NEXT GENERATION HEALTH CARE IN BANGLADESH USING BLOCKCHAIN TECHNOLOGY

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APPROVAL

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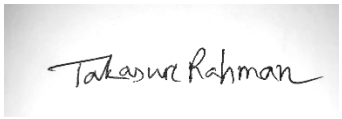

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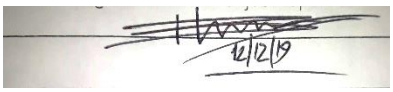

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ABSTRACT

Healthcare currently occupies the top position in any economy of the world. There are a number of good reasons for its status. However, Healthcare is a diverse and data-intensive field, security of data is a big deal. Data security here can be a matter of life or death. Therefore, these refer to the blockchain technology as a possible solution to some of the major problems facing healthcare. In Bangladesh's healthcare case, over 550 patients have died in the last six years from wrong medical treatment. In 2012, the highest rate was around 141 people who died for wrong treatment. The death toll in 2014 was 122, 104 in 2015, 65 in 2016, and 69 in 2017 according to data compiled by the Bangladesh Society for Enforcement of Human Rights (BSEHR). In this paper, we represent the blockchain technology that are proving to be quite useful in bringing transparency and immutability to track information of a patient's details and prescription. It offers security and transparency to pharmaceutical supply chains. To solve the issues, we ensure that the right medicine reaches only to the patients who need them and Doctor can know all the details of the past treatment of the patients. The healthcare industry has trusted this technology to address and solve the issue.

Keywords: Blockchain; semi-blockchain; treatment; smart contract.

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CHAPTER 1

INTRODUCTION

1.1 Background

BLOCKCHAIN is a technology that creates a decentralized, distributed ledger on a peer-to-peer network or, simply a chain of information broken up into blocks is called blockchain. Blocks are chained together and when every transaction is established, blocks are encrypted with cryptography. In 2008, Satoshi Nakamoto, an unknown person or group published a paper and proposed a new peer-to-peer currency system "Bitcoin" where the technology is not based on a centralized trusted authority, comes on eyes to the world. It is based on a peer-to-peer network, where each node is equal to all others. So, no controlling entity can influence the system and it will be distributed. It increases the overall security and resiliency of the system. For distributed consensus "prove of work" is a mechanism enabling peer-to-peer value exchange to reach agreement about which block is valid and which is not. Each transaction or data must be signed with the owner's private key and validated by the owner's public key, which is shared by anyone. Once the validation is complete (as cryptographical rules using some algorithm), a hash is created. After a block is accepted on the network, it is cryptographically bound in the distributed ledger. The ledger contains a full history of every transaction or data. Anyone can unambiguously determine past and the current state of transaction or data within the ledger. It's enabling the traceability of each asset. Data in the ledger will persist for as long as the system exists.

According to the assessment of the data and managing permission, blockchain is divided into permission (private) blockchain and permission less (public) blockchain. For public blockchain, anyone may access the information and submit transactions or

data that would be effectively confirmed. For private blockchain, the access permission is limited. Blocks with write access are controlled by one organization.

The digital ledger technology, Blockchain, can maintain the growing list of any data records and transaction. As the health sector has many data, Blockchain has the power to transform the health care system and can improve data accuracy and security.

Bangladesh covers an area of 1,47,610 square kilometers is located in the northeastern part of South Asia. According to the Bangladesh Bureau of Statistics (BBS), the population is about 158 million[3]. The population density is 1,070 people/square kilometer in 2014. The growth rate is 1.37% between 2011-2014. With a huge population growth, Doctor to population ratio is 1: 2000 and nurse to population ratio is 1:5000 [4]

From WHO's report, the same issue finds that there are 3.05 physicians per 10,000 population and only 1.07 nurses per 10,000 population. Only 28% of treatment provided in Govt. health facilities with alternative medicine. (Based on MoHFW HRD 2011)[5]. In Bangladesh, although 70% population dwell in urban areas,[6], they face some major problems like- centralized health system, worst public service delivery, lack of rules of private sectors with poor maintenance of health facilities and medical equipment. [7,8]

Table 1.1: Demographic indicators from selected sources, Bangladesh 2011 and 2014.

