Lightweight Proof of Game (LPoG)

Subjects: Others

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Interoperability is widely adopted in the case of cross-departmental or specialization cases. As the human body demands multiple specialized and cross-disciplined medical experiments, interoperability of business entities like different departments, different specializations, the involvement of legal and government monitoring issues etc. are not sufficient to reduce the active medical cases. A patient-centric system with high capability to collect, retrieve, store or exchange data is the demand for present and future times. Such data-centric health processes would bring automated patient medication, or patient self-driven trusted and high satisfaction capabilities. However, data-centric processes are having a huge set of challenges such as security, technology, governance, adoption, deployment, integration etc. This work has explored the feasibility to integrate resource-constrained devices-based wearable kidney systems in the Industry 4.0 network and facilitates data collection, liquidity, storage, retrieval and exchange systems. Thereafter, a Healthcare 4.0 processes-based wearable kidney system is proposed that is having the blockchain technology advantages. Further, game theory-based consensus algorithms are proposed for resource-constrained devices in the kidney system. The overall system design would bring an example for the transition from the specialization or departmental-centric approach to data and patient-centric approach that would bring more transparency, trust and healthy practices in the healthcare sector. Results show a variation of 0.10 million GH/s to 0.18 million GH/s hash rate for the proposed approach. The chances of a majority attack in the proposed scheme are statistically proved to be minimum. Further Average Packet Delivery Rate (ADPR) lies between 95% to 97%, approximately, without the presence of outliers. In the presence of outliers, network performance decreases below 80% APDR (to a minimum of 41.3%) and this indicates that there are outliers present in the network. Simulation results show that the Average Throughput (AT) value lies between 120 Kbps to 250 Kbps.

Keywords: game theory ; blockchain ; cryptocurrency ; lightweightness ; gash rate ; bit-exchange ; challenge-response ; attacks ; healthcare

1. Introduction

Blockchain is a peer-to-peer distributed data-ledger network constructed using consensus among nodes in a network as shown in Figure 1. Blockchain networks can be permission or permission-less. Blocks in blockchain network (BN) stores verified transaction records and are connected with relevance to its predecessor. The header of each block contains a cryptographic challenge and its solution. Nodes (miners) interested in adding a block to existing BN has to solve this challenge (usually in 10 min) before getting permission to add a block. This cryptographic challenge is generated using various means that are meaningful in consensus building [1][2] in different applications.There are various applications of blockchain in different domains. Some of these applications are as follows:

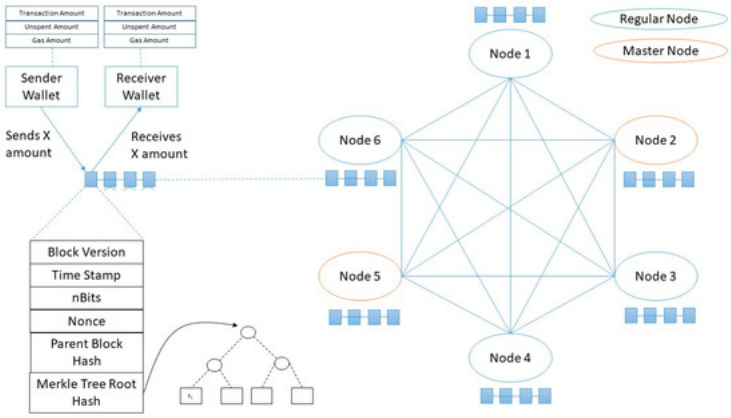

Figure 1. Blockchain and Its Network.

- Banking: Blockchain technology can replace both commercial and investment banking. Blockchain technology has solutions to every service of banking like international money transfer, letters of credit, forex, escrow, custody, initial public offering, mergers and acquisitions, restructuring, trading etc. In the banking system, people deposit their money and banks give them credits. Nowadays, banks charge a huge amount of their services. These charges can be minimized and services can be made faster with the help of a blockchain network. Further, a large part of the population is not associated with the banking system due to numerous reasons and blockchain can bring them into mainstream banking which would be a win-win situation for both investor and economy. Blockchain can control inflation

thus it is useful to countries having high inflation rates. Overall, it is very helpful in almost every national or international money-related transactions. Batavia [3] is an example of a blockchain-based trade finance platform to tackle inefficient processes in the business. It is developed using the IBM blockchain platform and consists of five banks (UBS, Bank of Montreal (BMO), CaixaBank, Commerzbank and Erste Group) and IBM. This platform aims to remove inefficient cross-border trading barriers. For example, all paper-based activities (bills, letters of credits etc.) are maintained electronically, money can be paid at different stages, tracking of goods exchange is much easier etc. Nordea has a blockchain-based platform as well to ease the trading finance for SMEs in Europe.

- Insurance: Blockchain is peer-to-peer based technology and it is helpful in insurance section by reducing the uncertainty in business, back-office costs and bureaucracy work is also reduced, faster execution of processes as compared to traditional ways, customer relationships and their satisfaction is improved with the usage of electronic smart contracts and their execution etc.

- Healthcare: This is an important sector where the necessity of blockchain is highly required. This sector demands accurate, immutable and easily accessible patient's historical and present medical records. In healthcare, industry 4.0 processes are required alongside blockchain technology. Industry 4.0 will be the communication backbone of the healthcare system, whereas, blockchain technology builds trust in the data-related system (collection, exchange, retrieval storage etc.). In healthcare, blockchaincan be used starting from patient records, drug supply system, staff's records, medical insurances, medical trials, equipment usage and supply system, medical board approval system, government monitoring system etc.

