(IJRST) 2022, Vol. No. 12, Issue No. IV, Oct-Dec **e-ISSN: 2249-0604, p-ISSN: 2454-180X**

Integration of Blockchain, Internet of Things and AI[1]

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DOI:10.37648/ijrst.v12i04.006

Received: 08 September 2022; Accepted: 09 November 2022; Published: 10 December 2022

ABSTRACT

The next phase of digital transformation will be propelled by technologies like blockchain, the Internet of Things (IoT), and artificial intelligence (AI). In this paper, we suggest that the convergence of these technologies will make possible novel forms of enterprise. Future autonomous agents will function as autonomous profit centers that have a digital twin leveraging IoT, send and receive money leveraging blockchain technology, and autonomously make decisions as independent economic agents utilizing artificial intelligence and data analytics. Further, we suggest that this convergence will propel the creation of such autonomous business models and, by extension, the digital transformation of industrial conglomerates.

Keywords: *Blockchain; IoT; AI; Blockchain Integration.*

INTRODUCTION

These days, it's common knowledge that developments like blockchain technology, the Internet of Things (IoT), and artificial intelligence (AI) have the potential to revolutionize established business practices, birth brand-new revenue streams, and upend entire markets. In this way, blockchain technology, by offering a shared and decentralized distributed ledger, can improve the trustworthiness, openness, safety, and confidentiality of corporate procedures. Distributed ledgers like the blockchain can be used to keep track of anything of value, just like a traditional ledger would Typically, financial and personal information can be gleaned from these records. Critical to the success of the European and German economies, the Internet of Things facilitates the automation of industries and the user-friendliness of business operations. Last but not least, AI helps businesses enhance their procedures by spotting patterns and optimizing the results.

Blockchain, the Internet of Things, and artificial intelligence have all been developed independently up until this point, and their interdependence has been largely ignored. Yet, it is possible to apply these advances together, and it is recommended that you do so. One probable link between these technologies is that Internet of Things (IoT) collects and gives data, blockchain provides the infrastructure and specifies the rules of engagement, and AI optimizes processes and rules (Salah et al., 2019; Zheng et al., 2020). These three developments were created to work together, and their full potential can be realized in that context. We assess and discuss the potential benefits of bringing these technologies together for use in data management and the automation of business processes.

THE RELATIONSHIP BETWEEN BLOCKCHAIN, THE INTERNET OF THINGS, AND ARTIFICIAL INTELLIGENCE

Prior to the last few years, blockchain technology was primarily mentioned when discussing cryptocurrencies like Bitcoin (Nakamoto, 2008) and Ether, which are used for making and receiving payments. Supply chain management and digital identities are only two examples of the growing number of non-financial use cases for blockchain technology in recent years (Treleaven et al., 2017). (Roeck et al., 2020). Newer works highlight the benefits of integrating blockchain with other advancements like the Internet of Things and artificial intelligence. To cite just one example, Huh et al. (2017) describe how blockchain technology might be used to enhance the underlying infrastructure of numerous Internet of

[1] *How to cite the article:* Vyshnavi K.D.S., Integration of Blockchain, Internet of Things and AI; IJRST, Oct-Dec 2022, Vol 12, Issue 4, 31-36, DOI: http://doi.org/10.37648/ijrst.v12i04.006

Things devices. In order to better service Internet of Things (IoT) devices, Dorri et al. (2017) detail how blockchains might be adjusted to improve their design, particularly in terms of transaction speed. Some research has also concentrated on the use of blockchain in tandem with artificial intelligence (AI) rather than just the Internet of Things (IoT) (Salah et al., 2019). To this far, blockchain has mainly been used in conjunction with a single other cutting-edge technology, such as the Internet of Things or artificial intelligence, rather than all three technologies being applied concurrently. But it is only via integration of these cutting-edge developments that their full potential may be realized. Using blockchain technology, Kumar Singh et al. (2020) creates a system that can be used with the Internet of Things and artificial intelligence. This work, in contrast to Kumar Singh et al. (2020), gives a non-technical summary of the advantages of each invention and how they complement each other. One real-world application of the potential synergy of blockchain, the Internet of Things (IoT), and artificial intelligence is presented.

It is important to keep in mind that the ideas presented in this paper can just as easily be applied to private blockchains. Data maintained on a public blockchain can be accessed by all participants in contrast to a private blockchain where only certain participants have access to the data. On the other hand, private blockchains only allow authorized users access to their data. Since the use cases discussed here would function similarly on either a public or private blockchain, the question of which to employ is academically moot. Not only that, but it's important to remember that blockchains, like any other database, can be negatively affected by inaccurate information. This study will not go into greater detail on this topic because it is not directly relevant to blockchain-based data.

