Blockchain Technology and Its Applications in Finance, Internet of Things, and Healthcare

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Abstract. The paper gives a full review of blockchain technology and its application in finance, IoT, and healthcare. It focuses on the basic elements of blockchain and its distinctive features like decentralization, can't change, and better protection. These are very important for how more and more industries pay attention to blockchain now. The paper lists specific blockchain solutions and algorithms for use with actual problem sets of these fields. It talks about the fundamental parts of blockchain, like the distributed ledger, the way everyone agrees on a decision (consensus), special codes that make information hard to change (cryptography), and smart contracts. These help it work and keep information safe and correct. The application of blockchain in finance for cost reduction, efficiency improvement, and trust enhancement is explored. IoT emphasizes privacy protection, resource utilization and data recording. In healthcare it is focusing on secure and decentralized EHR's as well as improved data sharing and patient-controlled data. The paper identifies several challenges that hinder the widespread adoption of blockchain, including scalability, privacy, regulatory compliance, and interoperability. It suggests that using blockchain together with new stuff like artificial intelligence and machine learning might work to fix these issues and make transactions better and protect private stuff better. The authors of the paper conclude that it is important for stakeholders from disparate sectors to foster collaboration in order to produce standardized solutions that enable seamless data sharing and interoperability. In summary, the block chain is full of huge potential, which needs to be addressed to enable its widespread use, which will make operations more efficient and create new values in all kinds of industries.

INTRODUCTION

Blockchain technology is a distributed bookkeeping method which ensures secure and unalterable data through cryptographical means. It has some key features such as decentralization, persistence, anonymity and auditability [1]. They make blockchain possess large application potential and applications in every field. The main benefit offered by blockchain technology is that it creates a transaction environment which needs no trusted middleman as that reduces the cost considerably and increases efficiency as well. Blockchain has great potential, but there are several technical problems. For example, there are challenges related to scaling, privacy and selfish mining [1]. Thus, it is necessary to continue researching into blockchain technology in order to solve its problems and enable it to be applied in more areas so as to generate widespread personal and social benefits.

The term of blockchain is not newly introduced, this technology was proposed by Nakamoto Satoshi in 2008 and realized in 2009 [2]. Technology was first intended to be the underlying technology for Bitcoin, but soon after its development, the potential for blockchain spread beyond just cryptocurrencies. As blockchain developed over time, plenty of people have enhanced and extended the core elements of it. of those from the past, Bityou offered a consensus mechanism with Proof of Stake (PoS), a more improved method which was designed to better the energy efficiency and security of the blockchain network [3]. But the idea of the Smart contract exists before blockchain. First appeared in 1997 by Nick Szabo [4]. But it was not UNTIL 2008 THAT smart contracts had decentralized grounds to exist upon, due to the emergence of blockchain technology. The combination of the two became popular around 2013 over Ethereum [5]. These components came along with the introduction & development, which brought a great deal of variety to the applications and what might be possible through the use of blockchain technology.

Presently, the block chain has substantial worth in many domains. On the Internet of Thing world, there is a lot of

potential. Blockchain can be used to improve security and interoperate between devices [6], then blockchain can let iot devices communicate with each other and share data in a secure way. Blockchain technology provides new ideas and applications for the use of iot equipment, such as smart city and supply chain management. In the financial sector, blockchain technology, known for its decentralization, security, transparency, censorship resistance, and traceability, is being applied in areas such as financial services, digital assets, remittances, and online payments. Not only does it improve the transparency and efficiency of transactions, but it also reduces transaction time and risk [7, 8]. The second area where healthcare in Blockchain is on the rise is to protect the health records' confidentiality and confidentiality [9]. This tech supplies a stable, unchangeable storage place for healthcare paperwork. This really helps make sure a person can keep private and also improve how openly and easily someone's medical facts can be seen.

This paper wanted to give an overall account of blockchain technology and how it is used in various areas as well as seeing some obstacles and future directions. The paper consists of 2 parts: the 2nd part introduces what's common between them and different basic parts/components & applications of blockchain such as finance, IoT and health detail the specific solutions and algos used & how to apply to real problems. The third part will be the current problems and shortcomings of blockchain technology. It covers the challenges and shortcomings of scalability, privacy protection, security and energy consumption. This part describes the impact of these problems on the development of blockchain technology and some ways to solve these problems. The fourth part is the Conclusion, which sums up the whole paper and gives suggestions for further studies.

