A Web Application to Promote Blood Donation in Russia

Pavel Smirnov
Institute of Computer Science and Technology
Peter the Great St.Petersburg Polytechnic University
St.Petersburg, Russia
smpashts@gmail.com

Vera Malinovskaya
Institute of Computer Science and Technology
Peter the Great St.Petersburg Polytechnic University
St.Petersburg, Russia
malinovskaya.vv@edu.spbstu.ru

Nikita Voinov
Institute of Computer Science and Technology
Peter the Great St.Petersburg Polytechnic University
St.Petersburg, Russia
voinov@ics2.ecd.spbstu.ru

Abstract—**The paper is devoted to the issue of blood donation and possible ways to promote this activity using modern information technologies. Existing software solutions are analyzed and new Web application is proposed to implement all features required for potential blood donors to make this process clearer and more comfortable.**

Keywords—blood donation, software requirements, web application, client-server architecture

I. Introduction

Gratuitous blood donation is a very important phenomenon for maintaining public health. Transfusion of blood and its components is required in many situations, such as surgery and emergencies. Many medical interventions would not be possible if voluntary blood donors did not exist.

Today, blood transfusion services around the world face two main challenges. The first of these is a guarantee of the quality and safety of blood. Quality control of donated blood allows medical professionals to be sure that in case of an emergency, the recipient of blood will not be harmed. The second important task is to ensure sufficient blood supplies. In spite of the fact that the first problem has been solved in recent decades, the problem of the shortage of donor blood is still acute in Russia. Today, according to the National Medical Research Center for Hematology [1], only 1.7% of Russians donate blood and its components [2]. However, to ensure a sufficient stock of blood, it is necessary to ensure at least 4% of the population to be donors.

To popularize voluntary blood donation among the population, it is necessary to make this process comfortable and pleasant. While the process of blood sampling itself is the business of medical professionals, it makes sense to provide all the previous stages, for example, searching for a blood donation point, registering for a donation, or filling out questionnaires on contraindications, using online services that allow the donor to quickly go through all these stages.

Another important task is to ensure the regularity of donations from each donor with an optimal interval between two donations of 3-6 months [3]. It is very important that the donor comes for the next donation exactly after this period, then his newly donated blood will be checked for infections therefore the old blood will be removed from quarantine and available for transfusion. To achieve this goal, the integration of the service with SMS or e-mail reminders about the opportunity to donate blood again can help.

Another problem is the suspension of a donor due to temporary contraindications (for example, vaccination, or a recent infectious disease). The solution to this problem could also be automatic reminders via SMS or e-mail after the expiration of the suspension of the donor.

In addition, today in Russia there is no possibility of universal registration at any donor center. To sign up for a donation, you first need to independently find the nearest blood donation point on the Internet, then find its website or a service for registration at this point and fill out an application. Consequently, there is an urgent need to create a single donation registration service.

Outside of Russia, there are applications that can solve some of these problems, but in all applications available on the Russian market, there is no functionality that is critical for comfortable interaction between donors and the blood service.

The main idea of this work is to develop an application that could be used in the Russian market and would enable donors to interact with blood donation points easily and conveniently. The creation of such application, considering successful foreign analogues, could, to varying degrees, solve the above problems, make the process of voluntary blood donation comfortable, and, possibly, attract new volunteers.

II. Current issues in the scope of blood donation

In this section several relevant works are reviewed to identify the most important requirements that an application should meet.

A. Global guide towards voluntary blood donation

The problem of an insufficient number of donors is acute in different parts of the world. To help governments move towards solving this problem, the World Health Organization [4], together with the Red Cross, has developed a global action plan to expand blood donation in countries around the world [5]. This publication outlines 20 strategies to help countries promote voluntary blood donation. Some of these strategies are of interest in this research work.

Strategy 2. Establish a national voluntary blood donation program.

Among other things, this strategy recommends raising donor awareness, and one of the steps to achieve this goal is to use communication tools for donors and blood services. Today in Russia there is no convenient and universal way to communicate with donor points, but the proposed application will create the ability to quickly correspond with any blood donation point using chat.

Also, this strategy proposes to store data on temporary or permanent contraindications of donors, successful donations, and test results in a centralized database, in order to then use this information to alert donors.

Strategy 4. Understand blood donors.

This strategy proposes to explore the factors that positively or negatively influence the motivation of donors, as well as the things that deter people from voluntary blood donation. In these terms it is proposed to create a section in which donors can leave feedback about the donation, as well as about the blood donation point itself.

Strategy 13. Keep in touch with infrequent, inactive, and suspended donors.

