2021 4th International Conference on Recent Trends in Computer Science and Technology (ICRTCST) | 978-1-6654-6633-2/22/$31.00 ©2022 IEEE | DOI: 10.1109/ICRTCST54752.2022.9781924

A Framework for Covid-19 Vaccine Management System Using Blockchain Technology

Shafayet Mahamud
Dept. of CSE
Daffodil International University
Dhaka, Bangladesh
Shafayet15-13202@diu.edu.bd

Syada Tasmia Alvi
Dept. of CSE
Daffodil International University
Dhaka, Bangladesh
syada.cse@diu.edu.bd

***Abstract*—The SARS-CoV-2 first surfaced in 2019 in China and later spread across the globe causing a pandemic. Immunisation has thus far been considered to be mankind's weapon of choice in the frontline fight against the virus defined as Covid-19. Mass vaccination programmes carried out by nations are closely related to public health information, data safety and data security. As countries roll out the immunisation efforts, cyber offenders try to exploit people's personal health data and inoculation records while citizens can also be exposed to fake vaccine certificates issued by hackers. To prevent such any data breach or data exploitation, an effective system is urgently required to be in place that ensures the maximum security at a time of the unprecedented global crisis. Blockchain can be the perfect solution in this case thanks to its transparency, trustworthiness, and decentralised operations. We have proposed a blockchain based framework for covid 19 vaccination process to provide data immutability, transparency and correctness of beneficiary registration for vaccination, eliminating identity thefts and impersonation, tamper proof self-reporting of side effects, person identification and vaccine certification.**

***Index Terms*—Covid19, Blockchain, Smart Contracts, Vaccine, Certificate**

I. INTRODUCTION

Coronavirus (Covid-19) is a newly discovered viral disease that causes an infectious illness [1]. It has emerged in 2019 and is rapidly spreading around the world, posing a threat to the global economy as well as health and human life [2]. The economic system is trying to recover from the pandemic fallouts. Financial losses from the pandemic are causing enormous strain on the economic system. Because of this, many businesses will be forced to close, resulting in the loss of thousands of jobs. Unexpected breaks in young people's learning paths are a concern that, according to the UN, affects the majority of individuals of school age all over the world. The education system is also in serious trouble [3]. It's been more than two thousand years since humans began looking for effective strategies to combat various infectious illness outbreaks. Many diseases have been effectively managed by vaccine immunisation, which is a cost-effective method of controlling or even eliminating infectious diseases. In other words, vaccination may be our society's sole effective tactic against infectious diseases like coronavirus, and the safety of vaccines is directly tied to public health and national security. There are still problems in vaccination supply chains as there are issues like fake coronavirus vaccine certification and vaccine record fraud. As a result, an efficient vaccination supply chain management system is urgently needed. Blockchain, the next major fundamental technology after the Internet, aims to create trust mechanisms that can revolutionise the way of current information management methods [4]. Estonia is a pioneer in this area, having started to use blockchain technology in the healthcare sector as early as 2012. In the country, blockchain is now used to manage 95% of all healthcare bills, 99% of all health data, and 100% of all prescription information [5]. One of the 10 technologies recognised by the European Parliament to combat Covid-19 is blockchain technology, which has blockchain infections tracking and health data monitoring as two of its primary current use scenarios [6].

Blockchain is generally characterised as a peer-to-peer network with a transparent, trustworthy ledger. A transaction is the blockchain's data unit, while a block is a collection of transactions. With all verified blocks, a decentralised blockchain ledger is established. The cryptographic hash code of a block in the distributed ledger is used to link it to an earlier authorised Block. Immutability, security, and integrity are at the heart of the blockchain's basic characteristics.

Multiple verification of the legitimacy of vaccination certificates might be made possible with blockchain's decentralised public ledger system, helping to reduce the spread of fraudulent certificates [7]. Hospitals in the United Kingdom are already implementing blockchain technology to keep track of vaccination batches and keep tabs on how long they are kept refrigerated [8]. It should be noted that Health Certsare a set of digital open standards and schema developed by the Singaporean government for the purpose of delivering digital Covid-19 test results and immunisation certificates. Our objective is to present such methodology in which blockchain technology is used for assuring data integrity and immutability in case of beneficiary registration for vaccination, eliminating identity thefts, impersonations and tamper-proof certificate. In this system user can perform registration process for vaccination. After performing registration, they can be vaccinated using the currency named lifecoin of blockchain. They will also get a certificate of vaccination through this system after submitting side effect report anonymously.

