

Addis Ababa
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ADDIS ABABA UNIVERSITY
SCHOOL OF INFORMATION SCIENCE
AND SCHOOL OF PUBLIC HEALTH
M.sc in Health Informatics Program

**Design and Development of a Web- Based Medical Equipment
Information System for Saint. Paul Hospital**

By: Getaneh Tilahun

**A Project Submitted to the School of Information Science and Public
Health of Addis Ababa University in Partial Fulfillment of the
Requirement for Degree of Master of Science in Health Informatics**

June, 2016
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Name and Signature of Members of the Examining Board

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Acknowledgment

I would like to thank Addis Ababa University school of Information Science and school of Public Health for providing me with this opportunity. My special heartfelt thanks go to my advisors Dr Dereje Teferi and Dr.Mesfin Addisse for their patience, encouragement, stimulating advices, and constructive suggestions, who helped me to pass through all the challenges and complete my project. A special thanks to Mesert Ayano for her kind and precious help on the administrative part.

I would like to pass my special thanks to my friends Amare kassie ,Alemayehu Dagnew,Natanael Daniel,Etsegennt Alemu and Selam Tamen for the information and supports they provide me, all the time I need, and all my staffs who support me and initiate me to join this study program. My special appreciations go to the staff of the Biomedical Department specially Ato Tesfaye Fekere for providing me all the necessary information.

Last but not least, I would like to pass my sincere gratitude to my beloved family, specially my mother who provides me special support and her limitless love.

Table of Contents

Acknowledgment	i
List of tables	v
List of Figures	vi
List of Acronyms	vii
Abstract	viii
Chapter One	1
1. Introduction	1
1.1. Background	1
2. Statement of the Problem	4
1.3 Objective of the project	6
1.3.1 General Objective	6
1.3.2 Specific Objectives	6
1.4 Significance of the Project	6
1.5. Scope of the project	7
Chapter Two	8
2. Literature Review	8
2.1. Medical Equipment and Medical Equipment Management Information System	8
2.1.1. Medical equipment	8
2.1.2. Medical Equipment Management Information System	9
2.1.3. Management Information System	9
2.2. System Development Methods, Tools, and Techniques	10
2.2.1. Modeling Method	11
2.2.2. Techniques	11
2.2.3. Use Case Diagram	12
2.2.4. Web based System Development	14
2.2.5. Related Works	15
2.3.1. An Equipment Maintenance system	15
2.3.2. KALMAN Equipment Management System (KEMS)	15

2.3.3. Management Information System of Medical Equipment using Mobile Devices	16
2.3.4. Medical Equipment Management System (MEMS)	16
2.3.5. AIMES	17
2.3.6. PRAXIS	18
2.3.7. EMIS for Fleet Management.....	18
2.3.8. ECRI-AIMS Hospital Equipment Management System.....	18
2.3.9. PTI/APWA Equipment Management Information System.....	19
2.3.10. Medical Equipment Workflow Management System	19
Chapter Three.....	20
3. Methodology	20
3.1. Introduction.....	20
3.2. Study Area	20
3.3. Study Design.....	20
3.4. Study Population.....	21
3.5. Sampling Method.....	21
3.6. Software Development Life Cycle (SDLC).....	21
3.7. Water Fall Approach.....	21
3.8 System Investigation Phase.....	22
Requirement Collection Instruments	22
Interview Guide	22
3.9. System Analysis Phase	23
3.10. System Design Phase	25
3.11. System Implementation/Coding Phase	25
3.12. System Testing Phase	25
3.13. Operational Definitions.....	27
3.14. Ethical Clearance	28
Chapter Four	29
4. System Development	29
4.1. Introduction.....	29
4.2 System Analysis.....	29
4.2.1. Current System.....	29
4.2.2 Proposed System.....	34

4.2.3. Stakeholders	36
4.2.4. System Analysis Models.....	37
4.2.5. System Requirements.....	41
4.3. System Design Models	42
4.3.1. System Class Diagram	42
4.3.3. System Architecture.....	44
4.4. Prototype Implementation.....	45
4.4.1. Presentation Layer.....	46
4.4.2. Database Layer.....	47
4.4.3. Middle Layer.....	49
4.4.4. User Interface Prototype Presentation.....	63
4.4.5. Usability Testing for User Interface.....	63
Chapter five.....	72
5. Conclusions and Recommendations	72
5.1. Conclusions.....	72
5.2 Recommendations.....	73
References.....	74
Annexes I	77
Annex II	83
Declaration.....	85

List of tables

Table 1: Summary of methods, techniques, and tools used in each phase of the project.....	26
Table 2: Hardware Inventory of the Existing System.....	30
Table 3: List of stakeholders and their roles and responsibilities.....	36
Table 4: Usability Testing for User Interface.....	63

List of Figures

Figure 1: The Organizational Structure of St. Paul Hospital.....	33
Figure 2: Context diagram for Medical Equipment Management Information System.....	35
Figure 3: System Use Case Diagram for Medical Equipment Information Management.....	38
Figure 4: Activity Diagram for Medical Equipment Registering Process.....	39
Figure 5: Class Diagram for Medical Equipment Management Information System.....	43
Figure 6: MEMIS Architecture.....	45
Figure 7: Medical Equipment Registry Form.....	46
Figure 8: The physical Database Model of MEMIS.....	47
Figure 9: Sample of PHP Cods.....	49
Figure 10: Activity diagram for spare part registration process.....	50
Figure 11: The activity diagram for login process.....	52
Figure 12: Activity Diagram for Preventive Maintenance Notification Message.....	54
Figure 13: Activity Diagram for Preventive Maintenance Recording.....	55
Figure 14: Activity Diagram for Corrective Maintenance Work Order.....	57
Figure 15: Activity Diagram for Corrective Maintenance information Recording Process.....	59
Figure 16: Activity Diagram for generating report.....	61
Figure 17: Login User Interface Design.....	64
Figure 18: medical equipment register User Interface Design.....	65
Figure 19: Spare parts register User Interface Design.....	66
Figure 20: preventive Maintenance record User Interface Design.....	67
Figure 21: corrective Maintenance work record User Interface Design.....	68
Figure 22: Corrective Maintenance record User Interface Design.....	69
Figure 23: home page User Interface Design.....	70
Figure 24: home page User Interface Design.....	74

List of Acronyms

AMT	Active Management Technology
BPR	Business Process Reengineering
CASE	Computer Aided System Engineering
CED	Clinical Engineering Department
CM	Corrective Maintenance
CRCP	Curative and Rehabilitative Core Process
DFD	Data Flow Diagram
DPCP	Disease Prevention Core Process
EFY	Ethiopian Fiscal Year
EMIS	Equipment Management Information System
FDA	Food and Drug Administration
FMoH	Federal Ministry of Health
GHTF	Global Harmonization Task Force
HR	Human Resource
HSDP	Health Sector Development Program
HTML	Hyper Text Markup Language
ISD	Information System Development
ITEA	Information Technology for European Advancement
KEMS	KALMAN Equipment Management System
MEMIS	Medical Equipment Management Information System
MEMS	Medical Equipment Management System
MySQL	My Structured Query Language
OO	Object Oriented
SDLC	System Development Life Cycle
PM	Preventive Maintenance
UC	Use Case
UIP	User Interface Prototype
UI	User Interface
UML	Unified Modeling Language

Abstract

Introduction: Medical equipment is used for the specific purposes of diagnosis, treatment, or rehabilitation of disease or injury, and can be used either alone or in combination with any accessory, consumable or other medical equipment. Medical equipment excludes implantable, disposable or single-use medical devices.

Objective: The objective of this project is to design Web- Based Medical Equipment Information Management System, for Saint Paul Hospital Millennium Medical College

Methodology: The project will use object oriented system analysis and design approach and includes requirement gathering tools such as (interview, observation and document review techniques) to collect sufficient information needed for the system to be developed. Analysis and design of the proposed system will be performed using the UML like the use case modeling and use case diagram.

Discussion of Result: The use case diagram identifies all the process and system boundary of the proposed system. Eleven processes were identified with their corresponding actors. Fourteen objects of the system were identified and modeled using the class diagram. The flow and sequence of the processes were presented using the sequence diagrams. User prototype was modeled for the system usability testing.

Conclusion: In the process of analysis and design this system, the investigator recognizes that the boundary of the system somehow overlaps with the system of pharmacy store, which captures the information of medical equipment at initial. The existing system documentation is not well organized and complete, that makes the investigator depends on literature to design the system.

Recommendation: - The hospital is recommended to initiate the revision of the pharmacy store computer system by;

- ✓ Reinforcing the supporting stakeholder to include medical equipment information into the system and

- ✓ Scale up the system to support the management of equipment performance after the installation

Chapter One

1. Introduction

1.1. Background

St. Paul Hospital Millennium Medical College is found in Addis Ababa and is administered by Federal Ministry of Health (FMOH) built in 1969 G.C. Since, 2007 G.C It has become a medical college by opening a medical school with the initiative of the Federal Ministry of Health. Currently the name of the hospital changed to St. Paul's Hospital Millennium Medical College and its core services are medical care as well as teaching and research. The college currently has more than 950 clinical and administrative staffs. Physicians and students of the college, besides their teaching learning activity are, serving in clinical areas. An average of 1700 patients and clients visit the hospital daily in emergency and regular bases. Inpatient services are also given with a total of 500 beds.

The partnership with the University of Michigan has helped to initiate an Ob/Gyn residency program that is competency based and focuses on developing the skills, knowledge and leadership ability of the residents through exposure to a wealth of national and international expertise and improving their access to information. It is also helping to build faculty capabilities through development of teaching and leadership skills, and increasing connectivity with the international academic community through a two-fold approach: Ensuring state-of-the-art technical assistance, training and mentoring in women's health care and treatment through staff exchange programs where faculty come from the University of Michigan to St Paul to train faculty and teach residents/students, and faculty from St Paul visit UM for training and observation.

Designing strategic interventions with local staff to increase the capacity, improve the organization, and strengthen overall Ob/Gyn department services and management. In addition, recently the partnership has expanded to other areas such as the institution of residency programs in Surgery and Internal Medicine, and the development of Ethiopia's first Kidney Transplant

program. Through the Partnership with Tulane University, St. Paul has received support in a wide range of areas, particularly for undergraduate medical education through ICT support in infrastructure and technical support, library resources (computers, books), financial support for staff development programs like training abroad, and other resources like buses for the students. In addition, their support has been critical in setting up the electronic medical records/EMR/.

There is a Health Facility Networking project to improve maternal health which is a two year implementation research project with the Maternal Health Task Force at Harvard School of Public Health. St. Paul's is in the process of initiating a five year project with University of Alberta through a CIDA grant on Improving Maternal and Neonatal Health. Through the collaboration with ENHAPA, St. Paul's is receiving support in various areas, particularly in strengthening Emergency and ICU care, by organizing different staff trainings and supplying books, medical equipment etc. They also support the GI/Endoscopy unit through training and equipment provision. Through the partnership with University of Bergen, Trauma Care Ethiopia and Children Burn Foundation, a bachelor's program has been started in both Critical Care Nursing and Operation Theater Nursing, with different faculty coming from Norway to teach in program.

There is a strong collaboration with the Egyptian MOH and teaching institutions through which a Hemodialysis Center was recently opened. Additionally, they have helped to strengthen the GI/Endoscopy unit which has been expanded into a Hepatology Unit. The partnership provides ongoing support in terms of starting Endourology service and strengthening all above programs through training. HIV care at St. Paul started more than 10 years ago through the support of JHU TSEHAI, which ranged from constructing and furnishing the current Adult HIV Unit, renovating the lab, and providing lab testing machines, ART medicine and technical support. The partnership later expanded and started pediatric ART, PMTCT, PICT, and a support group for mothers, among other things. Engender Health is also a long-time partner in terms of strengthening the Family Planning Unit by assisting with staff training, unit renovations and the procurement of medical supplies for the proper running of the FP program.

Health technologies are essential for a functioning health system. Medical devices in particular are crucial in the prevention, diagnosis, and treatment of illness and disease, as well as patient rehabilitation. Recognizing this important role of health technologies, the World Health Assembly adopted resolution WHA in May 2007. The resolution covers issues arising from the inappropriate deployment and use of health technologies, and the need to establish priorities in the selection and management of health technologies, specifically medical devices. By adopting this resolution, delegations from member states acknowledged the importance of health technologies for achieving health-related development goals; urged expansion of expertise in the field of health technologies, in particular medical devices; and requested that the World Health Organization (WHO) take specific actions to support Member States (1).

According to the definition by the Global Harmonization Task Force (GHTF), “medical device is any instrument, apparatus, implement, machine, appliance, implant, in vitro reagent or calibrator, software, material or other similar or related article which does not achieve its primary intended action in or on the human body by pharmacological, immunological or metabolic means, but which may be assisted in its intended function by such means”(2).

Medical equipment is used for the specific purposes of diagnosis, treatment, or rehabilitation of disease or injury, and can be used either alone or in combination with any accessory, consumable or other medical equipment. Medical equipment excludes implantable, disposable or single-use medical devices. (3)

According to the standard set by the Federal Ministry of Health (FMOH) of Ethiopia, primary hospitals, health centers and health posts should be equipped with 180, 150, and 120 different types of medical equipment respectively at a minimum (4).

The Biomedical department or clinical engineering department of a hospital is responsible for including and excluding medical equipment in the health technology management program for tests, repairs and maintenance. Appropriate management of medical equipment ensures safe and effective health service provision (5).

Medical equipment information management system (MEMIS) is used to automate the documentation of all activities relating to medical equipment and provide report and notification message for planned maintenance (6).

As WHO medical device technical series in 2011 stipulate, MEMIS incorporates equipment and spare parts inventory modules, preventive and corrective maintenance module, and contracts management module (6). The analyzed records of these modules can be used for the technology management, quality assurance, and work order control and budgeting of medical equipment.

2. Statement of the Problem

Medical devices can cause a serious problem on users and patients, if they are not well managed during health care service provision. Food and Drug Administration(FDA) agency of United States in 2006EC reported 187,086 device related injuries, 2630 deaths and 87,485 malfunctions of device. This shows, that consequence of mismanaged medical device has effect on the health care service quality and resource constraints directly or indirectly (7).

In a study done by the department of Mechanical Engineering of Laval University in Canada, it is found that 32.2% medical equipment repair calls made due to equipment management issues and 13.7% is related to inadequate preventive maintenance for the equipment, setup and uncategorized calls (8).

From this study, we can understand that the lack of medical equipment management can cause a failure of the equipment which results in repeated repair calls and increase in the cost of maintenance. On the other hand, if medical equipment information management system is put in place, it can help to implement a planned preventive maintenance for the equipment and reduces cost by providing adequate and proper information about the equipment being used.

The cost of medical devices is very high globally as well as nationally. In 2006EC global market figure of medical device was expected to exceed US333 billion Dollar (8). Nationally, from the report of Health Sector Development Programme (HSDP) performance in 2006E.C , the Pharmaceutical Fund and Supply Agency(PFSA) has distributed pharmaceuticals and medical equipment worth ETB 9.19 billion. This can helps us estimate the cost of medical equipment per year and show very huge figure for country like Ethiopia (8).

The research done over maintenance management of medical equipment in major hospitals of Kenya reported that, responsible public organization on maintenance does not have proper management of medical equipment. The problem identified in Kenya is also experienced by our country (9).

In Ethiopia, the lack of proper management of medical equipment has limited the capacity of health institutions to deliver adequate health care. It is estimated that only about 61% of medical equipment found in Ethiopian public hospitals and other health facilities is functional at any one time (9).

This project aim to develop medical equipment management system to help Hospitals to be more efficient and effective in managing and overcome the constraint of medical equipment management to provide a reliable and quality health care service.

As the information gained from the head of the biomedical case team of hospital Administration health bureau indicates, there are problems associated with the management and information availability on medical equipment. As health care delivery continues to expand and improve in the region and an increasing number of sophisticated medical equipment is introduced, a system capable of supporting and managing the inventory and maintainace medical technology must be put in place.

The intention of this project is therefore, to develop a medical equipment information management system that enable Hospitals to be more efficient and effective in managing the maintenance and use of medical equipment so that they can provide a reliable and quality health care service.

1.3 Objective of the project

1.3.1 General Objective

The objective of this project is to design Web- Based Medical Equipment Information Management System, for Saint. Paul Hospital.

1.3.2 Specific Objectives

The specific objectives are to

- ✓ Identify user and system requirements of medical equipment information management system for Saint Paul Hospital
- ✓ Analyze the system requirements identified;
- ✓ Design system model of the medical equipment management information system;
- ✓ Design general(high level) system architecture of the medical equipment information management system;
- ✓ Develop interface prototype model of the system;
- ✓ Develop a prototype of the medical equipment management information system to demonstrate its potentials;
- ✓ Evaluate the acceptability of the prototype.

1.4 Significance of the Project

The new medical equipment information management system will hopefully provide different functionalities for different unity of the hospitals.

For health professionals

- ✓ The system makes their work more easy, effective, and efficient.
- ✓ It helps them in tracing and controlling the performance of a specific medical equipment.
- ✓ It helps the health professionals in providing quality health care service.

For Patient

- ✓ Help parents to receive quality health care service.
- ✓ Reduce the risk of medical equipment accident on the patients.

