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A Survey of Blockchain From the Perspectives of Architecture and Applications

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ABSTRACT

The increasing need for organizations to keep a high level of synchronization around the world and the coming of new advancements are pushing increasingly more to move decision-making and operational power from the focus of associations to their edges. The blockchain could be the critical innovation to roll out this improvement conceivable. A blockchain is essentially a distributed database of records or public ledger of all transactions or digital events that have been executed and shared among participating parties. Blockchain is pleased with the fact that it provides high satisfaction and a trust bond to its users. Data immutability, decentralization, anonymity, auditability, and transparency are the main features that make blockchain an attractive technology. This paper presents a study of blockchain technology to provide a comprehensive analysis that includes types, architecture, components, characteristics, and applications of blockchain.

Key Words: *Blockchain, Distributed Ledger, Healthcare, E-voting, IoT.*

1. INTRODUCTION

Trust is the basis of the building and success of every business relationship. Intermediaries exist to create trust, they ensure the correct dealing with counterparts and that the transactions are for the right totals [1]. The presence of intermediaries is extremely puzzling, costs a great deal of time and money, and in this era of hackers, it also includes security risks [2]. Satoshi Nakamoto came up with the concept of blockchain to address concerns connected to trust in certain bonds. [3] to create the Bitcoin payment system, It eliminates the requirement for intermediaries between two entities [4]. Blockchain technology is a shared, distributed public ledger that records transactions in a way that makes it difficult or impossible to change, hack, or cheat the system, also stores the transactions in a secure and verifiable manner without the intervention of intermediaries[5] .

Block chain is a software mechanism that is primarily known as an open, distributed ledger that offers a way to transfer ownership and record transactions between two parties efficiently and in a verifiable and permanent way[6]. Whenever a consensus is reached on the network, each node participating in the network will update its copy of the ledger[7]. Also, it is a reliable and decentralized network that changes the entire transaction record database. Failure does not disturb the entire network, ensuring the great reliability of applications based on blockchain technology[8]. Blockchain technology can be divided into four generations, namely, blockchain 1.0, 2.0, 3.0, and 4.0. Blockchain 1.0 is mainly related to Bitcoin and Cryptocurrency widely used in many applications such as foreign exchange payment systems, micropayments, and one-to-one cash payment systems [9]. In 2013 blockchain 2.0 was introduced to overcome the limitation of version 1.0 by supporting all types of transactions, including a loop, anyone can create their own instructions for ownership, the format of the transactions, and define the state transition function. It used in many financial fields such as smart contracts, banking tools, payment, and settlement [10]. Blockchain 3.0 deals with government applications like medical, e-residency, and e-voting [11]. Blockchain 4.0 developed to deal with the growth of decentralized applications and permit customers from a different platform to work together as one unit. It widely used in many applications like support Supply-Chain Managements, and letting the IT systems to do business incorporation[12].

Despite the wonderful development in blockchain technology, it still suffers from some problems that need deep studies, including: a way to increase the speed of the transaction recording, improving consensus algorithms proficiency, and keeping private data secret. These problems have impacts on the advancement and application of blockchain. Among these problems, the third one is the most featured one, as numerous applications of blockchain worry about keeping the security of private data. For these and other reasons, the blockchain is considered a suitable environment to attract the attention of researchers[13].

2. TYPES OF BLOCKCHAIN

Blockchain structure falls into three categories:

A.Private Blockchain, In a private system, only personnel from a certain organization or approved employees who have been invited to participate exercise control. [14]. Joining a private blockchain is possible by the participant who has an authentic and documented invitation. In addition, the private blockchain is more centralized than the others type since it controlled by a specific group. There are many advantages for this type of blockchain such as high speed and pretty scalable, while there are many drawbacks such as lower security and centralization that need more control[15].

