Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 44 No. 3 (2023)

A New Infertility-Blockchain Model by Using User Modelling and Relevance Feedback for Medical Record Management

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Abstract

Electronic Medical Records (EMR) contain a significant amount of sensitive data that requires strict security measures. EMRs play a vital role in ensuring the smooth and efficient functioning of hospitals. However, the absence of accurate, complete, up-to-date, and easily accessible medical records could hinder medical personnel from delivering the most effective treatments, potentially leading to misdiagnoses and unfavorable outcomes. This could have widespread repercussions. Infertility is a pressing public health concern that demands thorough attention. Insufficient or inaccurately collected information could greatly diminish the likelihood of successful conception. Presently, blockchain technology stands out as one of the potential solutions for effective hospital record management. The purpose of this paper is to introduce the concept of an infertility record management system utilizing blockchain technology, incorporating two techniques: User Modelling (UM) and Relevance Feedback (RF). As a result, a prototype of the Infertility Blockchain Model has been developed to simulate a real-life system within the infertility medical department of a local hospital.

Keywords:-*Blockchain Technology, Infertility, Medical Record Management, Relevance Feedback, User Modelling.*

Introduction

Malaysia's Ministry of Health (MoH) has made rapid progress in integrating digital technologies and infrastructures as part of its strategic plan to achieve a standardized digital health agenda. The goal is to create an integrated healthcare system that will provide individuals with extensive healthcare. The Electronic Medical Records (EMR) system is one of the essential digital infrastructures for constructing a digital health ecosystem. Here, EMR need proper management through proper storage areas, controlled access, and adequate preservation measures to improve efficiency, safety, and quality of care. The most common relates to storage, access, safety, and security. The sensitivity of medical records especially on fertility treatment has brought several challenges to managing healthcare providers.

Infertility is a major public health issue. Infertility is widely defined as "the inability to achieve a clinical pregnancy after 12 months or more of unprotected sexual intercourse" [1]. Its affect millions of people of reproductive age worldwide. According to the World Health Organization, about 48 million couples and 186 million individuals live with infertility globally [2,3]. When contemplating various treatment options, concerns pertaining to financial matters, ethical considerations, and legal implications frequently become entangled, leading to unnecessary anxieties. This situation poses significant challenges for couples seeking assistance. The individuals are experiencing both bodily and psychological distress as a result of these superfluous concerns. In certain cultures, infertility is viewed primarily as a female issue, and women who experience infertility are often obliged to endure guilt and disgrace quietly. In Malaysia, for instance, an infertile married woman is shunned, has a lower social status, and is more likely to be divorced by her husband. Infertility has become a taboo subject in Malaysia, and as a result, little is known about infertile Malaysian women. Subsequently, many Malaysian women suffering from infertility are likely to keep their troubles to themselves, owing to a lack of knowledge about where or how to seek assistance[2]. This assistance or treatment requires the fertility data of both couples which involve information pertaining to their sexual, medical, surgical and family history.This data is often private and sensitive in nature, therefore requiring data security and data privacy that ethically and legally acceptable.

The main objective of this paper is to propose a new blockchain model for secured and dynamic infertility medical records management using User Modelling (UM) and Relevance Feedback (RF). The blockchain technology has introduced new ways of application development in a variety of fields include the Internet-of-Things, e-Government, and managing electronic data management. These applications employ blockchain technology and smart apps due to the peer-to-peer network's self-cryptographic validation structure and the public availability of a distributed ledger of transaction records [4].

The structure of this paper is organized as follows: Section 2 discusses on infertility and the techniques to conceive pregnancy. Next section describes about the blockchain technology and its characteristics. Section 4 and 5 explains on the techniques which are user modelling (UM) and relevance feedback (RF) implemented within blockchain technology model. Followed by Section 6 which discusses about the infertility medical blockchain model. In this section, an infertility blockchain model is proposed by implementing user modelling and relevance feedback techniques in blockchain environment. Section 7 is the result and discussion section which presents the prototype model. Lastly, section 8 concludes this paper.

Literature Review

A. Infertility

In the past 50 years, Malaysia's Total Fertility Rate (TFR) for women of reproductive age has dropped significantly, falling from 6.7 births per woman in 1957 to 1.7 in 2021[5]. Among the factors that contribute to this decline statistic are delayed marriage, smaller family sizes due to financial and health reasons, and infertility. This decrease in TFR will lead to a population decline in 2072, causing a shortage of labor and hindering economic growth.

