

Role of Blockchain in Forestalling Pandemics

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Abstract—The unexpected development and quick; however, the uncontrolled overall spread of the Coronavirus shows us the disappointment of existing human services observation frameworks to convenient handle general wellbeing crises. In spite of the fact that upgrades in medicinal services observation have been understood, these still miss the mark in forestalling commotion. Absence of important advances taken to guarantee control and following of the infection have bothered the circumstance. Blockchain innovation has progressively been referenced as an instrument to help with different parts of various applications. This paper highlights the role of blockchain in forestalling the future of pandemics. Various use cases of blockchain technology that can help in the battle against the COVID-19 are also highlighted in this paper.

Keywords—blockchain, pandemic, COVID-19, cryptography, distributed ledger

I. INTRODUCTION

Forestalling, and controlling sicknesses that have pestilence potential is a significant general wellbeing movement. Numerous observation frameworks are utilized to follow potential new ailments and control existing sicknesses. Despite the fact that administrations are making every effort to contain the spread of the Coronavirus, their battle is hampered by challenges in the convenient sharing of data with nearby and universal wellbeing requirement organizations on the ground. Lamentably, a considerable lot of these frameworks are obsolete, difficult to get to, or off base. China's ebb and flow infection reconnaissance framework, for example, is a refreshed adaptation of a framework that is five decades old. What's more, there is a protection and security issue when utilizing unified medicinal services reconnaissance frameworks. Time anyway is of the quintessence when managing episodes of this kind of fatal sickness. Blockchain [1] is nothing but a public ledger in which all the transactions are stored in linked lists of blocks (see Figure 1). Several organizations [2]–[10] that require transparency, honesty and reliability can adopt blockchain as a technology for their framework. According to the report provided WHO, FLU like infections or viral infections, cause that by coronaviruses can cause some critical health issues to the masses [11]. With the outbreak of COVID-19, several scientists and researchers studied various treatment strategies to handle this pandemic. In order to find out the clinical characteristics of COVID-19, Dawei Wang *et al.* have studied 138 infected patients of Wuhan, China [12]. The study reveals that the authors have considered various factors like the

medical history of the person, signs and symptoms, morbidity etc. In [13], the work related to the clinical treatments and features of COVID-19 has been summarized, and six clinical studies have been compared and summarised the symptoms and treatments. Many recent studies [14]–[17] shows that there is a need for some decentralized technology like blockchain that can be used in tracing down the spread of pandemics like COVID-19.

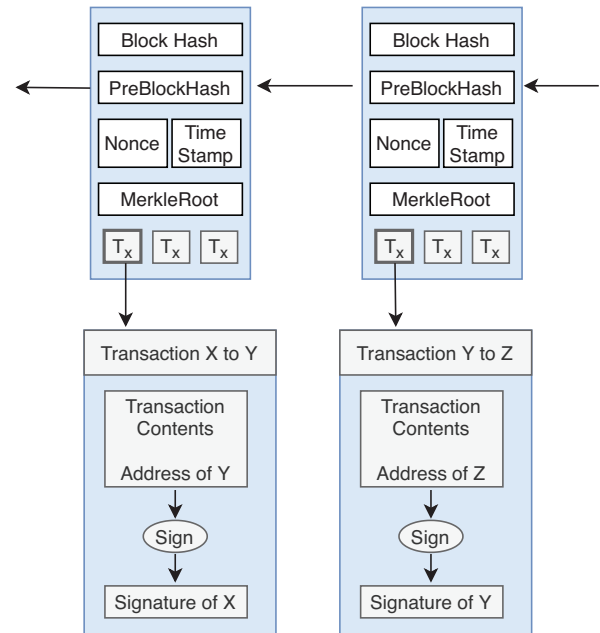


Fig. 1: Block Structure in Blockchain.

