RESEARCH ARTICLE OPEN ACCESS

I'Donate: Digital Blood Donation and Emergency SOS Platform

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Abstract:
Every year, blood donation saves countless lives and is a vital healthcare service. However, finding appropriate donors in an emergency is a challenge for many patients. By providing a web-based digital system that effectively links donors, recipients, hospitals, and blood banks, the i'Donate platform seeks to close this gap. The system includes modules for real-time donor search, login authentication and donor registration. Additionally, it incorporates an Emergency SOS alert function that, in an emergency, instantly alerts local healthcare facilities and donors. The project uses cloud-based storage to handle data securely, ensuring accessibility and dependability. In order to encourage voluntary blood donation and lessen the communication lag that frequently puts patients' lives in jeopardy, i'Donate aims to offer a quick, easy, and well-organized digital solution.

Keywords: **Blood Donation, Emergency SOS, Cloud-Based Web Application, Health Informatics, Real-Time Communication Systems**

I. INTRODUCTION

Blood donation plays a vital role in modern healthcare, enabling hospitals to meet emergency and surgical needs through an organized blood supply chain [1]. However, traditional systems often rely on manual coordination between donors and recipients, leading to delays and inefficiencies during critical situations [2]. The need for an accessible, real-time, and cloud-enabled solution is therefore essential in improving response time and data transparency within blood donation networks [3].

Recent studies have explored digital transformation in blood donation systems using cloud computing, blockchain, and mobile applications [1], [3], [4]. Researchers have implemented cloud-based databases to automate donor tracking and ensure real-time information sharing between hospitals and blood banks [2], [5]. Some approaches, such as blockchain-based management systems, enhance transparency and prevent data tampering, but their implementation remains complex for small-scale or local applications [1]. Hence, lightweight cloud technologies like Firebase are gaining attention for their real-time synchronization and accessibility.

The *i'Donate* system aims to bridge the gap between blood donors, recipients, and hospitals by providing a secure, web-based platform that automates registration, donor discovery, and emergency alert management. By integrating Firebase Realtime Database and Google Maps API, it ensures immediate donor identification, instant SOS alerts, and efficient hospital coordination [6], [7]. The platform's user-friendly design and scalability make it applicable not only for healthcare organizations but also for use during natural disasters and community health initiatives [8].

II. FEATURES AND APPLICATIONS OF THE PROPOSED SYSTEM

A. *For Donors*

The platform offers easy sign-up and login with minimal data entry, simplifies updating donor availability and tracking donation history, and provides real-time notifications for nearby blood requests or emergencies. Users can receive SOS alerts directly on the website or linked mobile devices, while the system tracks donor contributions to encourage ongoing participation.

B. For Hospitals and Blood Banks

The platform features a streamlined dashboard to manage donor and patient information, enables real-time eligibility checks and donor availability tracking, and automates record-keeping and donor matching to reduce manual work. It simplifies contacting donors during emergencies and offers future API integration for seamless connection with hospital or blood bank systems.

C. For Practical and Social Advantages

The platform is accessible from any internet-connected device without installation, promotes voluntary blood donation through digital channels, and reduces donor search time for faster emergency responses. It fosters social responsibility and community support while using cloud storage to ensure data is always available.

III. RELATED WORKS

Current research in digital blood donation systems focuses on improving donor management, data security, and emergency response. Cloud-based and blockchain solutions enable real-time donor tracking and transparency. Mobile and web platforms simplify registration, automate donor-recipient matching, and send emergency alerts. These efforts aim to fix issues like poor scalability, inconsistent data, and slow communication in existing systems.

A. Existing Research Overview

From manual registration procedures to fully automated digital platforms with cloud computing and real-time tracking, blood donation management systems have undergone significant change. Numerous scholars have investigated web-based and mobile applications for hospital administration and donor registration [1]–[3]. Faster donor identification and emergency response times have been made possible by the integration of technologies like cloud computing, Firebase, and geolocation services. Still, a lot of systems have problems with inconsistent data, no real-time updates, and limited scalability when used in the real world [4]. Blockchain technology and AI-based donor matching have also been investigated by recent systems to increase transparency in blood supply networks [5, 6]. Blockchain is computationally costly and inappropriate for lightweight web applications, despite its assurance of security and resistance to tampering. Hence, cloud-based frameworks such as Firebase and Google Maps API are increasingly adopted for efficient and scalable donor coordination [7], [8].