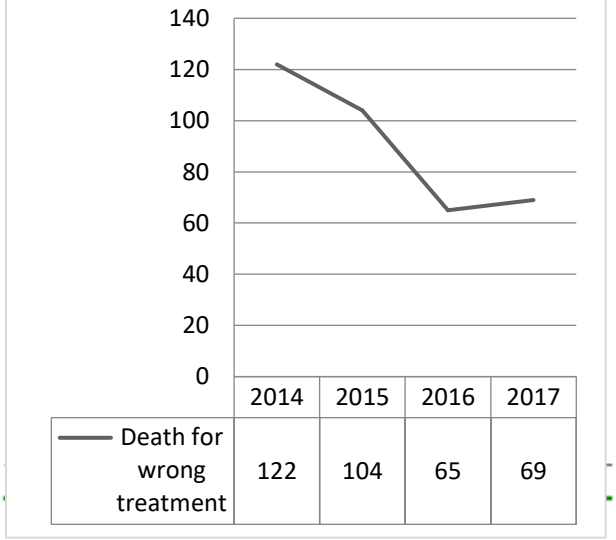
Indicators	**2011[1]**	**2014[2]**
Population (millions)	149.8	157.9
Intercensal growth rate (percent)	1.37	-
Density (population/km^2)	1,015	1,070

Here is some statistics of the death rate bellow:

A. Statistics of the death in Bangladesh[13]:

Table 2.1: Crude death rate per 1000 population by background characteristics, SVRS 2017

Background Characteristics	No of deaths	Population	Crude death rate



B. Statistics of death for wrong treatment in Bangladesh:

Figure 1.1 Statistics of death according to BSEHR

The reports of 2013 shows that for wrong treatment in 29 cases included 27 death cases and 2 infirmity. 7 cases death was happened due to "negligence" and most cases due to treatment by "False" doctors[12]. According to BSEHR, the number of deaths for wrong treatment was 122 in 2014, 104 in 2015, 65 in 2016, 69 in 2017. The highest rate in 2012, about 141 people died from wrong treatment alone. [1].

1.2 Motivation of the Research

Bangladesh has made a goal of 'Digital Bangladesh by Vision 2021' to build up a healthy population through well-known access to healthcare facilities.[9]

ICT enabled the healthcare service delivery and capacity building of tens of thousands of semi-skilled health workers around the country. Due to Digital Bangladesh campaign, the eHealth system is being given special importance. Currently, with the internet connectivity, at over 800 health centers, doctors can access through the mobile phone. They have the video conferencing facility in community clinics; OMR-based

patient-level data collection and mobile-based helpline with doctors are already running to develop the health care system in Bangladesh. Bangladesh takes this action to reduce Birth and Death Rates. Currently, it is respectively 5.4% and 3.8 %, to the target of Vision 2021 levels of 1.5% for both.[10]

As Bangladesh is a growing country, the health system needs more improvement. Though NGOs, private organization and Mobile Phone Companies are also providing e-Health services to the patients in different areas in Bangladesh.[42] Example: BIID launched e-Clinic service[25],D.Net providing e-Health service[34] and also Mobile operators lunched healthlink service for customers[28][29][30]. But Security and privacy is the major concerned in all aspect of e-Health in developing countries[26]. There must be specific privacy regulations on the practice of e-Health so that patients can feel secure in the discloser of their personal information[24].On the otherhand limitation of doctors is a problem in Bangladesh, it ensures that a doctor should give at least 20 minutes to observe a patient accurately [1]. For the leakiness of this situation.

1.3 Problem Statement

Growing demand for e-healthcare services and integrated-care delivery, coupled with increased focus on member-health management, accentuates the need for an information technology system that can remove dependency on middlemen. Blockchain can help overcome most, if not all, of these challenges- Fragmented Data, Timely Access to Patient Data, System Interoperability, Data Security, Patient Generated Data, Access and Data Inconsistency, Cost Effectiveness and Wrong Prescription.

