International Journal of Artificial Intelligence
p-ISSN: 2407-7275, e-ISSN: 2686-3251

Original Research Paper

Investigation and Development of a Data Acquisition System for Blood Bank

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Article History
Received:
03.02.2023

Revised:
26.02.2023

Accepted:
01.03.2023

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Abstract: Blood is a vital fluid where required for saving human's life. Blood is stored in a blood bank which is a bank of blood components, gathered as a result of blood donations that are responsible for collecting, storing and preserved for the use of medical purpose. Investigation of the existing blood collection and tracking system is essential to efficiently manage, control and monitor on all aspect of a blood bank. A comprehensive data acquisition system from collection location to a cloud-based system enables a paperless system with minimum human intervention to oversee the entire collection to dispatch process in a blood bank. A research has been made that most blood banks practicing stand-alone which may contribute to wastage of donated blood. For that matter, this collected data system allows connectivity between the blood banks to effectively conduct and systematically manage their daily activities within one integrated system. This application helps blood donation center receives the registered donated blood from any hospitals easily as it records the donated blood information in cloud immediately.

Keywords: Blood, Data Acquisition System, Monitoring System.

International Journal of Artificial Intelligence, vol. 10, no. 1, pp. 21-38, June 2023. **DOI: 10.36079/lamintang.ijai-01001.488**

1. Introduction

Blood is an essential fluid that existed in humans' body and the animals' body. Blood is considered very important because it is needed to deliver the nutrients and oxygen to the whole part of the body. There are three important functions of the blood which are transportation, regulation, and protection for the body [1].

There are four main types of blood which known as in categorization of ABO group which are A, B, AB, and O. Some of the blood contains additional marker which known as Rh factor. The blood can be classified as negative or positive such as A- or A+. The negative blood is the blood which does not contain Rh factor whereas the positive blood is the blood which contains Rh factor [2]. The least percentage of the population with negative blood according to the blood connection community blood center comes from AB- blood group which is 0.6%. The highest percentage of the population with negative blood comes from O- which is 6.6%. Apart from the population with negative blood, the least percentage of the population with positive blood comes from AB+ which is 3.4% only and the highest percentage of the population with positive blood comes from O+ which is 37.4% [3].

According to Recruitment and Publicity division head, Dr. Norris Naim, the rarest type of blood come from AB group and Rhesus negative. People with these types of blood are encouraged from not donating their blood when they feel like to donate. Instead, their names and informations will be kept so that hospitals will contact them once their blood is needed. This is because blood has specific amount of lifespan which means if the blood is not used it will be thrown away. This will lead to wastage of blood which is not a good thing to do. As there is small number of population with rare blood, the donations will be carried out when it is needed. This is due to it will be a problem if there is any emergency cases occur in the hospital as there is a three months recovery period after a person has donated his blood before they able to start donate their blood again [4]. Through the naked eyes, blood looks quite similar but after blood inspection done, the blood can be seen differently as not every human has the same antigens in their red blood cells. Blood carries the same basic constituent which are red cells, white cells, platelets, and plasma [5].

There is one engrossing thing about blood. Our own blood is not merely giving benefits to our own selves but also able to save other people's life who has a problem with their own state of blood in their body, for instance, those who have anaemia, leukemia, sickle cell disease, haemophilia and etc [6].

According to American Red Cross, after the donation which considered as the first step, there are another four steps to go to the distribution of donated blood which considered as the last step. The first step is the donation of blood. The donors will register themselves as the donor and the nurses will check the donors' health history and do some mini physical check-up such as body temperature, pulse, and blood pressure check-ups. Each blood donor will donate at least 1 pint of blood and the blood will be kept in the blood transfusion bag. The blood transfusion bag will be labeled with an identical barcode in order to facilitate the workers to keep track of the donated blood. The second step will be named as a processing. The blood will be separated into three components which are plasma, platelets and red blood cells. The third step is testing the donated blood. It needs to be further tested in the laboratories to acknowledge the condition of the blood [7].

The donated blood need to be checked to make sure there is no presence of five most common diseases in the blood. The most infectious diseases are HIV, hepatitis B, hepatitis C, human T-lymphotropic virus (HTLV), and syphilis. After the blood testing process has been done, the blood will be stored in blood storage or as known as a blood bank and this is considered as fourth step. The blood units which are fitting for transfusion will be labeled and stored. The blood bank is an area which the collected blood gained from the donors is stored, separated into components and a place where the preparation for the blood's transfusion to recipients is carried out [8]. Red blood cells will be stored at 6°c in the refrigerator within 42 days. The platelets will be kept at room temperature up to five days. Meanwhile, plasma will be stored in the freezer up to one year. The last step is the distribution which is the donated blood will be shipped to the hospitals [9].

Some blood banks using a manual system to keep all the blood collection data and some of the blood banks have updated to a web-based system to store the blood collection data. Based on a manual system, the hospital staffs will record each of bloodstock details on paper and keep it in the file. The web-based system able to greatly secure the bloodstock details as they will be saved in the cloud storage. The usual record of blood collection data are Date blood was collected, Expiry date of the component prepared. Blood group of the blood component, Donation or pack number, Name and

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volume of the anticoagulant solution, name of the blood bank producing the component, and Temperature of storage [10]. The management of the lifespan of blood is a very crucial part to take note because it is related to the quality of blood for transfusion. The additive solution which known as anticoagulant plays the main role in maintaining the viability of the blood. The benefits of anticoagulant are to maintain the viability of blood, avoid microorganism to grow and hinder the blood from clotting to occur [11].

The blood will be kept in the freezer or refrigerator with the specific temperature in order to remain the quality of blood. For ease of access, the blood or any other laboratory reagents are stored in the blood storage in an orderly way to make sure the blood with early expiry date will be used first [12]. This principle or as known as first-in-first-out policy (FIFO) should be followed as the usage of blood which closer to expiry date may avoid from blood wastage [13]. Blood bank will always maximize their effort to not let any blood to be thrown away. If there is any bigger hospital which is busier and need blood more it will be shipped over there to avoid blood wastage. Although, this matter is still unavoidable and if the blood gets expired, it will be thrown away in biohazardous trash properly.

