Blood Management System based on Blockchain Approach: A Research Solution in Vietnam

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***Abstract*— More and more new health care solutions are born based on the development of science and technology. The subjects who benefit the most, in this case, are not only patients (i.e., shorter healing time, faster recovery) but also medical staff, e.g., doctors/nurses (i.e., easy monitoring of the patient's recovery process, proposing new treatment). However, there are still products that have not found an alternative: blood and blood products. Regardless of how science and technology can affect all aspects of patient treatment as well as medical care, blood still plays an important role in the treatment method. In addition to the above, blood and blood products may only be obtained from volunteers (i.e., blood donors). The preservation process is also very difficult, and no medical facility has enough facilities to preserve them. Therefore, the current process of blood preservation and transportation is done manually and contains many potential risks (e.g., data loss, personal information collection). In addition to the above barriers, developing countries (including Vietnam) also face many difficulties due to limited facilities. It is for this reason that this paper aims at a Blockchain-based technology solution for efficient management and distribution of blood from blood products. On the one hand, the paper contributes to the limitations in the information management process of storing and transporting blood and its products in the traditional database being applied in medical facilities in the cities and provinces in the Mekong Delta (the West-South of Vietnam). On the other hand, the article offers technology-based solutions to increase transparency and reduce the fear of centralized data storage (i.e., security and privacy issues). We also implement a proof-of-concept to evaluate the feasibility of the proposed approach.**

Keywords*—Blood donation in Vietnam; blockchain; hyperledger fabric; blood products supply chain

I. INTRODUCTION

There is no denying in the contribution of technology in the treatment of diseases today. Specifically, it increases the patient's ability to recover after treatment and reduces the risk of human error. In parallel with those positive aspects, new diseases always appear with more dense frequency and more dangerous toxicity for patients (e.g., Covid-19). For this reason, treatment and health care procedures have changed dramatically from the same time period ten years ago. However, some products cannot be replaced in the treatment process regardless of the development of science and technology [1]. One of the prime examples of this type of product is blood. Indeed, blood and its products are important medical resources in long-term treatment as well as in emergencies [2], e.g. blood is often required for trauma victims, surgery, organ transplants, childbirth and for patients being treated for cancer, leukemia and anemia. Each unit of blood is very precious and gives hope to the patient. For example, a liter of blood can sustain the life of a premature baby for two weeks; 40 or more units of blood may be required for the survival of an accidental blood loss trauma victim, or eight platelets per day are the minimum level for the treatment regimen of blood cancer patients.

In addition to the irreplaceable requirements in the treatment of diseases, the supply of blood is extremely limited because only donated blood is used instead of other substitutes due to a number of medical reasons. Besides, the requirements on time of use are also very strict to ensure the safety of the recipient. Specifically, blood and its products cannot be stored for long periods of time. Red blood cells must be used within 42 days of collection. Meanwhile, platelets have a shelf life of five days of collection. On the other hand, checking blood group similarities between blood donors and recipients is extremely strict. In particular, all blood collected must be rigorously tested to reduce the risk of transmission of infection by blood transfusion (e.g., hepatitis B and C (HBV - HCV) or human immunodeficiency virus (HCV) (HIV)) before transmission to the recipient [3]. All three of the above reasons are the main reasons for the shortage of supply according to Chapman et al. [4]. The above article also shows that the best way to optimize the use of blood and blood products is to save the amount of blood that can be received from the donor.

In addition to the above obstacles affecting the blood supply chain management process, time requirements are also extremely important. Specifically, no one expects blood, but if it's not available when it's needed, the consequences can be deadly. While donors may tell you there's no better feeling than saving a life, only about 5% of eligible donors actually donate [5]. Therefore, maximising the amount of blood stored in the warehouse is imperative.

In addition to the above barriers, one of the main obstacles in blood collection and storage for developing countries is supply (i.e., volunteers still do not have a positive attitude towards blood donation) [6], and infrastructure and database management system (DBMS) for blood and its products' storage [7]. Vietnam is also on the list of developing countries and suffers from a shortage of supply. As far as we know, there is only one hematology hospital that supplies blood to the whole Mekong Delta. This article focuses on the second issue (i.e., infrastructure and DBMS) rather than increasing citizen blood donation behaviour-aware. Therefore, in the scope of this article, we only focus on technology solutions to improve the current management system as well as change from the centralized to the decentralized storage system. In particular, we aim to share donor data in a controlled manner; for example, reduce the medical declaration time from the second blood donation onwards. Indeed, each user can only donate blood at least 28 days after their previous blood donation (i.e., about a month) [8]. Hence, previously stored information must be stored decentralized, and volunteers can donate blood at a different location without providing the previous information.

