RESEARCH ARTICLE OPEN ACCESS

Implementation of a Blockchain based model for Health Information Exchange in Maternal Healthcare

Anthony Musabi [1], Moses M. Thiga [2], Simon M. Karume [3]

[1],[2],[3] Department of Computer Science - Kabarak University

ABSTRACT

Medical facilities in Kenya have adopted Electronic Health Records systems but lack a robust and secure system for sharing sensitive and confidential health records. These efforts do not provide comprehensive data integrity and non-repudiation of patient medical history as the patient seeks care from one provider to another. This situation is even dire and most detrimental to the most vulnerable of citizens, in expectant mothers, children and marginalized groups. These shared electronic health records which includes provision of historical health information, is critical to facilitate making of informed medical decisions. Therefore, a blockchain based solution would reliably address these concerns and result in access to better quality maternal healthcare services in Kenya. The study focused on developing a Blockchain based model for secure Maternal Health Information Exchange. The solution targeted inter health facilities information interchange while ensuring data protection and access to information. The study utilized a mixed method approach entailing design thinking methodology.

Keywords: - Electronic Health Records, Maternal Health, Blockchain, Information Exchange.

I. INTRODUCTION

The Kenyan government has made a number of key efforts such as the introduction of free maternity with an aim of increasing access to skilled delivery service, beyond zero campaign, aiming to improve maternal and child health outcomes in the country, among others (Njuguna, Kamau, & Muruka, 2017) [1]. Much of this intervention is evident in antenatal care process; during this care process a Professional health workers normally use the Antenatal Health Cards as a medical tool for recording a patient data (Lincetto, Mothebesoane-Anoh, Gomez, & Munjanja, 2016) [2]. The data in these registers form the basis for compilation of required routine reports (Chawani, 2014) [3].

Incomplete and inconsistency of data collection, inaccurate and unreliable reports, records redundancy, data inaccessibility, missing data in the records due to regular oversight, and data being difficult to read as records grow so large over time (Lincetto, Mothebesoane-Anoh, Gomez, & Munjanja, 2016) [4]. In addition the process is tedious and difficult to extract data from it for clinical research and reporting in health centers. (Kihuba E., 2014) (Chao, 2016) [5]. The challenge of ensuring continuity of care is one that has been addressed in many other settings such as National Commission on Correctional Health Care (NCCHC), Policy health projects Kenya, through the use of ICT's. The Kenya Government has also recognized that eHealth and mHealth solutions as a key strategic direction towards achieving this goal and is ably captured in the Kenya National eHealth policy 2016 – 2030 for the maternal and other health programs. To address the challenges facing the effective application of eHealth Kenya Government through the ministry of health has outlined a number of key measures in the eHealth policy 2016 – 2030. Key among these measures is the development of platforms for cross-border and inter facility sharing of health information about the medical incidences and history of patients without compromising privacy (MOH, 2016) [6].

Health Information Exchange (HIE) is a dissemination system for medical or healthcare data between different parties. It involves mobilization of health care information electronically across organizations within regions, community or hospital system (Williams, Mostashari, Mertz, Hogin, & Atwal, 2017) [7]. Consequently it guarantees accuracy by ensuring, every party involved in a patient's care whether in a primary care setting, a specialists' health institutions has access to the same information (Uwizeyemungu & Poba-Nzaou, 2017) [8].

Healthcare providers interact in health information exchange which in-turn helps facilitate coordinated patient care, reduce duplicative treatments and avoid costly mistakes (athenahealth, 2018) [9]. HIE encourages efficient care by enabling automatic appointment reminders or follow-up instructions to be sent directly to patients, and prescriptions directly to pharmacies which reduces the amount of time patients spend filling out paperwork and briefing their

providers on their medical history, allowing more time for discussions making on health concerns and treatments (Williams, Mostashari, Mertz, Hogin, & Atwal, 2017) [10].

In a healthcare context, transactions would consist of documentation of specific episodes of healthcare services provided (Szewczyk, 2017) [11]. Healthcare providers, payers and patients would contribute encrypted data, which would reference a patient ID, to a public blockchain. This could include clinical data that is stored in EHR systems today, claims history and gaps in care from payers and family history and device readings from patients (Azaria, Ekblaw, Vieira, & Lippman, 2016) [12]. This information would be encrypted and stored in the blockchain and could only be decrypted by parties that have the patient's private key (Zyskind, Nathan, & Pentland, 2015) [13].

