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HOSPITAL BILLING AND INSURANCE CLAIM MANAGEMENT USING THE BLOCK CHAIN BASED IDENTITY MANAGEMENT

Manish Pundlik and Dr. Pramod Pandurang Jadhav
Department of Computer Science & Engineering
Dr. A. P. J. Abdul Kalam University, Indore (M.P.) -452010
Corresponding Author Email: manishpundlik71@gmail.com

Abstract – Blockchain technology enables privacy, security, audit-ability, tracking and monitoring in a real world transactional systems. Due to its features in various other industries block chain has also being implemented. One of such essential application is found in Supply Chain Management (SCM). In this paper the block chain technology implementation has been explored in healthcare industry. The aim of applying the block chain technology is to recognize a hospital patient uniquely and settle the insurance claim automatically, securely and efficiently. In this context, first an algorithm has been introduced, which utilizes the user smart phone and government assigned ID to create a unique ID. The unique ID is stored and utilized with the user's smart mobile. After creation off identity the same ID is used to authenticate the transactions. In order to verify the transactions the mobile is used to create a signature which is submitted to the insurance company. The signature has used to verify the transaction performed by the patient to the hospital as claiming the insurance. The simulation of the proposed bock chain based system has been performed by using the JAVA technology. After implementation the experiments with the simulation has been carried out and performance has been measured. The performance for both the situations certificate creation and authentication has been measured based on time and memory utilization. The obtained performance shows the efficiency, security and confidentiality in managing transactions in health care system.
Keywords: Blockchain technology, supply chain management, large scale data handling, tacking, review, Blockchain modeling n healthcare.

I. INTRODUCTION

Block chain is a technology which is mainly used to track, monitor, and manage the real world entities into the web based identity. The block chain technique utilizes the mapping function which is secure and identification is easy and low cost. In this context, this technique has widely used in managing the supply chain systems. In recent years during the COVID-19 when the entire world is suffering from broken supply chain system, the block chain based supply chain management helped us to track and monitor the necessary supply of essential and life saving drugs.

Therefore block chain based supply chain management plays an essential role for efficient and temper proof product and service delivery. In this paper, we utilized the block chain system for managing the hospital billing and insurance claim. The presented model has focused on creation a digital identity of the hospital patient which will recognize by the government agencies, insurance company and hospital for managing efficient and secure billing and claim

settlement. The aim of the proposed concept is to design a secure and efficient system for recognizing a user system wide and also utilized to authorize the financial transactions based on hospitals. The proposed system is also promising to reduce the misuse of user identity by the malicious users because the compromised user tries to conduct malicious transactions based on a fake user identity.

Such kind of system design is need of current digital supply chain management systems due to the compromised supply chain may increase the chances of duplicate product supply, and negative affect on the reliability, maintainability, tracking, and monitoring of healthcare services. Therefore, in this paper, we first summarized the recent literature obtained from the publically available platform (Google scholar). Next, the key findings of the review have been highlighted. Further based on the collected information from the different research article the problem of hospital billing and insurance claim has been rectified. In this context, two different algorithms have been contributed, first algorithm is used for developing the unique user identity and second algorithm has used to verify the digital transactions made. Further, a complete flow of the process has been discussed for implementation point of view. Finally, the implementation details have been provided and the performance analysis has been discussed based on the different performance parameters. Finally the conclusion of the work has been presented and future research plan have been discussed.

Table 1 Review Summary

Ref	Research Problem	Solution
[1]	Review of block chain in healthcare	Review, assess and synthesize publications utilizing Blockchain.
[2]	No framework has defined where a supply chain implements Blockchain.	Measuring the impact on implementing the Blockchain in Supply Chain Management (SCM) performance.
[3]	Implications and gaps of Blockchain for improving healthcare processes.	Presents a review on Blockchain applications in healthcare. It incorporates 42 articles.
[4]	Impact of Blockchain on supply chain	Traceability through the applications, and future direction.
[5]	Supply chains become complex, to ensure transparency of supply chain.	Investigates recent publications combining the Blockchain and SCM and classifies them to be map on the Blockchain.
[6]	Data gathered can be used to improve patient safety and market analysis.	Outlines work in the areas of pharmaceutical traceability, data sharing, clinical trials, and device tracking.

