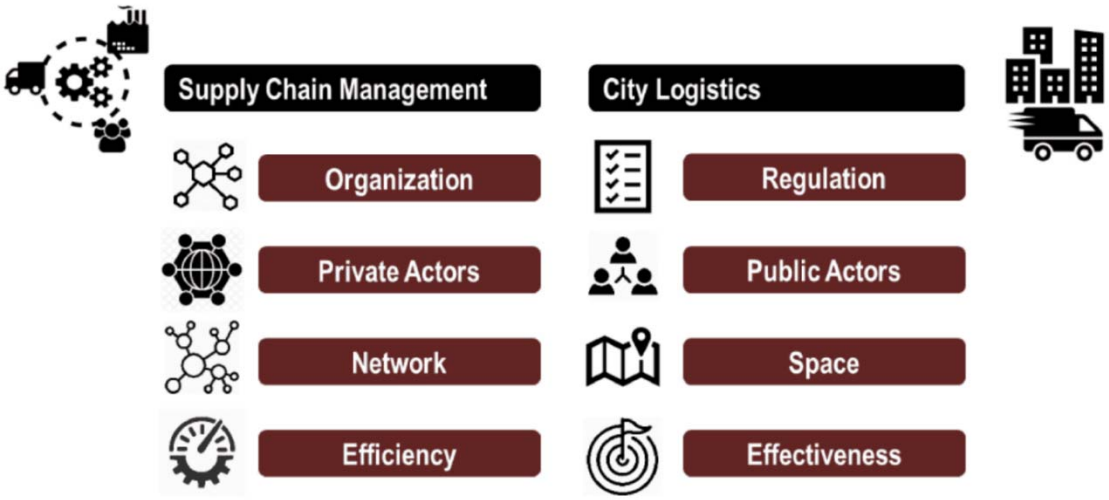

Fig. 1. Conceptual Differences between Supply Chain Management and City Logistics [9]

As a specificity of city logistics, we can state that in its realization, many participants appear who are less visible in other parts of the supply chain. Here, in the first place, we mean

public actors such as branches of government, advocacy groups, residents, and retail activities. These groups are often in conflict because of their viewpoints.

In recent years, more and more attention has been paid to sustainable development. Stricter requirements regarding environmental protection are forcing companies to introduce into their business the care of their product during the whole life of the product and to apply as many recycled parts as possible. What cannot be recycled must be disposed of in a way that will not endanger the environment. Given that a citizen appears as the end user, one can expect that the product's lifespan will expire in his place. That is why this location becomes the starting point in the return process. The initial activities related to the return of the product after its end of life (EOL), from the user to the manufacturer, can be classified as city logistics. Therefore, we can say that one part of city logistics relates to the group of waste management activities. Due to the human orientation and the organization of product return after the end of its life span, the term "Reverse Logistics 5.0" we can hear more and more often, such as in Frederico [10, p. 49], Jafari, Azarian, and Yu [11], and others. Industry 4.0 focuses on the development of autonomous solutions to replace human workers, and Industry 5.0 emphasizes the harmony between humans and technology. In the same way, Logistics 4.0, which relied on smart and autonomous logistics systems, is being transformed in the direction of sustainability. [12]

LAST-MILE DELIVERY

Last-mile delivery, also known as last-mile logistics, is becoming one of the biggest problems in supply chains. The goal is to deliver shipments from a distribution hub to customers' doors accurately, quickly, and at an acceptable price. Modern customers are very often able to track shipments throughout their journey from the seller (or manufacturer) to the moment of delivery. They become nervous when they see that a shipment has arrived in town and has not yet been delivered. Those moments can create an overall picture of the distributor's quality. 84% of customers said they would not buy again from a retailer that did not meet their expectations regarding last-mile delivery, and 98.1% of customers said this delivery was essential to brand loyalty [13]. According to Dolan [14], last-mile delivery takes more than 53% of the total shipping costs. According to research by Convey [13], 62% of surveyed cite cost as the most significant factor in delivery. We must note here that the term last-mile delivery does not mean the transfer of the shipment in the last mile literally, but from the distribution hub, which can be much further away.

