A Systematic Literature Review of Blockchain Technology

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Abstract—The Blockchain technology moves data nodes and data streams from one informatics center to another based on the importance of Bitcoins, resulting in a dedicated, public, and secure network for interpretation and development of the ensuing information chain reaction. Blockchains are frequently formed by connecting interrelated patterns of information in order to conduct a secure transaction. Blockchain has the characteristics of decentralization, transparency, immutability, autonomy, open-source, anonymity, and consensus. Block chains are being utilized in a variety of real-world applications, including business and economics, financial technology, and digital currencies. This article does a comprehensive review of the literature on blockchain technology. While searching for the keyword "blockchain" as a subject, we identified a total of 1882 entries in these databases. After removing the less common record kinds, the papers were reduced to 1246 articles, which were then used for further investigation.

Keywords—blockchain, security, working principle, applications, smart contracts

1 Introduction

The Blockchain technology [1] transfers data nodes and data streams from one informatics center to another depending on the importance of Bitcoins, resulting in a dedicated, public, and secure network for interpretation and development of the resultant information chain reaction. Blockchains are often created using interconnected patterns of information to execute a safe transaction. As a result, the technology was

concentrated and identified in the early 2015s, and since then, Blockchain has been concerned with the world of informatics and financial transactions.

The total information about the network is completely safe in the Blockchain and shared by all the peers engaged in the transaction (Figure 1) in a specific network. Typically, this data is saved in the form of a "Ledger." A ledger is a record log that contains data about the system, node values, and configuration datasets. The ledger is requested to retain the entire network information in terms of value at a given moment in time. The value assigned to each node represents the network's total censurability factor for processing the node. The value of each node on each address is referred to as Bitcoins or digital money; these currencies are not tied to any country and may be generated using the remitter's network address [2, 3].
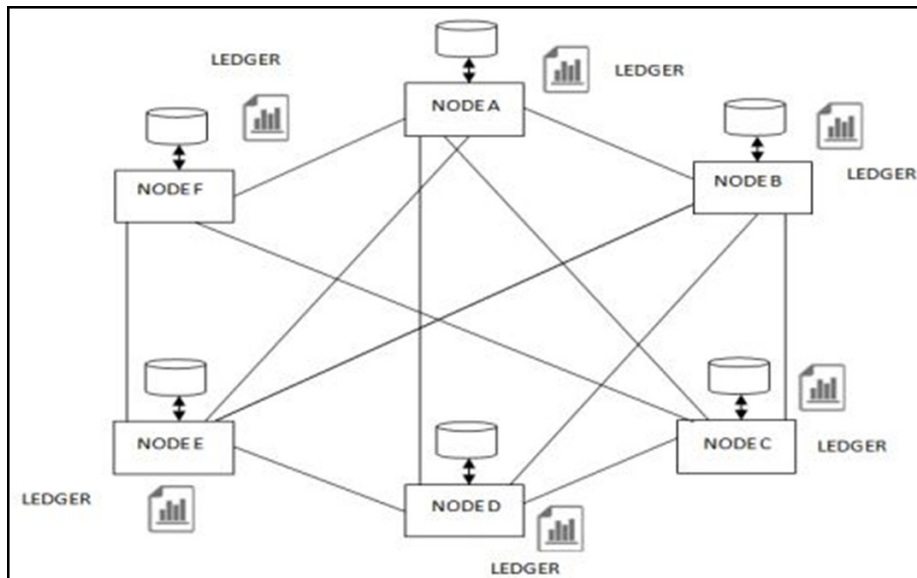

Fig. 1. Distributed ledgers

1.1 Blockchain working

A blockchain is a digital, restricted, open record in which bitcoin or advanced cash exchanges are documented in an extremely created record requirement. A block is the most recent or current' component of a blockchain that tracks ongoing transactions. Once a block has been completed, it is permanently recorded in the blockchain. As soon as a new block is started, a new one is formed. Many such blocks are linked to each choice when making a direct, constructed record request on an extraordinarily large blockchain.