The paper is organised as follows. In Section II, background

PART: CFP22P42-ART

study about blockchain and Covid-19 are discussed. In Section III, related works based on Covid-19 and blockchain are explained. In the following Section IV, Proposed methodology is presented. Different properties of our system are analysed theoretically in section V. In the final section, Section VI, future work of the system is discussed and conclusions about the research have been made.

II. BACKGROUND STUDY

A. Blockchain

People increasingly acclaiming blockchain as the next significant innovative technology because the idea has become so widespread. Its significance has been compared to thatof the Web and even the Internet. As a data storage and distribution method for assets, blockchain is nothing more than that. Its potential applications are what make blockchain technology so empowering: sharing asset transactions between different agents with unquestionable transparency – all while without a central authority controlling it. Using cryptographic operations to build trust, the blockchain allows users to safely transfer value without the need for a middleman [9]. Since it is necessary to select which blocks should be included in the blockchain, a distributed consensus method is used. This ensures that a consistent and correct version of the blockchain is maintained and shared among all participants [10]. The characteristics of blockchain are shown in fig 1.

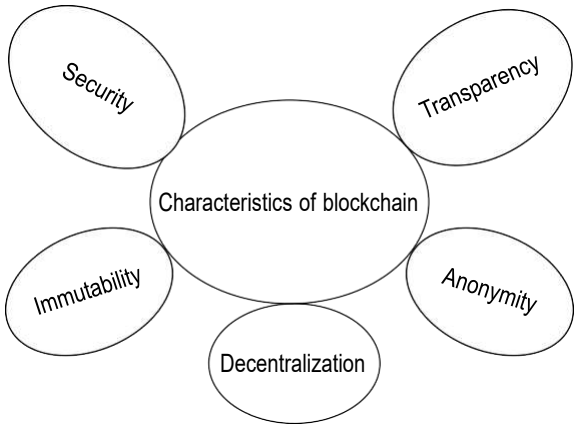

Fig. 1. Blockchain

1) Transparency: Every user on a blockchain network can see everything other on the network. Because of the transparency of blockchain, users of crypto currency may check the record of every transaction.
2) Security: There are no central servers, and so the network is completely decentralised [11].
3) Immutability: In a blockchain network, it is impossible to alter the information. This implies that tampering with the transaction data or hash value is impossible.
4) Anonymity: In a blockchain network, an individual can remain anonymous.
5) Decentralization: A peer-to-peer network eliminates the possibility of a single entity wielding dominance.

B. Smart Contracts

A blockchain smart contract operates on a computer program. As a trusted third party between untrustworthy parties, a smart contract might be viewed as such. Contract storage, a balance, and program code all go into smart contracts. Any node in the network can construct and make it accessible for usage by uploading a transaction to the blockchain [12]. Once a smart contract program code is placed in the blockchain, it cannot be changed. If and when the underlying criteria are satisfied, it is dynamically performed by the blockchain network's miners. A blockchain transaction triggers the execution of a smart contract, which results in a change to the blockchain's state [13].

C. How Blockchain Support for Vaccine Certification:

Vaccination certificates, formal papers verifying many aspects of a person's health, can be managed on the blockchain [14]. We can increase data security and decrease certificate forgery by utilizing blockchain's indisputable characteristics. As a result, individuals may be confident in the accuracyand security of the information they receive [15]. When the National Health Service representative performs a vaccine, the issuer authenticates the holder first and issues a digitally- signed Verifiable Credential [14].

III. RELATED WORKS

When it comes to vaccine supply chain management, researcher Yong et.al [16] recommend a blockchain-based method that uses machine learning (ML) techniques to assess the performance of each link in the chain. With the use of Ethereum's smart contracts, researchers were able to track vaccine production records and identify expiring vaccines. Only the traceability of vaccine delivery was addressed by this approach, which is a drawback.