This strategy states that donors who donate blood infrequently, or for some reason have stopped donating blood, are one of the target groups to attract donations. It is mentioned that returning former donors to blood donations is much less laborious than attracting new ones. Inactive donors may simply need to be reminded of the importance of their donations and invited to a new donation visit. Therefore, it makes sense to create an e-mail notification system for less active donors, and donors suspended due to temporary contraindications.

The next step is to segment the donor data according to variables such as the length of time since the last donation, the place of donation, and the total number of donations. This will make it possible to identify priority donors who have left; for example, it will be easier to reactivate a donor who last visited a donor site two years ago than one who donated blood ten years ago.

Strategy 14. Retain regular blood donors.

This strategy addresses the various motivations for voluntary blood donation and suggests:

- Give donors access to their donation history, it is important that it is updated every time they donate blood.
- Establish an easy appointment system, encourage donors to plan their next visit, and send a reminder in advance of the appointment using their preferred communication method (e.g., email, calls, or SMS).
- Identify donors with rare blood types and educate them about the importance of their blood type. Also motivate donors to donate blood during holiday periods or in critical situations when the number of donors is expected to be low.
- Conduct donor surveys to assess the quality of the blood transfusion service. Give donors the opportunity to leave feedback and suggestions for improving the blood donation process.

Strategy 16. Make blood donation convenient for donors.

Addressing issues that donors consider important goes a long way in strengthening donor loyalty and encouraging more regular donations. This strategy proposes:

- Optimize the donation process and donor flow by making the most efficient use of time.
- Establish appointments system to prevent delays and ensure a stable and manageable flow of donors throughout the donation process.

B. MHealth technology

The authors of the paper claim that only 1.8% of the world's population are blood donors, while the need for health systems can be met when 3 to 5% of people voluntarily donate blood.

In [6] the problem of increasing and maintaining the number of blood donors is considered. The authors of the paper believe that the use of mobile technologies in healthcare can increase the number of blood donors. To meet this need, a qualitative study was conducted to determine the availability of applications that support the activities of the Brazilian blood donation departments. As a result of this study, a list of requirements was proposed that an application must meet to be effective in recruiting blood donors, the most interesting of which are presented below:

- Registration of donors.
- Ability to schedule a donation.
- Identify contraindications to donation and inform the donor about them.
- Calculate and save the date of the next donation.
- Show the donor the closest blood donation point.
- Make an invitation to the donor to donate blood.
- Allow the donor to send invitations to friends to become a donor.
- Ensure constant communication with the donor via SMS messages.
- Allow posting infomercials and feedbacks in the app.
- Use gamification in the app (points, badges, etc.)
- Provide the donor with blood test results after donation.

Another useful result of this study was anonymous statistics on the popularity of using various functionalities. By collecting anonymous statistics about users of donor applications, it was found that the most popular functions are searching for information about blood donation, determining the nearest blood point, making an appointment to donate blood.

C. Russian specifics

Donors' blood scarcity is a major challenge in Russia nowadays. In [7] author investigates peculiarities of donor practices in Russia and considers obstacles to the dissemination of blood donation as well as motivation to donate blood.

It is noted that one of the reasons for the low involvement of Russians in blood donation is the lack of awareness about the process itself. Often, the reluctance to donate blood is associated with concern for health, for example, it is still widely believed that during donation there is a high risk of contracting infections. Therefore, potential donors should have access to accurate information and have at least a basic understanding of the field of blood donation.

Moreover, one of the obstacles is the laboriousness of the donation procedure. The practice of blood donation can be difficult to integrate into everyday life since the process itself is quite time-consuming. So, it is necessary to direct efforts to reduce the time spent by the donor at the transfusion point.

Apart from altruism, the author considers the opportunity to receive material rewards and benefits that are provided to all donors in Russia to be the major incentives towards blood donations. Consequently, it is necessary to inform both potential and active donors about benefits provided for blood donation.

All in all, the features of donor practice in Russia were highlighted, which are important to take into consideration while working towards the promotion of donation.

III. OVERVIEW OF EXISTING SOLUTIONS

Available Russian and foreign applications for donors were analyzed and summarized in Table 1 with the following numbering:

1) yadonor.ru (Russian blood service website) [8].

2) eliz-spb.ru/otdelenie-perelivaniya-krovi (blood transfusion point website) [9].

3) RedCrossBlood.org (American Red Cross blood services website) [10].

4) donorsearch.org (Russian donor community website) [11].

5) Proposed solution.

