A Prototype Design for Gamified Blood Donation App using Blockchain Technology, IPFS and NFTs

Gaushik M R
Center for Wireless Networks & Applications (WNA),
Amrita Vishwa Vidyapeetham
Amritapuri, India
gaushikrm@gmail.com

Jivtesh M R
Center for Wireless Networks & Applications (WNA),
Amrita Vishwa Vidyapeetham
Amritapuri, India
jivtheshm@gmail.com

Adarsh P
Center for Wireless Networks & Applications (WNA),
Amrita Vishwa Vidyapeetham
Amritapuri, India
adarshpranavam@.gmail.com

Sai Shibu N B
Center for Wireless Networks & Applications (WNA),
Amrita Vishwa Vidyapeetham
Amritapuri, India
saishibunb@am.amrita.edu

Sethuraman N Rao
Center for Wireless Networks & Applications (WNA),
Amrita Vishwa Vidyapeetham
Amritapuri, India
sethuramanrao@am.amrita.edu

ABSTRACT

Donating blood is a common practice that has a positive effect on the lives of several individuals. Daily, the number of people in urgent need of blood continues to rise substantially. It is often challenging to find a suitable donor in case of emergency. The situation is worse if it is a rare blood group. This paper introduces a blockchain-based decentralised application (DApp) to match recipients with blood donors during an emergency. Personal information such as name, location, blood group, and donation history is stored securely in the blockchain distributed ledger through IPFS. The donors' lack of awareness and motivation are the primary reasons for people not coming forward for blood donations. We propose to gamify the blood donation process by issuing NFT badges as a reward for donors. This paper explains the design of smart contracts for storing donor and recipient data on the ledger and issuing NFTs to donors. The article also briefly discusses the process of designing the DApp.

CCS CONCEPTS

• **Networks** → *Peer-to-peer networks*; • **Computer systems organization** → *Peer-to-peer architectures.*

KEYWORDS

Blockchain, Gamification, Blood donation, NFTs, Smart Contracts

ACM Reference Format:
Gaushik M R, Jivtesh M R, Adarsh P, Sai Shibu N B, and Sethuraman N Rao. 2022. A Prototype Design for Gamified Blood Donation App using Blockchain Technology, IPFS and NFTs. In *Fourth ACM International Workshop on Blockchain-enabled Networked Sensor Systems (SenSys '22), November 6–9, 2022, Boston, MA, USA.* ACM, New York, NY, USA, 6 pages. https://doi.org/10.1145/3560905.3568177

SenSys '22, November 6–9, 2022, Boston, MA, USA

ACM ISBN 978-1-4503-9886-2/22/11…$15.00
https://doi.org/10.1145/3560905.3568177

1 INTRODUCTION

As per World Health Organisation (WHO) data, around 118.5 million people donate blood globally. There are 13,300 blood donation centers in 169 countries. However, low-income countries report ten donations per 1000 people, whereas, in high-income countries, the blood donation ratio is around 32 per 1000 people [1]. The ratios are much less than 1% for rare blood groups such as AB negative. Three blood donors are voluntary-unpaid, family members, and paid donors. Voluntary unpaid donors donate blood regularly. Family members donate when an emergency needs, such as surgery or an accident. The third category is often the rare blood group donors who donate blood and earn an income.

Haemovigilance is a protocol described by WHO for tracking the entire blood donation to transfusion process [2]. Currently, the haemovigilance protocol is centralised and involves a central vigilance office to process and approve the data of donors and recipients. The centralised process is time-consuming and brings risks during an emergency. Decentralising this process by eliminating the central vigilance office and automating the validation will help accelerate the blood donation and delivery experience. Gamification is a process of improving the user experience by encouraging and motivating users by providing them with interactive tasks and rewards. We also envision that the poor donor-to-recipient ratios can be improved by gamifying the blood donation process. Blockchain technology has great potential in healthcare and supply chain management [3]. Users can store patients' sensitive data, medical history, and materials tracking in the tamperproof blockchain ledger [4]. In this paper, we propose a decentralised haemovigilance protocol, as mentioned by WHO [2], using blockchain technology. In the proposed system, the data of the donors and recipients are anonymised and stored securely in the blockchain ledger. We also introduce Non-Fungible Tokens (NFT), such as badges and reward

