DOI: https://doi.org/10.33103/uot.ijccce.23.1.3

Data Analytics and Blockchain: A Review

Safa S. Abdul-Jabbar[1], Alaa k. Farhan[2], Rana F. Ghani[3]
[1]Computer Science Department, College of Science for Women, University of Baghdad, Baghdad, Iraq
[2.3]Computer Science Department, University of Technology, Baghdad, Iraq
[1]safa.s@csw.uobaghdad.edu.iq ,[2]Alaa.K.Farhan@uotechnology.edu.iq, [3]110016@uotechnology.edu.iq

Abstract— *Blockchain technology relies on cryptographic techniques that provide various advantages, such as trustworthiness, collaboration, organization, identification, integrity, and transparency. Meanwhile, data analytics refers to the process of utilizing techniques to analyze big data and comprehend the relationships between data points to draw meaningful conclusions. The field of data analytics in Blockchain is relatively new, and few studies have been conducted to examine the challenges involved in Blockchain data analytics. This article presents a systematic analysis of how data analytics affects Blockchain performance, with the aim of investigating the current state of Blockchain-based data analytics techniques in research fields and exploring how specific features of this new technology may transform traditional business methods. The primary objectives of this study are to summarize the significant Blockchain techniques used thus far, identify current challenges and barriers in this field, determine the limitations of each paper that could be used for future development, and assess the extent to which Blockchain and data analytics have been effectively used to evaluate performance objectively. Moreover, we aim to identify potential future research paths and suggest new criteria in this burgeoning discipline through our review.*

Index Terms— *Blockchain, Distributed Database, Distributed Consensus, Data Analytics, Public Ledger.*

I. INTRODUCTION

One of the significant security problems is data security whenever it is transported via communication lines. It may be secured by encrypting the data, which can only be decrypted by an authorized person [1]. Another technique that may be utilized to secure data and provide other advantages is the Blockchain. Blockchain technology is a decentralized, digital public ledger that records transactions connected by a peer-to-peer network across multiple computers. This technique is thought to cut out the middleman in any digital asset exchange or transfer. This is a far more secure and decentralized method of communication. Organizations are looking into using this technology to ensure safe transactions. Blockchain functions similarly to a digital ledger, with the following features [2]:

- Blocks can only be attached.
- No block can be modified.
- The legitimacy of any transaction is dependent on the validity of prior transactions, preventing fraud.
- Transactions take place only after complete verification.

The Blockchain is formed by chaining blocks together, each containing the hash digest of the previous block's header. A different hash would be generated if a previously published block was modified. All following blocks will have different hashes because they

Received 03/April/2022; Accepted 10/May/2022
 ISSN (Print) 1811-9212 ISSN (Online) 2617-3352

DOI: https://doi.org/10.33103/uot.ijccce.23.1.3

include the previous block's hash. Consequently, it's simple to identify and reject tampered blocks[3]. The following *Fig. 1* shows a generic chain of blocks.

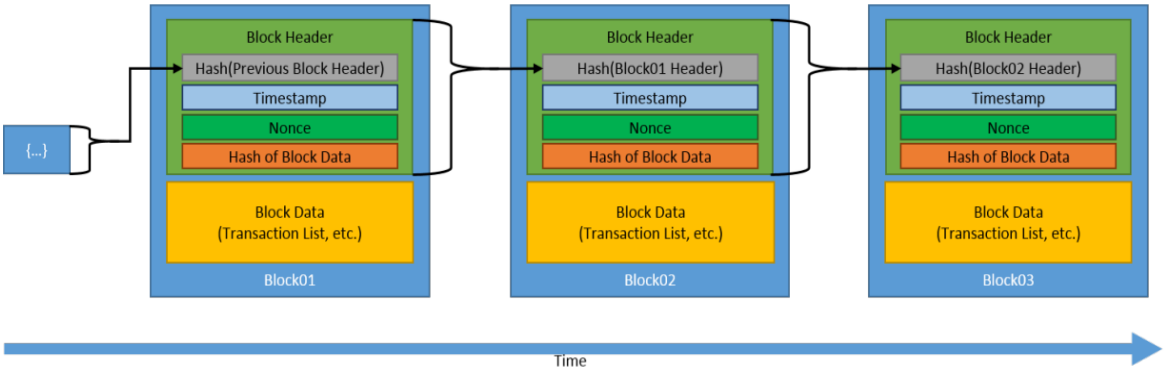

FIG. 1. GENERIC CHAIN OF BLOCKS [3].

On the other hand, Blockchain analytics is a new variant of analytics that has appeared in many recent types of research and shows the potential outcome of each decision; businesses must overcome obstacles to reap the benefits of analytics [4]. Data analytics is the process of analyzing massive data through an algorithmic or mechanical process to understand the correlations between patterns, trends & associations and draw conclusions about the information they contain. The purpose of this analysis for business entities can be divided into four categories [5], as shown in *Fig. 2*.