I.1 PROBLEM STATEMENT

Medical facilities in Kenya have made efforts to adopt Electronic Health Records systems; however, lack of a robust and secure system for sharing sensitive and confidential health records curtails the potential benefits that can be gained by shared electronic health records especially the antenatal care process. Current methods do not provide comprehensive data integrity and non-repudiation of patient medical history as the patient seeks care from one provider to another and some still rely on manual data records. The systems do not provide health officers with the ability to reconstruct patient's medical footprints, and to accurately predict and forecast possible ailments or complications through reports. While the lack of coordinated effort affects all medical cases, this study focuses on Maternal Health Information exchange which is most detrimental to the most vulnerable of citizens, in expectant mothers, children and marginalized groups. This study therefore developed a blockchain model for health information exchange to address the challenges of inconsistency, unreliability and security of medical records in maternal healthcare.

III . RESEARCH QUESTION

How can a Health Information blockchain model for maternal exchange be designed and implemented?

IV. RESEARCH OBJECTIVE

The overall objective of this study is to develop a Blockchain distributed ledger model for Enabling Secure Maternal Health Information Exchange.

V. JUSTIFICATION FOR THIS STUDY

Pregnant women and their fetuses have long been regarded as vulnerable, where being vulnerable indicates a likelihood of suffering harm (Ballantyne & Rogers, 2016) [14]. This can happen from anywhere regardless of whether they have carried their antenatal cards or not. It would therefore be prudent to ensure that their health records are accessible through a secure and interoperable system without impediments. This can be achieved through a blockchain distributed ledger.

VI. LITERATURE REVIEW

The Demand for electronic health information exchange among health professionals is increasing along with other efforts to improve health care delivery quality, safety, and efficiency (ONC, 2016) [15]. Significantly, the requirements for use, new approaches to payment that affects coordination of care and federal financial incentives all drive the interest and demand for exchange of health information through health information systems (ONC, 2016) [15]. Health Information Exchange enables health care professionals and patients to access and share the vital medical information of a patient electronically and securely improving the speed, quality, safety and cost of patient care (Health-IT, 2016) [16].

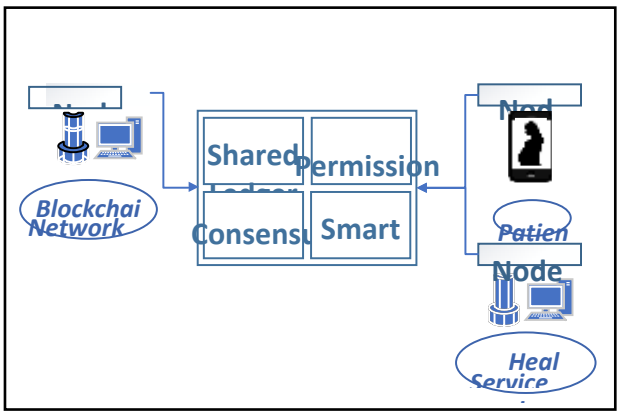
In Kenya the development of e-health and m-health policies has facilitated large number of projects with the use of ICTs to address health and health systems challenges (M. Njoroge, 2017) [17]. With the National ICT policy and e-Government strategy already in force, the health sector in Kenya envisions efficient, accessible, equitable, secure and consumer friendly healthcare services enabled by ICTs. Some technology bases projects within include:

- Medical Inventory Management system MIMS had been initiated for the purpose of automating the medical supply chain to grant access to real time, accurate information on transactions in the supply chain from the dispensaries in the field to the district stores (Bmz.de, 2014) [18].

The figure below shows the conceptual framework of the marternal health information exchange model on blockchain technology.

VII. METHODOLOGY

This study utilized design thinking methodology. Design Thinking is a design methodology that provides a solution-based approach to solving problems (Siang, 2010) [19]. It's extremely useful as it seeks to tackle complex problems, by understanding the human needs involved, re-framing the problem in human-centric design, by creating ideas in brainstorming sessions, and adopting a hands-on approach in prototyping and testing (Razzouk & Shute, 2012) [20]. It comprises of five stages: Empathize, Define, Ideate, Prototype and Testing.



VIII. ETHICAL CONSIDERATION

During the requirement gathering and model testing several ethical considerations will be adhered to. The researcher will seek to obtain information that will further the purpose of these study towards coming up with a model. The ethical consideration will be in line with regulating authorities'. This will be done through an introductory letter from the Institute of Postgraduate and Research of Kabarak University and a permit obtained from National Commission for Science Innovation and Technology (NACOSTI). The information that will be obtained from either source for the purpose of this research shall be treated confidentially.