Wrong prescription: Patients sometimes shift their doctor schedules. When they go to a new doctor, the new doctor doesn't know about the treatment procedure of the former

one. Doctor need to investigate again. And without knowing the past treatment history of the patient, the new doctor cannot ensure proper treatment. This problem can be solved by prescription details with the patient data history. The previous prescription will help a doctor to observe a patient correctly.

1.3 Research Questions

1. Question 1: Will the use of Blockchain technology improve the health sector's current system?
2. Question 2: How it works as a prescription transparency for doctors and patients?
3. Question 3: Is this possible to implement in the current Health system in Bangladesh?

1.5 Research Objectives

- The use of Blockchain technology can improve the health sector in Bangladesh. Because of the Blockchains' technology is open but secure. It supports seamless information sharing that can eliminate the duplication, errors and inconsistencies that can arise with traditional, centralized data storage.
- In the methodology section, the blockchain model will propose to solve the prescription problem for doctors and patients.
- As Bangladesh adopt the new technologies, so a secure and trustable technology 'blockchain' can improve the health sector. It is possible to integrate with the current health care system.

1.6 Research Scope

This thesis's general purpose to integrate blockchain into the health sector limited to the prescription problem. In the Methodology section, the proposed model will be describe and in the Result section the pseudo code results for the implementation. The research covered only the health sector area limited to prescription problem. So, a

doctor can easily observe a patient to provide him with proper treatment. It can reduce the timing problem , wrong prescription problems and the death rate.

1.7 Thesis Organization

The first part of this chapter is Introduction including background of the study, motivation of research, problem statement, research question, objective and research scope. The second part of this chapter provides an overview of available models and related work. In the methodology section, show the working process of proposed model and the final part discusses the results of the simulations, and offers recommendations for improvements to this work. Program algorithm and FORTRAN (pseudo) codes are contained within the Appendices.

CHAPTER 2

LITERATURE REVIEW

The Research contributes on blockchain technology and healthcare system in Bangladesh by providing a proper systematic process for reducing the death rate and helps to observe patient carefully to ensure the right prescription and understanding how the proposed technology changes the health care system in a proper way in Bangladesh. Whereas there are many different implementations of blockchain technology for this purpose of this paper in many other countries.Previous research in this emerging area has focused on Blockchain distributed ledger technologies for biomedical and health care applications.[14] (by "Tsung-Ting Kuo, Hyeon-Eui Kim, and Lucila Ohno-Machado" on the Journal of the American Medical Informatics Association, 24(6), 2017).They discuss the blockchain technologies and their applications in the biomedical/health care domains. Other researchers "Elyes Ben Hamida, Kei Leo Brousmiche, Hugo Levard and Eric Thea discuss the blockchain technologies challenges and the opportunities[15]. Another Bangladeshi researcher, "Shakeel Ahmed Ibne Mahmood" describe on his paper to look at factual evidence to describe the main challenges facing health care delivery in Bangladesh.[16]. Also in Bangladesh, Some authors discuss Public Health Problems in Bangladesh. Basically the health care issues and challenges[19]. David Randall, Pradeep Goel and Ramzi Abujamr examine the policy implications of deploying blockchain technology and finally suggest further areas of research. Mainly they discuss Blockchain Applications and the Use Cases in Health Information Technology[17]. In "Electronic Health Records using Blockchain Technology"[18] the authors contributed to their paper about the existing system "Electronic Health Records" (EHRs) on their region. They discuss the data privacy and accessibility issues in healthcare with a proposal of blockchain

based architecture. Wu et al. developed a method based on robust watermarking and combined with modulo addition[22]. The method generates the joint photographic experts group (JPEG) bit string of the selected region of interest (ROI) and then divides them into fixed length segments. Medical image is divided into blocks by the method, and hash bits are calculated for each of them excluding the block with ROI. Eswaraih et al. uses IWT to watermark a medical image[20]. The medical image is segmented into ROI and RONI regions. IWT is used to embed hash of ROI, recovery information, and EPR into RONI. The disadvantages of the method are as follows: The coordinates of ROI and the size of watermark are sent to the other side as side information; authentication of ROI depends on hash function, and it can be applied to only medical images whose ROI size does not exceed 20% of the whole image. In 2011, Memon et al. embeds the watermark information into LSBs of the ROI portion by using fragile watermarking[23]. RONI portion of the image is divided into N N pixel blocks, and then, embeddable blocks are determined. Location map of these blocks and a robust watermark are embedded into blocks on the RONI using integer wavelet transform (IWT).