For Hospitals

- ✓ It helps to have medical equipment inventory information of the hospitals.
- ✓ It helps in the procurement planning of medical equipment.
- ✓ It helps to identify the gaps of medical equipment management and solution.
- ✓ Help in resource allocation for medical equipment management and controlling activities.
- ✓ Provide system prototype ready for implementation

For Other student / Researcher

- ✓ Provides complete information of medical equipment for study and research purpose.
- ✓ It can be used as starting point for other related projects

1.5. Scope of the project

This project is limited to the development of a web based medical equipment management system prototype, for the biomedical case team of the hospital management system. The project assesses the existing situation of the case team and identifies user and system requirements. After identification of the system requirements is made, analysis and description is done using use case model. The design is modeled using UML (Unified Modeling Language) for the medical equipment management system. .

Chapter Two

2. Literature Review

2.1. Medical Equipment and Medical Equipment Management Information System

2.1.1. Medical equipment

To complete the diagnoses and treatment for patient with care, the medical environment is highly dependent on various types of medical equipment. Medical equipment means any instrument that may be used on the inner or outer part of the body for diagnosis or treatment of a disease in human. This includes various diagnostic, laboratory, surgery and dental medical instruments (11).

To complete the diagnoses and treatment for patient with care, the medical environment is highly dependent on various types of medical equipment. Medical equipment is any instrument, apparatus, implement, machine, appliance, implant, in vitro reagent or calibrator, software, material or other similar or related article which does not achieve its primary intended action in or on the human body by pharmacological, immunological or metabolic means, but which may be assisted in its intended function by such means. It excludes implantable, disposable or single use medical devices (2).

Medical equipment must be kept in good condition to prevent from injuries occurred in patient as well as in users. Moreover, to compete with the dynamic environment and complex health care system, health institutions should take the appropriate cost controls in response to that situation (13).

The biomedical engineering unit in health institution is responsible for the patient and clinical staff safety in using medical devices. In addition to the cost control in related operational activities of a medical device, such as purchase, contract, repair, and maintenance, is another important job for this unit. Equipment inventory is an essential part of an effective health-care technology management (HTM) system. In order to be effective in assisting with various HTM activities, the inventory must be updated continually so that it provides at any given moment a correct look at the status of medical equipment within the health-care facility (14).

2.1.2. Medical Equipment Management Information System

MEMIS is a system that deals with the management of medical equipment information, for the purpose of supporting health care technology management in making the equipment to be used safely and effectively. MEMIS incorporates equipment and spare part inventory modules, maintenance module, and contracts management module (2).

Each module has its own information table. Equipment inventory module contains manufacturer information, location and all fields necessary for effective health technology management. The modules help to record equipment. Information using the equipment code given to a specific device. The spare part inventory module tracks the spare part related to the equipment. It helps to manage the stock level and report on the consumption of reused parts. The two main parts of maintenance module are the planned preventive maintenance, which helps the user in calculating when a piece of equipment will require maintenance. The second part is the corrective maintenance, which helps in generating a work order for the specific equipment maintenance request and capture all information on maintenance. The contract management module is used to track all externally provided maintenance services (2).

MEMIS provides an advantage of automated preventive triggers, easy auditing process, reporting, centralize database, real time information, and communication among responsible staffs. It enables to track the status of maintenance work on items and the associated costs of that work in one system. MEMIS can be designed in a manner that suits with the interested institute. This system commonly has a different nomenclature in different places like, Enterprise Asset Management software, Maintenance Management software, Work Order Software, Work Order Management Software, Facility maintenance software and so on (15).

2.1.3. Management Information System

The information system performs transformation of data that consists of basic fact into an output that is valuable to users. It is the collection of technical and management resources that provide the storage, computing distribution, and communication for the information required by all or any part of an enterprise. Information system management is the application of information technology to support the major function and activities of the institution. It uses to solve business problems and the management of technology.

The goals of an MIS are to implement the organizational structure and dynamics of the enterprise for the purpose of managing the organization in a better way and capture the potential of the information system for competitive advantage. To the managers, Information System Management is an implementation of the organizational systems and procedures (17).

The three components of MIS provide a more complete and focused definition, where **System** suggests integration and holistic view, **Information** stands for processed data, and **Management** is the ultimate user, the decision makers. Management information system can thus be analyzed as follows (17).

Management

Management covers the planning, control, and administration of the operations of a concern. The top management handles planning; the middle management concentrates on controlling; and the lower management is concerned with actual administration (17).

Information

Information, in MIS, means the processed data that helps the management in planning, controlling and operations. Data means all the facts arising out of the operations of the concern. Data is processed i.e. recorded, summarized, compared and finally presented to the management in the form of MIS report(17).

System

Data is processed into information with the help of a system. A system is made up of inputs, processing, output and feedback or control. Thus MIS means a system for processing data in order to give proper information to the management for performing its functions (17).

2.2. System Development Methods, Tools, and Techniques

Information system development (ISD) is a set of steps taken to change object system in a specific environment using a different group of tools and an organized collection of techniques. Which is in general called method. ISD is expected to include manual and computerized parts of an object system. (16).

In addition to the techniques and tools, a developer can use the different process model and modeling methods in the development process of an information system.

2.2.1. Modeling Method

Modeling is a way of depicting the existing business domain in understandable system concept. It also shows the benefits of abstracting complex system to model form. Different system developers can use different modeling methods like, Traditional, structured and Object Oriented modeling methodology. Structured analysis and design are process centered approaches that transform data into useful information. It uses a series of phases, systems development life cycle (SDLC), to plan, analyze, design, and implement (17).

In an Object oriented analysis and design, describes the real world of its objects, the attributes, operations, and relationships. It is the object perspective of the problem domain. In contrast with the structured modeling, object oriented modeling combines data and processes that act on the data into things called objects. It is flexible, efficient, scalable and provides on easy transition to OO programming languages make it popular in an information system development (17).

The Object Oriented approach uses the inheritance principle that increases the advantage of reusability of functions and introduces standardized ways of performing basically similar functions on the data. This principle of OO contradicts with the principle of design used by the structured approach (18).

2.2.2. Techniques

Techniques mean a set of steps and a set of rules which define how a representation of an information system is derived and handled using some conceptual structure and related notation. Object oriented analysis and design use static and dynamic UML (Unified Modeling Language) techniques to visualize and document an information system. UML models are used to show the analysis and design of an information system in a modeling diagrams such as, Use Case, Activity, Class and Sequence diagrams (17).

Data Flow Diagram (DFD) is a technique used to show the business process and the data that pass among them. It focus mainly on the process or activities that are performed (17). From this point it is clear that DFD more goes with structural system analysis and design approach. CASE

is a Computer Aided System Engineering tool which uses to simulate and draw different models for the system to be developed. It visualizes the blueprint of the system for the users and make them evaluate and give feedback easily. This tool is important in helping the developer to identify the gaps of the system as early as possible. It makes life easy for the developer because it is easy to edit repeatedly. There are various tools available for modeling diagram like, Visio, and White Star (17). In contrast with the other tools, Visio can be used to draw the modeling diagrams as well as the user interface prototype.

2.2.3. Use Case Diagram

Using the Use Case Diagram model, developers can show the relationship among actors and use cases within a system. The Use Case diagram tracks various functions and those who interact with the functions within a system. An accepted way of accomplishing functional requirement of system is the use case analysis. Use case analysis is a case based way of describing the uses of the system with the goal of defining and documenting the system requirement. It is a powerful technique that describes the kind of functionality that a user expects from the system. It does this by defining a number of actors, which model the roles that users can play when interacting with the system, and describing the use case that those actors can participate in.

A use case diagram is a visual summary of several related use cases within a system or subsystem. It shows the system boundary clearly and what is included in the system. The description of each use case shown within the use case diagram can also be presented in a narrative form. The use case description documents the name of the use case, the actor, description of the use case, a step by step list of the tasks and action required for successful completion, a descriptive course of action, preconditions, post condition, and business rule (17).

2.2.3.1. Activity Diagram

Activity Diagrams are good for describing synchronization and concurrency between activities. Activity diagrams are useful for capturing detailed activities, but they can also capture elements of the high level work flow the system is intended to support. Partitioning can be helpful in investigating responsibilities for interactions and associations between objects and actors. An

activity diagram is a flow chart that shows the actions and events as they occur. They show the order in which the actions take place and identify the outcomes. Activity diagrams are dynamic Modeling tools that can help a system analyst understand how objects behave and interact with the system.

2.2.3.2. Class Diagram

A class diagram represents a detailed view of a single use case, shows the classes that participate in the use case, and documents the relationship among the classes. It is logical model, which evolves into a physical model and finally become a functioning information system (17). A class diagram is static models of system that describe the structural relationships that hold between the pieces of data manipulated by the system. They describe how data is parceled out into objects, how those objects are categorized, and what relationship can hold between them. They do not describe the behavior of the system, nor how the data in a system evolve over time.

2.2.3.3. Sequence Diagram

Sequence Diagram is used primarily to show the interactions between objects in the sequential order as those interactions occur. A business level sequence diagram can be used as a requirement document to communicate requirements for a future system implementation. The other primary uses of the diagram are in the transition from requirements expressed as use cases to the next and more formal level of refinement (17).

- ✓ capture the interaction between objects in the context of a collaboration
- ✓ show object instances that play the roles defined in a collaboration
- ✓ show the order of the interaction visually by using the vertical axis of the diagram to represent time what messages are sent and when
- ✓ show elements as they interact over time, showing interactions or interaction instances
- ✓ Do not show the structural relationships between objects.

2.2.3.4. Process Model

Process model is the type of model that shows how a system analysis and design phases proceed in a system development process. Iterative life cycle model is one type of process model. This model does not attempt to start with a full specification of requirements. Instead, development begins by specifying and implementing just part of the software, which can then be reviewed in

order to identify further requirements (19). This process is then repeated, producing a new version of the software for each cycle of the model. In working iteratively, creating a rough product or product piece in one iteration, then review it and improve it in the next iteration and so on until it's finished. It is building and improving the product step by step so that it is possible to track the defect at an early stage. This avoids the downward flow of defects. In this model it is easy to get the reliable user feedback. In the iterative model less time is spent on documenting and more time is given for designing (19).

Another model called the waterfall process model is simple to understand and use. In this process model each phase is processed one after another, and do not overlap. In this case the system is not tested unless it is developed completely, which reduces the usability of the system (20).

2.2.4. Web based System Development

Internet based system is a series of web pages that provides a user interface, which communicates with one or more levels of data management software and web based database server. A web base system developed and delivered in an internet based framework. This type of system is easily scalable and can run on multiple hardware environments and a standard web browser (17). HTML is a language for describing web pages. It stands for Hyper Text Markup Language. HTML codes are used to tell the browser how to display a text, image, and all things need to be displayed on the web page. In a web based system the database of the system needs to be connected with the web page, through which data can be accessed from the database using a web browser. To connect the database to the web, it is necessary to use middleware. A middleware can interpret client requests in HTML form and translate the requests in HTML form and translate the requests into commands that the database can execute (17). There are different languages used to state the middleware process like PHP. PHP is a server side language that allows to embed little programs into the HTML code of a webpage. It gives greater control over what appears in the browser window than HTML alone can provide. PHP-scripts are interpreted by the web server alone, which enable the user to use different type of browser without worrying about language compatibility. The other part in web based system development is the database management. MySQL is the most popular free database engine available today, which supports the standard language of SQL to interact with relational database (21).

2.2.5. Related Works

The medical equipment management information system is used for equipment inventory, a work order system, the preventive maintenance schedules/procedures, outsourcing contract management and all service history records. Moreover, it is an administrative tool to track equipment, to initiate work orders, to obtain performance indicators, to determine equipment failure trends, to identify training needs, and to produce management reports.

2.3.1. An Equipment Maintenance system

An equipment maintenance system used to maintain equipment master file using magnetic files. The system contains capital cost data, date of installation, summarized history information like maintenance cost, breakdown frequencies, maintenance work done, and maintenance spare part used for each item. Information stored in this system using punched paper tape or cards. The system provides monthly reports as an output and planned maintenance schedule (22).

2.3.2. KALMAN Equipment Management System (KEMS)

KEMS is a secure, web based equipment management system that provides real time info on the quantity, specific location, readiness status, and lifecycle history of all equipment items within a prescribed inventory. The KEMS internet browser interface provides a user friendly “look and feel” and is paired with established and stable component technologies like SharePoint and structured query Language (SQL). Hosted in secure environment, KEMS provides a suite of fully integrated modules that can be tailored to meet a specific equipment management challenge. KEMS is designed based on the success of the Vista Asset Management (VAM) solution. It is used by the department of defense agencies in the US. This system is a web base information system that provides real time information on the quantity, specific location, readiness status, and life cycle history of all equipment. The software is provided using an internet browser interface which is paired with share point and SQL. It captures critical information like start and stop time, material consumption, maintenance cost, calibration information and preventive maintenance schedules, and tracks item warranties expiry date (23).

Work orders, created and tracked in KEMS, capture critical information such as time stamped start and stop times, material consumption, costs associated to maintenance, and general fault condition information. This information allows KEMS users to calculate Turn-Around-Times

(TAT) between service events, active repair time, and other reliability, availability, and maintainability data. KEMS contains a full asset maintenance schedule that supports and tracks calibration information as well as Preventive Maintenance Checks and Services (PMCS). KEMS allows for the tracking of item warranties to include expiration date and can alert stakeholders of expired or expiring warranty prior to performing services on equipment. Because KEMS is accessed via a secure internet connection, the full range of KEMS capabilities can provide mobile maintenance management to users operating away from a fixed base (23).

2.3.3. Management Information System of Medical Equipment using Mobile Devices

Health care access, affordability, and quality are problems all around the world. There are well-established disparities based on income and geography, and the high costs of health care present affordability challenges for millions of different people. Large numbers of individuals do not receive the quality care that they need. Mobile technology offers ways to help with these challenges. Through mobile health applications, sensors, medical devices, and remote patient monitoring products, there are avenues through which health care delivery can be improved.

These technologies can help lower costs by facilitating the delivery of care, and connecting people to their health care providers. Applications allow both patients and providers to have access to reference materials, lab tests, and medical records using mobile devices (25).

This information system uses a mobile device as central axis of the system. It also uses Qr-codes (2D barcodes) which are decoded to receive on the mobile device critical information about the equipment. Through a web server connectivity the mobile platform uses to generate a service order for the maintenance of biomedical equipment. The main tools used to develop this information system; Java to develop cell phone software due to its compatibility with the device, 2.0 16 MP integrated camera for capturing of the barcodes of the equipment and GPRS/EDGE connectivity. It also uses Apache web server with PHP and MySQL programming language for the database development (25).

2.3.4. Medical Equipment Management System (MEMS)

MEMS is designed to manage equipment inventory, work order system, the preventive maintenance schedule, outsourcing contract management and all service history records. The system is developed

for in-house Clinical Engineering Department (CED). It is integrated with the health information system of the National Taiwan University Hospital. The web pages of MEMS were designed using Visual studio C#. The web server of CED designed by Front-page and Dream Weaver. To develop the database, they have used Microsoft SQL server and Oracle database (26).

Medical equipment is quickly becoming less manageable by traditional methods. Most healthcare delivery organizations (HDO) must manage tens of thousands of medical devices representing numerous makes and models. The management of these devices involves a wide array of activities including planning, procurement, inspection, inventory, testing, monitoring, maintenance, and de-commissioning. Common activities include unique device identification, ongoing or periodic determination of the device's location, operational status, battery level and charging profile, software / hardware configuration including serial numbers, pending upgrades or software updates, remote maintenance, and risk management. Traditionally medical devices have functioned as stand alone or perhaps locally networked without the capability to transmit information outside of their own realm. As more equipment becomes connected to the enterprise network, it would be beneficial to equipment management activities to also be able to use these networking capabilities. Currently there are no common standards-based technologies for supporting these device management and maintenance activities (26).

2.3.5. AIMES

Europe is developing a fully integrated approach which reduces manual process, errors, and improves quality with modern electronic business processes for suppliers and hospital on medical equipment management. The project result of AIMES, ITEA2 in Europe shows, the development of logistic management of medical equipment, including inventory control, tracking and dynamic scheduling, medical equipment maintenance, and development of adaptable user interface depending on the specific task. In the project technological advance, there was an end to end problem solving in the hospital based on standard smart phone by the device manufacture's service technician online. Integration between hospital and manufacturers using web service technology was implemented by the project, to make hospital access a device directly and obtain its status. Generally, this project can show us how information technologies advance the medical equipment management system as whole (27).

2.3.6. PRAXIS

PRAXIS system supports the CEDs in organizing their work in a better way and helps the department in taking maximum benefit from the use of medical equipment. The system also ensures secure and efficient operation of CEDs because it provides tools for management and technical support of medical devices. For that, the system includes a large number of functionalities covering all the phases in the life cycle of medical devices (27).

PRAXIS is an in-house developed computerized medical equipment management system. This software is used to enter and store data using relational database. It is networked with different work stations, which allows different user to enter data at the same database. Web-PRAXIS system implemented for the purpose of web-based application and service, centralized database management and support of an application upgrade and data update. WEB-PRAXIS is developed using PHP open source code, which is able to work with Oracle or MySQL (28).