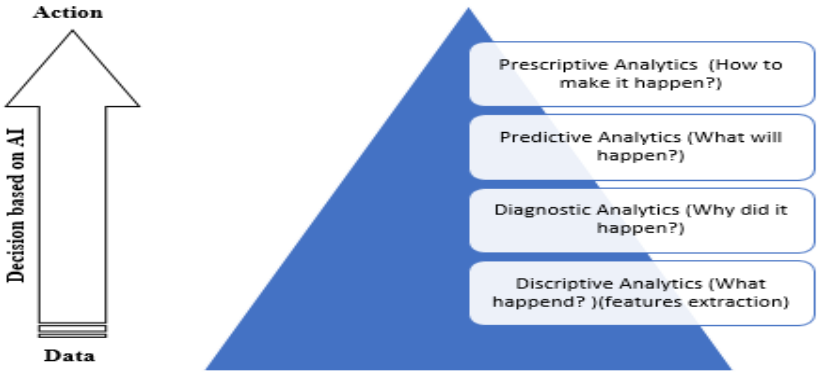

FIG. 2. DATA ANALYTICS CATEGORIES [6].

As a result, the main goal of this paper is to conduct a detailed review of the recent literature on Blockchain and Data Analytics and present a general overview of blockchain technology. Therefore, it is possible to summarize the main contributions of this paper as follows:

- A detailed description of the significant components of Blockchain and the fundamental function of a Blockchain network was presented in a logical and progressive sequence for readers to understand.
- This paper thoroughly delves into the possibility of encountering many challenges with applying Blockchain technology.
- Several studies have explored the possibilities and limitations of Blockchain in various application sectors.

Received 03/April/2022; Accepted 10/May/2022

ISSN (Print) 1811-9212 ISSN (Online) 2617-3352

DOI: https://doi.org/10.33103/uot.ijccce.23.1.3

- This paper identifies several key features and presents future research directions in Blockchain-based AI and data analytics.

II. BLOCKCHAIN TERMS GLOSSARY

In blockchain technology, several terms are used in general for this, an essential list of the technical terms associated with Blockchain has been provided in Table I as follows:

TABLE I. BLOCKCHAIN TERMS GLOSSARY

Term	Description
Hash function	A hash function is a method for creating a specific array from a data set. The hash value serves three purposes: it uniquely identifies the block and identifies the block's order or location in the chain [2]; using the hash method guarantees the data's integrity [7].
Merkle tree	Hash pointers connect the tree nodes in a binary search tree. The Merkle tree-building process then combines these nodes into disjoint groups. Then each time, two nodes at the lesser level are grouped into one at the upper level, and for each pair of lesser level nodes, a new data node is created, containing the hash value of each. This Technique is continued until the tree's root is reached. The Merkle tree has the benefit of demonstrating the membership of a data node effectively and succinctly by exhibiting this data node with all its ancestor nodes on their upward path to the root node. Furthermore, the Merkle tree's membership may be validated in logarithmic time by computing hashes on the route and comparing the hash value to the root [8].
Consensus	The mechanism by which the nodes in the public Blockchain network agree on the ledger that they individually possess. As a result, the consensus protocol is the most basic and essential component of Blockchain. It specifies the steps that nodes must follow to verify and validate each transaction and, as a result, add a new block to the Blockchain [9].
P2P Network	P2P communication takes place in a decentralized network without a centralized system or server, which means that all nodes have the same power and execute the same responsibilities. There are three types of peer-to-peer networks: hybrid, unstructured, and structured [10], and these types will be described in the following sections. The real benefit of adopting a P2P network is the rapid exchange of data between all nodes to reach a consensus [11].

III. LITERATURE REVIEW

As mentioned before, Blockchain technology is the most widely discussed topic among industry and academic specialists. Therefore, several previous works will be addressed and discussed in this section [6]:

A. Blockchain Concern

Table II provides a summary of prior research in the field of Blockchain.

TABLE II. BLOCKCHAIN LITERATURE REVIEW

Year	Authors Name	Research Scope	The used Technique(s)	Research Limitation(s)	Research Finding(s)
2018	Saranti, P., et.al. [12]	- Blockchain-Aided Transport Transaction System	- Autonomous Vehicles. - Blockchain - Real-time traffic information	- Vague description with no real system details. - Concerns about privacy, security, and ethics, with no obvious solution. - No time/space	- Public, accessible transport via CAV through an app. - High availability in any location. - Blockchain simplifies transactions. So, It can be used in areas such as parking and tolls. - Peer-to-peer

Received 03/April/2022; Accepted 10/May/2022
 ISSN (Print) 1811-9212 ISSN (Online) 2617-3352

