Enriching Drug Tracking Through Blockchain

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ABSTRACT

The human civilization progresses beyond contemporary conveniences, all aspects of life grow more sophisticated, and healthcare system is no exception. Individuals who are senior or incapacitated will benefit more from the breakthrough care delivery extrapolations. The pharmaceutical industries are the forerunners of this approach that perform tedious research into developing new and advanced drugs that are better and cheaper. These pharmaceutical companies work like any other companies where the scale of the economy and production is the driving factor towards the reduction of the costs of the medicines. This also has a side effect where a large number of medicines needs to be produced to keep the costs low that leads to an abundance of drugs that are not utilized by the time they are expired or not sold at the chemists. These drugs are often donated to the needy individuals at NGOs or other charitable organizations. But there isn't any effective framework to ascertain that these organizations indeed receive the drug donations. For this purpose, a system for accountable drug donation is proposed in this publication that utilizes the blockchain Framework to improve accountability. The experimentations have been crucial in the determination of the reliability of the presented methodology.

Keywords: *Pharmaceutical product tracking, Blockchain Framework, Drug Donation.*

1. Introduction:

There have been major advances in the medical fields in the recent times where a lot of research has been performed on these topics. This has been crucial as a number of different approaches have been utilized for the purpose of achieving an effective eradication of a number of diseases. This is in stark contrast to the days of the early humans as most of the diseases and the causes of these disease were unknown and a lot of lives were lost due to this occurrence. These early humans have been recorded to suffer and die due to some common illnesses that are easily curable nowadays. This is why the most useful and essential types of research has been performed for the maintenance of the health and the improvement of the healthcare infrastructure.

Amongst the most frequently utilized phrases is that "prevention is better than cure." It is also one of the more appropriate. Wellbeing is true riches since a healthy individual can perform to their full capacity and accomplish significantly more than someone who is unhealthy. This is a proven constant that has existed for millennia. To be competent to accomplish, work, or concentrate in a healthful, nutritious atmosphere, health must be valued in anyone's life.

As previously stated, healthcare is amongst the most essential aspects of life and must be prioritized in our lifestyles. But this is harder than it sounds, as many individuals do not even have opportunity to just go out and obtain treatments for a specific variety of symptoms since they work the whole day. However, are certain persons, such as the crippled or those who are physically constrained, who are unable to visit the hospital on a regular basis because it is uncomfortable. Some elderly persons are unable to go all the way to the medical facility.

There are also several older folks who would be suffering from a disease and are residing independently. This is a major issue since, in an emergency, there is very little time to intervene and give quick medical treatment, which is impossible. This is why many elderly people are confined to hospitals since their conditions might deteriorate at any time. They have an extremely bad experience of health as a result of this.

Drug monitoring is a critical component for ensuring the secure and consistent distribution of medication under appropriate settings. A standard medication's life cycle will begin with the producers who create thousands of sets of medications. These units are then vetted via a series of companies before being sold to clients by merchants. This distribution network goes through numerous management changes before pharmaceuticals are supplied to a consumer, and the procedure is documented to follow the medication from its beginning to its end. Nevertheless, the prescription medications might not have been taken for a myriad of purposes, including a modification in the doctor's recommended amount, a modification in the course of medication, or adverse reactions, among others, resulting in pharmaceuticals that the individual no longer requires. These medications should, preferably, be distributed to other individuals who would profit from these.

Unfortunately, this is a difficult procedure to handle since these pharmaceuticals must be inspected by competent organizations and confirmed to be safe for future use before even being distributed. Numerous patients who cannot purchase medications can be saved by dispersal of leftover, guaranteed medicines at a cheaper price or even for complimentary, particularly in states where such medications are pricey. Furthermore, because most unwanted drugs are generally discarded of in garbage containers or river systems, this technique can save hundreds

of thousands of dollars in medications that would otherwise go to throw away each year, along with having a good consequence on the environment.

A methodology for monitoring wasted pharmaceuticals and confirming their integrity usually necessitates the use of a centralized server to monitor each drug as it moves through multiple participants. Producers, wholesalers (dispensaries and clinics), and consumers are among the participants. Despite the fact that this centralized agency maintains record of the medicine's route, it has significant flaws. For example, centralized frameworks raise privacy and security problems since they are constantly vulnerable to intrusion and infiltration. A decentralized solution, such as employing blockchain innovation to monitor pharmaceutical distribution, minimizes the need for a central server. A blockchain is really a tamper-proof decentralized system that registers all operations. As a result, among the most efficient deployments for such a platform has always been the usage of blockchain.