2.3.7. EMIS for Fleet Management

Equipment management Information system (EMIS) is a computer based system that maintains data on motor vehicles owned by Florida state agencies, including car, truck, vans, heavy equipment, and watercraft. EMIS is an old computer application and operates on a mainframe computer system which makes it expensive. The OPPAGA of the state reported that, even though most of the Florida agencies were not satisfied with the performance of equipment EMIS, Three largest agencies were generally satisfied and helps them to control 60% of the motor vehicles within the agencies. The main complaint of the agencies were difficult to use, did not provide needed information, produce outdated reports and staff were reluctant to use EMIS's report believing that the data were inaccurate and unreliable. The EMIS was decided to be redesigned to meet the needs of state agencies (29).

2.3.8. ECRI-AIMS Hospital Equipment Management System

It is web-browser application for managing all aspects of technology based assets in hospitals. In the system, data of the equipment stored centrally in which can be accessed through the hospital intranet. The client uses browser to access central data, there is no software need to be installed on the client side. To develop the central database management system they have used standard Microsoft SQL server database. The system includes six basic system component; equipment, work order, data managers, Administration, customer service, and report. It helps 18 to manage equipment inventory, work order, service control, spare part, purchasing, and stock control (30).

2.3.9. PTI/APWA Equipment Management Information System

The public technology Information system groups were implementing a computer based information system called PTI/APWA equipment management information system, which helps an equipment manager to understand equipment cost, maintenance characteristics, and equipment performance. The software maintains records for the vehicles utilized by various organizational units. It is all about set of computer programs, worksheets, and forms. The system generates a series of reports monthly and some reports are generated only when requested (31).

2.3.10. Medical Equipment Workflow Management System

Medical equipment, workflow management system was developed to be a helpful tool in asset control and workflow management for the medical device service providers. The system designed in three main modules for its' standard system installation. The three main are equipment inventory, preventive maintenance, and corrective maintenance/repair module. The system contributes benefits of electronic document workflow, work records management, remote access dynamic web application, modular structure, simple software interface, and electronic preventative maintenance checklists (32). In general, the above literatures can teach us to what extent an equipment management system are being implemented. It shows how equipment can be managed and controlled using different technology in different level, place and time. It also helps us to identify the success and the failure point of a system, what an equipment management system should include, and how a medical equipment management system could be improved over time.

Chapter Three

3. Methodology

3.1. Introduction

A phased development methodology of object- oriented approach was applied in this study. Interview and document analysis were used as the main tools to capture the business system requirement along with observation. Unified modeling language (UML) development techniques is applied in the process of requirements capture, model organization business system and design. Visio and Argo UML Software were employed in analysis and design models diagramming. Besides, the study result disseminated to the responsible stakeholders by considering ethical issues with the appropriate operational definition.

3.2. Study Area

The project is implemented in St. Paul Hospital Millennium Medical College is found in Addis Ababa and is administered by Federal Ministry of Health (FMOH) which is built in 1969 G.C. Since, 2007 G.C the hospital has become a medical college by opening a medical school with the initiative of the Federal Ministry of Health. Currently the name of the hospital is changed to St. Paul's Hospital Millennium Medical College. Its core services are medical care as well as teaching and research. The college currently has more than 950 clinical and administrative staffs. Physicians and students of the college. In addition to their teaching learning process staff and students are serving in clinical areas. An average of 1700 patients and clients visit the hospital daily in emergency and regular bases. Inpatient services are also given with a total of 500 beds.

3.3. Study Design

The project is conducted from Dec 2015 to June 2016. This project follows the design science methodology, which uses techniques, methods, models, and theory for creating artifacts that satisfy given sets of functional requirement. Object Oriented analysis and design methodology is used for requirement analysis and design. This methodology makes the process of developing system more flexible, easily maintainable and scalable. It also supports the use of an iterative process model which helps to improve the system step by step in a cyclic way until it satisfies the users.

3.4. Study Population

The study population of the study was staffs working at biomedical equipment case team. And the source populations are all health professionals and others who are directly or indirectly working on biomedical activity. Medical service vice provost, administrative and biomedical Directorate Directors and end user of the system were included in the study. Observation of the overall activities is done to seek additional information.

3.5. Sampling Method

The project was done on St.paul's Hospital Millennium Medical College, which makes it purposive in finding the area of the project, where the situational analysis.

3.6. Software Development Life Cycle (SDLC)

A systems development life cycle is composed of a number of clearly defined and distinct work phases which are used by systems engineers and systems developers to plan for, design, build, test, and deliver information systems. An SDLC aims to produce high quality systems that meet or exceed customer expectations, based on customer requirements, by delivering systems which move through each clearly defined phase, within scheduled time-frames and cost estimates. To manage this level of software development life cycle, a number of SDLC models or methodologies have been created, such as "waterfall".

3.7. Water Fall Approach

The total time given for the accomplishment of the project was about 4 months and also selected respondents from the study area, source and study population were not available all the time to collect the relevant information. Therefore, for delivering the project within the specified time and due to the constraints of other resources Water Fall software development methodology is applied in the study. This method follows the following major phases in a sequential manner.

1. System Investigation phase
2. System Analysis Phase
3. System Design Phase
4. System Implementation or coding phase

5. System testing phase
6. System Deployment phase
7. System Maintenance phase

3.8 System Investigation Phase

Requirement Collection Instruments

Requirement collection instruments are used to collect detail and relevant information from managers and end users who are actually responsible and work on the current MEMIS system. It has helped us to collect the functional, non-functional requirements.

The requirement were collected using different types of instruments, including document review, observation, and interview. Interview was conduct for 8 peoples. It's used because through interview the feeling and opinions of the peoples can be understood easily rather than observation and documentation analysis. Interview and document analysis were used to know about how the existing system works especially to see how the data is collected, organized and summarize for report purpose , and also the different manual format they used for data entry and communication and hardware and software aspects existing infrastructure assessment through observation and document analysis was done.

Interview Guide

The interview guide is taken from the Provost Director of biomedical Directorate, Directors and end user of the system. Include the information about their opinion, resource available, experiences/lessons learned, future plan and recommendation about the MEMIS of this study in the organization.

Data/ Requirement Collection Instruments

Requirements for the project were collected from MEMIS experts in the institute, in order to gather facts and opinions through interview, observation and document review.

✓ **Interview**

In this project, Medical Service Provost Director , biomedical Directorate Directors and end user of the system were interviewed about the current paper based system and related work in order to identify the core problems that are happening in the existing system. Most of the functional and non-functional requirements of the designed and developed system are identified using interview guide.

✓ **Observation**

The current work process, the data flow of the current system in general and the day to day activities were observed in order to identify problems with the current system.

3.9. System Analysis Phase

After requirement was captured using the interview, observation and document review the result was analyzed. The result of the system modeling that helps to understand the system models used for analysis of the system was done using tools like the use cases, contextual diagram, flow chart, DFD (Data flow Diagram).

Models

A model is a representation of an important aspect of the real world. It is sometimes called an abstraction as it is used to separate out an aspect of particular importance. Data depiction were made using the following models

- ✓ System Use Case Description
- ✓ Contextual Diagram
- ✓ Data Flow Diagram
- ✓ Sequence Diagram
- ✓ Class Diagram
- ✓ Activity Diagram
- ✓ Entity Relationship Diagram

Tools

A tool in software development is a software support that helps create models or other components required in the project. The tools used for analysis and design in this project were.

- ✓ Microsoft Visio for drawing various modeling diagrams
- ✓ MYSQL Database Applications to store information
- ✓ Microsoft Project for planning

Techniques

A technique in system development is a collection of guidelines that help an analyst complete a system development activity or task. The techniques used in SSADM are logical data modeling, data flow modeling and entity behavior modeling.

✓ Logical Data Modeling

The process of identifying, modeling and documenting the data requirements of the system being designed. The result is a data model containing entities (things about which a business needs to record information), attributes (facts about the entities) and relationships (associations between the entities).

✓ Data Flow Modeling

The process of identifying, modeling and documenting how data moves around an information system. Data Flow Modeling examines processes (activities that transform data from one form to another), data stores (the holding areas for data), external entities (what sends data into a system or receives data from a system), and data flows (routes by which data can flow).

✓ Entity Event Modeling

A two-stranded process: Entity Behavior Modeling, identifying, modeling and documenting the events that affect each entity and the sequence (or life history) in which these events

occur, and Event Modeling, designing for each event the process to coordinate entity life histories.

3.10. System Design Phase

In this phase the system and software design is prepared from the requirement specifications which were studied in the first phase. System Design helps in specifying hardware and system requirements and also helps in defining overall system architecture. The system design was done on the basis of the functional and non-functional requirements identified on the previous phase. Microsoft Visio 2007/2013 is used to design the architecture of the MEMIS developed.

3.11. System Implementation/Coding Phase

In the prototype implementation of the project, the investigator used HTML to develop the user interface of client side web page. PHP was used to write the code that connects the web page and the relational database which is created using MySQL.

3.12. System Testing Phase

We used formative usability testing to maximize the usability of the prototype MEMIS developed. The prototype MEMIS is tested against the requirements to make sure that the system developed is actually solving the needs gathered during the requirement phase.

Table 1: Summary of methods, techniques, and tools used in each phase of the project

Phases of the software development	Models and Techniques	Tools	Approach
Feasibility, requirement gathering /planning phase	✓ Interview ✓ Observation ✓ Document analysis	✓ Questionnaire ✓ Observation Checklist	Water fall approach
Analysis phase	✓ System Use Case Description ✓ Contextual Diagram ✓ Data Flow Diagram ✓ Class Diagram ✓ Activity Diagram ✓ Entity Relationship Diagram	✓ Microsoft Visio 2007/2013	
Design phase	✓ Architecture layout of the proposed system. ✓ Working process of the mobile application. ✓ User interface design diagram	✓ Microsoft Visio 2007/2013	
Development Phase	✓ Object Oriented Analysis and Design Programming	✓ HTML ✓ MY SQL ✓ PHP	
Testing Phase	✓ Informal software usability testing	✓ Questionnaire checklist	

3.13. Operational Definitions

Health technology: The application of organized knowledge and skills in the form of devices, medicines, vaccines, procedures and systems developed to solve a health problem and improve quality of life. It is used interchangeably with healthcare technology.

Medical device: An article, instrument, apparatus or machine that is used in the prevention, diagnosis or treatment of illness or disease, or for detecting, measuring, restoring, correcting or modifying the structure or function of the body for some health purpose. Typically, the purpose of a medical device is not achieved by pharmacological, immunological or metabolic means.

Medical equipment: Medical devices requiring calibration, maintenance, repair, user training, and decommissioning – activities usually managed by clinical engineers. Medical equipment is used for the specific purposes of diagnosis and treatment of disease or rehabilitation following disease or injury; it can be used either alone or in combination with any accessory, consumable, or other piece of medical equipment. Medical equipment excludes implantable, disposable or single-use medical devices.

Data Flow Diagram: is a graphical representation of the "flow" of data through an information system, modeling its process aspects. Often they are a preliminary step used to create an overview of the system which can later be elaborated.

Data Flow Model: A data flow model is diagrammatic representation of the flow and exchange of information within a system. Data flow models are used to graphically represent the flow of data in an information system by describing the processes involved in transferring data from input to file storage and reports generation.

Entity Relationship Diagram: An entity-relationship diagram (ERD) is a data modeling technique that graphically illustrates an information system's entities and the relationships between those entities. An ERD is a conceptual and representational model of data used to represent the entity framework infrastructure.

SSADM: Structured systems analysis and design methodology (SSADM) is a set of standards for systems analysis and application design.

Use Case Diagram: is a graphic depiction of the interactions among the elements of a system.

User Interface Design: is concerned with how users add information to the system and with how the system presents information back to them.

3.14. Ethical Clearance

Ethical clearance to conduct the project was obtained from the School of Public Health Research and Ethical Committee of Addis Ababa University. Permission was obtained from the St.paul's Hospital Millennium Medical College in written form and from all departments involved in the project. This informed consent from each subject was obtained after clear explanation about the purpose of the project.

Chapter Four

4. System Development

4.1. Introduction

Object Oriented modeling methodology and iterative process model is used to analyze, design and implement the project. To design and develop an information system it is important to have a detailed understanding of the existing system. There are different techniques available for identifying the system requirements. As mentioned in the methodology the system requirement was identified and analyzed using UML modeling technique. The information about the existing system was collected using in-depth interview and document review. In this chapter the requirements analysis and design of the system will be presented.

4.2 System Analysis

4.2.1. Current System

The current system of the organization is reviewed in such a way that makes it simple to identify the gaps. The findings are organized under six main subtitles, the existing hardware, software, network, people, data and procedure, and management.

4.2.1.1 Hardware

In each health facility at the Hospital there is at least one idle desktop computer which is functional. In addition to this, the organization has financial resource which can make the health facilities and the FMOH equipped with necessary additional hardware. The main problem is that there is no specific requirement of hardware stated previously in the organization. Moreover, there is no structural design for the medical equipment information management system.

Table 2: Hardware Inventory of the Existing System

S.NO	Location	Quantity	Type and model of computer	RAM	Hard Disk	processer	purpose
1	Biomedical Department	3	Dell Opti Plex 7030 cori3	4GB	500GB	32bit Intel R Core (tm) CPU 2.50GHz	For office
		1	Toshiba satellite C55-b-896	4GB	500GB	Intel(R)Core(TM) 32 Bit	Inventory Record
2	Medical ICU	5	Dell Optiplex 7030 cori3	4GB	500GB	32bit Intel R Core (tm) CPU 2.50GHz	Office Purpose -Patient Medical Record Purpose
3	Dental Unit	6	Toshiba Intel core i3	4GB	400GB	32 bit Intel R core TM i3	Record system and office purpose

4.2.1.2 Software

Currently the organization is not using any specific software application related to the medical equipment information management. However the organization has plans to get a software to help them in the management of medical equipment in the near future.

4.2.1.3 Network

The hospital and the corresponding public health services are interconnected by the network. Moreover almost all branches have a broadband internet connection within their organization.

St.Paul Hospital has 8MB/S internet connection. Abet hospital has 2MB and National Kidney Transplant health center has 6MB. This internet availability can be a valid opportunity in the implementation of web based medical equipment information management system.

4.2.1.4 People

Under the hospital curative and rehabilitative core process, there are two biomedical engineers and four biomedical technicians in the pharmaceutical and medical equipment management and maintenance case team. They are responsible for the management and maintenance of medical equipment available in all public health facilities within the hospital. They use the workshop of Abet hospital as maintenance center. All the professionals have at least basic computer application skills.

4.2.1.5 Data / Process

Interviews and document reviews show that there is no enough documentation on medical equipment performance, maintenance, down time, and replacement, especially after the equipment were issued to the facilities. In 2006EFY a general inventory was done by the hospital biomedical department for the purpose of knowing the available equipment type in the hospital. The second inventory is done in 2007EFY. The inventory formats includes the following information, inventory number, type of equipment, manufacturer, model, serial no., country of origin, year of manufacturer, power requirement, spare part availability, manual available, location, and equipment user. Due to absence of organized information, preventive maintenance was not being done as per the equipment manufacturer standard. There are no records kept about the corrective maintenance being done.

4.2.1.6 Procedure

Figure1 shows the organizational structure of the hospital. It points the exact position of the biomedical case team, is responsible for in the overall management of medical equipment in the hospital. The process of managing medical equipment among the facilities of the hospital is limited only on the stores, in which the information on medical equipment received or issued by the stores are recorded using model 19 and model 22.

4.2.1.7 Management

a) Vision of the Department

- ✓ To see a healthy, productive, and prosperous society.

b) Mission of the Department

- ✓ To reduce morbidity, mortality, and disability through providing an express and qualitative curative and rehabilitative health service in collaboration with Stakeholder.

c) Responsibility of the Department

- ✓ The responsibilities of the department are planning, procuring, and distributing drugs and medical supplies including equipment and control over all management throughout the Hospital
- ✓ Develop and monitor implementation of a medical equipment strategy
- ✓ Oversee establishment of a medical equipment inventory
- ✓ Develop/approve a model medical equipment list
- ✓ Establish and monitor the implementation of policies for:
 - i. Procurement of medical equipment
 - ii. Donation of medical equipment
 - iii. Acceptance testing and installation of medical equipment
 - iv. Maintenance of medical equipment, including a list of external suppliers of maintenance service
 - v. Disposal of medical equipment
 - vi. Training of hospital staff for the use
- ✓ Determine the annual budget for implementation of the medical equipment strategy
- ✓ Review incident reports related to medical equipment

d) Job Description of the Professionals

The biomedical professionals are responsible for performing the following tasks.

- ✓ Planning on the usage and maintenance process of medical equipment.
- ✓ Requesting spare part procurement for maintenance service.
- ✓ Provide on-site maintenance service throughout the public facilities.

- ✓ Assist with an equipment specification plan.
- ✓ Provide training for health professionals on equipment usage.
- ✓ Reporting about medical equipment needed to be replaced or discarded to the responsible body.
- ✓ Perform annual medical equipment inventory.
- ✓ Make general performance report

e) Communication

- ✓ The biomedical department has direct communication with the facilities. Facilities make requests for corrective maintenance or consultancy verbally to the department.

