Blockchain based Security Solutions with IoT Application in Construction Industry

P Singh
Department of Civil Engineering, Amity School of Engineering & Technology, Amity University Uttar Pradesh, Noida, India

*Email: priyanka24978@gmail.com

Abstract. Blockchain Technology is an evolving digital technology that has become widely applicable in different industry and business sectors in recent years, particularly in financial and banking areas due to the rapid rise in the value of cryptocurrencies in recent years. A blockchain technology is basically a decentralized database that records any transaction made within the network, which is known as a 'node,' which includes encrypted data from the entire background of the transaction. In any sector, the implementation of decentralized technology lead to strengthening, protection, implementation of accountability and a transition from current centralized systems to a decentralized system, which is required in construction industry. The construction industry will continue to be a crucial engine of economic development for all nations. Construction industry is one of the world's most important sectors. Application of Blockchain and IoT plays a very important role in construction industry. In construction industry, the decentralized ledger of data gathered from sources includes transactions and accounts via a linked network and relies on the agreement between the node points, which strengthens Blockchain's transparency, traceability, and collaborative existence. This paper presents an overview and motivation for the application of IoT & Blockchain Technology in the construction industry. The integration of Blockchain technology and IoT (Internet of Things) strengthens the whole system and makes real time more applicable. This paper therefore shows Blockchain's potential applications with IoT in the infrastructure and construction industry.

1. Introduction
In The construction industry is the only sector that is consistently increasing and contributes to the central component of GDP. In India, the construction industry contributes 8% of Gross Domestic Product. The Gross Domestic Product (GDP) of the countries plays a significant role in the introduction of smart ledger technology, such as the Blockchain model [1]. The decentralized ledger of data gathered from sources includes transactions and accounts via a linked network. It relies on the agreement between the node points, which strengthens Blockchain's transparency, traceability, and collaborative existence. The innovations of intelligent contracts have gained popularity, allowing transparency and trustworthy security [2]. The use of robots, smart sensors, and Internet (IoT) shapes the construction industry's environment. Besides, drones can also carry out structural and land surveys. This technology is used to carry out maintenance checks on bridges and other major infrastructures. Sensors have been used to collect data on the construction and operation of the infrastructure asset during the life cycle. The connection of the sensors with the Internet of Things (IoT), process data on a
large scale in real-time and introduces precision. The construction industry's biggest concern is that they cannot keep financial records and therefore pinch margin profits. Blockchain's possible applications in the construction industry are a) payment and project management b) knowledge building and asset management c) chain management supply [3,4]. Nonetheless, late payments are the issue facing by the construction industry. Blockchain reduced the problem of building such as overdue payments, overflow cash, project management, proper employee documentation and clear charges [5]. Transparency, which is very useful for the construction industry, is the essential element of the Blockchain. It makes management of all intelligent contracts simple and increases the trust between the parties. The Blockchain presents an excellent opportunity to create a more reliable and secure enterprise for all parties [6,7]. Mega-construction projects in this industry require comprehensive supervision and preparation. Failure to be responsible causes delays and affects the project's profit margins, leading to a loss of forms and other forms. Induced payment and project management techniques that can be implemented in blockchain can easily make a significant difference [8,9]. It offers options for shaping a more efficient market climate, maintaining the transparency value feedback identified in a building project. The concept of Blockchain Technology could, therefore, be mentioned as a resource in the construction industry. The integration of Blockchain technology and IoT strengthens and opens up greater real-time applicability [10,11]. The basis of Blockchain technology is the idea of blockchain, i.e., Bitcoin, which has an extensive application and used in today's world as a digital currency network (see Figure 1). Blockchain may be defined as a decentralized ledger that records possible information sources in the encrypted form of a significant data source.

![Figure 1. Concept of Blockchain Technology [12]](image)

The legitimacy of Blockchain principles encompasses encryption, imposing transparency and, if used to their full potential, can also help maintain the cooperative management chain in building industries. This paper provides an overview and motive to facilitate blockchain technology & IoT in the building industry. The collaboration of Blockchain technologies and IoT (Internet of Things) enhances and enables more real-time applications [13]. The Blockchain principle overlooks third-party intervention, which makes the transaction seamless and provides more excellent protection. Blockchain was primarily implemented to preserve the secure transaction. Blockchain technology will provide IoT devices with authentication as one of the outstanding techniques. Frameworks that explain how blockchain functions for IoT are also demonstrated. This paper analyzes the safe data and IoT technologies of the construction industry focused on Blockchain solutions and address technological challenges in detail [14,15]
2. Blockchain Technology

It can, therefore, be stated that Blockchain is a tool to help the construction industry. It makes transparent payments and tracks the work progress along with all stakeholders of the team [16]. The cooperation between Blockchain technology and IoT (Internet of Things) and is growing and opening up more real-time applicability [17]. Features of Blockchain technology is illustrated in Figure 2.