[7]	Combine perspectives of Blockchain technology (BCT) in SCM	Summarize current methods and derive research avenues. A framework of use case clusters is developed.
[8]	Fragmented data affecting research and services, half of trials are never reported, cost of drug is increasing, and fake medicines are a problem.	Review use cases of Blockchain in: patient data management, pharmaceutical research, SCM, prescription management, billing claims management, analytics, and telemedicine.
[9]	Capabilities and applications have to extended beyond crypto-currencies	Conducting a review to produce new evidence, and identify applications in healthcare.
[10]	Energy management, smart logistics, smart business models	Design of incentive mechanisms and tokenization, enhance visibility of product lifecycle, increase systems efficiency and reducing costs, monitoring and reporting.
[11]	Address conflicting opinions hype of Blockchain and clarify applications.	Identified and explore applications of Blockchain and framework for analysis.
[12]	So far the implementation rate is very low because of the lack of knowledge and understanding.	Highlight the difference between the conventional and Blockchain based supply chain and the benefits in different sectors.
[13]	SCM challenge, in healthcare there is added complexity and risk in impact patient safety and health outcomes.	Overview of opportunities and challenges with Blockchain adoption and deployment, focus on pharmaceutical supply, medical device and supplies, Internet of Healthy Things (IoHT), and public health.
[14]	Need to deal with very large amount of data.	Demonstrate necessity of decentralized system based on distributed data-driven application, to assist maintaining inventory and monitor performance, usage, etc.
[15]	Globalization of supply chains makes management and control difficult.	Blockchain and smart contracts are examined with application to SCM.
[16]	How technology used with a system for smart contracts and challenges for all interrelated actors and assets.	(i) Review to identify, extract, evaluate and synthesize studies (ii) summarize and categorize benefits/ issues; (iii) Framework for new research; (iv) establish evidence.

[17]	Health informatics researchers and practitioners are struggling to keep pace with research progress	Review of application in healthcare. Methodology is based on Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) and a mapping process, search is used, to identify, extract and analyze.
[18]	gapped communications, inefficient report delivery, fragmented records	Provides evaluation metrics to assess Blockchain based Decentralized Apps (DApps) in terms of feasibility, capability, and compliance.
[19]	pandemic has impacted risk management	Validate Blockchain in healthcare, and suggest route for safe clinical practice. Creation of generalize predictive system. Analysis of adoption of a Blockchain-based prediction model.
[20]	Most of works focused on permission-less network suffers from high energy usage, scalability, and low throughput.	Lightweight Blockchain architecture to reduce overhead by network clustering and maintaining ledger per cluster. Avoid forking and demonstrate the security and privacy.
[21]	Research about Blockchain and healthcare is currently limited, but it can transform the healthcare system;	Blockchain can improve accessibility and security of patient information, and can healthcare hierarchy and build a system in which patients manages own care.
[22]	Need for patient-centric approach to connect disparate systems and accuracy of Electronic Healthcare Records (EHR).	Reveal applications, challenges and directions. Indicate that Blockchain research is used for data sharing, managing health records and access control.
[23]	Traditional activities involve intermediaries, trust, and performance issues.	Explore status, applications, and future directions. Understand the trajectory of research and benefits, issues, and challenges.
[24]	Lack of data sharing, delays for data retrieval, unreliable product tracing. Issues are not clearly identified.	Opportunities, requirements, and principles of designing SCM. Discuss challenges of scalability, throughput, access control, data retrieval and solutions with case study.