Infertility is generally defined as the inability to become pregnant after a year of trying. Most couples believe they are fertile and anticipate becoming pregnant shortly after discontinuing birth control. However, nearly 10% of women of childbearing age are infertile, and about a quarter will experience infertility at least once during their lives. The majority of couples facing difficulties in conceiving are not necessarily sterile; instead, they are often classified as either infertile or subfertility. This means they have a diminished likelihood of spontaneous conception through the usual means. Individuals grappling with infertility issues often experience profound and complex emotions that can be painful and challenging to navigateThe following are examples of common feelings experienced by many women dealing with infertility, such as confusion, frustration, fear, isolation, guilt, shame, anger, sadness, hopelessness, and loss of control in the relationship.

Two primary techniques are employed to enhance the TFR: intrauterine insemination (IUI) and in-vitro fertilization (IVF) [6]. In both techniques, experts require substantial and well-defined information pertaining to both partners. This information is essential for identifying the underlying causes and formulating the most effective solutions to enhance the couples' likelihood of achieving pregnancy. Both general and physical information, encompassing the patient's medical and sexual history, as well as sperm or egg analysis, play an indispensable role in aiding experts to accurately diagnose their patients. Due to the sensitive nature of these data, ensuring their security, immutability, and storage in a secure medium is of utmost importance.

Infertility is a prevalent issue that can exert both physical and emotional tolls on couples [7]. The integration of blockchain technology into the realm of infertility holds the potential to revolutionize how individuals and couples dealing with infertility can access and manage their medical data. Furthermore, it could enhance communication and collaboration among healthcare providers. By capitalizing on the security and immutability offered by blockchain, patient information can be shared and monitored securely, all while upholding patient confidentiality. Moreover, the implementation of smart contracts can streamline and automate various processes, such as appointment scheduling and treatment progress tracking. Consequently, couples facing infertility challenges could experience improved healthcare access, alongside a more comprehensive and harmonized approach to their treatment journey.In the next section, blockchain technology which is proposed in this paper to provide a better-quality control to the medical data management.

B. Blockchain Technology

A blockchain, in its simplest form, is a distributed database of records or public ledger of all transactions or digital events that have been executed and shared among participating parties. Each transaction on the public ledger is verified by a majority of the system's participants. Additionally, once information is entered, it cannot be deleted [8]. Notably, as illustrated in Figure 1, traditional ledger technologies require a trusted third party, such as a bank. However, Blockchain-based technology operates on a peer-to-peer network, as illustrated in Figure 2, which eliminates the need for a centralized trusted third party to manage transactions. Blockchain is essentially a "distributed ledger or database" in which all transactions involving all parties are recorded. A blockchain is a chronologically ordered series of blocks, each of which can be thought of as a page in a ledger [9].

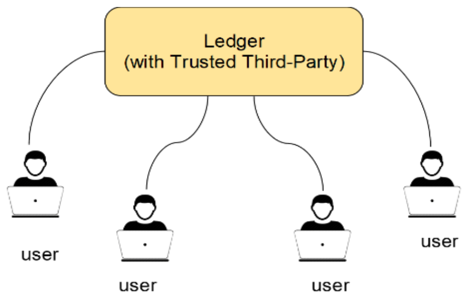

Figure 1: Traditional centralized ledger technology with trusted third-party

A blockchain is made up of data sets, each of which is composed of several blocks/data packages, each of which is composed of a number of transactions, and each block is made up of several transactions. Each additional block adds to the length of the blockchain and, as a result, represents a complete record of the transaction. The blocks can be cryptographically validated by the network as a whole. Each block also contains a timestamp, the hash value of the previous block (referred to as the "parent"), and a random number (a random number for the hash verification). The integrity of the entire blockchain (all the way back to the first or genesis block) is ensured by using this concept. Because the hash values are one-of-a-kind, it would be simple to prevent fraud because the manipulation of any block in the chain would immediately alter the value of the associated hash. Before a block can be added to the chain, the majority of the nodes must agree on the validity of the transactions contained within the related block, as well as the validity of the blocks themselves [10, 26].