The wastage of donated blood is still happening in this world eventhough the blood bank has put a lot of effort to avoid such event to occur. According to The Times of India news, there is about 2.8 million units of blood and its component has been thrown away by blood banks across the country. Besides that, in Iranian hospitals, there are about 77.9% units of donated blood were thrown away due to the blood has reached its expiry date. This is due to blood bank has insufficient system to facilitate the workers in prioritizing which blood need to be used first based on FIFO policy [14]. Other than that, the usage of paper to record donated blood information and donor could lead to redundant record and missing donated blood information records. This matter also will make it hard for the hospital staffs to search the blood packet details during emergency. Moreover, most blood banks have an inadequate quality of blood transfusion service. This is due to the fact that they are working in isolation and are not mutually consolidated with other blood banks and health organization.

This proposed work will come as a system that able to integrate the whole blood collection data between blood banks existed in this country. It will provide the visualization of whole blood packet details available in a country. It will be produced as an application based which is a web-based. This will come in handy as the user able to monitor the blood collection data regardless of their movement as they can access through a mobile browser. This system will use RFID reader and RFID tag to record and keep the donor's blood details rather than using barcode. The Arduino Leonardo will be used to memorize the program code and control the input and output device.

The working principle is when the blood donor comes to register, the ID in the RFID tag will be recorded as a blood ID. Then, as the blood donation taking place, it will write the date and times. The product ID, the expiration date will be recorded when the blood collections are manufactured and they are writeable. After identifying the blood type, the ABO/Rh will be written in the system. In order to read the blood collection details, the user only needs to swipe the RFID tag on the RFID reader and it will come out on the screen. This blood collection details will be stored in the cloud- based which can be accessed by other health organizations, blood bank and etc. This system will show a visualization of donated blood information in details.

2. Literature Review

2.1. The Blood Donation Service Using SMS-Based Functionality

SMS concept has been implemented in Bangladesh for the blood donation service which called as mHealth. It offers great perception for a blood donation service as it able to use mobile communication and SMS as the notification system.

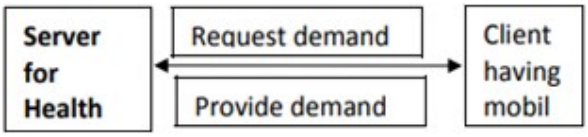

Figure 1. Architecture of Blood Donation Service

Internet-based system is not the most favorable solution for a blood donation service, based on the study made which considers cellular and internet infrastructure in Bangladesh. As the number of mobile users increasing exponentially, this matter can be extrapolated to other south nations. This system has very little necessity for its functioning. The system can be deployed only with the existence of the GSM modem and SIM card [15].

2.2. Smart Social Blood Donation System Based on Mobile Cloud Computing

This system's goal is to develop a Blood Donation System (BDS) based on two platforms which are cloud computing and mobile cloud computing. The mobile cloud computing comes up with a tool which facilitates user to do their work regardless of their movement. This platform will be used for the stakeholders of the blood donation to interact and request services from the cloud computing platform. The users and the cloud is provided the interfaces in the form of application in the smartphone. The users able to receive the notification or an alert in real time from blood banks and health organization based on this application. The emergency calls also can be put on view by users who really need for blood transfusion. There are two entities in the mobile computing platform which are service directory and user agent. Service directory is the directory for all blood donation services and the user agent allude to a mobile phone that receives a service request from the user and sends it to service directory. The cloud computing component has the ability to store all the data and information with a great security. This platform supply stakeholder such as donors, health organization staff and blood bank staff in the mobile computing platform with all blood donation services. There are five services such as ontology interface system, emergency service provided by national or regional donors database, blood donation registration service, and blood donation reservation service.

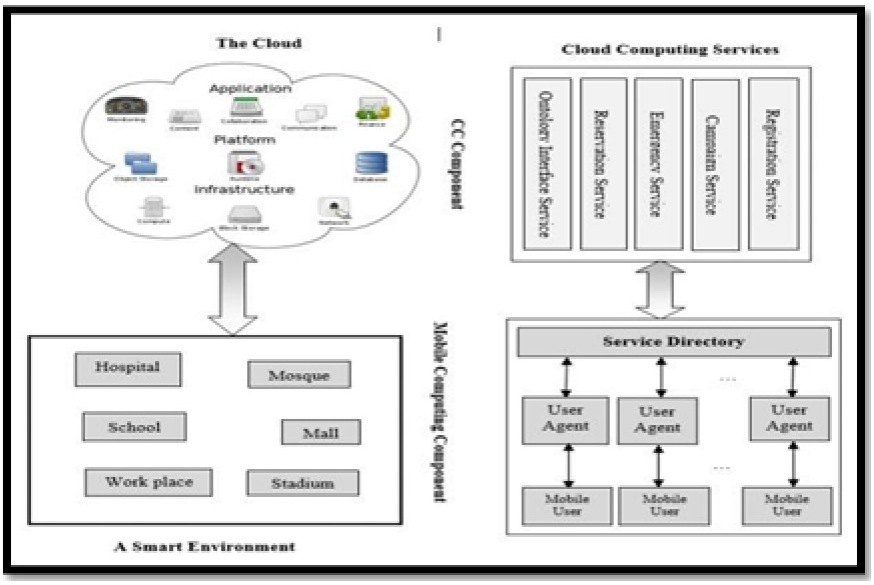

Figure 2. Framework for Blood Donation System

This system will make it easier for blood donors and blood donation centers to communicate with each other. This work also has an objective to integrate the whole blood collection details among each blood donation centers existed in this world. The application based on Blood Donation System can be installed by stakeholders on their smartphones to aid them to minimize their effort and time in completing the blood donation process. This application offers an ability to receive notifications if there are an urgent or emergency blood donation calls. Moreover, this application able to search the nearest blood centers for the users. Furthermore, users can reserve an appointment to do the blood donation or receive the donated blood [16].

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2.3. Automation of Blood Donor Classification and Notification Techniques

This system practices that when blood product falls below a threshold value, the notification will be pop out automatically. Furthermore, in this system, in order to check the blood stocks and calculate the threshold trigger, these both can be done by using periodical polling. A set of parameters for each blood type need to be set up in order to fulfill this objective. The first parameter is the saturation point which acts as the volume with which a hospital can operate ideally without any requirement to reload their stocks. A volume above saturation point contributes to wastage of blood due to expiry. The second parameter will be a sufficient point which acts as the minimal volume of blood stock which a hospital can operate. Any value less than this call for emergency re-stocking from other hospitals or blood banks. The third parameter is the maximum volume of blood that can be stocked at a given time. A stock of this volume has a high probability of contributing to wastage of blood due to expiry as all of it may not be used. The fourth parameter is the null point which acts as a hypothetical situation where there is absolutely no stock of a given blood type.