tokens for donors who meet specific targets or achievements. InterPlanetary File System (IPFS) is a protocol for distributed file sharing. We propose to use IPFS to store medical data and NFTs. Gamification could boost the number of blood donors by encouraging younger individuals to contribute. By introducing gamification, the system could facilitate awareness about blood donation and increase donor participation, thus encouraging more individuals to donate. A blockchain-based system for blood donation might significantly reduce the risk of disease transmission as the donor's medical history is also linked when they donate and enhance blood supply quality, reducing long-term medical risks [5].

The rest of the paper is organised as follows: Section 2 introduces various new solutions presented by several researchers. Section 3 explains the proposed system architecture for the blood donation application. In Section 4, we discuss the prototype and implementation of an application. Section 4.1 covers how we integrated gamification into our application's user experience. The paper is concluded in Section 5.

2 RELATED WORK

Subrata Talapatra et al. developed a cross-platform web interface that allows users to view the exact contact details of potential blood donors nearby [6]. They hosted a local XAMMP server to provide this service. Hai Trieu Le et al. proposed BloodChain, a blockchain-based system to enable blood donor information management [7]. BloodChain uses Hyperledger Fabric, a private blockchain protocol for transactions, as the prototype user base is very small. They performed a comprehensive evaluation in many scenarios to demonstrate the viability of their proposed model. Diana Hawashin et al. proposed a method that stores non-critical and massive data off-chain via the decentralized storage system using InterPlanetary File System (IPFS) [8]. They discuss their proposed blood donation management solution's system architecture, algorithms, and working principles. They also evaluated the performance of their proposed solution in terms of efficiency and effectiveness by conducting a security analysis. Aderonke Anthonia Kayode et al. presented web, and Android-based applications for improved and efficient blood bank information administration [9]. This paper aims to design an application with all the necessary characteristics to facilitate communication between blood recipients, donors, and blood banks.

Sivakamy Lakshminarayanan et al. proposed a system for tracking blood donation. They implemented the system using the Hyperledger Fabric framework and aim to increase the transparency of the blood donation process by tracing the blood's path and reducing unnecessary blood loss by providing a unified platform for the exchange of blood and its derivatives between blood banks [10]. They developed a web application for blood donation to access the system for ease of use. Mehmet Alyangil et al. propose an Ethereum blockchain-based framework called KanCoin to manage and adjust the processes for efficient distribution planning in the blood delivery system from donors to distribution centres and patients at medical centres in a more effective way than the conventional procedures [11]. Altahir Ahmed Saad et al. designed a system for blood transfusion services [12]. This system consists of two components: an android mobile app for donors' tasks and a web application for all blood banks' or their workers' functions or tasks, such as doctors and various laboratory divisions. The existing blood donation methods have fundamental concerns with security and efficiency. It depends on the system's ability to reduce costs and time while preserving efficiency. The centralized blood management system introduces a delay in blood transportation during emergencies. There were difficulties in securing and anonymizing the blood donation data. This paper presents a blockchain-based DApp to decentralize the blood donation process and improve the user experience by providing NFT-based rewards to donors.

3 PROPOSED ARCHITECTURE DESIGN FOR BLOOD DONATION APP

We developed a web and mobile application to manage the details of donors, hospitals, and recipients securely. This section describes the proposed system architecture, mobile and web app design. An overall architecture of the proposed system is represented in figure 1. The system consists of four active participants: the administration, Hospitals/Physician, Donors, and Recipients.

