DEVELOPMENT OF PRIMARY MEDICAL EXAMINATION TERMINAL AND PRE-REGISTRATION OF PATIENTS

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Summary. *The system of automated primary control and online monitoring allows you to quickly remove the data of primary medical control for a partial assessment of the state of health, keep an electronic diary of primary medical examinations, and / or prompt registration with a specialist doctor. For development, a microservice architecture was used in which the application consists of a set of small independent services that interact with each other through the API. The technology for developing the application will be ASP.NET Core, Message bus. The concept of Networking access is used to exchange data and resources. API Gateway is used to simplify access to security microservices, access control, improve performance and scalability. The mechanism of interaction between the application and the terminal is implemented using the API. After determining the basic technological structure of the terminal and its functions, the main functional map of the terminal was identified and created. A system based on a network of interconnected Arduino Uno programmable microcontrollers was chosen as the main mechanism for distributing and processing information.*

Keywords*: telemedicine, software, hardware, health monitoring, monitoring terminal, microservice system, web platform*

Introduction

The human body generates a lot of electrical and non-electrical signals, which are the result of the performance of its functions by the organs or tissues that make up the human body. The selective measurement of the signals generated by the human body allows obtaining useful clinical information about the specific state of the human body. Biomedical signals allow to conclude the current state of the human body by extracting information from the biological system [1].

One of the first steps in contacting a doctor is the triage step, or the step of collecting patient data. Determining the main indicators (temperature, blood pressure, pulse, saturation, weight and height) during the reception or before it with the help of manipulations by medical personnel creates certain inconveniences associated both with the discomfort of the patient and the doctor, and the duration of the examinations and the overexpenditure of the efforts with side of medical workers. The number of medical personnel involved is not always proportional to the flow of patients.

In the absence of a specially equipped medical office and a qualified employee, it is necessary to organize staff visits to a specialized medical center, which is very energy / financial / labor intensive.

The human factor in the preliminary examination of patients.

Advantages of remote examination: Facilitate the work of medical personnel; Speeding up the medical examination procedure; Impartiality of the results of the medical examination. Control system. Automated primary control system designed to carry out operational medical monitoring in order to detect such changes in the state as: excessive fatigue, fever; tachycardia or bradycardia; rhythm disturbance; increase / decrease in blood pressure, etc.

The online health monitoring system allows you to: have a partial assessment of the state of health according to primary indicators, set an electronic diary of primary medical examinations and not only, a permanent health monitoring by the family doctor, it is not necessary to go to on site to receive indications and/or registration with a specialist doctor.

The benefits of using the system are numerous and presented at different levels. For the state - the availability of medical care to the population in remote, hard-to-reach settlements, Monitoring the effectiveness of providing medical care to the population, assistance to labor protection and safety services in assessing the impact of working conditions on workers; For the healthcare service: acceleration and automation of the initial examination procedure, efficient use of the time of workers in the field of primary health care, obtaining information by the doctor about the patient's complaints and his main indicators before the patient's admission, The possibility of using artificial intelligence, Telemonitoring of chronic patients and rehabilitation patients, Effective fight with the spread of viral diseases, for patients, the availability of medical care anywhere and at any time, the availability of primary medical examinations and appointments with a doctor for the active population, self-monitoring of health status, due to the possibility of regular monitoring through terminals installed in accessible places.

Software and interface development

The terminal is intended for conducting a primary medical examination based on an analysis of objective indicators of the user's functional state and entering data on his well-being. The terminal automatically provides the whole range of examinations, general thermometry, blood pressure measurement, pulse examination. Also, the terminal allows you to automatically assume easily diagnosed diseases and redirect to medical personnel, or, in case of uncertain symptoms, take a primary history.
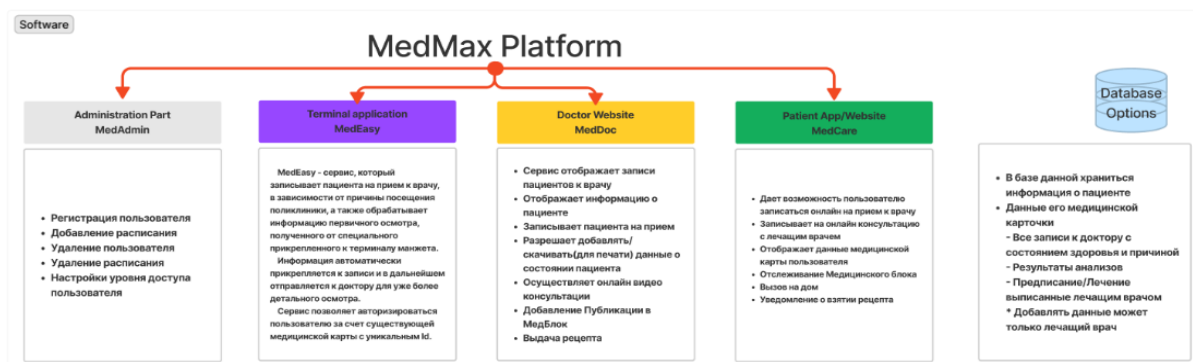

Figura 1. MedMax Platform functionality

After receiving data from Arduino, you need to create a service for working with data and their further application.