A Blockchain-Based resolution for Covid-19 Digital Medical Passports and Immunity Certificates has been proposedin [17]. In order to administer Covid-19 certifications decentralised, they describe a method that integrates decentralised identities with smart contracts and IPFS as off-chain storage for documents. To manage digital health passport information including travel history, immunisations, vaccinations and more, system players like the Ministry of Foreign Affairs and of Public Health, as well as the Covid-19 testing centers and the people use them. The Foreign and Health Ministries have the authority to grant or revoke verifiable credentials to testingfacilities and health authorities. Authors [18] expressed worry about the possibility of discrimination, fraud, and a lack of uniformity in the marketplace. There is no population-based data on how people perceive immunity certificates availableto date.

To establish a tracking system for Covid-19 data collected from external sources and to maintain privacy, trust, and traceability for patients' information, a solution for managing data

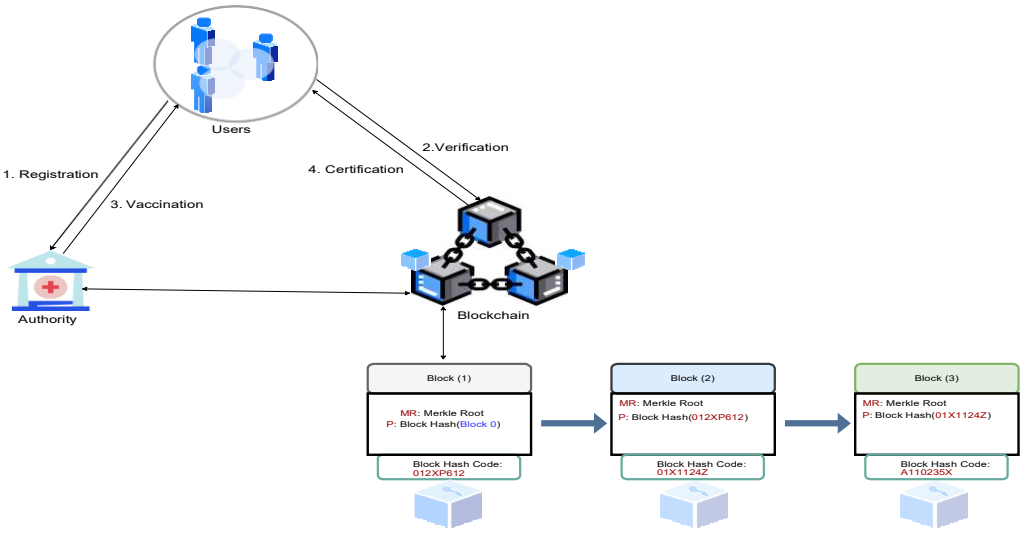

Fig. 2. Proposed Covid-19 Blockchain based Vaccine Management System

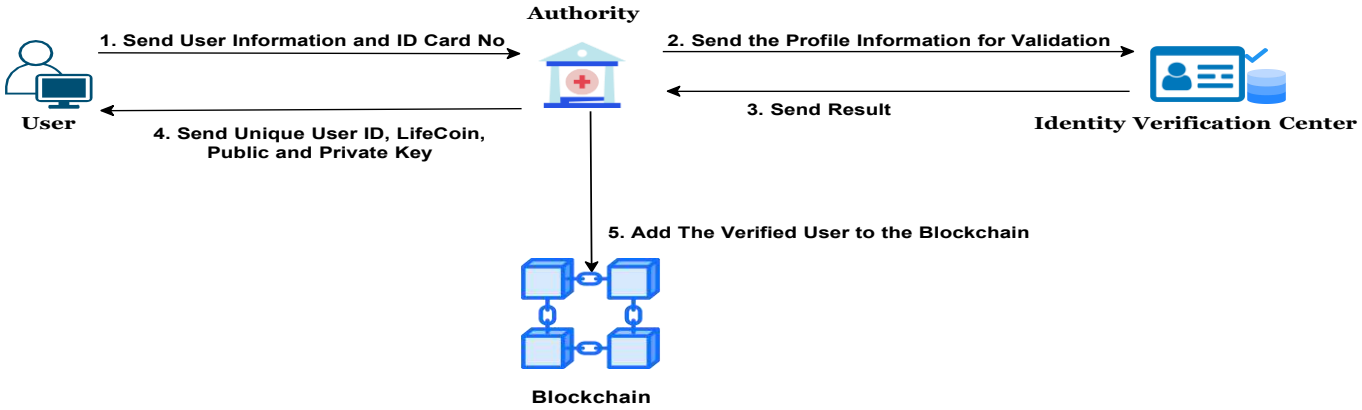

Fig. 3. User Registration Process for Vaccination

connected to the distribution and delivery of Covid-19 vaccines is needed [19]. Both the Covid-19 tests taken and immunity passports may be tracked and verified using a blockchain-based approach, according to Hasan et al [20]. Proxy re-encryption techniques are combined with peer-to-peer file storage in the suggested system in order to exchange medical information, identification, and travel information amongst users. It's worth noting that the system can only be used by government organizations who require travel immunity for the individuals.