METHOD

Basic Components and Features of Blockchain

Blockchain technology is a new kind of distributed ledger technology, and it uses cryptographic means to guarantee the safety and integrity of data. As per Manu et al. [10], basic elements of the blockchain includes (i) distributed ledger (ii) consensus mechanism (iii) crypographic algorithms (iv) Smart contract. All these parts together help block chain work, so it's a safe and clear way to write and do business with information. Due to its features like decentralization, persistence, anonymity, audit ability, blockchain can have a great impact on a variety of industries [11].

Decentralization is a crucial element of Blockchain, it means that all participants that make up the network hold their own ledger, so this gives more transparency and makes the system harder to attack. Consensus Protocols try and get total agreement from every network member to the current ledger state. At the same time using cryptographic technology to protect the integrity and security of transactions. And also, a contract is self-executing agreements containing terms encoded and stored in blockchain with all the participating nodes performing it on a network [10].

In addition, blockchain has several other key features that further enhance its potential for application in different areas [11]. These features include:

- Traceability: every transaction on the blockchain is traceable, which means that the origin and flow of transactions can be tracked, which is particularly important for auditing and regulation.
- Immutability: once data is recorded on the blockchain, it becomes immutable, which provides an extremely high level of data security and reliability.
- Transparency: the distributed nature of the blockchain allows all participants to see the records on the ledger, which increases the transparency of the system and helps in building trust.

These features have enabled blockchain technology to show potential for a wide range of applications in a number of areas, including finance, IoT and healthcare.

The Application of Blockchain in Various Domains

Finance

Cost Cut and Efficiency up: Peters et al. [7] proposed a blockchain-based clearing and settlement system that offers decentralized trading platforms, greatly cutting down on transaction expenses and boosting efficacy. The system will directly transfer the financial assets between the users without any of the intermediaries involved. This results in less time for the transaction as well as less cost. After removing a lot of the verifications and

reconciliations in traditional systems, the blockchain can make the financial deal process quicker and more convenient.

Enhancing Trust and Transparency: Yu et al. emphasize the use of blockchain to increase trust among market participants due to its transparent and secure nature and cannot be tampered with Blockchain could be a platform for voluntary financial disclosure, it could lessen the information asymmetry and improve the quality of financial information. and that transparency is key to building trust with investors, regulators and all, making a better financial system [12].

Smart Contracts for Automated Transactions: Research by Christidis and Devetsikiotis probed into the capabilities of blockchain to enable automatic, by means of a smart contract, carrying out of contract stipulations [6]. These contracts are in digital form, and being stored on the blockchain, would be carried out (executed) upon satisfying certain specific conditions. It cuts down on errors and fraud: the application of smart contract covers many financial fields. such as starting loan business, managing insurance claim, exchange and selling the securities. This can improve the reliability and effectiveness of operation.

Internet of Thing

Privacy and Security Protection: Gowri Sankar Ramachandran, Bhaskar Krishnamachari pointed out that the use of public key cryptography and Hashing algorithms in blockchain to generate digital identities can hide real identities in the network to provide privacy protection for IoT applications with sensitive information [6]. This way protects people's privacy by making sure each device gets its own special digital look so when the device talks to information, nobody can tell who the device is. Furthermore, they also put forward a blockchain-based distributed authentication and access control scheme, by recording the device identity information and access rights of the device on the blockchain, it guarantees the device is unique, it can make the access control transparent, and it can improve the security and resistance ability of IOT devices.

Resource Optimisation and Bandwidth Management: To cope with the constraints on the internet-of-things devices for space and bandwidth scholars came up with many optimisation solutions Among which, with such lightweight blockchain, the blockchain protocol is optimised so that the device requires less computation, storage and communication resources, which makes blockchain technology more apt for resource restricted resources in the IoT [6]. Also, it plans an edge omputing scheme that takes tasks of computation and storages to edge equipment so as to light up the load of Internet of Thing (IoT) devises by changing the structure of the blockchain, this scheme can also improve fault tolerance and adaptability of the system. So, it makes the devices can efficiently synchronize and update the blockchain data when there is intermittent connectivity.

Data Recording and Smart Contracts: Xu and Viriyasitavat stated that traditional supply chain monitoring systems uses a centralized structure, whereas blockchain is able to use a decentralized database in order to record information, which increases more trust to the movement of assets on multi-party infrastructures they put forward a blockchain distributed ledger solution aimed at enhancing the reliability and efficiency of supply chain monitoring, and they make use of the blockchain to record data about the supply, so that the records are both untouchable and open. and have looked at using smart contracts in IoT app and proposed building trust on business process executing via smart contracts [13]. Smart contract is a digital contract stored on the computer system that can be automatically enforced once the protocol conditions are met, solving the issue of trust in business processes and execution and IoT information.