- Administrator - The Administrator is responsible for registering and supervising clinics, hospitals, and donation centers. They organise fundamental data, facilitate searches, and connect the donor and recipient.
- Hospital/Physician - The Blood Donation System contains a directory of hospitals, donation centers, and physicians who can register a donor.
- Donor - A donor is a person who gives blood for use in transfusion.
- Recipients - Recipients receive blood from donors in an emergency.

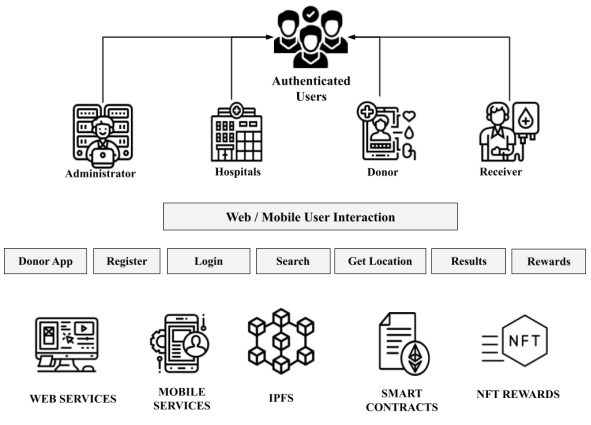

Figure 1: Proposed System Workflow

The web and mobile applications manage the interaction between these users. If a person wishes to donate blood, they must fill out the registration form with their full name, email address, mailing address, contact information, and blood group. Once a person has registered, the administration validates their details and provides a credential to access the application. This data is then stored to IPFS. The donor can log in to the app using the credentials to look

for blood requirements in their locality. The website also provides information on blood donors for recipients. They are provided with the contact information for hospitals and other organizations if no donors in their city belong to the same group. The information is decentralised using IPFS, which overcomes the constraints of the conventional system. The IPFS distributed ledger also ensures there is data tampering. The proposed system significantly decreases an individual's time and effort during emergency situations.

3.1 Web and Mobile App Design

Before beginning development, we developed the web and mobile applications' wireframe designs. Figure 2 depicts the wireframe model for the web application, and Figure 3 shows the wireframe design for the mobile application.

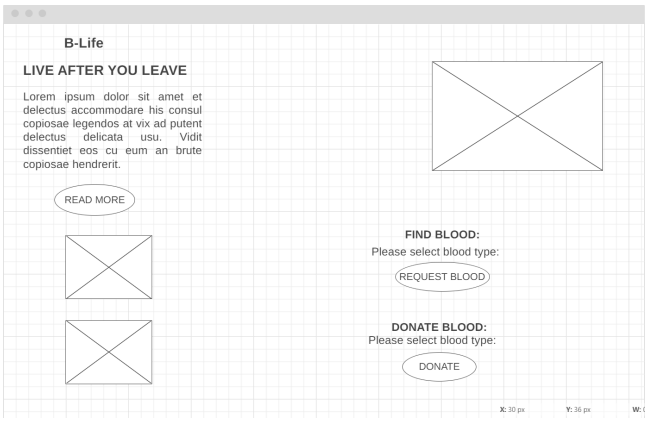

Figure 2: Wireframe Design of Web application

The web application wireframe consists of three sections. The first section is the main screen, where the user may find and learn more about blood donation and its benefits. Then the second section is "Find Blood", where they can select their blood type and request blood. The third section is a "Donate Blood" section where users can choose their blood type and start donating.

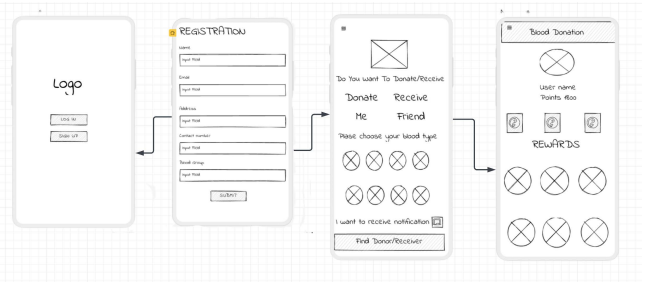

Figure 3: Wireframe Design of Web application

The mobile application wireframe has four screens as shown in figure 3. The first is the login screen, where the user can sign up if he is a first-time visitor or log in if he already has an account. The second screen is for user registration. The third screen is the main screen, where the user can choose whether they need to donate or receive for themselves or their friends. The last screen is the user profile screen, where the users can see their profile, current statistics, and earned NFT rewards.