Rapid prototyping is the act of creating a low-fidelity object for the purpose of testing a concept (Ranson & Lahn, 2017) [21]. The process for the study is as shown in the diagram 2 below;

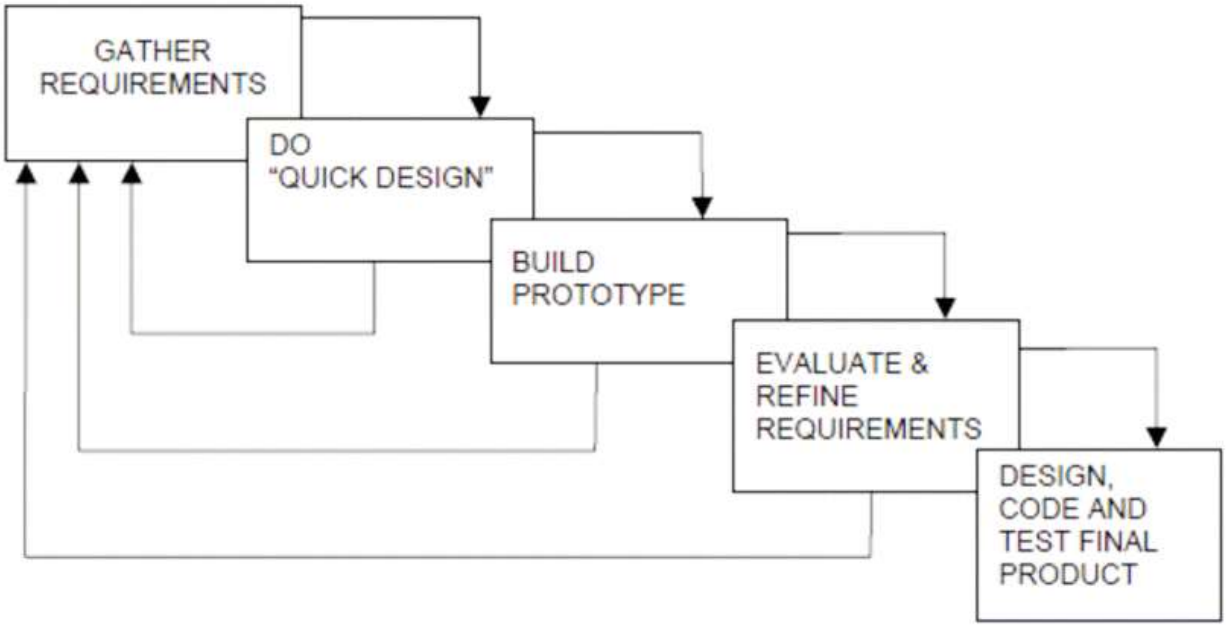


Figure 2: Rapid prototyping methodology

The following tools were installed.

i. **Solidity v0.5.7** - Solidity is a Programming Language for Ethereum's Smart Contracts. Smart contracts are programs which govern the behavior of accounts within an Ethereum state (Rothrei, 2019). The solidity software was used for designing the smart contracts for the maternal health information exchange.

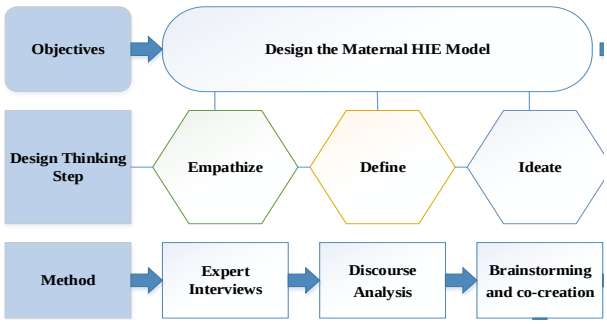
ii. **Remix IDE v0.7.5** - Remix is a compiler and debugging tool that takes the Solidity code for the smart contract and formats it to be read by the Ethereum Virtual Machine (Rothrei, 2019). Remix helps in writing Solidity contracts straight from the browser.

iii. **Geth (go-Ethereum) v1.8.27** – This is a Command Line interface that allows running of a full Ethereum Node (Beyer, 2019). In this study Geth will facilitate interaction with ethereum frontier live network and mine real ether, enable transactions between addresses, create contracts to send transactions and explore block history.

iv. **Ganache v2.5.6** – This is an Ethereum blockchain emulator used for development purposes. It creates a virtual Ethereum blockchain, and generates some test accounts that we will use during development (Nagpal, 2018). In this research Ganache will be used for creating a personal Ethereum Blockchain for testing smart contracts.

v. **Truffle v5** - Truffle is a development environment, testing framework and asset pipeline for Ethereum. Additionally the truffle framework provides built-in smart contract compilation, linking, deployment and binary management automated contract testing (Bhattacharya, 2018). In this study the truffle shall be you can used to deploy contracts, develop applications, and run tests.

