Sudan University of Science and Technology

College of Graduate Studies

Biomedical Engineering Department

Design of a Computerized Inventory and Maintenance Management System for Stack Laboratory

تصميم نظام حاسوبي لإدارة الجرد والصيانة بمعمل إستاك

A project Submitted in Partial Fulfillment for the Requirements of the Degree of M.Sc.in Biomedical Engineering

Prepared By:

Mihad Muddathir Eltayeb

Supervised by:

Dr. Zeinab Adam Mustafa

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الآية

قَالَ تَعَالَىٰ:

بسم الله الرحمن الرحيم

﴿ ٱقۡرَأۡ بِٱسۡمِ رَبِّكَ ٱلَّذِي خَلَقَ ١ خَلَقَ ٱلۡإِنسَٰنَ مِنۡ عَلَقٍ ٢ ٱقۡرَأۡ وَرَبُّكَ ٱلۡأَكۡرَمُ ٣ ٱلَّذِي عَلَّمَ بِٱلۡقَلَمِ ٤ عَلَّمَ ٱلۡإِنسَٰنَ مَا لَمۡ يَعۡلَمۡ ٥ ﴾

سورة العلق الآيات [1-5]

DEDICATION

I dedicate this study to my great Family and my Friends who supported me

I'm highly appreciate their efforts and energies they spent to rise and improve my skills and capabilities.

Thanks

ACKNOWLEDGEMENTS

My grateful thanks to ALLAH for guide and help me, and

I would like thank my supervisor Dr. Zeinab who guided me throughout this project, and I would like to express my gratitude to my family and my friends for their continued support and be beside me.

I would like to express my sincere gratitude to my coworkers in NPHL who supported and helped me

ABSTRACT

Hospitals, clinics and healthcare units depend on medical devices & equipment as an essential element to obtain the good performance, reduce staff and patients' risk, enhance patients care and quality of health services. The medical engineering department (MED) is responsible for all medical equipment; CIMMS is a software tool developed and used to assist medical engineer for managing and to reduce the problems of the traditional paper-based system. Equipment management is one of the essential elements of a quality management system. The improve of equipment management program (EMP) depends of three factors: Inventory documents, maintenance schedule and computerized program. The purpose of this project was to design and implement a Computerized Inventory and Maintenance Management System, CIMMS is designed to assist engineers in the medical engineering department in stack laboratory, and the result showed that user interface forms are easy to use and improve the efficiency of inventory and maintenance management of medical devices in the laboratory.

المستخلص

تعتمد المستشفيات والعيادات ووحدات الرعاية الصحية على الأجهزة والمعدات الطبية كعنصر أساسي لتحقيق الأداء المطلوب وتقليل الخطر على العاملين والمرضى وتحسين جودة رعاية المرضي والخدمات الصحية، ويعتبر قسم الهندسة الطبية هو المسؤول عن جميع الأجهزة والمعدات الطبية داخل هذه الوحدات وتم تصميم نظام الإدارة المحوسب لمساعدة المهندس الطبي في الإدارة وتقليل مشاكل نظام الإدارة التقليدي (الورقي)، كما تعتبر إدارة الأجهزة أحد اهم عناصر إدارة الجودة وتعتمد على ثلاث عوامل: الجرد وجدول الصيانة والبرنامج المحوسب والغرض من هذا البحث هو تصميم وتنفيذ نظام بالحاسوب لإدارة الجرد والصيانة، و قد تم تصميم النظام المحوسب لمساعدة المهندسين بقسم الهندسة الطبية بالمعمل القومي للصحة العامة(استاك) و أظهرت النتائج واجهة مستخدم سهلة الاستخدام و تحسن من كفاءة إدارة الجرد و الصيانة للأجهزة الطبية بالمعمل.

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ABBREVIATIONS

CMMS: Computerized Maintenance Management Systems.

PM: Preventive Maintenance.

MED: Medical engineering department

EMP: equipment management program

EM: equipment maintenance

DT: Down Time.

MC: Maintenance Cost.

CM: Corrective Maintenance.

SM: Scheduled Maintenance.

RCM: Reliability Centered Maintenance.

MEMP: Medical Equipment Management Program

WHO: World Health Organization

GUI: graphical user interface

NPHL: National Public Health Laboratory

AEM: Alternative Equipment Maintenance

CHAPTER ONE

INTRODUCTION

1.1 Introduction:

Medical devices and equipment are a significant, essential, and irreplaceable component in Medical and healthcare units. to support and enhance patients care and quality of health services. These medical devices must be kept in safe condition in order to prevent injuries in patients and staff [1].

Medical engineering department (MED) is responsible for all medical equipment in hospital and healthcare unit, the operation activities of these equipments: (purchase, installation, repair, corrective maintenance, and preventive maintenance, warranty assurance to promote the operating performance)[2]; to manage and facilitate the program to accomplish that; Promote safe and effective use of medical equipment by staff and physicians ,ensure that medical equipment used is performs within standards and is maintained within specifications. [3]

To reduce patient and practitioner safety and liability risks associated with medical devices and equipment, medical and healthcare organizations should have effective programs for managing equipment used in patient care, Considerations when developing an equipment management program include inventory management and documentation; evaluation of equipment; testing; maintenance and usage; and education and training [4]

Traditional paper-base management system depends on manual process that takes a long time to arrange items or to search about specific information about a certain item; it seems as time -consuming when the realization of many tasks is concerned, also paper system must require vest amounts of paper to handle with, less efficiency and takes massive space indeed to arrange and storage all that huge pile of papers.

Furthermore; it is difficult to manage medical equipment (ME) in medical and healthcare organizations and units with traditional system, and need to replace with computerized-based system that supports software program for managing.

1.2 Problem Statement:

Traditional paper-base management system depends on manual process; Relying on physical paper documents has drawbacks**:** Time Consuming**,** editing problems**,** piled up Paperwork and Lost Files, and storing paper records takes up space**.** Paper based system has high cost of: paper, printer, ink, and stationery. And low Security; It's impossible to know who accessed a paper file and when.

1.3 Objectives:

1.3.1 General Objectives:

The general objective of the research is to design computerized management system for inventory and preventive maintenance for medical equipment.

1.3.2 Specific Objectives:

- To maintain a high level of equipments performance.
- Promote safe and effective use of medical equipment by staff.
- Scheduled maintenance to lengthen instrument life and reduce the cost of repair and maintenance and
- To reduce service interruptions; that can occur due to malfunctions and failures.

1.4 Research Layout:

Chapter One: introduction of Management System, problem statement, objectives to be achieved and layout of research

Chapter Two: Theoretical background of maintenance and management system

Chapter Three: literature review of traditional management system.

Chapter Four: Determine methodology that follow to design software program.

Chapter Five: Show the Results and Discussions.

Chapter Six: conclusion and Recommendation.

CHAPTER TWO

THEORETICAL BACKGROUND

2.1 Equipment management:

Equipment management is one of the essential elements of a quality management system. Proper management of the equipment is necessary to ensure accurate, reliable, and timely testing.

The benefits of a good equipment management program are many:

1. Helps to maintain a high level of performance.
2. Reduces variation in test results, and improves the technologist's confidence in the accuracy of testing results.
3. Lengthens instrument life.
4. Reduces interruption of services due to breakdowns and failures.
5. Increases safety for workers.
6. Produces greater customer satisfaction. [5]

A good equipment management program provides evolve bridge between system and user that results in problems reduction and solution for paper-based system in productive way, and secure a high level of performance and maintain great confidence in the reliability of results and patient care.

An effective management program is designed to minimize downtime, maintain equipment in good operational state, and increasing the quality of health services and patient care.

2.2 Maintenance Management Program:

1.maintenance strategies:

Maintenance is defined as a combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function. The standard divides maintenance types into two major categories: preventive maintenance and corrective maintenance. Preventive maintenance is further divided into condition-based maintenance and predetermined maintenance.

Corrective maintenance is carried out reactively after a fault has been recognized. It aims to restore the equipment to perform a required function.

Preventive maintenance is performed proactively before the equipment fails. It intends to reduce the probability of failure or degradation of the functioning of an item. Preventive maintenance is scheduled: Predetermined maintenance is based on a maintenance program based on established intervals of time or units of use but without considering the actual condition of the equipment, Condition based maintenance tries to predict failure. It is based on regular monitoring of the condition [6]

These maintenance strategies assess or improve maintenance, quality and performance. Healthcare units should be considering their capability and situation to apply best maintenance systems for the large number of different medical devices in the equipment management processes [7].