Backend and frontend are the two main components of a website or application. The backend is the backend that runs on the server side and handles requests from the client, while the frontend is the client side that runs on the user's browser side and is responsible for displaying content.

To create the technical part of the site, we determined the requirements for the functionality and other aspects of the site (Figura 1), developed the application architecture, choose the appropriate technologies and tools to implement the requirements.

The **microservice architecture** (Figura 2) was chosen as the architectural style. Here, the application consists of a set of small independent services that interact with each other through an API.

The technology for developing the application will be **ASP.NET Core, Message bus**.

ASP.NET Core provides tools for building microservices, including RESTful API support, built-in Swagger integration for API documentation, and testing and deployment tools.

Message Bus is a technology that allows microservices to communicate with each other through asynchronous communication. Instead of directly calling services, microservices send messages through the Message Bus, which delivers them to their recipients. This allows you to reduce the dependencies between microservices and improve the scalability and fault tolerance of the system. In .NET, various technologies can be used to implement a Message Bus between microservices, such as Azure Service Bus, RabbitMQ, Kafka, and others.
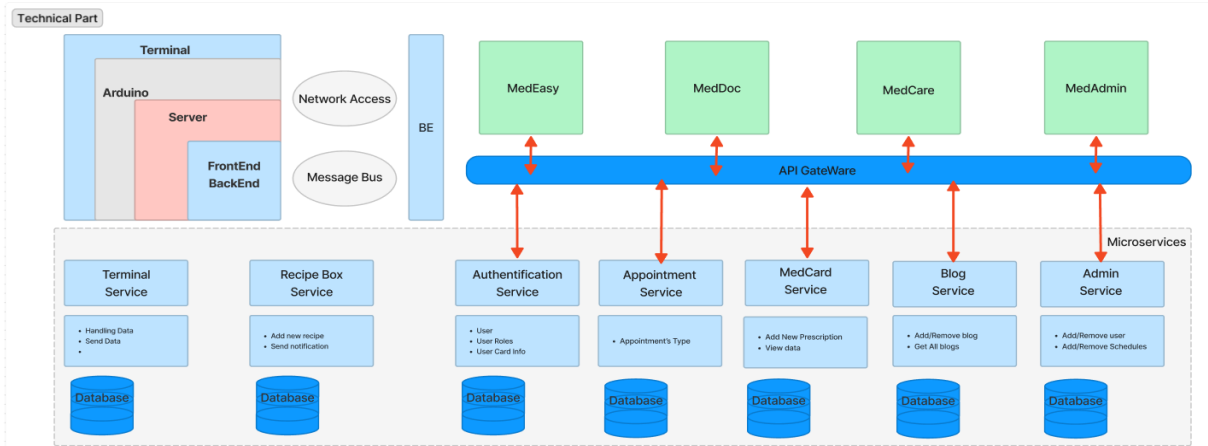

Figura 2. General Application Architecture

The concept of **Networking access** is used to enable devices and applications to connect to a network to exchange data and resources. Networking access is an important part of web applications and websites because these applications must be able to communicate with servers and other devices in order to download data and display it on the screen. Various technologies are used to achieve this goal, such as the **HTTP and HTTPS protocols**, the **TCP and UDP network layer protocols**, and programming languages for working with network protocols.

API Gateway is used to simplify access to security microservices, access control, performance and scalability. It provides a single interface for client applications, hiding the complexity of working with microservices and providing a single point of entry.

The backend and frontend interact with API Gateway as follows:
- Frontend sends requests to API Gateway using a single interface.
- The API Gateway checks the access rights and authenticates the client if necessary.
- The API Gateway forwards requests to the appropriate microservices and processes the responses from the microservices.
- The API Gateway can perform data transformation, caching, rate limiting, and other functions.
- The backend receives responses from the API Gateway and processes them to return data to the client.

To receive data from the terminal to the service, it is necessary to implement a mechanism for interaction between the terminal and the server. The service must be hosted on a server, which can be local or remote. The message bus and network access are used to provide communication between the terminal and the service.