To all these paper observations, There was a big lack for the prescription problem and the security issue for patients personal data. We are allowing our research to propose a model with the doctor, patient, health provider and prescription in Bangladesh. We technically discuss the proposed system with the procedure and with the diagram.

CHAPTER 3

RESEARCH METHODOLOGY

According to assess the data and managing permission, we simply talking about the types of blockchain in Chapter 1. They are the permission and permissionless. But there is one more type that is very essential for this proposal. The type is "Semi-private" Blockchain. Now, we discuss details about the semi-private blockchain technology.

3.1 Semi-private Blockchain

We recently discussed the permission blockchain and permissionless blockchain. In permissionless or public blockchain, anyone in the world can read and send transaction. That means, it is opened with no third-party verification. And for permission or private blockchain, where write permissions are kept to one organization or privately by someone.

But in Semi-private is totally different from those. Mainly it behaves as the same as public or permissionless blockchain. But it typically targets business-to-business users under a single owner's control where only qualified users can get access. Basically, it uses already existing models or wants to launch a new service under one owner control.

Some difference between the other types:

Table 3 .1: Difference between blockchain types

	Public	Private	Consortium	Semi-Private
Permission	No permission	Members only	Members only	Qualified users via online approvals
Implement	Via Public blockchain	Via Private blockchain	Via Private blockchain	One authority launches and acquires users.
Numbers of users	Millions	Dozens or few	Dozens or few	Hundred on thousand

Target	New business models	Process with existing Relationship	Process with existing Relationship	Both

3.2 PROCEDURE

In this section, we technically discuss about the procedure of the system with proper diagram.

3.2.1 Create genesis Block

Firstly we think about one health care provider with some doctors and patients. From the blockchain technology procedure, the systems need to first add the provider, doctor, patient and prescription block. First registration block will be the genesis block.

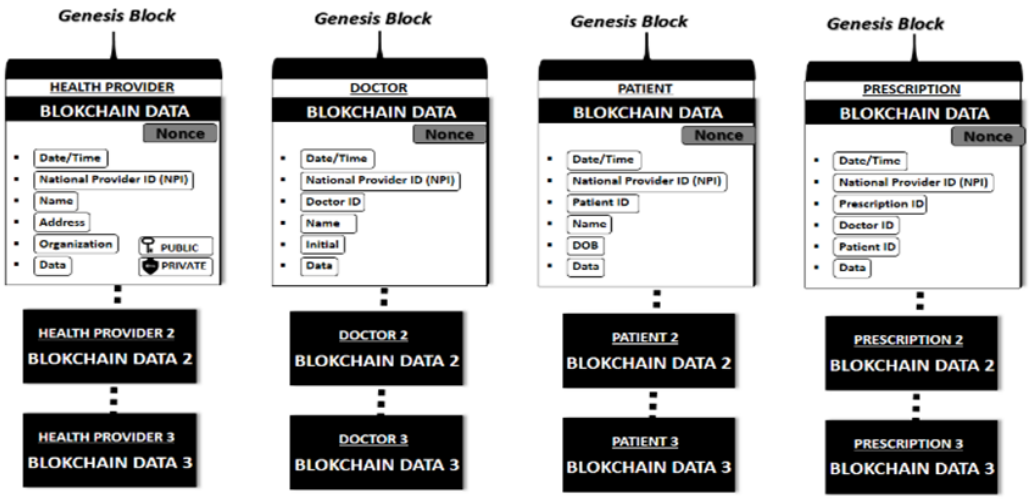


Figure 2.1 : Procedure of create new genesis block for every portion

3.2.2 Smart Contact

A genesis block is the first block of a blockchain. Every subject's block has some data to store, we called here "Blockchain data".(figure:1) Health provider has NPI(National Provider ID) which is unique for all over Provider. And also have some more information about the provider in the block. One health provider has many doctors,

