INFORMATION TECHNOLOGY, COMPUTER SCIENCE, AND MANAGEMENT
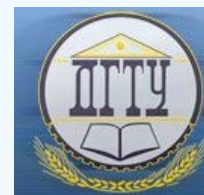
Modeling of information support to optimize logistics tasks in transport sector using a programmable container transformer simulator

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Introduction. The structure of the transport logistics system for the transportation of container transformers in an urbanized environment to optimize production costs with elements of intelligent urban mobility, as well as the simulation software for modeling and testing the developed system, are described. The basic principles of the interaction between elements of the system are presented through the behavioral modeling of containers and carriers. Software is created to simulate the operation of the logistics infrastructure for transformer containers using wireless technology and the Internet of Things; and services for the rapid information exchange between participants (objects and subjects) of this process are implemented.

Materials and Methods. A general method of organizing a network with a web server and a mobile client, as well as the basic principle of interaction between the server and the client, is described. The basics of developing a simulator designed to simulate all possible states of a container transformer are specified.

Results. A common system architecture and a simulator are created for the software debugging and testing under the organization of a single space to monitor and optimize cargo transportation using "smart" container transformers while providing transport services to the population and legal entities in an urban environment.

Discussion and Conclusions. The developed simulator as part of the information system provides speeding up the creation, debugging and testing of the software for solving logistics problems in the transport sector.

Keywords: transport logistics, container transformer, web server, client, simulator, transport, route optimization.

Introduction. There is a logistical problem associated with the transportation of cargo containers with empty crate resulting in added costs for fuel and labor, road congestion and, as a result, stress on the environment.

To solve the described logistics problem for the transportation of goods, containers-transformers SmartBoxCity are used, they are equipped with wireless technology and the Internet of Things[1]. The central element of the created product is a container equipped with IT system of remote administration and scripted control that can transform into operation condition. It is intended for large logistics companies. A container transformer provides stacking several empty containers in one vehicle, which saves logistics costs, since a specific volume of transportation is used more efficiently [1]. The proposed solution enables to reduce delivery costs, and it is a part of information system for optimizing the route of freight transport [2].

Due to the fact that the development and testing of the project components is a rather laborious and resource-intensive process, software is proposed to simulate the processes of the complex as a whole.

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[1] Petrov OA, Evstratov EM, Korotkii AA, et al. Collapsible shipping container. RF Patent 2672998, 2018. (In Russ.)

The work objectives were to create a software product that provides modeling of the logistics infrastructure for transformer containers using wireless technology and the Internet of Things; and to implement services for the rapid exchange of information between participants (objects and subjects) of this process [3].

Materials and Methods. To solve the task of developing a simulator application, first of all, it was necessary to select a web server. IIS (Internet Information Services) was chosen as a web server, a proprietary set of servers for several Internet services from Microsoft, as well as an ASP.NET Core web application, because applications built on this technology are portable and easy customizable[2]. The framework uses the C # programming language and the presentation engine Razor[3].

The relational database management system Microsoft SQL Server [4] was selected as the database for storing the modeled data.

Among the components included in the software, there is a mobile application for simulating the behavior of a transformer container. With its help, the user can create a model of the container, track its possible states and sensor readings. The application consists of the following functional blocks (sections of the main menu): "Sensor readings", "GPS coordinates", "Container condition" and Photofixation".

In the "Sensor readings" section of the main menu, the user can track and change the following sensor readings: temperature, cargo weight, illumination, humidity, battery charge level, network signal level. All changes made by the user are subsequently saved, and then access to the camera, which records the state of the cargo in the transformer container at the time of changing the parameters, is given (Fig. 1).
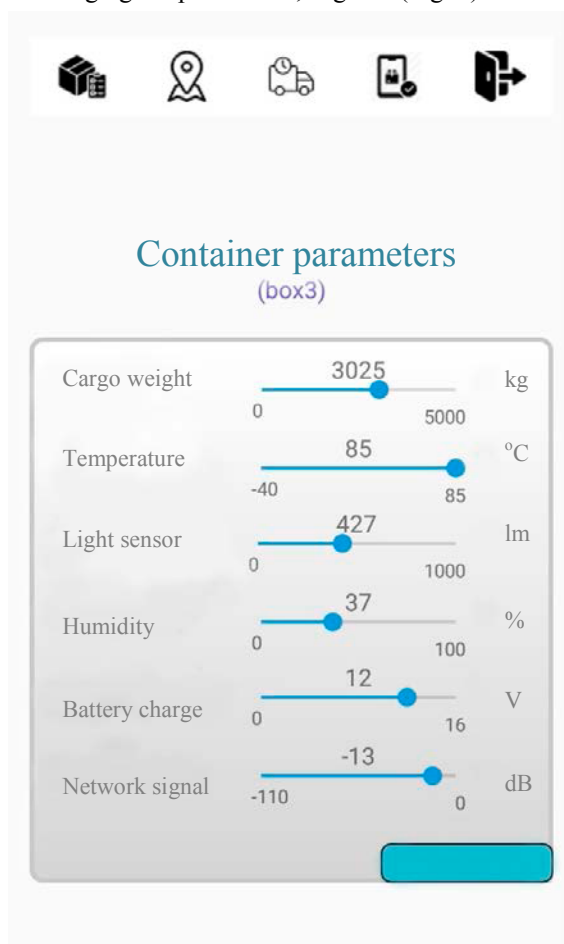

Fig. 1. Sensor readings

In the "GPS coordinates" section of the main menu, the user is presented with the real-time GPS coordinates of the container. Additionally, the date and time of coordinate change are tracked [5]. All changes at regular intervals are sent to the server and recorded in the database (Fig. 2).