IV. PROPOSED METHODOLOGY

In our proposed system, User perform registration process for vaccination at first. Then the first dose and second dose of vaccination are performed using blockchain technology. Here, blockchain contains all the information of vaccination of a user. After getting two doses, a user can get a certificate by providing a side effect survey of the two doses. The architecture of the proposed system is shown in fig 2.

There are three stages of our proposed system. They are:

- User Registration
- Vaccination/Vaccine Distribution
- Certificate of Vaccination

A. User Registration

Our system only permits those users who get enrolled by the authority. To apply for vaccination, users must have access to a smart device that allows them to register themselves with the system. Upon successful completion of a user registration procedure, the authority will provide the user with a one-of-a-kind user identification (User ID). In any event, it is possible that a few unscrupulous individuals would attempt to exploit the system by establishing fictitious user identities. The Sybil attack is the term used to describe this kind of disruption [21]. Hence, the user needs to submit a national identification card number to demonstrate his/her identity to avoid Sybil. Fig 3 shows the process of user registration process within the system. Initially, the user will be required to provide his or her profile information to the authorities, as well as his or her identity card. The information will be sent to the identity

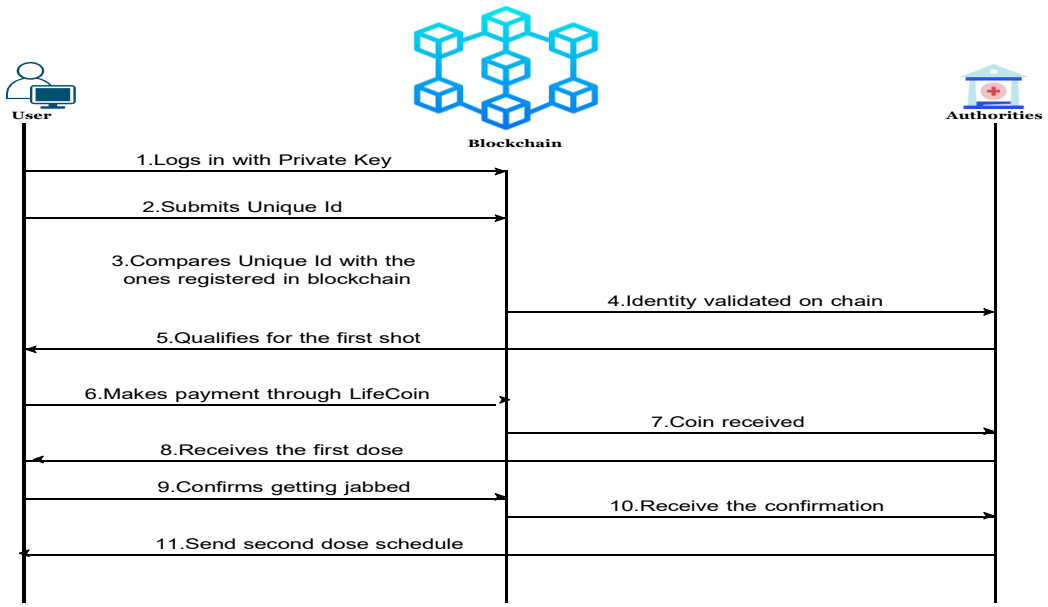

Fig. 4. Process of Vaccination

verification center for the purpose of user authentication by the authorities. If the user is genuine, the authority will give them a unique user ID, public key, private key, and two lifecoins. add the user ID will be added into the blockchain.