The working principles of this system at various possible ranges of the blood product can be observed from the figure shown in Figure 3.

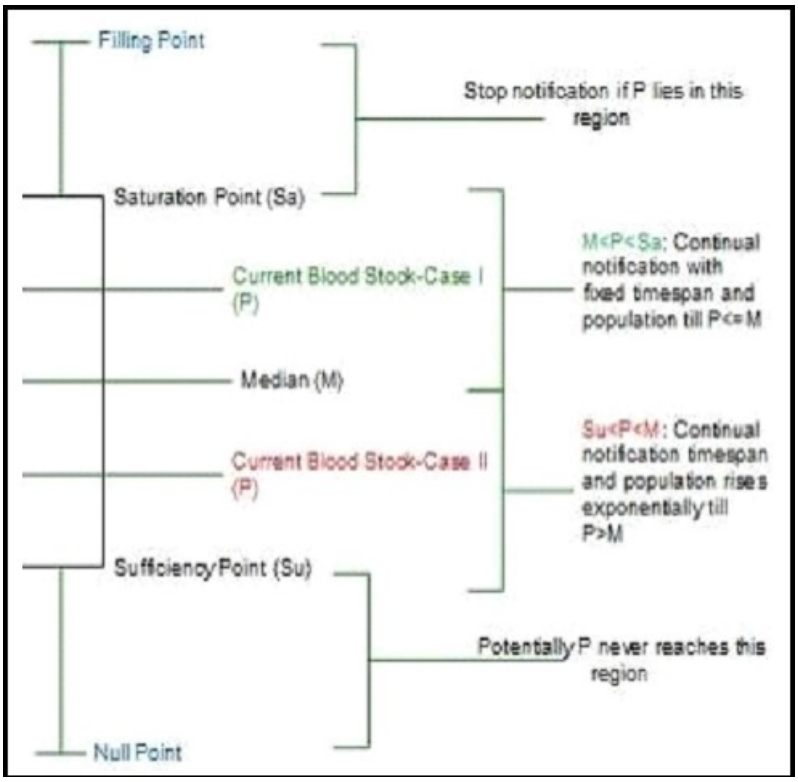

Figure 3. Threshold Level Calculation

At the range of saturation point < present volume < filling point shows that no blood collection required so there will not be a notification at this range. At the range of median < present volume < saturation point, the notification will be sent to a group of most eligible and optimal donors which is those with a relatively high probability of turning up for donation to collect blood. At the range of sufficiency point < present volume < median, the notification will be sent to a larger group of eligible and optimal donors to quickly increase the blood product level above the median value. At the range of null point < present volume < sufficiency point, this level is never attained because of constant polling and updating of blood product.

The number of donors to be potentially notified depends upon a sigmoid function. Lesser the deficit in blood product, fewer donors are notified, but with increasing deficit, the number of donors

notified increases exponentially. The arrest of the notification mechanism takes place once the value of the stock goes above the saturation point, thereby minimizing wastage due to expiry.

Aside from inherent pros and cons in systems discussed above, we find that all the systems aim to increase blood availability and reduce the latency in response. The huge support for the proposed idea suggests the need for such notification systems in developing and enhancing services in healthcare [17].

2.4. Integrated Management Principles and Their Application to Health Care Systems

The purpose of this research is to present the applications in the healthcare systems by searching the elements of the integrated models. In order to apply the integrated management into two different healthcare, there are some of the intervention is designed to test. The healthcare process is applied with improvement methodology in each case. There is an approach called as cohesive managerial which has been applied a concept that integrates the voices from customer, workforce and the process into the approach and it was depicted relevant in healthcare.

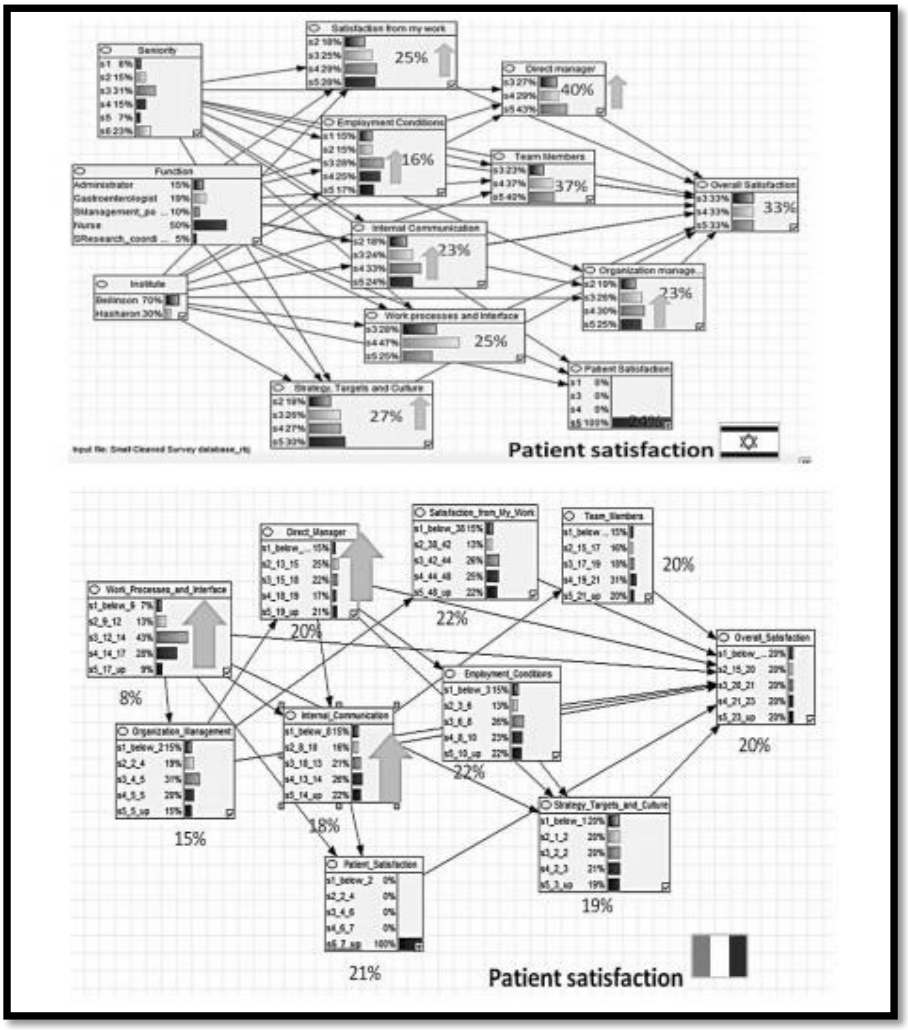

Figure 4. Comparison between the Israeli and Italian healthcare system

Healthcare systems have been known for having a complex organizational structure. The execution of a comprehensive integrated model is considered hard to achieve by managers of the healthcare system. The objective of integrated management is to attain a good balance between the requirements

of the customers, gratification of the workforce and the effectiveness of the process. This balance will supply added value to the organization stakeholders in the broad sense.