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[2]Internet Information Services. URL: https://ru.wikipedia.org/wiki/Internet_Information_Services (accessed: 15.04.2019) (In Russ.).

[3]Roth D, Anderson R, Luttin Sh. Introduction ASP. NET Core. URL: https://docs.microsoft.com/ru-ru/aspnet/core/introduction-to-aspnet-core?view=aspnetcore-3.1 (accessed: 13.04.2020) (In Russ.)
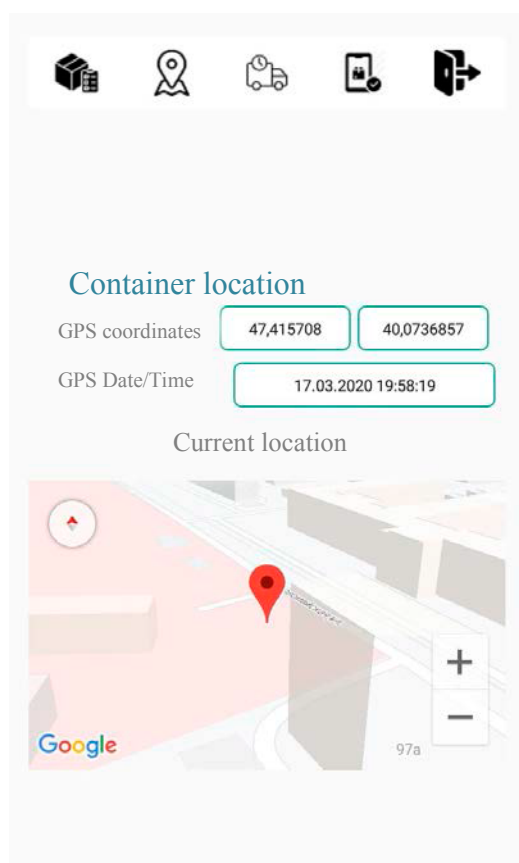
Fig. 2. GPS coordinates of the container

In the "Container condition" section of the main menu, the position of the doors (open/closed) and the container (unfolded/folded) is monitored, as well as its location: in the warehouse, by car and at the customer's [6]. As in the "Sensor readings" section of the main menu, after the user has modeled the object and clicked on the "Save changes" button, the application transfers him through the menu to the phone camera to take photographs (Fig. 3)
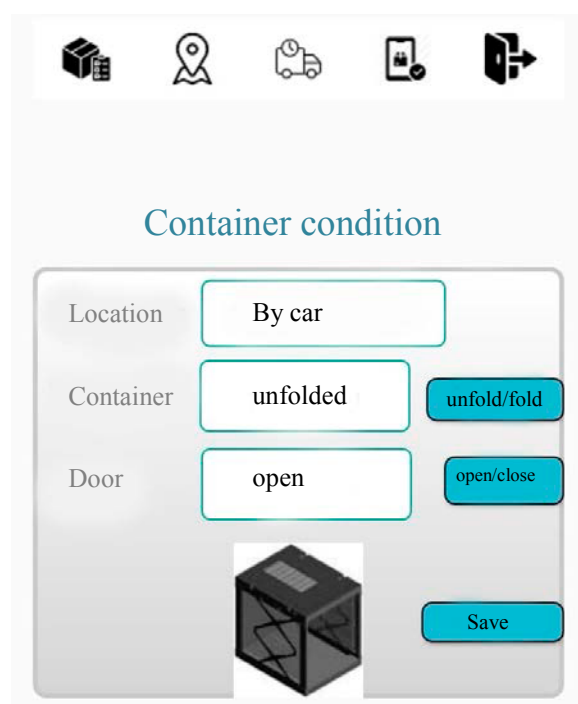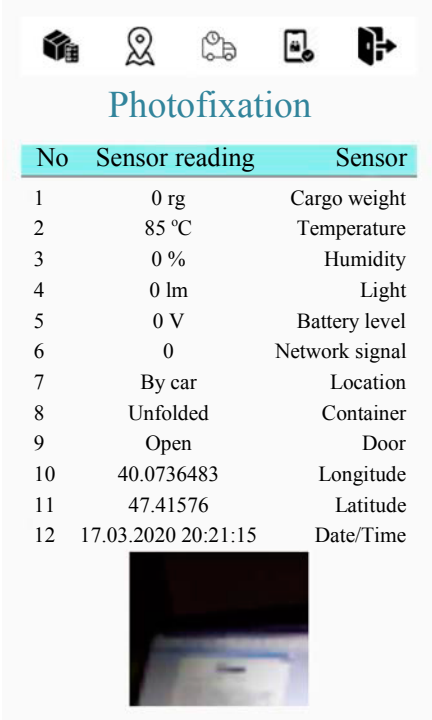

Fig. 3. Container condition

The "Photofixation" section of the main menu displays the latest readings of the transformer container sensors, as well as GPS coordinates. As a result, all simulated data is displayed in tabular form. The implementation of photofixation is a rather important component of the application since the client gets the opportunity to visually monitor the state of the cargo in the transformer container (Fig. 4).