In addition, data sharing among the hospitals and blood donation clinics makes donor management easier. Health workers have more options in contacting volunteers for the next blood donation, thereby promoting the blood donation movement in the community. To solve the second problem, we want to verify blood and blood products to achieve transparency-proof. As storage conditions (e.g. temperature, humidity) and storage time vary depending on the blood product collected. The storage and transportation of blood and blood products from storage to hospital (or vice versa) makes it difficult to identify relevant information, including time, location, health notes, and so on. To address the above issues, many methods have proposed blockchain technology to increase the transparency and traceability of information storage. There are several benefits of the blockchain approach proved in the management system. For instance, Cash-on-Delivery (COD) exploited the smart contract to set up the contract compliance among the stakeholders [9], [10], or define the shipper participant role in the marketplace [11], [12]. Moreover, in the Healthcare system, the patient can control the permission to show the necessary information to the authorized partner (e.g., nurse, doctor) [13], [14] or define the emergency between the medical staff and patient's friend or relative [15], [16] Besides, data stored decentralized is also a plus point compared to the current traditional storage model. Where all data is shared and easily traceable to identify the source of blood and blood products, however, current models cannot fully address the requirements for storing different information about blood and its products [17], [18] for proper storage (i.e., shelf-life of usage, temperature, humidity). Furthermore, there has not been an in-depth study to assess the appropriateness of the application of advanced technologies in supply chain management w.r.t. blood and its products in Vietnam. To address these problems, this paper proposes blood and its product management process by applying blockchain technology and decentralized storage for medical facilities in Vietnam.

The contribution of this article is three-fold: i) analyzing the current management mechanism of blood and its products in the provinces and cities in the Mekong Delta (southern Vietnam); ii) proposing a solution to manage the supply chain of blood and blood products based on blockchain technology; iii) implement the proposed model based on Hyperledger Fabric platform and evaluate their feasibility.

Following this introduction, the state-of-the-art is presented in Section II to summarize blockchain-based blood supply chain system approaches as well as that system for blood and its products management in Vietnam. Then, we analyze the current blood and the supply of its products chain system and our architecture before presenting the execution algorithm in Sections III and IV, respectively. Section V focuses on the analysis and evaluation. The following section presents the discussion of this article. Finally, suggestions for future research and conclusion are made in the last section.

II. Related Work

A. Blood Supply Chain Management Systems not Applying the Blockchain Technology

Supply chain management integrates core business processes and information. These processes use a central server to handle visibility and traceability issues. The system combines a very complex process that requires synchronization of different operations, leading to randomness and supply chain risk [19], [20]. For example, Nagurney et al. [21] proposed a model to minimize costs and risks by expressing the breakdown properties of blood as supply coefficients. Armaghan and Pazani [22] proposed a blood supply chain to handle urgent requests from blood units during the Iran earthquake. The authors build a multi-level, multi-objective model to find an optimal route based on the selected routes to transport blood. The main contribution of [22] is to reduce the cost of the blood supply chain network and maximize reliability. In addition, Eskandari-Khanghahi et al. [23] have developed a model that provides a combination of integer mixed linear programming while considering location, allocation, inventory, and distribution. On the other hand, Delen et al. [24] have integrated GIS (geographic information systems) and data mining techniques to build blood supply chain processes. The main purpose of [24] work is to build an optimal blood transport model to be applied in the military environment.

One disadvantage of centralized storage in the above approaches is transparency [25]. To address this issue, Lam et al. [26], [27] demonstrated the implementation of a micro services-oriented software architecture for middleware that collects, stores, and traces data in a centralized manner in order to provide data analysis. To apply these advantages, a centralized blood donation management solution has been proposed in [28]. This approach not only reduces the amount of information collected from blood donors but also improves the efficiency of blood donation management.

B. Blood Supply Chain Management Systems based on Blockchain Technology

Trieu [17], and Nga [18] propose a cold-blooded supply chain system based on Hyperledger Fabric called BloodChain. The proposed system supports the verification of blood-related transactions from donors to recipients. Moreover, BloodChain allows displaying the necessary information during the blood donation process. Specifically, the actors in the system only receive enough information to verify information about donors as well as recipients. Similarly, Lakshminarayanan et al. [29] propose a blood supply chain management system based on Hyperledger Fabric. Similar to BloodChain, it also ensures transparency of donated blood by tracking blood units between donors and recipients. Moreover, Toyoda et al. [30] have integrated the RFIDs into the blood bags using the EPC stored in the tag. This integration helps to ensure reliability and avoid tampering by tracking products and checking their tags.

However, there are some limitations to the aforementioned solutions. For example, the verification of the system proposed in [18], [17] is incomplete due to the lack of evaluation analysis. Moreover, they ignore the mobility role of the blood/its product, which exploits the transportation company [31] or shipper [32]. In particular, the blood and its product must be received from several mobility resources (e.g., mobile blood collection units, medical clinics) and stored at the blood bank/hematological hospital. Therefore, the role of transporter[33] is vital in blood donation environments. Furthermore, the monitoring solution proposed in [30] is limited to monitoring blood bags only, and it does not guarantee the traceability of blood components (i.e., red blood cells, platelets, white blood cells, platelets and plasma). Since different blood components have different shelf lives and storage temperatures, the order of user preference should also be considered.

III. The Blood Donation Traditional Process

A. The Current Blood Donation Process in Vietnam

To get the most unbiased view of the traditional blood donation and blood handling process, we collected information about the process in hospitals and healthcare facilities in the Mekong Delta, Vietnam. We conducted a short interview with the medical officers working at the hematology hospital in Can Tho, which supplies blood and blood products to hospitals and healthcare facilities not only in Can Tho city but also in neighbouring provinces (e.g., Vinh Long, Ben Tre, Hau Giang).