B.Public Blockchain, there is no restriction in the public blockchain. Anyone can get access to a network and begin the transaction exchange. The records are observable by any participant in the organization, which reduces the efficiency of the system since it needs more time to add a new record into blockchain construction [16]. The public blockchain is fully decentralized, all organizations share the control, permits were not required to send transactions at any time[17]. A public blockchain has many advantages such more secure, trustable that two nodes can exchange information without the need for the authenticity of the other, and finally a copy of the blockchain record is available at every node in the system. The drawback includes more computation time required and scalability issues[18].

C.Consortium Blockchain, is a system that is a semi-decentralized type and has a controlled user group, but works across different organizations. More than one organization can act as a node in this type of blockchain and exchange information or do mining [19].

3. BLOCKCHAIN ARCHITECTURE

Blockchain is a series of blocks, which connect sequentially to each other like a chain. Each block refers to the preceding block using a hash value. The first block of the blockchain sequence called the genesis block, there is no previous to the genesis block so the previous hash set to be zero[20]. The structure of the block includes two parts, head, and body. As shown in Fig.1 the head contains the hash of the previous block, Nounce, timestamp, and the value of Merkle tree root, while the body contains the transaction information[21]. The detailed description of block head and black body is explained below.

- Previous hash: this field used as a reference to the previous block. All information in the block introduced to the hash function to obtain a value. Usually, SHA-258 used to generate such value[22].
- Nounce: is an abbreviation for "number only used once," which is a random number added to a hashed—or encrypted—block[23] in a blockchain to prevent a reply attach on the blockchain. Nounce number generated by the blockchain miners[24].
- Merkle Tree Root: is an essential part of blockchain technology, which composed of hashes of various blocks of data. MTR stores all the transactions in the blockchain and emphasizes the data security of the block.
- Block version: indicates which version of the protocol used by the node introducing the block to the chain[25].

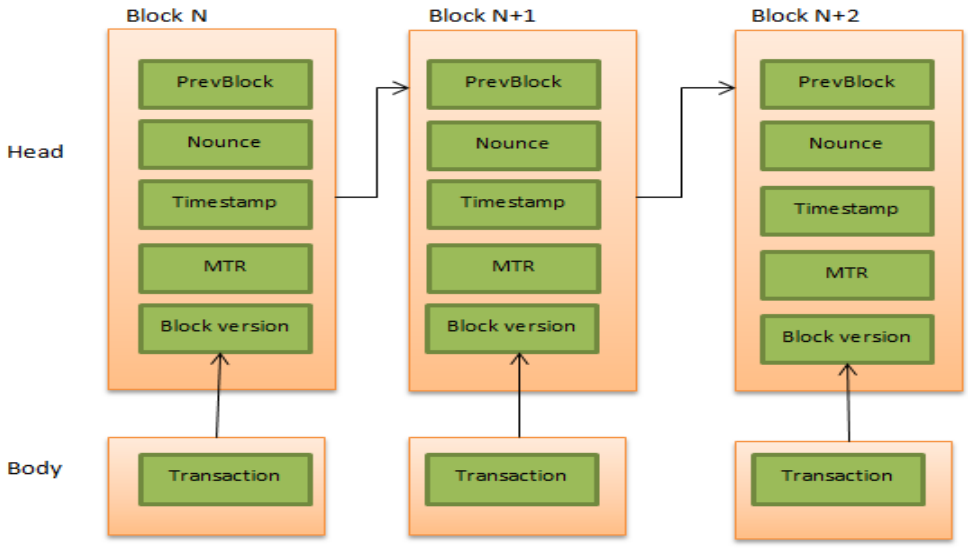

Fig.1 The structure of Blockchain

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4. COMPONENTS OF BLOCKCHAIN

The core components of blockchain architecture are:

A. Node: There exist two types of nodes within the blockchain: miner nodes and normal nodes. Miner node has the capability to add transactions to the blockchain,where all the transaction in the network can be used for many reasons such as authenticated, authorized, and audited. The miner node can store data temporarily in its own storage area. It uses Remote Switching units(RSU) to communicate with the controller node. The miner node used to authenticate all transaction data that pass through the controller node. After finishing the authentication process of the transaction, the transactional records joined to the block. While the normal node keeps a full copy of the blockchain. The transaction authenticated by the miner node is verified, coordinated, and validate by the normal node[26].
B. Block: a data structure for storing a set of transactions that is dispersed across all network nodes.. Also can be defined as a file where data relating to the blockchain network are always recorded. Transaction information is stored in the block. Each time a block is completed, it gives away to the next block in the blockchain. Once a block is written cannot be deleted or altered [27].
C. Chain: a series of blocks in a particular order.
D. Consensus: In a distributed computer network, a set of techniques is employed to assure that each new block added to the network is the only version of the truth that is agreed upon by all nodes[28]. The type of consensus algorithm to be used depends on the type of network. The most important algorithms include: Proof of Work (PoW), Proof of stake (PoS), **Delegated Proof-of-Stake (DPoS)**, and Proof-of-Probability (PoP) [29].

5. CHARACTERISTICS OF BLOCKCHAIN

There are many characteristics for blockchain technology. The following section describe them briefly.

5.1 Immutability

Based on the surge of cyber attacks, organizations are spending a lot of money to prevent their sensitive information from being hacked. This is why organizations need constant audits to maintain their database. Blockchain immutability reduces the risk of hacking, it's one of the important characteristics of block chain. The immutability of the blockchain certifies that the transactions cannot be edited or deleted once they are successfully verified and recorded in the blockchain. More succinctly, data in the blockchain cannot be altered. Blockchains are by default immutable ``append-only'' data ledgers[30].

There is only one hash value for each block, generated by applying a hash function to every information in the block. Every block not only contains a hash or digital signature for itself, but also for the previous one. This strategy enables the blocks to link together, so no one can delete or change the data saved in the block [31].

5.2 Decentralization

In centralized systems, users rely on authority to carry on transactions. Like, in banks the clients depend on a banking system that changes the client's record adjusts subsequent to making exchanges. In centralized, the central Permissions can change the entire system by straightly changing and modifying the database. There is only a single authority which means any failure in the center fails down the entire system [32].

The decentralized system used to overcome the problem of a centralized system and offer a fault-tolerant distributed computing system. Decentralization is one of the core characteristics of blockchain, meaning that the system is maintained and held by all nodes in the network. In decentralized, each node has a complete copy of all information and transaction recorded in the system [33].

5.3 Anonymity

Anonymity refers to the capacity for parties to communicate data without revealing their off-chain identities or other transactions. Anonymity differs from privacy, the anonymous concerned with hiding “who,” while privacy is concerned with hiding “what”. It can be achieved by linking a person to a public address, but no one will get to know the actual name or address [34].

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5.4 Auditability

Since all blockchain transactions are recorded by digital distributed ledger and verified by a digital time stamp. Therefore, you can audit and track previous records by visiting any node in the network[35].

5.5 Transparency

The degree of transparency that blockchain technology may provide is one of its most enticing features. One of the key capabilities of blockchain technology, which provides a completely auditable and effective transaction record, is to provide information transparency. The blockchain should be a transparent mechanism that allows anyone to join and observe all of the network's data. [36].

6.BLOCKCHAIN APPLICATIONS

Blockchain technology can be used in many applications. Some of these applications are described as follows.

6.1 Healthcare management

The field of healthcare has important social significance because the problems it solves are directly related to improving the quality of life, which can be achieved by overcoming actual health problems. Considering this, the computer has been utilized to complete errands that have prompted critical advancement in healthcare, such as (I) computerized medical services record system; (ii) valuable information exchange; (iii) Participate in diagnosing difficult disease cases [37].

Dealing with patients' Electronic Healthcare Records (EHRs) is probably the most developed area. An EHR covers all necessary information about the patient's medical history, as a feature of her clinical record, just as information, forecasts, and data of any sort identifying with the conditions and the clinical advancement of a patient throughout treatment. A blockchain can be used for EHR by enabling users to access and maintain their health data with keeping security and privacy. There are many advantages of blockchain for EHRs system such as: keeping records in distributed form, so there is no way for the hacker to corrupt or the breach, The availability and updating of data from different sources in a single and unified data repository [38].