DATA ADMINISTRATION

Raising Data Quality, Privacy, Security, and Scalability

Many Internets of Things (IoT) gadgets, such those found in smart homes, smart offices, smart cities, smart factories, smart vehicles, and smart grids, generate copious amounts of information. As a result, the data is generally stored in an unstandardized format on a centralized server. Several legacy systems in use by businesses make it challenging to extract and understand data in a unified manner. By creating a unified digital platform for IoT data that can be accessed by different parties, blockchain technology could aid in the standardization of data. One unified format for all data storage then becomes a reality. The hash functions used by blockchain systems mean that only one type of data may be kept there. Hence, better data management might be possible with more compatible data formats (Karafiloski and Mishev, 2017).

There are two main categories of blockchain data storage: on-chain storage and off-chain storage. The benefit of storing data on the blockchain is that it can be accessed from any node and restored at any moment. But storage demands are high, and too much data kept on the blockchain can cause a phenomenon known as "blockchain bloating," in which the network's throughput and scalability are impaired. As an alternative, off-chain storage stores the data themselves off-chain while keeping only the aggregated metadata on-chain. This option reduces data openness but has the advantage of being far more scalable than the on-chain method.

The encryption underlying blockchain platforms also allows for a great deal of data privacy to be implemented (Zyskind et al., 2015). Most blockchain transactions are done so under a fictitious identity, however others, like those using Monero or Zcash, are totally anonymous. Data stored and communicated within a blockchain system can be fully encrypted using a private/public key infrastructure, making it impossible for anybody other than the device itself to access the data (Es-Samaali et al., 2017). There is a lot of private information stored on equipment and devices in the IoT. The confidentiality and safety of this information are of the utmost importance. Currently, it is common practice for IoT data to be transmitted instantly from the device to the collecting database (often stored in the cloud). This information, however, is not encrypted and hence cannot be kept secret. In this regard, blockchain technology can be very useful because it can simply guarantee the anonymity of the obtained data. The following methodology was utilized in the creation of blockchain technology: Safer by design.

As an added bonus, a blockchain is very resistant to operational failures and hackers. This robust safety is a direct result of integrating cryptography with consensus processes. As a result, implementing blockchain technology can better protect sensitive information (Steger, 2017). High privacy, however, comes at the expense of oversight over potentially illegal behavior. If a blockchain network is designed to guarantee perfect anonymity, no one can be traced back to a specific transaction. Such anonymity facilitates criminal behavior like financing for terrorism or money laundering. Strengthening

defenses and uncovering criminal activity are two areas where AI has proven useful. To mitigate the potential for illegal activity on the blockchain caused by the anonymity of transactions, Yin et al. (2019) proposes utilizing AI leveraging data analytics. The greater the amount of IoT data used to train an AI algorithm, the better it will perform; hence AI technologies appreciate the large amounts of data that are made available.

Managing and storing massive amounts of data is now one of IoT's primary shortcomings. Convergence of technologies employing blockchain technology and AI together could make data management more scalable. Critics of blockchain technology argue that proof-of-work and similar energy-intensive consensus processes used to validate transactions limit the scalability of blockchain networks (Li et al., 2019). Proof-of-stake and proof-of-authority are two examples of energy-efficient consensus procedures that can improve scalability (Narayanan et al., 2016). Actually, the Bitcoin network's excessive energy usage will soon be an artifact. When combined with blockchain, AI can help enhance scalability even further. Liu et al. (2019) present a methodology for optimizing the performance of IoT systems that make use of blockchain technology. To improve throughput, this system could be based on deep reinforcement learning (DRL), a type of machine learning. For optimal performance, the authors recommend a "DRL-based mechanism to dynamically select/adjust the block producers, consensus algorithm, block size, and block interval."

To sum up, the trustworthiness, immutability, security, and privacy aspects of blockchain technology can enhance the data management of Internet of Things (IoT) gadgets. Together, AI and the IoT can overcome some of the data's current shortcomings.

