Journal of Advanced Health Informatics Research (JAHIR)
Vol. 1, No. 1, April 2023, pp. 10-15
DOI: https://doi.org/10.59247/jahir.v1i1.14

Private Blockchain in the Field of Health Services

Purwono [1], Khoirun Nisa [2], Sony Kartika Wibisono [3], Bala Putra Dewa [4]
Department of Informatics, Universitas Harapan Bangsa, Purwokerto, 53182, Indonesia

ARTICLE INFO

Article history:

Received December 18, 2022
Revised January 08, 2023
Published January 16, 2023

Keywords:

Blockchain;
Healthcare;
Hyperledger;
Private;
Patient;

ABSTRACT

Blockchain is a technology that is quite popular and has been adopted in various fields in recent years. This technology has caught the attention of researchers in the health sector because of its innovation which is considered capable of providing the necessary guarantees for the safe processing, sharing, and management of sensitive patient data. There are many problems with falsifying reports and withholding important information from patients, which is considered medical fraud. Hyperledger, a type of private Blockchain, is very suitable for healthcare applications. A private blockchain is a restricted type of blockchain network created by an entity. This type of network is limited to those with access permissions. In addition, private blockchains usually use a centralized verification system and are controlled by the network's creators. Hyperledger Fabric is one example of a permissioned blockchain that can play a role in implementing patient-centric, interoperable healthcare systems.

Corresponding Author:

Purwono, Universitas Harapan Bangsa, Jl. Raden Patah No.100, Purwokerto, Indonesia, 53182
Email: purwono@uhb.ac.id

1. INTRODUCTION

Blockchain is a technology that is quite popular and has been adopted in various fields in recent years [1]. This technology has caught the attention of researchers in the health sector because of its innovation which is considered capable of providing the necessary guarantees for the safe processing, sharing and management of sensitive patient data [2]. This is in line with the need for security guarantees for health data that are considered sensitive [3]. Various types of sensitive data contained in the Electronic Health Record (EHR) are regarded as one the privacy issues that make patients not interested in sharing their data [4]. The fact also states that one hospital with another does not necessarily have a compatible system, so it has profound implications for patients, especially in medical record data [5].

Currently, health service data is spread over various systems that have different architectures. There are also many problems of falsifying reports and withholding important information from patients, which are considered medical fraud [6]. In traditional healthcare systems, when patients wish to share their data with other parties, such as hospitals or research institutes, they have to go through manual approval processes, which are highly inefficient for care providers to coordinate, especially in situations where patients may move geographically without prior knowledge, where he will receive treatment [7].

Blockchain comes with a distributed database that forms a data blockchain as a decentralized data storage and processing solution [8] capable of solving various centralized system problems [9]. This technology is present as a solution that offers data security and privacy. Blockchain enables business process innovation in healthcare [10]. Blockchain can be used as a medium that can reduce the impact of health service challenges,

such as health data that is difficult to understand, use and share because its non-standard nature makes it difficult to disseminate to health networks [11].

Various types of research focus on the application of Blockchain in the healthcare sector. For example, research conducted by Amponsah [12] who have been testing new fraud detection and prevention methods for healthcare claims processing using machine learning and blockchain technology. Comparative experimental results show that the tool with the best performance achieves a classification accuracy of 97.96% and a sensitivity of 98.09%. This means that the proposed system enhances the ability of blockchain smart contracts to detect fraud with an accuracy of 97.96%. Other similar studies have also been carried out by Cerchione [13], who designed the distributed electronic health record ecosystem. The result is potentially benefiting from the deployment of distributed networks in terms of clinical outcomes (e.g., quality improvement, reduction of medical errors), organizational products (e.g., financial, operational benefits), and organizational outcomes (e.g., increased ability to conduct research, increased population health, cost reduction). The research was conducted by Karmakar [14], who created an Agent Free Insurance System using Blockchain for Healthcare 4.0. This research led to the conclusion that the proposed model has been implemented on an Ethereum test network, and its performance has been compared empirically with other state-of-the-art models. This method is considered to outperform the others in terms of service integrity, latency, and cost.