II. BACKGROUND

In order to understand the working and implementation of the block chain technology in healthcare industry for supply chain management a review is proposed to conduct. The presented work includes a study of 48 recently published research articles. These articles have collected from a public platform Google Scholar. Additionally, most relevant 24 articles have

been discussed for identifying gap and discussing the relevant solution. According to conducted study, Blockchain is one of the most studied technologies in managing the digital supply chain. The employment of the block chain technology provides a significant amount of benefits over the traditional supply chain management system, which is managed and maintained manually. However, in recent years the Blockchain technology is not only utilized in supply chain management it is being accepted in various other industries too. The summary of conducted review has been summarized in table 1, additionally the type of research done by using block chain technology is given in figure 1.
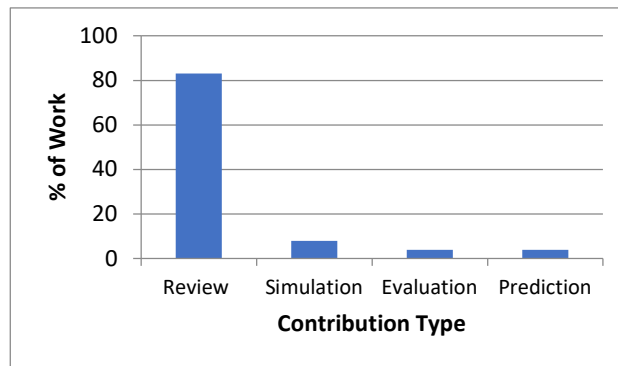

Figure 1 work trend using the Blockchain technology

According to the finding of the review, the most of the published article are limited only to the review, applications, ideas of implementation and deployment, framework design, and conceptual or theoretical overview in different industries. Additionally, when we explored the implementation of Blockchain in healthcare and SCM then we found the block chain in healthcare is mostly used for data sharing, managing records, and access control. It is also found that technical details about the used Blockchain are not given and do not present any implementation. Based on the conducted review, we have found that 83% of the work is dedicated to reviews of the Blockchain. 8% simulate the prototype, 4% of the work was focused on designing and identifying the evaluation parameters, and the remaining 4% of techniques are utilizing this technology as the predictive model with secure data analysis. Based on the contributions figure 1 demonstrates the % of work carried out using Blockchain technology in the field of supply chain management and the healthcare industry.

III.   PROPOSED WORK

The healthcare industry is a large domain and involves a number of actors and activities. Among these activities the patient enrollment, billing and insurance claim is one of critical task. In this scenario it is required to identify the specific patient and process their transaction is one of the essential tasks. In addition, for billing and insurance claim it is also provide an essential assistance to the medical and insurance system. In this paper, for maintaining the transactions and records of a unique patient we need to assign a unique id. The paper include how a patient is enrolled to the medical system and insurance system using an unique bock chain id and authenticated to ensure the specific patient during the transactions between

hospital billing department and insurance company. The proposed patient management system includes two key components:

1. Identity creation or patient enrollment
2. Identity management

Figure 2 provide an overview of the basic concept of user creation system which is utilized during the entire medical assistance.
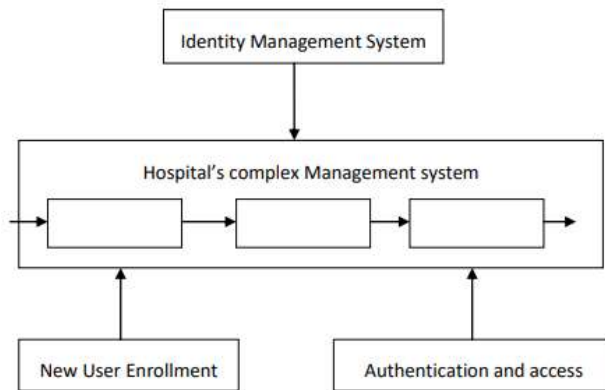

Figure 2 an overview of id creation and utilization

A. System components and assumptions

The proposed identity management system includes the following types of key components for managing the system:

- **Patient:** A person who is directly participating in the operation of a transaction. In other terms the user who wants to consume the health care services and insurance service. Therefore it is required to obtain an identity from the identity creator, which can be used on the block-chain to identify him. The user is not trusted and may try to use others' digital identities.
- **Smart-phone:** The patient's smart-phone is used with the created identity to interact with the block-chain-based system. Here, it is assumes that smart-phone is always pursue with some pre-defined steps for interaction with the block-chain system and the data secured in the phone.
- **Authority:** That is a person who helps the patient for creating a digital identity that can be used in the proposed block-chain system. It is assumed that the authority is a fully trusted and will never involve in malicious activities for creating fake IDs. This authority can be from a government agency.
- **Identity manager**: It is a group of identities and work together to submit identity related transactions in the block-chain system.