patients with prescriptions. So, every doctor and patient and prescription has a different block in the blockchain. When new doctor or patient are registered, their data will be stored and after verifying, will be shared on the blockchain network as a ledger. These ledgers are only applicable and showing by the doctors and patients under their provider only. Patient uses a public key to encrypt and secure their data. Patient's own private key can decrypt their data and the only permission doctors can check the past prescription from the block of a patient. And the public key and private keys are provided by the Health care.

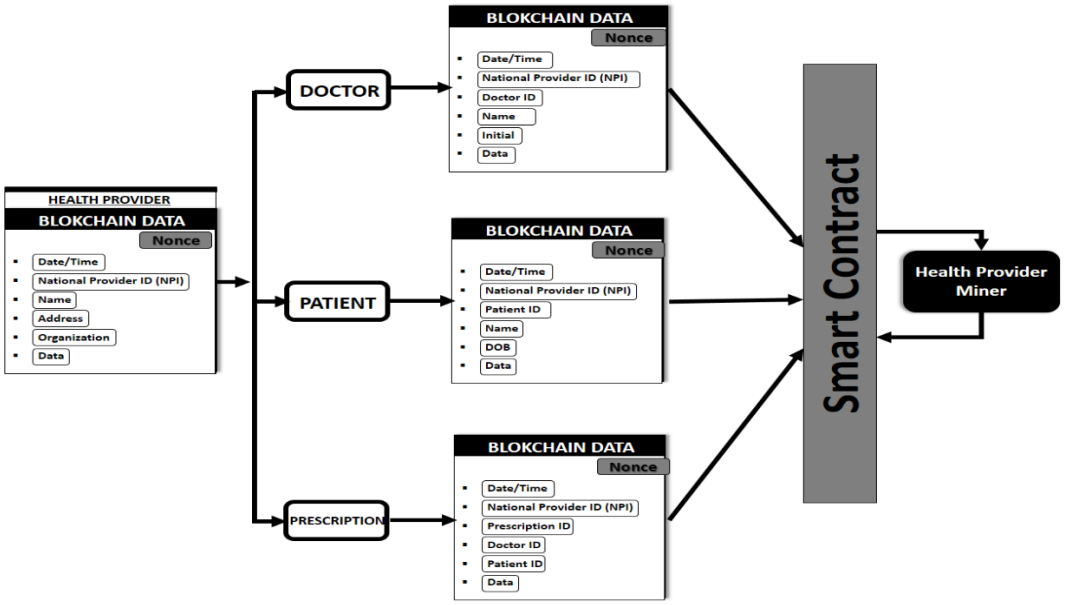


Figure 2: Data shared into smart Contract

3.2.3 Mining process

One provider has many doctors and patients. For example, (figure 3) if patient 1 has a health checkup with Doctor 1, so after a checkup with the given

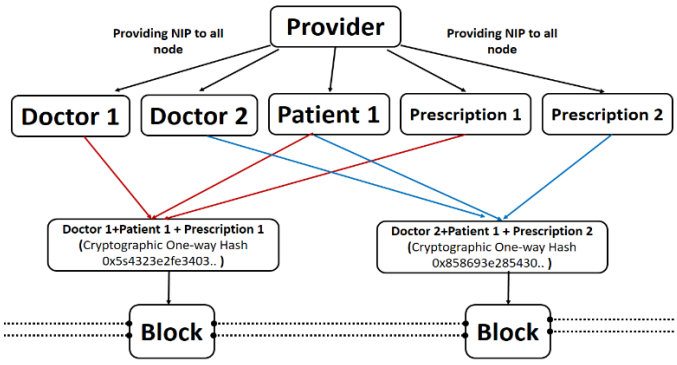


Figure 3: Process of mining

prescription 1, patient 1 and doctor 1 ‘s blocks data are cryptographically encrypted and stored to a block. Again if the same patient has an appointment with Doctor 2, So with the given prescription 2 data, Doctor 2 data, patient 1 are encrypted and stored in block. On the blocks, only doctors information are seen publicly but patient and the prescription details are seen by only the doctors who have permission to show the data of patient .(figure :3 show whole process at all).

