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## Distributed control system for mobile medical complexes.

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**Abstract.** Currently, high-tech service robotics is increasingly developing. Service robots perform various tasks: patient care, condition monitoring and alert medical personnel and patient registration. In connection with the urgency of the task, this article will consider a distributed control system for mobile complexes, which task is to control, manage, and distribute tasks for complexes for the operation of re-equipping hospital wards and transporting mobile equipment in a medical institution. For more accurate route building, a local positioning system can be used. Now there are no ready-made algorithms for solving such problems. There are algorithms for managing single complexes, complexes in a closed space, and the problems of transition from the initial state to the final state have not been considered either. In this connection, a number of problems arise, which are considered in this article: transfer of medical complexes from the initial state to the final state, determination of initial parameters and conditions, determination of final parameters and conditions. During the task creation with a distributed control system, the following factors should be taken into account: the availability of the resource required for delivery on the mobile complex, the priority of the task being performed. The practical significance of the work will be determined by the result of the development of a mathematical model that will take into account all current problems and factors. As a result, a theory was determined by which the theoretical aspects were analysed and the closest toolkit of interactions within the control system in a distributed environment was selected.

### 1. Disclosure of the concept of a mobile service robot

Now the role of medical service robots in the world is increasing, but this is mainly manifested in the development of service information systems. This article describes an automated medical system that is responsible for transporting service medical equipment to wards, based on RFID positioning system-using triangulation. The robotic system described in the article is intended to facilitate the work of medical personnel, since there is often a shortage of skilled workers in medical institutions. Using the local positioning system, the robotic complex, coupled with mobile equipment and mobile cabinets for medicines, will be able to move them around the medical institution in an automatic mode, as well as to re-equip the operating rooms and other chambers.

Accuracy of positioning at the optimum (from 4x to 1 room) number of access points is 30 cm, so the sensor system is present in the complex for accurate positioning of the object in the room. Also, this system is responsible for the exclusion of cases of the human factor.



The algorithm for moving the robotic complex work as follows: RFID tag is installed on the complex that receives data from the application server, requesting data about its own location, a signal about movement to the required area is sent from the control panel or in the automatic mode. In the Arduino IDE programming environment (Arduino C++ code), an algorithm was implemented that allowed the exchange of data between the server and the robotic complex.

Piece Arduino IDE C++ library for control RTLS System

```
void GetCoord()
{
  HttpClient client;
  char c;
  //Get coordinates
  client.get("http://192.168.99.5:9002/location/B0B448D4E282/get");
  String coordString = "";
  while(coordString == ""){
    coordString = "";
    while (client.available()) {
      c = client.read();
      coordString += c; } }
```

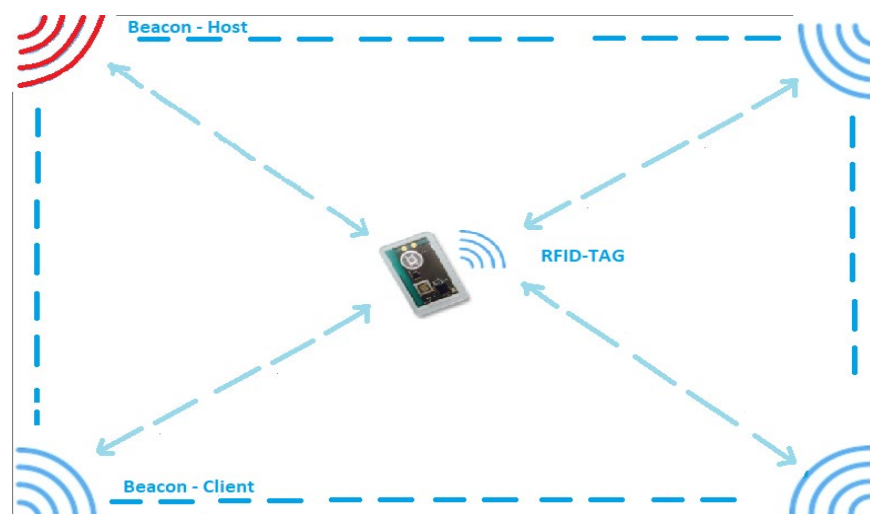
Testing of this program was carried out on the model of the robot. When assembling of which were used boards ShieldBot and Seeduino CLOUD, Optical distance sensors, Gyroscope. As a result of testing, the following practical results were obtained:

- the possibility of determining the robot coordinates in automatic mode and using them for movement;
- test routes were compiled, on which the robot performed the movement in real time. Real-time route change by the operator's command.