![Features of Blockchain Technology](image)

**Figure 2.** Features of Blockchain Technology [18]

Blocks are linked in blockchain technology in the form of chains, and genesis blocks are recognized as the first block of the chain. Blockchain has the potential to expand continuously into a new set of records or blocks. There is a timestamp for each block in the network and a relation to the previous blocks (the previous block hash value) [19]. The first block of any blockchain-based protocol is the genesis block. It is the baseline for adding further blocks into a blockchain; hence it is termed as blockchain. Often this block is referred to as Block 0. Each block stores a reference to the previous block in a blockchain. There is no previous block for reference in the case of Genesis Block [20]. Technically, it means that the "previous hash" value of the Genesis Block is 0. It means that before the Genesis Block, no data were processed (see Figure 3). All other blocks will have sequential numbers beginning with 1, and the "previous hash" of the previous block will have been set. The hash of the genesis block is inserted in a new block to all new transactions [21]. Each combination produces its unique hash. The cycle is repeated until all new blocks in a blockchain are added. The number used to order blocks is known as the number of block height. The Genesis Block starts at 0. The Block height of a block is the number of blocks in the chain before that given block. The height of the block Genesis is therefore 0 since no block has been set before it. Any change in the hash of the block disable all the successive blocks and their colours are changed since it is tampered proof (see Figure 4).

Hence in the construction industry, the maintenance of the database can be achieved so that everyone in the network gets a copy of the entire database. New blocks are irreversibly applied to the file, while
old blocks remain forever and cannot be manipulated by falsified documents or transactions [22,23]. Also, all blocks are uniquely encrypted that only a person with a picky encryption key can add a new record to a specific Blockchain and that someone else cannot control its transactions.

Figure 3. Genesis Block [24]
Figure 4. Disabled Block [24]

Blockchain's architectural components consists of nodes, transactions (records, documents, etc.), blocks (data structures used to manage the transaction), chain (block grouping), miners (hubs where confirmation is conducted before adding blocks to the Blockchain structure) and the Consensus protocol (Blockchain guidelines and plans). Each Blockchain record is carefully labeled to ensure its validity. Throughout the Blockchain architecture, a block hash is similar to a unique mark (a long record consisting of specific numbers and letters), using a cryptographic hash algorithm that effectively distinguishes each block of the Blockchain design [25,26].

Extensively speaking, there are two types of public and private blockchain network. These are peer to peer (P2P) networks in which the ledger is distributed by those who apply. Blockchain can be both permissible (like Bitcoin or Ethereum) and permitted (like the Hyperledger blockchain framework) alongside public or private. A public blockchain is a permissionless blockchain because anyone can
enter the network [27, 28]. Permitted networks are blockchain networks in which write transactions can only be conducted by registered users or organizations. Because of the limited nodes, they can be faster and cheaper and can easily be maintained. Pre-verification of the participating parties is mandatory for a permitted blockchain and therefore, the transacting parties are made. The approved P2P networks have to guarantee uptime and require a high degree of communication service efficiency.

Public and private blockchain networks on permissions may be classified as public and permissionless, public and permissioned, private and permissionless, and private and permissioned [29,30].

3. Smart Contracts
Blockchain technology enables 'smart contracts' to be formed. Such automated self-executing contracts automatically transfer currency or assets until the underlying code specifies that a default condition is met. Smart contracts can be used to automate the purchase of materials and equipment and to control intellectual property rights [31,32]. Payment between two contractors at one place may immediately result in an order for the production and delivery of materials to another part of the project at a different location.

A smart contract is a self-imposed agreement built in a blockchain programming code. It is governed by computer protocols in which credible transactions are carried out without third parties being involved. Smart Contract transactions can be trackable and permanent. A smart contract consists of components such as program code, data file and account balance. During the execution of the contract, you can read or write to your storage file [33]. Smart contracts are one of blockchain's most exciting opportunities, as they can develop, simplify and ultimately become more successful through several processes as shown in Figure 5. See a hypothetical example: for security, health and safety reasons, every worker who enters the site passes his identification card. The information about who visited the site and how much time they spent working on the premises is collected and documented on a blockchain, which allows the client, consultant and contractor to share information. Hence, no further administration is required to verify the information because it is already signed in on the blockchain [34,35].

There are no retrospective questions among the various stakeholders to compare the reported hours in their ledgers. It was already done based on a single blockchain source of truth, which is distributed and modified to-group [37]. This example is evident to shows the benefits of using a blockchain framework in the construction industry. Its application can be extended to complete payments, submissions, and project notifications, making the process more effective and automatic [38].

