







Solving the Last Mile Problem in E-Commerce

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Abstract: Physical distancing and isolation measures used during COVID-19 have played a huge role in the development of e-commerce. The increase in the number of online purchases around the world is forcing all courier services to adapt to new delivery conditions. This article tells about a solution that can help to cope with the problem of the last mile in Russia.

1 INTRODUCTION


The COVID-19 pandemic has led to the fact that people in the world have significantly limited any interaction with one another. Voluntary social distancing in order to avoid infection, as well as strict state measures, have actually suspended, at least temporarily, a significant share of traditional retail trade.


2 THE COVID-19 PANDEMIC AND E-COMMERCE


In the United States of America (Advance Monthly Sales For Retail And Food Services, May 2021), retail sales and food sales in the period from February to April 2020 decreased by 7.7% compared to the same period in 2019. Nevertheless, sales of any kind in online stores increased by 16% and 14.8%, respectively. In Europe, retail sales via the Internet in April 2020 increased by 30% compared to April 2019, while total retail sales decreased by


17.9%. As a result, the transition from retail to e-commerce will be significant in different countries. For example, while the share of e-commerce in total retail trade in the United States increased slowly between the first quarter of 2018 and the first quarter of 2020 (from 9.6% to 11.8%), it increased to 16.1% between the first and second quarter of 2020. The similar situation is observed in the UK, where the share of e-commerce in retail increased from 17.3% to 20.3% over the period from the first quarter of 2018 to the first quarter of 2020, and then significantly increased to 31.3% over the period from the first to the second quarter of 2020. Similar changes are observed in other regions, including China (Total Retail Sales of Consumer Goods Achieve Positive Growth in August 2020), where the share of online purchases in the total volume of accumulated retail sales over the period from January to August 2020 reached 24.6%, compared with 19.4% in August 2019 and 17.3% in August 2018.


Although official statistics are not available for most other countries, estimations show that in the first half of 2020, online orders increased in several regions, including Europe, North America and the Asia-Pacific region (Javier LOPEZ-GONZALEZ, Silvia SORESCU: Connecting Businesses and Consumers During COVID-19: Trade in Parcels). For the countries of the Asia-Pacific region, e-commerce had already increased significantly in the first quarter of 2020, while in Europe and North


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America growth occurred later, namely after several countries followed the example of Italy and introduced restrictive measures. The fact that requests to Google for the delivery of goods almost doubled in some countries before the actual restrictive measures were introduced (for example, USA, the UK) illustrates the close relationship between changes in consumers' behaviour, their expectations and government actions.

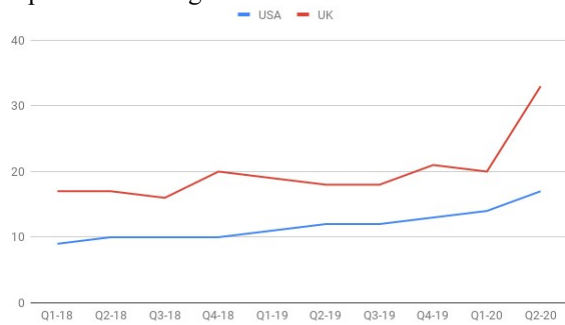


Figure 1, a: Share of e-commerce in total retail sales, United Kingdom and United States (2018-2020).

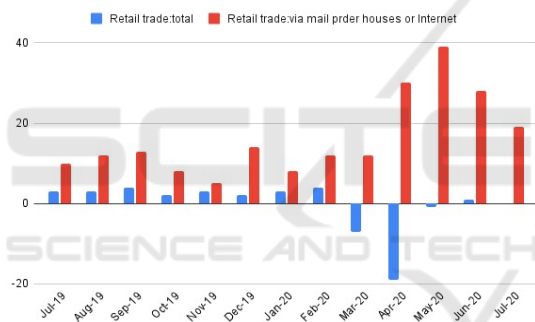


Figure 1.b: Retail turnover, year-on-year change, EU-27 (July 2019-20).

(US Census Bureau, Monthly Retail Trade; Internet sales as a percentage of total retail sales (ratio) (%); Turnover and volume of sales in wholesale and retail trade - monthly data).

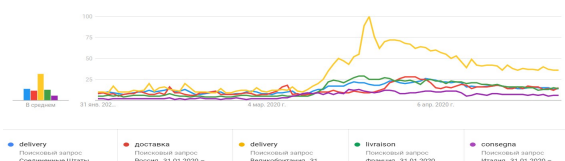


Figure 2: Statistics for the query "delivery" in the Google search engine in different countries of the world (January 2020 - April 2020).