There are several blockchains types, including private, public and consortium [15]. Public blockchains have been popular since the arrival of Bitcoin in 2008, which introduced the concept of a distributed ledger which has caught the attention of researchers because it is considered a revolutionary technology after the internet. [8]. Public blockchains are accessible to anyone, and anyone can participate in a consensus process to determine what blocks can be added to the chain [16]. A private blockchain is a restricted type of blockchain network created by an entity. This type of network is limited to those with access permissions. In addition, private blockchains usually use a centralized verification system and are controlled by the network's creators [17]. Based on the importance of patient data in healthcare, we summarize the use of private Blockchain by leveraging the Hyperledger Fabric platform. This platform has also previously been researched utilizing representative tests to assess the security criteria that support the Blockchain regarding data confidentiality, privacy, and access control. Experimental evaluations reveal the promising benefits of private blockchain technology in terms of security, regulatory compliance, compatibility, flexibility, and scalability [3].

2. BLOCKCHAIN APPLICATIONS IN HEALTH SERVICES

This section will discuss what health applications can be implemented with blockchain technology. Blockchain will play an essential role in transforming the healthcare sector. Blockchain enhances healthcare organizations to provide adequate patient care and high-quality healthcare facilities [18].

2.1. Data Security

As part of blockchain technology, consensus protocols significantly impact the safety and security of blockchain systems [19]. The blockchain system uses a consensus algorithm to build trust and properly store block transactions [20]. Blockchain-protected networks provide an advantage over older approaches to securing health information. Data cannot be modified or deleted once added to the Blockchain. Even if the data needs to be updated, a new record includes all previous entries. Additionally, each form is accessible via a unique private key controlled by the patient. Since a hash represents each document, verifying modifications to the original hash ensures the highest levels of transparency and verification.

2.2. Health Insurance Claims

Blockchain can also be adapted to health insurance claims [21]. When all data is appropriately connected to the Blockchain network, the processing time will be accelerated, the risk of fraud will be reduced, and time and money will be more efficient [14]. This further allows insurance claims to be processed in real-time.

2.3. Supply Chain

In the process of tracking medical supplies in real-time from manufacturers to minimize the danger of human error in sending transactions, Blockchain integration with an organization's supply chain can increase productivity and quality control [22]. It can also determine how much labour costs and how much carbon emissions a supply chain functions. Organ transplantation is another use case of Blockchain-based supply chains in healthcare that is becoming very popular. Blockchain technology offers a distributed, secure and transparent approach to exchanging information in the supply chain [23].

2.4. Medical Research

Medical research can only be successful if the data is high quality and readily available. The proprietary rights granted to patients on the Blockchain can be used for research purposes only if the information is subject to sufficient consent. This will enable research institutions to collect open data to advance clinical research and public health reporting. In short, blockchain qualities such as decentralization, data sources, reliability and smart contract support are ideal for advancing the modern healthcare system. The Hyperledger Fabric healthcare system takes it one step further by introducing modularity to the ecosystem.

While first-generation blockchain frameworks, such as Bitcoin, were designed primarily to facilitate cryptocurrency transactions [24], newer blockchain-based applications have also become available for healthcare use [25]. A different blockchain framework, Hyperledger, employs a healthcare business's technical requirements that require it to take a variety of things into account when developing healthcare applications. [26]. For example, the privacy of patients and their data is one of the most important requirements in the creation of Hyperledger healthcare applications [27]. While standard blockchain frameworks demand full transparency, the European General Data Protection Regulation (GDPR) regulates public access to that information [8]. Apart from that, transaction scalability is another important requirement of the healthcare industry that an ideal blockchain infrastructure must meet. Transaction validation and consensus protocols are critical in determining the scalability of transactions in healthcare applications.

3. HYPERLEDGER AS A HEALTHCARE BLOCKCHAIN PLATFORM

3.1. Hyperledger

Hyperledger is an open-source umbrella organization with several open-source projects. Where these projects are used to build Blockchain technology. Hyperledger is directly fostered by the Linux Foundation and has support from companies such as IBM and Intel to SAP Ariba. Hyperledger Fabric is a modular blockchain project regulated by The Linux Foundation, a consortium that promotes decentralized innovation [28].

Hyperledger has many frameworks and tools often used to build Blockchain networks [29]. Each of these frameworks and devices has a specific function, but they can also collaborate during the implementation process of creating a Blockchain network. Examples of hyper ledger frameworks are Hyperledger Fabric, Hyperledger Sawtooth, Hyperledger Burrow, Hyperledger Indy and Hyperledger Iroha. As for the tools used, among others, namely Hyperledger Explorer, Hyperledger Cello, Hyperledger Avalon, Hyperledger Cactus, and Hyperledger Caliper.

