A Web-based blood donor management information system for the Red Cross Society, Uganda (WBBDMI)

By

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Declaration

I Kanobe Fredrick do hereby declare that this project Report is original and has not been published and/or submitted for any other degree award to any other University before.

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Approval

This project Report has been submitted for Examination with the approval of the following supervisor.

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Dr. Tom Wanyama
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Dedication

This work is dedicated to my late Father and Mother Mr/Mrs Kanobe Asuspa for their commitment and sacrifice towards my education and my wife, Mrs Kanobe Victoria who has stood with me throughout the course.
Acknowledgement

I would like to acknowledge the following people without whose help, this work would never have come to completion.

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Abstract

The purpose of this study was to develop a blood management information system to assist in the management of blood donor records and ease/or control the distribution of blood in various parts of the country basing on the hospital demands. Without quick and timely access to donor records, creating market strategies for blood donation, lobbying and sensitization of blood donors becomes very difficult.

The blood management information system offers functionalities to quick access to donor records collected from various parts of the country. It enables monitoring of the results and performance of the blood donation activity such that relevant and measurable objectives of the organization can be checked.

It provides to management timely, confidential and secure medical reports that facilitates planning and decision making and hence improved medical service delivery. The reports generated by the system give answers to most of the challenges management faces as far as blood donor records are concerned.
Chapter 1

1.0 INTRODUCTION

1.1 Background to the Study

Blood Donor Recruitment (BDR) is the process of drawing blood from a voluntary Blood Donor (BD) for future blood transfusion, Wikipedia (2006). In Uganda, blood collection, safety and management is an activity that is carried out by Uganda Red Cross Society (URCS) in partnership with Uganda Blood Transfusion (UBTS). Founded in 1939, URCS is part of the world wide Red Cross Humanitarian Movement whose mission is to mobilize the power of humanity for improving the lives of the vulnerable in Uganda, Muller (2001). URCS fulfills this mission while adhering to the principles of impartiality, neutrality, independence, unity, universality and voluntary service for the Red Cross/Red Crescent Movement. It operates throughout Uganda with 45 branch offices. Besides providing adequate supply of blood for transfusion, URCS is involved in the first aid services, road safety, tracing, disaster mitigation/preparedness, mobilization for routine immunization, HIV homecare, youth empowerment and Community based HealthCare (CBHC).

URCS had a manual system using paper cards to recruit BDs, collect/keep blood donor records and disseminate results to BDs who are scattered throughout the country. The paper card system (PCS) used to specifically capture personal data and medical history of the BDs. This information would be used in identifying/locating existing BDs, carrying out pre-donation counseling and taking blood results. Unauthorized persons however, easily accessed the paper system and hence making it impossible to keep secrecy and confidentiality expected of medical records. The security of the medical records was also not inadequate as any person could easily access them. Lukande (2003), states that such a system is time consuming, prone to errors of entry and analysis resulting from the fatigue of the users. The PCS at URCS had lead to accumulation of physical paper cards due to increasing
number of blood donors, a situation that frustrated the system users because of the delays and at times failure to access historical records.

The safe blood policy was lacking at URCS because the PCS could not cater for the key attributes of the policy. Gerard (2002), states that the main principles upon which the safe blood policy is based on are the informed consent, confidentiality and secrecy of the BDs. The Ethiopian Red Cross Society publication, Development in the 1990 states that information from blood donors should be completely confidential and if this is not assured, names of the blood donors should not be recorded at all and/or an alternative record identification should be used.

Full implementation of the safe blood policy has called the use of information technology (IT) in providing working solution to the identified challenges. The associated problems with the PCS included delays in accessing historical records, inconsistencies and errors in data entry that stem right from acquisition of data from the blood donors because the exercise is of routine nature and very tedious to the system users. The automation of the system using modern IT has improved the quality of service. Secondly, with the use of IT, now relevant and timely blood donor reports can easily be generated and hence facilitating planning and decision-making.

Scolamiero (2000), recommends blood donor services automated information system as a solution to routinely collected, accurate and readily available information in blood transfusion services. It is also important to note that the impact of information technology on organizations is increasing as new technologies evolve and existing ones expand. According to Clifton (1995), nearly all business executives say that information technology is vital to their business and that they use IT extensively. Certainly business executives main concern is planning, coordination and decision-making, therefore, the role of IT in enhancing management of blood donor records is of major importance.

In all, the computerization of blood donor PCS at URCS came at the ripe time given the background to the situation. This is more so because the demand for safe blood in Uganda
has increased due to soaring increase in total population. Therefore, modern means to manage the PCS using IT had to take route.

1.1.1 Web Based Management Information System

Accessing databases using a web browser as if accessing a normal database application system can be a very significant advantage. Today’s database systems can be very efficient in processing large amounts of data by using different type of sources. Any information that can be defined by a relation can be fed into a database system, however making information available on the Web requires accessing the database via a special database algebra called SQL and by converting it to a markup language such as HTML or XML (Weigang, 1999).

Firstly, to understand this system, it is important to understand the meaning of the Web and how it can be integrated to a database. The WWW is a software environment based on a computer network called Internet. It is officially described today as a “wide-area hypermedia retrieval initiative aiming to give universal access to a large universe of documents (Orchard, 1995) and has a variety of uses throughout the world. However, in order to fully take advantage of these uses one must definitely be connected to the Internet and must use some kind of software package (Web Browser) that understands markup languages (i.e. hypertext, hypermedia)

An additional requirement of the system is for it to be able to integrate to the Endnote software. The drawback using this software tool is that it can only be run on a single computer and therefore users who are not using the computer Endnote is installed on cannot access its database. Therefore, it is essential to provide a “bridge” between the Web-based DBMS and the Endnote Software tool database system in order for bibliographical data to be transferred (import/export) between the above systems when desired. This integration will not only facilitate the need for continuity, it will certainly also provide a great degree of standardization to the system and its users.