Table I shows the current statistics acquired on August 30, 2020 from [18]. A blockchain is a ceaselessly growing record of exchanges between two gatherings. Such records can be utilized to check the cases of a gathering that an exchange has surely occurred. Blockchain is increasing increasingly more unmistakable quality every day on account of its wide applications in different backgrounds [19]. Seeing its utility, various organizations and specialists over the globe have begun utilizing blockchain to assemble applications that can

| Sr. No | Country, Other | Total Cases | Total Deaths | Total Recovered | Active Cases |
|--------|----------------|-------------|--------------|-----------------|--------------|
| | World | 2,51,69,549 | 8,46,778 | 1,75,09,305 | 68,13,466 |
| 1 | USA | 61,39,078 | 1,86,855 | 34,08,799 | 25,43,424 |
| 2 | Brazil | 38,46,965 | 1,20,498 | 30,06,812 | 7,19,655 |
| 3 | India | 35,42,733 | 63,657 | 27,13,933 | 7,65,143 |
| 4 | Russia | 9,85,346 | 17,025 | 8,04,383 | 1,63,938 |
| 5 | Peru | 6,39,435 | 28,607 | 4,46,675 | 1,64,153 |
| 6 | South Africa | 6,22,551 | 13,981 | 5,36,694 | 71,876 |
| 7 | Colombia | 5,99,914 | 19,064 | 4,40,574 | 1,40,276 |
| 8 | Mexico | 5,91,712 | 63,819 | 4,09,127 | 1,18,766 |
| 9 | Spain | 4,55,621 | 29,011 | N/A | N/A |
| 10 | Chile | 4,08,009 | 11,181 | 3,81,183 | 15,645 |

TABLE I: Current scenario of COVID -19 across various countries

help in countering the COVID-19. These applications plan to address a vital issue, which is the absence of coordination of checked information sources. As indicated by specialists, one of the principal focal points of utilizing blockchain-empowered applications is blockchain's ability to approve ceaselessly evolving information. This element can end up being very important in dealing with the quickly raising COVID-19 circumstance.

In Figure 2, the current COVID-19 situation is shown, in which the total number of cases is 25,166,528 whereas the actives cases are around 6,811,858 in which around 17,507,892 people are recovered, and unfortunately 846,778 people reportedly died due to COVID-19. The data (see TableI) was taken on 30 August 2020 from [20].

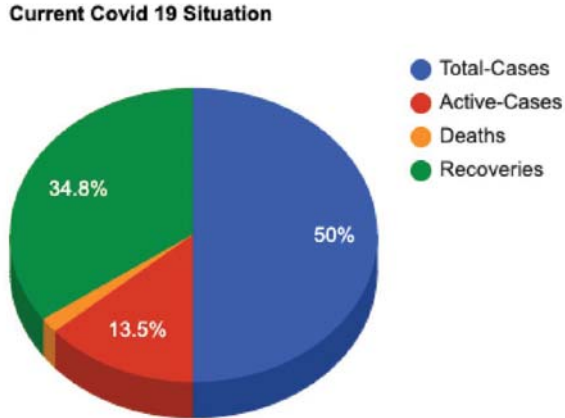


Fig. 2: COVID-19 situation (30 Aug 2020).

II. PRINCIPLE ISSUES RELATED TO PANDEMIC

Disease transmission specialists who concentrate on how maladies spread are being confronted with the errand of get-together, confirming, and cleaning information in a productive

way. Protection and security issues, language obstructions, the sheer separation between the geological area of an episode, social contrasts, and numerous different variables are issues that moderate the transmission and trade of vital data.

A. Non-ideal information

There is information about the executive's issue containing the Coronavirus could boil down to an issue of information the board. Get-together information, checking that information, and afterwards tidying up that information anyway is a long way from ideal. Disease transmission specialists need top-notch information to display infections; with models, they can give proposals about how to contain the sickness to governments. In any case, that information is difficult to get, or its trustworthiness can't be confirmed, subsequently of no utilization to disease transmission specialists.

B. Underreporting

Because of that, the present contamination and demise insights are theorized to be a lot higher than detailed. The coronavirus flare-up has raised worries over the Chinese government underreporting the quantity of tainted and expired. This underreporting can be brought about by numerous interruptions in the framework, for example, the absence of information straightforwardness. Yet additionally a deficiency of testing packs diminishes the quantity of affirmed cases, and passing can be credited to different causes. Tragically, it is difficult to know exactly how genuine this episode truly is, without access to a safe and decentralized observation framework.

C. Political Complications

In addition, there is the issue of national concentrated observation frameworks, not talking cross-fringe. Sickneses can spread rapidly across political fringes. Customary frameworks run by governments can miss episodes since they occur across physical outskirts. A decentralized framework is the quickest method to report episodes.

D. Absence of advancement in human services frameworks

In numerous nations, medicinal services observation frameworks need advancements, brought about by low interests in innovations prompting less compelling human services frameworks. This despite the up and coming new advances including fabricated consciousness, huge information the executives, and blockchain.