It is important to have a well-planned and managed maintenance programme that is able to keep the medical equipment in a health-care institution is critical to improve the reliability of medical equipment and significantly improve safety and cost-efficiency [8]. In addition, the Maintenance managers should ensure that the equipment are safe to use and complies with all required standards, specified performance criteria and should not be damaged [9].

2. Implementing an Equipment Maintenance Program:

Preventive maintenance includes measures such as systematic and routine cleaning, adjustment, and replacement of equipment parts at scheduled intervals. Manufacturers generally recommend a set of equipment maintenance tasks that should be performed at regular intervals: daily, weekly, monthly, or yearly. Following these recommendations will ensure that the equipment performs at maximum efficiency and will increase the lifespan of the equipment. This will also help to prevent:

• inaccurate test results due to equipment failure

• delays in reporting results

• lower productivity

• large repair costs.

3. Maintenance plan:

A maintenance plan will include preventive maintenance procedures as well as provision for inventory, troubleshooting, and repair of equipment. When implementing an equipment maintenance program, some of the initial steps will include what follows.

• Assign responsibility for providing oversight.

• Develop written policies and procedures for maintaining equipment, including routine maintenance plans for each piece of equipment. The plan should specify the frequency with which all maintenance tasks should be performed.

• Develop the format for records, create logs and forms, and establish the processes to maintain records.

• Train staff on the use and maintenance of the equipment, and assure that all staff understand their specific responsibilities. It is recommended that a label be attached to the instrument indicating when the next maintenance or service should be performed.[5]

4. Maintenance Objectives:

Maintenance in any activity is designed to keep the resources in good working condition or restore them to operating status.

The objectives of plant maintenance are:

1. To increase functional reliability of production facilities.

2. To enable product or service quality to be achieved through correctly adjusted, serviced and operated equipment.

3. To maximize the useful life of the equipment.

4. To minimize the total production or operating costs directly attributed to equipment service and repair.

5. To minimize the frequency of interruptions to production by reducing breakdowns.

6. To maximize the production capacity from the given equipment resources.

7. To enhance the safety of manpower. [10]

2.3 Traditional paper-base management system:

Traditional paper-base management system depends on manual process; it is traditional and primary method of storing records and other documents. Usually, it includes the processes of maintaining and storing hard-copy documents. [11] Relying on physical paper has drawbacks:

Lack of storage space

Paper documents can take up a significant amount of space, and the quantity of paper will increase day by day. Furthermore, documents will typically need to be stored close to hand so that they can be accessed as quickly as possible.

Security issues

Regardless of size, for any organization is important to protect its data and other valuable assets. One of the biggest information security risks for businesses is paper because printed documents can be easily lost, mishandled or damaged while digital data could be encrypted and safely keep in hard disks or electronic devices.

Prone to damage

Manual documents can be easily damaged, lost, misplaced or stolen. A fire or natural disaster could mean the loss of essential information. If you don't have any copies, once the files are gone, there is no way of getting the information back.

Document transportation

Transporting documents in a paper-based system is quite complicated, slow and inefficient. With a digital document management system in place, you can simply add attachments to an email and send information instantly.

Editing problems

If you want to make changes to a paper-based document, you will need to write all the content again. This will need to be repeated every time you want to make more corrections. You should make a copy of the original document to distinguish all the amendments that have be done.

High costs

One of the biggest drawbacks of paper-based document management systems is the associated costs. In addition to tones of paper, you will need more printers, photocopier, stationery and other office supplies. These costs add up and can become a significant expense in many organizations.

Limit communication and collaboration

When working with paper documents, collaboration is extremely difficult. If several department heads need to create a common document, they must have multiple copies printed, make all the necessary amendments separately and then share their version with each other before start working on the ultimate version. Digital document management systems allow users to collaborate in a way that is easily and fast. They can also track all the changes made.

Environmental damage

Using more paper is bad for the environment and won't help much to boost your company's green credentials. Many of today's employees want to work for businesses that prioritize sustainability and many consumers also prefer environmentally friendly alternatives so you do your best to attract and retain them. [12]

2.4 Computerized-base Management System:

computerized-based management system is a software tool develop and used to assist engineer for managing all medical devices and equipment that handle with, Computerized maintenance management system (CMMS), is a software package that maintains a computer database of information about an organization's maintenance operations. [13]. via user interface that view equipment information's, current situation, historical information and operational activates for each one, The MED should identify and select the devices to be included in the inventory, and which of those to include in the maintenance program.

There are three major factors have to develop to aid engineer for create and improve equipment management program (EMP). the factors are: Inventory documents, maintenance schedule and computerized program [14];

The inventory document it serves as an important and powerful tool to improve management and maintenance system; it is a working document that is regularly checked and updated to determine what items are to be managed.[6]

Maintenance schedule is a scheduled process for Maintenance's activity that required to assure all medical devices and equipment are kept in perfect working conditions and safe reliable performance of medical equipment in a timely manner.

So, inventory and scheduled maintenance may be integrated into a Computerized Inventory & Maintenance Management System (CIMMS)

The computerized management system reduces the problems of the traditional system; that maintains a computer database of information about all medical devices and equipment in units and maintenance operations schedules, and provides user interface that easy-to-use for managing all.

System also allows for record keeping may help MED to make decisions and helps engineers do their jobs more effectively. Manually this requires a tremendous amount of effort and time.

2.5 Inventory and Documentation:

A first step in designing an effective equipment management program is documenting what equipment you have. Each healthcare organization should: • Maintain an inventory of all medical equipment, whether it is leased or owned and whether it is maintained according to manufacturer recommendations or an alternative equipment maintenance (AEM) program.

• Include as part of the inventory a record of maintenance activities.

• Ensure that equipment managed through an AEM program is clearly identifiable as subject to AEM. Further, critical equipment, whether subject to AEM or not, must be readily identified as such

ISO 15189:

Is an international standard that specifies the quality management system requirements and competence particular to medical laboratories. The standard was developed by the International Organization for Standardization's Technical Committee 212 (ISO/TC 212)

According to Stepwise implementation of a quality management system for a health laboratory it states the following; "The laboratory should be furnished with all equipment needed for the provision of services.

The laboratory should verify upon installation and before use that the equipment is capable of achieving the necessary performance and that it complies with requirements relevant to any examinations concerned.

Equipment should be operated at all times by trained and authorized personnel.

Current instructions on the use, safety and maintenance of equipment, including any relevant manuals and directions for use provided by the manufacturer of the equipment, should be readily available.

Each item of equipment should be uniquely labelled or otherwise identified.

Records should be maintained for each item of equipment that contributes to the performance of examinations. These equipment records should include at least the following:

- identity of the equipment;
- manufacturer's name, type identification, and serial number or other unique identification;
- contact information for the supplier or the manufacturer and on-call service;
- date of receiving and date of entering into service;
- location;
- condition when received (e.g., new, used or reconditioned);

- manufacturer’s instructions;
- records that confirmed the equipment’s initial acceptability for use when equipment is incorporated in the laboratory;
- maintenance carried out and the schedule for preventive maintenance;
- equipment performance records that confirm the equipment’s ongoing acceptability for use (such as periodic calibration, verification, and quality control records); and
- Damage to, or malfunction, modification or repair of the equipment.[15]

2.6 National Public Health Laboratory (Stack):

All laboratories should have a well-organized equipment management program. The program should address equipment selection, preventive maintenance, and procedures for troubleshooting and repair. It is essential that good documents and records be maintained. These will include a complete and accurate inventory of all laboratory equipment, documents provided by the manufacturer on operation, maintenance, and troubleshooting, and records of all preventive maintenance and repair activities.

• A good equipment maintenance program results in a high level of performance and greater confidence in the reliability of results.

• A significant benefit to the laboratory will be fewer interruptions in test performance, lower repair costs, and elimination of premature replacement of equipment.

• Increased safety for laboratory workers will result from well-maintained equipment.[5]

National Public Health Laboratory (NPHL) or stack laboratory contains 20 specialized departments are: Chemical lab, Epi-bacteriology, Polio lab, Tb, Epi-virology, Molecular bio lab, Immunology, bacteriology, Virology, Medical entomology, Sterilization, Media & stain, Parasitology, Onchocerca, Clinical chemistry, Hematology, Regular lab for quality, Food & Water, Toxicology and Histopathology, with a lot of specialized and assistance devices and equipment in each department; more than 750, so to create a program to manage this huge number of devices and equipment, need to use national standards to ensure the success of an inventory process; Make full information inventory for all devices and equipment in (NPHL) by using inventory form according to ISO 15189.