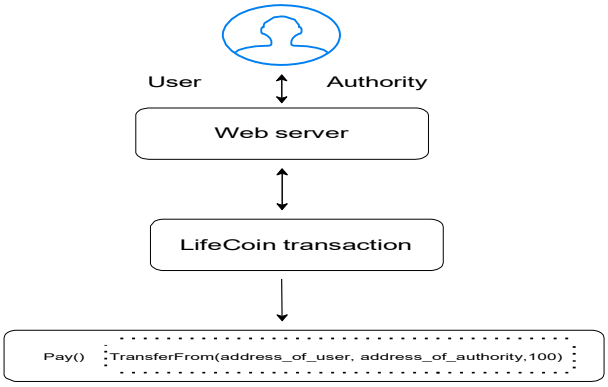

Fig. 5. User Registration Process for Vaccination

B. Vaccination/Vaccine Distribution

At first the user logs in with the private key into the chain and then submits the unique id which he or she got during the registration. Now the blockchain compares that id whether the registered client is unique or already is in the system. After that the chain passes it to the authorities for identity validation. If everything seems perfect, then the user will be qualified for the first dose of vaccine. To get the shot, the user makes payment through LifeCoin and then the authorities provide the dose. A confirmation needs to be sent from the user to authorities that he/she is vaccinated. While the authorities get the confirmation, they send the second dose schedule to the user. The process of taking the second dose is same as the first dose as shown in fig 4. To exchange values along the vaccine management blockchain, a Virtual currency like a payment system is needed. In our system we have named that currency lifecoin where each lifecoin contains 100 ethers. The transaction of lifecoin is shown in fig 5.

C. Certificate of Vaccination

After Receiving second-dose Covid-19 vaccine, a user will be periodically prompted to complete a side effect survey to monitor any potential side effects of Covid-19 vaccines and get certificate of vaccination as shown in figure 6. This enables the tracking of both long and short-term side effects as well as the efficacy of these vaccines.

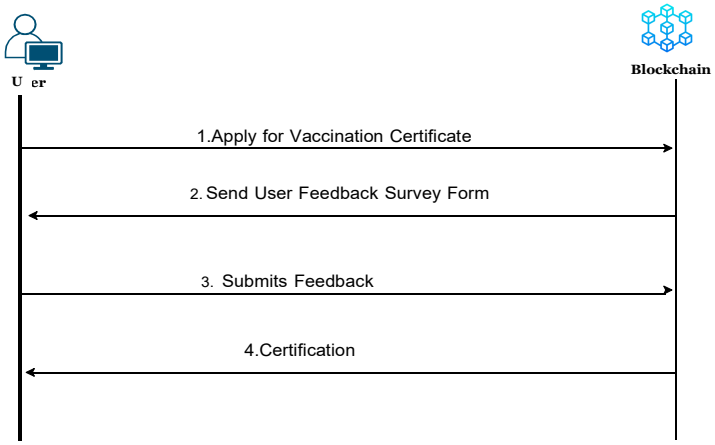

Fig. 6. Process of Certification of Covid19 Vaccine

V. PROPERTY ANALYSIS

A. Forge and Tamper Proof:

If a user is unable to create or modify the value of a certificate's associated attributes on their own, the requirement is satisfied [22]. By using blockchain technology our proposed methodology provide a forge and tamper proof system and provide a valid certificate.