Before this, the integrated models were constructed in the industry and their execution was tested. Observing the similarities and differences between healthcare organizations gave a proper view how that the healthcare system can gain benefit from the integrated models. This gives big possibility in planning the integrated model executions and has greater chance to achieve success [18].

2.5. Web-Based Blood Donation System

Based on this paper, this system is mainly used to record the bloodstock details. It is quite consuming time if the hospital personnel or any related party to stay keep using the traditional method which is a manual system for keeping the donated blood records on a paper. Time is very essential for the patient when it comes to dealing with blood transfusion in hospital. Hence, if the hospital personnel need to check the blood availability in other blood banks, it would consume time.

Thus, based on this introduced system, hospital staffs could check whether the particular type of blood does exist or does not. Moreover, this proposed system allows the user to check the availability of blood in another blood bank [19].

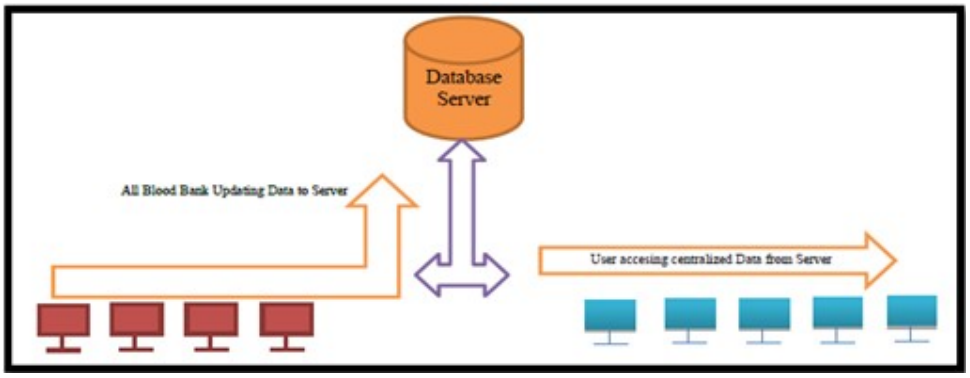

Figure 5. Representation of web-based donation system

2.6. Optimization of Blood Donor Information and Management System

Based on this journal, although the request of blood is rising, there are only 5% of Indian population who donates the blood. In this blood bank management system, they provided information about donor's name, blood group and email addresses. Whenever the user in the urgent time to get a blood, the contact details of the donor will be appearing on the screen. This proposed system provides a list of donors in both city and area. The users just have to check the blood contact which has matching to a search for blood and users able to directly contact them from the website.

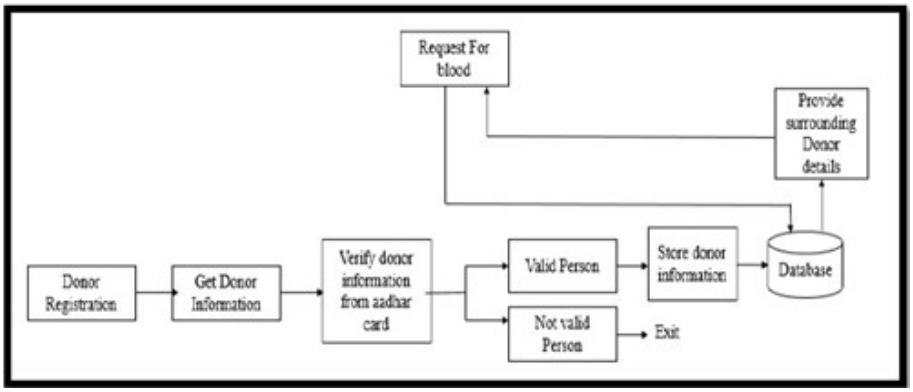

Figure 6. System architecture

This system can be used when it comes to the emergency case of needing blood. It can be accessed through mobile phone and it is a location-based application as it supplies immediate location tracking communication. Hence, it enables users to search donors in nearby locations [20].

2.7. A New Concept of Blood Bank System Using Cloud Computing for Rural Area

Authors from this paper introduced a technology of mobile SMS based in order to improve the facilities of blood bank management system in the rural area. The working principle of this proposed system is that the mobile SMS based directly connect to a cloud server which resided in a different place as the rural area does not have sufficient prerequisite to store the blood in a long time. The authors' main objective is to enhance the standard working of blood bank by applying cloud computing approach as the rural area has lack facilities standard blood bank management system accessible in the rural area [21].

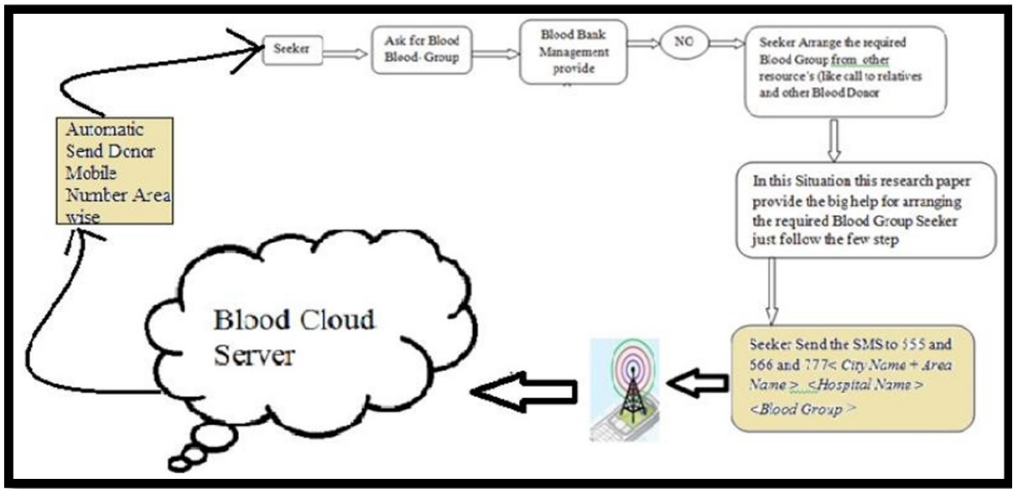

Figure 7. Block Diagram of the Proposed System

2.8. Smart Blood Bank Based on IoT

The main objective of this proposed system is to enhance the management of the blood collection data in blood bank by bridging all the blood bank to the cloud storage. The authors emphasized that the proposed work is built to avoid the blood collection out of stock. The cloud storage going to show all the availability of blood in order to keep all type of blood remain available in each blood bank. This system supplies the information of donors so that if any of blood bank run out of blood product, the responsible party can call them to ask whether the donor can make blood donation or not [22].