CHAPTER THREE

LITERATURE REVIEW

In this section, the previous similar projects which are to develop computerized Management System software will be discussed; to determine the software development tool used and technology used to create the software in the previous projects.

as previous studies are similar in their objective, as they helped in developing programs for managing and operating medical devices in medical and healthcare units and institutions.

Study 1: "Design of Computerized Maintenance Management System for the Chilean Naval Hospital Biomedical Engineering Department" 2005

In this study: Francisco J. Acevedo, Jose E. Fuentes and John D. Enderle designed computerized equipment management system;

The purpose of this project was to design and implement a Computerized Maintenance Management System (CMMS), and follow the Generic Clinical Engineering Maintenance Management System suggested by Association for the Advancement of Medical Instrumentation (AAMI). This system has run in the Chilean Naval Hospital Biomedical Engineering Department**Study 2: "A framework of medical equipment management system for in-house clinical engineering department" 2010**

In this study; Chia-Hung Chien and Y. J. Huang designed computerized equipment management system, it efficiently improved the operation management of medical devices immediately and continuously. This system has run in the National Taiwan University Hospital.

Study 3: "Developing an In-house Computerized Maintenance Management System for Hospitals" 2012

In this study: David Mutia, John Kihiu and Stephen Maranga developed system to enable the existing facility maintenance managers in major hospitals in Kenya to improve on their maintenance management of medical equipment, the equipment is initially identified in its category by the program and guides the user to identify the causes of the medical equipment faults.

The system would enable the hospitals achieve optimum utilization of hospital equipment and improve the management of medical equipment through a proper time management.

Study 4: "Up to Date Inventory System for Effective Management of Healthcare Technology: Case Study in Jimma University Specialized Hospital (JUSH)" 2012

In this study: Hundessa Daba, Mohammed Aliy and. T. Bheema Lingaiah developed up to date inventory system, The objective of this project is to replace manual inventory in different hospitals by taking Jimma University specialized hospital (JUSH) as a reference.

Study 5: "Computerized Preventive Maintenance Management System (CPMMS) for Haematology Department Equipments" 2012

In this study: Hosam H. Osman, Mawia A. Hassan, Nihal M. Elhady and Reem M. Elrasheed designed computerized equipment management system; The software has three main parts: data entry, reports and log book. Data entry to tables, Several reports are available to schedule the risk-based management of the equipment, The log book can be used to pre-process physical and financial details of the maintained device.

Study 6: "**Using Computerized Maintenance Management System (CMMS) in Healthcare Equipments Maintenance Operations" 2020**

paper aims to use CMMS in maintenance operations of equipments in healthcare sector, The second thing is to use Equipment maintenance (EM) number in classifying such devices to be ready for using CMMS.

In this study: Hesham Almomani

CMMS will manage the maintenance operations; first step determines the devices included in inspection and maintenance operations by using EM number, then specifying the maintenance period and inspection frequency after that following some specific steps to manage the maintenance operations followed by CMMS programs.

All these previous projects are similar in their purpose, is to design and implement a computerized maintenance management system or inventory management system, when the purpose of this project to design and implement a computerized inventory and maintenance management system.

About the methodology that was followed in previous projects, it differs over the years in database, system, programming language and applications:

In Study 1: They used Microsoft Visual Basic to display the visual interfaces, and Microsoft Access as a supporting database.

In Study 2: used the Visual studio C# and the web server of CED by the FrontPage and Dreamweaver, about the database tools, the Microsoft SQL server was adopted for local database of CED, and Oracle Database was used for HIS

In Study 3: The program was designed by C++ programming to flow maintenance management.

In Study 4: the system was designed using XAMPP open source software for database section and HTML and PHP for web template section by implementing web-based inventory system.

In Study 5: used Microsoft Access database and the graphical user interface (GUI).

In Study 6: Used HTM framework.

In this project and according to methodology of previous studies; CIMMS designed in two phases: back-end and front-end; use SQL server as database and Microsoft Visual Basic to display the visual interfaces.

CHAPTER FOUR

METHODOLOGY

In this chapter, the software development tool that used to develop the inventory and maintenance management System will be discussed, and the method used to create and design the software program will be explained in details with figures and flow charts.

System is a software program has two tools; will use first is front-end (VISUAL BASIC) and second is back-end (SQL Server); to develop software program that use as managing system for equipment.

IMPLEMENTATION:

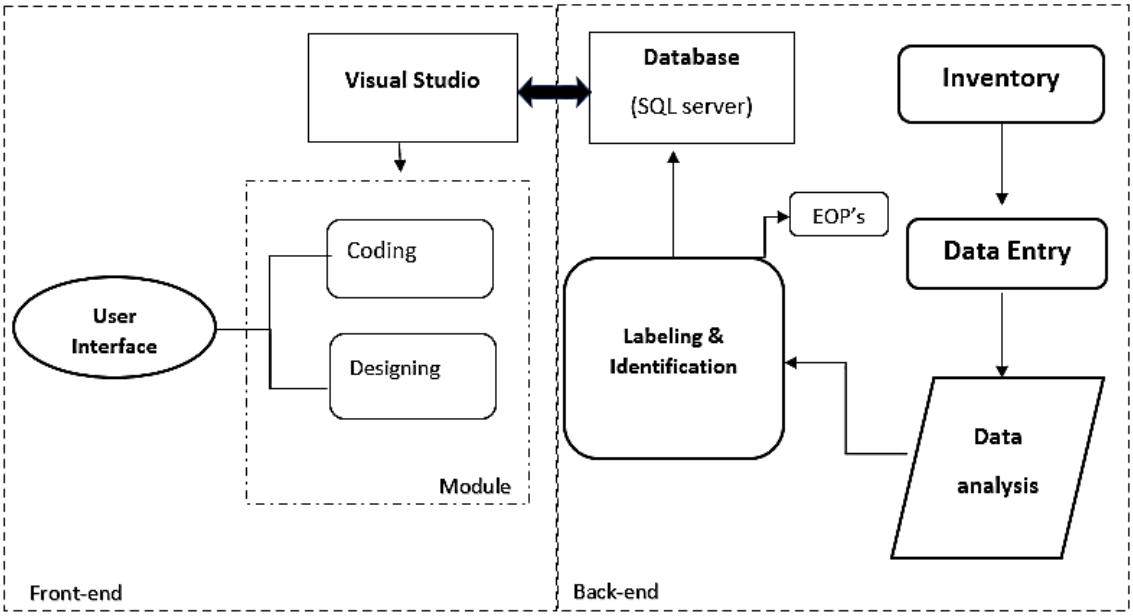


Fig. 4. 1: implementation flow chart

4.1. SQL Server (back-end):

SQL Server Management Studio (SSMS) V.15 is used as a GUI tool used to store and manipulate large amount of information that runs as a server. to build up the software of management system.[16]

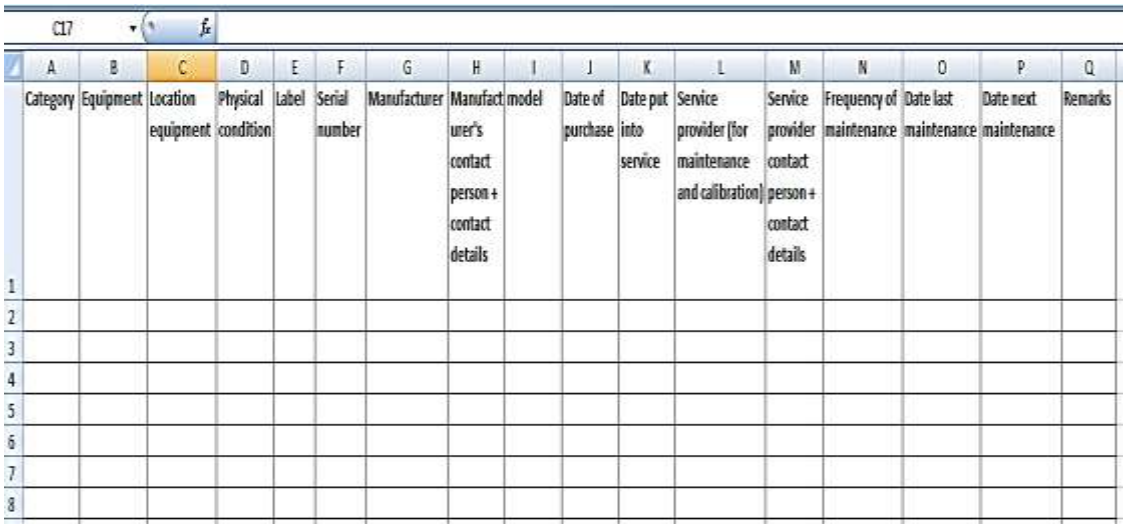
*Method has been used to create database will be explained in details:

1. Inventory:

The important essential step to implement a CIMMS is to have a complete and accurate inventory of all equipment to be managed, to create a program that provides a good guidance and tools for managing medical equipment; includes specialized and assistance equipment in all departments of the laboratory.