3.2 Tools used for Web and Mobile Application Development

we utilized the tools listed below in Table 1 in the process of developing our web and mobile applications.

Table 1: Tools used for web and mobile application development

Tools	Features
HTML	HTML is a markup language used to create web pages
CSS	CSS is used for styling a HTML document
Bootstrap	Bootstrap is a CSS framework for developing responsive websites
Python Flask	We used the Python Flask framework for backend server and IPFS implementations
Flutter	Google's Flutter is a free and open-source UI SDK for mobile application development.
Metamask	Metamask is a cryptocurrency wallet. We used metamask to interact with truffle suite and Remix IDE to generate ETH accounts for users and store their NFTs
Truffle suite	Truffle suite is a local ethereum test network. We set up a local test network to simulate transactions.

4 SYSTEM IMPLEMENTATION USING TRUFFLE SUITE, IPFS, PYTHON

As discussed earlier, we designed mobile and web applications for blood donation and user management. This section explains how we enabled blockchain to the applications using truffle suite, IPFS, and python libraries. Truffle suite is a local Ethereum test network. We set up the truffle suite on a personal computer (PC) running Ubuntu 21.04 Operation System. The PC has an Intel i7 Processor with 16GB of RAM, 1TB of hard disk storage, and an NVIDIA P1000 4GB Graphics Card [13]. We followed the truffle installation instructions available in Truffle Documentations [14]. Truffle also supports Smart Contract deploying and testing. While we set up the truffle test network, We get ten Ethereum accounts and 100 ETH test tokens in each of these ten accounts. We assigned these accounts to the donors, recipients, administrators, and hospital/physicians.

Remix IDE is a web-based Ethereum test network to develop and test smart contracts [15]. We used Remix IDE connected to Ethereum Rinkeby Test Network to develop smart contracts for NFT minting, NFT distribution, and user management. We initially deployed the smart contracts in Remix IDE to test NFT minting, NFT distribution, and user management. Figure 4 shows the smart contract deployed in Remix IDE. The red highlight shows the function for mining an NFT stored in IPFS and the green highlight shows the NFT transfer function.

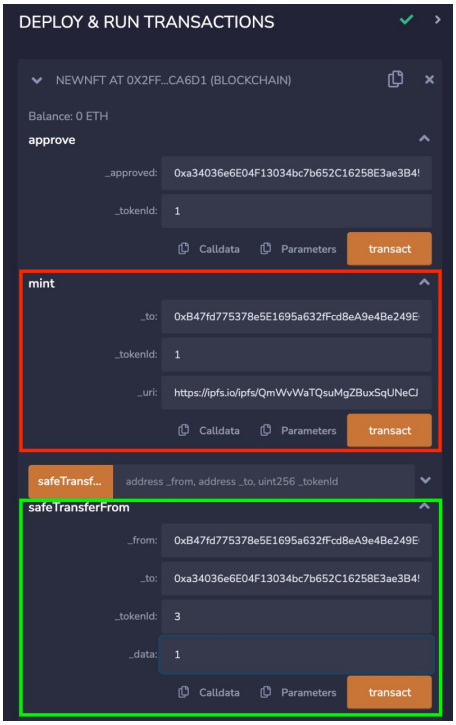

Figure 4: Minting and transferring NFTs using Smart Contracts in Remix IDE

We used IPFS to store NFTs and user data. IPFS is a distributed storage platform that is very similar to the blockchain distributed ledger. We can store photos, videos, and text. We created NFTs in jpg format (photo) and uploaded them to IPFS using the desktop client available for Ubuntu OS. Figure 5 shows the NFTs we uploaded to IPFS. IPFS provides an URL for each of these NFTs.

