Leukemia Medical Application with Security Features

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Abstract: Information on the Leukemia patients is very crucial by keep track medical history and to know the current status of the patient's. This paper explains on development of Hematology Information System (HIS) in Hospital Universiti Sains Malaysia (HUSM). HIS is the web application, which is the enhancement of the standalone application system that used previously. The previous system lack of the implementation of security framework and triple 'A' elements which are authentication, authorization and accounting. Therefore, the objective of this project is to ensure the security features are implemented and the information safely kept in the server. We are using agile methodology to develop the HIS which the involvement from the user at the beginning until end of the project. The user involvement at the beginning user requirement until implemented. As stated above, HIS is web application that used JSP technology. It can only be access within the HUSM only by using the local Internet Protocol (IP). HIS ease medical doctor and nurse to manage the Leukemia patients. For the security purpose HIS provided password to login, three different user access levels and activity log that recorded from each user that entered the system

Key words: Hematology information system, security feature, agile methodology.

1. Introduction

In developing software the main objective is the user requirements with addition features which are triple "A" (Authentication, Authorization and Accounting) security features. Currently, many software in the market especially on the Hospital Information System. But some of the software did not meet the user requirement and lacking of the security features. For example Hematology Information System (HIS) has been developed by the medical doctor with the standalone application which required licenses for additional user. Therefore, this paper will the explain on the improvement and enhance that system in term of HIS with using local Internet Protocol (IP), design and implement the triple 'A' security elements.

We are using agile methodology that used in developing the HIS application which required the involvement of the user at the beginning until the end of the project. At the same time, we will perform normalization the database from the previous system. The HIS is to make an easy procedure for users in order to manage leukemia patients. The target users for this system are the admin, medical doctor and nurse.

In this paper explained the previous study in developing the software. In section 3, mentions on the Agile methodology that we used in developing the HIS. Next section explains data gathering and observation then explain on the design. Section 6 will explain on coding. Section 7 explains on the testing and section 8 on the

result and analysis. Lastly we will conclude our finding in conclusion.

2. Previous Study

In the previous study include the two section which is previous study on software application and the second part will explain on the leukemia cells.

2.1. Security Features in Developing a Software

The application of various techniques of computerization in the medical field has helped medical doctors, researchers, specialists and patients in many ways such as blood medical images can be analysis [1]. Nowadays, there are many systems that related with Medical Information System (MIS) such as e-clinical system. There are a few existing software development such as Health, Safety and Environment System (HSES) on the web-based system and registration phase [2], Pet Shop Management System (PMS) [3] and Leukemia Information System (LIS) for collection, storage, retrieval and evaluation data [4]. All of the system does not fully concentrate on the security measure. It has been determined that in order to obtain a high level of security quality in Web-based applications system it is necessary to include good security practices during the whole software life cycle, and to make use of the available security assessment and security monitoring tools that provides to administrators, testers, and developers of valuable information for producing secure applications.

One of the important items in implementing the applications is system security and security frame. In the secure system is to understand that software is 100% secured [5]]. The main idea behind Software Security is to integrate the more level of security possible in software in order to diminish the possibilities of an attack [5]. A lot of software developments do not provide proper security because they were created with wrong suppositions in mind [5] such as that all users are friendly and will not be perform an attack, that requiring a password to login will prevent unwanted users to try to hack the application, and that a firewall is enough to protect a software from threats. Several approaches are identified often used in software development, which do not provide a valid solution to security issues in the final version of the product [6]. A Security Frame is a tool used in the creation of threat models, when is needed to identify threats and vulnerabilities [7]. It consists in a set of categories of recurring security vulnerabilities in an organized way that avoids overload of information, and helps to systematically and effectively reveals security threats [8]. In additional also required Authentication, Authorization and Accounting. These are the three basic issues that are encountered frequently in many applications [9]. Objective and measurable of security is playing an important roles in developing the software. One area in which progress is more tangible is software security assessment which can help to improve decision making on enterprise software. The software security assessment called by Vulnerability Distribution Scoring which evaluates as software product based on the characteristics of the vulnerabilities. [10]. Not only the software security but also security policy management is consider as critical to meet organisation needs and reduce potential risks because almost every organisation depends on computer network and the internet for their daily operations. The author [11] has introduced a policy framework called Chameleos-x which is designed to enforce security policies consistently across security-aware system with network services - primarily operating systems, firewalls and intrusion detection systems.