ISO15189 provides specific form (excel sheet form) to make sure that inventory is includes all necessary information that engineers need to manage all equipment.

Table 4. 1: inventory form



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Category	Equipment	Location equipment	Physical condition	Label	Serial number	Manufacturer	Manufacturer's contact person + contact details	model	Date of purchase	Date put into service	Service provider (for maintenance and calibration)	Service provider contact person + contact details	Frequency of maintenance	Date last maintenance	Date next maintenance	Remarks
2																	
3																	
4																	
5																	
6																	
7																	
8																	

2. Data Entry:

ISO inventory form used to make a complete and accurate inventory process for all medical devices and equipment in all specialize departments of NPHL and got inventory forms for all, to enter data and make excel sheet used for analyze collected data.

3. Data Analysis:

Collected data include a huge amount of equipment with a different operational statement need to analyze and sorting according to physical condition of all:

-Function: Equipments are in a peak performance operational statement.

-Un-function: Equipments are out of operational statement (in short term) due to technical failure; require spare parts and maintenance to return back into services with high performance as quick as possible.

-Out of services: Equipments are out of operational statement (in long term) due to Lifetime of the equipment, high cost of maintenance, or unavailability of solutions and reagents.

-excel tools are been used for statistical analysis for collected data:

Table 4. 2: analysis of collected data

	A	B	C	D
1		Physical Condition Of Equipments		
2	Function	570		
3	Unfuction	137		
4	Out Of Servi	17		
5				
6				

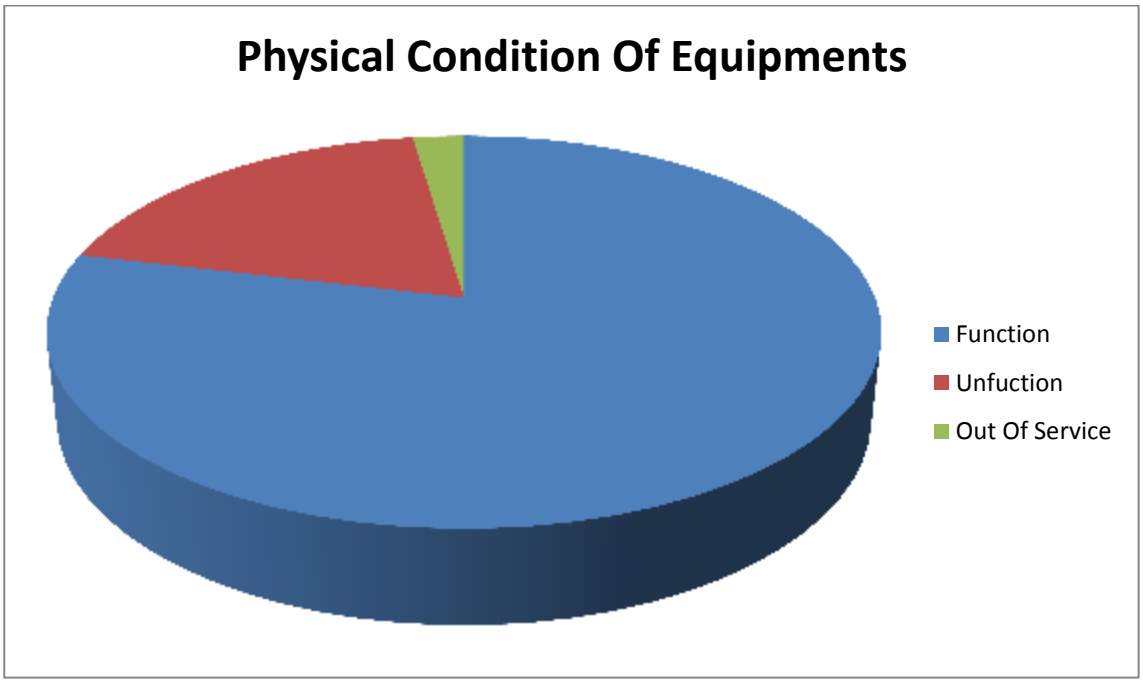


Fig. 4. 2: analytical chart of collected data

-Notice that equipment in function condition about 78% of all, equipment are in un-function condition about 18% and those are out of services are not exceed 0.02%

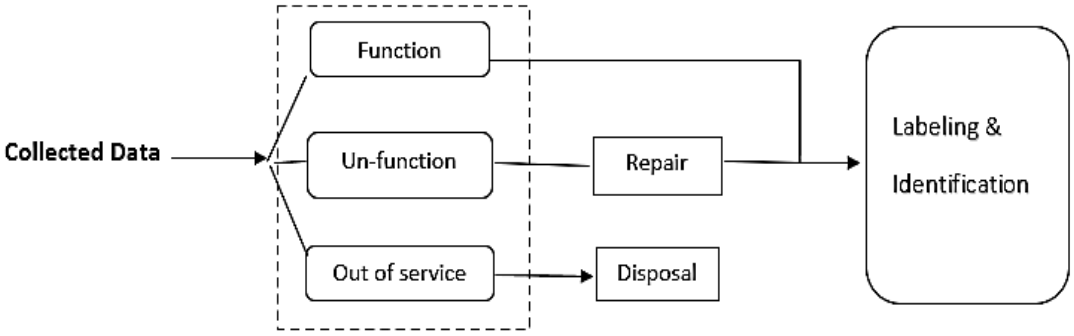


Fig. 4. 3: analysis process

All devices and equipment in a functional state applied to the coding and identification, but devices and equipment in a non-functional physical state must be repair before moving to the coding and identification, and the out of service equipment must be disposed.

4. Labeling and Identification:

Handle with a huge number of devices and equipment within one institution without distinction makes the tasks and activities of CED difficult and complex.

to distinguish devices from each other need to identify and label them, all equipment covered under this procedure will be inventoried and labeled with a unique code. The code will be assigned only to the identified equipment and will not be reused; so, a special simplified code has been defined for each device that contains set of characters and numbers: indicating the name of the device and its location within the laboratory (in which department!) and ID according to concerned department. Ex:

NCL-HTR-2 (indicate to a heater no2 in national chemical laboratory).

EPV-BSC-1 (indicate to biosafety cabinet no 1 in epi-virology lab).

MEL-DST-7 (indicate to distiller no 7 in medical entomology lab).

* According to stepwise of WHO, the identification process is done only for devices that in functional state.

for the labeling procedure; 3 formats of labels have been used; the label in white color used to identify the equipment in functional state; include name of equipment, code, model, serial number and date of labeling:

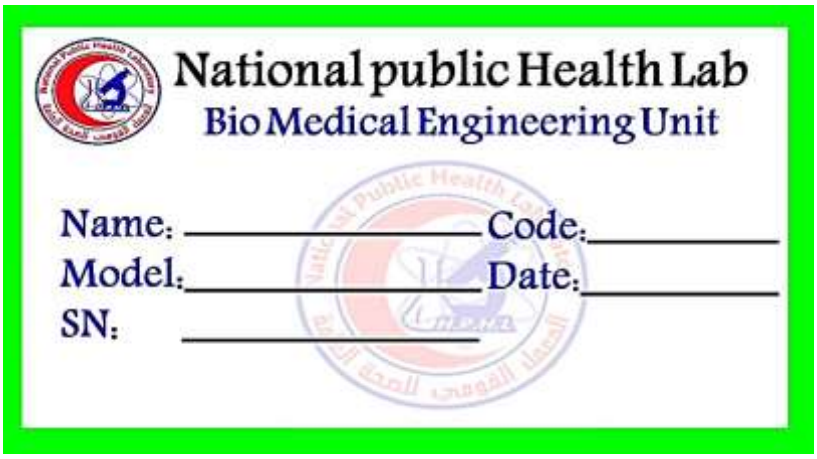


Fig. 4. 4: ID label

Red Label used for out of services equipment; to identify malfunction, date of device stopped working:

Fig. 4. 5: label for disposal equipment

-the blue label use for preventive maintenance

Fig. 4. 6: label for preventive maintenance

5. EOP's:

EOP is equipment's SOP; standard operation procedure document for specific piece of equipment

In ISO 15189 the recommended stepwise of WHO has special developed EOP template:

1. Framework for developing Equipment SOPs.
2. Objectives & Scope.
3. Abbreviations & definitions.
4. Tasks, responsibilities and accountabilities.
5. Description of the piece of equipment.
6. Safety and Environment.
7. Startup procedure (calibration, controls and maintenance).
8. Operation.
9. Problem solving.
10. Related Documents.
11. Related Forms.
12. References.
13. Attachments.