If there is a need to contribute the data to many providers, then the other provider must need to register same blockchain network and the blocks shared into provider to provider.(see figure 4). Then another provider has also the same ledger to identify a patient.

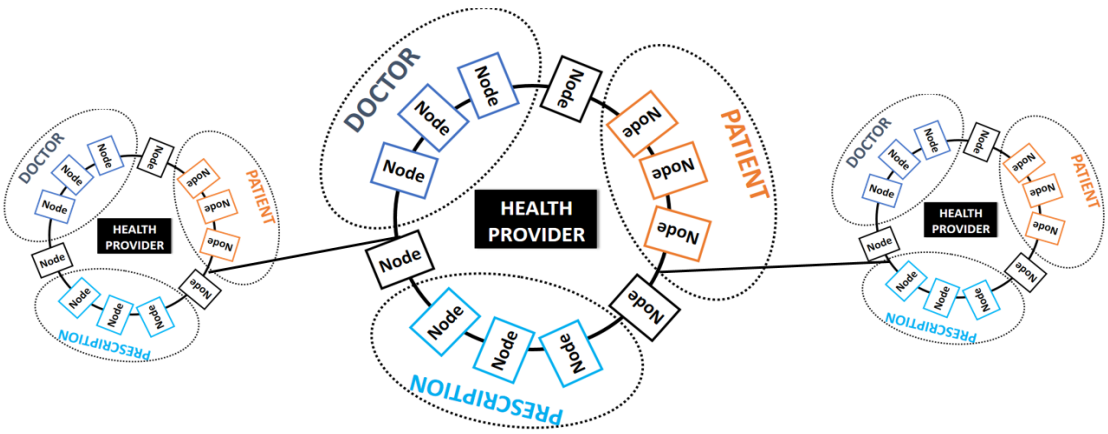


Figure 4: Contribute with various healthcare provider

When a patient is under a provider's doctor, but some other treatment procedure, he needs to go to another provider for checkup the health issue. On that case, the another provider have no data about the patient. So, it needs to clear that ,the another related provider also needs to connect with the first provider's blockchain network. So that, they can combine the patient data and health issue for proper treatment. For this, every health providers need node to node connection on blockchain network.

3.2.4 Deploy

The proposed model was deployed on a test server to ensure that the system work perfectly. The algorithm is displayed on the appendix-A and the screenshot of the pseudo code is displayed on Appendix-B.

3.2.5 Tokenization

The tokenization concept is taken from Brodersen et al of Accenture(2016),which was presented and discuss about how blockchain technology could assist patient health care data interoperability[21].