Healthcare

Secure and Decentralized EHR Management: Ratta et al. introduced a new EHR management system with support from blockchain technology [9]. This system capitalizes on blockchain's decentralized and tamper-evident properties to bolster data security and privacy. It distributes the place where patient data is stored, allowing patients to take charge of their own health-related information, so that it can only be accessed by healthcare organizations that have permission to see it. Blockchain deployment assures the immutability and transparency of EHRs and greatly cuts down on risks of data exposure and unauthorized access.

Enhanced Data Sharing and Interoperability: Xie et al. highlighted that blockchain facilitates better sharing and communication of EHRs [14]. Traditional EHR systems often suffer from data silos and interoperability issues between hospitals or organizations. This means patient information cannot be exchanged efficiently. Blockchain technology surmounts these challenges by establishing a secure, decentralized framework that enables the fluid sharing of EHRs across disparate healthcare platforms. Smart contract's creation made it so that sharing the

information is much smoother, the data gets passed along clearly from one party to another with no harm to a patient's privacy.

Patient-Centric Data Control: Azaria et al. put forward a blockchain-empowered EHR management system focusing on patient-centric data governance [1]. This system lets patients take over their own health report and gives them the ability to provide or withdraw the authority on how they wish to have for all healthcare personnel. It relies on the cryptographic tools in blockchain so as to secure the patient data's confidentiality and its integrity. It is a great way to make strong points on the privacy of the patient, as people are included in the care of the information about health.

DISCUSSION

Limitations and Challenges

Though blockchain tech has shown lots of possibilities in plenty of fields, there are still heaps of obstacles when it comes to using it practically. These problems come not only from the limitation of the blockchain itself, but it is closely related to the needs of each area as well. They will be mentioned below in common issues and domain-specific issues.

General Challenges

Scalability and Performance: Blockchain technology's scaling is one of the problems today. Let's take Bitcoin as an example. The current block size of Bitcoin is limited to 1MB, with one block produced every 10 minutes, resulting in the Bitcoin network being able to handle only around 7 transactions per second, far from meeting the needs for frequent transactions [2]. Also, as the transaction volume goes up, the storage space the blockchain has to use enlarges too, which increases the storage cost, and besides that, it might cause network latency and sync issues [1].

Privacy and Security: Though blockchain can provide very good privacy protection with cryptography, there is still a privacy leak problem. An example is that someone's real IP could be found out, and with it their identity if analyzing their transaction patterns and which networks they belong to [15]. Also, there are blockchain consensus problems like proof-of-work (PoW) and proof-of-stake (PoS). For example, PoW will waste a lot of electricity. PoS can easily lead to the rich getting richer [16].

Regulatory and Legal Issues: Regarding Blockchain technology application, there also exists complex laws and regulatory problems. As for the financial field, there is also no clear legal status on the issue of digital currency, many countries do not specify if financial institutions are required to adopt blockchain technology or not [7]. And as for cross-border transactions and data storage by blockchain itself, there is cross-border regulation [17].

Interoperability: Different blockchain systems interoperability is also an important issue. Currently, there are many blockchain application systems implemented independently, and there are no unified standards, which makes it difficult for different blockchain systems to share data and interact [1]. Take IoT space as an example: Different blockchain solutions might be adopted by device makers. Lack of interoperability would prevent cooperation among devices [6].

Domain-Specific Challenges

Financial Sector: Within the financial realm, blockchain's challenges mainly pertain to compliance and security. Take financial organizations as an instance that should make sure blockchain apps comply with AML and KYC rules, which might make the system more complex and costly [7]: Blockchain also has a decentralized system that can create oversights and interventions in regulation which makes it difficult to adopt as a regular part of traditional bank work [17].

Internet of Things (IoT): Within the scope of IoT, blockchain technology has to address problems like hardware resource constraints and privacy concerns of data. As IoT devices are quite constrained in computational ability and stor age capability, they have great tru dles in being active participants in cons enseumment of blockchain [6]. Moreover, there is lots of gathered information from the individual details of the IoT device. This needs protection when it comes to people's privacy. For example: In smart homes smart home devices will need to communicate securely with other smart home devices but it should also protect the privacy of the person who uses the device [1].

