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An Innovative Blockchain-based System for Employees in the Healthcare Industry

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***Abstract*—The pandemic caused by the COVID-19 virus has unquestionably opened our eyes to the possibility that we may run out of essential supplies, such as medications and medical equipment, which would result in people's deaths and increased anxiety. Insufficient funds and raw materials aren't the only factors contributing to this situation; there's also another factor that's much more discouraging. Even in the midst of these challenging circumstances, some individuals have been able to see an opportunity in the scenario that allows them to maintain and store vital equipment such as personal protective equipment kits, masks, sanitizers, and the like, and then start black-selling such items. This very problematic circumstance has arisen as a direct result of deficiencies in the supply chain's control, transparency, and traceability. Blockchain technology presents itself as a potentially useful answer to this issue. The information may be tracked and traced using blockchain technology, which can also be used to store the data in a decentralised and immutable manner, ensuring that it remains private and is protected from unauthorised users. This article discusses the many use cases for healthcare personnel as well as the various constraints of the present blockchain architecture for supply chain. [Citation needed] The shortcomings of the current blockchain framework for supply chains are then addressed via the proposal of a new framework.**

***Index Terms*— blockchain, healthcare workers, supply chain, COVID-19.**

I. INTRODUCTION

It is certain that the pandemic brought on by the COVID-19 virus has opened our eyes to the danger that we may run out of necessary resources, such as pharmaceuticals and medical equipment, which would result in the deaths of people and heightened levels of worry. Not having enough money or raw materials isn't the only thing that's contributed to this predicament; there's also another issue at play here that's even more disheartening. Even in the midst of these difficult circumstances, some people have been able to see an opportunity in the situation that allows them to maintain and store vital equipment such as personal protective equipment kits, masks, sanitizers, and other items of the like, and then begin black-selling such items. This opportunity allows them to profit from the situation even though it presents a challenge. This very difficult condition has emerged as a direct consequence of flaws in the control, transparency, and traceability of the supply chain. These problems have been present for some time. The distributed ledger technology known as blockchain offers itself as a potentially helpful remedy to this problem. Using blockchain technology, the information can be monitored and traced. This technology may also be used to store the data in a decentralised and irreversible way, guaranteeing that it stays secret and is secured from people who are not authorised to access it. This article examines the many different

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applications that may be useful for medical staff, as well as the numerous limitations that the current design of blockchains for supply chains imposes. The present blockchain architecture for supply chains is evaluated, and a new framework that addresses the flaws of that framework is then proposed.
Because there are so many imitation objects and copies available for practically all of the goods, it may be a challenging undertaking to differentiate genuine items from those that have been counterfeited. How can we be sure that the bottle of medication that we are using has the correct ingredients? Similarly, how can we be sure that the food that we are eating comes from the farm that it is said to come from, or if it comes from a different farm and is contaminated with pesticides? Do you ever find it difficult to differentiate between the original product and its copies? The news of people dying as a consequence of phoney medications, counterfeit masks of low quality, and other such products is everywhere. During this pandemic, healthcare personnel and the population as a whole had a great deal of hardship in obtaining the appropriate and sufficient supply of supplies such as vaccinations, PPE kits, and other such items.

II. Literature Review

The authors of reference 1 discuss how the primary obstacle in the healthcare industry is the protection of patients' personal information and medical records. Fraud detection, supply chain management, and the prevention of medicine counterfeiting are just some of the tremendous applications in the healthcare industry. Putting patient information on a blockchain is a viable alternative now that patients can no longer rely on the safety and dependability of third parties. They have suggested a mobile app that would function as both a database and a gateway. The sensors on the patient's body collect the raw data and transmit it to the master file. The smart contracts are called into action from the master file. After that, the block is confirmed and added to the blockchain.For verification purposes in reference 2, the author makes use of a hybrid signature model architecture, which is much quicker than RSA. The Internet of Things, sometimes known as IoT, is an essential component of smart cities and other types of next-generation information technology systems. Key exchange was usually used for authentication, despite the fact that this method had its own set of problems and computational limits. As a result, the architecture that is built on the blockchain may assist in overcoming the problems. For the purpose of reaching an agreement on transactions, the Merkel tree model and the Raft consensus method are used. People have suggested using a distributed architecture, which would have many levels like the database layer, the physical layer, the communication layer, and the interface layer.The authors of reference 3 discuss public blockchain in the context of the Internet of Things, where it is said that public blockchain will be necessary for various applications of the IoT. A public blockchain provides more data integrity than a private one since copies of the ledger are stored on several nodes. It offers a public blockchain in terms that are comparable to those that MIT has recommended for some projects.We receive an approach to how a blockchain may be generalised and is not reliant on an existing platform in reference 4, which we will discuss more below. The smart contracts are built and can be used for certain use cases. This is why a blockchain-enabled system for tracking medications is good for the pharmaceutical supply chain.In comparison to the currently available solutions, they highlight the important advantages that may be gained by implementing block chain solutions for the medication supply chain.Introduce two blockchain designs suitable for drug tracking: the Hyper Ledger Fabric and the Beau private blockchains.Find, write down, and talk about the many future research problems that might make it hard to use blockchain technology in the drug supply chain.