## 2. The principle of operation of the local positioning system RTLS.

The positioning system consists of several components:

Access points that contain RFID and WIFI modules, as well as one or several points, are "hosts" connecting to other points in an independent mode, exchanging the received information, and transmitting it to the server of the local positioning control system as well as the API application server [6].



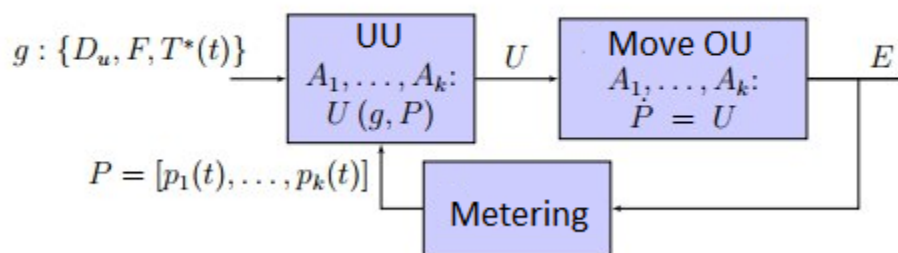
**Figure 1.** Figure with Real-time Locating System.

The location server described above performs the reception and transmission of signals from access points, is responsible for visualizing the information necessary for the operation of security systems and other needs, the server is based on the RTLS technology (Real-time Locating Systems - Figure 1) contact robot and local positioning system. The basis for this article is the RealTrac local positioning system, but any other similar system based on the principles described above can be used. Servers use the open operating system Linux Debian 8.

### 3. Mathematical algorithm for mobile service robots movement.

Control block diagram of a multiple system of  $A_1, \dots, A_k$  as a whole. OU - control object (equipment position). (see figure 2)

CU is the set of control devices of all equipment,  $U$  is the control generated by equipment based on parameters  $g$  and measurement results;  $E$  reflects an error in the formation of a system corresponding to the target geometric structure of the system.



**Figure 2.** Block diagram multi-system control.

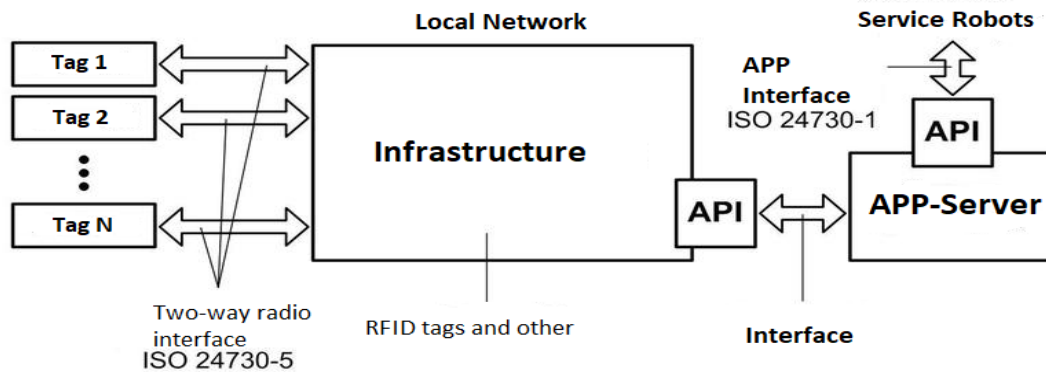
The practical significance of the work is determined by the result of the development of a mathematical model that will take into account all current problems and factors.

### 4. Distributed control system for mobile medical complexes.

To improve the accuracy of work and obtain the location data of medical complexes, a local positioning system (LPS) can be used for confined spaces.

The RTLS consists of several components: Access points that contain RFID and WIFI modules, as well as one or several points are “leading” connecting to other points in an independent mode and exchanging the received information and transmitting it to the server of the local positioning control system, as well as to the API application server (see figure 3), as well as radio tags that are part of a single information and management positioning system and are designed to determine the exact location of the object in the medical area facilities.

