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Improvement of megacity ecological conditions with the use of a clever SmartBoxCity container-tranformer

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Introduction. The paper proposes an option for improving the environmental situation in Rostov-on-Don. That is the optimization of the way of cargo delivery to the customer using the clever SmartBoxCity container-tranformer and the Dispatcher RD program.

Problem Statement. It is necessary to improve the ecological situation of the city by reducing the number of traffic jams and the time spent in them. The task was to develop and implement technical and information support, on which the driver's ability to get up-to-date information and reduce the delivery time of products to consumers depends.

Theoretical Part. The optimization of traffic within the city must be solved using the existing traffic scheme. Due to the optimization, you can significantly reduce the number of traffic jams and the time spent in them, and, accordingly, improve the environmental situation in the city. The way how the driver gets up-to-date information depends entirely on the information support. It is proposed to use a smart folding cargo container-transformer SmartBoxCity, which includes elements of intelligent urban mobility. To optimize the delivery path in the absence of the Internet, the Dispatcher RD software product can be used.

Conclusion. The effective management, monitoring and integrated planning of the movement is carried out with the use of mobile and server applications. To improve the professional competence of students of the relevant specialties, it is proposed to use the current SmartBoxCity layout, a developed mobile application and a computer program for optimizing the delivery path.

Keywords: ecology, smart container, mobile application, optimization of the cargo delivery route, computer program.

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Introduction. Currently, the transport channels of various goods are the main arteries of the economy. In most countries, 70-80% of national economic goods are transported by road, which is due to the high speed and maneuverability. Environmental pollution is caused by many factors, but car exhaust gases cause the greatest harm. Every year, hundreds of millions of tons of harmful substances enter the atmosphere with exhaust gases: sulfur dioxide, hydrocarbons, nitrogen oxides and many other pollutants. Fuel and a non-optimal approach to cargo delivery are the first in the list of factors that affect the environment and the cost of cargo transportation.

Problem Statement. It is necessary to develop technical and information support for the transport system of cargo transportation, which will allow you to effectively manage, control and plan the movement of transport and material flow. In this article, to implement the optimization of cargo delivery, it is proposed to use the SmartBoxCity smart folding cargo container-transformer, which includes elements of intelligent urban mobility and wireless communication technologies of the Internet of Things, as well as the software product Dispatcher RD.

Theoretical Part. As shown by numerous environmental studies conducted in recent years, there is a sharp increase in emissions of pollutants into the atmosphere. The greatest contribution to atmospheric pollution is made by road transport, which determines the undoubted relevance of the presented development [1].

Table 1 shows the main types of fuel and pollution from road transport. Table 2 shows the composition of the exhaust gases of gasoline and diesel fuel.

Table1

Types of pollution from the use of road transport

Fuel type	Type of pollution	Usage
Gasoline	Hydrocarbons, carbon monoxide, nitrogen oxides	Cars, buses, planes, motorcycles
Gasoline (with oil)	Hydrocarbons, carbon monoxide, nitrogen oxide, solids	Motorcycles, auxiliary motors
Ligroin	Nitrogen oxides, solid substances	Buses, tractors, cars, trains

Table 2

Exhaust gas composition

Exhaust gas composition	Gasoline	Diesel	Toxicity
	Content by volume, %		
Nitrogen	74.0–77.0	76.0–78.0	nontoxic
Oxygen	0.3–8.0	2.0–18.0	nontoxic
Water vapor	3.0–5.5	0.5–4.0	nontoxic
Carbon dioxide	5.0–12.0	1.0–10.0	nontoxic
Carbon monoxide	0.1–10.0	0.01–5.0	toxic
Non-carcinogenic hydrocarbons	0.2–3.0	0.009–0.5	toxic
Aldehydes	0–0.2	0.001–0.009	toxic
Sulfur oxide	0–0.002	0–0.03	toxic
Soot, g/m^3	0–0.04	0.01–1.1	toxic
Benzopyrene, mg/m^3	0.01–0.02	до 0.01	carcinogen