Healthcare is a big application scenario of blockchain, and blockchains used in healthcare are called health blockchain. Blockchain can provide the infrastructure through its immutable ledger for integrating medical records and data integrity functions between different medical institution's technology. Blockchain can establish a strong and secure transparent framework to store digital medical records, thereby bringing high-quality services to patients reduce treatment costs [39].

6.2 Governance

When the blockchain first appeared, the government didn't care at first. However, given its role in multiple fields, some governments are exploring the blockchain and its applications, aiming to improve the efficiency of government services. Blockchain can provide many benefits to the e-government such as: improving the quantity and quality of government services, high access to government information, increasing the information sharing between various government organizations, and being able to establish a credit system[40]. In addition over the years, the government has been entrusted to manage and maintain official records of citizens and/or businesses. Blockchain-enabled applications may change the way local or state governments operate by eliminating intermediary transactions and record keeping. Following some applications of e-government is explained [41].

6.2.1 E-residency

Estonia is the first country to use the e - residency in 2014. E-residency is a program that allowed anyone from anywhere to access government services such as banking, payment processing, and taxation [42]. An e-id provided to e-Residents, It is important to know that the e-residency does not provide citizenship and not a travel document. Blockchain technology applied to manage e-residency. The utilization of the blockchain to e-Residency can possibly essentially change the manner in which personal data is controlled and validated [43].

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6.2.2 E-voting

Building an efficient system of electronic voting is one of the biggest challenges that legislators faced. E-voting allows voters to ballot secretly [44]. Votes are saved in such a way that can be recalculated should the necessity arise. E-voting used to speed up voting processes and decrease the cost of elections by reducing the number of people responsible for managing the electoral process [45]. Most present e-voting systems depend on a centralized design managed by a single organization, this causes a loss of confidence in the voting process by the voters. According to the Blockchain characteristics that offer decentralization and peer-to-peer direct connectivity, it is used in e-voting, helps to increase the voters' confidence in the electoral process [46].

6.2.3 Developing the Individual Credit System

Personal records are stored in different places. For instance, educational information and official records are stored in a public form, while healthcare records must be stored in a secret way that not visible to everyone [47]. Blockchain technology used to create an individual credit system by keeping all personal records in the same system and giving every individual an inclusive digital identity, containing all information about the person which cannot be changed or destroy by an unauthorized one. So citizens have their individual identity, which plays a significant role to manage all information in an easy way[48] .

6.3 Education

Today, ledgers that include many records about students and teachers are maintained electronically using specific software and are usually centralized. The centralized method of storing ledgers causes a problem when they are stolen, damaged, or compromised in any way. So using blockchain technology is very powerful in the field of education since it provides the mechanism of distributed ledger which keeps exact copies of the ledger in different locations[49]. Blockchain can support decision-making about the school system by creating school information hubs to collect, analyze data, and reporting to evaluate the school performance. In addition, blockchain can help in the scholarly publishing situation, As known, the road of publication is so hard for a variety of reasons. Blockchain offers better handling of paper submissions and getting appropriate reviews in a short time [50].

6.4 Internet of Things

Internet of things (IoT), one of the most promising information and communication technologies, is ramping up recently. Nowadays, most of the created data in the world increased due to the growth of IoT. The concept of "IoT" is the interconnection of smart devices to gather information and make decisions. These communications can be with each other, with bigger PCs, and even with people—for instance, present security systems provide information to the homeowner if any motion observed in the home through sending a video to his room directly[51].

Though, Blockchain first effectively applied in Bitcoin has conceivably arisen to be an exceptionally secure and protection-saving innovation for IoT applications. Blockchain has a decentralized, tamper-proof, and transnational dataset that gives a protected method to store and handle data across many network members. In current settings, enormous amounts of information created from huge quantities of IoT devices may cause a bottleneck, bringing about the low quality of service (QoS), A single crash in the system components can cause the entire network to fail, which is undesirable in any system for accomplishing high accessibility and dependability. The use of Blockchain in the IoT can solve the problem of the bottleneck and overcome single-point failure[52].