III. USE OF BLOCKCHAIN IN PANDEMICS

An opportunity to construct borderless arrangements dependent on decentralized advancements has come. Featuring the requirement for various upgrades in the medicinal services segment, the U.S. Branch of Health and Human Services' Office of the National Coordinator for Health Information Technology gave a Shared Nationwide Interoperability Roadmap mentioning omnipresent, secure system framework; certain character and confirmation everything being equal; and steady portrayal of approval to get to electronic wellbeing data [21]. Here blockchain could offer approaches to improve numerous general wellbeing exercises related to forestalling and controlling maladies. Blockchain-fuelled arrangements could address and tackle different parts of the issue. Blockchain innovation can improve wellbeing, access to data, gracefully chains, and some more. These desires depend on the key parts of blockchain innovation, for example, decentralized administration, permanent review trails, information provenance, and strength. Also, different hubs in a permissioned blockchain can share and report crucial information in a flash, while consenting to information protection and security guideline. There are several use cases of blockchain, and it could be utilized to improve an assortment of human services related procedures, including record the board, social insurance reconnaissance, following illness flare-ups, the executives emergency circumstances, and some more.

A. Record the board: a solitary wellspring of data

Containing an infection ought to be taken a gander at as an information the board issue. The greatest open door for blockchain in the social insurance industry is as a solitary wellspring of truth for the information provenance, as the entire world is battling against this episode. It could be utilized to record the board purposes, to oversee ongoing information, and critically, to guarantee its respectability, while distinguishing and dispense with deception about the Coronavirus. In crises like these, there are high quantities of approaching information, "with very few hands on deck to deal with the equivalent". With the utilization of blockchain, information assortment will get computerized and unchanging nature of the record makes it difficult to adjust any of the records. By utilizing blockchain innovation, one might safely oversee wellbeing records, guaranteeing interoperability without trading off patient protection and security. Those records could incorporate patients' information, medicines given, and any advancement recognized. Blockchain will likewise ensure that information is chronicled and secured by any unapproved get to, yet at the same time keeping it accessible for the entire

social insurance framework. It will empower clients to see all the information and patterns on the infection continuously, including all data about affirmed instances of tainted, loss of life, recuperation, and so forth. The exponential development of network and the entrance to the abundance of information it offers would permit wellbeing authorities to rapidly follow the spread of illness, giving powerless populaces crucial data. This data can be utilized by inquiring about labs chipping away at an antibody.

B. Blockchain human services observation framework

Blockchain can likewise be utilized for observation purposes. A blockchain human services reconnaissance framework can give the way to forestall and control future episodes. A permissioned blockchain reconnaissance framework would permit neighbourhood and national wellbeing organizations to get to the observation information. A worldwide blockchain reconnaissance framework could without much of a stretch arrive at zones where availability is poor, and costs must be kept low. Neighbourhood professionals can get continuous data on encompassing regions, paying little heed to legislative or political obstructions. Furthermore, worldwide associations like the World Health Organization could get to the information. Since the framework is decentralized and made sure about through blockchain, the information stays secure, and numerous associations can report the information.

C. Following irresistible infection episodes

Blockchain could be utilized for following general wellbeing information observation, especially for irresistible malady episodes. Expanding straightforwardness will bring about increasingly precise revealing and progressively effective reactions. They would consider the quick handling of information, empowering early identification of diseases before they spread to the degree of plagues. Blockchain can help create medicines quickly, and help with the executives when pandemics do happen. This could empower government organizations to monitor the infection action, of patients, suspected new cases, and the sky is the limit from there. They could likewise utilize the blockchain to find where the infection started, presumably. It could empower specialists to survey patients' manifestations and symptomatic screen information progressively, incorporating persistent history data. Data can be gathered in a circulated manner and have that data accessible to various gatherings, including specialists, for example, the WHO.

D. The board emergency circumstances

Blockchain innovation cannot just assistance in monitoring the infection and episode movement. Blockchain could likewise be utilized to all the more likely oversee pandemic circumstances and the spread of treatment. It could in a flash caution people in general about the Coronavirus by worldwide establishments like the World Health Organization. It could in a split second suggest a course of movement should a flare-up be recognized. Utilizing blockchain could empower to give governments suggestions about how to contain the

infection. It would offer a stage where governments, clinical experts, wellbeing associations, media, and all the concerned gatherings can refresh each other of the circumstance and forestall compounding of the equivalent.