Organizational structure

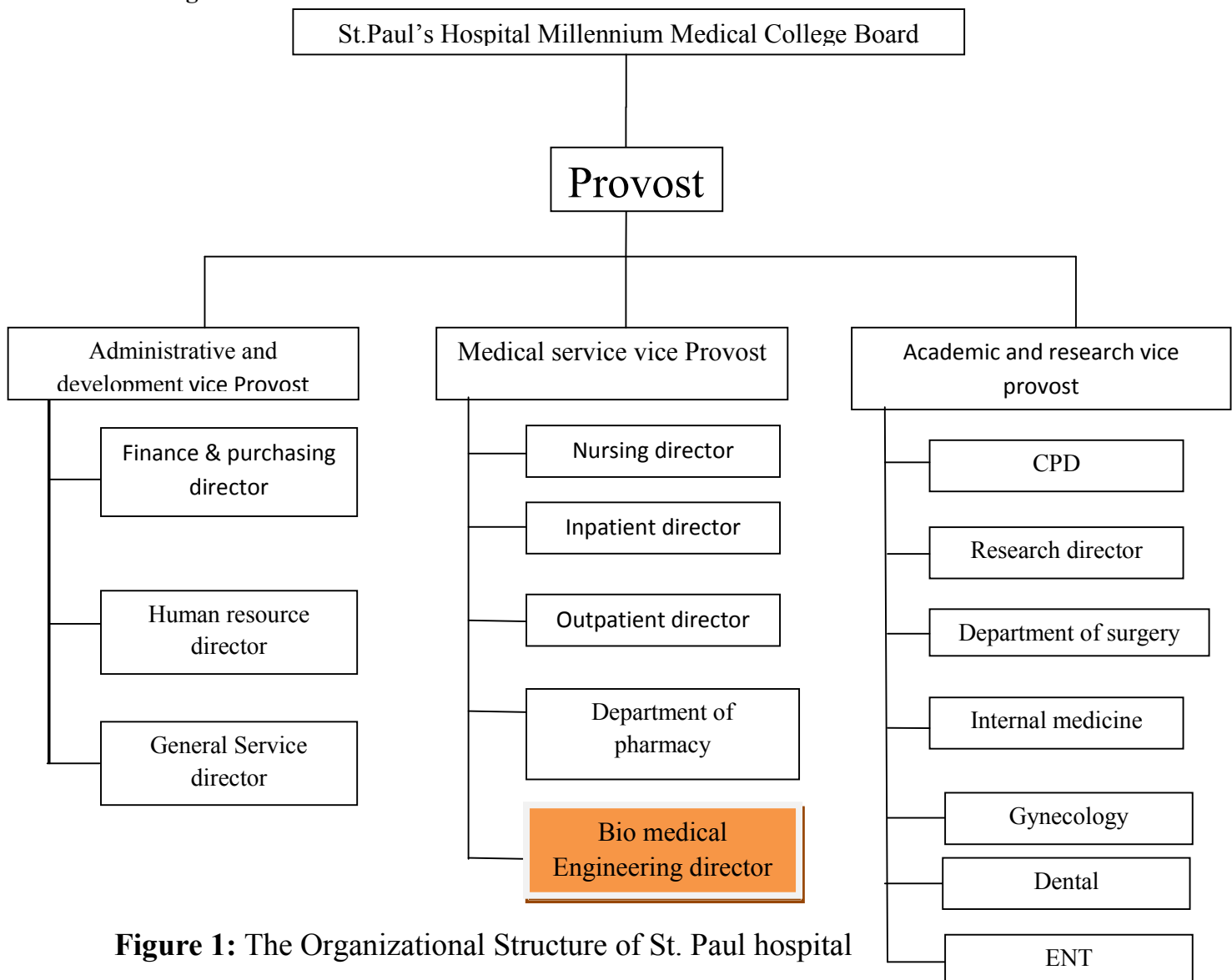


Figure 1: The Organizational Structure of St. Paul hospital

Generally, the existing system does not have a preventive maintenance tracing mechanism, there is no records on corrective maintenance done and spare part used. The corrective maintenance work order request is made verbally to the central biomedical department. The business process of the existing system is limited only to the receiving and issuing process of the pharmacy store. The central biomedical department has no controlling mechanism over the performance and maintenance of the medical equipment. Therefore, to manage the medical equipment performance, maintenance, down time, and on time replacement of equipment, it is important to have strong medical equipment information management system which keeps records and provide reports about all medical equipment.

4.2.2 Proposed System

The proposed system is applicable to the health facility and central biomedical department. It will be implemented using client/ server based system architecture. A computerized equipment maintenance system might include equipment inventory module, spare part inventory module, and maintenance module in addition to other optional modules. Hospital medical equipment management guide has stated nine operational standards for medical equipment management. From these nine standards the three indicate that a hospital must have a paper based or computer based equipment and spare parts inventory management system and equipment history file.[] The Proposed Medical Equipment Information Management System (MEMIS) includes medical equipment registry, spare part registry, preventive maintenance record, corrective maintenance record, and general report modules. Figure 2 shows the context diagram of the proposed system.

Proposed system

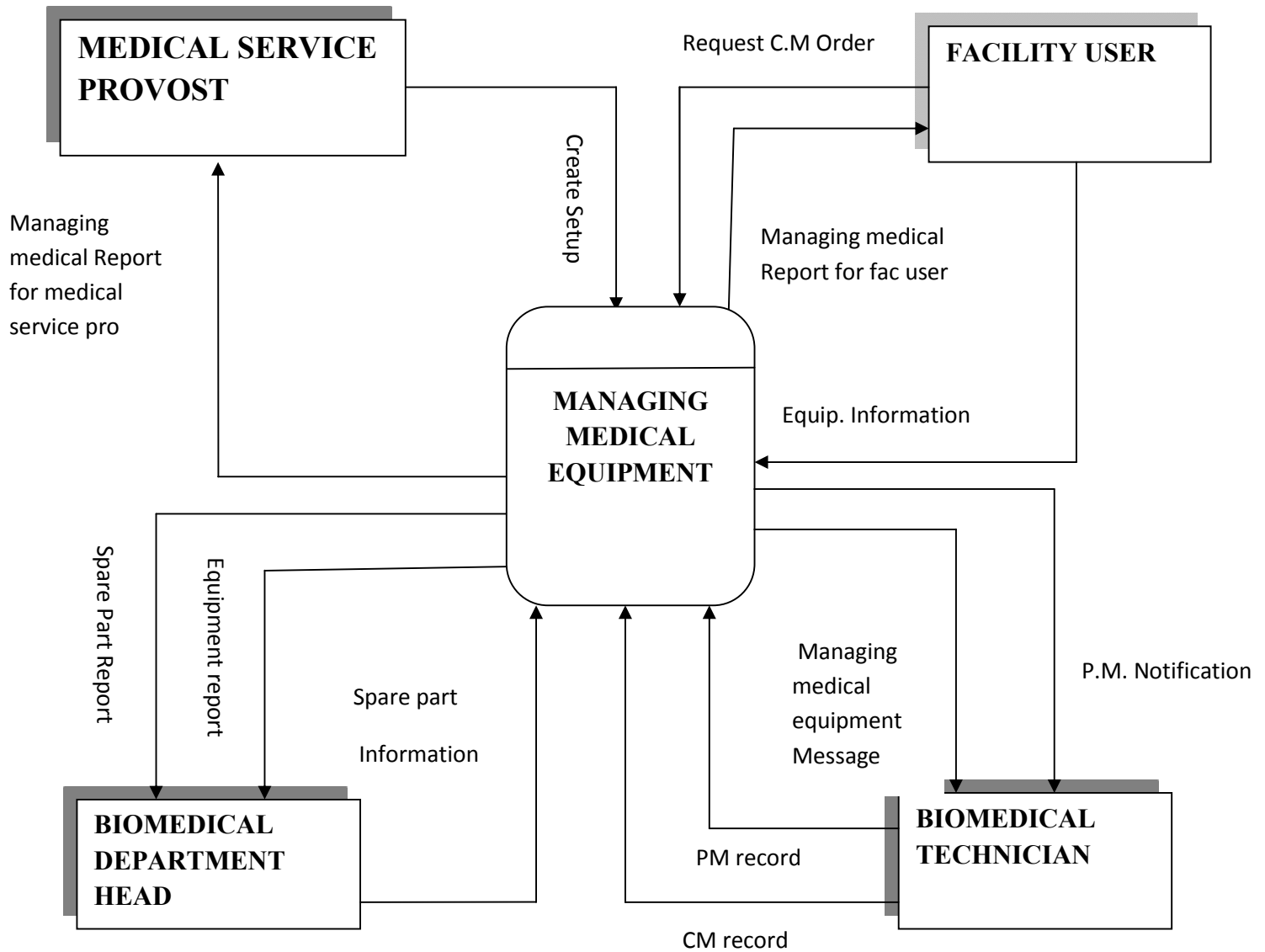


Figure 2: Context diagram for Medical Equipment Information Management System

4.2.3. Stakeholders

Stakeholders are individuals or organizations that could influence or be influenced positively or negatively by medical equipment information management system.

Table 3: List of stakeholders and their roles and responsibilities

Sn	Stake Holders	Role and responsibility
1	System Administrator	✓ Responsible for creating and updating user account, organizational setup, Manufacturer setup, supplier setup and department setup.
2	Facility focal Person	✓ Responsible for medical equipment information registry ✓ Responsible for sending a request for corrective maintenance work order ✓ Responsible for requesting the system to generate reports and use the report at the point of service.
3	Biomedical Technician	✓ Responsible for recording preventive and corrective maintenance details. ✓ Responsible for registering spare part information. ✓ Responsible for generating reports and use the report in the improvement of service provision.
4	Biomedical department head	✓ Responsible for generating equipment report. ✓ Responsible for disseminating the report for decision making bodies. ✓ Responsible for facilitating overall activities in the biomedical department.
5	Health Professional	✓ Responsible for providing appropriate information about medical equipment performance and incidence
6	Health Facility Management	✓ Responsible for providing administrative and infrastructure need ✓ Responsible for interpreting reports and make a decision at the facility level
7	Curative Department Head	✓ Responsible for controlling overall medical equipment management information system at the hospital. ✓ Interpret and use the report for decision making purpose at the hospital

4.2.4. System Analysis Models

The following use cases have been identified from the proposed system specification.

- ✓ Login
- ✓ Create an account
- ✓ Register medical equipment
- ✓ Register spare parts
- ✓ Produce preventive maintenance schedule
- ✓ Record preventive maintenance Information
- ✓ Complete corrective maintenance work order
- ✓ Record corrective maintenance record
- ✓ Generate standard report
 - Corrective Maintenance Report
 - Preventive maintenance Report
 - Medical equipment Report
 - Spare Part Report

4.2.4.1. Use Case Diagram

To create use case diagram for the proposed system, process that need to be included in the system are identified depending on the document reviewed and existing system assessment findings. The primary and the secondary actors for each use case are identified and each actor is related with its corresponding use cases. During identifying actors in the system use case, actors who are responsible in recording medical equipment, requesting corrective maintenance work order and the system administrator are not available positions in the existing organizational structure. The second point discovered in this process is, the system boundary overlaps somehow with the pharmacy store process.

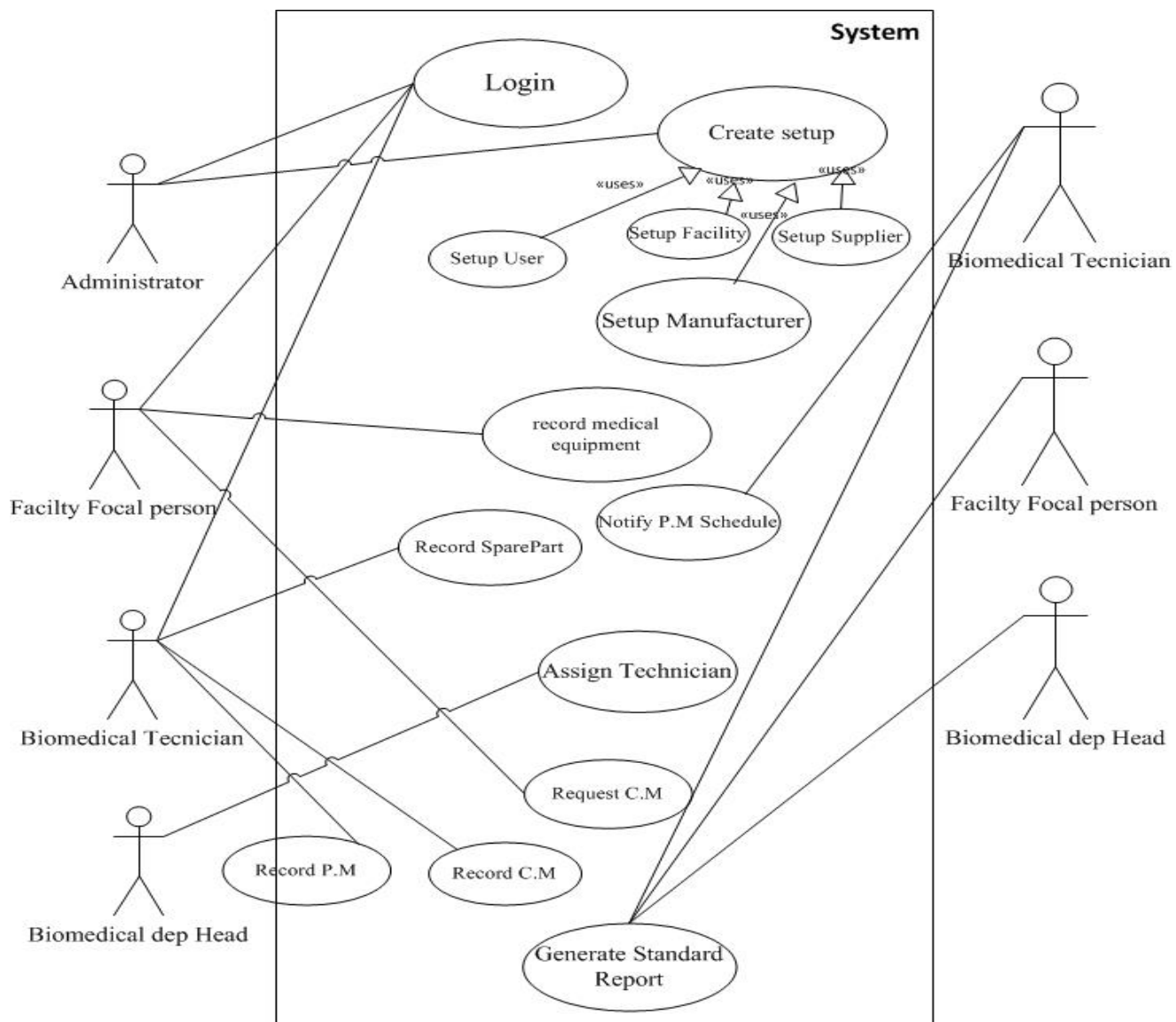


Figure 3: System Use Case Diagram for Medical Equipment Information Management

4.2.4.2. Use Case Narrations

The narrations of use cases are used to illustrate each use case or process identified in a use case diagram. It is helpful for the end user to understand the process of the system. In this case all the processes are narrated along with its actors, trigger point, the output of the processes and so on. A sample of the use case narration and activity diagram are presented in the following figure.

4.2.4.3. Activity Diagram Modeling

Activity diagrams are used to illustrate the process of the system in a diagrammatic form. It helps to present the process in a sequential order. The following activity diagram shows all objects within the medical equipment information management system and their interaction with the system.

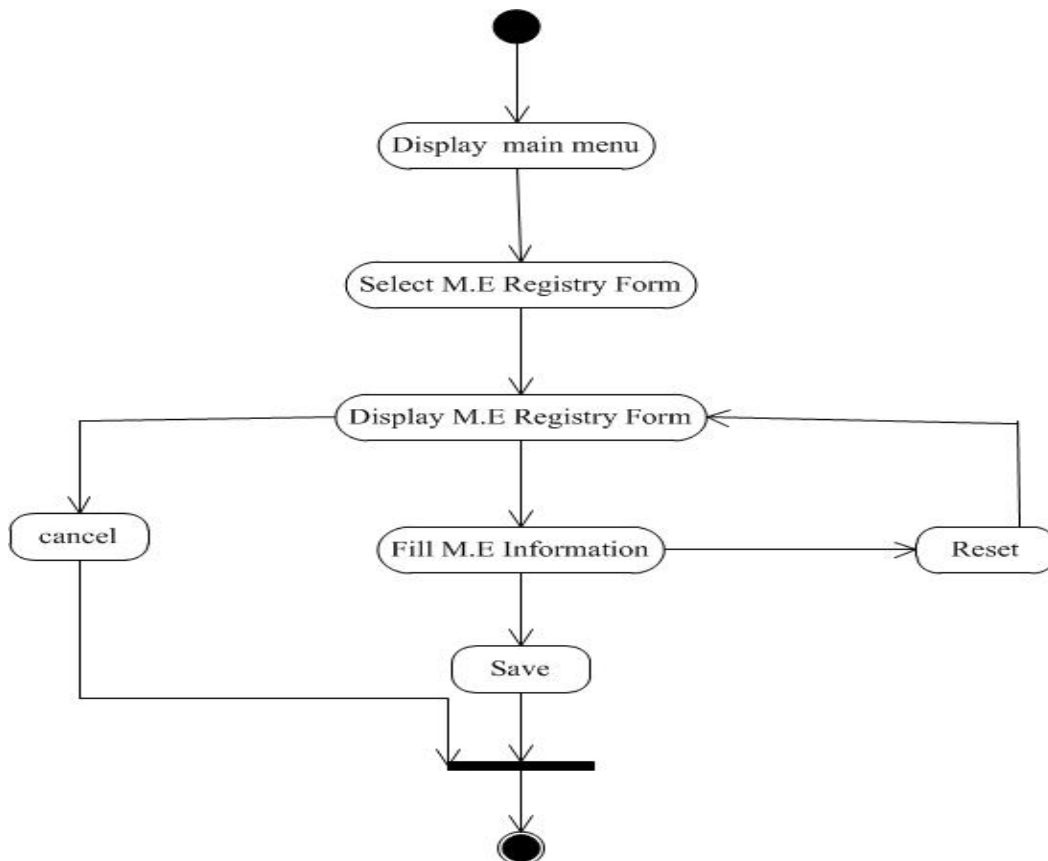


Figure 4: Activity diagram for medical equipment registration process

Use case ID:	UC-03
Use case title	Register medical equipment
Use case Description	This use case describes the process of registering electronic medical equipment information
Primary actor	Facility focal person
Trigger	The focal person attempts to register medical equipment by selecting the medical equipment option from system main menu
Pre-Conditions	The user is logged in to the system
Post-Conditions	Medical equipment information is recorded in the system database. The equipment is assigned a unique ID.
Main scenario	1.The user selects medical equipment recording menu option; 2.The system displays medical equipment recording form; (Figure 7) 3.The user fills the form with equipment information; 4.The user clicks submit button; 5.The system saves the equipment information on the system database and make the form ready for the next record;
Alternative scenario	4.1. If the user clicks on cancel button; 5.a. The system return to the main menu; 4.2. If the user clicks on reset button; 5.b. The system clear the input box;
Frequency of use	About 40 per month

4.2.5. System Requirements

Requirements constitute a specification for the proposed system. It is the starting point for measuring the performance, accuracy, and completeness of the finished system before entering the system design. In system analysis, it is important to identify the functional and Non functional requirement.