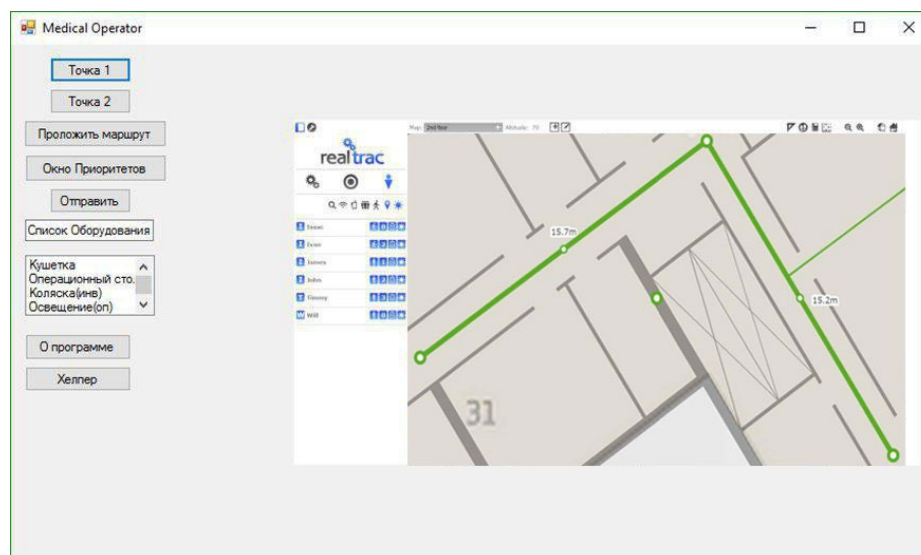
The application server provides the possibility of contacting the management system, the medical service complex and the RTLS. This article is based on the RealTrac RTLS, but any other similar system based on the same principles can be used.



**Figure 3.** Schematic diagram of the operation of the RTLS and the Distributed Control System through the API.

After authorization, it is possible to send service complexes in a medical institution by points [5] But only if the map is loaded and route graphs are added. (see figure 4) As for controlling the control points, the web application is used with the subsequent query of the coordinates of the points when pressing the buttons in the program and then using the coordinates data for sending to the mobile equipment.

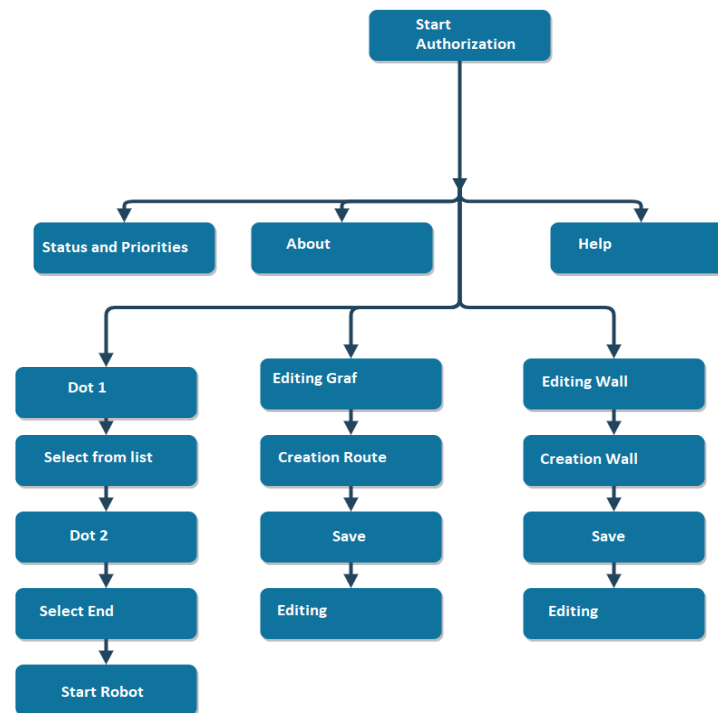
The route of the graph can be edited directly in the application window, just pull the vertices of the graph. All settings of the map, routes and walls are performed in a web form. Interface elements appear if the mouse cursor placed on the map of the medical institution. To send equipment you need to select it in the list or click on it on the map (pin). Press the “Dot 1” button to confirm. Select a destination and click “Dot 2”. To confirm, click the route button. The route graph selected by the system (the shortest path) will be displayed.



**Figure 4.** Dialog box of the developed distributed control system (in Russian language only)

After pressing the “Send” button, the array of coordinates of the selected route will be transferred to the equipment via a wireless connection, and the service complex will start moving to the specified point. Also the equipment priority will be changed in the priority window. In the graph editing

window it is possible to edit the track route of the mobile complex. All possible options for interaction with the program are indicated in the dialog box (see figure 5).



**Figure 5.** Graph of the distributed control system dialogue

As a result, a theory was determined by which the theoretical aspects were analyzed and the closest toolkit of interactions within the control system in a distributed environment was selected.

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