DOI: https://doi.org/10.33103/uot.ijccce.23.1.3

				analysis.	transactions can also benefit from Blockchain security.
2019	WANG, X., et al. [13]	- the Internet of Vehicles (IoV)	- Smart Contract with New Nodes - Integrating traditional PKI authentication with a new key distribution scheme based on the Blockchain - A new key distribution mechanism is designed using the Blockchain framework, a new node joining mechanism is designed using Blockchain ledger technology, and a new vehicle identity authentication process is designed using Blockchain consensus technology.	---	- Propose a decentralized authentication solution for IoV based on Blockchain technology's consensus algorithm. - Provide evidence of the scheme's feasibility in decreasing selfish conduct and malicious attacks in the IoV. - The revised authentication system can significantly improve authentication quality.
2019	Shen M. et. al. [14]	- Vehicular Social Networks	- They keep many training procedures local over original data, and the threshold Paillier protects crucial interactions between participants. - Establish a safe SVM classifier training platform without a trusted third party using the consortium Blockchain and threshold homomorphic cryptosystem.	- The training operations must be carried out on the original data on a local level.	- The suggested Technique can maintain the privacy of the original data and the intermediate training values. - A privacy-preserving SVM classifier training technique was presented over vertically partitioned datasets owned by various data sources.
2020	Ahmad I. [15]	- Estate Management	- Utilize the private Blockchain using smart contracts. - Personal digital keys	- The private Blockchain is only accessible to a small number of users.	- Providing a secure environment for the real estate business based on a private Blockchain. - Expedite the authentication process by speeding the completion of background checks.
2021	Černý M. [16]	- Supply chain and logistics	- Design two models the first one use the traditional supply chain while the second uses blockchain technology in the supply chain (apply the Blockchain to the Conclusion of contracts, tracking a shipment, identify the root of goods). - Intelligent contracts. - The traceability of shipments and raw materials has been improved.	- They relied only on their theoretical Knowledge when designing the proposed model. - They do not examine the obstacles and real impact of the proposed model. - high investment cost. - the time to implement the Blockchain and its management on the supply chain.	- Greater supply chain trust and transparency. - Connected with a higher level of confidence between the chain's component members. - Decrease the chances of fraud, forgery, and counterfeiting. - improve the Contracting utilization.

Received 03/April/2022; Accepted 10/May/2022

ISSN (Print) 1811-9212 *ISSN (Online) 2617-3352*

DOI: https://doi.org/10.33103/uot.ijccce.23.1.3

B. Blockchain-Based on Data Analytics Concern

Table III summarizes some previous research in the Blockchain and Data Analytics fields.

TABLE III. BLOCKCHAIN-BASED ON DATA ANALYTICS LITERATURE REVIEW

Year	Authors Name	Research Scope	The used Technique(s)	Research Limitation(s)	Research Finding(s)
2018	Li Z. et. al.[17]	Transportation Insurance	- A prototype of fine-grained transportation insurance to examine the confluence of the Blockchain and IoT Data Analytics technologies. - The insurance and payment models are developed using the Ethereum framework. - The Hyperledger Fabric per-missioned Blockchain stores a large amount of vehicle travel data. - The Insurance premiums were calculated using streaming IoT data obtained from mobile sensors to determine vehicle usage and driver behavior.	The proposed system can calculate vehicle travel speed on specific road segments with certain traffic conditions and speed limits.	- Based on Blockchain and IoT technology, a fine-grained transportation insurance system was proposed. - The proposed system ensures that all drivers are treated equally and fosters a safer driving style. - Utilizes both private and public Blockchains.
2019	Dillenberger, D., et al. [18]	Records Track Information About Financial Payments	- Blockchains are linked to analytics engines, which provide easy-to-use customizable dashboards, prediction models, traceability records, and compliance checks. - They combined Blockchain data with data from other sources for secure and private analytics. - Allow for the construction of artificial intelligence models from geographically dispersed data. - Construct a model production history that allows for provenance and lineage tracing in artificial intelligence	----	- Dramatically speed up complex processes for analysts, data scientists, and business specialists depending on the Blockchain and Hyperledger Fabric platform.
2019	Rahman, A., et al. [19]	Smart City (Sharing Economy Services)	- Immutable ledgers are stored using the Blockchain and off-chain infrastructure. - To facilitate sharing economy services, AI is used to process and extract crucial event information, producing semantic digital analytics and saving results in Blockchain and decentralized cloud repositories.	- The privacy of data has not been examined.	- For secure sharing economy services, a Blockchain-based infrastructure is being developed. - The system can provide complicated Spatio-Temporal services worldwide utilizing smart contracts without the need for a central verification authority.