E. Making sure about graceful clinical chains

The blockchain could likewise be utilized for “track and following” of clinical gracefully chains. Blockchain has just demonstrated its prosperity as a graceful chain, the board device in different ventures. Blockchain-based stages could be utilized to empower the survey, recording, and following of interest, supplies, and coordination of pandemic avoidance materials. As gracefully chains include numerous gatherings (from benefactors and beneficiaries to warehousing and conveyance coordination), the whole procedure of record and check by each gathering is carefully designed, while additionally permitting anybody to follow the procedure. It could help smooth out clinical gracefully chains, guaranteeing that specialists and patients approach the apparatuses when they need them, and keeping sullied things from arriving at stores. A blockchain-based framework could guarantee immunizations, testing gear and other aid projects are sent to the correct spots at the correct occasions and in the amounts required and have that recorded. Making sure about the flexible chains of these significant assets could have life-sparing impacts. Joined with a reconnaissance framework, a blockchain gracefully the board framework could change the manner in which the world reacts to scourges.

F. Forestall zoonotic sicknesses

Zoonotic sicknesses like Corona could be trapped in creatures before they make the bounce to people if veterinary field records were kept on a blockchain reconnaissance framework. Since numerous creatures are transient, – so not remaining in a similar territory - a decentralized blockchain framework would consider more noteworthy joint effort and straightforwardness over the world. Maladies could be “hailed” and dispensed within creature populaces before they make the bounce to people.

IV. MULTIPLE USECASES OF BLOCKCHAIN

Blockchain innovation has been under broad consideration among scientists and industrialists as of late, particularly since the beginning of Blockchain 2.0 and Blockchain 3.0 [22]. Step by step, this innovation is stretching out its essence to practically all the significant areas, including the protection part, the transportation business, drone correspondence advances, and even the social insurance division [23], [24]. Blockchain-based applications can be utilized to screen and deal with the COVID-19 patients carefully, in this manner, assuaging some weight on the clinic staff and other medicinal services workforce. Referenced beneath are portions of the critical manners by which blockchain innovation can help in the battle against the COVID-19:

- Blockchain-based COVID-19 patients contact tracing app and data recording

- Lockdown implementation for different Zones
- Blockchain solution for curtailing the Fake News on COVID-19

A. Blockchain based COVID-19 patients contact tracing app and data recording

Application or App that can track and trace the patients infected from novel Coronavirus plays an important role in fighting against the current pandemic. In one hand, due to their capability of early detection of infected people location and stop spreading further, such contact tracing apps became a necessary tool in reducing the virus spread globally. On the other hand, apps need to store some data such as patient personal information, COVID data and therefore, these apps are struggling to meet the expectations such as data security, data tempering and data privacy. Several countries, such as Australia, South Korea, Austria, United Kingdom, has started looking into blockchain technology to solve this issue. For example, in June 2020, a grant of 60,000 Euro for a project QualiSig is funded by the Austrian Federal Ministry for Digital and Economic Affairs. The project is focused on creating three COVID-related prototypes for health data, fraud prevention and fake news with the use of Ardor Blockchain [25]. Some of the blockchain-based contact tracing app “Beeprace” has already been proposed by the researchers from University of Glasgow [26]. This app uses global positioning systems (GPS) and smartphones to track users movements and uploads the data into the blockchain. For providing security, they encrypt the data before storing into Blockchain. South Korea’s most popular domestic tourist destination Jeju Island is using secure COVID-19 secure contact tracing app based on Blockchain Technology developed by ICONLOOP [27]. Therefore, it is fair to say that blockchain resolves the issues associated with COVID and patient-related data up to some extent, such as data security and data tampering. However, privacy has not been properly resolved as we know that these data contain sensitive information of patients. To solve this challenge, zero-knowledge proofs, along with the Blockchain technology, can further be investigated.

B. Lockdown implementation for different Zones

Implementing a lockdown condition is another issue in several places. There could be different types of restrictions approved by the government for different cities or areas, i.e. if a country is divided into different zones where few zones are under red alert due to a high number of infection rates while some other zones are free from covid infections. Therefore, the government will impose lockdown in several zones with different term and conditions that fulfils the requirement of that particular area. In such a situation, the whole network can be divided into several clusters (see Figure 3) of nodes, and each cluster has a different set of rules and regulations compared to others. This way, people can follow the set of rules and regulations imposed under that cluster network.