All blocks have their own unique hash data, as well as a copy of the data from prior blocks [4]. It is extremely difficult to alter data once it has been deposited in a blockchain because of that. For this reason, blockchains are used in applications like money

administrations and reasonable property. Customers can run their online apps on their local and primitive computers using Blockchain, a substitute blockchain-based technology. Customer data or apps can be stored or managed on their appliances using the blockchain instrument, which does not require a server.

Blockchains are distributed and maintained via peer-to-peer networks. Because it is a distributed ledger, it does not require a centralised authority or server to control it, and its data quality may be maintained by database replication and computational trust. Distributed ledger technology, such as blockchain, is a kind of it. A chain of blocks isn't necessary in all distributed ledgers to achieve a secure and reliable distributed consensus. The structure of the Blockchain is what sets it apart from other kinds of distributed ledgers. Data is captured and encrypted on the blockchain to prevent unauthorised access.
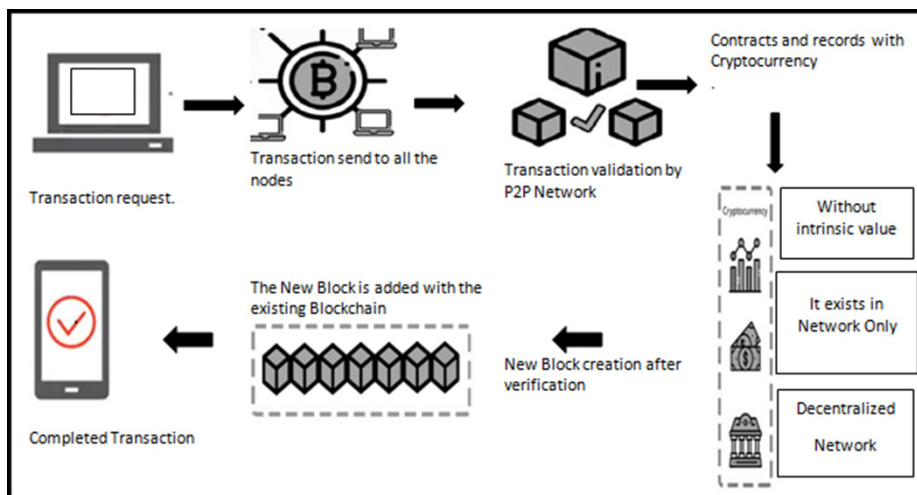

Fig. 2. Blockchain working

One of the most significant faults in current technical systems has been addressed with the most recent innovation in Blockchain technology. When Blockchain is used, a network or system can be made more interdependent and easier to access in terms of processing apps' profiles and schemas. In terms of its impact and applications, Blockchain technology has been quickly and thoroughly evaluated by several researchers [5–8].

Due to its decentralised nature, Blockchain technology can provide a new method for tracking and reconciling prior transactions. When it comes to networking, IoT, commercial transactions, and more, the overall security of the Blockchain system is a crucial concern. A small number of academics attempted to address the most significant challenges and complexities associated with the implementation of Blockchain technology at the physical layer.