B. Design requirements

Blockchain is a powerful information management technique. In order to effectively utilize the potential of block-chain concept, a reliable mapping between the real world and the web is essential. Additionally, it is also required to design a cost effective solution for mapping a person to web based identity by using block-chain. The proposed work considers the following requirements of the proposed model design:

- **Security:** A user can only use his own identity with the system, and the identity includes the information of insurance company based issued ID, which is used in existing system.
- **Cost:** It does not require expensive devices the user can use their smartphone to store their identity and interact with the block-chain system.

C. Identity Design

This section provides the method of identity creation and management. Therefore the key processes involved and functional aspects of the proposed block-chain based hospital billing and insurance management system has been discussed.

a. ID Creation

To create an ID, which is being used in the block-chain-based hospital billing and insurance system, the patient has needed to use a government issued ID and a smart-phone for identity creation. Additionally the process given in table 2 has been followed for creating the ID.

Table 2 ID creation

Input: Patient p with government ID gov_{id} and smart-phone p_h, the authority A.

Process:
 	
    1.p sends gov_{id} to A
    2.A checks
          a. $con_1 = true$ if gov_{id} is valid;
          b. $con_2 = true$ if consistency of gov_{id}
             with p;
    3.$if\ con_1 = con_2 = true$
          a. p provide p_h to A
          b. if p can solve the OTP then
                 i. $p_h(p_k, s_k) = A.genrateKey$
                ii. $i = A.CollectInfo(p, gov_{id})$
               iii. $C =$
                     $A.genratecertificate(p_k, i)$
               iv. Return C
          c. End if
    4.End if
    5.Return Error

The process given in table 3 demonstrate a certificate C is generated to identify a patient p in the hospital billing and insurance system. The composition of certificate C is given in Figure 3.
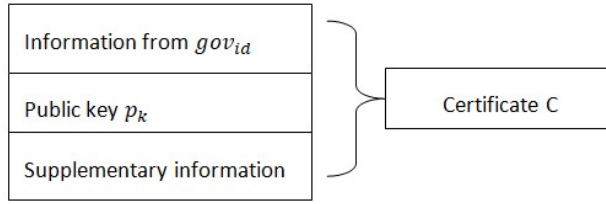
Figure 3 composition of certificate C

b. *Utilizing the certificate C*

In order to authenticate a patient the smart-phone p_h is used to verify patient's identity. In this context, an algorithm has been prepared to demonstrate how this smart-phone p_h based id is going to be use. The table 3 demonstrates the process of utilizing the user certificate. At the time of verification end I_c who receive signature S tries to locate corresponding certificate C, and verify signature S using private key p_k. If S and t_r are consistent, the patient p get recognized to include t_r with signature S into the billing and insurance claim system.

Table 3 utilization of certificate C

Input: patient p with smart-phone p_h, the blockchain-based Hospital billing H_b and insurance system I_c.

Process:
 	
    1. Patient p receives a transaction request t_r from $H_b \rightarrow I_c$
    2. if patient p wants to authorize t_r then:
        i.   p solve the OTP to authorize information
        ii.   if p_h accepts OTP then
                i. p_h uses s_k to generate a digital signature S of t_r and
                ii.   returns to p;
                iii.   p submit S to I_c
                iv.   return success
        iii.   end if
    3. End if
    4. Return Error