Many issues are related to the use of IoT technology. Security is the main concern with IoT that has prevented its huge growth. Its devices can be attacked by exploiting its security vulnerabilities[53]. The weak security protection for IoT devices provides an easy way for the attacker to destroy them. Scalability is another issue of IoT. As the number of devices connected through an IoT network grows, centralized management of these devices causes an overall system to destroy when the center stop. The adaptation of blockchain features with IoT can eliminate the lack of security and the centralization problem. Some of these features are transparency, readability, data encryption, and decentralized [54].

6.5 Financial applications

Blockchain technology widely used in many financial fields, including order-to-cash, trade finance, intercompany transactions, and reconciliation. The low cost of blockchain gives startups the opportunity to compete with major banks and promote financial inclusion. Due to restrictions on minimum balance requirements, low access rights and bank fees, many people are looking for alternatives to banks. Blockchain can offer an alternative to using digital identification and mobile devices to get rid of the hassle of traditional banking [55].

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Many companies in the economics commerce nowadays growing the usage of blockchain expertise to grow in the enterprise. Blockchain provides better security, reducing danger and fewer charges by taking discernibility and depressing contact along with the extensive lean of transactions that attend most financial interactions, conferring to economic manufacturing authorities and blockchain experts. Also, blockchain can be used by the financial industry to eliminate the manual procedures essential to gather and piece the documents that usually essential for transactions [56].

6.6 Business applications

Traditional Business Process Management (BPM) is dealing with the design, performance, checking, and development of business processes. Business processes are the sequences of procedures implemented by an organization to deliver a product or a service to customers[57]. Business processes classified as, intra and inter-organizational processes. Intra-organizational process deals within an organization, while inter-organization deals with others organizations. There is a lack of trust between parties that collaborate in the inter-organizational[58] .

Blockchain Technology can possibly give an appropriate platform to perform inter-organizational processes in a trustworthy way. Blockchain for business is important for substances transacting with each other. With distributed ledger technology, permissioned members can get to a similar data simultaneously to improve effectiveness, ensure trust and eliminate friction. Blockchain additionally permits an answer for quickly size and scale, and numerous arrangements can be adjusted to achieve multiple tasks across industries [59].

7. CONCLUSION

Block chain technology is a revolutionary innovation, which can support lots of existing traditional to be more efficient. Since 2008 bitcoin and Block chain are the two most important technologies in information systems. Blockchain widely used in many applications to process a transaction in a trustful way environment without the presence of intermediaries. This paper presents a comprehensive overview on blockchain. The investigation covers the main aspects of blockchain which include, type, architecture, components, characteristics, and applications of blockchain. There are as yet many open issues that should be additionally explored and examined to make more functional and compelling mechanical applications that can completely benefit from the utilization of blockchain and accomplish the desired goals.