1.2   Blockchain applications

Researchers spoke about the survey's potential security expansion, covering everything from implementation issues to security concerns. Information-centric processing systems identify a need, to which Block chain offers a direct solution. Many academics recommended an Information Centric Network (ICN) with trust dependencies on both sides for real data exchanges. A human interaction behavioral model is computed for the filtered data first in this architecture, followed by the trust factor processing for the transaction. Applications of block chain [9–16] are shown below in Figure 3.
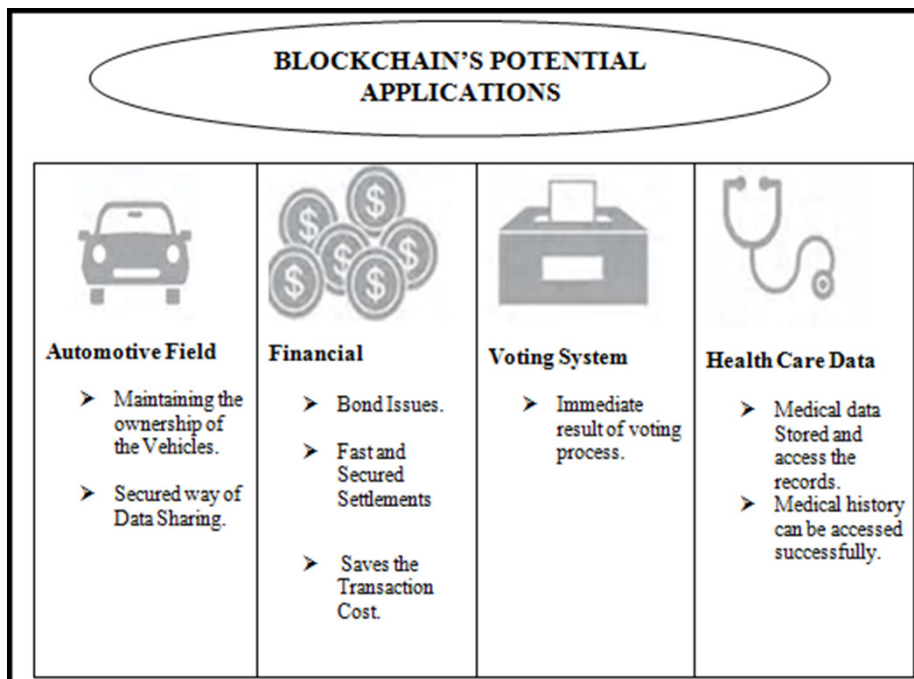

Fig. 3. Blockchain applications in various fields

The definition of blockchain under file sharing is limited to being a frequently shared file or documents; however, as mentioned in, the medical health records are filtered and processed with blockchain-based information to retrieve and analyze the importance of connecting every block with another to process data in charge and validate results.

The Electronic Medical Records (EMR) are a type of medical sensitive information secured in the form of files and shared under a decentralized architecture of a hospital ecosystem (Figure 3), and thus the security of such system can be defined and developed by blockchains, which improves the ability to protect files under various secure approaches.

1.3 Component of blockchain

The main component of blockchain is a distributed network, shared ledger, and digital transactions [17–19].

a) Distributed network – Because it's a peer-to-peer network, all peers can use it and participate. Using the shared ledger lists, each node application's rules may be tracked. Each peer will check and double-check digital transactions before approving them. With a unique cryptographic signature and timestamp, each record is infallible.

b) Shared Ledger – Blockchain security and performance are dependent on the Consensus algorithm, which determines how the blockchain will operate. In a blockchain, each block is linked to those that came before it. To begin, records are added to the transaction pool, then the miner creates a block and other miners in the network attempt to answer the mathematical problem. The first miner to solve the riddle successfully wins a reward in the cryptocurrency.

c) Digital Transactions – The block contains digital copies of each record. The blocks have been arranged in reverse chronological order. Every record is encrypted and digitally signed to assure its validity and correctness. All of the blocks are interconnected, so they can't stand alone.

1.4 Properties of blockchain

There are several characteristics of blockchain, as stated in Table 1. These characteristics are: decentralization; transparency; immutability; autonomy; open source; anonymity; and consensus.

Table 1. Properties of blockchain

Key Elements	Description
Transparent	The records stored in the blockchain, which is transparent.
Decentralized	The open-source anyone can connect to the network. No central authority.
Consensus	New transactions added to the blockchain after participant nodes agree that they are valid.
Open-source	It is an open-source anyone can connect to the network.
Autonomy	It is the independent system, and each node can access, store, update the record safely.
Anonymity	Each transaction is available in different nodes, and it is unique, and data are anonymized.
Authentication	Cryptography and digital signatures prove participants' identities.
Immutable	Data that exists earlier in a blockchain cannot modify.