To improve the environmental situation in Rostov-on-Don, the regional authorities plan to form a transport ring around the city, which will allow bringing transit transport outside the city. However, inside the city, the problem has to be solved using measures to optimize the existing traffic pattern. To clean the air from exhaust gases and improve the environment, it is necessary to reduce the standing time and exhaust emissions in traffic jams. The delivery time of the products and the possibility of getting the driver up-to-date information depends largely on the information support. Figure 1 shows the different states of the SmartBoxCity smart folding cargo container-transformer.



a) *b)* *c)*

Fig. 1. Folding cargo container: a — FCC in the assembled state;
b — preparation for loading; c — FCC is ready for loading

The hardware performs the functions of transporting piece, bulk and liquid cargo; it is automatically transformed (folding/unfolding); the weight of the container and the cargo being moved is measured; the location in space and time is tracked. The door mechanism can withstand at least 30 cycles. The container itself does not exceed the established norm. The efficiency of storage/opening is 50 cycles [2, 3]. For the software and hardware, a project for the electrical equipment of the container has been developed, including two electrical control cabinets with the control equipment.

A mobile Web application for users has been developed. It integrates with other corporate systems [4, 5]. The Web application functions:

— identification of the customer and the cargo;

— monitoring the location of the container.

The cargo is identified by type (piece, bulk, liquid) and mass-volume characteristics. Virtual administration is performed remotely. The weight and volume of the cargo, the temperature and humidity inside the container, and the opening/closing that indicates depressurization are measured by built-in sensors. The server includes a switching server for collecting, processing, storing and relaying data. The switching server ensures the smooth operation of the system as a whole. Drivers can monitor and dispatch equipment using a mobile app and a Web interface [6-8].

Mobile application and Web interface. The software also includes mobile applications written in the Pyton programming language. These applications constantly interact with a central Web server to transmit and receive data. The driver is provided with various information, including two lists of containers: containers in the car (Figure 2 a) and containers at the warehouse (Figure 2 b). For each of the container, you can view a more detailed information (battery charge, temperature, etc.) (Fig.2 c, 2 d).