Development of a block of sensors and transmission protocols

To receive data from an application on a terminal, it is necessary to implement a mechanism for interaction between the application and the terminal. This can be done with an API that allows the application to communicate with the terminal.

To conduct a full-fledged primary examination and obtain basic ideas about the patient's condition, the following measurements were chosen:

1. Patient temperature.

2. Patient's blood pressure.
3. Saturation of the patient.
4. Patient's pulse.
5. Body weight of the patient.

Having determined those indicators that should be read and transmitted in the form of information in the first place, the question arose of implementing the definition of each of the indicators, as well as their transfer both to the screen for visual presentation, and to further processing on the server side for subsequent transfer to the doctor for a full examination, diagnosis and further medical procedures.

The possibility of rapid delivery of medical drugs to patients was also determined to speed up the work of medical institutions, for the implementation of which a system was developed based on transport boxes mounted inside the terminal.

After determining the main technological structure of the terminal and its functions, the main functional map of the terminal was identified and created (Figure 3). A system based on a network of interconnected **Arduino Uno** programmable microcontrollers was chosen as the main mechanism for distributing and processing information.
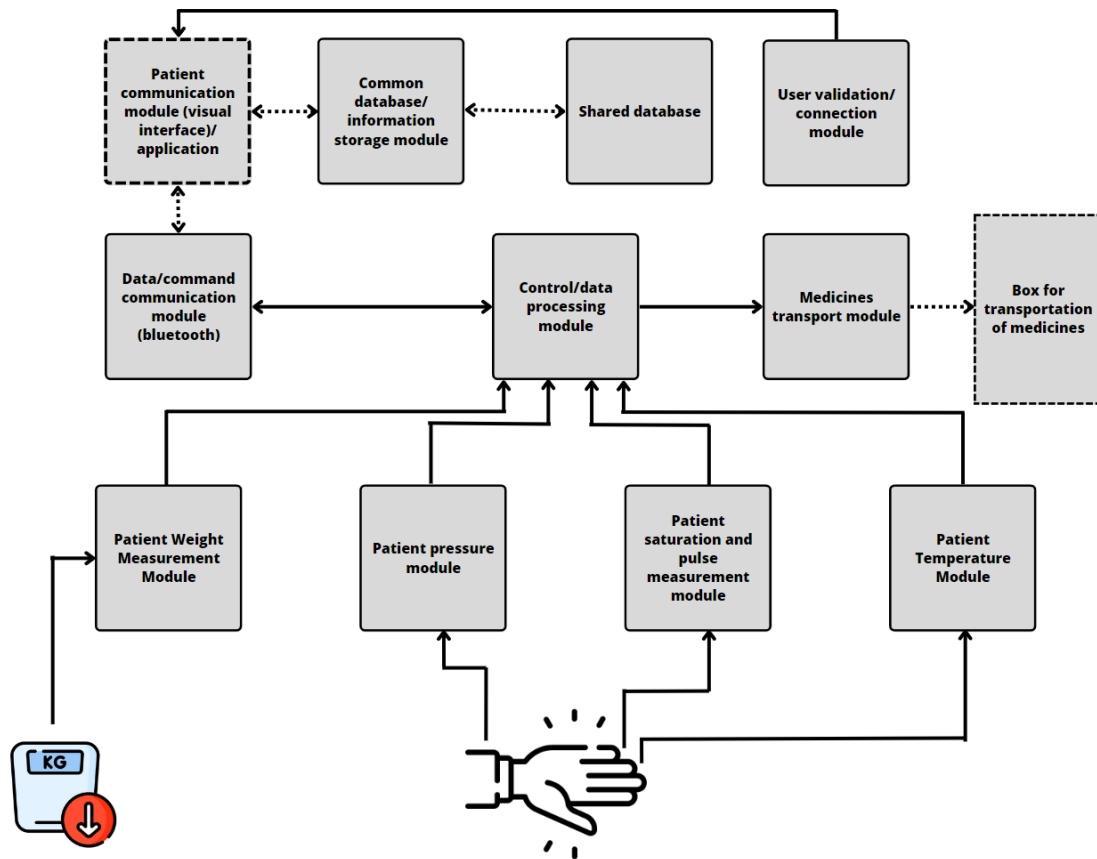

Figure 3: Functional card of the terminal

Arduino is a handy microcontroller with a wide variety of functionality, with the ability to create AC and DC, as well as a large number of pluggable ports and, last but not least, extreme programming convenience thanks to a large documentation base, an extensive number of created libraries and clear update cycles that allow to process the received information in an optimal format.

On the functional map, a module consisting of interconnected controllers is located in **the central part (control/data processing module)**.