Many technologies exist (and will be examined in depth) that can be adapted in order to integrate a web based front end to a database. By analyzing each technology’s strengths and weaknesses it will be easier for the system to be developed to provide the most optimal Web-to-database access and Endnote compatibility. Using more automated facilities for publication purposes will significantly improve the current system by decreasing the workload of specific members of staff and by increasing their productivity.
1.2 Statement of the Problem

The BDR management system at URCS exhibited a lot of ineffectiveness and inefficiency that had far fetched impact on the decisions taken by management. The system, which was manual that is based on paper cards to collect blood donor data, keep records of blood donors and disseminate results to BDs had weakness that needed IT based solutions. The system was characterized by delays and sometimes failure to access historical records, errors were witnessed in entry and manual analysis of results, secrecy and confidentiality of records lacked because unauthorized persons could easily access the records. Therefore, management decisions such as blood distribution to hospitals, mobilization/sensitization of blood donors were not taken basing on real facts. Under such a system, another challenge to management was quick generation of reports pertaining to blood groups for the big number blood donors in place. Indeed the application of IT-based solution in improving the system was envisaged. Therefore, the existing system was reviewed and an effective/robust blood donor management information system designed to assist management in implementing its strategic plan in order to achieve the over all mission, goals and objectives.

Douglas (2003), states that the traditional methods of medical data management have resulted into incomplete and inaccurate data in many cases. Incompleteness has resulted from lack of printed forms, unwillingness of staff to complete forms and sometimes loss of completed forms prior to data entry. The scenario explained by Douglas is not far from the PCS that was at URCS, a situation that rendered decision-making by management challenging and hence justified for the research of this project.

1.3 General Objective

The main objective of the study was to create electronic blood donor management information system in order to assist in the management of blood donor records, planning and share information in a more confidential, convenient and secure way using modern technology.
1.3.1 Specific Objectives
To conduct a study on blood donor management
To design an electronic blood donor management system
To validate the design using a prototype

1.4 Scope
The study geographically limited itself at the URCS blood donation/collection centers. It focused more on the acquisition, distribution and management of blood units for BDR activities. The study specially emphasized the creation and implementation of an electronic management information system that automated blood donor data acquisition and dissemination of results. This in turn will ease and speeds up the planning, decision-making process because of the timely, secure, confidential and reliable reports.

1.5 Significance of the Study
This study is important to URCS and the blood donors because it aimed at addressing problems of security, secrecy and confidentiality of blood donor records. It also strived to check the delays, errors, inconsistencies in medical records and timely access to historical records all of which had far fetched impact on planning and decision-making. The study resulted into the following benefits:

It has eased the control and distribution of blood in various parts of the country basing on the hospital demands.

URCS can now create market strategies for blood donation, lobbying and sensitization of the blood donors.

Automated data acquisition and quick access to medical records by the legal users of the system will be assured.
It has eased the monitoring of the results and performance of the blood donation activity and hence relevant and measurable objectives of URCS are checked.

It will continue to improve on the planning and decision-making process by providing to management timely, secure and confidential medical reports related to blood donation.

It will also improve medical service delivery due to timely and easy generation of management reports by the relevant entities.

The study will benefit the URCS management, who will find it easy to strategically plan, coordinate and take decisions concerning BDR activities. URCS counsellors on the other hand will be able to keep confidentiality of the donor’s results and disseminate blood results to donors with ease. Meanwhile that is the case, the automation of the data collection process will simplify the work of the data clerks. Equally important, the blood donor mobilizes will be have strong grounds for laying sensitization strategies between regions that yield more blood units and those with less. The study also has formed further environment of knowledge for students who may wish to take research in blood donor management.
Chapter 2

2.0 LITERATURE REVIEW

2.1 Management Information Systems in Medical Records

Overtime, there has been on-going digital revolution of the 21st century especially in the integration of Information Systems (IS) into the existing various sectors of human engagement. This revolution has come with a view of enhancing the quality of services provided, improve data systems and automate all the originally manual operation. Lucey (1997), defined information systems as formalized IB-based systems used to collect, store, process and generate reports based on data from various sources to aid management in taking decisions, coordinating, controlling, analysis and planning for the organization. Information systems whether automated or manual comprise of people, machines and methods of data collection, processing, transmission and dissemination. They therefore, play a vital role in facilitating planning, coordination and decision-making process.

The integration of IT in the medical sector has lead to the increase in the development of Health Information System (HIS) in the developing world. Ophelia and Chong (2004), defines HIS as a system that integrates data collection, processing, reporting, and use of information necessary for improving health service effectiveness and efficiency through better management at all levels of health services. Procter and Brown (1997), point out that this shift to automation by the integration of operations using computer technologies in medical records saves time and improves the reliability of ordering and obtaining results of the tests and therefore a generic system for Orders, Results and Reporting (ORR) was developed. An example of the integration talked of is the Hospital Information Support System (HISS). This electronic transfer system was introduced for hospital wards for purposes of ordering of patients’ tests and reporting results. Another example of integration of IT in medical sector is the use of handheld devices to collect data, carry information to
patients and used as references. In Ghana and Kenya, the mobile technology has been used successfully in the routine immunization campaign to collect data and analyze results and hence providing healthcare system.

Fadlalla and Wickramasinghe (2004) state that robust healthcare information system (HCIS) are important in enabling healthcare organizations, address challenges of medical data and that information captured, generated and disseminated is of possible integrity, quality and complaint with regular requirements. In one way or another, this is linked to the computerization of the blood donor records at URCS that is meant to focus on data acquisition, security, secrecy, consistence, easy access to medical records and generation of timely reports to facilitate decision-making. All attributes mentioned here were lacking at URCS and hence the shift from the manual system to IT aided system to enhance the management of the BDR unit.

Croasdell (2000); Hammoud (2001) note that Information Systems/Information Technology (IS/IT) have played a central role in enabling organizations across many segments to address many business challenges and achieve a lot of sustainable comparative advantage. Surely, an electronic management information system has offered similar benefits to the blood donor management at URCS. Specifically, it has offered a means to address the challenges that had crippled the blood donor records management.
2.2 Criteria for Setting up HCIS

Health/medical records must meet a number of criteria. Some of these criteria affect how the system can be accessed as well as how key players may interact with these systems. Moore and Welson (2002), point out security requirements, transmission standards, privacy, information integrity and quality as some of the essential criteria. Essentially security falls into three main categories namely; administrative, physical and technical. The privacy criterion deals with the purpose to maintain strong protections for individual identifiable health information/record.