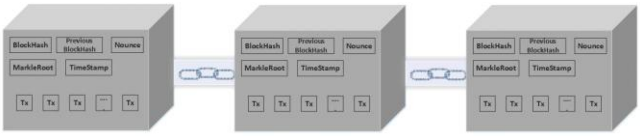

Figure 2: Blockchains in their conventional forms [8]

Blockchain technology has the following primary characteristics: Decentralization is the first priority [11]. A centralized servers are inevitably burdened with additional costs and performance bottlenecks. Unlike the centralized model, the blockchain eliminates the requirement for a third party. Blockchain technology makes use of consensus algorithms to ensure data consistency across a distributed network. Persistency/immutability is the second quality. Once a transaction is recorded on the blockchain, it is nearly impossible to delete or reverse it. If invalid transactions were present, blocks containing them could be discovered almost instantly. Anonymity is the third factor. Each user can communicate with the blockchain via a randomly generated address that conceals the user's true identity. It's worth noting that due to the technology's inherent constraints, blockchain cannot guarantee perfect privacy preservation. Auditability is the final component. Once the current transaction is recorded in the blockchain, any unspent transactions become spent. As a result, transactions can be easily monitored and verified [11].

According to the current consensus, there are three kinds of blockchain systems, which are as follows: public blockchains [12], private blockchains [12], and consortium blockchains [12]. Everyone can participate in the consensus process because all records are visible to the public in a public blockchain. A consortium blockchain, on the other hand, would only have a small number of nodes that were pre-selected to take part in the consensus process. Only those nodes that are part of a specific organization would be allowed to participate in the consensus process if it were a private blockchain. Due to the fact that a private blockchain is completely controlled by a single organization, it is considered a centralized network. The consortium blockchain, which is being built by multiple organizations, is partially decentralized, as only a small percentage of nodes will be chosen to determine consensus. Table 1 compares the three types of blockchains.

Table 1: Comparisons of the public, private, and consortium blockchains

	Public blockchain	**Private blockchain**	**Consortium blockchain**
Read permission	public	Can be public/restricted	Can be public/restricted
Immutability	Nearly impossible to be modified	Can be modified	Can be modified

Efficiency	Low	High	High
Centralized	No	Partial	Partial
Consensus determination	All miners	One Organization	Selected set of nodes
Consensus process	Permissionless	Permissioned	Permissioned

C. User Modelling Technique

User modelling is the process of gathering information about a specific user in order to create a personalised experience that meets their specific needs and preferences [13], [14], [20]. This procedure includes creating, maintaining, and updating the user's profile within the system. User modelling has many applications for making information systems more user-friendly, including information retrieval, filtering, extraction systems, adaptive user interfaces, and instructional software [15]. It is a crucial aspect of information systems that enables the system's behaviour to be tailored to the specific user. Rule-based modelling, statistical modelling, hybrid modelling, case-based reasoning, machine learning, and artificial intelligence are among the techniques utilised in user modelling. Utilizing predefined rules, statistical analysis, past experiences, data learning, and advanced techniques such as reinforcement learning and neural networks, these techniques adapt the system's behaviour to the user [23, 24].

User modelling for medical record management refers to the process of gathering information about healthcare providers and patients in order to create personalized medical records that are tailored to the specific needs and preferences of the users. The goal of user modelling in medical record management is to improve the efficiency and effectiveness of the healthcare system by providing healthcare providers with the information they need to make accurate diagnoses and treatment decisions, and patients with the information they need to manage their own health [15].

User modelling for medical record management employs numerous techniques, including rule-based modelling, statistical modelling, machine learning, and artificial intelligence. These techniques can be used to analyse data from electronic health records (EHRs), medical imaging, and other sources in order to develop user models that represent the knowledge, skills, and preferences of healthcare providers and patients. An instance of user modeling in medical record management involves employing machine learning algorithms to detect patterns within Electronic Health Record (EHR) data. These patterns can then be utilized to forecast patient outcomes or recognize individuals who may be susceptible to particular conditions [16]. Another illustration is the utilization of Natural Language Processing (NLP) to extract details from unstructured textual content in medical records, like progress notes and discharge summaries. This extraction facilitates the development of user models that encapsulate the insights and expertise of healthcare practitioners [17].

Overall, this technique allows expertise to gain information needed to diagnosis their patient to provide solution for infertility issue. Expertise usually takes notes and questionnaire on their patient as they manage one couple per doctor. This will build the trust and security to the patient in order to share their general and private information with the doctor in charge. The EMR allow the doctor to record every information given by the patient which can help the doctor identify the problem and provide solution needed for the couple. Every information is confidential and a system which can build trust while maintaining security, immutability and distributed storage is needed critically. The next technique which is relevance feedback will be explain on the next section of this paper.