To perform the functions of connecting related components and circuits at the first, prototyping stage, a connection scheme was chosen through **Breadboard** – a tool for manufacturing

a prototype of an electronic device without the use of soldering. Its main advantage is that changes can be easily made to a device assembled on a breadboard.

After determining the control core of the terminal, the question arose of taking the above-mentioned indicators, which led to the definition of more detailed systems related to measuring the patient's current indicators.

1. **Temperature (patient temperature measurement module)** - is a system consisting of an appropriate temperature sensor (MLX90614ESF-ACF-000-TU) and the corresponding Arduino connection circuit (Figure 4 a), b)). The choice was made in favor of optimizing the duration of the study and the high accuracy of the data obtained.
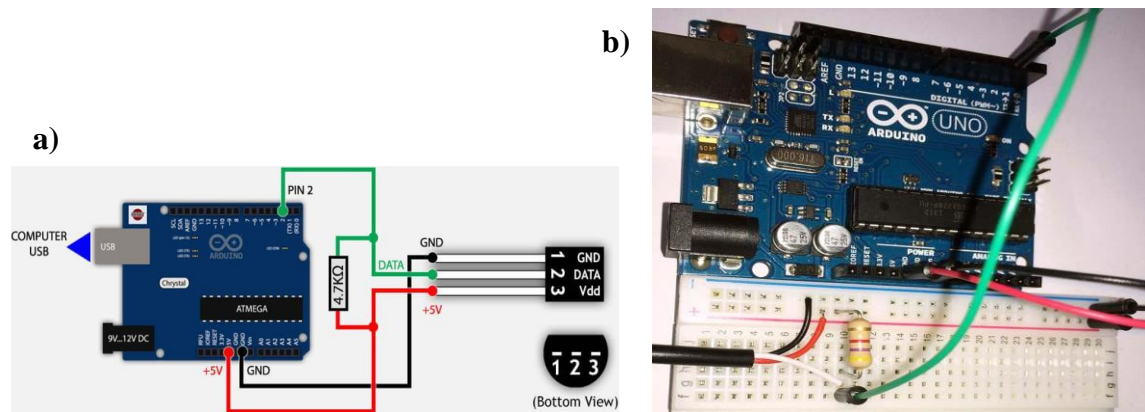

**Figure 4: a) Temperature sensor connection diagram,
b) Connecting the finished circuit through Breadboard [2]**

As follows from figures 4 and 5, the temperature sensor is connected to the Arduino microcontroller with 3 main pins. (**Pin -** contact connection of the microcontroller with an electrical circuit). These are the pins and their respective functions:
1) Pin2 – data
2) 5V – Vdd
3) GND – ground, grounding.

2. Pulse oximetry - system for collecting patient data on pulse and **saturation -** the fraction of oxygen-saturated hemoglobin relative to total hemoglobin in the blood.

In order to collect these indicators, it was decided to compile and apply an appropriate circuit based on a pulse oximetry data collection sensor, as well as a display (for the basic version) and an Arduino NANO microcontroller, for primary processing of the received data, as well as for the correct functioning of the circuit.

The final circuit can be seen in Figure 5.

In further development, there is a possibility of replacing the self-assembly of this module with an integrated module of real pulse oximeters, supplemented by a signal filtering system and data acquisition.
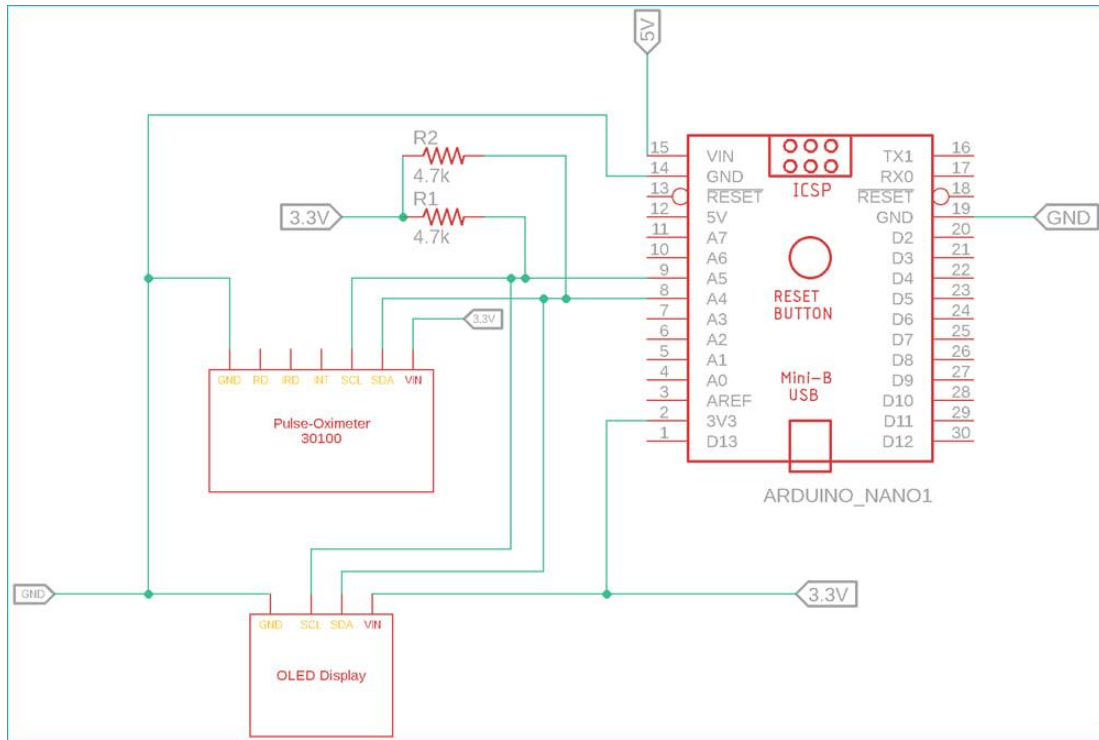
Figure 5: Pulse oximetry module [3]