Received 03/April/2022; Accepted 10/May/2022

ISSN (Print) 1811-9212 ISSN (Online) 2617-3352

DOI: https://doi.org/10.33103/uot.ijccce.23.1.3

2020	Lo. C. et. al.[20]	Create a Secure Decision-Making System	- During data analysis, machine learning techniques such as XGBoost and Artificial Neural Networks are used. - By keeping both the data and the result on the Blockchain, companies may combine data analytics with private Blockchain technology. - Only authorized people will be able to access it, and the data will remain intact since it cannot be manipulated due to the usage of smart contracts for access control.	- The number of iterations and the size of the search space were both limited.	- Predicting unknown data utilizes less power and time than XGBoost yet produces equivalent results. - It is critical to validate a model on preprocessed data before modeling to ensure that it is suitable. - Data integrity is ensured by applying data analysis, so consumers may be confident that the data is correct and free of tampering.
2021	Jatoth C. [21]	A Classification Model for Blockchain Risky Blocks Detection	- Data analytics using feature selection and extraction techniques (correlation-based feature selection). - Classifier Algorithm	----	- Improve the financial operations of the organization's automated procedure. - Improve the classification results. - Reduce the processing time.

IV. BLOCKCHAIN OVERVIEW

A. The Blockchain Architecture

A chained data structure is a typical feature of Blockchain technology, which is utilized in various applications. It consists of several blocks connected in ascending order of generation time. The "genesis block" is the first component of a chain. On the Blockchain, transaction information expresses the value transfer through the signature process where the transaction data is collected in the block. A block header and a block body make up the data block with the following fields, which are usually seen in the block header [22]:

- Version: It's used to keep track of software/protocol upgrades.
- Merkle Root: The Merkle tree root of this block's hash value is saved in the same block.
- PrevBlock Hash: The hash value of the preceding block is recorded in the current block. Through the hash algorithm, an irreversible unique hash value is created based on block information. The block is uniquely marked by the hash value, which is small and fixed in length. To guarantee that the current block is connected to its predecessors, the prior block's hash value is kept in the current block [7], [22].
- Timestamp: The timestamp of the block's creation is saved. The timestamp ensures that data in the Blockchain is retained in the order of the block's recorded genesis time, making it possible to track the origins of data in the chain using the timestamp.
- Difficulty Target: The current block's difficulty coefficient must be solved and recorded.
- Nonce: Nonce is a value that depends on the computational power of the node; it is usually smaller than the target.

The transaction content and data over the network are stored in the block body. A digital signature is attached to each transaction's data. The digital signature process is

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ISSN (Print) 1811-9212 ISSN (Online) 2617-3352

DOI: https://doi.org/10.33103/uot.ijccce.23.1.3

utilized to assure the security of the block data. The following items are commonly found in the block body [22]:

- The number of Transactions Bytes: The number of bytes consumed by the num transactions.
- Transactions Number: contain the value of how many transactions are recorded in the block.
- Transactions: The block stores numerous transaction data.

The Merkle tree structure in the block body processes all transaction information. The transaction information is saved in the Merkle tree's leaf nodes. By using a hash computation, the leaf nodes are paired and concatenated to form a hash value until the Merkle tree's root node is found. The whole network's nodes can query the transaction information on the tree node. The Merkle tree root's hash value is sensitive to the entire network's node information. The Merkle tree root's hash value will be modified if any transaction information is deliberately tampered with. These blocks are then performed, implemented, and placed on the Blockchain for all miners in the network to verify. Each prior transaction can be examined, but updates are not possible. *Fig. 3* shows a general diagram of Blockchain network functionalities [22].

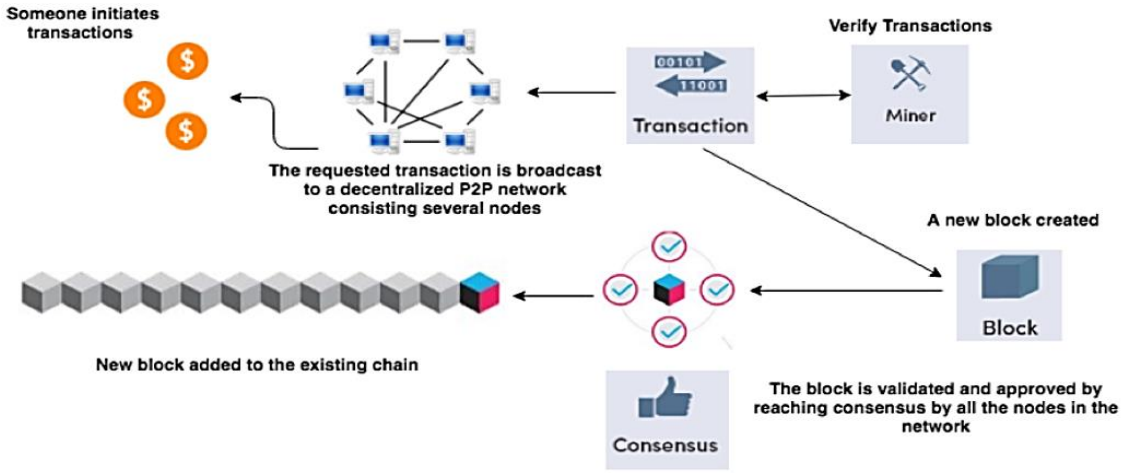

FIG. 3. A BLOCKCHAIN NETWORK'S FUNCTIONAL DIAGRAM [22].