D. Relevance Feedback Techniques

Relevance feedback (RF)is critical for retrieval accuracy. It is an iterative process that aids in the improvement of retrieval systems' performance and accuracy. The Relevance Feedback approach requires the user to submit feedback and then present it to the Infertility Medical Record system. When a user submits a query, the system processes it and returns results based on the user's requirements. After the user provides feedback on whether the retrieved results are relevant to his/her query, the system reformulates the relevant results based on the user's feedback and returns more relevant results. Thus, in information retrieval systems, this process is referred to as iteration of Relevance Feedback [18, 20, 25].

One of the techniques used in relevance feedback is query expansion. This technique adds additional keywords to the original query based on the contents of the retrieved documents. This allows the system to include synonyms or related terms that were not included in the original query, which can improve the accuracy of the search results [19].

Another technique used in relevance feedback is pseudo-relevance feedback. This technique assumes that the top-ranked documents from the initial search are relevant and uses them to expand the query. This can be useful when the user's query is too specific or not specific enough, and the top-ranked documents can provide a better understanding of the user's intent [20, 21].

Another approach is relevance feedback based on user behavior. This technique uses the actions of the user, such as clicks, scrolling, and time spent on a document, to infer relevance. This can be useful when the user is not able to provide explicit feedback, and the system can infer relevance based on the user's behavior. Collaborative filtering is another technique where the feedback and preferences of a group of users are taken into account to improve the search results for individual users [22].

EMRs need RF technique to retrieve all the information as accurate as possible. The system necessitates explicit feedback (EF) since all the data provided by the patient holds immense significance in arriving at the optimal solution for their condition. Inaccurate or insufficient data could lead to incorrect diagnoses, causing the patient unnecessary stress and time wastage while awaiting an inappropriate solution.

II. INFERTILITY MEDICAL RECORD BLOCKCHAIN MODEL

Outlined below are the steps to address the specific information pertinent to infertility medical record management, the foundational structure for research and development, and the design of a novel model utilizing blockchain technology, user modeling, and relevance feedback techniques. This innovative approach aims to bolster security through blockchain and deliver precise, timely information. This model's core lies in integrating user modeling and relevant feedback techniques into the infertility-blockchain framework. This strategy is founded on the Ethereum platform and is dubbed the Infertility Medical Record (IMR).

1. **Identifying Essential Information**: To develop the new model, it's crucial to identify the key elements of infertility medical record management. This includes data like patient medical history, diagnostic results, treatment plans, and personal information.

2. **Constructing the Research Framework**: A foundational structure should be created to guide the research and development process. This entails outlining the scope, objectives, and methodologies that will be employed to design and implement the Infertility Medical Record (IMR) model.

3. **Designing the New Model**: The novel model aims to fuse blockchain technology, user modeling, and relevance feedback techniques. This entails architecting a system where patient data is stored securely using blockchain's immutability and tamper-resistant features. User modeling ensures that the patient's historical data and preferences are taken into account, enhancing the accuracy of the system's predictions. Relevance feedback techniques enable the model to continuously learn and adapt based on patient feedback, refining its diagnostic and treatment recommendations over time.

4. **Security Enhancement through Blockchain**: By integrating blockchain, the model enhances security through decentralized data storage, reducing the risk of data breaches. The use of cryptographic techniques further ensures data privacy and integrity.

5. **Accurate and Timely Information**: Through user modeling and relevance feedback, the model aspires to provide patients with accurate and timely information. This not only aids in proper diagnosis but also minimizes stress and reduces the waiting time for effective solutions.

6. **Integration of User Modeling and Relevance Feedback**: The IMR model is built upon the integration of

user modeling and relevance feedback techniques. This fusion allows for a comprehensive understanding of patient history and preferences, leading to more personalized and effective medical solutions.

7. **Ethereum-based Framework**: The Ethereum platform serves as the foundation for the IMR model's implementation. Ethereum's smart contract capabilities enable the automation of various processes, such as data access permissions and feedback mechanisms.

8. **Infertility Medical Record (IMR)**: This coined term represents the culmination of the model's design and implementation, underscoring its innovative nature in medical record management for infertility cases.

In summary, the proposed approach envisions a comprehensive model that leverages blockchain, user modeling, and relevance feedback techniques to transform infertility medical record management. By integrating these elements, the Infertility Medical Record (IMR) model strives to provide heightened security, accuracy, and patient-centric care within the domain of infertility treatments.