Mandke and Geisler (2003), point out that information flow within the system and between the key participants in the system must exhibit both the attributes and dimensions of information integrity as well as satisfy the quality. Specifically, the information should display the attributes of accuracy, consistency and reliability of content and processes as well as the dimensions of usefulness, completeness, manipulability and usability.

2.3 Blood Donor Systems: Challenges and Successes

The blood donation service involve a series of interdependent operations such as donor registration, donor screening/evaluation, blood collection, blood screening, inventory management and blood dissemination. Most of the popular existing blood information systems in the western world today are mainly online systems. The systems interfaces do not meet fully the blood safe policy described in this study and as such not suitable for illiterate population. Most blood donors in Uganda are rural based where online systems may not be the best. The level of computer literate among the blood donors in Uganda is growing because the majority of them are school students. The main challenge remains customizing interfaces that are suitable for capturing basic donor information. Some of the attributes on the interfaces used in the western world such as state and province are not applicable in Uganda. Tripura blood donor information system is a good example of the blood donor system that is not suitable for Uganda. Also some key attributes such as age and sessions in
Uganda are lacking on most the interfaces viewed. The interfaces also are not user-friendly as there are many links within the system that can easily confuse the system users and hence leading to data entry errors and boredom.

At the Macau blood Transfusion Centre, system Integrado de Bancos de Sangue (SIBAS) works as its solution of computerized blood bank information system. SIBAS complies with the client/server infrastructure, as does its client, and provides an integrated environment for those isolated but interdependent operation in the blood center. With the introduction of the SIBAS the blood service at Macau has been enhance in the following aspect. Operational efficiency- the processing time has been shortened in that blood donors need not fill in many regular items. On the other hand, the steps for donor cards are under full control and hence leading to donor satisfaction and confidence. There is also improved information consistency and validity.

The Indian case study of Prathma Blood Center, Gupta (2004), promises insights into the integration of IS/IT in management of blood records. The Prathma Blood Center is a quest for modernizing blood banking. The entire function from blood donation to its testing and separation, storage, issue and usage have been integrated through a custom designed enterprise resource planning (ERP) software that minimizes human intervention and making it less error prone. The implementation of ERP in blood bank in India has registered many successes in medical data such as security, confidentiality, secrecy and quick retrieval of historical records all of which were challenges at URCS blood center. However, full automation of all blood donation activities like the case cannot be done in Uganda due to limited resources. It requires transition, as it is resource constraining in terms of IT, other equipments and human resources.

2.4 Mobile Technology and Health Management Information Systems (HMIS)

Ophelia (2004) defines HMIS as an information system designed to assist in the management and planning of health programmes, as opposed to delivery of care. Mobile technology is a term used to describe handheld devices such as personal digital assistant
(PDA), mobile phones a few to mention. Advance in mobile technology has changed the devices from electronic address books to powerful tools with wireless network connectivity. Chiarungi (2000) found out that mobile technology has the capacity of accessing Internet, sending and receiving email/text messages and functioning as information repository and this was related to healthcare industry. The technology in simple terms provides access to a wealth of medical information. He further states that mobile technology immediate and ubiquitous access to the patients integrated electronic health record. That such a record can be further enhanced if the device is also able to display graphical information related to clinical examination records. This sort of automation talked has eased data acquisition and dissemination of blood results.

In the event of URCS blood donor system, where counselors used to take blood donor results using sheets of paper that are subject to damage by rainfall, rodents and easily accessed by unauthorized parties, mobile technology can provide a better alternative. This is because it provides security, keeps secrecy, confidentiality and consistence as expected of medical records.

Jeeyapant (2003) emphasize that computer-based interview especially Audio-Computer Assisted Self- Interview (ACASI), is feasible and more accurate method for collecting data on sensitive risk behaviour than the traditional methods such as Face-to-Face Interview (FFI) and self administered questionnaire (SAQ). However, in the last few years mobile technology such as Microsoft Windows CE device have become widely popular and provide cheaper, long lasting battery powered and therefore, mobile technology has proved an alternative to desktop computers or laptops and more especially in changing and remote locations where power is not reliable.

The blood donor record management system at URCS shared similar scenario urged by Jeeyapant. The blood drawn from donors is tested against HIV and other sexually transmitted diseases hence making it an activity of sensitive risk behaviour. The blood donors are a mobile population that is scattered in remote areas all over the country; therefore, the routine collection of data from them necessitates the application of mobile technology.
Biswa (2003) assert that in the 21st century, the potential of mobile technology as a method to improve healthcare is widely acknowledged in developing countries. The technology has been applied even in other fields apart from medical sector. For example Zanzueta (2005) demonstrated the use of mobile technology in agricultural records and programmes. He points out trends in application of advanced mobile technology. Following the miniaturization of computer equipment however, the past few years, the capacity of the personal computer (PC) tended to migrate into handheld technology. The convergence of mobile technology with wireless networks, better software development tools and broad base of users that are skilled in using desktop computers and online resources, there is a clear trend towards nomadic computing. It is urged that early use of handheld technology focused on scheduling, note taking, email and storage of information such as telephone numbers and addresses but their maturing reached when they were able to run applications comparable in complexity to those executed on PC and to substantive amount of information. The costs, mobility, security, portability, convenience, battery power usage of mobile technology have made it more popular in rural areas than the traditional PCs.

There are a number of successful projects in the health sector where handheld technology was used as the main tool to collect, process and manage medical information in a professional manner. In Tanzania, the food and drug authority used handheld technology in collecting data on drug usage, track adverse reactions, track stock balances and other pharmaceutical data. In Bangladesh, hand held technology has been used successfully to collect data related to programme management at reproductive health. In South Africa, successful a pilot project in the use of handheld devices in rapid needs assessment of voluntary HIV testing and counseling has been conducted. Other areas outside the health sector where handheld devices have been successfully used in Africa include registration in Rwanda with the National Electoral Commission.

In all areas where handheld technology has been implemented whether medical or otherwise, their main strengths have been portability, easy access to data, user-friendly, ease of data entry and sharing while the major weaknesses are limited screen and data power.
The above literature reveal a number of weaknesses existed at URCS blood center and required IT based solution in order to get better service delivery. Data collection at URCS was a routine exercise that was boring and frustrating to the system users, therefore, automating it was necessary. The PCS was time wasting, subject to errors in data capture.
Chapter 3

3.0 METHODOLOGY

3.1 Introduction

In this chapter we discuss the approach used to achieve the objectives of the project. The techniques used to achieve the user requirements and the technologies used in the designing of the system.