A. Blockchain

A blockchain is a secure list or chain of data that has been timestamped and is controlled by a group of users that are members of a decentralised network. Blockchains are used in cryptocurrency transactions. Each node in the network has access to the whole blockchain despite the dispersed and decentralised nature of the block chain. Ensuring the confidentiality of the data stored in the blockchain relies on the use of cryptographic algorithms such as SHA256 to encrypt all of the vital information. The fundamental premise behind blockchain is that it should be possible to create a network of different users, or nodes, that are capable of conducting safe and direct transactions without the participation of a third party. Every node in the network has the ability to access the chain and obtain the information for which they have been granted permission. Because of this, the ledger is unchangeable and dispersed across several computers. It may be used to record financial transactions as well as any other kind of transaction.
•In the first step, two nodes want to engage in a transaction.
•In the second step, referred to as "mining," other nodes are required to verify the transaction using the predetermined method.

•In the third step, the validation of the nodes and other data is performed, and a decision is taken about whether or not the transaction may be added to the chain.
• The fourth step is for miners to validate the transactions, and if a transaction is confirmed to be valid, it is saved in a buffer memory.
The fifth step is the creation of a block, which takes place once a certain number of transactions have been received that are sufficient to construct a block.
•Step 6: An algorithm such as SHA256 or others will be used to generate a one-of-a-kind hash for each individual block. The blocks will also include additional information, such as the actual data summary, the hash of the block that came before it, and so on.
•Step 7: At this point, in order to add the block, the miners will check to determine whether the block is legitimate before adding it to the chain. A consensus procedure, like "proof of work," is used to figure out if the block in question is valid or not.
• Step 8: The leader miner will then add the verified block, and the transaction between the two nodes will be completed after this step is completed.The whole of this procedure constitutes the fundamentals of the blockchain technology, and the processes outlined above are carried out each time a block has to be added. There are many different methods available for reaching a consensus and generating a hash. The miners get compensation for their participation.

B. Examples of the use of blockchain technology in healthcare:

Example 1: Participating in Clinical Tests
What exactly is the issue? Several hypotheses are put to the test and verified by conducting clinical trials on a large number of patients. The data and the outcomes of these studies are then stored and examined to determine whether or not the hypothesis was validated. This data is highly significant and necessary, particularly for investigating the influence of specific drugs and vaccines, since the outcomes take a lot of time to show. Because of this, the outcomes take a lot of time to show the findings.
This kind of study often costs a lot of money, so having accurate data is quite necessary. Because of the vital importance of this data, it is often the target of fraudulent activity and manipulation, both of which go unreported and undiscovered. These have the potential to lead to the falsification of a theory that is, in all other respects, accurate.
How may the blockchain be of assistance? Because it can verify the presence of fresh documents, blockchain technology may be of use in this regard. After the data has been created, an authorised participant will add them, after which a hash will be generated for the data. Because these files are replicated on each node in the network, it is impossible to make any changes to them on any of the computers. As a result, they provide a technique for keeping data that is completely safe. In the event that we need to verify any data, we may feed it through an encryption technique such as SHA256 in order to create a hash. If the same hash is found on the blockchain, it indicates that the data has not been tampered with and that it is the authentic version.