F. Montecucco [12] concerns on the ethical/legal when developing of clinically applied technologies, the collection and analysis of data to improve the Cardiovascular diseases. But by developing the system medicine it gives the opportunity of improving different steps in medical practice, from diagnosis to healthcare management, including clinical research. In the clinical decision-support system (CDSSs) was developed by [13] is to store and manage the clinical data, tools to alert clinicians of problematic situation or decision making tools to assist clinicians by mapping with the electronic health records. Currently our

application only store and retrieve the information for patients. The author [14] has created an analytics platform for specifying and detecting clinical phenotypes especially on derived variables in electronic health record (EHR) data for quality improvement investigations.

The main objective in developing the software is to provide a model of what is needed in a clear, consistent, precise and unambiguous statement of the problem that needs to be solved. If the environment is not well the understood the design will be misleading and did not fullfill the object. Understand the user requirement one of the important tasks. [15]. Although the user design has been determine but the design patterns in object-oriented program play a main roles in source code that can help maintainers understand the design of a program. Through the detection, the understandability, maintainability and reusability of object-oriented programs can be improved. [16]. We developed our application using object-oriented program using Java Script Program (JSP). In developing the application, database playing an important role in allowing the implementation of searching methods on the data to reveal relationships. The data store and retrieve by using Structured Query Language (SQL) command in accessing the data [17]. After developing the application, we need to perform the testing. The test case prioritization techniques attempt to reorder the test cases manner that increases the rate at which faults are detected during regression testing. The prioritise test cases based on the total number of code. The testing not limited into the user testing but also code testing. [18], [19]. We also perform the integration testing between the program. After testing and the new software need to be release with the growing competition in the software industry. The software release process which broadly includes all the process that starts after the completion of development till the final deployment. The plan of the deployment need on time and changes also need to monitor. [20]

Nowadays, people are not looking for a traditional software development which is waterfall methodology. [21] mention recent studies show that traditional teaching strategies such as presentation of theory and lectures are differences scenario when working in industry. They have developed a training method called Software Kaizen for high-performance environment. From the study, shows good results in learning, posture change and teamwork and some of the expected characteristics of high-performance teams. Agile software engineering and user-centered design are two important development processes for ensuring that an application has good user experience. [22]. From the study by [23] communities of practice (CoPs) are groups of experts who share a common interest or topic and collectively want to deepen their knowledge. The use of CoPs for knowledge sharing and coordination in large-scale agile software developmends. From their study of large software development organization that successfully used CoPs to suppor their large-scale agile implementation as their transformation from the waterfall model to lean and agile.

In this paper highlighted the Hematology Information System. Authentication based on the role-based where doctor and nurse have differences role in the system. Authorization is the user name and password before access into the system. Accounting is the collection of the activity from access into the system until logout. From the literature review, mention that agile methodology has improved the high-performance development and it has been used in the large-scale software development. We performed our study in using agile methodology.

2.2. Leukemia Cells

Cancer has become a data-intensive area of research, with increasing rate of developments in data collection technologies and methodologies. In 1895, Wilhelm Roentgen discovered that X-ray tubes, used extensively for imaging bones and then for treating a variety of conditions. The technicians who ran the Radiograph machines, as well as many of the exposed patients, contracted skin tumours and leukaemia [24]. Accurate diagnosis and classification of blast cells is an extremely valuable requirement for the precise diagnosis of leukemia and has a positive impact on treatment and prognosis [25].

2.2.1. Types of leukemia

Leukemia is a disease of unknown cause where the bone marrow produces large numbers of abnormal cells white blood cells that stop developing before maturity [26]. There are four main types of leukaemia, namely Acute Lymphoblastic Leukemia (ALL), Acute Myeloid Leukaemia (AML), which is used as a case study in the thesis, Chronic Lymphocytic Leukemia (CLL) and Chronic Myeloid Leukaemia (CML). Most commonly, acute leukaemia patients are referred to specialist units for evaluation. Treatment is based on chemotherapy through the veins, lasting four to six months, which also kills normal body cells. Leukaemia can be diagnosed by blood tests while a bone marrow test serves to decide on the best choice of treatment.