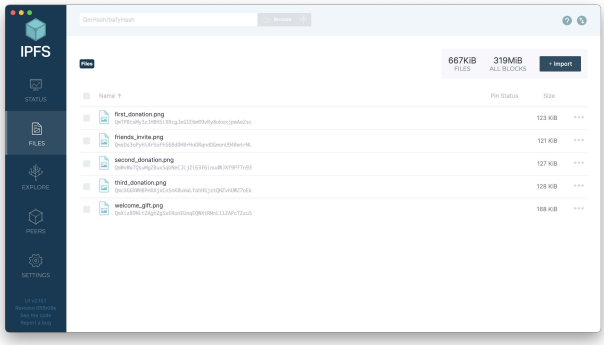

Figure 5: NFTs stored in IPFS

We designed the mobile applications using flutter and web applications using HTML, CSS, and bootstrap. Figures 6 and 7 shows the screenshots of web and mobile apps. Figure 8 shows the user registration web page.

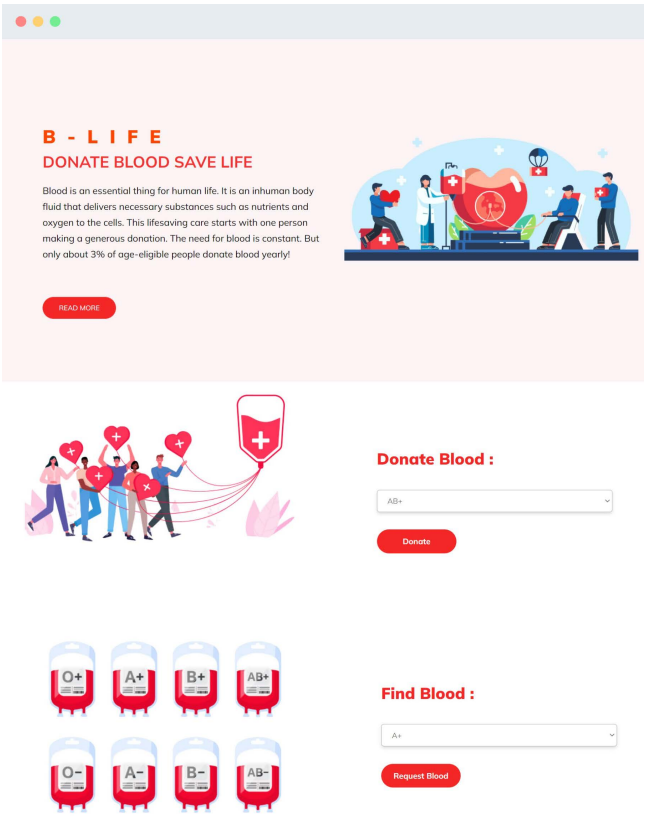

Figure 6: Screenshot of the Web Application

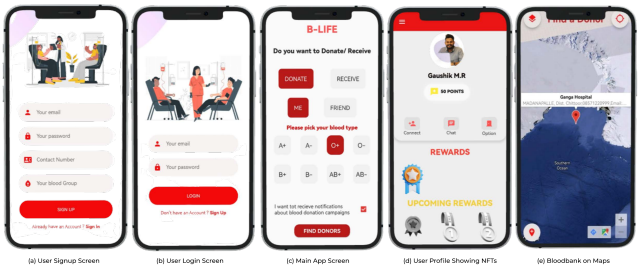

Figure 7: Screenshot showing the Mobile Application

4.1 Gamified User Experience using NFTs in Mobile Application

NFT minting is a process of adding an NFT to the blockchain. NFTs, we must mint the uploaded to IPFS before distributing it to the users. Once we mint the NFTs, they get associated with a user account, and here it is the administrator's account. The smart contract has a mint function that takes the user address, random ID for NFT and IPFS URL, and mints the NFT of the test network. We used Metamask Wallet to create test accounts and store the minted NFTs. Figure 9 shows the newly minted NFT collections. Similarly, a transfer NFT function lets administrators transfer NFT

