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Prototyping of the remote monitoring system of battery condition of the electric vehicle

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Abstract. Presently, one of the current problems of electric transport is the lack of means of effectively carrying out remote monitoring of the vehicle condition. Most of the actual devices meet the challenge of determining the coordinates of the monitored vehicle and in no way assist the driver in the vehicle diagnostics. Within the framework of this project, the hardware design and development have been carried out allowing remote communication with the CAN vehicle bus using wireless data interfaces Bluetooth and Wi-Fi, as well as via the Internet. The software part, represented by the Android client application and the server-oriented application complex, has been designed and implemented. The developed software system is distributed, the system modules communicate via the HTTPS protocol. This approach enables to distribute the computational load in the system and allows the “partial” system activity in case of failure of any unit.

1. Introduction

Current trends of the global transport engineering development are characterized by the mass adoption of electromechanical drives as part of powertrains. This is largely conditioned by the need to reduce the vehicle own cost under potential growth in the cost of hydrocarbon resources, as well as demands for the polluting emissions level. Thus, the electric vehicle market is one of the most promising markets for the automotive industry.

According to the applied terminology, an electric vehicle is a wheeled vehicle driven by one or more electric engines that receive energy from batteries (rechargeable battery), capacitive storage devices and (or) fuel cells, the vehicle intended for moving on public roads [1]. At the moment, the most common and mass-produced type of electric vehicles is a battery-powered electric vehicle [2].

Despite all the electric vehicle advantages, more incentives are needed to force people to purchase this kind of vehicles. One of these incentives is systems that allow remote vehicle diagnostics. Since the diagnostic system should be convenient and user-friendly, one of the most promising solutions for displaying data to the user is a mobile application.

2. Comparative analysis of existing solutions

Comparative analysis of the functional characteristics of the most developed applications for electric vehicles has been performed to determine application requirements (table 1).

As follows from the analysis, the majority of mobile applications for electric vehicles implement not only vehicle diagnostic functions, but signaling functions as well as some multimedia system functions. However, it stands to mention that users have access only to “basic” diagnostics, i.e. it is impossible to detect the traction battery state accurate to the element and, therefore, it is impossible to carry out timely diagnosis of battery systems.
Thus, based on the analysis and in accordance with the technical requirements of the work “Development of scientific and technical solutions for the realization of the Russian combined power plant for small city buses and suburban buses”, carried out in the framework of the Agreement No. 14.574.21.0178 (works unique identifier: RFMEFI57417X0178) and with financial support from the Ministry of Higher Education and Science of the Russian Federation, a list of electronic system functions for remote monitoring of the traction batteries state has been formed:

- diagnostics and indication of the traction drive system and the battery (cell voltage, battery breakdown, traction drive and battery errors, component temperatures);
- statistics with the economy (way of driving, energy consumption per 1 km, energy consumption by auxiliary systems);
- routes and charging strategy computation (map with charging points, calculation of mileage, taking into account consumption, assistant to arrange the most convenient routes);
- computation of optimal traffic and guaranteed travel of the assigned route during the day, determination of the current autonomous driving distance, taking into account energy consumption.

The main purpose of the developed pilot system is to provide the vehicle owner with the possibility of remote condition monitoring. In case the vehicle is a commercial one, the roles of driver, operators and computer manager are distinguished. The driver has access rights only to the vehicles assigned to him, the operator has access to all vehicles, and the computer manager can execute databases management.

3. Software part design

To meet all the requirements for the system, decision was taken to divide it into 2 parts: client and server. This approach will allow both to diagnose a vehicle in the immediate vicinity, and to carry out remote diagnostics via the Internet. Moreover, the server allows storing a larger amount of data compared to a memory card, which is especially important for analyzing the vehicle condition. Meeting the project requirements, the software part architecture of the system was developed (Figure 1).
The software complex consists of the so-called “back-end”, represented by five services (session service, car service, state service, statistics service and aggregation service), and the “front-end”, which is a client Android mobile application.

Session service is responsible for the user session and implements the following functions:
- user registration (driver or operator / computer manager);
- receiving and changing user data, removing a user;
- user authentication (session check);
- user authorization (login);
- logging off.

Car service is responsible for storing information about the vehicle and implements the following functions:
- vehicle registration in the system;
- receiving and changing data on the vehicle, removing the vehicle from the system;
- connecting the vehicle to the user (allows the user to view information about the vehicle).

State service stores information about the vehicle’s diagnosable systems (only traction batteries at the first stage) and carries out the following functions:
- the vehicle diagnosable system last status;
- diagnosable system reference during the specified period;
- new state record of the diagnosed system.

Statistics service performs the following functions:
- receiving statistics of adding records for the last week;
- receiving statistics of operations for a selected period of time.

Aggregating service performs request routing (all system requests pass an aggregating service), degradation of functionality, etc., and provides an external API for the front-end part of the software package and third-party applications.

As an example of the server part functioning, a conceptual model for requesting a list of vehicles available to the user is shown in Figure 2.
Figure 2. Detailed conceptual model of the request for the list of vehicles available to the user in IDEF0 notation

Front-end is a mobile Android application for Android 6.0 version and higher. This application is designed to provide a user interface that allows to visually monitor the status of the vehicle systems. According to modern requirements, the user interface in the developed system should have the following characteristics:

- Adaptability to the screen size - the user interface “adapts” to all possible sizes of device screens: mobile phones, tablets, etc. Depending on the screen size, the size of controls and structure of some elements are changed.
- Accessibility in triple-click - any application window should be available in triple-click from the main window.
- Intuitive interface - all buttons have names, many contain icons that facilitate user perception. Standard control is used.
- Quick responding - minimizing the size of the contents of the application window.

4. Discussion and results
On completing the development stage, a hardware block was assembled (Figure 3), having the following characteristics:

- Rated operating voltage - 24 V
- Rated load current - 500 mA
- Wireless module - ESP32
- Wireless Interfaces: Wi-Fi, Bluetooth Classic, BLE
- Wired communication interfaces: 2xCAN2.0B, UART
- GPS module
- GSM module with dual SIM card support
- SD card slot
- Housing material - plastic
- Weight - 730 g
User interface development has been implemented through the Xamarin framework. This framework was chosen for the following reasons:

- Microsoft official support and, as a result, high-quality integration of the tool into Microsoft products (for example, Visual Studio);
- cross-platform, which is subsequently necessary for the commercialization of the product and its marketing;
- C# development language.

Figure 4 shows the photos of the phone with the live application.

5. Conclusion

As a result of this work, a prototype of remote monitoring system of traction batteries condition of an electric vehicle was developed. The following competitive advantages of the project were identified:

- As opposed to the solutions offered in the market, the developed system provides simultaneous access to information on the traction batteries state for the driver and operator (not only corporate, but also personal monitoring).
- As opposed to the products of other Russian developers (StarLine, R-telematica, SpaceTeam, Smart Driving Laboratory) local monitoring is available via wireless interfaces and remote monitoring via the Internet.
- The possibility of diagnostics and indication of the traction batteries state (cell voltage, battery degradation, battery error, etc.) is implemented.

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