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A Secured Supply Chain Management System for Pharmaceutical Companies using Blockchain

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ABSTRACT

Digitalization is spreading all over the world in a vast way. This work presents us with a different prospective and view upon the use of the most recent technology of the market that is blockchain. An effective supply chain management is the biggest challenge in every industry. In healthcare, there is additional risk and complexity as a compromised supply chain in healthcare can affect the patient's safety. Increased adoption of technology, globalization and industry populated with multiple stakeholders in various jurisdictions has given rise to a complicated health supply chain. The pharmaceutical supply chain is one of the most prominent verticals when it comes to the damaged areas of health supply chain. A lot of patients endure due the utilization of terminated and falsified meds and gadgets. Patients are unconscious of systems to see whether the medication is consumable or not. For solid and legitimate data to shoppers from the pharmaceutical organizations, Blockchain gives adaptable however made sure about information passage and extraction. Information Stored is homogeneous and predictable all through the framework at any of the companions. Implementation of Blockchain in pharmaceutical supply chain, not only reduce counterfeiting and theft issues but also help manage inventory.

Key words: Blockchain, Proof-of-Work, Consensus, QR code, Smart Contract.

1. INTRODUCTION

Blockchain is technology which gives an advanced record framework to log and record exchanges by gathering them into sequentially requested blocks. These blocks are connected and made sure about on a shared system utilizing cryptographic technologies. As the innovation is equitably appropriated over a system of different PCs, it has no particular window for entry in the centralized system, giving included security from cyber threats. At present the Supply Chain must permit numerous stakeholders to change and share information, it must check that such data can be trusted and it might need to communicate with national and global confirmation authorities, transport frameworks and administrative bodies. Blockchain is helpful in furnishing a dependable framework with least chance of disappointment and written falsification. Our framework can likewise give the usefulness of keeping up the stock for the pharmaceutical organization.

A significant amount of deaths are caused due to medical negligence, counterfeiting of medication, use of expired products. Our system can provide trusted knowledge about these medicines to the user. Consumer can reference the batch Id to get the information and check if the medicine is consumable or not. This can help in saving lives as well as creating awareness among people, so that they're not fooled and harmed in any ways.

The principle motivation behind our push to build up a Supply Chain Management utilizing BC is to lessen the count of the deaths and medical issues caused due to duplicating and utilization of lapsed meds by blameless clients. The reason for the framework is to make mindfulness among individuals and illuminate them about the item they're consuming. Motivation behind Supply Chain Management using BC is improvement of the quality of user's life by reducing fraudulent products in the market with the proper and ethical use of technology that is present today at our disposal.

Motivation behind Supply Chain Management utilizing BlockChain is likewise to offer some incentive to the pharmaceutical organizations which are utilizing the framework. Pharmaceutical organizations can utilize the Supply Chain Management utilizing BlockChain framework to keep stock of their items. The intention is to give homogeneous information section administrations to all the friends in the production network.

2. RELATED WORK

Identify practical applications in mathematics that have actual or possible significance to the pharmaceutical industry [1]. The article is divided into the three main stages of a creative drug

product's lifecycle: product creation, power preparation and supply chain management. Kwon et al conducted a review of the different aspects of the pharmaceutical supply chain management [2]. It brings into account key ways in which the supply chain needs to achieve cost-efficiency, such as customer partnership management, manufacturing operating resources, and process development. Another review was conducted involving research on management issues in the pharmaceutical industry and this study uses a classification in terms of geographical zones, research methodologies, and managerial questions. Save for recognizing new problems for health care professionals, the research is not committed to discovering specific models of the pharmaceutical supply chains. [3]A further research highlights main threats to the global health supply chain. The challenges are found to be lack of coordination, inventory management, lack of demand information, dependency on human resources, 9 order management, avoidance of shortages, expiry, warehouse management, temperature control and visibility of shipments. It can be noted, as a tentative inference, which this analysis leads to the detection of at least four of the above listed challenges. [5] The point of view is provided by Alverson in which the key problems encountered by pharmacies are categorized into a lack of quality management, surplus quality rates, regular stock outages and costly emergency delivery, additional labour demands for the health system, process interruptions and unnecessary overtime and missing contract enforcement. Shah builds upon the literature to identify the most important problems in the architecture and function of the supply chain. Some features addressed in the current article are mentioned, but the article also presents several viewpoints arising from the author's experience in this research field. It is important to note that Shah presents a similar review of this work; however, the current study focuses on research on quantitative models within the pharmaceutical chain's various echelons. [6] Volland et al present a new study of the distribution of supplies in hospitals. In this study the hospitals' administrative operations are analyzed and many gaps are established for future studies. Although this is not a analysis of comprehensive pharmaceutical supply chain models, some of the aspects of this research are close to the existing work, as it analyses inventory models. In addition, there are several studies that have established various methods to typify and describe [7] logistics issues in hospitals and pharmaceutical supply chains as inventory management in clinics, supply chain architecture and pharmacy processes or obstacles in the global health supply chain. In addition, a new taxonomy is introduced in this review phase which helps readers to easily classify a paper based on the pharmaceutical supply chain actors [8].