Proving Your Identity with A Blockchain

In addition, the identity of IoT devices may be managed securely and reliably through the use of blockchain technology, which can also be used to verify the identities of those participating in the IoT network. Identity management in the Internet of Things environment includes not only people and businesses, but also the devices and technologies that make up the IoT. In a blockchain-based transaction, each party is assigned a unique digital identifier that corresponds to their actual, identifying information (e.g., identity card for individuals, commercial register entry for companies). A digital identity allows for the swift and cheap processing of transactions between individuals and businesses (such as car sharing), between individuals and machines (such as autonomous car passenger transport), and between machines (such as autonomous car paying for parking) (Zhu and Badr, 2018).

Money will be moved in the future between people, businesses, gadgets, and machines. IoT Insights predicts that by 2025, there will be more than 20 billion internet-connected gadgets (IoT Analytics, 2020). The devices will also play a role in the financial transaction. As a result, a brand-new, perhaps decentralized, payment system will be essential. Every entity, be it human or computer, must have a unique digital identifier in order to participate in a blockchain network. Thus, blockchain-based identity management will be crucial.

These identities must be granted and managed in accordance with privacy regulations. The criticism that blockchains are inadequate because of their architecture to ensure data privacy is, nevertheless, justified. This is because blockchain technology, with its integrated access mechanisms and encryption procedures, is superior to non-blockchain-based systems in three key respects: (i) protecting data by design; (ii) organizing data ownership; and (iii) enabling the monetization of data (Suliman et al., 2018).

The unchangeable record of the digital identity provided by blockchain technology also makes forgeries very difficult to pull off. Confidence in the identification of things, which can be attained with the use of blockchain technology, is vital in the context of autonomously interacting machines and gadgets.

Automation Through the Use of "Smart Contracts"

Combining blockchain technology, the Internet of Things, and artificial intelligence holds great promise for automating corporate operations in addition to data and identity management. The usage of smart contracts is an important link in the chain connecting these three technologies.

Digital agreements, or "smart contracts," are spelled out in a system that ensures their fulfillment (Szabo, 1996). By analogy with "if-then" functions in computer programming, smart contracts specify what should happen if a given condition is met. Assuming that a product has been successfully delivered (the "if"), then the corresponding payment (the

"then") will be processed immediately. That is to say, smart contracts are the glue that hold the Internet of Things (IoT), artificial intelligence (AI), and blockchain technologies together.

Smart contracts have a lot of potential, but they aren't used by industrial firms yet. Classical smart contracts have the fundamental problem of transferring sums of crypto assets like Ether or EOS, which is why they require these assets. Although crypto assets have many advantages, corporations are cautious to employ them due to regulatory and economic concerns. The extreme price volatility of crypto assets is a major drawback. The other party in a smart contract runs a significant risk of having their funds fluctuate in value if the transaction is settled in Ether. There are occasions when the value of crypto assets rises or falls by more than 10% in a single day. Stablecoins may be a solution to the extreme volatility of "traditional" crypto assets, but they will not be widely adopted by industrial firms or in business-to-business transactions for the following reasons. To begin, there are currently no rules governing stablecoins. As a result, cautious businesses shun the usage of uncontrolled devices. Second, organizations' books and databases are set up to deal with and denominate transactions in fiat currencies like the Euro. So, it is an administrative hassle for businesses to exchange the stablecoin for their "system- based" currency. Both time and money are expended throughout this transformation (i.e., transaction costs, hedging for price fluctuations).

Smart contracts can only be used to their full potential with a blockchain-based fiat money that "flows through" the smart contract. For services like pay-per-use, leasing, and factoring to be offered directly by machines, automobiles, or sensors, only a digital Euro backed by the blockchain can be used in smart contracts. The advent of a digital, blockchain-based Euro could pave the way for entirely new types of business models, such as fully automated devices that make decisions autonomously using AI and "economically survive" independently using blockchain for financial transactions while implementing a profit-center logic at the device level.

The advantages of a digital Euro based on DLT are numerous. It's important for the development of the Internet of Things that micropayments for IoT devices may be conducted with cheap transaction fees, and a digital currency based on the blockchain would make this possible. Second, all Euro-denominated transactions made using this blockchain-based digital currency would be recorded in the company's internal Enterprise Resource Planning (ERP) systems and easily accessible for billing and financial reporting. Third, converting fiat currency would be unnecessary as compared to crypto assets and stablecoins, freeing up significant resources. And fourth, this type of digital fiat currency would be legal tender under the rules in effect today. The first firms to employ e-money licenses for the tokenization of fiat currencies are developing blockchain-based fiat currencies (CashOnLedger, 2020; Monerium, 2020). When existing e-money regimes are utilized, industrial firms seeking such blockchain-based Euro solutions should not worry about legal ambiguity (Sandner et al., 2020b).