Healthcare Sector: In healthcare, the first things to come with blockchain will be data privacy, interoperability, and compliance. Health care data may have personal data that has to be sent in a secure way on the blockchain [9]; Moreover, data sharing among different healthcare organizations need deal with interoperability issue so as to make sure smooth data exchange. For example, electronic health record (EHR) sharing needs to ensure data integrity and privacy protection [9].

Future Prospects

With the continuous development of blockchain technology, it is expected that there will be more applications in some areas like finance, IoT and healthcare. Although currently there are many problems with blockchain technology, it is expected that the problems will be further resolved, and the applications of blockchain can be further expanded as these new technologies such as artificial intelligence and machine learning, and existing technologies are being improved.

General Future Directions

Integration with Artificial Intelligence and Machine Learning: It's thought that by combining blockchain with AI and ML many problems which currently plague blockchain would be resolved. Take the example of AI+ML helping improve the Blockchain's consensus system to hasten the transaction process to increase efficiency. By means of application of smart contracts and automatic decision-mechanism, AI could be used for reducing human errors and frauds, so as to strengthen the secure and reliable condition of blockchains' systems [18]. Also, it is possible to utilize the predicting power of AI and ML in places like EHRs. Where they would be able to analyze big chunks of data from all over to predict future diseases and other things and therefore would improve the quality and effectiveness of healthcare services.

Enhanced Privacy and Security Mechanisms: In order to deal with difficulties concerning privacy and security, future studies could attempt formulating enhanced forms of encryption as well as additional privacy-protection procedures. In other words, something like zero-knowledge proofs and homomorphic encryption which is there to keep an individual's privacy safe, it allows for the secure transfer and use of data inside the blockchain [19]. They can be used to verify transactions without exposing the contents of the data, so that privacy is protected while the visibility and auditability of the blockchain remain.

Scalability Solutions: Regarding the scalability problem of Blockchain, in future studies it is possible to explore various consensus algorithms and blockchain architectures. Take sharding as an example, it can greatly increase the transaction processing speed by dividing the blockchain network into many subnetworks, where each network handles a part of the transactions [5]. And also, solutions from layer 2 like Lightning Network can help take the pressure off the main chain, as it deals with transactions in off-chain space, which would then improve how well the system works.

Domain-Specific Future Directions

Financial Sector: In the financial sector, blockchain + AI+ ML can be used for risk control and fraud detection. AI models can figure out odd transaction patterns by checking through tons of transaction data and stop fraud as soon as possible [7]. Besides, blockchain can make decentralized finance platforms, and it would make financial services like international transfers and financial instrument trading more efficient and transparent.

Internet of Things (IoT): On the Internet of Things, block chain technology can combine edge computing and fog computing to solve the problem of the lack of device-side resource resources. Through the dispersion of calculations and tasks into the nearby edge nodes rather than depending heavily on central servers, it will increase how promptingly and efficiently done [20]. In addition, blockchain can also use authentication and data integrity of IoT devices to achieve secure interactions.

Healthcare Sector: In the healthcare sector, blockchain can be combined with AI, ML, etc., for the treatment and analysis of intelligent EHR. Healthcare systems are able to utilize the predictive power of AI to predict disease trends, so as to deliver personalised healthcare [18]. Moreover, it could also be used for healthcare data sharing and interoperability, which is basically exchanging healthcare data between different healthcare providers without any hassle, and this would result in improvement in the quality as well as efficiency healthcare service delivery.

CONCLUSION

This paper has provided a detailed study of blockchain technology and their usages in different sectors like finance, iot, healthcare etc. This review looked at the basic elements of blockchain, it pointed out its distinctive traits, things like being decentralized, impossible to change once made, and its security that is better, these make it more important. many important barriers that prevent widespread blockchain application have been found, covering worries like being able to use it on a large scale, whether personal information is secure, and whether it obeys relevant rules. and particularly because, in spite of the different blockchain systems do not have the interoperability feature between them, as well as due to the growing number of blockchain apps on different industries, it's important for the next batch of studies to tackle these problems by integrating block chains plus some cool new tech, like AI and ML. These kinds of integration are expected to make things more efficient when transactions happen, also making privacy protections stronger, and making the entire system much better overall: And also, it is required to promote everyone participating in different sectors to work together to establish the same solution, so that everyone can easily exchange data and system compatibility. In summary, there is immense power when it comes to what blockchain tech could do and these obstacles need to be overcome in order for it to be used more and have the operational productivity higher as well as introducing many new benefits all through a wide variety of sectors.

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