EOP’s designed according to WHO eop’s template for each category of equipment with full description in every single point mentioned above.

4.2. Visual Basic (front-end):

Visual Basic is programming language that directly support programmable graphical user interfaces (GUI) using language-supply objects.

Visual Basic is an object-oriented language that consists two fundamental elements of a visual part and a language part. The visual part is a set of objects, while the language part is programming language, used to create software of managing system by using visual basic management studio v.19.

Data Imported from SQL Server to Visual Studio as data source use for designing and coding elements using to create window forms of program; the system is configured of 8 window forms:

1. Splash form:

Is introduction form consisting of: label tool to display the computerized system’s name and progress bar tool with timer for system loading, configured with programming code (See appendix A)**.**

2. Login form:

Login form is allowing user to apply specific credentials to access a restricted program; contains: labels, two textboxes for username and password, and two buttons for login and exit. configured with programming code (See appendix B).

3. Main form:

Main form is user interface which allows users to access particular specific forms for managing tasks and activities by using toolstrip menu item as approach to: Entry form, maintenance form, request form, eop’s form and administration form. Configured with programming code (See appendix C).

4. Entry form:

Entry form is form that support inventory management, used DataGrid view to allow user to managing database, combobox to search by departments, multiple textboxes, buttons for remove, edit, add and save new item. Configured with programming code (See appendix D).

5. Maintenance form:

Maintenance form allow users to manage scheduled preventive maintenance used data grid view to show all equipment to manage, date and time picker for scheduling, 6 buttons for: maintenance schedule, maintenance for today, maintenanced, 3month P.M, save button and exit button. configured with programming code (See appendix E).

6.Forms:

Contain request form use in corrective maintenance,

Ax framer control used as function to open word file of request form. Configured with programming code (See appendix F).

7. EOP's form:

Eop form use to show equipment's EOP documents,

DSO framer control used as function to open word file of EOP, configured with programming code (See appendix G).

8. Adminstration form:

Form that allows the administrator only to decide and specify privileges of users. Use as security form, consist of: data grid view, labels, textboxes, check boxes and buttons. Configured with programming code (See appendix H).

CHAPTER FIVE

RESULTS AND DISCUSSIONS

5.1 Results and Discussions:

CIMMS was designed by Visual management studio (VB) as frond-end, and SQL server (database) as back-end. The results provide user interface for managing inventory and maintenance of all medical equipment in NPHL.

The CIMMS covers maintenance activities in MED on medical equipment management. Through accurate inventory include fully information for each equipment (such as category, location, physical condition, code, serial no, model, manufacturer and contract details), it provides useful information for effectively and efficiently management.

The system is configured of 8 window forms:

1. Splash Form:

Fig. 5. 1: Splash form

Splash screen is introduction screen designed to notify the user that the program is in the process of loading, consist: label to show name of software program and a progress bar with timer to indicate the loading progress.

2. Login form:

Fig. 5. 2: login form

It is a security screen, allowing only permitted persons to login to the system. Consist of: 2 text box, 2 labels and 2 buttons; The user must log into the system by providing the username and password.

3. Main form:

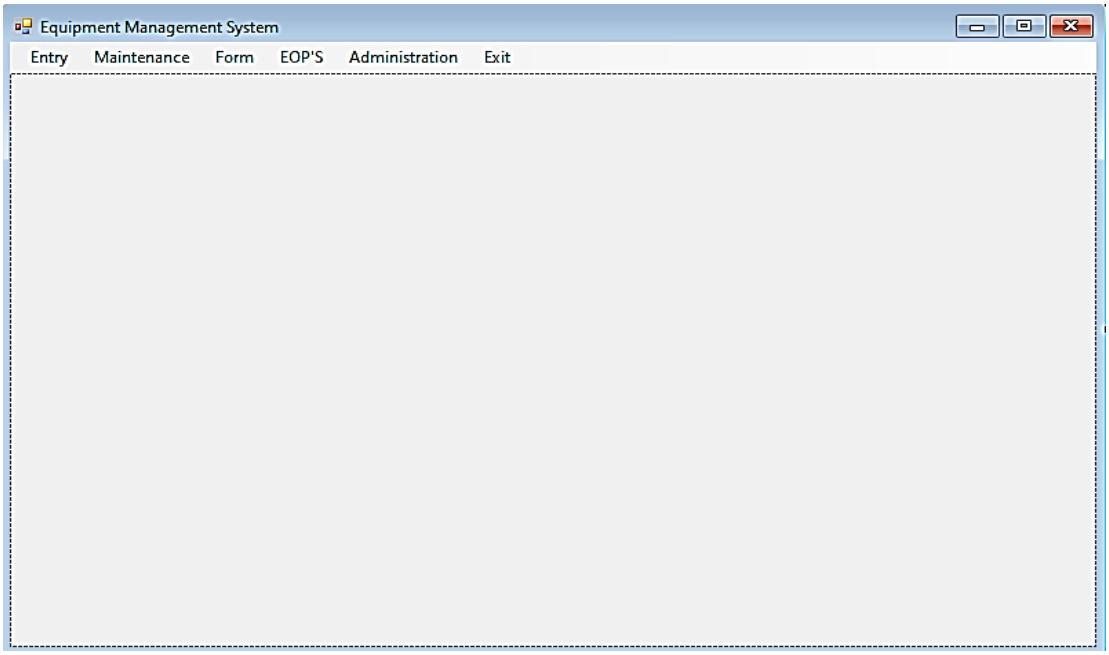


Fig. 5. 3: main form

Is a screen allowing user to use system's properties and access particular specific forms for managing tasks and daily operational activities by using toolstrip menu item as approach to: Entry form, maintenance form, request form, EOP's form and administration.

4. Entry form:

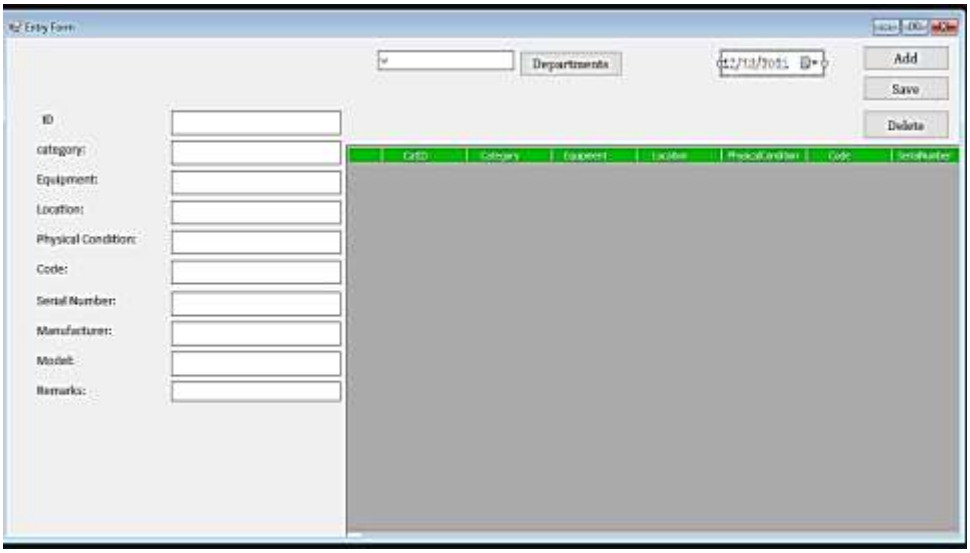


Fig. 5. 4: Entry form

It is a screen responsible for displaying and managing the inventory system, consist of:

-data grid view to show all medical equipment allow user to managing database,

- Buttons allow user to add, save and delete inside inventory database
- Labels and textboxes use for data entry
- Combobox to search inside departments
- date and time picker

5. Maintenance form:

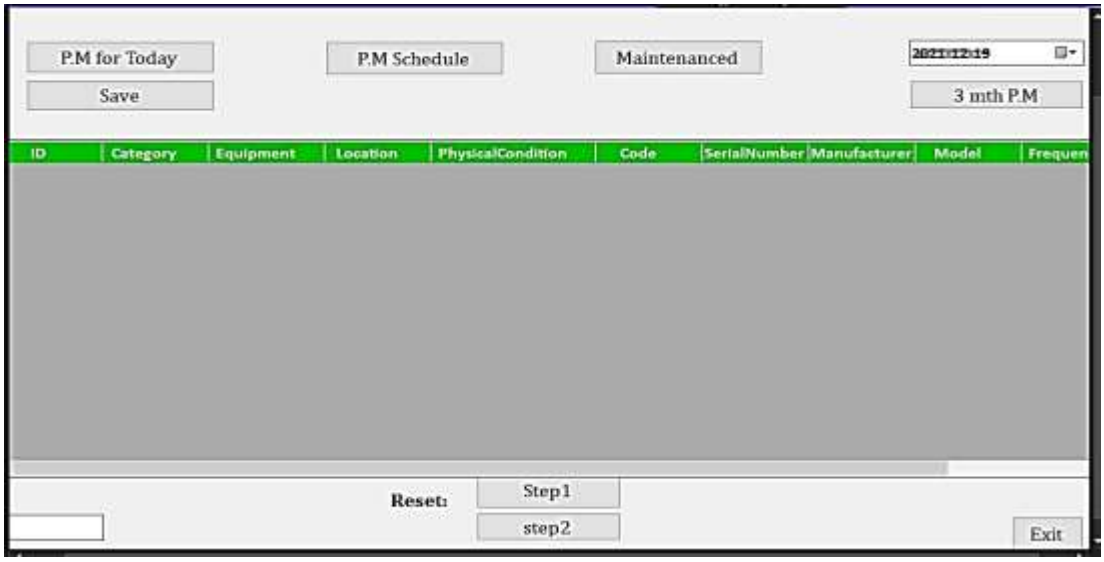


Fig. 5. 5: Maintenance form

It is screen that allowing user to manage scheduled maintenance program of medical equipment, consist of:

- Data grid view to show table of equipment's
- Date and time picker
- PM for today (button) that show about 6 equipment's per day for maintenance
- PM schedule (button) that show all equipment in function physical condition
- Maintained (button) that show maintained equipment that with full check box of PM
- 3-month PM (button) that show scheduled maintenance program per 90 days
- Reset (buttons) use step1 and step2 to restart maintenance schedule

6. Form:

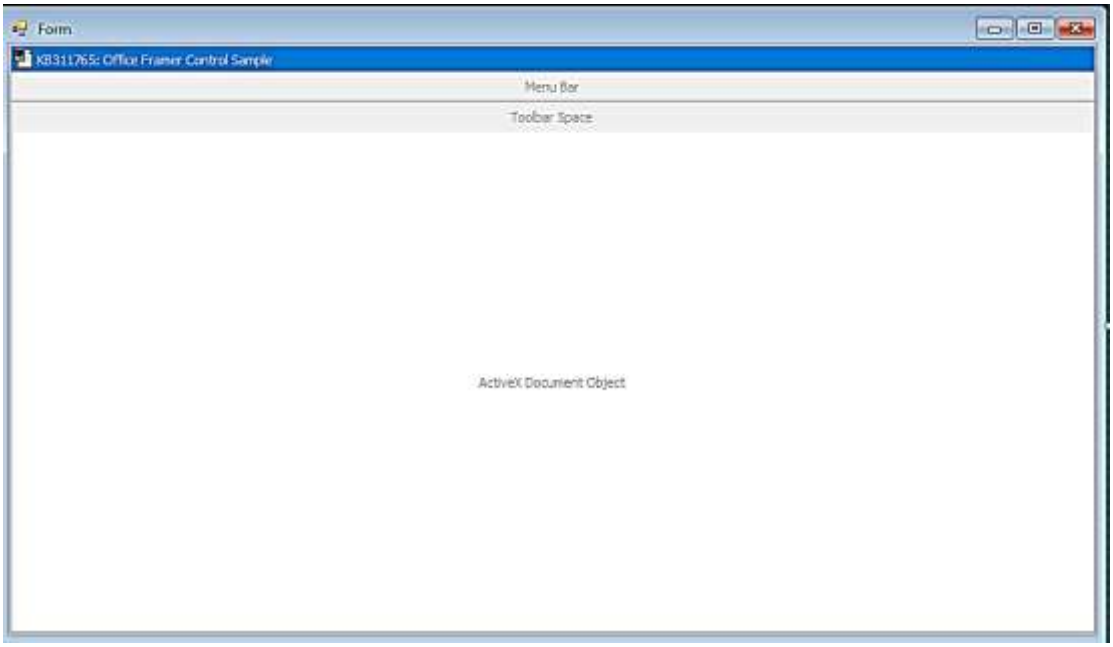


Fig. 5. 6: Request form

It is screen that allows user to open word file (request form) with full properties: save, edit, delete and print by used AX framer as function to runout word file.

7. EOP's Form:

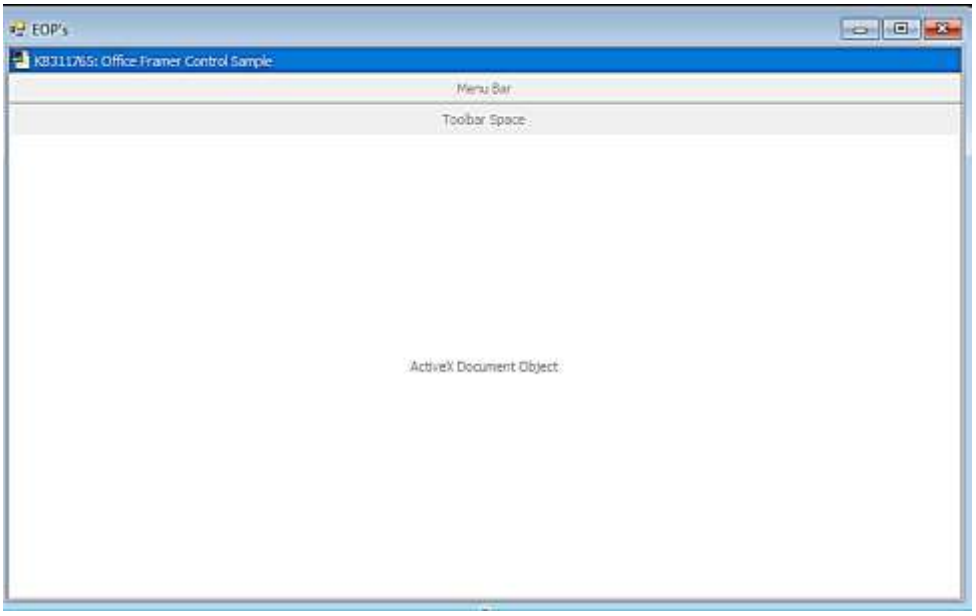


Fig. 5. 7: EOP's form

It is screen that allows user to open word files (EOP's) with full properties: save, edit, delete and print by used DSO framer as function to runout word files.