Fig. 1 presents the current blood donation process. In particular, the donors are able to donate blood through four ways, including medical clinic, mobile blood collection unit, medical facility (e.g., hospital), and hematology hospital. Except for the second blood donation method (i.e., mobile blood collection unit) which is held in public places for a short time (usually 1 day), donors can donate blood at any time at the three remaining medical facilities. For blood donation at the medical clinic and mobile blood collection unit, the collected products are transferred to the storage facility at the hematology hospital. Here, blood is separated into several components including plasma, red blood cells, white blood cells, and platelets, and then stored according to the specific conditions of the blood product (e.g., temperature, humidity, duration). For the two remaining ways of donating blood, the collected blood does not need to go through a transportation step because these medical facilities have the facilities/equipment to conduct separation and storage. Finally, the blood and its products are delivered to the hospital for recipients. All these steps are performed manually and stored locally at each location (e.g., hematology hospital, medical clinic, hospital).

Although the traditional approach is simple and easy to apply to all medical facilities because it does not require high support technology as well as easy to deploy in a practical environment. However, the above approaches face many inherent risks for systems based on centralized management. Verifying the reliability of the data is admissible to this approach. In particular, any data displayed is only taken from the data available in the database, which is provided by the central server. Moreover, the important information that affects the treatment process can be lost if the central server is hacked. This is an extremely dangerous thing for medical/healthcare organizations. Due to these dangerous risks, it is urgent to find a decentralized storage solution as well as increase the authenticity of data. Blockchain technology can fulfil both of these issues. The next sections will detail the blockchain-based management models to address the current blood management model.

B. The Process Requires Blood and its Products

This procedure outlines the basic steps for transferring blood from hematology hospitals to hospitals when blood is in short supply or in an emergency (e.g., platelet request). Fig. 2 shows the procedure for requesting blood when a specific type of blood product (e.g., platelets) is needed. New blood recipients go to hospitals or healthcare centers for treatment as a first step. We assume that the requested amount of blood/its products is a rare blood type or that the treatment site has no corresponding blood/blood product. To solve this request, the medical center/hospital sends a request to the hematology hospital to find the corresponding blood/blood product source. At this point, the medical staff will find candidates based on the previous list of donors. They filter information by matching requests received from lower-level hospitals with information available from donors in the system. As a next step, medical staff at the hematology hospital contact the selected candidates to determine if they can donate blood (with a pre-set time). After selecting potential candidates (at least two people), the medical staff conducts a health assessment and blood tests to rule out those with weak health or blood problems at the time request point. Finally, they selected a single candidate to draw blood and transferred it to the respective treatment facility.

C. Limitations of the Two Traditional Processes

As described in the Introduction (i.e., Section I), all data is stored and managed centrally. The information is easily attacked by malicious users resulting in data loss. In addition, it is difficult to evaluate the stored information because all blood/its products data is displayed from the information stored in the central server. In terms of management processes, health care systems lack linkage, i.e., only supporting the link between hematology hospitals and lower-level hospitals. Hence, it is difficult to take advantage of the available blood volumes in the system. All requests are handled single-line (i.e., send directly to the hematology hospital) when an emergency occurs. Information about donors and recipients is easily stolen.

IV. Approach

A. Blood Donation Process based on Blockchain Technology

The biggest difference between the proposed model based on blockchain technology and the traditional model is that all data and retrieval requests are stored in a distributed ledger. Specifically, Fig. 3 shows the storage process of the stakeholder who has a role in the system, i.e., medical facilities (e.g., hospital, medical clinic or hematology hospital); donors; blood products (e.g., red blood cells, white blood cells, platelets); transportation; and blood bank. All data related to blood/blood products are stored, but also all requests for data retrieval from relevant parties (e.g., healthcare workers, carriers) are stored in a log book. dispersion one. This increases transparency for the whole system. Data owners easily know which users can access their data. As for blood records, all information about donors is stored in a distributed ledger. Information about blood type, time, date, and other preservation information are all stored and processed in a decentralized form. Thereby, medical facilities can retrieve and confirm data related to the treatment process. Besides, the data of medical centers/hospitals is also very

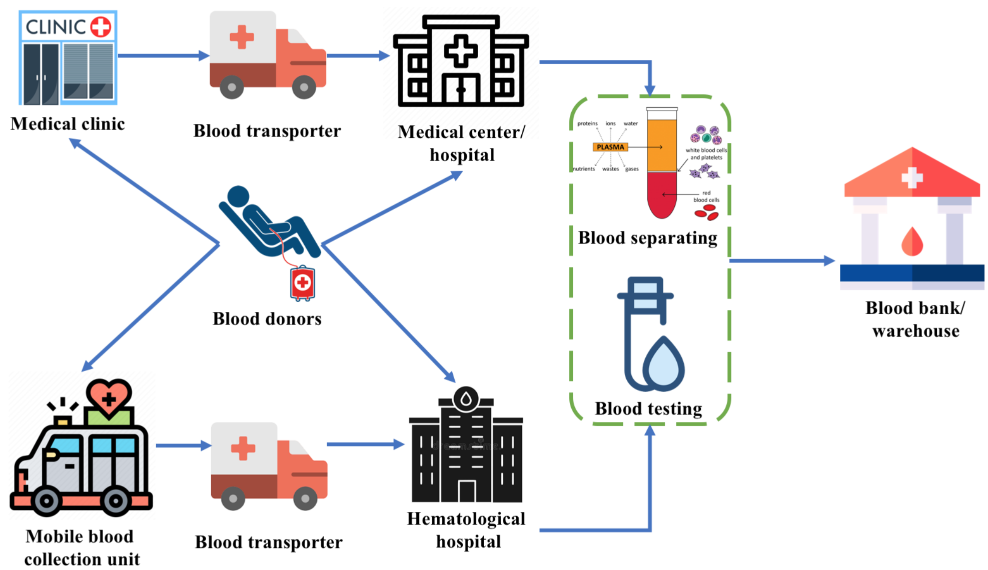

Fig. 1. The Current Blood Donation Process.