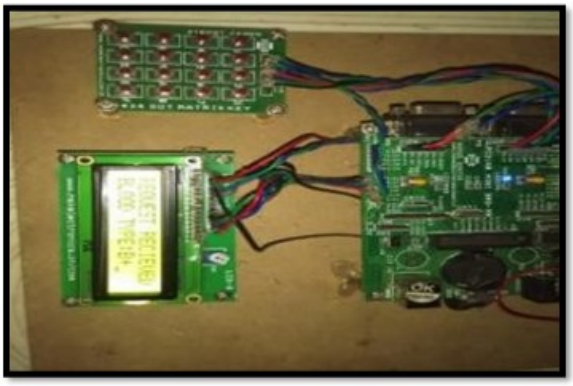

Figure 8. System Overview of Smart Blood Bank

2.9. Design of SMS Based Automated Blood Bank Using Embedded System

The main purpose of authors to develop this system is to help the needy patients to get the blood in an easier way. The authors used the SMS-based to create a bridge between donor and patients. In this proposed system, the donor is required to register with the blood bank through SMS. Their information will be shared where those people who would like to make blood request can view it [23].

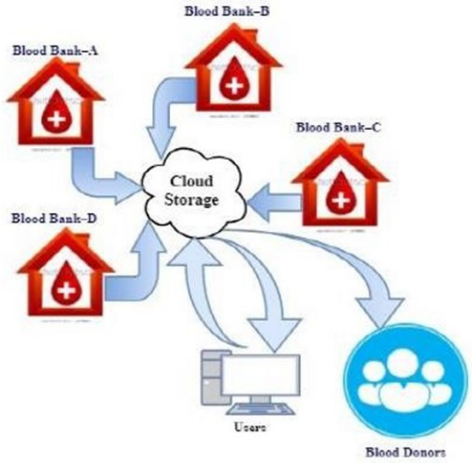

Figure 9. Exchange Information between Hospital and Donor

2.10. Automated Blood Donating and Managing System Using Raspberry Pi B+

As villagers have a hard time to access the internet to running an application, this paper provided a way for them by applying SMS based accessing technique. This proposed system goal is to conduct all voluntary student blood donors to one location. They used SMS based GSM module to consummate each blood request. This proposed system also builds a bridge between the blood donor and blood recipient to communicate, so it minimizes the time span between them.

Gathering of all the database of the blood donors details from all the organization are used by Raspberry Pi B+ and GSM modem SIM900A. The device will send the information of the recipients of blood to the foregoing donors of that particular blood [24].

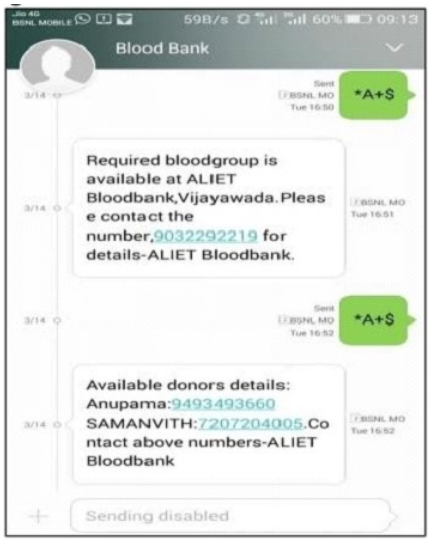

Figure 10. Screenshot of Blood Request by the User and its Response

2.11. Automated Blood Bank System Using Raspberry Pi

This proposed work implements the usage of Raspberry Pi and Android application to develop a blood bank system. The main goal of this proposed work is to improve the blood request process to manage it more effectively. The android application and the Raspberry Pi in this proposed system are employed to gather the information and data of the donors and all of these obtained data will be stored in the database. These systems will be installed in the blood bank, health organization, blood donation center, hospital and etc. Patients have to inform the blood group that they need in the application. Right after that, the information that they submitted will be stored in the database. This database then will start to do matching to the suitable donor through GSM modem [25].

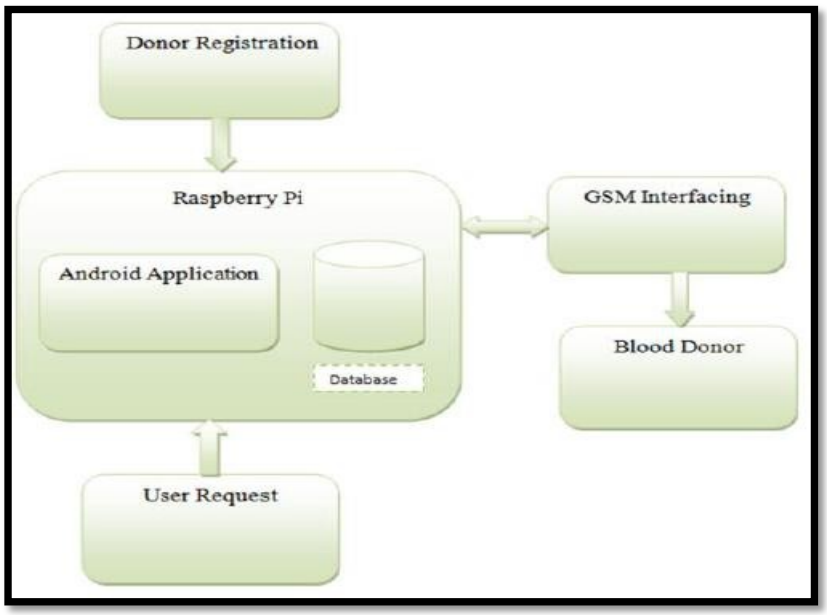

Figure 11. Block Diagram of the Automated Blood Bank System Using Raspberry Pi

3. Methodology

The overall flowchart in Figure 12 shows the whole process of the proposed work from literature review until the end. The literature review has been made by reviewing past papers which related to this proposed work and by visiting the blood bank in Malaysia which Hospital Melaka has been chosen for that. The pathology in Hospital Melaka was asked how the existing system works and how the blood banks operate to keep the blood safe for later use. In order to develop the data acquisition system for blood bank, a database and web application was built. The hardware construction was developed for the purpose of showing the blood collection details is kept in a new technology by replacing paper and current technology used to keep the blood records. Then, both software and hardware development integrated to build a complete system. In order to ease panels to understand how the system works, a prototype has been made.