Infertility Medical Record (IMR) aims to provide a new dynamic and collaborative blockchain algorithm in infertility medical health record management. By acquiring knowledge and information related to the patients, an accurate profile can be achieved and the return feedback from user and medical officer can help providing an excellent answer to user's need. Privacy and integrity of data must be protected from all malicious activities and human-error issues. Normally, the patient's data is collected from paper and being stored using third-party application which then store into the servers. Blockchain technology help providing security, immutability and avoid centralized storage which help to regain the data if one server is down, the other can help regaining back the data.

The user modeling (UM) technique is used to get user interest and profile in order to filter the answers [23]. User is required to give information needed. Past medical history, past surgical history, drug history, social history, body mass index (BMI) and hygiene is mandatory to be recorded and produce diagnosis before medical officer/experts can provided the best solution or treatment suitable to the infertility patient. Both man and woman are required to undergo the process to increase the chance to conceive a child. In additional, to avoid ambiguity in user's question, relevance feedback (RF) technique is applied in the second phase of question analysis process. The patient is required to give their information as accurate as possible. When the user gives their information into the system, then the data will be recorded into Ethereum blockchain platform. By securing the data using blockchain technology, users can be ease about their data from being mistreated and medical system can interact with each other providing user less time to repeatedly fulfilling all of their medical information where the medical officer from general hospital and private hospital can easily get the information with a single piece of information. Figure 3 shows the illustration of the Infertility Medical Record (IMR) model. To complete the Infertility Medical Record (IMR) model, user modeling and relevance feedback must be applied to the blockchain technology system.

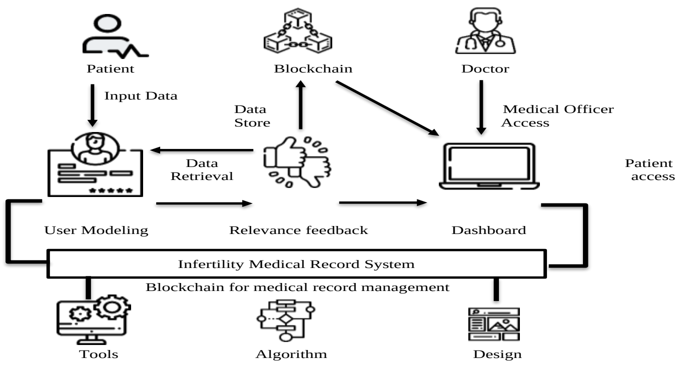

Figure 3: Infertility Medical Record (IMR) model.

Result And Discussion

For a start, a basic prototype of the proposed approach as mention above is developed. The assessment environment comes first, then a smart contract's functionality is evaluated based on gas use. The prototype also implemented the two techniques, UM and RF to check if the combination of the techniques can be implemented

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and combine within blockchain environment. Later on, a set of criteria to evaluate and measure data uploading and storage on the blockchain, query response (i.e., performance), and algorithmic execution (i.e., efficiency) for the prototype.

The result is tracked using a set of hardware and software resources called the evaluation environment. On the hardware side, assessment trials on the Windows Platform use queries of general information of the patient, appointments with the doctor, and access to the patient's data by the doctor in charge (core AMD Ryzen 9 4900HS with 16 GB of runtime memory). In the software industry, a testing method called execution evaluation or evaluation scripts is used to test systems automatically. Equivalent scripts were written in NodeJS and executed in Visual Studio Code by means of the ReactJS programming language. Several pre-existing libraries, including react, ganache and web3 were also utilized during the evaluation process.

For this prototype, a service called Infura is utilized, which is a public Application Programming interface (API) that provides the user with access to a node hosted on the Goerli network by Infura, as opposed to utilizing a local full Ethereum node, which required a significant amount of time and effort to set up. Beyond web3.0, Infura is essentially a portal into the Goerli network. The provider is then thrust into Web 3.0 and given the network instance with which it must interact. To implement the smart contract, the provider must have an ether-containing Mnemonic Account on the Goerli network. Mnemonic Account refers to the 12-word phrase provided by Metamask when a user first created an account. The provider is then issued a Mnemonic Account, which is used to deploy the smart contract in web3.0. Web 3.0 instance makes possible the deployment phase for smart contracts. The browser extension Metamask [27] was used to connect the distributed web. The Metamask plugin act as a Mnemonic account linked Ethereum accounts on the Goerli test network to the Infura API, which then executed system operations using the gas transaction cost [28].