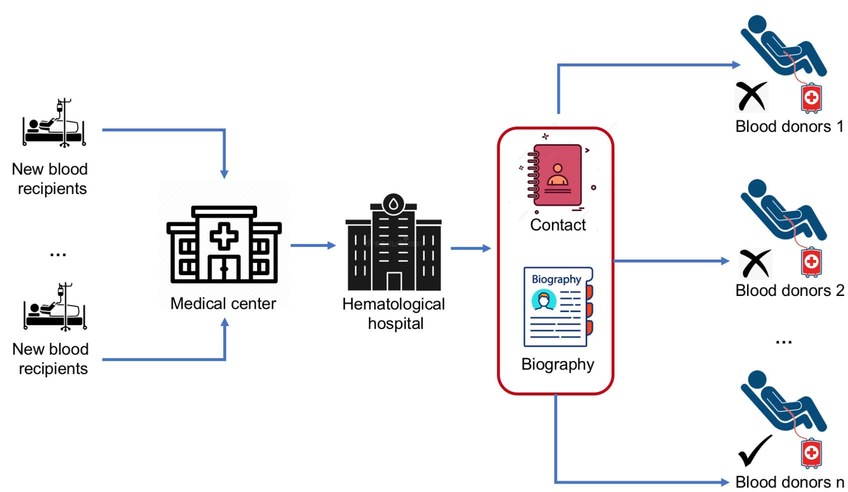

Fig. 2. The Current Blood Request Procedure

important. Instead of local storage, our proposed model is towards a decentralized model, where data can be shared for healthcare purposes. Specifically, medical centers/hospitals can exchange information on blood volume and blood products that can be shared in an emergency, reducing requirements for hematology hospitals. On the other hand, information about donors donated at one medical facility in the past can be easily retrieved by another facility, thereby increasing the quality of treatment for patients.

Fig. 4 details the process of sharing donor data between different health facilities. Specifically, basic information (i.e., biography) about addresses and phone numbers is shared for health care purposes. In addition, information about the amount of blood in stock is shared with other medical facilities. In addition, the conversion process is always up to date if there are any shipping requirements for healthcare purposes. However, the results of donor blood tests are not shared in the current model to limit privacy violations. The information shared by donors is only related to health care needs. In unsatisfactory blood test results, the donor's personal data will be deleted from the distributed ledger. We do not support off-chain executions (i.e., out-of-scope) in the current approach, so data sharers (i.e., medical officers) must secure on-chain data uploads.

B. Algorithms

In the proposed blockchain-based system, we have two main algorithms to control the process. As explained in Section IIB, our methods apply the Hyperledger Fabric platform to conduct the transactions. Moreover, due to these approaches are suitable for a hybrid business environment [32], we exploit JavaScript format for the information structure and the blockchain system for the process structure below::

```
bloodRecords = {
"donorID": donor ID,
```

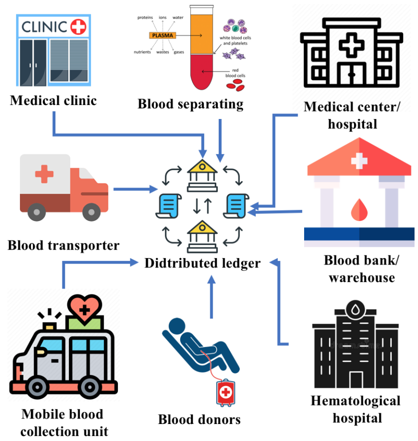

Fig. 3. The Distributed Storage of Blood Donation Process.

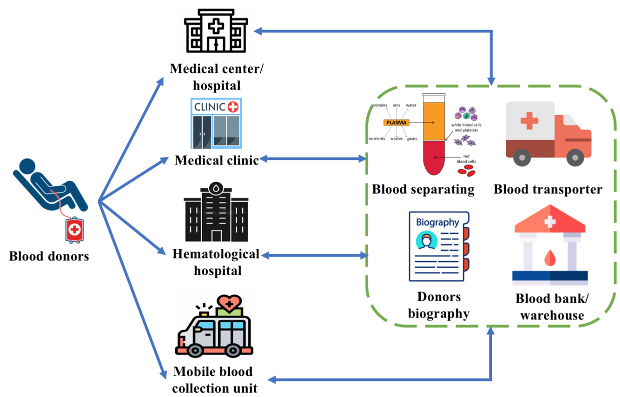

Fig. 4. The Blood Donation Process based on Blockchain Technology.

```
"bloodID": blood and its production ID,
"bloodGroup": blood group,
"bloodProduction": blood production,
"temp": temperature,
"humidity": humidity,
"time": time,
"date": date,
"duration": duration,
"state": 0,
"medicalFacility": locate of medical facility,
"amount of blood unit": 350
};
```

This section targets two main algorithms, including Algorithm 1 describing the data creation to store the blood and its products; whereas Algorithm 2 presents the delivery of blood samples from the donation place to the hematological hospital/medical facility).