- Intellectual Property Rights (IPRs): It is an important area where the importance of blockchain technology is realized in recent times. Using blockchain, IPR's ownership, copyright protection, and smart IP rights management are managed efficiently. This is possible through distributed ledger technology in the blockchain. For example, IP rights are managed from the moment of their inception rather than the time of patent or publication. This protects the invention and false claims. IPRs using blockchainare helpful in various domains like software, music, films, research, business etc. For example, payments can be made instantaneously for the usage of anything (watching a mobile, listening to music etc.) and it is possible for even a microsecond. As blockchain is a P2P system using smart contracts thus it is efficient, secure, faster and economical.

- Food Supply Chain: There are many departments associated with the food supply business as well. For example production, processing, distribution, marketing, and consumption. In real scenarios, present supply chain management is not trustworthy because of various incidents like illegal practices, frauds, improper food storage systems, laborious and error-prone data records, for example.

Likewise, there are many other areas such as supply management system, transportation sector, smart city, industrial networks, etc., where blockchain technology can bring a great revolution through data transparency, immutability, security, availability etc. As the blockchain technology is widely accepted in several domains, the challenges in adopting this technology in a systematic, secure and trustworthy way are also very large. Various important challenges in blockchain network-based applications are briefly explained as follows:

Scalability: In blockchain networks, every node has to communicate transaction information to every other node in the network. With the increase in the number of nodes in a network, the number of transactions increases exponentially. In a blockchain network, every node does not have the same resources/configuration. This restricts the feasibility of extending the Blockchain network beyond a certain size.

Restricted Blockchain Users: One major application of blockchain is to bring those people in the banking domain who live in rural areas or do not have any banking solutions. However, the limited blockchain network's scalability restricts these users to become part of the blockchain-based banking system. As the world population is increasing day-by-day, requirements for a large scale blockchain-based applications are increasing proportionately. Otherwise, it would restrict the usage of applications to certain people only.

Resource limitations: Various concepts in the blockchain network consumes large resources. For example, an electricity-based PoW consensus algorithm permits nodes to add several blocks proportionate to electricity consumed or produced. In both cases, the chances of building a large blockchain network reduces. Other popular cryptocurrencies are based on a platform that uses a proof-of-stake (PoS) consensus algorithm. Although various attempts have been made in implementing PoW and PoS integrated consensus solutions, no pure PoS-based blockchain solution has been implemented yet in a real application.

2. Related work

In healthcare, various challenges include scalability and performance, usability, interoperability, and adoption. These challenges are briefly explained as follows:

A large amount of data is generated from medical records including electronic health records or electronic medical records [4][5][6][7]. Blockchain features makes the data to be stored at every node with hash values. This will increase the storage demands and requirements.

Patient data should be easy to access as and when required. Manual or partial automated data access does not solve the problem. A complete medical record with required statistics is mandatory for a doctor before treatment. Similar importance is required to all form of data exchanged in the healthcare domain whether it is for drugs, suppliers, producers, suppliers, government policies etc.

Interoperability is another major challenge. In the present scenario, healthcare organizations are targeting cross-discipline or specialization interoperability for patient treatment rather than patient-centric approaches. A patient-centric approach is more transparent, useful and secure.

Adoption is another major challenge in healthcare. Many sub-systems in healthcare are used for unethical and economic gains. This would bring down the importance of healthcare. Thus, there is a need to design more transparent and efficient mechanisms.

Performance is another major issue. In populated countries or pandemic situations, a large number of patient approach hospitals. Thus, an exponentially large amount of data is processed which lower down the overall system, processes.

After understanding the importance of blockchain-technology, healthcare systems, and Industry 4.0 processes, this work considers a wearable kidney-based system for data collection, sharing, processing, and analysis. Wearable kidneys have many electronic and sensor components and these components can be controlled remotely through advanced processes for medication and handling during emergency cases. Here, blockchain technology can be integrated to obtain records of kidney functionalities in the form of transactions. Here, the individual component is generating the block and they are integrated to construct the blockchain. The successful construction of blockchain ensures that kidney record is successfully recorded.The exchange of information to a remote location is ensured through Industry 4 processes. These processes allow data analysis, interpretation, secure exchange, and provide timely information to patients and doctors as well. Such records are helpful for analysis later and subsequent medications. While keeping all importances of blockchain into consideration, the objectives designed for this work are briefly explained as follows:

- To integrate Healthcare 4.0 processes with a patient-centric healthcare system. Healthcare 4.0 includes Industry 4.0 processes (Internet of Things (IoT), Industrial IoT (IIoT), cognitive computing, machine learning, AI, etc.) integrated with the healthcare system. Healthcare 4.0 processes are capable to handle a large amount of data efficiently. The major aim of this integrate is to design a large scale patient-centric healthcare system and test the performance.
- To consider a wearable kidney patient system and simulate it with Healthcare 4.0 processes. A wearable kidney consists of electronic, medical, fluid, and other systems. The integration of all of these components with an automated consensus algorithm ensures smooth functionality. Thus, a lightweight consensus algorithm is integrated. Further, Healthcare 4.0 processes ensure faster data accessibility and statistical results.
- To proposed lightweight and new challenges-based consensus algorithms and integrated with the wearable-kidney patient system and determines the performance. As a consensus algorithm is part of the blockchain network, a blockchain-based consensus algorithm with game theory is proposed for healthcare. The proposed algorithm is variable in bits-based challenge generation and verification. The performance of the blockchain network with a lightweight consensus algorithm is required to be determined as well.
- To consider different patients with kidney diseases and simulate it with a change in the amount of data required to treat them. Further, the performance of these cases is required to be determined for analyzing the proposed framework efficiency.

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