3.2 Fact Finding Techniques

3.2.1 Interviews

The researcher opted for this type of fact finding technique because at first the people in the blood bank section were not cooperative since blood donation involves knowing peoples HIV status and these people are compelled to keep confidentiality. Because of this problem, the needed information could not be got from other methods of fact finding techniques as the researcher had to first build confidence in the respondents and assuring them that the research was purely academic. Those interviewed were the managers, blood bank staff and some few donors. The interview guides and findings are as shown in (Appendix A).

3.2.2 Reading available Literature

The researcher also read the available literature in form of reports and brochures. However little information was available as regards to information processing. Most of the available literature was purely demographic.

3.3 Web Application Technologies

A web application is an application that runs on a web server and is accessed by users over the Internet or a local intranet. Web applications usually consist of static resource files (e.g. Images), web components, helper classes and libraries. A web browser is commonly used as a thin client hence all the processing is done on the server. Web applications are usually organized in a three-tier architecture – a user interface level, a functional process logic level, and data storage level. A web browser is the user-interface level and dynamic web content technology such as CGI, ASP or Java Servlets, is used in at the functional (business logic) level. Data Storage is handled by a database.

Web applications are an extension of a web server (Armstrong et al, 2004). Web applications are either service oriented or presentation oriented. A presentation oriented web application produces interactive web pages containing mark up languages like (XML and HTML) and dynamic content in response to requests. Many of these open source LAMP (Linux, Apache,
MySQL and PHP). A service oriented web application then implements the endpoint of the web service.

3.3.1 Linux, Apache, MySQL and PHP (LAMP)

Linux, Apache, MySQL, and PHP/Perl/Python (LAMP) are a set of software increasingly being used to run dynamic web sites. Their popularity arises from the fact that they are basically free. These open source software can be easily downloaded from the net, or come bundled with Linux distributions (WWW2).

3.3.2 MySQL

MySQL is a multithreaded, multi-user, SQL relational database server. Programming languages that can access a MySQL database include C, C++, Java, PHP, and Perl. The MyODBC interface allows other programming languages which support the ODBC interface to communicate with MySQL. MySQL runs on many different operating systems including Linux and Windows. MySQL offers a lot of improvement over previous versions including transactions (with save points), SSL support, nested SELECTS, ACID compliance and Query Caching.

3.3.3 PHP

PHP stands for Hypertext Pre-processor. It is mainly used as a general purpose scripting language used to develop dynamic web content and can be embedded in HTML. PHP can be used as an alternative to Macromedia ColdFusion, ASP.NET/C#/VB.NET and the JSP/Java System. PHP is easy to use and is very similar to structured programming languages like Perl. PHP is more than just a scripting language. It is a full programming language and can be used from a command line and also be used to develop Graphical User Interface Applications. PHP runs on many of the major operating systems, including Linux and windows and also supports many database systems, including MySQL. One feature that leads to the popularity of PHP is that it is dynamically typed. Variables do not have to be declared and they can hold any type of object. The arrays in PHP can hold objects of different types, including other arrays. PHP includes many open-source libraries and includes modules built in for accessing FTP and database servers.

3.3.4 HTML and CSS

Hypertext Markup Language (HTML) is based on the Standard Generalized Language (SGML). HTML is a language for describing the structure of a document, not its presentation (Lemay, 2001). HTML defines a set of common styles for web pages: headings, paragraphs, lists and tables. HTML provides a means by which a document's main content can be annotated with various kinds of meta-data and rendering hints. The rendering hints include specifying scripts, imagemap forms definitions for web browsers. Macromedia Dreamweaver and Microsoft Frontpage are the leading software tools for editing HTML. Content and presentation can be combined using server side scripting languages like PHP and ASP to make the final HTML.
3.4 Chosen Web Application Technologies

The combination of PHP and MySQL was chosen for this research project because of the following reasons:

i. They are open source which implies that they are cheap to get since one just need to download them from the net.

ii. PHP is a rapid application development environment and is known for its ease of use. It enables most developers get involved with dynamic web applications without having to learn entirely new set of functions because it is very similar to structured programming languages.

iii. MySQL has very fast database management system and is also easier to use than many other database systems.

3.5 The architecture of WBBDMI -system

A schematic representation of the overall architecture of the system is given in Figure 3.1 below WBBDMI architecture is based on the existence of different independent modules that are integrated into a communication protocol and operate as a single entity. The modularity that characterizes the system, gives great flexibility and expansion capabilities without undesirable side-effects, since all the changes effect only a part of the system.

To be more precise all available information are stored and organised into five distinct database modules. This distribution depends on the nature of information and it takes place in a way that the five modules co-operate as a whole, while on the other hand they preserve their independence. The linking between the database modules is made via some common fields in a way that the retrieval and manipulation time of data is reduced. Moreover, the remote access to the system is quite easy, as the distant user doesn't have to manipulate a great deal of useless information.

The five distinct database modules are the following:-

- DonorDB
- Donation DB
- DiseaseDB
- Transfusion DB
- Statistical DB
Donor Database is the one that manipulates the basic donor's information. This is actually the kernel of the whole system since every other information is referred to its tuples. Basic demographic elements and contact information can be stored there. Secondary information such as the preferable time for transfusion, donation period etc. can also be stored. The database can handle the case of voluntary donation of individual persons or donations organized by different groups. Queries like "find the donor with number xxx", or "find all the donors that can give blood in a given hospital" can be performed in the Donor DB. Every person gets a personal unique number as soon as he becomes donor. This number follows a predefined format that describes his blood type, rhesus and the preferred way for donation (e.g. with other members of a group, or when a relative needs blood). Using this number the system can search for every information relative to the donor very quickly. Moreover in case of power failure or system crash, the personnel of the blood centre can easily find out a few things about the donor by just looking at his number.
The **Donation Database** contains information about each person's donations, that is blood pressure measurements, temperature, hematocrit, etc. The dates of donations can also be found there. In this database a user can execute queries that present the measurements of a donor's condition during donations. More time consuming queries can be also performed. For example a user can ask for a list of all donors with predefined blood type, rhesus and antigens that should give blood (meaning that the necessary interval from the previous donation has passed). Another important query, called emergency list, can present the donors that have more than three months to give blood. This query can help to cover emergency needs for blood products.