3. PROPOSED WORK

In our proposed strategy we are going to apply Blockchain in pharmaceutical inventory network. We've got three individual modules, fixing modules, stockpiling subtleties of the item, and utilization subtleties (expiry date and assembling dates). We apply agreement calculation to supply hinders for above subtleties which makes our information increasingly dependable and secure.

A Consensus calculation may be a technique through which all the companions of the Blockchain organize agree about the present situation with the dispersed record. Along these lines, agreement calculations accomplish dependability within the Blockchain arrange and founded trust between obscure friends in an exceedingly conveyed figuring condition.

In this framework we do hashing to create blockchain of medication subtleties. Hashing implies taking an input string of any length and giving out a yield of a fixed length. With regards to our system, the exchanges are taken as entries and undergo a hashing calculation (using SHA-256) which provides a yield of a fixed length. This hashing algorithm likewise gives security to the blockchain.

The system also provides reports for every individual module of the system in which the sensitive data is encrypted. Any change in the data about the medicine will result in the change of hash ID which can be pinpointed to the source of alteration. The system has an Admin who has control to every functionalities of the system, while other stakeholders have different and limited access to the system.

4. SUPPLY CHAIN FRAMEWORK

This section overviews the architecture of the proposed Supply-Chain framework for pharmaceutical inventory network. Supply-chain framework consists of three entities: input module, blockchain module, Application module which is described in the following:

A. Input Module

The system is basically divided into three input dataset: Manufacturer details, Storage details and Medicine details. This module plays an important role in supply-chain management for pharmaceutical company. The data stored in these categories are necessary for the functioning, security and integrity of the pharmaceutical company. This type of information need to be keep safe, thus blockchain technology is applied to create a secure supply chain management.

1. Manufacturer Details: This detail created to store information about the different manufacturers of the medicines. It includes professional, business as well as personal

information about the manufacturer or their representative. A manufacturer detail helps us track which medicine is developed by which manufacturer. The manufacturer is allowed to make changes in storage module and medicine as they can add, edit or delete their own storage unit and medicine. Manufacturers are not allowed to access details of other manufacturer. They also have no authority on the users who can access the system and different roles the system has to offer. Manufacturers are allowed to add medicine to the blockchain, which secures the medicine data.

2. Storage Details: This detail created to store information about the different manufacturer where the medicines are stored. It includes information about the person in-charge of the storage unit. Storage details help us track which medicine which is stored in a storage unit. The storage unit can be added, edited and deleted by manufacturers only. This module has no data entry permission in the system except the storage unit. This module is important in transportation and delivery part of the Supply Chain. A storage unit often acts as the bridge between the other two modules. Storage unit helps in keeping inventory of the medicines, so that the Supply Chain runs smoothly.
3. Medicine Details: In this the details of medicine is stored mentioned in Fig. 3. [9]These medicine details are created or changed by the authorised personnel of the manufacturer. These details are helpful for keeping integrity of the medicine and keep the user informed. The medicine details which are provided as: Medicine Usage: In this Correct usage of the medicine are mentioned in this section and proper direction for using medicine is given, So that the user get proper guidance. Temperature detail: Many medical products don't have any details about the temperature in which it should be kept. Due to this medicine gets spoil and medicine gets less effective or may be the details in label are counterfeited. in this section temperature of the medicine is mentioned, in what temperature the medicine should be kept. This data provided to the user using device data as QR code, so that they can keep it in right temperature. Expiry Date: Expiry date is an important detail about the medicine. There are lots of medicine which gets expired and vendors might counterfeit the details and sell that. So to overcome this problem the correct expiry date is mention in this section so that it can made accessible to the user, they can stay safe. Substances detail: Information about substances present in the medicine are provided for the proper knowledge and transparency to the user. Price details: Pricing of the medicine in their label can be changed by the vendor or by the person who sells it. So, correct price of the medicine is given, user can scan and get the correct price details from here. Humidity details: This is same as the temperature details, in this the humidity details are provided to the user that the medicine doesn't give any side effects.