3 THE LAST MILE PROBLEM IN DELIVERY PROCESS

The number of consumers shopping online is growing along with the demand for fast and free delivery of goods. Thus, in order to remain competitive, e-commerce companies are constantly looking for ways to increase efficiency and reduce costs to improve their logistics. The main player in this movement is the process of the so-called "last mile".

In other words, in order for a company to survive in the modern market, it must find ways to increase efficiency primarily in this area.

The last mile is the final stage of the delivery chain, and its most important part, because that's when the goods are delivered to the final destination, to the customer.

Customers want their goods to be delivered quickly and for free — or at least for a very small fee. However, the last mile is also the most difficult and expensive part of logistics, which is quite a big problem for online stores. The last mile is a large part of the total cost of delivery. With e-commerce giant Amazon delivering products in just two hours now, companies are looking for ways to deliver their own products as quickly as possible to keep their customers happy and loyal.

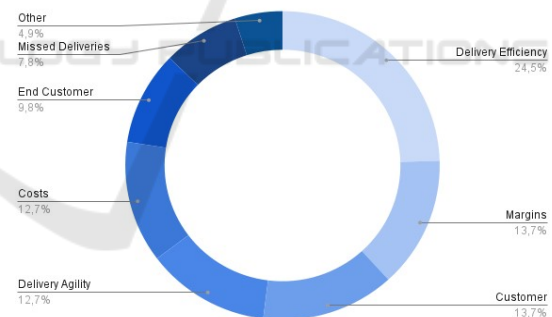


Figure 3: Biggest challenge for logistics providers in last mile (The Last mile Logistics whitepaper. The Iconomization of the last mile // Localz, 2018.).

Companies know that they need to adapt to survive. This often means reducing the additional costs, which are about 25% of the price on average (Kees Jacobs, Shannon Warner, Marc Rietra, Lindsey Mazza, Jerome Buvat, Amol Khadikar, Sumit Cherian, Yashwardhan Khemk: "The last-mile delivery challenge: Giving retail and consumer product customers a superior delivery experience without impacting profitability".), to meet consumer demand, and this number only increases as inefficiency becomes more and more expensive.

Thus, you can imagine the potential return on investment in improvement, especially considering that the number of deliveries in most industries continues to grow rapidly.

Most often, the introduction of goods pick-up services and the installation of postamates are used to solve the problem of the last mile at present. This eliminates some problems, shifting the responsibility to consumers. This can also significantly reduce the amount of time that couriers spend on the road, since they only need to visit several selected pick-up points, and not several residential addresses.

This saves time twice, since often when people do not open the door to receive a parcel, it is delivered to the nearest pick-up point for receiving or re-attempt delivery the next day.

4 LIMITATIONS

But, unfortunately, in Russia, this solution to the problem of the last mile has little possibility of implementation at the moment. Pick-up points and postamates are still very unevenly developed, for example, according to open data from the Moscow government, which we were able to analyze, the percentage of penetration in the Moscow region is 56%, and for the Krasnoyarsk region it's only 6%.

According to M.S. Logachev, the work process of modern companies requires an IT infrastructure, providing not only data transfer, but also the ability to make decisions and perform various business operations, that can be considered as a structural approach to systematizing processes. (Logachev M S, Voronin I V, Britvina V V, Tichtchenko S A and Altoukhov A V 2020 Local Area Network Monitoring: The Issue of Broadcast Storm. International Journal of Advanced Trends in Computer Science and Engineering 9 4216-4222)

5 A SOLUTION TO THE PROBLEM OF THE LAST MILE IN RUSSIA

To solve this problem, a web application was developed, the main competitive advantage of which is direct access between the courier and the client without intermediaries in the form of a company. Common thing for courier services is when a customer has a problem, they are sent to the support service of the company, which cannot solve the problem promptly, which reduces the customer's

loyalty. Another advantage is the ability of customers to share GPS coordinates for quick adaptation of couriers to their movements, the courier will be able to find out how far from the place of delivery or dispatch the customer is before heading to it. Also, if we take into account the fact that the application is designed exclusively for courier services that deliver documents and / or small-sized cargo, it will allow the courier to see how far away his current customers are on the map. And if, for example, one of the customers is within walking distance from the courier and is ready to accept the order, then he can do it without waiting for the courier to arrive at the place of delivery or dispatch, which will increase the key performance indicators of the courier.

After registration, the user sees the adaptation screen, which immerses him in the application. When a user launches an application for the first time, the adaptation process increases its value and provides instructions that highlight key advantages and functions. Next, the user places an order through the application, choosing a convenient time for its delivery and dispatch. Also, when placing an order, the customer can choose to enable or disable the geolocation tracking function. The courier also monitors the customer's location before delivery to optimize routes.

The latest web development technologies were used, and we divide them into the following groups while creating the application.

