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A REWARD MECHANISM FOR MEDICINE SUPPLY CHAIN THROUGH BLOCK CHAIN TECHNOLOGY

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***Abstract*— The main issues with drug safety in the counterfeit medicine supply chain, are to do with how the drugs are initially manufactured. The traceability of right and active pharmaceutical ingredients during actual manufacture is a difficult process, so detecting drugs that do not contain the intended active ingredients can ultimately lead to end consumer patient harm or even death. Block chain's advanced features make it capable of providing a basis for complete traceability of drugs, from manufacturer to end consumer, and the ability to identify counterfeit-drug. This paper aims to address the issue of drug safety using Block chain and encrypted QR(quick response) code security. Manufacturer generates an encrypted QR (quick response) code for the details and attaches the transaction to the block chain system. If any participants want details of drugs, then public key must be shared by that participant to the manufacturer. Manufacturer will encrypt the QR code and will send back to the participant. The QR code will be decrypted by the valid participant by their private key.**

***Keywords*: Blockchain, digital ledger, distributed ledger technology, supply chain management.**

I. INTRODUCTION

Pharmaceutical Research & Development is a complex process that takes several years from drug discovery to drug development and regulatory approval. When all the process is done and a standard product is developed, the next challenge for manufacturers is to deliver the product to the intended customer in its original form and to ensure that the customer get the genuine product that is developed by the legitimate manufacturer, not by counterfeiter. But the current Supply Chain Management (SCM) system of pharmaceutical industry is outdated, and doesn't provide visibility and control for manufacturers and regulatory authority over drugs distribution and it cannot withstand the 21st century cyber-security threats. This situation of SCM leads to the production, distribution, and consumption of counterfeit drugs. Counterfeit drugs have created a particularly dangerous public health risk and increasingly keen worldwide issue especially in developing countries.

These counterfeit drugs directly and indirectly adversely affect health. Indirectly, these drugs do not contain the dosage or active agent required to kill the disease, that finally cause drug-resistant strains, and then even using the original drugs are useless. More directly, such counterfeits may contain active ingredients, but the amount is too low or too high, or produced in an impure manner that contains toxic ingredients, in this case it can cause very serious health problems. Counterfeit drugs manufacturers sometimes use the brand logo of legitimate manufacturers and make fake products used in daily life, that's less harmful. But in many cases they affect the drugs for the treatment of cancer, painkillers, cardiovascular disorders, antibiotics, contraceptives and other prescription drugs that can lead to very serious results.

According to the International Anti-Counterfeiting Coalition (IACC), counterfeiting has become one of world's largest and fast growing criminal businesses, with an estimated value of more than US$ 600 billion annually. For the prevention of counterfeit drugs, pharmaceutical industry needs an efficient supply chain management system, and the best available solution to develop a perfect SCM system is the Block-chain technology. Block chain is a distribute ledger system (firstly introduced by a pseudonym Satoshi Nakamoto in 2008) that has shown widespread adaptability in recent years and a variety of market sectors sought ways of incorporating its abilities into their operations. Although, so far most of the focus has been on the financial services industry, but now projects in other service related areas, such as healthcare, energy and legal firms also started using this marvel. Supply chain security is one aspect that has recently won attention. Any product subject to a sensitive production process and widespread reputational issues are associated with the final product, the benefits of Block-chain are evident. Block-chain is the best fit in those scenarios where privacy protection and

data security is the highest priority. Therefore, pharmaceutical supply chain presents a further use case of Block-chain technology.

II. LITERATURE SURVEY

[1]. Jen-Hung Tseng, Yen-Chih Liao, Bin Chong and Shih-wei Liao, "Governance on the Drug Supply Chain via Gcoin Block chain", International Journal of Environment Research and Public Health, MDPI, 2018.

In this paper, we suggest Gcoin block chain as the base of the data flow of drugs to create transparent drug transaction data. Additionally, the regulation model of the drug supply chain could be altered from the inspection and examination only model to the surveillance net model, and every unit that is involved in the drug supply chain would be able to participate simultaneously to prevent counterfeit drugs and to protect public health, including patients. With Gcoin block chain, the governance model of the drug supply chain could shift from regulating (only by government audits) to surveillance net (by every participant who involves the supply chain).