TABLE I. ANALYSIS OF EXISTING SOLUTIONS

Feature	1	2	3	4	5
Donor registration	+	-	+	+	+
Finding the nearest point on the map	-	-	+	-	+
Questionnaire with temporary contraindications	-	-	+	-	+
Registration for blood donation	-	+	+	-	+
Reminders for upcoming donations and opportunities to donate blood	+	-	+	+	+
Donor traffic light	+	+	-	+	+
Sorting donor points by donor traffic light[1]	-	-	-	+	+
Feedbacks	+	+	-	-	+
Chat with donor point	-	-	-	-	+
Donor point news	+	-	-	-	+
Viewing personal donations	+	-	+	+	+
Countdown to the title of "Honorary Donor"[2]	+	-	-	+	+
Analysis statistics	-	-	-	-	+
Intuitive interface	-	+	+	+	+
Russian language support	+	+	-	+	+

[1] *The Donor Traffic Light* is a system that aims to create an optimal supply of donated blood and alert donors to the need for blood components at a specific blood transfusion point (Fig.1). It is used throughout Russia, as well as in countries of the Commonwealth of Independent State [12].

A. *yadonor.ru*

The site *yadonor.ru* is the largest website for donors in Russia, it is the official website of the Blood Service. This site provides for the possibility of registering donors, allows you to view the donor traffic lights of different blood donation points, and also makes it possible to leave feedback on donations. There is also a convenient section with donation statistics and an interactive donation counter showing the required number of donations to receive the title of Honorary Donor of Russia.

The main advantage of this application, of course, is the support of the Russian language and the ability to receive data on donations from Russian blood donation points using unique donation codes. But a very serious drawback of this web-application is the inability to register for a donation, and as mentioned above, the most popular function of sites for donors is the ability to sign up at any convenient blood donation point. In addition, this site has a rather confusing and non-intuitive interface. However, interface intuitiveness to the end uses affects communicability, understandability, user satisfaction and these subsequently affect on system's usability [13].

B. *Websites of Russian blood transfusion points*

The only way to register for blood donation in Russia is through separate websites of blood transfusion points. Since the main functionality of these sites is limited and very similar, only one specific point is considered - the site of the transfusion department of the Elizabethan Hospital in St. Petersburg. This site allows you to view the donor traffic light of this point, find out the working hours, read the news of the change point. The sites of transfusion points do not provide other functionality, they do not allow donors to register, they do not allow receiving reminders of upcoming blood donations, and they do not allow contacting the staff of the blood collection point.

C. *RedCrossBlood.org*

Of all the considered analogs of the developed application, the RedCrossBlood WEB-application of the Red Cross public charitable organization, available in the USA and some other countries of the world, has the most complete functionality. This application allows users to conveniently search for blood donation points by location, allows them to register for a donation at any convenient point, manage upcoming donations, and view donation statistics in a convenient way.

The most interesting and important function of this application is the RapidPass technology [14], which offers donors to answer questions about their health when

[2] *Honorary Donor of Russia* is a badge which expresses recognition by the state of a citizen's contribution to the development of blood donation in Russia. It also allows the donor to receive some privileges and is a way to encourage donors in Russia [15].

registering for a donation, thereby either immediately learning about temporary contraindications, or simply reducing the time spent at the blood transfusion point. Another useful feature of this application is the ability to view data on blood tests and thus monitor the dynamics of donors' health.

D. donorsearch.org

DonorSearch is another Russian-language website for donors. This web-application is quite different from the previously reviewed analogues and rather resembles a social network for donors.

Just like yadonor it does not provide an opportunity to register for a donation, but it has a more intuitive interface, it also allows donors to independently keep a record of their donations and makes it possible to independently plan future donations. In addition, this site provides access to the donor traffic lights of various donation points and sends you reminders of upcoming donations.

IV. PROPOSED SOLUTION

In this work, it is proposed to develop a Web application focused on donors in Russia.

The application users should be able to get information about blood donation points in their city: opening hours, the ability to donate plasma, current news, and a donor traffic light. In addition, the possibility of filtering by distance from the current location and/or donor traffic light should be implemented.

Green color means that the blood of this group and the Rh factor[3] is in sufficient quantity. Yellow color means that the blood of this group and the Rh factor is not enough. Red color means that there is an increased need for blood of this group and the Rh factor.

Feedbacks can help donors to choose a blood donation point, on the other hand, point administration can receive feedback and suggestions on how to improve the blood donation process at a particular point and make blood donation as convenient as possible for donors.

The feed section will help transfusion centers to get the important information out to donors, as well as to draw more donors. This section is expected to include information such as the introduction of additional blood donation dates, emergency and critical blood need alerts, and additional donor incentives such as Donor Day, which will help maintain donor loyalty and serve as an additional motivation to donate.