4.2.5.1. Functional Requirements

Functional requirement defines a function of a system or its component and specify particular results of the system. It also describes the interaction between the system and the users independent of its implementation. The functional requirements of the proposed system are listed as follows

- ✓ Differentiate ordinary user and administrator.
- ✓ Enable authenticated user to log in to the application.
- ✓ Enable the user to register medical equipment information.
- ✓ Enable the user register spare part information.
- ✓ Provide preventive maintenance schedule notification.
- ✓ Enable the user to record preventive maintenance information.
- ✓ Allow the user to send corrective maintenance request.
- ✓ Enable the user to record corrective maintenance information.
- ✓ Enable authenticated user to edit and delete records
- ✓ Generate all types of standard reports
- ✓ Enable the administrator to create, delete, update user setup
- ✓ Enable the administrator to create, delete, update facilities setup
- ✓ Enable the administrator to create, delete, update Manufacturer Setup
- ✓ Enable the administrator to create, delete, update Supplier setup

4.2.5.2. Non-functional Requirement

A non-functional requirement (qualities of the system) is a requirement that specifies criteria that can be used to judge the operation of a system rather than specific behaviors. It defines how a system is supposed to be. The following are the non-functional requirements of the proposed system:

- ✓ The system shall provide 8 hours per day service.
- ✓ The system shall uses English language.
- ✓ The system shall provide error message whenever the user attempts to enter invalid Data.
- ✓ The system shall provide notification message whenever the user leave crucial text box empty.
- ✓ The mean time between failure must be 3 month
- ✓ The average user learning time must be less than 1 day
- ✓ The system shall be available 99.99% of time
- ✓ The system shall be modifiable
- ✓ The system shall use client server system architecture

4.3. System Design Models

4.3.1. System Class Diagram

Uses class and sequence diagrams are used to design MEMIS. The class diagram is used to present the system classes (object), their attributes, association between classes, attribute type, class methods (what a class can do), navigability of class, and dependency between classes. All the classes are identified by taking noun words from the narrated use cases defined previously and differentiate the words that should not be a class. After identifying all possible classes, the second step was looking for the association between each class. The classes identified were, 'UserAccount' class, which is inherited by 'User' and 'Administrator' class. 'Department', 'Supplier', 'Facility' and 'Manufacturer' classes are managed by the administrator class. The class 'Registration' captures information about 'Equipment', 'Sparepart', 'PreventiveMaintenance', and 'CorrectiveMaintenance' classes. The rest of the interface class 'Report' and class 'C.Mworkorder' are performed by the class 'User'. Depending on the existing system document and literature reviewed, the attributes of each class were identified by their type. The attributes are used as an identity for a class. The functions of all classes are identified as well as the parameter they get or set using the narrative use cases as a reference see figure 5.

4.3.3. System Architecture

System architecture translates the logical design of an information system into a physical structure (17). This medical equipment information management system is designed to have three tiers Client/Server architecture. The client/server architecture refers to systems that divide processing between one or more networked clients and a central server. In this system, the client handles the entire user interface, including data entry, data query, and screen presentation logic. The server stores the data and provides data access and database management functions. Application logic is divided in some manner between the server and the clients. In a client/server interaction, the client submits a request for information from the server, which carries out the operation and responds to the client. Only the request and the result are transmitted across the network. Client/Server system architecture is proposed because, it Client/Server is cost effective in large scale networks, flexible, and scalable (17). The following diagram shows the system architecture for medical equipment information management system.

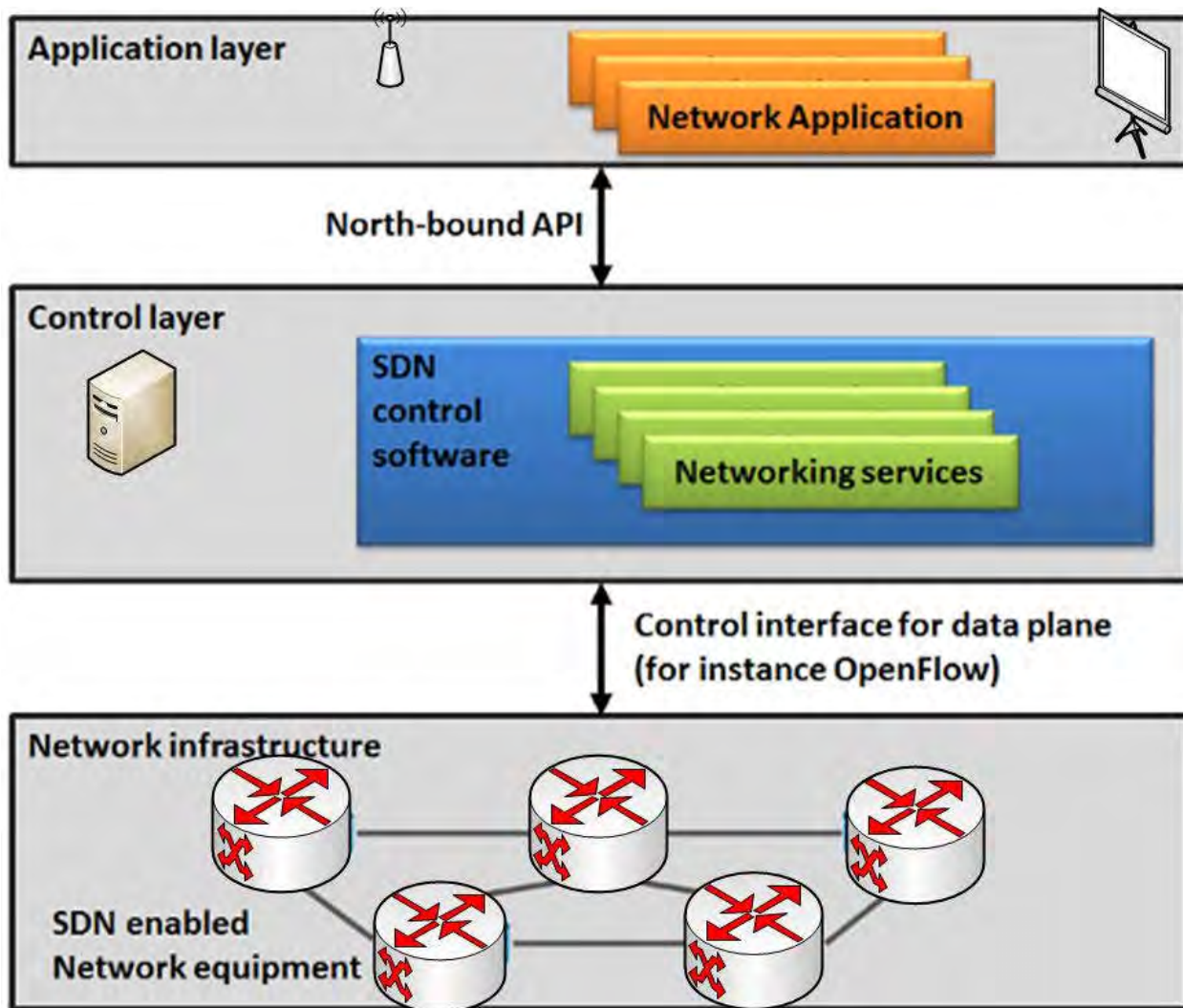


Figure 6: MEMIS Architecture

4.4. Prototype Implementation

The implementation of MEMIS is done in three parts, the presentation layer, Database layer, and the middle layer. The user interface/ presentation part is implemented using HTML and CSS coding. The database is developed using MySQL database management system and the middleware, which connects the user interface and the database, is implemented using PHP. The following snapshots present some of the user interface of the system.

4.4.1. Presentation Layer

4.4.1.1. Medical Equipment Registry Form

Figure 7 shows Medical Equipment Registry that allows the user to register medical equipment information into the system. To open the registry form, the user only needs to select medical equipment option from the main menu. It contains all information about a specific equipment that need to be captured.

The screenshot displays the 'Medical Equipment Registry' form within a web application. The interface features a blue header with navigation tabs: 'medical', 'sparepart', 'PMR', 'C.Mwork', 'C.Morder', 'Biomedical', 'Report', 'users', 'AboutUs', and 'Logout'. On the left, a sidebar contains a logo for 'St. Paul's Hospital Millennium Medical College' and a menu with options: 'HOME', 'M.E Registry', 'S.P Registry', 'P.M Record', 'C.M Work worder', and 'C.M Record'. The main form area is titled 'Medical Equipment Registry' and contains the following fields:

Equipment code:		Equipment Description	
Model:		Warranty Expiration:	
Date recieved:	Year Month Date	Consumable Requirment	
Serial no		P.M Schedule	
Manufacturer		Manufacturer Address:	
Supplier:		Supplier Address	
cost::		Status:	
Avialable::		Instalation Date:	Year Month Date
Expected life::		Equipment Risk Classification:	
Use of the Item:			

At the bottom right of the form, there are two buttons: 'ADD RECORD' and 'Refresh'.

Figure 7: Medical Equipment Registry Form

Usability Testing aids, to identify whether the system satisfies the requirements of its end users. In the case of MEMIS design, usability testing is done initially by using the user interface to identify the gaps of the requirement need to be achieved by the system as early as possible. The testing is done by introducing closed ended questions to the end user of the organization. It five users have participated in the evaluation after the use of the test and how to use the user interface. This test is the initial test to be done in the first iteration of the system development

process and which should be continued in each iteration until the system achieves the specified requirement. Table 4 shows the summarized results of the test done by the five participants.

Generally, the users agree with most parts of the interface, but still there are some more need of improvement to achieve user salutation. The points where the users are not satisfied include attractiveness, sequence, consistency and the learn ability of the user interface.

4.4.2. Database Layer

4.4.2.1. Database Model

As per the needs depicted in the class diagram, data storage area is created using tables in the database. All fields of the table and the corresponding primary key within each table are identified. The primary key is a unique parameter used to identify a specific record within a table. To create a simple and flexible table that is free from data redundancy, normalization is done on the tables. “Normalization is the process of creating table designs by assigning specific fields or attributes for each table in the database” (21). After passing through a different normalization stage the database is modeled using relational model. The relational model uses a foreign key to establish relationships between tables and form an overall data structure. The relational database is used because it is well suited to client/server computing (21).

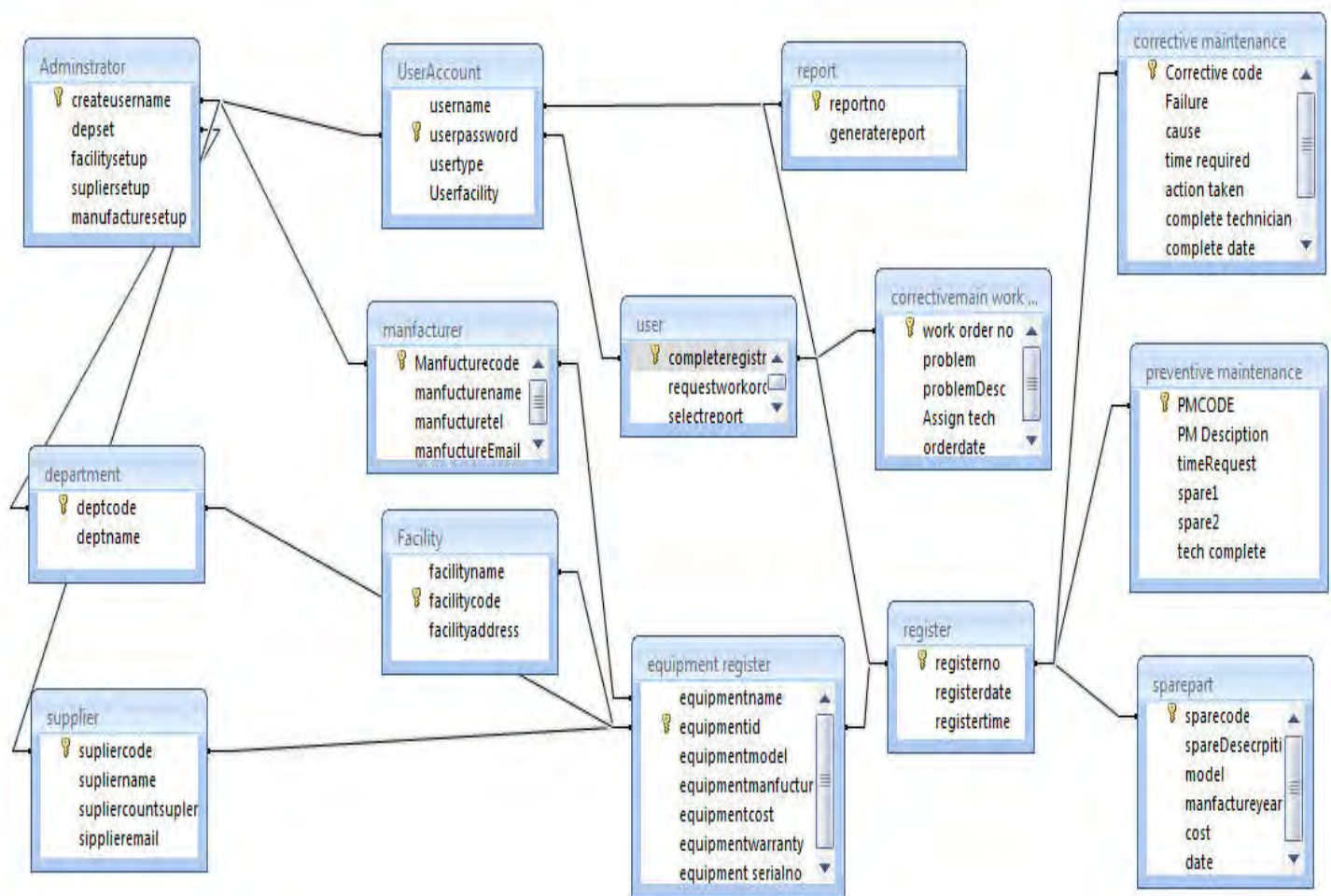
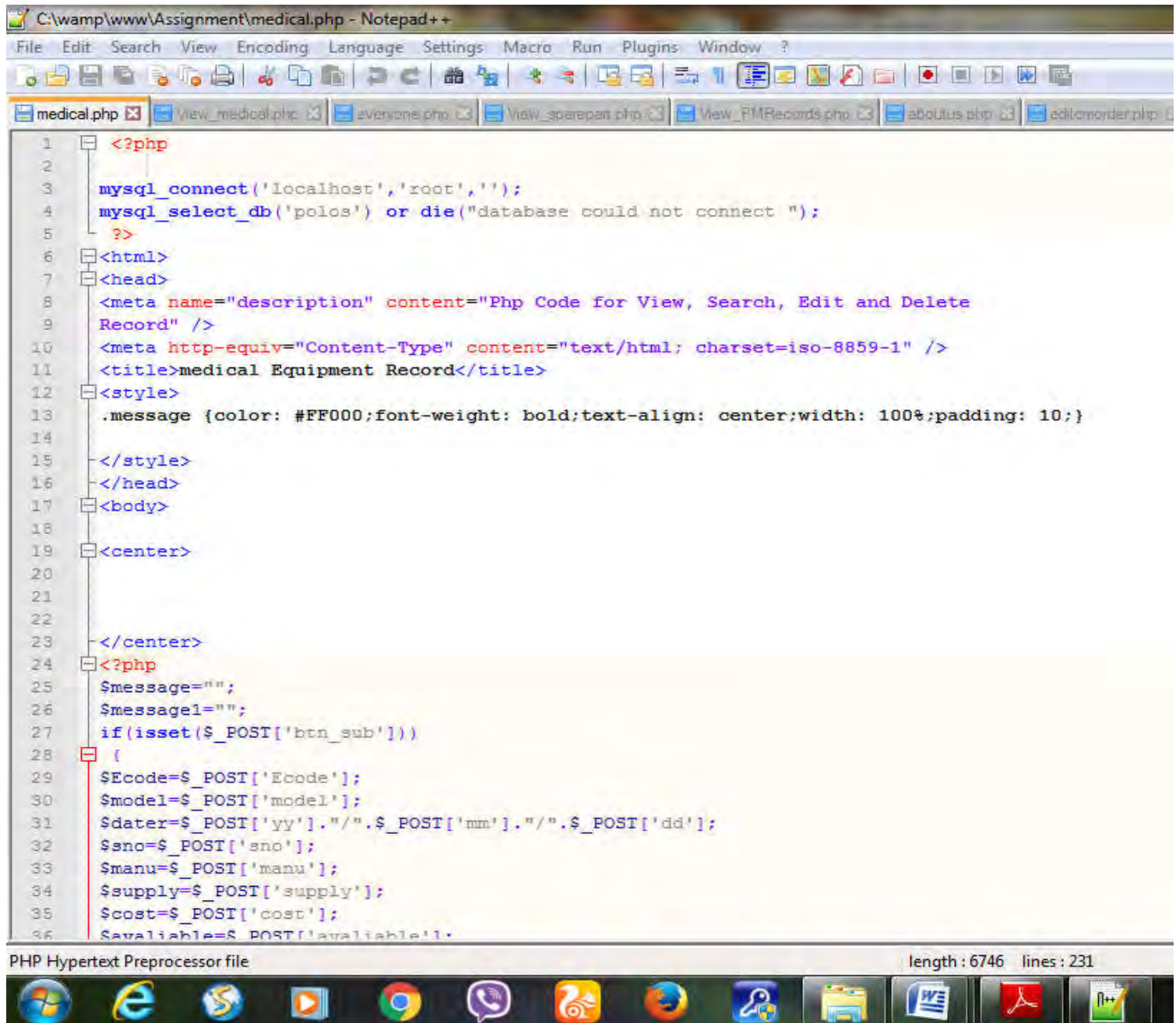