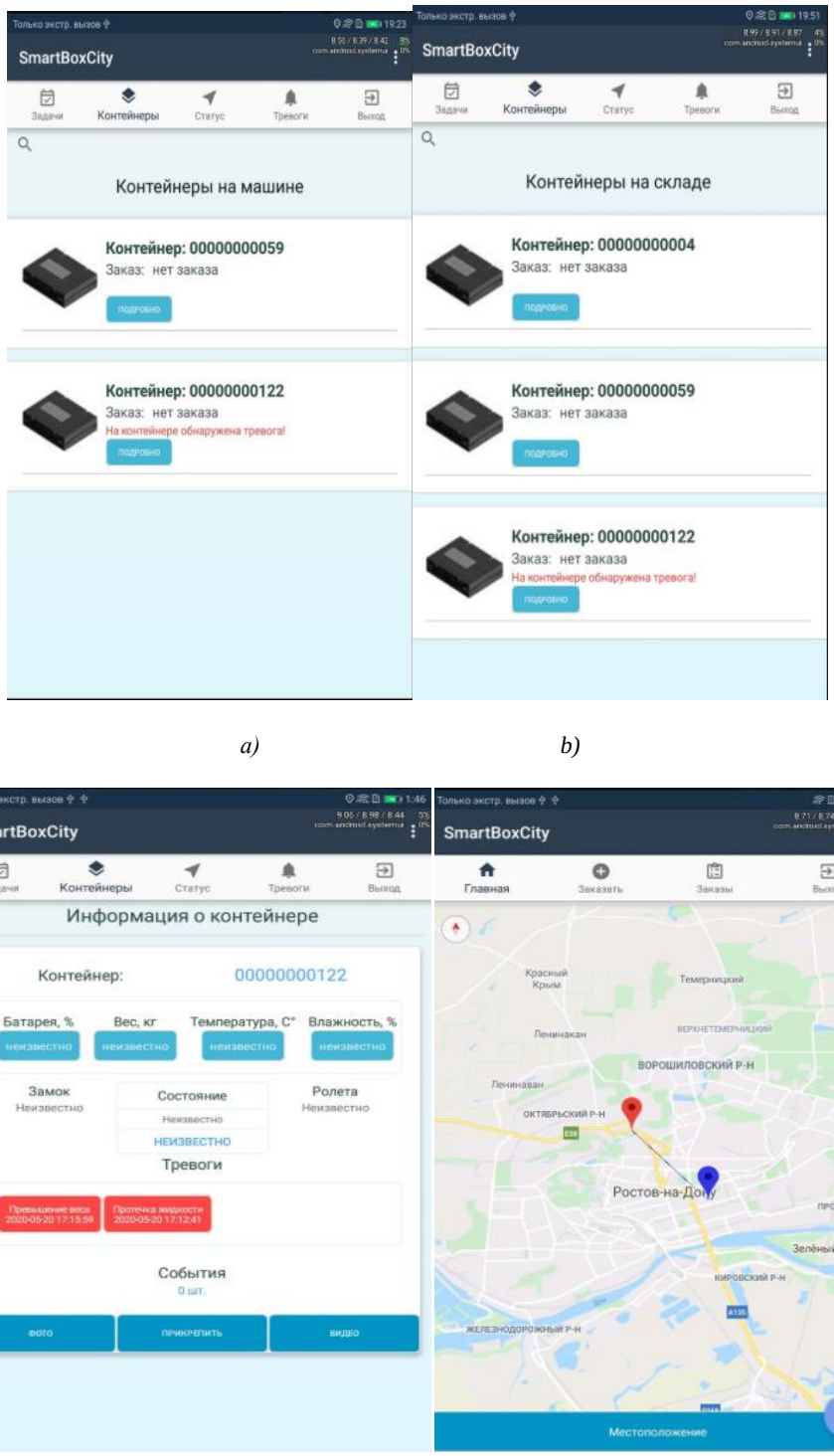

Fig. 2. The menu of the mobile application: a — container in the car;
b — container at the warehouse; c — information about the container;
d — location of the container

The software part of the container management consists of the server and client parts. The server part of the solution is a Web site — a server for collecting, processing, relaying data and transferring it to the database. The web service is an environment for interaction between the customer, the delivery driver and the SmartBoxCity hardware. To log in to the Web service you need a browser and a mobile application, in which users, depending on their rights, get access to the corresponding functionality for configuring and managing the SmartBoxCity system.

If there are several cars with empty containers on the route, moving next to each other, then at a certain place in the parking lots, they can be reloaded from car to car. At the same time, logistics optimization is carried out to free one of the cars from empty containers. The joint operation of vehicles when loading stacked containers into the body of one of the vehicles is an element of the so-called "caravan movement" in optimizing cargo transportation.

Various tables are designed to store information about the events that occurred on the container. Tables 3 and 4 and Figures 3–-5 show the structure of the EVENT and ALARM tables and the structure of the alarm messages on the container.

Table 3

EVENT table structure

EVENT table	
id	event identification number
type	event type
message	event message
created_at	event date and time
ontainer_id	reference to the FCC ID

Fig. 3 shows the structure of tables for storing information about the container events.