2.2.2. Flow chart of patients admitted with leukemia

Fig 1 shows the steps that need to be taken by a hematologist in order to diagnose a patient with acute leukemia. Table 1 provides a more detailed explanation of the individual steps in Fig. 1 [27].

Steps	Descriptions from Figure 1			
1	Patient warded in hospital.			
2	In acute leukaemia patients, the White Blood Cell (WBC) count and morphology will be abnormal. Doctor will suspect that a patient has leukaemia based on:			
	a) Clinical presentation: patient presented with hepatosplenomegaly and/or lymphadenopathy.			
	 b) Abnormal blood count: haemoglobin and platelet count is low, WBC is normal, low or high. 			
	Blood test will be taken from the patient. In a healthy adult the differential WBC test should show the following results:			
	 Neutrophil - 40% - 70% Eosinophil - 5% 			
	 Basophil – 1% 			
	• Monocyte – 6% - 10%			
	• Lymphocyte – 20% - 50%			
	I ne blood count will be performed by the Machine.			
	prepared and the slide is referred to a haematologist for examination.			
3	The blood smear is scanned through a microscope by a haematologist to see the white blood cell morphological			
4	If the blood smear test reveals no evidence of leukaemia, i.e.			
	normal blood cell count and morphology, other underlying causes need to be investigated.			
5	If the patient is suspected of suffering from leukaemia, bone marrow sample is required to confirm the diagnosis.			
6	The marrow smear is scanned under a microscope by a haematologist with 10x, 40x and 100x magnifying power.			
7	The haematologist will calculate the WBC differential count manually preferably based on 300-500 cells			
8	Blasts should account for about 20% of cells, based on the WHO classification. Less than 5% is considered normal.			
9	The image allows identification of ALL or AML.			
10	If the patient diagnosed with ALL then required treatment.			
11	In the case of AML, the subtype must be identified as either M3 or non-M3 (M0-M7 except M3).			
12	If the patient is suspected as M3 based on the blood smear and bone marrow smear test, Cytogenetic/molecular follows to confirm the diagnosis.			
13	Confirm M3: Treatment for M3; All-Trans-Retinoic-Acid (ATRA).			
14	If non-M3 - Another Chemotherapy			

 Table 1. Analytical Description of Each Step in Fig. 1

3. Methodology

The objective of the paper is to develop software application HIS in HUSM by collecting the user requirements. We choose Agile methodology in developing the HIS where from the previous study mention

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agile methodology has proven better than traditional study and last objective is to develop the security framework by using triple "A" elements (authentication, authorization and accounting). Below in the Figure 1 show the Agile Methodology that we used in developing the HIS. In this methodology, we used requirement and analysis, design (user interface design, database design and system design), coding and testing were perform repeatedly until user satisfied before we implemented.

The activities carried out in HIS in Table 3 which illustrates the Fig. 2.



Fig. 1. Steps to confirm AML – M3.

4. Data Gathering and Observation

The development of HIS in Hospital Universiti Sains Malaysia (HUSM). Medical Doctor at Department of Hematology was interviewed to understand the user requirement and the user interface design. In order to achieve the first objectives, an interview was conducted with medical and the system user at Hematology Department. The questionnaires are based on the qualitative method. The questions can be referred in Appendix A. Based on that, we understand the current process and the problem in the current system of Hematology.

5. User Design, System Design and Database Design

In the current situation for HIS, the software application has been developed but there is limitation where

the application needs licenses if required more users, lacking on the security features and database is not been normalized. Fig. 3 and Fig. 4 are the interface of existing system that used at Hematology Department HUSM.



Fig. 2. Agile methodology.