Use Case 2: Patient Data Management
What exactly is the issue? When it comes to the administration of patient data, the challenges include the following: Since each patient is an individual, their bodies need individualised care that takes into account their medical history. It's possible that two distinct bodies won't respond the same way to the same therapy. The doctor has to know the patient's complete medical history in order to determine what therapies the patient has already had, if the patient has any allergies, and so on. Only then can the doctor recommend an appropriate therapy for the patient. Second, there are difficulties involved in the exchange of information. Information pertaining to a patient is private and must be handled, maintained, and distributed with extreme care. All of this data is dispersed and exchanged via a variety of methods that lack security. Also, the doctor needs all of the information to do a proper investigation and come up with the right treatment.
How may the blockchain be of assistance? Blockchain technology organises all of the data into a single chain and stores it there in a safe way. The patient can give the healthcare provider certain access to the data while still keeping the data's privacy and security. This way, the patient can share the data with the healthcare provider when it's needed.

C. Different Types of Blockchain

The Cosmos SDK is yet another well-known application-centered framework. Nevertheless, it is not used in the healthcare industry very often. The Cosmos network is decentralised, and it functions similarly to a distributed ledger network. It utilises the Tendermint consensus, which is based on the Byzantine Fault Tolerance consensus

TABLE I. TYPES OF BLOCKCHAIN, (SOURCE REFERENCE 37.)

	Bitcoin	Ethereal	Hyperledger Fabric
Privacy features	No private transactions	Private transactions,	Private channels, private transactions,
Security	Public, access permission not required, more prone to attacks	Public, but supports permissioned networks	Permissioned, granular access control, less prone to attacks
Consensus	Compute-intensive Plow	Compute-intensive Plow, Pops	Multiple approaches
Speed	Seven transactions per second	15 transactions per second	3000 transactions per second
Scalability	Low transaction throughput	Low transaction throughput	Higher transaction throughput
Transaction cost	High	High	Low
Incentive	Crypto currency required	Crypto currency required	No crypto currency required
Smart contracts	Not available	Solidity	Java, Node.js, Go, Higher-level abstraction (composer, JavaScript)

algorithm and functions according to its principles. Atoms were a kind of token that could be obtained after successfully completing a transaction. Blockchains like Ethereum and Hyperledger make up Cosmos, which is a network comprised of blockchains.

When compared to other blockchains currently available, Cosmos provides consumers with much quicker transaction speeds. Additionally, it enables transactions at lower costs. Scalability is another problem that the Cosmos SDK helps to tackle.

III. PROBLEM DEFINITION

Because of Covid 19, we are now aware of the many weaknesses in our system, one of which is the lack of transparency in our supply chain. Several members of our healthcare staff passed away while assisting patients in their struggle against the infection. There have been reports that there is an inadequate supply of obligatory items such as PPE kits, masks, and gloves, which are needed for healthcare professionals to replace every day. The news of black marketing of such products has been even more upsetting. These products must be changed every day. Because the government was unable to keep track of the mafia, citizens were left with little choice than to purchase the very expensive goods.

To add insult to injury, healthcare professionals were negatively impacted even more as a result of the fact that the reached were fake and did not adhere to the necessary criteria.

The use case that will be used to define the issue in this context is the one in which healthcare professionals are negatively impacted because the supply of medical items does not reach them on time and also because it is counterfeit. There is no method to monitor the supply chain, and due to the fact that the data storage is centralised, the system has a single point of failure, which means that anybody has the ability to alter or corrupt important information contained in the database. This information is very crucial, and any misunderstanding might result in unintended repercussions. Additionally, a lot of individuals are hesitant to adopt blockchain technology since a lot of them are not drawn to it either they are not informed about it or they are not driven.

We also need to develop a means to store the data offline rather than on the blockchain, so that the strain is not placed on the blockchain itself. Because it is a chain of continuous data, scalability is a challenge, and we need to make the blockchain scalable so that it can function properly.

Additionally, physicians should be encouraged to guarantee that adequate waste disposal of the goods that have been used is provided in order to minimise the spread of infections and other dangers. Existing systems suffer from a number of significant constraints, the most significant of which are a lack of scalability, traceability, and motivation; these issues must be investigated.

IV. PROPOSED FRAMEWORK

The suggested structure, which may be seen in Fig. 4, investigates the limitations that are now imposed by the blockchain on healthcare professionals and the supply chain for pharmaceuticals. It looks into the problems of scalability, the cost of storing data, getting rid of trash in the right way, and getting people to use the technology.