4. Blockchain & IoT in Construction Industry
IoT refers to the thousands of physical devices worldwide connected to the internet that gathers information and shares it. It promises the world that it will become intelligent and constructive by allowing things to interact with one another [39]. The data collected on the sensors is maintained on central servers on the Internet of Things (IoT), which can lead to many intricacies when devices try to communicate via the internet (see Figure 6). Centralized platforms can have security issues that can...
lead to their misuse. In the context of a decentralized platform, Blockchain technology may provide a solution. A decentralized model can handle billions of operations between various IoT devices. It minimizes the construction and operating costs of the central location server [40]. Through IoT, sensing systems send the data for processing at a centralized location and a data flow occurs [41]. Blockchain technology replaces the IoT central server model by implementing the distributed ledger system's legal authentication for each transaction. It helps to ensure that the transaction information does not have to be stored with third parties, as records are available on many chain computers. Multi-signature protection is, however, required to authorize a transaction procedure to be successful. Researcher's observations show that blockchain -IoT combinations are prone to be most useful to deal with security and privacy issues, which can transform the construction industry. Blockchain technology can play a significant role in solving IoT issues related to privacy and protection [42,43].

5. Challenges of Blockchain & IoT
The companies that incorporate the Blockchain Ideas supporting IoT concept have established the potential challenges to incorporation and completion of the project. Regulatory ambiguity and also lack of trust among its users are new challenges. The next challenges are maintenance costs and lack of governance. The next significant issue is the application of the various companies' standards, which enables the use of private blockchains and their rules. The biggest challenge for network architects when it comes to IoT is future-proofing the network. They make the right decisions when it comes to sensor hardware, radio technology, or cloud platforms. It will maintain confidentiality & integrity, as technology design problems grow faster. There have been designing challenges, including limited processing capacity, limited resources and limited memory [45].

6. Conclusions
This paper overview the wide application related to the construction industry where Blockchain with IoT may play a huge role in the execution and management of the construction site. In order to maximize productivity, smart contracts can be implemented in real time, in business processes and administrative tasks. Furthermore, the project management model could theoretically minimize late payments, remediation and conflicts if implemented, making the organization a more trusted business with a consistent cash flow and reliable checked information. Application of Blockchain is important to procure project management and also for the supply chain management. Along with IoT and the Blockchain, redefine the realities of the building industry. Such a model may become a digital twin for
construction industry, maintenance and service. Blockchain and IoT promotes the digital transformation of the construction industry and thus affects business development and productivity. Blockchain is a decentralized distributed ledger that offers many advantages, including immutability, openness, trust, protection, and audibility. Blockchain consists of a network of peers that helps mining validate records before building blocks. Blockchain is based on decentralization, open governance (or self-governance) concepts, accountability and eradicates intermediation. IoT aims to enhance construction operations, reduce waste and optimize savings in the building industry. With the assistance of IoT sensors, construction companies can optimize the performance of their equipment. This allows them to assess the safety condition of equipment and to take sufficient precautions. IoT allows real-time site monitoring to improve operational control. IoT may be used to produce safety information for equipment to direct maintenance operations for prompt repair and failure prevention.