Design Thinking Approach



IX. RESULTS

The research was able to identify the challenges encountered by various personnel within the provision of antenatal care at the current disposition of maternal healthcare. The methodology was used to identify these challenges was achieved using literature review and expert interviews of the stakeholders within provision of maternal healthcare. The results of this section guided the implementation of the model.

X. CONCLUSION

The Kenyan government should look at re-evaluating the current ICT policy to include use of more ICT solutions especially blockchain for provision of a secure, open, reliable, and interoperable system. The current ICT policy 2019, does not factor in blockchain as an essential tool for provision of healthcare services, specifically maternal health.

There is need as well, to decongest the bureaucracy within healthcare systems in Kenya, with a view of reducing time taken in procurement of ICT services, equipment and human resource thus, speed up the absorption of bleeding edge technology in healthcare provision.

REFERENCES

[1] (Hirvi & whitfield, 2015) public service provision in Clienteles political settlements: Lessons from Ghana's Urban Water Sector. Development policy review, 33(2), 135-138.

[2] Heymans C.,Eales K.,Franceys R.,2014) The Limits and Possibilities of Prepaid Water in Urban Africa : Lessons from the Field.

[3] Kamal S.(2015)The Technical Faculty of IT and Design Wireless Communication Networks.

[4] Froehlich,J.,E.,Larson,E.,Campell,T.,Haggerly,C.,For garty,J.,&Partel,S.N.(2009,September). Hydrosenense: infrustrctutre –mediated single point sensing of allhome water acrtivity 11th conference proceedings on computing (pp235-244.ACM.

[5] Khutsoane O., Isong B., Abu-Mahfouz A.M. IoT devices and applications based on LoRa/LoRaWAN; Proceedings of the IECON 2017—43rd Annual Conference of the IEEE Industrial Electronics Society; Beijing, China. 29 October–1 November 2017; pp. 6107–6112.

[6] Lauridsen M., Vejlgaard B., Kovacs I.Z., Nguyen H., Mogensen P. Interference Measurements in the European 868 MHz ISM Band with Focus on LoRa and SigFox; Proceedings of the 2017 IEEE Wireless Communications and Networking Conference (WCNC); San Francisco, CA, USA. 19–22 March 2017; pp. 1–6.

[7] Rezgui, Y., Zarli, A., Ellis, K. A., & McCann, J. A. (2015).Optimized Water Demand Management Through Intelligent Sensing And Analytics: The WISDOM Approach.

[8] Agapiou, A., D. D. Alexakis, K. Themistocleous, and D. G. Hadjimitsis. 2016. "Water Loss Detection Using Remote Sensing, Field Spectroscopy and GIS in Semiarid Areas of Cyprus." Urban Water Journal 13 (3): 221–231. doi:10.1080/1573062X.2014.975726

[9] Brown, C. M., Lund, J. R., Cai, X., Reed, P. M., Zagona, E. A., Ostfeld, A., et al. (2015, August). The future of water resources systems analysis: Toward a scientific framework for sustainable water management. *Water Resources Research*, *51*(8), 6110–6124.

[10] Morison, J.,&Friedler,E. (2015).A critical review of methods used to obtain meter paterns and volumes of individual domestic water using appliances. Urban water journal,12(4),328-343.

[11] Ibrahim, A. (2015). Using ZigBee for Wireless Remote Monitoring and Control.Journal of Energy, 2(5), 189-197.

[12] Almazyad, A.S.; Seddiq, Y.M.; Alotaibi, A.M.; Al-Nasheri, A.Y.; BenSaleh, M.S.; Obeid, A.M.; Qasim, S.M. A Proposed Scalable Design and Simulation ofWireless Sensor Network-Based Long-DistanceWater Pipeline Loss Monitoring System. Sensors 2014, 14, 3557–3577,doi:10.3390/s140203557

[13] Sanchez-Iborra R., Sanchez-Gomez J., Ballesta-Viñas J., Cano M.-D., Skarmeta A. Performance Evaluation of LoRa Considering Scenario Conditions. Sensors. 2018;18:772. doi: 10.3390/s18030772

[14] Yu, X.; Wu, P.; Han, W.; Zhang, Z. Overview of wireless underground sensor networks for agriculture. Afr. J. Biotechnol. 2012, 11, 3942