Algorithm 1 present all the steps to collect the data relate to donors, blood and its product, storage requirement as well as their metadata (date, time). Blood and its products, once collected, are identified by the donorID of the respective donor. Each blood and its item has a distinct bloodID. This data is unique and not repeated in the ledger; the blood is then stored at the blood bank or the other facility of medical with the identity info being donated. Finally, all the collected data (i.e., blood and its products, their metadata) have updated the status in the ledger.

Algorithm 1 The Blood and its Products Data Creation

Input: Donor ID, blood group, blood production, blood donation metadata (i.e., time, date), storage requirements (i.e., temperature, humidity, duration), and blood unit amount
Output: all the related data is stored in the ledger
for blood unit and its metadata **do**
  storing all the blood unit and its metadata to the ledger;
end for

Algorithm 2 shows process of blood and its product delivery from the blood bank or donation place to the recipient (i.e., patient) or clinical center. This process may transfer among the medical facilities in emergency situations. Since the time of storage is limited, they first update the time of remaining usage and then select the oldest one to transfer the destination (i.e., other facilities or recipient). To speed up this process, the shipping company selected and detect the destination address. During the transportation process, the stakeholders are allowed to update the status of the blood units. In particular, the transportation process received several inputs namely, the shipping unit's information, blood units as well as its metadata and the output is the delivery data (time, date, address) and the updated institution of the clinical center (corresponding ID_Center).

Algorithm 2 Delivery of Blood and its Product from Donation Places (e.g., Medical Clinic) to Blood Storage (e.g., Blood Bank)

Input: the blood delivery unit's data
Output: the blood delivery' data
for delivery unit **do**
  for blood and its products **do**
    Blood_Unit_ID
  end for
  for blood and its products **do**
    update the new location of the medical center
  end for
end for
return Encrypted hash

V. Evaluation

A. Environmental Setting

Our proposed framework is deployed in the Hyperledger Fabric platform. We simulate the environment requirement inside docker containers. This section measures the chaincode's performance of the two scenarios in the algorithms (see Section IV-B), namely initializing and querying data. The experiments are deployed on Ubuntu 20.01 configuration, Core i5 with 2.7Ghz and 8GB RAM.

To collect all information related to the performance, we exploited the Hyperledger Caliper[1]

[1]Hyperledger Caliper deploys the test situations and gathers all the data with respect to the execution. See more related information in this link https://www.hyperledger.org/use/caliper

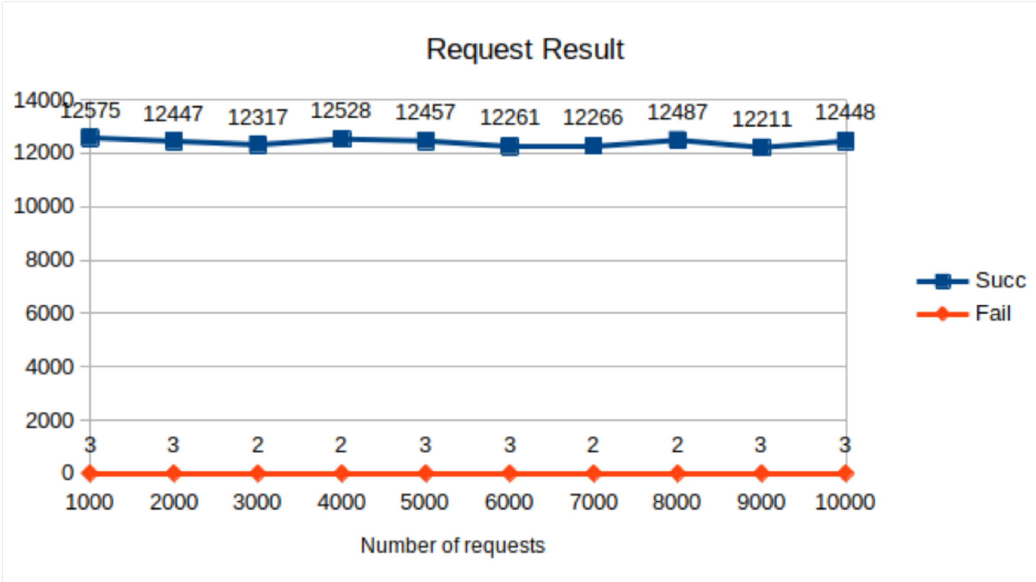

Fig. 5. The Results of the Create Data Functions.

B. Execution Time

In the data creation execution, we measure how long to response time (i.e., seconds) is to create a data request function. In this case, for each worker, they initially created 1000 requests for each second in the system. We stop at 10,000 requests for each second. The #requests are then consistently transferred to the system (i.e., at most 2 minutes of waiting) and slowly rise by 1,000 requests for each performance test until 10,000 requests/s. All the results of these executions are recorded and presented in Fig. 5. From this figure, we are able to detect that the #requests w.r.t successful execution is high compared to the other ones (especially the failed requests are tiny). In fact, the number of successful execution requests is higher than 12,000 request/s; in contrast, this amount of unsuccessful ones is a range of 2-3 requests.