8. Administration form:

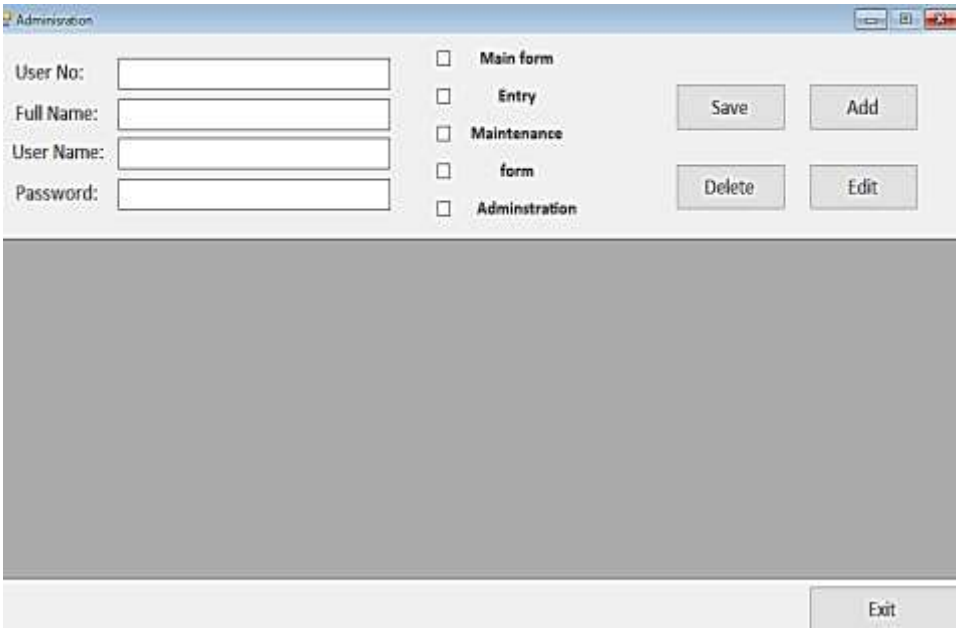


Fig. 5. 8: Administration form

It is screen use as security form of the system that allowing only approval administrator to manage process settings, manage data, specify the tasks and responsibilities of engineers in MED and access to screens of system.

Consist of:

- data grid view to show table of users
- labels and textboxes to entry data to table
- buttons to save, add, delete and edit data in the table
- checkboxes to specify access to system's forms

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion:

Hospitals, clinics and healthcare units depend on medical devices & equipment as an essential element to obtain the good performance, reduce staff and patients' risk and enhance patients care and quality of health services

MED is responsible for managing all medical equipment in units, Proper management of the equipment is necessary to ensure accurate, reliable, and timely testing; by Scheduled maintenance to reduce failure time and maintain equipment in good operational state; reduce time and cost of repair.

The use of the traditional management system (paper-based) depends on manual process consumes a lot of time and effort in addition to the cost of papers and storage space. It is ineffective system; data may lose.

CIMMS is a software tool developed and used to assist medical engineer for managing all medical devices and equipment that handle with, configured by SQL database at (back-end) and Visual basic at (front-end).

The computerized management system reduces the problems of the traditional system; that maintains a computer database of information about all medical devices and equipment in units and maintenance operations schedules, and provides user interface that easy-to-use for managing all.

System also allows for record keeping may help MED to make decisions and helps engineers do their jobs more effectively. Manually this requires a tremendous amount of effort and time.

An effective management program is designed to minimize downtime, maintain equipment in good operational state, and increasing the quality of health services and patient care.

6.2 Recommendations:

-The use and application of CIMMS in MED is recommended to assist engineers in managing medical devices and ensuring that the devices are in a high operational state, which reduces cost and effort and increases performance in hospitals, clinics and healthcare units.

-According to the results obtained in this research, the design and development of the CIMMS depends on two essential factors, Inventory; The inventory must be accurate, clear, and detailed, full of all the important and required information, and it is recommended to follow an approved methodology. And scheduled maintenance program It is recommended to set up a program with intervals according to the device categories and manufacturers' recommendations.

-In scheduling maintenance, consider the priority of maintenance for devices according to malfunctions, operating condition and manufacturer’s instructions.

-To design CIMMS, is recommended using an easy and flexible programming language, and to use a server to support the database; easy connection high data security.

-The improvements that could be on system are: Add a form that supports calibration scheduling, and system can be upgraded to a web-based system.

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APPENDICES

Appendix A: "Splash Form**"**

```
Public Class splash
Private Sub Splash_Load(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles MyBase.Load
Timer1.Start()

End Sub

Private Sub Timer1_Tick(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles Timer1.Tick
ProgressBar1.Increment(5)
If ProgressBar1.Value = 100 Then
login.Show()
Me.Hide()
Timer1.Stop()

End If
End Sub

Private Sub ProgressBar1_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles ProgressBar1.Click

End Sub
End Class
```

Appendix B: “Login Form”

```
Public Class Frm_Login

Public Sub login(ByVal txtusername As String, ByVal txtpassword As String, ByVal Frm As Form)

con.Open()
Dim cmd As New SqlCommand("select * from User_Tbl where UserName = @UserName and Password = @Password", con)
cmd.Parameters.Add("@UserName", SqlDbType.VarChar).Value = txtusername
cmd.Parameters.Add("@Password", SqlDbType.VarChar).Value = txtpassword
Dim adp As New SqlDataAdapter(cmd)
Dim dt As New DataTable
adp.Fill(dt)
If dt.Rows.Count() <= 0 Then
MessageBox.Show("username or Password is incorrect")

End If
con.Close()

Private Sub Frm_Login_Load(sender As Object, e As EventArgs) Handles MyBase.Load

End Sub
```

```
Private Sub btnSave_Click(sender As Object, e As EventArgs) Handles btnSave.Click
login(TxtUserName.Text, TxtPassword.Text, Me)
End Sub

Private Sub btnClose_Click(sender As Object, e As EventArgs) Handles btnClose.Click
Close()
End Sub
```

Appendix C: "Main Form**"**

```
Public Class Main
```

-To open Entry form:

```
Private Sub EntaryToolStripMenuItem_Click(sender As Object, e As EventArgs) Handles EntaryToolStripMenuItem.Click
Dim frm As New Epi_Bacterology1
frm.TopLevel = False
HomePanel.Controls.Add(frm)
frm.BringToFront()
frm.Show()
End Sub
```

-Search in departments in Entry form:

```
Private Sub SeachDepartmentToolStripMenuItem_Click(sender As Object, e As EventArgs)
Dim frm As New Bacterology
frm.TopLevel = False
HomePanel.Controls.Add(frm)
frm.BringToFront()
frm.Show()
```

```
End Sub
```

-To open Maintenance form:

```
'Private Sub MaintenceToolStripMenuItem_Click(sender As Object, e As EventArgs) Handles MyBasetenceToolStripMenuItem.Click
'  Seach_Bacterology.ShowDialog()
'End Sub
```

-To open Form in Entry form:

```
Private Sub FormToolStripMenuItem_Click(sender As Object, e As EventArgs) Handles FormToolStripMenuItem.Click
Dim frm As New word
frm.TopLevel = False
HomePanel.Controls.Add(frm)
frm.BringToFront()
frm.Show()
End Sub
Private Sub MaintenceToolStripMenuItem_Click(sender As Object, e As EventArgs) Handles MaintenceToolStripMenuItem.Click
Dim frm As New Bacterology
frm.TopLevel = False
HomePanel.Controls.Add(frm)
frm.BringToFront()
frm.Show()
End Sub
Private Sub ToolStripMenuItem1_Click(sender As Object, e As EventArgs) Handles ToolStripMenuItem1.Click
Frm_Users.ShowDialog()
End Sub
```

-To open EOP's Form:

```
Private Sub EOPSToolStripMenuItem_Click(sender As Object, e As EventArgs) Handles EOPSToolStripMenuItem.Click
Dim frm As New eop
frm.TopLevel = False
HomePanel.Controls.Add(frm)
frm.BringToFront()
frm.Show()
End Sub
End Class
```

Appendix D: “Entry Form**”**

Public Class Entry-form

-When ADD new ID:

Public Function Max_Bacterlogy()

Dim Number As Integer

Try

Dim cmd As New SqlCommand("Select Max(CatID) From Bacterlogy ", con)

If con.State = 1 Then con.Close()

con.Open()

Number = cmd.ExecuteScalar

con.Close()

Catch ex As Exception

Number = 0

con.Close()

End Try

Return Number

End Function

-To load table of equipments from SQL database to Data grid view:

Public Sub LoadAllTable_Bacterlogy_InDirect(ByVal dgv As DataGridView)

Dim dt As New DataTable

Dim da As New SqlDataAdapter

dt.Clear()

da = New SqlDataAdapter("select * from Bacterlogy", con)

da.Fill(dt)

dgv.AutoGenerateColumns = False

dgv.DataSource = dt

```
End Sub
Public Sub Search()
Dim dt As New DataTable
Dim da As New SqlDataAdapter
dt.Clear()
da = New SqlDataAdapter("select * from Bacterlogy where Location = N'"
& ComboBox1.Text & "'", con)
da.Fill(dt)
Me.dgv.AutoGenerateColumns = False
Me.dgv.DataSource = dt

End Sub
```