The blockchain stores a list of transactions and combines them into a block. The structure starts with a single block known as the genesis block. As the size of the transaction grows, new blocks are added. The preceding and current blocks were connected. This data structure is provided by the block chain. Normally, blockchains are designed to be tamper-proof and irreversible.

An important characteristic of the blockchain is its peer-to-peer decentralised network, which is made decentralised by its various organisations. The health record's cryptographic hash value. The asset can be saved by anyone and accessed online

without the need for third-party support. Using the private key, you may subsequently access any transaction you've stored, including crypto currency, documents, contracts, and digital assets.

Before a transaction can be put to the blockchain, it must be approved and trusted by the whole network through consensus. A transaction will be deemed void if it violates one of the agreed-upon guidelines. Permissionless or permissioned blockchains are used depending on the agreement-based standard they adhere to. If there is a public consensus, anyone can try to include transactions and participate in the consensus. Nodes participating in permission-based protocols must be permitted and distinguished before transactions can be added to the chain.

It's impossible to undo a transaction once it's entered the ledger. If something goes wrong, you'll have to utilise different transactions to fix it. Both transactions should be visible after they've been recorded. The blockchain maintains a record of all transactions that have been agreed upon by the chain's members.

Because every transaction is encrypted, the system is made much more secure. As a defense against intrusions, cryptography is a more complicated mathematical technique. The SHA256 cryptographic hashing method creates a fixed-length hash value for each transaction.

The blockchain's digital address is normally available to everyone, but the identities of the people who use it are kept secret. The blockchain keeps track of every transaction for the foreseeable future. The hash value of the transaction can be seen by everyone, but the identity of the user is hidden.

2 Systematic literature review of blockchain technology

We have searched, for the first time, the WSI, the Science-EXPANDED Citation Index, the SSCI Index, and ESCI. We picked WOS because the papers in the databases generally represent the wisdom of blockchain. We discovered a total of 1882 entries in these databases while searching for the keyword "blockchain" as a subject.

Once the less typical record types were filtered, the papers were reduced to 1246 articles which were then utilized for further examination. We collected full bibliographical information from the articles we recognized from WOS.

The number of scholarly articles produced year is shown in Table 2. The number of publications and the number of articles in all fields have been mentioned in WOS. In recent years, the number of articles has kept rising, suggesting that blockchain is developing. All the documents derived from WOS were released after 2015 which was originally mentioned by Nakamoto seven years after Blockchain and bitcoin. Many articles have been published online or indexed to various databases over these first seven years. We did not address these documents here, though. Only WOS, high-level representative datasets, have been selected.

Table 2. Year wise published articles related to blockchain

Year	No of Articles in WoS
2015	0
2016	3
2017	39
2018	191
2019	540
2020	692
2021	417
Total	1882

The most popular terms in the 1246 articles we have found are Bitcoin, Smart Agreement, and crypto-currency, with 193, 120, and 113, respectively. These are shown below in Figure 4. In the 1246 articles we found, this indicates that most literature addresses blockchain's fundamental technology and its most commonly recognized application – bitcoin.
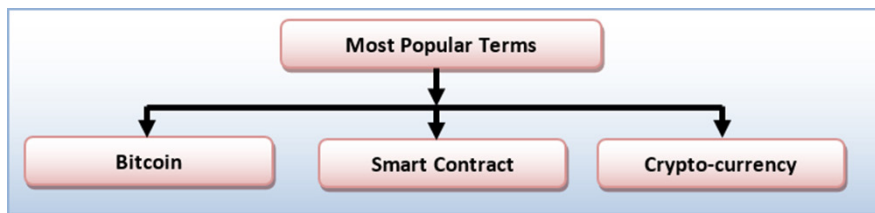