This literature survey paper segregates the section 2 for the evaluation of the past work in the configuration of a literature survey, and finally, section 3 provides the conclusion and the future work.

2. Related Works:

Anupam Kumar [1] the pharma distribution system in India was expected to undergo a much-needed transformation from its own convoluted architecture to anything a little more accountable and productive. India's pharmaceuticals manufacturing costs are far cheaper than those in Western European countries, enabling it a worldwide participant in the medicine industry. Countless lives are also on the line, and block chain technology is the solution. A comprehensive and safe distribution network, in addition to the existing government initiatives and expenditures on medicine, is what can ensure the well-being of their friends and family. The administration intends to make significant progress in the area of accountability in the next decades at least. The openness of interactions, the accountability of medications by producing an examination, and the capacity to identify any efforts at data manipulation are all important benefits of the blockchain-based global supply chain.

Yue Li [2] discusses how medication accountability uses blockchain solutions in conjunction with other networks including the Internet of Things and artificial intelligence to ensure a stable, trustworthy, and predictable transportation network from manufacture to distribution. Each member administers the participating nodes through the use of blockchain technology, but each operation requires concurrence to guarantee that knowledge from the commencement of operations to all components of the supplier network is non-tamper able and identifiable. Stakeholders can use unique identifiers to upload the drug's distribution statistics into the blockchain at every step of the supply chain. Whenever an authorized node performs a "transaction" with some other location, the two nodes' integrity inspections must concur and sign electronically.

Randhir Kumar [3] the conceptual Approach is a safe blockchain-based architecture for healthcare availability and utilization amongst legitimate stakeholders. The architecture suggested can guarantee medication protection as well as manufacturing legitimacy. The present healthcare supply chain relies on third-party agreement, which is insecure in terms of medicine protection. The suggested approach is premised on public key infrastructure (PKI)

and digital signatures, and it can avoid replaying and man-in-the-middle attacks. Pharmaceutical companies will create drugs with data such as medicine identity, position, chronology, components, drug consumption, and adverse effects, all of which will be permitted by a statutory requirement shared ledger. For the information, the supplier creates an anonymized QR (quick response) barcode and adds the transactions to the public ledger. Whether any of the members wants to know more about the medications, they simply submit their public key with the producer. The supplier will secure the unique code and return it directly to the consumer, allowing them to scan it.

Mazin Debe [4] suggested method for tracking the route of pharmaceuticals from its source to purchase behavior. Existing research has focused on this distribution chain; nonetheless, the suggested scheme integrates all participants through a blockchain network that includes all types algorithmically. For this approach's utilization, a variety of blockchain networks can be used. The Ethereum platform, both personal and publicly, Hyperledger Fabric, and Multi-chain are among them. While certain aspects of the distribution chain can be removed from the internet, the vast majority of smart tender documentation must be made public. The public Ethereum blockchain was selected as the blockchain network for our application.

Herbert Melendez Garcia [5] the suggested medication inquiry solution can satisfy the same need to deliver trustworthy value to the customer with a lower proportion than the entire supply chain transparency since blockchain as a service provides us assurance regarding information management in an accessible and irreversible way. Similarly, for agreement to be successful, a decentralized business connection is needed. Moreover, because our framework is an experimental study executed alternative, the restrictions placed by information sources are appropriate. As a result, when it is accomplished on a wider scale and also with the required funding, the segment of performance benchmarks established in this venture must be taken into account. Finally, this approach might pave the way for future initiatives involving medication provenance or the development of the coverage intended at the Peruvian health sector through the usage of blockchain as a utility.

Erick Fernando [6] the implementation of blockchain technology utilizing microprocessors or mini products and consumer is the subject of this study. Ethereum is the blockchain - based platform that has been used. Ethereum is utilized in the architecture since it is a popular environment for building blockchain-based apps nowadays. The Microcontroller is the tiny PC instrument developed since it is a low-cost mini PC gadget that is extensively employed in the creation of integrated devices. Ubuntu 18.04 was utilized as the operating system. The findings show that the Raspberry Pi gadget may be employed in the establishment of distributed ledger technology as being one of the major nodes in a blockchain network that could be used in the biopharmaceutical industry. Further study will reveal how important blockchain technology would be for many firms and the corporate sector in the 21st century. One instance is the corporate sector, which could be used to assist all of its operations, such as drug manufacturers, shipping drugs (drug packaging histories), verifying drugs, and using this technology to classify drug facilities (publishing drug histories), read comments on drug panels, and enhance consumer commodities.