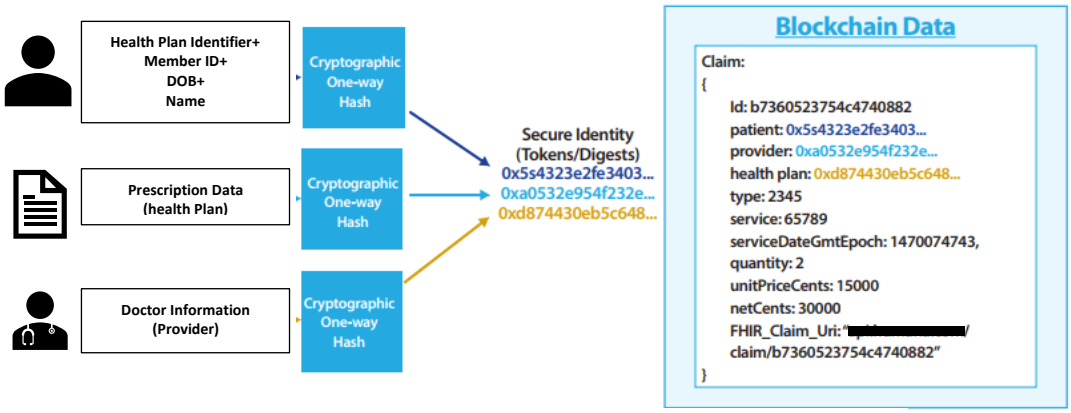


Figure 5: Contribute with various healthcare provider

CHAPTER 4

RESULTS AND DISCUSSION

In the growing generation, Security and data privacy issues are too sensitive for any organization.Blockchain was created for a financial transaction but recently Blockchain 3.0 has been proposed to indicate application in currency, markets, and economy. [11] In the results section, according to our objective, the research ensure the blockchain with the benefits to decentralize data like- Immutability, security issues and redundancy.

• **Immutability:** In our current general system, the stored data, that easily can be edited or deleted. But Blockchain has the decentralized data and it is distributed to all the existing users. So, no one can tamper the data of records. In this portion, blockchain solved the immutability issue.

• S**ecurity:** Healthcare's traditional servers are basically centralized and can be attacked by hackers or not much trusted. Decentralization via blockchain increases the difficulty to be attacked. In blockchain, the data is securely hashed on a block. And all the blocks are connected to the chain. And it is distributed to all of the users as a same copy of data. If someone tries to tamper with any of the data, he needs to change every single node to do this. It is hard to break. Therefore, Blockchain can secure the data from tampering.

• **Redundancy:** Healthcare system has some sensible data and there is a possibility of losing those data forever. If this happens, it is the worst situation at that time for anyone. Blockchain gives the data redundancy. It basically has the same data distributed to all the users.

Because of the technology's security and immutability, Blockchain is the best for storing smart contracts. Smart contracts is similar to a contract in the real world, but it is a computer protocol intended to digitally facilitate and is represented by a program stored inside a blockchain. Smart contracts' data is encrypted on a shared ledger and it is impossible to lose the information stored in the blocks in the blockchain.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Findings and Contributions

In this Research, we proposed to apply blockchain technology in health care, specially provide a decentralized and distributed healthcare system between doctor, patient with prescription. We pointed out the issues in current portion in health care on Bangladesh with the death rate and prescription problem and explained how blockchain can help in the limitation of health service. How the data identity process work with securely in the blockchain network and how it is helpful to share the patient private's data between two providers. We highlight, the different types of blockchain and use the semi-private blockchain procedure to develop a proper decentralized network system and technically discuss about the proposed system with the whole procedure and with diagram.

5.2 Recommendations for Future Works

As our observation was only with the prescription to decrees the wrong treatment and reduce the death ratio, though in future we will implement the full health system and the supply chain of medicine delivery with the blockchain network. However, if it is implemented on Bangladesh healthcare system, it may lead to develop the health sector.