Fig. 4. Most popular terms in blockchain related articles

The network of these categories is shown in Figure 5 most of the articles belong to computer science category. Next category is engineering. At third position, telecommunication category is available. Business and economics is also a popular blockchain topic. We will thus carry out more investigation in this subject in the upcoming session.
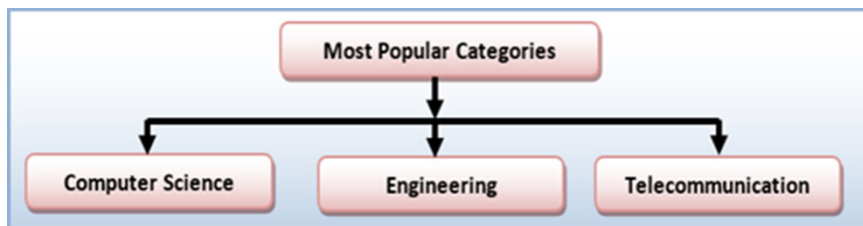

Fig. 5. Most popular categories in blockchain related articles

Table 3 represents top journals publishing research work related to blockchain. It is followed by "Financial Innovation" and "The Asia Pacific Journal of Innovation and Entrepreneurship," the first being: "Strategic Change: Entrepreneurial Finance Briefings."

Table 3. Journals with highest blockchain related articles

Journal Name	No of Articles Published
IEEE Blockchain	55
Blockchain: Research and Applications	42
Financial Innovation	15
Asia pacific journal of Innovation and Enterpreneurship	12
Journal of Risk and Financial Management	8

Security issues [20–27] need to be addressed to comprehend an area for research and to explore potential prospects for research. This article examined the subject of research using keywords. Specific and succinct descriptions of the content of this article are keywords. First, the most prevalent terms in the articles have been evaluated. We identify "blockchain," "bitcoin," "cryptocurrency," "fintechnical" and "smart contract" to be the top five most commonly utilized terms. Researchers have analyzed the fundamental characterstics of blockchain and concluded that there are a few concerns which are required to be solved before using blockchain. Other investigators have looked from various viewpoints at the properties of blockchain technology. Some authors revealed that the security threats and identification related issues are a threat to users of Blockchain. Also blockchain is vulnerable to security attacks.

Applications of blockachain are not only limited to digital currencies. But blockchain along with bitcoin and crypto currencies is a vital technology for areas like- financial industry and healthcare. Smart contract allow companies to enable automatic transactions. It enhances security and also facilitates customer. Smart contract and block chain are also useful in business and economics. They are considered as most significant financial technologies [28].

Many investigators have investigated blockchain's economic advantages. They believe that applying blockchain technology to expedite transactions and settlement procedures can cut human expenses efficiently. For example, blockchain may play an essential role in centralizing research, preventing medication fraud via prescription, and lowering administrative burdens in the health care sector. In the music business, blockchain might enhance the accuracy, availability and transparency of copyright data [29, 30].

Another study issue that is quite important for researchers is the initial sale of coins (ICO). Many scientists evaluate how the initial coin offering has succeeded. A researcher analyzes the drivers of the funding in ICOs and considers the importance of technical capacity of ICOs companies. The open restriction on ICOs may hinder revolutionary technology progress and made several proposals for a regulatory change concerning the present ICO prohibition in China [31].

Many academics have investigated assistance for different sectors via blockchain, address developments in four areas: administration of operations, payment, lending and deposit services. Some researcher discusses the influence on the character of financial transactions using blockchain technology from the standpoint of business ethics [32].

The sharing economy is also a cluster. A few scientists concentrated on this area and highlighted the supportive function of blockchain in the shared economy. Researcher

describes a conceptual economic model of decentralized collaboration based on Blockchain that can support social sharing dynamics more effectively [33].