Fig. 4. Photofixation

"SmartBoxCity" mobile application that simulates transformer containers has been developed to test the functionality of software using wireless technology and the Internet of Things. Data on the parameters of the transformer containers is transmitted to the server and recorded in the database. To test the created model, it is possible to enter your personal account, and, based on a previously created account, view the condition of objects in real time, track their location using Google Maps technology [7]. It is possible to make settings that imitate the "behavior" of the transformer container through the mobile application. The data obtained by this simulator is used to solve logistics problems of the cargo transportation optimization.

Research Results. Thus, we can conclude that the user is able to exercise full control over the process of modeling the transformer container behavior through the simulator application.

The components developed as part of the simulator application are the basis for testing the future information system, which provides the implementation of the information component of the motor transportation infrastructure software to support and optimize logistics tasks.

Fig. 5 shows the developed architecture of the information system, which has been tested to support work with a variety of transformer container simulators and has shown resistance to loads and completeness of functionality for solving and optimizing logistics tasks.
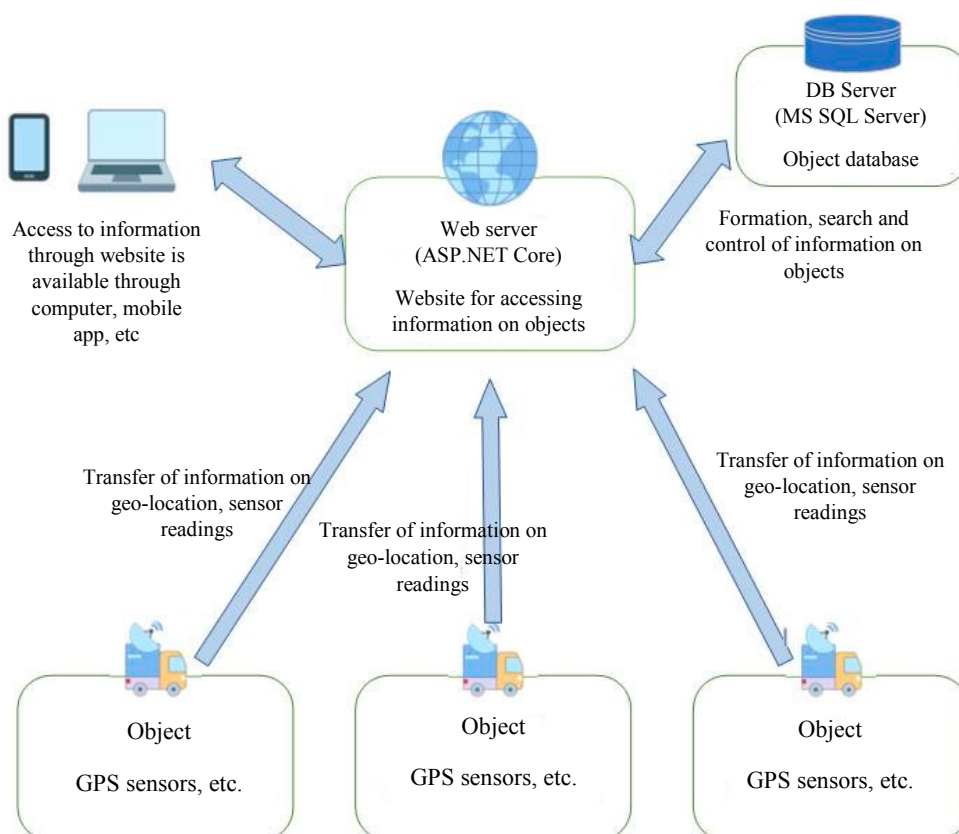
Fig. 5. Architectural scheme of the system

In the process of the software implementation, a web server that provides processing of information received from the developed mobile application, a simulator of a container transformer, and also a subsystem for interaction with real sensors that are part of the object was organized were created [8].

Discussions and Conclusions. The created simulator will provide the user with simulation of the container behavior and tracking all kinds of readings of its sensors. It is an integral part of the software for its debugging and testing when organizing a single space for monitoring and optimizing cargo transportation using "smart" transformer containers under trucking for population and legal entities in an urbanized environment.

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Claimed contributorship

A. A. Korotky: basic concept formulation; the text revision. D. A. Yakovleva: text preparation; analysis of the research results; formulation of conclusions; A. A. Maslennikov: research objectives and tasks; correction of the conclusions; the text revision. description of the programmable simulator. I. V. Golovko description of the programmable simulator.

All authors have read and approved the final manuscript.