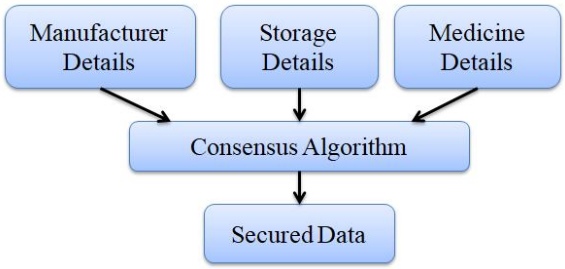

Figure 1: System Overview

B. BlockChain Module

1. Blockchain: It is an entity, digitally distributed ledger containing all the information about medicine in the kit. The data structure of block used by the supply-chain framework is presented in Figure 3. The structure of each block contains eight fields.
    a) Block index field is a unique number for each block
    b) Hash field is the hash value of the block information
    c) Previous block field is the hash value of the previous block
    d) Medicine field contain the details of the medicine like, manufactured date, temperature, humidity, storage unit and QR code
    e) Expire date field is the data to be secured.
    f) Timestamp field is the date and time of the creation of block
    g) Merkle root field is the structure of all hashed pairs in the tree
    h) Nonce field is the number that blockchain miners are solving for.

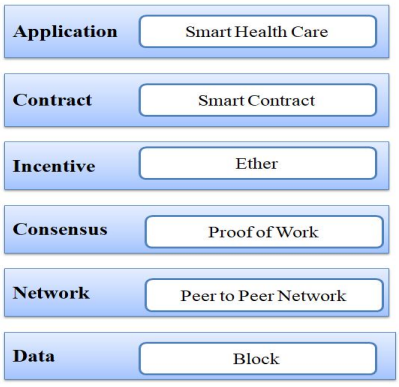

Figure 2: Overview of Blockchain

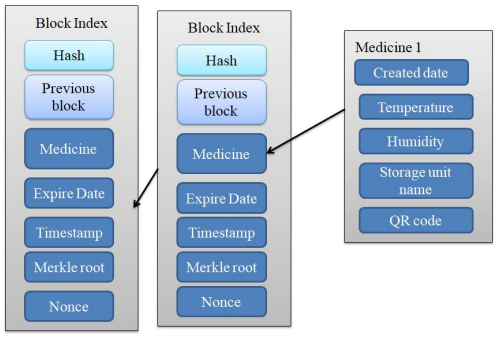

Figure 3: Structure of Block

2. Hashing

Hashing implies taking an info string of any length and giving out a yield of a set length. With regards to cryptographic varieties of money like Bitcoin, the exchanges are taken as info and undergo a hashing calculation (Bitcoin utilizes SHA-256) which supplies a yield of a set length.
In this module SHA-256 [10] (Secure Hashing Algorithm 256) is utilized for hashing in Fig. 3, the input block into a set length. As should be obvious, on account of SHA-256, irrespective of how large or little your information is, the yield will consistently have a hard and fast 256-bits length. This becomes basic after you are managing an infinite measure of data and exchanges. So essentially, instead of recalling the knowledge which may well be enormous, you'll simply recollect the hash and follow along. Before we go any more we've to initially observe the various properties of hashing capacities and the way they get executed within the blockchain. The Secure
Hash Algorithm (SHA) is a very popular cryptographic hash function used to generate unique signature for a plain text.

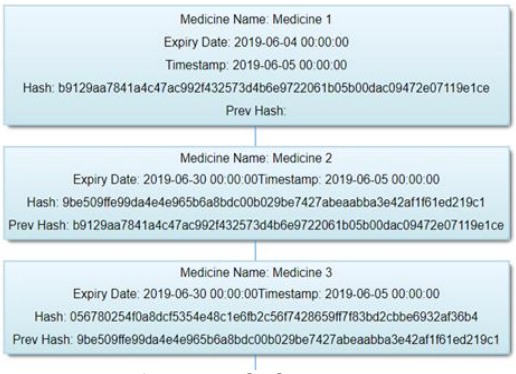

Figure 4: Block Creation

In Figure 4, Shows creation of block which holds hash value of each previous block, current hash value, medicine name, expire date and timestamp. To generate a hash value here SHA-256 hashing algorithm is used. Here Message digest size used her is 256 bits, block size is 512 bits, number of round for encryption is 64 and input size is less than 2^{64} bits.