The system flowchart in Figure 13 shows how the software works and how the data flows in the system. There are two architectures here which are the authorized users and also the public users. The public users only can view the homepage and list of hospitals page and the rest pages can only be accessed by authorized users. They need to login the page by providing registered email and password in the database. All the activities in the web-based application will be recorded in the database such as the registration of new blood donor. Each time a new blood donation is recorded, an email will be sent to the responsible party to acknowledge the new donated blood came into the system. The visualization of blood can be accessed by authorized users such as hospital staffs and national blood centre. The RFID tags are used to keep all the blood records information as a replacement of current technology which is barcodes technology.

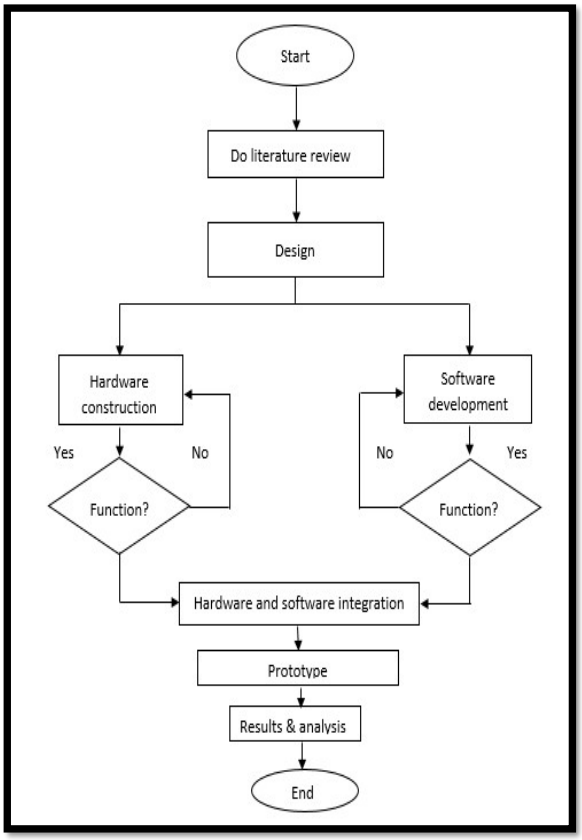

Figure 12. Overall Flowchart of the Proposed Work

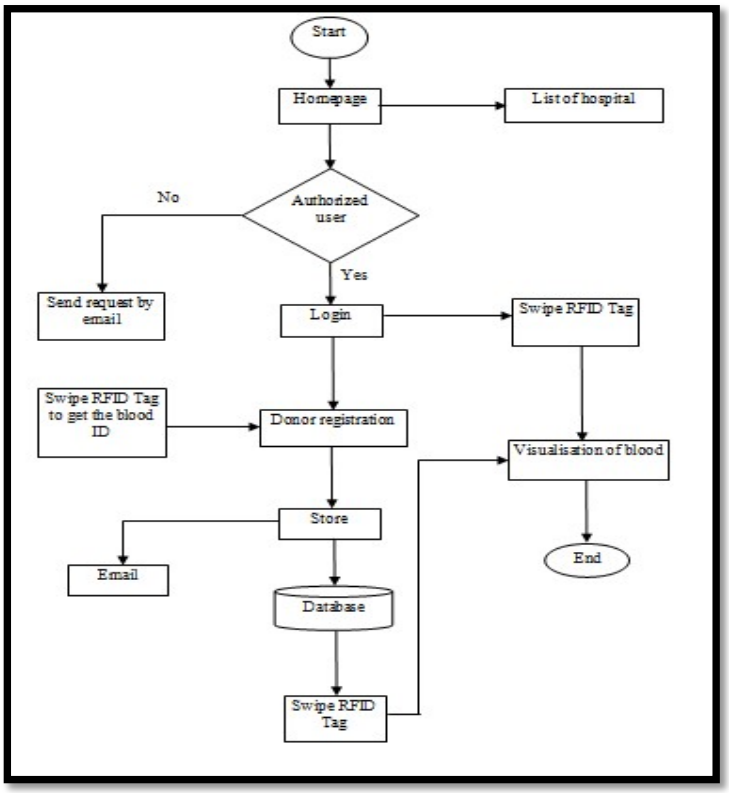

Figure 13. System Flowchart

The hardware flowchart in Figure 14 shows how the device works. This hardware device was developed by using an Arduino microcontroller called Arduino Leonardo. Then, the Mifare RC522 RFID reader is connected to the Arduino Leonardo in order to read the RFID tag to track the blood collection details in the blood bank system. All they need to do to keep the donated blood details in the RFID tags for the blood bag is just by scanning the RFID tags on the RFID reader and record it in system. It also can be viewed in the system just by repeating the same technique.