3 Conclusion

The Blockchain technology moves data nodes and data streams from one informatics center to another based on the value of Bitcoins, resulting in a dedicated, public, and secure network for interpreting and developing the ensuing information chain response. Blockchains are frequently formed by connecting interrelated patterns of information in order to conduct a secure transaction. Blockchain has the characteristics of decentralization, transparency, immutability, autonomy, open-source, anonymity, and consensus. Block chains are being utilized in a variety of real-world applications, including business and economics, financial technology, and digital currencies. This article does a comprehensive review of the literature on blockchain technology. While searching for the keyword "blockchain" as a subject, we identified a total of 1882 entries in these databases. After removing the less common record kinds, the papers were reduced to 1246 articles, which were then used for further investigation. During the systematic literature research, the most prominent themes, journals publishing blockchain papers, most prevalent terminology, and most common categories were discovered.

4 References

[1] J. Abdella, Z. Tari, A. Anwar, A. Mahmood, and F. Han, "An Architecture and Performance Evaluation of Blockchain-based Peer-to-Peer Energy Trading," *IEEE Transactions on Smart Grid,* 2021. https://doi.org/10.1109/TSG.2021.3056147

[2] J. Sengupta, S. Ruj, and S. D. Bit, "A Comprehensive Survey on Attacks, Security Issues and Blockchain Solutions for IoT and IIoT," *Journal of Network Computer Applications,* vol. 149, p. 102481, 2020. https://doi.org/10.1016/j.jnca.2019.102481

[3] M. Alisawi, A. Al-Dawoodi, Y. M. Wahab, L. Hammood, A. Y. Nawaf, and A. Ghazi, "Developing the Real Estate Rental Sector in Third World Countries Using Blockchain Technology: Iraq as Case Study," in *Blockchain Technologies for Sustainable Development in Smart Cities*, 2022, pp. 87–109: IGI Global. https://doi.org/10.4018/978-1-7998-9274-8.ch006

[4] J. Xu, S. Guo, D. Xie, and Y. Yan, "Blockchain: A New Safeguard for Agri-foods," *Artificial Intelligence in Agriculture,* vol. 4, pp. 153–161, 2020. https://doi.org/10.1016/j.aiia.2020.08.002

[5] R. M. Garcia-Teruel, "Legal Challenges and Opportunities of Blockchain Technology in the Real Estate Sector," *Journal of Property, Planning Environmental Law,* 2020. https://doi.org/10.1108/JPPEL-07-2019-0039

[6] H. Salim and I. A. Aljazaery, "Encryption of Color Image Based on DNA Strand and Exponential Factor," *International Journal of Online and Biomedical Engineering (iJOE),* vol. 18, no. 3, pp. 101–113, 2022. https://doi.org/10.3991/ijoe.v18i03.28021

[7] A. Ghazi, S. Aljunid, S. Z. S. Idrus, R. Endut, C. Rashidi, N. Ali, A. Al-dawoodi, A. M. Fakhrudeen, A. Fareed, and T. Sharma, "Hybrid WDM and Optical-CDMA over Multi-Mode Fiber Transmission System based on Optical Vortex," in *Journal of Physics: Conference Series*, 2021, vol. 1755, no. 1, p. 012001: IOP Publishing. https://doi.org/10.1088/1742-6596/1755/1/012001

[8] H. Tauma, H. ALRikabi, and N. Alseelawi, "A Novel Method of Multimodal Medical Image Fusion Based on Hybrid Approach of NSCT and DTCWT," *International Journal of Online and Biomedical Engineering (iJOE),* vol. 18, no. 3, pp. 114–133, 2022. https://doi.org/10.3991/ijoe.v18i03.28011

[9] M. Pournader, Y. Shi, S. Seuring, and S. L. Koh, "Blockchain Applications in Supply Chains, Transport and Logistics: A Systematic Review of the Literature," *International Journal of Production Research,* vol. 58, no. 7, pp. 2063–2081, 2020. https://doi.org/10.1080/00207543.2019.1650976