Bidi Ying [7] give the infrastructure for prescribed medication distribution blockchain system because the pharmaceutical distribution has various severe concerns, such as transparency, complication, and patient confidentiality. Dynamic identity is supplied to safeguard patient

confidentiality, and an inexpensive authenticating methodology is devised. Components are meant to offer transparency for interactions in the supply of drugs, and activities with signature are acknowledged. Following that, a vulnerability assessment reveals that the methodology is capable of meeting the security standards.

Shaoliang Peng [8] we offer a novel approach for monitoring vaccine manufacturing. To increase vaccine manufacturing safety, we employ blockchain technologies to optimize the conventional production technologies monitoring method. It guarantees the protection and dependability of production data by combining multiple technologies with fast data transfer. It achieves blockchain integrity by utilizing the principal supervisory node's filtering function. By using a hash and a constant amount of transactions, it preserves the anonymity of vaccine manufacture. Finally, to prevent redundant information and create a stable and appropriate preservation, we suggest a cropping technique. Of course, there are still significant issues with our technique in practice. This kind of manufacturing oversight necessitates the participation of multiple stakeholders, including FDA administration and vaccine manufacturing collaboration. This type of manufacturing surveillance increases the difficulty of production technologies monitoring and may lower pertinent agencies' objectives.

Nazmul Alam [9] Researchers provide a viable blockchain-based safe architecture for the healthcare distribution network amongst authorized parties in the conventional medication distribution network in this article. Our solution uses blockchain technology to precisely and independently recognize medications, allowing a counterfeit pharmaceutical or a fraudulent supplier to be recognized quickly and simply. The design reconfigures the entire conventional pharmaceutical distribution network platform architecture, ensuring both healthcare security and vendor credibility. It also shows the current position of each operation, which improves the reliability of the system. By eliminating outdated medical data from blockchain data storage, the chain becomes more reliable and consistent.

Yulia Kostyuchenko [10] Blockchain is still a new innovation that can assist with a variety of problems in medicine, particularly in the pharmaceutical sector. Implementing Blockchain technologies in the instance of counterfeit drug repurposing will minimize administrative burden while also establishing confidence, transparency, and information exchange consistency. Medicines may be validated and their validity assured using Blockchain, the data model will be safeguarded, and all stakeholders will be able to acquire and respect the information. In this article, researchers showcase some of the most prominent blockchain solutions for reducing fraudulent medicines and customer risk. Researchers also suggested possible research problems and prospects.

Anitha Premkumar [11] the report forecasts the fundamental necessity for a hand-in-hand electronic merger of Blockchain with IoT in the medical industry in the future. When it comes to supply chain operations, which are made up of a succession of interconnected although distinct occurrences, players frequently join groups to purchase information in order to acquire a better understanding of the items that would be used or ingested. Such innovations are established to accommodate to the community of stakeholders who are at the center of the difficulty with a shared resolution. This article addresses any need for Blockchain and IoT in the pharmaceutical business from a technological standpoint, as well as workable alternatives based on various usage scenarios.