Figure 8: The physical Database Model of MEMIS

4.4.3. Middle Layer

To connect the user interfaces and the database created, PHP codes are used the HTML. The following snapshot presents the sample of these codes.



```
1 <?php
2
3 mysql_connect('localhost','root','');
4 mysql_select_db('polos') or die("database could not connect ");
5 ?>
6 <html>
7 <head>
8 <meta name="description" content="Php Code for View, Search, Edit and Delete
9 Record" />
10 <meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1" />
11 <title>medical Equipment Record</title>
12 <style>
13 .message {color: #FF0000;font-weight: bold;text-align: center;width: 100%;padding: 10;}
14
15 </style>
16 </head>
17 <body>
18
19 <center>
20
21
22
23 </center>
24 <?php
25 $message="";
26 $message1="";
27 if(isset($_POST['btn_sub']))
28 {
29 $Ecode=$_POST['Ecode'];
30 $model=$_POST['model'];
31 $dater=$_POST['yy']."/".$_POST['mm']."/".$_POST['dd'];
32 $sno=$_POST['sno'];
33 $manu=$_POST['manu'];
34 $supply=$_POST['supply'];
35 $cost=$_POST['cost'];
36 $available=$_POST['available'];
```

PHP Hypertext Preprocessor file length : 6746 lines : 231

Figure 9: Sample of PHP Codes

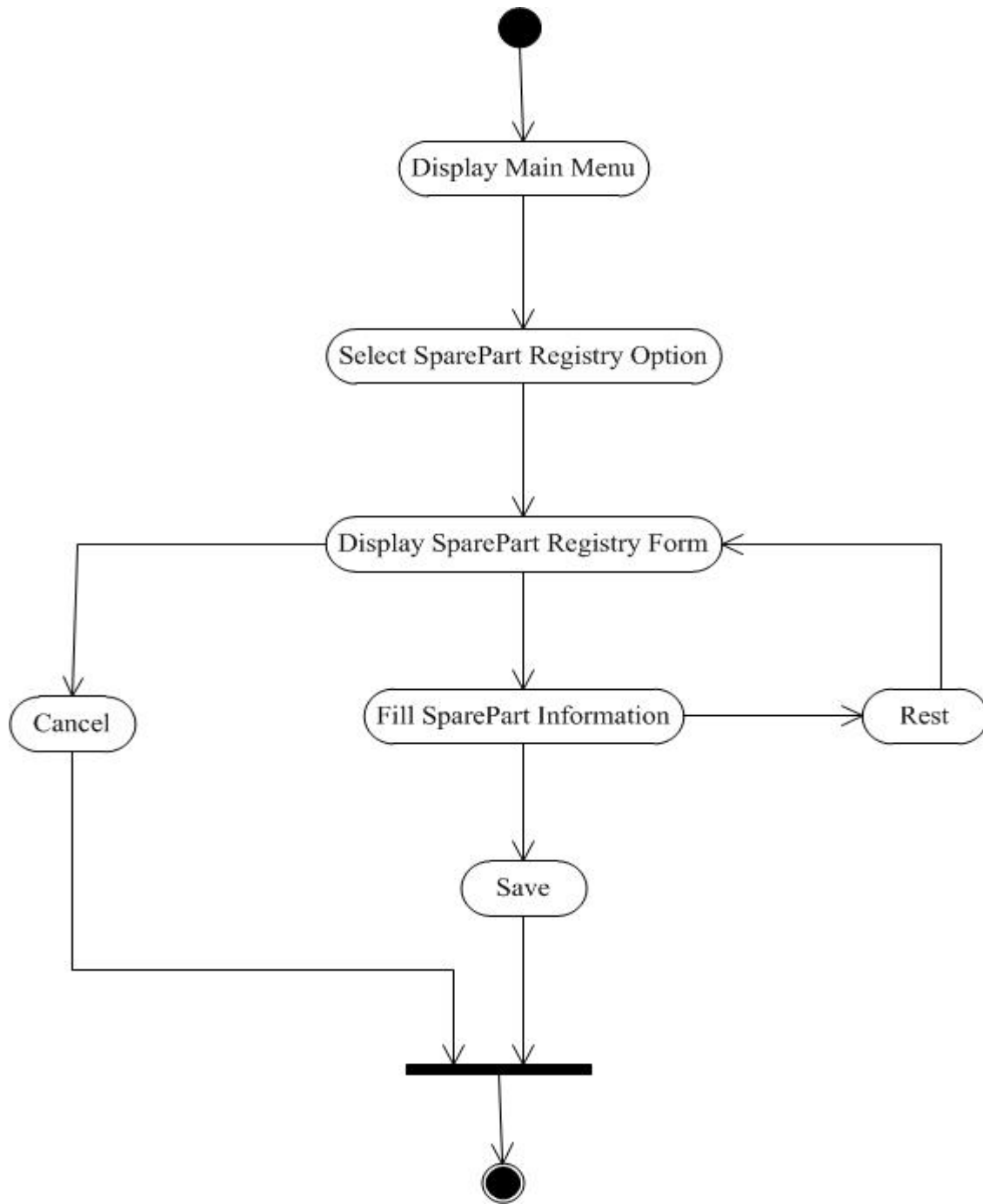


Figure 10: Activity diagram for spare part registration process

Use Case ID:	UC-04
Use Case Title	Register Spare parts
Use case Description	This use case describes the process of recording electronic spare part information.
Primary Actor	Biomedical Technician.
Trigger	The technician attempts to register spare part by selecting the spare part recording option from system main menu.
Pre-Conditions	The user is logged in to the system.
Post-Conditions	The spare part information is recorded in the system database. The spare part is assigned a unique ID.
Main scenario	1. The user selects spare part recording menu option; 2. The system displays spare part recording form(Figure4.6); 3. The user fills the form with spare part information; 4. The user clicks submit button; 5. The system save spare part information in the system database and makes the form ready for the next record;
Alternative scenario	4.1. If the user clicks on cancel button; 5.a. The system return to the main menu; 4.2. If the user clicks on reset button; 5.b. The system clear the input box;
Frequency of Use	About 30 per month
Business Rule	

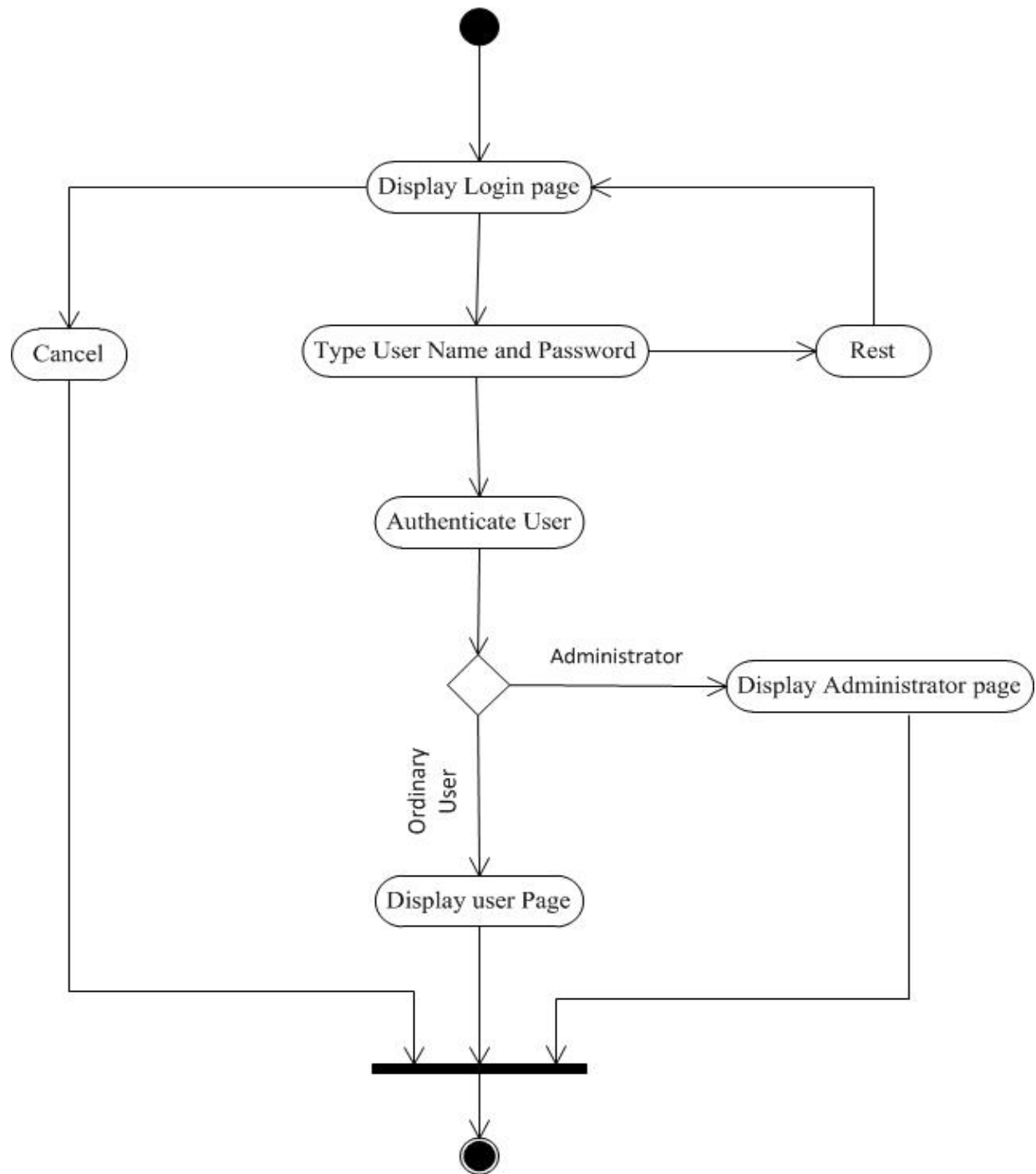


Figure 11: The activity diagram for login process

Use Case ID:	UC-01
Use Case Title	Login
Use case Description	This use case describes the user login process to enter into the system and use other functionalities.
Primary Actors	Biomedical technician, Biomedical department head, Facility focal person, Administrator.
Trigger	User tries to access the medical equipment information system
Pre-Conditions	The user has authorized user name and password.
Post-Conditions	The system displays system main menu screen.
Main scenario	6. User opens the medical equipment information system screen; 7. The user clicks login button; 8. The system displays login form; 9. The user enters ordinary user name and password and presses login button; 10. The system displays main menu screen;
Alternative scenario	4.1 If the user enters administrator name and password; 4.1. A. The system displays Administrator screen;
Frequency of Use	More than 88 per month
Business Rule	The system allows only two trials to access the system. If the user fails to enter valid Username or password, the system locks for one minute automatically.

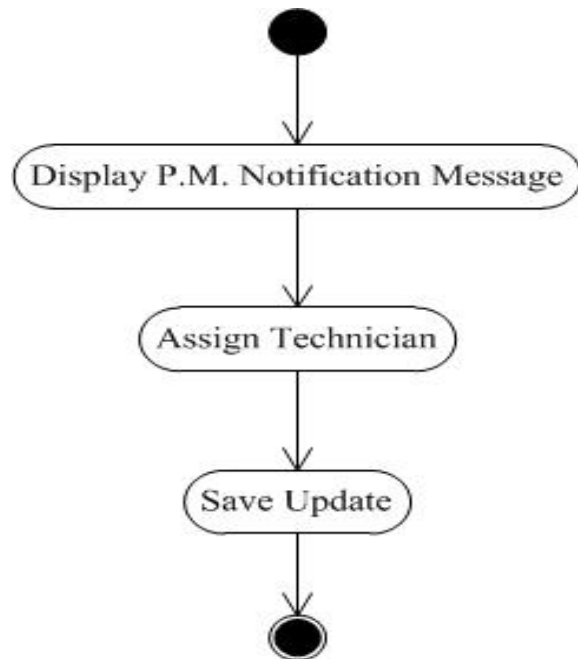


Figure 12: activity Diagram for Preventive Maintenance Notification Message

Use Case ID:	UC-05
Use Case Title	Produce preventive maintenance schedule.
Use case Description	This use case describes the process of producing electronic preventive maintenance schedule.
Primary Actor	The MEMIS
Trigger	When time is due for preventive maintenance.
Pre-Conditions	The frequency of preventive maintenance schedule of each equipment is recoded on the equipment database registration.
Post-Conditions	The information of preventive maintenance schedule will be displayed.
Main scenario	1. The system checks time of preventive maintenance of equipment from the system database; 2. The system displays preventive maintenance notification message;
Alternative scenario	
Frequency of Use	About 20 per month
Business Rule	

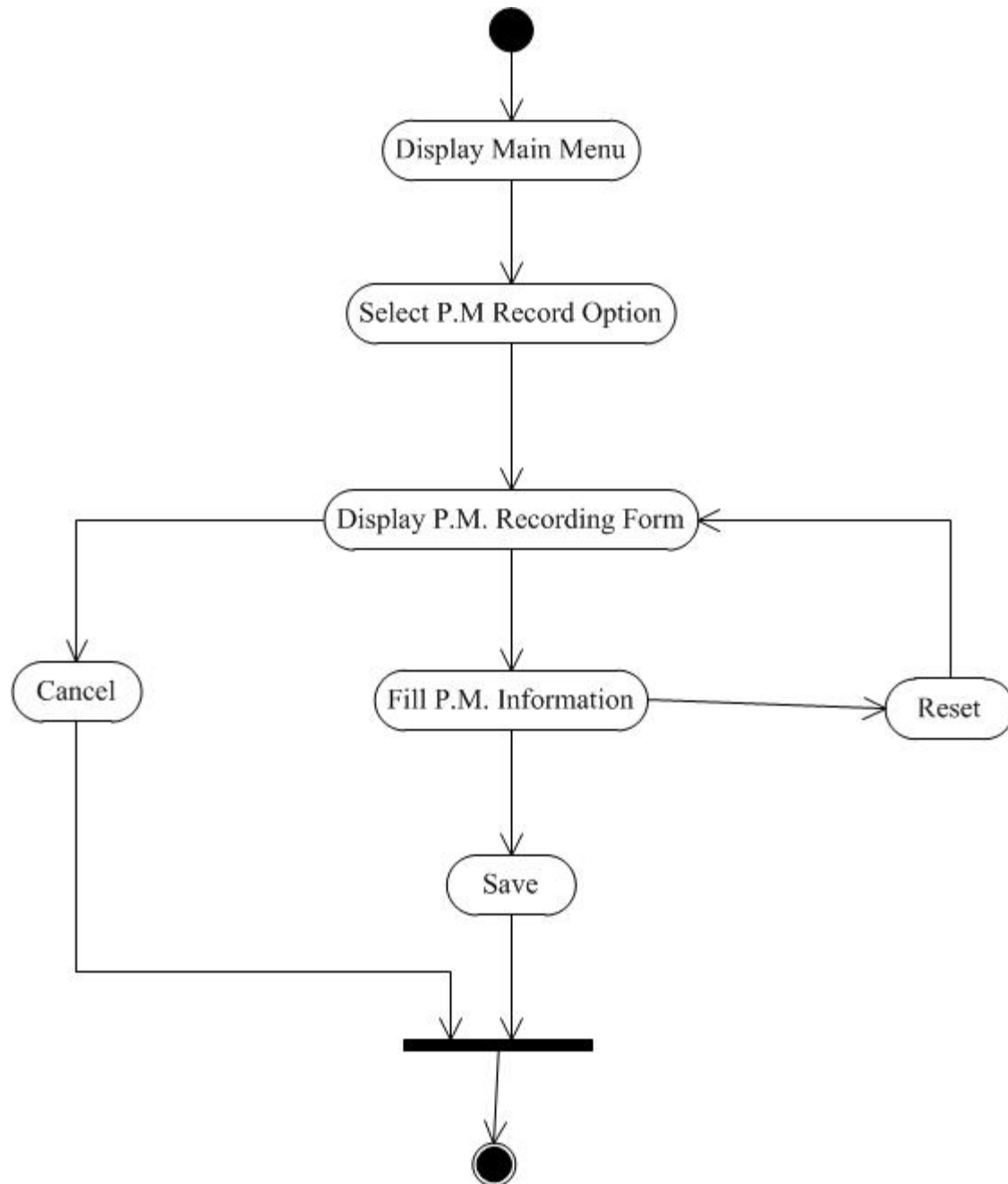


Figure 13: Activity Diagram for Preventive Maintenance Recording

Use Case ID:	UC-07
Use Case Title	Record preventive maintenance information
Use case Description	This use case describes the process of recording electronic preventive maintenance.
Primary Actor	Biomedical technician
Trigger	The technician attempts to record preventive Maintenance by selecting the preventive maintenance recording option from system main menu.
Pre-Conditions	The user is logged in to the system.
Post-Conditions	The preventive maintenance record is saved in the system database.
Main scenario	1. The user selects preventive maintenance recording form options; 2. The system displays preventive maintenance record form; 3. The user selects the equipment and fills the preventive maintenance form and clicks on save button; 4. The system saves the record in the preventive maintenance database;
Alternative scenario	3.1. If the user clicks on cancel button; 4.a. The system return to the main menu; 3.2. If the user clicks on reset button; 4.b. The system clear the input box;
Frequency of Use	About 20 per month
Business Rule	No