Table 2.	Process	in	Devel	oping	HIS
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Phases	Descriptions
Requirement and analysis	Goals:
	To identify the project problem statements, research questions, objectives and motivations
	Tasks:
	Define the project problem statements, research questions, objectives, motivations and scope.
	Outputs:
	The project problem statements, objectives and scope
Design	Goals:
	The design phase consists of logical and physical design. The goals in this phase are to design
	and model the system design using UML diagram and produce a detail design and model for
	the system. Design the prototype model and the system interface using graphic software tools.
	Tasks:
	Build and design the system structure. Determine the system flow.
	Transfer the system requirements into system design and system model. Draw use case
	diagram and sequence diagram. Design and build the interface of the system.
	Output:
	The use case, sequence diagram and user interface built
Coding	Goals:
	Coding the component and modules for the system using JSP technology and MySQL for
	database.
	Tasks:
	Transfer the design and model of the system into coding part.
	Outputs:
	Full coding of the system will be constructed after the design process. Therefore, complete
	system will be produced within the complete functionality.
Test	Goals:
	To test part of the system.
	Tasks:
	Provide input and unexpected data value for testing during implementation. Repair any errors
	of bugs during the implementation.
	Outputs:
	The system will be tested whether it is working or not after the developing of the system.
Implement	Goals:
	To test full version system with real time environment.
	Tasks:
	Run the Hematology Information System on the different environment, such as different
	computer and Operating System (OS). Deploy the project based on user requirement and
	linkage with other department.
	Goals:
	A system that is capable to operate correctly.

HUSM Hematology Patient Management Information System	
Newsteless Information Custom	
Created by Abu Dam Aboliah (2015-2011) 946	
Version 4.2 : 30 Sept 2011 (Optimised for 1024 x 768)	
(All nutaliation must be via the apped installer Ne, and folder placed in C drive)	
UserName	
Password	
If this software is behaving erratically please inform Dr Abu Dzarr Abiulikh: 013-9332372	
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Fig. 3. Login page.

Fig. 3 shows the login page for the existing system at Hematology Department and Then Fig. 4 shows the patient's profile page from the existing system. The design look nice, but some of the field provided are not fully functional.

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rn A002231 nric 820304123451 name Che Ku Alyn	Lb Che Ki Category	
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Fig. 4. Patient's profile.

5.1. User Design

We performed the agile methodology which needs user involvement from beginning. The first user design

as shown in the Fig. 5 and Fig. 6 where the users are not keen with the design. Then we change the design as show in the Fig. 7 and Fig. 8. In a conclusion we have completed the design with agree by medical doctor at Hematology Department. The design of each page shows the different function respectively. Further discussions in this section involve with system structure, system architecture and system design.

← → C	Di localhost:8080/husm/project/login.jsp	9 0 E
	Department of Haematology Hospital Universiti Sains Malaysia (HUSM)	
	Login	
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	Login Reset	
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	Fig 5 Login nage	03/12/2014
	rig. 3. Login page.	
€ ⇒ C	bccalhost 8080/husm/project/blood jsp?id=A1110004	0 =
	Department of Haematology Hospital Universiti Sains Malaysia (HUSM)	
		111

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Date (Data Input) Date (Blood Test)				Summary		
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Fig. 6. Blood series.

HIS is capable to offer 12 pages that perform difference task and function for difference interface respectively. The medical doctors were accepted these latest designs based on the user requirement. Fig 7 to offer different types of important function for the user. Fig 8 show the activity log in the menu. Other menu design can be found in the Appendix B where we have implemented the authorization each user has own roles of job for example nurse and doctor.

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	ما	gin Admin		
	P	assword		
		Login		

Fig. 7. HIS Login page.

Part	Description
User tab	There are 3 types of user, which each of user performed the different task
Login field	User must enter their username and password in the provided field

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	Welcome » Admin	
🐵 Home		
🖏 System User 🔍	Admin Privileze Activity og	
🗏 Logout	Autor Have a Autor of	
Network Status	List of All User	× .
Good Connection 76%	*	
Host: 127.0.0.1 IP: 127.0.0.1	Dr.Radhi logged in at 2014-11-20 12:16:08.0 MYT	
Port: 51431	Nadia logged in at 2014-11-20 12:14:19.0 MYT	
	Dr.Radhi logged in at 2014-11-20 11:41:55.0 MYT	
	Dr.Radhi logged in at 2014-11-20 11:38:05.0 MYT	
	Dr.Waidah logged in at 2014-11-20 11:23:47.0 MYT	
	Syawati logged in at 2014-11-20 11:14:17.0 MYT	
	Dr.Nadia logged in at 2014-11-20 11:12:45.0 MYT	
	Dr.Radhi logged in at 2014-11-20 11:10:01.0 MYT	

Fig. 8. Activity log.