c. *Confidentiality/integrity*

The algorithm 1 and 2, is providing the way how to smart-phone stores secret information and interacts with the block-chain based hospital billing and insurance claim system.
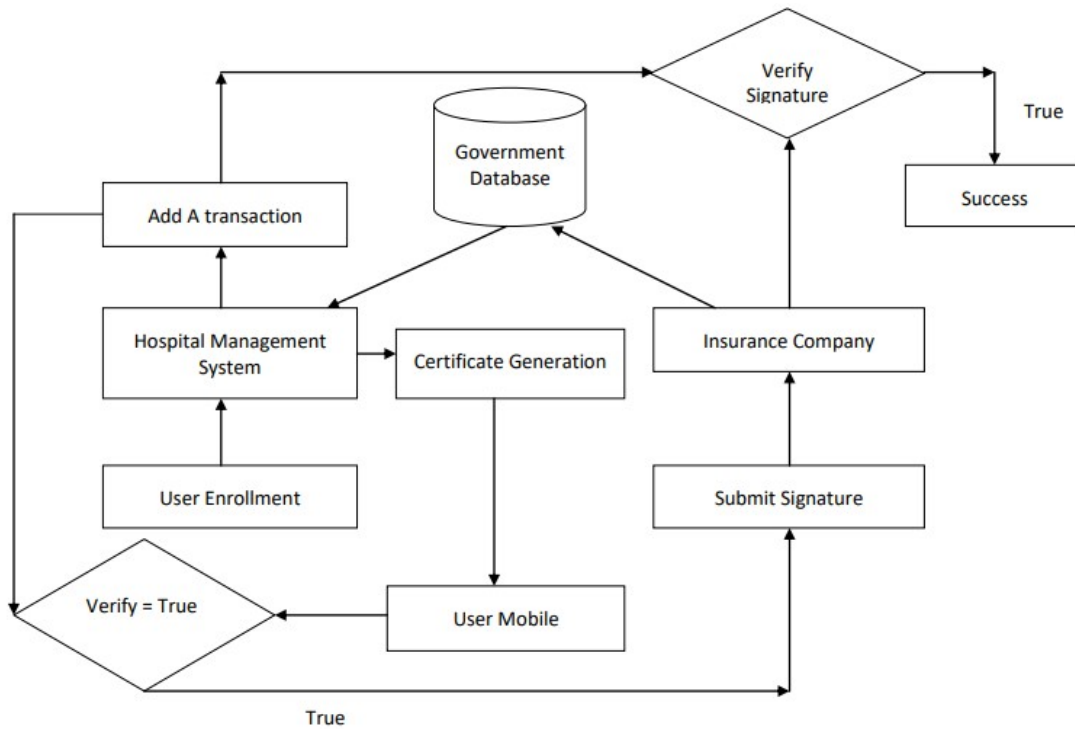
Figure 4 working of the proposed hospital billing and insurance claim under block chain system

If an attacker wants to damage confidentiality and extract the secret key s_k stored in the p_h, the attacker can use it directly to interact with the system or by using the secret information attacker may try to modify or delete it. This does not allow the attacker to mimic the user. It prevents the legitimate user to use identity in the system. Confidentiality and integrity of the s_k is protected by the hardware of the smart-phone. The hardware only allows authorized software to use the secret to signatures to use.

IV. IMPLEMENTATION AND RESULTS

In this section the implemented simulation system and the performance evaluation of the proposed system has been discussed.

A. Implementation

The required process of the proposed system functioning is demonstrated in figure 4. In this system, it is assumed that the government agencies are keeping record of the patient health insurance. Additionally it is connected with the block chain system. When a person comes to the hospital for enrollment the hospital system by using government ID generate a certificate. The certificate contains the insurance company information also as the supplementary information. This certificate is stored in device storage for future use. In near future when the hospital generate a bill for the patient then a transaction is needed to be add in insurance company. In this situation, the system asks to authorize the transaction to the user. Patient utilizes their mobile to generate a signature and generated signature is submitted to insurance company. Hospital billing system and insurance company verify the same signature for authenticating the transaction. The prototype of this system is developed using the JAVA

technology and their performance for certificate generation and authentication process has been evaluated. The obtained performance has been given in next section.