Fig. 6 shows the outcomes of requests measurement that execute the update methods for blood and its products. #Workers rose by 2 in this attribute which is higher than the beginning data creation requests; the number of requests. In the same situation, we start from 1,000 requests/second and increase another 1,000 requests/second until stop at 10,000 requests/second for each worker. The number of successful execution requests increased not noticeably, range 15K to 16K requests for each second. However, compared to the initial process with only one worker, the number of failed requests is higher. To explain this point, we consider the number of workers who creates the request (i.e., the number of workers has increased) and analyse the latency aspect of the system (see more detail in the next subsection). From this point, we can claim that the time of response is longer when the number of users is increased.

For the data query, Fig. 7 describes the outcomes and quantity of requests to query the blood and its products recorded in the distributed ledger. In the last scenario, we increase the number of workers to 10 workers[2]. Similar to the two above scenarios, we start from 1,000 requests/second and increase another 1,000 requests/second until stop at 10,000 requests/second for each worker. According to the outcomes of Fig. 7, we found that the results are still steady. Specifically, #succeeded requests varies from the lowest rank, around 37K, to the highest, approximately 42K requests. Whereas #unsuccessful requests for data query are at most one request (negligible). This further proves the outstanding advantages of the distributed system compared to the traditional centralized ones.

C. Latency

In this second scenario, the article gauges and assesses the latency situation to three functions: data initialization, query, and update.

Fig. 8 indicates the latency of the information initialization function of the blood samples. In which the majority of the three latency levels are steady. Specifically, the highest latency index varies in the range of 500s when the quantity of requests rises from 1000 to 10,000 requests. However, a certain case happens in case 6 with 6000 requests/s; the latency increases significantly at 2240.21s, which may arise when the system has a bottleneck in processing transactions, so arriving transactions take more time to complete processing. Nevertheless, at Min and Avg latency indicators, the processing time for requests is still stable at the level of 363.16s/request and 0.64s/request, respectively.

The latency of data query requests is indicated in Fig. 9. The greatest latency index varies quite importantly from 1.41s/request to 4.64s/request. Nonetheless, the system's processing time progressively diminished and stayed stable when the number of requests rose from 1000 to 10,000. The most noteworthy value is 4.65s for a total of 2000 requests.

[2] We assume that workers are the doctors/nurses/officer in the medical facilities

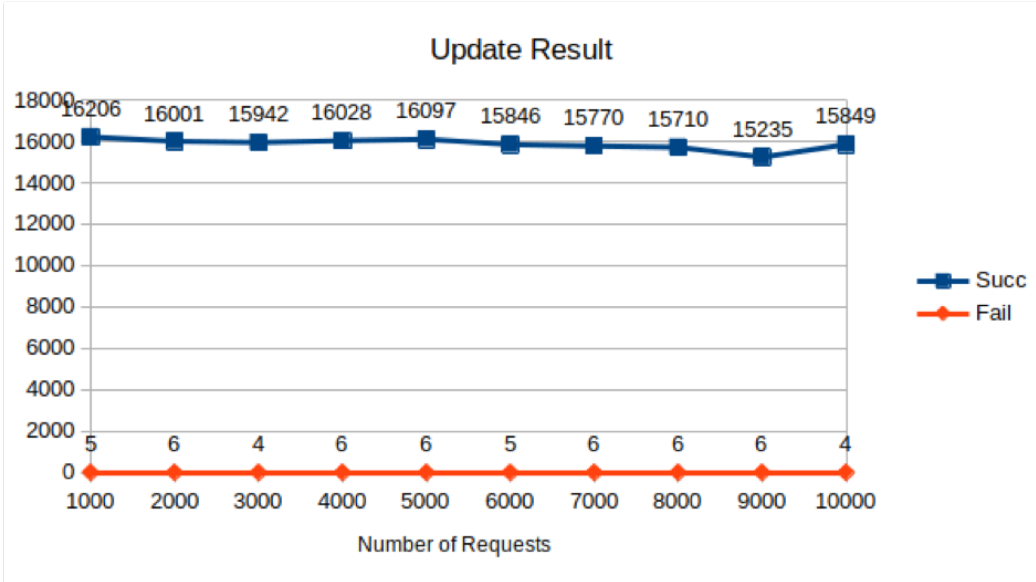

Fig. 6. The Results of the Update Data Functions.

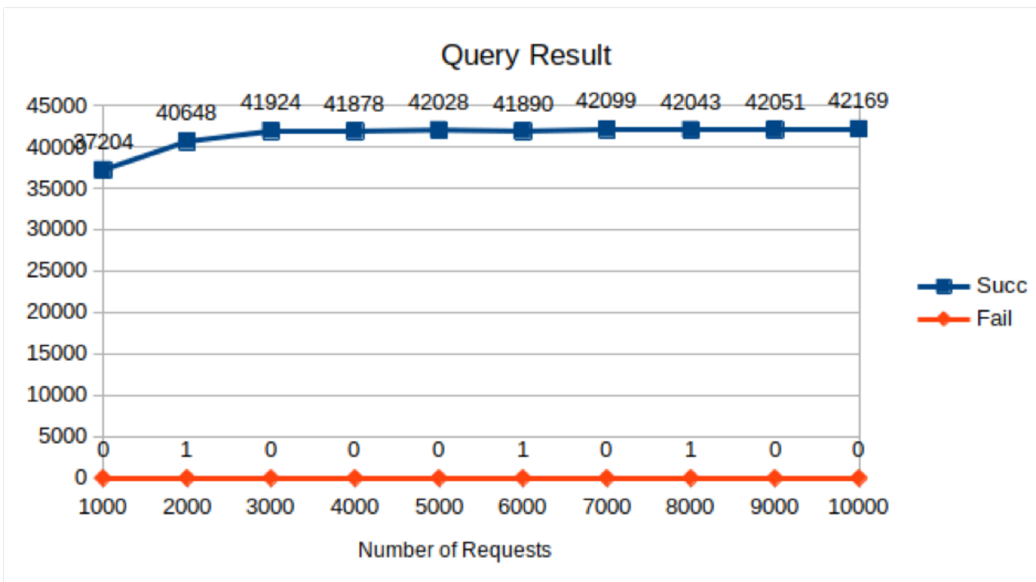

Fig. 7. The Results of the Request Data Functions.