Financial organizations, electronic money issuers, unregulated entities, and even central banks are all viable options for issuing the blockchain-based Euro (Sandner et al., 2020b). More than seventy national governments are mulling over the prospect of issuing their very own digital currency, per a recent Bank for International Settlements report (Barontini and Holden, 2019). (CBDC). Not a single government institution has issued such a currency as of yet, yet the Swedish and Chinese governments are blazing new trails and may soon introduce the world's first government-issued digital currency. Several cities around China, as well as local branches of multinational corporations like McDonald's and Starbucks, are now testing the Chinese CBDC project DC/EP. No announcement of a CBDC issuance by the European Central Bank (ECB) has been made as of yet. Yet, the use of a central bank-backed Euro for smart contracts in European industry would necessitate the development of a CBDC based on the European blockchain.

It's fair to wonder why we need a central bank-issued Euro if e-money providers have already developed a Euro based on the blockchain. Specifics are the key: The funds provided by the central bank are considered central bank money, whereas those issued by commercial banks are considered electronic money. Both central bank money and commercial bank money represent the Euro, however commercial bank money could default in the event of insolvency, whereas central bank money represents a claim to the central bank, which cannot, by definition, go bankrupt. This distinction may not appear important when the economy and the financial markets are well, but it becomes critically important during times of crisis.

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USING BLOCKCHAIN, INTERNET OF THINGS, AND ARTIFICIAL INTELLIGENCE

Evident from the above explanation, new business models for the monetization of IoT devices can be unlocked by combining blockchain technology with IoT devices and AI. This section describes one possible application.

Consider a lamp (e.g., a street light) that is registered on the blockchain (see "Data Management"), and uses a cryptocurrency token (see "Automation Via Smart Contracts") to run. The light is now considered an independent entity that can "do its own thing." Micropayments can be paid to the lamp via smart contracts, which will then switch on the light. The light will come on once someone, be it an individual, a business, or the government, pays for it. There is potential for the implementation of pay-as-you-go pricing models here. The lamp can generate its own revenue thanks to its digital wallet.

Because every light is linked to the distributed ledger, it can keep track of metrics like how often it's used, how well it performs, and how often it goes offline. With this information, AI could streamline the servicing of the network. For regularly used lights, for instance, the system may recommend more frequent maintenance and send out the maintenance personnel immediately in the event of a malfunction. Artificial intelligence (AI) can also streamline network upkeep by facilitating the ordering of replacement parts or by assisting with more accurate forecasting of the quantity of replacement parts necessary. There would be less network downtime if this assistance was provided.

Tokenizing lighting as assets makes them accessible to investors (International Institute for Sustainable Development, 2019). As a result, financiers might be open to constructing and operating a vast network of such lights. And the investors would get their cut of the lamps' profits. The implications of this program could be profound. As a result of receiving a proportional return on the tokenized asset, in this case the lamp, investors may be more motivated to put their money into this type of investment if it were to become widespread. Tokenization's advantages are applicable not just to lamps, but to all Internet of Things devices and, by extension, several commercial uses. For instance, once sensors, automobiles, machines, cameras, and trucks are online and linked to a blockchain network, they fall under this category.

CONCLUSION

Blockchain, the Internet of Things (IoT), and artificial intelligence are all technologies that can be combined in a wide variety of ways. We contend that a confluence of these developments is inevitable, given the mutual benefits to business models, goods, and services. A wide variety of autonomous agents, including sensors, vehicles, machinery, trucks, cameras, and other Internet of Thing’s devices, could benefit from such a business model. These agents could function as autonomous economic actors, able to send and receive funds and use AI and data analytics to inform their decision making.

Such business model innovation and the digital transformation of industrial conglomerates are propelled by convergence. Chiefs need to address these technologies if they want to reap the benefits of massive productivity increases. When paired with the Internet of Things and artificial intelligence, blockchain technology will usher in a new era of digitization.

Blockchain technology has come a long way in the past decade. Among the main complaints leveled against blockchains in the past was their supposed inefficiency and inability to scale. Initiatives like EOS, which can compete with a modern transaction system in terms of the number of transactions processed per second, have solved these problems. There are, however, other obstacles that must be resolved. The right to be forgotten under the General Data Protection Regulation (GDPR) and the challenge of integrating with legacy systems are two such examples. We propose that, like efficiency and scalability, these deficiencies will be addressed by blockchain technology as it evolves and improves.

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