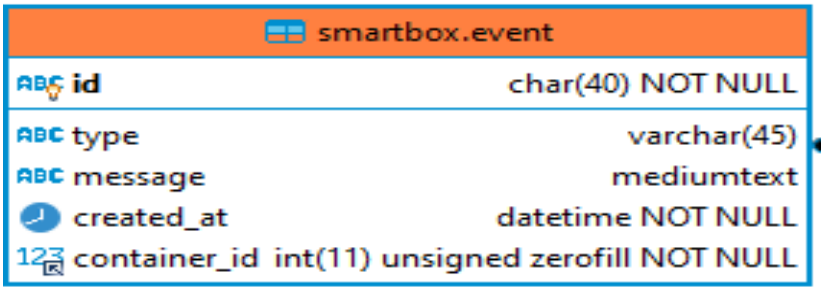

Fig. 3. The structure of tables for storing information about the container events

Table 4

ALARM table structure

ALARM- table	
id	alarm identification number
message	alarm message
alarm_type_id	alarm type number
name	alarm name
persistent	auto fix
alarm_status	alarm status
acknowledged	notification confirmation

Figures 4 and 5 show information about the container alarms.

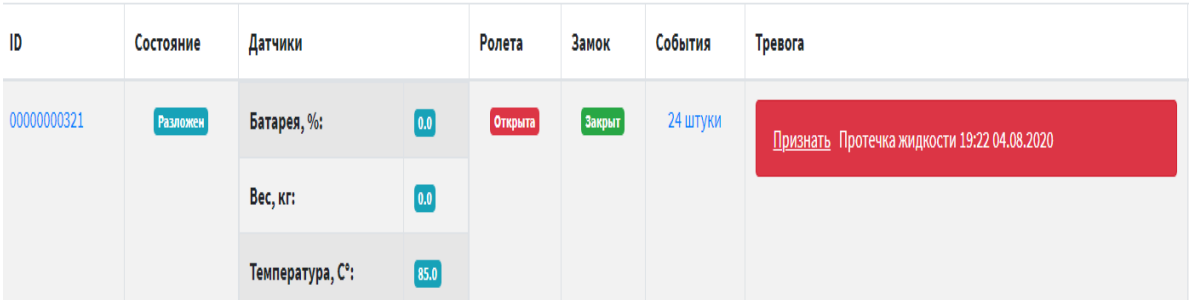

Fig. 4. Information about alarms on the container

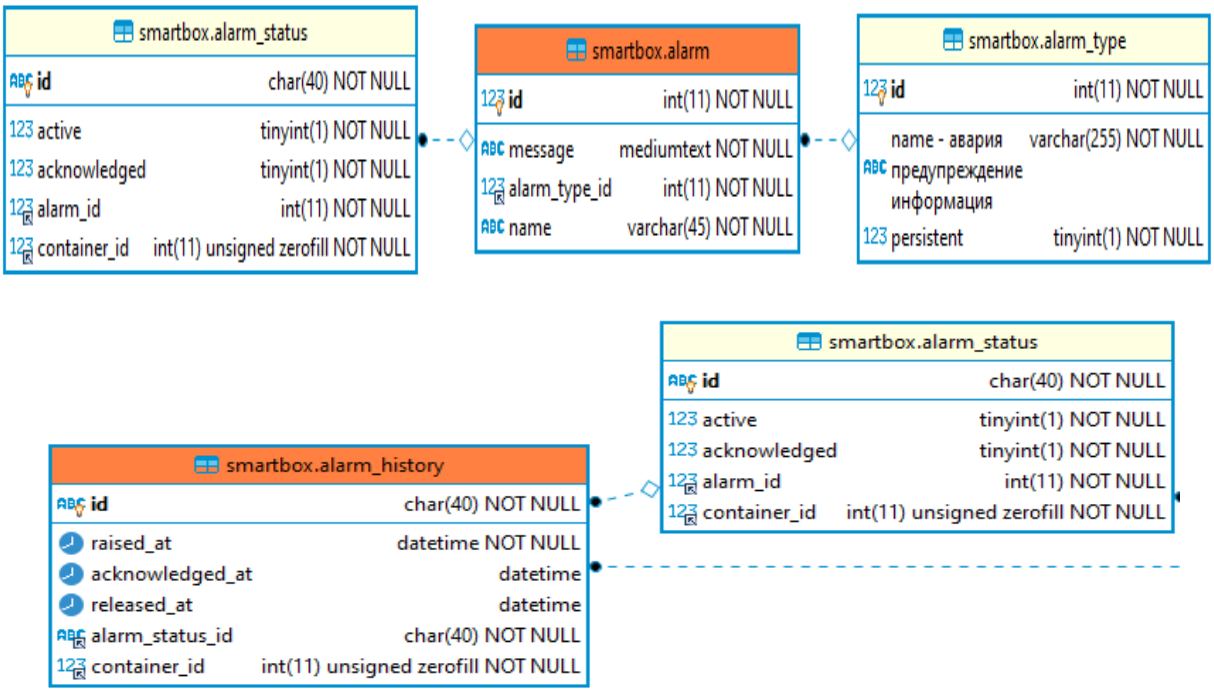

Fig. 5. Table structure for storing the container alarm information

The developed software application communicates with Yandex, the router. To optimize the delivery path without the Internet, the software product Dispatcher RD can be used.

Numerous field observations and mathematical calculations of transport characteristics based on the method of electrodynamic modeling served as the basis for the creation of the Dispatcher RD software product [9–11]. The article [11] shows the work of the program on the example of delivery of FCC from the manufacturer in Novocherkassk to the Rostov-Tovarny station. This program will allow the system to work without the Internet and can be used for educational purposes

Figure 6 shows the view of the initial menu of the Dispatcher RD program: selection of the city, departure point, and intermediate points. You should select the type of the map, the area of cargo dispatch; determine the intermediate points and the delivery point. The example of the FCC delivery from the point of manufacture to the Rostov-Tovarny station shows the initial menu of the program (Fig. 6). The map of the city of Novocherkassk is presented. In the menu window, you must specify the departure point and intermediate delivery points of the FCC, if there are any. Figure 7 shows an example of calculating the optimal path for the FCC delivery from the place of manufacture (Novocherkassk) to the Rostov-Tovarny station with the indication of intermediate points and the built route.