B. Blockchain Types

Blockchain technology has been used in many applications, and according to different applications and thresholds, Blockchains are divided into three categories (Public, Private, and Hybrid) chains [10], as follows:

- **Private Chain (Permissioned)**

A Blockchain that is controlled by a single entity. The central authority controls the access permissions to the data on the chain, and the read permission can be selectively released to the public, primarily for internal data management or auditing of specific enterprises. Other distributed storage techniques are similar to the private chain. However, they are used for a small set of entities.

- **Public chain (Permissionedless)**

A completely decentralized Blockchain. According to the contribution, any node of the distributed system can participate in the reading, writing, verification, and consensus

Received 03/April/2022; Accepted 10/May/2022

ISSN (Print) 1811-9212 ISSN (Online) 2617-3352

DOI: https://doi.org/10.33103/uot.ijccce.23.1.3

procedures of the data on the chain. Public chains were the first to appear, and they are now seen in a wide range of disciplines. Bitcoin is a common example of a public chain.

- **Consortium chain (Hybrid)**

partially distributed (multi-center) which means each block's generation is determined by a group of pre-selected nodes. Other nodes can only access the Blockchain to handle transactions, but they are not involved in the consensus process. Multiple organizations can join together to form a consortium system for everyday purposes by reaching a consensual agreement.

C. Blockchain Key Features

Many features can be noticed when using Blockchain technology. Here are the key features summarized that can be common for all applications of the Blockchain [21]:

- There is no need for middlemen because the system is decentralized.
- All participants are in the same state.
- Data storage that is write-only, immutable, and transparent.
- Open to everyone.
- Able to withstand harmful participants

D. Applications of Blockchain

As mentioned in the previous section, the Blockchain can be used in many applications. Whilst IoT, AI, and cloud computing are just a few examples of modern technology. It also enables the transmission of autonomy, intelligence, and self-driving decision-making devices. The technological breakthrough, as well as the proliferation of data-gathering components, has brought to light the issues of information security and communication dependability. The capacity of Blockchain to provide information dependability, transparency, and legitimacy, as well as intelligent contractual agreements for a trustless environment, portends a massive overhaul of distribution networks and chain operations [23]. The recruitment of Blockchain has been proposed for a variety of applications and use cases as shown in *Fig. 4*. As an example of these applications, in the following section, the appliance of blockchain technology in AI will be described.

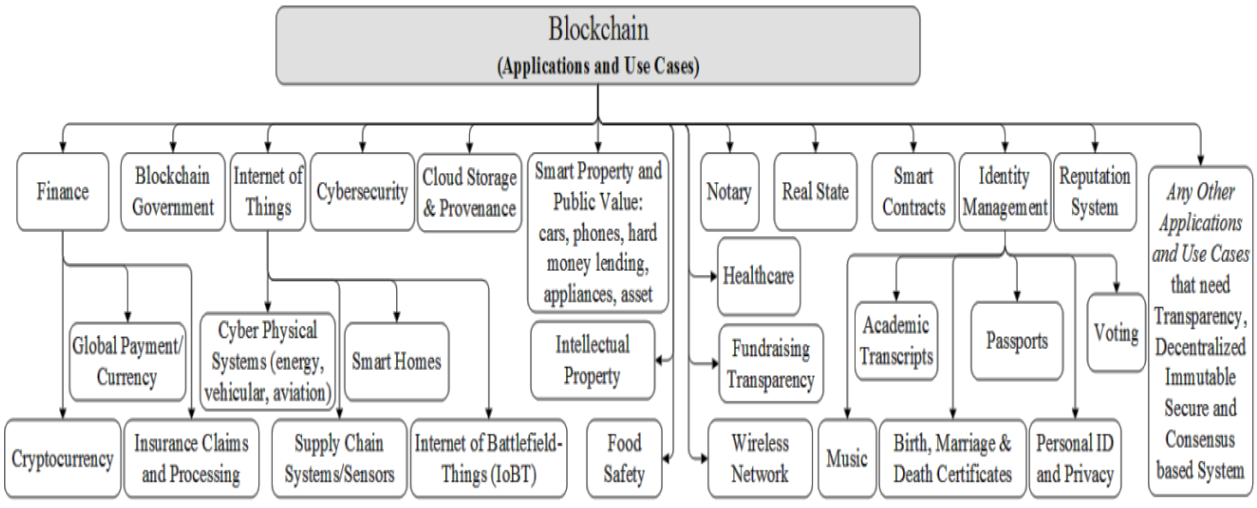

FIG. 4. POPULAR BLOCKCHAIN APPLICATIONS AND USE CASES[24].