Application user requirements and roles:

1) Donor:

After registration, the donor can specify personal information, including the preferred method of communication.

On the page of a particular donor point, the user will be able to view information about the point, current news, leave a review and read the reviews of other donors. In addition,

---

[3] *Rh factor* is an inherited antigen found on the red blood cells of most people and certain other primates: those with this antigen are Rh positive while those lacking it are Rh negative [16].

the user can ask any questions to the employees of the donor center in the chat.

Maps to display blood donation points and find the nearest point will be implemented via 2GIS API [17].

When registering for an appointment, donor is invited to fill out a blood donor questionnaire in order to identify temporary contraindications, as well as speed up the process of donating blood. The introduction of such a system has a number of advantages: it reduces the time that donors spend on donating blood up to 15 minutes; donors who pre-filled the questionnaire online are much more likely to show up to donate blood than donors who do not.

Fig. 1. Donor Traffic Light

In case the donor is temporarily suspended from donating blood, it will be proposed to set a reminder that will be sent to the mail after the expiration of the contraindications. Also, the user will be able to enable notifications with an invitation to donate blood after the minimum interval between donations.

In the personal account, an authorized user will be able to see the history of his donations, namely the number of donations made with detailed information about each of them. Before each donation, a blood test of the donor is carried out, so the results of the tests will also be available in the personal account. The results will be presented both as a table and as a graph, which will allow donors to track the trends in their health. Also, the personal account will display the number of blood and plasma donations that must be made before receiving the title of "Honorary Donor". Honorary Donor of Russia is a badge which expresses recognition by the state of a citizen's contribution to the development of blood donation in Russia. It also allows the donor to receive some privileges and is a way to encourage donors in Russia.

2) Administrator:

The administrator should be able to view the registry of donors and filter the data by the time elapsed since the last donation, place of donation, or total number of donations.

In addition to viewing a list of all donors, the administrator can view the personal information of a particular donor and find out his contact details with the specified preferred method of communication.

It is also possible to keep in touch with donors directly on the site: view chat messages and reviews on the page of the blood transfusion point and respond to them. In addition, the administrator can update the donor traffic light, publish, delete, and edit the news of his point.

V. CLIENT-SERVER ARCHITECTURE

To implement the application, a three-tier client-server architecture was chosen, which implies the presence of three types of components in the application: the application server, the database server, and the client application (Fig.2).

A. Server-side implementation

The Java programming language and the Spring Framework [18] were chosen to create the application server.

The server of the developed product itself is a Spring Boot [19] application that makes it easy to use all the necessary layers of the Spring Framework.

The interaction between the application server and the client application is proposed to be organized using the REST API [20] provided by the server. REST (English Representational State Transfer) is an architectural style of interaction between the components of a distributed application. It usually represents a GET, POST, UPDATE and DELETE HTTP requests. The data exchange format is JSON.

Fig. 2. Software architecture

To store all the information, the PostgreSQL database management system [21] was chosen. The database server itself is planned to be launched using the appropriate Docker container for development convenience.

The four main types of application server components are entities, repositories, services, and controllers. Entities describe the objects stored in the database, and the database itself is accessed using JPA repositories. One of the Spring modules (Spring Data JPA) [22] is used for this. All business logic is described in the service layer, and REST controllers are created to provide a strict REST API.

Secure access to REST API is organized using another Spring module - Spring Security. JWT (Json Web Token) [23] is used to authorize system users. The scheme for working with JWT consists of the following steps:

1) The user contacts the endpoint for authorization.

2) The server checks authentication while attempting to login. If the username and password are correct, a JWT is generated, otherwise the user will be denied access.

3) The server returns a token in the form of json-a, which is stored in the local storage of the client application.

4) When a user tries to access a secure API, a JWT must be sent along with the request.

The server verifies the token, and if it's valid, it opens access to the API endpoint. Chat messaging is planned to be organized using WebSocket [24], a thin and lightweight layer over TCP, and the messaging protocol that is planned to be used is STOMP (Simple Text Oriented Message Protocol) [25].
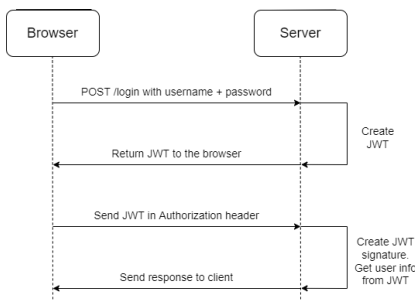

Fig. 3. JWT authorization scheme

B. Client-side implementation

The site is a responsive single page application (SPA). A single page application is a site that contains a single HTML document that updates dynamically and does not require a full page reload during use.