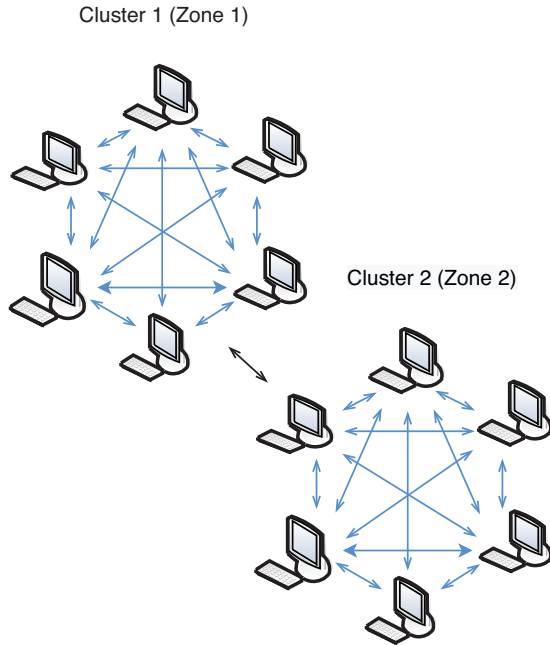


Fig. 3: Blockchain Cluster Zone-wise.

C. Blockchain solution for curtailing the Fake News on COVID-19

Social media platforms are the main source for the propagation of fake news or rumour about COVID-19. Blockchain can play an important role in curtailing the fake news. Several works are already done in the same direction to implement blockchain-based social media platform to find the source of fake news. Other research areas that are important to analyse fake news are text analysis, artificial intelligence and machine learning that can detect the fake news based on content published.

V. RELATING BLOCKCHAIN AND CHINA

Chinese associations are attempting to execute blockchain-based answers for battle the Coronavirus and diminish its monetary effect on the nation. They have revealed various applications for quick and crisis use, to battle the spread of the Coronavirus in open organizations, medical clinics, colleges, and the monetary area. These are touted as playing out a wide range of capacities. These blockchain arrangements are now being utilized by neighbourhood specialists to oversee personality data and gift stages. Also, different nations overall are utilizing blockchain-based apparatuses to follow patients determined to have Coronavirus and distinguish the individuals who may have been tainted. The applications are intended to guarantee individuals' protection, personality, and clinical records utilizing the blockchain against Coronavirus and other ailments.

A. HashLog

One of the intriguing applications is HashLog, an answer propelled by Acer, a designer of blockchain-empowered applications for general wellbeing and worldwide wellbeing associations, to battle against the dangerous Coronavirus. The HashLog representation motor connects progressively with Hedera Hashgraph's appropriated record innovation to guarantee ongoing logging and information perception of the spread of the infection. With the assistance of open information from the US Centers for Disease Control (CDC) and the World Health Organization (WHO), Acer's Hashlog Dashboard is equipped for giving constant data to following this scourge. For instance, this application is following individuals venturing out to and from the nation, to pinpoint patients and forestall further diseases. "HashLog takes into consideration the continuous perception of coronavirus information and patterns. This incorporates the general number of cases all-inclusive, paces of passings and recuperation per diseases (where we have dependable information), cases separated by nation, just as Google drifts by intrigue and locale on Coronavirus." Acer's CEO, Jim Nasr. This should assist disease transmission specialists with confirming the honesty of records that have been transferred to their investigation frameworks. Every exchange is recorded through a checked hash reference on Hedera's record, which means disease transmission experts can confide in information to be genuine. This permits specialists, researchers, and writers to comprehend the spread of the Coronavirus and its patterns after some time through visuals introduced on Acer's HashLog dashboard.

B. IBM Food Trust

This isn't the first run through blockchain is being applied to follow sicknesses. There have just been various activities utilizing blockchain and circulated record innovation to follow the roots of food, for instance. The IBM Food Trust has been utilizing blockchain to help improve sanitation by overseeing and directing food tracings so as to distinguish wellsprings of pollution for events of Salmonella. By having the option to recognize the reason rapidly and adequately, it is a lot simpler to contain the issue and treat it at the source.