5.1 Interface Generation and Data Processing

JavaScript / ES2020 is a multi-paradigm programming language. Supports object-oriented, imperative and functional styles. It is an implementation of the ECMAScript specification.

SASS / SCSS is a CSS-based metalanguage designed to increase the level of abstraction of CSS code and simplify cascading style sheet files.

5.2 Organization of Development and Uploading to the Server (Devops)

Docker is a software for automating the deployment and management of applications in environments with containerization support, application containerizer.

Docker-compose is a tool designed to help define and share multi-container (microservice architecture) applications. With Compose, you can create a YAML file to define your services and start

and stop whatever you want with a single command. The big advantage of using Compose is that you can define the application stack in a file, save it to the root of the project repository (version control is now supported), and easily let another user participate in the project. Another user will only need to clone the repository and start creating the application (Logachev, M.S., Voronin, I.V., Britvina, V.V., Tichtchenko, S.A., Altoukhov, A.V., 2020.).

Webpack is an open source JavaScript module builder. It parses the modules of the application, creates a dependency graph, then assembles the modules in the correct order into one or more bundles, which can be referenced by the "index.php" file. npm is the package manager included with Node.js.

Nginx is an HTTP server and reverse proxy, mail proxy, and general purpose TCP / UDP proxy.

5.3 Technical Debt

Git and GitHub is a distributed version control system. The development is used, which includes GitHub Flow and work with the branch system;

Prettier is a code formatting tool that aims to use hard-coded rules for the formatting of programs. It formats the code automatically, helping to maintain consistency and accountability in the Git version control system.

Eslint is a static code analysis tool for identifying problematic patterns found in JavaScript code. Rules in ESLint are configurable and custom rules can be defined and loaded using packages such as

Eslint-plugin-prettier - Runs Prettier, typically ESLint and reports differences as separate ESLint issues.

Babel-eslint - Allows cross-platform Babel code.

5.4 Interface Design

Figma is a graphical online collaboration editor. You can create a website prototype, an application interface and discuss edits with colleagues in real time in it.

Adobe Illustrator is a vector graphics editor developed and distributed by Adobe Systems.

Adobe Photoshop is a multifunctional graphics editor developed and distributed by Adobe Systems.

5.5 Client Part

The front end is based on Vue.js technology (Glazkov N. O., Belyaeva D. V., Designing an Online Generator Of Math Tasks For Students Of

Secondary, Vocational And Higher Educational Institutions. Journal of scientific publications "Theory and practice of project education", No. 4(12)/2019), an open source JavaScript framework for building user interfaces. Easily integrates into projects using other JavaScript libraries, such as: Vue-router is the official routing library for Vue.js. It integrates deeply with Vue.js and makes it easy to create SPA applications. Includes the following features:

1. Nested routes / views;
2. Modular router configuration;
3. Access to route parameters, query, wildcards;
4. Vue.js based view transition animation;
5. Convenient navigation control;
6. Automatic setting of the active CSS class for links;
7. HTML5 history or hash modes, with auto-switching in IE9;
8. Configurable page scrolling behavior;

Vuex - state management pattern + library for Vue.js applications. It serves as a centralized repository for all application components, with rules to ensure that state can only be changed predictably;

Vuelidate - Simple and lightweight model-based Vue.js validation;

Vue-clickaway - Reusable "clickaway" directive for reusable Vue.js components to detect clicks outside of component boundaries;

Vue I18n is a plugin for Vue.js internationalization. It easily integrates some localization features into your Vue.js application;

Chart.js - Simple and flexible JavaScript charts for designers and developers.

5.6 Server Part

Node.js is a V8-based software platform that transforms JavaScript from a highly specialized language into a general-purpose language. Node.js is used primarily on the server, serving as a web server. Node.js allows you to connect other external libraries and use technologies such as (Kees Jacobs, Shannon Warner, Marc Rietra, Lindsey Mazza, Jerome Buvat, Amol Khadikar, Sumit Cherian, Yashwardhan Khemk, 2020.):

- Dotenv is a zero dependency module that loads environment variables from a .env file into process.env. Keeping configuration in an environment separate from code is based on the Twelve Factors application methodology;

- Compression - Node.js compression middleware Debug is a tiny JavaScript debugging utility modeled after the Node.js core debugging technique. Works in Node.js and web browsers;
- Express.js is a web application framework for Node.js, released as free and open source software under the MIT license. It is designed for building web applications and APIs. This is the de facto standard framework for Node.js;
- Faker is a library that allows you to generate a huge amount of fake data for testing the system in the browser and Node.js;
- Sequelize is a promise-based Node.js ORM for Postgres, MySQL, MariaDB, SQLite, and Microsoft SQL Server. Has robust support for transactions, relationships, active and lazy loading, read replication, and more;
- PostgreSQL is a free object-relational database management system. Available in implementations for a variety of UNIX-like platforms, including AIX, various BSD systems, HP-UX, IRIX, Linux, macOS, Solaris / OpenSolaris, Tru64, QNX, and Microsoft Windows (Zhichkin, K.A., Starikov, P.V., Zhichkina, L.N., Mamaev, O.A., Artemova, E.I., Levochkina, N.A., 2020.).