Disease and other laboratory tests are manipulated by the **Disease Database**. The contents of this database are actually "sensitive" data and can be retrieved only by authorized personnel. For this reason, special care is taken to ensure system's security. First of all, every tuple in the database uses the serial number of the blood bag to identify the input. This guarantees that all tests are not connected to the donor himself, but to the bag containing the blood. Moreover every positive test result is stored as negative.

The fourth database, called **Transfusion Database**, contains information about blood transfusion. The whole history of a blood bag can be found here. Information for every blood unit that has been transfused into any patient at the local hospital or at any hospital, results of compatibility tests and all the possible blood reactions in the transfusion are also stored here. In case of reactions in blood transfusion all the actions taken are stored here. Quality control tests for the blood, for all its products and for blood bags can be inserted in the proper tuples of the database. The contents of the blood refrigerators are organized in the Transfusion DB. The system will inform the personnel for the items that are near the expiration date every morning during the boot process.

The last database, the **Statistical Database**, is a database storing statistical data. More precisely reports of the way donors are distributed according to their sex, age, job, family state (married, single, divorced), education, frequency of donation and many other criteria are provided by the Statistical Database.

### 3.6 Queries performed by WBBDMI-system

Every user has different privileges on the systems queries, depending on his access level. Low level users, such as those working at the reception of the blood centre, can execute simple search queries for information related to a donor. Information about a transfusion, e.g. the date of a transfusion, contact information, blood pressures etc. are easily executed using hash procedures with the personal number of the user. These users have the minimum access privileges in WBBDMI’s data. Users of the next level, that is doctors, can perform queries that help them to find transfusion and clinical information about any donor stored in a file in the centre.

Non available donors and clinical examinations are available to authorized doctor personnel. The availability of blood type can also be seen from this level. It is actually the level where strategic decisions can be made, such as when to call donors for donation, how many of them etc.
Finally there is a great variety of statistical queries that can be performed in printed reports based on different parameters. Reports can be generated for the way donors are distributed according to their sex, age, job, education, family condition, frequency of donation and many other criteria. These queries are a very valuable tool for the social workers of the blood centre.
Chapter 4

4.0 SYSTEMS ANALYSIS AND DESIGN

4.1 Introduction

Following the literature review, background information and correlative knowledge regarding this research project follows. In the first part of this chapter, the demand and requirements of the proposed system are discussed and analyzed through dataflow diagrams, the entity relations model and the data dictionary. According to this analysis, the specification of the system is defined. This provides the foundation for chapter 5 (Implementation and Testing). This chapter presents the various design techniques and processes available for building web based applications. It explains the design technique chosen, showing its advantages and disadvantages.

4.2 A different approach for designing web based applications

Traditionally, software has been broadly classified into different categories. Some of these categories include real-time software, personal computer software, artificial intelligence software and business software. Web-based systems and applications (WebApps) such as web sites and information processing applications that reside on the Internet or an intranet, require a somewhat different method of development than these other categories of computer software (Pressman, 2000) [xx]. This is because web based systems involve a mixture of print publishing, software development, marketing, computing, internal communications, external relations, art and technology. WebApps are network intensive, content driven, continuously evolving applications. They usually have a short development time, need strong security measures, and have to be aesthetically pleasing. In addition, the population of users is usually diverse. These factors all make special demands on requirements elicitation and modelling.

4.3 Requirements and Analysis

The requirement analysis stage of a software engineering project involves collecting and analyzing information about the part of the organization that is supported by the application. This information is then used to identify the users' requirement of the new system (Conolly et al, 2002) [xx]. Identifying the required functionality of the system is very important as a system with incomplete functionality may lead to it being rejected. A description of the aim of the project is given here along with details of the functional and non-functional requirements for the system. The test sheets for evaluating the completed system are also presented.
4.3.1 Requirements

The requirements of the Web-based management information system are to develop:

- a web based front end for entering donated blood details including the donor, his/her blood group, sex, age, and status of the donated blood
- a web based front end for searching the information relating to a given donor or a given blood group;
- a facility to still enter donor and donated blood information via Endnote and also maintain the Endnote database using those details entered via the web front end and
- a facility to produce summary information of donor and donated blood particulars and any other related activities.

4.3.2 Functional Requirements

In this research project we aim at developing a system which should improve on the current one with a lot of functionalities and therefore the Major target or goal here is to:

- to develop a blood donor database that can support the five above mention sub-databases that is to say; DonorDB, Donation DB, DiseaseDB, Transfusion DB and Statistical DB
- to develop a client interface that allows privileged users to carry out tasks such as inserting or modifying and deleting data in the database;
- to develop a searching functionality in order to allow normal and privileged users to search the details of a given donor, blood group, stakeholder and if necessary a type of disease common which causes one to need the donated blood
- to fully integrate the Web-based management information system to the World-Wide-Web and hence allow access from any Internet networked terminal and Web browser around the world;
- to develop a facility that can export details entered via the web front end to Endnote as well as import and confidential detail from the Endnote Database;
- to develop a functionality that produces summary information of required data to enhance decision making;
- to embed high security features in the Web DBMS to provide privacy, integrity;
- to allow privileged users to maintain the Web-based management information system by adding/deleting particulars, backing-up or resetting the database and extract online summary in the form of histograms for each donor and lists of free-format comments. Thus a graphical reporting tool should be provided for analyzing the data.
- and finally the system should be flexible enough to store data for several years and also be able provide sufficient User and Administration Guides.

4.3.3 Non-functional Requirements
The system must be developed to suit the particular needs of a user-friendly environment. This means that the system must accommodate a clearly understandable user interface as well as clear online help documentation at any stage of the user interaction with the system. A fast response time in obtaining and providing information to the system may also prove to be a significant advantage. In addition to these requirements, the system should also embrace the following requirements:

**Security:** Each user is required to log in. The system should log staff that has been assigned user names and passwords. The system should be designed to make it impossible for anybody to logon without a valid username and password. Data encryption should be employed to keep the user login name and password secret.

**Reliability:** The system would be used by about 50 staff working at the Red Cross head quarters and also some other many staff in the collaborating clinics and hospitals. The system should have little or no downtime and be able to handle multiple concurrent users.