Hyperledger Fabric is one example of a permissioned blockchain that can play a role in implementing patient-centric, interoperable healthcare systems. It is an open-source distributed ledger technology (DTL) platform that supports strong security and privacy features [26]. Because Hyperledger Fabric is licensed and provides smart contract (chain code) support, it is becoming popular for many applications in multiple domains. The Fabric enables participants in the consortium to develop and deploy applications using the Blockchain [27]. Hyperledger Fabric has a modular design and architecture and therefore has a high degree of flexibility and extensibility [30]. The Hyperledger fabric can be divided horizontally into four components: identity management, ledger management, transaction management and smart contracts; and vertically. Hyperledger Fabric can be divided into five components: member management, consensus services, chain code services, security, and cryptographic services.

The difference between Hyperledger and other platforms, such as Bitcoin and Ethereum, is that Hyperledger is widely used in building private/permissioned blockchain networks. Meanwhile, Ethereum and Bitcoin are more public blockchains. Because it is commonly used in making private blockchain networks, users/participants in the Hyperledger platform are also more controlled and supervised [31].

3.2. Hyperledger Healthcare System

Based on the developer's need for a complete toolkit that can rapidly implement multiple privacy and security standards, the Hyperledger platform is a perfect fit for healthcare applications. [32]. In addition, it has complete control over smart contracts that can be executed in multiple computer languages, including Node.js and Javascript [33]. Smart contract technology is a computerized transaction protocol that independently executes the contents of an agreement and aims to conclude an agreement or agreement between several parties [34].

While Bitcoin and Ethereum can complete seven and fifteen transactions per second, respectively [35], Hyperledger outperforms the competition with transaction speeds of up to 3000 transactions per second [36]. This technology does not use cryptocurrency as a motivator, which is certainly different from public blockchains such as bitcoin or Ethereum. Another advantage is that it has high transaction throughput and low transaction fees. Hyperledger Fabric is the most comprehensive blockchain framework accessible compared to other blockchain frameworks.

Implementation of blockchain technology in health management systems can be used to track transactions that occur so as to create transparent data integrity and security [37]. The following are some implementations of the hyper ledger Fabric in the health sector [38]:

1. Axuall is a digital network for verifying identity, credentials, and authenticity in real time using the Sorvin Network and Hyperledger Indy. The Axuall network is currently in pilot with Hyr Medical and their 650+ physician network in addition to two other health systems. Physicians' time is better spent practising medicine than filling out redundant, repetitive credentialing paperwork consisting of unchanging information. Using Axuall's digital credentialing network, physicians will be able to present fully compliant credential sets to participating healthcare systems and medical groups they are affiliated with or applying to. Utilizing the cryptographic constructs from Hyperledger Indy, healthcare organizations will be able to verify the validity of a physician's credentials – spanning medical education, training, licensing, board certification, work history, competency evaluations, sanctions, and adverse events – ensuring compliance with industry standards, regulatory mandates, and health system bylaws.
2. LedgerDomain joined forces with other industry leaders like Pfizer, IQVIA, UPS, Merck, UCLA Health, GSK, Thermo Fisher, and Biogen to build out a pilot on Hyperledger Fabric called KitChain. Scoped and developed over the course of two years, KitChain aims to demonstrate a robust collaborative model for managing the pharmaceutical clinical supply chain, creating an immutable record for shipment and event tracking without the need to resort to paperwork and manual transcription. KitChain has two major components: a front-end mobile application and a back-end blockchain server. The backend was implemented in Golang and used Hyperledger Fabric, the LedgerDomain Selvedge blockchain app platform, and LedgerDomain's DocuSeal framework, encompassing smart contracts and application logic. As such, the pilot has a fully functioning, highly secure blockchain backend.
3. This drug discovery project uses Amazon Web Services technologies to execute Machine Learning algorithms from academic partners on a large scale. The data never leaves the owner's infrastructure, and only non-sensitive models are exchanged. A central dispatcher allows each partner to share a common model to be consolidated collectively. To provide full traceability of the operations, the platform is based on a private blockchain and uses Substrate, a software framework for orchestrating distributed machine learning tasks in a secure way. Substrate is based on Hyperledger Fabric. MELLODDY is designed to prevent the leaking of proprietary information from one data set to another or from one model to another while simultaneously boosting the predictive performance and applicability domain of the models by leveraging all available data.
4. Medicalchain was one of the first healthcare blockchain companies to join the Hyperledger community, signing on as a member in 2017. The company's ethos is to empower patients to have access to their medical records. Providing patients with direct access to their data unlocks the barriers we face in healthcare today, such as patient choice and interoperability issues. A doctor-led team based in the UK, Medicalchain trialled the first telemedicine consultation using blockchain technology. The company's first blockchain-based product to market, MyClinic.com, makes it easy to schedule appointments, review medical reports and request further investigations or assistance using an Android and iOS app. Now the company is set to focus on scalability with the view to onboarding clinics and patients locally, nationally, and internationally.
5. SecureKey launched its innovative and in-demand network to Canadian consumers in early 2019. Verified. Me is a blockchain-based digital identity network built upon Hyperledger Fabric 1.2 that lets consumers stay in control of their information by choosing when to share information and with whom, reducing unnecessary oversharing of personal information. Sun Life Financial has signed on as an early adopter and the first North American (health) insurer,