In this prototype, user or patient is required to create a profile for them. This prototype starts with general information to test this simulation to be include in the Ethereum blockchain platform. Since current prototype do not have access to doctor, the prototype requires the doctor to make their own profile. Both user profile can be edit themselves [29]. Next the doctor will create an appointment for their patient and the patient will get notified within their profile. In this simulation, the patient can protect their data from being misuse by giving them the ability to allow or revoke the doctor’s access to the patient’s information. Patient and doctor also can check their own record list for their appointment schedule [30]. Finally, on the dashboard, the number of patients, doctors and appointment created within the web. For each profile and appointment created, the fuel must be purchased. Gwei is the smallest unit of Ether, the cryptocurrency of the Ethereum network used to measure fuel consumption Gwei is made up of 10^9Wei. A pop-up from Metamask plugin will be shown to verified the transaction in order that the data will be included in Ethereum blockchain. Since the prototype system runs on the Ethereum platform, each transaction or data transfer for uploading general information about a patient costs Ether. The task is completed successfully, as shown in Figure 4.

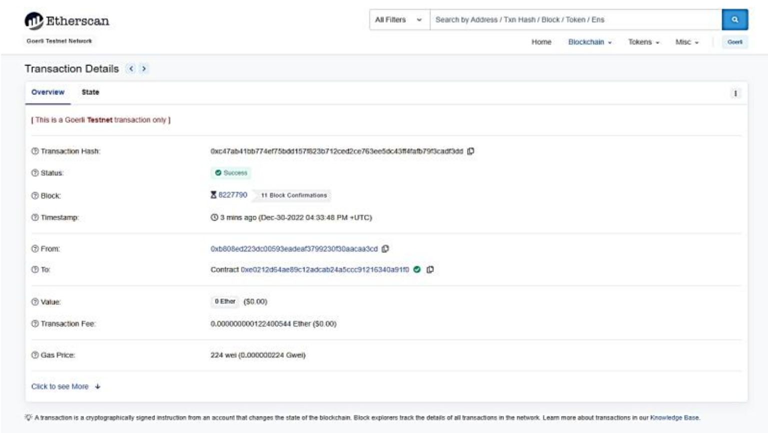

Figure 4: General information related to patient submitted into Goerli test network in Ethereum platform

Conclusion

The application of decentralization and system traceability receive considerable attention. The public's awareness of the sensitivity of their health care institution data has increased. As mentioned in the previous sections, the proof-of-concept architecture model for the proposed system has been presented as an infertility blockchain model using user modelling and relevance feedback for medical record management. The prototype system has been deployed on a smart contract-enabled Ethereum blockchain test network with permission. This article discusses the global infertility problem, including Malaysia, as well as the prototype of a blockchain-based system for securing infertility medical data record management and the techniques used to implement blockchain environments. Using on-chain storage, the relevant smart contracts in the paper made use of on-chain storage. Individual Ethereum addresses within the system contain the self-sovereign identities of the participants, as well as re-encryption and any pertinent data.

The proposed method not only gives patients their appointment, but it also gives them access to an immutable medical database. This results in improved productivity, data provenance, and audit effectiveness. Due to the fact that the method of storing data and exchanging it is decentralized, there is no need for any administrative entities or third parties to act as middlemen. In addition, two techniques are use in the blockchain architecture design for information gathering and retrieval. The first technique is user modelling technique allow the system to gather the information critically needed about infertility patient help to generate a personalized answer from user to identify problems and find the best solution for them. The second technique is a critical for retrieval information accuracy and the process is iterative that aid in the improvement of retrieval system's performance and accuracy.

As a result, the current prototype solution will be upgrade with a thoroughly details that the patient needs to fill up to create solid user profile that allow medical officer or infertility expert to provide diagnosis. Only appointed medical officer or infertility expert that allow to access their patient without interfering with other patient unnecessary. Multiple parties can safely access the web using blockchain Ethereum encryption. The data uploader will begin by encrypting the data with a symmetric secret key before proceeding further. In the smart contracts, only the hash of the encrypted data will be stored, and this hash will later be uploaded to web3.0. Patient can view their appointment with the appointed doctor and view their diagnosis based on the information they give in user profile. The patient will keep the private key, while the public key will be sent along with a request and used by the doctor. The patient will then use his or her private key to decrypt the secret key and obtain the symmetric secret key. Finally, the doctor will use the symmetric key to decrypt the patient content.