Part	Description
Home (sidebar)	List of all system user appear on the screen once admin login into the system
System user (sidebar)	Admin can register new medical doctor and nurse to use the system
Logout (sidebar)	Clear the current session and logout to the system

5.2. HIS Structure

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Medical doctor in hematology department manually updated the data. It is easier for the medical doctor to maintain and enhance the patient's data. Fig. 9 illustrates the structure of HIS that contains 3 phases; there are interface layer, abstract layer and physical storage layer. The user interface designs of the system are delivered on interface layer, while the process of the system and storage are occurs on abstract layer and physical storage layer respectively. To make the system running properly, the three layers of the system structure must have integration within it.



Fig. 9. HIS structure.



Fig. 10. Model of system architecture.

5.3. HIS System Architecture

The system architecture of HIS consists of 3 parts as shown in Fig. 10. There are presentation layer (User Interface), business layer (Java EE Server) and data layer (Database Server). From the design, it consists of 1 database with 3 main modules, the admin module, medical doctor module and nurse module. The admin module is designed to manage the user of the system. The medical doctor and nurse module is designed to manage information relating to patient's personal and medical information. The HIS database is used to store user and patient's information, which includes the personal data, clinical summary and blood series record.

5.4. HIS Database Design

Database Design show in Fig. 11 is the relationship between the entity within the HIS. For example one patient can have multiple blood series and clinical summary. The result of blood series will be taken before chemotherapy and after chemotherapy. As for security reason, in the medical records, the data cannot be deleted or updated but only add the new one.



Fig. 11. Entity relationship diagram (database design).

5.5. HIS Sequence Diagram

Fig. 12 shows the model flow of logic within HIS in a visual manner. It enables to document and validate the system logic and is commonly used for analysis and design purposes.

5.6. HIS Use Case Diagram

Use case diagram describes the scenario of the system. This scenario is an interaction between actors and the use case. In Fig. 13, actors involved in this use case are admin, medical doctor and nurse while the use case involved are register new user, view user activity log, register new patients, update patient details, add

clinical summary, view patient records, search patients and add patient's blood details.



Fig. 12. Sequence diagram of HIS.



Fig. 13. Use case diagram.

6. Coding

In developing the Hematology Information System, some of tools have been used to design, coding, and deploy the system. The tools shows in Table 3 ease the researcher to develop the system.

Tools / Technology	Description
Eclipse	Develop a coding on this software and run the apache server by using this
	platform.
Java Server Pages (JSP)	JavaServer Pages (JSP) technology provides a simplified, fast way to create
	dynamic web content. JSP technology enables rapid development of
	web-based applications that are server- and platform-independent.
MySQL database	This is a database system that used in the web-based application or
	system. That is ideal for both small and large applications. In addition, it is
	very fast, reliable and easy to use and compiles on a number of platforms.
	The database system runs on a server provided.
Javascript	JavaScript is a dynamic scripting language supporting prototype
	based object construction.
Apache	Apache is generally recognized as the world's most popular Web server
	(HTTP server) (Bradley Mitchell, 2013). It provides a full range of Web
	server features, such as CGI (Common Gateway Interface), anonymous
	user access, virtual domain, server status display, and others.
LucidChart	Tools to draw and design UML diagram. To sketch the proposed system
	logically.
iMacros	Integration testing tools. iMacros can automate it from web
	automation/web scripting, to data extraction and to web testing.

Րable 3. Software Used i	n Developing	the Hematology	Information S	ystem
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All of the functions use add and update method. There is the first page of the system. During the development process, programming that has been used to implement this system is JSP. Therefore, Eclipse Kepler Web Tools Platform has been used as a development tool. The template of the page was designed by using css bootstrap as mentioned at design phase in previous chapter. The button and the header of the page totally designed by using Adobe software. After making analysis for the system design, and functional flow, the system translated into the system coding to make sure that compiler understand the command. Every single button of each page of the system has an own function.