3. Consensus

A consensus algorithm is a technique through which all the friends of the Blockchain arrange agree about the current situation with the disseminated record. Along these lines, agreement calculations accomplish dependability in the Blockchain organize and build up trust between obscure friends in a dispersed processing condition. Basically, the accord convention ensures that each new square that is added to the Blockchain is the unrivaled rendition of reality that is settled upon by all the hubs in the Blockchain.
The motivation behind an accord instrument is to get all the hubs understanding, that is, trust each other, in a situation where the hubs don't confide one another.
In our proposed system, we have implemented Proof-of-work algorithm to create new blocks on the blockchain. Proof-of-work is generally used to confirm med details and produce blocks to the chain. The main motive of PoW is to find out whether there is any change in medical detail, which solves a problem. This detail found should be such that it is difficult to change but easy to verify computationally, by anyone on the network.
Proof-of-Work framework: The 'hard numerical issue' can be written in a theoretical route like beneath: Given information A, locate a number x, for example, that the hash of x added to an outcomes is a number not as much as B.
The excavators wrap up a gathering of exchanges into a square and attempt to mine. To mine it, a hard numerical issue must be illuminated. This issue is known as the evidence of work issue which must be unraveled to show that the digger has accomplished some work in discovering the answer for the issue and henceforth the mined square should be legitimate. The response to the issue should be a lower number than the hash of the square for it to be acknowledged, known as the 'target hash'.A target hash is a number that the header of a hashed square should be equivalent to or not exactly for another square, alongside the prize, to be granted to an excavator. The lower an objective is, the more troublesome it is to produce a square.
An excavator keeps testing distinctive novel qualities (known as nonce(s)) until an appropriate one is created. The digger who figures out how to take care of the issue gets the bitcoin prize and includes the square into the blockchain by communicating that the square has been mined.

C. Application Module

System Analysis: One of the essential decisions we face for our Supply Chain the board venture executions is "Which advancement system should we use?" There are different programming improvement philosophies are accessible in the ICT business. [11] They are Dynamic Systems

Development Model (DSDM), Lean Development (LD), Agile Software Development, Joint Application Development (JAD), Feature Driven Development (FDD), Extreme Programming (XP), Crystal Methods, Rational Unified Process (RUP), Rapid Application Development (RAD), Spiral, Scrum, Waterfall (a.k.a. Customary) and Systems Development Life Cycle (SDLC). Among every one of these approaches, we have chosen to look at the two generally well known and broadly utilized systems: Waterfall Model and RAD Model

Web Development: Web development is that the umbrella term for conceptualizing, making, operating and deploying web applications and application programming interfaces for the Web. Python language used to develop web application. Framework used here is Flask Microframework for our application. Carafe is a lightweight mainstream Python WSGI web application system. It is expected to make starting quick and basic, with the ability to scale up to complex applications. It began as a fundamental wrapper around Werkzeug and Jinja and has ended up being one of the most notable Python web application

Google Chrome browser could be a free and one among the famous internet browser made by Google that utilizes the WebKit design motor. The main purpose of choosing Google Chrome as browser is it extremely quick internet browser; it loads and shows pages rapidly, Tab autonomy, Support for most recent EcmaScript, Modern Layout, Cross Platform Browser

In application part, block creation detail Figure 4, block generated detail and device date details are set. In Figure 5, the device data shows the block created date, temperature, humidity, storage unit and QR code of each block which are stored in block.

Created Date	Temparature	Humidity	Storage Unit Name	QR Code
2020-03-09 00:00:00	43.0	31.0	Storage Unit 2	
2020-03-05 00:00:00	43.0	31.0	Storage Unit 2	
2020-03-05 00:00:00	43.0	31.0	Storage Unit 2	

Figure 5: Device Data.

5. CONCLUSION

A large amount of patients suffer due the use of expired and counterfeited medicines and devices. It is because there isn't a solid digitalized system to avoid counterfeiting. Patients are unaware of techniques to find out if the medicine is consumable or not. The existing system focuses on the new trends to optimize costs in healthcare supply chain operations that include virtual centralization of supply chains, supply utilization management practices, use of RFID technologies, use of analytics, streamlining workflow. The application of these techniques can provide affordable healthcare solutions in developing countries but it doesn't consider security issues as well as integrity of data. Blockchain in Pharmaceutical Supply Chain secure the data stored about the medicines by creating a decentralized system. It can not only reduce counterfeiting and theft issues but also help manage inventory.

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