B. **Results Analysis**

The implemented model is evaluated to measure the performance. There are two parameters are considered i.e. time and memory usage for both certificate generation and authentication. The memory usage an algorithm demonstrates the amount of main memory resource has utilized for conducting the task. That can be calculated using the following formula:

$$memory\ Usage = total\ assigned - free\ memory$$

Next, performance evaluation parameter is time consumption. The time consumption is measured using the following formula.

$$time\ consumption = end\ time - start\ time$$
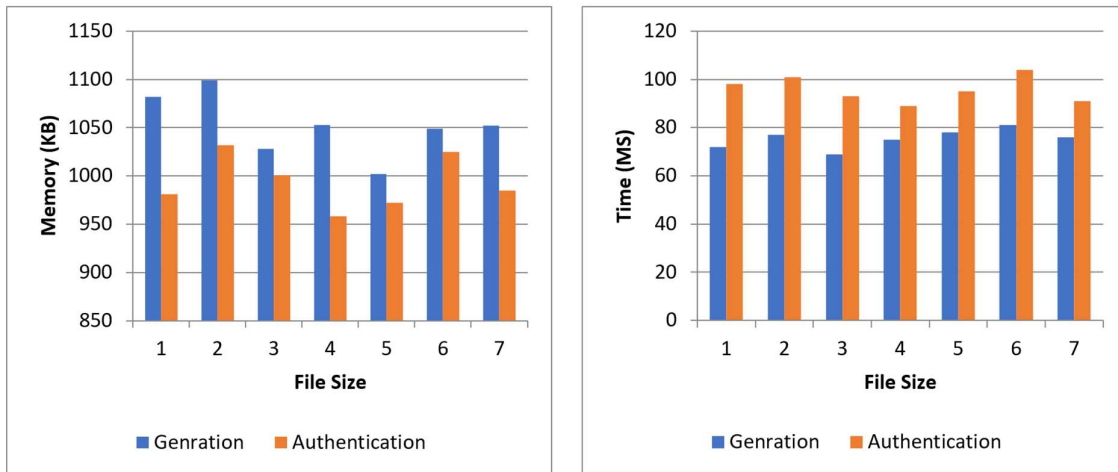
The performance of the proposed model for both the tasks has been demonstrated in figure 5(A) and table 5(B). The figure 5(A) shows the memory utilization of both the solutions incorporated in different experimental observations. In addition, the figure 5(B) shows the time consumption of the system. The memory usage of the algorithm has measured in terms of kilobytes (KB) and time consumption of the system has been measured in milliseconds (MS). In both the diagrams the blue color bar is used for providing the performance of certificate generation algorithm and orange color bar represent the performance of authentication system. According to the obtained results in terms of time consumption, we found that the time required to generate certificate is higher than the time required verifying the transaction. In addition, the memory usage of the certificate generation is lower than the authentication. However, the different among both the both the processes have very fewer differences in terms of computational resource consumption. Therefore the proposed system is low time and memory resource consuming technique. Additionally has low cost system which does not require an expensive hardware or device to verify the transactions.

V.   CONCLUSION AND FUTURE WORK

The Blockchain is one of the secure and efficient technologies for tracking, monitoring and authenticating the digital transactions and activities. Therefore, the block chain technology is being accepted in a wide verity of applications in supply chain management system. In this presented work, a simulation of block chain based system has been discussed for managing the

hospital billing and insurance claim system. In this context, a review of the recent block chain based supply chain management system has been performed. The review has specifically considering the health care industry to understand the working and need of applicability of block chain technology for performing the smooth and low cost billing management, securely and efficiently. According to the review, it is found 83% of the research is performing review of block chain, 4% is providing a simulation, 4% of is contributing for performance evaluation, and remaining 8% is demonstrating the implementation based research.

Further a block chain based patient enrollment and their utilization in insurance claim settlement has been proposed for design and implementation. The proposed system includes the creation of certificate which can be used for authenticating the transactions between hospital billing system and insurance claim company. The system is low cost, efficient and secure system which securely deals with the patient management and their utilization for authenticating the transactions. Further a simulation has been developed using the JAVA technology and the performance of the implemented system for certificate creation and authentication has been discussed. Based on the performance evaluation of the implemented model the proposed system has found efficient and secure for managing the supply chain in health care system.

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