making it easier for their clients to do business with the company. Dynacare, one of Canada's largest and most respected health and wellness solutions providers, has joined the Verified. Me network. Dynacare's participation will make it easier for Canadians to verify their identities and gain safer and faster access to their health information.

4. CONCLUSION

Blockchain is a technology that is increasingly in demand in the health sector. This is evidenced by the increasing number of researchers who take advantage of the sophistication of this technology. Based on the developer's need for a complete toolkit that can rapidly implement multiple privacy and security standards, the Hyperledger platform is a perfect fit for healthcare applications. Hyperledger has complete control over smart contracts that can be executed in multiple computer languages, including Node.js and Javascript. The difference between Hyperledger and other platforms, such as Bitcoin and Ethereum, is that Hyperledger is widely used in building private/permissioned blockchain networks. Meanwhile, Ethereum and Bitcoin are more public blockchains. Because it is widely used in making private blockchain networks, users/participants in the Hyperledger platform are also more controlled and more supervised.

REFERENCES

[1] Purwono, A. Ma'arif, W. Rahmaniar, Q. M. ul Haq, D. Herjuno, and M. Naseer, "Blockchain Technology," *J. Ilm. Tek. Elektro Komput. dan Inform.*, vol. 8, no. 2, pp. 199–205, 2022, doi: 10.26555/jiteki.v8i2.24327.

[2] V. Merlo, G. Pio, F. Giusto, and M. Bilancia, "On the exploitation of the blockchain technology in the healthcare sector: A systematic review," *Expert Syst. Appl.*, vol. 213, p. 118897, 2023, doi: https://doi.org/10.1016/j.eswa.2022.118897.

[3] M. Antwi, A. Adnane, F. Ahmad, R. Hussain, M. Habib your Rehman, and C. A. Kerrache, "The case of HyperLedger Fabric as a blockchain solution for healthcare applications," *Blockchain Res. Appl.*, vol. 2, no. 1, p. 100012, 2021, doi: https://doi.org/10.1016/j.bcra.2021.100012.

[4] A. Hajian, V. R. Prybutok, and H.-C. Chang, "An empirical study for blockchain-based information sharing systems in electronic health records: A mediation perspective," *Comput. Human Behav.*, vol. 138, p. 107471, 2023, doi: https://doi.org/10.1016/j.chb.2022.107471.

[5] G. Al-Sumaidaee, R. Alkhudary, Z. Zilic, and A. Swidan, "Performance analysis of a private blockchain network built on Hyperledger Fabric for healthcare," *Inf. Process. Manag.*, vol. 60, no. 2, p. 103160, 2023, doi: https://doi.org/10.1016/j.ipm.2022.103160.

[6] I. Riadi, T. Ahmad, R. Sarno, P. Purwono, and A. Ma'arif, "Developing Data Integrity in an Electronic Health Record System using Blockchain and InterPlanetary File System (Case Study: COVID-19 Data)," *Emerg. Sci. J.*, vol. 4, no. Special issue, pp. 190–206, 2020, doi: 10.28991/esj-2021-SP1-013.