6.1. Functional Requirements of HIS

The Internet application typically runs on a web server. In this report, JSP and java will be the implementation language. To support the requirements, the system will be built on a platform, which supports java. Since Java language is platform independent, the system could be in Windows 98/2000/NT/XP or Unix/Linux platform with a Java server. In this Hematology Information System, hundreds of data will be stored. The data access involves reading and writing. Therefore, it will need a database management system to manage the data.

Based on the above reason, those are the recommended system requirement for Hematology Information System:

- 1) Computer with processing unit at least 1.5 GHz and above.
- 2) 512 MB of RAM
- 3) Portable (No need installation)
- 4) Operating System:
- Microsoft Windows XP Home Edition (Service Pack 2), Microsoft Windows XP Professional (Service Pack 2), Microsoft Windows XP Professional x64 Edition
- Microsoft Windows Vista, Microsoft Windows 7, Microsoft Windows 8
- Linux/Unix

For this system, it is a special web site for special users. The server will put inside the hospital's intranet. So, physically, the server should be secure because it is behind the firewall. A steady Internet connection is required for running the web server. DSL high-speed connection or cable connection is recommended, though dial-up connection with at least 56kbps modem can also be considered. Besides, a user friendly GUI (Graphic User Interface) is required for frequent visitors to browse through the web browser. The web browser should be Internet Explorer 7.0 or higher. The user interface will be transparent to the user, and extremely easy to learn. No special skills are required to use the system, just the ability to read and understand the displayed textual information.

7. Testing

In this section explain on the testing of HIS to ensure the system is acceptable by the user. It includes the goal of testing, step of testing, result of testing, and the changes made after testing if there is a problem occurred. The testing of the system is important to help in identifying the errors and bugs occur in the system so that the system running smoothly. The integration testing was conducted before the evaluation process start by using iMacros tool. iMacros is a tool that can automate in browser tests. It is also perform in-browser tests of Java, Flash, Flex or Silverlight applets and all AJAX elements. Integration testing tests integration or interfaces between components, interactions to different parts of the Hematology Information System. The form of this testing was shown at *Appendix C*.

Next stage of testing is the user acceptance testing (UAT). The form of the UAT as shown at *Appendix D* The evaluation process was conducted at HUSM and Faculty of Medicine and Science Health, USIM. We want to ensure that our software can be applied to any hematology department. The evaluation processes consist of system acceptance testing by user. To test the major component and module of the Hematology Information System, three medical doctors and two student of medicine have been decided to test the system in real environment. The two students were act as nurses. They used the system at the same time in the same network. The purpose is to find out whether there is any error or fault in the program. As for integration testing, all the system components work had together as required by the system requirement. With regard to system testing, the entire system was tested with all possible triggers and the system was capable and succeeded to handle the said triggers. All of the testing conducted allowed the researcher to detect errors and to ensure the quality; security and reliability of the program code from the earliest stages of the development until the final stage and managed to reduce potential errors. Below is the example of the testing requirement

Admin Login and Register User

Goals:

This testing is carried out to verify that all the features fully functional. This login part is very important to make sure that the system is running properly based on the priority of each user.

Steps:

- Admin login the system and register the medical doctor and nurse.
- Medical doctor and nurse login the system.
- Results:
- Activity log of medical doctor and nurse were recorded in database and admin can view their activity log.
- Medical doctor and nurse view a different page after login the Hematology Information System.

Patients Registration

Goals:

To make sure that registration form and the information entered by medical doctor pass through the

validation process.

Steps:

- Click the "Register" button on the sidebar menu.
- Medical doctor should enter the patient's information and click "Submit" button at the bottom of the page.
- Results:
- Once medical doctor submit the registration form, the system directly go to the patient's detail page.
- If the submission is failed to pass through the validation process, the system will return back to the registration page again and medical doctor must correct the erroneous.

Search Patients By Registration Number

Goals:

Medical doctor and nurse carry out this testing to verify that search function will work after clicking the search button.

Steps:

- Entered patient's RN into the search box, then click the search button
- Results:
- Within 2 seconds, the patient's detail appears at the bottom of the search box.
- If the user entered the wrong patients RN, the system will noticed to enter a RN again.

Edit Patient Details

Goals:

Medical doctor carry out this testing to verify that update function is running properly with real running time Hematology Information System. This function is prioritized to medical doctor only.