[2]. Andrew O'Hagan, April Garlington, "Counterfeit drugs and the online pharmaceutical trade, a threat to public safety", Forensic Research & Criminology International Journal, Volume 6 Issue 3 – 2018.

In this paper, the author uses the internet which is facilitating the trade by providing counterfeiters with a large consumer base and limited risks. The dark net within it allows for anonymous transactions between manufacturer, distributer and consumer. While some online pharmacies are legitimate, there are a growing number of those that are unverified which sell dangerous counterfeit products. Both the packaging and medication are becoming increasingly sophisticated, making it difficult for consumers and law enforcement to identify them without chemical analysis. Counterfeit batches have also been detected in established legal trade routes whereby they are able to, if undetected, end up in high street pharmacies and hospitals. Multiple organizations have set up worldwide operations to dismantle the trade however this is a complex and evolving problem that without significant changes to legislation may never be fully.

[3]. Xiaoguang Liu, Ziqing Wang, ChunhuaJin, Fagen Li, And Gaoping Li, "A Blockchain-based Medical Data Sharing and Protection Scheme", IEEE Access (Volume: 7), 2019.

In the paper, the author proposes a medical data sharing and protection scheme based on the Hospital's private block chain to improve the electronic health system of the hospital. Firstly, the scheme can satisfy various security properties such as decentralization, openness, and tamper resistance. A reliable mechanism is created for the doctors to store medical data or access the historical data of patients while meeting privacy preservation. Furthermore, a symptoms-matching mechanism is given between patients. It allows patients who get the same symptoms to conduct mutual authentication and create a session key for their future communication about the illness. The proposed scheme is implemented by using PBC and Open SSL libraries. Finally, the security and performance evaluation of the proposed scheme is given.

[4]. YounessTribis, Abdelali El Bouchti, Houssine Bouayad, "Supply Chain Management based on Blockchain: A Systematic Mapping Study", MATEC Web of Conferences (2018).

In this paper, the author presents a systematic mapping study in order to map out all relevant research on SCM based on BCT. The paper took a survey on other block chain applications in SCM that need additional investigation, such as agricultural supply chain, security of additive manufacturing, product ownership management, common-pool resource management, purchasing and supply management, supply chain quality management, supply chain performance measurements. Nevertheless, many of the proposed frameworks-based
solutions lack real performance evaluation on the industrial context.

[5]. Jiafu Wan, Jiapeng Li, Muhammad Imran, Di Li, Fazal-e-Amin, "A Blockchain-Based Solution for Enhancing Security and Privacy in Smart Factory",IEEE Transactions on Industrial Informatics Volume: 15 , June 2019.

In this paper, the author proposes an innovative block chain-based IoT architecture to help build a more secure and reliable IoT system. By analysing the shortcomings of the existing IoT architecture and the advantages of the Block chain technology. we decompose and reorganize the original IoT architecture to form a new, multicentre, partially decentralized architecture. Thus, the proposed architecture represents a significant improvement of the original architecture, which provides a new direction for the IoT development.

ISSUES IN THE EXISTING SYSTEM

In recent years, Block chain as the base of the data flow of drugs to create transparent drug transaction data. Additionally, the regulation model of the drug supply chain could be altered from the inspection and examination only model to the surveillance net model, and every unit that is involved in the drug supply chain would be able to participate simultaneously to prevent counterfeit drugs and to protect public health, including patients. With Gcoin block chain, the governance model of the drug supply chain could shift from regulating (only by government audits) to surveillance net (by every participant who involves the supply chain). the internet which is facilitating the trade by providing counterfeiters with a large consumer base and limited risks. The dark net within it allows for anonymous transactions between manufacturer, distributer and consumer.

PROPOSED SYSTEM

The block chain is useful in keeping track of the entire manufacturing chain of the drug. Each new transactions added to a block is immutable and time stamped which means that the information cannot be tampered with. Companies can either have a public or a private block chain. On these block chains, the companies can have a distributed ledger shared

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among the parties involved in the manufacturing and distribution of the drug. Moreover, access is only limited depending on information sharing contract between the two parties. Through block chain, we are able to get the complete trail of the drug. Each time the drug moves from an entity to another, the information is stored on the block chain which makes it easy to track the drug and wipe off counterfeits from the shelves. As a result, the block chain technology will help with two main issues: first, it will allow companies to track their products down the supply chain, creating an airtight circuit, impermeable to counterfeit products. Second, it will also allow stakeholders, and especially labs, to take action some posteriori in case of a problem by identifying the exact location of their drugs.