Acknowledgement

This research was supported by Ministry of Higher Education (MOHE) through Fundamental Research Grant Scheme (FRGS) for grant with VOT: FRGS/1/2021/ICT03/UNISZA/02/3(UNISZA: RP404)) and Universiti Sultan Zainal Abidin (UniSZA), Malaysia

A sincere thanks to all authors: Assoc. Prof. Dr. Syarilla Iryani Binti Ahmad Saany as the FRGS's leader and the grant members Prof. Ts. Dr. Mokhairi Bin Makhtar, Prof. Dr. Mohd Nordin Bin Abdul Rahman, Dr. Julaily Aida Binti Jusoh, Assoc. Prof. Ts. Dr. Yousef Abubaker Mohamed Ahmed El-Ebiary and Dr. Malini Binti Mat Napes as well as Mr. Mohd. Airil Solehan Bin Johari as the FRGS postgraduate student (GRA). Special thanks also go to all collaborators from UniSZA for networking and technical support in proofreading for spelling errors and synchronization inconsistencies.

References

[1] Macaluso, Maurizio & Wright, Tracie & Chandra, Anjani & Johnson, Robert & Satterwhite, Catherine & Pulver, Amy & Berman, Stuart & Wang, Richard & Farr, Sherry & Pollack, Loria. (2008). A public health focus on infertility prevention, detection, and management. Fertility and sterility. 93. 16.e1-10. 10.1016/j.fertnstert.2008.09.046.

[2] Ibrahim, Noorfaizah & Mohamed, Salina & Ismail, Zaliha & Salleh, Mohd. (2020). Psychological distress and quality of life of Malaysian infertile couples. International Journal of Reproduction, Contraception, Obstetrics and Gynecology. 10. 61. 10.18203/2320-1770.ijrcog20205755.

[3] World Health Organization (WHO). International Classification of Diseases, 11th Revision (ICD-11) Geneva: WHO 2018

[4] Razzaq, A., Mohsan, S. A. H., Ghayyur, S. A. K., Al-Kahtani, N., Alkahtani, H. K., & Mostafa, S. M. (2022). Blockchain in Healthcare: A Decentralized Platform for Digital Health Passport of COVID-19 Based on Vaccination and Immunity Certificates. Healthcare (Basel, Switzerland), 10(12), 2453. https://doi.org/10.3390/healthcare10122453

[5] Mohd Yusrizal Ab Razak. (2021). Department Of Statistics Malaysia, Press Release, Vital Statistics, Malaysia, 2021.

[6] Zhong, Yiping & Li, Jin & Ying, Ying & Haitao, Wu & Zhou, Canquan & Xu, Yanwen & Wang, Qiong & Li, Jie & Xiaoting, Xiaoting. (2012). The efficacy of conversion from IUI to IVF-ET in infertility patients with hyper-response to ovulation induction: A retrospective study. Biomedical papers of the Medical Faculty of the University Palacký, Olomouc, Czechoslovakia. 156. 159-63. 10.5507/bp.2012.044.

[7] Podolska, Magdalena & Bidzan, Mariola. (2011). Infertility as a psychological problem. Ginekologia polska. 82. 44-9.

[8] Crosby, M., Pattanayak, P., Verma, S. and Kalyanaraman, V. (2016) Blockchain Technology: Beyond Bitcoin. Applied Innovation, 2, 71.

[9] Nakamoto, S. Bitcoin: A Peer-to-Peer Electronic Cash System. 2008. Available online: https://bitcoin.org/bitcoin.pdf (accessed on 10 September 2020)

[10] M. Nofer, P. Gomber, O. Hinz, and D. Schiereck, "Blockchain," Business & Information Systems Engineering, vol. 59, pp. 183-187, 2017.

[11] Zheng, Zibin & Xie, Shaoan & Dai, Hong-Ning & Chen, Xiangping & Wang, Huaimin. (2017). An Overview of Blockchain Technology: Architecture, Consensus, and Future Trends. 10.1109/BigDataCongress.2017.85.

[12] D. Lee Kuo Chuen, Ed., Handbook of Digital Currency, 1st ed. Elsevier, 2015. [Online]. Available: http://EconPapers.repec.org/RePEc:eee:monogr:9780128021170.

[13] Quarteroni, S. (2010). Personalized Question Answering. TAL, 51(1), 97-123.

[14] Quarteroni, S. & Manandhar, S. (2009). Designing an Interactive Open-Domain Question Answering System. Journal Language Engineering, 15(1), 73-95.