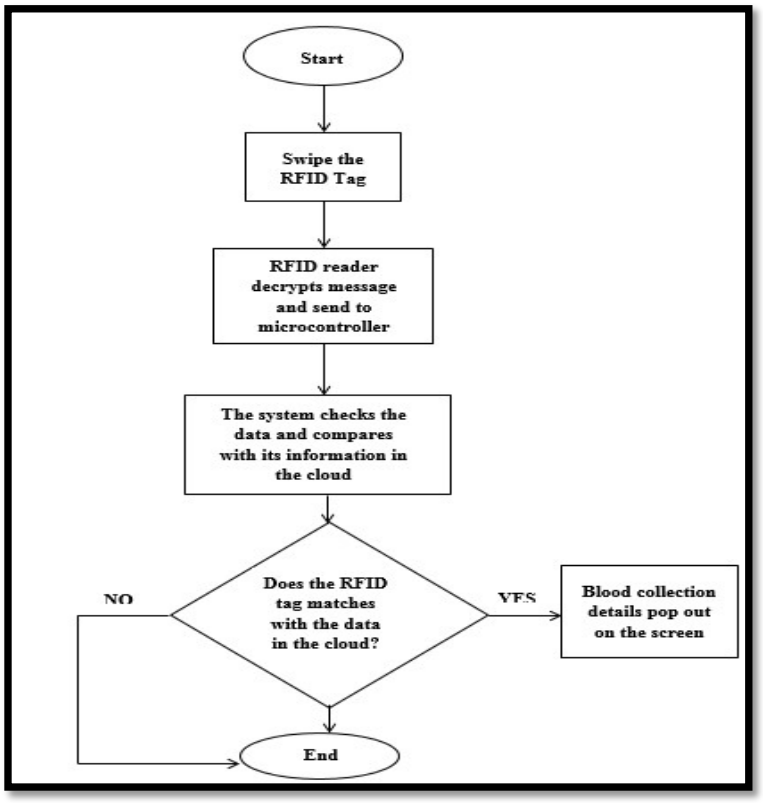

Figure 14. Hardware Flowchart

4. Finding and Discussion

This proposed system is built to help the blood bank administrator and hospital staffs to manage all the collected donated blood. The authorized users can observe all of the existing blood collection data such as the expiry date of the blood which play the biggest role in dispatch process to avoid the wastage of the blood. This system also can be accessed by the public but there are some parts are filtered from them which merely can be accessed by authorized users like doctors, admins, and hospital staffs. Moreover, this proposed system technically enable a paperless system as all the information of the blood are kept in the cloud. Besides, this promotes reduction amount of time in accessing the donated blood details. Apart from that, from a technical point of view, the cloud system instinctively amass, integrates and configures technology which in simpler words, it removes the requirement for a physical configuration to be present at each emplacement from where the blood bank operates. This facilitates the blood bank to install services quickly and at a lesser cost.

4.1. Modules of Proposed System

4.1.1. Web Application

This module consists of the process of registering blood donor. After registration of blood donor submitted, the donor's information will be updated in cloud system. This also automatically updates the availability of blood in the visualization of donated blood. The authorized users can check the availability of blood of all the blood types. They also able to monitor the donated blood details and manage their daily activities to keep alert which blood is getting closer to the expiry date so that it

could be dispatched to any hospitals that having shortage amount of that specific blood or if there are any blood banks that already sent a request to have that specific blood, it could be dispatched to them straight away. This web-based system enables the blood banks to work in an integrated way as the authorized users from each blood bank can see all the bloodstock details from each blood collection storage. As for this proposed system, Yola which a site builder is used to build the website. The proposed system's web application named as a Blood Info.

4.1.2. Database

The database is primarily held by national blood health centre where all of the bloodstock details and the information about the blood bank and users will be kept in database. Besides, the database that utilized in this proposed system is very essential as it is a bridge to send and receive information from activities that occurs in the web application. A database that is being used for this proposed system is Caspio. It offers a lot of advantages to build an application.

4.1.3. Radio Frequency Identification Reader

The blood bag usually has the barcode attached on it to acquire data by scanning the barcode. The main objective for the application of barcode technology in blood bank is to lessen the jeopardy of irreconcilable transfusions generated through human errors by displaying essential information in a simply perceptible format. Its readable texts enhance the arrangement and resolving ability in the matter of large storage and management of donated blood and blood components.

However, the proposed system used Radio Frequency Identification Reader (RFID) to replace the barcode system. Eventhough the barcodes had offered a lot of benefits but it also has some shortcomings which are not compatible with the world's technology in these recent years. RFID can overcome all of those lacking that consists of the barcode. A lot of people said that RFID tags are pretty costly to be used in the blood bank compared to the barcode. It is true however, the RFID tags could be reused which this brings the positive return on investment. Besides, when they purchase the RFID tags in bulk, the cost would be reduced based on suitable price.

4.2. Homepage

Figure 15 shows the homepage of Blood Info website. This interface can be accessed by authorized users as well as public users. This homepage generally explains the benefits of this proposed work could offer. All of the objectives of the proposed work are stated in the homepage to make users understand of how this web- based application work.

Figure 15. Homepage: Data Acquisition System for Blood Bank

4.3. Database

Every time each blood bank recorded new donated blood details in Blood Info, that information will be stored in the database. Figure 16 depicts the bloodstock details which have been registered through the online website.

Blood_ID	Blood_Type	Donor_Name	Date_Blood_Collected	Expiry_Date	Fridge_Name	Shelf_Column	Name_Volume_Anticoagulant	Name_Blood_Bank_Prod
13920769115	A-	Damia Asyira Binti	03/07/2018	04/17/2018	A-	3	Warfarin	Sultan Ismail Hospital
803787115	B+	Nur Diyana Binti M	03/07/2018	04/17/2018	B+	2	Apixaban	University Malaya Medical
1602771115	O+	Muhammad Danial	03/07/2018	04/17/2018	O+	2	Warfarin	Hospital Kuala Lumpur
5518018163	A-	Hanis Shahfiqah B	03/07/2018	04/17/2018	A-	3	Warfarin	Hospital Pakar Sultanah Fa
20420086115	O-	Nurul Ayuni Binti M	03/07/2018	04/17/2018	O-	1	Apixaban	Hospital Ampang
463871115	AB+	Nur Zafirah Binti Za	03/07/2018	04/17/2018	AB+	1	Apixaban	Hospital Kuala Lumpur
1612414499	O-	Muhammad Hazim	03/08/2018	04/18/2018	O-	2	Apixaban	Hospital Tengku Ampuan A
2192819163	A+	Hanisah Fira Binti I	03/08/2018	04/18/2018	A+	3	Warfarin	Pantai Hospital Ayer Keroh
514887115	A+	Ahmad Zaki Bin Nu	03/09/2018	04/19/2018	A+	1	Warfarin	Hospital Tampin
11714066115	B+	Batrisya Aisyah Bir	03/09/2018	04/19/2018	B+	3	Apixaban	Hospital Melaka
1713886115	B-	Muhammad Syahic	03/09/2018	04/19/2018	O-	2	Warfarin	Pantai Hospital Ayer Keroh
1572486115	O-	Muhammad Hassa	03/12/2018	04/22/2018	O-	1	Apixaban	Hospital Selayang
7424685115	AB-	Noor Masdalina Bi	03/12/2018	04/22/2018	AB-	3	Apixaban	Hospital Ampang

Figure 16. Database of the Blood Product

4.4. Hardware

As shown in the Figure 17, it shows a PCB circuit with RFID reader and Arduino Leonardo which acts as a device to track the blood collection data in the system. The RFID tag is attached to the side of the blood bag as shown in the figure. The RFID reader just needs to read the tag to obtain all the information of the donated blood which has been kept in the system. The RFID tag with 13.56 MHz frequency only can keep the unique ID. Therefore, the unique ID which stored in the RFID tag act as a blood ID in the system. Then, through the blood ID, it tracks all other information about the blood product.