VI. CONCLUSION

The specialists everywhere throughout the world are attempting their best to contain the Coronavirus as it has demonstrated the capability of transforming into a pandemic. In addition, that is the place blockchain can help. We have seen that illness flare-ups can occur whenever, anywhere on the planet, with practically no notice. These characteristic occasions have happened before and will re-happen later on. Blockchain will not forestall the development of new infections itself. Nevertheless, what blockchain can do is make the mainline of the quick barrier through a system of associated gadgets whose lone reason for existing is to stay alert about ailment flare-ups. The utilization of blockchain can help forestall pandemics by empowering early discovery of plagues,

optimizing drug preliminaries, and effect the board of flare-ups and treatment. With simple access to such information, the control of an episode gets reasonable and is of extraordinary assistance to the wellbeing specialists. Right now, reaction ability can speak to the distinction between brisk control and worldwide infection. While blockchain holds guarantee for the wellbeing business, experts caution various issues, including information normalization, expenses of activity, and administrative contemplations, despite everything should be tended to before this innovation is appropriate for wide reception. Nevertheless, with this genuine Coronavirus pandemic, some of these contemplations could be fathomed rather rapidly.

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REFERENCES

- [1] G. Srivastava, S. Dhar, A. D. Dwivedi, and J. Crichigno, "Blockchain education," in *2019 IEEE Canadian Conference of Electrical and Computer Engineering, CCECE 2019, Edmonton, AB, Canada, May 5-8, 2019*. IEEE, 2019, pp. 1–5. [Online]. Available: <https://doi.org/10.1109/CCECE.2019.8861828>
- [2] R. Singh, A. D. Dwivedi, and G. Srivastava, "Internet of things based blockchain for temperature monitoring and counterfeit pharmaceutical prevention," *Sensors*, vol. 20, no. 14, p. 3951, 2020. [Online]. Available: <https://doi.org/10.3390/s20143951>
- [3] A. D. Dwivedi, "A scalable blockchain based digital rights management system," *IACR Cryptol. ePrint Arch.*, vol. 2019, p. 1217, 2019. [Online]. Available: <https://eprint.iacr.org/2019/1217>
- [4] G. Srivastava, A. D. Dwivedi, and R. Singh, "Automated remote patient monitoring: Data sharing and privacy using blockchain," *CoRR*, vol. abs/1811.03417, 2018. [Online]. Available: <http://arxiv.org/abs/1811.03417>
- [5] R. Singh, A. D. Dwivedi, G. Srivastava, A. Wiszniewska-Matyszekiel, and X. Cheng, "A game theoretic analysis of resource mining in blockchain," *Clust. Comput.*, vol. 23, no. 3, pp. 2035–2046, 2020. [Online]. Available: <https://doi.org/10.1007/s10586-020-03046-w>
- [6] A. D. Dwivedi, L. Malina, P. Dzurenda, and G. Srivastava, "Optimized blockchain model for internet of things based healthcare applications," in *42nd International Conference on Telecommunications and Signal Processing, TSP 2019, Budapest, Hungary, July 1-3, 2019*, N. Herencsar, Ed. IEEE, 2019, pp. 135–139. [Online]. Available: <https://doi.org/10.1109/TSP.2019.8769060>
- [7] A. D. Dwivedi, G. Srivastava, S. Dhar, and R. Singh, "A decentralized privacy-preserving healthcare blockchain for iot," *Sensors*, vol. 19, no. 2, p. 326, 2019. [Online]. Available: <https://doi.org/10.3390/s19020326>
- [8] G. Srivastava, A. D. Dwivedi, and R. Singh, "PHANTOM protocol as the new crypto-democracy," in *Computer Information Systems and Industrial Management - 17th International Conference, CISIM 2018, Olomouc, Czech Republic, September 27-29, 2018, Proceedings*, 2018, pp. 499–509. [Online]. Available: https://doi.org/10.1007/978-3-319-99954-8_41
- [9] G. Srivastava, J. Crichigno, and S. Dhar, "A light and secure healthcare blockchain for iot medical devices," in *2019 IEEE Canadian Conference of Electrical and Computer Engineering, CCECE 2019, Edmonton, AB, Canada, May 5-8, 2019*. IEEE, 2019, pp. 1–5. [Online]. Available: <https://doi.org/10.1109/CCECE.2019.8861593>