-To fill combobox in table:

```
Public Sub fillcmb(ByVal cmb As ComboBox)
‘Fill combobox’
Dim dt As New DataTable
Dim da As New SqlDataAdapter
dt.Clear()
da = New SqlDataAdapter("select * from Bacterlogy", con)
da.Fill(dt)

If dt.Rows.Count > 0 Then

cmb.DataSource = dt
cmb.ValueMember = "CatID"
cmb.DisplayMember = "Location"

dgv.AutoGenerateColumns = False
dgv.DataSource = dt
```

Else

cmb.DataSource = Nothing

End If

End Sub

Private Sub Button3_Click(sender As Object, e As EventArgs) Handles Button3.Click

Search()

End Sub

Private Sub Button2_Click(sender As Object, e As EventArgs) Handles Button2.Click

-Save button:

Save_Supplier_InDirct()

LoadAllTable_Bacterlogy_InDirect(dgv)

End Sub

-Delete texts from textboxes after click save button:

Private Sub Button4_Click(sender As Object, e As Event Args) Handles Button4.Click

Clear Controls()

End Sub

If Message Box. Show("delete item?", "warning!", Message Box Buttons. Yes No, Message BoxIcon .Question, MessageBoxDefaultButton.Button2) = Windows.Forms.DialogResult.No Then

Exit Sub

Else

Delete_Bacterlogy(dgv)

End If

LoadAllTable_Bacterlogy_InDirect(dgv)

End Sub

End Class

Appendix E: “Maintenance Form”

```
Imports System.Data.SqlClient
Imports System.Data.DataTable
Imports System.Data
Public Class Maintenance- form
Dim dr As SqlDataReader
Dim dr1 As SqlDataReader
Dim ra As Integer
Dim cmd As New SqlCommand
Dim dt As New DataTable
Dim index As Integer
Dim dateb As String = "2020-12-2"
-Load PM Schedule from database:
Dim table As New DataTable("PM_Schedule")
Public dt_PM As New DataTable

Public Sub Search_marda_InDirect()
-Fill data grid view from database:
Dim dt As New DataTable
Dim da As New SqlDataAdapter
dt.Clear()
da = New SqlDataAdapter("select * from PM schedule ", con)
da.Fill(dt)
dgv.AutoGenerateColumns = False
dgv.DataSource = dt

End Sub
```

-Load table from sql database to data grid view:

```
Public Sub LoadAllTable_Supplier_InDirect(ByVal dgv As DataGridView)
Dim dt As New DataTable
Dim da As New SqlDataAdapter
dt.Clear()
da = New SqlDataAdapter("select * from Bacterlogy", con)
da.Fill(dt)
dgv.AutoGenerateColumns = False
dgv.DataSource = dt

End Sub
```

-PM for today button:

```
Private Sub Button2_Click(sender As Object, e As EventArgs) Handles
Button2.Click
PM for today
DataGridView1.Visible = False
dgv.Visible = True
Dim dt As New DataTable
Dim da As New SqlDataAdapter
Dim i As Integer = 0
dt.Clear()
```

-Select 6 items from PM schedule to show in table:

```
da = New SqlDataAdapter("select TOP 6 * from Bacterlogy where
PhysicalCondition = 'Function'and Frequencyofmaintenance ='false'", con)
da.Fill(dt)
Me.dgv.AutoGenerateColumns = False
Me.dgv.DataSource = dt

"Have2main()
```

```
End Sub

Private Sub Button1_Click(sender As Object, e As EventArgs) Handles Button1.Click
dgv.Visible = False
DataGridView1.Visible = True
PM for today
Dim dt As New DataTable
Dim da As New SqlDataAdapter
Dim i As Integer = 0
dt.Clear()
da = New SqlDataAdapter("select * from Bacterlogy where PhysicalCondition = 'Function'and Frequencyofmaintenance ='true'", con)
da.Fill(dt)
Me.DataGridView1.AutoGenerateColumns = False
Me.DataGridView1.DataSource = dt

"Have2main()
End Sub

Private Sub Button4_Click(sender As Object, e As EventArgs) Handles Button4.Click
Dim frm As New Form1
frm.TopLevel = False
Main.HomePanel.Controls.Add(frm)
frm.BringToFront()
frm.Show()

End Sub
```

-3mth PM button:

```
Private Sub Button7_Click(sender As Object, e As EventArgs)
'TextBox1.Text = Today.AddMonths(3)
End Sub

Private Sub ComboBox1_SelectedIndexChanged(sender As Object, e As EventArgs)

End Sub
```

-Search in Date:

```
Private Sub Button6_Click (sender As Object, e As EventArgs)

End Sub

Private Sub DataGridView1_CellContentClick(sender As Object, e As DataGridViewCellEventArgs)

End Sub

Private Sub Date1_ValueChanged(sender As Object, e As EventArgs) Handles Date1.ValueChanged

End Sub

Private Sub Button7_Click_1(sender As Object, e As EventArgs) Handles Button7.Click
Update_Bacterlog1()
End Sub
```

-To load PM Schedule from Database:

```
Private Sub Seach_Bacterology_Load(sender As Object, e As EventArgs) Handles MyBase.Load
'Fill_cmb("Bacterlogy", ComboBox1, "Location", "CatID")

TextBox1.Visible = False
'Date1.Value = dateb

'fillcmb(ComboBox1)

End Sub
```

Appendix F: “Request Form**”**

```
Public Class word

Private Sub word_Load(sender As Object, e As EventArgs) Handles
MyBase.Load
-use AX framer to open word file:
AxFramerControl1.Open("D:\request form.docx")
End Sub

Private Sub AxFramerControl1_OnFileCommand(sender As Object, e As
AxDSOFramer._DFramerCtlEvents_OnFileCommandEvent) Handles
AxFramerControl1.OnFileCommand

End Sub
End Class
```

Appendix G: “EOP’s Form **“**

Public Class eop

Private Sub eop_Load(sender As Object, e As EventArgs) Handles MyBase.Load

End Sub

-use DSO framer to open file:

Private Sub DSOFramerControl1_OnFileCommand(sender As Object, e As DSOFramer._DFramerCtlEvents_OnFileCommandEvent) Handles DSOFramerControl1.OnFileCommand

End Sub

End Class

Appendix H: “Administration Form”

```
Public Class Frm_Users
Public DT_User_Tbl As New DataTable
Public Sub Load_User_Tbl(ByVal DGV_User_Tbl As DataGridView, ByVal Meform As Form)
```

-Load table from sql database to Data grid view:

```
Public Sub Insert_User_Tbl(ByVal Userid As Int32, ByVal FullName As String, ByVal UserName As String, ByVal Password As String, ByVal ChkIs_User As Boolean, ByVal Entary As Boolean, ByVal Maintence As Boolean, ByVal Form As Boolean, ByVal Employee As Boolean)
Dim Cmd As New SqlCommand
With Cmd
.Connection = con
.CommandType = CommandType.Text
.CommandText = "Insert Into User_Tbl ( Userid, FullName, UserName, Password,ChkIs_User,Entary,Maintence,Form,Employee)values(@Userid,@FullName,@UserName,@Password,@ChkIs_User,@Entary,@Maintence,@Form,@Employee)"
Public Sub Update_User_Tbl(ByVal FullName As String, ByVal UserName As String, ByVal Password As String, ByVal ChkIs_User As Boolean, ByVal Entary As Boolean, ByVal Maintence As Boolean, ByVal Form As Boolean, ByVal Employee As Boolean)
```

-When ADD new ID:

```
Public Function Max_User_Tbl()
Dim Number As Integer
Try
Dim cmd As New SqlCommand("Select Max(Userid) From User_Tbl ", con)
```

If con.State = 1 Then con.Close()

con.Open()

Number = cmd.ExecuteScalar

con.Close()

Catch ex As Exception

Number = 0

con.Close()

End Try

Return Number

End Function

-load users table from database:

Private Sub Frm_Users_Load(sender As Object, e As EventArgs) Handles MyBase.Load

Load_User_Tbl(DGV_User_Tbl, Me)

FormatDGV_User_Tbl(DGV_User_Tbl)

End Sub

Private Sub btnEdit_Click(sender As Object, e As EventArgs) Handles btnEdit.Click

End Sub

Private Sub btnSave_Click(sender As Object, e As EventArgs) Handles btnSave.Click

End Sub

Private Sub ChkIs_User_CheckedChanged(sender As Object, e As EventArgs) Handles ChkIs_User.CheckedChanged

End Sub