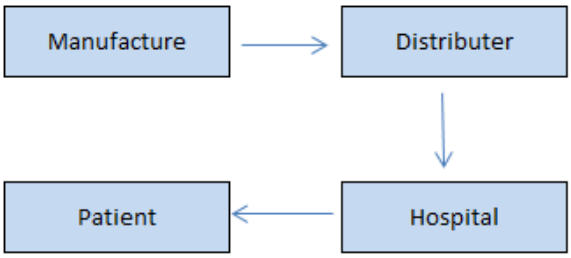

Figure 1: Data flow diagram

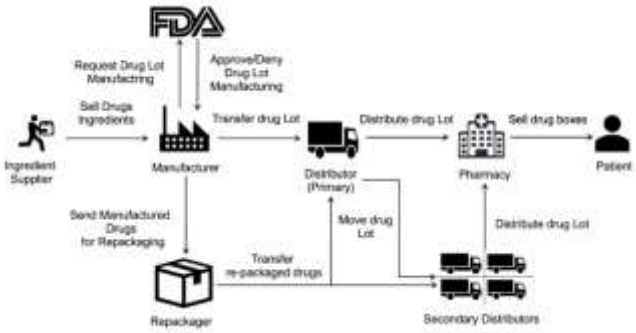

Figure 2 : Drug supply chain stakeholders and their relationships

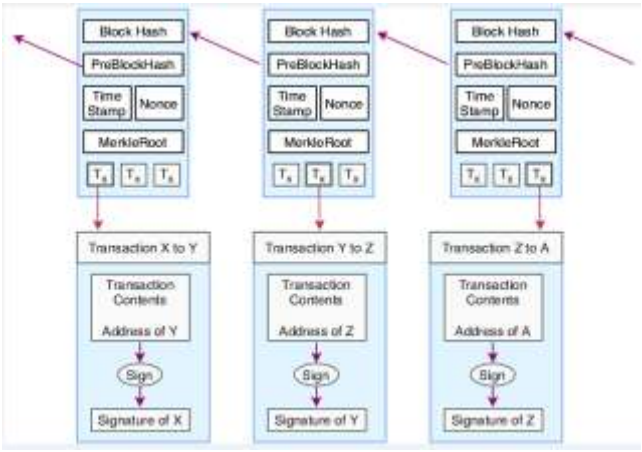

Figure 3 : Structure of a block in PoW based blockchain

The primary reason for counterfeit drugs to reach end-user marketplace is due to the complex structure of a ealthcare supply chain. Leveraging the complexity of this distribution process, medications can easily pass through with little or no trail of information and verifiable documentation . Consequently, monitoring, effective control and tracking of products in healthcare supply chain is fundamental to combating counterfeits. The importance of drug traceability (track and trace) is increasingly emphasized and mandated by several countries across the world. For example, the U.S. Drug Supply Chain Security Act (DSCSA) has made it mandatory for the pharmaceutical industry to develop an electronic and interoperable system that identifies and tracks prescription drugs as they are distributed across the United States . Similarly, over the last 8 years, China required all the stakeholders involved in the drugs supply chain to record information of individual pharmaceutical products in a specialized IT system whenever drugs are sent to/from their warehouses . Therefore, drug traceability has become an integral part of the pharmaceutical supply chain as it establishes authenticity, and aims to track and trace chain of custody of the product across drug supply chain. Blockchain technology has introduced a new model of application development primarily based on the successful implementation of the data structure within the Bitcoin application. The fundamental concept of the blockchain data structure is similar to a linked list i.e. it is shared among all the nodes of the network where each node keeps its local copy of all the blocks (associated with the longest chain) starting from its genesis block . recently, many real-world applications have been developed in diverse domains, such as the Internet of Things , e-Government and e-document management . These applications leverage benefits of blockchain technology due to its self-cryptographic validation structure among transactions (through hashes), and public availability of distributed ledger of transaction-records in a peer-to-peer network. Creating a chain of blocks connected by cryptographic constructs (hashes) makes it very difficult to tamper the records, as it