3. Proposed System:

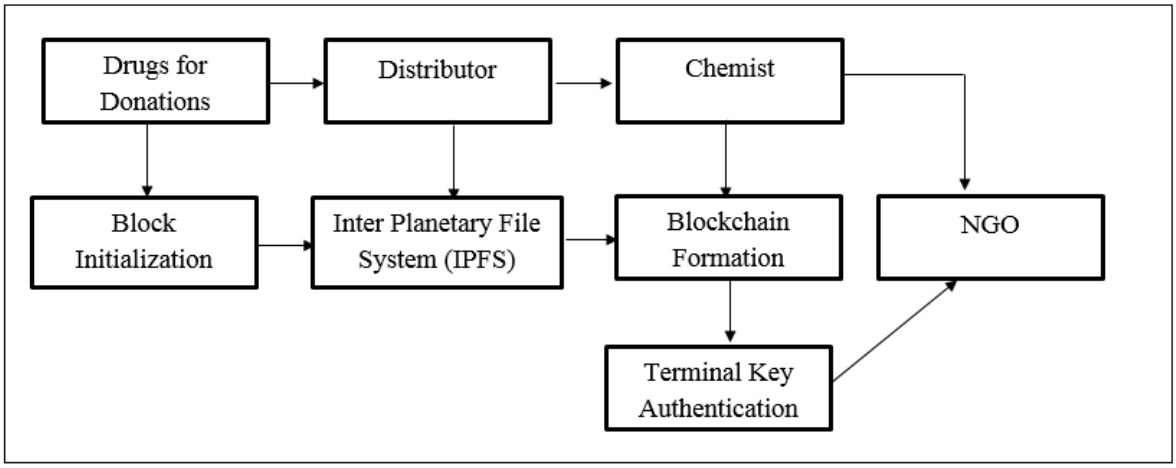

Figure 1: System Overview

The proposed approach for enabling effective tracking is represented in Figure 1 above, and the procedures taken to implement it are described below.

Step 1: *Drugs for Donation from the Manufacturer* – The system is initialized through the registration of the manufacturer which provides the relevant details along with the username and password which will be utilized further for gaining access into the application. Once the manufacturer has logged in, it also registers distributor by providing the relevant details and generating a username in password for them to use so that they can access the system.

An interactive user interface has been designed for the purpose of handling the drugs received by the manufacturer. Most of the time the drugs that are expired or returned to the chemist are diverted back to the manufacturer. Some of these drugs can be still used effectively. Therefore, for this purpose and interactive application has been designed using the swings framework in the JAVA programming language. The manufacturer tests and qualifies certain medicines from the ones received as return that can be reused and marks them for donation.

The manufacturer also creates a supporting document containing the various products and their descriptions and other drug related information. The donation medicines are there bundled and send to the distributor for the purpose of eventually getting to the NGO through the chain of events. As the product is being sent the document containing the various details of the medicine is provided as it input to the application which takes that information along with the current date and time. These details are sent to the MD5 hashing algorithm for the purpose of key generation. The MD5 hashing algorithm generates a hash key of 32 characters out of which 8 characters are selected at random. This key (considered as the manufacturer head key) and the documents are sent to the distributor which performs the next steps in this methodology.

Step 2: *Distributor Receiving the Donation* – The distributor receives the product as well as the documents and the date and time along with the hash key generated previously from the manufacturer. The hash key can be accessed by the distributor by logging into the system using the credentials provided by the manufacturer. The hash key received by the distributor it is

checked for its validity and integrity by generating a hash key again from the documents and the date and time provided by the manufacturer. This has key is correlated with the hash key received by the manufacturer to identify any indications of an avalanche effect.

If there is any disparity between the hash key received from the manufacturer and the hash key generated by the distributor then there has been some kind of tampering that has been performed on the data in transit. This way the integrity of the documents and the drugs being donated is maintained effectively. Once the integrity has been proven to be intact the distributor will now take the hash key of the manufacturer a long with the documents and the current date and time and provide it to the MD5 hashing algorithm for the purpose of hash key generation and blockchain formation. The resultant has key will be 32 characters long from which 8 characters at random will be selected and the hash key along with the documents and the date and time will be provided to the chemist as the distributor terminal key through the interactive user interface. The procedure of forming a blockchain is depicted in algorithm 1 below.

ALGORITHM: Blockchain Formation

//Input : Document and Data and Time D_{DT}
//Output: Terminal Key T_{KEY}
blockchainFormation(D_{DT})
1: Start
2: P_K =" " [Previous Key]
3: ***for*** i=0 to size of D_{DT}
4: $T_{PL}=B_{L[i]}$ [T_P = Database Tuple]
5: P_{KEY}= getBodyKey(T_{PL})
6: T_{KEY} =P_{KEY}
7: ***end for***
8: return T_{KEY}
9: **Stop**

Step 3: *Chemist Receiving the Donation* – The login ID and password for the chemist will be generated by the distributor and provided to respective authorized chemist to gain access to the system. Once the chemist gains its access to the system it receives the distributor terminal key, the document along with the current date and time utilized by the distributor to generate the hash key. Now the chemist has to validate the distributor terminal key utilizing the document along with the current date and time as input given by the distributor for the purpose of comparison. If there is any evidence of an Avalanche effect it indicates that the data has been tampered and unreliable.