**Ease of Use:** The general and administrative views should be easy to use and intuitive. Online help and documentation should be provided.

**Performance:** The system should have a quick response time. For the purpose of this research project, this would be defined as less than 5 seconds.

**System and Browser compatibility Testing:** The system should be accessible on the following browsers - Microsoft Internet Explorer 5.5+, NetScape Navigator 6.0+ and Mozilla 1.3+.

**System requirements:** Red Cross society Uganda has a UNIX server. This system would be designed to run on a minimum hardware configuration of 500MHz x86 machines. Considering the vast hardware available at the society, this would not pose any problems.

**Server Software:**
- Operating System: UNIX (Sun Solaris), Windows 2000, or Windows XP
- PHP version: PHP 5.0+
- Web Server: Apache Web Server. 2.0+
- Database: MySQL 4.01+
4.4 Access Level Analysis

In order to take closer look into what the system should do and how, it was necessary to decompose the system's functionalities based on the user type and levels of access. The three main user groups and access levels are:

- Global User Group (normal access level)
- The Red Cross User Group (privileged access level)
- The Administration (privileged access level)

Therefore, the requirements could be efficiently analyzed depending on the user group and the functionalities they should be allowed to perform.

4.4.1 Main System Page (Index)

It is required for the system to provide a Main Page where any Global user (any user within and outside the Red Cross Organization) will be able to access. The main functionality of this page will be to allow any user to search the database by using information such as quantity of donated blood, available blood and the groups, or any other general information which may not be considered confidential. The search capabilities of the main page might not be limited to the exact blood donor, but may for example provide the means for displaying any information that might be relevant but not confidential. The Main Page should also include a Login facility for any privileged or normal user to be able to have access to more advanced functionalities of the System.

4.4.2 The Red Cross User Group

When a Red Cross user has successfully logged into the system via the Main Page Login facility, it will be necessary for the system to display a specific menu with all available option that can be carried out. Therefore by taking into account the system requirements, it will be necessary to include options such as Enter donor details, Search donor, Use Endnote Facilities, Produce Summary Information as well as an option that will be related to the appropriate User Guide. A Logout option will also be appropriate for the Red Cross user to be able to logout when desired.
4.4.3 Entering-Amending Blood donor Details

For a user to be able to amend and enter into the system’s database it will be essential to take into account that the blood donor system will be integrated to Endnote. Therefore, it will be essential for the system to provide to the user the exact fields as Endnote does for any particular type of details. In addition, when a particular of a given donor has successfully been submitted or amended into the database it will be essential for the system to display the appropriate message (i.e. Blood donor successfully entered into database).

4.4.4 Searching the Blood Donor Database

The Searching Facility for the Red Cross user should not differ from the facility that will be provided on the Main Page of the system for all users. Therefore, the Red Cross user will be able to search any type of information in the database using the same way as specified for the Global User.

4.4.5 Producing Summary Information

For this requirement it is essential to firstly understand why and when it will be used and to adjust the functionality to best suit these purposes. In order for the system to efficiently produce summary information it will have to provide a menu providing options such as Produce Annual Report, or Produce General Report etc.

4.4.6 Endnote Facilities

In order for the system to be effective, it will be necessary for it to be integrated with the Endnote software. Therefore, it will be very significant to accommodate two options that will include Importing blood particulars from Endnote and Exporting blood particulars to Endnote. How this will be done will mainly rely on taking full advantage of particular Endnote filters that are provided for these reasons.

4.4.7 Administrator

For maintenance purposes it will be of great significance to include advanced Administrator functionalities that can only be accessed by this particular user group. The most reasonable options for an administrator to perform may include tasks such as deleting donors (should not be provided to the Red Cross user group for security reasons), Backing-up and Restoring the database, Resetting the blood donors database etc. In addition to these functionalities the administrator may also be asked to perform tasks related to Red Cross or Global user (i.e. Entering new donors, Searching for a given donor or available blood group) and therefore any functionality provided by the system must be included in the administrator capabilities.

4.5 Task Structure Diagrams

For the development of a more consistent and effective system, it was essential to firstly identify which information should be included accomplish this, it was first of great significance to group all the relevant tasks (system functionalities) depending on the users.
The way the systems tasks could be efficiently identified was by using a special technique from the Discovery method called Task Structure Sketching (Simons, 2002).

4.5.1 The Red Cross User

![Fig 4.1: The Red Cross User Task Structure Diagram]
4.5.2 The Administrator User

Fig 4.2 The Administrator Task Structure Diagram
4.5.3 The Global User

Fig 4.3 The Global User Task Structure Diagram

4.6 Tests

The requirement analysis stage involves the design of test cases for the completed system. Test cases are specifications of inputs to the test and the expected output from the system plus a statement of what is being tested (Sommerville, 2004) [xx].

4.6.1 Designing of test cases

The test cases designed at this stage are for system testing – testing the integrated system with all the components and functions in place. It is a black-box approach because the tester may not know how the system works but wants to know if it works.

The approach followed at this stage can be termed as requirements-based testing – test cases are designed to test the system requirements. For each requirement, test cases were identified to demonstrate that the system meets the requirement. It is a general principle in software engineering that requirements should be testable. This requirements testing is a validation test because it demonstrates that the system has properly implemented the requirements.
4.7 Web Engineering

Web engineering is the process used to create high quality Web-based systems and applications (WebApps). Web engineering (WebE) exhibits the fundamental concepts and principles of software engineering by following a disciplined approach to the development of computer-based systems, emphasizing the same technical and management activities (Pressman, 2000) [xx].

The design and production of a software product (such as a web application) involves a set of activities or a software process (Sommerville, 2004) [xx]. A software process model is an abstract representation of a software process. Three generic process models usually adopted in projects are

- **The waterfall model** – This has distinct project phases, which can be easily monitored. These phases are requirements specification, software design, implementation and testing.

- **Evolutionary development** - An initial system is developed quickly from abstract specifications. This is later refined with the input of the user to produce a system that meets the users needs. It is an iterative model. Two refinements of this approach are the incremental and the spiral models. The incremental model of evolutionary development delivers software in small but usable “increments”, where each increment builds on those that have already been delivered. The spiral model couples the iterative nature of prototyping with the controlled and systematic aspects of the waterfall model.