One of the biggest challenges of this part of the logistics chain is the number of shipments that need to be delivered to different addresses. Each shipment has its special recipient at a different address. The traveling salesman problem and the vehicle routing problem should be solved here. Both belong to the group of NP-hard problems. When solving these problems, a series of additional factors appear, and they need attention. These factors do not always have the same weight. Depending on the situation, each factor can become dominant. Such factors can relate to:

- the priority of delivery,
- time windows for delivery,
- driver's schedule,
- track's capacity,
- expected traffic jams during peak hours or due to work on certain streets,
- the time of traffic jams coinciding with the time scheduled for delivery, or
- the number of locations where shipments are delivered.

In connection with the last one, the transporter must calculate the expected stops at those locations and the possibility of parking near the delivery point.

There are also frequent situations when the shipments cannot be delivered to the client because, for example, they are not currently present at their addresses. Undelivered shipments create specific problems because they require re-communication with the recipient and new delivery planning.

The use of computers in planning is unavoidable. With a small number of clients, the use of brute force in solving problems may be applicable, but with the increase in the number of clients, different branch-and-bound, branch-and-cut, and branch-and-price algorithms, and algorithms that use techniques reminiscent of linear programming. The assumption is that it is rare to find an ideal solution to a problem, so by applying heuristics and meta-heuristics, one strives for an optimal solution close to the ideal. It often resorts to hybrid methods that include all or some of the mentioned procedures [15]. Smart cities by providing complete data on traffic conditions can contribute to the efficiency of last-mile delivery and lower delivery costs.

Blockchain technology can also be of great help. The application of blockchain technology and the Industrial Internet of Things is described in detail in the paper of Cekerevac, Prigoda, and Maletic [16]. Here we will only point out that we believe that consortium or private blockchains are a good solution for logistics chains, especially in cooperation with the IoT. We expect a modern supply chain to provide end-to-end visibility, flexibility, trust, and process control. With its transparency, the Internet of Things brought revolutionary changes to supply chains. At the same time, it provides operational efficiency and the possibility of income. [17]

When analyzing the factors that affect the price of last-mile delivery, we can see many factors. There are the price and depreciation of the vehicle, fuel consumption, salaries of drivers and workers who work on the selection and loading of packages, salaries of workers who work on route planning and various records, cost of software, and many other costs. It is not the same whether the shipment is transported on the highway, by a large vehicle that goes at a constant speed, or in urban conditions at low average speeds with frequent stops, accelerations, and braking. Fuel consumption in urban conditions is much higher. The more stops, the vehicles will be idle longer and less used. Likewise, the driver will spend significantly more time for the same mileage. Since smaller vehicles are used in urban conditions, more drivers are needed. With the more complex routes company can expect more out-of-route miles. Research shows that out-of-route miles account for up to 10% of total kilometers traveled [18].

Returned shipments are a special problem for companies. When shopping online, the share of returned shipments reaches 20% [19]. In those cases, the seller must either return the money or deliver other goods free of charge, i.e., at their own expense. It is not uncommon for the seller to deliver a new shipment to the buyer without asking to return the previous shipment. All this affects the cost of delivering goods in the last mile.

CONCLUSIONS

When companies talk about logistics, they first consider delivery times and cost prices and act accordingly.

Customers expect same-day, or eventually, next-day, delivery. They expect delivery on time and in good condition, without damage, and in the agreed quantity. That poses challenges for all participants in the logistics chain. Advanced technologies can solve many problems, but people remain very significant, if not the most important, participants both in the organization of the process and in its implementation. The results achieved so far testify to the successes achieved. The average person is impressed by the speed and precision of handling luggage at airports between two flights or delivering luggage to passengers upon arrival at their destination. Technology is a big help here, but the time since the lifting of

travel restrictions due to the pandemic has shown that technology is powerless without trained staff.

The COVID-19 pandemic has changed people's behavior, including their habits. Individual deliveries of food and necessities have become visible in everyday life. Changes in customer habits and online shopping have posed significant challenges to carriers, primarily in cities, or, more precisely, in the phase of last-mile delivery. At this stage, challenges related to city traffic jams, parking problems, and problems with increased needs for smaller delivery vehicles, but also for drivers, need to be overcome. In the technology field, carriers can be helped by what we call a smart city. Primarily, that is data about everything. The "smarter" the city is, the easier it will be to provide transport services.

Nevertheless, we would like to point out that the bigger the city, the bigger the problems of living in it. It is much more favorable in every way if the entire territory of a country develops evenly, and the population does not feel the need to seek happiness in a big city.

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