On the other hand if the generated hash key matches the distributor terminal key sent by the distributor, the integrity has been maintained. Then the chemist itself will utilize the document along with the distributor terminal key and the current date and time to provide it to the MD5 hashing algorithm which results in a chemist hash key. The chemist Hash key along with the relevant documents, current date and time is then provided to the NGO.

Step 4: *NGO Receiving the Donation* – The login credentials for the NGO are generated by the chemist which provides them with respective username and password for getting authorized access into the system. The NGO now receives the end product along with the document, the chemist terminal key and the current date and time from the chemist. NGO itself also performs the integrity evaluation of the chemist terminal key received from the chemist with the hash that is generated by the information provided by the chemist.

If the hash key and the terminal key match then that means that the data and its integrity has been maintained throughout from the manufacturer right to the NGO which has received the drug donation. If the integrity evaluation fails and there is an indication of an avalanche effect this proves that some kind of tempering or some kind of modification has been done to the data this can be traced back to the chemist as all the earlier integrated checks have been successful. This way the integrity of the data is maintained effectively along with the reliability and the integrity of the medicine donated to the NGO.

4. Result and Discussions:

The prescribed approach for enabling Drug Tracking for donated drugs through the implementation of the Blockchain Framework which has been realized through the Java programming language and the NetBeans IDE has been used for the deployment. The implementation laptop is furnished with a Windows Operating System, assisted by 8 GB of RAM, and 1 TB internal memory. The MySQL database is tasked with the database management.

The proposed approach has been examined extensively for evaluation over a wide range of criteria. The results of this experimentation has been elaborated in the section given below.

Scalability Analysis of Blockchain Transactions:

The blockchain transactions have been evaluated for their ability to be scalable as well as maintain the integrity of the drugs being donated from the Manufacturer right up until the NGO. The verifiable Drug Donation scheme has been put under the hammer for realizing the accurate implementation of the Blockchain approach. The transactions performed by the Blockchain approach have been recorded in the table 1 given below.

Table 1: Blockchain Transaction Time Estimation Table

Sr.No.	No of Documents/ Blockchain Transactions	Time Taken (in seconds)
1	257	0.512
2	542	1.005
3	802	1.764
4	966	2.005
5	1301	2.219

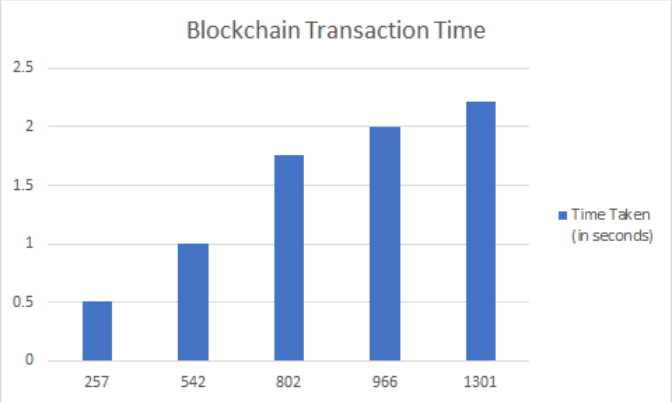

Figure 2: Blockchain Transactions

The graph shown in Figure 2 is created using the tabular results. The graphical representation has proven to be useful in demonstrating the relationship between the number of operations and the time it takes to execute them on the Blockchain infrastructure. The analysis' findings provide a deeper understanding of the approach and the application of the Blockchain technology to assure the drug donation's trustworthiness. The amount of data or Blockchain activities is clearly not proportional to the time it takes to execute the transaction. This demonstrates that the Blockchain concept was applied successfully. The findings helped to explain why the entire Drug Donation process was more secure.