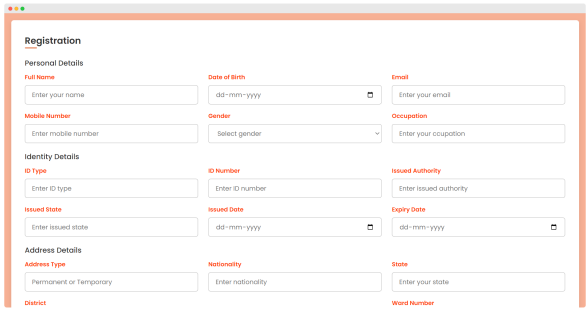

Figure 8: Screenshot of Donor Registration Form

from their account to a donor account. Figure 4 shows the transfer NFT function highlighted in green box.

Figure 9: Metamask Wallet Showing the NFT Collections

The transfer NFT function requires the from address; to address; and the token id of the NFT that the user wishes to transfer. The app distributes NFTs to donors based on specific activities and tasks that the donor must complete. We have programmed basic tasks like welcome credits, introducing friends to the app, first donation and frequent donations. We plan to introduce other tasks in future.

4.2 Integration of all sub components

We used the Python Flask framework for the backend services to integrate all the subcomponents developed for this project. The HTTP Post method collects the users' data and passes it to IPFS using the native IPFS Python library. Figure 10 shows the user data from the registration page in the Linux terminal, and Figure 11 shows the user data stored on the IPFS desktop client. Similarly, the python app uses the web3 API to interact with smart contracts, fetch information about the NFTs and display it appropriately to the user account [16].

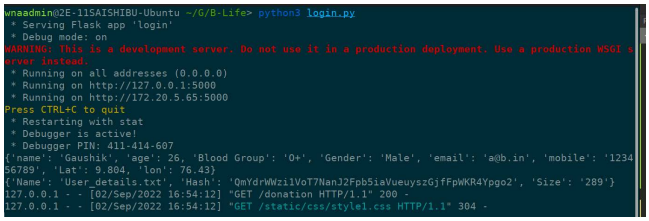

Figure 10: Data collected from a user displayed on the Linux terminal

Figure 11: IPFS Desktop Client showing the data received from the web or mobile app

5 CONCLUSION

Our solution uses blockchain technology to build a decentralized platform to simplify blood donation and gamify the experience to engage more donors. This paper uses the Ethereum test network to deploy the proposed application. We designed this DApp using tools such as truffle suite, Remix IDE and IPFS. We used Flutter, HTML, CSS and Bootstrap to develop mobile and web apps. We integrated the apps and the blockchain component using python open source libraries. We envision that the proposed app provides traceability of blood donations, motivates more people to come forward and donate blood and helps recipients to find suitable donors during an emergency. Although the overall cost of operation is higher, we propose to use NFTs because the NFTs benefit creators and the collectors. The creators can generate an income when they mint NFTs on our platform. Similarly, the collector can also trade this NFT on our platform or any NFT platforms and generate and income. In the future, we plan to focus on introducing more tasks for the donors and monitor the complete blood transfusion process using blockchain technology. We also plan to improve the app by addressing the privacy issues in IPFS, optimise the performance such as reduce latency, reduce gas costs and introduce it in the market.

ACKNOWLEDGMENTS

We express deep gratitude to our beloved Chancellor and world-renowned humanitarian leader, Shri. (Dr) Mata Amritanandamayi Devi (AMMA), for inspiration and motivation.

REFERENCES

[1] WHO. 2022. Blood safety and availability. (2022). https://www.who.int/news-room/fact-sheets/detail/blood-safety-and-availability.

[2] WHO. 2016. A guide to establishing a national haemovigilance system. (2016). https://www.who.int/publications/i/item/9789241549844.