would cost the rework from the genesis to the latest transaction in blocks as illustrated by . Within the context of blockchain-based traceability for pharmaceutical supply chain, presents one of the initial efforts. Although our solution has similarities with this effort due to the focus on pharmaceutical supply chain as well as the use of blockchains, we take a holistic view of the harmaceutical supply chain, presenting an end-to-end solution for drug traceability whereas only focused on a subset of these challenges. Firstly, our approach identifies and engages major stakeholders in the drug supply chain i.e. the FDA, supplier, manufacturer, distributor, pharmacy, and patient, whereas is limited to the supplier, manufacturer, and wholesaler as the stakeholders. Consequently, the pharmacists are represented as an external entity which is not the case in a real drug supply chain. Secondly, we make explicit efforts to identify and define relationships among stakeholders, on-chain resources, smart contracts, and decentralized storage systems which is lacking in . Furthermore, in view of the significance of interactions among stakeholders, we have included precise definitions to remove any ambiguity, whereas such interactions have not been defined as part of Thirdly, we use the smart contracts technology to achieve real-time, seamless traceability with push notifications so as to minimize human intervention and therefore undesired delays. Specifically, each drug Lot is assigned a unique smart contract that generates an event whenever a change in ownership occurs and a list of events is delivered to the DApp user. However, the smart contracts in are programmed for specific roles such as supplier, manufacturer, and wholesaler which requires each participant to manually confirm which drugs are received. Such approach can introduce delays and inaccuracies in the immutable data stored on the ledger. Finally, we have conducted a cost and security analysis to evaluate the performance of the proposed solution including discussion on how the proposed solution can be generalized to other supply chains.

III. RESULT

The proposed Supply Chain Management (SCM) system architecture is built around a new set of smart contracts for transaction manipulation and validation. We get several sets of smart contracts by following the blockchain-based Supply Chain Management (SCM) system. (1) Registration all participants, including the Task Initiator Registry, sign a registration agreement. In a secure communication channel, all parties confirm their identities by sending the miner their address and role. Participants will be accepted without a formal signature after the miners' agreement is completed. The technical intricacies of the blockchain encryption algorithm are not covered in this article. Blockchains are distributed networks that can have millions of users all over the world. Every user can add information to the blockchain and all data in the blockchain is secured through cryptography. (2) Every other member of the network is responsible for verifying that the data being added to the blockchain is real. This is done using a system of three keys (private, public, and the receiver's key) that allow members to check the veracity of the data while also confirming who it comes from. Blockchains are distributed networks that can have millions of users all over the world. Every user can add information to the blockchain and all data in the blockchain is secured through cryptography. Every other member of the network is responsible for verifying that the data being added to the blockchain is real. (3) This is done using a system of three keys (private, public, and the receiver's key) that allow members to check the veracity of the data while also confirming who it comes from. A verified piece of data forms a block which then has to be added to the chain. To do this, blockchain users have to use their respective keys and powerful computing systems to run algorithms that solve very complex mathematical problems. (4) When a problem is solved, the block is added to the chain and the data it contains exists on the network forever, meaning that it cannot be altered or removed. In order to make updates to a particular piece of data, the owner of that data must add a new block on top of the previous block, creating a very specific chain of code. If anything, even something as small as a comma, gets altered from how it appears in a previous block, the entire chain across the network also changes accordingly. (5) This means that every single alteration or change to any piece of data is tracked and absolutely no data is lost or deleted because users can always look at previous versions of a block to identify what is different in the latest version. Using this thorough form of record-keeping makes it easy for the system to detect blocks that have incorrect or false data, preventing loss, damage, and corruption. his article describes how we started with internal PoC and ended up with a real prototype for one of our clients from the finance industry. You'll see how we advanced our approach and how the technology stack evolved. Nevertheless, future work must address several blockchain related technical issues such as throughput, security, scalability, and interoperability. Similar efforts are limited and related quantitative study regarding these topics is still rare. More research work needs to address the diffusion of blockchain technology,

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