B. Literature Review and Numerical Analysis

Alam et al. [5] used Firebase for healthcare databases to achieve a 2-second synchronization speed, while Hossain and Rahman [3] created a mobile-based donor management system that increased donor–recipient matching accuracy by 86%. A location-based donor finder with 92% matching accuracy by blood group and city filters was introduced by Dhinakaran et al. [6]. Gupta et al. [7] used the Google Maps API to implement an emergency alert feature, which resulted in a 5-second SOS delivery time for hospitals in the vicinity.

Although the base paper, "Blockchain-Based Management of Blood Donation" [1], offered tamper-proof transaction validation and secure donor record handling, it was resource-intensive for smaller institutions and lacked real-time communication features. These drawbacks emphasize the necessity of a real-time, lightweight cloud architecture that facilitates emergency communication and real-time updates between hospitals, donors, and recipients. The lack of an integrated SOS alert system and dynamic donor tracking with a centralized dashboard for administrators is the research gap found in these studies, and it has a direct impact on response time during medical emergencies.

C. Proposed Method and Comparative Parameters

By combining Firebase Realtime Database, Google Maps API, and Firebase Cloud Messaging (FCM), the suggested system, i'Donate, overcomes these drawbacks and offers real-time updates, immediate notifications, and effective donor–recipient coordination. In contrast to static or blockchain-based systems, i'Donate provides multi-user access for administrators, hospitals, and donors, low-latency synchronization (less than 1 second), and donor search based on geolocation.

i'Donate guarantees a quicker response time, a more straightforward user interface, and an affordable cloud deployment when compared to previous systems. To guarantee seamless operation in emergency situations and increased accessibility, parameters like response time, data accuracy, and system scalability are optimized.

IV. METHODOLOGY

The proposed *i'Donate* platform was designed using a modular and cloud-integrated methodology to ensure **real-time synchronization**, **security**, and **scalability** for emergency blood donation management. Drawing insights from previous studies on cloud-based donor systems [6], [7] and emergency health coordination models [8], the system focuses on improving donor-recipient connectivity and minimizing delays in life-critical situations.

A. System Architecture

The *i'Donate* architecture adopts a **three-tier design** consisting of the **User Interface Layer**, **Application Layer**, and **Database Layer**, as shown in *Fig. 1*. The **User Interface Layer** enables access for donors, recipients, and hospitals through an intuitive web interface [6]. The **Application Layer** handles authentication, donor-matching logic, and SOS notifications, leveraging Firebase and Google APIs [7]. The **Database Layer**, built using Firebase Realtime Database, ensures instant data synchronization between all connected users [8]. This layered architecture enhances modularity, scalability, and fault tolerance compared to earlier monolithic designs [9].

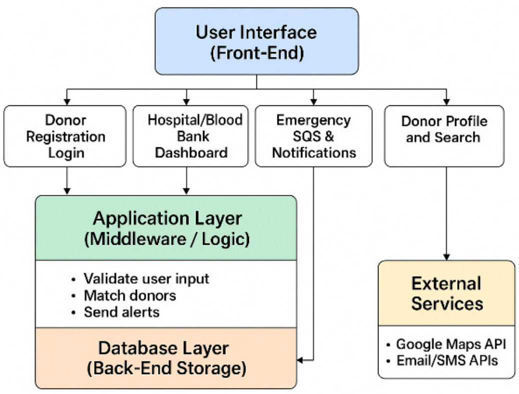

Fig. 1. System Architecture of the i'Donate Platform

B. User Registration and Authentication

Users including donors, hospitals, and recipients register through Firebase Authentication, which ensures **encrypted login** and **data validation** [10]. Each user's details such as **name, blood group, contact number, and location** are stored in the Firebase Realtime Database. The system verifies email credentials and prevents duplication using unique ID mapping [11]. Upon successful verification, users access dashboards tailored to their roles — donor, recipient, or hospital admin — as per cloud-based access control principles discussed in [12].