[3] Sai Shibu Narayanan Babu and Balamurugan Sukumar. 2022. Architecture and proof of concept design for community marketplace using blockchain technology and fuzzy intelligence. *International Journal on Communications Antenna and Propagation (IRECAP)*, 12, 1, 54. DOI: 10.15866/irecap.v12i1.21514.

[4] Athira Nair K, Chaitanya Kapoor, Nidhin Mahesh A, Sai Shibu N B, and Balamurugan S. 2021. Exploring blockchain enabled smart community with electric vehicles. In *2021 10th IEEE International Conference on Communication Systems and Network Technologies (CSNT)*, 745–750. DOI: 10.1109/CSNT51715.2021.9509598.

[5] Priyanka Kumar, G. A. Dhanush, D. Srivatsa, A. Nithin, and S. Sahisnu. 2019. A buyer and seller's protocol via utilization of smart contracts using blockchain technology. In *Advanced Informatics for Computing Research*. Ashish Kumar Luhach, Dharm Singh Jat, Kamarul Bin Ghazali Hawari, Xiao-Zhi Gao, and Pawan Lingras, editors. Springer Singapore, Singapore, 464–474. ISBN: 978-981-15-0108-1.

[6] Subrata Talapatra, Raihanul Kabir, and Akash Bappy. 2019. Development of an online blood management system. In (March 2019).

[7] Hai Le, Lam Nguyen Tran Thanh, Tuan Nguyen, Son Ha, and Nghia Duong Trung. 2022. Bloodchain: a blood donation network managed by blockchain technologies. *Network*, 2, (January 2022), 21–35. DOI: 10.3390/network2010002.

[8] Diana Hawashin, Dunia Mahboobeh, Khaled Salah, Raja Jayaraman, Ibrar Yaqoob, Mazin Debe, and Samer Ellahham. 2021. Blockchain-based management of blood donation. *IEEE Access*, PP, (December 2021), 1–1. DOI: 10.1109/ACCESS.2021.3133953.

[9] Aderonke Kayode, Emmanuel Adeniyi, Roseline Ogundokun, and Simon Ochigbo. 2019. An android based blood bank information retrieval system. *Journal of Blood Medicine*, Volume 10, (April 2019), 119–125. DOI: 10.2147/JBM.S197350.

[10] Sivakamy Lakshminarayanan, P. Nagaraja Kumar, and N. M. Dhanya. 2020. Implementation of blockchain-based blood donation framework. In.

[11] Mehmet Cagliyangil and Sabri Erdem. 2019. A blockchain based framework for blood distribution. *Contributions to Management Science*.

[12] Altahir Saad and Lars Christensen. 2019. Improving and supporting blood donation practices in khartoum, sudan blood banks through android mobile app and web application system, (April 2019).

[13] A. Nidhin Mahesh, N. B. Sai Shibu, and S. Balamurugan. 2019. Conceptualizing blockchain based energy market for self sustainable community. In *Proceedings of the 2nd Workshop on Blockchain-Enabled Networked Sensor* (BlockSys'19). Association for Computing Machinery, New York, NY, USA, 1–7. ISBN: 9781450370127. DOI: 10.1145/3362744.3363345. https://doi.org/10.1145/3362744.3363345.

[14] [n. d.] Truffle suite - docs. (). https://trufflesuite.com/docs/truffle/.

[15] [n. d.] Remix ide. (). https://remix.ethereum.org/.

[16] Priyanka Kumar, G. A. Dhanush, D. Srivatsa, S. Nithin Aakash, and S. Sahisnu. 2020. An efficient and novel buyer and seller's distributed ledger based protocol using smart contracts. In *Distributed Computing and Internet Technology: 16th International Conference, ICDCIT 2020, Bhubaneswar, India, January 9–12, 2020, Proceedings*. Springer-Verlag, Bhubaneswar, India, 349–363. ISBN: 978-3-030-36986-6. DOI: 10.1007/978-3-030-36987-3_23. https://doi.org/10.1007/978-3-030-36987-3_23.