[10] M. A. Uddin, A. Stranieri, I. Gondal, and V. Balasubramanian, "A Survey on the Adoption of Blockchain in IOT: Challenges and Solutions," *Blockchain: Research Applications,* p. 100006, 2021. https://doi.org/10.1016/j.bcra.2021.100006

[11] A. I. Ozdemir, I. M. Ar, and I. Erol, "Assessment of Blockchain Applications in Travel and Tourism Industry," *Quality Quantity,* vol. 54, no. 5, pp. 1549–1563, 2020. https://doi.org/10.1007/s11135-019-00901-w

[12] S. E. Chang and Y. Chen, "When Blockchain Meets Supply Chain: A Systematic Literature Review on Current Development and Potential Applications," *IEEE Access,* vol. 8, pp. 62478–62494, 2020. https://doi.org/10.1109/ACCESS.2020.2983601

[13] S. Tanwar, K. Parekh, and R. Evans, "Blockchain-based Electronic Healthcare Record System for Healthcare 4.0 Applications," *Journal of Information Security Applications,* vol. 50, p. 102407, 2020. https://doi.org/10.1016/j.jisa.2019.102407

[14] A. S. Khairy, and H. TH., "The Detection of Counterfeit Banknotes Using Ensemble Learning Techniques of AdaBoost and Voting," *International Journal of Intelligent Engineering and Systems,* vol. 14, no. 1, pp. 326–339, 2021. https://doi.org/10.22266/ijies2021.0228.31

[15] H. T. Salim and N. A. Jasim, "Design and Implementation of Smart City Applications Based on the Internet of Things," *International Journal of Interactive Mobile Technologies (iJIM),* vol. 15, no. 13, pp. 4–15, 2021. https://doi.org/10.3991/ijim.v15i13.22331

[16] R. A. Azeez, M. K. Abdul-Hussein, M. S. Mahdi, and H. T. S. ALRikabi, "Design a System for an Approved Video Copyright Over Cloud Based on Biometric Iris and Random Walk Generator Using Watermark Technique," *Periodicals of Engineering Natural Sciences,* vol. 10, no. 1, pp. 178–187, 2021. https://doi.org/10.21533/pen.v10i1.2577

[17] O. Ali, M. Ally, and Y. Dwivedi, "The State of Play of Blockchain Technology in the Financial Services Sector: A Systematic Literature Review," *International Journal of Information Management,* vol. 54, p. 102199, 2020. https://doi.org/10.1016/j.ijinfomgt.2020.102199

[18] A. S. Hussein, R. S. Khairy, S. M. M. Najeeb, and H. T. ALRikabi, "Credit Card Fraud Detection Using Fuzzy Rough Nearest Neighbor and Sequential Minimal Optimization with Logistic Regression," *International Journal of Interactive Mobile Technologies,* vol. 15, no. 5, 2021. https://doi.org/10.3991/ijim.v15i05.17173

[19] A. Fareed, A. Ghazi, A. Al-Dawoodi, S. Aljunid, S. Z. S. Idrus, C. Rashidi, A. Amphawan, A. M. Fakhrudeen, and I. E. I. Fadhel, "Comparison of Laguerre-Gaussian, Hermite–Gaussian and linearly polarized modes in SDM over FMF with electrical nonlinear equalizer," in *AIP Conference Proceedings*, 2020, vol. 2203, no. 1, p. 020045: AIP Publishing LLC. https://doi.org/10.1063/1.5142137

[20] F. A. Khan, M. Asif, A. Ahmad, M. Alharbi, and H. Aljuaid, "Blockchain Technology, Improvement Suggestions, Security Challenges on Smart Grid and Its Application in Healthcare for Sustainable Development," *Sustainable Cities Society,* vol. 55, p. 102018, 2020. https://doi.org/10.1016/j.scs.2020.102018

[21] B. K. Mohanta, D. Jena, U. Satapathy, and S. Patnaik, "Survey on IoT security: Challenges and Solution Using Machine Learning, Artificial Intelligence and Blockchain Technology," *Internet of Things,* vol. 11, p. 100227, 2020. https://doi.org/10.1016/j.iot.2020.100227