[7] A. Dubovitskaya, Z. Xu, S. Ryu, M. Schumacher, and F. Wang, "Secure and Trustable Electronic Medical Records Sharing using Blockchain," *AMIA ... Annu. Symp. proceedings. AMIA Symp.*, vol. 2017, Aug. 2017.

[8] R. Belen-Saglam, E. Altuncu, Y. Lu, and S. Li, "A systematic literature review of the tension between the GDPR and public blockchain systems," *Blockchain Res. Appl.*, p. 100129, 2023, doi: https://doi.org/10.1016/j.bcra.2023.100129.

[9] R. Yang *et al.*, "Public and private blockchain in construction business process and information integration," *Autom. Constr.*, vol. 118, p. 103276, 2020, doi: https://doi.org/10.1016/j.autcon.2020.103276.

[10] D. Aloini, E. Benevento, A. Stefanini, and P. Zerbino, "Transforming healthcare ecosystems through blockchain: Opportunities and capabilities for business process innovation," *Technovation*, vol. 119, p. 102557, 2023, doi: https://doi.org/10.1016/j.technovation.2022.102557.

[11] I. Erol, A. Oztel, C. Searcy, and İ. T. Medeni, "Selecting the most suitable blockchain platform: A case study on the healthcare industry using a novel rough MCDM framework," *Technol. Forecast. Soc. Change*, vol. 186, p. 122132, 2023, doi: https://doi.org/10.1016/j.techfore.2022.122132.

[12] A. A. Amponsah, A. F. Adekoya, and B. A. Weyori, "A novel fraud detection and prevention method for healthcare claim processing using machine learning and blockchain technology," *Decis. Anal. J.*, vol. 4, p. 100122, 2022, doi: https://doi.org/10.1016/j.dajour.2022.100122.

[13] R. Cerchione, P. Centobelli, E. Riccio, S. Abbate, and E. Oropallo, "Blockchain's coming to hospital to digitalize healthcare services: Designing a distributed electronic health record ecosystem," *Technovation*, p. 102480, 2022, doi: https://doi.org/10.1016/j.technovation.2022.102480.

[14] A. Karmakar, P. Ghosh, P. S. Banerjee, and D. De, "ChainSure: Agent Free Insurance System using Blockchain for Healthcare 4.0," *Intell. Syst. with Appl.*, p. 200177, 2023, doi: https://doi.org/10.1016/j.iswa.2023.200177.

[15] B. Bera, A. K. Das, and A. K. Sutrala, "Private blockchain-based access control mechanism for unauthorized UAV detection and mitigation in Internet of Drones environment," *Comput. Commun.*, vol. 166, pp. 91–109, 2021, doi: https://doi.org/10.1016/j.comcom.2020.12.005.