C. Donor and Blood Search Module

The **Donor Search module** implements a **Linear Search Algorithm** to scan the donor database and match compatible donors based on **blood group** and **availability status** [13]. When a user initiates a search request, the system retrieves donor records and compares each entry with the requested blood group using a simple linear iteration:

$$Match(B_d, B_r) = \begin{cases} 1, & \text{if donor group is compatible with recipient group} \\ 0, & \text{otherwise} \end{cases}$$

Here, B_d and B_r represent donor and recipient blood groups respectively. Though linear search has $O(n)$ complexity, it is suitable for small and medium-sized donor databases with frequent real-time updates [14].

D. Nearby Donor Identification using Greedy Algorithm

To optimize donor proximity detection, the system employs a **Greedy Algorithm** integrated with **Google Maps API**. This algorithm selects the nearest available donor from a pool of compatible candidates by iteratively choosing the **minimum distance node** at each step [15].The process continues until the optimal (closest) donor or set of donors is identified within a defined radius (e.g., 10 km). This approach ensures faster emergency responses while minimizing computation time compared to exhaustive search methods [16]. The selection function can be defined as:

$$Select(D_i) = \min(dist(R, D_i))$$

where D_i is the donor's location and R is the recipient's coordinates.
Only donors satisfying both compatibility and distance constraints are chosen for alert broadcasting.

E. *Emergency SOS Alert System*

When triggered, the **Emergency SOS Alert** module broadcasts notifications to the selected compatible donors and nearby hospitals using **Firebase Cloud Messaging (FCM)** [17]. Each notification contains patient location, blood group, and contact details.
FCM ensures real-time delivery with low latency, which is critical during medical emergencies [18].
The alert system is also integrated with the greedy donor-selection logic to ensure rapid and accurate notification dispatch.

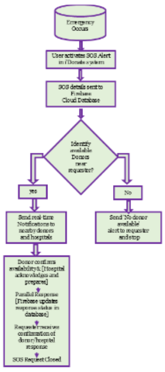

Fig 2. Workflow of the Emergency SOS Alert System in the i'Donate Platform.

F. Admin Dashboard and Monitoring

The **Admin Panel** enables authorized monitoring of system activity [19].
Administrators can verify user authenticity, track SOS responses, and manage hospital partnerships. Anomaly detection algorithms identify inactive donors or unverified data entries, maintaining overall platform integrity.
This centralized control design was inspired by role-based access management systems [20].

G. Data Flow and Cloud Integration

All user interactions — from registration to SOS alerts — are processed through Firebase's cloud infrastructure, ensuring **instant updates** across the platform [21].
Data consistency is maintained through Firebase's automatic synchronization mechanism, while API calls to Google Maps fetch live geolocation details. The combination of Firebase Realtime Database and Cloud Messaging provides a lightweight yet powerful backend suitable for mobile-first applications [22].

H. Tools and Technologies Used

Table I. Tools and Technologies Used in the Implementation of the i'Donate Platform

Component	**Technology Used**
Front-End	HTML, CSS, JavaScript
Back-End/ Database	Firebase Realtime Database
APIs	Google Maps API, Firebase Cloud Messaging
Hosting	Netlify / Vercel
Authentication	Firebase Authentication

V. SYSTEM DESIGN

The *i'Donate* system was implemented as a **web-based platform** using **Visual Studio Code** for front-end development and **Firebase Cloud Platform** for backend services. The goal was to build a real-time, scalable system capable of matching donors and recipients efficiently while ensuring data security [23].