[22] S. Singh, A. S. Hosen, and B. Yoon, "Blockchain Security Attacks, Challenges, and Solutions for the Future Distributed IOT Network," *IEEE Access,* vol. 9, pp. 13938–13959, 2021. https://doi.org/10.1109/ACCESS.2021.3051602

[23] Y. Ma, Y. Sun, Y. Lei, N. Qin, and J. Lu, "A Survey of Blockchain Technology on Security, Privacy, and Trust in Crowdsourcing Services," *World Wide Web,* vol. 23, no. 1, pp. 393–419, 2020. https://doi.org/10.1007/s11280-019-00735-4

[24] A. Ghosh, S. Gupta, A. Dua, and N. Kumar, "Security of Cryptocurrencies in Blockchain Technology: State-of-art, Challenges and Future Prospects," *Journal of Network Computer Applications,* vol. 163, p. 102635, 2020. https://doi.org/10.1016/j.jnca.2020.102635

[25] H. A. Naman, N. A. Hussien, M. L. Al-dabag, and H. T. Alrikabi, "Encryption System for Hiding Information Based on Internet of Things," *International Journal of Interactive Mobile Technologies (iJIM),* vol. 15, no. 2, pp. 172–183, 2021. https://doi.org/10.3991/ijim.v15i02.19869

[26] H. Tauma, and H. Alrikabi, "Enhanced Data Security of Communication System using Combined Encryption and Steganography," *International Journal of Interactive Mobile Technologies,* vol. 15, no. 16, pp. 144–157, 2021. https://doi.org/10.3991/ijim.v15i16.24557

[27] A. Ghazi, S. Aljunid, A. Fareed, S. Z. S. Idrus, C. M. Rashidi, A. Al-dawoodi, and A. M. Fakhrudeen, "Performance Analysis of ZCC-Optical-CDMA over SMF for Fiber-To-The-Home Access Network," in *Journal of Physics: Conference Series*, 2020, vol. 1529, no. 2, p. 022013: IOP Publishing. https://doi.org/10.1088/1742-6596/1529/2/022013

[28] G. Giambelluca, "Blockchain: The Regulatory Challenges for Central Banks and Financial Sector," in *Blockchain, Law and Governance*, pp. 99–102: Springer, 2021. https://doi.org/10.1007/978-3-030-52722-8_7

[29] M. Kołodziej, "Development Factors of Blockchain Technology Within Banking Sector," in *Contemporary Trends and Challenges in Finance*, pp. 125–138: Springer, 2021. https://doi.org/10.1007/978-3-030-73667-5_8

[30] A. Tandon, P. Kaur, M. Mäntymäki, and A. Dhir, "Blockchain Applications in Management: A Bibliometric Analysis and Literature Review," *Technological Forecasting Social Change,* vol. 166, p. 120649, 2021. https://doi.org/10.1016/j.techfore.2021.120649

[31] R. Kher, S. Terjesen, and C. Liu, "Blockchain, Bitcoin, and ICOs: A Review and Research Agenda," *Small Business Economics,* vol. 56, no. 4, pp. 1699–1720, 2021. https://doi.org/10.1007/s11187-019-00286-y

[32] A. Sharma and P. Gupta, "Blockchain Revolution: Adaptability in Business World and Challenges in Implementation," in *Revolutionary Applications of Blockchain-Enabled Privacy and Access Control*, pp. 189–218: IGI Global, 2021. https://doi.org/10.4018/978-1-7998-7589-5.ch009

[33] S. Nanayakkara, M. Rodrigo, S. Perera, G. T. Weerasuriya, and A. A. Hijazi, "A Methodology for Selection of a Blockchain Platform to Develop an Enterprise System," *Journal of Industrial Information Integration,* vol. 23, p. 100215, 2021. https://doi.org/10.1016/j.jii.2021.100215

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