[16] H. Tang, Y. Shi, and P. Dong, "Public blockchain evaluation using entropy and TOPSIS," *Expert Syst. Appl.*, vol. 117, pp. 204–210, 2019, doi: https://doi.org/10.1016/j.eswa.2018.09.048.
[17] T. Ncube, N. Dlodlo, and A. Terzoli, *Private Blockchain Networks: A Solution for Data Privacy*. 2020.
[18] A. Haleem, M. Javaid, R. P. Singh, R. Suman, and S. Rab, "Blockchain technology applications in healthcare: An overview," *Int. J. Intell. Networks*, vol. 2, pp. 130–139, 2021, doi: https://doi.org/10.1016/j.ijin.2021.09.005.
[19] Q. Bao, B. Li, T. Hu, and X. Sun, "A survey of blockchain consensus safety and security: State-of-the-art, challenges, and future work," *J. Syst. Softw.*, vol. 196, p. 111555, 2023, doi: https://doi.org/10.1016/j.jss.2022.111555.
[20] H. Guo and X. Yu, "A survey on blockchain technology and its security," *Blockchain Res. Appl.*, vol. 3, no. 2, p. 100067, 2022, doi: https://doi.org/10.1016/j.bcra.2022.100067.
[21] A. A. Amponsah, A. F. Adekoya, and B. A. Weyori, "Improving the Financial Security of National Health Insurance using Cloud-Based Blockchain Technology Application," *Int. J. Inf. Manag. Data Insights*, vol. 2, no. 1, p. 100081, 2022, doi: https://doi.org/10.1016/j.jjimei.2022.100081.
[22] J. S. Jadhav and J. Deshmukh, "A review study of the blockchain-based healthcare supply chain," *Soc. Sci. Humanit. Open*, vol. 6, no. 1, p. 100328, 2022, doi: https://doi.org/10.1016/j.ssaho.2022.100328.
[23] I. A. Omar, M. Debe, R. Jayaraman, K. Salah, M. Omar, and J. Arshad, "Blockchain-based Supply Chain Traceability for COVID-19 personal protective equipment," *Comput. Ind. Eng.*, vol. 167, p. 107995, 2022, doi: https://doi.org/10.1016/j.cie.2022.107995.
[24] A. Brauneis, R. Mestel, R. Riordan, and E. Theissen, "Bitcoin unchained: Determinants of cryptocurrency exchange liquidity," *J. Empir. Financ.*, vol. 69, pp. 106–122, 2022, doi: https://doi.org/10.1016/j.jempfin.2022.08.004.
[25] T. M. Ghazal, M. K. Hasan, S. N. H. S. Abdullah, K. A. A. Bakar, and H. Al Hamadi, "Private blockchain-based encryption framework using computational intelligence approach," *Egypt. Informatics J.*, vol. 23, no. 4, pp. 69–75, 2022, doi: https://doi.org/10.1016/j.eij.2022.06.007.
[26] M. Kumar and S. Chand, "MedHypChain: A patient-centered interoperability hyperledger-based medical healthcare system: Regulation in COVID-19 pandemic," *J. Netw. Comput. Appl.*, vol. 179, p. 102975, 2021, doi: https://doi.org/10.1016/j.jnca.2021.102975.
[27] X. Zhao, S. Wang, Y. Zhang, and Y. Wang, "Attribute-based access control scheme for data sharing on hyperledger fabric," *J. Inf. Secur. Appl.*, vol. 67, p. 103182, 2022, doi: https://doi.org/10.1016/j.jisa.2022.103182.
[28] D. Ravi, S. Ramachandran, R. Vignesh, V. R. Falmari, and M. Brindha, "Privacy preserving transparent supply chain management through Hyperledger Fabric," *Blockchain Res. Appl.*, vol. 3, no. 2, p. 100072, 2022, doi: https://doi.org/10.1016/j.bcra.2022.100072.
[29] H. Foundation, *An Overview of Hyperledger Foundation*. 2021.
[30] N. Lu, Y. Zhang, W. Shi, S. Kumari, and K.-K. R. Choo, "A secure and scalable data integrity auditing scheme based on hyperledger fabric," *Comput. Secur.*, vol. 92, p. 101741, 2020, doi: https://doi.org/10.1016/j.cose.2020.101741.
[31] R. M. Stulz, "Public versus private equity," 2020. doi: 10.1093/oxrep/graa003.
[32] Q. Wang and S. Qin, "A hyperledger fabric-based system framework for healthcare data management," *Appl. Sci.*, vol. 11, no. 24, 2021, doi: 10.3390/app112411693.
[33] Hyperledger, "Hyperledger Architecture, Volume II," 2018. doi: 10.1016/0378-1119(82)90151-2.
[34] E. S. Negara, A. N. Hidayanto, R. Andryani, and R. Syaputra, "Survey of smart contract framework and its application," *Inf.*, vol. 12, no. 7, pp. 1–10, 2021, doi: 10.3390/info12070257.
[35] M. Schäffer, M. di Angelo, and G. Salzer, "Performance and Scalability of Private Ethereum Blockchains," *Lect. Notes Bus. Inf. Process.*, vol. 361, pp. 103–118, 2019, doi: 10.1007/978-3-030-30429-4_8.
[36] C. Gorenflo, S. Lee, L. Golab, and S. Keshav, "FastFabric: Scaling Hyperledger Fabric to 20,000 Transactions per Second," in *2019 IEEE International Conference on Blockchain and Cryptocurrency (ICBC)*, 2019, pp. 455–463, doi: 10.1109/BLOC.2019.8751452.
[37] A. Jain and D. S. Jat, "Implementation of Blockchain Enabled Healthcare System using Hyperledger Fabric," *ACM Int. Conf. Proceeding Ser.*, pp. 37–47, 2021, doi: 10.1145/3484824.3484914.
[38] Hyperledger, "Five Healthcare Projects Powered by Hyperledger You May Not Know About," 2020. https://www.hyperledger.org/blog/2020/01/29/five-healthcare-projects-powered-by-hyperledger-you-may-not-know-about.