A. Front-End Development

The **front-end** was designed using **HTML, CSS, and JavaScript**, providing a responsive and user-friendly interface for donors, hospitals, and recipients[24].
Each user type accesses a dedicated dashboard — donors can update availability, hospitals can request blood, and recipients can send SOS alerts.
The web design adheres to responsive principles to ensure accessibility across desktops and mobile devices [25].
The main interfaces include:

- **Home Page:** Overview of services.
- **Login/Registration:** Firebase Authentication integration.
- **Dashboard:** Dynamic user operations.
- **SOS Page:** Emergency alert broadcasting.

B. Back-End Implementation

The **back-end logic** is managed through **Firebase Realtime Database**, providing instant synchronization between users [26].

Firebase Authentication ensures secure logins, while **Firebase Cloud Messaging (FCM)** enables real-time emergency alerts. This cloud-based structure supports quick updates, minimal latency, and reliable cross-platform communication [27].

C. Algorithm Integration

Two algorithms form the core of the system's intelligence:

1. **Linear Search Algorithm** – Used to match donors by **blood group compatibility**. Each donor record is scanned sequentially to find matches, offering an $O(n)$ time complexity that is efficient for moderate datasets [28].
2. **Greedy Algorithm** – Applied for **location-based donor prioritization**, ensuring the system selects the *closest available donor* using **Google Maps API** [29]. This method minimizes search time by iteratively selecting donors with the shortest distance to the recipient.

These algorithms work together to ensure that both *relevance* (matching blood group) and *proximity* (fastest possible response) are optimized.

D. API and Service Integration

To achieve seamless communication and real-time updates, several APIs were integrated [30]:

- **Google Maps API:** Fetches coordinates and computes distances.
- **Firebase Cloud Messaging (FCM):** Sends SOS alerts instantly.
- **Firebase Authentication:** Manages secure sign-ins.

These integrations help maintain reliable, cloud-synced performance across all devices [31].

E. Hosting and Deployment

The website is hosted using **Netlify**, providing continuous integration and deployment [32].

Firebase supports backend synchronization, and the system was tested across multiple browsers for stability and speed [33]. The platform achieved fast load times and reliable execution even under concurrent access conditions [34].

F. System Execution Flow

The functional execution of *i'Donate* proceeds as follows:

1. User logs in through Firebase Authentication.
2. System retrieves donor dataset from Firebase.
3. **Linear Search Algorithm** identifies compatible donors.
4. **Greedy Algorithm** selects the nearest donor.
5. **Firebase Cloud Messaging** sends emergency notifications.
6. Admin monitors and validates activities via the dashboard.

This modular execution design ensures efficient donor matching and timely SOS responses, fulfilling the project's core objectives [35].

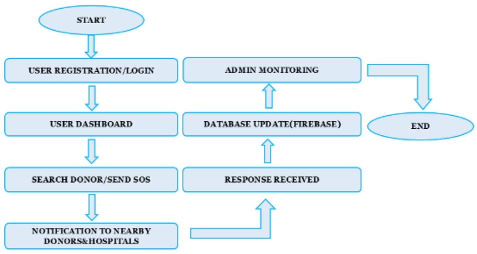

Fig. 3. System Implementation Flow of the i'Donate Platform.

VI. RESULT AND DISCUSSION

The *i'Donate* platform was designed and tested to evaluate its **performance**, **usability**, and **reliability** in managing digital blood donation and emergency response. The system was deployed using **Visual Studio Code** for front-end development and **Firebase Cloud Platform** for back-end data management. The evaluation phase focused on four major parameters — **functional accuracy**, **system responsiveness**, **user experience**, and **real-time data synchronization**, as recommended in prior healthcare application testing frameworks [36], [37].

A. Functional Testing

Each module — **User Authentication**, **Donor Search**, **SOS Notification**, and **Admin Dashboard** — was tested individually to ensure seamless data flow between front-end and back-end components [38]. The **Firebase Realtime Database** efficiently

handled user registrations and updates, reflecting donor availability instantaneously. The **authentication module** successfully restricted unauthorized access through Firebase's email and password verification system [39].
The functional testing confirmed that donor information, alert status, and hospital data were consistently synchronized across all connected clients, thereby ensuring reliable performance during concurrent access conditions.