REFERENCES

1- Primavera D. F. , Morshed M., Wessel R.(2020), Blockchain as a confidence machine: The problem of trust & challenges of governance, Technology in Society, Vol.62.
2- Timothy C. E. ,(2009), Trust, Confidence, and the 2008 Global Financial Crisis, Risk Analysis, Vol. 29, No. 6.
3- Nakamoto S,(2008), Bitcoin: A Peer-to-Peer Electronic Cash System Available online: https://bitcoin.org/bitcoin.pdf
4- Wubing C., Zhiying X., Shuyu S. ,Yang Z., Jun Z. (2018), *International Conference on Blockchain Technology and Applications (ICBTA)*.
5- Kogure, J., Kamakura, K., Shima, T., Kubo, T., 2017. Blockchain technology for next generation ICT. Fujitsu Sci. Tech. J. Vol.53,No. 5,PP: 56–61.
6- Fran C., Thomas K. D., Constantinos P. (2019), Telematics and Informatics, A systematic literature review of blockchain-based applications:Current status, classification and open issues,Vol. 36,PP:55-81.
7- Lei H., Do-Hyeun K,(2020). Optimal Blockchain Network Construction Methodology Based on Analysis of Configurable Components for Enhancing Hyperledger Fabric Performance, *Blockchain: Research and Applications*, https://doi.org/10.1016/j.bcra.2021.100009.
8- Preeti B., Chandan K. T. ,Amit J.(2020), Blockchain in education management: present and future applications, Interactive Technology and Smart Education, DOI 10.1108/ITSE-07-2020-0102
9- Stefano F, Gabriele D. ,(2019),On the Ethereum Blockchain Structure: a Complex Networks Theory Perspective, Concurrency and Computation: Practice and Experience (Wiley), https://doi.org/10.1002/cpe.5493.
10- Vitalik B., (2018),Ethereum white paper: a next generation smart contract & decentralized application platform," 2013, available at: http://www.theblockchain.com/docs/Ethereum.

DOI : 10.31695/IJERAT.2022.8.3.2

11- Damiano D. F., Paolo M.(2020), Blockchain 3.0 applications survey, Journal of Parallel and Distributed Computing, Vol.138,PP:99-114.

12- UMESH B., SUDEEP T., KARAN P., PIMAL K., SUDHANSHU TY A., NEERAJ K., MAMOUN A.(2016), Blockchain for Industry 4.0: A Comprehensive Review,IEEE, Vol.4.

13- Divyakant M.(2018), Issues and Challenges with Blockchain: A Survey, International Journal of Computer Sciences and Engineering,Vol.6,No.12.

14- Yue H., Yi L., Xinghua D., Li F., Ping C.,(2018), Performance Analysis of Consensus Algorithm in Private Blockchain, IEEE Intelligent Vehicles Symposium,

15- Suporn P., Chaiyaphum S., Suttipong T.(2017), Performance Analysis of Private Blockchain Platforms in Varying Workloads, IEEE, doi 978-1-5090-2991-4/17/$31.00

16- Garry G.(2016), Policy Considerations for the Blockchain Technology Public and Private Applications, Science and Technology Law Review,VOl.19, No.3.

17- Azhar U.,(2019), Blockchain Insight, International Journal of Computer Science Trends and Technology,Vol. 7,No.2.

18- Wei-Tek T.(2018), Lessons Learned from Developing Permissioned Blockchains, IEEE International Conference on Software Quality, Reliability and Security Companion, DOI 10.1109/QRS-C.2018.00014

19- Tsz H. Y.,(2020), PAChain: Private, authenticated & auditable consortium blockchain and its implementation, Future Generation Computer Systems , doi:https://doi.org/10.1016/j.future.2020.05.011.

20- Neeraj K., Shubhani A.(2020), chapter: Architecture of blockchain, Advances in Computers, https://doi.org/10.1016/bs.adcom.2020.08.009

21- Bhabendu K. M. , Debasish J., SoumyashreeS. P., Srichandan S.,(2019), Blockchain technology: A survey on applications and security privacy Challenges, Internet of Things,Vol. 8, 100107.

22- Zibin Z., Shaoan X., Hong-Ning D., Xiangping C., Huaimin W.,(2018), Blockchain challenges and opportunities: a survey, International Journal of Web and Grid Services,Vol.14, No.4.

23- Guipeng Z., Zhenguo Y., Haoran X, Wenyin L.(2021), A secure authorized deduplication scheme for cloud data based on blockchain, Information Processing and Management, Vol.58, 102510.

24- Guangkai M. , Chunpeng G., Lu Z., (2019), Achieving reliable timestamp in the bitcoin platform, Peer-to-Peer Networking and Applications, https://doi.org/10.1007/s12083-020-00905-6.

25- Xiaojing Y., (2019), Research and Analysis of Blockchain Data *J. Phys.: Conf. Ser.* 1237 022084.