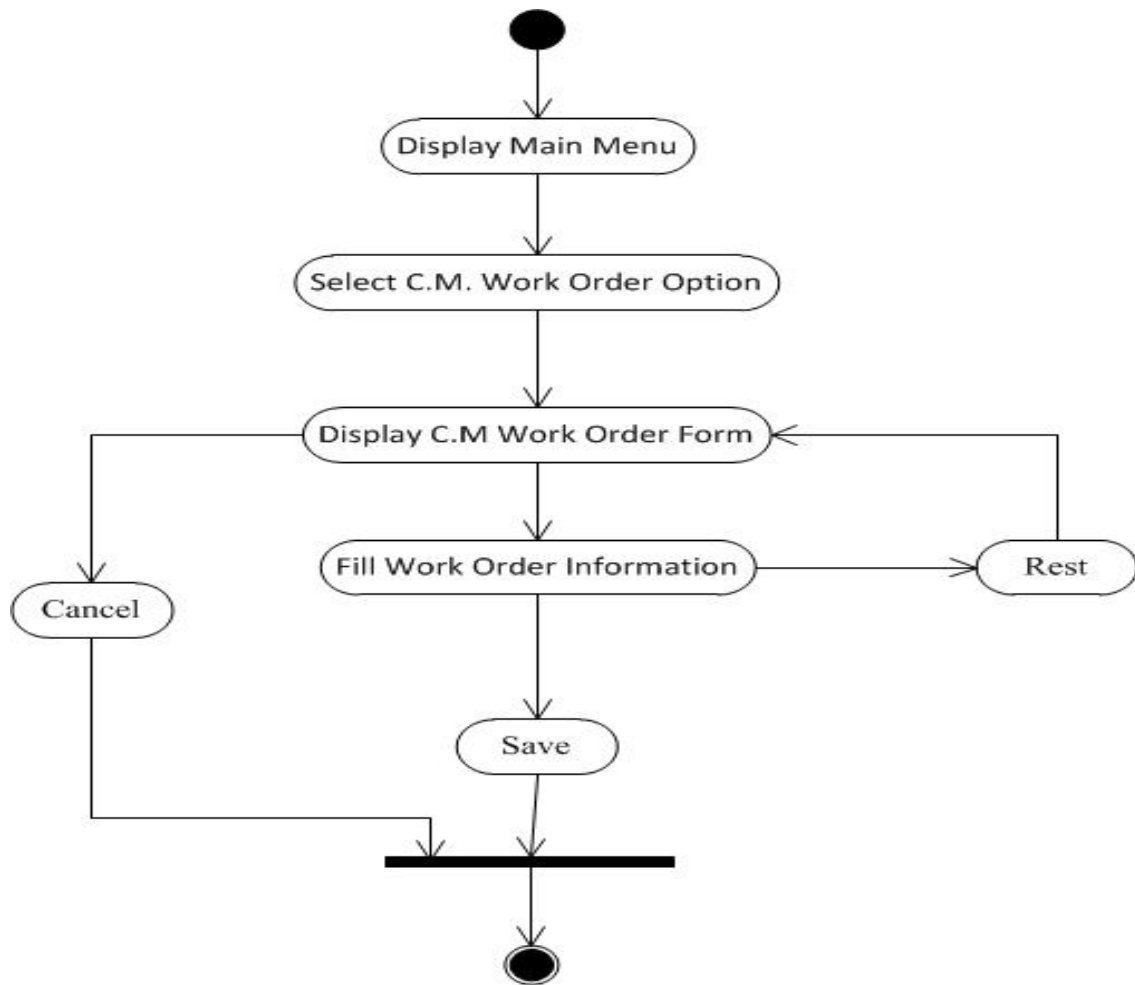


Figure 14: Activity Diagram for Corrective Maintenance Work Order

Use Case ID:	UC-08
Use Case Title	Complete corrective maintenance work order
Use case Description	This use case describes the process completing electronic corrective maintenance work order.
Primary Actor	Facilities focal person
Trigger	The focal person attempts to fill corrective maintenance request form by selecting the work order option from system main menu.
Pre-Conditions	The user is logged in to the system.
Post-Conditions	The corrective maintenance work order is recorded in the system database.
Main Scenario	1. The user selects corrective maintenance work order form(Figure4.24); 2. The system displays maintenance work order form; 3. The user fills the work order requests form and click on save button; 4. The system saves the work order in to the system database and display work order message;
Alternative scenario	3.1. If the user clicks on cancel button; 4.a. The system return to the main menu; 3.2. If the user clicks on reset button; 4.b. The system clear the input box;
Frequency of Use	30 per month
Business Rule	

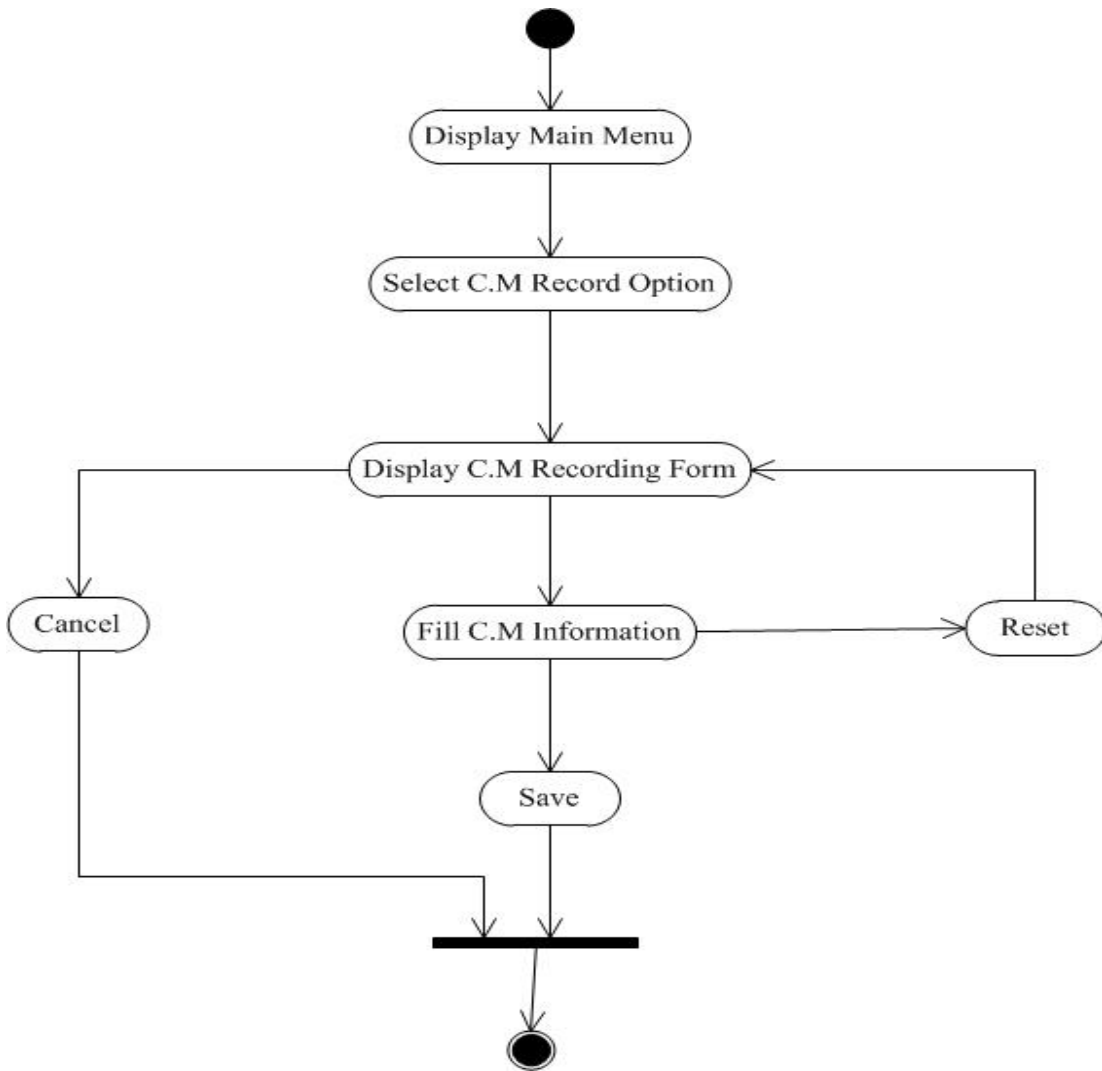


Figure 15: Activity Diagram for Corrective Maintenance information Recording Process

Use Case ID:	UC-09
Use Case Title	Record corrective maintenance information
Use case Description	This use case describes the process of recording electronic corrective maintenance.
Primary Actor	Biomedical Technician
Trigger	The biomedical technician attempts to record corrective maintenance by selecting the corrective maintenance recording option from system main menu.
Pre-Conditions	The user is logged in to the system .
Post-Conditions	The corrective maintenance record is saved in the system database.
Main Scenario	1. The user selects corrective maintenance recording form options; 2. The system displays corrective maintenance record form; 3. The user selects the equipment and fills the corrective maintenance form and clicks on save button; 4. The system saves the record in the corrective maintenance database; 5. The user click on print button; 6. The system print out the corrective maintenance recorded;
Alternative scenario	3.1. If the user clicks on cancel button; 4.a. The system return to the main menu; 3.2. If the user clicks on reset button; 4.b. The system clear the input box;
Frequency of Use	30 per month
Business Rule	

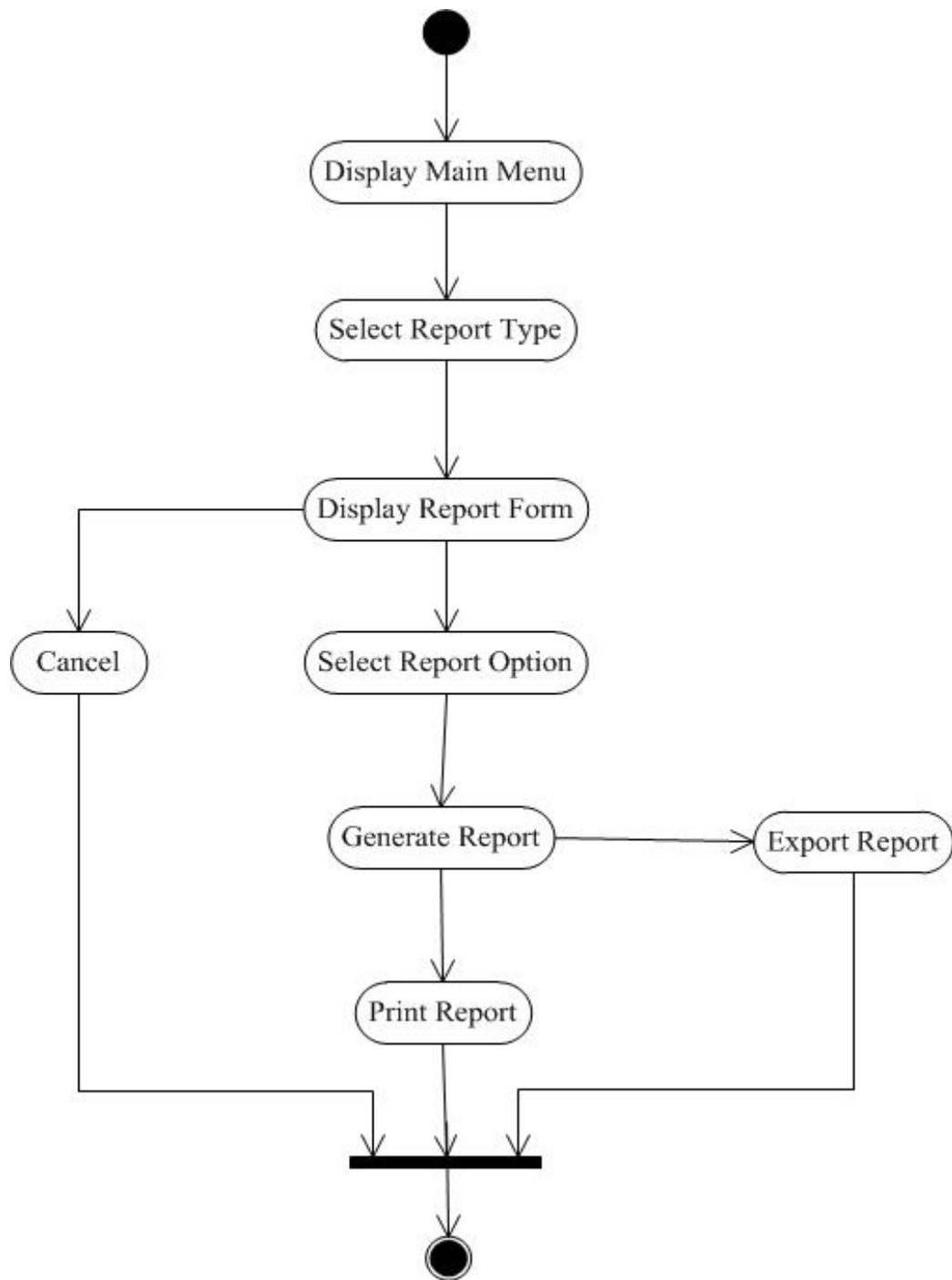


Figure 16: Activity Diagram for generating report

Use Case ID:	UC-10
Use Case Title	Generate standard report
Use case Description	This use case describes the process of producing an electronic standard report.
Primary Actor	Biomedical Department head, Facility focal person, Biomedical technician, Administrator
Trigger	The user attempts to generate report by selecting the report option from system main menu.
Pre-Conditions	The user is logged in to the system.
Post-Conditions	The system generate reports
Main Scenario	1. The user selects report menu; 2. The system displays report option for the user; 3. The user selects option of the report to be generated and clicks on generate button; 4. The system generates report from the database on the selected option;
Alternative scenario	3.1. If the user clicks on export button; 4.a. The system export the report; 3.2. If the user clicks on print button; 4.b. The system print out the report; 3.3. If the user clicks on cancel button; 4.c. The system return to the main menu;
Frequency of Use	Minimum 1 per month
Business Rule	

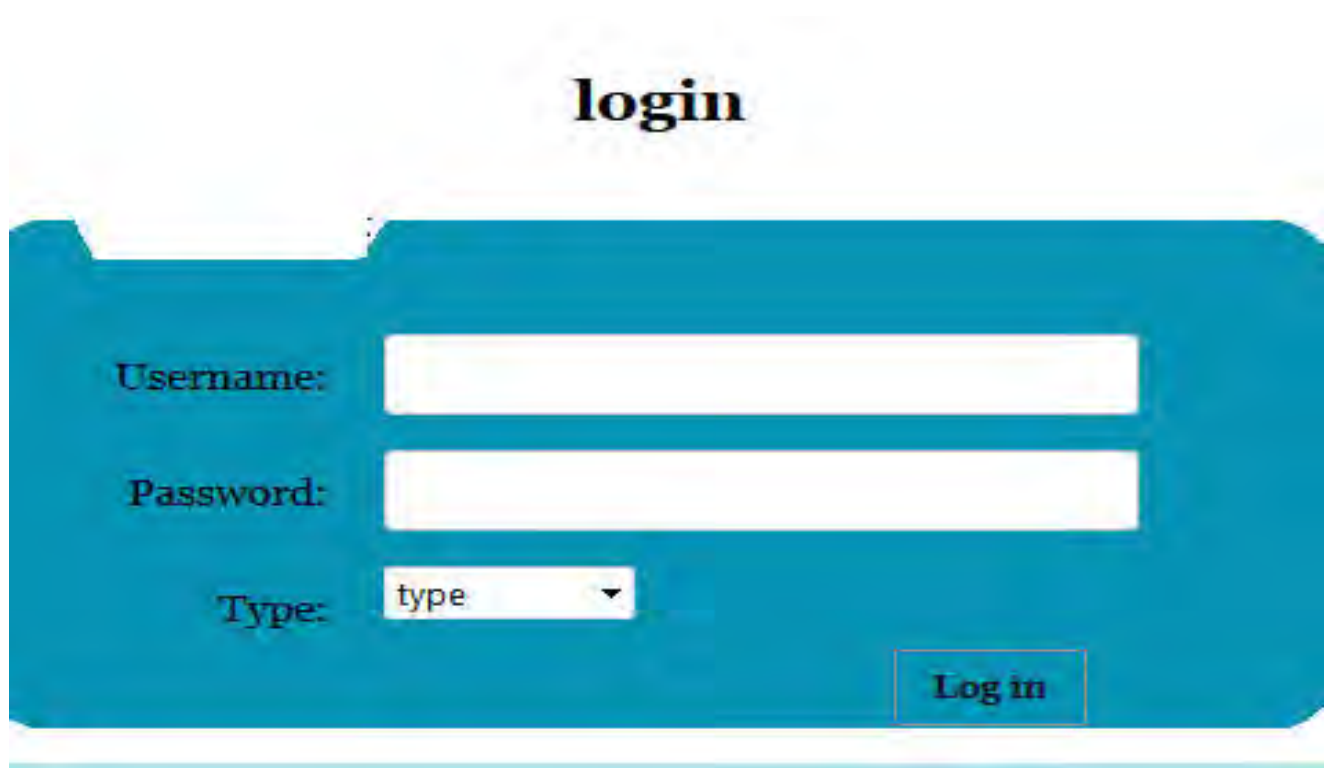
4.4.4. User Interface Prototype Presentation

User interface prototype is a model used to simulate the system user interface at an early stage of the system design. It can be developed using hand drawing or CASE tool like Visio. It helps to enable the end user to test the system at an early stage and identify the gaps in very low cost and time. It also helps to communicate ideas between designer, developer, users and stakeholders. The following user interface prototype is developed using Visio.