To develop the client side, the TypeScript [26] programming language and the React library [27] were chosen in combination with the Redux [28] library to save the state of the site when navigating through history. TypeScript extends the power of JavaScript by adding static typing.

As a Redux middleware for working with the REST API and WebSocket it is planned to use the Redux-Thunk module [29]. The react-router [30] library will be responsible for organizing routing to match requests to the application with certain interface components.

VI. CONCLUSION

The problem of shortage of donor blood is still acute both in Russia and around the world. At the moment, this process is quite laborious and takes a lot of time for donors.

This paper explores ways to promote donation, attract new donors, and retain regular donors. Domestic and foreign applications for donors were reviewed, their advantages and disadvantages were analyzed, and a list of requirements that an application must meet was identified.

The proposed solution is designed to facilitate the process of donating blood for donors, as well as to popularize blood donation and ensure the regularity of donations. Such system would allow donors to quickly receive the necessary information, provide convenient registration for donations, as well as the ability to track health indicators. In addition, this system will help speed up the process of donating blood, provide blood banks with a large number of supplies, and, as a result, save many lives.

In the future, the developed system can be improved by expanding the functionality by adding the ability to record bone marrow donors. Also, it is planned to perform load testing of the Web application in real and peak load conditions because our implementation should remain stable with a large number of active users. Moreover, it is considered to implement mobile version of designed application.

REFERENCES

[1] National Medical Research Centre for Hematology official website: http://blood.ru/
[2] National Medical Research Centre for Hematology official website, frequently asked questions: http://blood.ru/transfuziologiya-i-donorstvo-krovi/donoru/chasto-zadavaemye-voprosy.html
[3] D.J. Myers, and R.A. Collins, "Blood Donation", StatPearls Publishing, 2021.
[4] World Health Organization official website: https://www.who.int/
[5] World Health Organization & International Federation of Red Cross and Red Crescent Societies, "Towards 100% Voluntary Blood Donation: A Global Framework for Action", 2010.
[6] J. Silva, C. César Praça Brasil, B. Praça Brasil, L. Barbosa Paiva, V. Freire de Oliveira, J. Eurico de Vasconcelos Filho, and F. Rodrigues dos Santos, "MHealth Technology as a Tool to Promote Blood Donation", In Proc. of the 11th International Joint Conference on Biomedical Engineering Systems and Technologies, 2018, pp. 471-477.
[7] A.G. Orlovetskaya, "Blood donation as social practice: Russian specificity, Personality", Culture. Society, 2016.
[8] Russian blood service website: https://yadonor.ru/

[9] St. Petersburg Federal State Budgetary Institution Elizabeth's Hospital web site, blood transfusion unit: https://eliz-spb.ru/otdelenie-perelivaniya-krovi

[10] American Red Cross blood services website: https://www.redcrossblood.org/

[11] Russian donor community website: https://donorsearch.org/

[12] Petersburg Blood Transfusion Station official website, donor traffic light: http://yadonorspb.ru/svetofor/

[13] M. N. Islam, "Towards Designing Users' Intuitive Web Interface," 2012 Sixth International Conference on Complex, Intelligent, and Software Intensive Systems, 2012, pp. 513-518.

[14] American Red Cross, RapidPass. Save lives in less time, 2017.

[15] National Medical Research Centre for Hematology official website, Honorary Donor of Russia: http://blood.ru/transfuziologiya-i-donorstvo-krovi/donoru/kak-stat-donorom/pochetnyj-donor-rossii.html

[16] Digital dictionary, Rh factor: https://www.dictionary.com/browse/rh-factor

[17] 2GIS maps API documentation: https://api.2gis.ru/doc/maps

[18] Spring Framework official website: https://spring.io/

[19] Spring Boot project: https://spring.io/projects/spring-boot

[20] IBM corporation official site, REST APIs: https://www.ibm.com/cloud/learn/rest-apis

[21] PostgreSQL database official website: https://www.postgresql.org/

[22] Spring Data JPA: https://spring.io/projects/spring-data-jpa

[23] Internet Engineering Task Force (IETF), Json Web Token: https://datatracker.ietf.org/doc/html/rfc7519

[24] Internet Engineering Task Force (IETF), The WebSocket Protocol: https://datatracker.ietf.org/doc/html/rfc6455

[25] The Simple Text Oriented Messaging Protocol: https://stomp.github.io/

[26] TypeScript programming language official website: https://www.typescriptlang.org/

[27] React library official website: https://reactjs.org/

[28] Redux library official website: https://redux.js.org/

[29] Redux Thunk middleware source code and documentation: https://github.com/reduxjs/redux-thunk

[30] React Router official website: https://reactrouter.com/