5.7 Client-Server Interaction

To organize client-server interaction, it was decided to abandon the classic use of RESTful APIs in favor of using GraphQL technology - an open source query and manipulation language for APIs, as well as a runtime environment for executing queries with existing data. This method has the following list of advantages (Glazkov, N.O., Belyaeva, D.V., 2019.):

1. Simplicity of fetching all the necessary data with one single request;
 2. Caching;
 3. Query performance;
 4. Accurate data sampling;
 5. Compatibility with modern applications;
 6. Deprecation at the field level;
 7. No need to create multiple REST requests.
- To retrieve data, you only need to enter one query;
8. Not tied to a specific database or storage engine;
 9. A whole system of data types is used, etc.

Apollo GraphQL is a comprehensive state management library that allows you to manage both local and remote data using GraphQL. This technology is used to retrieve, cache, and modify application data when the user interface is automatically updated.

6 TESTING AN INNOVATIVE SOLUTION ON REAL CUSTOMERS USING THE USER'S GEODATA

To test the theory that our unique ideas can actually influence the solution to the last mile problem, we conducted testing. For this we have gathered two groups of participants. The experimental group used our application and the control group did not. The experimental group consisted of 28 people, 47% of whom were women, and 53% were men, their age ranges from 20 to 35 years (20-25 years - 2%; 25-30 years - 92%; 30-35 years - 6%). The control group consisted of 29 people, women were 58%, and men 41%, their age also varied from 20 to 35%, but participants from 25 to 30 years old were 90%, from 20 to 25 years old 7%, and from 30 to 35 years 3% respectively.

All participants rated the delivery on a five-point system, where 2 is unsatisfactory and 5 is excellent. You can see how the grades were distributed in the following tables:

Table 1: Distribution of ratings of the participants of the experiment.

Groups	Evaluations			
	2 (unsatisfactory)	3 (satisfactorily)	4 (good)	5 (excellent)
Experimental	1	5	12	10
Controls	5	11	8	5

Table 2: Grouping of the ratings of the participants of the experiment.

Groups	Evaluations			
	2 or 3 (no effect)		4 or 5 (there is an effect)	
Experimental	6	21%	22	79%
Controls	16	35%	13	47%

Further, two hypotheses were put forward:

H_0 - the proportion of customers who rated the delivery as "good" and "excellent" in the experimental group, no more than in the control group.

H_1 - the proportion of customers who rated the delivery as "good" and "excellent" in the experimental group is higher than in the control group.

Determined the φ values corresponding to the percentages in each of the groups:

$$\varphi_1 (79\%) = 2.19 \quad (1)$$

$$\varphi_2 (47\%) = 1.511 \quad (2)$$

Set the significance level to 0.01.

A significance level of 0.01 corresponds to a critical value:

$$\varphi_{crit} = 2.31 \quad (3)$$

The empirical value of φ_{emp} was calculated by the formula:

$$\varphi_{emp} = (\varphi_1 - \varphi_2) \cdot \frac{\sqrt{n_1 \cdot n_2}}{n_1 + n_2} = \quad (4)$$

$$(2.19 - 1.511) \cdot \frac{\sqrt{28 \cdot 29}}{28 + 29} \approx 2.56$$

Since $\varphi_{emp} \geq \varphi_{crit}$, the hypothesis H_0 is rejected and, therefore, the noted difference between the experimental and control groups in the results of evaluating the delivery of goods is statistically significant.

The participants in the experimental group were satisfied with the delivery and became more loyal to the courier service.

7 CONCLUSION AND FUTURE WORK

These results confirm that the problem of the last mile in the delivery of goods is significant. To solve it and improve the delivery process of goods, it is necessary to use all modern e-commerce capabilities. As we have stated elsewhere, the use of user geodata for accelerated and high-quality delivery can be considered as a promising direction for solving the last mile.

Future research is needed to confirm what conclusions can be drawn from this study.

Further research could fruitfully continue the consideration of this issue in modern realities.

For further development of the product, we plan to commercialize the system, provide services to small and medium-sized businesses, and integrate our web application into eco-systems popular in Russia, such as Yandex inc. and OZON inc. The functionality of the system will be also expanded by optimizing processes using digitalization tools.

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