- [10] G. Srivastava, A. D. Dwivedi, and R. Singh, "Crypto-democracy: A decentralized voting scheme using blockchain technology," in *Proceedings of the 15th International Joint Conference on e-Business and Telecommunications - Volume 2 SECRIPT: SECRIPT*, INSTICC. SciTePress, 2018, pp. 508–513.
- [11] M. Cascella, M. Rajnik, A. Cuomo, S. C. Dulebohn, and R. Di Napoli, "Features, evaluation and treatment coronavirus (covid-19)," 2020. [Online]. Available: <http://europepmc.org/books/NBK554776>
- [12] D. Wang, B. Hu, C. Hu, F. Zhu, X. Liu, J. Zhang, B. Wang, H. Xiang, Z. Cheng, Y. Xiong, Y. Zhao, Y. Li, X. Wang, and Z. Peng, "Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in wuhan, china," *JAMA*, vol. 323, 02 2020.
- [13] F. Jiang, L. Deng, L. Zhang, Y. Cai, C. W. Cheung, and Z. Xia, "Review of the clinical characteristics of coronavirus disease 2019 (covid-19)," *Journal of General Internal Medicine*, vol. 35, no. 5, pp. 1545–1549, 2020. [Online]. Available: <https://doi.org/10.1007/s11606-020-05762-w>
- [14] D. C. Nguyen, M. Ding, P. Pathirana, and A. Seneviratne, "Blockchain and ai-based solutions to combat coronavirus (covid-19)-like epidemics: A survey," 04 2020.
- [15] N. Upadhyay, "Blockchain: A call for action to fight covid-19," 2020. [Online]. Available: <https://timesofindia.indiatimes.com/blogs/futurelocus/blockchain-a-call-for-action-to-fight-covid-19/>
- [16] D. Tapscott and A. Tapscott, "What blockchain could mean for your health data," 2020. [Online]. Available: <https://hbr.org/2020/06/what-blockchain-could-mean-for-your-health-data>
- [17] A. K., "Use of blockchain technology to curb novel coronavirus disease (covid-19) transmission," 04 2020.
- [18] "Coronavirus update (live)," <https://www.worldometers.info/coronavirus/>.
- [19] T. Alladi, V. Chamola, J. Rodrigues, and S. Kozlov, "Blockchain in smart grids: A review on different use cases," *Sensors*, vol. 19, p. 4862, 11 2019.
- [20] "Current covid-19 situatio," 2020. [Online]. Available: <https://covidgraph.com/>
- [21] V. Chamola, V. Hassija, V. Gupta, and M. Guizani, "A comprehensive review of the covid-19 pandemic and the role of iot, drones, ai, blockchain, and 5g in managing its impact," *IEEE Access*, vol. 8, pp. 90 225–90 265, 2020.
- [22] A. Miglani, N. Kumar, V. Chamola, and S. Zeadally, "Blockchain for internet of energy management: Review, solutions, and challenges," *Computer Communications*, vol. 151, pp. 395 – 418, 2020. [Online]. Available: <http://www.sciencedirect.com/science/article/pii/S0140366419314951>
- [23] T. Alladi, V. Chamola, N. Sahu, and M. Guizani, "Applications of blockchain in unmanned aerial vehicles: A review," *Vehicular Communications*, vol. 23, p. 100249, 2020. [Online]. Available: <http://www.sciencedirect.com/science/article/pii/S2214209620300206>
- [24] V. Hassija, V. Chamola, D. N. G. Krishna, and M. Guizani, "A distributed framework for energy trading between uavs and charging stations for critical applications," *IEEE Transactions on Vehicular Technology*, vol. 69, no. 5, pp. 5391–5402, 2020.
- [25] "Austrian government funds development of blockchain-based covid-19 app," 2020. [Online]. Available: <https://www.coindesk.com/austrian-government-funds-development-of-blockchain-based-covid-19-app>
- [26] H. Xu, L. Zhang, O. Onireti, Y. Fang, W. B. Buchanan, and M. Imran, "Beeprace: Blockchain-enabled privacy-preserving contact tracing for covid-19 pandemic and beyond," *ArXiv*, vol. abs/2005.10103, 2020.
- [27] "South korea's jeju island selects iconloop blockchain technology for private, secure covid-19 contact tracing," 2020. [Online]. Available: <https://www.globenewswire.com/news-release/2020/08/19/2080612/0/en/South-Korea-s-Jeju-Island-Selects-ICONLOOP-Blockchain-Technology-for-Private-Secure-COVID-19-Contact-Tracing.html>