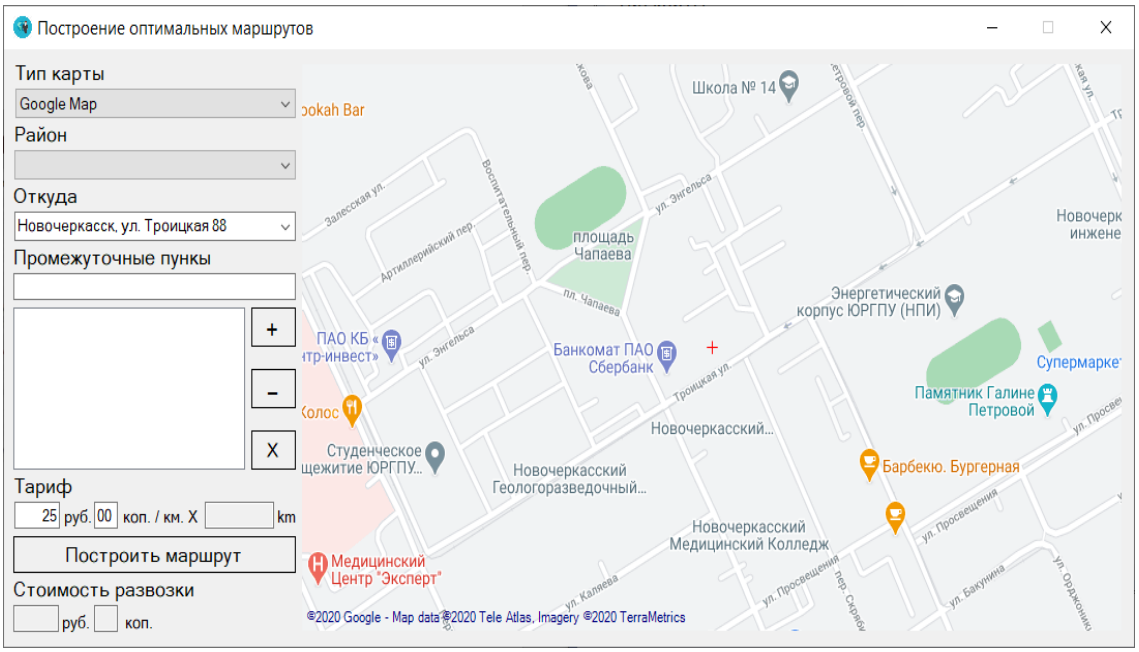

Fig. 6. View of the program's start menu

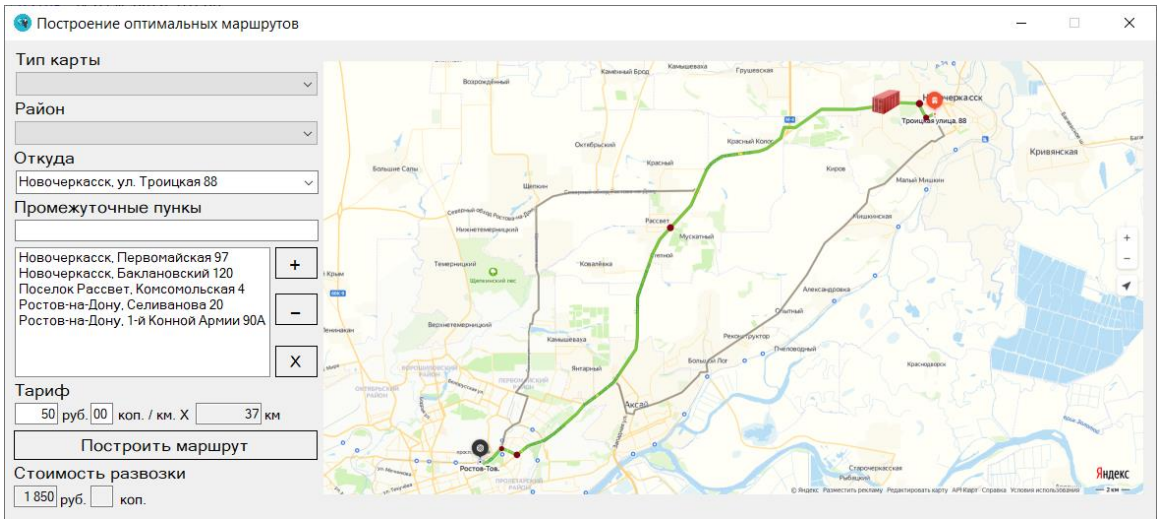

Fig. 7. The built route

Conclusion. The competition between the transport companies is quite big. Saving fuel and travel time provides additional opportunities to improve the performance of the transport company. The FCC, software and the mobile application for managing the FCC are available for purchase by transport companies. The managed SmartBoxCity mockup, a mobile application, and a software package for modeling the optimal route can be used by specialized secondary and higher educational institutions for educational purposes. The reliability of the obtained results was confirmed by conducting full-scale tests on a special stand and transport using mockup, and then prototype samples of the SmartBoxCity transformer container. An exhibition copy was made — a working model of a vehicle in the form of a car with a manipulator and two SmartBoxCity transformer containers, which will be shown at exhibitions to attract potential consumers. Agro-industrial group of companies Yug Rusi, Rostov-on-Don, showed some interest to the product to use SmartBoxCity in logistics transportation for its own needs (Yug Rusi is the world leader in the production and sale of bottled vegetable oil, sunflower seeds, grain and flour).

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Contribution of the authors:

A. A. Korotkiy — formulation of the main concept, goals and objectives of the study; G. A. Galchenko — scientific supervision, analysis of the research results, revision of the text, correction of conclusions; D. S. Drozdov — development of a software package, menu design, calculations.