B. Binding:

If a user can successfully utilise only the certificate that was assigned to him/her and has not been revoked, then this property is satisfied. An unissued certificate is prevented from being used by the user [22]. As each user contains a unique user id in our proposed system and for each user only one certificate will be generated using blockchain technology so it is not possible for user to use more than one certificate.

C. Availability

In our system all the transactions are available using the availability proper of blockchain. The decentralised and distributed nature of the blockchain makes it appealing. As a result, all logs and transactions related to the smart contract will be logged by all nodes involved. Even if a node in the blockchain network fails, the network will continue to function [23].

D. Privacy

While ensuring privacy, it is critical to think about how data can be accessed and used safely. To keep user identities safe, blockchain technology makes use of private and public keys. Because public keys are exposed to everyone, the blockchain cannot guarantee the privacy of transactions. As a result, the privacy-protecting systems built into the blockchain have flaws that could lead to anonymous misuse. Protecting user identities by building a mapping link between pseudonyms and actual identities is therefore crucial [24]. For this we have used unique user id in our system.

E. Immutability

Blockchain technology's immutability means that no record stored in the blockchain repository can be altered. You can get all three of these benefits from it [25]. As a result, our technology makes Covid-19 certificates readily available online, saving you both time and money If your original certificates are damaged or lost, you can get a replica of them online, which gives you a lot of freedom. Data in the blockchain repository is secure because it can't be changed or destroyed.

VI. CONCLUSIONS

This article explore the goal of implementing blockchain technology to vaccination management system. We create a blockchain-based system for Covid-19 vaccination registration, verification, certification and side effects self-reporting. We also offer a virtual currency named LifeCoin. User may pay using the Coin and then the authorities will deliver the dosage. Blockchain is utilised to give data immutability, transparency and accuracy of beneficiary registration for vaccination, avoiding identity thefts and impersonations. Also, byleveraging the unchallengeable characteristic of blockchain, we can provide better security for data and decrease the certificate forgery. After obtaining complete dose user can anonymously report the adverse effects. In future we will discuss broadly implementation of this system.

REFERENCES

[1] S. Lall and N. Singh, "Covid-19: Unmasking the new face of education," *Int. J. Res. Pharm. Sci.*, pp. 48–53, 2020.

[2] R. W. Ahmad, K. Salah, R. Jayaraman, I. Yaqoob, S. Ellahham, and M. Omar, "Blockchain and covid-19 pandemic: Applications and challenges," *IEEE TechRxiv*, 2020.

[3] L. Ricci, D. D. F. Maesa, A. Favenza, and E. Ferro, "Blockchains for covid-19 contact tracing and vaccine support: A systematic review," *IEEE Access*, vol. 9, pp. 37936–37950, 2021.

[4] B. Yong, J. Shen, X. Liu, F. Li, H. Chen, and Q. Zhou, "An intelligent blockchain-based system for safe vaccine supply and supervision," *International Journal of Information Management*, vol. 52, p. 102024, 2020.

[5] D. L. Thomas, "Blockchain applications in healthcare," 2021.

[6] W. J. Buchanan, M. A. Imran, M. Ur-Rehman, L. Zhang, Q. H. Abbasi, C. Chrysoulas, D. Haynes, N. Pitropakis, and P. Papadopoulos, "Review and critical analysis of privacy-preserving infection tracking and contact tracing," *Frontiers in Communications and Networks*, vol. 1, p. 2, 2020.

[7] G. Caldarelli, "Understanding the blockchain oracle problem: a call for action," *Information*, vol. 11, no. 11, p. 509, 2020.

[8] J. J. Klemeˇ, P. Jiang, Y. Van Fan, A. Bokhari, and X.-C. Wang, "Covid-19 pandemics stage ii–energy and environmental impacts of vaccination," *Renewable and Sustainable Energy Reviews*, vol. 150, p. 111400, 2021.

[9] K. Sultan, U. Ruhi, and R. Lakhani, "Conceptualizing blockchains: characteristics & applications," *arXiv preprint arXiv:1806.03693*, 2018.

[10] L. Ricci, D. D. F. Maesa, A. Favenza, and E. Ferro, "Blockchains for covid-19 contact tracing and vaccine support: A systematic review," *IEEE Access*, vol. 9, pp. 37936–37950, 2021.