Steps:

- Edit patient's category, from Outpatient to Inpatient.
- Update the changes by clicked the update button.
- Results:
- The system shows the related patient, changes into the new category.

8. Result and Analysis

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	HOSPITAL	UNIVERS	SITI SAIN	S MALAYSIA	
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	Username				
		Login			

Fig. 14. Login page.

During implementation, we faced problems when conversion data from old system to new system. The old database is had been un-normalized and same. The table is not used, we need to export the data into excel for matching our new database. From the solution, we successful convert our database. During the user acceptance testing (UAT), they have commented on the design phase that required the calculation on blood series. The reason is to automate the blood calculation and reduce the human errors on the calculation. Finally, we have enhanced the user requirement.

Login Page and Activity Log Page

Once the medical doctor and nurse login into the HIS, their username and timestamp of login will be recorded into the activity_log table. This page will be automated refresh within 60 seconds. So that, admin can view and trace who use the HIS at that time.

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	Welcome » Admin	
🗈 Home		
🚓 System User 🛛 🔇	Adimin Rehiding La Adhiding Lang	
🗏 Logout	Admin Privilege Activity Log	
Network Status	List of All User	~
Good Connection 76%	*	
Host: 127.0.0.1 IP: 127.0.0.1	LT:Radhi logged in at 2014-11-20 12:16:08.0 MYT	
Port: 51431	Nadia logged in at 2014-11-20 12:14:19.0 MYT	
	Dr.Radhi logged in at 2014-11-20 11:41:55.0 MYT	
	Dr.Radhi logged in at 2014-11-20 11:38:05.0 MYT	
	Dr.Waidah logged in at 2014-11-20 11:23:47.0 MYT	
	Syawati logged in at 2014-11-20 11:14:17.0 MYT	
	Dr.Nadia logged in at 2014-11-20 11:12:45.0 MYT	
	Dr.Radhi logged in at 2014-11-20 11:10:01.0 MYT	

Fig. 15. Activity log.

$$S(user_id, pass, role) = \begin{cases} 1, & if \text{ open table Admin,} \\ 2, & if \text{ open table Doctor} \\ Otherwise, & if \text{ open table Nurse} \end{cases}$$
(1)

Input: user_id, pass, role Read user_id; Read pass; Read role; Perform Eq (1) Search user_id Search pass End

9. Conclusion

In conclusion, by performing Agile methodology can reduced time consuming and meet the user requirements. Although in the beginning will takes more time to finalise the user requirement and design but during the development it takes less time. At the same time, the full commitment from the user in user interface design and create the database design. The medical data can consider as high-risk application and need to develop more on the security features.

Appendixes

Appendix A

Hematology Information System

User Requirement Questionnaire

Types of Requirements:

Requirements state expectations at two levels. The first are high-level functional requirements that state goals the system will achieve. The second are more fine-grained procedural expectations that describe how the system will behave. As might be expected, it is possible to fulfill a set of functional requirements in multiple ways using different instantiations of procedural requirements.

- 1) What are the perspectives and objectives of the project? Based on the problem.
- 2) What are the functions and workflow that the system must be able to perform?
- 3) What are the types of information that a system must be able to process?
- 4) What the new features do you want in this system?
- 5) What type of security do you want in this system? Except login session.
- 6) What the screen do after user login the system?
- 7) Who can use or access the system? Based on user classes and characteristics.
- 8) What are the types of operating environments that can run this system?
- 9) What are the types of hardware interface use in this system? E.g.: Internet connection.
- 10) What are the types of software interface use in the system? E.g.: Web Browser.
- 11) What is the communication interface uses in this system? E.g.: IP, HTTP and MYSQL.