Received 03/April/2022; Accepted 10/May/2022

ISSN (Print) 1811-9212 ISSN (Online) 2617-3352

DOI: https://doi.org/10.33103/uot.ijccce.23.1.3

E. Blockchain in AI Appliance

As an example of Blockchain technology, this paper can briefly explain how it can be used in artificial intelligence. Whereas artificial intelligence (AI) in many settings to inform decision-making and assist predictive analytics has grown in popularity. Recently, there have also been attempts to use Blockchain (a peer-to-peer distributed system) to assist AI applications, such as unsecured data sharing (for model training), data privacy, and facilitating trustworthy AI judgments and decentralized AI [25], such as:

- Data Sharing
- Privacy-Preserving
- Trusted AI Decision
- Decentralized Intelligence

F. Blockchain Challenges (Technical challenges)

Many challenges can be faced when dealing with Blockchain technology. This paper will briefly discuss the technical challenges that can appear in almost all applications based on Blockchain technology [22].

- Performance and scalability are essential topics of concern in Blockchain technology. Larger blocks require more storage space and take longer to propagate through the network, which can result in slower transaction processing times and higher fees.
- Privacy: Instead of employing a unique identity, Blockchain is thought to ensure safety and secrecy by using created addresses.
- Energy Consumption: Bitcoin's proof-of-work (PoW) algorithm allows peer-to-peer transactions in a trustless, decentralized system. On the other hand, Miner computers use a lot of electricity while doing their task.
- Interoperability: Many sectors are now interested in implementing Blockchain technology, as can be shown. However, they will be unable to interact and integrate since there is no standard protocol. This is known as a lack of interoperability, and it has a negative influence on the Blockchain industry's growth.
- Fairness and Security: Some vulnerabilities expose people to criminality due to the technology's immaturity. One of the most well-known Blockchain security vulnerabilities is 51 percent of attacks.
- Current Regulation Problems: The regularity of Blockchain systems, such as cryptocurrency, is a problem.

V. DISCUSSION AND FUTURE DIRECTIONS

This paper presents a review that shall serve as a snapshot of the current research used to depict the recent research trends on this subject, the situation in the Blockchain and data analytics technology, and an overview of the Blockchain (including Blockchain architecture, types, challenges, and key features.).

Also, in the related works, as shown in Table II, which discusses the first category of problems related to the Blockchain concern, almost all these researches are mainly dependent on modifying the intelligent contract to match the need of each application of each scope. For example, WANG [13] proposed a new system that relies on smart contracts and introduces a new key distribution mechanism, This will provide a decentralized authentication solution for the IoV applications domain. While in Ahmad I. [15] they use the personal digital keys (public and private keys) that are sent to parties participating in a contract, reducing the possibility of fraud. The main limitations in this area, in general, are

Received 03/April/2022; Accepted 10/May/2022

ISSN (Print) 1811-9212 ISSN (Online) 2617-3352

DOI: https://doi.org/10.33103/uot.ijccce.23.1.3

privacy and the limited number of users, which represent a critical problem in applying the proposed systems in real-world applications. Also, in 2021 Černý M. [16] suggests a new model depending on the comparative study based on the traditional model and the improved supply model by using blockchain technology. The suggested model provided promising results that were observed. Still, the primary defect in this system is that it has not been realistically applied but has only been examined theoretically and has not been implemented realistically".

On the other hand, Table III discusses the use of data analytics as a tool to improve the blockchain result efficiency and reduce the processing time by employing data analytics and AI to perform feature selection and extraction, as seen in Rahman, A. [19] and Jatoth C. [21], or make a decision using machine learning techniques, as in Lo. C. [20]. The limitations in this concern are the conditions and situations that can be applied to the proposed systems, as noted in Li Z.[17], the issue of data privacy is discussed in Rahman, A. [19], and the number of iterations with the search space size used in Lo. C. [20].

A summary can be reached from the previous studies' most important problems and the proposed methods to solve these problems in future work, as shown in the following Table IV.

TABLE IV. THE MOST CRITICAL PROBLEMS AND THE PROPOSED METHODS TO SOLVE IT

Most important problems	Proposed methods for future work
1- A decentralized autonomous transportation real-world system should provide users with safe and secure payment services such as taxes.	- Blockchain's digital encryption and distributed consensus techniques with hybrid PKI (Public Key Infrastructure) depending on data analytics tools could address this problem.
2- the prospect of a rogue node on the Blockchain that can become a Miner node	- design a security vector model with a robust algorithm and message authentication
3- Time-consuming during training level when using ML algorithms to help in any proposed system	- Using Data Analytics tools to remove redundant data and select only the most relevant data to train the model with it.
4- When the system uses the private Blockchain is only accessible to a small number of users.	- Need to design a hybrid system that uses private and public Blockchains to increase the number of users

It is also worth mentioning the primary lack of using data analytics in Blockchain that may negatively affect the implementation time, especially in the real-world environment. The suggested solution for this problem is using hybrid optimization tools to speed up the performance of data analysis algorithms. Another solution is using parallel programming to analyze (process) a large amount of data within a short time with cloud resources or private resources. In addition, data analytics processes data sequentially, meaning it operates on one file at a time. Therefore, one of a significant weakness occurs when the file is distributed over multiple sites (fragmented files) when using blockchain technology. On this basis, data analytics processing will be weakened by the possibility of a conflict or error.