3. Pressure is a system for collecting patient indicators about the state of his blood pressure. After an in-depth study, a schematic diagram of the module for measuring this indicator was revealed, which is presented in Figure 6.

The main collection of information is carried out by a pressure sensor, and the information received is processed by a microcontroller, which also provides control over this module in the process of collecting information.
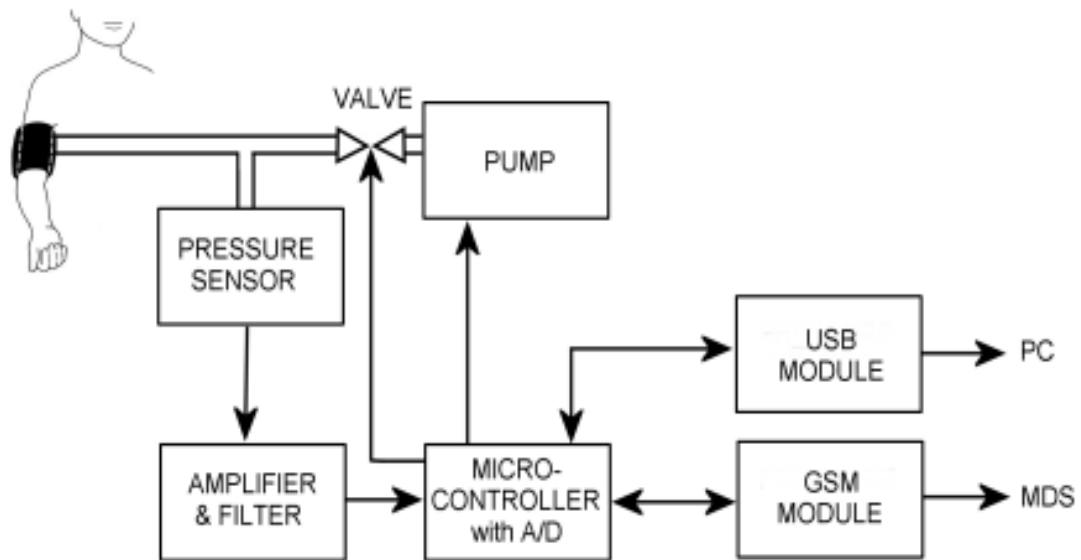

Figure 6: Pressure measurement module [4]

Due to the complexity of developing our own module, and also due to the fact that in this case the final device will be much less convenient to assemble and will be more expensive, it was decided to introduce a real pressure measuring device as this module, combined with a filtration circuit of the finished signal and data processing on the control module (Figure 3).

Conclusions

In general, the medical terminal described in this article represents an important step towards improving primary health care. Through the use of pressure sensors, Spo2 measurement and temperature, the terminal is able to carry out primary medical examination and enter data into the database and keep records of the patient's visit and health status. This simplifies the doctor's appointment process, making it faster and more efficient, especially for those who live in remote or remote areas.

In addition, the use of .net 6 technology and the application's microservice architecture makes it possible to provide fast and efficient patient care, as well as provide security and data protection.

Finally, the application associated with the terminal provides additional features such as online doctor appointments and additional functions. Overall, this new technology in medicine represents an important step forward in improving the quality of medical care.

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