- **Component-based software engineering** - This is based on the existence of a large number of reusable components and is best suited in an object-oriented environment. A process model helps address the complexity of software, minimize the risk of project failure, deal with change during the project and help deliver the software quickly. For this project two process models were considered: 1. Spiral model 2. A waterfall model.
4.8 A WebE Spiral model

The spiral model shown in Fig 4.4 is suggested by Pressman (2000)[xx]. The process consists of 6 main stages, outlined below:

1. **Formulation**: This is an activity in which the goals and objectives of the WebApp are identified and the scope for the first increment in the process is established.

2. **Planning**: This stage estimates overall project cost, evaluates risks associated with the development effort, prepares a detailed development schedule for the initial WebApp increment and defines a more coarsely granulated schedule for subsequent increments.

3. **Analysis**: This stage is the requirement analysis stage for the WebApp. Technical requirements and content items to be used are identified. Graphic design requirements are also identified.

![Fig 4.4: The WebE Spiral Model](image)

4. **Engineering**: Two parallel set of tasks make up the engineering activity. One set involves content design and production, which is non-technical work. This involves gathering text, graphics, and other content to be integrated into the WebApp. At the same time, a set of technical tasks (Architectural design, Navigation design, and Interface Design) are carried out.

5. **Page generation**: This is the construction activity that makes use of automated tools for WebApp creation and the content is joined with the architectural, navigation and interface designs to produce executable Webpages in HTML.

6. **Customer Evaluation**: During this stage, each increment of the WebE process is reviewed. Powell (2002) [xx] presents a waterfall model for web engineering (Fig 5.2).
The advantage of this model is that it helps developers plan most of the work up front.

4.9 Design Phase

The design involves the production of technical and visual prototypes. This stage has some non-technical aspects such as gathering of web content. Powell (2002)[xx] points out that content gathering can be one of the biggest problems in web projects. This clearly is not the case with this survey application as there is very little content required. For the server side programming and other technical aspects of the design emphasis will be laid on such design concepts and principles as effective modularity (high cohesion and low coupling), information hiding and stepwise elaboration. The goal is to make the system easier to adapt, enhance, test and use (Pressman, 2000) [xx].

4.9.1 Producing HTML

There are basically 4 methods of producing HTML –

1. Coding by hand using a simple text editor
2. Translation in which content produced in a tool such as note pad is saved as a HTML document.
3. Using a tagging editor that helps fill in the required tags
4. Using a “What you see is what you get editor” (WYSIWYG) such as MS FrontPage or Macromedia Dreamweaver.

All these methods have their advantages and disadvantages.

While coding by hand may be slow and error prone, it does provide great control over markup, as well as help address bugs and new HTML/XHTML elements immediately. At the other extreme, “What You See Is What You Get” (WYSIWYG) editors provide visual representation of a page and require no significant knowledge of HTML or CSS. However they often generate incorrect or less than optimal markup and tend to encourage fixed size presentations that do not separate the look and the structure (Powell, 2003) [xx]. Putting all these into consideration, a tagging editor, HTML-kit was chosen for this work. While tagging editors can be slow and require intimate knowledge of HTML and CSS, they provide a great deal of control and are a lot faster than hand editing.
4.10 Architectural Design

WebApps fall into 4 main structures. They can be linear, grid, hierarchical, or networked (fig 4.5). In practice most web sites are a combination of some of these structures.

![Navigational Structures of websites/Web Applications](lemay.png)

**Fig. 4-5. Navigational Structures of websites/Web Applications (Lemay, 2000)**

Considering the nature of this web application, a combination of both hierarchical and linear structures will be adopted. The actual survey web pages will have a linear structure while the Admin pages will have a more hierarchical nature.

4.11 Database Design

Database design involves the production of a model of the data to be stored in the database. A data model is a diagram of the database design that documents and communicates how the database is structured. The database design methodology followed in this project is that suggested by Connolly et al (2002)[xx]. Connolly presents quite a detailed guide to designing databases, but not all of those steps may apply here, as this project is not too complex.

The design process is divided into three main stages – conceptual, logical and physical database design. The purpose of the conceptual database design is to decompose the design into more manageable tasks, by examining user perspectives of the system. That is, local conceptual data models are created that are a complete and accurate representation of the
enterprise as seen by different users. Each local conceptual data model is made up of entity types, relationship types, attributes and their domains, primary keys and integrity constraints. For each user view identified a local conceptual data model would be built. (Connolly et al, 2002) [xx]. In building the conceptual data model, a data dictionary is built to identify the major entities in the system.

An entity relationship (ER) diagram is used to visualize the system and represent the user’s requirements. The ER diagram is used to represent entities and how they relate to one another. The ER diagram also shows the relationships between the entities, their occurrence (multiplicities) and attributes. Following the view integration approach, a different data model (ER diagram) is made for each user.

**Data Dictionary**

<table>
<thead>
<tr>
<th>Entity Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Donors</td>
<td>A person who donates blood</td>
</tr>
<tr>
<td>Recipients</td>
<td>A person who receives blood</td>
</tr>
<tr>
<td>Diseases</td>
<td>The diseases which are found in the infected donated blood</td>
</tr>
<tr>
<td>Blood group</td>
<td>The blood that is donated by the donors</td>
</tr>
<tr>
<td>Hospital/Clinic</td>
<td>Hospitals to which donated blood is distributed</td>
</tr>
<tr>
<td>Staff</td>
<td>Red Cross staff</td>
</tr>
<tr>
<td>District</td>
<td>Districts from which donors and recipients originate from</td>
</tr>
</tbody>
</table>

Table 4.1: Data Dictionary
4.11.1 Conceptual Database Design

In this stage, a local conceptual data model is built for each identified view in the system. A local conceptual data model comprises of entity types, relationship types, attributes and their domains, primary and alternate keys, and integrity constraints. The conceptual data model is supported by documentation such as a data dictionary.

The entity types are the main objects the users are interested in. Entities have an existence in their own right. Entity types are identified and their names and description are recorded in a data dictionary. Care is taken to ensure that all relationships in the users requirements specification are identified.