Appendix B

			localhost		C	۵	Ø
	Welcome » Dr. Wa	idah					
ne							
ients ~	All Search I	npatient Observe Ho	me Alive				
	RN	Name	ю	Diagnosis	Category	View	Edit
out	1110006	Che Ku Khalaf Che Ku Lyn	920205-01-6201	AML	Observe	Q	1
k Status	1110005	Syazwani Zakariya	921116-01-5613	CLL	Inpatient	Q	1
	1110007	Abu	921111-04-3432	AML	Home	Q	1
	1114321	Abdul Hassan Basri	890102-03-9871	CLL	Home	Q	1
	1112323	Farhan Ibrahim	871203-05-5643	ALL	Home	Q	1
						-	1
	1110213	Jumahat Ngadimin	651209-12-8891	CLL	Observe	હ	
	1110213 1110001	Jumahat Ngadimin Nur Liyana Ramli	651209-12-8891 890508-02-9344	AML	Observe	ଷ	1
	1110213 1110001 1110004	Jumahat Ngadimin Nur Liyana Ramli Nur Sofeah Masruhan	651209-12-8891 890508-02-9344 920205016202	AML ALL	Observe Inpatient Home	ଷ ଉ ଉ	1

List of all patients page

Journal of Software

Part	Description
Patients > All (sidebar)	Show all the registered patients in te system.
View button	Once the user click on the view button, the system will show the detail of that patient,
	such as biodata, clinical summary and blood series
Edit button	Edit and update patient details. Only medical doctor can perform this action

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	Patient Details	Cir	Contract Summary Bloo	G d Series	
Home	List of All Summ	ary Re	port		
a¢ Patients ~	Date & Time		Subject	Report Details	Initials by
- All	2013-12-11 02:09	0.09	Blood Sample	Patient came to Hematology department. Nurse was take blood sample from patient	Dr.Radhi
 Register 	2013-09-09 02:09	0.00	Blood Disease	Store blood sample at blood banking system at blood department	Dr.Radhi
Logout	2014-02-05 01:13	:35.0	Emergency Meet Up	Hematology tests include the Complete Blood Count (CBC)	Dr.Radhi
ature Catus	2014-11-15 14:43	0.803	Blood Disease	Leukemia detected in phase 3	Dr.Radhi
ood Connection 76%	Add New Summ	ary Re	port		
ost: 0:0:0:0:0:0:0:0:1 1: 0:0:0:0:0:0:0:0:1	RN	1110	003 \$		
ort: 51459	Subject				
	Report Details	Enter	text here		
	Initials by	Dr.A	dan 0		
	Submit				

Patient's clinical summary record

Part	Description
Add new summary report	When click 'submit' button, the input entered by user will automatically update by the
	system and the time is record via timestamp. This action only can be done by medical
	doctor. Medical doctor have a privilege to add new clinical summary record

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HEM	ATOLO	GY DEPARTMENT, H	IOSPITAL UNIVERSI	TI SAINS MALAYSIA	
Blood Test					
Name		Radhi Rafiee Afandi			
RN		1110003			
Test		White Blood Sample			
Date		2014-11-18			
wbc 10^9/L	10	hb g/dL	12	plt 10^9/L	32
hct	12	rbc 10^12/L	45	MCV fL	89
MCH pg	45	MCHC g/dL	32	neu 10^9/L	12
lym 10^9/L	45	eos 10^9/L	65	baso 10^9/L	76
mono 10^9/L	12	blast	34 %	prom	56 %
myelo	56 %	meta	12 %	band	23 %
reac L	reac L 12 % re		43 %		
Comment		Patient in critical condition			
© 2014 Hematology Information System, All F	Rights Rese	rved.			

Blood Series printout version

Part	Description
Plood series teh	From blood series tab, user can print the blood series for each paients. This action are
Blood series tab	performed by medical doctor or nurse.

Appendix C

Result of Integration Testing

Journal of Software

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Admin module.

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Save & Close Save As & Close Cancel

Medical doctor module.

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Appendix D

Hematology Information System Evaluation Form

No.	Criteria	Yes	No
1.	Is the level of language that the system offers clearly indicated?		
2.	Is it easy to start the system?		
3.	Is the user interface easy to understand? (For example, is the screen layout clear and		
	easy to interpret?)		
4.	Is it easy to navigate through the program?		
5.	Are icons that are used to assist navigation (e.g. back to the homepage, exit) clear and		
	intelligible?		
6.	Is it always clear to the learner which point s/he has reached in the program?		
7.	Is the learner offered useful feedback if s/he gets something wrong?		
8.	If the system use automated data retrieval, is it effective?		
9.	Do you think the system is secure ?		
10.	Is the system relevant to your department?		

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