The proposed paradigm identifies several stakeholders as being active participants in the supply chain. • Suppliers—every single raw material source must be certified and a confirmed blockchain participant.The manufacturer sends a request for raw materials to the company's suppliers. Then, he or she makes the needed equipment and drugs and sends them to the distributors.• Distributor-Responsible for providing the required

materials to the appropriate healthcare personnel.• The product is used by hospitals, physicians, and other healthcare personnel, who request it from distributors or manufacturers.•It is the job of garbage managers to make sure that trash is thrown away in the right way, according to the rules set by the government.• A government official verifies the persons and investigates the participating nodes' histories, looking for things like criminal records and the like. If everything checks out, they provide a clearance certificate to the node.Offsite storage in the form of the Interplanetary File System is used by the proposed architecture (IPFS). The distributed network stores the hash for future use, while all of the data is simply dispersed and shared. Either the IPFS blocks themselves may be used to establish the blockchain, or the hash can be used to create the blockchain on any other blockchain that already exists. This takes some of the data load off of the blockchain, and it is kept in a decentralised way across the many nodes that make up the IPFS network.The stakeholders who utilise the blockchain technology are provided with several incentives in order to inspire and entice them to adopt the system. These incentives include: This is an essential stage since none of the other technological advancements will be of any help if people are unwilling to utilise the chain. In addition, the provision of such benefits and points encourages individuals to experiment with new activities. Stakeholders are given incentives in the form of loyalty points, and these loyalty points help improve a doctor's rating.It utilises a permissioned blockchain, in which any node that is ready to join has to be authorised by the management as well as all of the stakeholders. This ensures that only legitimate and reliable individuals are a part of the network.

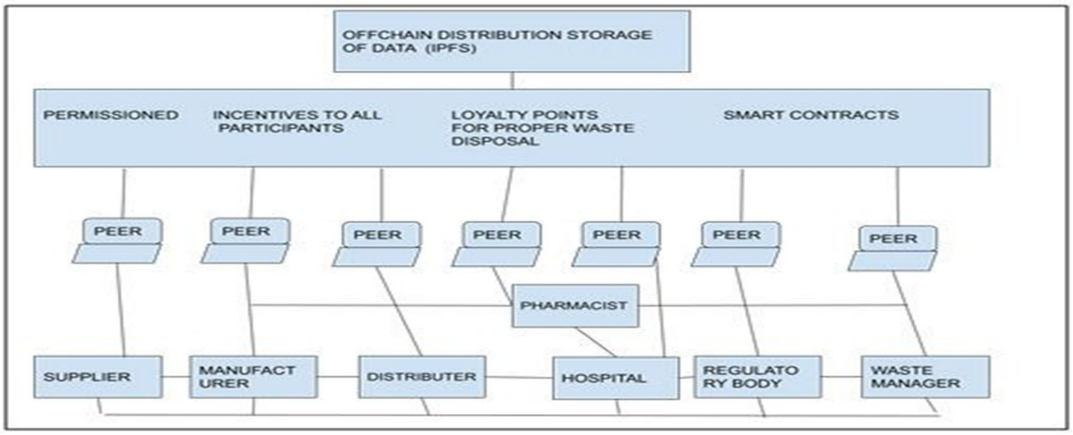

Figure 4: Proposed Architecture

The frameworks proposed suggest various stakeholders involved in the supply chain. They are: Suppliers-all the suppliers of raw material should be certified one and a verified blockchain participant.

- Manufacturer - It requests a demand of raw materials to the suppliers and produces the requested equipment, drugs to be supplied to the distributors.
- Distributor- Distributes the requested material to the healthcare workers.
- Hospitals, doctors and healthcare workers -They use the product and raise a request for the same to the manufacturers or the distributors.
- Waste managers- They are responsible for the proper disposal of the waste as per the guidelines issued by the government.
- Government official: they verify the individuals and check the background of the participating nodes for criminal records etc. and green a clearance certificate to the node.

The proposed framework uses offsite storage in the form of Interplanetary File System (IPFS). All the data is shared in the distributed network and the hash is saved for reference. Either the IPFS blocks can be used to create the blockchain itself or the hash can be used in any other blockchain existing. This helps to take the data burden away from the blockchain and is stored in a distributed fashion amongst the different nodes of the IPFS network.
Some incentives are given to the stakeholders who use the blockchain technology so that they are motivated and attracted to use the technology. This is a crucial step as if people are not willing to use the chain then the whole technology is a waste. And such perks and points help attract people to try something new. Incentives in the form of loyalty points are given to the stakeholders and these loyalty points help increase the rating of a doctor.
It uses a permissioned blockchain where every node willing to participate needs to be authenticated by the manager and all the stakeholders so that only genuine and trustworthy people are part of the network.