An Entity-Relationship diagram is used to represent the relationship between entities. The multiplicity of each relationship is included. This is because a model that includes multiplicity constraints gives a better representation of the enterprise. Relationship descriptions and the multiplicity constraints are recorded in the data dictionary. Each model is validated to ensure it supported the required transactions.

<table>
<thead>
<tr>
<th>Entity name</th>
<th>Attributes</th>
<th>Description</th>
<th>Data Type</th>
<th>Size</th>
<th>Nulls</th>
<th>Multi valued</th>
</tr>
</thead>
<tbody>
<tr>
<td>Donors</td>
<td>donorId (PK)</td>
<td>Donor identification number</td>
<td>Text</td>
<td>8</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>-dNames</td>
<td>Donor’s names</td>
<td>Text</td>
<td>30</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>-sex</td>
<td>Donor’s sex</td>
<td>Text</td>
<td>6</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>- dob</td>
<td>Date of birth</td>
<td>Date</td>
<td>30</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>- distId (FK)</td>
<td>District of origin</td>
<td>Int</td>
<td>3</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>- doreg</td>
<td>Date of registration</td>
<td>Date</td>
<td>30</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Recipients</td>
<td>-rId (PK)</td>
<td>Recipient’s identification number</td>
<td>Text</td>
<td>8</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>-rNames</td>
<td>Recipients names</td>
<td>Text</td>
<td>30</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>-sex</td>
<td>recipient’s sex</td>
<td>Text</td>
<td>6</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>- dob</td>
<td>Date of birth</td>
<td>Date</td>
<td>30</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>- distId (FK)</td>
<td>District of origin</td>
<td>Int</td>
<td>3</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>- doreg</td>
<td>Date of registration</td>
<td>Date</td>
<td>30</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Table</td>
<td>Column</td>
<td>Description</td>
<td>Type</td>
<td>Length</td>
<td>Nullable</td>
<td>Unique</td>
</tr>
<tr>
<td>------------</td>
<td>--------</td>
<td>---------------------------------------------------------------</td>
<td>--------</td>
<td>--------</td>
<td>----------</td>
<td>--------</td>
</tr>
<tr>
<td>Diseases</td>
<td>dId (PK)</td>
<td>Disease identification number</td>
<td>Text</td>
<td>8</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>dNames</td>
<td>Disease names</td>
<td>Text</td>
<td>30</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>drating</td>
<td>Disease rating on how people are infected from it</td>
<td>text</td>
<td>20</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Blood</td>
<td>bGroup(PK)</td>
<td>Blood group</td>
<td>Text</td>
<td>2</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>donorId (FK)</td>
<td>Donor identification number</td>
<td>Text</td>
<td>8</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>rId (FK)</td>
<td>Recipient identification number</td>
<td>Text</td>
<td>8</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>status</td>
<td>Status of the donated blood whether infected or not</td>
<td>text</td>
<td>15</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Hospital/Clinic</td>
<td>hId (PK)</td>
<td>Hospital identification number</td>
<td>text</td>
<td>8</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>hNames</td>
<td>Hospital name</td>
<td>text</td>
<td>100</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>distId (FK)</td>
<td>District identification number</td>
<td>int</td>
<td>3</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Staff</td>
<td>staffId (PK)</td>
<td>Staff identification number</td>
<td>text</td>
<td>8</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>staffNames</td>
<td>Staff names</td>
<td>text</td>
<td>50</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>sex</td>
<td>Sex</td>
<td>sex</td>
<td>6</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>dob</td>
<td>Date of birth</td>
<td>date</td>
<td>15</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>department</td>
<td>Department to which the staff belongs</td>
<td>text</td>
<td>100</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>District</td>
<td>distId</td>
<td>District number</td>
<td>int</td>
<td>3</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>distName</td>
<td>District name</td>
<td>text</td>
<td>100</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Entity name</td>
<td>Multiplicity</td>
<td>Relationship</td>
<td>Entity Name</td>
<td>Multiplicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td>--------------</td>
<td>--------------</td>
<td>-------------</td>
<td>--------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Donors</td>
<td>1</td>
<td>Donates</td>
<td>Blood</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recipients</td>
<td>1</td>
<td>Receives</td>
<td>Blood</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diseases</td>
<td>1</td>
<td>Contained in</td>
<td>Blood</td>
<td>0 ..*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blood</td>
<td>1</td>
<td>Donated by</td>
<td>Donor</td>
<td>1 ..*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital/</td>
<td>1</td>
<td>Receives</td>
<td>Blood</td>
<td>1 ..*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staff</td>
<td>1</td>
<td>Registers</td>
<td>Donors</td>
<td>1 ..*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>District</td>
<td>1</td>
<td>Has</td>
<td>Recipients</td>
<td>1 ..*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.2: An extract from the data dictionary showing a description of the relationships between the entities.

4.11.2  Logical Database Design

The process of logical database design constructs a model of the information used in an enterprise based on a specific data model, such as the relational model, but independent of a particular DBMS and other physical considerations (Connolly et al, 2002)[xx]. The logical database design consists of an ER diagram, a relational schema, and any supporting documentation for them. In the logical data model, all attributes of entities are primitive.

Producing a logical data model involves normalization. The aim of normalization is to eradicate certain undesirable characteristics from a database design. It removes data redundancy and thus prevents update anomalies. Normalization helps increase the clarity of the data model.

Integrity constraints are imposed in order to protect the database from becoming inconsistent. There are five types of integrity constraints – required data, attribute domain constraints, entity integrity, referential integrity and enterprise constraints. The resulting relations are validated using normalization. For this project, producing relations in third normal form (3NF) will suffice. Non-relational features, such as many-to-many relationships and some one-to-one relationships, are removed from the conceptual data model. The design is also reviewed to make sure it meets all the transaction requirements.
Fig. 4.6: The ER diagram
4.11.3 Physical Database Design

Physical database design translates the logical data model into a set of SQL statements that define the database for a particular database system. In other words, it is the process of producing a description of the implementation of the database on secondary storage. It describes the base relations and the storage structures and access methods used to access the data effectively, along with associated integrity constraints and security measures. The target DBMS in this case is MySQL.

The following translations occur:

1. Entities become tables in MySQL.
2. Attributes become columns in the MySQL database.
3. Relationships between entities are modeled as foreign keys.
Chapter 5

5.0 IMPLEMENTATION AND TESTING