References
[1] Economics, Oxford, 2015 “A Global Forecast for the Construction Industry to 2030”.
[2] Belle I 2017 *DADA International Conference on Digital Architecture*, Nanjing, China, pp 279-284.
[3] Li J, Greenwood D, Kassem M 2019 *Automation in Construction* **102** 288-307.
[4] Turk Ž, Kline R 2017 *Procedia engineering* **196** 638-645.
[5] Rejeb A, Keogh JG, Treiblmaier H 2019 *Future Internet* **11**(7) 161.
[6] Perera S, Nanayakkara S, Rodrigo MNN, Senaratne S, Weinand R 2020 *J Industrial Information Integration* **17** 100125.
[7] Wang J, Wu P, Wang X, Shou W 2017 *Frontiers of Engineering Management* **4** 67-75.
[8] Lanko A, Vatin N, Kaklauskas A 2018 *Matec Web of conferences* **170** 03032.
[9] Barima O 2017 Leveraging the Blockchain Technology to Improve Construction Value Delivery: The Opportunities, Benefits and Challenges *Construction Projects: Improvement Strategies, Quality Management and Potential Challenges* eds Hall K (New York: Nova Publisher) chapter 3 pp 93-112.
[10] Hargaden V, Papakostas N, Newell A, Khavia A, Scanlon A 2019 *IEEE International Conference on Engineering, Technology and Innovation* (ICE/ITMC), Valbonne Sophia-Antipolis, France, pp 1-6.
[11] Heiskanen A 2017 *Construction Research and Innovation* **8**(2) 66-70.
[12] Ahram T, Sargolzaei A, Sargolzaei S, Daniels J, Amaba B 2017 *IEEE Technology & Engineering Management Conference*, Santa Clara, CA, USA, pp 137-141.
[13] San KM, Choy CF, Fung WP 2019 *IOP Conference Series: Materials Science and Engineering* **495** 012005.
[14] Hultgren M, Pajala F 2018 Blockchain Technology in Construction Industry: Transparency and Traceability in Supply Chain.
[15] Sivula A, Shamsuzzoha A, Helo P 2018 *International Conference on Industrial Engineering and Operations Management*, Bandung, Indonesia.
[16] Hewavitharana T, Nanayakkara S, Perera, S 2019 *Proceedings of the 8th World Construction Symposium: Towards a Smart, Sustainable and Resilient Built Environment*, Colombo, Sri Lanka, pp 137-146.
[17] Andoni M, Robu V, Flynn D, Abram S, Geach D, Jenkins D, McCallum P, Peacock A 2019 *Renewable and Sustainable Energy Reviews* **100** 143-174.
[18] Samudaya N, Perera S, Bandara D, Weerasuriya TG, Ayoub J 2019 *Proceedings of the 43rd Australasian Universities Building Education Association Conference: Built to Thrive: Creating Buildings and Cities that Support Individual Well-being and Community Prosperity*, Noosa, QLD, Australia, pp 662-672.
[19] Allison N, Warren M 2019 Applying Blockchain to Product Compliance and Assurance in the Construction Industry, Institution of Civil Engineers, London, UK.
[20] Rodrigo MNN, Perera S, Senaratne S, Jin X 2018 Proceedings of ICEC-PAQS Conference, Sydney, Australia.
[21] Kifokeris D, Koch C 2019 Proceedings of the 2019 European Conference on Computing in Construction, Crete, Greece.
[22] Mondragon AEC, Mondragon CEC, Coronado ES 2018 IEEE International Conference on Applied System Invention, Tokyo, Japan, pp. 1300-1303.
[23] Wang Z, Wang T, Hu H, Gong J, Ren X, Xiao Q 2020 Automation in Construction 111 103063.
[24] Friedlmaier M, Tumasjan A, Welpe IM 2018 Proceedings of the 51st Annual Hawaii International Conference on System Sciences, Hawaii, USA.
[25] Tezel A, Papadonikolaki E, Yitmen I, Hilletofth P 2019 CIB World Building Congress Constructing Smart Cities, Hong Kong SAR, China.
[26] Nawari NO, Ravindran S 2019 J Building Engineering 25 100832.
[27] Pan X, Pan X, Song M, Ai B, Ming Y 2020 Int J Information Management 52 101946.
[28] Singh S, Ashuri B 2019 ASCE International Conference on Computing in Civil Engineering, Atlanta Georgia. pp. 393-401.
[29] Mason J 2017 J Legal Affairs and Dispute Resolution in Engineering and Construction 9(3) 04517012.
[30] Ahmadisheykhsarmast S, Sonmez R 2018 In 5th International Project & Construction Management Conference, Cyprus, pp 767-774.
[31] Luo H, Das M, Wang J, Cheng JCP 2019 Proceedings of the International Symposium on Automation and Robotics in Construction 36 1254-1260.
[32] Lamb K 2018 Blockchain and Smart Contracts: What the AEC sector needs to know, University Cambridge, Cambridge, UK.
[33] Safa M, Baeza S, Weeks K 2019 Incorporating Blockchain technology in Construction Management, Strategic Direction, San Luis Obispo, CA.
[34] Mason J, Escott H 2018 Proceedings of FIG Conference, Istanbul, Turkey.
[35] Li J, Kassem M, Ciri bini ALC, Bolpagni M 2019 International Conference on Smart Infrastructure and Construction, Cambridge, UK, pp 275-282.
[36] Cohn A, West T, Parker C 2017 Georgetown Law Technology Review 1(2) 273-304.
[37] Gatteschi V, Lamberti F, Demartini C, Pranteda C, Santamaría V 2018 Future Internet 10(2) 20.
[38] Heiskanen A 2017 Construction Research and Innovation 8(2) 66-70.
[39] Jo BW, Khan RMA, Lee YS 2018 Sensors 18(12) 4268.
[40] Bai L, Hu M, Liu M, Wang J 2019 IEEE Access 7 58381-58393.
[41] Atlam HF, Alenezi A, Alassafi MO, Wills G 2018 Int J Intelligent Systems and Applications 10(6) 40-48.
[42] Dai HN, Zheng Z, Zhang Y 2019 IEEE Internet of Things J 6(5) 8076-8094.
[43] De La Peña J, Papadonikolaki E 2019 Proceedings of 2019 European Conference on Computing in Construction, Crete, Greece.
[44] Choi BG, Jeong E, Kim SW 2019 J Open Innovation: Technology, Market, and Complexity 5(4) 87.
[45] Alamri M, Jhanjhi NZ, Humayun M 2019 Int J Comput Sci Netw Secur 19 244-258.