V. ANALYSIS

IPFS is used to store the data, which ensures that the data is stored offsite and thereby increases the scalability of the blockchain. Using the IPFS platform, a p2p network is successfully built, and an IPFS blockchain is produced by adding nodes and blocks to the network, as illustrated in Figure 5. Using the hash code, it is possible to successfully extract the data from the blocks. Consequently, storing data offsite using IPFS would assist in lowering the burden on the blockchain network and maintaining the dispersed nature of the data. This hash is what is utilised as the data that will be sent throughout the blockchain network that is seen in Figure 6.

Figure 5: Adding the Hash Value in Blockchain

Output 1: Scalability

ALGO 1 IPFS off chain storage algorithm:
We have used the COSMOS Blockchain for implementing the framework. COSMOS is an application oriented blockchain and used tendermint works with proof of stake consensus as shown in Fig. 9. It is a highly scalable and effective blockchain and much study for this has not been done for healthcare.

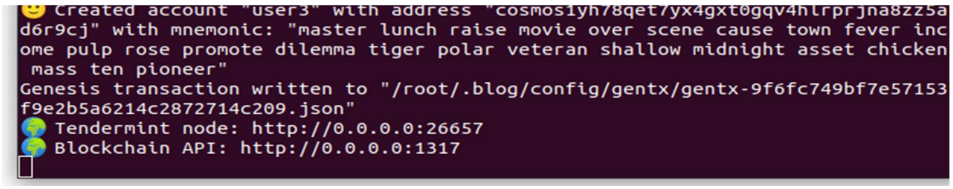

Figure 9: Cosmos Blockchain Started

Output 2

ALGO 2: Alg_motivation_ chart
With every some loyalty points are given which increases the motivation of the people.

TABLE IV: LOYALTY EARNED

Every 100 successful transaction	Doc	Supplier	Manufacturer
Between doc and waste manager	20	5	5
between supplier to doctor	-------	5	5

uccessful transaction tx between doc and waste_manager doc gets 20 loyalty points suppliers 5 manufacturer 5 between supplier and doctor supplier gets 5 manufacturer gets 5

Figure 10:Algorithm Showing Loyalty Points Being Granted

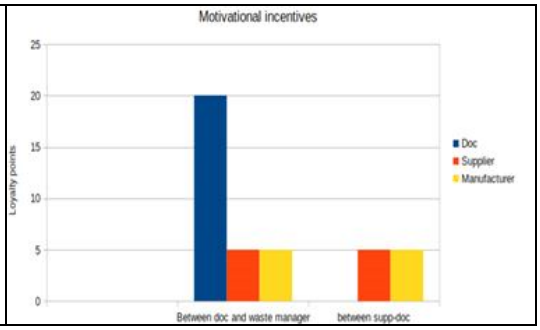

Figure 11:Chart Showing The Loyalty Earned

VI. Conclusion and Further Research

The research has shed light on the architectures of blockchains, as well as their applications and limitations. As was seen, the two primary categories are private and public. Security, scalability, and transparency are three key areas of differentiation. Because of the limitations of the private network, it may not be beneficial to use that network in certain circumstances; as an alternative, the data integrity benefits of the public network may be utilised. The block chain offers a significant advantage to workers in the healthcare industry. Because immutable data is one of its features, the chain cannot have any data that is not authentic added to it. This ensures that the record is always accurate and up-to-date. Since the technology is currently quite reliable and promising, the potential and applications of Blockchain are not dependent on the technology at this time. At this point, everything hinges on whether or not people are willing to embrace and make use of it. The blockchain is already taking the healthcare and IT industries to new heights, and it has the potential to take them even further. The current pandemic presents a number of different use cases that are suitable for the implementation of block chains, one of which is the supply chain. Traceability is required so that the genuineness of the product can be determined and so that the correct product can be delivered to the people, particularly our healthcare workers, who face this terrible situation on a daily basis. The framework that was proposed eliminates issues that were related to the supply chain, such as a lack of traceability and scalability, and provides a solution that is both cost-effective and appealing. This solution offers some kind of reward to healthcare workers, which will encourage more people to become interested in this technology. A smart contract has been developed and a consensus algorithm has been proposed, both of which can undergo additional development to produce outcomes that are even more desirable.

Together, the COSMOS Software Development Kit (SDK) and the IPFS file system have done a great job of reaching this goal and making sure that our healthcare workers have the right tools to do their jobs.

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