Appendix – A

Deploy Smart Contact

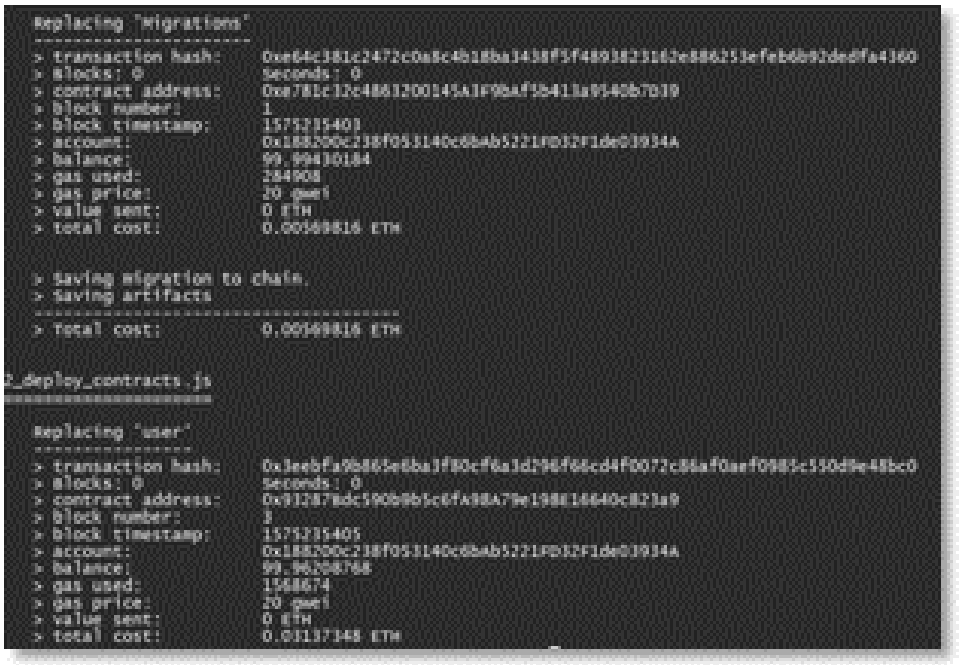


Figure 6: Deploy Smart Contact

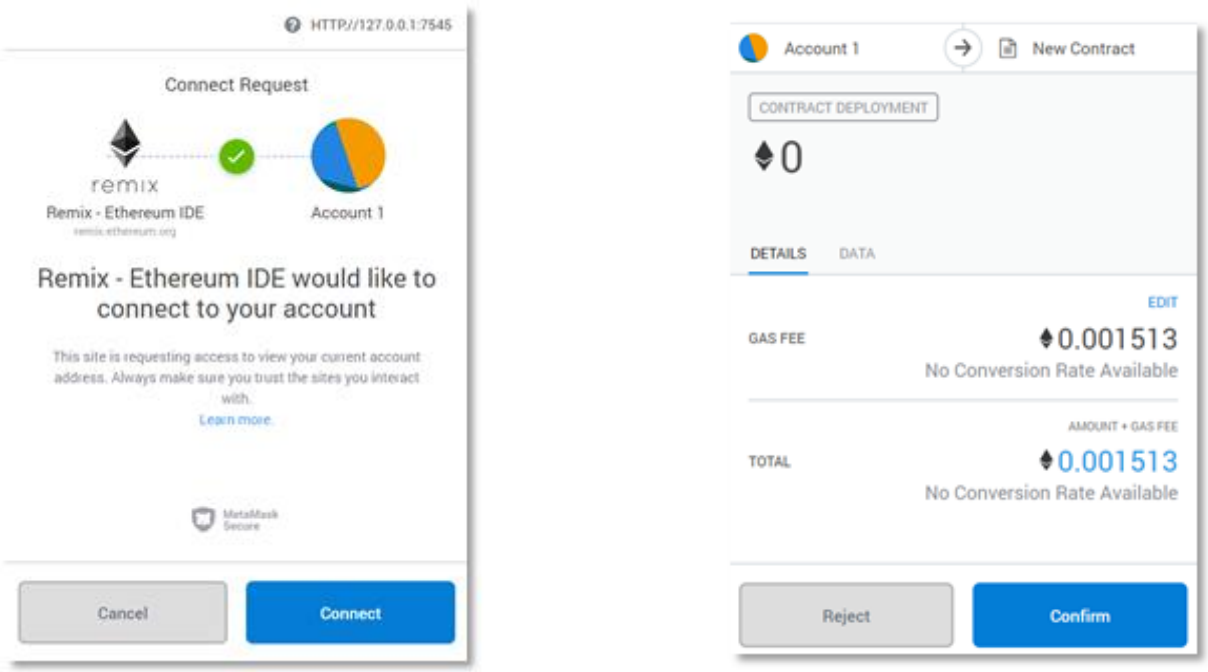


Figure 7 : Test network to confirm transection

Appendix – B

Pseudo code of mining the blocks

Procedure

P:= The hash of the previously mined block
B:= A block of transactions
H:= A hash of transactions
D:= Difficulty Level

0 Retreive P
1 Construct/Modify B
2 IF H (P, B, Some Random Number) > D END
3 GOTO 1

end procedure

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