26- Wenbo W., Dinh T. H., Peizhao H., Zehui X., Dusit N. , Ping W., Yonggang W., Dong I. K., A Survey on Consensus Mechanisms and Mining Strategy Management in blockchain Networks, IEEE Access , Vol. 7 , **DOI:** 10.1109/ACCESS.2019.2896108.

27- Zibin Z., Shaoan X., Hongning D., Xiangping C., Huaimin W., (2017), An Overview of Blockchain Technology: Architecture, Consensus, and Future Trends, IEEE 6th International Congress on Big Data, DOI 10.1109/BigDataCongress.2017.85.

28- Giang N. , Kyungbaek K., (2018), A Survey about Consesus Algorithms Used in Blockchain, Journal of Information processing systems, Vol. 14, No.1 ,PP:101- 128.

29- Huanhuan Z. , Gang K. , Yi P., (2019), Soft consensus cost models for group decision making and economic interpretations, European Journal of Operational Research, Vol. 277, 964-980.

30- Landerreche E.; Stevens M., (2018), On Immutability of Blockchains, In: W. Prinz & P. Hoschka (Eds.), Proceedings of the 1st ERCIM BlockchainWorkshop 2018, Reports of the European Society for Socially Embedded Technologies

31- FRAN C., EUGENIA P., EFTHIMIOS A., CONSTANTINOS P., (2019), Immutability and Decentralized Storage: An Analysis of Emerging Threats, IEEE Access, Vol.8 .

32- Zhiqin Z., Guanqiu Q., Mingyao Z., Jian S., Yi C. Blockchain based consensus checking in decentralized cloud storage, (2020), Blockchain based consensus checking in decentralized cloud storage, Simulation Modelling Practice and Theory, Vol. 102, 101987

33- Elnaz I. ,(2020), The Architectural Design Requirements of a Blockchain-Based Port Community System, MDPI, doi:10.3390/logistics4040030

DOI : 10.31695/IJERAT.2022.8.3.2

34- David S., Weige W., Alex P., (2016), white paper Blckchain & Infrastrcture, MIT Connection Science.

35- *Damiano Di F. , Paolo M. , Laura R.,(2019),* A blockchain based approach for the definition of auditable Access Control systems, Computer & Security, Vol. 84, PP:93-119.

36- Asif k. Bross P. ,(2018), TRUST, PRIVACY AND TRANSPARENCY WITH BLOCK-CHAIN TECHNOLOGY IN LOGISTICS , The 12th Mediterranean Conference on Information Systems (MCIS), Corfu, Greece

37- Anushree T., Amandeep D., A.K.M. Najmul Islam, Matti M., (2020), Blockchain in healthcare: A systematic literature review, synthesizing framework and future research agenda, Computers in Industry,Vol. 122, 103290.

38- Evans RS., (2016), Electronic Health Records: Then, Now, and in the Future. *Yearb Med Inform*,Suppl 1(Suppl 1):S48-S61., doi:10.15265/IYS-2016-s006

39- Anton H., Katina K., Danilo G., Sindre A., Arild F.(2020), Blockchain in healthcare and health sciences—A scoping review, International Journal of Medical Informatics, Vol. 134, 104040.

40- Allessie, D., Sobolewski, M. and Vaccari, L., Blockchain for digital government, Pignatelli, F. editor(s), EUR 29677 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-00582-7, doi:10.2760/93808, JRC115049.

41- Lemura C. , Jollen U., (2018), Challenges of Blockchain Technology Adoption for e-Government: A Systematic Literature Review, Proceedings of the 19th Annual International Conference on Digital Government Research: Governance in the Data Age,

42- . *Clare S., Eric B.*,(2017), E-residency and blockchain, Computer Law & Security Review, Vol.33, No. 14,PP:470-481.

43- Ragouguelaba A. K., Hirohide H., (2020), Design and Implementation of Highly Secure Residents Management System Using Blockchain, Journal of Computer and Communications,Vol. 8, PP:67-80.