[15] Ehrenstein, V., Kharrazi, H., Lehmann, H., & Taylor, C. O. (2019, October 1). Obtaining Data From Electronic Health Records - Tools and Technologies for Registry Interoperability, Registries for Evaluating Patient Outcomes: A User's Guide, 3rd Edition, Addendum 2 - NCBI Bookshelf. Obtaining Data From Electronic Health Records - Tools and Technologies for Registry Interoperability, Registries for Evaluating Patient Outcomes: A User's Guide, 3rd Edition, Addendum 2 - NCBI Bookshelf. Retrieved January 12, 2023, from https://www.ncbi.nlm.nih.gov/books/NBK551878/

[16] Ali Aliabadi, Abbas Sheikhtaheri, Hossein Ansari, Electronic health record–based disease surveillance systems: A systematic literature review on challenges and solutions, Journal of the American Medical Informatics Association, Volume 27, Issue 12, December 2020, Pages 1977–1986, https://doi.org/10.1093/jamia/ocaa186

[17] Stephen B. Johnson, PhD, Suzanne Bakken, RN, DNSc, Daniel Dine, BA, Sookyung Hyun, RN, DNSc, Eneida Mendonça, MD, PhD, Frances Morrison, MD, MPH, Tiffani Bright, BA, Tielman Van Vleck, BA, Jesse Wrenn, BA, Peter Stetson, MD, MA, An Electronic Health Record Based on Structured Narrative, Journal of the American Medical Informatics Association, Volume 15, Issue 1, January 2008, Pages 54–64, https://doi.org/10.1197/jamia.M2131

[18] Belkin, Nicholas & Cool, Colleen & Head, J. & Jeng, Judy & Kelly, Diane & Lin, Shin-jeng & Lobash, L. & Park, Soyeon & Savage-Knepshield, Pam & Sikora, Cynthia. (1999). Relevance Feedback.

10.1007/978-0-387-39940-9_931. Hamid, Anmol. (2017). Relevance Feedback in Information Retrieval Systems.

[19] Saany, A., & Iryani, S. (2014). Question analysis model using user modelling and relevance feedback for question answering.

[20] Raman, Karthik & Udupa, Raghavendra & Bhattacharyya, Pushpak & Bhole, Abhijit. (2010). On Improving Pseudo-Relevance Feedback Using Pseudo-Irrelevant Documents. 573-576. 10.1007/978-3-642-12275-0_50.

[21] M. Nofer, P. Gomber, O. Hinz, and D. Schiereck, "Blockchain," Business & Information Systems Engineering, vol. 59, pp. 183-187, 2017.

[22] Fischer, G., (2001). User Modeling in Human–Computer Interaction., User Modeling and User-Adapted Interaction, 11(1), 65- 86.

[23] Fink, J & Kobsa, A., (2002) User Modeling for Personalized City Tours., Artificial intelligence review, 18(1), 33-74.

[24] I. Ruthven and M. Lalmas, “A survey on the use of relevance feedback for information access systems,” The Knowledge Engineering Review, vol. 18, no. 2, pp. 95–145, 2003

[25] Sabah, Sana & Mahdi, Nada & Majeed, Israa. (2019).The road to the blockchain technology: Concept and types. Periodicals of Engineering and Natural Sciences (PEN). 7. 1821-1832. 10.21533/pen. v7i4.935.

[26] MetaMask. Available online: https://metamask.io/ (accessed on 25 December 2022)

[27] Y. A. B. El-Ebiary, S. Almandeel, W. A. H. M. Ghanem, W. Abu-Ulbeh, M. M. M. Al-Dubai and S. Bamansoor, "Security Issues and Threats Facing the Electronic Enterprise Leadership," 2020 International Conference on Informatics, Multimedia, Cyber and Information System (ICIMCIS), 2020, pp. 24-28, doi:10.1109/ICIMCIS51567.2020.9354330.

[28] Y. A. Baker El-Ebiary et al., "Blockchain as a decentralized communication tool for sustainable development," 2021 2nd International Conference on Smart Computing and Electronic Enterprise (ICSCEE), 2021, pp. 127-133, doi: 10.1109/ICSCEE50312.2021.9497910.

[29] Y. A. Baker El-Ebiary et al., "Track Home Maintenance Business Centers with GPS Technology in the IR 4.0 Era," 2021 2nd International Conference on Smart Computing and Electronic Enterprise (ICSCEE), 2021, pp. 134-138, doi: 10.1109/ICSCEE50312.2021.9498070.