Fig. 9 depicts the latency of requests to query information of all users in the system. The lowest latency 0.01 - 0.02 and average latency 0.19 - 0.82 are negligible even when the quantity of requests rises to 10,000 requests at the same time. The highest value of Max latency is 4.65s, correspondent with the scenario of 10 users delivering 2000 requests to the system at that point.

Ultimately, the latency of the data update function of the blood samples is also depicted in Fig. 10. The latency of the requests is kept stable when the number of requests increases from 1000 to 10,000. However, the processing time is at the most significant rank in comparison with 2 requests: to initiate and query data; this occurs when the system begins to query the information and then upgrade the data fields requesting data and stores new ones. The highest value of Max Latency is 795.4s for 1000 requests; moreover, the other cases are steady with a postponement of over 700s.

VI. Discussion

A. Remarkable

It is easy to see that the execution time of initialization, query and surrogacy requests is quite stable and does not depend on the number of requests sent to the system per second. However, they show the opposite when analyzing the response delay. Specifically, we recorded anomalies in two specific cases (i.e., initialization and query), while the latency of on-chain data updates is quite balanced and does not depend

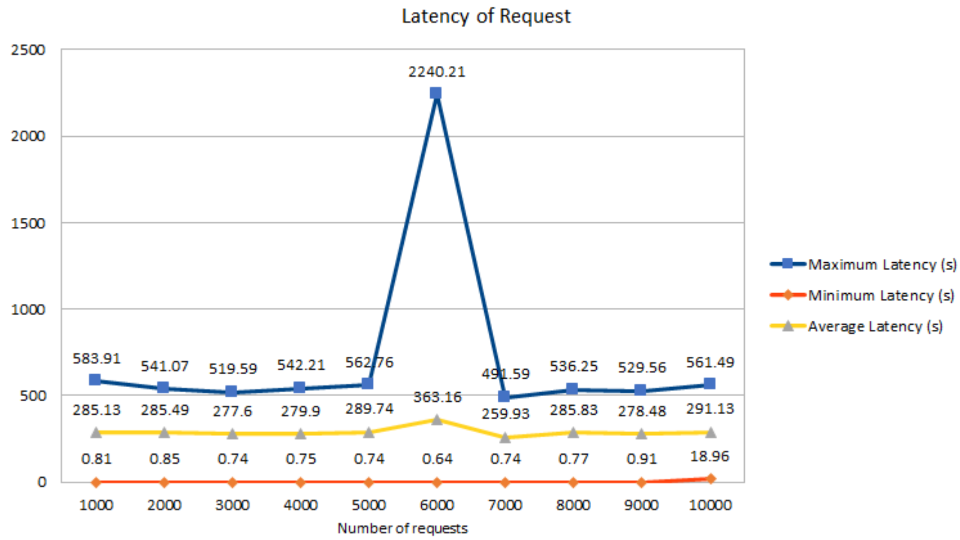

Fig. 8. The Latency of the Data Initialization Functions.

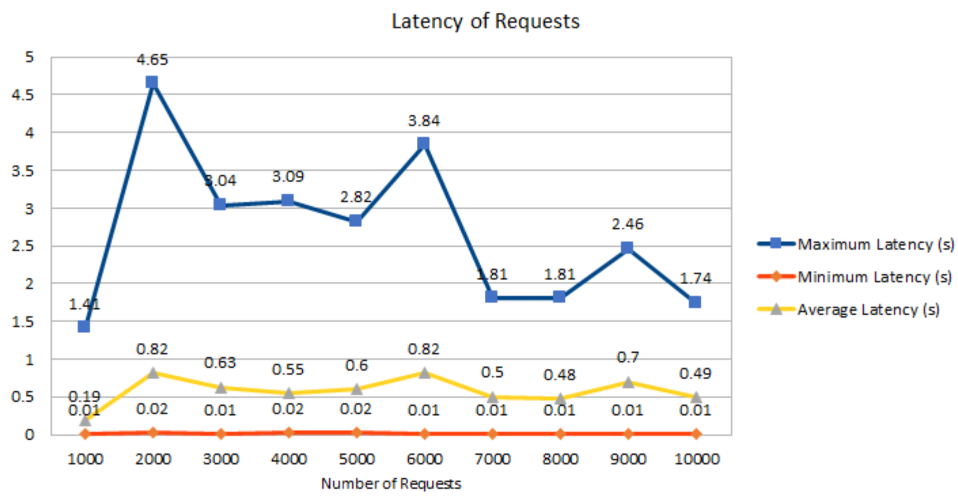

Fig. 9. The Latency of the Request Data Functions.

on the number of responses per second. Specifically, in the case of 6000 requests/second, the latency spikes and drops immediately for the next case. We assume that a problem may occur in the in-chain processing, severely affecting the system's response time. Proof of our claim is that latency tends to be stable from the 7000 requests/second (see Fig. 8). To prove the above statement, we closely observed the peer pairs with transactions during operation and discovered a serious error affecting the whole system. Specifically, when a peer belonging to a specific transaction has not completed the execution request, the whole system must wait until that peer completes, seriously affecting the whole system. We further assume that executing requests on a system that is limited to our hardware equipment is responsible for the above risk.