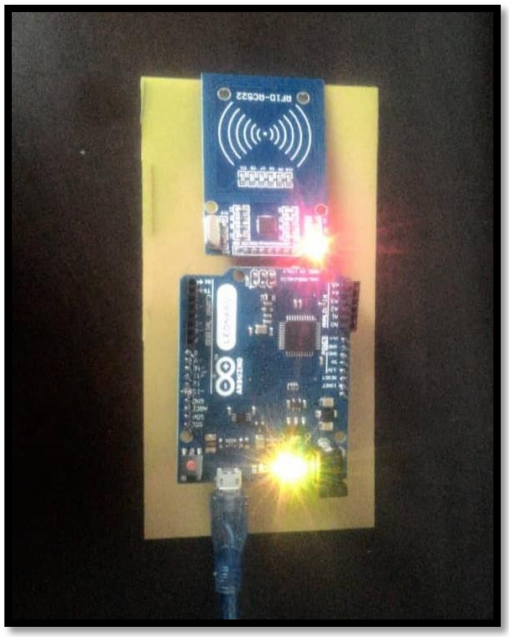

Figure 17. Arduino Leonardo and RFID Reader on PCB Board

International Journal of Artificial Intelligence, vol. 10, no. 1, pp. 21-38, June 2023. **DOI: 10.36079/lamintang.ijai-01001.488**

Figure 18. Prototype of the Proposed Work

Figure 19. The Whole Proposed Work in View

4.5. Discussion

During the first development of this proposed work, the Raspberry Pi Zero W was suggested to be implemented as a microcontroller to memorize the codes while controlling the input and output of the hardware and work as a web server. After a very long period of time in semester 1 spent on working the Raspberry Pi Zero W to keep the program codes so that the RFID reader working on, it was replaced by the Arduino Uno to see whether the hardware is compatible to be used with the RFID

reader. The connection was working fine, but the coding used to enable the RFID reader to read the RFID tags was not working. Hence, there was a person who has a lot of experience with Arduino recommended to use Arduino Leonardo instead as it able to directly come into sight to a connected computer as a keyboard and mouse. Therefore, the hardware development is achieved by using Arduino Leonardo.

As for the system, the Microsoft Excel Spreadsheet was one of the software tools to develop the proposed system which is the data acquisition system for the blood bank. In addition, the Arduino Uno was tried to be applied to make a connection with Microsoft Excel Spreadsheet. The Microsoft Excel Spreadsheet can be connected to the Arduino by using PLX-DAQ which only can be plugged in with the Microsoft Excel Spreadsheet. The gathered data which detected by any sensor will come out in the Excel Spreadsheet. The problem was, it was kind of consuming time and it needs more time to make it succeed as this proposed work need to store more information of the donated blood beside of the blood group and donor's name which means this method is not practical and plays old modus operandi to build the proposed system.

Consequently, the Caspio program which acts as a database online is used to observe the whole daily activities of the blood collection as well as plays an important role to develop the web-based application. It offers a lot of speedy ways to create a web-based application and requires only a little coding to create the website. It is one of the main reasons of the proposed system could achieve all the objectives to solve the problems existed in the blood bank. Although, in this proposed system, Caspio is used as a trial version and this has made it complicated to enhance the system by adding more functions on the web-based application. In order to upgrade Caspio, around RM 200 need to be allocated which has already out of financial planning. The site builder also has a limited version where it needs to be upgraded to add more data pages. Thus, the proposed system could be more interesting if Caspio and the site builder could be upgraded as it offers more function to be implemented on the website.

5. Conclusion

This research presents all about the development of a data acquisition system for blood bank which able to be applied in all of the existing blood banks. This proposed work is designed to investigate the lifespan of the blood collection to enhance the dispatch process of blood in order to avoid the possibility of the donated blood goes to waste. As mentioned above, the lifespan of donated blood is only 42 days and after it has reached the day after 42nd day, it can no longer be used for blood transfusion. Then, it needs to be thrown away in a proper method which has been stated in the standard operating procedure (SOP). Thus, this proposed system solved the problem of blood bank having an insufficient system in prioritizing which blood need to be used first based on FIFO policy.

Apart from that, the proposed work able to replace the practice of paper chart recorder into a cloud-based system by monitoring the donated blood details through an online website with mobile phone or computer. This able to minimize the difficulty for the hospital staffs to search the blood packet details during an emergency. Besides, the proposed system supplies proper information in less time when it is compared to the traditional practice. On top of that, with this proposed system, all blood banks and blood donation centers can be brought together to productively manage their daily activities within one integrated system. Hence, the inadequate quality of blood transfusion service as the effect of the blood bank not mutually consolidated can be diminished. Besides, this proposed work came out with a new replacement of technology that used to track the blood collection data which from a usage of barcode technology to RFID tags sensor. Although the price of purchasing the RFID tags is higher compared to the barcodes, it brings a positive return on investment as it can be reused and rewrite. RFID tags are more as the barcodes can cause readability issues if there are any icy patches on the blood transfusion bag.

Many several of implements have been left undone due to lack of time, financial problem and issues encountered while developing this proposed work. As the proposed system only introduce a system which includes the involvement of blood donation system personnel and doctors, it could be a little bit more interesting to consider donor and recipients to be a part of the architecture in the system. This would enhance the system even more, as the recipients could communicate with the donor to make blood request and set an appointment for the blood donation. Furthermore, in order to improve the proposed work, the pop-out bubble on the map that depicts the address of the hospitals could be replaced with the amount of each blood group available in the hospital so that before them heading

towards any hospital, they would know which hospital with the needed blood available that they could go. This could make the web-based application becomes more user-friendly as the public could oversee the availability of blood in each blood bank.

Apart from that, the building of a mobile application together with the web- based application could enhance the system as the system could be working better rather than using the mobile browser if the users intend to access the system with mobile phones instead of using laptop or computer. On top of that in order to ameliorate the proposed work, the current RFID reader used for the proposed system could be replaced with a RFID reader which able to get the tag IDs from a greater distance which able to go through the obstacles and able to read multiple data at the same time and thus, lessen the time to track the blood products in the blood bank.

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