On the topic of Blockchain, there are several avenues for future research. Future research focuses on building an effective incremental learning technique, improving work on real-time data coming in as a stream, and refining the classification model to accurately represent the problem's complexity.

Received 03/April/2022; Accepted 10/May/2022

ISSN (Print) 1811-9212 ISSN (Online) 2617-3352

DOI: https://doi.org/10.33103/uot.ijccce.23.1.3

VI. CONCLUSIONS

Blockchain technology serves as the foundation for a variety of digital currencies. In a decentralized and distributed network, a Blockchain is a chain of blocks that stores information with digital signatures. The unique combination of well-known qualities, such as hashing, decentralization, and immutability, makes Blockchain an increasingly attractive field for both science and business.

This paper provides a comparison between Blockchain and blockchain-based data analytics in construction tools. It illustrates that utilizing blockchain-based data analytics tools can provide better privacy, more efficient results, and economic services while consuming less power than relying solely on Blockchain technology to solve research problems in different scopes. Moreover, the appropriate use of data analytics in blockchain applications can result in high-quality performance.

To maintain the success of Blockchain and encourage more companies to adopt it, there is a need to educate readers who are interested in learning more about Blockchain research. Therefore, this paper aims to provide simple research that examines Blockchain technology from various perspectives and fills in gaps in knowledge.

REFERENCES

[1] G. Abdul Majeed, A. Kadhim, and R. Subhi Ali, "Retrieving Encrypted Query from Encrypted Database Depending on Symmetric Encrypted Cipher System Method," *Diyala J. Pure Sci.*, vol. 13, no. 1, pp. 183–207, 2016, doi: 10.24237/djps.1301.103c.

[2] M. Ahmed, *BlockChain in Data Analytics*, Edited Book ver. 2020.

[3] D. Yaga, P. Mell, N. Roby, and K. Scarfone, "Blockchain Technology Overview,", *arXiv preprint* arXiv:1906.11078, 2019, doi: 10.6028/NIST.IR.8202.

[4] C. G. Akcora, M. F. Dixon, Y. R. Gel, and M. Kantarcioglu, "Blockchain Data Analytics," *Intelligent Informatics*, 2018.

[5] R. R. K. Sharma, "Relating Analytics to Strategy, Culture and Personalities Involved in Decision Making," *International Conference on Management and Information Systems*, vol. 21 pp. 22, 2018.

[6] I. A. Ajah and H. F. Nweke, "Big data and business analytics: Trends, platforms, success factors and applications," *Big Data Cogn. Comput*., vol. 3, no. 2, pp. 32, 2019, doi: 10.3390/bdcc3020032.

[7] A. K. Farhan and M. A. Ali, "Database Protection System Depend on Modified Hash Function," *Conference of Cihan University-Erbil on Communication Engineering and Computer Science*, p. 84. doi: 10.24086/cocos17.15.

[8] R. Zhang, R. Xue, and L. Liu, "Security and privacy on blockchain," *ACM Comput. Surv.*, vol. 52, no. 3, 2019, doi: 10.1145/3316481.

[9] D. Khan, L. T. Jung, M. A. Hashmani, "Systematic literature review of challenges in blockchain scalability". *Applied Sciences*, vol 11, no. 20, pp. 9372, 2021, doi: 10.3390/app11209372.

[10] Y. Lu, "The blockchain: State-of-the-art and research challenges," *J. Ind. Inf. Integr.*, vol. 15, pp. 80–90, 2019, doi: 10.1016/j.jii.2019.04.002.

[11] E. Zaghloul, T. Li, M. W. Mutka, and J. Ren, "Bitcoin and Blockchain: Security and Privacy," *IEEE Internet Things J.*, vol. 7, no. 10, pp. 10288–10313, 2020, doi: 10.1109/JIOT.2020.3004273.

[12] P. G. Saranti, D. Chondrogianni, and S. Karatzas, "Autonomous vehicles and blockchain technology are shaping the future of transportation," *Data Analytics: Paving the Way to Sustainable Urban Mobility: Proceedings of 4th Conference on Sustainable Urban Mobility (CSUM2018*), vol. 24-25 May, Skiathos Island, Greece, pp. 797-803. Springer International Publishing, 2019. doi: 10.1007/978-3-030-02305-8_96.