To answer this question, we continue to observe in the query scenario (i.e., Fig. 9) and update (i.e., Fig. 10) on the data. whether on-chain. Our assumption is not entirely correct for two reasons. The first reason comes from a detailed assessment of client data queries' response time. Specifically, the 2000 milestone is unusually higher than the other observed milestones. This leads to concerns about process interruptions and system-wide effects (since 2000 requests/seconds is not a theoretically alarming milestone). However, when we observed two other anomalies in the same scenario (i.e., 6000 and 9000 requests Fig. 9), we noticed a gradual decrease in latency. This proves the opposite of the assumption above that latency is inversely proportional to the system's processing speed (i.e. the more processing, the more latency increases and vice versa). This proves that the latency of the whole system does not depend on the system configuration but is affected by the sequence processing (i.e., priority).

In the third scenario, we ignore the peers when there is a

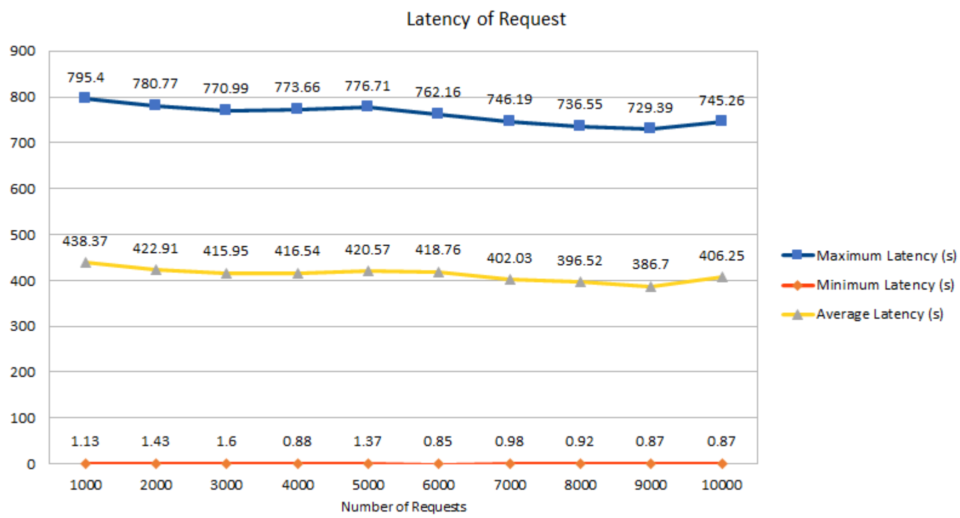

Fig. 10. The Latency of the Update Data Functions.

problem in a corresponding transaction to substantiate these remarks. Fig. 10 proves that our assessment is correct as changes in the number of requests do not affect system latency.

B. Security and Privacy Discussion

The blockchain has a key role in the modern system, which satisfies the transparency and availability conditions for the supply chain [34], [35], [14]. However, the blockchain-based system has some troubles documented in [36], particularly in the security and privacy perspective. To enhance the security and privacy matters in the blockchain-based blood donation system, we consider the authorization for the parties within the same transaction and the flexibility in the clinical environment.

For the authorization factor, we will take the advantage of attribute-based access control (ABAC) [37], [38] to handle the access control process. The primary advantage of this model is that only accepted users can get to the released data. Moreover, the query rewriting can be utilised for a complicated context where the released data is disseminated to numerous users [39], [40]. Eventually, a few methodologies split the original policy into sub-policy [41], [42] (i.e., public and private policy) to assure that the information is only accessed through permission even the parties in the same transaction.

Finally, comparing to the previous papers, this is the first approach supplying the proof-of-idea to target blood donation management. In other words, several papers pay attention to the general problems in the healthcare system instead of focusing on the specific concern, i.e., blood management. This paper underlined BloodChain as a technology to manage the benefits of this system. We also show the outcome of our suggested model derived from some experiments.

VII. Conclusion

The article applies the benefits of Blockchain technology (i.e., transparency, decentralized storage) to propose a blood and blood product processing process based on the limitations of the current traditional process in Vietnam. Vietnam. The paper provides a proof-of-concepts based on the Hyperledger Fabric platform, which stores information about blood and its products during the storage and transport processes. The information is stored transparently for easy verification in transit and storage. This is an initial effort in applying the benefits of blockchain technology in designing and managing the supply chain of blood and its products for Vietnam in particular and developing countries in general.

In future work, we aim to manage stakeholders based on constraints defined in the form of Smart Contracts. Moreover, this research result is only the first step to build a system based on blockchain technology in a real environment. Therefore, we aim to deploy the proposed model for exporting in more complex scenarios where there are multiple-role of users and off-chain executions (i.e., out of scope for current version) processes of the medical facilities.

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