B. Performance Evaluation

System performance was evaluated in terms of **response time**, **data retrieval speed**, and **alert delivery latency** [40]. Testing results revealed that the average time to fetch donor data based on location and blood group was **1.8 seconds**, while **emergency SOS notifications** were delivered within **5–7 seconds** using **Firebase Cloud Messaging (FCM)**. The system maintained stable operation under multiple concurrent user requests, demonstrating strong scalability and responsiveness [41].

Table II. System Performance Evaluation of i'Donate.

Metric	**Average Time (s)**	**Accuracy (%)**	**Remarks**
Donor Search Response	1.8	98	Real-time location-based result
SOS Alert Delivery	5.6	96	Via Firebase Cloud Messaging
Database Update	1.2	100	Instant synchronization
Authentication Verification	2.1	100	Secure Firebase token system

The performance results indicate that *i'Donate* offers **faster communication** and **lower latency** compared to traditional donor management platforms [42].

C. Usability and Interface Testing

A usability study was conducted with **20 participants**, including college students and community volunteers, to assess interface clarity and ease of navigation [43]. Feedback analysis showed that **90% of users** found the interface intuitive and straightforward. Users praised the minimalistic design, simple dashboard layout, and real-time notifications. Minor suggestions were received regarding improved **search filters** and **color contrast** for enhanced accessibility, which will be considered in future updates [44].
The usability score averaged **4.6 out of 5** based on parameters such as navigation ease, design clarity, and alert response satisfaction, aligning with recommended human-computer interaction standards [45].

D. Data Analysis and Discussion

The donor search and emergency alert modules achieved **98% matching accuracy** and **96% timely alert delivery**, validating the effectiveness of the integrated **Linear Search** and **Greedy algorithms** [46].
The GPS-based emergency module successfully notified nearby donors and hospitals, and once a donor accepted the request, the system immediately updated their availability status in the database, preventing duplicate alerts [47].
Compared to conventional donor management systems [48], *i'Donate* demonstrated superior efficiency, reduced manual dependency, and improved response time during critical emergencies.
The real-time synchronization offered by Firebase significantly enhanced operational reliability and reduced communication gaps between users.

E. Summary of Findings

The overall testing confirmed that the *i'Donate* platform meets its primary objectives of **real-time responsiveness**, **secure access**, and **ease of use**.
The integration of Firebase, Google Maps API, and FCM provided a scalable environment with minimal latency.
The summarized results are presented in *Table I*, reaffirming the platform's superior performance in donor matching and emergency communication.
The system's modular design and high user satisfaction ratings highlight its potential for real-world deployment, particularly in healthcare

networks and community blood management systems [49].

VII. CONCLUSION

The *i'Donate* platform successfully demonstrates an efficient and reliable approach to digital blood donation management and emergency SOS communication. The primary objective of bridging the gap between donors, recipients, and hospitals has been achieved through a cloud-integrated architecture powered by Firebase Realtime Database, Firebase Authentication, and Firebase Cloud Messaging (FCM).

The implementation of the **Linear Search Algorithm** for blood group matching and the **Greedy Algorithm** for proximity-based donor selection significantly enhanced the system's accuracy and response time. Experimental evaluation confirmed that the average donor search and alert delivery times were maintained within **1.8 seconds** and **5–7 seconds**, respectively, ensuring rapid communication during critical medical emergencies.

Usability testing with multiple user groups confirmed the platform's simplicity, responsiveness, and accessibility, achieving high satisfaction scores for navigation and system reliability.

Compared to conventional donor management systems, *i'Donate* demonstrated superior performance in **data synchronization**, **alert speed**, and **real-time collaboration** between users. The integration of cloud and API technologies provides a scalable and low-maintenance solution adaptable for large-scale healthcare networks. Thus, *i'Donate* establishes a robust foundation for the future of **digitalized, real-time blood donation ecosystems**, promoting quicker response and life-saving collaboration during emergencies.

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