5. Conclusion and Future scope:

This proposed approach implements the procedure of secure Drug Donation utilising the Java programming language in a well-organized and structured manner. Most of the time the drugs that are expired or returned to the chemist are diverted back to the manufacturer. Some of these drugs can be still used effectively. The manufacturer registers themselves and the distributor on the system and provides the supporting document containing the various products and their descriptions and other drug related information. These details are sent to the MD5 hashing algorithm for the purpose of key generation. The MD5 hashing algorithm generates a hash key of 32 characters out of which 8 characters are selected at random. This key (considered as the manufacturer head key) and the documents are sent to the distributor. The distributor logs into the system generates the chemist profile and verifies the key before bundling the hash key of the manufacturer a long with the documents and the current date and time and provide it to the MD5 hashing algorithm for the purpose of hash key generation and blockchain formation and sending it to the Chemist. The chemist logs into the system, verifies the key and the integrity of the blockchain after which another blockchain transaction is added through the key generation and sent to the NGO. The NGO will do a final integirty check on the blockchain upon receiving the documents verifying the reliability of the Drug Donation approach.

This research concept might be expanded in the future to execute in a real-time scenario and it can also be developed as a mobile application to achieve easier operation.

6. References:

*[1] A. Kumar, D. Choudhary, M. S. Raju, D. K. Chaudhary and R. K. Sagar, "Combating Counterfeit Drugs: A quantitative analysis on cracking down the fake drug industry by using Blockchain technology," 2019 9th International Conference on Cloud Computing, Data Science & Engineering (Confluence), **(2019)**, pp. 174-178, doi: 10.1109/CONFLUENCE.2019.8776891.*

*[2] Y. Li and Q. Ruan, "Petri Net Modeling and Analysis of the Drug Traceability System Based on Blockchain," 2021 IEEE International Conference on Consumer Electronics and Computer Engineering (ICCECE), **(2021)**, pp. 591-595, doi: 10.1109/ICCECE51280.2021.9342402.*

*[3] R. Kumar and R. Tripathi, "Traceability of counterfeit medicine supply chain through Blockchain," 2019 11th International Conference on Communication Systems & Networks (COMSNETS), **(2019)**, pp. 568-570, doi: 10.1109/COMSNETS.2019.8711418.*

*[4] M. Debe, K. Salah, R. Jayaraman and J. Arshad, "Blockchain-Based Verifiable Tracking of Resellable Returned Drugs," in IEEE Access, vol. 8, pp. 205848-205862, **(2020)**, doi: 10.1109/ACCESS.2020.3037363.*

*[5] H. M. Garcia, M. M. Cortez and E. D. Amaya, "Blockchain-based Website Solution for Controlling the Authorized Sale of Drugs in Peru," 2020 IEEE Engineering International Research Conference (EIRCON), **(2020)**, pp. 1-4, doi: 10.1109/EIRCON51178.2020.9253764.*

*[6] E. Fernando, Meyliana and Surjandy, "Blockchain Technology Implementation In Raspberry Pi For Private Network," 2019 International Conference on Sustainable Information Engineering and Technology (SIET), **(2019)**, pp. 154-158, doi: 10.1109/SIET48054.2019.8986053.*

*[7] B. Ying, W. Sun, N. R. Mohsen and A. Nayak, "A Secure Blockchain-based Prescription Drug Supply in Health-care Systems," 2019 International Conference on Smart Applications, Communications and Networking (SmartNets), **(2019)**, pp. 1-6, doi: 10.1109/SmartNets48225.2019.9069798.*

*[8] S. Peng et al., "An Efficient Double-Layer Blockchain Method for Vaccine Production Supervision," in IEEE Transactions on NanoBioscience, vol. 19, no. 3, pp. 579-587, July **(2020)**, doi: 10.1109/TNB.2020.2999637.*

*[9] N. Alam, M. R. Hasan Tanvir, S. A. Shanto, F. Israt, A. Rahman and S. Momotaj, "Blockchain Based Counterfeit Medicine Authentication System," 2021 IEEE 11th IEEE Symposium on Computer Applications & Industrial Electronics (ISCAIE), **(2021)**, pp. 214-217, doi: 10.1109/ISCAIE51753.2021.9431789.*

*[10] Y. Kostyuchenko and Q. Jiang, "Blockchain Applications to combat the global trade of falsified drugs," 2020 International Conference on Data Mining Workshops (ICDMW), **(2020)**, pp. 890-894, doi: 10.1109/ICDMW51313.2020.00127.*

*[11] A. Premkumar and C. Srimathi, "Application of Blockchain and IoT towards Pharmaceutical Industry," 2020 6th International Conference on Advanced Computing and Communication Systems (ICACCS), **(2020)**, pp. 729-733, doi: 10.1109/ICACCS48705.2020.9074264.*