44- Boucher, P., (2016) What if blockchain technology revolutionised voting? Scientific Foresight Unit (STOA), European Parliamentary Research Service.

45- Nca.tandfonline.com. (2015). Pirates on the Liquid Shores of Liberal Democracy: Movement Frames of European Pirate Parties. Available at: https://nca.tandfonline.com/doi/abs/10.1080/13183222.2015.1017264#.Wr0zCnVl8YR

46- Friðrik Þ., Gunnlaugur K., (2018), Blockchain-Based E-Voting System, IEEE International Conference on Cloud Computing, CLOUD, **DOI:** 10.1109/CLOUD.2018.00151

47- *Yinsheng L., Xu L., Xiao Z., Bin W.,(2018),* A Blockchain-Based Autonomous Credit System, IEEE 15th International Conference on e-Business Engineering (ICEBE), **DOI:** 10.1109/ICEBE.2018.00036

48- Xingxiong Z., (2020), Blockchain-Based Identity Authentication and Intelligent Credit Reporting *J. Phys.: Conf. Ser.* **1437** 012086.

49- Nelson B., Samuel K., Juliet M., (2017), Towards Blockchain-enabled School Information Hub, Proceedings of the Ninth International Conference on Information and Communication Technologies and Developmen

50- Bdiwi, R., De Runz, C., Faiz, S., Cherif, A.A.,(2017), Towards a New Ubiquitous Learning Environment Based on Blockchain Technology. In: Proceedings – IEEE 17th International Conference on Advanced Learning Technologies, ICALT 2017, pp: 101–102.

51- M.A. Uddin, A. Stranieri, I. Gondal, V. Balasubramanian, A Survey on the Adoption of Blockchain in IoT: Challenges and Solutions, Blockchain: Research and Applications, https://doi.org/10.1016/j.bcra.2021.100006.

52- Zhao, Q., Chen, S., Liu, Z., Baker, T., & Zhang, Y. (2020). Blockchain-based privacy-preserving remote data integrity checking scheme for IoT information systems. Information Processing & Management, Vol.57, No.(6), 102355. doi:10.1016/j.ipm.2020.102355.

53- Malak A., NZ J., Mamoona H., (2019), Blockchain for Internet of Things (IoT) Research Issues Challenges & Future Directions: A Review, IJCSNS International Journal of Computer Science and Network Security, Vol.19, No.5.

54- Kshetri, N., (2017). Can blockchain strengthen the internet of things? IT Professional, Vol. 19, No. 4,PP: 68–72.

55- Tejal S., Shailak J.,(2018), APPLICATIONS OF BLOCKCHAIN TECHNOLOGY IN BANKING & FINANCE, DOI: 10.13140/RG.2.2.35237.96489

DOI : 10.31695/IJERAT.2022.8.3.2

56- Nijeholt, H.L.A., Oudejans, J., Erkin, Z., (2017), DecReg: a framework for preventing double-financing using blockchain technology. In: BCC 2017 – Proceedings of the ACM Workshop on Blockchain, Cryptocurrencies and Contracts, co-located with ASIA CCS ,pp. 29–34.

57- Kitsantas, T. , Vazakidis, A. & Chytis, Evangelos. (2019). A Review of Blockchain Technology and Its Applications in the Business Environment.

58- Konstantinidis I., Siaminos G., Timplalexis C., Zervas P., Peristeras V., Decker S. (2018) Blockchain for Business Applications: A Systematic Literature Review. In: Abramowicz W., Paschke A. (eds) Business Information Systems. BIS 2018. Lecture Notes in Business Information Processing, vol 320. Springer, Cham. https://doi.org/10.1007/978-3-319-93931-5_28

59- Weking, J., Mandalenakis, M., Hein, A. ,(2020), The impact of blockchain technology on business models – a taxonomy and archetypal patterns. Electron Markets Vol.30, PP: 285–305. https://doi.org/10.1007/s12525-019-00386-3.

DOI : 10.31695/IJERAT.2022.8.3.2