[11] S. T. Alvi, M. N. Uddin, L. Islam, and S. Ahamed, "A privacy-aware digital voting system employing blockchain and smart contracts," in *2020 IEEE Asia-Pacific Conference on Computer Science and Data Engineering (CSDE)*, pp. 1–6, IEEE, 2020.

[12] M. Alharby, A. Aldweesh, and A. van Moorsel, "Blockchain-based smart contracts: A systematic mapping study of academic research (2018)," in *2018 International Conference on Cloud Computing, Big Data and Blockchain (ICCBB)*, pp. 1–6, IEEE, 2018.

[13] Alex M. Goh and Xiaoyu L. Yann, (2021), "Food-image Classification Using Neural Network Model" Int. J. of Electronics Engineering and Applications, Vol. 9, No. 3, pp. 12-22, DOI 10.30696/IJEEA.IX.III.2021.12-22.

[14] L. Ricci, D. D. F. Maesa, A. Favenza, and E. Ferro, "Blockchains for covid-19 contact tracing and vaccine support: A systematic review," *IEEE Access*, vol. 9, pp. 37936–37950, 2021.

[15] A. Gayathiri, J. Jayachitra, and S. Matilda, "Certificate validation using blockchain," in *2020 7th International Conference on Smart Structures and Systems (ICSSS)*, pp. 1–4, IEEE, 2020.

[16] B. Yong, J. Shen, X. Liu, F. Li, H. Chen, and Q. Zhou, "An intelligent blockchain-based system for safe vaccine supply and supervision," *International Journal of Information Management*, vol. 52, p. 102024, 2020.

[17] H. R. Hasan, K. Salah, R. Jayaraman, J. Arshad, I. Yaqoob, M. Omar, and S. Ellahham, "Blockchain-based solution for covid-19 digital medical passports and immunity certificates," *IEEE Access*, vol. 8, pp. 222093–222108, 2020.

[18] M. A. Hall and D. M. Studdert, "Privileges and immunity certification during the covid-19 pandemic," *Jama*, vol. 323, no. 22, pp. 2243–2244, 2020.

[19] A. Musamih, R. Jayaraman, K. Salah, H. R. Hasan, I. Yaqoob, and Y. Al-Hammadi, "Blockchain-based solution for distribution and delivery of covid-19 vaccines," *IEEE Access*, vol. 9, pp. 71372–71387, 2021.

[20] H. R. Hasan, K. Salah, R. Jayaraman, J. Arshad, I. Yaqoob, M. Omar, and S. Ellahham, "Blockchain-based solution for covid-19 digital medical passports and immunity certificates," *IEEE Access*, vol. 8, pp. 222093–222108, 2020.

[21] Xiong LIU and Haiqing LIU, (2021), "Data Publication Based On Differential Privacy In V2G Network" Int. J. of Electronics Engineering and Applications, Vol. 9, No. 2, pp. 34-44, DOI 10.30696/IJEEA.IX.I.2021.45-53.

[22] A. Abid, S. Cheikhrouhou, S. Kallel, and M. Jmaiel, "Novidchain: Blockchain-based privacy-preserving platform for covid-19 test/vaccine certificates," *Software: Practice and Experience*, 2021.

[23] A. Musamih, R. Jayaraman, K. Salah, H. R. Hasan, I. Yaqoob, and Y. Al-Hammadi, "Blockchain-based solution for distribution and delivery of covid-19 vaccines," *IEEE Access*, vol. 9, pp. 71372–71387, 2021.

[24] B. Awaji, E. Solaiman, and A. Albshri, "Blockchain-based applications in higher education: A systematic mapping study," in *Proceedings of the 5th International Conference on Information and Education Innovations*, pp. 96–104, 2020.

[25] XIAOYU YANG, (2021), "Power Grid Fault Prediction Method Based On Feature Selection And Classification Algorithm" Int. J. of Electronics Engineering and Applications, Vol. 9, No. 2, pp. 34-44, DOI 10.30696/IJEEA.IX.I.2021.34-44..