4.4.5. Usability Testing for User Interface

Table 4: User Interface Test Result

S.no	Test Questions	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
1	The interfaces are attractive			2	3	
2	I like the color of the interface				3	2
3	The font of the interface are Good				4	1
4	The sequence of the interface is clear			3	1	
5	All important content addressed well				2	3
6	There is too much inconsistency in the system interface			1		
7	I found the interfaces are very cumbersome to use		2	1		
8	The interfaces are easy to understand			1	4	
9	I need more time to learn it			2	3	
10	There is unnecessary content available in the interface		1			



The image shows a login interface with a light blue background. At the top center, the word "login" is displayed in a large, bold, black serif font. Below this, there is a dark blue rounded rectangular box containing the login form. Inside this box, the labels "Username:", "Password:", and "Type:" are in a black serif font. The "Username:" and "Password:" labels are followed by white rectangular input fields. The "Type:" label is followed by a white dropdown menu showing the word "type" and a small downward arrow. A red rectangular box highlights the "Log in" button, which is a dark blue rectangle with white text, located at the bottom right of the dark blue box. A thin light blue horizontal line is at the bottom of the page.

login

Username:

Password:

Type:

Log in

Figure 17: Login User Interface Design



[HOME](#)
[M.E Registry](#)
[S.P Registry](#)
[P.M Record](#)
[C.M Work worder](#)
[C.M Record](#)

[medical](#)
[sparepart](#)
[PMR](#)
[C.Mwork](#)
[C.Morder](#)
[Biomedical](#)
[Report](#)
[users](#)
[AboutUs](#)
[Logout](#)

Medical Equipment Registry

Equipment code:		Equivment Description	
Model:		Warranty Expiration:	
Date recieved:	Year Month Date	Consumable Requirment	
Serial no		P.M Schedule	
Manufacturer		Manufacturer Address:	
Supplier:		Supplier Address	
cost::		Status:	
Avialable::		Instalation Date:	Year Month Date
Expected life::		Equipment Risk Classification:	
Use of the Item:			

Figure18: medical equipment register User Interface Design



[HOME](#)
[M.E Registry](#)
[S.P Registry](#)
[P.M Record](#)
[C.M Work worder](#)
[C.M Record](#)
[General Report](#)

[medical](#)
[sparepart](#)
[PMR](#)
[C.Mwork](#)
[C.Morder](#)
[Biomedical](#)
[Request](#)
[users](#)
[AboutUs](#)

Spare Part Registry

Spare part code:		Location	
Spart Part Description::		Use for::	
Model:		Cost:	
Manufacturer		Manufacturer Address:	
Supplier:		Supplier Address	
Year Manufactured:	Year	Equipment Risk Classification:	

[Logout](#)

Figure19: Spare parts register User Interface Design



[HOME](#)
[M.E Registry](#)
[S.P Registry](#)
[PM Record](#)
[C.M Work worder](#)
[C.M Record](#)
[General Report](#)

[medical](#)
[sparepart](#)
[PMR](#)
[C.Mwork](#)
[C.Morder](#)
[Biomedical](#)
[Request](#)
[users](#)
[AboutUs](#)

Preventive Maintenance Record

Equipment code:

Date

Equipment Description:

Facility:

Assigned Technicial:

Priority of Task :

Preventive maintenace done

Cost:

Description:

Time Required to Prevent:

spare part replaced

Spare part code	descripton	cost	quality
1	item name	in birr	
2	item name	in birr	
3	item name	in birr	

ADD RECORD

Refresh

[Logout](#)

Figure 20: preventive Maintenance record User Interface Design



[medical](#)
[sparepart](#)
[PMR](#)
[C.Mwork](#)
[C.Morder](#)
[Biomedical](#)
[Request](#)
[users](#)
[AboutUs](#)

[HOME](#)

[M.E Registry](#)

[S.P Registry](#)

[P.M Record](#)

[C.M Work worder](#)

[C.M Record](#)

[General Report](#)

corrective Maintenace work Record

Equipment code:

Equipment Description: model:

faculty: Department :

priority of Task

work order no

problem

Description

Assign Techicial

[Logout](#)

Figure 21: corrective Maintenance work record User Interface Design



[HOME](#)
[M.E Registry](#)
[S.P Registry](#)
[P.M Record](#)
[C.M Work worder](#)
[C.M Record](#)
[General Report](#)

[medical](#)
[sparepart](#)
[PMR](#)
[C.Mwork](#)
[C.Morder](#)
[Biomedical](#)
[Request](#)
[users](#)
[AboutUs](#)

[corrective Maintenance Record](#)

Equipment code:
Equipment failure

Equipment Description:
part to maintain

Assigned Technicial:
Priority of Task :

corrective maintenace done
Department

problem

work order number:

spare part replaced

Spare part code	description	cost	quality
1	item name	in birr	
2	item name	in birr	
3	item name	in birr	

ADD RECORD
Refresh

[Logout](#)

Figure 22: Corrective Maintenance record User Interface Design



[medical](#)
[sparepart](#)
[PMR](#)
[C.Mwork](#)
[C.Morder](#)
[Biomedical](#)
[Request](#)
[users](#)
[AboutUs](#)

[HOME](#)
[M.E Registry](#)
[S.P Registry](#)
[P.M Record](#)
[C.M Work worder](#)
[C.M Record](#)
[General Report](#)

biomedical workshop

Department		Warranty/Services?	
Type of equipment		location	
Inventory		exact location	
Model:		Correctly working?	
Year of manufacture	Year ▼		
Country of origin			
Manufacturer:			
Main or accessory			

[Logout](#)

Figure 23: biomedical workshop User Interface Design

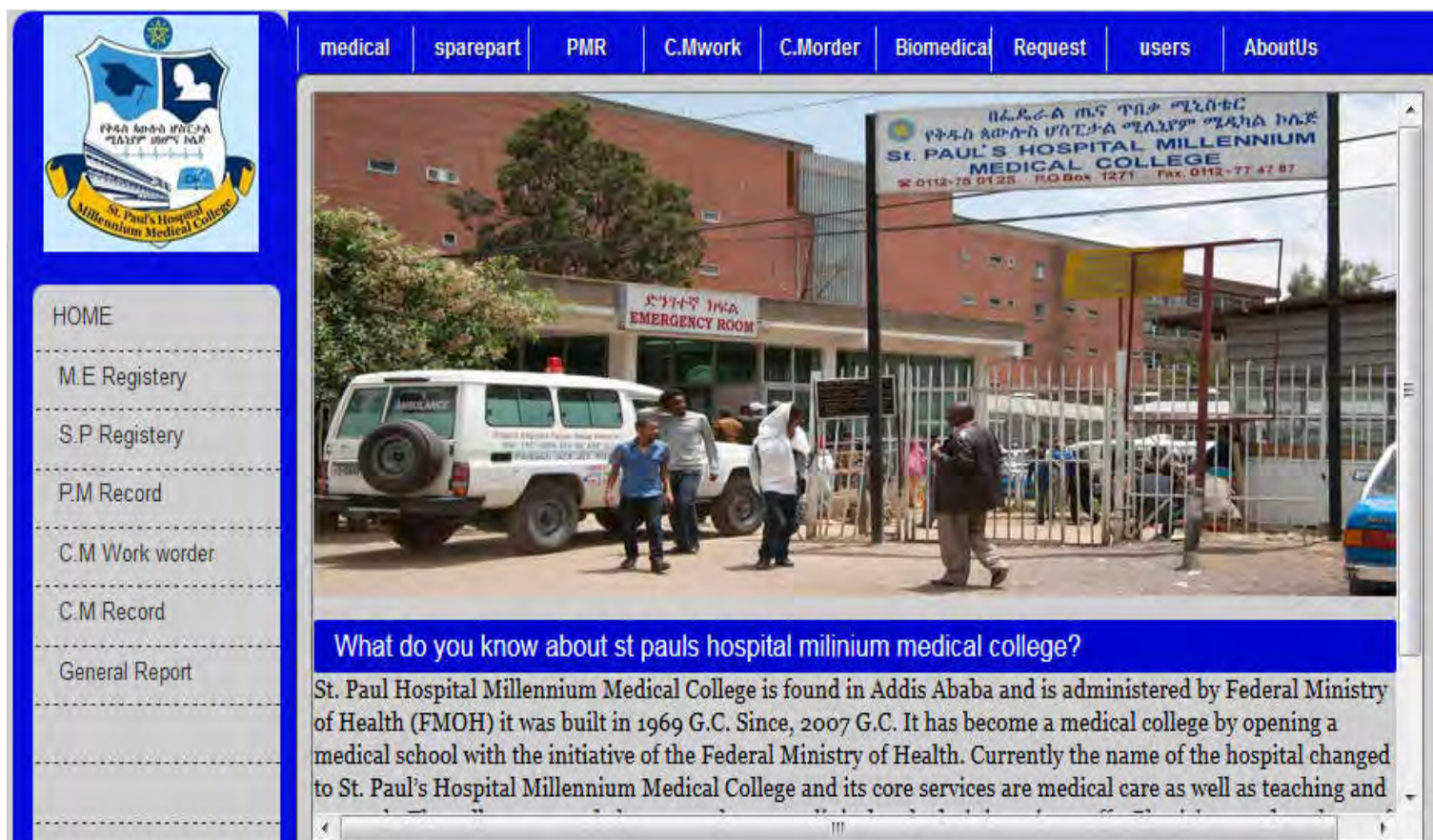


Figure 24: home page User Interface Design

Chapter five

5. Conclusions and Recommendations

5.1. Conclusions

MEMIS is a system that records all information about medical equipment available in the piloted city public health facilities. The information includes the life history of the medical equipment, preventive and corrective maintenance of the equipment, the cost for the maintenance and records for the spare part availability. The system supports follow up of performance of specific equipment and its lifetime cost. It also provides an information for planning and decision making in management.

This project represents the first step towards developing MEMIS. As it follows an iterative process, it shows, the first blueprint of the iteration that will be improved through the cyclic development process of the project until it satisfies the user of the system.

In the process of analysis and design of this system, the investigator recognizes that the boundary of the system somehow overlaps with the system of pharmacy store, which captures the information of medical equipment at initial. The existing system documentation is not well organized and complete, that makes the investigator depends on literature to design the system. A manual documentation system is used as the bases for implementing the proposed system. It is identified that the system may need additional human resource especially at the health facilities, who will be responsible in implementing the system. There are some opportunities identified like computer hardware and internet access at the central office and the piloted three facilities, though they need to be scaled up in capacity. In designing process, the security issues and hardware design were not well addressed by this project. The user interface of the system needs to be improved according to the test result identified.

Generally, this project does not show the final product of the system, rather provides system prototype for further continuous evaluation and development along with the user feedback input.

5.2 Recommendations

Saint .Paul Hospital

The hospital is recommended to initiate the revision of the pharmacy store computer system by;

- ✓ Reinforcing the supporting stakeholder to include medical equipment information into the system and
- ✓ Scale up the system to support the management of equipment performance after the installation.

The Hospital is recommended to strengthen the documentation system centrally and at the facility level by;

- ✓ Including all important information in the documentation and,
- ✓ Reinforcing the biomedical technicians to keep records of preventive and corrective maintenance, during receiving and handover of equipment, and spare part used for maintenance.
- ✓ The hospital should plan to assign one responsible person at the facility level to organize and manage medical equipment information.

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Annexes I

Requirements Collection Check List

I. Consent Form

ADDIS ABABA UNIVERSITY

School of information science And School of public health

MSC in health informatics program

Consent form

This Interview guide is for a Design and development of Web- Based Medical Equipment
Management Information System, For Saint .Paul Hospital

To the respondents:

The result of this interview will be utilized for project purpose only. It is hoped that the outcome of this study will contribute to the improvement of Medical Equipment Information System Management in Saint .Paul Hospital. Therefore, you are kindly requested to provide genuine response to the questions that follow.

Thank you in advance for your Cooperation”

Data Collection Tool

In Depth Interview Guide

Data and Process

1. How does the medical equipment inventory process look like?(generally)

2. How are medical equipment problems traced out?

3. How do you control the medical equipment inventory process?

4. How do you monitor equipment status? (life cycle cost, maintenance cost, equipment replacement)

5. How do you schedule preventive maintenance for the medical equipment? , how often?

6. How do work orders come to you from facilities for corrective maintenance?

7. Do you have record of corrective maintenance done previously?

8. Can you determine equipment failure trends? How?

9. Is there any problem on the existing medical equipment management system?

Report / Communication

10. How do you produce report? How often?

11. For whom do you submit the report?

12. How do you report?

13. Does the organization have communication infrastructure in the implementation of medical equipment management system? What does it seem?

People

14. How many personals (professionals) involved in the medical equipment management system? List all

15. How do you identify training needs for the professionals?

16. Is there any record related to professionals' performance in the case team?

Procedure (Management)

17. What is the organizational structure look like?

18. Who is responsible on what?

19. How do you plan for medical equipment procurement?

Computer Software

20. Is there any computer software in use for the existing system? What are they?

21. What are the functions of the software?

22. Does the organization have plan to automate the existing medical equipment management system?

23. Does the organization ready to support the development of medical equipment management information system for the biomedical case team? To what extent?

Computer Hardware

24. Is there any computer hardware being used in the existing medical equipment management information system? What are they?

25. Is the organization ready to fulfill suitable hardware infrastructure in the development of medical equipment management information system? To what extent?

1. Is there any recording process available for medical equipment?

2. What types of records are there?

3. What does each record include? (information included)

4. Is there any structured inventory record format?

5. What information does it include?

6. Are the records complete?

7. What is the mostly missed part in the record? Why?

8. Is there problem with the existing reporting format? What is that?

9. Who are the users of the formats?

10. Is there a separate record for spare parts?

11. What information does it include?

Annex II

User interface Usability Testing Checklist

1. The interfaces are attractive

1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐

Strongly Disagree

Strongly Agree

2. I like the color of the interface.

1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐

Strongly Disagree

Strongly Agree

3. The font of the interface are good.

1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐

Strongly Disagree

Strongly Agree

4. The sequence of the interface is clear.

1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐

Strongly Disagree

Strongly Agree

5. All important content addressed well.

1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐

Strongly Disagree

Strongly Agree.

6. There is too much inconsistency in the system interface.

1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐

Strongly Disagree

Strongly Agree.

7. I found the interfaces are very cumbersome to use.

1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐

Strongly Disagree

Strongly Agree.

8. The interfaces are easy to understand.

1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐

Strongly Disagree

Strongly Agree.

9. I need more time to learn it.

1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐

Strongly Disagree

Strongly Agree.

10. There is unnecessary content available in the interface.

1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐

Strongly Disagree

Strongly Agree

Declaration

I declare that this project is my original work and has not been presented for a degree in any other university, any that all sources of materials used for the project have been acknowledged.

Getaneh Tilahun

June, 2016

Place: AAU, Graduate studies School of Public Health and Information Science

Date of Submission: July 05, 2016

This project has been submitted for examination with our approval as the university advisors.

Name of the Advisors:

1) **Dr. Dereje Teferi** _____

2) **Dr. Mesfin Addisse** _____