[13] X. Wang, P. Zeng, N. Patterson, F. Jiang, and R. Doss, "An improved authentication scheme for internet of vehicles based on blockchain technology," *IEEE Access*, vol. 7, pp. 45061–45072, 2019, doi: 10.1109/ACCESS.2019.2909004.

[14] M. Shen, J. Zhang, L. Zhu, K. Xu, and X. Tang, "Secure SVM Training over Vertically-Partitioned Datasets Using Consortium Blockchain for Vehicular Social Networks," *IEEE Trans. Veh. Technol.*, vol. 69, no. 6, pp. 5773–5783, 2019, doi: 10.1109/TVT.2019.2957425. '

[15] I. Ahmad, M. A. Alqarni, A. A. Almazroi, and L. Alam, "Real estate management via a decentralized blockchain platform," *Comput. Mater. Contin.*, vol. 66, no. 2, pp. 1813–1822, 2020, doi: 10.32604/cmc.2020.013048.

[16] M. cerný, M. Gogola, S. Kubalák, and J. Ondruš, "Blockchain technology as a new driver in supply chain," *Transp. Res. Procedia*, vol. 55, no. 2021, pp. 299–306, 2021, doi: 10.1016/j.trpro.2021.06.034.

[17] Z. Li, Z. Xiao, Q. Xu, E. Sotthiwat, R. S. Mong Goh, and X. Liang, "Blockchain and IoT Data Analytics

Received 03/April/2022; Accepted 10/May/2022
 ISSN (Print) 1811-9212 ISSN (Online) 2617-3352

DOI: https://doi.org/10.33103/uot.ijccce.23.1.3

for Fine-Grained Transportation Insurance," *Proc. Int. Conf. Parallel Distrib. Syst. - ICPADS*, vol. 2018-Decem, no. June 2020, pp. 1022–1027, 2019, doi: 10.1109/PADSW.2018.8644599.

[18] D. N. Dillenberger, P. Novotny, Q. Zhang, P. Jayachandran, H. Gupta, S. Hans, D. Verma, and S. Chakraborty, J. J. Thomas, M. M. Walli, R. Vaculin, "Blockchain analytics and artificial intelligence," *IBM J. Res. Dev.*, vol. 63, no. 2, 2019, doi: 10.1147/JRD.2019.2900638.

[19] M. A. Rahman, M. M. Rashid, M. Shamim Hossain, E. Hassanain, M. F. Alhamid, and M. Guizani, "Blockchain and IoT-Based Cognitive Edge Framework for Sharing Economy Services in a Smart City," *IEEE Access*, vol. 7, pp. 18611–18621, 2019, doi: 10.1109/ACCESS.2019.2896065.

[20] C. K. Lo, N. K. Batcha, and R. Mafas, "Applying Blockchain Technology to Secure Dataset Used for Data Analytics," *J. Appl. Technol. …*, no. January, 2020, [Online]. Available: https://www.researchgate.net/profile/Mafas_Raheem/publication/339513479_Applying_Blockchain_Technology_to_Secure_Dataset_Used_for_Data_Analytics/links/5e56f667a6fdccbeba056e63/Applying-Blockchain-Technology-to-Secure-Dataset-Used-for-Data-Analytics.pdf.

[21] C. Jatoth, R. Jain, U. Fiore, and S. Chatharasupalli, "Improved Classification of Blockchain Transactions Using Feature Engineering and Ensemble Learning," *Futur. Internet*, vol. 14, no. 1, pp. 1–12, 2022, doi: 10.3390/fi14010016.

[22] A. A. Monrat, O. Schelén, and K. Andersson, "A survey of blockchain from the perspectives of applications, challenges, and opportunities," *IEEE Access*, vol. 7, pp. 117134–117151, 2019, doi: 10.1109/ACCESS.2019.2936094.

[23] S. Saberi, M. Kouhizadeh, J. Sarkis, and L. Shen, "Blockchain technology and its relationships to sustainable supply chain management," *Int. J. Prod. Res.*, vol. 57, no. 7, pp. 1–19, 2019, doi: 10.1080/00207543.2018.1533261.

[24] D. B. Rawat, V. Chaudhary, and R. Doku, "Blockchain Technology: Emerging Applications and Use Cases for Secure and Trustworthy Smart Systems," *J. Cybersecurity Priv.*, vol. 1, no. 1, pp. 4–18, 2020, doi: 10.3390/jcp1010002.

[25] R. Wang, M. Luo, Y. Wen, L. Wang, K. K. Raymond Choo, and D. He, "The Applications of Blockchain in Artificial Intelligence," *Secur. Commun. Networks*, vol. 2021, 2021, doi: 10.1155/2021/6126247.

Received 03/April/2022; Accepted 10/May/2022
 ISSN (Print) 1811-9212 *ISSN (Online) 2617-3352*